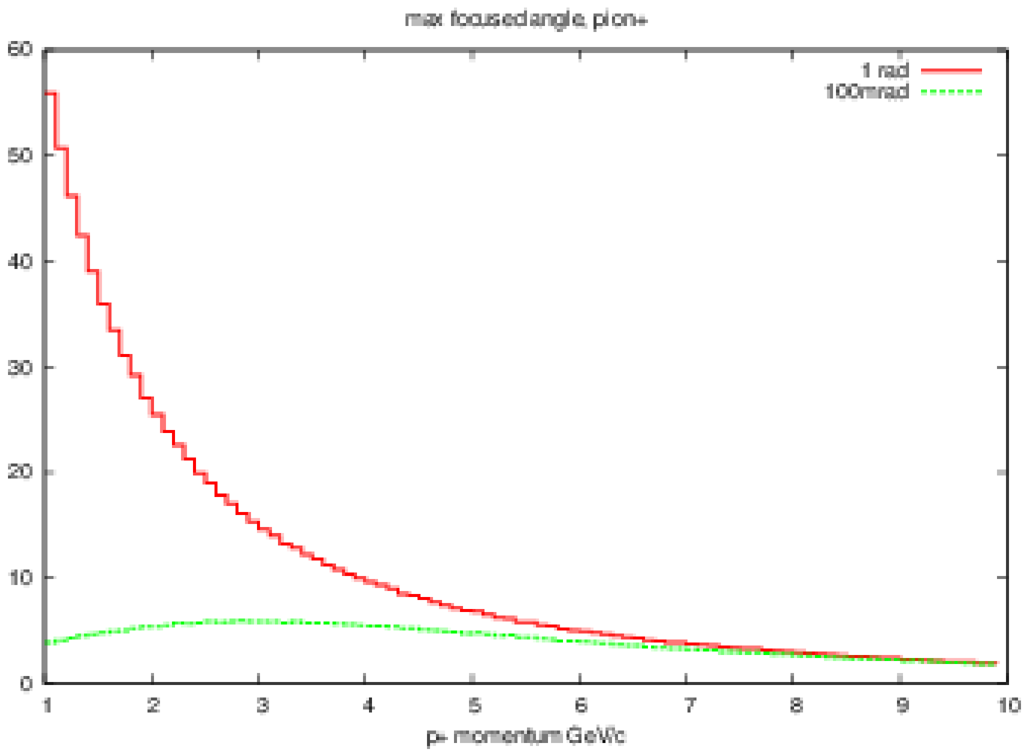
Initial thoughts on targets

Disclaimer

- This is not a full optimization
- Just a few ideas about trends vs length/thickness/beam size
- NO focusing included

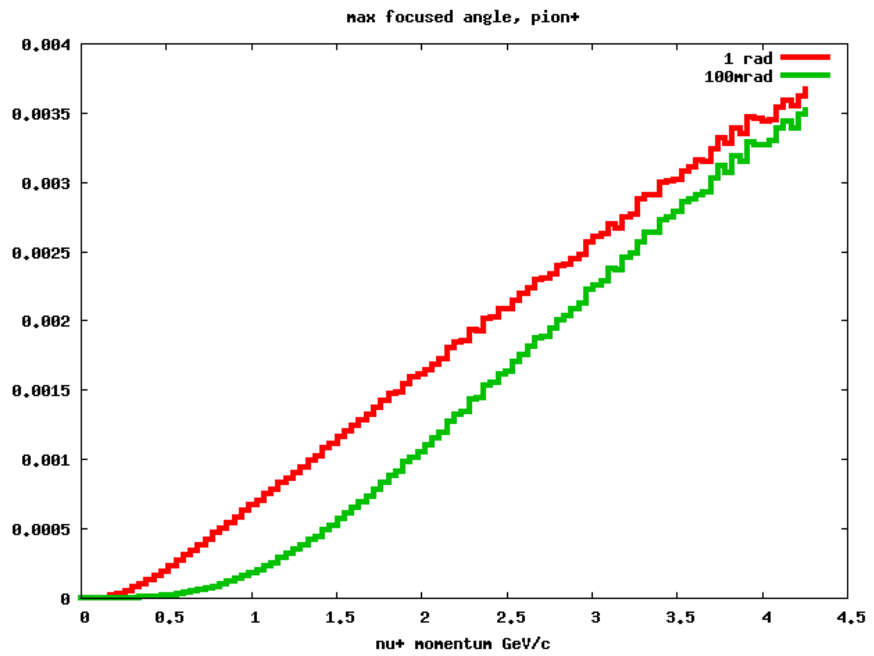
- Simulated (FLUKA)
  - Numi-like target (graphite fins, 90 cm) with numi-like beam
  - Cylindrical targets with various lenghts., radii, and beam sizes, keeping $\sigma < R/3$
  - Particle fluxes and energy deposition
  - 120 GeV/c protons, 60 GeV /c protos
  - Today: graphite. Beryllium is running
- I apologize for the quality of plots/slides, it's work of today

