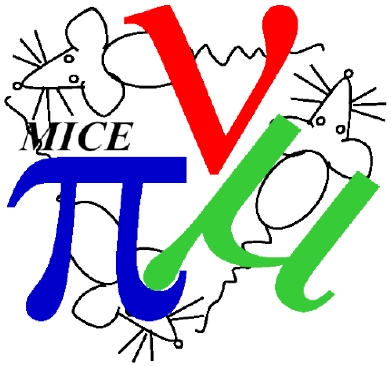
MICE Demonstration of Ionisation Cooling



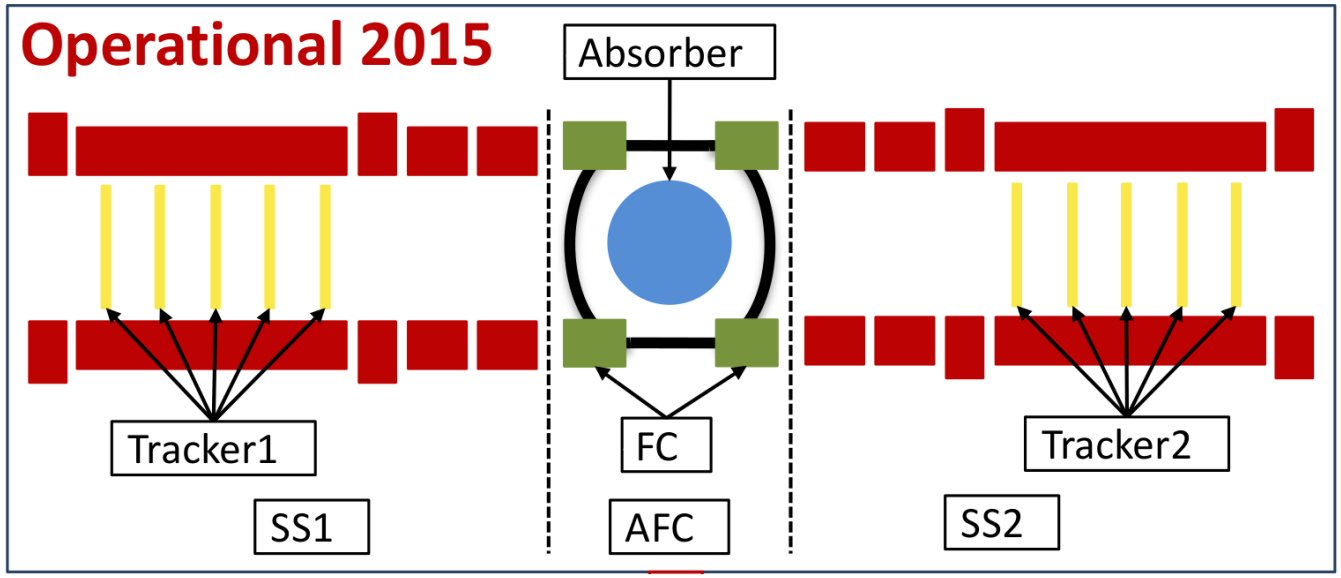
C. Rogers, V. Blackmore, C. Hunt, J.B. Lagrange, J. Pasternak, R. Preece, P. Snopok, J. Tarrant, H. Witte and others

