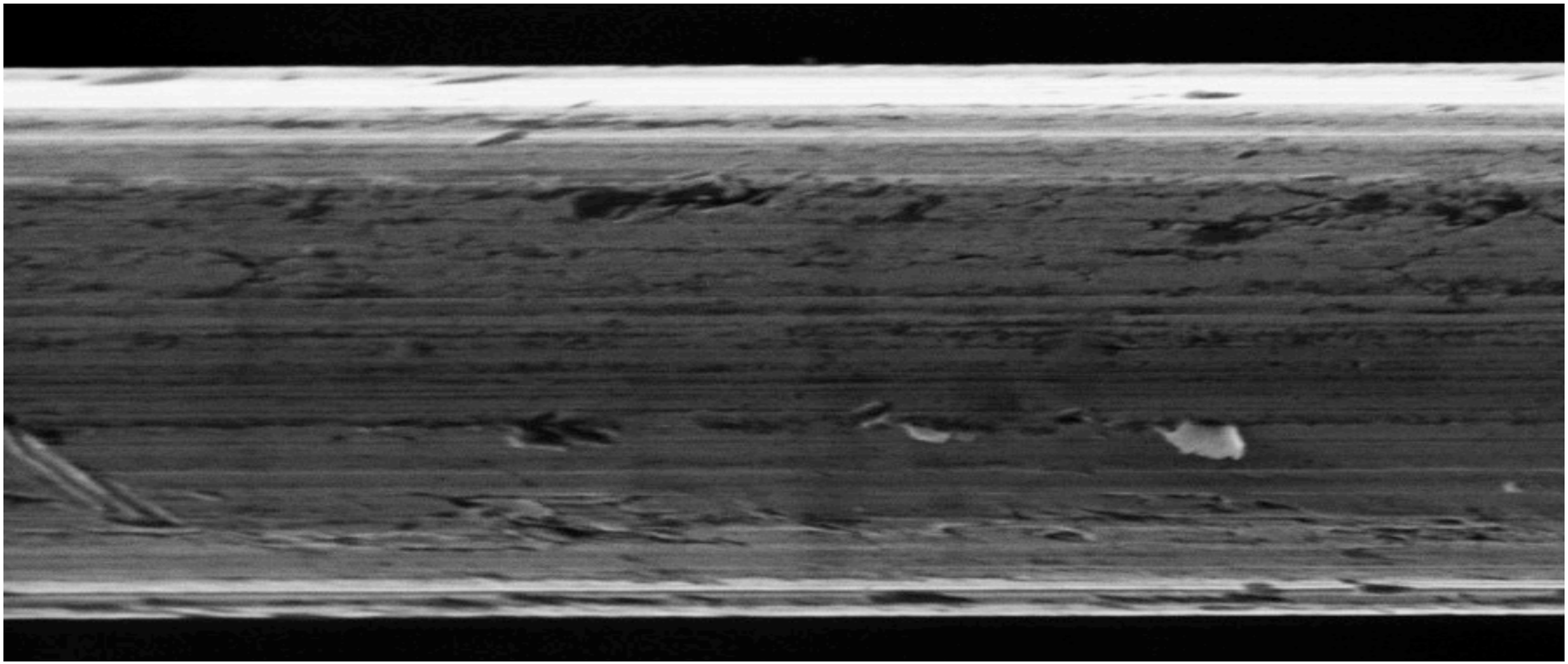


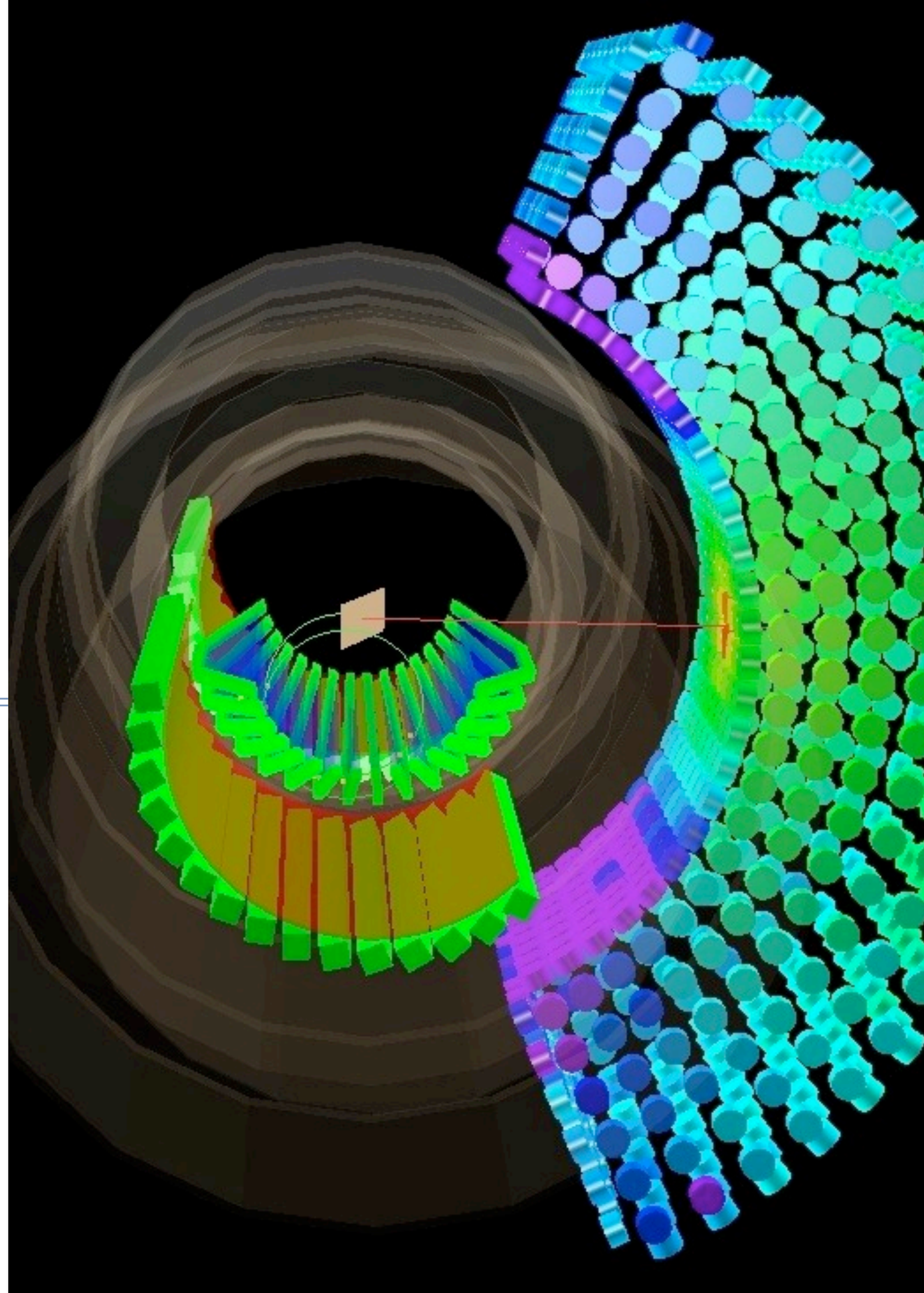
He/C_2H_6 を用いたドリフトチェンバーの高頻度照射下でのエイジング

西口 創 (KEK素核研), 他 MEG コラボレーション

JPS Meeting, 11-14/Sep./2010, Kyushu Institute of Technology

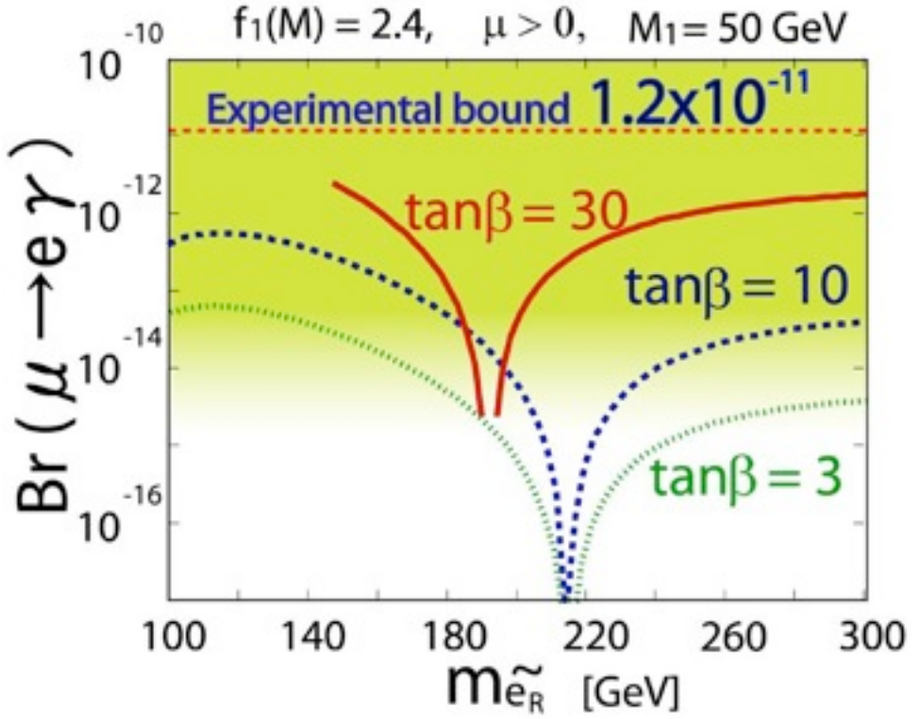
contents

MEG Experiment



MEG Experiment

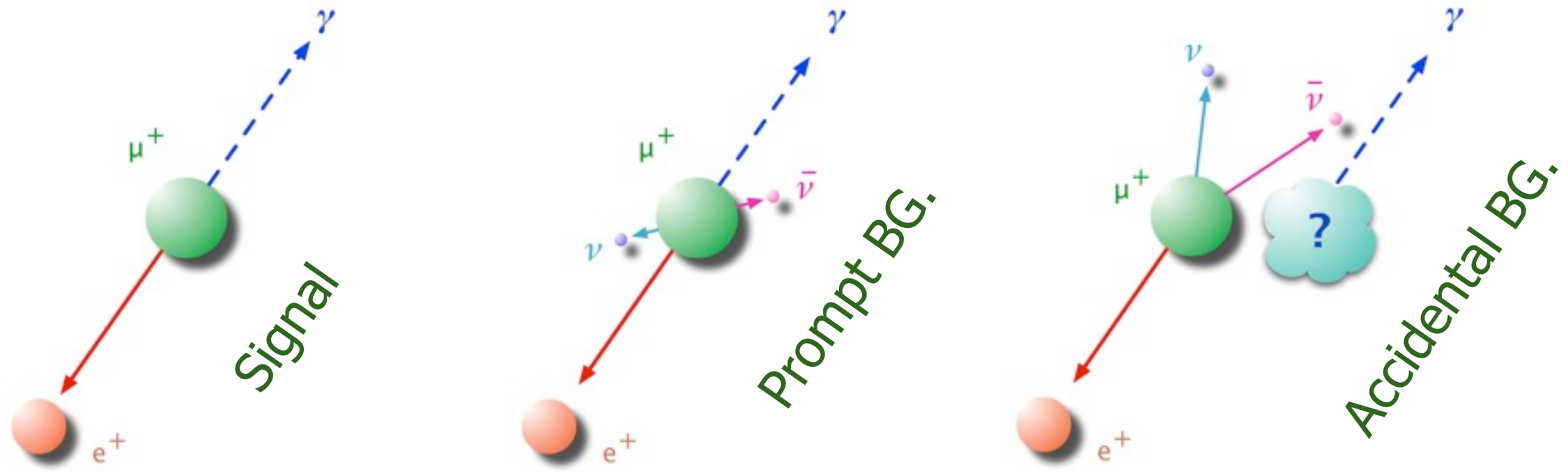
- **Search Experiment for "$\mu \to e\gamma$"**
  - $\mu \to e\nu\nu \sim 100\%$ (normal muon decay in SM)
  - $\mu \to e\gamma$ violates Lepton Flavour Conservation
  - Even assuming "SM" + "Neutrino-Oscillation", $B(\mu \to e\gamma)$ is predicted to be $< 10^{-50}$
  - However many models of beyond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

