

The EIC Physics List

EIC Workshop (29 July – 1 August, 2018)
Dennis Wright (SLAC)

Outline

- Focus of EIC Physics List
- Physics list features
- Hadronic Physics Constructors
- Gamma-nuclear and lepto-nuclear

Physics List Focus

- Calorimetry, energy range 100 MeV – 10 GeV
 - tuning aims at best hadronic physics in this region
 - high precision neutron modeling not required
 - radioactive decay not required
 - but all energies, all particles covered
- “Standard” electromagnetic physics is assumed
 - tried and true for 1 keV – 1 PeV
 - more precise treatment of atomic effects and low energy models unnecessary
 - gamma- and lepto-nuclear physics included as special package
- Standard optical physics package added
 - for EIC needs, no modifications anticipated, but can be made

Physics List Features

- Non-templated, modular physics list
 - derived from G4VModularPhysicsList
 - chose this style because it's easy to read, understand, modify and trouble-shoot
 - hadronic part built from scratch
- Physics constructors are organized by particle type
 - e.g. ProtonPhysics, PionPhysics, KaonPhysics, ...
 - All hadronic processes, models and cross section classes invoked here
- New EIC physics list is currently zeroth order
 - so far, only very basic testing
 - Tuning, validation and modifications to come pending collaboration input

Physics Constructors

- Seven hadronic constructors
 - ProtonPhysics
 - NeutronPhysics
 - PionPhysics : π^+ , π^- (π^0 handled implicitly by models)
 - KaonPhysics : K^+ , K^- , K^0_L , K^0_S (K^0 , anti- K^0 handled implicitly by models)
 - HyperonPhysics : Λ , Σ^+ , Σ^- , Ξ^0 , Ξ^- , Ω^- (Σ^0 handled implicitly)
 - AntiBaryonPhysics : anti-(p, n, d, t, ^3He , α), anti-(Λ , Σ^+ , Σ^- , Ξ^0 , Ξ^- , Ω^-)
 - IonPhysics : d, t, ^3He , α , GenericIon (e.g. ^{41}Ca , ^{207}Pb)
- Standard EM package not organized in same way, but
 - handles EM interactions of γ , e^- , e^+ , μ^- , μ^+ , τ^+ , τ^- , all of above hadrons + some strange and charged mesons
- Single decay process handles all weak, EM decays
 - neutrinos produced, but do not interact

ProtonPhysics()

- G4ProtonInelasticProcess
 - Models
 - Bertini cascade from 0 to 12 GeV
 - FTFP from 5 GeV to 100 TeV
 - Cross sections
 - Barashenkov-Glauber-Gribov (BGG) inelastic at all energies
- G4HadronElasticProcess
 - Models
 - G4ChipsElasticModel at all energies
 - Cross sections
 - G4ChipsProtonElasticXS at all energies

NeutronPhysics()

- G4NeutronInelasticProcess
 - Same models and cross sections as proton inelastic
- G4HadronElasticProcess
 - Same models as proton elastic
 - Cross sections
 - G4NeutronElasticXS at all energies
- G4HadronCaptureProcess
 - Model
 - G4NeutronRadCapture at all energies
 - Cross section
 - G4NeutronCaptureXS at all energies

PionPhysics()

- G4PionPlusInelasticProcess, G4PionMinusInelasticProcess
 - Models
 - Bertini cascade from 0 to 12 GeV
 - FTFP from 10 GeV to 100 TeV
 - Cross sections
 - G4PiNuclearCrossSection with Glauber-Gribov extension at all energies
- G4HadronElasticProcess for π^+ , π^-
 - Models
 - G4HadronElastic: 0 to 1 GeV
 - G4ElasticHadrNucleusHE above 1 GeV
 - Cross sections
 - Barashenkov-Glauber-Gribov elastic (BGG) at all energies
- π^- stopping process : Bertini absorption at rest

KaonPhysics()

