STATUS OF ANALYSIS & SIMULATION

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IIT, Chicago

MAP Spring Meeting
30 May 2014

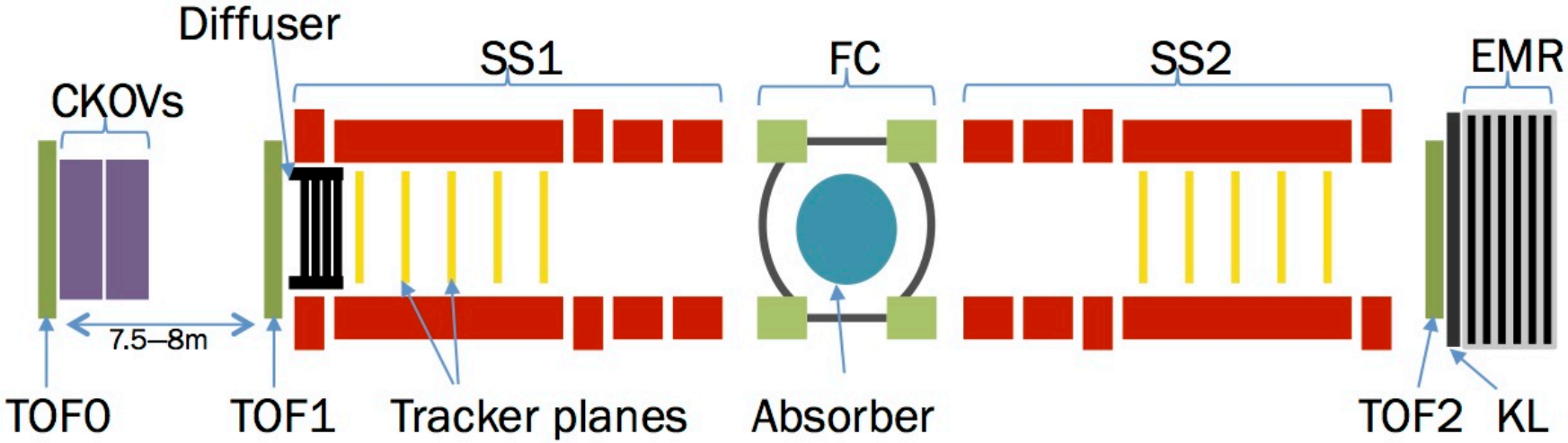
Overview

- Deliverables
- Organization
- Status
  - What's available, what's missing
  - Detectors, MC, Batch, CDB, API, Online
- CM38 report summaries
- Work plan
- Risks & Priorities

