Hadronic problems for Geant4 10.0

V.Ivanchenko

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Motivation

- There was a sudden problem in CMS Monte Carlo production during winter break
- The problem was understood and the fix was provided
- This needs to be discussed within the group
- Some actions are proposed

Bug in CMS Production

- Specific CMS simulation jobs crash over Christmass production
  - ADDMonoJet 8 TeV (1 case)
  - QCD_Pt15to3000_Tune4C_Flat_13TeV_pythia8
    - 77% events produced – 10 M requested
  - GJet_Pt-15to3000_Tune4C_13TeV_pythia8
    - 80% events produced – 10 M requested

Description of 1 event which crashes

- K- with E= 108.1 MeV interact inside calorimeter
- The list of secondaries:

```
462.94611066257 -1216.9784501607 1765.7986925122 40.45223880619 7.3653879760619       pi+
462.94611066257 -1216.9784501607 1765.7986925122 13.77457224717 7.3653879760619       proton
462.94611066257 -1216.9784501607 1765.7986925122 10.415974425165 7.3653879760619      neutron
462.94611066257 -1216.9784501607 1765.7986925122 4.947160460271 7.3653879760619       neutron
462.94611066257 -1216.9784501607 1765.7986925122 4.1779372348452 7.3653879760619      neutron
462.94611066257 -1216.9784501607 1765.7986925122 4.0393838801232 7.3653879760619      neutron
462.94611066257 -1216.9784501607 1765.7986925122 2.9006638881963 7.3653879760619      sigma-
462.94611066257 -1216.9784501607 1765.7986925122 2.8048326605548 7.3653879760619      gamma
462.94611066257 -1216.9784501607 1765.7986925122 2.5319219985922 7.3653879760619      neutron
462.94611066257 -1216.9784501607 1765.7986925122 2.3302907463081 7.3653879760619      gamma
462.94611066257 -1216.9784501607 1765.7986925122 1.8616579021685 7.3653879760619      neutron
462.94611066257 -1216.9784501607 1765.7986925122 1.7845537007782 7.3653879760619      neutron4
62.94611066257 -1216.9784501607 1765.7986925122 1.5630561389648 7.3653879760619       neutron
462.94611066257 -1216.9784501607 1765.7986925122 1.26074160224  7.3653879760619       neutron
462.94611066257 -1216.9784501607 1765.7986925122 1.2480532990276  7.3653879760619     gamma
462.94611066257 -1216.9784501607 1765.7986925122 1.0351838176639 7.3653879760619      neutron
462.94611066257 -1216.9784501607 1765.7986925122 0.83203415190699  7.3653879760619    gamma
462.94611066257 -1216.9784501607 1765.7986925122 0.66796127556836  7.3653879760619    neutron
462.94611066257 -1216.9784501607 1765.7986925122 0.55035528834333  7.3653879760619    neutron
462.94611066257 -1216.9784501607 1765.7986925122 0.1123047088407  7.3653879760619     gamma
462.94611066257 -1216.9784501607 1765.7986925122 0.36696848631254  7.3653879760619    Hg192[0.0]
```

Crash follows this interaction

Begin processing the 105th record. Run 1, Event 5147305, LumiSection 51474 at 30-Dec-2013 21:41:18.746 CET

G4VParticleChange::CheckSecondary : the global time of secondary goes back comapared to the parent !! Difference: 0.99775225901356[ns]

pi- E=98.67839939458 pos=0.46293420981106, -1.2170107912801, 1.7657666988138 time=6.3676357170484 parent time=7.3653879760619

*** G4Exception : TRACK001 issued by G4VParticleChange::CheckSecondary

Secondary with illegal energy/momentum

*** Event must be aborted

Crash happens with Sigma-

- 3 MeV Sigma- tracking fails:
  - Decay on-fly was selected as a process limited the step
  - Due to fluctuations of ionisation loss AlongStep all kinetic energy was lost
  - Decay on-fly with zero kinetic energy provides wrong position and time of secondary products
- Hisaya provided a patch of G4Decay class for 10.0
  - Patch was prepared for CMSSW based on 9.6p02 and implementing the Hisaya patch
  - This patch of Geant4 now is integrated into CMSSW
  - Validation of the patch will require some time

Open Questions

- Why bug start to be seen in Geant4 9.6p02?
- Why it is seen only in some circumstances?
  - When we tried to reproduce the bug in different primary generators we fail to see it
  - The bug was identified and fix when we have reproduced the particular run which failed

Annoying printouts

- When we was hunting CMS production problem CMS users point me out to well known warning:

G4Fragment::CalculateExcitationEnergy(): WARNING

Fragment: A = 26, Z = 12, U = -5.947e-01 MeV IsStable= 1 P = (1.038e+02,3.127e+00,1.449e+02) MeV E = 2.420e+04 MeV

- I would propose to try to fix and remove this warning because
  - Users are confused
  - Some hadronic models prepared 4-momentum in non-accurate way but G4Fragment constructor has to fix this
  - Why not to fix models?
- For this I would propose to substitute this warning by fatal G4Exception just now and try to fix all places

Memory churn in de-excitation module

- Today the leader in memory churn in hadronics is de-excitation module
- G4Fragment is created and delete too frequently
  - Number of new G4Fragments created by photon evaporation may reach 30
  - Number of evaporated G4Fragments may reach 100 in high energy cascade
- Manipulation of G4Fragment inside de-excitation module is too complex, so the only straightforward method to improve memory management is to use G4Allocator
  - This can be done now and be included into the 1st patch of 10.0
- As a long-term goal for 2014 we may have redesign of de-excitation, so G4Allocator will not be needed at all