Mu2e-II: Sensitivity Estimate

Lisa Goodenough,
Sophie Middleton &
Yuri Oksuzian

**Working Group Report for
Mu2e-II Workshop
23rd September 2020**

Introduction

- The Sensitivity & Simulation group brings together everyone's efforts and aims to make the final calculation of the SES for the Mu2e-II design for Snowmass 2021.
- It is vital that we engage with all the other sub-groups and experts to ensure we have the most up-to-date information in the Mu2e-II Offline Software.
- Once we have updated geometries we can begin the large scale simulation campaign which is necessary for the physics analysis.
- Today we will document progress made since the previous Workshop in August 2020.

Sensitivity Estimates Group Details

- Co-conveners are **Lisa Goodenough (FNAL), Sophie Middleton (CalTech), and Yuri Oksuzian (ANL)**
- Current group members: Rebecca Chislett (UCL), Michael Hedges (Purdue), Cole Kampa (Northwestern), Manolis Kargiantoulakis (FNAL), Michael Mackenzie (Northwestern)

- Mailing list: mu2e-ii-sensitivity@listserv.fnal.gov
- Slack channel: #mu2e-ii_sensitivity_and_simulations (in Mu2e domain)

Please contact us if you are interested in joining

Requested Computing Resources

- We have applied for 6M (1.5M/quarter) CPU hours on the HPC system at ANL
- These resources can be used for Mu2e and Mu2e-II simulations efforts
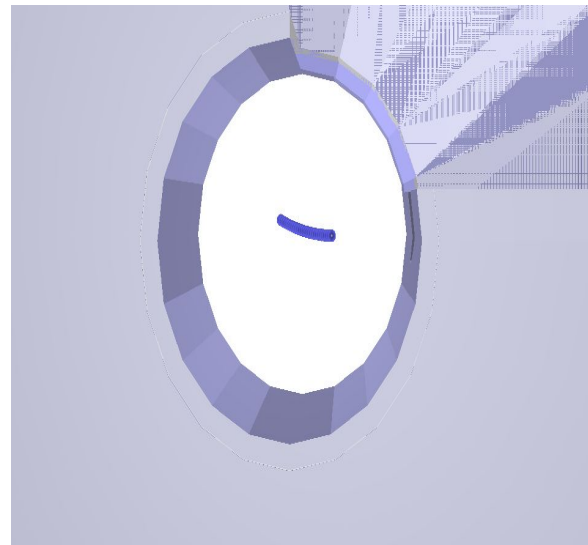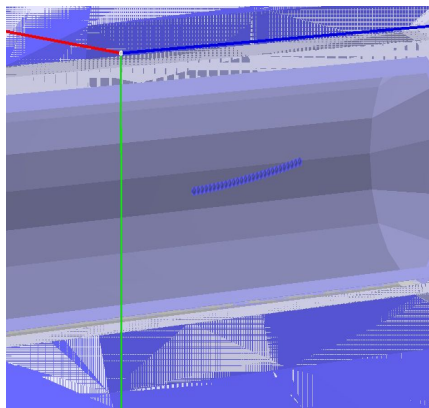
Status of Production Target

Work done by M. Mackenzie (Northwestern)

- M. Mackenzie has implemented a preliminary design into Mu2e-II Offline.
- Designs is based on work done by Vitaly et al. as part of LDRD work - carbon target in "conveyor" style and "rotating" style options.
- Removed p-bar windows.
- This is crucial first step in Mu2e-II Simulation Campaign.
- Will begin the first Stage 1 simulation in the next few days.

