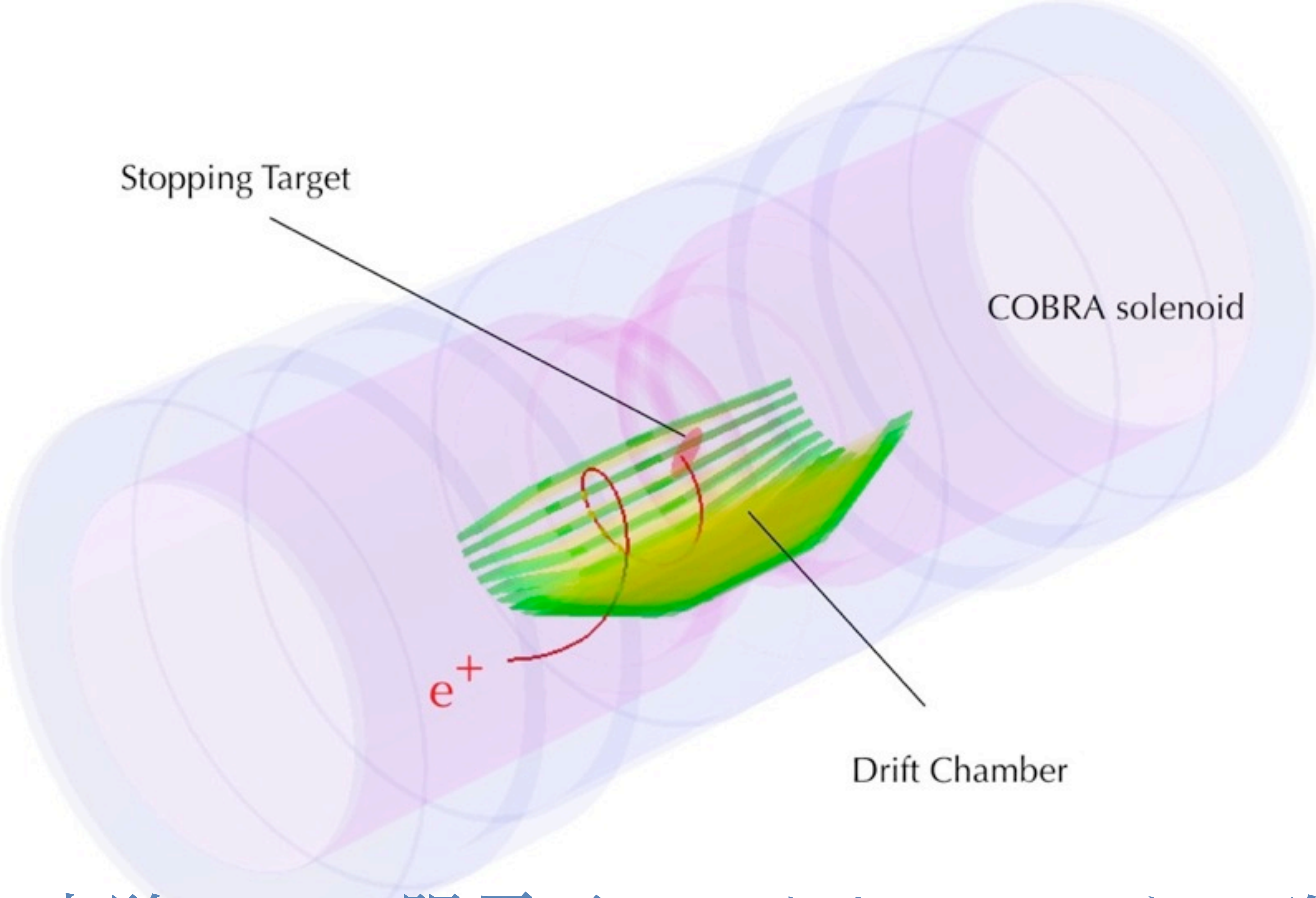


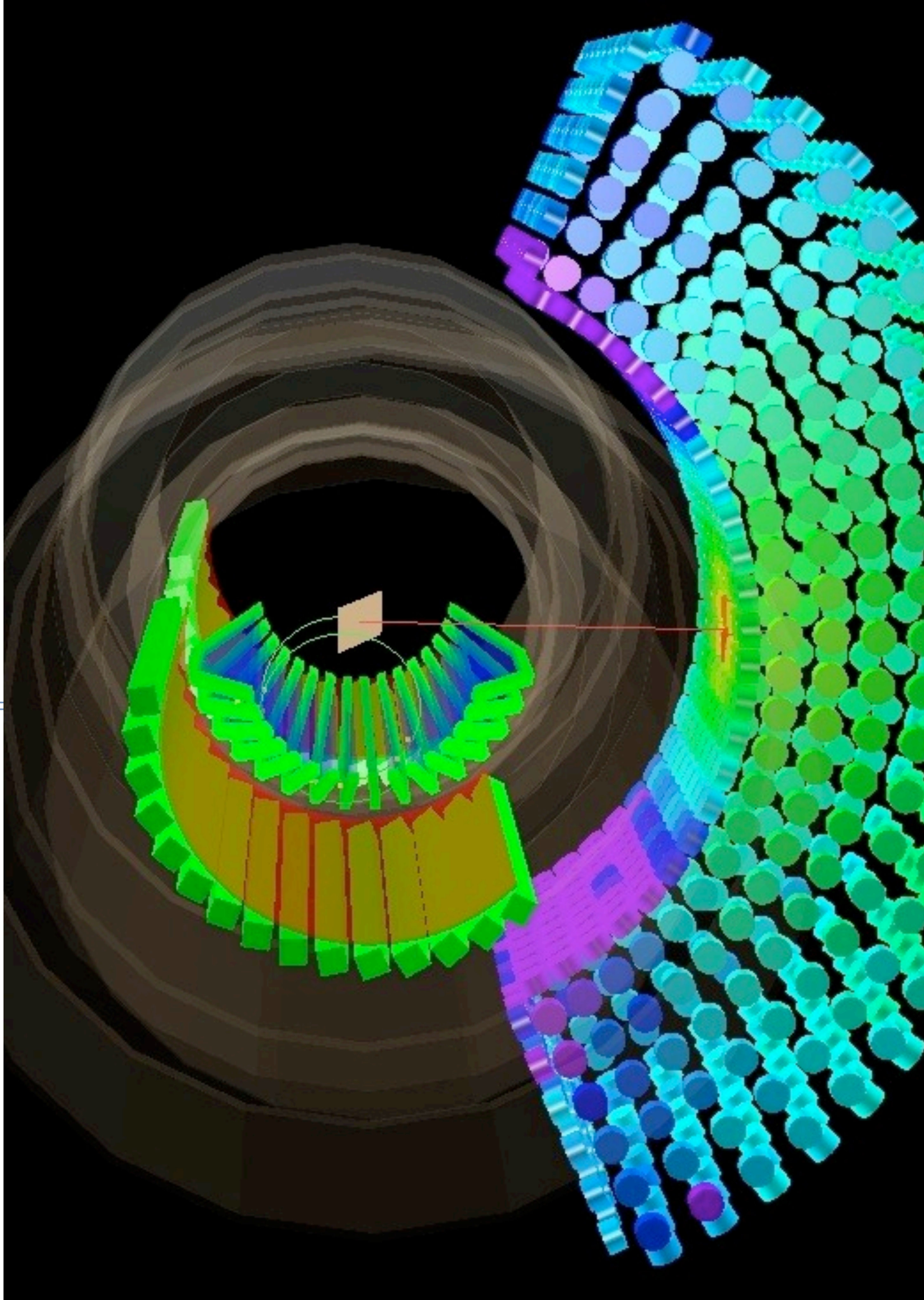
MEG実験2009：陽電子スペクトロメータの改良

西口 創 (KEK素核研), 他 MEG コラボレーション

JPS Meeting, 20-23/Mar./2010, Okayama University

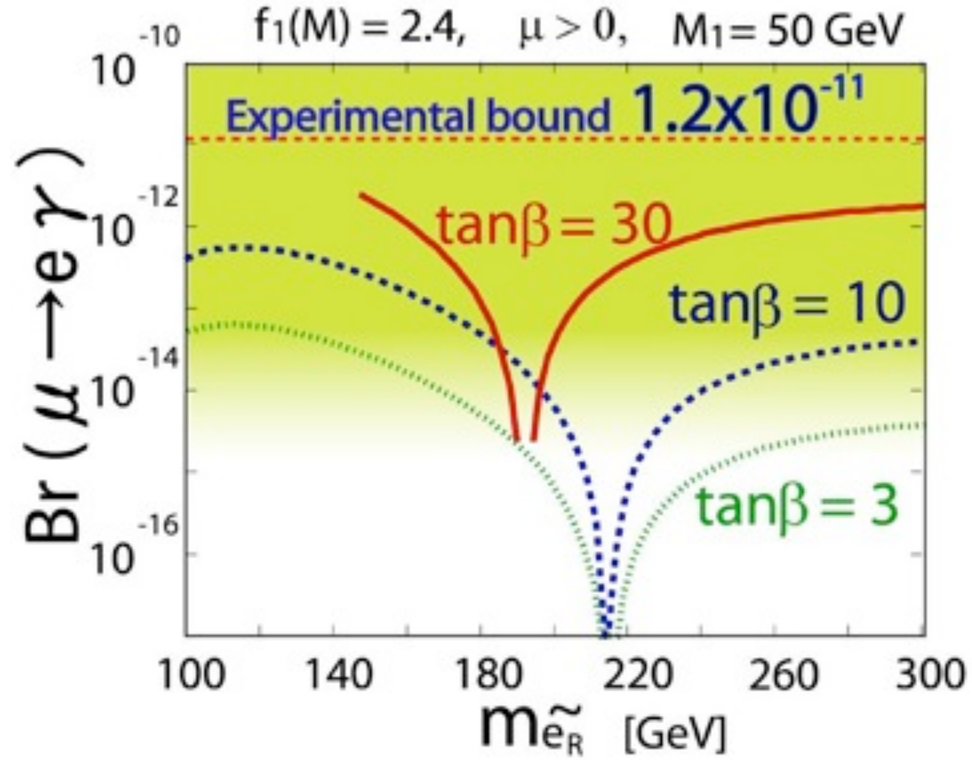
contents

MEG Experiment



MEG Experiment

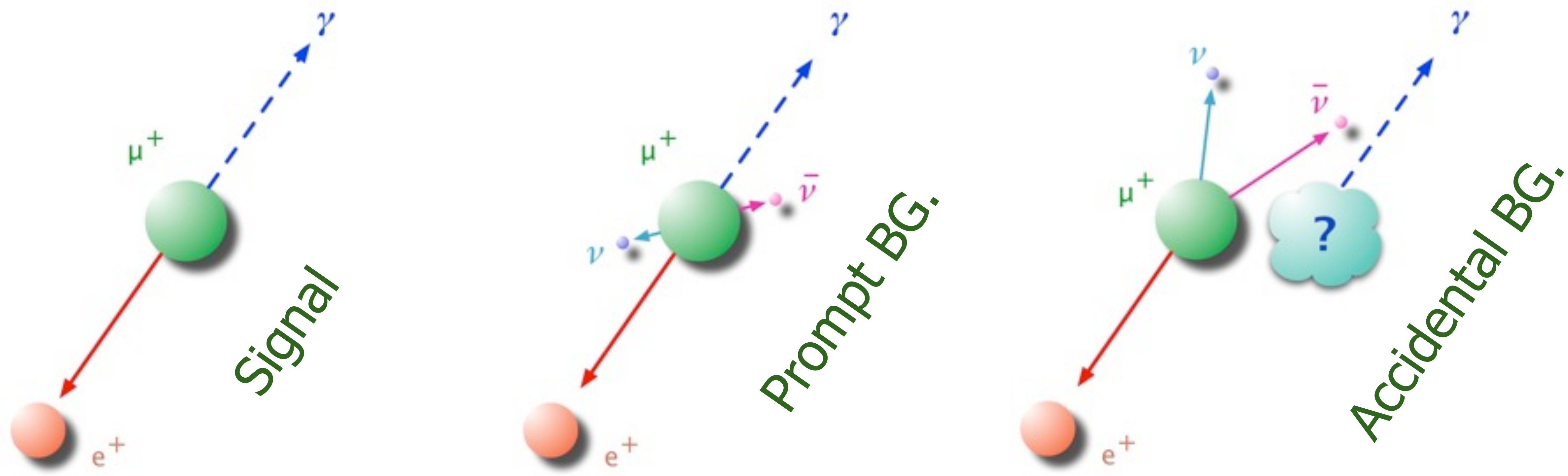
- **Search Experiment for "$\mu \rightarrow e\gamma$"**
  - $\mu \rightarrow e\nu\nu \sim 100\%$ (normal muon decay in SM)
  - $\mu \rightarrow e\gamma$ violates Lepton Flavour Conservation
  - Even assuming "SM" + "Neutrino-Oscillation", $B(\mu \rightarrow e\gamma)$ is predicted to be $< 10^{-50}$
  - However many models of beyond SM predicts large $B \sim 10^{-15} \sim 10^{-11}$ (present limit $= 1.2\times10^{-11}$)



- New experiment with a Sensitivity of $B \sim 10^{-13}$ was proposed at PSI
  - Two orders of magnitude better than current best limit
  - Cover the most of theoretically predicted region
  - Physics data-taking started 2008 and is currently running.

