Cooling Ring Concept

Chris Rogers,
ASTeC,
Rutherford Appleton Laboratory
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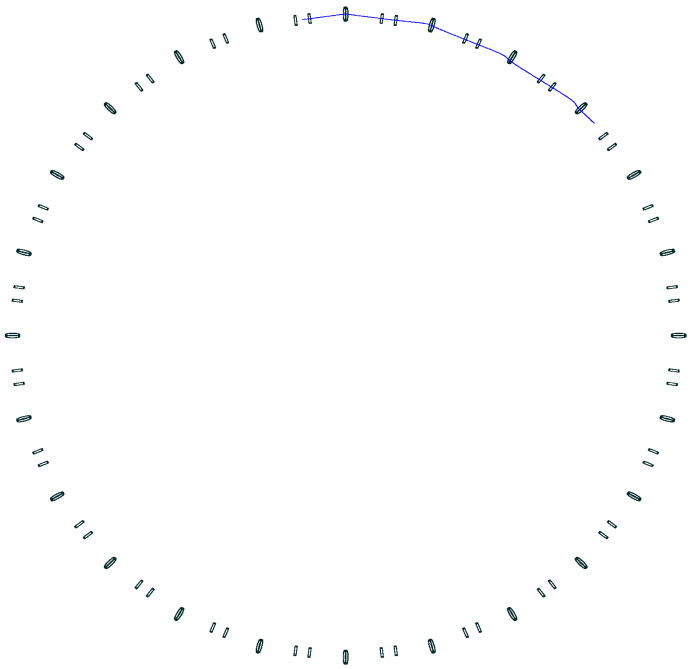
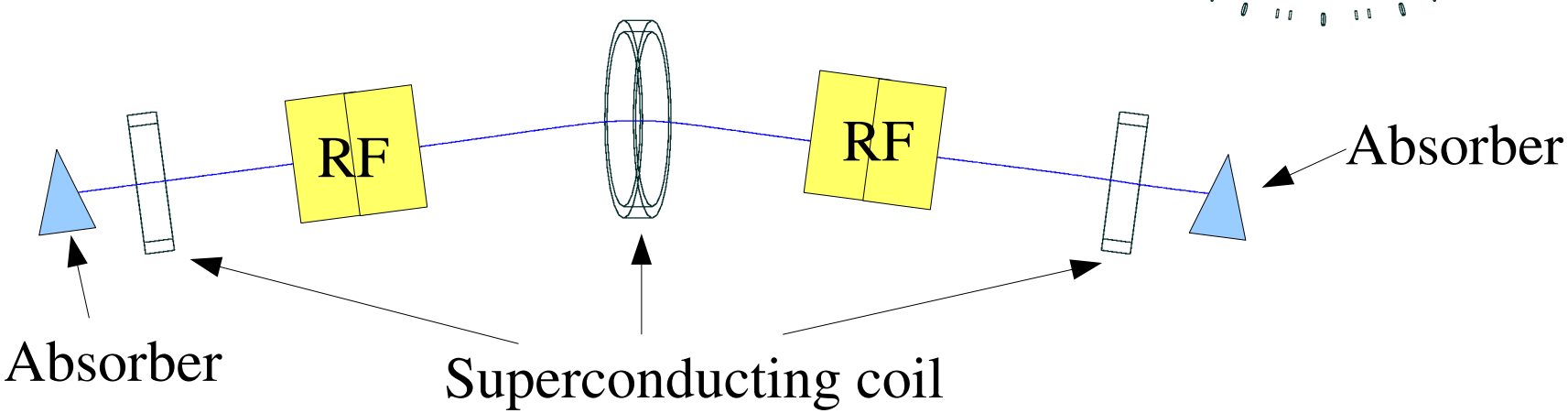
Cooling Ring Concept

- Cooling rings using tilted solenoids have been considered for 6D cooling
  - Shown to be very effective and cheap
  - But impossible to inject/extract beam
  - Very short, tight cooling lattice
- As part of work for dogbone cooler I developed a long cooling lattice
  - More spacious
  - If I could turn this into a ring, there would be room to inject/extract
- Consider cooling ring with tilted solenoids
  - Use tilt to produce bending field
  - Conventional dipoles are awkward because of extended solenoid fringe field
  - May choose to use dipoles either by careful optics or by shielding from the solenoid fringe field
- Nb: back of envelope indicates cost of ring = cost of ISS cooling

