Summary of Parallel Session 8A "Hadronic Discussion"

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Geant4 Collaboration Meeting, Chartres, 10-14 September 2012

Muon Stopping (1/3)

Krzysztof Genser, Fermilab/SCD
17th Geant4 Collaboration Meeting
Chartres, September, 2012

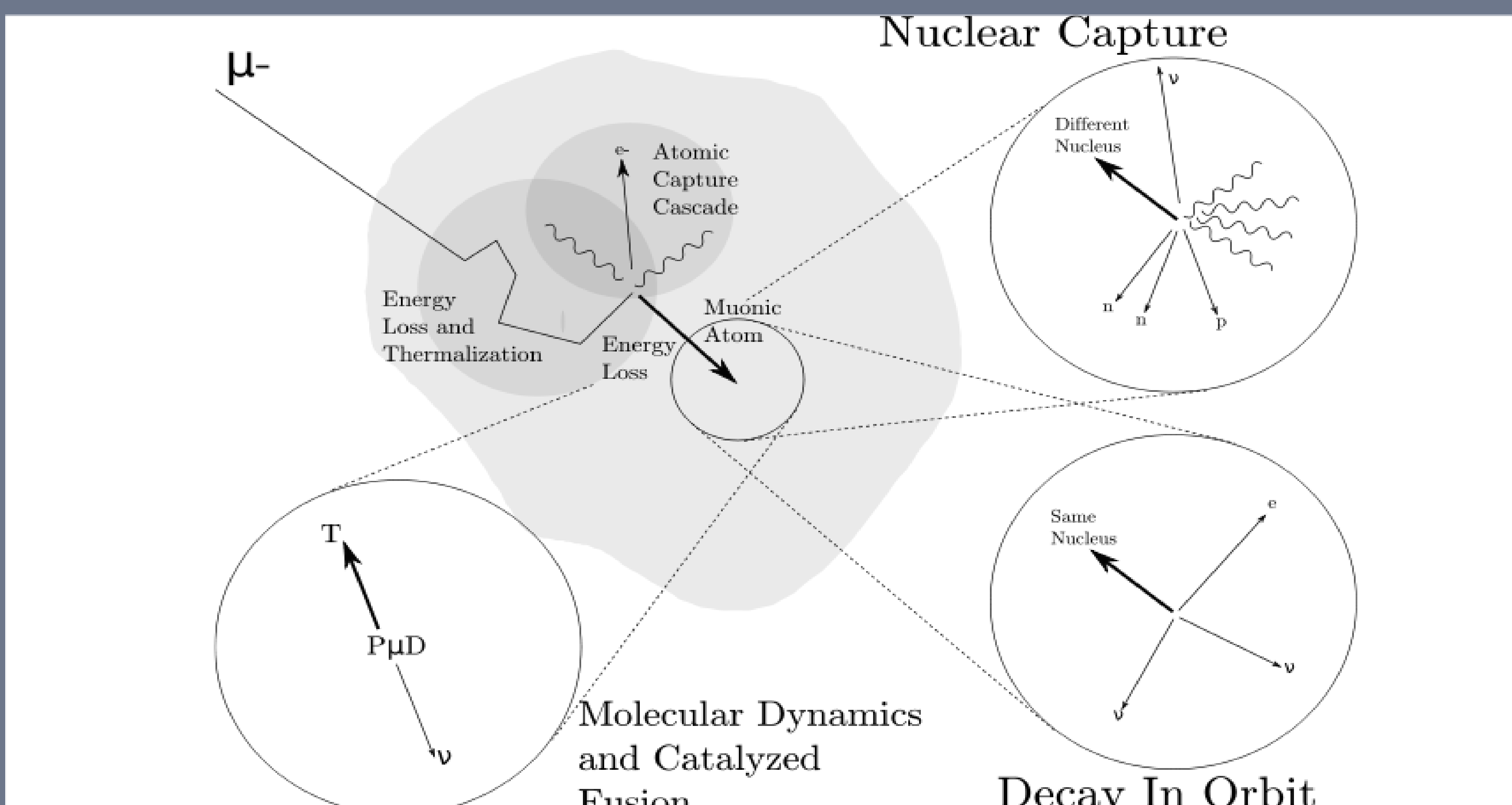
Muon Stopping Discussion

Muon Stopping (2/3)

- Need of a sophisticated muon stopping process in Geant4 for the **mu2e** experiment (being designed at Fermilab)
  - Neutrinoless muon to electron conversion in the Coulomb field of a nucleus (27Al target)
  - Simulating all known processes is very important for background calculations
- The muon stopping available in Geant4 before 9.6.beta, *G4MuonMinusCaptureAtRest* was too simple and monolithic
- Kevin Lynch prepared a prototype
- We agreed on a new design, implemented by Vladimir I.
  - *G4MuonMinusCapture* inherits from *G4HadronStoppingProcess* which is a *G4HadronicProcess* (discrete, not at-rest processes)
  - Factored out Atomic Capture, Nuclear Capture, and Bound Decay
- Further refinements of the design discussed yesterday

