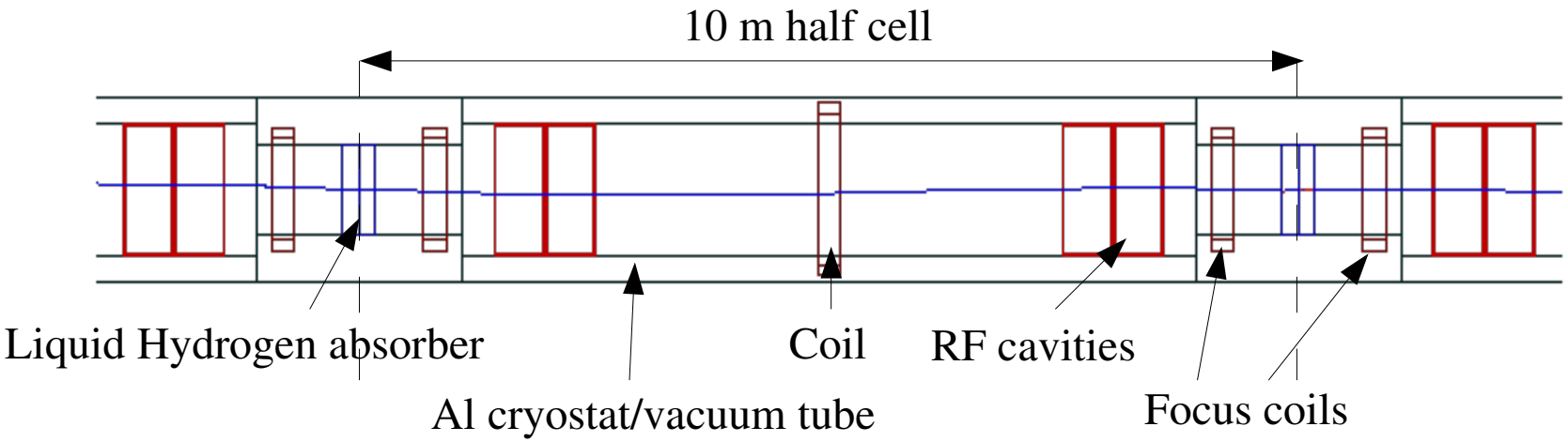
A Lower B-Field Lattice

Chris Rogers,
ASTeC,
Rutherford Appleton Laboratory

Low B-Field Lattice

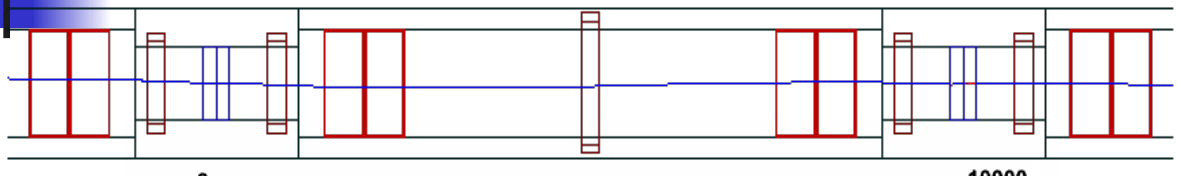
- Have seen ISS cooling performance when peak field is limited
  - Peak RF cavity field limited by high B-fields
- Can we design a lattice to take some of the field off the RF cavities?
  - How does such a lattice perform with “realistic” beam?
- What happens as a function of RF voltage/B-field?
  - Position of cavities
  - RF phase
  - Absorber thickness

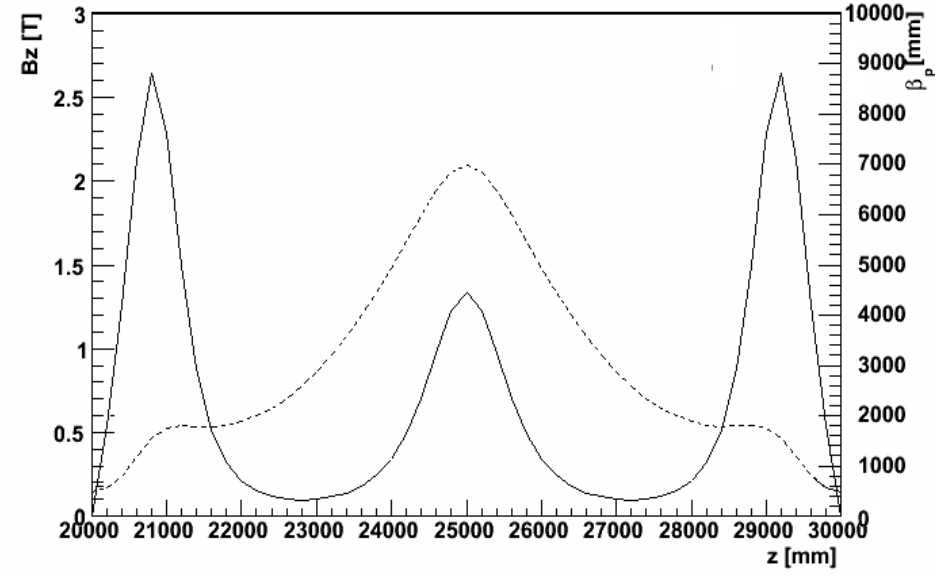
Reminder - geometry



- Much more space to move around
  - RF cavities can be taken away from magnetic fields
    - Limiting apertures
    - Focus is on LH2 => scrape more as they move towards cell middle
  - Big vacuum vessels/coils
    - 50 cm radius coils and 75 cm radius coils
  - No windows yet (RF or absorber)
  - 35 cm cylindrical liquid Hydrogen absorbers

