



# Introduction and Aims; Integration Issues

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Science & Technology Facilities Council

ISIS Neutron and Muon Source

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ISIS

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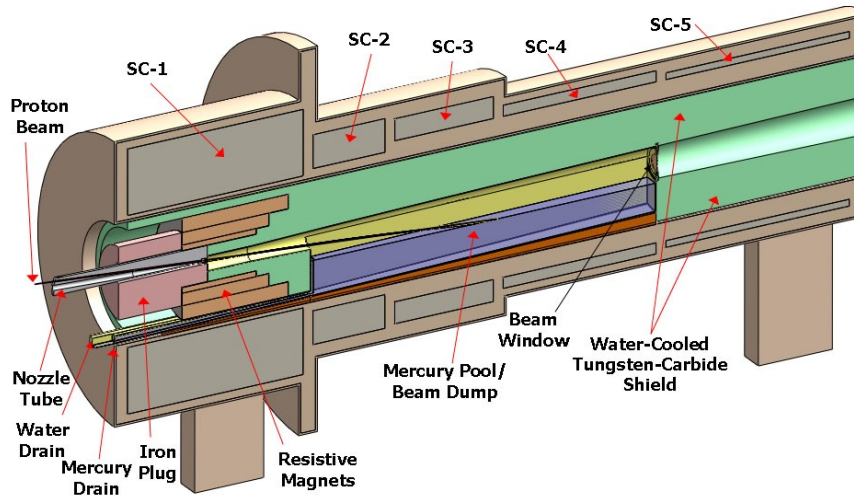


# Muon Cooling and Production

- Muon cooling and production (MPC)
  - Multi-MW target with solenoid focusing
  - Collection of resultant pions and decay to muons
  - Clean-up of beam impurities
  - Sorting muons into (several) RF buckets
  - Cooling
  - Separating  $\mu^+$  and  $\mu^-$
  - Merging RF buckets into one bunch
  - More cooling
- Key technologies
  - High power targetry
    - Solenoid capture with multi-MW target
  - Ionisation cooling
    - RF
    - High field solenoids

- Aim is to build a **prioritised** R&D list
- Where are there potential problems?
  - How severe?
  - Can we fix with paper studies? Hardware studies?
  - Do we need to develop a “plan B”?
- Where are there opportunities?
  - Can R&D investment deliver improvement on the MAP baseline?
    - Paper studies?
    - Hardware studies?
  - Can we exploit new or alternate technologies?

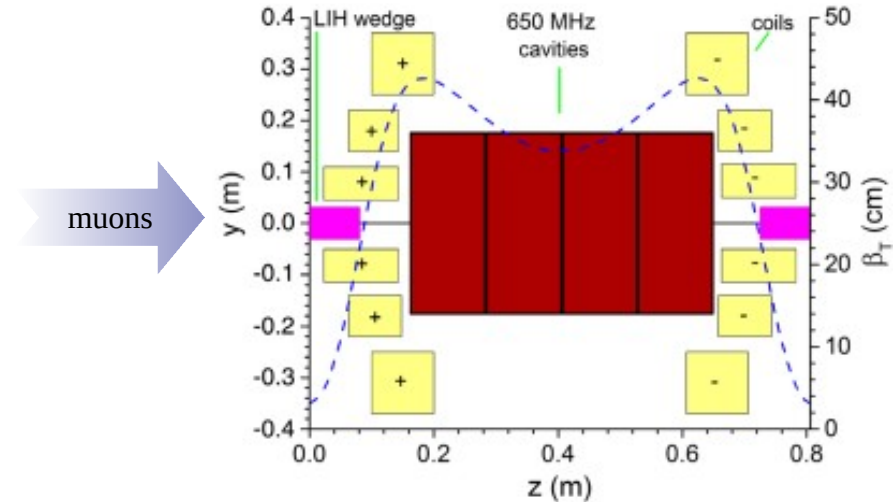
# Target



- High power target **in solenoid** very challenging
  - Factor 100 beyond state-of-the-art in power
  - Factor 10 beyond state-of-the-art in field
- Challenges
  - Power deposit on target
  - Radiation load on the solenoid
  - Extraction of residual beam/heat
- Mitigations
  - Do we need a prototype? If so what?
  - Do we need to develop a plan B (target + horn)?

