Emittance Exchange in MICE

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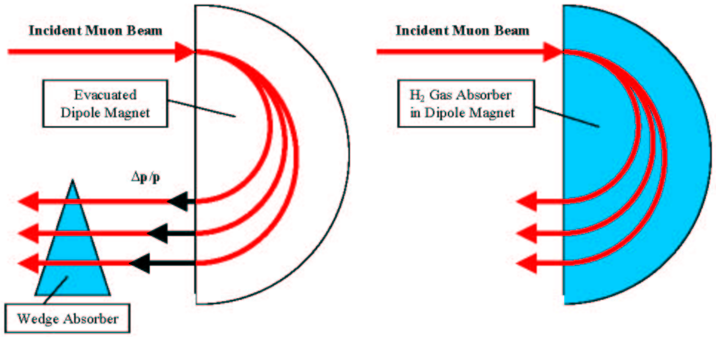
Emittance Exchange

- “Standard” MICE can only reduce transverse beam emittance
  - Slightly increases longitudinal emittance
- Aim: Exchange emittance from longitudinal to transverse space



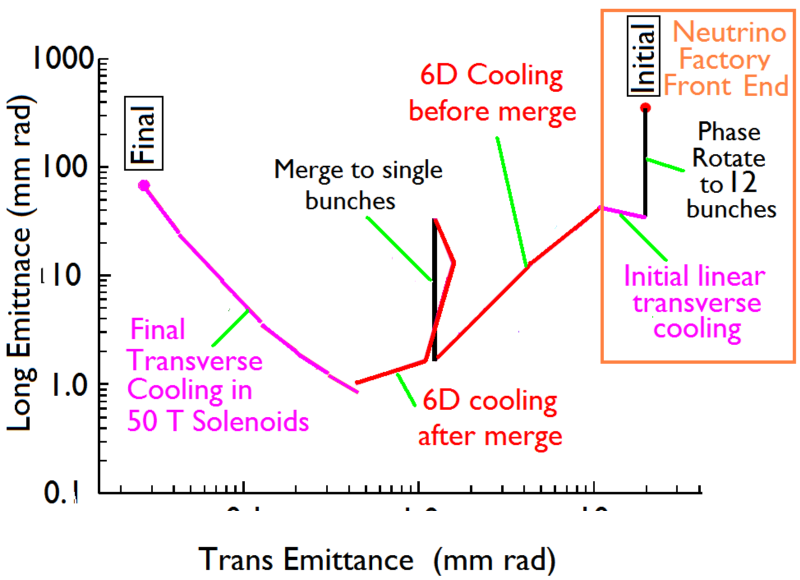
- In a dipole, fast particles go at higher radius
  - Introduce energy-position correlation, increasing beam width
  - Keep energy spread constant
- In a wedge, high radius particles lose more energy
  - Remove energy-position correlation, decreasing energy spread
  - Keep beam width constant
- Energy spread has decreased and beam width has increased
  - Emittance exchanged