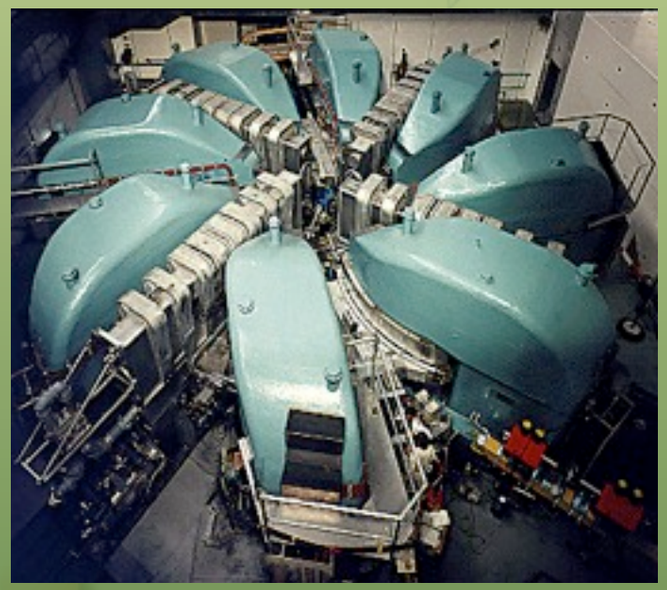
- Signal and Backgrounds



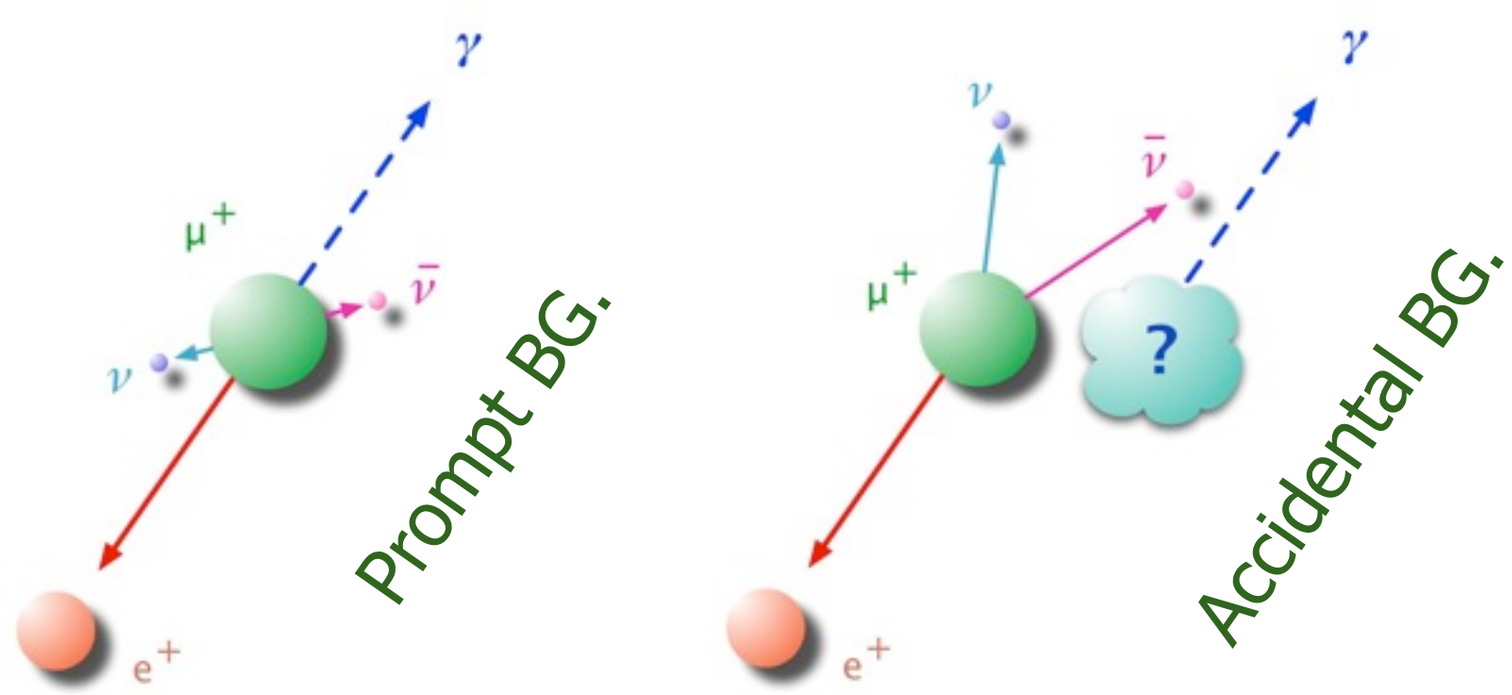
- Clear 2-body kinematics (E_e=E_γ=52.8MeV, $\theta_{e\gamma}$=180°, Time Coincidence)
- Sensitivity is Limited by "Accidental Overlap"
  - **DC muon is the Best Solution**
  - **Good Resolution (Energy, Spacial and Timing) under Very High Rate**

Hunting for $\mu \to e\gamma$

- Signal and Backgrounds



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



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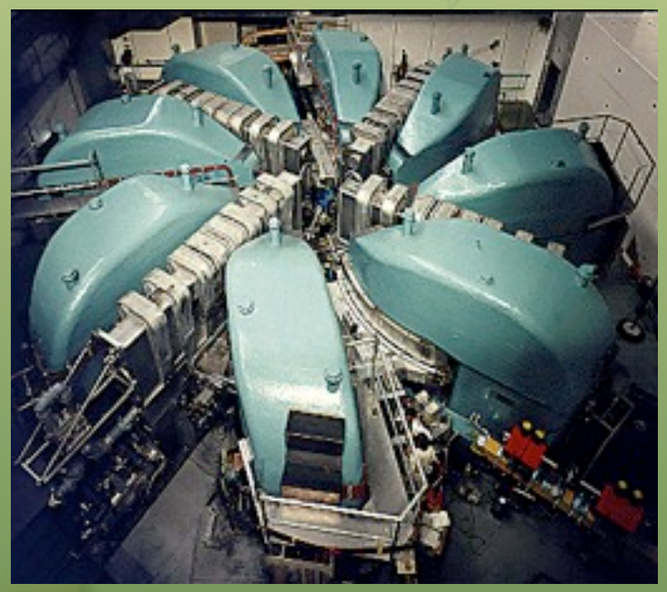
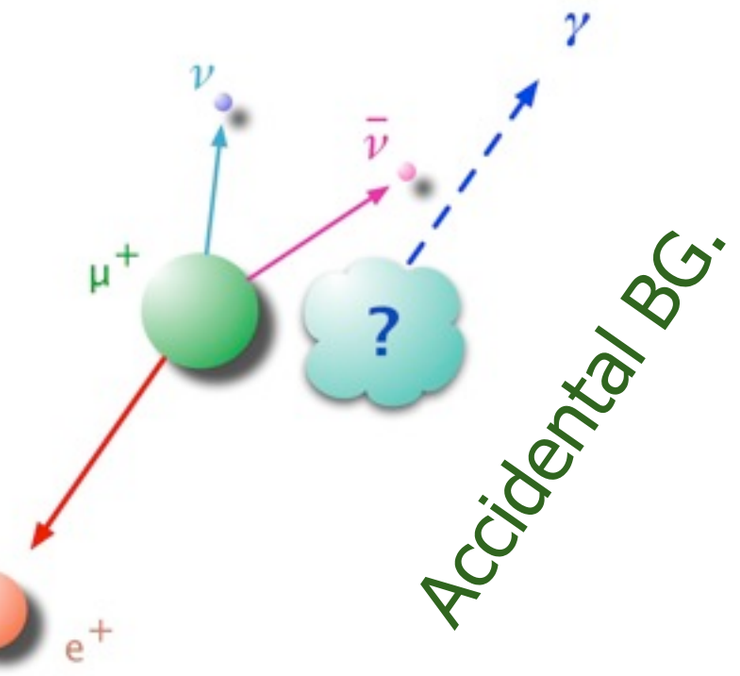


World Most Intense
DC Muon Beam at PSI
10^8 muon/sec

Liquid Xenon
Scintillation Detector
for gamma-ray
(13pSM03, 白)



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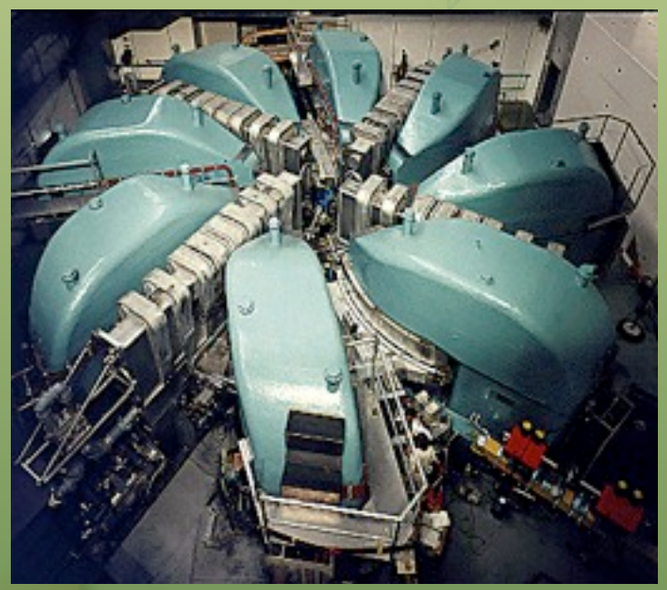

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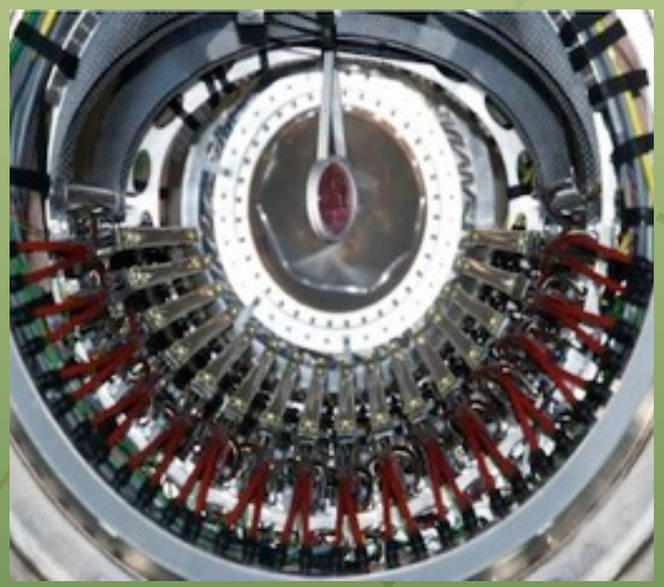
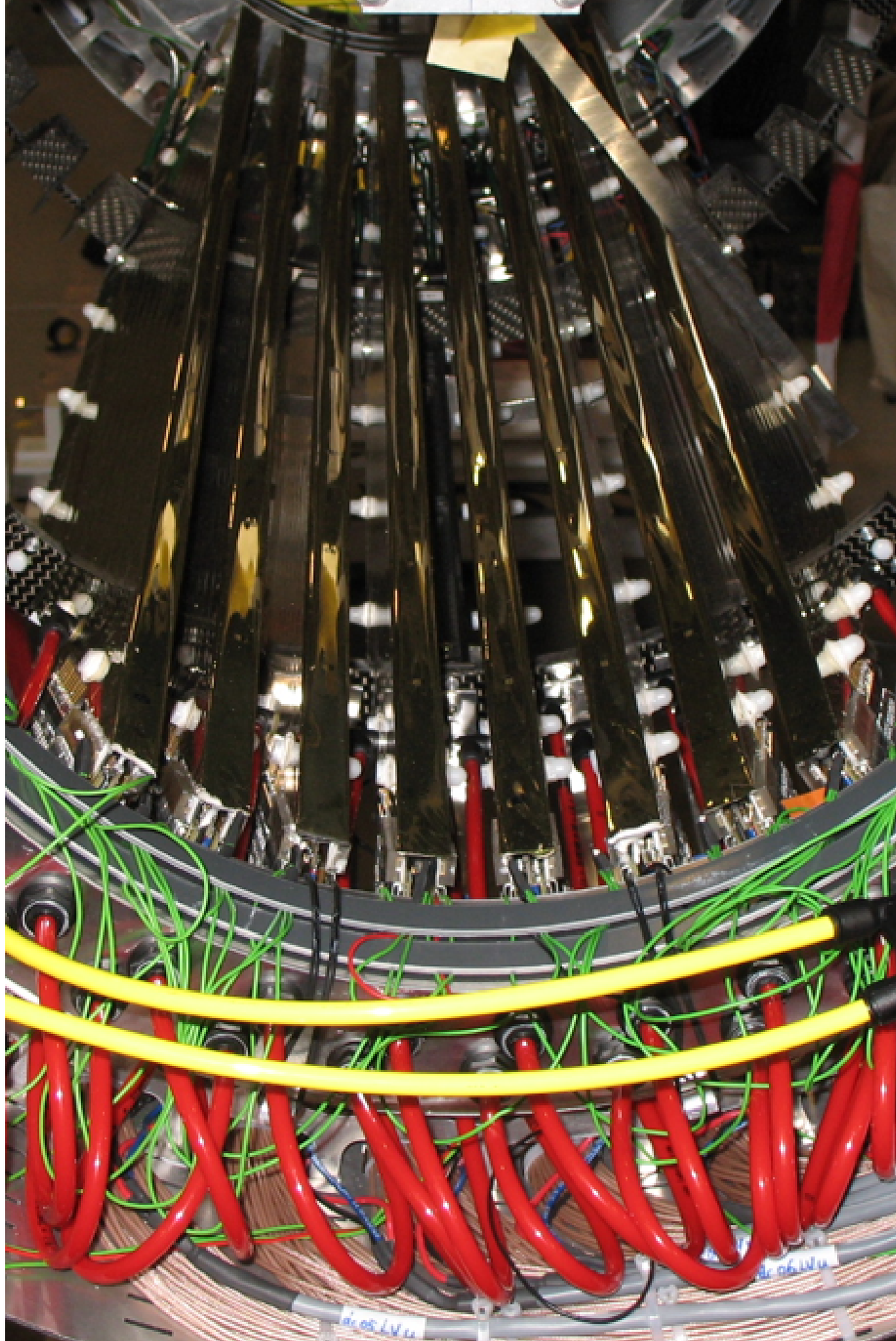


