Memo on
Proton Drift Chamber (PDC)

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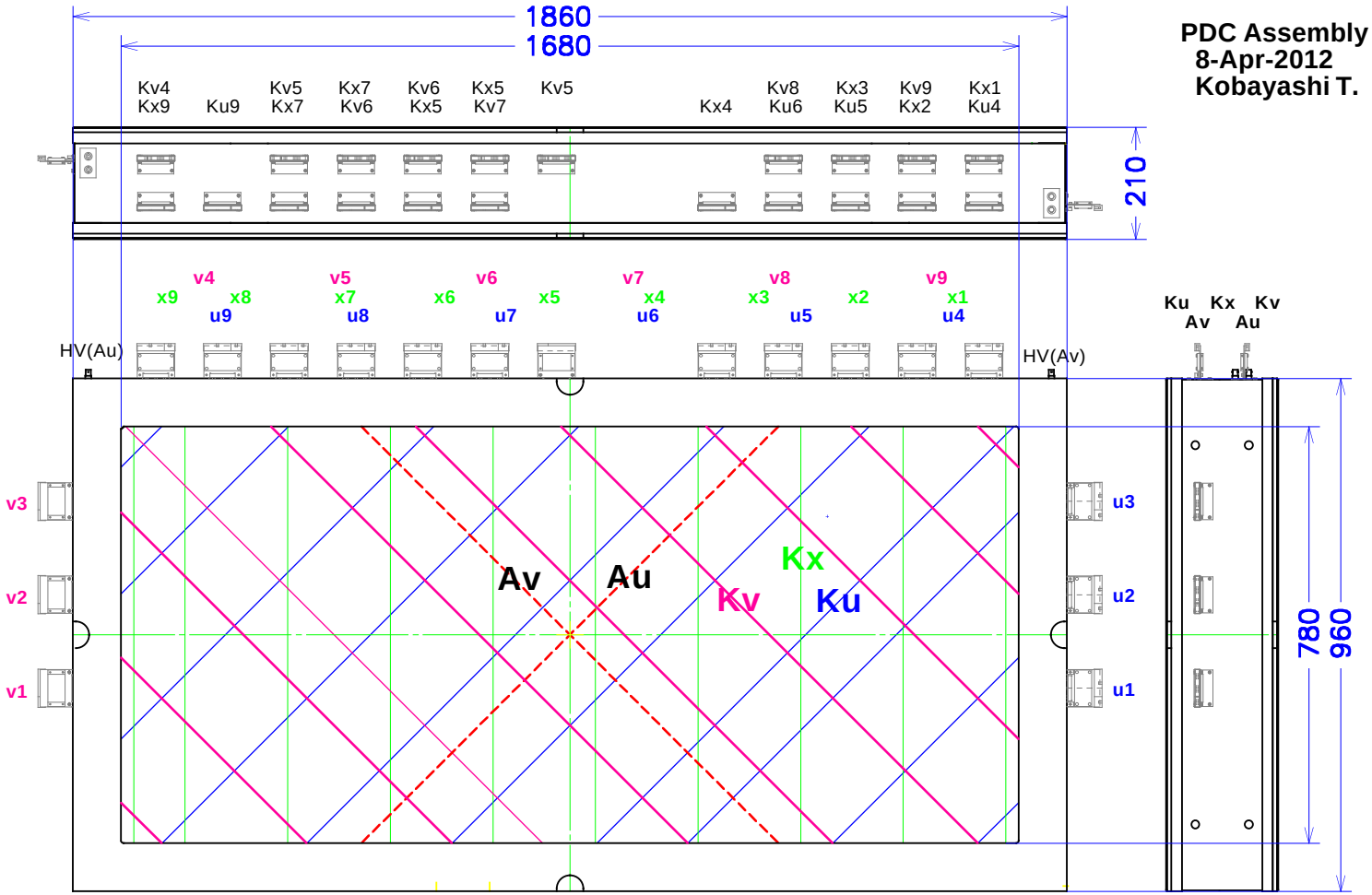
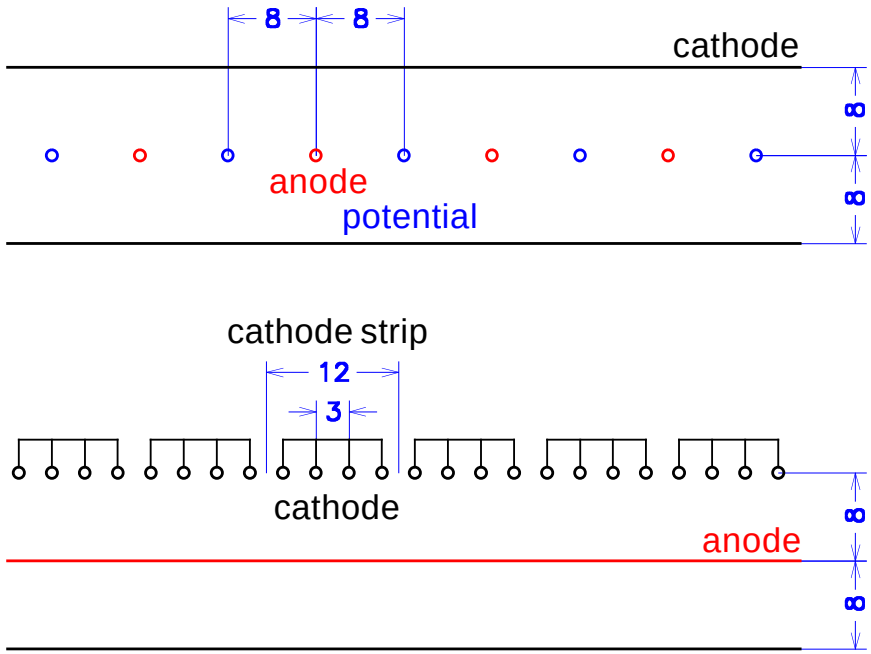
Proton Drift Chamber (PDC)

