8th Nov. 2003 NBI03@KEK

J-PARC Neutrino Beam Optimization

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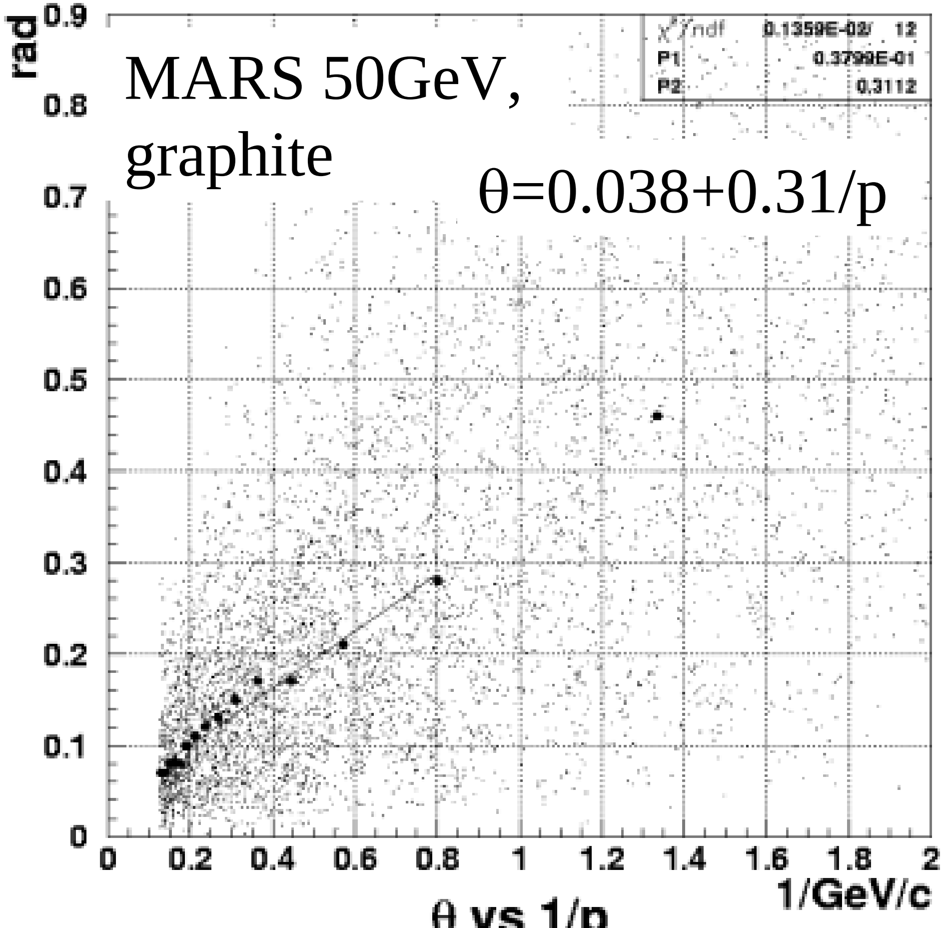
π production –Model-

Momentum and angle of π

$$<\theta>=\text{const.}+\text{const.}/<p>$$



MARS

50GeV : $\theta=0.038+0.31/p$

30GeV : $\theta=0.038+0.33/p$

GFLUKA+GCALOR

50GeV : $\theta=0.023+0.33/p$

FLUKA2000

50GeV : $\theta=0.026+0.31/p$

Horn parameters depends

not on primary proton energy

but on focusing pion momentum

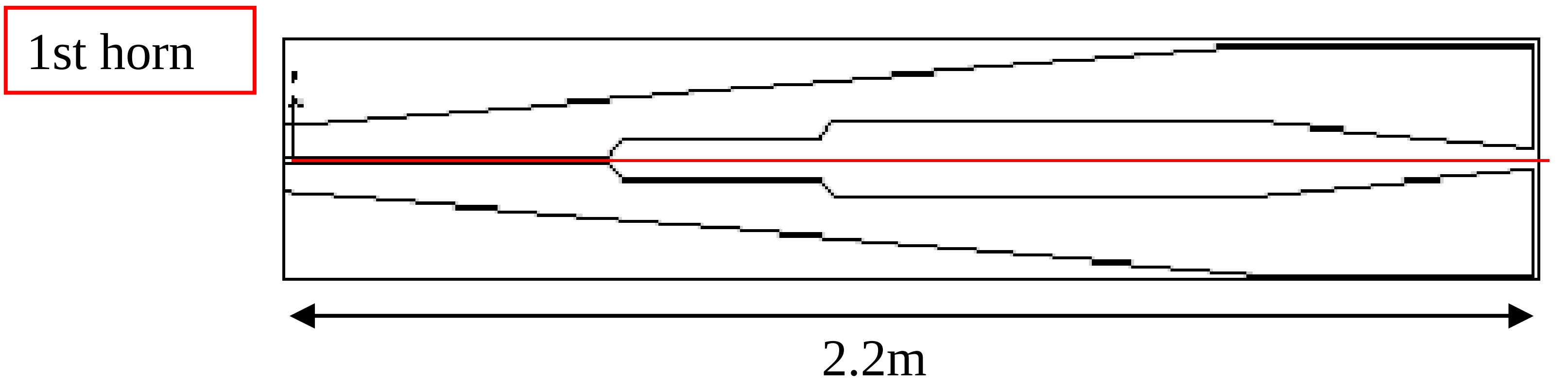
~2GeV/c

J-Parc horn should be rather similar to K2K type than NuMI or CNGS types.

Horn design starting point

Horns proposed in BNL-E889

which is appropriate for ~2GeV/c pions



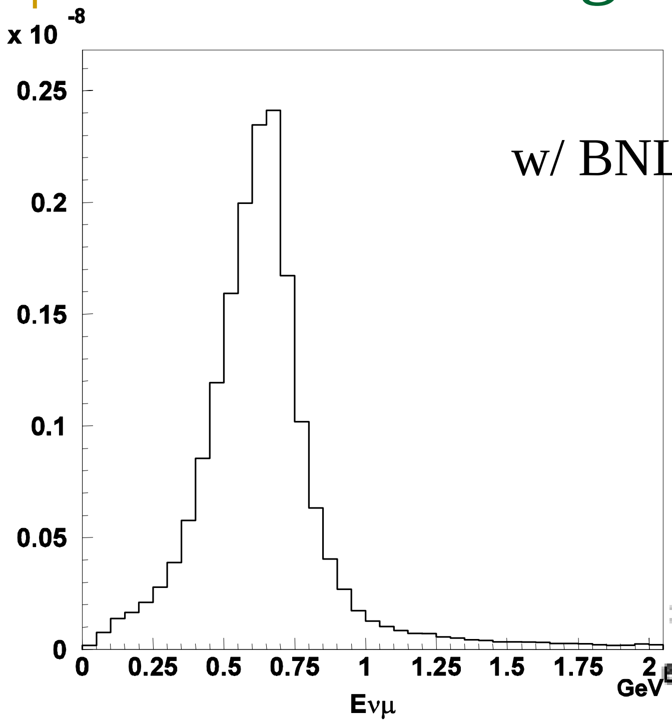
- D_{in} = 1.9cm$^{\phi}$, I=250kA
- Sapphire target (Al_2O_3, ρ=4g/cm^3) D=0.64 cm, L=45cm

