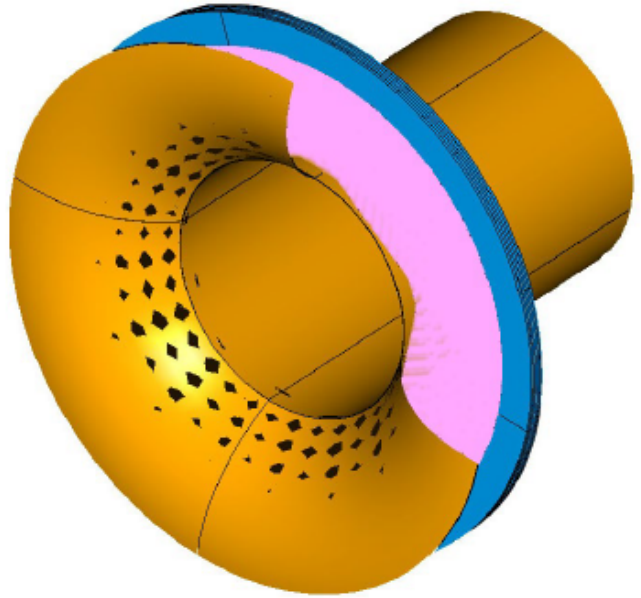
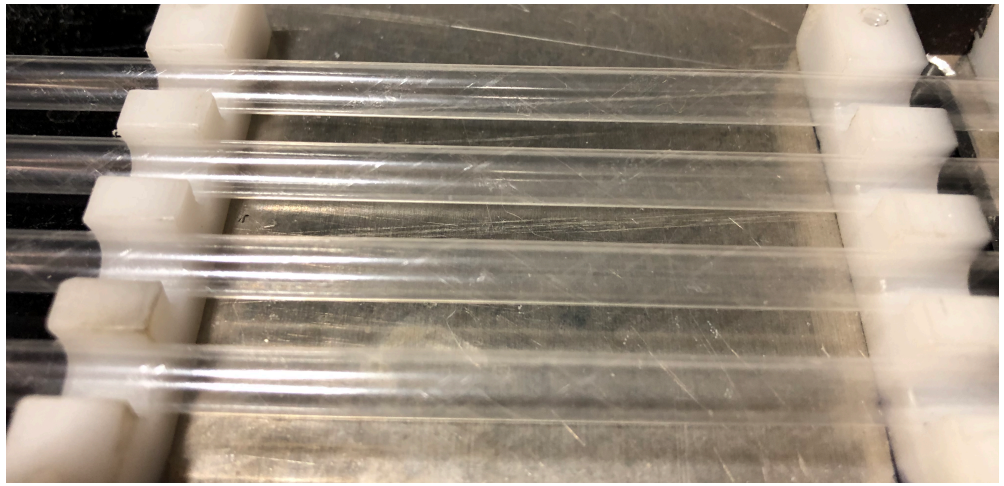
Mu2e-II Tracker Workgroup Report

Dan Ambrose
University of Minnesota
Jul 21st, 2021





Mu2e-II Tracker Workgroup:

Join the list-serve : MU2EII-TRACKER@fnal.gov

Meeting Schedule : Bi-weekly Tuesdays 12:00 PM CST. Next one is Aug 3rd.
Zoom link sent through list-serv
or online on the calendar of
https://mu2eii-internal-wiki.fnal.gov/wiki/Main_Page

Workshop Scheduling : Doodle poll has been sent out to the list-serv.
Expected to be in the middle of August

We would gladly welcome more interested people.

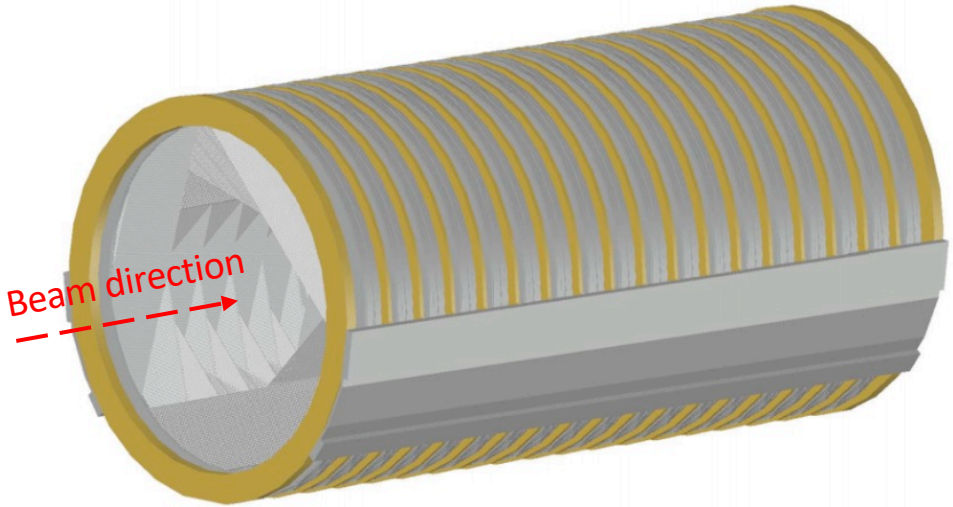
Please contact Gianfranco(giovanni.tassielli@le.infn.it), me(ambr0028@umn.edu), or come to the workgroup meeting though the list-serve

