Pion production and capture for VLENF

Sergei Striganov

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OUTLINE

- Model description
- Target length and material
- Li lens capture
- Horn capture

Model description

Production of positive pion with momentum 3 +- 15%(10%,5%) was simulated using MARS.

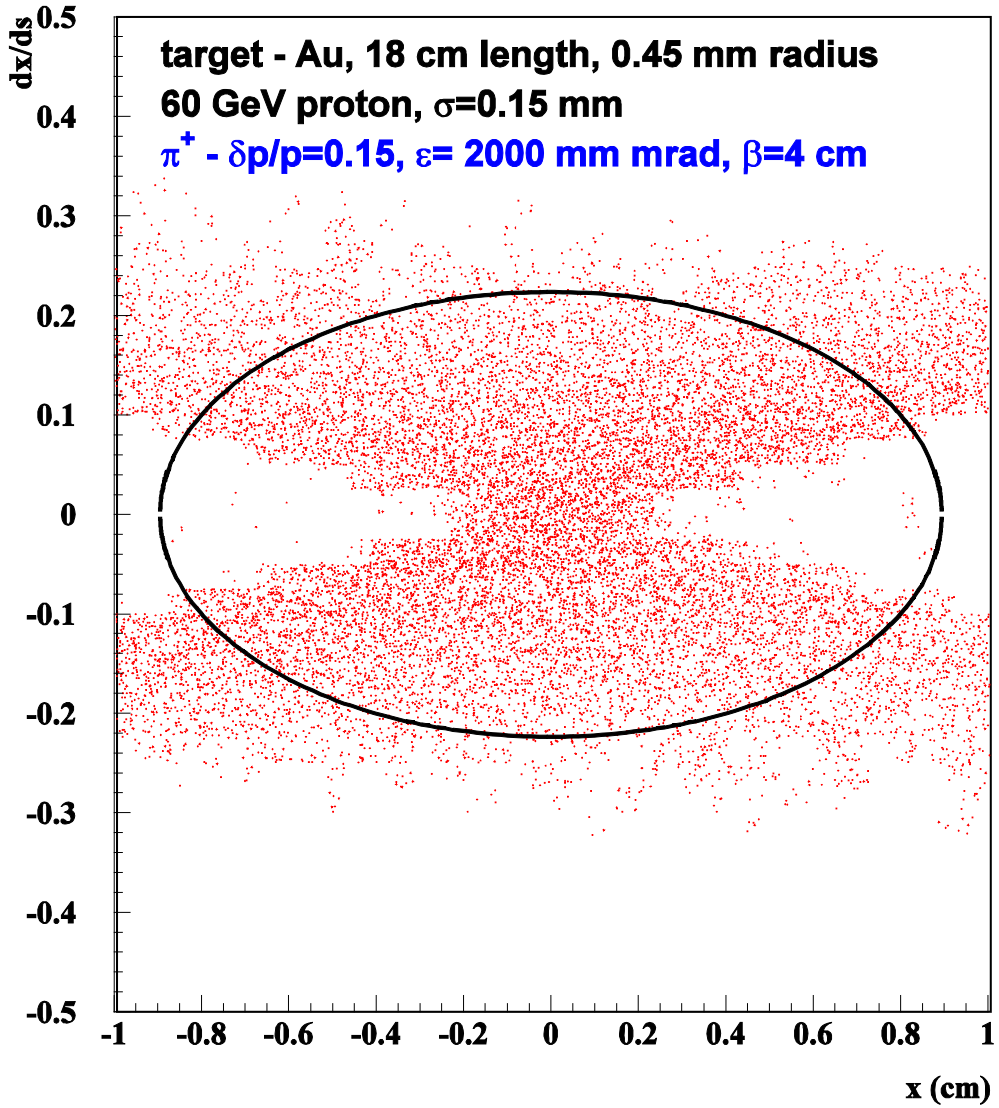
Pion coordinates were translated to the longitudinal coordinate at which second order moments $\langle x\theta_x \rangle = \langle y\theta_y \rangle = 0$.

Pion within phase space determined by

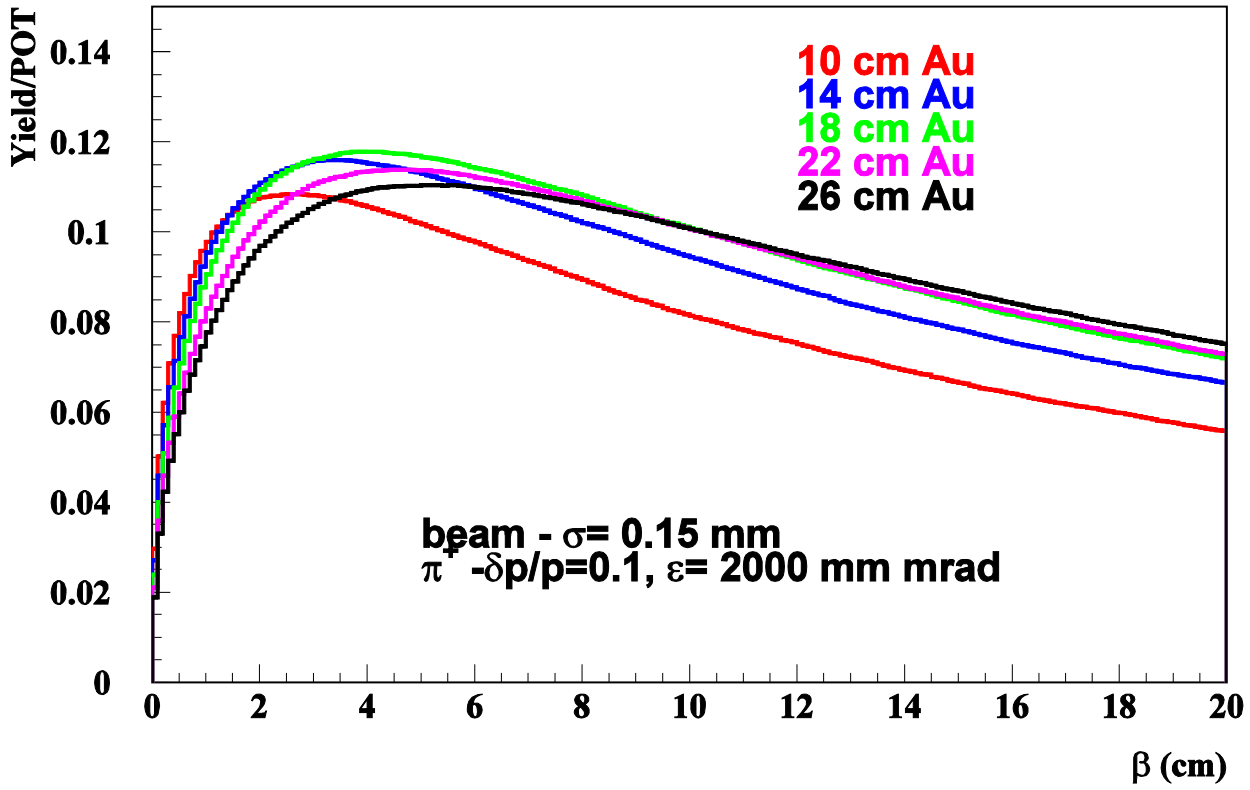
$$\frac{x^2}{\beta} + x'\beta + \frac{y^2}{\beta} + y'\beta \le \varepsilon$$