ASTeC

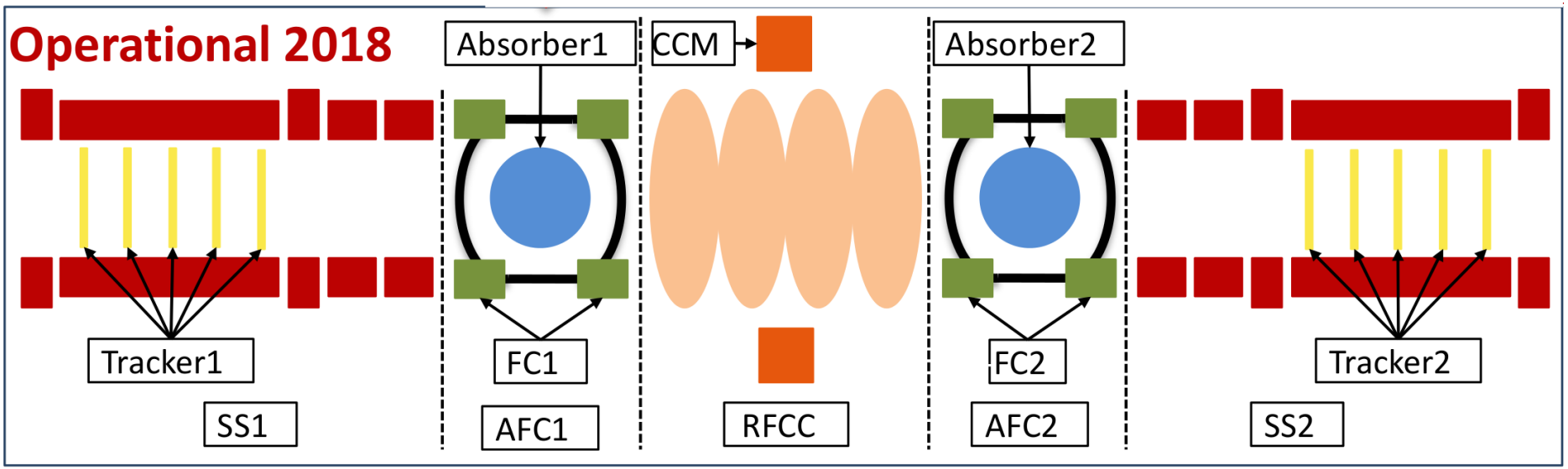
Overview

- Planned Step V in April 2014
- DoE Review in August → revised final step of MICE
  - MICE Demonstration of Ionisation Cooling
  - No coupling coil
- What do the optics look like?
- What is the cooling performance?

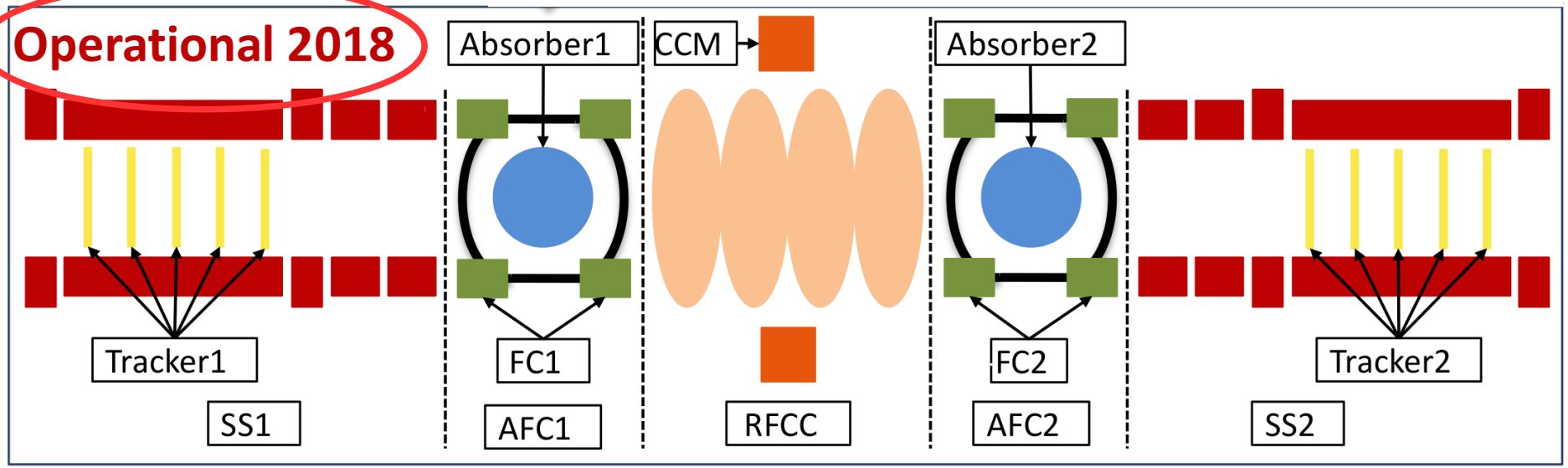
MICE Steps (April 2014)



