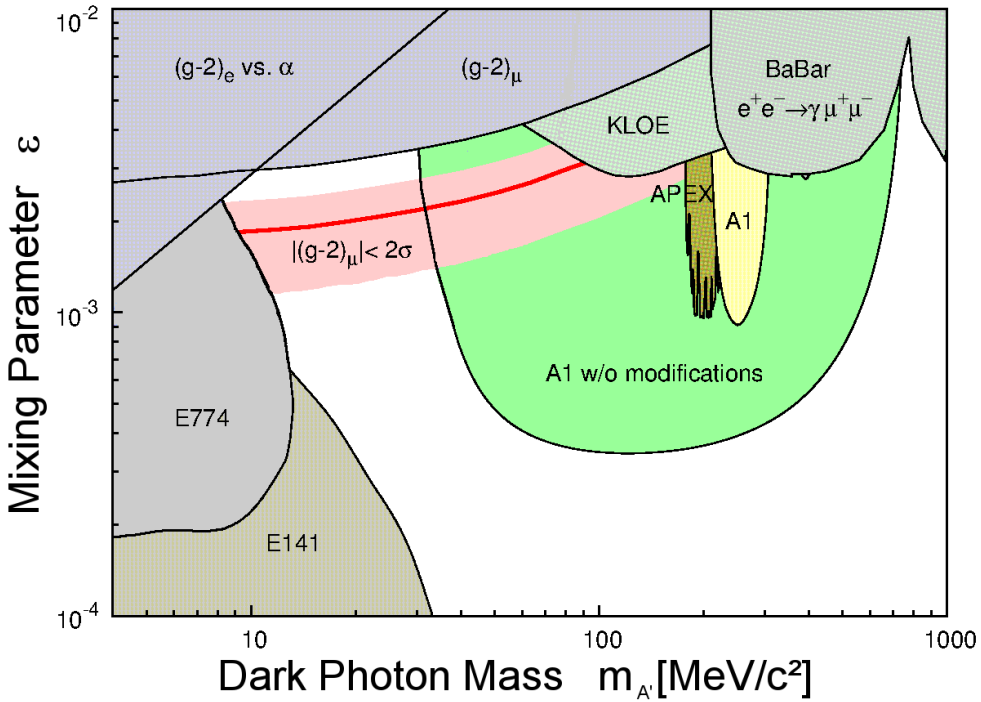
Detectors for dark photon search with MESA

Matthias Molitor

March 15, 2013

Content

Exclusion limits and measurements



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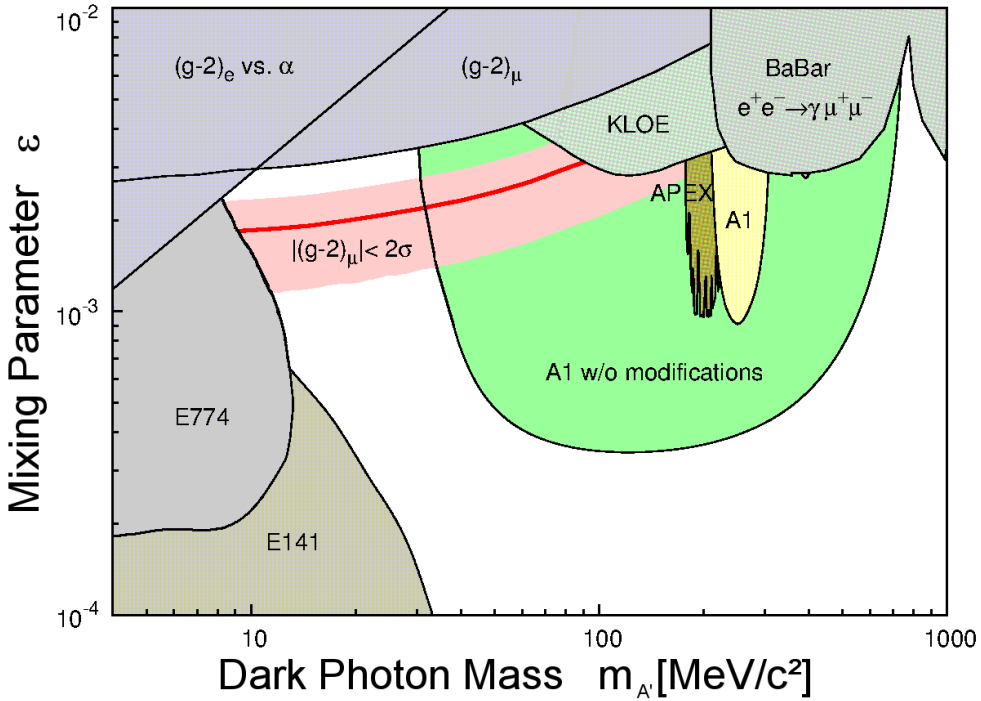

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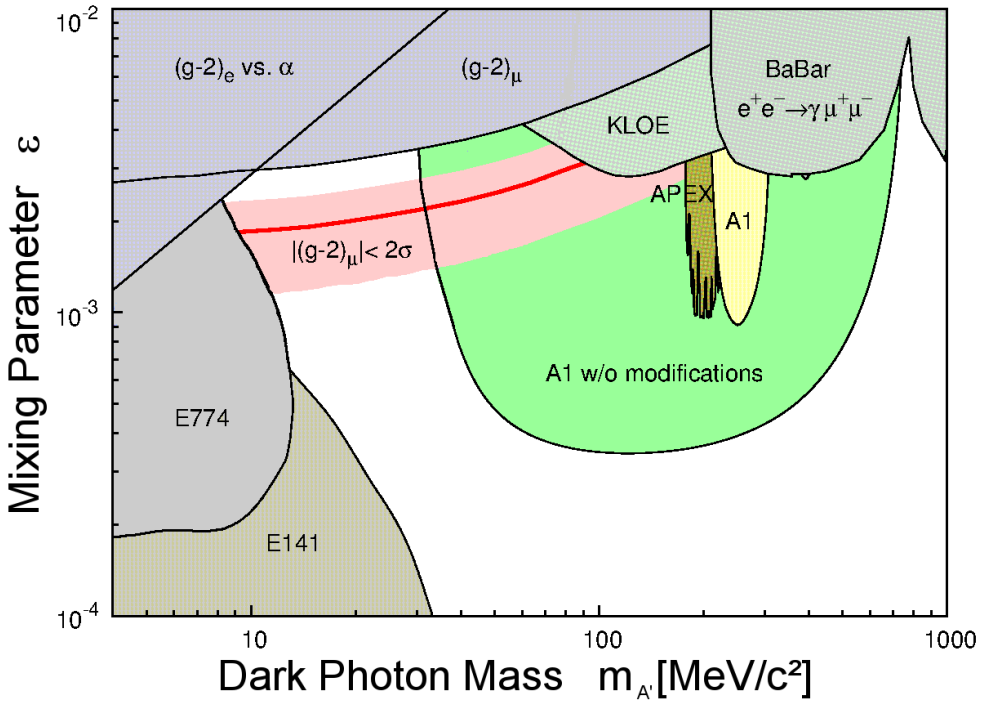

