Progress Towards (e,e'γ) Experiments at the S-DALINAC

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- Motivation
- QCLAM Spectrometer
- High Energy Scraper
- Detector Array
- (e,e'γ) Commissioning Experiment
- Status/Schedule
- Summary

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Motivation

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Why do we plan (e,e′γ) coincidence experiments?

- Probe is purely electromagnetic and allows for nuclear structure studies of highest precision
- Background suppression
- Branching ratio
- Angular distribution

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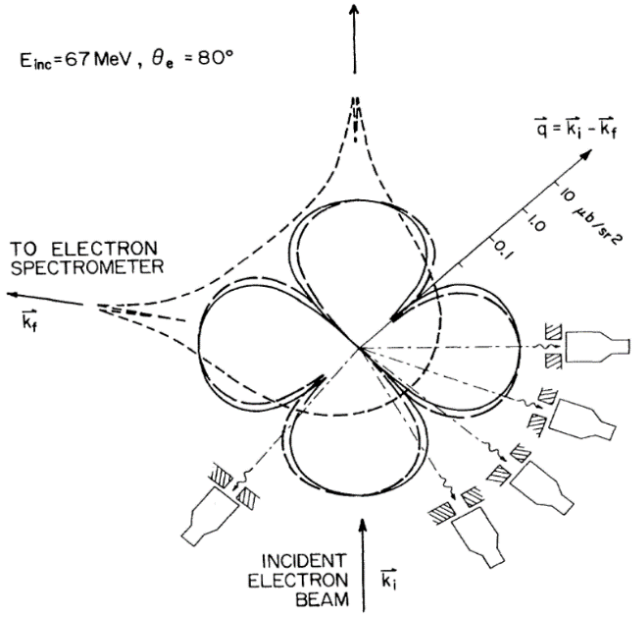
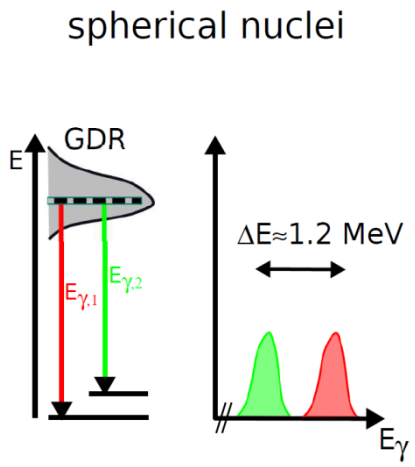
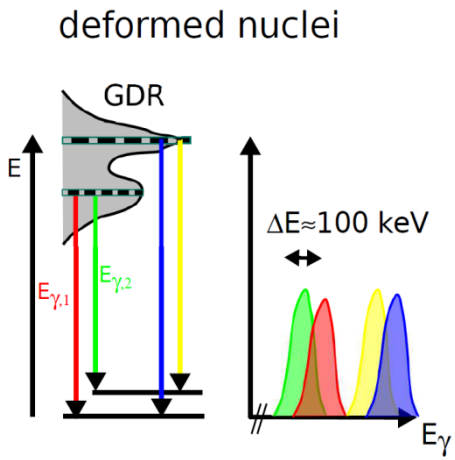
Project Goal

- Search for rotation of angular distribution to investigate vorticity in ^{92}Zr
- Gamma branching ratio of the giant dipole resonance (GDR) in $^{112,124}Sn$



C. N. Papanicolas et al.,
Phys. Rev. Lett. **54** (1985)





Requirements

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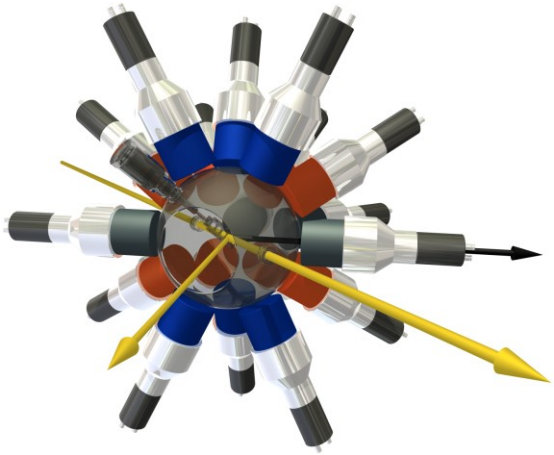
- Spectrometer with large solid angle and high momentum acceptance
  → QCLAM spectrometer (Talk by M. Singer)

