Report S-DALINAC

Norbert Pietralla

TECHNISCHE UNIVERSITÄT DARMSTADT

- **Role of S-DALINAC in CRC 1245**
  - Reminder at research proposals
  - Overview on accelerator complex
- **Recent Upgrades**
  - 3rd recirculation
  - Scraper system
  - Cooling plant
  - Miscellaneous
- **Thanks & Conclusions**

SFB 1245

S-DALINAC-Projects in SFB 1245 – Area A

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- **A01**:

  Precision measurem.of EM-M.E.‘s:

  ^{4}He in (e,e‘) on LHe-Target;

  ^{6}Li, ^{11}B, ^{27}Al in Relat.Self-Absorption,

  Charge radii: ^{6}Li, ^{11}B in (e,e)

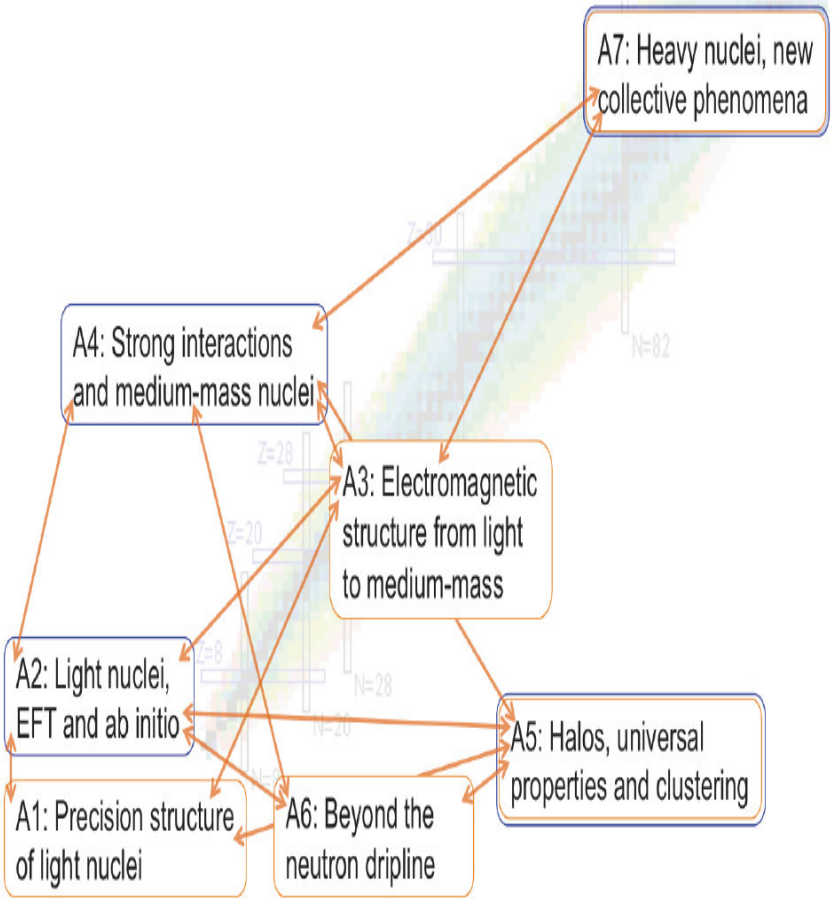
- **A03**:

  B(E2) in ^{12}C (NRF), B($\pi\lambda$) in ^{14}C (e,e‘)

- **A07**:

  Nuclear vorticity (e,e‘γ): ^{92}Zr, ^{208}Pb,

  γ-decay of GDR (Sn)



SFB 1245

S-DALINAC-Projects in SFB 1245 – Area B

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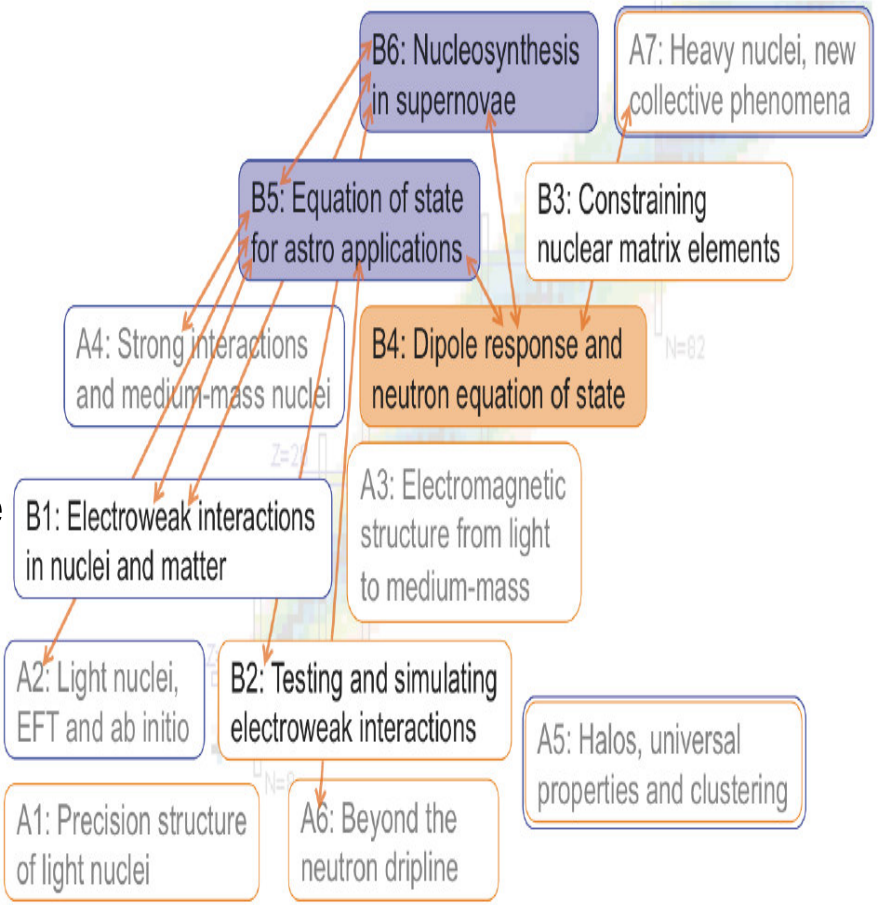
- **B02**:
  q-dependence of magnetic form factors: ^{10}B, ^{16}O ^{40,48}Ca in 180^{o} -(e,e‘)
- **B03**:
  γ-decay and E0 M.E.‘s in $\beta\beta$-emitters
  NRF:^{150}Nd, ^{82}Se/Kr; (e,e‘) on ^{76}Ge/Se
  Transition form factors ^{129,131}Xe
- **B04**:
  Complete decay scheme after photoexcitation with tagged photons



SFB 1245

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The S-DALINAC is the most-heavily used research infrastructure of the CRC 1245

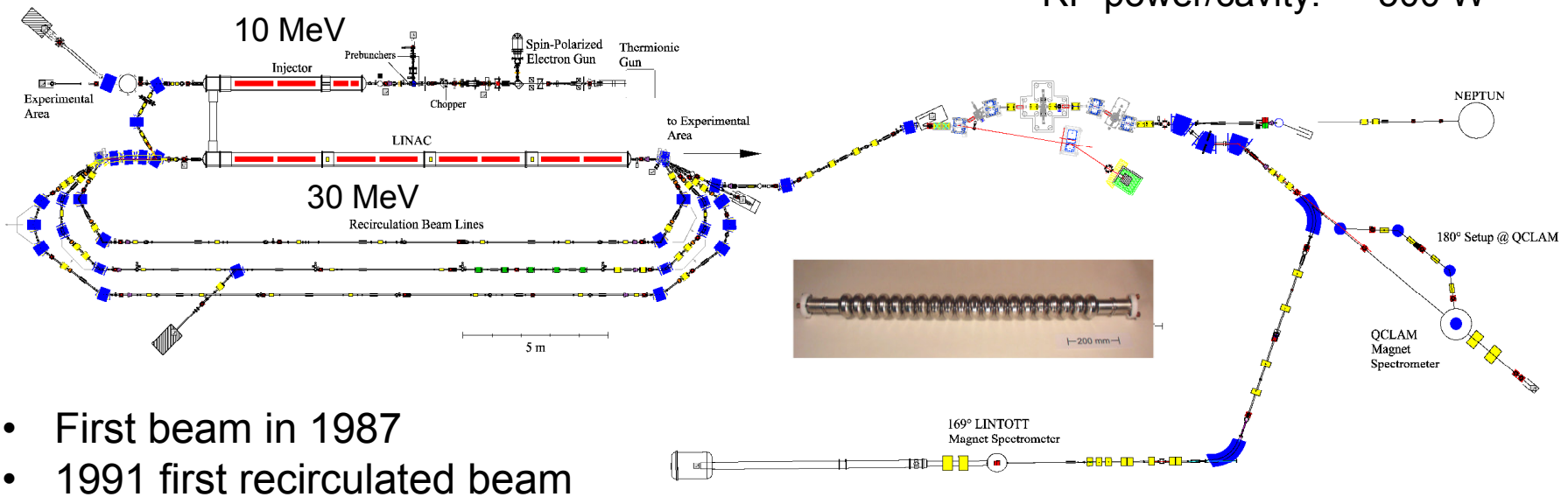
SFB 1245

S-DALINAC Overview

- Built in the 1980s
- 12 Nb-SRF Cavities, λ = 0.1 m
- Liquid helium @ 2 K
- Cryo-plant: 100 W cooling power

