Low Energy Positron Polarimetry

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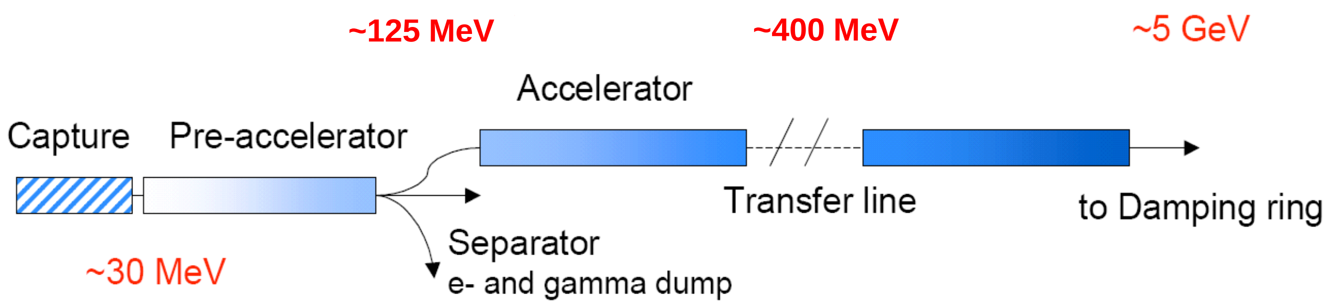
LEPOL – purpose, demands

- Optimization of the positron beam polarization/intensity
- Control of polarization transport

Criteria: (in spite of rather poor beam quality at the source)

- Non destructive
- Reasonable sensitivity to long. Polarization
- Reliability
- Signal / background ratio
- Accuracy - few percent

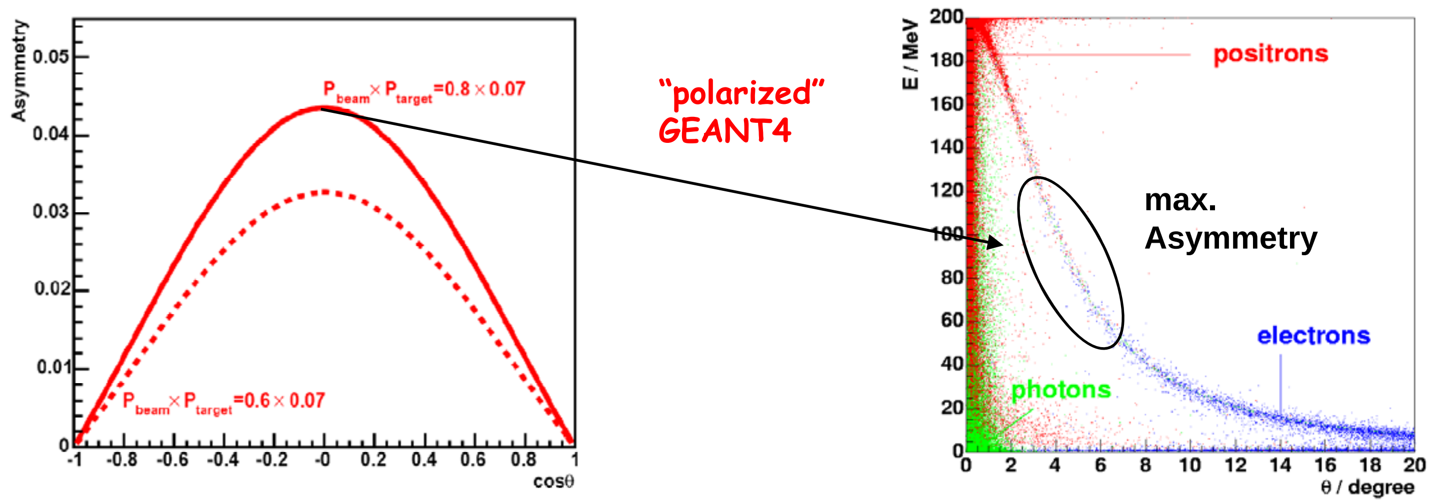


Bhabha-Polarimeter

- E_{beam}: after pre acceleration ~ 400 MeV
- cross section:

$$\frac{d\sigma}{d\Omega} = r_0^2 \frac{(1+\cos\theta)^2}{16\gamma^2 \sin^4\theta} \left\{ \left(9 + 6\cos^2\theta + \cos^4\theta\right) - P_{e^+} P_{e^-} \left(7 - 6\cos^2\theta - \cos^4\theta\right) \right\}$$

- theor. max. asymmetry bei 90°(CMS) ~ 7/9 ≈ 78 %
- example: P_{e+}= 80%, P_{e-}= 7% A_{max} ~ 4.4 %



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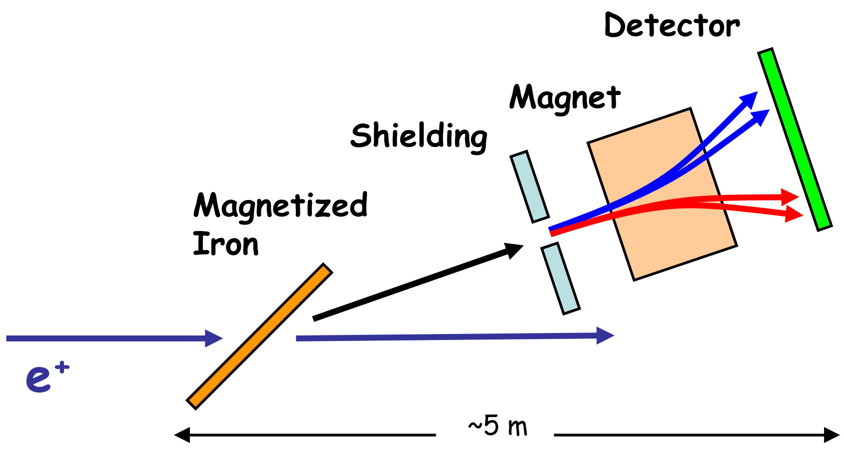
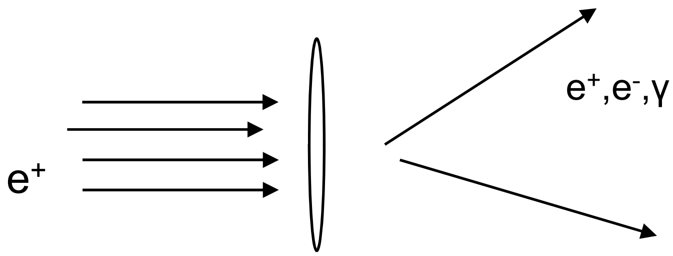


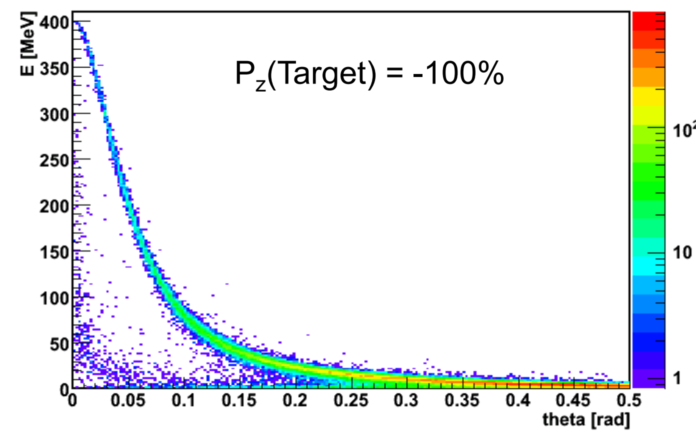
- Mask/shielding selects angular range with max. asymmetry
- spectrometer -> particle separation, energy selection
- Polarization measurements
  -> Asymmetry measurements of opposite polarization states of the target

