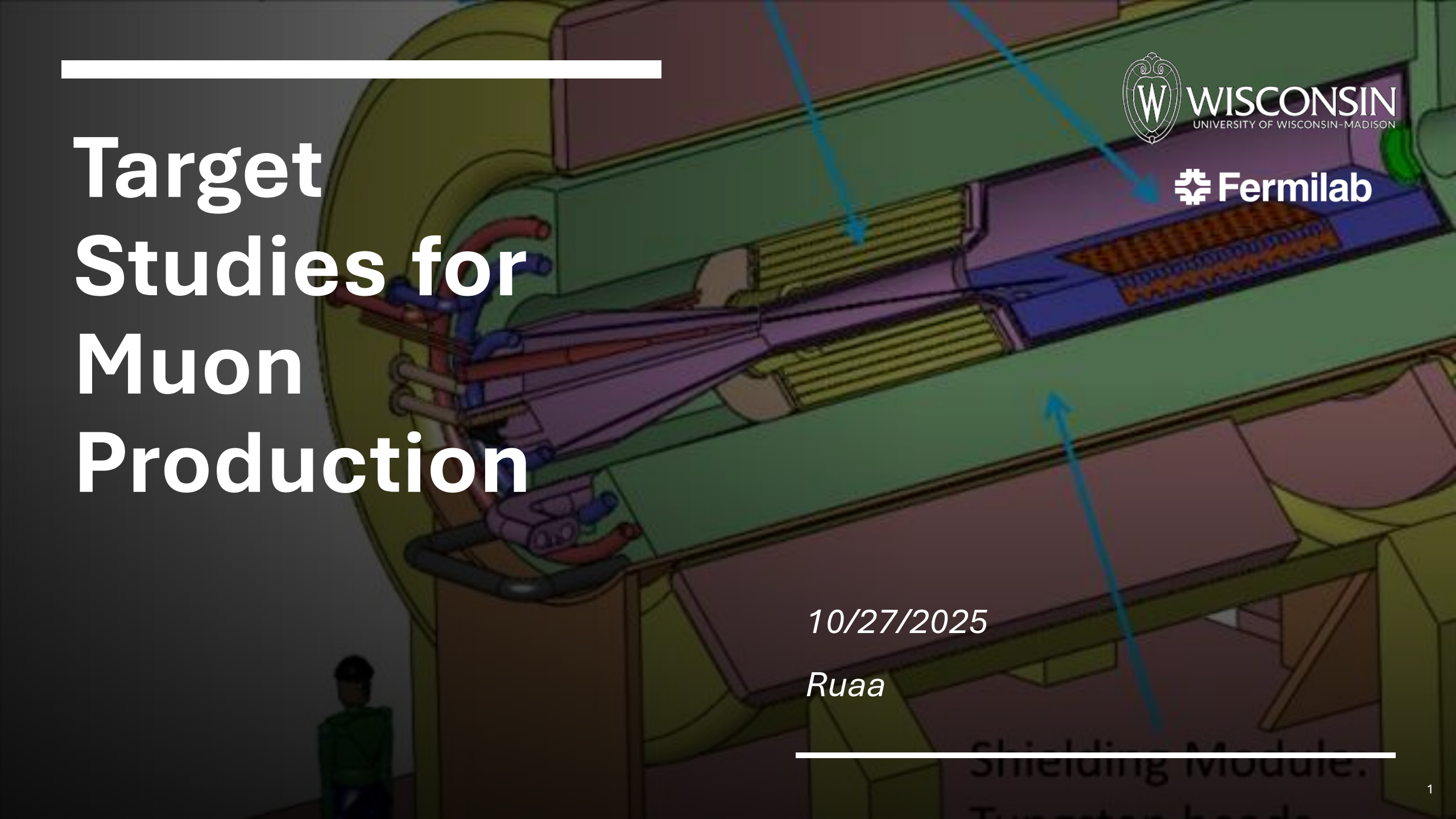
Target Studies for Muon Production



WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

Fermilab

10/27/2025

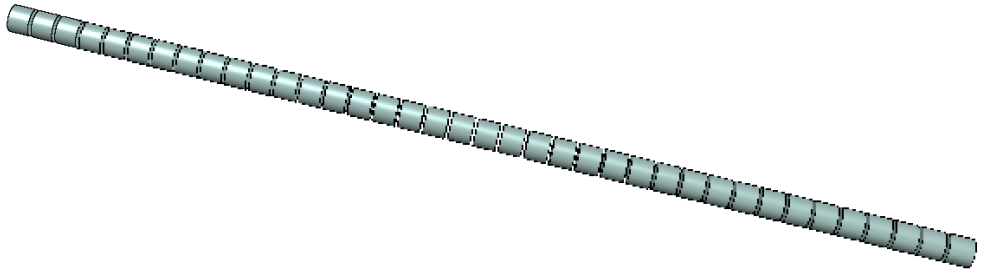
Ruaa

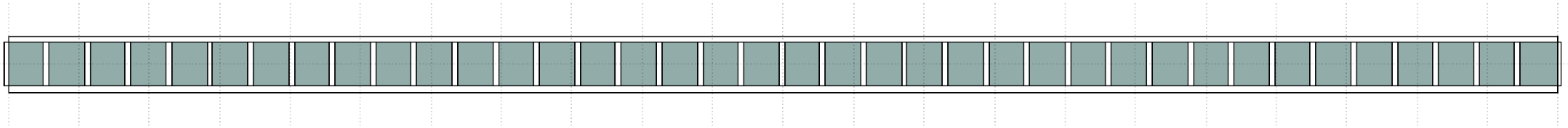
Mu2e target design

→Material: Tungsten

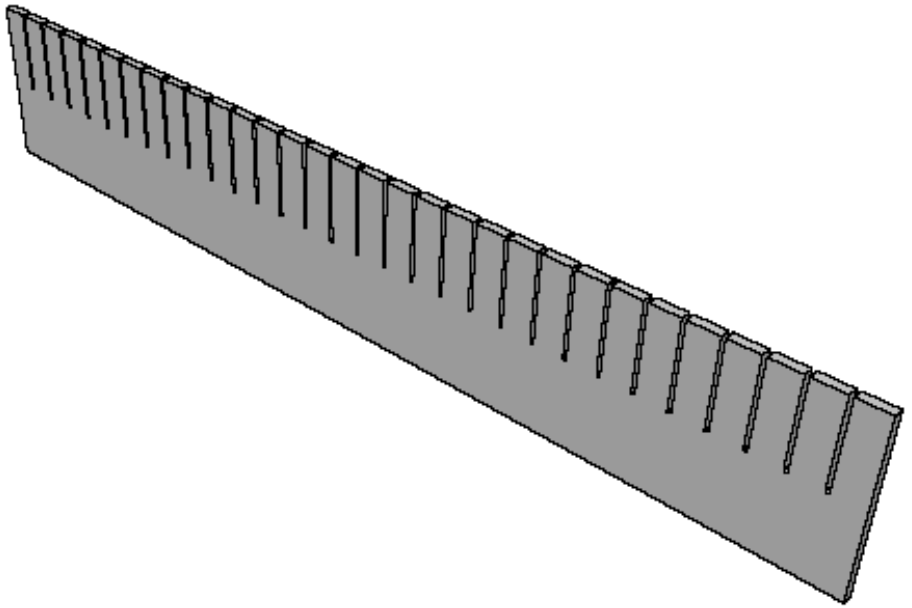
→The target is **20** cm in length and has radius of 0.315 cm.

→The target is divided into **34** sections, each 0.5 cm wide, separated by 0.08 cm gap.





