MICE SOFTWARE

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IIT, Chicago

MAP Winter Meeting
6 December 2014
SLAC

OVERVIEW

- MICE Software & Computing goals
- Organization
- Status
  - Detector reconstruction, Monte Carlo
  - Software Infrastructure
- Summary

MICE Software & Computing

- Wide range of tasks
  - Read out detectors – DAQ
  - Provide controls hardware & monitoring
  - Manage and maintain Control Room servers
  - Reconstruct data
  - Provide online monitoring & reconstruction
  - Describe geometry, fields
  - Provide Monte Carlo simulation of MICE
  - Manage data storage
  - Provide database tools to manage configurations
  - Web services
- Aim to turn around reconstructed data within 24 hours of data taking

MICE Software & Computing

- Wide range of tasks
  - Read out detectors – DAQ
  - *Provide controls hardware & monitoring (cf. Pierrick Hanlet's talk)*
  - Manage and maintain Control Room servers
  - Reconstruct data
  - *Provide online monitoring & reconstruction (cf. Pierrick)*
  - Describe geometry, fields
  - Provide Monte Carlo simulation of MICE
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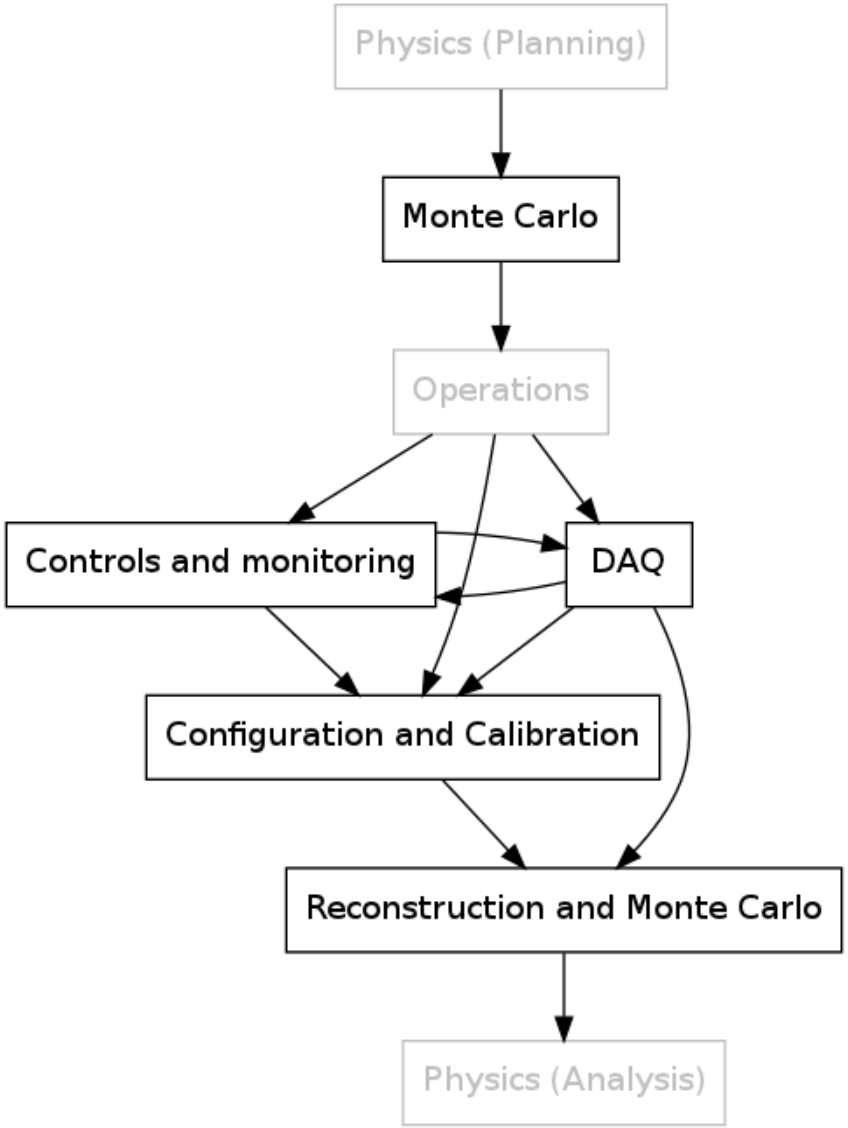
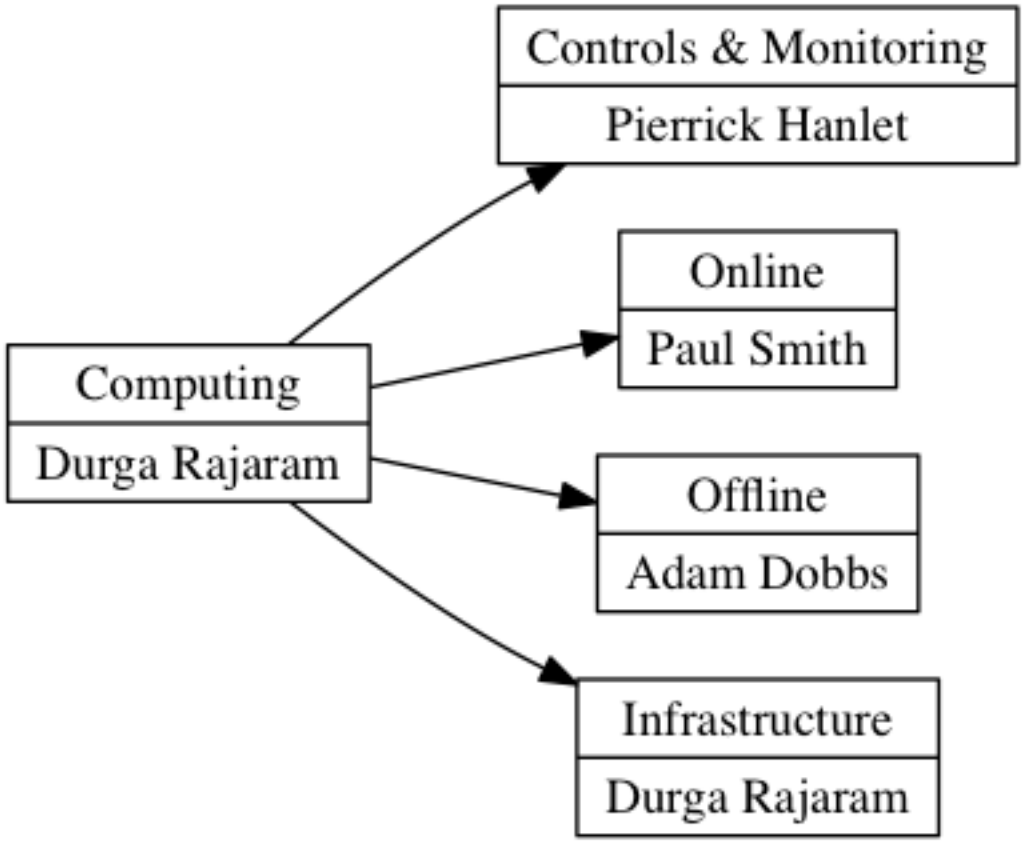
WORKFLOW