Field

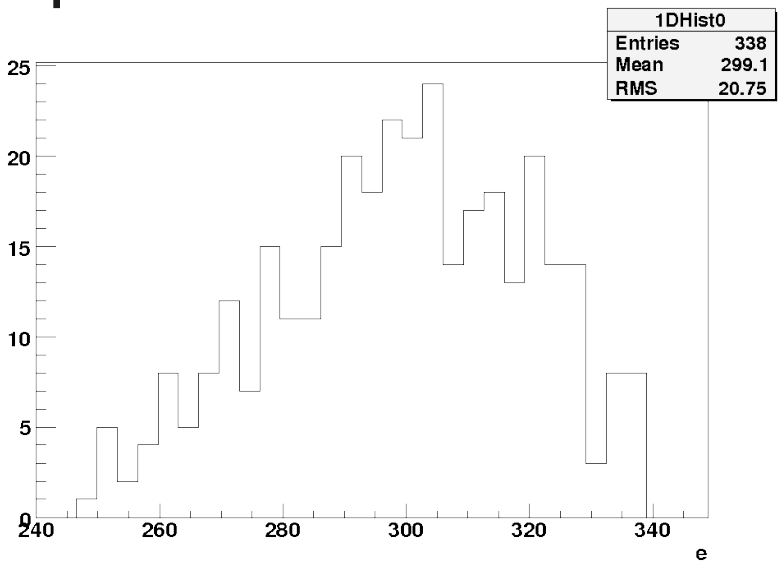




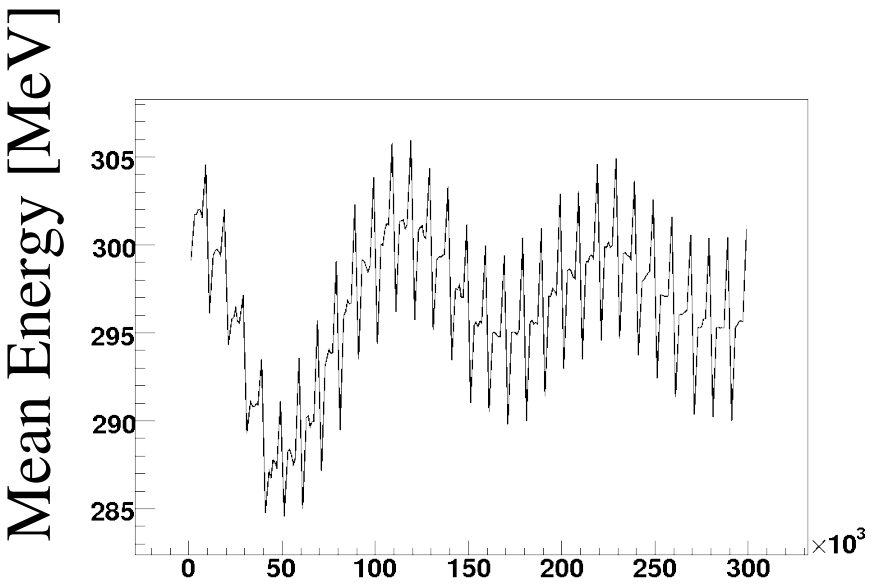
z [cm]	On-axis Bz [T]
11.5	1.69
13	1.15
14.5	0.77
16	0.51
19	0.26
22	0.15

- B-field on cavity is less than FS2A field
  - Still non-negligible
  - Baseline -> outside (highest field) edge of RF cavity at 14.5 cm
  - Two cavities are 1 m long
    - Try to keep them in the lower B-field region...

Beam Energy



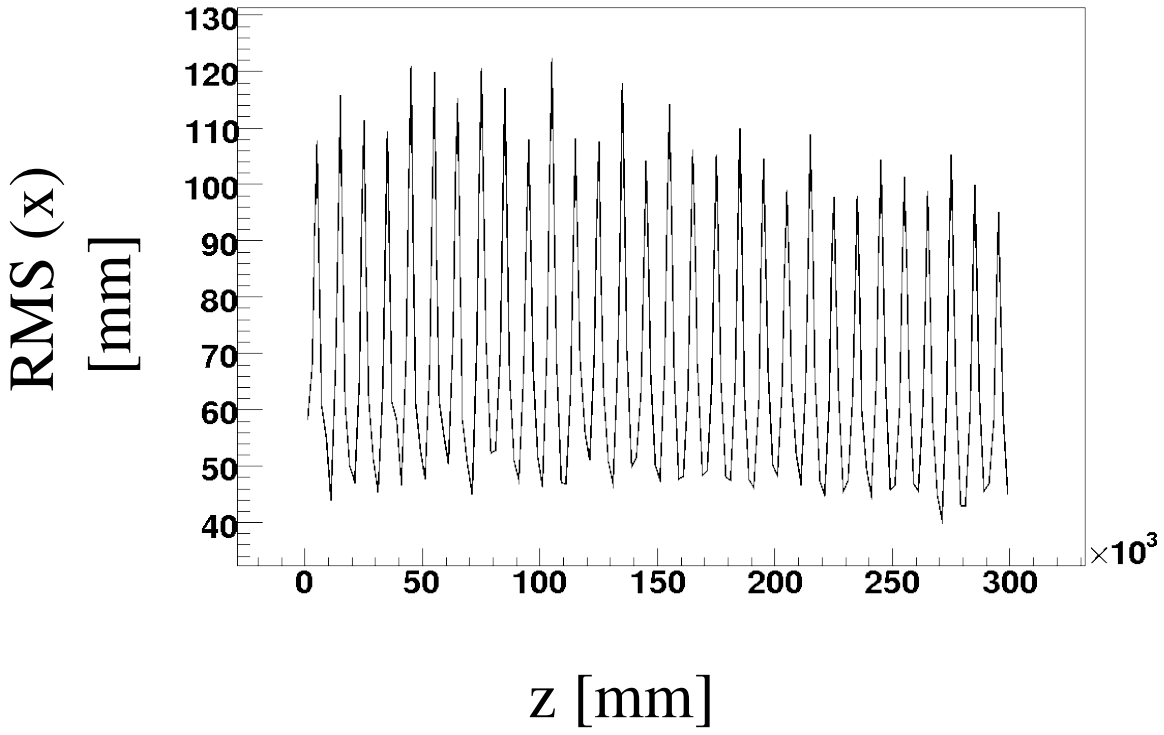
Input Energy [MeV]



