Grid testing of Geant4 10.5.ref08

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Main Changes in Hadronics vs. 10.5.ref07

No changes in QGS, BERT, BIC, INCLXX, etc.

- **Cross sections**: Several changes
- **Elastic**: Use new parameterisation below **1 GeV**
- **FTF**: Improvement in the annihilation at rest
- **Pre-equilibrium**: Minor changes
- **De-excitation**: Several changes; introduced max excitation energy per nucleon for precompound: **100 MeV**
- **ParticleHP**: Added a few protections
- **RadioactiveDecay**: Bug fixes, protections, clean-ups

- **Physics lists**: Changed transition region (string – cascade) in most physics lists, from **[3, 12] GeV** to **[3, 6] GeV**
  - Exceptions: FTFP_BERT_ATL, INCLXX-based P.L., NuBeam, ShieldingM
Crashes & Warnings

- No crashes, no infinite loops
- New warning “had0034”, appearing very frequently
  - Example:
    
    *issued by*: G4ExcitationHandler::BreakItUp()
    
    High excitation Fragment Z= 3 A= 8 Eex/A(MeV)= 107.208
  - A fix has been proposed in Precompound/de-excitation

Reproducibility

- A few violations observed
  - E.g. 20 GeV pi- on Cu-LAr with FTFP_BERT
  - Only for MultiThreaded mode vs. Sequential mode
  - It is due to the Starkov's elastic class G4ElasticHadNucleusHE which has been substantially modified in Ref08
    - Fix under investigation
Pion- showers: FTFP_BERT

G4 10.5.ref08
G4 10.5.ref07.tr3_6gev

Note: conventional Birks treatment
(easier and no experimental h/e to fit !)
FTFP_BERT : Energy Width

Normalized width | Beam: pi- | Target: TileCal | FTFP_BERT

π⁻ on Fe-Sci

Normalized width | Beam: pi- | Target: AtlasHEC | FTFP_BERT

π⁻ on Cu-LAr

Normalized width | Beam: pi- | Target: AtlasCAL | FTFP_BERT

π⁻ on W-LAr

Normalized width | Beam: pi- | Target: AtlasCAL | FTFP_BERT

π⁻ on Pb-LAr
FTFP_BERT: Energy Resolution

π⁻ on Fe-Sci

π⁻ on Cu-LAr

π⁻ on W-LAr

π⁻ on Pb-LAr

Energy resolution | Beam: π⁻ | Target: TileCal

Energy resolution | Beam: π⁻ | Target: AtlasHEC

Energy resolution | Beam: π⁻ | Target: AtlasECAL | FTFP_BERT

Energy resolution | Beam: π⁻ | Target: AtlasECAL | FTFP_BERT
FTFP_BERT : Longitudinal Shape

Longitudinal shower shape | Beam: pi- | Target: TileCal | FTFP_BERT

\(\pi^-\) on Fe-Sci

Longitudinal shower shape | Beam: pi- | Target: AtlasHEC | FTFP_BERT

\(\pi^-\) on Cu-LAr

Longitudinal shower shape | Beam: pi- | Target: AtlasFCAL | FTFP_BERT

\(\pi^-\) on W-LAr

Longitudinal shower shape | Beam: pi- | Target: AtlasECAL | FTFP_BERT

\(\pi^-\) on Pb-LAr
FTFP_BERT : Lateral Shape

Lateral shower shape | Beam: pi- | Target: TileCal | FTFP_BERT

π⁻ on Fe-Sci

π⁻ on Cu-LAr

π⁻ on W-LAr

π⁻ on Pb-LAr

\begin{align*}
\langle r^2 \rangle, \text{ cm}^2 \\
E_{\text{beam}}^{\text{kin}}, \text{ GeV}
\end{align*}
FTFP_BERT cross sections

G4 10.5.ref08
10.5.ref07

- Discontinuities in $n$ & $K^+$ elastic and inelastic cross sections (vs. projectile kinetic energy) seen in Ref0{5,6,7} have been fixed in Ref08
- New discontinuities appear in Ref08 for $p$, $\pi^+$, $\pi^-$
Proton elastic & inelastic cross sections

**Elastic cross section | Beam: proton**

- **p on Be**
- **Elastic**

- **p on Fe**
- **Elastic**

**Inelastic cross section | Beam: proton**

- **p on Be**
- **Inelastic**

- **p on Fe**
- **Inelastic**
π+ elastic & inelastic cross sections

Elastic cross section | Beam: π+ | Target: Fe | FTFP_BERT

π+ on Fe
Elastic

Inelastic cross section | Beam: π+ | Target: Fe | FTFP_BERT

π+ on Fe
Inelastic

Elastic cross section | Beam: π+ | Target: Pb | FTFP_BERT

π+ on Pb
Elastic

Inelastic cross section | Beam: π+ | Target: Pb | FTFP_BERT

π+ on Pb
Inelastic
π- elastic & inelastic cross sections

Elastic cross section | Beam: pi- | Target: Cu | FTFP_BERT

π- on Cu
Elastic

Inelastic cross section | Beam: pi- | Target: Cu | FTFP_BERT

π- on Cu
Inelastic
Conclusions

- **G4 10.5.ref08**
  - No crashes, no infinite loops
  - A new warning, appearing very frequently
    - Fix proposed
  - A few reproducibility violations
    - Fix under investigation
  - Two problems introduced in Ref05 on elastic and inelastic cross sections for $n$ & $K^+$ have been fixed, but 3 new problems appear in Ref08 for $p$, $\pi^+$, $\pi^-$
  - Similar hadronic showers as in G4 10.5.ref07 except for the energy response in Tungsten
    - For FTFP_BERT and most of other physics lists
      - Still under investigation
        (Precompound/de-excitation and neutron capture seem innocent...)