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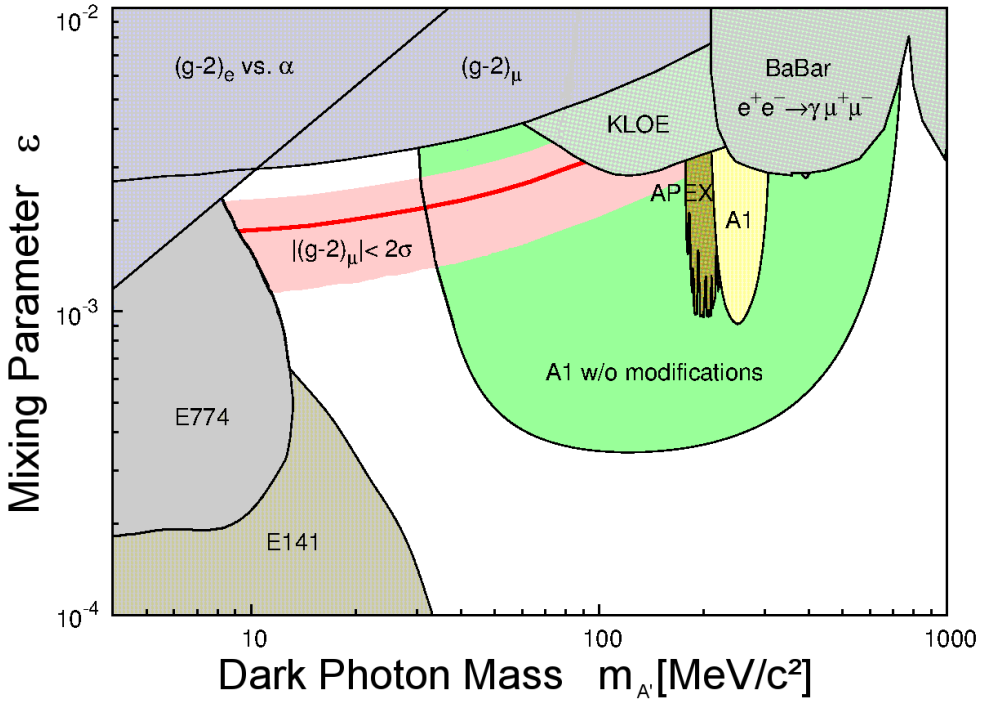

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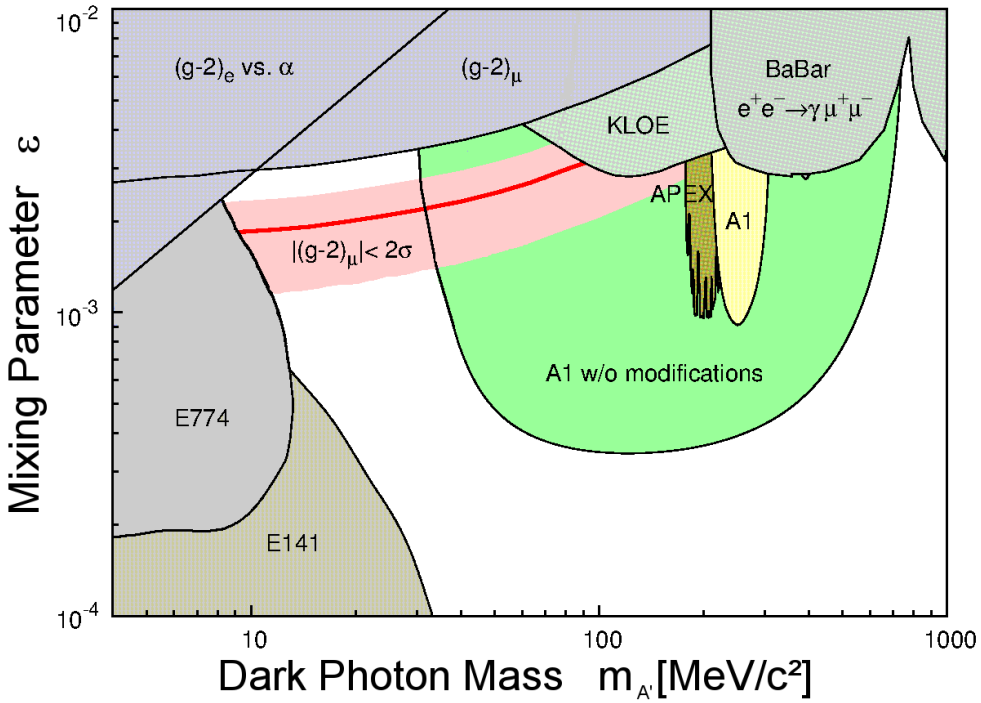

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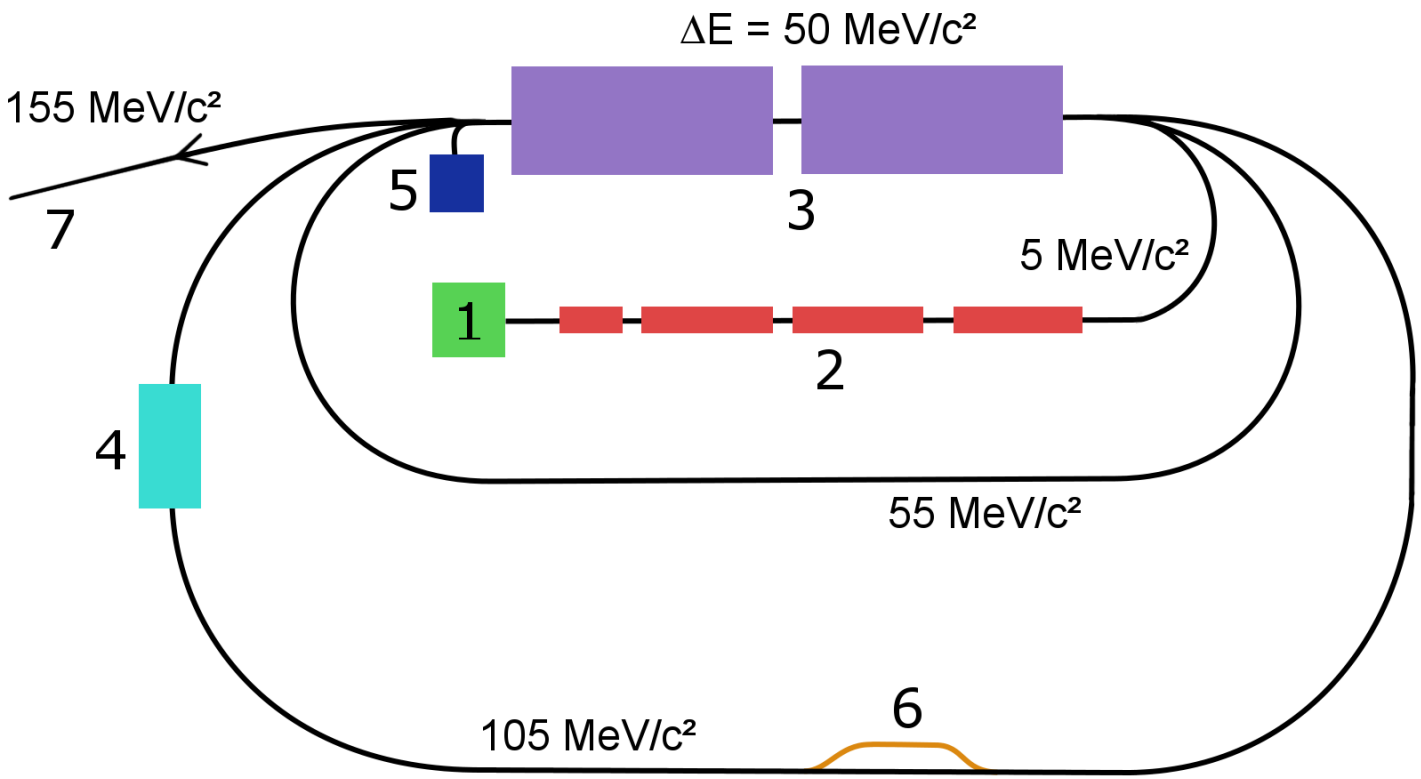
Therefore:

- MAMI not feasible for masses below 40 MeV/c^2
- new accelerator needed

MESA

Mainz Energy recovering Superconducting Accelerator



Sensitive area of MESA

- 100 days beam on target
- 1 mA beam current
- luminosity: $10^{36}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$
- Θ - acceptance: 20^{o} - 160^{o}
- $\Delta m = 1\ \mathrm{MeV}/c^2$

