Physics Lists

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Automatic Documentation
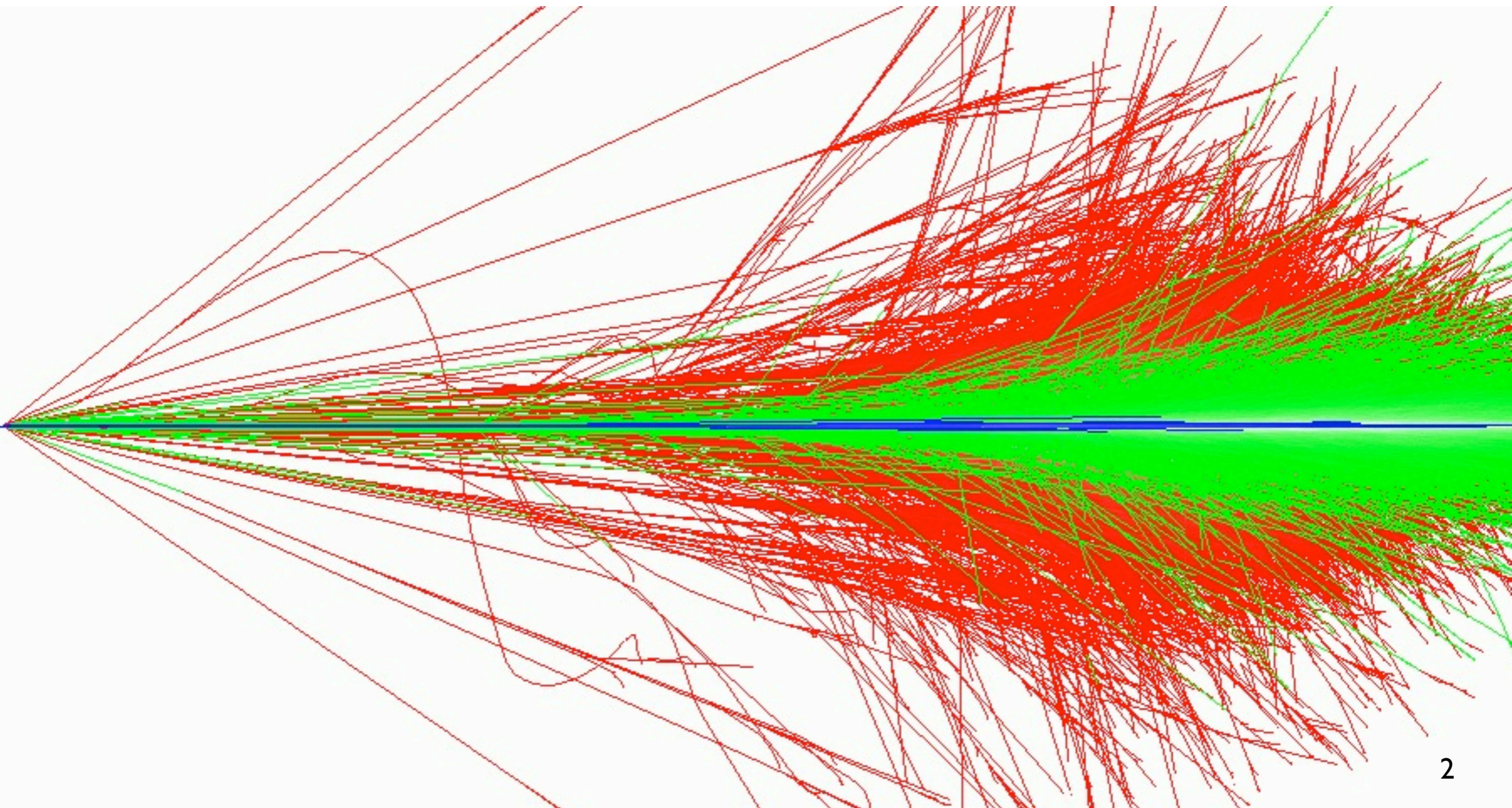
History

- For several years there have been **requests from users and collaborators to better document** the contents of our physics lists
  - Especially the hadronic part

- Two years ago, a physics list documentation task force was created to address these requests
  - a distillation of these requests resulted in requirements for physics list documentation

Requirements (I)

- **Each reference physics list should have a document describing:**
  - constituent processes, models, cross sections
  - the energies and particles for which they are valid
  - the cases in which the physics list should be used

- **The document should be easily generated by collaborators or users**
  - an official copy of it should be part of the online Geant4 documentation
  - it should be regenerated with each Geant4 release

Requirements (2)