Hunting for $\mu \to e\gamma$

- Signal and Backgrounds



- Clear 2-body kinematics ($E_e = E_\gamma = 52.8$MeV, $\theta_{e\gamma} = 180°$, Time Coincidence)
- Sensitivity is Limited by "Accidental Overlap"
  - **DC muon is the Best Solution**
  - **Good Resolution (Energy, Spacial and Timing) under Very High Rate**

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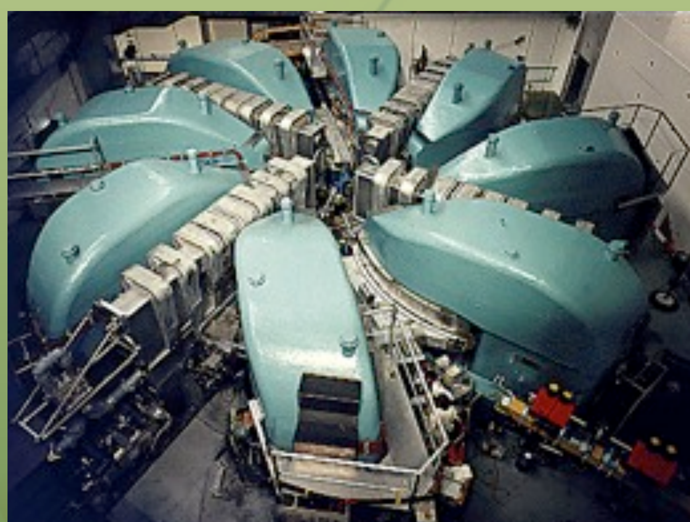
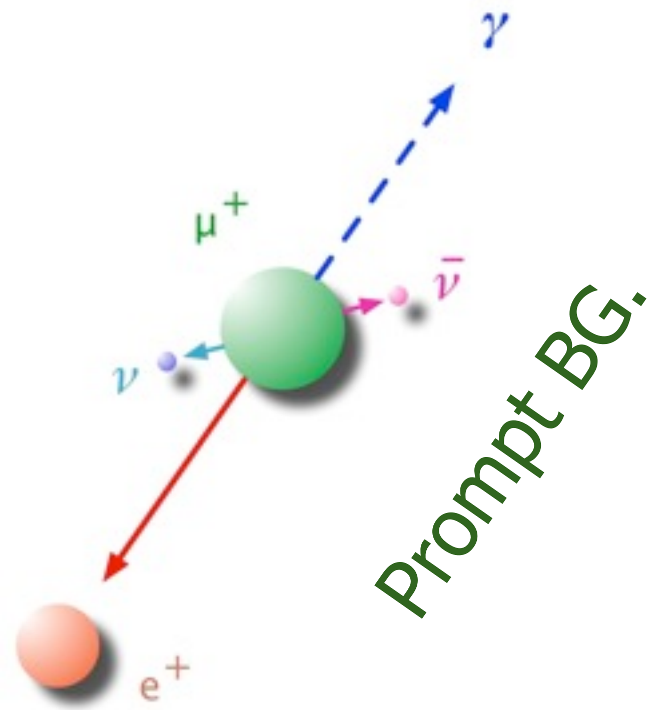
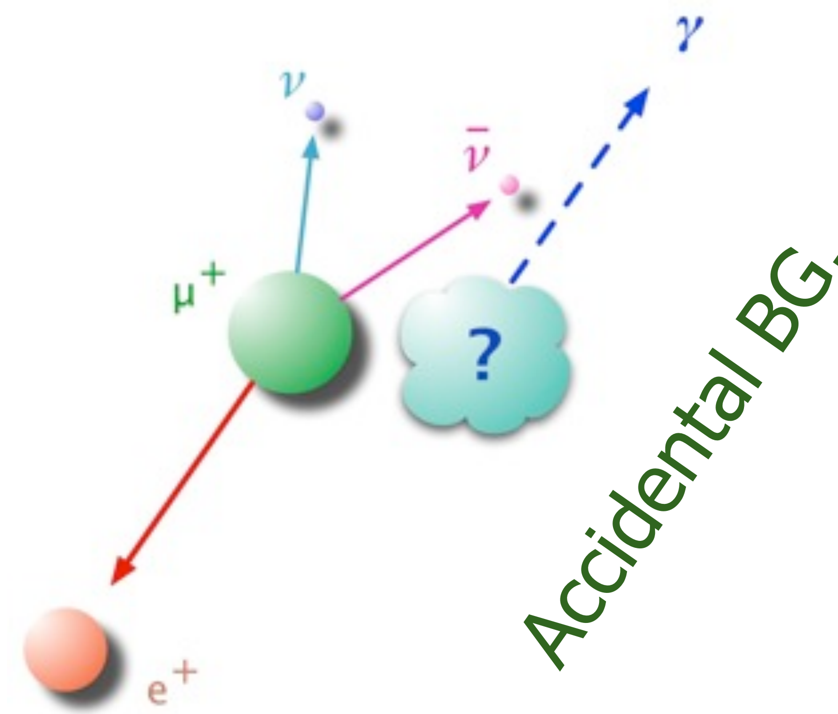


World Most Intense
DC Muon Beam at PSI
10^8 muon / sec





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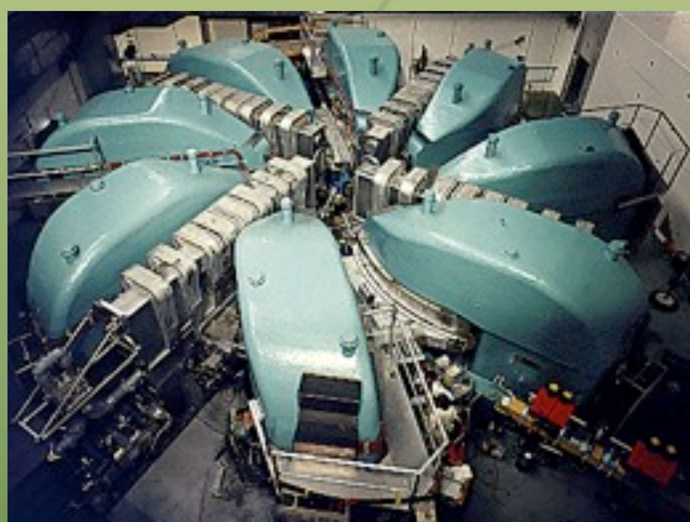

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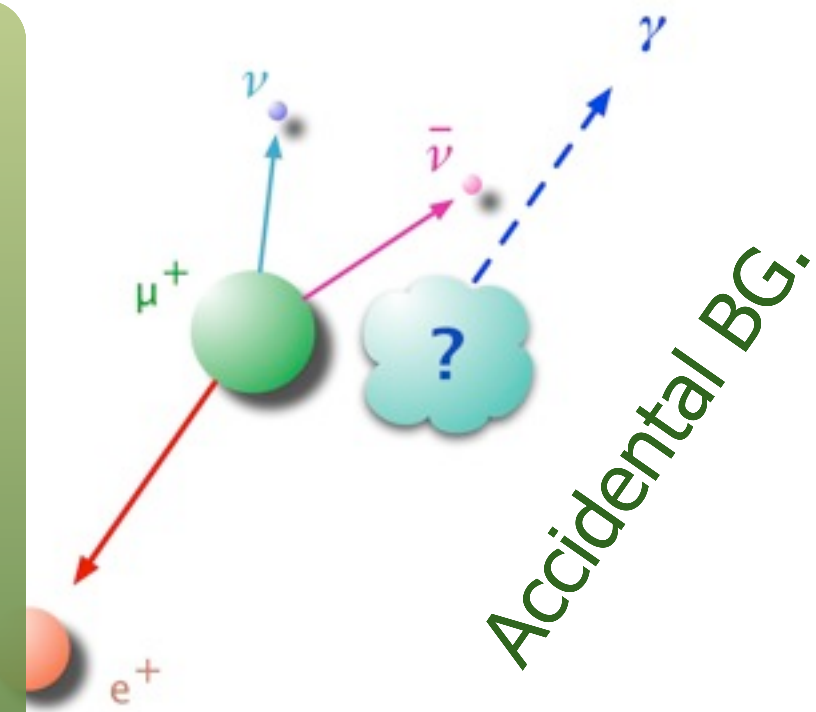
Liquid Xenon
Scintillation Detector
(gamma)



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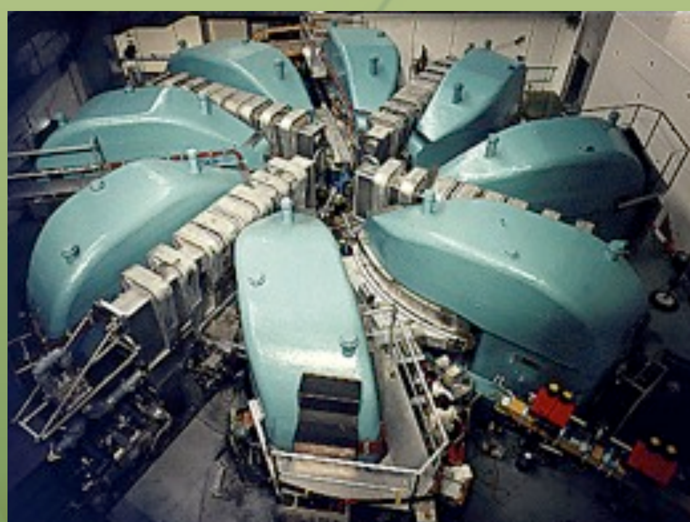

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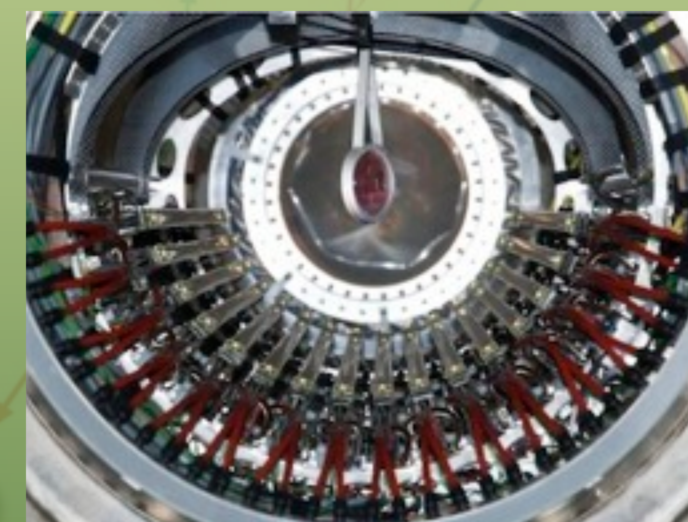
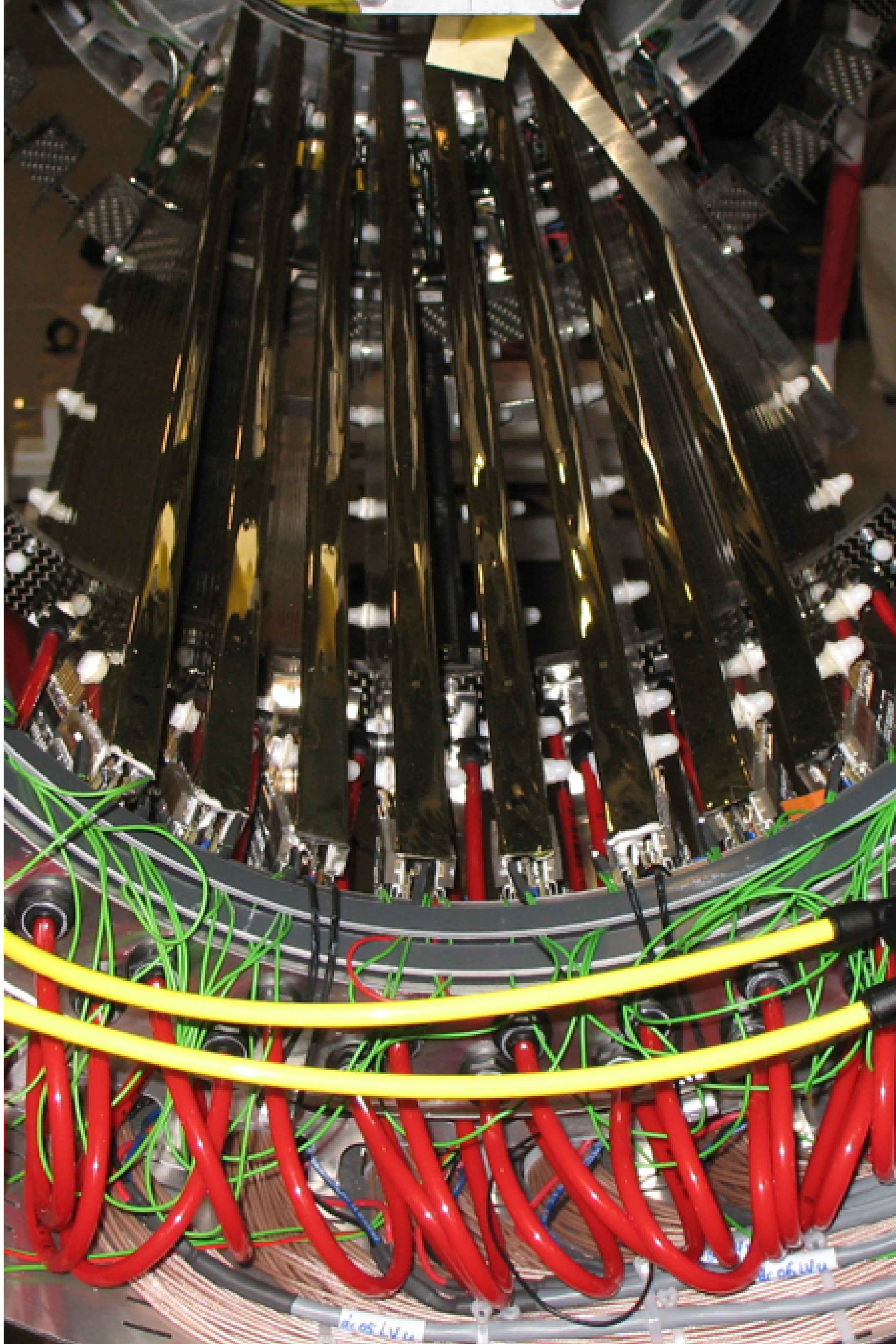