are considered to be accepted to the ring. Pion acceptance ε=2000 mm mrad (from Neuffer) – ring with 15 cm radius and β=6m.

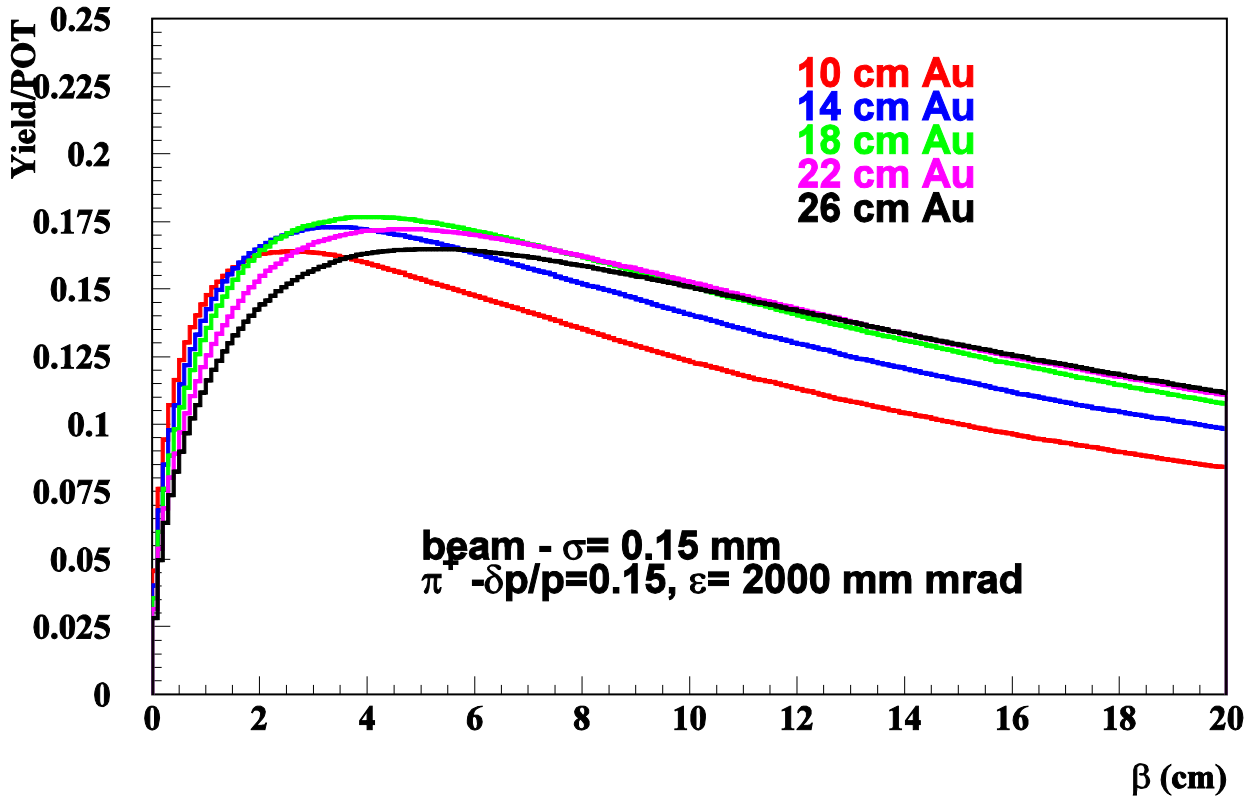
This is maximal number of pion could be collected into considered acceptance if target is not inside magnetic field