- **Each component process, model and cross section class should be accompanied by a brief description**
  - description should be written in "plain language", so that it can be understood by non-experts
  - Each description must be linked to the particle as it appears in the physics list

- **All lists and descriptions must be auto-generated**
- Descriptions must be available for the generation of other documents if needed
  - there should be no duplication of descriptions

Implementation (hadronic part)

- **A Description() method is to be added to each process, model and cross section class**
  - this method to write an html description file
  - call to this method chosen by environment variable
- G4HadronicProcessStore::PrintHtml()
  - sorts through all the processes, models and cross sections assigned to a particle
  - collects the description files written by Description()
- G4HadronicProcessStore::DumpHtml()
  - writes the "PhysicsList".html file to a specified directory

Usage

- **Currently the user must**
  - specify the name of the desired physics list in an enviromment variable
  - specify in an environment variable the path to a directory where all process, model, cross section description files will be dumped
  - run the named physics list in an example or other application
  - For example, if FTFP_BERT is specified, the file FTFP_BERT.html will be created

Physics List Documentation Sample

Summary of Hadronic Processes, Models and Cross Sections for Physics List FTFP_BERT

- **proton**

  process : hadElastic
  - models :
    - **hElasticCHIPS** from 0 GeV to 100000 GeV
  - cross sections :
    - **CHIPSElasticXS** from 0 GeV to 100000 GeV

  process : ProtonInelastic
  - models :
    - **FTFP** from 4 GeV to 100000 GeV
    - **BertiniCascade** from 0 GeV to 5 GeV
  - cross sections :
    - **G4CrossSectionPairGG** from 0 GeV to 100000 GeV

Physics List Documentation Sample

- **neutron**

  process : hadElastic
  - models :
    - **hElasticCHIPS** from 0 GeV to 100000 GeV
  - cross sections :
    - **CHIPSElasticXS** from 0 GeV to 100000 GeV

  process : NeutronInelastic
  - models :
    - **FTFP** from 4 GeV to 100000 GeV
    - **BertiniCascade** from 0 GeV to 5 GeV
  - cross sections :
    - **G4CrossSectionPairGG** from 0 GeV to 100000 GeV

  process : nCapture
  - models :
    - **G4LCapture** from 0 GeV to 20000 GeV
  - cross sections :
    - **GheishaCaptureXS** from 0 GeV to 100000 GeV

  process : nFission
  - models :
    - **G4LFission** from 0 GeV to 20000 GeV
  - cross sections :
    - **GheishaFissionXS** from 0 GeV to 100000 GeV

Physics List Documentation Sample

- **pi+**

  process : hadElastic
  - models :
    - **hElasticLHEP** from 0 GeV to 1 GeV
    - **hElasticGlauber** from 1 GeV to 100000 GeV
  - cross sections :
    - **Barashenkov-Glauber-Gribov** from 0 GeV to 100000 GeV

  process : PionPlusInelastic
  - models :
    - **FTFP** from 4 GeV to 100000 GeV
    - **BertiniCascade** from 0 GeV to 5 GeV
  - cross sections :
    - **G4CrossSectionPairGG** from 0 GeV to 100000 GeV

