ALICE Simulation

LHCC Manpower Review of Computing
September 3, 2003

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Questions to be answered

- For the Monte Carlo simulations, the collaborations are also asked to present their plans for simulations.
- This should include an update and future plans of the Data Challenges as well as information on validating and improving the simulations, for example by benchmarking against test beam data, as well as presenting the associated uncertainties and ways to mitigate them.

Contents

- ALICE Simulation Strategy
- Physics Data Challenges
- Simulation Validation

ALICE Simulation Strategy (1)

- Coherent simulation framework for detector and physics performance studies in the AliRoot Framework based on ROOT
  - Physics simulation
  - Detailed detector response simulation
  - Fast simulation
- Use of Transport MC transparent to the user
  - Virtual MC Interface
    - Maximum reuse of user code
    - One single development line (in C++)

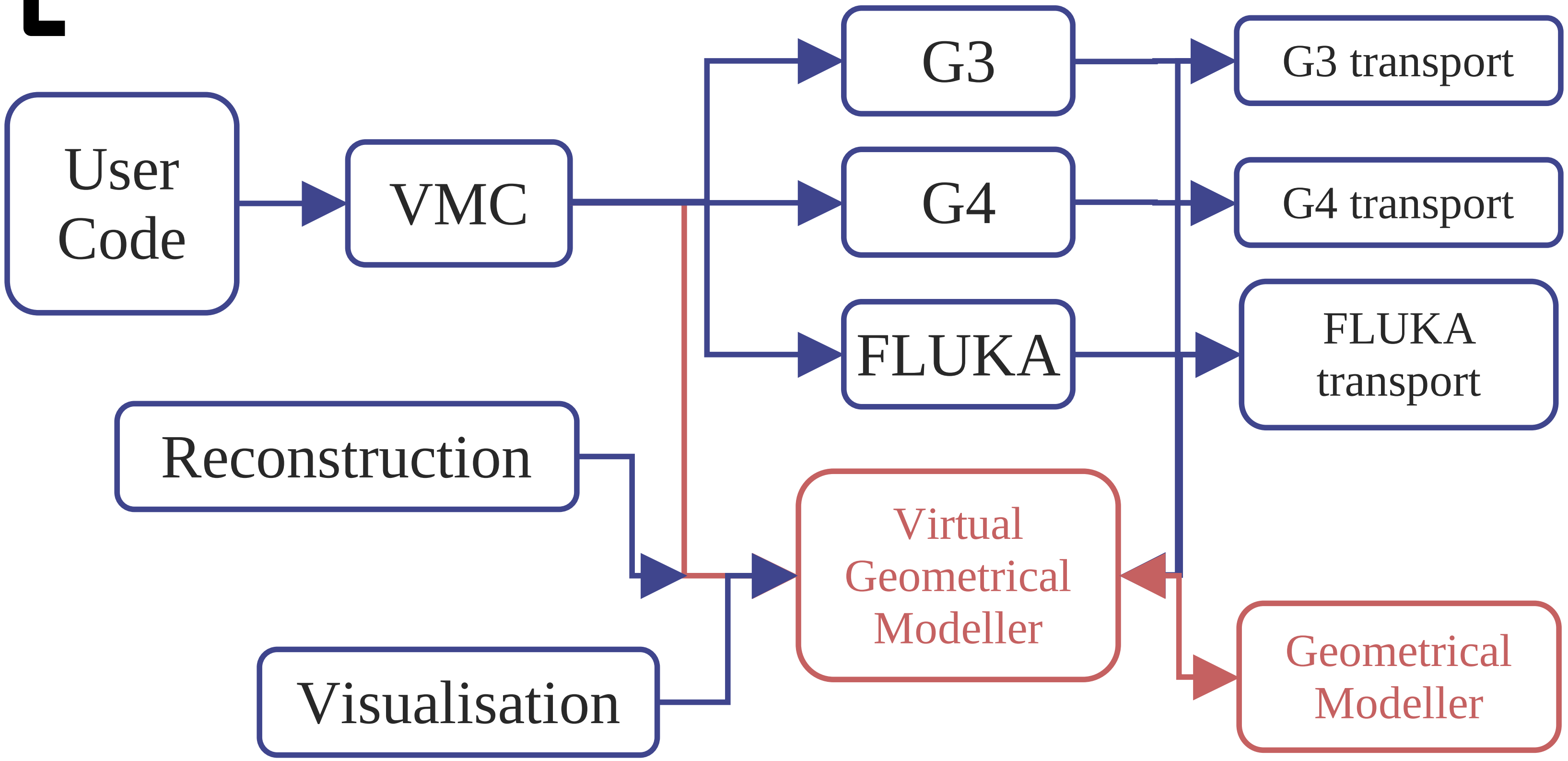
ALICE Simulation Strategy (2)

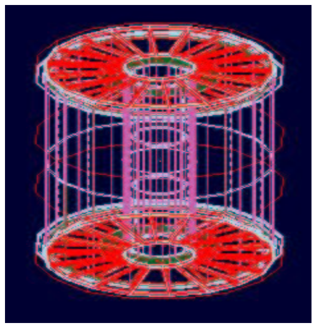
- Event Generator Interface tailored to the needs of the Heavy Ion Physics Community
  - Soft Uncorrelated Background, Correlations, Hard Processes
    - For pp, pA, A-A and for different collision geometries
  - Maximum of flexibility and user configuration capabilities