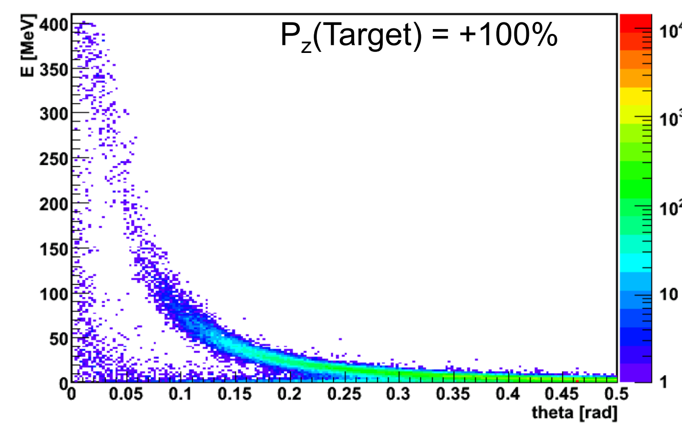
e^- produced in the target

- 30 µm magnetized Fe-Foil
- E_{beam} : 400 MeV (10 % spread)
- Ang. Spread : 0.5°

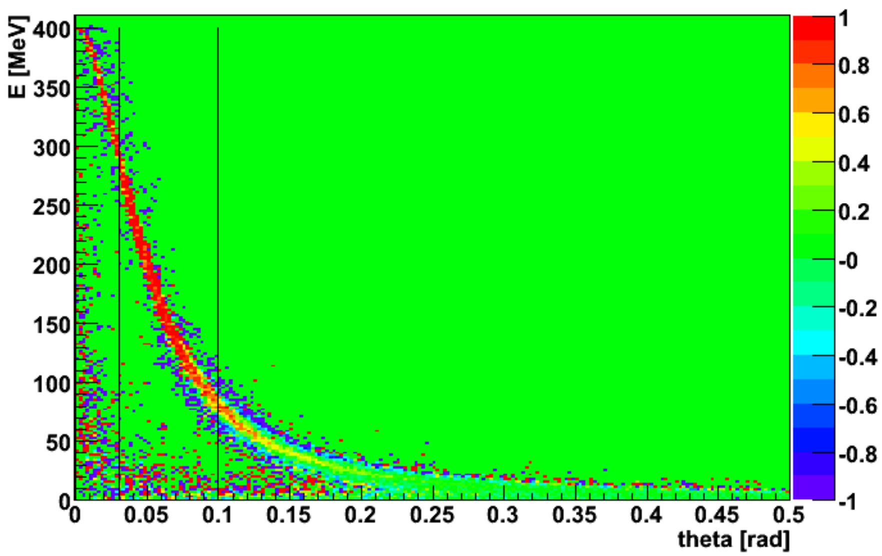


e^- distribution





asymmetry (analyzing power)



ang. range of interest: 0.03 – 0.1 rad
-> Asymmetry in the ang. range: A_{e-} ~50 %
(A_{e+} ~5%, A_{γ} ~-15%)

e^- produced the target

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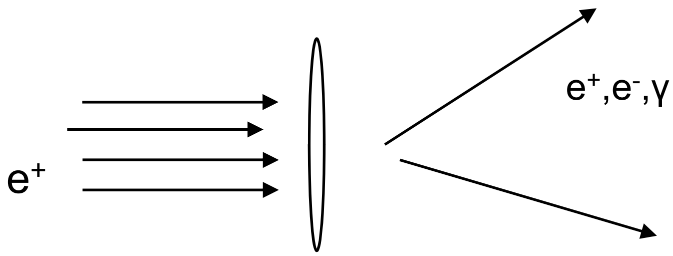
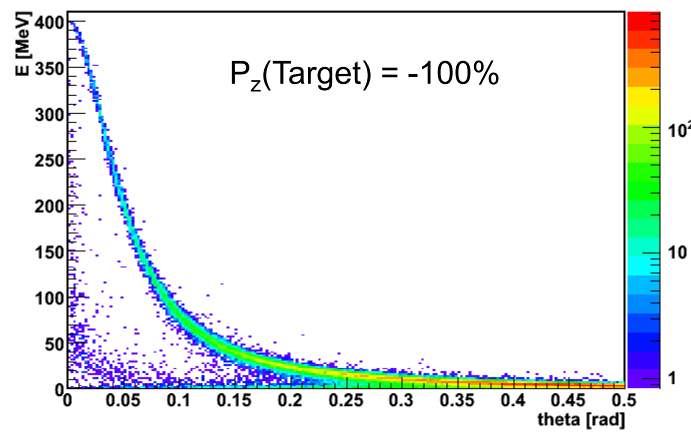
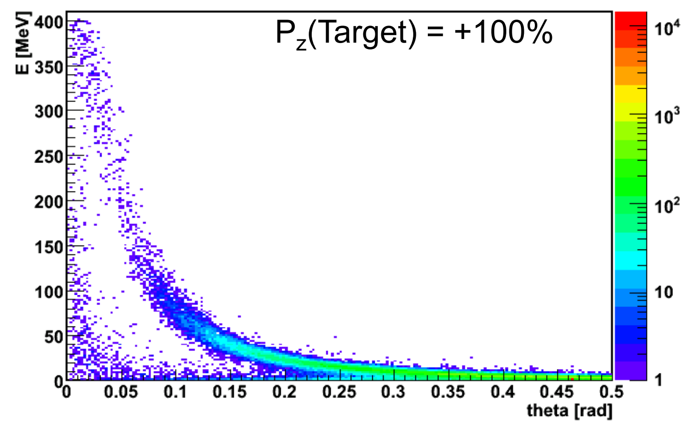


e⁻ distribution





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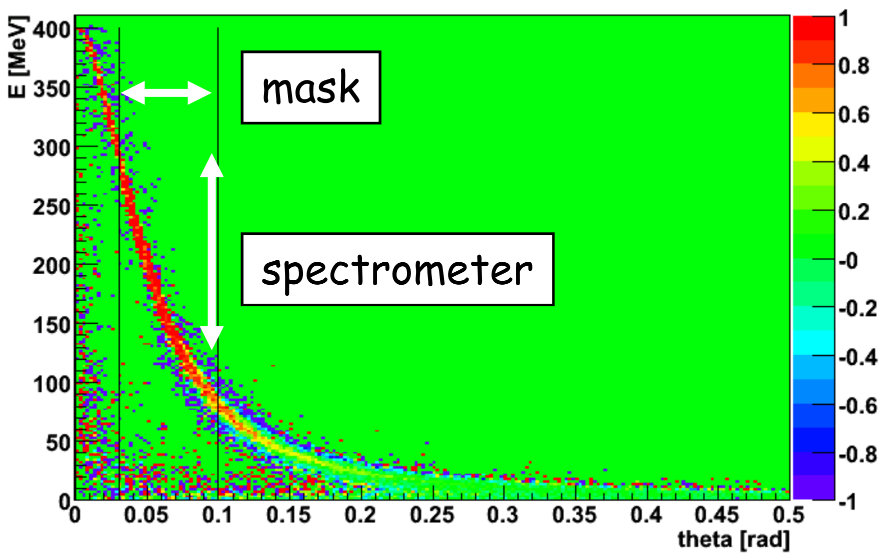

