Neutrino Beam Optimization

Essential Issues for CD-1

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27 Feb 2009

Outline

1. Meta-details
2. Tools for optimizing
3. Key Detector Issues
4. Key Design Issues
5. Summary of progress
6. Proposed timeline / Discussion

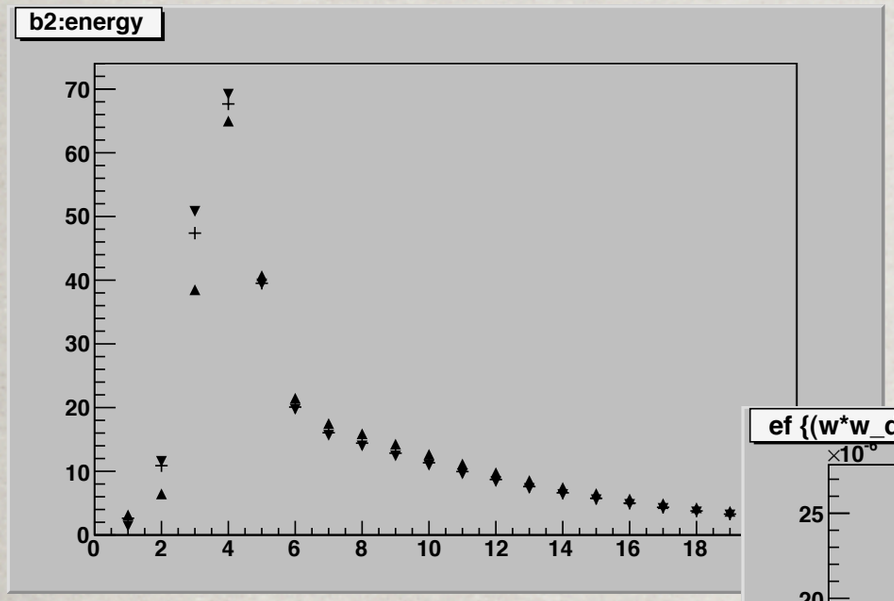
Meta-Details

- Level of Detail for "optimization"
  - Quantify? ~20-30% uncertainty
  - Do not require <u>unique</u> solution at this time
    - But... we can eliminate some possible solutions now
    - Can keep two options for costing, maybe three
- Concentrate on defining underground volumes

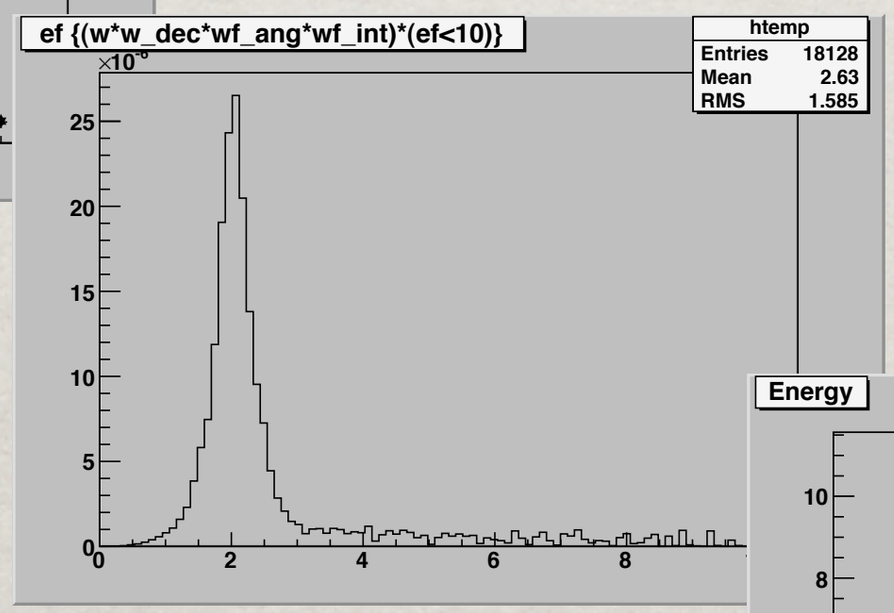
Tools

- MARS π / K production + transport thru Horns
- Code for π decay ; ν interaction in Near/Far
- Have a “horn” library (NuMI, T2K, BNL...)
- other code for quick looks at tgt/horn geom.