COBRA Spectrometer
for positron
(13pSM02, 藤井)

- 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 : 3×10^7 muon/sec

→ Special B-field

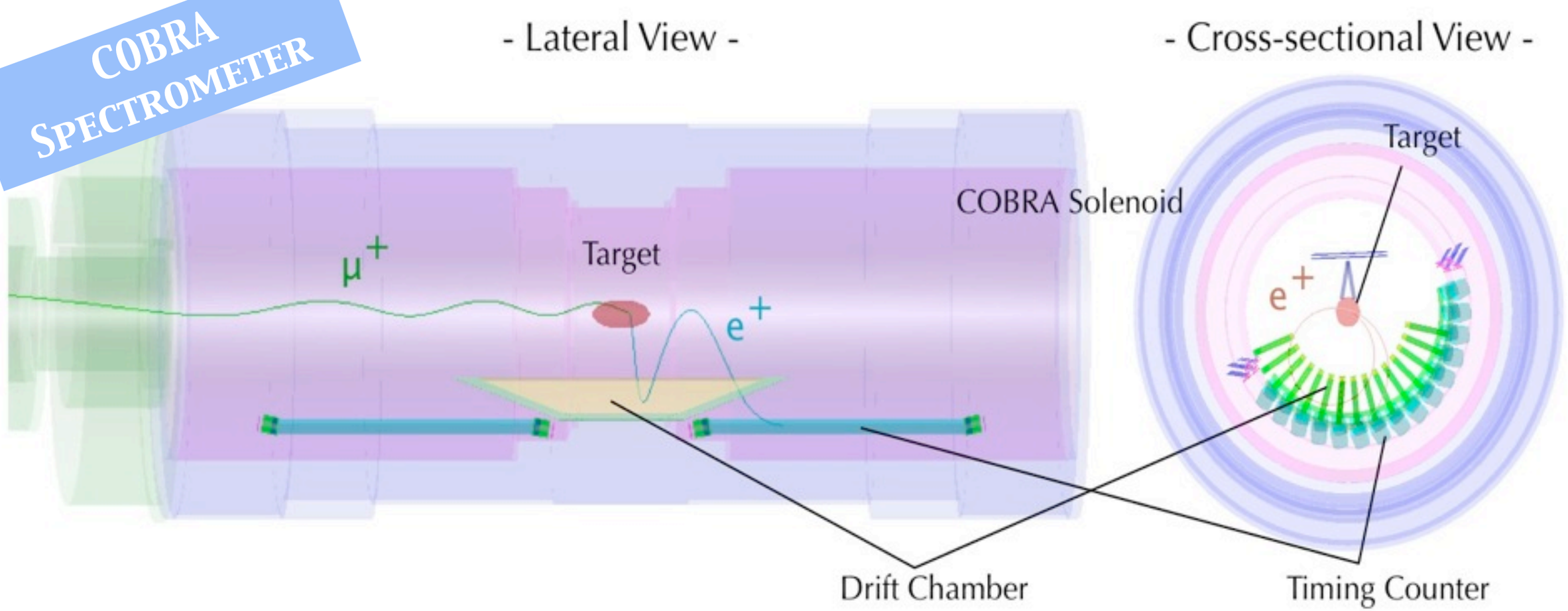
- **Good momentum/position/timing resolution**
  - aiming excellent sensitivity
  - <1% momentum resolution, 500μm position resolution for both direction(r,z) and 50 ps timing resolution

- **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

COBRA SPECTROMETER



Solenoid

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

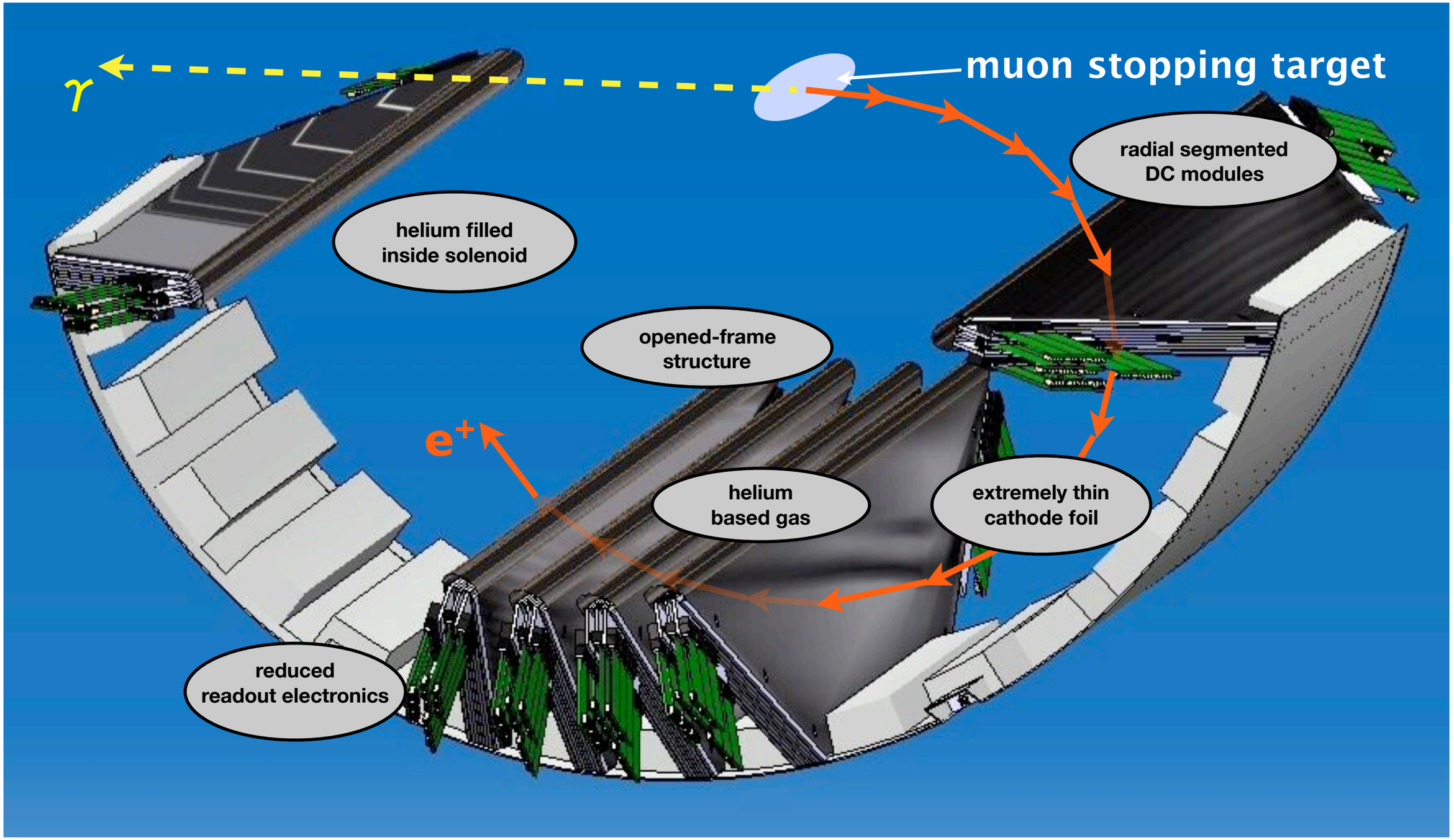
Drift Chamber

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

Timing Counter

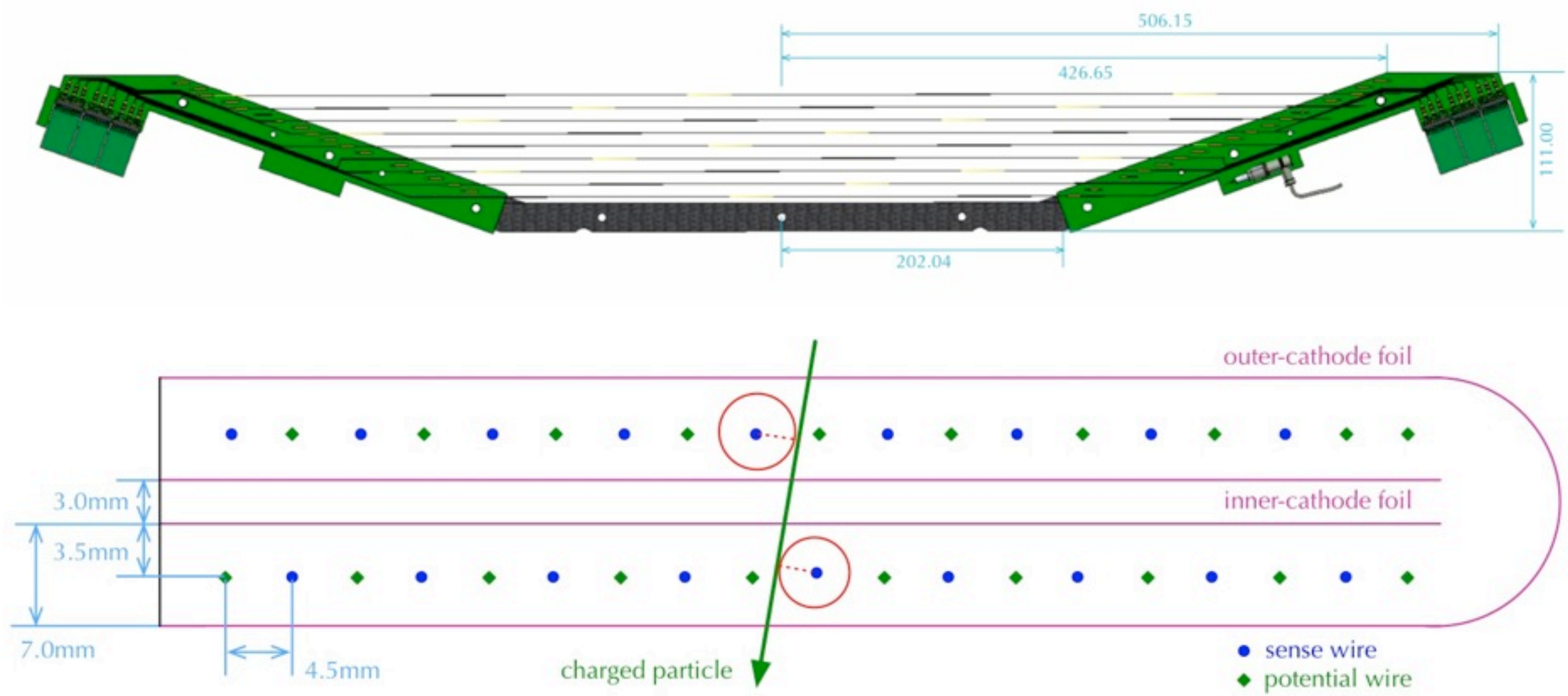
2-layers of scintillators
- scintillator bars (outer)
- scintillator fibres (inner)

MEG Drift Chamber



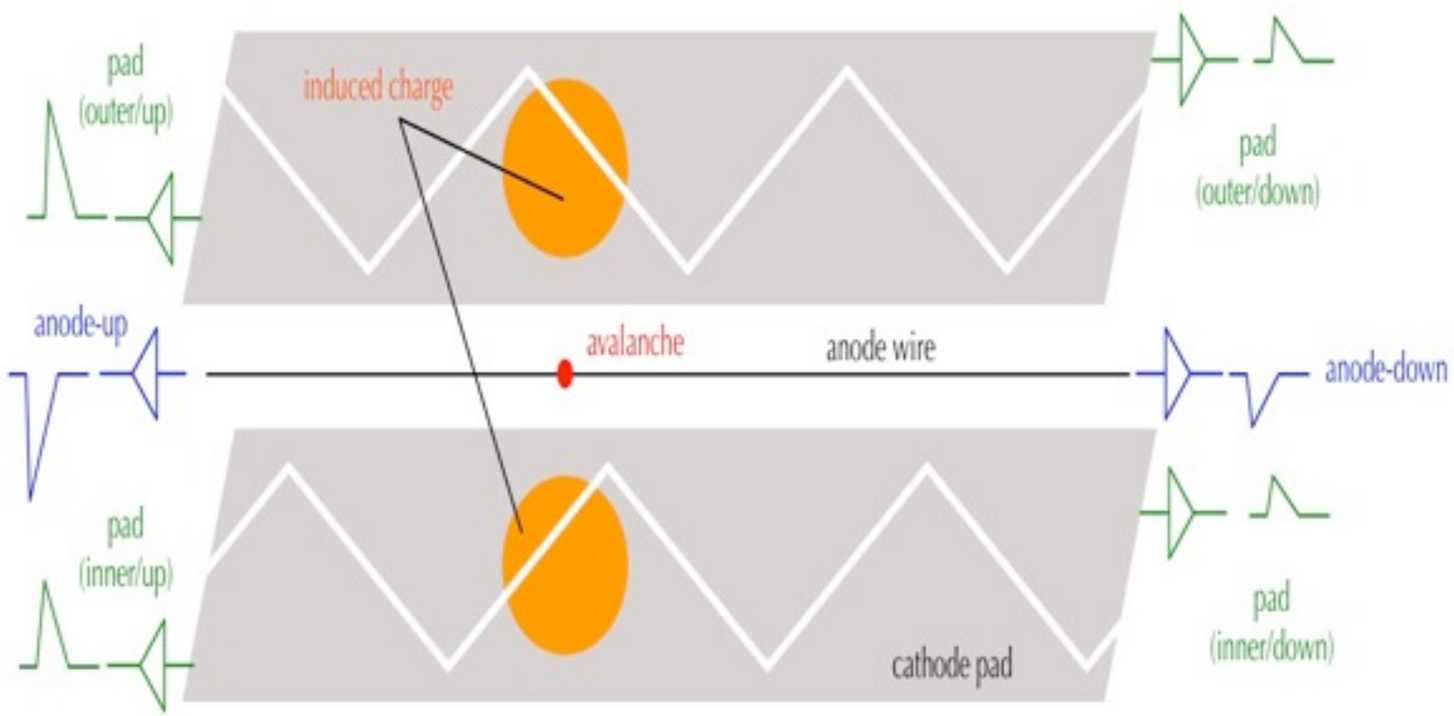
MEG Drift Chamber - Anode

- He-C_2H_6 (50:50) , 16 modules (2 layers of axial wires) have 4.5mm cell space.
- Trapezoidal Open frame (Carbon Fibre) have 4 cathode planes (See Next Slide)



