

Department of Clinical Physiology, Nuclear Medicine & PET

Annual Report 2013





Rigshospitalet

King Frederik V founded Rigshospitalet in 1757. Today, it has 1,200 beds, 8,500 employees and an annual budget of 6.4 billion DKK. Research at Rigshospitalet is published in more than 2,000 peer review papers per year, including around 90 higher academic theses (PhD and Doctor of Medical Science). Rigshospitalet is part of The Capital Region of Denmark and is a Copenhagen University Hospital.

University of Copenhagen

The University of Copenhagen was founded in 1479. The Faculty of Health Sciences has 4,000 students and 10 bachelor- and master educations, including medicine and bioengineering in collaboration with The Technical University of Denmark, DTU. The University of Copenhagen is member of IARU, The International Alliance of Research Universities. www.ku.dk

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Preface

The Department of Clinical Physiology, Nuclear Medicine & PET has had yet another record year in 2013 with 76,700 patient investigations, again showing a significant increase in productivity in comparison to previous years. We would like to express our genuine thanks to the entire staff for this major achievement.

This year has been a special challenge as the ICT has suffered severe difficulties. The PACS system (Picture Archiving & Communication System) is out of date, and until the new system can be installed it continues to be a trial to complete clinical services for our patients. It has required many extra hours and effort, and we owe the entire department our most sincere thank you for a great job done.

In spite of the trouble with the PACS system, the research programmes have performed on the most exceptional level. Thank you to Professor Andreas Kjær and the whole department for this impressive effort. Again this year the research program resulted in more than 100 peer review publications and seven theses (PhD and Doctor of Medical Science). These strong papers are pushing the boundaries of nuclear medicine and we are collaborating with our colleagues worldwide through attendance at important meetings and numerous publications. It is the aim of our department that all patients receive the best and most appropriate research based investigations, and that our patients are treated at all times in a dignified and professional atmosphere. We continue to strive to accomplish this aim.

Thank you to our directors at the Centre of Diagnostics, Rigshospitalet; Centre Director Bettina Lundgren, MD, DMSc and Vicedirector Karin Nørgaard and their team for important positive and helpful collaboration. Thank you to the Board of Directors, Rigshospitalet: Torben Stentoft, CEO, Jannik Hilsted, Chief Medical Officer and Helen Bernt Andersen, Chief Nursing Officer for their assistance throughout the year.



Liselotte Højgaard and Linda M. Kragh

Thank you to the Department of Radiology for positive collaboration on patients and research, Head of Department Ilse Vejborg and Chief Radiographer Johnny Madelung.

The highlight of 2013 was the opening of our new section, KF4112, for Pediatric Nuclear Medicine with fascinating wall art sponsored by the Obel Family Foundation and accomplished by Set Designer Nina Flagstad, Theatre Artist Christine Bechameil and Light Artist Jonas Bøgh. Thank you very much to the Obel Family Foundation. This project was coordinated by Dr. Lise Borgwardt, Chief Consultant in Pediatric Nuclear Medicine. Congratulations to the entire team, and especially to all our young patients with this new section, which includes a Siemens PET/CT 128 slice scanner recently installed - an exemplary system designed specifically for pediatric use. The hard work and efforts of our team of nuclear medicine technologists and radiographers, Viktoria Setterberg, Anja Vallin Hansen, Solveig Linnet, Ghina Nehme, Stine Holm, Mariam Hassan and Elisabeth Abrahamsson, is greatly appreciated. The Pediatric Team has set the stage for an exceptional standard of care for children referred to our department.

Our aim is to deliver the best patient treatment and the best research and education. Without all your great effort it would not have been possible. Thank you to all staff, collaborators and international colleagues.

A handwritten signature in blue ink, reading 'Lotte'.

Liselotte Højgaard
Professor, Head of Department

A handwritten signature in blue ink, reading 'Linda'.

Linda M. Kragh
Chief Technologist



Mission and objectives

The mission of Rigshospitalet is to be the leading hospital in Denmark for patients in need of highly specialized treatment.

The general objectives are:

- » to be at the forefront of highly specialized diagnostic treatment and nursing
- » to carry out research and development at an advanced international level
- » to educate staff in the health services to a highly specialized level
- » to contribute with professional advice and exchange of knowledge and expertise to the wider healthcare community
- » to be characterized by openness and human respect

The objectives of the Department of Clinical Physiology, Nuclear Medicine & PET are:

- » to provide optimal clinical physiology and nuclear medicine for patient investigation
- » to carry out research at the highest international level in clinical physiology and nuclear medicine with special emphasis on molecular imaging, isotopes and radiopharmaceuticals
- » to deliver undergraduate and postgraduate education for all relevant professionals within the relevant expert clinical fields, nationally and internationally
- » to provide a good patient experience and ensure the wellbeing of the staff

The staff participates in many congresses, symposias, meetings and workshops with invited lectures, oral presentations, abstracts and posters. We have a comprehensive program for all staff members at the department, and frequent visits from Danish and international research groups.

In 2013 more than 250 groups and individuals visited the department.

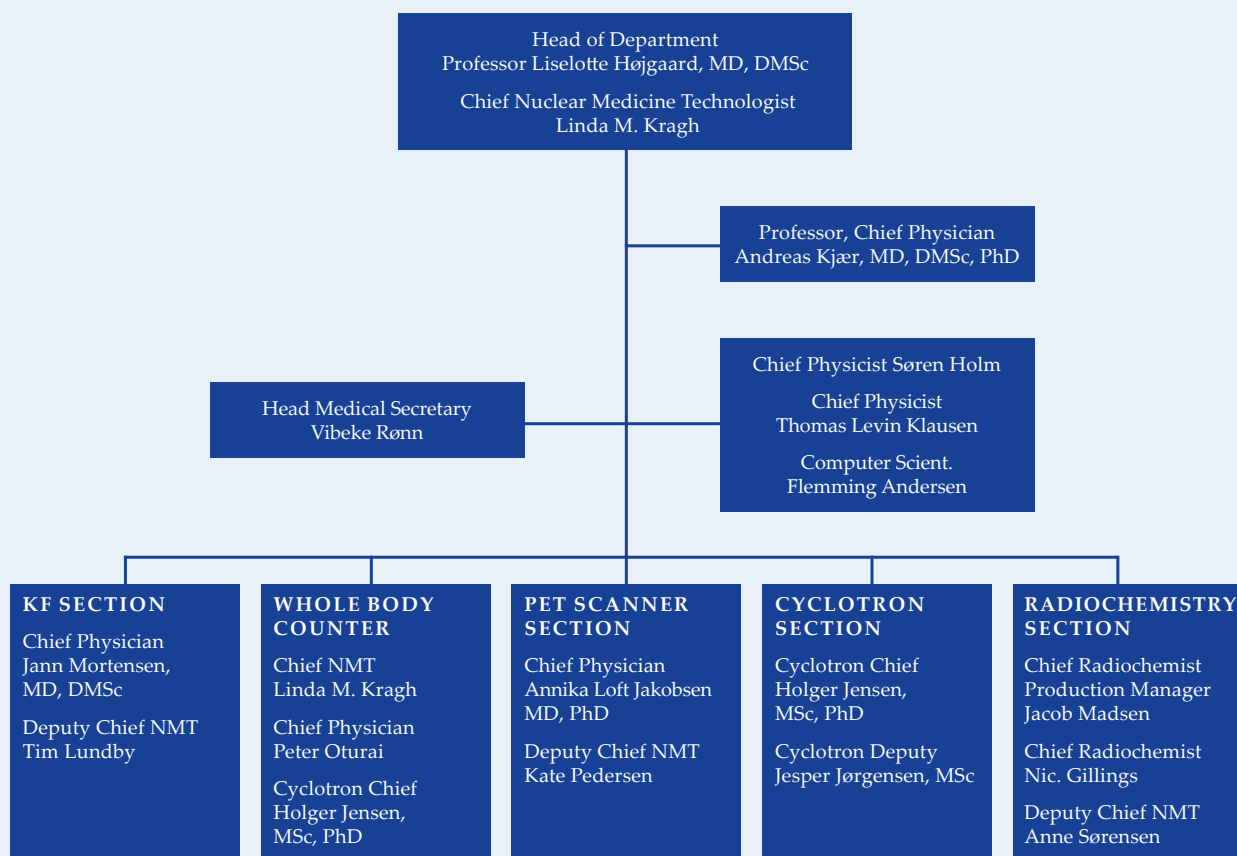
Organisation and staff



Department of Clinical Physiology, Nuclear Medicine & PET is part of The Diagnostic Center headed by Bettina Lundgren, Director, MD, DMSc and Karin Nørgaard, Vicedirector

Abrahamsson, Elisabeth, Radiographer.
Agner, Elissaveta Castella. Radiographer.
Ahmadi, Davud, Engineer.
Albers, Mia C. Hjorth, Teaching NMT.
Alslev, Louise, Senior Registrar.
Amtoft, Annemarie Gjelstrup, Chief Physician.
Andersen, Anne Sofie Bech, Student.
Andersen, Flemming, MSc, PhD, Chief Computer Scientist.
Andersen, Julie Bjerglund, MD, PhD Student.
Andersen, Kim Francis, Senior Registrar.
Andersen, Kjeld, Registrar.
Azizi, Nadia, Radiographer.
Bender, Thomas., Student.
Benoit, Didier, Physicist, Post Doc.
Benzon, Eric von, MD, Chief Physician.
Berthelsen, Anne Kiil, MD, Chief Physician.
Beyer, Thomas, Physicist.
Binderup, Tina, MSc Human Biology, PhD, postdoc.
Birk, Kirsten Junker, NMT.
Bodholt, Rasmus Poul, Research Fellow.
Bojesen, Christina, Teaching NMT.

Borgwardt, Henrik Gutte, MD, Research Fellow.
Borgwardt, Lise, MD, PhD, Chief Physician.
Børresen, Betina, DVM, PhD Student.
Brandt-Larsen, Malene, MSc, PhD, Chemist.
Butt, Sedrah, Student.
Cappelen, Katrine Louise, Engineer.
Christensen, Anders, MD, PhD Student.
Christensen, Camilla, Chemist and NMT.
Christensen, Camilla, NMT.
Christensen, Charlotte Birk, MD, Senior Registrar.
Christensen, Helle, NMT and Nurse.
Christensen, Jan Damgaard, Cyclotron Technician.
Christensen, Thomas Emil, MD, PhD Student.
Christensen, Tine Nøhr, MD, Research Fellow.
Clausen, Malene, MD, PhD Student.
Clemmensen, Andreas Ettrup, MSc Med.Tech, Research Fellow.
Cortsen, Annette, NMT.
Costa, Junia, MD, Senior Registrar.
Dahan, Daniel, Cyclotron Technician.
Dähnhardt, Andreas, Computer Assistant.
Dall, Bente, NMT.
de Nijs, Robin, Medical Physicist, MSc, PDEng, PhD.
Demant, Cecilia. Student.
Denholt, Charlotte Lund, MSc, PhD, Chemist.
Drachmann, Anders Paaske, Student.
Dunbar, Douglas, NMT.
Durmus, Sevil, Medical Secretary.



El-Ali, Henrik, Physicist, PhD, Ass. Prof.

El-Faitarouni, Alisar, Student.

Elkington, Sakeena, NMT.

Ellegaard, Andreas Høyby, Student.

Elsgaard, Maria Stenvig, Secretary.

Engberg, Astrid, Student.

Engelmann, Bodil, PhD Student.

Erlandsson, Maria, MSc, PhD, Chemist.

Ettrup, Anders, MSc, PhD, Chemist.

Federspiel, Marianne, NMT.

Fischer, Barbara Malene, MD, DMSc, PhD, Senior Registrar.

Frederiksen, Mette, NMT.

Gathigia, Purity, NMT.

Ghotbi, Adam Ali, MD, PhD Student.

Gillings, Nicholas, MSc, PhD, Chief Radio Chemist.

Grüner Julie Marie, MD, PhD Student.

Hag, Anne Mette Fisker, MSc Human Biology, PhD, Post Doc.

Hansen, Adam Espe, Physicist.

Hansen, Anders Elias, DVM, PhD, Post Doc.

Hansen, Anja Vallin, NMT.

Hansen, Casper, Student.

Hansen, Christian, Student.

Hansen, Ingeborg, Student.

Hansen, Lasse, NMT.

Hansen, Nini, NMT.

Hasbak, Philip, MD, Chief Physician.

Hassan, Mariam, NMT.

Hassing, Christina, Student.

Hayat, Anbreen, NMT.

Henning, William Sebastian, Engiener.

Henriksen, Martin Romme, Student.

Henriksen, Otto Mølby, Senior Registrar.

Hesse, Birger, MD, DMSc, Chief Physician.

Hildebrand, Sanne, Secretary.

Højgaard, Liselotte, MD, DMSc, Head of Department, Professor.

Holm, Søren, MSc, PhD, Chief Physicist.

Holm, Stine, NMT.

Holtz, Simon Herken, MSc, QA Academic.

Husted, Frederik Agner, Student.

Iljazovska, Cejlan Zulfovskaja, NMT.

Jakobsen, Annika Loft, MD, PhD, Chief Physician.

Jensen, Holger, MSc, PhD, Physicist, Cyclotron Chief.

Jensen, Martin Ravn, NMT.

Jensen, Mette Munk, MSc Human Biology, PhD, Post Doc.

Jensen, Tina Gade, QA-Assistant.

Jeppesen, Troels Elmer, Chemist, PhD Student.

Johannesen, Helle Hjorth, Chief Physician.

Johnbeck, Camilla Bardram, MD, PhD Student.

Jørgensen, Jesper Tranekær, MSc Human Biology, PhD, Post Doc.

Jørgensen, Jesper, MSc, Cyclotron Physicist.

Jørgensen, Louise, Registrar.

Jørgensen, Mette Møller, NMT.

Juhl, Karina, MSc Human Biology, Research Fellow.

Kaijer, Michelle Nymann, Technologist.



Keller, Sune Høgild, MSc, PhD, Computer Scientist.
 Kjær, Andreas, MD, DMSc, PhD, MBA, Chief Phys., Professor.
 Klausen, Thomas Levin, MSc, Chief Physicist.
 Klyver, Cecilia, Student.
 Knudsen, Camilla Sloth, NMT.
 Knudsen, Jesper Andreas, MD, PhD Student.
 Korsholm, Kirsten, MD, Registrar.
 Kragh, Linda M., Chief NMT.
 Kristensen, Lars Kristian, Cyclotron Technician.
 Kronvall, Johanna, NMT.
 Ladefoged, Claes Nøhr, Computer Scientist.
 Lærke, Sonja Pedersen, Technician.
 Langer, Natasha Hemicke, Scholarship.
 Larsen, Camilla, Student.
 Larsen, Mette Fabiansen, Medical Secretary.
 Larsen, Thorvald Wadum, Student.
 Lassen, Martin, Engineer.
 Law, Ian, MD, PhD, Chief Physician.
 Lehel, Szabolcs, MSc, PhD, Chemist.
 Li, Fan, MSc Med Tech, PhD Student.
 Lindell, Elin, NMT.
 Linnet, Solveig, NMT.
 Ljunggren, Anna, NMT.
 Löfgren, Johan, MD, Chief Physician.
 Lundby, Tim, Deputy Chief NMT.
 Madsen, Casper Lillegård, Student.

Madsen, Jacob, MSc, PhD, Chemist, Chief Production Manager.
 Madsen, Lasse Ahlbech, Student.
 Magnusson, Linda, Technologist.
 Mark, Peter Dall, Student.
 Marner, Lisbeth, MD, Registrar.
 Mohebi, Ali, Student.
 Mørk, Mette Louise, Registrar.
 Mortensen, Jann, MD, DMSc, Chief Physician, Ass. Professor.
 Mørup, Peter, Senior Registrar.
 Munkholm-Larsen, Mathias, Student.
 Myltoft, Mette Gylling, Medical Secretary.
 Myschetzky, Rebecca, NMT.
 Nedergaard, Mette Kjølhed, MD, PhD Student.
 Nehme, Ghina, NMT.
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 Nielsen, Carsten Haagen, MSc Med Tech, PhD Student.
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 Nielsen, Tina Vikmann, Medical Secretary.
 Nørgaard, Martin, Student.
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 Omanovic, Dzenita, Student.
 Ørting, Silas, Student.
 Østergaard, Daniella E. , Student.



