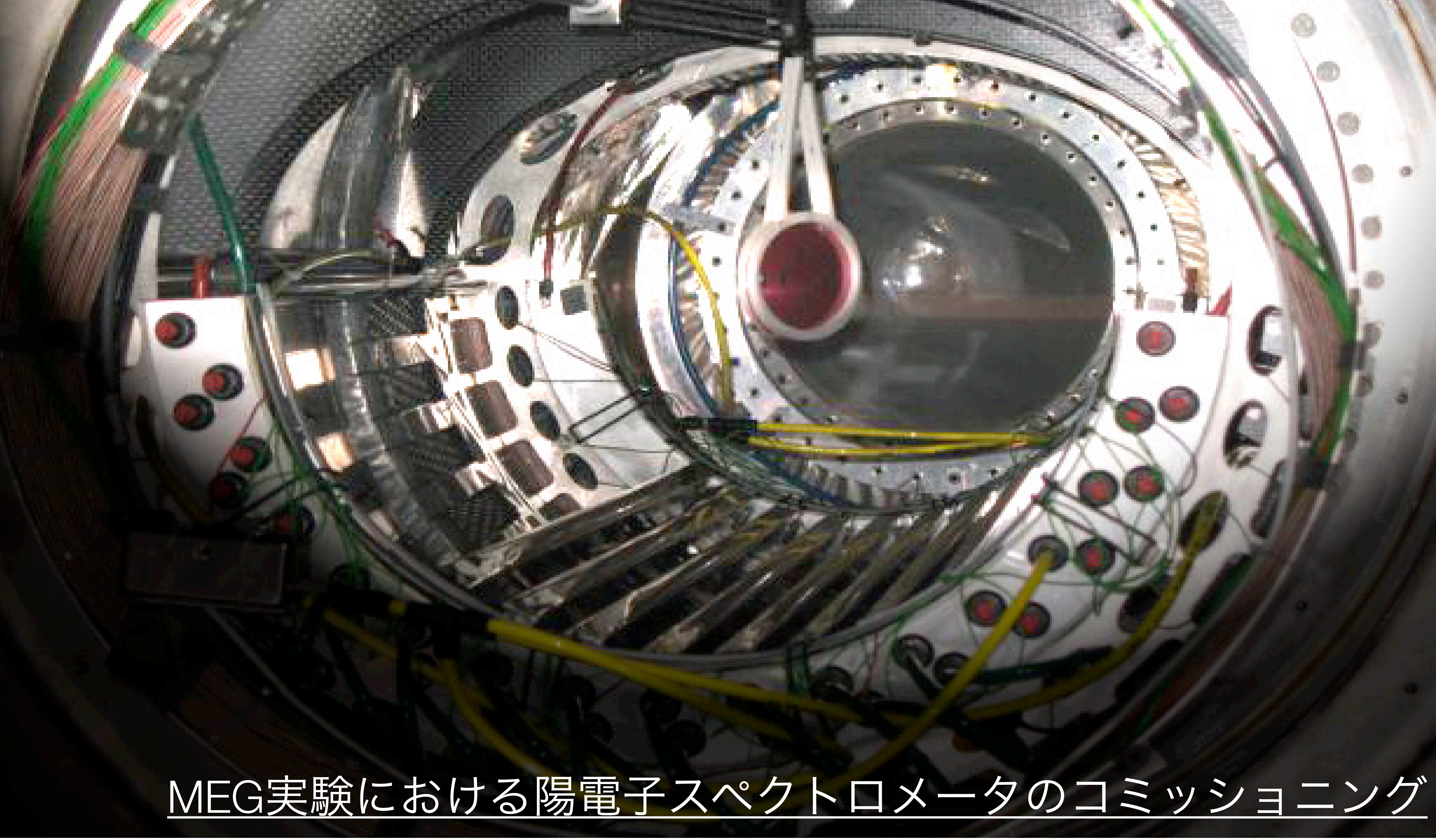

MEG実験における陽電子スペクトロメータのコミッショニング

西口 創 @ 東京大学

東大素セ、PSI[A]、チューリッヒ連邦工科大[B]

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JPS meeting , 2007 spring
Tokyo Metropolitan University
2007.03.25-28

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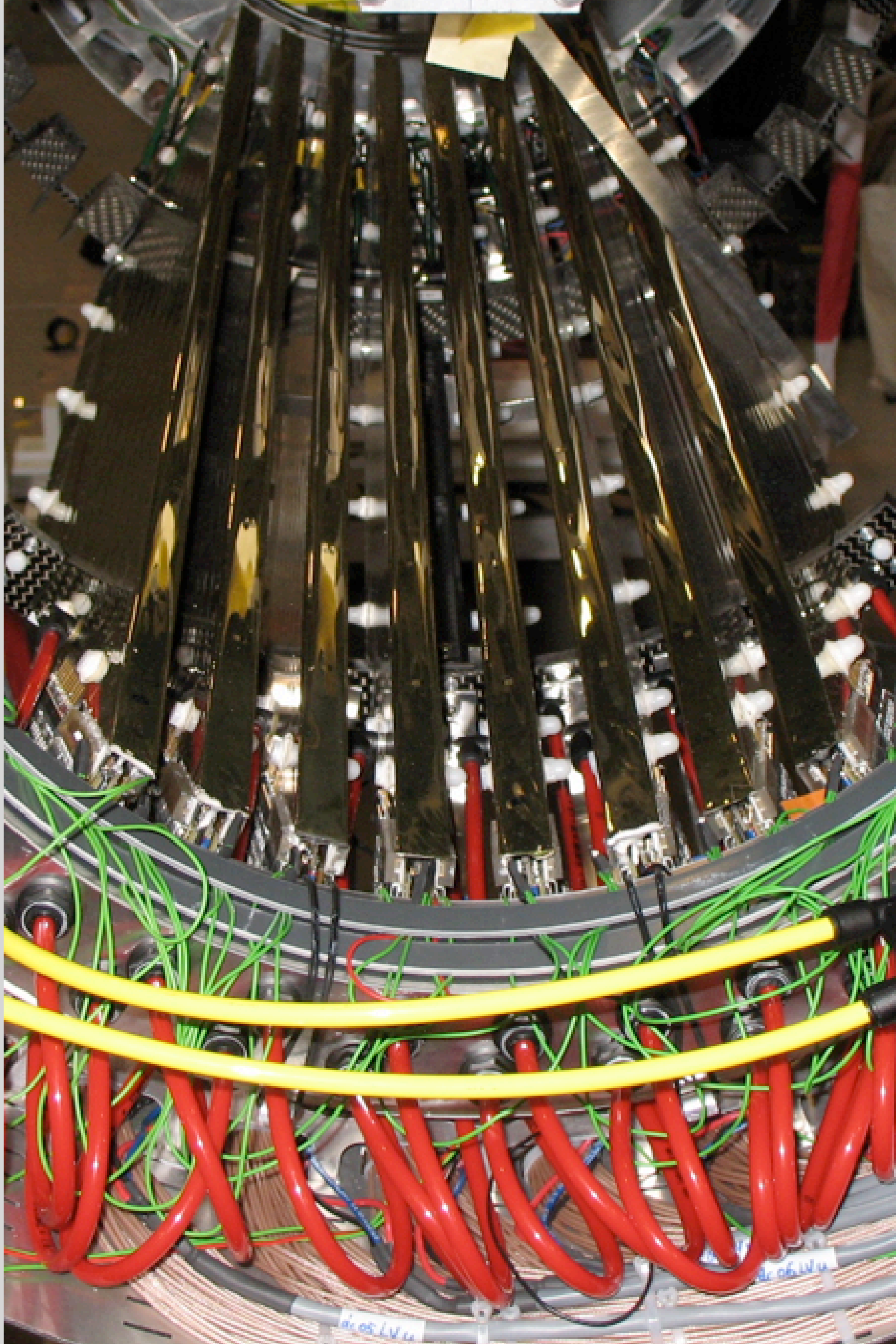
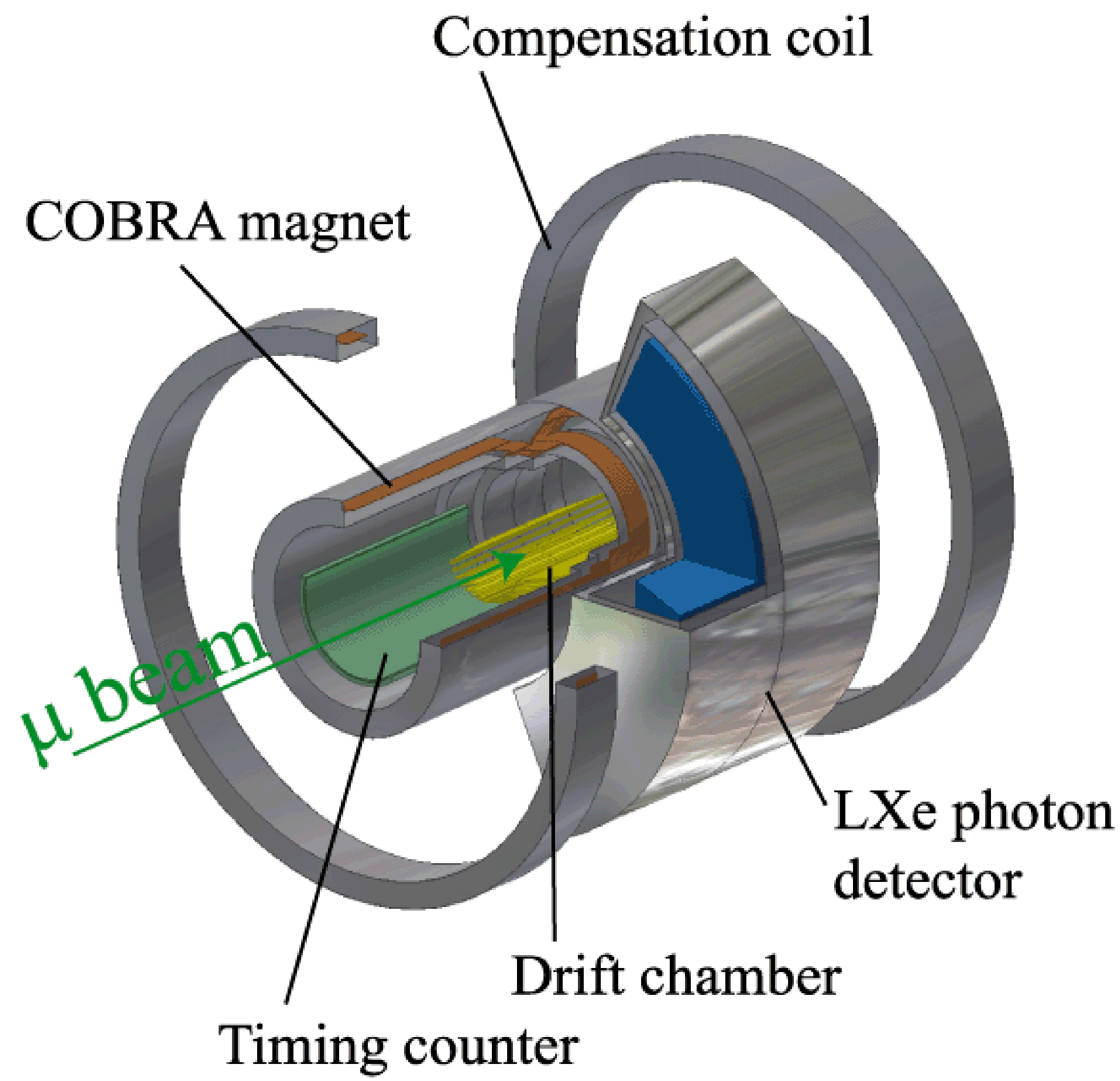
- Positron Spectrometer
- Commissioning Run 2006
- Plan in 2007 and Future
- Conclusions



MEG experiment

- Search experiment for "$\mu \to e\gamma$"
  - "$\mu \to e\nu\nu$" (Michel decay) ~ 100% in SM
  - SUSY-GUT models predict higher branching ratio $Br(\mu \to e\gamma) = 10^{-11} \sim 10^{-15}$
  - "$\mu \to e\gamma$" decay is the most sensitive, exploring GUT/seesaw via SUSY
  - New experiment, MEG, with a sensitivity of $Br = 10^{-13}$ will start soon at Paul Scherrer Institut (PSI) in Switzerland
- Detector concept
  - The most intense DC muon beam @ PSI
  - Liquid xenon photon detector
  - Positron spectrometer with gradient magnetic field
  - "Light" drift chamber system and high-accuracy timing measuring counter



- MEG detector -

Requirements for the e^+ spectrometer

- **Very high counting rate**
- the most intense DC muon beam in the world
- muon stopping rate : $2.5\times10^7 \sim 10^8$ muon/sec