- Purpose : momentum reconstruction of projectile-rapidity protons combined with Si-strips
  - 2 identical chambers for 2 dim. position (vector) information : (u1,v1), (u2,v2)
  - with multi-particle capability : u,v + x
- Effective area : 1.7 m x 0.8 m (1680mm x 780mm)
- Cathode readout : Ku1, Kx1, Kv1, Ku2, Kx2, Kv2, ~820 channels
- Gas : He+60% CH_4 or P10 (Ar+10%CH_4)



PDC Parameters

- Anode
  - Walenta-type drift chamber
    - drift distance= 8mm
    - half gap= 8mm
  - wire
    - anode : 30μmϕ Au-W/Re (+HV)
    - potential : 80μmϕ Au-Al (-HV)
- Cathode
  - wire : 80μmϕ Au-Al (ground level)
    - wire pitch= 3mm
    - strip pitch= 12mm (4 wires)
- Configuration :
  - Ku(+45°)-Av(-45°)-Kx(0°)-Au(+45°)-Kv(-45°)
  - for 2-dim. information + multi-particle capability
- Readout
  - cathode readout : DC coupled
  - 136 (144) ch / plane → 816 (864) ch / 2 PDC's
    - ASD (16ch x 54 modules)
    - ASD-PS (10ch x 6 modules)
    - TDC (64ch x 14 modules)