Oturai, Peter, MD, Chief Physician.
 Oxbøl, Jytte, Chief Technologist.
 Pedersen, Kate, Deputy Chief NMT.
 Pedersen, Sune Folke, MSc Human Biology, PhD Student.
 Pejtersen, Maria, NMT.
 Perez, Nicolas Palm, Student.
 Persson, Morten, MSc Pharm, PhD Student.
 Pfeifer, Andreas, MD, PhD Student.
 Porojan, Monica, Technician.
 Poulsen, Jákup Martin, Radiographer.
 Rahbek, Rikke Sofie, Student.
 Rahimi, Khalida, NMT.
 Rask, Charlotte Krogh, Senior Registrar.
 Rasmussen, Kirstine, Technician.
 Rasmussen, Sine Hvid, Student.
 Rasmussen, Thomas, Registrar.
 Reichkender, Michala, Registrar.
 Ripa, Rasmus S, MD, DMSc, Post Doc.
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 Rønn, Vibeke, Head Medical Secretary.
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 Schulze, Christina, NMT.
 Semitoje, Gudrun, Medical Secretary.
 Setterberg, Victoria, NMT.

Sibomana, Merence, IT-expert.
 Sinik, Elida, NMT.
 Skovgaard, Dorte, MD, PhD, Post Doc.
 Sørensen, Anne B., NMT.
 Sørensen, Anne, Deputy Chief NMT.
 Sørensen, Louise Sørup, NMT.
 Stahlfest, Marianne, Medical Secretary.
 Stahr, Karin, NMT.
 Strøm, Emil, Student.
 Svalling, Susanne, NMT.
 Thuesen, Rosa, Medical Secretary.
 Tidemann, Linette, Technician.
 Værgø, Thorkil Kowalski, Student.
 Vejstrup, Charlotte, NMT.
 Vensby, Philip Hvalsøe, Student.
 Weihrauch, Filip, Student.
 Weihrauch, Per, Cyclotron Technician.
 Weihrauch, Simone, Student.
 Westh, Louise, Medical Secretary.
 Wikke, Tina, NMT.
 Wittekind, Anne-Mette Nielsen, QA Pharmacist.
 Ybæk, Helle, Radiographer.
 Yerst, Joo, NMT.
 Zornhagen, Kamilla Westarp, DVM, PhD Student.

Highlights 2013



Celebration of the 100 years anniversary of the Niels Bohr atom model.

Rigshospitalet participated in the celebration in 2013 of the 100 years anniversary of the three famous articles presenting Niels Bohr's atom model. We had a one day symposium about the fathers of nuclear medicine, Niels Bohr and George de Hevesy with a program comprising Prof. Liselotte Højgaard, Prof. Helge Kragh, Prof. Mikael Jensen, Prof. Finn Aaserud, Ass. Prof. Karin Tybjerg, Prof. Jens H. Henriksen, Prof. Vilhelm Bohr, Prof. Andreas Kjær and Dean, Prof. John Renner. More than 400 people participated in the symposium, and it was a great success.

The new Pediatric Nuclear Medicine Section

We celebrated the opening of the new Pediatric Section on the 22th of August 2013, and we can already now report, that it is a great success if we ask our small patients and their families. The artists, who decorated the section were invited to the symposium and the opening: Set Designer Nina Flagstad, Theatre Artist Christine Bechameil and Light Artist Jonas Bøgh as well as The Obel Family Foundation who graced us with their presence at the opening: Chairman of the Board Christen Obel, Director Søren Bojer Nielsen and Project Manager Hanna Line Jakobsen.



In the Fall 2013 we had the annual Theme Day about the future development of our department. We established three strategy groups working with the plans for how to strengthen and develop our department towards 2020 with special focus on innovation. Three groups were established: 1) Better Patient Care, 2) A New Department and 3) Improved and Seamless ICT. In the evening there were dinner and carnival at Hellerup Sejlklub.





Nuclear Medicine Technologist Camilla Christensen was bicycling from Copenhagen to Paris as part of the Team Rynkeby, an annual event where staff from Rigshospitalet bicycle together with others to Paris to help the children with cancer in our hospital. We are extremely proud of Camilla's grand achievement.



Professor Andreas Kjær opened his new PET/MRI animal scanner donated by the Infrastructure Commission at the Ministry of Research Denmark as support for the EATRIS ESFRI Research network where Professor Andreas Kjær is National Director.



The Danish National Research Foundation, where Liselotte Højgaard is Chair of the Board, were subject to international evaluation in 2013. The evaluation report was handed over by the Leader of the Panel, Dr. Wilhelm Krull, Secretary General of Die Volkswagenstiftung in the presence of the Minister of Research Morten Østergaard.

Pediatric nuclear medicine



Lise Borgwardt

Each year we perform 1600 pediatric nuclear medicine investigations, thereof 300 pediatric PET scans, mainly for the large pediatric departments at the hospital. It is a special focus area for our department to perform these investigations at the highest level of excellence, and at the same time make it a positive experience for both the child and its parents. The department is a member of the EANM Pediatric Committee and the Pediatric Imaging Harmonization SNM/EANM.

In August we opened up our new children section. We now have a children-friendly PET/128SliceCT, SPECT/CT, EDTA Clearance room and a renography room in the section. The section is decorated by the artists Set Designer Nina Flagstad, Theatre Artist Christine Bechameil and Light Artist Jonas Bøgh by donations from The Obel Family Foundation. In each scanner-room, high quality projectors are showing movies at the ceiling to secure and entertain the child during the scan. In the waiting area the children have the opportunity to watch the animated decorations, use apps or watch movies at the tablets, giving when entering the section, or play in the toy corner.

We have participated in Health Days with great success at the Øksnehallen in Copenhagen, communicating our speciality to the public and especially for children.

Our multidisciplinary pediatric haematology and oncology conferences are presented as a web-based nuclear medical platform combined with videoconference including districts outside the capital. Our collaborators are very pleased with the possibilities and the advantages in the diagnostic evaluation of the children.

Research in pediatric nuclear medicine and PET is necessary, as we have an increasing amount of medical doctors, students and technicians involved in the field and we conduct research protocols in children primarily with PET/MRI in order to develop this interesting area.

The work in the Pediatric Committee, EANM this year has been very interesting and inspiring, and we are looking forward to next years work in the committee.







We celebrated the opening of the new Pediatric Section on the 22th of August 2013, and we can already now report, that it is a great success if we ask our small patients and their families.

The artists, who decorated the section were invited to the symposium and the opening: Set Designer Nina Flagstad, Theatre Artist Christine Bechameil and Light Artist Jonas Bøgh. Here celebrated and gifted with flowers.

The decoration of the new Pediatric Section is founded by The Obel Family Foundation who graced us with their presence at the opening; Chairman of the Board Christen Obel, Director Søren Bojer Nielsen and Project Manager Hanna Line Jakobsen.

The children sang a Danish traditional song; "I østen stiger solen op" and the red ribbon was cut by Director Søren Bojer Nielsen.

Afterwards the children demonstrated the new possibilities in the new Pediatric Section.







Hybrid PET/MR



Ian Law, Andreas Kjær and Adam Espe Hansen

The integrated PET/MR system, which allows simultaneous acquisition from both modalities, was installed at the end of 2011. Activity on the PET/MR scanner in 2013 comprised clinical, translational and basic research as well as clinical scans. Fig. 1 illustrates the distribution of PET/MR examinations in 2012-2013, with a total of 282 PET/MR exams in 2012 and 573 in 2013.

Current research topics include oncology, dementia, atherosclerosis and pediatric imaging. 18 ethically approved research protocols were running at the end of 2013. Also, clinical use was being implemented, with 260 clinical exams until the end of 2013, primarily of the brain. We show examples of basic research aimed at neonatal imaging (Fig. 2), and clinical research in the context of neuroendocrine tumors (Fig. 3).

The novel hardware combination of PET and MR scanners gives rise to new challenges and opportunities for reconstruction of PET images. Physics research was in particular aimed determining the effect of bone and metal on clinical image interpretation. An approach for using low-dose CT scans for PET/MR attenuation correction in the brain was implemented, and fundamental research aimed at using MR data for long-term clinically viable solution was boosted with the arrival of a postdoc.

In 2013 a MR hyperpolarization facility was acquired, as the first worldwide for an integrated PET/MR system. Future use of multi-modality functional molecular imaging based on PET and hyperpolarized MRI for human use will be very important for new knowledge in physiology and pathophysiology. An example of physics research aimed at developing procedures for simultaneous PET and ^{13}C imaging is shown in Fig. 4. The facility will be installed at the start of 2014.

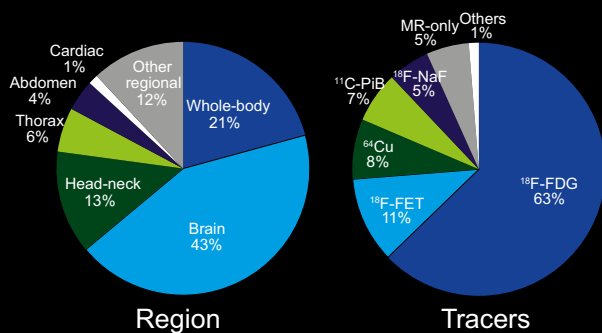


Figure 1. PET/MR examinations 2012-2013 according to anatomic region and PET tracer.

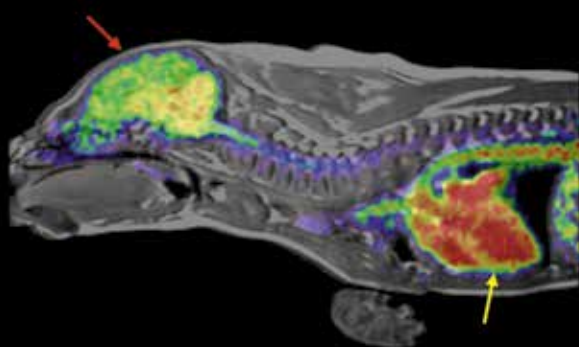


Figure 2. Sagittal section of a neonatal pig. The image shows the regional blood flow in the brain (red arrow) and the heart (yellow arrow) using the short lived isotope ^{15}O -water performed as a simultaneous PET/MRI acquisition. The object of the study is to establish methods for the evaluation of brain function in neonatal children suspected of suffering from ischemic damage using little or no radioactive exposure. Project leader Julie B Andersen, MD.

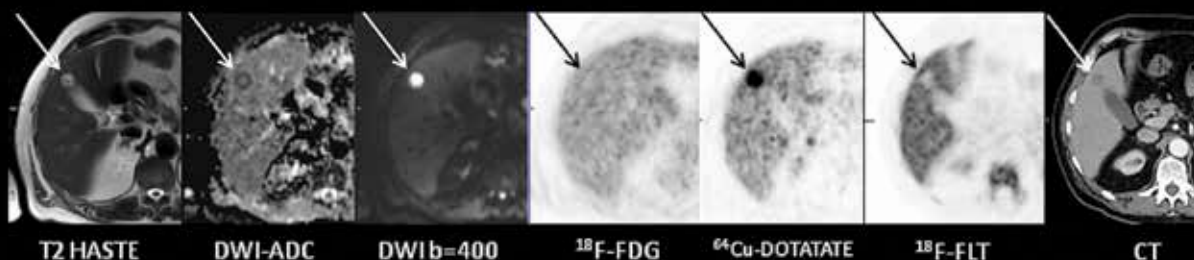


Figure 3. Example of multiparametric imaging of neuroendocrine tumors. 63 year old man, carcinoid of the small intestine (Ki-67 = 2-3%) with liver metastasis. PET/MR images, from left, anatomic MRI (T2 HASTE), apparent diffusion coefficient (DWI-ADC), diffusion weighted MRI (DWI b=400), FDG-PET, ^{64}Cu -DOTATATE-PET and FLT-PET. For comparison, CT is also shown. Project leader Camilla Bardram Johnbeck, MD. Figure by Johan Löfgren.

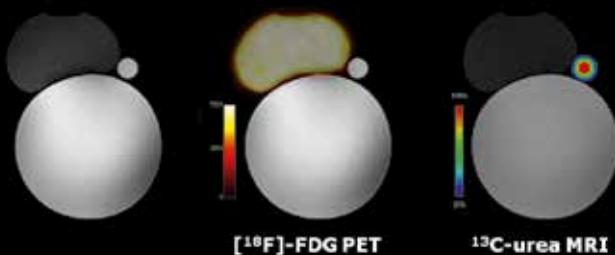


Figure 4. Simultaneous PET and ^{13}C MR imaging in a phantom. Left: proton-based MRI. Middle: overlay with PET activity. Right: overlay with ^{13}C -Urea concentration.

Radionuclide therapy



Peter Oturai and Jann Mortensen

Treatment with ^{177}Lu -DOTATATE in Denmark to patients with neuroendocrine tumors (NET) has been performed routinely in the department since May 2009. The area has been strengthened by the introduction of more imaging techniques for these patients. Until the end of 2013, 100 patients have been given a total of 311 treatments. Being one of the two highly specialized centers using this treatment modality in Denmark we work in close collaboration with the Departments of Gastrosurgery, Oncology, Radiology, Pathology and Endocrinology at Rigshospitalet. More patients from Odense University Hospital - and abroad - are now referred to us, including patients from Sweden, Norway and Canada.

The NET-Center at Rigshospitalet has been accredited as *Center of Excellence* by the European Neuroendocrine Tumour Society (eNETS).

A prerequisite is somatostatin receptor imaging (previously an ^{111}In -Octreotide scan, now an ^{68}Ga -DOTATOC-PET scan) demonstrating a high density of somatostatin receptors in the tumors. ^{177}Lu -DOTATATE is synthesized and labelled at the Hevesy Laboratory at Risø, DTU. ^{177}Lu -DOTATATE is administered in our dedicated facilities in the department and the patients stay overnight at the endocrinology ward.

The rationale for the treatment, is that the radio labelled somatostatin analogue binds to neuroendocrine tumors expressing somatostatin receptors. The emitted beta-particles from the ^{177}Lu -isotope destroy the tumor cells. Gamma photons from ^{177}Lu allows for scintigraphic imaging and dosimetry.

The clinical effects are comparable to what is reported in the litterature, i.e. some measurable effect in the majority of the patients, and relatively few side-effects.

For many years the department has successfully treated patients with benign thyroid diseases – goiter and hyperthyroidism – with ^{131}I -Iodine. Zevalin (with Yttrium-90) has been used for treatment of non-Hodgkin lymphoma.



Nuclear medicine

In 2013 we installed a PET/CT scanner (mCT, Siemens) in our section, which allowed a transition from SPECT/CT to PET/CT for relevant types of examinations. Thus, based on comparison studies we changed our routine diagnostic somatostatin receptor imaging of neuroendocrine tumors from ^{111}In -Octreotide SPECT/CT to ^{68}Ga -DOTATOC PET/CT (or ^{64}Cu -DOTATATE PET/CT). This resulted in higher diagnostic values, shorter examinations and referrals from abroad. Likewise, we have changed our routine myocardial SPECT/CT to ^{82}Rb -PET/CT for detection of ischemia. Currently, we compare the diagnostic value of ^{18}F -NaF-PET/CT and ^{99}Tc -HDP SPECT/CT for malignant bone disease.

The gamma camera equipment for routine nuclear medicine imaging and research studies comprise three hybrid SPECT/CT cameras, one dual-head gamma camera and four single-head cameras. On these we perform many different types of planar and SPECT/CT studies such as sentinel node scintigraphy for oral cancer, breast cancer, malignant melanoma, penile and vulva cancer, ventilation/perfusion SPECT/CT for pulmonary embolism and pre- and postoperative assessment for transplantation or lung volume reduction, bone SPECT/CT for primary and secondary malignant tumors and benign disorders, and radio-aerosol mucociliary clearance scintigraphy to diagnose primary ciliary dyskinesia, etc.

For lung function testing we have two Jaeger body plethysmographs. Frequent indications for lung physiology measurements are pre- and postoperative evaluation of endobronchial stents in COPD, transplantation and lung cancer, control after chemotherapy. A large multicenter study to establish a Danish reference material for static and dynamic lung volumes and diffusion capacity was initiated in 2013.



Receptor targeted radionuclide therapy with ^{177}Lu -DOTATATE against neuroendocrine tumors has become a major routine function in our department.

In 2013 we have published the results of our radioisotope leakage monitoring procedures, that are used during isolated limb perfusion with melphalan and tumor necrosis alpha for recurrent melanoma and soft tissue sarcoma.

Our DEXA-scanner has been extensively used for bone mineral density and whole body composition investigations – for both routine patients and research projects.

Diagnostic ultrasound is used as an adjunct to thyroid scintigraphy in patients having thyroid diseases or hyperparathyroidism.

In 2013 we have had weekly and monthly conferences dealing with neuroendocrine tumors, thyroid diseases, pediatric oncology, cardiology, and lung-, adrenal- and orthodontic diseases.