Status of Production Target
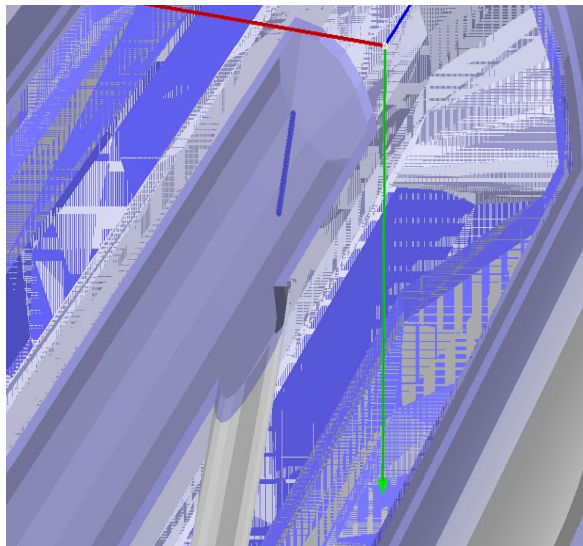
Work done by M. Mackenzie (Northwestern)

The production target here is the "conveyor," which is a series of carbon balls in a bent configuration to follow the proton path in the magnetic field.

Stopped Muon Rate

Work done by M. Mackenzie (Northwestern)

- M. Mackenzie got:

  87 stops / 1 x 10^6 POT = 0.87 x 10^{-4} +/- 0.09 x 10^{-4} stops/POT

  With the new Production Target and Mu2e Stopping Target

- Compare to 0.00152 stops/POT at Mu2e Energies with the 37 foil Al Stopping Target.

Work done by S. Middleton (Caltech)
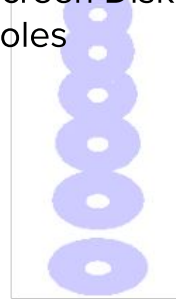
Progress on Al Stopping Target Studies

- Several designs have been built within Mu2e-II/Offline.
- Geometries and materials
- Simulations of Stopped Muons and Pions have been run.
- Example designs for Al primary target shown here.

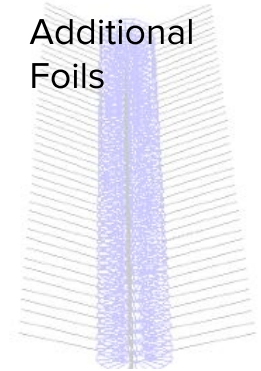Cylinder design i.e tubes with differing radi - muons still captured but easier for CE to get through.
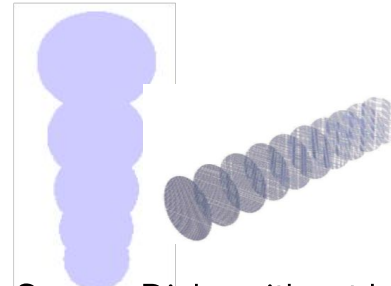
Screen Disks with holes

Hexagonal transverse view
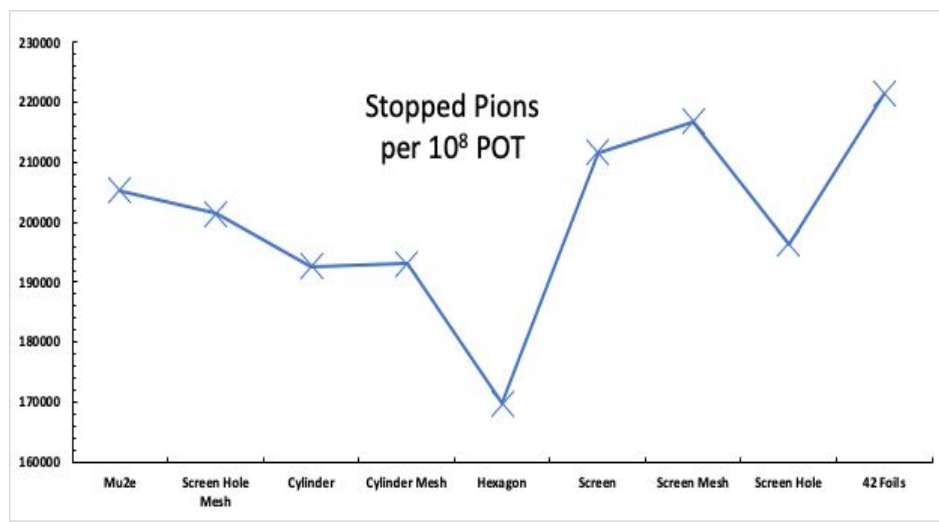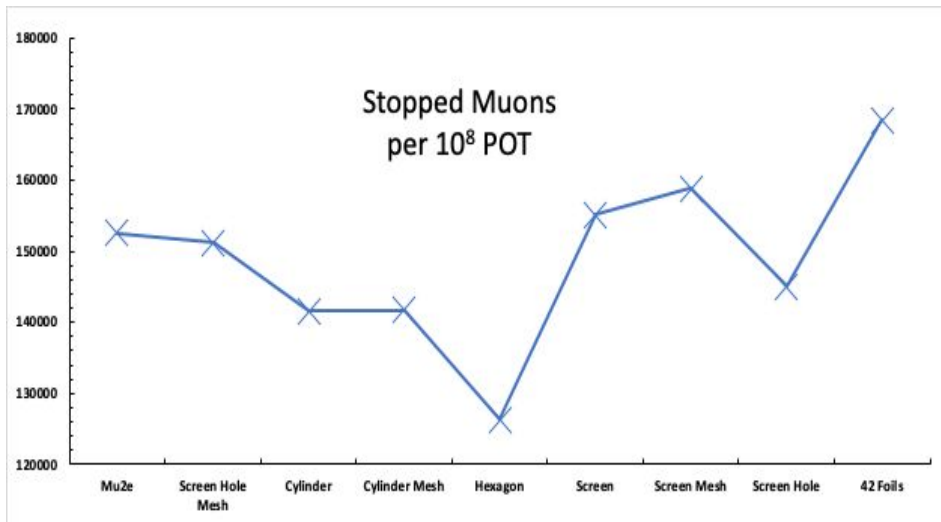
Additional Foils

