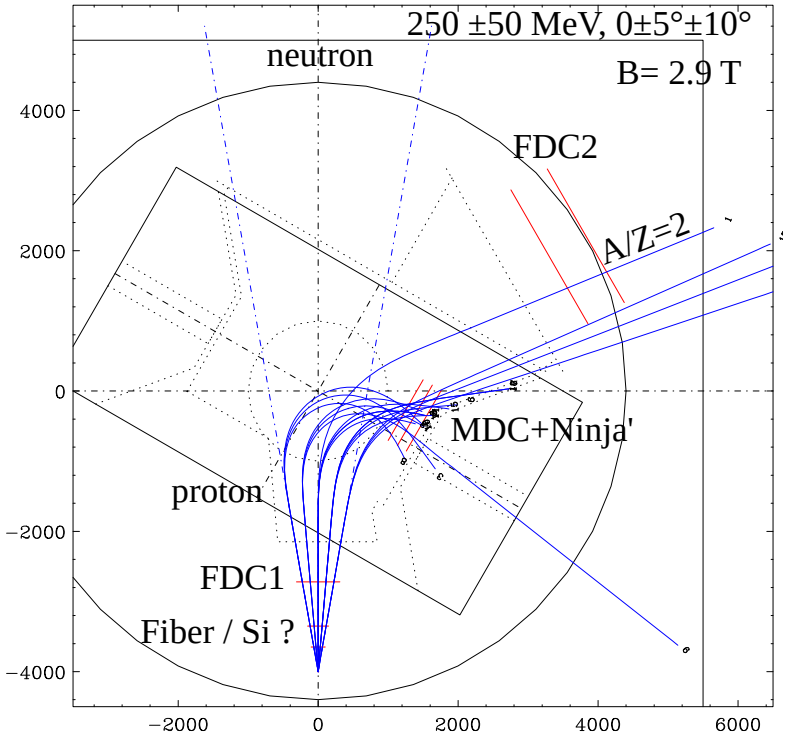
Memo on position detector for protons in magnetic field & vacuum

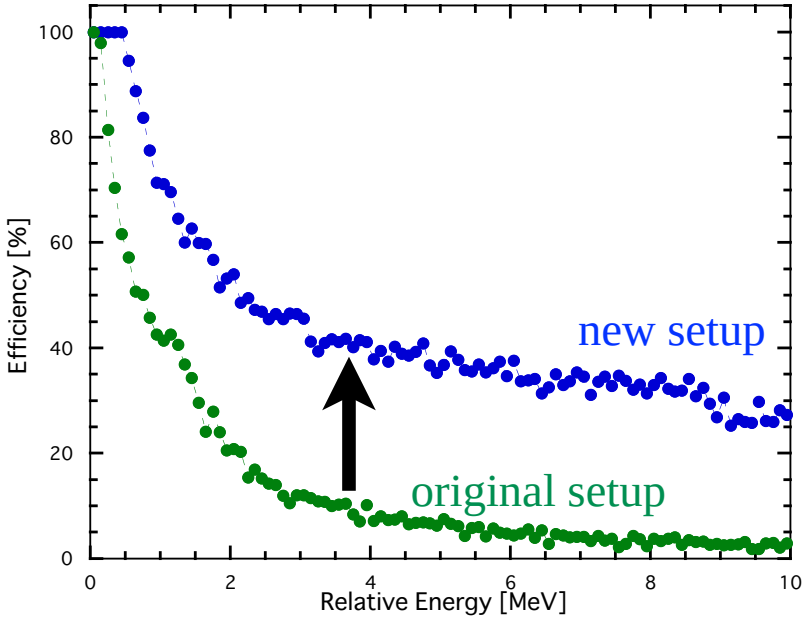
- Prototype test
  - Drift chamber
  - Cathode MWPC
- Tentative summary

Ideas for (γ, xnyp)-type exp. : ideal case

- Setup : standard setup+α



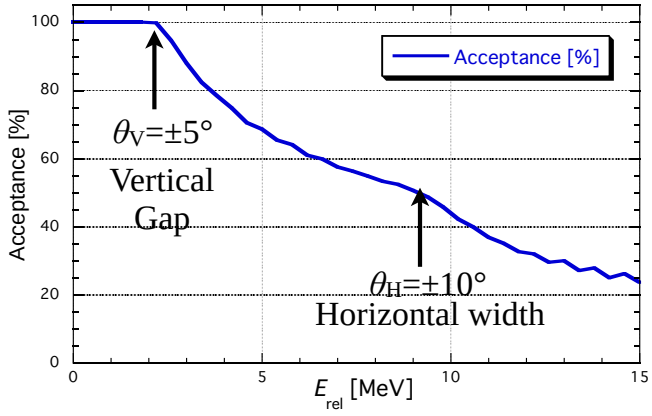
- Geometrical acceptance (proton)