Pion yield



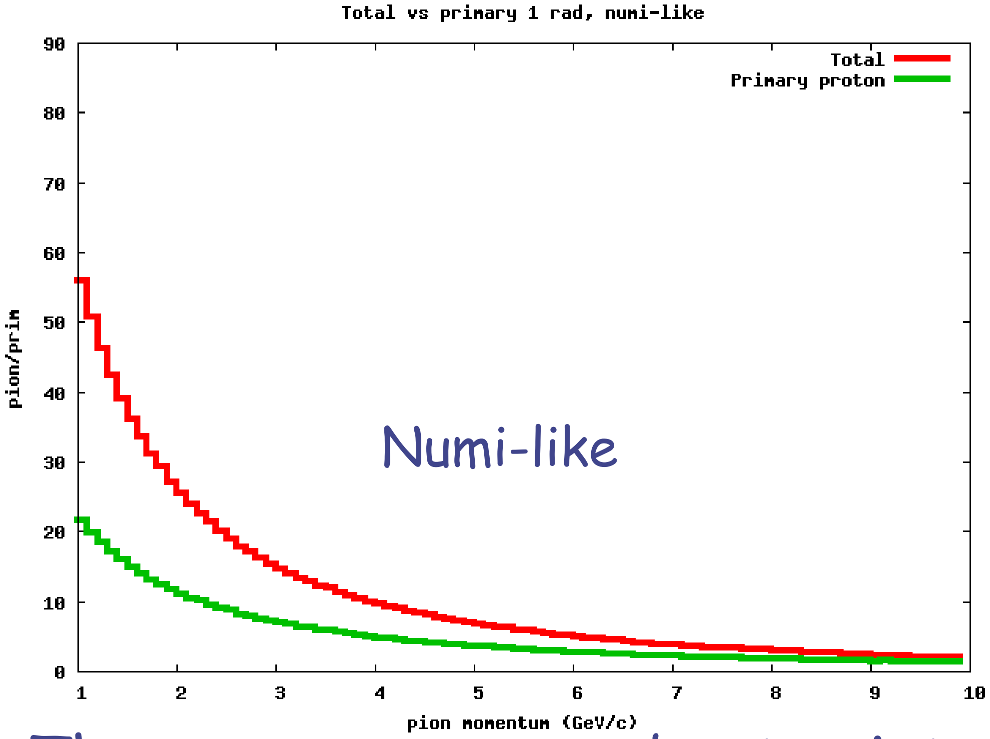
Positive pion spectra from numi-like target, within 1 rad (red) and 100 mrad (green) acceptance

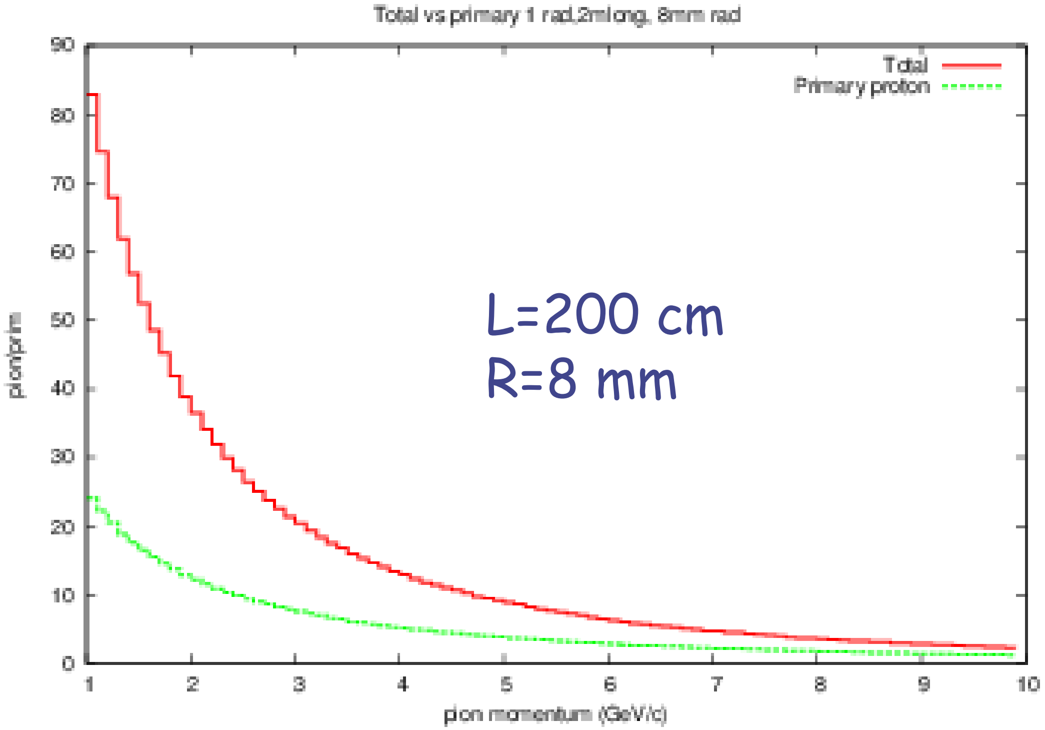
- Not simulating the focusing, have to define limits for the pion phase-space
- Assume 1<P<10 GeV/c
- Look at either 1 rad or 100 mrad angular acceptance
- …hope we are closer to 1 rad, see plots



Perfectly focused neutrino event rate: multiply by σ_ν and E^2 factor from Lorentz boost

Reinteractions





- There was a worry about reinteractions in long targets affecting syst. errors.
- At low pion energy, indeed reinteractions play a major role..**already in short targets**
- So.. Let's have more neutrinos?

