Implementation Of “New” Physics Generators And Their Maintenance In The LHCb Framework

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OUTLINE

- Motivations Of Our Proposal
- Event Record Standardization
- Sicb Implementation
- I/O streams and event display
- The CLEO Monte Carlo (QQ)
- First experiences with the latest 6.1xx pythia versions (BUG DISCOVERED!)
- Feedbacks from the physics groups

Motivations and methods

Why do we need many Physics Monte Carlos ?

Motivations:

- Reliable physics studies in view of the LHC Standard Model Workshop and LHCb TDR:

  Systematics studies at physics and detector level such as the ongoing background studies that require comparison between different QCD models (ex. Herwig).

- Simulation of physics processes not available to pythia 5.7xx:

  Rare B decays (ex. QQ - the CLEO Monte Carlo)

  Supersimmetry (ex. Isajet and pythia 6.1xx)

  Different Implementations of coherence, fragmentation, hadronization etc. (ex. Herwig)

Methods:

- A Sicb interface has to be provided in order to achieve the event production with as many generators as we can → standardization.
- Maintenance is required, as all the generators are a sort of "work in progress" with changing physical inputs!!!
- Official responsibles for generators maintenance are needed that serves also as potential "link persons" to the program authors (Sjöstrand, Webber, Marchesini etc.) for possible feedbacks.

Event record standardization

Workshop on Physics at LEP2 → General agreement on:

- Particle Numbering Scheme

  The revised scheme includes systematic numbering of quark model states which are as yet undiscovered and numbering for hypothetical particles such as SUSY particles

- Standard output common block /HEPEVT/ :

  Id; status code; mothers; daughters; 4 momentum, 4 position.

An interface routine is generally needed → StdHep:

- Developed at Fermilab by L. Garren; also maintained at CERN
- Provide translation routines:

  generator commons → /HEPEVT/

  /HEPEVT/ → generator commons, geant 3 (KINE and VERT).

- Provide utility routines:

  QQ related (decay particles and update /HEPEVT/)

  quark contents; mother/daughter operations; rotations; boosts

- Provide tools:

  machine independent I/O streams

  event display (at generator level)

Event generation in Sicb

Generation handled by geant 3; routines called by GUKINE:

- EGINIT (Pythia 5.7 initialization)
- EGGETE (Generator input stream = ntuple)
- EGEVENT (Pythia 5.7 event Generation)
- SIKINE (Store kinematics of the "stable" particles in the geant 3 structures)

Philosophy:

- The "interesting" particles (ex. B_d and/or B_s etc.) are forced to be "stable" and inserted into the Monte Carlo bank (ATMC) at the reconstruction time
- The decays and the oscillations are handled by geant through Pythia calls in GDECAY and GUDCAY (the B decay products are treated as secondaries)

Advantage:

- In large productions, the same simulated, reconstructed and digitized events can be used for many B decay channels; only the B daughters have to be re-simulated, re-reconstructed and re-digitized for each B decay channel

Sicb problems and possible solutions

Sicb problems:

1. Hardcoded pythia 5.7 commons and calls (difficult maintenance!)
2. Double pythia-geant particle coding (even in data cards)
3. The ATMC bank contains only the secondaries and the particles considered "stable" at generation time while event record /HEPEVT/ is available only on direct pythia generation and on generator streams (i.e. unavailable on MC and DSP streams)
4. Problems with decays not implemented in Pythia 5.7 :

   geant don't know how to handle resonances

Solutions (preserving backward compatibility and current advantages):

1. Replace the pythia commons and calls with the analogous StdHep ones:

   notice that the simple pythia maintenance (upgrade from 5.7 to 6.1) requires almost the same effort
2. Can be easily fixed if the production team does agree (see point # 4)
3. A new generator bank should be created that keep track of all the ancestors
4. The StdHep interface can drive QQ, that currently contains the best known and the most updated routines for decaying B particles.

   it is not clear where to place it (i.e. in SUDECAY, hardcoded in GDECAY or even before it)

generator I/O streams and event display

O. Dormond agrees to be our contact person

generator I/O streams:

- Sicb currently use an ntuple that reflect the /HEPEVT/ common
- Geant 4 (ascii file ?)
- Mcfio: A machine independent I/O system for Monte-Carlo studies (P. Lebrun)

  maintained at CERN

  based on the XDR protocol from the RPC software

  support a variety of sequential media

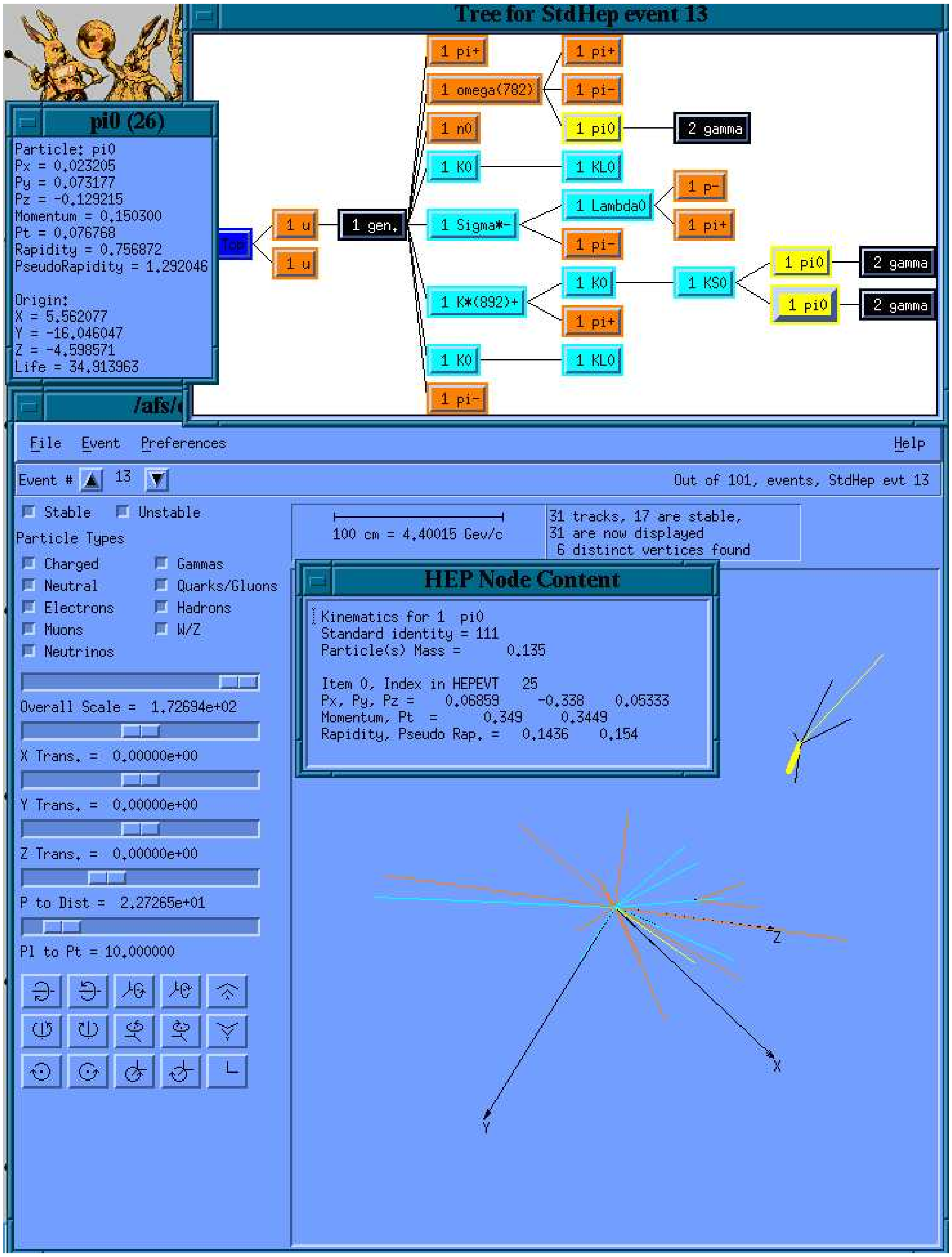
  direct access capabilities have been implemented, such as the automatic searches for specific triggers

  event structures can be retrieved from fortran (ex. StdHep library) and *C* (ex. event display)

Event Display (P. Lebrun) :

- Motif based; uses the Nirvana spin widget
- We are writing a standalone filter program that convert the Sicb event generator format to the Mcfio one in order to make available the event display for LHCb generated events
- Is it possible to achieve an interactive display ?

