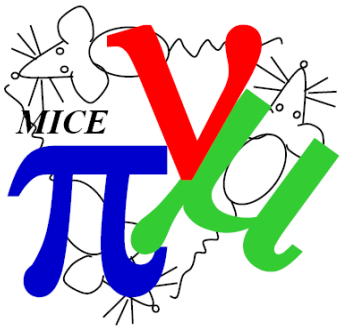


University of Glasgow

MICE Step IV Run Plan

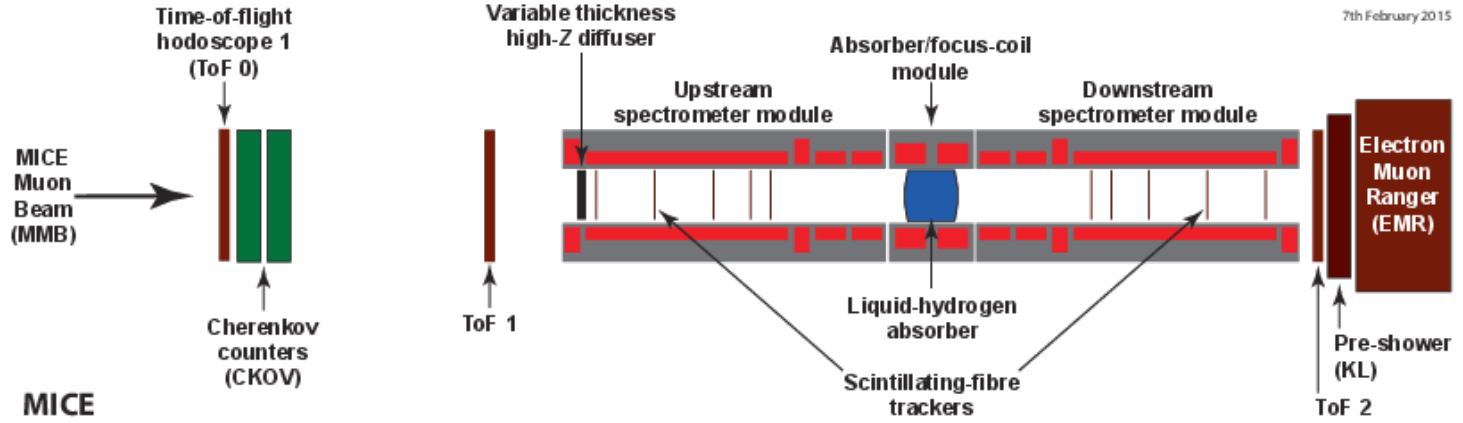
MAP Meeting

FNAL, 21 May 2015

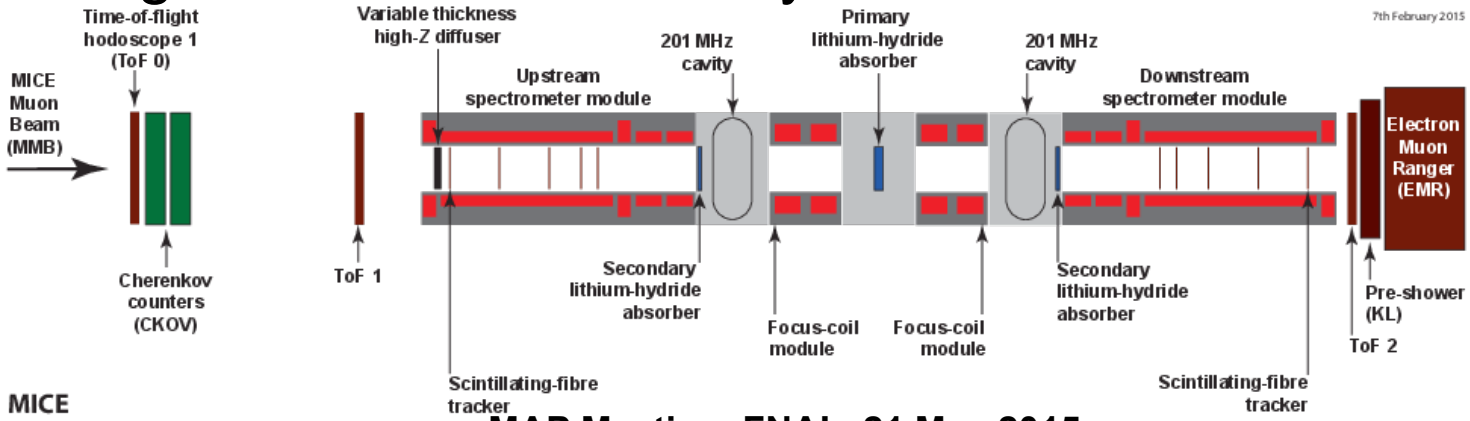
Paul Soler
University of Glasgow

Muon Ionization Cooling Experiment

- MICE will demonstrate ionization cooling in steps
  - Step IV: demonstration of reduction of normalised emittance