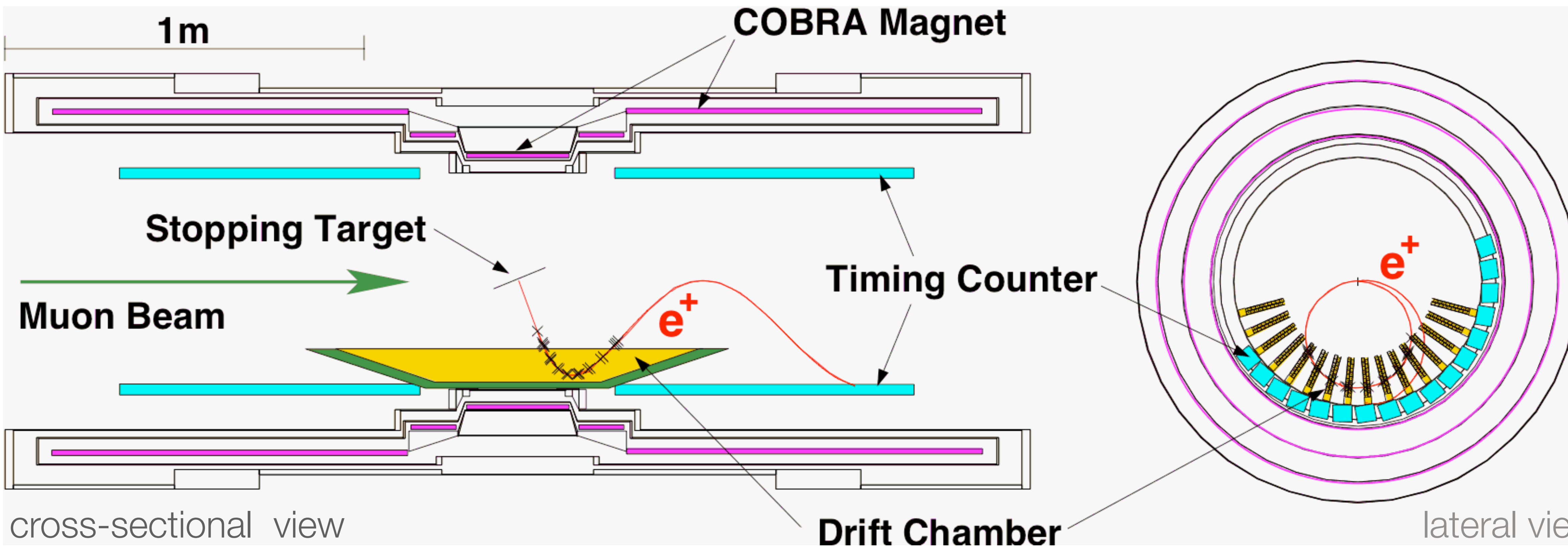
Special B-field

- **Good momentum/position/timing resolution**
- aiming excellent sensitivity
- 0.4% momentum resolution, 300μm position resolution for both direction(r,z) and 50psec 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

>> see later slide in detail

Timing Counter

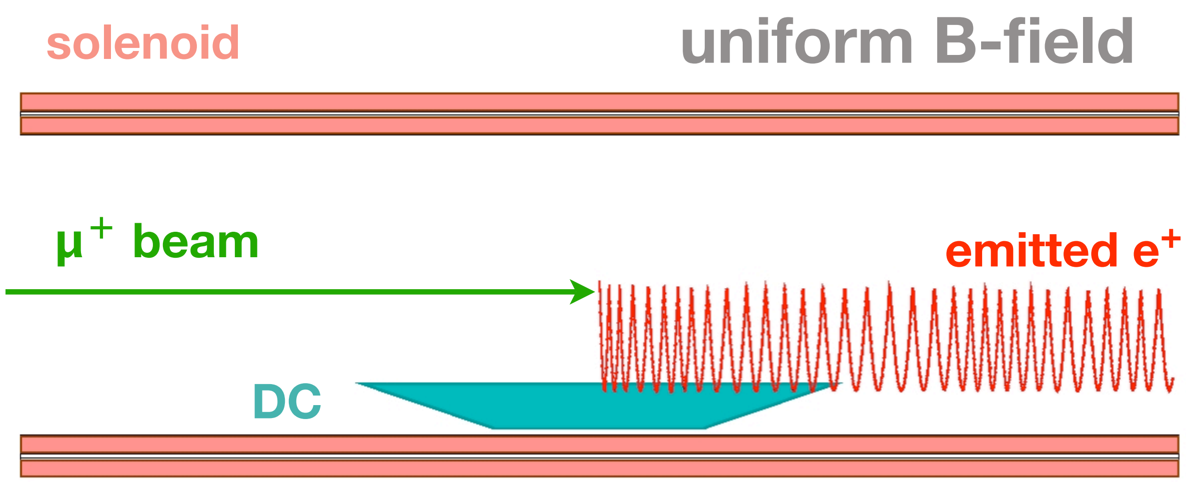
2-layers of scintillators
- scintillator bars (outer)
- scintillator fibres (inner)

