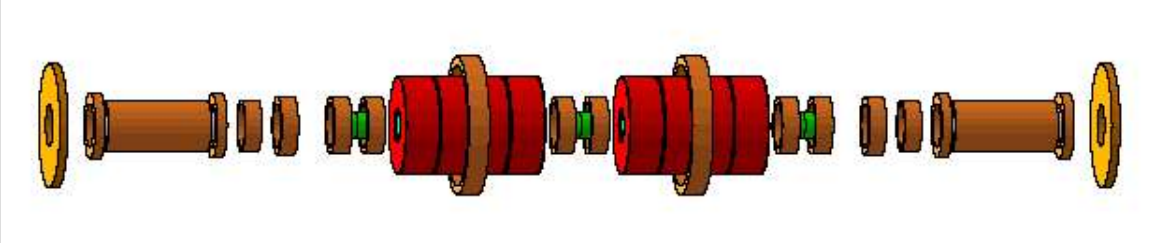
--G4MICE Status--

http://mice.iit.edu/software/



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Illinois Institute of Technology

Muon Collaboration
Weekly Meeting
Mar. 4, 2005 - FNAL

Reminder

- Simulation is critical for MICE:
  - trying to understand a 10% effect to 0.1%
  - in full engineering detail
- G4MICE project
  - GEANT4 based simulation to model geometry and physics accurately
  - Modular design derived from user requirements
  - Central source code repository and bug database
  - Tried to build complete up-to-date documentation and full set of unit tests to ensure code quality
  - Small, distributed (US, Europe, Japan) team coordinated through email list, bi-weekly phone meetings, workshops and visits

6th MICE Software Workshop Feb 3-9, LBNL

- Successful organization:
  - Programmer fuel (coffee/pizza/cookies) provided by Mike Zisman and Tom Gallant
  - Good participation: Malcolm Ellis, Aron Fish, Steve Kahn, Amit Klier, Chris Rogers, Rikard Sandström, YT, Katsuya Yonehara
  - Tutorial/demo at the end attended by ~15 people

Software Workshop
http://mice.iit.edu/sm/sm6/

- Lots of progress on practical issues
  - Completed basic documentation (MalcolmE, SteveK, YT)
  - Implemented new tests for PID detectors (SteveK, RikardS, AronF, YT)
  - Reimplemented EMCal geometry and digitization (RikardS)
  - Investigated and closed 12 bugs (ChrisR, RikardS, YT)
  - Updated formats and analysis tools (ChrisR, RikardS, MalcolmE)
  - Built novice-friendly documentation, tools and demo (MalcolmE, ChrisR, YT)
  - Leading to → mice-1-0 (Feb 12, 2005)
- Design discussions on
  - Optics and user analysis tools
  - Simulation of MICE stages including KEK test beam
  - Track matching and global particle ID
  - Data I/O, persistency

G4MICE Release 1.0

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----------------------  Release Notes for G4MICE 1.0  ----------------------

This release (cvs tag mice-1-0) of the MICE software distribution includes
a full simulation of the experiment with

o A modular set of package libraries with documentation and unit tests for
  most packages and subsystems

o A chain of user applications for
  - energy deposition in particle detectors (Simulation)
  - raw data output from detector electronics (Digitization)
  - pattern recognition and track reconstruction (Reconstruction)
  - emittance calculation (Analysis)
  and a complete set of tools for building and running them

o Muon beam options including
  - an internal model with choice of sign and adjustable parameters for
    position and time offsets, energy, transverse size, bunch length,
    energy spread as well as contamination levels from electrons, pions,
    protons and kaons
  - externally generated track sets from programs G4BeamLine, ICOOL,
    TURTLE and G4MICE itself as well as the HEPEvt format
  - generation of track sets with user-defined phase space distribution
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G4MICE Release 1.0

- o A model of the downstream portion of the MICE beamline around the MICE detectors (after the last bend) which currently consists of the final two quadrupole triplets with their materials and magnetic fields including fringe effects and the beam diffuser

- o A model for the rf induced background from the cavities using electron and/or photon sources with adjustable position, size and energy distributions as well as support for an externally generated set of background tracks

- o A model of the nominal (stage VI) MICE cooling channel including
  - magnetic fields constructed from individual coils and support for an external field map as well as a constant field
  - electromagnetic fields with proper time and spatial dependence and support for constant static field within the rf cavities
  - liquid hydrogen absorber vessels with curved windows (spherical and torispherical shells) and support for simpler cylindrical versions
  - the magnetic shields at the outer ends