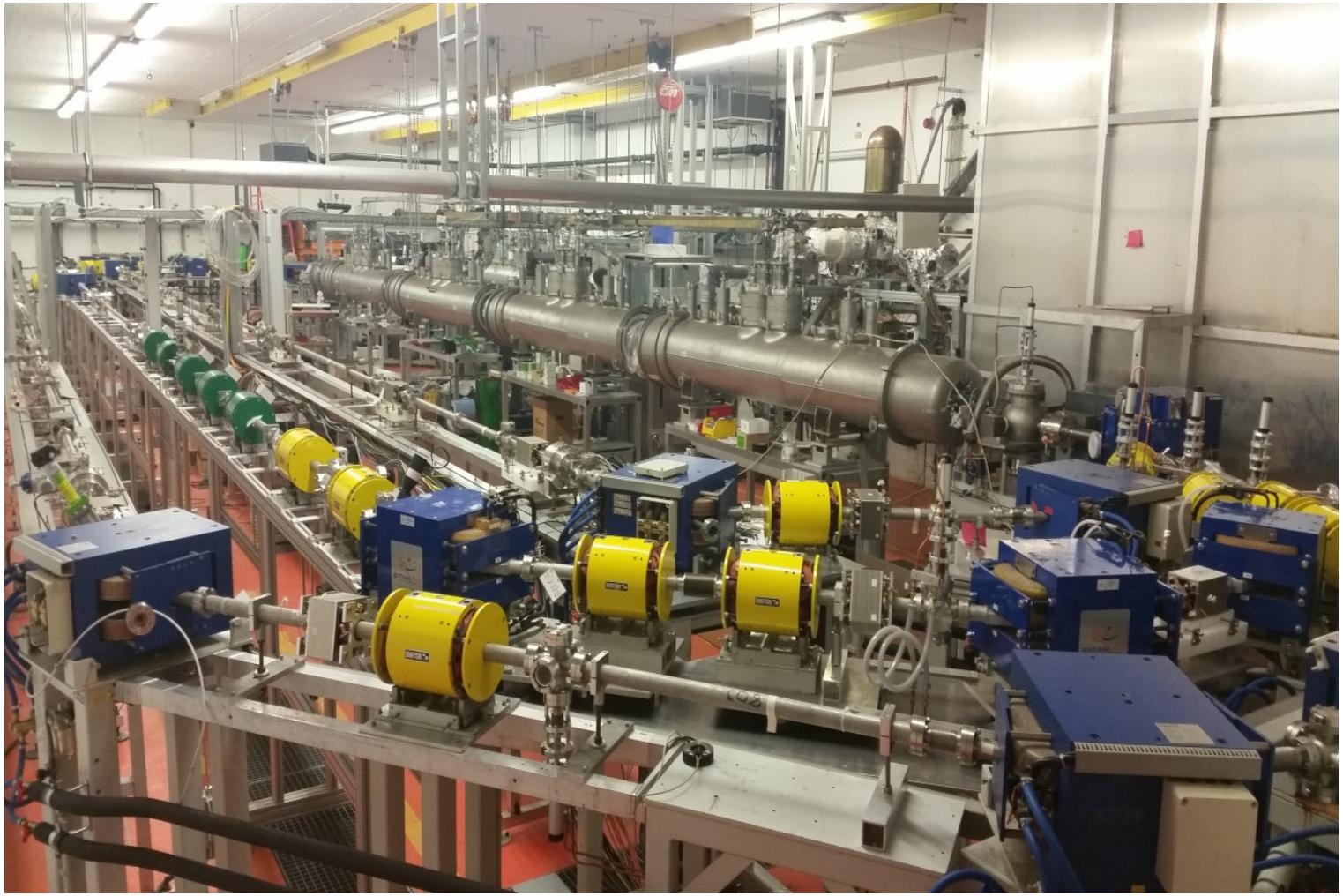
Parameters:

Max. Energy:	130 MeV
Beam Current:	20 µA
Duty cycle:	cw
Frequency:	3 GHz
RF-power/cavity:	500 W



- First beam in 1987
- 1991 first recirculated beam
- 3rd recirculation in 2016

Accelerator hall



S-DALINAC (since 2016)

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Parameters:

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Beam Current:	20 µA
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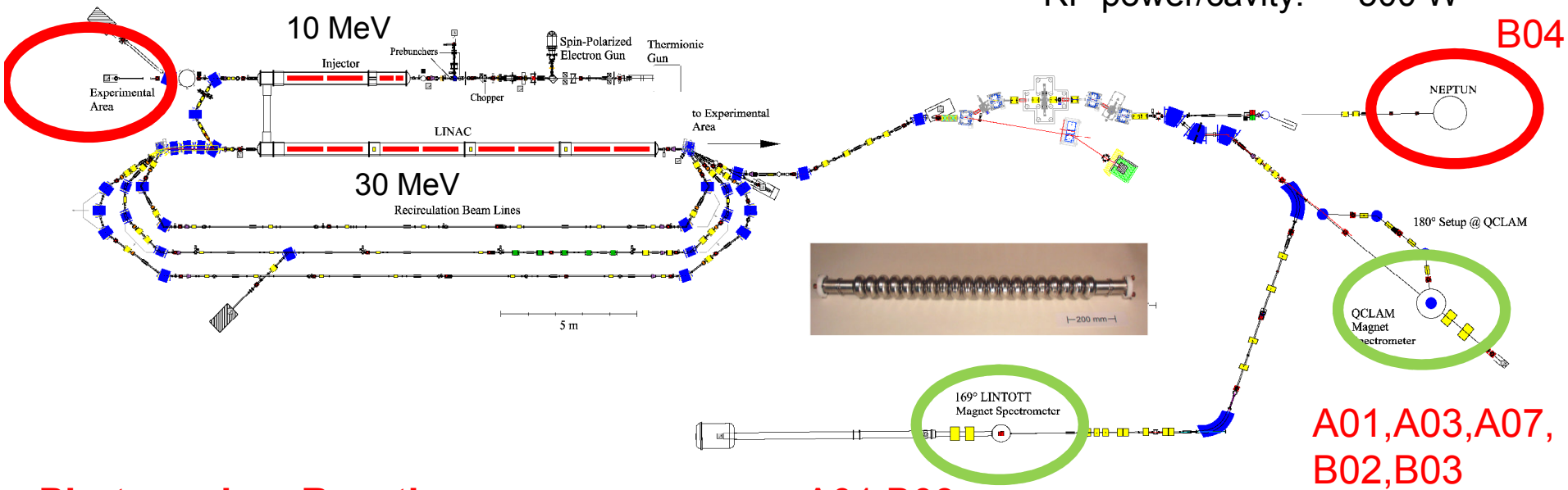
A01,A03,B03



Photonuclear Reactions

A01,B03

A01,A03,A07, B02,B03

Electronuclear Reactions

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Status after CRC 634 (mid-2015)

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- Cooling-water stabilized (± 0.1 K)
- RF stabilized (digital RF-control system)
- Energy-spread set by injector (due to non-isochronous mode), $\Delta E \approx 22$ keV
- 130 MeV design energy was not reached
- Cryo-plant leaking and aged (short operating times)
- Cooling-water piping eroding
- Accelerator alignment unsatisfactory
- Too few diagnostics (BLM, RF, magnets, halo)

3rd recirculation

A Third Recirculation with ERL-Option for the S-DALINAC
- Design and Implementation

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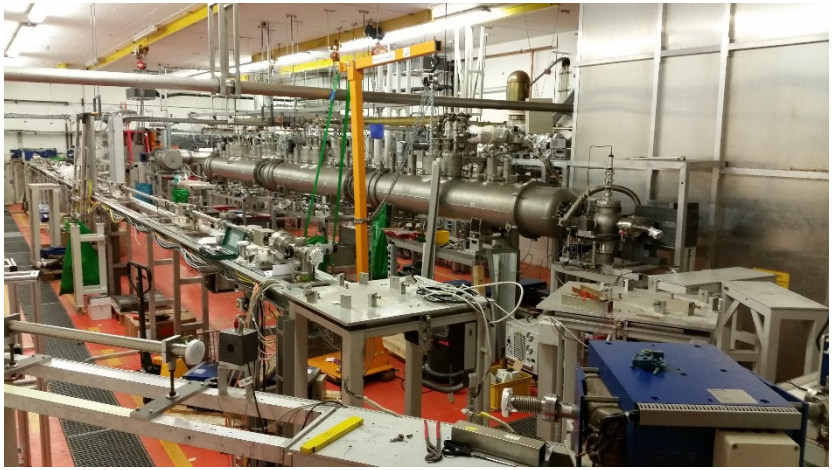
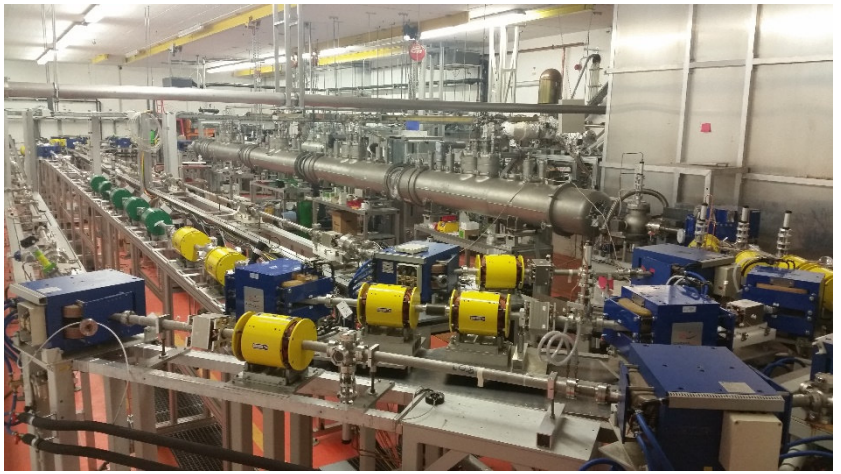
Fall 2015



Summer 2016



SFB 1245

Motivation

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- Final design energy of 130 MeV (cw) has not been reached yet

  ⇨ lower Q and higher dissipated power of the sc cavities
- Stable and reliable beamtime possible at 85 MeV (cw)
- Important experimental parameter: cross section

$$\left(\frac{d\sigma}{d\Omega}\right)_{Mott} = 4(Ze^2)^2 \frac{E^2}{(q\hbar c)^4}\left(1 - \frac{(q\hbar c)^2}{4E^2}\right)$$

with q = const.

