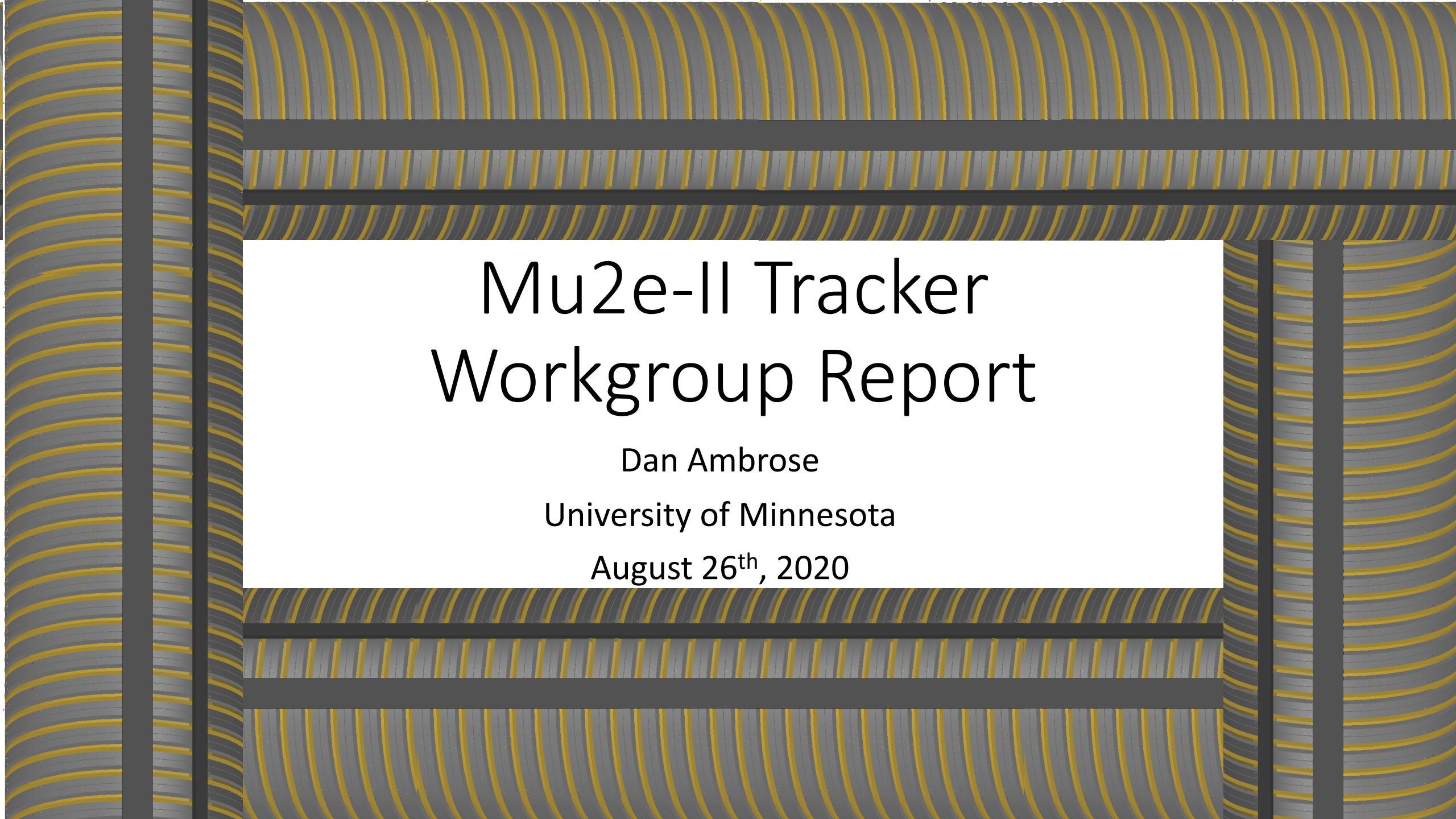


Mu2e-II Tracker Workgroup Report

Dan Ambrose

University of Minnesota

August 26th, 2020

Overview

- Mu2e-II Tracker Workgroup
- LOI
- R&D : Ongoing and Proposed

Prototype 8 μm Mylar Straws

Tracker Working Group:

- **Conveners :** Gianfranco Tassielli, INFN
  Dan Ambrose, UMN
- **Members :** Brendan Casey, FNAL
  Mete Yucel, FNAL
  Manolis Kargiantoulakis, FNAL

Join the list serve : MU2EII-TRACKER

Meeting Schedule : Undetermined, fixing a biweekly time

We would gladly welcome more interested people especially with simulation and software expertise.

