

Modellistica Medica

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Anno Accademico 2002-2003

Lezione 36

Highlights of other physics features

Hadronic physics

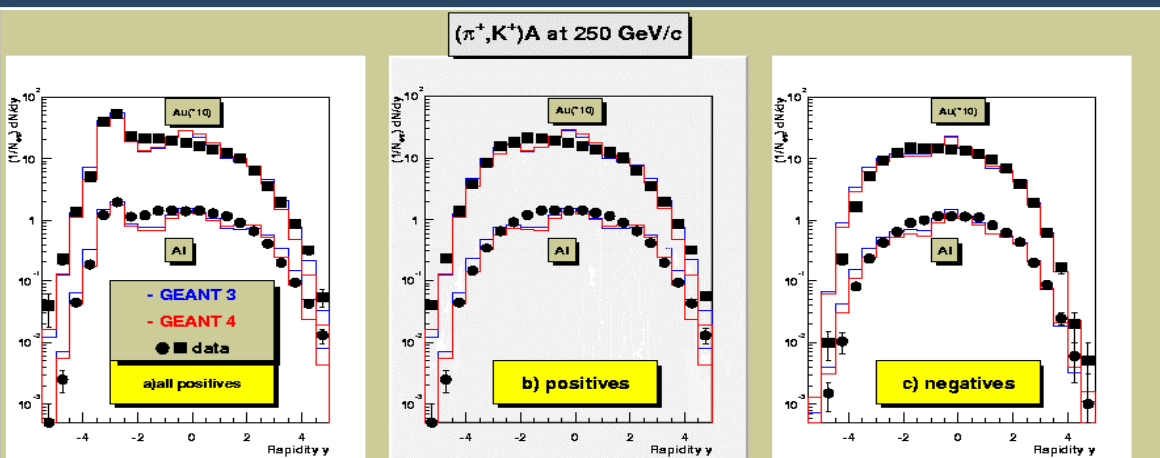
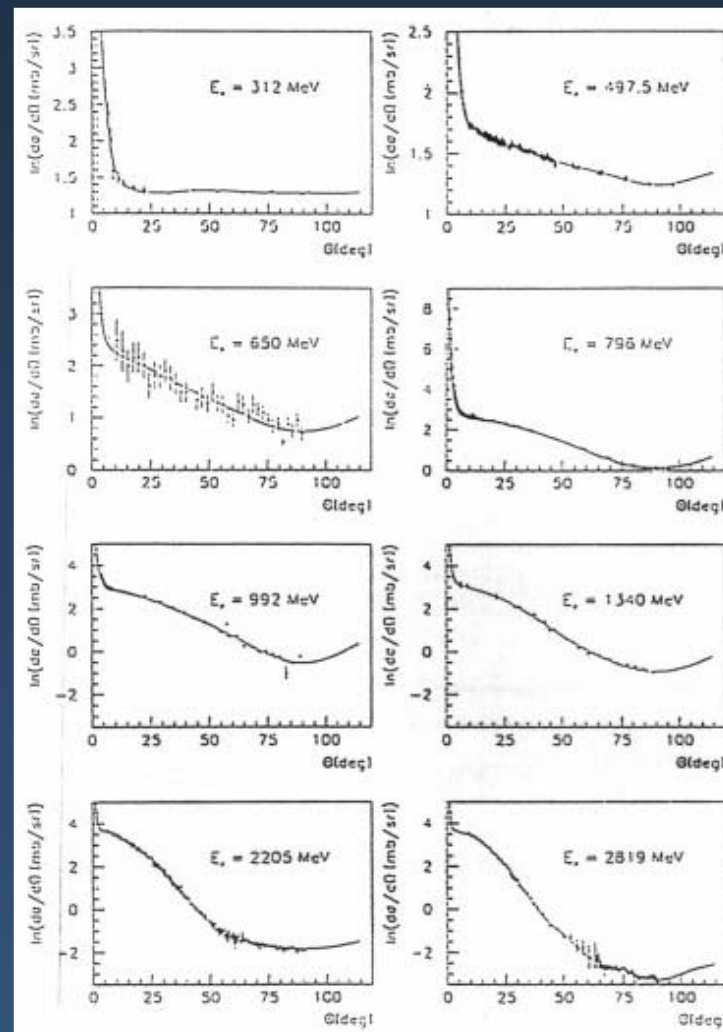
- Completely different approach w.r.t. the past (Geant3)
 - native
 - transparent
 - no longer interface to external packages
 - clear separation between data and their use in algorithms
- Cross section data sets
 - transparent and interchangeable
- Final state calculation
 - models by particle, energy, material
- Ample variety of models
 - the most complete hadronic simulation kit on the market
 - alternative and complementary models
 - it is possible to mix-and-match, with fine granularity
 - data-driven, parameterised and theoretical models
- Consequences for the users
 - no more confined to the black box of one package
 - the user has control on the physics used in the simulation, which contributes to the validation of experiment's results