COBRA Spectrometer (positron)

- Clear 2-body kinematics ($E_e=E_\gamma=52.8$MeV, $\theta_{e\gamma}=180°$, Time Coincidence)
- Sensitivity is Limited by "Accidental Overlap"
  - **DC muon is the Best Solution**
  - **Good Resolution (Energy, Spacial and Timing) under Very High Rate**

MEG e^+ Spectrometer



Requirements for Positron Spectrometer

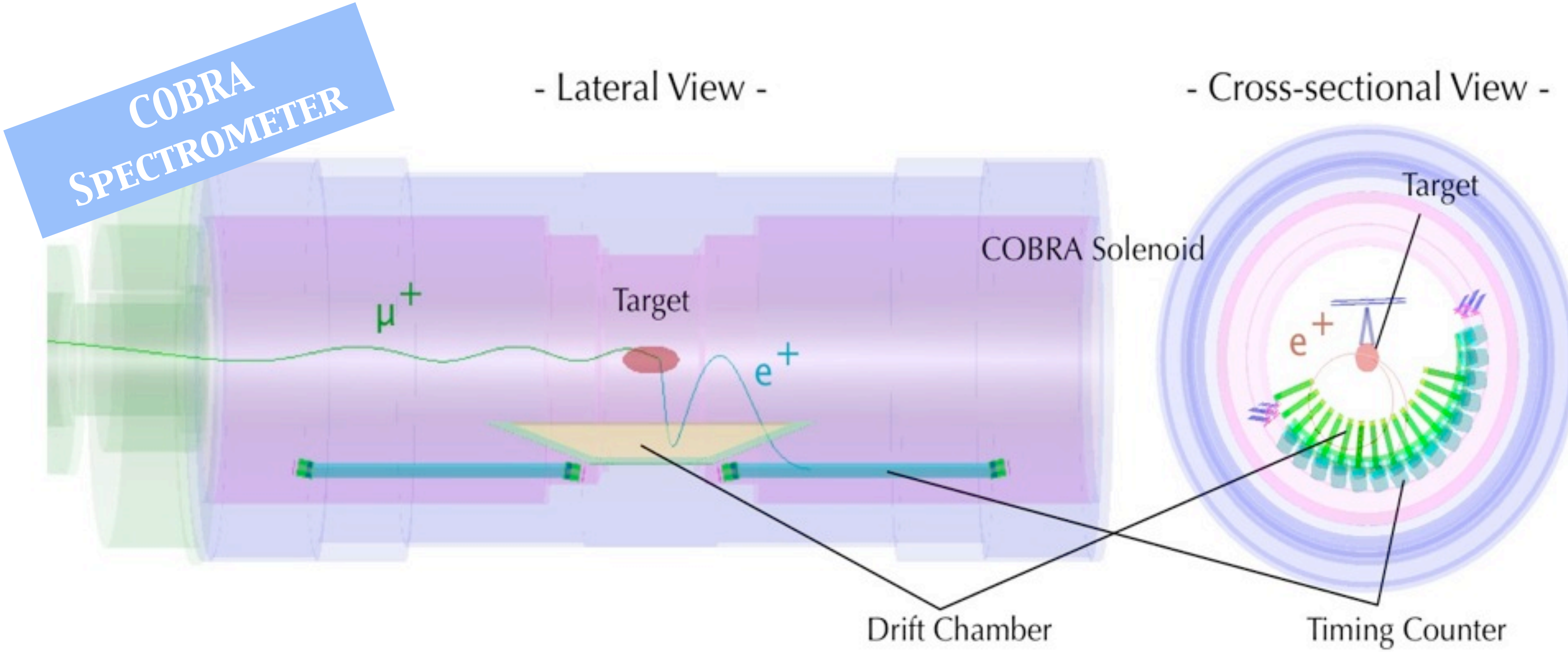
- **Very high counting rate**
  - the most intense DC muon beam in the world
  - muon stopping rate : $3\text{x}10^7$ muon / sec

→ Special B-field

- **Good momentum/position/timing resolution**
  - aiming excellent sensitivity
  - <1% momentum resolution, 500μm position resolution for both direction(r,z) and 50 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



Solenoid

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

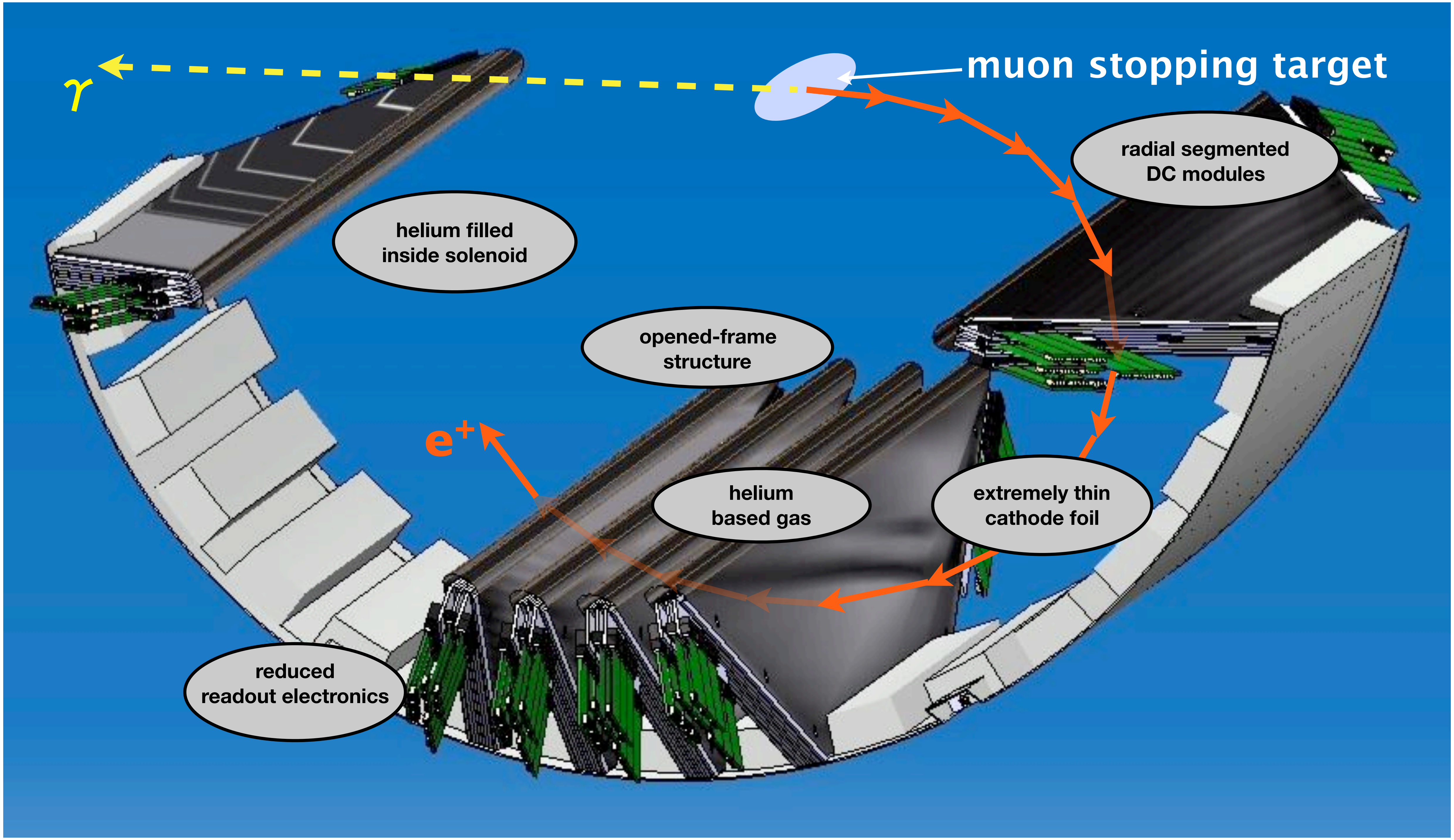
Drift Chamber

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

Timing Counter

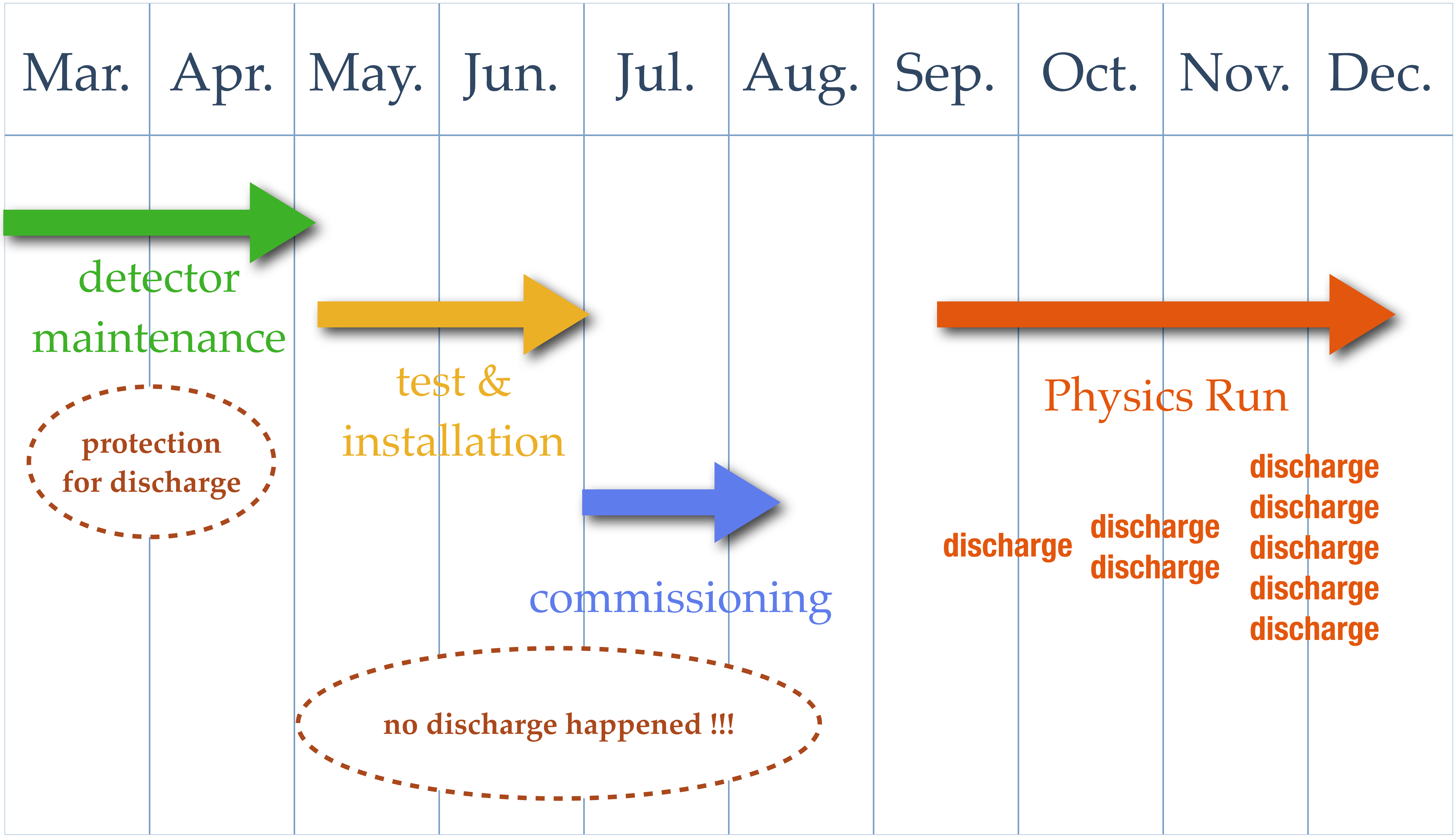
2-layers of scintillators
- scintillator bars (outer)
- scintillator fibres (inner)

