



# Capture and Cooling Working Group Summary and Progress

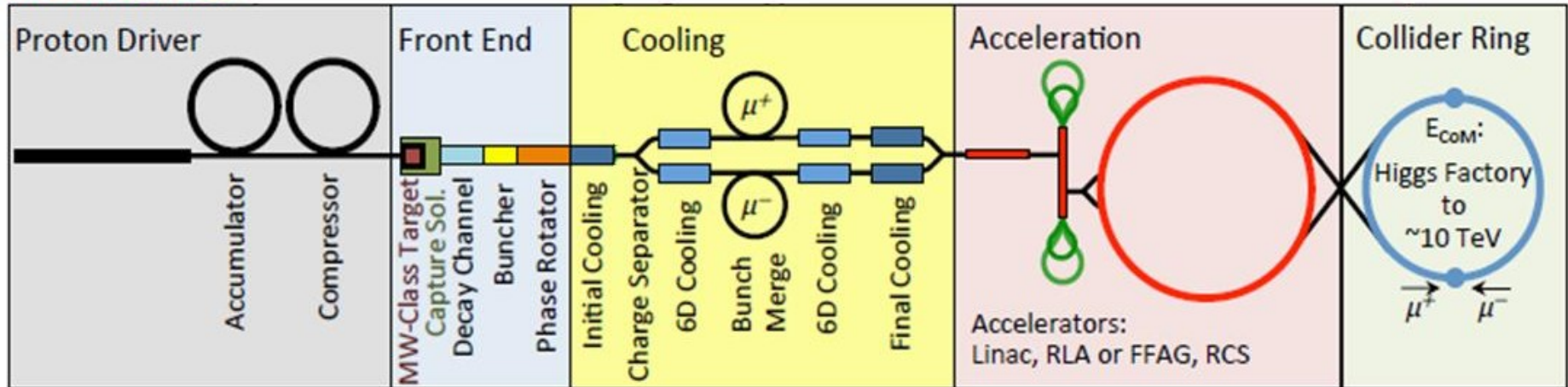
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C. T. Rogers  
ISIS  
Rutherford Appleton Laboratory

# Muon Collider Facility

## Muon Collider



- Reminder – muon collider facility (proton-based)
    - Protons on target in high-field solenoid → 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!**



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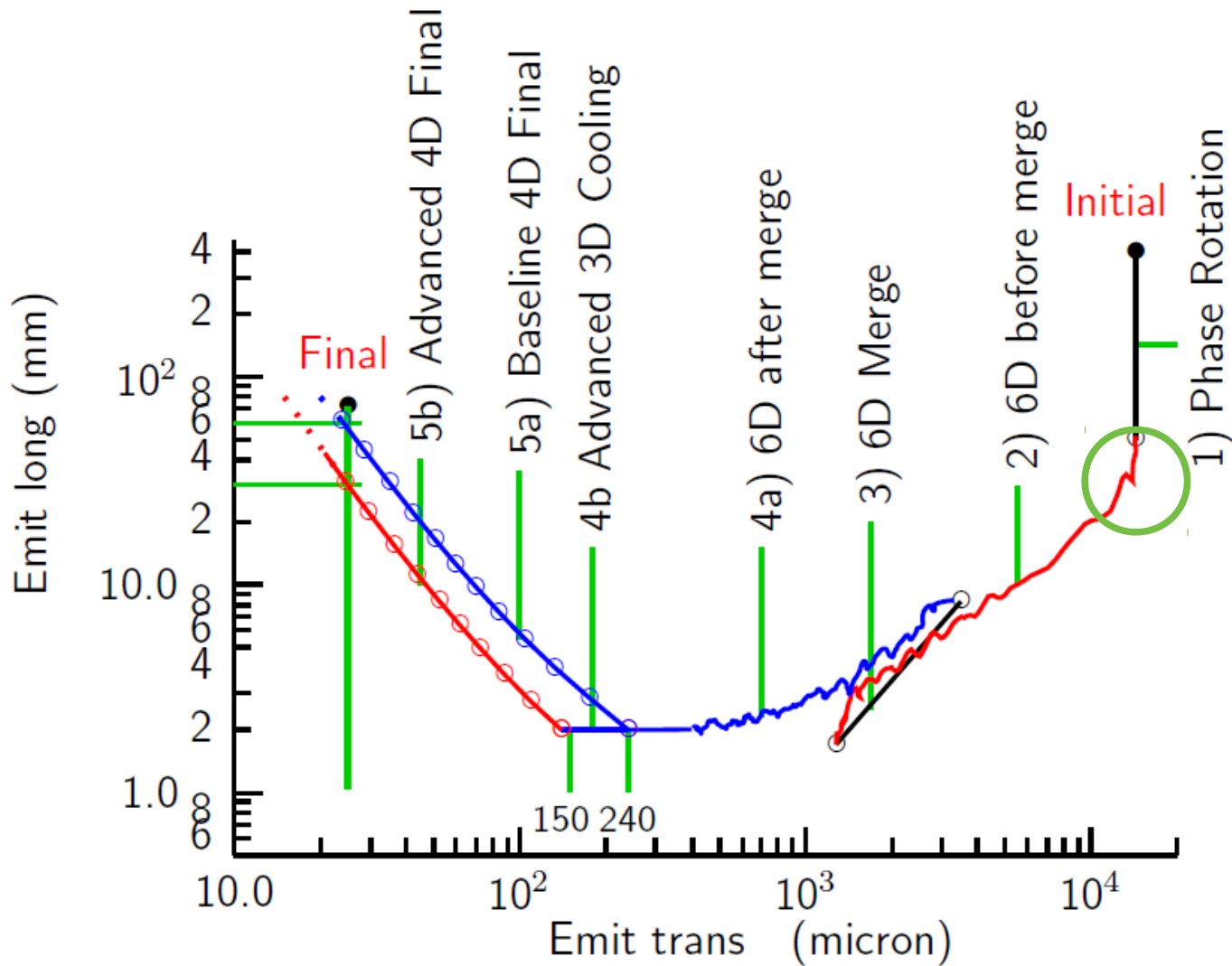