Parameterised and data-driven hadronic models

Based on experimental data

- Some models originally from GHEISHA
 - completely reengineered into OO design
 - refined physics parameterisations
- New parameterisations
 - pp, elastic differential cross section
 - nN, total cross section
 - pN, total cross section
 - np, elastic differential cross section
 - π N, total cross section
 - π N, coherent elastic scattering

p elastic scattering on Hydrogen



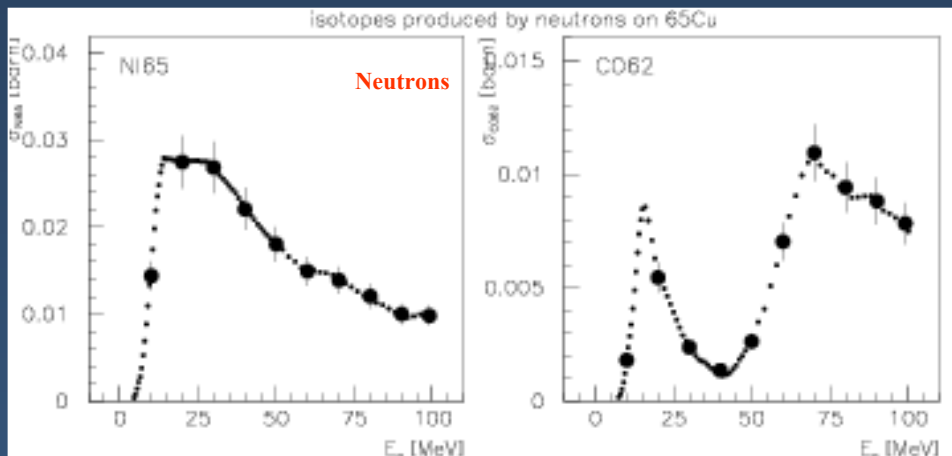
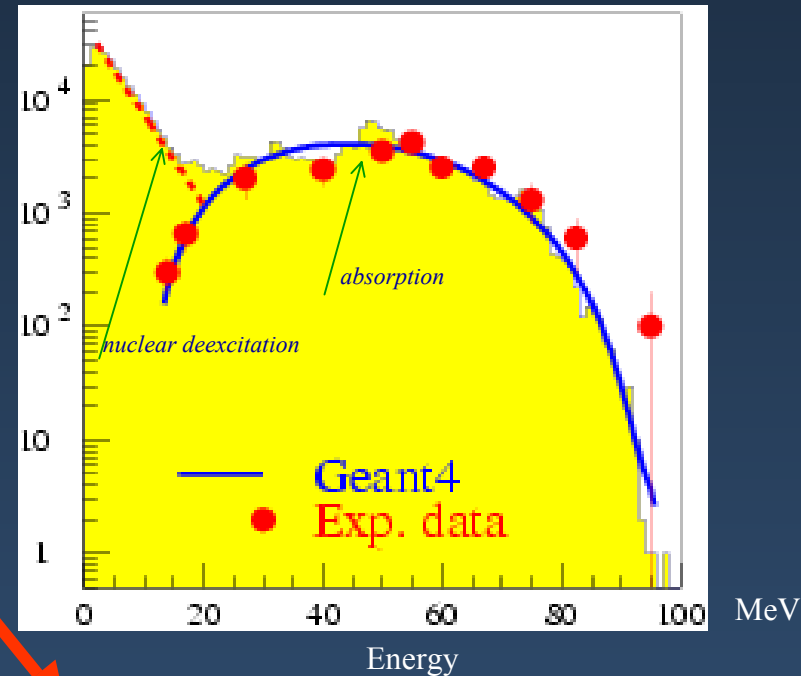
Parameterised and data-driven hadronic models

Other models are completely new, such as:

stopping particles: π^- , K^-
(relevant for μ/π PID detectors)