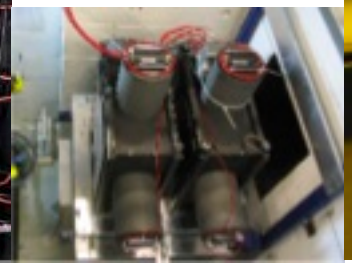
DELIVERABLES

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

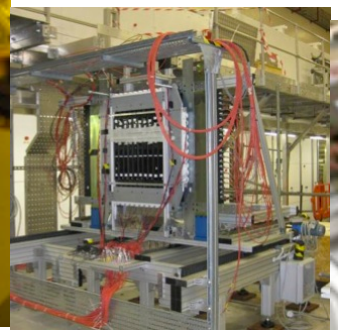
MICE Detectors

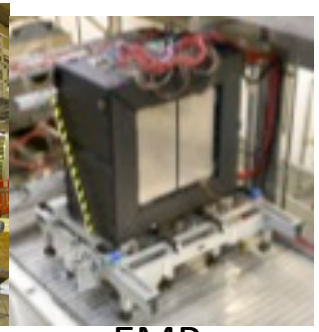



TOF

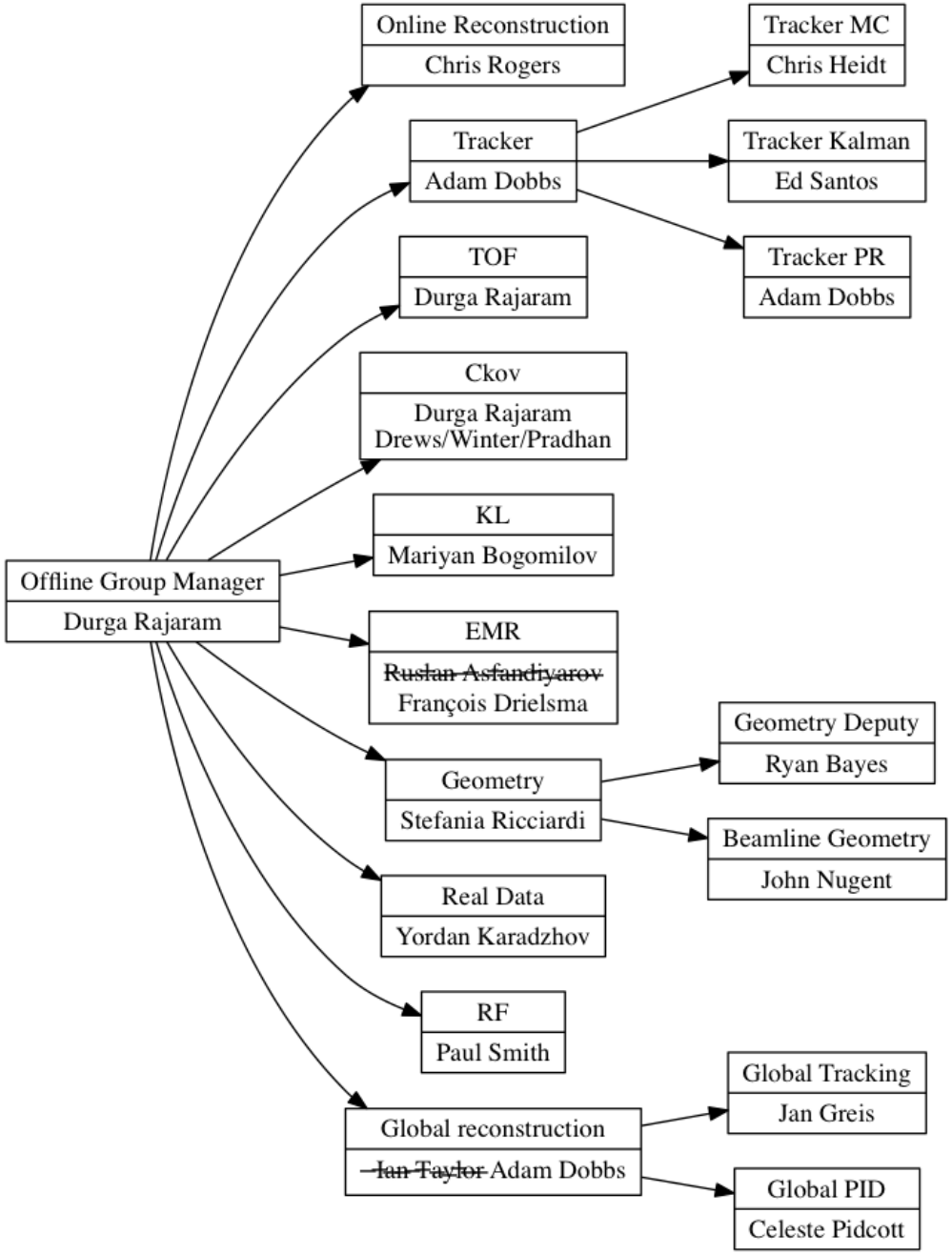

Ckov


Tracker


KL


EMR

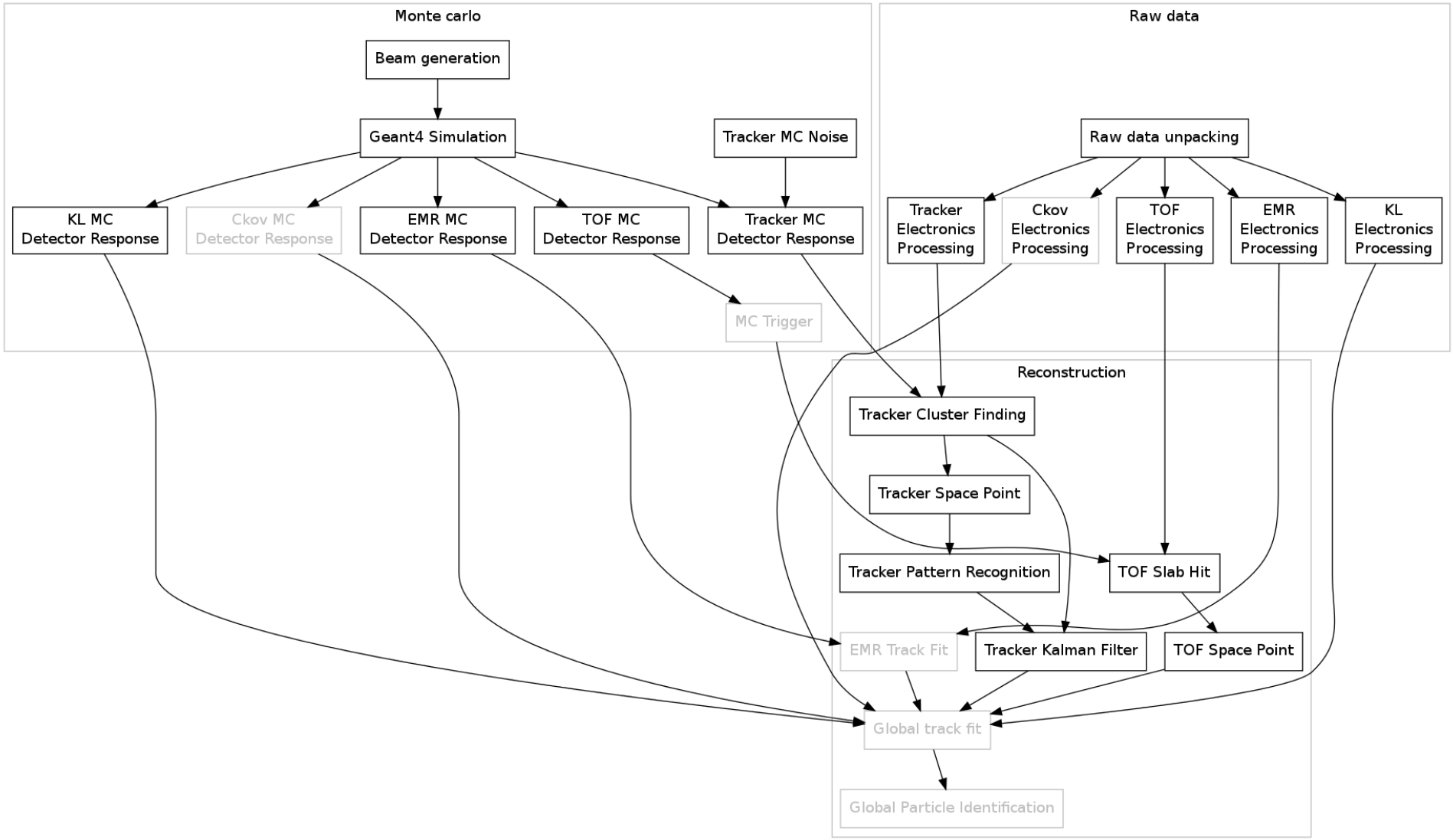
ORGANIZATION



Changes:

- EMR
  - Student taking over from Asfandiyarov
- Ckov
  - New Undergraduate students at IIT and UMiss
- Global
  - Jan Greis replaced Lane
  - Adam Dobbs replaced Ian Taylor

OFFLINE DATA FLOW

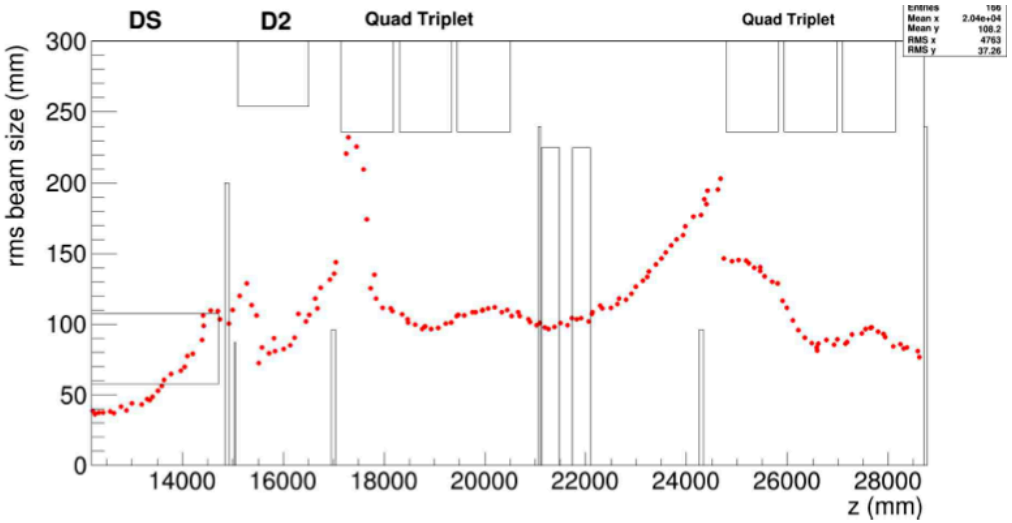


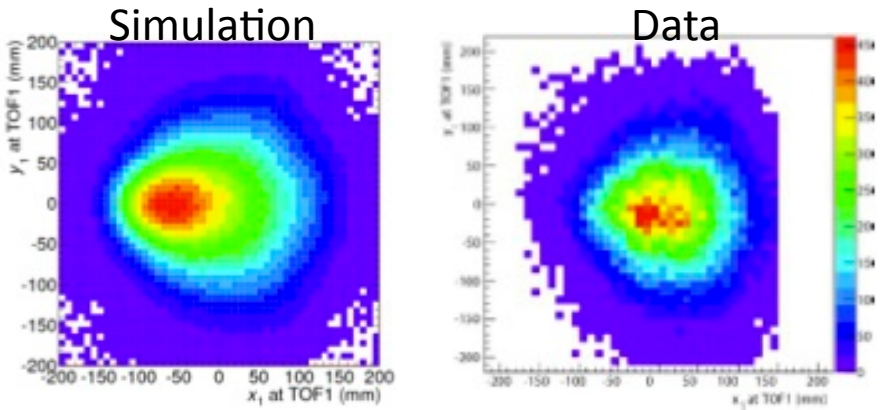
Monte Carlo

- Beam
- Geometry
- Particle tracking
- Detector response

BEAM GENERATION

- Previously:
  - Generate pencil beam, or sample from a user-defined gaussian, or read in from a file
- Now added G4Beamline as a generator
  - Updated survey, geometries and currents
  - Generates beam upto D2
  - More realistic beam, better agreement with data (Step I)
    - *cf. Analysis presentation*
  - Ability to generate beam based on data-run currents

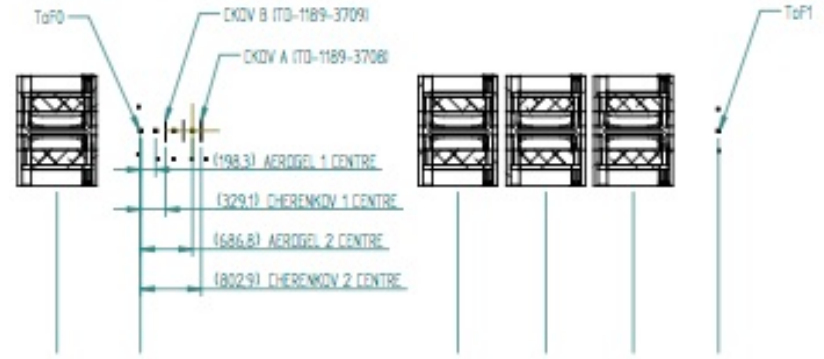


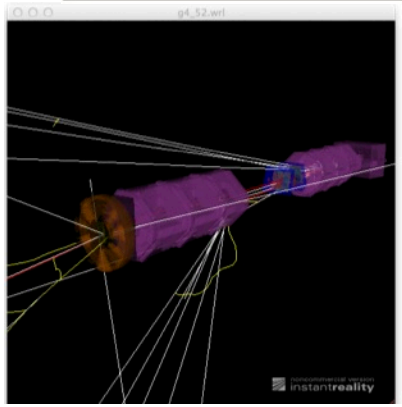


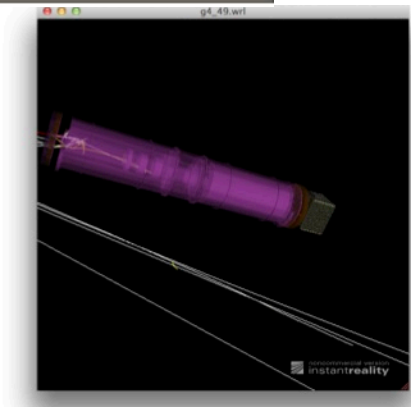
GEOMETRY

Bayes/Ricciardi

- Default geometry description has been through flat text files
  - no surveying or versioning information
  - Prone to errors and outdatedness
- It was decided to have a CAD-based geometry description that is stored in the database
  - Significant progress
  - CAD models converted to GDML descriptions and stored in CDB
  - Realistic Step I & Idealistic Step IV geometries now available
    - *Except Ckov which is being finalized*
  - Requires validation and shakedown
  - Geometry loading time is an issue especially for user-testing, tuning, studies, etc
  - This is a new system, so there is risk associated with its deployment and usability
  - "Legacy" geometry continues to be supported and will be until the new geometry is proven





