Muon Front End in the IDS-NF

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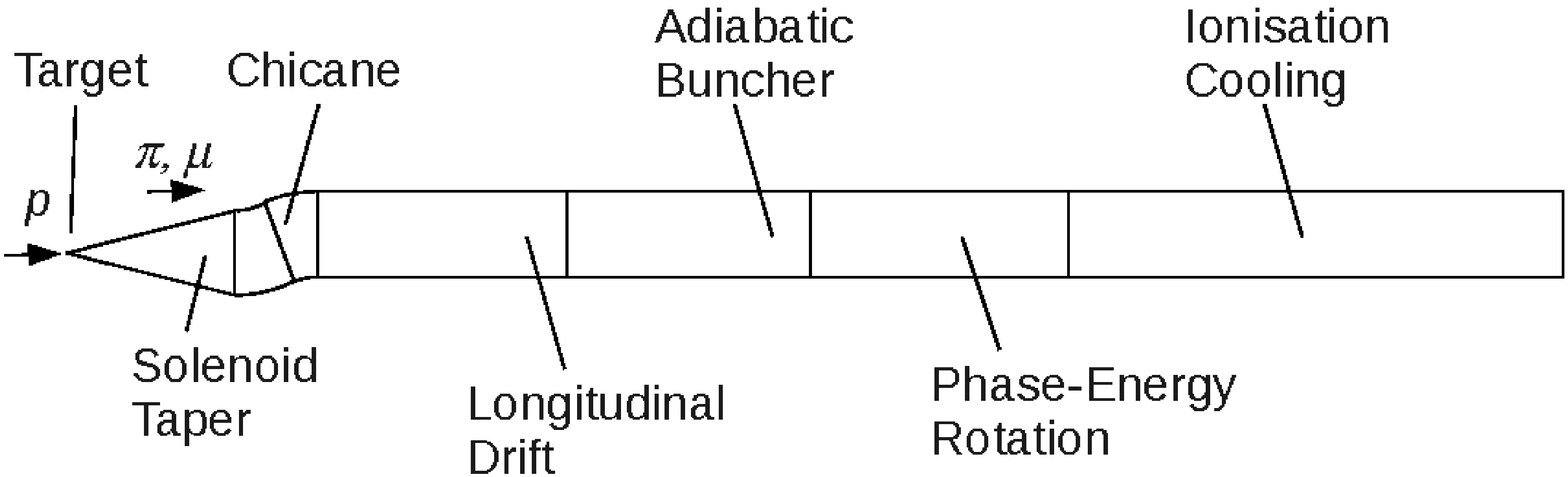
RAL

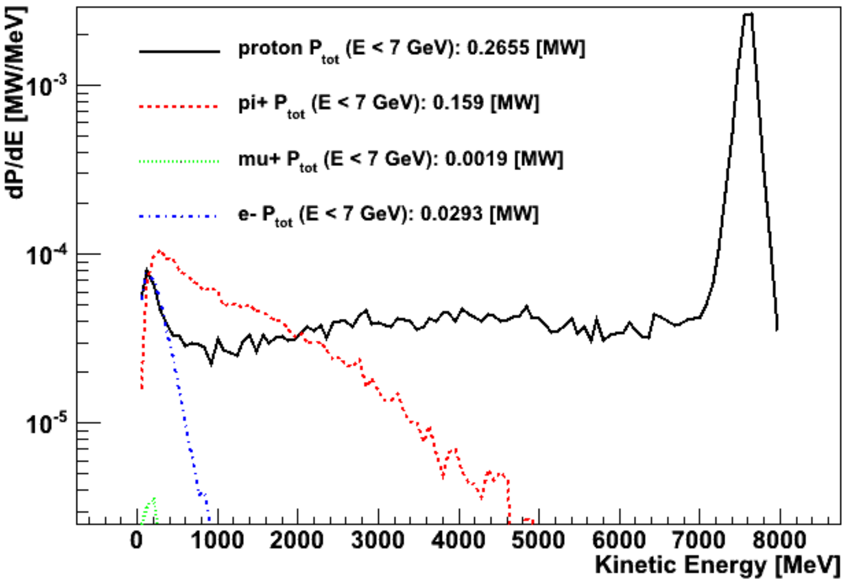
Aims of the IDS-NF

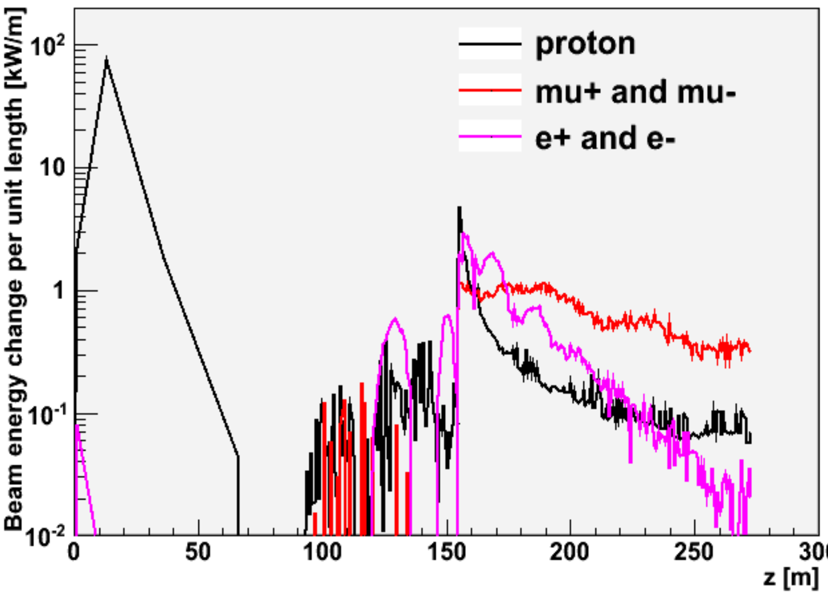
- IDS-NF design study commenced 6 years ago
  - Aim was to move from feasibility studies to conceptual design report
  - In Front End group we had a robust, well-optimised design from ISS
  - Focus has been on mitigating associated risks
    - Also bring in some engineering issues
- Risks
  - Radiation issues
  - Magnet packing issues
- Mitigations
  - Chicane and proton absorber
  - Bucked coil and shielded lattices
- Engineering
  - "First pass" engineering has been completed
  - Alignment study for RDR
- Luminosity staging