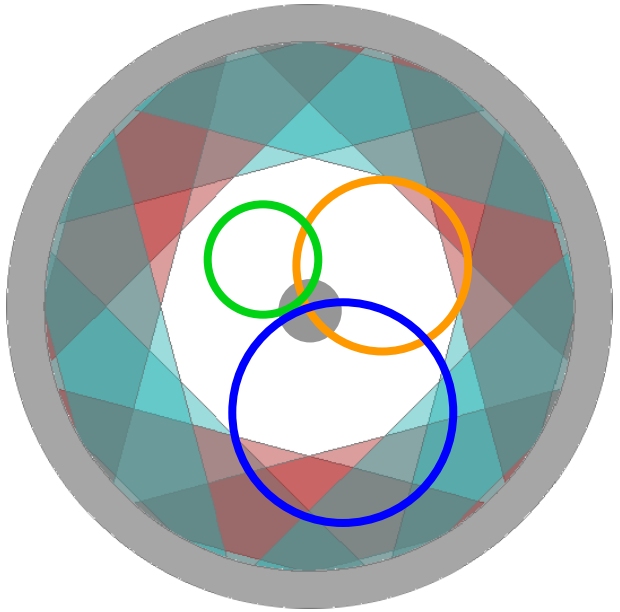
Mu2e Tracker Requirements

- **Electron momentum resolution: < 180 keV/c at 105 MeV/c**
- **Efficiency for acceptance and reconstruction of 105 MeV/c electron tracks: >20%**
- **Work in vacuum: operation limits for outgassing rate : < 6 sccm**
- **Hit rate: > 5MHz/channel, 500 ns after proton bunch hits production target**
- **Access : < once per year**
- **Operation time: > 10 yrs**

Tracker Design: Straw drift tubes measure track curvature through a 1 T magnetic field.

- **Segmentation to minimize occupancy**
- **Thin walls minimize multiple scattering**
- **No support structure in tracking region**
- **High radiation survival (structure & electronics)**