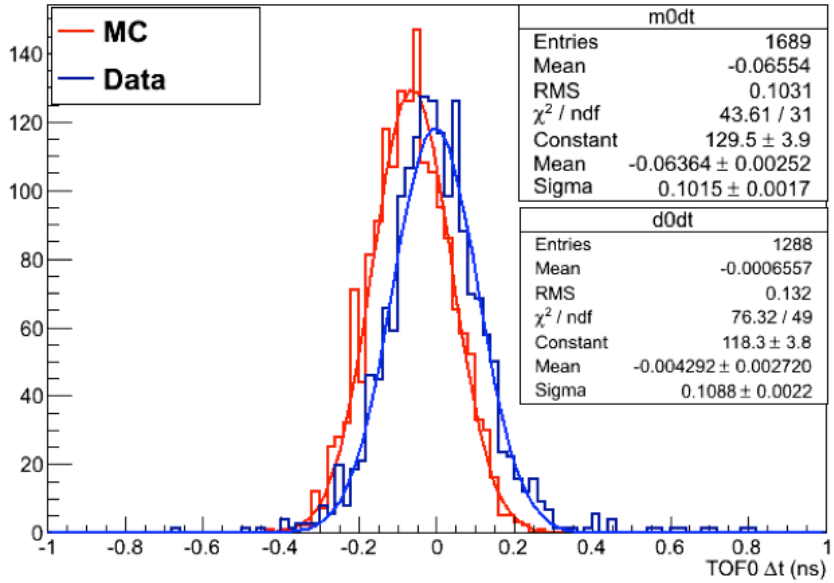


SIMULATION

- Particle tracking, energy loss, and scattering are done through GEANT
  - Upgraded to GEANT 4.9.6 – better handling of tessellated solids in geometry
- 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…

Detector Response (TOF)

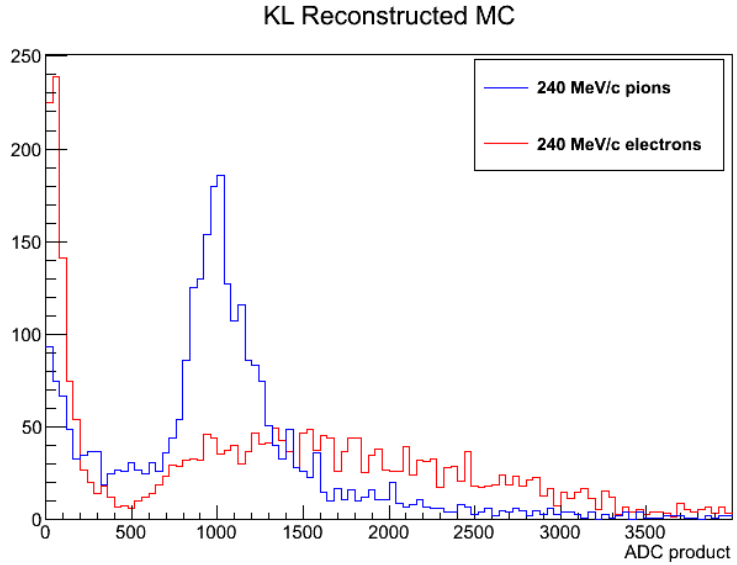
- Stable
  - Energy deposited is first converted to photoelectrons and then to an ADC count
  - Time of the hit is propagated to PMTs and converted to a TDC count
  - Calibration corrections are *added* in so that they can be taken out at reconstruction stage as is done with data

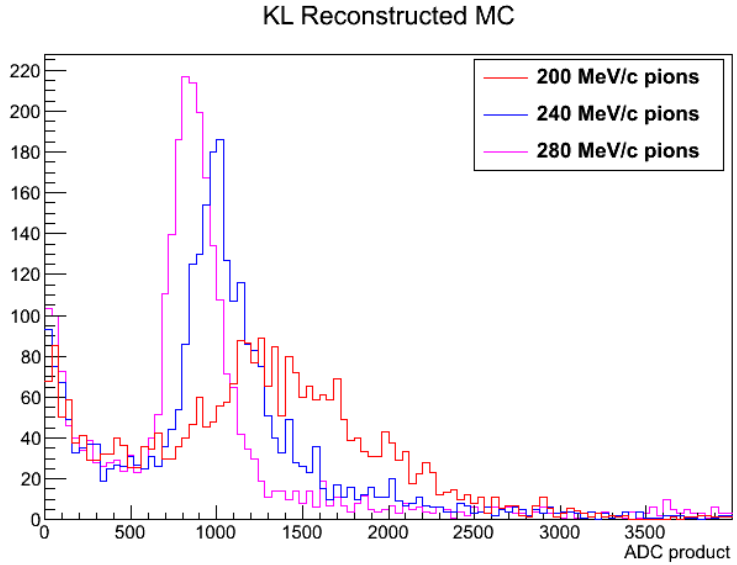


- Potential restructuring for trigger simulation (TOF is experiment's trigger)

DETECTOR RESPONSE (KL)

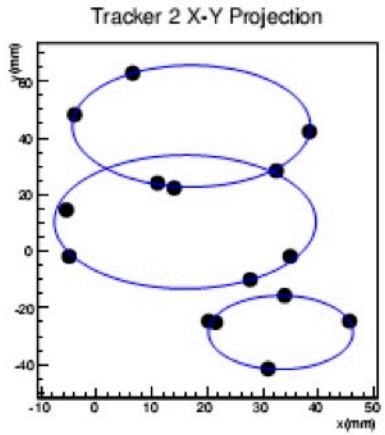
- New: Digitizer added along with updated geometry, and software to store hits in sensitive volumes
  - Outputs are ADC counts converted from energy deposits
  - Conversion factors are preliminary and likely require tuning
  - Needs validation against Step I data
  - Step I PID analysis can now use digitized and reconstructed KL

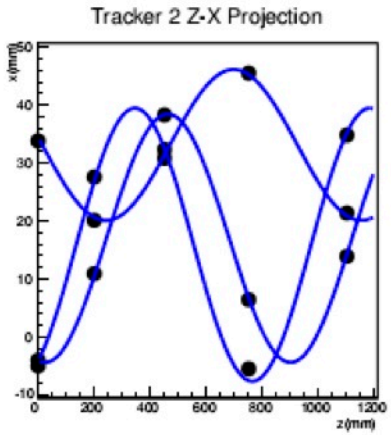


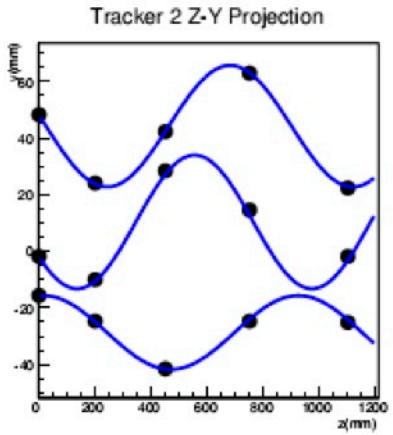


Detector Response (Tracker)

- Stable
  - Energy deposited is converted to photoelectrons, photoelectrons from a fiber channel are then summed and converted to an ADC
- New
  - Added Poisson noise to simulate VLPC dark current

