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Proposal for refactoring PLs

Focus on hadron_inelastic constructors

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Motivation

<https://jira-geant4.kek.jp/browse/UR-26>

<https://jira-geant4.kek.jp/browse/DEV-285>

Improve memory handling in MT mode: delete all objects

Issue:

- Single instance of Physics List is shared among threads
- Only master calls destructor
- Threads call `ConstructProcess()`
 - hadronic inelastic constructors create builders that are not deleted

Strategy

1. Add a base class for all builders (to respect dependencies: in run category)
2. **New:**

```
virtual void G4VUserPhysicsList::TerminateWorker() {}
```

 - a. called by each thread at the end-of-life
 - b. For `G4VModularPhysicsList`, it iteratively calls similar method in owned constructors (also empty by default)
 - c. Developers can add thread-specific cleanup here
3. **You need to:** In each constructor add calls: `AddBuilder(...)`

Minimal Example

```
auto neu = new G4NeutronBuilder;
AddBuilder(neu);
auto ftfpn = new G4FTFPNeutronBuilder(QuasiElastic);
AddBuilder( ftfpn );
neu->RegisterMe(ftfpn);
ftfpn->SetMinEnergy(minFTFP_neutron);
auto bertn = new G4BertiniNeutronBuilder;
AddBuilder(bertn);
neu->RegisterMe(bertn);
bertn->SetMinEnergy(0.*GeV);
bertn->SetMaxEnergy(maxBERT_neutron);
neu->Build();
```

Since I was working on that...

Clean up code (remove the awful `tpdata` structs)

Refactor code, creating more granular methods

- Variants of given family of physics lists can inherit to minimize code changes

FTFP_BERT: what you know

```
class G4HadronPhysicsFTFP_BERT : public G4VPhysicsConstructor
{
public:
    G4HadronPhysicsFTFP_BERT(G4int verbose =1);
    G4HadronPhysicsFTFP_BERT(const G4String& name, G4bool quasiElastic=false);
    virtual ~G4HadronPhysicsFTFP_BERT();

public:
    virtual void ConstructParticle() override;
    //This will call in order:
    // DumpBanner (for master)
    // CreateModels
    // ExtraConfiguration
    virtual void ConstructProcess() override;

    virtual void TerminateWorker() override;
```

FTFP_BERT: new

```
protected:
    G4bool QuasiElastic;
    //This calls the specific ones for the different particles in order
    virtual void CreateModels();
    virtual void Neutron();
    virtual void Proton();
    virtual void Pion();
    virtual void Kaon();
    virtual void Others();
    virtual void DumpBanner();
    //This contains extra configurataion specific to this PL
    virtual void ExtraConfiguration();

    G4double minFTFP_pion;
    G4double maxBERT_pion;
    G4double minFTFP_kaon;
    G4double maxBERT_kaon;
    G4double minFTFP_proton;
    G4double maxBERT_proton;
    G4double minFTFP_neutron;
    G4double maxBERT_neutron;
```

Example of Variants

Create variants inheriting from basic:

1. FTFP_BERT_ATL : in constructor change transition region
2. FTFP_BERT_HP : reimplement Neutron and ExtraConfiguration

```
G4HadronPhysicsFTFP_BERT_ATL::G4HadronPhysicsFTFP_BERT_ATL(const G4String& name, G4bool quasiElastic)
    : G4HadronPhysicsFTFP_BERT(name, quasiElastic)
{
    //Change configuration parameters of FTFP_BERT
    minFTFP_pion = 9.0 * GeV;
    maxBERT_pion = 12.0 * GeV;
    minFTFP_kaon = 9.0 * GeV;
    maxBERT_kaon = 12.0 * GeV;
    minFTFP_proton = 9.0 * GeV;
    maxBERT_proton = 12.0 * GeV;
    minFTFP_neutron = 9.0 * GeV;
    maxBERT_neutron = 12.0 * GeV;
    QuasiElastic = false;
}
```

Validation

Run before and after, compare banners

Run 5k SimplifiedCalorimeter job, perform statistical tests on output

Tag proposing refactored FTFP_BERT is accepted

Future Work

Modify all other inelastic constructors (being validated now)

Warning: FTFP_BERT is basis of others, if we want to modify FTFP_BERT all others will inherit changes

- Introduce a BASELINE_FTFP_BERT ?

10.4+ : Extend GenericPhysics List to allow run-time configuration of some parameters (transition region, builders)

- No users, so we can change it as we want
- Anyway no use-case and not very useful in current state, use it as playground
- Could be useful for development

Example of a true GPL

```
/PhysicsList/defaultCutValue 0.7  
/PhysicsList/SetVerboseLevel 1
```

```
/PhysicsList/RegisterPhysics G4EmStandardPhysics  
/PhysicsList/RegisterPhysics G4EmExtraPhysics  
/PhysicsList/RegisterPhysics G4DecayPhysics  
/PhysicsList/RegisterPhysics G4HadronElasticPhysics  
/PhysicsList/RegisterPhysics MyHadronPhysics  
/PhysicsList/RegisterPhysics G4StoppingPhysics  
/PhysicsList/RegisterPhysics G4IonPhysics  
/PhysicsList/RegisterPhysics G4NeutronTrackingCut
```

```
/processTest/physics/hadronic/inelastic/addModel pion BERT 0. 15.  
/processTest/physics/hadronic/inelastic/addModel pion FTFP 14. 100000.  
#...
```