Peter Oturai and Jann Mortensen

Cyclotron Unit



Holger J. Jensen

During the last 8 years we have experienced a steady increase in our total number of productions of 6,4% per year in average as seen in figure 1. In 2013 we had in total 1145 successful productions (539 and 606 for our Scanditronix MC32 and Siemens RDS Eclipse cyclotrons respectively) or 16.6% less than in 2012. The decrease can mainly be explained by a different need of ^{11}C . All other productions stayed at a constant level. As in the previous years we also managed to keep the average doses to the employee in the Cyclotron- and Radiochemistry unit at a low level, see figure 2. Due to the high flexibility of running two cyclotrons we succeeded to have less than 0.5% cancelled productions in 2013.

The year was relatively quiet without any major technical problems for the two cyclotrons. But if 2013 was quiet with respect to technical problems it was very busy with respect to new and ongoing projects:

- » In 2012 a Master of Science project in cyclotron physics on the development of a new $^{62}\text{Zn}/^{62}\text{Cu}$ generator as a source of ^{62}Cu (97.4% β^+) for PET radiopharmaceuticals was started by Thorkil K. Værge from NBI and finished in 2013. The short half-life of ^{62}Cu (9,74 min) makes the use of ^{62}Cu very limited, when produced directly in a cyclotron. But with the 9.13 h half-life of ^{62}Zn the generator can be used for more than one day and can potentially at the same time be distributed to many hospitals in Denmark and Sweden. The nuclear fusion reaction used for producing ^{62}Zn requires beam energies of 30 MeV or higher. This is much higher than the available energies for typical medical cyclotrons and therefore ideal for our Scanditronix MC32 cyclotron. The design of the production target was one of the major results obtained by Thorkil K. Værge. The target is planned to be build and tested in 2014 together with the company HRS, from Kalundborg.

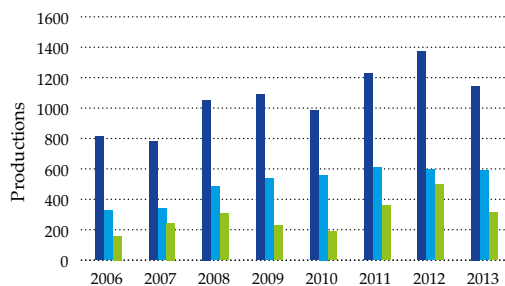


Figure 1 Development in total number of productions, ^{18}F and ^{11}C productions since 2006.

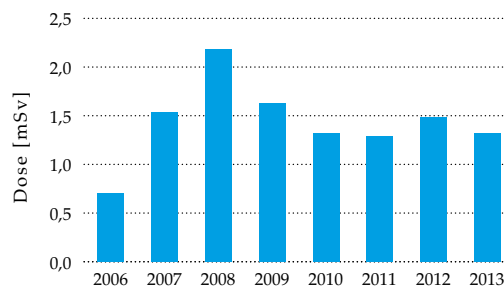


Figure 2 Average received doses for employee in the Cyclotron- and Radiochemistry unit since 2006.

- » In 2013 our stack monitoring system was upgraded successfully together with the company CANBERRA from Belgium. The main purpose of the upgrade was to solve problems with saturation in the gamma counting system in connection with high releases of activity, but improvements in software, handling of alarms and power interrupts were implemented at the same time.
- » Several upgrade projects for our Scanditronix MC32 cyclotron were initiated in 2012 and continued in 2013:
 - a) A new ^{18}F target was developed together with our colleagues in Uppsala and Lund. With the new target it has been possible to increase the maximum beam current at the target from the present 30 to around 50 μA without any significant reduction in the target yield. On basis of our experience with the first target version we plan to build a new version in 2014 and increase the beam current to above 60 μA .
 - b) In 2013 we designed and build a new target loading and unloading system together with our colleagues in Uppsala. The target system can serve two ^{18}F targets at the same time. The control system is integrated in our new S7 PLC cyclotron SCADA system and makes the old IBA system obsolete. The new system gives us full control and flexibility on all details of the system. Hardware, coding and operation details can easily be copied to other targets that are planned to be renovated/ upgraded in near future (^{13}N , ^{15}O and Rb/Kr).
 - c) The high-vacuum pumps were modified in 2012 and 2013 in various ways (better cooling of the baffles and better oil) to reduce the back streaming of oil into the vacuum chamber and consequently give a better beam. The project is still ongoing, but already now we have achieved clear improvements in both vacuum and beam performance.

- d) In order to improve the vacuum and the beam optics and performance for the first critical orbits in the central region, we started in 2012 a process of constructing new parts for the central region and our ion sources together with the company HRS. This work was continued in 2013 and today we have full control of design and construction of all critical parts. In 2013 we have seen clear improvements as a consequence of all our efforts. Today the performance is in many cases better than at the cyclotron acceptance tests in 1992
- e) A replacement of the original Siemens Simatic S5 and CP521 based control system from 1992 with a S7 and IGSS based SCADA system was started in 2012 and continued in 2013. The work is still ongoing and in 2014 all I/O boards for the more than 1000 digital and analog signals will be changed. The update, which still needs to be validated, gives us a modern software and hardware platform and an up to date system with modern features of easy handling of alarms and coding of new logic, the possibility of logging parameters and making various reports and graphs. The upgrade plays an important part in our many future plans for the MC32 cyclotron.
- f) The last project to be mentioned here is our plans for replacing major parts of the electronics in the RF system. The system is more than 20 years old and it is getting more and more difficult to find spare parts for this subsystem. Consequently a new project were started in 2012, where we together with Axcon Aps carried out a detailed pre-investigation of the system in order to establish the necessary knowledge to design new electronic boards and to estimate the cost for a total replacement. The project was finally funded in 2013 and is planned to be implemented and installed in 2014.



Radiochemistry



Nic Gillings and Jacob Madsen

Highlights

Throughout 2013 we regularly produced [^{11}C]Cimbi-36 for a clinical trial. [^{11}C]Cimbi-36 is a novel in-house developed serotonin receptor agonist tracer, and data from 60 scans is currently being analysed. Another serotonin tracer, [^{11}C]10419369, was validated in 2012-13 and approval for human use was received in September 2013. In June 2013, our new GMP hotlab was inspected and approved by the Danish Health and Medicines Authority. This lab expands the capacity for production of new tracers for human use. Productivity has increased steadily during the last 8 years, with an average yearly growth of 11% (see figure).

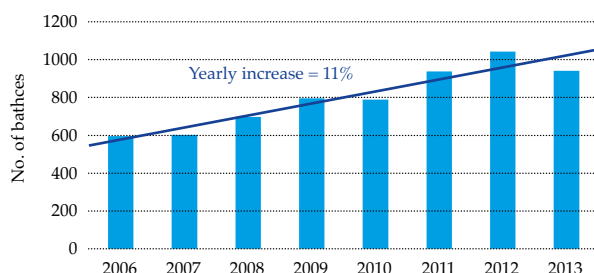
Production for clinical and research PET in humans

Production of [^{18}F]FDG and [$^{81\text{m}}\text{Kr}$] generators along with [^{18}F]FET and [^{18}F]FLT was on a par with 2012, whilst production of [^{68}Ga]DOTATOC for neuroendocrine tumors increased dramatically from 36 productions in 2012 to 146 in 2013. Due to the complexity of the clinical trial with [^{11}C]Cimbi-36 compared with other studies, the overall number of carbon-11 productions decreased in 2013. However, the production of the Alzheimer tracer, [^{11}C]PIB, increased compared with previous years, with a total of 100 productions in 2013.

Radiopharmaceutical development

Oncology — Production of the in-house developed radiopharmaceutical, [^{64}Cu]DOTA-AE105, which shows great promise for uPAR imaging, was validated in 2013 and a clinical trial application for this tracer will be submitted in early 2014. Development of various fluorine-18 labelled analogues of AE105 is currently also underway. The search for a suitable tracer for angiogenesis imaging agent continued in 2013. Monomers and dimers of NODAGA-cRGDyK were labelled with gallium-68 and copper-64. All 4 compounds were evaluated with PET in small animals which indicated that the copper-64 labelled dimer had the most favourable properties for PET imaging. Radiolabelling of the proteins annexin V and ASIS (active site-inhibited factor VIIa) with [^{18}F]SFB continued and was further optimized. In a PhD project more sophisticated and site-specific strategies for radiolabelling of ASIS and its derivatives are currently being investigated.

Radiopharmaceutical Productions 2006-2013



Amyloidosis — Optimization and validation of technetium-99m labelling kits for preparation of ^{99m}Tc -Aprotinin for amyloidosis imaging using SPECT was carried out in 2013 and the application for human use for this radiopharmaceutical will be submitted to The Danish Health and Medicines Authority in early 2014.

Neurobiology — Aside from production of routine PET tracers for brain research we also have a strong collaboration with The Neurobiology Research Unit, Rigshospitalet and the Department of Medicinal Chemistry at PHARMA (University of Copenhagen) under CIMBI (Centre for Integrated Molecular Brain Imaging) with respect to new tracer development and evaluation. Activities focused mainly on 5-HT₇ antagonists and fluorine-18 labelled analogues of [^{11}C]Cimbi-36 (5-HT_{2a} agonist). There were 29 productions of new compounds in 2013 for evaluation in pigs.

Radiochemistry — A new strategy, based on a reductive amination, was envisaged and realised for development of new [^{11}C]Cimbi-36 analogues. This strategy will significantly increase the number of available tracers for evaluation and will also allow for more effective evaluation of compounds with potential for fluorine-18 labelling.

Reactions which potentially can occur with high speed and specificity inside the living body, often referred to as “in-vivo click chemistry”, were also investigated. With carbon-11 we were, for the first time, able to show that the reaction between a carbon-11 labelled tetrazine and a trans-cyclooctene was feasible.

Radiopharmaceutical	Usage/target
[¹⁸ F]FDG	Oncology/Glucose metabolism
Krypton-81m generator	Lung ventilation
[¹⁸ F]FLT	Oncology/cell proliferation tracer
[¹⁸ F]FET	Oncology/amino acid transport
[⁶⁸ Ga]DOTATOC	Neuroendocrine tumors/Somatostatin receptors
[¹¹ C]PIB	Alzheimers Disease/ β -amyloid plaques
[¹⁸ F]Altanserin	Brain Research/5-HT _{2A} receptors
[¹¹ C]Cimbi-36	Brain Research/5-HT _{2A} receptors
[¹¹ C]CUMI-101	Brain Research/5-HT _{1A} receptors
[¹¹ C]DASB	Brain Research/serotonin transporter
[¹¹ C]Flumazenil	Brain Research/central benzodiazepine receptors
[¹¹ C]SB207145	Brain Research/5-HT ₄ receptors
[¹¹ C]AZ10419369	Brain Research/5-HT _{1B} receptors
[¹⁵ O]water	Cerebral blood flow
[¹³ N]ammomia	Cardiology/cadiac blood flow

Radiopharmaceuticals for human use produced at Rigshospitalet

Radiopharmaceutical	Usage/target
[⁶⁴ Cu]DOTA-AE105	Oncology/uPAR receptor
[⁶⁸ Ga/ ⁶⁴ Cu]RGD analogues	Oncology/angiogenesis
[¹⁸ F]Annexin V	Oncology/apoptosis
[¹⁸ F]ASIS	Oncology/tissue factor overexpression
[¹⁸ F]Cimbi analogues	Brain Research/5-HT _{2A} receptors
[¹⁸ F]Cimbi analogues	Brain Research/5-HT ₇ receptors
[¹¹ C]NS14492	Brain Research/nicotinic receptors
[¹¹ C]AZ10419369	Brain Research/5-HT _{1B} receptors

Radiopharmaceuticals evaluated in animals/in vitro in 2013



Oncological PET/CT scanning

Positron emission tomography is a well-established imaging modality in oncology and due to the high sensitivity and specificity for diagnosis and treatment response monitoring, it plays a major role in the diagnostic work-up for many patients.

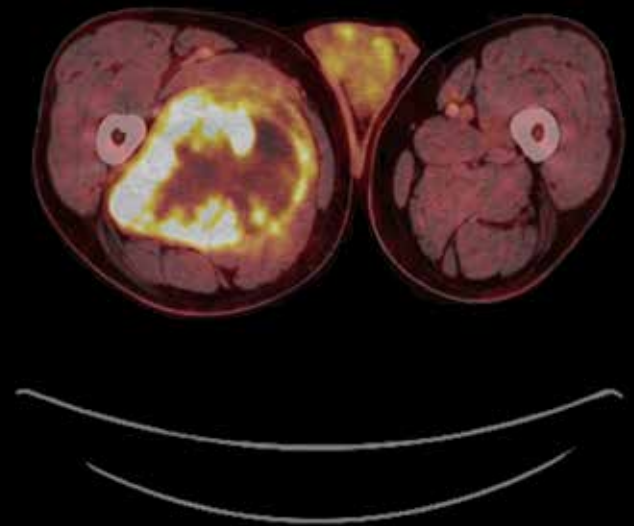
The CT scans of our PET/CT 's are performed as high quality diagnostic scans with the use of oral and intravenous contrast media. The PET- and the CT scans are initially interpreted separately followed by a joint interpretation of the fused images and a final, combined conclusion taking both examinations into account. This provides the clinician with a more precise PET result, a better CT result and also a more useful conclusion. The CT result improves in quality because PET can help depicting small tumors that could easily have been overlooked even by a trained radiologist's eye. The PET positive foci are more precisely determined as correct or false positive with the help of the CT information. An important fact is, that the combined PET/CT conclusion is superior to both scan results alone. Furthermore, the patient is spared from an extra CT examination at The Department of Radiology as well as an extra radiation dose.

In oncology the indications for PET/CT are diagnosis, staging, therapy planning and monitoring besides detection of recurrent disease in patients with a variety of malignant diagnoses. As a routine, we have included a supplementary CT of the lungs with breath hold technique to improve the diagnostic quality. Approximately 50% of our patients participate in clinical research protocols. Our main topics are gynaecological cancers, malignant lymphoma, neuroendocrine tumors, head & neck cancer and lung cancer. We have 17 weekly multidisciplinary team conferences, where our PET/CT scan results are discussed with the clinical experts.

FDG is still the main tracer in oncology, but we also use ^{18}F -NaF, ^{18}F -FET, ^{18}F -FLT, ^{68}Ga -DOTATOC and ^{64}Cu -DOTATATE in clinical studies as well as in research protocols.

Working with PET/CT for many years now, we are convinced of the usefulness of PET/CT in the everyday clinical work. However clinical trials are still necessary to verify the usefulness of the method, refine the scanning protocols and to exploit new indications.

Annika Loft Jakobsen and Anne Kiil Berthelsen



Coronal and transaxial PET/CT images of a 23-year old man with a tumor in his right thigh. The scan revealed an inhomogenous tumor without metastatic disease and the images were used for biopsy guidance. Histology showed osteosarcoma

PET/CT scanning in radiation therapy

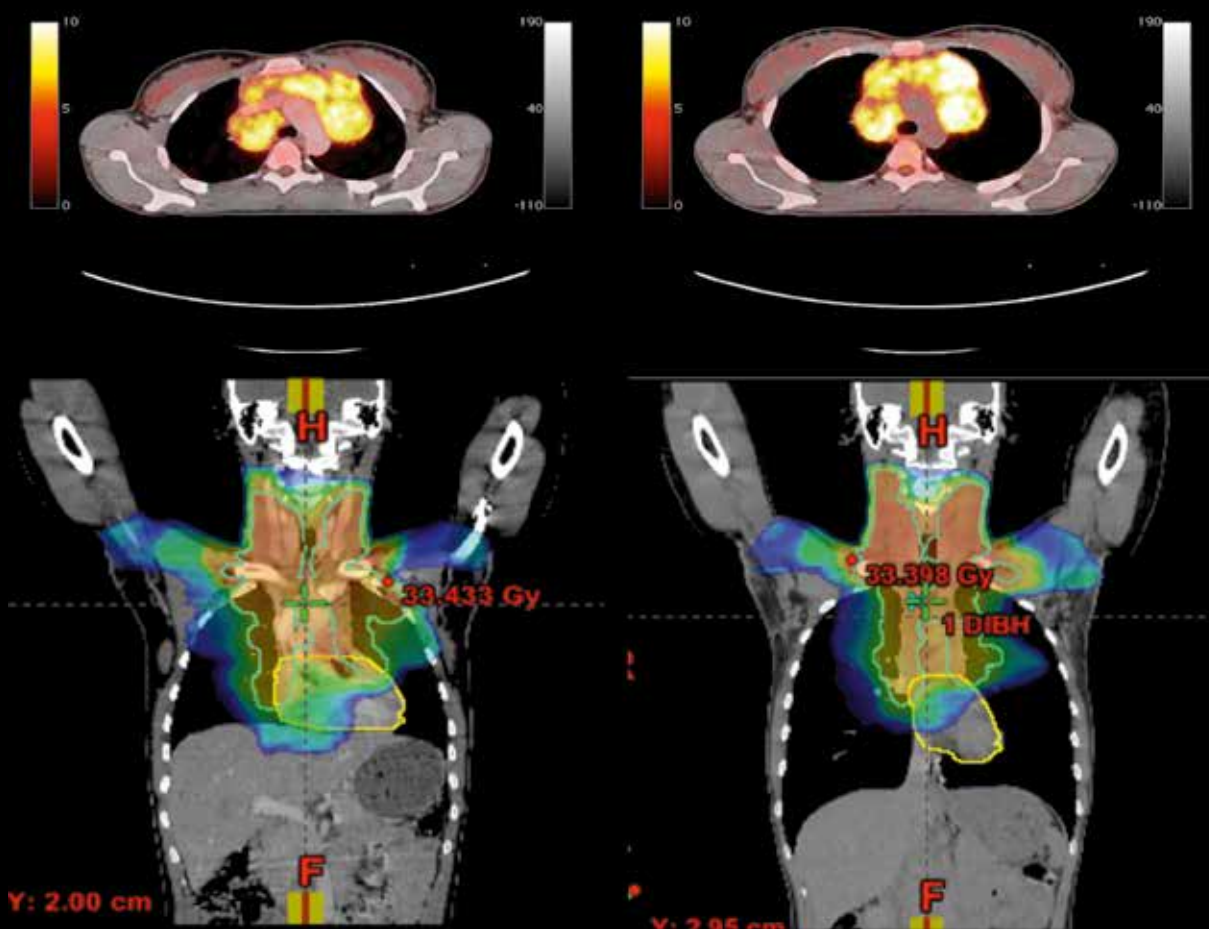
PET/CT in radiotherapy planning of cancer patients is a daily routine in our department. We perform 1,500 PET/CT scans for radiotherapy every year for patients with brain-, head & neck-, lung-, oesophageal-, cardia-, cervix- vulva- , rectum- and anal cancer as well as malignant lymphoma and sarcoma.

