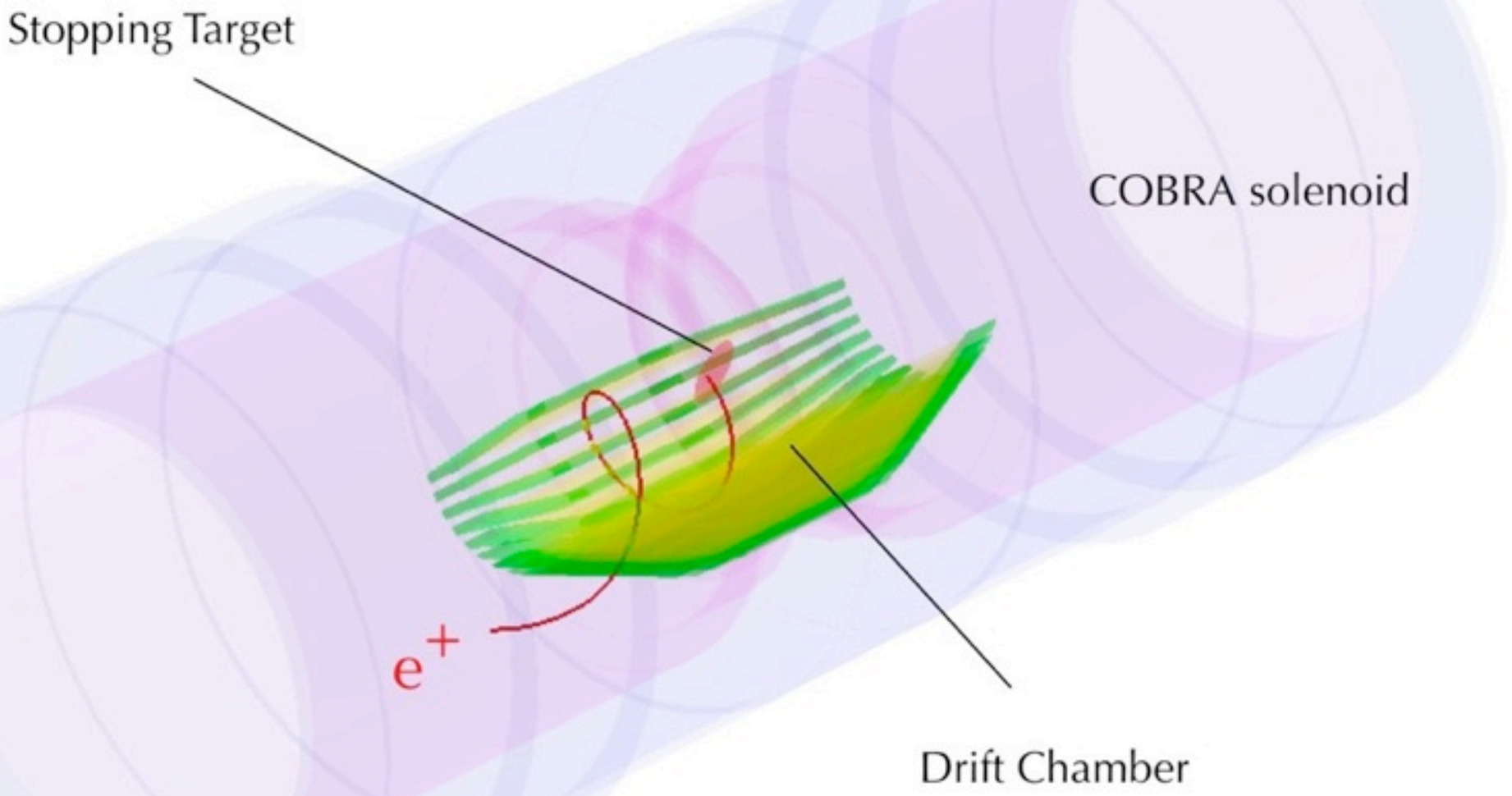


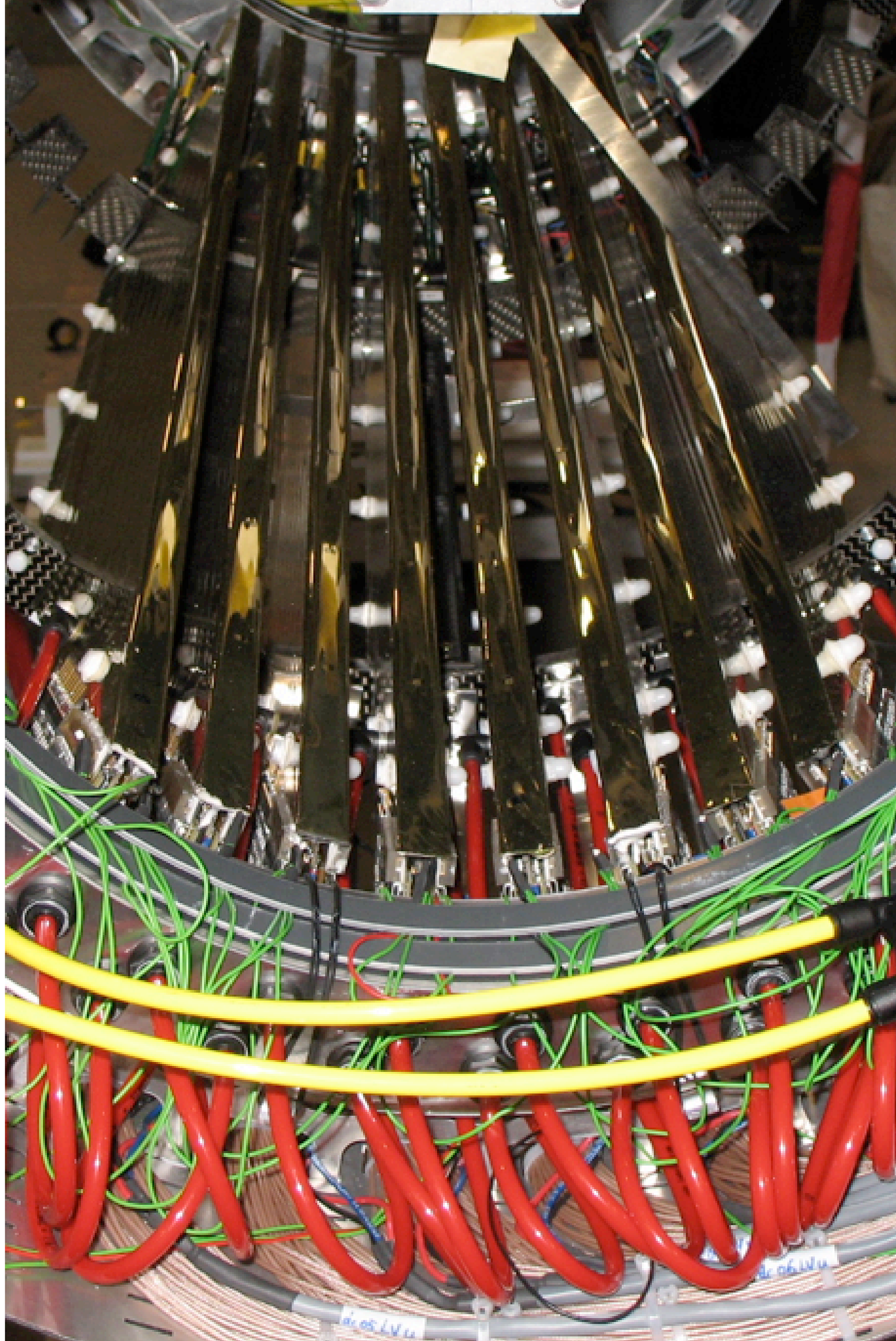
MEG2008 データ解析：陽電子スペクトロメータ

西口 創 (KEK素核研), 他 MEG コラボレーション

JPS Autumn Meeting, 10-13/Sep./2009, Konan University

contents

MEG e^+ spectrometer



Requirements for Positron Spectrometer

- **Very high counting rate**
  - the most intense DC muon beam in the world
  - muon stopping rate : 3×10^7 muon/sec

→ Special B-field

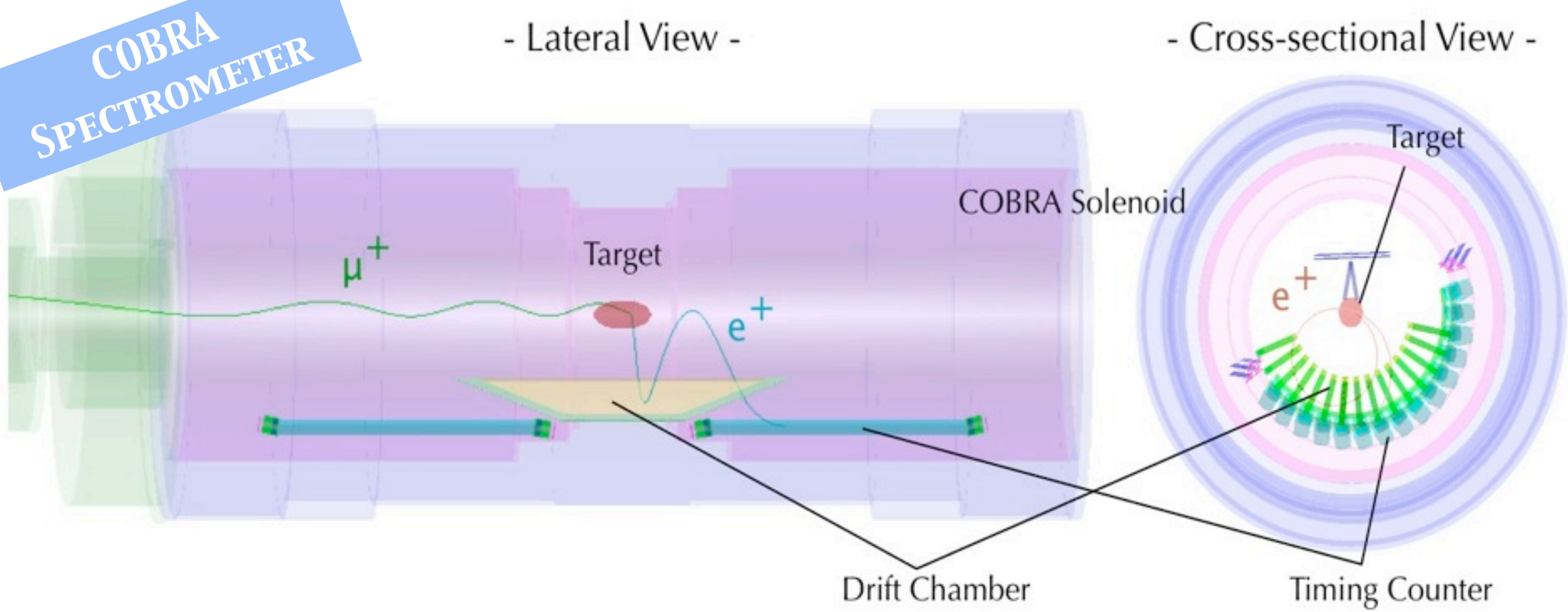
- **Good momentum/position/timing resolution**
  - aiming excellent sensitivity
  - ~1% momentum resolution, 500μm position resolution for both direction(r,z) and 40 ps timing resolution

- **Low-mass material**
  - 52.8MeV/c positron can be affected by multiple Coulomb scattering easily
  - γ background generation should be suppressed as much as possible

→ new sensitive & light DC

MEG Positron Spectrometer

COBRA SPECTROMETER



Solenoid

superconducting solenoid
gradient B-field (0.5-1.7 T)
very thin conductor and
cryostat wall ($0.2X_0$)