Positive pion spectra within 1 rad

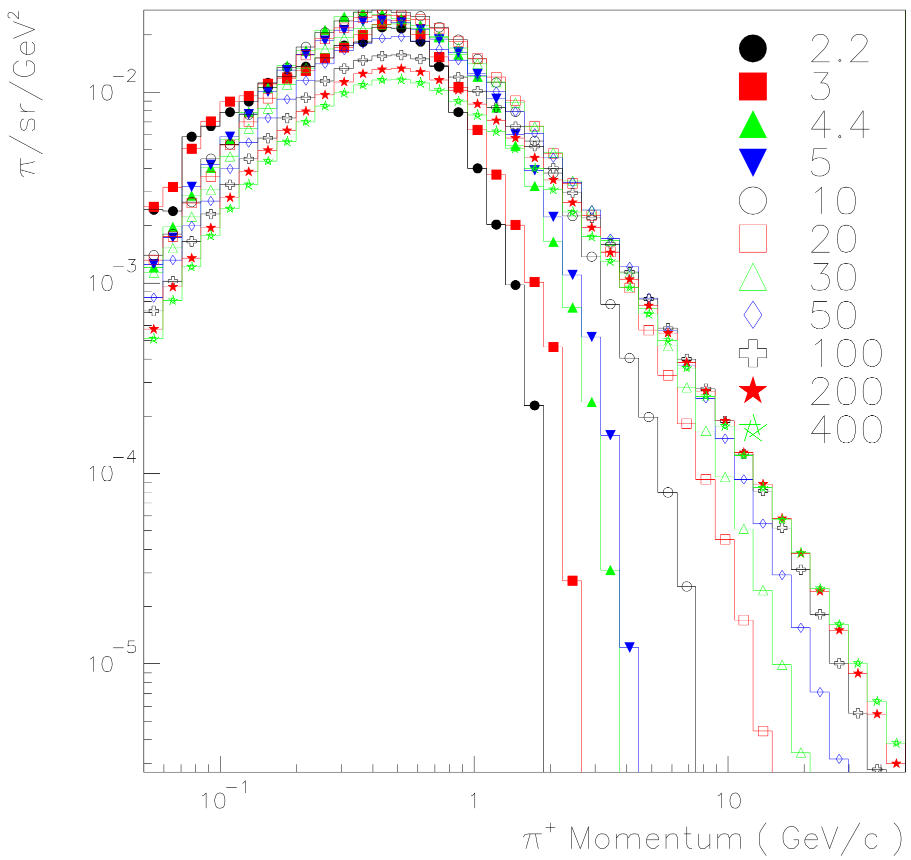
Red : total

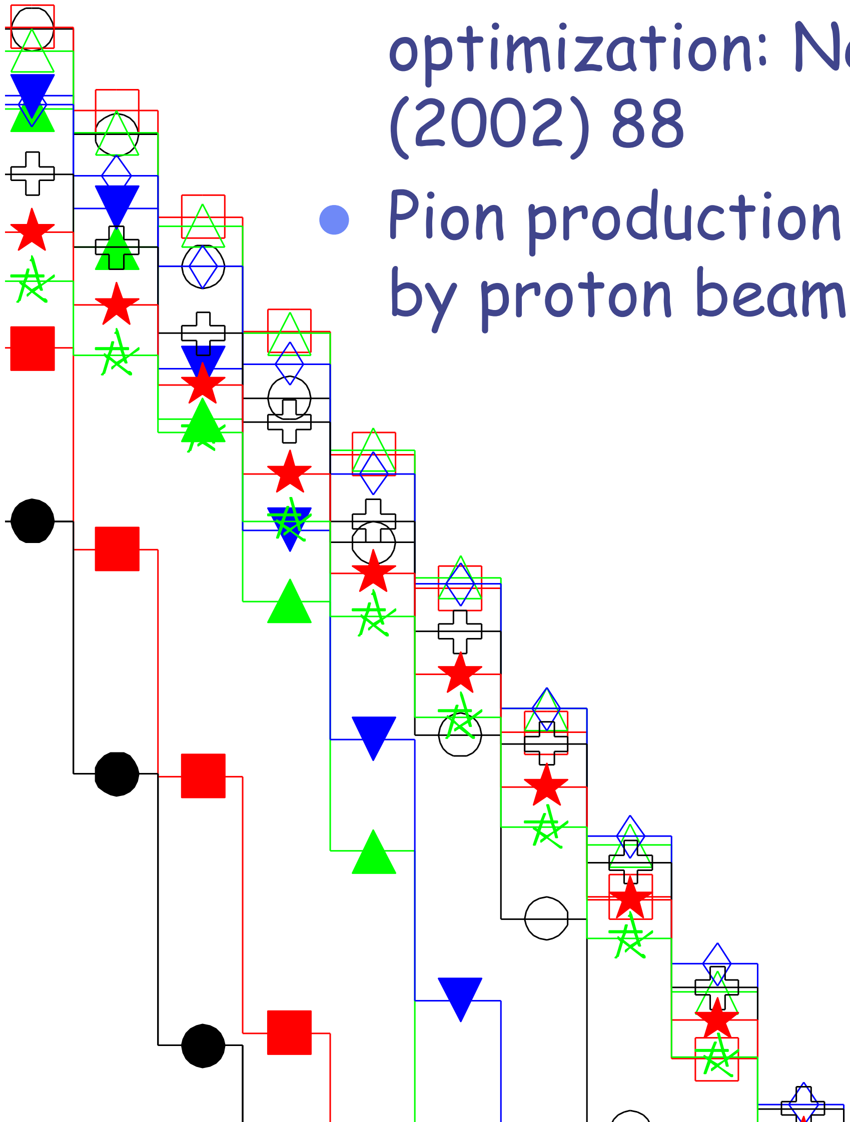
