ESS neutrino Super Beam plus

Co-funded by the European Union

WP3 : Target Station and Pion Extraction

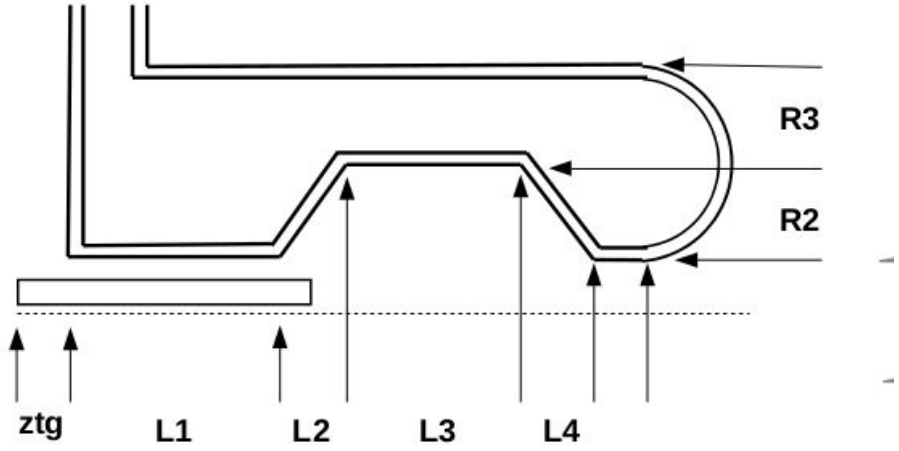
"Horn Simulation"

Eric Baussan on behalf WP3+ Members

ESSnuSB+
2nd Annual Meeting
Hamburg (23-27/09/2024)

WP3 : Horn optimisation

Horn Parameters:



For this work, the following parameters of the horn have been considered:

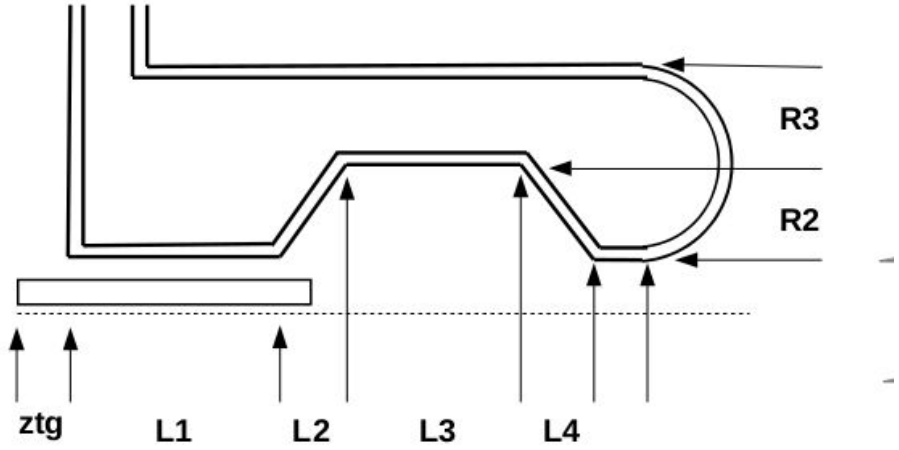
- L1, L2, L3, L4, R2, R3, ztg

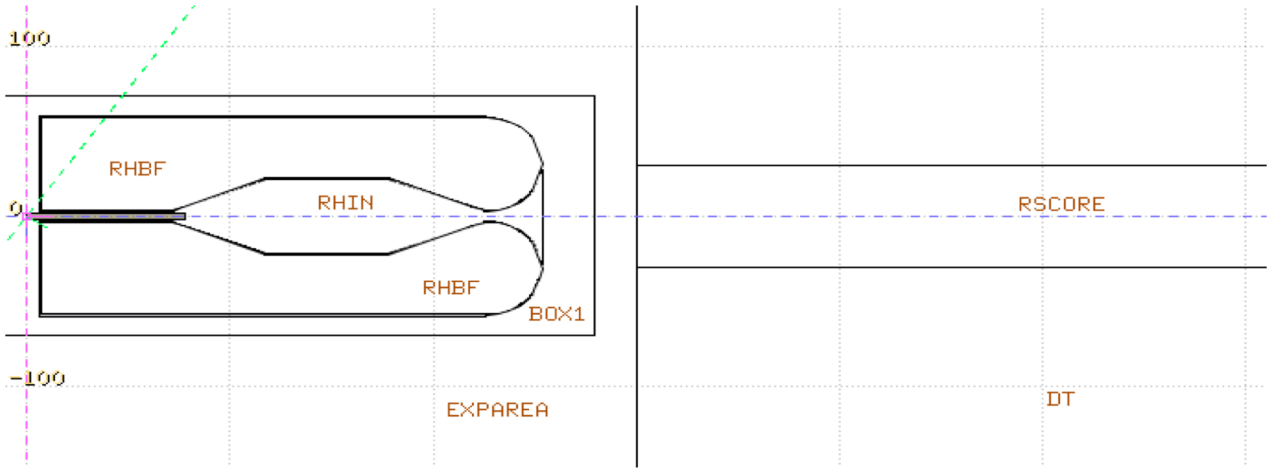
The value of the i-th parameter has been rescaled by a scale factor, which value is included in the range [0.5, 1.5], w.r.t. the corresponding baseline value.