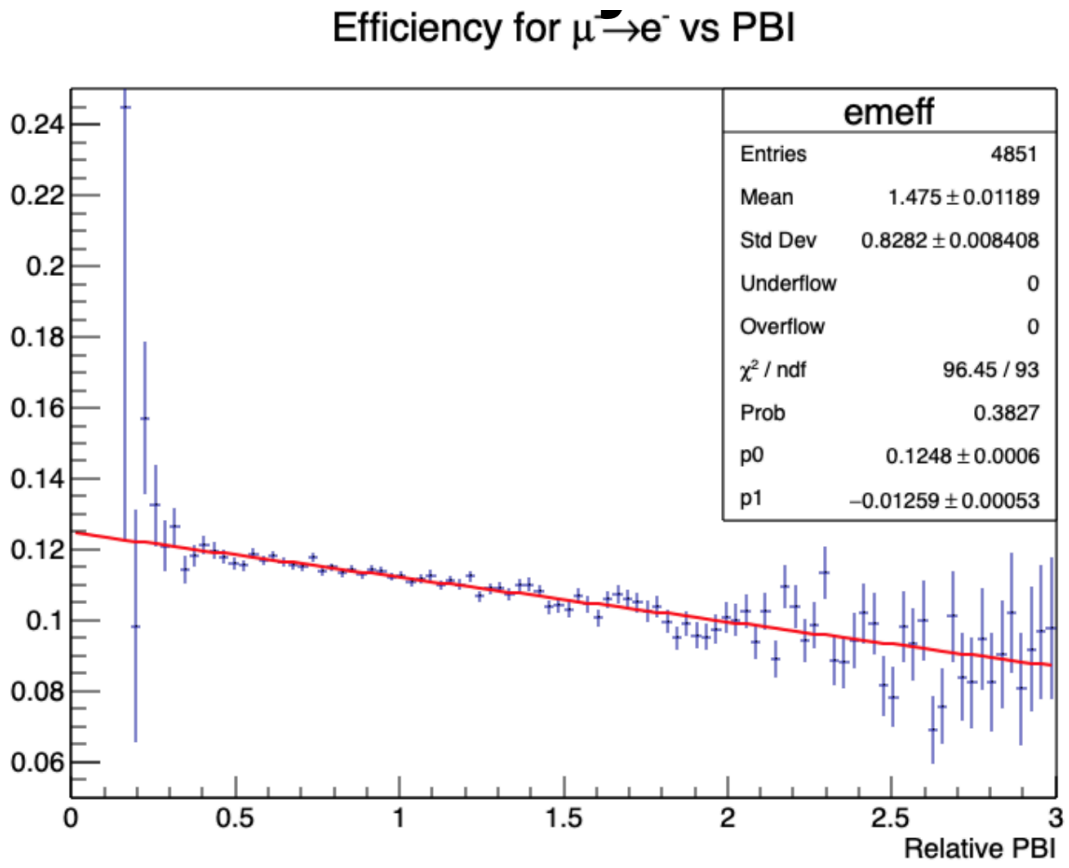




beam's-eye view of the tracker

Mu2e-II Tracker Requirements

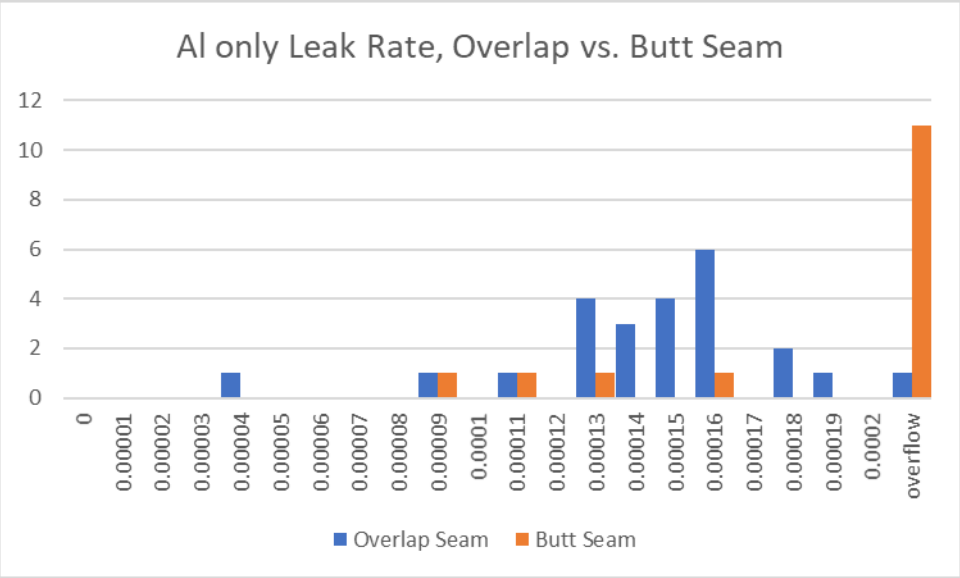
- **Lower mass**
  - **To meet Mu2e-II momentum resolution/background separation goals**
  - **Looking into :**
    - **Thinner straws**
    - **Different Geometry**
    - **Lower mass gas or sense wires**
    - **Pursuing alternative new technologies**
- **Survive the increased charge deposition and beam flash radiation :**
  - **Develop radiation-resistant front-end electronics**
    - **ASICS**
    - **DC-DC converter**
    - **Optical components**
- **Increased hit occupancy and timing window**
  - **4x increase in Proton bunch intensity reduces reconstruction efficiency by 30% (extrapolated)**



MDC2018, Dave Brown
Docdb# 28281

Straws Studies

- Difficulty finding vendors for aluminum only 3 µm Mylar for Straw tests and a possible small prototype
- Designed and constructing a permeation test stand to try and understand what the minimum thickness of coating we can get away with and also study gap/overlap/butt seams.
- Looking into different metal deposits
- Communicate with COMET and NA-62 about other straw production options



Overlap Seam removes holes created in paper removal

Overlap Seams **Butt Seam**

Overlap Seams stick out!

This is probably a dead end unless we can redesign the winding process/where the adhesive is applied.

8 μm thin-walled straw's material studies

We have been examining material properties of straws.

REU Student Anjali Dziarski (Indiana University) has been instrumental in designing experiments and gathering data on the straws.