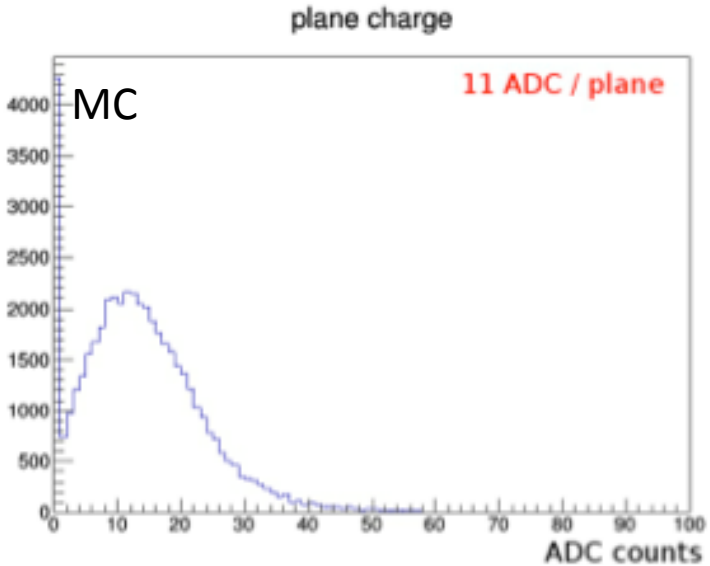


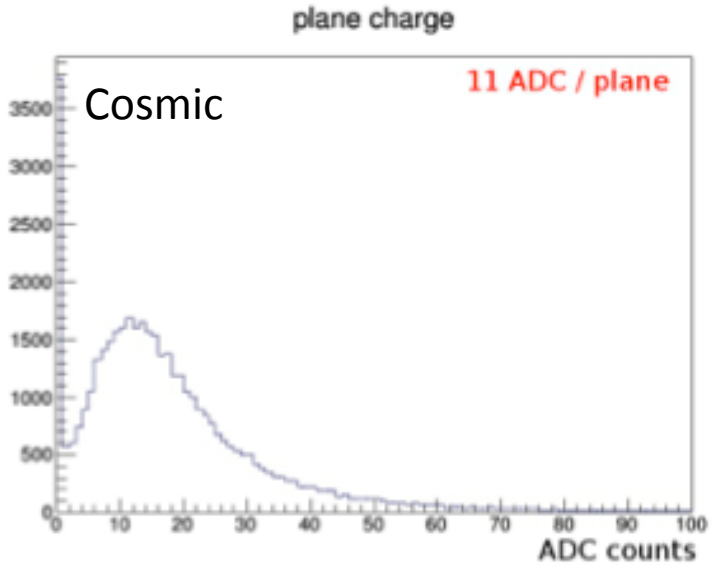




DETECTOR RESPONSE (IN PROGRESS)

- The Ckov and EMR digitizations are not yet in the production release of MAUS
- Ckov:
  - digitization depends on finalizing geometry (Cremaldi and student), simulating optical photons and collecting hits and digitizing (Rajaram and students).
  - Possible refactoring, or rewrite
  - Risk: undergraduate students who are new to this and have to balance effort with coursework
- EMR:
  - The final geometry and hit collection are now complete and in MAUS
  - Digitization is being developed





RECONSTRUCTION

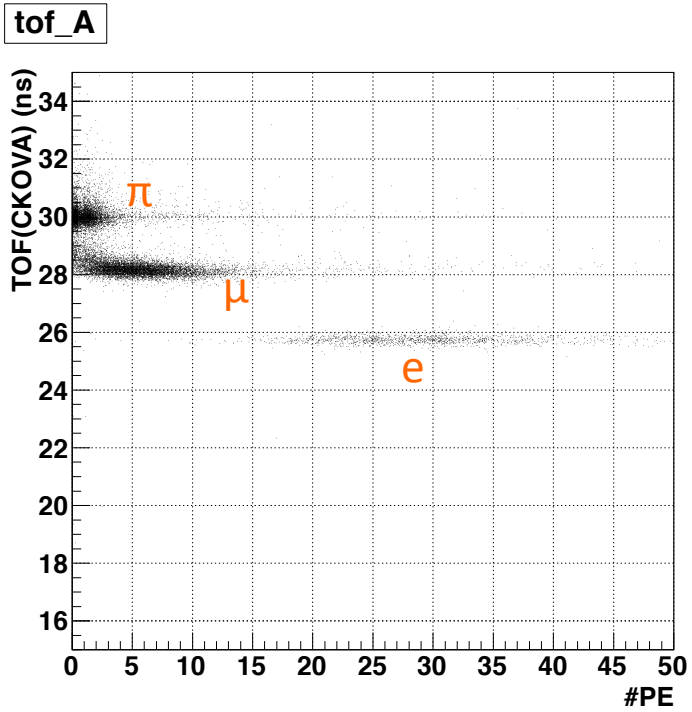
- For any given detector, the reconstruction algorithm is required to be agnostic about input – should not distinguish data from MC
- At the moment, MAUS can reconstruct every single Step IV detector
  - TOF, Ckov, KL, Tracker, EMR
  - Some are mature, some functional with optimizations and tuning in progress, some preliminary
- The final Global reconstruction (in progress) will take the individual detector reconstructions and provide a global track and an associated particle identification hypothesis

RECONSTRUCTION (TOF)

- Stable
  - Digits (MC or DAQ) are converted to slab hits.
  - x-y slab combinations are then used to form space-points
  - Space-point times are corrected for time-walk and trigger offsets based on calibrations stored in the DB
- RFI: Calibration algorithm needs some optimization to cover slabs/pixels with lower statistics
  - Reconstruction discards uncalibrated pixels resulting in a loss in acceptance

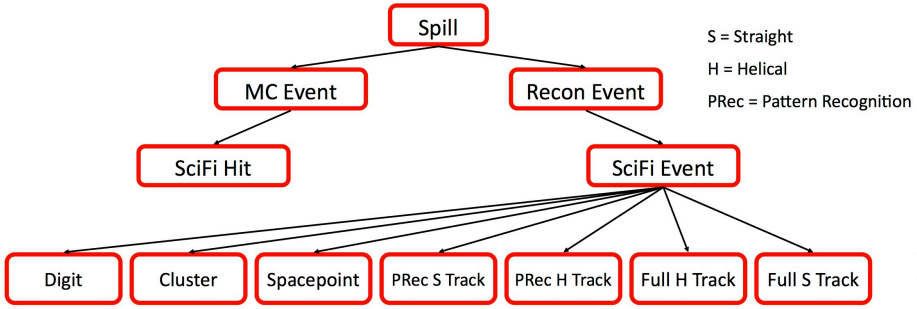
Reconstruction (Ckov)

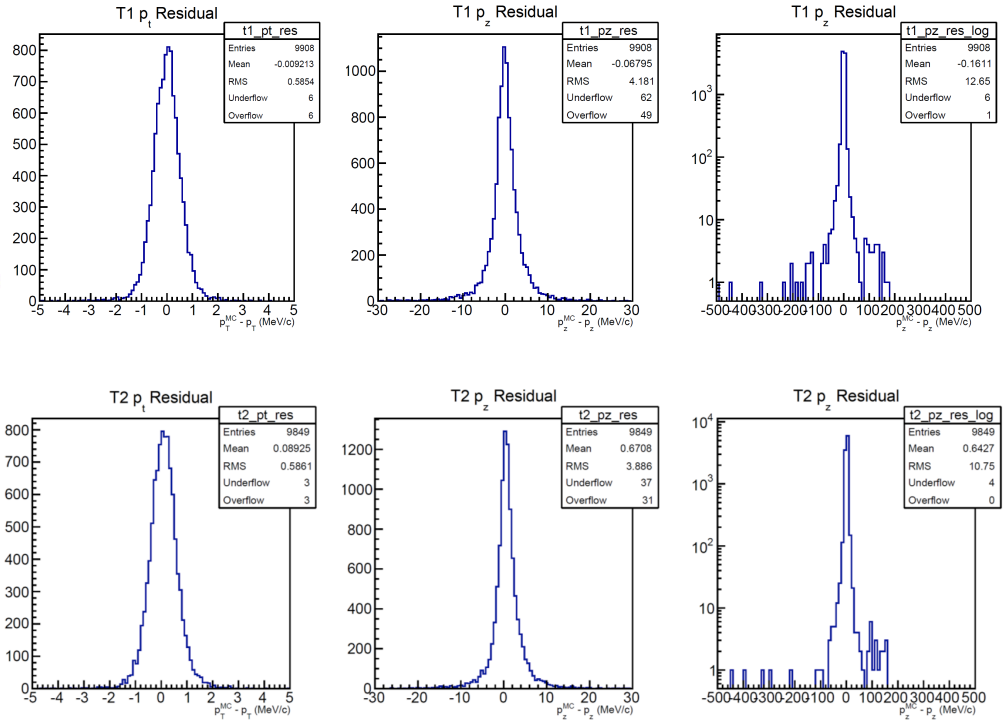
- Functional
  - Flash ADC samples integrated and converted to number of photoelectrons
  - Conversion factor requires tuning based on single-photoelectron fits and should be stored in DB (hard-coded now)
  - Charge integration window may need to be optimized
  - Add multi-peak reconstruction



