Status of the Kinetic Model

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for the

Kinetic Model **Group**

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Geant4 Workshop

ESTEC, 20-24 September 1999

A bit of history

- The development of the Kinetic Model was originally scheduled for the Geant4.0 release (December 1998)
  - original design by J.-P. Wellisch
  - theoretical consultancy by N. Ameline
  - implementation under the responsibility of Dubna Collaborators
- The resulting code was not judged by the Collaboration as of production quality
  - released in the Geant4.0 R&D version
- The responsibility of the Kinetic Model was taken over by a new group in Feb. 1999
  - C. Dallapiccola (Univ. of Maryland, COMMON): field transport
  - A. Feliciello (INFN-Torino): had previously worked on the ‘loop’ and resonance decay
  - M.G. Pia (INFN-Genova & CERN/IT): scatterer
  - to collaborate with N. Ameline (CERN/IT & Dubna): theory consultancy & data
- First implementation of production quality planned for the ‘July’ release

Manpower evolution

- C. Dallapiccola and A. Feliciello decided to quit Geant4 in May 1999, without having done any work on the parts of their responsibility
- *substantial investment of MG's time into their training, of CERN/IT support etc.*
- Difficulties of contribution from the original theoretical consultant
- MG only *woman*power left → release delayed
- New recent acquisitions to the Kinetic Model group
  - Lorenzo Bellagamba (INFN Bologna, will start next month)
  - Alessandro Brunengo (INFN Genova)
  - Elvio Di Salvo (INFN Genova, theorist)
    - *all novice to OO technology, C++, simulation, kinetic model physics...*
    - *need to invest time into initial training*
- Other (partly unexpected) workload on MG in addition to the Kinetic Model: involvement in the 'May' release, INFN user support, other INFN issues...

The process

- **Study of the physics of the Kinetic Model**
  - theoretical consultancy provided by E. Di Salvo in the later phase
- **Analysis of the 'Dubna' code**
  - *not compliant with the original design*
  - *very poor code quality*
  - *unacceptable physics approximations*
  - identification of some algorithmic parts that could be extracted and reused
- **OOAD**
- **Code development**
- **Unit software testing**
  - development of test code in parallel with the model development
  - high granularity testing
- **Physics testing**
- *Design/Implementation/Testing iterations foreseen*

Physics

- Theoretical model specialized for the resonance energy range
  - up to a few GeV
  - theoretical investigations in progress about possible extensions to higher energy
- Detailed description in the Physics Reference Manual
  - ...only 20 minutes for this talk + discussion!
- Some physics derived from the URQMD model (S. A. Bass et al., Prog. Part. Nucl. Phys. 41 (1998), 225
  - physics only, not implementation (URQMD is copyright-protected Fortran code, not in public domain)

Design

- Initial design review at the start of the project
  - original design
  - ‘Dubna’ implementation, not compliant with the original design
- Problem domain analysis, connected with the study of the underlying physics
- Result: keep the higher level interface, but ***major internal design iteration required***
- Initial approach:
  - **complete OO redesign of the Scatterer**
  - design review of the other components
- Will consider design iterations
  - in the other components
  - after the first implementation

The Scatterer

- Handles **baryon-baryon, baryon-antibaryon, meson-baryon** collisions
  - Calculation of total and partial cross-sections
  - Generation of the final state
- Includes treatment of elastic, inelastic and annihilation channels
- MG's responsibility
- **Major redesign** + implementation + ad hoc testing
- Status:
  - ***cross-sections***
    - baryon-baryon implemented and tested
    - meson-baryon and baryon-antibaryon at an advanced stage
    - complex treatment of the resonances (inspired by the URQMD model)
    - many common utilities already developed during the baryon-baryon implementation
  - ***generation of the final state***
    - to be done

The field transport

- Handles the propagation in the nuclear field
- Various phenomenological nuclear potentials implemented
  - details in the Phys. Ref. Manual
- Currently hadrons are transported along straight line paths
  - we are aware this approach is not adequate
  - joint Hadronic/Transportation parallel session scheduled in this workshop to discuss field transport together and profit of the expertise of the Geometry&Transportation Group
  - Alessandro's responsibility

The 'loop' (HadronKineticModel)

- Controls the logic of the model
  - very complicated algorithm!
- Has also responsibility for some physics modeling
  - application of the Pauli principle
- 'Dubna' implementation not only does not respect the design, but does not respect the basic logical foundation of the model either
- of no use, even for extraction of algorithmic parts
- **To be completely reengineered**
- Complex and delicate work
  - to be done 4-hands by Alessandro + MG

Other utilities

- Various classes of the hadronic theoretical models
  - G4KineticTrack, G4KineticNucleon, G43DNucleus
  - developed by Gunter et al.
- Further development required to handle resonance decay more correctly
  - resonance decaying into two resonances
- Plan to propose involvement of Lorenzo
  - as first G4 project, start next month

Testing

- ***Unit testing***
  - developed and performed in parallel with the model code development
  - high granularity, mostly at the single class level
  - includes
    - software testing
    - physics testing at the microscopic level (including comparison with data)
  - lots of complicated mathematical equations and complex algorithms
    - *what a delight to test Clebsch-Gordan coefficients, Wigner 3-j symbols etc.!*
  - tedious, time consuming... but of fundamental importance in the process
- ***Physics testing***
  - <u>is a major issue</u>
  - need to develop a powerful testing suite
  - need experimental data (in a usable format)

Ideas for new developments

- Valuable input from our theoretical consultant (E..d.S.)
- Investigations in progress to evaluate the possibility to use ‘Reggeology’ to describe exclusive processes at higher energies
  - would represent a major improvement
- Areas where investigations of new/alternative physics models would be desirable
  - field transport
  - Pauli blocking mechanism

What is left to do

- ***Complete the implementation of the Scatterer***
  - some parts of the cross sections (but most of the work done)
  - generation of the final state
- ***Field transport***
  - collaboration with the Geometry and Transportation working group
  - investigate potential models
- ***Implementation of the main loop***
  - mostly a problem of tricky logic
- ***Investigate the application of the Pauli principle***
  - is the current model correct?
- ***Testing, testing, testing...***
  - main issue is the collection of experimental data and their conversion into a user-friendly computer-usable format

Plans

- **Have a first implementation ready for next release**
- Have a minimal test suite to be used for the validation of the first implementation
- *...yes, we know it's going to be hard work*
- Extensive **physics testing** will be the major task after the first release
  - will certainly lead to software and physics improvements
- Investigate **further extensions**
  - at the theoretical level in parallel with the first implementation
  - to be implemented after the first release
- Need <u>collaboration for the collection of experimental data</u>
  - also to be formatted into a computer-readable format

Conclusions

- Work in progress in the Kinetic Model
  - ***major redesign***
  - ***first implementation***
  - ***thorough unit testing***
- The group suffered **serious manpower losses** and unexpected distractions, that caused a delay
  - new collaborators joined, but training required
  - new theoretical consultancy acquired
- Concern about the **physics testing**
- <u>First production release foreseen in Geant4.1</u>
- Major physics testing and design/implementation iterations planned to follow the first release