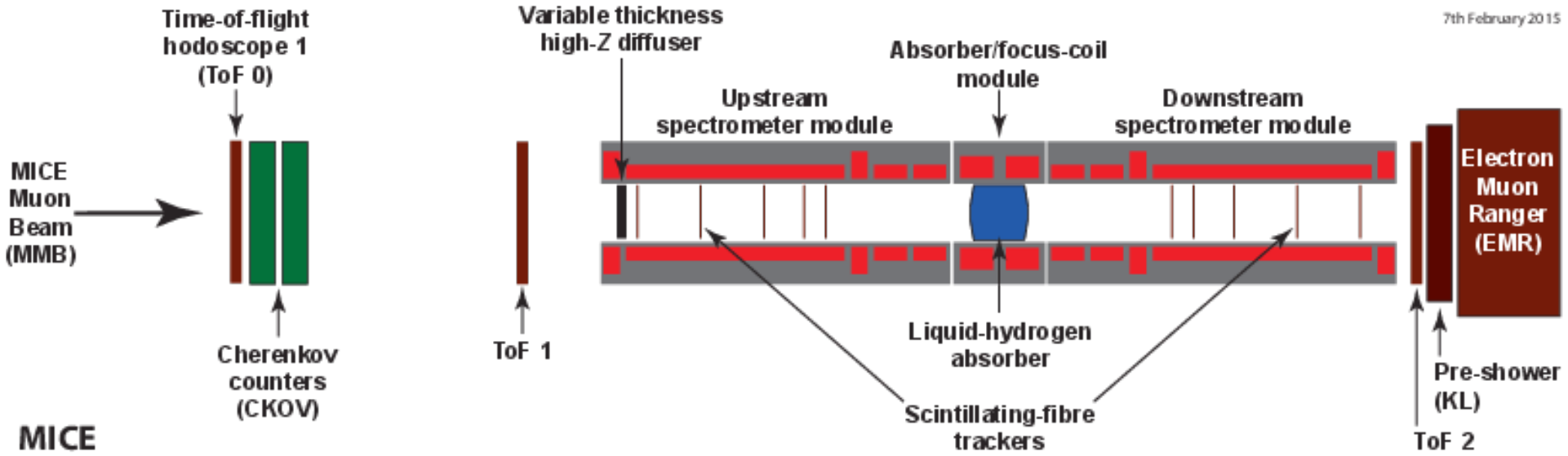


  - Final cooling demonstration step will demonstrate ionization cooling with reacceleration by RF cavities



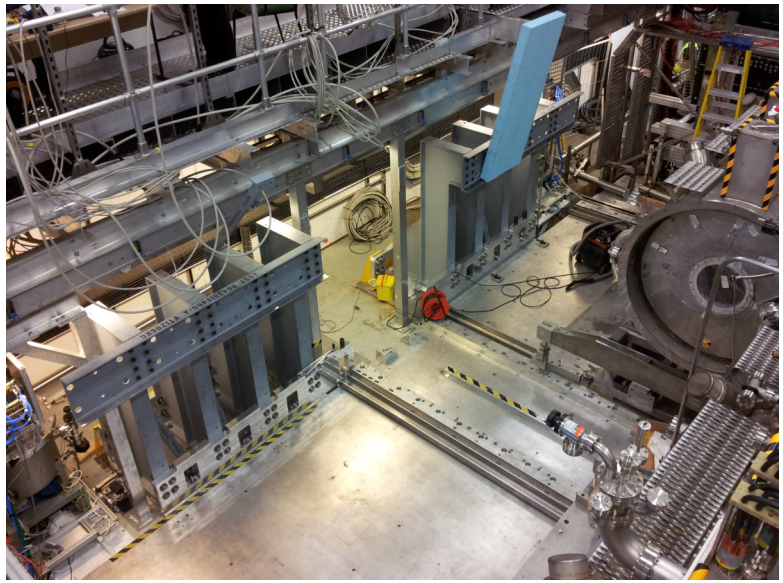
MICE Step IV

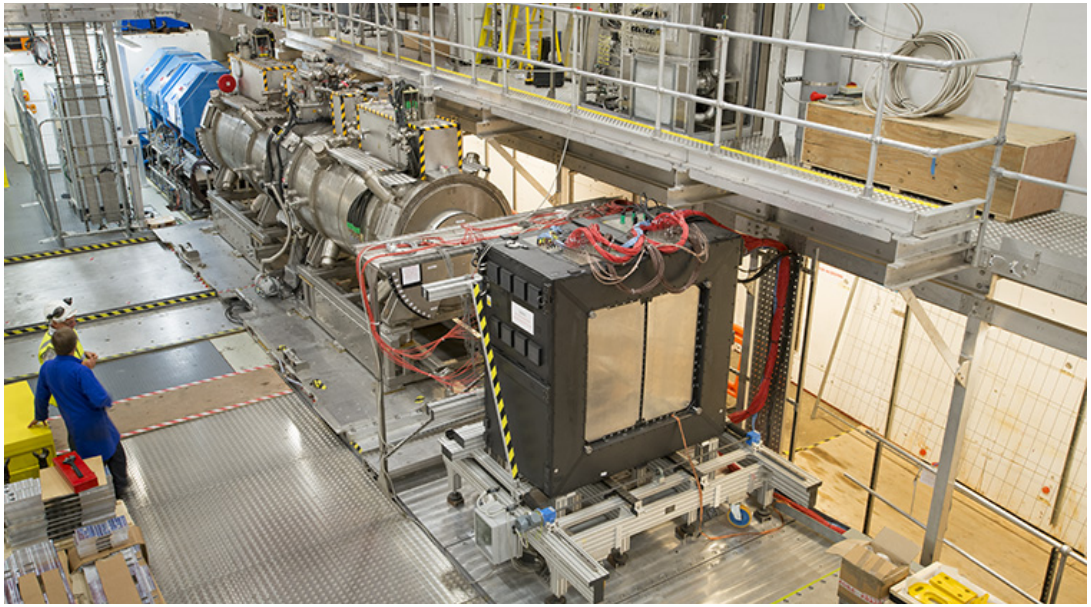
- MICE Step IV goals:
  - Step IV does not have RF restoration of energy
  - First measurement of reduction of normalised transverse emittance in two absorbers: LiH and liquid H_2
  - Measurement of absorber material properties
  - Validation of optics for demonstration of ionization cooling

