Muon Front End Status

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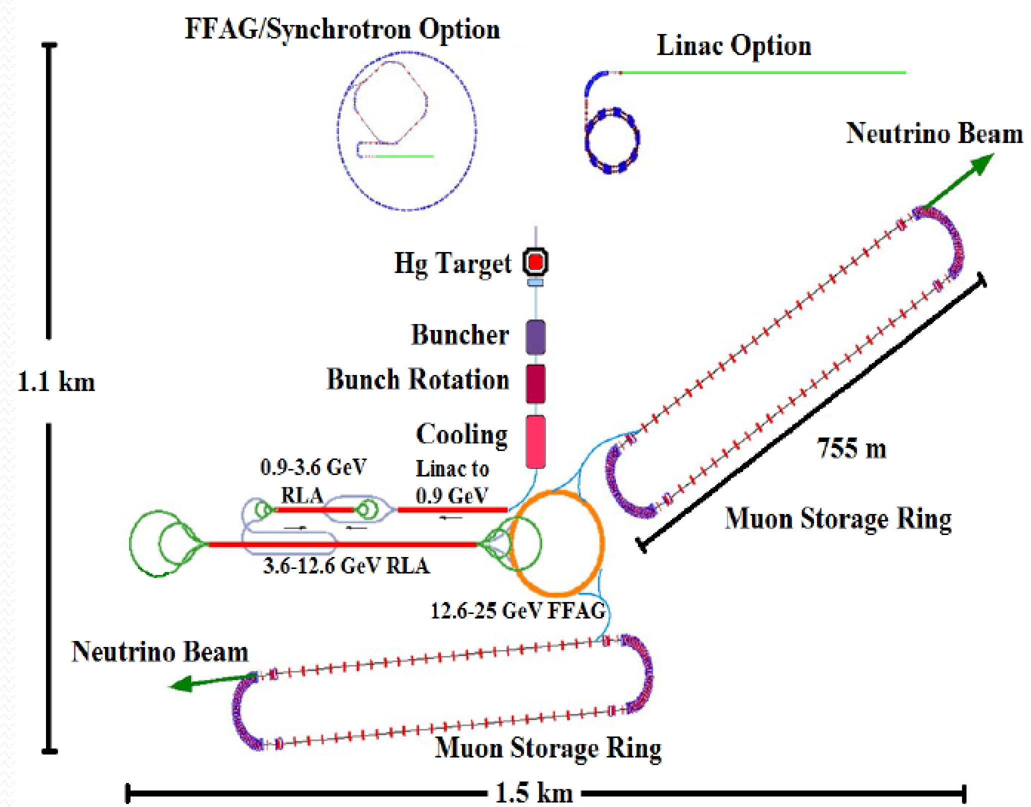
Muon Front End Status

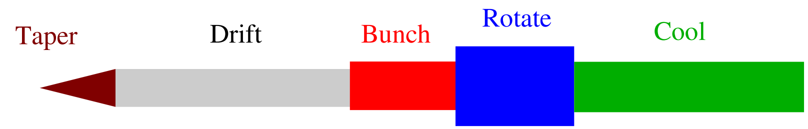
- Overview of Front End Design
- Managing secondary particle contamination
- New cooling lattice design (Alekou)
- Costing and engineering progress

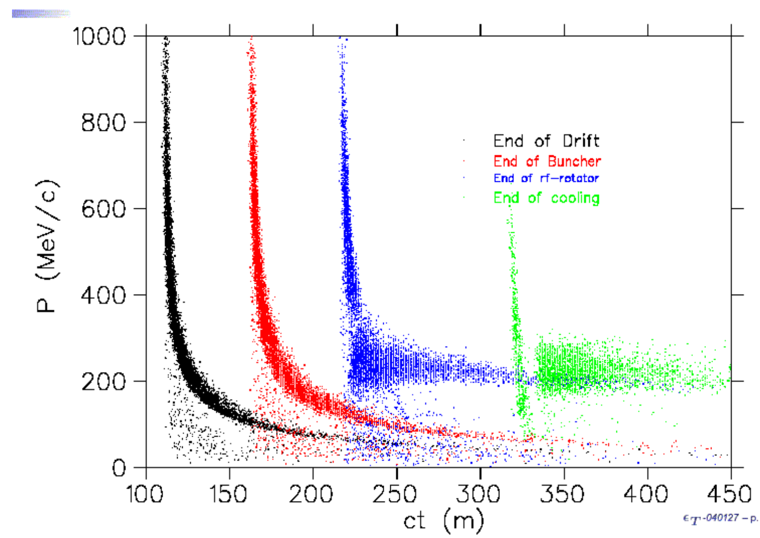


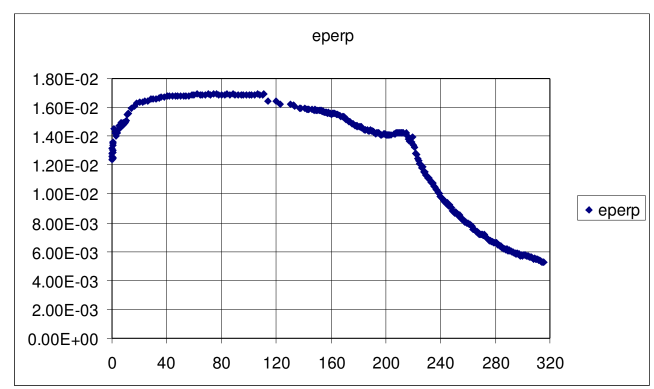
Neutrino Factory Layout

Baseline Front End

- Adiabatic B-field taper from Hg target to longitudinal drift
- Drift in ~1.5 T, ~100 m solenoid
- Adiabatically bring on RF voltage to bunch beam
- Phase rotation using variable frequencies
  - High energy front sees -ve E-field
  - Low energy tail sees +ve E-field
  - End up with smaller energy spread
- Ionisation Cooling
  - Try to reduce transverse beam size
  - Prototyped by MICE
  - Results in a beam suitable for acceleration

