Project B02: Testing and Simulating Electroweak Interactions in Nuclei

TECHNISCHE UNIVERSITÄT DARMSTADT

~ A status report ~

J. Isaak, P. von Neumann-Cosel, J. Enders, M. Singer
& spectrometer group and accelerator group

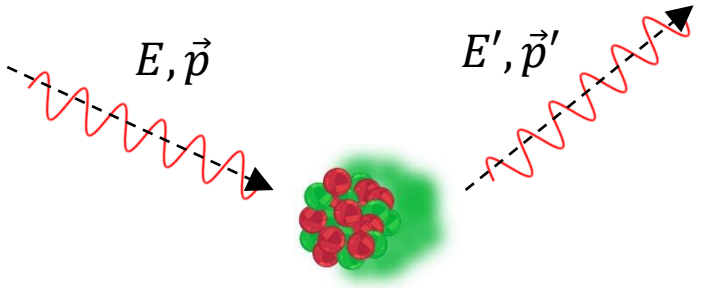
Institut für Kernphysik
TU Darmstadt

SFB 1245

Inelastic electron scattering…

… in general

- purely electromagnetic interaction
- differential cross section $\frac{d\sigma}{d\Omega}$



→ nuclear structure information

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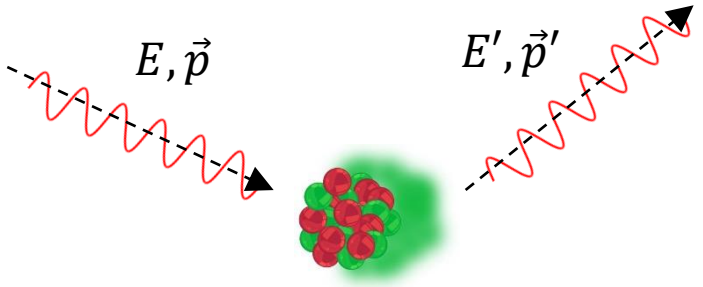
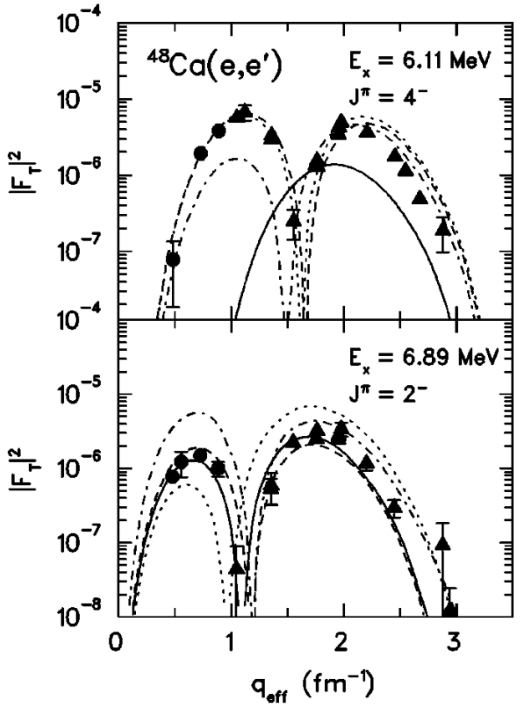


→ nuclear structure information

→ form factors

- momentum transfer dependence
- reduced transition strengths $B(E/M\lambda)$
- spin-isospin response
- $(e, e') \leftrightarrow (\nu, \nu')$: electroweak theory



P. vNC *et al.*, PRC **62** (2000) 034307.

Inelastic electron scattering…

… in general

$$\left(\frac{d\sigma}{d\Omega}\right) = \left(\frac{d\sigma}{d\Omega}\right)_L + \left(\frac{d\sigma}{d\Omega}\right)_T \rightarrow \boxed{\left(\frac{d\sigma}{d\Omega}\right)_L \propto V_L \times |F_L(\vec{q})|^2} \quad \boxed{\left(\frac{d\sigma}{d\Omega}\right)_T \propto V_T \times |F_T(\vec{q})|^2}$$

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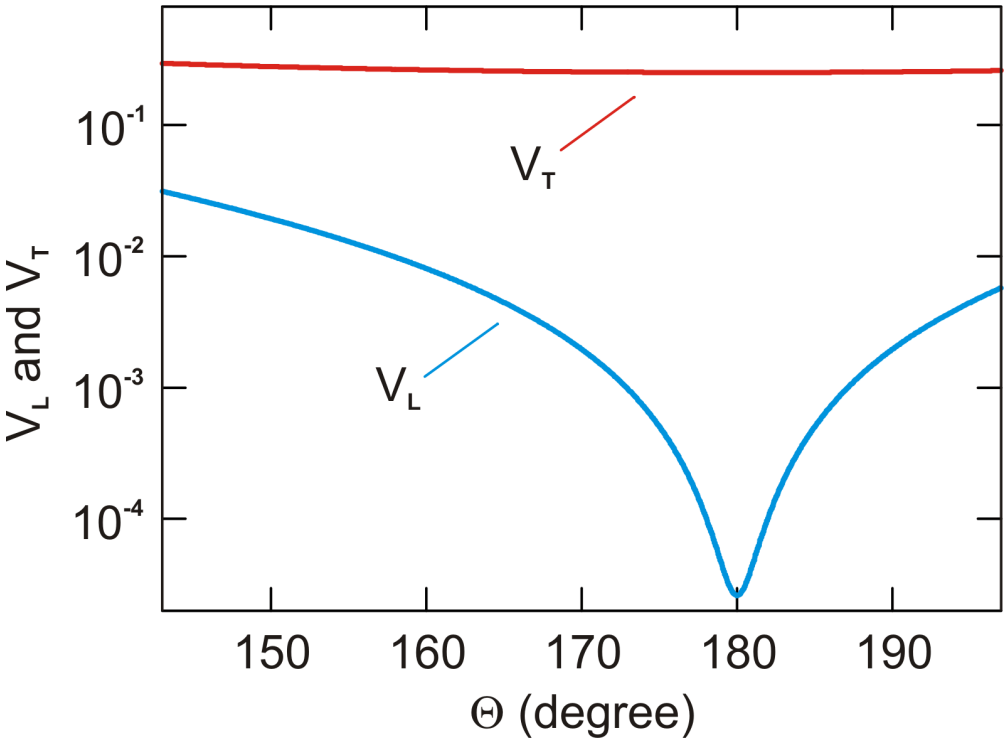

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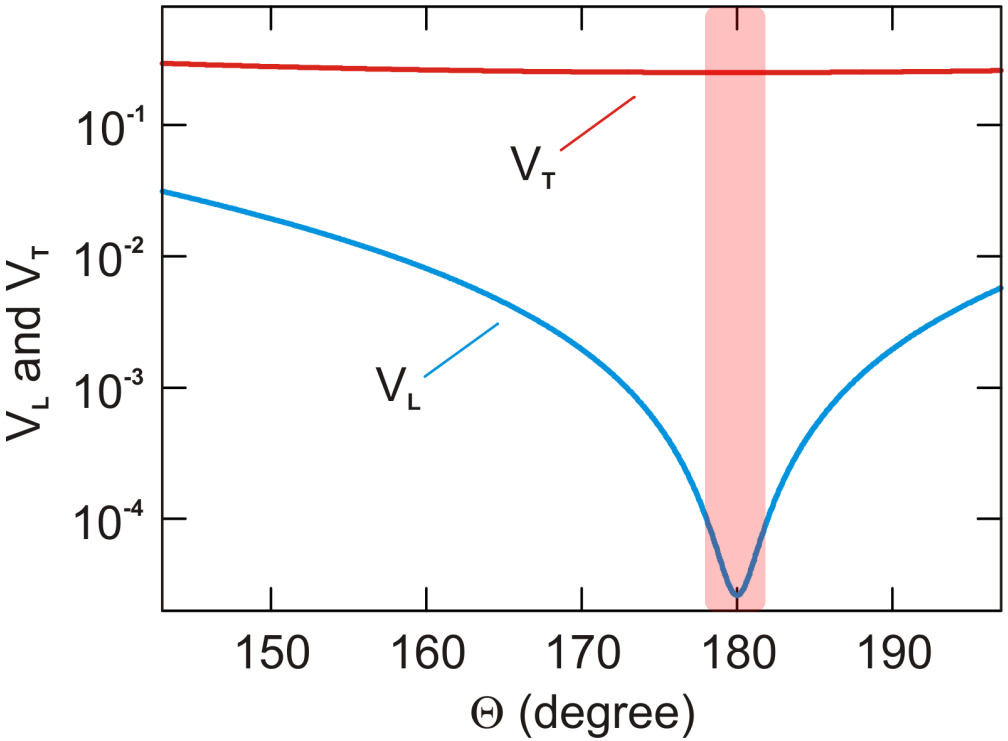


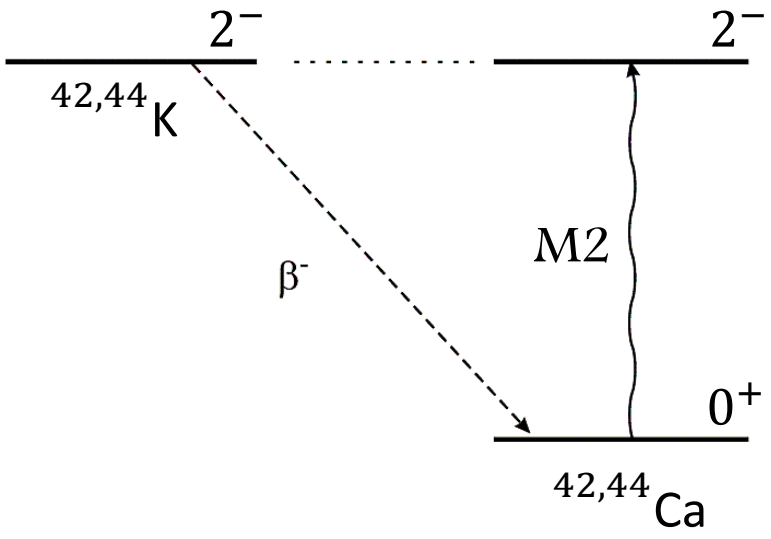
$$\rightarrow \frac{V_T}{V_L}(180°) \sim 10^3$$

ideal for measuring transverse excitations!