# Lattices, etc

| 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> | ?                     |
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| <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>                                 |                       |



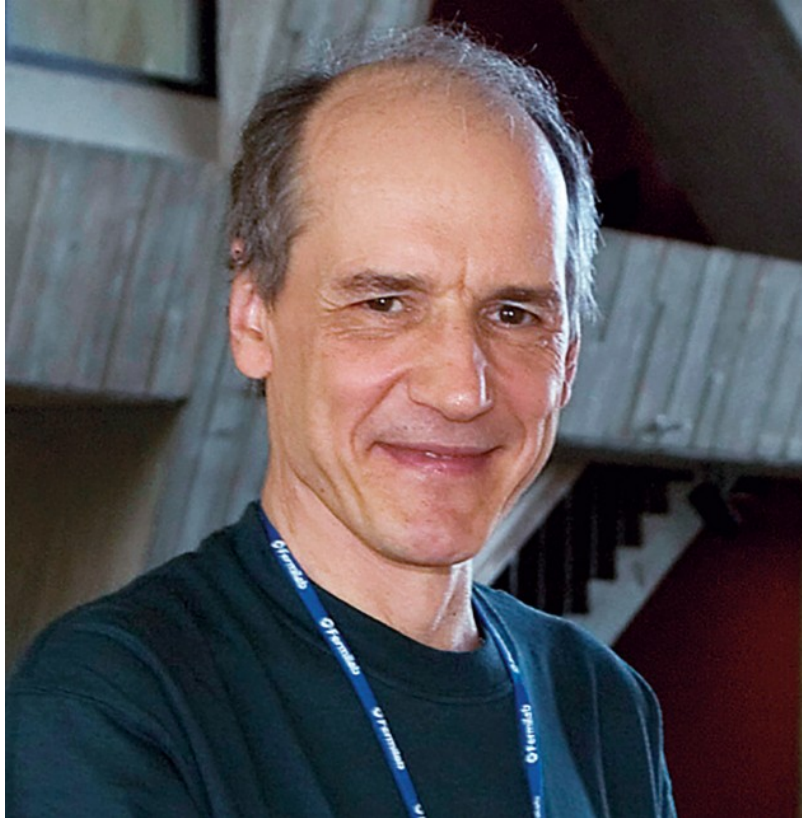
# Lattices, etc





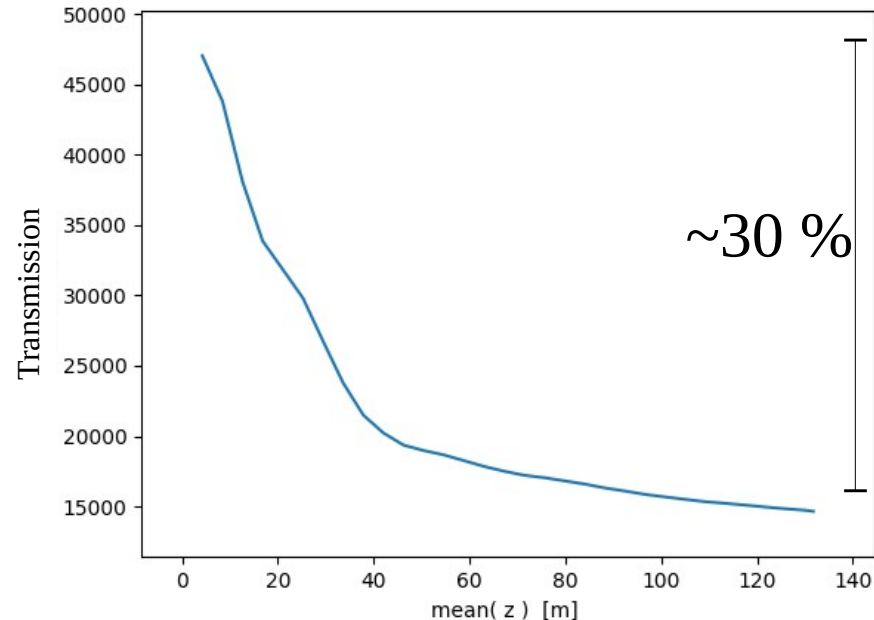
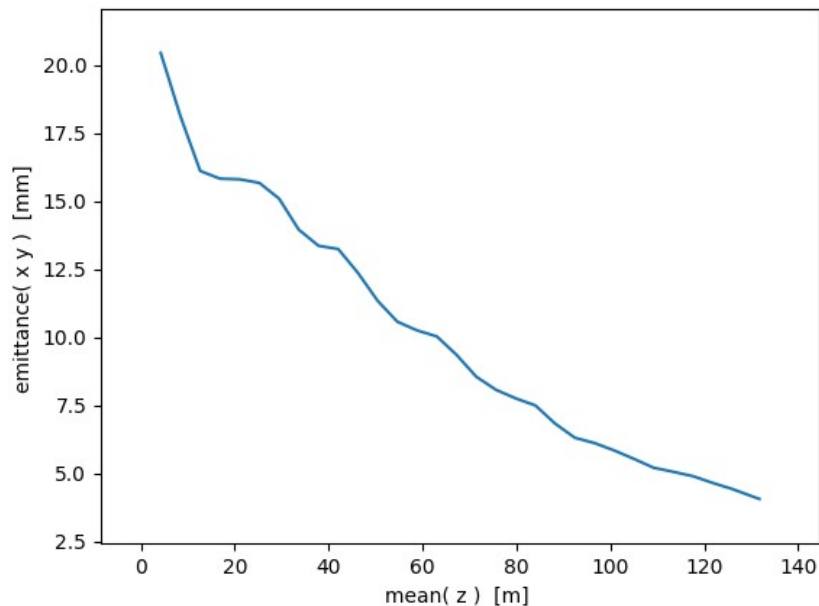
# Yuri Alexahin

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Science & Technology Facilities Council