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-> Asymmetry in the ang. range: A_{e-} ~50 %
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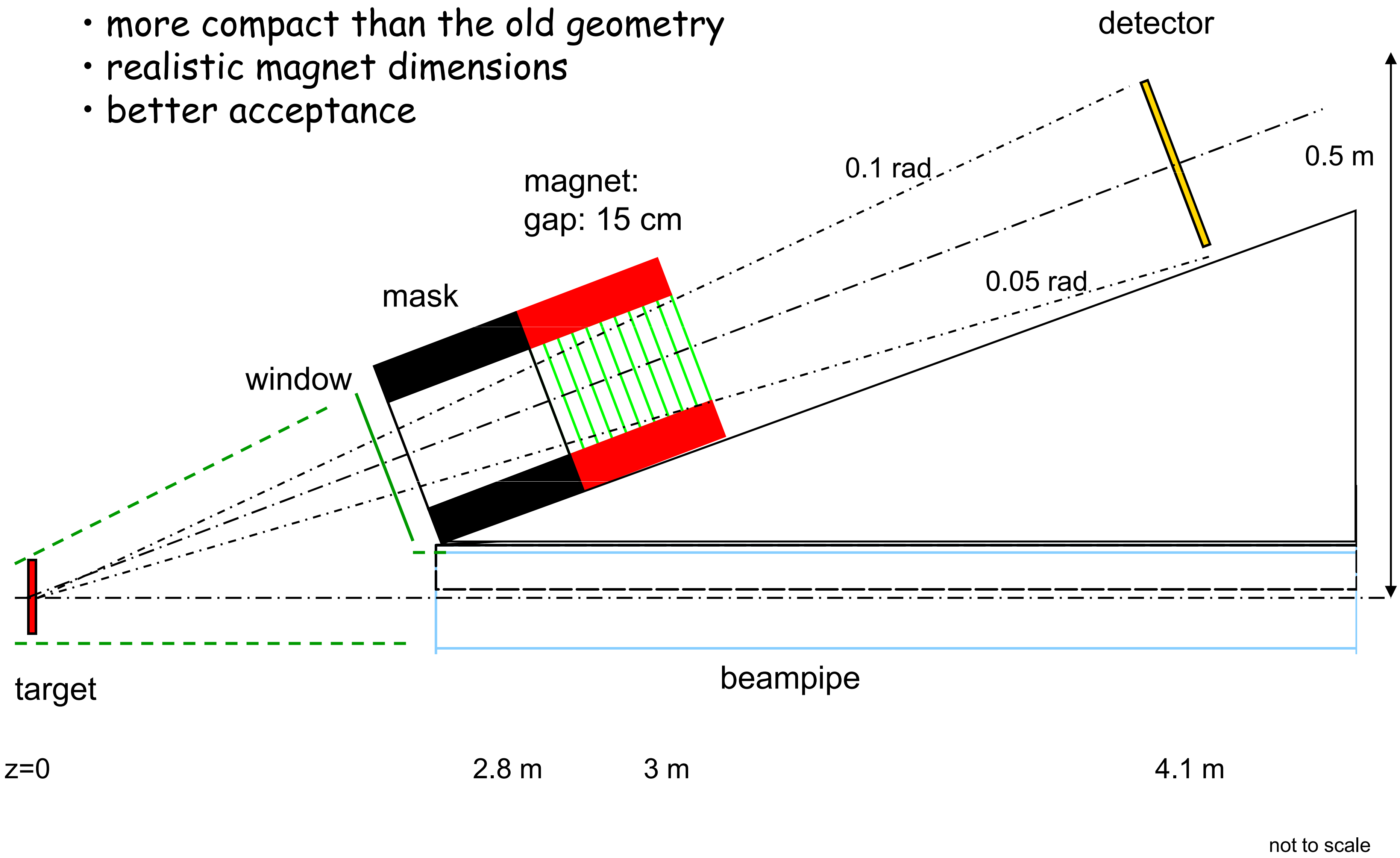
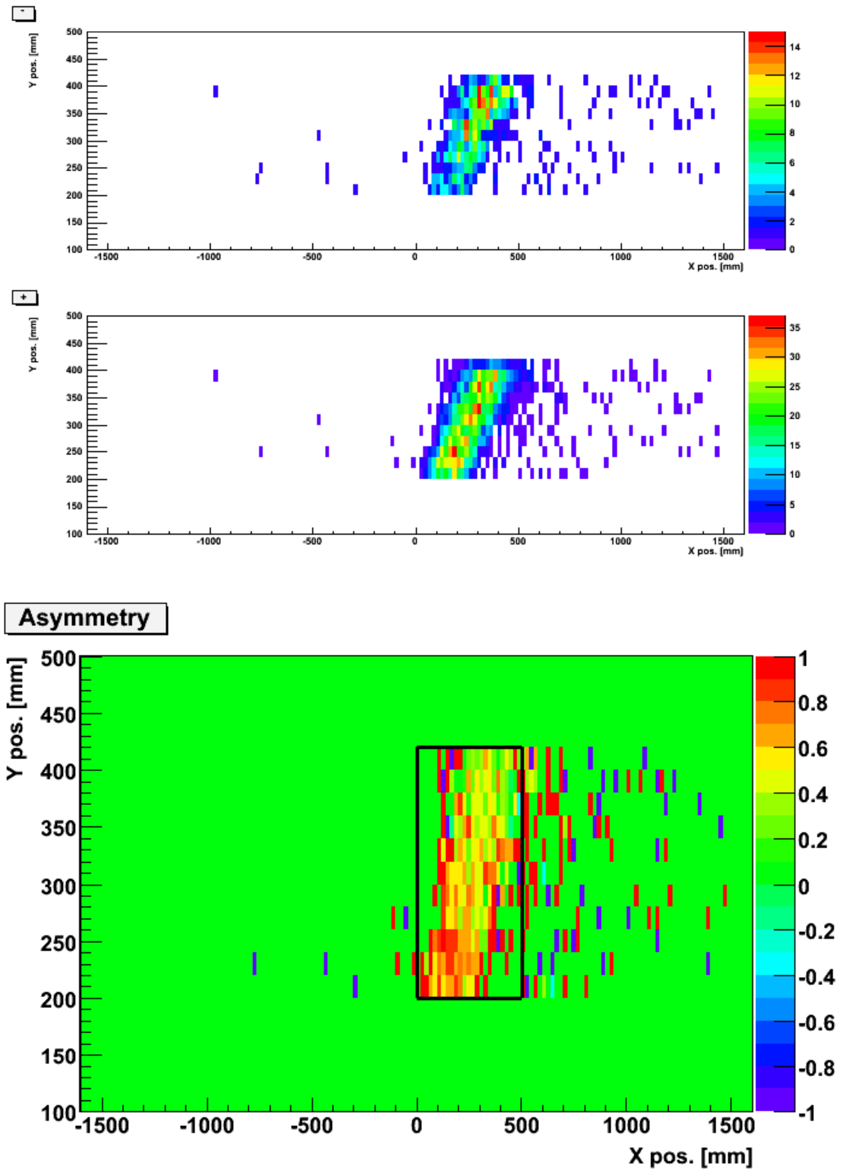
New geometry

- more compact than the old geometry
- realistic magnet dimensions
- better acceptance



e^- detected



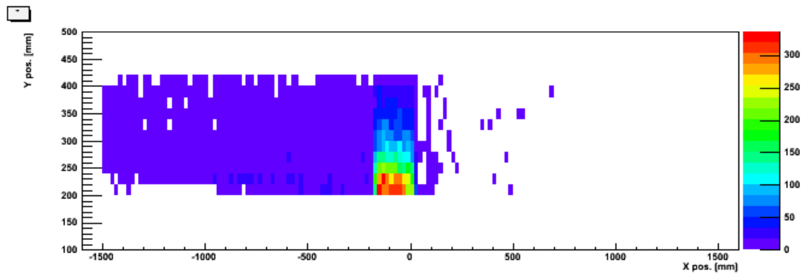
- Distribution of electrons and the asymmetry (analyzing power)