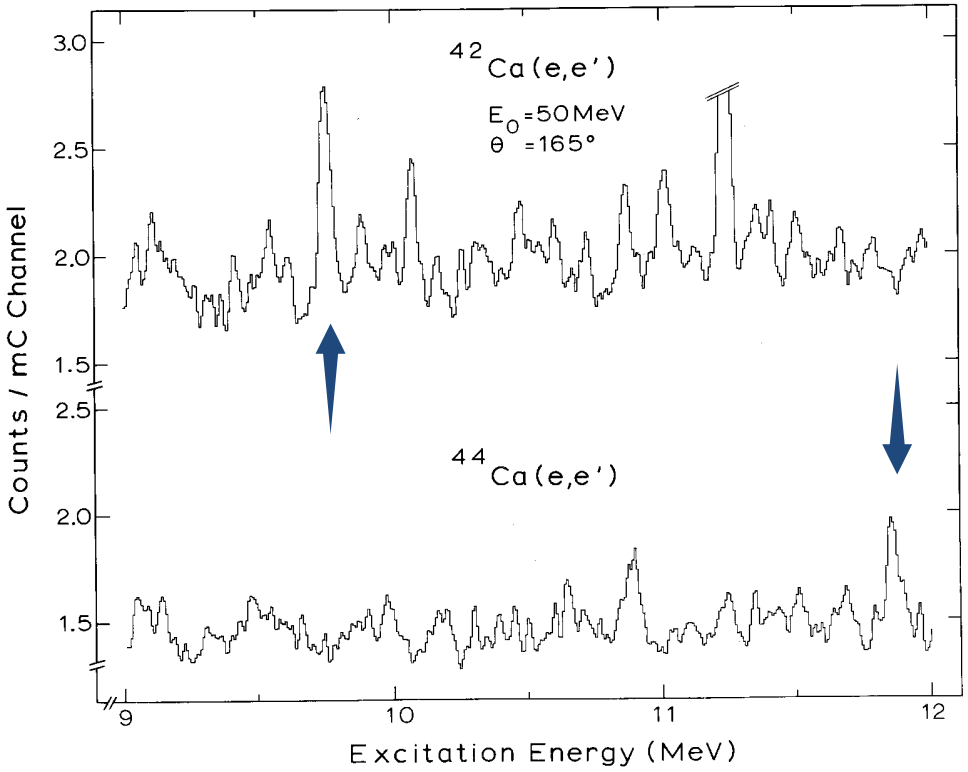
Physics cases …

… analogue to forbidden transitions

→ e.g., first-forbidden (M2) in ^{42,44}Ca

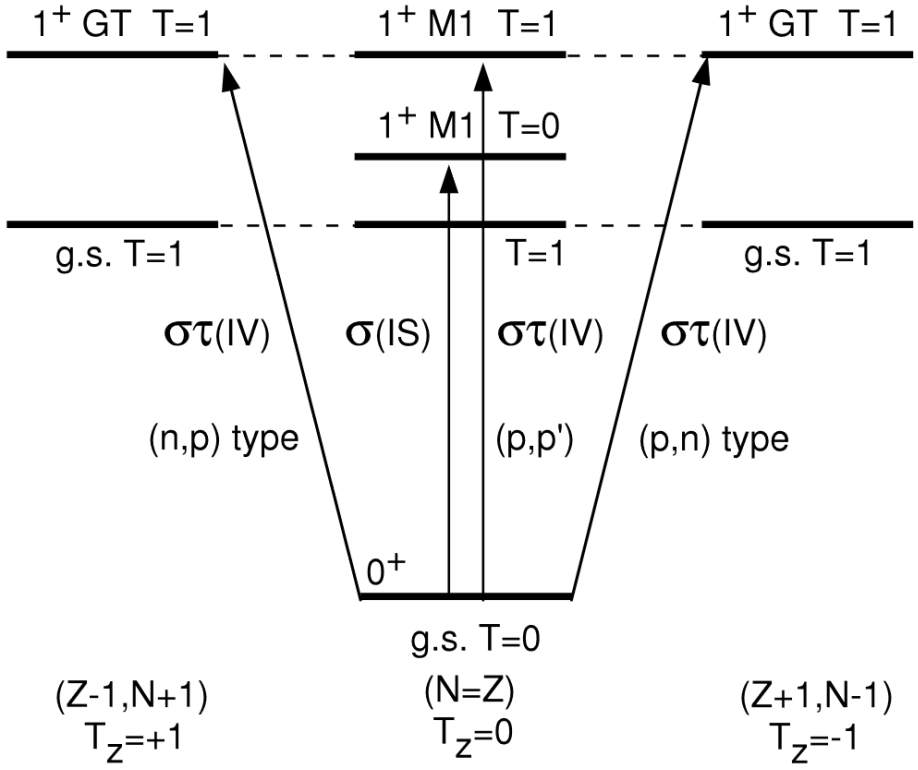


C. Rangacharyulu et al., Phys. Lett. **B 135**, 29 (1984)



Physics cases …

… spin-M1 and GT strength



Y. Fujita et al., Prog. Part. Nucl. Phys. **66** (2011) 549-606.

Physics cases …

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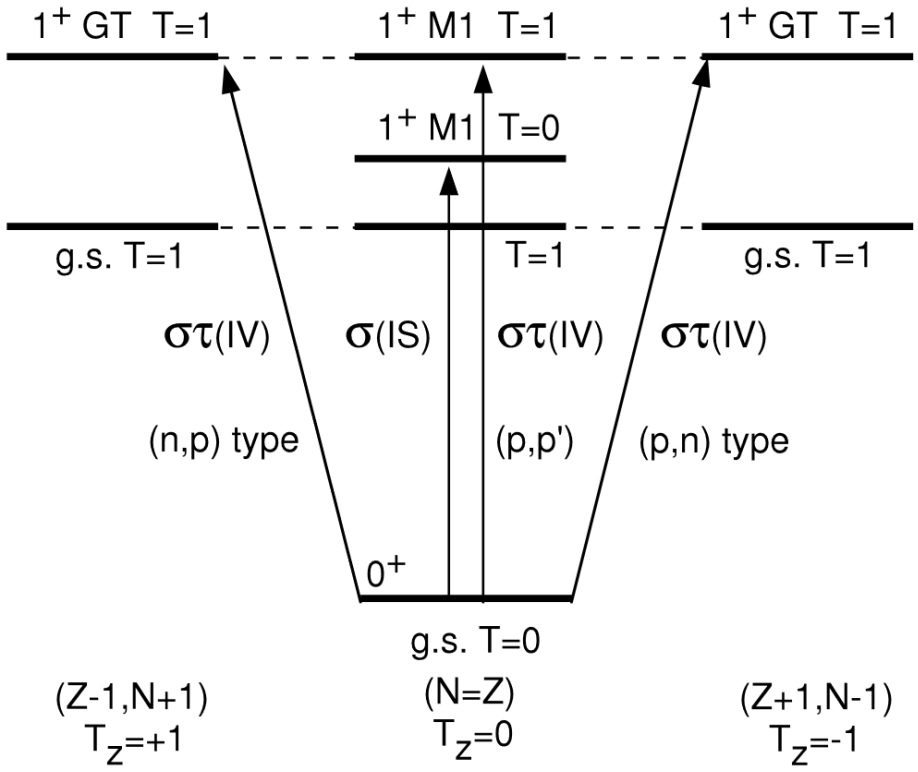


isobaric analogue states

- same underlying structure
- transition strengths
- etc.

Y. Fujita et al., Prog. Part. Nucl. Phys. **66** (2011) 549-606.

Physics cases …

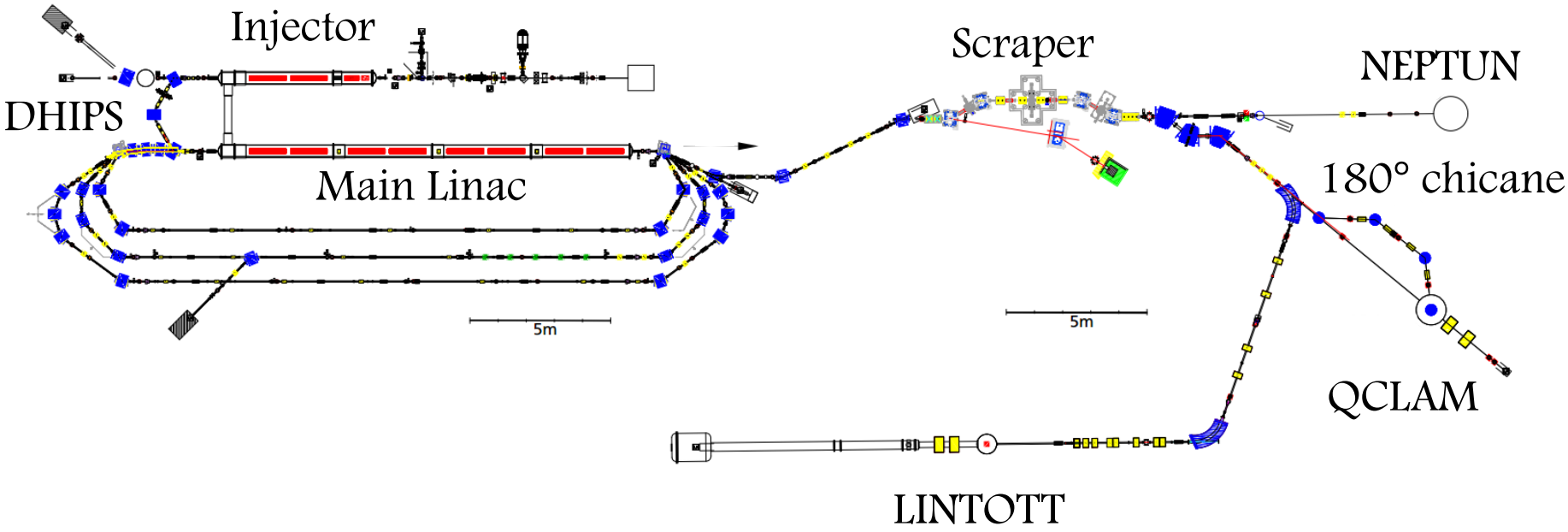
… analog to forbidden transitions

- M2 (first forbidden): ^{16}O, $^{42,44}Ca$
- M3 (second forbidden): ^{10}B, ^{22}Ne
- M4 (third forbidden): ^{40}Ar, ^{40}Ca

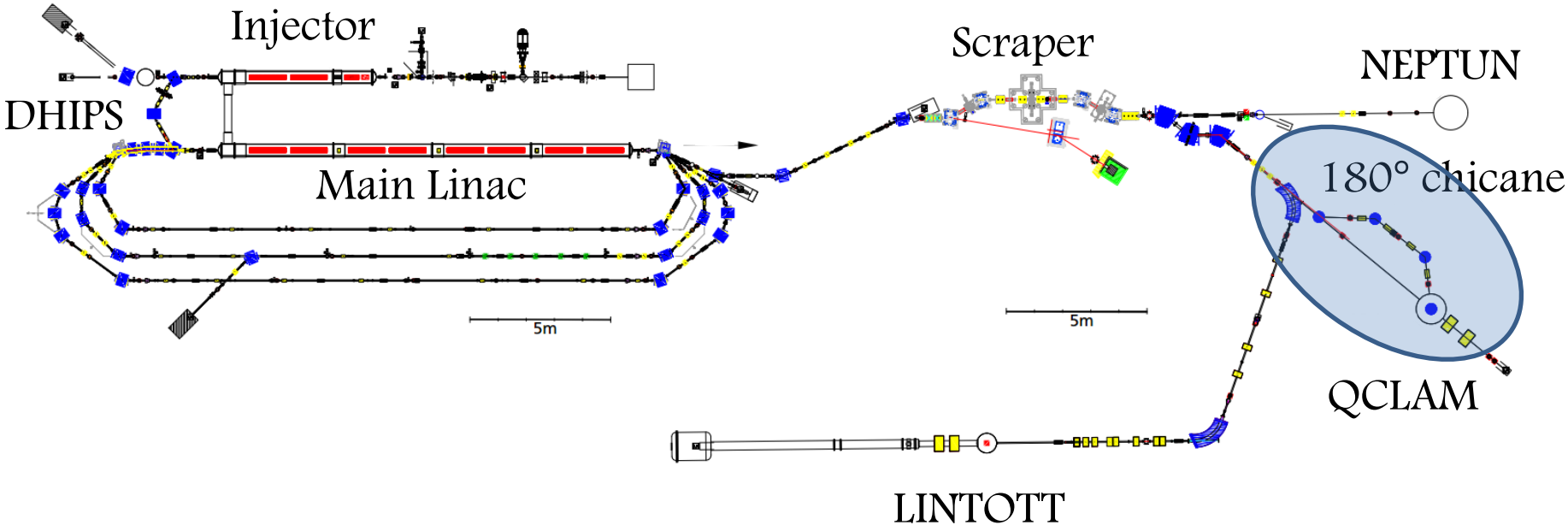
… momentum-transfer dependence of quenching

