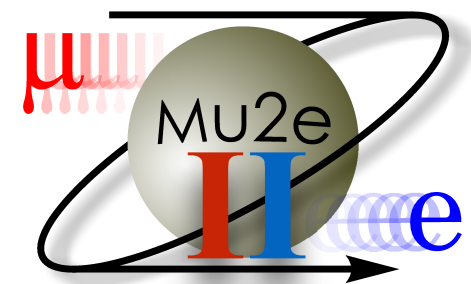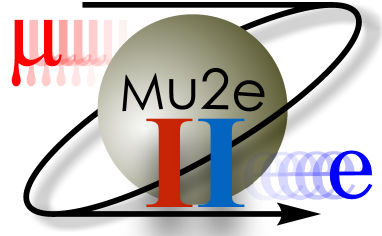# Tracking Summary

Mete Yucel
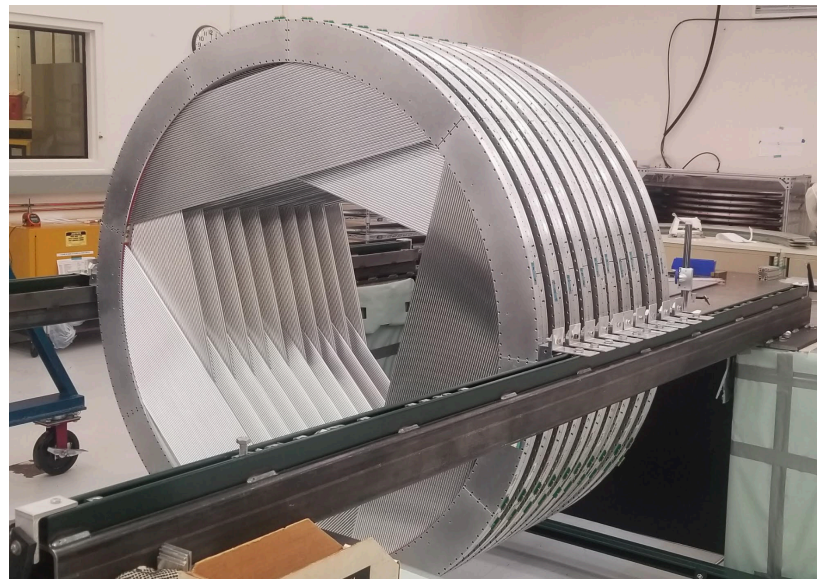
Future Muon Facilities at Fermilab Workshop March-2023

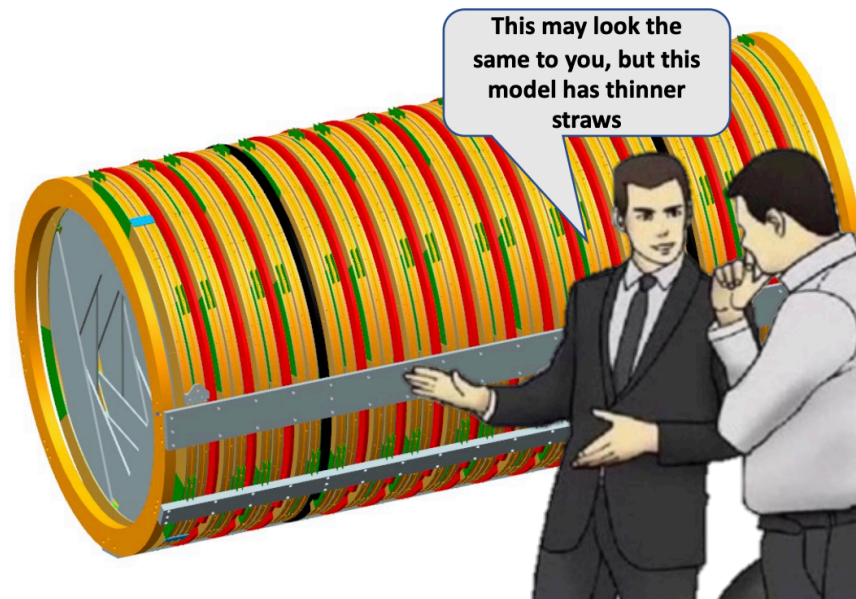# Mu2e-II tracker introduction - 3 possible paths

Using existing tracker

- Tungsten wire does not expected to sag.
- 60% of straw sag happens in the first year.
- Aging implication is unclear.
  - Could go either way.
  - We will know more after Run-1.

