# Jet-ISR Experiment at A1

definitely the attempt to make an almost zero background experiment


**Sören Schlimme**

**A1 Collaboration**
**Institut für Kernphysik**
**JGU Mainz**

*1st official collaboration meeting*
*of the MAGIX-collaboration at MESA*

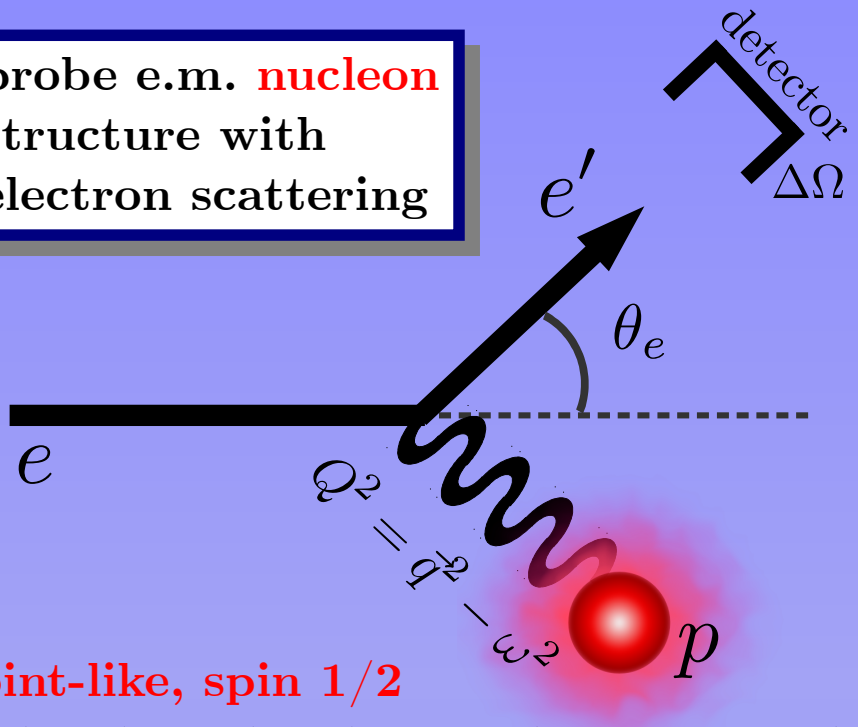
Feb. 15-17, 2017, Mainz

JG|U SFB 1044 THE LOW-ENERGY FRONTIER OF THE STANDARD MODEL mami MAINZER MIKROTRON A1 DFG

- **reminder ISR-2013**
- **planned improvements**
- **challenges**

# Elastic ep -scattering → ISR

**probe e.m. nucleon structure with electron scattering**




**point-like, spin 1/2**

$$\left(\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega_e}\right) = \left(\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega_e}\right)_{\mathrm{Mott}} \cdot \left(1 + 2\tau \tan^2 \frac{\theta_e}{2}\right)$$

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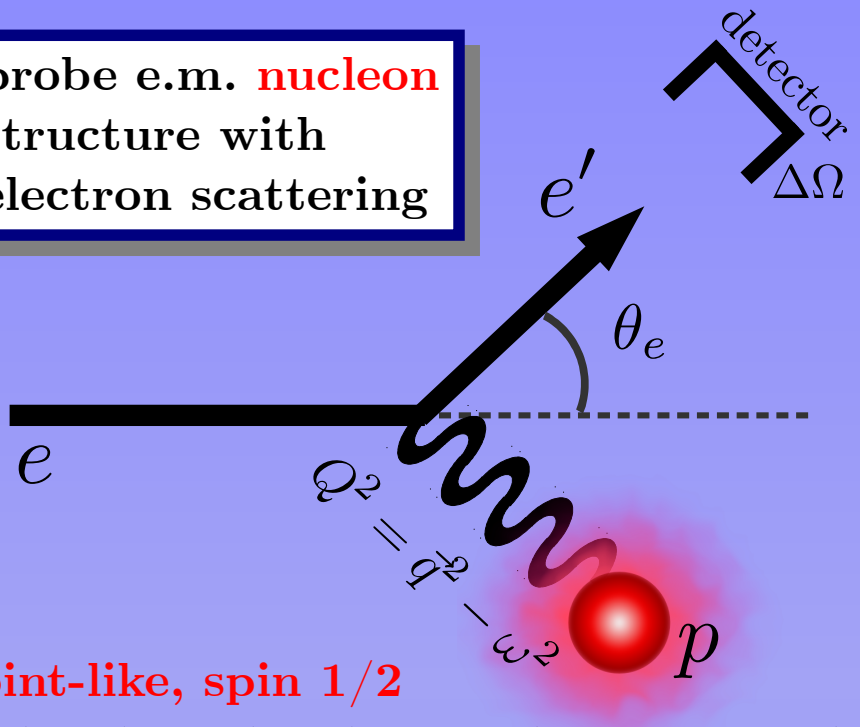


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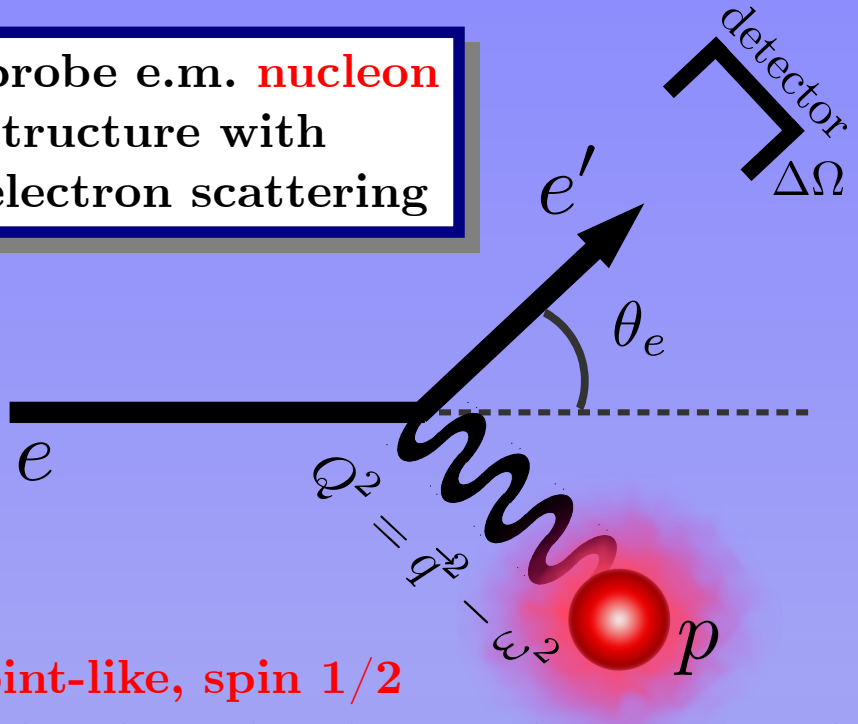


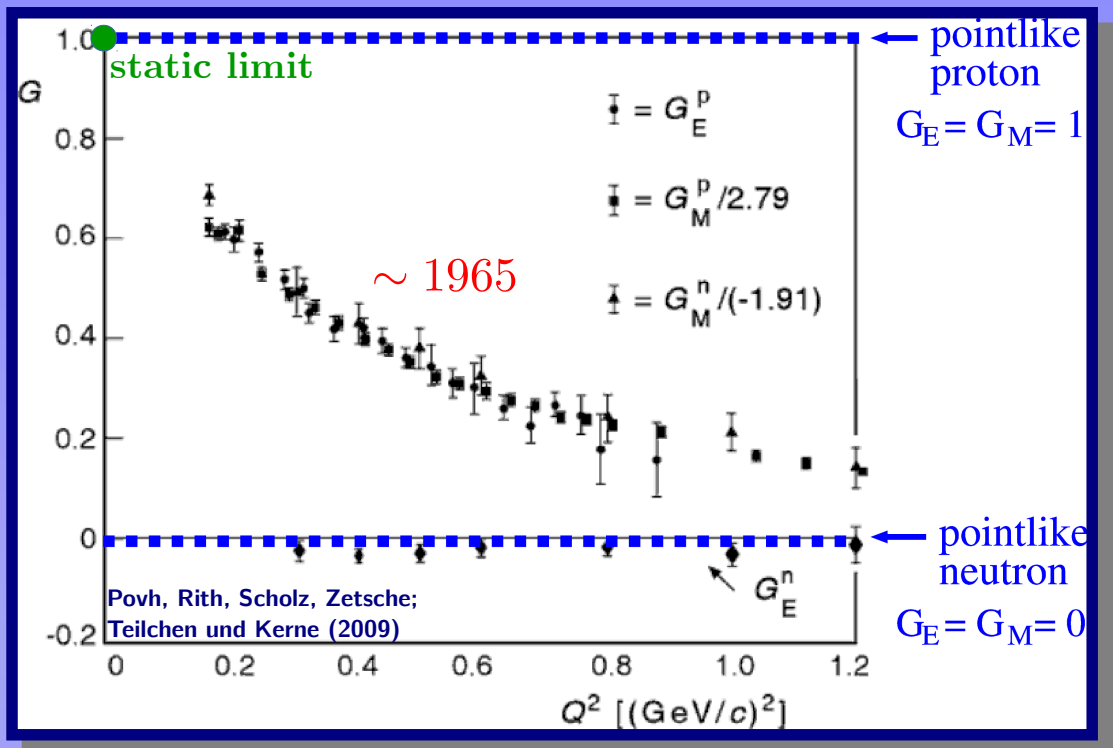


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## radius determination limitations

**extrapolation model**
- systematic studies

**limited Q²-range**
- reduce beam energy
- reduce scattering angle
- different measurement technique

**data unprecise/inaccurate**
- work, work, work

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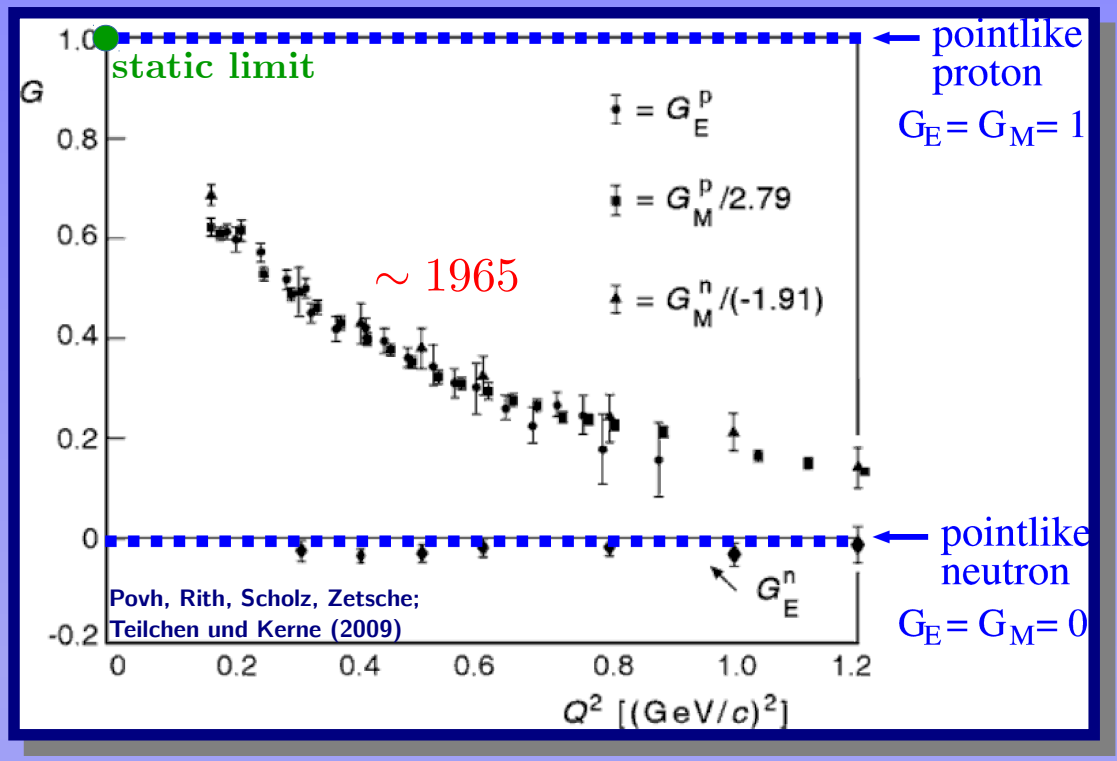