Please contact Gianfranco, me, or come to the workgroup meeting

LOI :

We have a rough draft, outlining research which will be examined in the next 9 months and presented for Snowmass 2021.

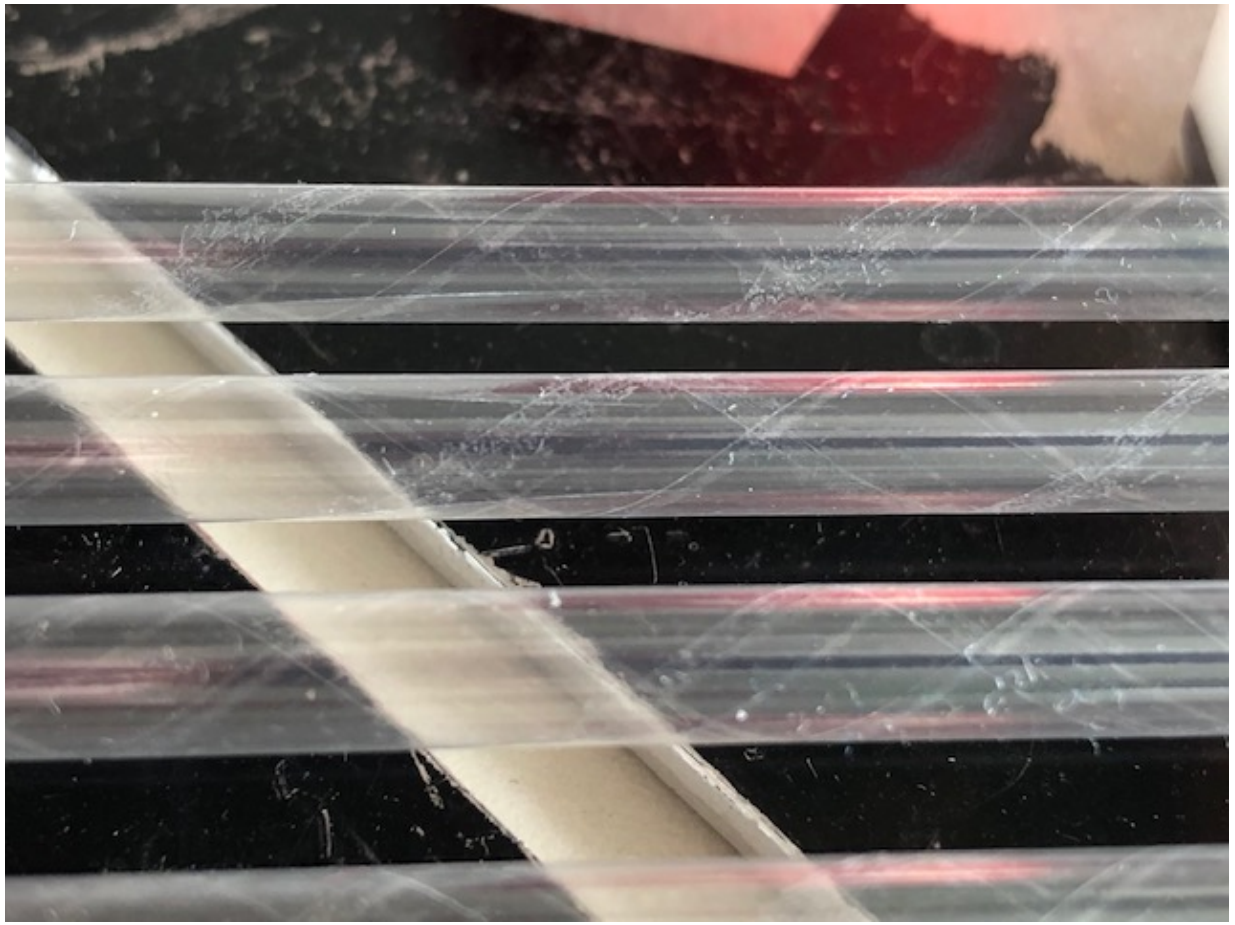
If you have an interest on being on this paper or seeing the draft send me an email (Ambr0028@umn.edu)