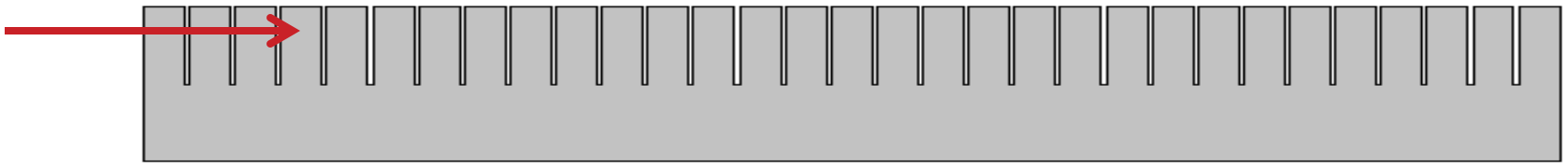
NOvA target design



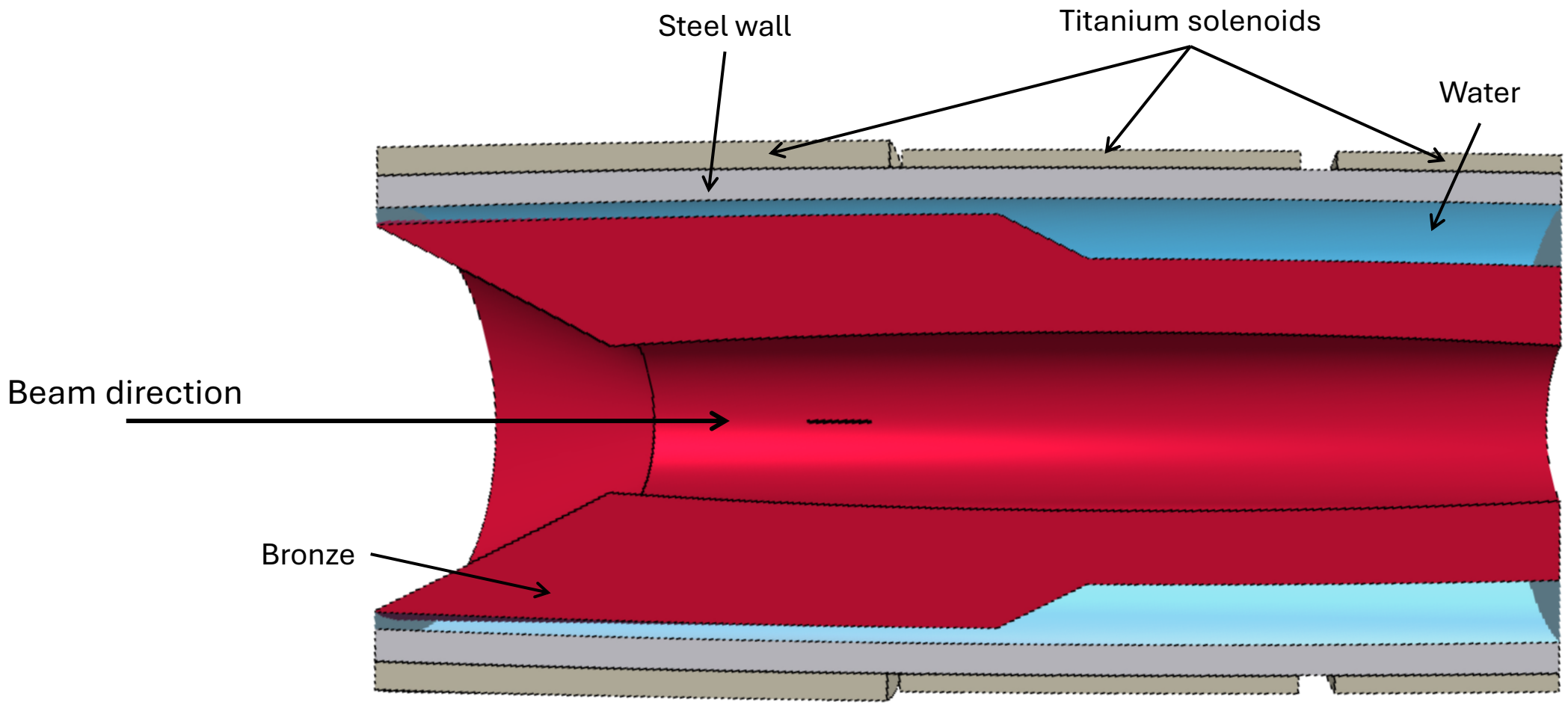
→ Material: Graphite

→ The target is **78** cm in length and 0.74 cm wide.

→ The target has 31 fins, each measuring 2.4 cm in length along the beam direction, and 6.3 cm in height, spaced by 0.05 cm gaps.

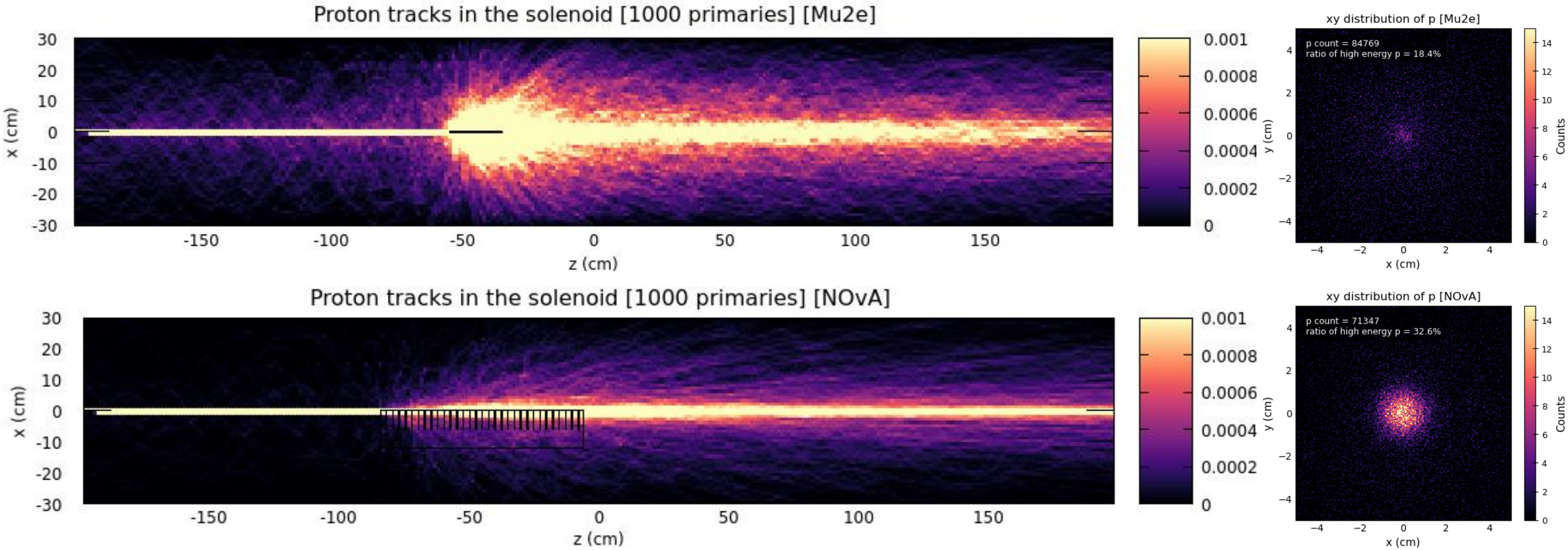


Mu2e Solenoid

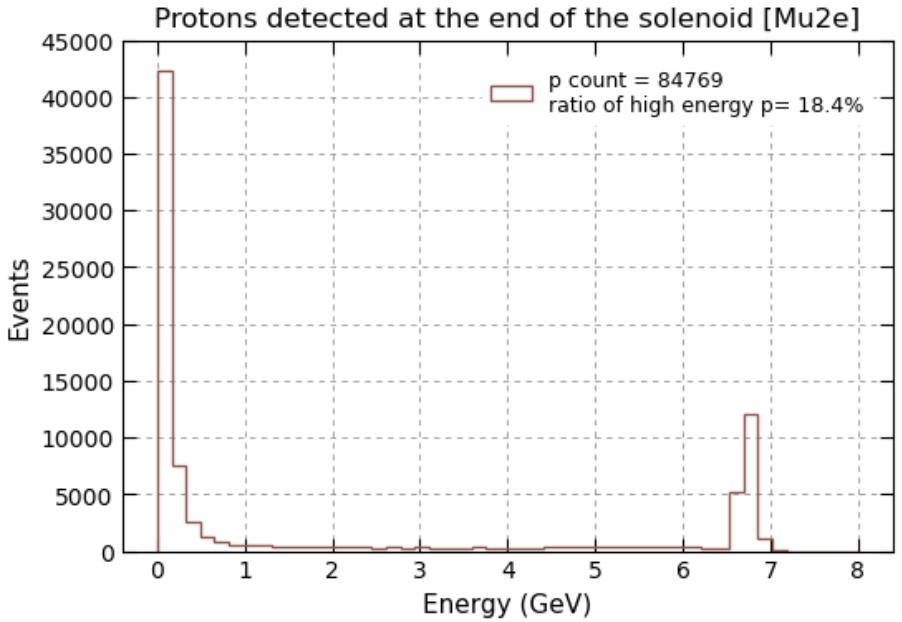


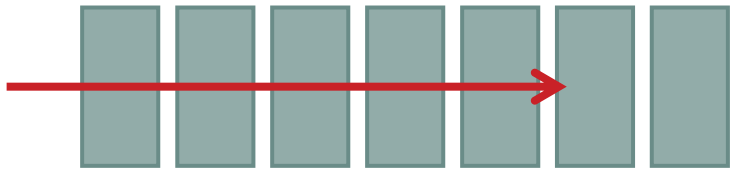
Analysis of the proton beam

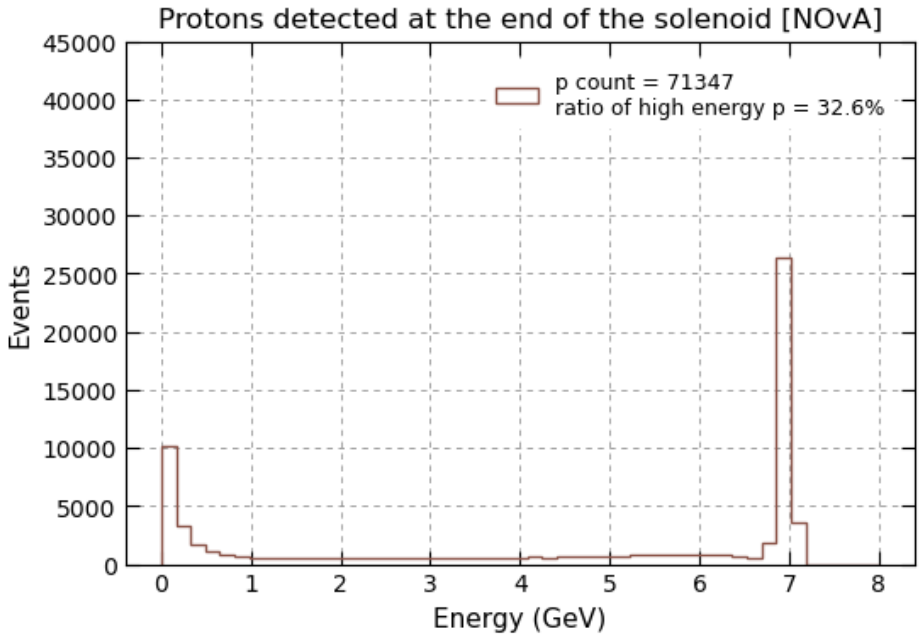
pions

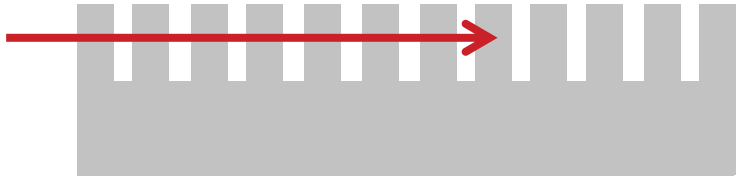

Proton tracks in the solenoid [1000 primaries] [Mu2e]
x (cm)
z (cm)
xy distribution of p [Mu2e]
p count = 84769
ratio of high energy p = 18.4%
y (cm)
x (cm)
Counts
Proton tracks in the solenoid [1000 primaries] [NOvA]
x (cm)
z (cm)
xy distribution of p [NOvA]
p count = 71347
ratio of high energy p = 32.6%
y (cm)
x (cm)
Counts

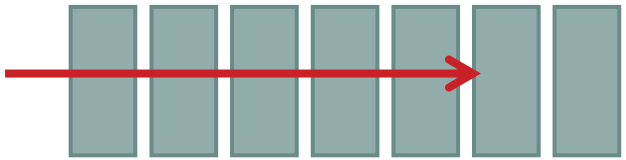
Protons energy distributions at the end of the solenoid

