# Discussion of In-Vacuo Tracking Technologies

## (Mainly Straws)

- Proposed uses for straw trackers
- What has been achieved with straws
- Out standing technical issues
- Other In-vacuo tracking technologies

Hogan Nguyen, Fermilab
Project X Physics Workshop.
Kaon Session. Jan 25-26, 2008

| Property | Typical Values |
|---|---|
| Hit Resolution | 100 μm |
| cell-size | 5 mm – 10 mm |
| Material | Kapton, Mylar, Carbon-loaded plastic |
| Wall thickness | 25 μm |
| Conductive Lining | Cu, Au, Al Graphite |
| Lining thickness | 100 μm |
| Wire support | once per meter |
| Electronics | Similar to a wire drift chamber |
| hit rate/meter | 100 KHz – 1 Mhz |
| other | mechanical and electrical separation between channels |

Straws are likely the **thinnest** tracking detector while capable of:

- Having ~100% hit efficiency
- Surviving a vacuum environment
- Maintaining a good vacuum (typically $10^{-6}$ Torr needed for a high rate kaon experiment)

However, straw material is always under pressure, and will creep over time.

| Group | Proposed Use in Vacuum |
| --- | --- |
| NA-62 | pion tracker |
| Jparc E-14 | charged tracker<br>charged veto |
| KOPIO@ Project-X | photon tracker |
| MU2E@ Project-X | electron tracker |

Lots of straw experience within the field

CLEO (pre-silicon)
BNL-E871
FOCUS
ATLAS TRT
Compass
BTeV
CKM
MECO
etc ...

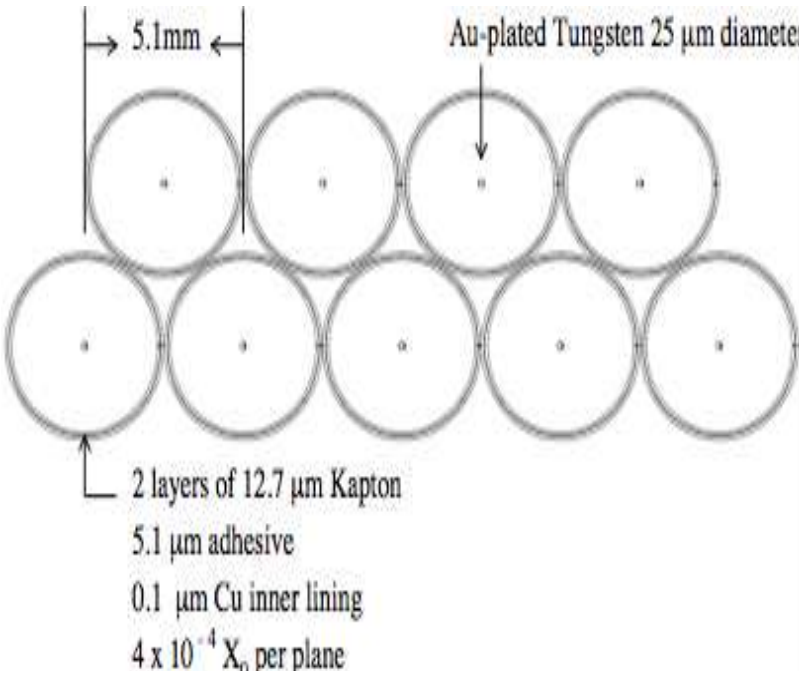
# Material Comparison

| Layout | ($10^{-3}$ $X_0$) |
|---|---|
| KTeV Drift Chamber (X,X',Y,Y') | 1.1 |
| 2 close-packed layers of NA-62 straws | 1.0 |
| 5 close-packed layers of CKM straws | 2.1 |
| 300 μm double-sided silicon strips | 3.2 |
| 4-layers of 500 μm sci-fibers | 5.7 |
| BTeV Silicon Pixels | 8.9 |
| 4-layers of 835 μm sci-fibers | 9.5 |