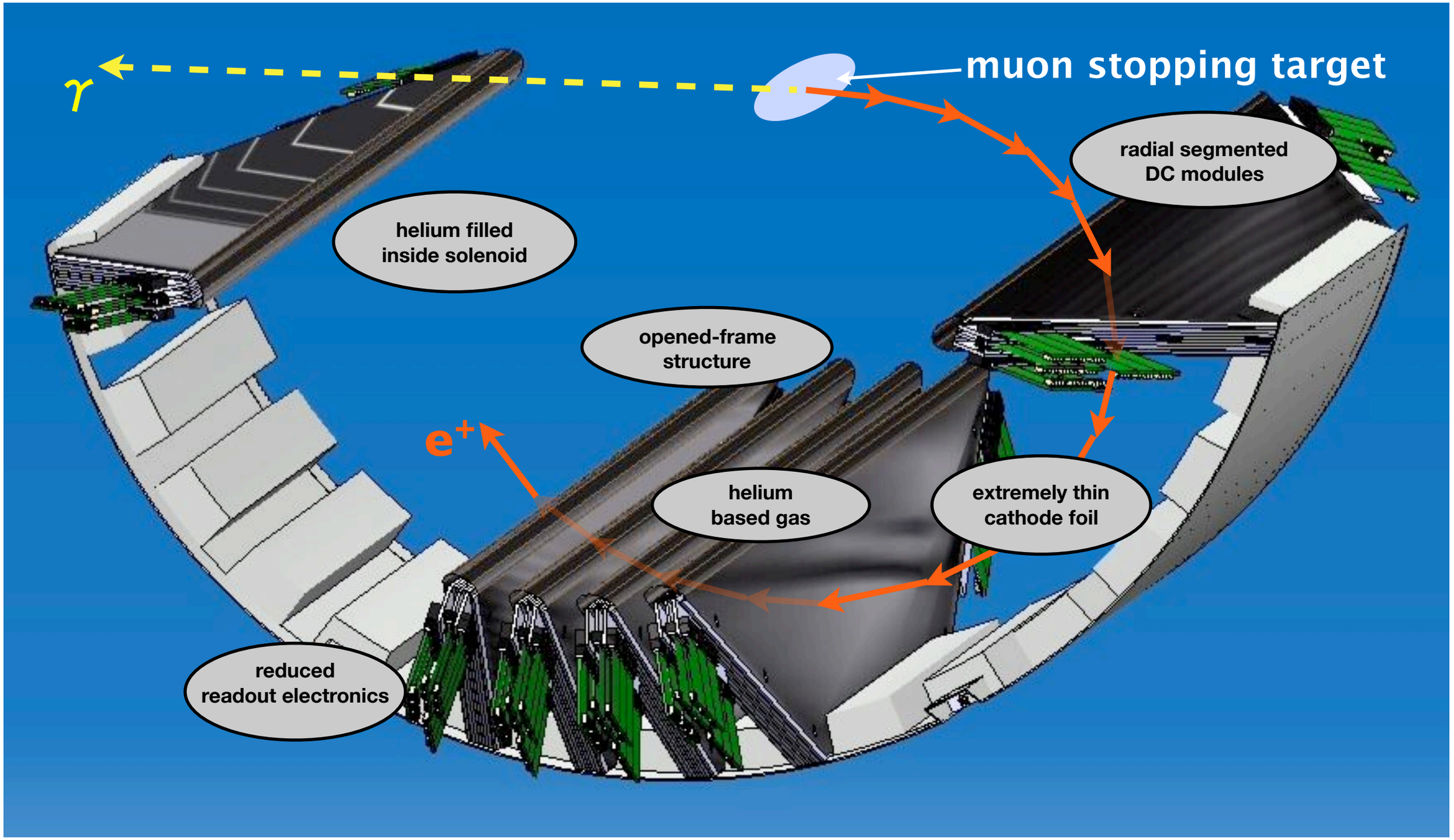
Drift Chamber

segmented radially (16 sectors)
helium:ethane (50:50)
opened-frame
very thin cathode foil with pads

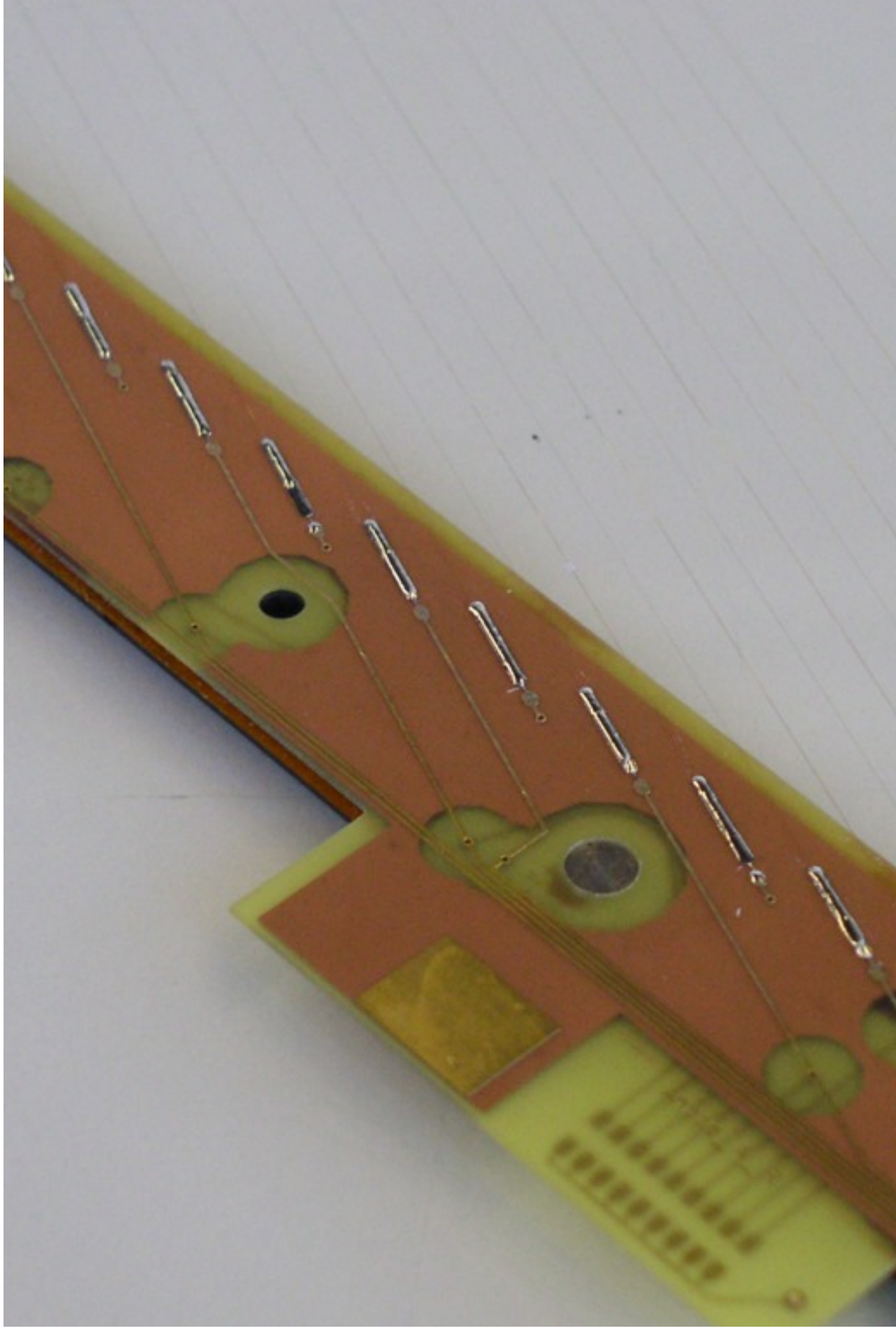
Timing Counter

2-layers of scintillators
- scintillator bars (outer)
- scintillator fibres (inner)

MEG Drift Chamber



Run 2008



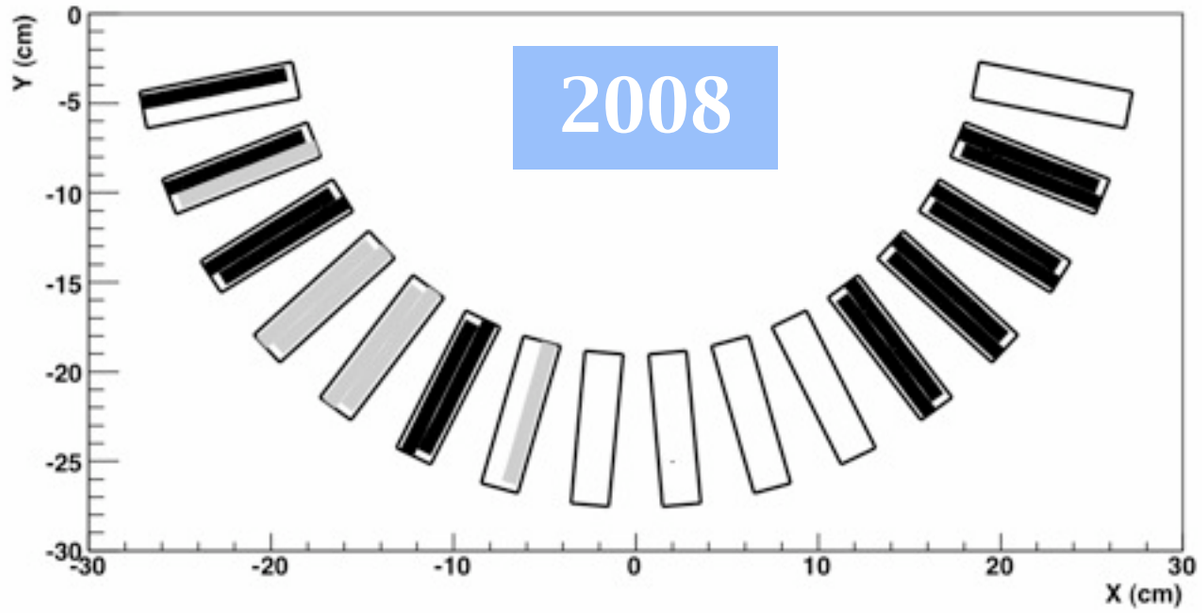
Spectrometer in 2008

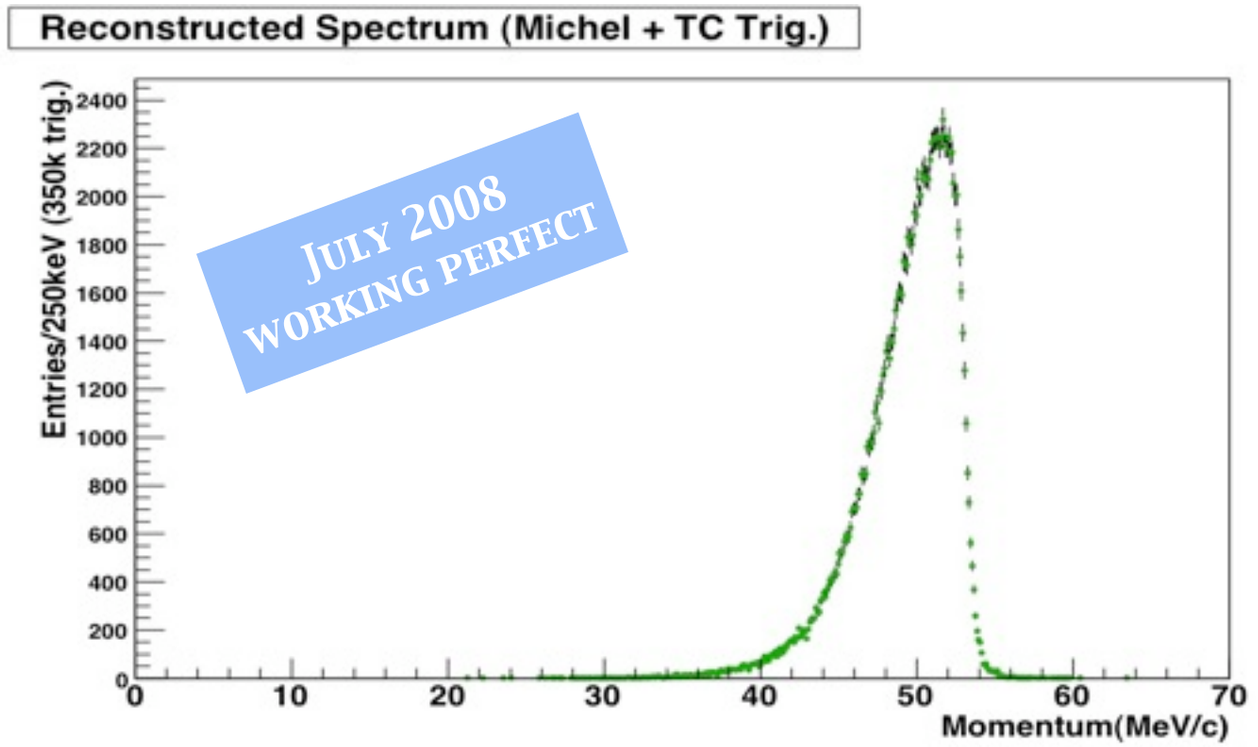
- We had the first long term experiment (***physics data taking***) in 2008.