- $\varepsilon_{p(det)} \sim 100\%$, $\varepsilon_{n(det)} \sim 40\%$
  - total efficiency for proton is higher

- Detectors
  - FDC1+FDC2 : for heavy fragment
  - MDC : 1000x650 mm^2 for proton detection
  - Fiber : heavy fragment + proton
    - Si (80x80) is too small even at D=350 mm
    - 140(H) x 80(V) mm^2 @ D= 350 mm
    - 250(H) x 160(V) mm^2 @ D=650 mm

- cf: Geometrical acceptance (neutron by NEBULA)

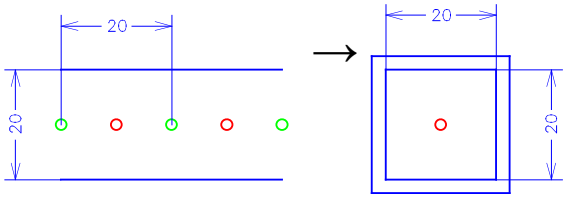


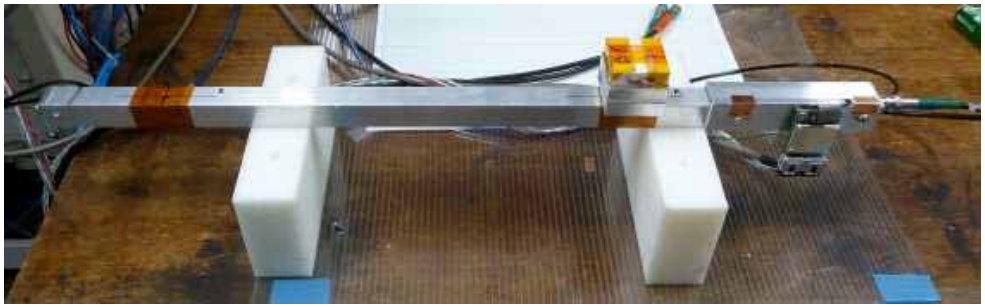
Position detector for proton

- Used in the non-uniform magnetic field & vacuum (SAMURAI vacuum chamber)
  - with NINJA
- Possible designs
  - drift chamber
    - + stable operation
    - - position dependent Lorentz angle, XYU(UVX) for multi tracks
  - cathode-readout MWPC
    - - large MWPC: difficult & unstable
    - + small Lorentz angle effect
  - MWPC
    - + probably best
    - - large number of readout channels
- Common problems
  - strength of gas window
    - ~860 kg on 100cm x 65 cm at 100 torr