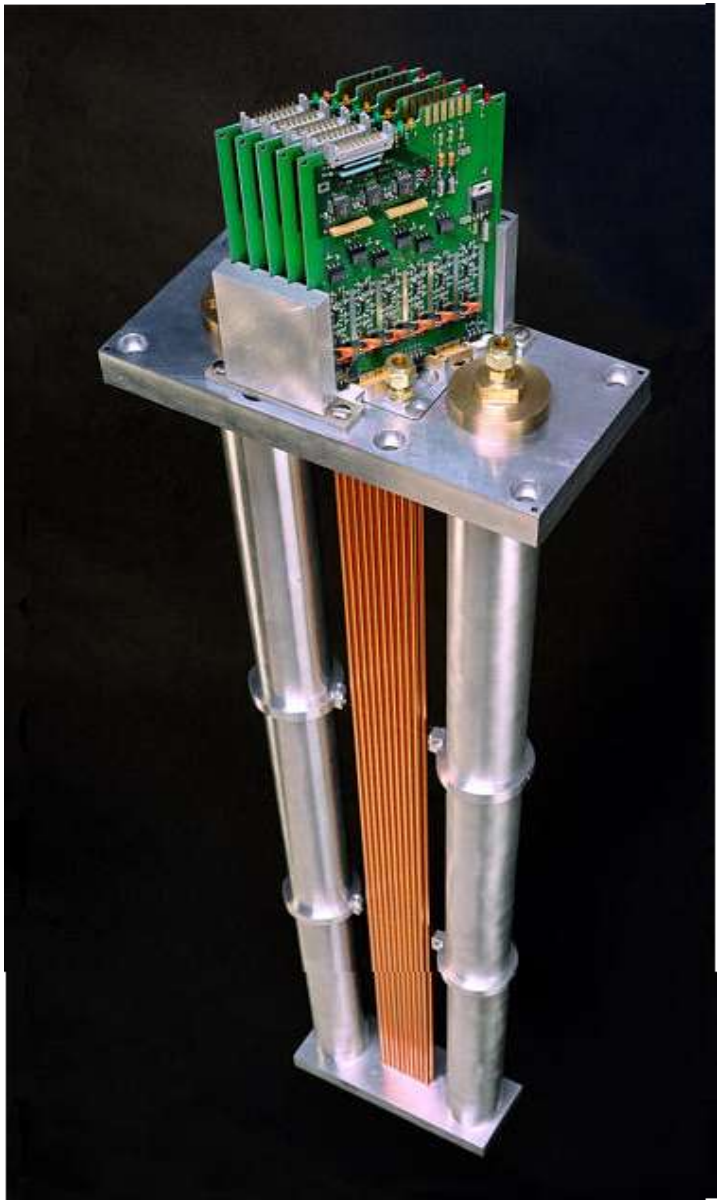
Comparable

Micromegas and GEM trackers may be the thinnest.
But probably won't survive vacuum environment.

CKM-style straws
(idea stolen from BNL-E871)