The RDR front end



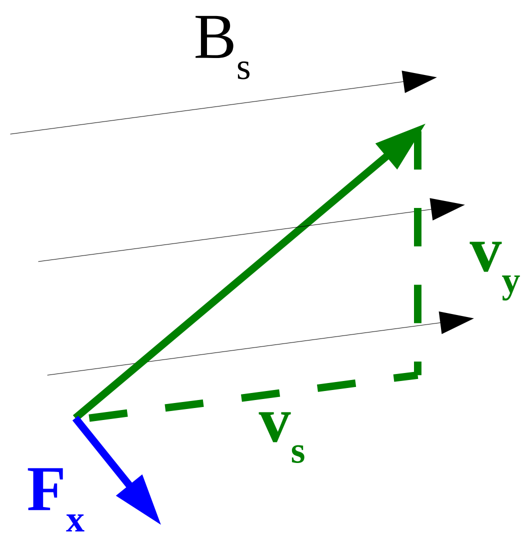
Risks - radiation

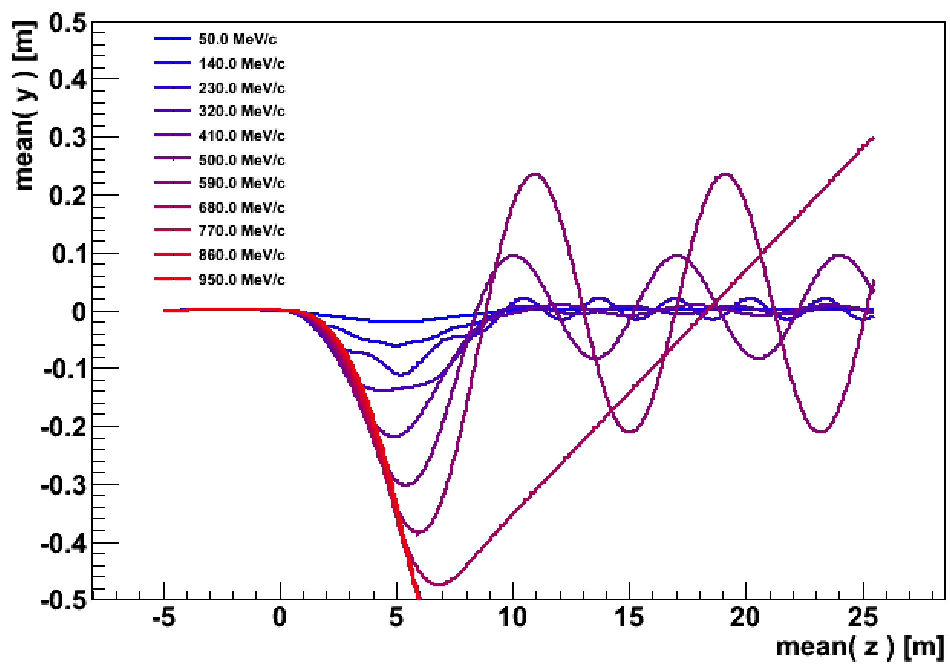




- Identified uncontrolled losses as a feasibility issue
  - Significant radiation across entire front end
  - Cooling channel especially problematic
  - Expected downstream equipment to also suffer significant radiation
- Combat using chicane and proton absorber system

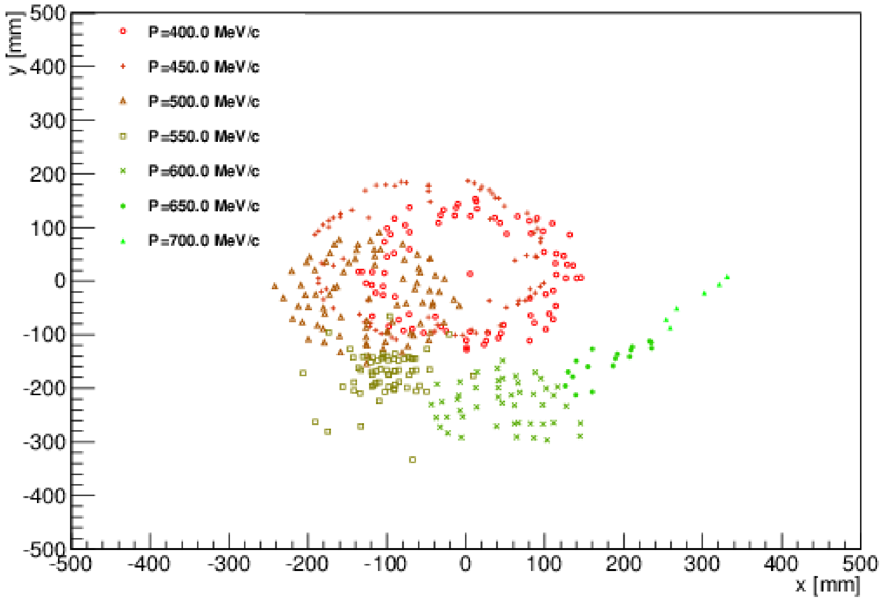
Chicane (1)