- Rough Time-line 2008 ;
  - **January - May : *Drift Chamber Maintenance***
    - Repair work for bad cable connection
    - Modification to avoid discharge problem
  - **June - July : *Installation and Commissioning Run***
    - Michel e^+ Run was performed for Calibration/Conditioning
  - **August : $\pi^0 \rightarrow \gamma\gamma$ *Run***
    - Spectrometer was in Summer Vacation
  - **September - December : *MEG Physics Run***
    - Problems : Discharge on DC, Noise on Fibre Counter, *etc.*

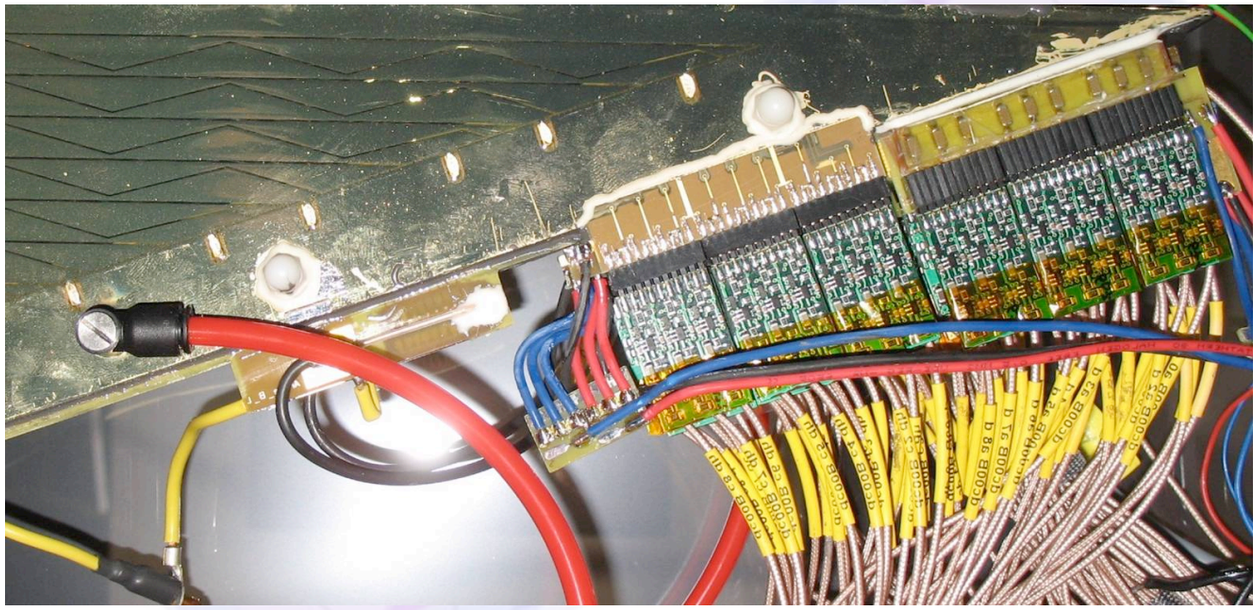
Several DCs were inactive...

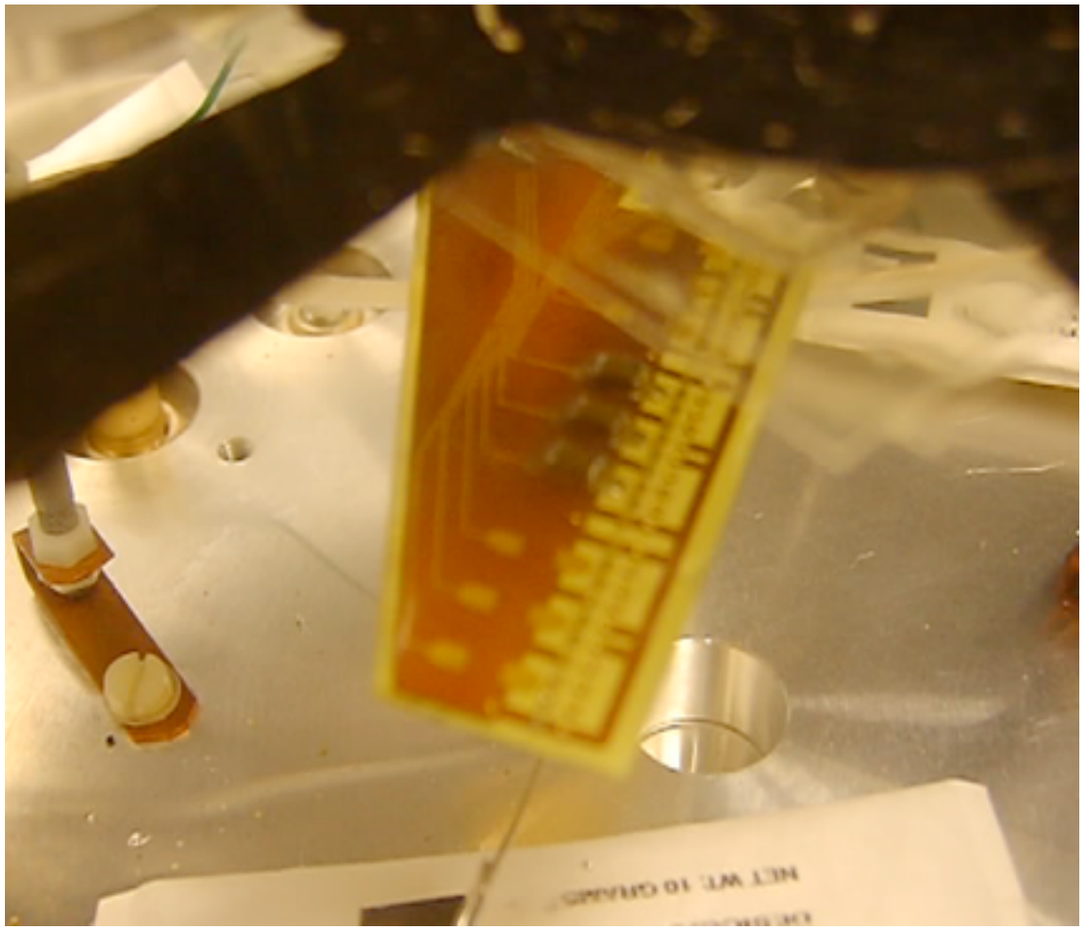
- Discharge on DC happened frequently during Run2008.
- Discharge problem happened 2007 originally, it was fixed at the beginning of 2008, but slowly happened again.
- Finally, 18 planes were operational, only 12 planes were working with nominal voltage...(HV is applied to each plane individually; 32 planes)





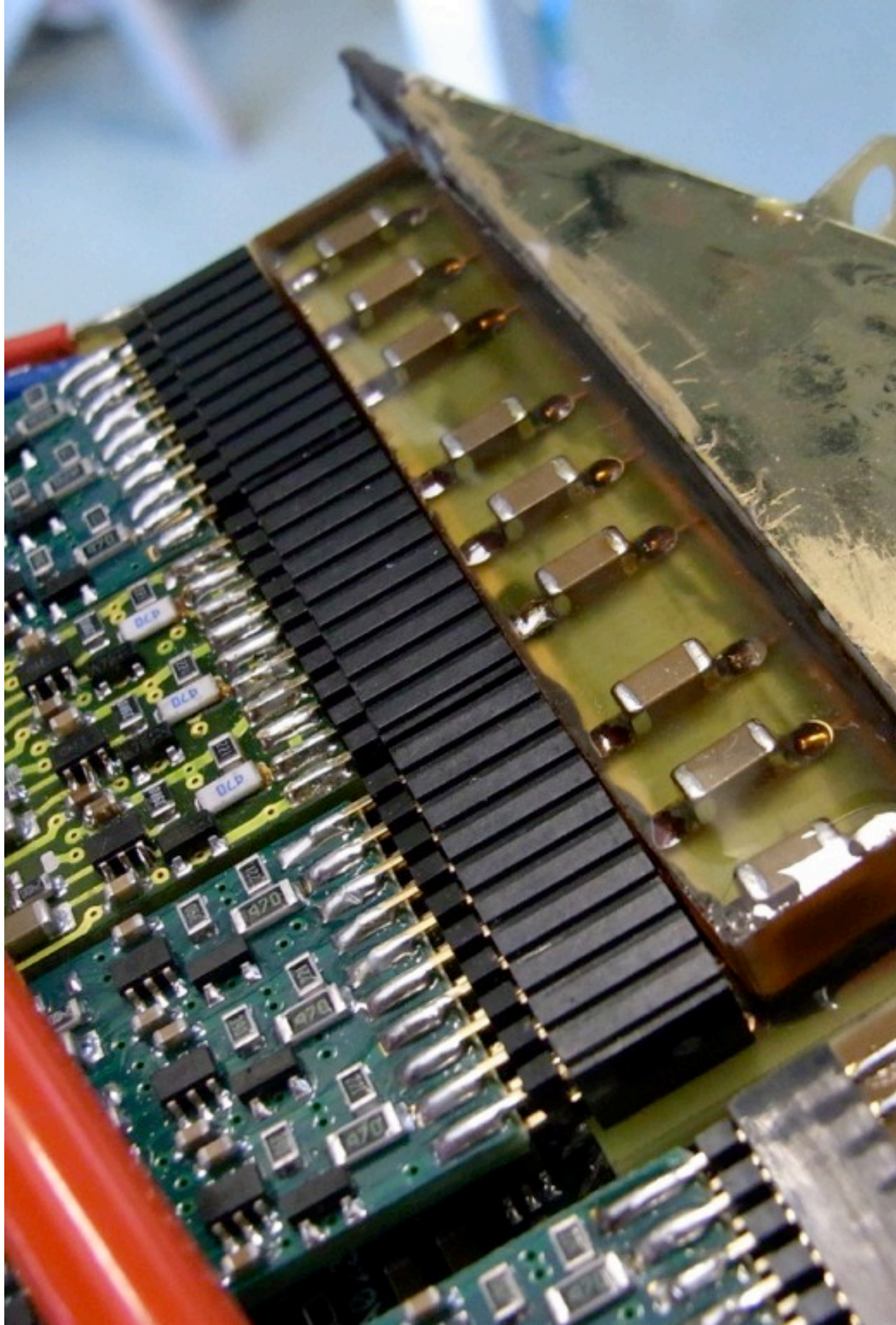
Discharges





- Inside COBRA is filled with pure helium, then DC-outside is exposed in helium atmosphere.
- HV-tracer-line is partially naked to helium in 2007, then discharged...
- We made the protection for helium in 2008 maintenance period, but...