Parameter	Baseline (cm)	Scale factor range
L1	83.08	[1.0, 2.5]
L2	46.80	[0.5, 2.5]
L3	60.30	[0.5, 2.5]
L4	47.50	[0.5, 2.5]
L5	1.08	—
R0	54.40	[0.5, 2.5]
h0	3.30	—
h1	22.10	—
ztg	8.10	[0.5, 2.5]

WP3 : Horn optimisation

Horn Parameters:





For this work, the following parameters of the horn have been considered:

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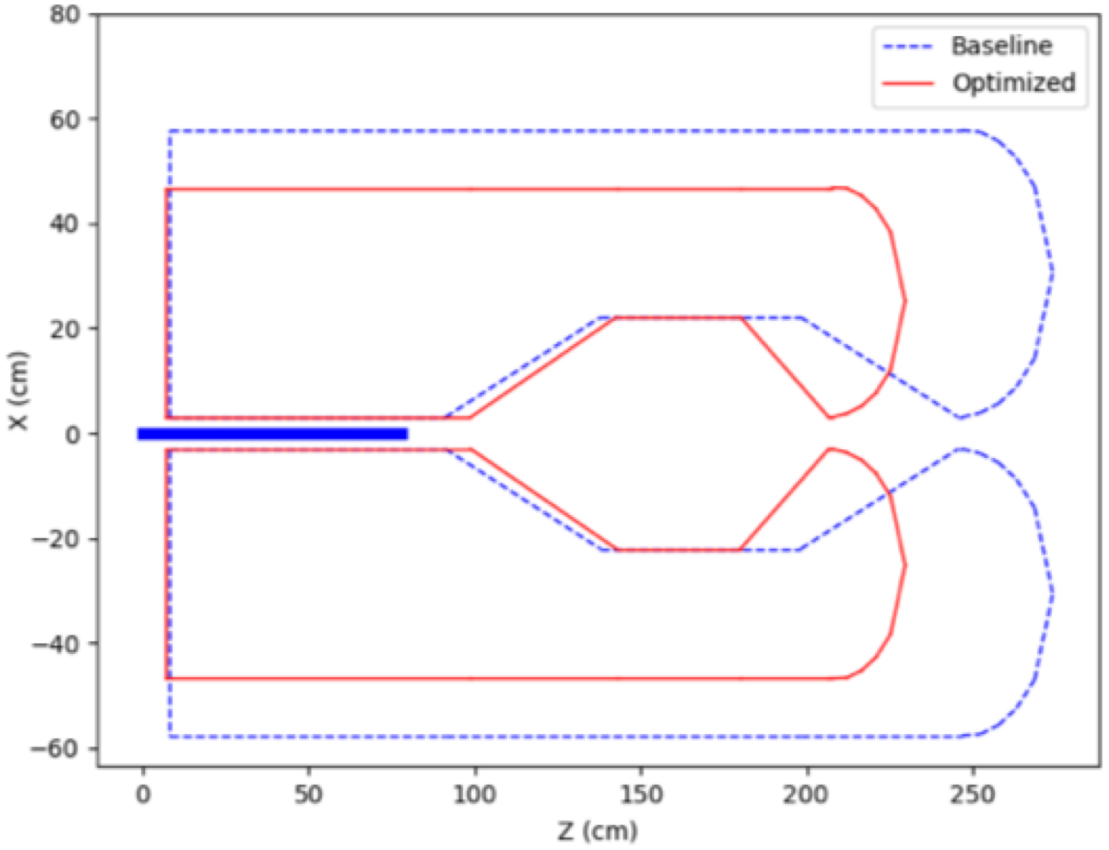
The value of the i-th parameter has been rescaled by a scale factor, which value is included in the range [0.5, 1.5], w.r.t. the corresponding baseline value.