Mu2e-II Tracker Requirements

- **Lower mass**
  - **To meet Mu2e-II momentum resolution/background separation goals**
  - **Looking into :**
    - **Thinner straws**
    - **Lower mass sense wires(molybdenum)**
    - **Pursuing alternative tracking technologies**
    - **Pursuing alternative geometries**
- **Survive the increased charge deposition and beam flash radiation :**
  - **Develop radiation-resistant front-end electronics**
    - **ASICS**
    - **DC-DC converter**
    - **Optical components**
- **Increased hit occupancy and timing window**
  - **4x nominal Mu2e hit rate, only 5% reduction in momentum resolution and reconstruction efficiency**
  - **Current design and software is capable of this**

Update LDRD Research : Straw Tests

- **Brendan Casey is leading a team working on LDRD research**
- **First test batch of 8 μm straws made!**
  - **Arrived last week**
  - **Made from unmetalized Mylar**
    - **Two 3 μm mylar layers with 2 μm adhesive**
  - **Holds 30 PSI gauge pressure**
    - **No noticeable deformation at 30 PSI**
  - **Being tested for mechanical properties**
    - **Subjected to linear tension and inflation pressure**
    - **Measure material creep**
- **First batch appears to have been successful**
- **Second batch**
  - **Metalized Mylar being ordered**
  - **Metalized straws used for leak tests**
  - **Charge Load/Aging tests**
  - **Long term tension and creep measurements**



Pressurized 8 μm Mylar Straws

Initial impressions

Difficult to handle.

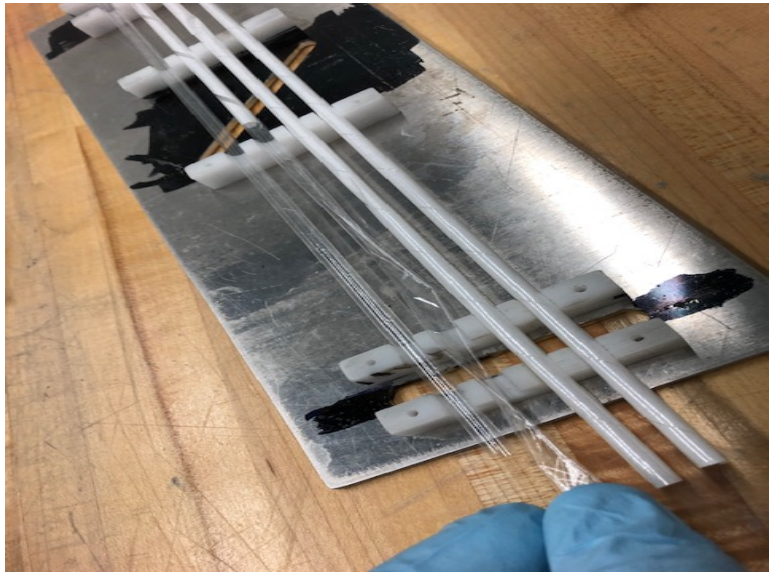
- Crinkles during all steps when not inflated.
- Significant static causing parts of straws to collapse in initially
  - This should improve w/ metalization
- **If these straws can pass requirements, we can find a way to safely handle and install**
  - Thinking about keeping straws individually inflated in tracker construction

Straws become robust when inflated.

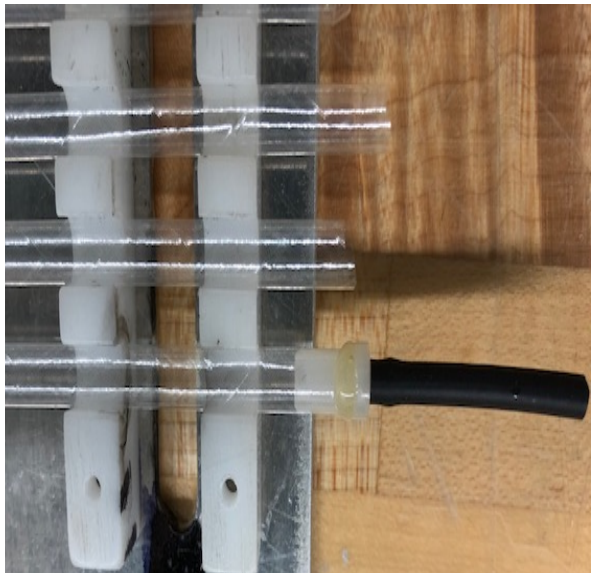
- All 4 samples held 2 atms without deformation.
- Took 2 straws above 2 atms.
- One “popped” at 2.8 atms, while the other held over 3 atms.

Straws felt noticeably more elastic.

- Tension and creep studies to begin shortly.