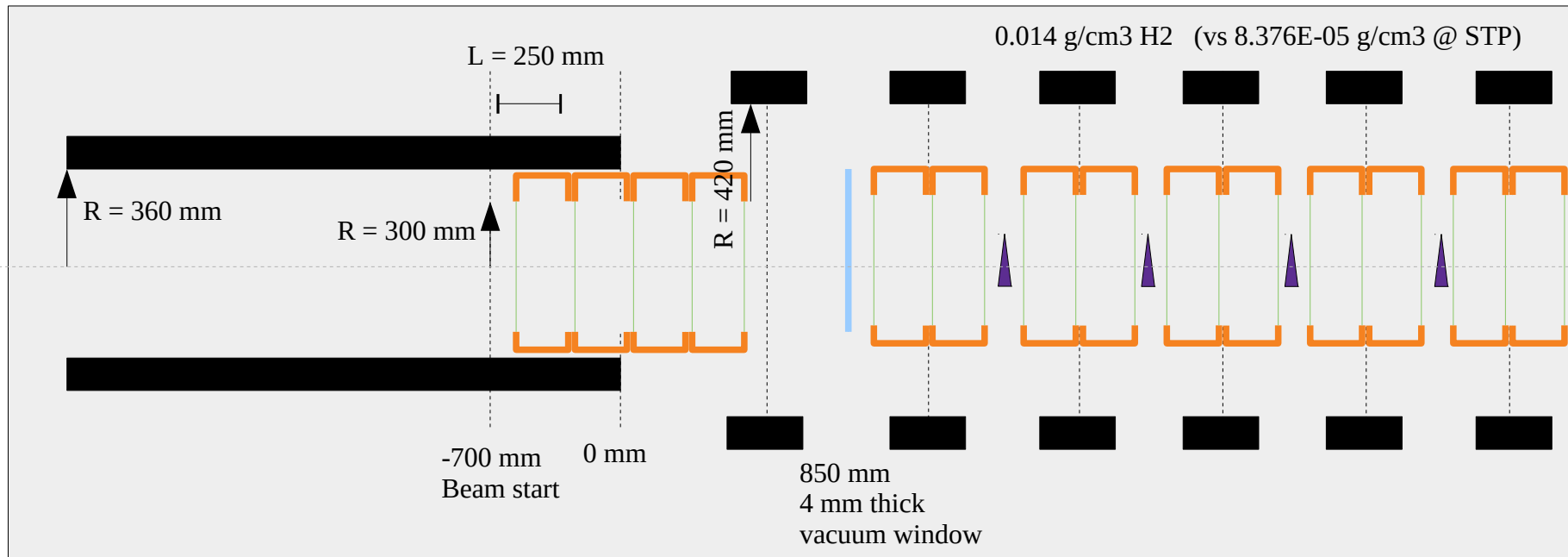
ISIS Neutron and Muon Source



- 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