z [mm]

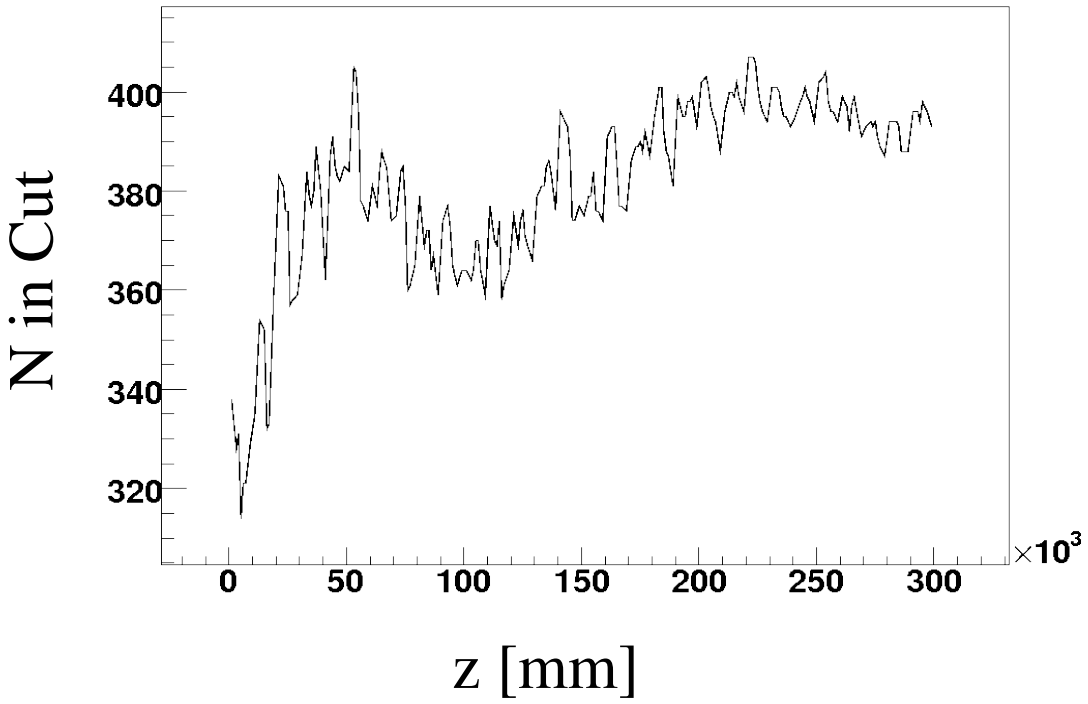
- For input beam I take the Study 2A beam but with higher energy
  - Increase energy of all muons by ~ 50 MeV
  - Note I overdid this a bit
    - Reference energy is 293 MeV
    - Need to fix that