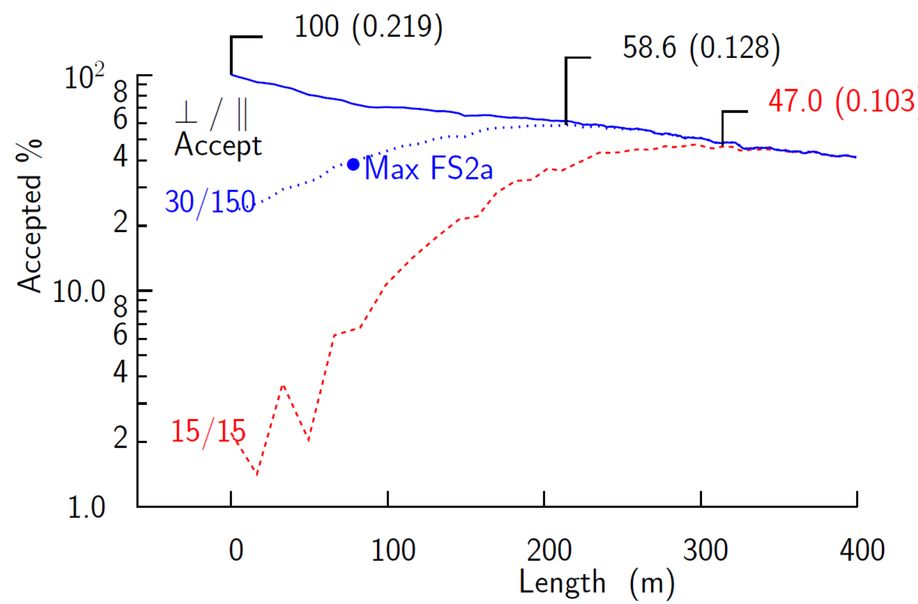
EmEx For Muon Accelerators

6D Cooling is Vital for a Muon Collider (MC)

And may be important for a Neutrino Factory (NF)

Under consideration in IDS-NF Muon Front End group

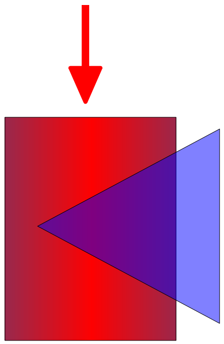


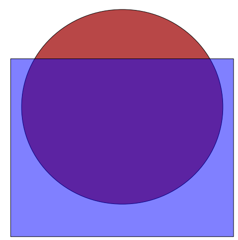


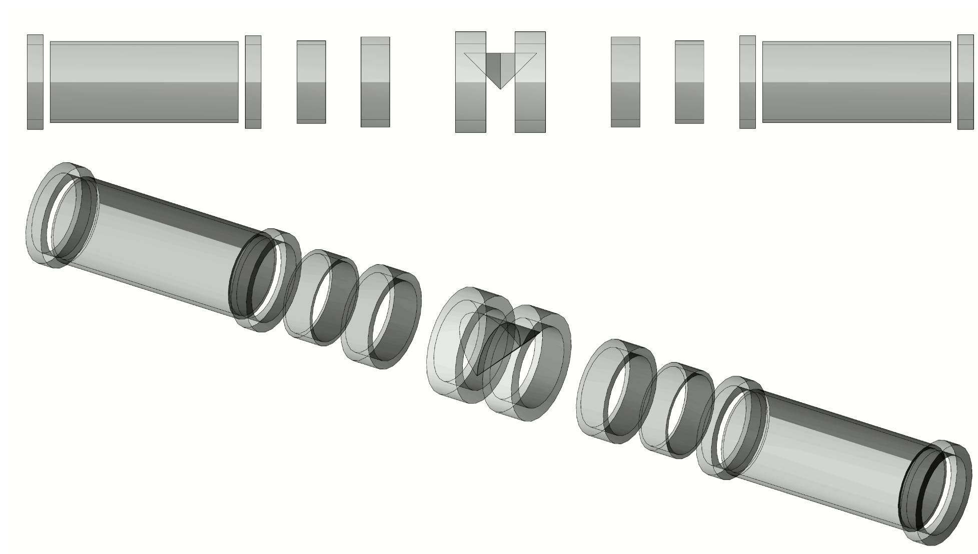
Wedge Geometry

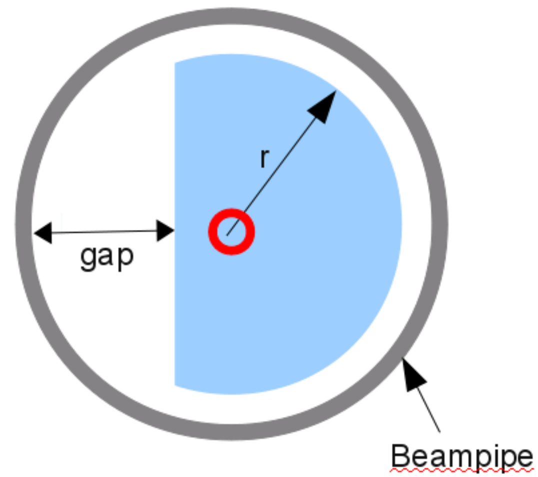
Geometry of wedge in MICE

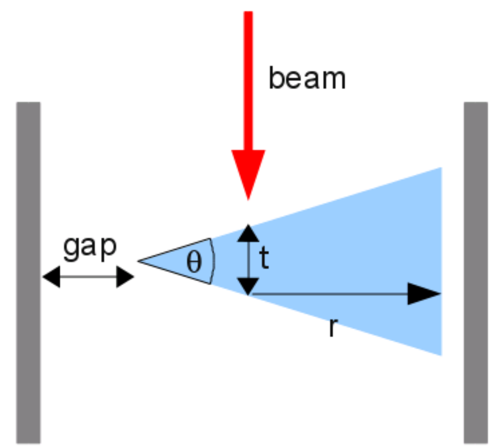
- Wedge is an intersection of a cylinder and a prism
- Introduce dispersion by beam selection