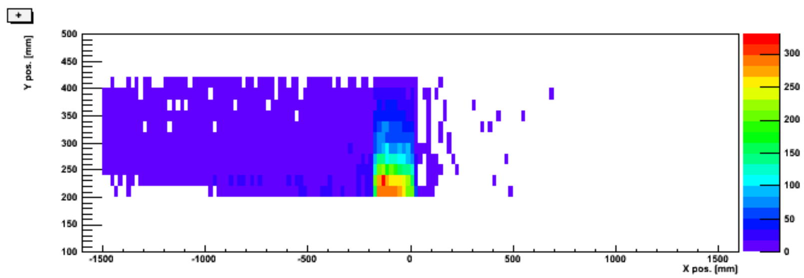
- Target 30 μm Fe
- E_{beam} 400MeV
- BdL 0.1 Tm
- P(100%/100%)

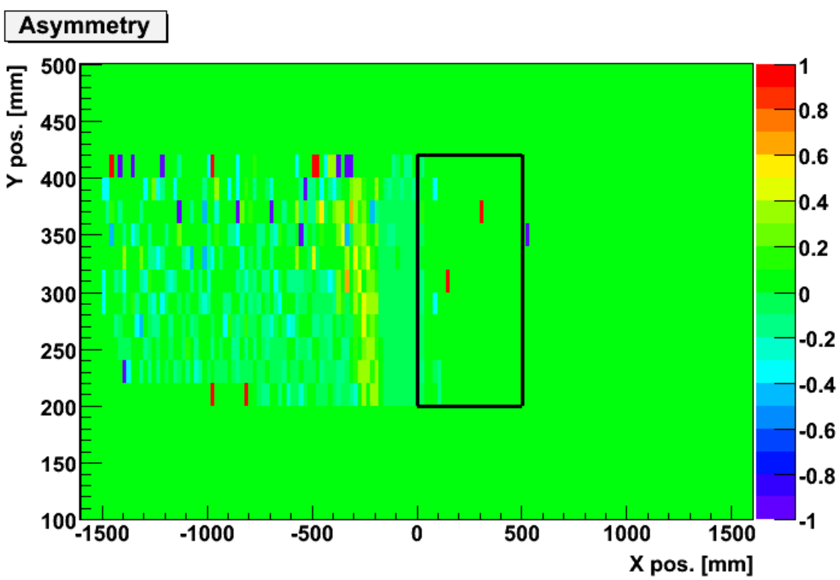
- 2 x 10^9 positrons on target
- A ~ 55 %

pol. G4 results

e^+ detected







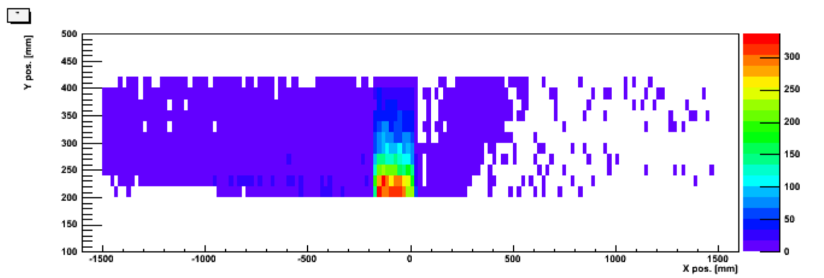
- Distribution of positrons and the asymmetry (analyzing power)

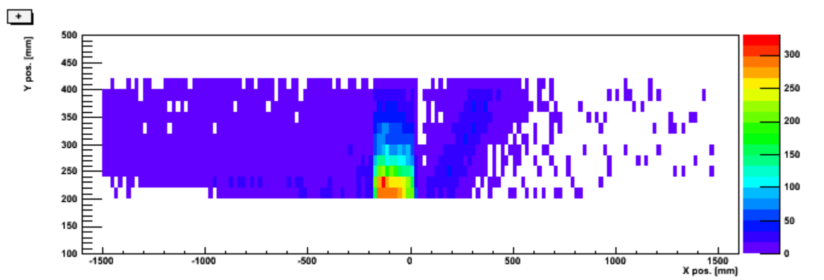
- Target 30 μm Fe
- E_{beam} 400MeV
- BdL 0.1 Tm
- P(100%/100%)

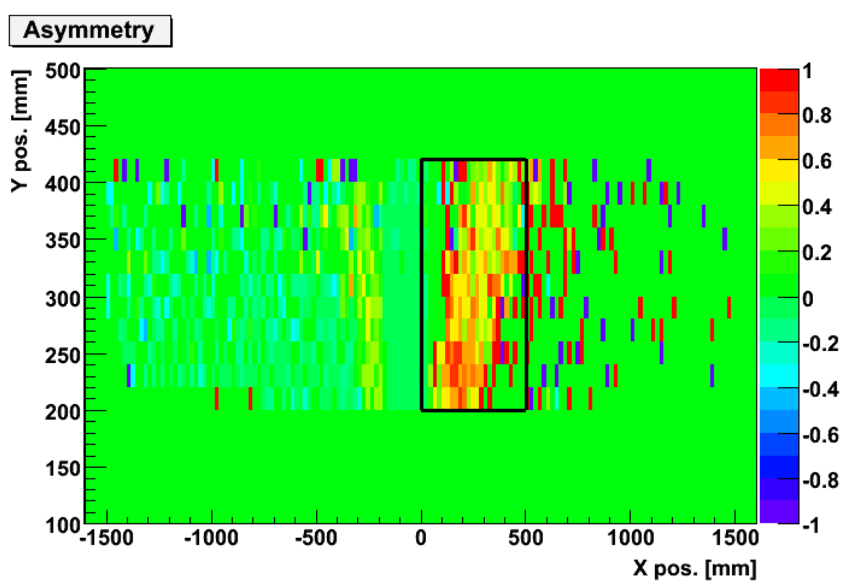
- 2 x 10^9 positrons on target

pol. G4 results

e^- and e^+ detected







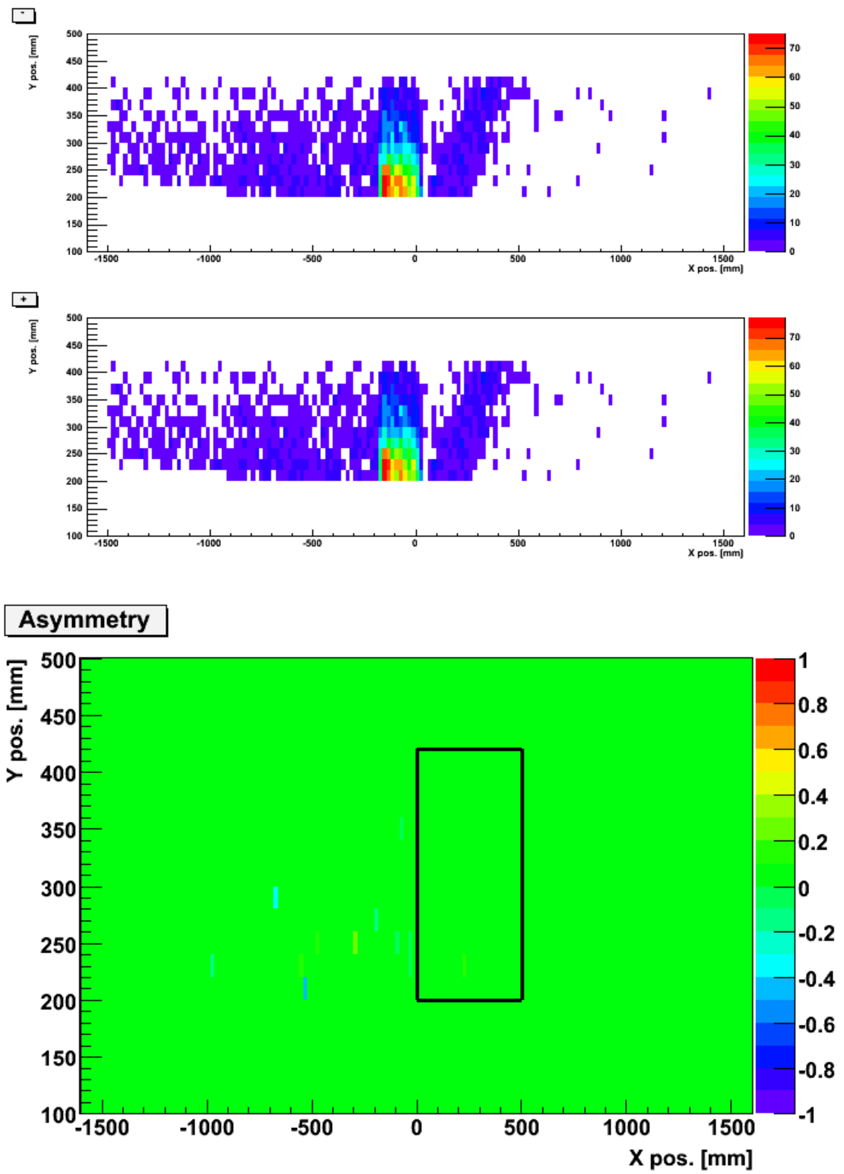
- Distribution of both, positrons and electrons and the asymmetry (analyzing power)