The demanding collaboration between mould technicians, nuclear medicine physicians and technologists, radiologists and radiology technologists, radiation oncologists, physicists and dosimetrists must be emphasized.

The advantages are numerous: the anatomical localisation and the metabolic activity of the tumor are defined, especially when the tumor density in CT images is difficult to differentiate from that of the surrounding normal tissue and the tissue heterogeneity can then be taken into account when choosing radiation technique and energy, and only one scan is necessary. All our PET/CT scanners have the possibility of performing PET/CT scans for radiotherapy planning. The nuclear medicine specialist delineates the viable tumors depicted by PET on the fused PET/CT images after interpretation together with the radiologist. We rely on visual analysis more than fixed threshold levels. The regions are exported to the radiation dose planning system together with the CT scan, and the information is incorporated in the treatment planning.

Research in this field is necessary. We have finalized our study using breathhold PET in mediastinal lymphoma. The results are so encouraging, reducing the radiation dose to the heart and lungs, that we have implemented the method in our routine management of lymphoma patients with mediastinal involvement. We are involved in numerous research protocols, local as well as multicentre, and we are also looking at the possibilities of using PET/MR for radiotherapy planning.

Annika Loft Jakobsen and Anne Kiil Berthelsen



A: Standard PET/CT with free shallow breathing of a patient with malignant lymphoma involving the mediastinum. The image below shows the radiation dose plan based on the PET/CT.

B: Breath hold PET/CT of the same patient as in A. Notice the changes in configuration of the tumor volume and the heart due to inflation of the lungs hereby reducing the radiation dose to the heart and lungs.

Nuclear cardiology



Philip Hasbak

Cardiac Rubidium PET

At Rigshospitalet there is a special need to provide cardiac Rubidium PET every day, since a large proportion of our patients with ischemic heart disease need an acute or sub-acute work-up that requires quick decision making as to coronary revascularisation strategy. Patients with unstable angina or non-STEMI should be revascularised with percutaneous coronary intervention (PCI) within 3 days after admission or with coronary artery bypass graft surgery (CABG) within 5-7 days according to The Danish National Board of Health. Non-invasive assessment of myocardial function is an important domain of PET. Traditionally cardiac PET images have been visually interpreted, using uptake as a measure of function. This approach, however, takes only a fraction of the full PET information into account. In contrast, the application of tracer kinetic modeling to dynamically measured data is able to extract objective measures of perfusion and/or metabolism, depending on the tracer. While such true cardiac quantification has been troublesome and time-consuming in the past, our new cardiac tool now makes this state-of-the-art technology readily available

Research-wise we have a close and good cooperation with various clinical departments. Certain ongoing projects should be emphasized:

In collaboration with

- » Department of Cardiology: Molecular imaging in patients suspected of acute ST-elevation myocardial infarction (STEMI) with angiographically normal coronary arteries.
- » Department of Oncology: Cardiac side effects in radiation therapy for breast cancer.
- » Department of Vascular Surgery and Department of Anesthesiology: Buttock ischemia after endovascular abdominal aortic aneurysm repair.

Cardiac ^{123}I -MIBG

In 2010 we introduced cardiac ^{123}I -metaiodobenzylguanidine (^{123}I -MIBG). Radiotracer analogs of the sympathetic mediator norepinephrine have been investigated extensively, and are at the brink of potential widespread clinical use, especially after the presentation of the ADVANCE-HF trial. The most widely studied SPECT tracer, ^{123}I -MIBG has consistently shown a strong, independent ability to risk stratify patients with advanced congestive heart failure. One ongoing project should be emphasized:

In collaboration with the Department of Cardiology: Cardiac sympathetic activity in patients suspected of Takotsubo-cardiomyopathy.

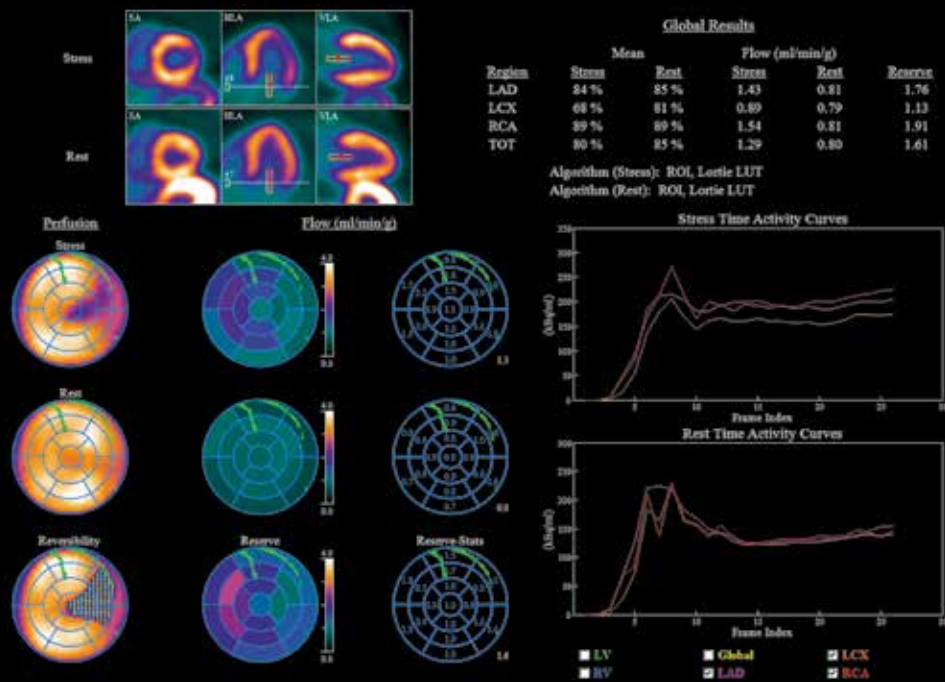


Fig 1. Myocardial blood flow evaluation of Rb-PET/CT perfusion study shows reduced blood flow at peak stress in lateral wall with normal flow at rest suggesting reversible ischemia in Cx coronary artery territory.

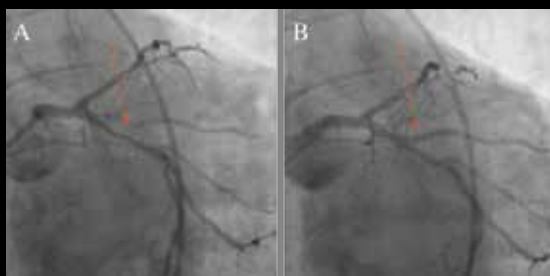


Fig 2. (A) Pre PCI. A diffuse severe stenosis could be seen in the proximal segment of the obtuse marginal branch of Cx (arrow). (B) Post PCI. One stent were deployed in OM1 and the lumen diameter was normalized

PET scanning of the brain



Ian Law

In 2013 we performed 1,300 clinical PET scans of the brain, an increase of 10% over the previous year. The investigations cover the range from neurooncology over neurodegenerative disease, cerebrovascular disease, neuroinflammation and epilepsy. Our most important clinical neuro PET tracer is still ^{18}F -Flouro-Deoxy-Glucose (FDG) that accounts for 57% of our investigations.

This was the year when we took a further step towards using the Siemens hybrid PET/MRI scanner to solve real life clinical diagnostic dilemmas. As an important addition to our team Senior Registrar, Otto M. Henriksen, MD, PhD, with expert knowledge in the field of functional MRI, was employed to facilitate this process. We started scanning in selected clinically referred patients and patients in experimental protocols. This was after initial testing and the implementation by our instrumentation team of a practical solution to the challenge with attenuation correction in the brain. In total 20% of our PET brain scans were performed on the PET/MRI scanner. We have performed scans in neurodegenerative diseases measuring the glucose metabolism using FDG and amyloid imaging using ^{11}C Pittsburgh compound B (PiB) and brain tumor imaging with the amino acid analogue ^{18}F -Flouro-Ethyl-Tyrosine (FET). Through fruitful collaboration with the Department of Neuroradiology and The Functional Imaging Unit, Glostrup hospital, our clinical MRI protocols are optimized, and we are able to supplement our brain PET tumor investigation with advanced MRI techniques evaluating the angiogenetic tumor activity (fig 1).

This phase of the implementation process shows that PET/MRI is indeed a technique that can be used robustly in clinical practice. In a single session a patient may receive a thorough and comprehensive examination of outstanding image quality in a short duration and with little risk.

For radiotherapy planning and the evaluation of recurrent meningioma we are increasingly employing ^{68}Ga -DOTATOC on our high resolution research tomograph (HRRT) PET scanner, as the growth pattern of meningioma and the small margins of the stereotactic radiation therapy employed make a 2 mm resolution desirable (fig 2).

Amyloid uptake in the brain is considered an important risk factor in Alzheimers disease and can be used to differentiate between dementia types. We have introduced new standardized methods to measure and report amyloid binding in the brain (fig 3) that have been well received by our clinical partners.

In 2013 we participated in 2 randomized clinical treatment trials for Alzheimers disease in collaboration with the Memory Disorders Research Group. These trials are given a high priority as they give access to a potential treatment for a serious progressive condition. Further they enable us to evaluate new tracer technology before they are introduced nationally, e.g. alternative brain amyloid tracers.

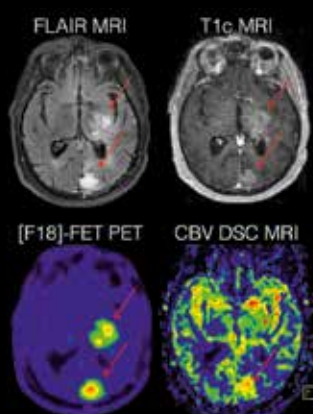


Fig 1 Patient with malignant brain tumor (Glioblastoma). A short and focused examination that supplements standard structural MRI sequences (top:FLAIR, T1 weighed after contrast) with (bottom) metabolic activity using FET PET, and cerebral blood volume (CBV) using Dynamic Susceptibility Contrast (DSC) MRI in one simultaneous acquisition. The examination gives a detailed fingerprint of the anatomical and physiological nature of the tumor (red arrows) to be used in treatment selection and monitoring.

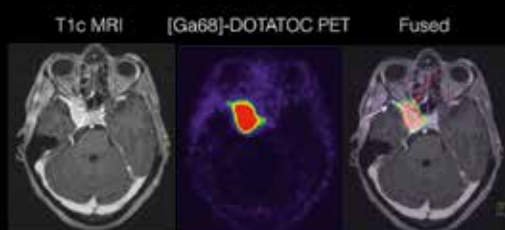


Fig 2 Patient with meningioma at the skull base. Imaging is performed as part of stereotactic radiotherapy planning using T1 weighted MRI after contrast (left), and ^{68}Ga -DOTATOC (middle), that are subsequently fused (right). ^{68}Ga -DOTATOC binding to the tumor is high and aid in the delineation of the tumor. The tumor is invading the right orbit (red arrow) and extending laterally in a dural tail (white arrow).

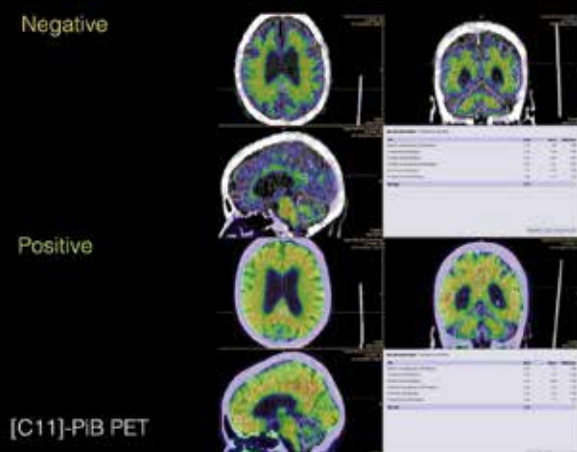


Fig 3 Amyloid negative (top) and amyloid positive (top) patient showing standardized presentation with calculation of the uptake in grey matter relative to the cerebellum.

Collaboration with Landssygehuset, Faroe Islands

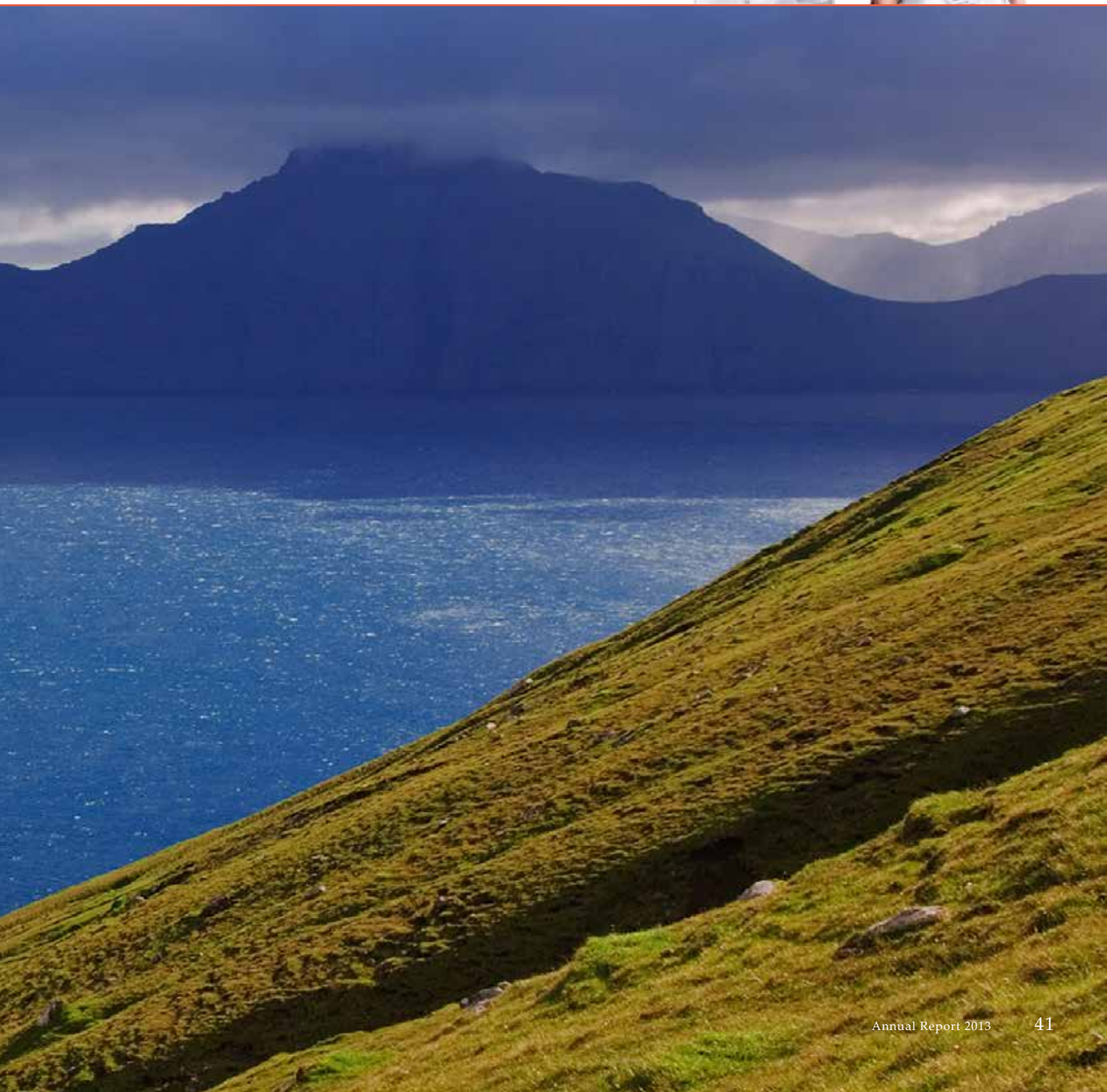


The Department of Clinical Physiology, Nuclear Medicine & PET, Rigshospitalet has a close collaboration with Landssygehuset in Tórshavn, Faroe Islands.