Aims and Methodology

Aims

- First priority is to observe longitudinal cooling
- Second priority is to observe longitudinal and 6D cooling
- Third priority is to observe transverse, longitudinal and 6D cooling
- Fourth priority is to get cooling over a broad range of conditions

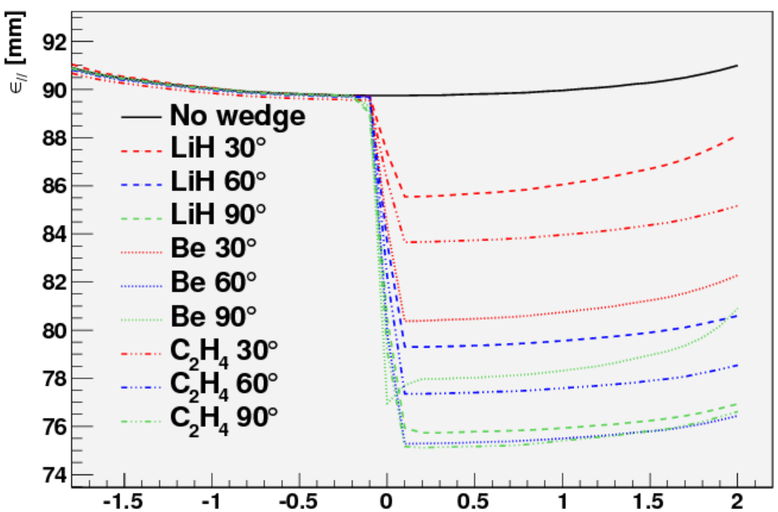
Candidate materials

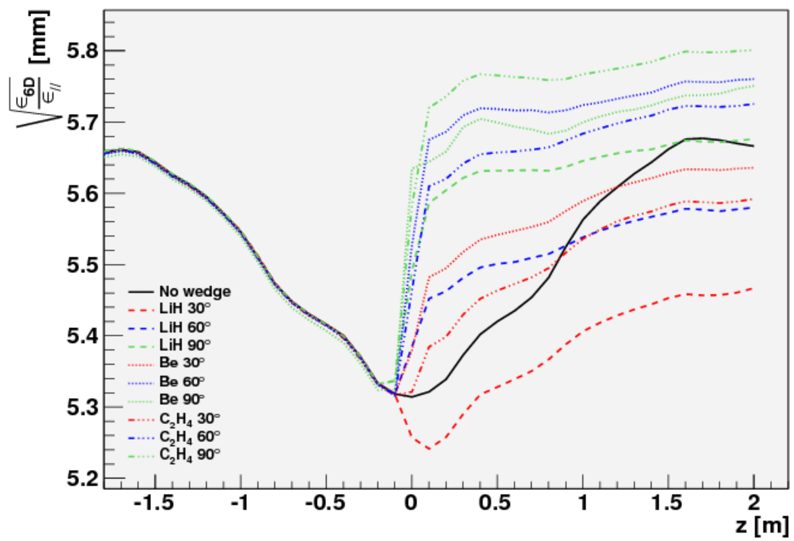
- For less scattering, would like low Z materials
- For less straggling, would like low Z/A materials
- Would like materials that might turn up in a MC/NF
- Cost/practicality also an issue
- Consider Be, LiH, Polyethylene $(C_2H_4)_n$