# Lattice





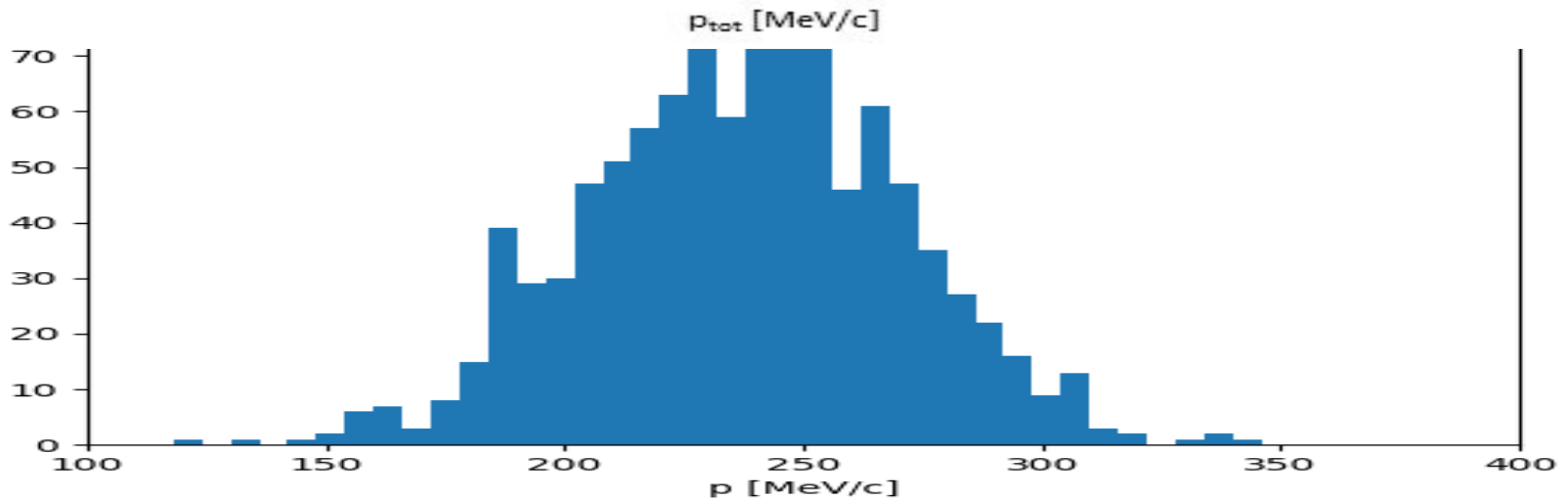
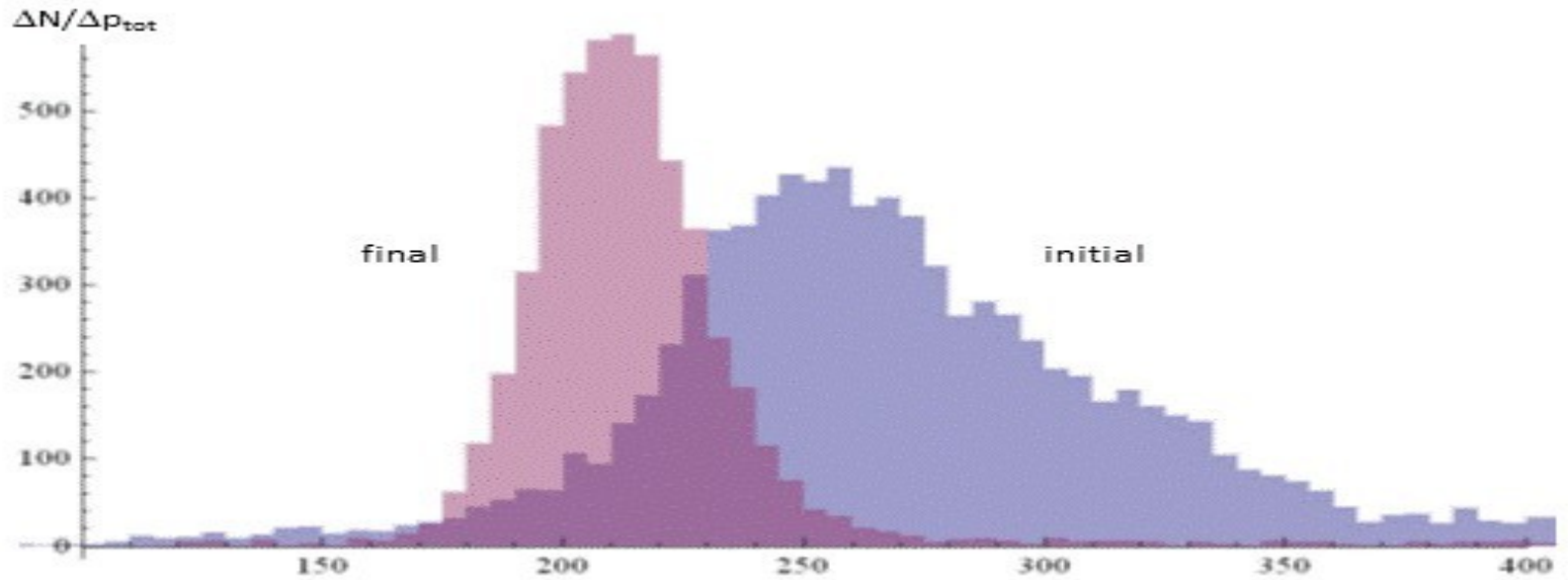
# Input beam