(1-1) Drift chamber prototype

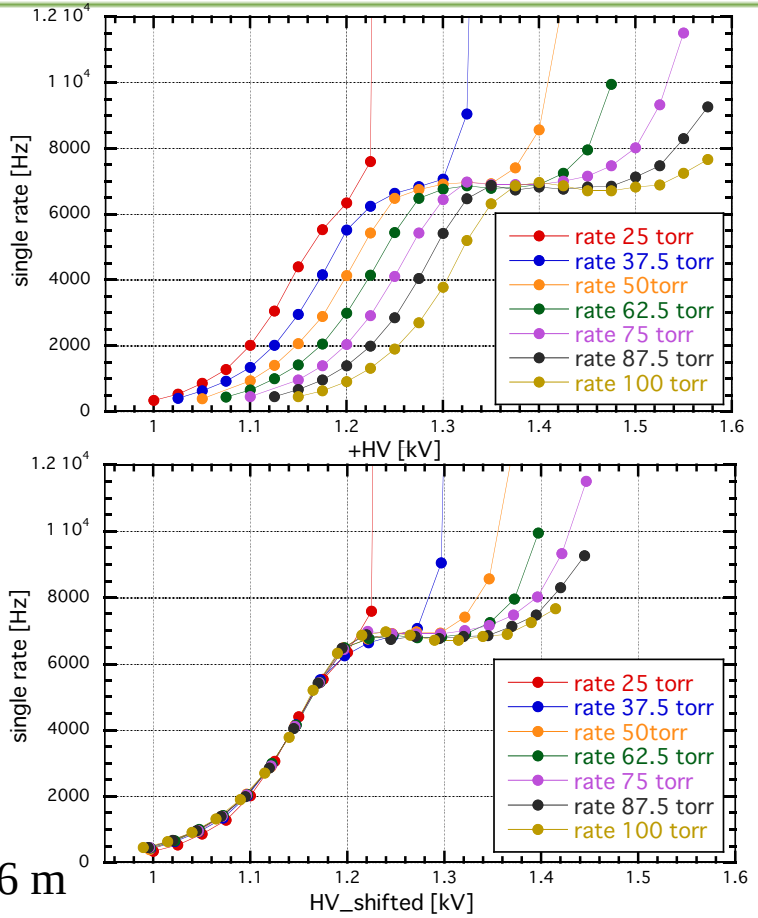
- Drift chamber for position detector in the magnetic field & vacuum for protons
  - cell size : drift distance~ 10mm, with moderate # wires & readout
  - smaller cell size preferred : but no space for ASD(X)
    - gas : i-C_4H_{10} at low pressure : large load on the gas window
      - pressure, HV?
- Prototype
  - for rough guess on gas pressure & HV
  - similar structure
    - cathode : Al square pipe, ID 20mm x 20mm
    - anode : 20 μm φ Au-W, L= 600 mm
- Test bench



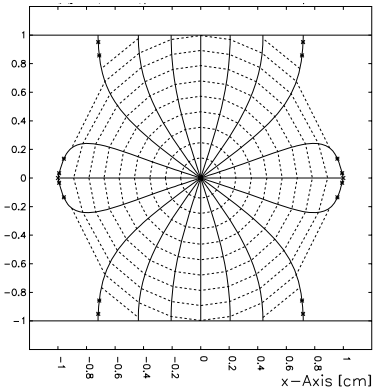


(1-2) prototype bench test

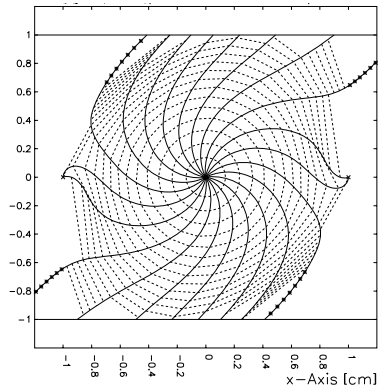
- Test conditions
  - Gas : i-C_4H_{10}, P= 25 ~ 100 torr
  - ASD : τ= 80 nsec, V_{th}= -0.4 V
  - +HV(anode) : 1.0 ~ 1.6 kV
- Single rate for MIP
  - source: ^{90}Sr β rays, collimated
  - plotted with HV shifted : ΔHV~ 27 V
  - gas pressure ?
    - if plateau length > 100 V required for stable operation
      - P= 50 torr, marginal
        - probably OK for protons
      - P > 60 torr OK
        - load on window~ 500 kgw for 1 m x 0.6 m
  - high voltage ?
    - HV(MIP)~ 1.35 kV @~60 torr
      - ΔG= 2 for ΔHV= 45~50 V
    - HV(250 MeV proton)~ 1.3 kV
- Drift time distribution (estimation)
  - i-C_4H_{10} 60 torr, HV= 1.35/1.45 kV, B= 0, 0.5 T
  - probably very difficult for analysis



