

Introduction and overview

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- **Organisation (update)**
- **Steps IV, V & VI: scenarios and options**
- **Orientation**

Introduction and overview

Highlights of progress

Headlines only; details in MPB talks.

Progress: Step IV:

- **Spectrometer solenoids:**
 - **Upstream:**
 - Met acceptance criteria, mapped;
 - Tracker installed, will be moved to Hall 06 May 14.
 - **Downstream:**
 - Met acceptance criteria, mapped;
 - Scheduled to arrive in UK today.
- **Focus coil:**
 - **FC1:**
 - Trained to full current in solenoid mode;
 - Training failed to reach full current in flip mode
 - Viable programme at reduced current
 - **FC2:**
 - Thermal (and other) issues; Being repaired by TESLA;
 - Retesting will start May 2014
- **Partial return yoke:**
 - Procurement started in UK and US
 - Schedule for integration shows completion before ISIS restart in 2015

Confident that Step IV commissioning/data taking will start Q1/Q2 2015

STEP V:

- **Coupling coil:**
 - **Being trained at FNAL; in the test cryostat it reached 194A (of 210A);**
 - **“Remembers” its training;**
- **Cavities:**
 - **Cavity production complete; single-cavity test in preparation;**
- **RFCC module:**
 - **Delivery to RAL in present plan: 06Mar18;**
- **Partial return yoke:**
 - **Conceptual design exists; detailed design awaits engineering effort;**
- **Absorber/focus-coil module:**
 - **Two focus-coils “in hand”; have to make both work;**
 - **Second absorber being shipped from Osaka;**
 - **LH2 system 2**
- **RF power:**
 - **2 MW operation demonstrated at DL;**
 - **Amplifier successfully commissioned in MICE Hall (TIARA);**
 - **Need to complete one more amplifier (underway).**

**UK contributions to Step V largely in hand.
US components to Step V well advanced.**

Step VI:

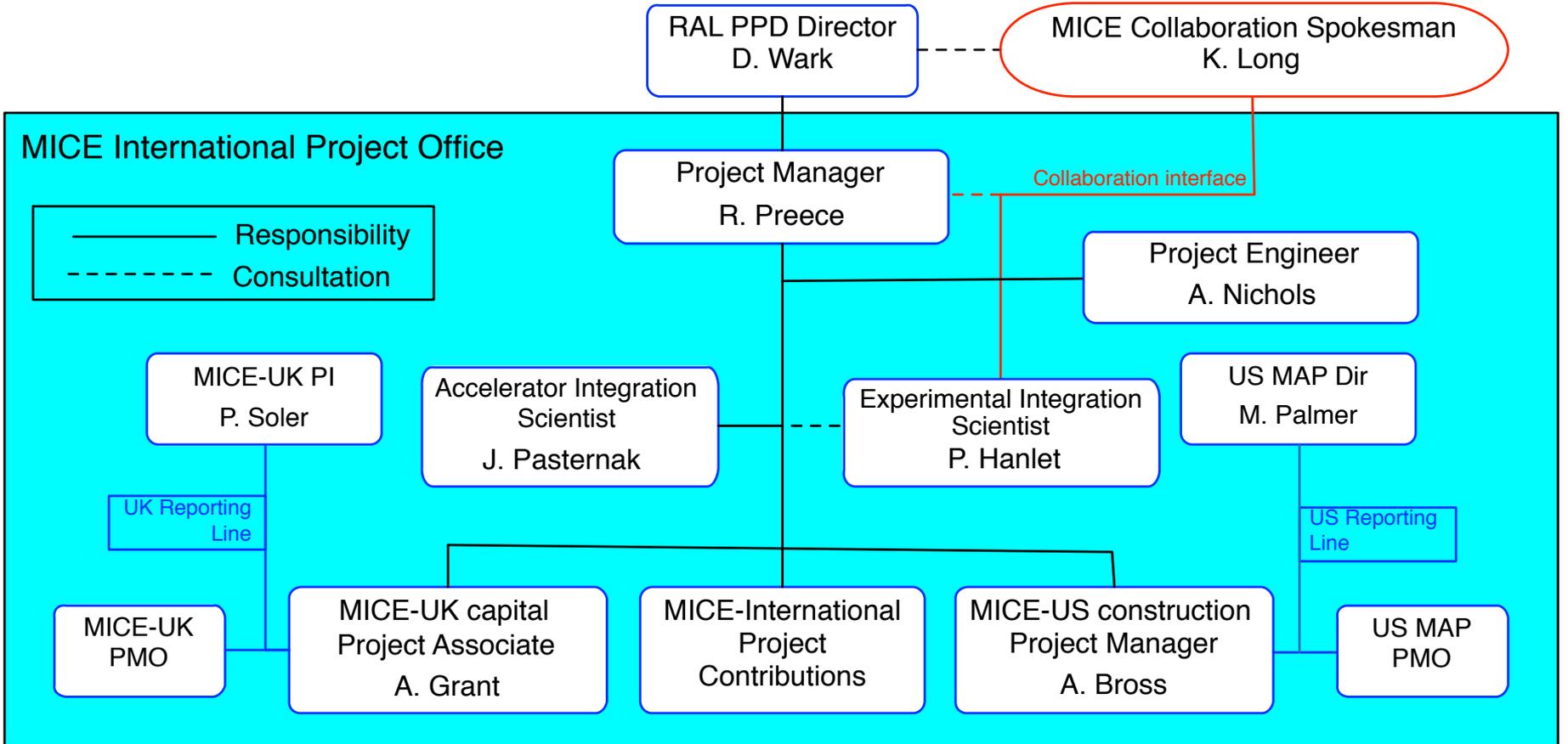
- **Absorber/focus-coil module:**
 - Necessary to procure third module;
 - Option exists in present contract with TESLA.
- **Coupling coil:**
 - Need to produce second coil;
 - Procurement/fabrication plans advanced.
- **Cavities:**
 - Cavity production complete; windows, couplers etc. to be fabricated.
- **RFCC module:**
 - Plan shows delivery of second RFCC in Sep19;
- **Partial return yoke:**
 - Conceptual design exists; detailed design awaits engineering;
- **RF power:**
 - All components of RF-power amplifiers and distribution system in hand;
 - Need to build up amplifiers, commission/test and install.