⇨ Higher energies lead to higher cross sections and shorter measurement times

⇨ Goal: 130 MeV final energy (cw)

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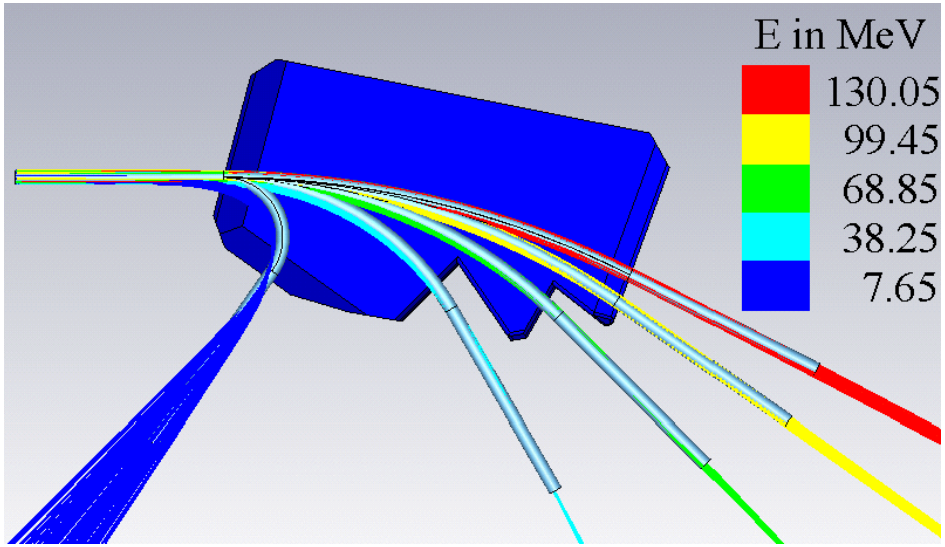
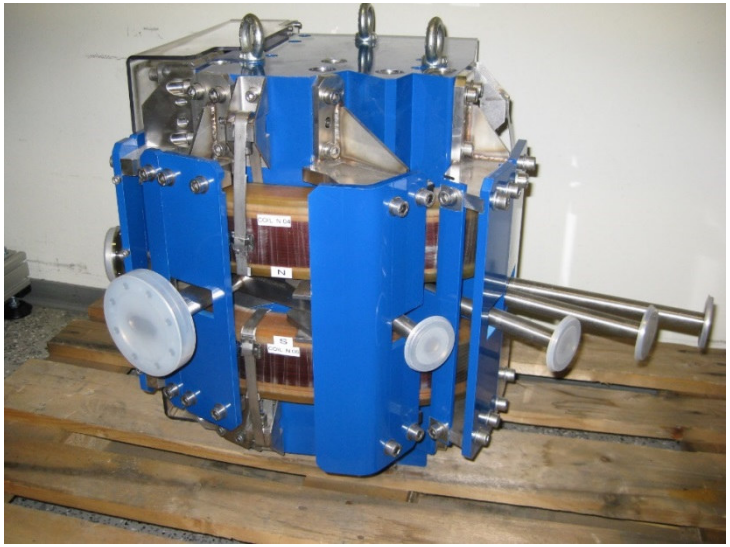
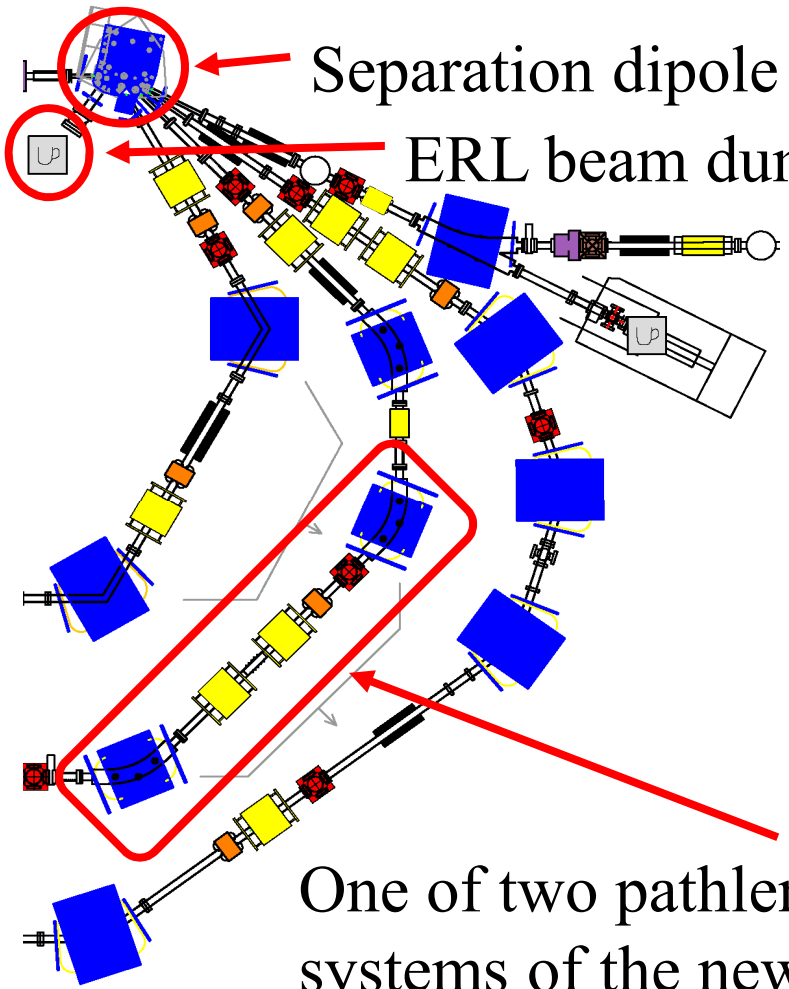
Separation Dipole

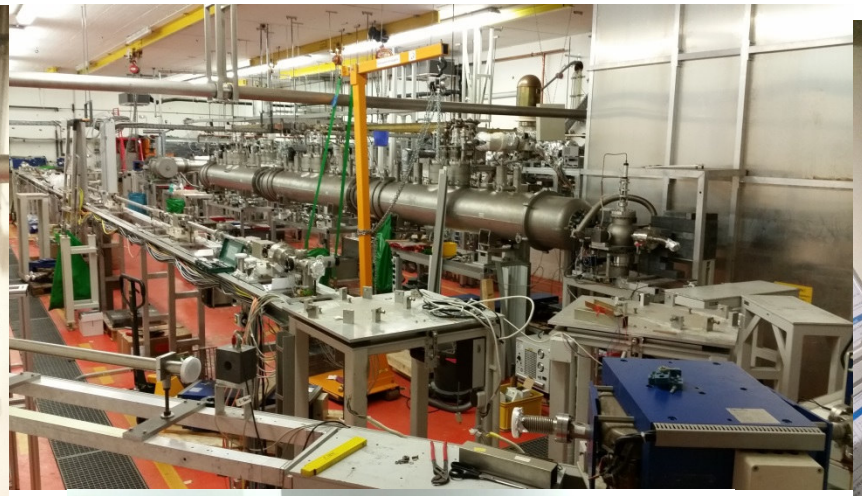
- Particle tracking of all beam energies (CST Particle Studio)
- Conservative starting conditions
  - Beam diameter: 10 mm
  - Energy spread: $1 \cdot 10^{-3}$
  - Angular spread: 0.1°





Extraction Arc





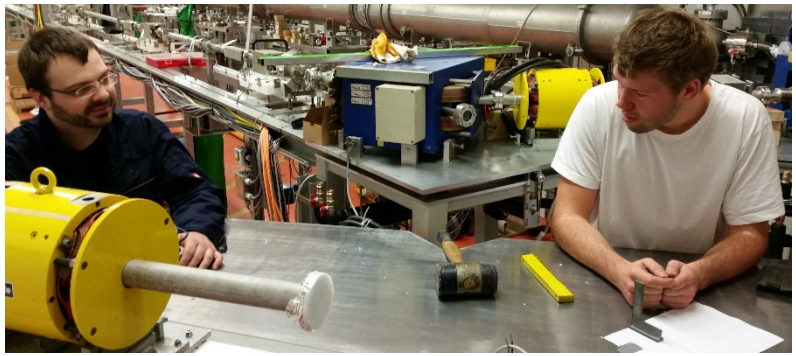
- 15 km cables
- 500 cables
- 500 m copper-pipes for water
- 250 m flexible tubes

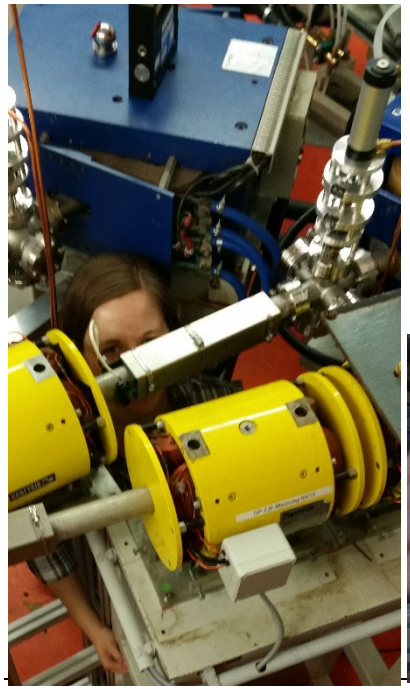
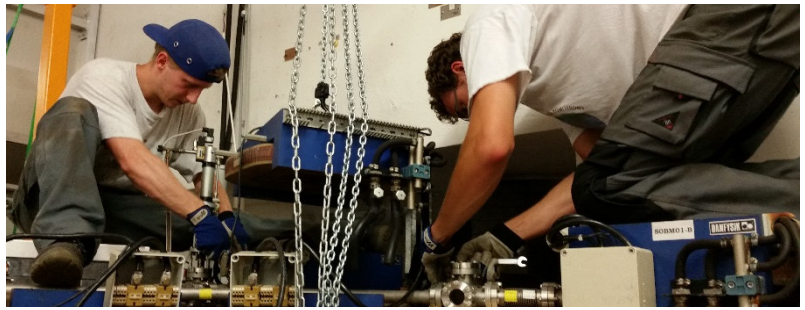
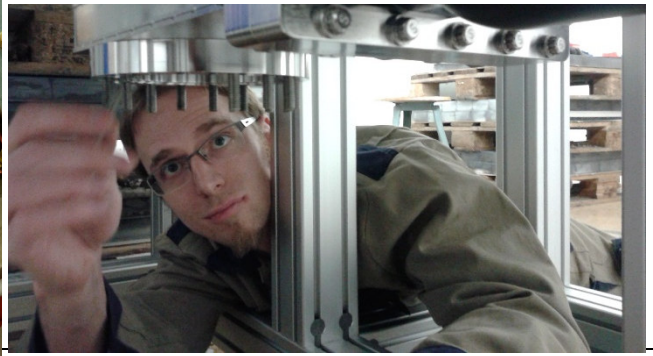
Fachbeitrag Lösler et al., Hochpräzise Erfassung von Strahlführungselementen ...

Hochpräzise Erfassung von Strahlführungselementen des Elektronenlinearbeschleunigers S-DALINAC

Michael Lösler, Michaela Arnold, Hermann Bähr, Cornelia Eschelbach, Thore Bahlo, Ruben Grewe, Florian Hug, Lars Jürgensen, Philipp Winkemann und Norbert Pietralla

346 zfv 6/2015 140. Jg.