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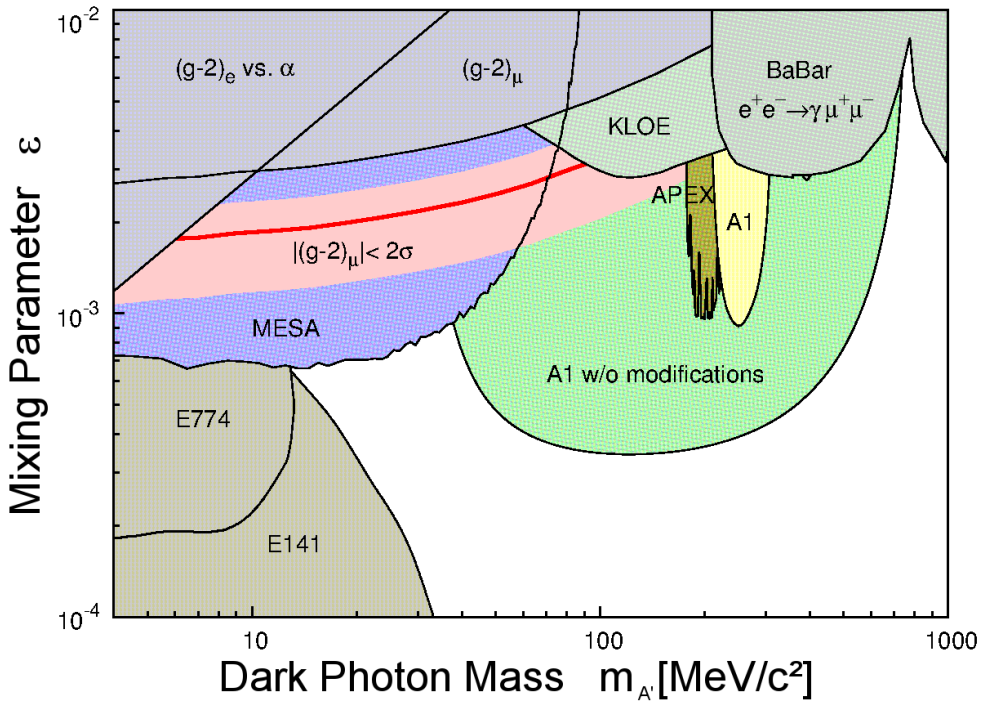

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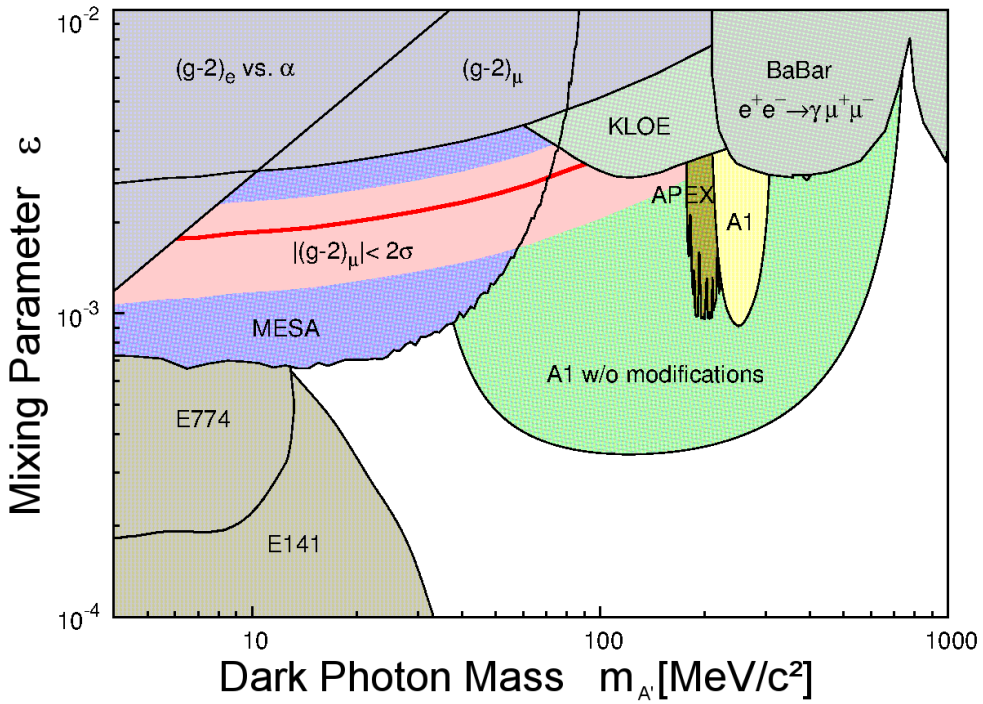

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- luminosity: $10^{36}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$
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- estimated elastic event rate: $\approx 180\,\mathrm{MHz}$

Detector configurations

4π detector

with solenoid field

with toroid field

→ No spiralising tracks accepted

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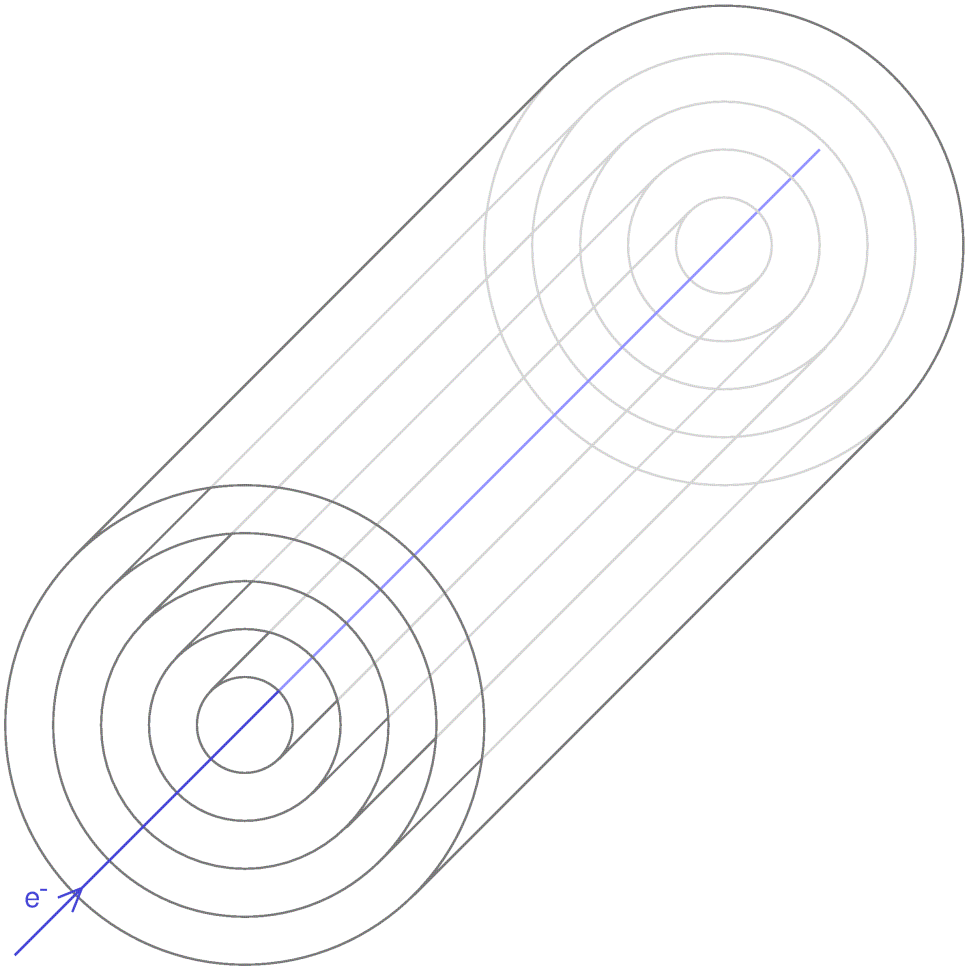
High resolution detector