# Capture and Cooling

- Solenoids
  - Minimum emittance  $\sim 1/B_z$
  - Field flips/etc
  - What is the maximum field?
- High gradient RF
  - Large bucket required
  - What is the maximum gradient that can be achieved?
- Integration
  - RF tends to break down in solenoids
  - Mitigations
    - Gas filled cavity
    - Beryllium walled cavity
- Other issues? Space charge, beam loading, etc etc
- What should go in the “test facility?” Other tests/prototypes?



# Agenda (Thursday)

Coffee break Zoom 12:45 - 13:00			
Objectives... Alex...	Common i... Don...	Joined session with HEC in HEC room	Introduci... Chris Rog...
Introduci... Jea...	Zoom 13:00 - 1...		Introduca... Ela...
<b>Muon Pro... Dav...</b>	M... IR a... Ni...		Brief intro... Dr S...
<b>Capture &amp; Cooling Chris Rog...</b>	S...ies @... Di...		Short intro... Dr A...
<b>6D Cooling Dikys Stra...</b>	Discussion		High pow... Kar...
<b>Discussion Ever...</b>	En...apolat... Yi...		Overview ... Shn...
	Zoom 13:00 - 14:40		Thoughts J. S...
	Joined session with Magnets in MDI room		Overview ... Chri...
	Joined session with MDI in MDI room		SPL-II Frank Gerigk
			Zoom 14:00 - 1...
			Coffee break Discussion Ever...
			Zoom 14:30 - 14:50
			Coffee break
			Coffee break
			Coffee break
Low Energ... S. A...	Joined session with MPC in MP room		SNS Acce... And...
High Energ... J. S...			Coffee break
Discussion Ever...	Zoom 15:10 - 16:10		Coffee break
SRF techn... Rob...	Joined session with HEC and RPOT in MDI room		Coffee break
High-gradi... Sam...	Joined session with HEC and RPOT in MDI room		Coffee break
SRF techn... Ser...			Coffee break
NRF techn... Walt...			Coffee break
Cu Cryoge... Sam...			Coffee break
Coffee break			Coffee break
Experimental Vacuum RF R&D at MTA for Muon Cooling Yagmur Tonur	Coffee break Zoom 18:00 - 18:10		PIC/HCC/HFOF: lattice and beam physics issues and opportunities Katsuya Yonehara
Experimental High Pressure RF R&D... Katsuya Yonehara	BD WG alone Elias Mestral		Target: visions and opportunities Chris Densham
NCRF R&D for Muon Cooling and Int... Banbuan Luo	Zoom 18:10 - 19:00		

RF joint session in RF room

Magnets joint session in MPC Room

# Agenda (Friday)

High-cha... Tor...	Joined session with MPC in MPC room	<b>Target c...</b> Dr ...	Proton d... Fra...	Magnets	PC	MDI	Synergy	
Joined session with RF in RF room	Zoom 09:00 - ...	<b>Radiatio...</b> Cla...	Joined session with RF room					Lo...nce d... Chr...
Coffee break		<b>Slow ext...</b> Oli...	Coffee break					Exotic op... Shi...
BD WG alone: preparati... of the afternoon summary of BD R&D list Elias Met...		<b>HiRadMa...</b> Nik...	Zoom 10:00 - ...					Preparation of the HEC summary + R&D list
		<b>Frictional cooling</b>	R&D roa...					Zoom 10:20 - 11:30
		<b>Prioritisa... discussion</b>	R&D roa...					
Zoom 10:20 - 12:00			SRF and ...					
		Zoom 11:00 - 12:00	Discussion	Zoom 09:00 - 12:00	Zoom 09:00 - 12:00	Zoom 09:00 - 12:00	Zoom 09:00 - 12:00	

Radiation Protection joint session in MPC room

RF: summary preparati...	Magnets: summary preparati...	HEC: summary preparati...	MPC: summary preparati...	PC: summary preparati...	BD: summary preparati...	RPOT: summary preparati...	MDI: summary preparati...	Synergy: summary preparation
Zoom 13:00 - 14:00	Zoom 13:00 - 14:00	Zoom 13:00 - 14:00	Zoom 13:00 - 14:00	Zoom 13:00 - 14:00	Zoom 13:00 - 14:00	Zoom 13:00 - 14:00	Zoom 13:00 - 14:00	Zoom 13:00 - 14:00

# Integration issues

- Potential issues pertaining to the whole system
  - Transmission and matching
  - Quench Protection System
  - Charge separation
  - Codes



- Final cooling paper:

with absorber material. This includes energy loss, straggling, multiple scattering, and muon decays.

