

Two Proposals for Hadronics

Alberto Ribon
CERN EP/SFT

Outline

- **Replace environmental variables with UI macro commands**
 - Discussed in the previous hadronic working group meeting on May 20th
 - Now more details and concrete plan of actions
- **CreatorModelID associated to G4Track**
 - First discussion

From environmental variables to UI macro commands

Environmental variables in hadronics

- There are **73** environmental variables used in hadronics
- Most of them are for internal, debugging purposes only for the developers : for these, we don't need to do anything !
- For the **10** environmental variables related to data libraries, Ben Morgan will provide a common, consistent solution together with the EM data libraries
 - G4LEVELGAMMADATA, G4RADIOACTIVEDATA, G4NEUTRONHPDATA, G4PARTICLEXSDATA, G4SAIDXSDATA, G4ENSDFSTATEDATA, G4PARTICLEHPDATA, G4ABLADATA, G4INCLDATA, G4LENDDATA
- There are **15** remaining environmental variables of interest for users which should be replaced by UI commands

Special case: PHP_AS_HP

- This is the only hadronic environmental variable used at **build-time** of Geant4 (all the rest are used at run-time)
- Leave this environmental variable as it is only for the GNUmakefile system
- For CMake, replace it with a new build option
 - `GEANT4_BUILD_PHPASHP` or `GEANT4_BUILD_PHP_AS_HP`
 - By default is OFF (equivalent to the present default)
 - For G4 10.7, still accept the environmental variable `PHP_AS_HP`, but print a warning saying that it is deprecated and will be removed in the next major release, G4 11 , and please use the CMake option:
`-DGEANT4_BUILD_PHPASHP=ON`

UI macro commands (1/3)

- For the **14** hadronic run-time environmental variables of interest for users to be replaced by UI macro commands:
 - Leave also the environmental variables only temporarily for G4 10.7, with a warning message saying that they are deprecated and will be removed in the next major release, G4 11 ; please use the UI macro...
 - All should have the prefix ***"/process/had/"*** .
General hadronic UI commands, e.g. ***"/process/had/verbose 0"*** do not have any further prefix.
For those related to the hadronic model *"modelName"* should be: ***"/process/had/modelName/..."***. This is already the case for:
 - ***"/process/had/cascade/..."***
 - ***"/process/had/inclxx/..."***
 - ***"/process/had/particle_hp/..."***

UI macro commands (2/3)

- But NOT for the following cases:
 - *“/heptst/...”* (hadronic energy/momentum tests)
 - *“/process/deex/”* (de_excitation/)
 - *“/grdm/”* (radioactive_decay/)

For these, I propose the following:

- For G4 10.7, we leave these old UI macro commands, but we also introduce the equivalent ones with the new name *“/process/had/...”*. When an old UI macro command is used, a warning will inform that this command is deprecated and will be removed in the next, major release G4 11, and please use *“/process/had/...”* instead
 - This is particularly important for *“/grdm/”* which are used a lot, whereas for *“/heptst/”* and *“/process/deex/”* we could go straight to the replacement...

UI macro commands (3/3)

- Of these **14** environmental variables of interest to users, **10** have already a UI corresponding command (that we did not advertise), so nothing more needs to be done (except informing the users).

The **4** new UI macro commands that needs to be defined are :

- *“/process/had/epReportLevel ...”*
- *“/process/had/epCheckAbsoluteLevel ...”*
- *“/process/had/epCheckRelativeLevel ...”*
- *“/process/had/use_wendt_fission_model ...”*

Environmental variables to be deprecated / removed

- G4Hadronic_epReportLevel
G4Hadronic_epCheckAbsoluteLevel
G4Hadronic_epCheckRelativeLevel
- G4CASCADE_USE_PRECOMPOUND
G4CASCADE_DO_COALESCENCE
- G4NEUTRONHP_USE_ONLY_PHOTONEVAPORATION
G4NEUTRONHP_NEGLECT_DOPPLER
G4PHP_NEGLECT_DOPPLER
G4NEUTRONHP_SKIP_MISSING_ISOTOPES
G4NEUTRONHP_PRODUCE_FISSION_FRAGMENTS
G4PHP_USE_NRESP71_MODEL
G4PHP_DO_NOT_ADJUST_FINAL_STATE
G4NEUTRONHP_DO_NOT_ADJUST_FINAL_STATE
G4NEUTRON_HP_USE_WENDT_FISSION_MODEL