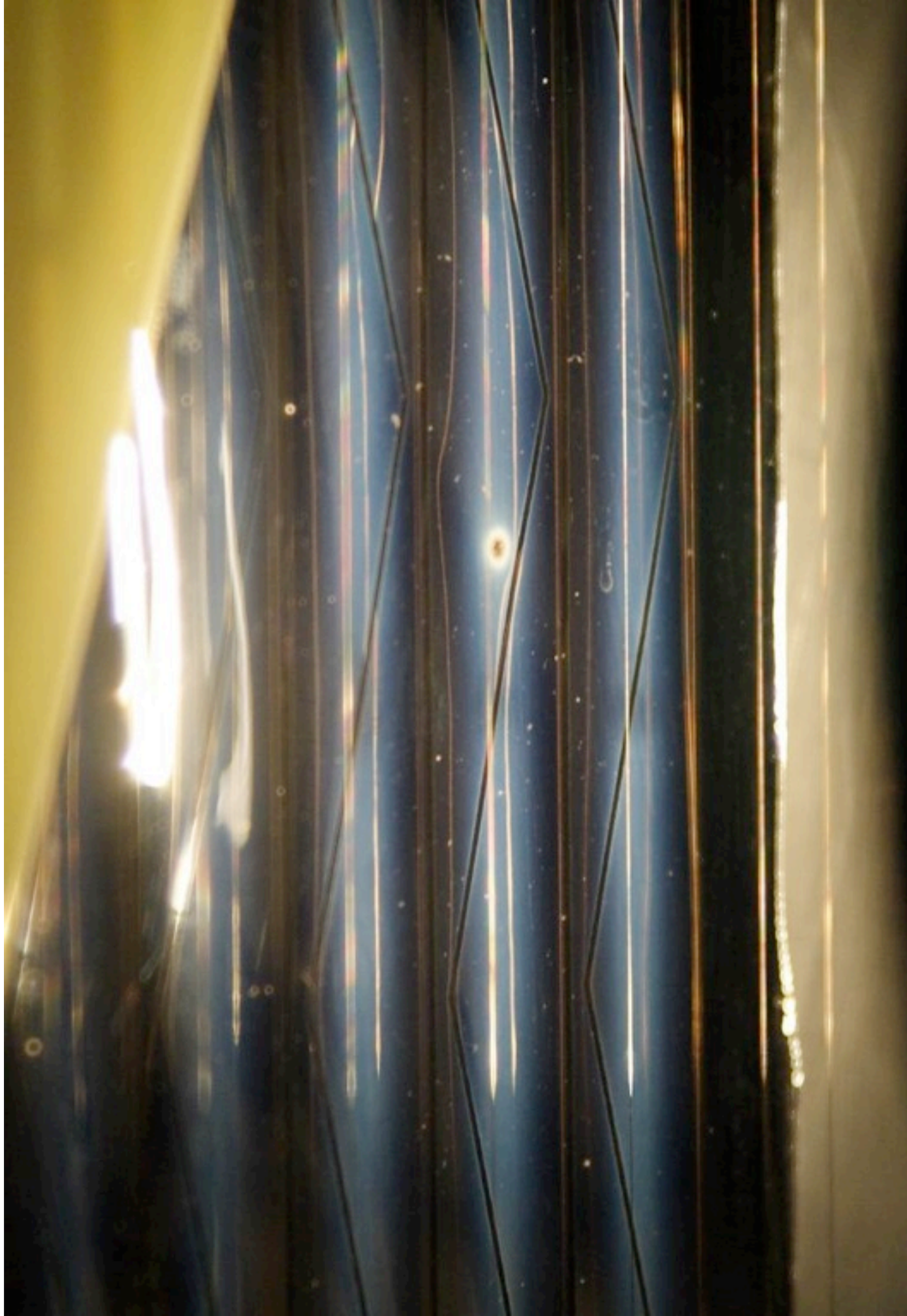
MEG Drift Chamber - Cathode

- Each Plane has 2 cathode foils with patterned Aluminum electrode.
  - 12.5 μm polyimide with 250 nm Aluminum etching
  - **Vernier Pad** method is adopted to obtain good resolution with low material



- Thanks to this open-frame structure, helium-base gas mixture, ultra-thin cathode, $0.00025X_0$/module ($0.002X_0$/track) is achieved.

Phenomena of DC (after beam operation)



Expectation

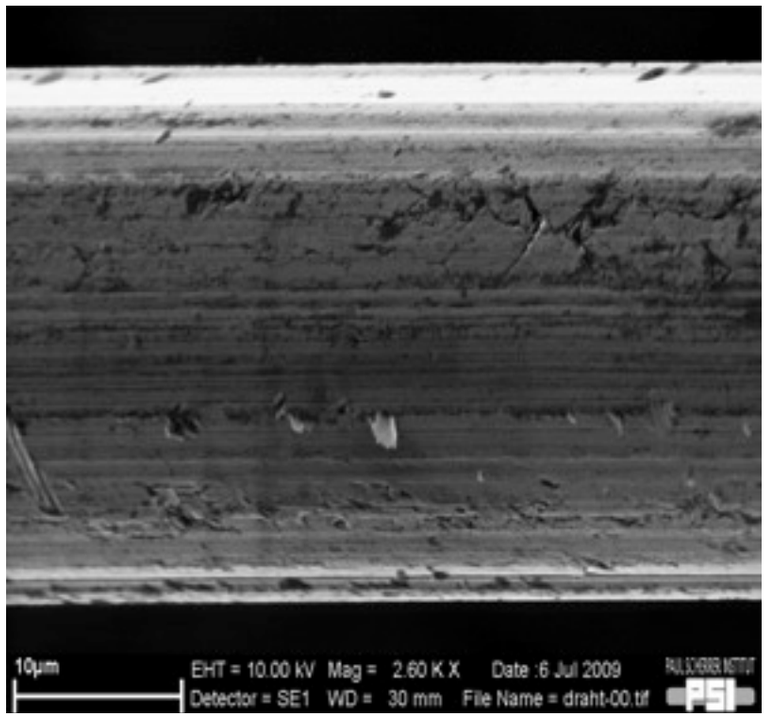
- **Anode Damage:**
  - Due to 50% of C_2H_6 content (quencher for high gas gain) and high counting rate (~10kHz/cm^2), anode coating is possibly occurred.
    - Very Small Cell Size (9mm x 7mm) , Only 3 Months of Operation could cause such a serious damage ???
  - Any other damages ?

- **Cathode Damage:**
  - Same as anode, coating with hydrocarbon is possibly occurred.
    - Should be much safer than anode due to large surface.
  - Any other damages ?

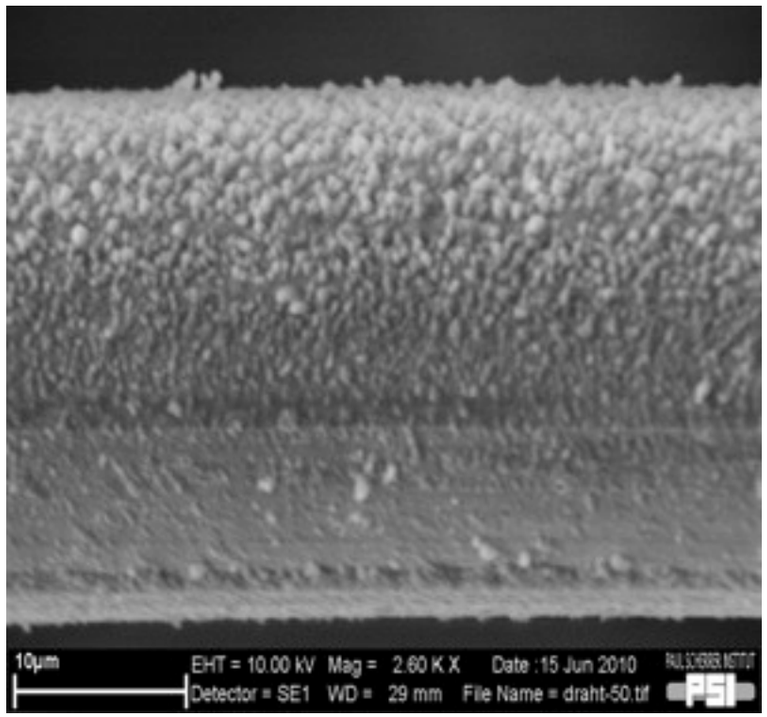
- If we would be suffered from any unexpected damages, how can we survive ??

Observations on Anode

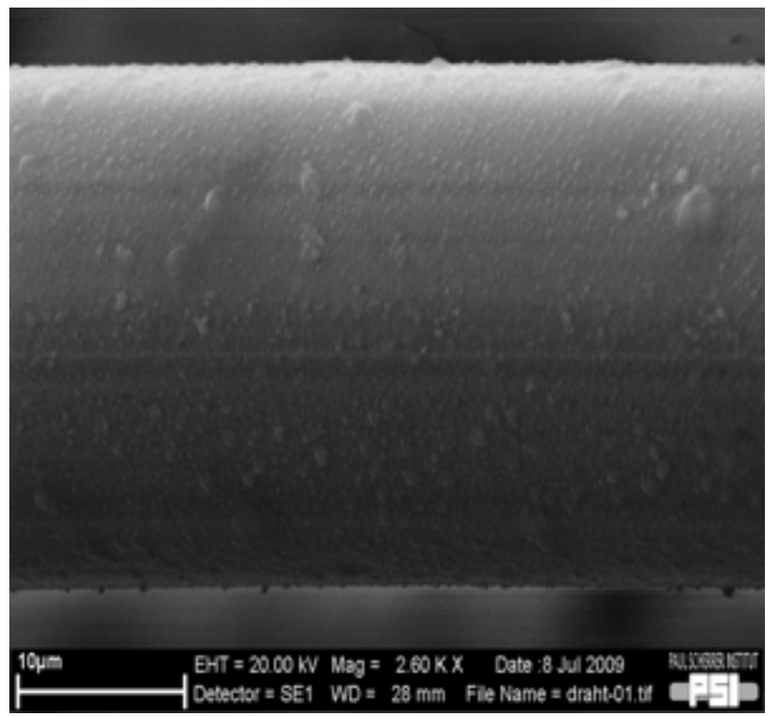
- Anode Coating is Observed in some modules @ shut down maintenances
- Comparison; “Brand-New”, “3 Months Operation”, “6 Months Operation”