RECONSTRUCTION (TRACKER)

- Functional
  - Space-point reconstruction, Pattern Recognition, Kalman tracking complete
  - Optimization underway
  - Efficiency studies in progress using MC
  - Calibration interface needs to be added
- Much improved documentation

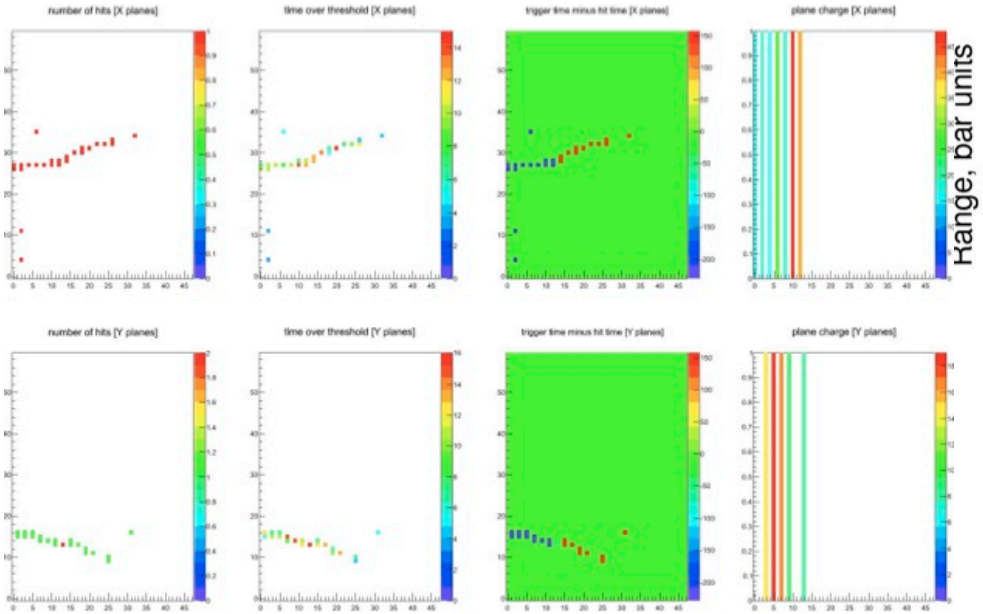


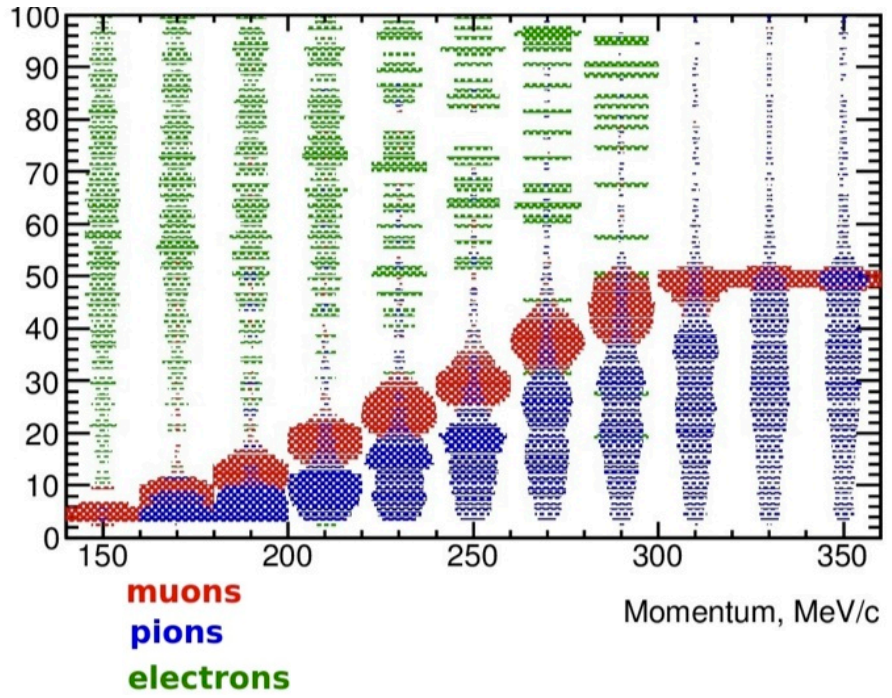


~~Asfandiyarov~~, Drielsma, Karadzhov

RECONSTRUCTION (EMR)

- New: Reconstruction of plane hits complete
- Higher level reconstruction (tracks, charge ratios, range) are being developed – to be integrated
- Asfandiyarov is moving on, and Drielsma is taking over, so there is some learning curve & risk



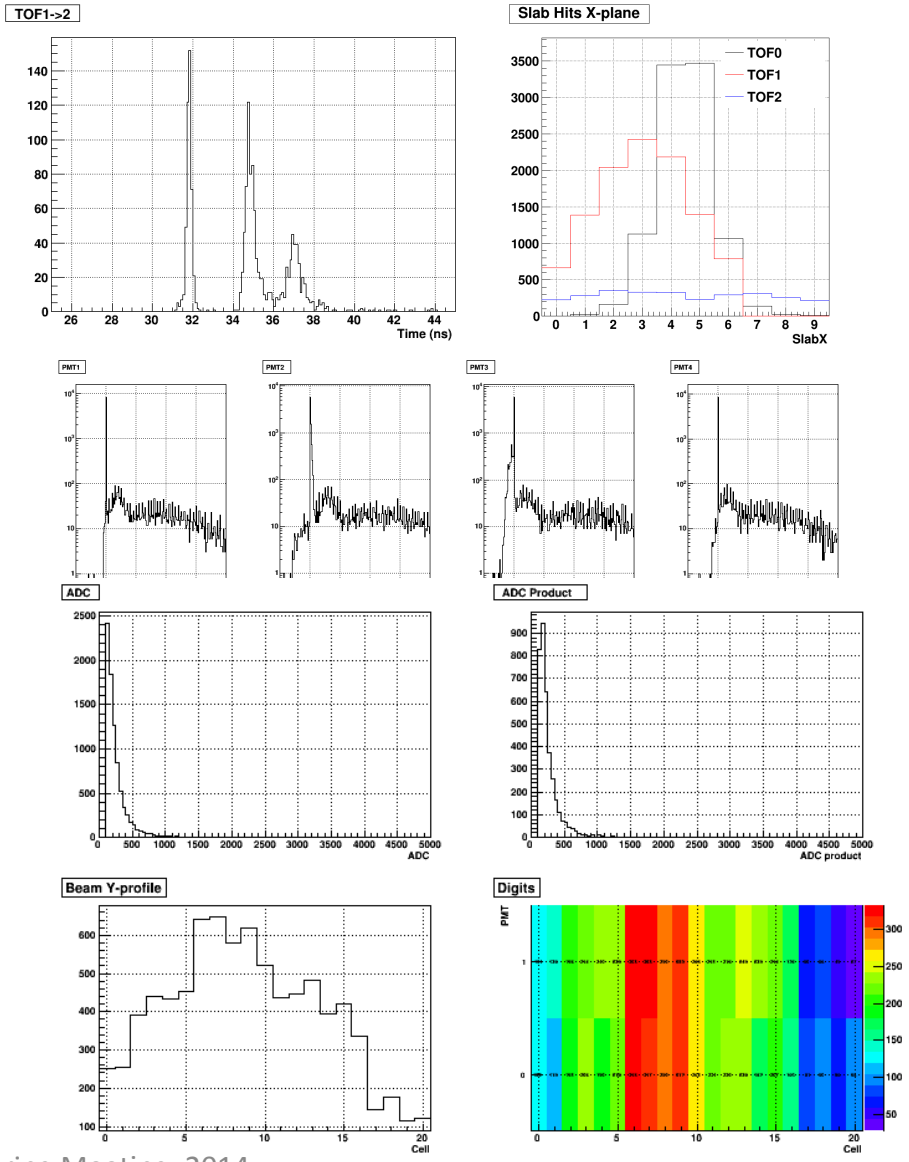


Reconstruction (Global)