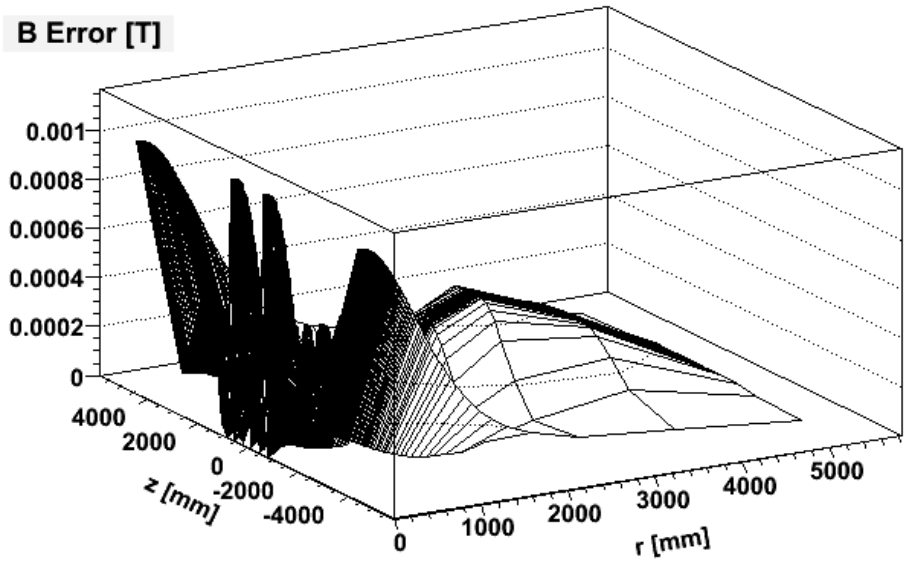
Cooling Ring Concept

- Current work in progress
  - 24 cells
  - 15° bend
  - ~10°-15° tilt
  - Only tilting central coil
- Cooling hardware only exists in powerpoint!
  - Still sorting out lattice optics
- All simulation is in G4MICE