Physics (Planning)
Monte Carlo
Operations
Controls and monitoring
DAQ
Configuration and Calibration
Reconstruction and Monte Carlo
Physics (Analysis)

ORGANIZATION



- Personnel changes
  - Chris Rogers has taken over the Physics group
  - Rajaram took over from Rogers
    - Also interim manager for Infrastructure until Warwick postdoc takes over in Jan 2015
  - Adam Dobbs who was coordinating tracker s/w is now head of Offline

ONLINE

- Online group responsible for MLCR systems:
  - Control Room servers & networking
  - Operator interface machines
  - DAQ
  - Online monitoring of DAQ
- *Not responsible for the software that runs in MLCR*
- Have a working system, continuing to make improvements

OFFLINE: SOFTWARE SCOPE

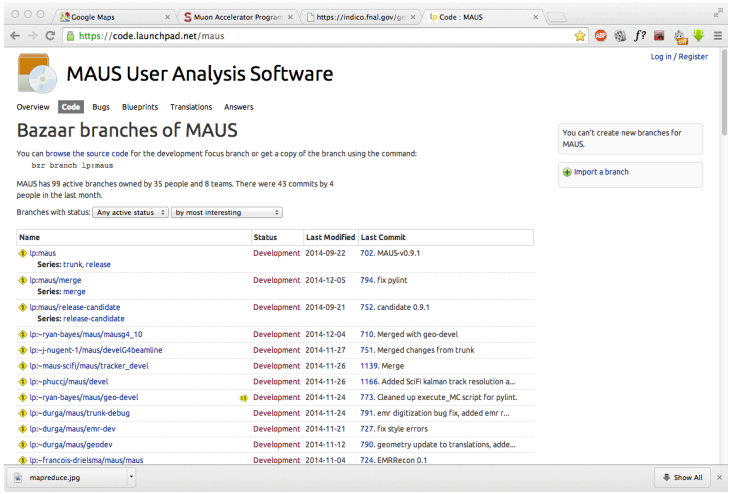
- Reconstruction
  - Detectors
  - Global Tracks & Particle ID
- Simulation
  - Beam + Geometry description + Fields + Detectors
- Online Reconstruction
  - Detector-level shifter monitoring
- Data validation & quality checks
- Analysis tools
- Single-event display

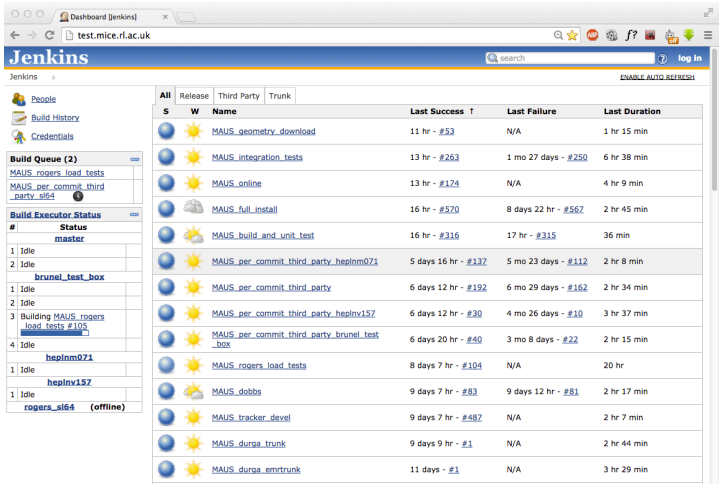
MAUS: MICE ANALYSIS USER SOFTWARE

- Plug-in modular design
- Map-Reduce framework (Google, Hadoop, etc)
  - Input-Map-Reduce-Output
  - Map – operation on single event, e.g. reconstruction
  - Reduce – operation on all events in spill
- Input: Read data
  - Read DAQ data & unpack, or MC beam input
- Transform: Process spill & return modified data
  - MC digitization
  - Reconstruction, tracking
- Merge: Summarize data
  - Detector summary, efficiency plots, etc
- Output: Write out data
  - ROOT (default) or JSON formats