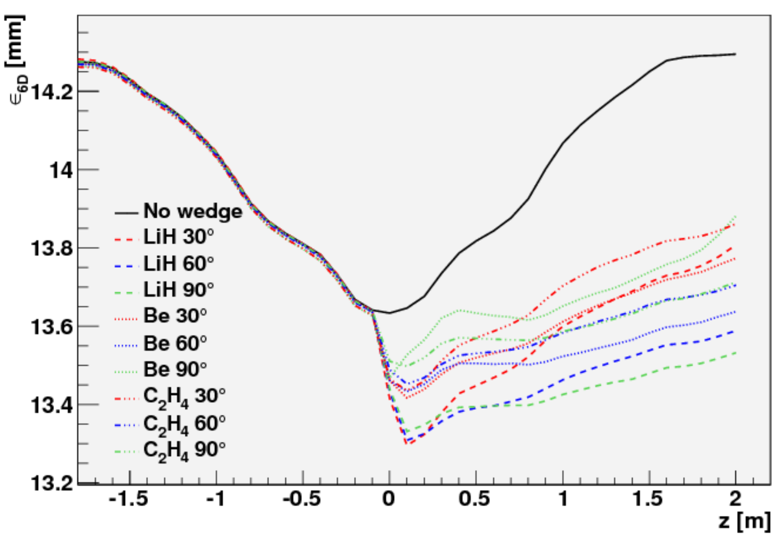
Candidate geometry

- Can handle any wedge opening angle up to about 90^o
  - I take this as a maximum (though might be able to go higher)
- Thickness chosen to give comparable energy loss to lH_2 absorber
  - Thicker wedges excite worse non-linearities

Cooling Signal at 6 mm



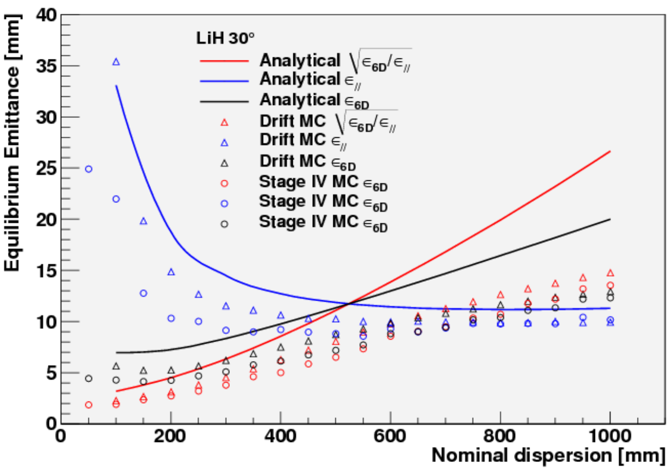


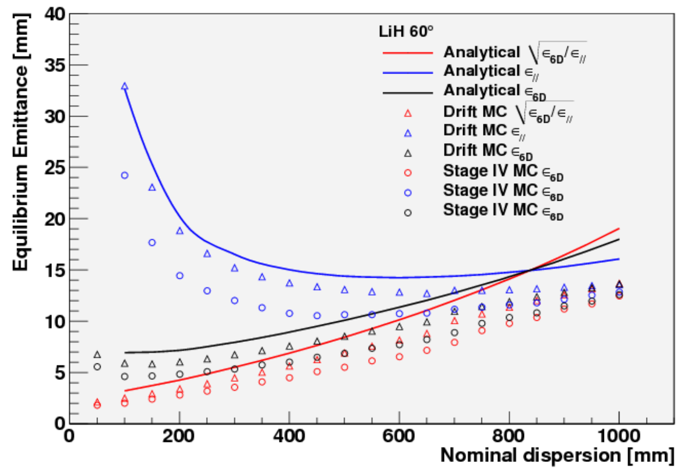


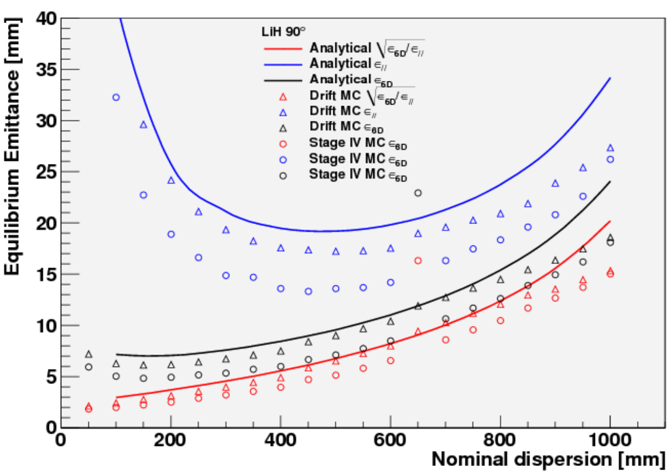
andard MICE beam”