G4MICE Release 1.0

o A model of tracking and particle identification detectors including
  - scintillating fiber tracker (SciFi) geometry with individual fibers, planes, stations and support frames and glue
  - time projection chamber with GEM readout (TPG) geometry including active and high voltage gas and membranes, hexaboard and GEM plate layers
  - 3 time-of-flight walls (TOF) with 2-plane scintillator slab geometry
  - 2 aerogel Cherenkov detectors (Ckov) with radiators, mirrors and windows
  - Electromagnetic calorimeter (EMCal) with lead-scintillator spaghetti geometry including individual fibers
  - Analysis planes (Virtual detectors) to record the Monte Carlo truth information

o A model of the readout electronics for all the detectors including
  - Light generation and transport (TOF, SciFi, Ckov, EMCal): scintillation and trapping efficiency, attenuation, transmission loss at connectors, reflectivity at mirror surfaces
  - Light detection: quantum efficiency of VLPC and PMT detectors, gain
  - Generation and transport of electron clusters (TPG)
  - Gain and electronics noise
  - Dead channels

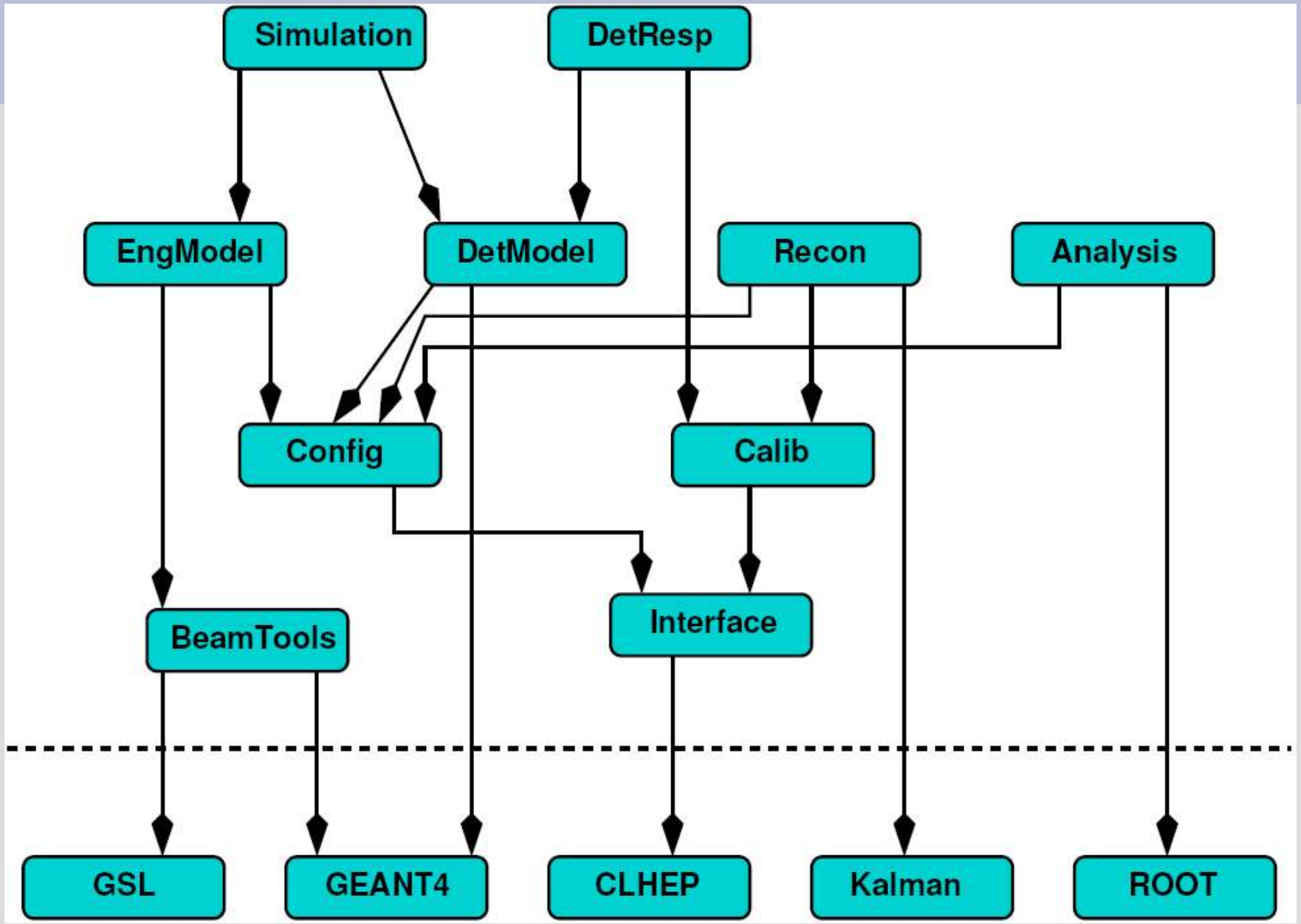
G4MICE Release 1.0

o Track reconstruction including
  - Pattern recognition for hit clusters in the SciFi tracker
  - Space points in SciFi and TOF
  - Road finding and extraction of optimal track parameters for the 2 SciFi trackers through a Kalman filter
  - Matching of SciFi tracks to TOF space points

o Calculation of beam dynamics quantities for physics analysis including
  - 2, 4, and 6-dimensional emittance in longitudinal (time-energy) and transverse (x-px, y-py) coordinates
  - Moments and covariance matrices