- Global track fitting and particle ID are critical items
  - Tracking suffered from lack of experienced hand and grad student working on it has moved on.
  - A grad student (Jan Greis) has taken over and is getting up to speed
  - PID: framework developed & tested for TOF
  - In development: PID using TOF (time) + Tracker (momentum)
  - PID needs integration with the global tracking as that develops
- Adam Dobbs is now the head of Globals, taken over from IJT
- 9 months should be enough time, but requires fine breakdown to allow monitoring and catching risks early

ONLINE RECONSTRUCTION

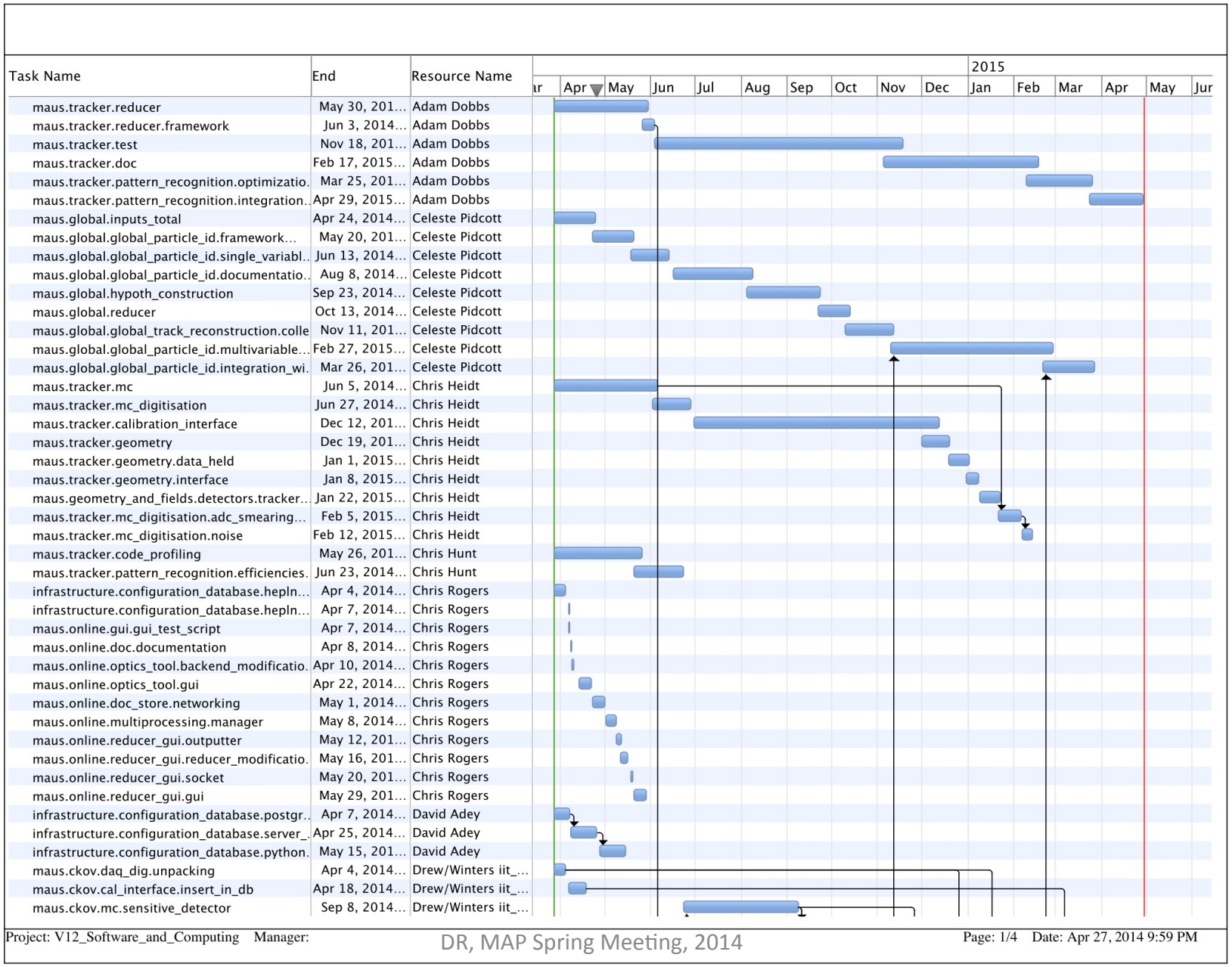
- Reconstruction software is same as for offline
- Distributed processing over worker nodes
- Summary and monitoring histograms visualized in MLCR as images via web interface
  - Plots intended to provide summary view of reconstruction quality
  - Lower level reconstruction plots serve to identify problems with detectors – e.g. inefficient tubes, dead channels…
  - Changes being made to visualization infrastructure (ROOT objects instead of raw images)
- Online reconstruction is available for TOF, Ckov, KL
  - Preliminary EMR display is available stand-alone, to be integrated with MAUS



Software QA & Testing

- Software QA process
  - Style tests: does the code conform to style guidelines?
  - Unit tests: does the function do what's expected?
    - Currently, python coverage is ~68%, C++ coverage is ~78%
  - Integration tests: testing workflow – do all the pieces play nice together
  - Validation tests: does the simulation/reconstruction produce expected results?
- Continuous Integration test servers provide offline and online environments for developers to test their code before merging with the development branch
- Redmine issue tracker for bugs and features
- New release every ~2-4 weeks

