# Observations on the feasibility of Mu2e-II Straws

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# Decreased Straw Wall Thickness to will reduce the DIO yield

- Mu2e-II is looking to see ~10x more captured muon
- Therefore we would expect the DIO electrons also increase by ~10x
- Reducing the material in the detector would reduce deflected DIO electrons which can act as signal

| | | DIO Yield |
|---|---|---|
| Aluminum | 15 $\mu m$ straws | 2.14 |
| | 8 $\mu m$ straws | 0.26 |
| Titanium | 15 $\mu m$ straws | 2.25 |
| | 8 $\mu m$ straws | 1.19 |

Table from Snowmass "Feasibility Study for a Next-Generation Mu2e Experiment", 9/27/13

# What percent of the electron interactions with the straw is due to Mylar thickness?

| | Thickness (μm) | Rad Length (g cm$^{-2}$) | Density (g cm$^{-3}$) | Ratio of $\frac{\chi_{straw}}{\rho_{straw} l_{straw}}$ to $\frac{\chi_i}{\rho_i l_i}$ |
|---|---|---|---|---|
| Mylar | 15 | 39.95 | 1.38 | 88.0% |
| Aluminum | 0.1 | 24.01 | 2.7 | 1.9% |
| Gold | 0.02 | 6.46 | 19.3 | 10.2% |

- Current Mu2e straws consist of 15 μm Mylar, two thin layers of Al, and an inner thin layer of Au.
- Mylar thickness is the main factor in the straws interaction with electrons

# Side Note : Losing our Straw Bling

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# Side Note : Losing our Straw Bling

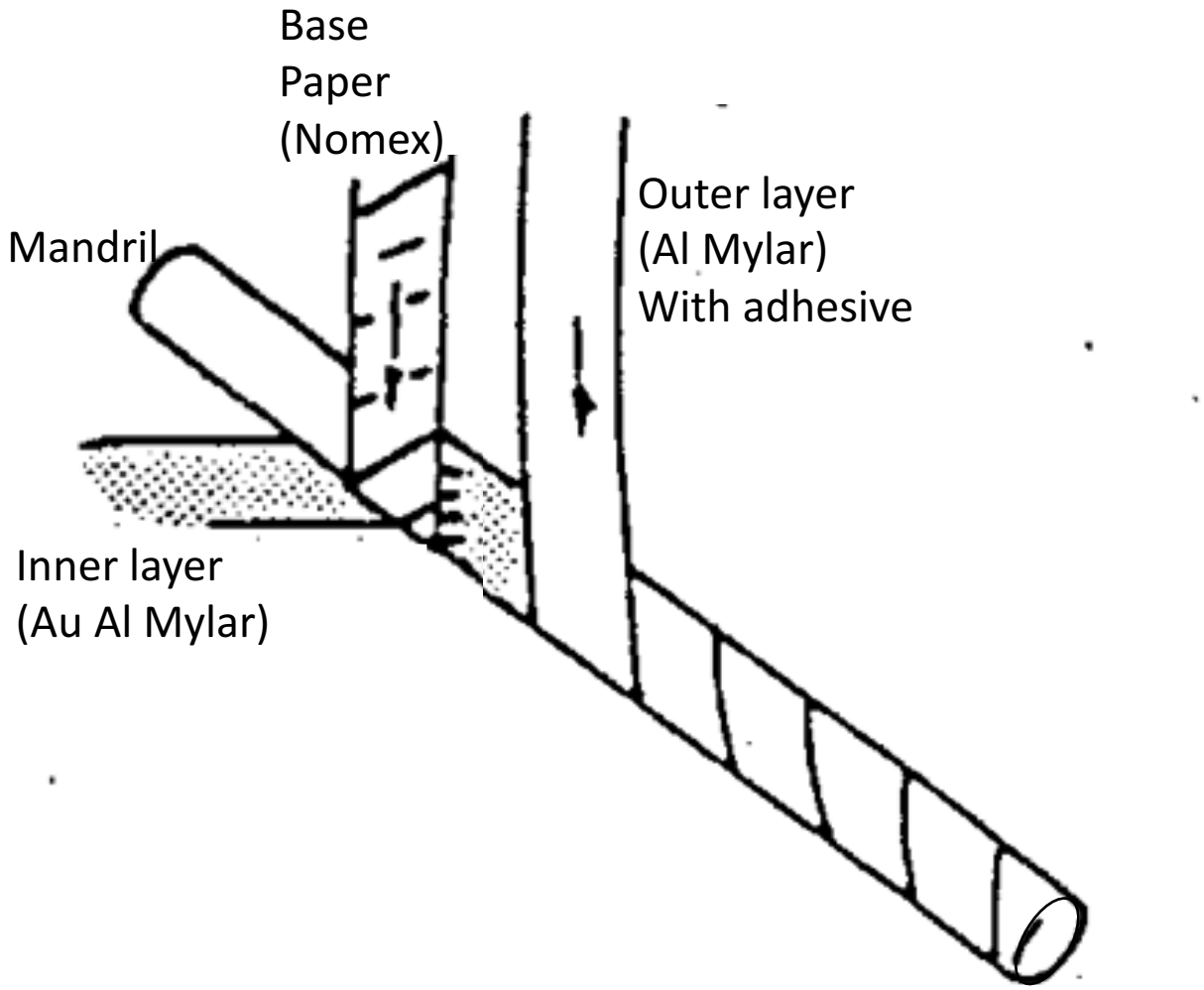
## Why would we want to get rid of the Au layer?:

- Au makes up 10% interactions from straws in tracker (17.3% of 8 μm straws)
- About 60% of straw production cost ($200K) was for the Au Al Mylar

## Can we? Maybe:

- The Panda experiment is using Al only straws
- Al oxide layer is very thin, hasn't been a problematic when conductively attaching
- The Mu2e straws the Au Al formed an alloy and it is unclear that it is better than just Al
- We have a couple thousand Al-only practice straws for Mu2e, a few of which could be used for aging studies to confirm or refute this idea.

# Anatomy of 2 Ply Spiral Winding for Mu2e




- Each layer is 0.5 inch strip at ~45° wind
- Straws are constructed around a mandrill
- Base layer is “Nomex” paper for structure off of mandrill
  - Prevents Mylar from touching mandrill
  - ~60 µm laminate paper
- Inner layer
  - 200 Å Au inside surface
  - 500 Å Al
  - 6.1 µm Mylar® C Polyester Film, 24 Gauge
- Outer Layer
  - Adhesive 4.5 ± 0.5 µm
  - 6.1 µm Mylar® C Polyester Film, 24 Gauge
  - 500 Å Al

Average straw is about 16.8 µm thick

# Does the material exist?

- Mylar C Polyester film comes in 2.54 µm, 3.56 µm, and 6.10 µm
  - Straws would be 7.0 µm, 9.7 µm, and 16.6 µm (assuming 25% adhesive layer)
- Kapton Polyimide Film also possible, but smallest size 7.5 µm

# Current technology (Talking with Paramount Tubes)

They are open to seeing if thinner Mylar can be used in a similar winding method.

(doesn't have to be metalized for initial R&D).

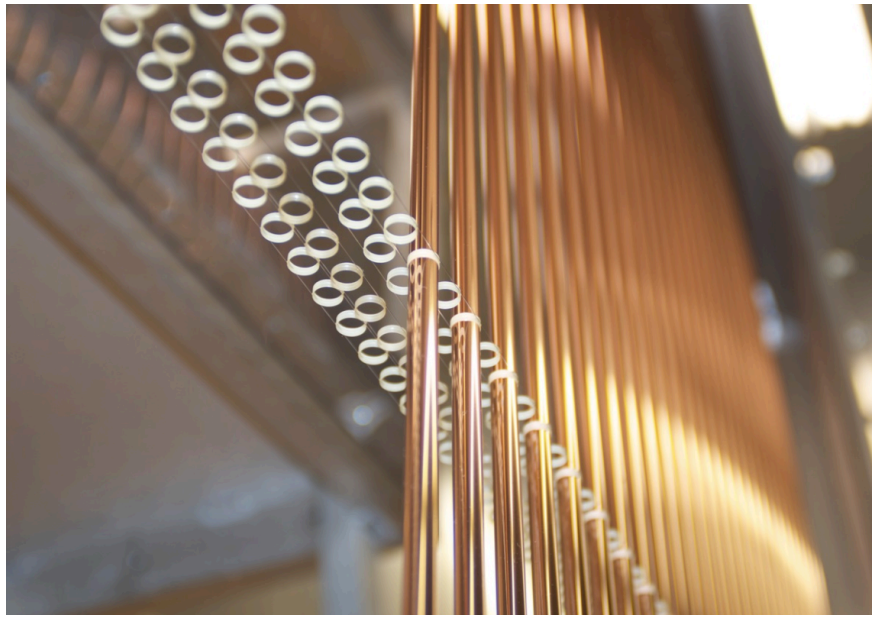
- Thinnest walled straws they have made by Spiral wound : 15 µm
- Thinnest walled straws they have made by Lateral seams : 50 µm, not metalized, lay flat method
- Thinnest walled straws they have made by extrusion : 150 µm

- Difficulties :
  - Tension on the material could be problematic
  - Slitting might be more difficult
  - Structure for packing (thinner Nomex Paper?)

