Multi-Anode Straw Tracker

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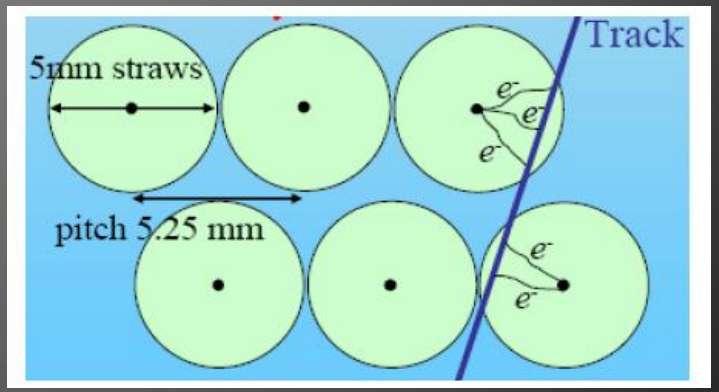
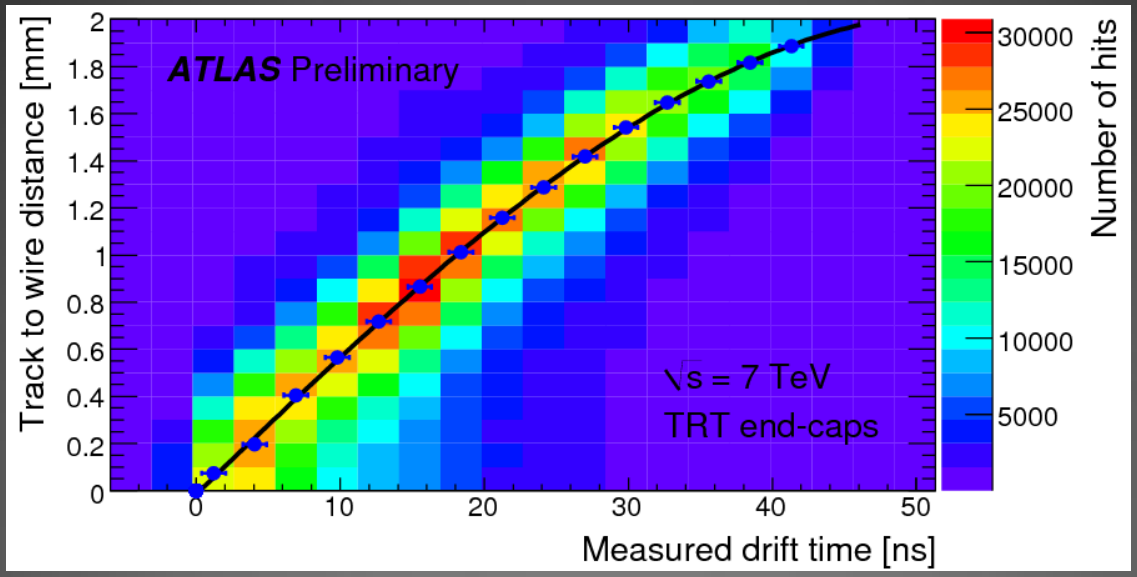
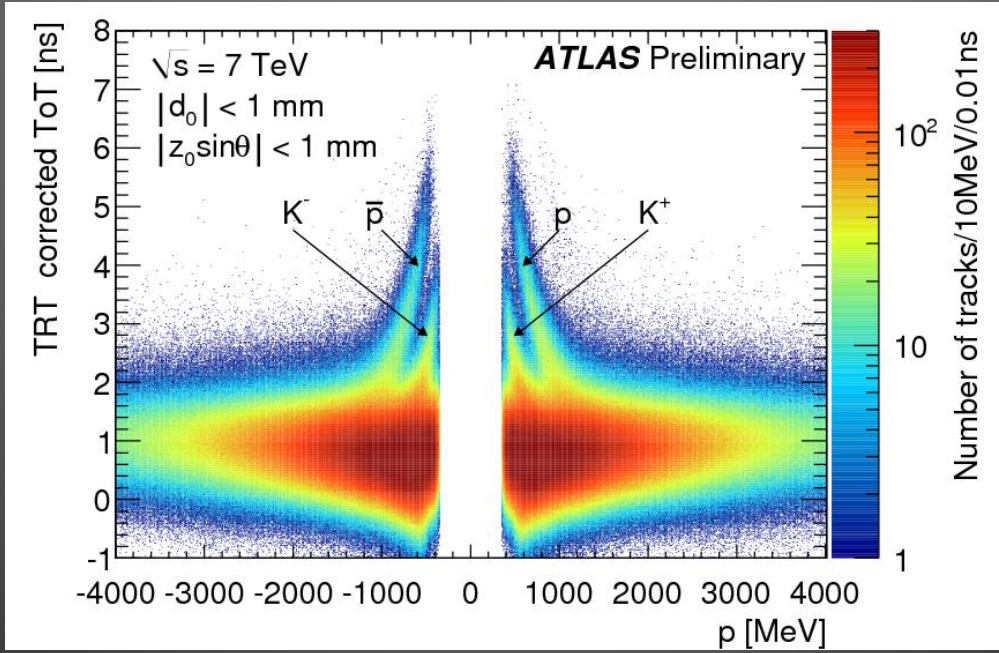
Principle of straw tracker