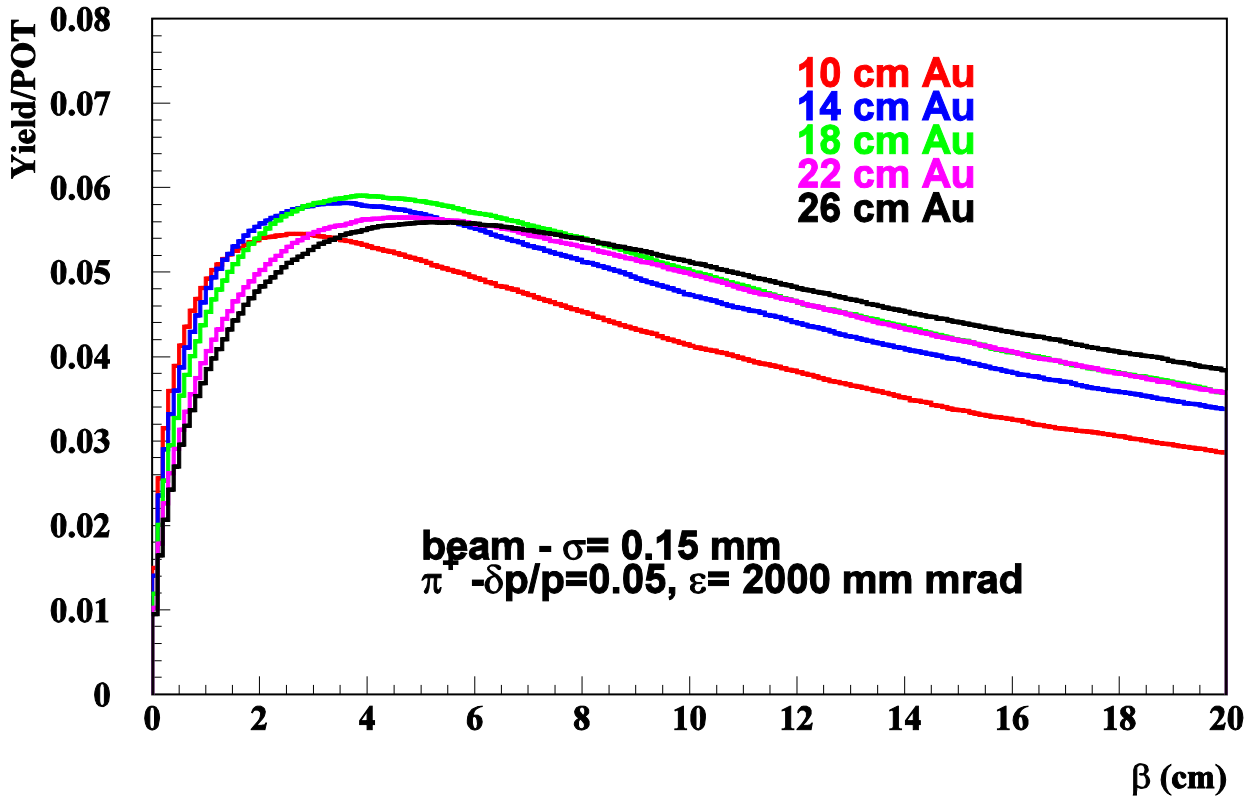
Dependence of positive pion yield on beta function for gold target ($\Delta p/p=\pm 0.1$) at 60 GeV



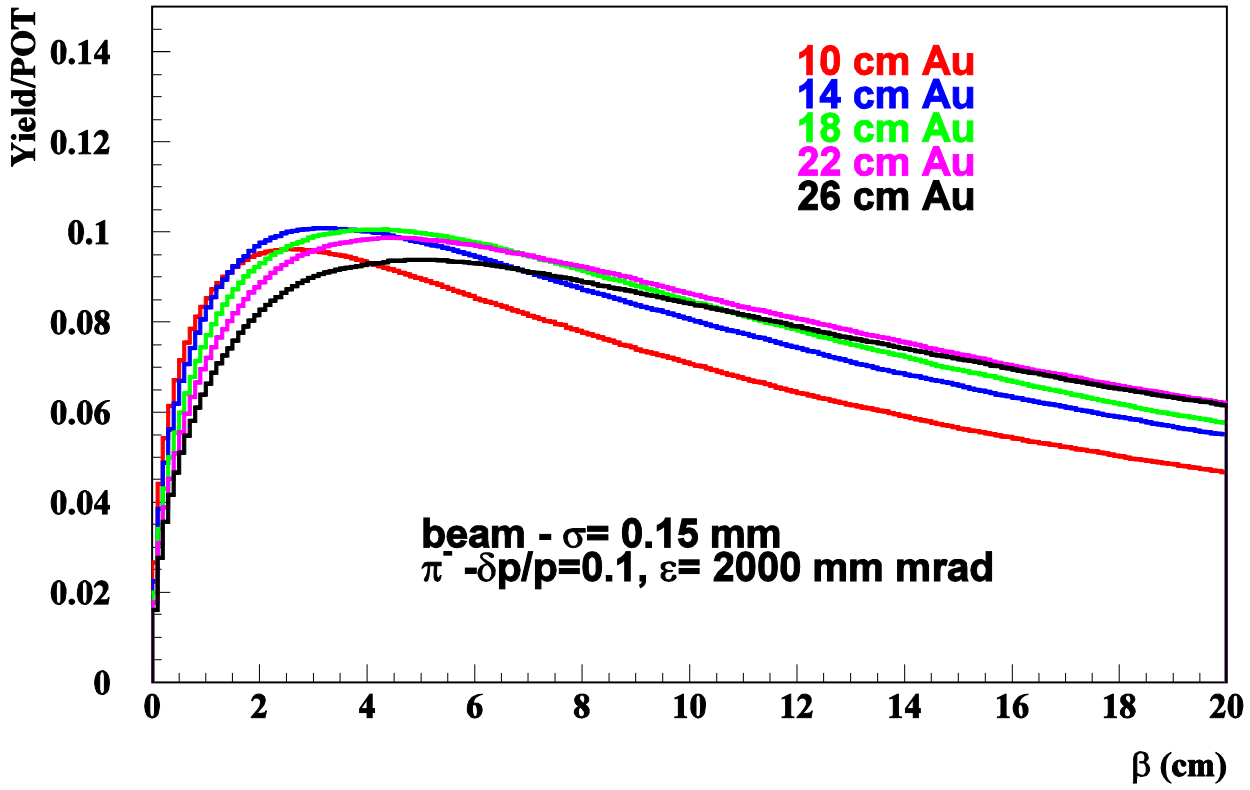
Dependence of positive pion yield on beta function for gold target ($\Delta p/p=\pm 0.15$) at 60 GeV