UK: require to procure third focus-coil.
US: require to provide second RFCC.

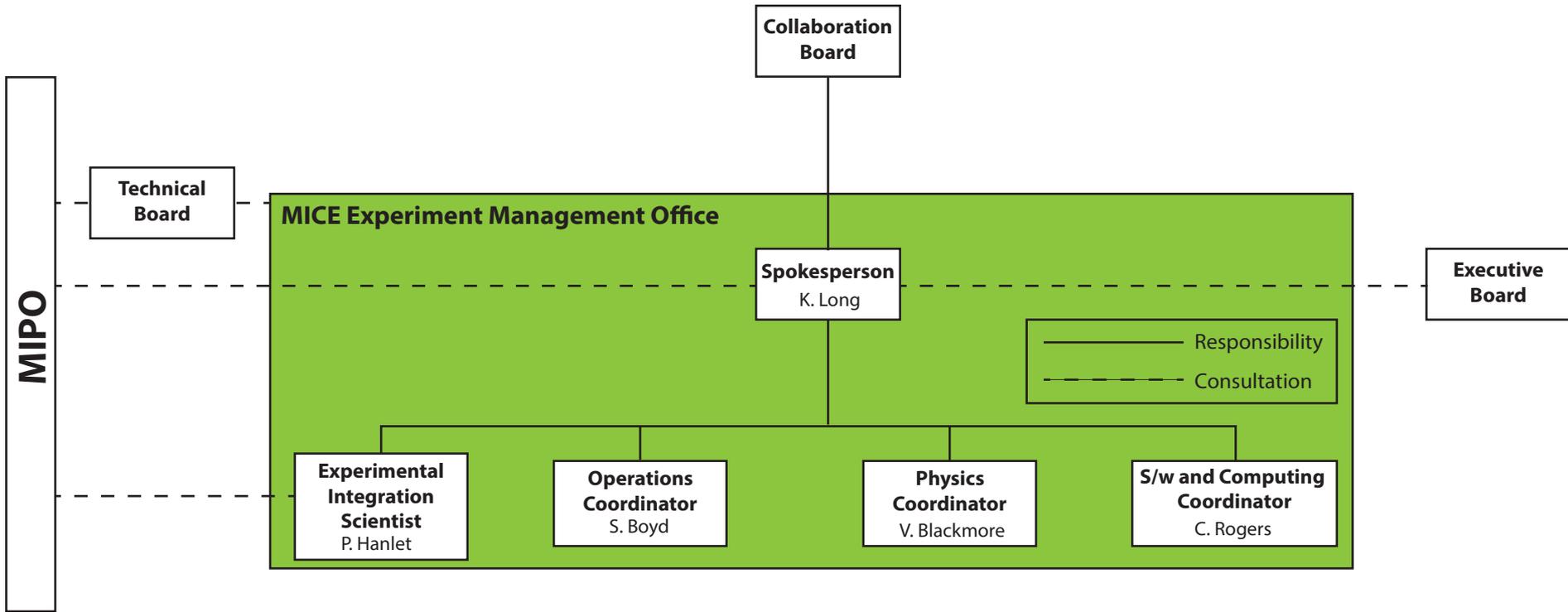
Introduction and overview

Organisation update

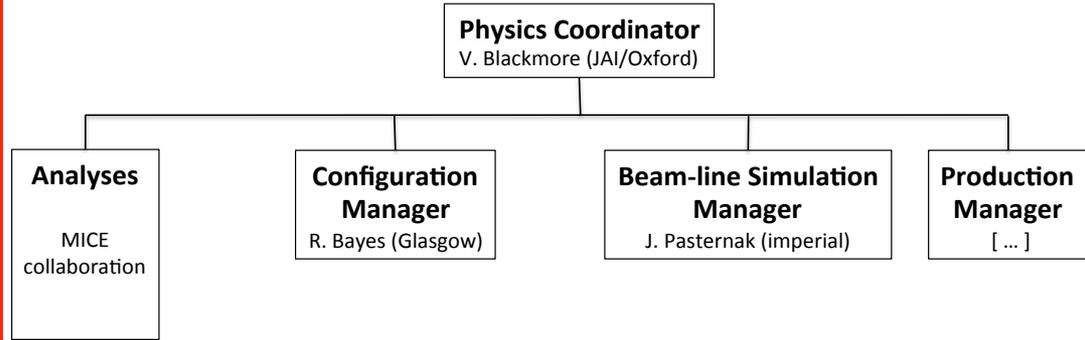
MICE International Project Team



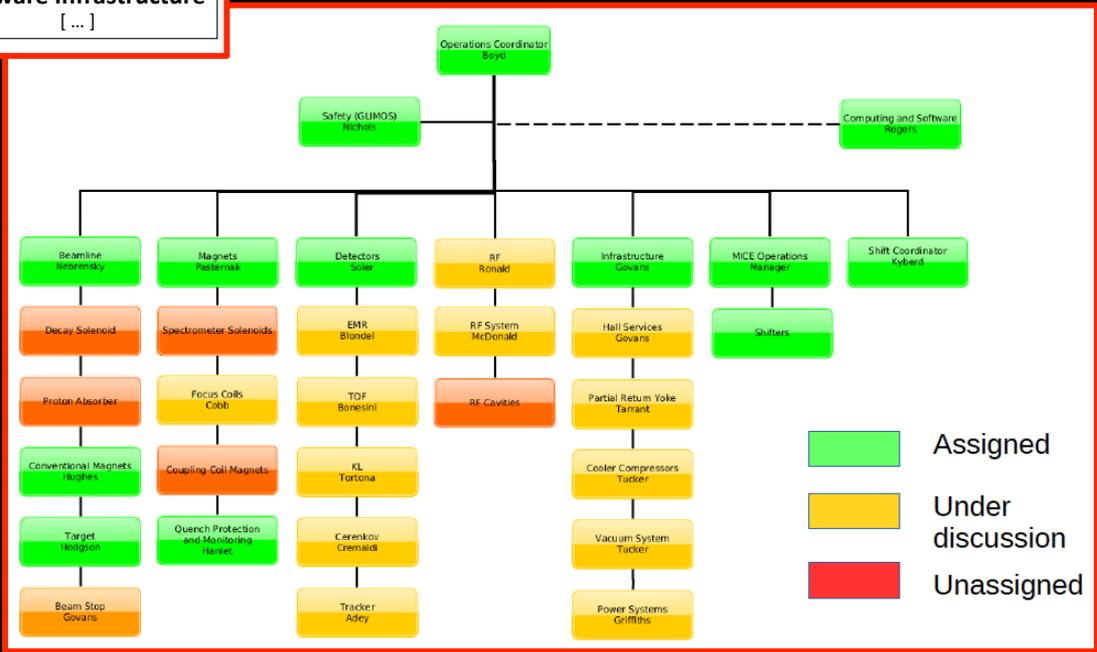
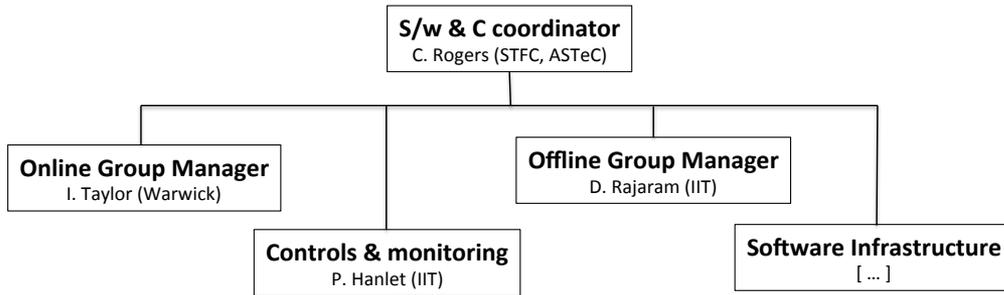
MICE Experiment Management Team



MICE physics analysis activity



Software and computing



Introduction and overview

Steps IV, V and VI: scenarios and options

Success scenarios for MICE:

	Step IV	Step V	Step VI
Cooling			
Observation of ϵ_{\perp}^n reduction	Yes	Yes	Yes
Cooling with LH ₂ and LiH	Yes	No	No
Sustainable cooling			
Observation of ϵ_{\perp} reduction with re-acceleration		Yes	Yes
Observation of ϵ_{\perp} reduction with ϵ_{\parallel} “management”		Yes	Yes
Observation of ϵ_{\perp} reduction with $\epsilon_{\parallel} \oplus \mathcal{L}$ “management”		Partial [†]	Yes ^{††}

[†] Requires systematic study of “flip” optics.

^{††} Full cooling cell: odd symmetry in magnetic field.