Spectrometer

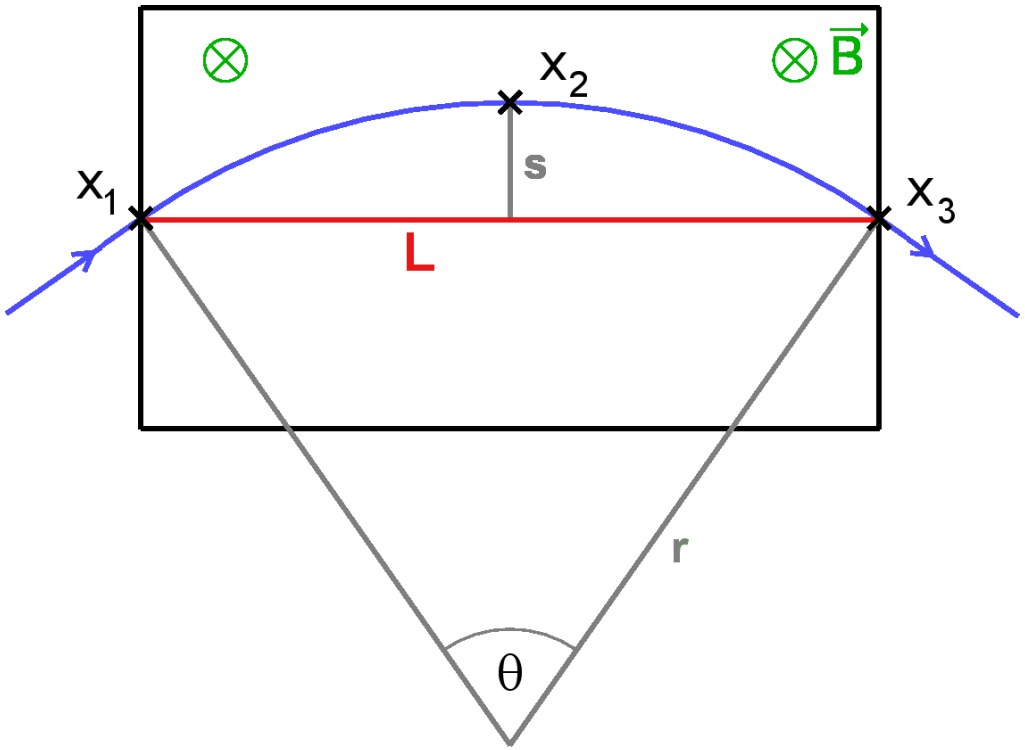
Detector with solenoid field

- 1 m diameter
- 2 m long
- 5 detection layers with 10 cm intervals



Relative resolution of the solenoid

given by: $\frac{\Delta p}{p} = \frac{\Delta x \; p}{0{,}3 \; B \; L^2} \sqrt{\frac{720}{N+4}}$



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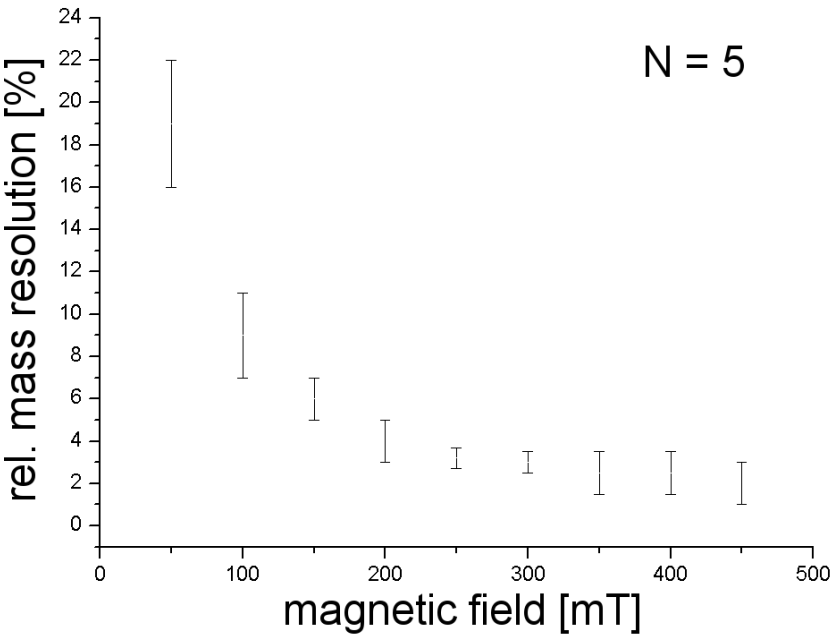