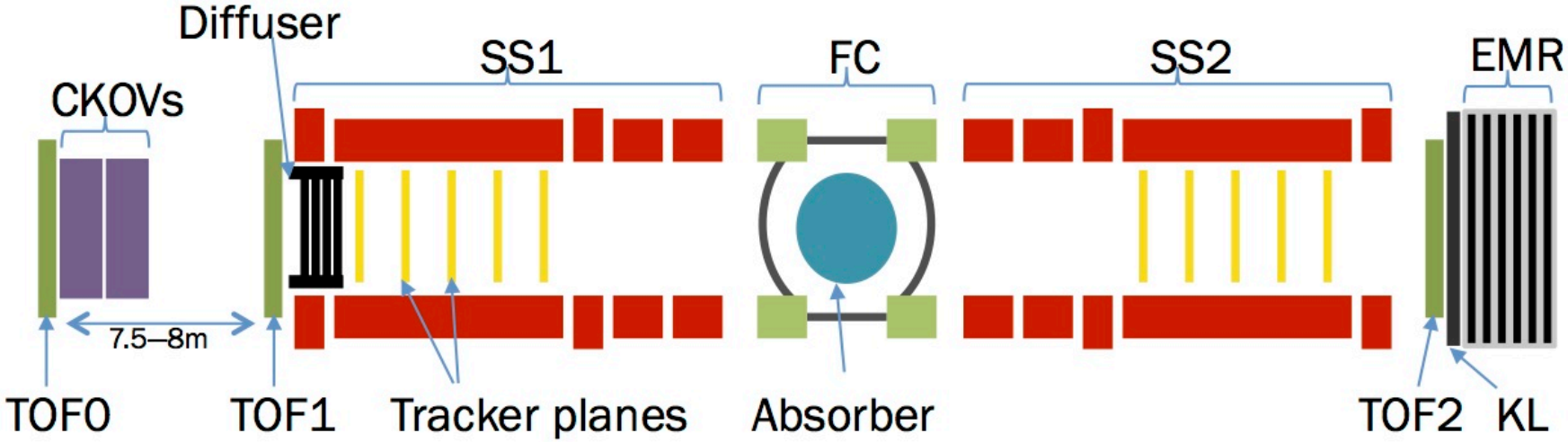
Code Management

- Code hosted on launchpad
- Bazaar DVCS repository
- Development trunk with stable releases every ~2 weeks (currently at 0.9.1)
- Code is a mixture of Python and C++
  - Python for simple, high-level code
  - C++ for complex algorithms
  - Users allowed to write in either language
  - Python bindings to C++ handled by SWIG
- Dependent packages e.g. GEANT, ROOT, etc are installed as part of MAUS installation
- Continuous Integration test server (Jenkins) allows users to test development code before merging with official trunk
- Redmine Wiki for issue tracking