Actions

- Ben Morgan will take care of the following environmental variables: `PHP_AS_HP` + those related to data libraries
- For the rest of the changes:
 - Deprecate (and remove in G4 11) the 14 run-time environmental variables
 - Introduce 4 new UI commands
 - Deprecate (and remove in G4 11) existing hadronic UI commands which are not name `"/process/had/..."` and introduce the corresponding ones with the proper name `"/process/had/..."`

I volunteer to do it, unless the responsables of the models prefer to take care themselves of the changes – please let me know in this case !

CreatorModelID of G4Track

Introduction

- Useful for both electromagnetic and hadronic physics to know which is the model that has produced a secondary
 - e.g. for a secondary proton produced by a pion inelastic nuclear interaction on Iron, was it FTF, BERT or Preco that produced it ?
- Related methods of the ***G4Track*** class:
 - *void G4Track::SetCreatorModelIndex(G4int idx)*
 - *G4int G4Track::GetCreatorModelID() const*
 - *const G4String& G4Track::GetCreatorModelName() const*
- Implemented via the class ***G4PhysicsModelCatalog***
 - Introduced in G4 10

Current solution: *G4PhysicsModelCatalog*

- Singleton : `std::vector` of strings (unique names of models)
 - `G4PhysicsModelCatalog::Register(G4String& nameModel)`
 - `G4String& G4PhysicsModelCatalog::GetModelName(G4int indexModel)`
 - `G4int G4PhysicsModelCatalog::GetIndex(G4String& nameModel)`
- Elegant solution: works fine, does not need any assumption on the ID number to be assigned to each model (needs only a unique name), can be easily extended
 - The model-ID (i.e. vector index) numbers depend on the registration order
- The only “negative” side – in my opinion – is for users who naively expect that the model-ID numbers are the same “forever”
 - The model-ID numbers are guaranteed to be the same only for a given application execution, not for all applications, physics lists, G4 versions

Do we really want to change it ?

- In my opinion, there is no need to change anything
 - There is already an example, *extended/electromagnetic/TestEm5/* , which shows how to use it properly
 - We might add a new one, if needed for users
- If, instead, we prefer to opt for a less elegant solution – but perhaps easier to handle in practice for some users – with **fixed model-ID numbers** assigned to each model, then:
 - We need to agree on these model-ID numbers
 - See one proposal in the next slides
 - We need to make several changes in Geant4
 - In *process/electromagnetic/* and *process/hadronic/*
 - In *process/biasing/generic/* and *process/solidstate/channeling/*
 - In *track/* and *tracking/*

Fixed model-ID numbers (1/9)

- Hadronic model-ID numbers assigned in *enum { }* in *G4HadronicParameters* (for EM in *G4EmParameters*)
- For the model-ID – model-Name relation, 3 possibilities :
 1. Keep *G4PhysicsModelCatalog*, but as a *std::map* (instead of a *std::vector*), where the key of the map is the integer model-ID number
 - Registration requires both model-ID and model-Name. I would vote for this
 2. Get rid of *G4PhysicsModelCatalog*, and introduce such a *std::map* in *G4HadronicParameters* (and *G4EMParameters*)
 3. Get rid of *G4PhysicsModelCatalog*, and use only model-ID (i.e. give up the connection between model-ID and model-Name)
 - This would require to remove the convenient method:
G4String& G4Track::GetCreatorModelName()

Fixed model-ID numbers (2/9)