New tracker based on Mu2e design

This may look the same to you, but this model has thinner straws

- Lots of ideas based on experience of building the tracker.
- Future requirements to handle rates and reach target sensitivity.
- It must be optimized for constructibility and pattern recognition with the goal of achieving best momentum resolution.

Something else entirely
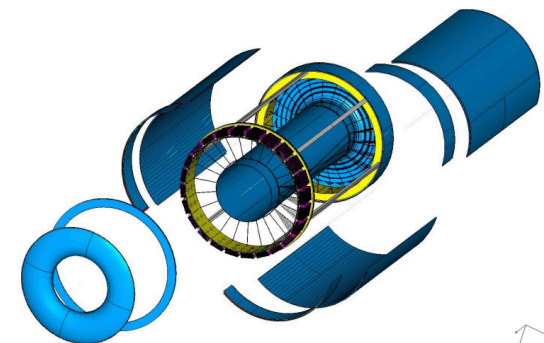
Possible Mu2e-II Alternative I-Tracker Design

Mu2e-II White paper
https://arxiv.org/pdf/2203.07569.pdf
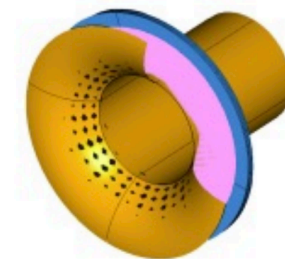
FIG. 24. Pictorial views of tracker alternative, a station of a Mu2e tracker like inserted in the C-fiber gas vessel.
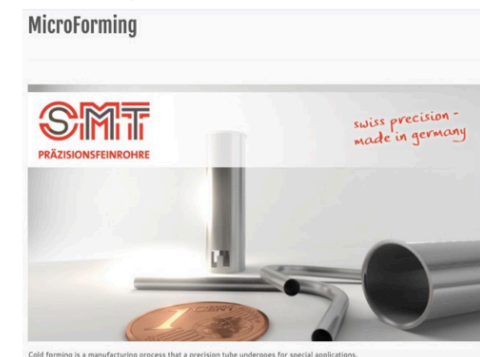
- I-tracker.
- Pressure vessel tracker.

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Mu2e-II construction of straws

- Straw thickness.
  - 8 um mylar straw.
  - Ultrasound weld.
  - Microforming.
- Reducing metallization.
  - Profound effect on performance and leaks.
  - Needs testing for other metallization candidates and thicknesses.
- LDRD exist for developing Mu2e-II straws.
- Track Toy is suitable for this kind of study.