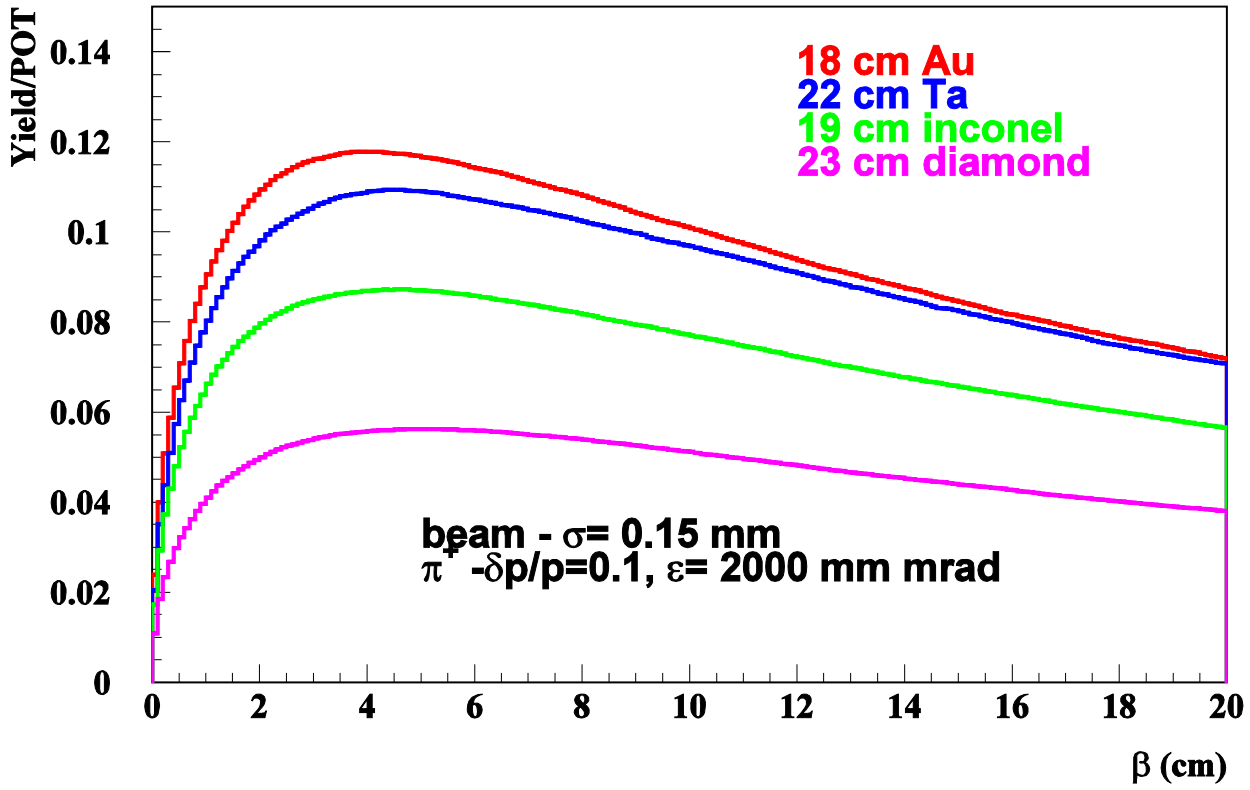
Dependence of positive pion yield on beta function for gold target ($\Delta p/p=\pm 0.05$) at 60 GeV



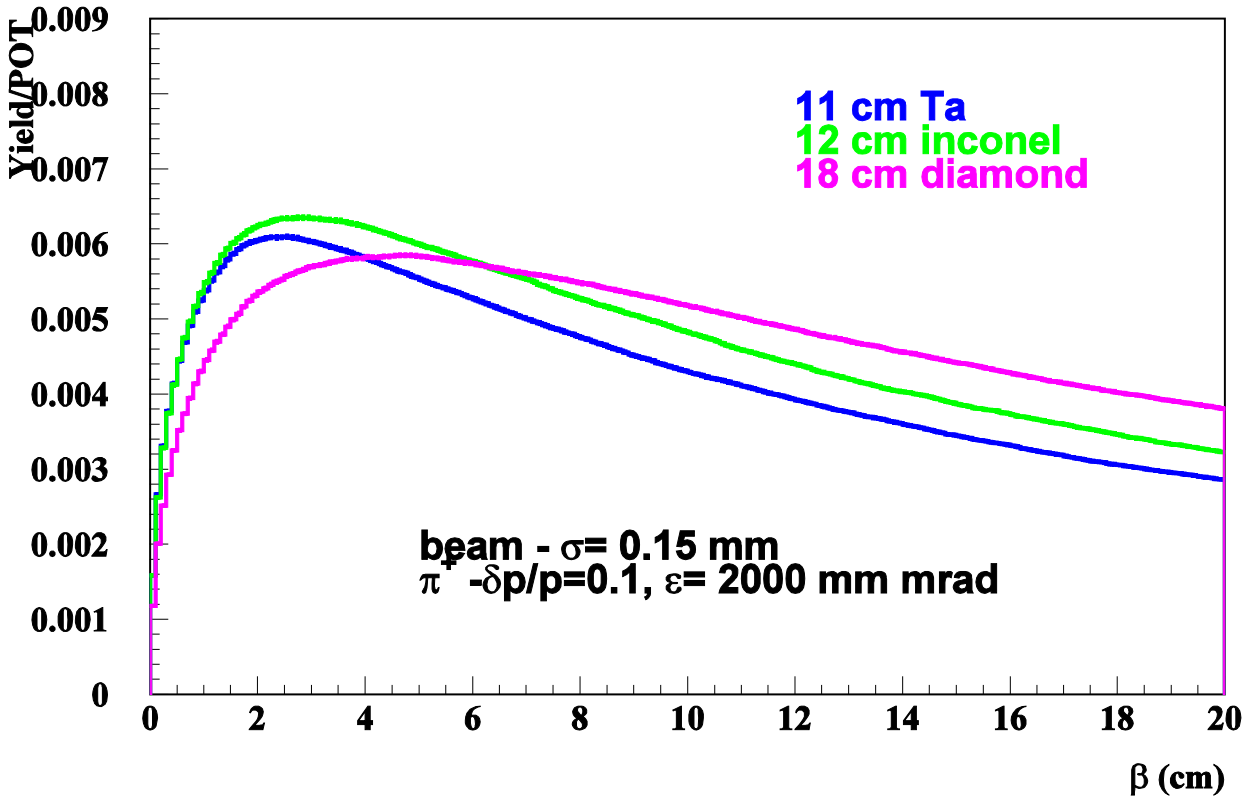
Dependence of negative pion yield on beta function for gold target ($\Delta p/p=\pm 0.1$) at 60 GeV



