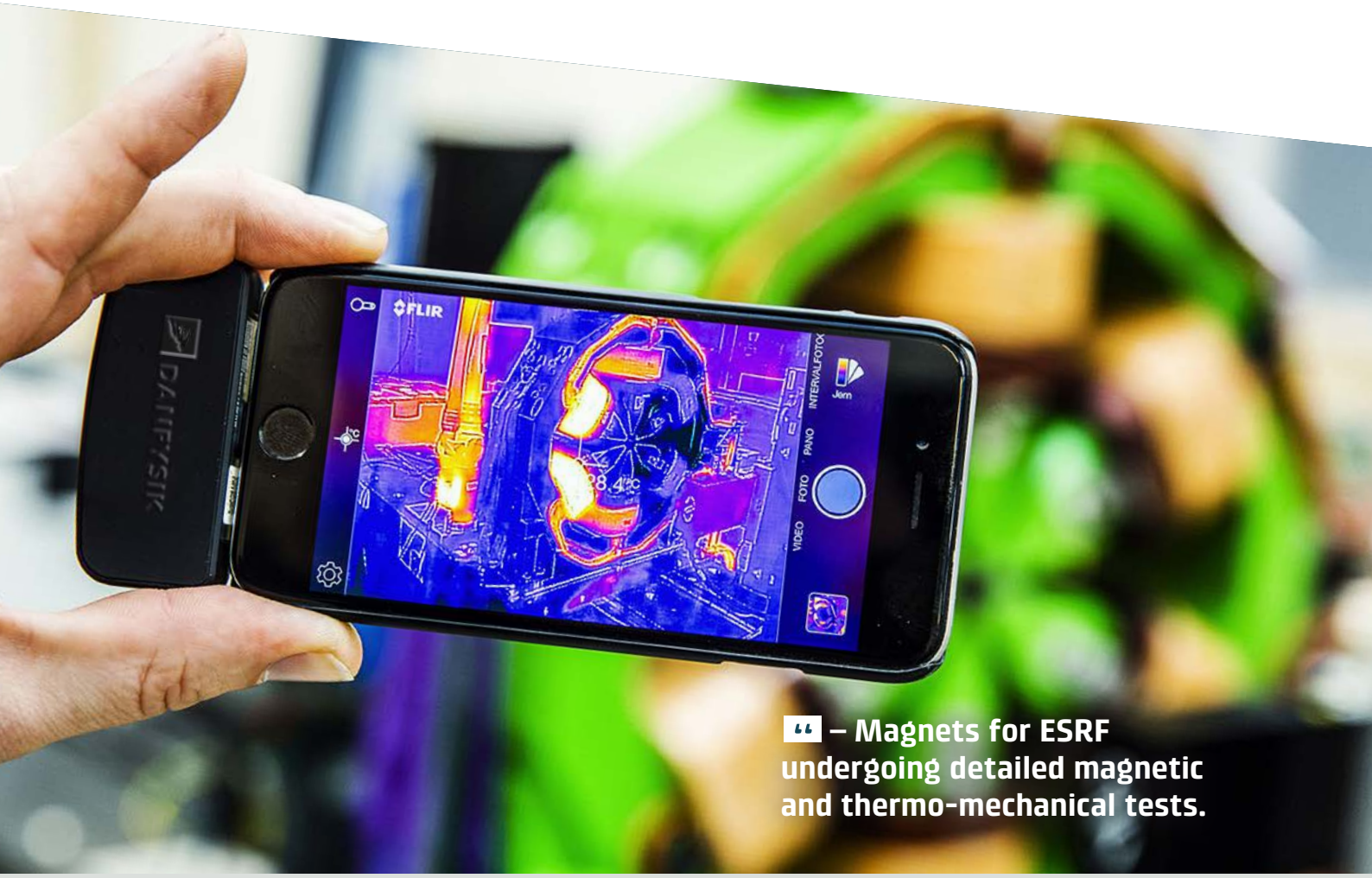
DANFYSIK

# Newsletter 2017




**“ – Magnets for ESRF undergoing detailed magnetic and thermo-mechanical tests.**

## New series production facility

–

For producing, assembling and testing large series

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## 52 phase shifters for LCLS-II

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For tuning the phase delay between undulator segments

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## New versatile Ion Implanter