Cannot survive heat load from radiation at J-Parc

⇩

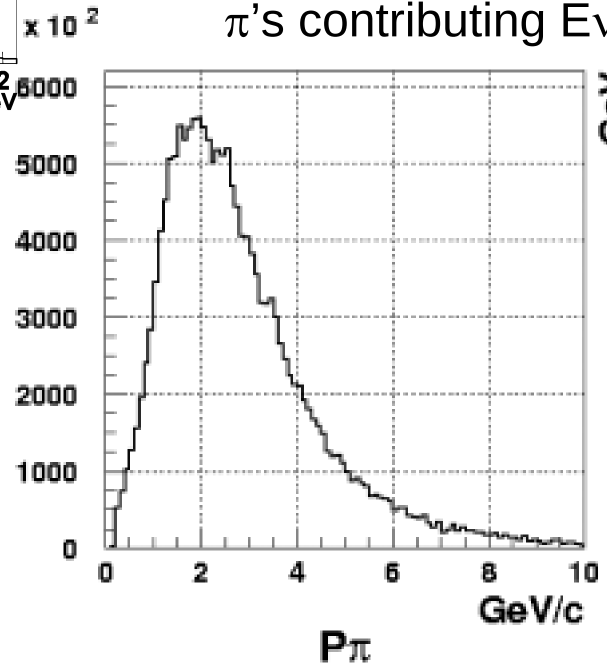
Need realistic design work

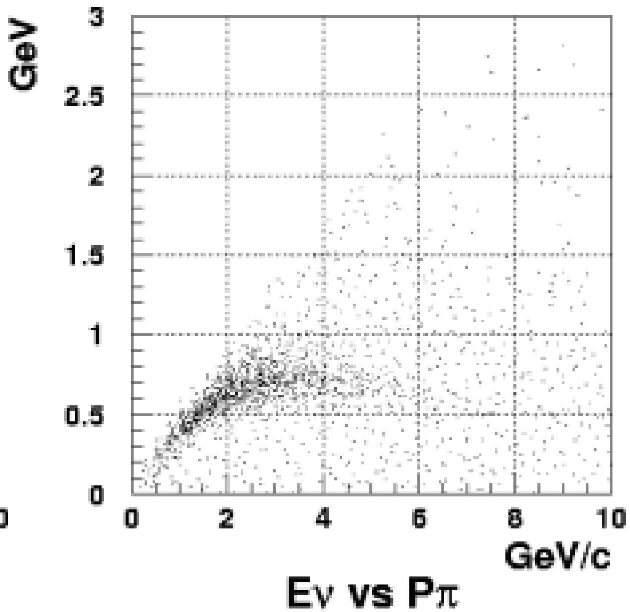
Momentum region of π's



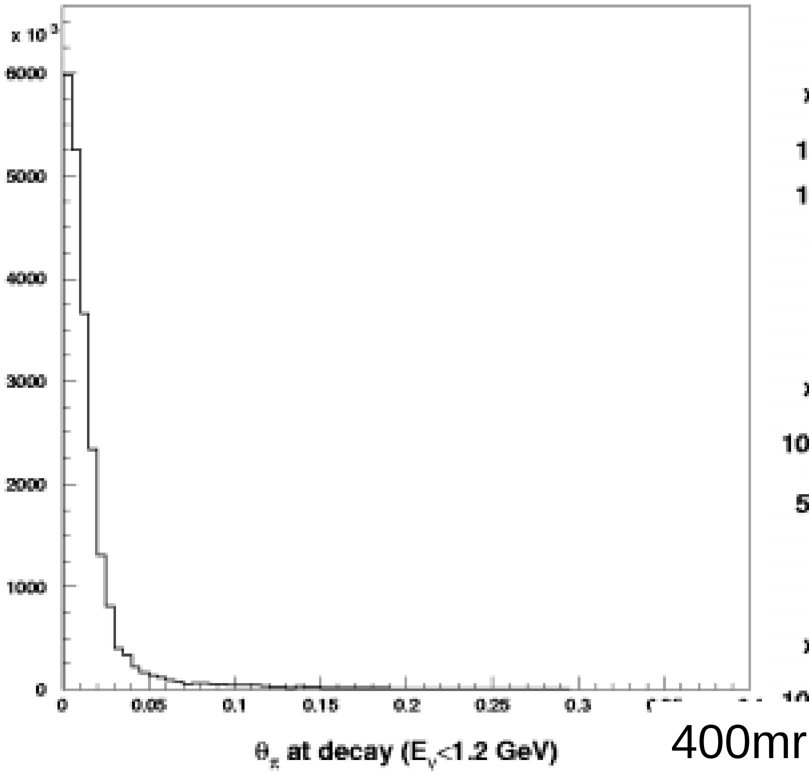
w/ BNL-type horn, 2.5 ° OAB

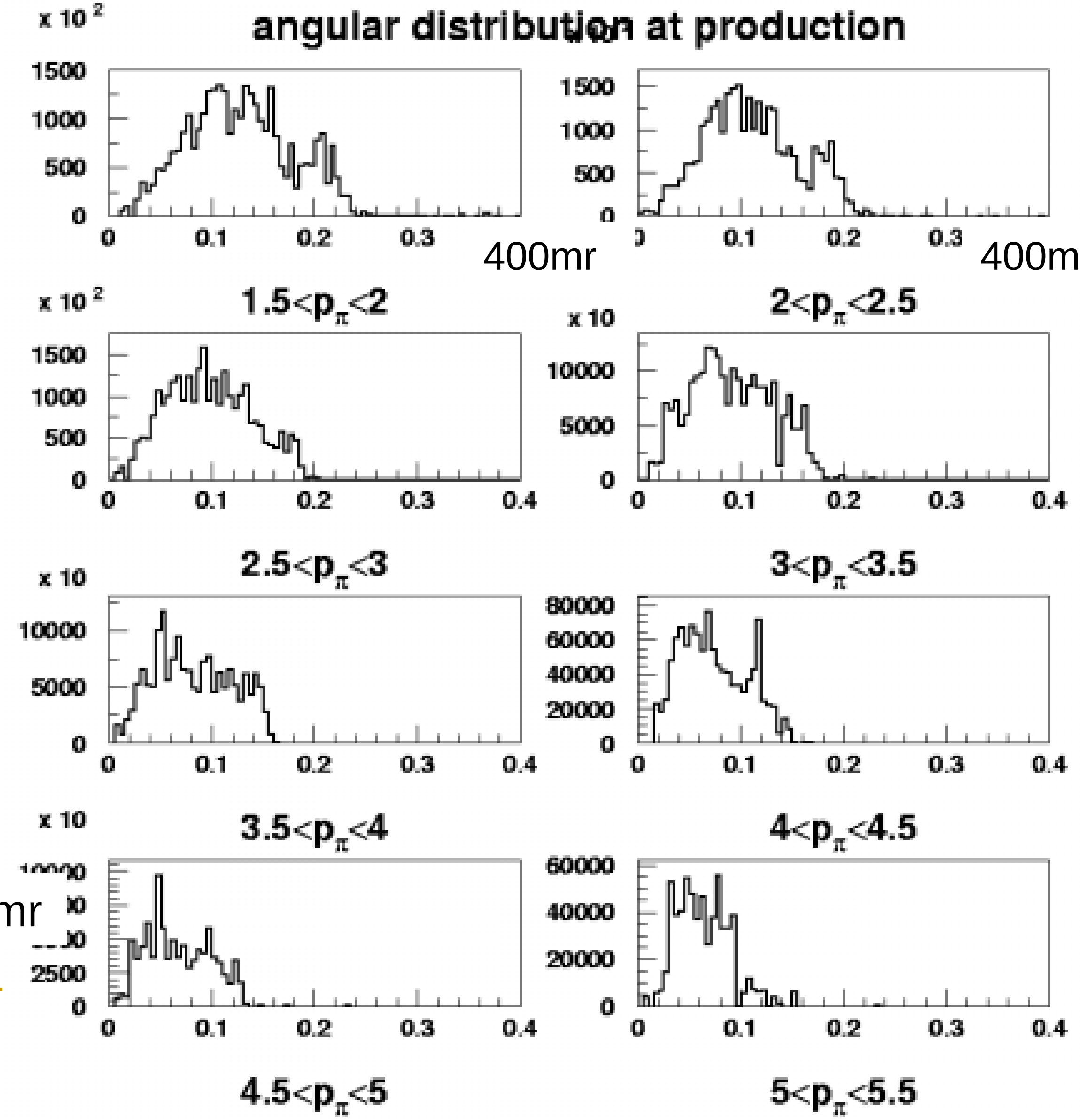
π's contributing Eν<1.2GeV





Angular region of π's which generate $\nu(E_\nu<1.2$ GeV)





Target Size

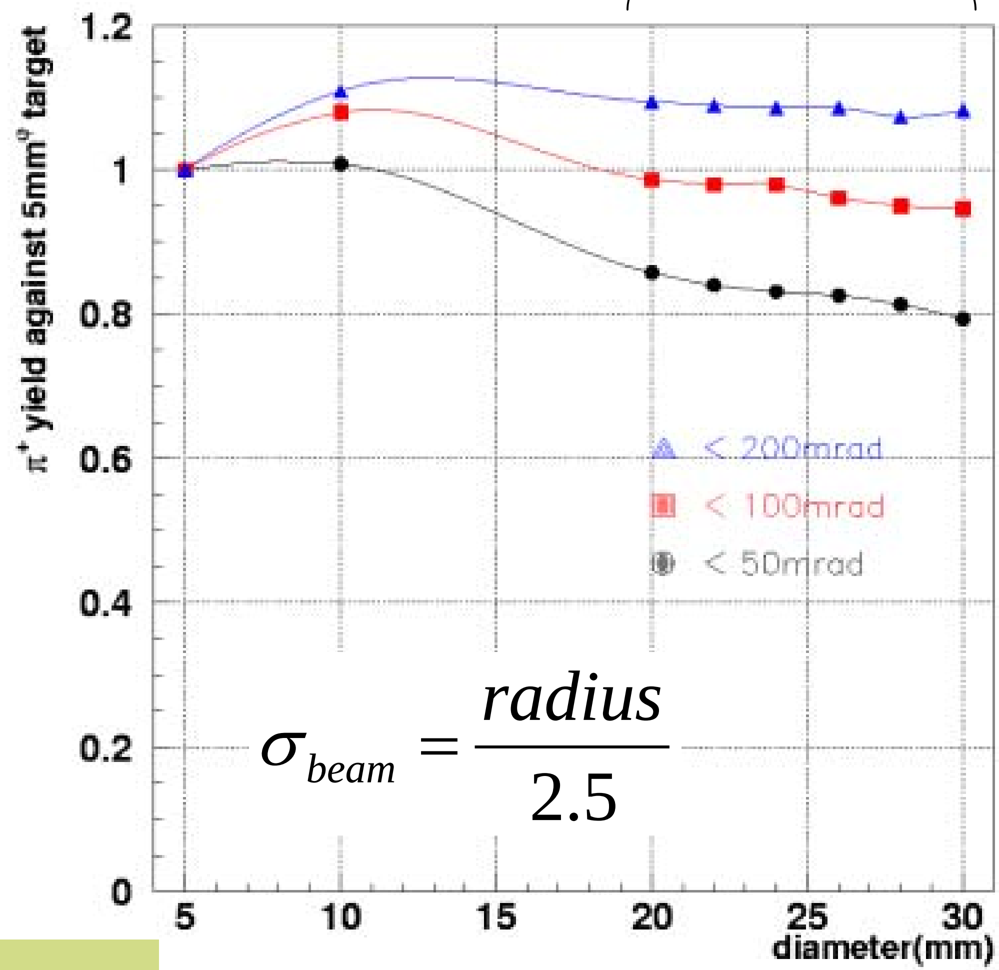
90cm long graphite ($2\lambda_{int}$)

- Pion absorption