DOI: 10.1134/S1547477122020108
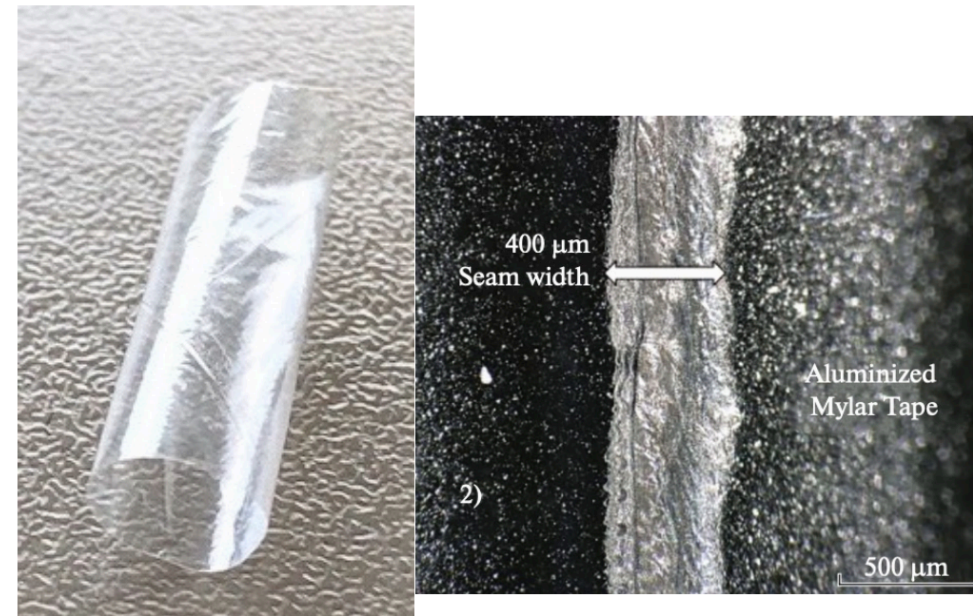
8 μm Mylar Straw　　**12 μm Comet : ultrasound weld**
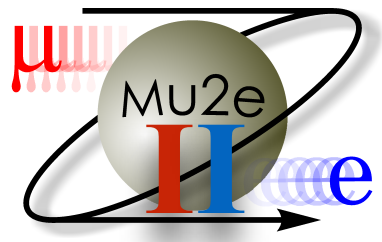

Microforming a new extremely thin extrusion method

Mu2e-II construction of a tracker panel

- 3 layer straw design.
- PIR improvements/redesign.
  - Hard to establish the middle layer seal.
  - Need to look at current 3d printing capabilities.
- Bigger diameter straws.
- Crimping vs soldering.
  - Both are viable.
- Track Toy is suitable for this kind of study.
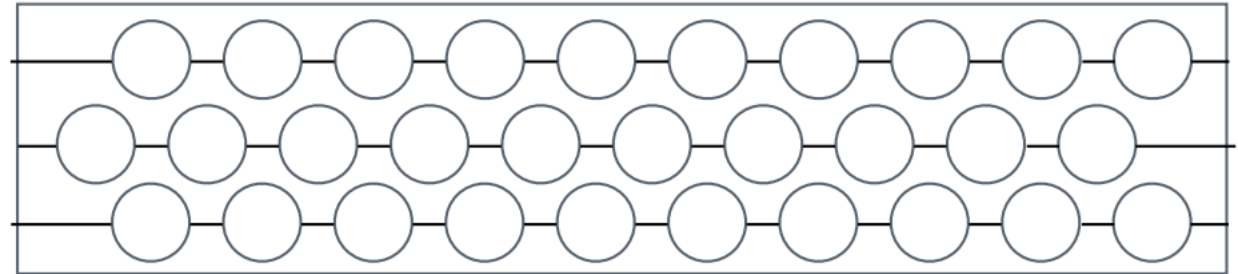
Mu2e-II tracker gas change

- Switch to different gas.
  - ArCO2CF4
  - Helium isobutane.
  - New mixture R&D.
- Switching gas or gas pressure has effect on;
  - Gain
  - Drift velocity and reso.
  - Diffusion.
- It also has effect on aging.
  - Needs to be studied.
- In the end, it is a matter of optimization.
  - Other gas mixtures may require gas recovery.
- Track Toy is suitable for this kind of study.
- Also need Garfield/Spice sim for different running conditions.

