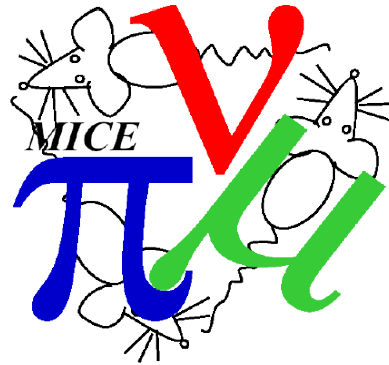




# Step IV Measurements and Analysis Planning

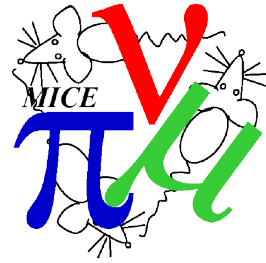
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C. T. Rogers, on behalf of the MICE analysis group  
ASTeC Intense Beams Group  
Rutherford Appleton Laboratory

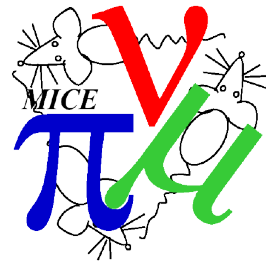


# Overview



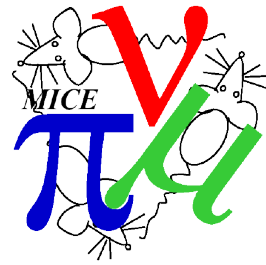
- “Top down” outline of physics goals
- Status updates
- Plan for ISIS User Run 2015-01a/01b
- Planning for subsequent runs
- Analysis group support of Step IV operations

# Step IV Physics Goals



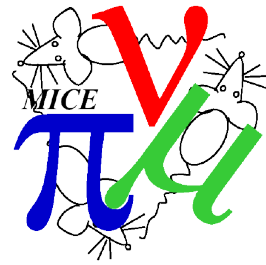
- For quick release (these are papers):
  - **Description of MICE Step IV**
  - **First observation normalised transverse emittance reduction**
- Subsequently:
  - **Diagnostics**
    - Detector alignment
    - Integrated detector resolutions and efficiencies
    - Measurement of beam purity (validation of particle ID routines)
  - **Magnetics**
    - Magnet mapping and analysis
    - Beam-based measurement of magnet alignment
    - Demonstration of beam quality
    - Measurement of optical emittance growth and non-linearities
    - Direct measurement of the transfer map

# Step IV Physics Goals (cont)



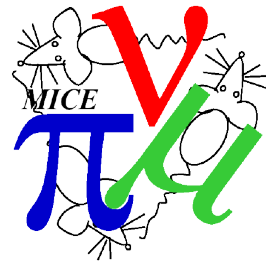
- Subsequently (cont):
  - **Absorber**
    - Energy loss
    - Multiple scattering
    - Angular momentum
    - Beam (de)polarisation
    - (Wedge shaped absorber)
  - **“Cooling Channel”**
    - (Long, probably following end of Step IV with all results in) Observation of normalised transverse emittance reduction
    - (Emittance exchange with wedge)
      - Extension of Step IV programme

# Step IV Cooling Analysis



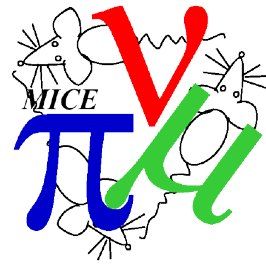
- Blind analysis of an MC dataset is ongoing
  - Tracking simulation of MICE from ISIS target to EMR
    - Including all magnets and materials
    - Using surveyed positions where available
    - Simulation of electronics response of each detector based on energy deposited
  - Successful reconstruction of detectors
    - Using simulated electronics response as an input
    - Following full reconstruction chain
  - Successful data analysis
    - Using only data that would be available from the reconstruction
  - Further development required in a few areas
    - Particle Identification routines
    - Beam selection routines
    - Estimation of reconstruction errors
    - **All known issues - no surprises**

# Other Step IV Analyses



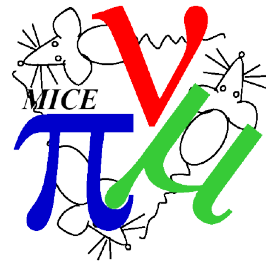
- Preliminary analysis of the measured solenoid axes complete
- Studying non-linear effects at Step IV
  - Validated tracking against Lie Algebra code and Taylor series code
  - Seeking beam optics settings that can enhance the effect for a direct measurement
- Monte Carlo studies ongoing for commissioning runs
  - Beam-based measurement of detector and magnet alignment
  - Beam-based measurement of reconstruction efficacy
  - Validation of beamline and cooling channel optics calculations
- Adopted a data analysis tool
  - Use ROOT, PyROOT, numpy/scipy for standard analysis tools
  - Use xboa for accelerator specific analyses
    - Developed by C. Rogers for Neutrino Factory studies