The hospital has a staff of 850 and 170 beds. The 8,000 in-patients and 60,000 out-patients annually are taken care of by 29 specialities, of which 9 are via consultant collaborations, including collaboration in Clinical Physiology and Nuclear Medicine, Rigshospitalet.

The Department of Clinical Physiology and Nuclear Medicine in Tórshavn performed 477 scintigraphies of lungs, bones, thyroid, kidneys, sentinel nodes and renography in 2013. A total of 609 lung functions test were performed. The department is equipped with one 2-headed Skylight camera, a Jaeger whole body plethysmograph and a DEXA scanner. The old Norland DXA scanner was replaced with a new 840 series in March 2013 and it was used as part of randomized exercise training study and for regular clinical examinations (551 in total). Second opinion on scintigraphy and lung function measurements is provided via a direct telemedicine connection. The responsible physician and physicist for Nuclear Medicine in Tórshavn is Consultant, DMSc Jann Mortensen and Physicist Thomas Levin Klausen.

Jann Mortensen and Thomas Levin Klausen



Academic and other activities

Andreas Kjær, Professor, Chief Physician, is President of the Scandinavian Society of Clinical Physiology and Nuclear Medicine (SSCPNM), board member of the Cancer Research Foundation at University of Copenhagen, previous member of the Scientific Committee of the Danish Cancer Society, Editor-in-Chief of Open Neuroendocrinology Journal as well as for Diagnostics. Leader of a project for development of theranostics for the aggressive cancer funded by the Danish National Advanced Technology Foundation, Leader of a project on new PET tracers funded by the Strategic Research Council and Partner of the Danish Chinese Center for Proteases and Cancer funded by the National Natural Science Foundation of China and the Danish National Research Foundation, National Director and partner of EATRIS (the European Advanced Translational Research Infrastructure in Medicine) under the EU 7FP, and Head of the Cluster for Molecular Imaging and Director of the Postgraduate School for Medical & Molecular Imaging at the Faculty of Health Sciences, University of Copenhagen.

Anne Kiil Berthelsen, Chief Physician, is a member of the International Lymphoma Radiation Oncology Group, Steering Committee (ILROG), "European Organisation for Research and Treatment of Cancer Lymphoma Group" (EORTC), the Danish Radiology Society, the Danish and the Nordic Society of Gynaecological Oncology, British Institute of Radiology (BIR), Billedagnostisk udvalg Ukendt Primær tumor (DAHANCA), National PET/CT Group, the Danish Society of Clinical Oncology and the Danish Society of Magnetic Imaging

Annika Loft Jacobsen, Chief Physician, is involved in teaching at national and international courses pre- and post graduate for medical doctors, technologists, radiographers and nurses and invited speaker at national and international meetings and congresses. She is supervisor for several PhD students. Responsible for the specialist course in oncology for nuclear medicine physicians. She is a member of the "European Organisation for Research and Treatment of Cancer" (EORTC). Member of the EANM, BIR,

Danish Society of oncological Radiology and Danish Society of Clinical Physiology and Nuclear Medicine. Member of Regional Working Groups for implementation of clinical guidelines for: Colorectal liver metastases, lymphoma, malignant melanoma, cancer of unknown primary, prostate, penile and testicular cancer and unknown primary cancer. Member of National Working Groups for Lymphoma (Chair of the Diagnostic Imaging Group under Danish Lymphoma Group (DLG) and pharyngeal/laryngeal cancer. Member of the Steering Group for Danish Liver and Biliary Cancer and board member of DGCG (Danish Gynecological Cancer Group).

Camilla Sloth Knudsen, Nuclear Medicine Technologist, is member of the Board of LSB (Laboratoriemedicins Selskab for Bioanalytikere).

Helle Hjorth Johannesen, Chief Physician is a member of Danish Society of Radiology, Vice Chair of Danish Society of Oncoradiology, member of Danish Society of Medical Magnetic Resonance Imaging and Danish Society for Good Clinical Practice.

Jacob Madsen, Chief Production Manager, is member of the Board of DSKFNM (Danish Society of Clinical Physiology and Nuclear Medicine).

Jann Mortensen, Clinical Associate Professor, Chief Physician, is member of "Den Regionale Videnskabetiske Komité for hovedstaden (Regional Ethics Committee). He is a member of the steering committee of "Dansk Lungecancer Gruppe" (Danish Lung Cancer Group), the subcommittees for "Dansk Diagnostisk Lungecancer Gruppe" (Danish Diagnostic Lung Cancer Group) and "Lungecancer Screeningsgruppen" (Screening of Lung Cancer Group). Member of the Regional Working Group for implementation of clinical guidelines for Breast Cancer workup, member of the steering committee and the quality subcommittee for creating Danish reference values for lung function. He is responsible for the specialist course in "Clinical Respiratory Physiology" for nuclear medicine physicians and respiratory physicians. Member of editorial board of two medical journals.

Linda Kragh, Chief Nuclear Medicine Technologist, is member of Sundhedsfagligt Råd i Klinisk Fysiologi og Nuklearmedicin i Region H, SFR, (the Speciality Advisory Committee in Clinical Physiology and Nuclear Medicine in the Capital Region), Head of the DRG Committee of SFR, member of Uddannelsesrådet for Bioanalytikeruddannelsen i Region H, (the Speciality Council for the Education of Technologists in the Capital Region).

Lise Borgwardt, Chief Physician, is a member at the Pediatric Committee under EANM, member of the Tumorboard for Pediatric Solid Tumors at Rigshospitalet, member of the Pediatric Imaging Harmonization Group, Chair of the Pediatric Network Group at Rigshospitalet and Chair of the Pediatric Focus Group at the Department of Clinical Physiology, Nuclear Medicine and PET.

Liselotte Højgaard, Professor, Head of Department. From 1st of January 2013 Liselotte Højgaard is appointed Chairman of the board of the Danish National Research Foundation. She is Member of Conseil d'Administration, INSERM, L'Institut National de la Santé et de la Recherches Médicales, Frankrig. Chair of EC Science Advisory Board in Health Research. She represents the University of Copenhagen, Rigshospitalet in the Medicine and Technology Bioengineer program, The Technical University of Denmark (DTU), where she is also Adj. Professor. Member of ATV "The Danish Academy of Technical Sciences". Advisory Board member of DKFZ, Deutsche Krebsforschungs Zentrum and member of the board of Arvid Nilssons Foundation and Tagea Brandt's prize.

Malene Fischer, Senior Registrar, is Head of YNK (Yngre Nuklearmedicineres Klub) and Member of the Board of DSKFNM (Danish Society of Clinical Physiology and Nuclear Medicine).

Maria Helene Pejtersen, Nuclear Medicine Technologist is member of the Symposiagroup for Technologists at Rigshospitalet.

Marianne Federspiel, Nuclear Medicine Technologist, is member of EANM Technologists Committee.

Nic Gillings, Chief Radiochemist, is member of the Editorial Board of ISRN Molecular Imaging.

Peter Oturai, Chief Physician, is responsible for the postgraduate education in the department. He is Danish delegate, representing Danish Society for Clinical Physiology and Nuclear Medicine (DSKFNM), in the European Union of Medical

Specialists (UEMS) and deputy delegate in the European Association of Nuclear Medicine (EANM). He is a member of the board of the Danish Endocrine Society (DES), member of the board of the Danish Thyroid Association (DTS), and member of the Danish Thyroid Cancer Guideline Group. Member of the Doctors Clinical Physiology and Nuclear Medicine Training Committee of the DSKFNM. He is responsible for the specialist course in Endocrine Pathophysiology for nuclear medicine physicians in Denmark. He is webmaster of the website of DSKFNM.

Robin de Nijs, MSc, PDEng, PhD, Specialist Medical Physicist, is member of the European Association of Nuclear Medicine's Network of Excellence for Brain Imaging and member of the Danish Society for Medical Physics.

Søren Holm, Chief Physicist, is a delegate for the DSMF at the European Federation of Organizations in Medical Physics (EFOMP), a board member of the Nordic Society for Radiation Protection (NSFS), a member of an IAEA advisory group concerned with QA/QC and image artefacts affecting quantitation in PET/CT, a member of Sundhedsfagligt Råd i Klinisk Fysiologi og Nuklearmedicin in the Capital Region, the Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine, and an external lecturer at Copenhagen University.

Tim Lundby, Deputy Chief Technologist, is member of Lederrådet i Danske Bioanalytikere.

Vibeke Rønn, Head Medical Secretary, is member of the Contact Group in Head Medical Secretaries Committee at Rigshospitalet.

Patient investigations 2013

CNS and peripheral nervous system

Regional cerebral blood flow, DIAMOX, $^{15}\text{O-H}_2\text{O}$	10
Regional cerebral blood flow, $^{15}\text{O-H}_2\text{O}$	45
Regional cerebral metabolism, $^{18}\text{F-FDG}$	763
Regional cerebral receptor, $^{11}\text{C-PIB}$	171
Regional cerebral receptor, $^{18}\text{F-FET}$	458
Regional cerebral metabolism, $^{18}\text{F-Altanserin}$	6
Regional cerebral receptor, $^{11}\text{C-DASB}$	7
Regional cerebral receptor, $^{11}\text{C-SB}$	3
Regional cerebral receptor, $^{18}\text{F-Florbetaben}$	7
Regional cerebral receptor, $^{18}\text{F-Florbetapir}$	13
Regional cerebral receptor, $^{18}\text{F-FLT}$	40
Regional cerebral receptor, Miscellaneous NRU	68
Regional cerebral receptor, $^{68}\text{Ga-Dotatoc}$	18
Regional cerebral receptor, $^{68}\text{Ga-Dotatoc}$, therapy	11
CT-scanning of cerebrum	264
MR-scanning of cerebrum	148
Total	2,032

Respiratory organs

Lung function test, whole body plethysmography	1,897
Lung function test, whole body plethysmography w/reversibility	224
Lung function test, spirometry	1,631
Lung function test, spirometry w/reversibility	96
Lung function test, spirometry, physiological provocation	5
Lung function test, diffusion capacity (CO)	3,773
Max. insp. abd expir. muscle pressure	101
Lung perfusion scintigraphy, $^{99\text{m}}\text{Tc-MAA}$	22
Lung perfusion scintigraphy, regional, $^{99\text{m}}\text{Tc-MAA}$	69
Lung perfusion scintigraphy, SPECT, $^{99\text{m}}\text{Tc-MAA}$	289
Lung ventilation scintigraphy, SPECT, $^{81\text{m}}\text{Kr-gas}$	312
Lung ventilation scintigraphy, $^{81\text{m}}\text{Kr-gas}$	25
Lung ventilation scintigraphy, regional, $^{81\text{m}}\text{Kr-gas}$	182
Lung ventilation scintigraphy, $^{99\text{m}}\text{Tc-Technegas}$	3
Lung ventilation scintigraphy, regional Technegas	3
Lung ventilation scintigraphy, SPECT $^{99\text{m}}\text{Tc-Technegas}$	13
Mucociliary clearance, $^{99\text{m}}\text{Tc-Venticolloid}$	20
Total	8,665

Heart and cardiovascular system

Isotope cardiography, RVEF pass, $^{99\text{m}}\text{Tc-HSA}$	13
Isotope cardiography, LVEF, $^{99\text{m}}\text{Tc-HSA}$	1,652
Isotope cardiography, volumina, $^{99\text{m}}\text{Tc-HSA}$	2
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc-MIBI}$, pharmacol. stress, dipy.	8
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc-MIBI}$, pharmacol. stress, adeno.	53

Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc-MIBI}$, physiological stress	54
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc-MIBI}$, NTG	91
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc-MIBI}$, pharmacol. stress, Dobutamin	2
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc-MIBI}$	21
Myocardial perf. scintigr. gated, $^{99\text{m}}\text{Tc}$, MIBG,	75
Sympaticus activity	527
Myocardial calcium score	96
PET myocardial metabolism, $^{18}\text{F-FDG}$	513
PET myocardial perfusion, ^{82}Rb	445
PET myocardial perfusion, ^{82}Rb , pharmacology. stress, adeno	26
Exercise electrocardiography	1
Electrocardiography	1
Total	3,579

Peripheral vessels

Isolated limb perfusion leakage monitoring, $^{99\text{m}}\text{Tc-erythrocytes}$	16
Total	16

Gastrin intestinal tract, liver, biliary tract and pancreas

Salivary gland scintigraphy $^{99\text{m}}\text{Tc-Pertechnetat}$	26
Biliary tract scintigraphy, $^{99\text{m}}\text{Tc-Mebrofenin}$	17
Meckels diverticulum scintigraphy, $^{99\text{m}}\text{Tc-Pertechnetat}$	6
Total	49

Kidneys and urinary tract

Glomerular filtration, $^{51}\text{Cr-EDTA}$, several samples	210
Glomerular filtration, $^{51}\text{Cr-EDTA}$, one sample	4,520
Renal scintigraphy, $^{99\text{m}}\text{Tc-DMSA}$	32
Renography, $^{99\text{m}}\text{Tc-MAG}$, diuresis	27
Renography, $^{99\text{m}}\text{Tc-MAG}$ 3, graft	9
Renography, $^{99\text{m}}\text{Tc-MAG}$ 3, ACE-inhibitor	78
Renography, $^{99\text{m}}\text{Tc-MAG}$ 3	1,990
Renography, $^{99\text{m}}\text{Tc-MAG}$ 3, dual head	6
Total	6,872

Bone and joint

Bone scintigraphy, $^{99\text{m}}\text{Tc-HDP}$, regional, static	37
Bone scintigraphy, $^{99\text{m}}\text{Tc-HDP}$, whole body, static	850
Bone scintigraphy, $^{99\text{m}}\text{Tc-HDP}$, SPECT	264
Bone scintigraphy, $^{18}\text{F-Fluorid}$, whole body, static	50
Osteodens. dual X-ray absorptiometri (DXA), columna lumb.	1,540
Osteodens. dual X-ray absorptiometri (DXA), lat. spine	3
Osteodens. dual X-ray absorptiometri (DXA), radius	124
Osteodensitometri, dual X-ray absorptiometri af collum fem.	3,032
DXA, body composition	349
Total	6,249

Endocrine organs

Thyroid scintigraphy, ^{99m} Tc-Pertechnetat	615
Thyroid, ultrasound	604
Parathyroid scintigraphy, ^{99m} Tc-MIBI/Stamisis	
SPECT + CT	79
Tumorscintigraphy, ¹²³ I-Iodid	39
Adrenal marrow scintigraphy, ¹²³ I-MIBG	65
Scintigraphy after ¹⁷⁷ Lu-Dotatate therapy	82
Total	1,484

Blood and lymph system

Erythrocyt volume, ^{99m} Tc-erythrocytes	12
Plasma volume, ¹²⁵ I-HSA	11
Lymph scintigraphy, extremities, ^{99m} Tc-HSA, leakage	2
Sentinel node, tumor drainage, ^{99m} Tc-Nanocolloid	161
Sentinel node scintigr. tumor drainage, c. mammae, ^{99m} Tc-Nanocolloid	35
Sentinel node scintigr. tumor drainage, mel. malign., ^{99m} Tc-Nanocolloid	96
Sentinel node scintigr. tumor drainage, c. penis, ^{99m} Tc-Nanocolloid	28
Sentinel node scintigr. tumor drainage, c. vulvae, ^{99m} Tc-Nanocolloid	40
Sentinel node scintigr. tumor drainage, head/neck SPECT, ^{99m} Tc-Nanocolloid	2
Sentinel node, peroperative with gamma probe, ^{99m} Tc-Nanocolloid	2
Peritumoral injection of ^{99m} Tc-Nanocolloid for sentinel node	708
Spleen scintigraphy, ^{99m} Tc-erythrocytes, heated	1
Total	1,098