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Now in 200keV and 350keV versions with options for specific applications

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# News From the Sales Director

## Dear reader,

Throughout 2016 Danfysik went through a period with particular focus on the capacity to deliver larger volumes of magnets and equipment, for example to synchrotron upgrade projects with a tight time frame, and at the same time provide even higher quality to tight specifications for modern and ground-breaking applications.
Digitalization of design, procedures and automation of manufacturing processes are steadily being implemented to further enhance our service and performance to meet your demands. Our broad product portfolio and expertise remain unchanged, and will continue to support the many diverse system projects to provide solutions that are best for our customers - this is a vital part of Danfysik's DNA.

We are looking at an exciting year 2017 and beyond, where accelerator technology is maturing into industrial applications faster than ever, - and Danfysik is ready to support and service your requirements.

Henning Bach Christensen
VP, Sales & Marketing
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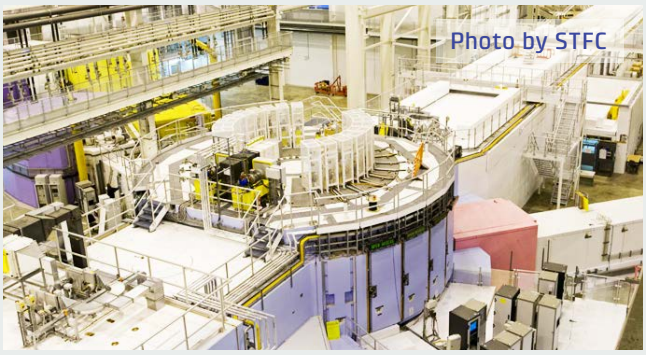
# Gigantic pulsed power supply for ISIS Neutron Source at RAL




ISIS pulsed neutron and muon source – a pioneering research centre in the physical and life sciences, ISIS has an impact in fields such as energy, biotechnology, materials development and information technology.

A new power supply for the injection kicker magnet system at the ISIS neutron source at STFC's Rutherford Appleton Laboratory, UK, is being designed and manufactured by Danfysik. A linear accelerator accelerates $H^-$ ions to 70MeV which are then injected into the synchrotron via four injection dipole magnets. When the dipoles are energized (see specs in the box below), the beam passes through a stripping foil, allowing only the protons to pass. The protons are accelerated up to 800MeV in the synchrotron before they are extracted to one of two target stations. The extracted beam will deliver protons in two 100ns long pulses to the neutron and muon targets.

**ISIS kicker power supply:**
**Output current: 15kA**
**Output voltage: ±2500Vpk**
**Repetition rate: 50Hz**
**Waveform: 500µs flattop, 100µs rise and fall time**
**Output Accuracy: ±1000ppm**

# Dedicated solutions for analysis instruments

Danfysik has the organization and processes for designing and manufacturing high-end magnet beamline solutions for leading research laboratories.

We are well ahead with the manufacturing solutions for the SPES project in Italy and the SECAR project in Michigan USA.

## Magnets and Wien filter for Michigan State University

The Separator for Capture Reactions (SECAR) facility at MSU will be used to separate nuclei formed in rare collisions of unstable low energy beams with hydrogen or helium. The experiments will focus on beams of proton-rich species and aim to increase the understanding of the nuclear processes in exploding stars.

Since the reaction product beams for analysis have very different magnetic rigidities, the magnets must be able to operate at all excitation levels from 10 to 100%. To ensure the required precision and stability of the magnetic field boundaries over the full excitation range, and to avoid interference from neighboring magnetic components, we have devised a design with adjustable field clamp "fingers" on the dipole magnets. The scope also includes two very large Wien filters, comprising a ± 300kV electrostatic analyzer and a 30 ton dipole magnet.

Most of the components were shipped to MSU in March, except for the two Wien filters which will be completed and shipped during 2017.

## SPES solution at INFN in Legnaro, Italy

The idea behind this project is to isolate and analyze specific non-stable rare earth neutron-rich elements generated either by the ISOL method or by uranium fission.

SPES is short for "Selective Production of Excotic Species". The analysis instrument comprises a beamline consisting of dipole magnets, quadrupole magnets, solenoids and electrostatic elements. The system will be delivered complete including vacuum system and stands.