# Thoughts on Lateral Seam Method

Paramount tube doesn't create straws similar to what we would like with a lateral seam.

NA62 did make straws using this method. Unknown whether this method could be used at 1/4$^{th}$ the straw thickness.



***NA62 straws manufactured from 36 μm thin PET foils coated with two thin layers of Cu and Au.***

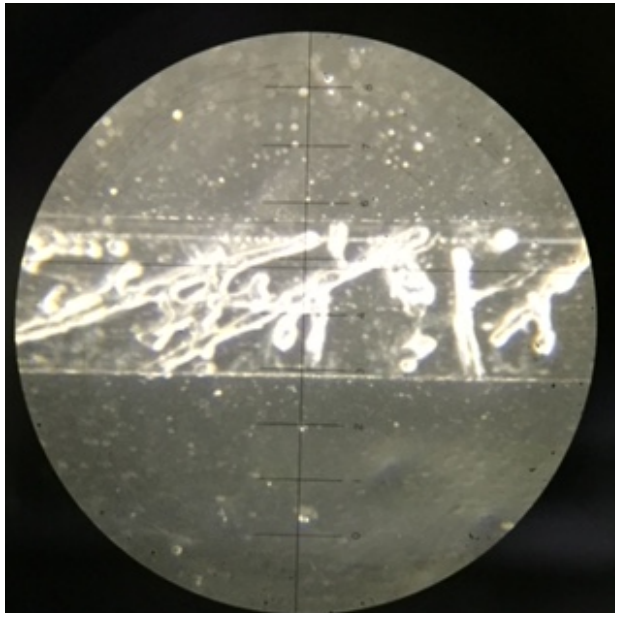
***Panos Charitos,*** **New straw tracker for the NA62 experiment, EP Newsletter**

# Mu2e Straw requirements

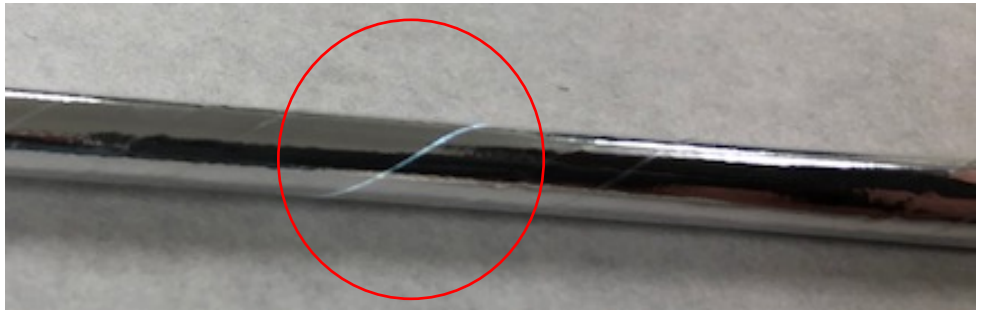
| Straw Requirements | Mu2e result | Mu2e-II difficulty |
|---|---|---|
| 5 mm ID metalized Mylar tube | Fine | Production will be more difficult |
| Sustains > 1 atm pressure difference | Easily sustains > 1 atm<br>Damaged > 4 atm | More difficult |
| Leak rate < 6 ccm / detector volume | Ave. Straw is half the allotted max (~15% straw failure rate) | More difficult |
| Straw straightness: max. transverse deviation/sagging < 0.3 mm for HV stab | Worse case straw needs > 250 g tension to retain straightness | Probably easier |
| 800g Initial tension needed to counter for material relaxation over time. | Can handle ~2 kg before seams start stretching. | Probably easier |
| Sustains radiation over the life time of operation. | No noticeable charge build up when exposed to 1 C/cm | More difficult |

# Seams : Butt or overlap

- The CKM straw tracker found the leak rates were proportion to the seam width.
- Mu2e has seen less of an effect, mostly due to the extra outside layer of metallization.
- Instead of some parts of the straw where there is 1 layer Mylar (butt seams), it might be safer to instead have parts with 3 layer Mylar (overlap seam)
- Some possible concerns with capacitance or adhesive not fully covering overlap, This can be investigated as we made some overlap Al-only straws from mu2e



Inner Seam under a microscope,
Adhesive drying leaves structure in seam



LED inside shows light through inner seam

# Conclusions:

- Reducing Straw thickness would reduce DIO backgrounds
- Material is available to try and make these thinner walled straws
- Production could be attempted using current methods (limited R&D needed on part of manufacturer)
- Current Al-only straws can be used for aging studies and to answer questions:
  - Is Gold needed on the inside?
  - Structural gains/problems from overlap seams instead of butt joint?