- **pi-**

  process : hadElastic
  - models :
    - **hElasticLHEP** from 0 GeV to 1 GeV
    - **hElasticGlauber** from 1 GeV to 100000 GeV
  - cross sections :
    - **Barashenkov-Glauber-Gribov** from 0 GeV to 100000 GeV
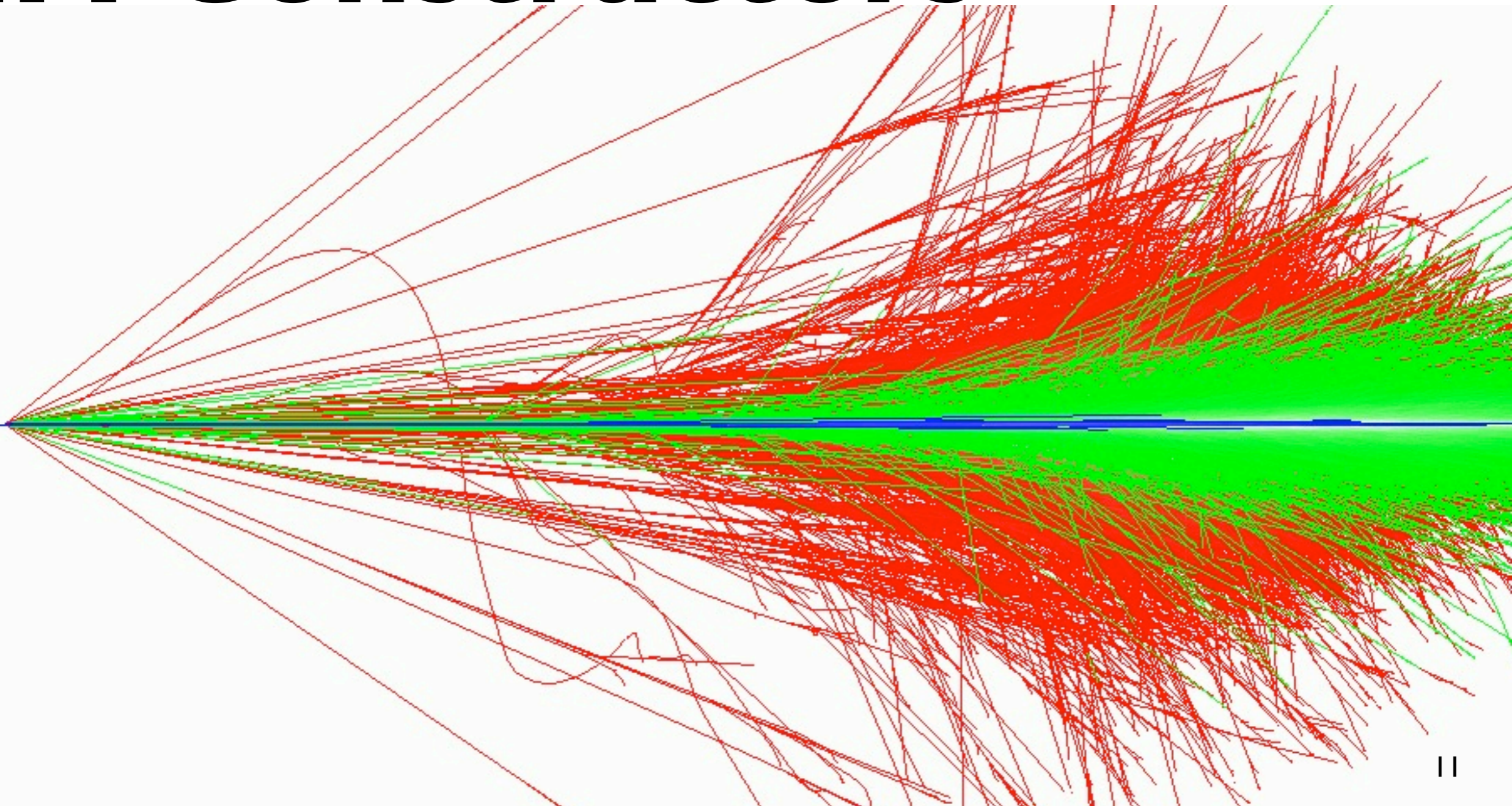
  process : PionMinusInelastic
  - models :
    - **FTFP** from 4 GeV to 100000 GeV
    - **BertiniCascade** from 0 GeV to 5 GeV
  - cross sections :
    - **G4CrossSectionPairGG** from 0 GeV to 100000 GeV

EM Constructors

EM Physics List constructors for High Energy Physics for 9.5

- Used by Geant4 validation suites
  - Are robust due to intensive tests by Geant4 team
  - well known precision and limitations
- May be used in any application domain

| Constructor	Components	Comments
G4EmStandardPhysics	Default (QGSP_BERT, FTFP_BERT…)	ATLAS, and other HEP productions, other applications
G4EmStandardPhysics_option1	Fast due to simple step limitation, cuts used by photon processes, WentzelVI model of multiple scattering for muons and hadrons (QGSP_BERT_EMV, …)	CMS and LHCb production, good for crystals not good for sampling calorimeters
G4EmStandardPhysics_option2	Experimental: WentzelVI model of multiple scattering (QBBC, …)	Used for testing of new models

Combined EM Physics List constructors for 9.5

- For today focus more to precision than to maximum simulation speed
- Ion stopping model based on the ICRU'73 data
- Strong step limitation from ionisation and multiple scattering per particle type
- UrbanMscModel95 for e+,e- (Goudsmith-Saunderson needs improvements)
- Recommended for hadron/ion therapy, space applications

Constructor	Components	Comments
G4EmStandardPhysics_option3	Urban MSC model (QGSP_BIC_EMY, Shielding)	Proton/ion therapy
G4EmLivermorePhysics	Livermore models for γ, e⁻ below 1 GeV, Standard models above 1 GeV	Livermore low-energy electron and gamma transport
G4EmPenelopePhysics	Livermore models for γ, e± below 1 GeV, Standard models above 1 GeV	Penelope low-energy e± and gamma transport