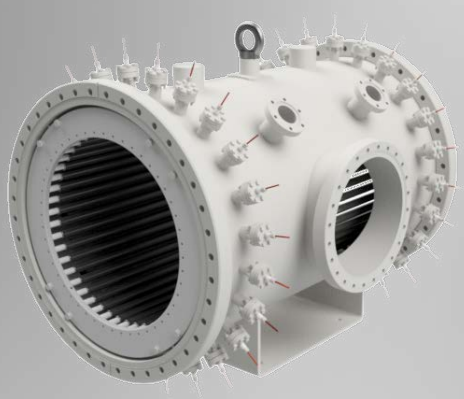
**SECAR scope of delivery**
8 Dipole magnets
15 Quadrupole magnets
4 Multipole magnets
2 Wien Filters

Dipole magnet with adjustable field clamp "fingers"

**SPES instrument scope of delivery:**

- 4 Dipole magnets
- 16 Quadrupole triplet magnets
- 3 Solenoid magnets
- 10 Steerer magnets
- 2 Electrostatic quadrupole triplets
- 4 Electrostatic quadrupole singlets
- 1 Electrostatic 48-pole multipole
- Vacuum chambers and stands

Electrostatic 48-pole for SPES



# Three projects for European Spallation Source

The European Spallation Source (ESS) is under construction in Lund, Sweden, and is planned to have first beam in 2019. When the powerful 2GeV proton beam from the approx. 500m long linear accelerator hits the giant helium cooled tungsten target, neutron beams more intense than ever seen on earth will be used by researchers in many different areas of science. The ESS is funded by the two hosting countries, Sweden and Denmark together with 13 other member states in Europe. The majority of the accelerator system components will be provided as in kind contributions from individual members, except from Sweden and Denmark. Danfysik has recently won three contracts for important components of the accelerator system.

Two collaboration partners in the three projects

## Quadrupole magnets for the MEBT section

Quadrupole magnets with built-in steerers will be positioned in the 3.8m long MEBT section. Their purpose is to match and steer the beam from the RFQ accelerator into the DTL accelerator. Danfysik will design, manufacture and test the 11 quadrupole magnets with their built-in beam steerers. They are designed to fit the tightly limited space between the RFQ and DTL segments. The magnets will eventually be provided by ESS Bilbao as an in kind contribution from Spain to ESS. Each quadrupole will have a beam position monitor mounted around the beam aperture. These will be installed by ESS-Bilbao in Spain prior to shipment to the ESS in Lund.

## Wire beam scanners for beam diagnostics at ESS

Many instruments will be needed to control the operation of the accelerator. One type of beam diagnostic instrument is a wire scanner, which consists of a thin wire that is moved through the beam while the current is logged as function of the wire position. This allows precise assessment of the beam profile. The wire scanners will be installed at selected positions along the complete accelerator system, providing alternating horizontal and vertical beam profiles. In total sixteen wire scanners are required. The scanners will be positioned inside the accelerator UHV system and will intercept a very powerful beam. The design, manufacturing and clean room assembly will take these conditions into account. Danfysik has won the contract for developing and manufacturing the wire scanners in collaboration with the ISA synchrotron team at Aarhus University.

## Beam raster scanner system for the ultimate beam delivery on the target

The magnet system will provide horizontal and vertical scanning of the 2GeV proton beam with an average power of 5MW, in order to deliver a homogeneous rectangular foot print on the target.
The system consists of four horizontal and four vertical scanning magnets. The nominal beam pulse duration is 2.86ms with a repetition rate of 14Hz. The magnets will run with a triangular pulse shape between 10kHz and 40kHz. By maintaining a H-V waveform frequency ratio differing from unity, the proton beam centroid follows a Lissajous-like displacement pattern during the raster pulse.
The operating frequency requires high frequency material with high permeability and resistivity. The air cooled coils require special attention to reduce eddy current heating.
The raster scanner magnet system is currently in the design and prototype phase at Danfysik.
The project benefits from a close collaboration with ISA Aarhus University.