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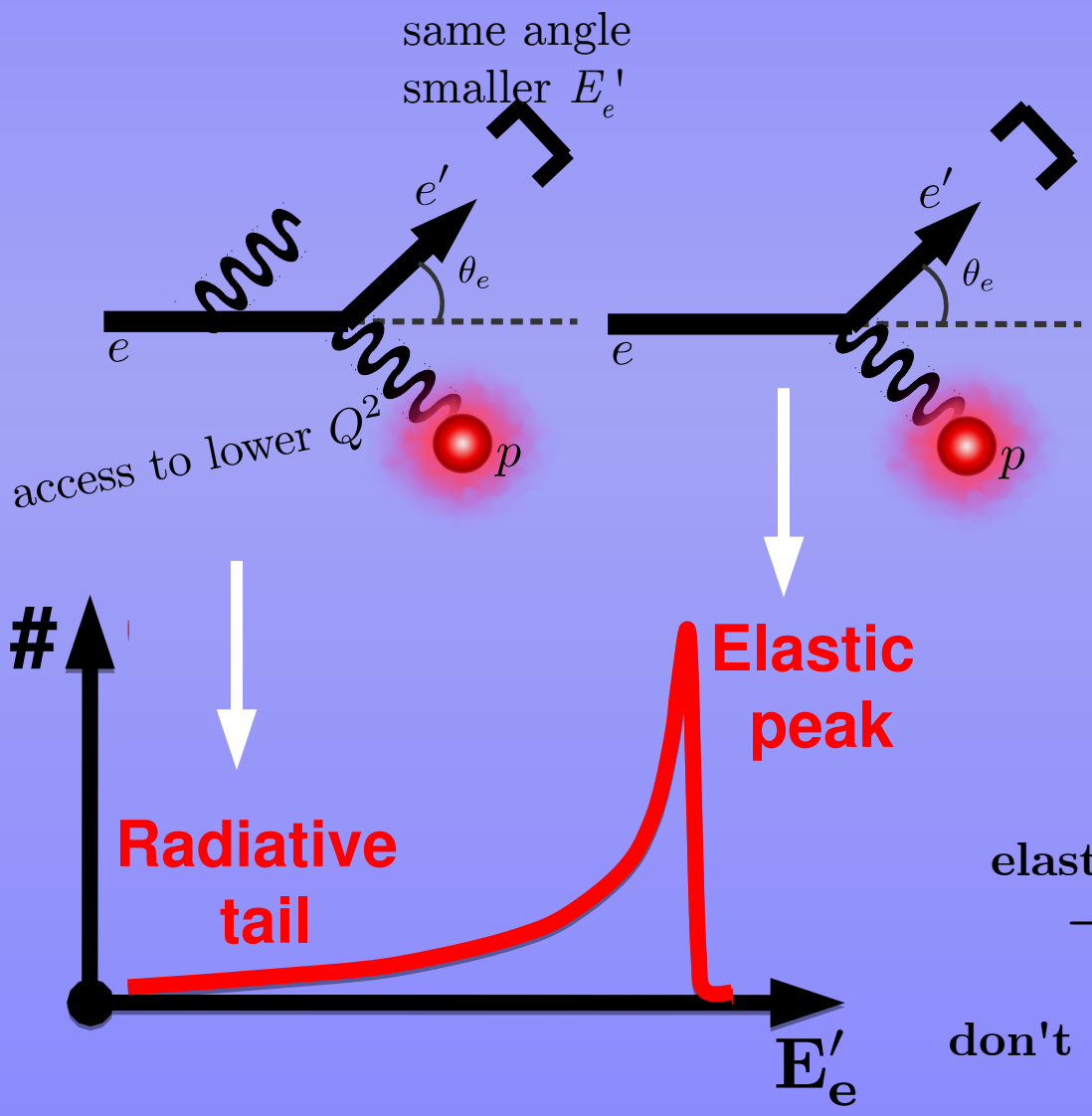
**Initial State Radiation Technique**

**Probe $G_E$ at reduced $Q^2$**

details: Mihas presentation

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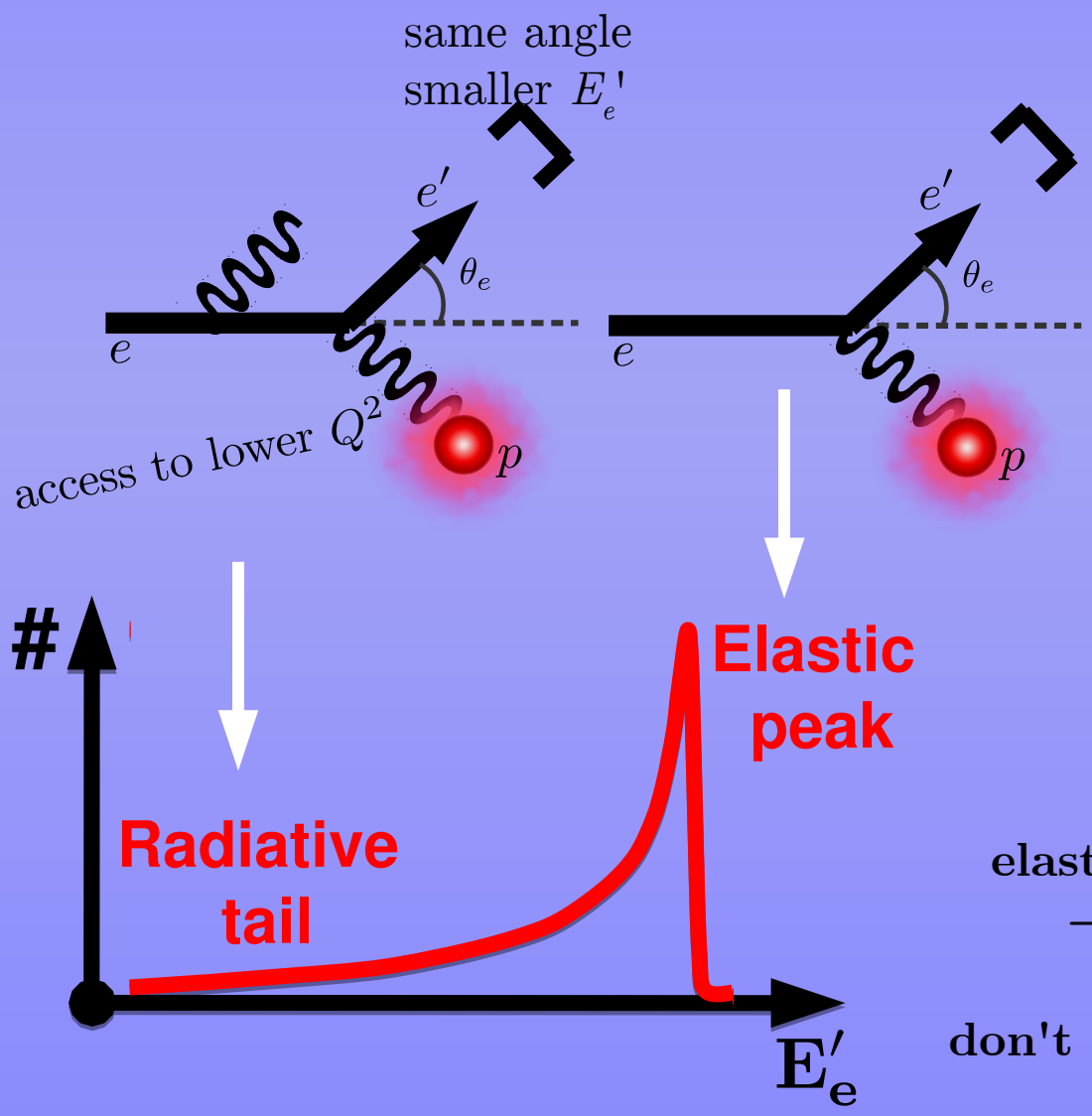
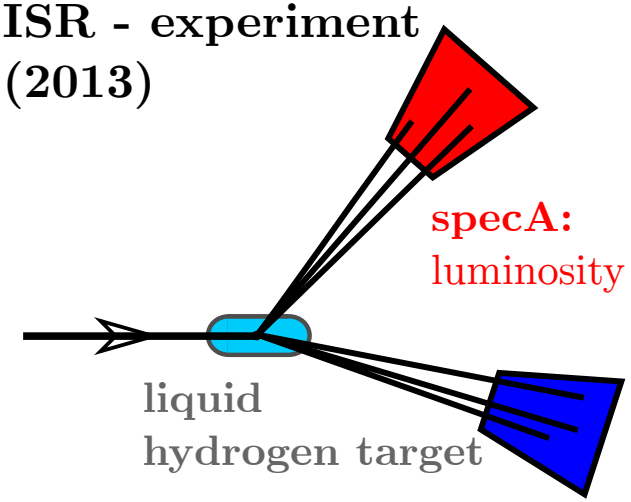



**ISR - experiment (2013)**

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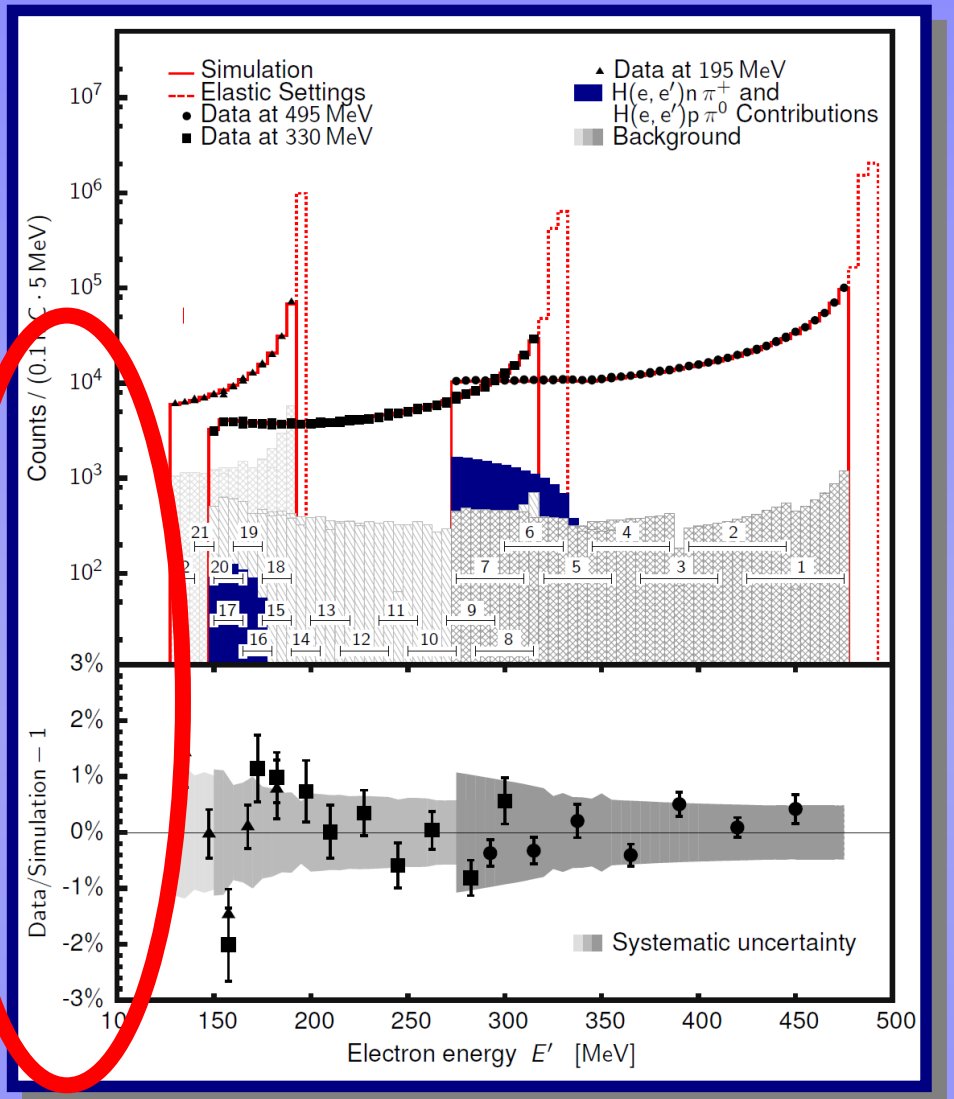
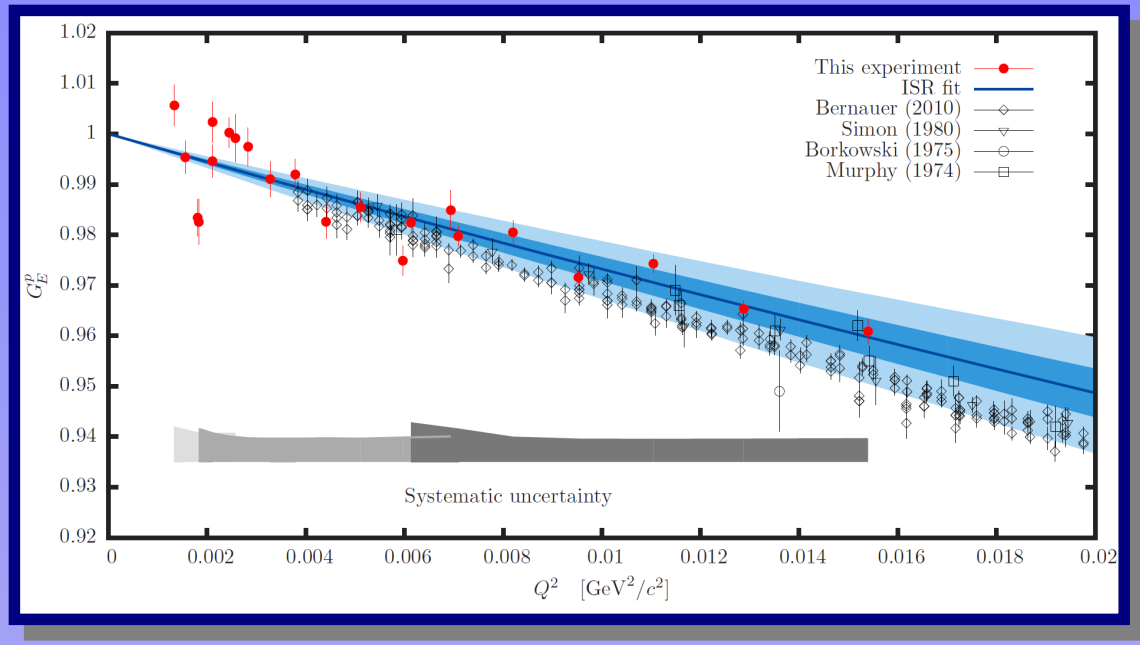



