Pion Production Targets at 800MeV

Kevin Lynch

Mu2e-II Workshop
Argonne National Laboratory
December 9, 2017

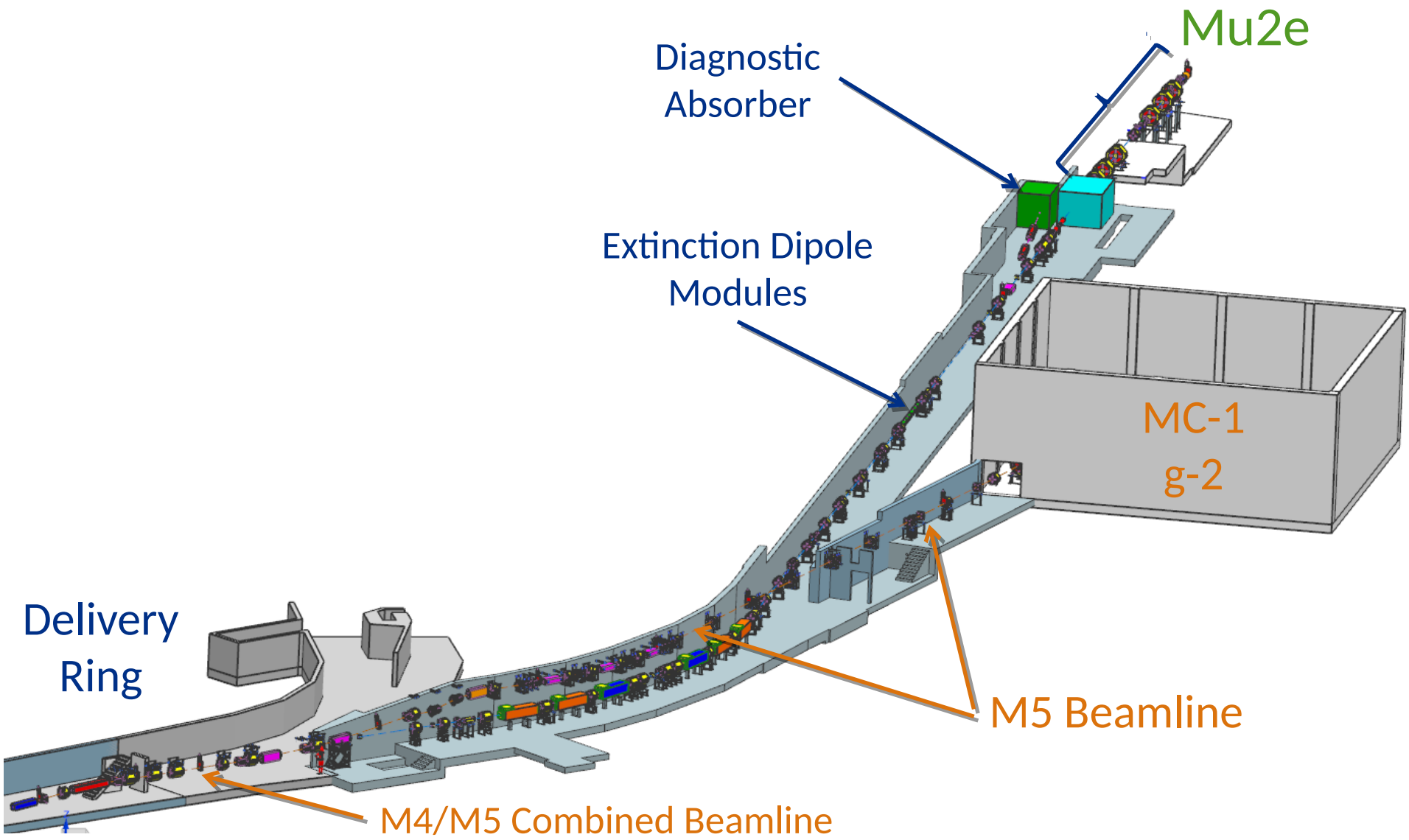
THE GRADUATE CENTER
CITY UNIVERSITY OF NEW YORK
YORK College
THE CITY UNIVERSITY OF NEW YORK

There are a number of pion production challenges for the Mu2e systems at 800 MeV

- Over the last year, we've been looking at a few of them:
  - Can you get an 800 MeV proton beam to a production target inside the current PS?
  - How can we address the complications of H- rather than proton delivery from PIP-II?
  - Can we reduce power density in the production target to survive in a 100kW beam environment?

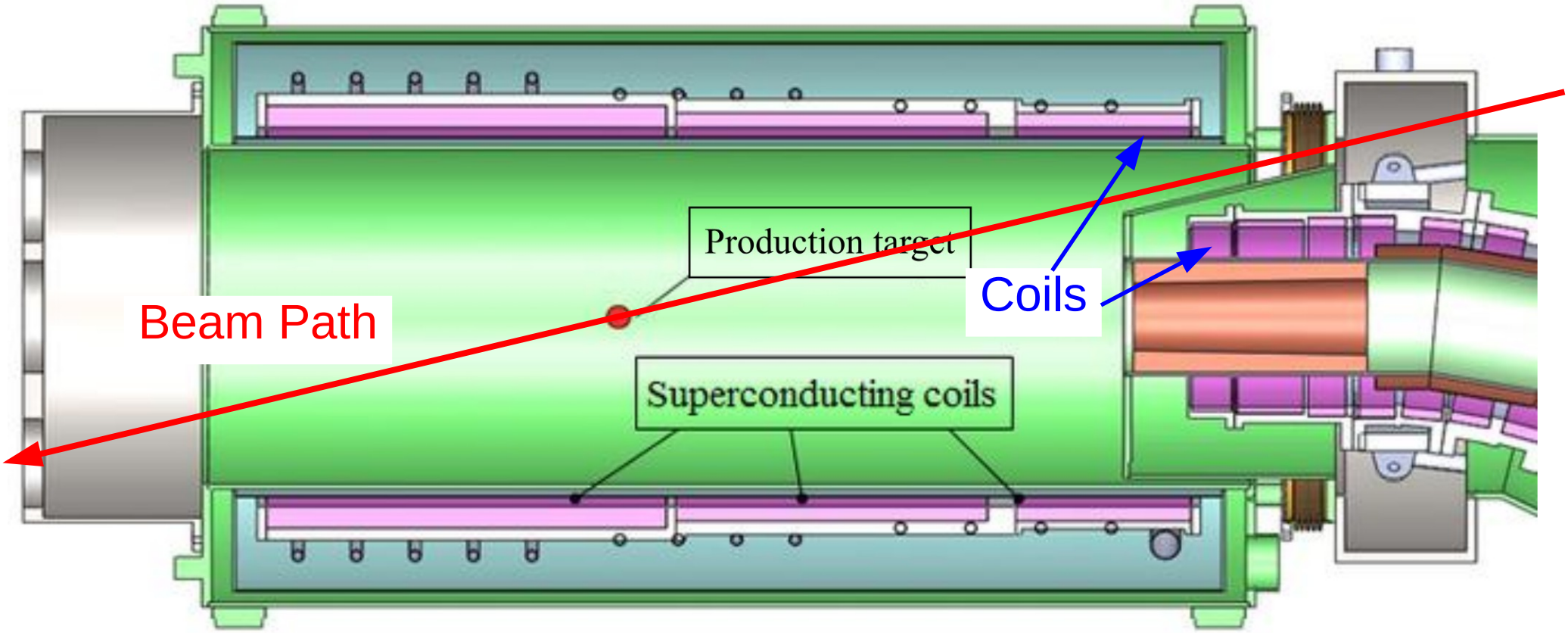
Today, I'll focus on the last issue … for more details on the other topics, see Mu2e DocDB 12500