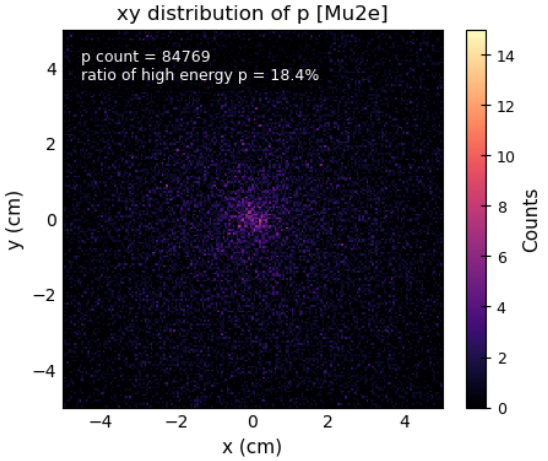


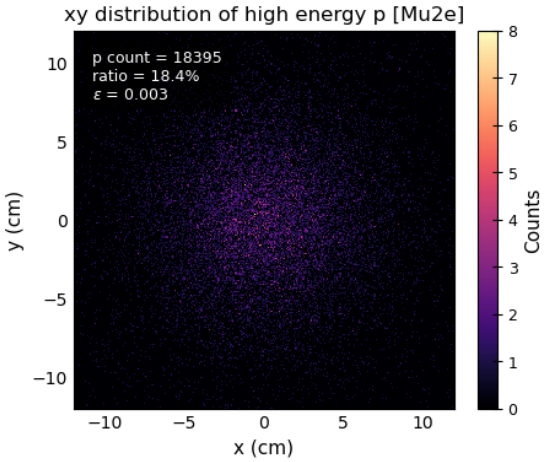


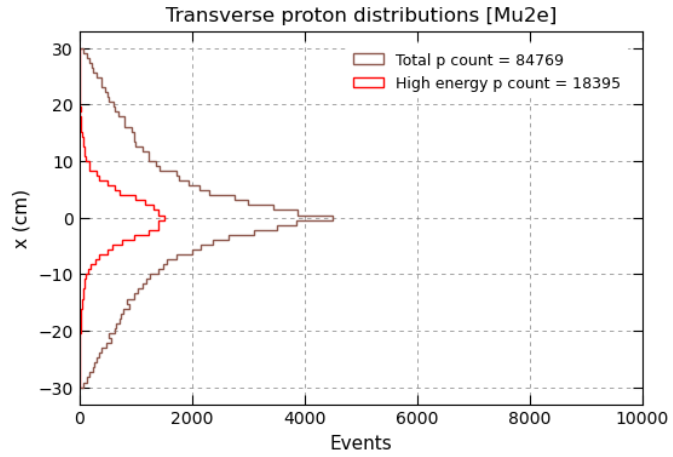


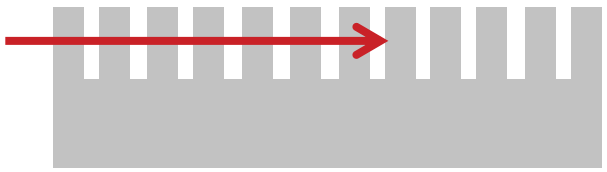


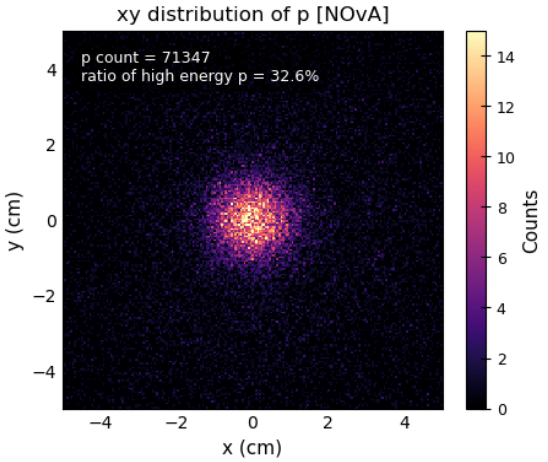


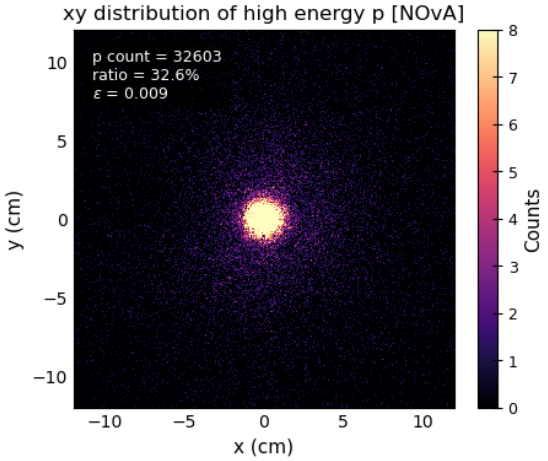

xy distribution of p [Mu2e]
p count = 84769
ratio of high energy p = 18.4%
x (cm)
y (cm)
Counts

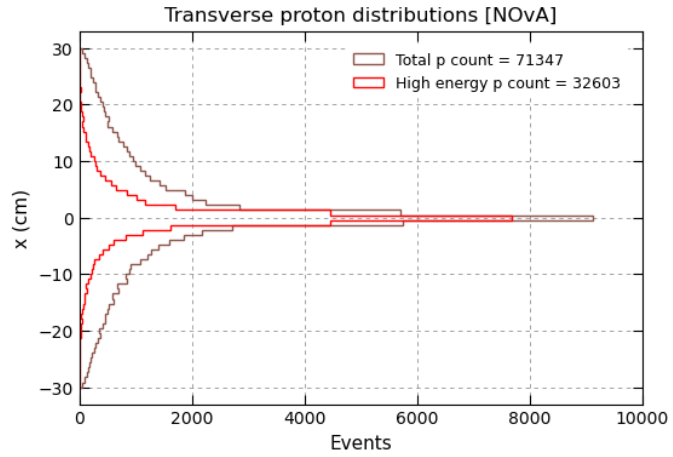

xy distribution of high energy p [Mu2e]
p count = 18395
ratio = 18.4%
ε = 0.003
x (cm)
y (cm)
Counts

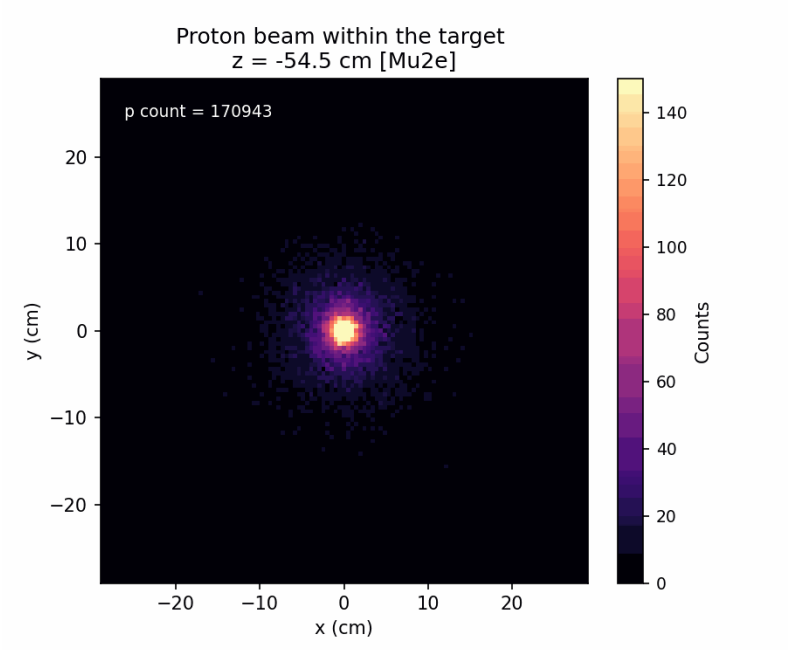

Transverse proton distributions [Mu2e]
Total p count = 84769
High energy p count = 18395
Events
x (cm)

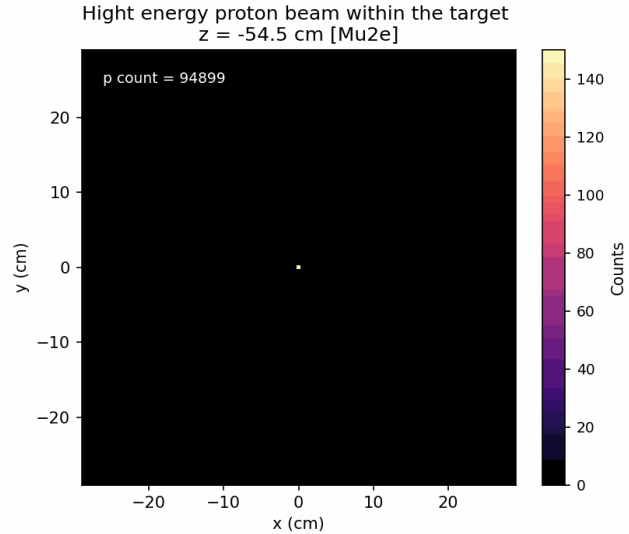


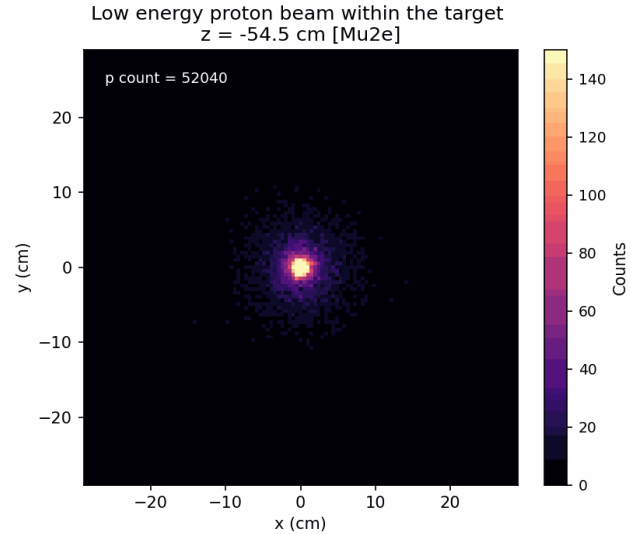

xy distribution of p [NOvA]
p count = 71347
ratio of high energy p = 32.6%
x (cm)
y (cm)
Counts