- To demonstrate, and to measure the performance of, a realistic section of cooling channel requires reacceleration;
- Step V is essential:
 - If executed appropriately will allow study of canonical angular momentum

Options to achieve success:

- **Step VI:**
 - Full programme
 - Budget pressures imply execution unacceptably slow or impossible
- **Step V:**
 - **Cooling with re-acceleration:**
Essential for the success of the MICE scientific programme
 - **Procurement of “high-tech” equipment largely in hand:**
 - Technical risk mitigation part of present programme
 - Step V integration risk reduced by (presently approved) Step VI implementation
 - PRY for Step V does not present new R&D risks
 - **Budget pressures + recent R&D successes imply consideration of options to:**
 - Reduce integrated cost (TPC);
 - Expedite the successful completion of the MICE programme;
 - **Scientific pressures:**
 - Aligned; successful demonstration of ionization cooling will unlock progress in muon beams for particle physics

Step IV options:

- Classification of physics output underway:
 - **Essential:**
 - **Measurements critical to deliver the principal objective (measure the performance of a realistic section of cooling channel);**
Principal scientific objectives can not be achieved if these measurements are compromised.
 - **Core:**
 - **Measurements that are needed to understand fully the cooling effect but that could be done (or done better) at Step V;**
Significant damage to the programme if these measurements are compromised.
 - **Optimal:**
 - **Measurements allowing a detailed understanding of muon/matter interactions to be developed or fine details of the cooling lattice (e.g. initial study of emittance exchange) to be studied;**
Programme damaged if these measurements are compromised.

Towards Step IV categorisation:

- **Essential:**

- **Observation of ionization cooling**
- **Measurement of ionization cooling using LH2 and LiH absorbers**

	Step IV	Step V	Step VI
Cooling			
Observation of ϵ_{\perp}^n reduction	Yes	Yes	Yes
Cooling with LH ₂ and LiH	Yes	No	No
Sustainable cooling			
Observation of ϵ_{\perp} reduction with re-acceleration		Yes	Yes
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- **Core:**

- **Initial study of the factors affecting the performance of ionization-cooling lattices**
 - **Can be done at Step V**

- **Optimal:**

- **Study of the properties of additional materials (LHe, (CH₂)_n, ...)**
- **Initial study of emittance exchange**

Expediting success for MICE:

- Options to bring forward Step V will be discussed by M. Palmer;
 - Attractive, reducing TPC and advancing science programme

- Minimally require:

- Step IV “essential” programme; and
- Step V such that longitudinal dynamics and canonical angular momentum can be studied.

	Step IV	Step V	Step VI
Cooling			
Observation of ϵ_{\perp}^n reduction	Yes	Yes	Yes
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Sustainable cooling			
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[†] Requires systematic study of “flip” optics.
^{††} Full cooling cell: odd symmetry in magnetic field.

- Minimal Step IV programme:

- User Run #1: Technical run
 - Shake-down/commissioning/calibration & alignment etc.
- User Run #2: Liquid-hydrogen absorber
- User Run #3: Empty absorber
- User Run #4: Lithium hydride absorber

Under review

Introduction and overview

Orientation

Day Tuesday April 29**CR4 in R1 at RAL**

9:45	RLSR presentations & questions	
	Introduction and overview	K. Long (Imperial/STFC)
	The MICE construction project	R. Preece (STFC)
	Integration of Step IV	A. Nichols (STFC)
	Integrated financial report	A. Grant (STFC)
	Current Funding Constraints, Future Profile and US P5 Process	M. Palmer (FNAL)
	Scenarios for ceasing operations at Step IV or Step V	P. Garbincius (FNAL)
	Discussion	
14:00	Data taking, simulation & reconstruction	
	Software and computing overview	C. Rogers (STFC)
	Data taking and online	I. Taylor (Warwick)
	Simulation and reconstruction	D. Rajaram (IIT)
	Status of the physics analysis	V. Blackmore (Oxford)
Day	Wednesday April 30	CR4 in R1 at RAL
9:00	SC magnets & RF	
	Status of the focus coil project	T. Bradshaw (STFC, RAL)
	Status of the spectrometer solenoid and RFCC projects	A. Bross (FNAL)
	Status of the implementation of the partial return yoke	J. Tarrant (STFC, RAL)
	Status of the RF power project	K. Ronald (Strathclyde)
13:00	Commissioning, operations & controls	
	Operations project overview	S. Boyd (Warwick)
	Magnet commissioning at Step IV	J. Pasternak (Imperial/STFC)
	Controls and monitoring	P. Hanlet (IIT)
	Discussion/contingency	

Introduction and overview

Backup

- **Scientific objectives** [MICE-Note 21]:
 - Design, build, commission and operate a realistic section of cooling channel; and
 - Measure its performance in a variety of modes of operation and beam conditions.