Mu2e Pion Production Target



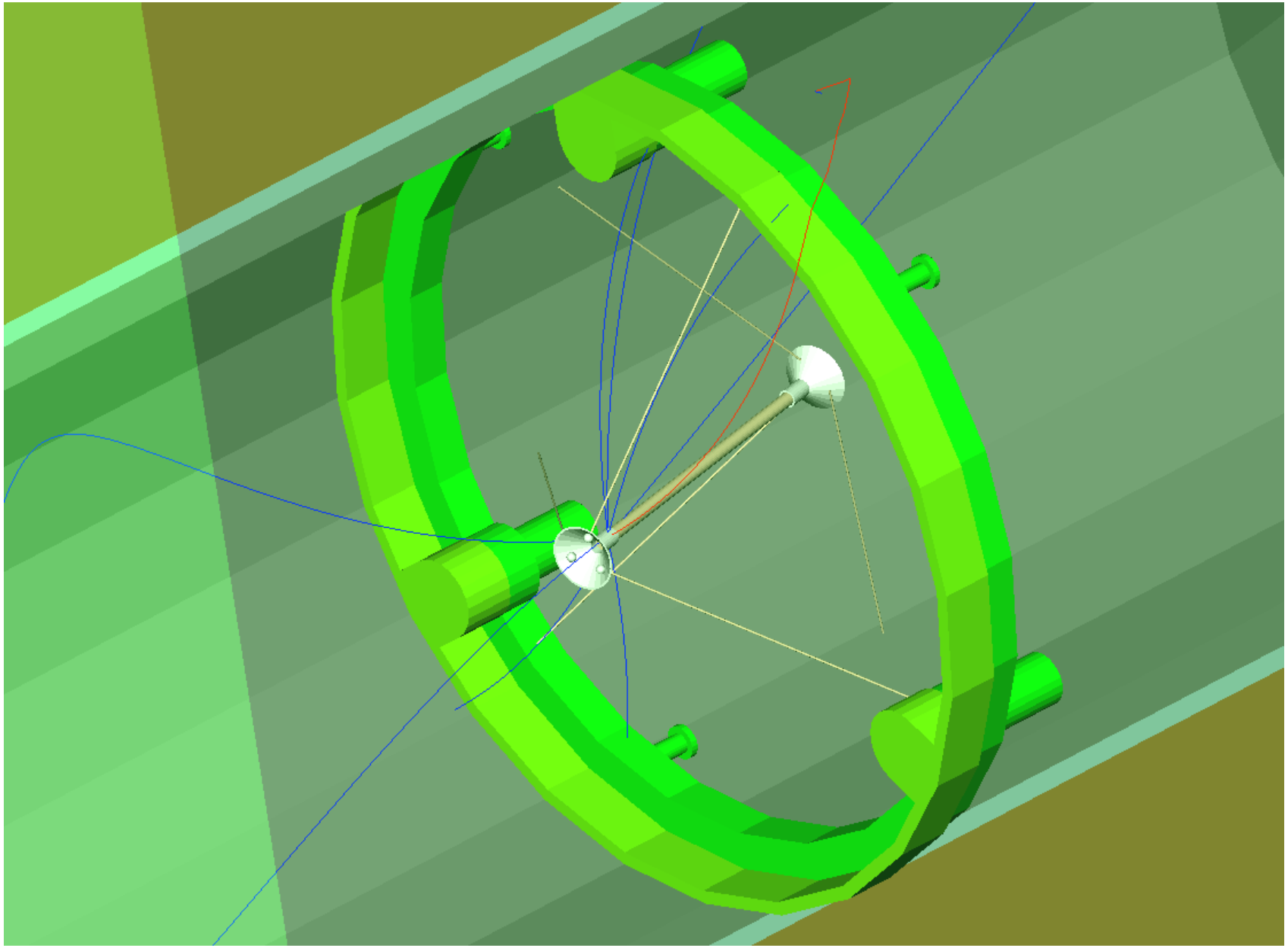
3

Mu2e Pion Production Target

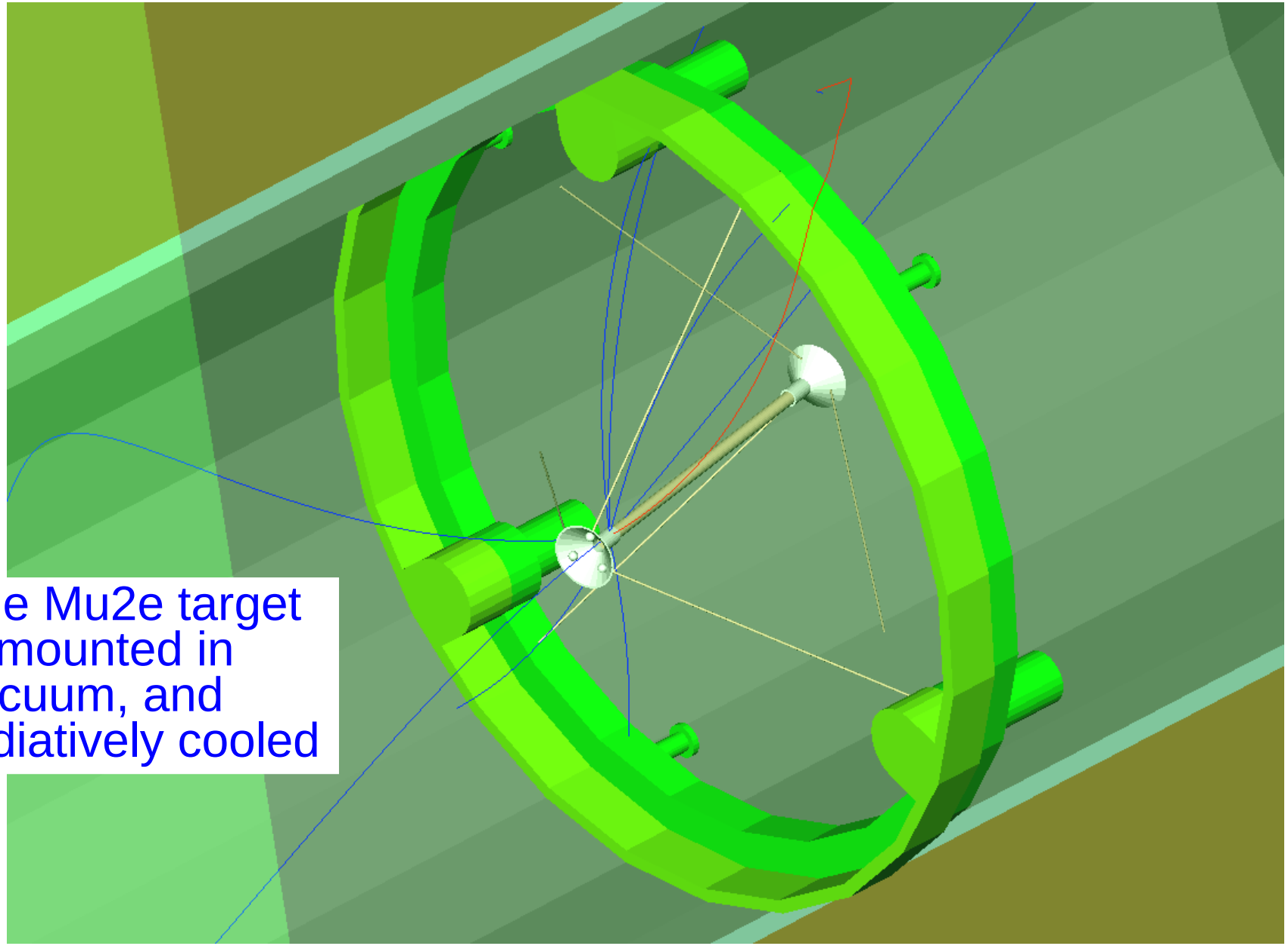


Images from TDR

Mu2e Pion Production Target

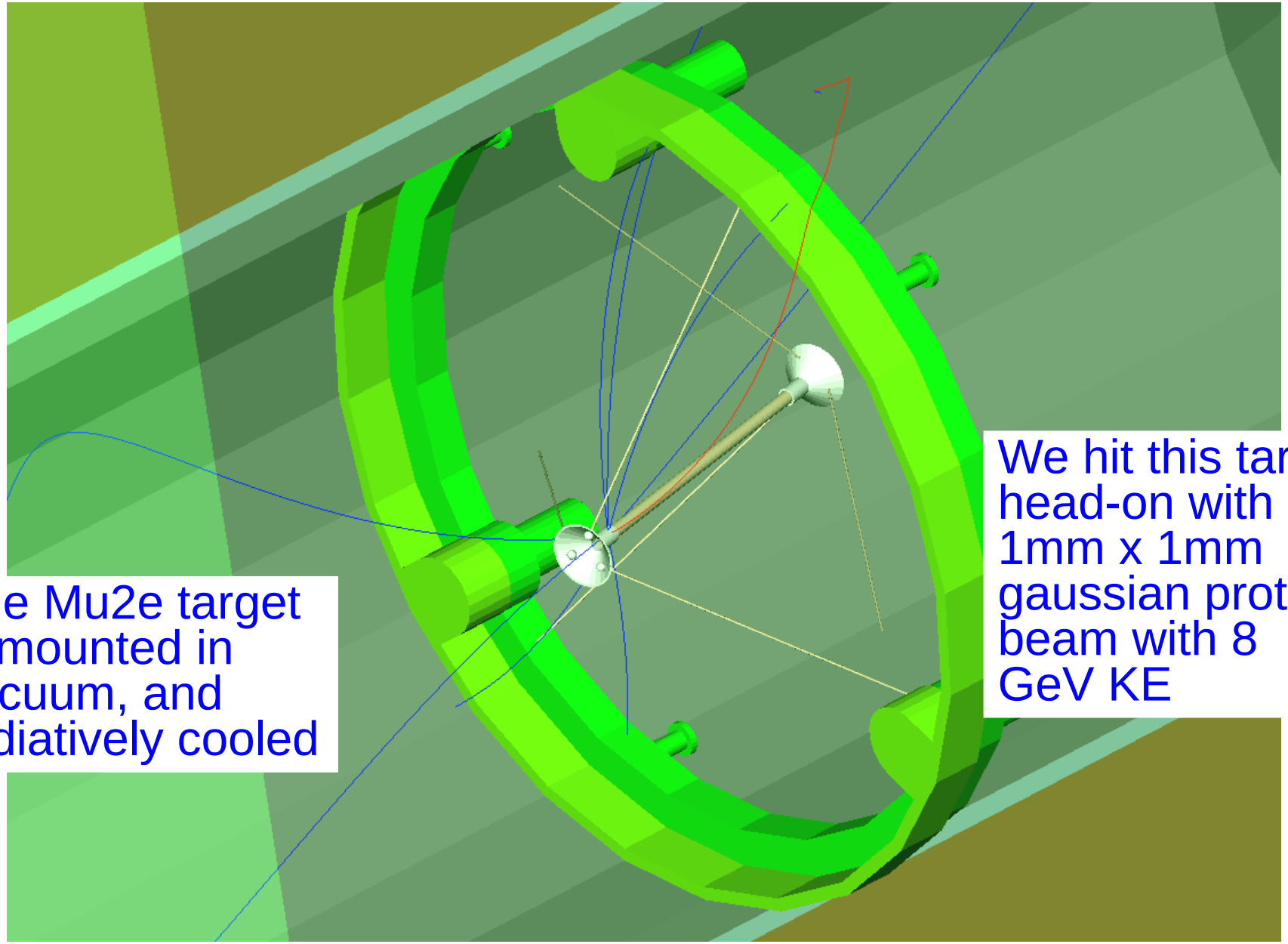


Mu2e Pion Production Target



The Mu2e target is mounted in vacuum, and radiatively cooled

Mu2e Pion Production Target



The Mu2e target is mounted in vacuum, and radiatively cooled

We hit this target head-on with a 1mm x 1mm gaussian proton beam with 8 GeV KE

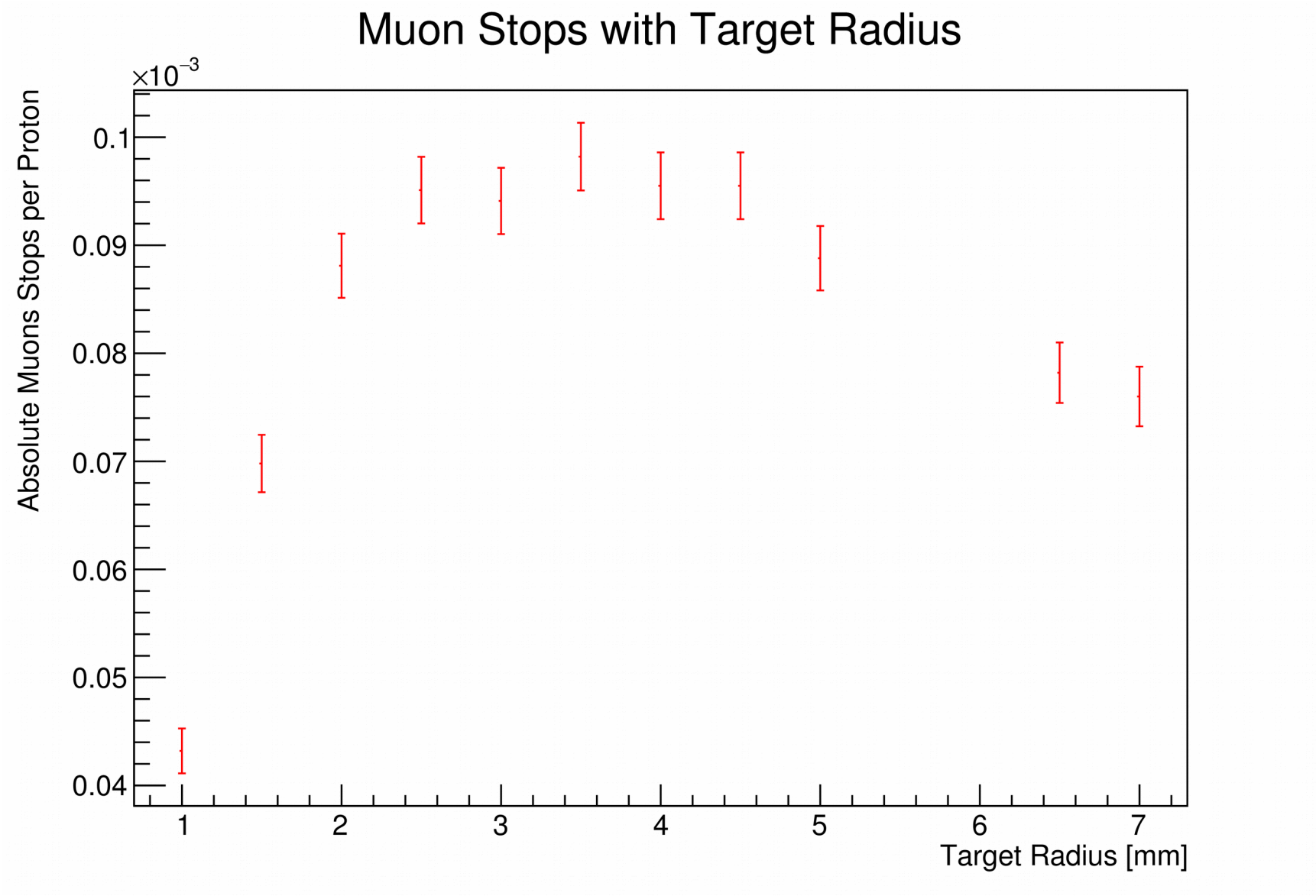
Stopped muon yields are sensitive to many target parameters