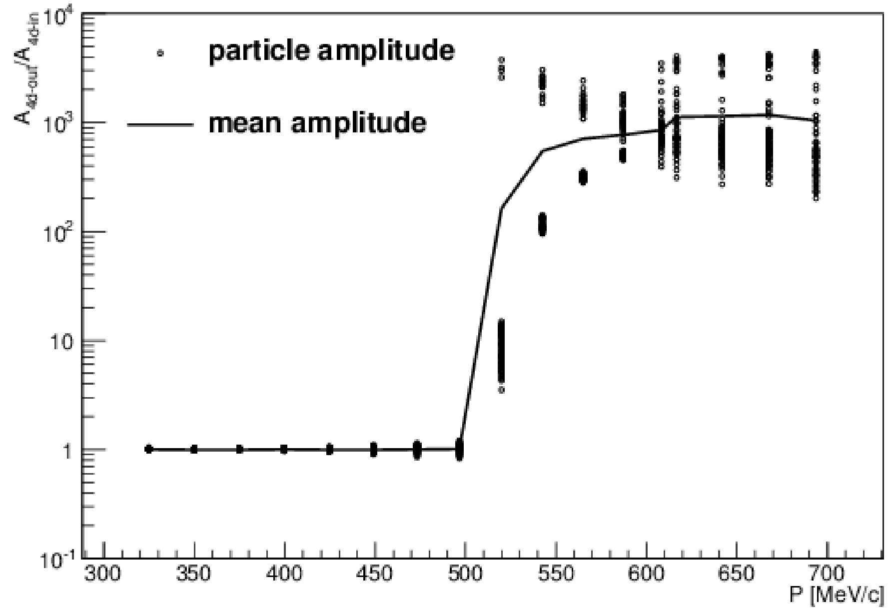




- Colleagues in the mu2e business use a solenoidal chicane to reject backgrounds
  - Borrowed in turn from stellarator concept
- In a bent solenoid particles take a vertical velocity
  - Provides a horizontal force to bend particles
  - Higher **p** particles need more velocity => larger dispersion
  - At some threshold **p**, particles are not contained

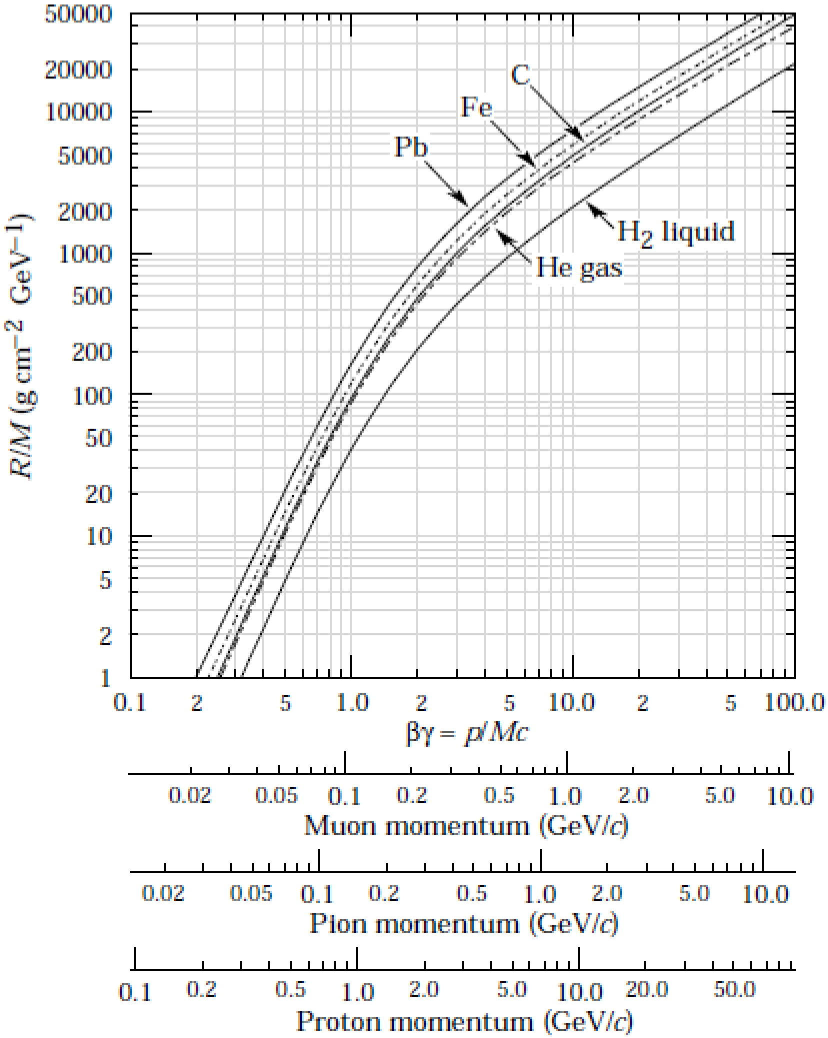
Chicane (2)

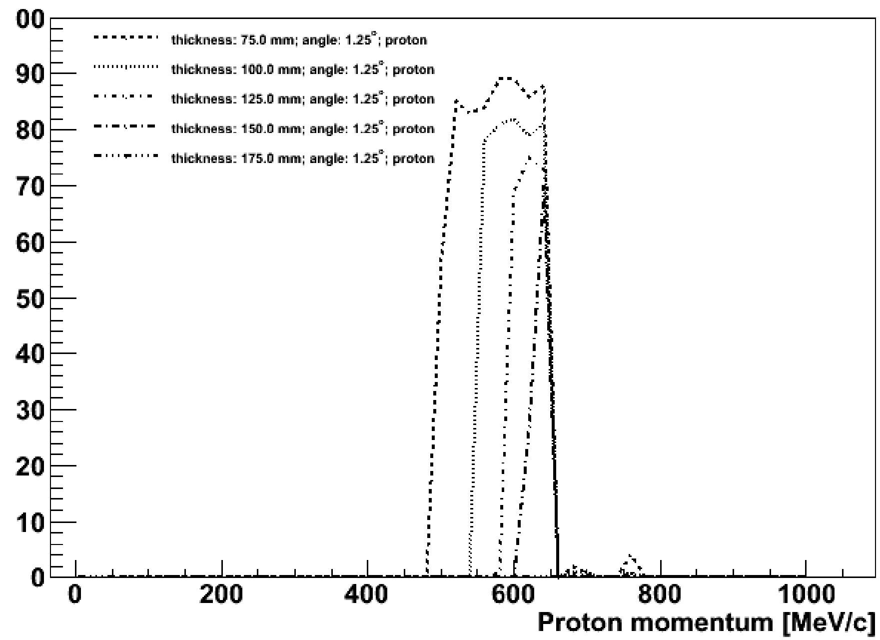




- Can transport a beam with large transverse size
  - Shell of particles with 50 mm transverse amplitude
  - Get a very nice, sharp momentum cut-off
  - Very little emittance growth in “good beam” region p < 500 MeV/c