Other diagnostic procedures

Tumor scintigraphy, ¹¹¹ In-Octreotide	175
PET tumor scanning, ¹⁸ F-FDG	5,007
PET infection scanning, ¹⁸ F-FDG	82
PET tumor scanning, ⁶⁸ Ga-Dotatoc	273
PET tumor scintigraphy, ⁶⁴ Cu-Dotatate	27
White blood cell scint., ^{99m} Tc-white blood cell	139
White blood cell scint., ¹¹¹ In-white blood cell	59
White blood cell scint.y, ¹¹¹ In-white blood cell, SPECT	1
Whole body, contamination measurement	46
Image fusion (PET, SPECT, MRI, CT or planar)	8,432
CT head/neck SPECT/CT	97
CT wb SPET/CT	205
CT thorax SPECT/CT	405
CT pelvis SPECT/CT	202
CT abdomen SPECT/CT	71
CT lower extremities SPECT/CT	5
CT wb PET/CT (KF)	654
CT wb PET/CT	4,732
MR wb PET/MR	118
CT lover extremities PET/CT	3
CT therapy scanning, wb	720
CT therapy scanning, brain	127
Second opinions external PET, PET/CT, SPECT/CT, CT and MR investigations	817
Extra tumor delineation	90
Other investigations	182
Supplementary/repeated imaging	2,434
Total	25,103

Radiotherapy

Treatment with ¹³¹ I, benign thyroid	77
Isotope treatment with ¹⁷⁷ Lutetium-dotatate	65
Total	142

In vitro analysis

Plasma analysis	15,506
Gene expression analysis	5,224
Immunohistiochemistry	703
Total	21,433

Total number of patient investigations	76,722
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Animal Studies**Dogs**

¹⁸ F-FDG	2
¹⁸ F-FET	1
⁶⁴ Cu-DOTATATE	1
⁶⁴ Cu-liposomer	2
⁶⁴ Cu-ATSM	2
MR	2

Rats

¹⁸ F-Annexin	10
¹⁸ F-FDG	6
⁸² Rubidium	48
^{99m} Tc-Sestamibi	5
MR	17

Mice

¹⁸ F-andet	70
¹⁸ F-Annexin	18
¹⁸ F-MISO	42
¹⁸ F-FDG	116
¹⁸ F-FET	233
¹⁸ F-FLT	112
¹⁸ F-NaF	0
⁶⁴ Cu-andet	3
⁶⁴ Cu-ATSM	64
⁶⁴ Cu-Cl2	4
⁶⁴ Cu-liposomer	246
⁶⁴ Cu-DOTATATE	2
⁶⁴ Cu-DOTA-AE105	72
⁶⁴ Cu-NODAGA-RGD	10
⁶⁸ Ga-andet	3
⁶⁸ Ga-NODAGA-RGD	86
⁸⁹ Zirconium	40
Au-gel cytokin	440
Guldparkler	32
Optisk imaging	793
MR	136

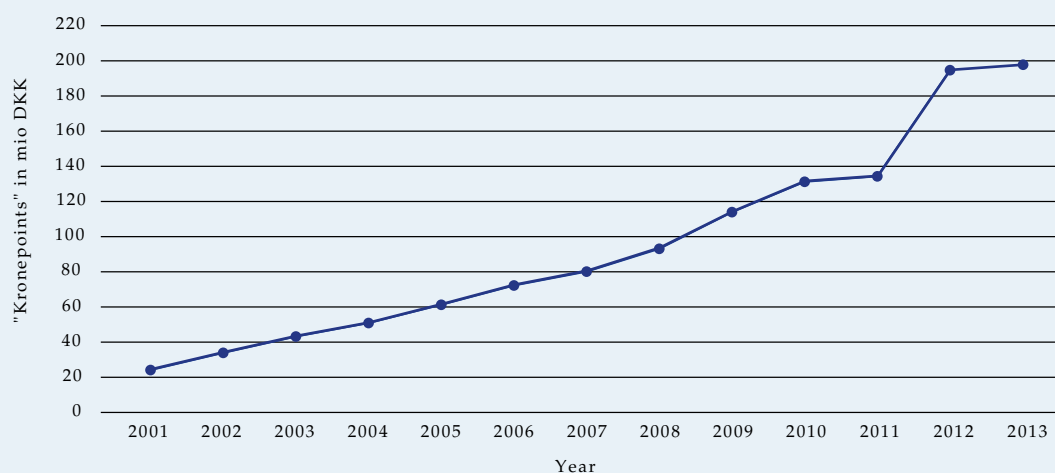
Pigs

¹⁵ O-H ₂ O	1
¹⁸ F-FDG	5
MR	5

Total	2,624
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Finance

Turnover



The increase in activities measured in "krone points" rose from 43,5 mio DKK in 2003 to 198 mio DKK in 2013.

"Krone points": Price for each patient investigation multiplied with number of investigations, summarized for all patient studies performed during the year.

Balance 2013

Expenditure (DKK mio.)

Running costs	17,7
Staff	51,0
In total	68,7
Receipts	16,1

Publications 2013

PhD theses

- Haahr ME. PhD thesis. In Vivo PET Imaging of the Cerebral 5-HT₄ Receptors in Healthy Volunteers - In Relation to Appetite, Memory and Pharmacological Intervention. København: Own publishing 2013:1-67. Defended on January 11, 2013, University of Copenhagen.
- Hag AM. Atherosclerosis. PhD thesis. ¹⁸F-FDG PET and Gene Expression - Studies in Mice. Defended on February 22, 2013, University of Copenhagen.
- Hansen HD. PhD thesis. Evaluation of PET radioligands for the cerebral 5-HT₇ and 5-HT_{2A} receptors. København: Own publishing 2013:1-63. Defended on, October 11, 2013, University of Copenhagen.
- Jensen MM. PhD thesis. FLT and FDG PET for non-invasive treatment monitoring of anti-cancer therapy – preclinical studies in mouse models of human cancer. Defended on September 27, 2013. University of Copenhagen.
- Jørgensen JT. PhD thesis. Molecular Imaging of Tumor Hypoxia using Cu-ATSM - Preclinical Studies of Temporal changes in Tumor Uptake. Defended on June 26, 2013. University of Copenhagen.
- Persson M. PhD thesis. Towards uPAR as a new imaging biomarker: development and characterization of radiolabeled ligands targeting uPAR in human cancer xenograft mice models for PET imaging and therapy. Defended on March 22, 2013. University of Copenhagen.
- Reichkendler M. PhD thesis. Dose-response effects of endurance training on metabolic risk and regional glucose uptake in overweight men. Defended August 26, 2013. University of Copenhagen.

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- WO/2013/167130: Kjaer A (together with 2 co-inventors): ¹⁷⁷-Lu labeled peptide for site-specific uPAR-targeting. Published November 13, 2013.

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Equipment 2013

Equipment	Product	Purchase year
Gamma cameras	Mie-Scinttron	2004
	Mediso N-TH45-D	2008
	DDD SoloMobile	2012
SPECT cameras	Philips ADAC Skylight	2002
	Mediso Nucline X-Ring-R/HR	2009
SPECT/CT cameras	Philips, Precedence 16-slice CT	2006
	Philips, Precedence 16-slice CT	2008
	Siemens Symbia 16-slice CT	2011
PET scanners	HRRT Siemens/CTI	2007
PET/CT scanners	Siemens Biograph TrueV 40-slice CT	2007
	Siemens Biograph TrueV 64-slice CT	2009
	Siemens mCT-S (64)	2010
	Siemens mCT-S (64)	2011
	Siemens mCT-S (128)	2013
PET/MR scanner	Siemens mMR	2011
Lung function	Jaeger Masterscreen w/bodybox	2005
	Jaeger PFT pro w/bodybox	2007/13
DXA scanner	GE Lunar Prodigy	2011
Whole body counter	WBC w/Nal counting chamber	1977
	WBC w/plast counting chamber	1978
Cyclotrons	Scanditronix 32 MeV	1991
	RDS Eclipse cyclotron, CTI	2005
Cluster for Molecular Imaging	Provivo/ ADAC mobile gamma camera	1990
	PET scanner GE 4096	1991
	SPECT Mediso Nucline X-Ring/R	2004
	Siemens Micro-PET Focus 120	2006
	Micro-CT Siemens Micro-CAT II	2006
	Phosphor Imager Perkin Elmer cyclone	2007
	Bruker preclinical MRI PharmaScan 7T	2013
	Siemens preclinical PET/CT Inveon	2013
	PX Inc. preclinical RT X-RAD 320	2013



Research

A continued strong focus on research is a cornerstone of the department. We have over the years developed an extensive research program and collaborate with several national and international partners. Our research program focuses on development of new tracers for PET, PET/MRI hybrid imaging, theranostics, clinical evaluation of new diagnostic methods, and on the use of methods from clinical physiology and nuclear medicine to study pathophysiology. Translational research in molecular imaging is given special attention in order to accelerate translation of new tracers into clinical use in patients. Some current major research areas are mentioned below.

New tracers

A series of projects are aimed at development of new, specific tracers for non-invasive tissue characterization are currently undertaken. These tracers are to be used for the diagnosis of different cancer types as well as for planning and monitoring of therapy. The projects, translational in nature, are carried out in collaboration with other departments and laboratories both nationally and internationally to obtain the necessary expertise in molecular biology, chemistry, radiochemistry, cancer biology and imaging. A recent example of such a new tracer developed at the department and now used in more than 200 patients with neuroendocrine tumors, is ^{64}Cu -DOTATATE. Patients from USA have come to our department to get this scan performed. In addition, we develop new peptide-based PET tracers for imaging of the invasive phenotype and targeted nanoparticles for PET. We have developed a comprehensive platform for validation of new tracers including cell laboratory, molecular biology (proteomics and genomics), histology and biomarker laboratory facilities at the department.

PET/MRI

With installation of the first integrated PET/MRI scanner in the Nordic Countries, we have developed an extensive research program with focus on the added value of combining PET and MRI. A large number of clinical trials, as well as projects on method development, are currently undertaken with focus on the combined use of the modalities for improved tissue characterization and response monitoring in cancer treatment, pediatric studies, brain studies and atherosclerotic plaque characterization. Focus on



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MRI includes the use of diffusion weighted images (DWI)/apparent diffusion coefficient (ADC) and magnetic resonance spectroscopy (MRS).

Hyperpolarized ^{13}C -MRSI

With the installation of equipment for dynamic nuclear polarization of ^{13}C -labeled compound, e.g. ^{13}C -pyruvate we have developed a research program with focus on the use of this technique for tissue characterization in cancer, but not limited to this field. Since the system is the first in the World that is installed next to a PET/MRI scanner, special attention is given to how the combination of hyperpolarized ^{13}C -MRS and PET can be combined in what we have named “hyper-PET”. We aim at developing methods with through use of the combined modalities are superior in cancer phenotyping and therapy monitoring than the techniques alone. Also this area of research is approached translational.

Clinical PET/CT

A large number of prospective protocols are performed to evaluate the diagnostic and prognostic value of PET/CT with different tracers in various forms of cancer in children and adults. Head-to-head comparison studies of new PET tracers and established imaging methods are also performed. The use of PET/CT for the planning of radiation therapy (“dose-painting”) and the use of respiratory gating are also currently being evaluated. Many of these studies now include PET/MRI to study the added value compared to PET/CT.

Pediatric nuclear medicine investigations

The department conducts many pediatric investigations. Several research protocols with the use of PET and SPECT are carried out in cooperation with clinical departments, particularly within oncology. The use of PET/MRI in children to save radiation dose is also the subject of investigations.

Neuro PET

With the use of PET/CT, including HRRT, studies on brain tumors are undertaken. Studies of brain perfusion using PET or DCE-CT are also performed. In addition, imaging of dementia with new tracers and brain tumors with FET is studied. PET/MRI is now integrated

into many of these studies. In cooperation with Neurobiology Research Unit and Centre for Integrated Molecular Brain Imaging, neuroreceptor ligands have been developed and used for research in neurobiology. The focus has mainly been on the serotonergic system.

Atherosclerosis

With the use of PET/CT and PET/MRI we can non-invasively visualize atherosclerosis and probably predict vulnerability of atherosclerotic plaques. With this technique, several studies in different groups of patients at risk and with the use of new PET tracers are currently undertaken. The goal is to develop an image-based algorithm for identification of patients at risk that will benefit from surgery. Recently, we published as the first, the use of PET/MRI for carotid artery imaging and its advantage over PET/CT.

Nuclear cardiology

With the introduction and use of ^{82}Rb PET coronary flow regulation is studied quantitatively in connection with a variety of cardiovascular diseases and the influence of interventions including gene therapy, pharmacological treatment and exercise. With the use of SPECT/CT or PET/CT the development of ischaemic heart diseases is studied in selected groups of patients, e.g. HIV patients. On basis of this, screening algorithms for detection of ischaemic heart disease are evaluated. Some of the studies are combined with PET tracers characterizing other aspects of the myocardium and its viability. Several of the studies are performed using PET/MRI to obtain additional information.

Lung studies

Research using lung function testing and lung scintigraphy in different patient groups, e.g. lung transplantation and endobronchial stenting for emphysema, are undertaken. The value of combined use of SPECT/CT for diagnosing pulmonary embolism has recently been evaluated. The value of biomarkers in combination with imaging is also studied. In addition, evaluation of the different ventilation tracers for assessment of ventilation inhomogeneity is undertaken. Research is also being conducted into mucociliary clearance, a method pioneered at the department, of the nose and lungs.

Radionuclide treatment and theranostics

Localized radiation therapy using specific ligands binding to certain cancer forms has recently been implemented. The department takes part in research within this area by testing new ligands and producing relevant isotopes. We also develop several new theranostics based on promising imaging ligands labeled with beta or alpha emitting radionuclides. Cancers that are currently being targeted clinically include neuroendocrine tumors and ovarian cancer. Treatment with radionuclides will in part be based on imaging using new tracers for molecular profiling or the same ligand as the therapy (theranostics) for better outcome and fewer side effects. The concept of a tracer that visualizes the target prior to starting therapy is also known as companion diagnostics.

Whole body counting

Together with external partners, whole body counting is used for exact measurements of body composition in a series of studies. In addition we are investigating absorption of certain minerals from the gastrointestinal tract.

⁶⁴Cu-DOTATATE PET:

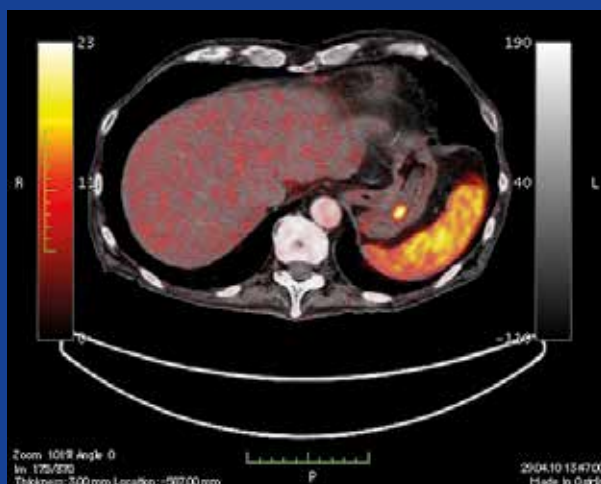
Presentation of results from the first 100 neuroendocrine tumor patients wins prize at the SNMMI Annual Meeting in Vancouver

Recently we introduced a new PET tracer ⁶⁴Cu-DOATATE for use in neuroendocrine tumor patients. Advantages include low-energy positrons and an intermediate-half-life of 13 hours allowing for high spatial resolution and delayed imaging. Data from a head-to-head comparison with ¹¹¹In-DTPA-Octreotide in 100 patients was presented at the Annual Meeting of the Society for Nuclear Medicine and Molecular Imaging (SNMMI) in Vancouver, Canada. The presentation was awarded First Place Poster in the General Clinical Track (presenter Dr. Camilla Bardram Johnbeck).

The main finding was that ⁶⁴Cu-DOATATE could detect considerably more foci than ¹¹¹In-DTPA-Octreotide and during follow-up the majority of additional foci could be proven to be true positive. In no case were additional foci found on PET identified as false positive.

In 2013 we have had patients from abroad visit us to have the scan performed. The long half-life of the tracer allows for performing early images (1 h) as PET/CT and delayed images (3 h) as PET/MRI.

Development of the new tracer, headed by Professor Andreas Kjær, is in line with Rigshospitalets position as a European Center of Excellence for Neuroendocrine Tumors and that we have been awarded Global Excellence by the Capital Region of Denmark. The development and testing of the new tracer involves several of the partners of the ENETS Centre at Rigshospitalet as well as the Hevesy Laboratory at Risø, DTU.