3rd recirculation: S-DALINAC @ 130 MeV

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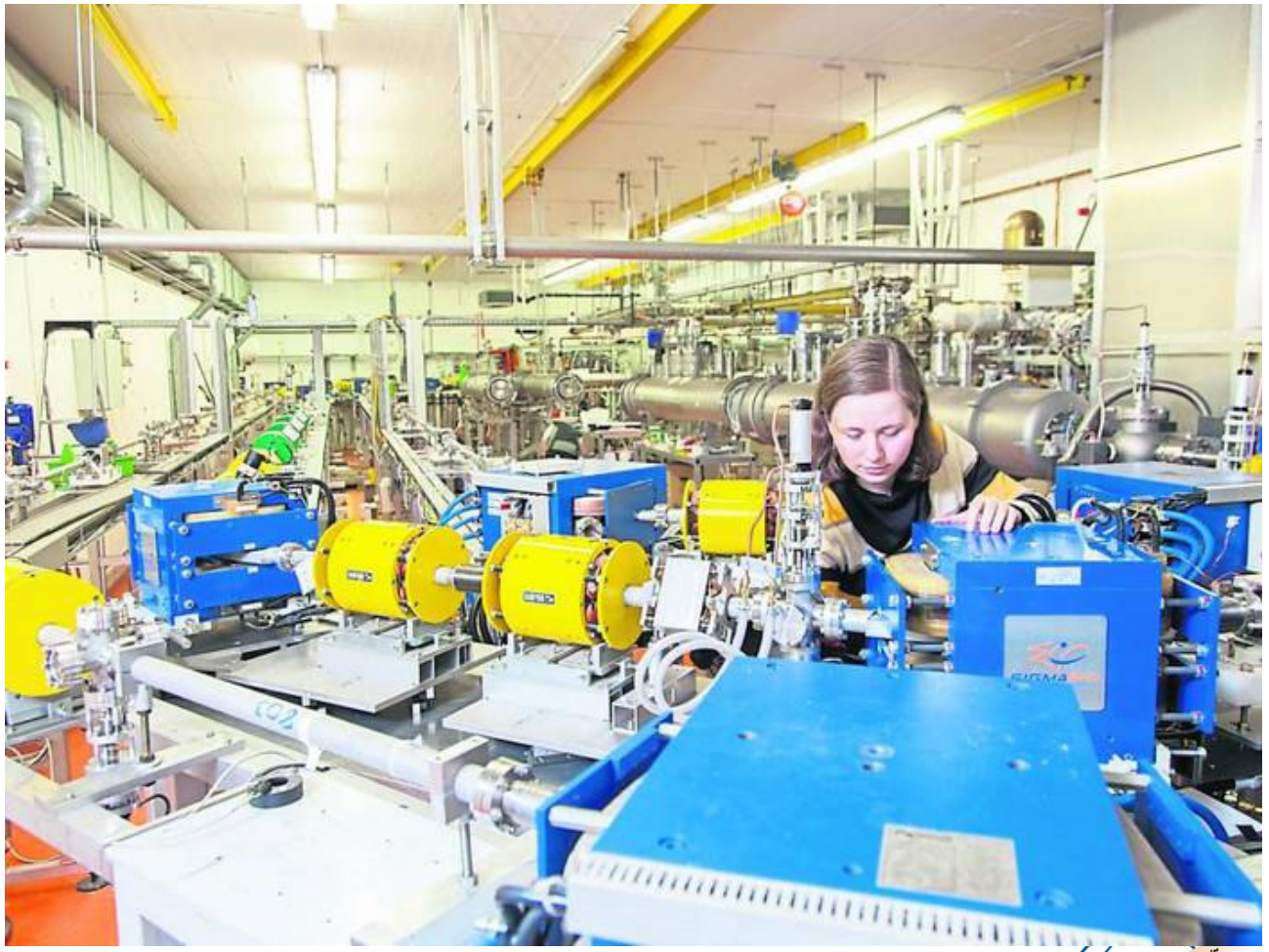

+ ERL Operating Schemes

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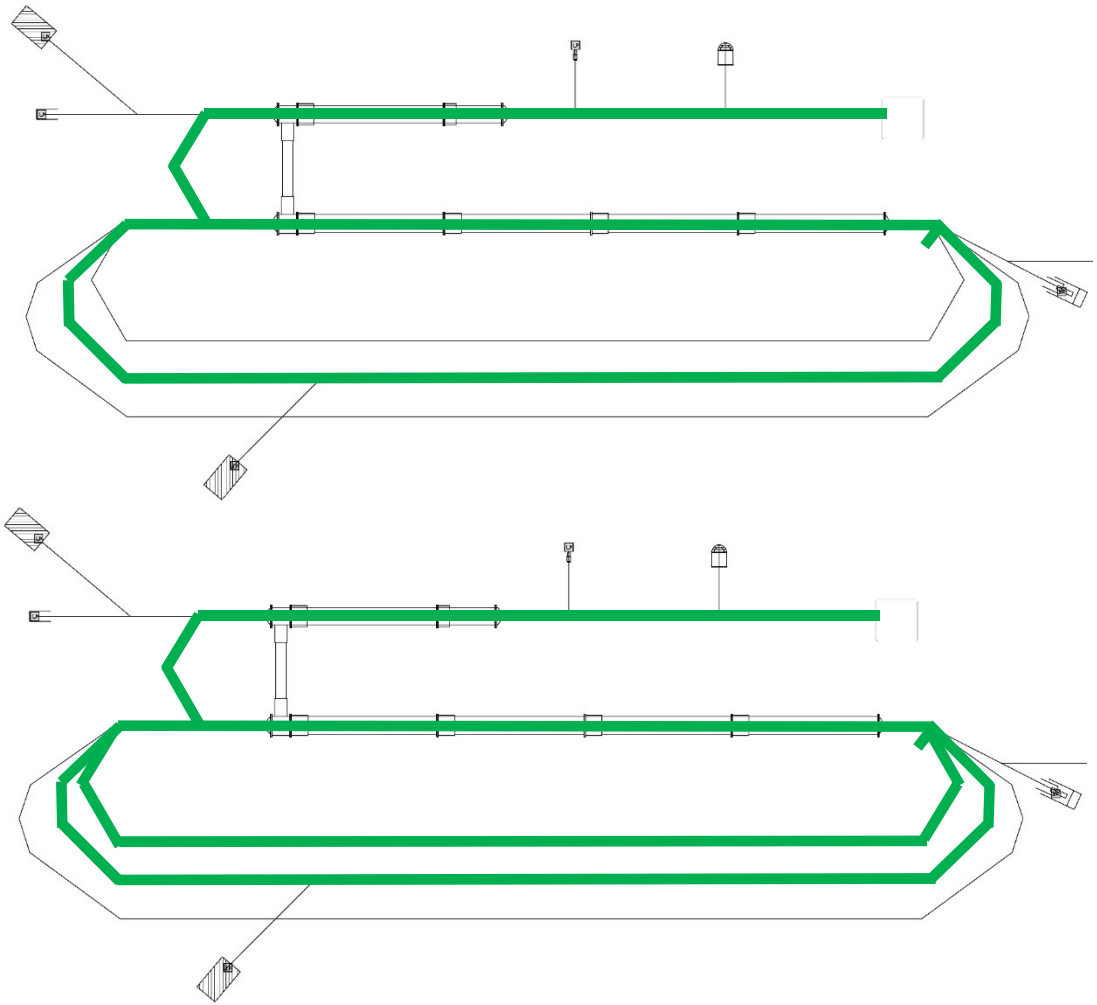

Twice-recirculating ERL

Beam dynamics for non-isochronous ERL to be investigated…

(world-first)

GRK 2128

ACCELENCE

JG|U JOHANNES GUTENBERG UNIVERSITÄT MAINZ

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High-Energy Scraper System

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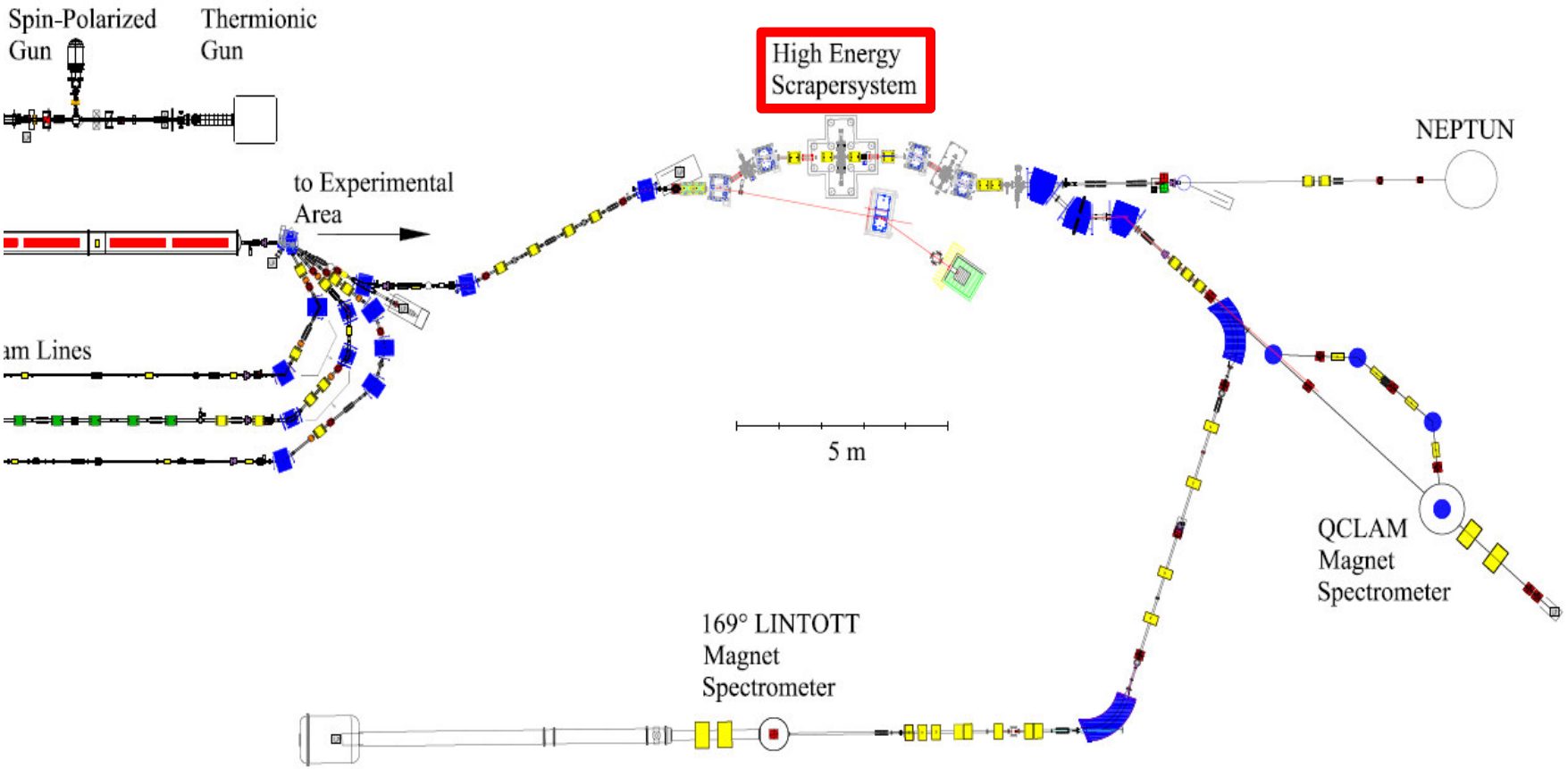
Status extraction beamline