- 6 mm transverse emittance
- Large 90 mm longitudinal emittance
  - 25 MeV energy spread
- 200 mm dispersion at the wedge

Equilibrium Emittance

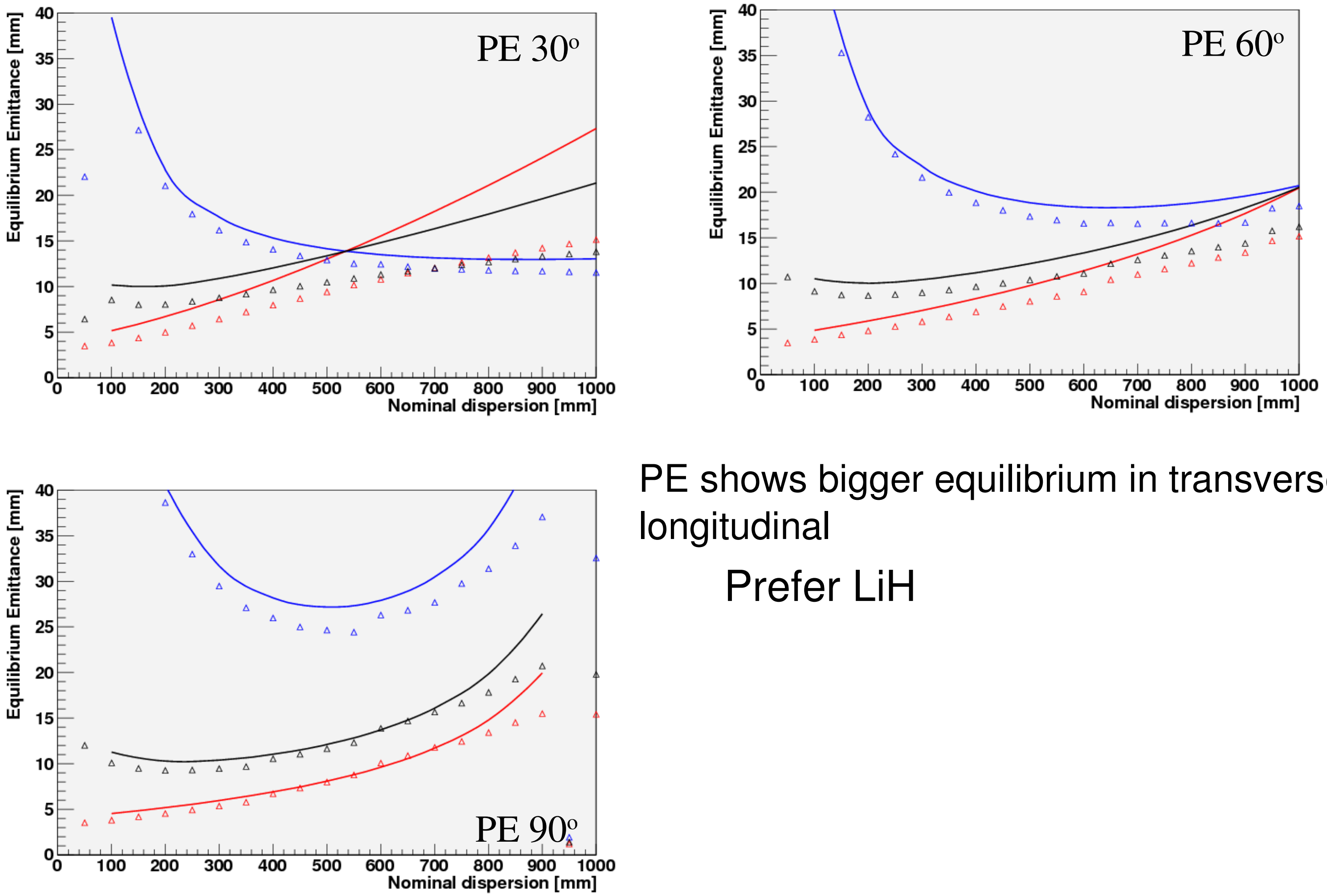






- Equilibrium emittance
  - Minimum beam emittance for cooling
  - "Quality" of wedge, independent of beam emittance
- Calculate analytically
  - Seed Monte Carlo for wedge only
  - Seed Step IV Monte Carlo