⁶⁴Cu-DOTATATE-PET/CT revealing a gastric neuroendocrine tumor that was later confirmed by biopsy. The tumor was not seen on the ¹¹¹In-DTPA-Octreotide.

Cluster for Molecular Imaging



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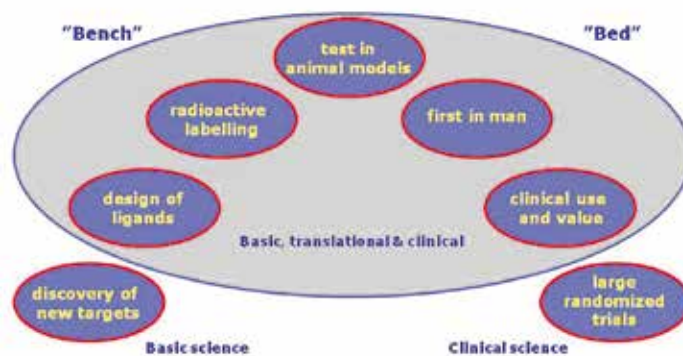
The paradigm of individualized, tailored therapy has led to a need for diagnosing at the molecular level. Molecular biology methods need tissue sampling for in vitro analysis. In contrast, molecular imaging allows for non-invasive studies at the molecular level in intact organisms. Also, such non-invasive imaging is not prone to sampling error since whole-body imaging is obtained. With PET it is possible to label bio-molecules with radioactive isotopes. This method can be used for non-invasive visualization of tumor specific receptors and tissue characteristics such as angiogenesis and ability to metastasize. Especially within cancer biology the technique is expected to lead to a break-through in diagnosing and treatment. Among the different techniques for molecular imaging, the nuclear medicine based technologies have the greatest translational potential since methods developed in animal models may directly be transferred and used in humans. In addition, successful imaging ligands may be developed into radionuclide therapy, such an imaging therapy pair is known as theranostics.

Our current molecular imaging and theranostics research program is aimed at through use of molecular biology and imaging techniques in both animals and humans to develop, evaluate and use non-invasive molecular imaging for human tissue characterization. Major applications of these tracers are expected to be: 1) planning of individualized, tailored therapy, 2) testing of new drug candidates and 3) basis for development of radionuclide therapy (theranostics).

The development of new molecular imaging tracers for PET is a very complex process that involves many steps from definition of target to final use of the tracer in patients.

Major steps involved in PET tracer development and translation into patients

- » Selection of key-processes involved in the pathophysiology of the disease
- » Definition of relevant molecular targets of the key-processes
- » Design of specific ligands
- » Radioactive labelling of ligands
- » Test of imaging ligands in relevant animal models



The “translational bridge” with our key competences highlighted in grey

- » Use of imaging data for therapy planning and monitoring of response
- » Use for diagnosing, therapy planning and monitoring in patients
- » Use for testing of new drugs
- » Use as starting point for new targeted therapies, in particular radionuclide based therapies

Through formation of Cluster for Molecular Imaging at the Faculty of Health Sciences, University of Copenhagen (headed by Professor Andreas Kjær) a core facility at the Panum Institute for molecular imaging in animals with PET, SPECT, CT, MRI and optical imaging (2003) has been established. This has improved our translational capacity since we are now able to test new tracers and radionuclide therapies in animal models prior to clinical use. In accordance with this we have currently several new tracers in preclinical testing in animal models that already have or soon will become available for human use. A strong focus has recently been on the use of clinically relevant animal cancer models, which include orthotopic human xenograft tumors as well as metastatic cancer models using human cancer cell lines. Furthermore, we have also introduced and developed animal models of cardiovascular diseases including atherosclerosis, myocardial infarction and takotsubo.

Over the last 10 years we have build a translational platform for development of new PET tracers in cancer. The platform includes, after testing in orthotopic human xenograft tumors in mice, early use of promising PET tracers in companion dogs with spontaneous tumors scheduled for cancer therapy. In this way we bridge between xenograft models and first-in-man studies.

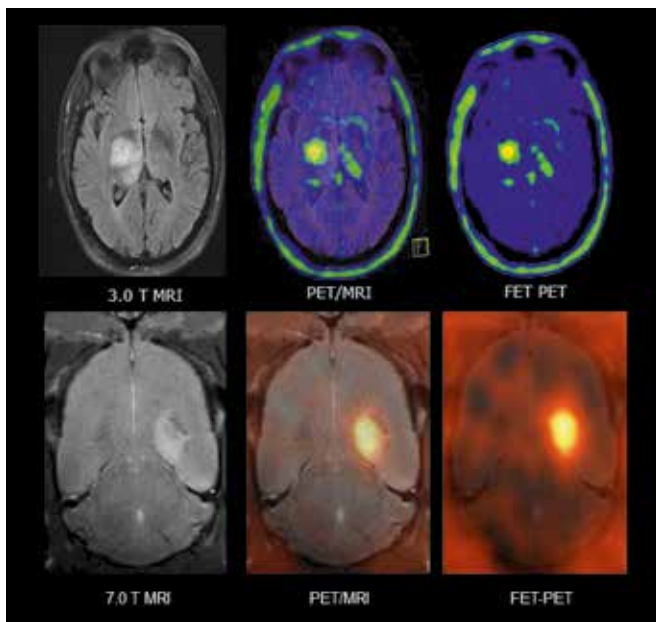
At Cluster for Molecular Imaging we always seek to match our clinical methods to be able to develop new techniques for use in patients. Recent examples include the establishment of PET/MRI/MRS capabilities to be used in oncology and cardiology studies. Also, we currently perform preclinical studies in the field of hyperpolarized ^{13}C -MRS in collaboration with Hvidovre Hospital and DTU.

Cluster for Molecular Imaging is imaging partner in the European Advanced Translational Infrastructure in Medicine (EATRIS) under EU 7FP.

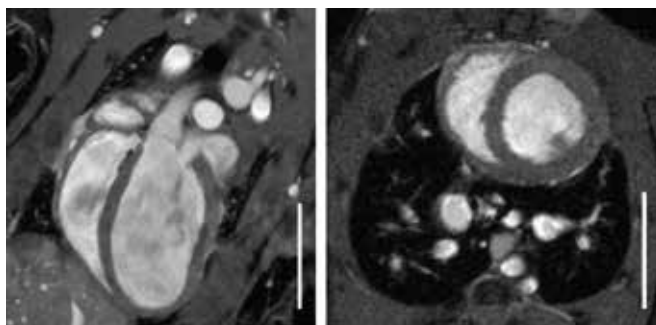
Currently the main focus of the translational research in tracers for non-invasive tissue characterization is on the use in cancer and cardiovascular disease and new targeted radionuclide therapies for cancer. However, several other applications are also foreseen.

Some tissue characteristics currently targeted for imaging:

- » Cancer specific receptors (several projects)
- » Glycolytic activity
- » Cell proliferation
- » Amino acid transport
- » Hypoxia
- » Apoptosis
- » Angiogenesis
- » Invasive phenotype



The figure shows translational imaging of brain tumors. In the lower panel a 1.4 mm large orthotopic human glioblastoma multiforme tumor (white arrows) in the brain of a mouse is shown. MRI was acquired using our 7T dedicated animal scanner. PET was performed using the aminoacid tracer FET and images were fused. The model is used to study how early response to therapy is best monitored non-invasively using PET/MRI. For comparison, the upper panel shows the same methodology applied in a patient with a 4 cm glioblastoma multiforme tumor (images provided by Ian Law and Mette Kj  llhede Nedergaard).



The figures show long and short axis views of a rat heart obtained on a 7T MRI system. Images are gated and function can easily be evaluated. White scale bars represent 1 cm. The model will be used to follow functional parameters obtained with MRI with that of new PET tracers for use in e.g. early prediction of final damaged myocardial area following acute myocardial infarction (Images provided by Henrik El Ali).





Danish Chinese scientific collaborations

Also in 2013 the Department has continued its collaborations with hospitals and research institutions in China. Our Danish-Chinese collaborations are centred at development of new molecular PET imaging probes for cancer and their use in evaluation of anti-cancer therapies, including Traditional Chinese Medicine (TCM).

Professor Andreas Kjær is partner in one of the Danish-Chinese Research Centers funded by the Danish National Research Foundation (Danmarks Grundforskningsfond) and the National Natural Science Foundation of China. The Center is currently funded until the end of 2014. The main focus of the Centre is to perform high level research leading to new molecular imaging ligands and tailored therapies. Our current focus is on new PET imaging ligands to identify the invasive cancer phenotype and to translate one or more of these into clinical use. There have been a break-through in this development and currently we expect the first of these tracers to be tested in humans during 2014. In addition to Rigshospitalet, the partners are Aarhus University, Chinese Academy of Sciences, Fuzhou and Soochow University, Suzhou. Also in 2013 meetings have been held both in China and in Denmark.



Danish-Chinese Centre for Proteases and Cancer
The Danish National Research Foundation and
The National Natural Science Foundation of China

Young investigator prizes

PhD student Camilla Bardram Johnbeck

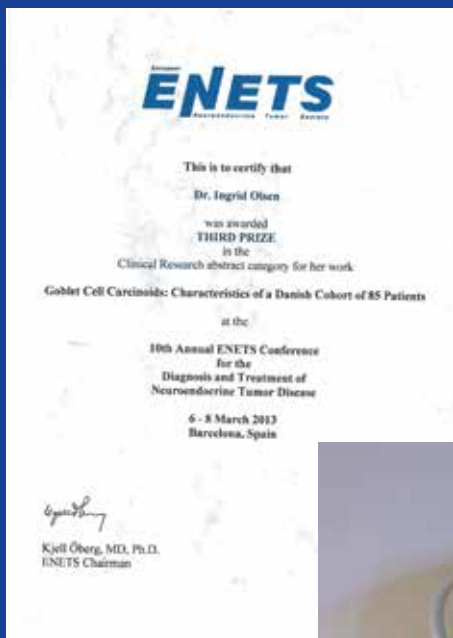
Society for Nuclear Medicine (SNM), Annual Meeting, Vancouver, Canada, June 2013.
Best poster prize in the General Clinical Track.

PhD student Camilla Bardram Johnbeck

Faculty of Medical and Health Sciences, University of Copenhagen, PhD Day, May 2013.
Best Poster Presentation.

PhD student Ingrid Holst Olsten

European Neuroendocrine Tumor Society, Annual Conference, Barcelona, March 2013.
Third prize in the Clinical Research Abstract Category.



Anniversaries



Secretary Sanne Hildebrand celebrated her 40 years anniversary in August 2013.



Nuclear Medicine Technologist Bente Dall, celebrated her 25 years anniversary in September 2013.

CIMBI

**Center for Integrated Molecular Brain Imaging,
University of Copenhagen, Rigshospitalet**



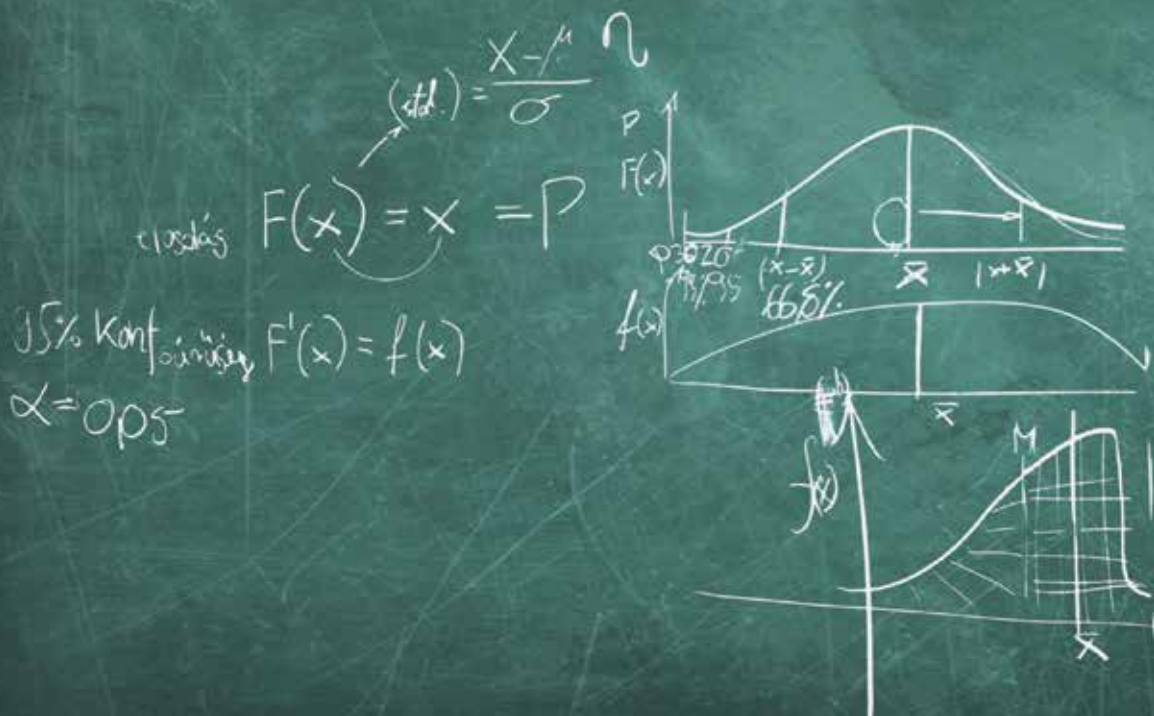
We are proud to contribute and collaborate with Professor Gitte Moos Knudsen, Chair of the Neurobiology Research Unit at Rigshospitalet, University of Copenhagen and also Director of the CIMBI, Center for Integrated Molecular Brain Imaging, funded by the Lundbeck Foundation. The focus of the research program is on neurobiology, physiology and pathophysiology, molecular imaging and neuroreceptor ligands with focus on the serotonergic system. Gitte Moos Knudsen and her research team are highly appreciated and we appreciate the excellent collaboration.



Education

Educational activities are part of the daily functions of most staff members. The department is highly active in education at different levels of various health related professionals.

In postgraduate education, the department plays an active role in the specialist education of physicians in clinical physiology and nuclear medicine in different ways. The dedicated courses in oncology-, cardiology-, lung-, and endocrinology- pathophysiology are all held at our department and arranged by our chief physicians, and the department has four educational positions for young physicians training to become specialists in clinical physiology and nuclear medicine. Furthermore, we contribute to the specialist education of physicians from other specialities such as urology, nephrology, radiology, oncology, haematology, pulmonology and thoracic surgery. A high number of PhD students are associated with the research activities in the department.





Jann Mortensen and Peter Oturai

Regarding undergraduate education, the department contributes to the activities of the Faculty of Health Sciences at the University of Copenhagen for medical students, human biology students in collaboration with DTU in various subjects, e.g. physiology, nuclear medicine and medical technology. Nuclear medicine technologist students and radiography students receive part of their education from the department.

The department delivers extensive training programmes to staff from other nuclear medicine and radiological departments in Denmark and the Nordic countries.

Colleagues, both students and postgraduate from Denmark and abroad, have visited the department for educational purposes for periods ranging from weeks to months.

The departments educational activities have been accredited by the Danish National Board of Health and by the Accreditation of Nuclear Medicine Training Centres Committee of the Section of Nuclear Medicine of the European Union of Medical Specialists (UEMS).

Chief Physician Peter Oturai is responsible for the postgraduate education of physicians in the department. Clinical Associate Professor Jann Mortensen is responsible for the undergraduate education of medical students. Professor Liselotte Højgaard is responsible for under- and postgraduate education for bioengineers.



Nuclear medicine technologists

Technologist Award 2013 Rigshospitalet

Our nuclear medicine technologist Annette Cortsen received "The Annual Technologist Award" from Rigshospitalet with the following explanation: Annette Cortsen is a role model for technologists. She is passionate about her job with the aim of helping patients and being a good colleague. Annette is always focusing on the patient first with professionalism and quality as the key words. Annette Cortsen is Technologist with a capital T (In Danish: Bioanalytiker with capital B).

In her work with the patient and their diagnostic imaging scans, Annette Cortsen is uncompromising, and patients are always treated with great professionalism to fulfil the needs of each. There is always room for an extra image to secure top quality, and there is always time for information. The honours to Annette Cortsen were so laudable that she made it to national television, where she was very modest at the interview and expressed that she just did what could be expected to secure optimal patient treatment.



*Vicedirector Karin Nørgaard and
Nuclear Medicine Technologist
Annette Cortsen*



Tim Lundby, Kate Pedersen and Anne Sørensen

In 2013 our technologists and radiographers have shown that they are willing to provide an extra effort to secure that our patients can have their diagnostic investigations performed without waiting. If we, even on a Friday afternoon, see that we will have a waiting list accumulating, we plan extended hours 4-7 pm. Thank you so much to every one.