MEG Drift Chamber



Run 2008 ;
Discharge Crisis

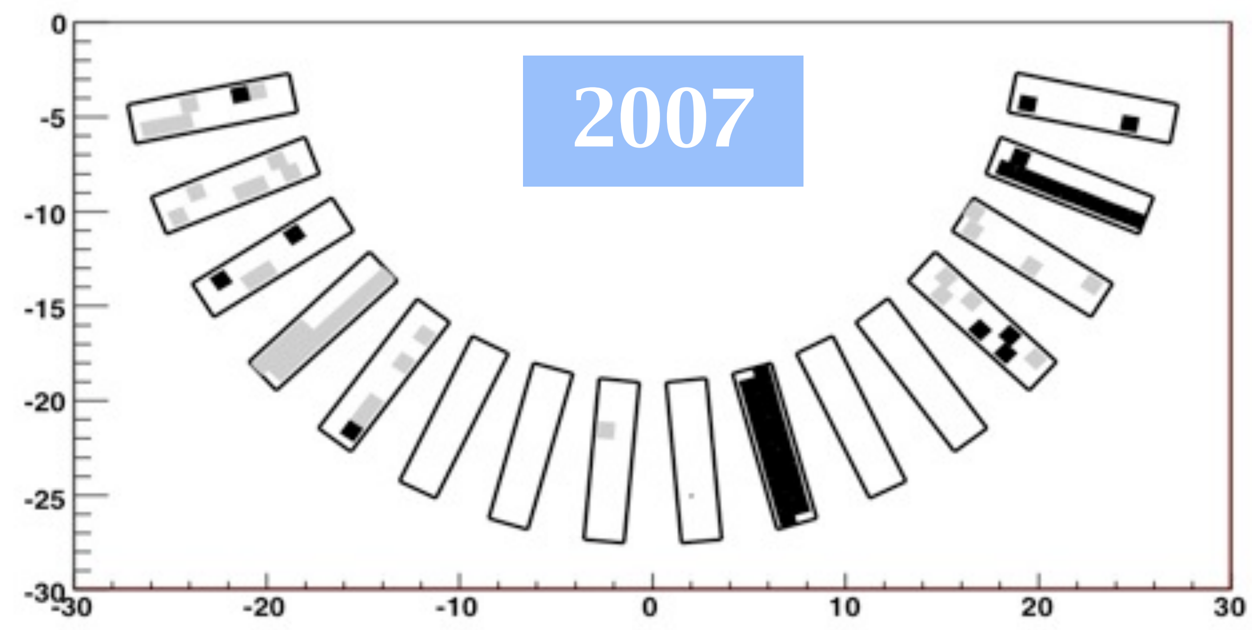
Run 2008 (*inter.alia.* spectrometer)

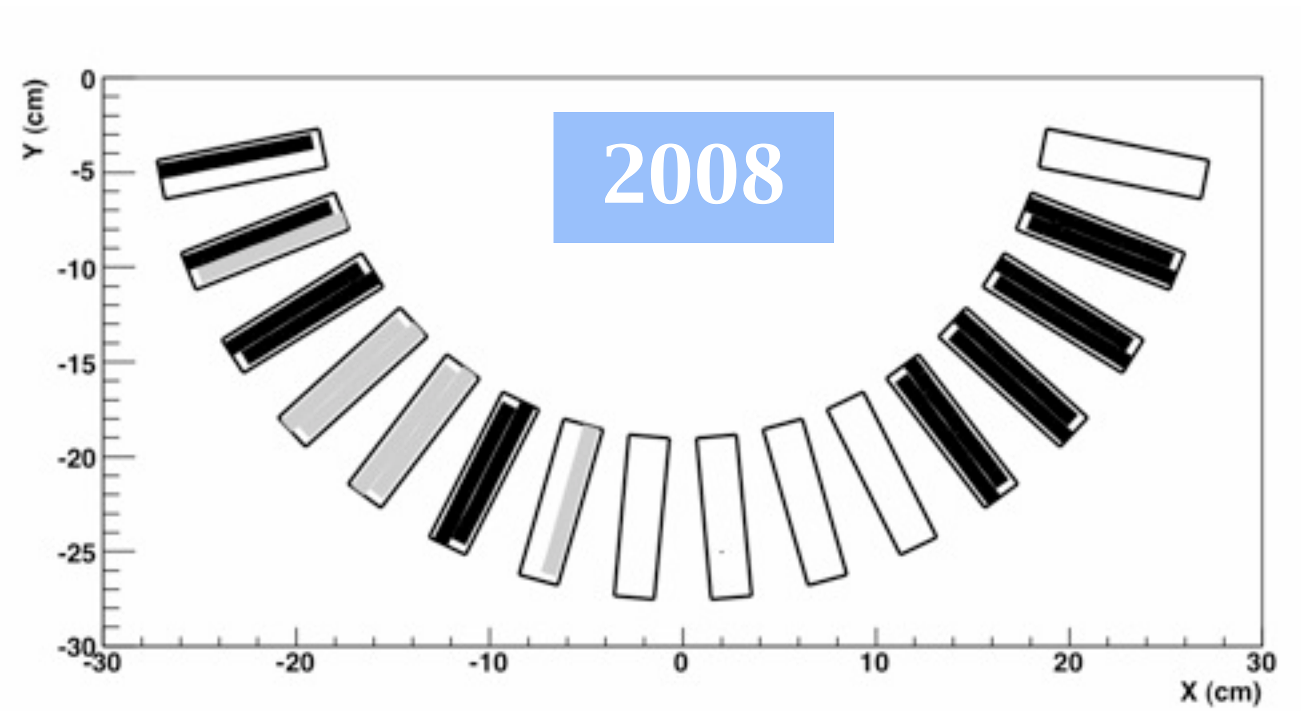


Many DCs were not operational

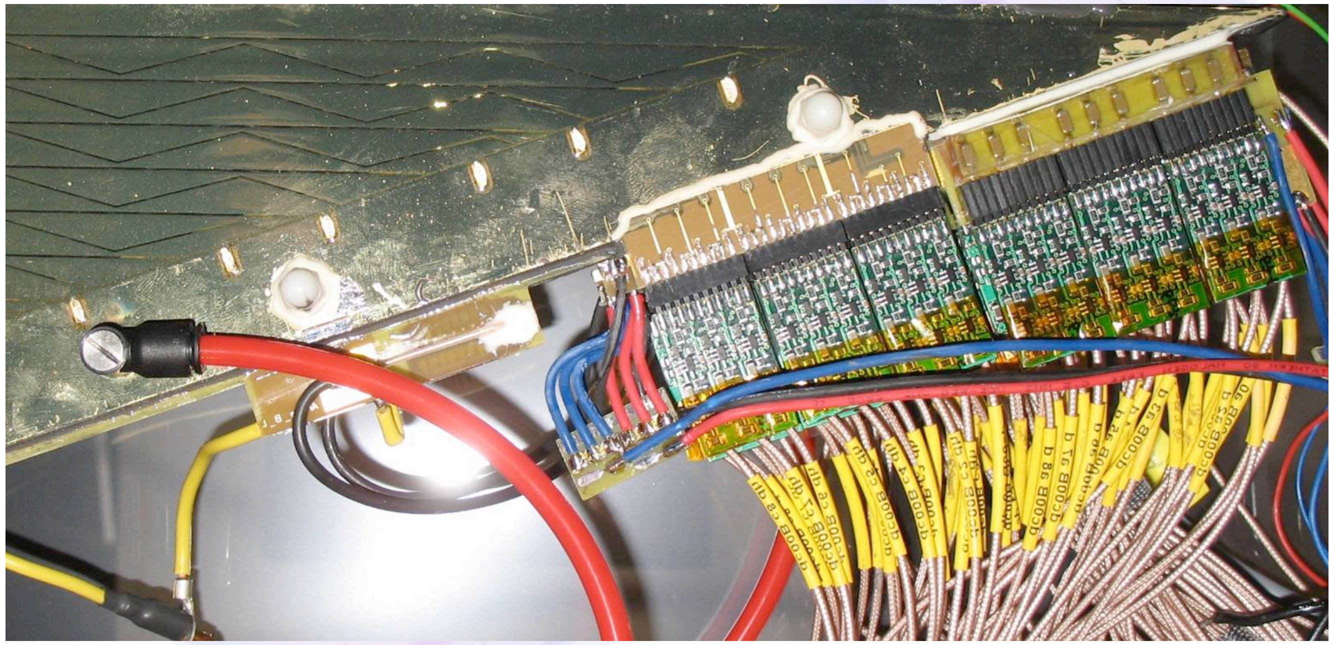
- Discharge on DC happened frequently during Run2008.
- Discharge problem happened 2007 originally, it was fixed at the beginning of 2008, but slowly appeared again.
- Finally, 18 planes were operational, only 12 planes were working with nominal voltage...(HV is applied to each plane individually; 32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

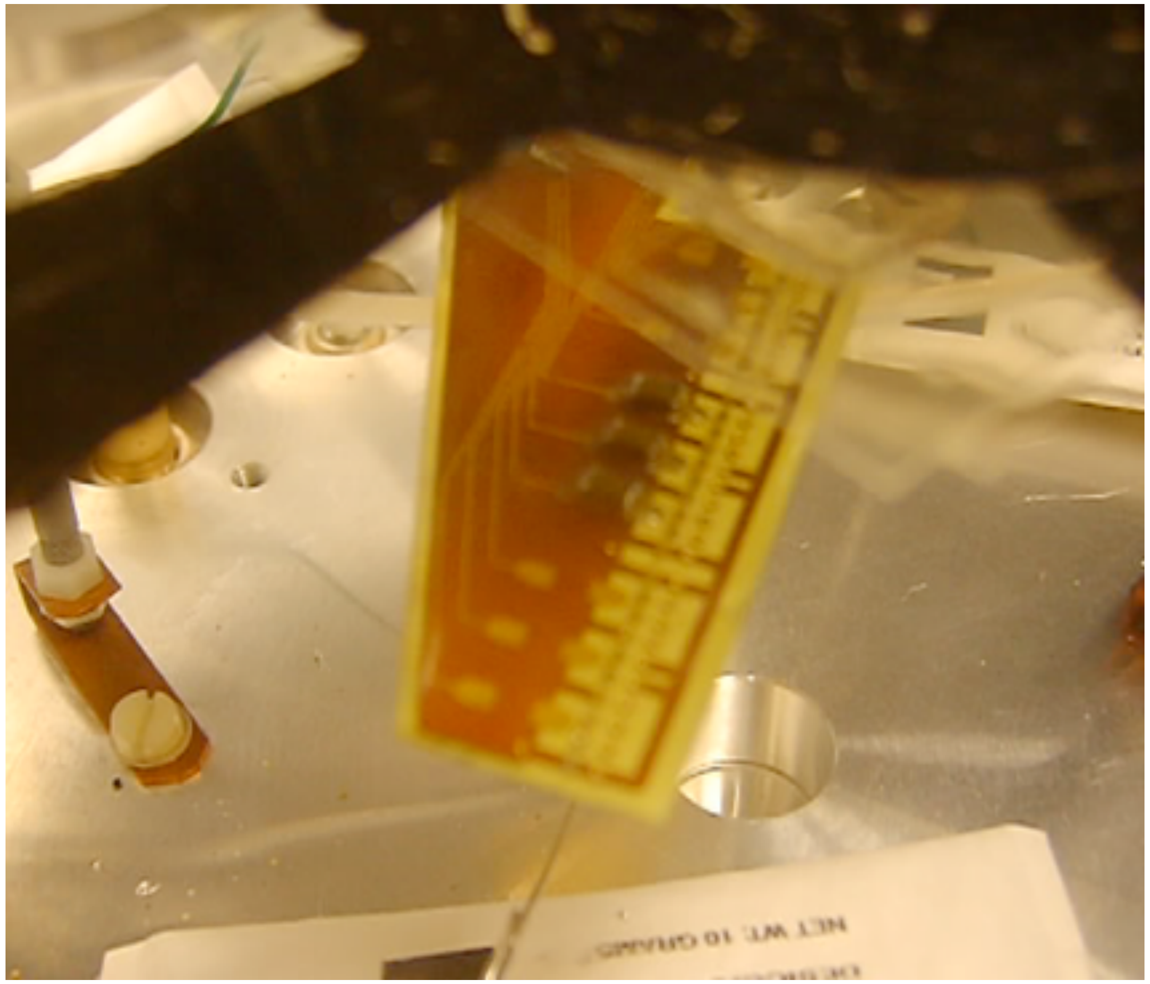
$$\varepsilon^{2008}(e^+) \sim 14\% \; ...$$