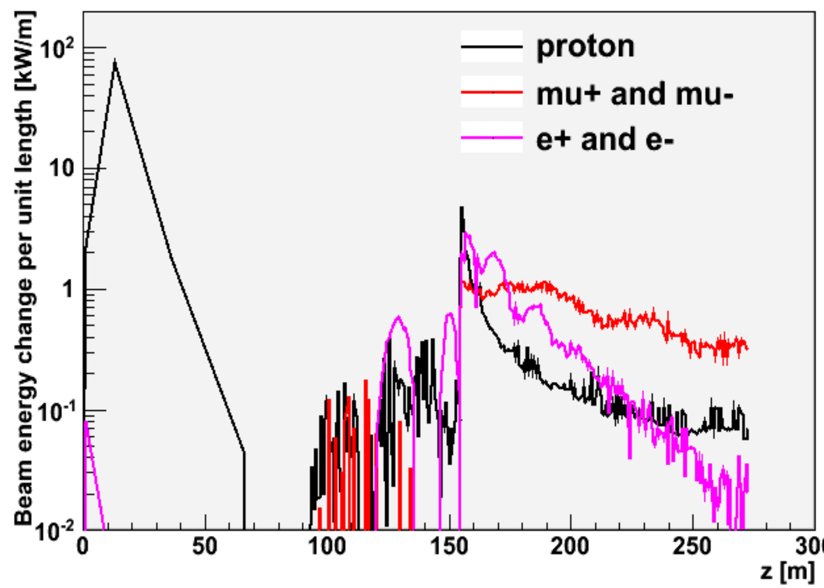


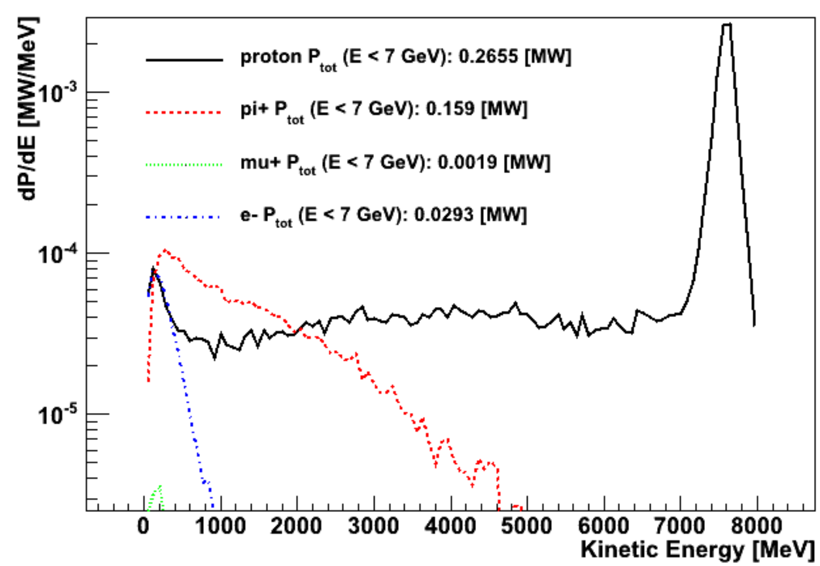




Secondary Particle Contamination

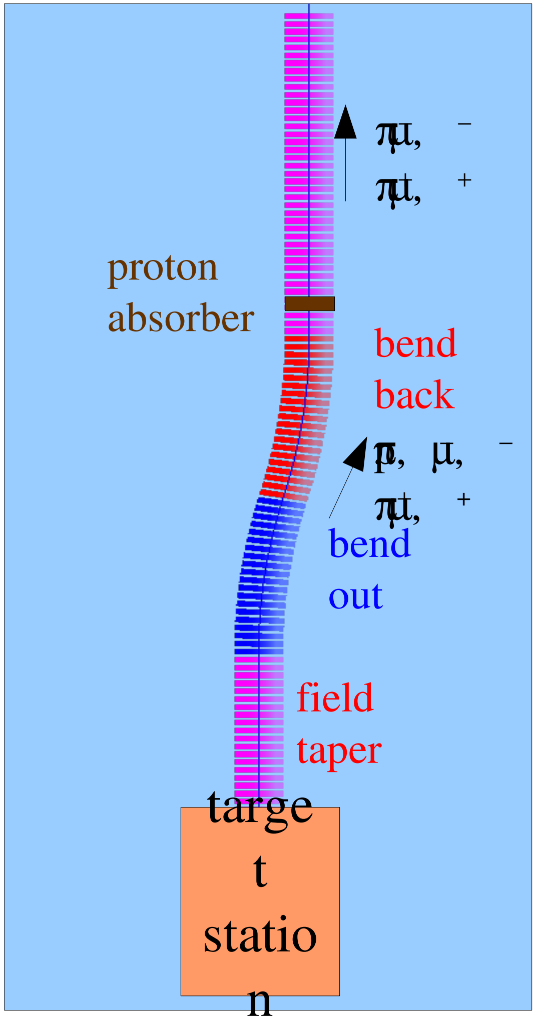
- Significant problem with secondary particles in the front end
  - Potentially activate the entire front end
  - Potentially activate later acceleration system
    - Kickers, septa, etc
  - Additional heat load on e.g. superconductors
  - Not acceptable
- Plan is to manage using chicane and proton absorber
  - Chicane removes high energy particles (p > 500 MeV/c)
  - Absorber removes low energy protons (p < 500 MeV/c)
  - Leaves low energy electrons and muons





Particle selection scheme

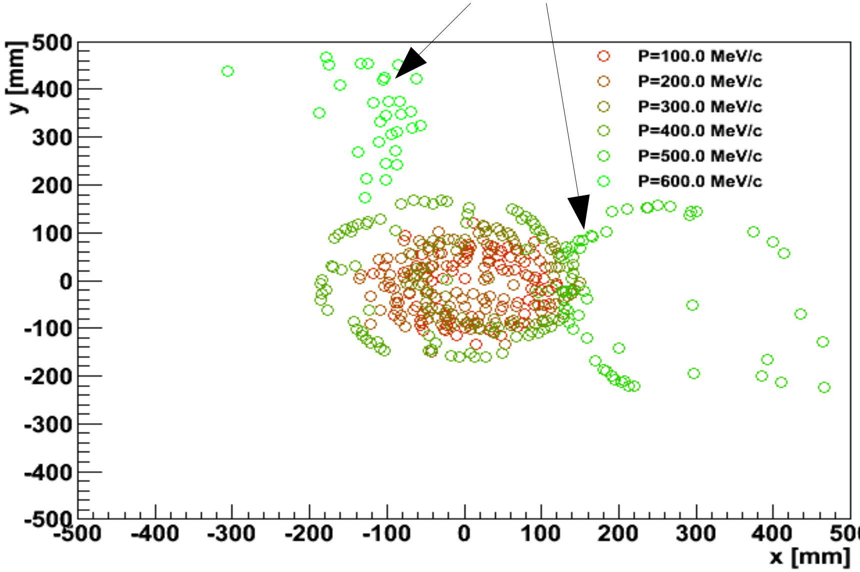
- Bent solenoid chicane induces vertical dispersion in beam
  - Single chicane will contain both signs
    - Opposite signs have dispersion in opposite sense
    - Dispersion is **vertical**
  - Little disruption to the actual beam
  - High momentum particles scrape
- Subsequent proton absorber to remove low momentum protons
  - Non-relativistic protons don't have much energy, even for relatively large momenta