- spin-flip M1: ^{40}Ar, ^{40}Ca

S-DALINAC


Injector
DHIPS
Main Linac
5m
Scraper
5m
NEPTUN
180° chicane
QCLAM
LINTOTT

S-DALINAC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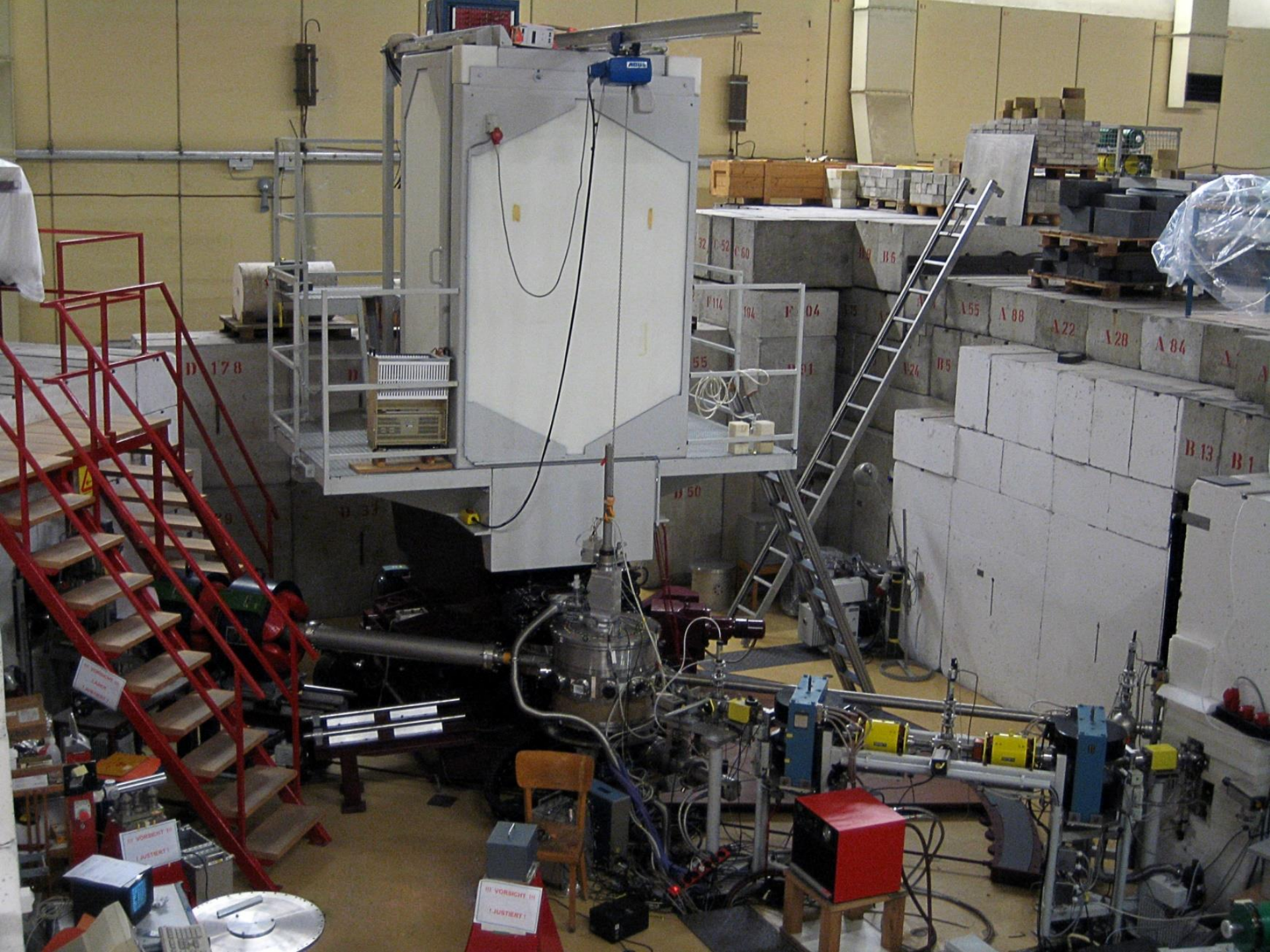
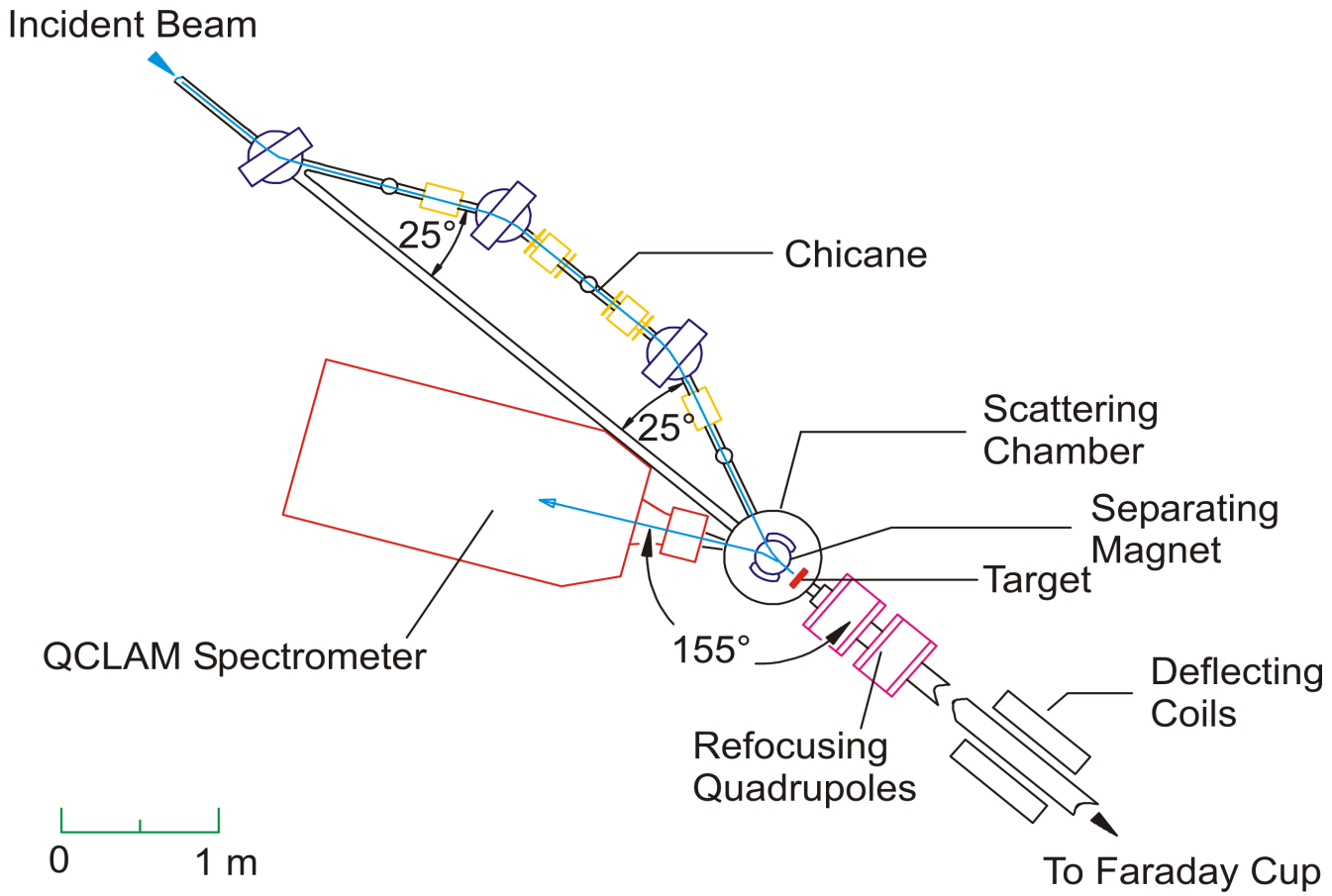

!!! VORSICHT !!!
! JUSTIERT !

180° chicane


Incident Beam
25°
Chicane
25°
Scattering
Chamber
Separating
Magnet
Target
QCLAM Spectrometer
155°
Deflecting
Coils
Refocusing
Quadrupoles
0
1 m
To Faraday Cup

Preparation & Achievements

TECHNISCHE UNIVERSITÄT DARMSTADT

- Mechanical setup of 180° system
  - Testing of separation magnet
  - Assembling of separation magnet
  - Alignment of chicane
  - Vacuum test
- Refurbishing of wire drift chambers @ GSI
- Data acquisition
- Commissioning
  - Tune magnets in chicane & separation magnet
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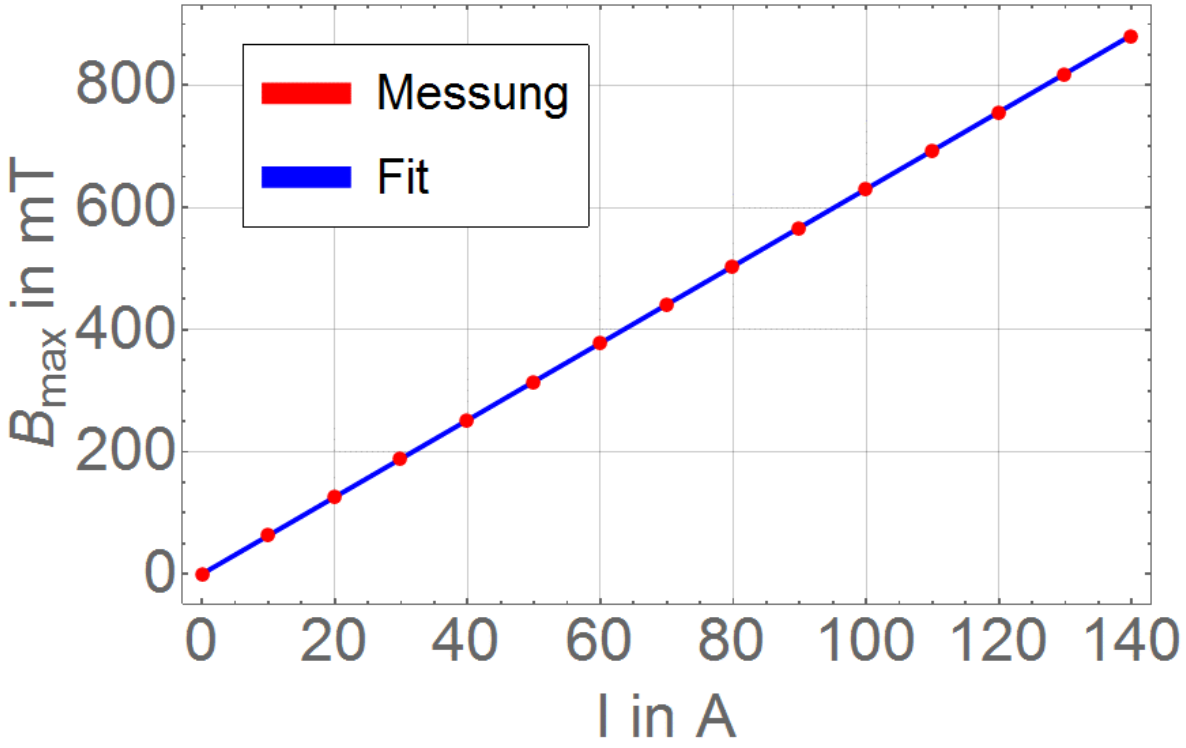
Separation magnet ~ B vs. I

magnetic field vs. coil current



G. Steinhilber, private communication

Separation magnet – effective length

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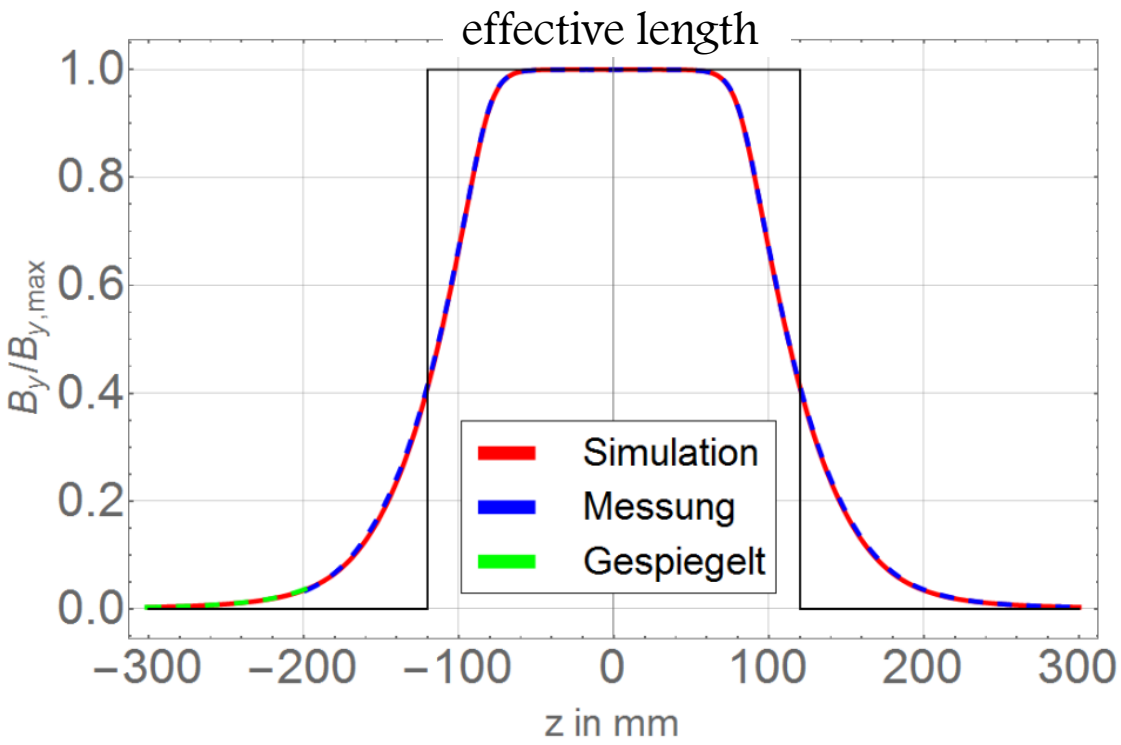
magnetic field vs. position



