



# Cooling Simulation Update

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Science & Technology Facilities Council

ISIS Neutron and Muon Source

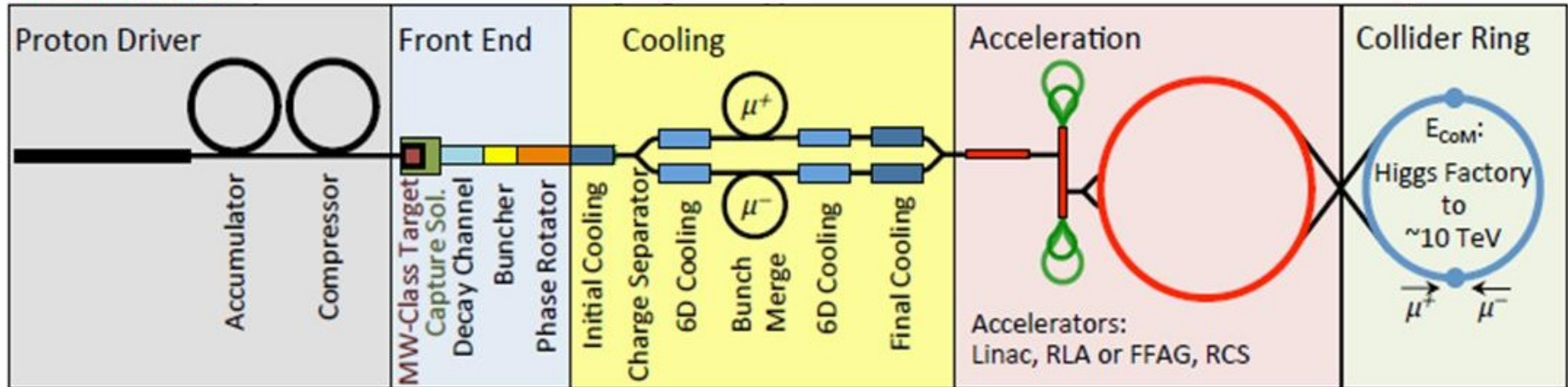
C. T. Rogers

ISIS

Rutherford Appleton Laboratory

# Muon Collider Facility

## Muon Collider



- Reminder – muon collider facility (proton-based)
    - Protons on target in high-field solenoid  $\rightarrow$  pions, muons et al.
    - **Clean up beam impurities**
    - **Capture muons longitudinally**
    - **Transverse and longitudinal cooling**
    - Acceleration
    - Collider ring
- } Capture and cooling Working group

# Job List

- Get hold of lattices
- Check they run and we can reproduce results
- Establish where lattices are missing or incomplete
- Develop and maintain hardware requirements
  - Liaise with magnet and RF teams as required
- Work on improving performance
  - Especially final cooling
- Identify technical issues/risks
- Work on mitigating risk
  - What experimental data/demonstrations do we need?
  - (MICE Results)
- Cost optimisation
  - E.g. rings
- **Please let me know if you would like to help!**