B= 0 ΔT= 20 ns

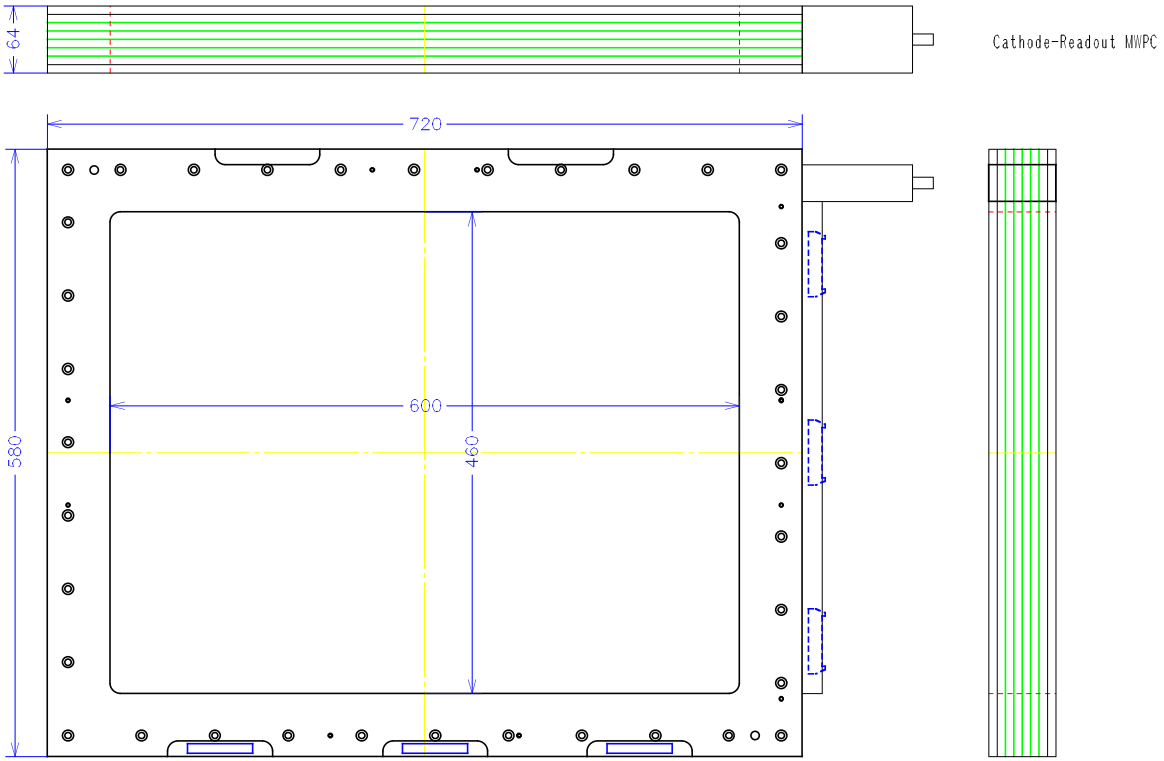


B= 0.5 T



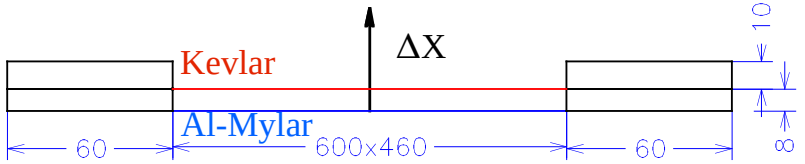
(2-1) Cathode-readout MWPC

- Prototype
  - effective area : 600 mm x 460 mm
  - configuration
    - F, Kx, Ay, Ku, Ax, Ky, Sp, F
  - anode planes : 20μmφ Au-W, 2.5 mm spacing
    - Ax: 250 anodes
    - Ay: 190 anodes
    - half gas : 8 mm
  - cathode planes : 75 umφ Cu-Be, 2.5 mm spacing
    - cathode readout pitch : 12.5 mm
    - # readout : 160 ch total
      - Kx : 16ch x 3
      - Ky : 16ch x 3
      - Ku : 16ch x 4