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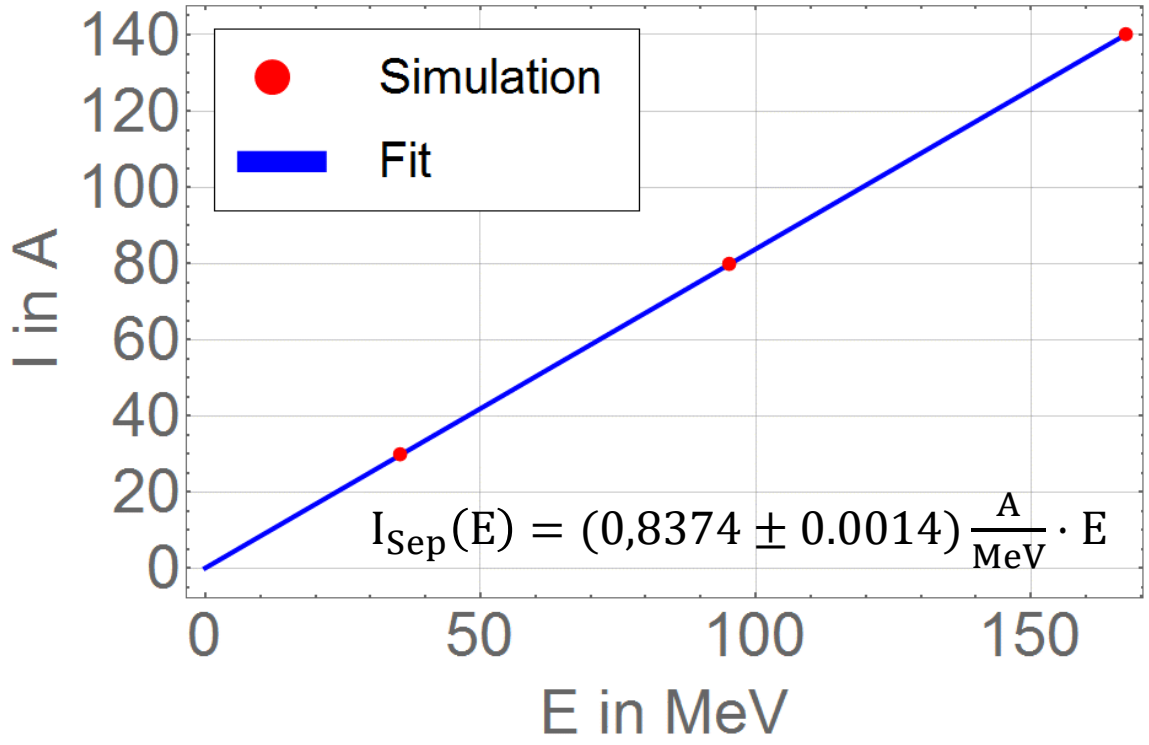
Separation magnet - calibration

coil current vs. electron energy



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Mechanical setup

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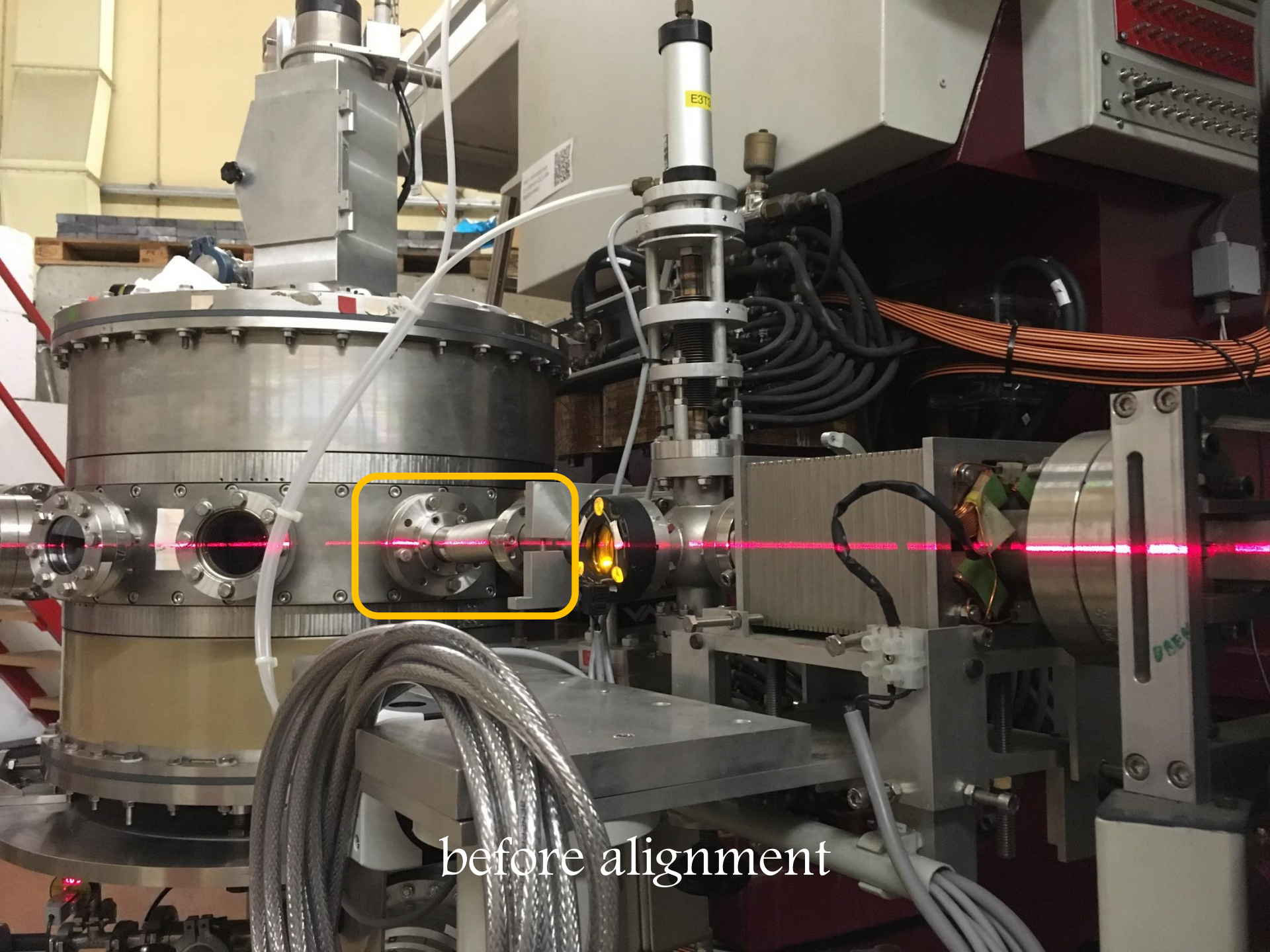
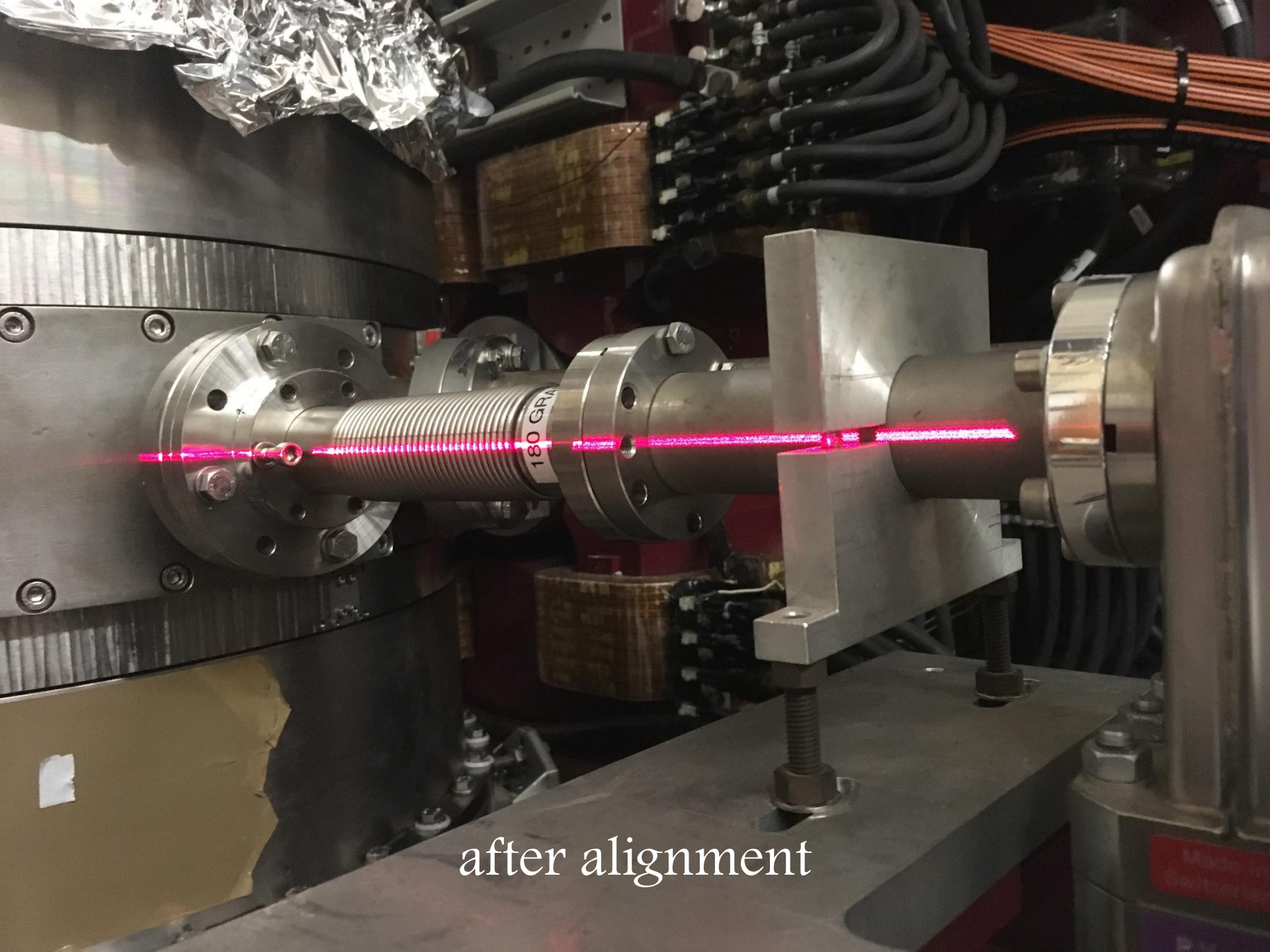
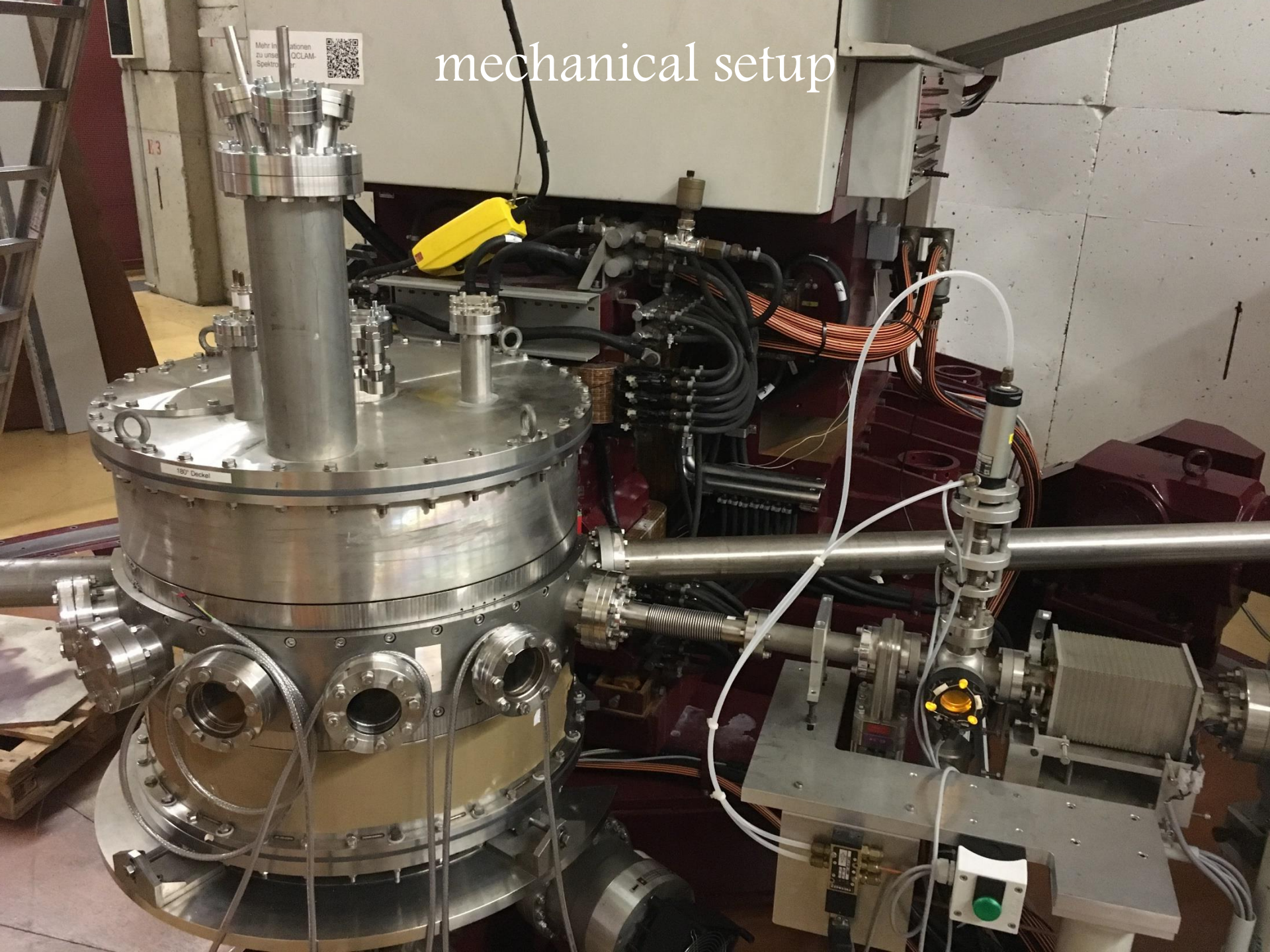

before alignment


after alignment

height adjustment

height adjustment

mechanical setup



Preparation & Achievements

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→ Mechanical setup of 180° system