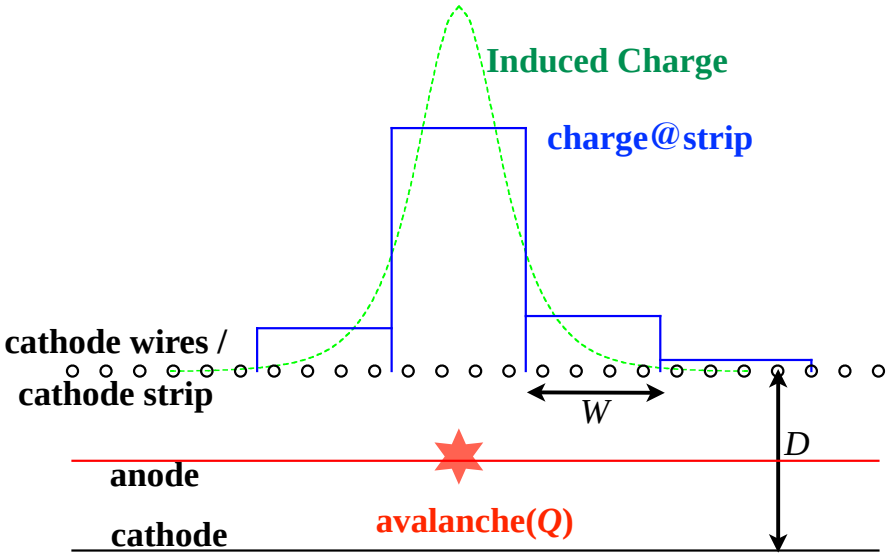


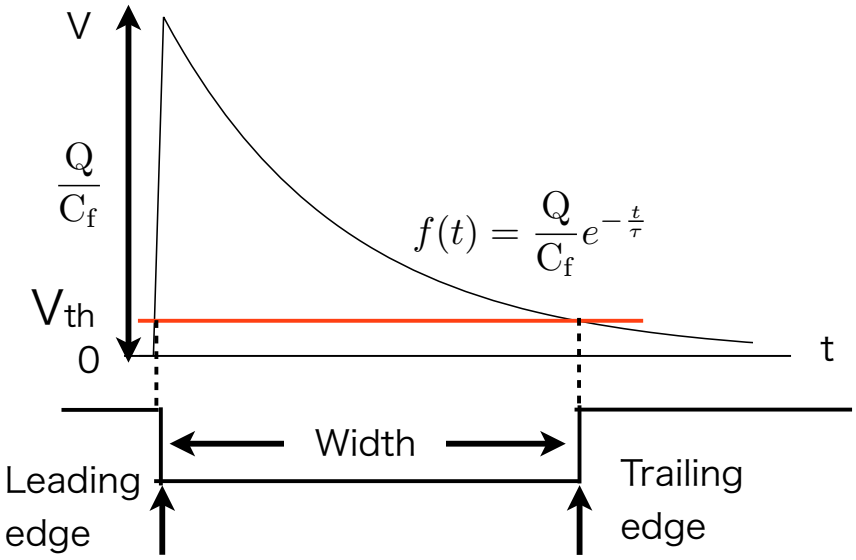
Cathode readout

- Position determination
  - 2 dim. info with only 2 sense planes
  - induced charge on the strip
    → avalanche position
  - "analog" readout needed, ~ 1000 ch
    - standard : analog readout
      - charge-sensitive PreAmp + Amp/Shaper + Peak-sensitive ADC
      - no experience before the contract in 2008
    - charge division (initial plan)
      - σ~ 1 mm
      - poor two particle separation

↓

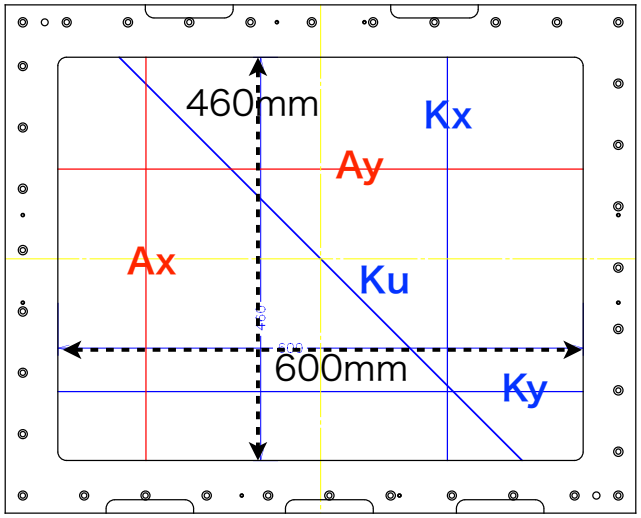
- Readout method : "digital" method
  - ASD discriminator (time over threshold) + TDC (width encoding)
  - common to BPC, BDC1,2 & FDC1,2
  - logic signal width (w) → charge Q
    - $Q \approx C_f V_{th} \exp(w/\tau)$ τ = 80nsec
  - additional drift time information





Prototype & Readout-Method Test

- Prototype Chamber : modify existing cathode MWPC
  - configuration : Kx - Ay - Ku - Ax - Ky
  - slightly different parameters
    - drift distance = 7.5 (8) mm, half gap= 8.0 (8)mm
    - cathode pitch= 2.5 (3) mm, strip pitch= 12.5 (12)mm (PDC)
  - 3 cathode chambers