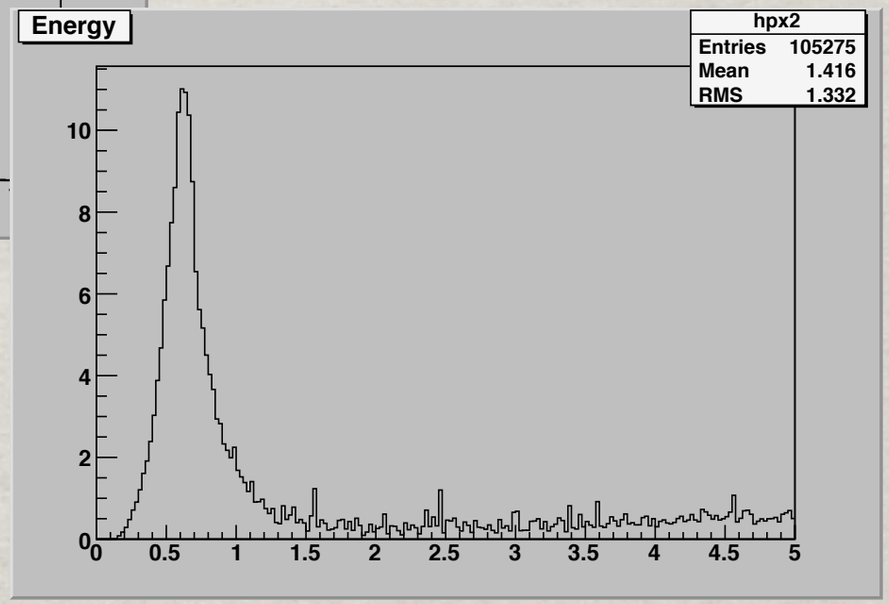
Examples: Spectra



MINOS

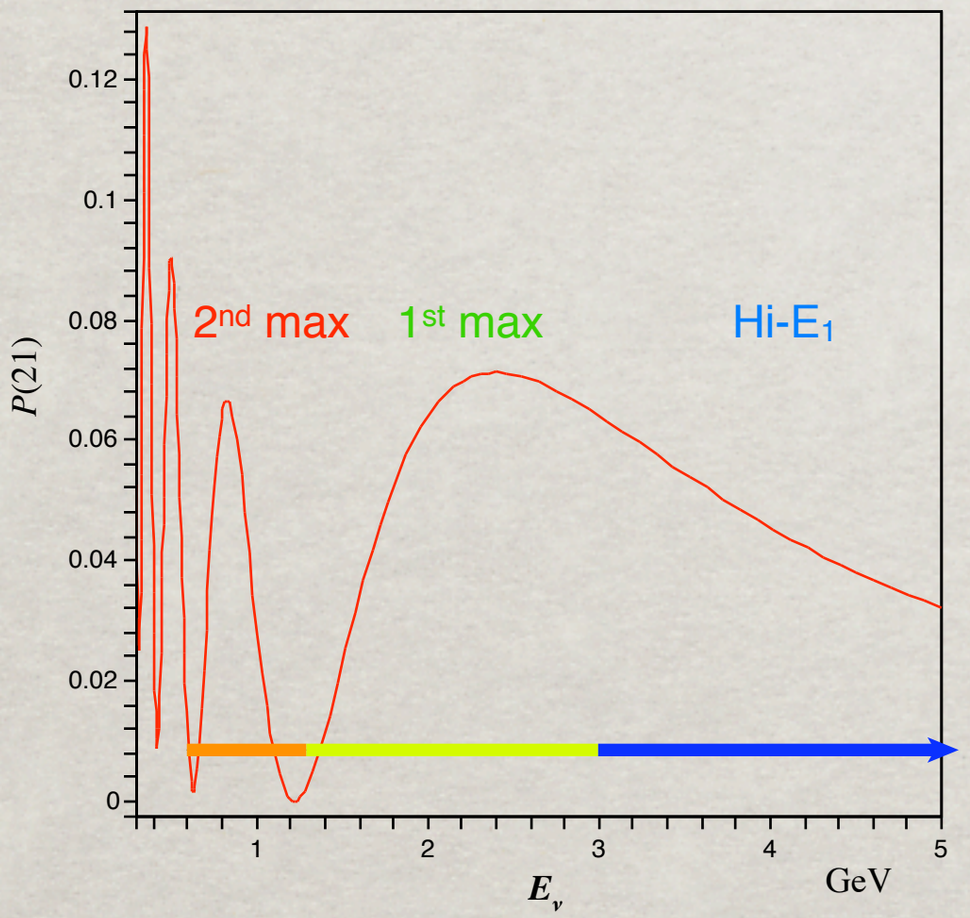


NOνA



T2K

Physics: Oscillation Maxima



Physics:

θ_{13} - 1st max 1.5 to 3 GeV

sign Δm^2 - up to 5 GeV

δ_{CP} - down to ~ 0.5 GeV

Key Detection Issues

- For water Čerenkov : reduce 5-15 GeV tail
- Maximize Low E_ν flux (0.5 - 1.5 GeV)
- Maximize flux (1.5 - 5 GeV)