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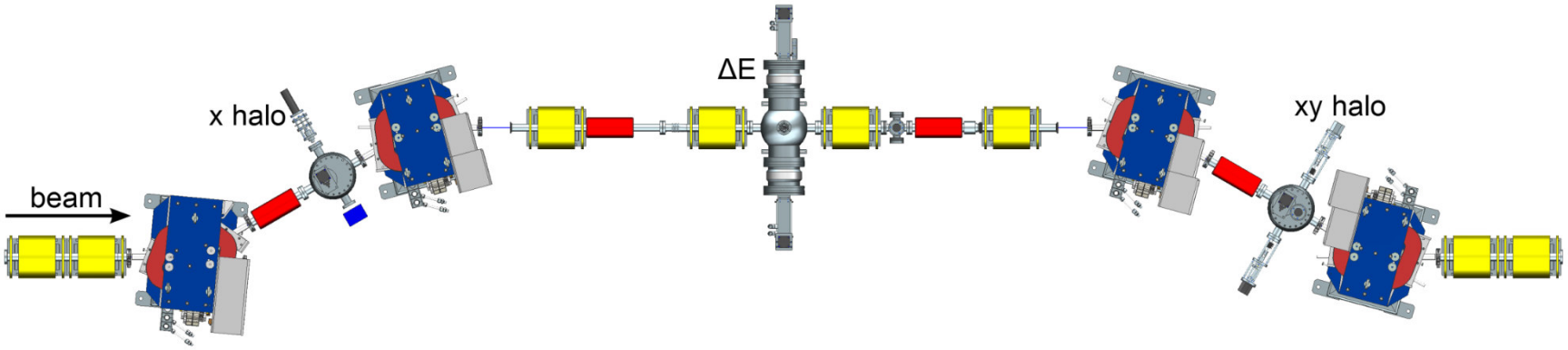
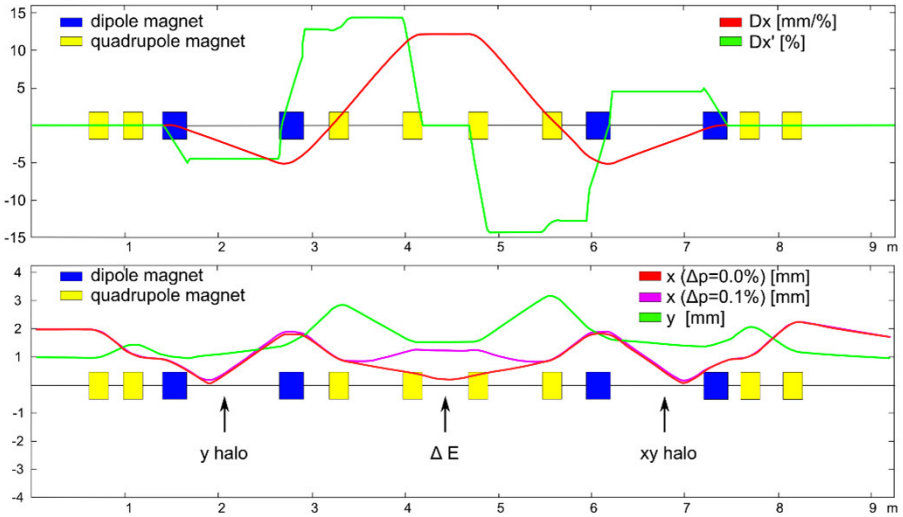
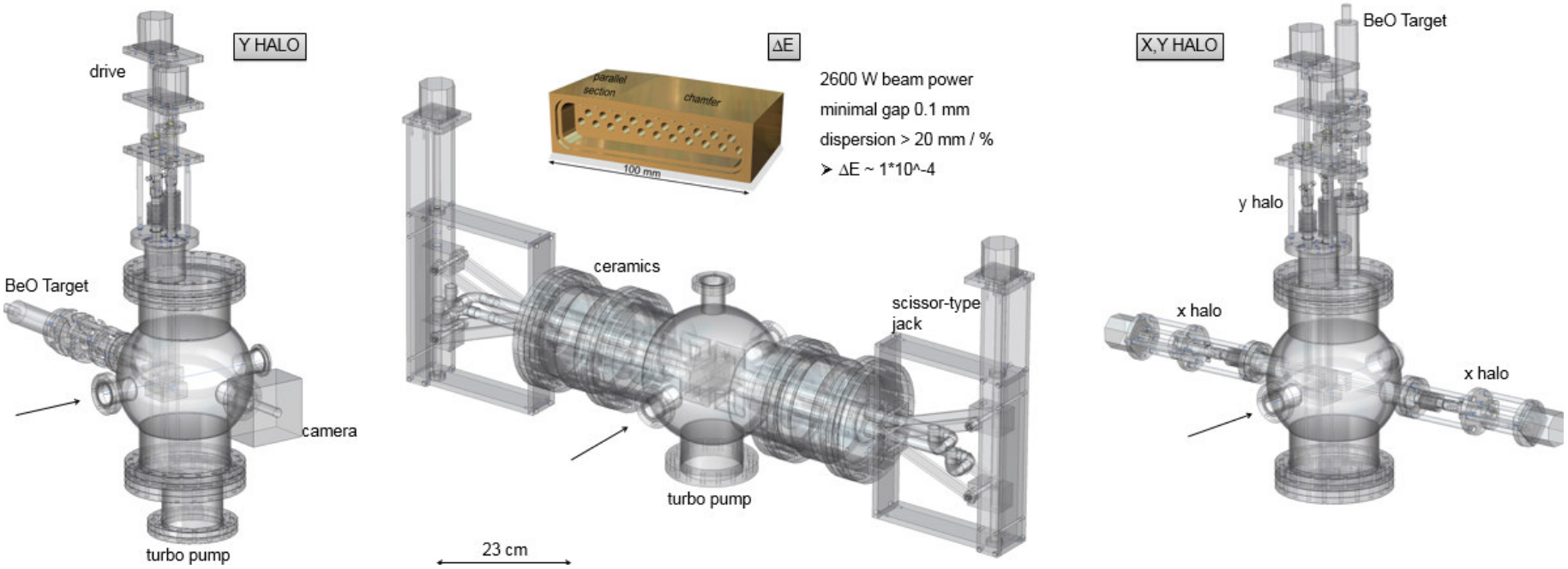


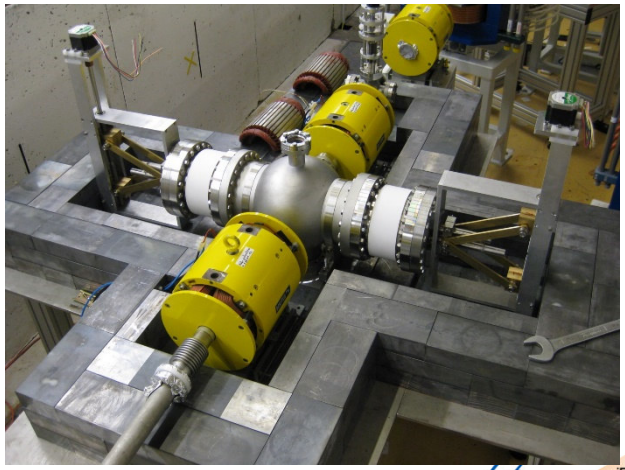


Status extraction beamline

Scraper Chambers



Status extraction beamline



Status extraction beamline

Status extraction beamline

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- four-dipole-chicane installed
- three scraper chambers installed
- vacuum leaks eliminated (old components repaired)
- radiation shielding pre-installed
- slit-positions aligned
- Moeller magnet and Faraday cup in position
- New person safety cage installed
- additional steerer magnet for Q-CLAM spectrometer installed
- alignment of beamline towards Lintott- and Q-CLAM-spectrometer corrected
- spectrometer-heights corrected (-8 mm, -4 mm [THW])

- ToDo:
  - cabling of ~ 30 devices (magnets, drives, pumps, valves)
  - installation of compressed-air (5 targets and 6 valves)
  - installation of cooling water (4 magnets and 8 scrapers-brackets)
  - installation of rough-vacuum piping

During upgrade shutdown

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- Upgrade required numerous changes in infrastructure
- In addition, long-time overdue work had to be done:
  - Cryo-plant
  - Cabling / electricity / power supplies
  - Cooling water
  - Vacuum system
  - Different repairs
  - Replacing aging components (e.g. steerers)
  - Additional diagnostics (e.g. BLMs, RF-monitors, rotating coils)
  - Alignment
  - etc.

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Cryo-Plant

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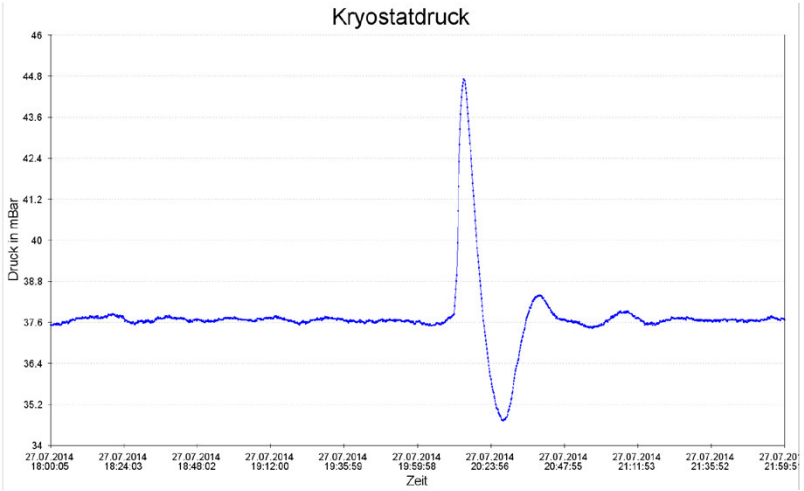
Pressure problem in the 2 K helium



- Since 2014, the pressure of the 2 K helium bath did rise on a regular basis (e.g. every 12h)
- Pressure rose from 35 to 45 mbar
- Pumping units turn up speed and overheat → beam loss for 1 h
- Desorption of cryosorbed He in stainless steal by small temperature fluctuations; cold-leak between LHe and shield vacuum
- Fixed by replacements of all seals in 1. linac module