- Testing of separation magnet ✓
- Assembling of separation magnet ✓
- Alignment of chicane ✓
- Vacuum test ✓

→ Refurbishing of wire drift chambers @ GSI

→ Data acquisition

→ Commissioning

- Tune magnets in chicane & separation magnet
- Focal plane calibration for 180° measurements

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Wire drift chamber

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old cathode foil

A. D'Alessio, private communication

Wire drift chamber

TECHNISCHE UNIVERSITÄT DARMSTADT

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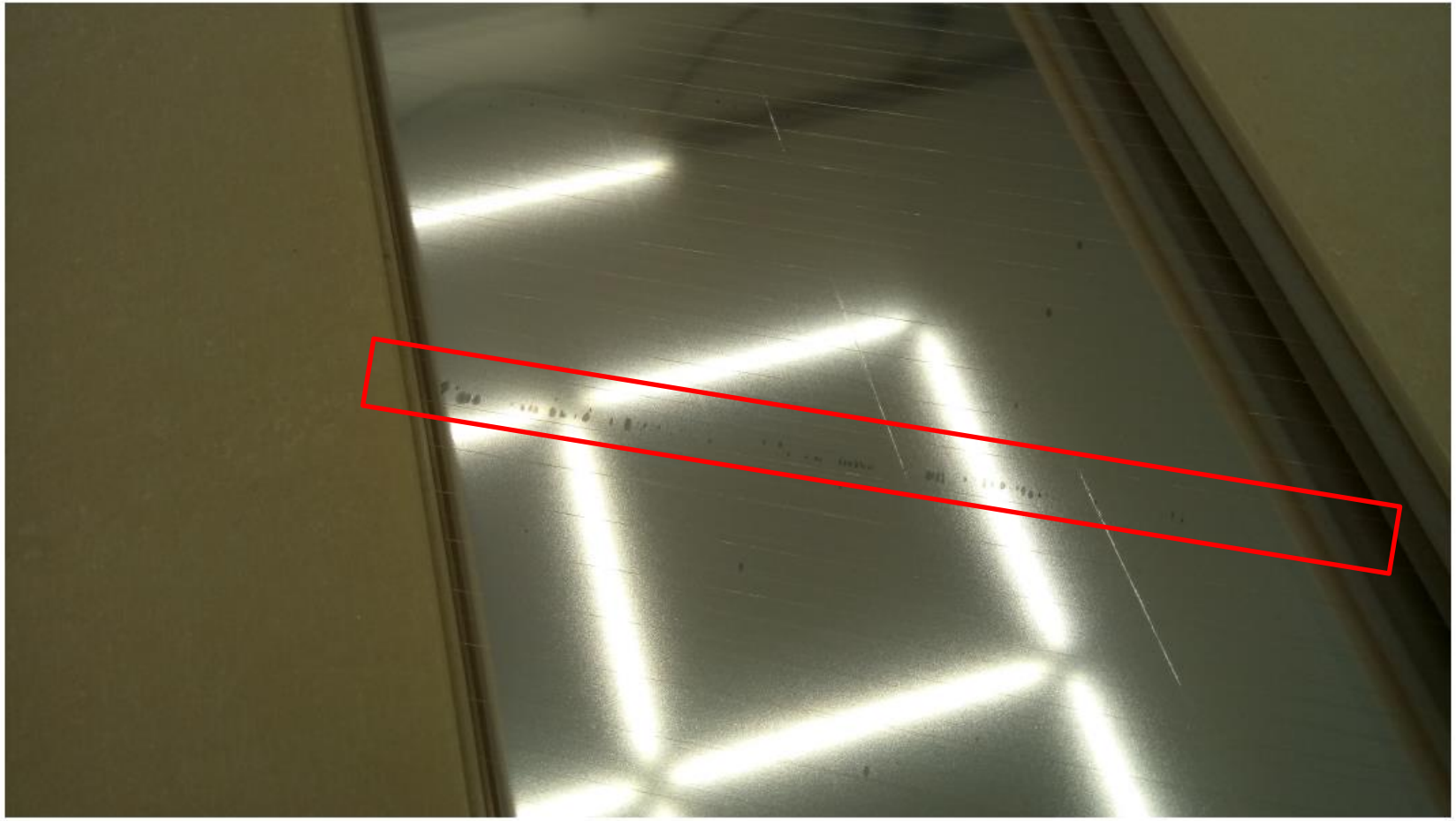

A. D'Alessio, private communication

Wire drift chamber

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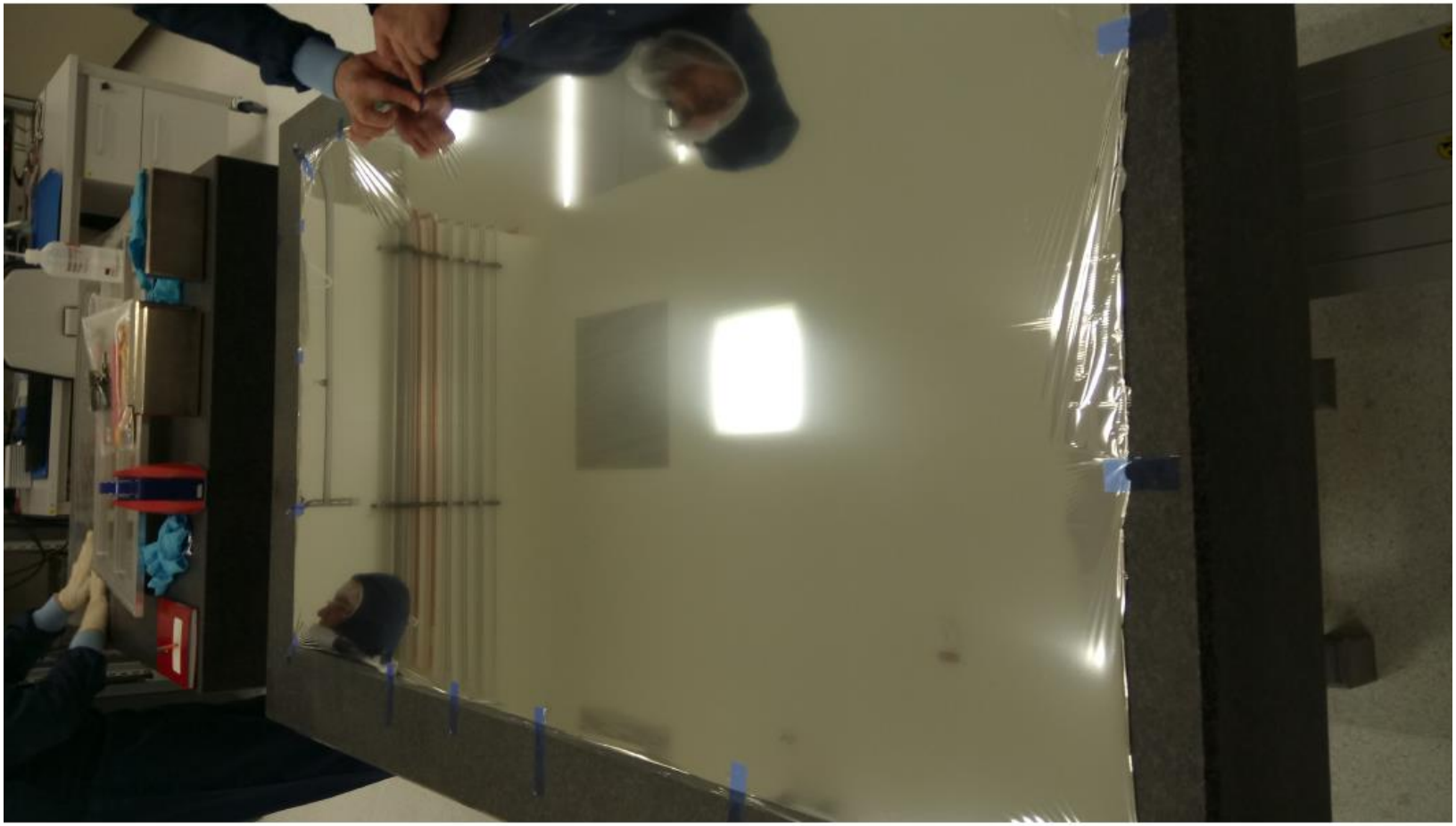
mounting new cathode foil



A. D'Alessio, private communication

Wire drift chamber

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mounting new cathode foil

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Wire drift chamber

TECHNISCHE UNIVERSITÄT DARMSTADT

mounting new cathode foil

A. D'Alessio, private communication

Wire drift chamber - improved gas purity

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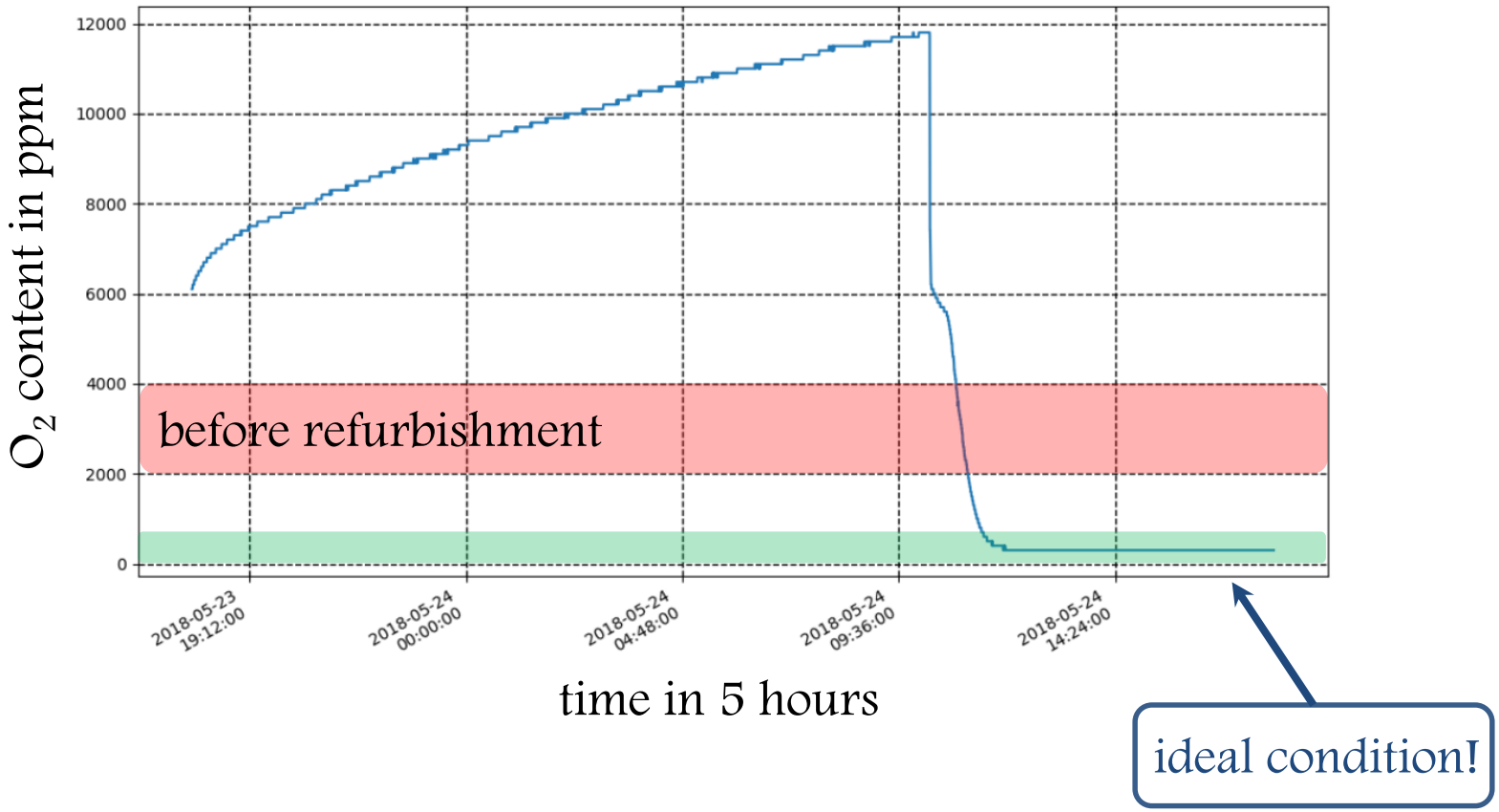
Measurement of O_2 content