Beam Matching



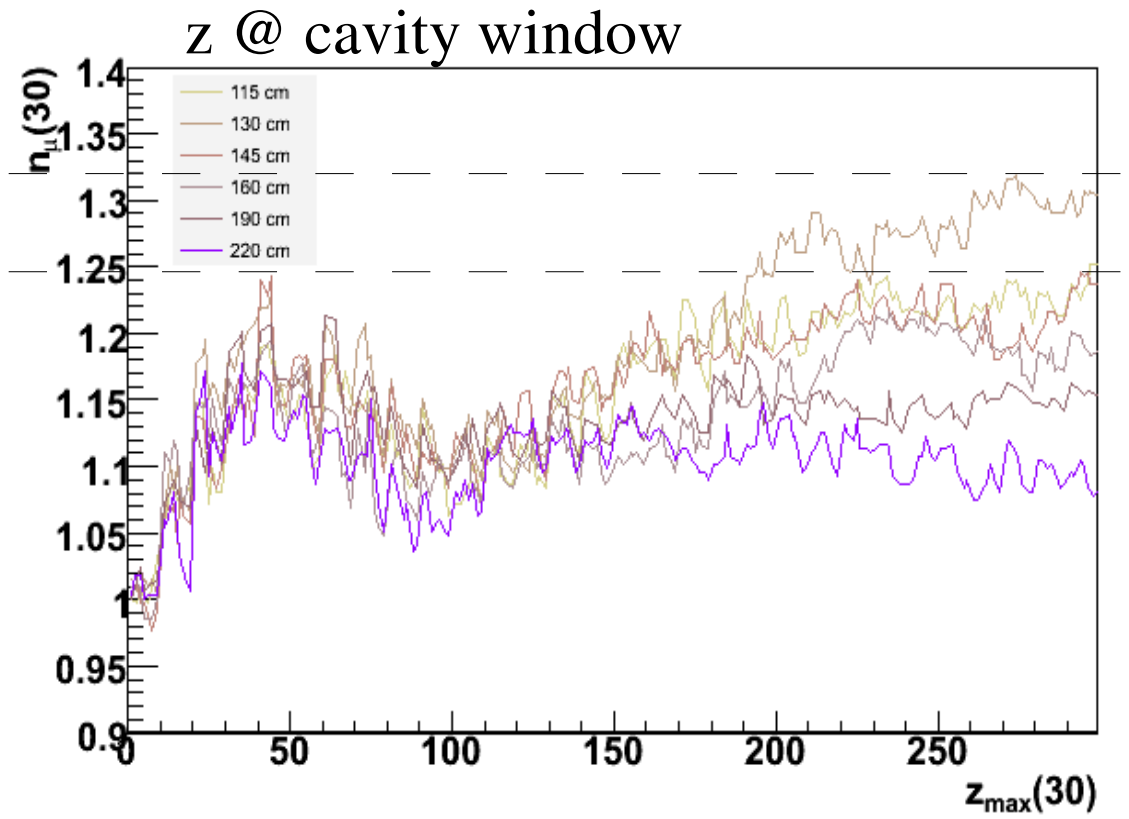
- Assume ideal matching
  - Make a linear transformation from FS2A beam
    - Force it to be emittance conserving
- Limiting aperture is RF cavity window
  - Can I make it bigger?

Cooling



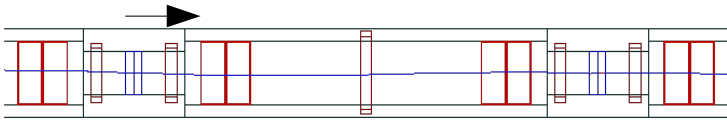
- Plot number of muons inside cut
  - 273 < p < 323 MeV/c
  - Amplitude < 30 mm
- Get increase ~ 25 %
  - Not so great – compare to FS2A performance of 70%
  - Let's see if we can do better...