- Temperature rise
- Energy concentration

Hayato's talk

- Inner radius of the horn
- Beam size ~1cm

Effect is not large around here



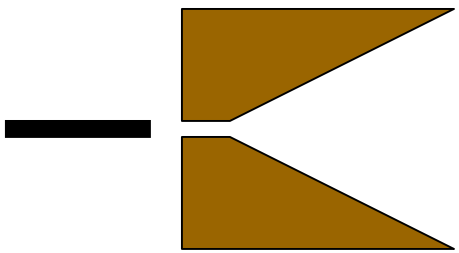
$$\sigma_{beam} = \frac{radius}{2.5}$$

Target 3cm$^{\phi}$

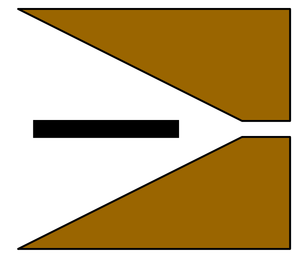
Horn inner conductor radius > ~45mm$^{\phi}$

Types for the 1st horn

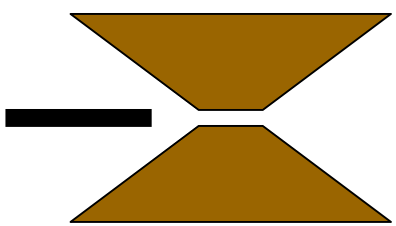
(a)



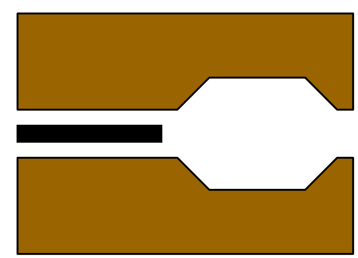
(b)



(c)



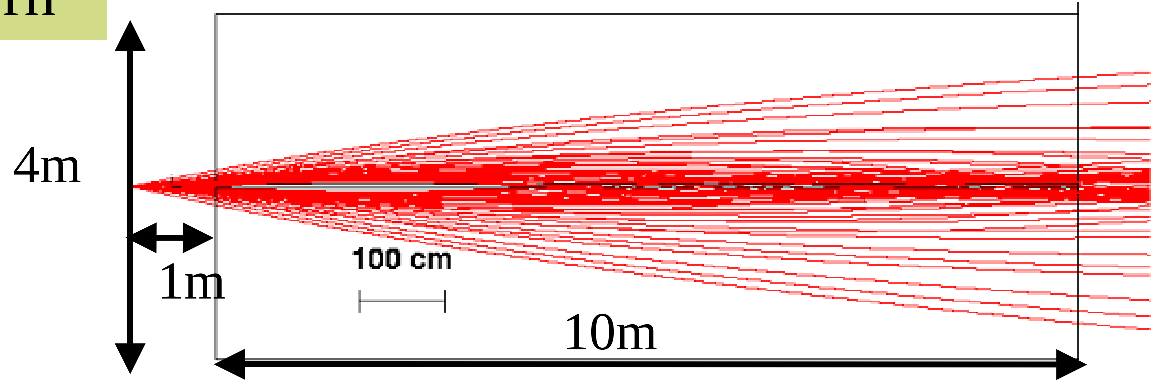
(d)