A. D'Alessio, private communication

Wire drift chamber - stable working plateau

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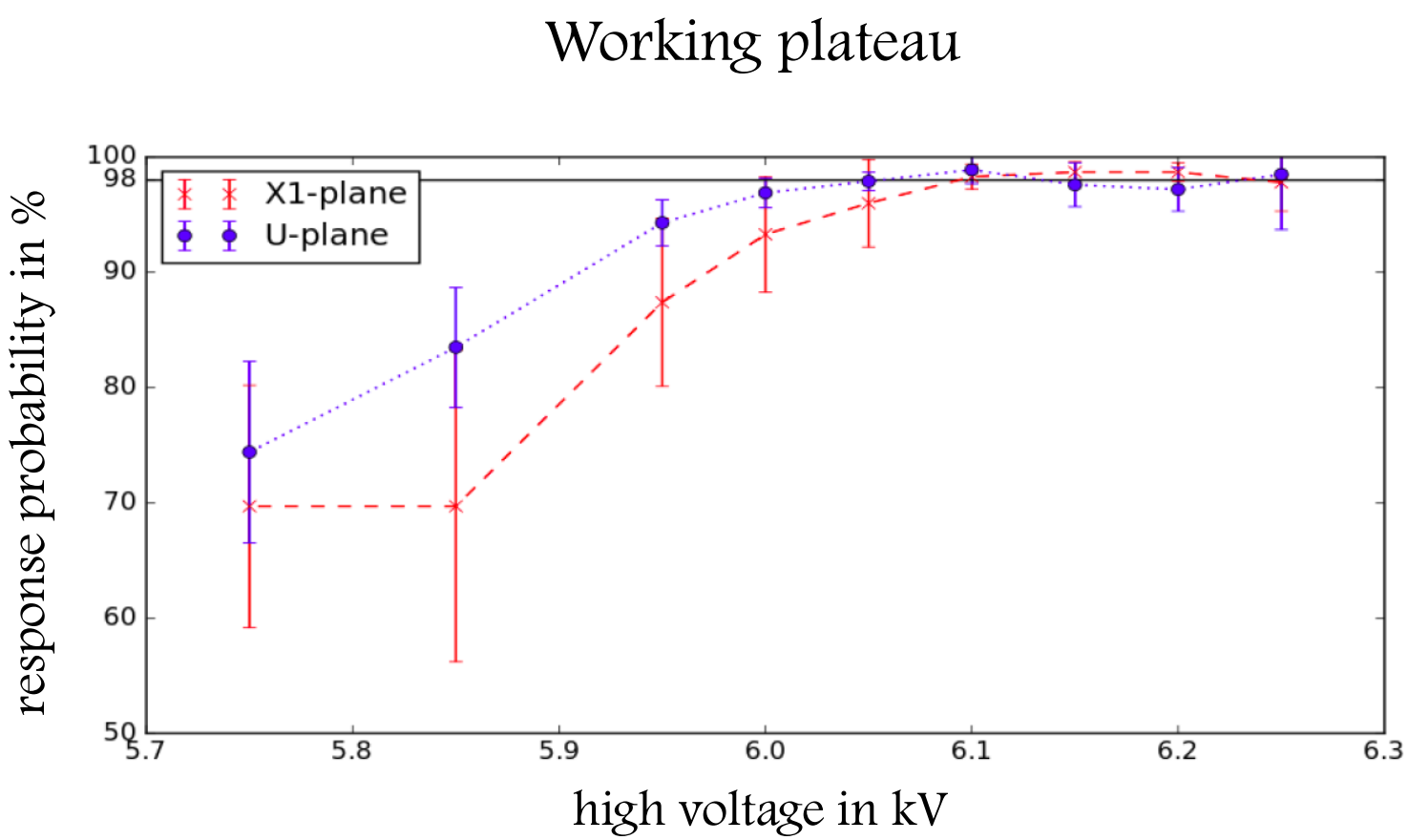

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Preparation & Achievements

TECHNISCHE UNIVERSITÄT DARMSTADT

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Data acquisition

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New digital data acquisition system for Lintott and QCLAM

→ Maxim Singer (about 1,5 years of effort!)

Data acquisition

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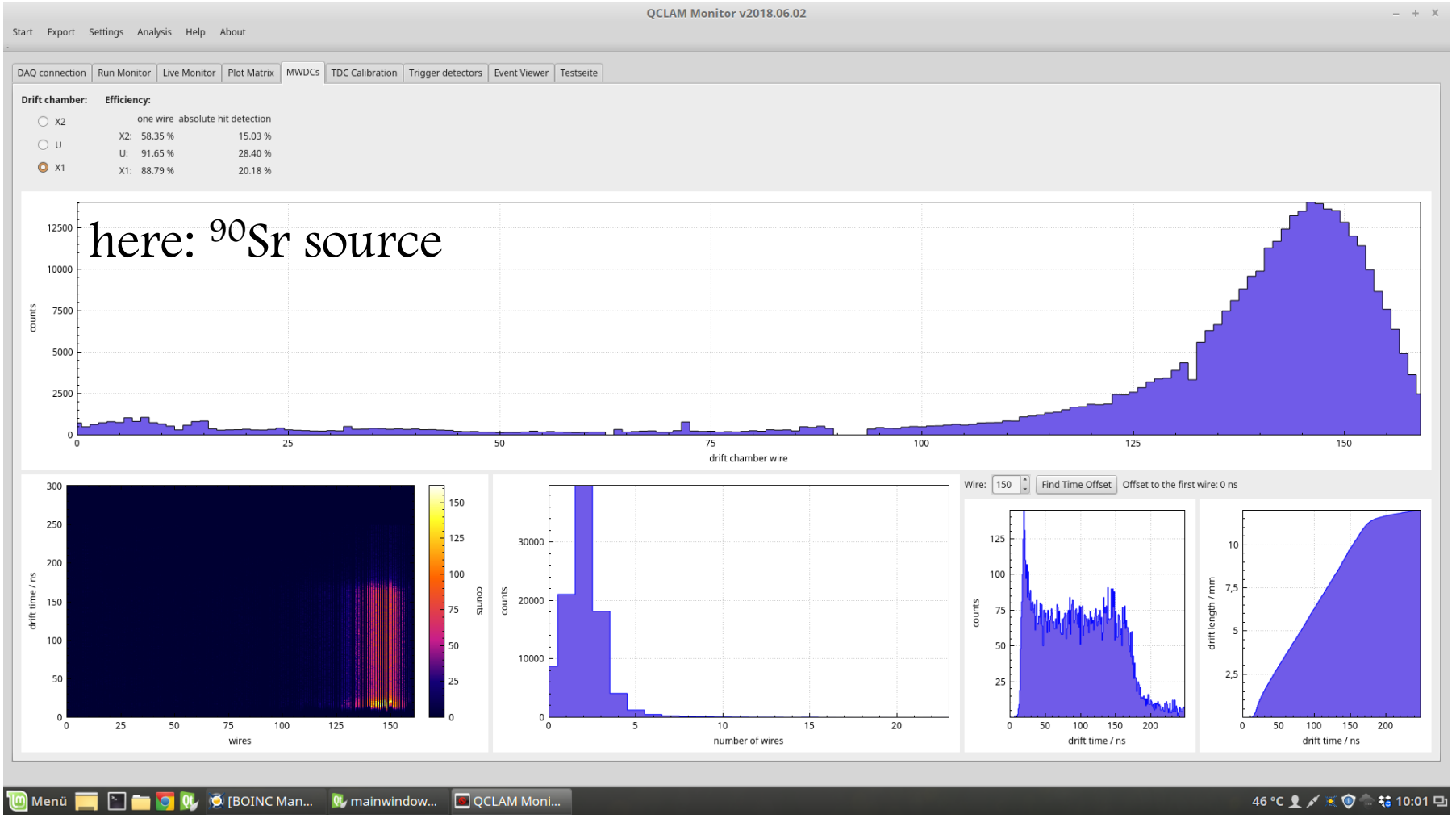
raw output: signals for each wire in the chambers



Data acquisition

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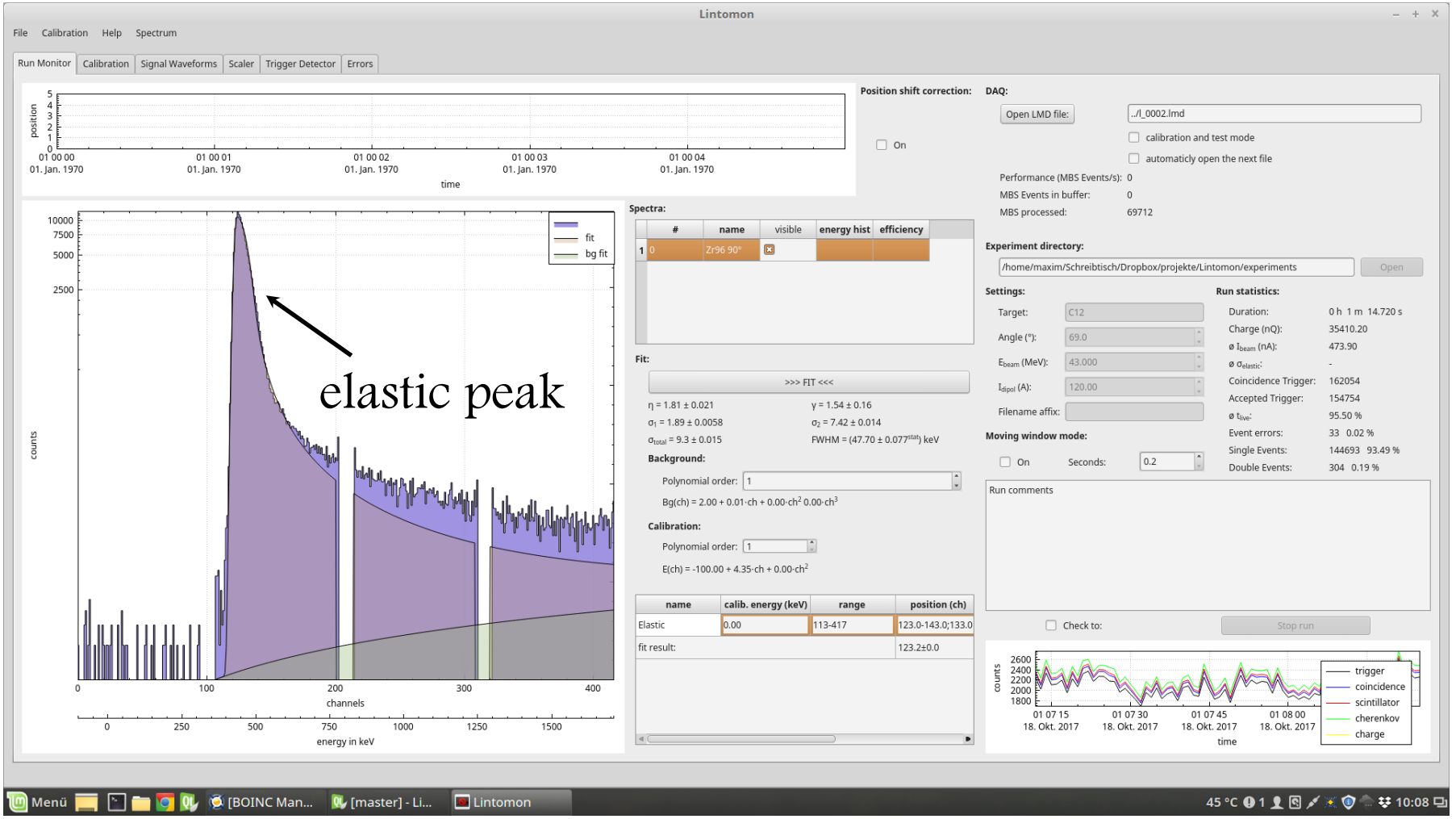
^{12}C test measurement at Lintott in winter 2017