- Plan endorsed by MICE project board in April

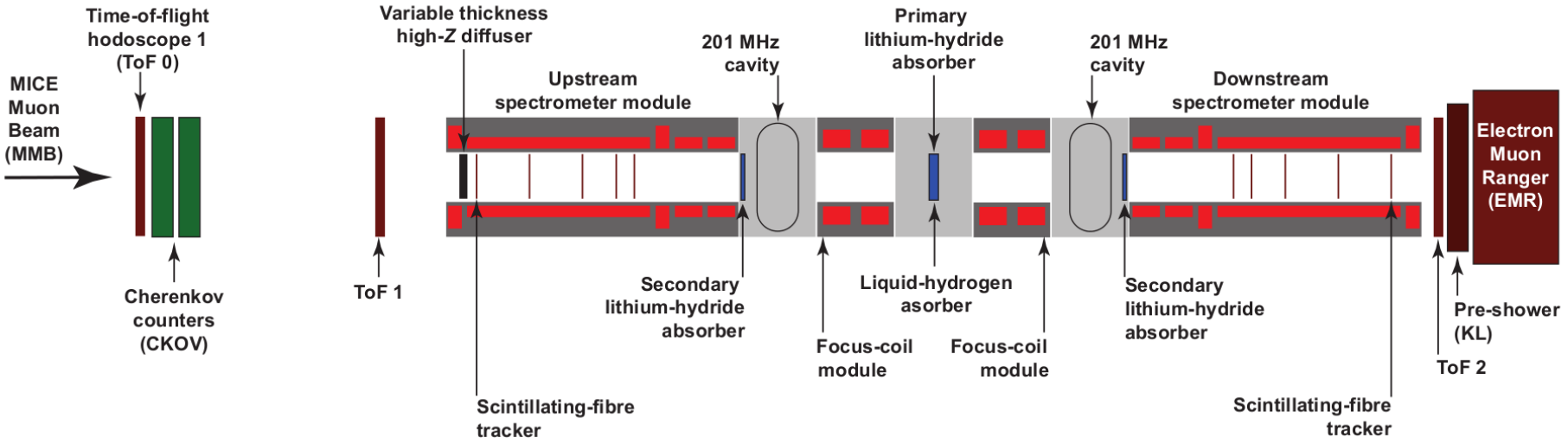


MICE Steps (April 2014)



- DOE decision that 2018 is too late
  - Too much cost
  - Too much risk
- Investigate alternatives to “Step V”

MICE Demonstration of Ionisation Cooling

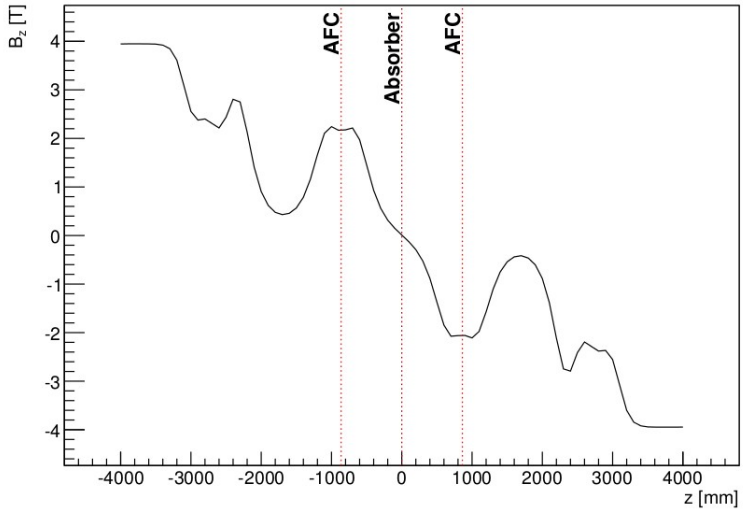


- Without CC
  - Focus is at midpoint between the “Focus” coil modules
  - Anti-focus is in the AFC centre
- Need a longer distance between FC and SS
  - Makes a convenient gap
- Need a shorter distance between FCs
  - Motivates moving RF cavities out