Solenoid Mods

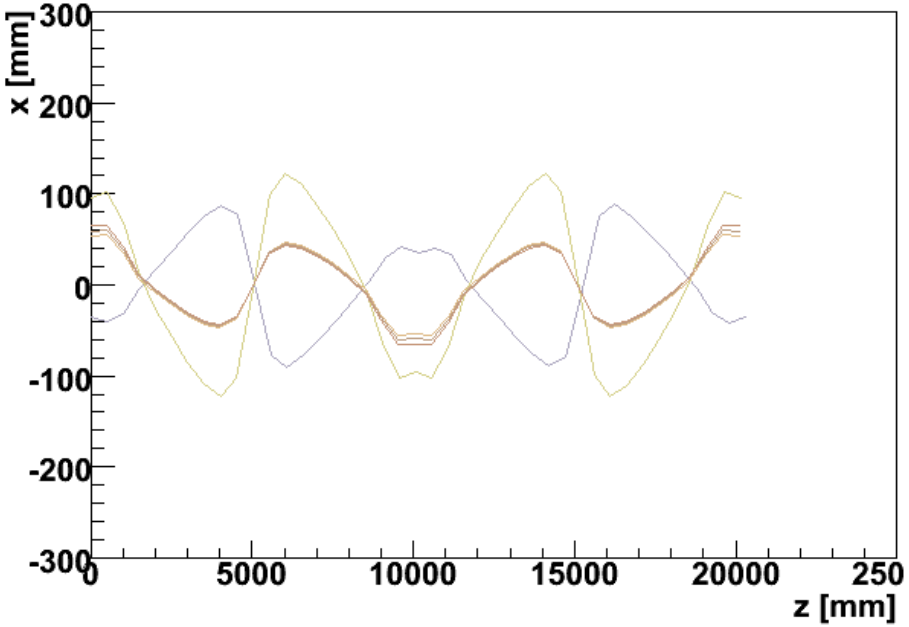


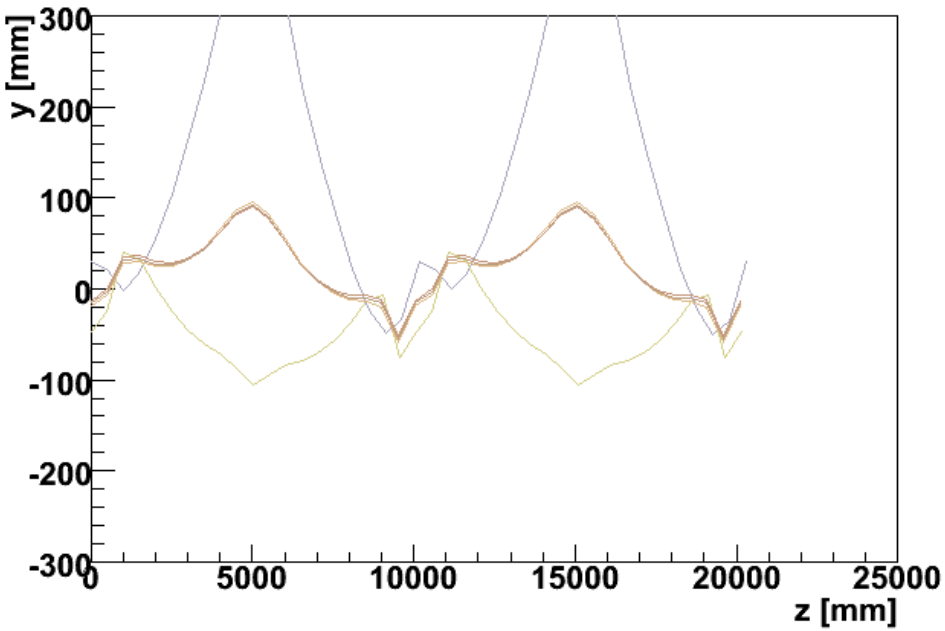
- Two issues with tilted solenoid ring field map
  - Tracking is sensitive to interpolation errors
  - Tracking is sensitive to extent of field map
- Constraining field map accuracy => very big field maps
- Dynamically select field map grid spacing and extent according to required field tolerance

Optics Algorithm

- Nicely automated optics algorithm to deal with full 6D coupling
  1. Use minimising package e.g. minuit to find closed orbit
     - Fire particles from beginning of cell to end of cell
     - Seek to minimise phase space vector between in and out
  2. Use tracking information to construct transfer map ***M***
     - Construct matrix ***U*** from tracks like $\begin{pmatrix} t+\delta t \\ E \\ x \\ p_x \\ y \\ p_y \end{pmatrix} \begin{pmatrix} t \\ E+\delta E \\ x \\ p_x \\ y \\ p_y \end{pmatrix} \begin{pmatrix} t \\ E \\ x+\delta x \\ p_x \\ y \\ p_y \end{pmatrix} \begin{pmatrix} t \\ E \\ x \\ p_x+\delta p \\ y \\ p_y \end{pmatrix} \begin{pmatrix} t \\ E+\delta E \\ x \\ p_x \\ y+\delta y \\ p_y \end{pmatrix} \begin{pmatrix} t \\ E+\delta E \\ x \\ p_x \\ y \\ p_y+\delta p \end{pmatrix}$
     - Fire tracks through cooling cell
     - Solve $\boldsymbol{M}\,\boldsymbol{U}_{in} = \boldsymbol{U}_{out}$ to get ***M***
  3. Solve transport equation to extract matched 6D covariance matrix ***V***
     - Solve $\boldsymbol{M}^T\,\boldsymbol{V}_{in}\,\boldsymbol{M} = \boldsymbol{V}_{out}$ with $\boldsymbol{V}_{out} = \boldsymbol{V}_{in}$
  4. Repeat over a range of momenta to get chromatic aberrations
  - I might like to extract spherical aberrations as well at some point
- Takes about 1 minute for each step
  - Next: put this into an optimiser to optimise lattice