lowest $Q^2$ settings lost
due to huge background

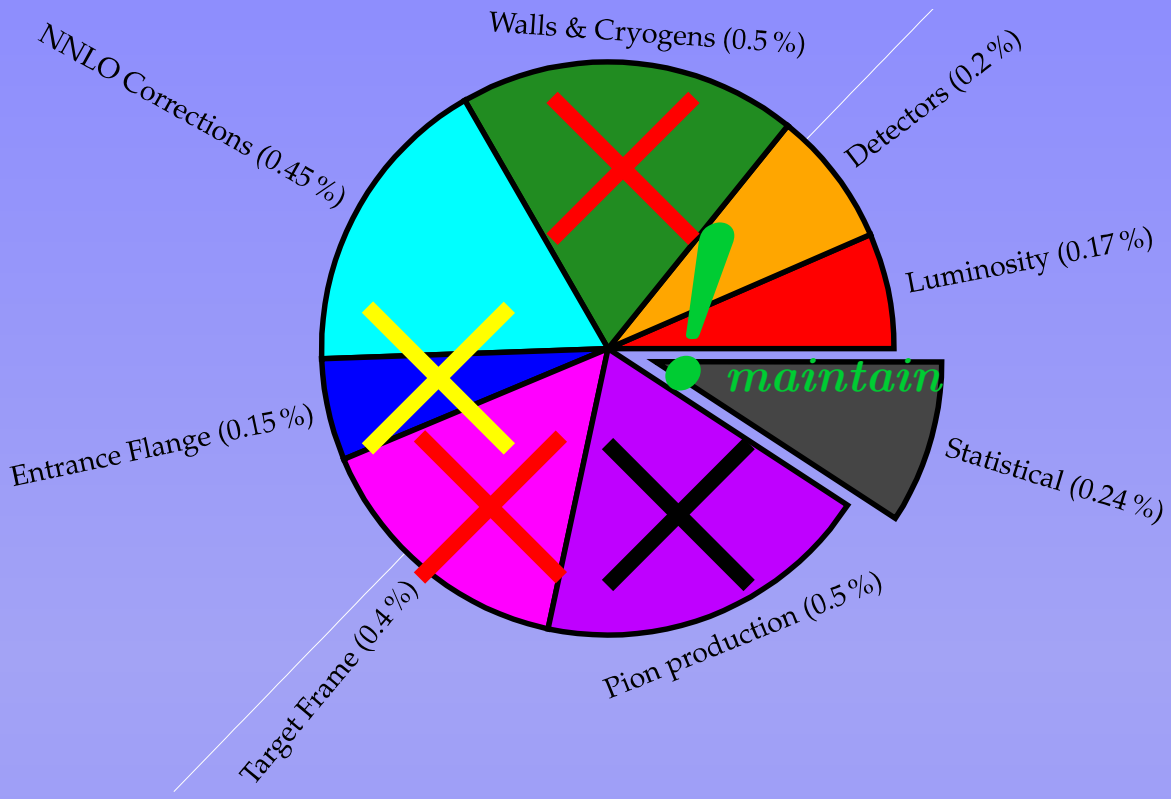
## ISR - goals

- Precisely Extract $G_E$
- compare with elastic ep
  - test description radiative tail
- evaluate $G_E$ very low $Q^2$
  - precise radius extraction

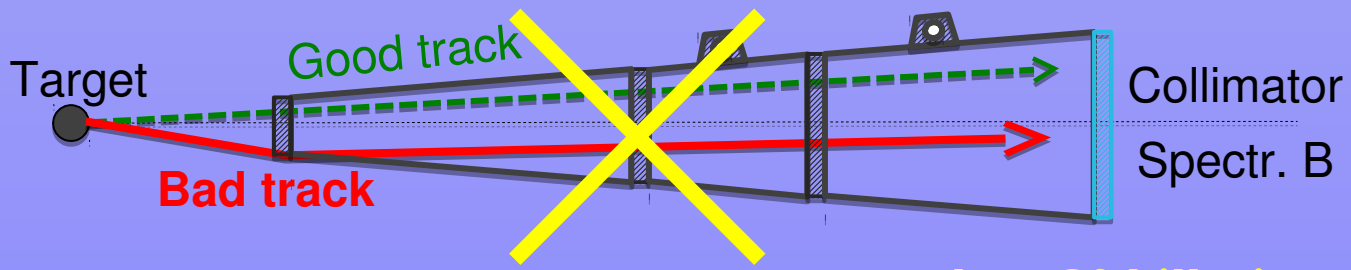
## Redo experiment

- similar measurements / kinematics
- improved setup

# ISR 2013 → ISR 2017



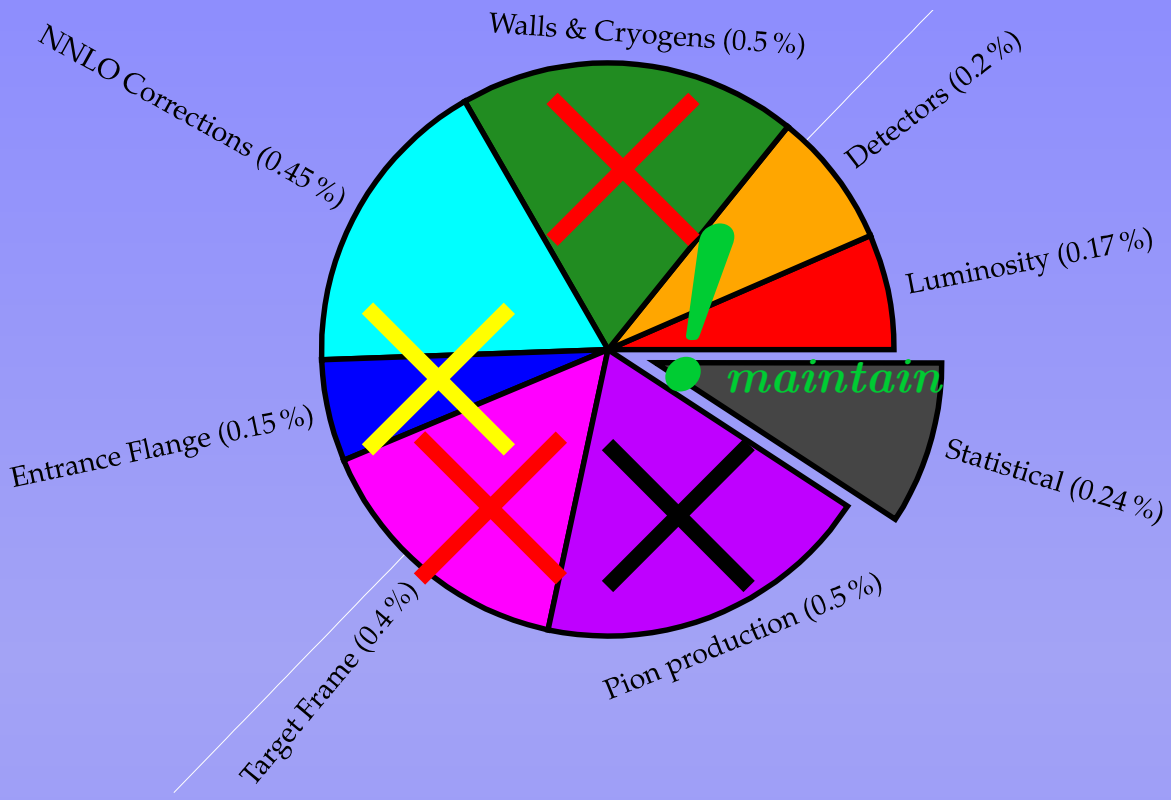

**Total systematic uncertainty of cross-section ≤ 1.0 %**




**low $Q^2$-killer!**

- ~~bigger entrance~~
- ~~air gap~~
- helium balloon ($X_0^{He} = 570$ km) + foils

# ISR 2013 → ISR 2017

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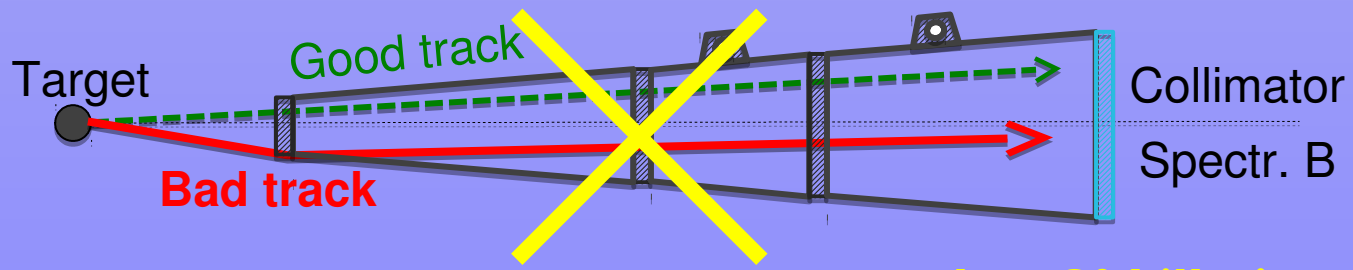


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$\Delta E' \geq$ ~~Pionthreshold~~

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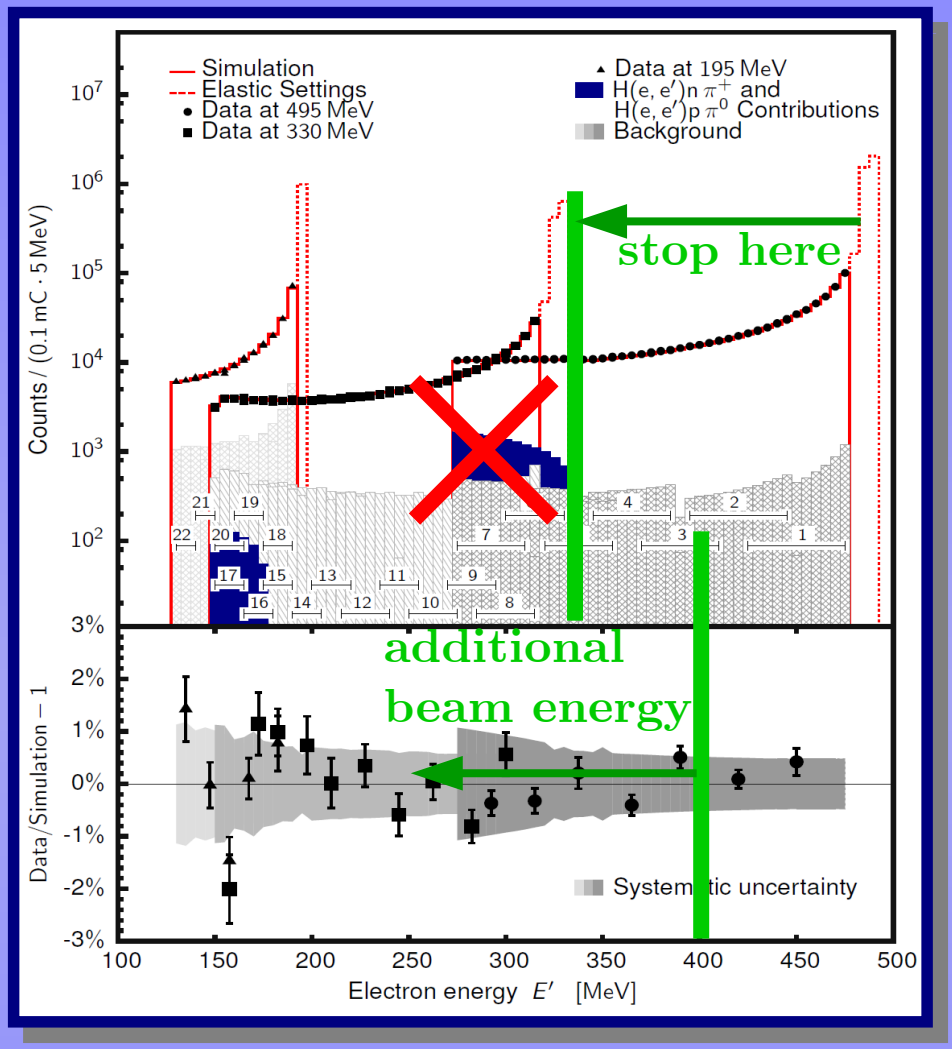
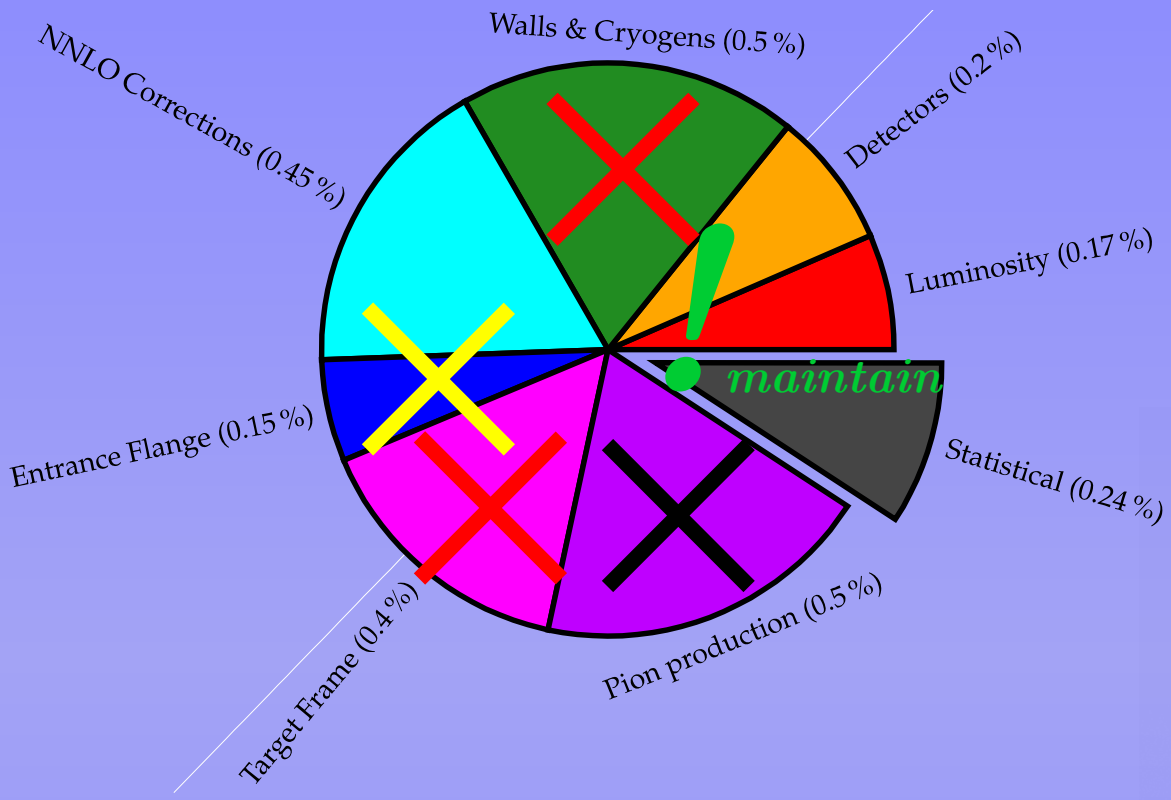