Screen Disks without holes. Screens made of strings - vary strings = mesh style alternative.

Progress on Al Stopping Target Studies

Work done by S. Middleton

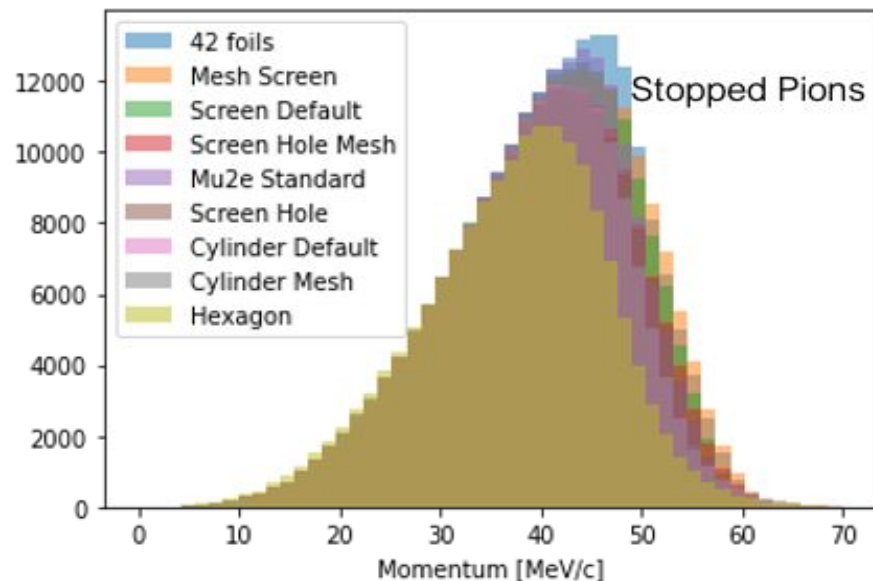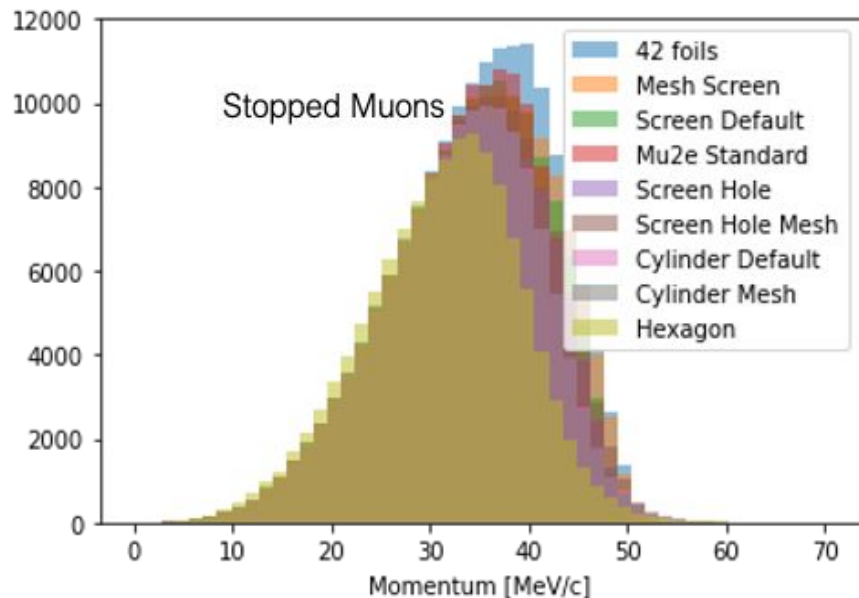- Variations in Stopped Particle yields are observed and are of the order of +/- 10-20% for both Muons and Pions. Note this is for Mu2e Era Code.