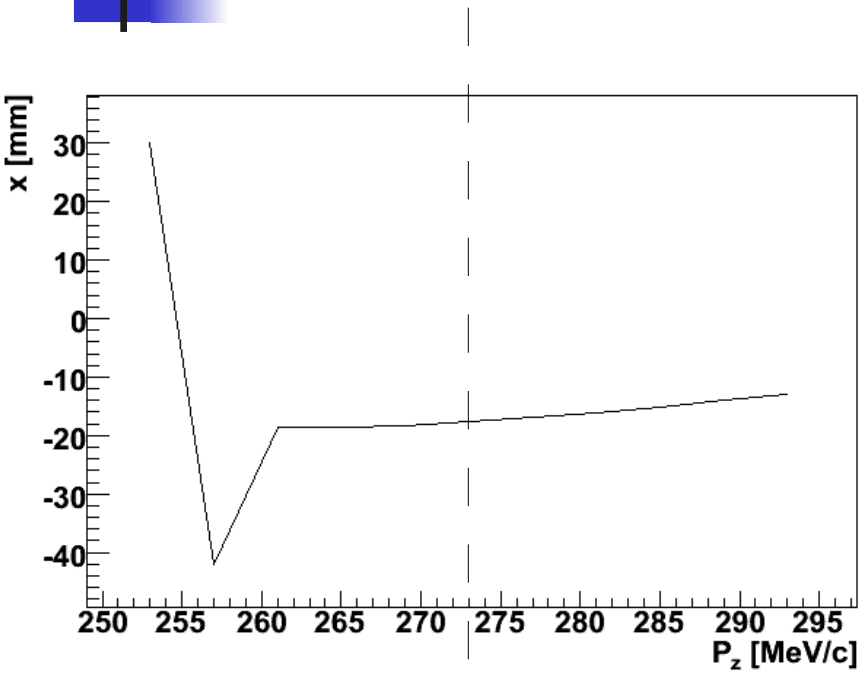
Closed Orbit vs Path Length

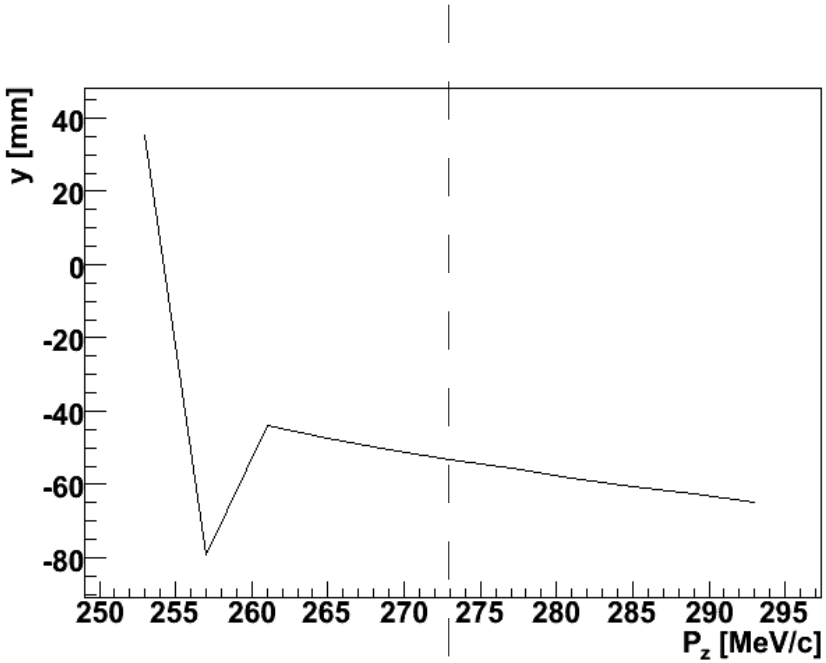




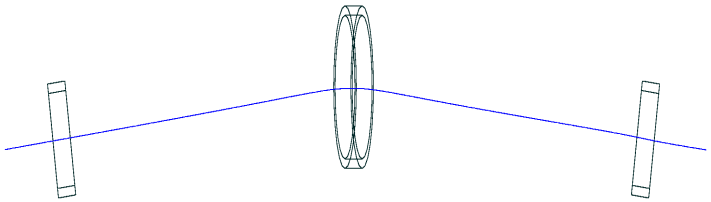
- Closed orbits for momenta between 250 – 290 MeV/c
  - Quite tightly bunched for momenta 260 – 290 MeV/c
  - Unstable below 260 MeV/c