Leakage of helium pumping station

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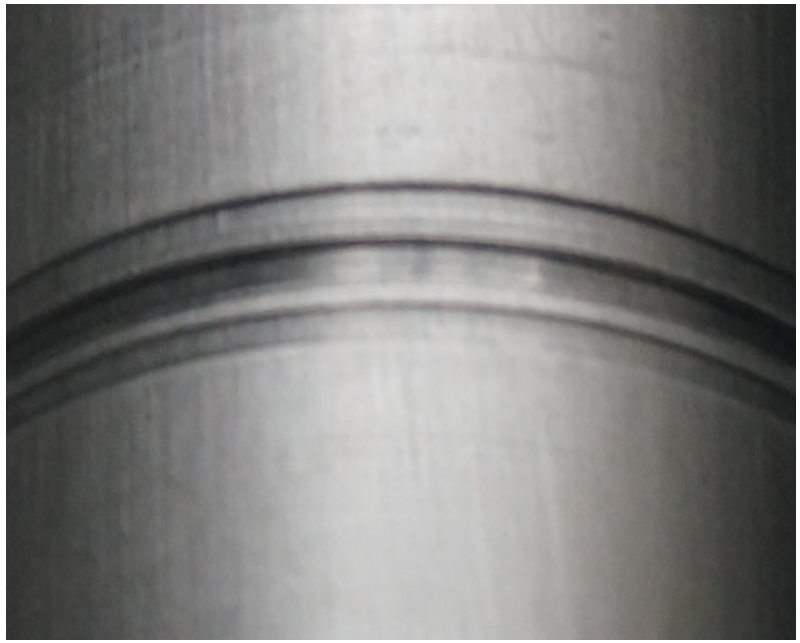
- High oil temperature leads to wear and heat cracks at the shaft seal and roping begins at the surface of the sleeve.
- The notch on the sleeve leads to an air leakage into the helium system



- Intense collaboration (1/2 year) with vendor (Leybold) and DESY lead to solution
- Ceramic-coated bushing was applied, maximizing skin hardness of bearing surface
- Leakage problem was fixed
- At the moment we perform an endurance test

Replacement of Radial Shaft Seal Ring of high pressure screw compressor

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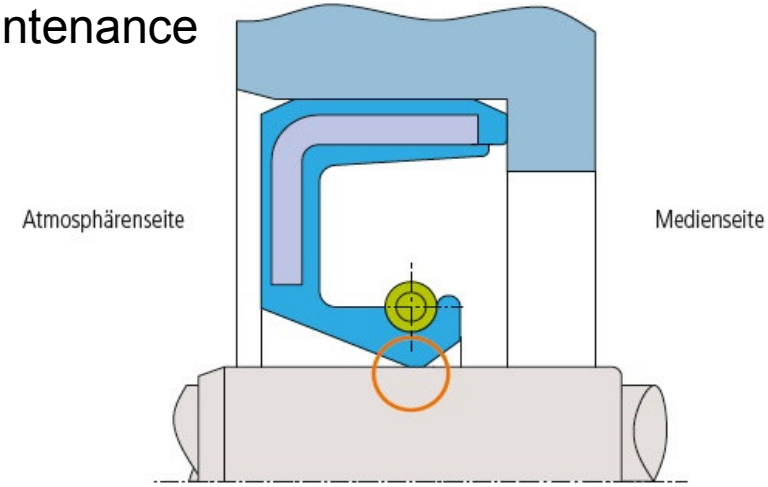
- Radial shaft seal rings are seals with a circumferential sealing lip
- Used for sealing of rotating elements
- Separates the inside of the screw compressor, filled with oil, from the outside, the ambient air
- Has to be replaced during scheduled maintenance



- Small impurities on the sealing lip cause ambient air flow against the print direction to the inside of the compressor and contaminates the helium
- Impurity problem of LHe caused by the high pressure screw compressor is fixed

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Replacement of adsorber heating in Coldbox 1

- Activated charcoal adsorber located in Coldbox 1 (CB 1) after the first heat exchanger
- Operated at a temperature of 80 K
- Adsorbs impurities from the helium flow to avoid damage of the expander turbines
- If saturated: shutdown of the cryo-plant and regenerating
- Regenerating the charcoal by helium purging and heating at once

Replacement of adsorber heating in Coldbox 1

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- Adsorbs impurities from the helium flow to avoid damage of the expander turbines
- If saturated: shutdown of the cryo-plant and regenerating
- Regenerating the charcoal by helium purging and heating at once
- Problem: adsorber heater did not work for many years, no complete regeneration possible
- Result: Stand-time of cryo plant unsatisfactory (≈2 months)

Replacement of adsorber heating in Coldbox 1

- Broken heater is soldered on the charcoal box
- Heating line cannot be removed from the box without damage

- A new flexible heating band was double-ply wrapped around the box
- Additional temperature sensors were installed
- Regeneration now possible, H_2O level in residual gas significantly reduced

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Further essential work

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Further upgrades during shut-down

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- Complete replacement of cooling water supply for all bending magnets in the accelerator hall and extraction area

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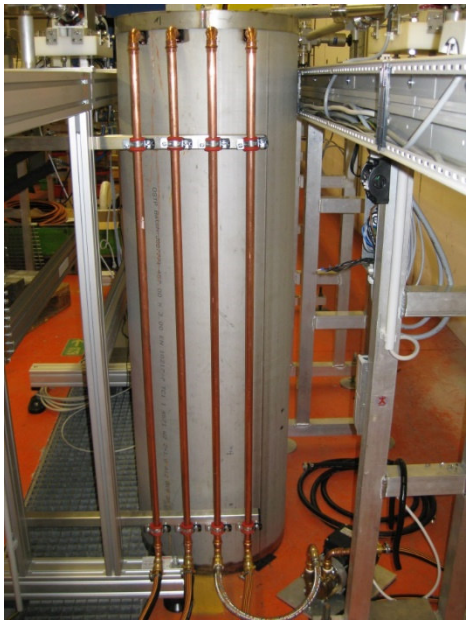
Further upgrades during shut-down

- Complete replacement of the cooling water supply for all bending magnets in the accelerator hall and extraction area
- Installation of new separate cooling water supplies for the ERL-cup as well as for the FEL-cup



Further upgrades during shut-down

- Complete replacement of the cooling water supply for all bending magnets in the accelerator hall and extraction area
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- Design and assembly of customized cooling water manifolds for three power supply racks

Further upgrades during shut-down

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- Complete replacement of the cooling water supply for all bending magnets in the accelerator hall and extraction area
- Installation of new separate cooling water supplies for the ERL-cup as well as for the FEL-cup
- Design and assembly of customized cooling water manifolds for three power supply racks
- Replacement of one cryo pump, two cryo compressors and one gate valve for the beam vacuum

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Further upgrades during shut-down

- Installation of a customized heating sleeve for the external high pressure adsorber including a sensor system for inside temperature measuring
- Replacement of a broken ECO-Drain oil return unit and fixing a PLC bug

Further upgrades during shut-down

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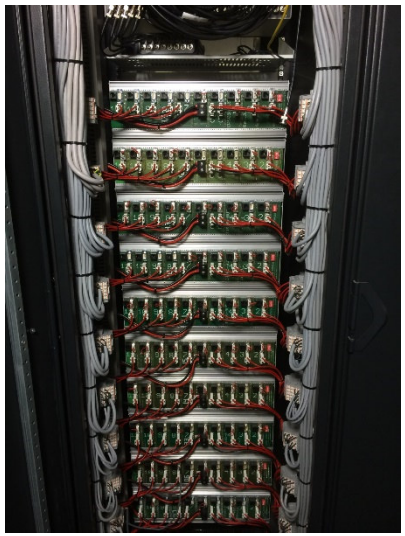
- Cables and new power supplies for most of the magnets



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Further upgrades during shut-down

- Cables and new power supplies for most of the magnets
- Updating database, Integration of all new parts in EPICS
- CSS optimized
- Radiation safety signs

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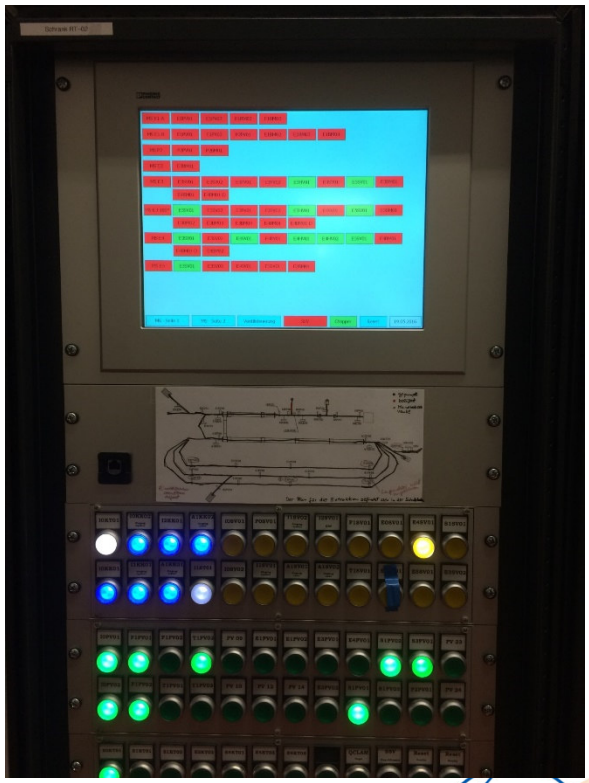
- Update: Interlock and vacuum valve control



Further upgrades during shut-down

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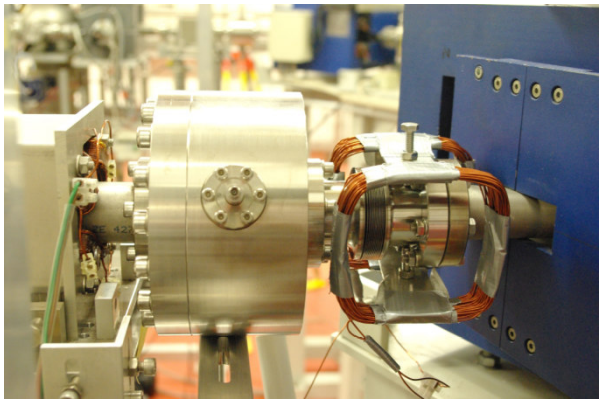
- Cables and new power supplies for most of the magnets
- Updating database, Integration of all new parts in EPICS
- CSS optimized
- Radiation safety signs
- Update: Interlock and vacuum valve control
- New RF-Amplifiers
- New electric supplies for spectrometer

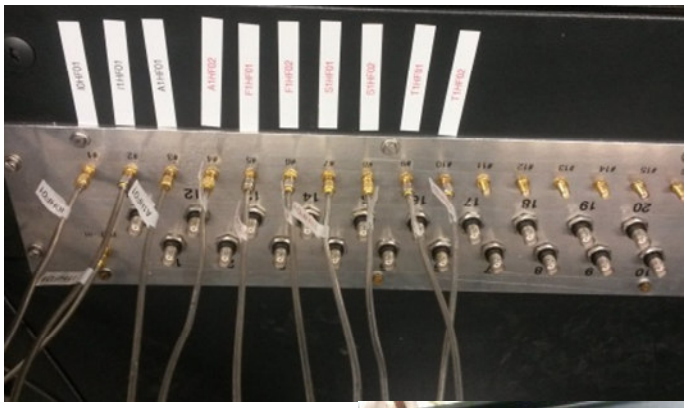
Further upgrades during shut-down

- Cables and new power supplies for most of the magnets
- Updating database, Integration of all new parts in EPICS
- CSS optimized
- Radiation safety system updated
- Interlock and vacuum valve control updated
- New RF-Amplifiers
- New electric supplies for spectrometer
- New coils for extraction dipole
- GUN-Computer replaced with CAN-Gateway
- Rotating coils for measurement of B-field
- Installation of additional BLMs