# Plan for User Run 2015/01



- Constraints
  - Magnet training has priority over data taking
    - May take the entire user run
  - 1 shift per night during first part of the user run (01a)
  - 3 shifts per day during second part of the user run (01b)
- Two outline run plans prepared
  - Optimistic / best case scenario
  - Pessimistic / worst case scenario
- Priorities:
  - Commission the tracker
  - Check integrated detector efficacy
  - Beam-based measurement of detector and magnet alignment
  - MICE muon beamline to MICE cooling channel matching
  - Demonstrate cooling channel optics
- Initially no absorber

# Optimistic run plan

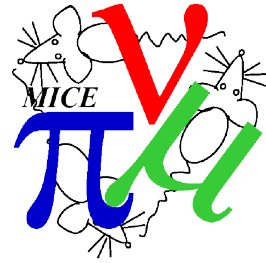


Task	Number of Shifts	Magnets	Shifts Per Day	ISIS	Start Date	End Date
TOF Calibration and Ckov Commissioning	2	SS	1	01a	02/06/15	04/06/15
Tracker Hardware Commissioning	6	SS	1	01a	04/06/15	10/06/15
Tracker Validation	2	SS	1	01a	10/06/15	12/06/15
Beamline Pre-commissioning	4	SS	1	01a	12/06/15	16/06/15
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

- Blue – external constraint
- Red – ran out of time
- 9 shifts required to complete commissioning after 01b



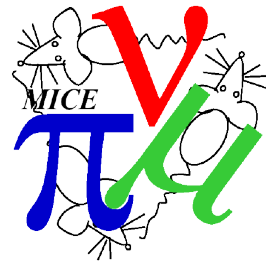
# Pessimistic run plan



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

- Blue - external constraint
- Red - ran out of time
- 68 shifts still required to complete commissioning after 01b

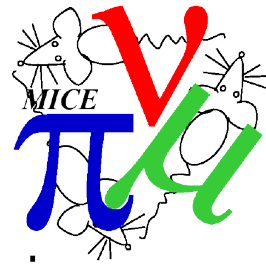
# Plan for subsequent user runs



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	
2015-04	Physics	LiH	Flip	15	45
	Calib/Setup			7	
	Physics	IH2	Flip	18	
	Physics	IH2	Solenoid	18	43
					126

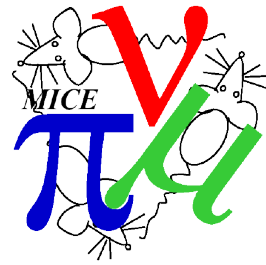
- Lithium Hydride will now be installed before liquid Hydrogen
  - Subject to readiness for liquid Hydrogen operations
  - Extra 6 days for LiH install in each run eats into our contingency
- Subject to progress in 2015-01

# Physics support of operations



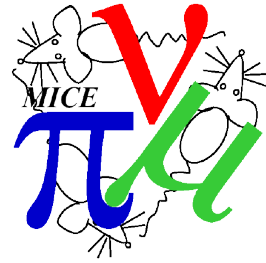
- Each “measurement” has a coordinator who must organise
  - Experimental configuration (currents, etc)
  - MC and analysis/planning
  - Any fast turnaround analysis tools
  - Coordination with MOM during data taking
  - Liaise with physics coordinator to arrange “physics shifters”
  - Evaluate need for more data following data taking
    - In liaison with operations/physics coordinators
- “Physics shifters”
  - Check e-log
  - Check that they can analyse the reconstructed data
  - Check that the analysis of the data looks sensible
  - Run any checks specified by the measurement coordinator
- Physics shifter has been in place for all 2015 physics runs

# “Physics devil” software tool



- Checks that infrastructure is working correctly
  - Checks that Configuration Database was updated
  - Checks that raw data file was uploaded
  - Checks that data was reconstructed offline
  - Reports reconstruction efficiencies and errors
- Extensible
  - Plan to add detector reconstruction histograms based on offline data
  - Plan to add “analysis” variables e.g. transmission, delta emittance, etc
  - Plan to run automatically and publish output to MICE website
    - Has been run manually for March/April data taking period

# Conclusions



- Physics goals have been outlined
- Status of Step IV analysis preparation has been discussed
- Plan for June/July has been presented
- Planning for subsequent runs discussed
- Plan for analysis group support of Step IV operations was described