Muon Stopping (3/3)

Muon Capture Physics - artistic drawing from Kevin's talk



Hybrid Processes (1/3)

Some Thoughts on the Consistent Treatment of Hybrid Processes

Geant4 Collaboration Meeting
13 September 2012
Dennis Wright (SLAC)

Hybrid Processes (2/3)

The Problem

- Several "hybrid" processes in hadronics should, strictly speaking, be considered as EM as they must be assigned to gammas or leptons
  - mu-nuclear
  - electron- and positron-nuclear
  - mu capture
- Others belong in the decay category:
  - radioactive decay
- Some hadronic processes have EM (atomic) components
  - various hadron capture reactions (π-, K-, etc.)

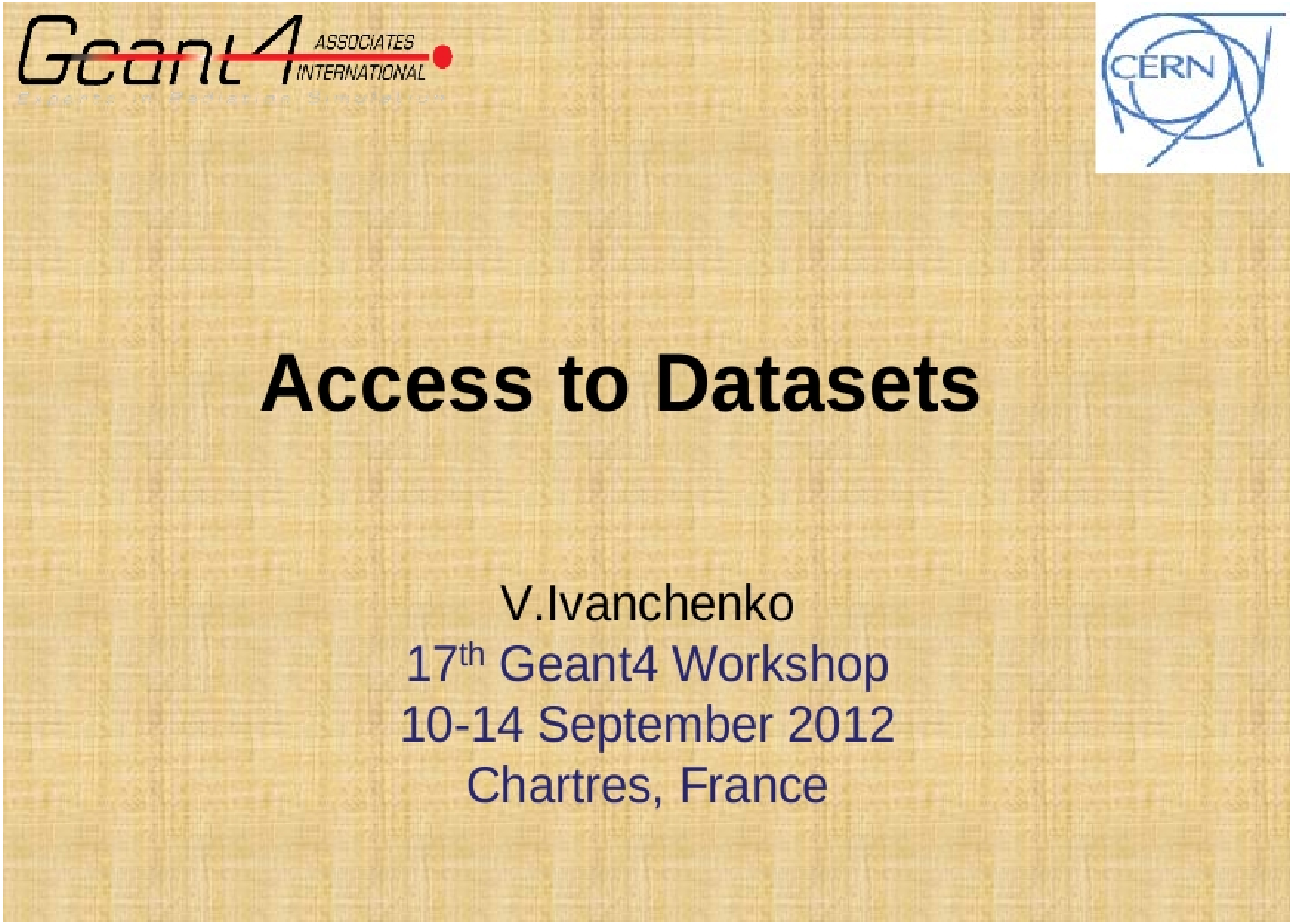
- Any future neutrino interaction code would fall into yet a different category