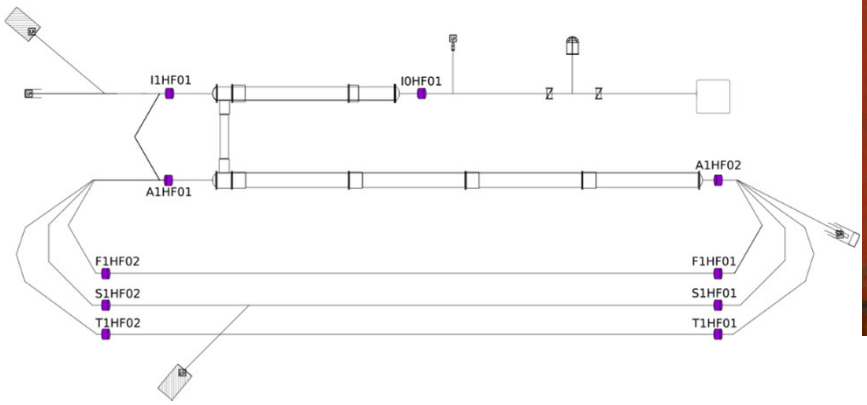
RF-Monitors (phase measurement)

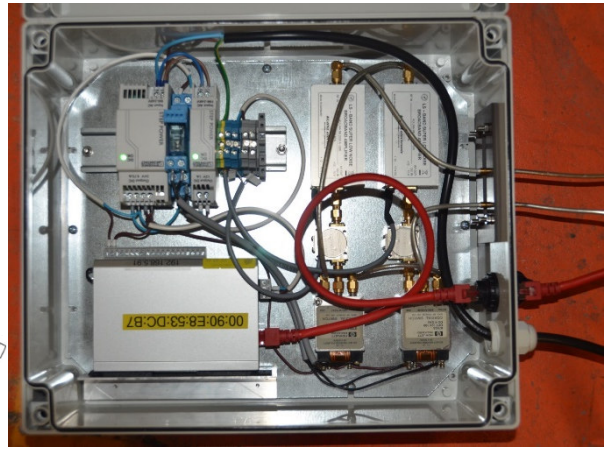
- 14 in total
- 13 installed
- Read-out electronics for 16 available





Up to 2015 only 2 could be read-out with a prototype setup





Amplifiers installed on site

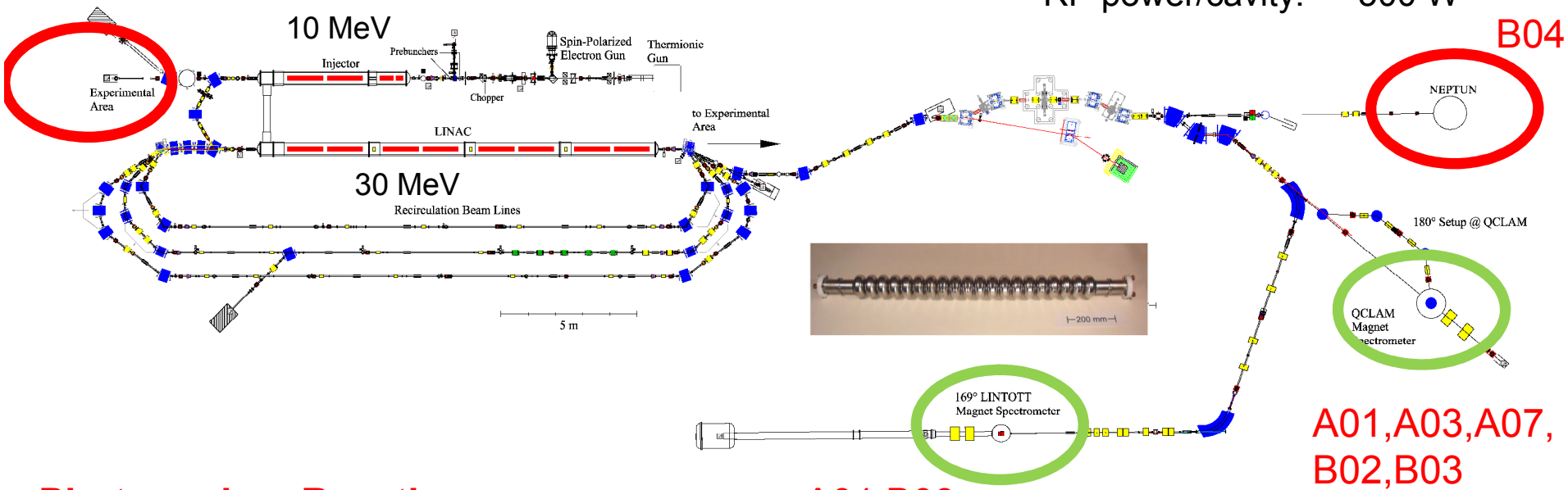
S-DALINAC (in Nov. 2016)

- Issue with 5-cell cavity (→ DESY)
- Commissioning accelerator hall
- Completion/commissioning extraction beam line

Parameters:

Max. Energy:	130 MeV
Beam Current:	20 µA
Duty cycle:	cw
Frequency:	3 GHz
RF-power/cavity:	500 W

A01,A03,B03



Photonuclear Reactions

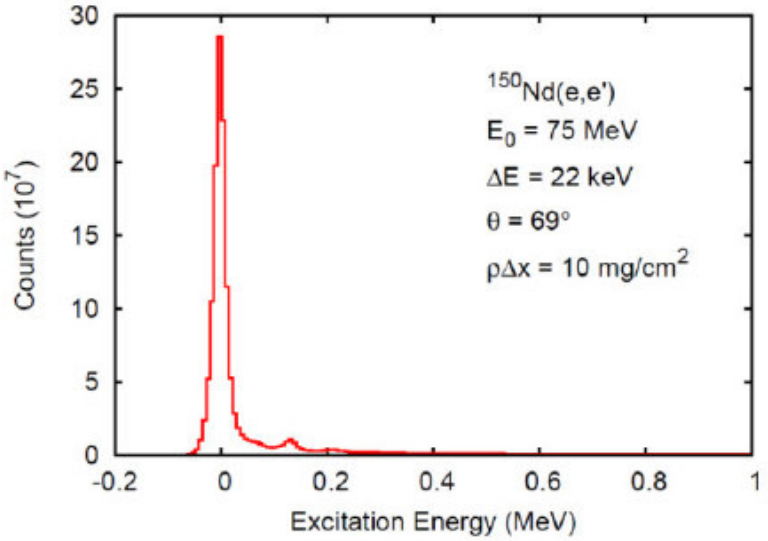
A01,B03

A01,A03,A07, B02,B03

Electronuclear Reactions

Conclusion

- S-DALINAC is the most complex research infrastructure at TU Darmstadt
- Enables lectron spectroscopy at highest-possible energy resolution
- Photonuclear research complementary to „Nuclear Photonics“ at HIγS and ELI-NP
- Unique research asset for TU Darmstadt and CRC 1245
- Experimental program recommences in spring 2017 (while waiting for CRC projects)



Thank you

TECHNISCHE UNIVERSITÄT DARMSTADT

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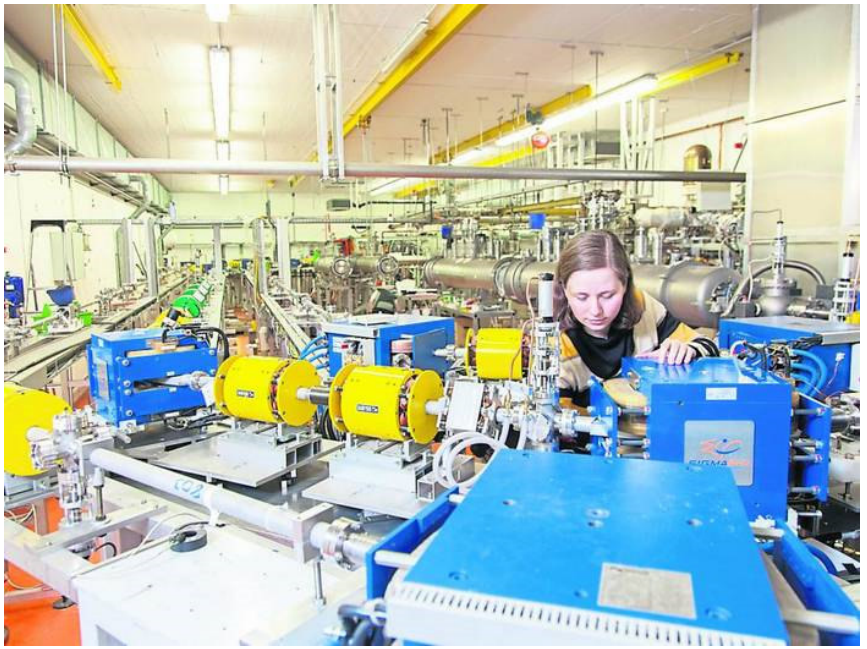
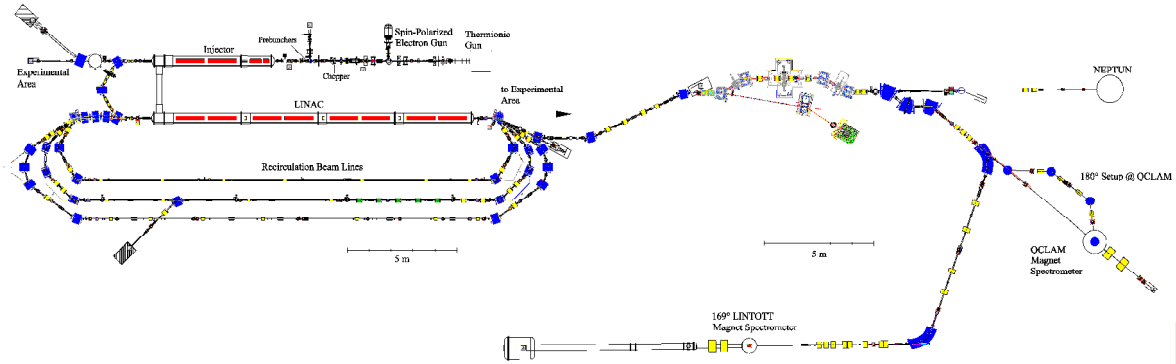
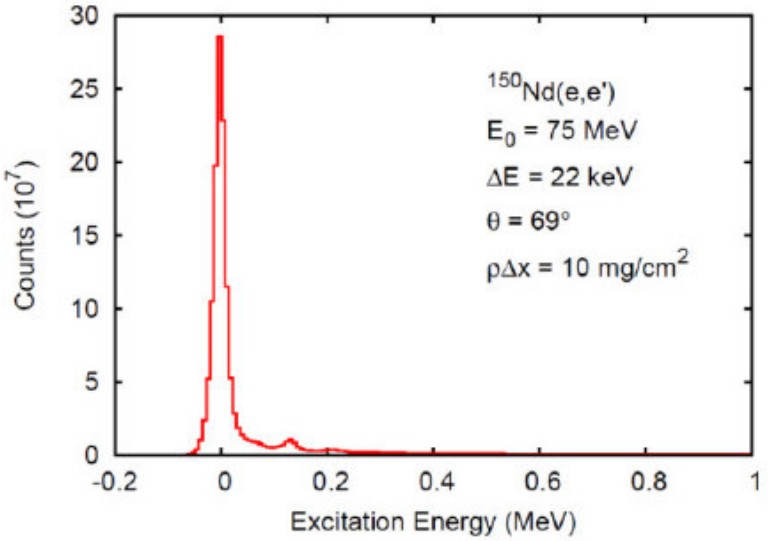