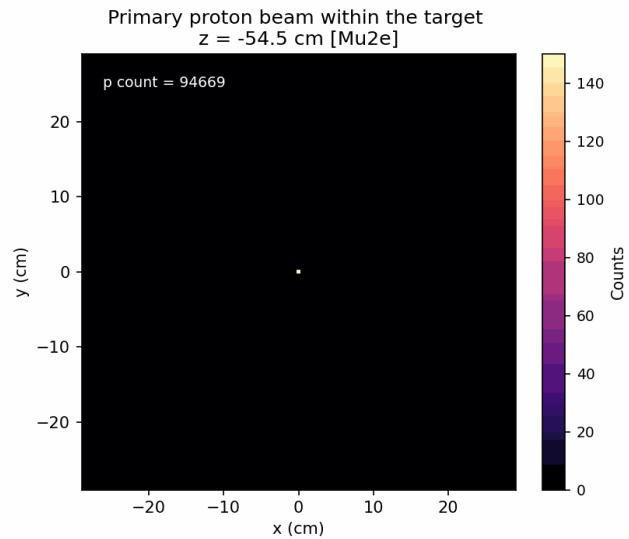

xy distribution of high energy p [NOvA]
p count = 32603
ratio = 32.6%
ε = 0.009
x (cm)
y (cm)
Counts

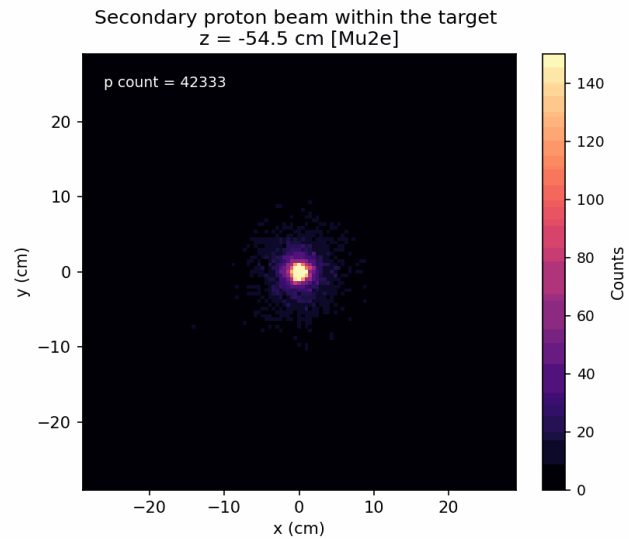

Transverse proton distributions [NOvA]
Total p count = 71347
High energy p count = 32603
Events
x (cm)

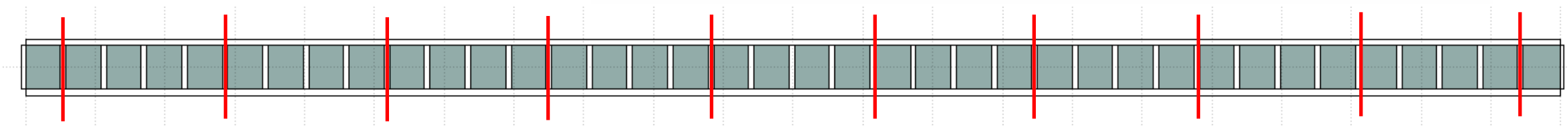

Proton beam within the target
z = -54.5 cm [Mu2e]
p count = 170943
x (cm)
y (cm)
Counts

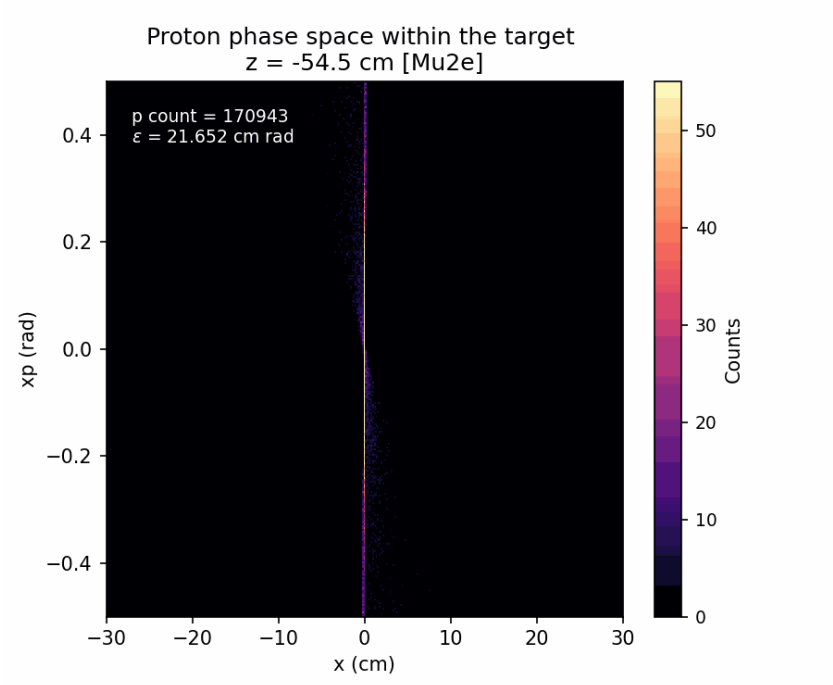

Hight energy proton beam within the target
z = -54.5 cm [Mu2e]
p count = 94899
x (cm)
y (cm)
Counts

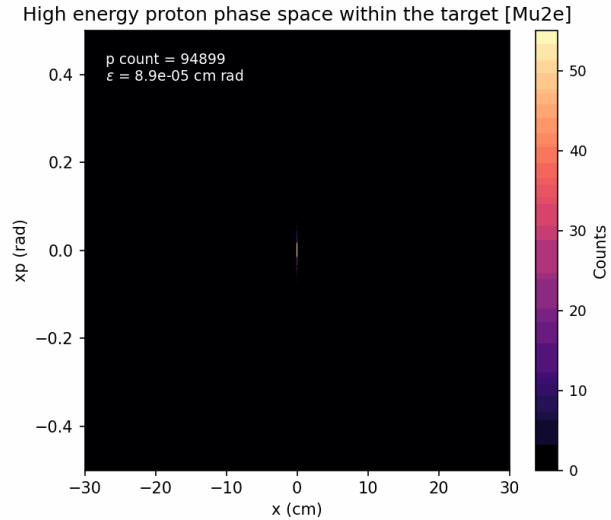

Low energy proton beam within the target
z = -54.5 cm [Mu2e]
p count = 52040
x (cm)
y (cm)
Counts

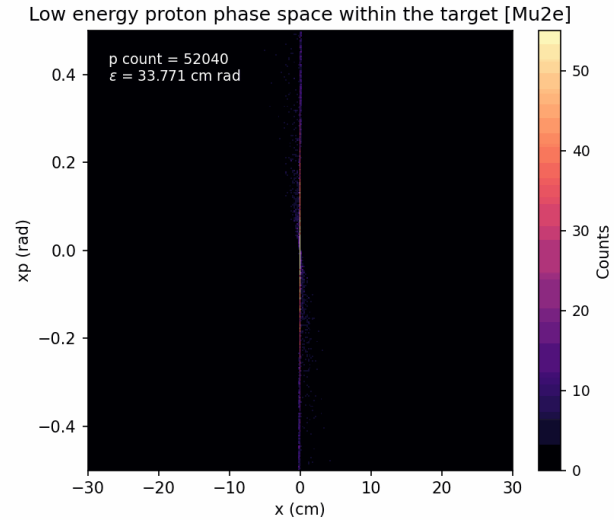

Primary proton beam within the target
z = -54.5 cm [Mu2e]
p count = 94669
x (cm)
y (cm)
Counts

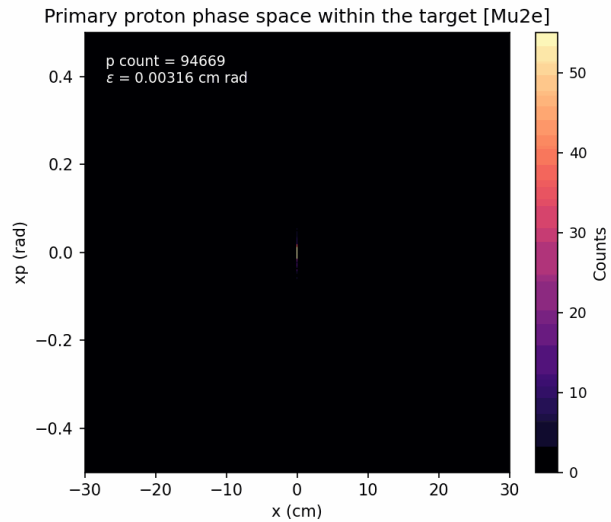

Secondary proton beam within the target
z = -54.5 cm [Mu2e]
p count = 42333
x (cm)
y (cm)
Counts

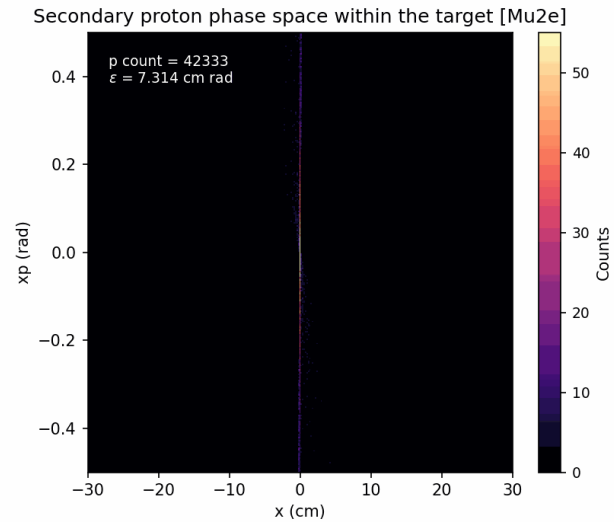

-54.5
-35.36

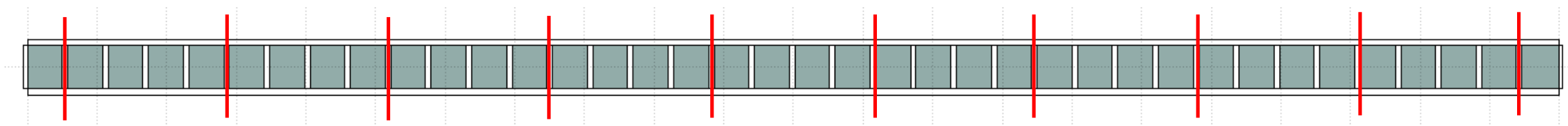

Proton phase space within the target
z = -54.5 cm [Mu2e]
p count = 170943
ε = 21.652 cm rad
xp (rad)
x (cm)
Counts