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Mu2e-II electronics

- Mu2e-II rate rough guess at 1.6MHz/straw.
- Need to deal with this rate.
- Need to keep an eye on rad.
- <u>ASICs were a hot topic.</u>
  - Lower power.
  - Takes less space in the panel.
  - Digital instead of analog.
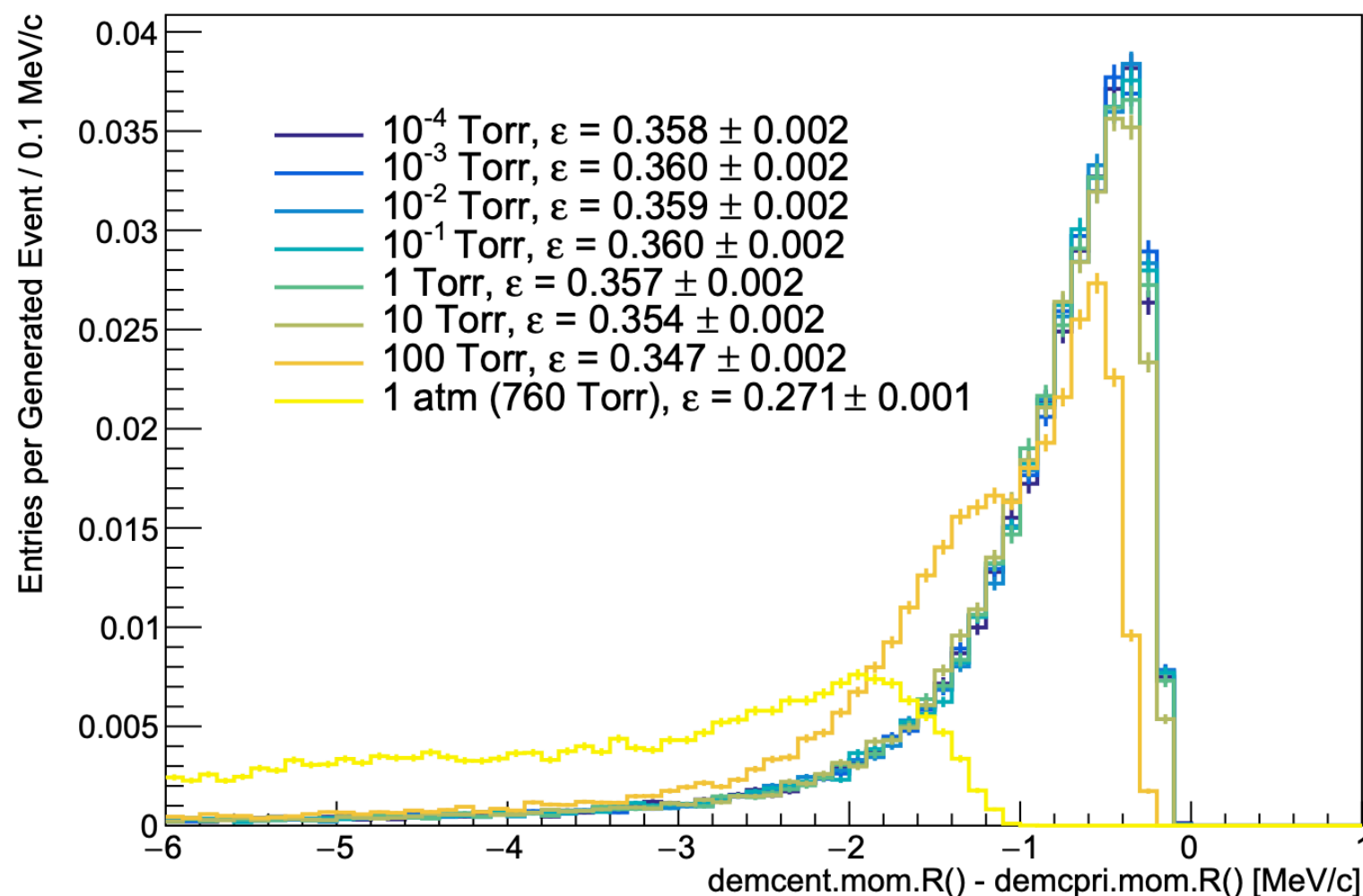- <u>FPGA hit classification/ filtering.</u>
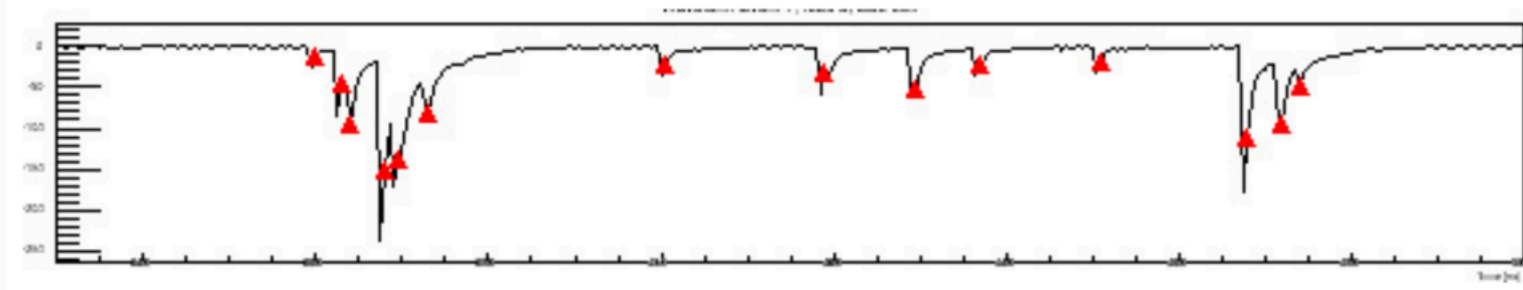