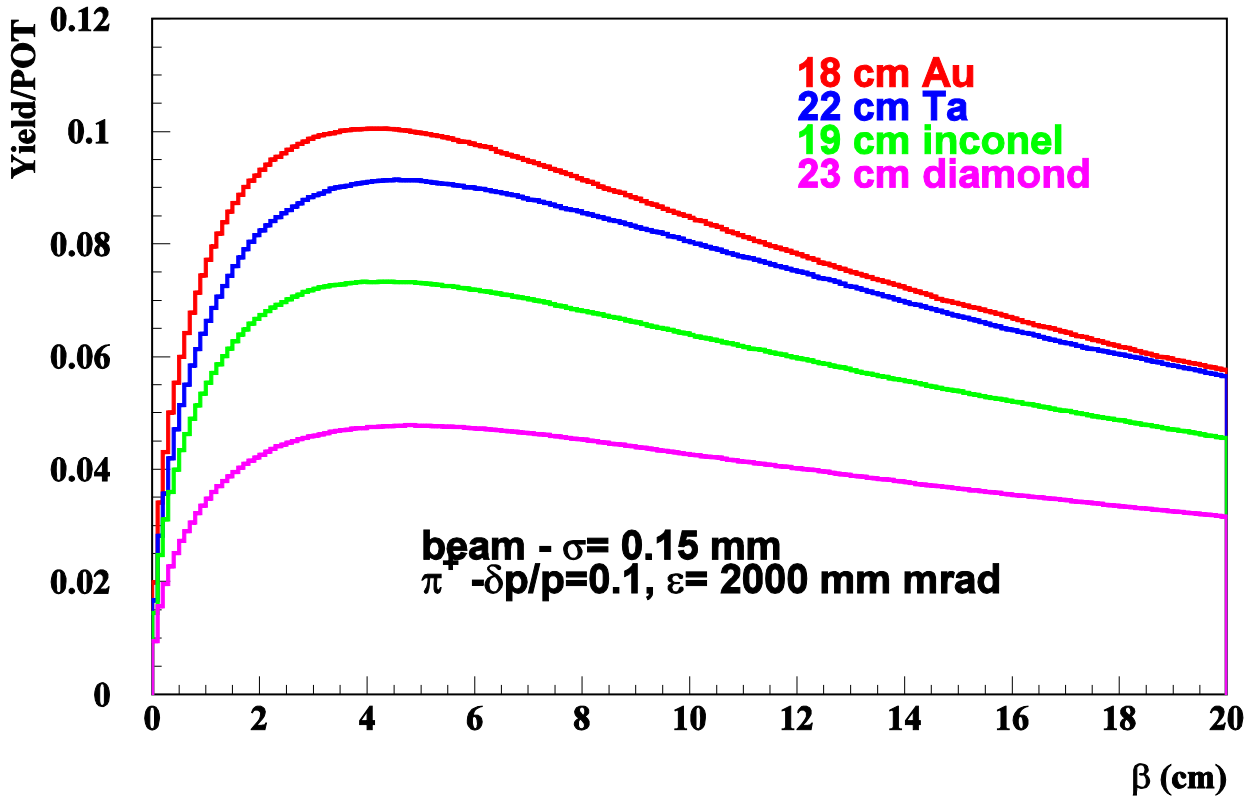
Dependence of positive pion yield on beta function for different target ($\Delta p/p=\pm 0.1$) at 60 GeV