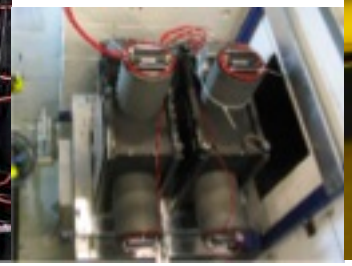




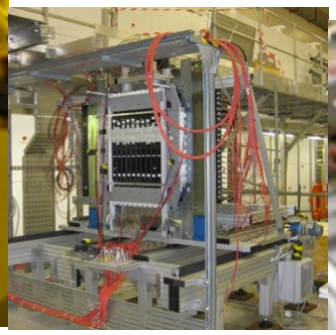
SIMULATION & RECONSTRUCTION
MICE DETECTORS

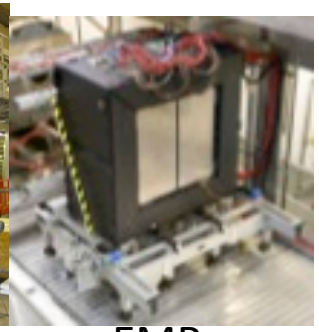



TOF

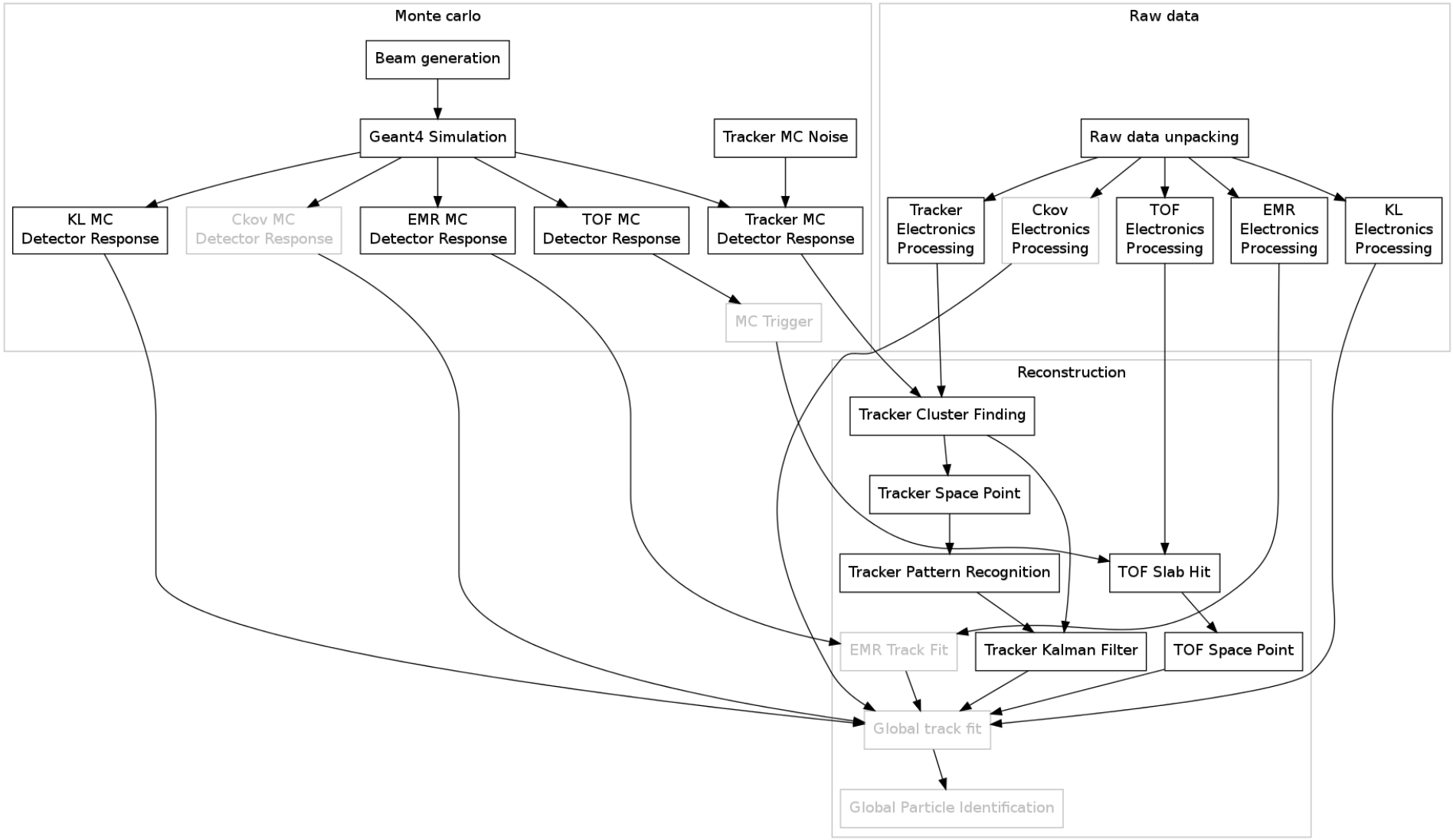

Ckov


Tracker

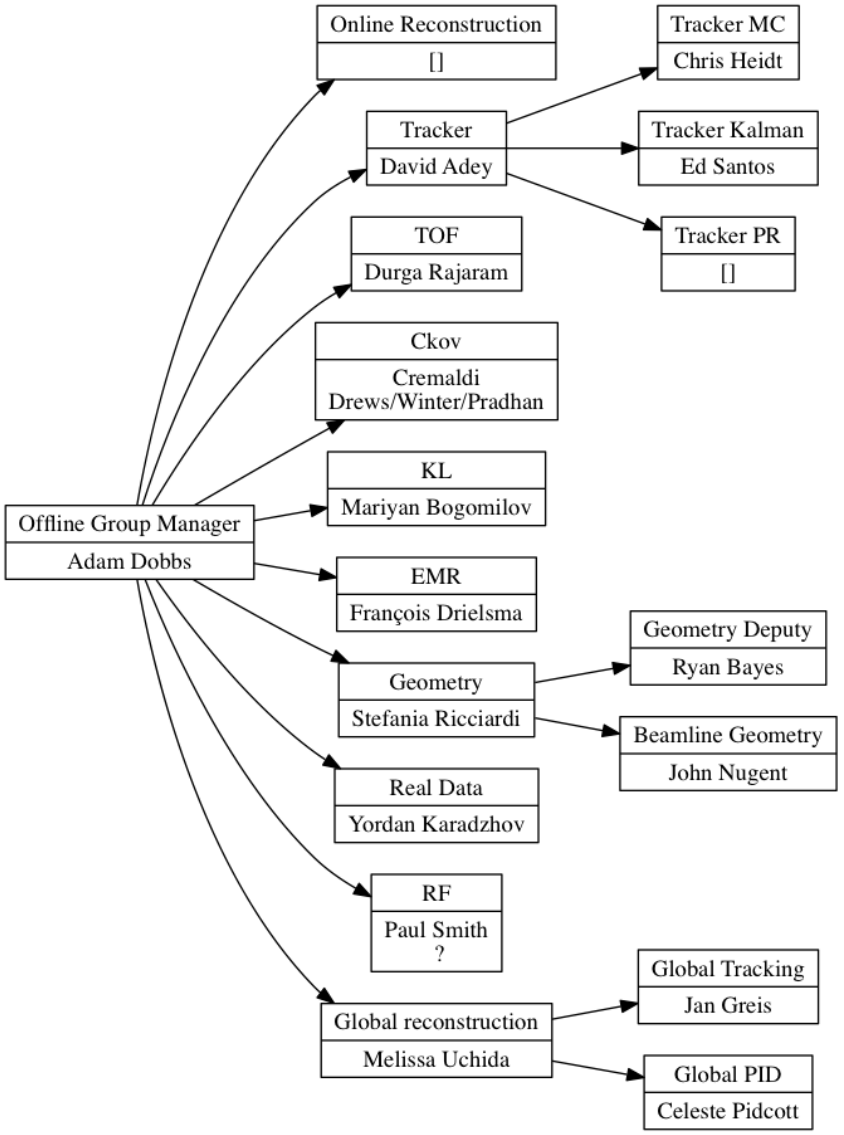

KL


EMR

OFFLINE DATA FLOW



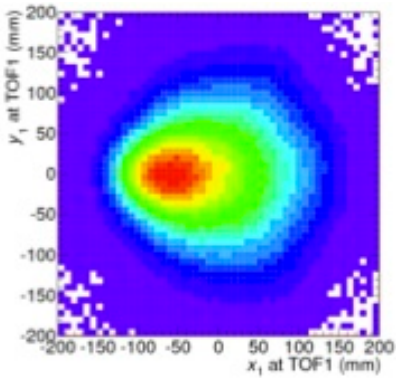
OFFLINE ORGANIZATION



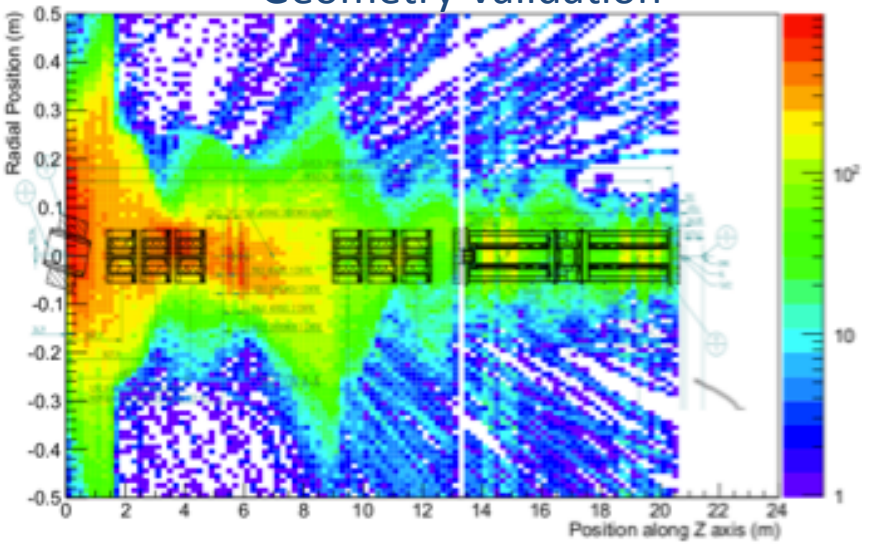
MONTE CARLO

- Beam (*Nugent*)
  - pencil beam, or sample from a pre-defined distribution or read in from a file, or
  - use G4Beamline as a generator: generates beam up to D2, ability to generate beam based on data-run currents
- Geometry (*Bayes/Ricciardi*)
  - CAD models converted to GDML descriptions and stored in CDB
  - CDB geometry has been thoroughly vetted
  - Implementing a GDML parser to speed up loading performance
  - "Legacy" geometry continues to be supported until CDB geometry perfomance improvements are completed