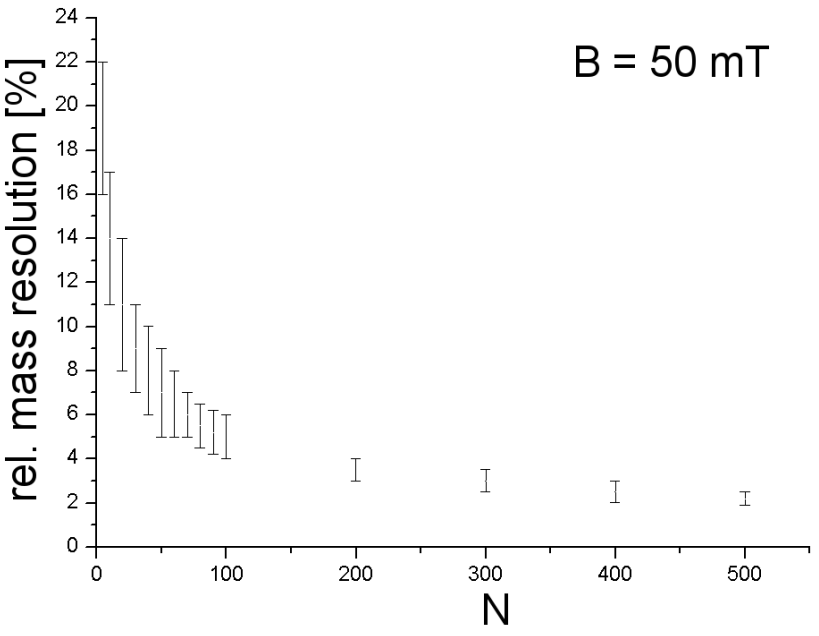

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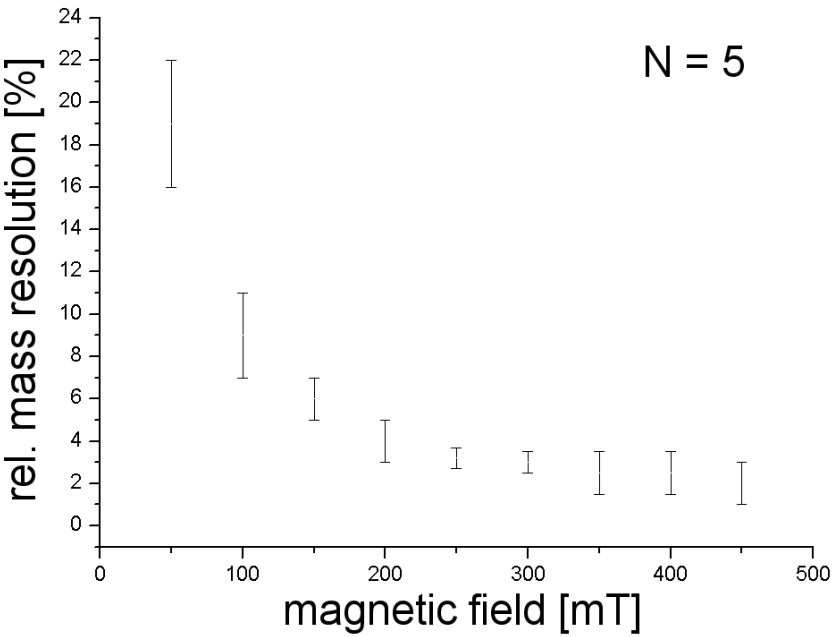
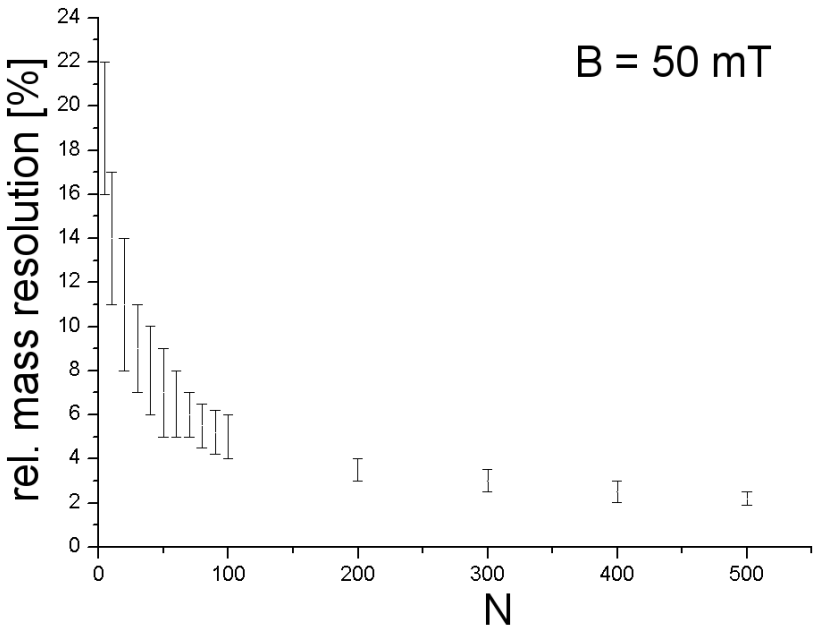
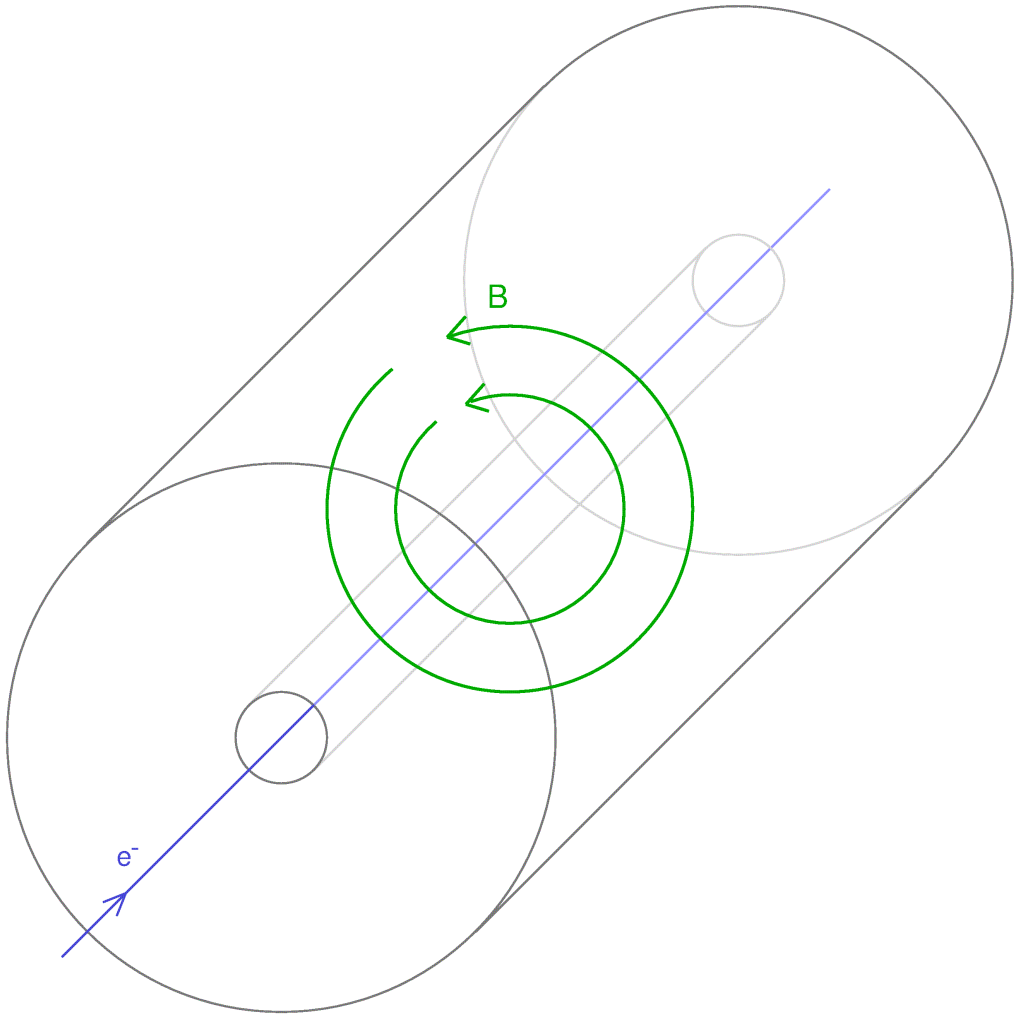




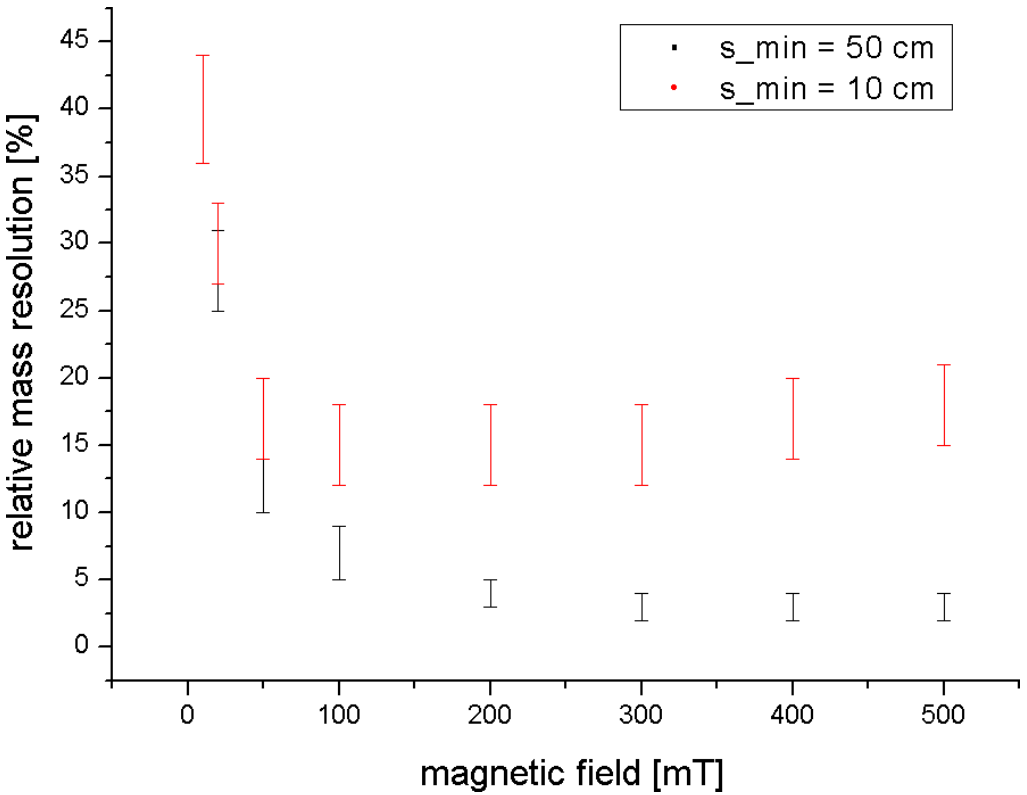
⇒ Maximum Resolution ≈ 4 %

Detector with toroidal field

- 1.2 m diameter
- 2 m long



Relative resolution of the toroid



Resolution

- maximum reached at $B = 200\,mT$
- worse for shorter tracks

Comparison of resolution

solenoid field

- B = 100 mT, N =5
- passing all detection layers

toroid field

- B = 100 mT, N =5
- trace length greater 50 cm

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Uncertainties

- $\Delta\Theta = \Delta\Phi = 0.1^o$
- $\Delta x = 0.1\,mm$

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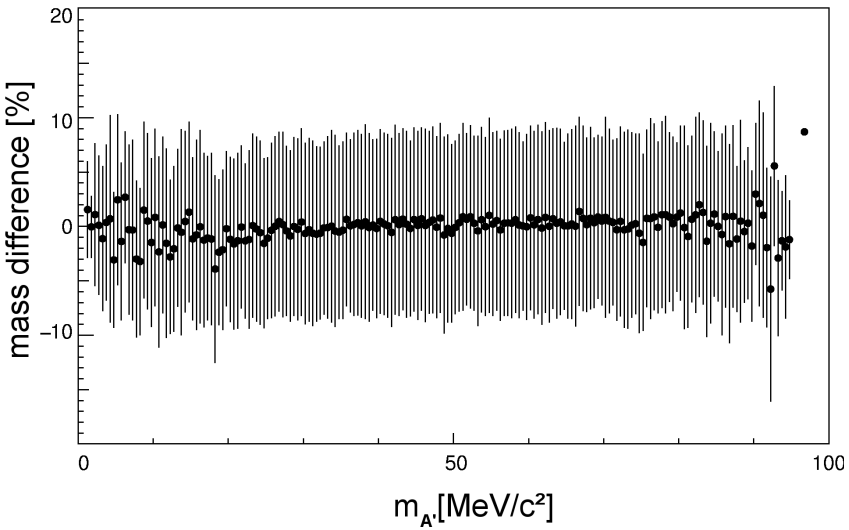

