Physics Coordinators Report

1356

C. Rogers, ISIS Intense Beams Group
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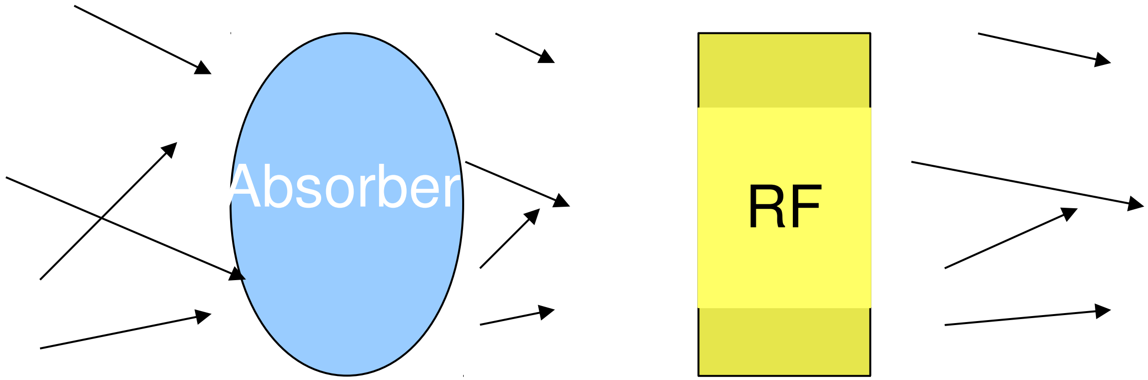
Physics Report

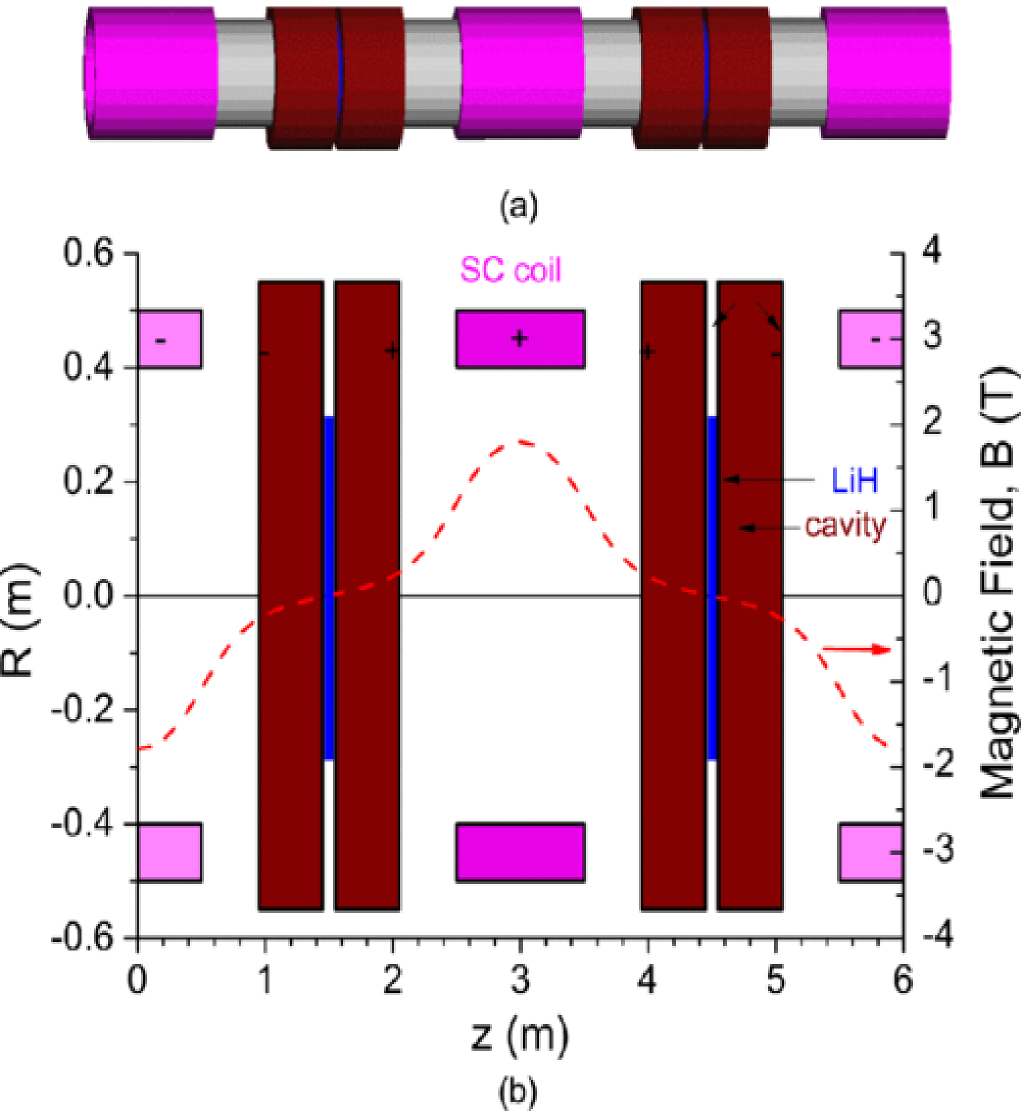
- Step IV is almost complete
- Struggling to fund Demonstration of Ionisation cooling
- Worth taking stock
  - What does MICE aim to achieve
  - What has/will MICE achieve at Step IV?
- Some context from the accelerator world