**8 magnets (4 vertical and 4 horizontal)**

| | |
|---|---|
| Nominal field: | 10mT |
| Maximum field: | 17mT |
| Magnetic length: | 300mm |

**8 pulsed power supplies**

| | |
|---|---|
| Output current: | ±340App |
| Output voltage: | ±650Vpp |
| Output frequency: | 40kHz (max) |
| Waveform: | Triangular |
| Output Accuracy: | ±1% |

ESS and MAX IV sites in Lund

# MAX IV 1.5 GeV synchrotron radiation source in operation

## Twelve magnet blocks make up the complete soft X-ray synchrotron

In September last year, only three months after the inauguration of the 3 GeV ultra bright synchrotron light source at MAX IV, the first electron beam was stored in the smaller 1.5 GeV synchrotron radiation ring at the same lab in Lund, Sweden.

The MAX IV 1.5 GeV storage ring is based on a compact double-bend achromat lattice for the production of bright soft x-ray and UV radiation. It has a circumference of 96 m and comprises 12 double bend achromats. Each achromat is constructed as one 4.5 m long monolithic soft magnetic iron block containing 13 precision machined magnetic elements (2 combined function dipoles, 4 quadrupoles, 3 combined quadrupoles with sextupole content, 4 combined sextupoles and steerers). Each achromat has a total weight of 7 tons.

The magnet systems were delivered to MAX IV in summer 2015. The monolithic magnet system design made assembly of the magnetic elements in the ring a quite simple task as it only required positioning and alignment of the twelve monolithic blocks, and already 15 months later the first beam was stored in the ring.

The commissioning work is progressing well. In April the stored beam was close to 200 mA, and already during the summer break the first insertion device will be installed.


**Congratulations to the MAX IV team with this successful start of the 1.5 GeV synchrotron light source!**

# Magnets for the new and brighter ESRF storage ring

## Manufacturing and testing of 328 magnets in progress at our new production facility

As reported in the previous newsletter, the contract for the design, manufacture and test of 132 quadrupole magnets (two types) and 196 sextupole magnets (two types) for the European Synchrotron Radiation Facility in Grenoble, France was received last year.

In the meantime the magnetic and detailed manufacturing design has been completed and prototypes of each of four magnet types have been manufactured and subsequently undergone detailed magnetic and thermo-mechanical tests. The project is now in the production phase at our new series production facility (see next page). The magnets will be thoroughly tested and documented and will eventually undergo the final factory acceptance before they are shipped in large batches to their final destination in Grenoble.

# New series production facility

## For production, assembly and test of large series of magnets

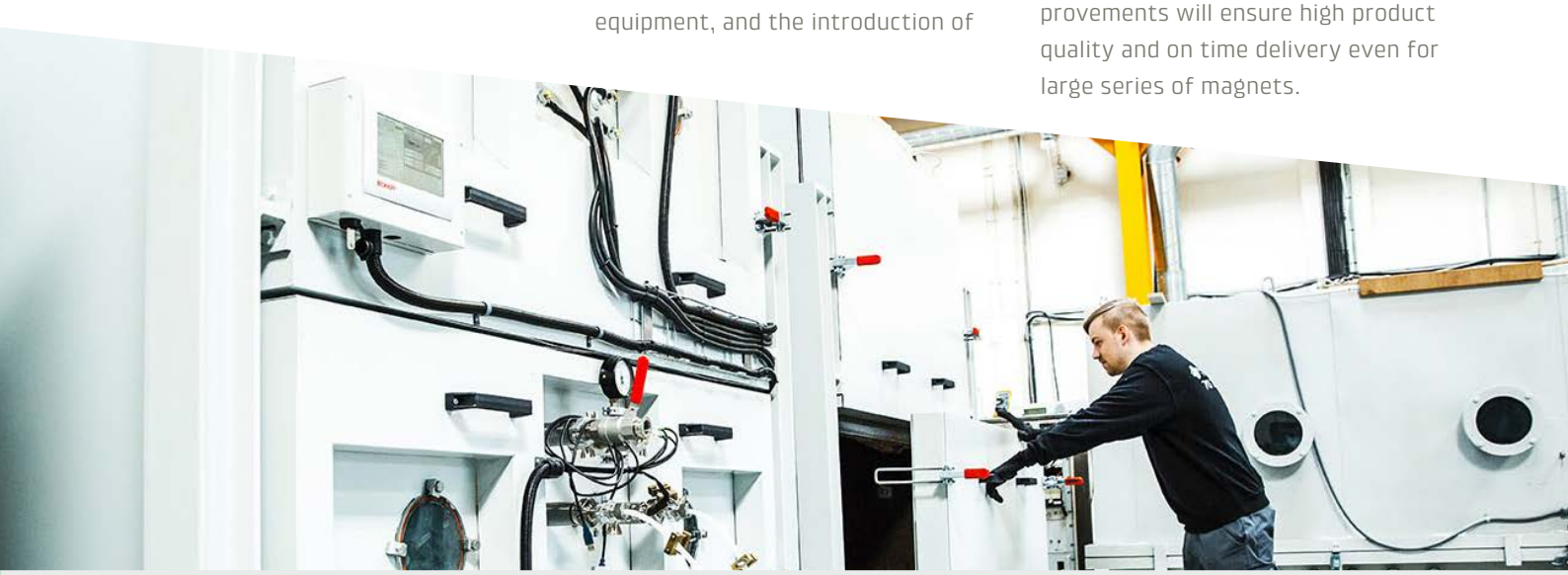
In order to strengthen our capability to manufacture large series of magnets, we have dedicated our production site in Jyllinge to series production of magnets. The new facility includes production of coils, laminated yokes, as well as the assembly and test of magnets. A new coil impregnation line has been established which allows vacuum impregnation of large batches of magnet coils. The new setup triples the impregnation capacity and provides high flexibility with a significantly shorter throughput time.