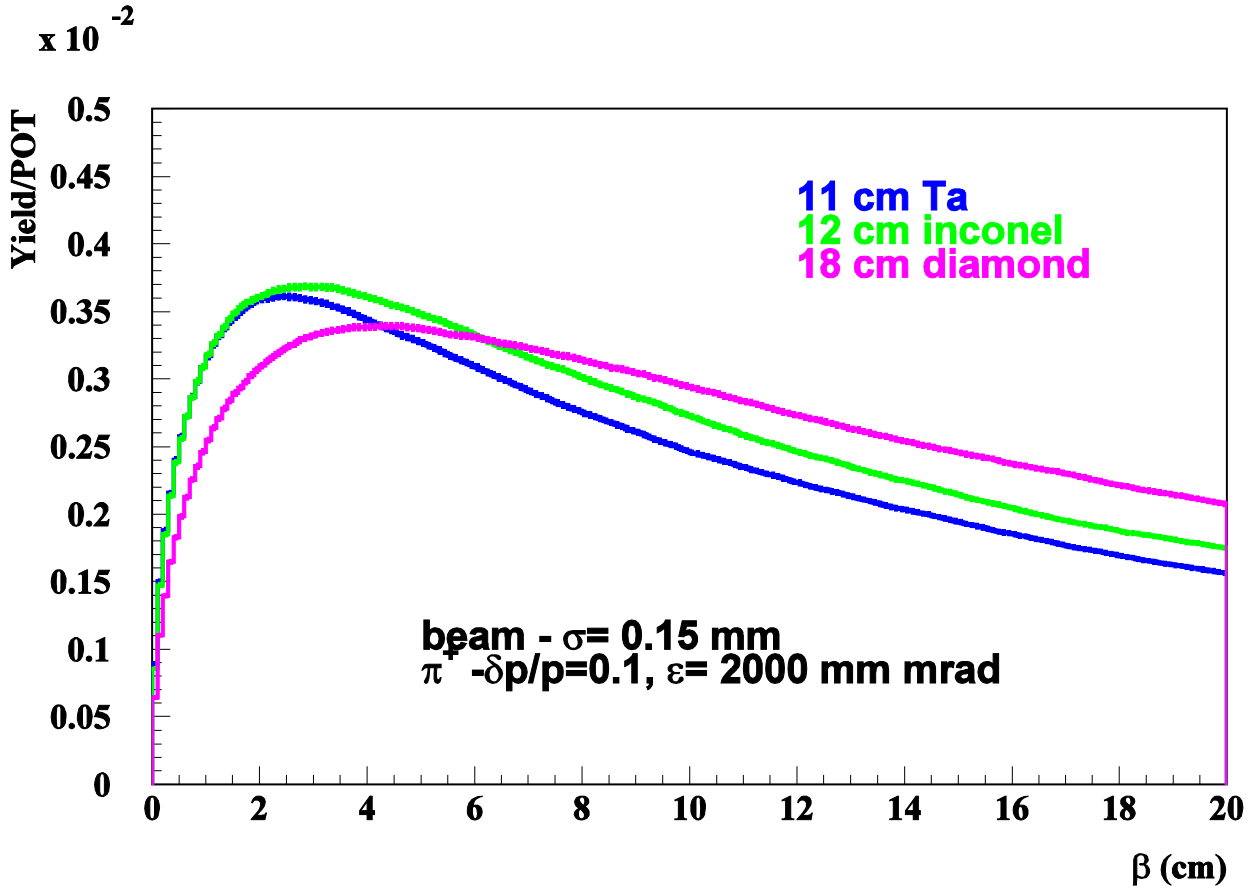
Dependence of positive pion yield on beta function for different target ($\Delta p/p=\pm 0.1$) at 8 GeV



Dependence of negative pion yield on beta function for different target ($\Delta p/p=\pm 0.1$) at 60 GeV



Dependence of negative pion yield on beta function for different target ($\Delta p/p=\pm 0.1$) at 8 GeV



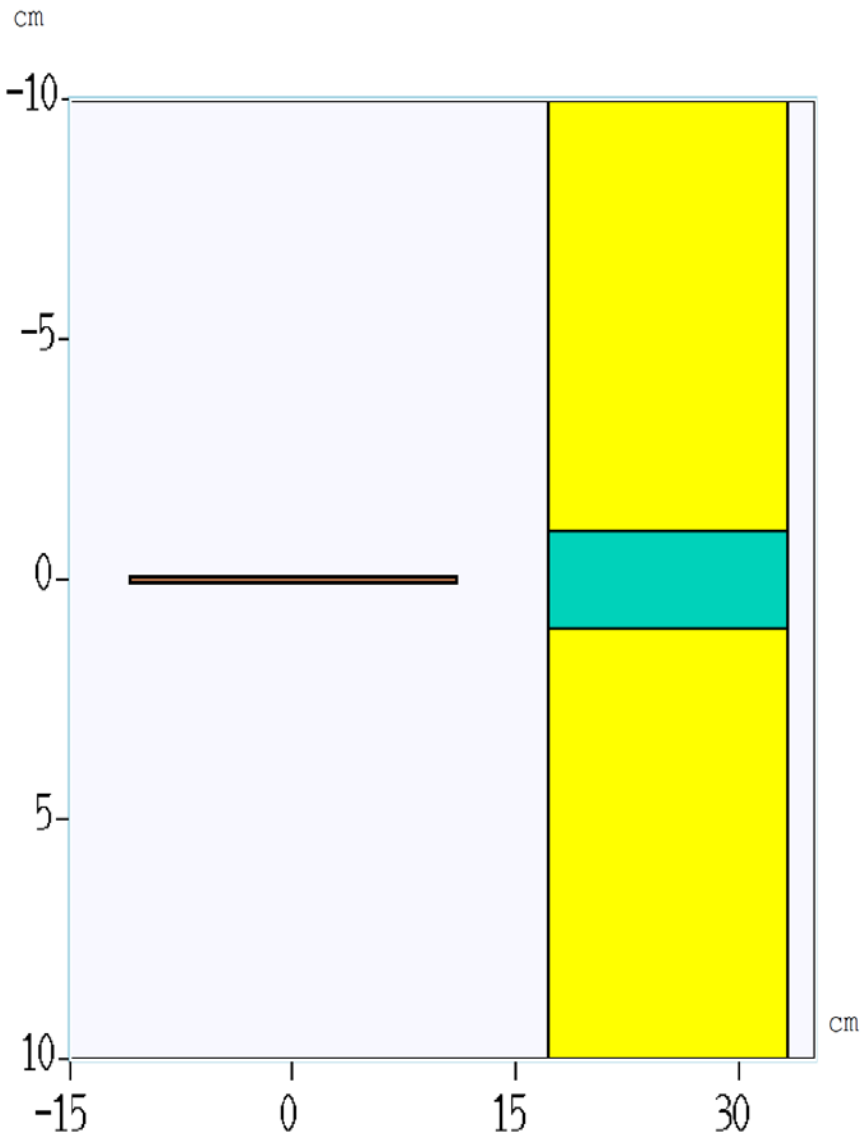
Lithium lens capture

Existing Fermilab lithium lens - 16 cm length and 1 cm radius.
2.6 Tesla/cm gradient at 15 Hz.
Optimal focal distance – distance between target and lens center is about 25 cm.