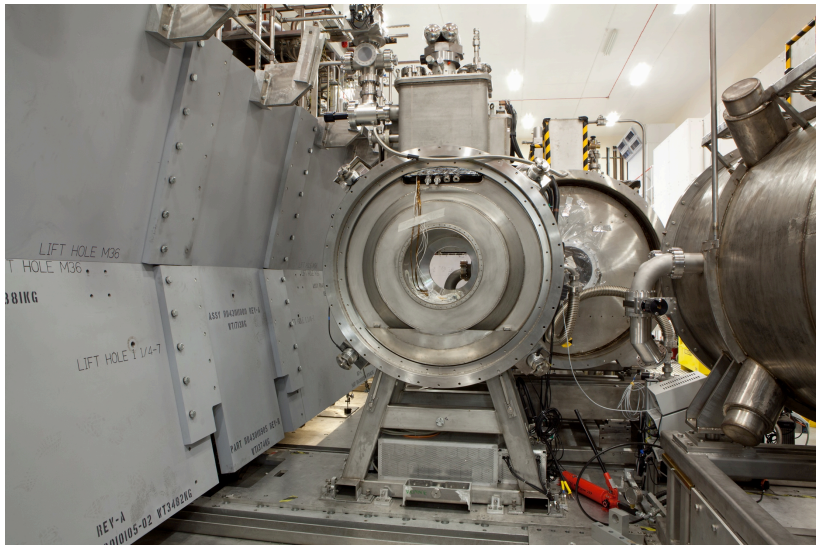


Step IV Construction

- Construction of Step IV:
  - Beam line installed and working
  - Two spectrometers and the focus coil module installed
  - Partial Return Yoke: south side installed, north side being installed this week

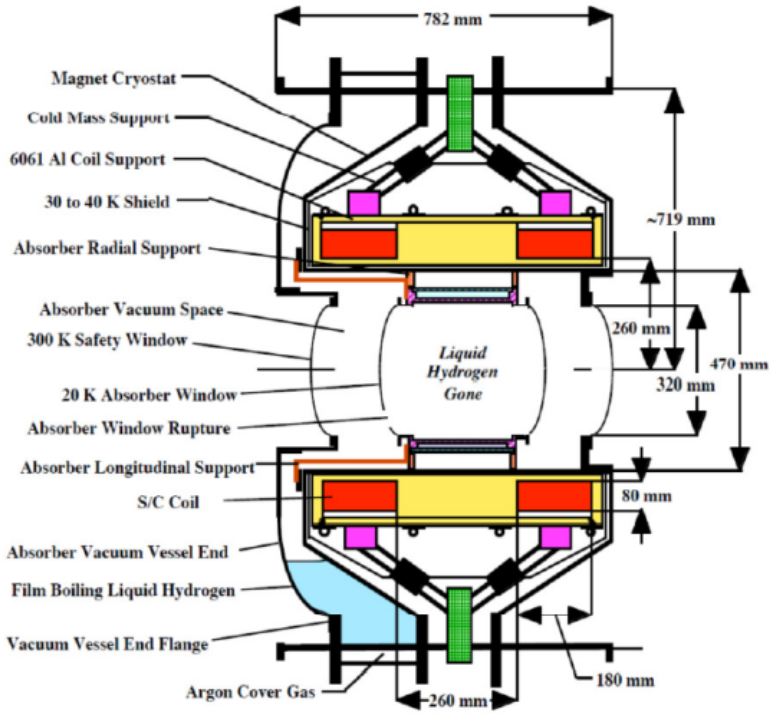






Step IV Absorbers

- Two absorbers in step IV:
  - Liquid hydrogen
  - Lithium hydride (LiH)
- Liquid hydrogen review
  - Held January 2015
  - Approval, subject to design changes due to absorber window failure mode
    - Boil off of LH2 in vacuum
    - Change diameter of relief line to cope with increased pressure (5-8 bar)
    - Burst test of thin window (25%): 7.66 bar
    - Installed window should burst at ~8.5 bar
    - Install a relief line to give safety factor of 2 in pressure rise (< 4.25 bar)