SCHEDULE



Task Name	End	Resource Name
maus.tracker.reducer	May 30, 201...	Adam Dobbs
maus.tracker.reducer.framework	Jun 3, 2014...	Adam Dobbs
maus.tracker.test	Nov 18, 201...	Adam Dobbs
maus.tracker.doc	Feb 17, 2015...	Adam Dobbs
maus.tracker.pattern_recognition.optimizatio.	Mar 25, 201...	Adam Dobbs
maus.tracker.pattern_recognition.integration..	Apr 29, 2015...	Adam Dobbs
maus.global.inputs_total	Apr 24, 2014...	Celeste Pidcott
maus.global.global_particle_id.framework...	May 20, 201...	Celeste Pidcott
maus.global.global_particle_id.single_variabl..	Jun 13, 2014...	Celeste Pidcott
maus.global.global_particle_id.documentatio..	Aug 8, 2014...	Celeste Pidcott
maus.global.hypoth_construction	Sep 23, 2014...	Celeste Pidcott
maus.global.reducer	Oct 13, 2014...	Celeste Pidcott
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maus.global.global_particle_id.integration_wi.	Mar 26, 201...	Celeste Pidcott
maus.tracker.mc	Jun 5, 2014...	Chris Heidt
maus.tracker.mc_digitisation	Jun 27, 2014...	Chris Heidt
maus.tracker.calibration_interface	Dec 12, 201...	Chris Heidt
maus.tracker.geometry	Dec 19, 201...	Chris Heidt
maus.tracker.geometry.data_held	Jan 1, 2015...	Chris Heidt
maus.tracker.geometry.interface	Jan 8, 2015...	Chris Heidt
maus.geometry_and_fields.detectors.tracker...	Jan 22, 2015...	Chris Heidt
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maus.tracker.code_profiling	May 26, 201...	Chris Hunt
maus.tracker.pattern_recognition.efficiencies.	Jun 23, 2014...	Chris Hunt
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infrastructure.configuration_database.hepln...	Apr 7, 2014...	Chris Rogers
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maus.online.doc.documentation	Apr 8, 2014...	Chris Rogers
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maus.online.optics_tool.gui	Apr 22, 2014...	Chris Rogers
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maus.online.reducer_gui.gui	May 29, 201...	Chris Rogers
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infrastructure.configuration_database.python.	May 15, 201...	David Adey
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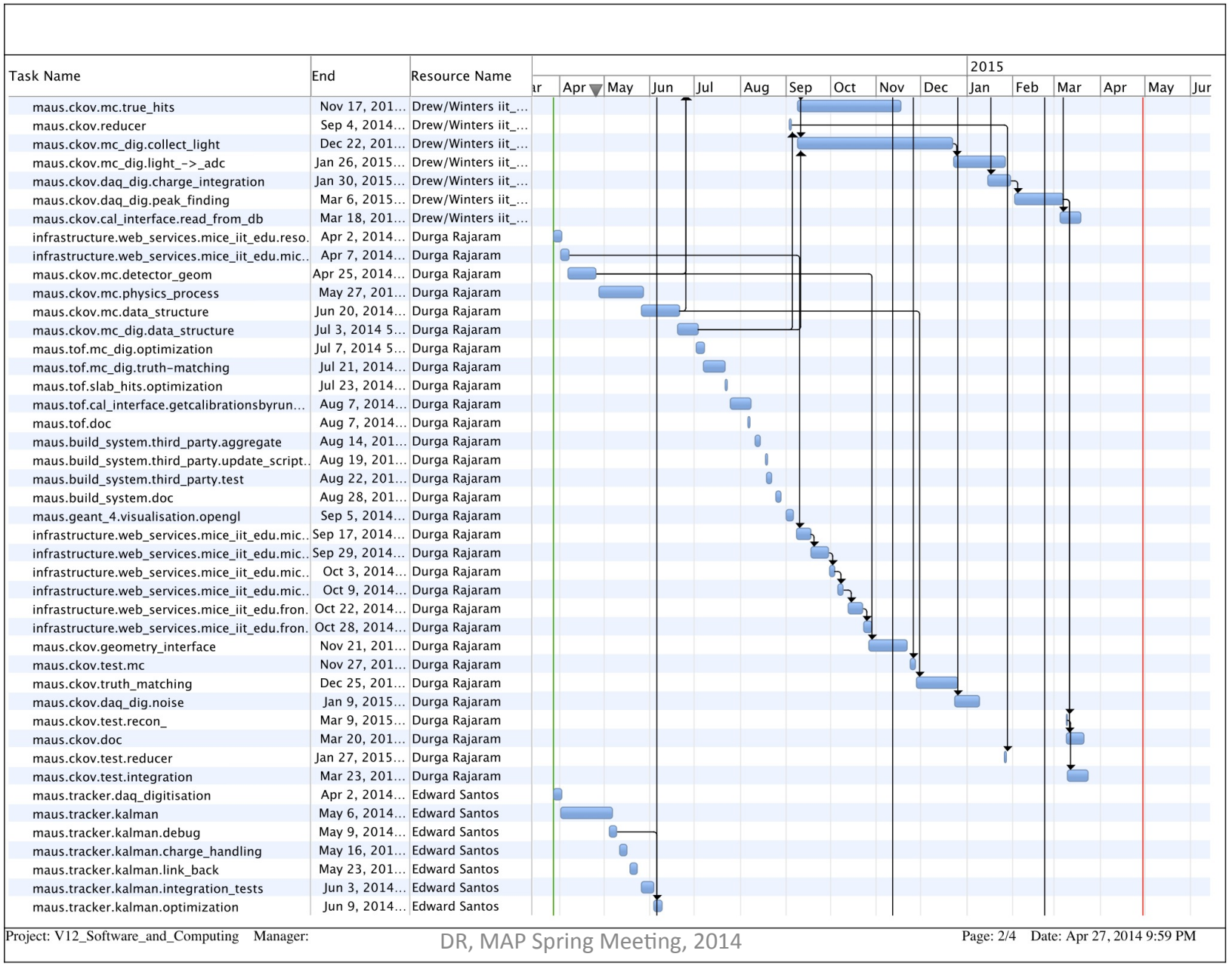
maus.ckov.cal_interface.insert_in_db	Apr 18, 2014...	Drew/Winters iit_...
maus.ckov.mc.sensitive_detector	Sep 8, 2014...	Drew/Winters iit_...

SCHEDULE



Task Name	End	Resource Name
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maus.ckov.mc_dig.data_structure	Jul 3, 2014 5...	Durga Rajaram
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maus.ckov.test.mc	Nov 27, 201...	Durga Rajaram
maus.ckov.truth_matching	Dec 25, 201...	Durga Rajaram
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maus.tracker.kalman.charge_handling	May 16, 201...	Edward Santos
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maus.tracker.kalman.integration_tests	Jun 3, 2014...	Edward Santos
maus.tracker.kalman.optimization	Jun 9, 2014...	Edward Santos

SCHEDULE

Task Name	End	Resource Name
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maus.emr.calibration.calibrate_+_validate...	May 8, 2014...	Francois Drielsma
maus.emr.cal_interface	May 29, 201...	Francois Drielsma
maus.emr.geometry_interface	Jun 5, 2014...	Francois Drielsma
maus.emr.truth_matching	Jul 17, 2014...	Francois Drielsma
maus.emr.reducer	Aug 4, 2014...	Francois Drielsma
maus.emr.test	Aug 22, 201...	Francois Drielsma
maus.emr.doc	Sep 11, 2014...	Francois Drielsma
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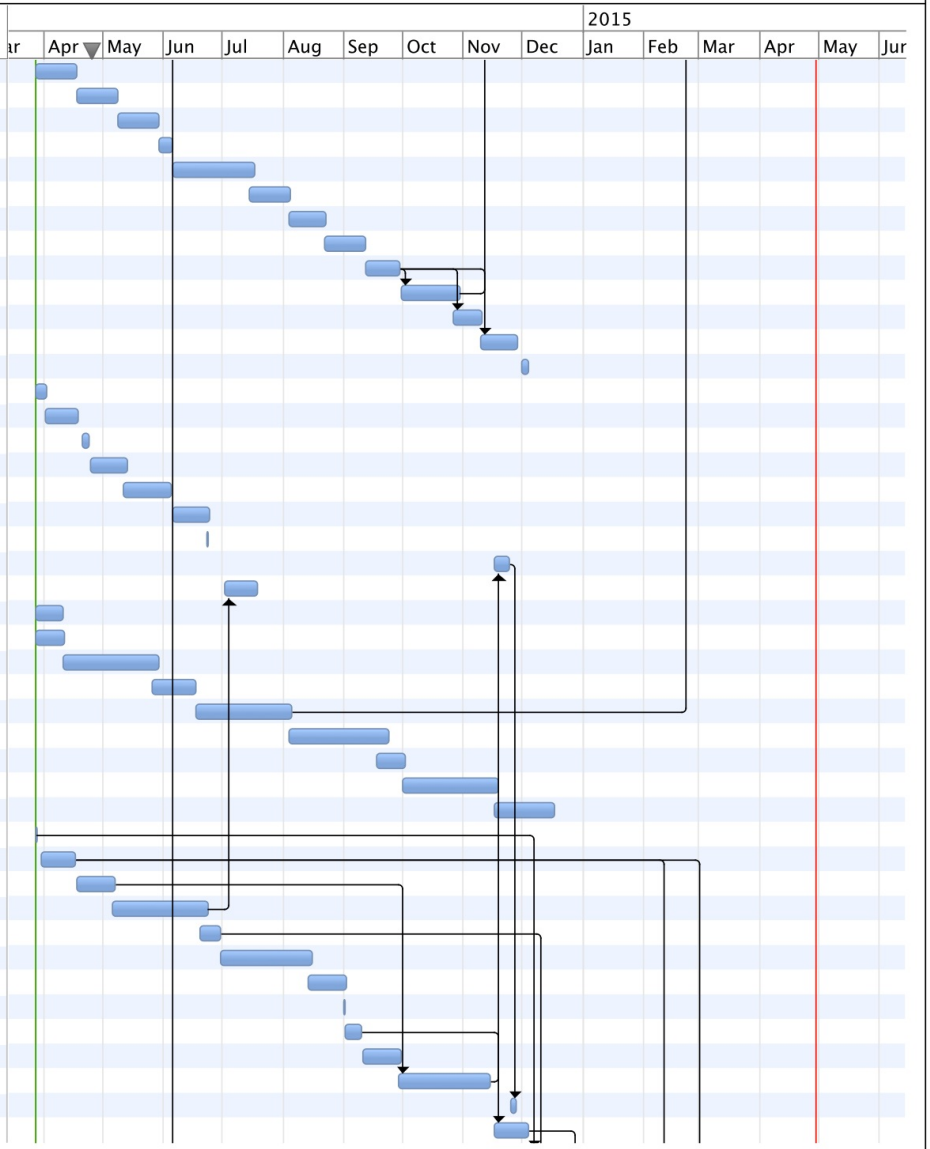
infrastructure.grid.data_mover.fix_incorrect_..	Apr 2, 2014...	Henry Nebrensky
infrastructure.grid.file_compactor.automation	Apr 18, 2014...	Henry Nebrensky
infrastructure.grid.miscellaneous_data_archiv.	Apr 24, 2014...	Henry Nebrensky
infrastructure.grid.miscellaneous_data_archiv.	May 13, 201...	Henry Nebrensky
infrastructure.grid.miscellaneous_data_archiv.	Jun 5, 2014...	Henry Nebrensky
infrastructure.grid.miscellaneous_data_archiv.	Jun 24, 2014...	Henry Nebrensky
infrastructure.grid.miscellaneous_data_archiv.	Jun 23, 2014...	Henry Nebrensky
infrastructure.grid.data_mover.move_to_sl6_..	Nov 24, 201...	Henry Nebrensky
infrastructure.grid.data_mover.dongle_-_har..	Jul 18, 2014...	Henry Nebrensky
maus.api.data_structure	Apr 10, 2014...	Ian Taylor
maus.global.global_track_reconstruction.extr.	Apr 11, 2014...	Jan Greis
maus.global.global_track_reconstruction.extr.	May 29, 201...	Jan Greis
maus.global.global_track_reconstruction.sim..	Jun 17, 2014...	Jan Greis
maus.global.global_track_reconstruction.sim..	Aug 5, 2014...	Jan Greis
maus.global.global_track_reconstruction.kal...	Sep 23, 2014...	Jan Greis
maus.global.global_track_reconstruction.mon.	Oct 2, 2014...	Jan Greis
maus.global.global_track_reconstruction.inte..	Nov 18, 201...	Jan Greis
maus.global.global_track_reconstruction.doc..	Dec 17, 201...	Jan Greis
infrastructure.configuration_database.postgr..	Mar 28, 201...	Janusz Martyniak
infrastructure.configuration_database.c_api.b.	Apr 17, 2014...	Janusz Martyniak
infrastructure.grid.data_mover.move_to_sl6_..	May 7, 2014...	Janusz Martyniak
infrastructure.grid.data_mover.dongle_-_inst..	Jun 23, 2014...	Janusz Martyniak
infrastructure.configuration_database.postgr..	Jun 30, 2014...	Janusz Martyniak
infrastructure.grid.data_mover.store_state_in.	Aug 15, 201...	Janusz Martyniak
infrastructure.configuration_database.viewer..	Sep 2, 2014...	Janusz Martyniak
infrastructure.configuration_database.postgr..	Sep 1, 2014...	Janusz Martyniak
infrastructure.configuration_database.postgr..	Sep 10, 2014...	Janusz Martyniak
infrastructure.configuration_database.hepln...	Sep 30, 2014...	Janusz Martyniak
infrastructure.grid.data_mover.move_to_sl6_..	Nov 14, 201...	Janusz Martyniak
infrastructure.grid.data_mover.remove_move..	Nov 27, 201...	Janusz Martyniak
infrastructure.configuration_database.server_.	Dec 4, 2014...	Janusz Martyniak