- Note: aperture at ~50 cm from horn
- Pions scored with all energies
- Figure of merit for optimization:

$$f_{\pi^{\pm}} = \frac{N_{\pi^{\pm}}^{Scored}}{N_{\pi^{\pm}}^{Target}}$$

Note: Current is fixed at 350 kA
Parameters h0, h1 and L5 are fixed

WP3 : Horn optimisation

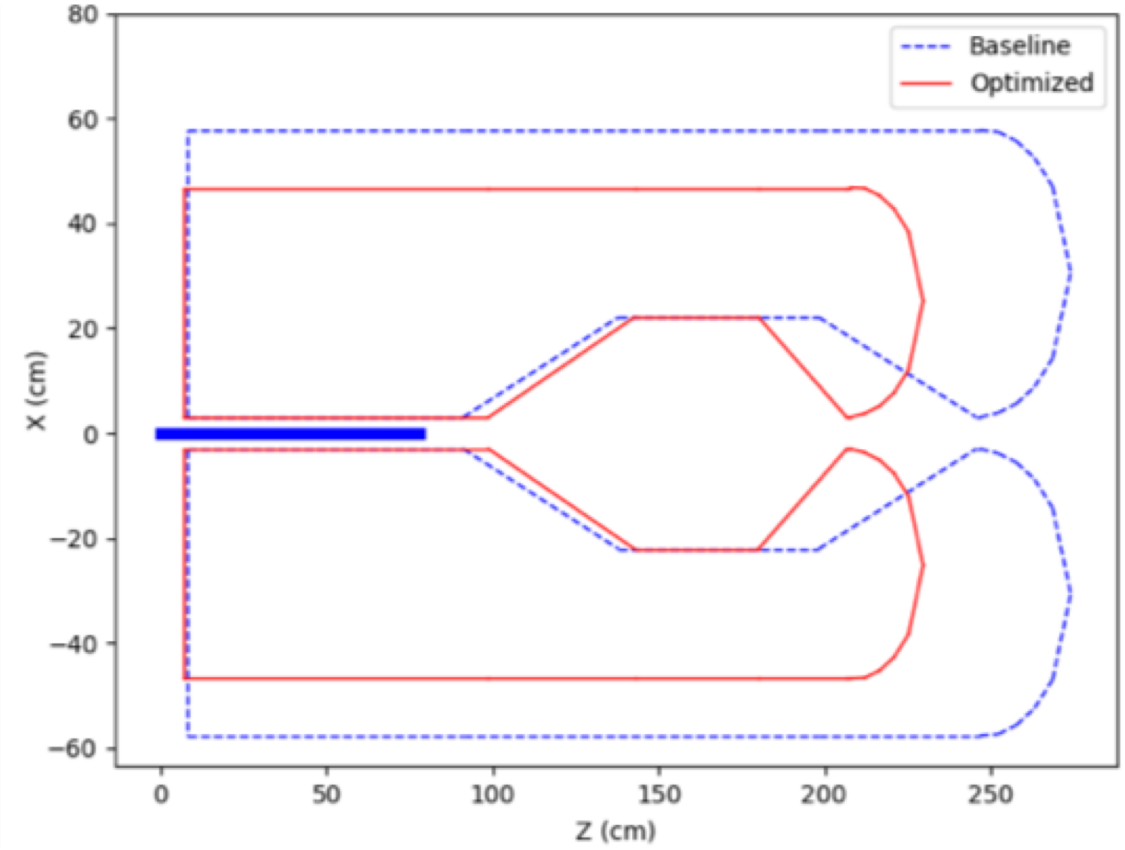


Reshaped horn

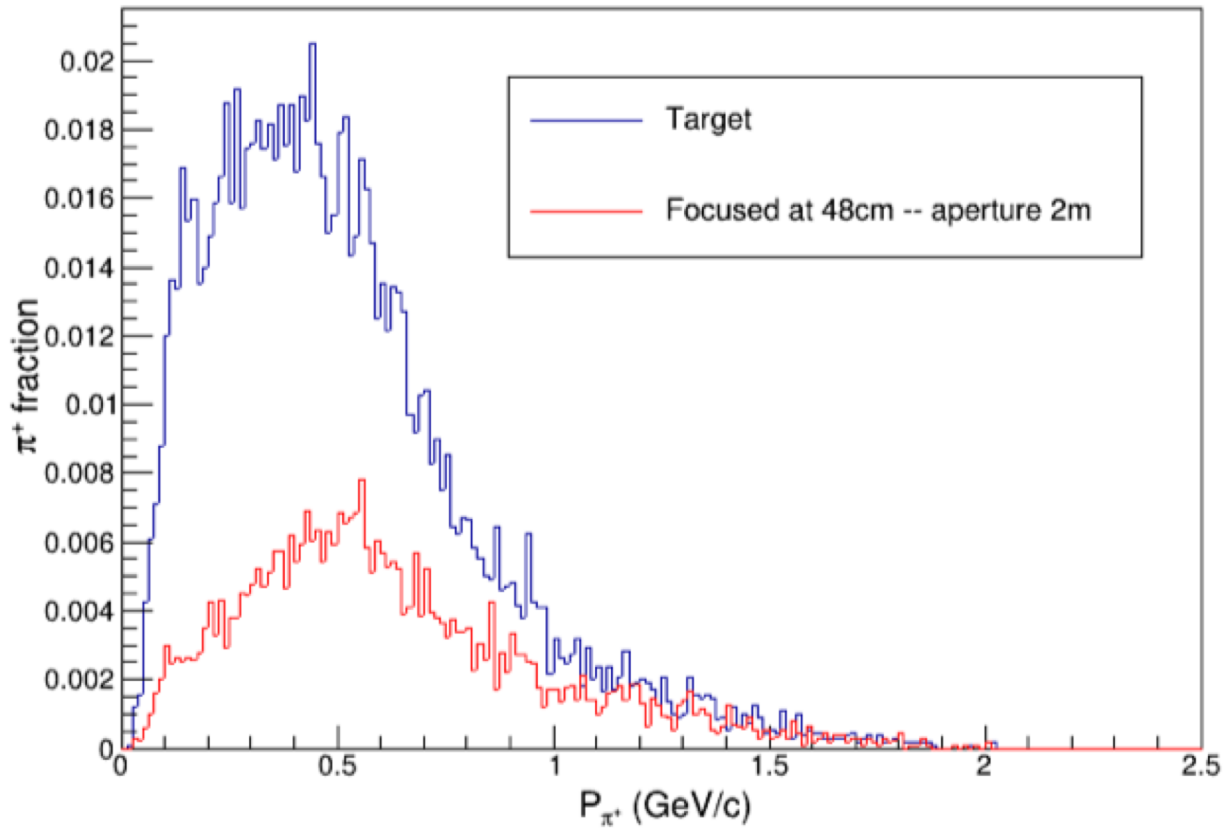
Parameter	Baseline (cm)	Scale factor range	Best fit (cm)
L1	83.08	[1.0, 2.5]	91.66
L2	46.80	[0.5, 2.5]	43.99
L3	60.30	[0.5, 2.5]	37.38
L4	47.50	[0.5, 2.5]	26.60
L5	1.08	—	1.08
R0	54.40	[0.5, 2.5]	43.52
h0	3.30	—	3.30
h1	22.10	—	22.10
ztg	8.10	[0.5, 2.5]	7.14