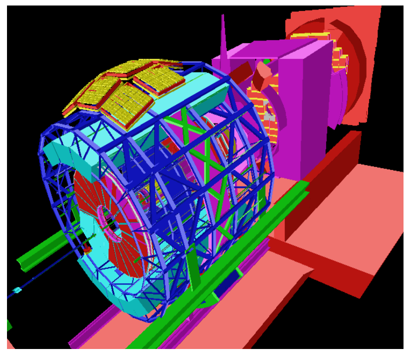
Relevance for Manpower Requirements

- Early investment in loosely coupled interface components (VirtualMC, Generator Interfaces) pays off
  - Ease of use of different Transport MCs (Geant3, Geant4, Fluka) without changing user code
  - Ease of integration of new physics simulation components as physics analysis interests evolve.
- At the same time ROOT provides the necessary “strong” coupling between modules: interactivity, GUI, object browsers, ...
  - Ease of debugging and testing
  - Speeds up the development cycle

Virtual Monte Carlo

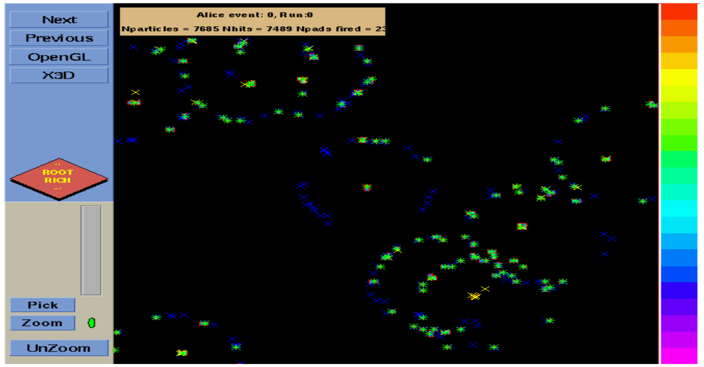


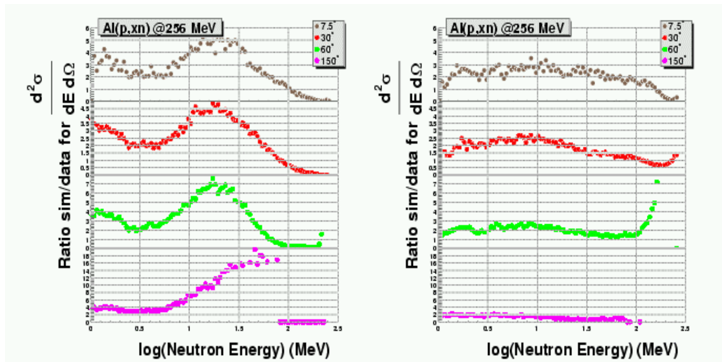


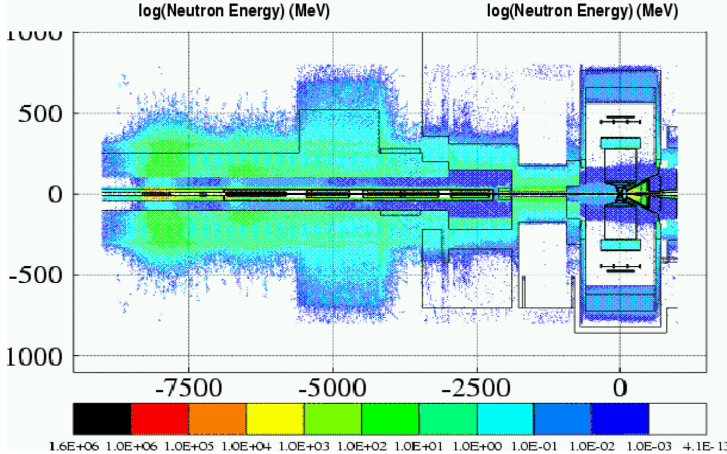


Virtual Monte Carlo: Status and Plans

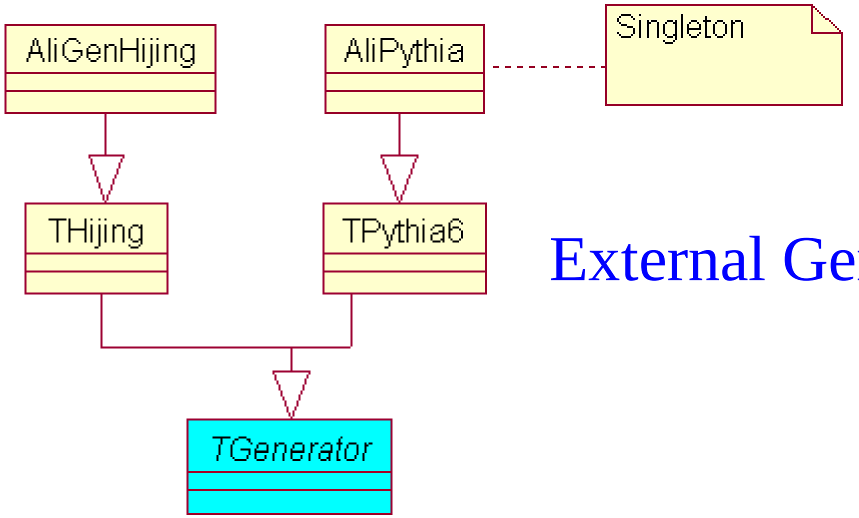
- TGeant3
  - Used in production
- TGeant4
  - Used for Geant4 physics validation
- TFluka
  - Under development
  - Full chain from primary particle generation, transport, hits running
- Root Geometry Modeller *TGeo* to be used as tracking machine