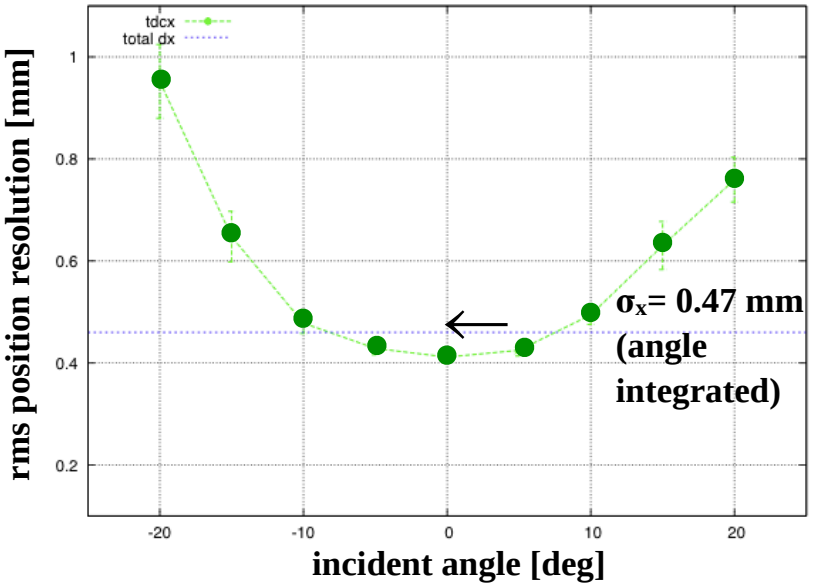


- Readout : Analog & Digital

PreAmp G= 0.8V/pC τ= 80nsec → Receiver/Amp/Shaper/Delay (500nsec)/Driver → Fera 4300B ADC → "analog"

ASD PostAmp (G=7) /Discriminator → LVDS-ECL → LRS 3377 TDC → "digital"

- Result for cosmic rays (MIP)
  - Gas : He+60%CH_4, V_{th}=+0.4V
  - Position resolution
    - σ_{analog} ~ 0.25 mm
    - $\sigma_{digital}$ ~ 0.47 mm : probably OK
  - necessary improvement
    - large incident-angle dep.



Position determination

- Charge Distribution

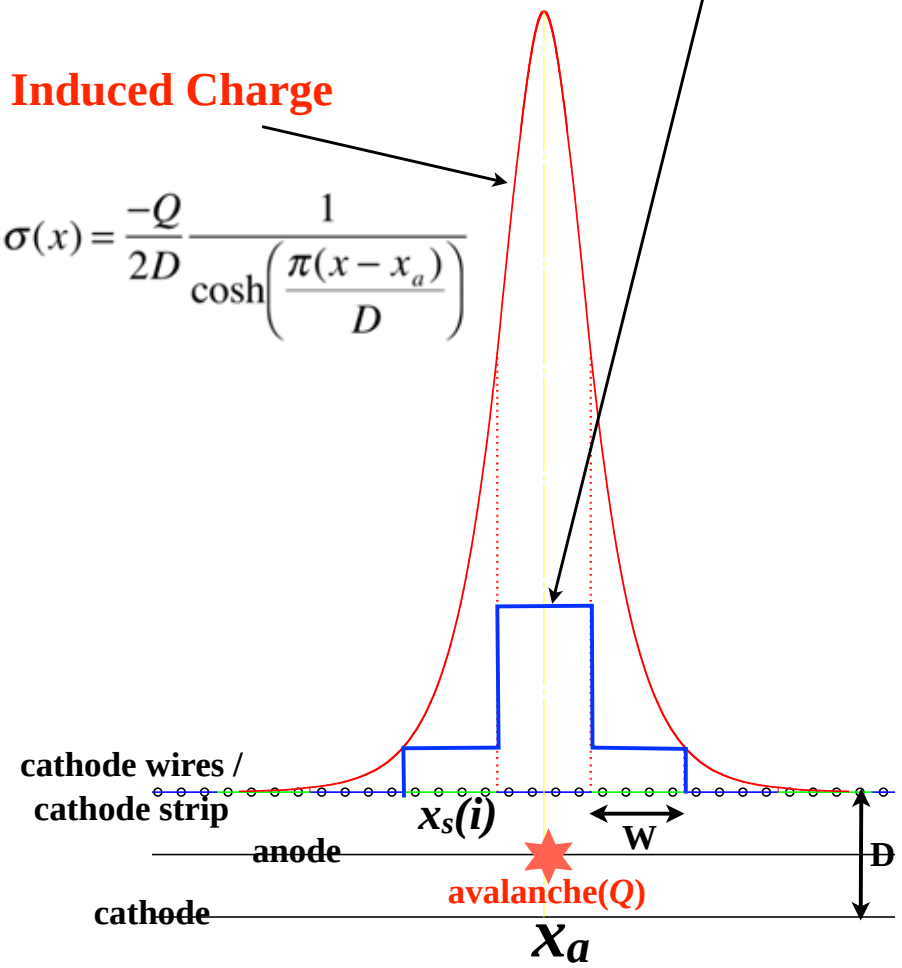
charge@strip

$$q_i(x_s(i)) = \frac{-Q}{\pi}\left[\tan^{-1}\left(e^{\frac{\pi(X+W/2)}{D}}\right) - \tan^{-1}\left(e^{\frac{\pi(X-W/2)}{D}}\right)\right]$$