Position of RF cavities



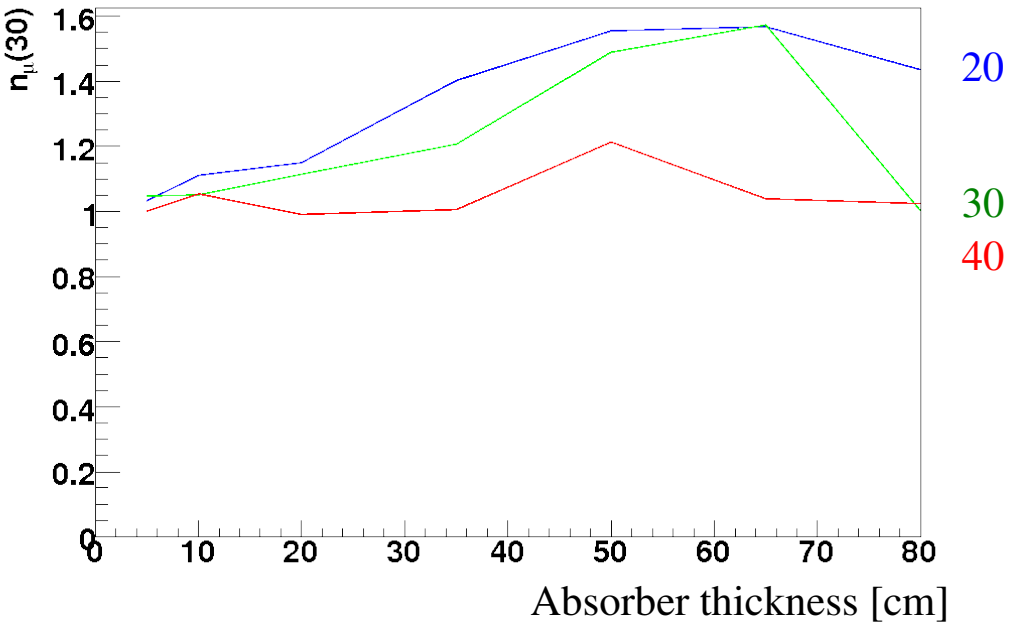
130 cm

115/145 cm



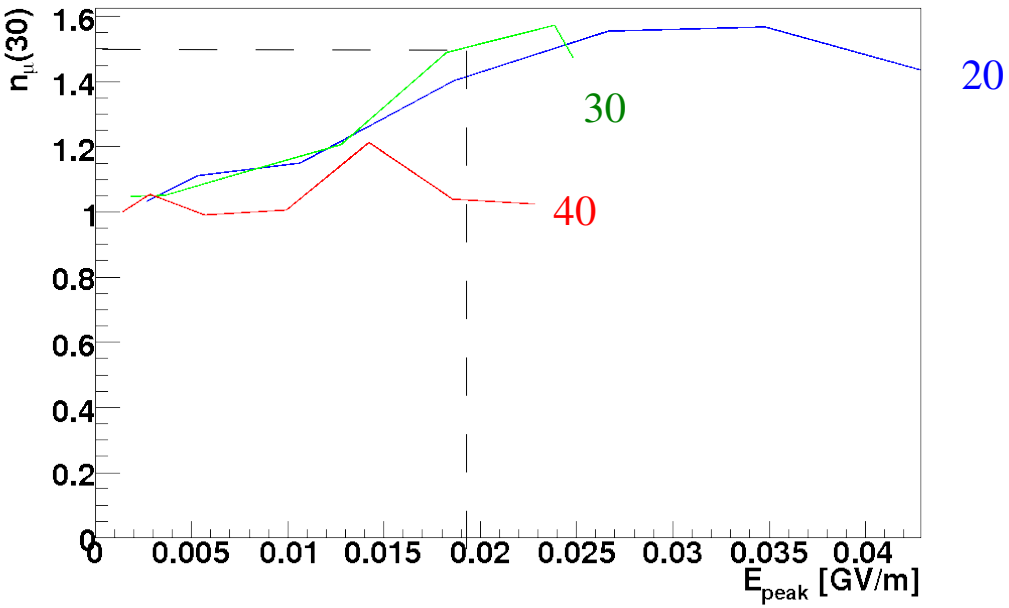
- As I move RF cavities towards focus, reduce scraping
  - Improves transmission a bit
  - But pushes cavities into higher fields
- Might be desirable to make RF windows bigger (copper?)

Absorber thickness



- As I increase absorber thickness cooling performance improves
  - I tried a few different phases

Peak voltage



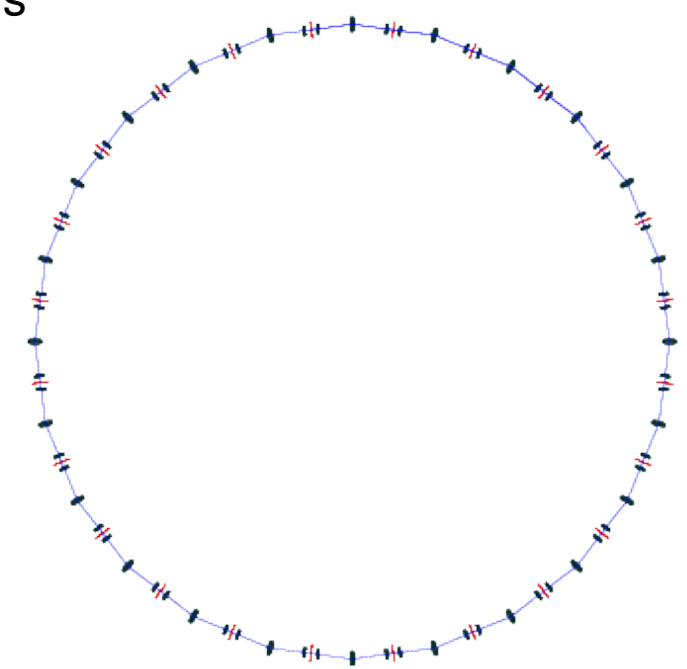
- Same plot but plotting peak voltage
  - 30 degrees comes out on top
  - Factor 50% increase in number of muons @ 19 MV/m
- Compare with FS2A
  - Factor ~ 50% increase in number of muons @ 7 MV/m
  - (Approximate limit from B-field?)
- Not clear whether there is a real gain from this lattice!

Dynamic Aperture

- It turns out the limit comes from dynamic aperture
- Seek to improve this by bringing magnets closer together
  - I have a bit of space after the RF cavities
- Increase beta function at the absorber
  - Feel that more even beta function should improve things
- Other ideas
  - Try flipping central coil to reduce Bz on cavities
  - Move to a two-coil lattice like FS2A
- Previous optimisations focussed on making beta function even with energy
  - Perhaps this is not the right thing to optimise on