Green: from primary proton

Numi-like : 50% from reint.

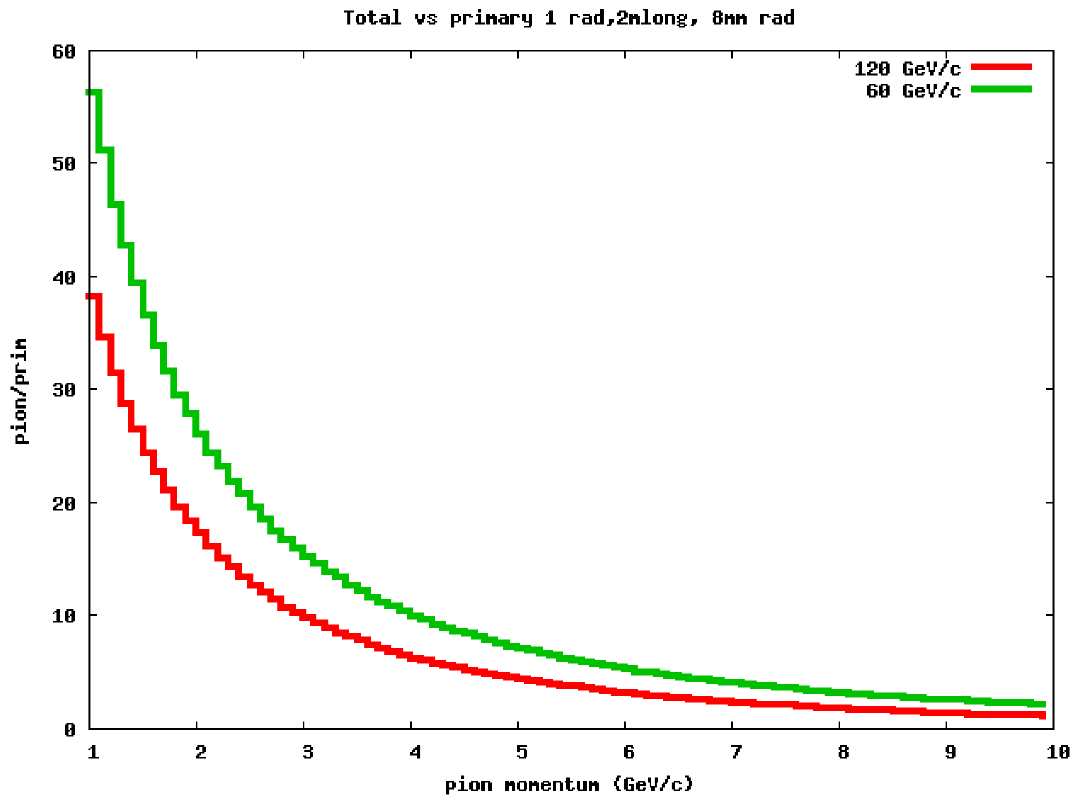
Long: 64% from reint.