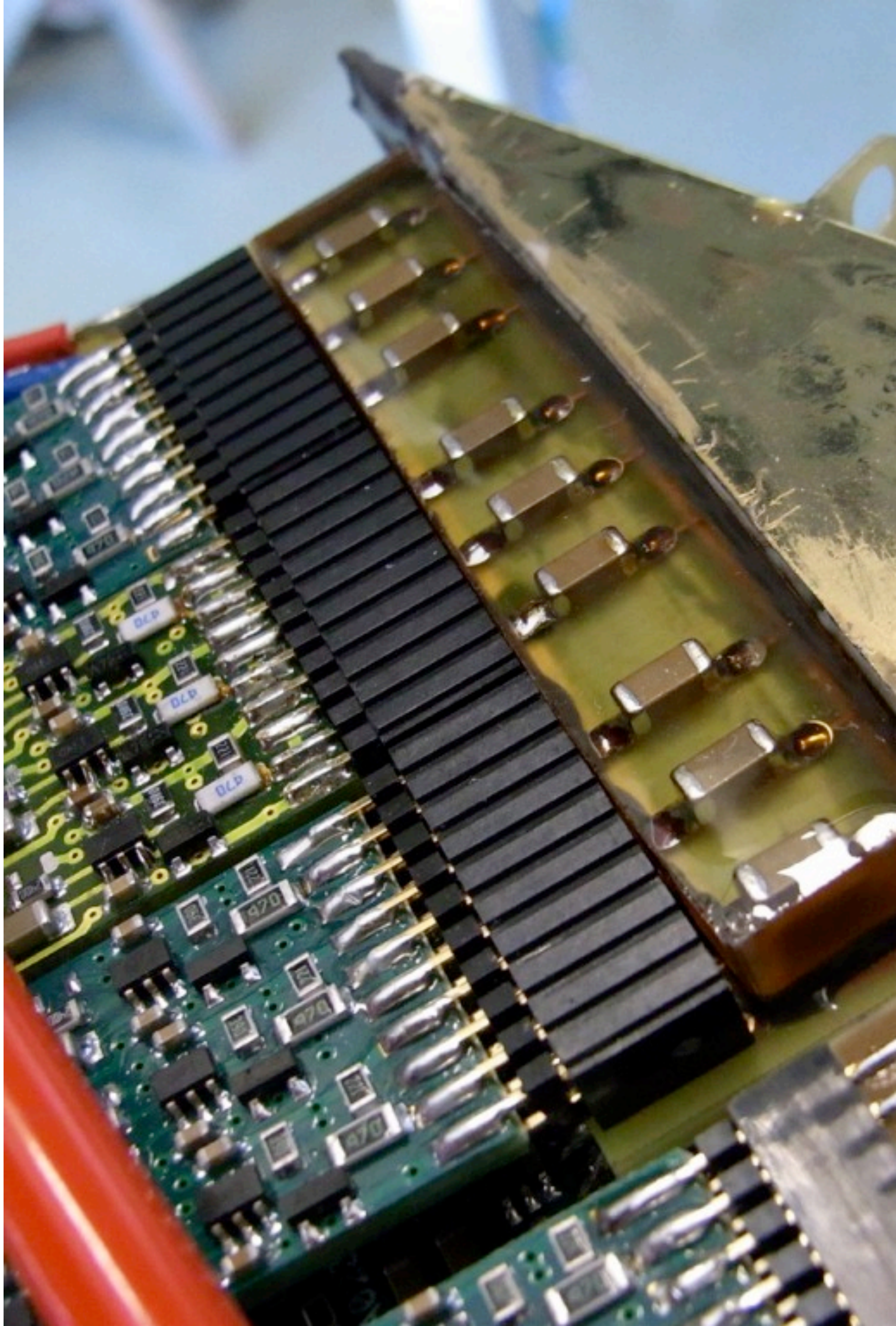
Discharges





- 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...

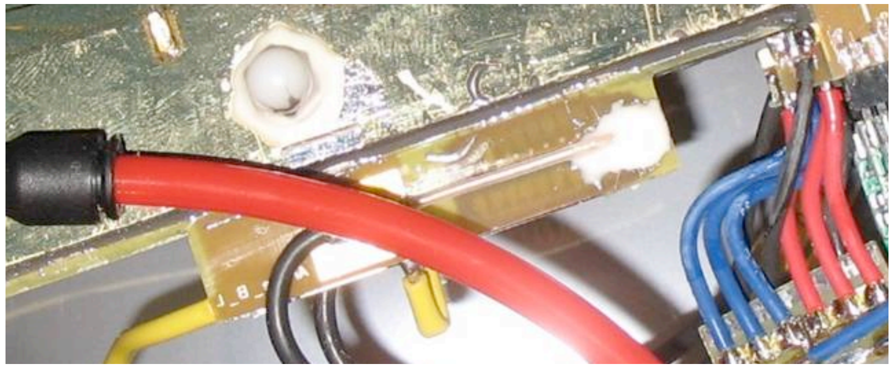
Run 2009 ;
Getting Over



What is still Weak for Discharge ?

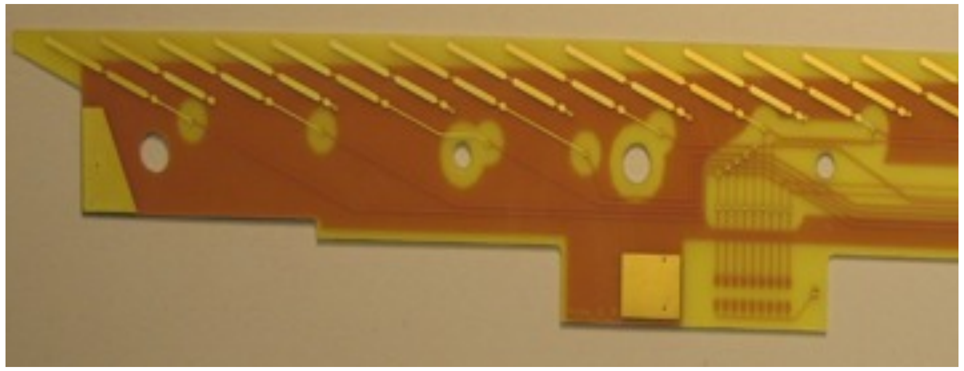
Suspicious Weak Point (1)

“Potting for HV-cable contact”



Suspicious Weak Point (2)

“HV-via on anode PCB“



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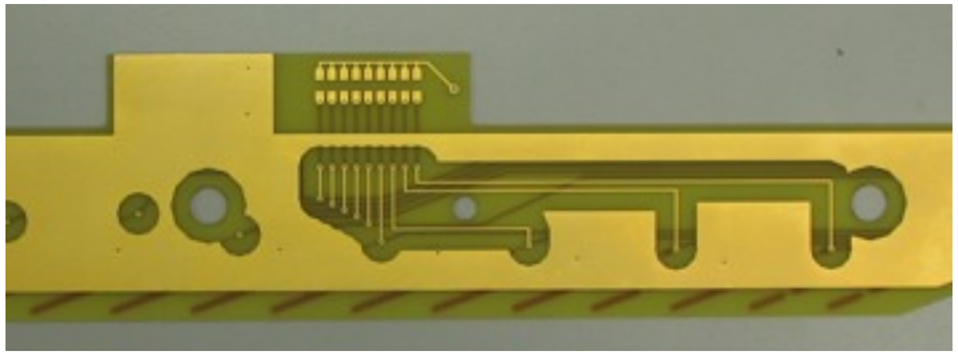
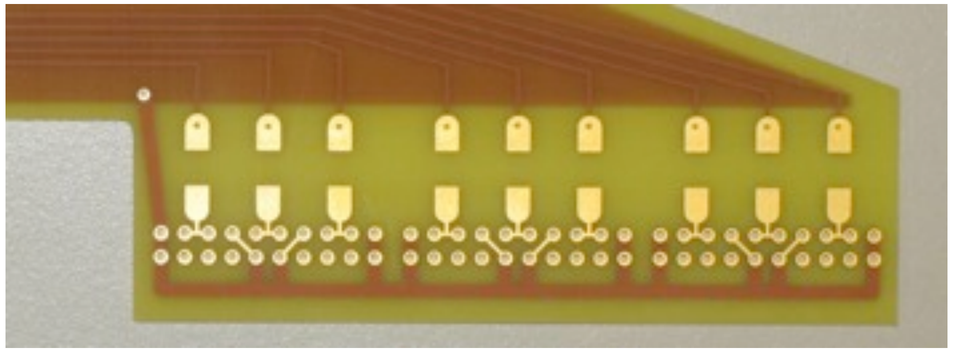


Suspicious Weak Point (4)

“Land for decoupling-C”



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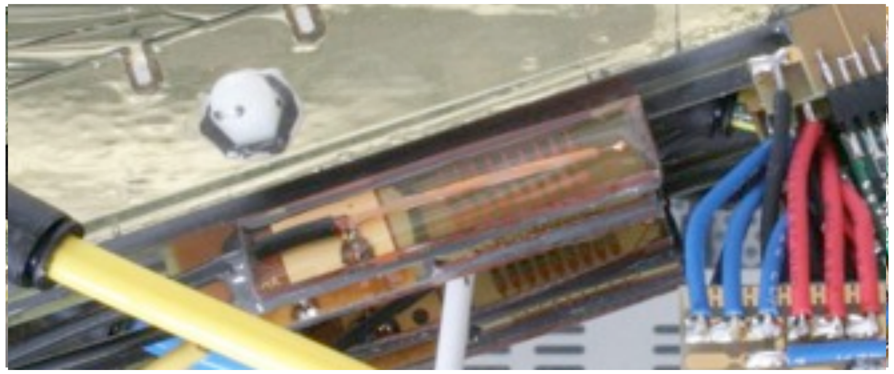

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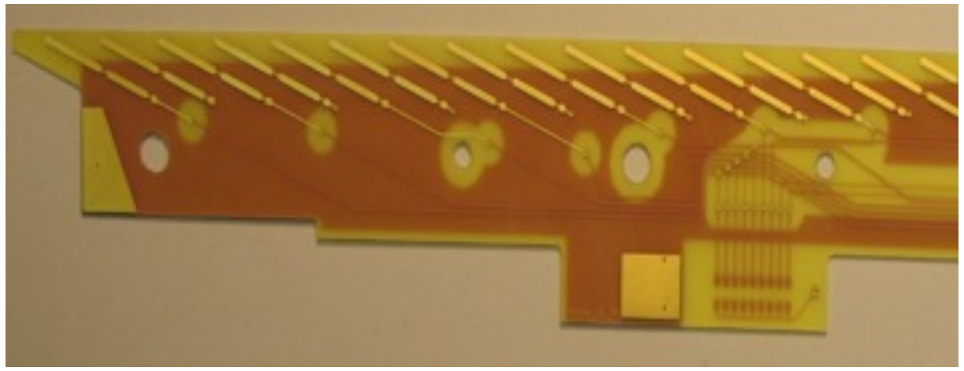

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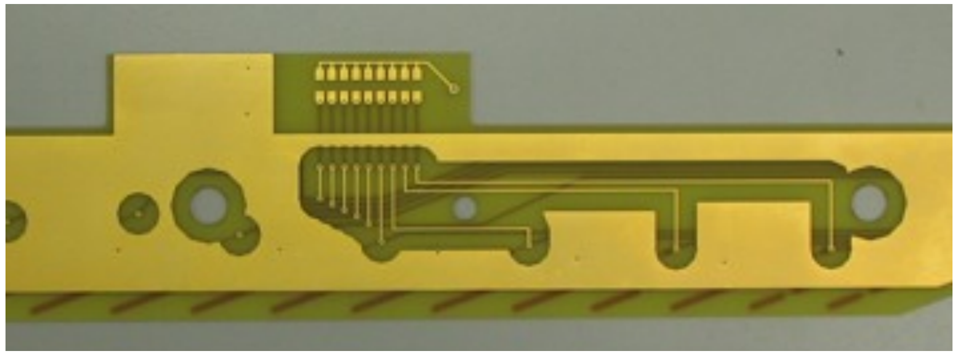

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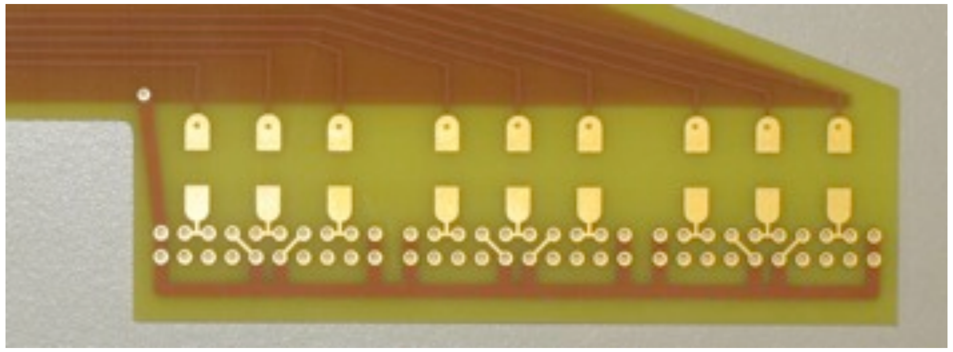