Parameters of the reshaped horn

WP3 : Horn optimisation

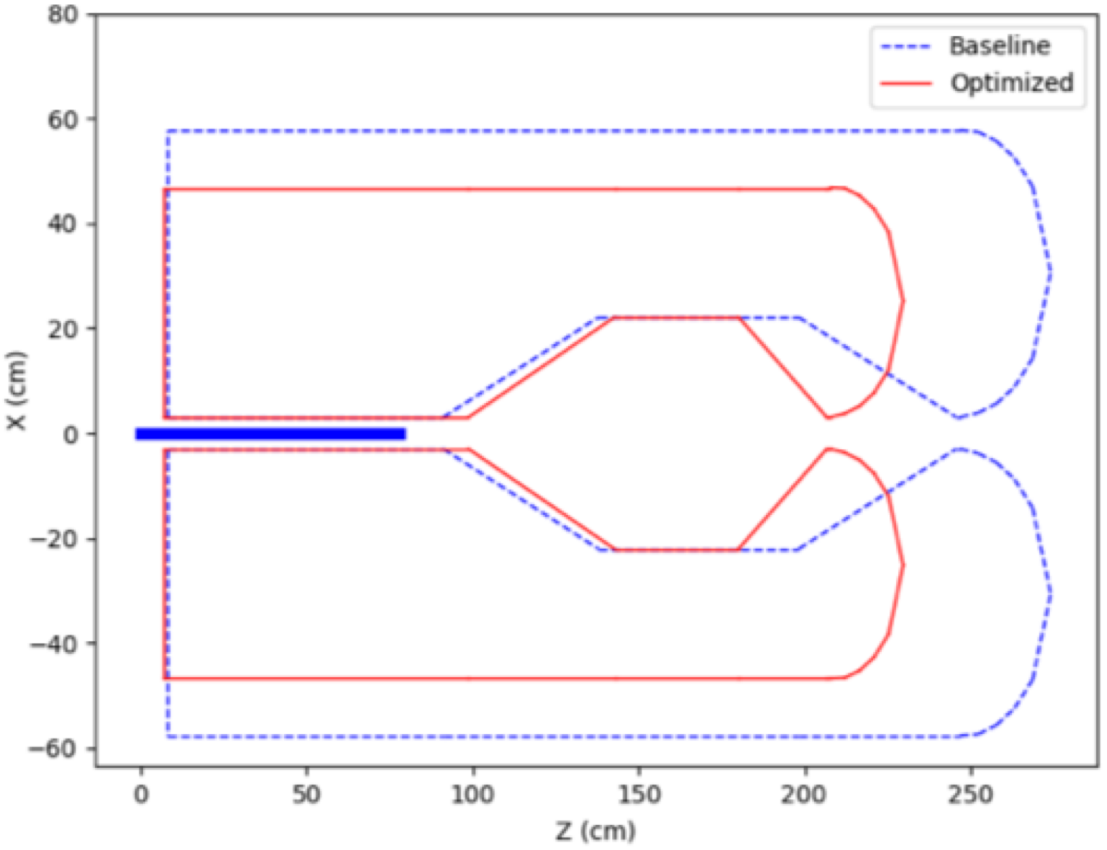


Reshaped horn

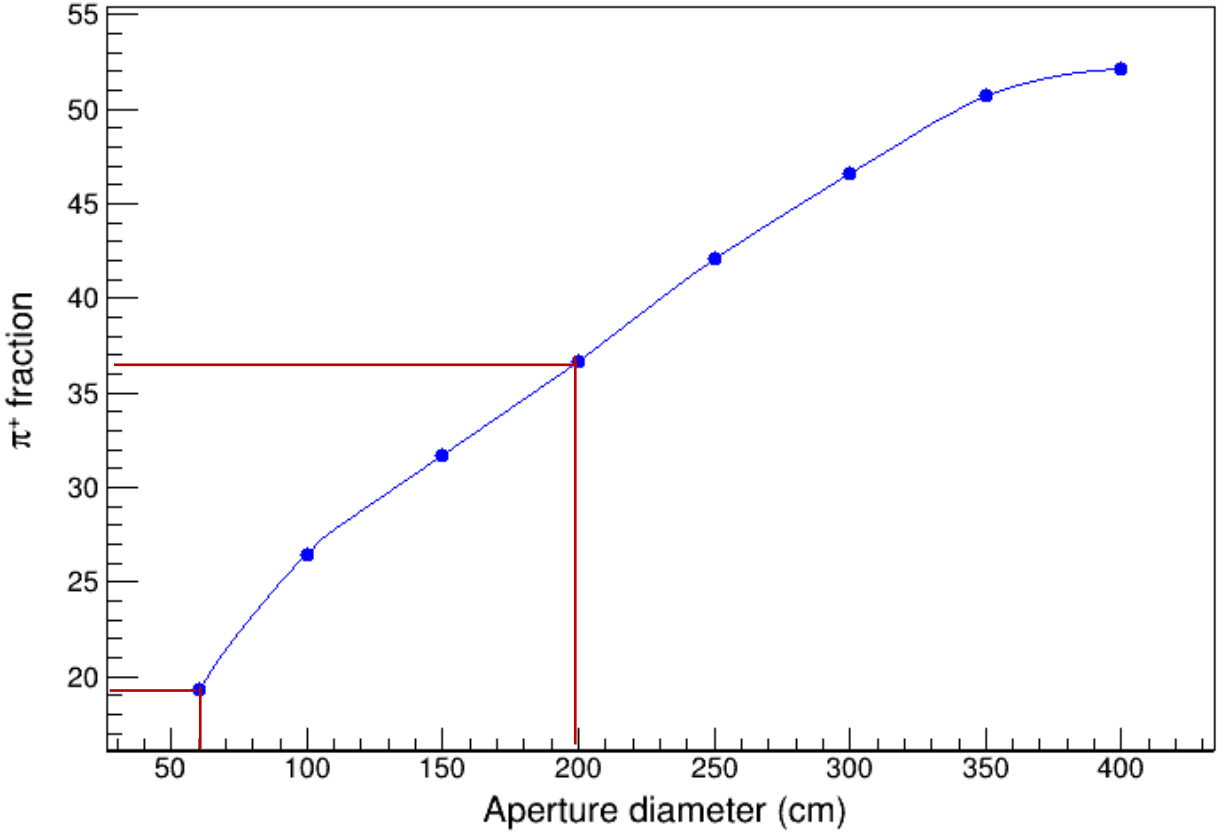


Pion flux over different volumes

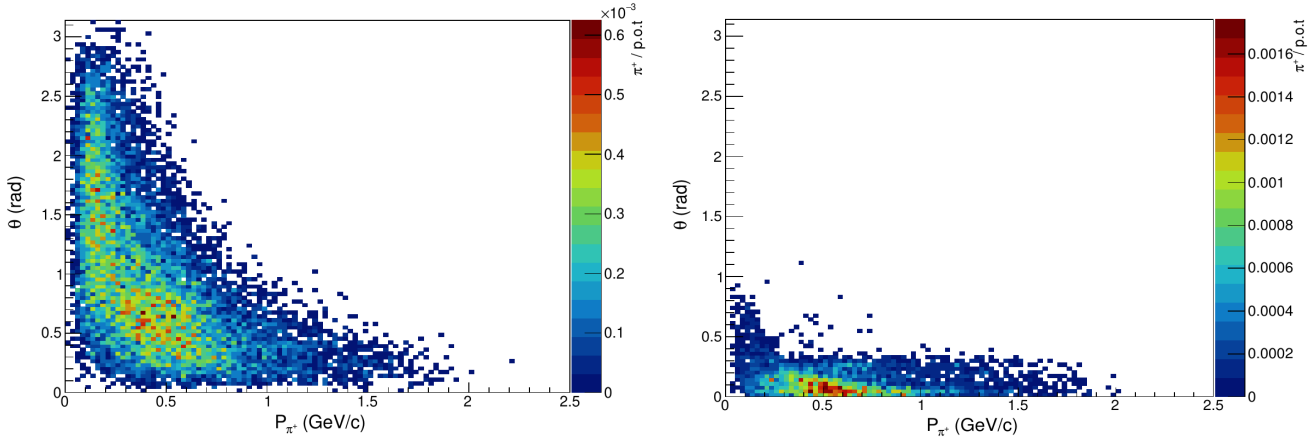
WP3 : Horn optimisation



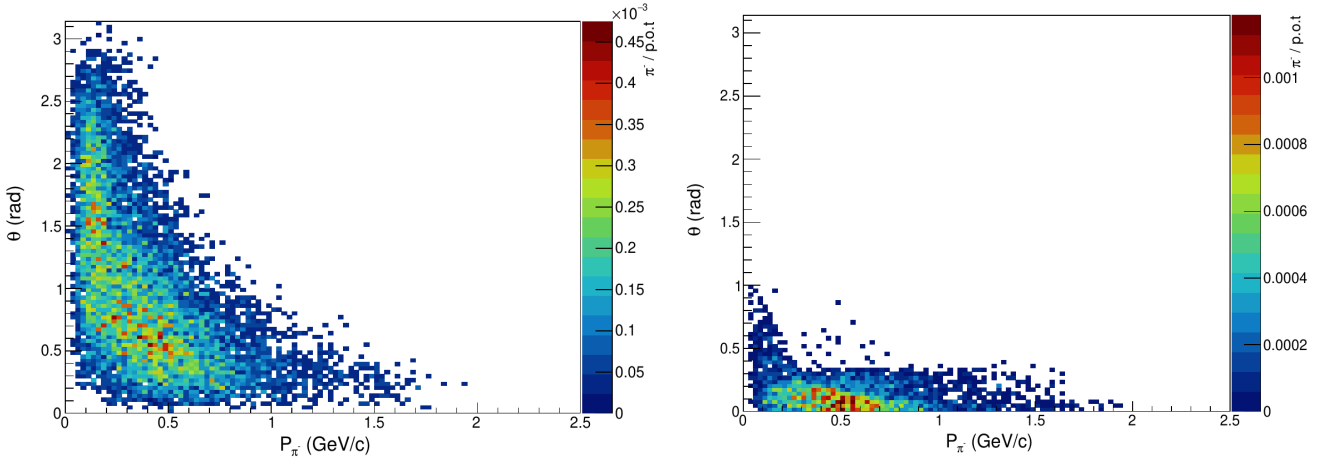