$$X \equiv x_s(i) - x_a$$

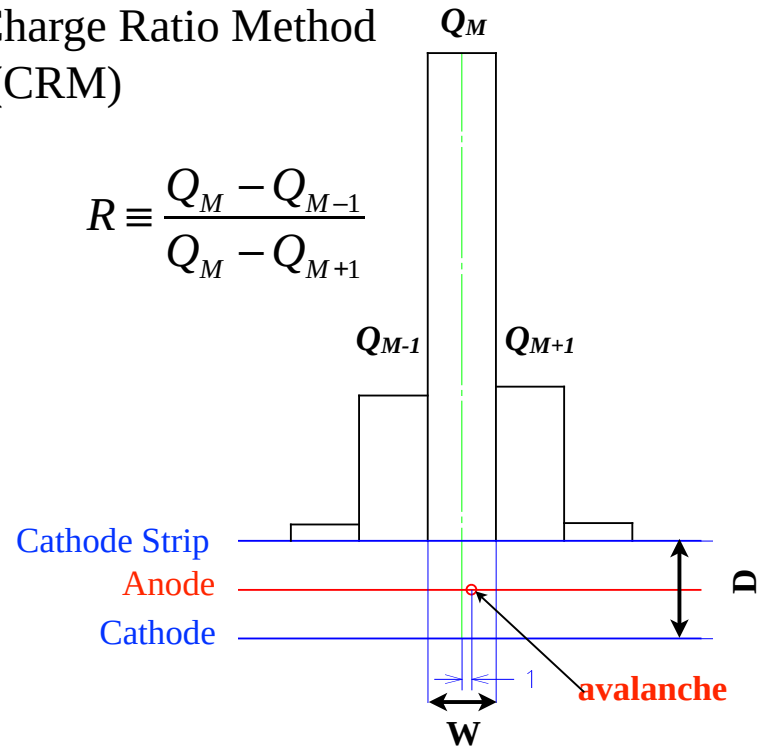
Induced Charge

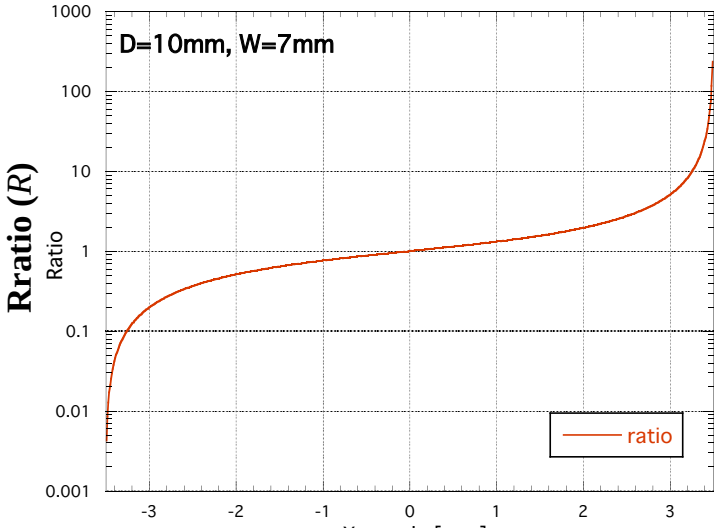
$$\sigma(x) = \frac{-Q}{2D}\frac{1}{\cosh\left(\frac{\pi(x-x_a)}{D}\right)}$$