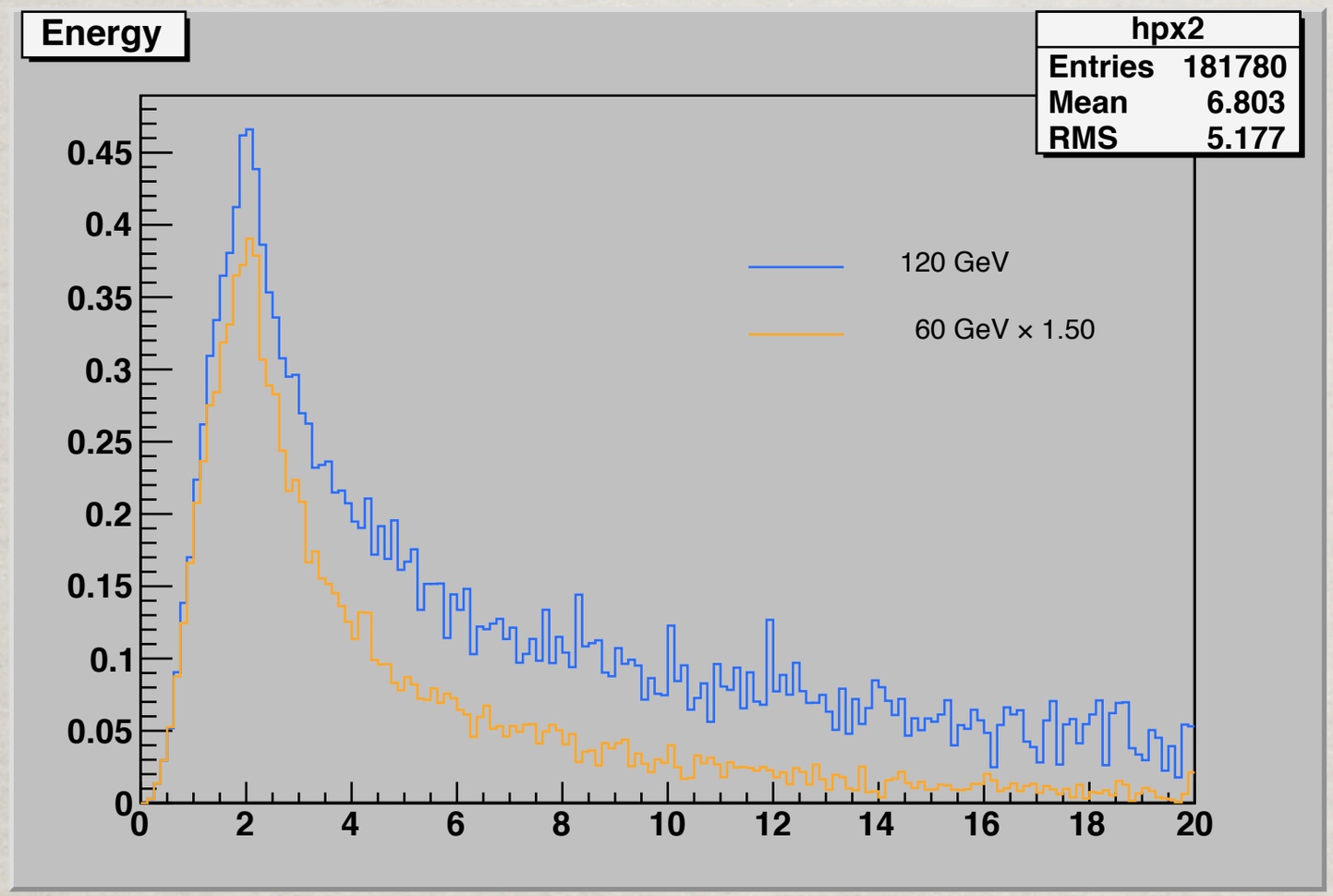
Key Design Issues

1. Beam Energy
2. On vs. Off - axis
3. Beam Plug
4. Length / Shape of Decay Region
5. 1st Pass Target / Horn Configuration
6. Size of Target Hall
7. AOKI

Key Design Issue 1: Beam Energy

- CD of beamline has range <60 to 120 GeV
- ∴ we need not decide now
- Lower beam E has some advantanges

60 GeV Primary



Comparison
60 GeV / 120 GeV

60 GeV scaled by 1.5
$\{T_{cycle}=0.4+0.00742E\}$
or 0.885s vs 1.33s

1- Lower hi-E tail:
1/3 @ 10 GeV

2- 85% no. int.

Useful beam Power

Primary E	E_ν 0-3.75	E_ν >3.75	"S/B"
60GeV	0.829	0.686	1.21
90GeV	0.923	1.26	0.73
120GeV	1.00	1.72	0.58

Number of ν events relative to $E_{primary}$ = 120 GeV

"useful"

"not so useful"

Key Design Issue 2: On or Off Axis?

- I hope there is a consensus that Off-axis is not very practical since:
  - The spectrum is too narrow to cover 1 *and* 2nd maxima without loss of factor >2 at one or other
  - The Decay region would need to be wide ~6+2m to cover 2° , i.e. both 1st and 2nd osc. max.
  - Can go slightly (0.5°) off-axis to reduce tail