Closed Orbit vs Momentum

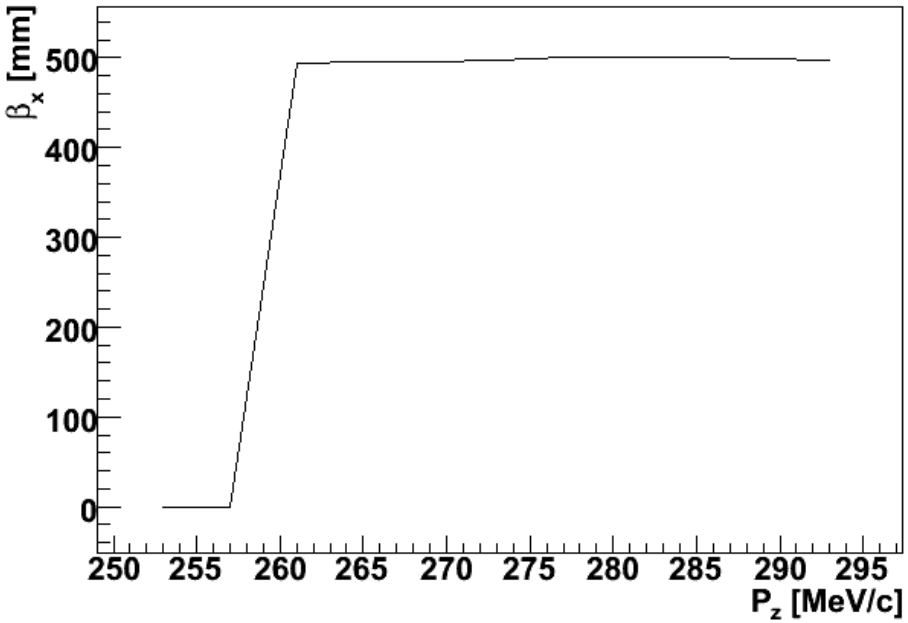


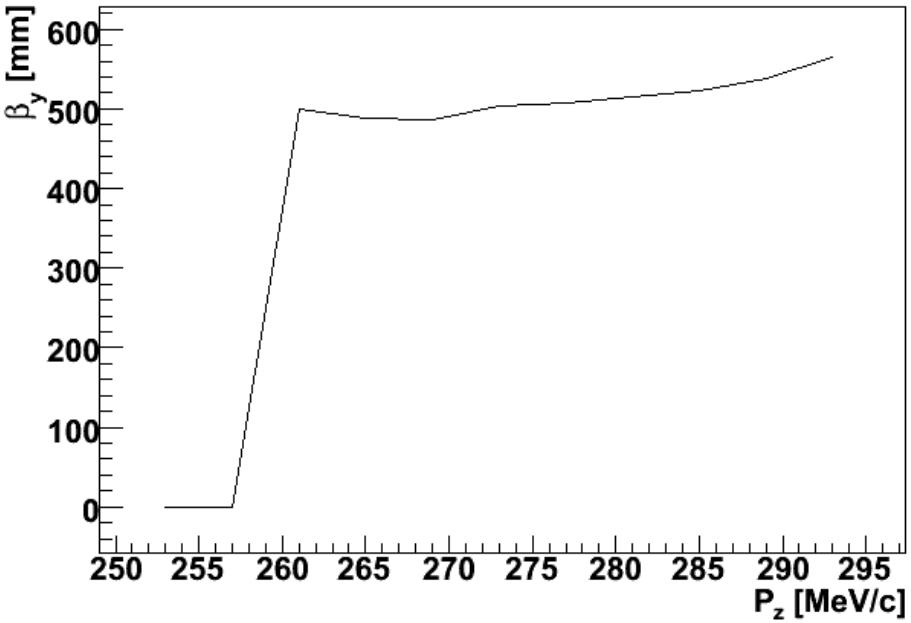


- Closed orbit at absorber moves by only ~20 mm over 30 MeV/c
  - If I want to put wedges in, I need to increase the dispersion here
  - At the moment I am tilting centre coil
  - May choose to tilt end coil
- Instability below ~ 260 MeV/c