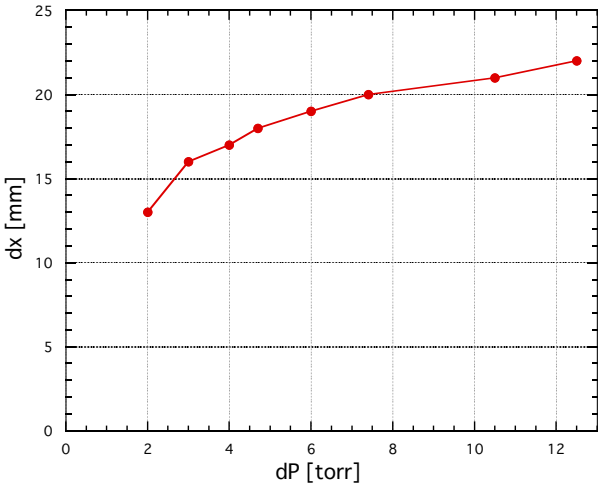


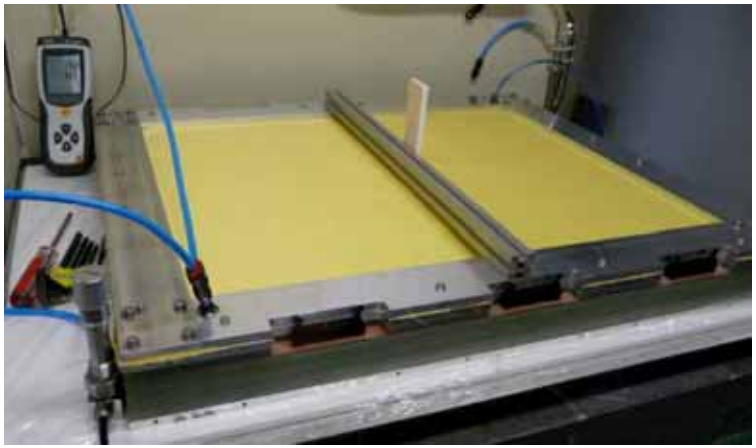
(2-2) K-MWPC : gas window test -1

- Kevlar protection window with frame added outside 12 um-Al-Mylar gas window
  - Kevlar sheet (T740, ~0.13 mm^T, ~7 mg/cm^2)



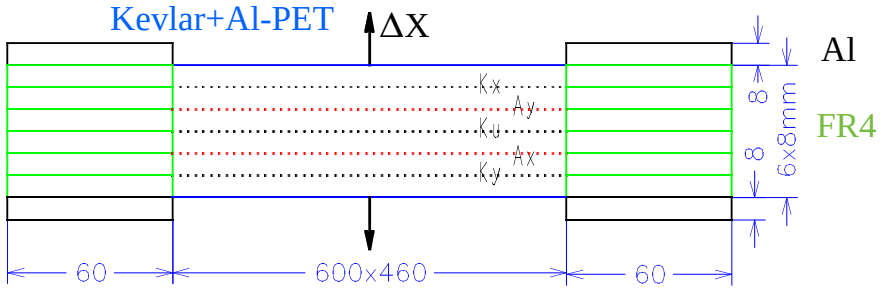
- Pressure test
  - differential pressure : Δp= 0 ~ 13 torr
  - deformation : Δx~ 22 mm
  - test stopped (gave up) at ~13 torr

