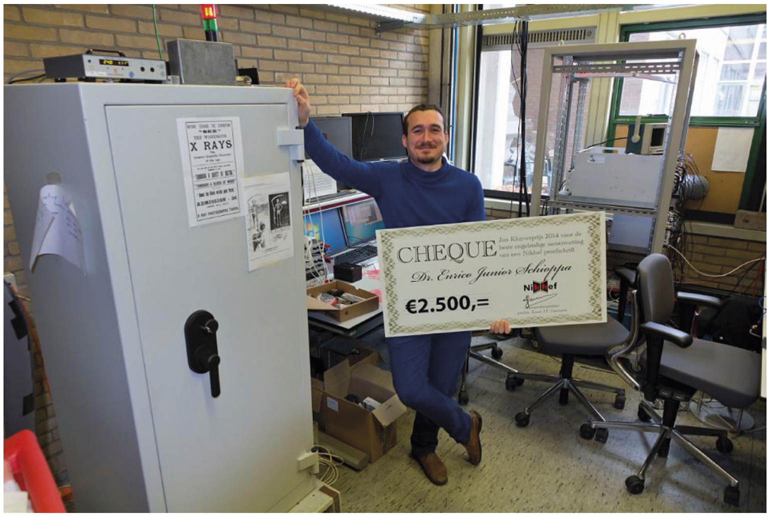
Detector Research & Development

PhD student Erik Hogenbirk adjusting the XAMS experimental setup. XAMS is a small-scale xenon TPC to test calibration and detection principles for the XENON1T Dark Matter experiment.



Enrico Schioppa shows the 2014 Jan Kluyver price in his research lab of the Detector R&D group.

Management
dr. N.A. van Bakel

Answering the biggest mysteries in physics requires pioneering experiments. New instrumentation ideas need to be initiated and developed long before they can be implemented in Nikhef's scientific experiments. In addition, today's push for knowledge transfer to industry leads to a diverse detector R&D programme. For years, detectors developed for particle physics find applications in various fields. Two examples are presented here.

Imaging with muons

High up in the Earth's atmosphere cosmic radiation creates an avalanche of secondary particles, bombarding the Earth's surface in high numbers with nearly the speed of light. Within such an avalanche C.D. Anderson discovered the muon in 1936. The muon is basically a heavy cousin of the electron. High energetic muons can penetrate far more deeply into matter than electrons and photons. The exact penetration depth depends on the energy of each individual muon and the material properties. A cosmic muon has an average energy (4 GeV in physics unit of energy) and will be stopped by four meter of iron or 12 meter of rock. Less energetic muons will be stopped earlier and more energetic muons penetrate deeper.

Since the energy distribution and the muon flux reaching the Earth are known with high precision, one can determine the amount of material above a muon detector by measuring the decrease in flux. The idea is to use cosmic muons in combination with a smart detector topology, to image the interior of a steel furnace during production. In practice this means that we measure the muon flux along several lines-of-sight through the furnace with pairs of muon detectors (also see *Knowledge Transfer*). This way we compare the penetrated with the expected flux to quantify the amount of iron along a line-of-sight. By measuring with high statistics we get a detailed image of the iron-coke ratio inside the steel furnace. A quantity that is not known very accurately today.

Proton therapy

The number of people that survive up to five years after the diagnosis of cancer increases rapidly. Many of these survivors suffer from (long-term) side effects of cancer treatment in general and more specifically from treatment with (conventional) radiotherapy. In the Netherlands the future of radiotherapy will include the use of proton beams. With protons the dose release can be targeted to a volume as small as a green pea, leading to dose reduction in healthy organs, glands or nerves surrounding the tumour. By preventing such collateral damage, the quality of life can be improved considerably. For head and neck cancer this may be the difference between losing or maintaining vision, speech and the ability to swallow. In some cases of breast cancer the risk of damage to the heart can be decreased significantly.

Els Koffeman (photo right) develops techniques, experimental methods and instruments that exploit and enhance the intrinsic benefits of the proton beam precision. Her work focusses on novel and more accurate imaging techniques: spectral CT scanning and proton radiography. Present imaging techniques are adequate but not dedicated for proton therapy and this opens the opportunity to conceive a genuinely new experimental approach with 'smart' pixel detectors. The goal is to extract data on the tissue composition of a patient with a fast scan that can be used during the course of proton treatment.