Proton absorber

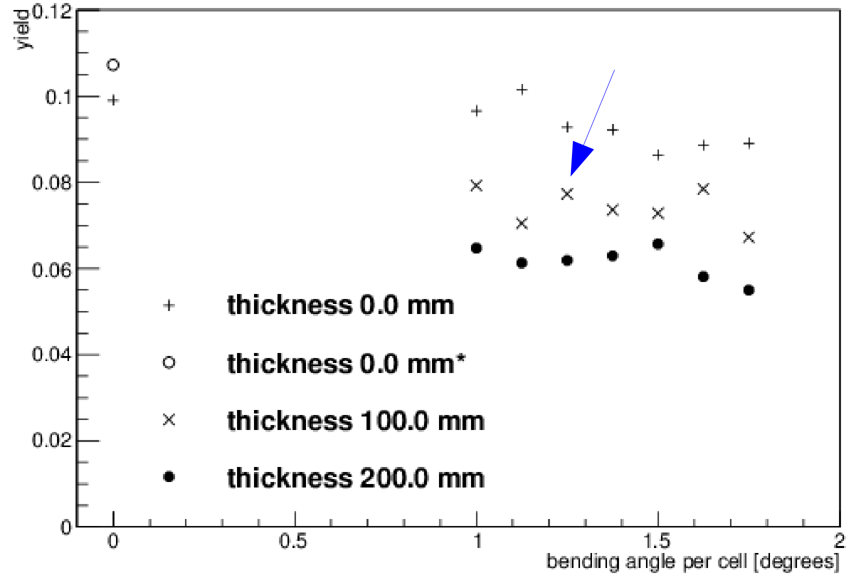


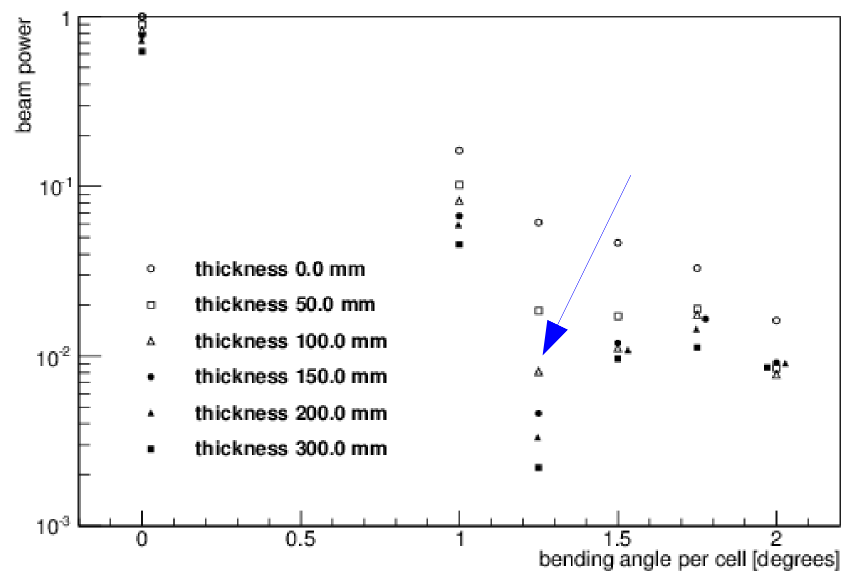


- Introduce a Be plug
  - Aim to range out the (< 500 MeV/c) protons
  - Must come after the chicane