2008 Performances

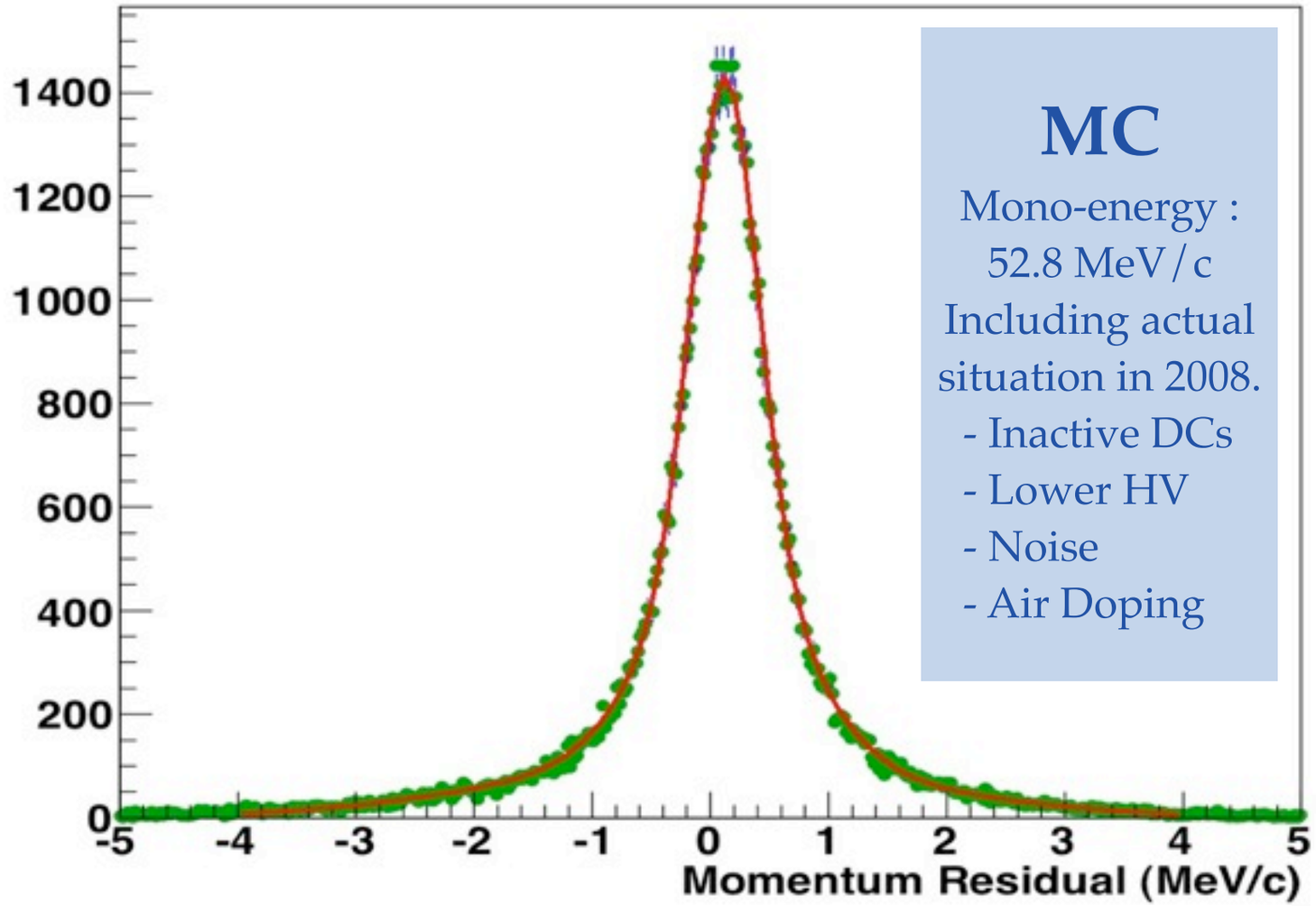


Performance Evaluation

- Positron Spectrometer Performances
  - Momentum Resolution ; σE_{e^+}
  - Angular Resolution ; $\sigma\phi_e$, $\sigma\theta_e$
  - Vertex Resolution ; σ_x, σ_y
- Combined Performances (LXe Calorimeter + e^+ Spectrometer)
  - Opening Angle Resolution ; $\sigma\theta_{e\gamma}$, $\sigma\phi_{e\gamma}$
  - Timing Resolution ; $\sigma t_{e\gamma}$
- Spectrometer Efficiency ; ε_e
- Probability Density Function (PDF)
  - For the Likelihood Analysis
  - E_{e^+}, $\theta_{e\gamma}$, $\phi_{e\gamma}$, $t_{e\gamma}$: for Signal, Background, both

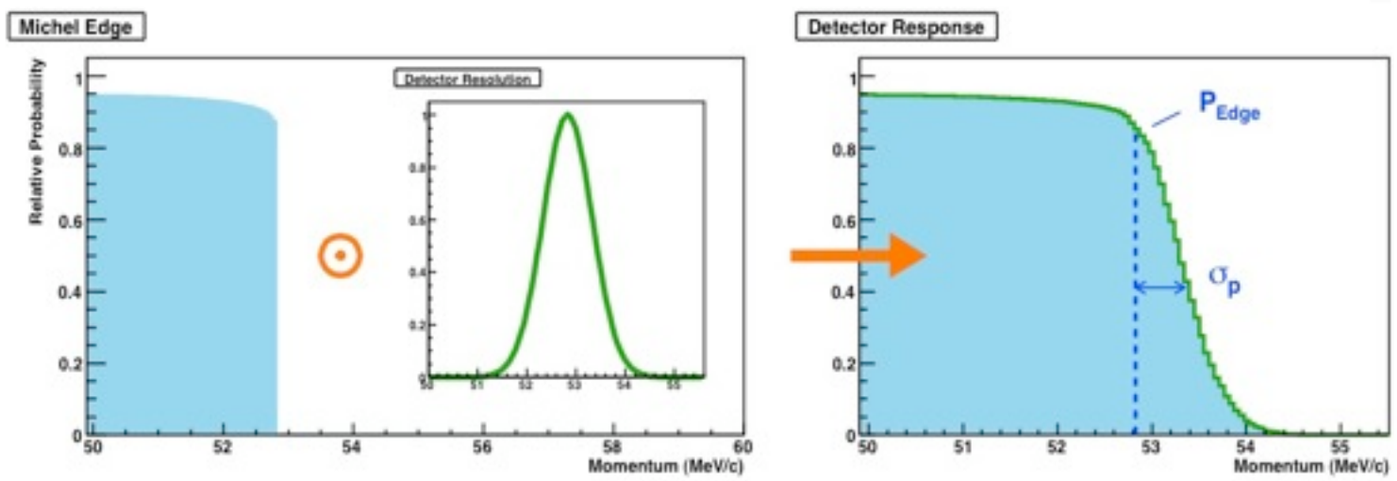
Momentum Resolution Estimation

- Momentum-Resolution function is represented by Triple-Gaussian
  - Studied by mono-energetic e^+ in MC
  - σ_{core}, σ_{out}, σ_{tail} and their fractions are referred as resolution
- Fitting the kinematical edge of Michel spectrum to the convolution of resolution function and (theoretical) response function

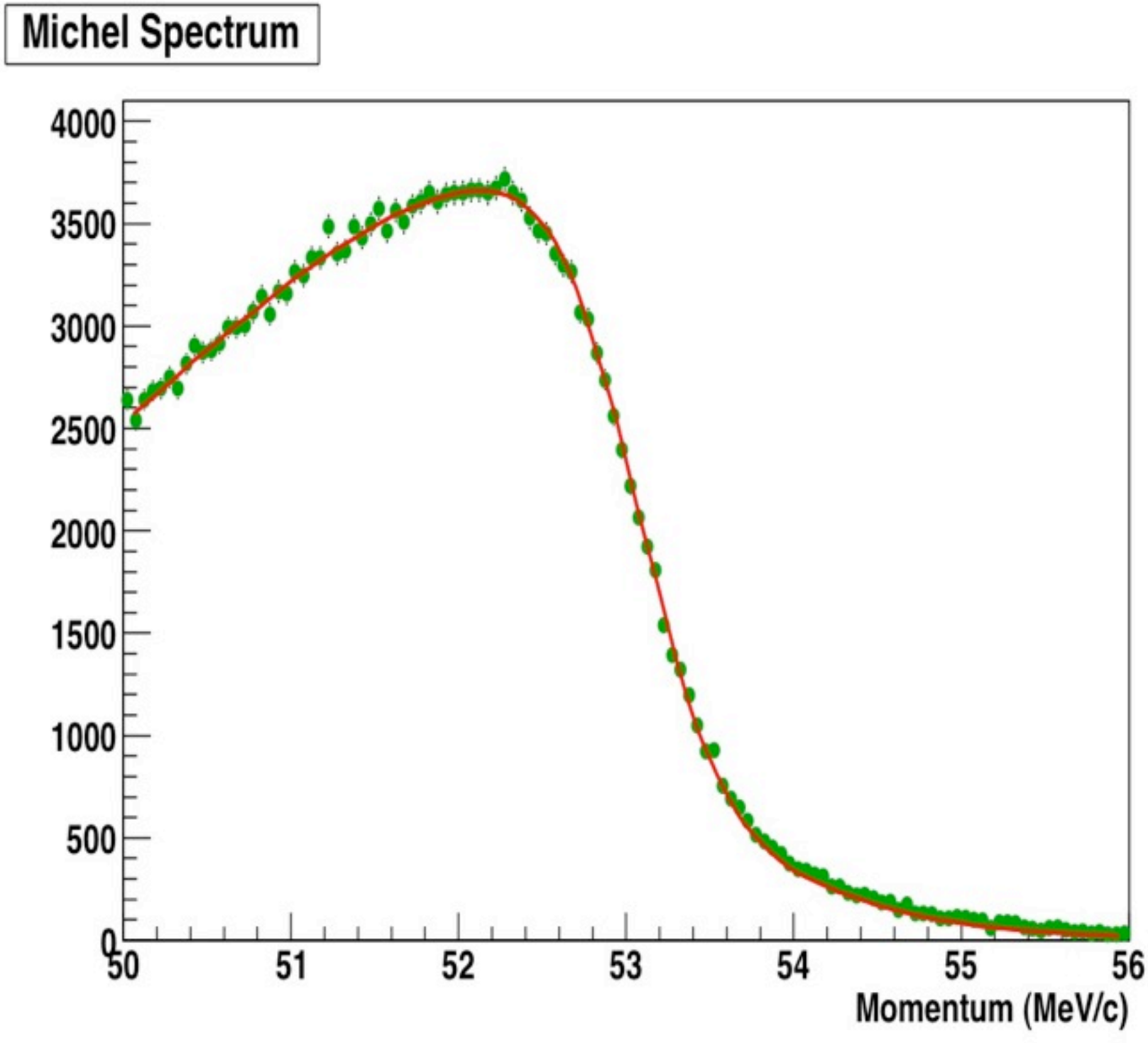


MC

Mono-energy : 52.8 MeV/c
Including actual situation in 2008.
- Inactive DCs
- Lower HV
- Noise
- Air Doping