4D Ionisation Cooling



- 4D (transverse) cooling achieved by ionisation energy loss
  - Absorber removes momentum in all directions
  - RF cavity replaces momentum only in longitudinal direction
  - End up with beam that is more straight
- Stochastic effects ruin cooling
  - Multiple Coulomb Scattering increases transverse emittance
  - Energy straggling increases longitudinal emittance
- Needed in IDS-NF to improve muon capture
- Needed in Muon Collider to provide luminosity

FS2A Muon Front End



- Baseline lattice for Neutrino Factory Muon Front End
  - Singlet lattice with alternating +- coils
  - Cell length ranging between 1-2 m
- This has been the NF cooling lattice design since ~2005
  - Mature, stable on paper
  - Some discussion of 6D cooling approach

Questions

- Questions to answer (copied from CM40)
  - Step IV stuff is in **bold**
  - I only list beam-based questions
- Magnetics
  - **Did we do the alignment well enough?**
  - **Do we understand the linear beam optics?**
  - **Do we understand the non-linear beam optics?**
  - Do we understand the resonance structure/stop bands?
- Absorber
  - **Do we understand MCS?**
  - **Do we understand Energy Loss?**
  - **What about longitudinal-transverse correlations?**
  - **What about high Bz?**
  - **What about polarisation?**
  - **What about funny absorber geometry? And materials?**

Questions (2)

- RF
  - Do we understand the RF beam dynamics when RF is superimposed on solenoids
    - Probably no one has studied this problem
    - Certainly not higher order terms
  - What about alignment?
  - What about stability across the RF pulse?
- Integration
  - **Do we see the expected emittance change?**
    - **Transverse?**
    - **Longitudinal?**
    - **Emittance exchange?**
  - Do we see the expected transmission
    - **Have we correctly modelled our apertures?**

Answers (1)

- **Did we do the (magnetic) alignment well enough?**
  - The physical bore of the magnets has been aligned carefully
  - The relationship between the physical bore of the magnets and the actual coils is unclear
  - A detailed field mapping programme was carried out
    - But the SS field map was not tied in to the survey fiducials!
    - Guess work based on knowledge of the flange positions required
  - Position of the magnetic axis was never written up (not a MICE note)
  - Analysis of field off-axis is still ongoing
  - Simulation indicates the emittance reduction is not terribly sensitive to alignment – in one cell
  - **Analysis is ongoing**
  - *Talk by Jo Langlands this morning*

Answers (2)

- **Do we understand the linear beam optics**
  - The behaviour of the beam appears to tie in pretty well with the field map model
  - Need to quantify “pretty well”
  - Certainly not been written up yet
  - **Probably**
- **Do we understand the non-linear beam optics**
  - Simulation indicates that we get quite a bit of emittance growth in SSD
  - Sometimes appears in Match coil region (simulated)
  - Some agreement between tracking and data
  - No theoretical understanding
  - **Probably not**
- *At the moment, this is covered by the emittance evolution paper (Wednesday morning)*
  - *Details could be studied as a separate analysis*

Answers (3)