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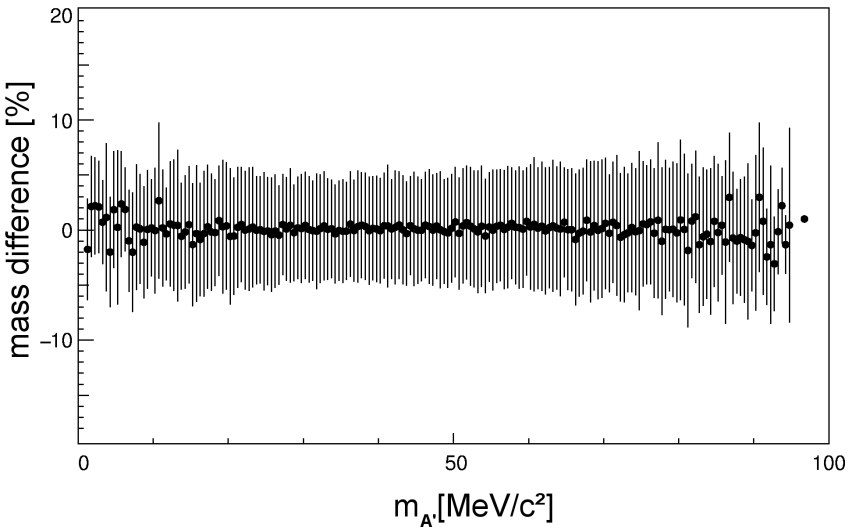
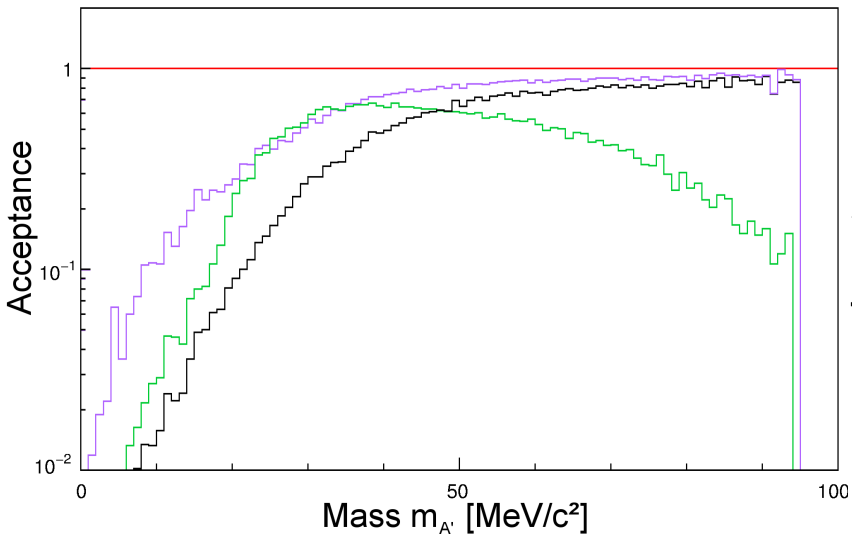


Comparison of acceptance

solenoid field



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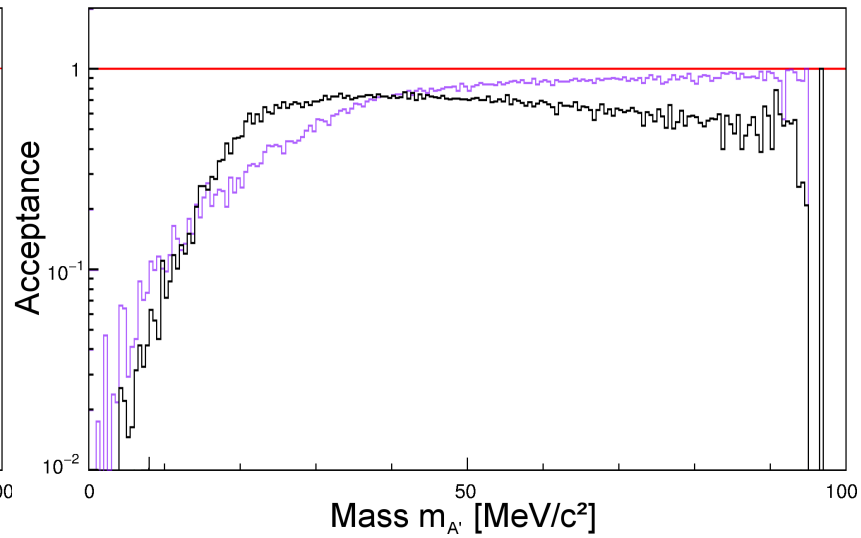
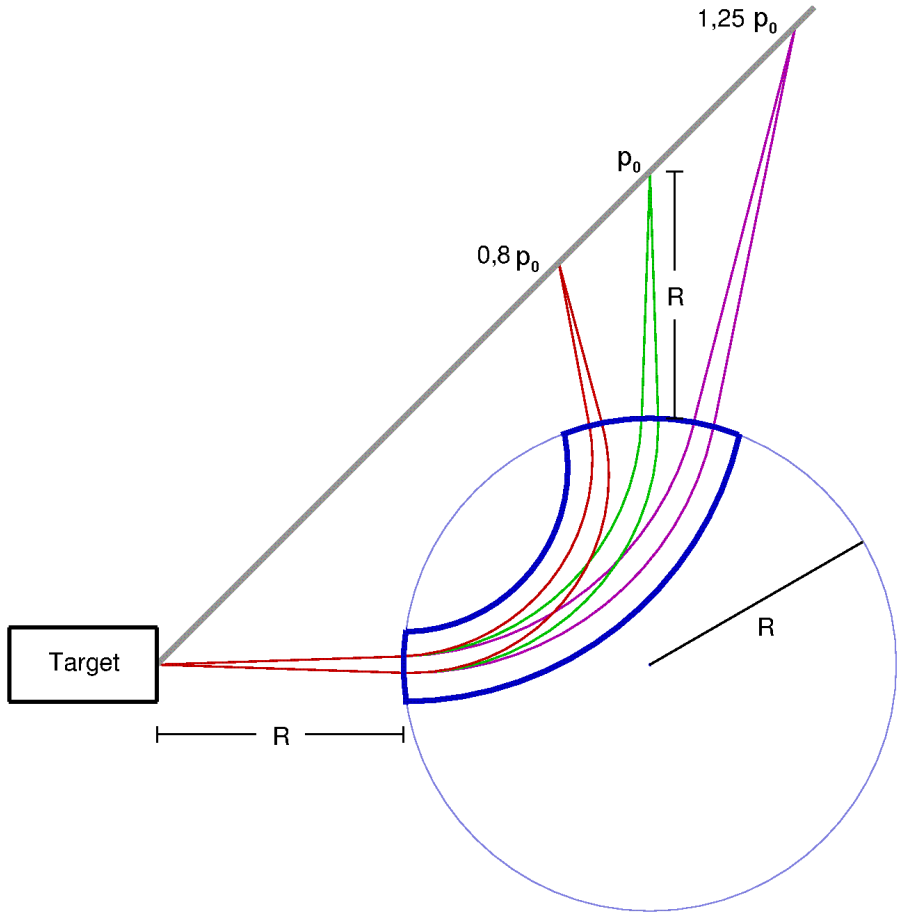


Blue: Reference from first estimations
Black: Target in the middle of detector
Green: Target at beginning of detector