Fabricated by conventional
2-ply wrapping method



20-straw prototype

CERN NA-62 Straws

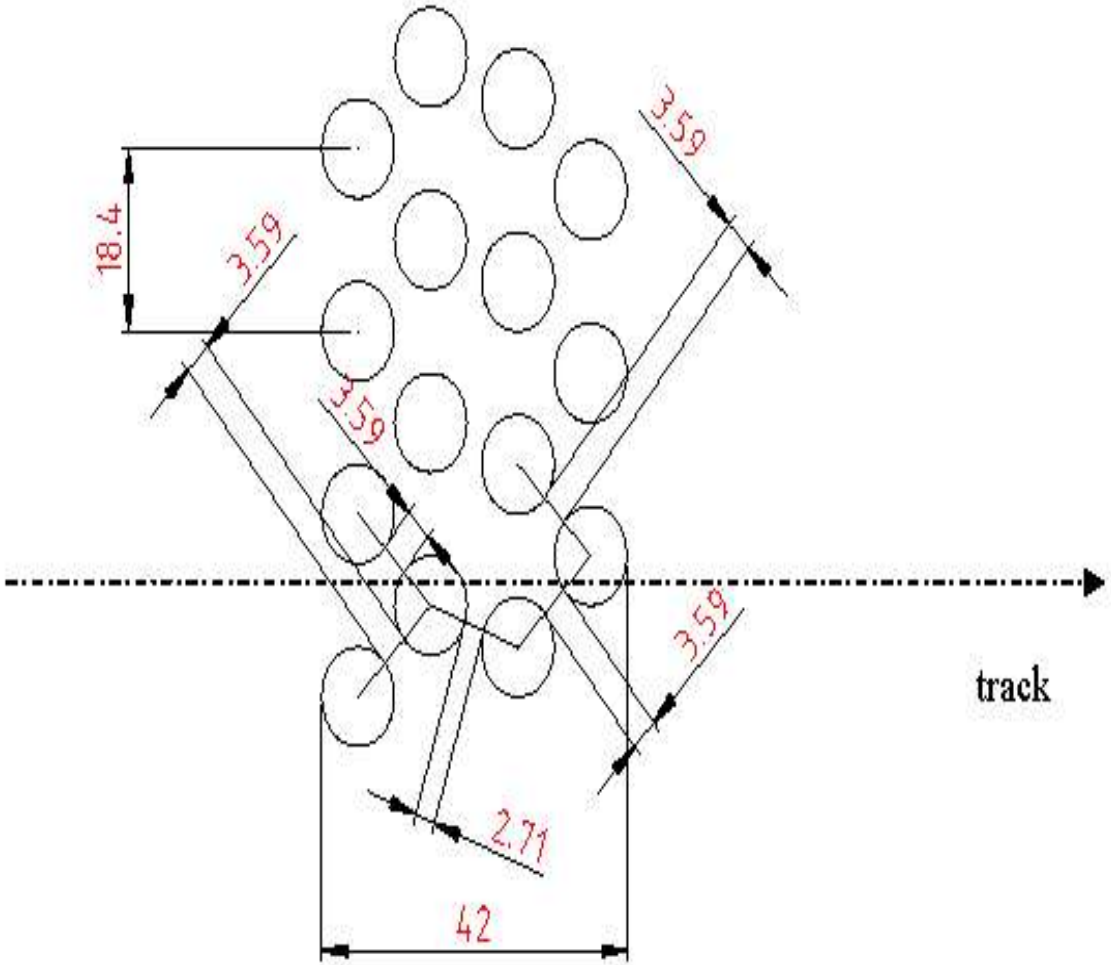
36 μm Mylar wall
9.6 mm diameter straws

70-100 nm Au-Cu lining
(or 200 nm Al lining)

**Gaps** between straws to allow for transverse creep and reduce material.

Fabricated by ultrasonic welding of mylar to reduce creep under longitudinal tension.

Could be stronger and lighter than straws made via 2-ply wrapping method.



NA-62 straws to be fabricated by ultrasonic welding of mylar.