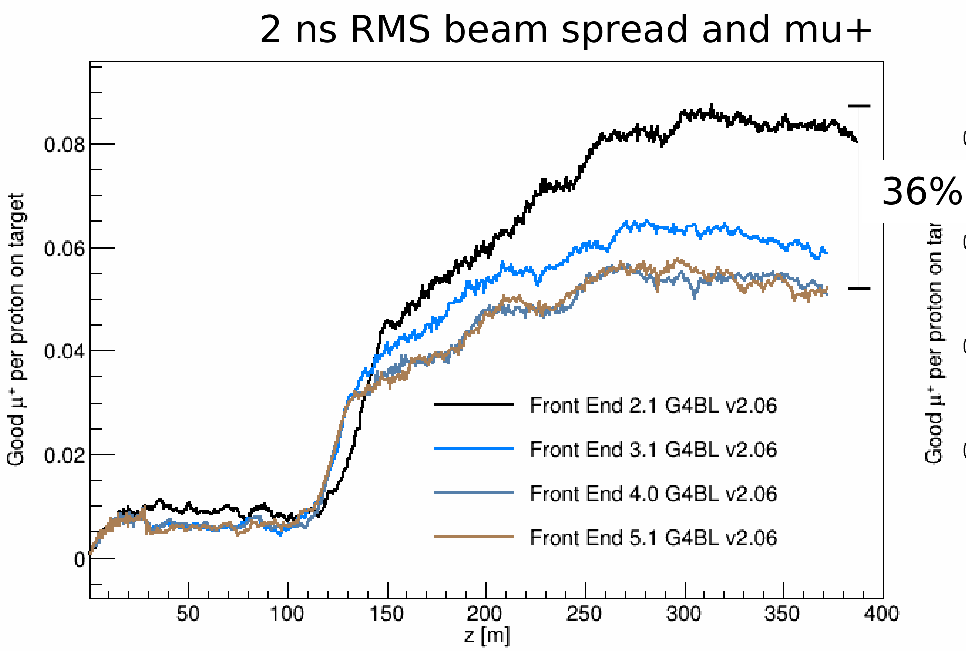
Chicane + proton absorber performance

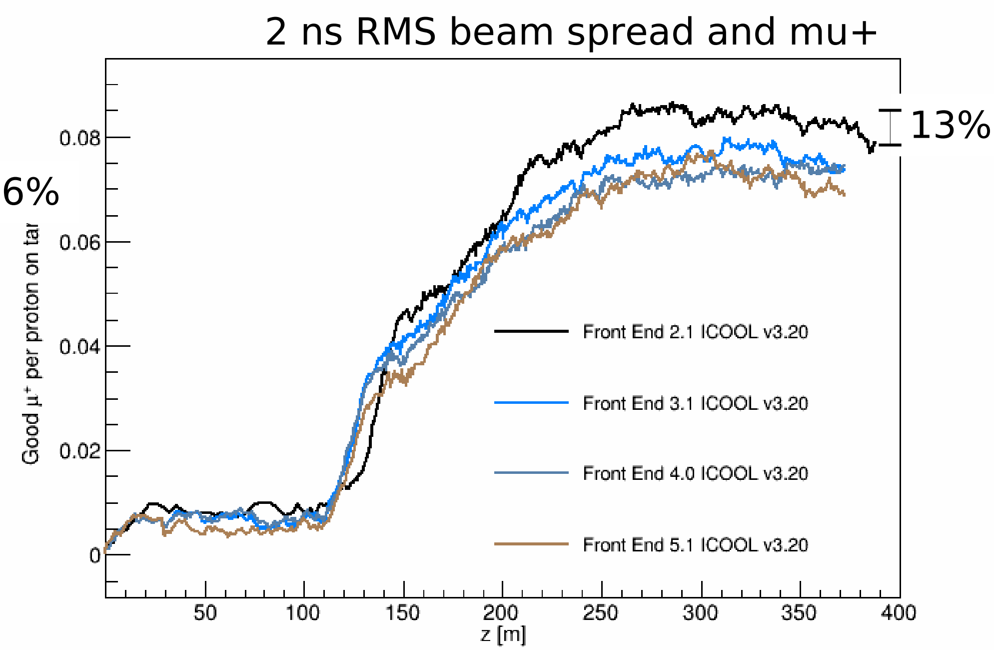
- System performance (g4bl)
  - Lose about 23% of good muons
- Proton leakage (g4bl)
  - Still see 0.8×10^{-2} of proton beam power
  - Corresponds to 2-3 kW
  - Highly dependent on tails of straggling distribution
  - Statistically limited?
- Nb:
  - old cooling channel
  - discretised RF, change only drift length





Reoptimised RF capture



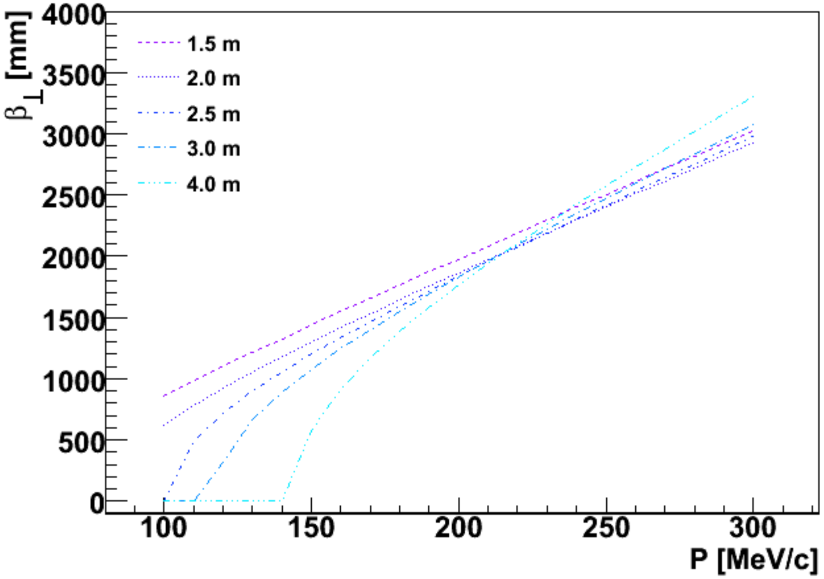


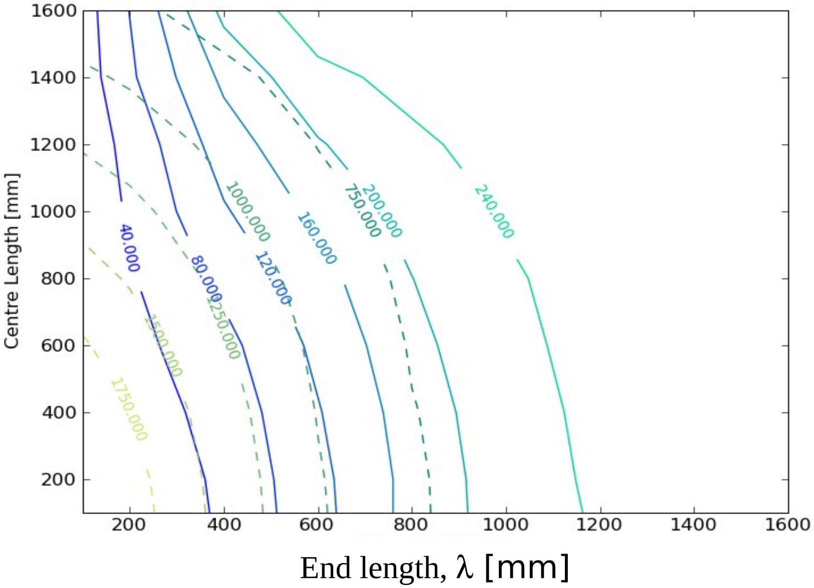
- v2.1 – engineering details in cooling channel (D. Stratakis) + discretised RF
- v3.1 – chicane + continous RF (reoptimised)
- v4.0 – chicane + discretised RF (reoptimised)
- v5.1 – chicane + discretised RF + correct target fields/geometry
- Note discrepancy between ICOOL and G4BL

Risks – Magnet Packing Issues

- Neutrino factory front end would be world's longest multi-coil magnet
  - Stored energy per length is ~ same as LHC dipole
  - Cooling channel magnets are coupled to radioactive liquid Mercury target
    - Quench one coil and we quench whole line?
    - Do we need to train the magnets together?
    - What happens if something goes badly wrong?
  - Tightly packed in with other components e.g. RF
    - Magnetic fields may cause breakdown in RF
- This will not be an easy system to operate
  - Can we make it easier?
  - Can we reduce or remove coupling between magnets?
  - Can we reduce or remove magnetic field on RF?
  - Can we introduce any space for services, bellows, diagnostics?