- Charge Ratio Method (CRM)

$$R \equiv \frac{Q_M - Q_{M-1}}{Q_M - Q_{M+1}}$$

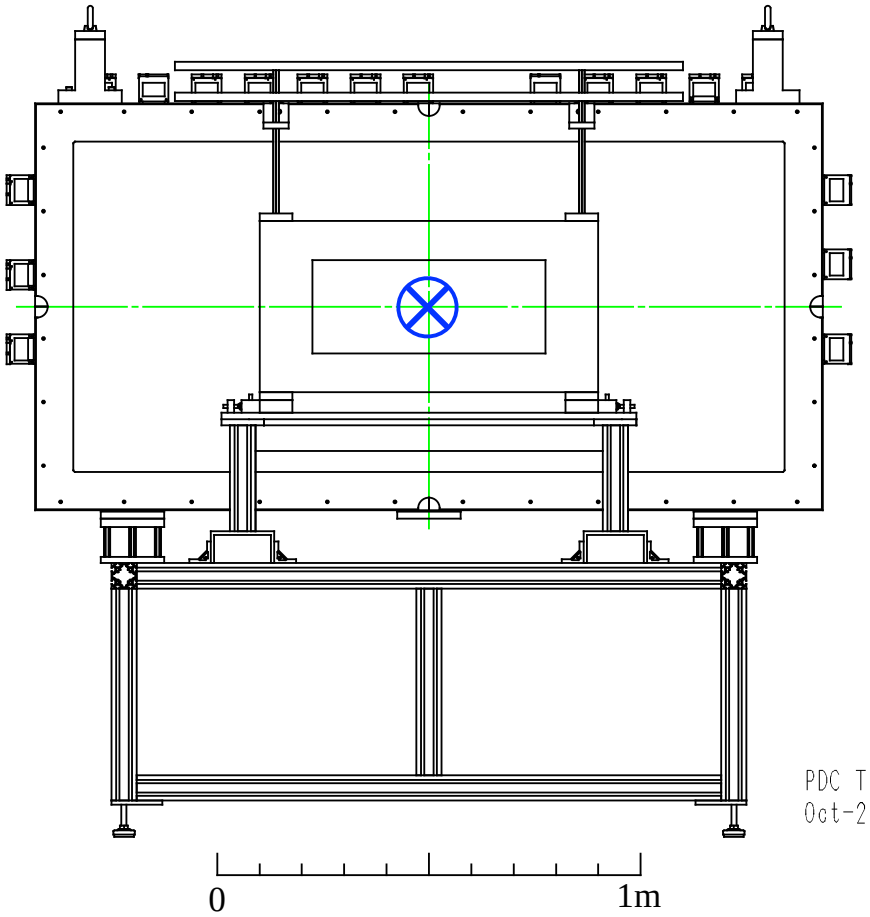


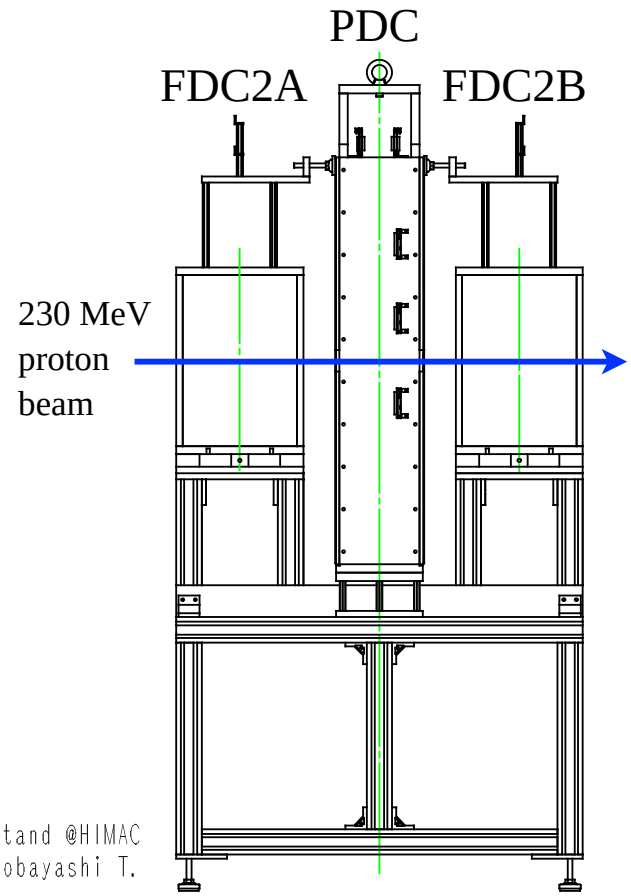


xposition in strip with Q_M [mm]