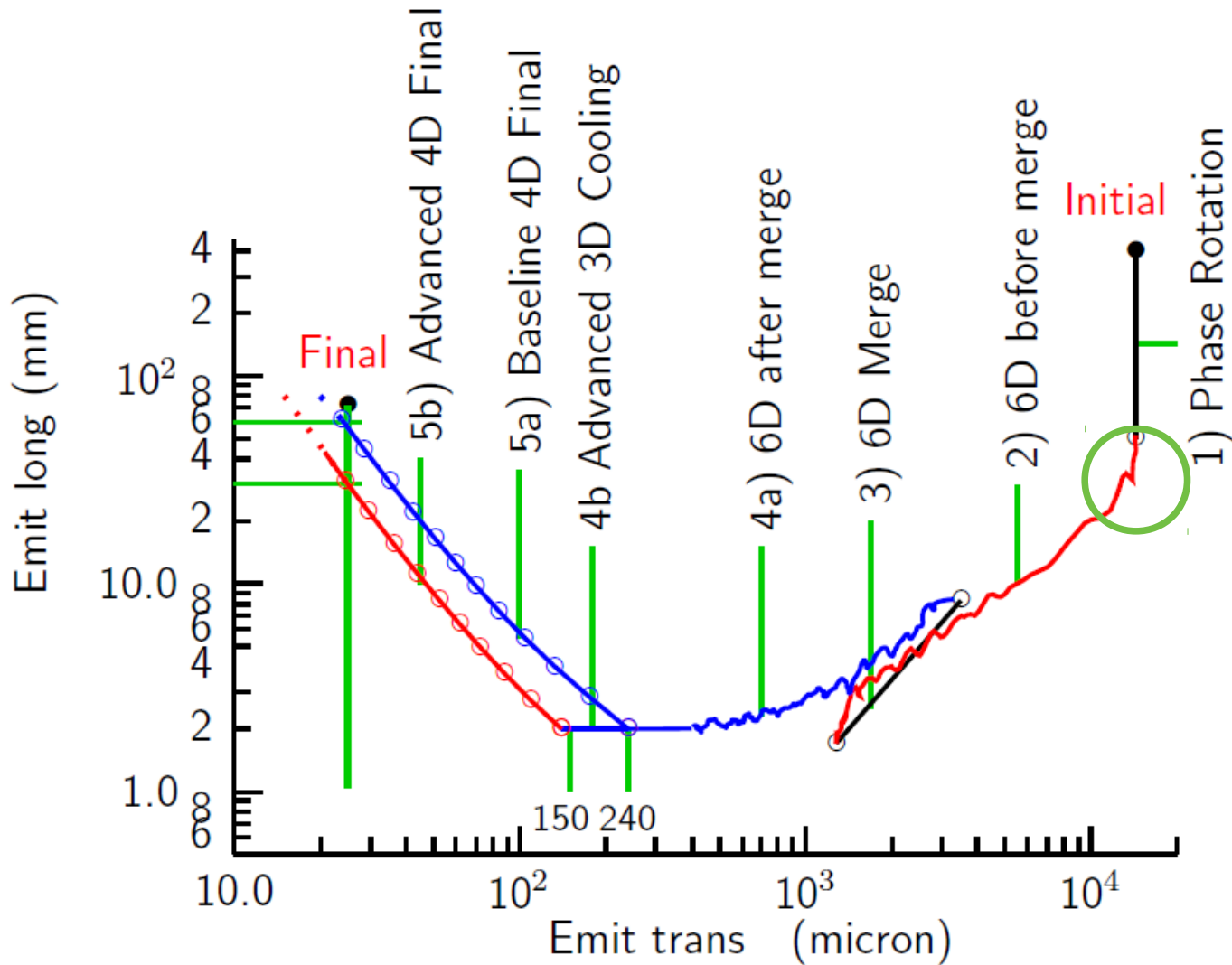


# Lattices, etc

Subsection	Designer	Reference	Lattice Files
<b>Capture</b>			
Particle Selection	Scott Berg	Proc. IPAC2014 TUPME022	With Rogers – checked
Buncher	Dave Neuffer?	<a href="https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4355">https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4355</a>	?
Phase Rotator	Dave Neuffer?	<a href="https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4355">https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4355</a>	?
<b>Initial Cooling</b>			
HfoFo – gas filled	Yuri Alexahin	<a href="https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4377">https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4377</a>	With Rogers – checked
HfoFo – vacuum	Yuri Alexahin	<a href="https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4377">https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4377</a>	?
<b>Charge Separation</b>			
Charge Separation	Cary Yoshikawa	<a href="https://www.osti.gov/biblio/1113648">https://www.osti.gov/biblio/1113648</a>	?
<b>6D Cooling</b>			
Rectilinear	Diktys Stratakis	<a href="https://journals.aps.org/prab/abstract/10.1103/PhysRevSTAB.18.031003">https://journals.aps.org/prab/abstract/10.1103/PhysRevSTAB.18.031003</a>	With Rogers – not run
Helical snake	Katsuya Yonehara	<a href="https://iopscience.iop.org/article/10.1088/1748-0221/13/09/P09003">https://iopscience.iop.org/article/10.1088/1748-0221/13/09/P09003</a>	With Katsuya
<b>Bunch Merge</b>			
Phase Rotator and trombone	Yu Bao	<a href="https://journals.aps.org/prab/abstract/10.1103/PhysRevAccelBeams.19.031001">https://journals.aps.org/prab/abstract/10.1103/PhysRevAccelBeams.19.031001</a>	?
<b>6D Cooling</b>			
Rectilinear	Diktys Stratakis	<a href="https://journals.aps.org/prab/abstract/10.1103/PhysRevSTAB.18.031003">https://journals.aps.org/prab/abstract/10.1103/PhysRevSTAB.18.031003</a>	With Rogers – not run
Helical snake	Katsuya Yonehara	<a href="https://iopscience.iop.org/article/10.1088/1748-0221/13/09/P09003">https://iopscience.iop.org/article/10.1088/1748-0221/13/09/P09003</a>	With Katsuya
<b>Final Cooling</b>			
Linear Cooling	Hisham Sayed	<a href="https://journals.aps.org/prab/abstract/10.1103/PhysRevSTAB.18.091001">https://journals.aps.org/prab/abstract/10.1103/PhysRevSTAB.18.091001</a>	?
PIC	James Maloney?	<a href="https://arxiv.org/pdf/1401.8256.pdf">https://arxiv.org/pdf/1401.8256.pdf</a>	?
Potato slicer	Don Summers?	<a href="https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4403">https://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4403</a>	