  - Kinematic cuts and statistical weighting

---------- February 12, 2005 ----------

Current G4MICE Design



User Requirements

- Document was built based on feedback (use-cases) from the collaboration (version-1.5, Apr 2004, MalcolmE)
- Example: 1. Channel modeling and representation
  - UR-1.1 The user shall be able to supply all relevant parameters that completely describe the cooling channel and detectors
  - UR-1.2 The user shall be able to supply field maps for one or more sections of the experiment to describe the electric and magnetic fields
  - UR-1.3 The user shall be able to describe magnets as a collection of coils and the software calculate the fields from this description
  - UR-1.11 A description of the MICE experiment from downstream of B2 to the last particle ID detector shall be provided for the MICE stage V (two absorbers, one RF cavity).
  - UR-1.12 A description of the MICE experiment from downstream of B2 to the last particle ID detector shall be provided for the MICE stage VI (three absorbers, two RF cavities)

User Requirements

- Document was motivated by a design iteration which hasn't been implemented yet due to lack of manpower and time pressure
- So far, we have concentrated on the most urgent requirements and implemented those successfully

Issues

- Implementation
  - Simulation should accurately reflect the actual experiment
- Software project management
  - Releases, testing, bug handling, etc.
  - Verify user requirements
- User interface
  - Should be in the user's language
  - Simple things should be easy, complicated things should be possible
- Analysis tools
  - Should be accurate, flexible and extensible