- A simple device :
  - A tube with an anode wire at the center.
    - Anode wire is at positive potential while straw tube is at ground.
    - Anode wire is at ground while straw tube is at negative potential
  - For timing, detect the first electron cluster
    - Convert arrival time to distance (RT relation)
    - Operation inside a strong B field is no problem
    - Resolution ~120 microns (it is function of distance from the wire –worse near the wire)
    - dE/dx can be done

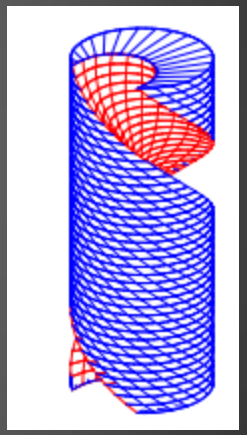



ATLAS Preliminary
√s = 7 TeV
TRT end-caps
Track to wire distance [mm]
Measured drift time [ns]
Number of hits


ATLAS Preliminary
√s = 7 TeV
|d0| < 1 mm
|z0sinθ| < 1 mm
K⁻
p̄
p
K⁺
TRT corrected ToT [ns]
p [MeV]
Number of tracks/10MeV/0.01ns

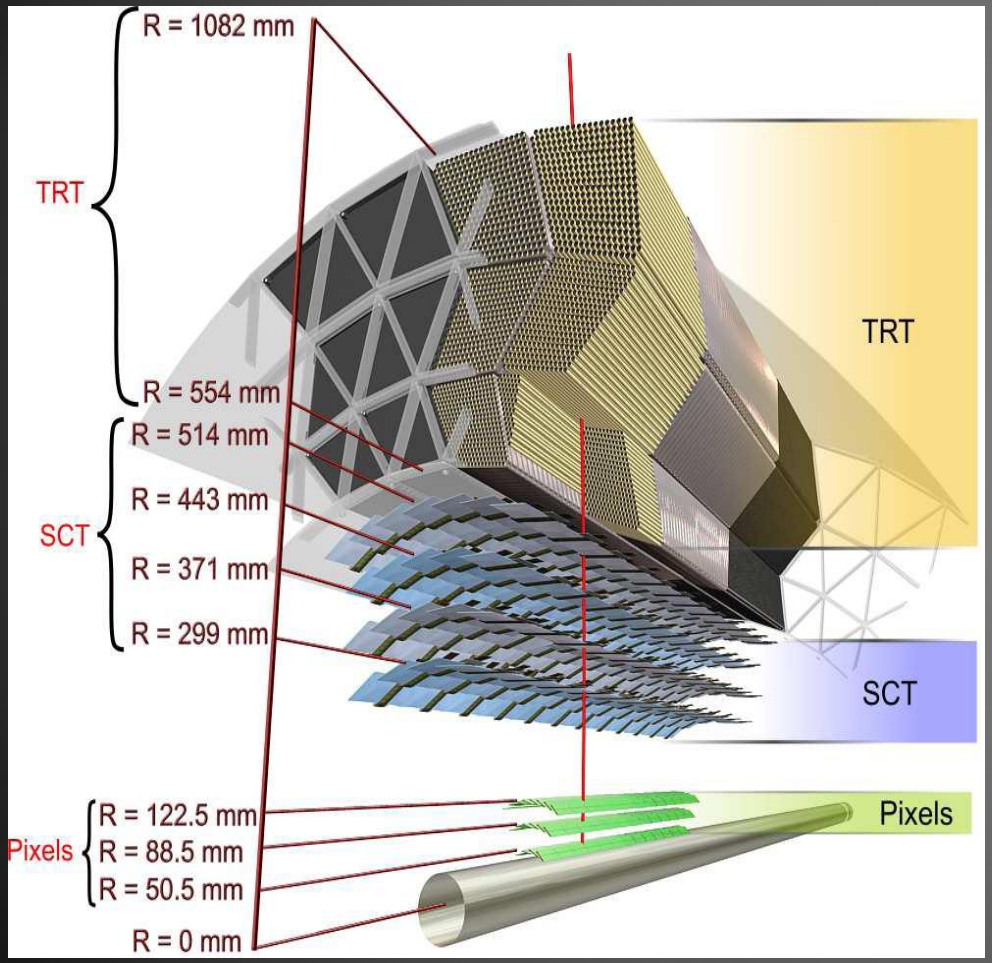
Detectors

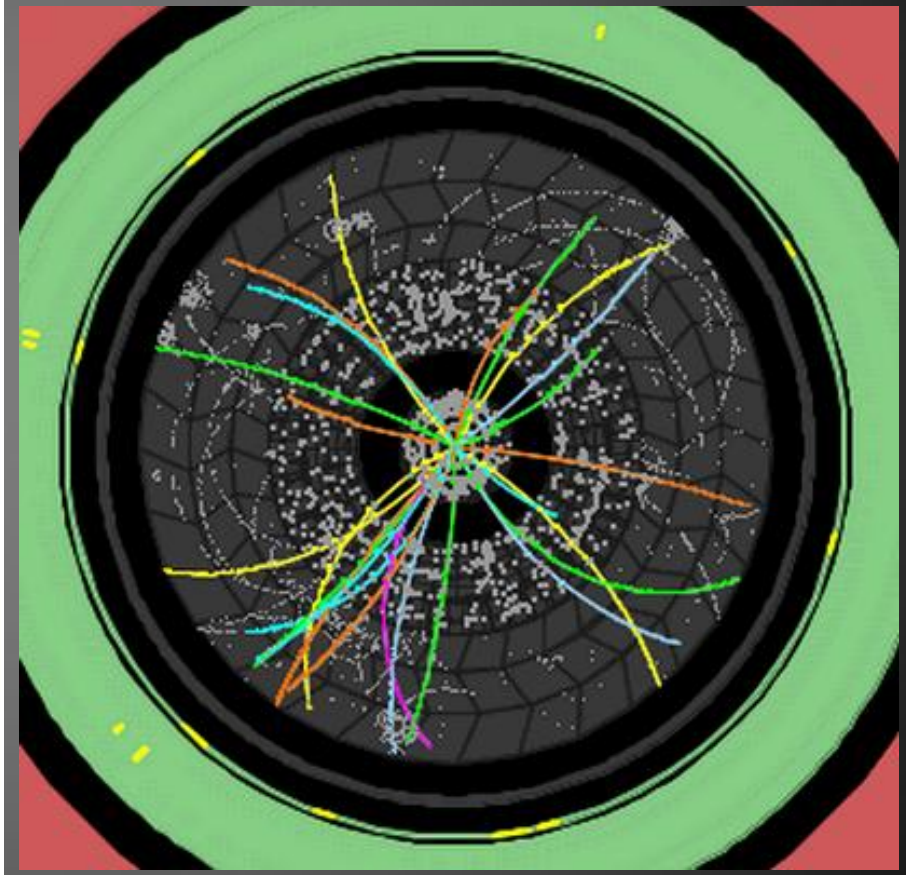
- Radius of straw tubes varies from 2 mm (ATLAS TRT) to a couple of cm. The longest detector with 4 mm tube was 4 m long although 8 m long prototype was built.
  - Require wire support every ~75 cm (2 mm radius tube) for electrostatic stability