- Particle tracking
- Detector response

Beam at TOF1



Geometry Validation



MONTE CARLO

- Particle tracking, energy loss, and scattering are done through GEANT
- Custom field map models, or read in maps from file
- Two steps to simulating detector response
  1. Collect hits in each sensitive volume – volume ID, energy deposit, hit position, momentum, time…
  2. Electronics response aka digitization – mock DAQ readout – volume ID to cable map, energy to ADC…

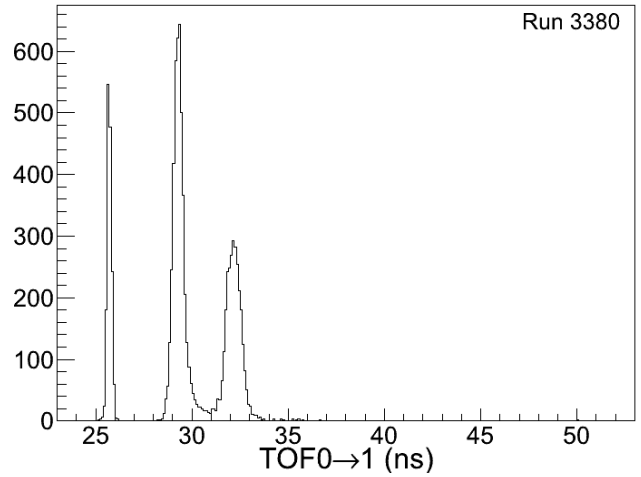
RECONSTRUCTION

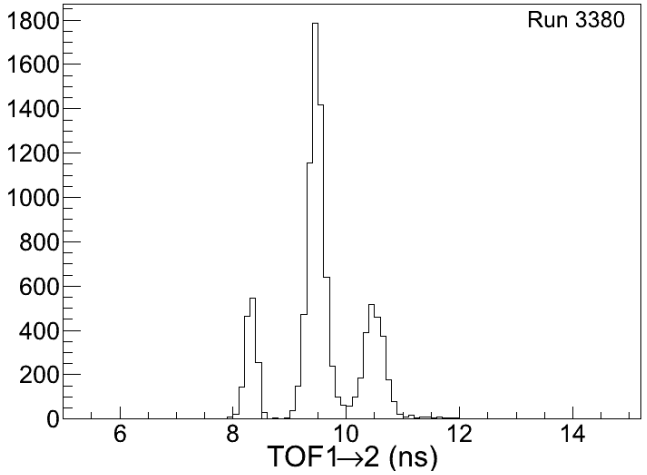
- For any given detector, the reconstruction algorithm is required to be agnostic about input – should not distinguish data from MC
- We seek to reconstruct:
  - TOF, Ckov, KL, Tracker, EMR
- The final Global reconstruction will take the individual detector reconstructions and provide a global track and an associated particle identification hypothesis