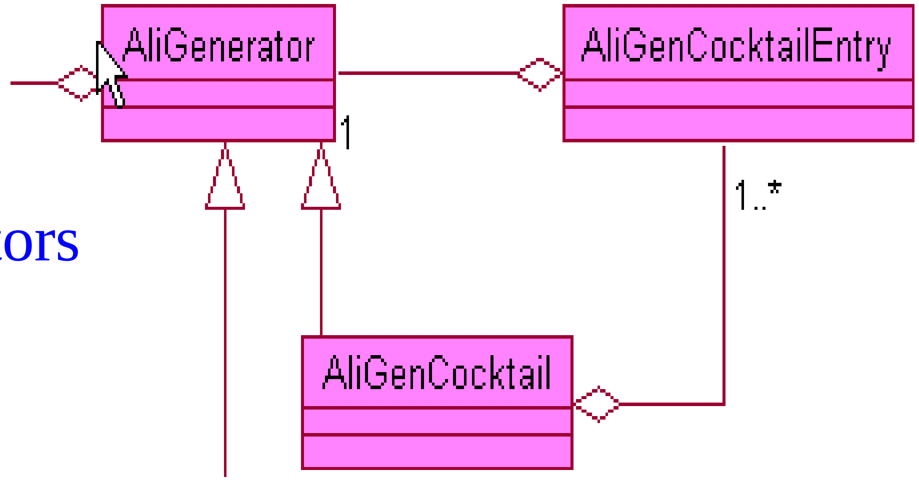




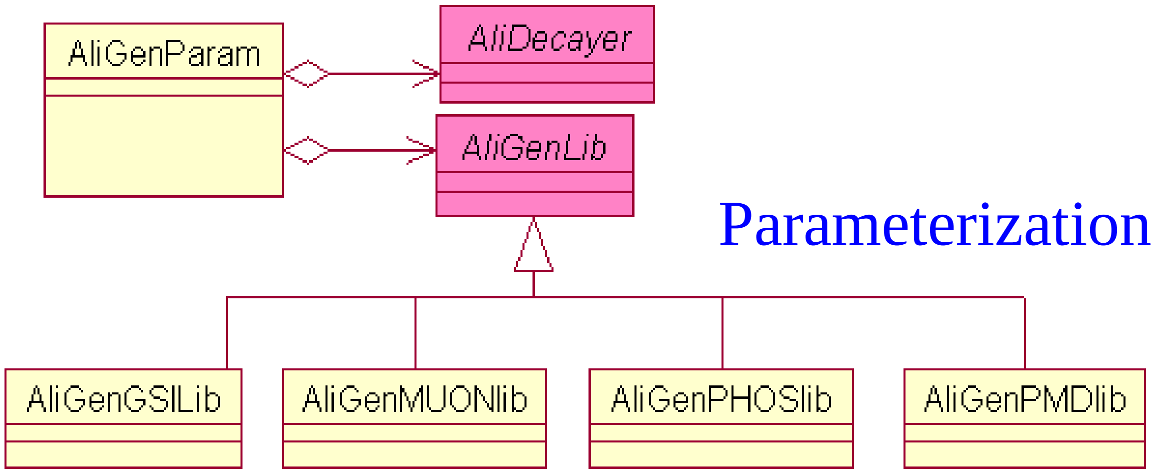
Main Event Generator Interfaces



External Generators



Event cocktails



Parameterization Libraries

Generators: Status and Plans

- Framework complete
  - Manpower needed for maintenance and user support
- Implementation of new components
  - Ongoing external and at CERN according to physics requirements
- Activities on comparison and physics validation of event generators
  - HIJING, DPMJET, PSM, ...
  - Pythia, Herwig, ...

Plans for Physics Data Challenges

- Objectives
  - Determine readiness of the offline system for data processing
  - Validate the distributed computing model
  - Test scalability

Period (milestone)	*Fraction of the final capacity (%)*	*Physics Objective*
06/01-12/01	1%	pp studies, reconstruction of TPC and ITS
06/02-12/02	5%	First test of the complete chain from simulation to reconstruction for the PPR Simple analysis tools. Digits in ROOT format.
01/04-06/04	10%	Complete chain used for trigger studies. Prototype of the analysis tools. Comparison with parameterised MonteCarlo. Simulated raw data.
01/06-06/06	20%	Test of the final system for reconstruction and analysis.

Physics Validation

- ALICE specific validation tasks
  - Central ALICE
    - Open geometry, no hadronic calorimeter
    - Emphasis on response simulation and digitisation
      - Tracking: ITS, TPC, MUON
      - PID: RICH, TRD, TOF, PHOS, ...
      - Response at high particle densities
  - Forward Muon Arm
    - Residual background from Front and Small Angle Absorbers
      - Hadronic showers 1 – 1000 GeV, longitudinal and transverse leakage, backscattering into central ALICE

Physics Validation

- Validations along three main lines
  - Absorber tests (completed)
  - Detailed detector response tests in high particle density environments (ongoing)
  - Simple hadronic benchmark tests (ongoing for FLUKA and Geant4)
- Simulation of test-beam data
  - Dominated by detector response
    - Tuning of response and material parameters
  - Limited relevance for test of transport MC

Test Beam Simulation

- Under the responsibility of sub-detector groups
- Analysis not in all cases done within the general simulation framework
  - Reason: Priority of response simulation
  - However, the final outcome is always integrated into AliRoot
  - More manpower in the external institutes dedicated to the test beam simulation would be crucial

Improvement of Simulation

- In the past driven by requirements of the TDRs
- Internal review in summer 2002
- New improvements for
  - Physics Performance Report (PPR) and
  - as new testbeam data comes up

Simulation Uncertainties

- Main uncertainty influencing the physics performance
  - Primary particle density in the barrel part
    - ALICE designed for dN/dy = 8000
    - More than a factor two more than the present best estimate
  - Secondary particle density in the Muon Spectrometer
    - Design uses security factor 2 on occupancies
    - Evaluate physics performance for even higher occupancies