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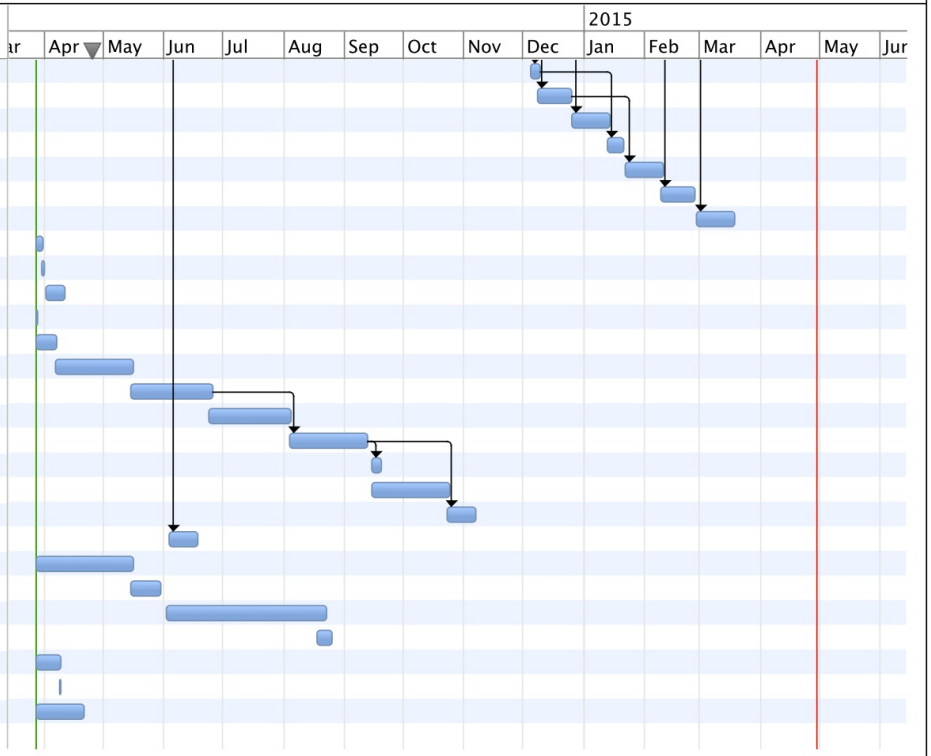
SCHEDULE

Task Name	End	Resource Name
infrastructure.configuration_database.server_.	Dec 9, 2014...	Janusz Martyniak
infrastructure.configuration_database.server_.	Dec 25, 201...	Janusz Martyniak
infrastructure.configuration_database.python.	Jan 14, 2015...	Janusz Martyniak
infrastructure.configuration_database.python.	Jan 21, 2015...	Janusz Martyniak
infrastructure.configuration_database.python.	Feb 10, 2015...	Janusz Martyniak
infrastructure.configuration_database.c_api.c.	Feb 26, 2015...	Janusz Martyniak
infrastructure.configuration_database.c_api.s.	Mar 18, 201...	Janusz Martyniak
maus.geometry_and_fields.cad_import.step_i.	Mar 31, 201...	Jason Tarrant
maus.geometry_and_fields.cad_import.step_i.	Apr 1, 2014...	Jason Tarrant
maus.geometry_and_fields.cad_import.step_..	Apr 11, 2014...	Jason Tarrant
maus.geant_4.beam	Mar 28, 201...	John Nugent
maus.kl.mc_dig	Apr 7, 2014...	Mariyan Bogomilov
maus.geometry_and_fields.detectors.kl	May 16, 201...	Mariyan Bogomilov
maus.kl.mc_dig.tuning	Jun 25, 2014...	Mariyan Bogomilov
maus.kl.geometry_interface	Aug 4, 2014...	Mariyan Bogomilov
maus.kl.mc_dig.validation	Sep 12, 2014...	Mariyan Bogomilov
maus.kl.test	Sep 19, 2014...	Mariyan Bogomilov
maus.kl.cal_interface_to_cdb	Oct 24, 2014...	Mariyan Bogomilov
maus.kl.doc	Nov 6, 2014...	Mariyan Bogomilov
maus.tracker.reducer.online_plots	Jun 18, 2014...	Melissa Uchida
maus.geometry_and_fields.detectors.integrat.	May 16, 201...	Ryan Bayes
maus.geometry_and_fields.detectors.diffuser.	May 30, 201...	Ryan Bayes
maus.geometry_and_fields.software_infrastru.	Aug 22, 201...	Ryan Bayes
maus.geometry_and_fields.software_infrastru.	Aug 25, 201...	Ryan Bayes
maus.geometry_and_fields.validation	Apr 9, 2014...	Stefania Ricciardi
maus.geometry_and_fields.documentation...	Apr 9, 2014...	Stefania Ricciardi
maus.geometry_and_fields.fields	Apr 21, 2014...	Victoria Blackmore



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Conclusions

- MAUS can reconstruct data from every Step IV detector
- Capable of simulating the TOF, KL, and Tracker
  - EMR and Ckov in development
- The big gap is global track reconstruction
  - New manager, two students ramping up
- CAD-geometry implementation has progressed
  - Ongoing validation against full simulation
  - Usability and optimization issues to be evaluated
- Need to focus and make sure we have working simulation and reconstruction (beam + geometry + detectors + global) ready for Step IV