- Optimized beam at the target: low energy spread, halo free
  → High energy scraper (L. Jürgensen)

- New large solid angle detector array
  → LaBr detector array (similar to GALATEA)

- Data acquisition (DAQ) for e‘ and γ



GALATEA

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QCLAM Spectrometer

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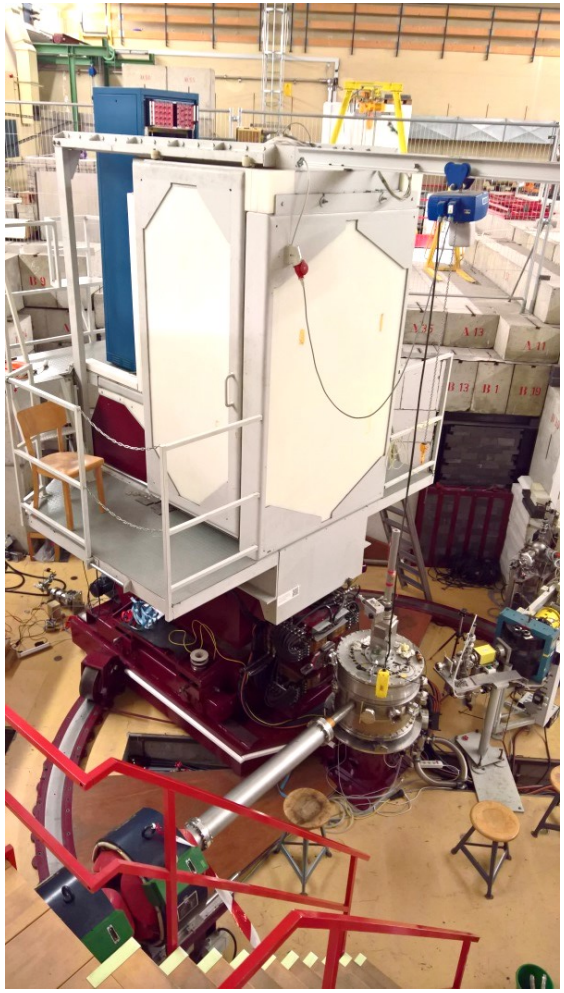
- Max. momentum: 200 MeV/c
- Momentum acceptance ± 10 %
- Solid angular acceptance 35 msr
- Scattering angles 25°-155°, 180° (B02)
- Energy resolution $\frac{\Delta E}{E} \approx 10^{-4}$

→ Well suited for coincidence experiments



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High Energy Scraper at the S-DALINAC