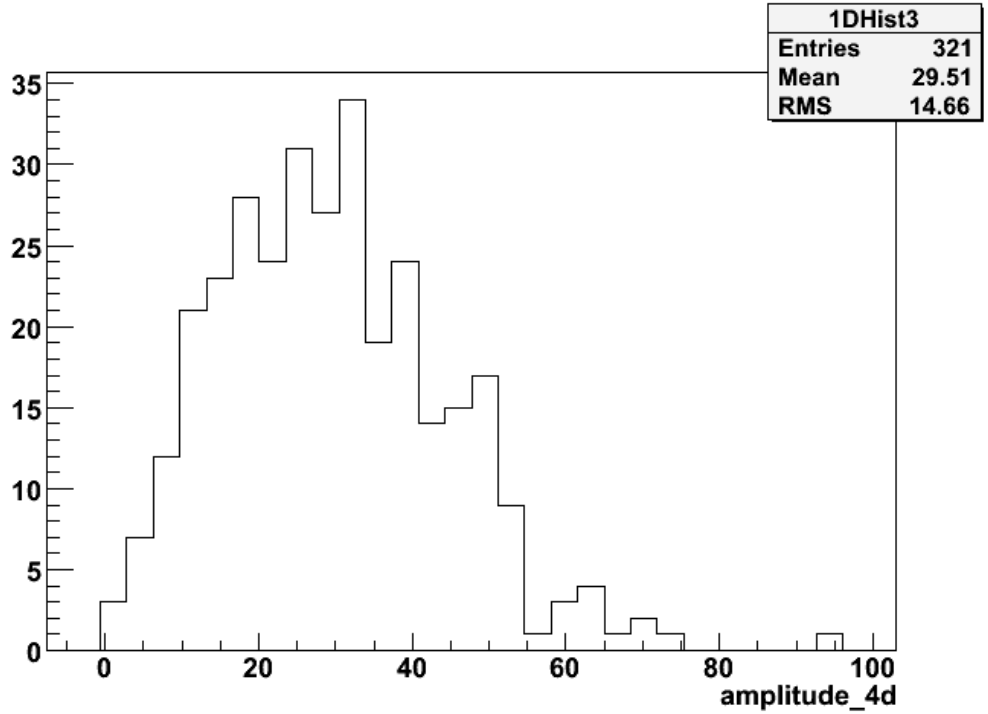
Cooling Ring

- Ring may be plausible as an extension of baseline cooling channel
  - Get transverse emittance down “somehow”
  - Then inject into cooling ring
  - Reduces acceptance requirement on accelerator systems
- Working on this until EPAC
  - Then got carried away by other things
  - Got transverse cooling but not 6D
  - But still feasible...
- Upgrade path to Muon Collider?



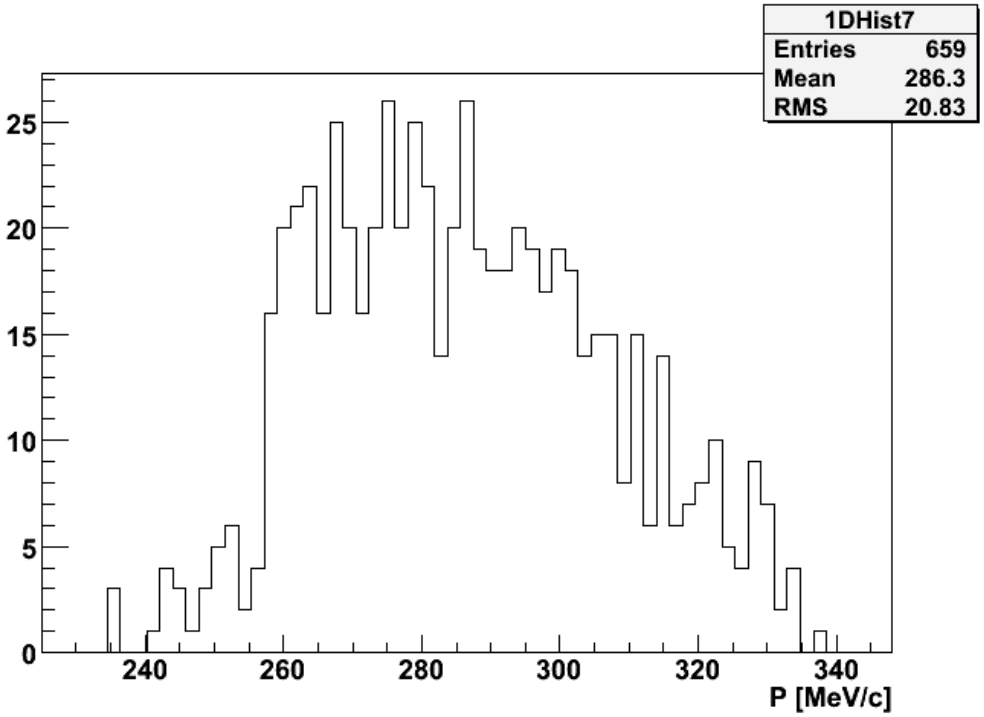
Transverse Acceptance

- Transverse acceptance
  - Initial amplitude distribution of the particles that survive 3 turns
  - Monochromatic beam with cooling hardware