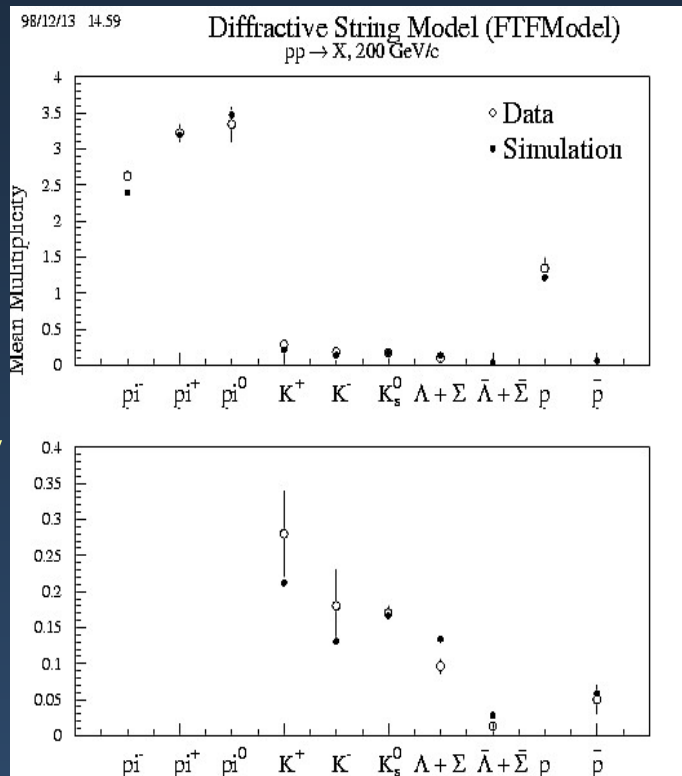
Isotope production

neutrons



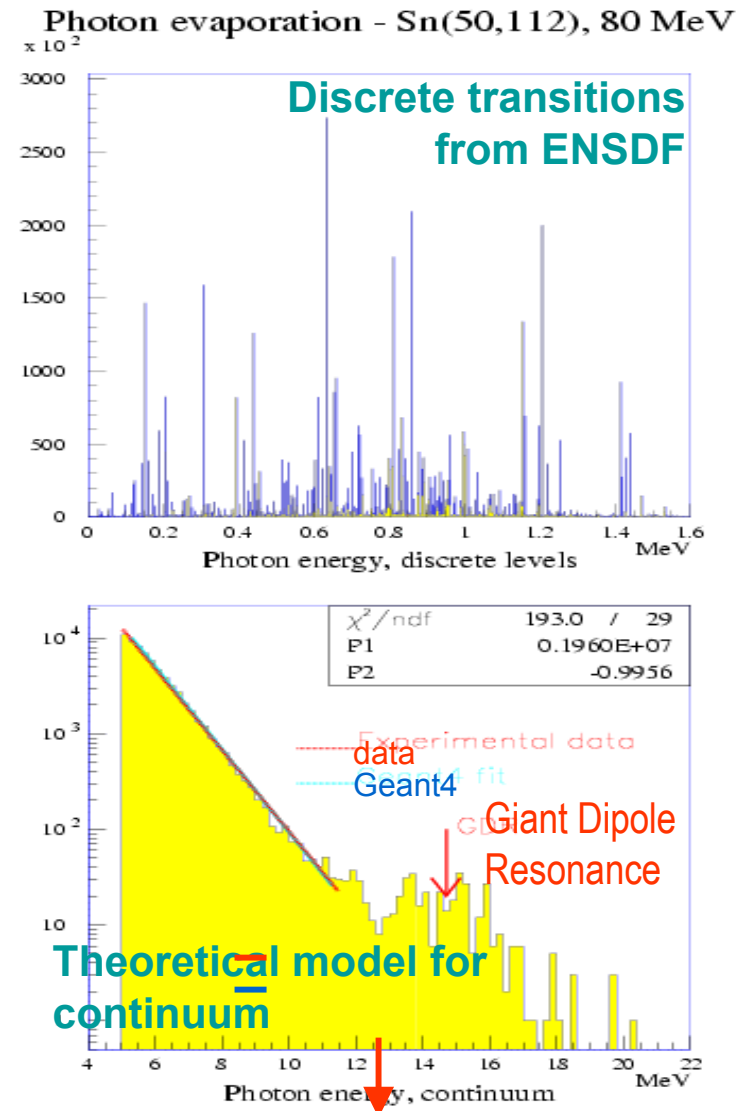
All worldwide existing
databases used in **neutron**
transport
Brond, CENDL, EFF, ENDFB,
JEF, JENDL, MENDL etc.

Theory-driven models



Complementary and alternative models

- *Evaporation phase*
- Low energy range, *pre-equilibrium*, $O(100 \text{ MeV})$
- Intermediate energy range, $O(100 \text{ MeV})$ to $O(5 \text{ GeV})$, *intra-nuclear transport*
- High energy range, *hadronic generator* régime



Radioactive Decay Module

- Handles α , β^- , β^+ , ν and anti- ν , de-excitation γ -rays
 - can follow all the descendants of the decay chain
 - can apply variance reduction schemes to bias the decays to occur at user-specified times of observation
- Branching ratio and decay scheme data based on the Evaluated Nuclear Structure Data File (*ENSDF*)
- Geant4 photo-evaporation model is used to treat prompt nuclear de-excitation following decay to an excited level in the daughter nucleus
- Applications:
 - underground background
 - backgrounds in spaceborne γ -ray and X-ray instruments
 - radioactive decay induced by spallation interactions
 - brachytherapy
 - etc.

Fast simulation

Geant4 allows to perform full and fast simulation in the same environment

- The parameterisation process produces a direct detector response, from the knowledge of particle and volume properties
 - hits, digis, reconstructed-like objects (*tracks, clusters etc.*)
- Great flexibility
 - activate fast /full simulation by detector
example: full simulation for inner detectors, fast simulation for calorimeters
 - activate fast /full simulation by geometry region
example: fast simulation in central areas and full simulation near cracks
 - activate fast /full simulation by particle type
example: in e.m. calorimeter, e/γ parameterisation + full simulation of hadrons
 - parallel geometries in fast/full simulation
example: inner and outer tracking detectors distinct in full simulation, but handled together in fast simulation

Event biasing

- Geant4 provides facilities for event biasing
- The effect consists in producing a small number of secondaries, which are artificially recognized as a huge number of particles by their statistical weights
- Event biasing can be used, for instance, for the transportation of slow neutrons or in the radioactive decay simulation
- Various variance reduction techniques available