- Target 30 μm Fe
- E_{beam} 400MeV
- BdL 0.1 Tm
- P(100%/100%)

- 2 x 10^9 positrons on target
- A ~ 47%

pol. G4 results

Crosscheck – zero beam polarization



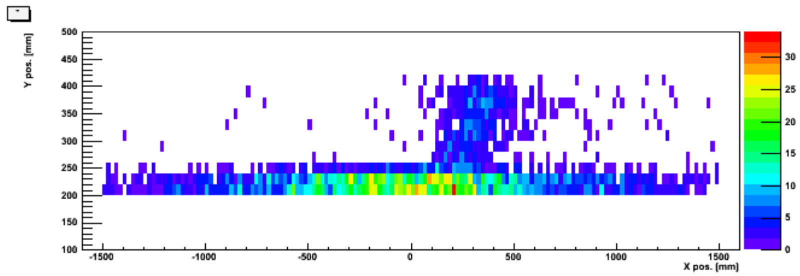
- Distribution of both, positrons and electrons and the asymmetry (analyzing power)

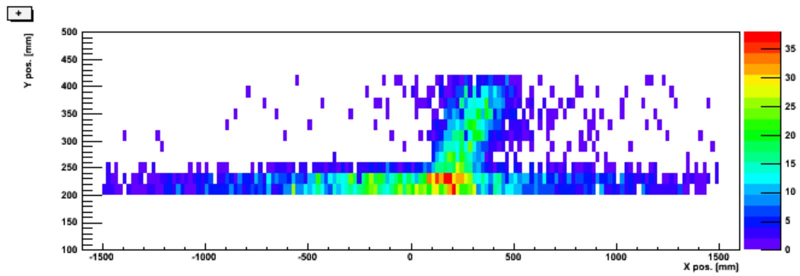
- Target 30 μm Fe
- E_{beam} 400MeV
- BdL 0.1 Tm
- P(100%/100%)

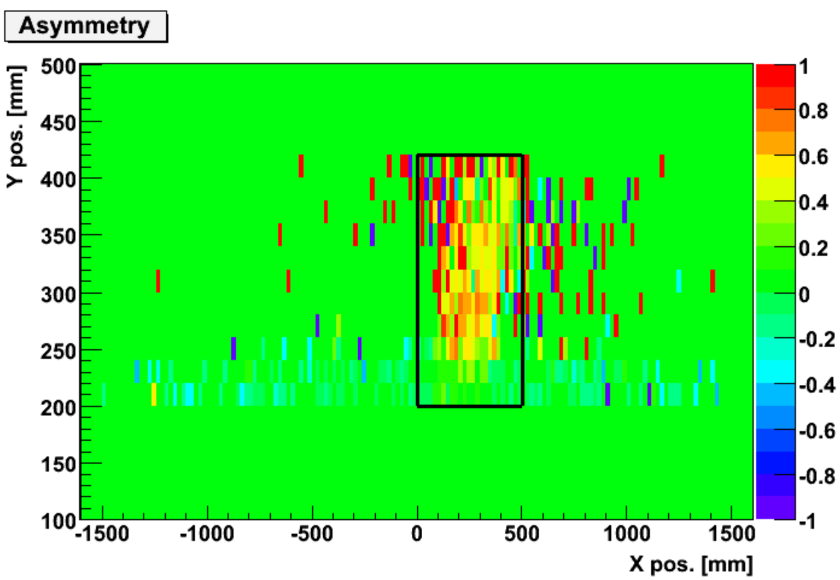
- 4 x 10^8 positrons on target

pol. G4 results

e^- detected (w beam pipe window)







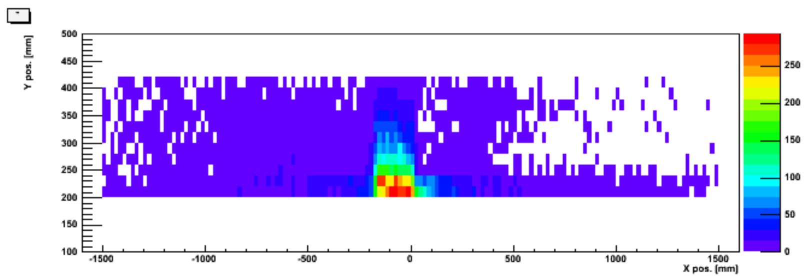
- Distribution of electrons and the asymmetry (analyzing power)

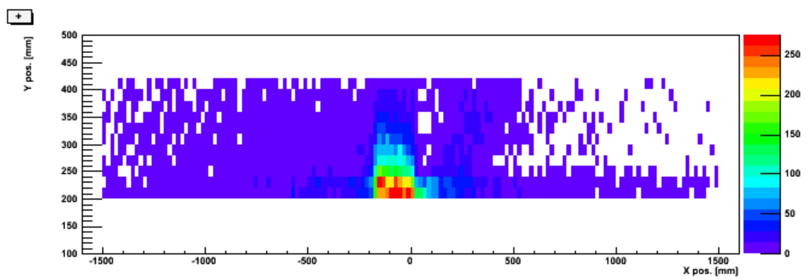
- Target 30 μm Fe
- E_{beam} 400MeV
- BdL 0.1 Tm
- P(100%/100%)
- w. beam pipe exit window

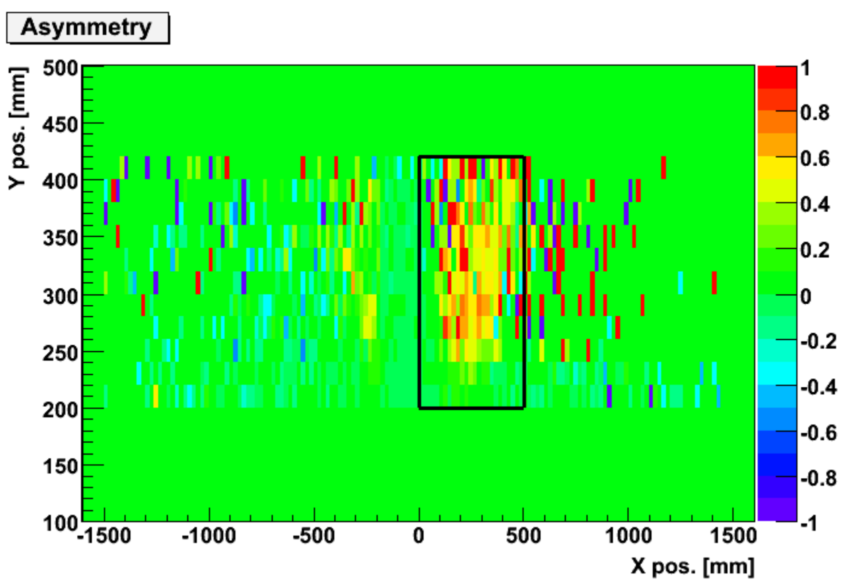
- 1.4 x 10^9 positrons on target
- $A \sim 38\%$

pol. G4 results

e^- and e^+ detected (w beam pipe window)