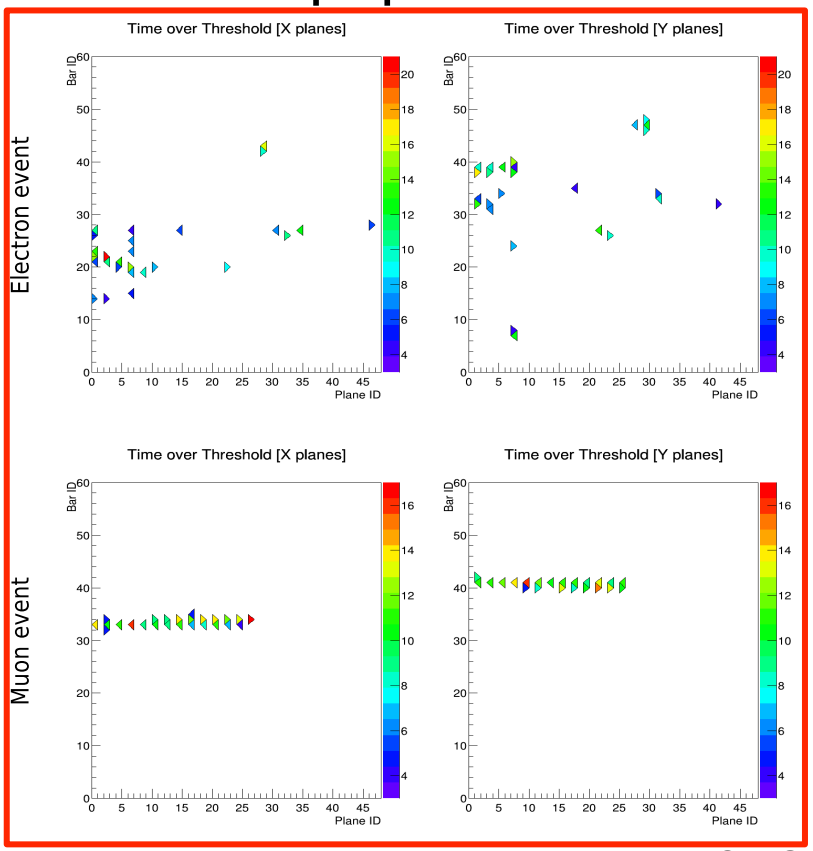


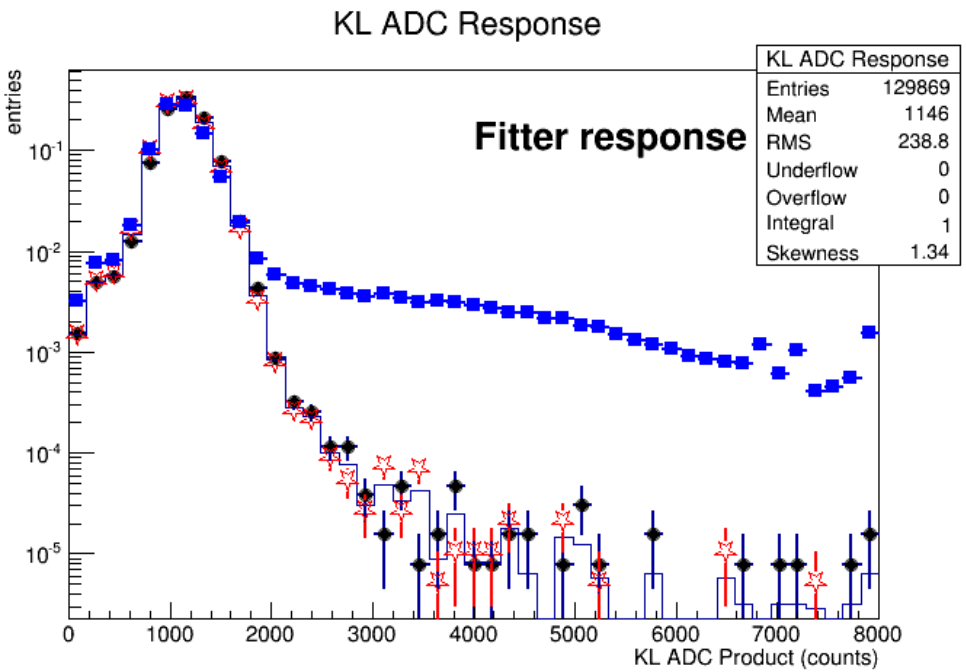
Original plan: start data taking with LH2

New plan: start with LiH to accommodate changes to LH2 design

Step I Analyses

- Demonstration of beam and detectors :
  - Pion contamination paper: upper limit on pion contamination of beam based on KL distributions
  - EMR paper: muon-electron separation based on EMR

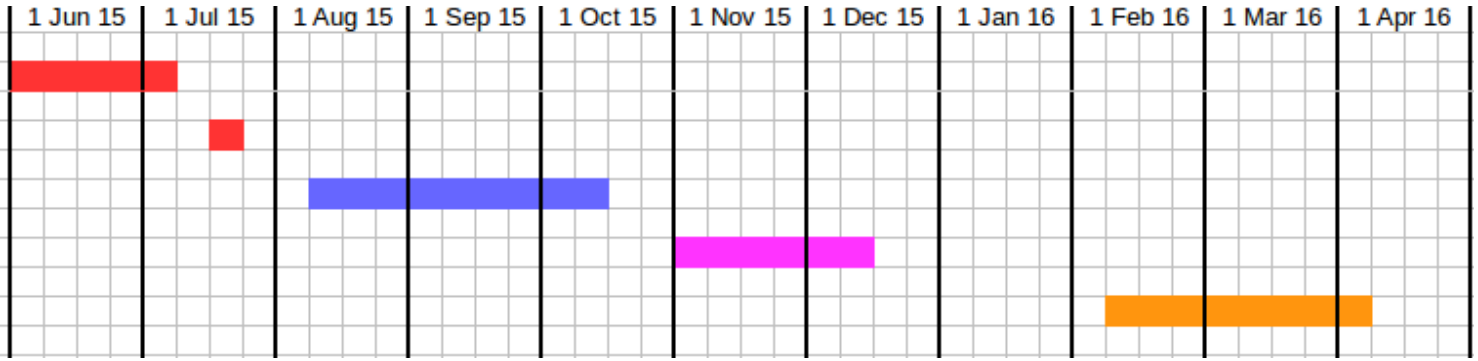




MICE Running Schedule

- Operational plan for Step IV
  - All Step IV MICE Operations Managers (MOM) appointed
  - ISIS schedule for Step IV:

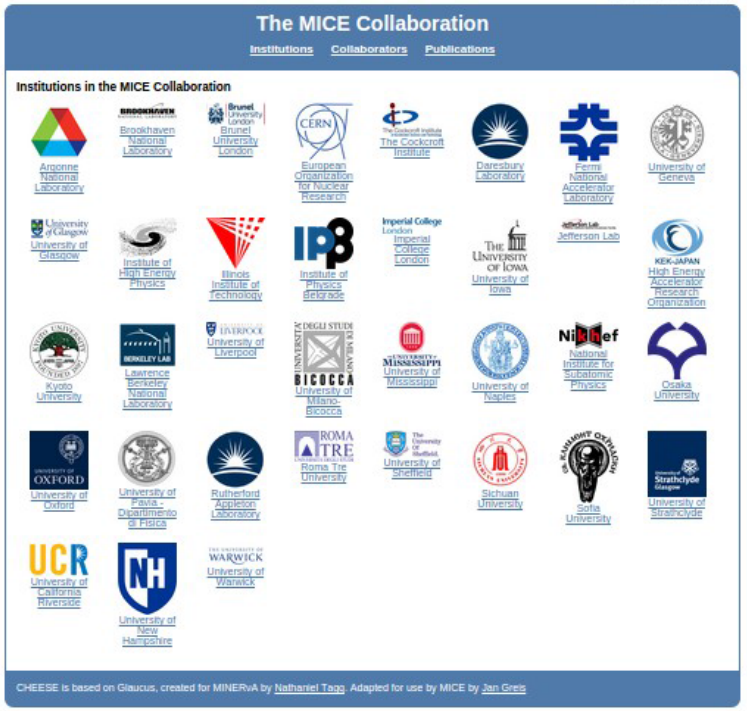
ISIS Cycle	Date From	Data To
2015/01a	2 Jun 15	5 Jul 15
2015/01b	14 Jul 15	24 Jul 15
2015/02	8 Aug 15	16 Oct 15
2015/03	3 Nov 15	18 Dec 15
2015/04	14 Feb 16	1 Apr 16