Obtained goal σ_T ~ 40psec

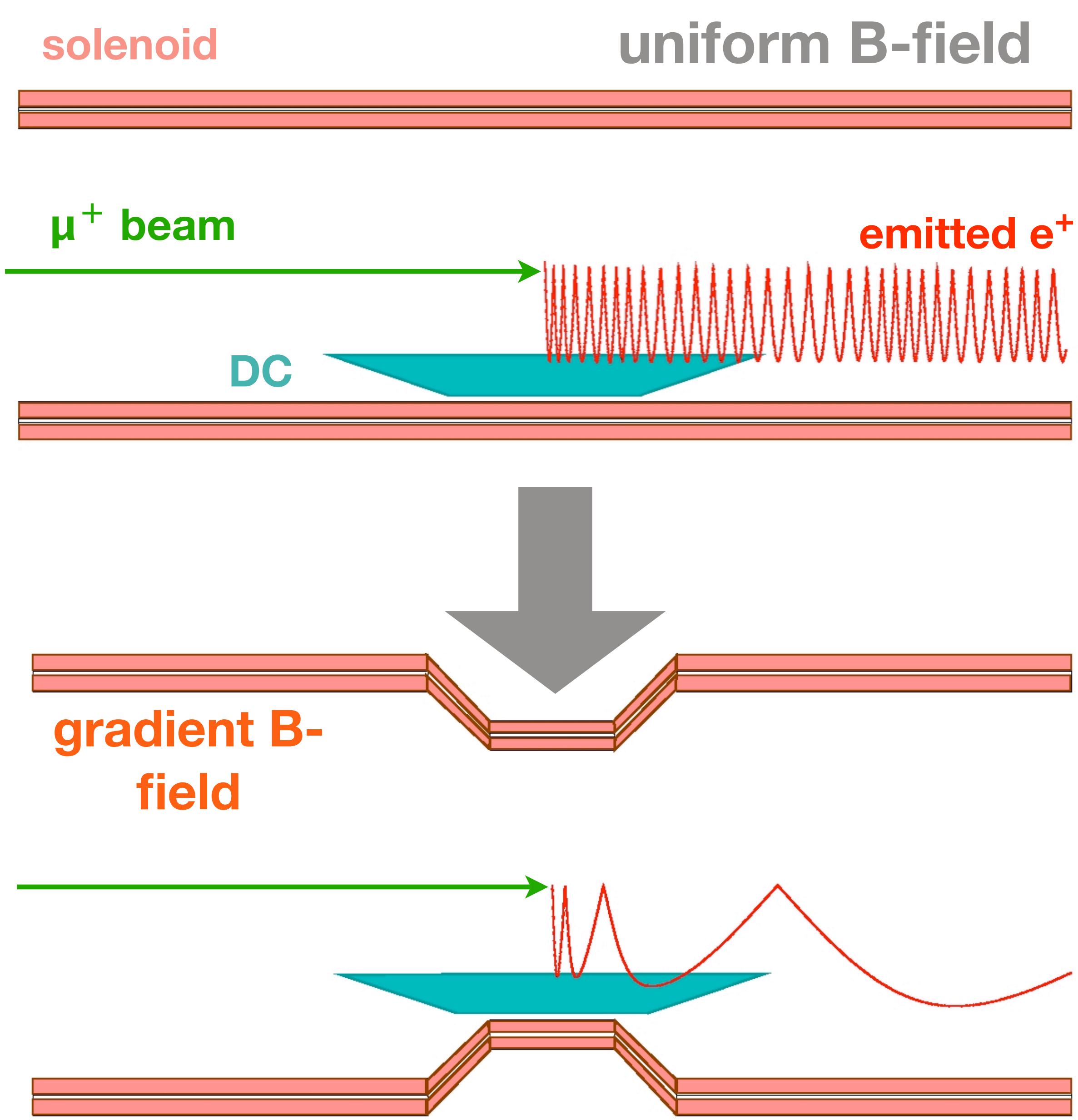
>> see **next talk**

COnstant Bending RAdius solenoid

COnstant Bending RAdius solenoid

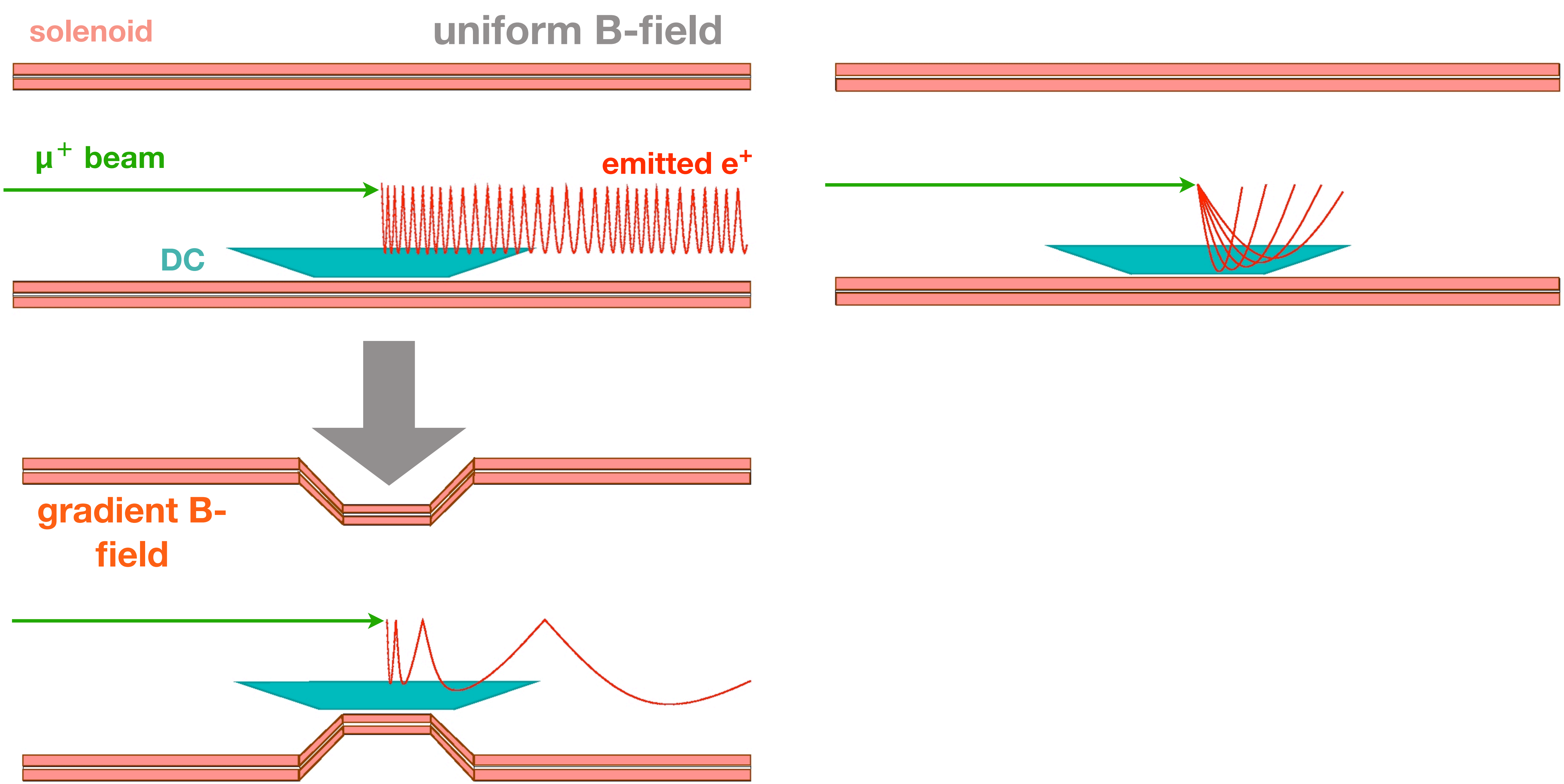


COnstant Bending RAdius solenoid



Low energy positrons quickly swept out

COnstant Bending RAdius solenoid



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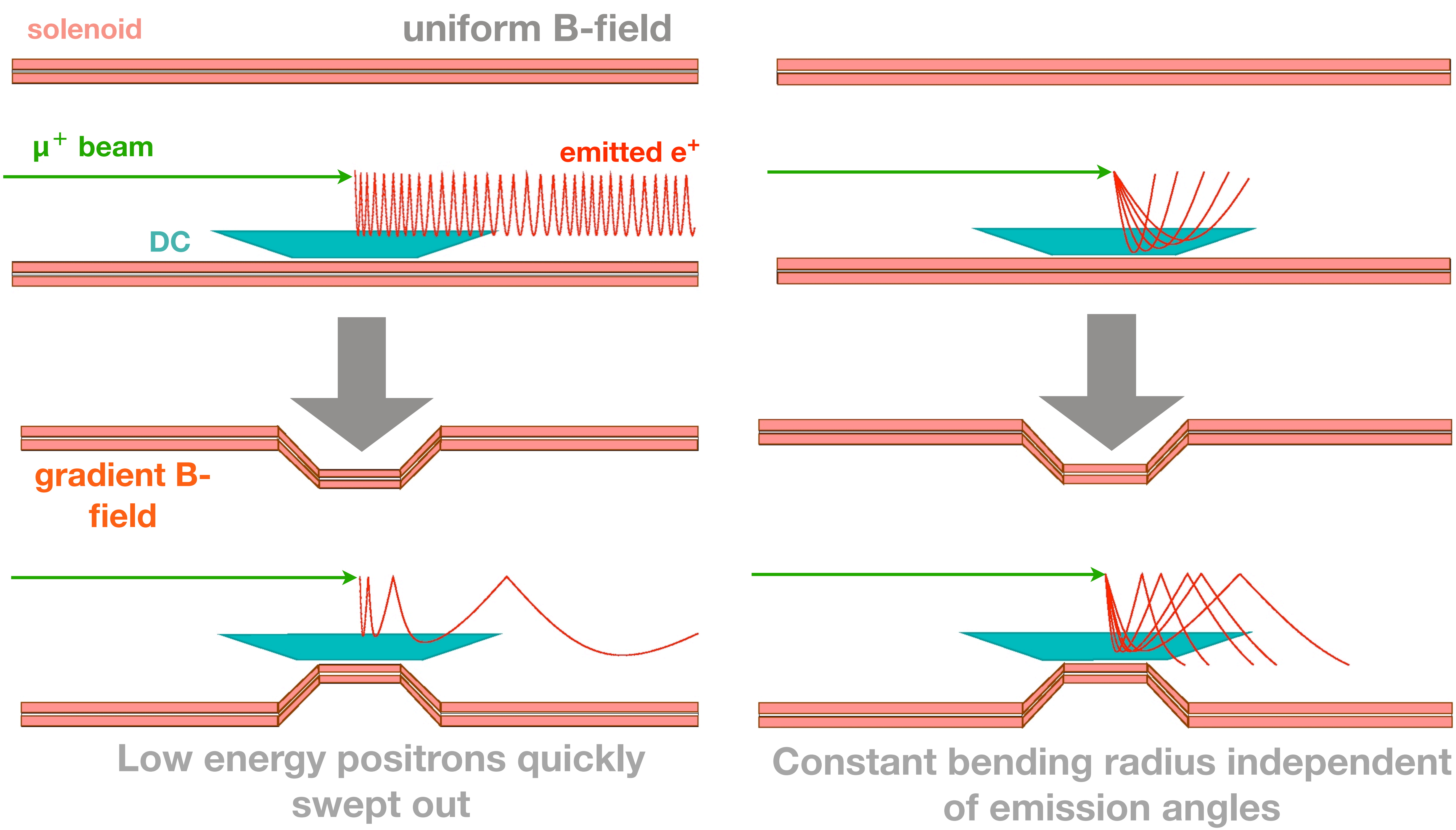

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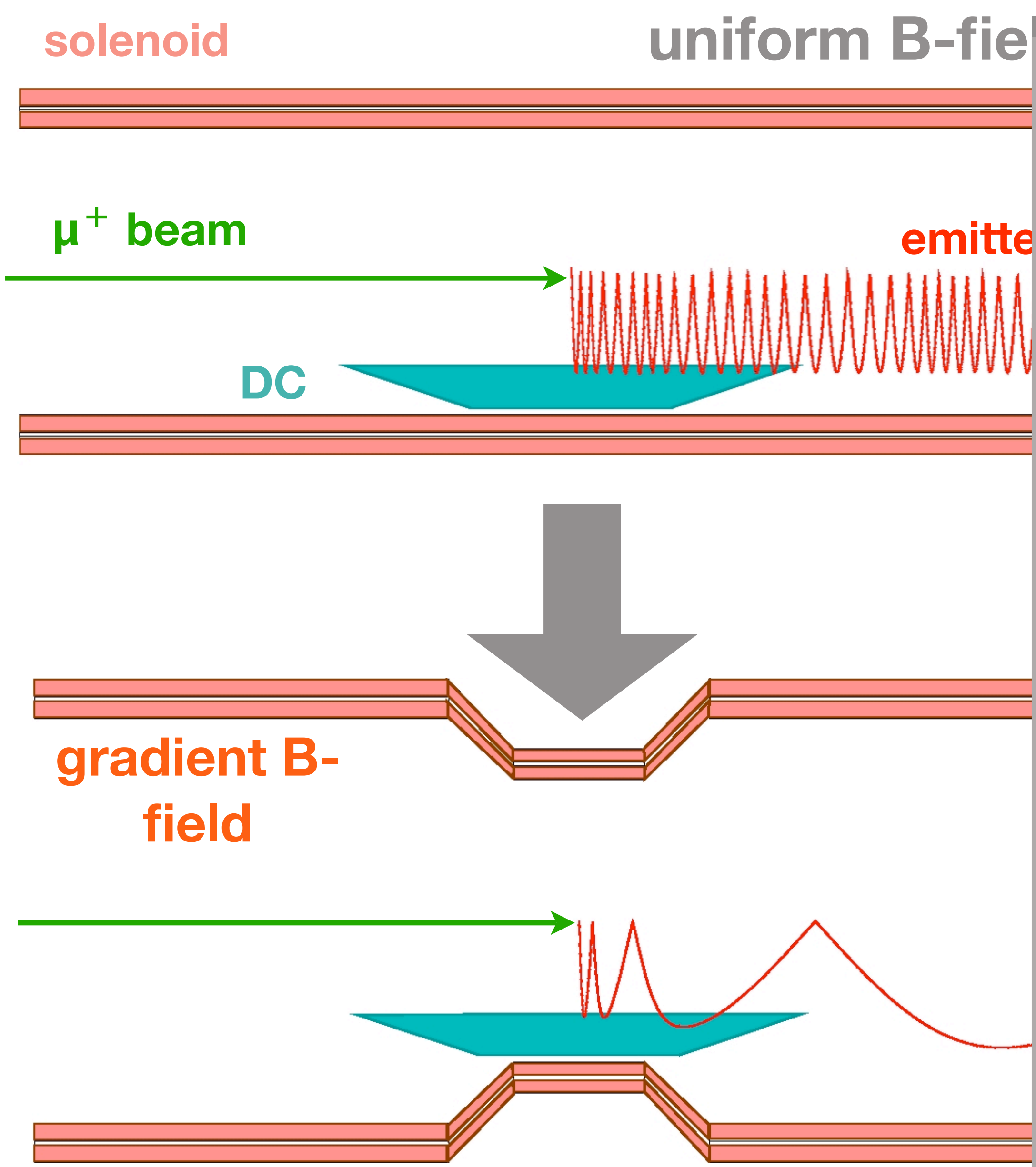