New



3 Months

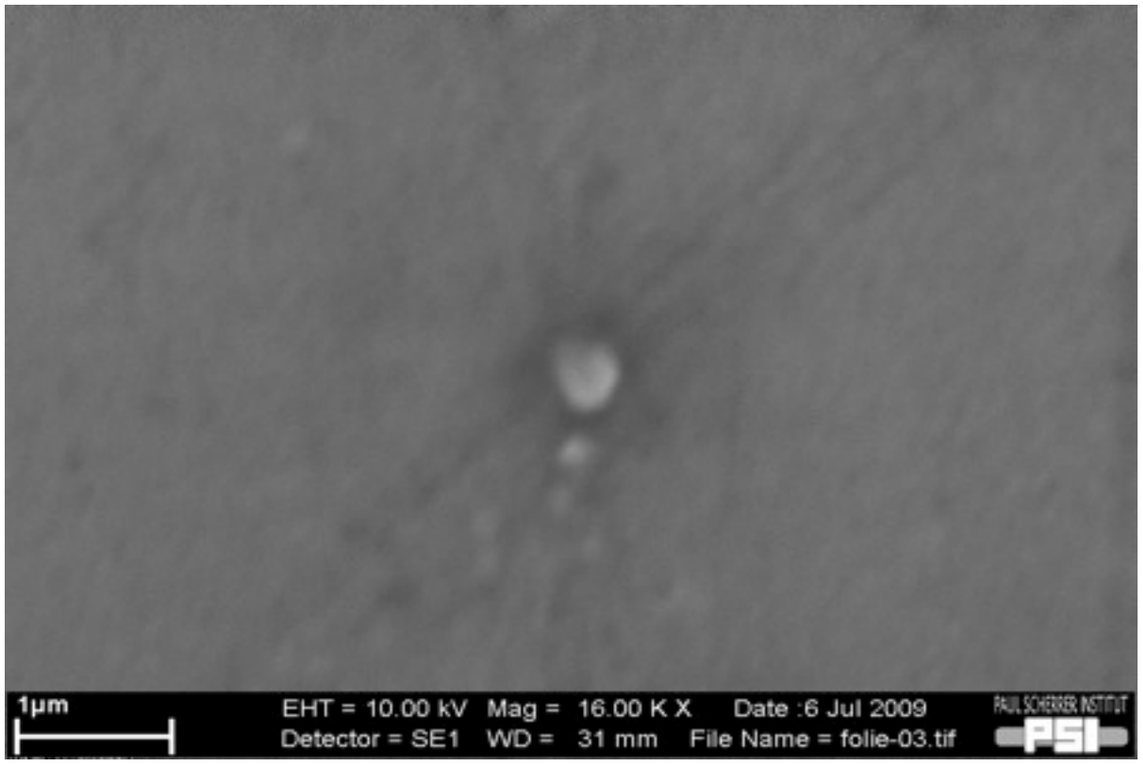


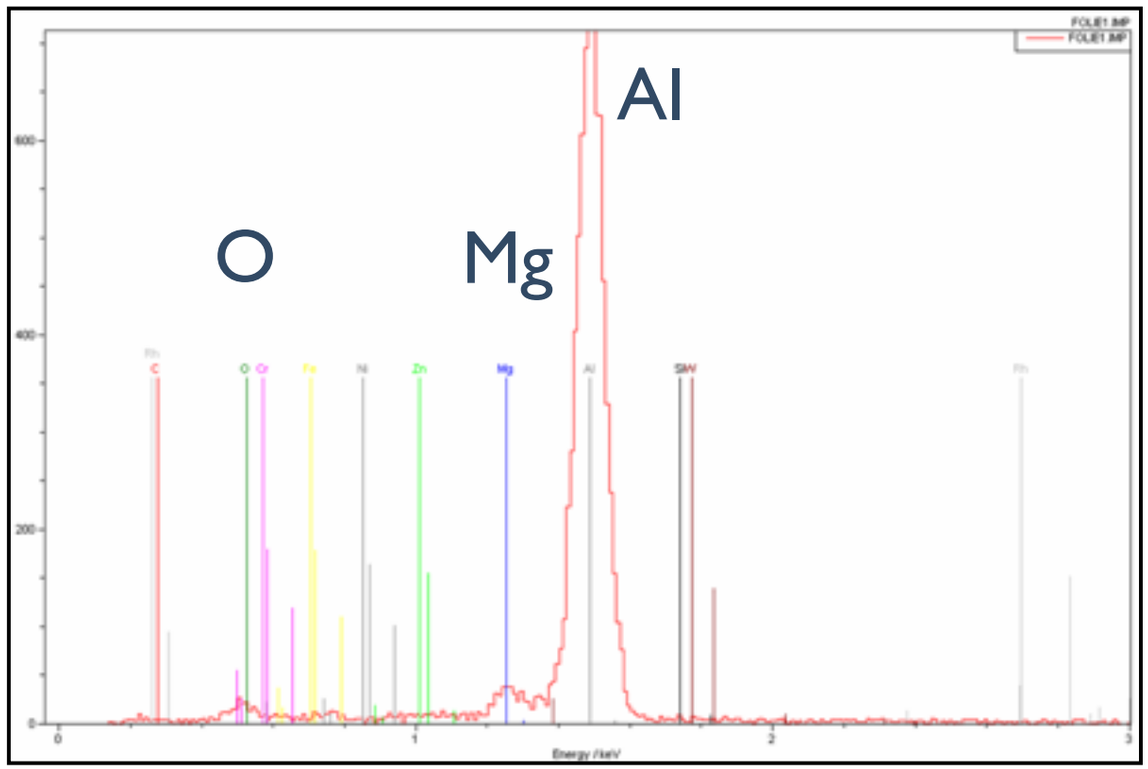
6 Months

- Obviously a certain coating is confirmed, and it is growing up.
- However, there is no clear evidence whether it causes a problem on operation.

Observations on Cathode

- Electron Microscope view and it's EDX (energy dispersed x-ray spectroscopy)

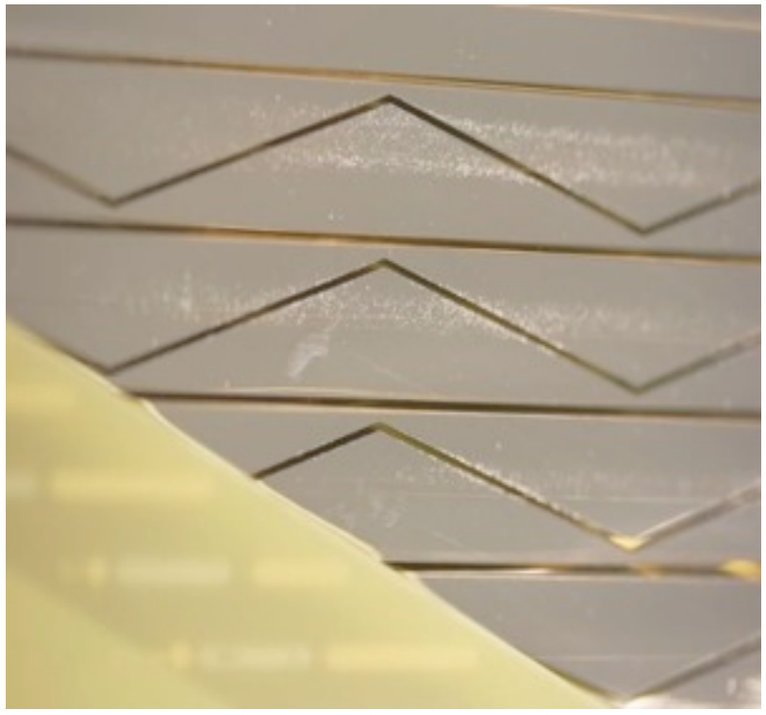


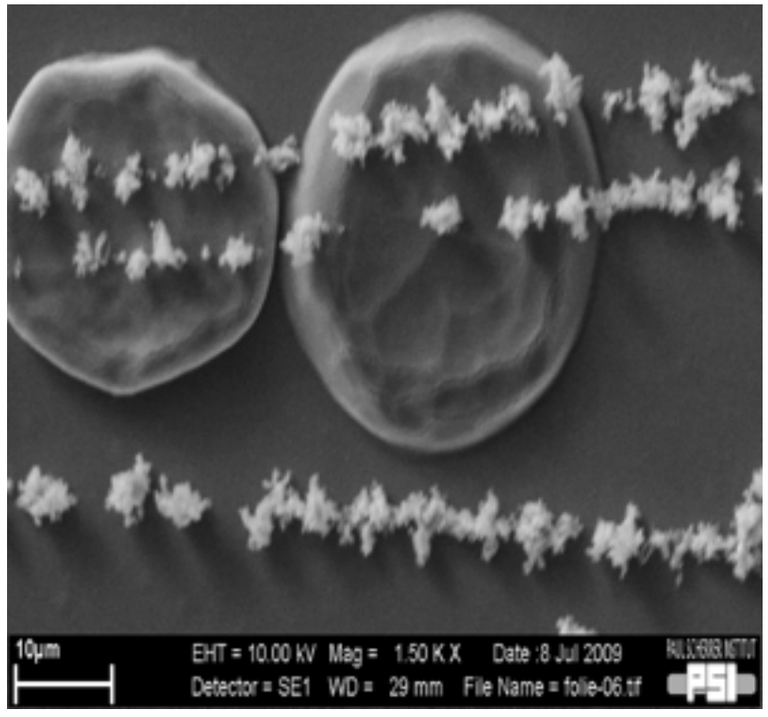


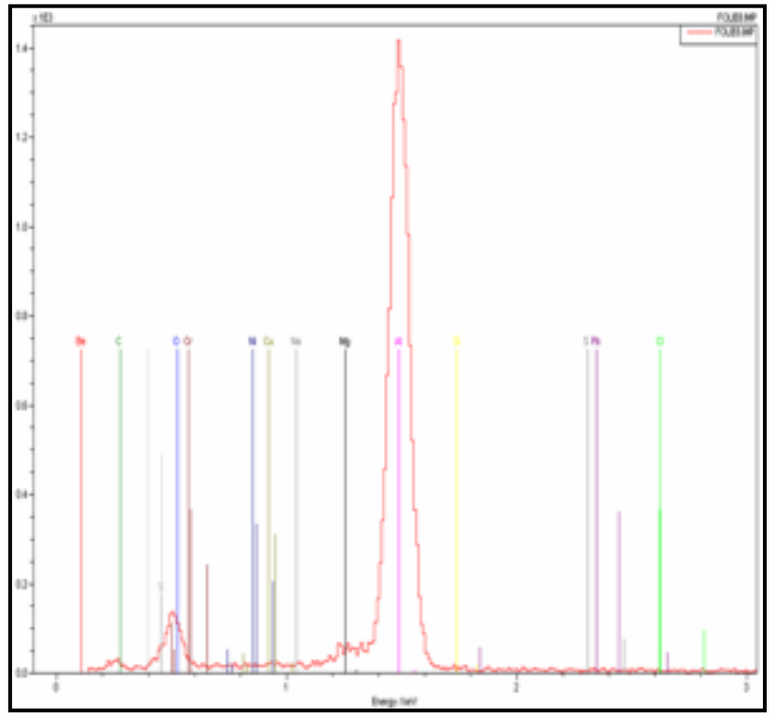
- No clear observation of hydrocarbon coating !
- But...
  - there were many unexpected observations...

Unexpected Observations (1)