Our focus this year will include lean optimization of coil winding and semi-automatic coil taping, allowing winding of both small and medium coils faster than before.

By utilizing the factory in Jyllinge for series magnet assembly and testing, it will be possible to operate several assembly lines in parallel, and hence increase the production volume.

The investment in new production equipment, and the introduction of

lean activities and continuous improvements will ensure high product quality and on time delivery even for large series of magnets.



# New! Green magnet technology

## Now also available for dynamic range quadrupoles*

A license agreement has been entered between Danfysik and STFC Innovations to develop and sell permanent magnet-based quadrupoles that can be adjusted in a wide range (10-100%) within seconds, with no need of power supplies or cooling. The invention was developed and patented by the Accelerator Science and Technology Centre (ASTeC) at STFC Daresbury Laboratory. We can offer various solutions for excitation adjustment, manually or motor actuated. A solution with a detachable motor stage is also possible, thereby enabling remote tuning of individual beamline quadrupoles, e.g. in a commissioning process, without having motor stages for each quadrupole. Dynamic green quadrupoles are ideal for both fixed field beamlines or beamlines that need adjustment within seconds – and with low infrastructure demands and practically no power consumption.

Science & Technology Facilities Council

*) Patented technology (WO 2012/046036) under license from STFC Daresbury Laboratory, UK

# In-vacuum undulator twins in one box

## Shifting In-vacuum Undulator widens the spectroscopic energy range for the X-SPEC beam line at ANKA

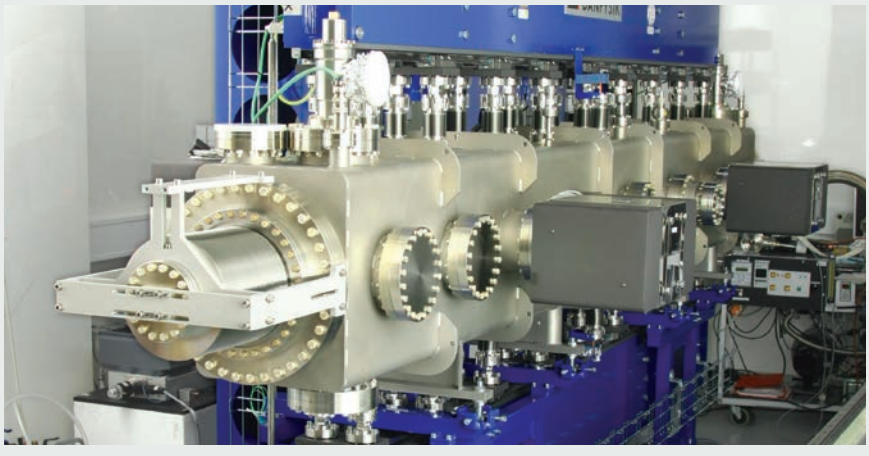
The new X-SPEC beamline of the Institute for Photon Science and Synchrotron Radiation (IPS) at the Karlsruhe Institute of Technology (KIT) in Germany, will deliver soft and medium hard X-rays in the worldwide unique energy range from 70 eV to 15 keV for spectroscopic analysis of electronic and chemical structures of materials. In close collaboration with the IPS and the Institute for Beam Physics and Technology (IBPT) at KIT, Danfysik has designed, manufactured, and installed the radiation source, a high performance "Shifting In-Vacuum Undulator" (SIVU) as a turnkey system including the vacuum and control system.