  - March-June 2015: installation and running simultaneously (weekend running)
  - June-July 2015: cooling channel commissioning
  - August 2015-April 2016: Step IV running
  - Likely to have another period running between April-June 2016 but ISIS schedule not available yet

Shift Allocation Tool

- Shift allocations
  - Shift allocation system rolled out (CHEESE): https://cheese.mice.rl.ac.uk/public
  - 79 people eligible for shifts (including new collaborators from Belgrade and China)
  - Will run 24/7 from July: blocks of shifts, each shifter to do 3 blocks
  - MOMs do not do shifts
  - Training on Fridays for now
  - Wednesdays will be maintenance day when running 24/7, so can offer training on Wednesdays
  - Shifters take two shadow shifts before allocated shift blocks

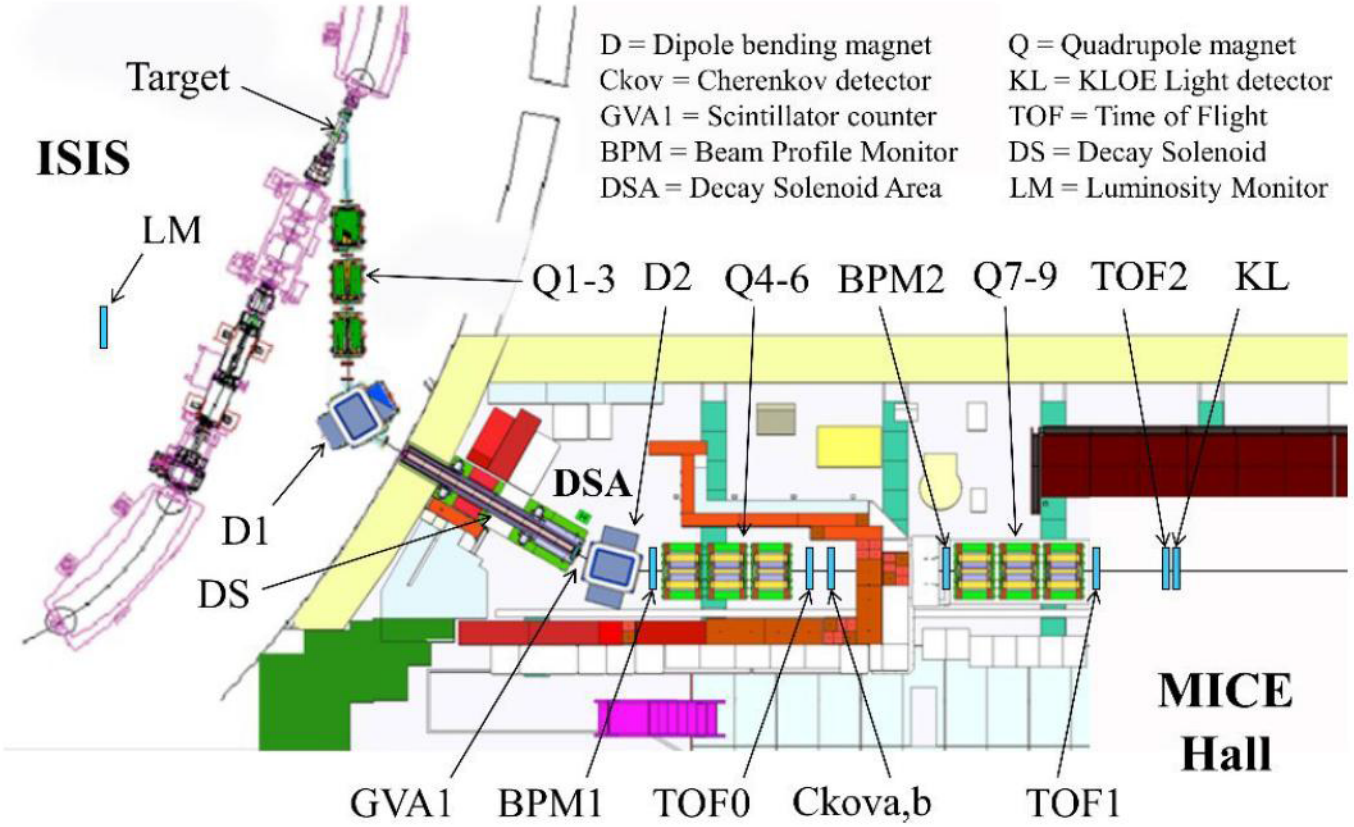


Step IV Physics Goals

- Physics analysis goals for Step IV:
  - Description of MICE Step IV
  - First observation normalised transverse emittance reduction
  - Diagnostics: detector alignment, resolutions, efficiencies, particle ID
  - Magnetics: magnet mapping and analysis, magnet alignment, beam quality, optical emittance growth, transfer map, study of non-linear effects, validation cooling channel optics
  - Absorber properties: energy loss, multiple scattering, angular momentum, beam depolarization
  - Final paper on beam cooling channel: final long paper with all physics of normalised transverse emittance reduction