Non-Linear Terms

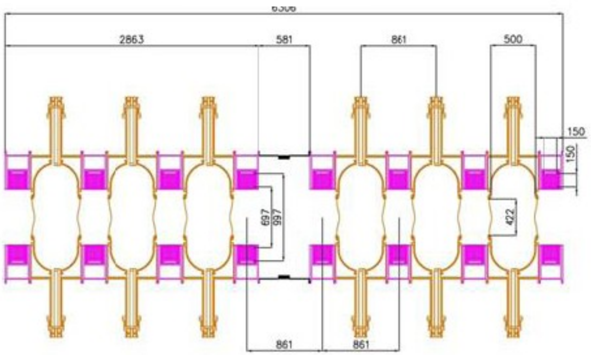




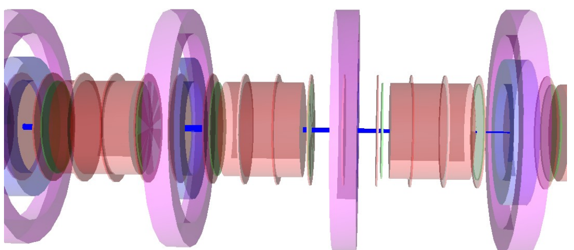
- As we lengthen the cell length momentum acceptance is reduced
  - dβ/dp gets large
- As we shorten the coil end field dynamic aperture is reduced
  - Spherical aberrations are excited by short fringe field

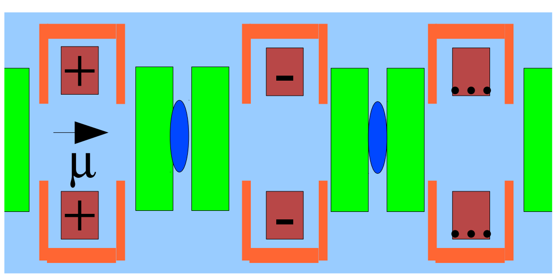
Bucked/shielded lattices

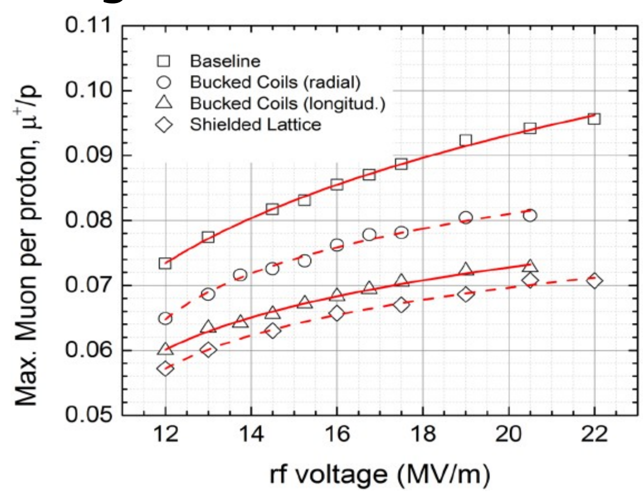
- Baseline modified following engineering constraints
  - Space added for bellows, insulation
  - Still no diagnostics
- A number of solutions for different requirements on e.g. Bz vs E
  - Different levels of coupling between magnets
- We can now present optimised lattices independent of requirements from engineering constraints