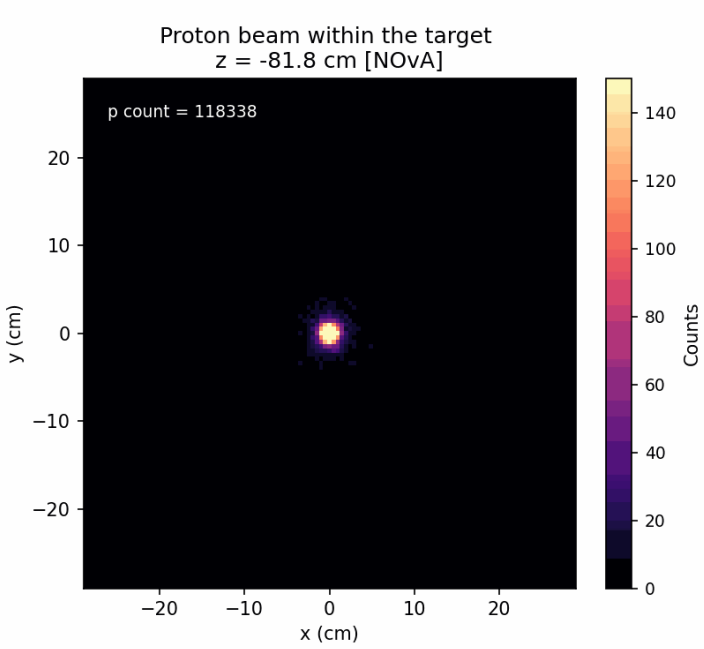

High energy proton phase space within the target [Mu2e]
p count = 94899
ε = 8.9e-05 cm rad
xp (rad)
x (cm)
Counts

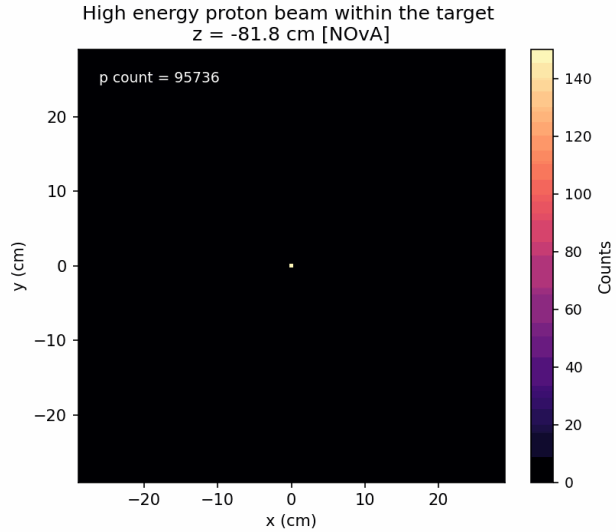

Low energy proton phase space within the target [Mu2e]
p count = 52040
ε = 33.771 cm rad
xp (rad)
x (cm)
Counts

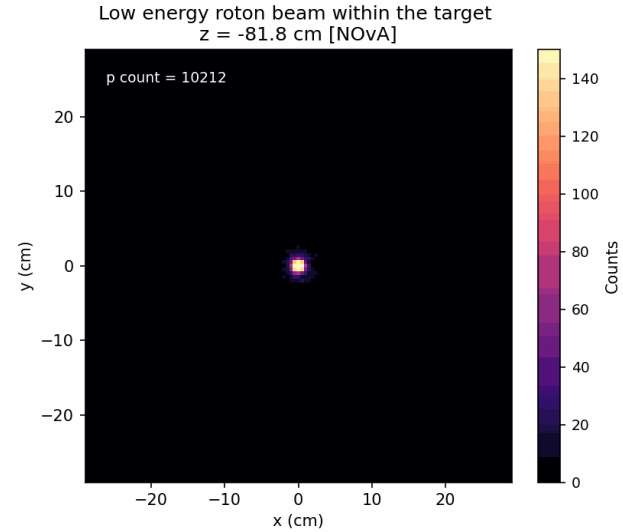

Primary proton phase space within the target [Mu2e]
p count = 94669
ε = 0.00316 cm rad
xp (rad)
x (cm)
Counts

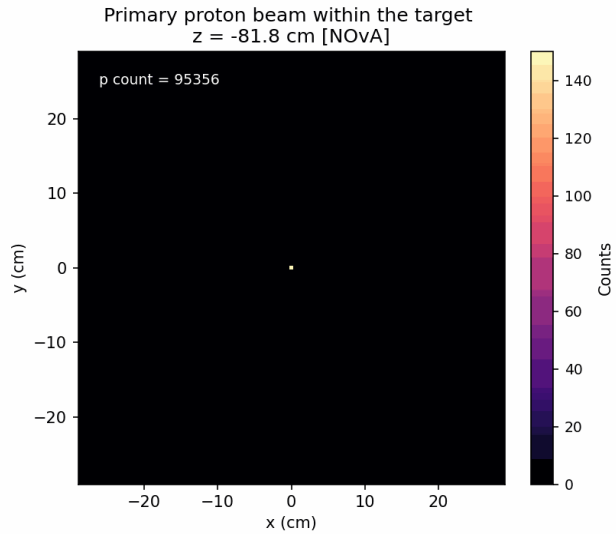

Secondary proton phase space within the target [Mu2e]
p count = 42333
ε = 7.314 cm rad
xp (rad)
x (cm)
Counts

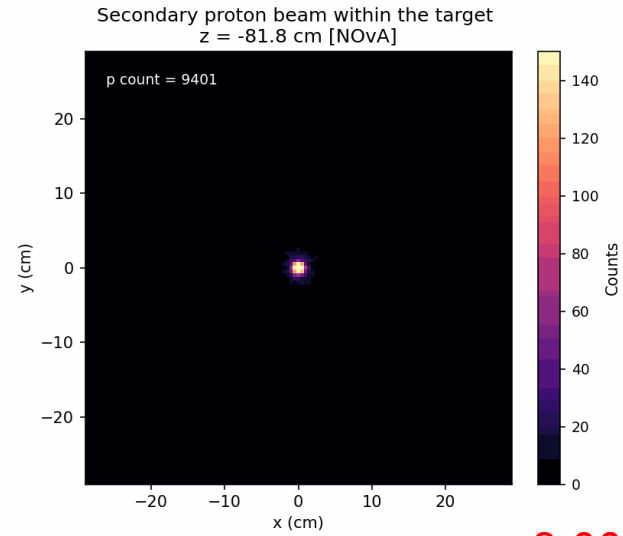

-54.5
-35.36

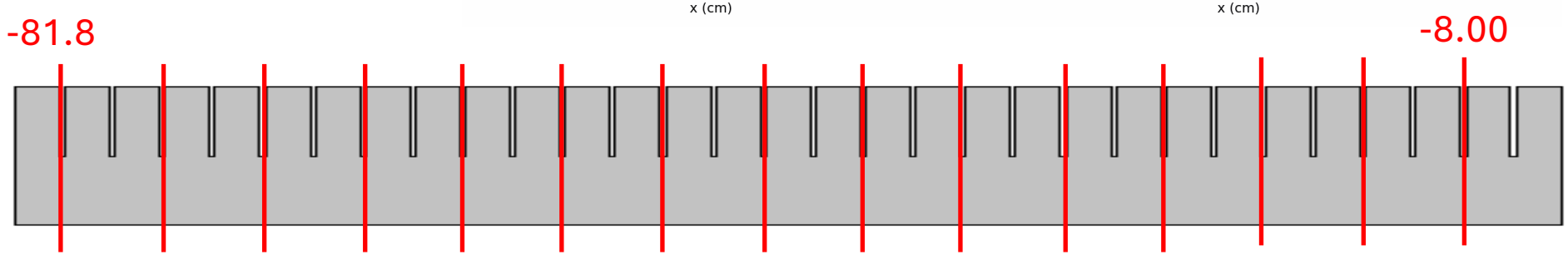

Proton beam within the target
z = -81.8 cm [NOvA]
p count = 118338
y (cm)
x (cm)
Counts

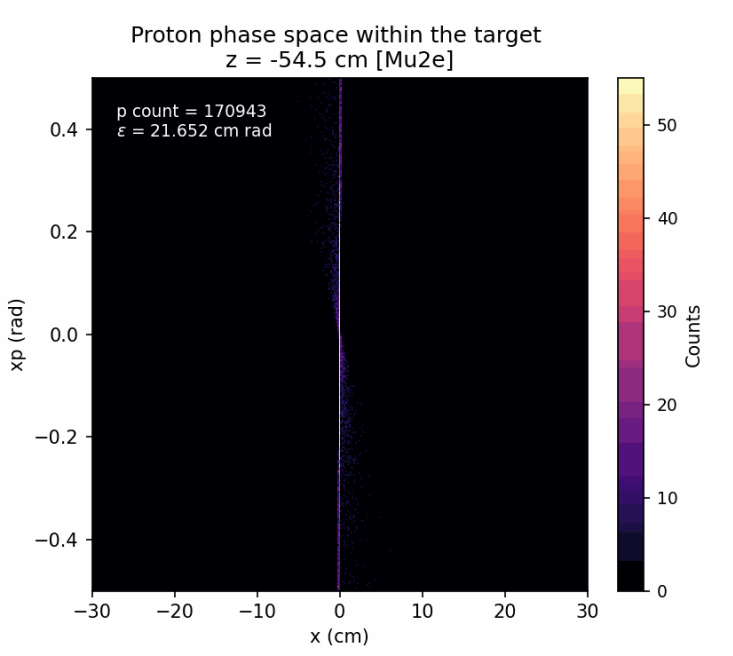

High energy proton beam within the target
z = -81.8 cm [NOvA]
p count = 95736
y (cm)
x (cm)
Counts