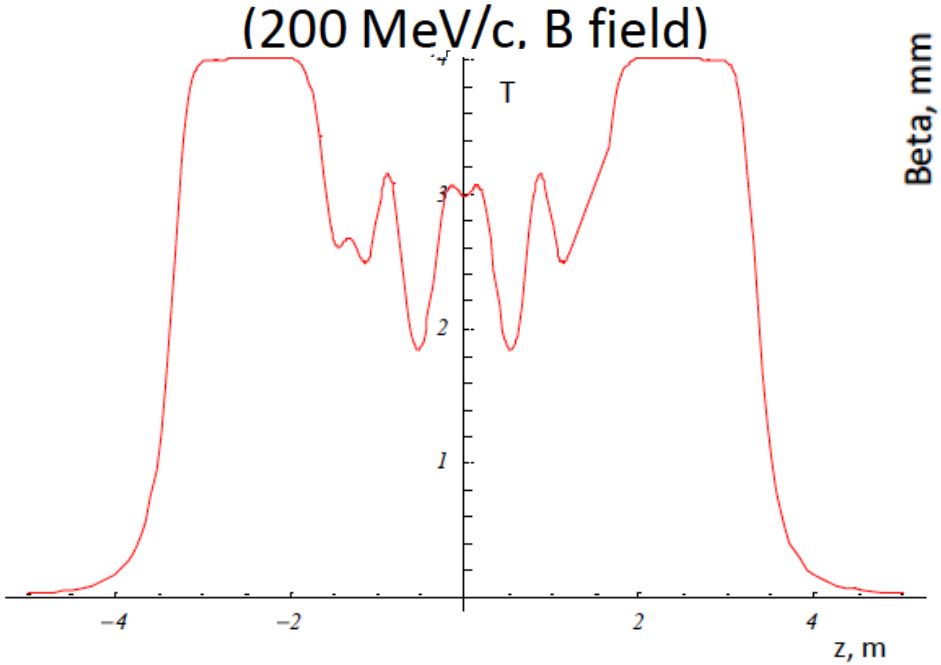
Beam Pre-commissioning

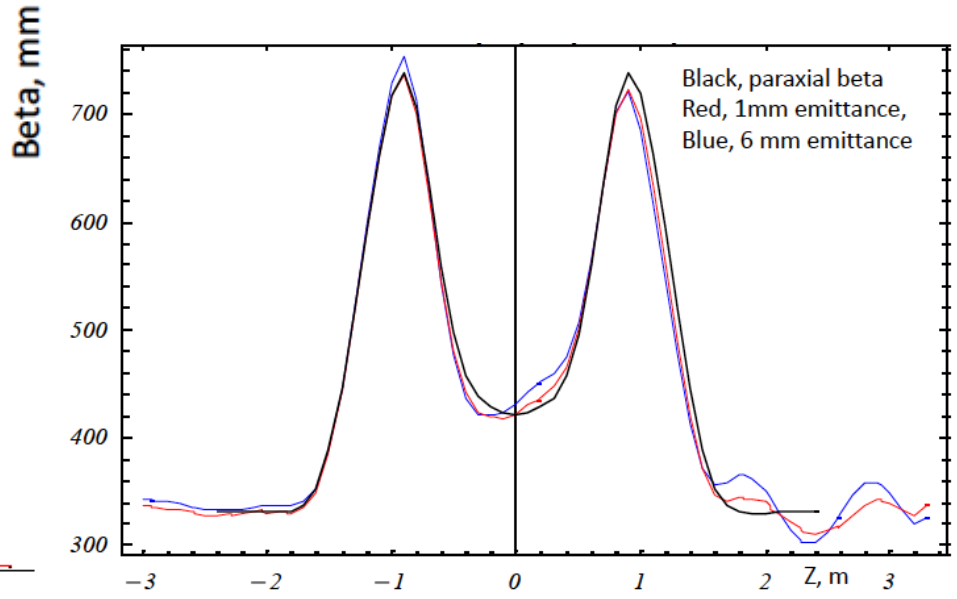
- Pre-commissioning plans: period 2015-01 (May-June)
  - Commission beam settings: magnet scans
  - Commission particle ID detectors



Beam Line Commissioning

- Commissioning plans: period 2015-01 (May-June)
  - Muon beam matching to the MICE Channel
  - Requires beta, alpha and emittance reconstruction at all five upstream tracker planes to test behaviour of the beam
  - Magnet Commissioning: assess beam optics
  - Measure transfer matrix through the channel





Beam Line Commissioning

- Beam commissioning plans during 2015-10
  - Train magnets during day, one data-taking shift at night

Task	Number of Shifts	Magnets	Shifts Per Day	ISIS	Start Date	End Date
TOF Calibration and Ckov Commissioning	2	SS	1	01a	02/06/15	04/06/15
Tracker Hardware Commissioning	6	SS	1	01a	04/06/15	10/06/15
Tracker Validation	2	SS	1	01a	10/06/15	12/06/15
Beamline Pre-commissioning	4	SS	1	01a	12/06/15	16/06/15
EMR Commissioning 1	1	SS	1	01a	16/06/15	17/06/15
ISIS Maintenance Day	0	FC	0	Maintenance	17/06/15	18/06/15
EMR Commissioning 2	3	FC	1	01a	18/06/15	21/06/15
EMR Commissioning 3	2	CT	1	01a	21/06/15	23/06/15
Complete magnet training	0	CT	0	01a	23/06/15	25/06/15
Tracker External Alignment	1	Done	1	01a	25/06/15	26/06/15
Alignment to Other Detectors	1	Done	1	01a	26/06/15	27/06/15
Beam-Based Alignment 1	7	Done	1	01a	27/06/15	04/07/15
ISIS Machine Physics	0	Done	0	Machine Physics	04/07/15	14/07/15
Beam-Based Alignment 2	2	Done	3	01b	14/07/15	14/07/15
Validation of Track Matching	1	Done	3	01b	14/07/15	15/07/15
Validation of Particle Identification	2	Done	3	01b	15/07/15	15/07/15
Beamline Commissioning	15	Done	3	01b	15/07/15	20/07/15
Optics Validation	21	Done	3	01b	20/07/15	27/07/15