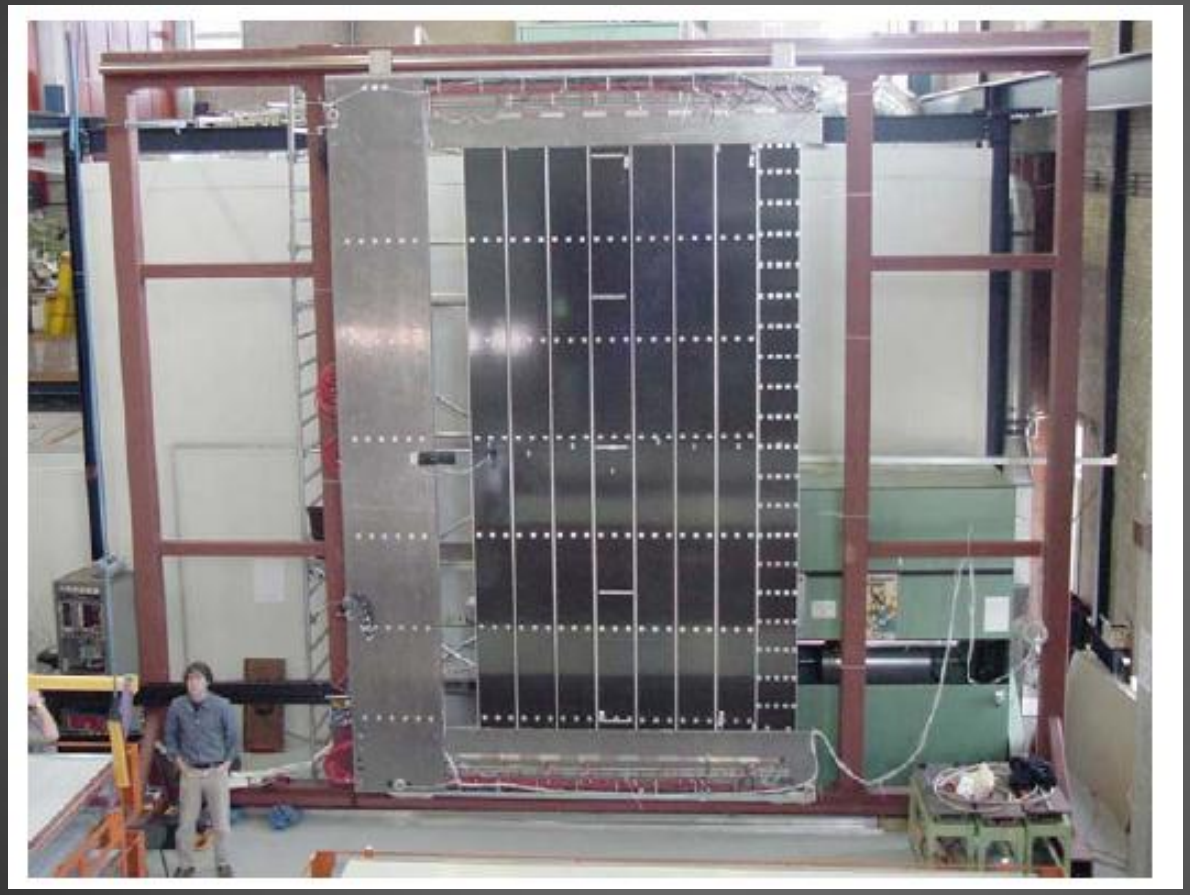
- Detectors
  - SDC : t: 33 μm, r: 2 mm, L: 4 m
  - TRT : t: 37 μm, r: 2 mm, L:1.5 m
  - Mu2e : t: 16 μm, r: 2.5 mm, L: 0.4-1.2m
  - NA62: t: 36 μm, r: 5 mm, L: 2.1 m
  - LHCb : t: 35 μm, r: 2.5 mm, L: 2.4 m