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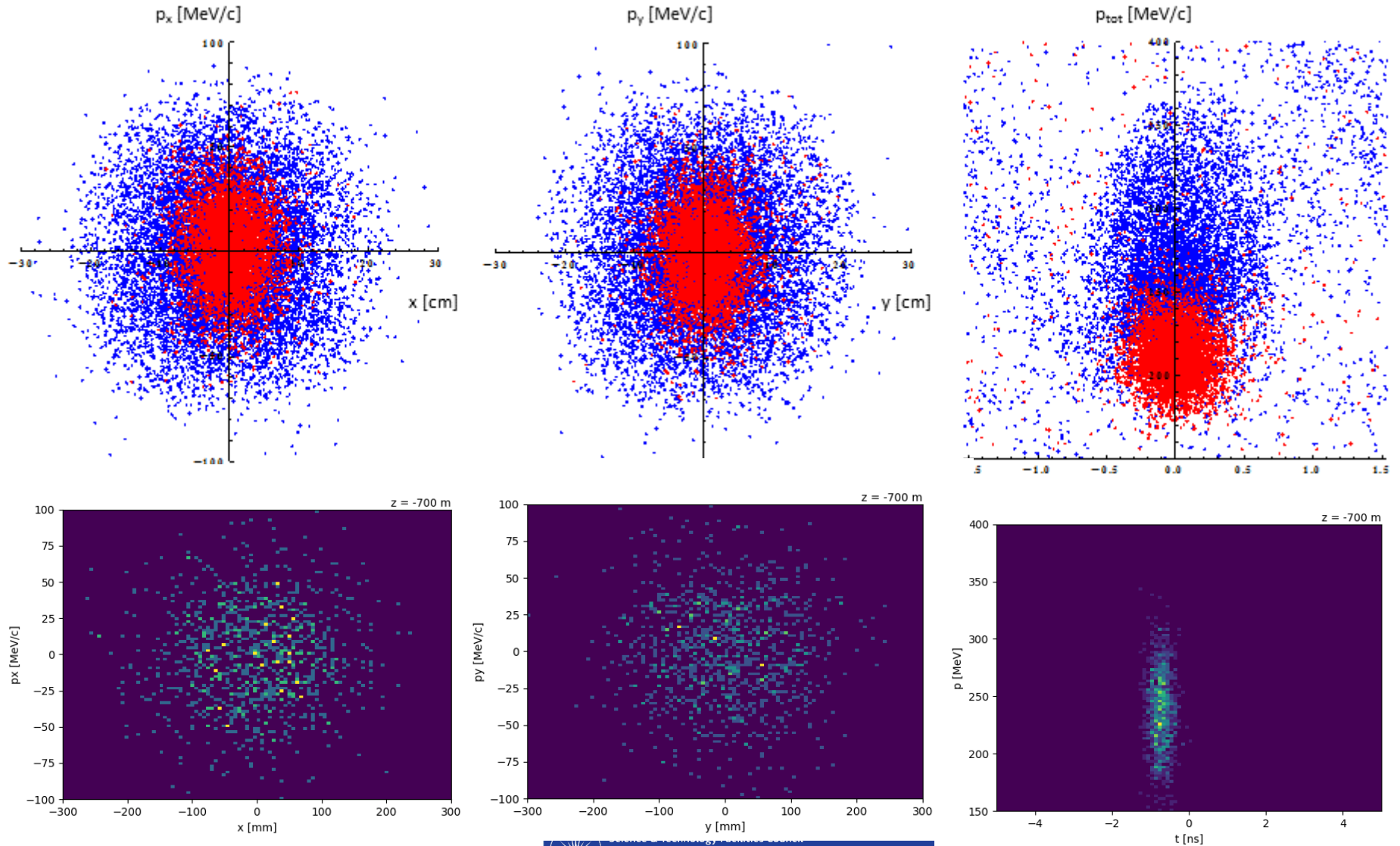
- Ideal input beam
- Multivariate gaussian
  - Matched to 2 T field
    - → x and y cylindrical symmetry
    - Transverse  $\beta \sim 700$  mm
    - Angular momentum ( $x-p_y$  and  $y-p_x$  correlation)
  - Upright longitudinal
    - $\sim 0.2$  ns time spread
    - $\sim 30$  MeV energy spread
  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