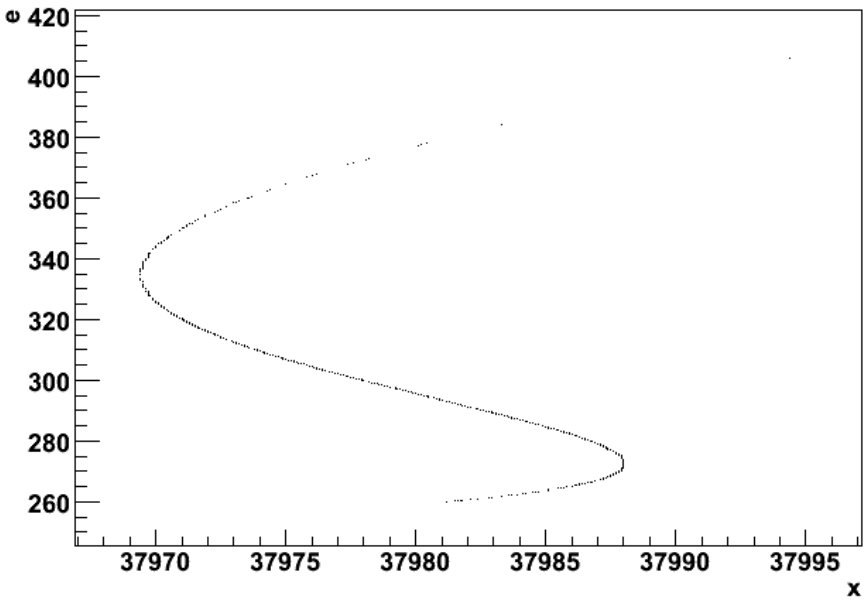
Momentum Acceptance

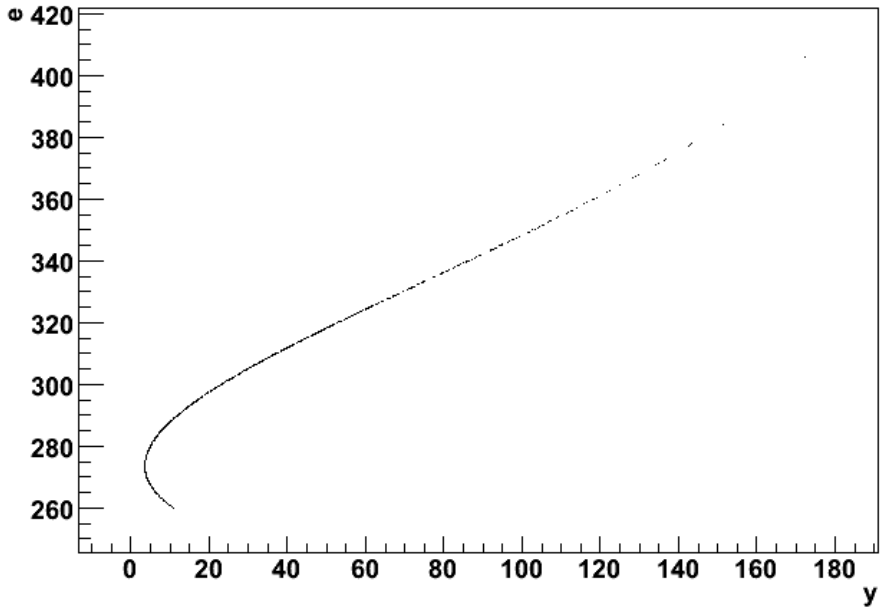
- Momentum acceptance
  - Polychromatic beam with 0 transverse emittance after 1 complete turn
  - No cooling hardware



“Dispersion”

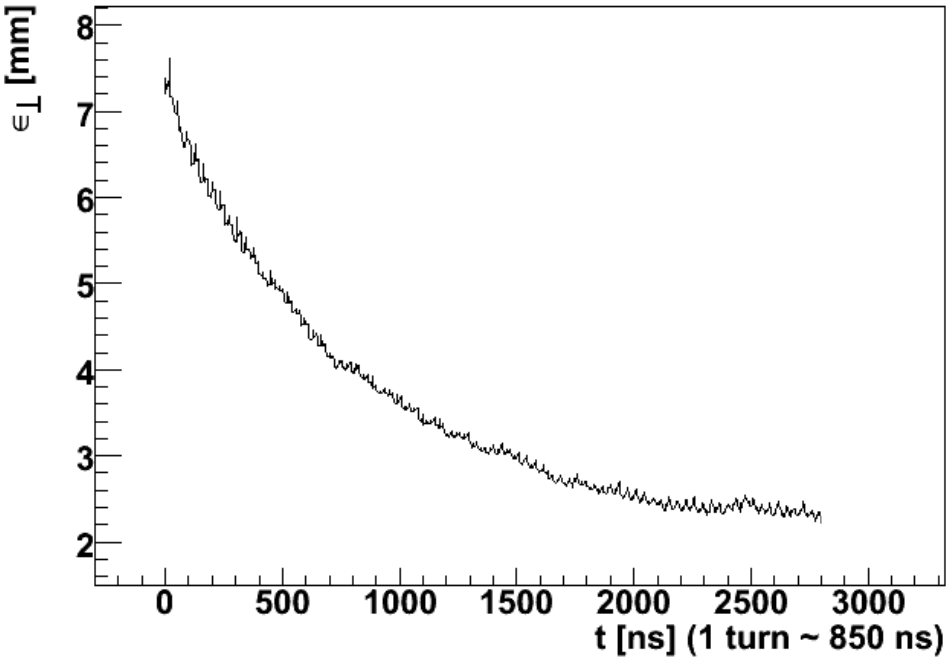
- Not true dispersion
  - This is the x/y position of a polychromatic beam initially on-axis after 1 cell