- **Do we understand MCS**
  - Currently analysis indicates strange momentum dependence
  - Cross-checking analysis
  - **Analysis ongoing**
- **Do we understand energy loss**
  - Resolution appears insufficient for deconvolution analysis
  - Convolution with Landau shows agreement with mean energy loss
  - Landau width – studies ongoing
  - **Probably**
- *Material physics session on Wednesday morning*

Answers (4)

- **What about longitudinal-transverse correlations in material physics?**
  - We probably don't have the resolution for this
- **What about depolarisation from materials?**
  - Measure using decay positron spectrum in EMR
  - Depolarisation in the EMR introduces too much systematic bias
- **What about high Bz?**
  - **No analysis done**
- **What about funny absorber geometry? And materials?**
  - Wedge absorber – it would be great to get this in the programme, but time pressure is considerable
  - We have taken data with Neon and Xenon – there may be a measurable effect in the data
- *Discussion of the programme to the end of Step IV on Thursday*

Answers (5)

- **Do we see the expected emittance change?**
  - **Transverse?**
  - **Longitudinal?**
  - **Emittance exchange?**
- **Have we correctly modelled our apertures?**
- *Analysis is ongoing as part of the emittance evolution analysis (Wednesday morning)*

Context from Accelerator World

- Driven by users
- Muon acceleration for HEP
- Secondary particle production via internal targets
  - Neutron/radioisotope production
  - Muon production

Muon acceleration for HEP

- Muon accelerators are big facilities
- Need high level funding/political clearance even for R&D
- Not much activity since end of MAP

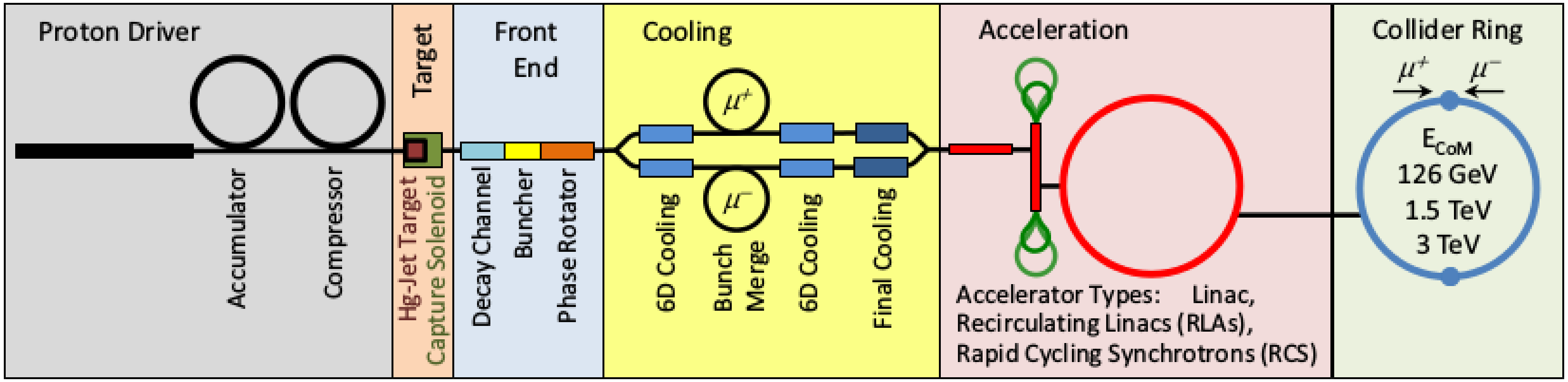
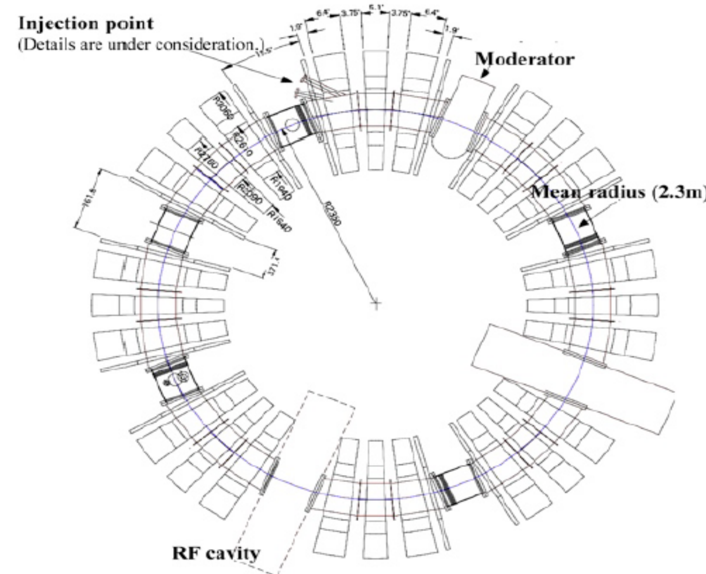
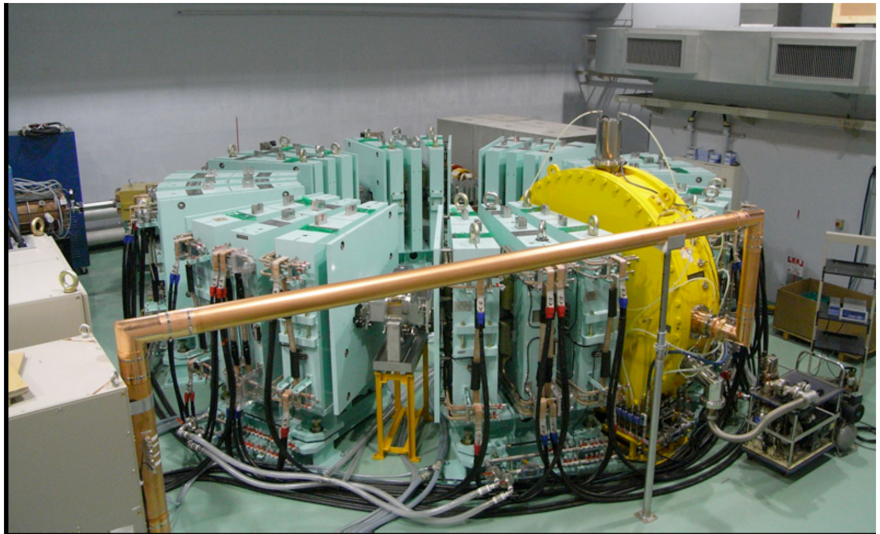