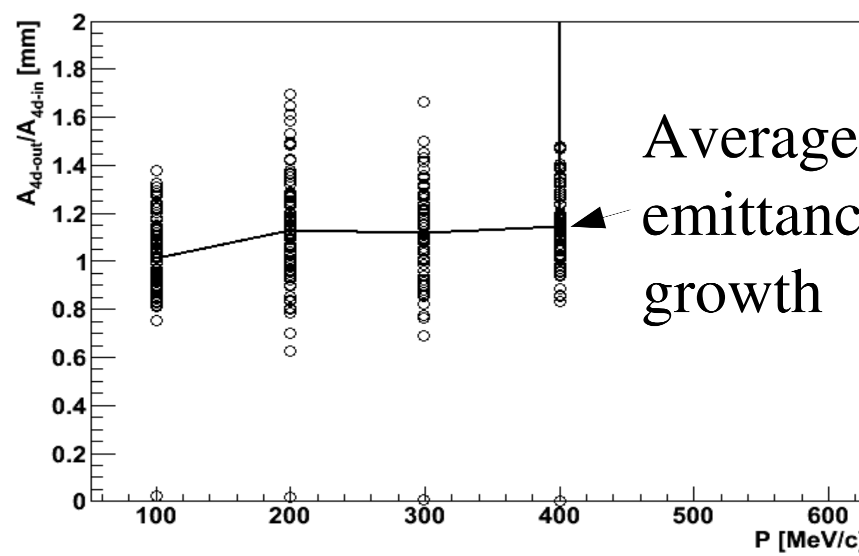


Chicane acceptance

- What happens when a finite beam is passed through the chicane?
- Look at emittance increase of a shell of particles on 4D hyperellipsoid
  - Initial amplitude typical of particles in the beam~ 50 mm
  - Shell in x-px-y-py phase space, initially matched to 1.5 T solenoid
- Not much emittance growth in front end momentum acceptance
  - Front end only designed to capture muons 100 < p < 500 MeV/c