Rajaram

TOF

- MC & Reconstruction stable
- MC:
  - Energy deposited is first converted to photoelectrons and then to an ADC count
  - Time of the hit is propagated to PMTs and converted to a TDC count
  - Calibration corrections are *added* in so that they can be taken out at reconstruction stage as is done with data
- Reconstruction:
  - Individual PMT hits associated to form slab hits
  - x & y slab hits combined to form space-points
  - Slew and trigger time corrections applied to reconstructed space-point time

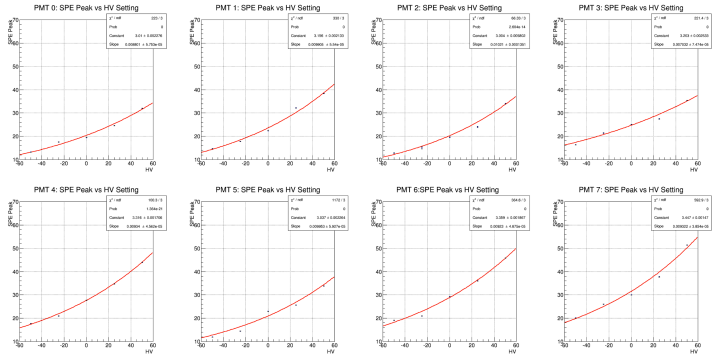


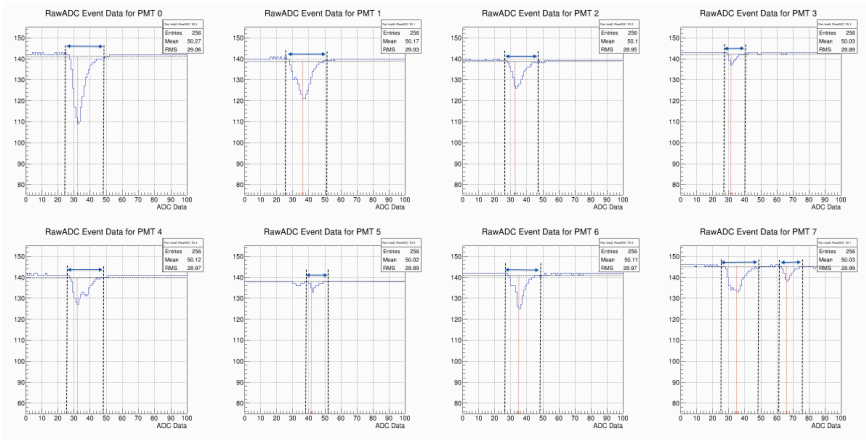


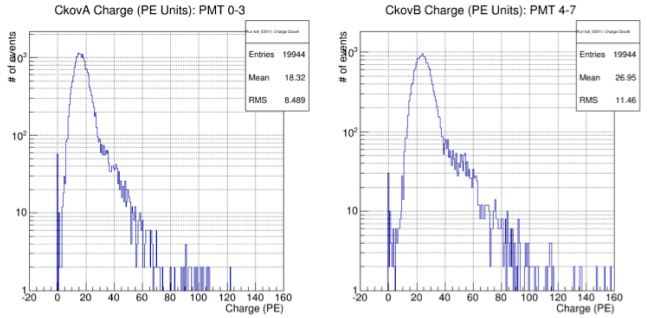
CKOV

Cremaldi/Drews/Winter/Pradhan

- HV scan in June to determine voltage settings to balance tubes
- Improved reconstruction
  - Flash ADC samples integrated and converted to number of photoelectrons
  - Conversion factor tuned based on single-photoelectron fits
  - Pedestal calculation revised to exclude contamination from SPE noise & out-of-time pulses
  - Peak-finding improved to look for multiple peaks and find integrate in-time pulses
  - Preliminary efficiency studies with electrons suggest ~ 0.5% inefficiency
- MC Geometry description has been revised.
  - Need hit collection and digitization
  - Resource-limited right now