Next Slides

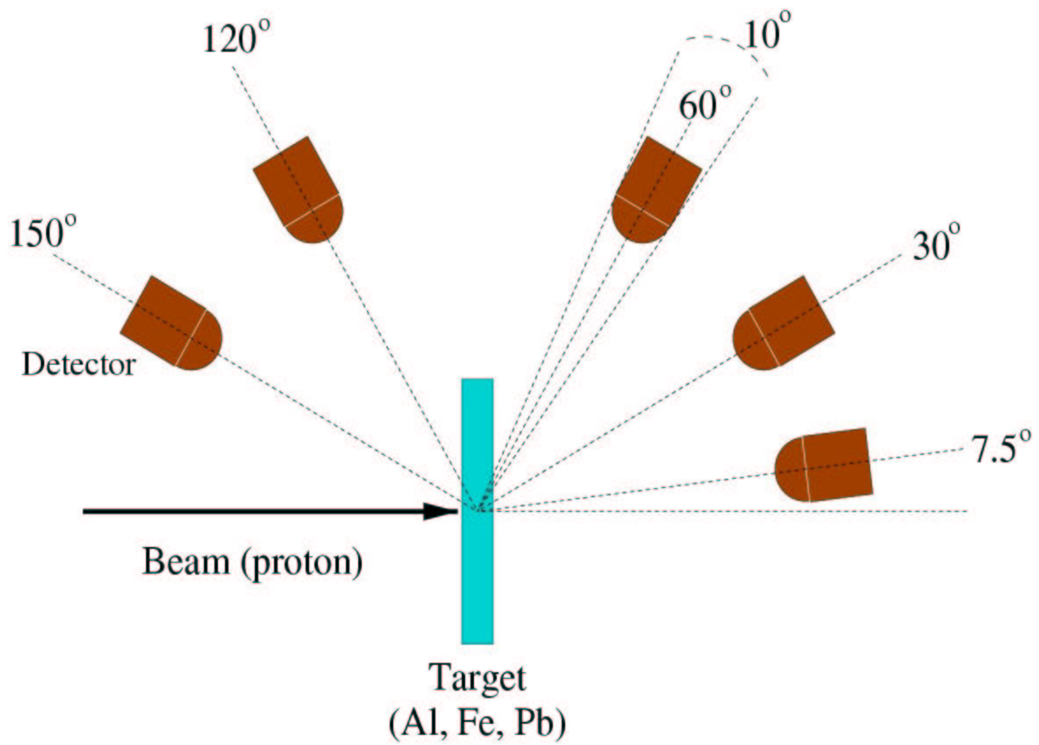
- Examples of completed and ongoing simulation validation activities
  - Benchmark tests
  - Absorber tests
  - Test-beam simulation
    - Time Projection Chamber (TPC)
    - TRD (Transition Radiation Detector)
    - ITS (Inner Tracking System)
    - PHOS (Photon Spectrometer)
    - HMPID (High Momentum Particle Identification)

Benchmark Tests

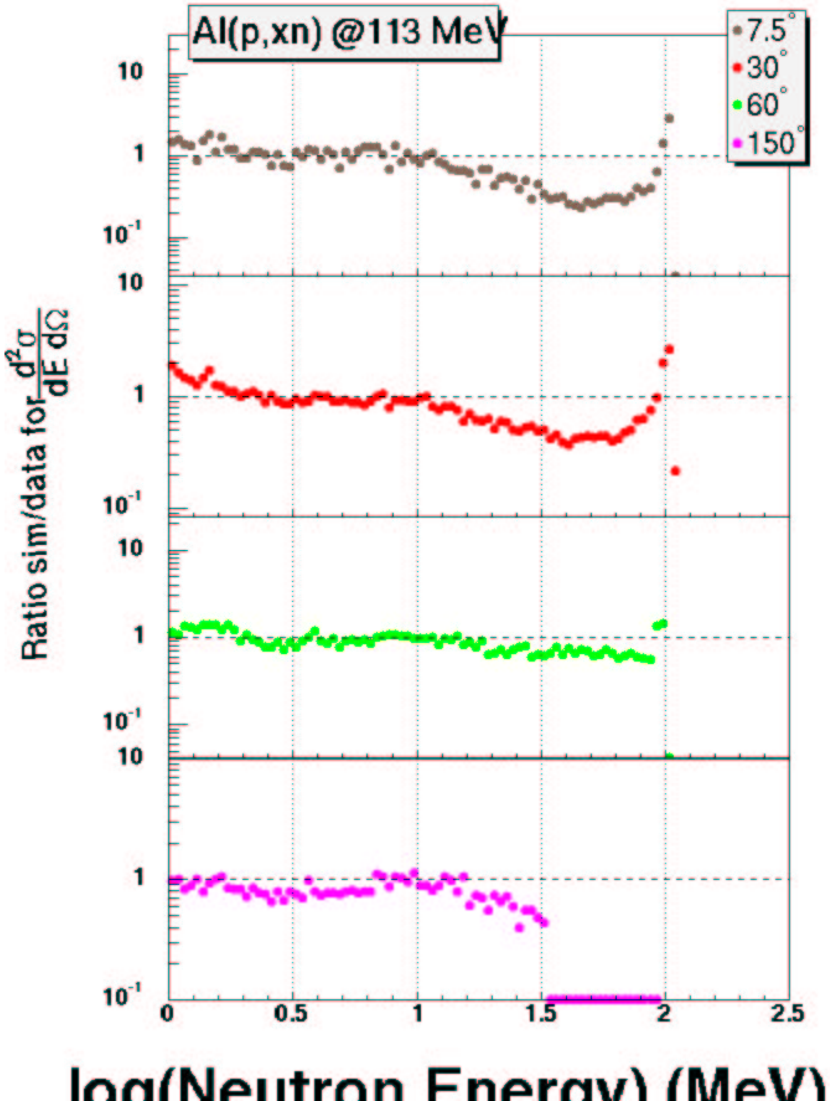
- Motivation
  - As a contribution to the Geant4 physics validation
  - Delivered reasons for decision to use FLUKA as our main transport code
- Simple Tests
  - Conservation laws
  - Azimuthal distributions
- Thin Target
  - p Al (Fe, Pb) 100-800 MeV
  - Double differential distributions
- Neutron Transport
  - Tiara Experiment