TRT


R = 1082 mm
TRT
R = 554 mm
R = 514 mm
R = 443 mm
SCT
R = 371 mm
R = 299 mm
TRT
SCT
Pixels
R = 122.5 mm
Pixels
R = 88.5 mm
R = 50.5 mm
R = 0 mm

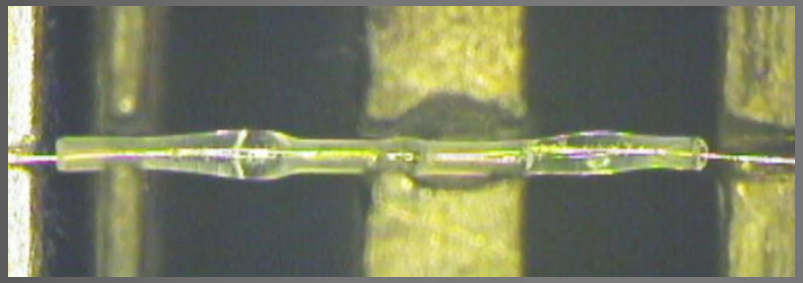


LHCb



Advantages

- Stable under extremely high rate
  - TRT: ~20MHz/50 cm
  - Wire-joint technology increases the rate by x2 by reading out a straw tube from both ends.



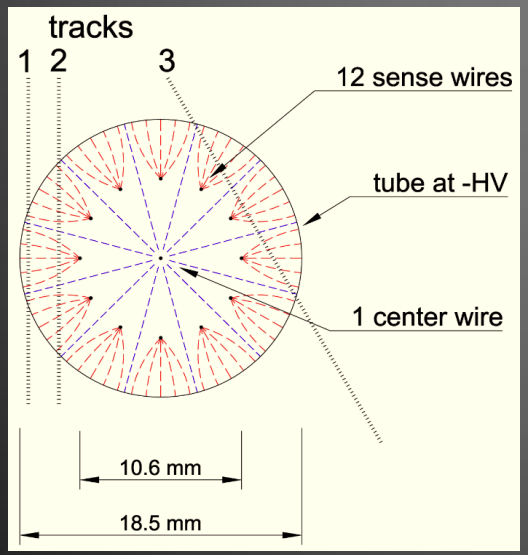
- Operation in vacuum – Mu2e/NA62
- Broken wire and gas leak problem during operation can be isolated and controlled.
  - HV lines to straws have fuses (TRT/Mu2e)
- Cross talk is low

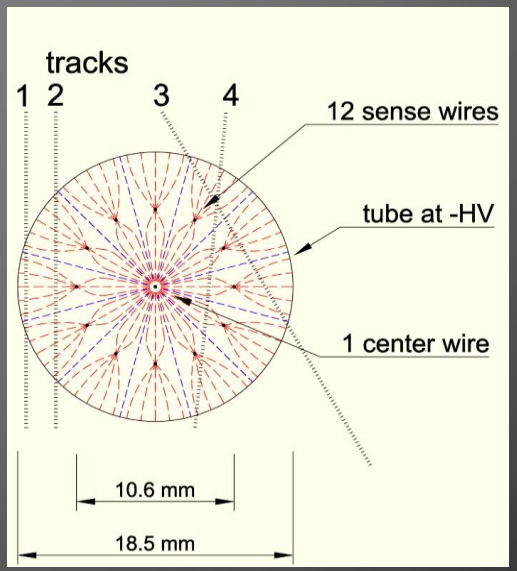
Limitation

- Material
  - one tube/hit
- Difficulty of stringing for long straws (wire support)
- Difficulty of supporting stereo straws (or modules) in a cylindrical geometry
  - A detector with stereo has not yet been constructed