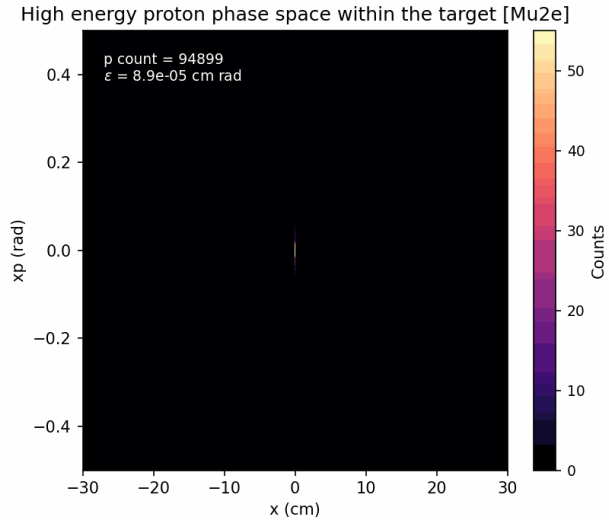

Low energy roton beam within the target
z = -81.8 cm [NOvA]
p count = 10212
y (cm)
x (cm)
Counts

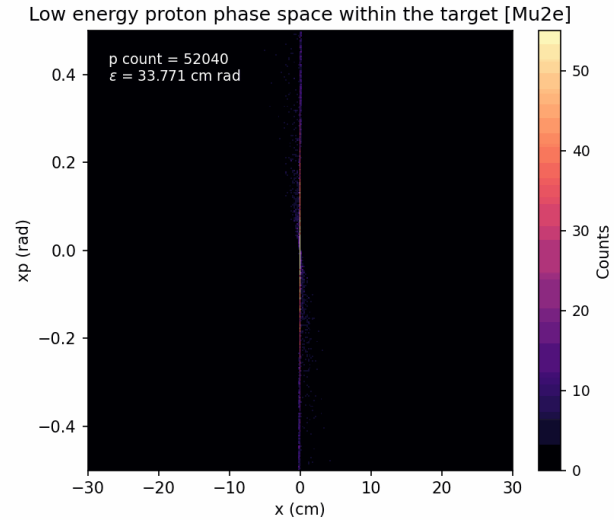

Primary proton beam within the target
z = -81.8 cm [NOvA]
p count = 95356
y (cm)
x (cm)
Counts

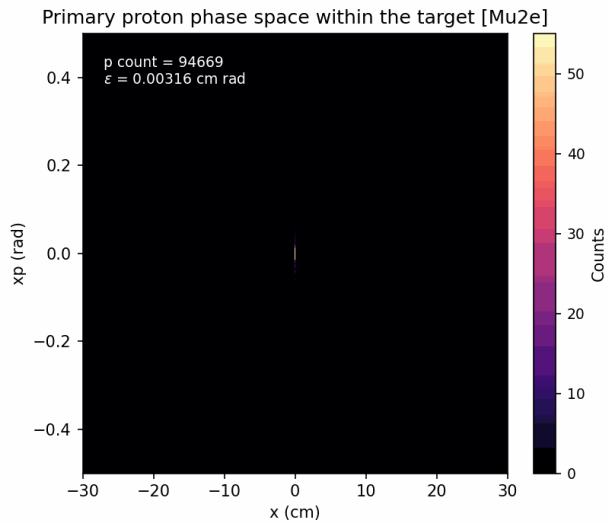

Secondary proton beam within the target
z = -81.8 cm [NOvA]
p count = 9401
y (cm)
x (cm)
Counts

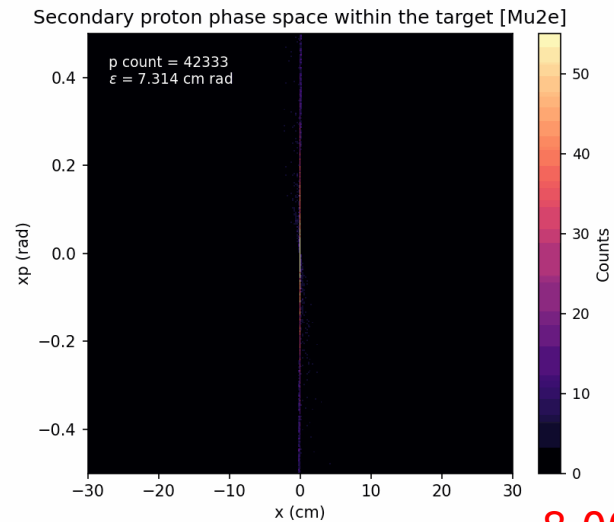

-81.8
-8.00

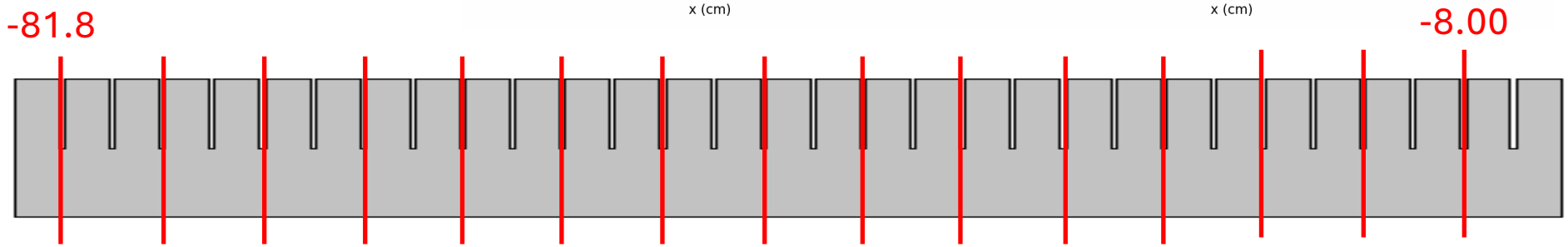

Proton phase space within the target
z = -54.5 cm [Mu2e]
p count = 170943
ε = 21.652 cm rad
xp (rad)
x (cm)
Counts


High energy proton phase space within the target [Mu2e]
p count = 94899
ε = 8.9e-05 cm rad
xp (rad)
x (cm)
Counts


Low energy proton phase space within the target [Mu2e]
p count = 52040
ε = 33.771 cm rad
xp (rad)
x (cm)
Counts

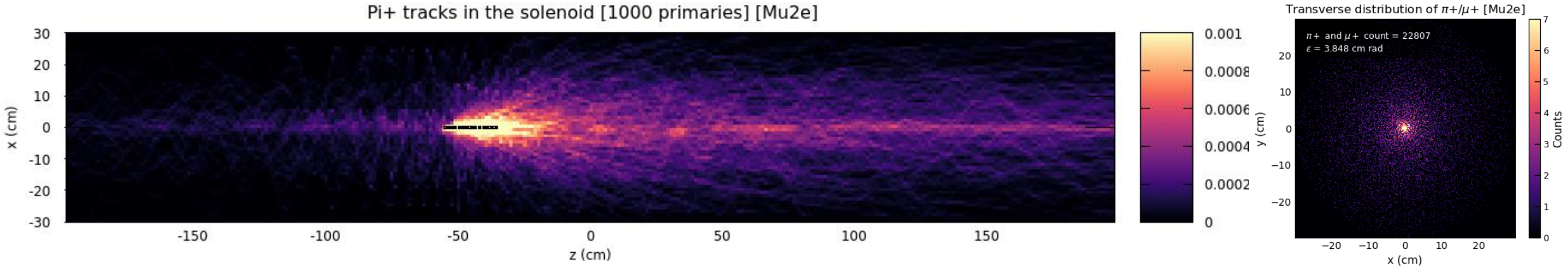

Primary proton phase space within the target [Mu2e]
p count = 94669
ε = 0.00316 cm rad
xp (rad)
x (cm)
Counts

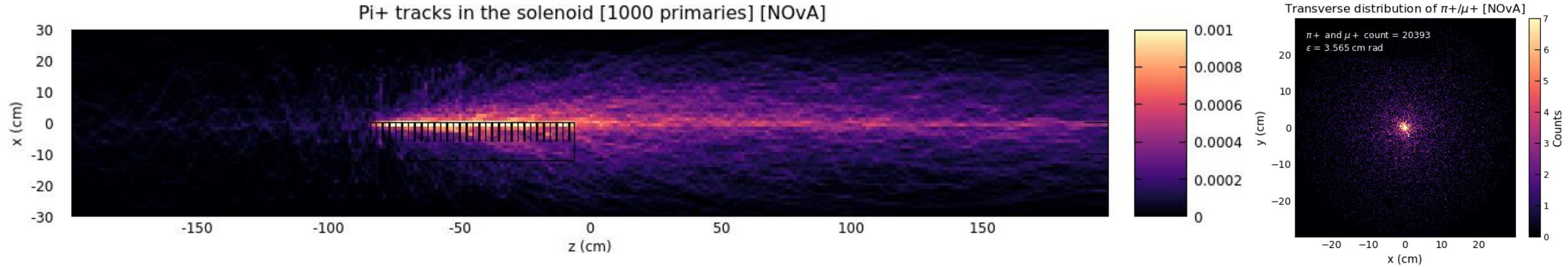

Secondary proton phase space within the target [Mu2e]
p count = 42333
ε = 7.314 cm rad
xp (rad)
x (cm)
Counts