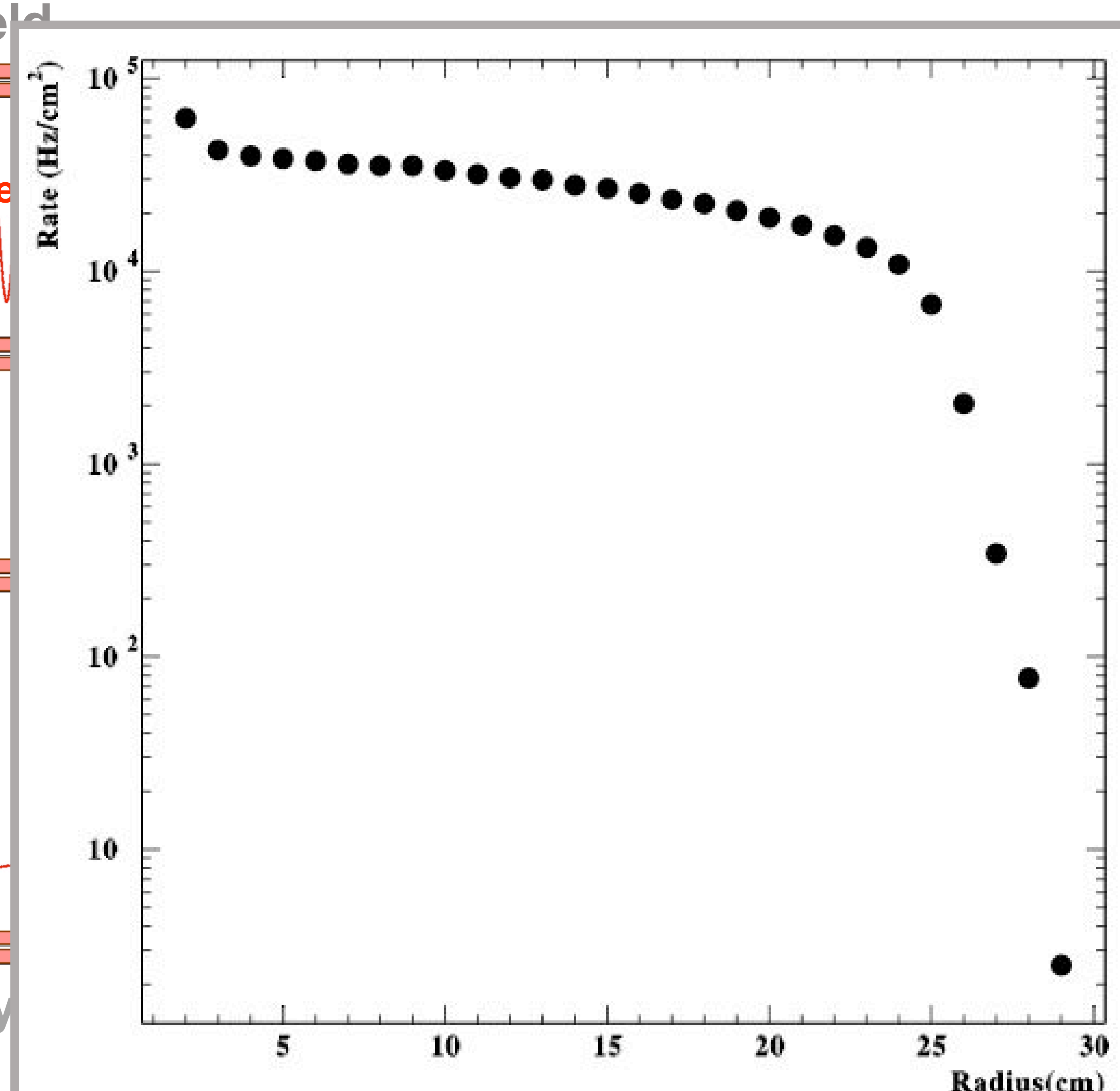

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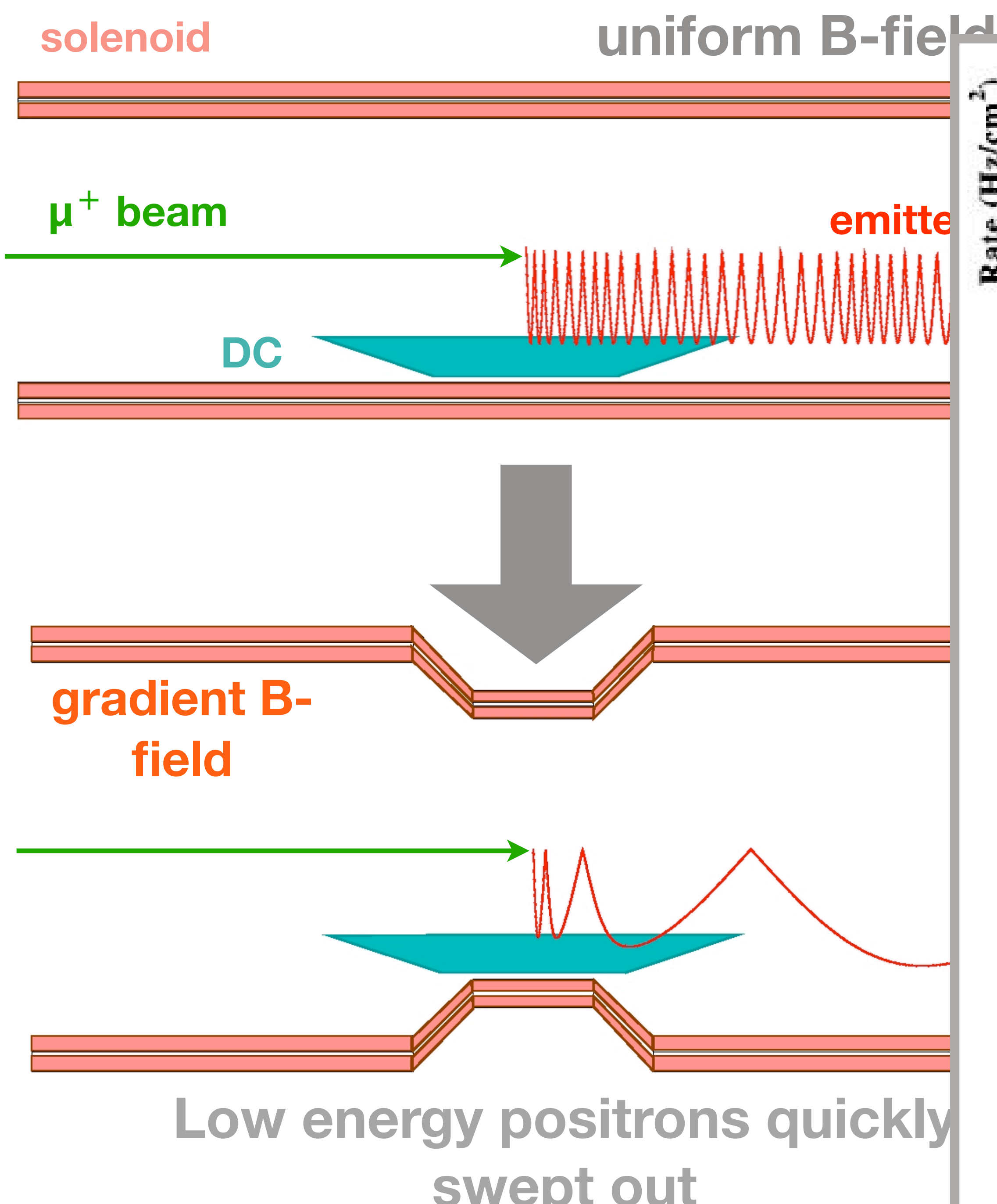
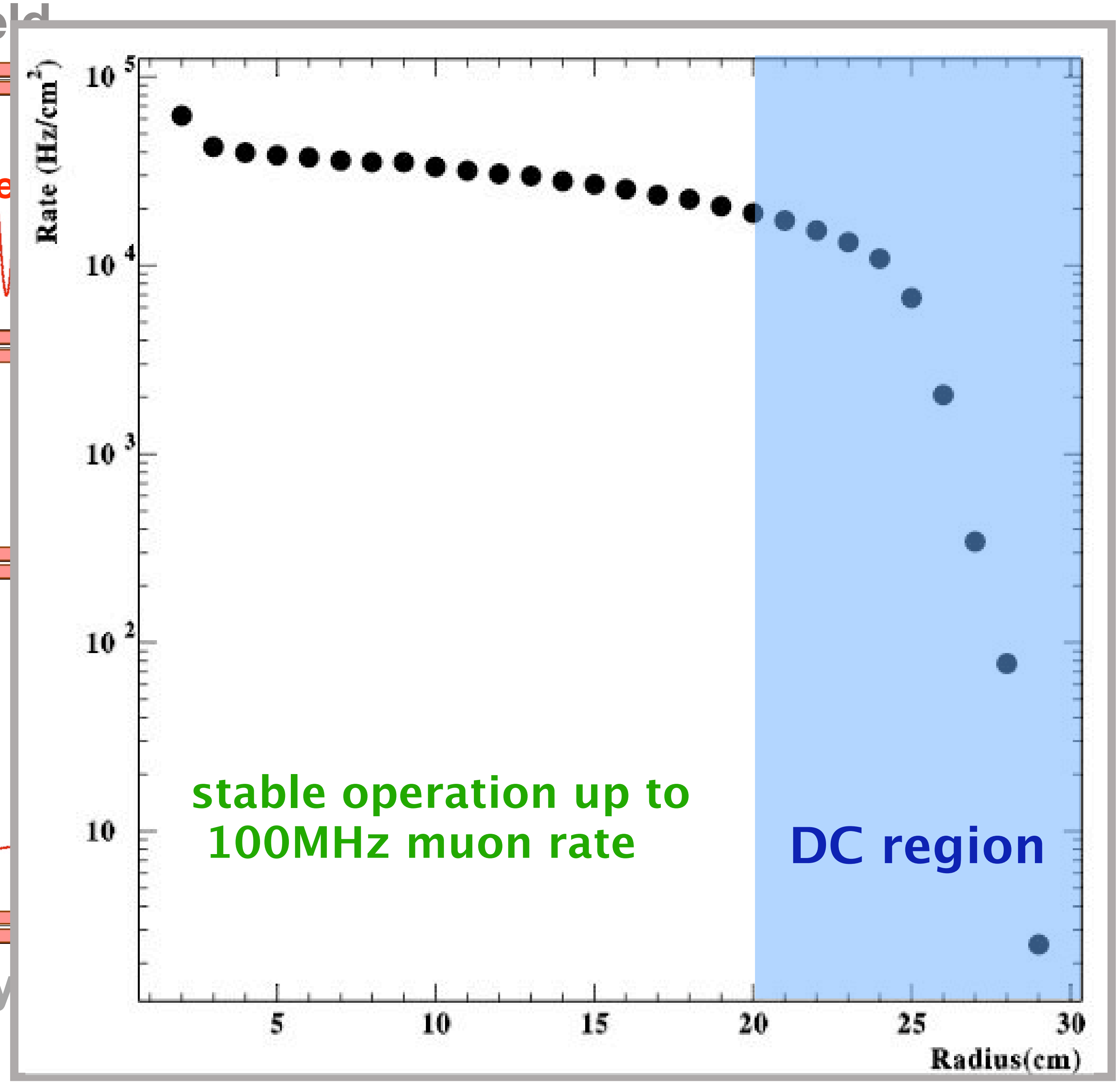
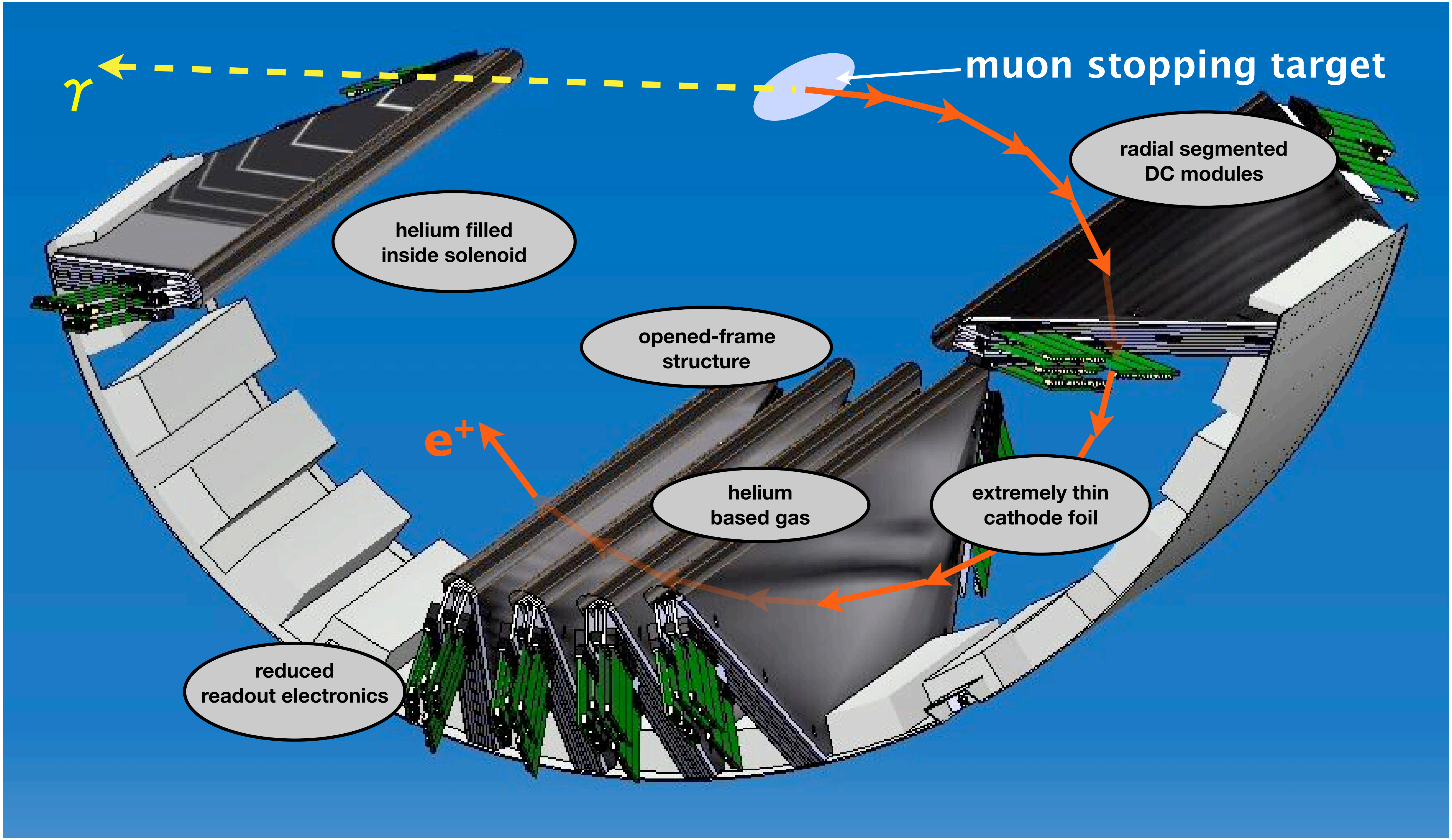