With current lens we could capture only 40% of pions with 3 ± 10% .

With 2 cm lithium radius transmission could be increased up to 60 %.

With rising field we need to reduce focal distance and reduce target length. With 2 cm radius and 4 Tesla/m transmission could be rise up to 80%. But there are no gap between downstream end of tantalum target and lens in this case.

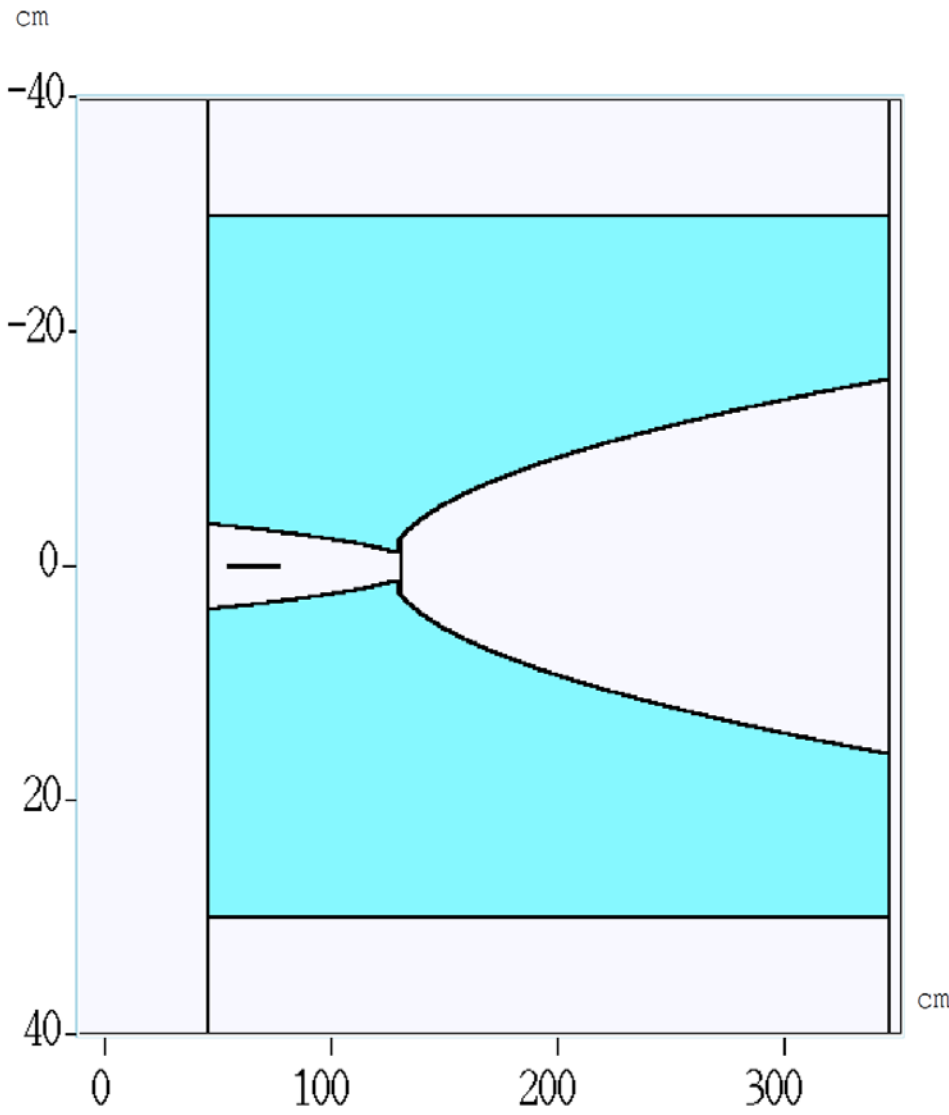


Horn capture

Existing NuMi horn has parabolic shape of the inner conductor. Shape and currents were optimized to maximize neutrino yield with energy less than 12 GeV with second horn.

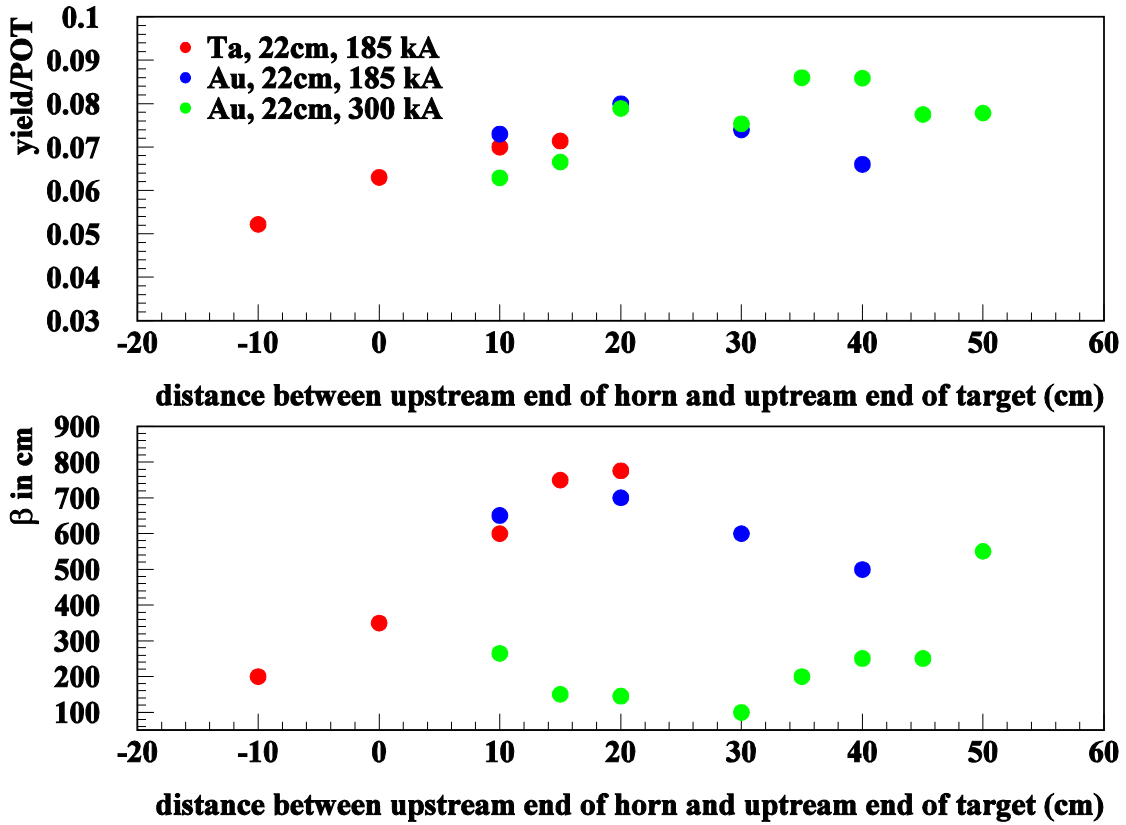
Recent NuMI Monte Carlo are using 185 kA current. With NuMI target (graphite -94 cm long,7.5x3.2 mm) and 60 GeV beam positive pion yield at 3 +- 10% GeV is 0.042 π^+/POT.