Beam energy



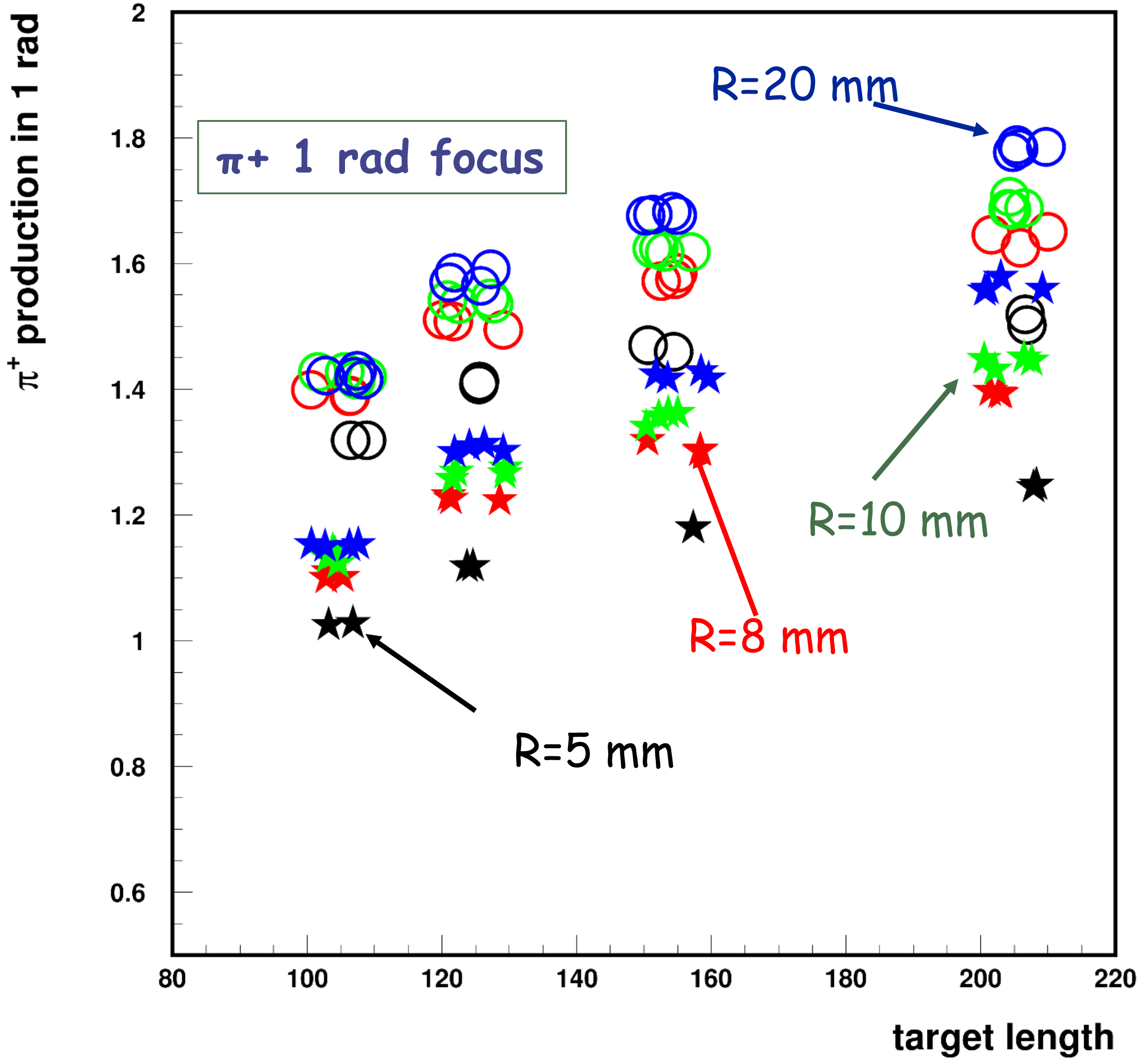


- From old work on proton driver optimization: New J.Phys. 4 (2002) 88
- Pion production in 1rad, divided by proton beam energy



Total vs primary 1 rad,2mlong, 8mm rad
120 GeV/c
60 GeV/c
pion/prim
pion momentum (GeV/c)
0
10
20
30
40
50
60
1
2
3
4
5
6
7
8
9
10