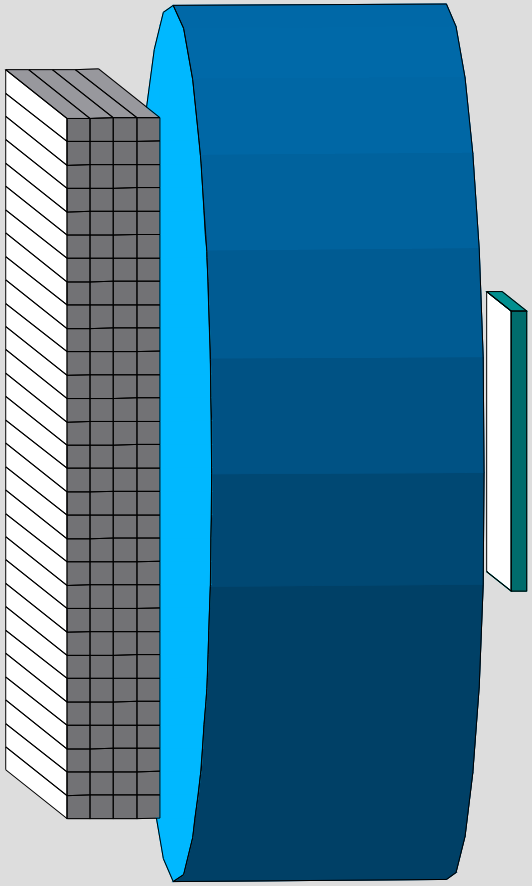
Implementation Issues

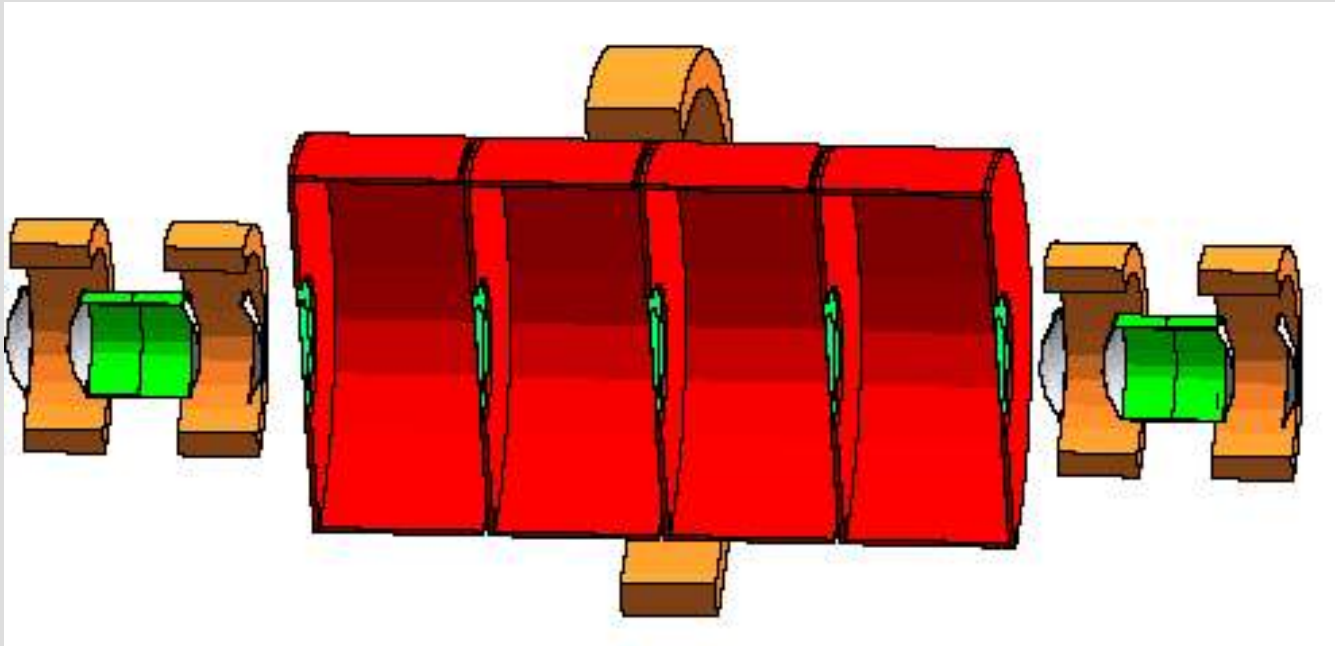
- Engineering detail for components
  - Need to make sure all material in/around beam path is accounted for correctly
  - Recheck detector details against TRD
  - Clean up electromagnetic field interface
- Support for different [stage|step|phase]s of MICE
  - KEK test beam setup will be implemented as one
- Event model/trigger
  - Verify we have adequate information in the output
  - Need to simulate spill structure and trigger timing in digitized output
- Persistency
  - Implement transparent, backward-compatible data I/O
  - Tools for managing calibration data
- Streamline analysis tools
  - Large scale production
  - Add/rearrange functionality into new optics module
  - Add hooks for user-built analysis code

Analysis Issues

- Optimize PID detector configuration
  - Beam sizes, segmentation
  - Timing and trigger
  - Track matching and global PID
- Tracker performance well-established for SciFi
  - Planning to do more for the TPG option
- Look at cooling channel performance in more detail
  - Scraping
  - Errors and tolerances
- Add optics functionality
- Tools for tolerance analysis
- More tools for forming virtual bunches in software from data

Action Shots





G4MICE in Action

- Recent G4MICE-Notes (Feb 05)
  - Simulation of Rf-induced Background in G4MICE (MICE-Note 92, RikardS)
  - G4MICE Tracking and Cooling Performance (MICE-Note 93, ChrisR)
- More to follow soon (Apr-May 05)
  - Downstream track distributions (HartW)
  - Cooling channel performance (ChrisR)
  - Calorimeter optimization (RikardS)

Outlook

- We have designed and implemented a MICE simulation environment that meets the most important user requirements:
  - An essentially complete software model of the experiment
  - Reliable tools for analysis
- We are working on making G4MICE more user-friendly while producing detailed results
- More collaborators welcome – no excuse to wait any longer, everything you need is at http://mice.iit.edu/software/