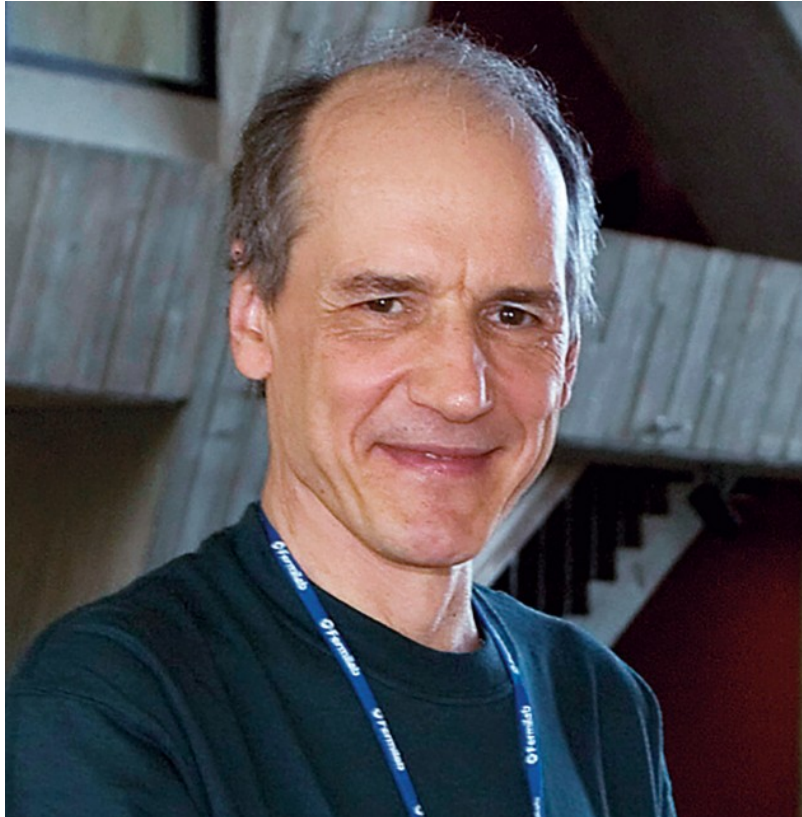
# Lattices, etc





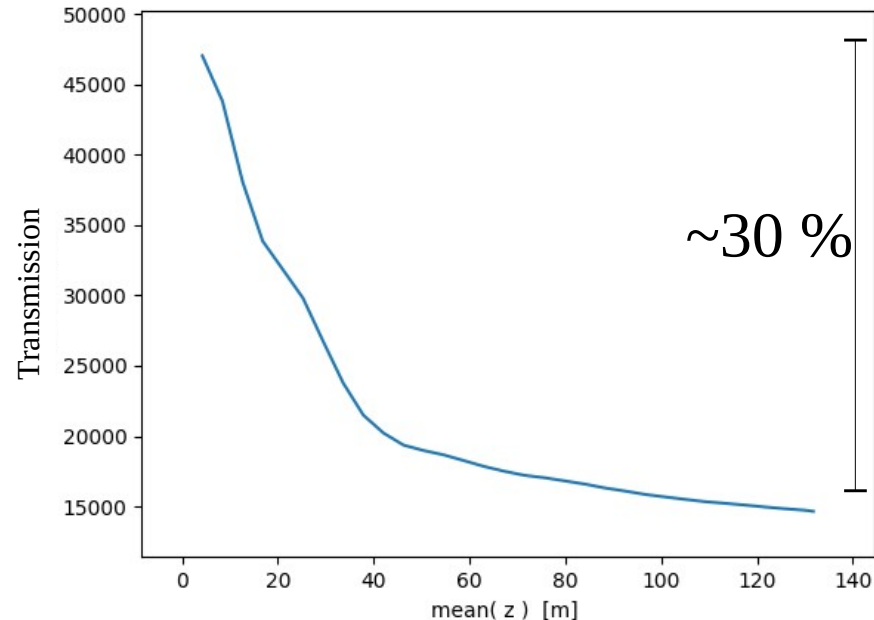
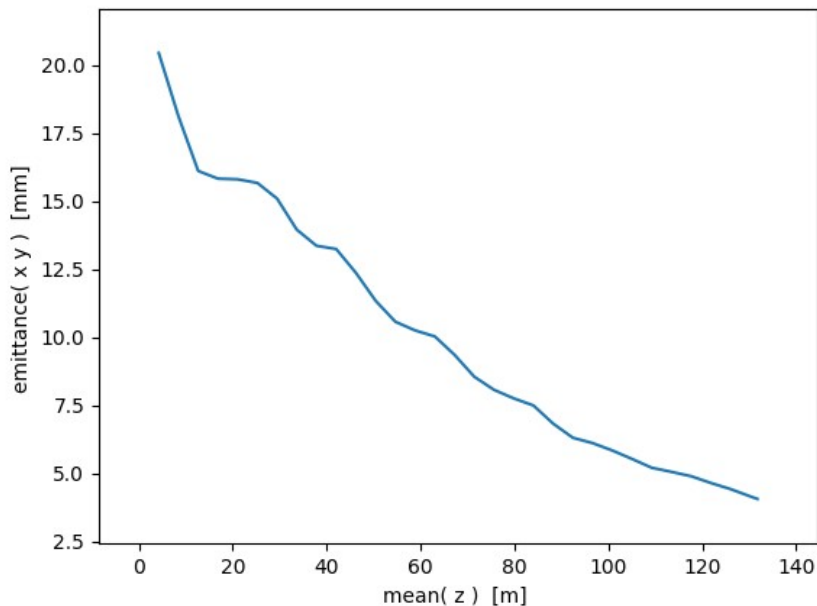
# Yuri Alexahin