Engineering Considerations

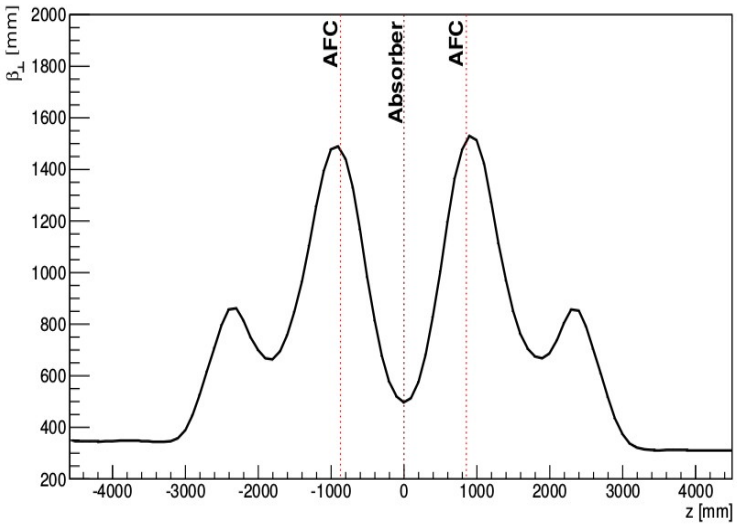
- No Coupling Coil
  - Takes significant risk off the project
- Lithium Hydride baseline “primary absorber”
  - Liquid Hydrogen is under investigation as an alternative
  - Removable/changeable absorber is under consideration
- Lithium Hydride “secondary absorber” shields trackers
  - Not yet manufactured
  - Provide additional cooling
  - Plastic is fall-back
  - Removable/changeable absorber is under consideration

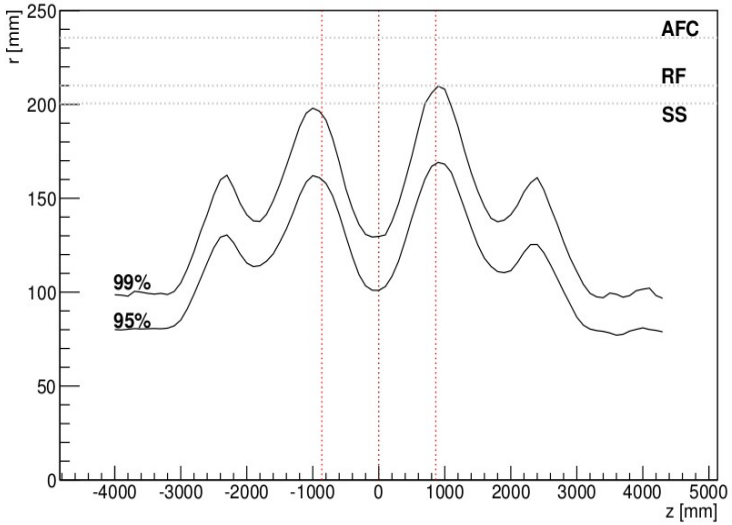
Magnetic Field



- Baseline option has FC module working in same polarity
  - Polarity ++--
  - FC current is rather relaxed, well within operational limits
- Maintain options with FC in other polarities
  - +--+ less preferred due to dynamic aperture issues
  - ++++ less preferred due to angular momentum issues