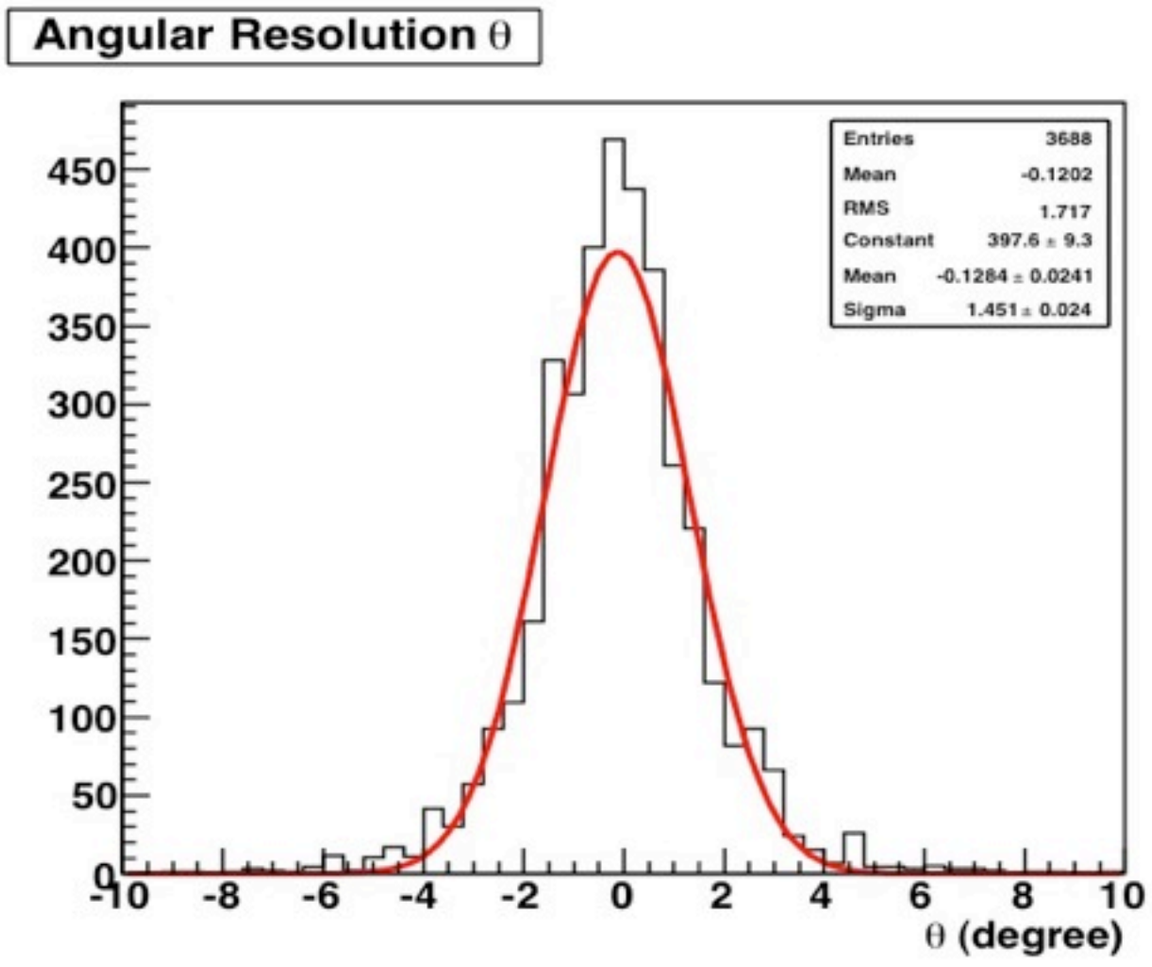
Momentum Resolution (Run2008)

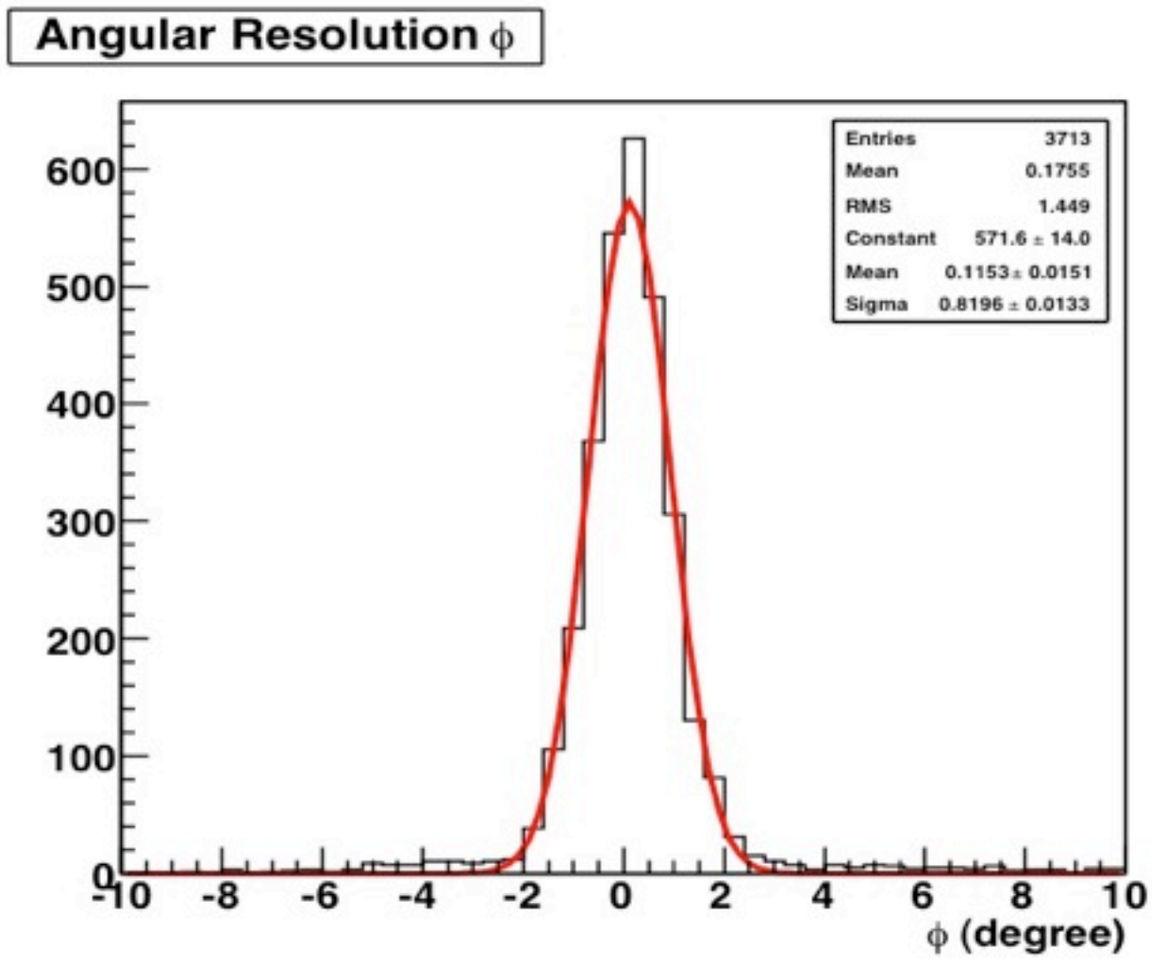


- Obtained Resolution
  - $\sigma E_{core} = 374$ keV
    - $frac_{core} = 60\%$
  - $\sigma E_{out} = 1.06$ MeV
    - $frac_{out} = 33\%$
  - $\sigma E_{tail} = 2.00$ MeV
    - $frac_{tail} = 7\%$
  - ave. $\sigma E = 714$keV
  - **$\sigma E/E \sim 1.3\%$**

Angular Resolution (Run2008)

- Angular resolution is estimated by doubly curling track.
- Subtracted angular residual of each turn gives intrinsic angular resolution.





- $\sigma_\theta = 1.45$ deg. $/\sqrt{2}$

  $\approx$ **18 mrad.**

- $\sigma_\phi = 0.81$ deg. $/\sqrt{2}$

  $\approx$ **10 mrad.**

(*) *N.B.* Taking the z-axis as the beam-axis, θ is defined as the polar angle, while ϕ is the azimuthal angle.

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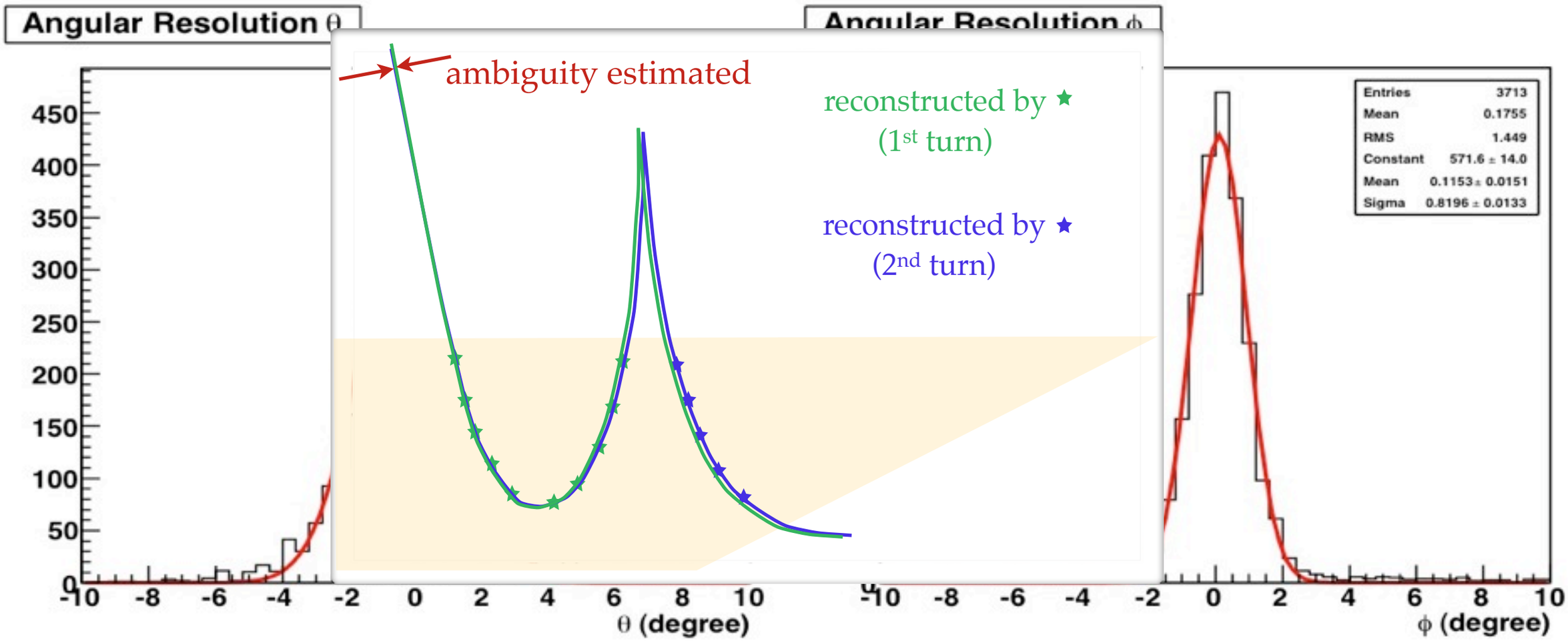


- $\sigma_\theta = 1.45$ deg. $/\sqrt{2}$

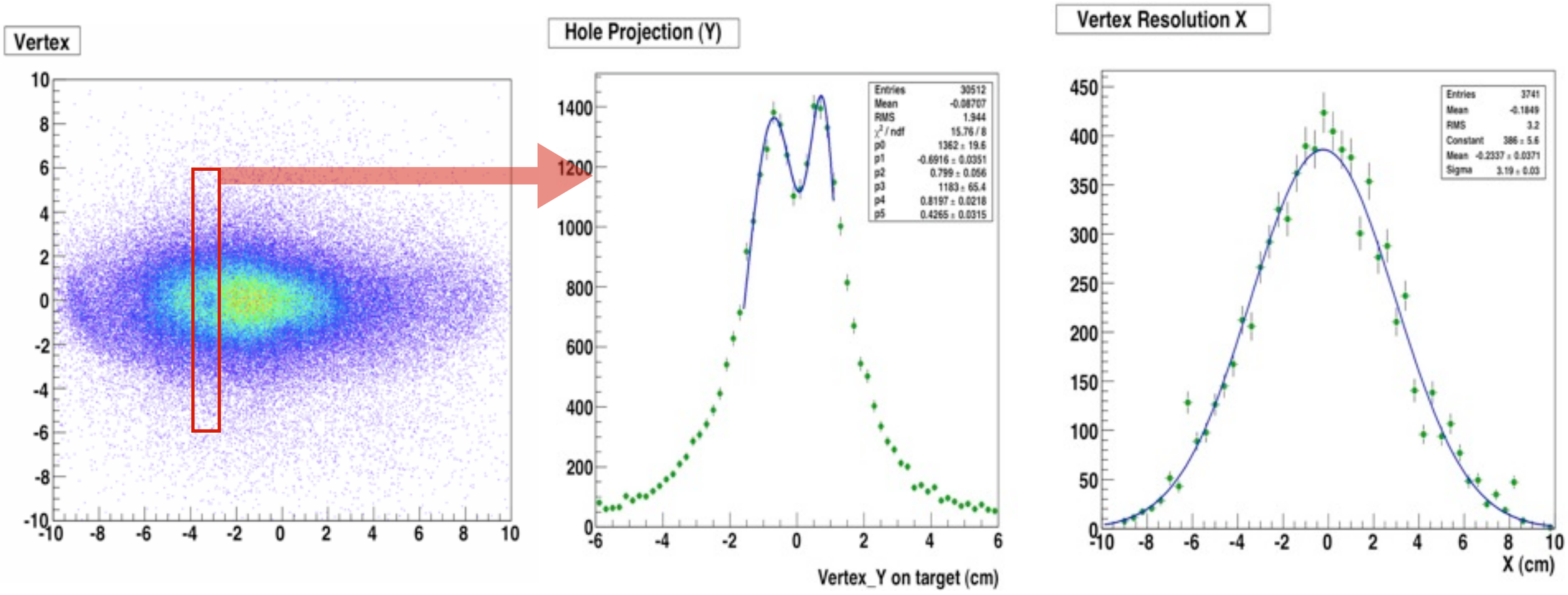
  ≈ 18 mrad.