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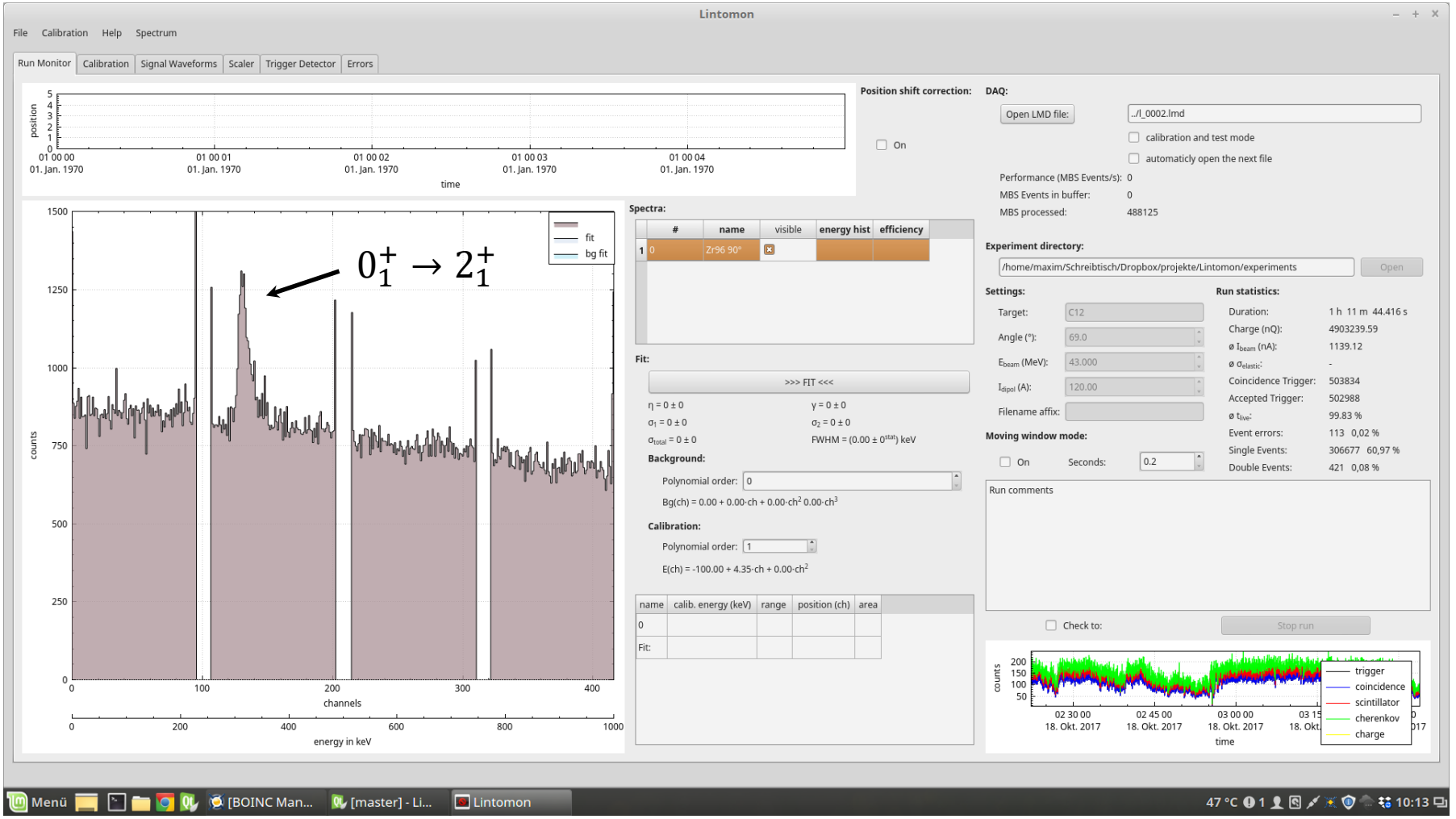

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- Commissioning under experiment conditions → ToDO
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Preparation & Achievements

August: QCLAM commissioning

November / December: 180° measurements

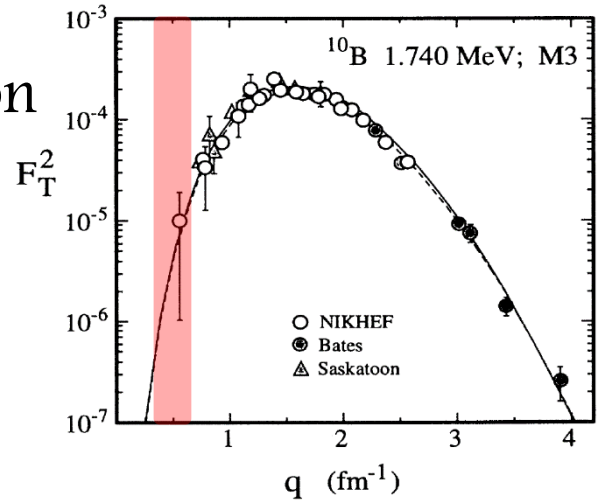
Preparation & Achievements

August: QCLAM commissioning

November / December: 180° measurements

- ^{10}B: $3^+_{g.s.} \rightarrow 0^+_1$
  analogue to second-forbidden transition

A. Cichocki et al., PRC 51 (1995) 5.



- ^{16}O: $0^+_{g.s.} \rightarrow 2^-$
  analogue to first-forbidden transition (Ex = 12.9 MeV)
  ➞ using a Mylar foil!

Preparation & Achievements

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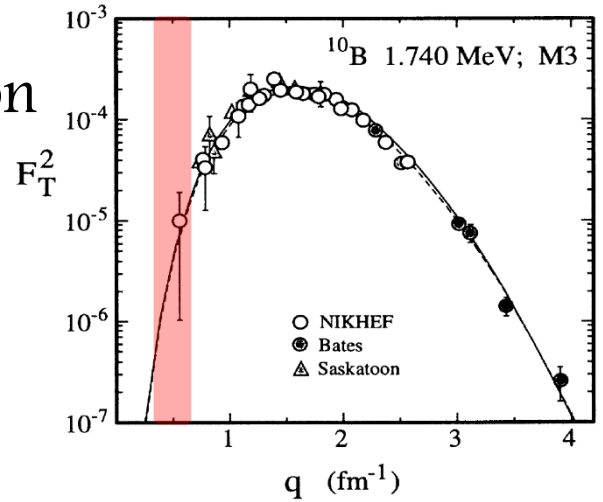

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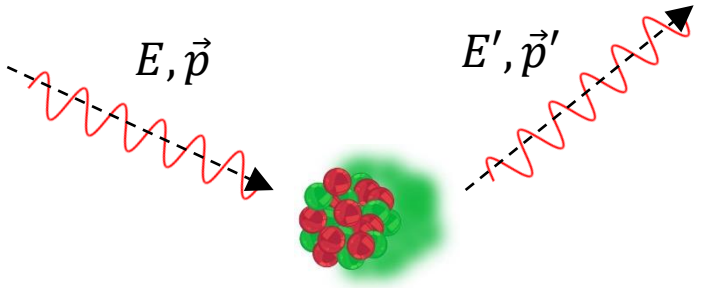

➞ nuclear structure information

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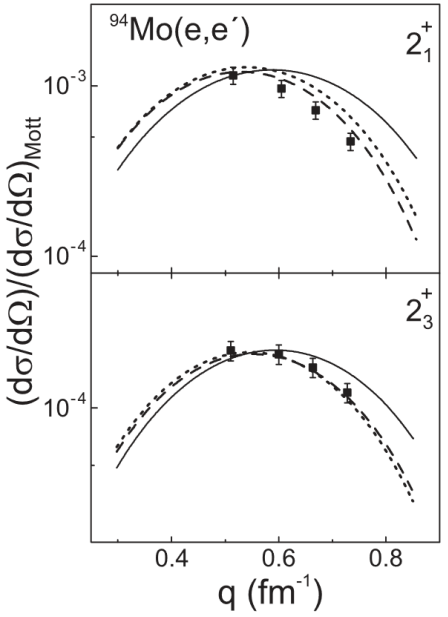
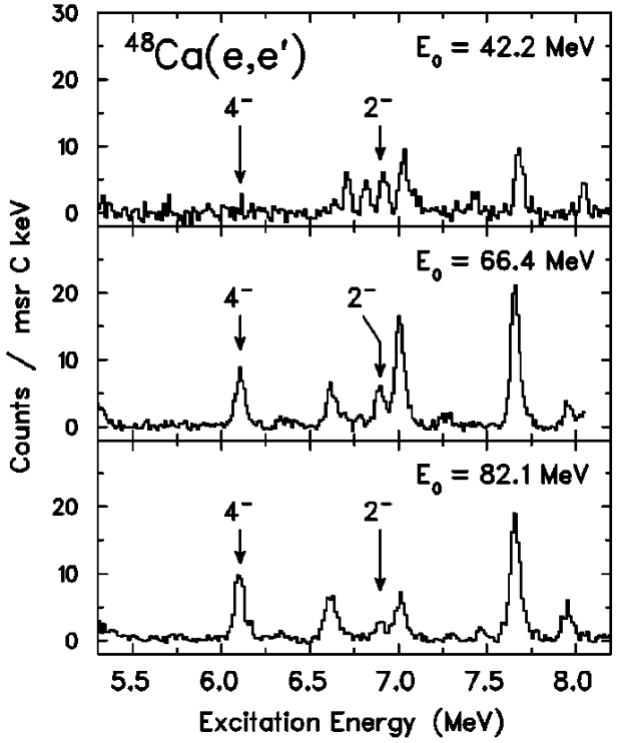
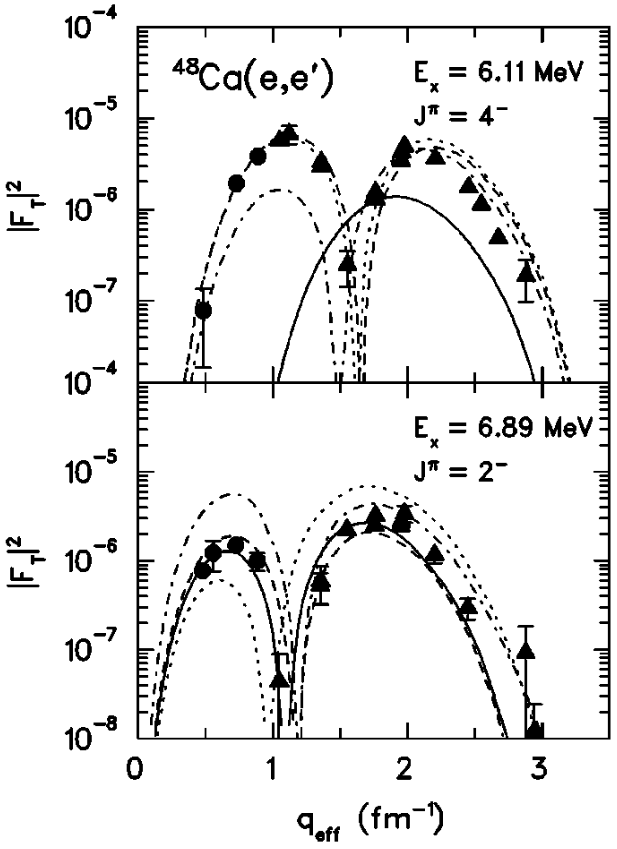
- spin-isospin response
- $(e, e') \leftrightarrow (\nu, \nu')$: electroweak theory