The wide radiation energy range is achieved by building two undulator arrays side-by-side with different period lengths of 28 mm and 50 mm, respectively. Both arrays are of the Pure Permanent Magnet (PPM) type, which limits the magnetic cross-talk between the arrays. The magnet block material is NdFeB, and the blocks are TiN-coated for vacuum compatibility.

Switching between the two undulator arrays is achieved by shifting the complete device - including the vacuum chamber - transversely to the electron beam. A completely new sliding mechanism was designed, which includes large flexible bellows at each end of the device to allow for the transverse movement of ±57.5mm relative to the central synchrotron beam position.

Like most in-vacuum undulators, the device is equipped with a flexible taper section at each end for carrying the mirror current between the magnet array and the end flanges of the vacuum chamber. With the X-SPEC Undulator, a promising device has been built which will allow constant-rate scanning of the radiation energy within the operational range of each array as well as fast and easy shifting between arrays.

The achievement of this required good alignment and thorough, iterative shimming of the arrays.



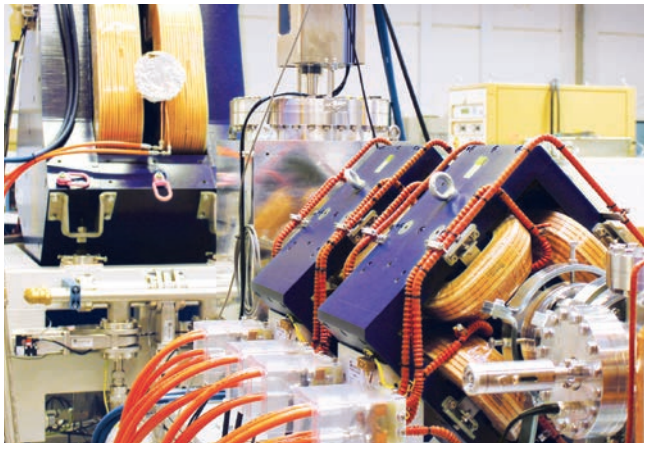
# Phase shifters for LCLS-II

When upgrading the Linear Coherent Light Source (LCLS) at SLAC, Stanford, USA, to a tunable X-FEL, the phase delay in between the different undulator segments must also be tunable. This can be achieved by installing so-called phase shifters, which are devices with two full and two half-length poles of an undulator array, with variable gap.
Last year the magnetic and mechanical design and the prototype were completed, and some small modifications compared to the prototype have been introduced in the final design. We are now assembling and testing the complete series of phase shifters, comprising 20 devices for the soft X-ray line and 32 devices for the hard X-ray line. The NdFeB magnet blocks for the pure permanent magnet arrays have been carefully sorted and selected to match up and yield very small field integrals. Each individual device is measured magnetically and shimmed if necessary. For this project a Hall measurement scheme was developed, facilitating full temperature correction and directly referencing the Hall measurements to an NMR-probe.
This ensures that the phase integral vs gap measured at Danfysik can be implemented directly in the LCLS-II control systems.  The phase shifters are being manufactured, tested and shipped in batches from early spring 2017, and the delivery will be completed during fall 2017.

# Two beamline systems for high power medical cyclotron at VECC, Kolkata

## The beamlines will be used for production of medical isotopes

A Medical Cyclotron (30 MeV, 500 micro-amp, proton beam) is being set up by the Variable Energy Cyclotron Centre, Department of Atomic Energy, India at Kolkata. Danfysik has designed, built and shipped two high current proton beamlines. One is for carrying out activities related to liquid metal lead bismuth eutectic (LBE) target. The other which is a dual beamline is for carrying out materials science related activities such as damage studies, production of radioactive isotopes as positron sources, for charge particle activation analysis etc. The two beamlines will be installed and commissioned by Danfysik as soon as the cyclotron commissioning has been performed. One beamline transports the beam from a switching magnet directly on the cyclotron down to the basement 8 meters below the cyclotron vault. The other beamline is connected to a transport beamline connected to the same switching magnet. This beamline is supplied with its own switching magnet that divides it into two separate beamlines, one for full beampower, 15 kW and one for reduced power, 1.5 kW.
The beamlines are delivered as turnkey systems including magnets, vacuum system, diagnostics, magnet power supplies and control systems.