i.e. results will allow Neutrino Factory complex to be optimised

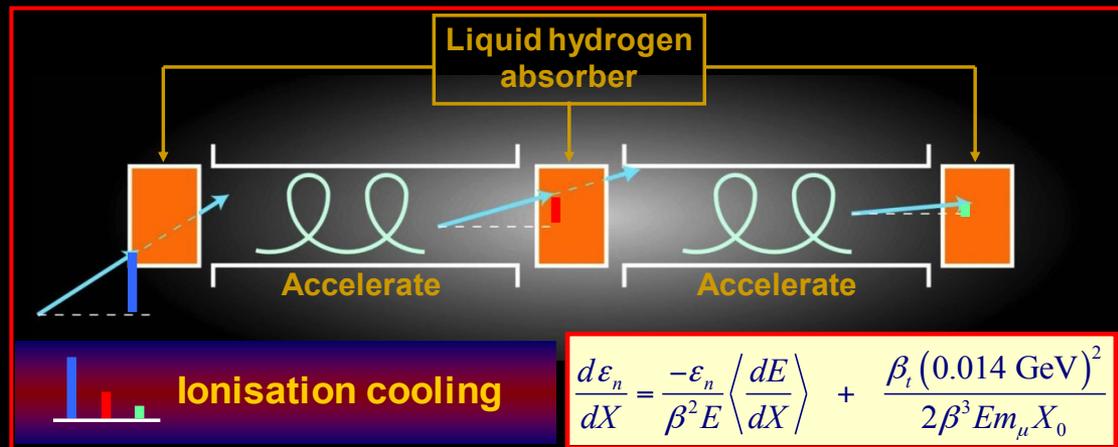
Particle-by-particle measurement, accumulate $\approx 3 \times 10^5$ muons
 $\Rightarrow \Delta [(\epsilon^{\text{in}} - \epsilon^{\text{out}}) / \epsilon^{\text{in}}] = 10^{-3}$

- **Principles:**

- Cooling results from energy loss in low-Z absorber:
 - Decrease in normalised transverse emittance
- Re-acceleration restores p_z ;
 - Decrease in transverse emittance
 - Sustainable cooling

- **Practical implementation requires:**

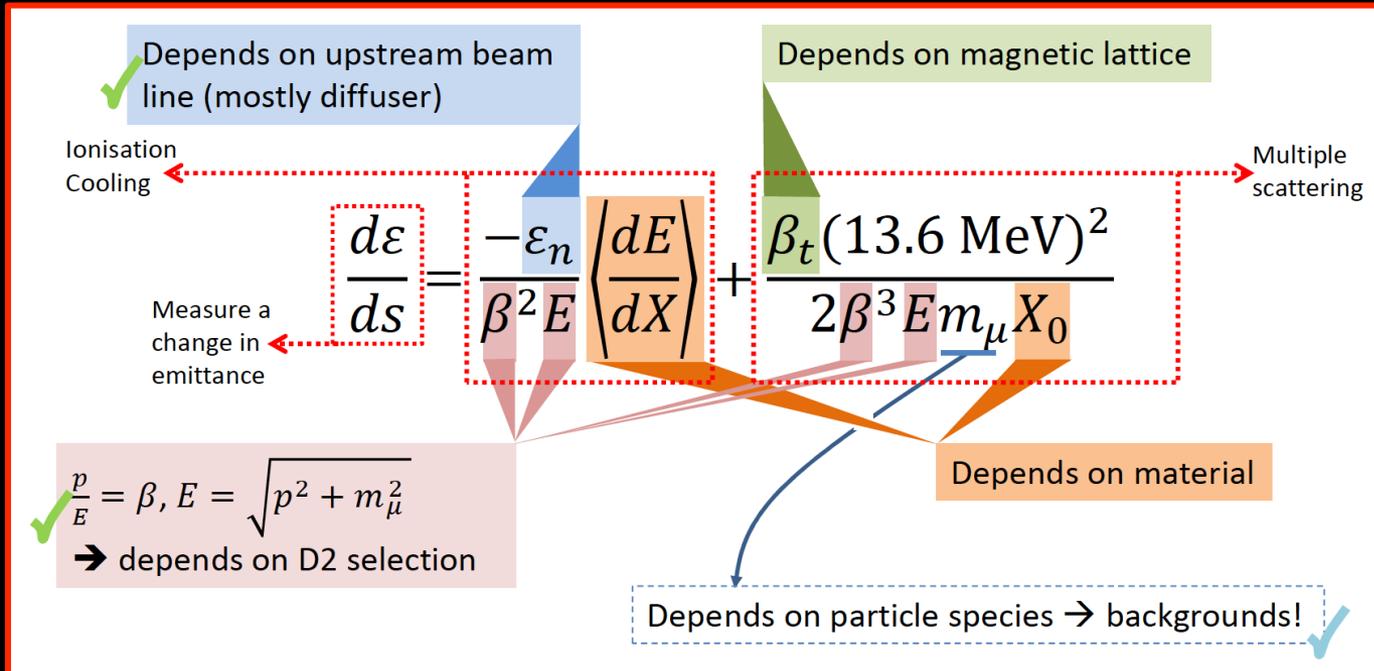
- “Management” of:
 - Longitudinal emittance
 - Canonical angular momentum



Criteria for success:

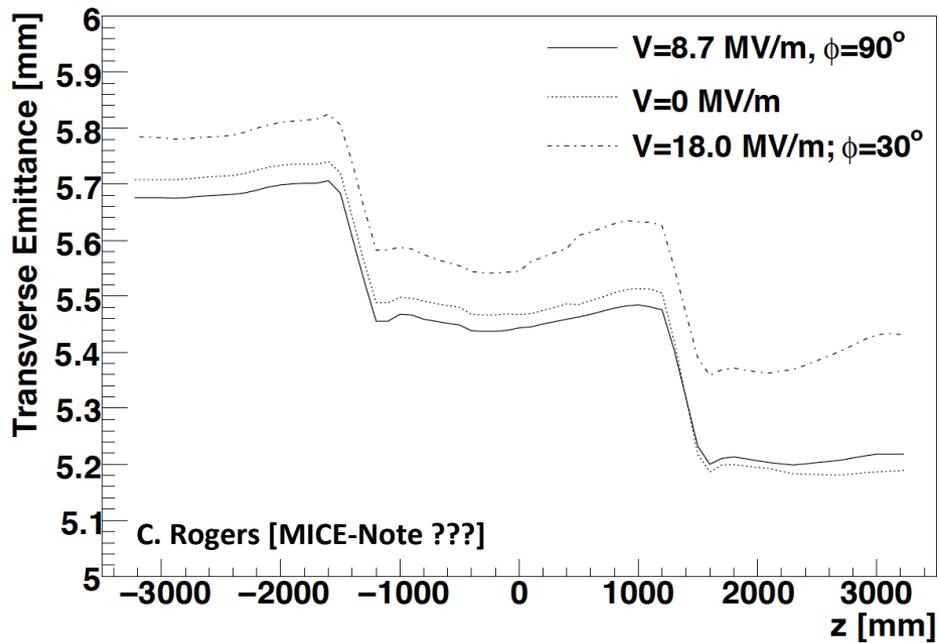
	Step IV	Step V	Step VI
Cooling Observation of ϵ_{\perp}^n reduction Cooling with LH ₂ and LiH			
Sustainable cooling Observation of ϵ_{\perp} reduction with re-acceleration Observation of ϵ_{\perp} reduction with ϵ_{\parallel} “management” Observation of ϵ_{\perp} reduction with $\epsilon_{\parallel} \oplus \mathcal{L}$ “management”			

• Exploration of the cooling equation:

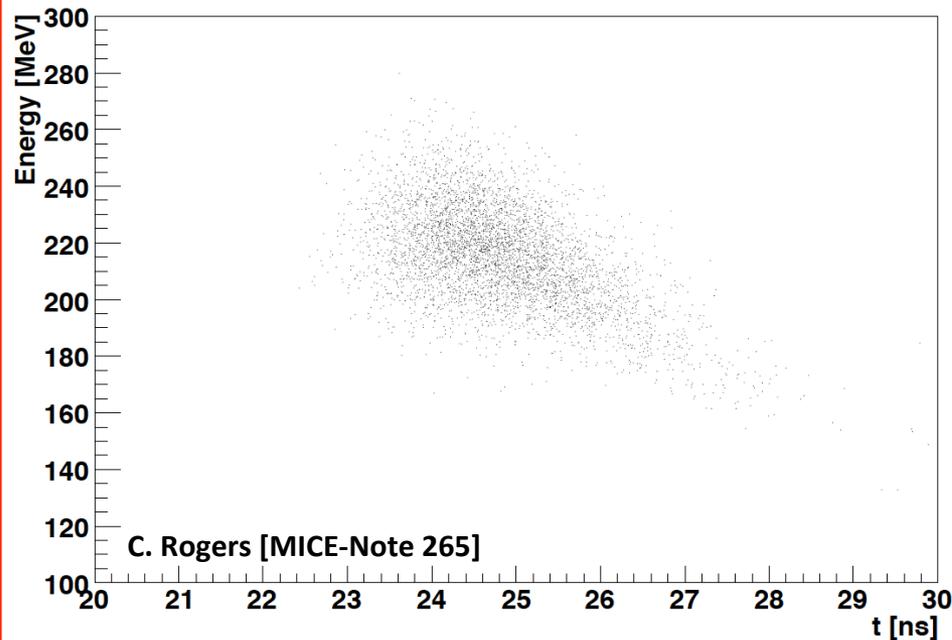


- Emittance:
 - MICE Muon Beam optics and diffuser settings
- Material:
 - Absorber change (LH2; LiH);
- p, E and β :
 - Vary beam momentum, optics

Step V:

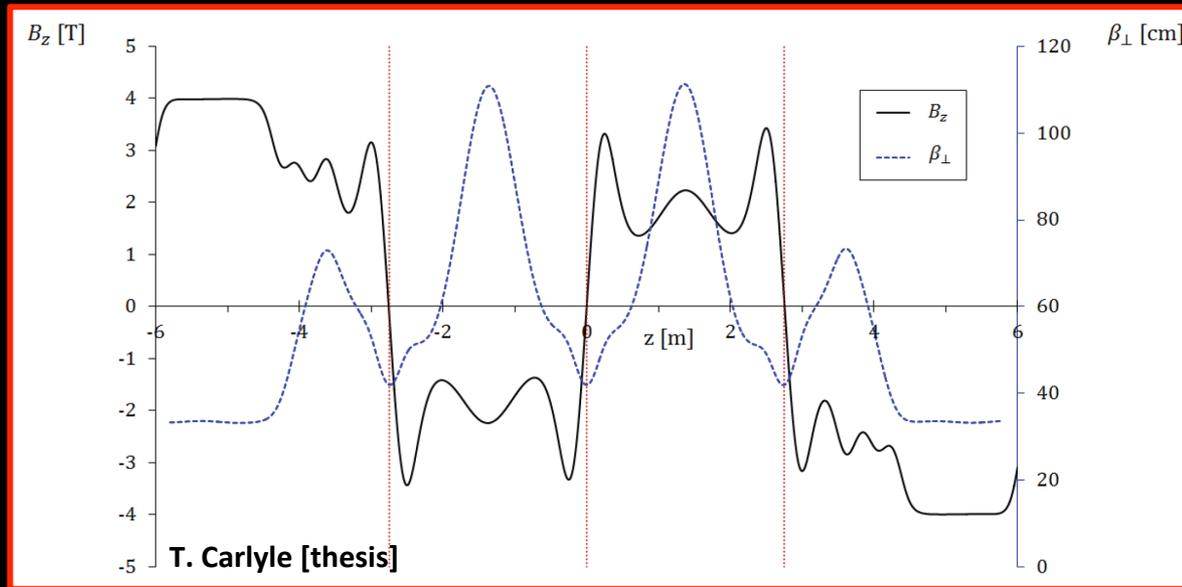


- Transverse emittance reduction at Step V

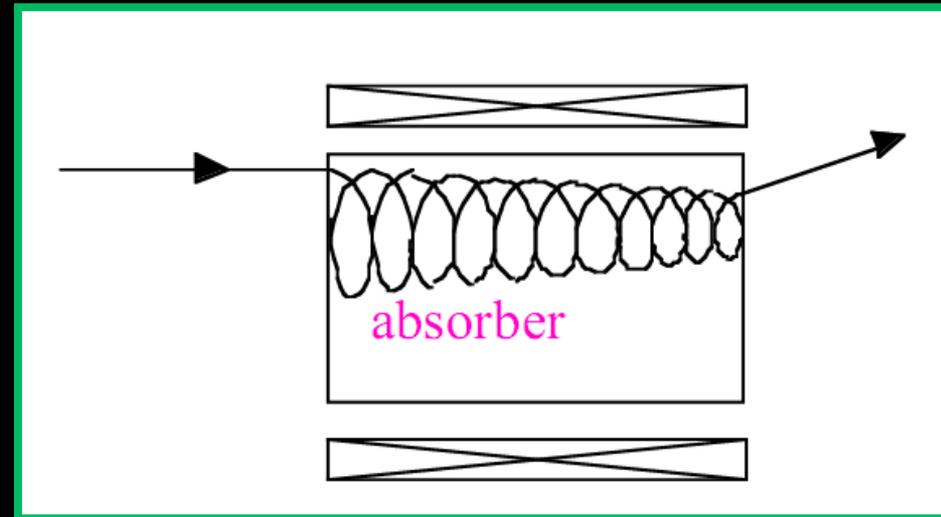


- Longitudinal phase space at the exit of the downstream absorber at Step V

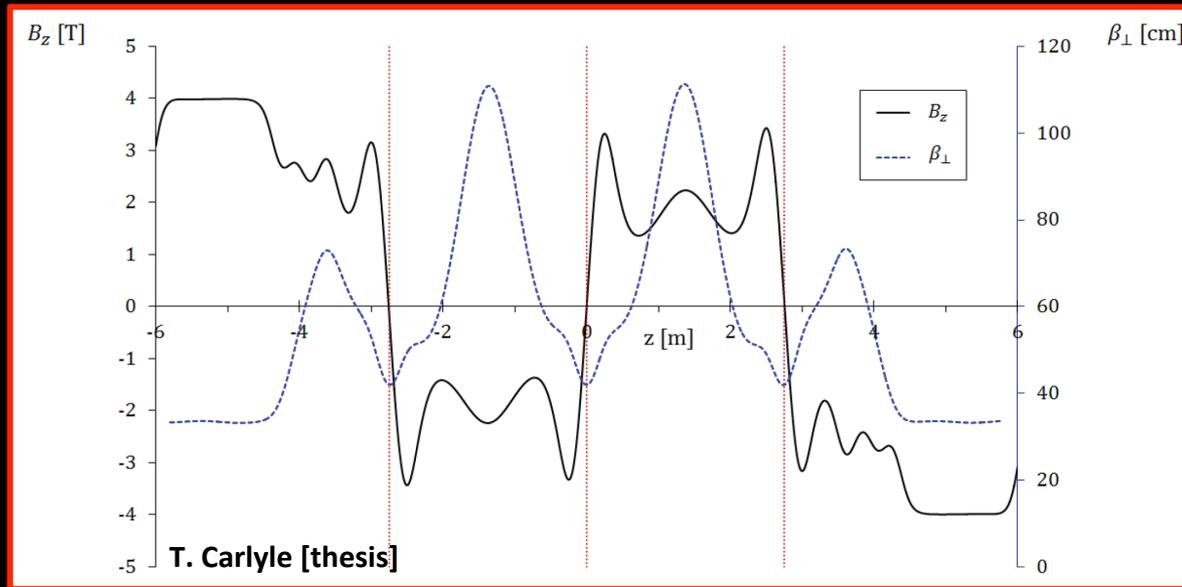
Angular momentum: the need for a field flip:



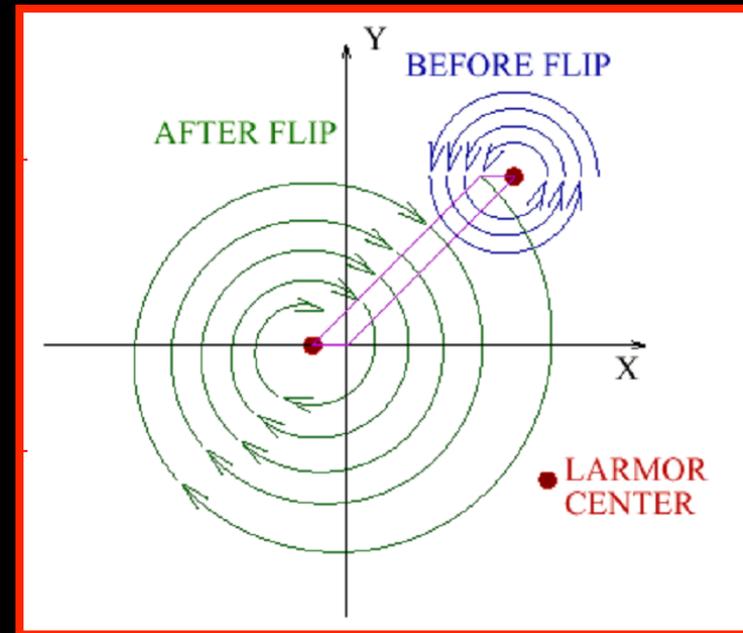
- Angular momentum introduced as beam enters channel:
 - Kick increases with radius
 - Would disrupt beam on exit if not mitigated



Angular momentum: the need for a field flip:



- Angular momentum introduced as beam enters channel:
 - Kick increases with radius
 - Would disrupt beam on exit if not mitigated
- Field flip:
 - Achieves better match of muon position and muon angular momentum



Step VI:

- Transverse emittance reduction at Step VI

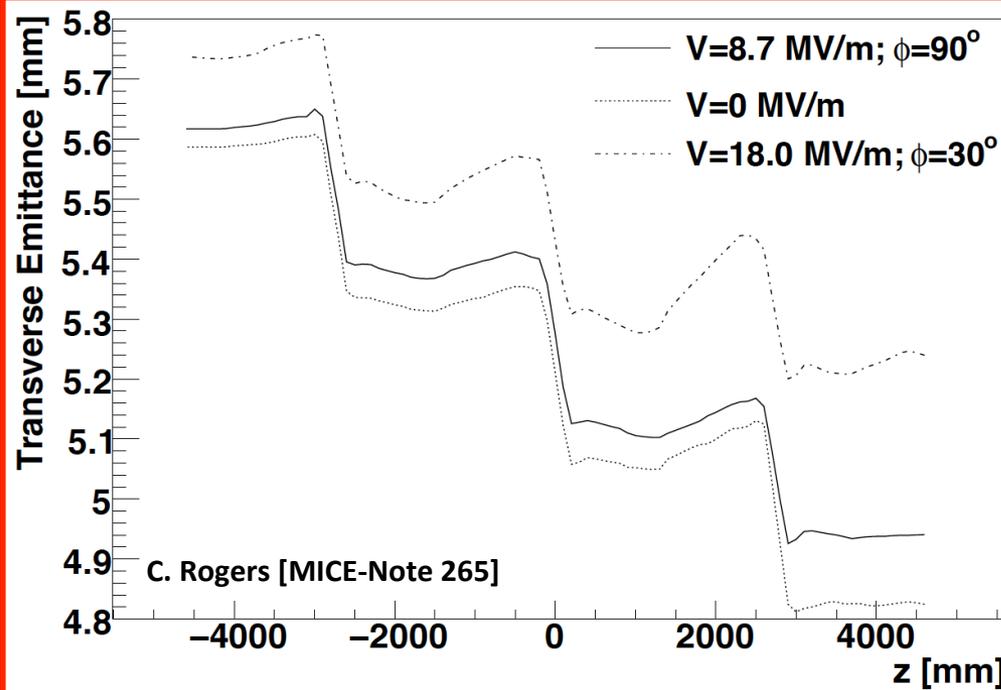
- Full cooling cell:

- 15% cooling effect:

- More precise measurement;

- Many more optical modes can be studied:

- In particular, allows the “odd symmetry” in the magnetic lattice that is required to manage the angular momentum



C. Rogers [MICE-Note 265]