Equilibrium Emittance



PE shows bigger equilibrium in transverse and longitudinal

Prefer LiH

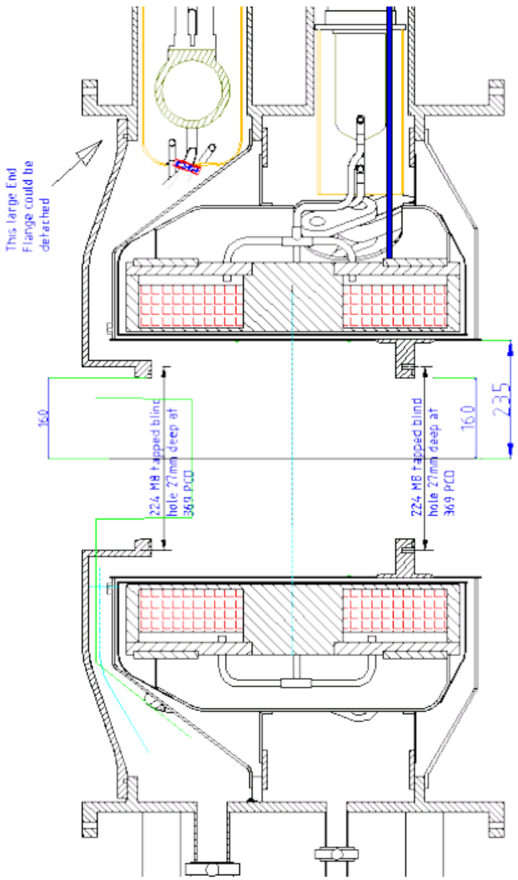
Wedge Choice

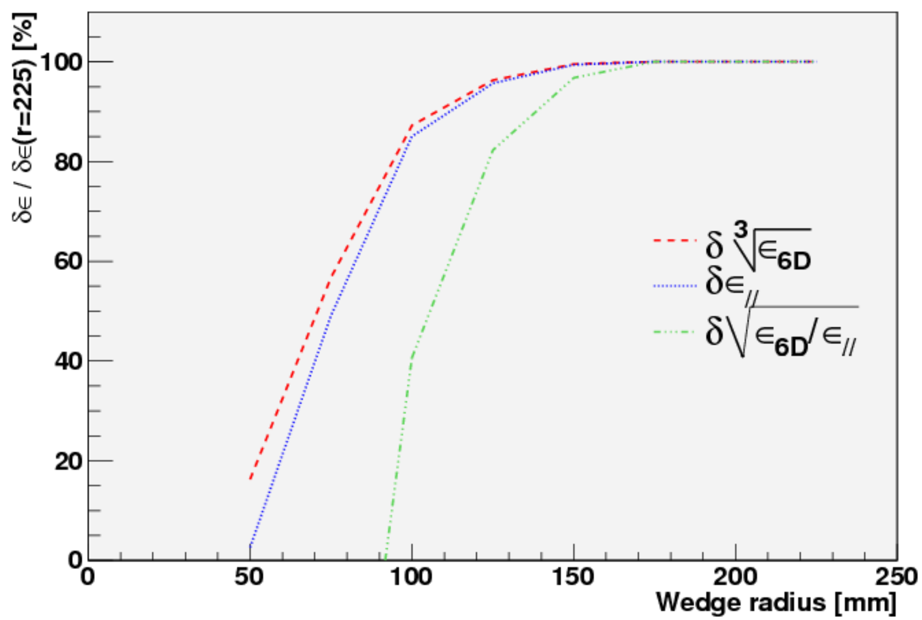
- 90^o LiH wedge promising
  - Good longitudinal emittance reduction
  - Transverse heating not too bad
  - Fulfils aim 1 and 2
  - Failing LiH, fall back is polyethylene
- 30^o LiH wedge promising
  - Some longitudinal emittance reduction
  - Some transverse emittance reduction
  - Fulfils aim 3
  - Failing LiH, fall back is polyethylene
- May want some Polyethylene wedges as well
  - Test a different material (aim 4)
- Beryllium performance is bad
  - Plus safety and handling issues
  - Discounted
- Note optical heating/cooling
  - Project emittance measurement to wedge?
  - Requires knowledge of fields

Caveats 1: Wedge Radius

What wedge radius can we tolerate?