Multi-anode Straw Tracker (NIM *A640 (2011) 160-163)*

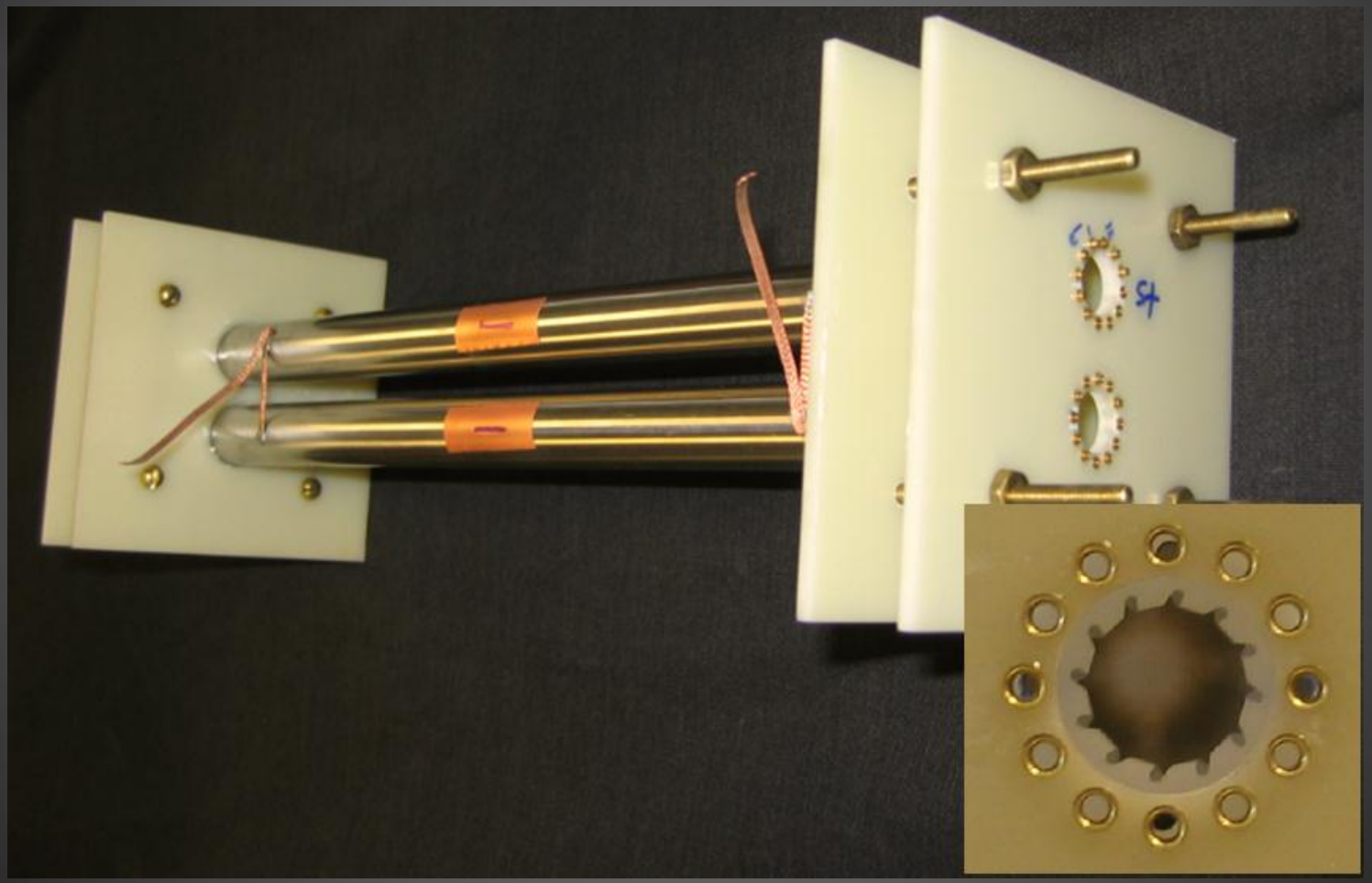
- Insert several anode wires inside a straw.
- There are two operational modes depending on the center wire potential.
  - $HV_{center\ wire}=HV_{anode}$ $HV_{cente\ rwire}=HV_{straw}$