Progress on Al Stopping Target Studies

Work done by S. Middleton

- Mean momentum and RMS of stopped particles varies by +/- a few %.
- Next Steps: change in SES and BFUL (in progress)

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Progress on AI Stopping Target Studies Work done by S. Middleton

- Relative changes in SES - <u>Note: still uses all mu2e detectors/production target and is from very simple assumptions about backgrounds (detailed study in progress)</u>

$$SES = \frac{1}{\left(POT \times \frac{stop}{POT} \times \frac{Capture}{stop} \times \frac{N_{rec}^{CE}}{N_{gen}^{CE}}\right)}$$

Mu2e-II: Sensitivity Estimate - Introductory Discussion, Snowmass Workshop September 2020
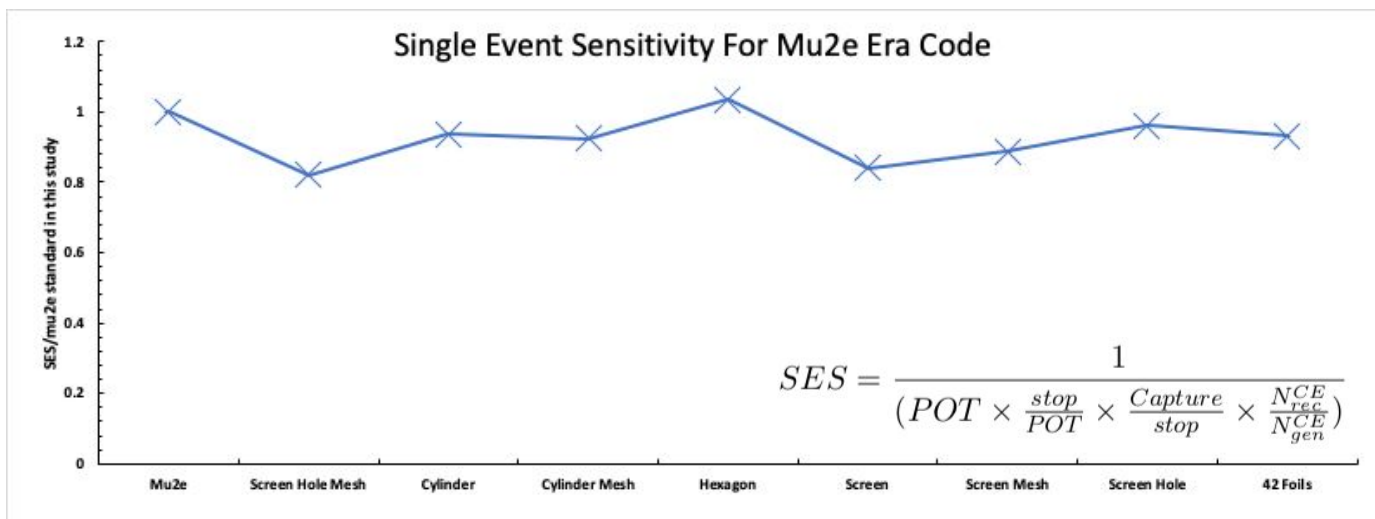
In Progress: Analysis Tool Development Work done by S. Middleton