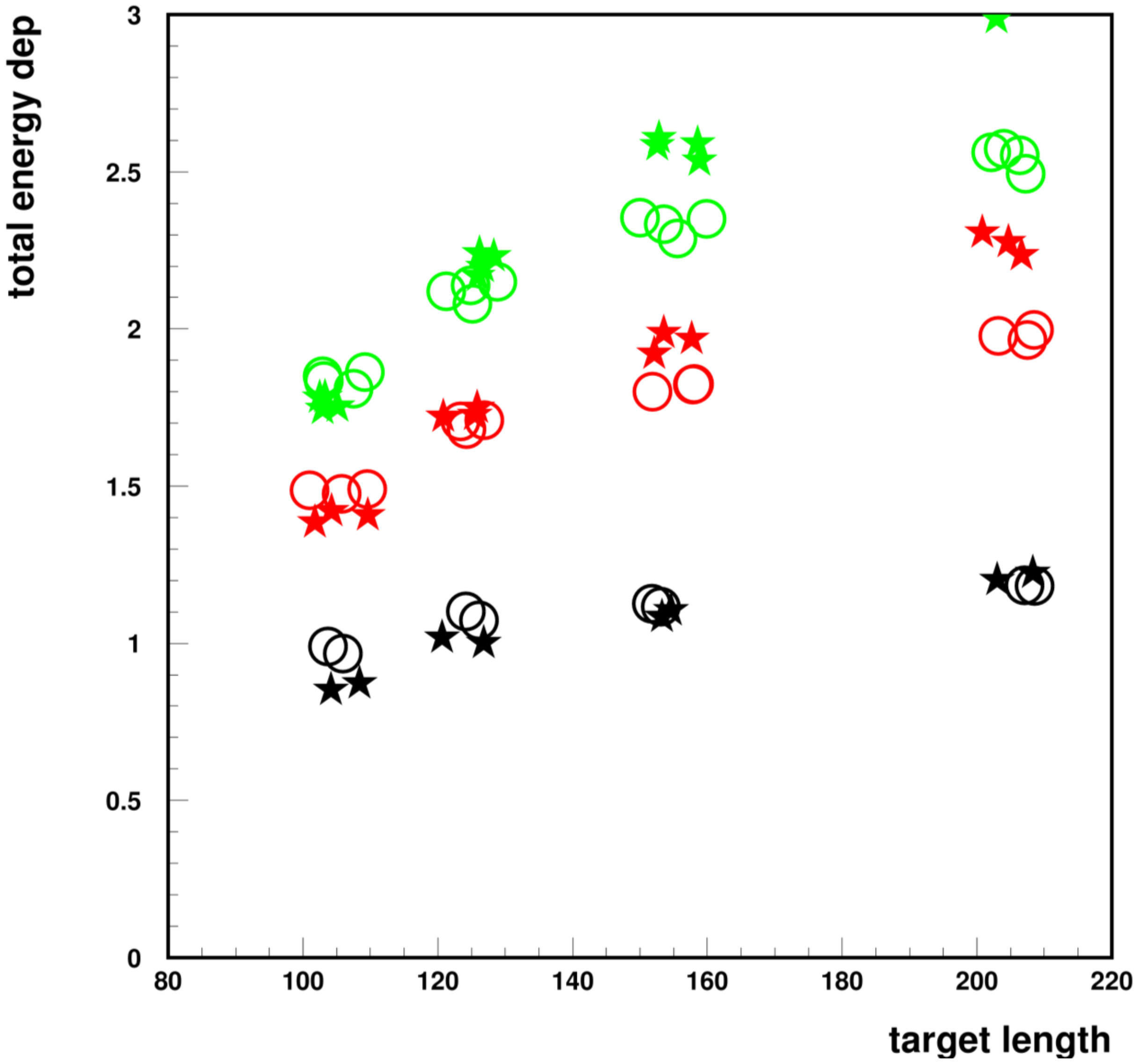
Pions



- Positive Pion yield
- Normalized to numi-like target AND to same beam power (60 GeV multiplied by factor 2)
- 120 GeV/p protons : stars ★
- 60 GeV :circles ○
- Different colors== different radii
- For every R-L combination all possible beam sizes are plotted.

  - Beam size has no effect on pion yield
  - Length and diameter do, up to 50% more
  - Lower beam energy are better if same beam power can be achieved