Reshaped horn



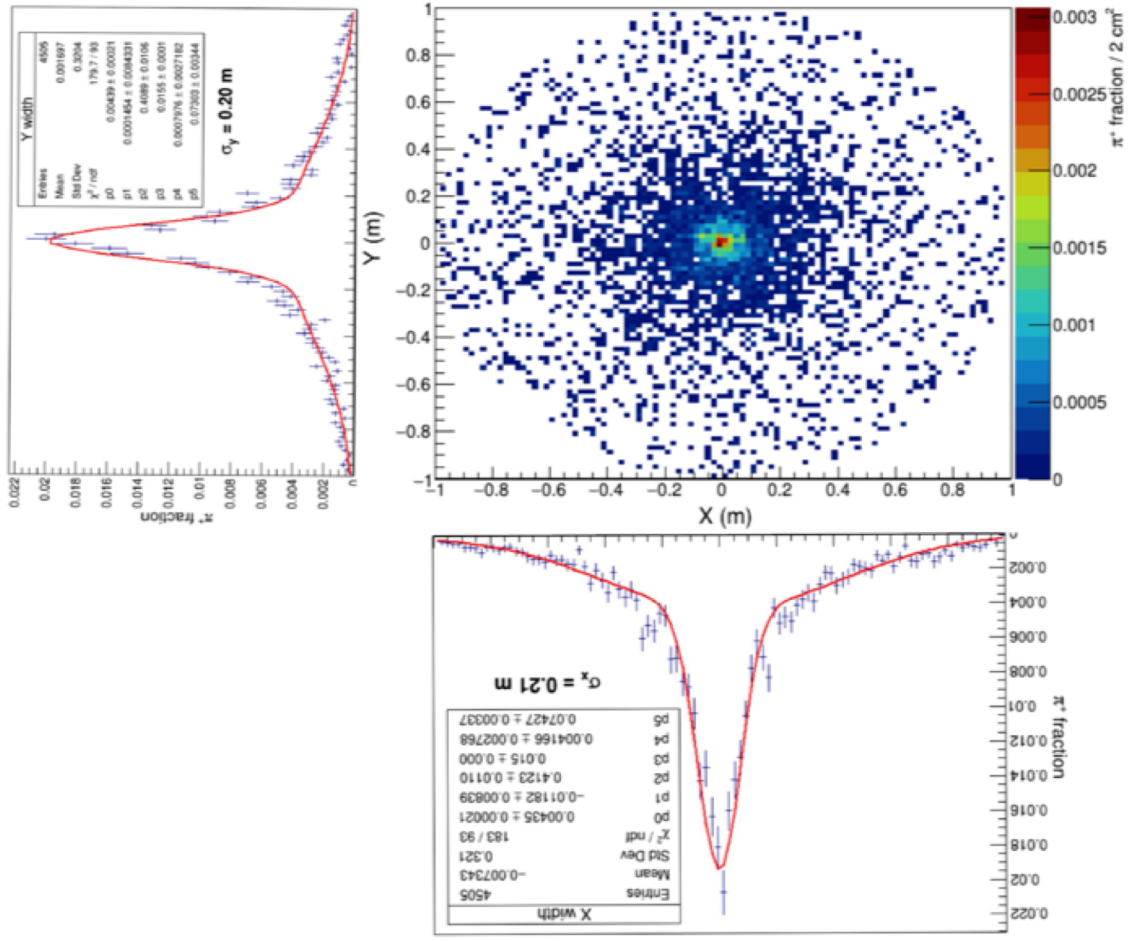
WP3 : Horn optimisation



(Left) Momentum vs. angle distribution of positive pions exiting the target and (right) entering the aperture of 2m diameter 50 cm from the horn.



(Left) Momentum vs. angle distribution of negative pions exiting the target and (right) entering the aperture of 2m diameter 50 cm from the horn.



Pion beam spatial distribution at the entrance of the magnetic dipole. Upper and left plots show the projections on the X- and Y-axis of the pion beam distribution with Gaussian fit.