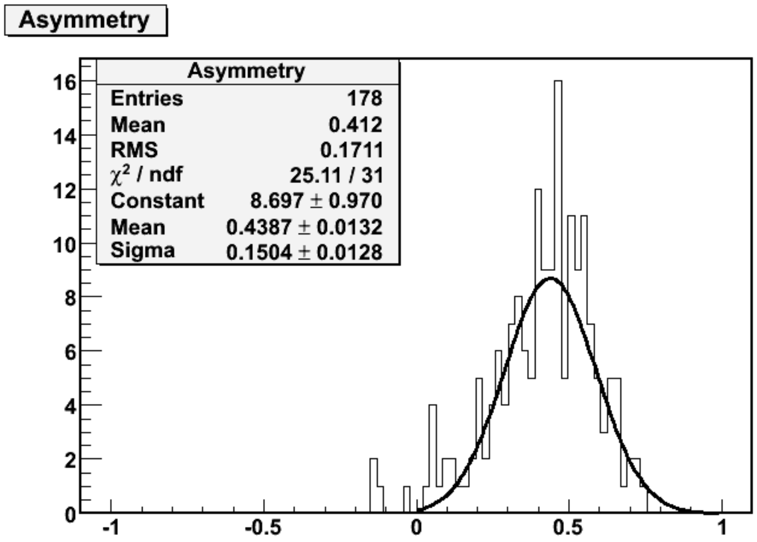
- Distribution of both, positrons and electrons and the asymmetry (analyzing power)

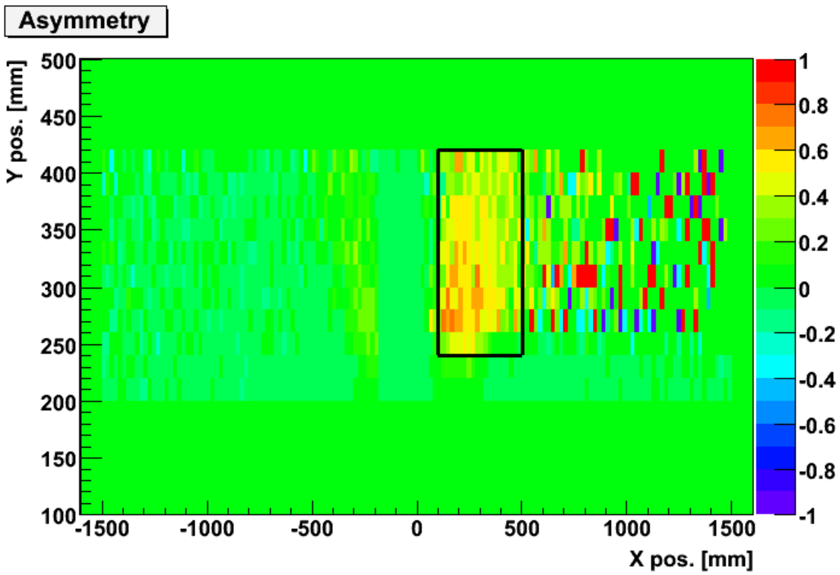
- Target 30 μm Fe
- E_{beam} 400MeV
- BdL 0.1 Tm
- P(100%/100%)
- w. beam pipe exit window

- 1.4 x 10^9 positrons on target
- A ~ 30%

pol. G4 results

… and higher statistics





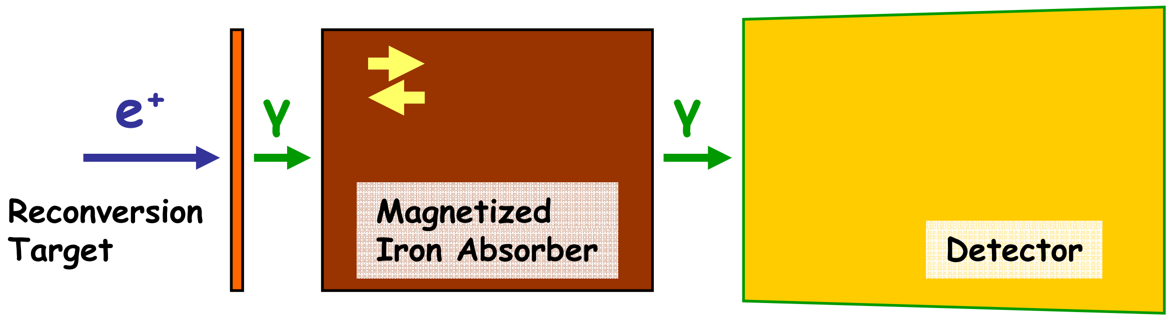
- Distribution of both, positrons and electrons and the asymmetry (analyzing power)

- Target 30 μm Fe
- E_{beam} 400MeV
- BdL 0.1 Tm
- P(100%/100%)
- w. beam pipe exit window

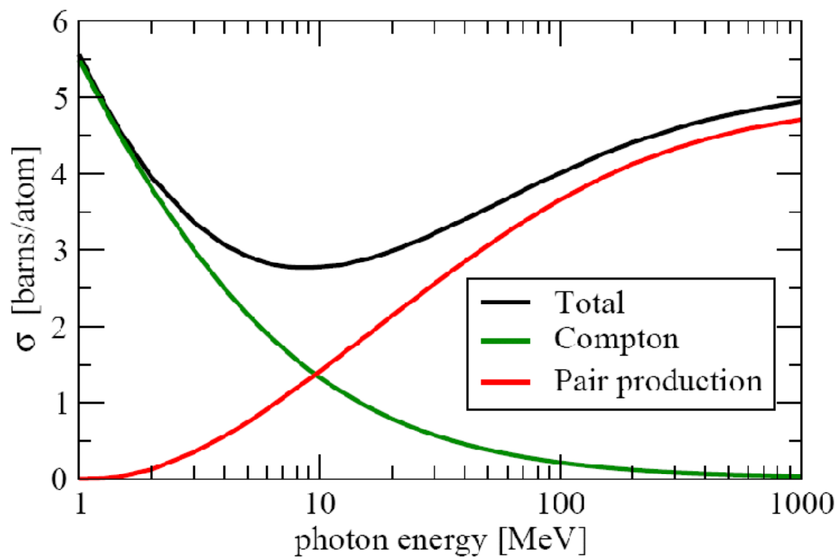
- 1.14 x 10^{10} positrons on target
- A ~ 41% (RMS 17%)

pol. G4 results

Compton Transmission Method



- Destructive !
- Polarized positrons reconverted into polarized gammas
- Polarization dependent transmission due to Compton scattering in magnetized Iron
- Working point: $E_{e^+} < 100$ MeV
  ideal after capture section O(~30 MeV)