- $\sigma_\phi = 0.81$ deg. $/\sqrt{2}$

  ≈ 10 mrad.

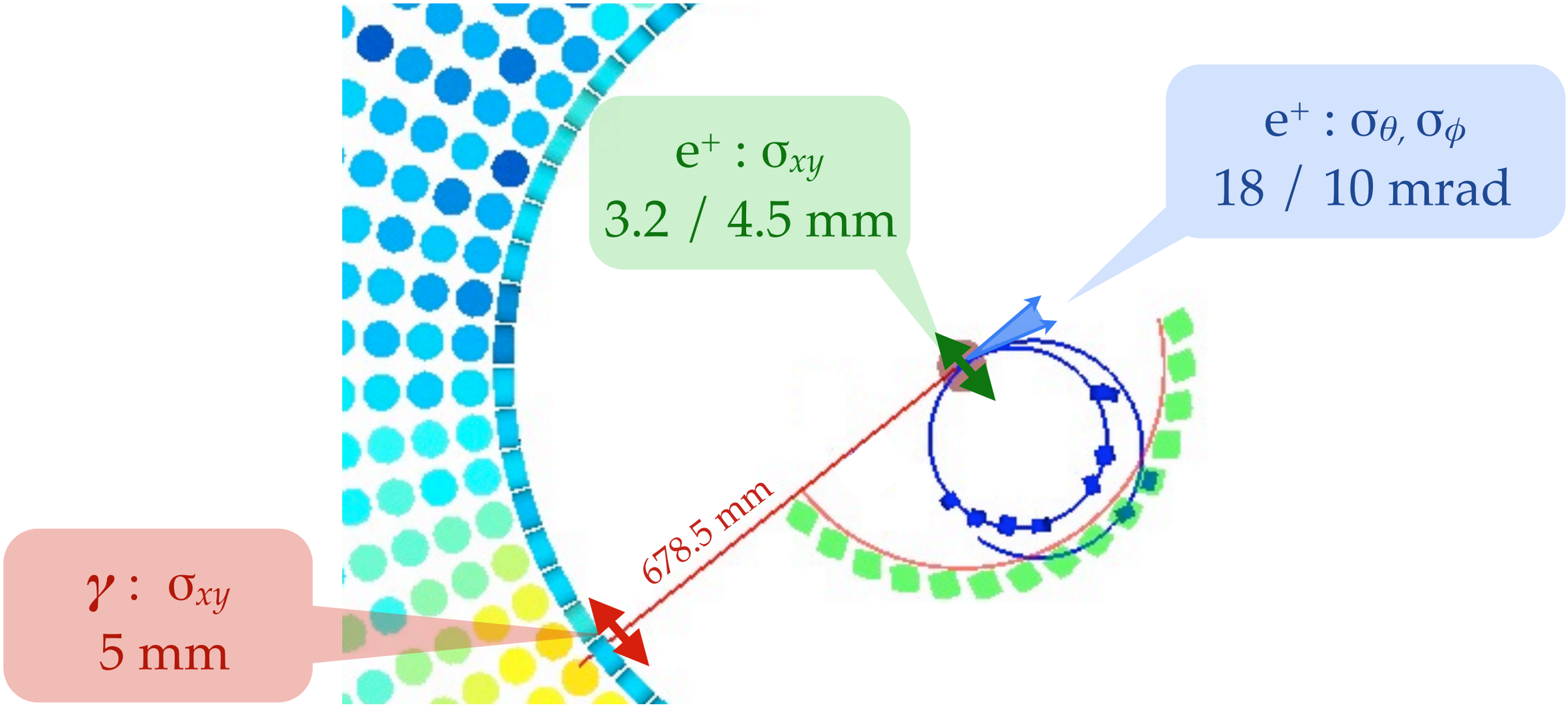
(*) *N.B.* Taking the z-axis as the beam-axis, θ is defined as the polar angle, while ϕ is the azimuthal angle.

Vertex Resolution (Run2008)



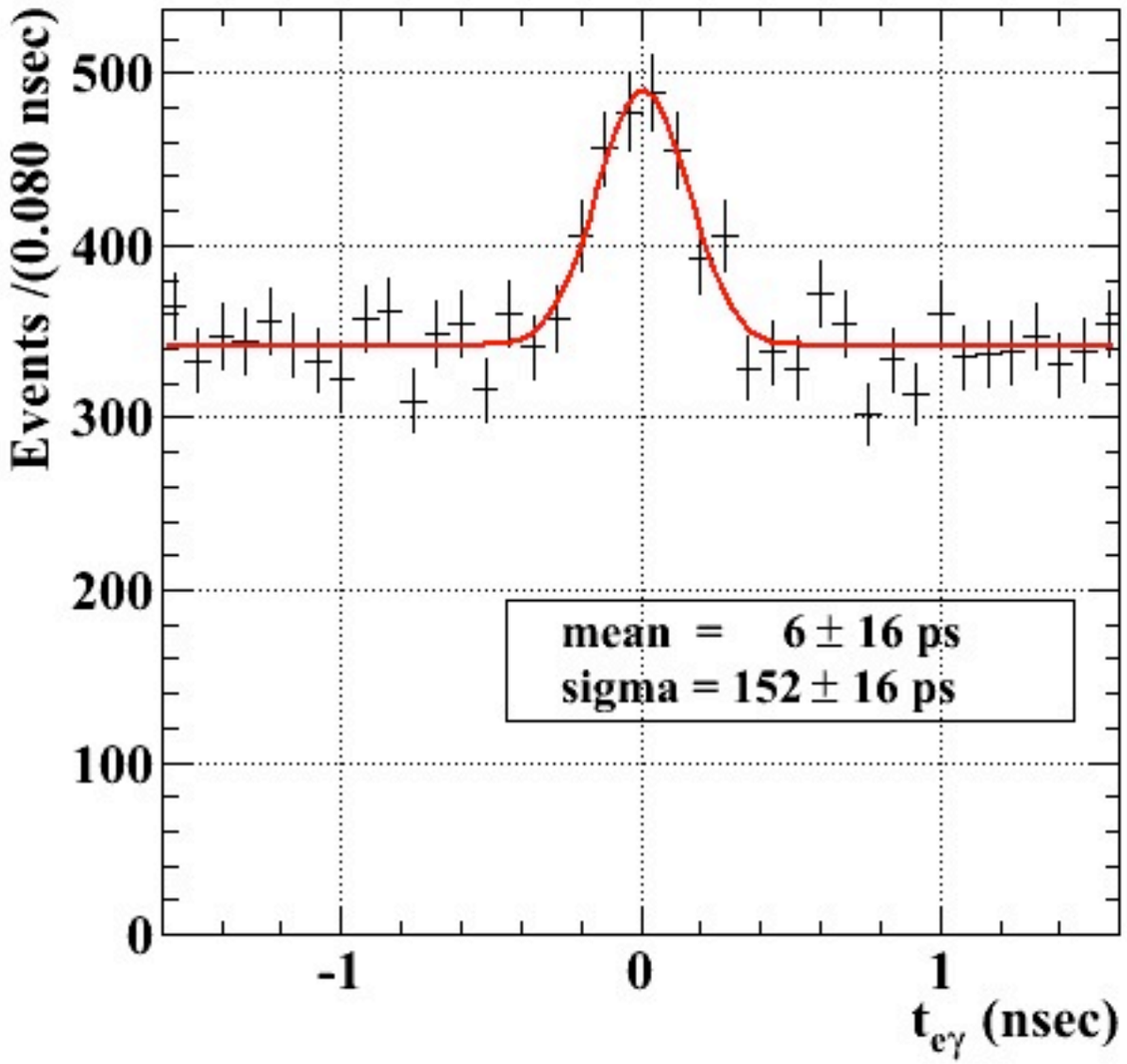
- Vertex (muon decay position) Resolution can be evaluated by two way
  - (1) Fitting the image of hole / (2) Subtracting the double curing track
  - Both show consistent results; **σ_x ~ 4.5 mm** and **σ_y ~ 3.2 mm**

Opening Angle Resolution (Run2008)



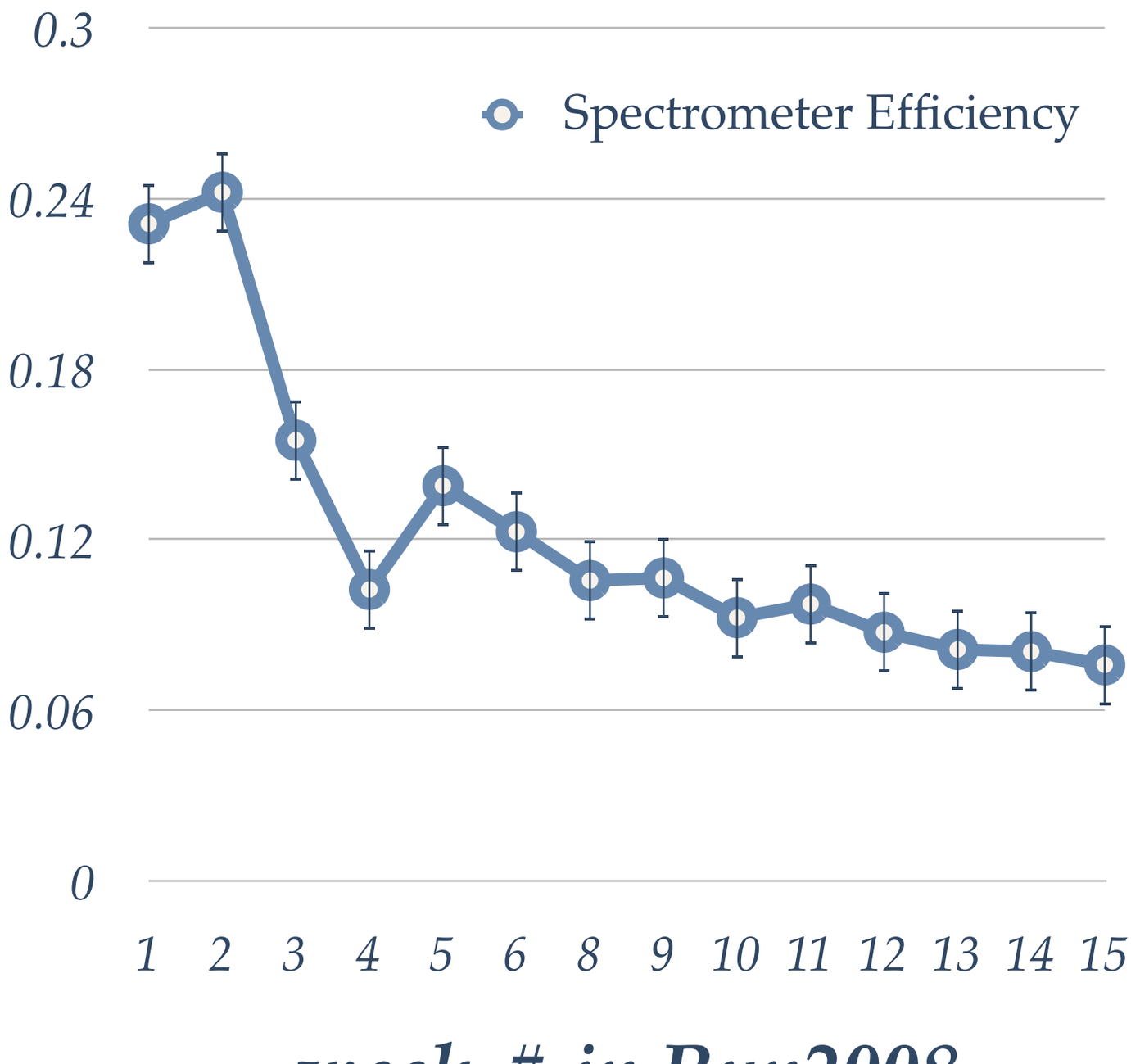
- Liquid Xenon Detector knows only the incident position, not angle.
- **Combined Angle Resolution : $\sigma\theta_{e\gamma}$ = 20.6 mrad. / $\sigma\phi_{e\gamma}$ = 13.9 mrad.**