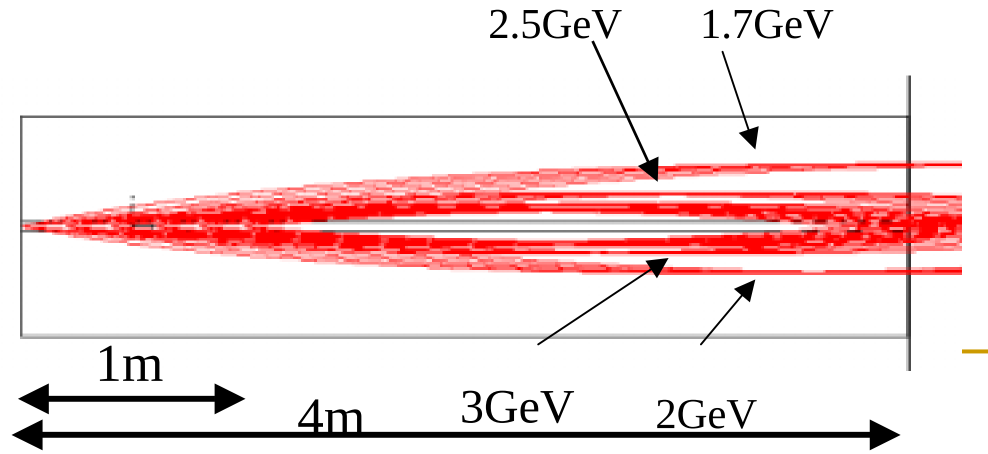
Target in/not-in the horn?

Inner conductor 4.6cm$^{\phi}$ I = 250 kA

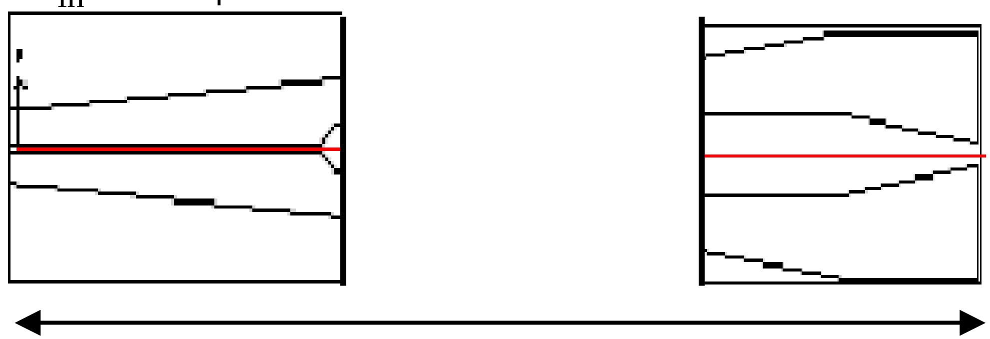
Target outside the horn

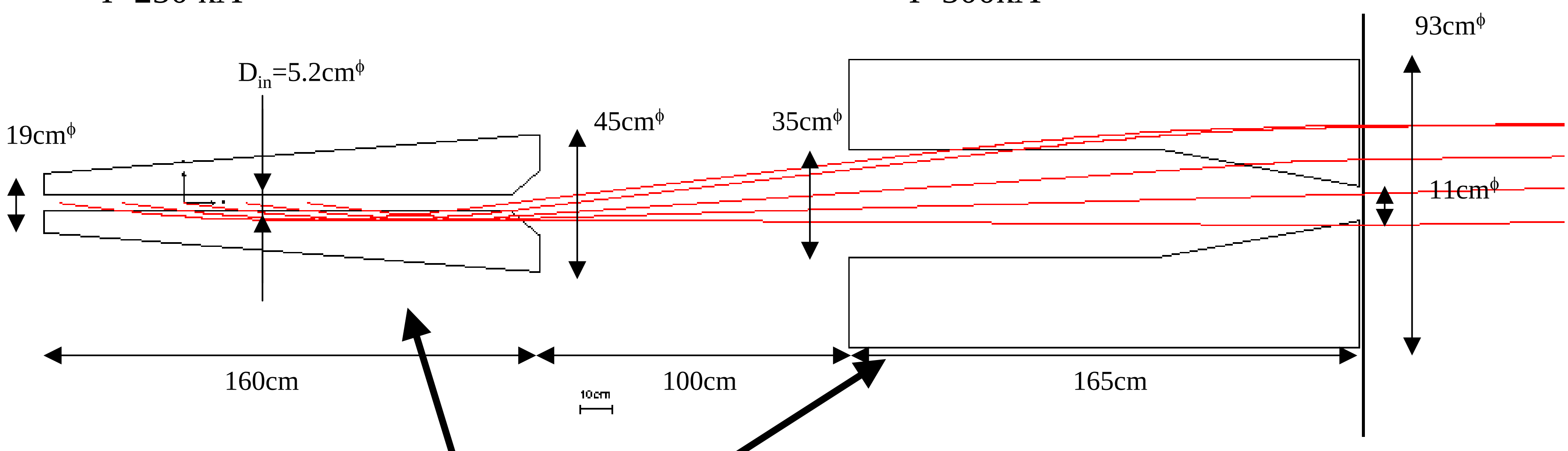


Target in the horn



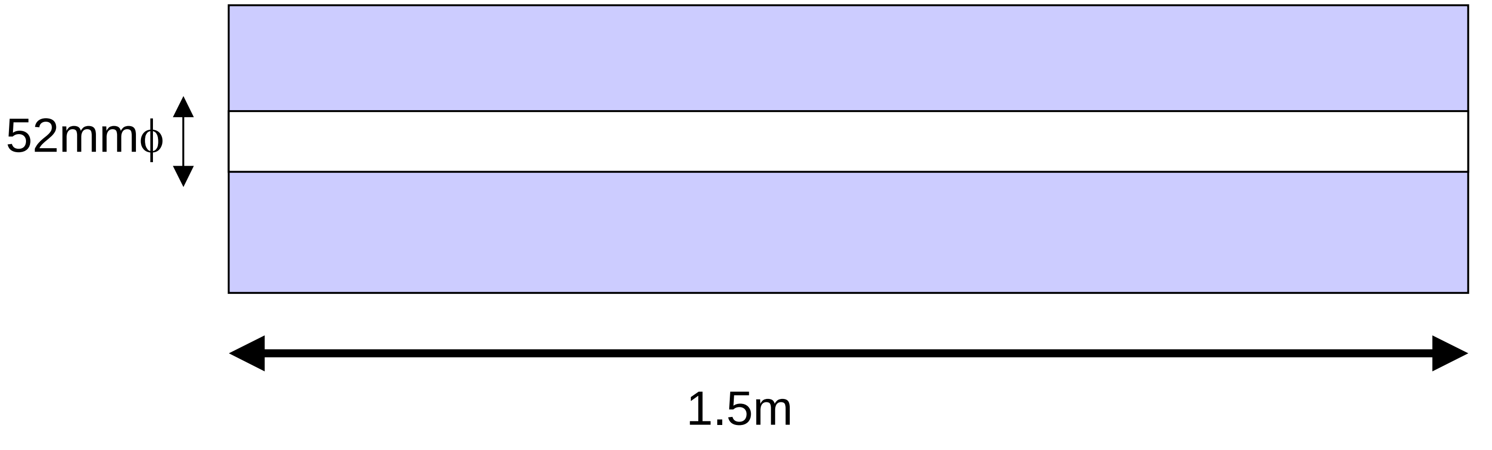
Idea for '1st horn'