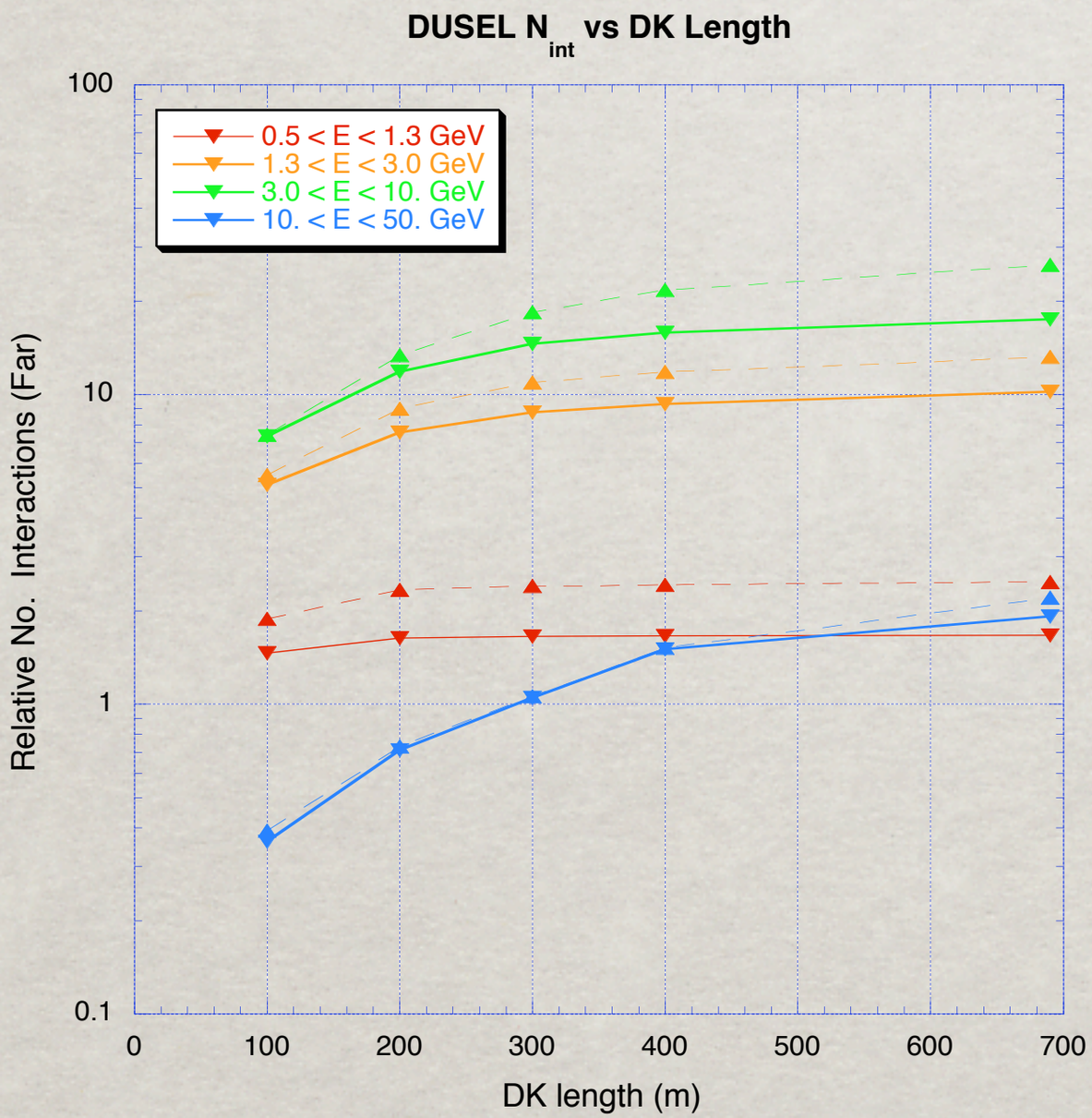
Key Design Issue 3: Beam Plug

- Mary can take on this issue
- I think the beam plug :
  - Is hard to implement
  - Wastes beam power ⇒ go to lower primary E

Key Issue 4: Decay Region

- The “nominal” radius is now 2m
- The length is 200±50m
  - 250m gives ~18% more interactions @ 1st max.
  - 2m necessary: ~40% more at 2nd max w.r.t. 1m
- Hi-E tail ~linear with decay length