Removing paper support



Gas seal for straw inflation

Straw Property Comparison

Straw Requirements	Mu2e 15 µm straws	Mu2e-II 8 µm straws	Challenges
5 mm ID metalized Mylar tube	Fine	Fine	none
Sustains > 1 atm pressure difference	Easily sustains > 1 atm Damaged > 4 atm	*Sustains > 1 atm *Damaged > 2.5 atm	Higher hoop stress *Initial test looks good
Leak rate allowance	Ave. Straw is half the allotted max (~15% straw failure rate)	TBD	Expect a higher failure rate
Straw straightness: max. transverse deviation/sagging < 0.3 mm	Worse case straw needs > 250 g tension to retain straightness	TBD	New creep tests needed
Initial tension needed to counter for material relaxation over time.	Initially 800 gf is needed. Straws can handle ~2 kg before seams start stretching.	TBD	New creep tests needed
Sustains radiation and charge build up over the lifetime of operation.	No noticeable charge build up when exposed to 1 C/cm	TBD	Test at 10 C/cm

Simulations Work:

A lot of simulation work is needed for the Snowmass paper.

Estimating the effect of reducing straw wall thickness is an easier task.

Testing ideas of changing the geometry or type of tracker will require more simulation work.

More expertise in simulations would be gladly welcome in the tracking workgroup.

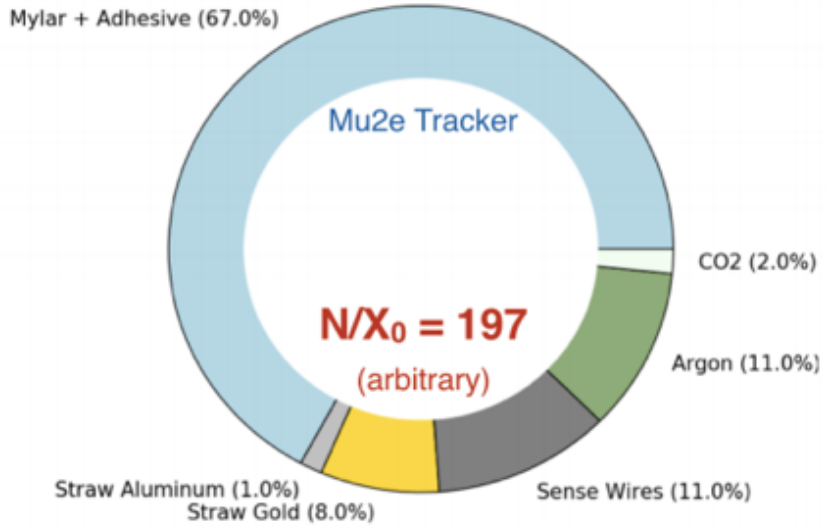
Conclusion

- **Tracker work group has begun preparing for Snowmass2021**
- **LOI is in drafting process**
- **Succeeded in constructing straws with 8 μm wall thickness**
  - **More research to follow**
- **You are welcome to join us. Plenty of room for new people and new ideas.**

Backup slides

Current Mu2e Tracker Requirements:

- 5 mm ID metalized Mylar tube cathode
- 15 µm wall thickness
- Operates in vacuum
  - Sustains > 1 atm pressure difference
  - Leak rate < 6 sccm for entire detector
- Stability
  - Straw straightness: max. transverse deviation/sagging < 0.3 mm for HV stability.
  - Longitudinal tension is applied to keep straw straight.
  - Initial tension need to be higher to account for material relaxation over time (creep).
  - Sustains functionality while aging past the lifetime of operation (10 years).