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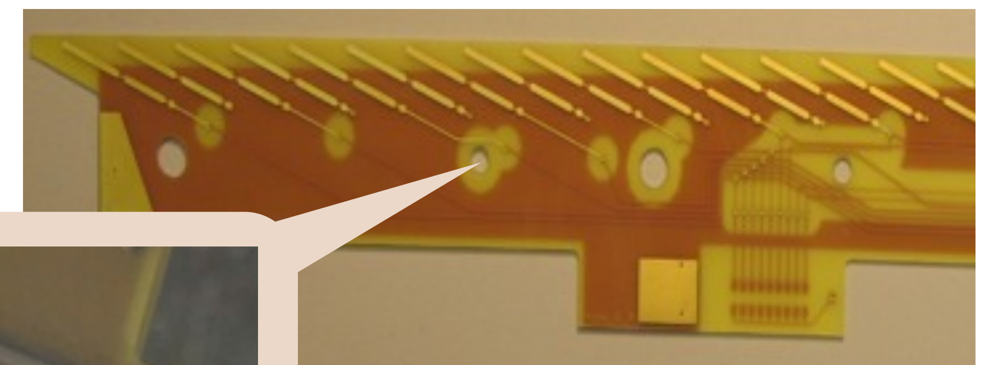
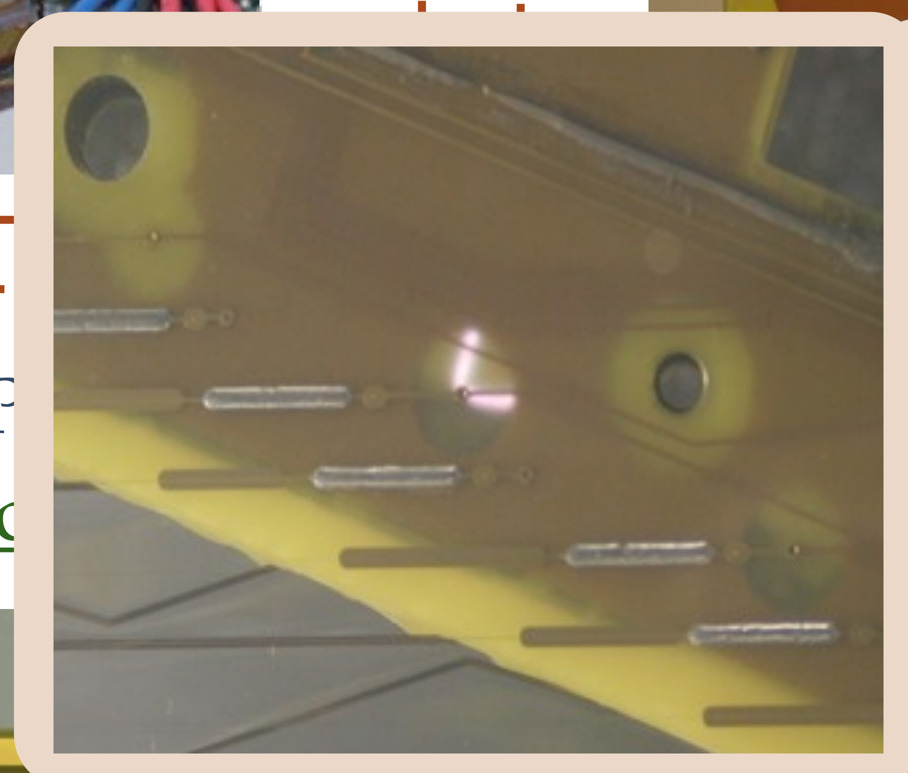
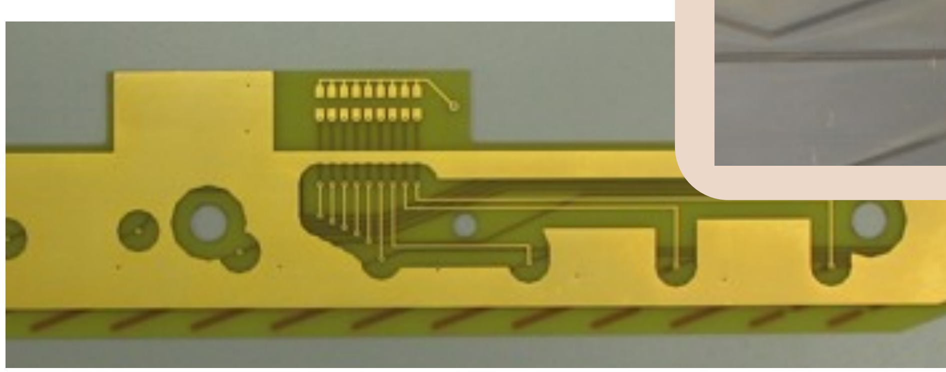




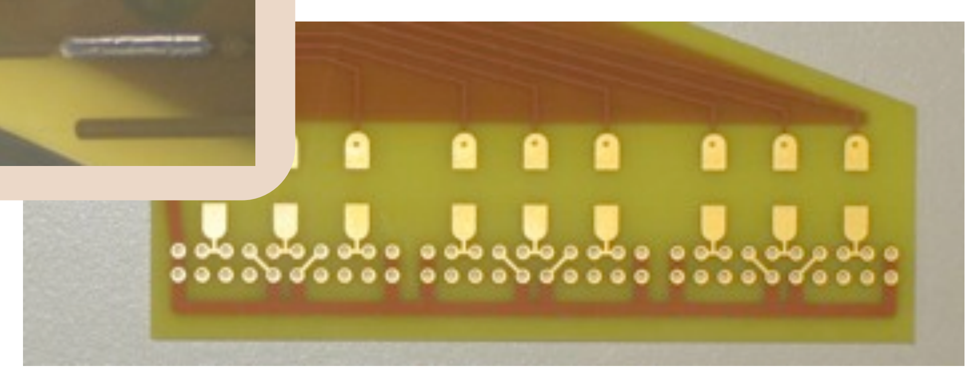
Suspicious Weak P

"HV-tracer print o



ous Weak Point (4)

for decoupling-C"



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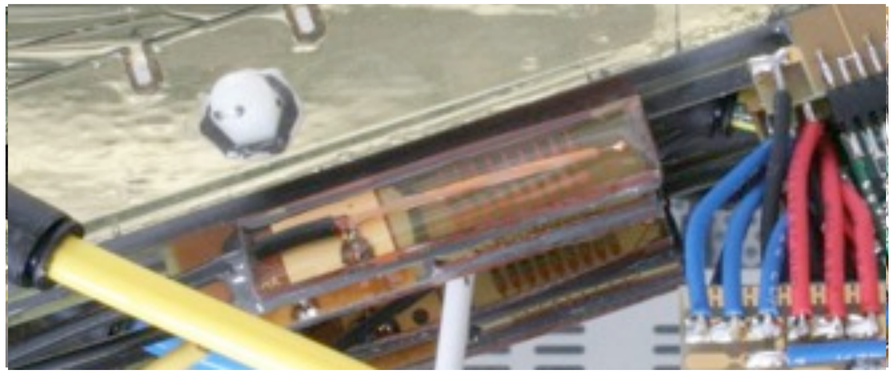

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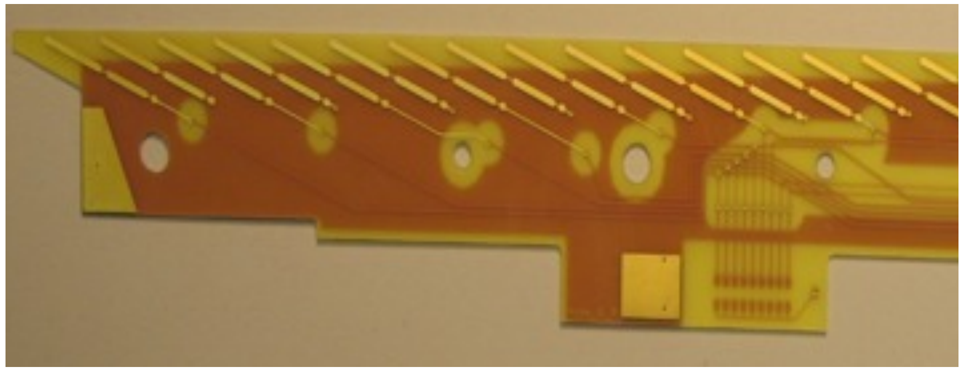

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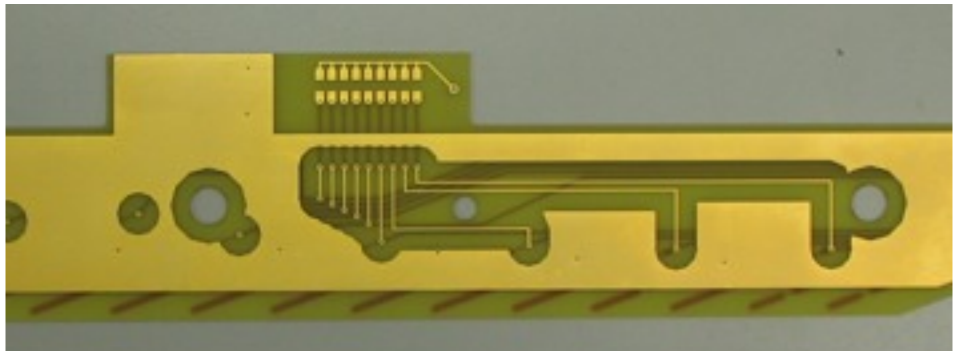

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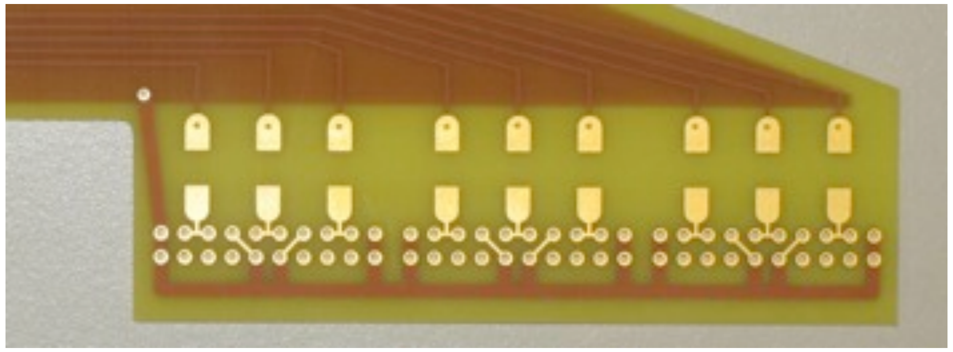

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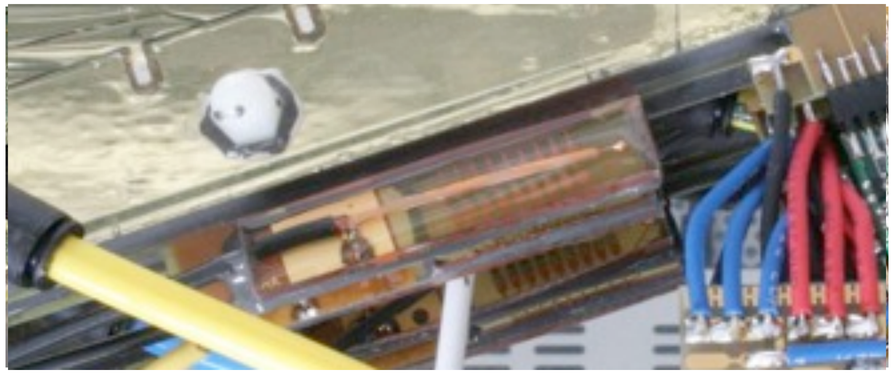

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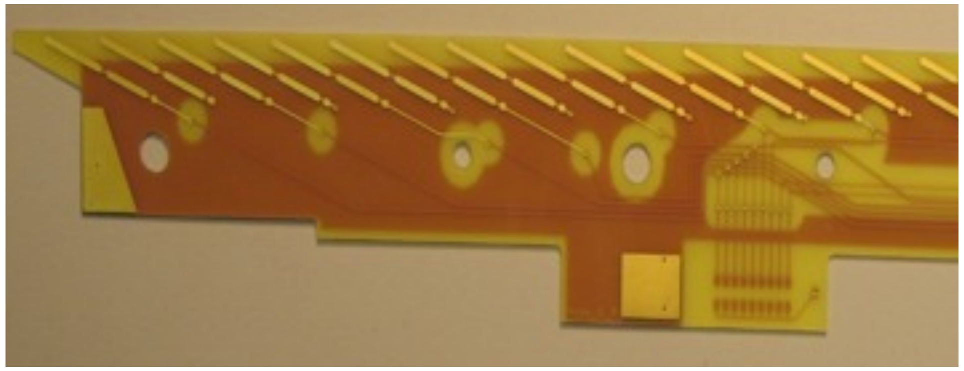

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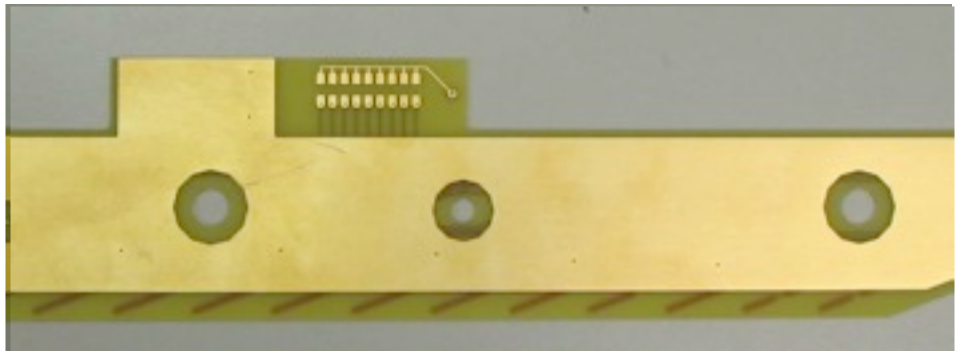

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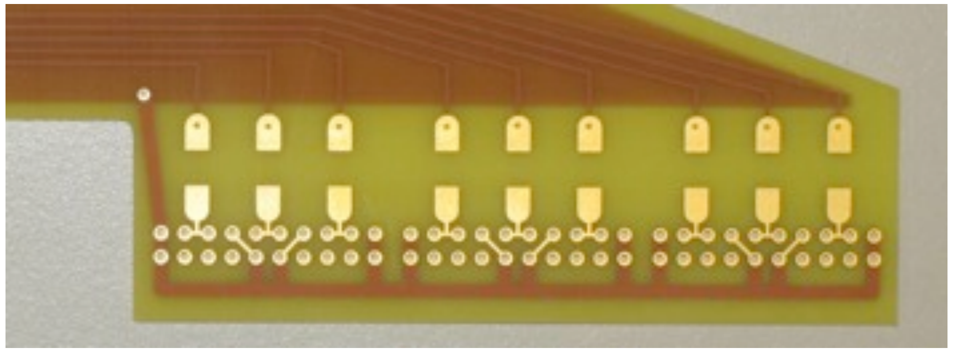