Figure 27: Functional elements of a Higgs Factory/Muon Collider complex

ERIT

- Neutron production for medicine
  - Use internal target to enhance production
- ERIT scaling FFAG
  - FDF lattice
  - 11 MeV H- injection onto foil
  - 2.35 m radius with 8 sectors
- Large momentum acceptance
- Large horizontal acceptance
- Small vertical acceptance
- Finished running ?2012?





Y. Mori et al, Kyoto Univ RRI

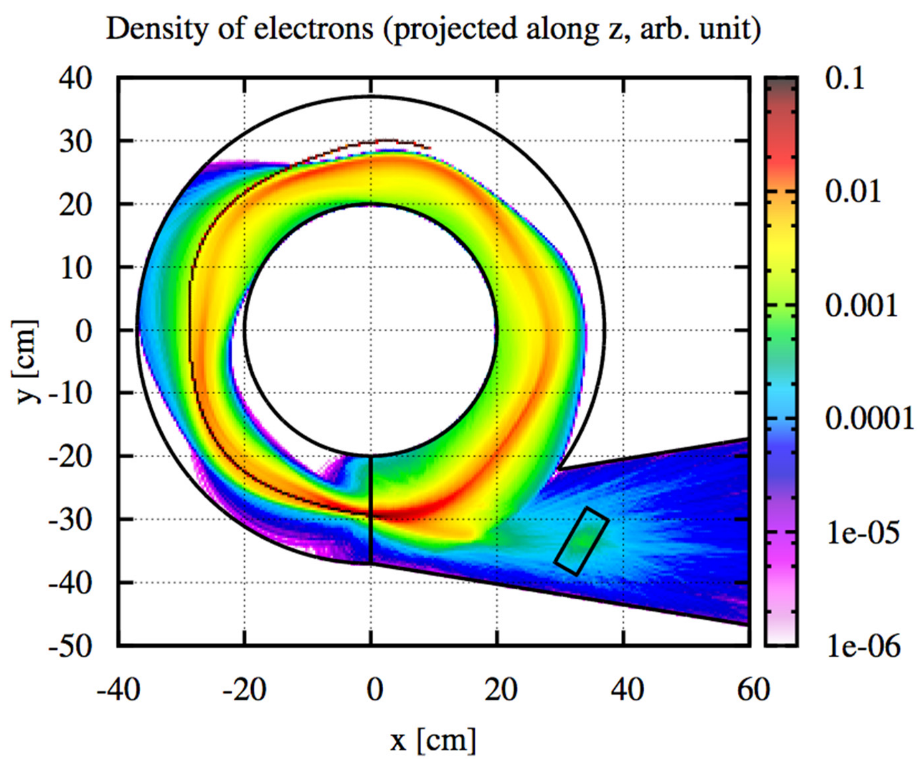
MERIT

Ring configuration	H_FFAG
Energy range	500MeV-800MeV
Magnetic rigidity	3.633 -4.877Tm
Lattice	FDF
Average radius	5.044-5.5m
Magnetic field(F)	1.96-2.41T
Magnetic field(D)	1.71-2.11T
Number of cell	8
Packing factor	0.7
Magnet opening angles	
Focusing	0.2032
Defocusing	0.1432
gap	0.01732
Geometrical field index	2.4
F/D ratio	1.1
k	2.4
Qh	0.2188
Qv	0.1797
ρf	2.0233m(2.411T)
ρd	2.3157m(2.106T)

- High energy proton internal target
- Produce muons for nuclear waste transmutation
- Claim 10^{16} muons/second
- Use ERIT to prototype
  - Data taking autumn 2017

Y. Mori et al, Kyoto Univ RRI, FFAG16

Photoproduction of rare isotopes