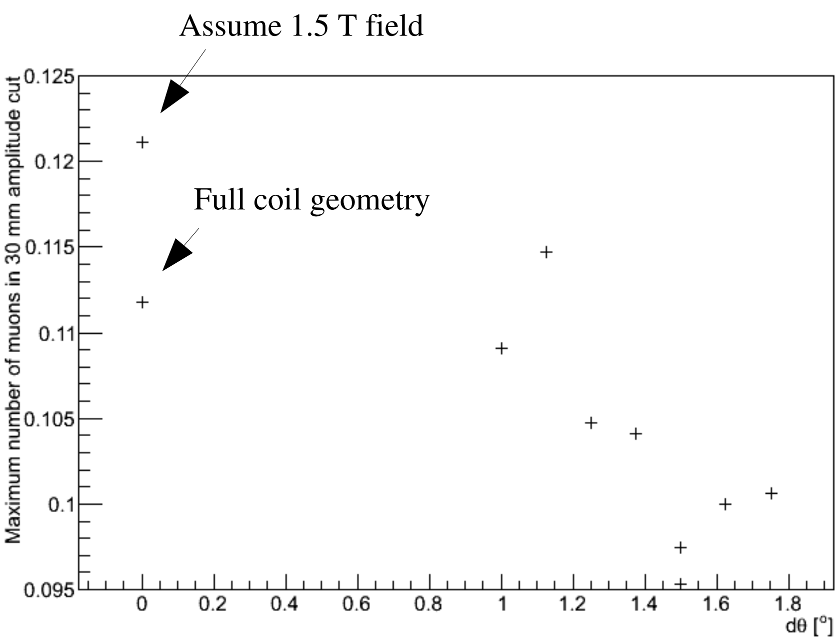
Muons with momentum >= 500 MeV/c lost

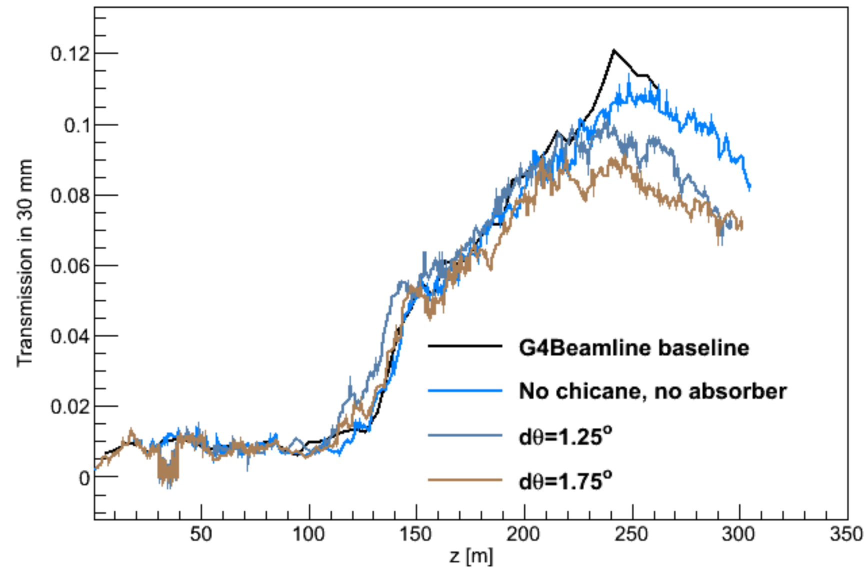




Average emittance growth

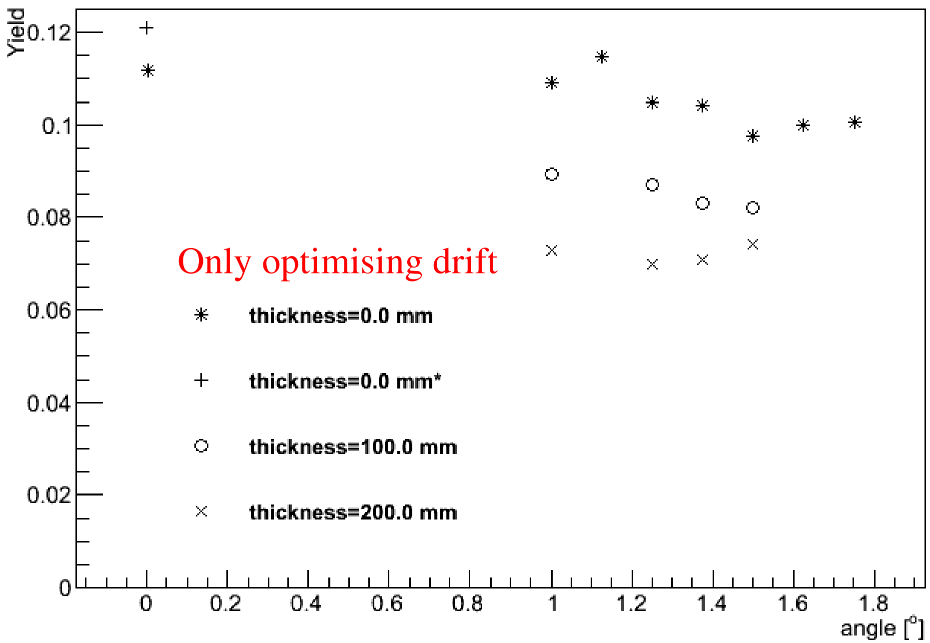
Muon yield - chicane only





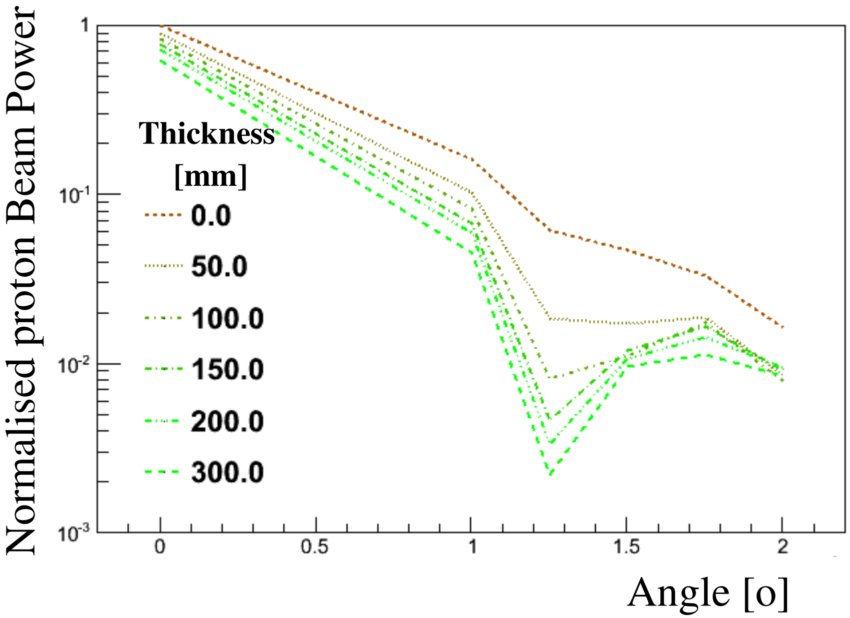
- In the absence of an absorber muon yield through the chicane is ok
  - Looks like about 5% reduction in yield
  - Note this uses full coil geometry
    - Match from field taper to 1.5 T region
    - Match from small coils to large coils (for RF)
    - Match from 1.5 T to cooling channel
  - Quite a bit of noise
- Preliminary studies on proton absorber + chicane

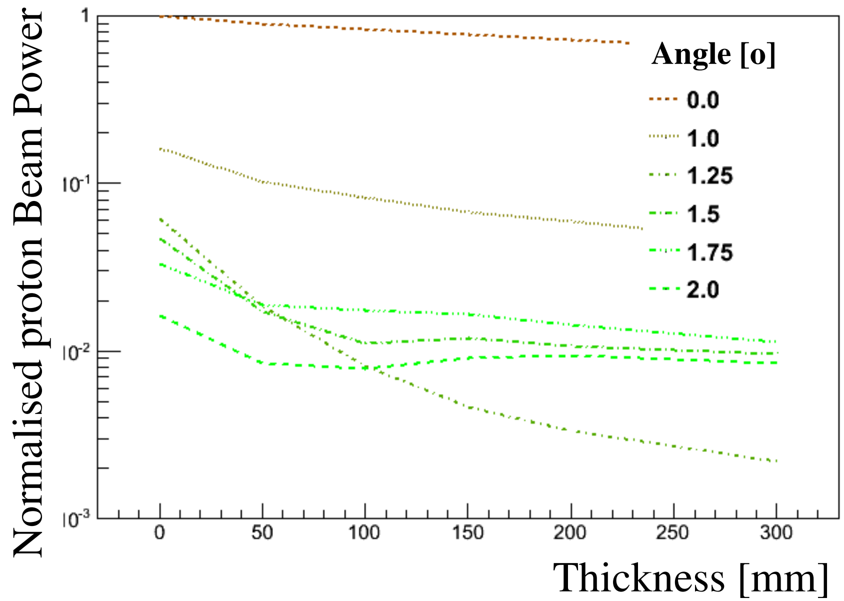
Muon yield - chicane plus absorber



- Getting a good muon yield requires reoptimisation of the muon capture
  - The longitudinal phase space gets messed up by the absorber
- Two approaches
  - Redo chicane in ICOOL (Neuffer)
  - Redo RF capture routines using G4Beamline (Rogers)
- Further optimisation in progress