- no more than 150 MeV off peak
- additional $E_{beam} \approx 400$ MeV
  to maintain overlapping data
  → test ISR method

$\Delta E' \geq$ Pionthreshold

# ISR 2013 → ISR 2017

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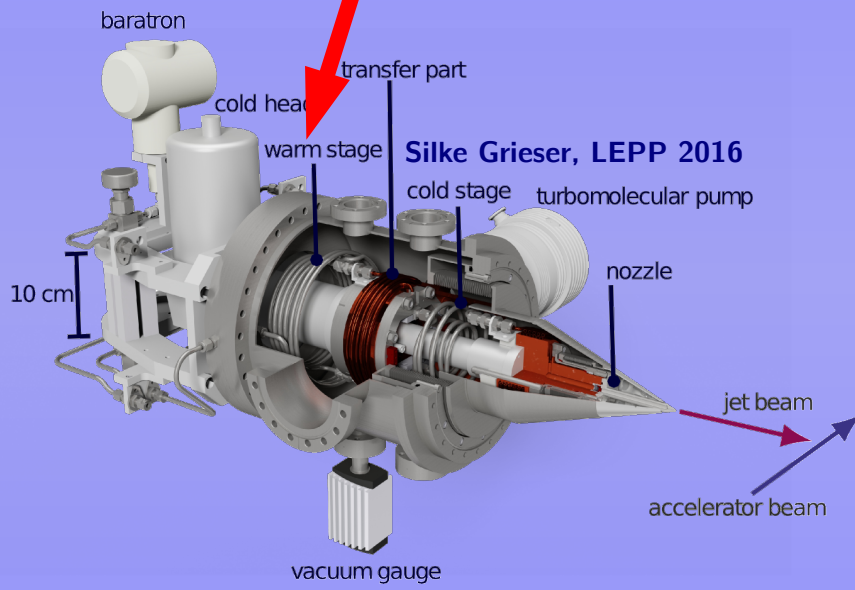


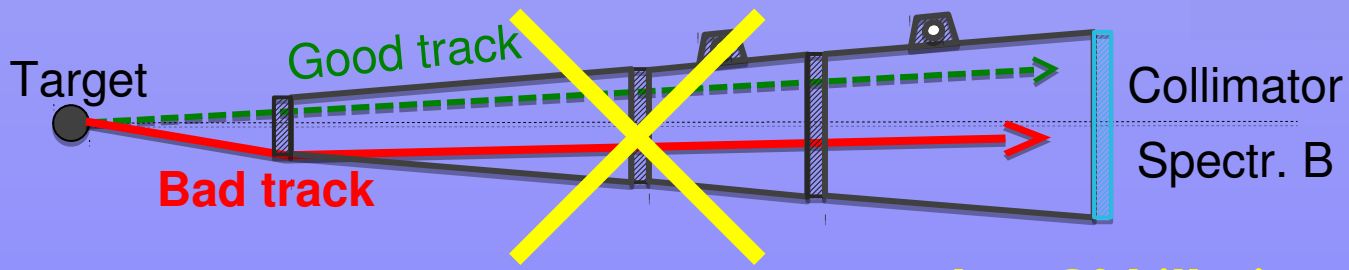


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# ISR 2013 → ISR 2017

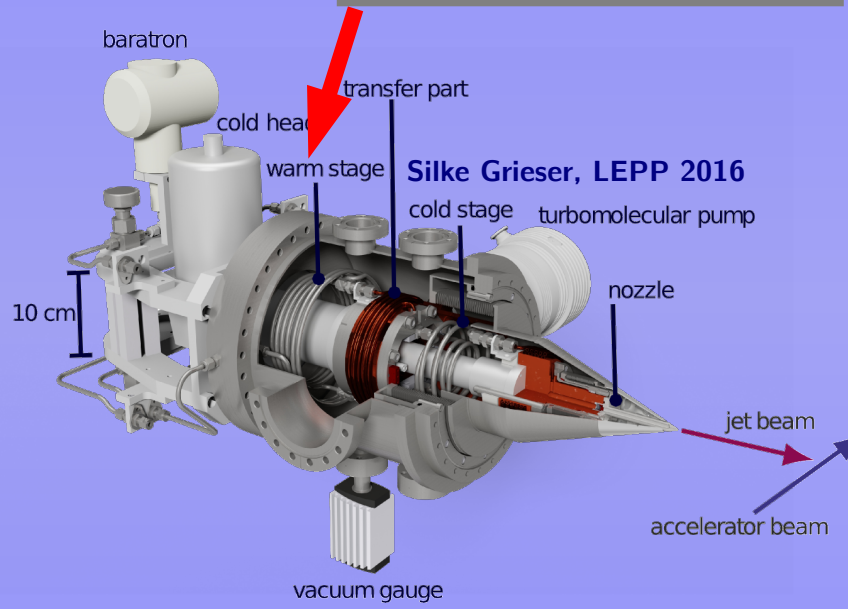
## Benefits Jet-Target

- no background
  - Havar foil
  - cryogenic depositions
  - target frame (!?)
- small effects
  - external radiation
  - multiple scattering
  - ionization loss
- no extended target issues

## Challenges

- fail-safe beam pos. stability
- luminosity determination / monitoring
- drastically reduced target thickness

$$\frac{70\,\mathrm{mg/cm^3}}{0.1\,\mathrm{mg/cm^3}} \cdot \frac{50\,\mathrm{mm}}{2\,\mathrm{mm}} = 17500$$



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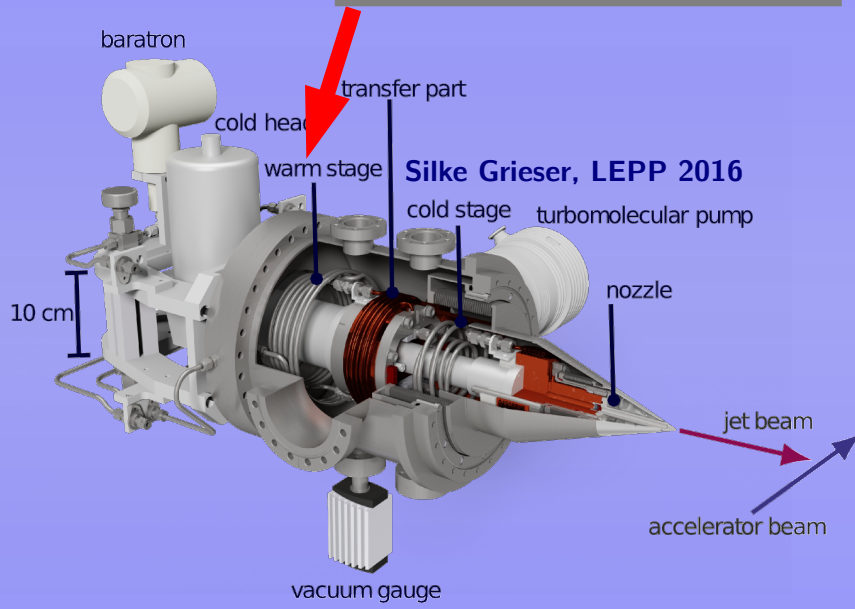



***Save Our Statistics***

$2 \times 5$ no brutal analysis cuts (target + snout)

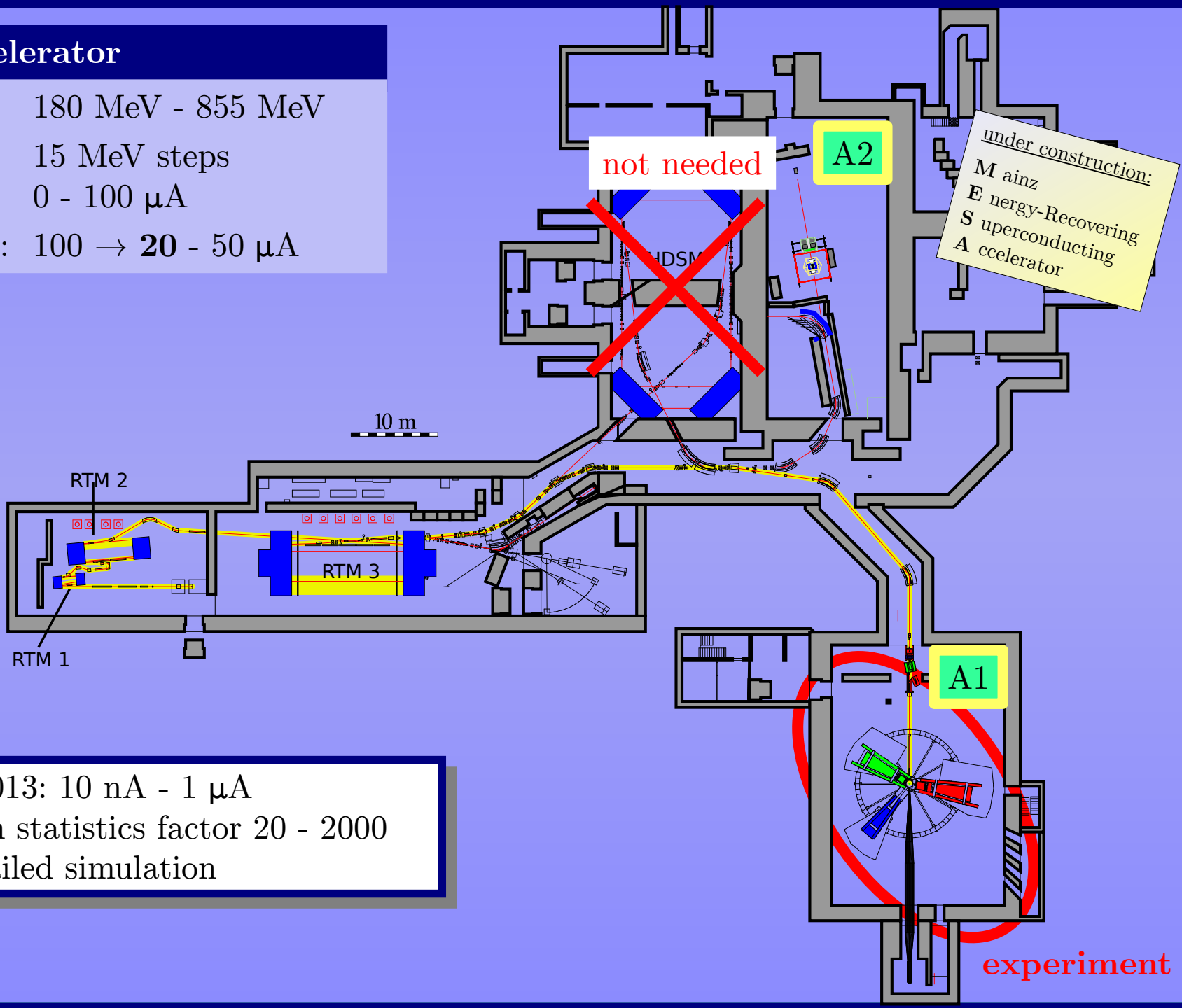
no empty cell runs (hopefully)

**Still 1750 to go... beam intensity?**

# MAMI electron accelerator

## cw electron accelerator

- $E_{beam}$ (MamiB): 180 MeV - 855 MeV
  15 MeV steps
- $I_{beam}$: 0 - 100 µA
  stable operation: 100 → **20** - 50 µA

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⇒ gain statistics factor 20 - 2000
detailed simulation

