# MICE Step IV
# Software & Analysis Plans

D. Rajaram
IIT

Dec 20, 2013

# Step IV Analysis

- Step IV will measure cooling effect with different materials
- Requires us to understand:
  - Momentum selection & transport of particles
    - Alignment of beamline
  - Detection of particles
    - Reconstruction of tracks and particle ID
    - Alignment and calibration
  - Background
  - Beam matching and emittance generation through diffiuser
  - Transmission efficiency through the lattice
  - Multiple scattering & energy losses in material
  - Timing/spill structure (important for Step VI)
- Measure cooling for each material

# Analysis Overview:

Key:
- Completed (paper published)
- Near completion (paper being drafted)
- In progress (paper being thought of)
- At risk (not <u>currently</u> being looked at)

1. Momentum selection/transport of particles, alignment of the beam line
   a) Beam ~~line documentation – Step I "beam line paper"~~
   b) Characterisation of the upstream beam line – Step I "emittance paper"
   c) Understanding the momentum and spatial distributions
      - Step I "emittance paper" looked at expected vs. measured momenta and spatial distributions
      - Mismatch observed between simulated and measured dispersion in the beam (i.e. incorrect beam line assumptions in simulation)
      - New G4BL simulations of upstream beam line are in <u>much better agreement</u>
   d) Transport of particles – Step I "emittance paper" demonstrates we can do this

   Nugent, Soler, Blackmore

   ) Alignment of Q789 using Step I data
      - Upstream beam line (possibly) not perfectly aligned. Measured beam is smaller than expected. Scan Q789 quadrupoles and look at beam position at TOF1 to judge alignment.

Thanks to: V. Blackmore

# Analysis Overview:

Key:
- Completed (paper published)
- Near completion (paper being drafted)
- In progress (paper being thought of)
- At risk (not currently being looked at)

2. Detection of particles
   a) CKOV, TOFs, KL instrumentation documented in beam line paper
   b) EMR and tracker(?) instrumentation documented
   c) Particle ID with EMR
   d) Particle ID using TOFs/KL/Ckovs (?) – Pion contamination paper
   e) Global PID

4. Alignment and calibration
   a) Calibration of TOFs is documented (bar "rate effect"!)
   b) Calibration of EMR (plan being developed)
   c) Alignment and calibration of trackers
   d) Alignment of Step IV PID detectors (*i.e.* straight track check, all detectors)

   *NB: A lot of "alignment" is just a survey of the main body of the detector*

5. Background rates
   a) Demonstrate understanding of our pion and muon production – pion contamination paper
   b) EMR analysis, further information on pion and muon production. Standalone or could feed into pion contamination paper depending on analysis requirements.

Uchida, Dobbs

Blondel, Asfandiyarov, Drielsma

Orestano

Taylor, Pidcott

Rajaram, Bonesini

Blondel, Asfandiyarov, Drielsma

Uchida

Needs Step IV

Needs a champion: Taylor, Pidcott?

Orestano

Blondel, Asfandiyarov, Drielsma

Thanks to: V. Blackmore

# Analysis Overview:

Key:
- Completed (paper published)
- Near completion (paper being drafted)
- In progress (paper being thought of)
- Not looked at yet

5. Beam matching and emittance generation
   a) Required for maximising beam without field and matching through new diffuser with/without field. Depends on 1c, 6a (with field). ← Leonova, Nugent
   b) Measure multiple scattering through diffuser in Step IV (no field) ← Blackmore
      i. Confirms beam behaves as expected through distributed diffuser, gives confidence in matching abilities
   c) Measure beam matching (with field) in Step IV upstream and downstream of cooling channel (depends on 5d, 6a)
   d) *Lattice re-match with reduced FC currents*

Needs Step IV → 5b, 5c, 5d, 7b, 7c, 8a

7. Transmission efficiency through lattice
   a) Understand solenoid field ← Blackmore
   b) Study of transmitted number of muons through Step IV with/without field ← Santos
   c) Expected efficiency of cooling in Step IV (with/without reduced FC currents) ← Santos

8. Canonical angular momenta
   a) Understand what happens to canonical angular momentum in flip and solenoid mode



Thanks to: V. Blackmore

# Analysis Overview:

Key:
- Completed (paper published)
- Near completion (paper being drafted)
- In progress (paper being thought of)
- At risk (not currently being looked at)

8. Multiple Scattering
   a) Multiple scattering in channel is a background we must understand
   b) Multiple scattering in an absorber is part of the cooling formula
      a) Same input beam, same absorber, different $\beta_t$ at absorber
      b) Same input beam, same absorber, different $p$ at absorber
      c) Repeat for different absorbers
      d) No absorber, detector limitations (background)
   c) Multiple scattering is best measured without field

Thesis completed

Cobb, Carlisle

Santos

Needs Step IV

9. Energy Losses
   a) Similar to multiple scattering, but comparison momentum loss instead of scattered angles (also useful for RF in Step V/VI)

Needs champion

10. Timing/spill structure
    a) Depends on understanding 9.
    b) Timing of muons passing through Step IV upstream/downstream as expected
    c) Required confirmation for Step V/VI with RF
    d) Using Step IV beams as input, propagate through RF simulation

Needs champion



Thanks to: V. Blackmore

# Step IV Analysis:

Key:
- Completed (paper published)
- Near completion (paper being drafted)
- In progress (paper being thought of)
- At risk (not currently being looked at)

By this point we should:

i. Understand our measurement techniques, detectors, and errors on those measurements
ii. Understand our backgrounds
iii. Understand our PID and track reconstruction
iv. Understand the lattice behaviour
v. Understand all of the "inputs" into the cooling formula and be able to estimate the amount of cooling we expect to see in Step IV
vi. Exploit the measurements to improve our understanding of Step V/VI

Step IV complete (**and an awful lot learned**)!

Thanks to: V. Blackmore

# MICE Step IV Analysis

- Analysis group led by Victoria Blackmore drives analyses and requirements
- Software (IO, detector reconstructions, online) & Infrastructure (DB, batch processing) handled by computing group (head – Rogers, offline – Rajaram, online – Taylor)
- Computing and software plan being revised with input from subgroups and developers to identify needs, get realistic resource-loaded schedules, and monitor progress
- Regular bi-weekly meetings for MAUS, Geometry, Grid, Online, Analysis.
- Goal is to have a preliminary global reconstruction & end-to-end MC simulation of Step IV by CM38 (end Feb 2014)