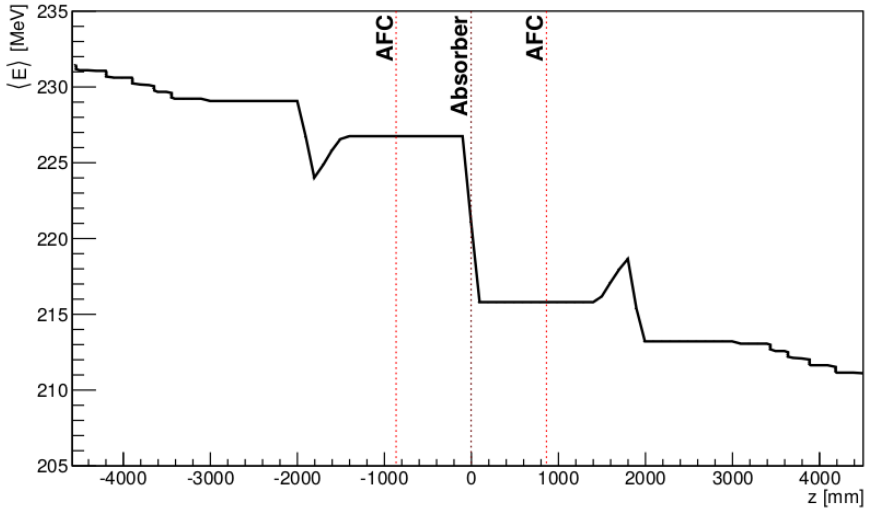
Optics

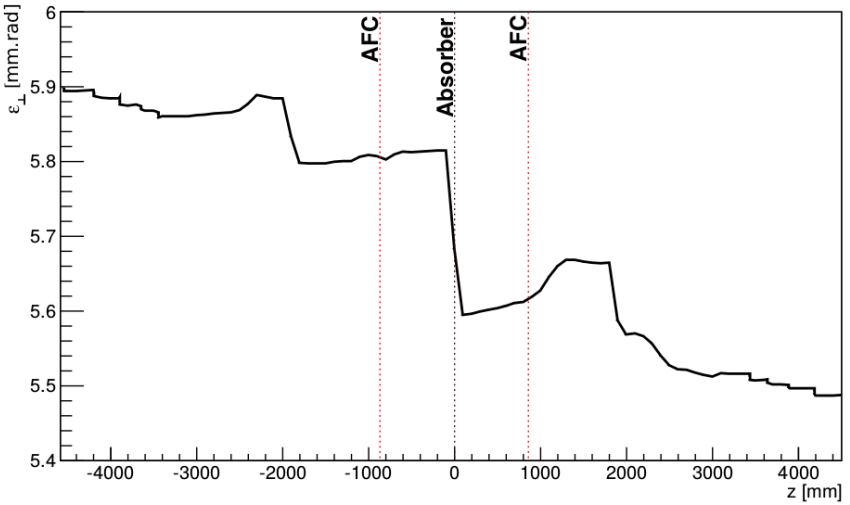




- Good focus at the primary absorber
  - β = 450-500 mm
- Secondary absorbers may be required to shield tracker from RF cavity x-rays
  - Acceptable β-function in this region

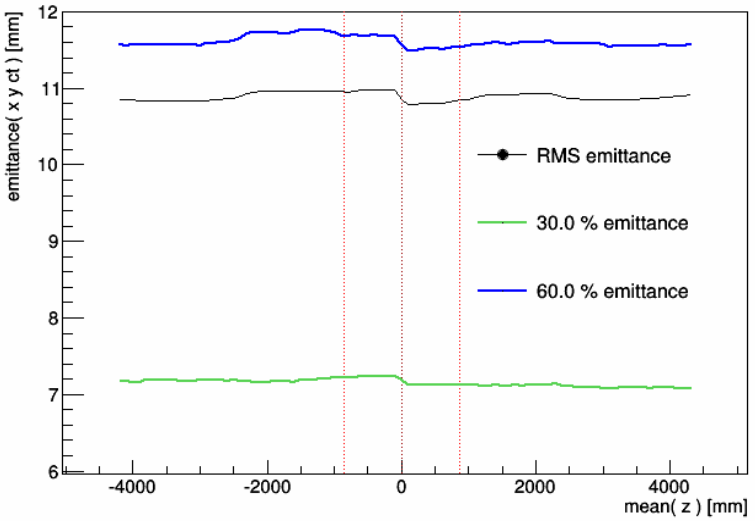
Cooling performance

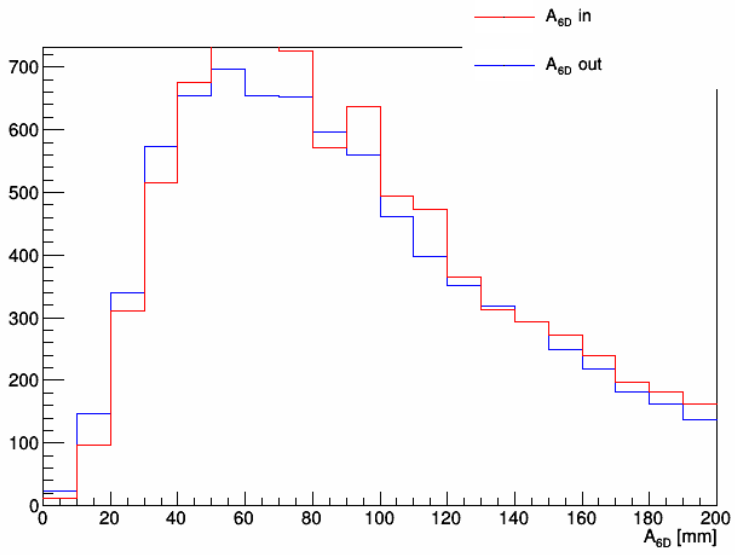




- Recover most of the energy loss from the primary absorber
  - Aim for 8 – 9 total MV
  - Aimed for 12-13 total MV in Step V
- Get a good cooling signal
  - Note significant optical aberrations in region of FC