In this simulations we used a Gaussian input beam with normalized transverse emittance  $\epsilon_{\perp}$  of  $300 \mu\text{m-rad}$  and longitudinal emittance  $\epsilon_L$  of  $1.5 \text{ mm}$ . The initial momentum distribution was generated with an average longitudinal momentum of  $135.0 \text{ MeV}/c$ . Tracking was performed using an initial sample of  $10^7$  particles matched and injected into the first ionization cooling stage.

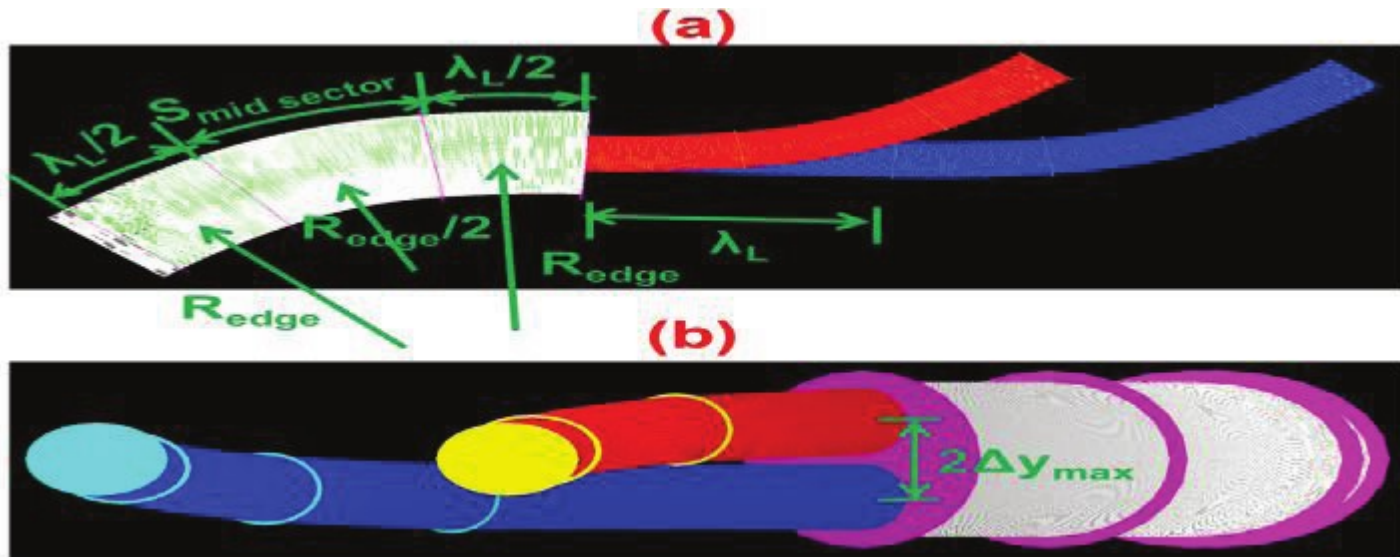
- What about rectilinear, bunch merge, etc?
  - How good is matching between different lattices
- Start-to-end simulation is desirable

# Quench protection system

- Solenoid lattice – from target to end of cooling – is coupled
  - Fringe field of adjacent magnets overlaps
- Is it possible to make a QPS that does not quench the entire system?
  - Do we need to make an optics solution?

# Charge separation

- Charge separation



charge of the muon, but a charge separator had not been designed. The tight time constraint forbade the design of a realistic charge separator, so a study was performed to emulate the effects of a simplified charge separator on muons exiting the front end of a muon collider. The output of the study provides particle distributions that the competing designs will use as input into their cooling channels.

# Codes

- Two codes in common use
  - ICOOL (BNL)
  - G4Beamline (Muons, Inc / Fermilab)
- For collective effects, Warp
- They do everything we want – at the moment
- As time goes by, we will want new features
  - Deal with novel physics issues
  - Add in new beam elements, as required
- Need to ensure that we maintain the capability