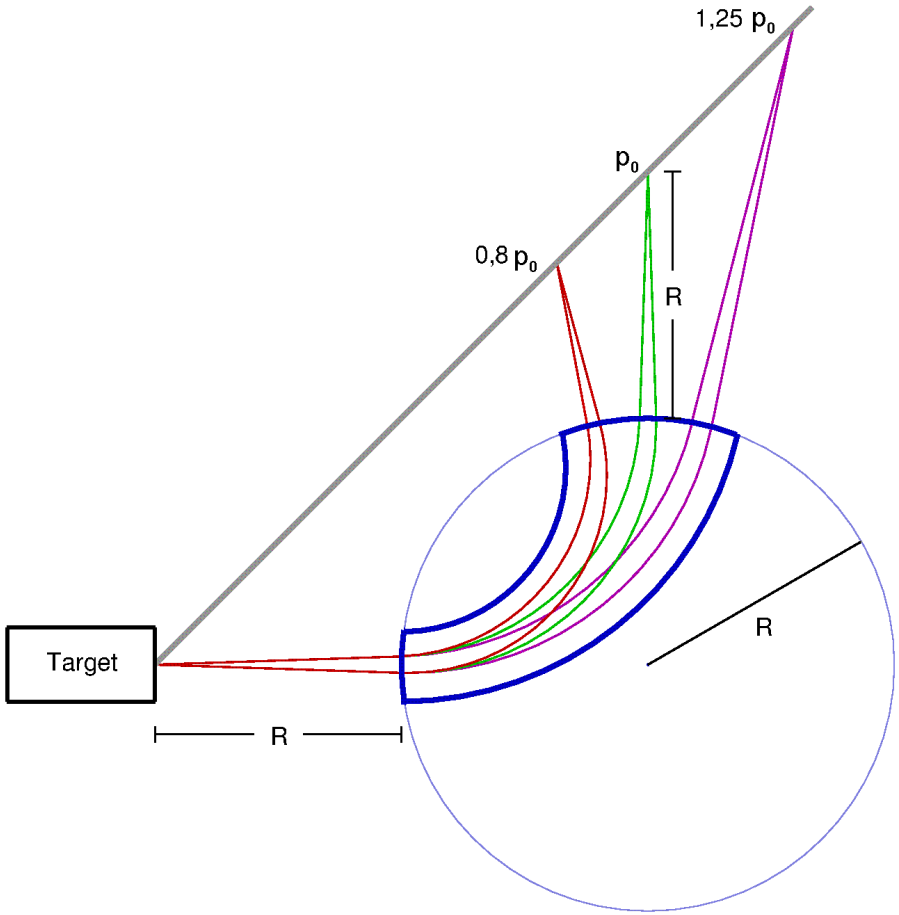
Browne-Buechner-Spectrometer



Browne-Buechner-Spectrometer

+

- simple spectrometer using just a dipole



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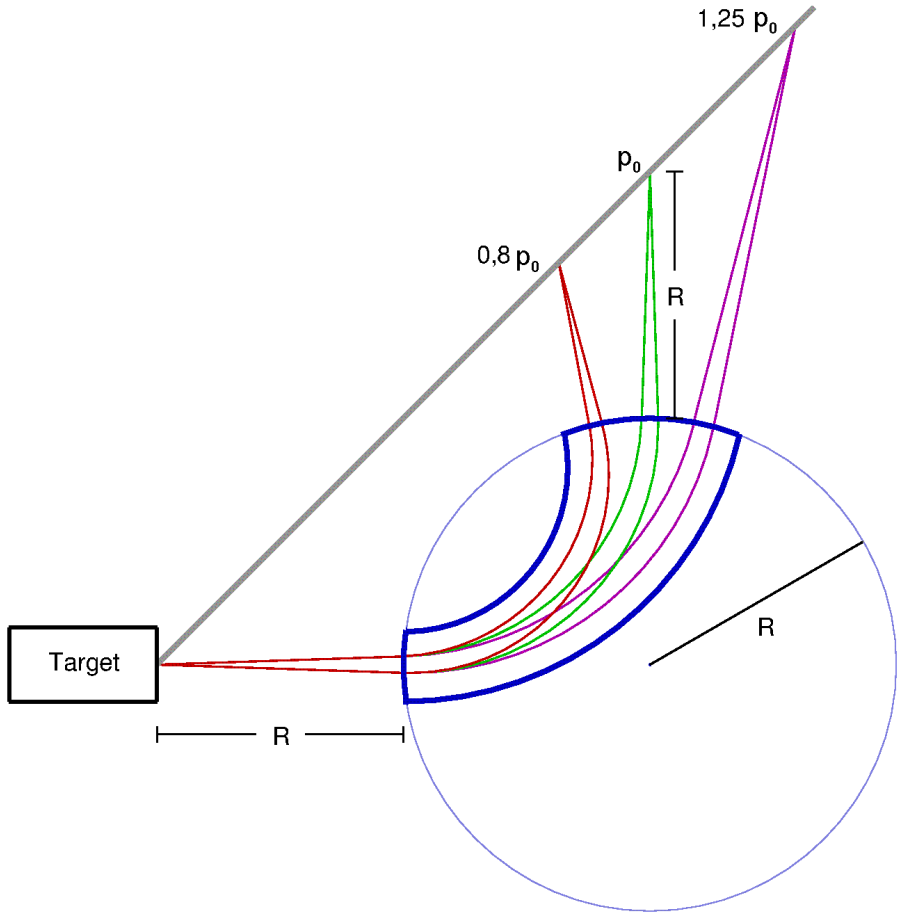

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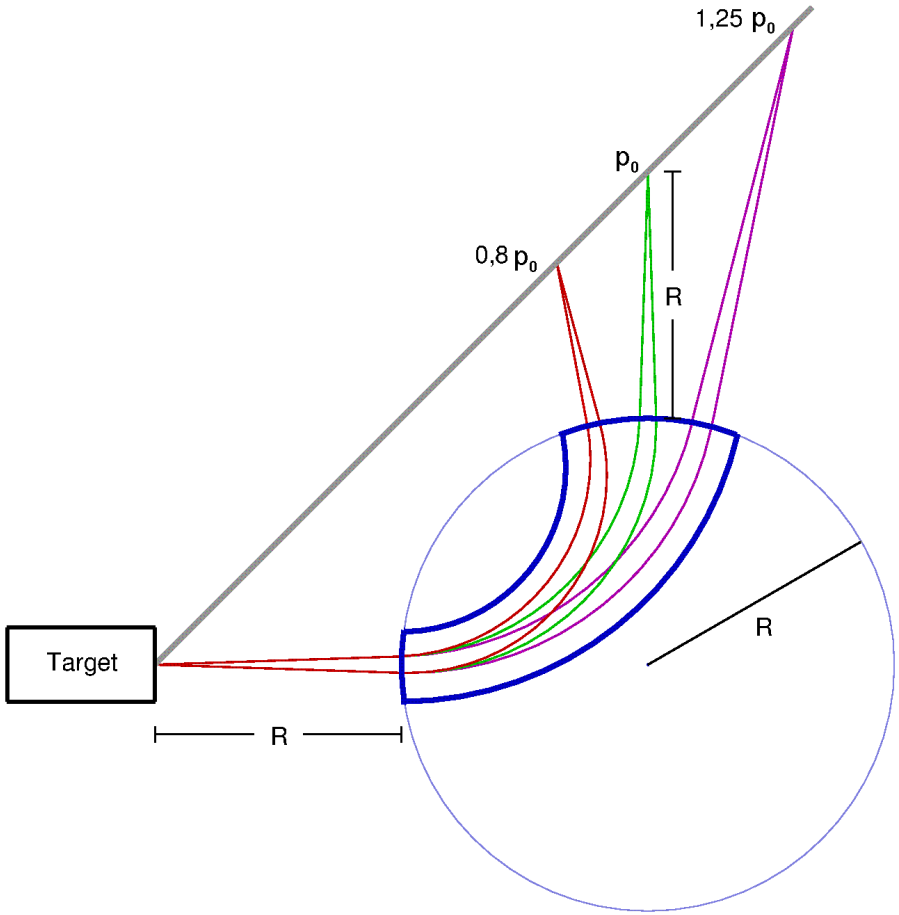