Benchmark Tests: Thin Target

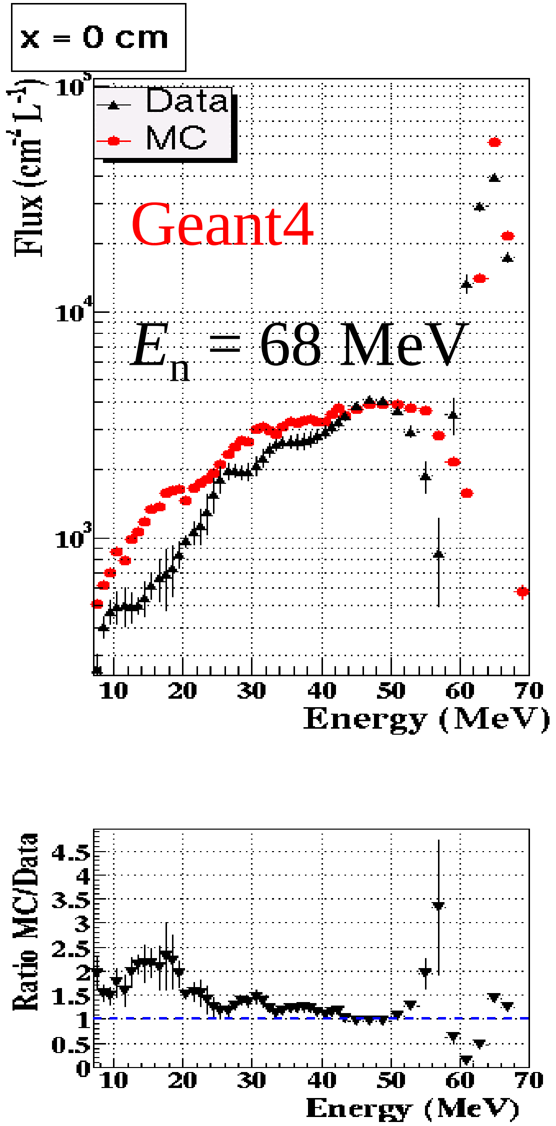
- Data information from Los Alamos in: Nucl. Sci. Eng., Vol. 102, 110, 112 & 115
- Beam energies: 113, 256, 597 & 800 MeV
- Materials: aluminium, iron and lead