Beam Line Commissioning

- Pessimistic run plan
  - Depends on magnet training and number of quenches when three solenoid magnets trained jointly

Task	Number of Shifts	Magnets	Shifts Per Day	ISIS	Start Date	End Date
TOF Calibration and Ckov Commissioning	3	SS	1	01a	02/06/15	05/06/15
Tracker Hardware Commissioning 1	12	SS	1	01a	05/06/15	17/06/15
ISIS Maintenance Day	0	SS	0	Maintenance	17/06/15	18/06/15
Tracker Hardware Commissioning 2	3	SS	1	01a	18/06/15	21/06/15
Tracker Validation 1	4	SS	1	01a	21/06/15	25/06/15
Tracker Validation 2	5	FC	1	01a	25/06/15	30/06/15
Beamline Pre-commissioning 1	4	FC	1	01a	30/06/15	04/07/15
ISIS Machine Physics	0	CT	0	Machine Physics	04/07/15	14/07/15
Beamline Pre-commissioning 2	2	CT	0.75	01b	14/07/15	16/07/15
EMR Commissioning	9	CT	0.75	01b	16/07/15	28/07/15

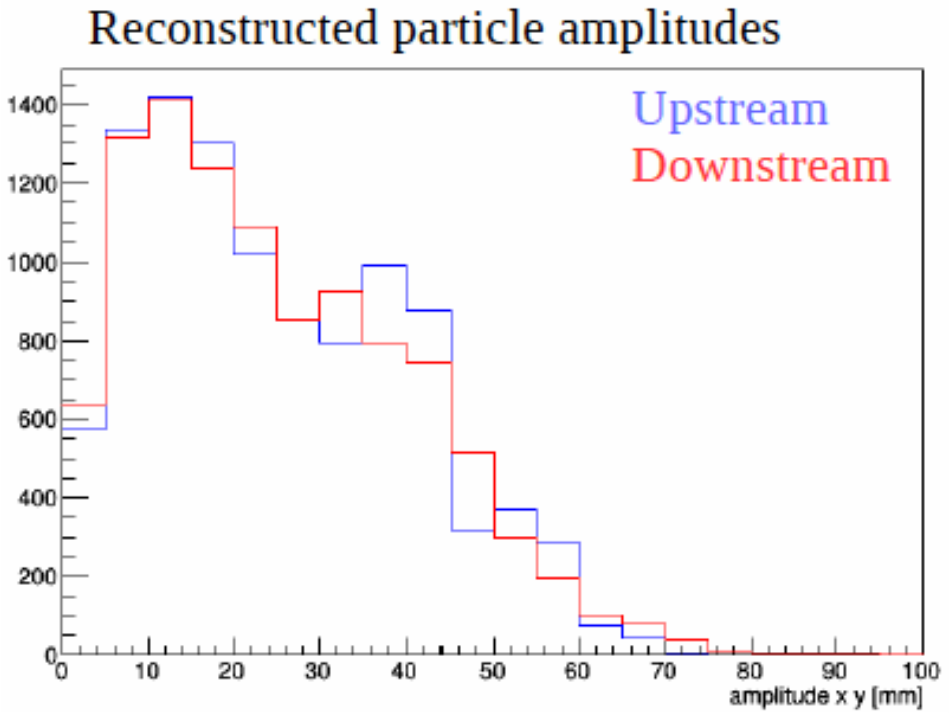
Operations and Analysis

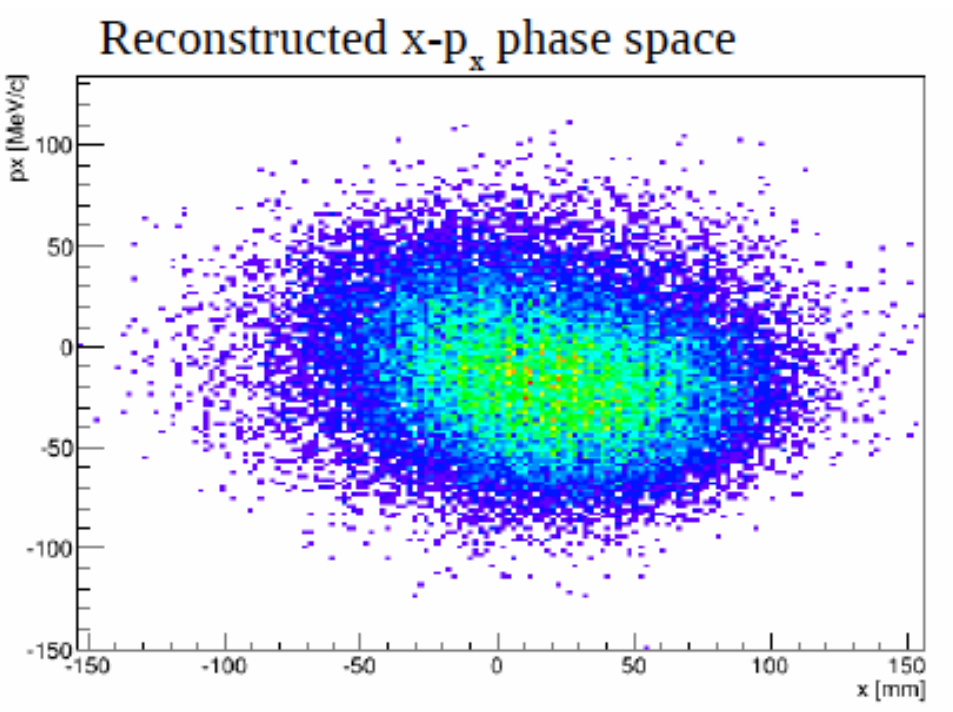
- Data taking plan:
  - Start data taking with Empty and LiH absorber
  - Each measurement has a “proponent” with configurations, Monte Carlo, physics analysis, etc.