Improves ability for straw to hold tension*

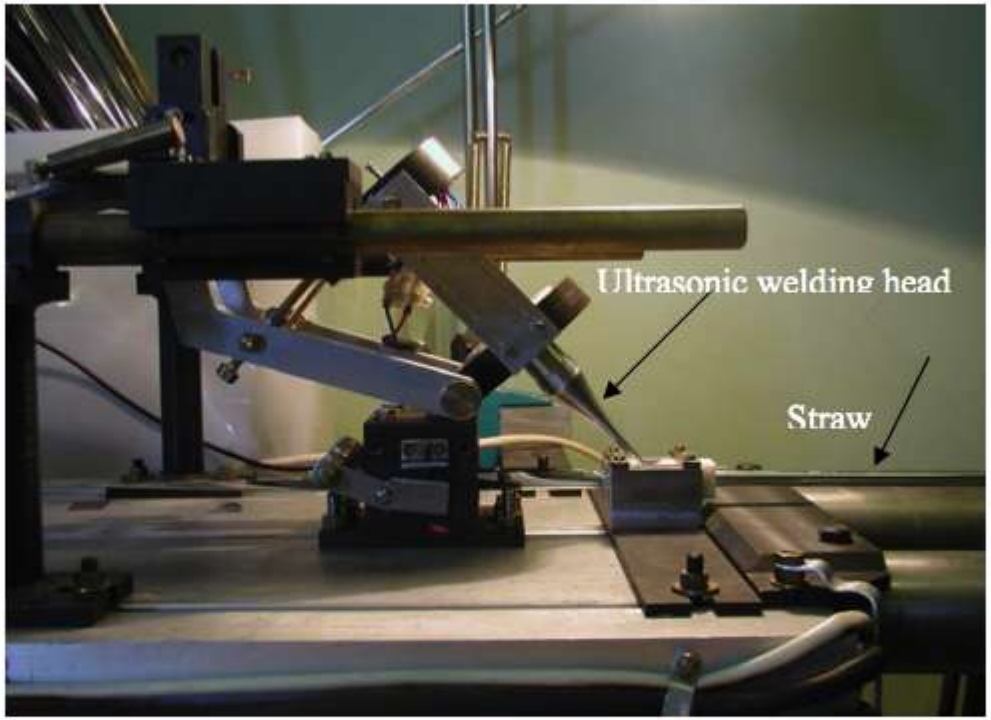
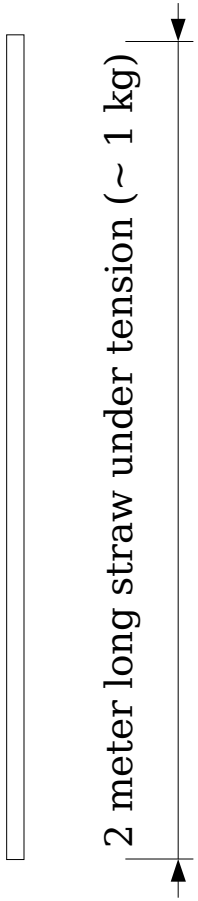
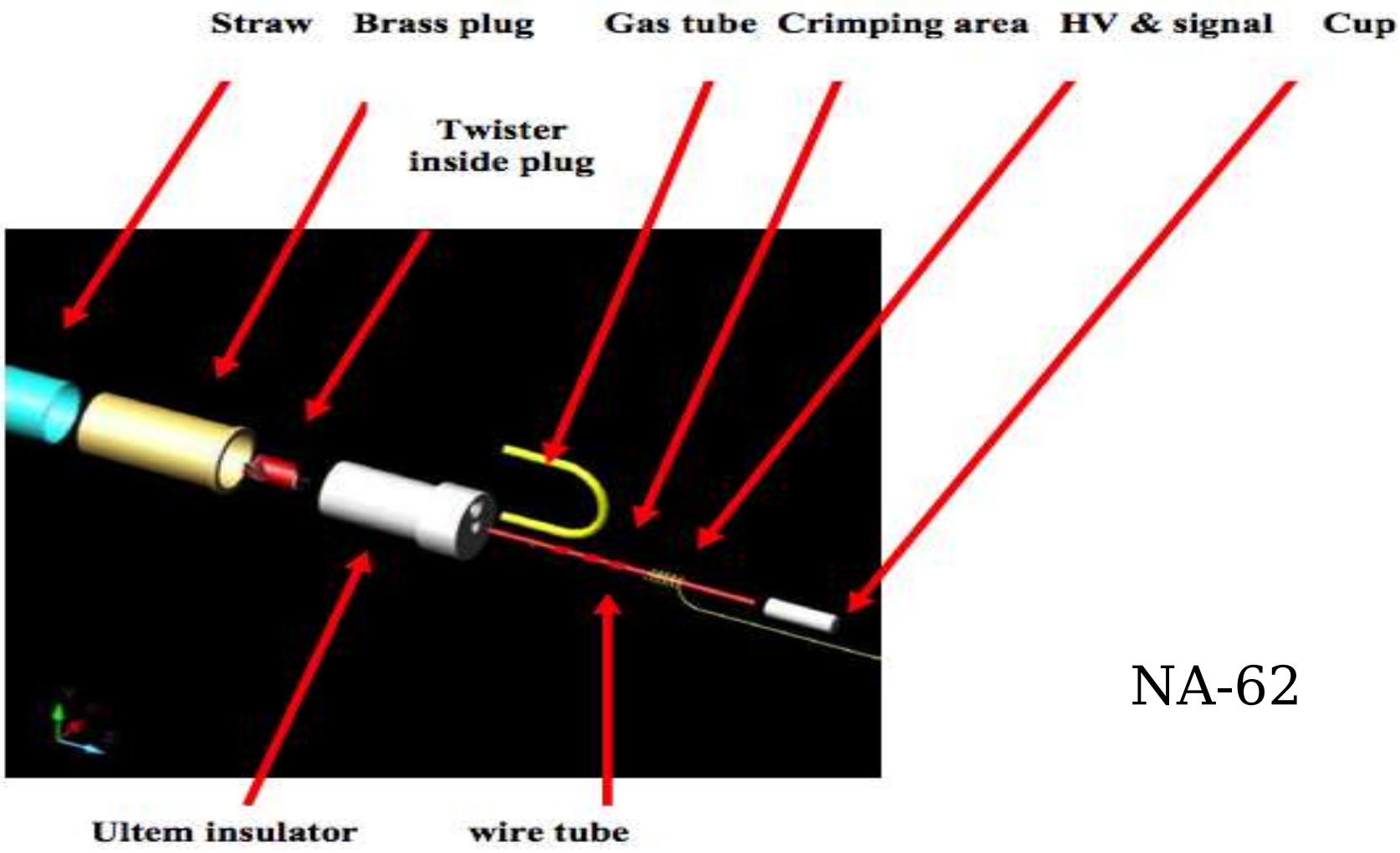