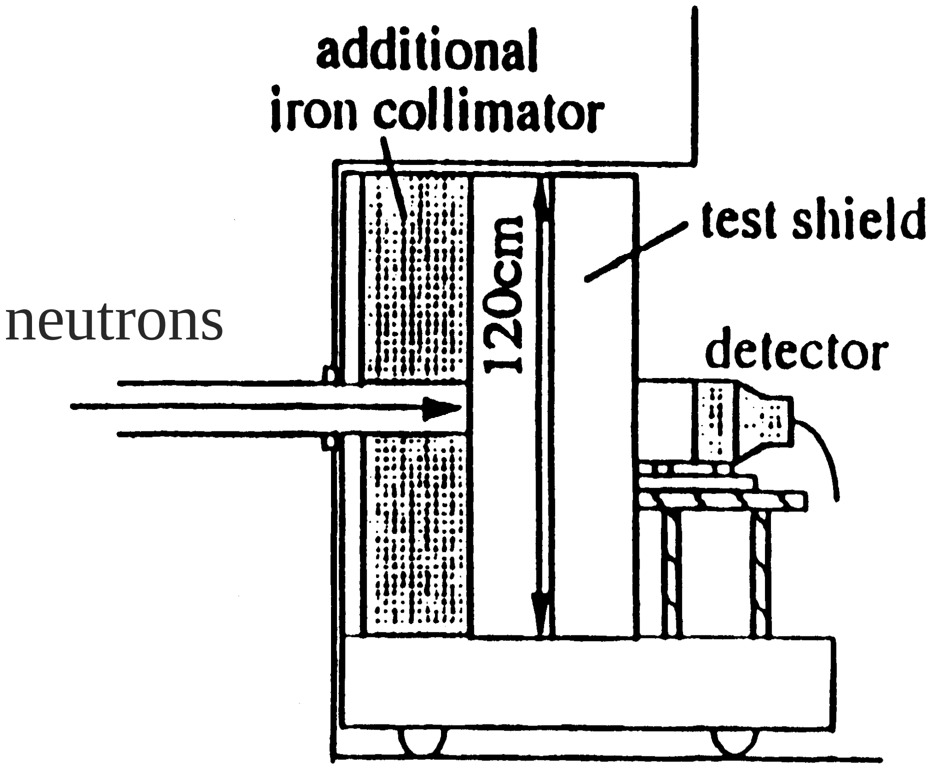


Geant4 / Data

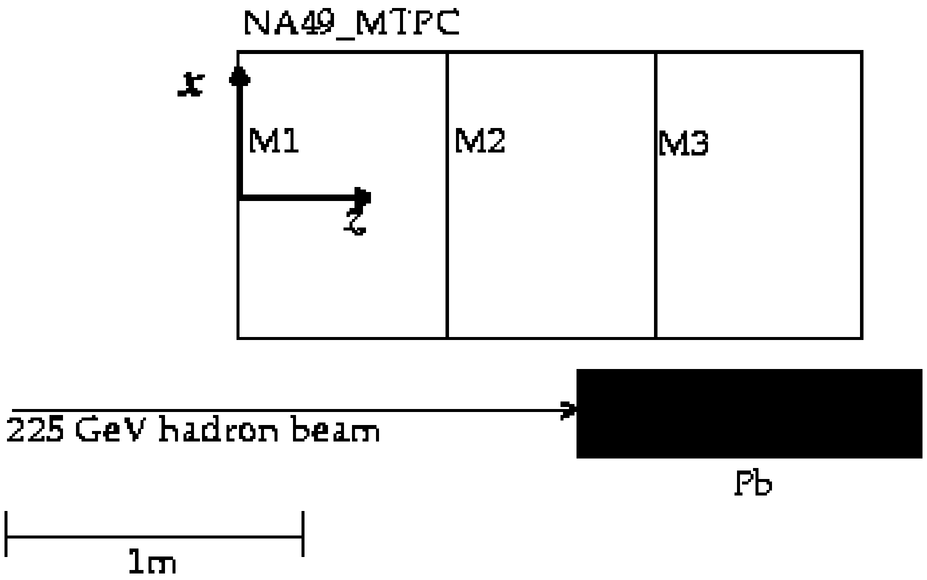


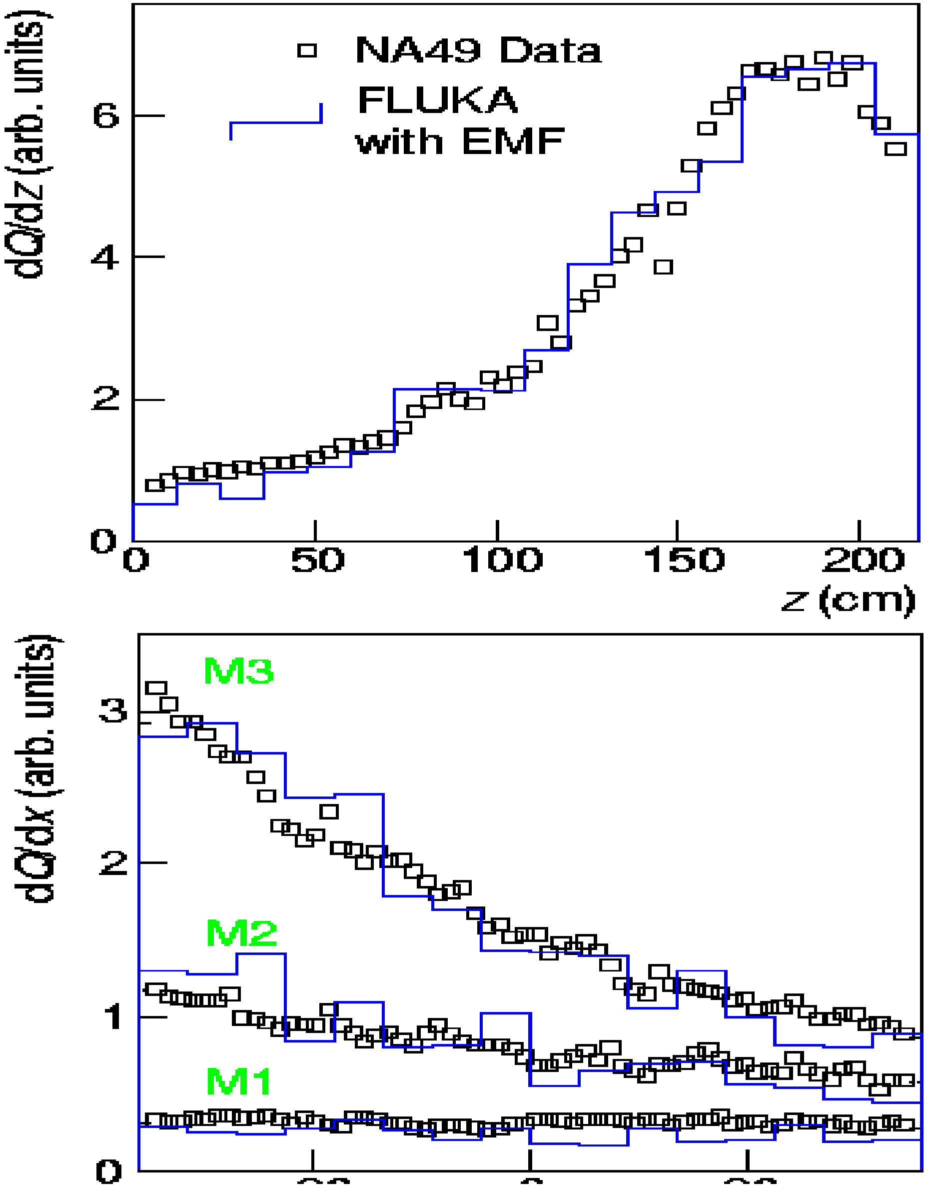
Tiara Facility: Neutron Transport





Absorber Tests: NA49 TPC

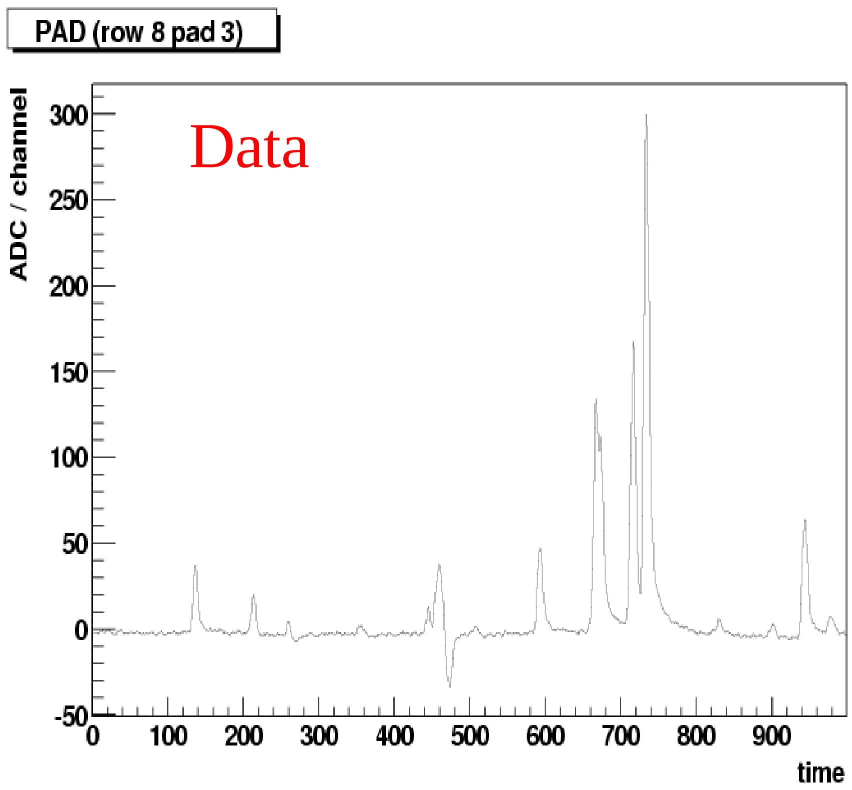