Multi-layered Thickness Measurement

Density measurement

	Metallization	Wall Thickness (µm)	Linear Density (g/m)	Max Internal Pressure (atm)	Noticeable inelastic deformation tension (g)
Mu2e Straws	0.02 µm Au 0.10 µm Al	18 ± 1 *Batch Dependent	0.35 ± 0.01	5	1500
Mu2e-II Prototype Straws	*None Investigating Al only option	8.2 ± 0.1	0.15 ± 0.01	3	500

To Do:
Sag vs. Tension
Long Term Creep Test
***Leak Rate Measurement**
***Charge Deposition Study**

***Need metalized Mu2e-II straws**

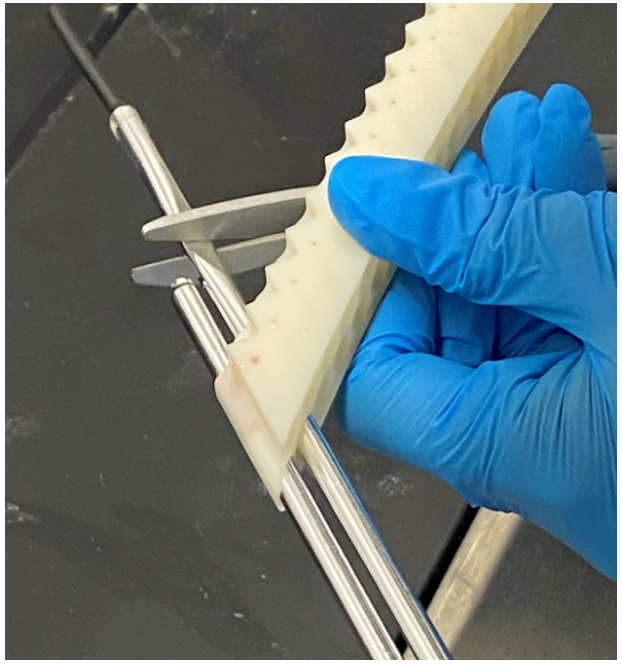
Tracker Construction Techniques

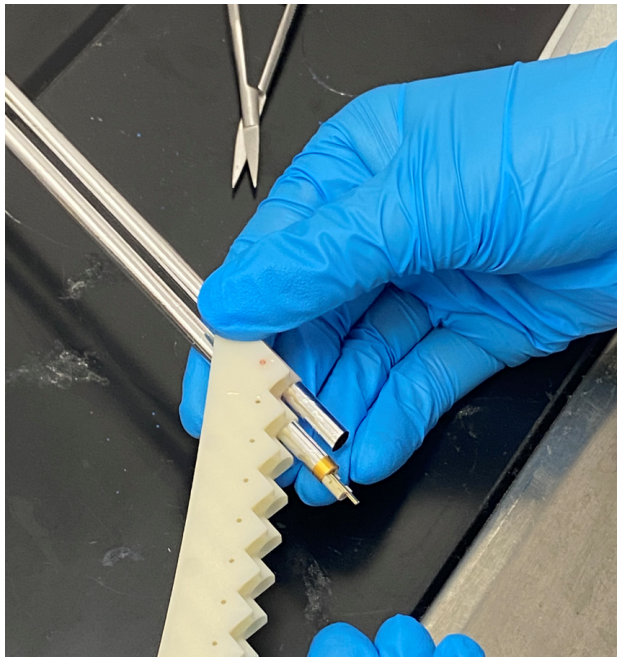
We're testing proof of concept for ideas for handling these thinner straws :

- **Installing inflated straws**
- **Cutting straws to length in Panel**
- **Installing endpieces in Panel**

Observations :

- **Modified Sealing endpiece fits through inner ring and seals straw**
- **Cutting jig needed**
- **Installing terminations is very doable, cleaning up silver epoxy is difficult**





Tracker Simulation Update

Goal is to have a simulation to estimate tracker requirements and test different options including different technologies.

- **Mu2e configuration with reduced straw material**
- **Drift chamber alternative**
- **Radial TPC based on u-well technologies**
- **A tracker based on light Si sensors (Mu3e like)**

Geant-4 Simulation being used to explore different geometries and detector options.

Building a toy MC to study momentum resolution (Conversion / DIO separation power).