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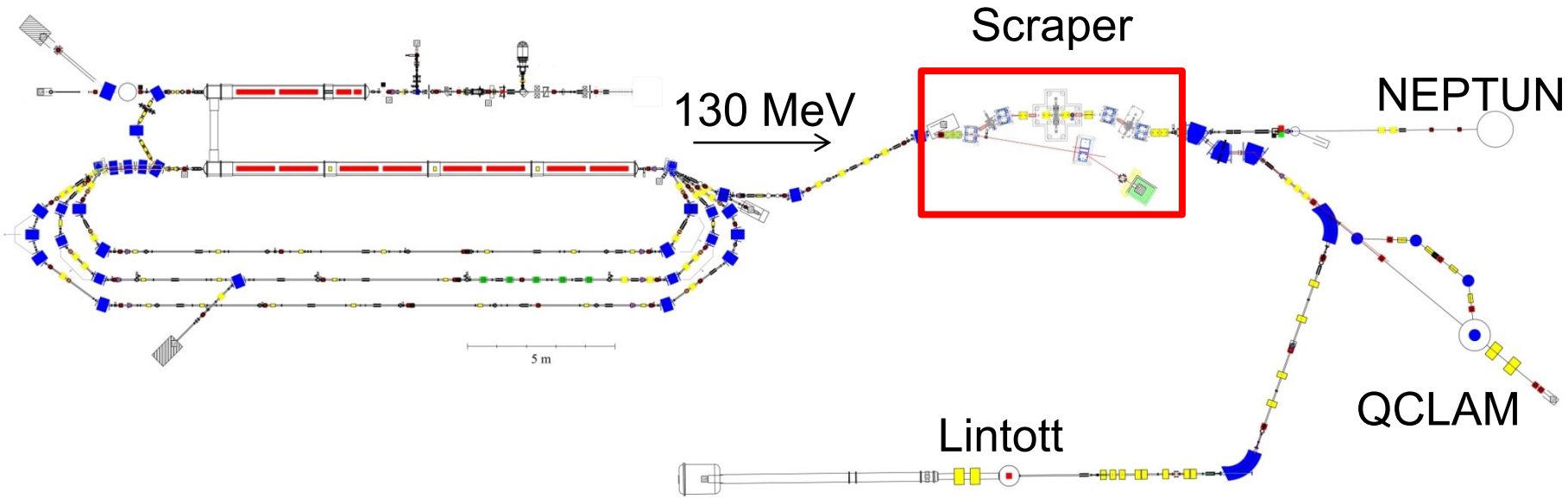
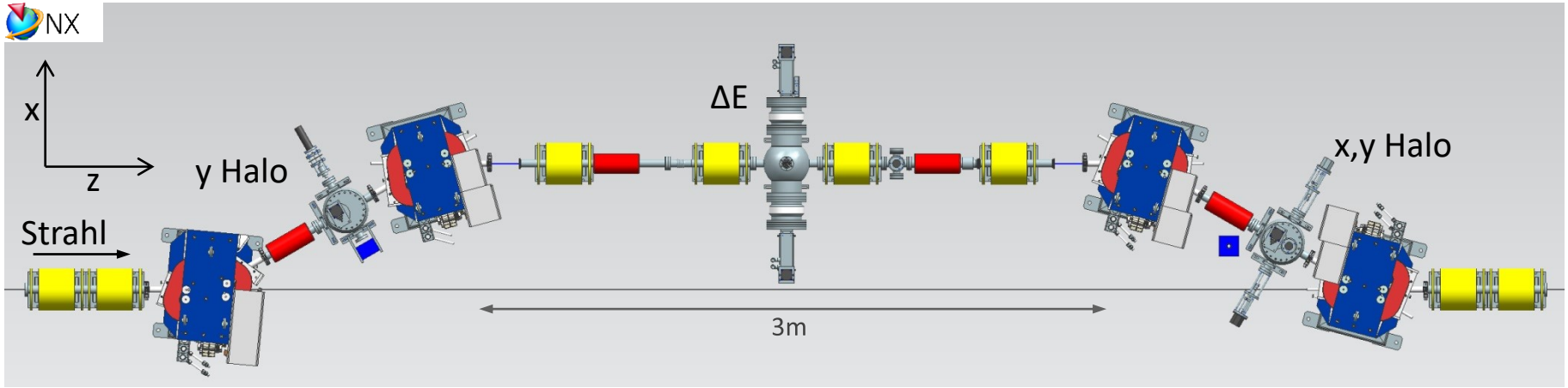
- Energy resolution of $(\Delta E/E)_{beam} \approx 10^{-4}$ needed for the QCLAM
- Halo electrons increase bremsstrahlung