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- Last time: Take beam from the front end
- Last time: Track beam in cut through HfoFo lattice
  - Mismatch between 1.5 T and 2 T fields
    - Clearly needs fixing! Transverse mismatch







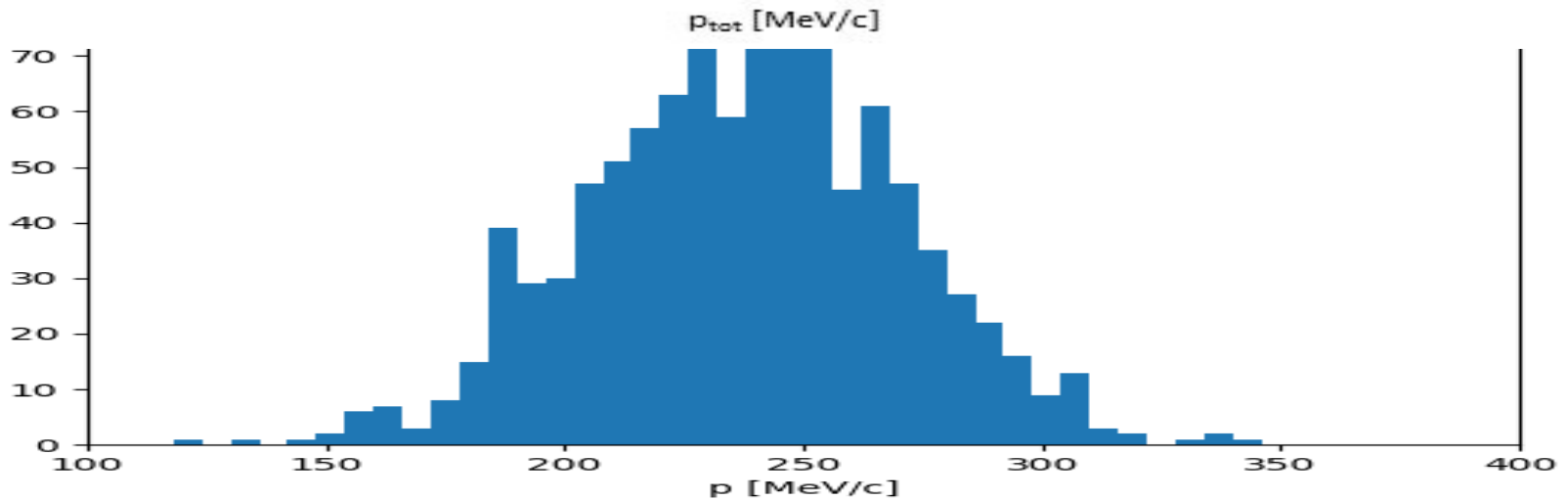
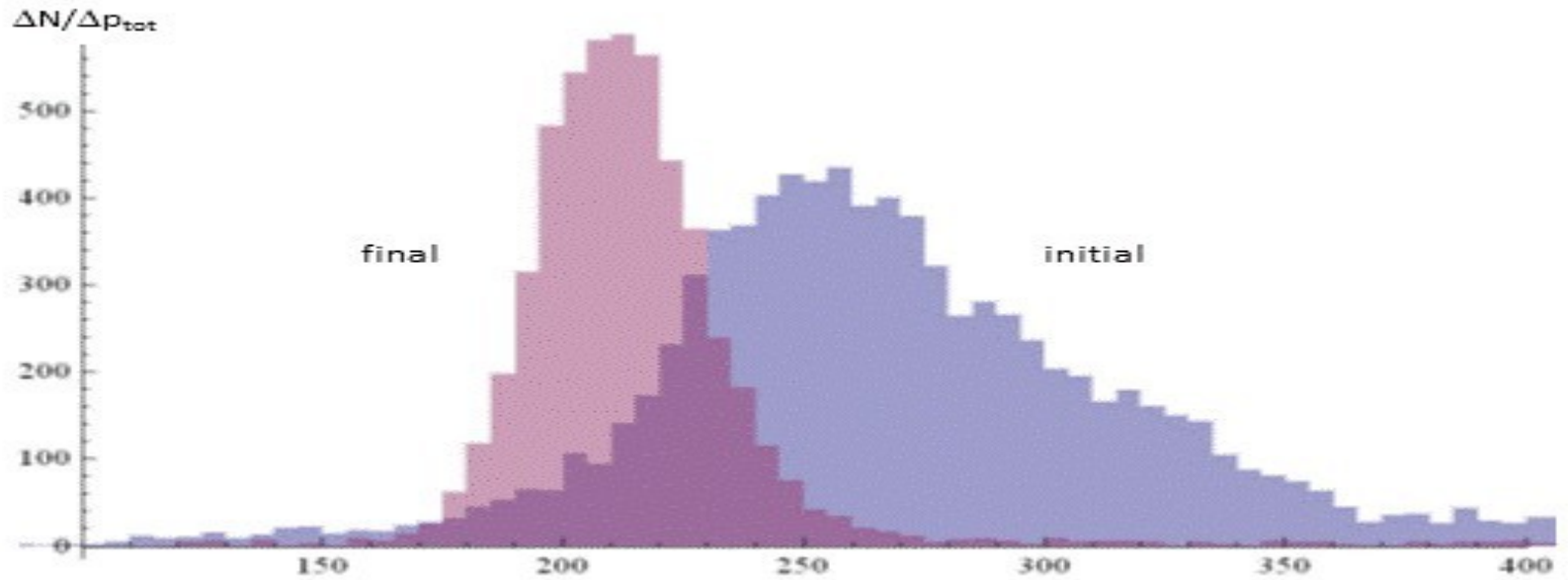
# Input beam