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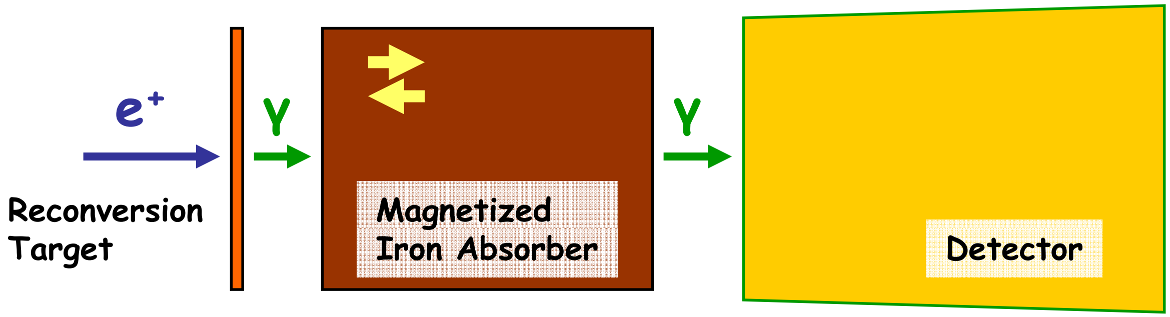
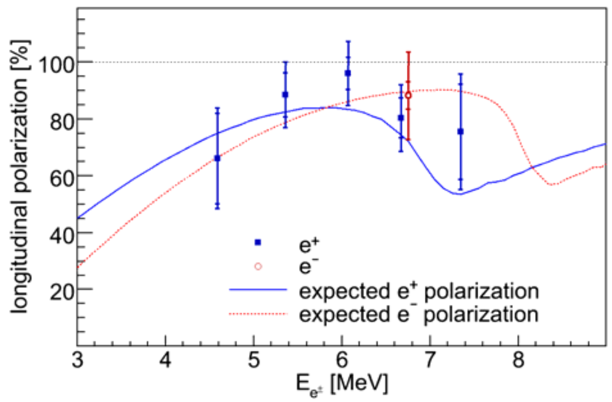




☺ Dimensions O(1m)
Many experiences from E166

☹ Thick Target (1 to 3 X_0)
with high energy deposition O(~KW)
Small asymmetries O(<1%)

Simulation results for E_{beam} =30 MeV, P_{e-}=7.92%, Target: 2X_0 W, Absorber 15cm Fe

P_{e^+}	A
30%	~ 0.4%
60%	~ 0.8%

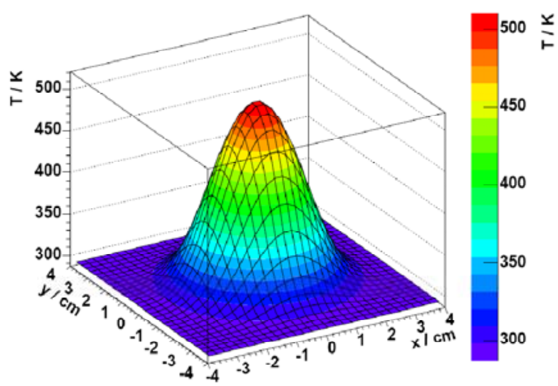
Summary

- Simulation studies for Bhabha polarimeter at 400 MeV are promising …
- … with help of a powerful simulation tool (polarized G4) and the experience from E166

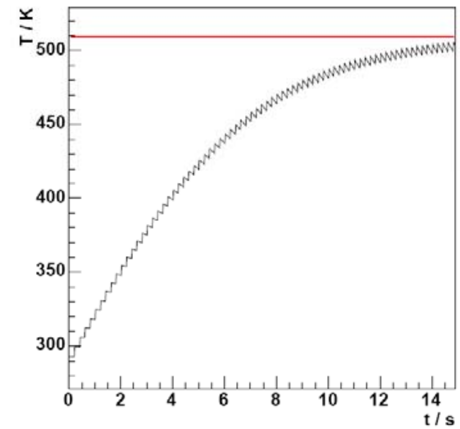
Ongoing simulation studies:

- Bhabha Polarimeter – preferred and only method
  - high statistics studies with ideal setup
  - analyzing power for real. polarization values (P_{beam}30(60)% / P_{e-}7%)
  - background studies (optimization of shielding, materials, geometry)
  - implementation of real beam properties
- Compton Transmission Polarimeter
  - high statistics for 35 MeV beam energy and real beam properties

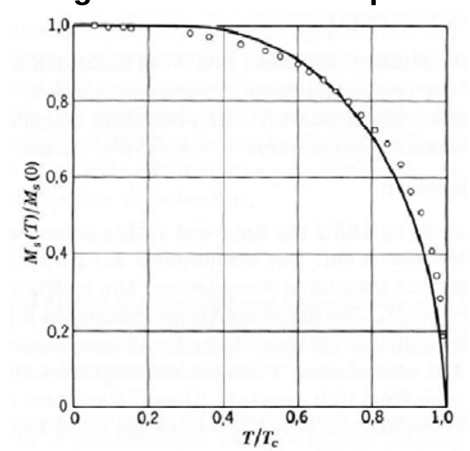
- Magnetized thin IronTarget
- Heating of the target -> Magnetization decreases
  - T_C (Fe) = 1039 K; melting point 1808 K
- $\Delta T \rightarrow \Delta M \rightarrow \Delta P \rightarrow \Delta A$