- Target radius
- Target length
- Target position
- Target angle
- Relative beam angle
- Beam radius

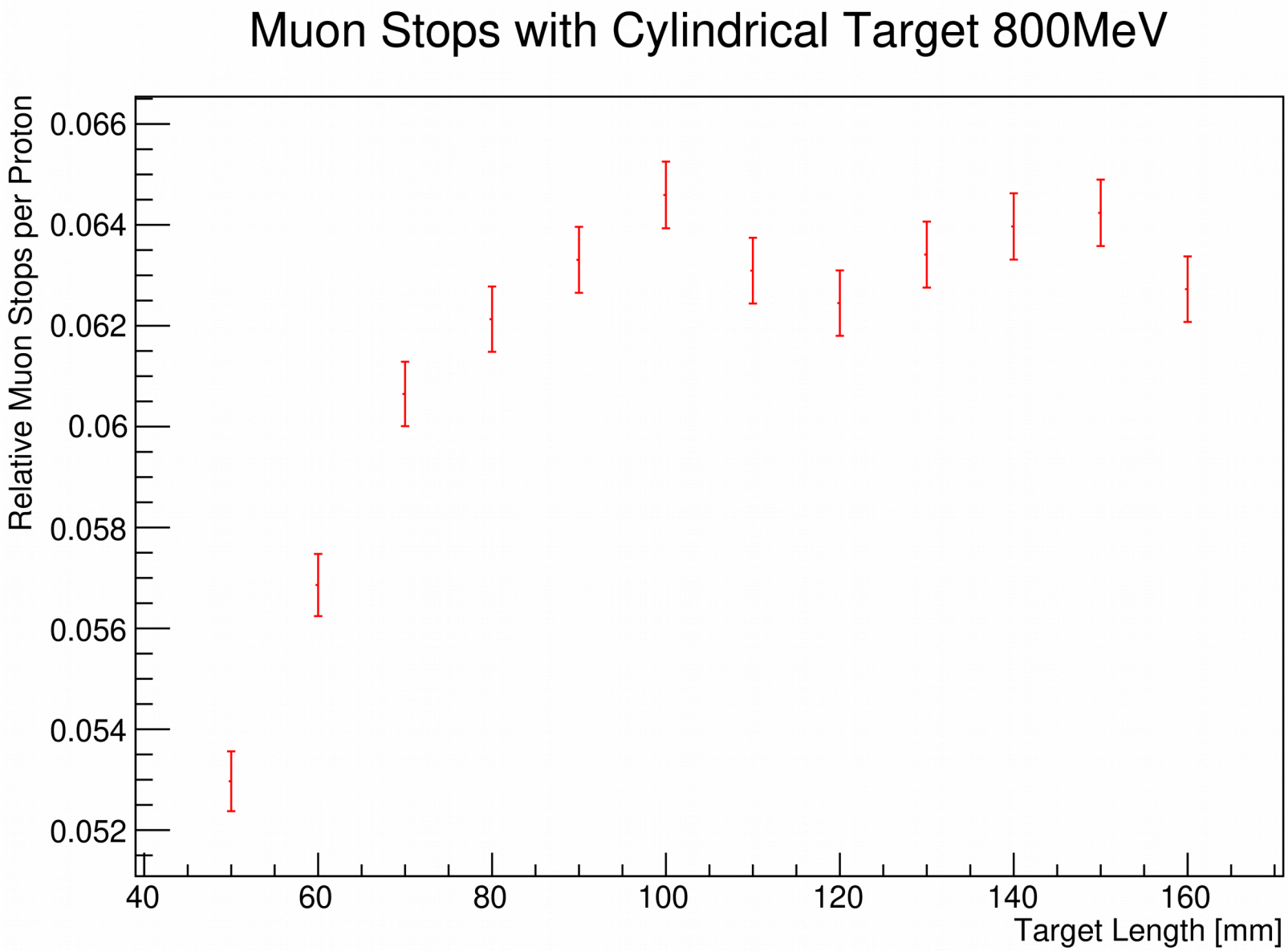
We'll look at some yield plots to give you an idea of the sensitivity to some of these parameters … many of these parameters are insensitive to beam energy!

Rule of thumb: 2.5% yield loss is roughly equivalent to a week of experiment downtime per year!