- G4KaonPlusInelasticProcess, G4KaonMinusInelasticProcess, G4Kaon0LInelasticProcess, G4Kaon0SInelasticProcess
 - **Models**
 - Bertini cascade from 0 to 12 GeV
 - FTFP from 10 GeV to 100 TeV
 - **Cross sections**
 - G4ChipsKaonPlusInelasticXS with Glauber-Gribov extension, G4ChipsKaonMinusInelasticXS with Glauber-Gribov extension, G4ChipsKaonZeroInelasticXS with Glauber-Gribov extension: at all energies
- G4HadronElasticProcess for K^+ , K^- , K_L^0 , K_S^0
 - **Models**
 - G4HadronElastic at all energies
 - **Cross sections**
 - Glauber-Gribov Hadron-Nucleus at all energies
- K^- stopping process: Bertini absorption at rest

HyperonPhysics()

- G4LambdaInelasticProcess, G4SigmaPlusInelasticProcess, G4SigmaMinusInelasticProcess, G4XiZeroInelasticProcess, G4XiMinusInelasticProcess, G4OmegaMinusInelasticProcess
 - Models
 - Bertini cascade from 0 to 6 GeV, FTFP from 4 GeV to 100 TeV
 - Cross sections
 - G4ChipsHyperonInelasticXS at all energies
- G4HadronElasticProcess for Λ , Σ^+ , Σ^- , Ξ^0 , Ξ^- , Ω^-
 - Model
 - G4HadronElastic at all energies
 - Cross sections
 - Gheisha (default) at all energies
- Σ^- , Ξ^- , Ω^- stopping processes: Bertini absorption at rest

AntiBaryonPhysics()

- G4AntiProtonInelasticProcess, G4AntiNeutronInelasticProcess, G4AntiDeuteronInelasticProcess, G4AntiTritonInelasticProcess, G4AntiHe3InelasticProcess, G4AntiAlphaInelasticProcess, G4AntiLambdaInelasticProcess, G4AntiSigmaPlusInelasticProcess, G4AntiSigmaMinusInelasticProcess, G4AntiXiZeroInelasticProcess, G4AntiXiMinusInelasticProcess, G4AntiOmegaMinusInelasticProcess
 - **Models**
 - FTFP at all energies
 - **Cross sections**
 - G4ComponentAntiNuclNuclearXS for anti-(p, n, d, t, He3, α), G4ChipsHyperonInelasticXS for anti-(Λ , Σ^+ , Σ^- , Ξ^0 , Ξ^- , Ω^-)
- **Anti-(p, d, t, ^3He , α), anti- Σ^+ stopping processes: Fritiof absorption at rest**

AntiBaryonPhysics() -continued-

- Elastic
 - **Models**
 - Anti-(p, d, t, He3, α): G4HadronElastic from 0 to 100.1 MeV, G4AntiNuclElastic above 100 MeV
 - G4HadronElastic for n, anti-(Λ , Σ^+ , Σ^- , Ξ^0 , Ξ^- , Ω^-) at all energies
 - **Cross sections**
 - AntiNuclElastic cross section for anti-(p, d, t, He3, α) all energies
 - Gheisha (default) for n, anti-(Λ , Σ^+ , Σ^- , Ξ^0 , Ξ^- , Ω^-)

IonPhysics()

- G4HadronInelasticProcess for d, t, He3, α , generic ion
 - **Models**
 - BinaryLightIonReaction from 0 to 110 MeV
 - QMD from 100 MeV to 10 GeV
 - FTFP from 10.01 GeV to 1 TeV
 - **Cross sections**
 - Glauber-Gribov nucleus-nucleus cross sections at all energies
- G4HadronElasticProcess for generic ion only
 - **Models**
 - G4NuclNuclDiffuseElastic at all energies
 - **Cross sections**
 - Glauber-Gribov nucleus-nucleus cross sections at all energies

Gamma-, Lepto-Nuclear

- G4PhotoNuclearProcess, G4ElectronNuclearProcess, G4PositronNuclearProcess, G4MuonNuclearProcess
 - **Models**
 - γ : Bertini cascade from 0 to 3.5 GeV, QGSP from 3 GeV to 100 TeV
 - e^+ , e^- : G4ElectroVDNuclearModel all energies
 - μ^+ , μ^- : G4MuonVDNuclearModel all energies
 - **Cross sections**
 - γ : G4PhotoNuclearCrossSection at all energies
 - e^+ , e^- : G4ElectroNuclearCrossSection at all energies
 - μ^+ , μ^- : G4KokoulinMuonNuclearXS at all energies