User Period	Run Type	Absorber	Focus Coil Mode	Run-time (days)	Total (days)
2015-02	Physics	Empty	Solenoid	15	
	LiH Install			8	
	Physics	LiH	Solenoid	15	38
2015-03	Calib/Setup			7	
	Physics	Empty	Flip	15	
	LiH Install			8	
	Physics	LiH	Flip	15	45
2015-04	Calib/Setup			7	
	Physics	lH2	Flip	18	
	Physics	lH2	Solenoid	18	43
					126

Step IV Cooling Analysis

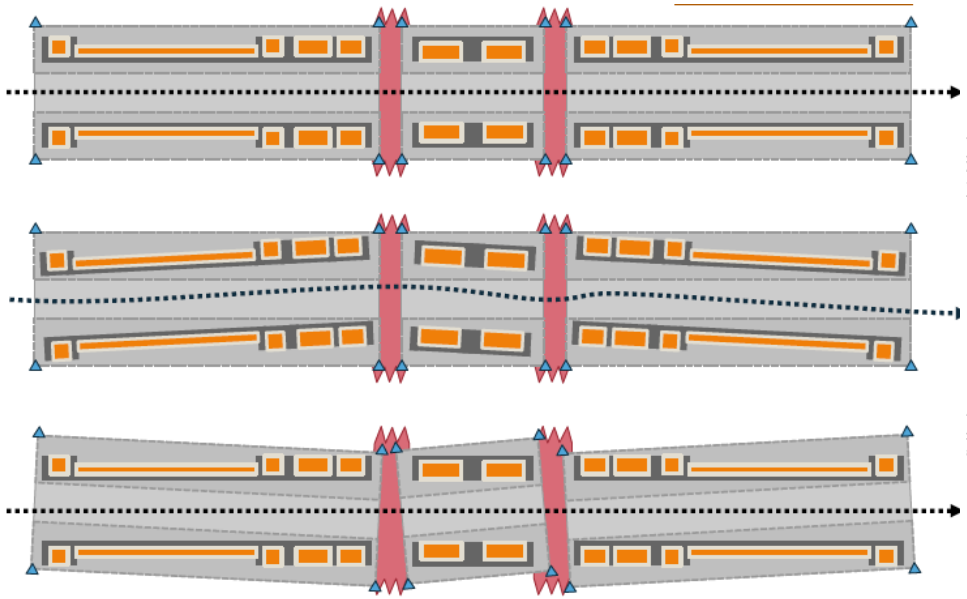
- Blind analysis of a MC data set (MC data challenge)
  - Realistic beam configuration
  - Reconstruction of all detectors
  - Reweighting technique to simulate matched beams

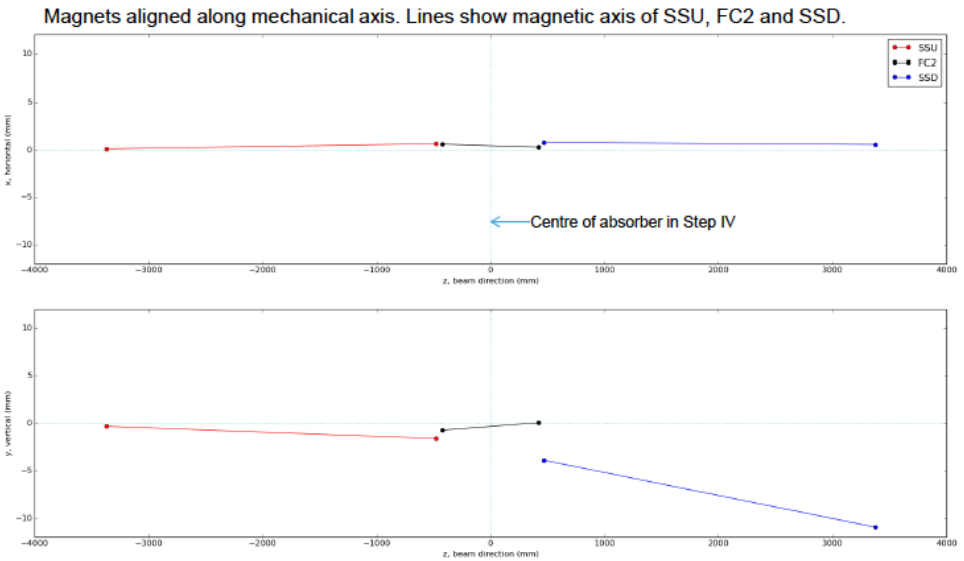




Step IV Magnetic Field Analysis

- Magnetic alignment (preliminary) using three methods:
  - Perform fit of magnetic field map with respect to geometric axes from survey information
  - Minimise |B| to find axis
  - B_T should also point to axis





Start of Step IV Operations Event

- STFC and RAL want to mark start of MICE Step IV with an open event at RAL on 25 June 2015
  - Mini-conference for scientists followed by a public lecture
  - Tentative Schedule (all times BST=GMT+1):
    - 13:30-17:00: Extended seminar on the physics and technology of cold muon beams
    - 17:30-18:30: Public Lecture by a distinguished scientist
    - 18:30-19:00: Reception
    - 19:00: Adjourn

Conclusions

- MICE is proceeding towards Step IV and detector commissioning has already commenced
- Run plan includes:
  - Pre-commissioning of muon beam
  - Commissioning of detectors (including tracker)
  - Commissioning of magnets and cooling channel
  - Full data taking to commence in August 2015
  - New baseline is to start with LiH (but could change to liquid hydrogen if new relief line ready in time)
  - Software and systems in good shape and operational plan ready for running 24/7 from July 2015