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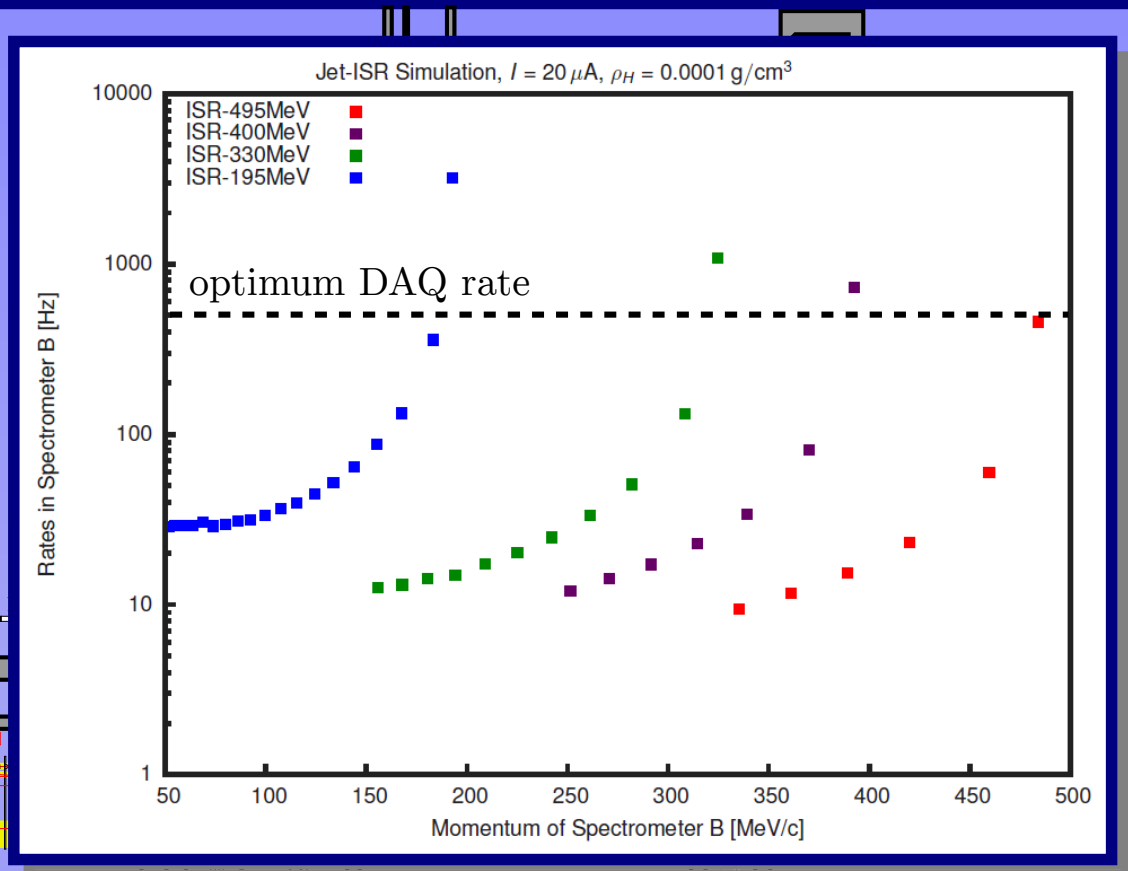


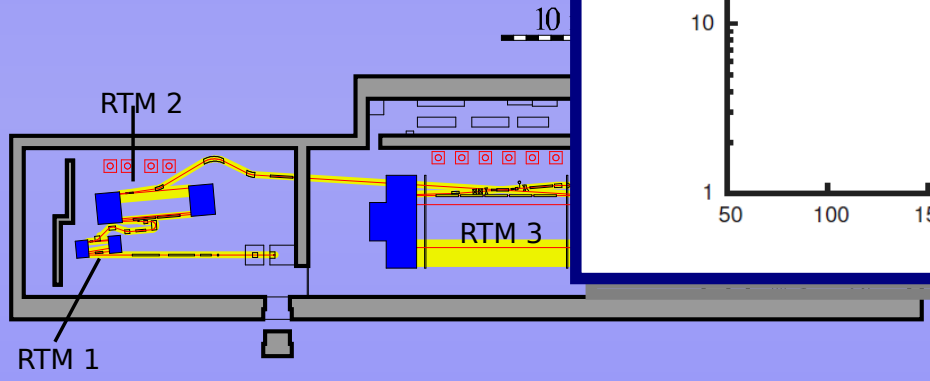


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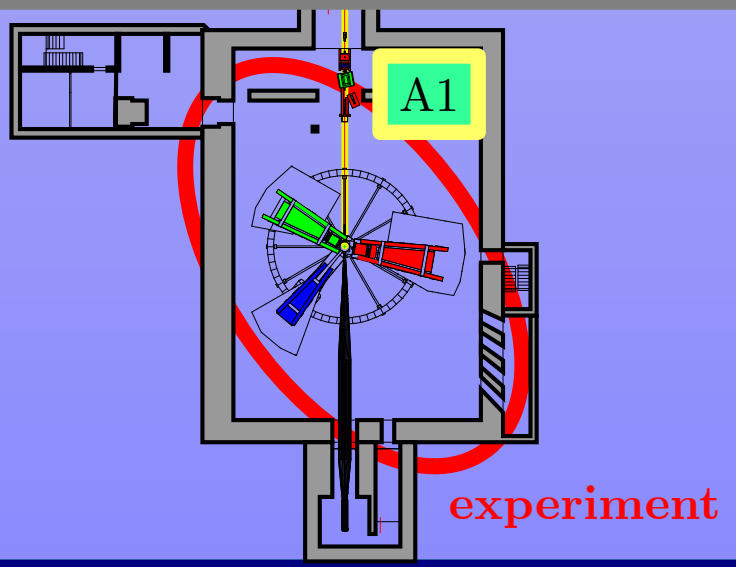
- rates spekB low
- rates spekA (lumi monitor)
  too low: 50° → 25° ⇒ $10^2$-$10^3$ Hz

→ suboptimal, but feasible



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## beam energies

- 180 MeV
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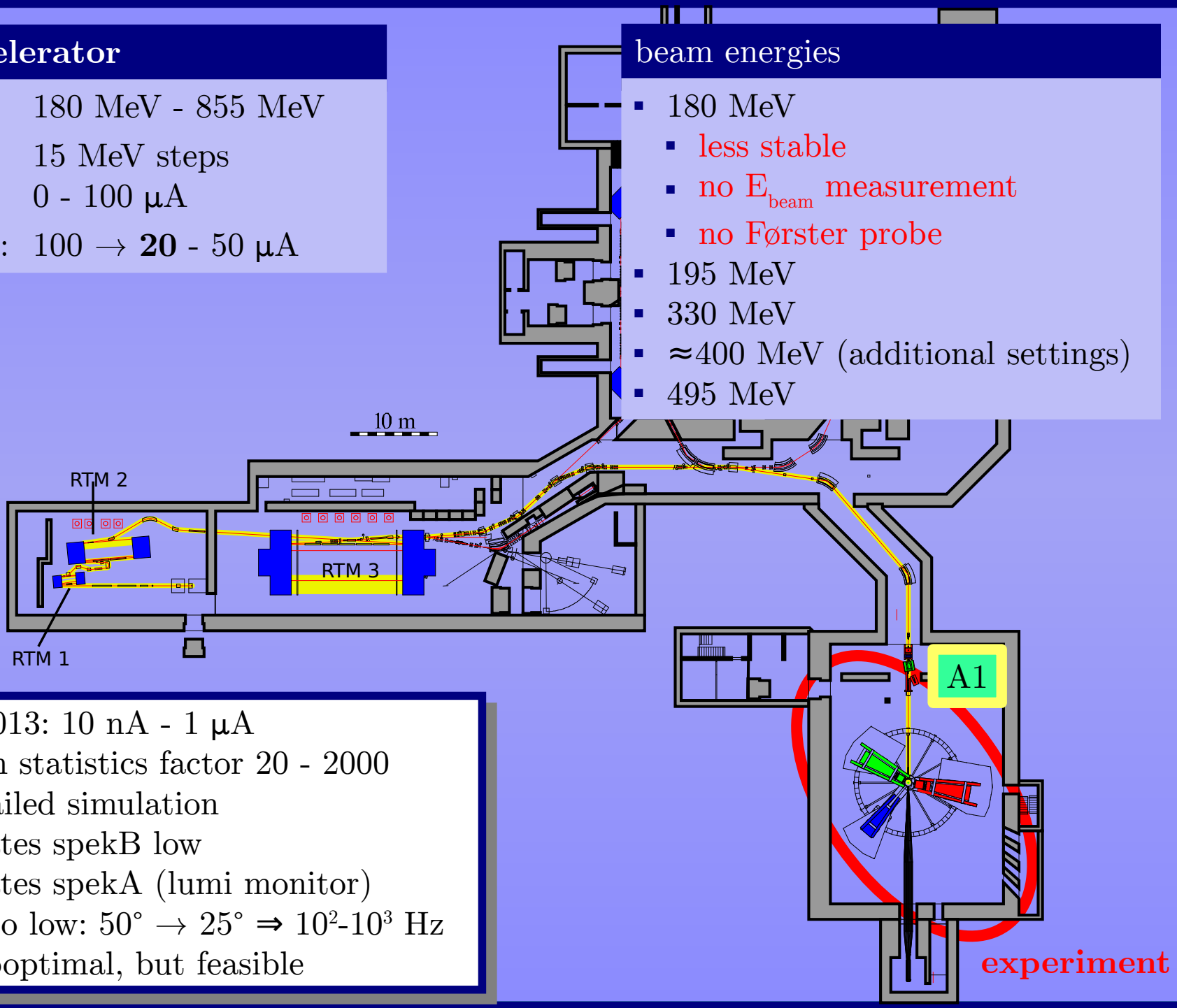
  - no $E_{beam}$ measurement
  - no Førster probe
- 195 MeV
- 330 MeV
- ≈400 MeV (additional settings)
- 495 MeV

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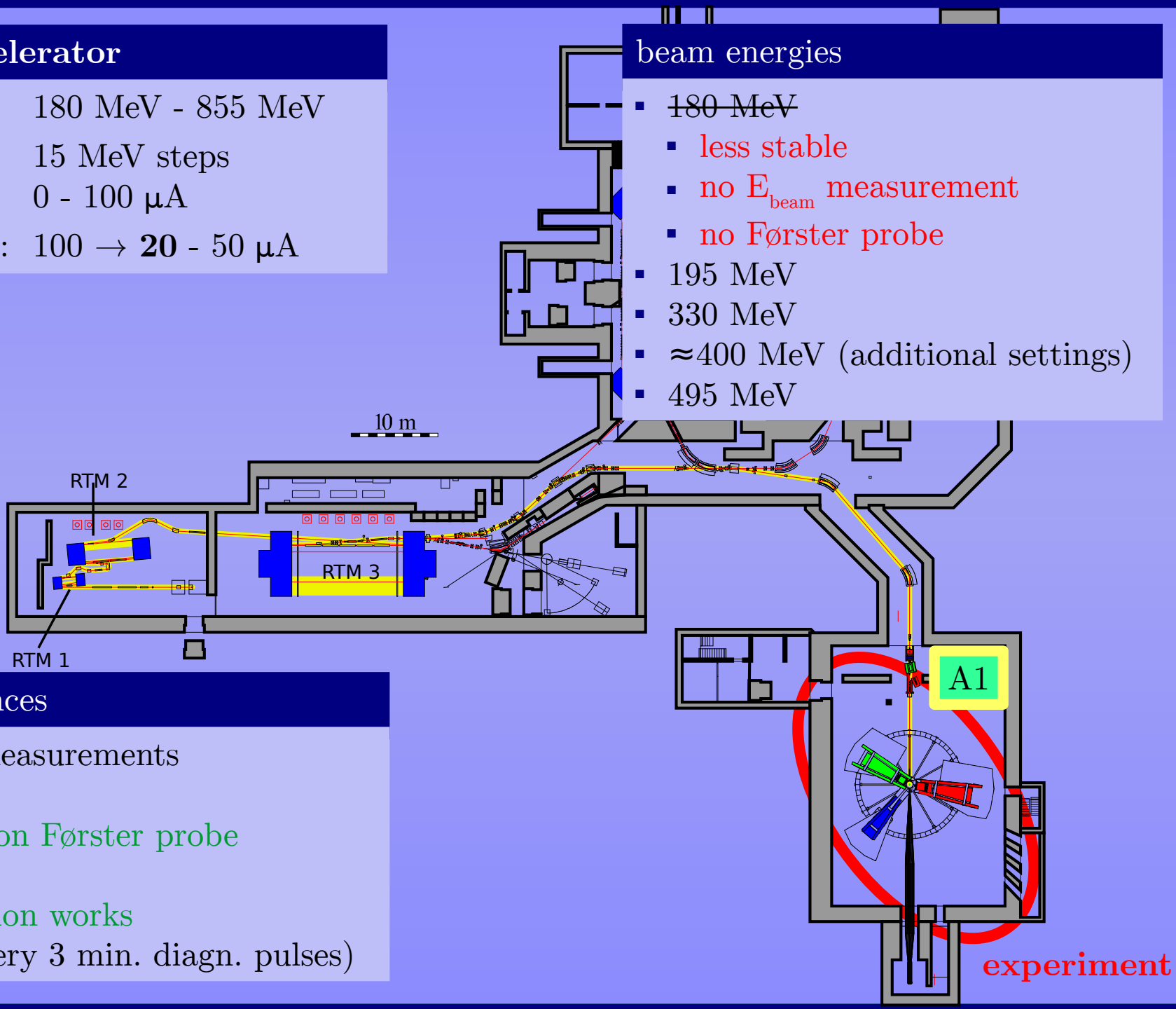
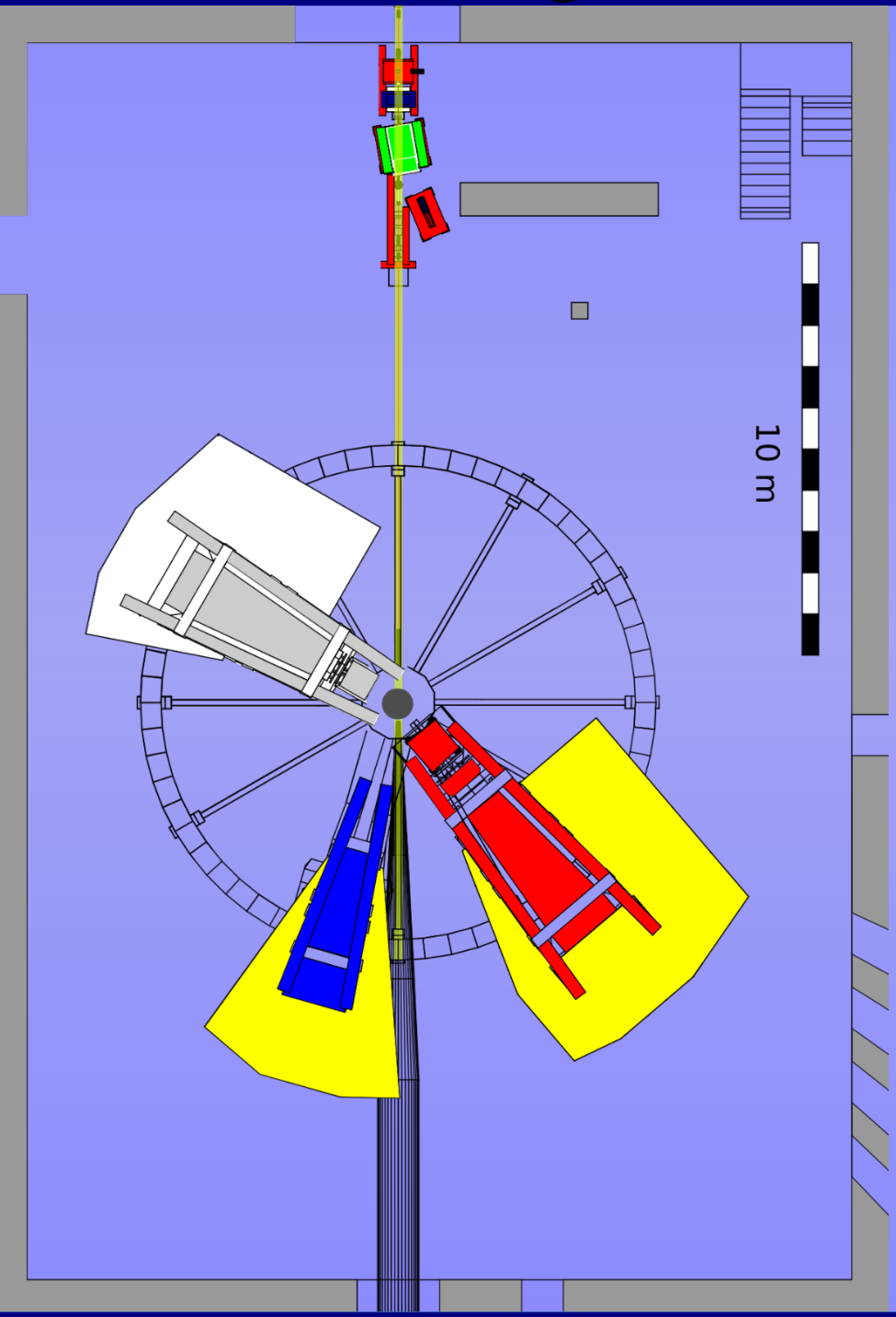