Start with radiative spectra of e^- from muons stopped on Al

- **Czarnecki and Szafron calculations**

The toy will scale, shift and smear those distributions

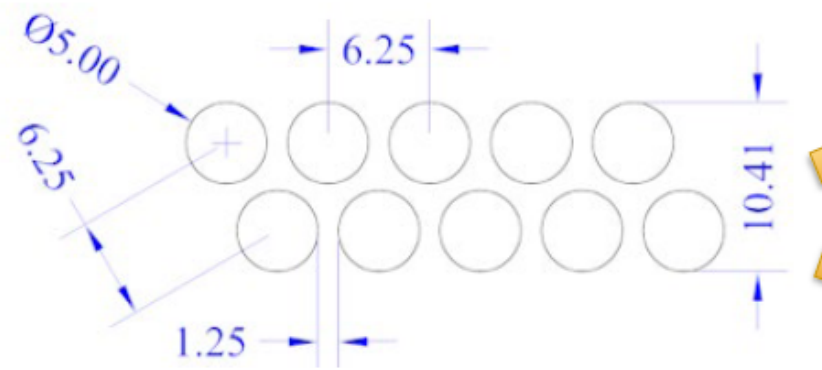
- **Scaled by muon stopping rate**
  - **depends on target mass**
- **Shifted and smeared by energy loss and straggling**
  - **Target, IPA, and Straws separately**
- **Smeared by momentum reconstruction resolution**
  - **Straw multiple scattering**
  - **Intrinsic straw resolution**
  - **Tails due to background rates**
- **Scaled by acceptance X efficiency**
  - **Geometry affects acceptance**
  - **Background hit rate effects efficiency**

Simulation help welcome!

A possible alternative to Straws

Instead of using straws for the cathodes use:

- all thin wires (conf. 1)
- thin metalized Maylar foils and thin wires (conf. 2/3)

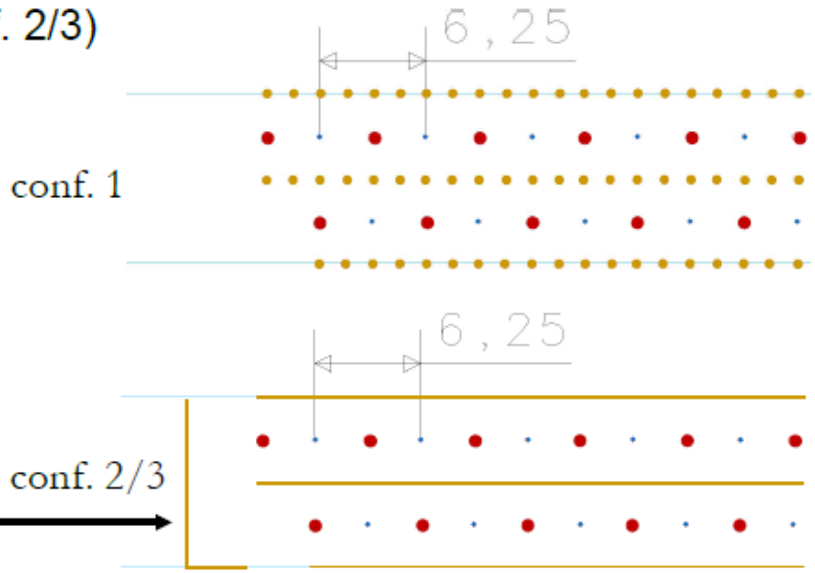


or

Option: use unique foil to be gas-tight

Assumption:

- 20 μm W wires
- 50 μm Al wires
- 40 μm Al wires
- 2.5 μm Mylar with 500 Å Al



Simple construction (as used for MEG-II drift chamber):

- with a wiring robot, build 3 layers of cathode wires (or use 3 foils)
- build 2 layers of anode and cathode wires
- machine 4 planar spacer layers
- stack the wire layers and the spacer layers (in the right sequence) on a support frame.
- use dowel pins and screws to align and to lock (no glue, apart from conf. 3).

G.F. Tassielli DPF2021

Summary

Planning on hosting an online workshop in middle of August

Simulations to study the expected performance and to evaluate different options in ongoing:

- **Using Geant-4 simulation looking into different tracker geometries**
- **Toy MC being developed to estimate electron energy resolution based on parameters of the tracker, stopping target, and proton absorber.**

Tracker designs being tested by simulation and building prototypes:

- **Initial batch of 8 μm thin straws have passed multiple material requirements.**
  - **Purchase of metalized prototype batch has run into significant delays in material procurement.**
  - **Designed test stand for determining amount and type of metallization required of the straws**
  - **Material tests on the initial batch continue.**
- **Developing techniques in Tracker construction**
  - **Building a small prototype with inflated straws**
  - **Material testing on overlapped seam straws**