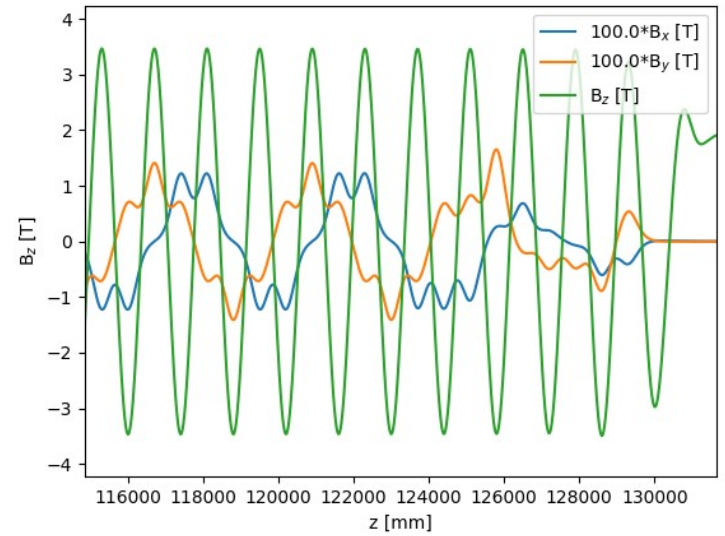
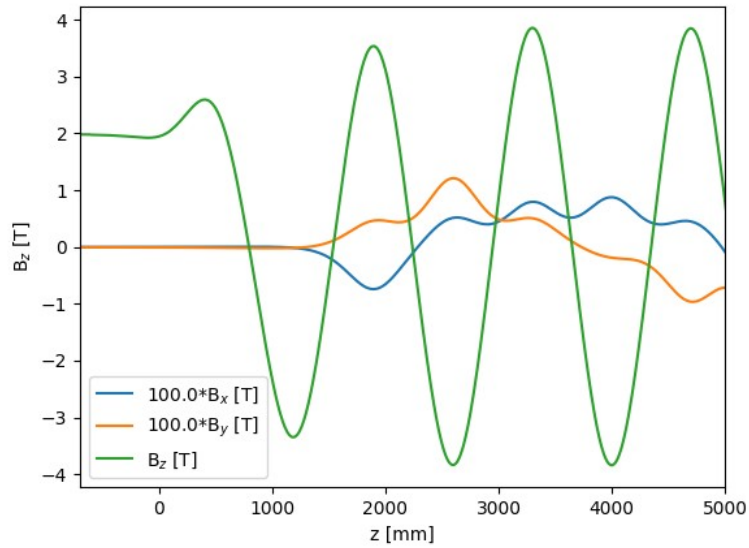
# Momentum spread



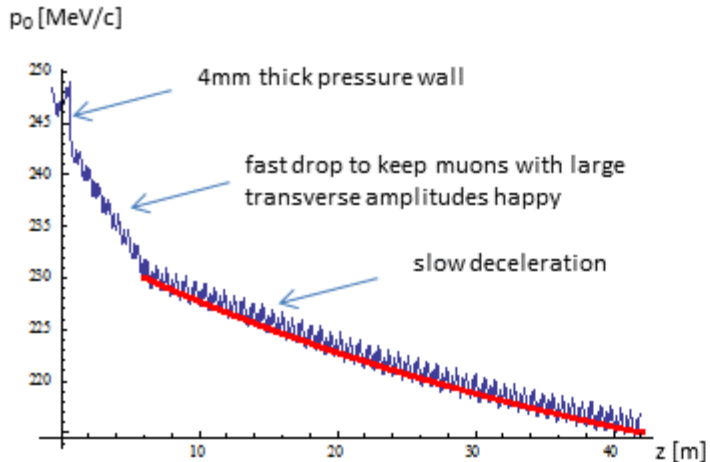
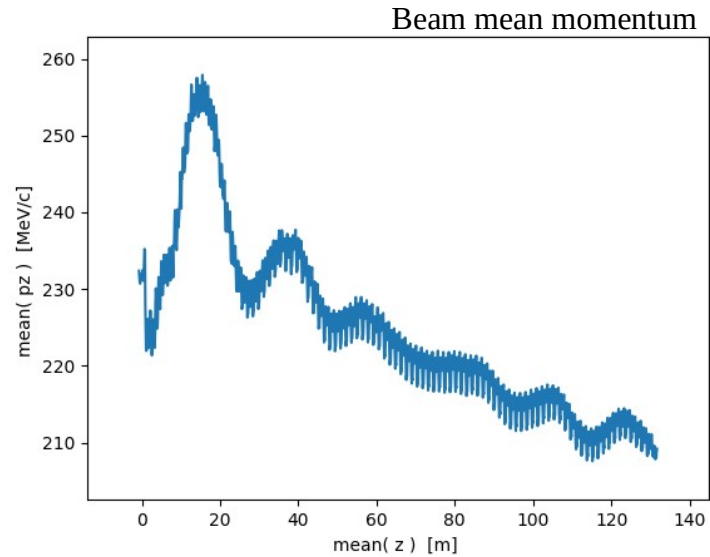
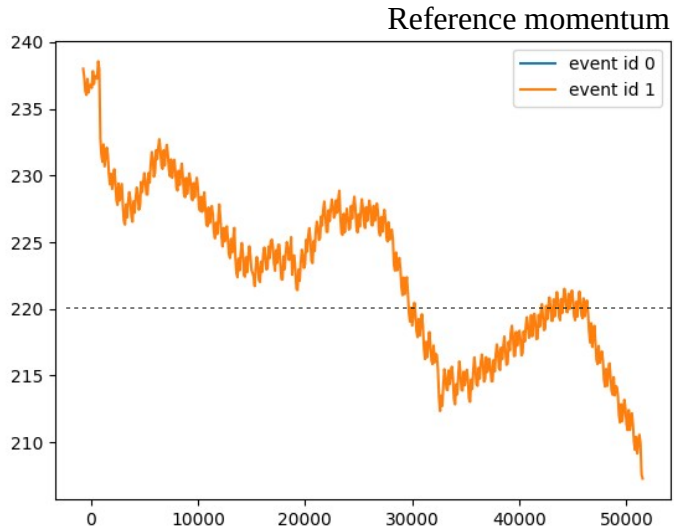
# Phase space