## 20 µA - consequences

- beam current measurements
  - no pA-meter
  - higher precision Førster probe
- beam position
  - DC stabilization works
    (last time: every 3 min. diagn. pulses)

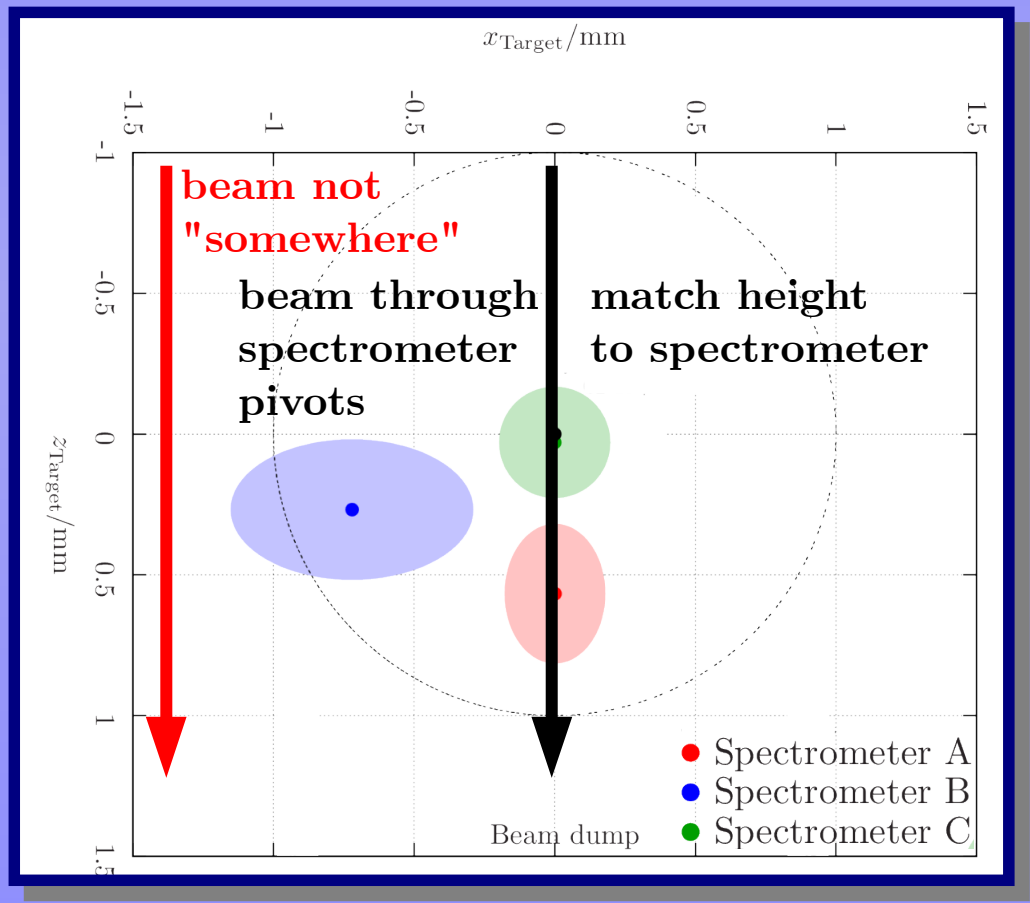
# Geometric alignment




## Beam + target alignment

- cross section: very angle-sensitive
- reconstructed particle momenta
  ↔ beam height

→ beam + target position!



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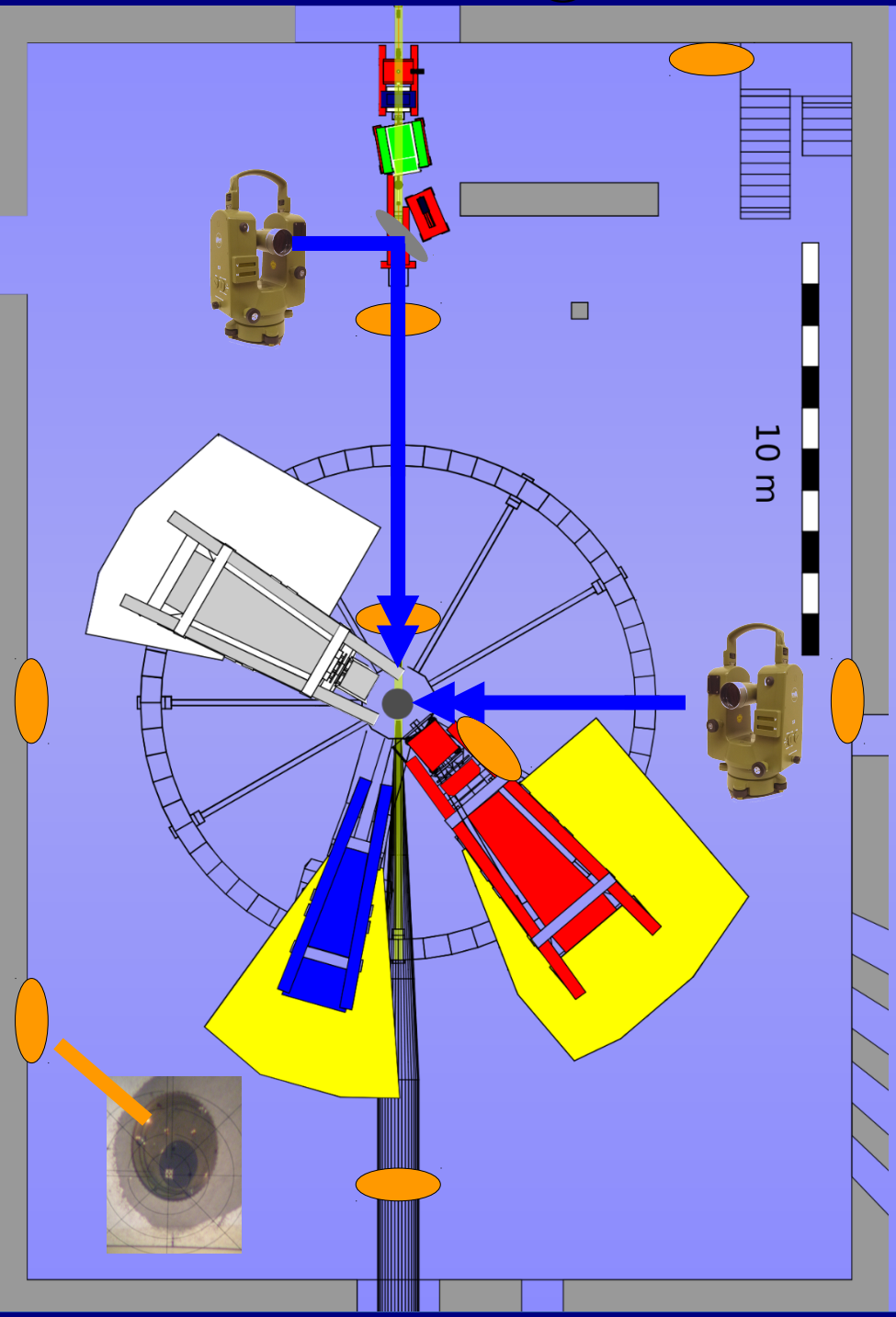


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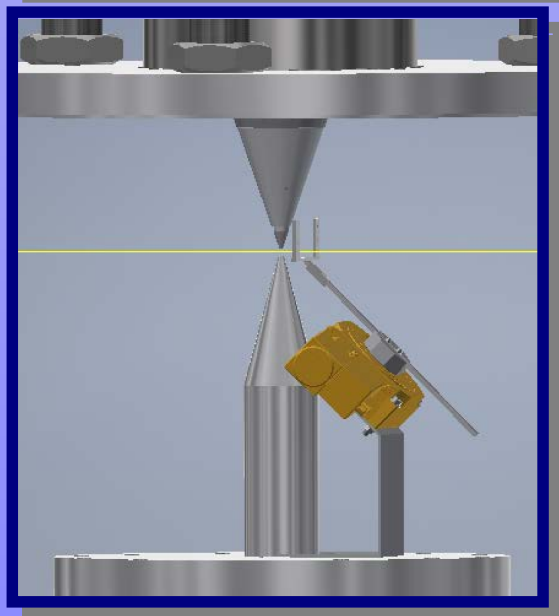
**screen target**

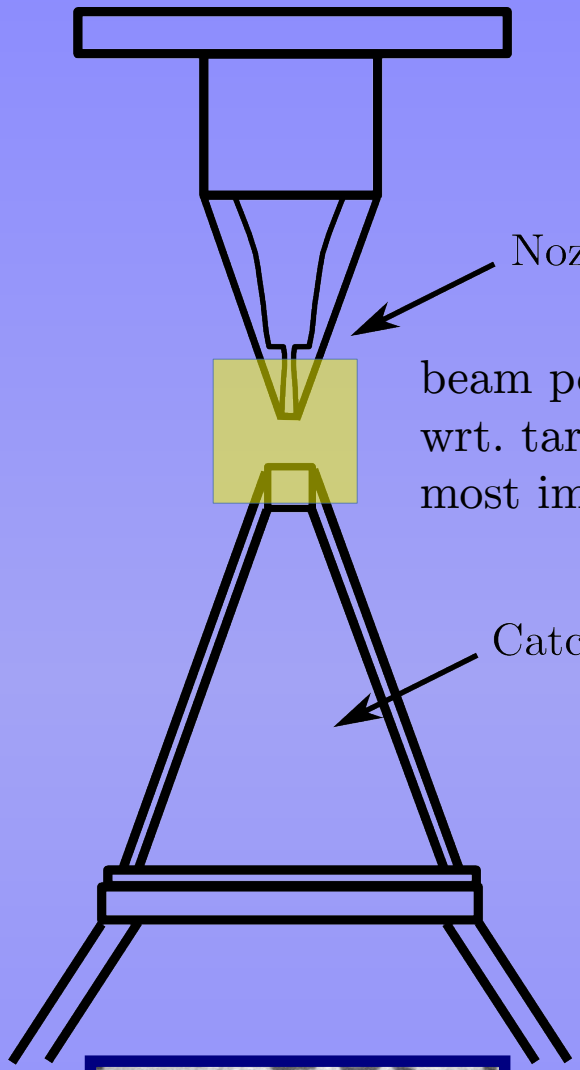
- 15mm before Jet
- well centered (also height)
- use for beam alignment during experiment