- Many Spots along wire



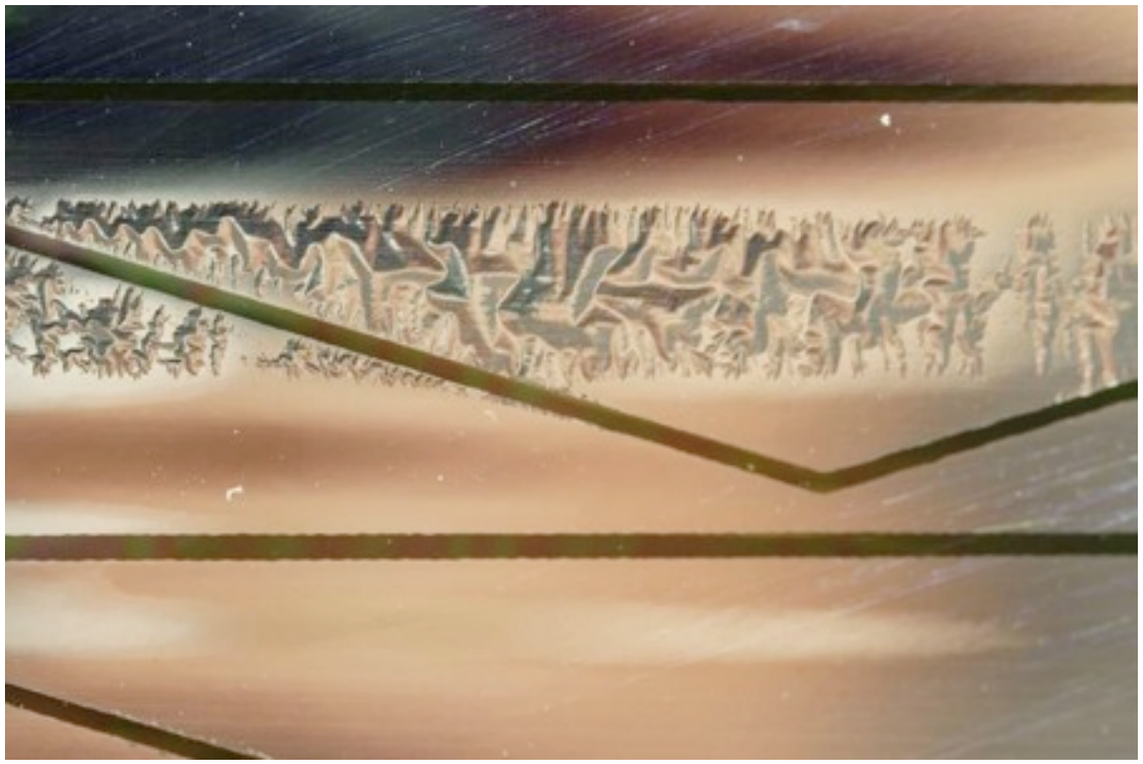


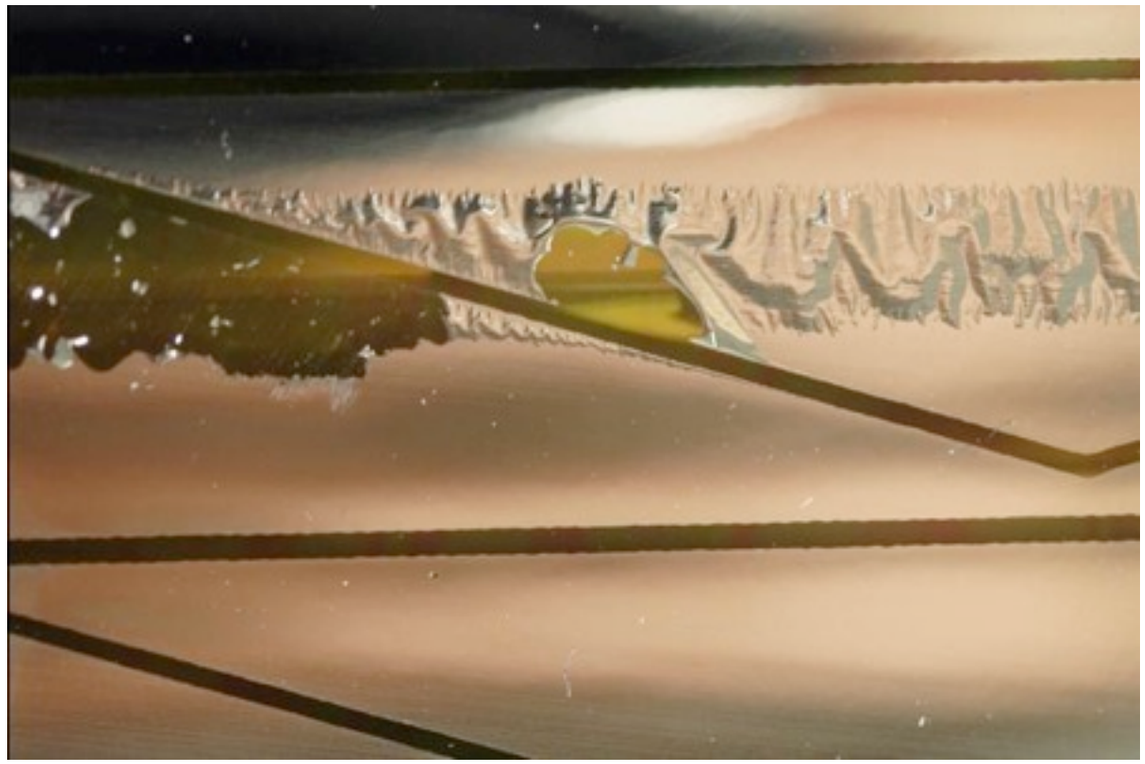


- Only central part of slab, Only innermost (and some more) cell has such spots.
  - Related to irradiation ??? (innermost cell is the hottest cell, ~10kHz/cm^2)
  - EDX said a little more carbon content, but no objection...

Unexpected Observations (2)

- Aluminum Pealing Off

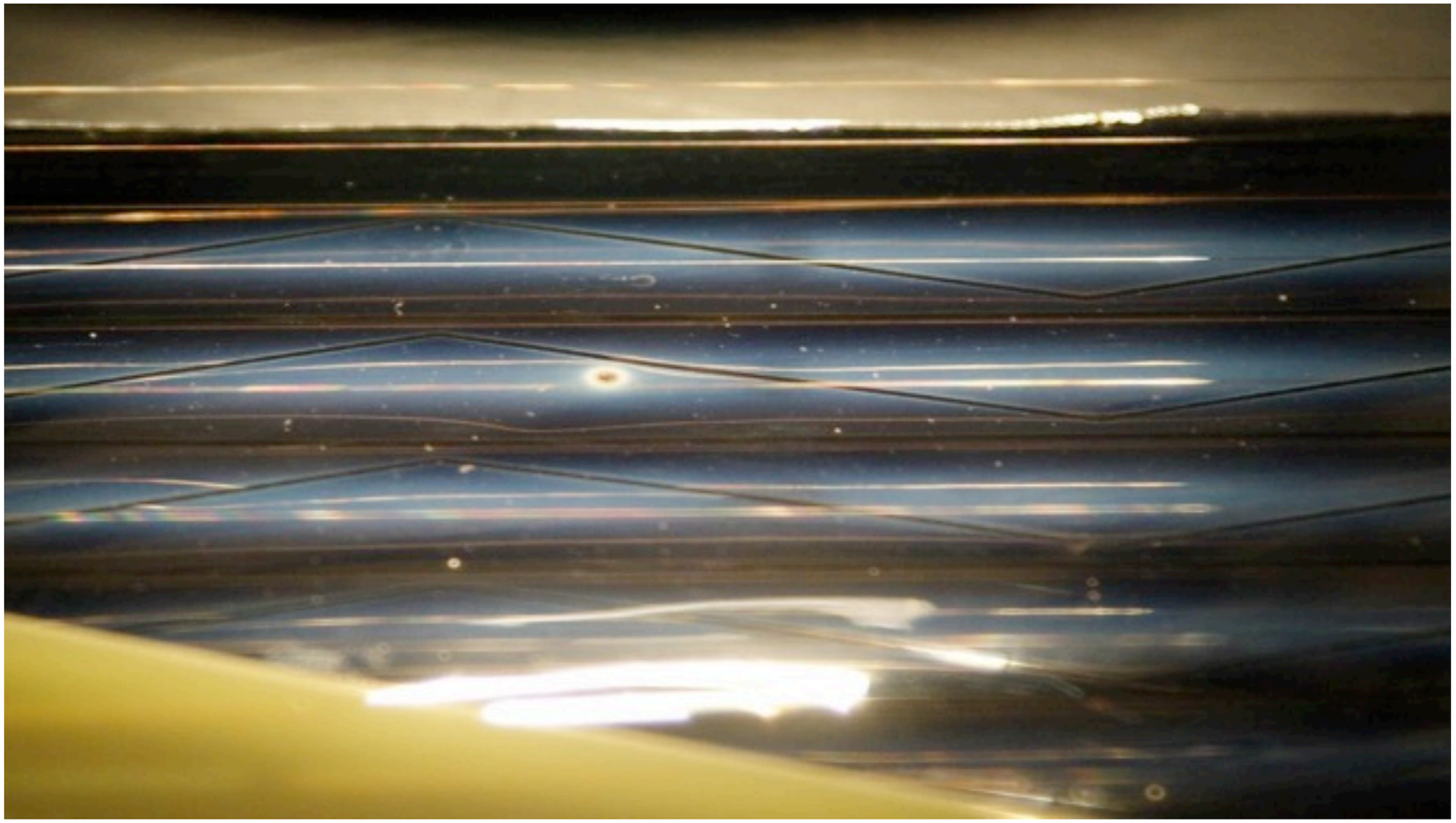




- Observed in several modules at very similar region of Observation-(1).
  - Only central part, Only Innermost cell...

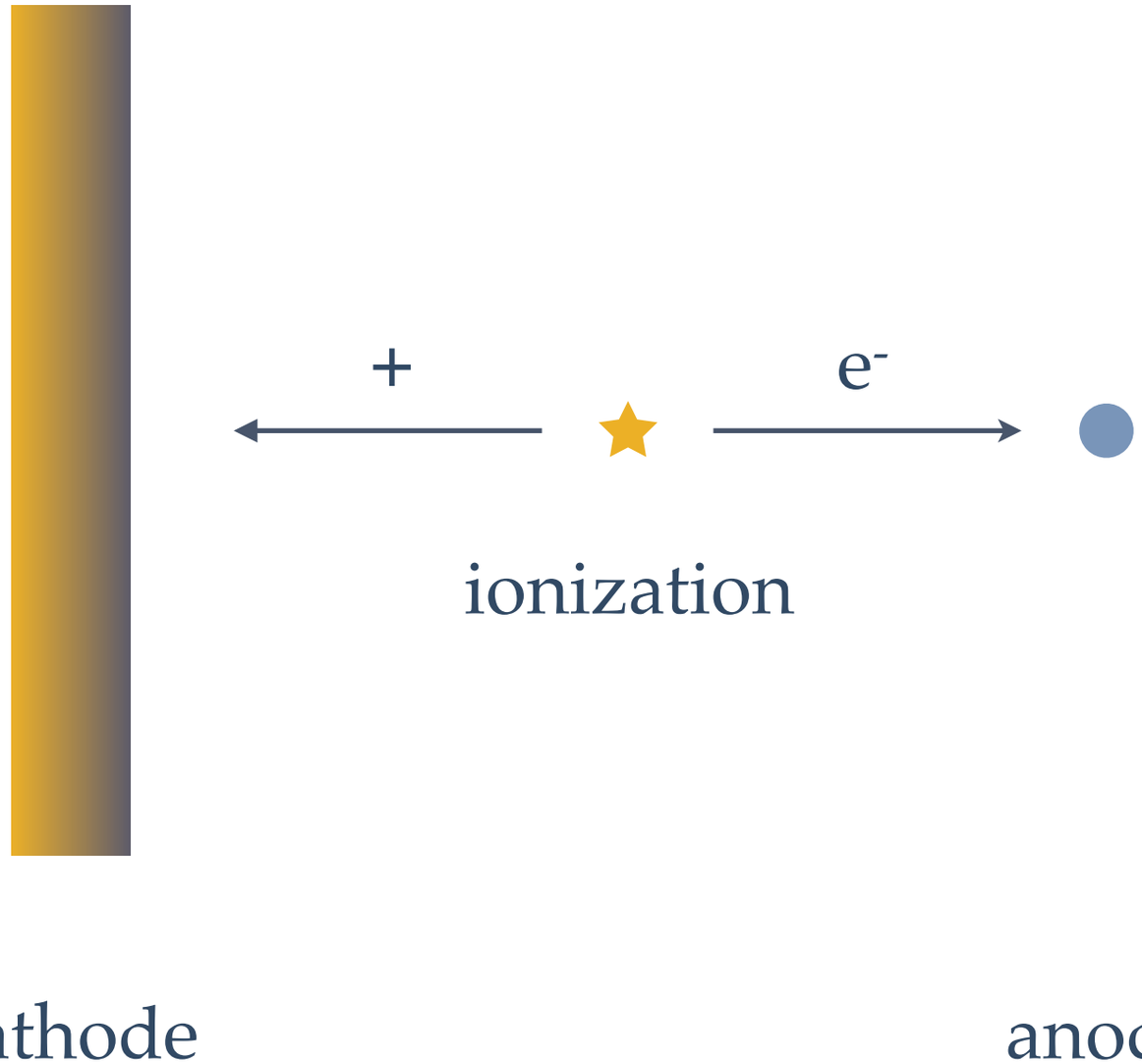
Unexpected Observations (3)

- White Shadow on Cathode pads



- Such planes showed a certain remaining current after beam blocked, so called "self-sustaining field emission (Malter effect)"
  - Thus, probably these shadow is a cover of insulated material.

Self-Sustaining Field Emission



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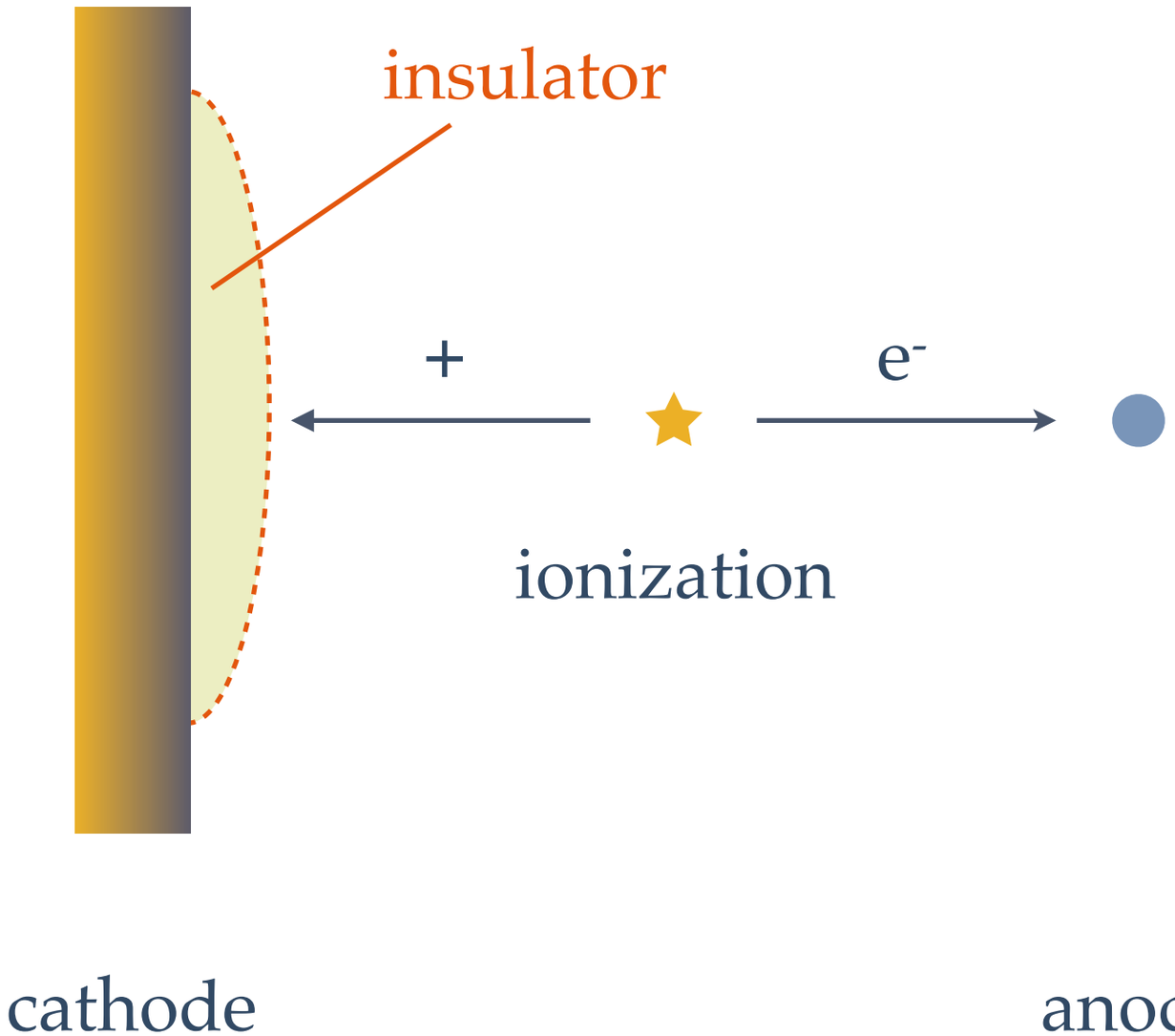