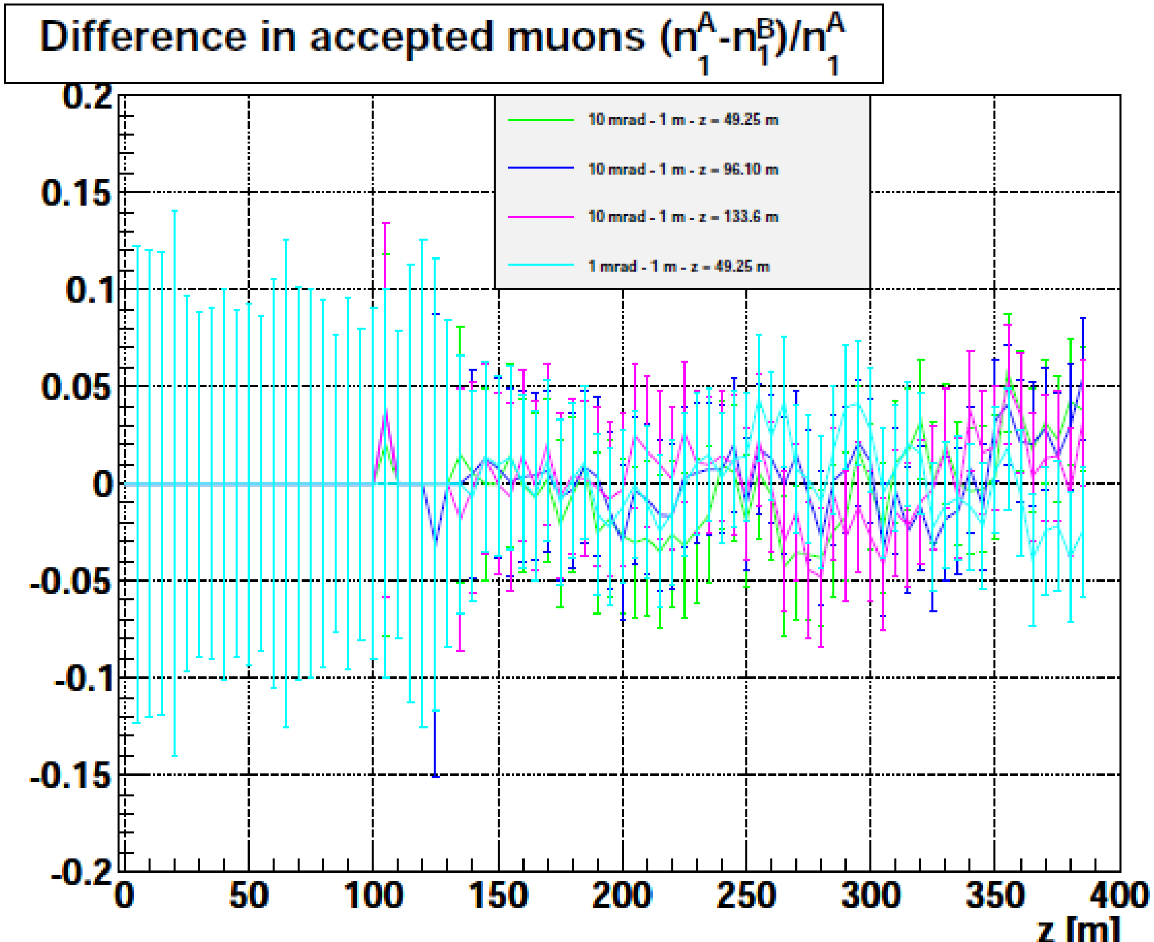
N Collomb, D Stratakis


A Alekou, J Pasternak



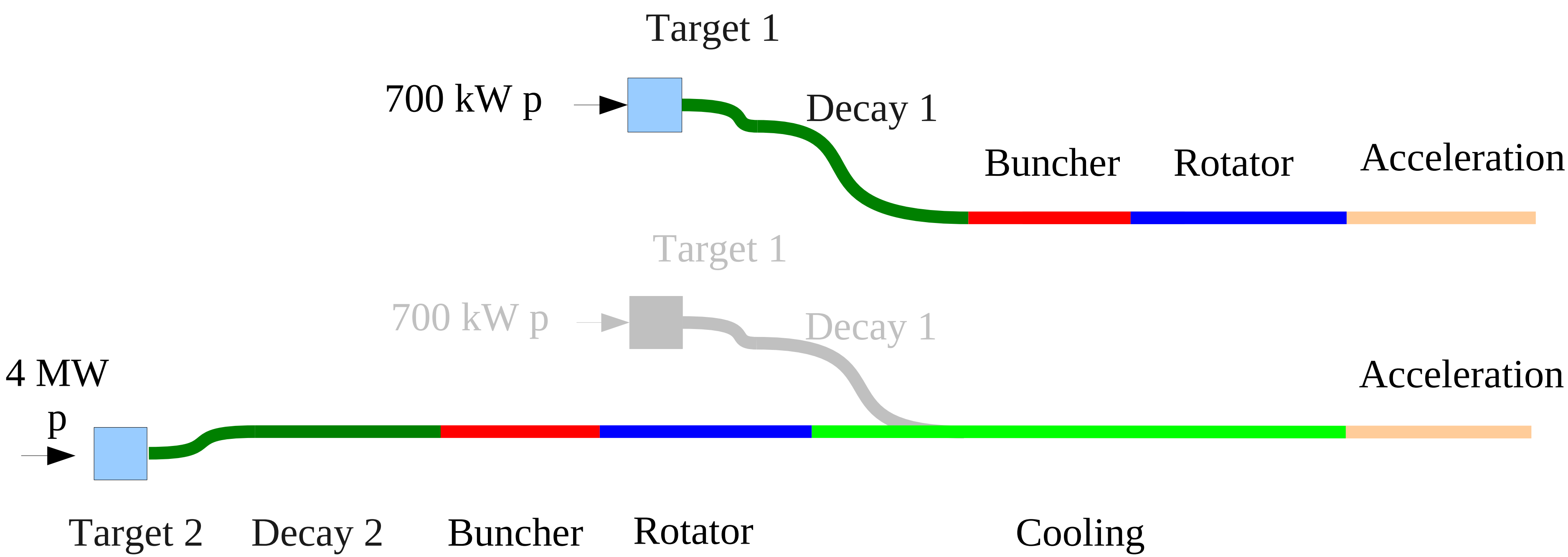


Alignment tolerances



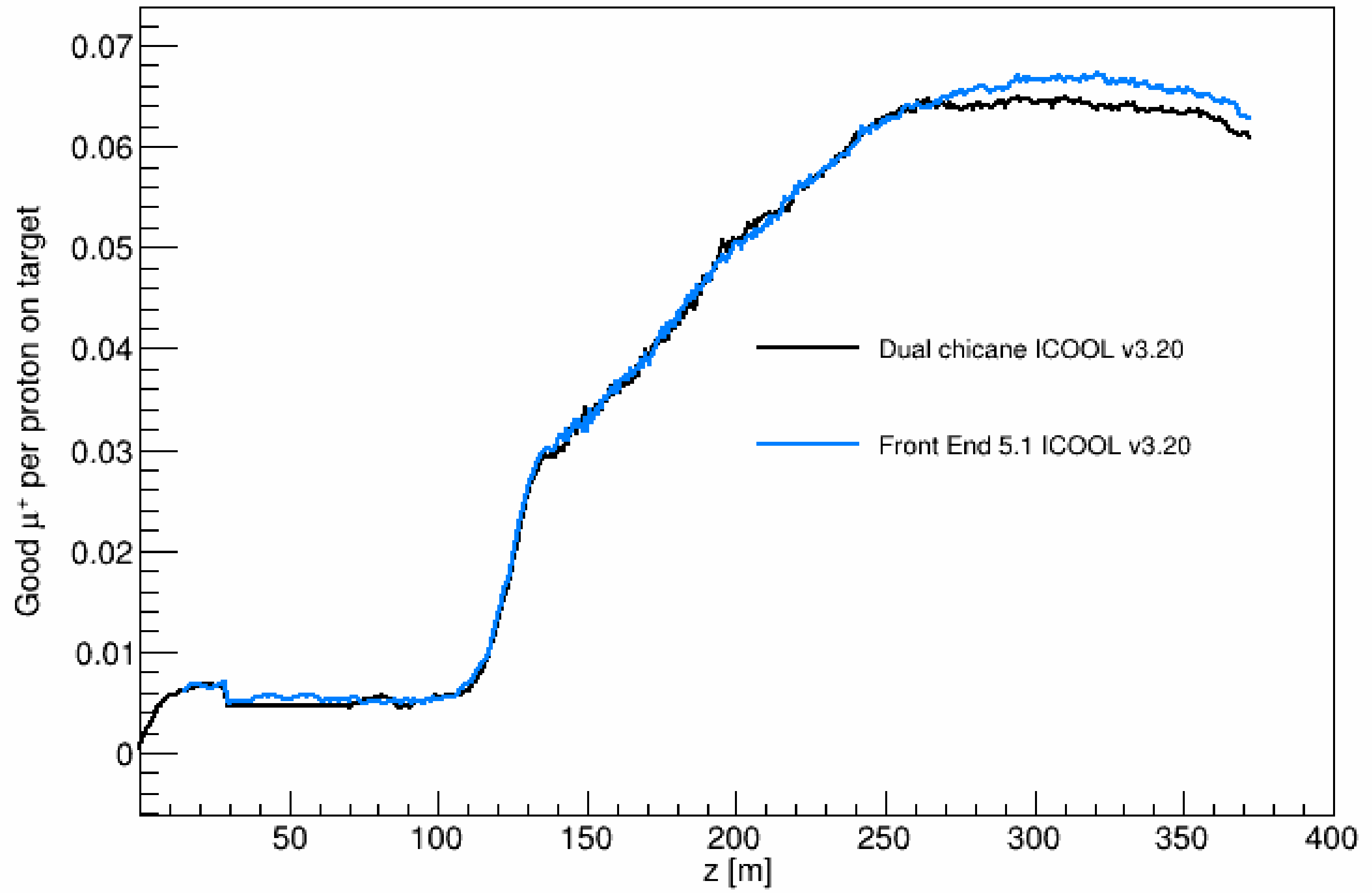
- First look at alignment tolerances (G. Prior)
  - Misalign a single coil at few different z locations
  - Study change in capture rate
  - No statistically significant effect