Physics List Developments
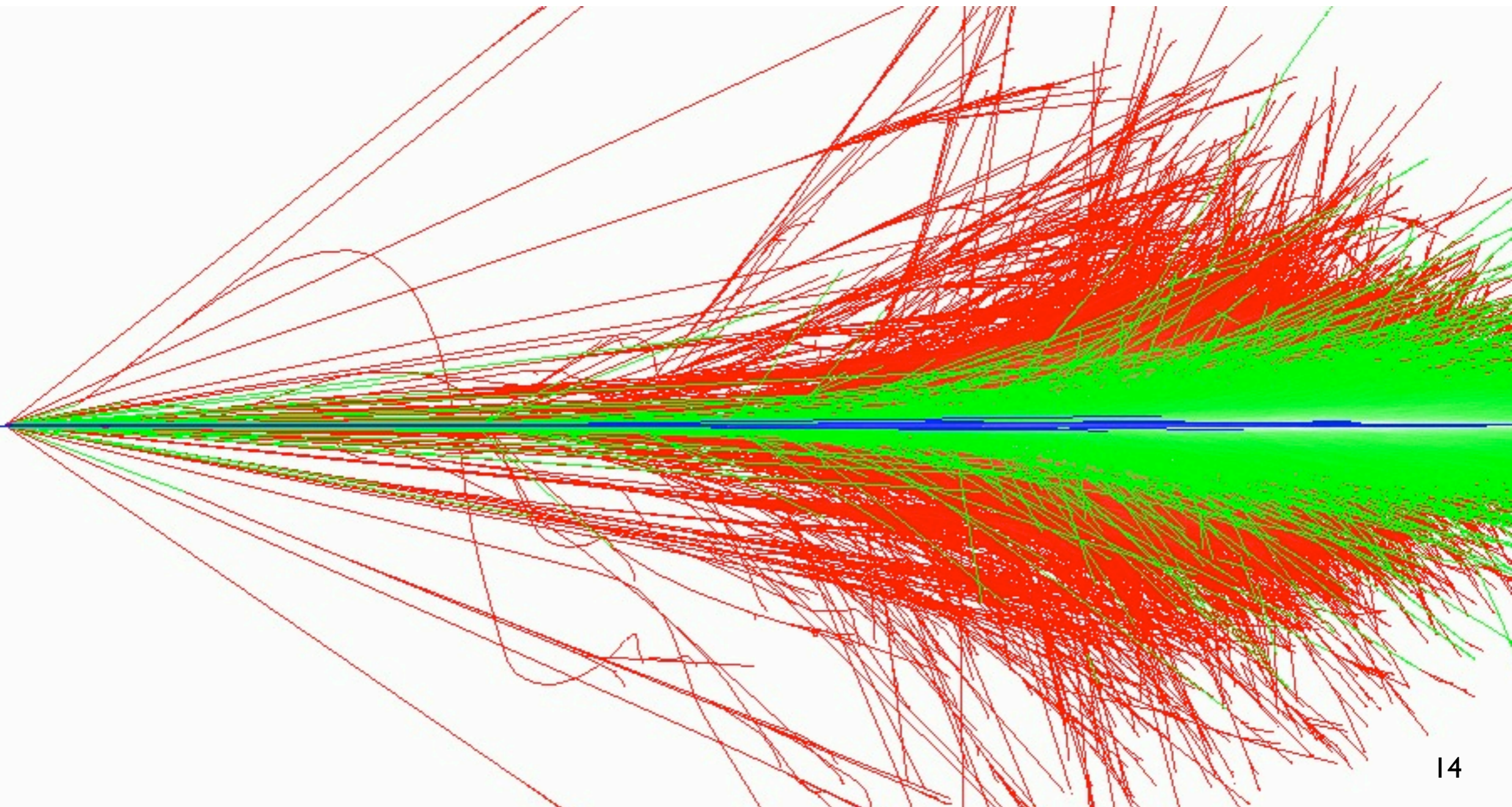
- **Stability** for supported lists
- Attempt to **replace weak models** or cross sections by better alternatives
  - Based on validation results
  - CPU performance always considered
- Emphasis **shifting towards FTF** based lists
  - Integrate recent developments, try options

  - Attempts to **reduce dependence on CHIPS** components (starting)
    - Need to have stability in lists used in production by LHC

Reduce Use of Parametrised models

- "Misc" particles
  - Lambda, Sigma+/-, Xi-/0, Omega-
- FTF lists switched to use Bertini & FTF for these
- QGS use CHIPS (unchanged)

- QGSP_FTFP_BERT, FTFP_BERT are free of parameterised modeling

Add interactions for anti-nuclei

— Using new cross sections G4ComponentAntiNuclNuclearXS developed by A.Galoyan and V.Uzhinsky

— Final state generation by FTF