Figure 57: Ultrasonic welding machine for Mylar straws. The welding seam is straight and parallel to the straw axis.




* tension needed to keep straw straight

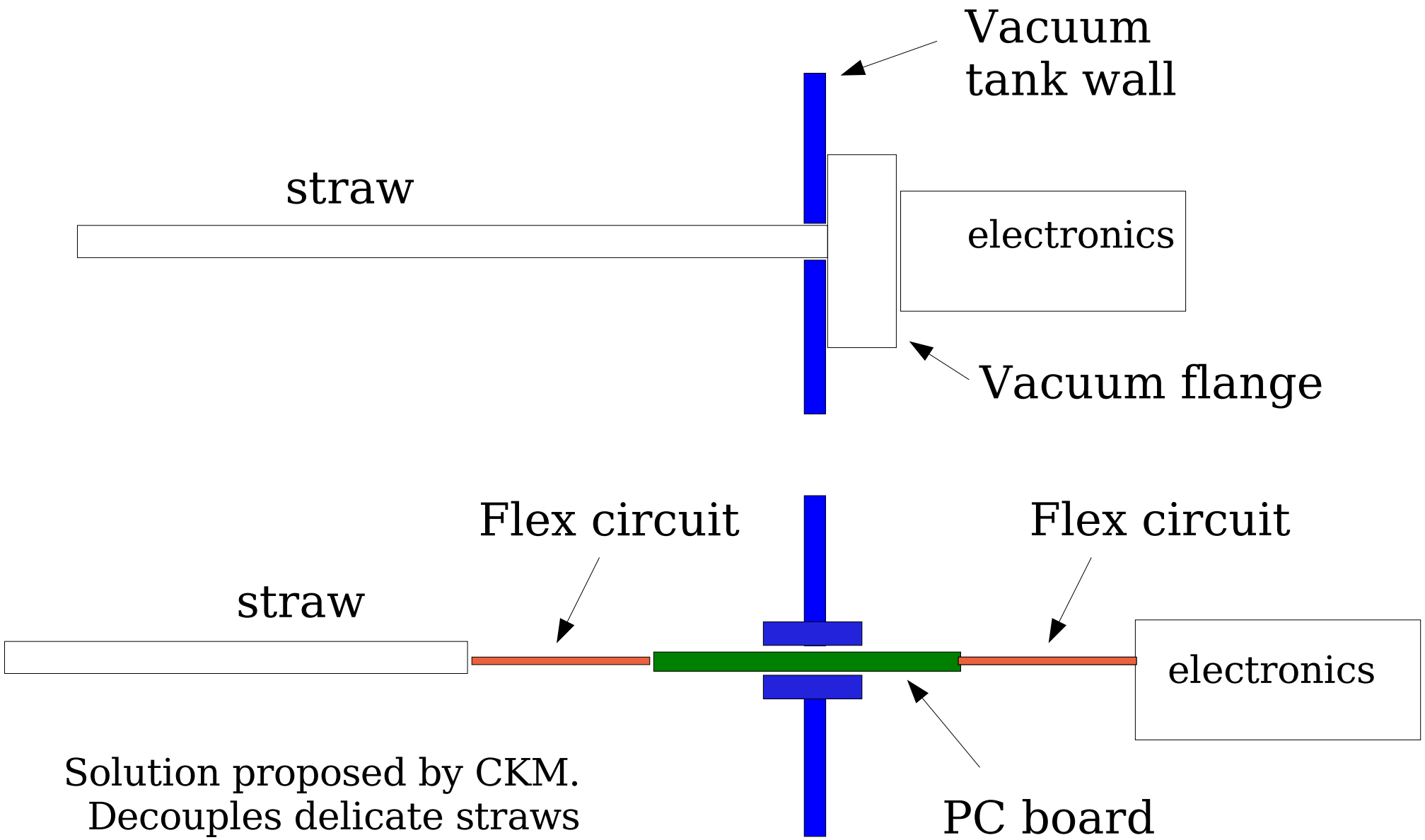