→ Scraper chicane in front of the spectrometer



M. Arnold, Dissertation, TU Darmstadt (2016)

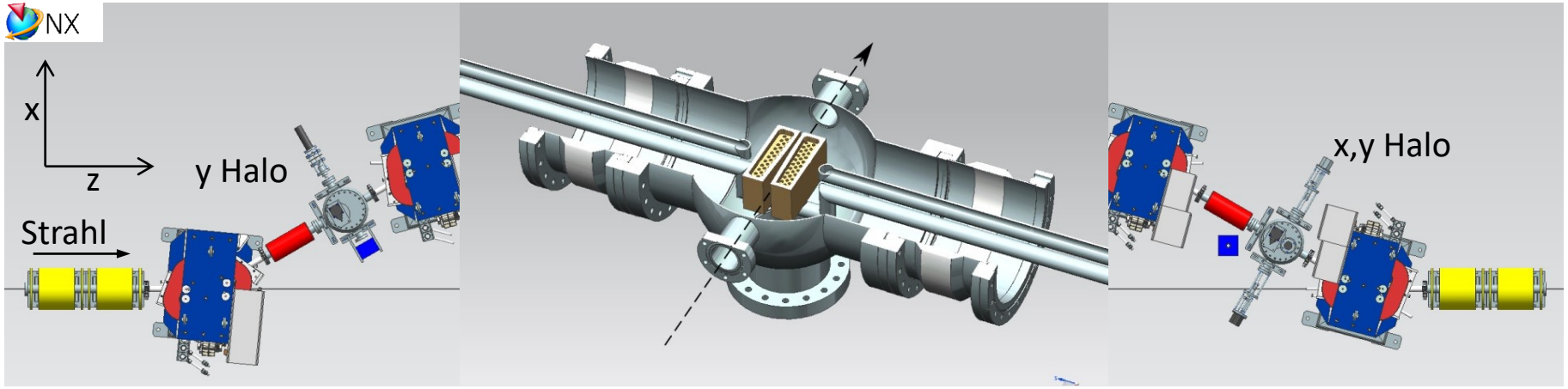
Scraper Chicane



L. Jürgensen, Dissertation in preparation

- Scraper chicane: y-scraper → high energy → x-y-scraper
- Positioning of copper boxes with high precision (0.01 mm steps)
- Dispersion: 22 mm/% → $\Delta E/E = 2 \cdot 10^{-4}$ leads to 0.44 mm

Scraper Chicane



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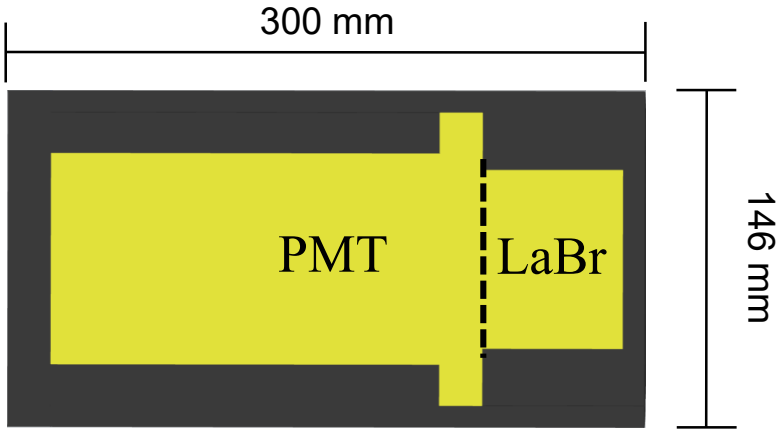
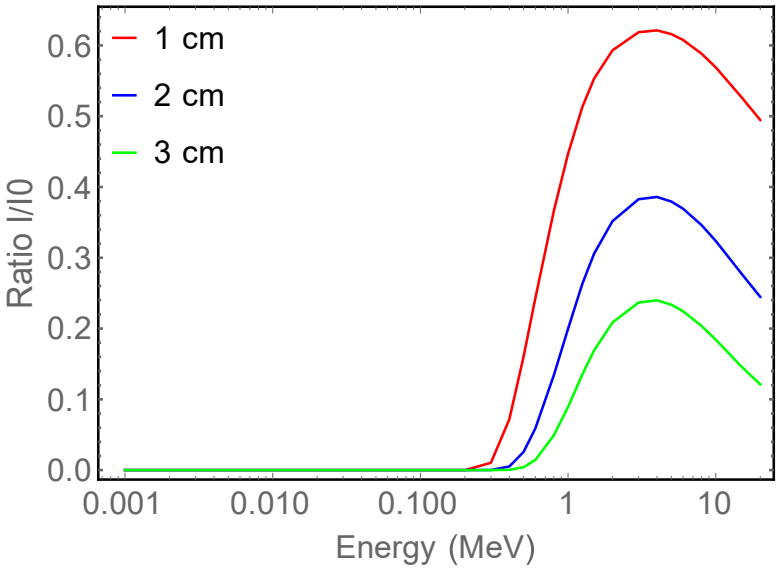
(e,e'γ) LaBr:Ce Detector