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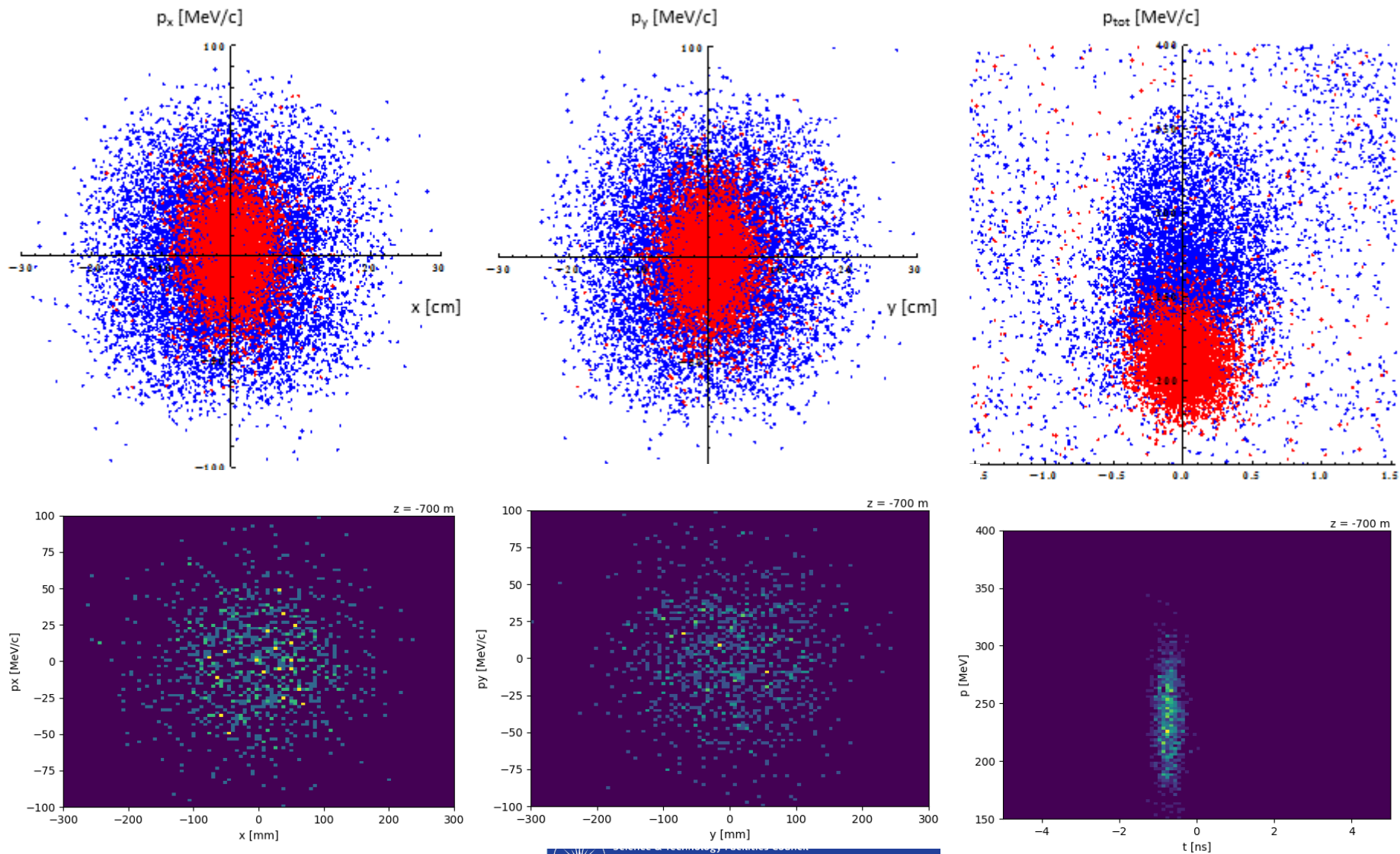
- Ideal input beam
- Multivariate gaussian
  - Matched to 2 T field
    - → x and y cylindrical symmetry
    - Transverse  $\beta \sim 700$  mm
    - Angular momentum ( $x$ - $p_y$  and  $y$ - $p_x$  correlation)
  - Upright longitudinal
    - $\sim 0.2$  ns time spread
    - $\sim 30$  MeV energy spread
    - Mean momentum 258 MeV/c