# Gas Handling and Wire Positioning




NA-62

Non-trivial issue, but is a solved problem

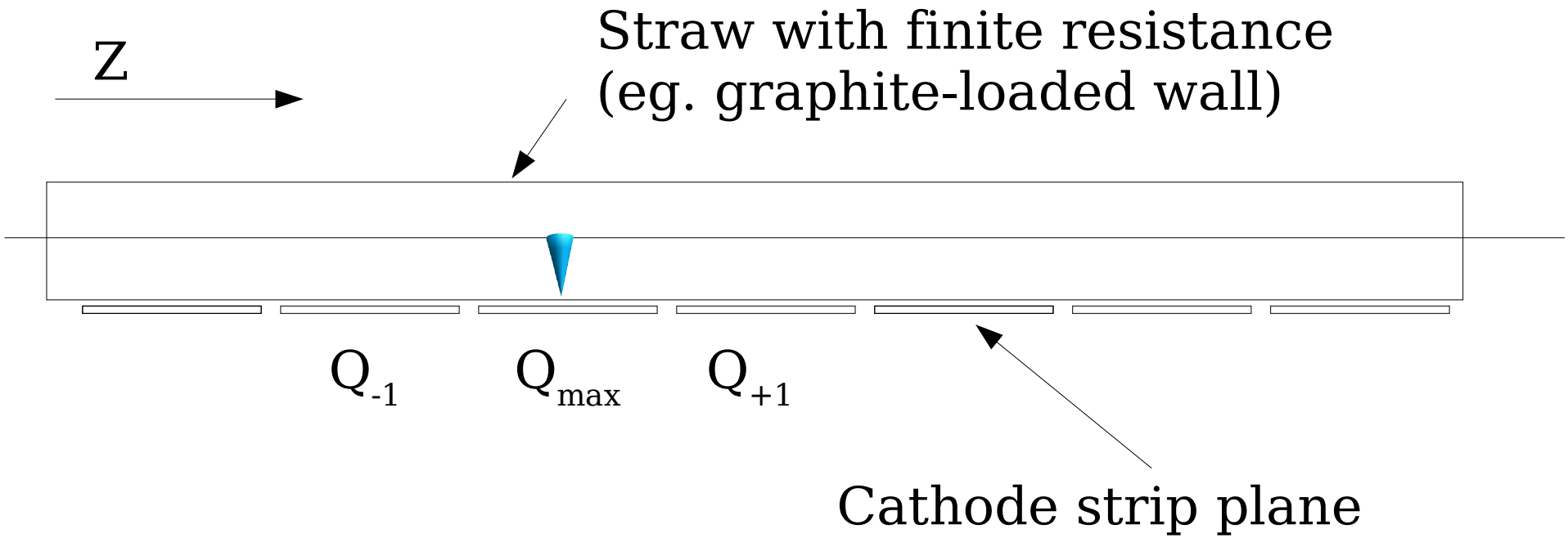
# Remaining R&D ? : Style of Vacuum Penetration