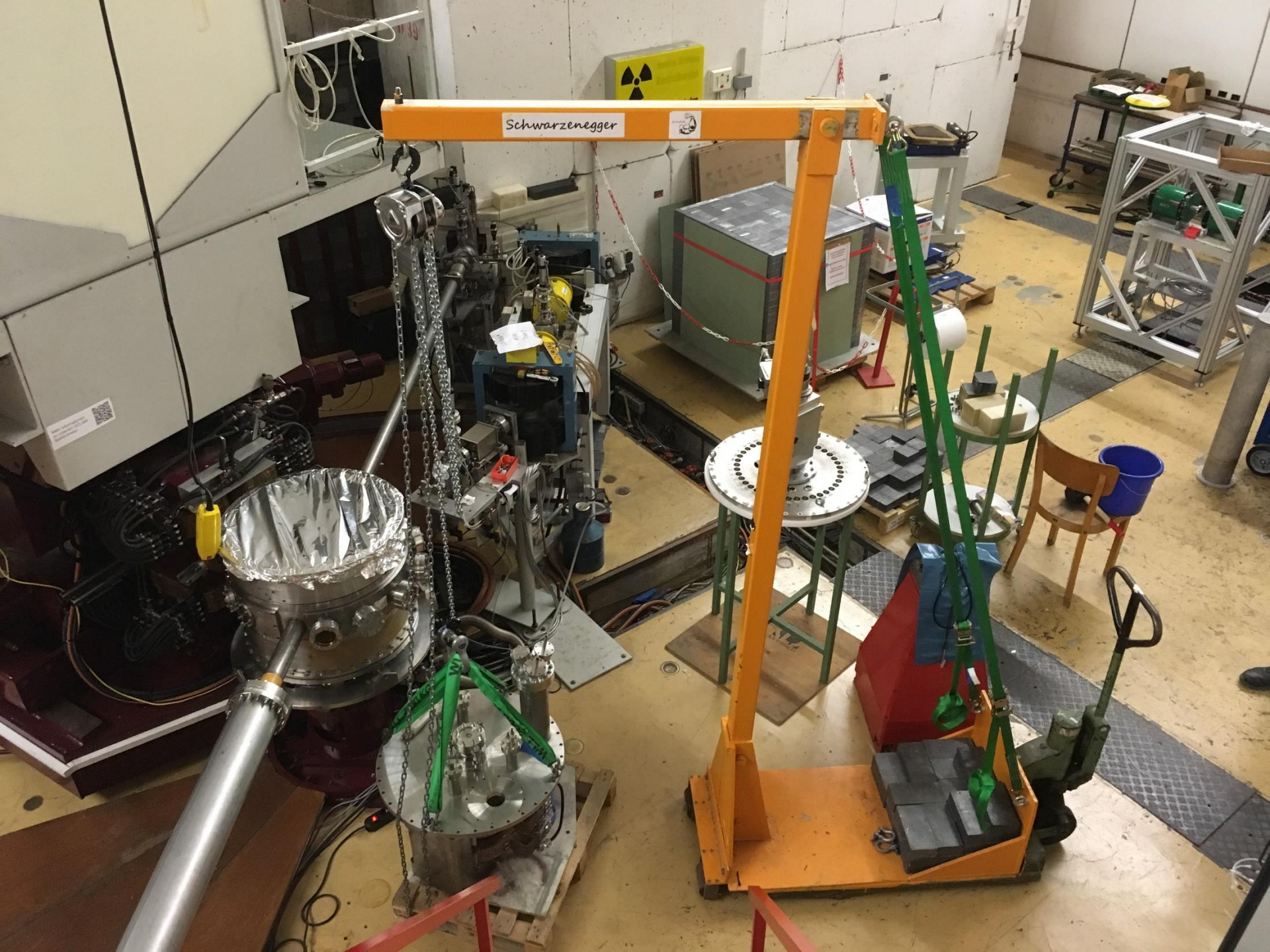
O. Burda *et al.*, PRL **99** (2007) 092503.

Physics cases …






Schwarzenegger
Schwarzenegger


Schwarzenegger

Preparation & Achievements

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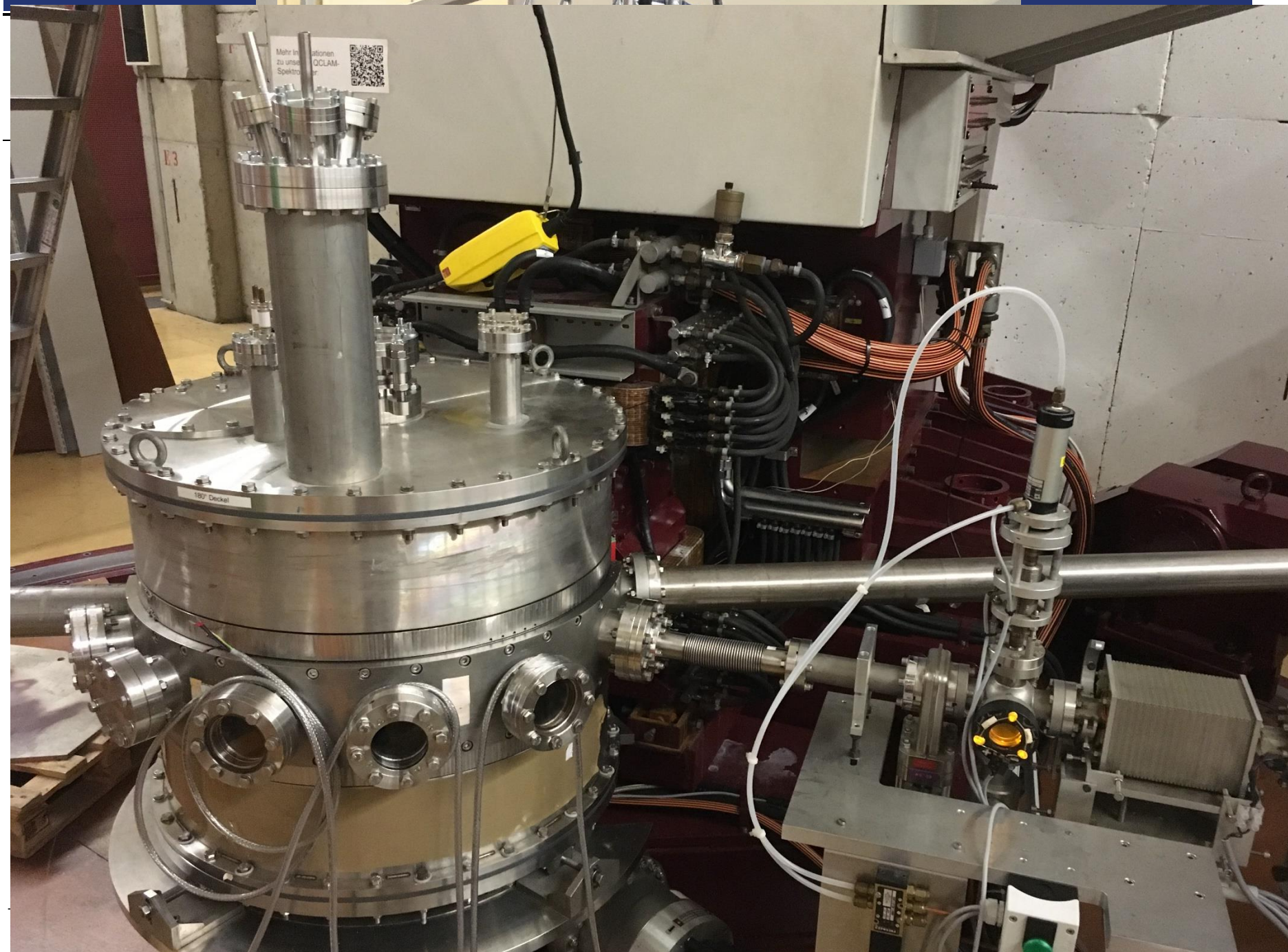
August: QCLAM commissioning

November / December: 180° measurements

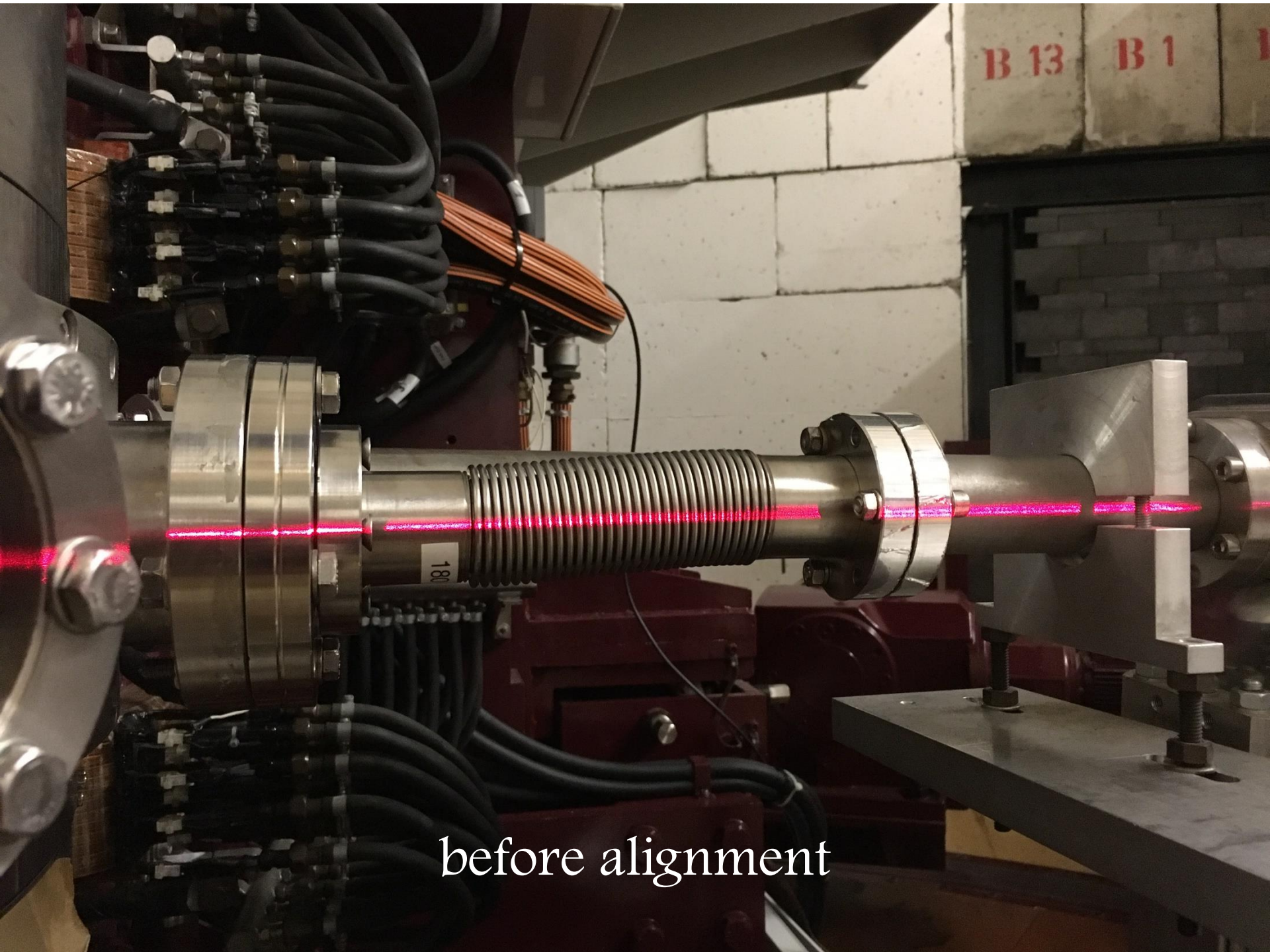
- ^{10}B: $3^+_{g.s.} \rightarrow 0^+_1$
  analogue to third-forbidden transition (E_x = 1.74 MeV)

- ^{16}O: $0^+_{g.s.} \rightarrow 2^-$
  analogue to second-forbidden transition (Ex = 12.9 MeV)

Thank you for your attention!


180° Deckel


D 178
D 15
2000 KG



before alignment

Preparation & Achievements

TECHNISCHE UNIVERSITÄT DARMSTADT

August → Mechanical setup of 180° system ✓

- Testing of separation magnet ✓
- Assembling of separation magnet ✓
- Alignment of chicane ✓
- Vacuum test ✓

November / December → **180° measurements**

^{10}B: $3^+_{g.s.} \rightarrow 0^+_1$ → analogue to third-forbidden transition with Ex=1.74 MeV

^{16}O: $3^+_{g.s.} \rightarrow 0^+_1$ → analogue to second-forbidden transition

→ Refurbishing of wire drift chambers @ GSI ✓

→ Data acquisition (✓)

→ Commissioning under experiment conditions → ToDO

- Tune magnets in chicane & separation magnet → ToDO
- Focal plane calibration for 180° measurements → ToDO