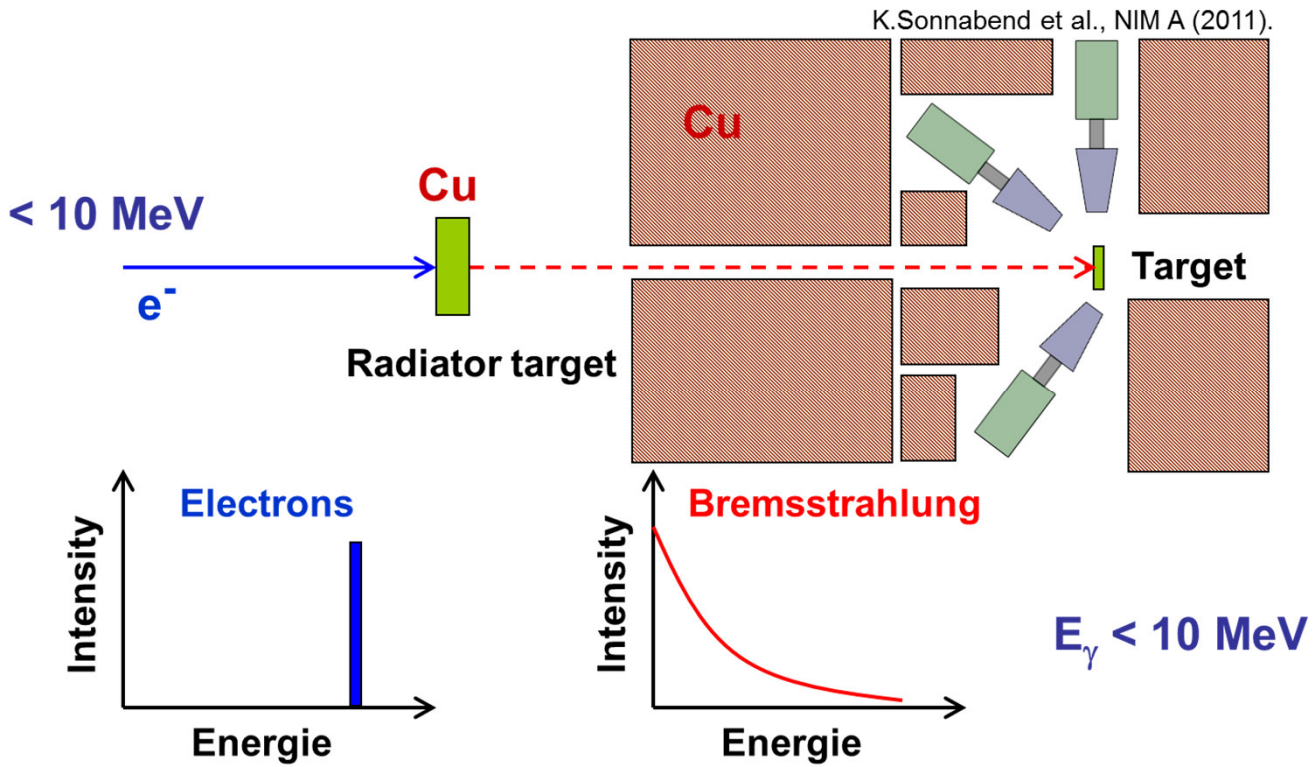
SFB 1245

Conclusion

- S-DALINAC is the most complex research infrastructure at TU Darmstadt
- Enables lectron spectroscopy at highest-possible energy resolution
- Photonuclear research complementary to „Nuclear Photonics“ at HIγS and ELI-NP
- Unique research asset for TU Darmstadt and CRC 1245
- Experimental program recommences in spring 2017 (while waiting for CRC projects)



Darmstadt High-Intensity Photon Setup (DHIPS)



Photoresponse

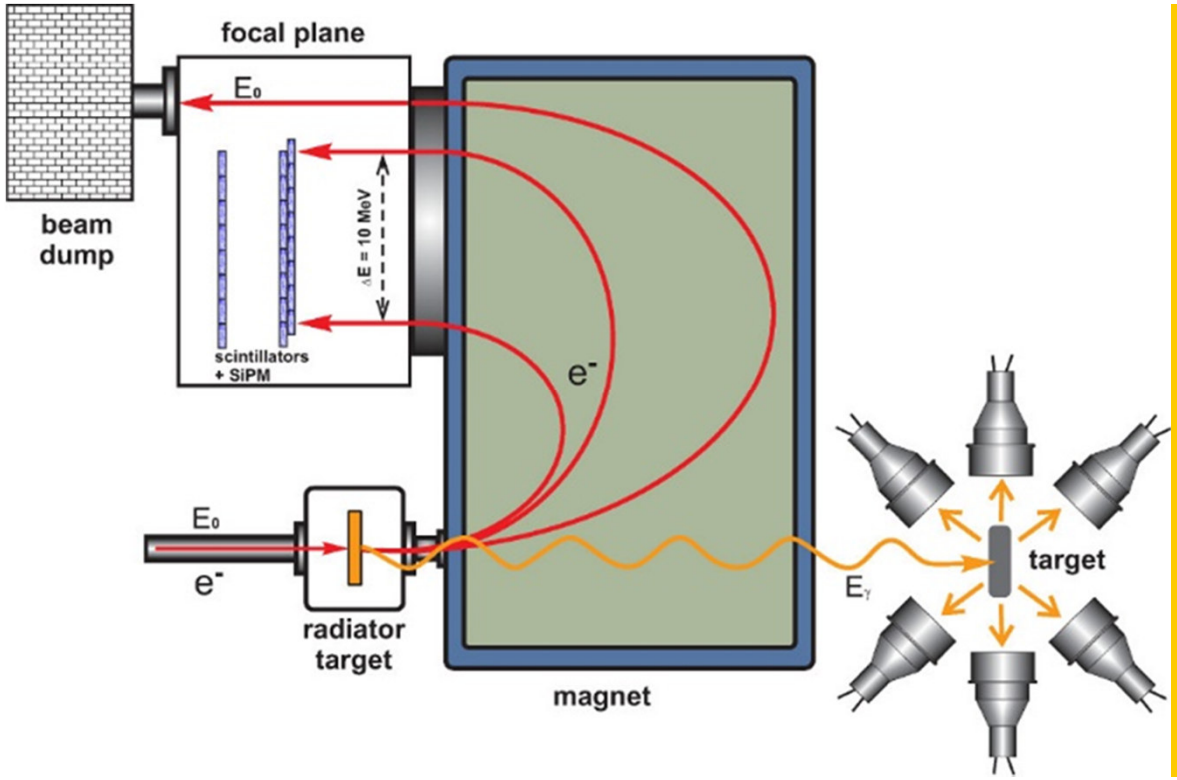
- dipole strength
- level densities
- statistical model

Photofission

- fission modes
- fission isomers

Photoactivation

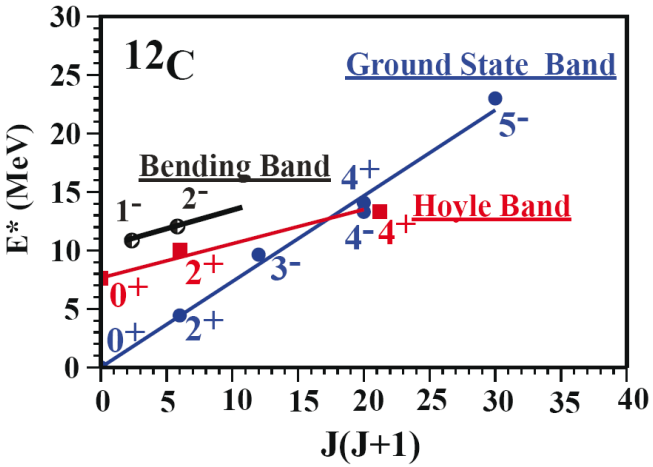
New Photon Tagger of Unprecedented Resolution (NEPTUN)

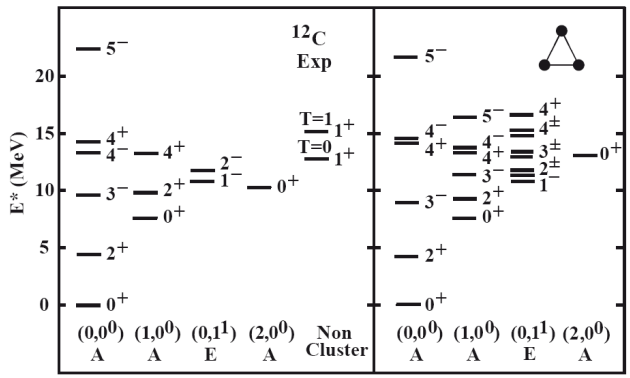


Photoresponse to quasi-monochromatic beam

- pygmy dipole resonance
- below and above threshold
- $\gamma\gamma$-cascades
- dipole polarizability
- nuclear EoS

Electron-spectrometry @ S-DALINAC





High-resolution electron-spectroscopy

- α-cluster structure of light nuclei
- structure of nuclei for ν- or WIMP detection

180°-scattering for Mλ-modes

- EM-analogue of GT-strength
- spin-quenching of higher multipoles

D.J. Marin-Lambarri et al., Phys.Rev.Lett. 113, 012502 (2014)