Timing Resolution (Run2008)



- Relative Timing (e^+/γ) in physics data shows Radiative Decay Peak on the accidentals.
  - Positron timing is measured by TC and corrected by track length.
  - Gamma-ray timing is corrected by ToF to the conversion point in LXe.
- Peak width is corrected by small energy dependence
  - **$\sigma t_{e\gamma}$ = 148 psec**

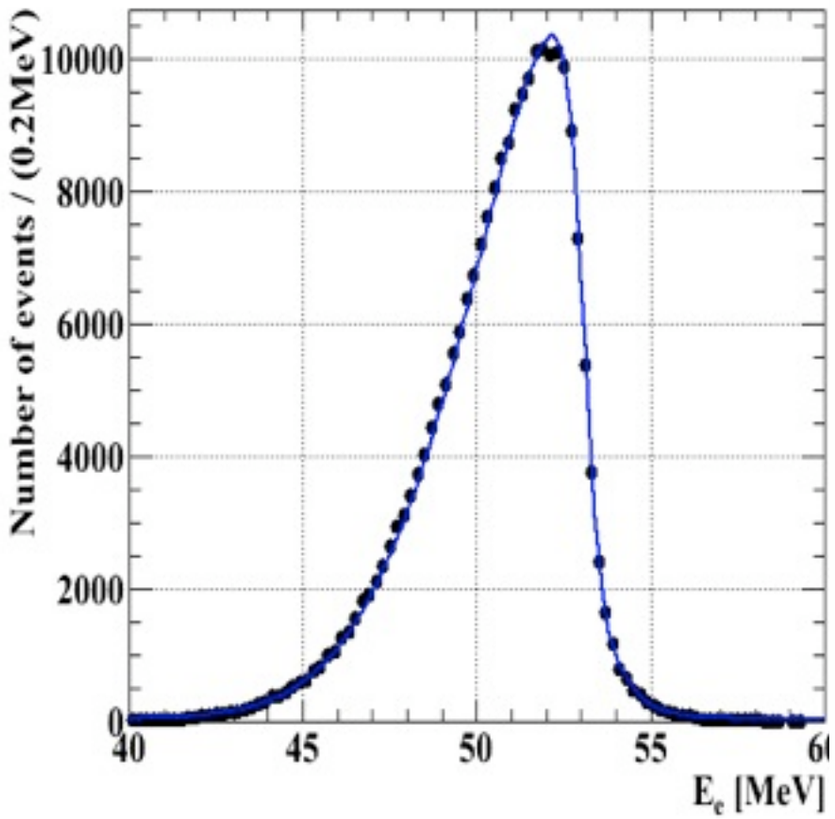
Spectrometer Efficiency (Run2008)



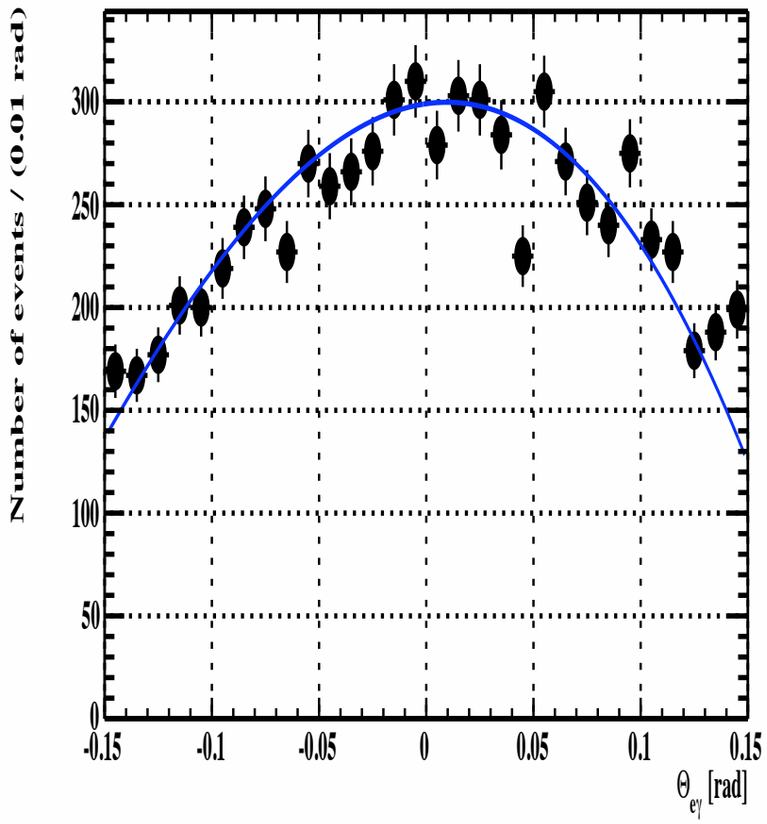
- Spectrometer Efficiency ε_{e^+} consists of two efficiencies
  - Track Reconstruction ε_{DC}
    - affected by lack of hit
  - DC-TC matching $\varepsilon_{DC\text{-}TC}$
    - affected by material between DC-TC
  - $\varepsilon_{e^+} = \varepsilon_{DC} \times \varepsilon_{DC\text{-}TC}$
- ε_{e^+} was degrading over physics-run period

Background PDFs : Ee^{+}, $\theta_{e\gamma}$, $\phi_{e\gamma}$

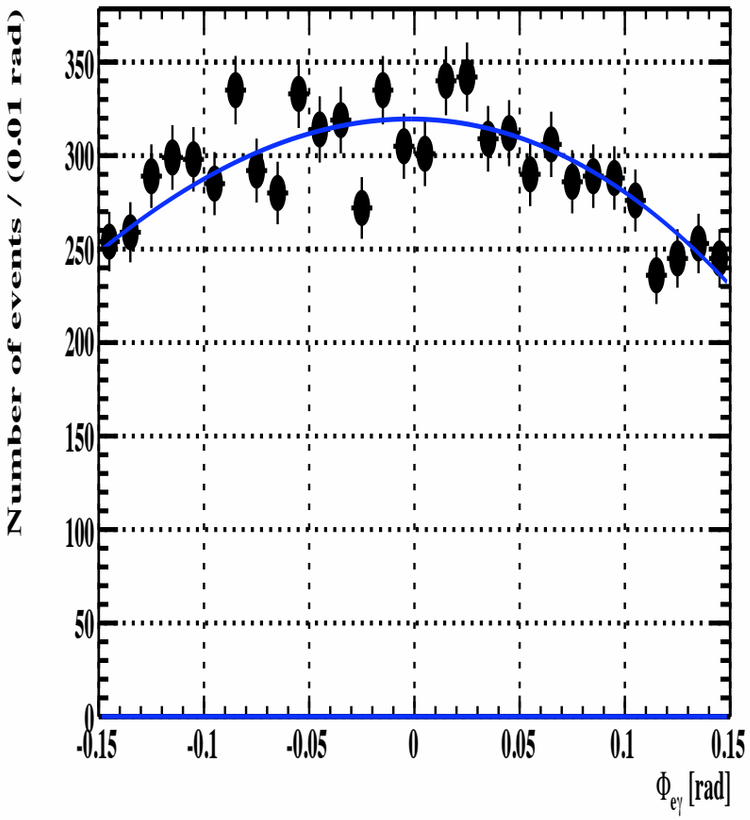
Ee^{+}



$\theta_{e\gamma}$ (example)



$\phi_{e\gamma}$ (example)



- Background PDF (radiative muon decay and accidentals) are obtained by unbiased-trigger data. (Michel Trig. and RMD Trig.)
- Used by ***Physics Analysis*** ➡ Next Talk

Summary of Performances Run2008

- Even though we had worse performances than the design value, the performance of Run2008 was evaluated to perform physics analysis.

Items	2008	2009 expectation
Momentum Resolution; σE_{e^+}	~1.3%	~0.9 %
Angular Resolution; $\sigma\theta_e$, $\sigma\phi_e$	10-18 mrad	10-13 mrad
Timing Resolution; $\sigma t_{e\gamma}$	148 psec	~100 psec
Spectrometer Efficiency; ε_{e^+}	7~24 %	~40% (80% × 50%)

Conclusions

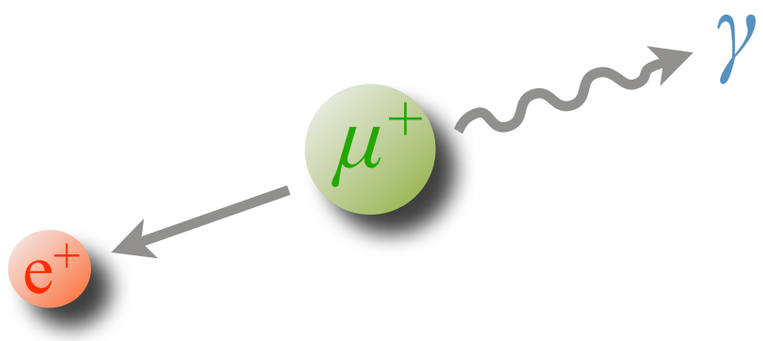
- **MEG e^+ Spectrometer have run the first long-term experiment 2008.**
- Unfortunately, several problems happened during the physics run, in particular, HV discharge problem.
- Due to discharge, DC system was operational partially, and thus the spectrometer performance was limited. **Inefficiency was particularly severe, *i.e.* statistics was limited.**
- Performance is estimated even it is limited, PDF's for Signal and Background are obtained.

- Now, ready to discuss "***Physics Analysis***". → Next Talk.
- Spectrometer should be improved. → Next to Next Talk.

backups

Signature and Backgrounds

- Signal



- $E_e = E_\gamma = m_\mu/2 = 52.8\text{MeV}$
- $\theta = 180\text{deg.}$
- time coincidence

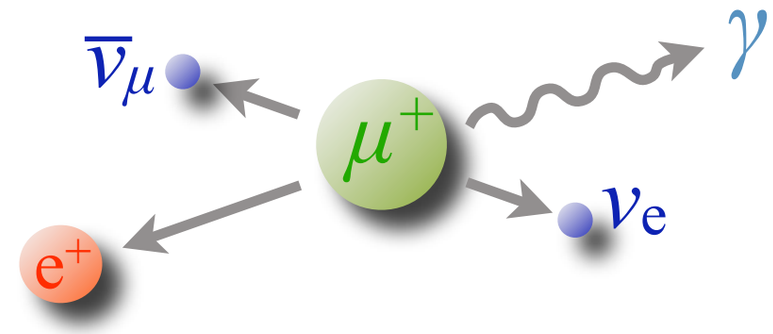
Clear 2-body kinematics

use μ^+ to avoid capture inside stopping target

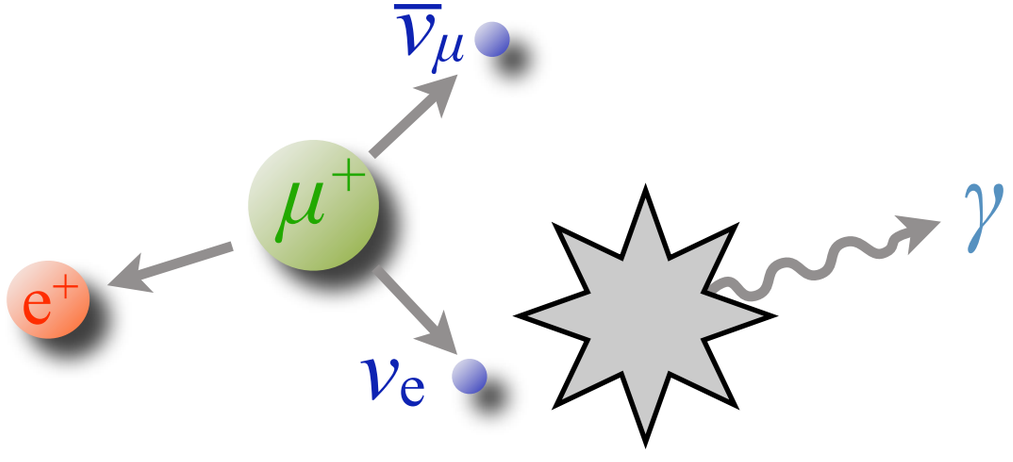
Background dominated by Accidental overlap