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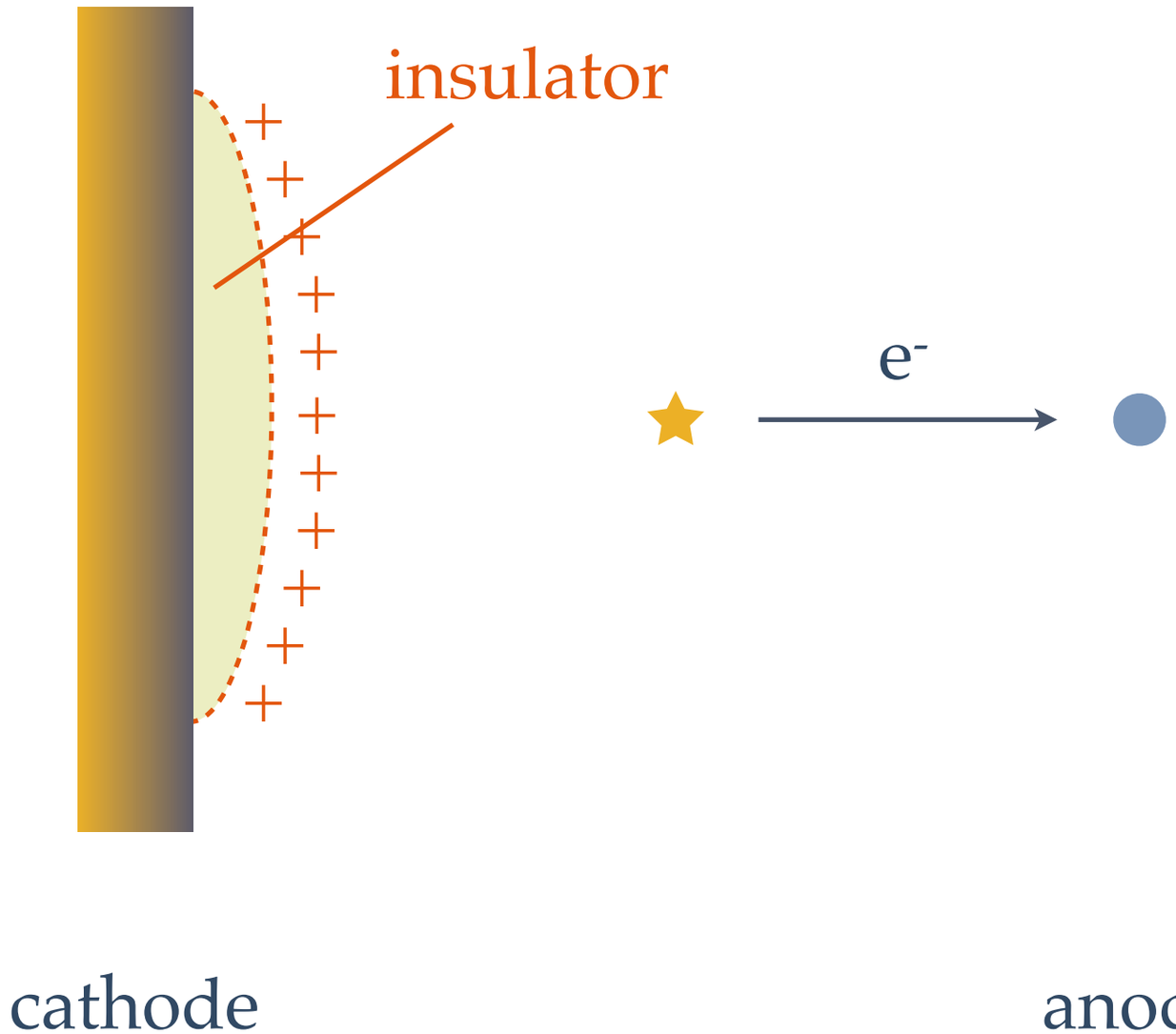

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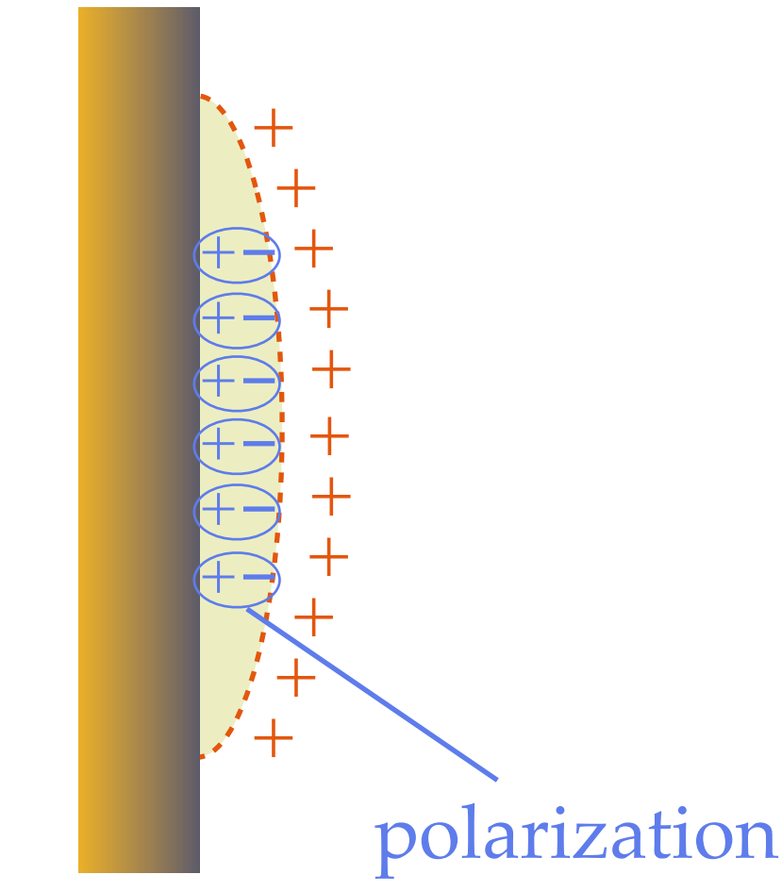
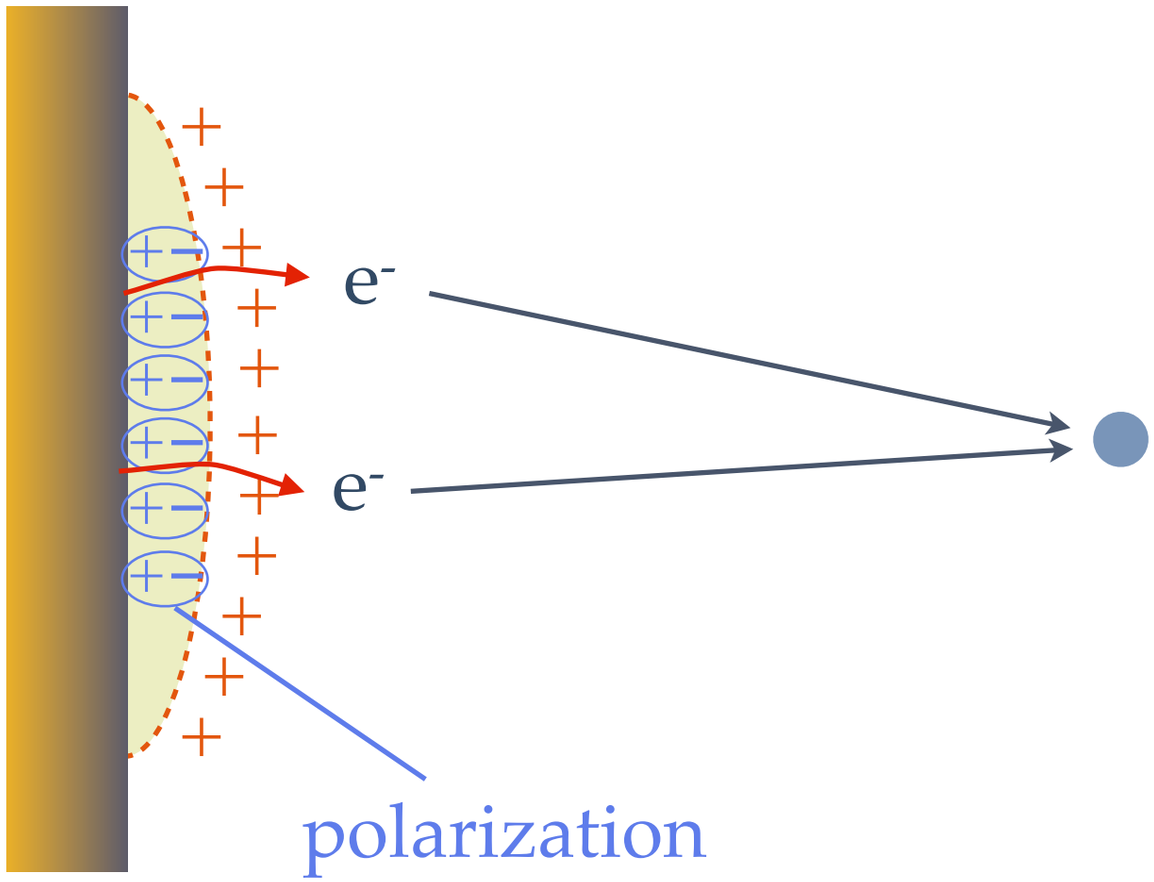


cathode

anode

Self-Sustaining Field Emission



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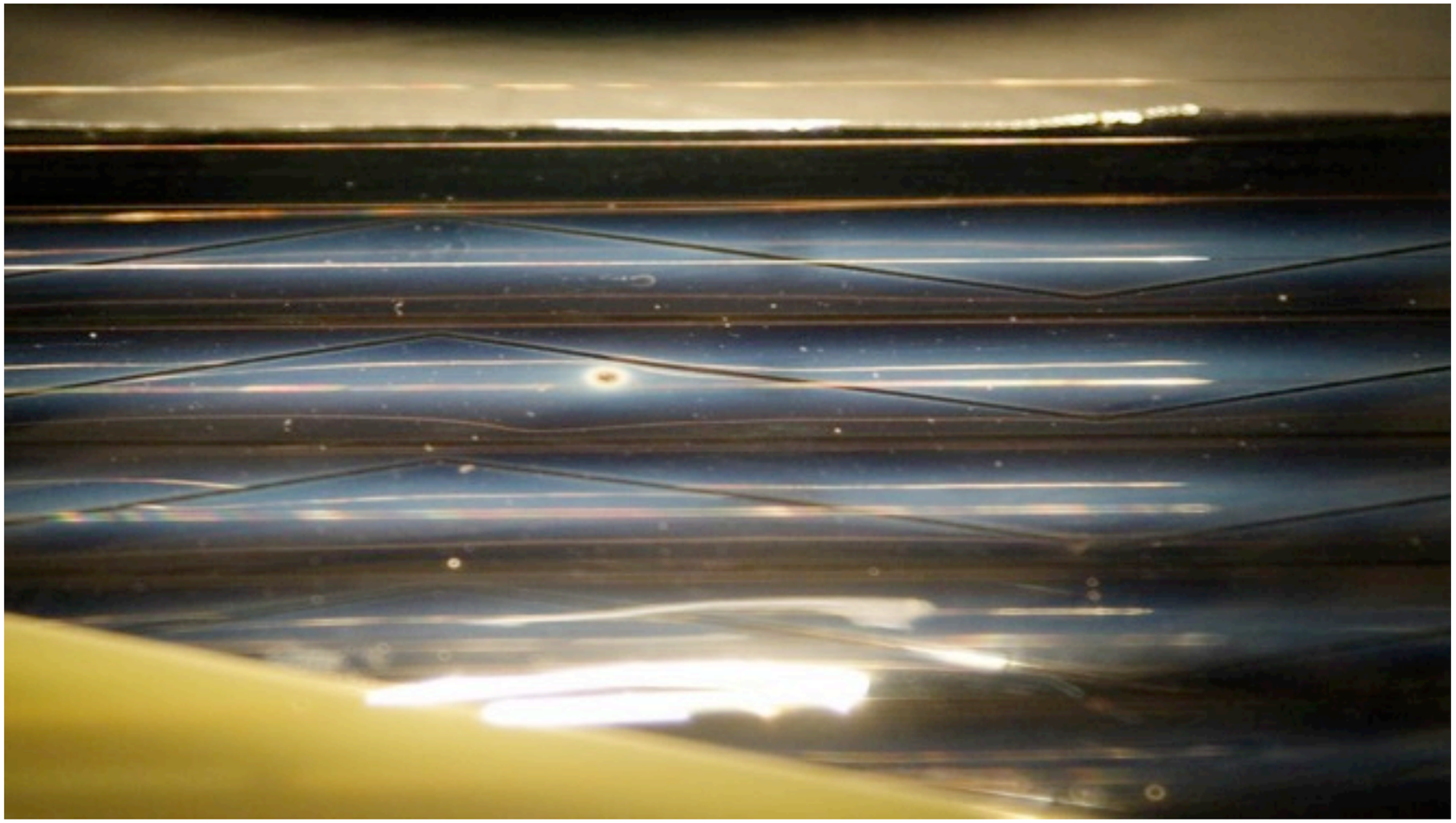