Test @ HIMAC, 230 MeV proton beam

- Test Setup





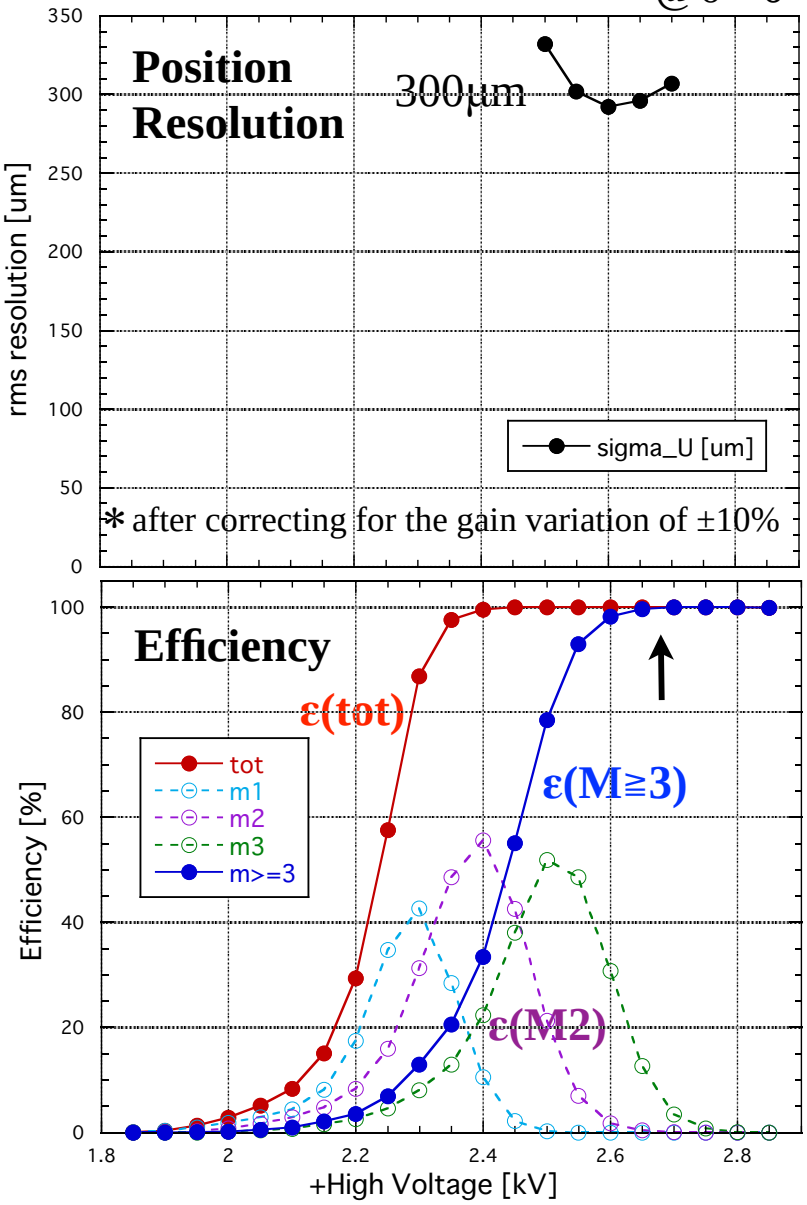
- Efficiency : HV-dep.
  - V_{th}= +0.8V(fixed)
- Position resolution
  - HV-dep
  - incident angle-dep.

- FDC2 : x-y-x'-y'-x'-y'-x-y
  - drift chamber with field shaping
  - drift length=25mm
  - $\sigma < 100$ μm
- PDC : u-x-v, 64 strips/plane
- Gas : He+60%CH_4