- Development of sensitivity tool in early stages.
- Python based tool which takes in "generated histograms" and "reconstructed histograms" of momentum (eventually time too) for all backgrounds and signals.
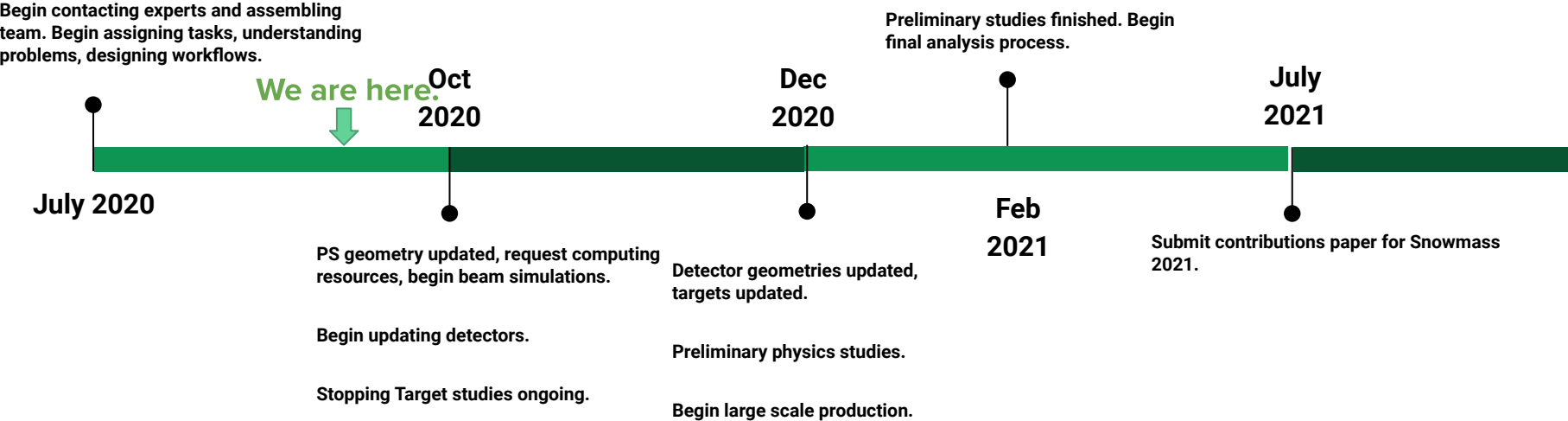- Calculates an SES and BFUL based on input.
- Interface for mu➡ e- developed for ST studies.
- Requires upgrades for the mu ➡ e+ and mu➡ e+X interfaces.

Estimated Timeline

Reiterating the estimated schedule from last meeting:

Begin contacting experts and assembling team. Begin assigning tasks, understanding problems, designing workflows.

We are here.

Oct 2020

Dec 2020

Preliminary studies finished. Begin final analysis process.

July 2021

July 2020

PS geometry updated, request computing resources, begin beam simulations.

Begin updating detectors.

Stopping Target studies ongoing.

Detector geometries updated, targets updated.

Preliminary physics studies.

Begin large scale production.

Feb 2021

Submit contributions paper for Snowmass 2021.

Next Steps

- Next steps:
  - Contact detector groups to get updated geometries:
    - Calorimeter: Bertrand Echenard & Leo Borrel
    - Tracker: ?
    - CRV: Yuri?
  - Finish off ST analysis and get a few designs which we then take to more higher stats simulation. I will need to re-do the study once we have stable PT in place.
  - Begin large scale simulations (Stage 1)
  - A second meeting with theory group to discuss alternative target?
  - Begin simulation studies using Titanium and other materials (others require more work)

Summary

- Since the last Workshop we have made significant progress.
- We now have the Production Target in our Mu2e-II Offline code.
- Computing resources have been requested.
- Stopping Target studies are well underway.
- Will shortly begin the first Stage 1 simulation.