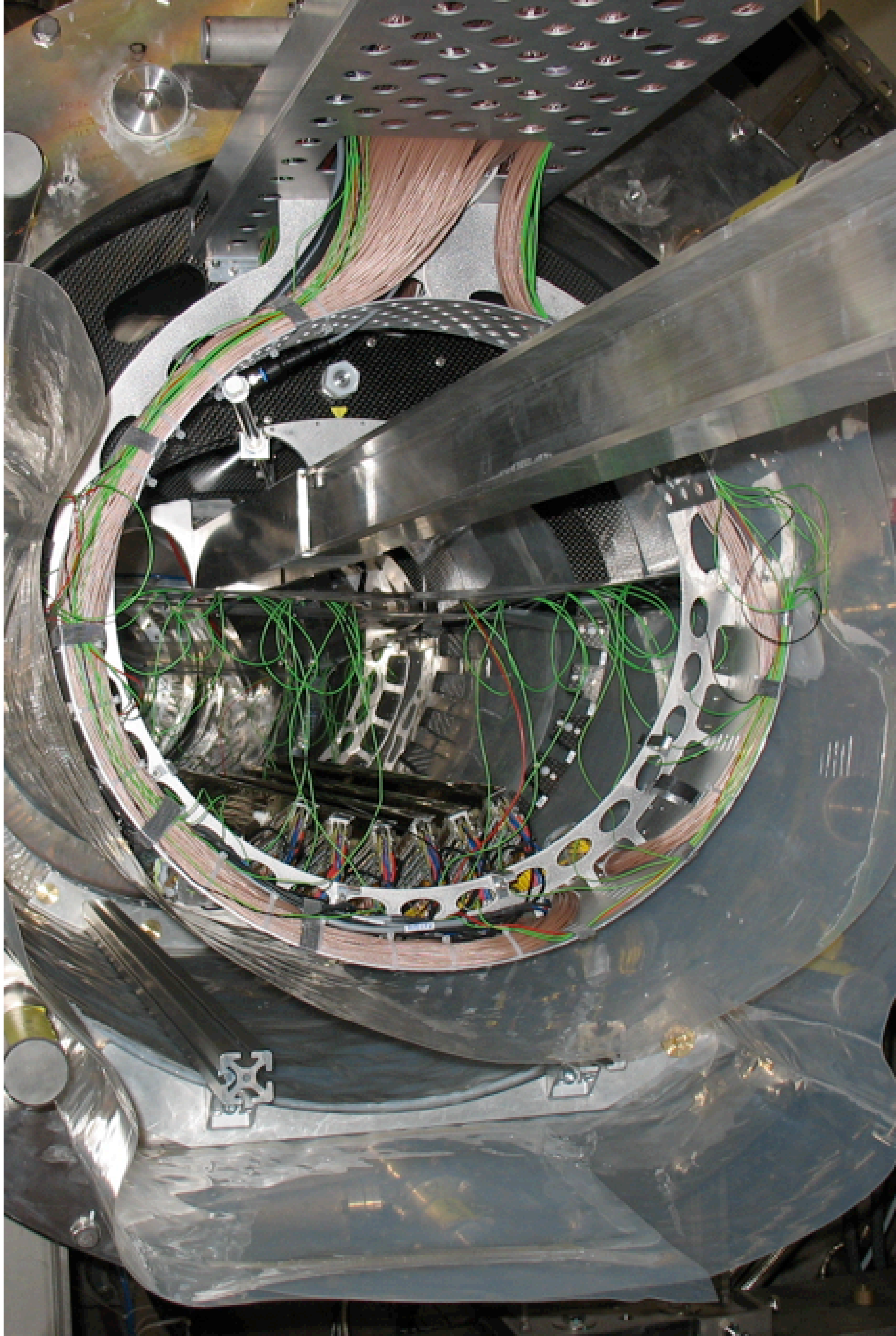


Drift Chamber System



Drift Chamber module

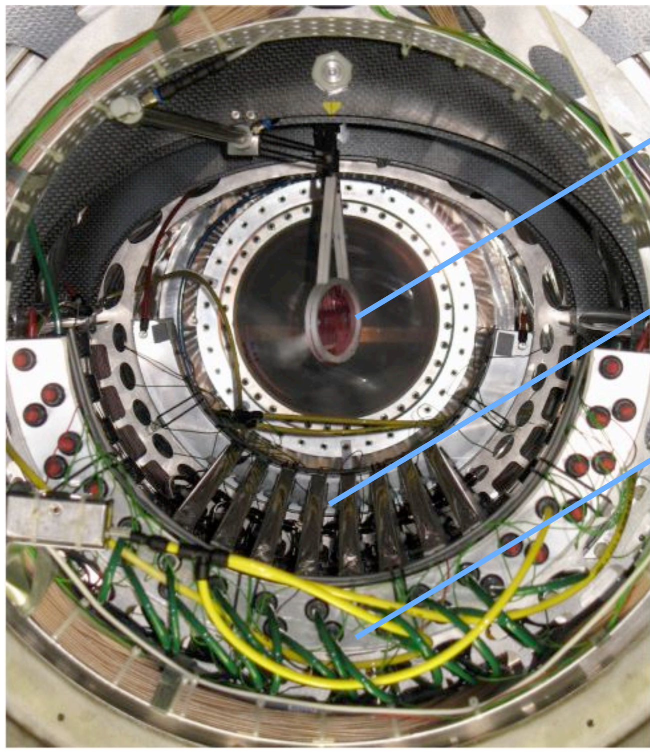
Commissioning Run 2006



purposes

- Drift Chamber & Timing Counter operation in COBRA magnet
    - HV conditioning for DC and TC
    - pressure control for DC
- find beam settings with various muon beam rates
- operate detectors with the full intensity beam
- test the trigger & DAQ electronics
- perform calibrations of drift chamber and timing counter
- estimate resolutions

setup and schedule

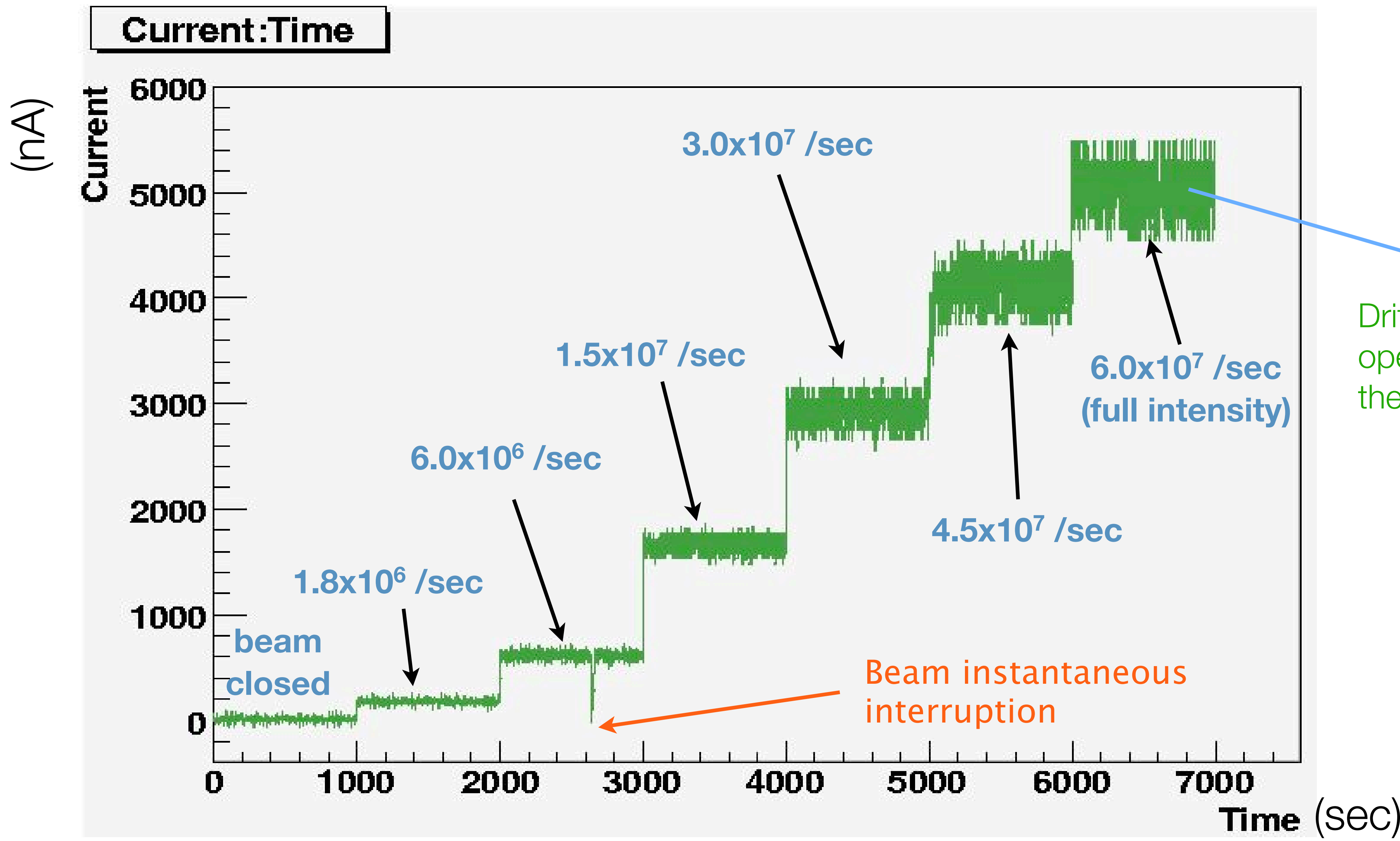


- COBRA magnet operated with final condition
- 8 DCs (out of 16), all TC bars installed
- 6 beam settings (primary proton = 1.6mA);
  - 3% intensity : 1.8×10^6 /sec
  - 10% intensity : 6.0×10^6 /sec
  - 25% intensity : 1.5×10^7 /sec
  - 50% intensity : 3.0×10^7 /sec
  - 75% intensity : 4.5×10^7 /sec
  - full intensity : 6.0×10^7 /sec

- November : detector setup w/o magnet
- December 1-2nd week : beam commissioning
- - 3rd week : detector conditioning with B-field
- - 4th week : DAQ with muon beam

DC monitoring

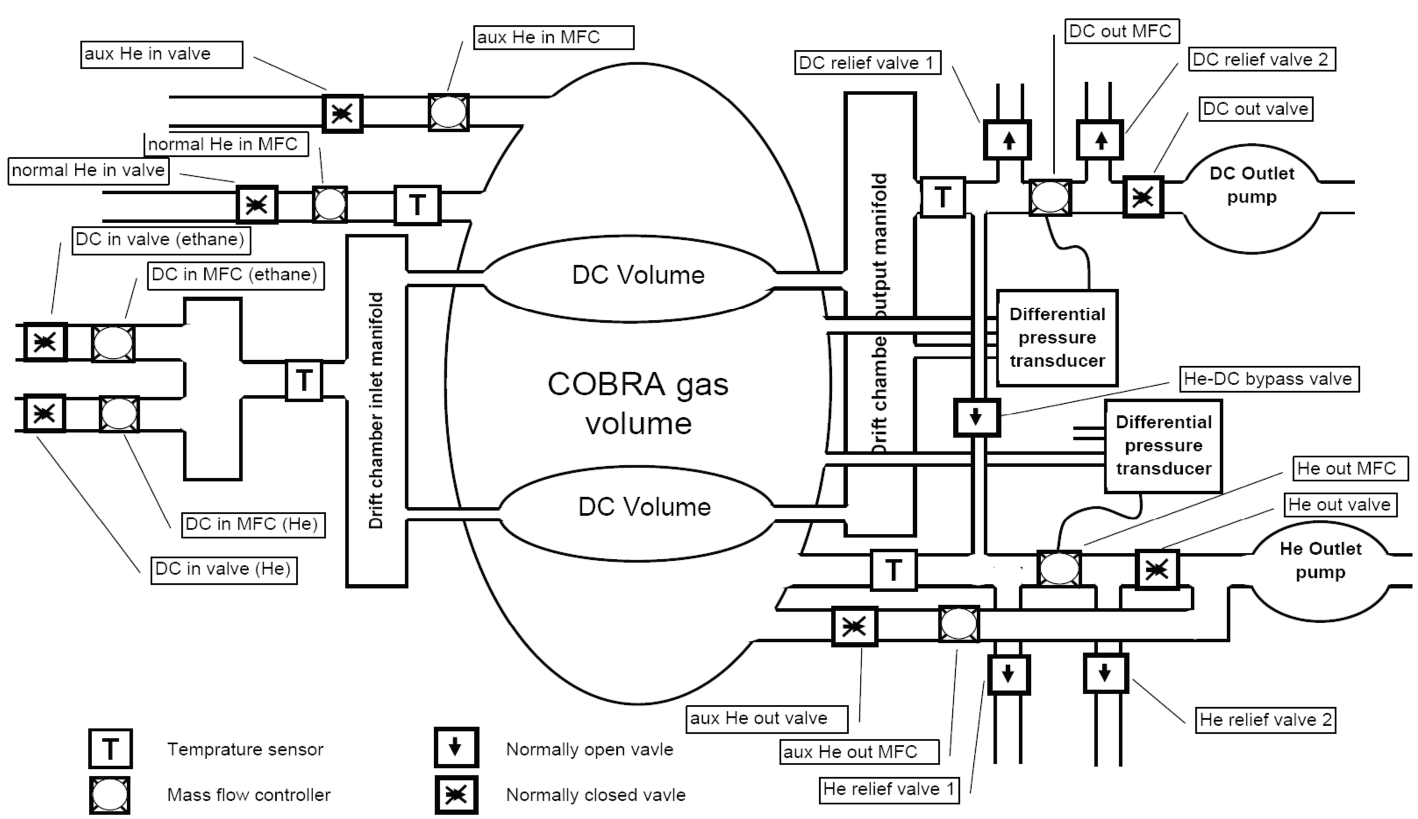
- anode current has been monitored during whole beam time
- this can be good DC stability monitor and also “beam current monitor”