T. Planche and A. Laxdal, TRIUMF, IPAC17

- Rare isotope production
- Electrons on internal target
- Produce photons for fission
- Non-adiabatic
  - 10-12 turns
- Paper study

Photoproduction of rare isotopes

Preliminary scheme for low emittance μ beam production

Goal:

@T ≈ 10^{11} μ/s

Efficiency ≈ 10^{-7} (with Be 3mm)→

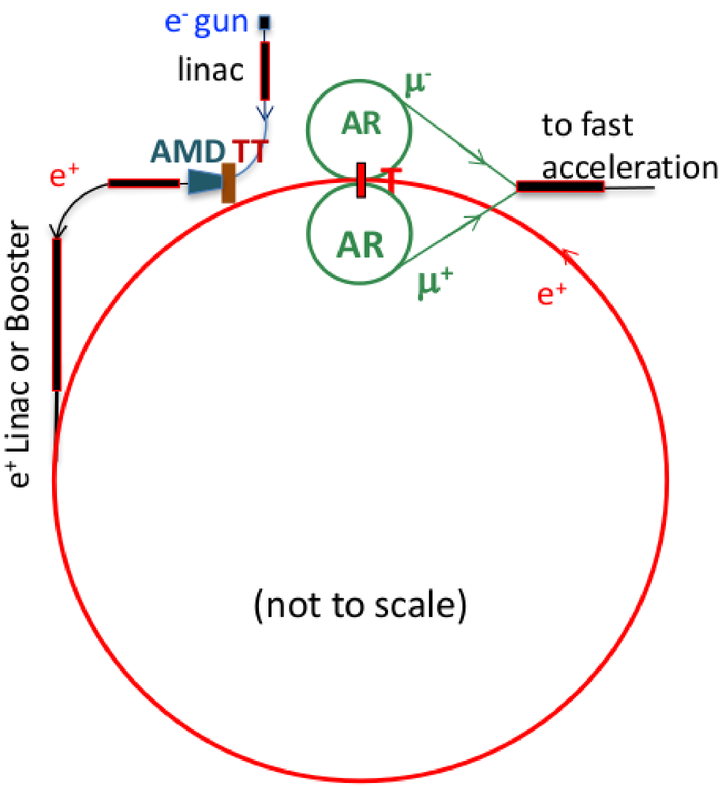
10^{18} e^+/s needed @T →

e^+ stored beam with T

need the largest possible lifetime to minimize positron source rate

LHeC like e+ source required rate with lifetime(e+) ≈ 250 turns [i.e. 25% momentum aperture] →

n(μ)/n(e^+ source) ≈ 10^{-5}



M. Boscolo et al, INFN, IPAC17

Conclusions

- Even without Demonstration of ionisation cooling, MICE can answer many of the questions surrounding ionisation cooling
  - Serve the accelerator community by validating high energy muon accelerator programme
  - Demo would certainly add to our understanding
- Internal target machines are rather topical
  - Applicable to real world issues
  - Small, relatively easily funded
  - Validate much of the physics required for ionisation cooling