- Unique positive integer assigned to each model
- Use non-contiguous numbers (to fit future new/variant models)
- Use 4-digits (**1000 – 9999**) for model-ID
 - Given that process type/subtypes ranges between 1 and 210
 - EM process types/subtypes are below 100, HAD ones above 100.
There is an exception for ultra-cold-neutrons {41,42,43,44},
which I would propose to change to {341, 342, 343, 344}
- I propose to reserve:
 - **1000 – 1999** : for electromagnetic models
 - **2000 – 8999** : for hadronic models
 - **9000 – 9999** : for others (i.e. non-EM and non-HAD)

Fixed model-ID numbers (3/9)

- **2000 – 2999** : Gamma / Lepto / Neutrino – nuclear
 - **2000** : *G4EMDissociation*
 - **2100** : *G4LENDorBERTModel*
 - **2200** : *G4ElectroVDNuclearModel*
 - **2300** : *G4MuonVDNuclearModel*
 - **2400** : future tau-nuclear model
 - **2500 – 2999** : Neutrino models...

Fixed model-ID numbers (4/9)

- **3000 – 3999** : Elastic, Charge-Exchange, Quasi-Elastic, Diffraction
 - **3000 – 3199** : Elastic models
 - **3000** : *G4HadronElastic*
 - **3010** : *G4LowEHadronElastic*
 - **3020** : *G4ChipsElasticModel*
 - **3030** : *G4ElasticHadrNucleusHE*
 - **3040** : *G4DiffuseElastic*
 - **3050** : *G4AntiNuclElastic*
 - **3060** : *G4NuclNuclDiffuseElastic*
 - **3070** : *G4hhElastic*
 - ...

Fixed model-ID numbers (5/9)

- **3200 – 3299** : Charge-Exchange models
 - **3200** : *G4ChargeExchange*
 - ...
- **3300 – 3499** : Quasi-Elastic models
 - **3300** : *G4QuasiElRatios*
 - ...
- **3500 – 3999** : specialized Diffraction models
 - **3500** : *G4LMsdGenerator*
 - ...

Fixed model-ID numbers (6/9)

- **4000 – 4999** : String / High-Energy models
 - **4000** : *FTF*
 - **4100** : *QGS*
 - ...
- **5000 – 5999** : Intra-nuclear Cascade / Medium-Energy models
 - **5000** : *BERT*
 - **5100** : *BIC*
 - **5200** : *INCL*
 - **5300** : *QMD*
 - ...

Fixed model-ID numbers (7/9)

- **6000 – 6999** : Pre-equilibrium / De-excitation models
 - **6000** : precompound
 - **6050** : internal BERT pre-equilibrium
 - ...
 - **6100 – 6999** : De-excitation models
 - **6100** : Evaporation
 - **6110** : Photon evaporation
 - **6120** : GEM evaporation
 - **6200** : Fermi Breakup
 - **6300** : Multifragmentation
 - **6400** : Wilson ablation
 - **6500** : Fission
 - **6600** : ABLA
 - **6700** : internal BERT de-excitation
 - ...

Fixed model-ID numbers (8/9)

- **7000 – 7999** : Low-Energy Data-Driven models
 - **7000** : ParticleHP
 - **7100** : LEND
 - ...
 - **7500 – 7999** : Radioactive Decay
 - **7500** : alpha emission
 - **7510** : beta- emission
 - **7520** : beta+ emission
 - **7530** : gamma (isomeric transition & internal conversion) emission
 - **7540** : electron capture
 - **7550** : proton emission
 - **7560** : neutron emission
 - ...

Fixed model-ID numbers (9/9)

- **8000 – 8999 : Other models** (everything not yet included)
 - **8000 – 8099** : Stopping
 - **8000** : EM cascade
 - **8010** : DIO (Decay-In-Orbit)
 - **8020** : Nuclear Capture
 - ...
 - **8100 – 8199** : Fission
 - **8100** : *G4LFission*
 - **8110** : *G4FissLib*
 - **8120** : *G4LLNLFission*
 - ...
 - **8200** : Wilson Abration
 - **8300** : RPG
 - ...