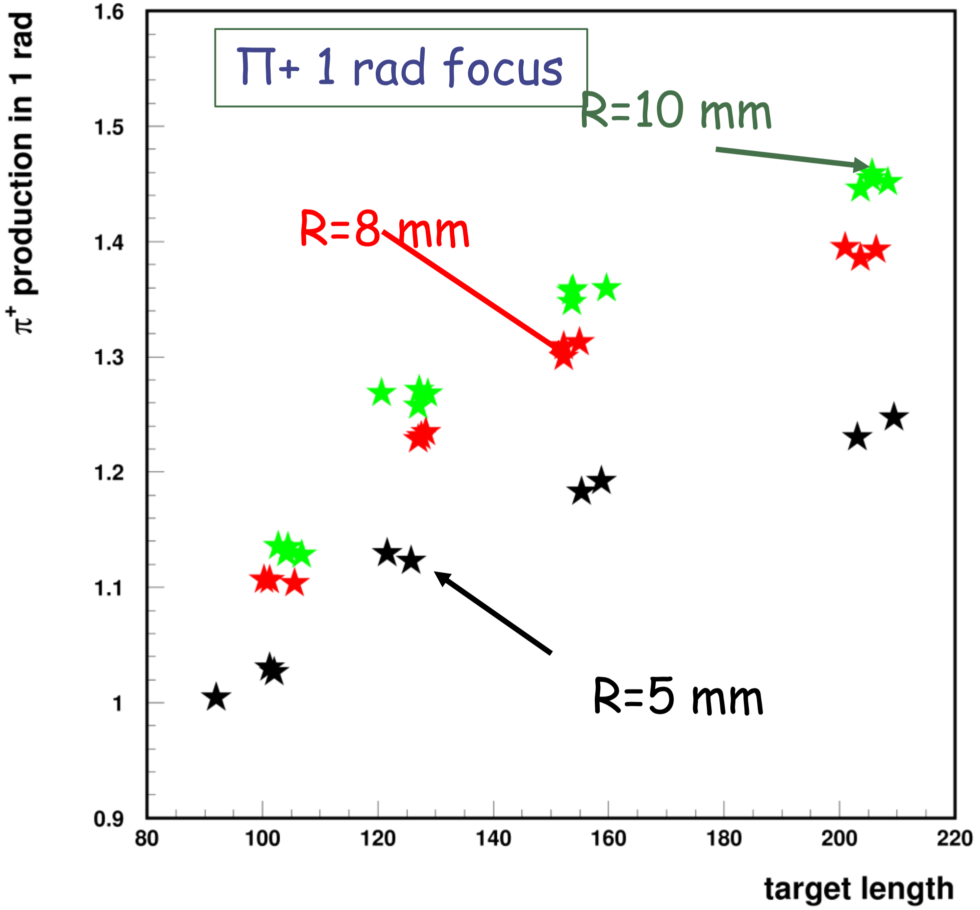
Energy

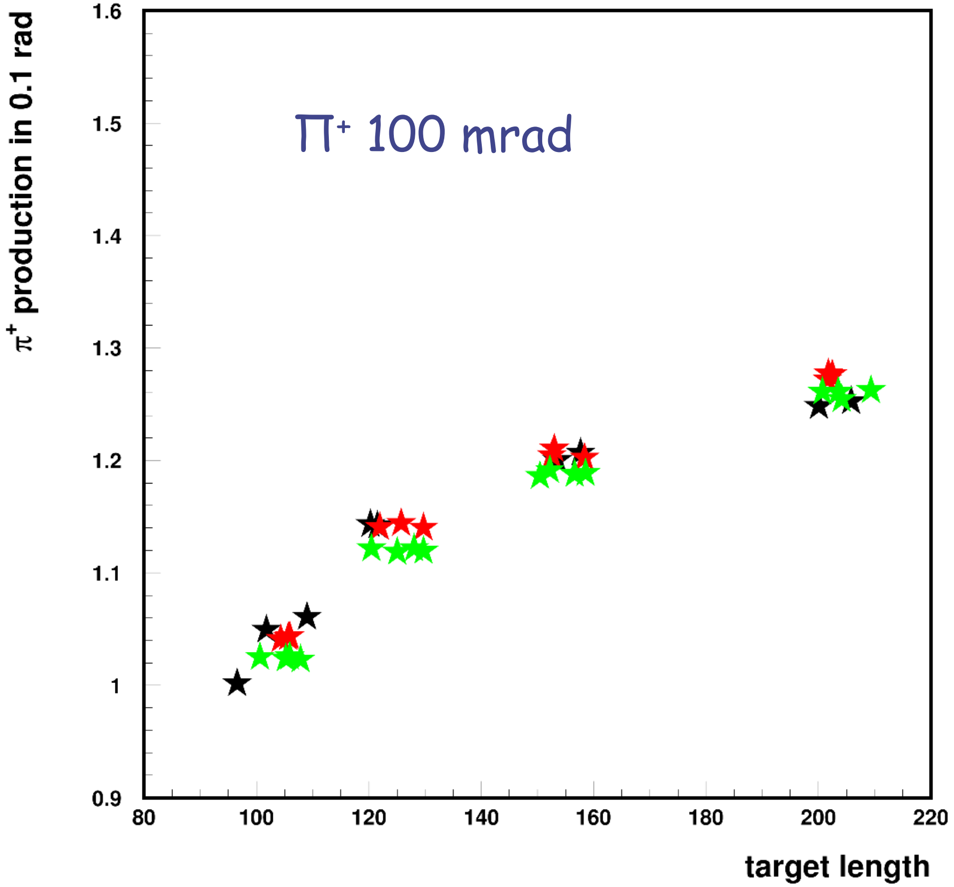


- Total deposited energy in the target
- Normalized to numi-like target
- Normalized to beam energy

- Total energy deposit can more than double (horn backsplash not accounted for)
- Small dependence on beam energy (if same power)