Proton power escaping proton abs

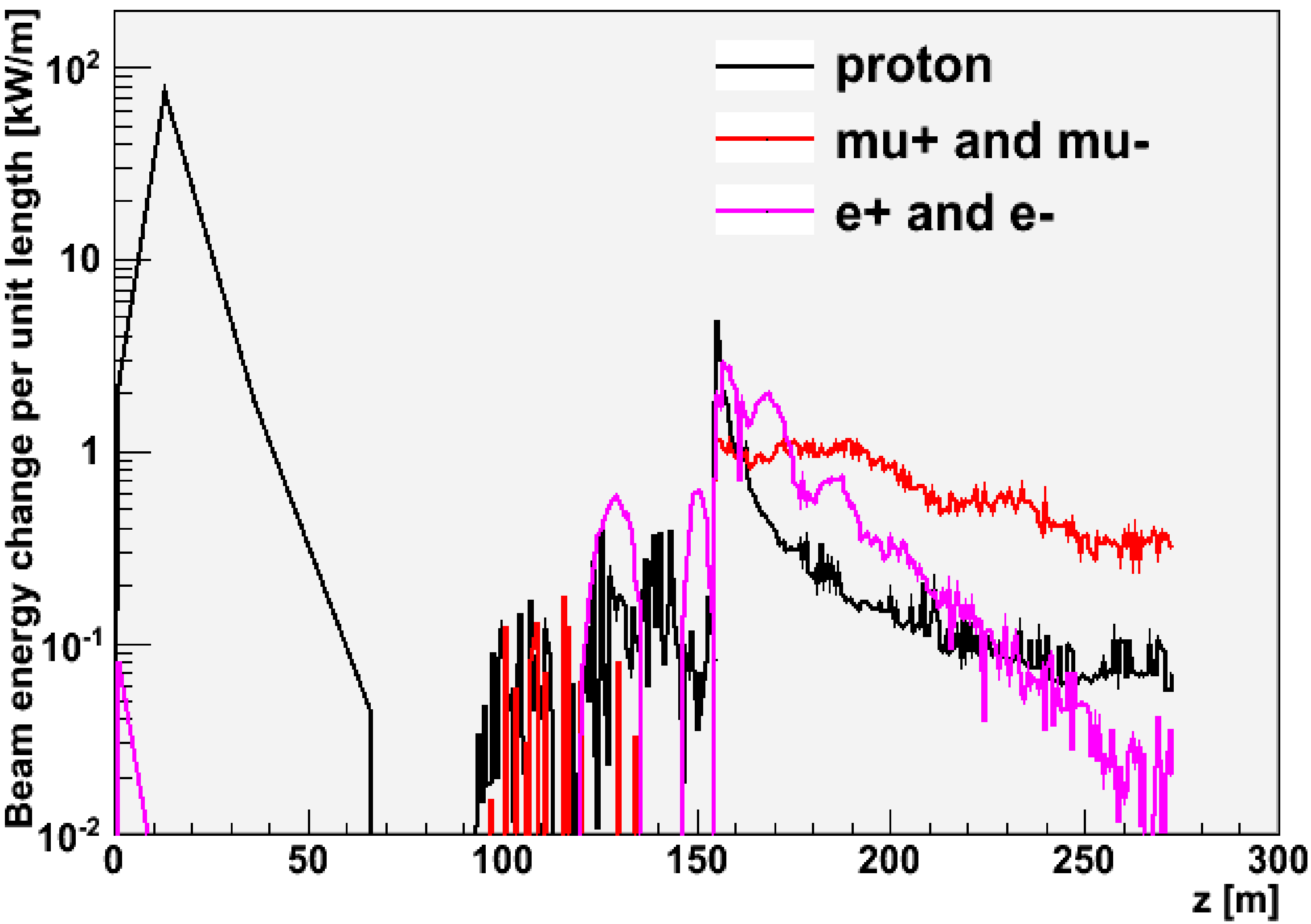




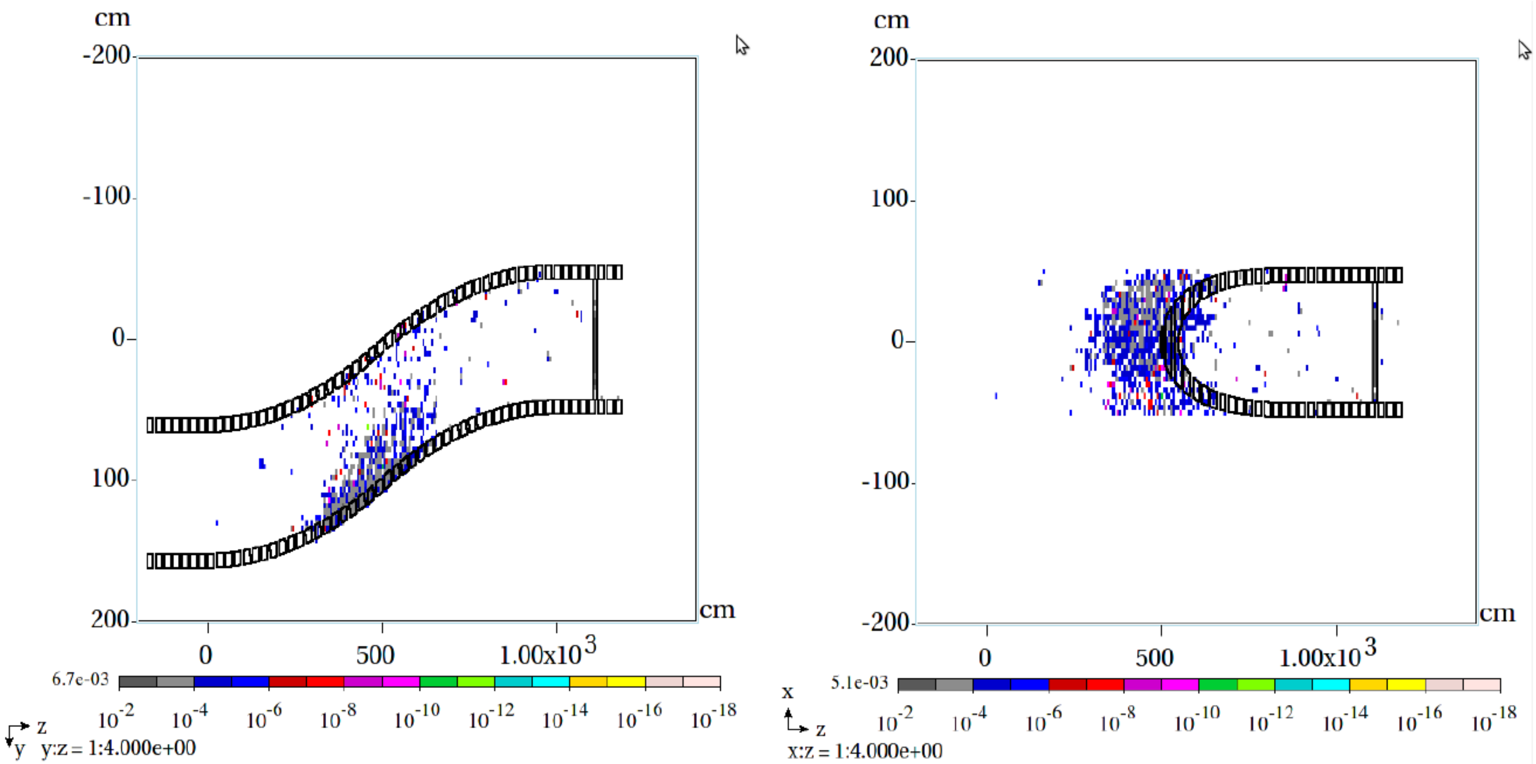
- Minimum proton power is in 1.25^{o} case
- Basically - the more absorber the better
  - A lot of noise at the 10^{-2} level
  - For 100k primaries this is ~ few 10s of protons
- To avoid remote handling in the cooling section, we need to have proton background reject at 10^{-4} level

Power deposition

Power deposited, no absorber, no chicane



MARS Energy Deposition (Snopok)