Solution proposed by CKM.
Decouples delicate straws
from vacuum tank distortions

Gas connections omitted

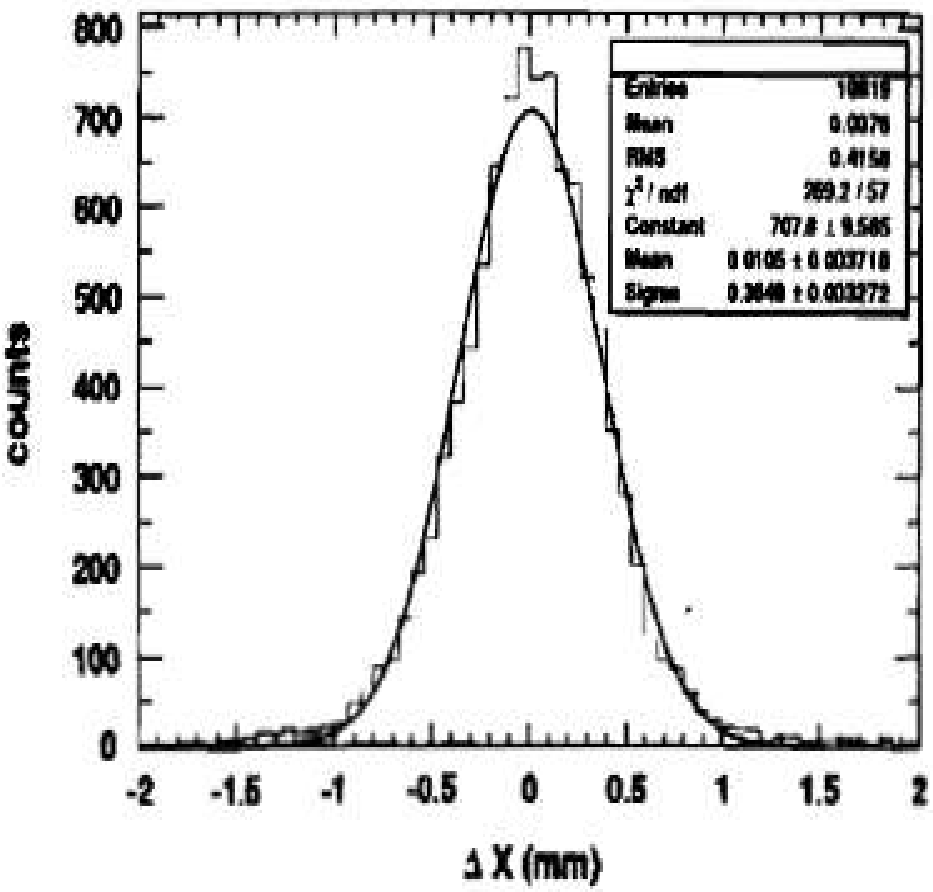
# Z-coordinate measurement via Capacitive coupling to Cathode Plane




Measure Z by gauging the charge sharing between strips $Q_{-1}$ , $Q_{max}$, and $Q_{+1}$