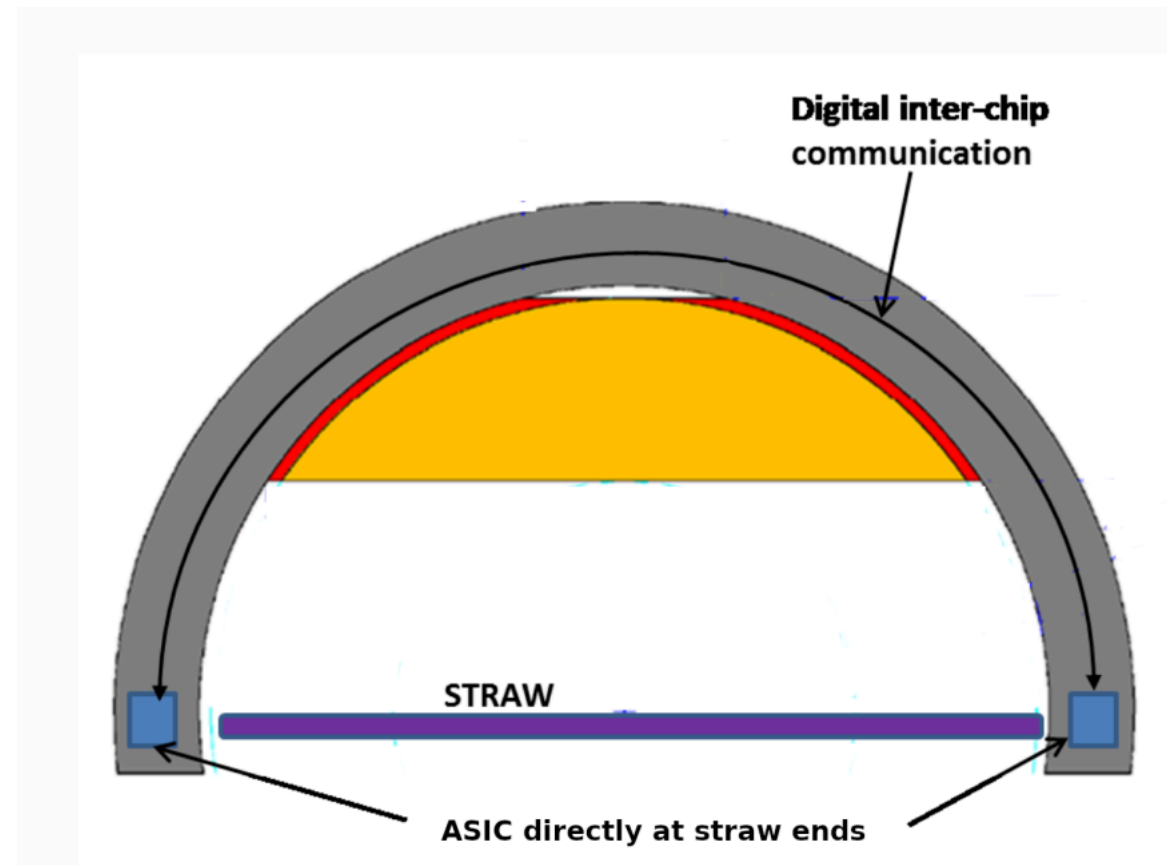
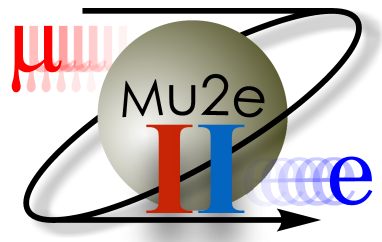G. Chiarello et al 2017 JINST 12 C07021, algorithm implemented on FPGA
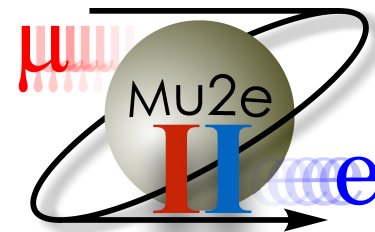
Vacuum studies