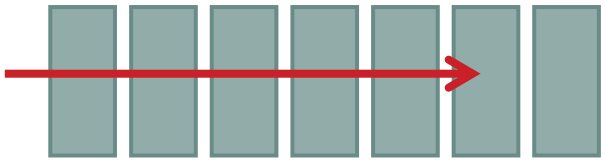

-81.8
-8.00

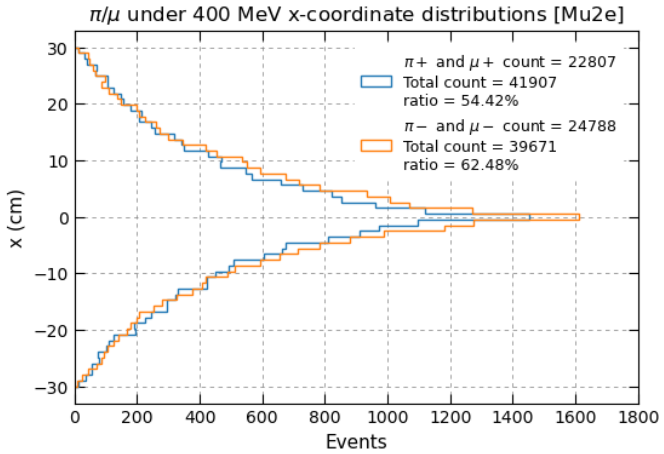
Analysis of the π/μ beam

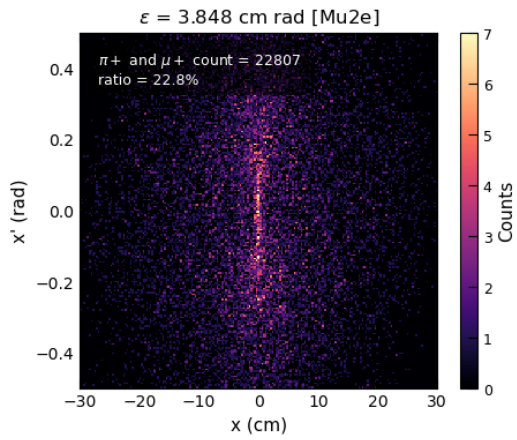
protons

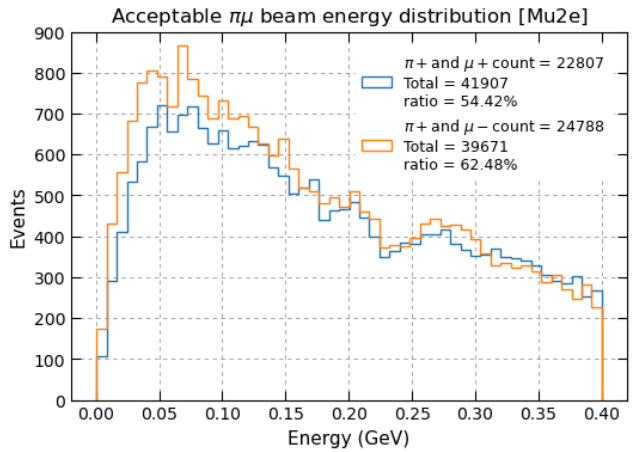

Pi+ tracks in the solenoid [1000 primaries] [Mu2e]
x (cm)
z (cm)
Transverse distribution of π+/μ+ [Mu2e]
π+ and μ+ count = 22807
ε = 3.848 cm rad
y (cm)
x (cm)
Counts

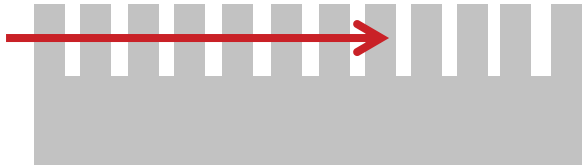

Pi+ tracks in the solenoid [1000 primaries] [NOvA]
x (cm)
z (cm)
Transverse distribution of π+/μ+ [NOvA]
π+ and μ+ count = 20393
ε = 3.565 cm rad
y (cm)
x (cm)
Counts

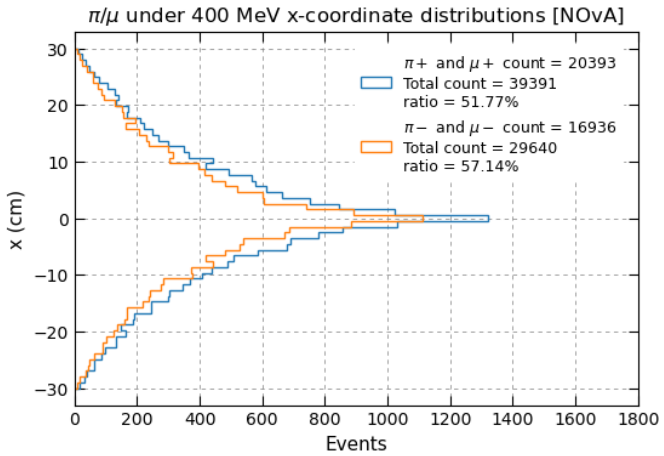


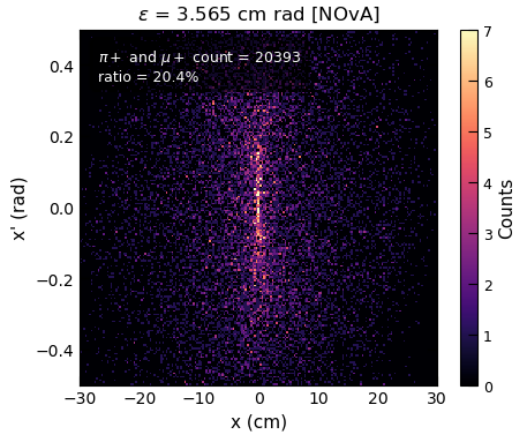

π/μ under 400 MeV x-coordinate distributions [Mu2e]
π+ and μ+ count = 22807
Total count = 41907
ratio = 54.42%
π− and μ− count = 24788
Total count = 39671
ratio = 62.48%
x (cm)
Events

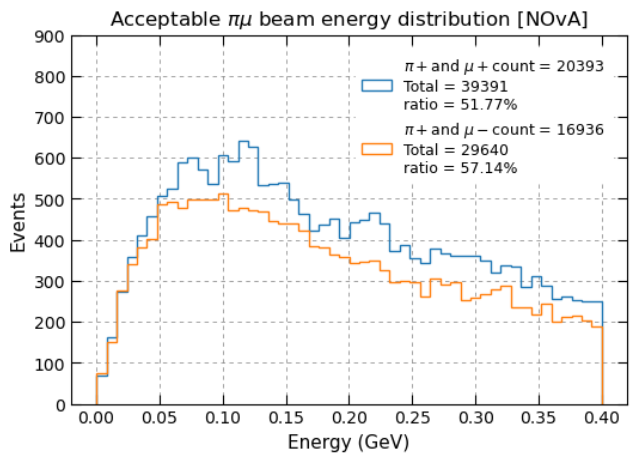

ε = 3.848 cm rad [Mu2e]
π+ and μ+ count = 22807
ratio = 22.8%
x' (rad)
x (cm)
Counts

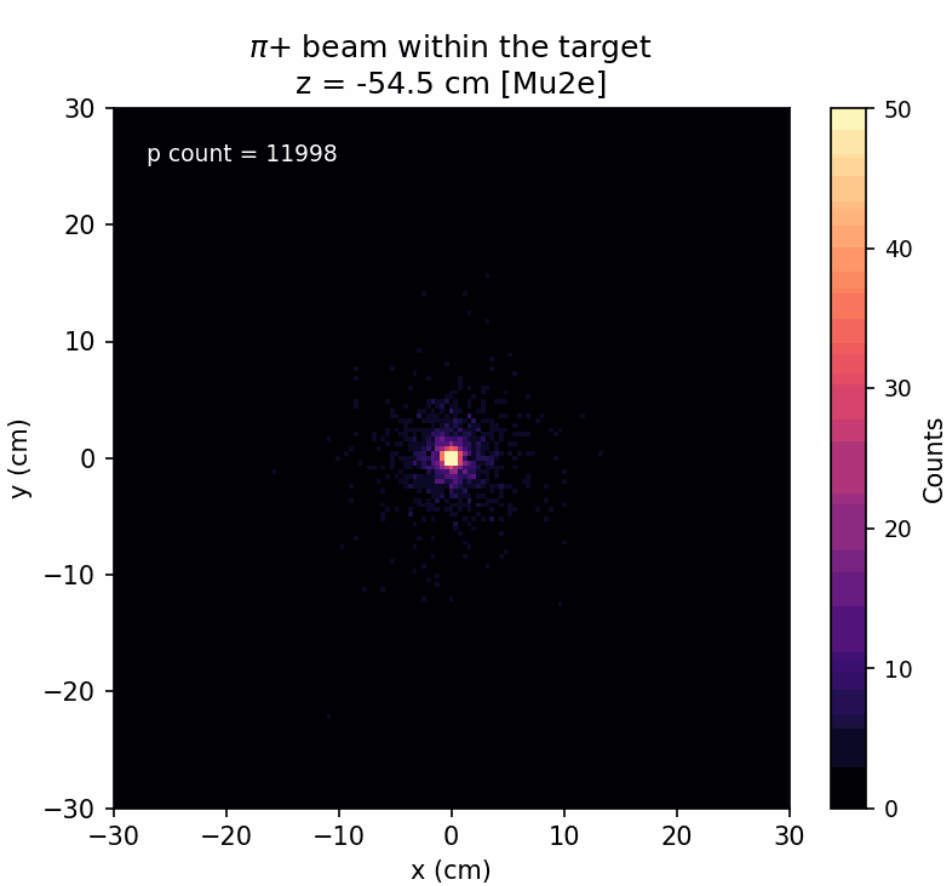

Acceptable πμ beam energy distribution [Mu2e]
π+ and μ+ count = 22807
Total = 41907
ratio = 54.42%
π+ and μ− count = 24788
Total = 39671
ratio = 62.48%
Events
Energy (GeV)