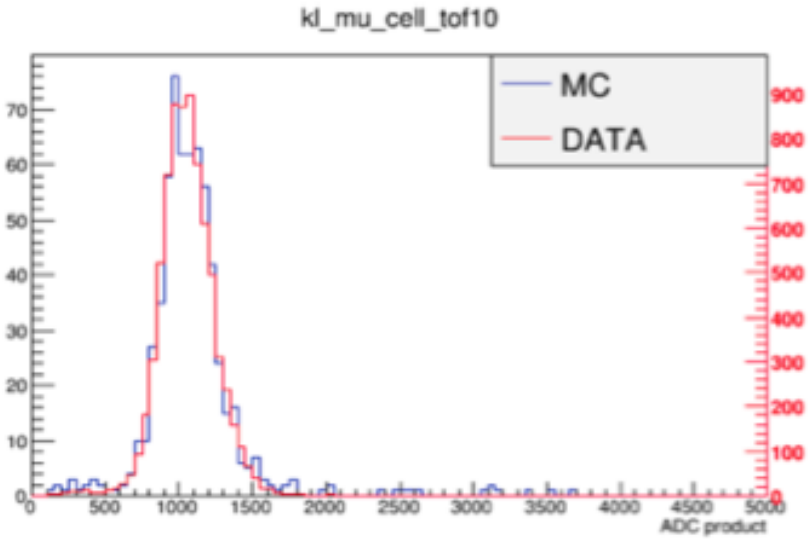




KL

Bogomilov/Nugent

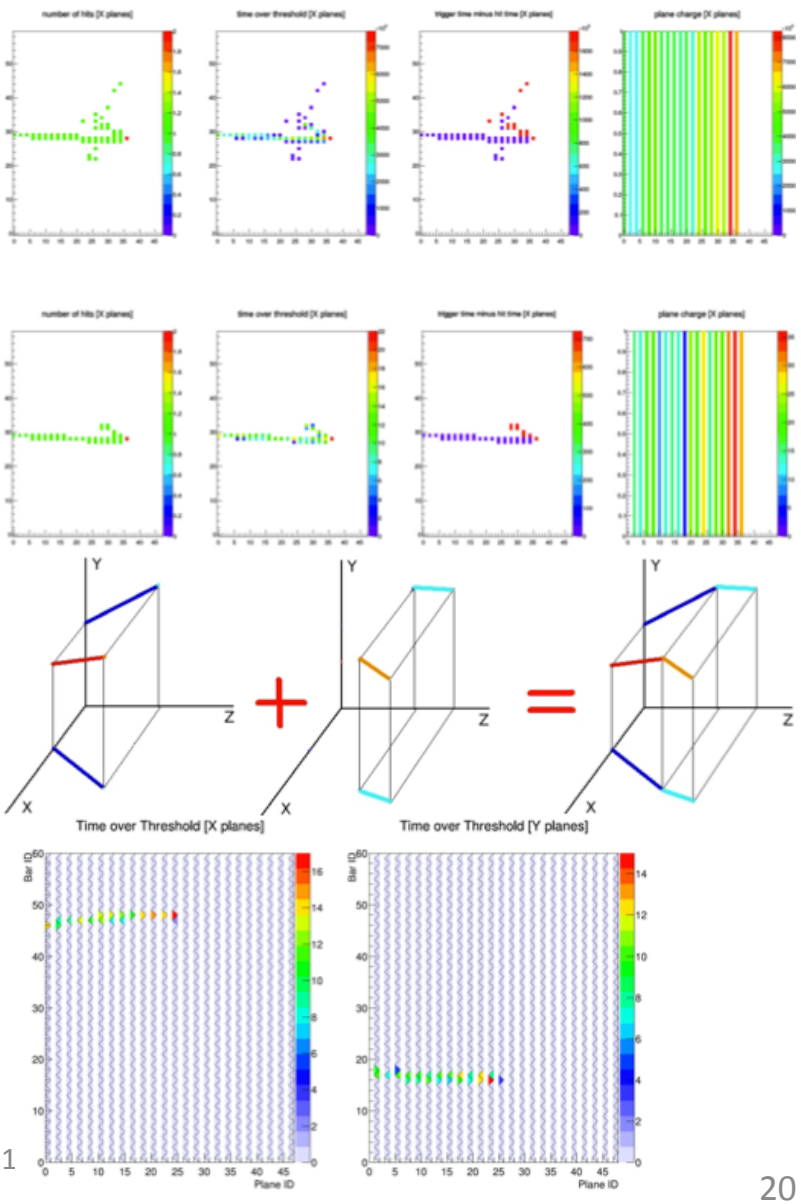
- Several improvements to simulation & digitization
  - By-region + by-particle production thresholds implemented for KL
  - PMT gain calibrations and smearing updated
  - KL digitization parameters tuned
  - MC/Data agreement much improved
- Reconstruction: stable, being used for Step I Pion Contamination analysis



EMR

Drielsma

- MC Digitization is now available in MAUS
- First pass of track reconstruction available
  - Hit Reconstruction, Time association, Primary & Secondary tracks, track matching, range calculation
  - Can then add it to Global Reconstruction as an input
- Calibrated with cosmics and calibration map shipped with MAUS
- New display coming for online reconstruction



TRACKER *Adey/Dobbs/Heidt/Hunt/Santos*

- D. Adey is now head of tracker software – taken over from Adam Dobbs
- Space-point reconstruction, Pattern Recognition, Kalman tracking are complete
- Optimization & efficiency studies in progress
- Calibration interface needs to be added
- See Chris Heidt's talk for details

GLOBAL

Uchida/Greis/Pidcott

- Melissa Uchida is now Global reconstruction manager, taken over from Dobbs

Tracking (Greis)

- Code refactoring – data structure – complete
- Studying extrapolation (transport) from tracker to TOFs
- Some issues with transfer matrices need to be resolved
- Plan to do a 1st pass with Tracker+TOF1 upstream & Tracker+TOF2 downstream
- Can then combine with other PID up- and downstream

Particle Identification (Pidcott)

- PID framework now includes tracker (momentum), TOF (time), KL (charge), Ckov (PE yield)
  - EMR will be added -- this will give inputs from all the PID detectors
- Preliminary efficiency and purity studies are in progress
- Will need to integrate with global track when they come along

OFFLINE SUMMARY

- Overall the reconstruction is in good shape
- MAUS can now reconstruct all MICE detectors
  - + EMR digitization & range reconstruction
  - + Improved Ckov reconstruction
  - + Improvements to tracking
- CDB geometry validated
- – Some tasks outstanding; will improve the software
  - – Ckov MC, Trigger MC
- MAUS paper draft in circulation
- Tracker software documentation posted as MICE-Note and paper draft in circulation
- We're starting to use the software to simulate, reconstruct, and think about MAUS from an analysis viewpoint – Physics Block Challenge

INFRASTRUCTURE

- Infrastructure group responsible for:
  - Configuration & calibration management tools
  - GRID services
    - Data curation
    - Batch processing
  - Web services