Decay Length / Width

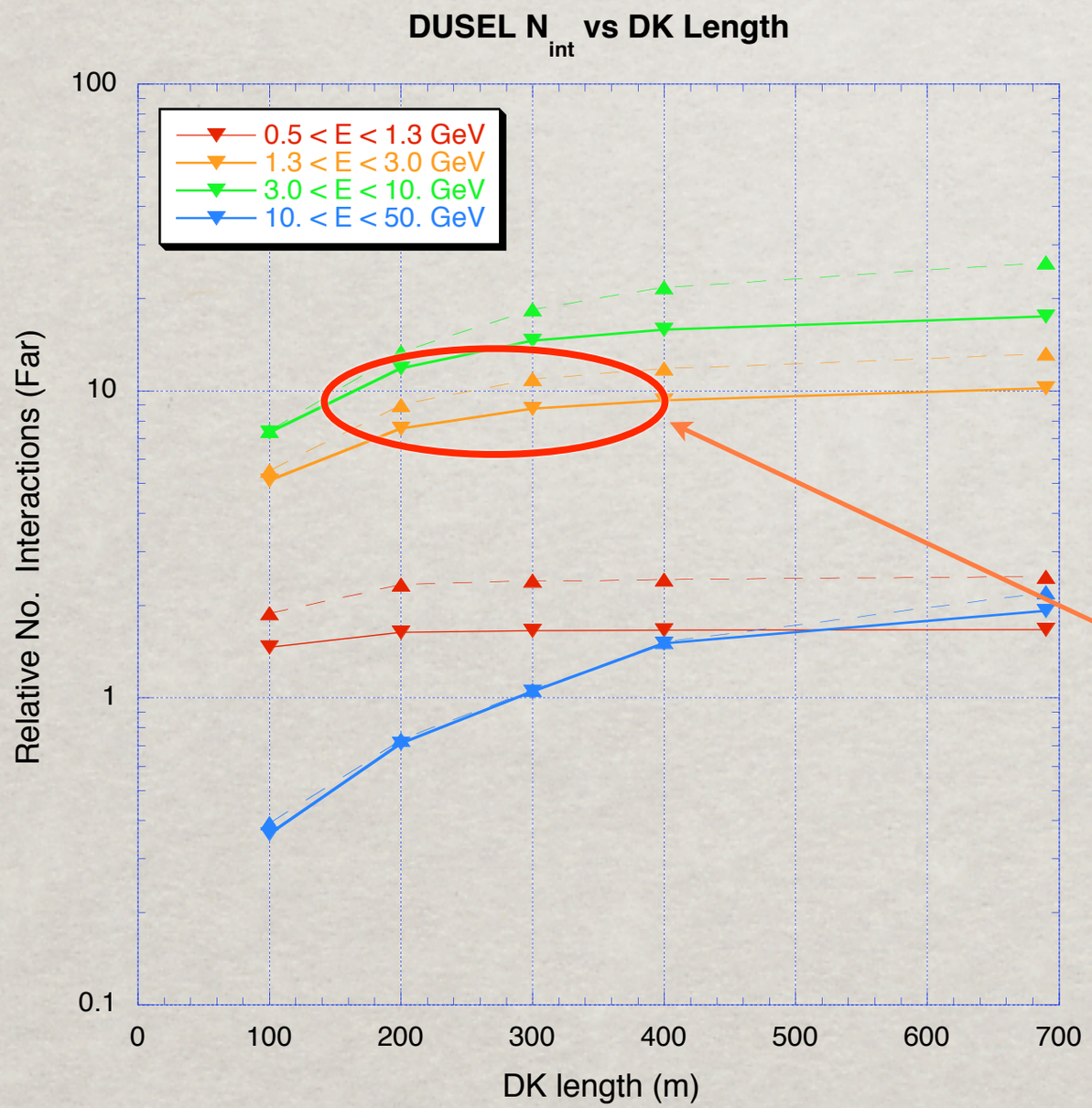


4 E_ν regimes

Solid → 1m radius

Dash → 2m radius

Decay Length / Width



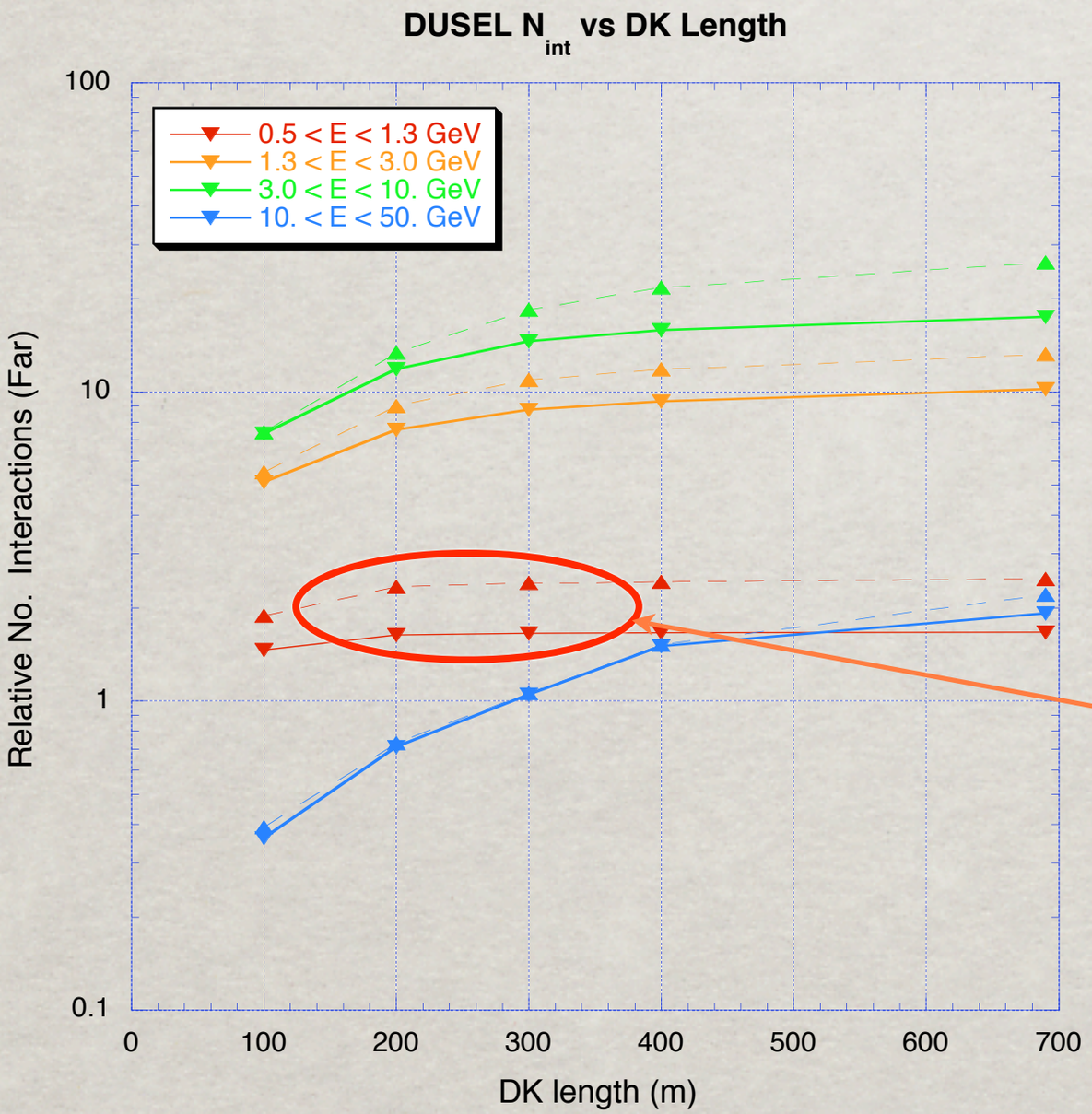
4 E_ν regimes

Solid → 1m radius

Dash → 2m radius