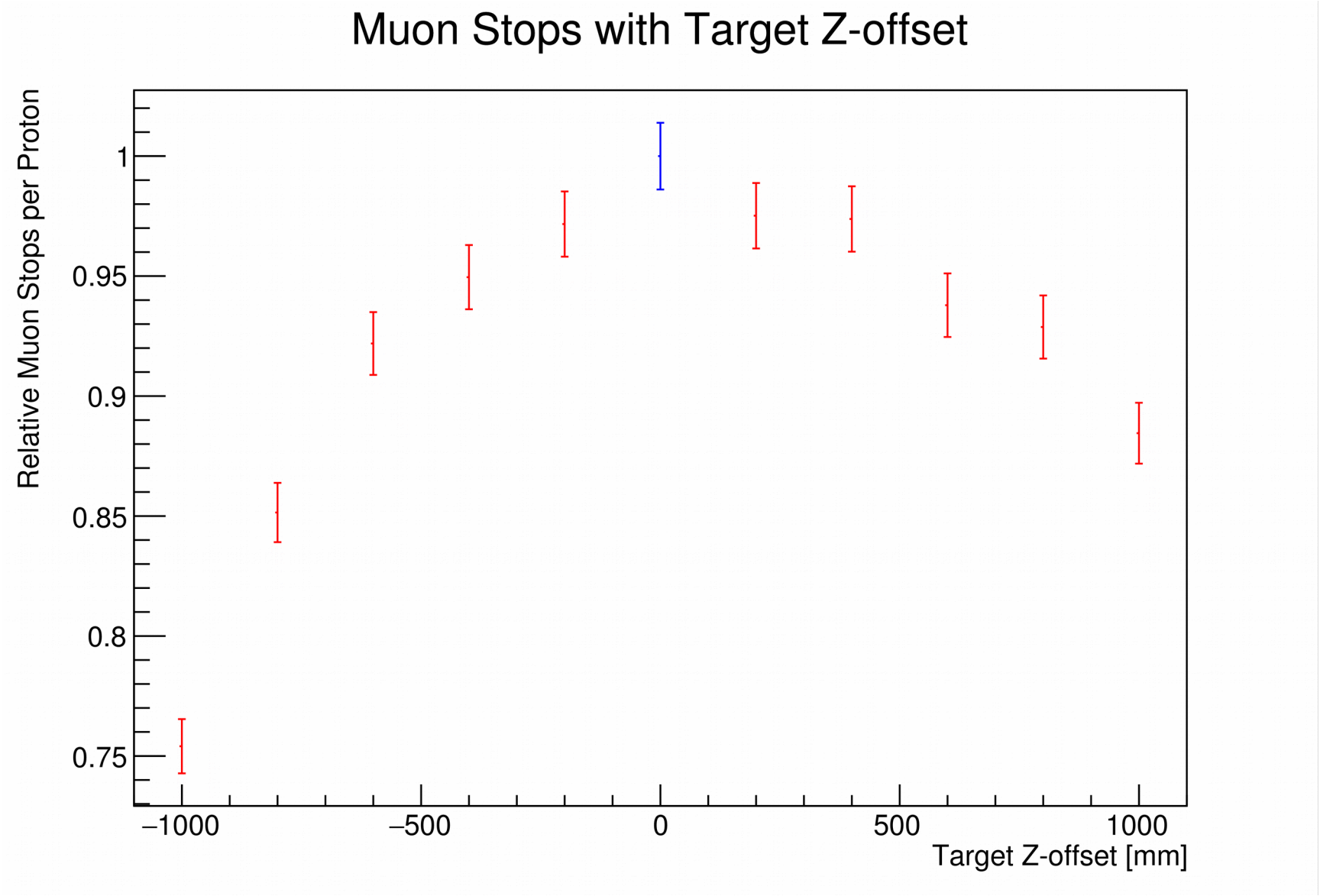
Target Radius, 800 MeV



Target length, 800 MeV

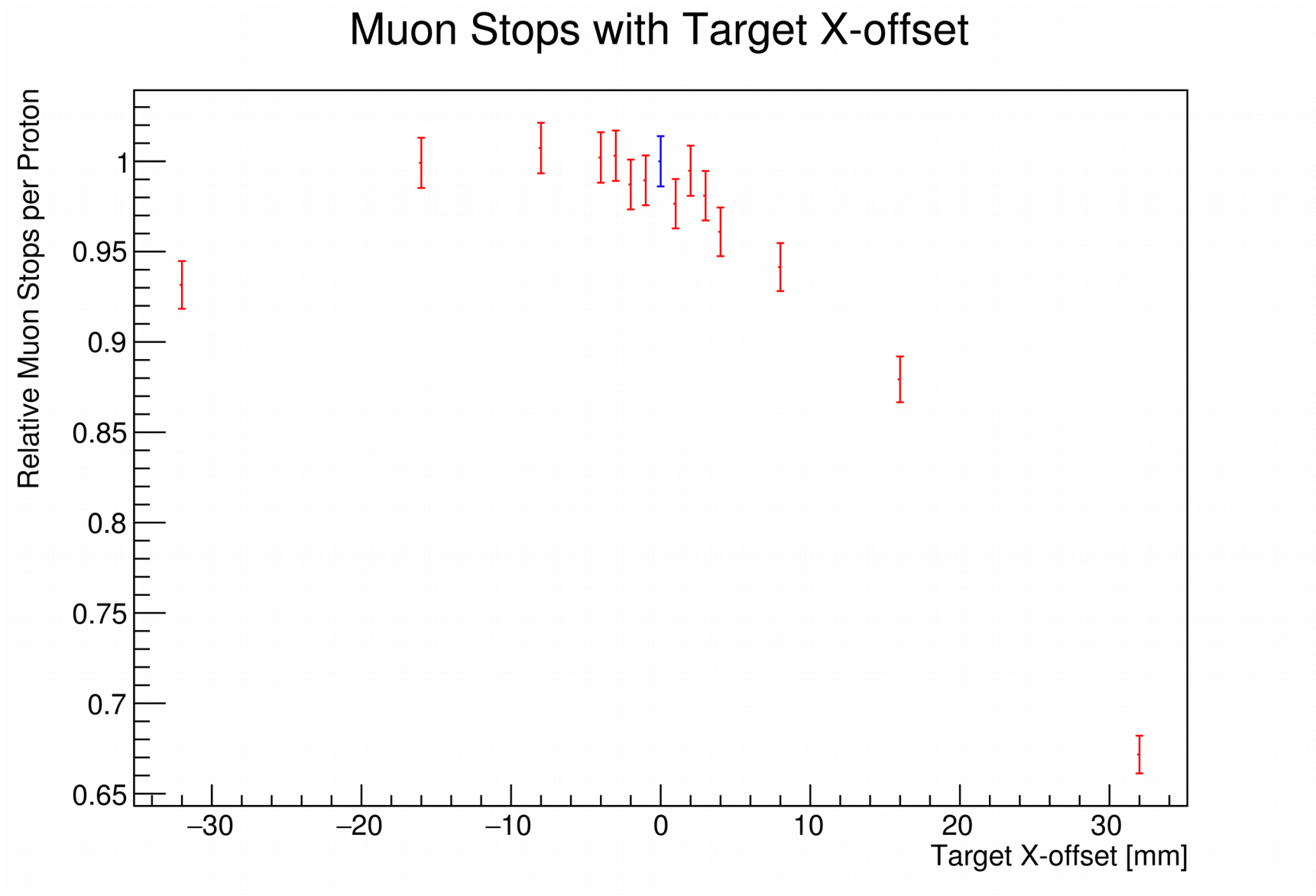


Z-Offset, 800 MeV

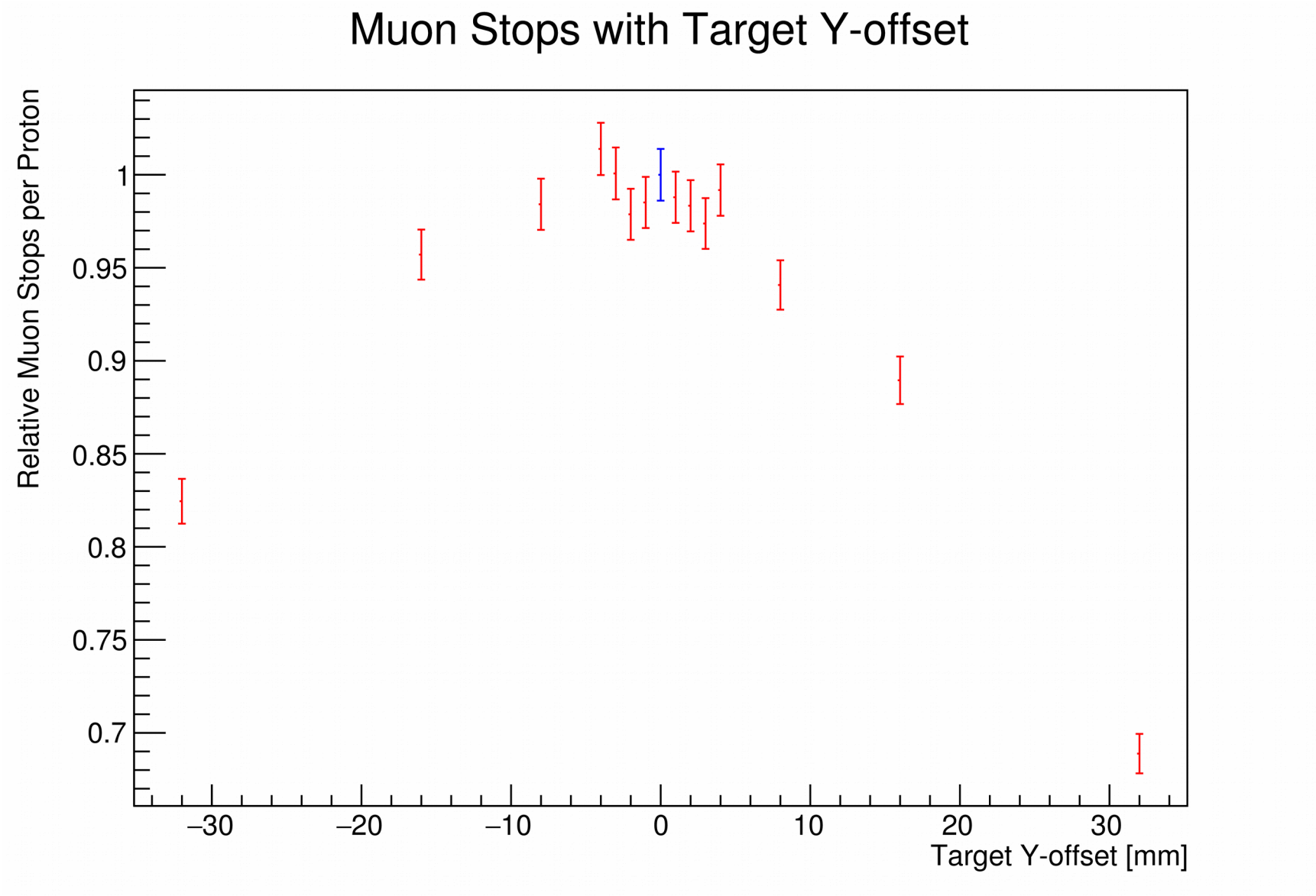


10^8 POT per data point; statistical errors only

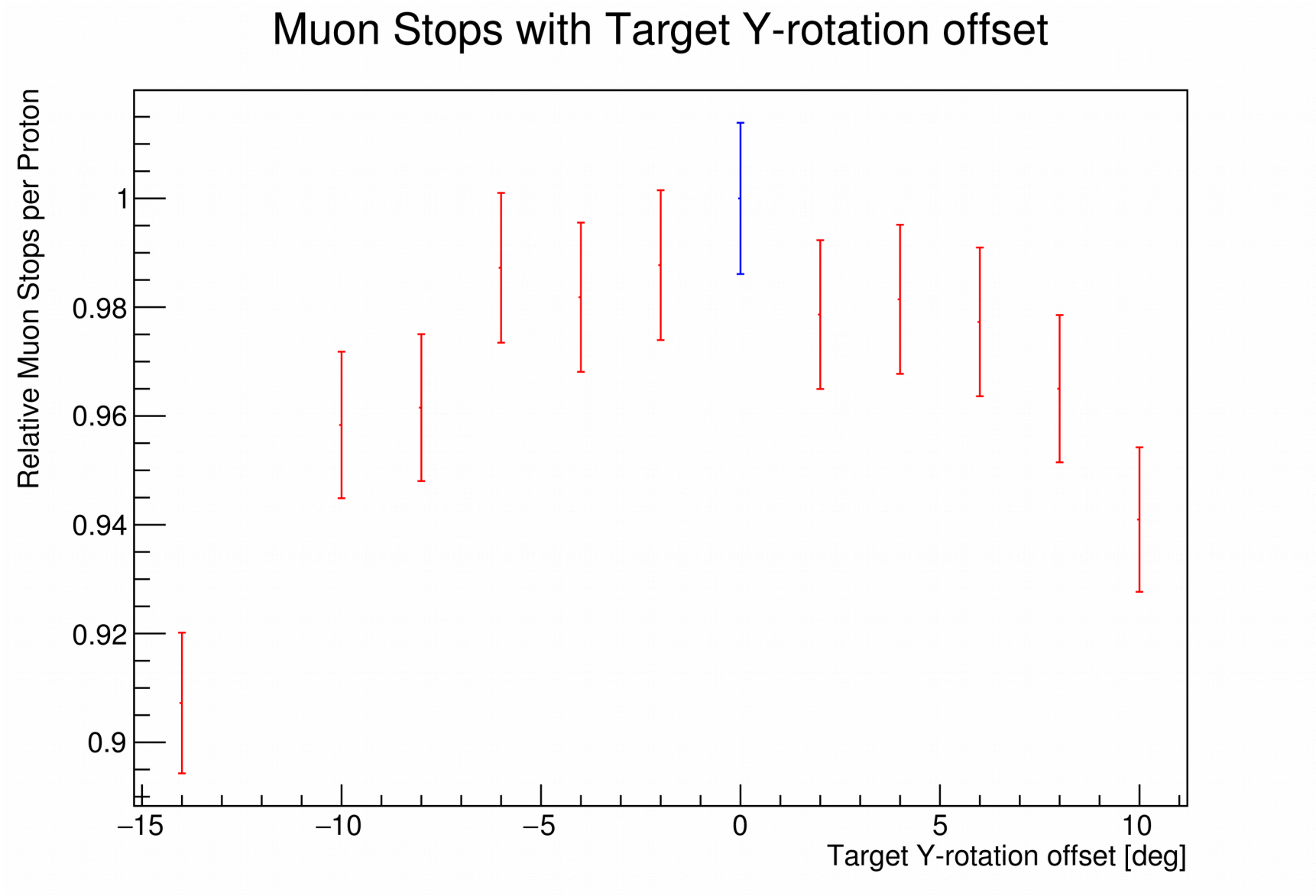
X-Offset, 800 MeV



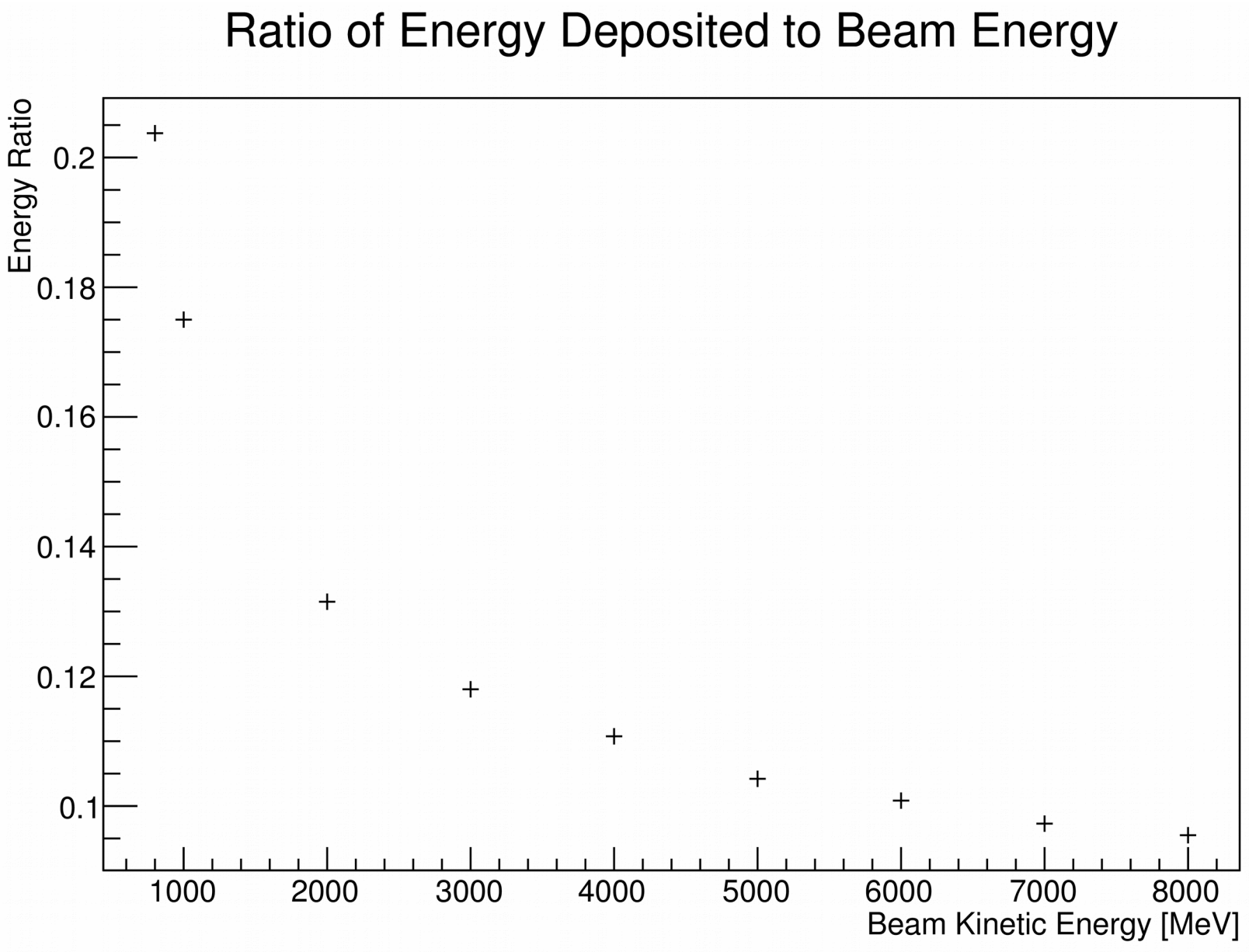
Y-Offset, 800 MeV



Y-Rotation, 800 MeV



Energy/power deposition in the Mu2e target



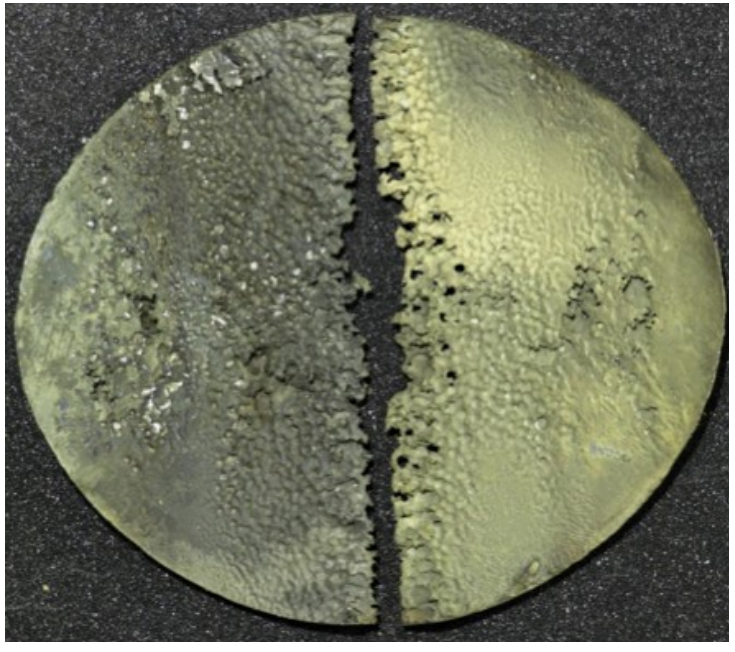
Power deposition

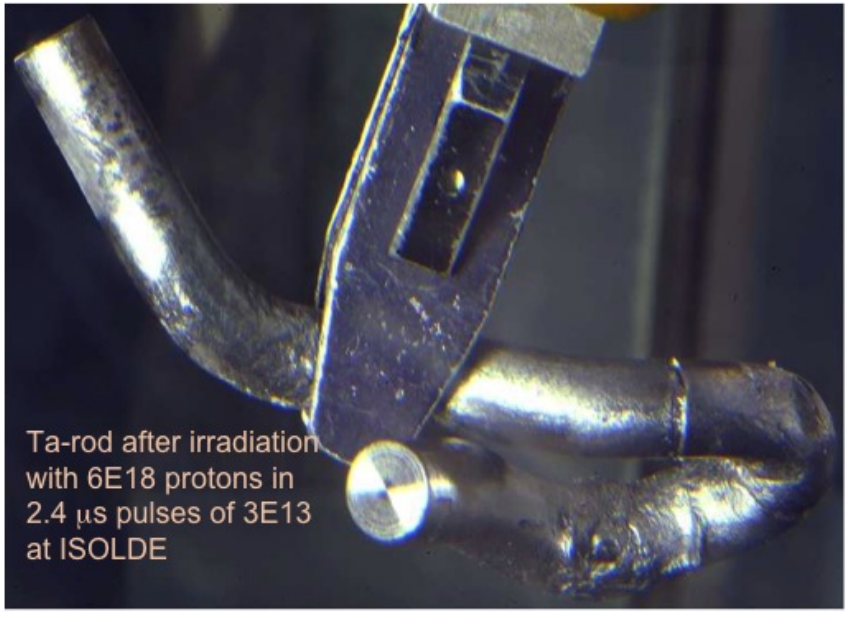
- Mu2e
  - 8 GeV, 8 kW beam that deposits ~700 W of power in a 16mm long x 3.15mm radius passively cooled tungsten target
    - Target power density of order 150 MW/m^3, heavily concentrated at the proton upstream end
      - This is already and extreme challenge!
- Mu2e-II
  - 800 MeV, 100 kW beam that would deposit about 22.5 kW in the same target
    - Target power density of order 4.5 GW/m^3
      - This would be one of the highest power density targets to run
    - Target DPA significantly exceeds 1 during the run!
    - Can we do something with the 75kW spent beam?

It's clear that a Mu2e-like target at Mu2e-II power densities is a significant design and materials challenge!

It’s clear a radiatively cooled target is a no-go

- We could probably build an actively cooled small cylindrical target
  - It’s clear that there are significant material, mechanical, and cooling design issues
- It would be useful to reduce the power density requirements to simplify these very difficult issues
  - How badly does that hurt our physics reach?