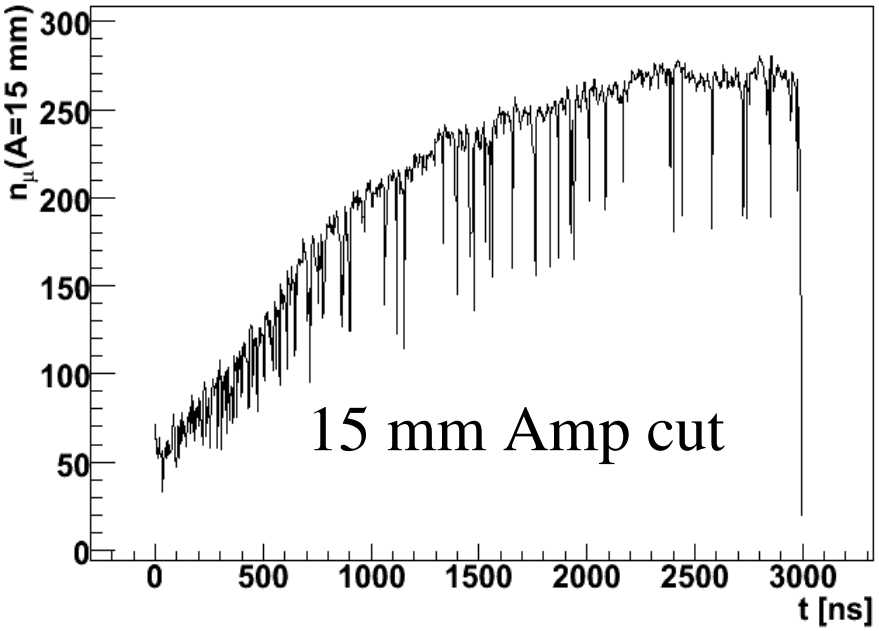
Transverse Cooling

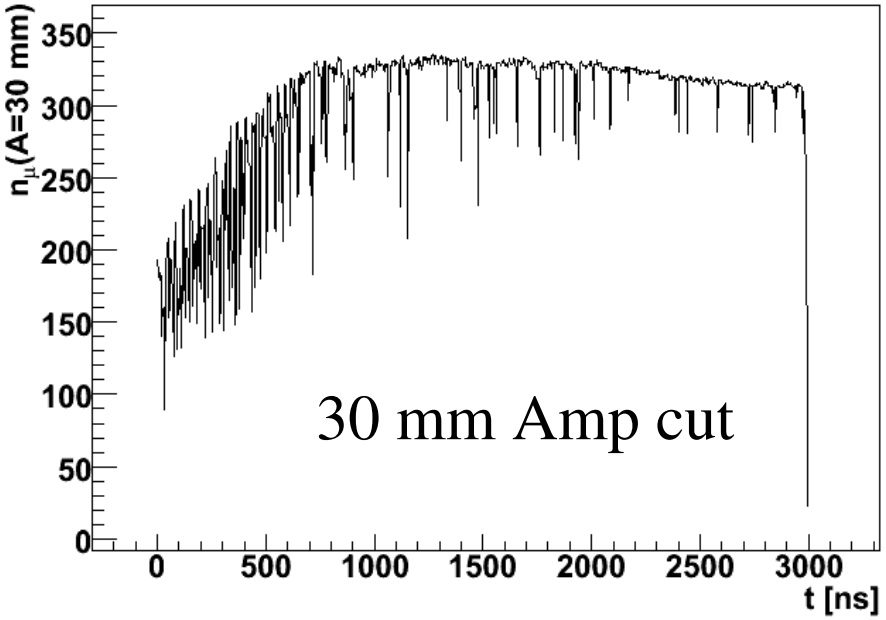
- Transverse emittance
  - Initially monochromatic beam
  - Electrostatic cavities



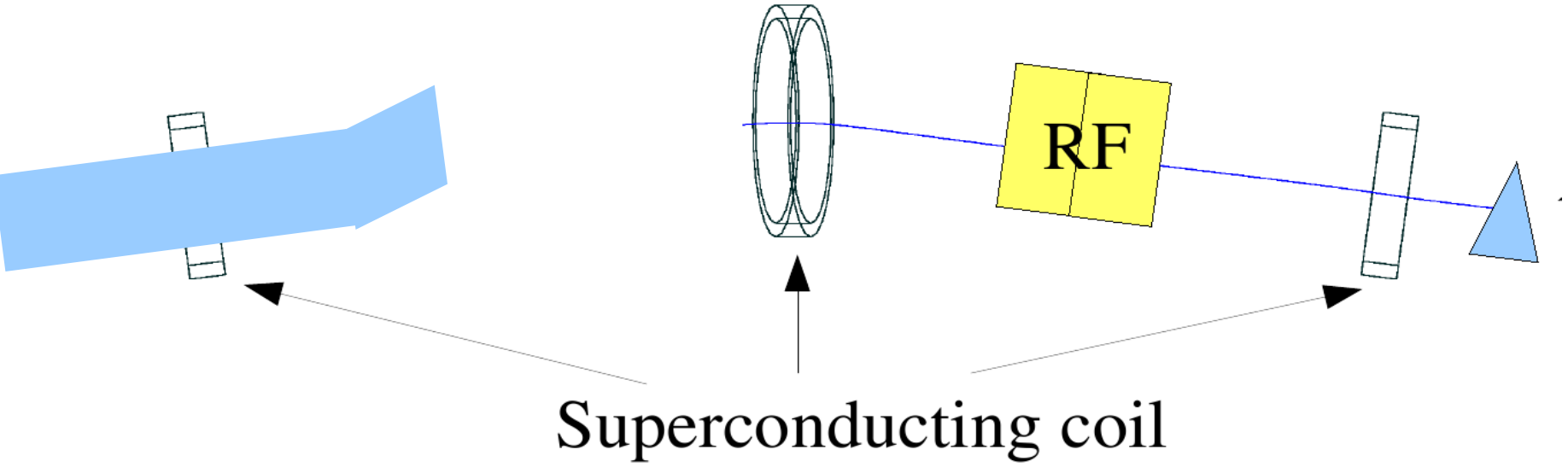
Transverse Cooling

- Transverse emittance
  - Initially monochromatic beam
  - Electrostatic cavities





Injection/Extraction



- Injection + Extraction
  - Room inside focus coils for injection kicker
    - Beam has ~ 25 cm radius at absorber
    - Coil has ~ 50 cm radius
  - Would fixed field from the focus coil be okay on the kicker?
  - 4 m gap to make about 50 cm transverse kick into septum => 0.1-0.2 T
  - 500-600 ns rise time
- Would need to negotiate solenoid fringe field...