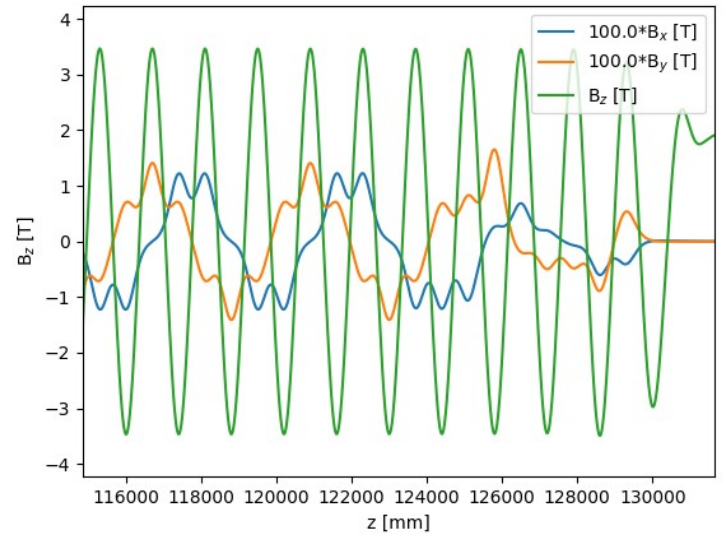
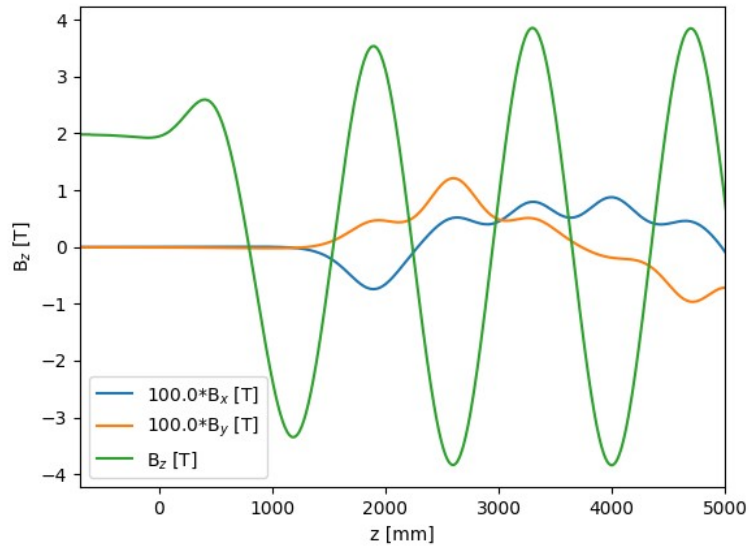
# Momentum spread



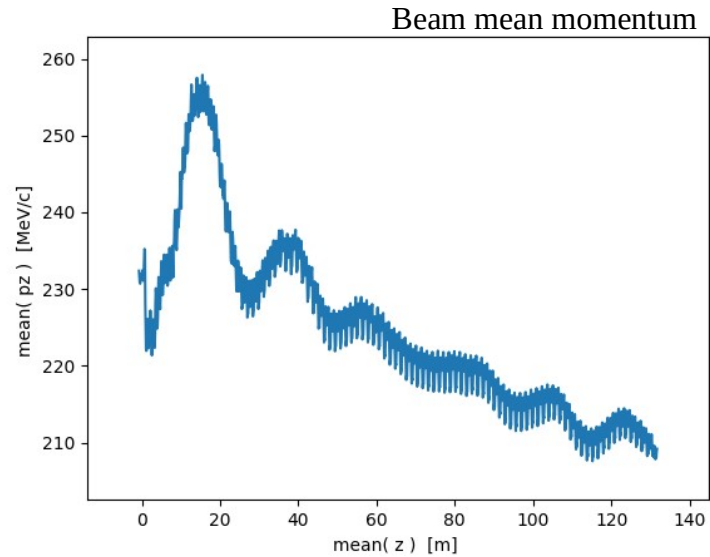
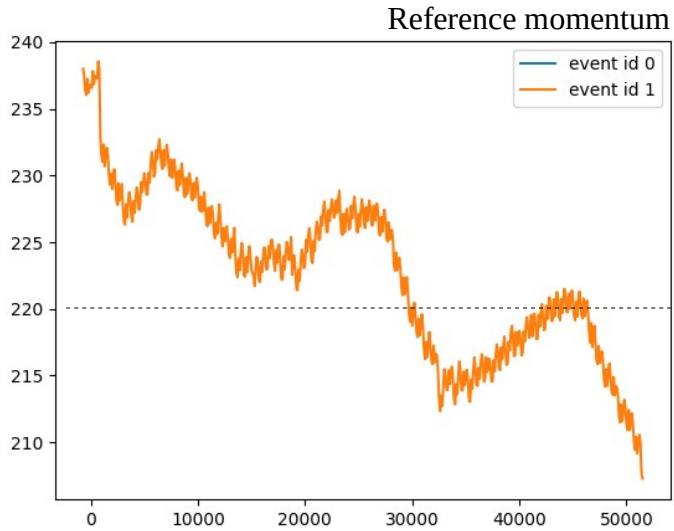
# Phase space