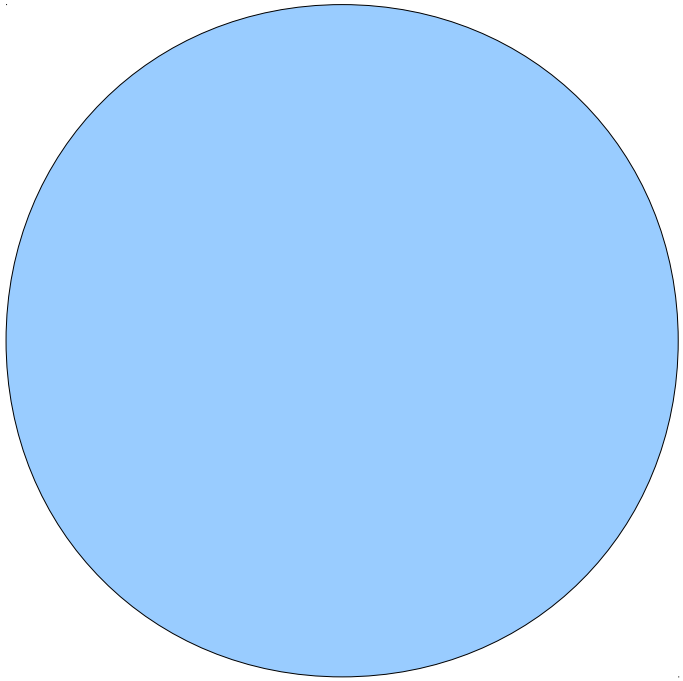


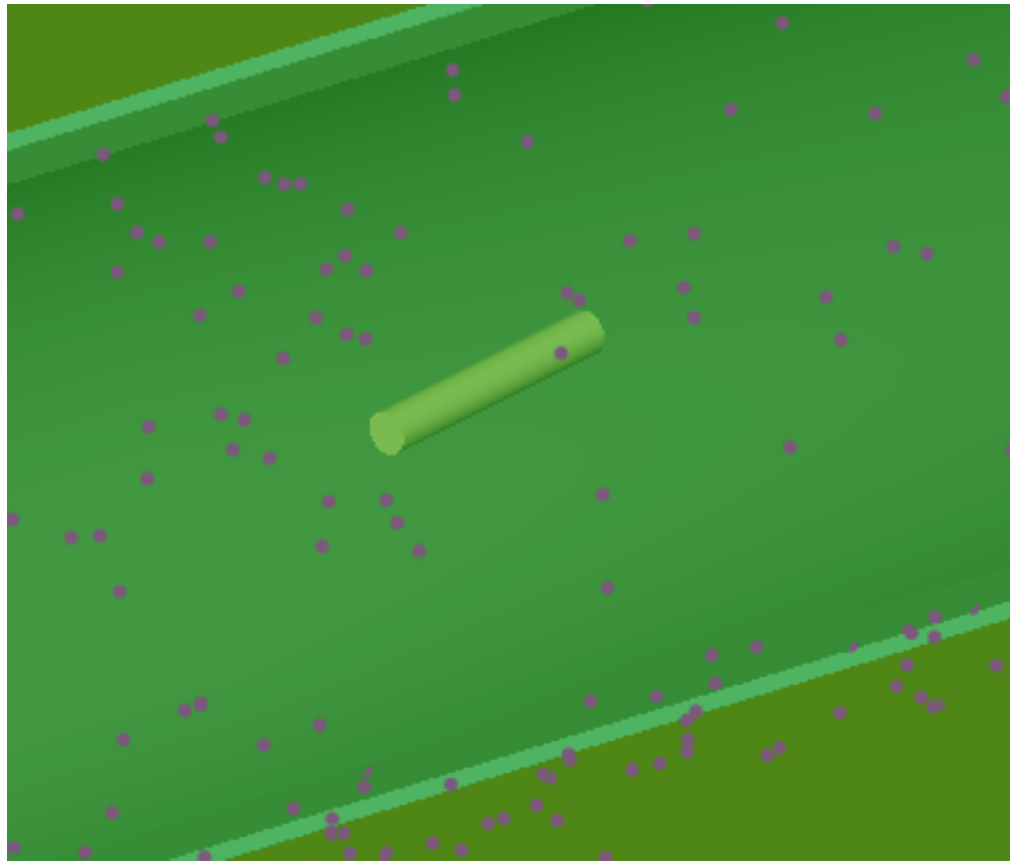


It’s clear a radiatively cooled target is a no-go

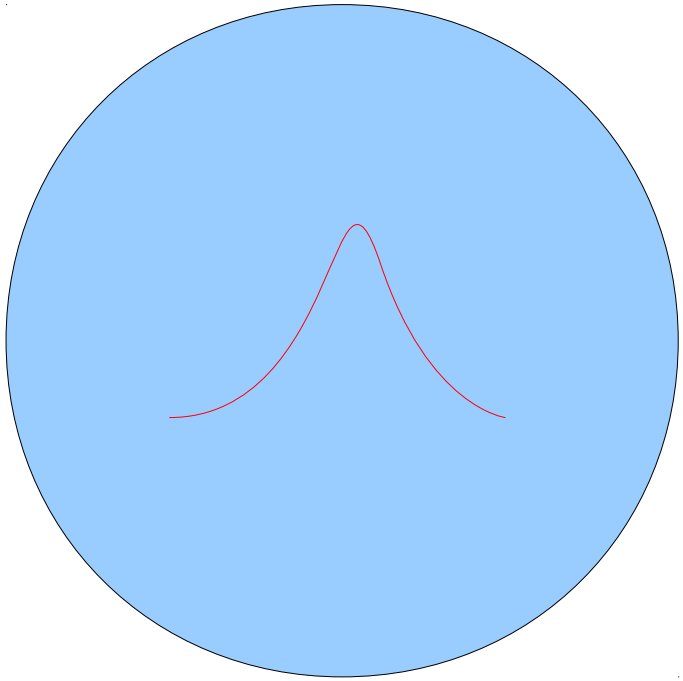
- Could other geometries or active scanning help us?
  - Edge rastering has been suggested by FNAL experts
  - Let’s look at stopped muon yields for a few options.
    - The Mu2e stopped muon yield is about 1.6e-3/POT
    - The baseline Mu2e target would yield a 9.9e-5/POT stopped muon rate at 800 MeV.
    - Here, we use simple floating targets without support structures

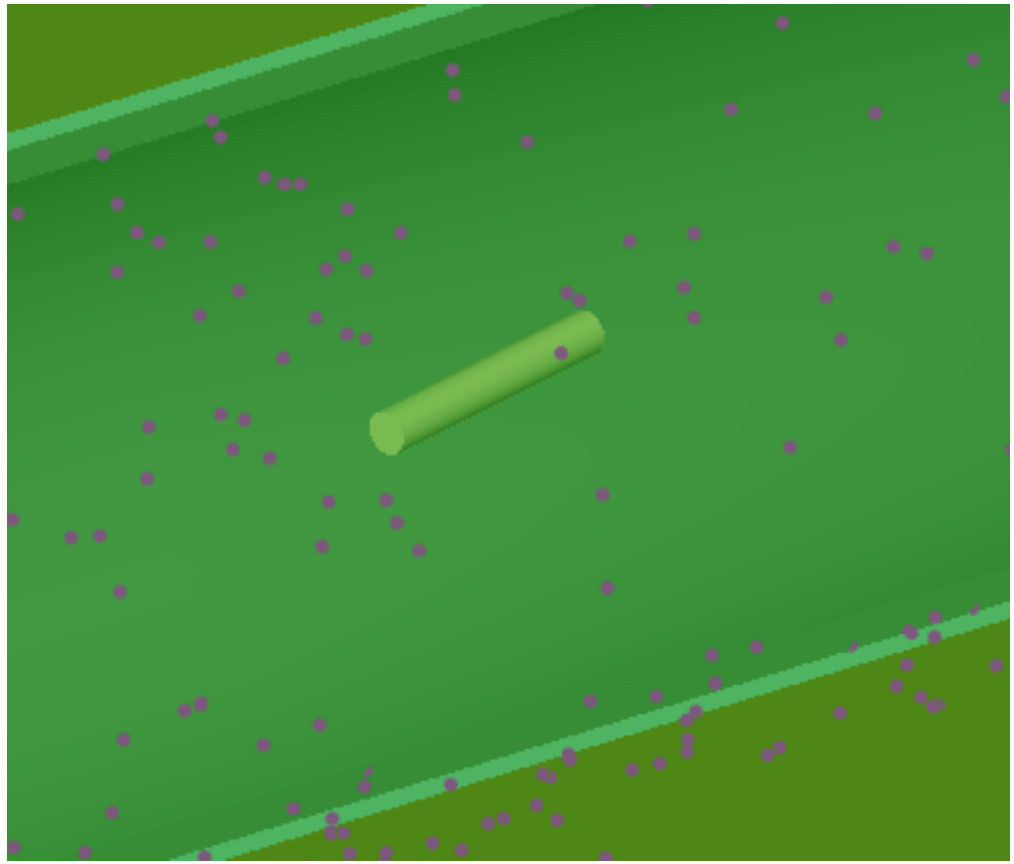
How about fat cylinders where we raster around the target edge?



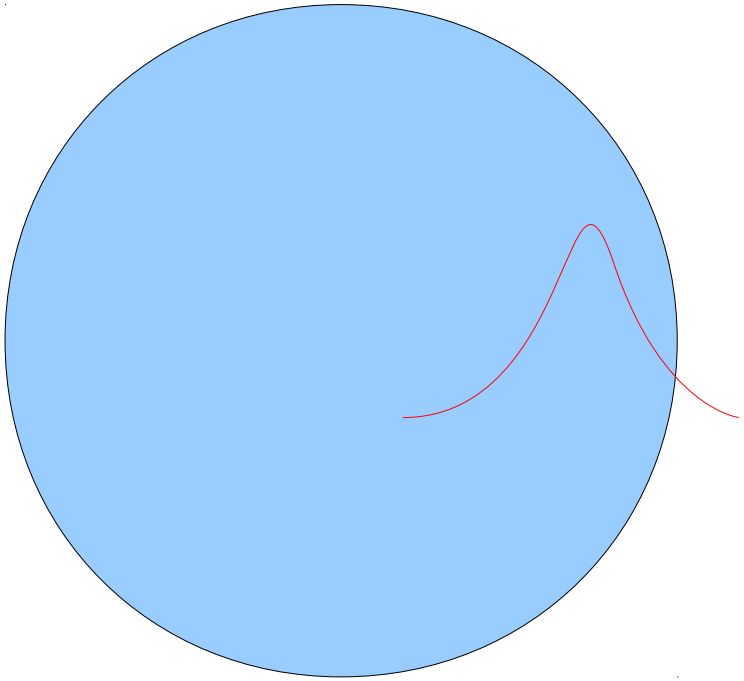


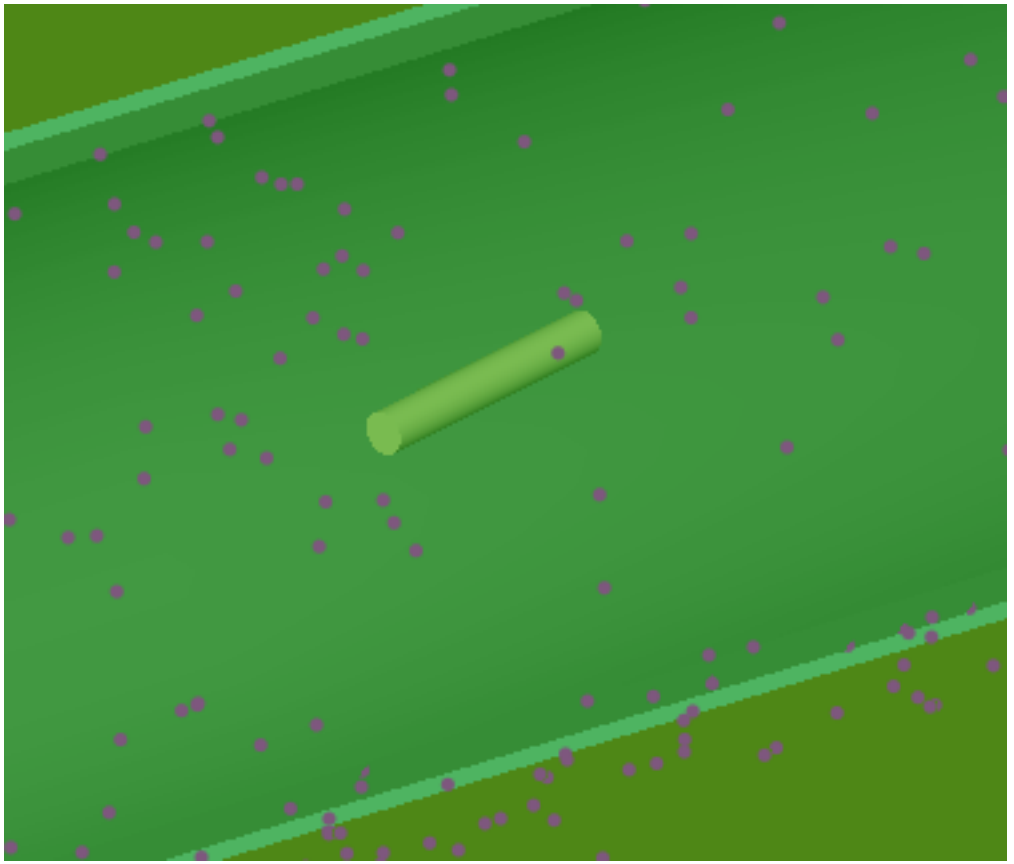
How about fat cylinders where we raster around the target edge?