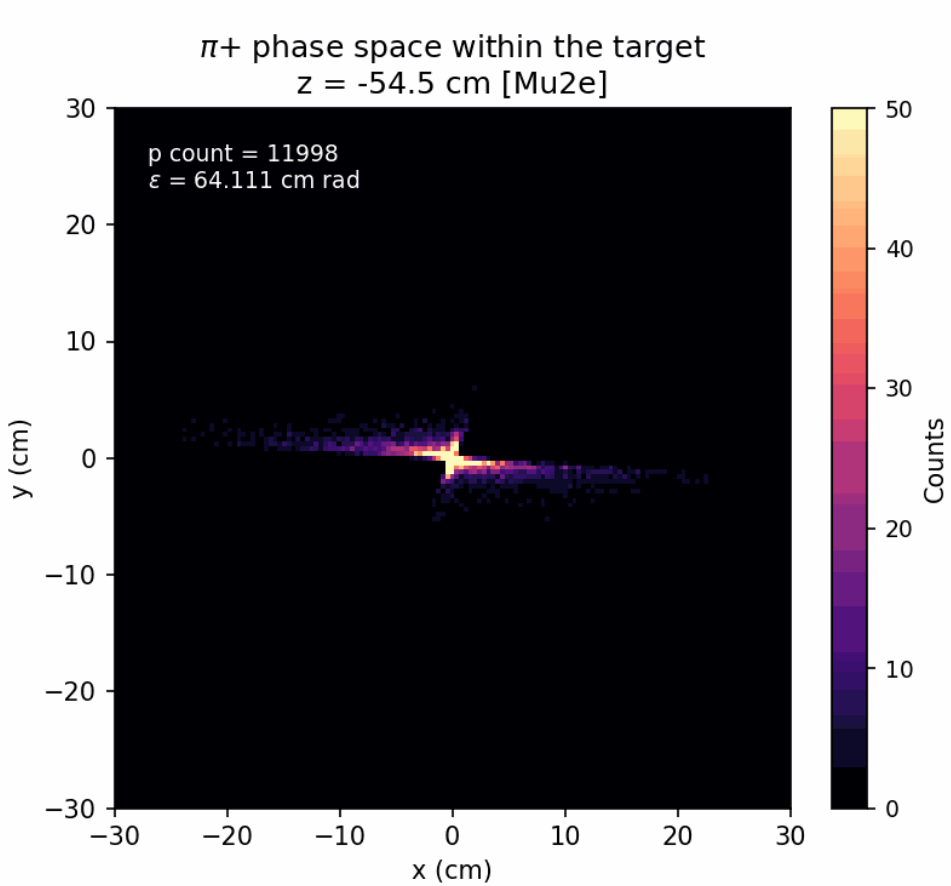


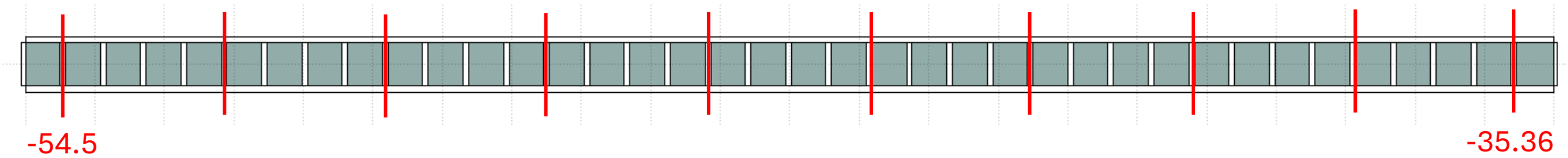

π/μ under 400 MeV x-coordinate distributions [NOvA]
π+ and μ+ count = 20393
Total count = 39391
ratio = 51.77%
π− and μ− count = 16936
Total count = 29640
ratio = 57.14%
x (cm)
Events

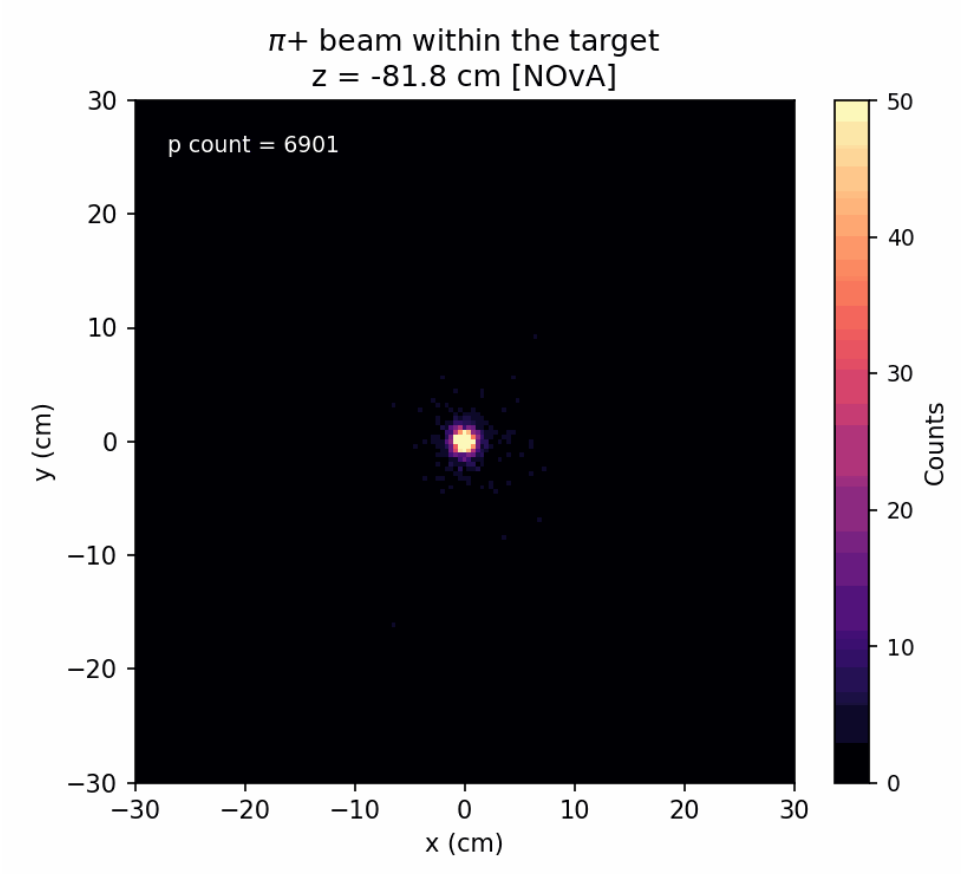

ε = 3.565 cm rad [NOvA]
π+ and μ+ count = 20393
ratio = 20.4%
x' (rad)
x (cm)
Counts

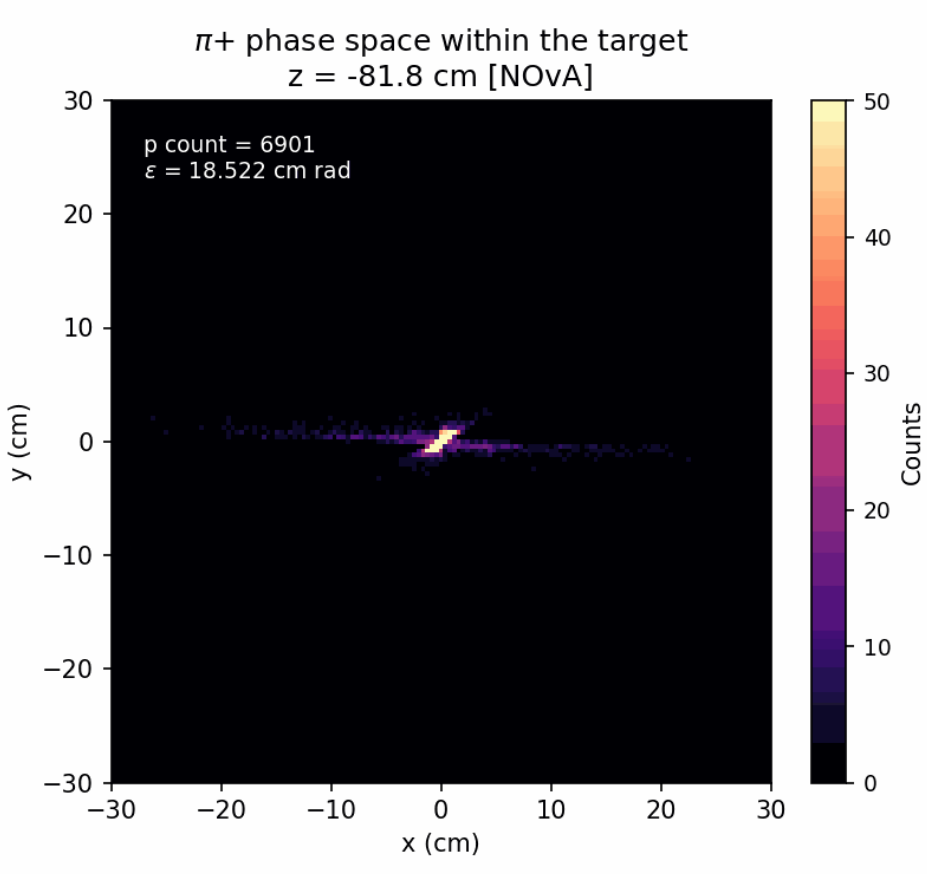

Acceptable πμ beam energy distribution [NOvA]
π+ and μ+ count = 20393
Total = 39391
ratio = 51.77%
π+ and μ− count = 16936
Total = 29640
ratio = 57.14%
Events
Energy (GeV)

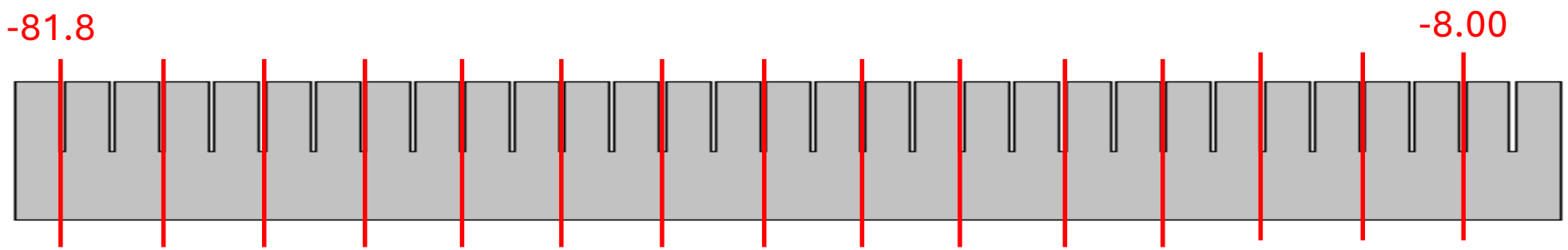

π+ beam within the target
z = -54.5 cm [Mu2e]
p count = 11998
y (cm)
x (cm)
Counts


π+ phase space within the target
z = -54.5 cm [Mu2e]
p count = 11998
ε = 64.111 cm rad
y (cm)
x (cm)
Counts


-54.5
-35.36


π+ beam within the target
z = -81.8 cm [NOvA]
p count = 6901
y (cm)
x (cm)
Counts


π+ phase space within the target
z = -81.8 cm [NOvA]
p count = 6901
ε = 18.522 cm rad
y (cm)
x (cm)
Counts


-81.8
-8.00

For next week...

→**Focus on the target damage studies.**

→ Learn more about DPA and H/He appm and how to quantify damage in different materials using these units.

→**Learn more about the time structure of the beams.**