Event display windows



The QQ Monte Carlo

P. Koppenburg agrees to be our contact person

Developed by the CLEO collaboration. The program authors are P. Avery, R.A. Fulton, P.C. Kim, J.L.Rodriguez et.al.

- Any types of B decay can be programmed by the user $\longrightarrow$ decay table
- The CLEO collaboration maintain both the Monte Carlo code and the official frequently updated decay table
- Fermilab maintain QQ in the StdHep framework
- The decay table can be written in a simple language (see example), providing informations of the decay like helicity state, angular distributions of decay products etc.
- Mixing and CP violation

Example of a B^0 decaying with the same probability to $J/\psi K_s$ (unpolarized) and to $J/\psi K^{*0}$ (74% longitudinal polarized):

DECAY	B0		
HELICITY	1.00	0	0
CHANNEL	0	1.	PSI K0S
HELICITY	0.13	1	-1
HELICITY	0.74	0	0
HELICITY	0.13	-1	1
CHANNEL	0	1.	PSI K*0

Bug discovered in Pythia 6.115

- The higgs group report a problem observed in their fast simulation: the new version of pythia (in /cern/pro we can still find only the 6.115) seems to produce too many partons, strings and stable particles with respect to the version 5.724

Multiplicities predicted by different pythia versions for 1000 QCD minimum bias events:

Version	Settings	$< N_{str} >$	$< N_{sta} >$	Observations
5.724	default	9.7	282	CTEQ2L
6.115	default	31	678	GRV94L
6.120	default	8.4	280	running P_T cut (m.i.)
6.115	PARP(81)=2.75	9.2	292	P_T cut (m.i.) by hand
6.120	MSTP(51)=1	4.5	173	CTEQ3L

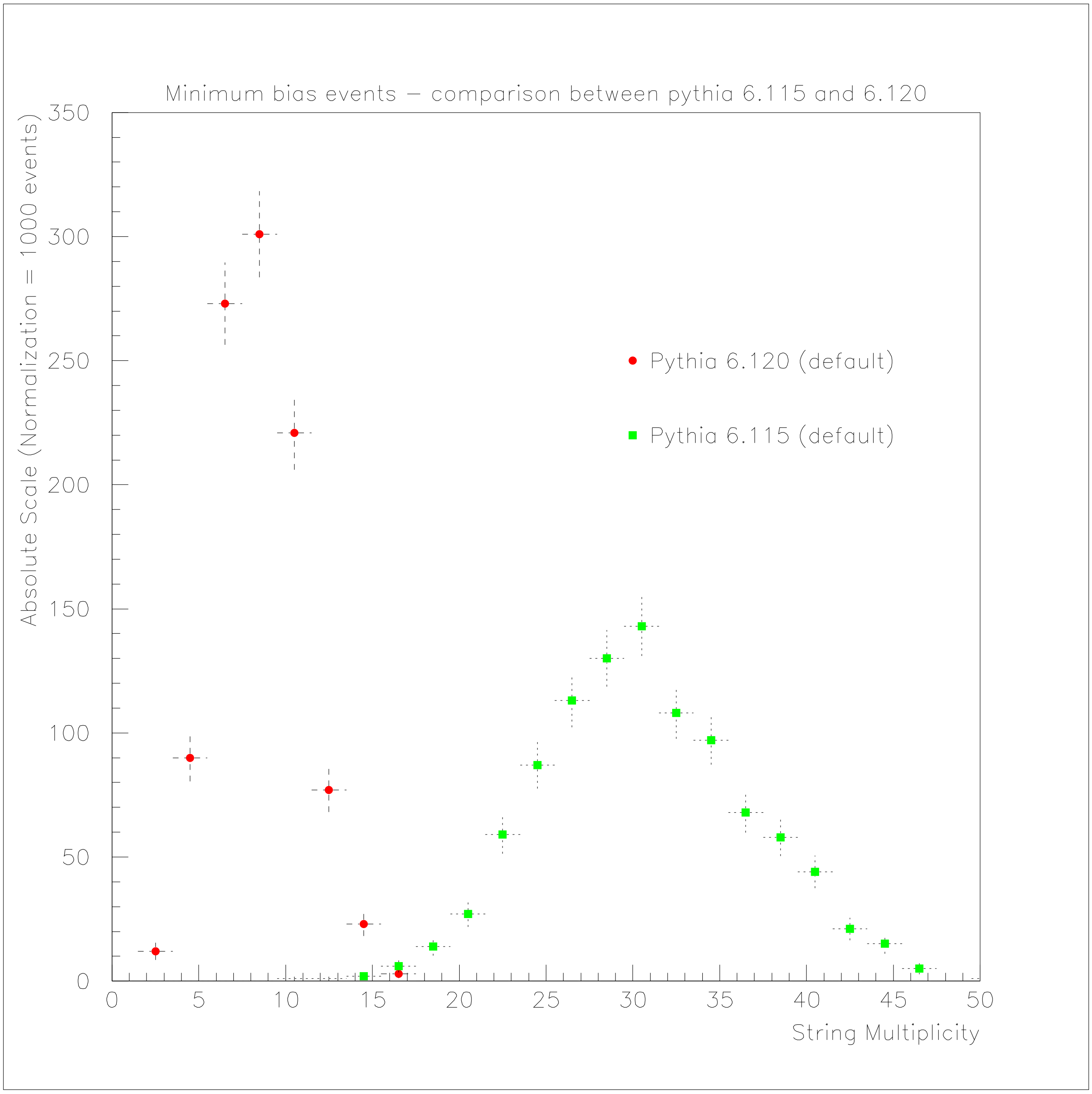
Starting from version 6.120 a running $P_{T\,min}/P_{T0}$ lower cut-off (multiple interactions) has been introduced that deeply affect all the multiplicity distributions at the ECM=14000 GeV LHC energy:

$$P_{T\,min} = PARP(81) * (ECM/PARP(89))^{PARP(90)}$$

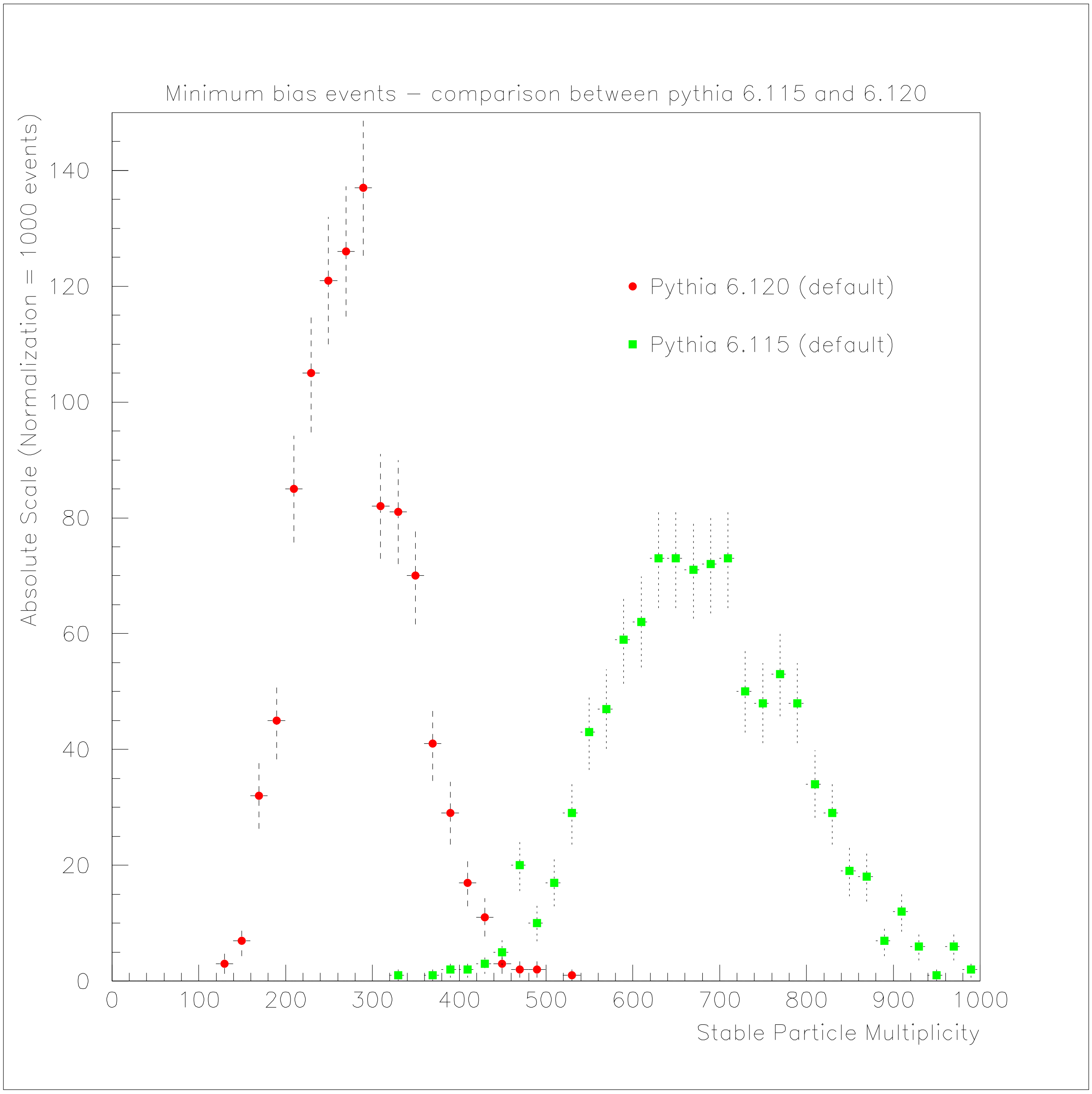
Questions for Sjöstrand:

1. does this expression phenomenologically describe the $P_{T\,min}$ running for all the p.d.f. ?
2. do the multiplicity observables at LHC take such high theoretical uncertainties ?

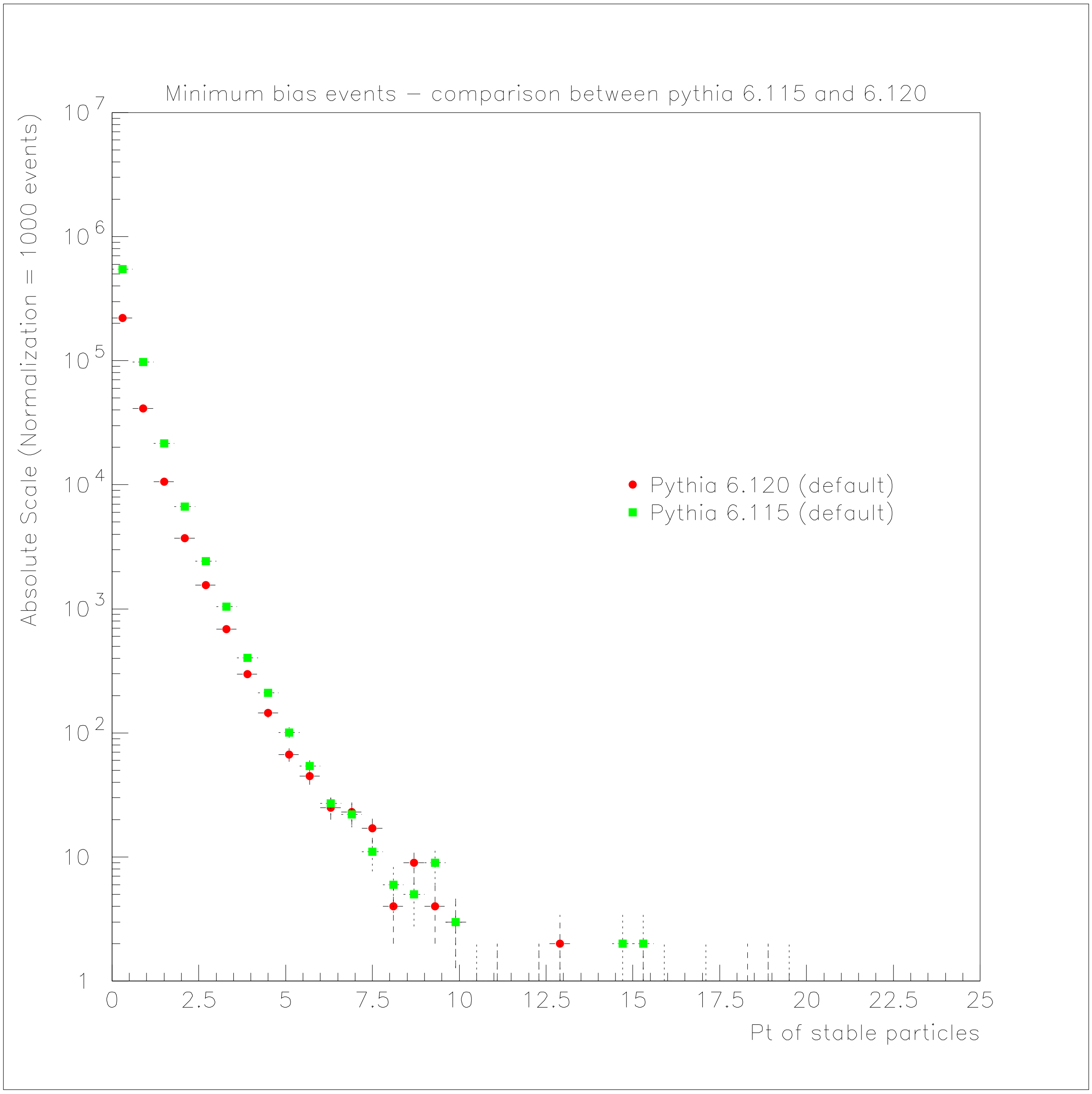
Comparison pythia 6.115 ÷ pythia 6.120



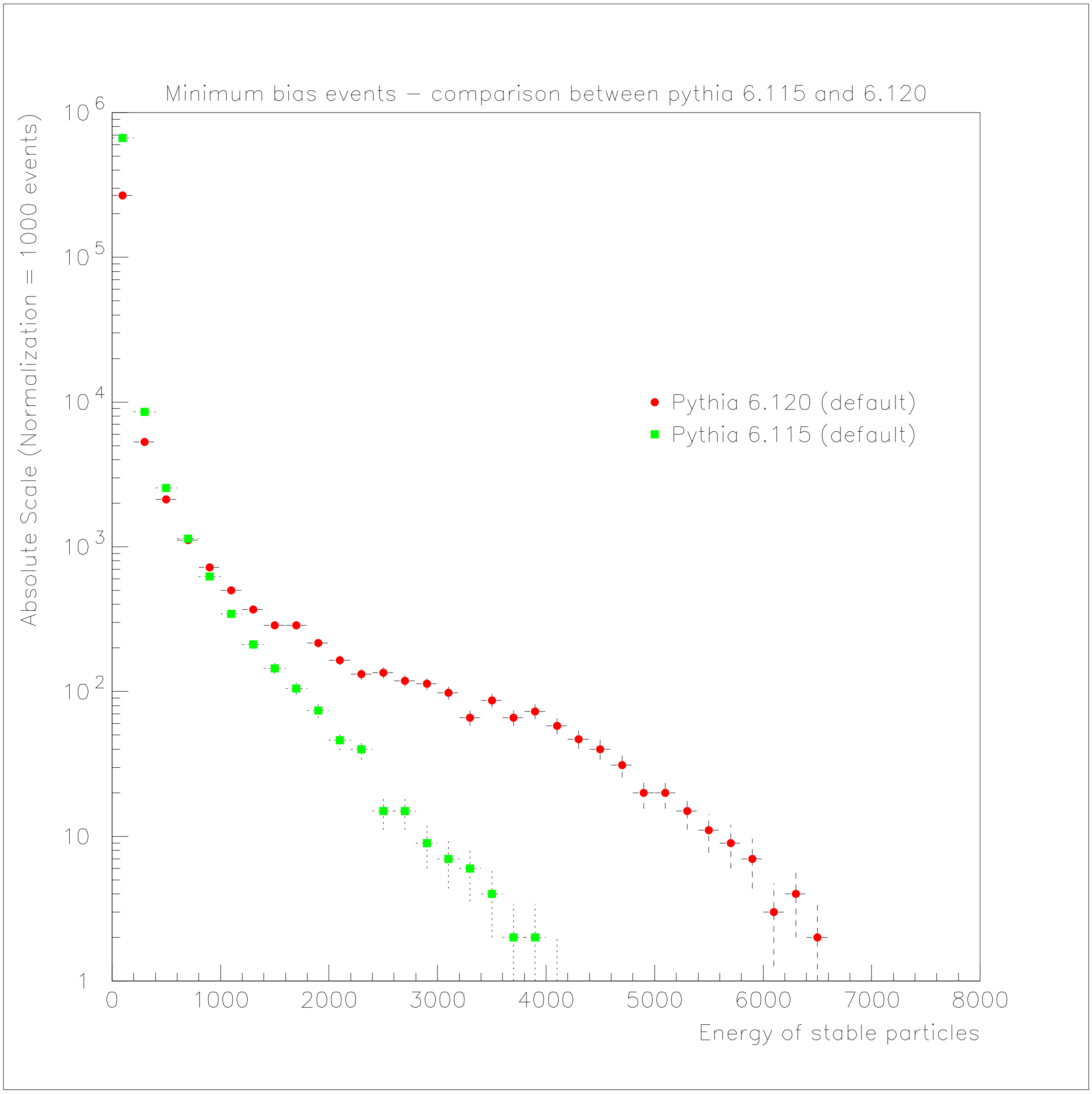
Comparison pythia 6.115 ÷ pythia 6.120