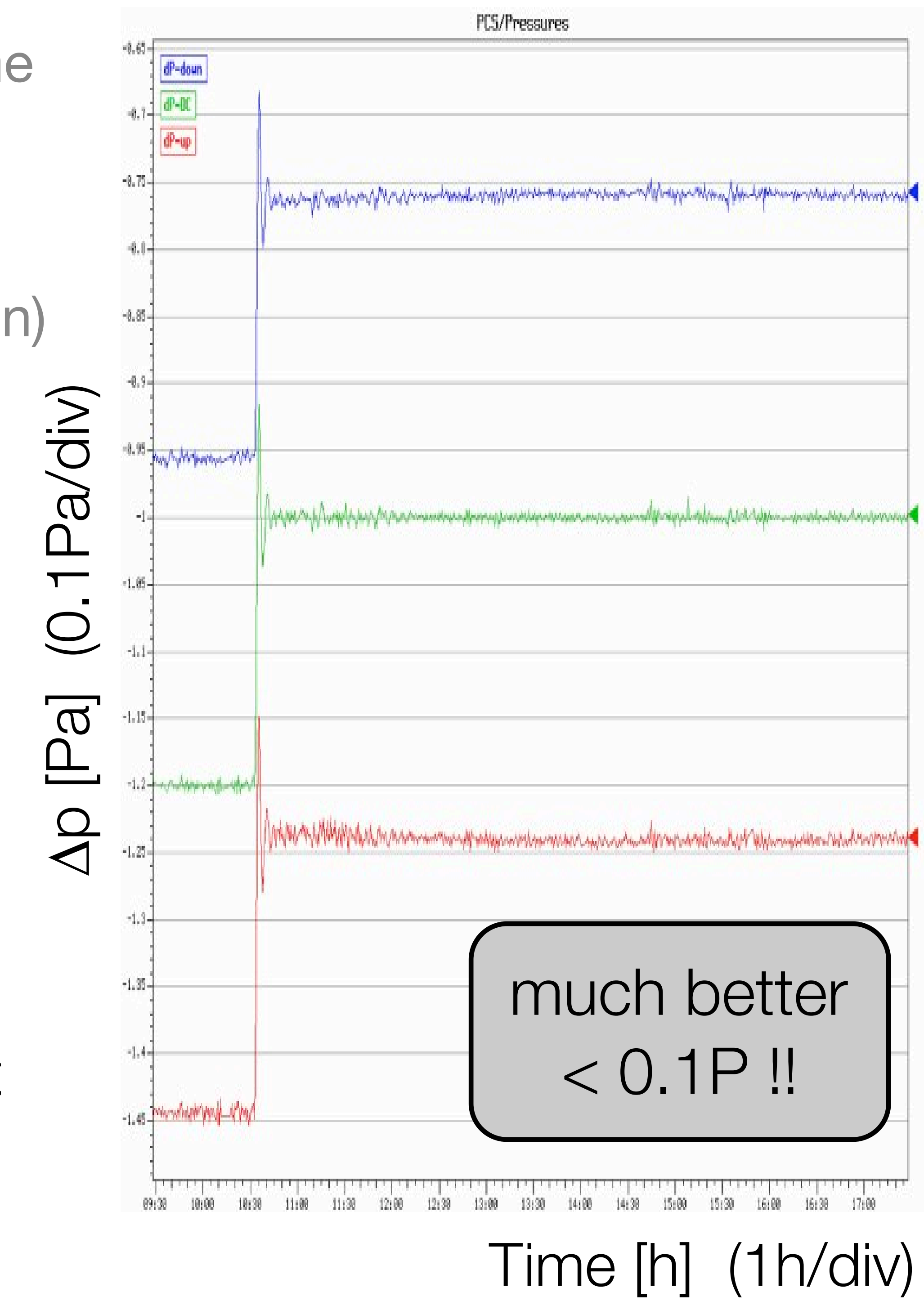


Drift Chamber could be operated successfully with the full muon intensity

pressure control system

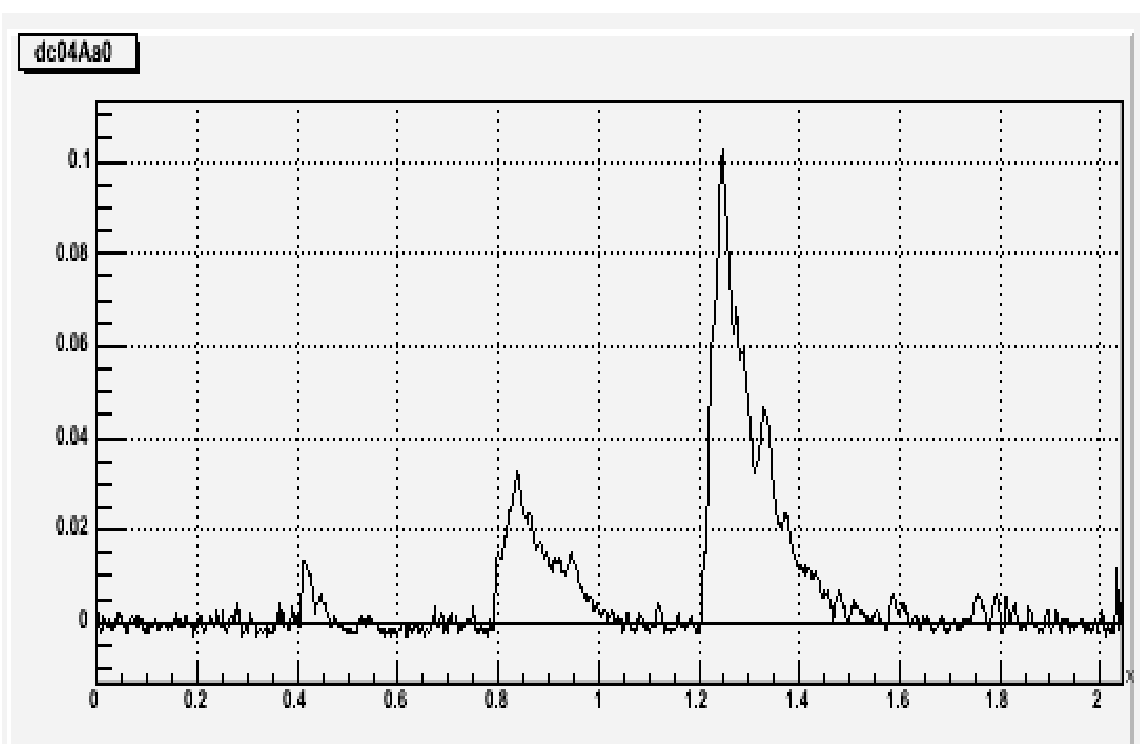
- very thin foil and opened-frame enclose gas volume
- extremely precise gas pressure control system is necessary to maintain cell spacing
- Δp b/w DC and COBRA : <1Pa (0.1mm deformation)
- Δp b/w COBRA and external : <10Pa
- DC gas flow : 0.1 lpm, He gas flow : 4 lpm



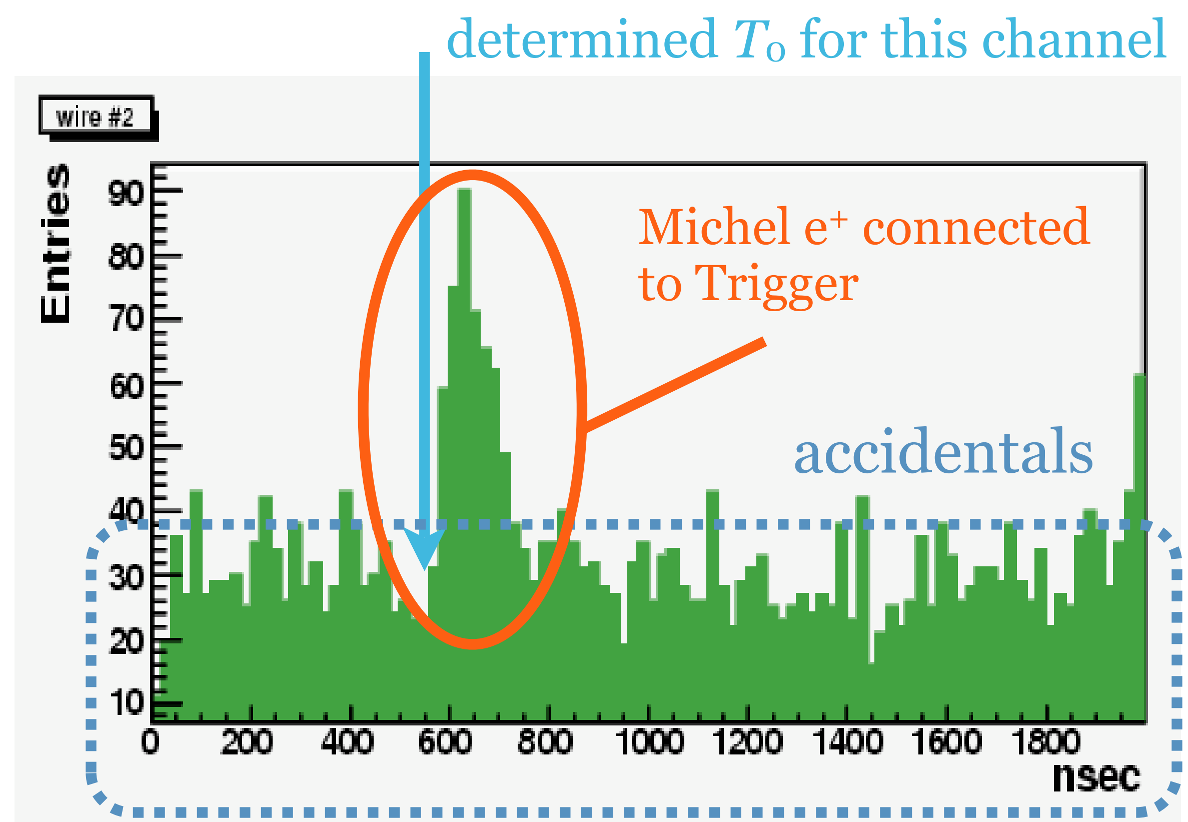


trigger and DAQ electronics

- for this commissioning, event was triggered by timing counter only
- DC event significance was not so good...
- all data is recorded in waveform sampler (500MHz sampling for DC and 2GHz sampling for TC respectively)