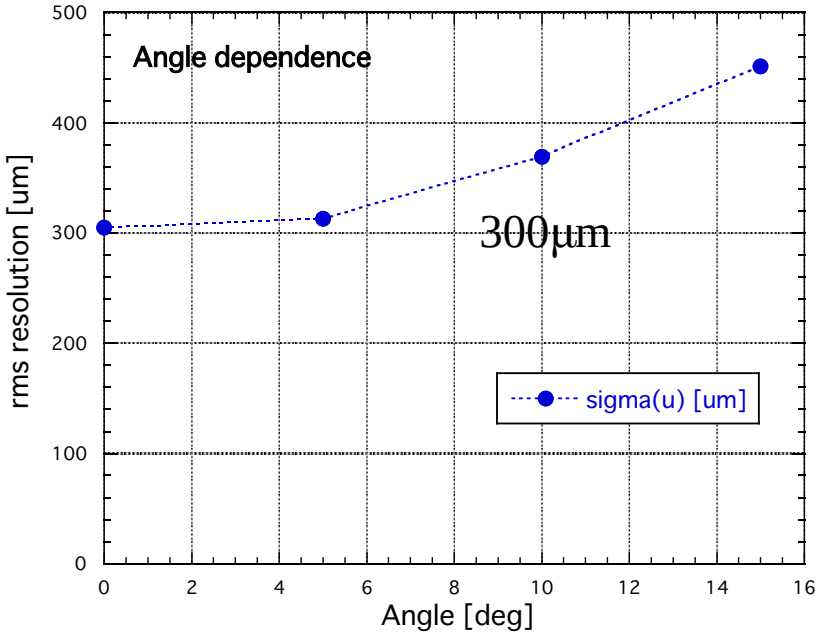
Response for 230 MeV proton

- Efficiency & Position resolution

@θ= 0°



- Incident-angle dependence @+2.70 kV

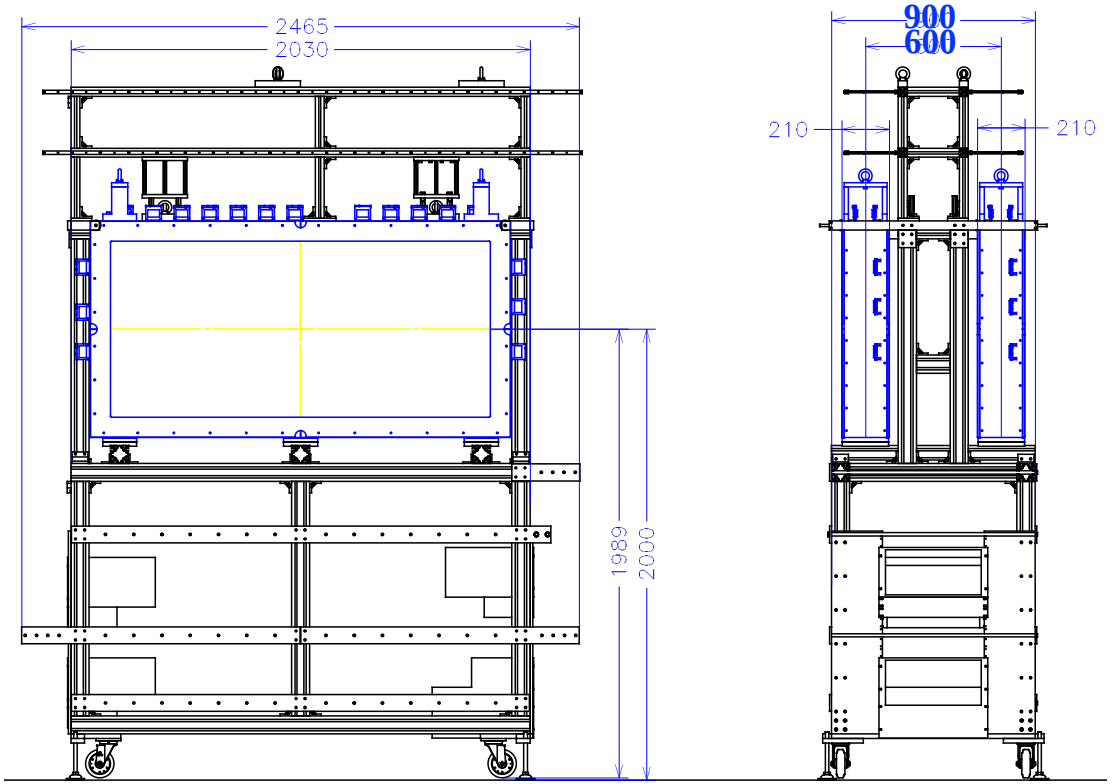


- stable plateau
- position resolution
  - σ~ 300 μm @0° by adjusting D_{eff}
  - σ~ 450 μm @15°, large angle dependence

avalanche : point → distributed

Installation

- Detector stand & 2 PDC's



- Electronics

  no dedicated TDC, Crate, SBS etc

  interference with other experiment

  - ASD ×54 : ok
  - ASD-PS ×6 :
    - using 3 BDC/FDC spares
    - 3 short
  - VME-TDC ×14 :
    - using 7 BDC/FDC spares
    - 7 short
  - VME Crate : 1 short
  - SBS : 1 short

- Full test on site
  - noise etc

- **to be solved or improved**
  - **lower threshold (noise)**
  - **angle dependence (avalanche distribution)**
  - **uniformity (D_{eff}?)**
  - **prepare dedicated electronics + faster readout scheme**
  - **calibration procedure : reference chambers needed**

Status