# Always at your service

**At Danfysik we believe that our level of customer service support is just as important as the quality of our products**

Power Supply loan unit.

Our insight into the operation of accelerators and other installations enables us to continuously develop our service maintenance products into a combination of products and services that allow customers to optimize the use of their resources and Danfysik equipment.

**Loan a Power Supply**

While your power supply is in for repair or maintenance or if you have a temporary need for a high stability power supply, Danfysik can provide a loan unit.

**Features and benefits:**

- ✓ Minimize downtime during the repair or maintenance
- ✓ Ready-to-use loan power supply
- ✓ Suitcase with tailored foam for maximum protection and safe transportation
- ✓ Simplifies the organization of transport to and from Danfysik.

**Upgrade Kits**

Investing in brand new equipment is not always an option. When your installation is aging and your operation requirements change, we offer options that extend the life of your equipment. An upgrade may be just the right way for you to benefit from our latest inventions or replacements of obsolete parts. The end result will give you a safer, more reliable and productive piece of equipment.

**Features and benefits:**

- ✓ An upgrade kit contains a thorough description of how to carry out the upgrade.
- ✓ All parts needed in order to carry out the specific upgrade are included
- ✓ Access to support from Danfysik by phone or mail

**For more information about these services, please contact:**

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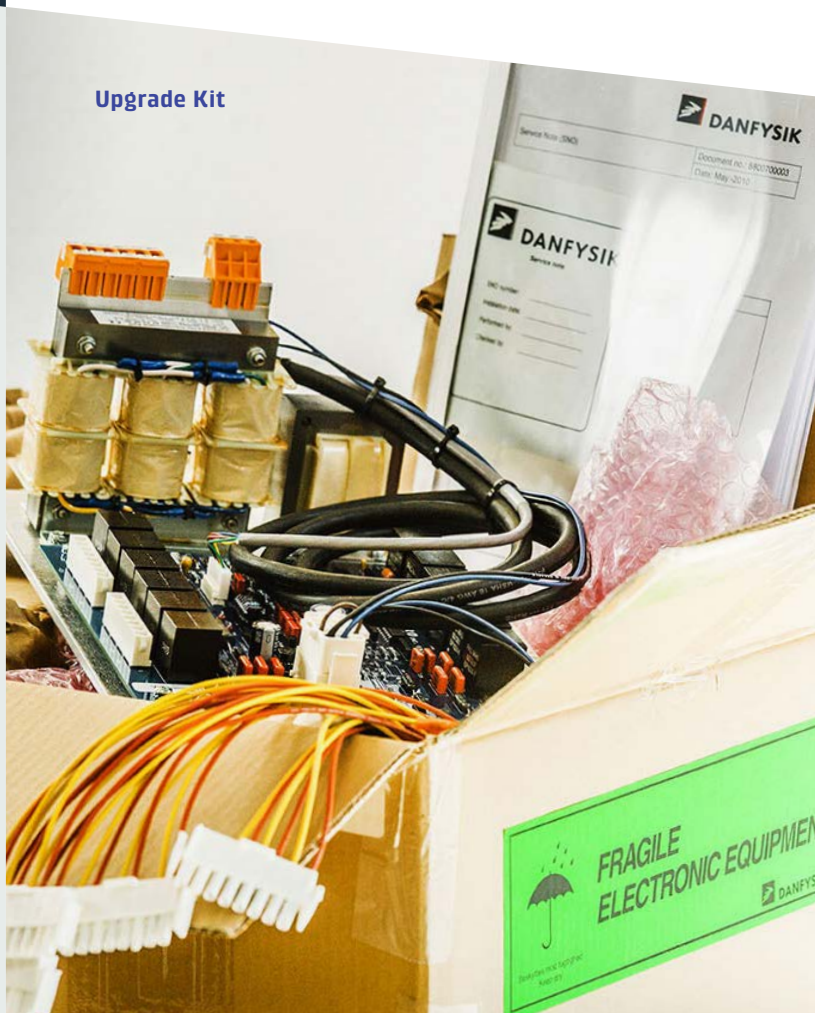