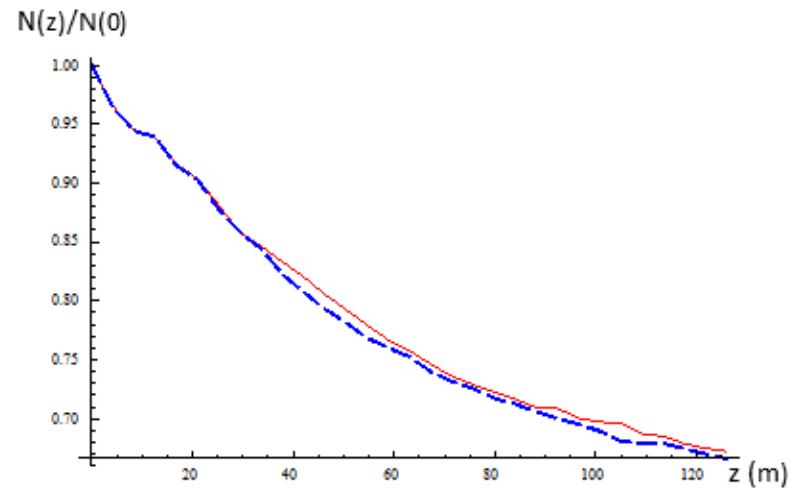
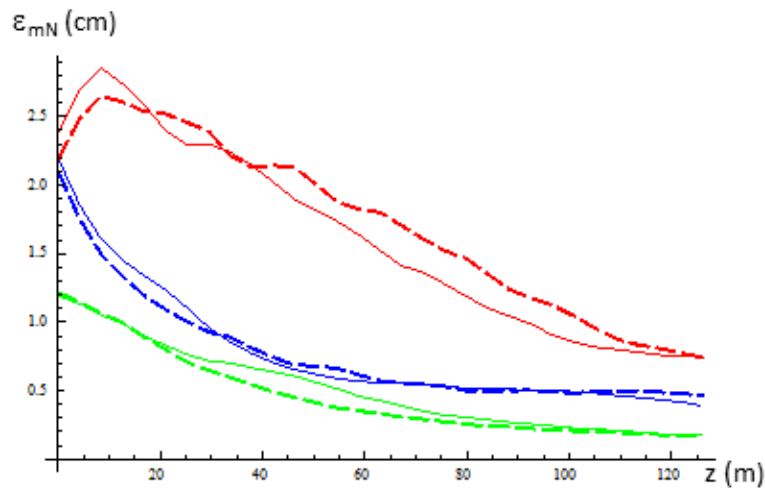
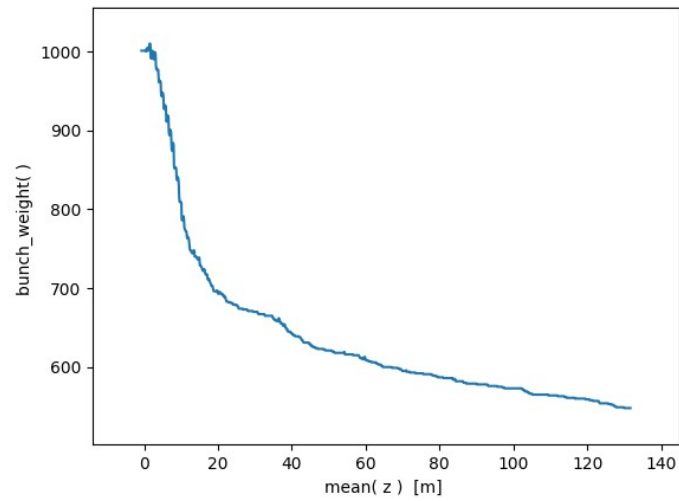
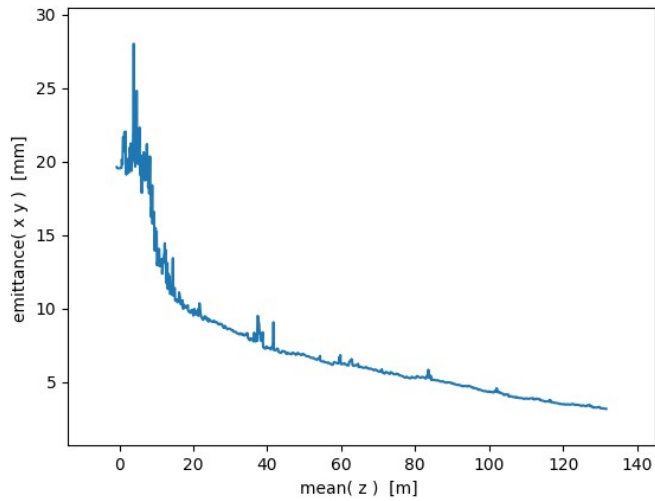
# Fields