18% gain 200 to 250m*

Decay Length / Width



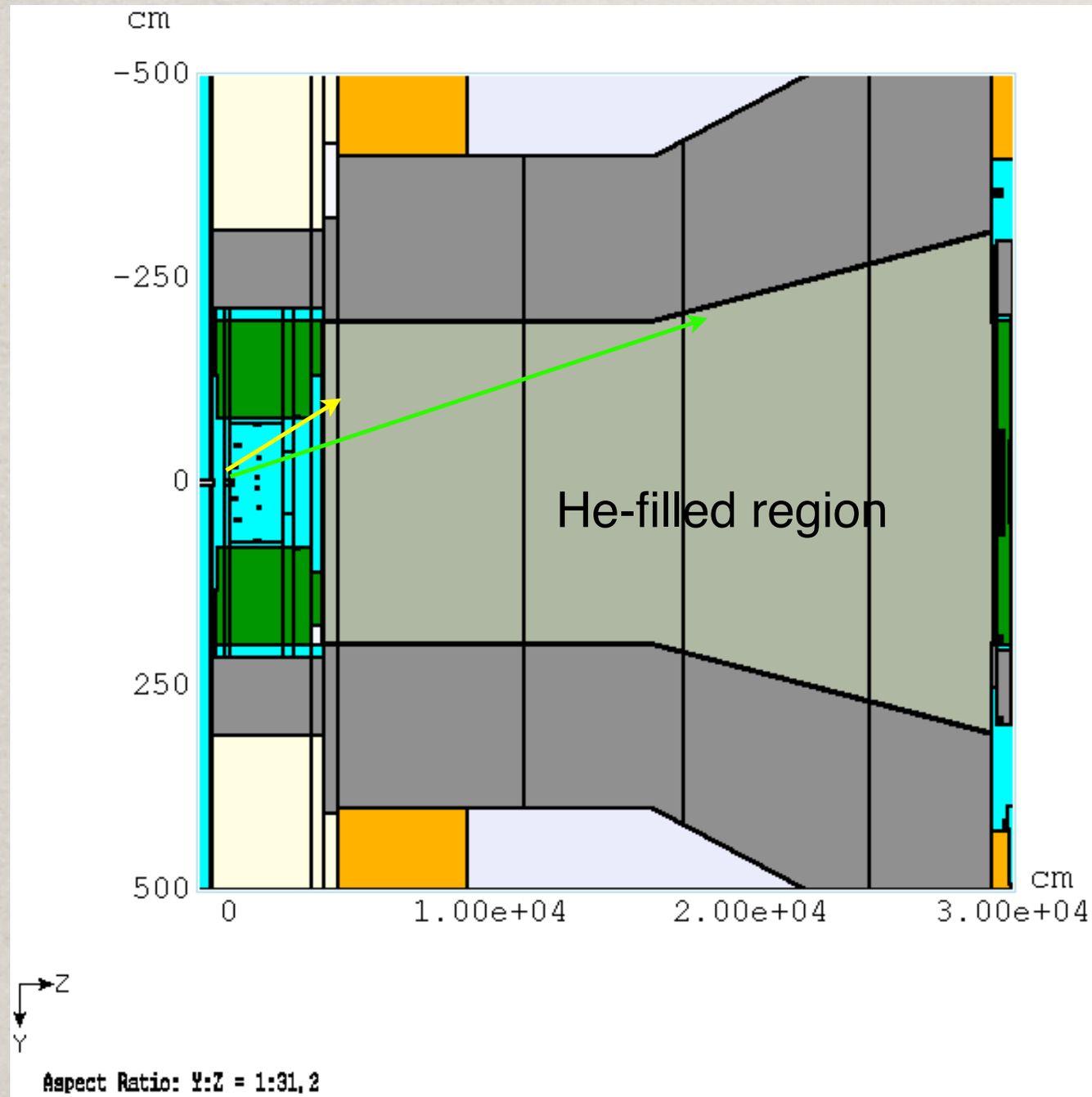
4 E_ν regimes

Solid → 1m radius

Dash → 2m radius

40% gain 1m to 2m

Decay Region: Alternate Design



Keep line-of-sight paths occluded or at grazing incidence:

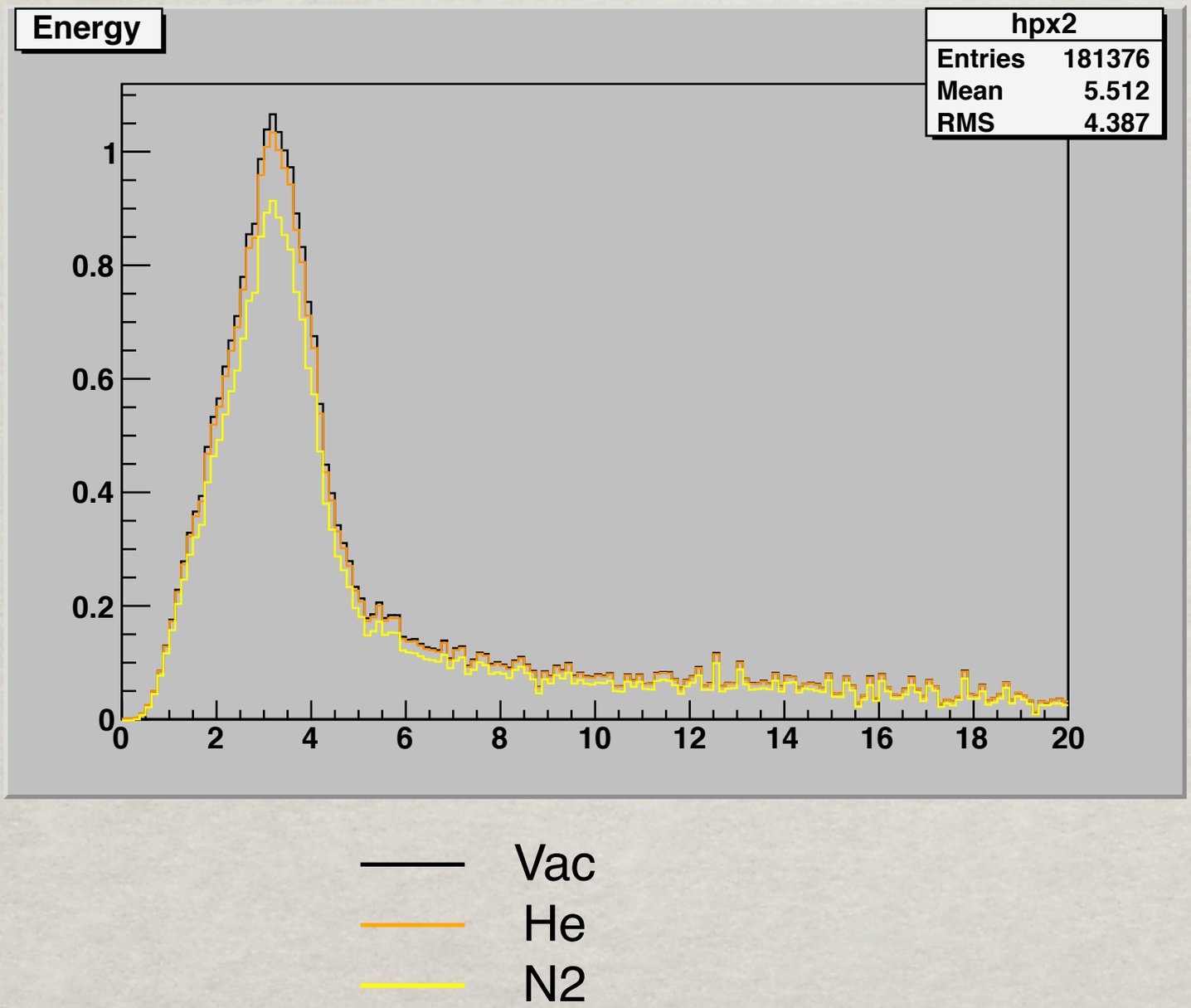
⇒ Reduce heat load

⇒ Reduce ^{3}H production

This example :
reduction ~2.4

~20% more volume

Decay Region: Fill it with something



Compare filling DK volume with He or N_2 with vacuum

➢Nitrogen (~STP)

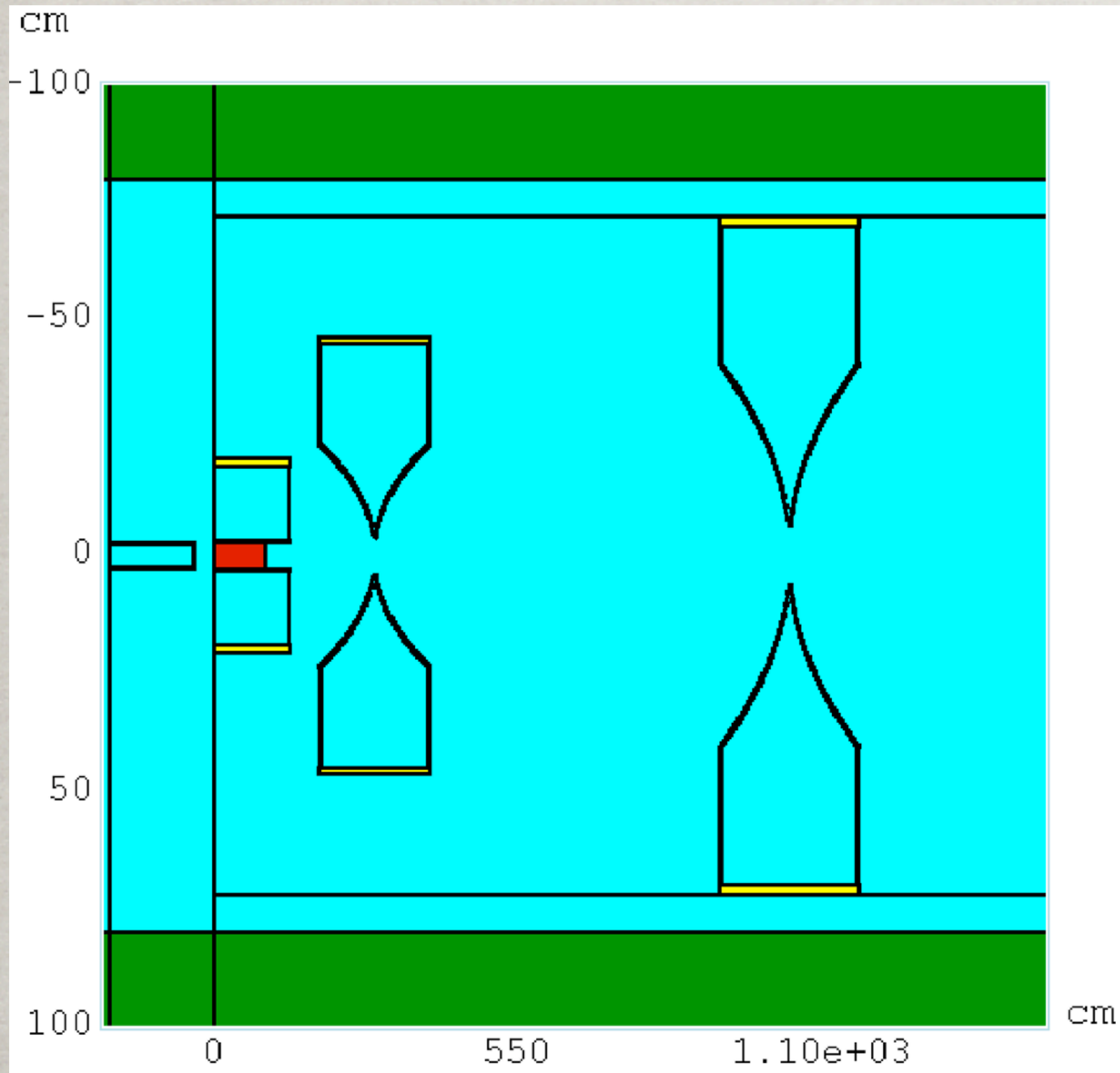
- 13% more heat in DK walls

- 15% loss in ν events (3% loss with He)

Key Design Issues 5: Target / Horns

- My present "Baseline" is variation of T2K
- Three horn system
  - Two horn config. a compromise
- Horn 1 modified w/ integrated target
- Can provide ν spectra