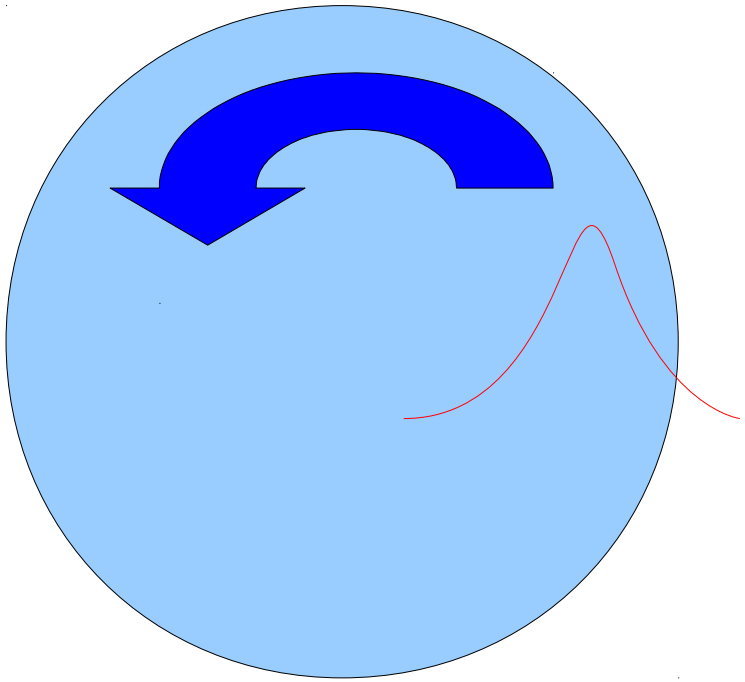


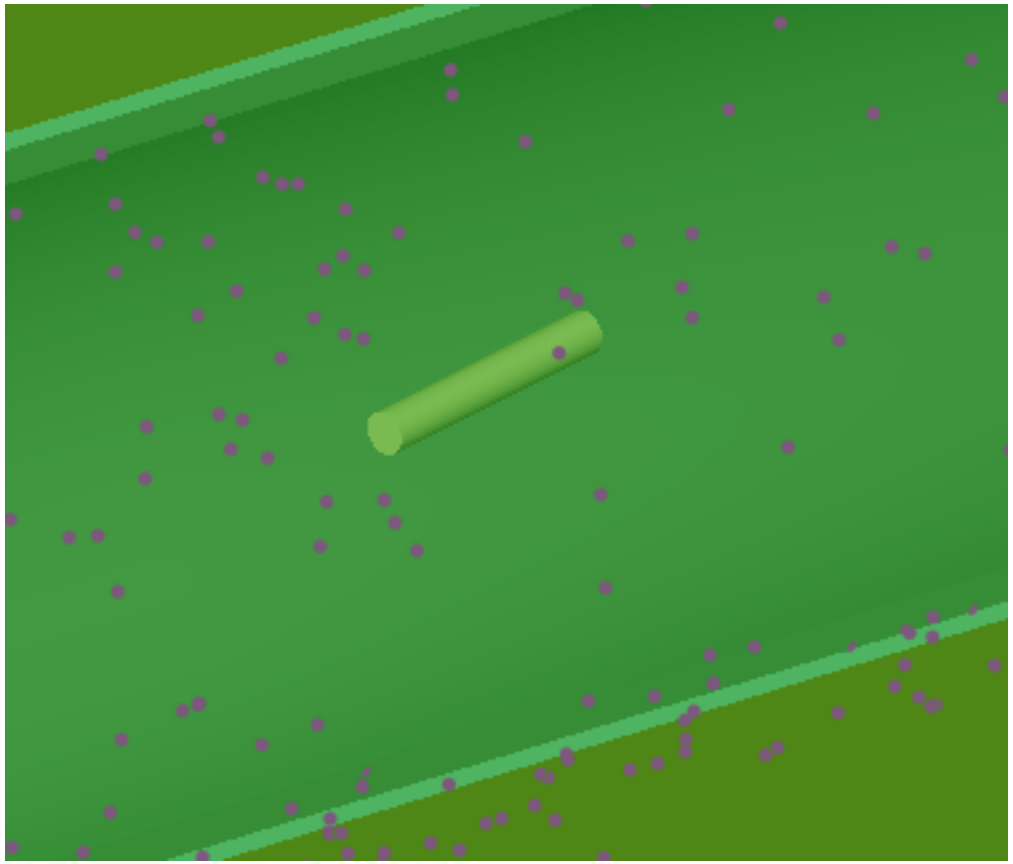
How about fat cylinders where we raster around the target edge?



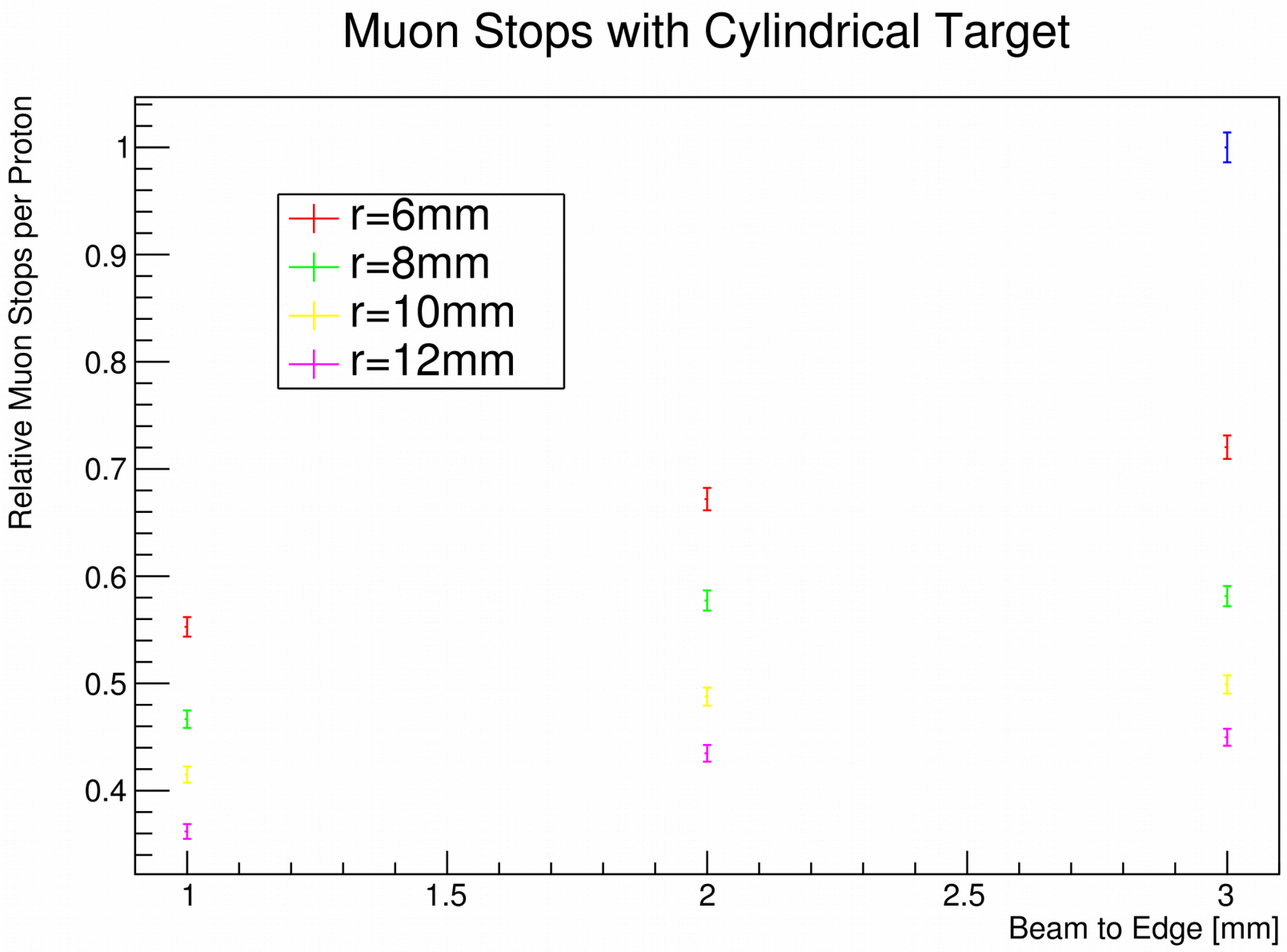


How about fat cylinders where we raster around the target edge?