- Using 17 LaBr detectors:
  - Time resolution: ~ 0.5 ns
  - Energy resolution: 2.9%-3.1% @662 keV
  - Maximum rate: 215 kHz
- Lead shield → reduce bremsstrahlung



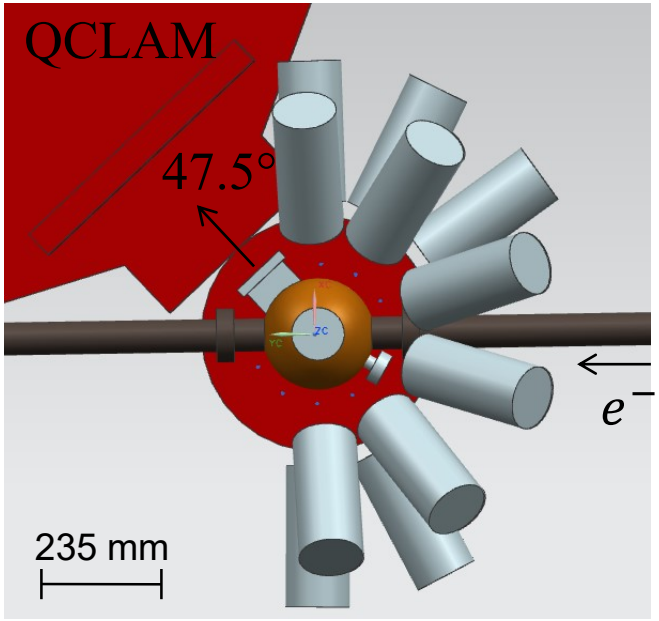
$$I(E) = I_0 \exp(-\mu(E)\, b)$$



Data from NIST

(e,e'γ) LaBr:Ce Detector Array

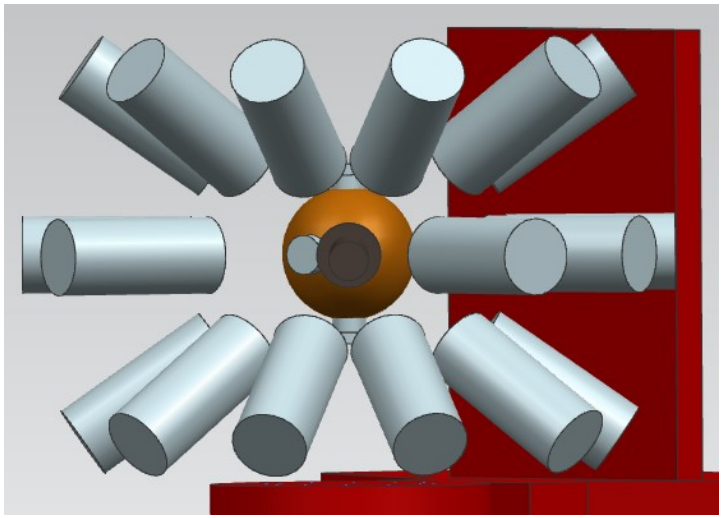
- Detector array placed around ball chamber
- High bremsstrahlung at forward angels
  → detectors are placed mainly at backward angles
- Distance: 290 mm → ~ 10% of the solid angle