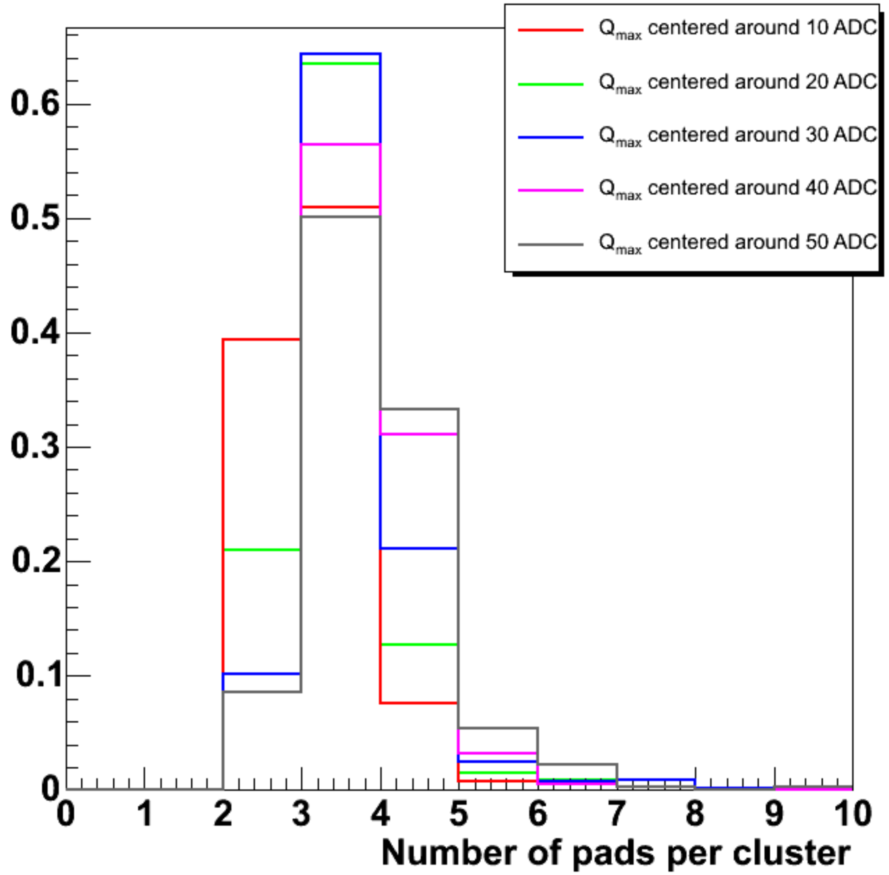


TPC

- Main concern: High Particle density
- Electronics response
  - Baseline restoration
  - Tail cancellation
- Tests
  - Now: Cosmic tests with prototype
  - Later: If necessary, test-beam with particle densities equal to LHC Pb-Pb runs