Hybrid Processes (3/3)

Agreed decisions:

- **Not** to put any of these hybrid processes in **electromagnetics**
- Study in detail the dependencies of these hybrid processes
- Study the cases of duplication of code and how to avoid them
- Either leave the processes inside the hadronic directory, or move them in a new directory, with dependencies on| both electromagnetic and hadronic, and following the hadronic framework

Datasets (1/3)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Access to Datasets
V.Ivanchenko
17th Geant4 Workshop
10-14 September 2012
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Datasets (2/3)

CMS request to reduce size of data files

- Studying migration of CMS software to Geant4 9.5 a problem have been identified:
  - HP data structure size was increased by factor 5
  - This make a problem for software distribution
- I make a surway of existing data structures:
  - G4EMLOW2.27 – 72.6 M
  - G4RadioactiveDecay3.4 – 6.0 M
  - G4PhotonEvaporation2.2 – 30.9 M
  - G4NEUTRONXS1.1 – 4.2 M
  - G4NDL3.14 – 223.7 M
  - G4NDL3.15 – 1064.7 M
  - G4DNL3.16 – 803.9 M
  - G4NDL4.0.PUB – 1432.5 M
  - G4NDL4.0.PUB (all files compressed) – 411.9 M
- Can we consider situation as an issue and think about reading of compressed files?

Datasets (3/3)

Agreed actions:

- For **G4 9.6**, to ask Tatsumi to separate the neutron library into two pieces:
  - Thermal scattering
  - All the rest

- For **G4 X**, to ask Tatsumi to investigate the following
  - Restructuring the directories and file structure in order to have a single file for each isotope
  - Compress datasets
  - Allow a user to specify its own provided neutron file(s) for a particular isotope

Bertini Nucleus Parameters (1/5)

Bertini Nucleus Parameters

Michael H. Kelsey
SLAC GEANT4 Group

GEANT4 Collaboration Meeting
13 Sep 2012

Bertini Nucleus Parameters (2/5)

Nuclear Structure

Current code has mismatch of length and cross-section (h–N total) units in nuclear structure model

$$r \sim 2.8179 \times \text{fm} \qquad \sigma \sim \text{mb} \; (\times \; 10 \; \text{fm}^2)$$

True physical units (fm, fm^2, 1/fm^3) changes thin-target and calorimeter performance noticeably

- Thin-target response reduced by factor of 2
- Calorimeter visible energy increased by 10–15%

Scaling up total cross-sections $\times 3$ restores data-MC comparison

Bertini Nucleus Parameters (3/5)

Final-state Coalescence

Bertini generally understimates light ions (D, T, ^{3}He, α)

Only produced in non-equilibrium evaporation or breakup

New optional code (envvar `G4CASCADE_DO_COALESCENCE`) finds clusters of final-state nucleons which can be bound

Momentum spread in cluster below thresholds:

$$\begin{array}{rcll} pn & \Rightarrow & \text{D} & 90\ \text{MeV} \\ pnn & \Rightarrow & \text{T} & \multirow{2}{*}{\Big\} 108\ \text{MeV}} \\ ppn & \Rightarrow & {}^3\text{He} & \\ ppnn & \Rightarrow & {}^4\text{He} & 115\ \text{MeV} \end{array}$$

Other light-ion sources (collective states within cascade, nucleon-induced "evaporation") not implemented

Bertini Nucleus Parameters (4/5)

Trailing Effect

Also known as "shadowing"

Emulates true time-dependent cascade by skipping interactions at locations of previously hit nucleons

Enabled by setting non-zero effective radius of nucleon (envvar `G4NUCMODEL_RAD_TRAILING`)

Comparison with data suggests small radius, 0.7 fm

Bertini Nucleus Parameters (5/5)

NN Cross Sections

Degradation in Bertini-related performance on SATIF benchmarks (neutron spallation)

Could be related to changes in pp, nn, pn cross-section tables

New low-energy SAID calculations for total and elastic provided by GWU collaborators

- pp and np calculated for 0 to 320 MeV
- nn calculated using pp with Coulomb interactions turned off (in progress)
- PDG values used above 320 MeV
- Analytic functions for 0–20 MeV, replacing interpolation
  $\sigma(pp) \sim 1/T \qquad \sigma(np) \sim \frac{a}{bT+(1-cT)^2} + \frac{d}{eT+(1-fT)^2}$