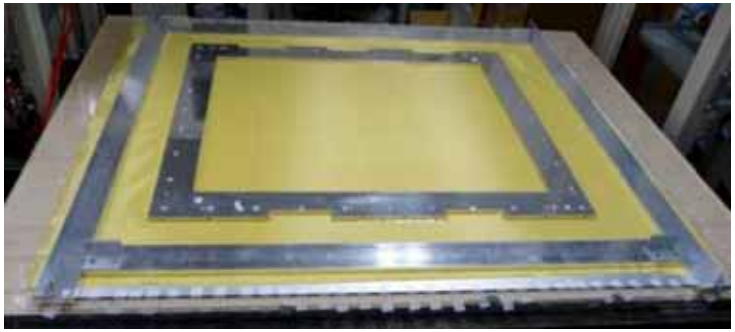


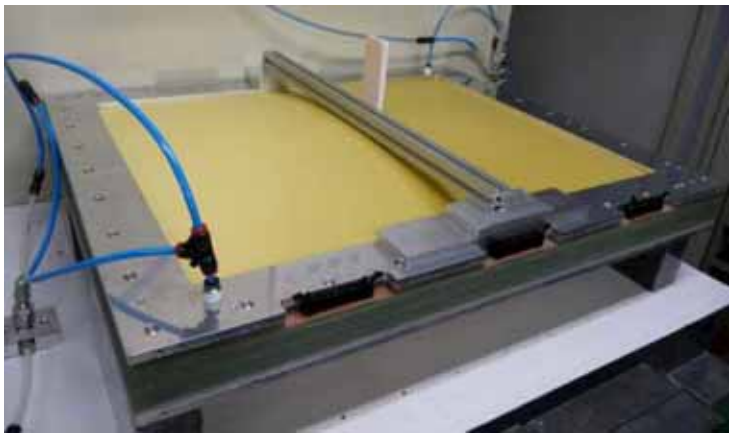


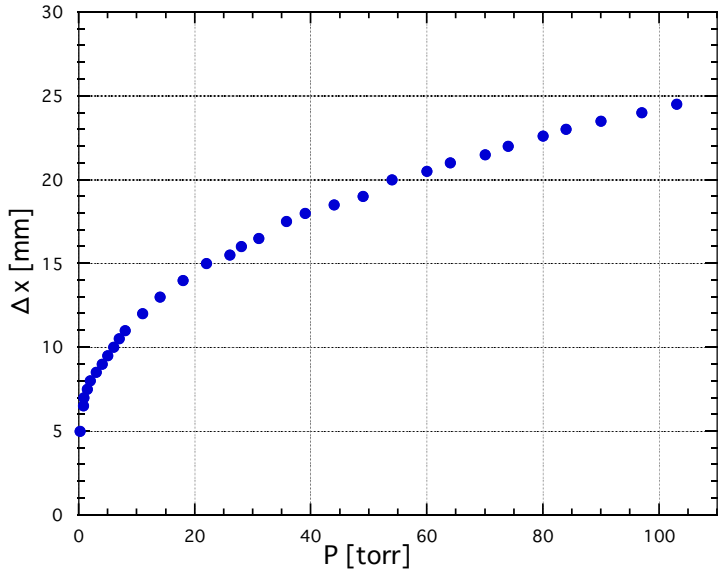
(2-3) K-MWPC : gas window test -2

- Kevlar & Al-PET glued directly to Al frame
  - Kevlar sheet : T740, ~0.13 mm^T, ~7 mg/cm^2
    - max. tension ~ 60 kgw/cm
  - Al (7 um) - PET (100 um) : ~ 17 mg/cm^2
    - Al part is used for EM shielding
    - max. tension ~ 24 kgw/cm
- Pressure test
  - differential pressure : $\Delta p = 0 \sim 110$ torr
  - deformation : $\Delta x < 25$ mm
    - OK up to ~ 100 torr
  - leak rate ?

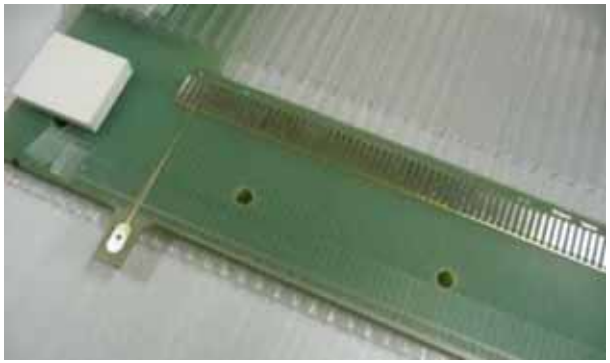








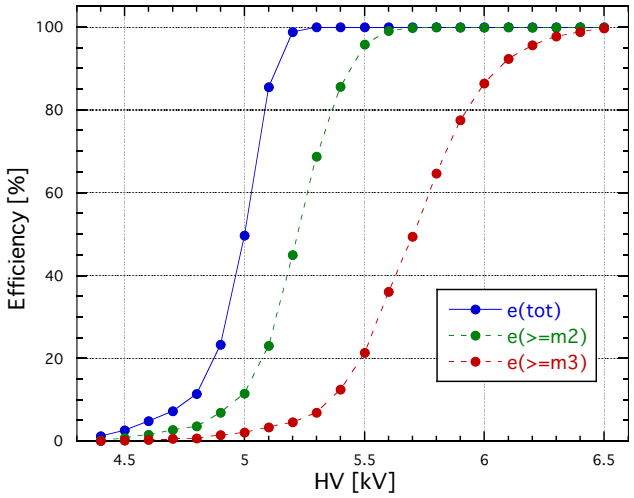
(2-4) K-MWPC : anode planes, 1st HV test



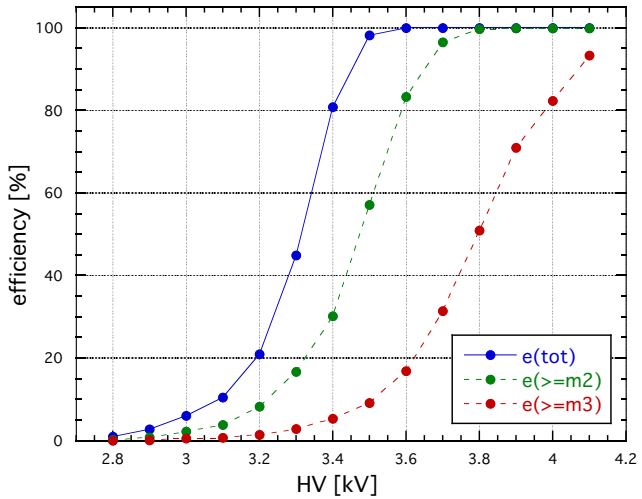
- Wire winding + transfer : Nov-2016
  - problems: gap uniformity
- Soldering + cleaning : Dec-2016