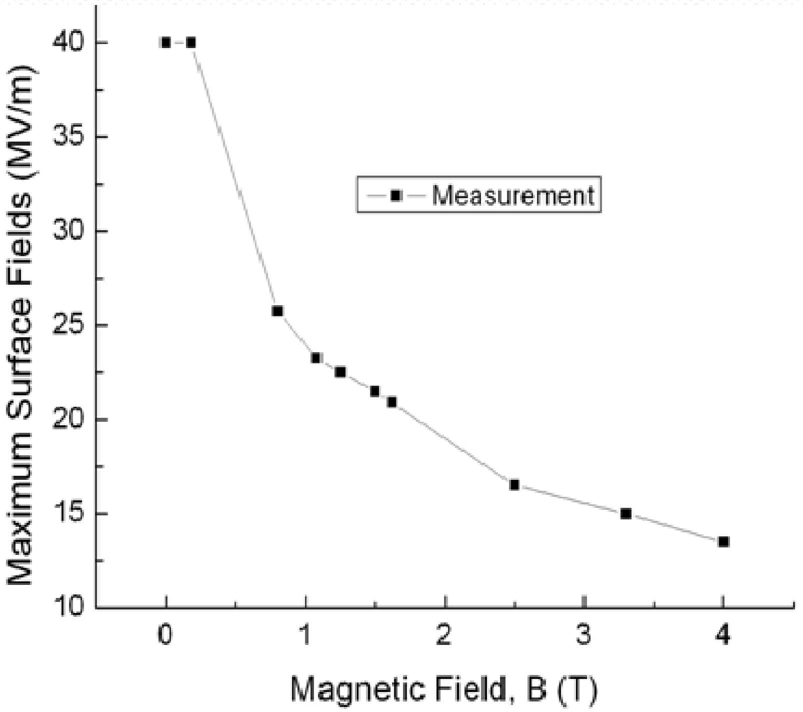


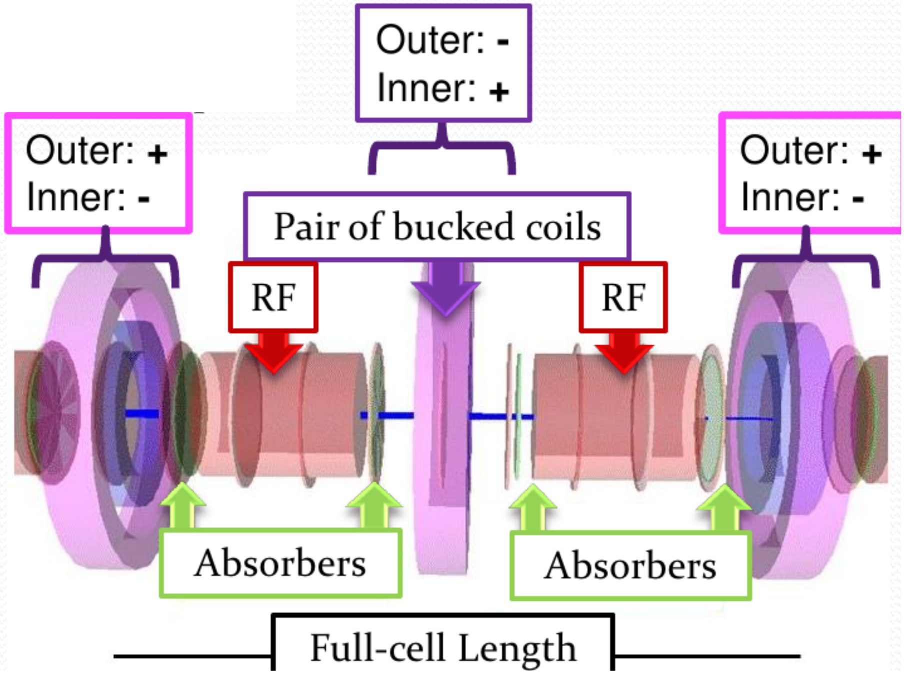
- Investigating energy deposition on coils
  - 100-200 kW proton beam power is deposited in chicane
  - Can we use shielded superconducting coils?
  - Probably we need a normal conducting insert
    - Quite demanding field strengths

Particle Selection System - Summary

- We have a working design
- It looks good
  - Very high acceptance chicane
  - Excellent momentum cut-off
- Awaiting final optimisation
  - Needs re-optimisation of the RF capture
  - Reasonably complicated task
  - Just optimising the drift length, we get
    - ~ 20 % reduction in good muon yield with 100 mm absorber
    - ~ 30 % reduction in good muon yield with 200 mm absorber
  - Preliminary optimisations for full RF capture indicate
    - ~ 10 % reduction in good muon yield with 100 mm absorber
  - Probably we still end up with remote handling in the cooling channel
    - Unpleasant
- Then propose new baseline

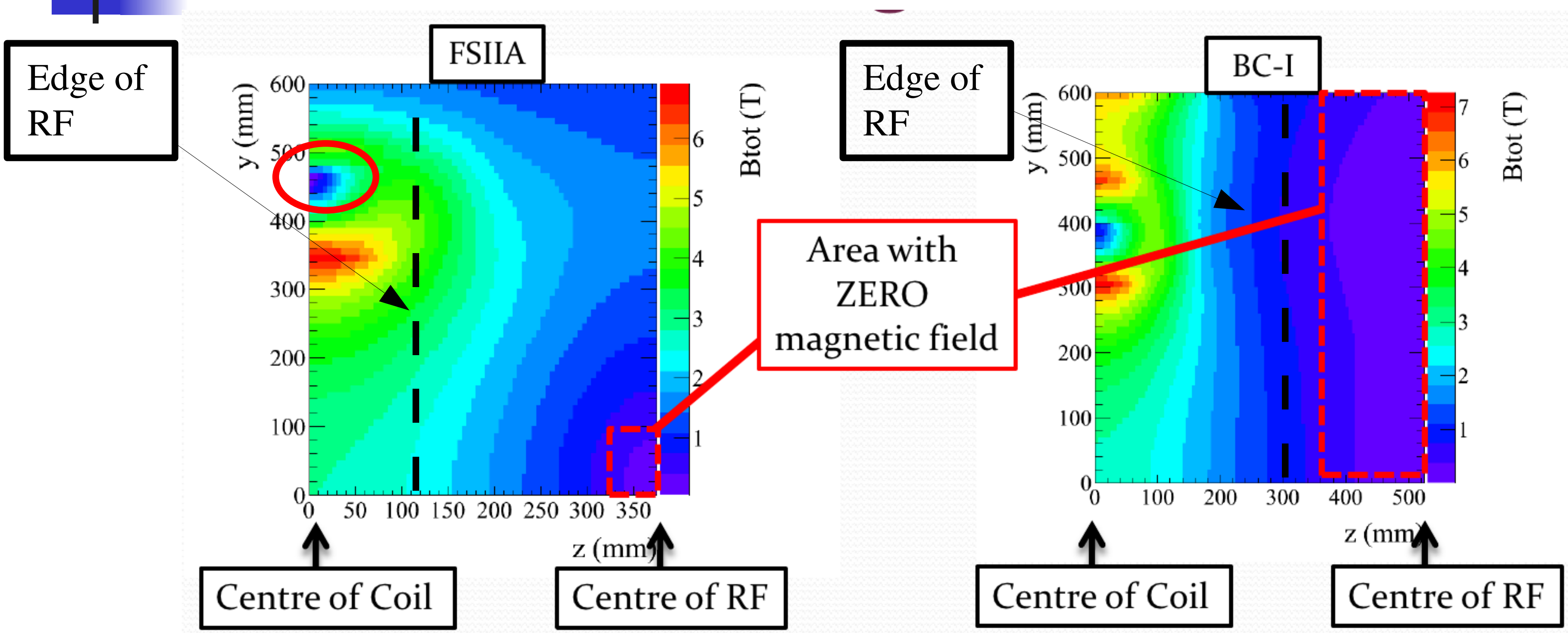
Bucked coil lattice (Alekou)