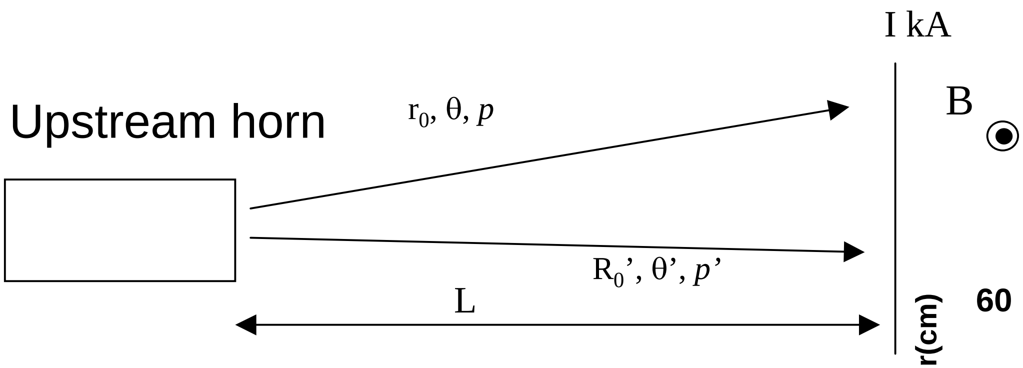


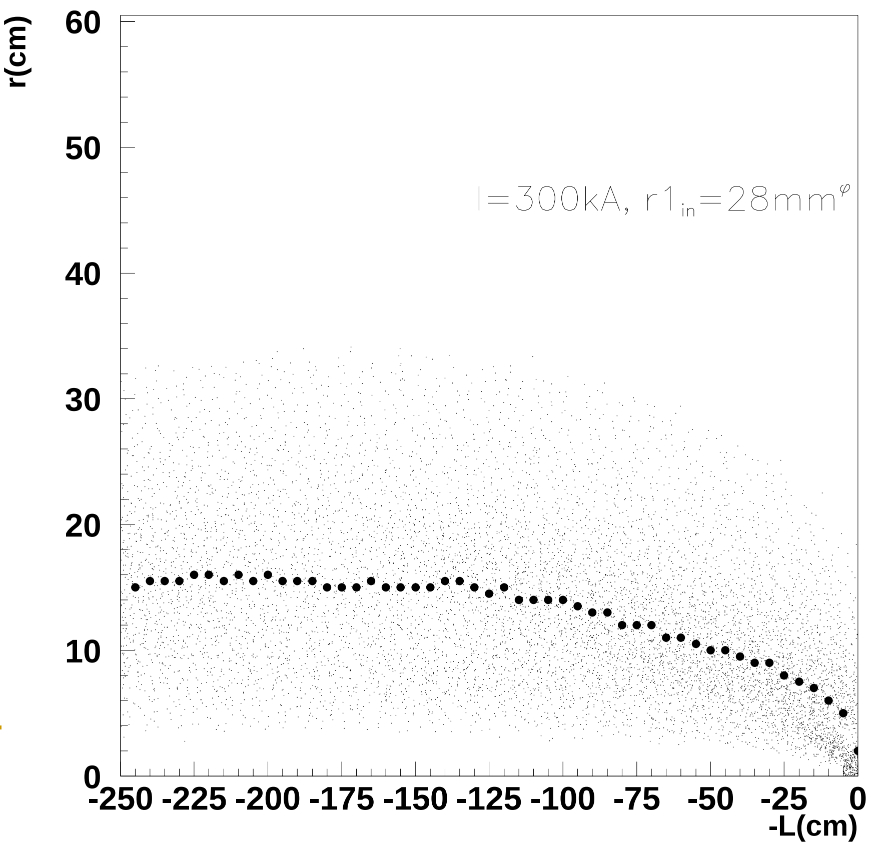
3 horns, I=320kA

1st horn

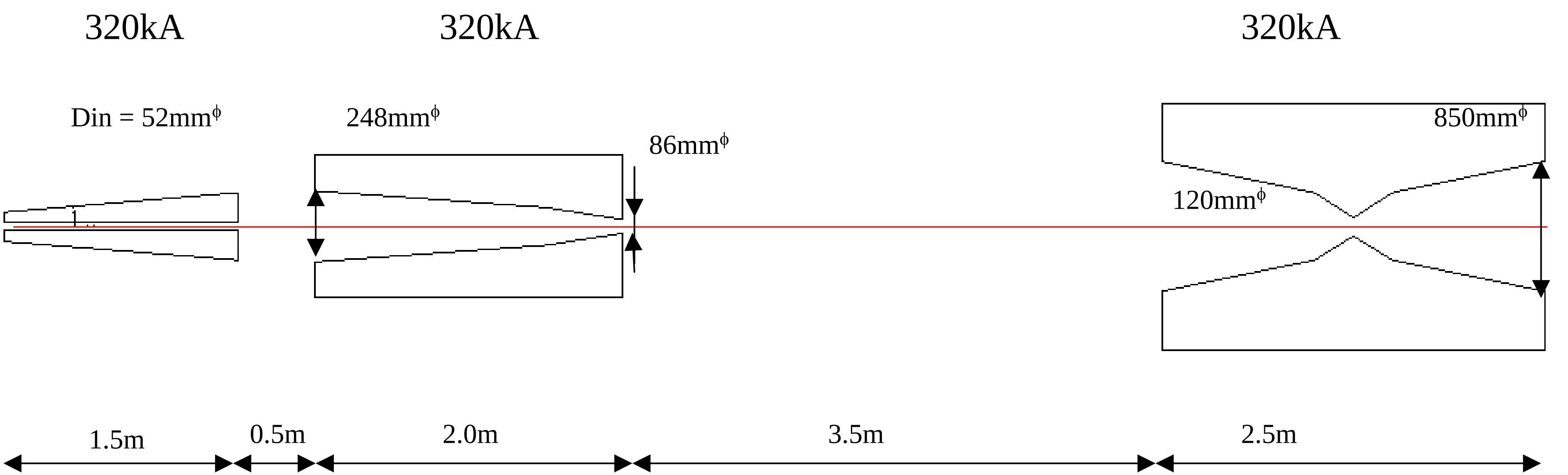


Optimization procedure 1.
(optimization of 2^{nd} and 3^{rd} horns)