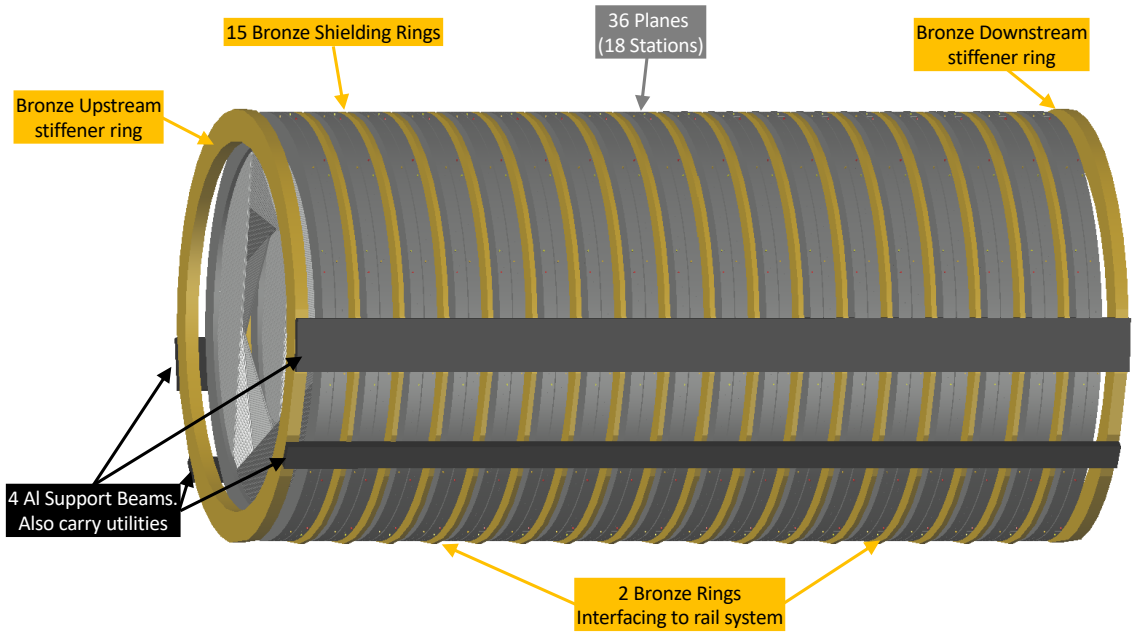
Jason Bono

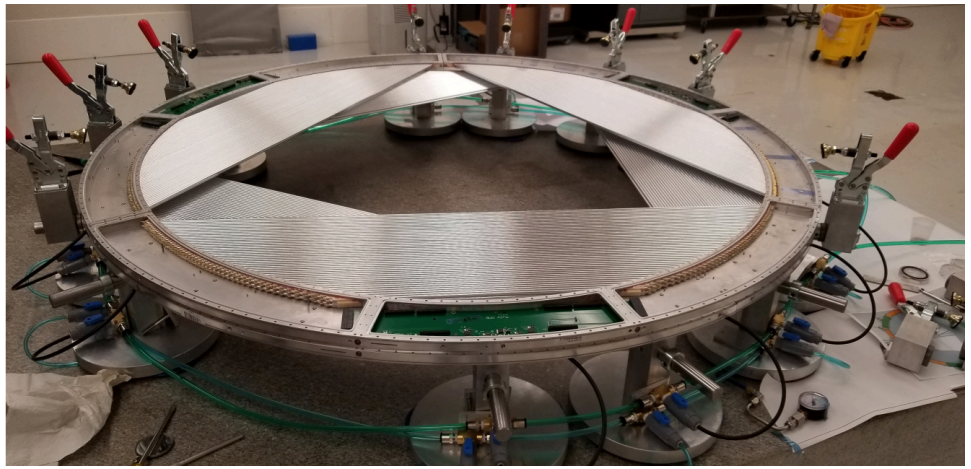
Component	Key Dimension		Density (g/cm^3)	Cross section (cm^2)	X_0 (g/cm^2)	$L\rho/X_0$	Fraction of Total
Mylar	15	µm	1.4	2.36E-03	40.00	1.32E-04	67.1%
Aluminum	1000	Å	2.699	1.57E-05	24.01	2.83E-06	1.4%
Gold	200	Å	19.3	3.14E-06	6.46	1.50E-05	7.6%
W (25µm)	25	µm	19.3	4.91E-06	6.76	2.24E-05	11.4%
Argon	80%		0.00133	1.96E-01	19.55	2.13E-05	10.8%
CO_2	20%		0.00037	1.96E-01	36.20	3.19E-06	1.6%
Total (one straw)						1.97E-04	

Table 1. Composition of a straw.

From Mu2e Tracker Geometry Docdb#888

Current Mu2e Tracker





Design Features:

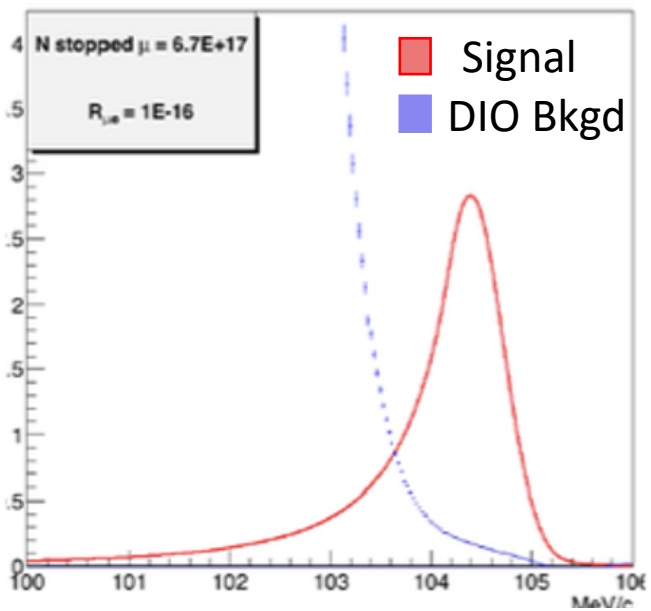
- **Made from 20,736 Proportion Drift Tubes**
- **Gap through middle to blind to low momentum background and avoid much of the beam flash.**
- **Detection region is low mass**
- **Structural components, electronics and shielding in outer cylinder.**

Requirements:

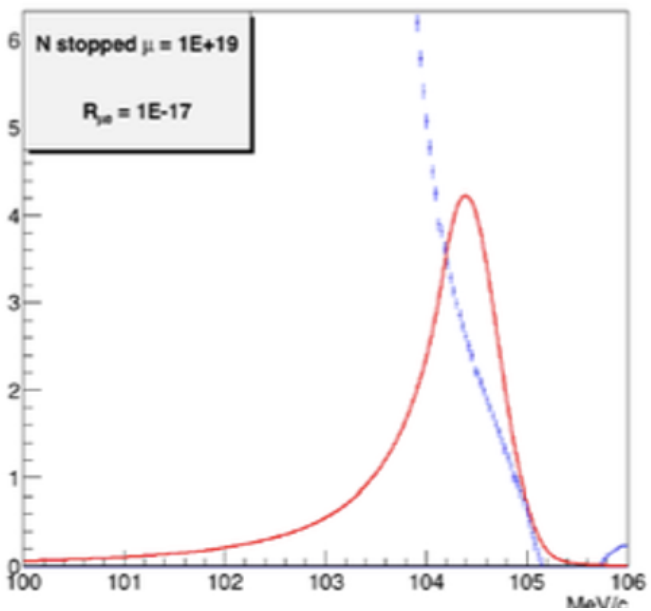
- **Core momentum resolution < 180 keV/c at 105 MeV/c**
- **Efficiency for the combined acceptance and reconstruction of 105 MeV/c electron tracks around 20%**
- **Leak plus outgassing rate below 6 sccm**
- **Operates without access to the detector train for repairs more frequently than once per year**
- **Handle a hit rate of up to 5MHz/straw, 500 ns after the peak of the proton bunch reaches the production target**

The Tracker requirements are described in DocDB #22804

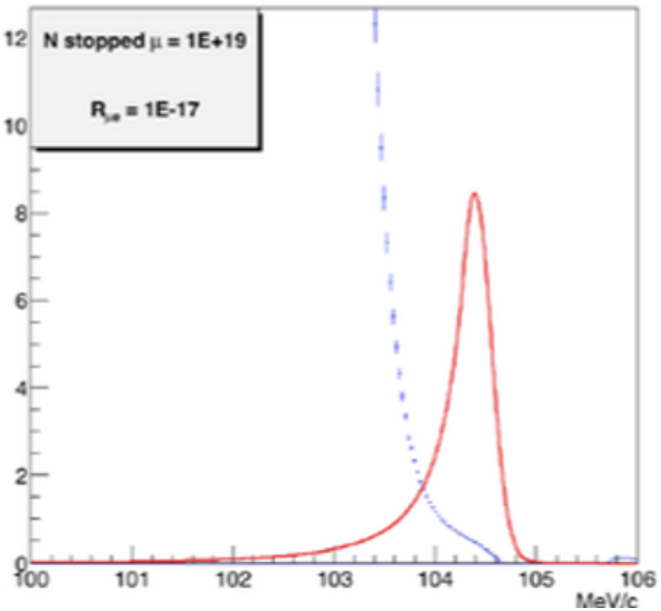
Would the same tracker work in Mu2e-II Environment?



Mu2e Rate and Background



Mu2e-II Rate and Background
With Mu2e Tracker
(15 μm wall straws)



Mu2e-II Rate and Background
With Lower Mass Tracker
(8 μm wall straws)

Toy MC from Dave Brown

- The reuse of the Mu2e tracker would exceed allowed background budget of Mu2e-II which is 1 event
- Biggest concerns:
  - DIO background
  - Increased aging effects from radiation