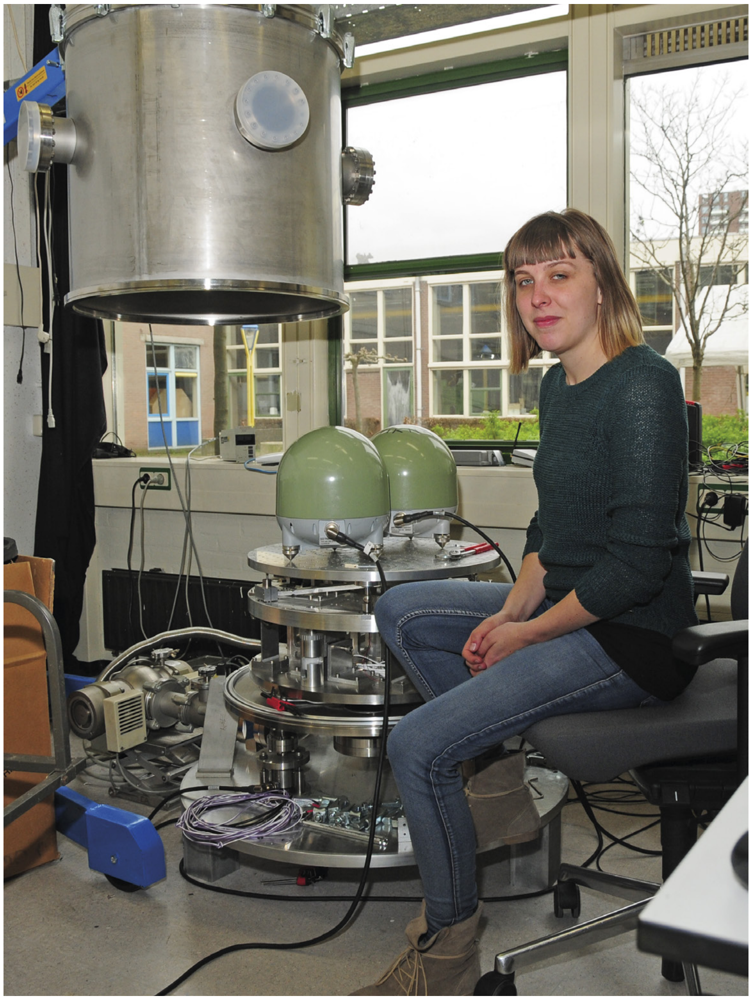
Given our expertise the R&D group aims to become a serious partner on different medical imaging techniques. For mammography we work with Andre Mischke and Utrecht Medical center, for proton radiography with Sytze Brandenburg in Groningen and others.

Els Koffeman lectures advances in medical imaging at the UvA/VU master program.

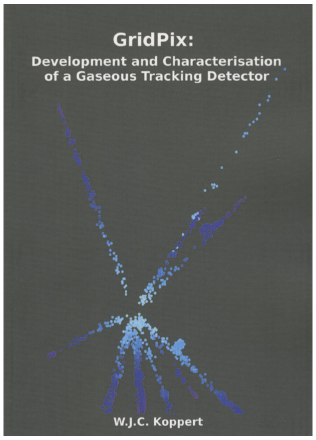
Highlights

Enrico Schioppa received the Jan Kluyver-prijs of 2014 in February 2015. Enrico did his PhD research within the Detector R&D-group and graduated in December 2014 with his thesis *"The Color of X-Rays"*. The Jan Kluyver-prijs for the best English summary of a Nikhef PhD thesis was established in 2010 by the Education Committee of the Research School for Subatomic Physics. The jury consists of the former directors of Nikhef.

SENSEIS, Nikhef's first HTSM top-sector project together with Twente University started in 2015. Future Gravitational Wave detectors require the development of state-of-the-art seismic sensor networks for subtraction of so-called gravity gradient noise. SENSEIS will develop ultra-sensitive readout electronics for micro-electromechanical (MEMS) accelerometers in the low 1–100 Hz frequency band. The innovative integrated circuits and MEMS accelerometers will also find applications in consumer electronics and scientific instrumentation. Partners in this project are Shell, semiconductor multinational STMicroelectronics, and Nikhef's spin-off Innoseis.



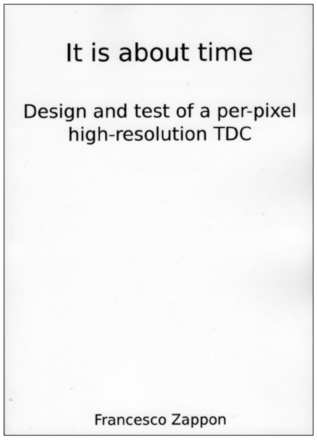
Maria Bader with seismometers developed for the Virgo project.



GridPix:
Development and Characterisation of a Gaseous Tracking Detector

W.J.C. Koppert

Willem Jakobus Cornelis Koppert
13 January 2015



It is about time

Design and test of a per-pixel high-resolution TDC

Francesco Zappon

Francesco Zappon
5 June 2015