- Assembly : mid Dec-2016
- Gas : pure i-C_4H_{10} at P= 1 atm & β (MIP)
  - tripped @3.5 kV, and HV(Ax) shorted
    - → Ax grounded, test using Kx, Ay, & Ku
  - ε(m3)~ 100% @6.5 kV : OK
- gas : Ar(75%) + i-C_4H_{10}(25%)
  - 4.2 kV : current increased & some hot wires
    - ε(m3)~ 88 % @4.2 kV : slightly higher HV needed

Kx: i-C_4H_{10}, V_{th}= 0.4 V



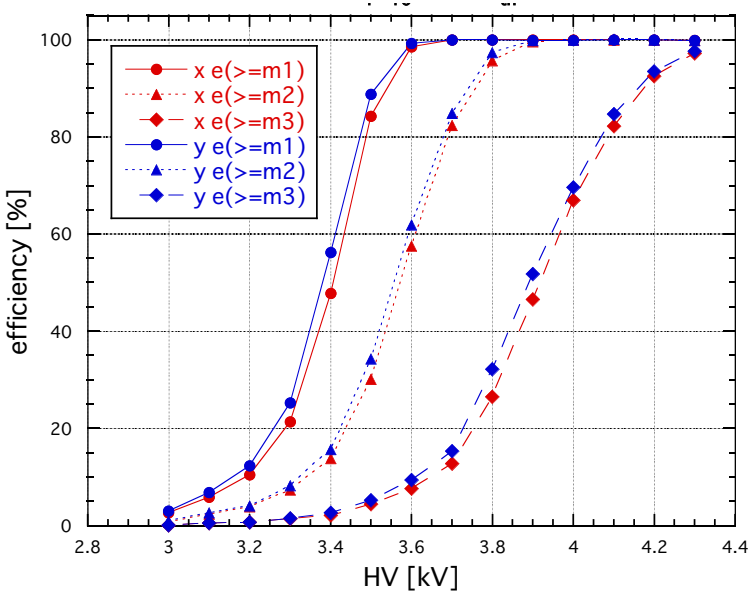
Kx: Ar+i-C_4H_{10}, V_{th}= 0.4 V



(2-5) K-MWPC : 2nd test

- Ay plane fixed, re-assembly, read Kx & Ky : late Dec-2016
  - combination of Kx & Ky readout caused noise problems
  - managed to operate at V_{th}= 0.4 V, but slightly unstable
- HV test using Ar(75%)+i-C_4H_{10}(25%)
  - @3.6 kV : some Ky wire became hot, current increased
  - @4.2 kV : some Kx wire became hot, current increased
- HV conditioning
  - 30-Dec-2016 ~ 10-Jan-2017
  - slight improvement
- Test using β (MIP)

Kx,Ky: Ar+i-C_4H_{10}, V_{th}= 0.4 V



(2-6) K-MWPC Status

- To-do list
  - probably more HV conditioning necessary
  - test using pure i-C_4H_{10} at 1 atm
  - test at low pressure
    - in the large vacuum chamber @ B2F
  - re-wind anode planes for better uniformity

Tentative summary

- Position detector for proton in the magnetic field & vacuum
  - problems of gas window is probably OK for P < 100 torr
    - leak rate ?
  - Drift chamber
    - P(i-C_4H_{10})~ 60 torr is enough for MIP detection, from prototype test
    - straight forward construction
      - but tracking may be difficult due to position-dependent Lorentz angle
  - Cathode MWPC
    - in general, large chamber difficult due to MWPC anode structure
      - anode planes will be re-wound for better uniformity
    - suited for operation in the non-uniform magnetic field
    - prototype test : 600 x 460 mm^2 more or less OK
    - need to be tested at low pressure (<100 torr) for MIP
      - 100% efficiency can be achieved for MIP ?