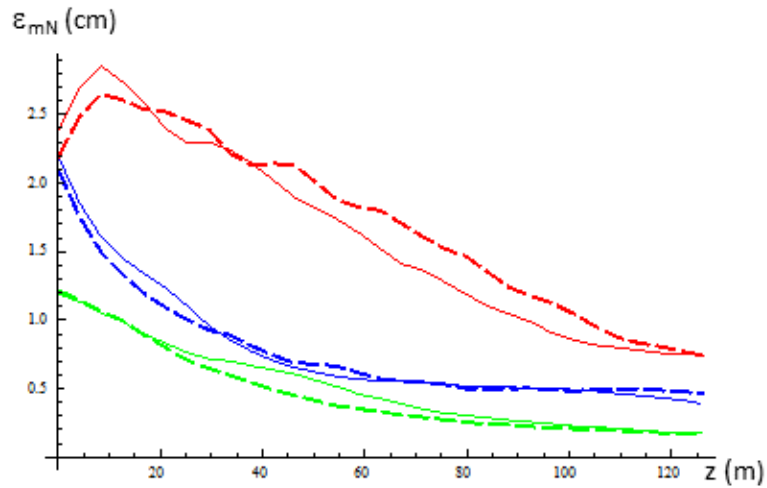
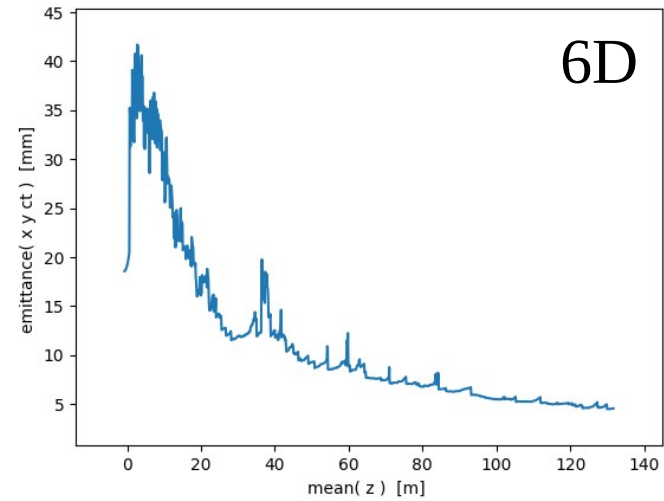
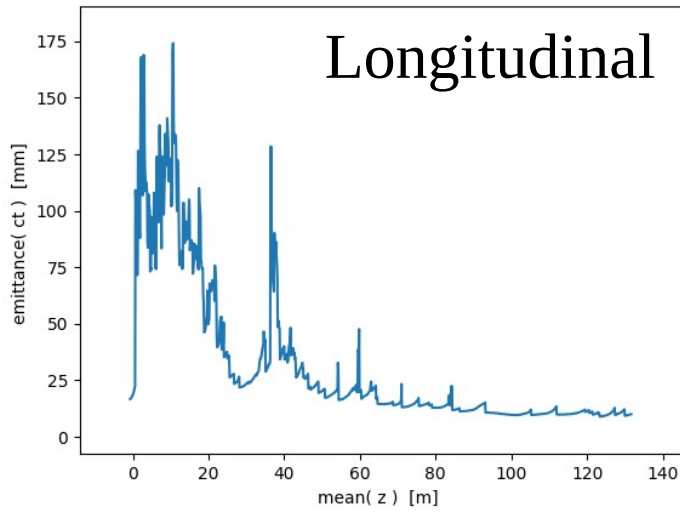
# Reference Momentum



# 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