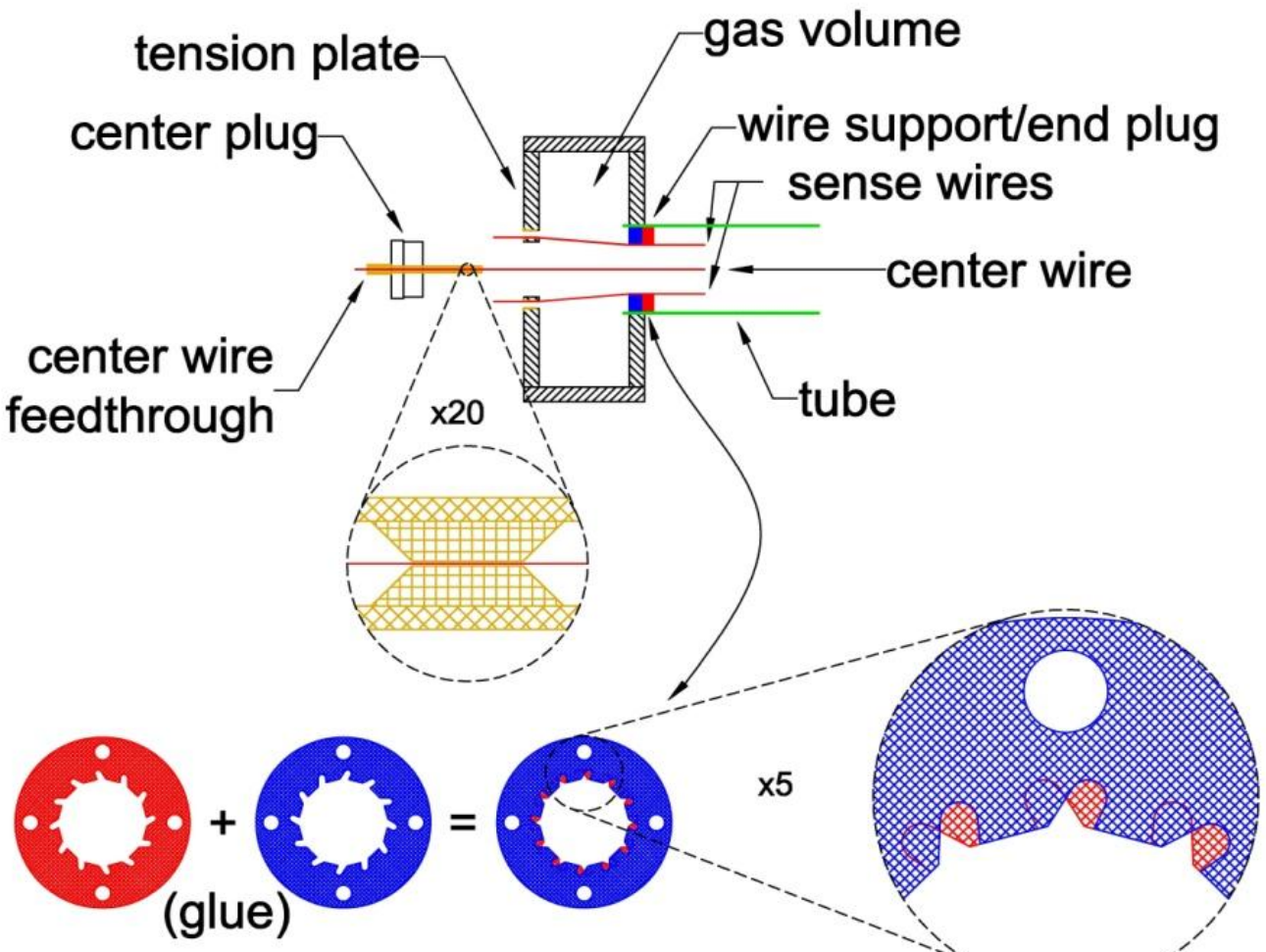


- Stereo configuration
  - Rotate the wire plane at ends by some angle, (15 degrees in our prototype) in opposite direction.