Reasonable restriction (10 years ago):
- horn radius does not exceed 50 cm
- horn length is in order of 3 m
- maximum horn current is equal to 300 kA



PI+ Yield, Δp/p=±0.1, NuMI horn, 60 GeV

Pion beam size = sqrt(Εβ),
Ε=0.2 cm and β=500 cm => 10 cm radius!



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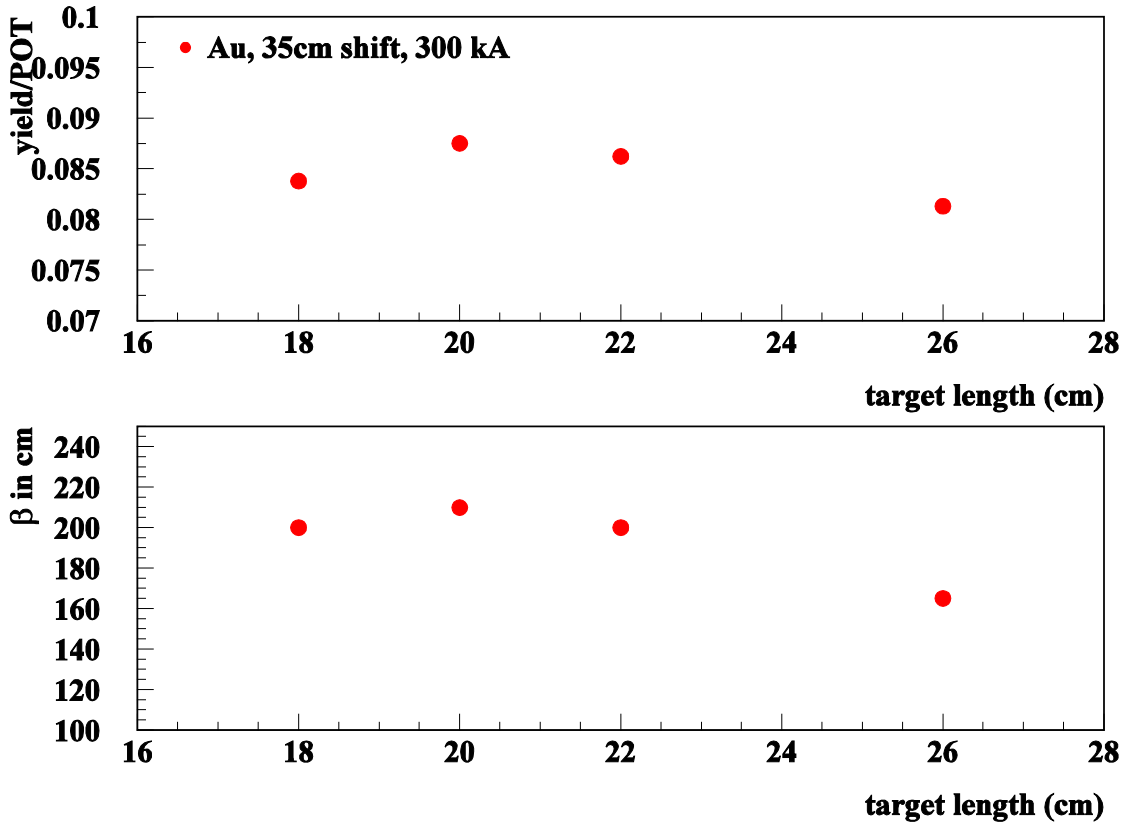

CONCLUSIONS

We could get about 0.12 π+/POT and 0.1 π-/POT with 3 ± 10% GeV momentum from gold target at 60 GeV into 2000 mm mrad acceptance with ideal capture. Yield for carbon is about 2 times lower at this energy.

We could get about 0.006 π+/POT and 0.0035 π-/POT with 3 ± 10% GeV momentum from gold target at 8 GeV into 2000 mm mrad acceptance with ideal capture. Yield has weak dependence on target material at this energy.

Pion capture using lithium lens looks like problematic due to large radius of pion beam.

Pion capture using horn looks like reasonable. Without optimization of inner surface shape it is possible to get 0.088 π+/POT with existing NuMI horn and 300kA current.

Could we use large Z target inside horn at 60 GeV?

Could we optimize horn shape to get better transmission factor? Very low energy horn with conical shape (Beams-doc-724) provides yield 0.11 π+/POT with gold target, but β = 2000 cm is too large.

Verification of MARS pion yield near 3 GeV is needed.