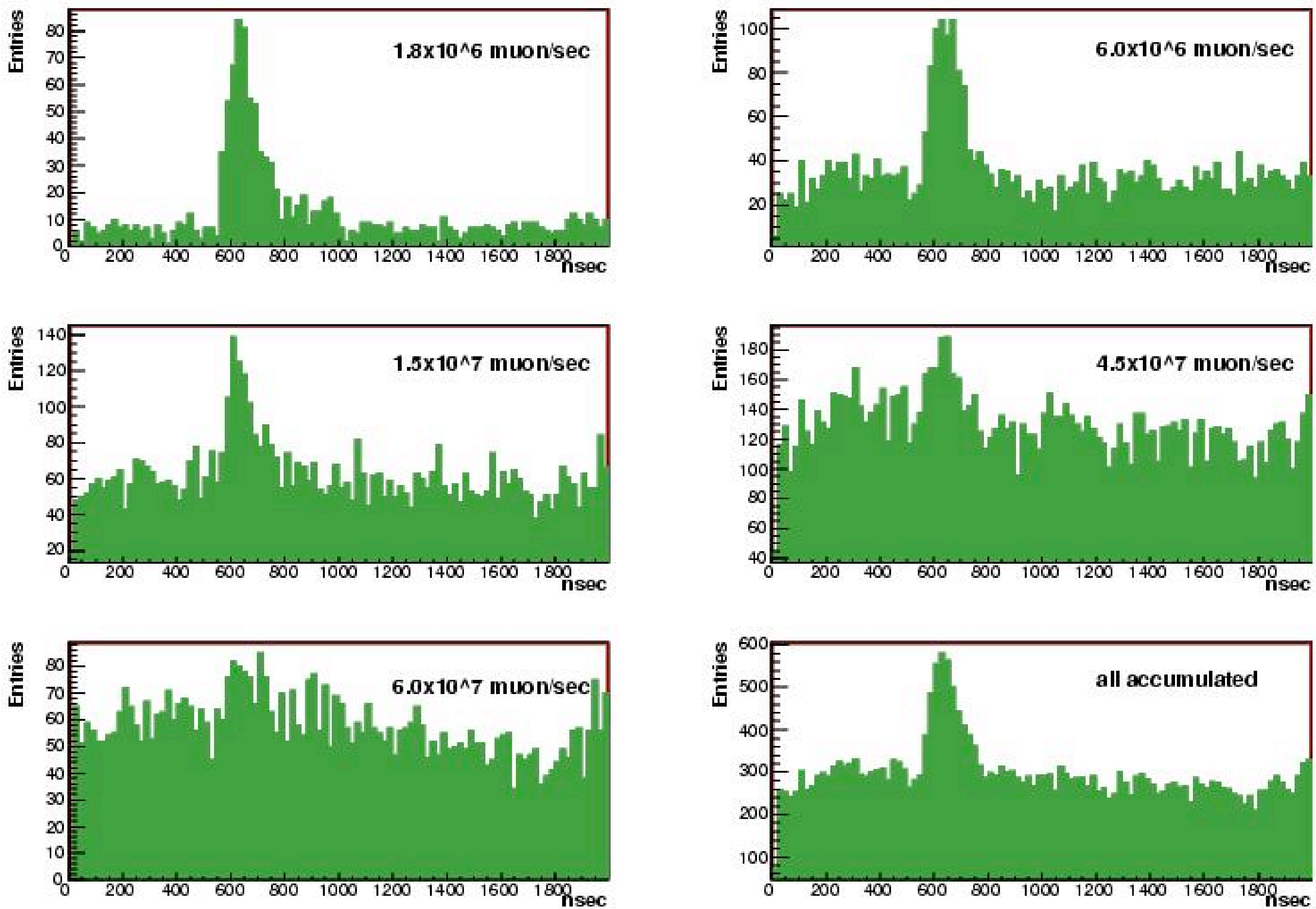


recorded waveform of DC output



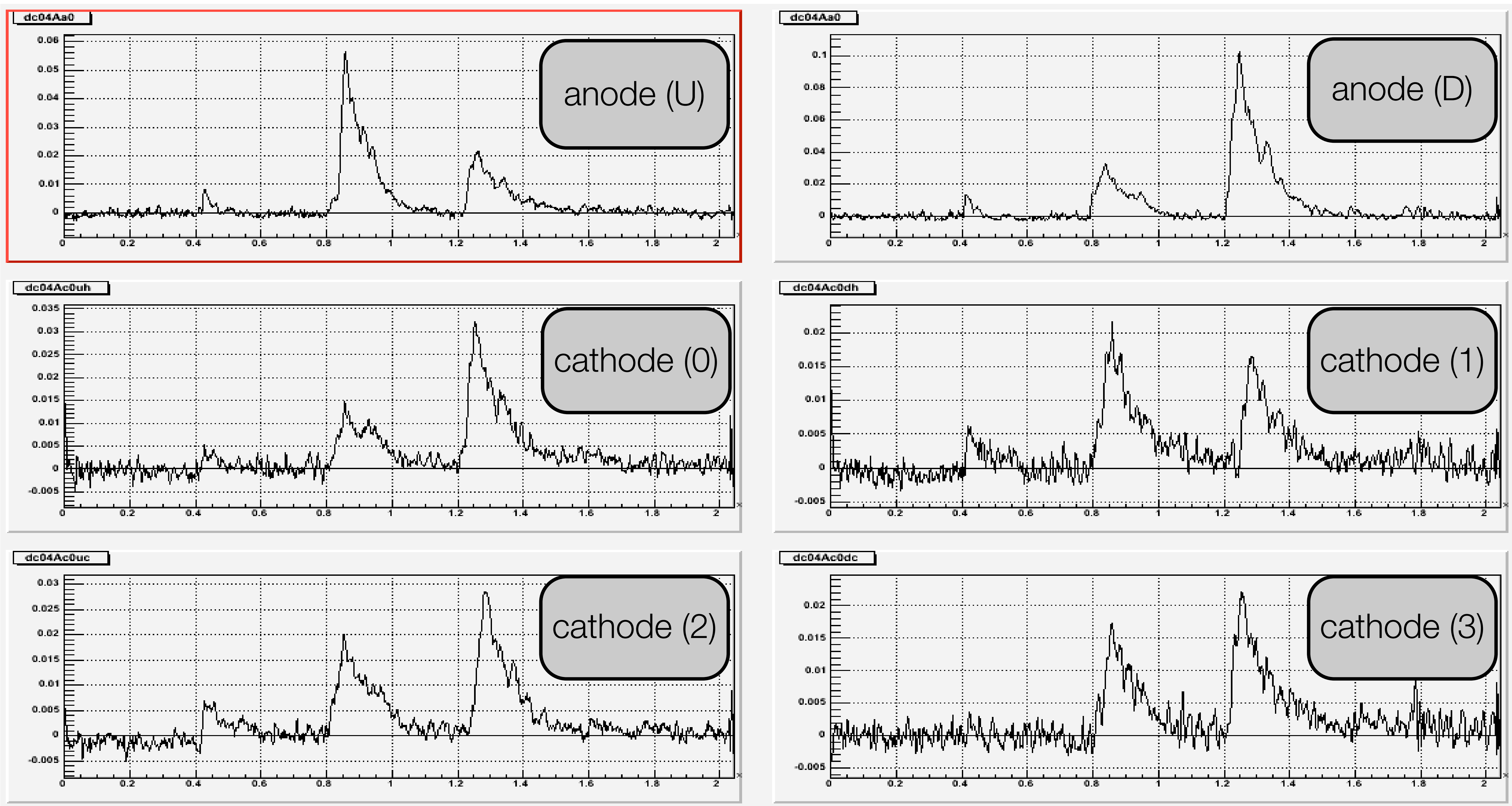
pulse timing distribution

DC event significance in TC trigger

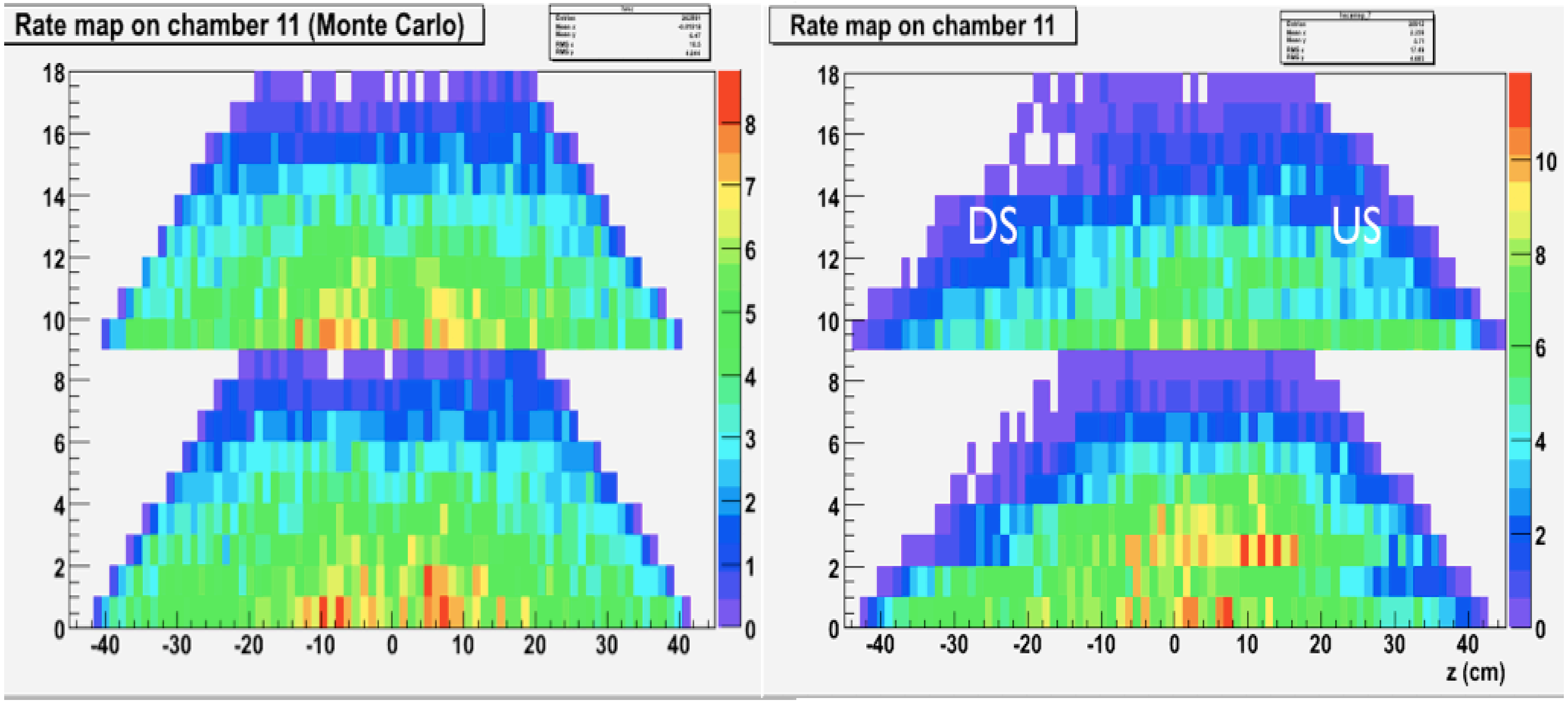


DC data 1st look

- 3 multi-hit example (full intensity, innermost wire)

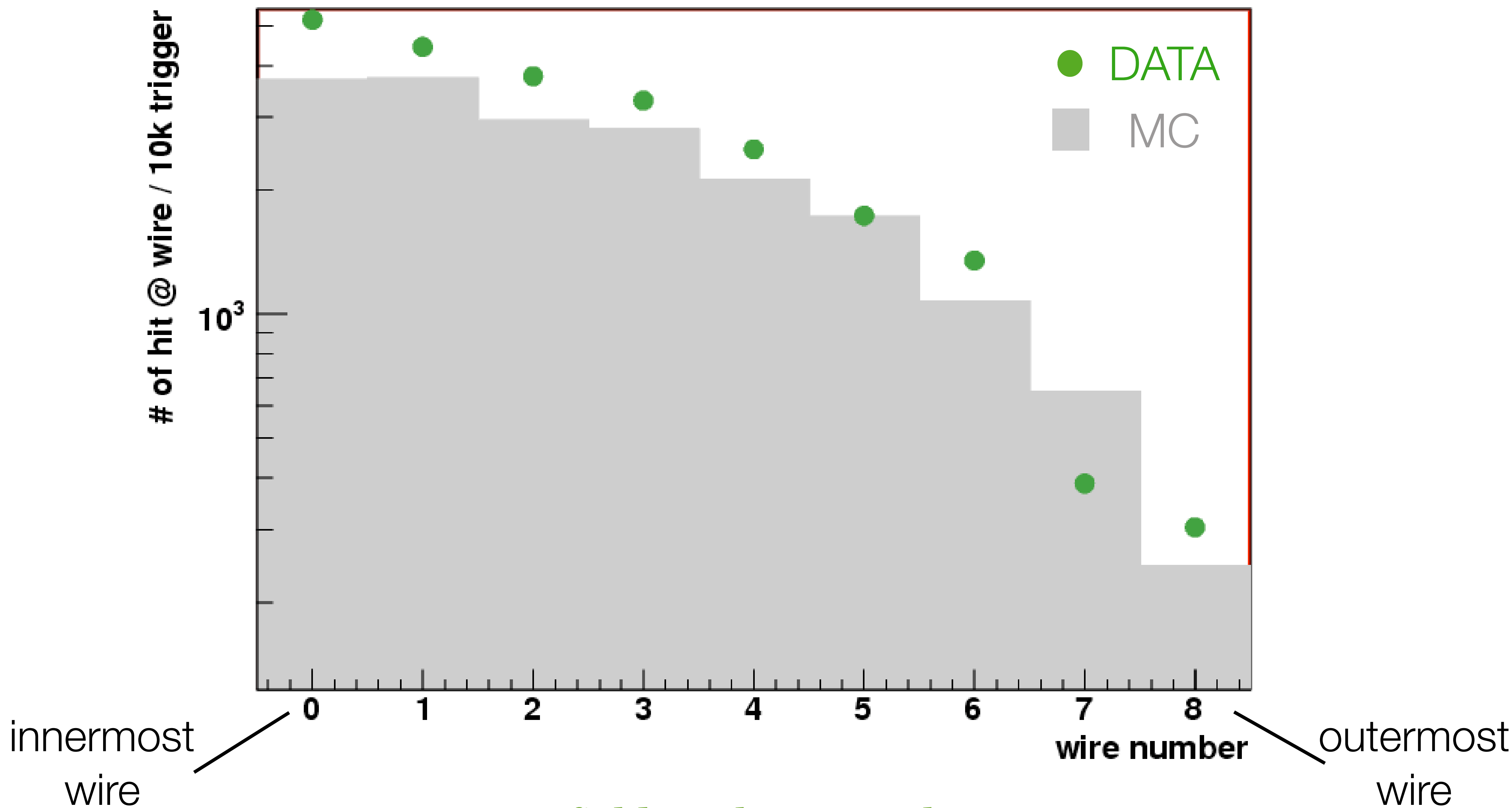


hit rate analysis, comparison with MC



- 2-D hit map is created by the charge division at both ends of wire
- difference b/w 2 layer comes from HV difference (efficiency is different)
- good agreement with MC
- hit rate shows COBRA graded field effect

hit rate analysis, comparison with MC - cont'd. -



- COBRA field works correctly !!

plan in 2007

- We are rebuilding the all DC to fix some problems.
- Many small modifications are performed ; feedbacks from the Commissioning Run 2006,
  - HV supply/divider (to suppress the noise)
  - anode voltage tracer print circuit (to stabilize the anode current)
  - gas tightening
- DC production will be completed in mid.-June and the e+ spectrometer will be ready in this summer.
- Data analysis of the commissioning run 2006 is progressing now
  - will be tracked by using available wires data
  - will be used for the calibration and estimate the resolutions

conclusions

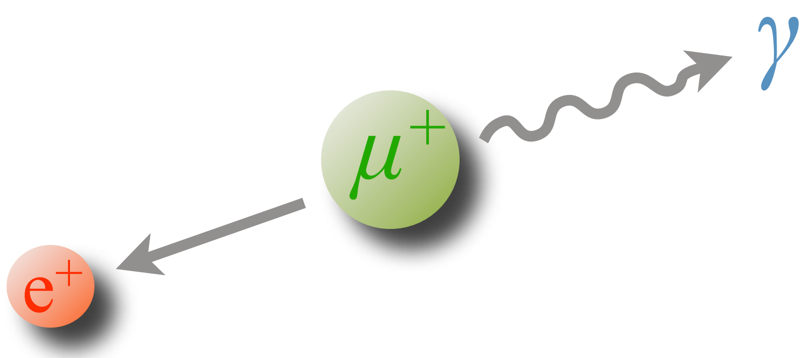
- MEG will start soon at Paul Scherrer Institut
- Special superconducting solenoidal magnet which has gradient magnetic field allows a background of lower energy Michel positrons to be swept away more effectively from the fiducial tracking volume.
- In order to detect low-momentum positrons (52.8MeV/c) with a high degree of accuracy with very high counting rate, ultimate lower-mass drift chamber is necessary.