WP3 : Horn optimisation

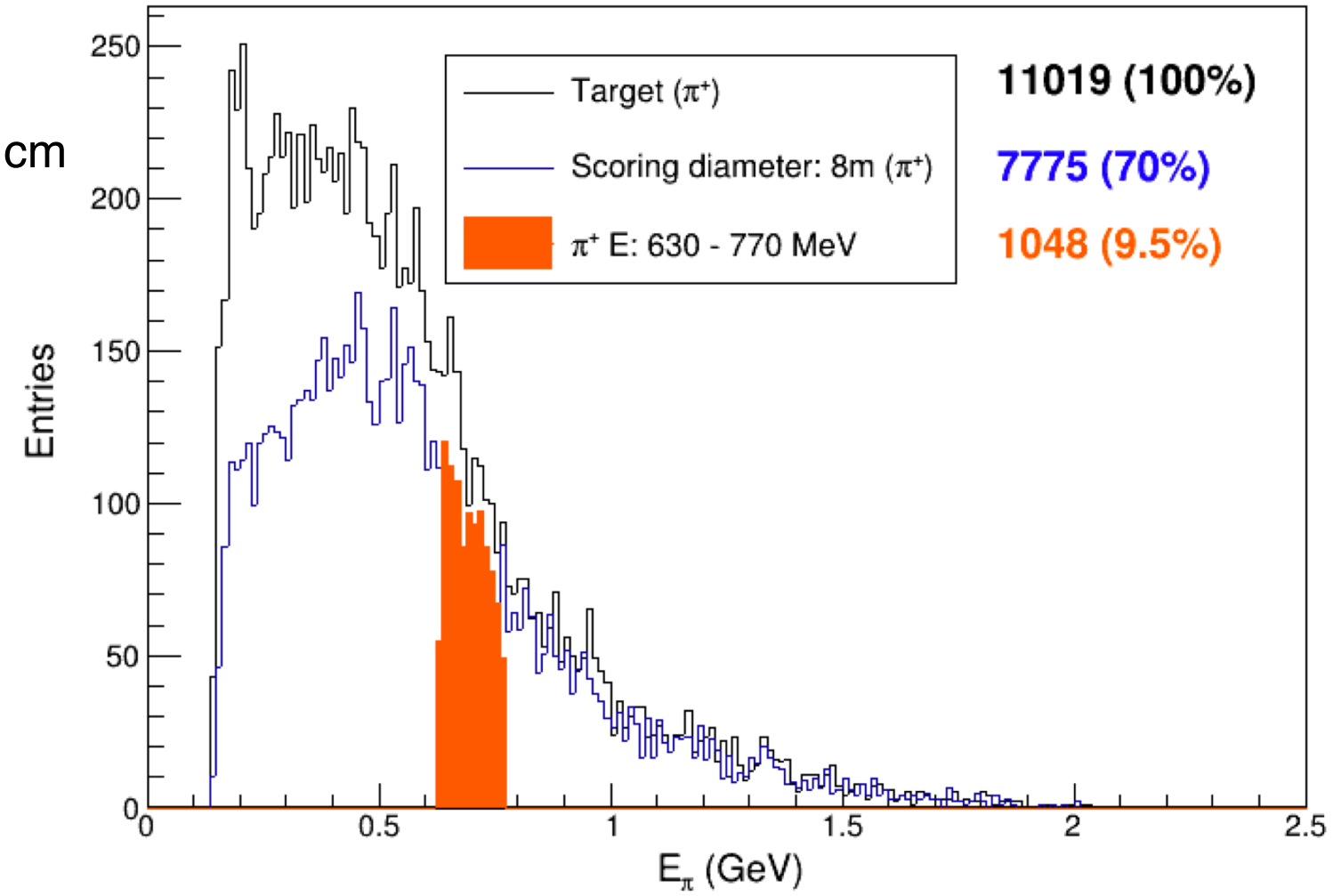
Study pions with energy : 700 ± 70 MeV

Scored in a 8 m decay tunnel and at ~50 cm from horn.

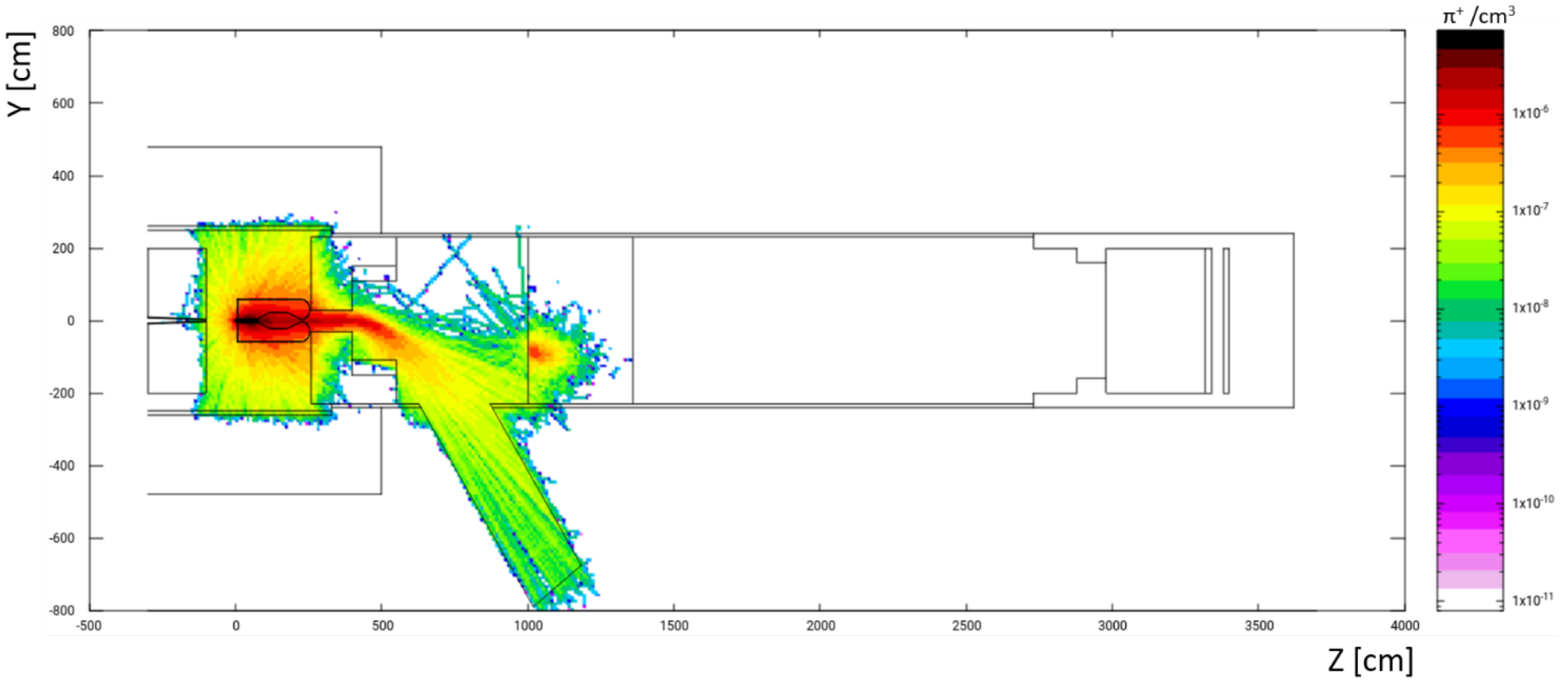
Pions available: 9.5%

~2.7% pions in 60 cm aperture
Not enough pions at high energy

p.o.t: 4*e4



WP3 : Horn optimisation



Summary:

- Horn optimization studied with different aperture sizes
- An overall reduction in the size of the horn is obtained
- Pion fraction in 2 m aperture ~ 37%
- Studied pion fractions with energies 700 ± 70 MeV
- Obtained ~2.7% in 60 cm diameter