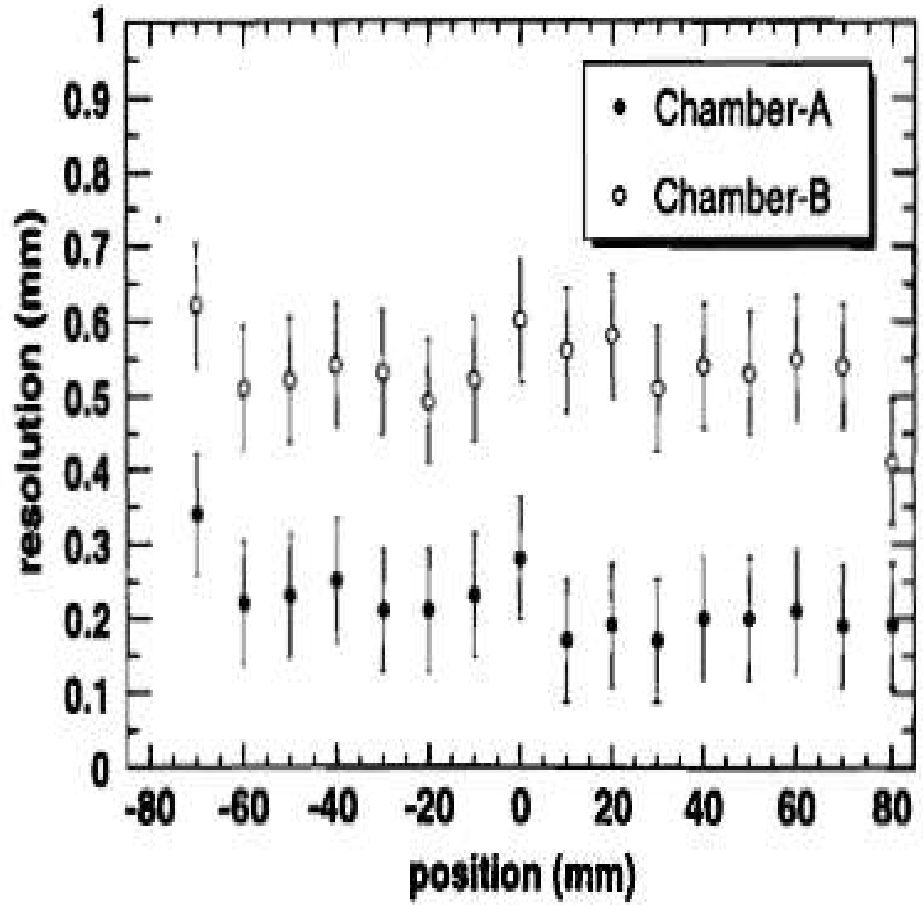
# R&D for MECO Straws: Y. Takubo, et. al. NIM-A 551 (2005)

Achieved 220 μm Z-resolution

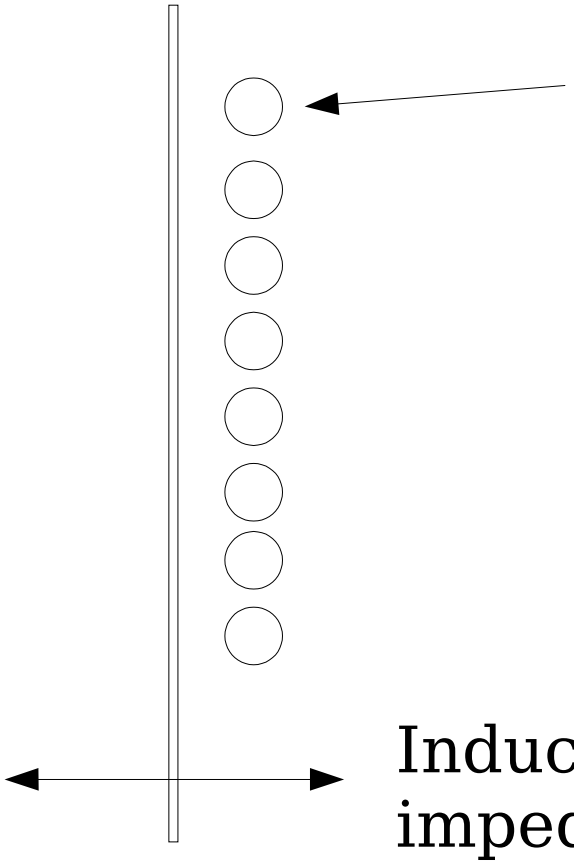



Resolution improves with increasing straw wall electrical resistance

6 MΩ/square vs 0.7 MΩ/square



# Remaining R&D for Capacitive-pickup Cathode Readout ?



Does graphite coating/loading reduce gas permeation to sufficient levels ?

Inductive cathode plane should not impede vacuum

## Other Issues

Can 12 μm thick straw walls be made ?
Uniformity of resistive coating.

## Other Vacuum-Tracking Technology Candidates

- Silicon strips and pixels
- Scintillating Fibers