TPC Simulation

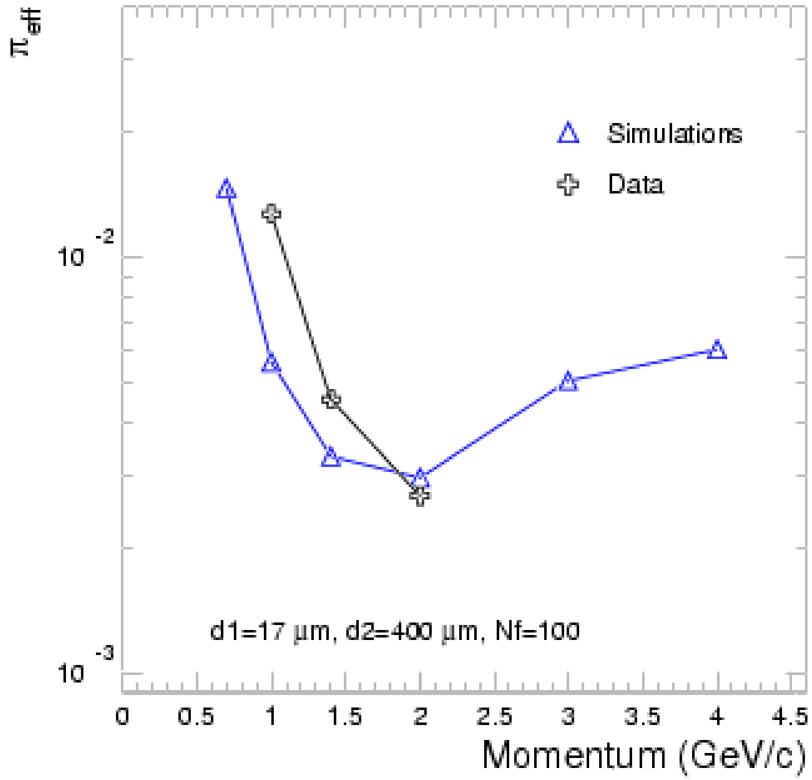




- Time response for high particle densities
- Offline simulation of ALTRO for baseline restoration and tail cancellations
- Validation of design parameters (cluster size, resolution, …)

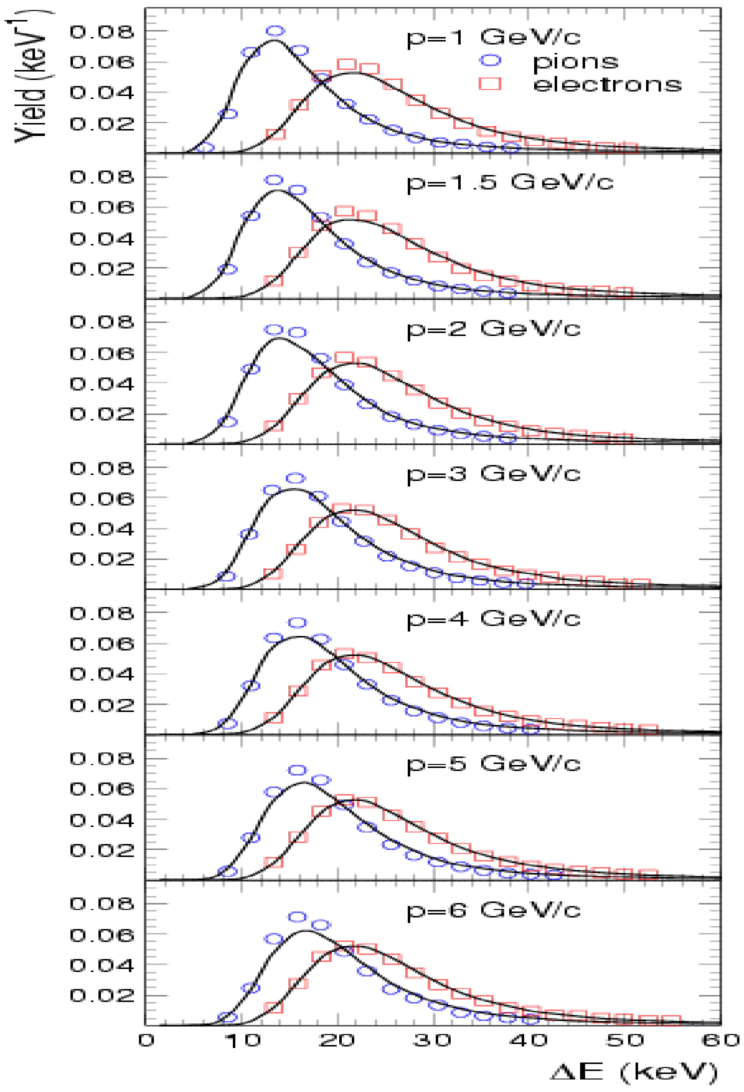
TRD

- TR photon yield
  - Approximated by analytical solution for foil stack
  - Adjustment of yield for real radiator including foam and fibre layers from test beam data.
  - Alternatively using directly the measured photon spectrum



TRD

– Correct simulation of energy loss of pions and electrons in Xe,CO_2 is essential



ITS

- Silicon Pixel
  - Comparison Simulation/Test-beam ongoing
- Silicon Drift Detector (SDD)
  - 5 years of test-beam activities
  - Interaction between test-beam and simulation to optimise simulation parameters and design
  - More tests ahead
- Silicon Strip detectors
  - Established technology
  - Huge experience from NA57
  - Test-beam planned once read-out electronics complete

PHOS

- Test Beam Data can be read by AliRoot
  - Direct comparison with simulation
  - Optimization reconstruction algorithms

HMPID (RICH)

- Detailed simulation of test beam data
  - Tuning of simulation parameters
    - Quantum efficiency, absorption length, refraction index, ..
    - Feed-back photon production
- RICH has been already used successfully in a running experiment (STAR)

Conclusions

- The ALICE Offline Team has built a simulation framework which has been designed
  - To keep manpower requirement at a minimum by avoiding duplicated user code
  - To evolve easily with the changing
    - Physics interests
    - Transport codes (currently Geant3, Geant4 and FLUKA used within the same framework)
    - Detector geometry and response simulation
- Physics validation activities concentrate on
  - Simple benchmark tests
  - Comparison of detector response simulations with test-beam data for the tuning of simulation parameters.