92.5°, 127.5°, 162.5°

89°, 117°, 145°

92.5°, 127.5°, 162.5°



(e,e'γ) Photo Multiplier Tubes (PMT) in magnetic fields

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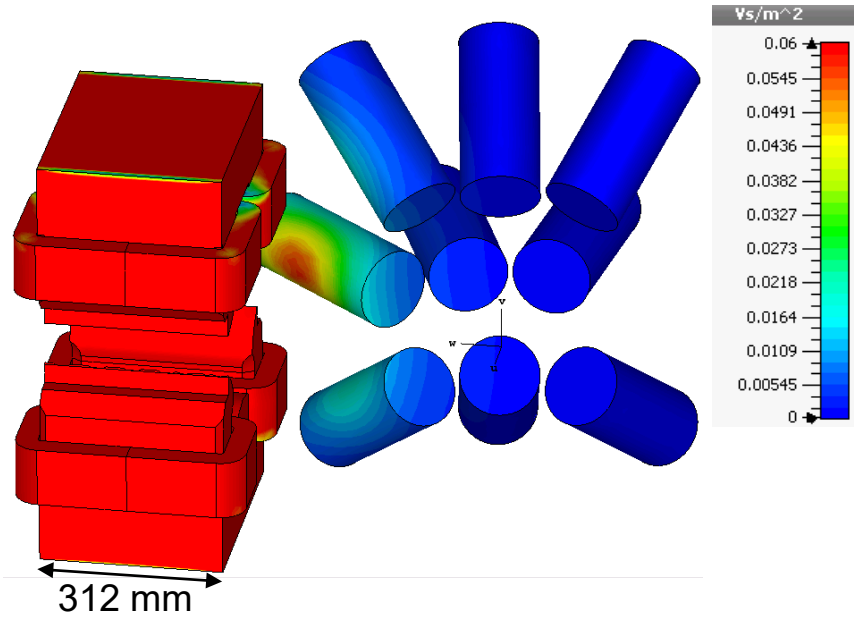
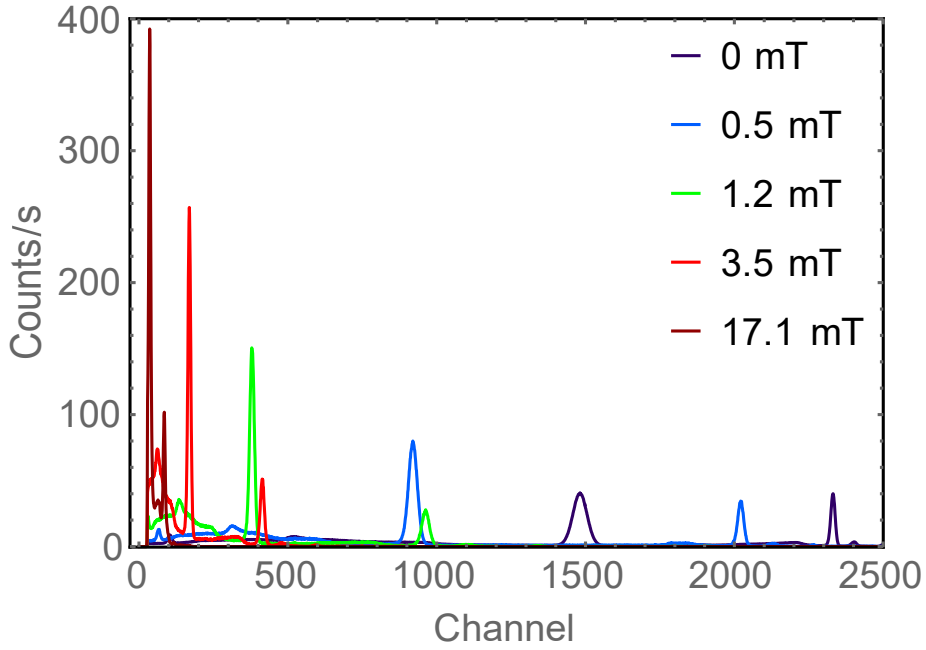
- Investigate influence of the quadrupole magnet on the PMT's
- B-field simulation using CST: B_{max}=57 mT
- Test of the influence with permanent magnet
- We have to use μ metal