Prototype (30 cm long)

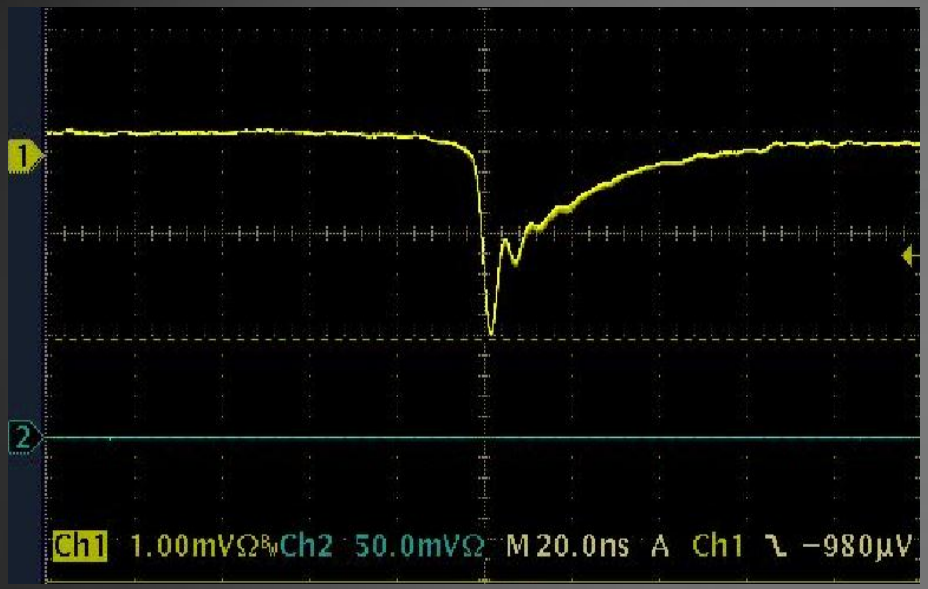


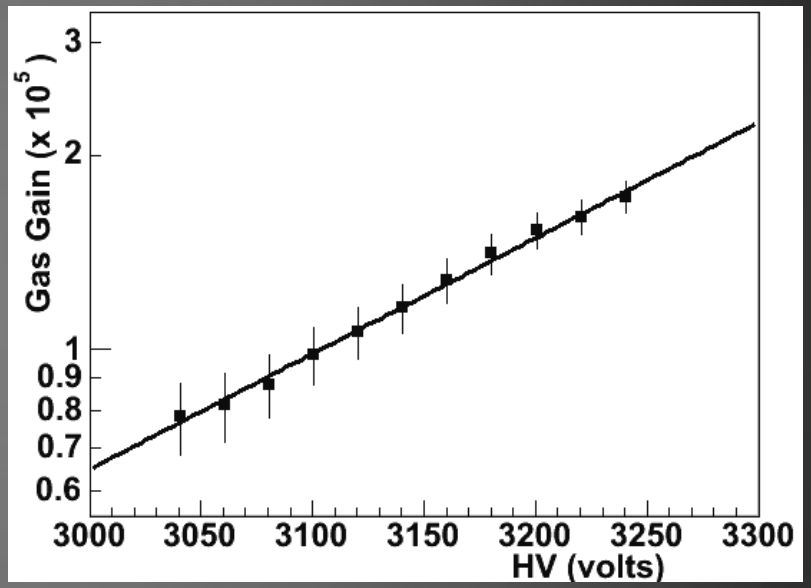
Detector components



wire support/end plug - each piece ~ 2.3 mm thick

Performance





Summary

- Straw tube detector is a mature technology and ideal for operation under extremely high rate
- With muti-anode concept, the straw tube material per hit can be reduce by ~3
  - ~0.6 mm kapton/mylar equivalent thickness for ~60 hits/track
  - A design and a prototype are presented
  - Need a cosmic ray test
    - to measure the resolution as a function of track angle
    - Check the stability and high rate capability
    - Verify stereo concept – also need a MC simulation