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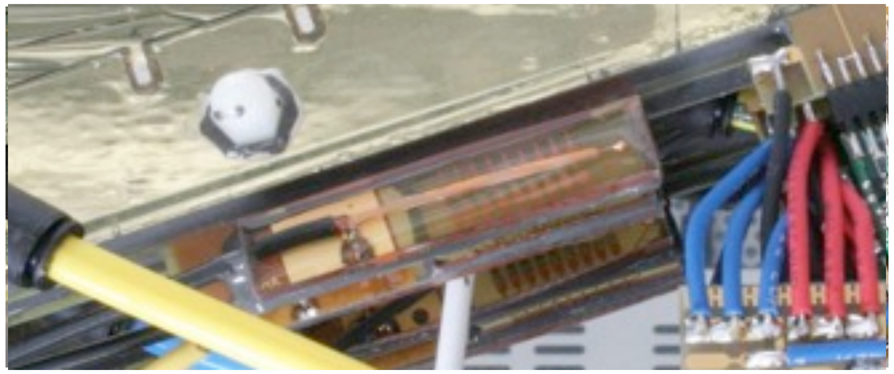

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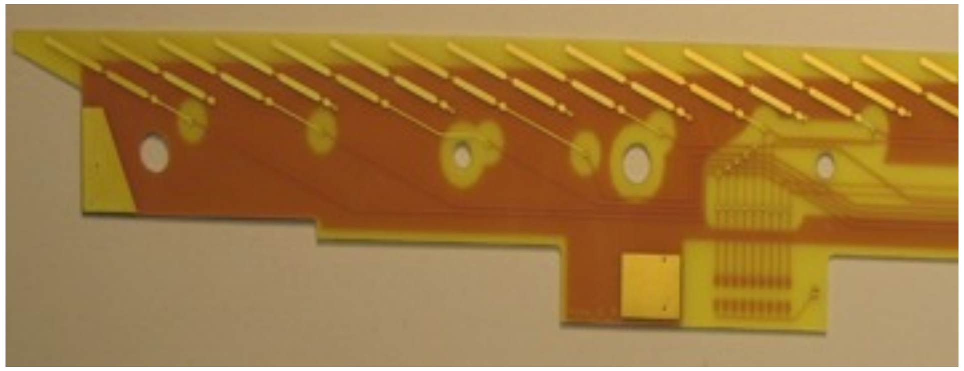

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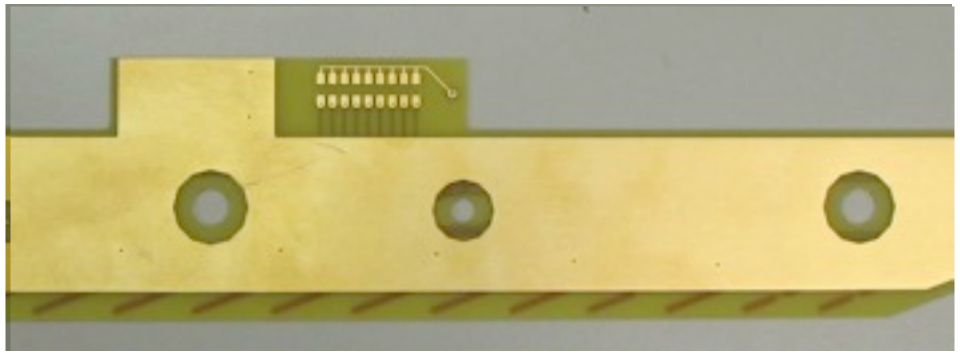

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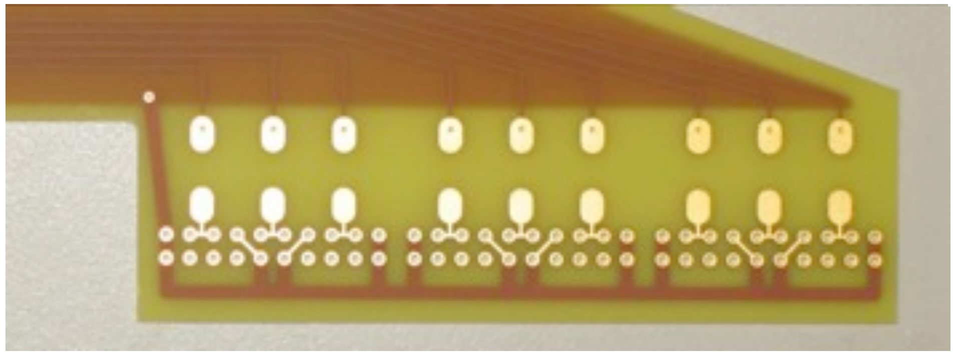
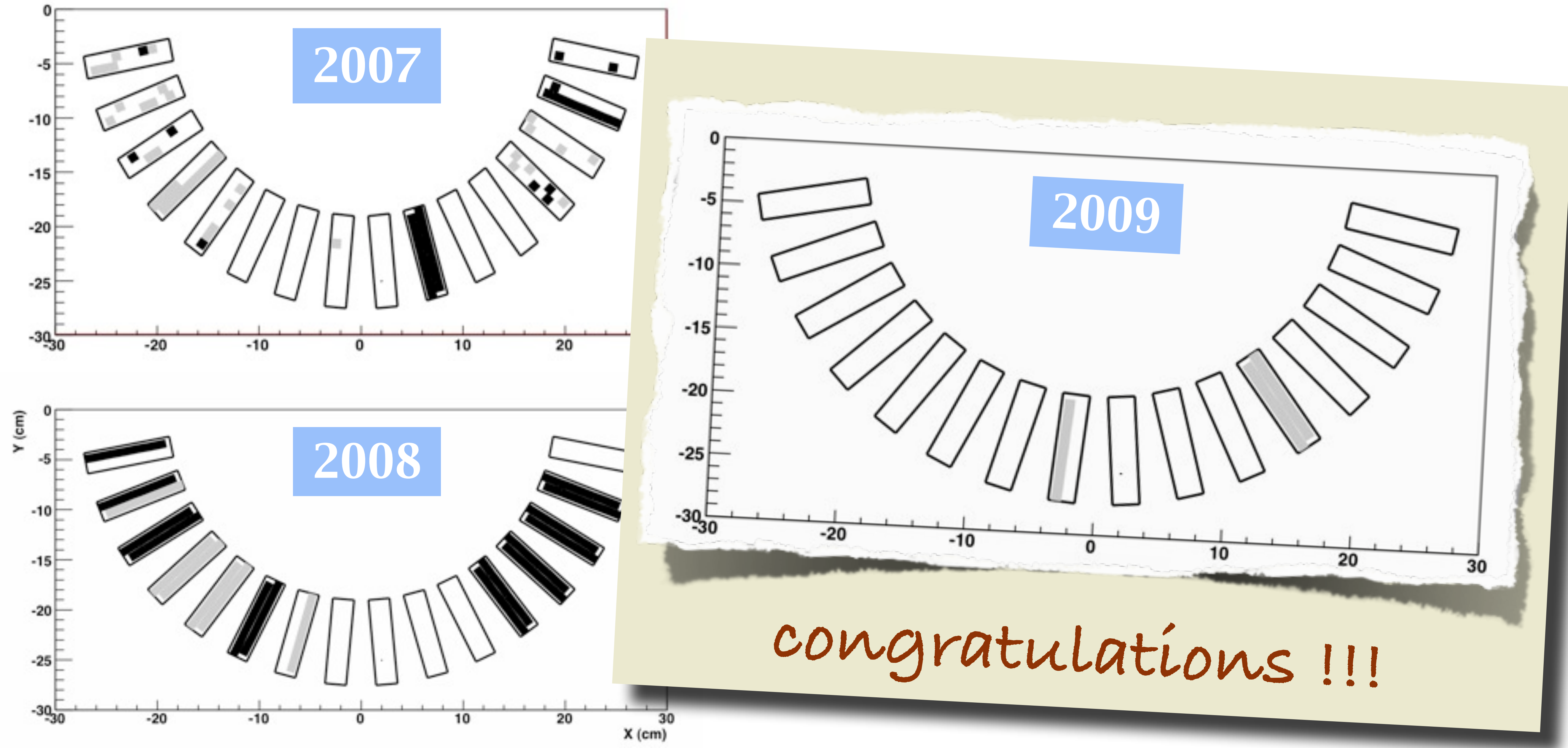


2009 Result

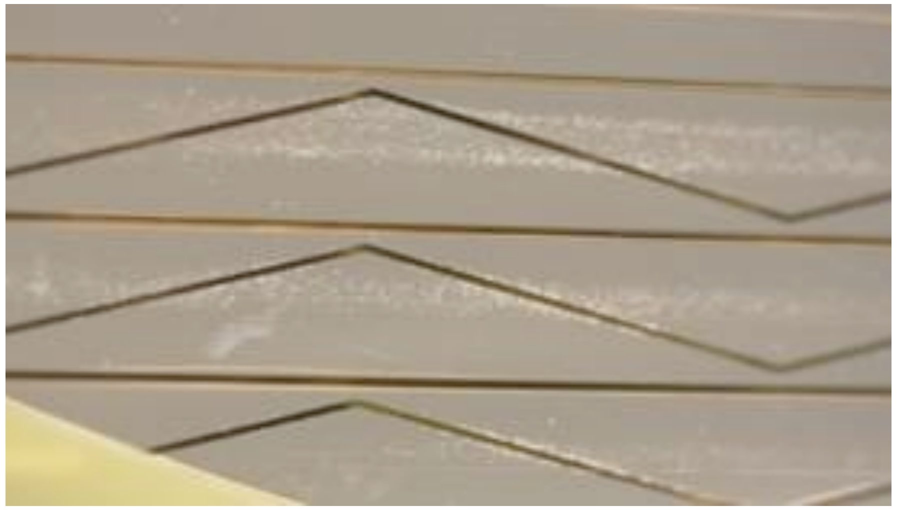


$$\varepsilon^{2008}(e^{+}) \sim 14\% \rightarrow \varepsilon^{2009}(e^{+}) = ??\ \%$$