- The 1st e^+ Spectrometer Commissioning RUN has been performed in December 2006.
- Detectors (DC/TC) could be coped up to the full intensity (7×10^7 muons/sec).
- According to the hit rate analysis, the benefit of the COBRA field is confirmed.
- more detailed analysis, tracking, calibration e.t.c. is progressing now.
- Assembly and installation of MEG e^+ spectrometer will be completed soon.

backup slides

$\mu\rightarrow e\gamma$ Signal and Background

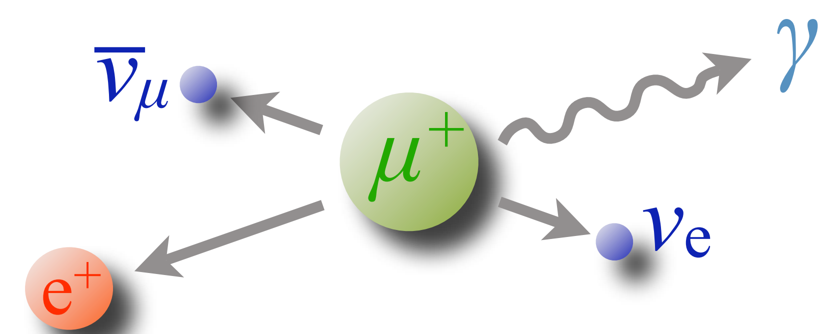
- Signal



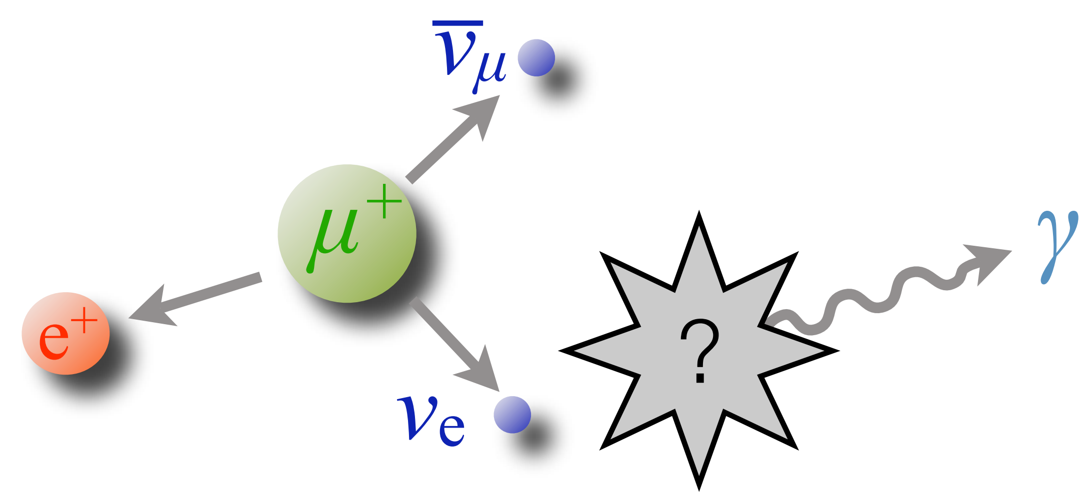
- $E_e = E_\gamma = m_\mu/2 = 52.8$MeV
- $\theta = 180$deg.
- time coincidence

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

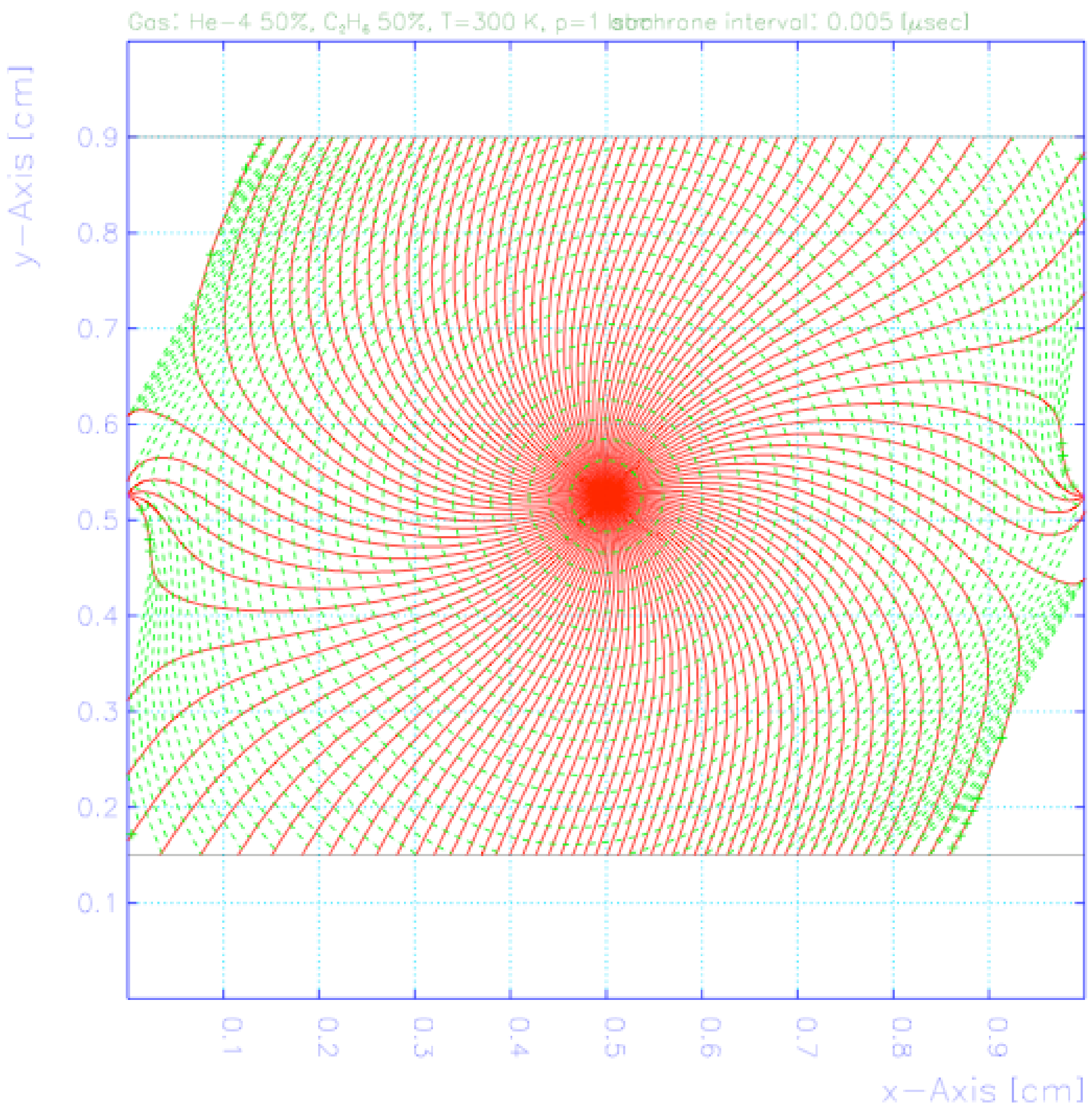


  - accidental overlap

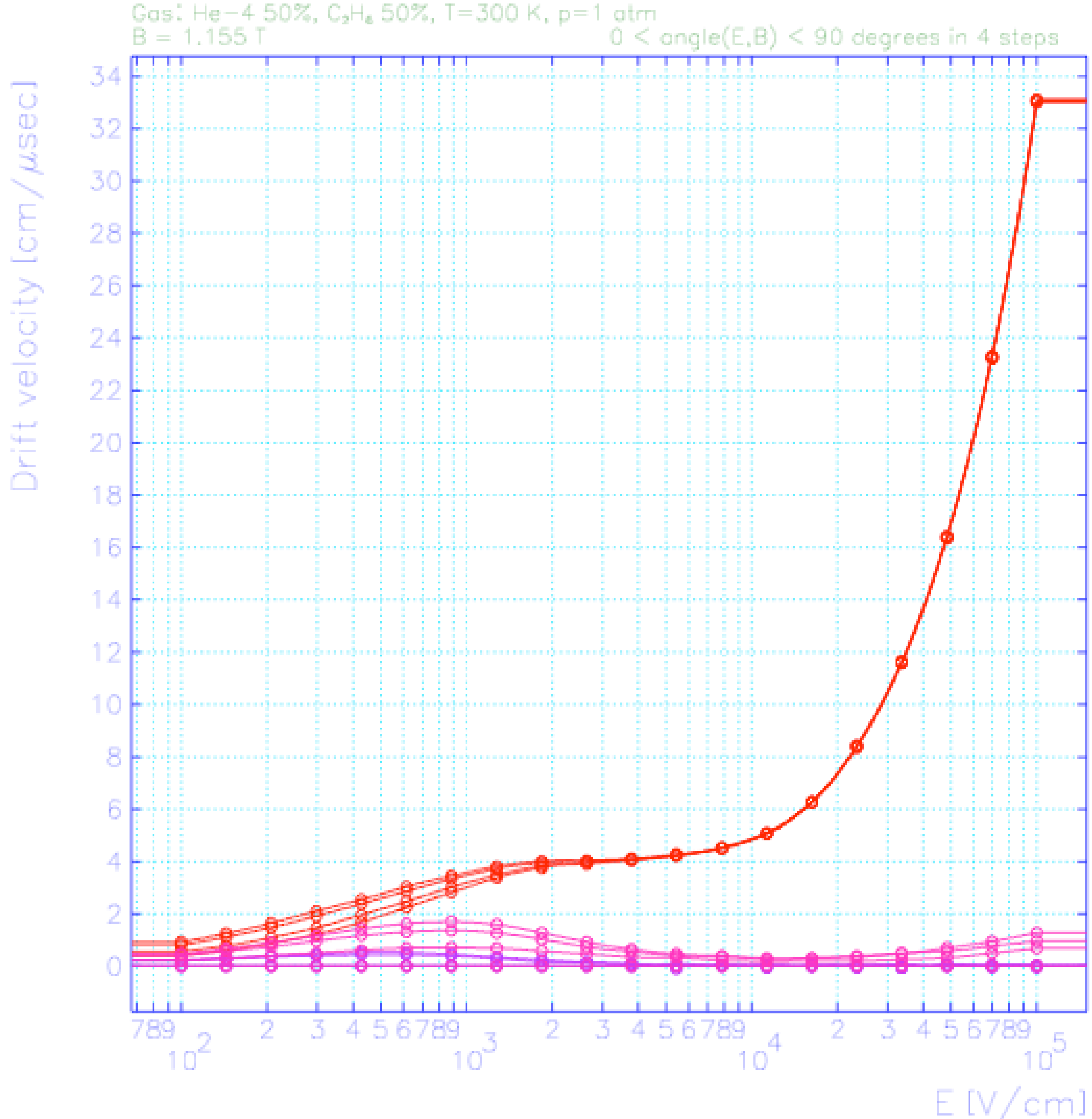


DC characteristics simulation (Garfiled)

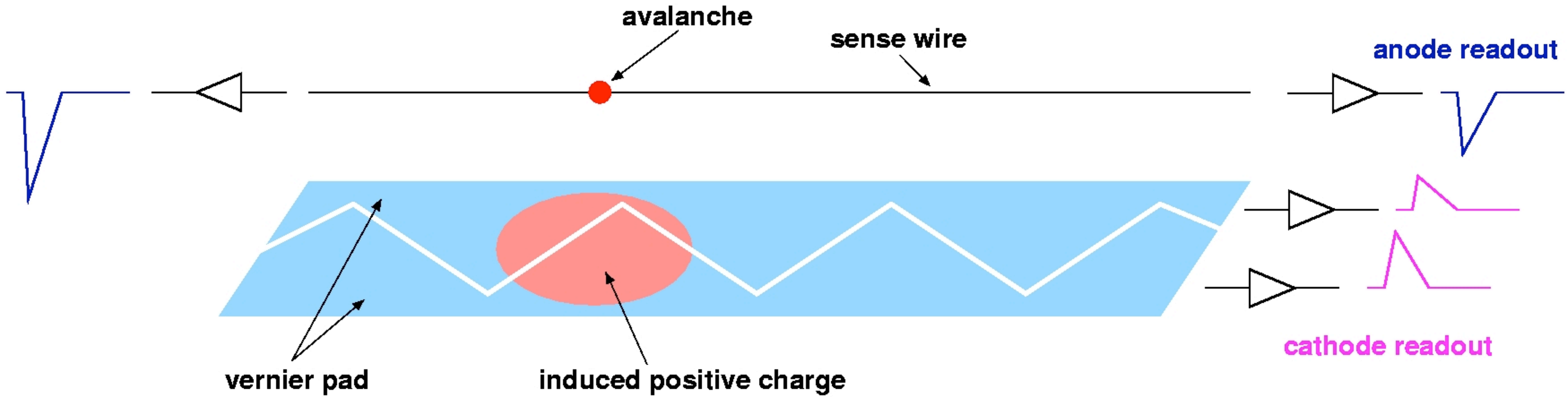
Electron drift lines from a wire



Drift velocity vs E



Cathode pads with vernier pattern



- there are 2 big advantage, position resolution improvement and readout channel decrease
- rough estimation by charge division method (~1cm)
- using the ratio of induced charge on each 4 strips, we can get the z-position with 300μm accuracy
- drop-off in readout channel and electronics