- Study by Andy.
- Physics impact is minimal up to 1 Torr for Mu2e.
- <u>Study will be done for Mu2e-II as well.</u>

MC True Energy Loss (CeEndpoint)

Legend:
- 10^{-4} Torr, $\varepsilon = 0.358 \pm 0.002$
- 10^{-3} Torr, $\varepsilon = 0.360 \pm 0.002$
- 10^{-2} Torr, $\varepsilon = 0.359 \pm 0.002$
- 10^{-1} Torr, $\varepsilon = 0.360 \pm 0.002$
- 1 Torr, $\varepsilon = 0.357 \pm 0.002$
- 10 Torr, $\varepsilon = 0.354 \pm 0.002$
- 100 Torr, $\varepsilon = 0.347 \pm 0.002$
- 1 atm (760 Torr), $\varepsilon = 0.271 \pm 0.001$

Y-axis: Entries per Generated Event / 0.1 MeV/c

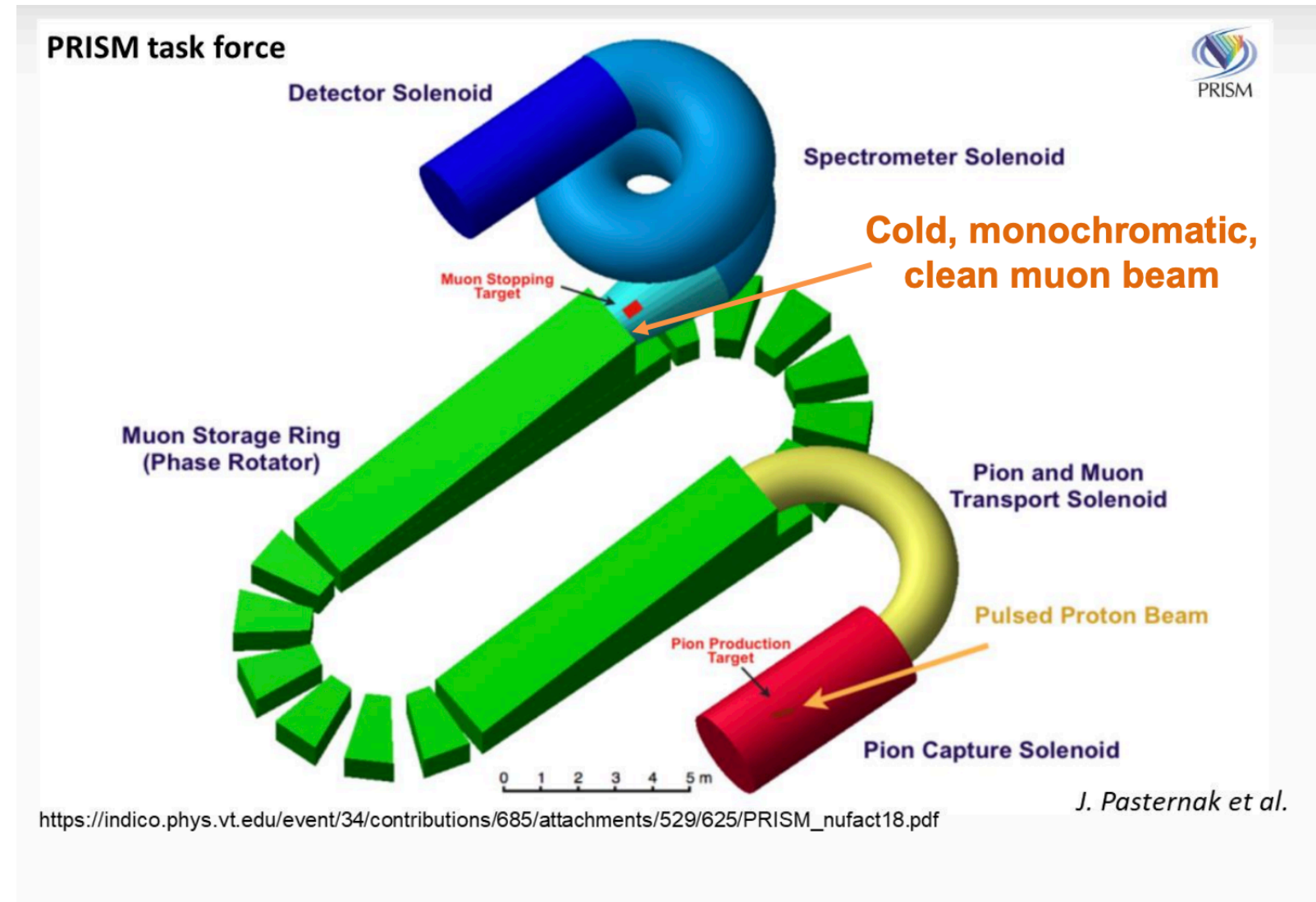X-axis: demcent.mom.R() - demcpri.mom.R() [MeV/c]

"demcent" = mc momentum of particle at tracker entrance

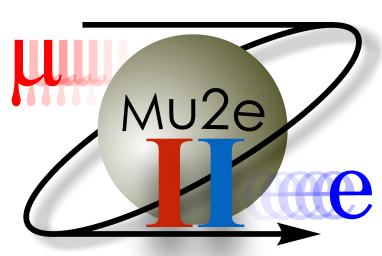"demcpri" = mc momentum of particle when created