Run 2010 ;
Next Step

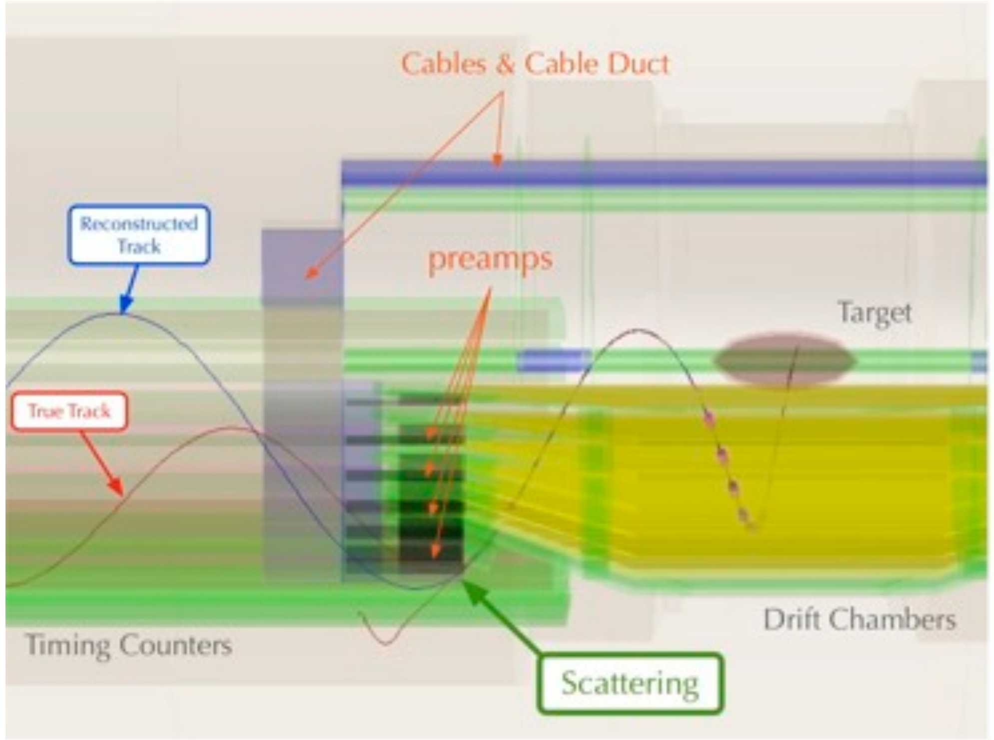
Damaged Cathode Foil

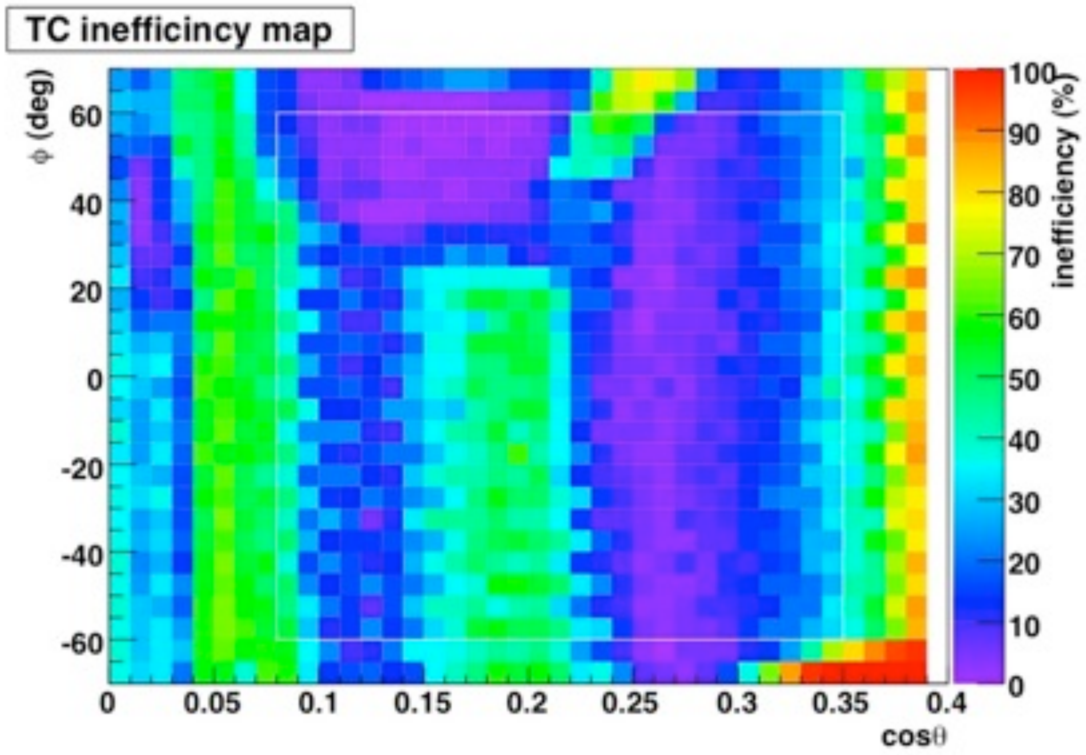
- Several "Damage" of cathode foil were observed during disassembly.
  - aging ?
- Special Vernier pattern by "^{t}250nm Al with 100 μm accuracy pattern over 1m length"
- Peeling off, Micro-holes(?), Isolating layer.
- "Source" is still unclear, but this must be solved ASAP.
- Just a quick solution; New Vernier foil with Better Adhesion by adding ^{t}0.5nm Ni-Cr sub-layer.
- 3 modules with new foil are getting ready, and will replace the current module.



Improve Efficiencies

- Spectrometer Efficiency is recovered by fixing discharge.
- However, overall spectrometer efficiency is still lower than 50%
- This is due to materials "after DC" but "before TC".
- New Studies to improve the Spectrometer Efficiency is just started.
    - Change Cable ?
    - Big modification is needed...



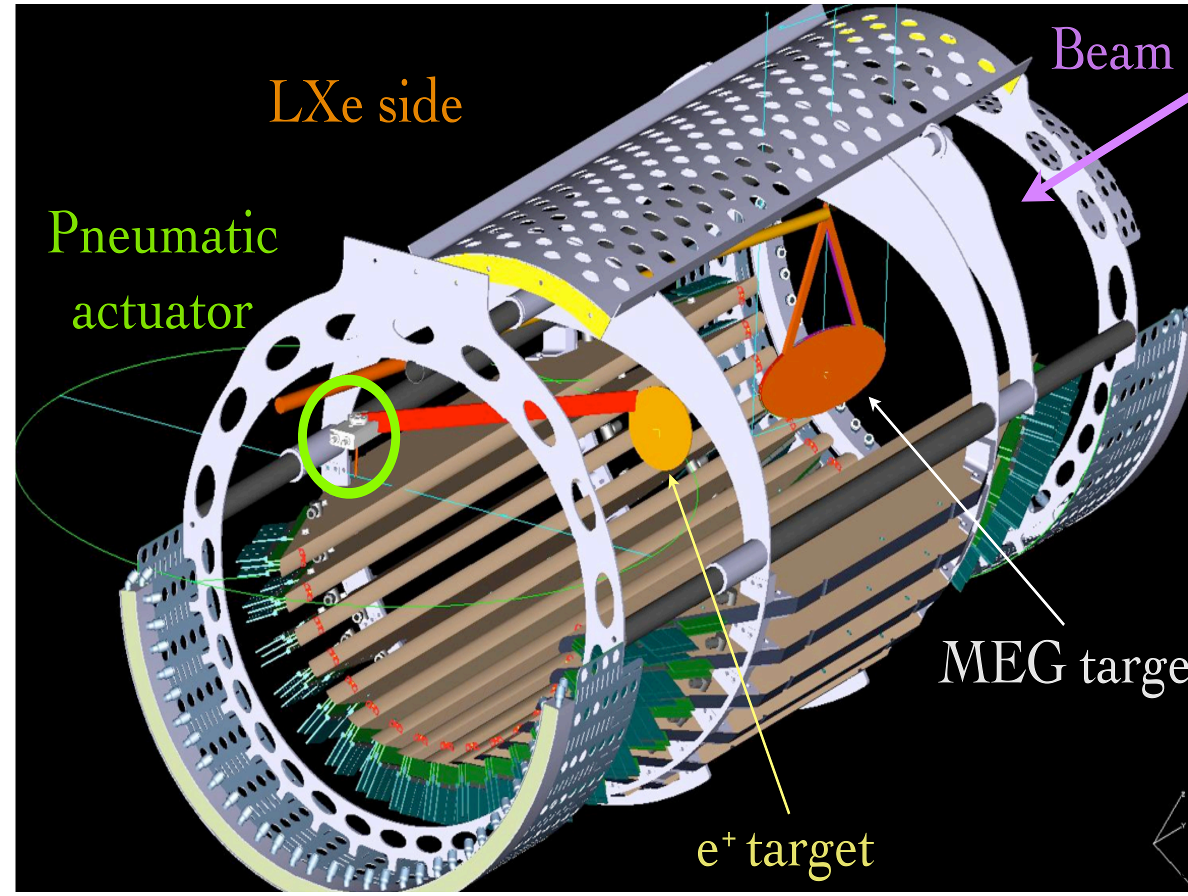


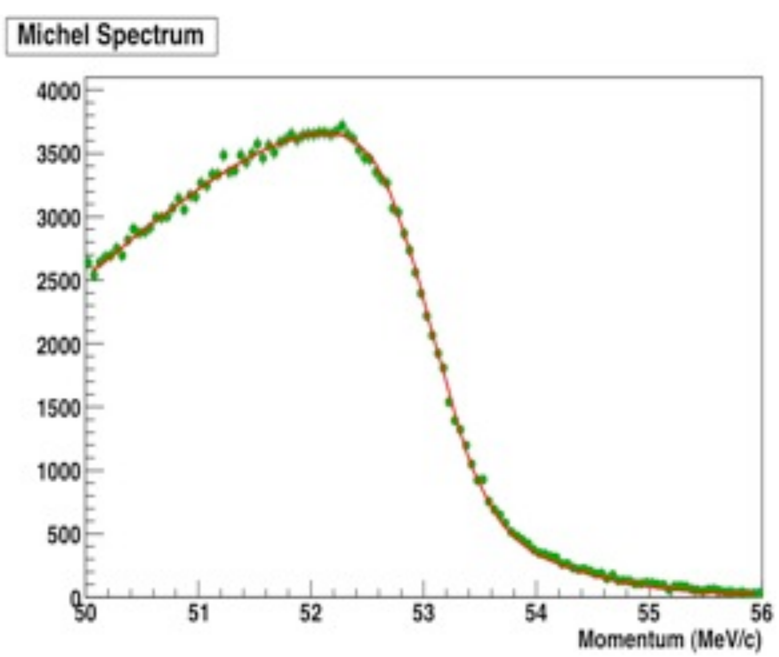
Improve Resolutions

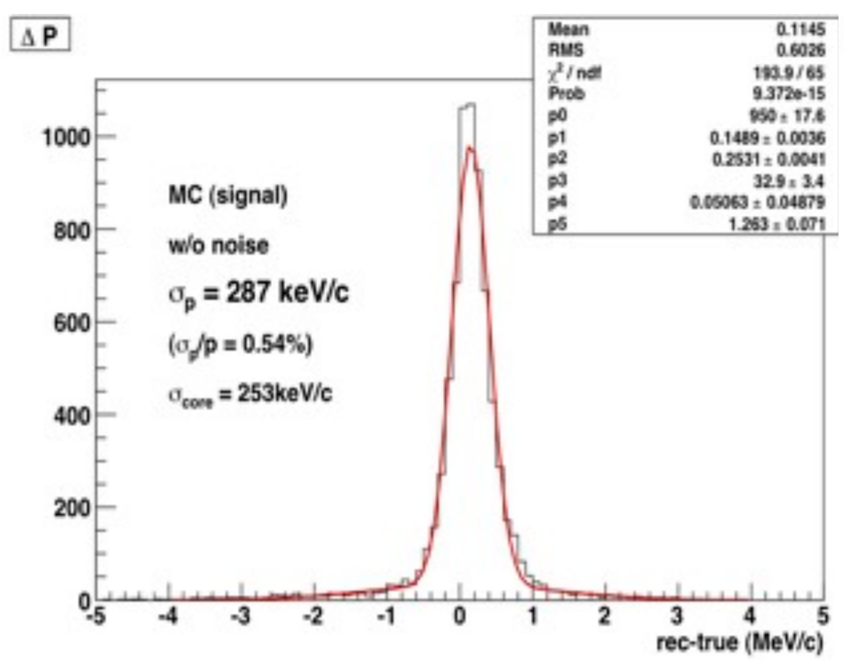
- Efficiency is largely recovered, and resolution is improved (**See Next Talk**)
- But the resolution improvement is not so much...
- **Next Crucial Issue is Noise**
  - Precision of the Z-coordinate (along wire) measurement is dominated by S/N. → Leading Bad Angular Resolution.
  - Noise level is ~1.8mV (*cf*. signal-pulse height is ~several ten mV)
    - unfortunately, noise situation was worse than 2008...
    - present σ_Z = 800~900 μm... (300〜400 μm is expected)
  - Several Studies are ongoing;
    - better grounding, noise subtraction, increasing HV, wire-configuration modification

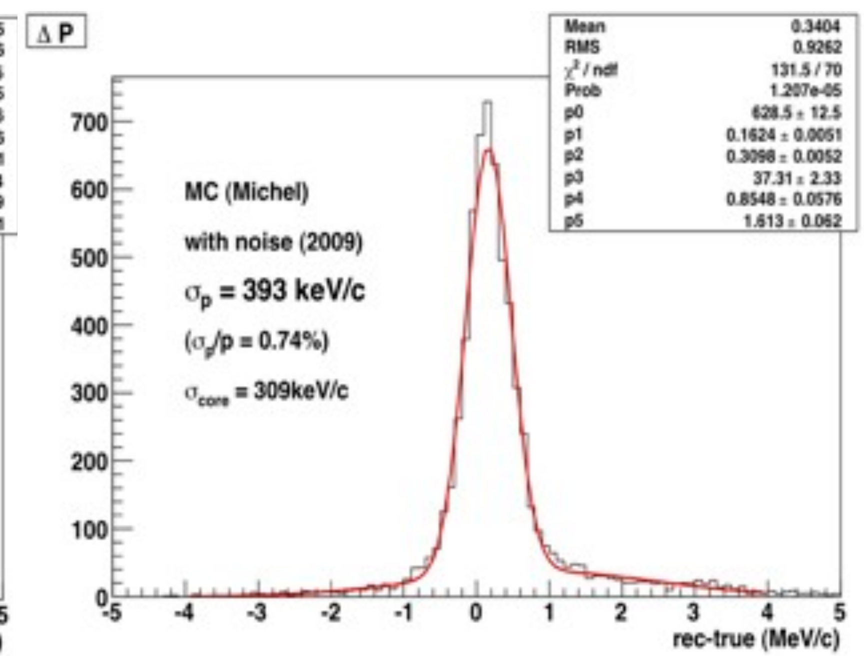
Improve Resolutions, contd.

- New Calibration Source will be implemented.
- Using Mott-Scatt. (coherent elastic) on light nuclei.
- " **Variable** / **Monochromatic** " e^+ is available.
- Momentum Calibration and Resolution Understanding will be improved.









Conclusions

- MEG is searching for $\mu^+ \rightarrow e^+\gamma$, and currently running at PSI from 2008.
- In the first physics-run period (2008), sever discharge problem was occurred on DC system, and hence Spectrometer Performances (efficiency and resolution) were much worse than expected.
- Intense Investigations / Modifications / Repair Works / Tests were done.
- After this "***counter-discharge*** campaign", <u>Positron Spectrometer has been fully running !! without discharge, very stable !!</u>
- Efficiency / Resolutions were improved and closing to expectations.
- Next Issues, & Next Steps;
  - Noise is limiting the position measurement (**See Next Talk**)
  - Low Efficiency due to materials outside DC, Studies are starting
  - Damaged Cathode Foil, New foil R&D is ongoing.
  - New e^+ source for Better Calibration and Resolution Studies.