- Well rehearsed problem of RF cavities in magnetic fields
- Still little experimental data for 200 MHz
- 800 MHz data indicates factor ~2-3 fall off in peak gradient for ~few T field
- (A Alekou) try shielding the RF from the coils?

Field

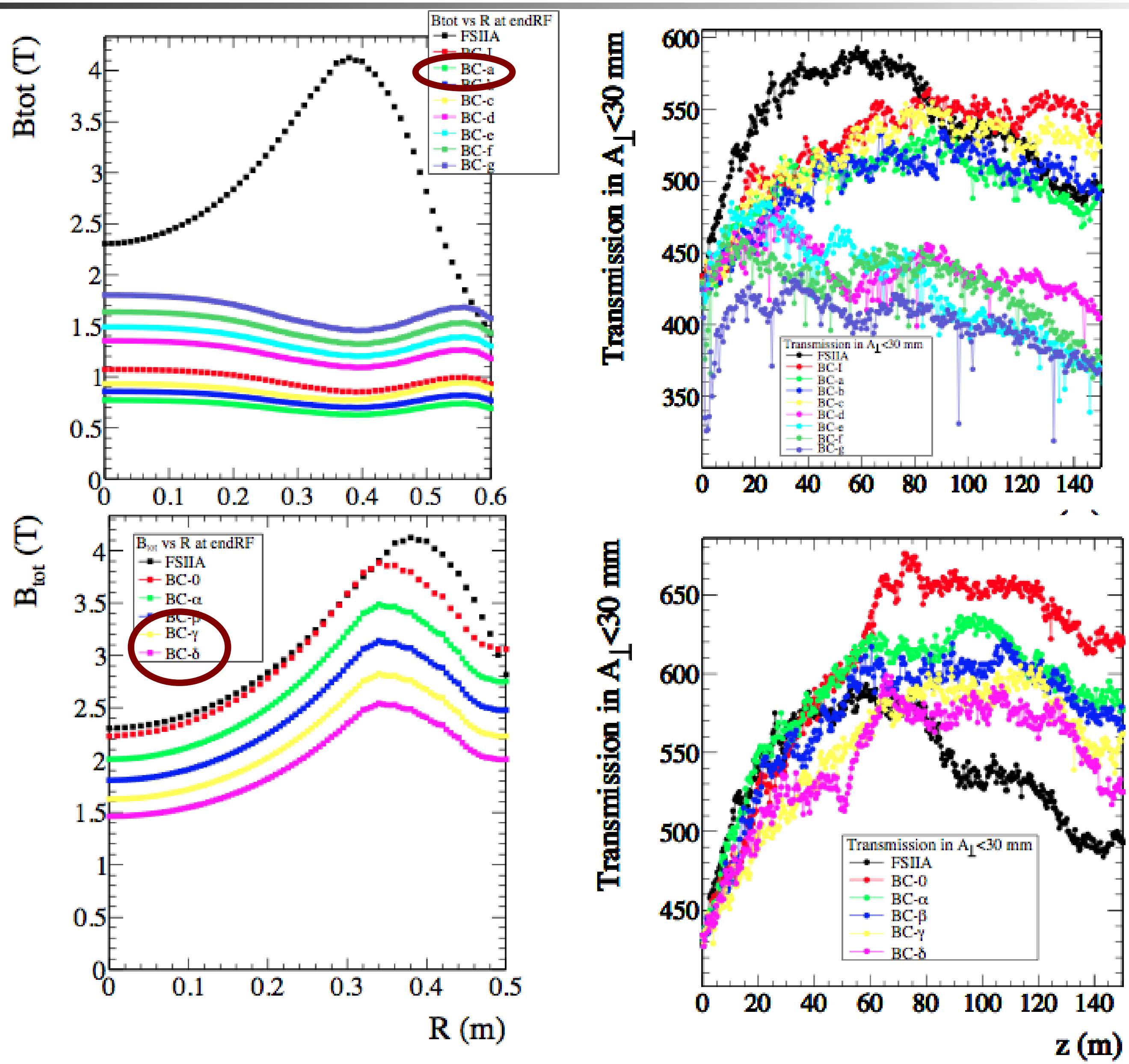


- Field on RF cavity is much reduced
  - Use bucking coil to shield cavity
  - Possibly enables higher field gradients in the cavity