Transverse optics



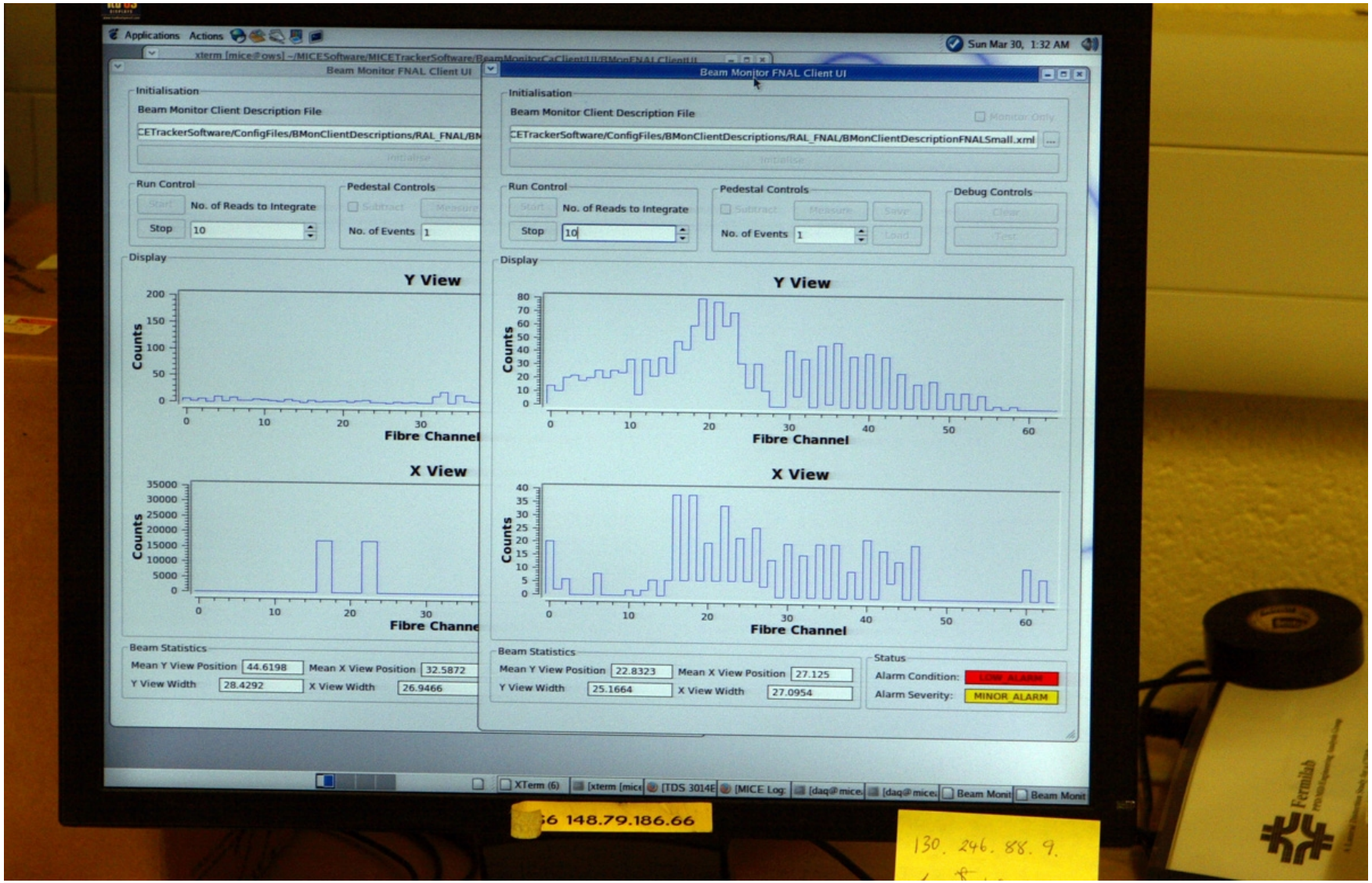


- Transverse optics looks quite reasonable
  - Quite achromatic above the instability
  - β ~ 500 is very reasonable for cooling
  - Momentum acceptance ~ 30 MeV/c is a little smaller than I would like

Continuing Work...

- An interesting candidate for a high energy cooling ring
  - Optics seems to be quite achromatic
  - I have not looked for spherical aberrations
- This has potential to make a cheap but efficient cooling channel
  - Very challenging to get a high emittance beam through
  - A kicker for this device would still be tough
- Would like to simulate full beam
- Would like to pursue aggressive optimisation

Finally…


Applications Actions
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Initialisation
Beam Monitor Client Description File
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Run Control
Start
Stop
No. of Reads to Integrate
10
Pedestal Controls
Subtract
Measure
Save
Load
No. of Events
1
Debug Controls
Clear
Test
Display
Y View
X View
Counts
Fibre Channel
Beam Statistics
Mean Y View Position
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Mean X View Position
27.125
Y View Width
25.1664
X View Width
27.0954
Status
Alarm Condition:
LOW_ALARM
Alarm Severity:
MINOR_ALARM
148.79.186.66
130. 246. 88. 9.