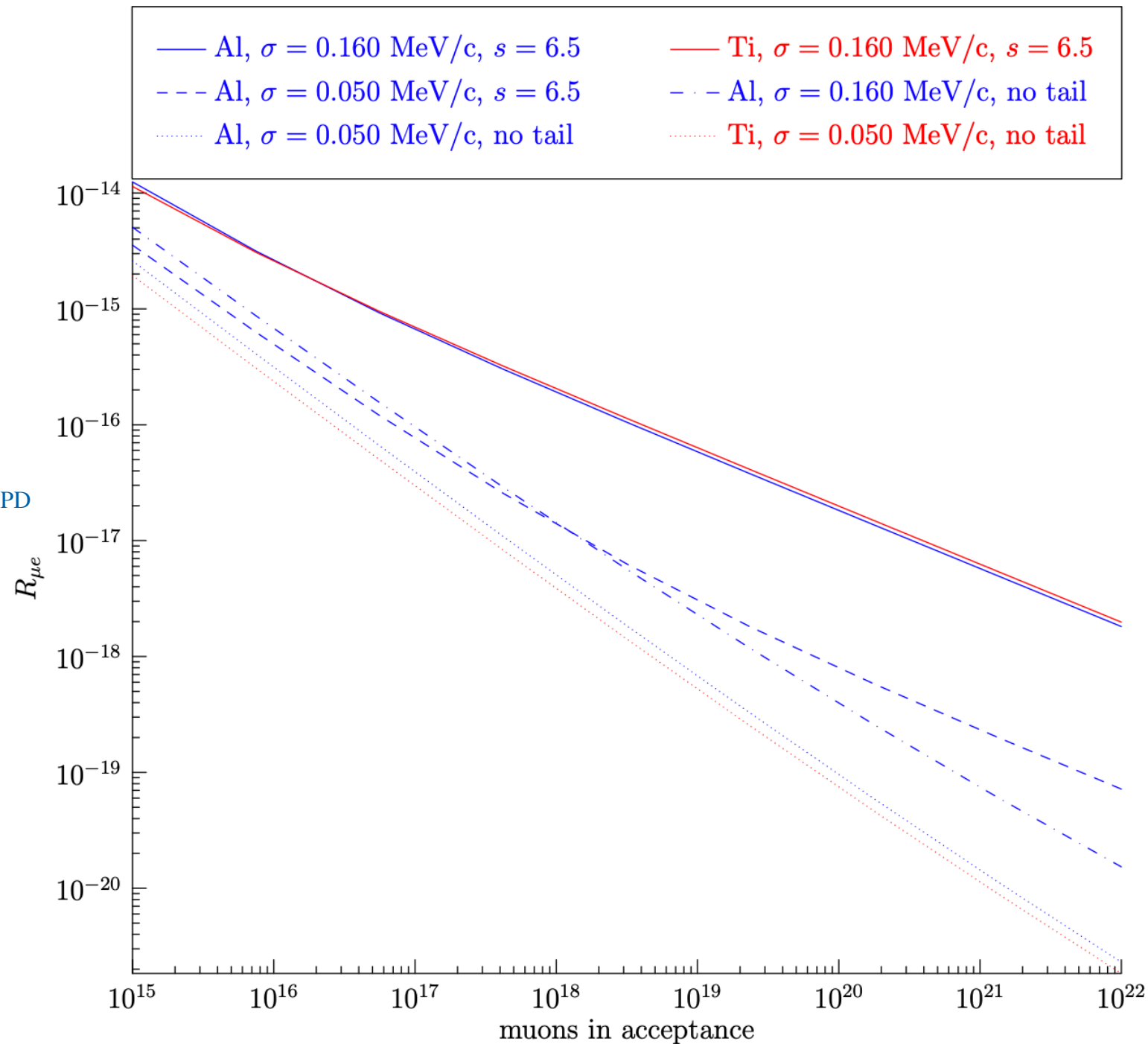🔷 Fermilab

Tracking at AMF conversion experiment

- No beam induced bkg!
- Only worry about DIO, cosmics and limited secondary particles from muon captures.
- Muon beam profile and corresponding conversion profile will be different.
  - No need for annular design.
  - Open for different/simpler tracker geometry.
- Losing RMC for calibration.
- <u>We should make a g4beamline sim to explore experimental configurations.</u>

PRISM task force

Detector Solenoid

Spectrometer Solenoid

Cold, monochromatic, clean muon beam

Muon Stopping Target

Muon Storage Ring (Phase Rotator)

Pion and Muon Transport Solenoid

Pulsed Proton Beam

Pion Production Target

Pion Capture Solenoid

0 1 2 3 4 5 m

J. Pasternak et al.

https://indico.phys.vt.edu/event/34/contributions/685/attachments/529/625/PRISM_nufact18.pdf

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Sensitivity scaling for future conversion exp.

Median 5σ discovery sensitivity scaling

Andrei;
FERMILAB-PUB-22-117-PPD

Final thoughts

- There is a breadth of R&D opportunities at the tracker detector for Mu2e-II.
  - We will be better informed after engineering run and run-1.
- Reconstruction and sensitivity improvements will be mostly done during Mu2e.
- AMF needs to start simulations to explore configurations for possible conversion/decay experiments.
  - Compatibility between different parts of the simulation is strongly desired.