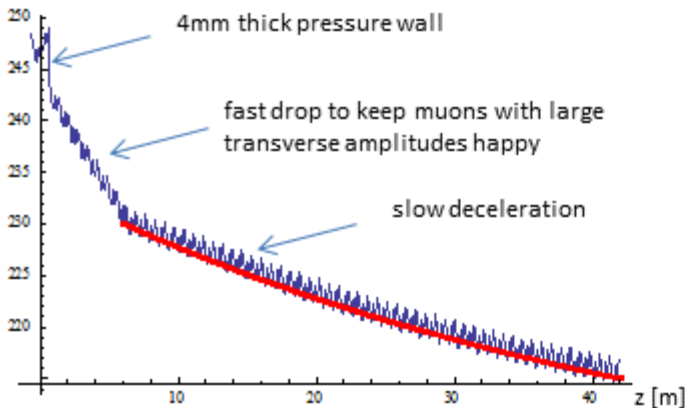
# Fields



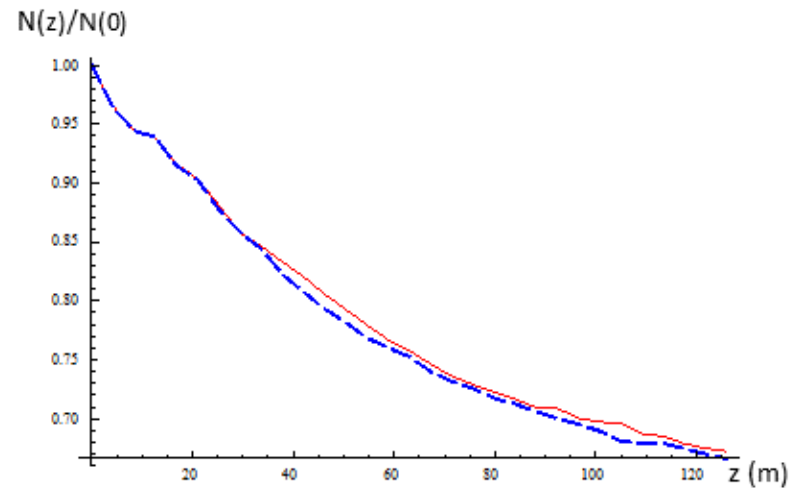
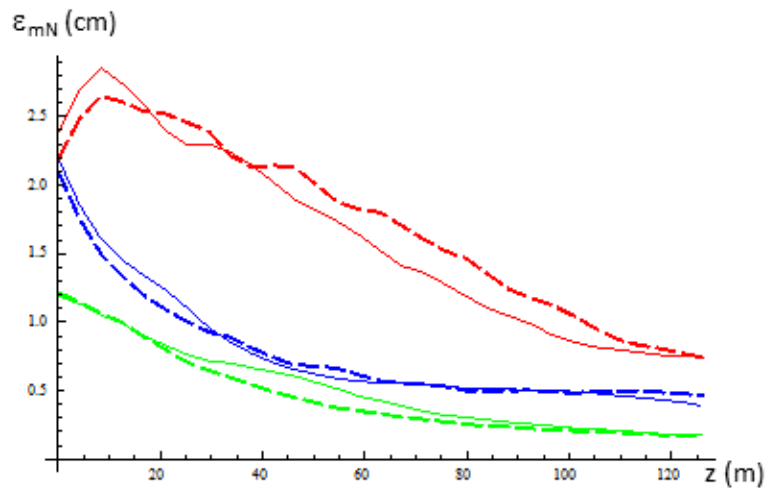
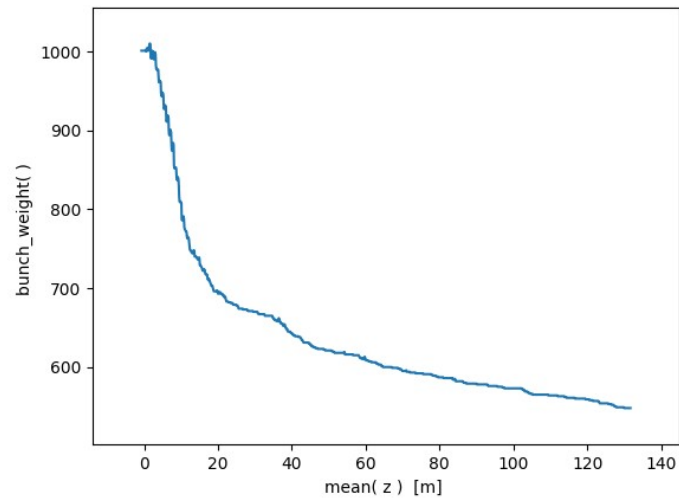
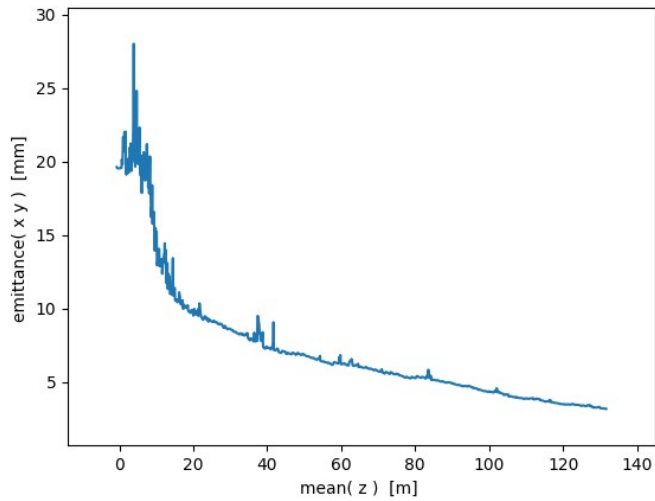
# Reference Momentum