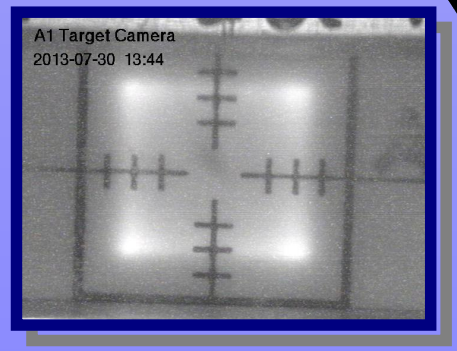


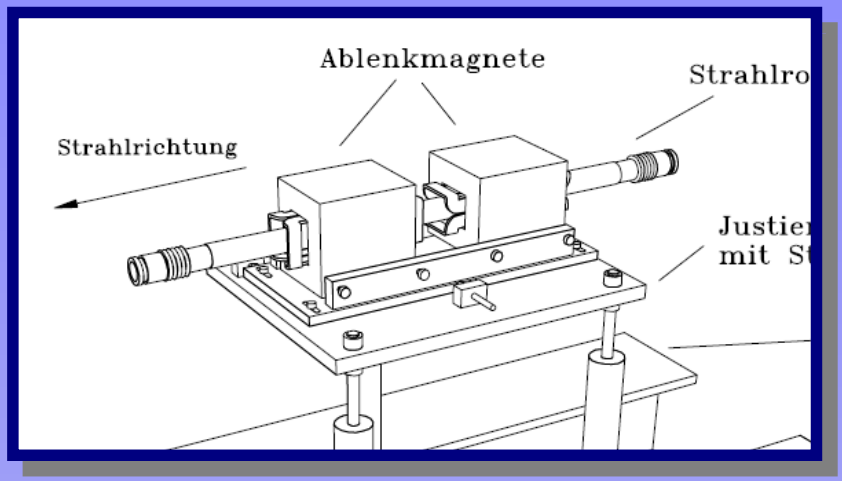
**Jet-Target**

- nozzle + catcher well centered
  - relative
  - absolute

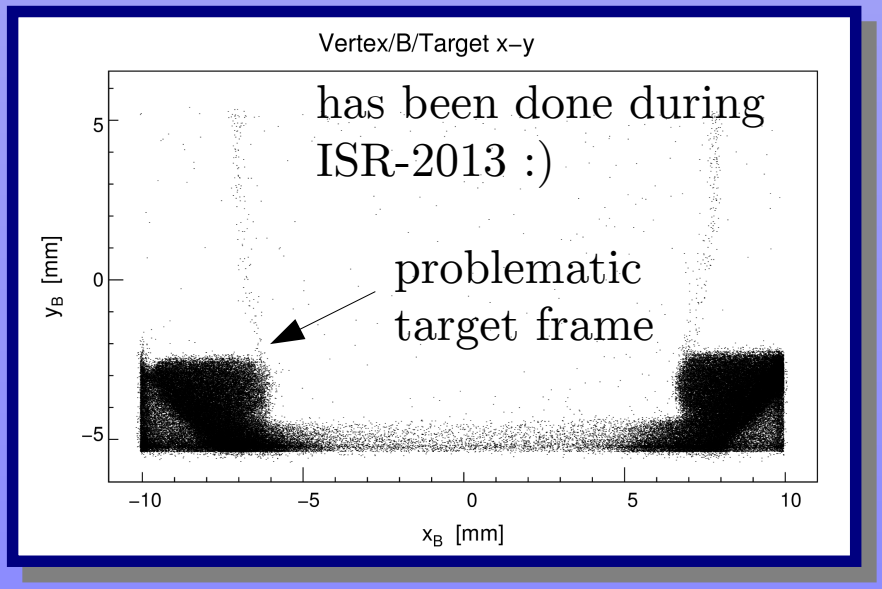
# Double-check alignment with beam




Use wobbler to raster beam
(very low beam current)
look at detector rates



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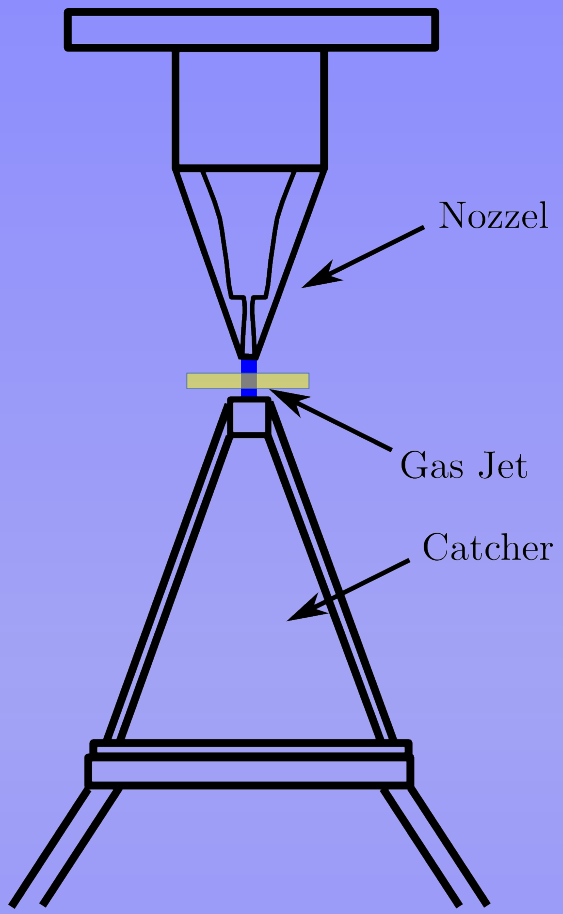


Can even try to measure jet-beam profile

- 1d / 2d
- not along beam direction
  - in principle with spectrometer, but resolution insufficient

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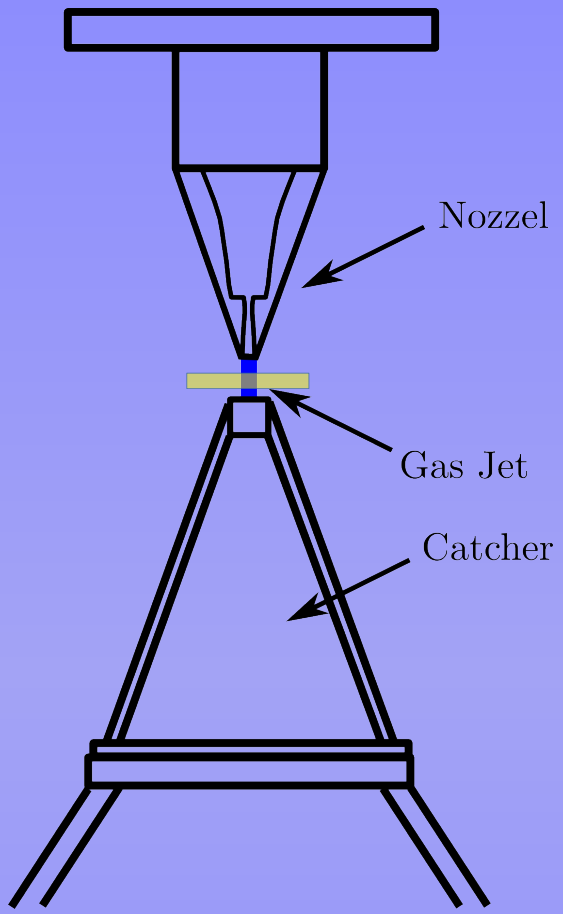


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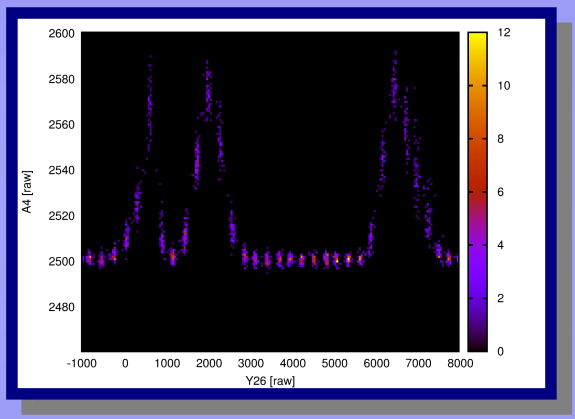
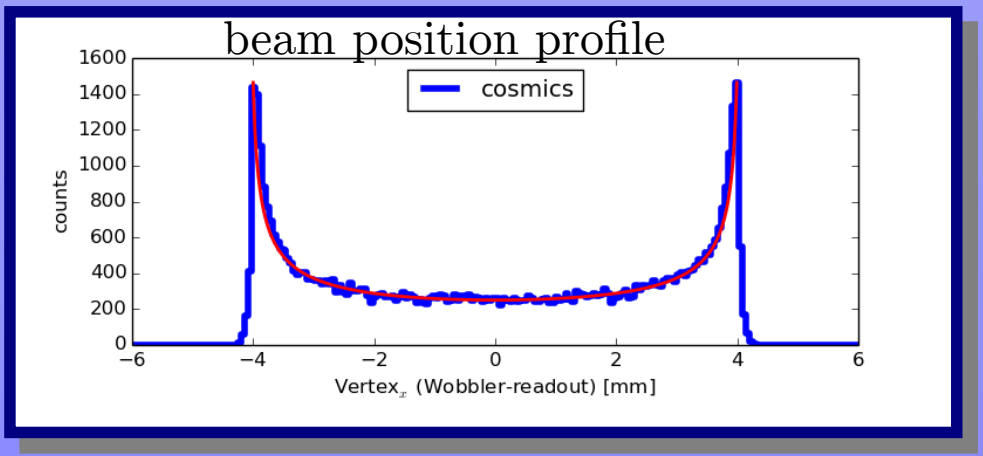
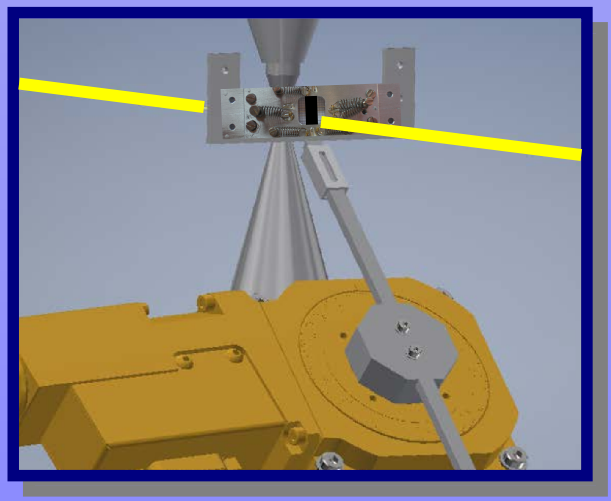
**need control of**

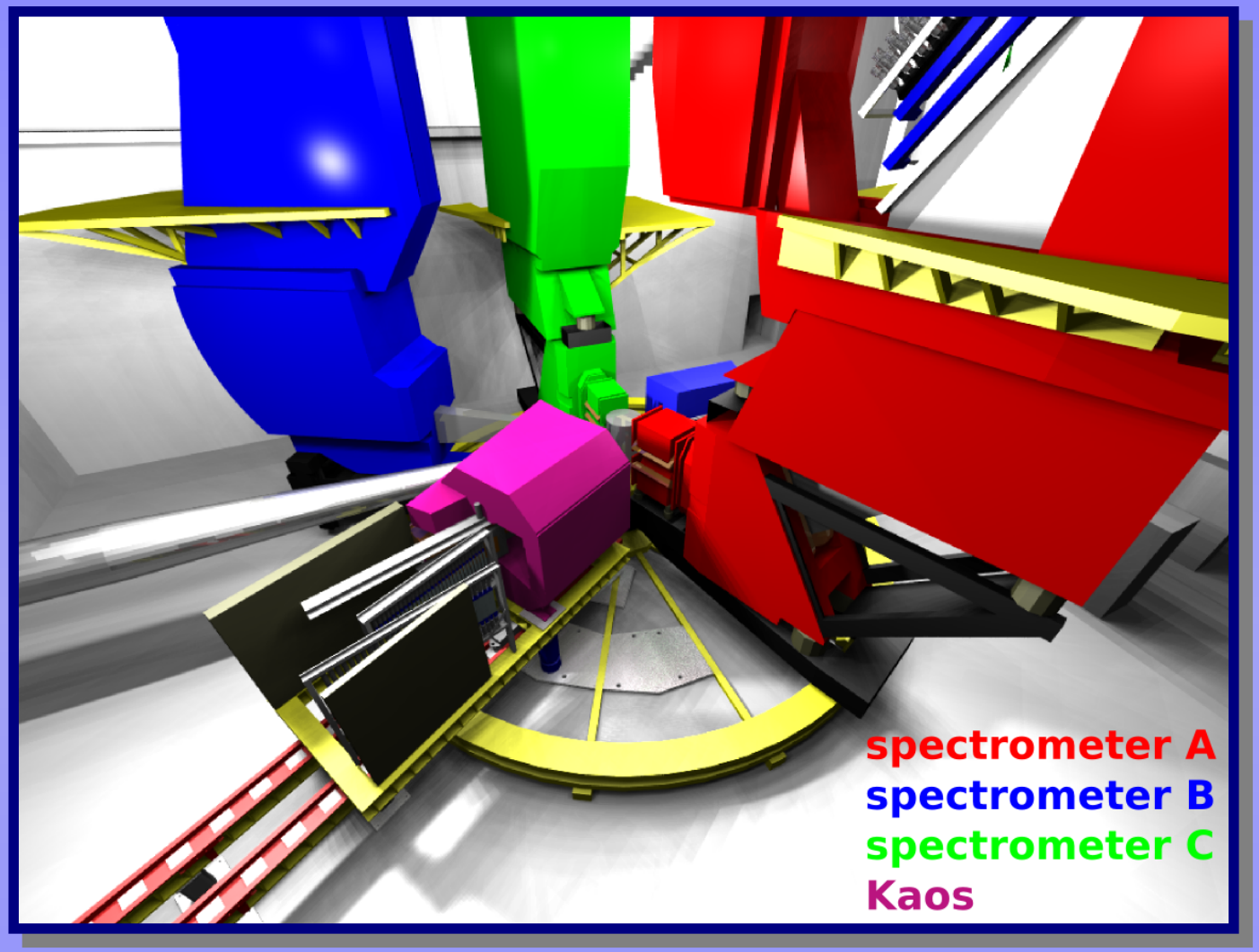
- wobbler calibration
  - wire targets
    - move target
    - step beam
- beam position profile
- beam spot size