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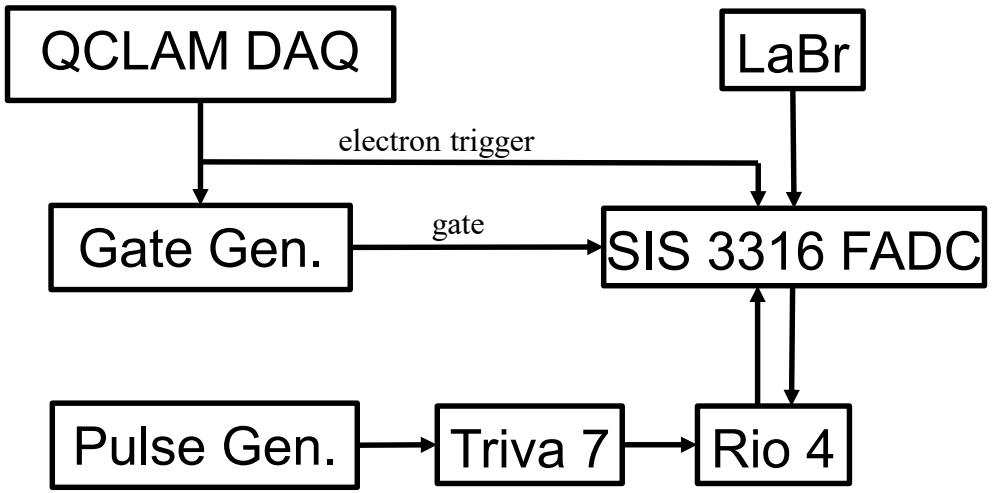
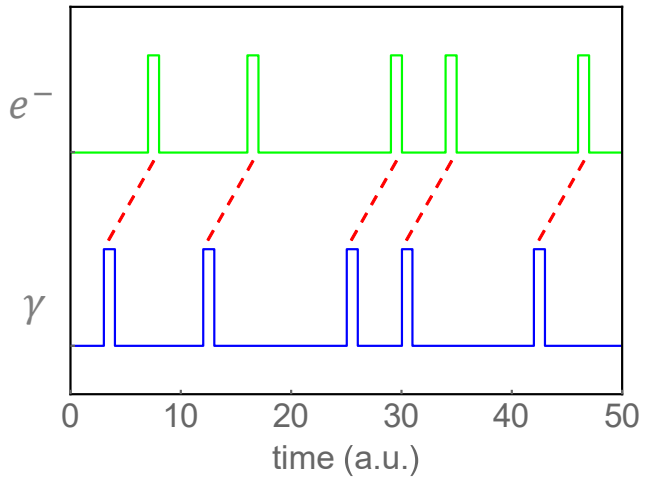
(e,e'γ) Data Acquisition

- Modified DAQ from Galatea
- Assign e to γ by comparison of trigger patterns
- Tested in Lab
- Time resolution of SIS 3316: 160 ps
- Time of flight correction





(e,e′γ) First Experiment

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- Commissioning experiment at QCLAM on ^{12}C (30 mg/cm²)
- Beam: 70 MeV, 1µA
- Scattering angle: 47.5°

- Estimated measure time (e,e′γ) :
  - Rotated angular distribution of the γ-decay of 2_1^+ at 4.438 MeV
    ~ 0.06 Counts per Second → 5 200 Counts per day
  - Gamma decay transition from the 1^- at 15.1 MeV to the ground state
    ~ 0.02 Counts per Second → 1 500 Counts per day

  - For 10 000 Counts we need one week

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Review / Status

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- QCLAM height adjustment
- Cameras
- Vacuum system/pumps
- Beam line adjustment
- Targets for beam monitoring
- Improved slide rail for drift chambers
- New power supplies for magnets
- New cables water/electric
- CST Simulation of QCLAM

⋮

- Ball chamber vacuum test
- Target ladder
- Step motor for target ladder
- New beam pipes for the ball chamber
- Gamma-DAQ modification and test
- Designing and optimizing LaBr detector array
- Magnetic field influence on LaBr PMT‘s

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Review / Status

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- QCLAM almost ready for tests
- Scraper chicane is ready for tests
- DAQ ready for tests at Lintott
- Design of detector array almost done

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Preliminary Schedule

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- Mid October 2017 First test of the high energy scraper
- Mid November 2017 ^{12}C at Lintott, first (e,e′γ) DAQ test
- November 2017 Beam at QCLAM spectrometer for tests
- December 2017 – April 2018 Accelerator shut down
  During winter shut down:
  - Build a lead wall between beam dump and detector array
  - Analyze data from ^{12}C measurement at Lintott
  - Spring 2018 detector array is ready
- May/June 2018 Commissioning experiment at QCLAM spectrometer ^{12}C

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Summary

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- S-DALINAC is well suited to perform (e,e′γ) coincidence experiments
  - Halo free beam (Scraper)
  - Large acceptance spectrometer (QCLAM)
  - Detectors with excellent time resolution (LaBr)

- Planned experiments
  - Investigate vorticity in ^{92}Zr
  - Gamma branching ratio of the GDR in ^{112,124}Sn

- Commissioning experiment using ^{12}C at QCLAM

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Thank you for your attention!

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