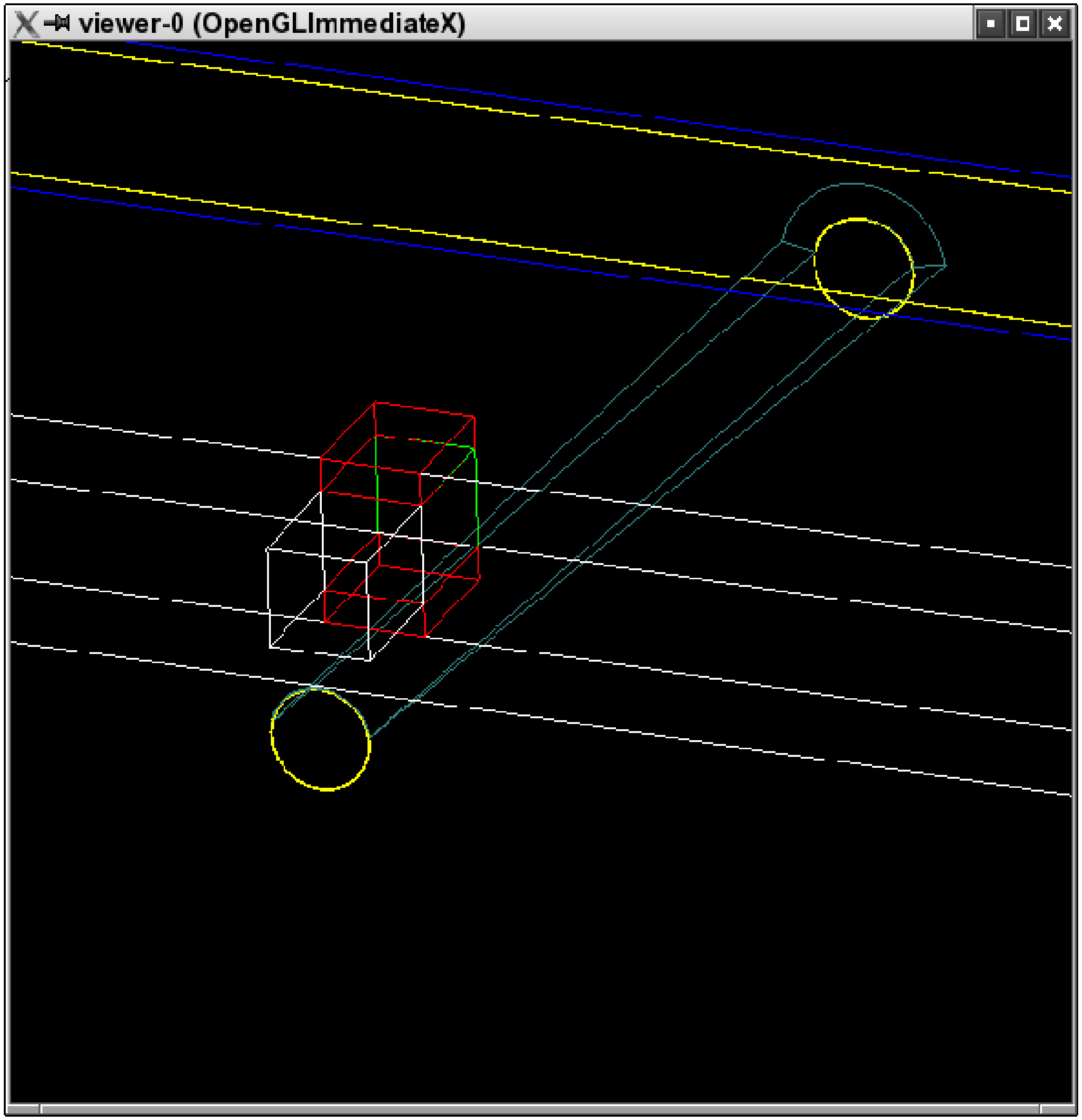
Target temperature vs. time



Magnetisation vs. Temperature



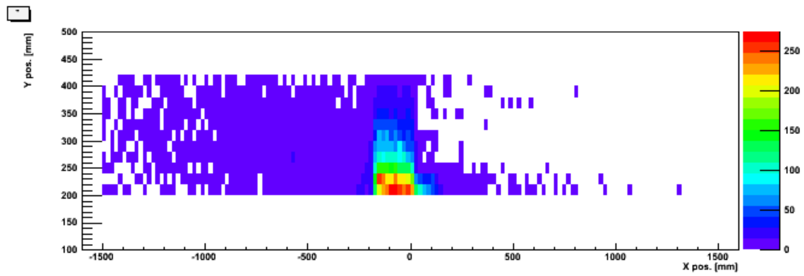
- Magnet design
- Background optimization

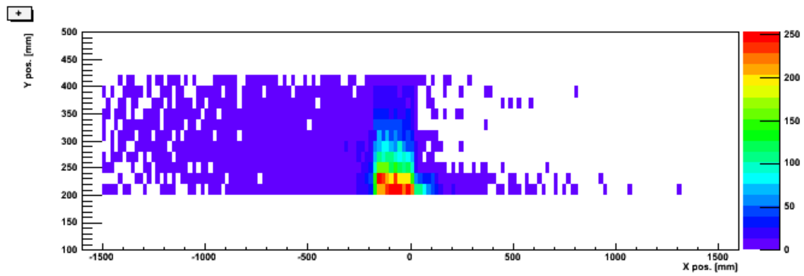

viewer-0 (OpenGLImmediateX)

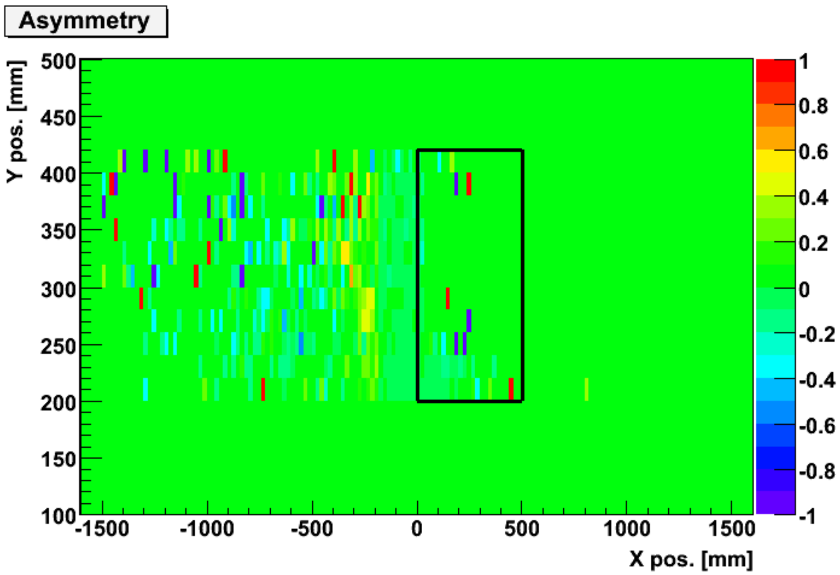
Available Processes

- **Laser Compton Scattering** (ex.: SLC, HERA)
  - High intensity Laser on low emittance beam
  - Only after Damping Rings (Intensity, Energy)
  - High precision
- **Bhabha/Møller** (ex: SLAC, JLAB, VEPP-3)
  - Thin magnetized Target
  - Suitable for desired energy range
- **Compton Transmission** (ex.: E166, KEK-ATF Pol. Experiment)
  - Beam absorbed in thick target
  - Very low energy (< 100 MeV)
- **Mott**
  - Transverse polarized positrons, high background
- **Synchrotron radiation** (ex.: VEPP-4 storage ring)
  - Transverse polarization
  - Near/in damping ring ?
  - Low signal – Asymmetry < 10^{-3}

e^+ in detector







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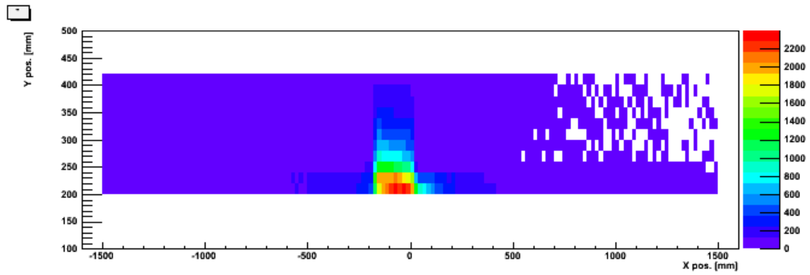
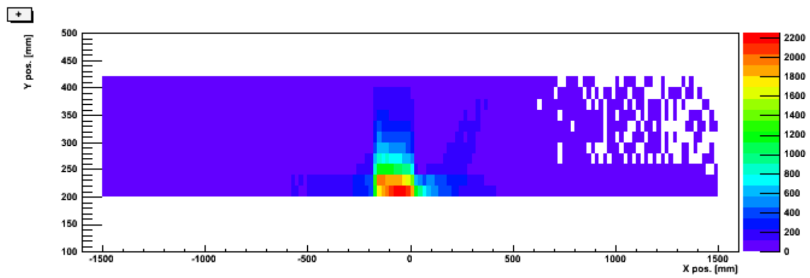
- P(100%/100%)
- w. beampipe window

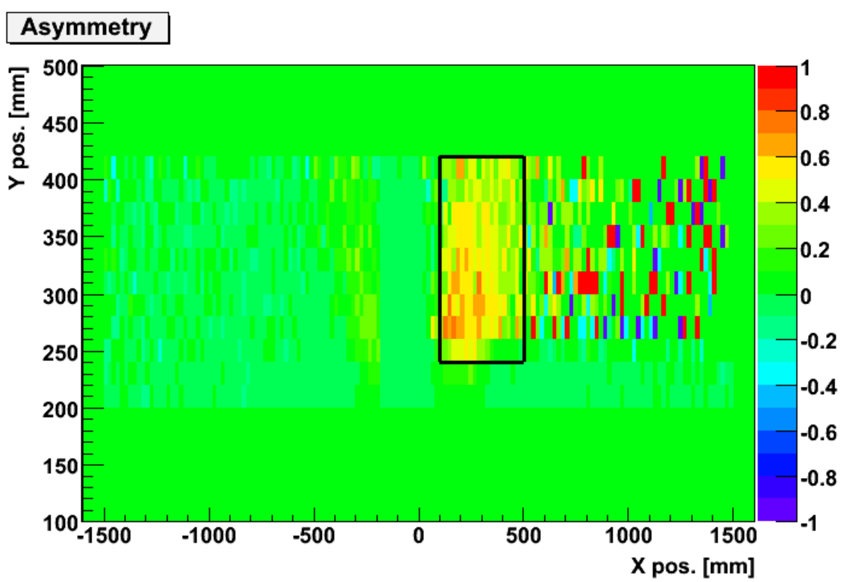
- 1.4 x 10^9 positrons on target

pol. G4 results

… and high statistics







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