# Spectrometer alignment

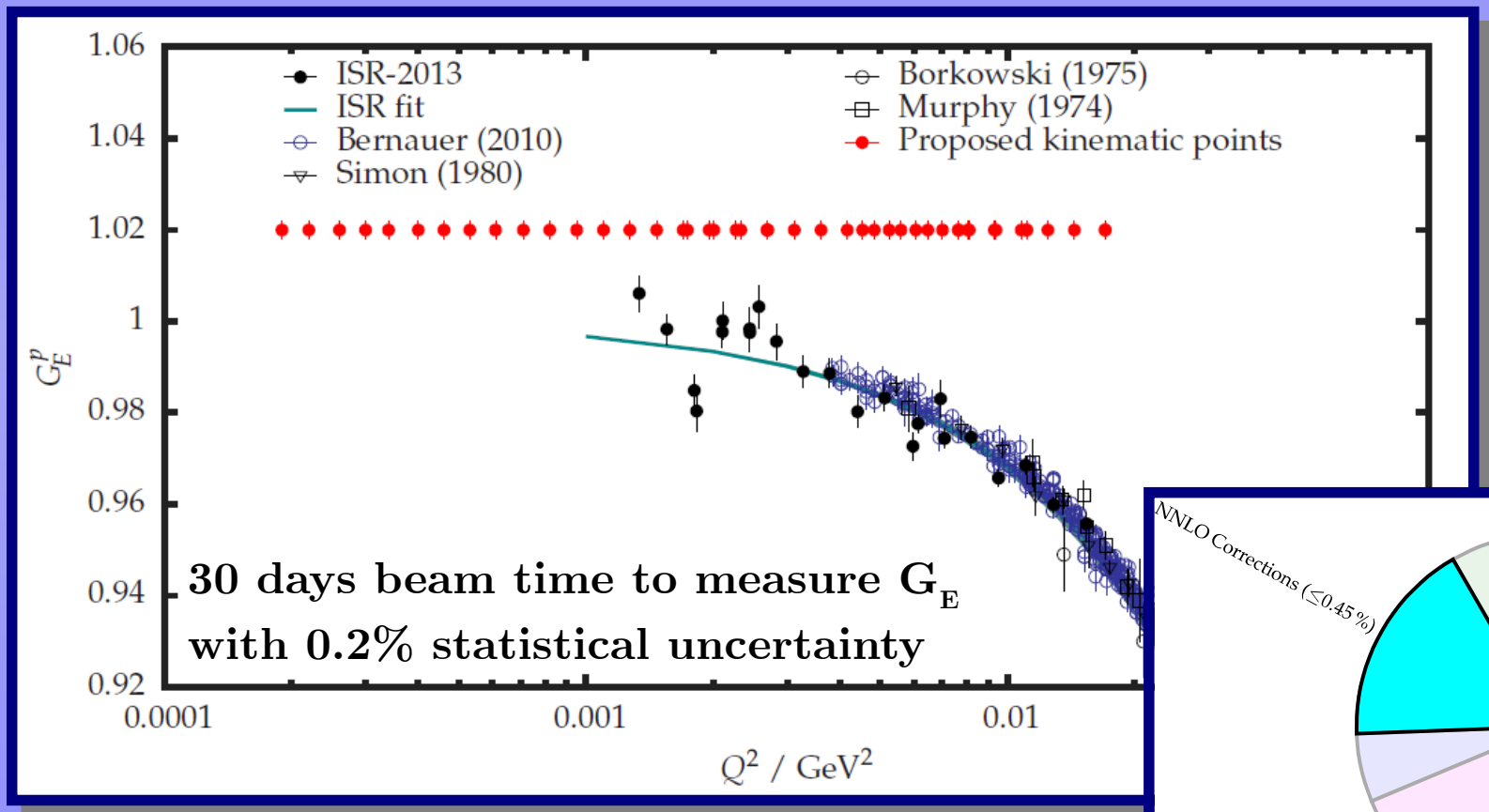


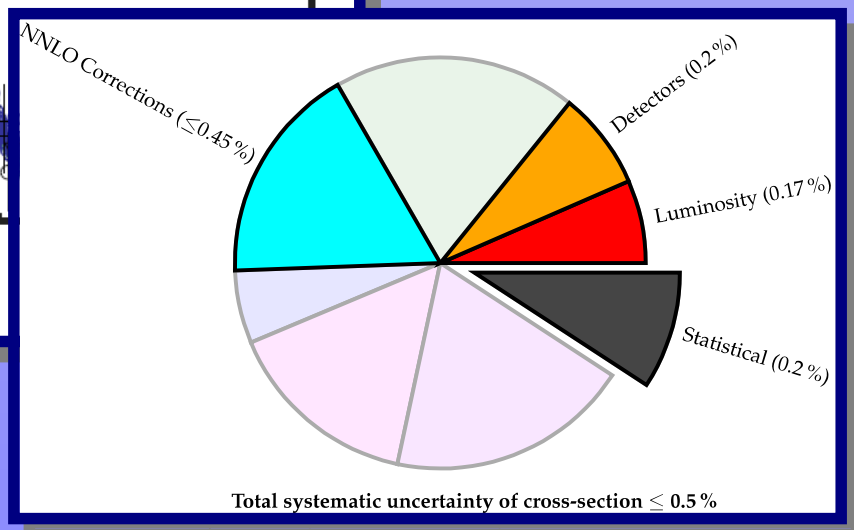

## Spectrometer positioning

- positioning resolution ≈0.013°
- sometimes issues with collimator specB → validate correct position **before** Jet-Target setup!

# Estimated statistical precision + systematics

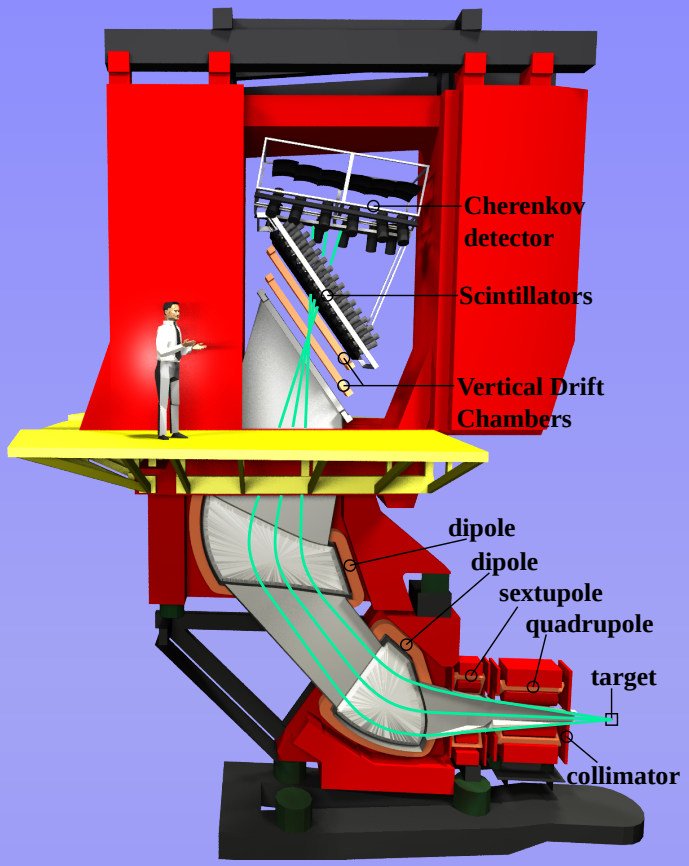
- Measurements will be performed similar to previous experiment
- Despite limited luminosity, high statistical precision seems achievable
- Expected main background from cosmics (several 10 Hz)
  - suppression with Cherenkov detectors




**both spectrometers should perfectly work**

# Calibration runs / systematic checks




## auxiliary measurements

- data without jet-beam (bgr)
- cosmics data
- full Cherenkov-B - acceptance?
  (inefficient corner, irrelevant in 2013 - hard cuts)
- test influence quadrupole A $\rightarrow$ B
  (specA: 50° $\rightarrow$ 25°)
- q.e. scattering carbon target
  - detector calibration specA (specB)
- scintillator efficiency runs
- ....

## spectrometers

- collimators (well-defined acceptance)
- scintillators (trigger)
- VDCs (track reconstruction)
- Cherenkov-detector
  (PID, cosmics suppression)
- well known magnetic properties
  $\rightarrow \theta_0, \phi_0, p, y_0$

| | A | B |
|---|---|---|
| magnets | QSDD | D |
| $\Delta\Omega_{max}$ [msr] | 28 | 5.6 |
| ang. res [mrad] | $<3$ | $<3$ |
| $p_{max}$ [MeV/$c$] | 735 | 870 |
| $\Delta p/p$ | 20% | 15% |
| $\delta p/p$ | $10^{-4}$ | $10^{-4}$ |

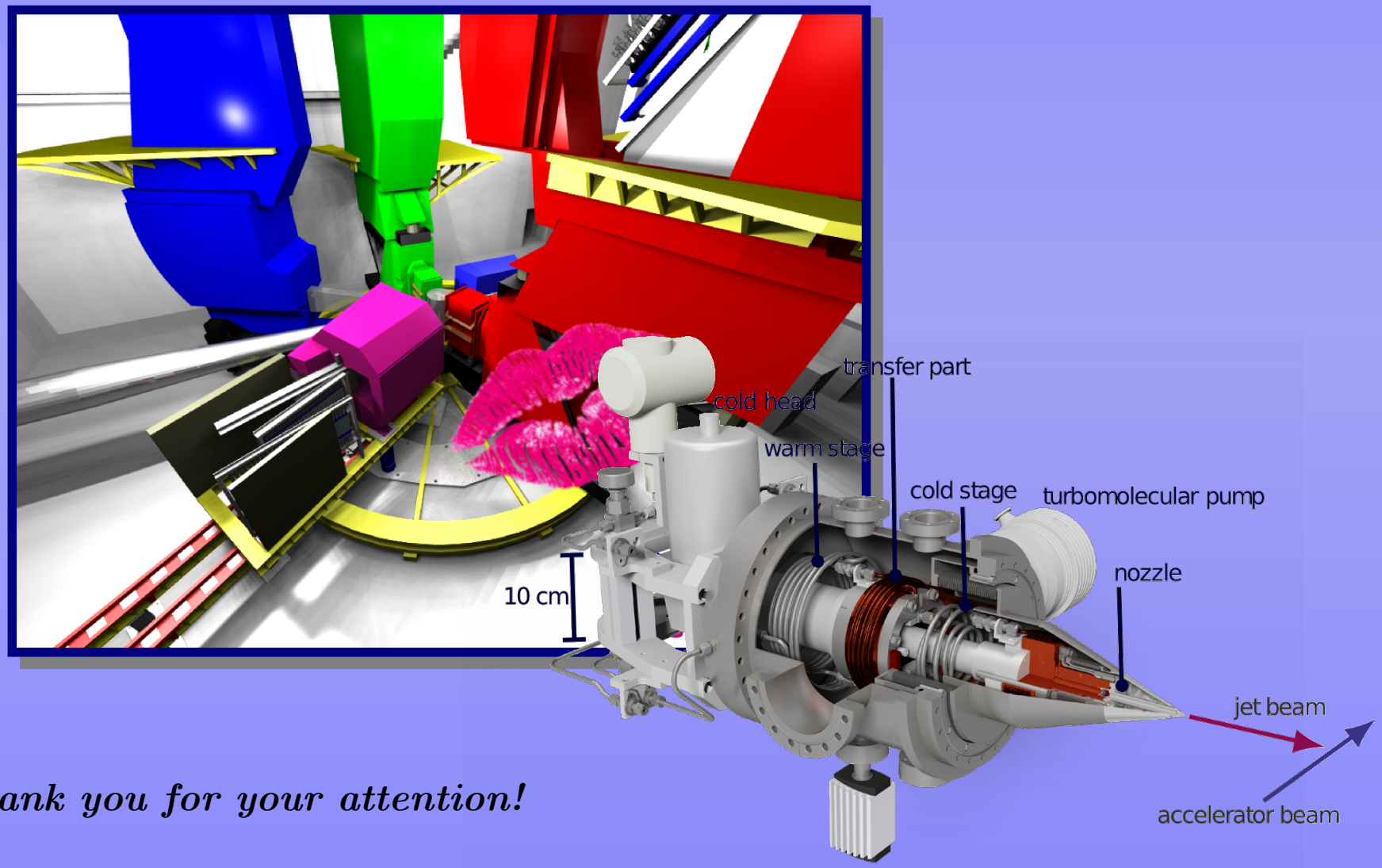
# Summary

- ISR technique for FF determination was successfully validated
- result was limited by background

- experiment will be repeated with improved setup
  - Jet-target
  - spectrometer entrance replaced

- Ultimate goal: measure proton charge FF down to $Q^2=10^{-4}$ GeV with commensurate precision

$e, \overrightarrow{e}$ ~~low beam quality~~ ~~medium beam quality~~ high beam quality → ↑⊗ 80% Pol 160 MeV - 1.6 GeV 0 - 100 µA




*Thank you for your attention!*