Pions with different acceptance

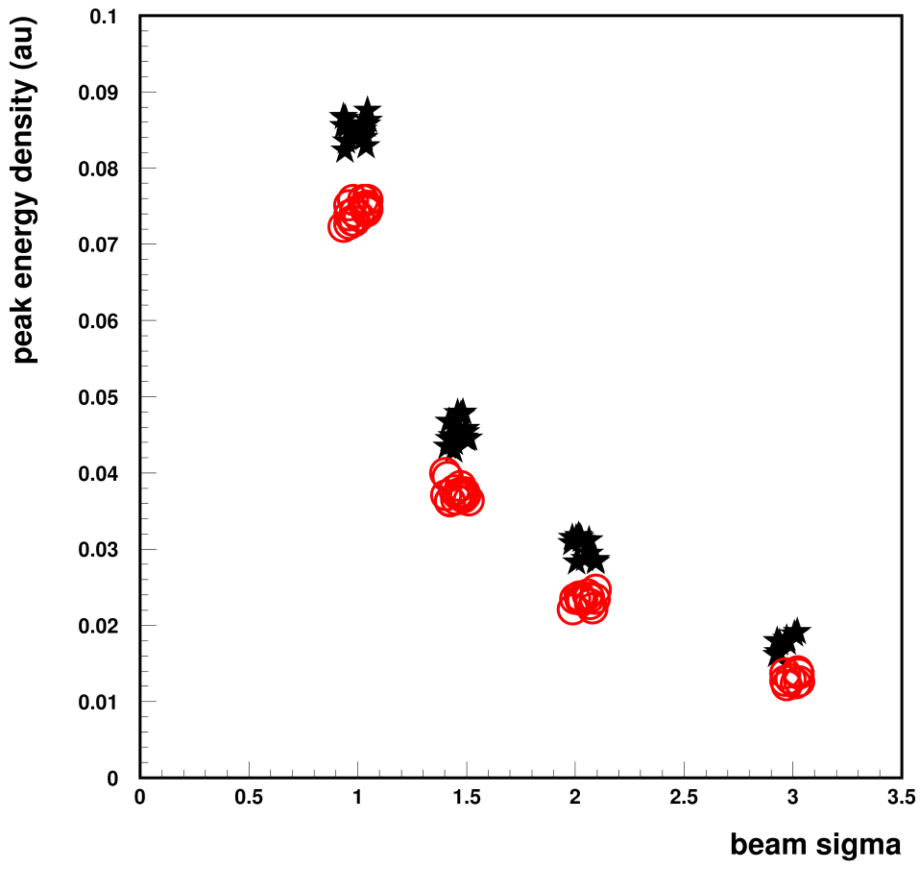




Forward pions are almost independent on target radius

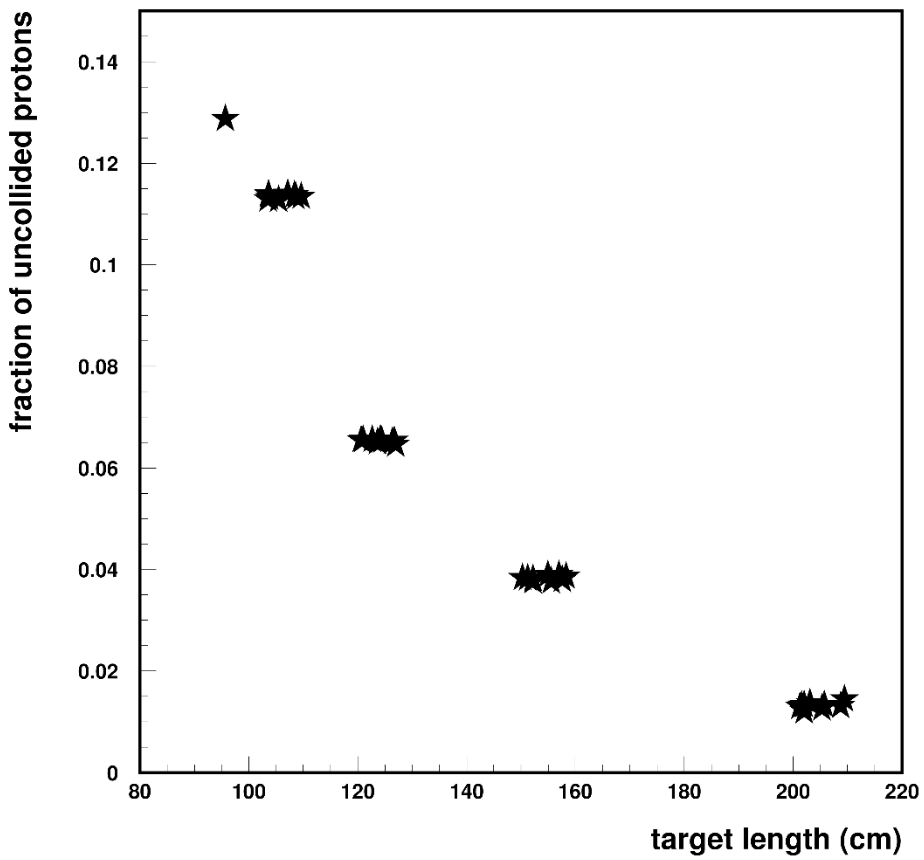
Still, a long target is more effective

Peak energy deposit



- Maximum energy deposition density in the target (fast thermal stress)
- For all radii and lengths
- For 120 (black stars) and 60 GeV (red circles)
- NO other normalization here: simply peak density per primary proton (effects might depend more on protons/spill than on beam power)
- Depends only on beam spot, as expected, roughly quadratical with rms, as expected.

Uncollided beam



- Fraction of uncollided beam downstream of target as a function of target length
- All radii and beam sizes
- Must check, but apparently no dep on radius? Remember: $\sigma < R/3$

Conclusion

- From this very basic study:
- Long target == more pions (+20%)
- Thick target == even more, only if horns have large acceptance (+40% total)
- Low proton energy is better if same beam power
- And we need large acceptance for low energy
- Reinteractions: already a lot for numi-like target. Longer target will be only a bit worse
- Energy deposition: up to a factor 2 or 3 increase for a long and thick target
- Peak energy deposition: inversely proportional to beam sigma
- Uncollided: as expected
- Full beamline work started (thanks to Laura for GDML files)

Reinteractions, 100 mrad