Muon Yield

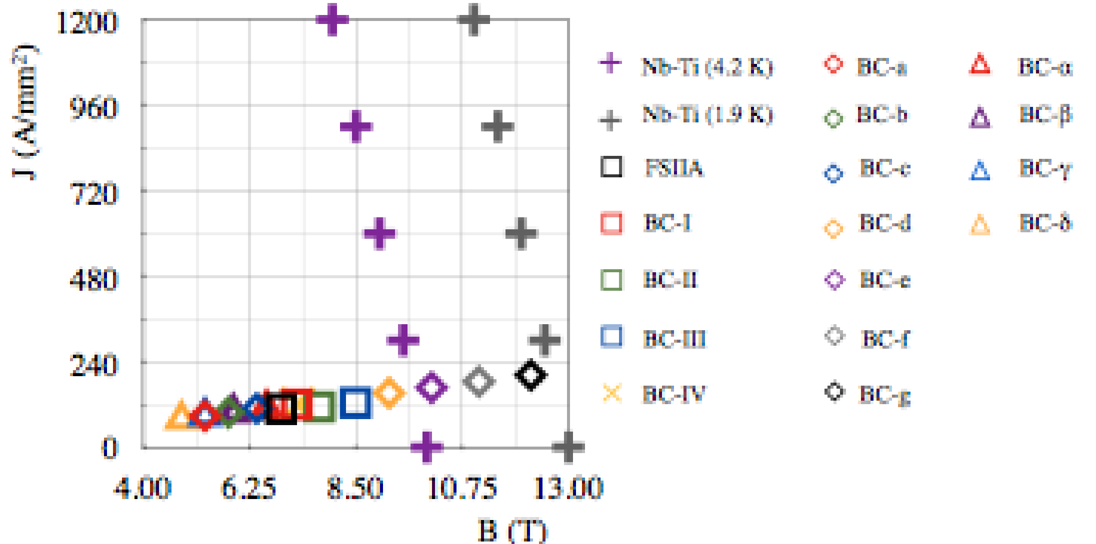
0.75 m cell

1.05 m cell



Lattice	35 cm	50 cm
FSIIA	238.9	232.0

Lattice	30 cm	45 cm	60 cm	75 cm
BC-I	260.6	334.8	345.3	176.0
BC-II	288.2	403.4	521.1	279.2
BC-III	316.8	398.0	416.9	215.9
BC-IV	196.3	248.3	304.0	156.0
BC-α	213.8	262.4	272.9	146.2
BC-β	172.0	214.3	223.7	120.6
BC-γ	139.1	173.2	180.0	98.7
BC-δ	113.4	141.7	145.6	75.5
BC-a	139.1	177.1	188.2	124.6
BC-b	169.1	223.1	249.9	130.2
BC-c	209.0	272.2	382.3	202.5
BC-d	419.0	544.7	556.0	283.1
BC-e	505.9	646.2	672.0	349.2
BC-f	610.8	777.0	812.3	419.4
BC-g	739.5	945.6	977.5	666.7



Critical surface looks okay

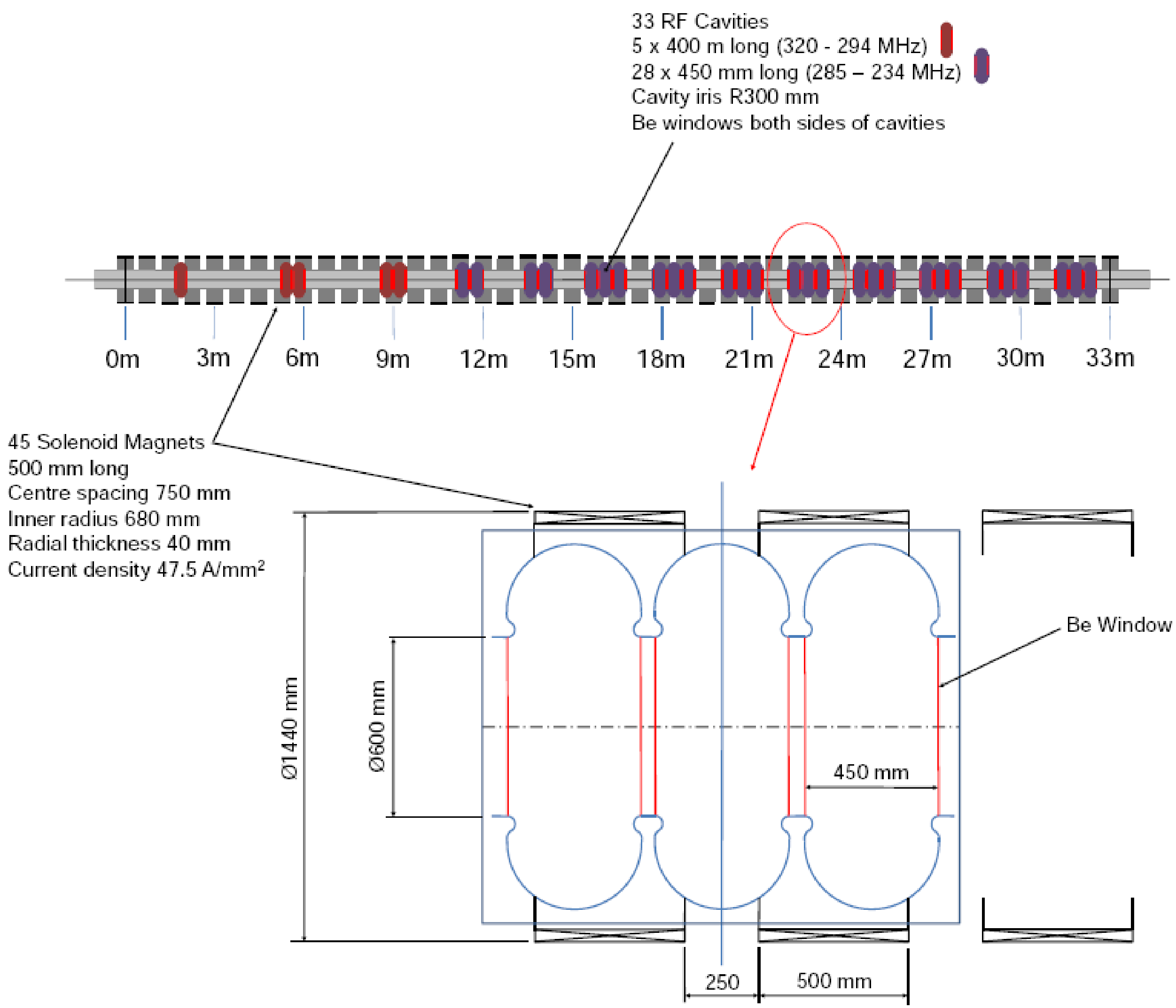
Only lattices with
hoop stress < 200 MPa

Costing and Engineering

- First round of engineering is in progress
  - First look at the optics design to bring forward to engineering design
  - Few geometry issues raised
  - Hope to get engineering feasibility on e.g. cooling channel

NF Adiabatic Buncher Section

Cavities are organised in 13 groups
Each group has the same RF frequency



Plans

- Two new items may provoke a new baseline in coming months
  - Particle selection scheme
  - Revised cooling channel
- Particle selection scheme
  - Needs a comprehensive study on the muon yield (vs chicane bend vs proton absorber)
- Bucking coil scheme
  - Needs an integrated simulation with the standard baseline
  - Would be interesting to take this lattice back into the phase rotation
  - Waiting on MTA for 200 MHz results in field
- Costing/engineering
  - Turning up a few interesting issues
  - Need support from engineers to get a robust engineering design