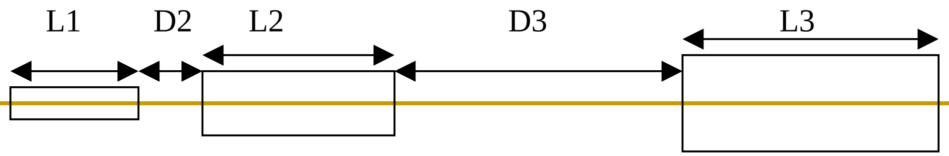


Horn system –1st version?-

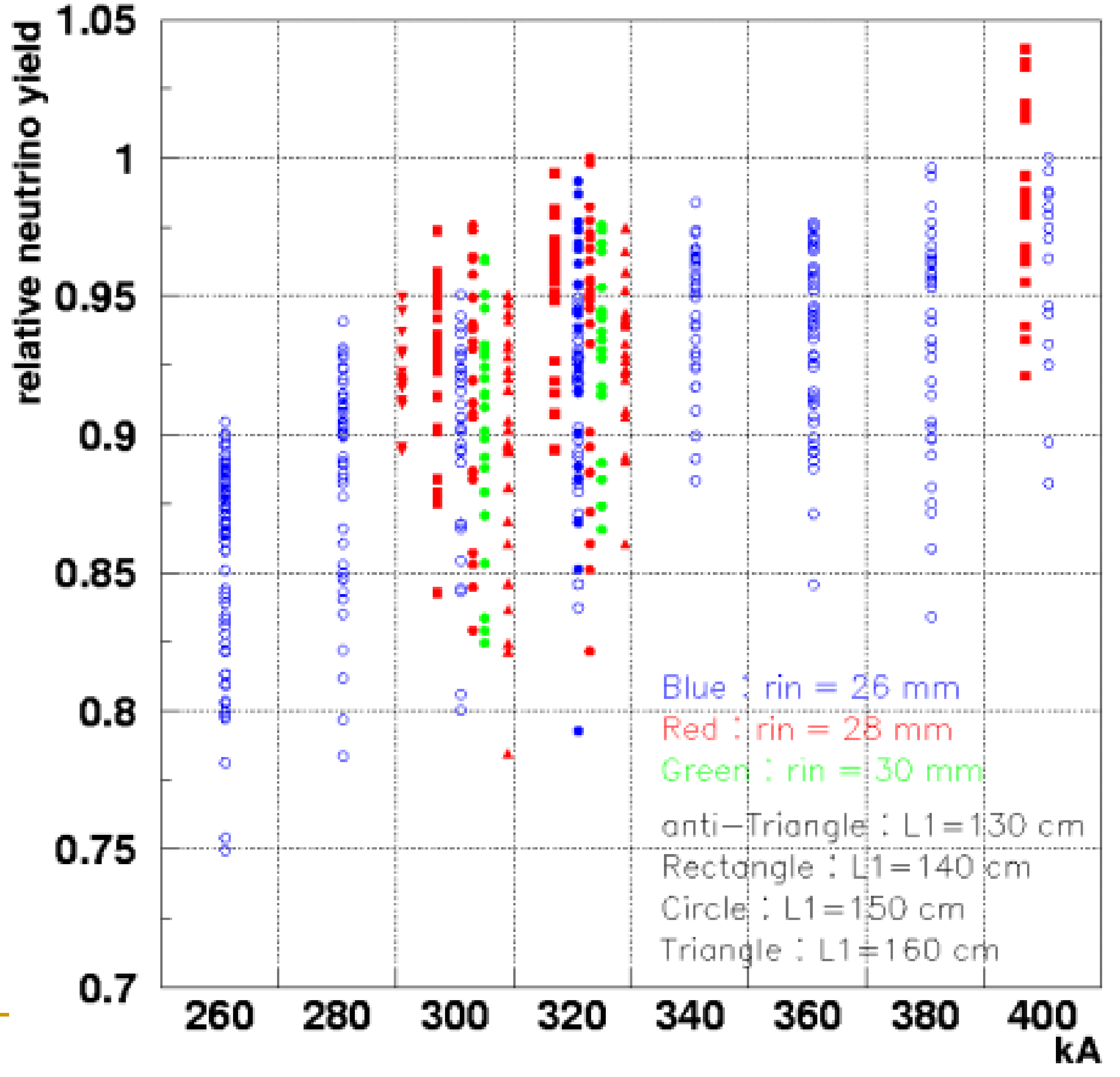


Further optimization –Horn1-

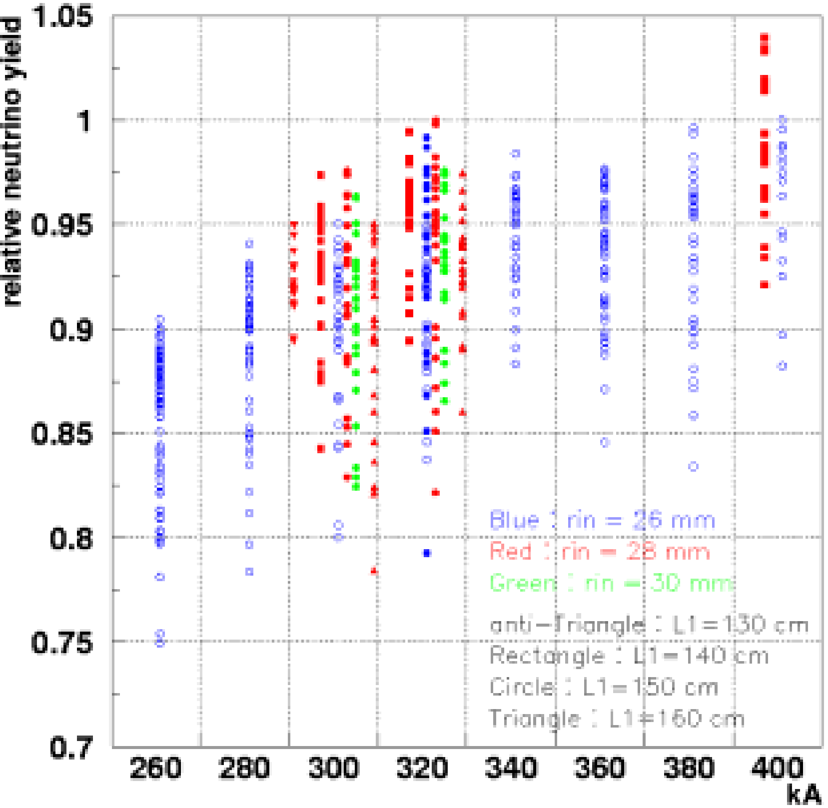
Parameters	default
Current I	320kA
Inner conductor radius r_{in}	26 mm
Horn1 Length L1	1.5 m
Distance to Horn2 D2	0.5 m
Horn2 shape parameter a2	0.609
Horn3 shape parameter a3	0.0661
Fixed Parameters	
Horn2 Length L2	2 m
Horn3 Length L3	2.5 m
Total Length	11.5 m



Further optimization



What can be said w/ this?



Flux increases with higher current.

~5%/100kA

Diff.btw. 300kA & 320kA is only 2~3%.

Almost same yields with r_{in}=26mm & 28mm,

while decreased w/ 30mm.