All technologists and radiographers are heavily engaged in all tasks in the department and no challenge is too big. They participate and initiate research projects, they work long hours in the evening and in the weekend to assure that research investigations are performed. This year with special focus on PET brain scanning, DEXA scanning and lung function investigations (DALFUMAT, the new Danish national study collecting a reference material of all age groups for Denmark).

In the PET scanner section the LEAN project is now part of the every day life.

The Cyclotron and Radiochemistry laboratories are placed in the lower basement, and this year new daylight equipment has been installed and in radiochemistry the new facilities have led to a better daily flow, although the activities are still very high and square meters are sparere.

In the Nuclear Medicine Section KF rebuilding has taken place, and the section has been renovated with new ceiling and lightning. The individual rooms have been renovated and a more optimal solution for placing of equipment has been implemented. Children and pediatric patients have been in focus in 2013 in our Department of Clinical Physiology, Nuclear Medicine and PET. In March 2013 we participated in "Health Days" arranged by the Capital Region of Copenhagen in Øksnehallen in central Copenhagen, where children and adolescents and the Copenhagen population where the target of the Grand Festival. Our nuclear medicine technologists and radiographers where on the spot for three days, and the Pediatric Team in our department had produced a very fine exhibition area, and Nuclear Medicine Technologist Stine Holm had drawn a special cartoon PET/CT scanning for children, and Radiographer Elisabeth

Abrahamsson had build a very cute miniature PET scanner, where the children could scan their teddybears and make fine black and white images they could colour themselves. A very nice teddy had a metal piece in his inner parts, and the kids had to find it with a metal detector. This idea from Nuclear Medicine Technologist Viktoria Setterberg was developed to explain the children, how we can see radioactivity in patients. To the annual Summer Theme Day in May 2013 the Pediatric Team had made a miniature of the exhibition area from Øksnehallen, and they explained about the day with fotos from the three exhibition days.

The Pediatric Team did a great job with the development of the first Danish dedicated pediatric nuclear medicine section inaugurated in August 2013. Nuclear Medicine Technologist Stine Holm had designed a special brochure explaining to patients, what was going on in the section, and what the different pictures and paintings on the walls were ment for.

In 2013 Nuclear Medicine Technologist Eunice Saxtoft got the idea and finished the subsequent project with use of Nexus tablets in the PET Scanner Section for management of PET research studies. On the tablets we have now updated and easily accessible documents with an overview of the different scientific projects in the PET Scanner Section. The tablet fits in the white coat pocket, and the use of them create easier work flow. It is used for accessing information about projects, tracers in Tracershop, follow up of patient transportation, an easier access to SOPs, a mutual google chalendar, access to net radio, patient login to Spotify and much more. The process has been difficult, as it is a challenge to secure tablets on the hospital internal network, but the Department of Medical Technology has helped us with the project, and we can now work smarter instead of harder. "We can save time and resources, we can be more effective, and it is nicer to be happy in the every day work life" says Eunice Saxtuft. Fast access to important information has created a more happy work life.





In the Radiochemistry Section we extended the nuclear medicine technologist staff from 4 to 5, and we initiated the routine production of ^{68}Ga -Dotatoc with 5 productions per week. ^{68}Ga -Dotatoc has a half life of 68 minutes, and in every production we can produce to 3-4 patients. Diagnosing neuroendocrine tumors with ^{68}Ga -Dotatoc scanning is performed with a PET scanner, and it takes about 2 hours for each patient. This investigation is the next generation after the previous old ^{111}In -Octreotide investigation with gamma camera, where the patient had to come in on 3 different days. This is real “win-win” for our patients and also for the department.

Due to the low halflife of ^{68}Ga -Dotatoc it is important that 4 patient investigations can be made in several PET scanners at the same time, so PET scanners are at use simultaneously. To solve this logistic challenge, and divide the radioactive medicinal product a good coordination is needed between the KF and PET sections. This is solved through close contact and collaboration between staff nuclear medicine technologists in the two sections and by mutual booking.

This year we initiated a bachelor project to label thrombocytes with ^{111}In -Cl3 for a research project investigating the coagulation profile in HIV infected patients. The research question is whether the thrombocytes will have a biodistribution as in healthy persons. Our nuclear medicine technologists are heavily involved.

Radiochemistry meeting for nuclear medicine technologists in September

In September 2013 the department participated in The Annual Meeting in Radiochemistry, where our nuclear medicine technologists and technicians from PET-centers in Denmark exchange information and share common knowledge. One of the highlights where “Labs without paper” an IT system developed for PET center use.

Technologist Day 15th of May 2013, Rigshospitalet

Our nuclear medicine technologists Maria Pejtersen and Elin Lindell gave a very fine presentation: “Will ^{82}Ru -PET/CT cardiac scanning replace classical myocardial scintigraphy?”.

EANM in Lyon October 2013

Our nuclear medicine technologists participated with the following posters:

- » *How to increase the distance between myocardia and subdiaphragmatic ^{82}Ru -uptake in PET.*
Maria Pejtersen, Elin Lindell and Martin Lyngby Lassen.
- » *PET/CT imaging of head/neck patients: Comparison of a one-step protocol and a two-step protocol.*
Camilla Sloth Knudsen, Anna Ljunggren, Thomas Beyer, Flemming Andersen, Thomas Levin Klausen, Katrine Cappelen, Anne Kiil Berthelsen, Søren Holm and Annika Loft Jakobsen.
- » *A multidisciplinary approach to the education and operative responsibilities ensures an efficient adoption of PET/MRI in clinical routine.*
Karin Stahr, Jákup Poulsen, Marianne Federspiel, Sune Keller, Adam Hansen, Helle Hjorth Johannesen, Thomas Beyer and Johan Löfgren.
- » *High impact of a simple warming regime on the FDG uptake in brown tissue.*
Elisabeth Abrahamsson, Marianne Federspiel, Søren Holm, Charlotte Birk Christensen and Lise Borgwardt.
- » *Labeling activated autologous cytotoxic T lymphocytes with ^{111}In -Tropolone and $^{99\text{m}}\text{Tc}$ -HMPAO.*
Tim Mølgaard Lundby, Walther Fischer and Jann Mortensen.

Deputy Chief Nuclear Medicine Technologist Kate Pedersen and Nuclear Medicine Technologist Marianne Federspiel were moderators at the EANM in Lyon 2013, EANM/ESTRO Radiation Therapist Committee Joint Session: Evolution of radiotherapy planning”.

Kate Pedersen is former member of the European Association of Nuclear Medicine Technologist Board, and Marianne Federspiel is the present member of the Board. We are very proud of both of them.

SNM June 2013

Our Nuclear Medicine Technologist Karin Stahr participated with an oral presentation: *A multidisciplinary approach to the education and operative responsibilities ensures an efficient adoption of PET/MRI in clinical routine.*

Karin Stahr, Jákup Poulsen, Marianne Federspiel, Sune Keller, Adam Espe Hansen, Helle Hjorth Johannesen, Thomas Beyer and Johan Löfgren, from Rigshospitalet, University of Copenhagen and from Zurich, Switzerland.

Annual meeting of Danish Society of Clinical Physiology and Nuclear Medicine
Deputy Chief Nuclear Medicine Technologist Kate Pedersen participated with an oral presentation: “Lean optimized patient flow in PET”.

Rigshospitalet:

Centre of Diagnostics course for LEAN agents: Also here Deputy Chief Nuclear Medicine Technologist Kate Pedersen gave her presentation about LEAN in the PET Scanner Section.



EATRIS

European Infrastructure for Translational Medicine

Following years of preparation on November 2013 the constitutional meeting establishing EATRIS, the European Infrastructure for Translational Medicine, as a legal entity ERIC was held at the Dutch Ministry of Education, Culture and Science in den Haag. The Board of Govenors, the Board of National Directors as well as representatives from the EU Commission and the Dutch Ministry were present. In the evening a banquet was held in Gemeentemuseum Den Haag.

Our Department participates in EATRIS with imaging expertise and services and Professor Andreas Kjær serves as the National Director of Denmark in EATRIS. In addition to our participation, also Aarhus University and Danish Technical University are part of the Danish commitment.

EATRIS was established to facilitate translation of research into clinical use through match-making between researchers and high-level infrastructure in Europe.



Group photo from the reception of the constitutional meeting at the Gemeentemuseum Den Haag, the Netherlands. Board of Govenors, Board of National Directors as well as representatives from the EU Commission and the Dutch Ministry were present. From Denmark Govermental Representative Peter Uffe Meier, National Director Andreas Kjær and coordinator of the Danish EATRIS office Anne Mette Fisker Hag participated.

MSc in Medicine and Technology





Liselotte Højgaard

In cooperation with the Technical University of Denmark (DTU) and the University of Copenhagen (KU), the Department represented by Professor Liselotte Højgaard is involved in the MSc program in Medicine and Technology. It is a five year bioengineering degree at bachelor and master's level. The first master graduated in 2008. Since the launch of the program in 2003 more than 200 students have applied for the 60 available places each year. You can read more about the program at www.medicin-ing.dk.

At present several of these bioengineers are seconded to the Department as PhD students and we have numerous students working with bachelor and master reports in collaboration with DTU, IMM (Institute for Mathematical Modelling), Professor Rasmus Larsen and DTU, Electro with Professor Jørgen Arendt Jensen and our department here at Rigshospitalet. In 2010 the course was subject to accreditation with a positive result. A warm thank you to Professor Jørgen Arendt Jensen, Associate Professor Kaj-Åge Henneberg, Reader Jens E. Wilhjelm, DTU and Associate Professor Bente Stallknecht, University of Copenhagen, for their great effort and our great collaboration both on education and research.



PET and PET hybrid systems

The department has 1 dedicated, stand-alone brain PET system, 5 combined whole-body PET/CT systems and 1 integrated PET/MR system in the hospital itself. We are also involved in the experimental work with PET, CT and MR at Cluster for Molecular Imaging at the Faculty of Health Sciences at the University of Copenhagen.

In the Cluster for Molecular Imaging, we operate 3 research scanners for PET and CT of small animals. The “older” systems (from 2006) are a separate PET (Focus 120) and CT (microCAT II). Recently, a more integrated PET/CT system, the Inveon, was acquired. Also, during 2013, a Bruker 7T MR scanner for small animals was installed.

In the hospital, brain research continues on the PET HRRT (High Resolution Research Tomograph) in close collaboration with the neurobiology research group (NRU), but the system has also become a clinically useful instrument. Designed in cooperation by several research groups in Europe and USA, and built by CTI in Knoxville, Tennessee (now owned by Siemens) the HRRT project resulted in the building of one series of 18 instruments; the Copenhagen installation from 2007 is among the last of these, but nevertheless at the front in application.

The 4 PET/CTs in the PET-section (Finsen building) are all Siemens systems, 2 are Biograph TrueV, 1 with 40 and 1 with 64 slice CT, acquired in 2007 and 2009. The other 2 (from 2010 and 2011) are mCTs with 64 slice CT and time-of-flight but overall with rather similar specifications, which provides an important flexibility in patient scheduling. The majority of the studies in the PET section continue to be FDG whole-body scans for cancer diagnosis, staging, planning and follow-up, but in recent years a significant number of FET, FLT, ^{11}C -PiB, and ^{68}Ga -Dotatoc examinations have been added. All these scans are routinely performed with the use of combined PET and CT, and most CT scans are performed as full diagnostic quality CT including contrast enhancement. One of the mCTs is run in a unique well-functioning collaboration with the Department of Radiotherapy, and it is extensively used for therapy planning, for which purpose its large opening (78 cm) is an important design improvement over the previous generation of systems.



Søren Holm and Thomas Levin Klausen

The most recent (5th) PET/CT is similar to the two previous mCTs, although with an upgrade on the CT-part to 128 slices. It is not installed in the PET-section, but rather “up-stairs” in connection with the rest of the nuclear medicine section. This scanner mainly performs scans with ^{82}Rb (heart perfusion), ^{68}Ga -Dotatoc (neuroendocrine tumors), and ^{18}F -NaF, replacing some bone scintigraphy or SPECT/CT.

The fully integrated PET/MR scanner (Siemens mMR) was installed by the end of 2011 and was among the first in the world to become operational in early 2012. Previous attempts to combine the two modalities have either been limited in use (PET insert for brain only) or not fully integrated (two separate gantries). In the mMR, a new amplifier principle in the PET detectors makes them insensitive to the magnetic field, and small enough to allow the PET scanner’s detector ring to be placed inside the 3-tesla MR-magnet between the gradient coils and the RF transmitter. The receiver coils have been re-designed to minimize absorption of the PET-photons. This makes it possible to perform truly simultaneous measurements of PET or MR. The combined scanner is anticipated to improve the diagnostic power (in particular soft tissue differentiation) but also has the potential of reducing radiation exposure, which is particularly important in children’s examination. The physics group is working on the issues of attenuation correction and artefact suppression in order to support the clinical research protocols. In particular for quantitative results in brain scanning, the lack of direct attenuation measurements is a challenge, and we are addressing these issues with a post.doc and a PhD-project in collaborations with Siemens (Erlangen and Knoxville), University of Leuven, and the institute of Computer Science at Copenhagen University.

Danish National Research Foundation



Professor Liselotte Højgaard is Chair of the Board of the Danish National Research Foundation as of 1st of January 2013. The board members are: Professor Liselotte Højgaard, Professor Eivind Hiis Hauge, Professor Bo E. Honoré, Professor Kirsten Hastrup, Professor Svend Erik Larsen, Professor Birgitte Possing, Professor Eero Vuorio, Professor Dr. Bart De Moor and Professor Christina Moberg.

The Foundation is run by Director, Professor Thomas Sinkjær together with Vicedirector Mogens Klostergaard Jensen and Senior Viceconsultant Vibeke Schrøder and the team in Holbergsgade.

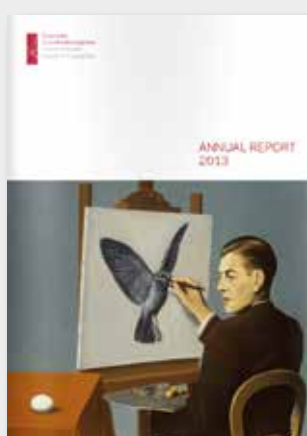
The Danish National Research Foundation (DNRF) is an independent organisation established by the Danish Parliament in 1991 with the objective to promote and stimulate basic research at the highest international level at the frontiers of all scientific fields. The Center of Excellence (CoE) program is the main funding mechanism. Since 1991 the Foundation has committed itself to support Danish research with more than 6 billion DKK (more than 800 mio €).

The Center of Excellence (CoE) is the primary funding mechanism and the foundation's flagship. A center grant is large and flexible, and a center may have a lifetime up to 10 years. Only top researchers with the most ambitious ideas will be awarded a CoE through fierce competition involving a two-stage application process.

The objective of the CoE program is to strengthen Danish research by providing the best possible working conditions and organisational set-up for selected top researchers. Centers may be established within or across all fields of research.

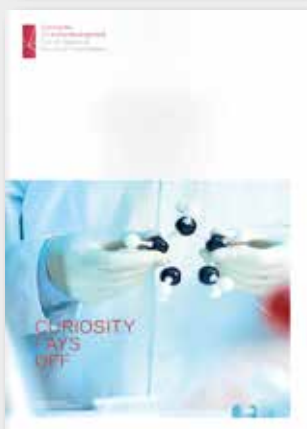
A total of 88 Centers of Excellence have been established so far, and a new generation of centers will be up and running by January 1st, 2015 as a result of the 8th application round.

The DNRF also has the Niels Bohr professorships. In 2013 DNRF was evaluated by an international panel leader by Dr. Wilhelm Krull. The outcome was very positive, and a continuation of DNRF was recommended to the Danish Parliament and Government.



Annual Report DNRF 2013

http://issuu.com/dnrf/docs/dg_annualreport2013_web



Curiosity pays off

http://issuu.com/dnrf/docs/curiosity_pays_off?e=3758829/3228694



Panel Evaluation

http://dg.dk/filer/Publikationer/Evaluering2013/Evaluation_of_the_Danish_National_Research_Foundation_web.pdf

Accreditation

Rigshospitalet and our department have been accredited succesfully by:

- » Center of Excellence by the European Neuroendocrine Tumor Society
- » Certified by SIS, National Institute of Radiation Protection, The Danish National Board of Health
- » Danish Medicines Agency
- » The Danish National Board of Health, MD Specialist education
- » EURATOM, The European Atomic Energy Community
- » Section of Nuclear Medicine of the European Union of Medical Specialists (UEMS)s
"Accreditation of Nuclear Medicine Training Centers Committee", MD Specialist Education.
- » European Association of Nuclear Medicine.
- » The Specialty Advisory Committee (SFR) in Clinical Physiology and Nuclear Medicine

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