Mounting flanges to 160 mm, looks ok

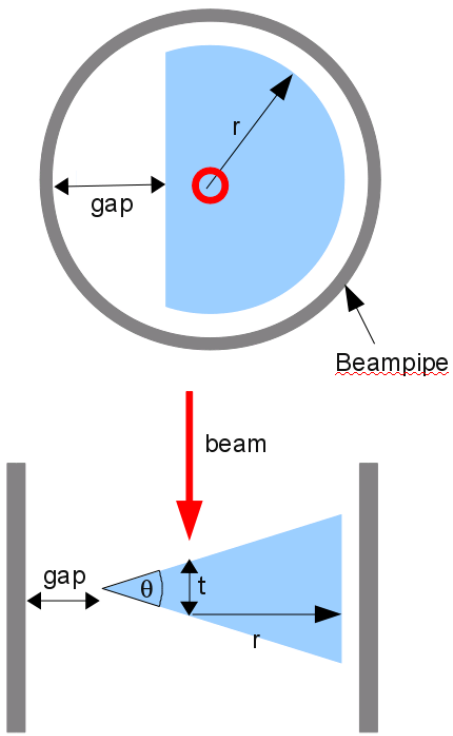


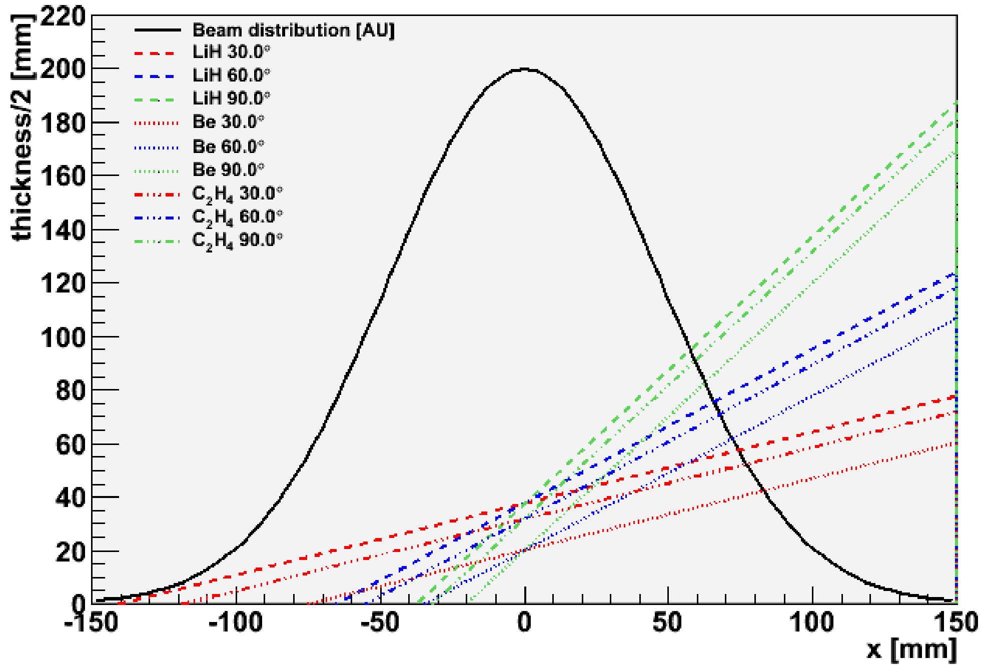


Caveat 2: Mind the Gap!