Staging Scenario



- Outlined a staging approach to a Neutrino Factory based on upgrades to the front end and target
  - Low power target using existing proton driver
  - No cooling channel
  - Factor 20 reduction in rate

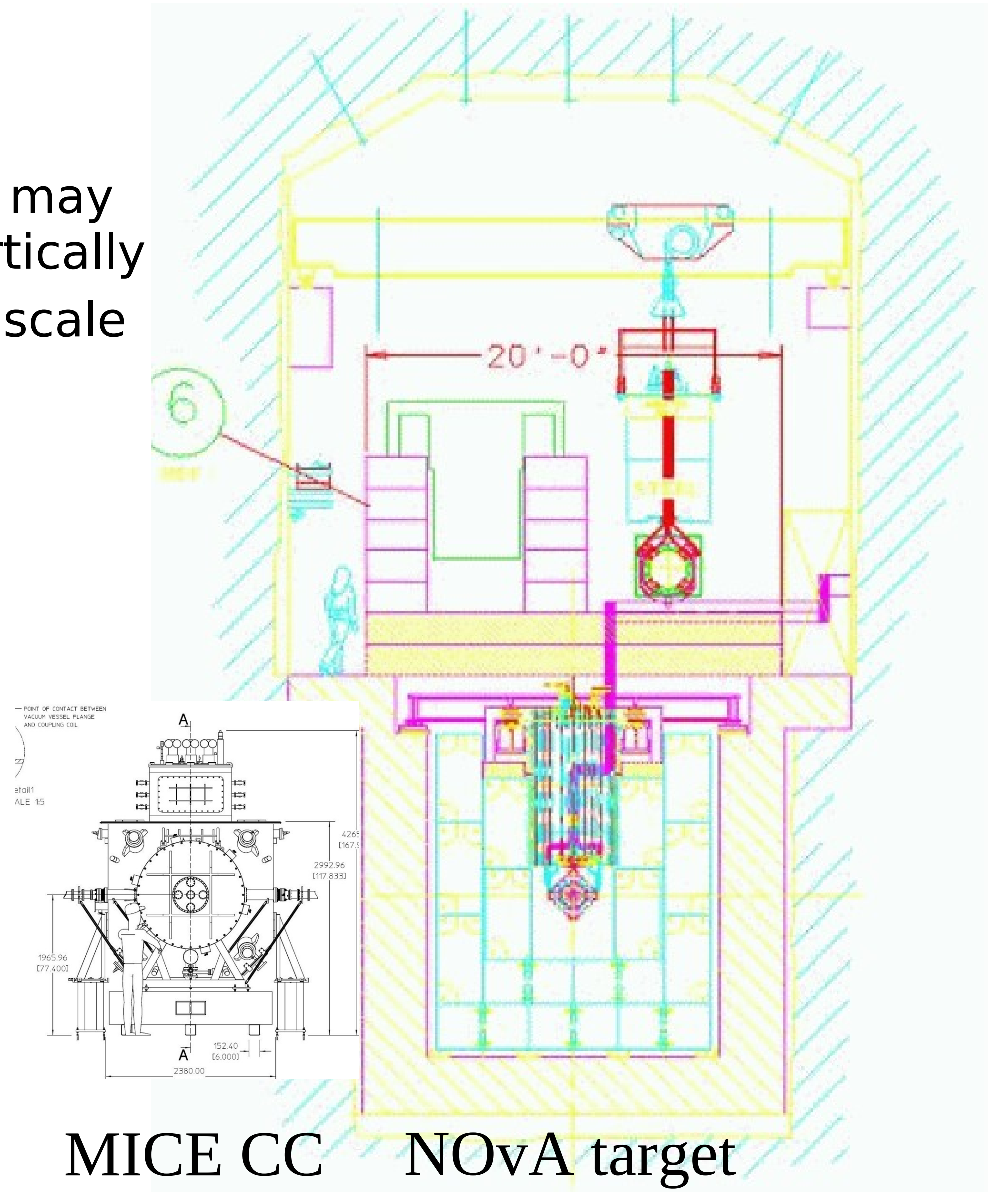
Effect of additional chicane



- Adding a second chicane has little impact on yield

Space constraints near target

- There may be space
  - e.g. power couplers may need to come in vertically
  - Diagram roughly to scale
- Would need some engineering
  - 1.2 m for CC
  - 3.0 m for target
  - 0.8 m for bracing, services, etc...



MICE CC NOvA target

Conclusions

- We have met a number of challenges in the IDS-NF front end group
  - Evolved a realistic lattice with a number of backup options in the event of trouble
  - Developed a rate staging scenario that may enable an upgrade path to be defined
- “Evolution, not revolution”