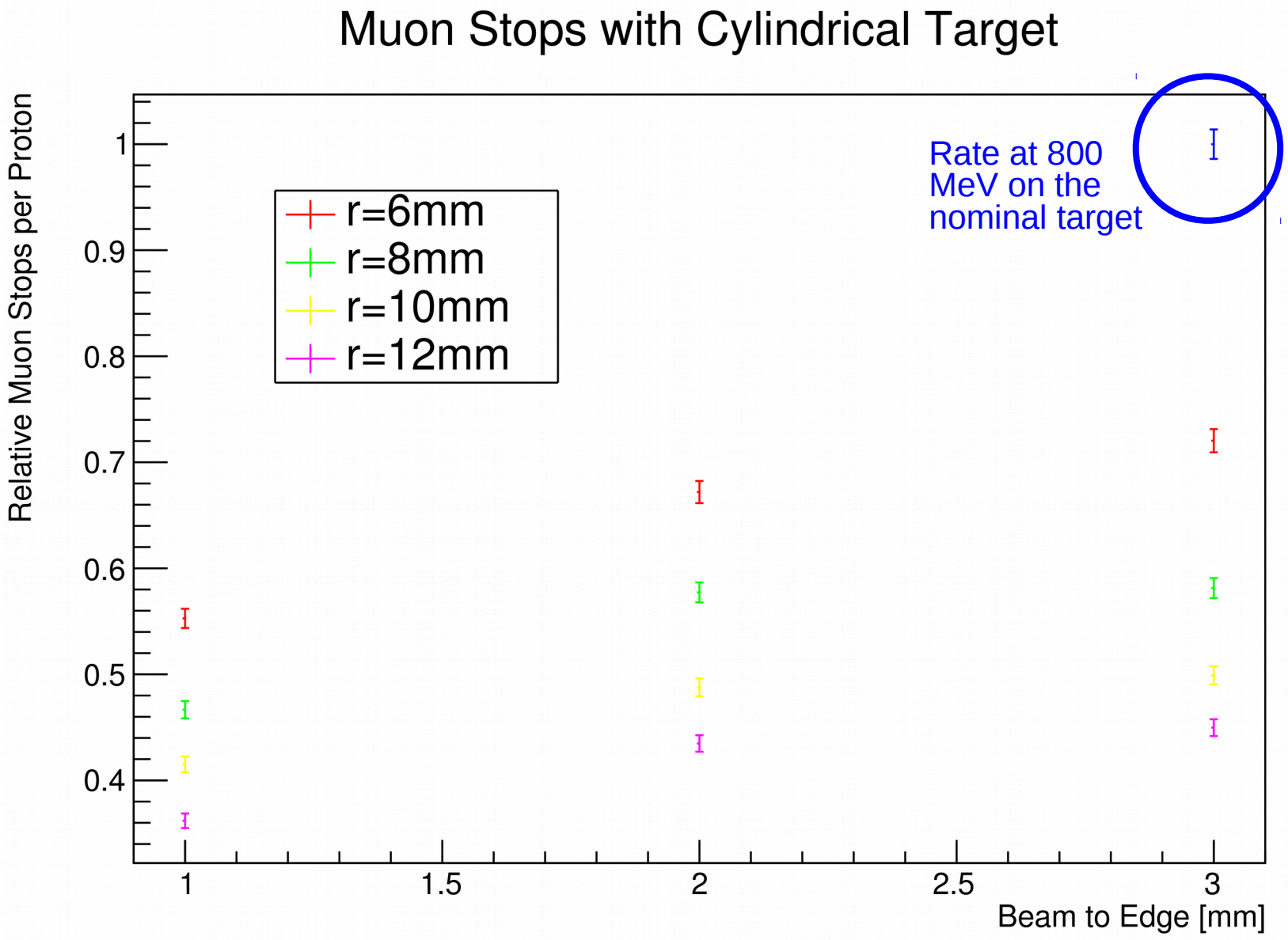




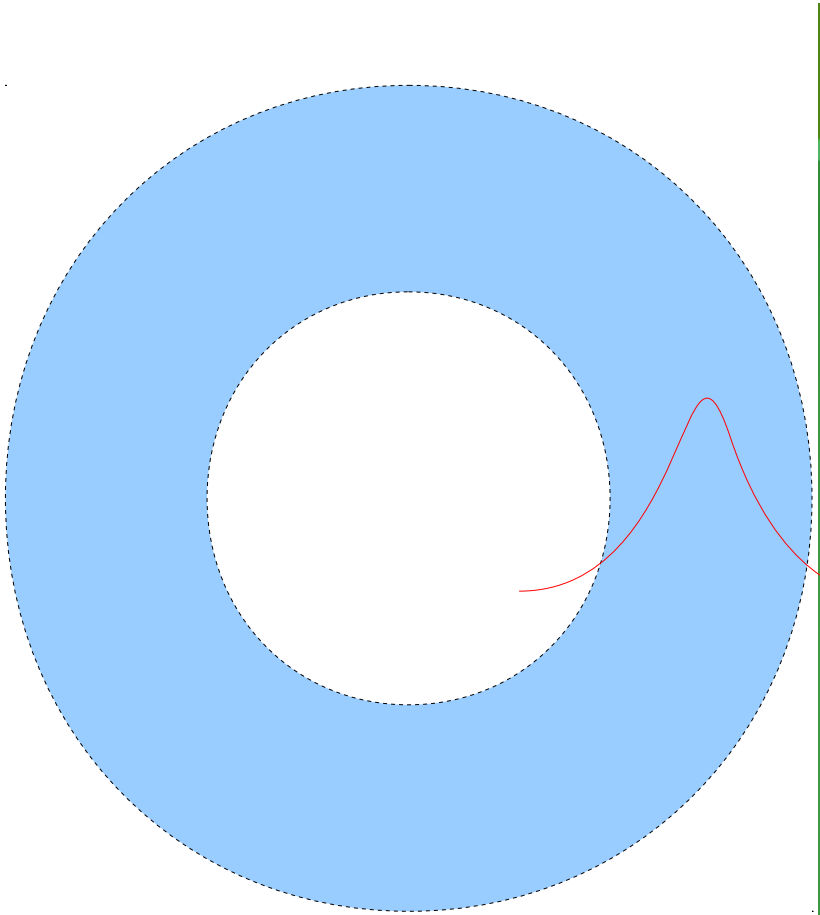
How about fat cylinders where we raster around the target edge?

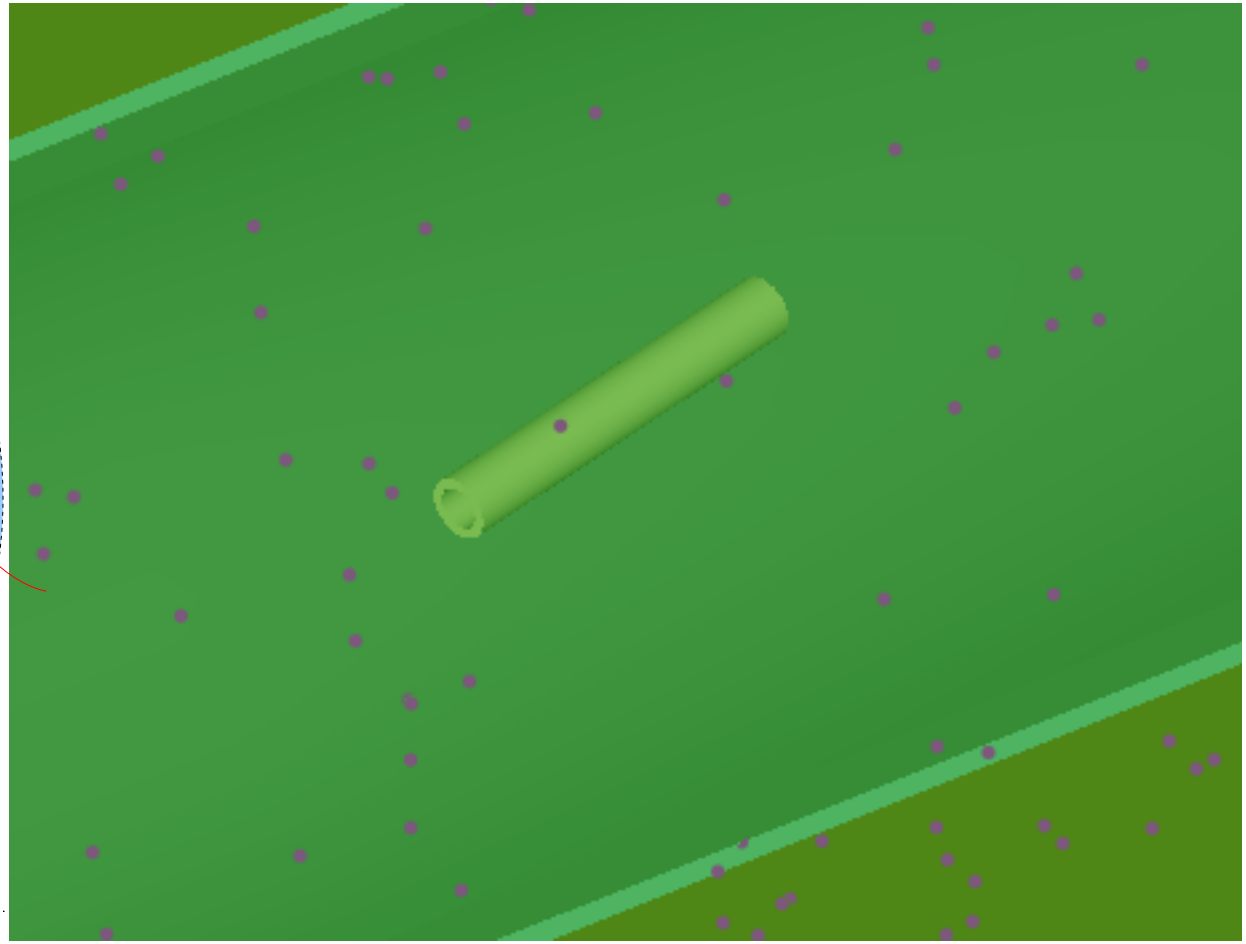


How about fat cylinders where we raster around the target edge?

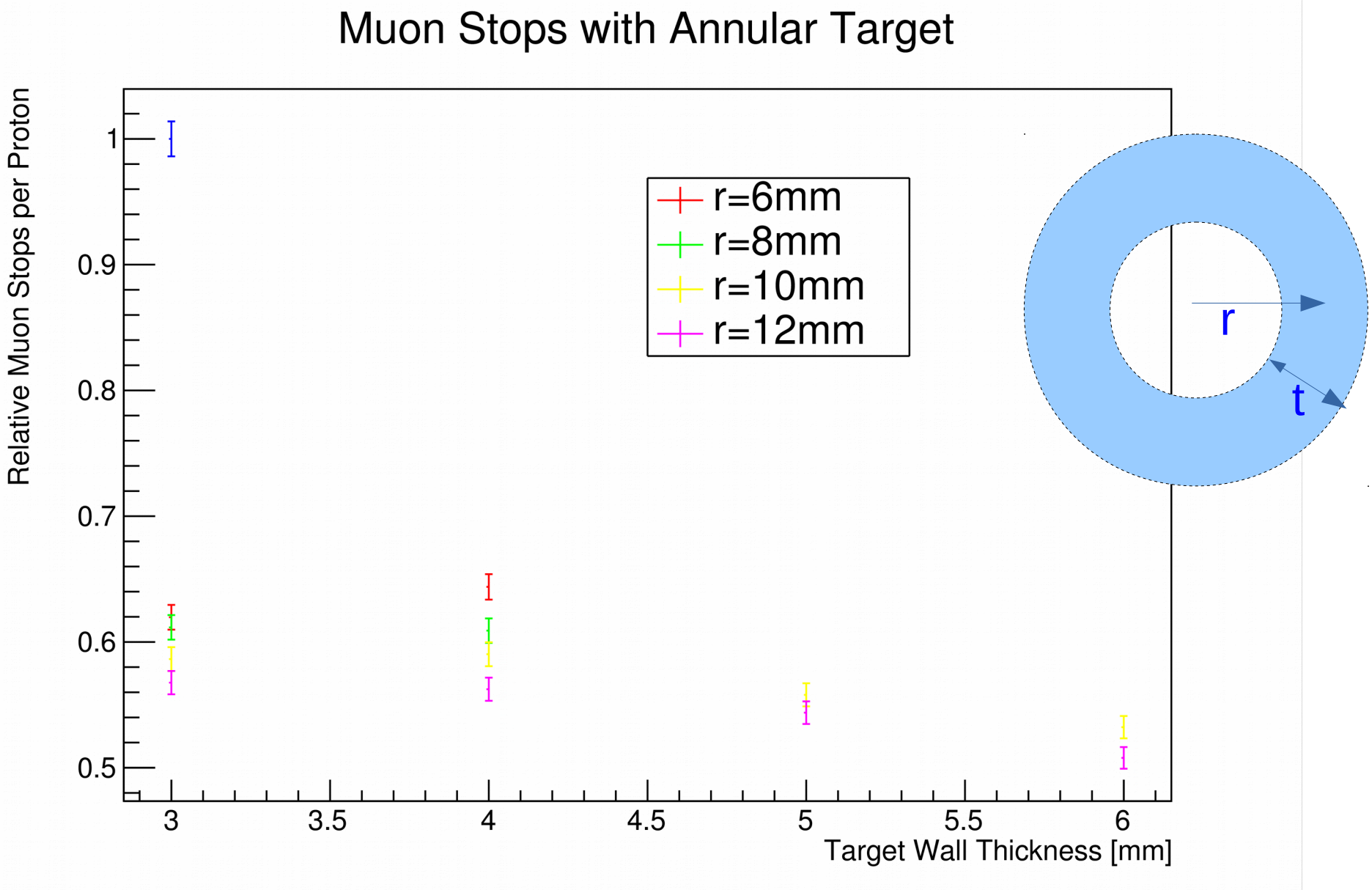


How about fat annular target where we raster around the target edge?





How about fat annular target where we raster around the target edge?



Summary

- Step away from the Mu2e scenario, and you take a terrible hit to stopped muon yield …
  - … which will only get worse when supports and gas lines are incorporated
- How much yield do we need to give up to obtain a survivable target?
  - 2.5% yield loss equals a week of downtime per year
- Significant R&D is needed on materials selection and cooling strategies