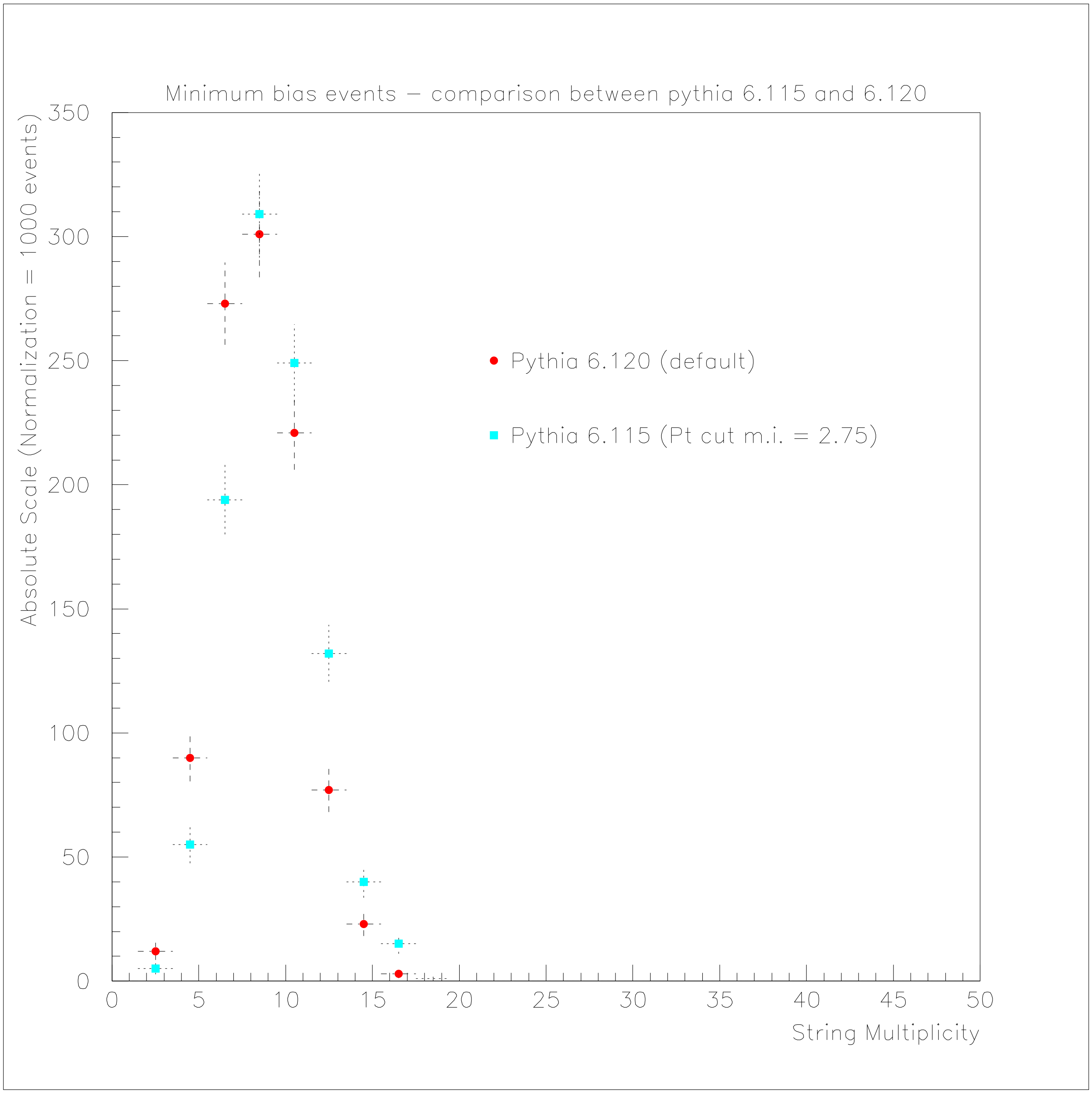
Comparison pythia 6.115 ÷ pythia 6.120



Comparison pythia 6.115 ÷ pythia 6.120



pythia 6.115 with modified P_T cut (m.i.)