INFRASTRUCTURE: DATABASE

- Variety of configurations & calibrations in MICE
  - Run conditions, magnet currents, Hardware state machines, alarms, geometry, field maps, electronics cabling maps, detector calibrations
- Configurations & calibrations are handled by a PostgreSQL database (CDB)
  - CDB master is hosted in the MLCR with slave and web interface service hosted in RAL PPD
  - Write access to the DB is only from the MLCR
- Web service layer provides interface to DB
- Configuration Filestore provided for storing pre-calibration data & miscellaneous data such as field maps, surveys
- Production database has tables implemented for all subsystems
  - beamline, cooling channel, state machine, alarm handler, cabling, calibrations, geometry
  - C API developed for C&M EPICS interface to accommodate multithreading
- Plans to store data quality and reconstruction quality flags from data-taking and batch reconstruction

INFRASTRUCTURE: GRID

- Data movement
  - DataMover moves raw data from MLCR to permanent tape storage
  - Grid Download Agent downloads data to other other GRID sites
  - Imperial College makes all data available on the web
  - Book-keeping of stored data is via a Metadata Database
- Batch
  - Reconstruction of MICE data
  - Re-process data with for e.g. new software version, revised calibrations, etc
  - Monte Carlo production
  - *Configurations to simulate are dictated by physics group & simulation and reconstruction software come from offline group*
  - All data taken so far have been batch-reconstructed with latest MAUS
    - Fixed issues which affected previous batch reconstruction: memory leaks in MAUS, certificate issues
  - Automation of data-movement from MLCR to tape is in progress
  - Quick turnaround offline reconstruction has been tested but needs to be automated

INFRASTRUCTURE: WEB

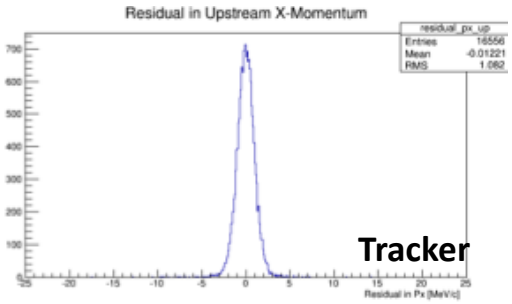
- http://mice.iit.edu: primary MICE website
  - Has been redesigned for easier navigation & outreach
- micewww.pp.rl.ac.uk: Wiki, working group pages
- SSH bastion: Gateway to access MLCR machines
- EPICS gateway: Remote read-only access for C&M
- cdb.mice.rl.ac.uk: Web interface to CDB
  - Experienced some instabilities earlier in the year, leading to ~2.5% downtime, has since been patched
- test.mice.rl.ac.uk: CI test server for MAUS

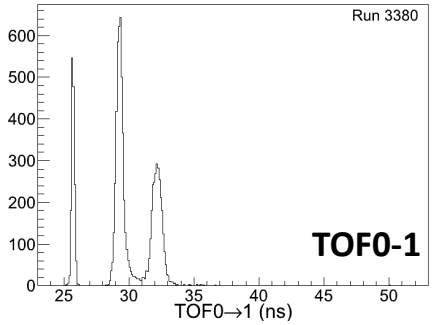
SUMMARY

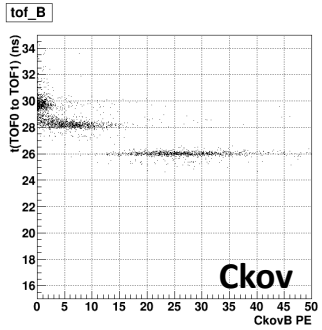
- The Software & Computing project encompasses a broad spectrum of tasks
  - DAQ, controls, reconstruction, database
  - Precision requirements
  - Complex, changing configurations
- In good shape to be ready for Step IV
- Offline software can identify & reconstruct muons if we took data now

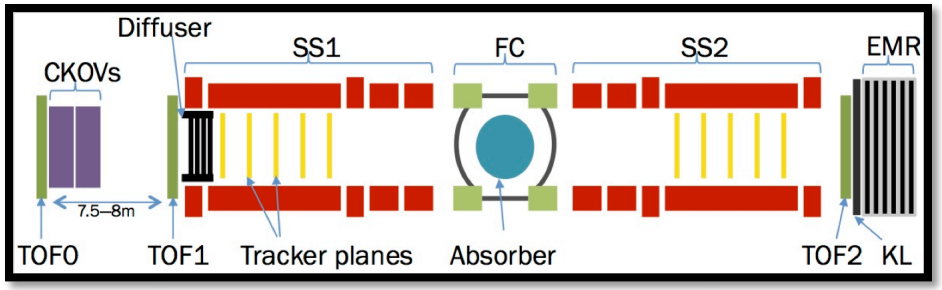
STEP IV

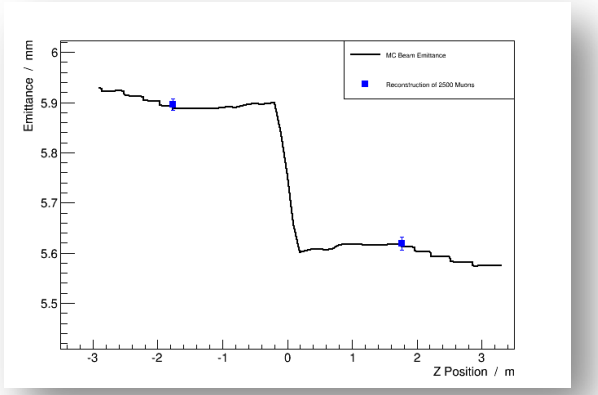
UPSTREAM











DOWNSTREAM