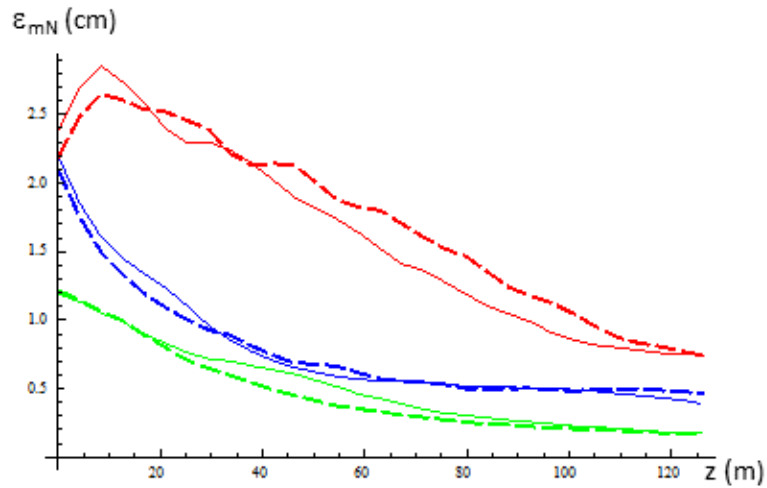
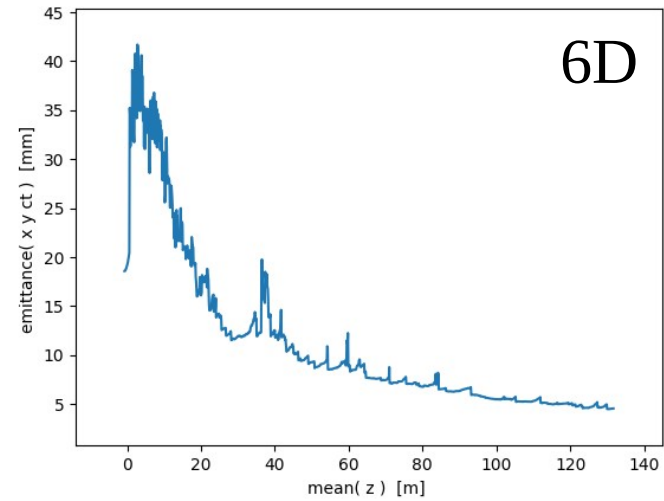
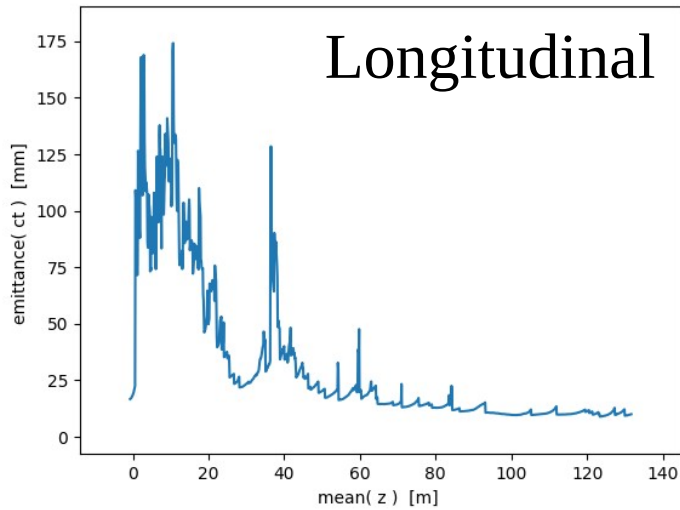
$p_0$  [MeV/c]



# Phase space



# Phase space





# Conclusion

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- Performance of HFoFo is closer to design by taking an ideal beam
  - Note that front end was mismatched to HFoFo before
- May be able to improve things by taking a different momentum bite
  - Consider retuning RF phases
- Implement proper decoupled analysis