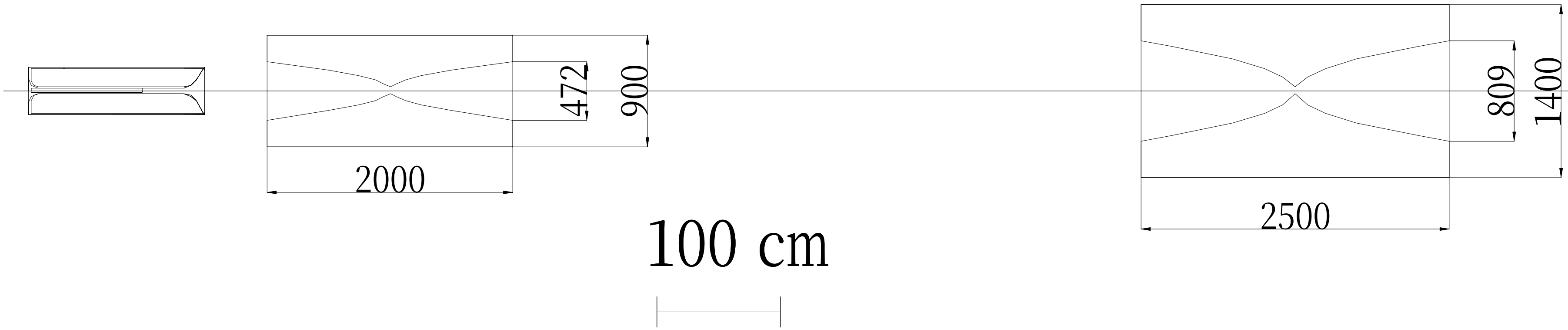
Yield is maximum at L1=140cm or 150cm.

I=300kA ~320kA

r_{in}=28mm (safer than 26mm)

L1=140cm (easier than 150cm)

I=300kA~320kA

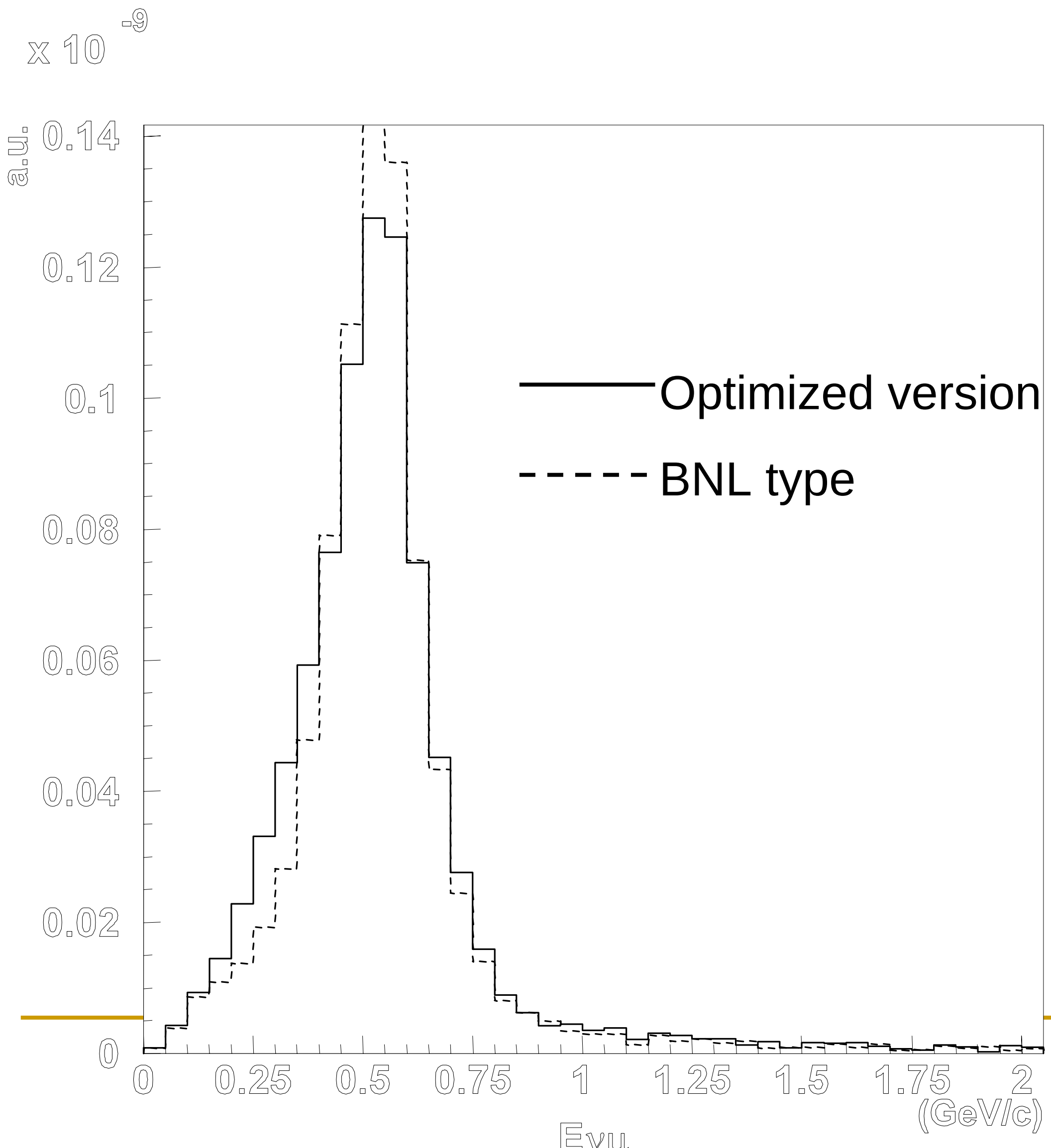


Rin = 28 mm

L1 = 140cm

D2 = 50cm

Flux w/ New horn



Comparison btw. optimized version & BNL-type(starting point)

(aluminum is not included.)