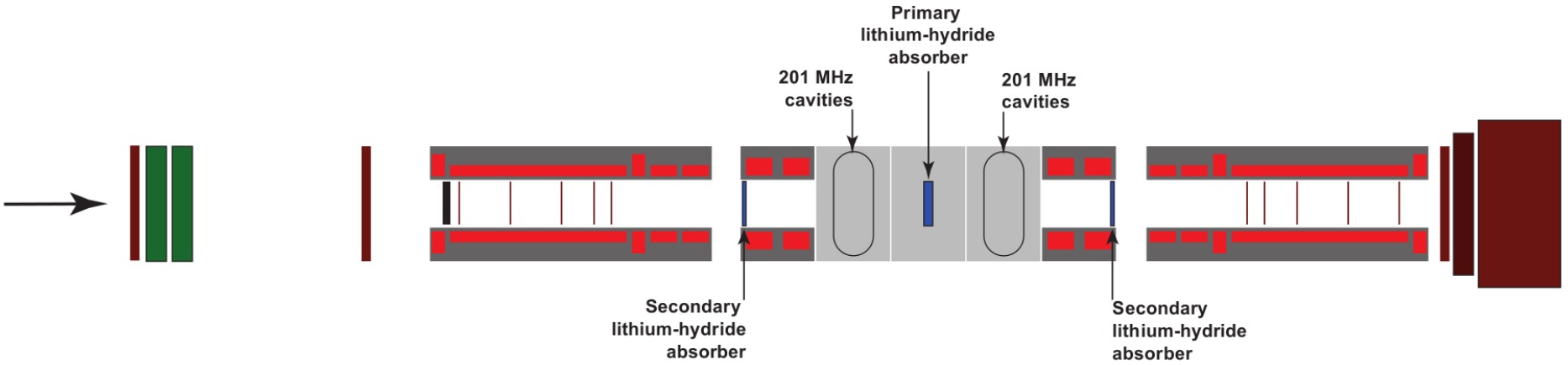
6D cooling

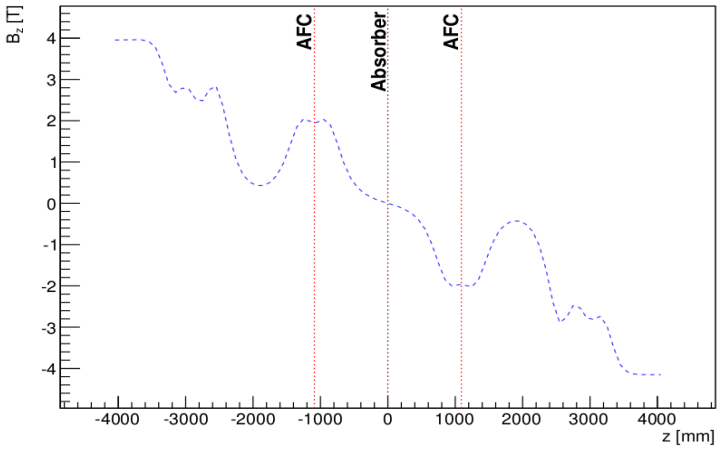


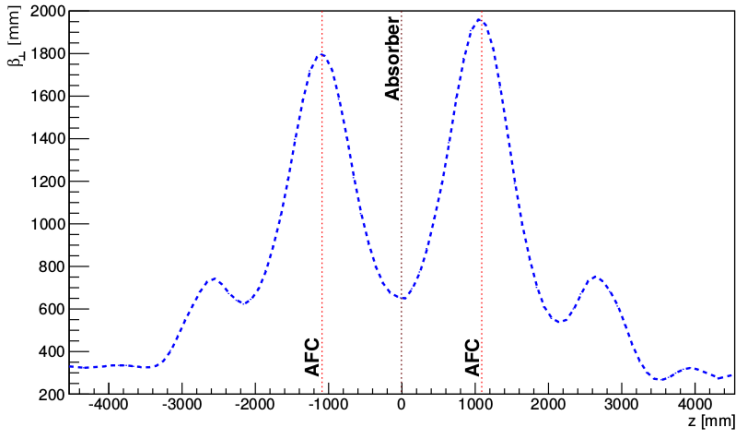


- 6D cooling performance is marginal
  - Increase in phase space density in the beam core
  - Aberrations in beam tails driven by high β in the FC
  - Longitudinal-transverse coupling
  - Not fully understood within the collaboration
- At best ~ 1 % effect
  - May not be measurable

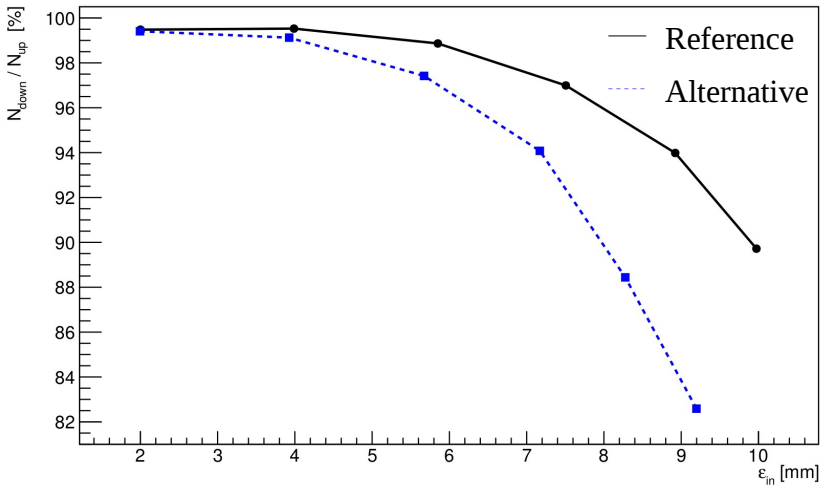
Alternative Design

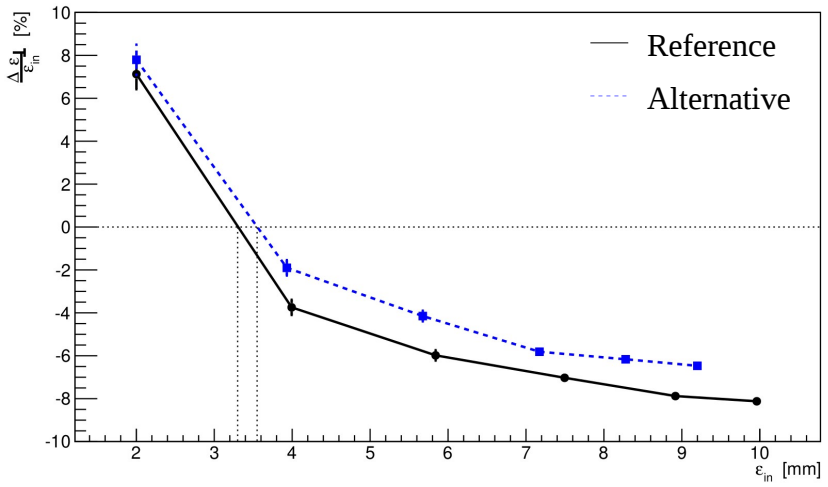






Performance





- Reference shows good cooling performance
  - Equilibrium emittance
- Reference performs better than alternative
  - Lower β function in reference FC results in better transmission
  - Lower β function at reference absorber results in better cooling
- Reference is currently preferred option

Conclusions

Parameter	Reference Lattice	Alternative Lattice
Equilibrium emittance (mm.rad)	3.30	3.55
Minimum transmission (%)	90	82
Observe $\varepsilon_\perp$ reduction	Yes	Yes
Demonstrate energy restoration	Yes	Yes

- MICE Demonstration of Ionisation Cooling will demonstrate
  - Reduction of transverse emittance
  - Energy recovery
- Marginal demonstration of 6D emittance reduction
- Performance is robust
  - Good range between equilibrium emittance and aperture