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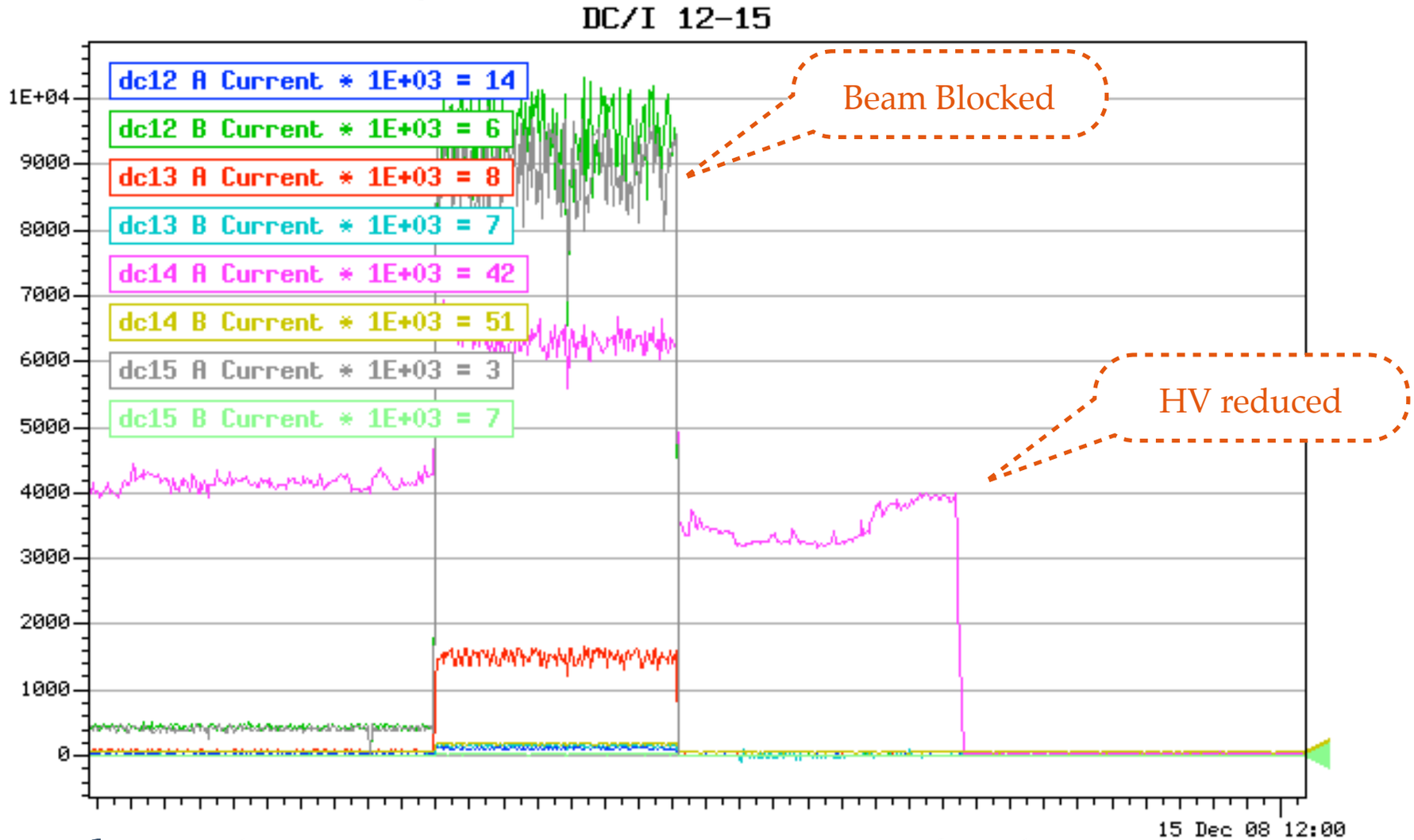


- Such planes showed a certain remaining current after beam blocked, so called "self-sustaining field emission (Malter effect)"
  - Thus, probably these shadow is a cover of insulated material.

Provision

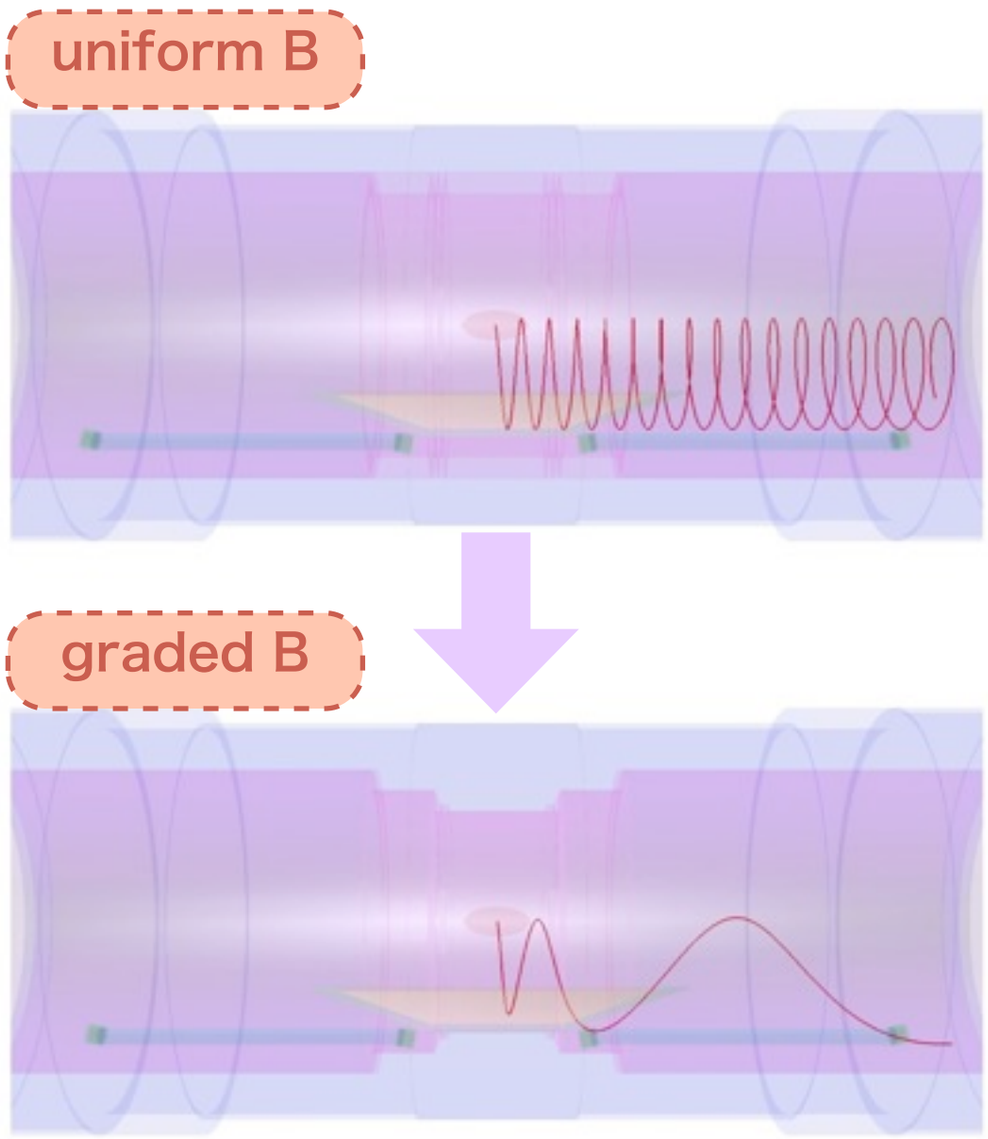
- For Anode:
  - Nothing is Done (several modules were replaced at every shutdown)
- For Cathode:
  - For Aluminum peeling off and mysterious spots
    - No clear reason was found.
    - Just to have a good adhesion of sputtering is tried; Adding 0.5 nm of Ni-Cr under-layer could help a lot.
- For Self-Sustaining Field Emission
  - Just “Clean/Careful” production... Let’s see how is it going during this year’s First long-term operation.

Conclusions

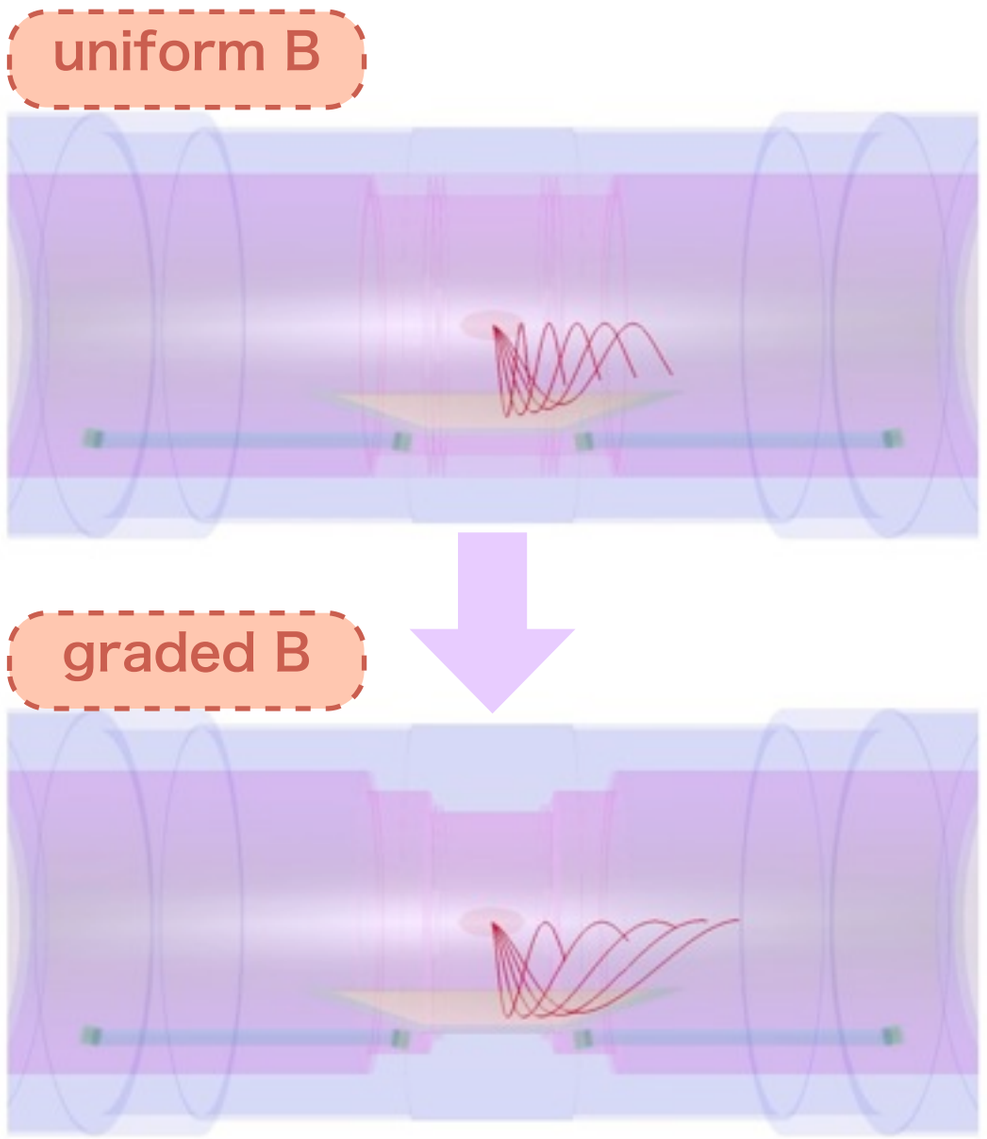
- After two operation periods (2008 and 2009) of the MEG experiment, several DC modules showed certain radiation damages.
- No clear reason for these phenomena was found so far.
- We need treatments to improve the situation.
- Following provisions were made;
  - No special action for anode, just replace modules by new one as occasion arises.
  - Good adhesion of aluminum sputtering by adding a Ni-Cr sub layer.
  - Clean/Careful production of foil to avoid any insulator growth.
- Let's see how is it going for this year's operation (the 1st long term operation.)

backups

COBRA Solenoid



low energy e^+ quickly swept out



constant bending radius
independent of emission angles

Hit Rate in COBRA