There is a gap between thin end of the wedge and beam pipe

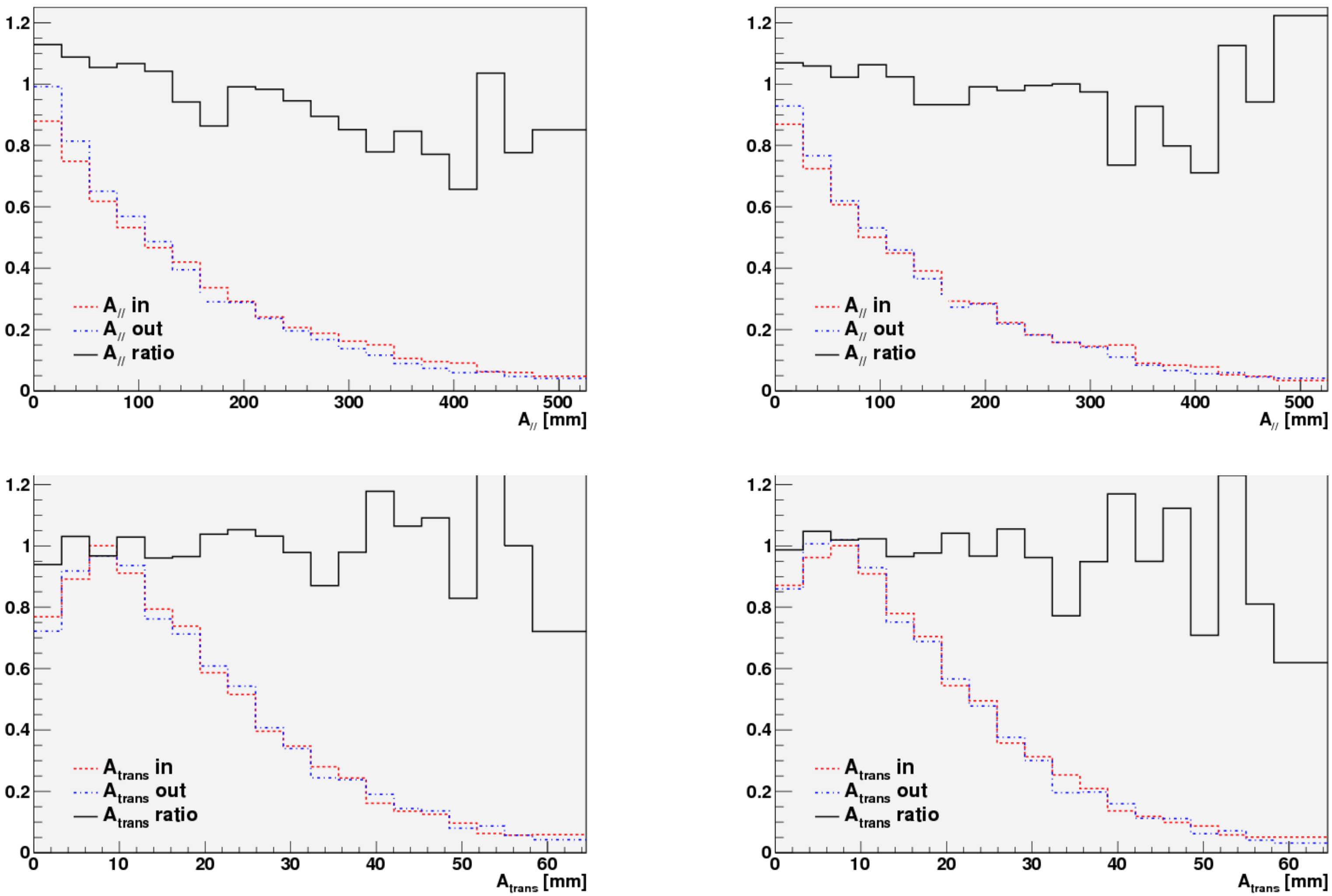
What effect?





Caveat 2: Mind the Gap!

no cut   cut



Practicalities

- Require about 3 weeks per run
  - 4-14 days to change target (need to confirm)
  - ~3 days of beam (3 emittance settings)
- We would want to do the experiment blinded
  - Some input needed from the software group
  - Weight upstream data without access to downstream data
    - Well maybe a small subsample to check data integrity
- Would like to be able to place wedge at any angle
  - Mass up to 20 kg => big torque

Practicalities

AFC Flange