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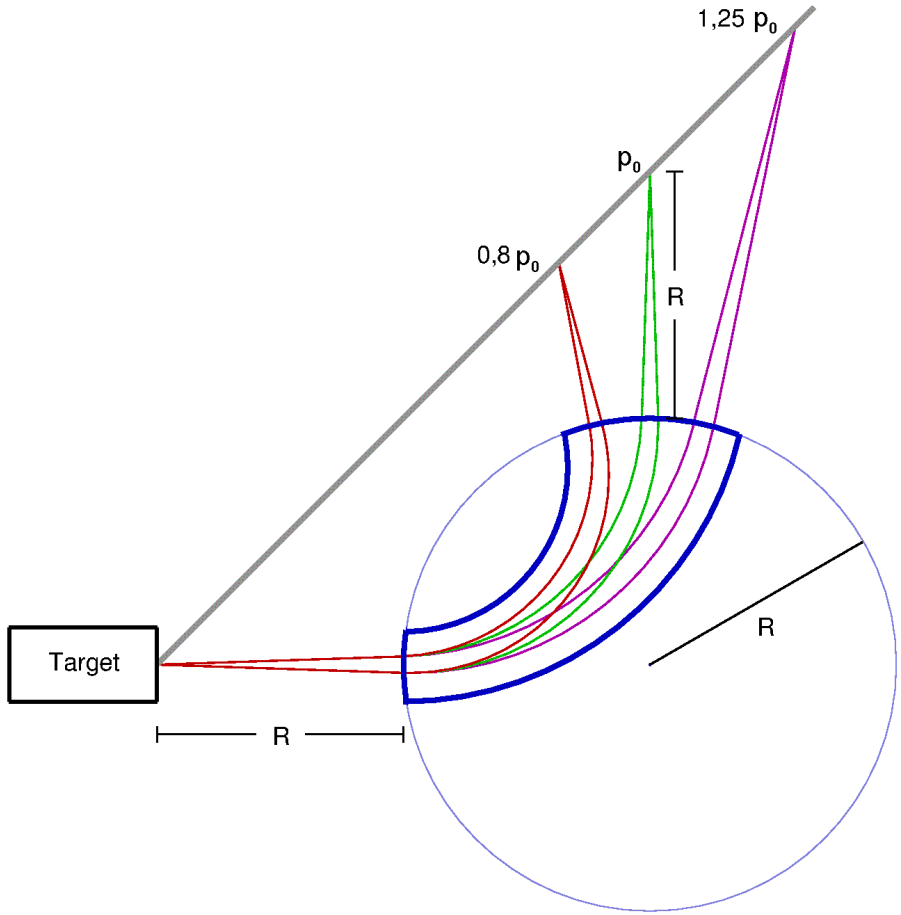
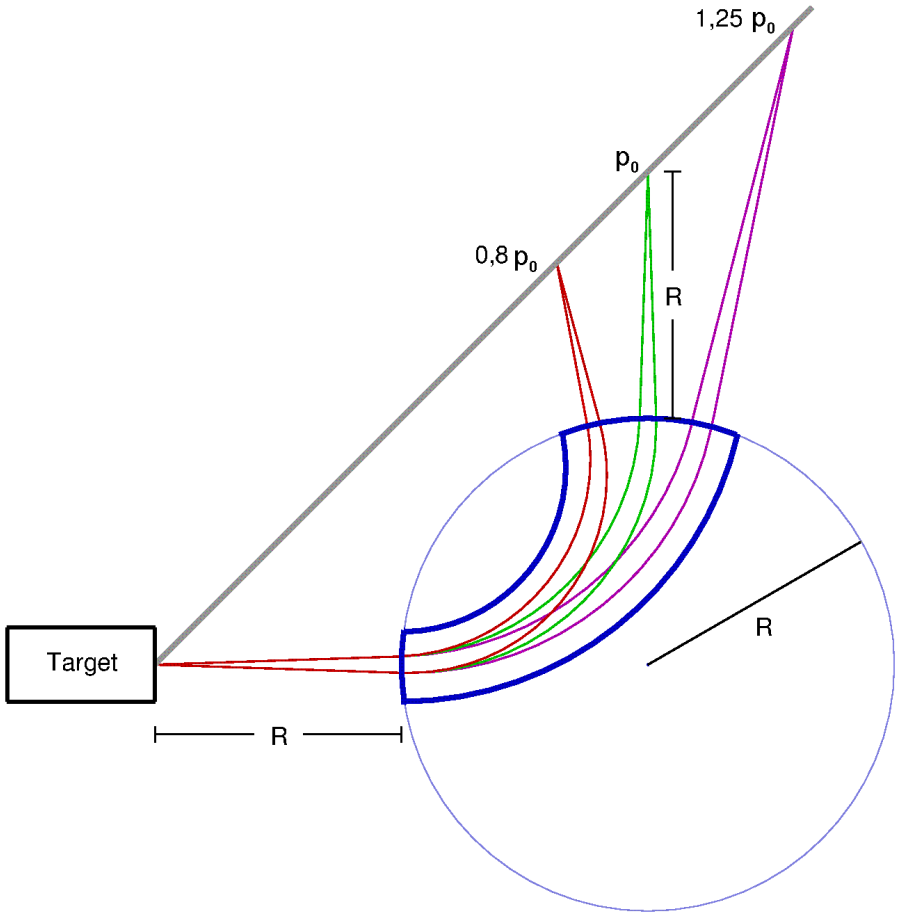
- mass spectrum must be scanned in intervals



Resolution of the spectrometer

Parameters

R	50 cm
B	42 - 333 mT
focal plane	68 cm
Δx	0.1 mm



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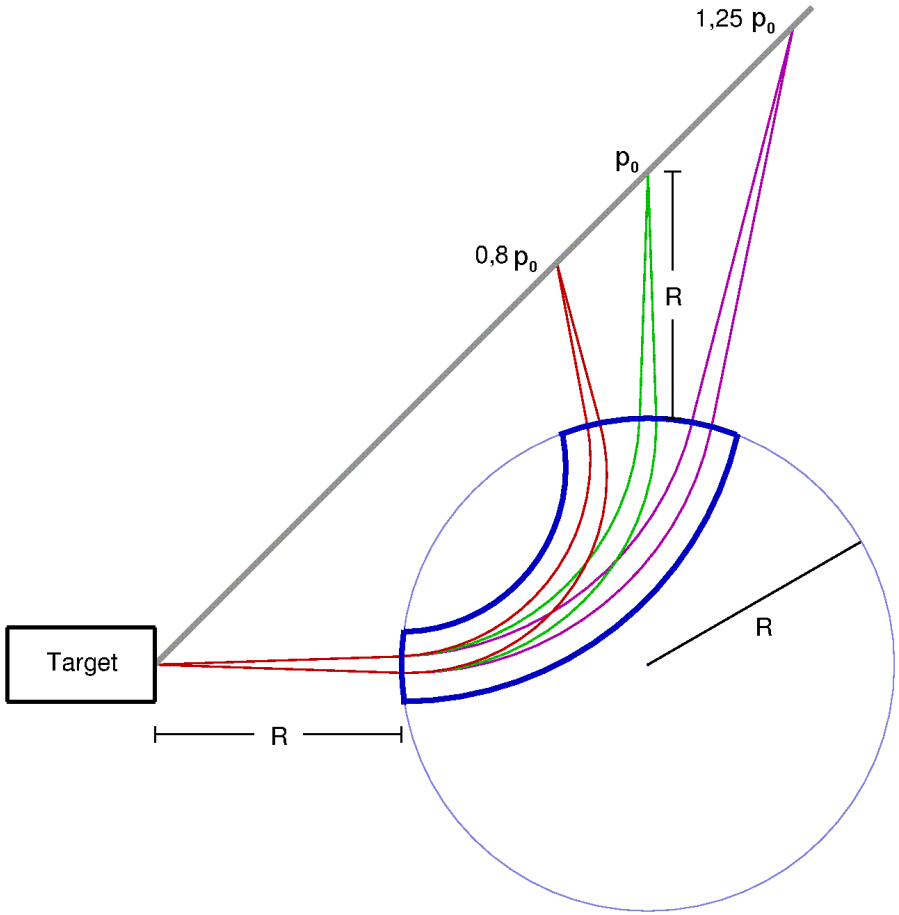
Resolution

$$\frac{\Delta p}{p} = 6.62 \cdot 10^{-5}$$

$\Rightarrow$ relative mass resolution $\approx$ 0,03 %



Spectrometer acceptance

momentum acceptance: 80 % to 125 % of p_0

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$\Rightarrow$ use of higher Z target (e.g. Xe): $d\sigma/d\Omega$ increases with Z^2 by a factor of 2900

Conclusion

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- MESA suitable for masses below 60 MeV/c^2
- simple detector construction with solenoid field
- better acceptance and resolution with toroidal field
- best resolution with spectrometers
  - $\rightarrow$ lower acceptance can be compensated
  - $\rightarrow$ suitable for hadron and other nuclear physics

Thank you for your attention