- lower muon beam rate is better
- DC muon beam is the best

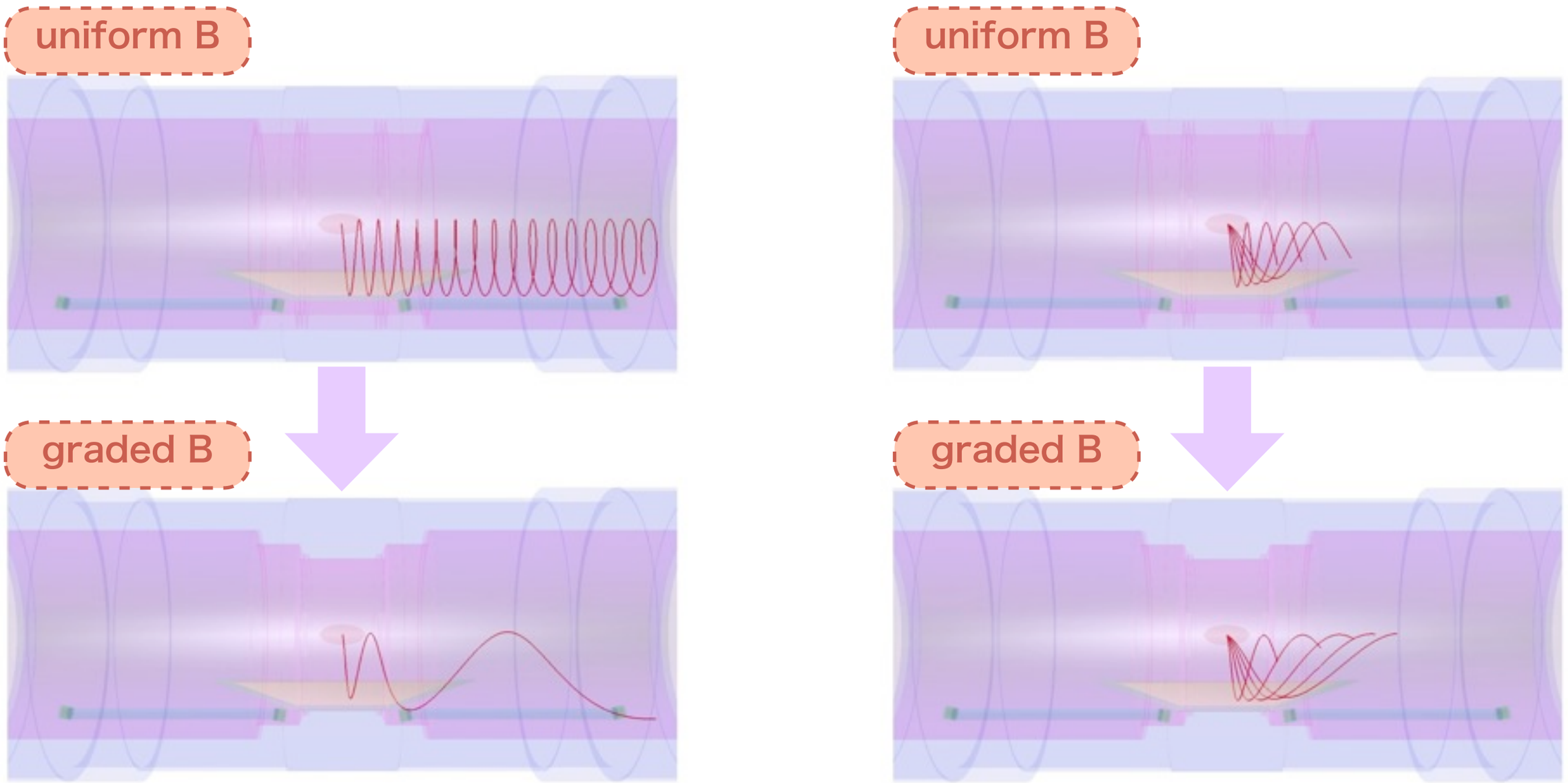
- Background
  - radiative muon decay



  - accidental overlap



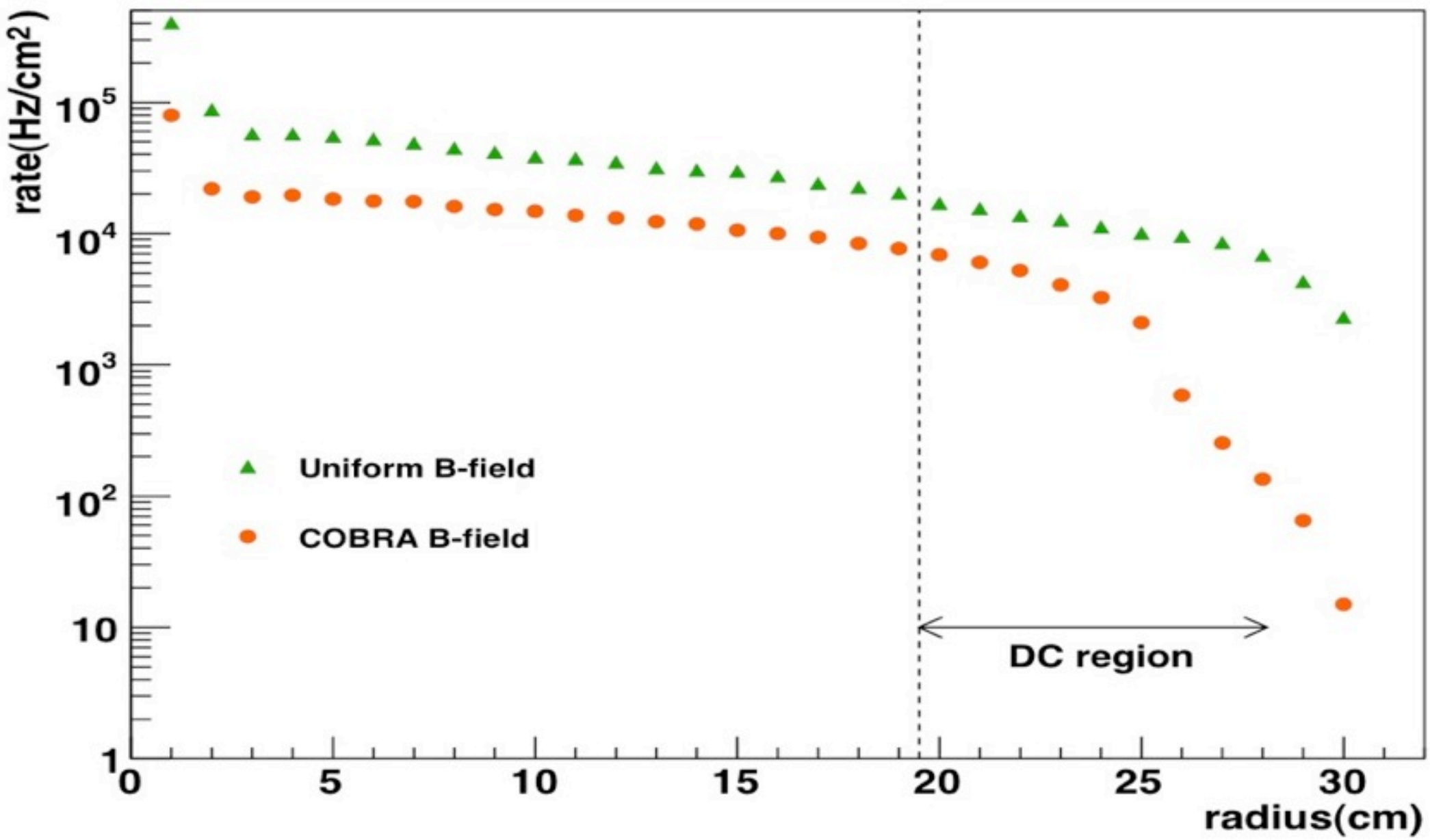
COBRA Solenoid



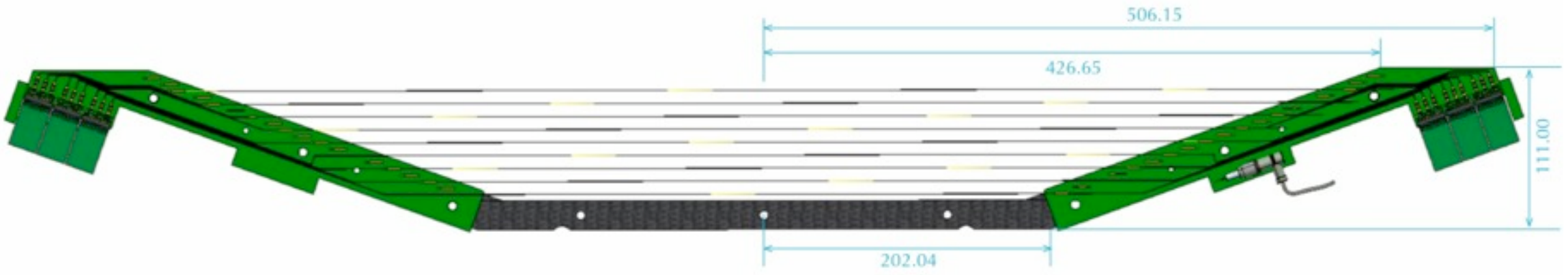
low energy e^+ quickly swept out

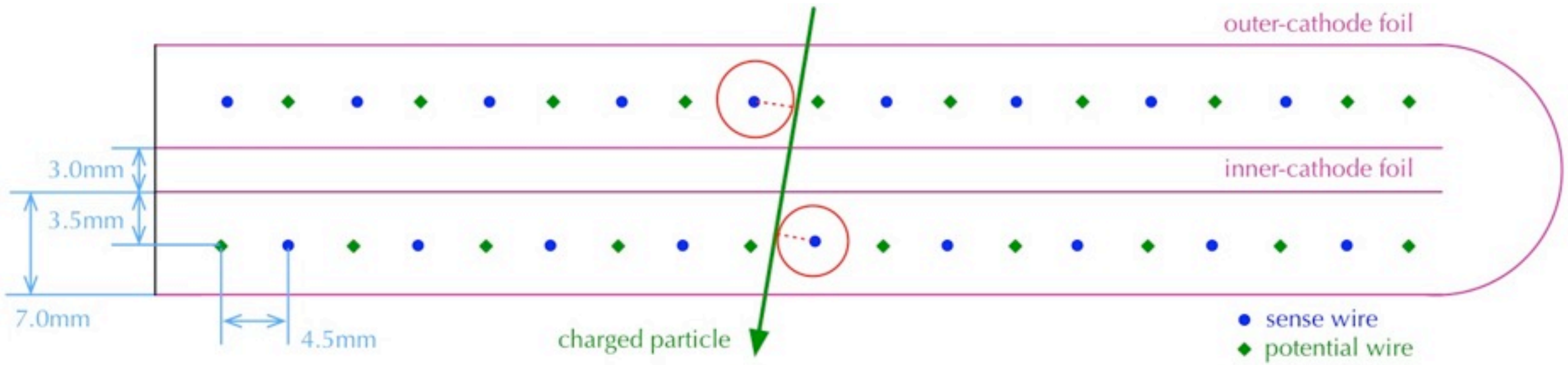
constant bending radius
independent of emission angles

Hit Rate in COBRA



MEG Drift Chamber





2008 Summary of MEG-DC

Discharge Studies