Upgrade Kit

# Superconducting solenoids commissioned at CERN

The first two superconducting solenoids for HIE-ISOLDE compact SC linac have been delivered from Danfysik, commissioned and installed by CERN as part of the first linac upgrade.
In September 2016 the system was operated at 5.5MeV per nucleon (MeV/u), corresponding to an increase of more than 80% compared to the previous maximum energy (3MeV/u) of REX ISOLDE. The first experiments on the upgraded HIE-ISOLDE have been performed at this beam energy level. The last of the four solenoids manufactured by Danfysik have completed the factory acceptance tests and will be shipped in April to CERN for installation in the SC linac tank, to be ready for the final upgrade. This will bring the beam energy up to 10MeV/u corresponding to a further 80% increase in beam energy. Operation at 10MeV/u is expected to take place in 2018.

Installation of the SC solenoid at CERN

Photo by CERN

New Model 1090 Ion implanter

# Ion Implanter

## New updated version of the versatile High Current Model 1090 Ion implanter

During the past year DANFYSIK manufactured and delivered two Model 1090-200 keV implanters, one for Lockheed Martin Space Systems in San Francisco and another for the Danish Tribology Center in Aarhus, Denmark.
Both machines are of the same basic construction but they will be used for very different applications. One for investigation of accelerated degradation of electronics due to cosmic background radiation in space missions, and the other for small series tribology modifications of industrial tooling. This shows the large versatility and range of use of the Model 1090.
The double production program in 2016 initiated a major upgrade of the present design. This included numerous updates and improvements and a completely new control system with a new intuitive graphical user interface. The control system is modular and expandable for customized solutions. The new baseline of Model 1090 Implanters comprises two versions, a 200 kV with 160 kV post acceleration and a 350 kV with 310 kV post acceleration. Both versions are available in the basic standard configurations and various options are available for specific applications. The basic standardized configuration is designed and manufactured modularly to ease of production and serviceability, offering a very attractive pricing level with short delivery time.

# A new "healthy life" after 40 years in service

When KU Leuven decided to stop the operation of its 40-year-old on-line isotope separator, LISOL, essential parts of the facility had already been guaranteed a second life.
Danfysik delivered the isotope separator in 1974 to the cyclotron laboratory CYCLONE at KU Leuven, Belgium. LISOL has since then been in service for four decades in nuclear research and for production of rare isotopes. After the last experiment took place in 2014 the separator dipole magnet and dispersion chamber were provided to the MEDICIS project at CERN.
MEDICIS is a spin-off dedicated to R&D in life sciences and medical applications. Innovative isotopes will progressively become accessible from the start-up of this facility, at the end of 2017. These include new chemical elements with adequate radioactive emission properties to develop personalized treatment that combine functional imaging and therapy.
After arrival at CERN the separator magnet was thoroughly examined, disassembled, cleaned and repainted, and some modifications made, e.g. to power- and water connections to match the infrastructure in the new lab. The magnet is now reassembled, tested and ready for use in its second life at CERN, delivering high purity radioactive beams for use in the medical field.

LISOL separation system at KU Leuven anno 1974

The magnet at its new location in the MEDICIS bunker

**We are pleased to learn that equipment manufactured in our factory so long time ago still is operational and can be used for advanced research activities in 2017.**

# New man in sales

We welcome our new sales manager Dr. Søren Vinter Weber (41). Søren has a long background within physics and has been with Danfysik for several years after receiving his PhD in accelerator physics. Søren has a broad experience within accelerators gained from being responsible for key areas of particle therapy systems, commissioning of accelerators and beamline design and optics. Please contact Søren concerning your application and receive comprehensive advice and suggestions on how we can meet your requirements.

## Facts

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**Danfysik would like to talk to you about how our competence in accelerator technology could benefit your business.**

To hear more, please contact our sales team at sales@danfysik.dk or our service team at service@danfysik.dk

**www.danfysik.com**

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