Target / Horns

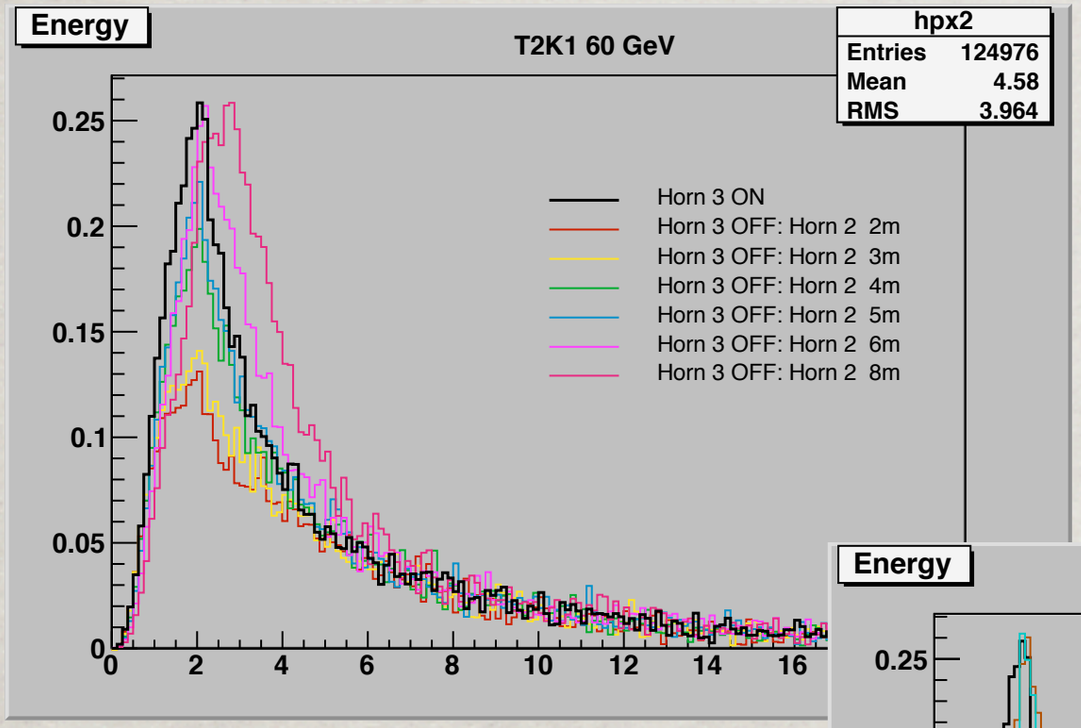


Modified T2K Horns

Carbon target integrated with Horn 1 (can)

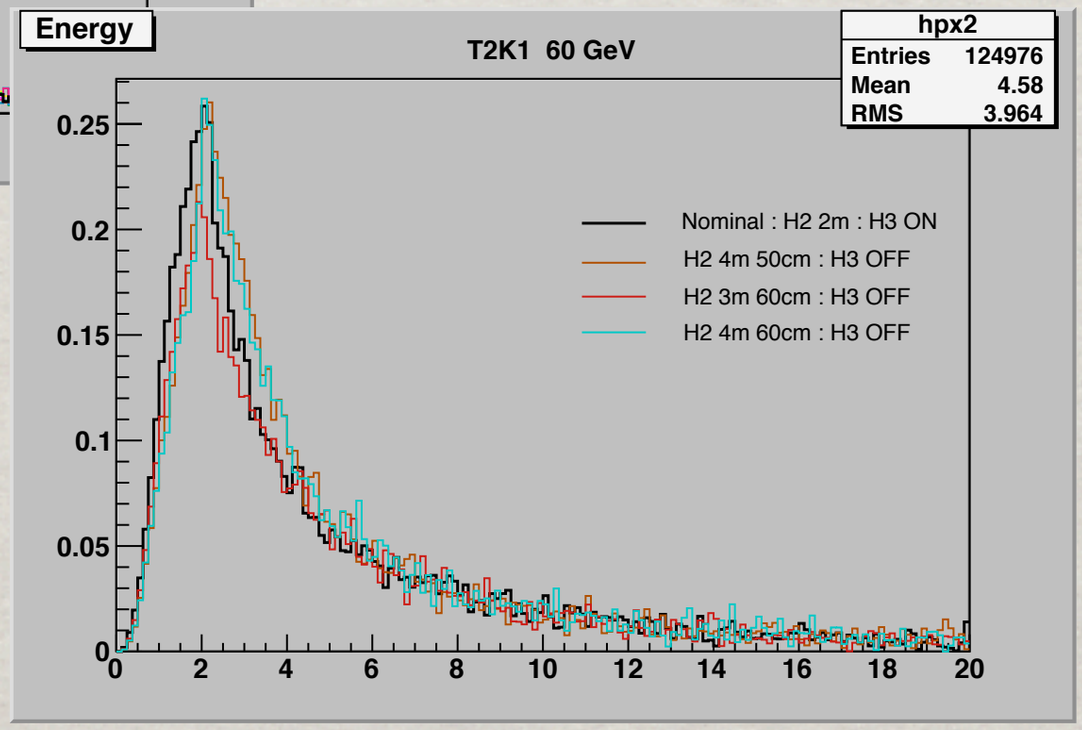
Two horn config. w/o H3 and H2 pulled 2-3m dnstr. ~NuMI LE

Target / Horns



Studies aimed at low-E part of spectrum

Here tune H2 with H3 off



Key Design Issue 6: Target Hall

- A low-E beam can be compact (~10m) so length determined by other factors
- Space for hot horn handling / replacement
- This issue needs more thought for CD-1

Summary

1. Need to converge on one or two Target / Horn configurations (not exact shapes)
2. Beam plug?
3. Decay region: give a length
4. Target Hall needs others for input

Schedule

- Converge on items 1, 2 and 3 by next mtg.
- Continue tweaking horns "
- Try to get a Target Hall geometry "