Optimized

Rin=28mm

30mm$^{\phi}$ graphite target

BNL-type

Rin=9.5mm

6.4mm$^{\phi}$ sapphire target

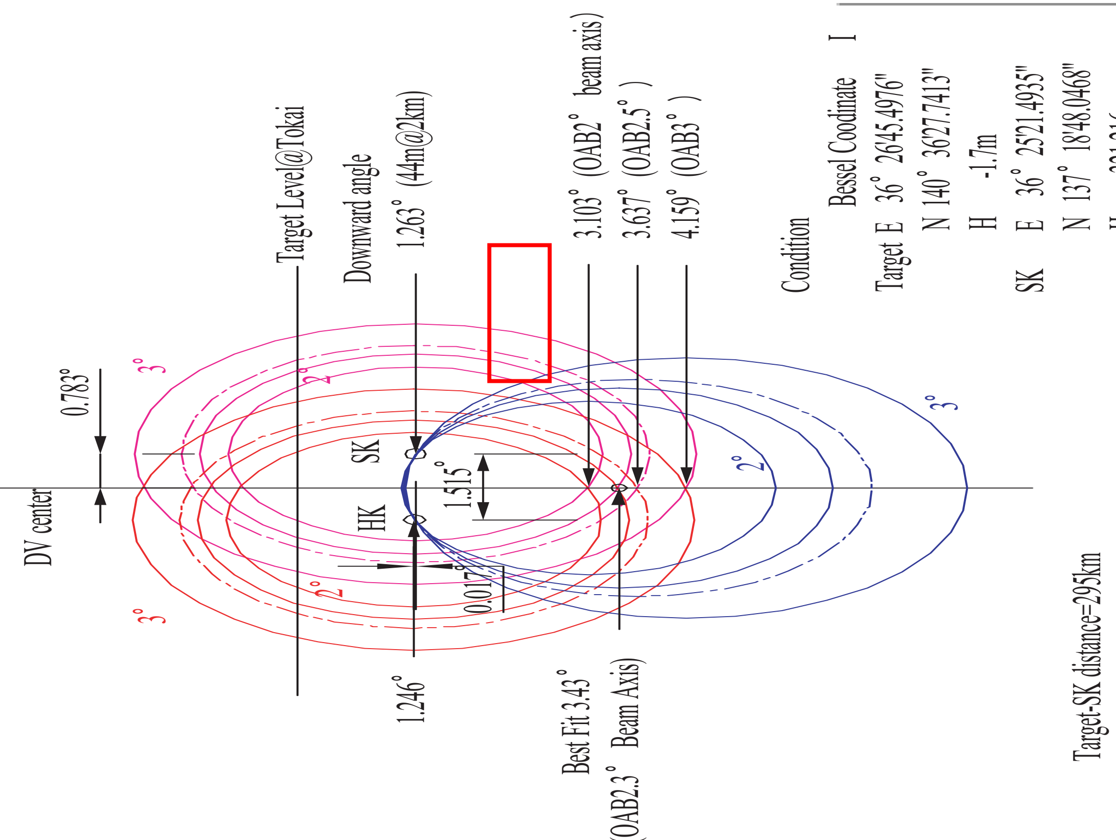
Optimization of Decay Volume -1-

Peak Eν is determined by off-axis angle.

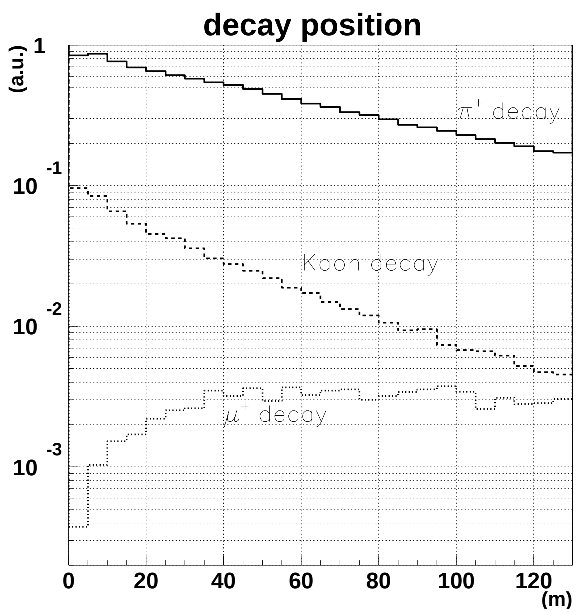
表 3.1: E_ν at the oscillation maximum for the baseline length of 295km and corresponding off-axis angle.

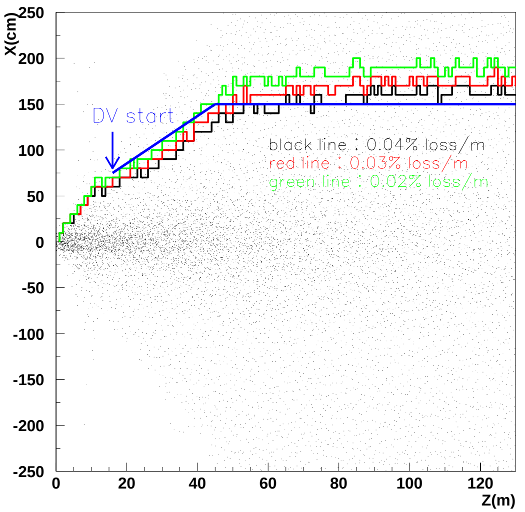
Δm^2 $[10^{-3}eV^2]$	2.04 (90% A.R.)	2.18 (80% A.R.)	2.75 (best fit)	3.17 (80% A.R)	3.28 (90 % A.R)
$E_\nu[GeV]$	0.487	0.520	0.656	0.756	0.782
OA angle[deg.]	3.1	3.0	2.4	2.1	2.0

Cover this region



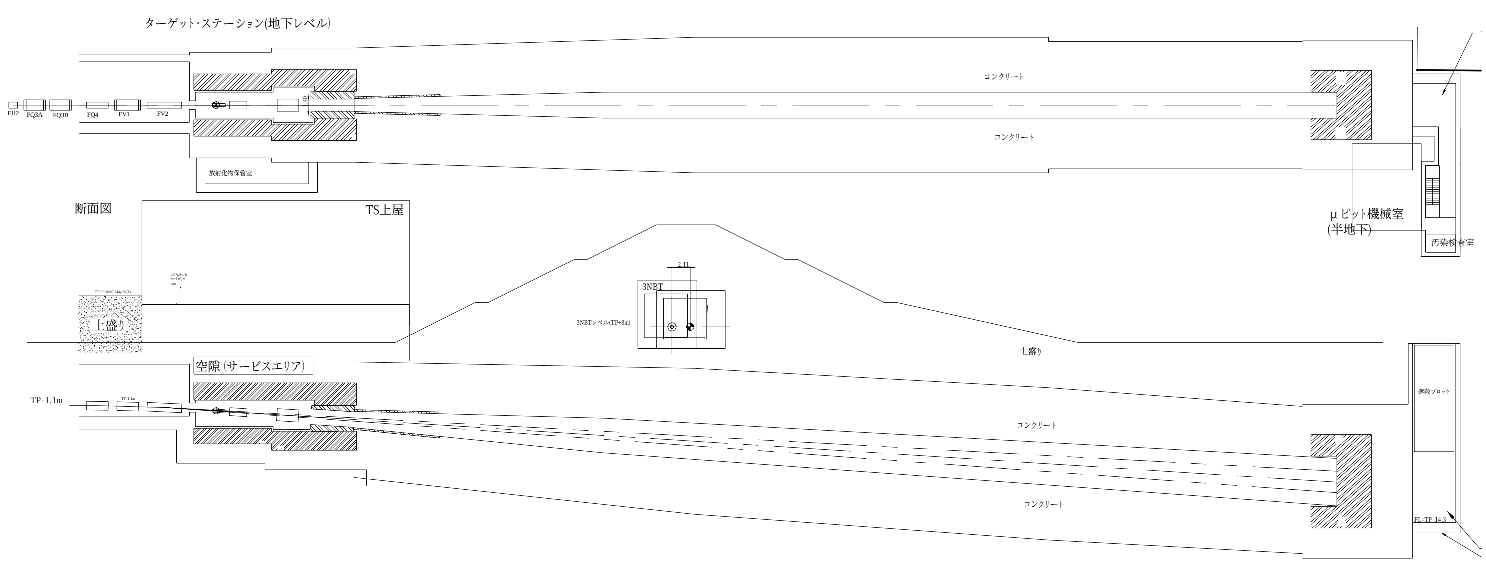
Optimization of Decay Volume -2-





Top view

Side View



Summary

- Conceptual optimization of target, horns and decay volume was done.
- Now, need to move imaginary world to real world!