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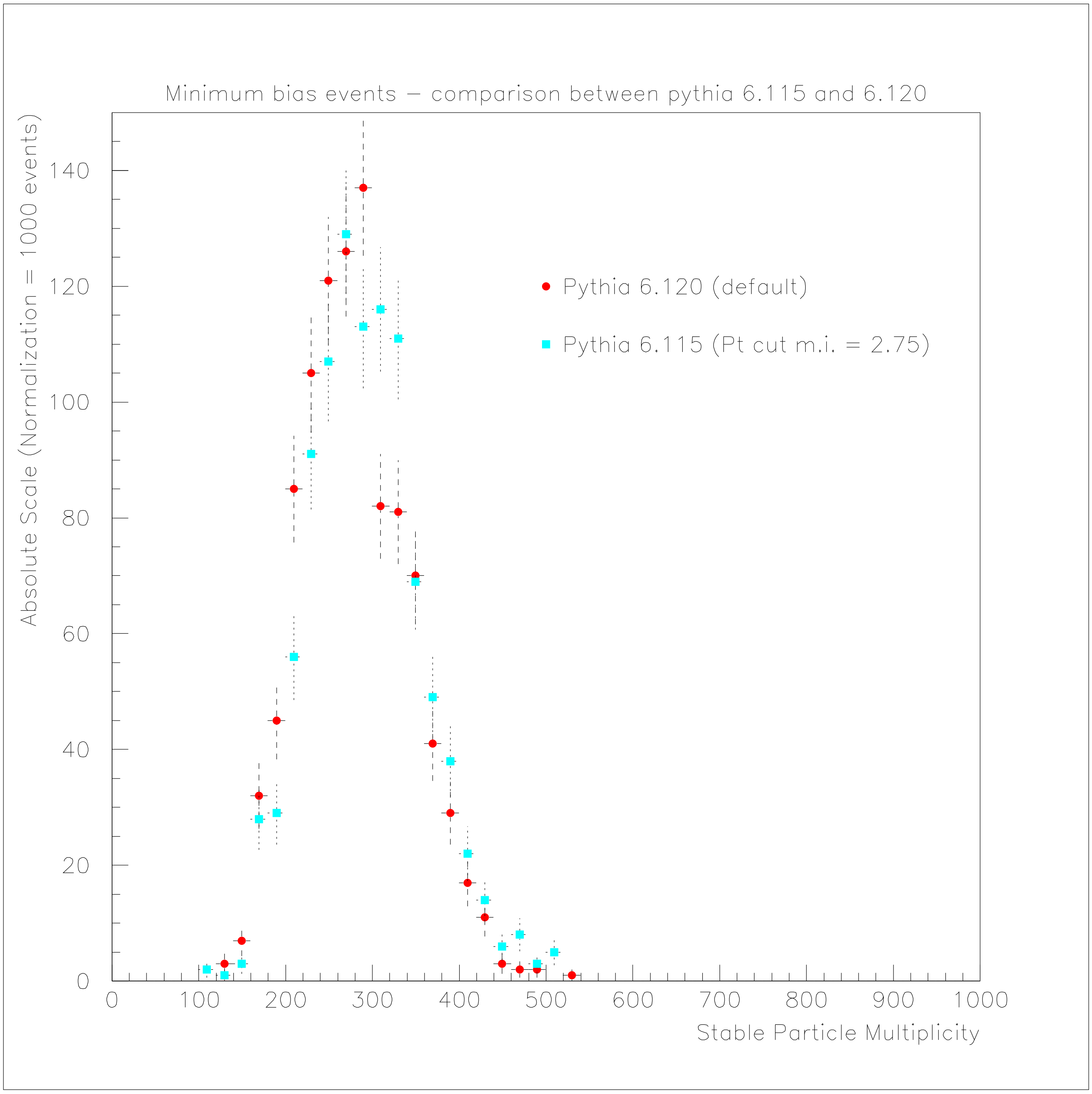

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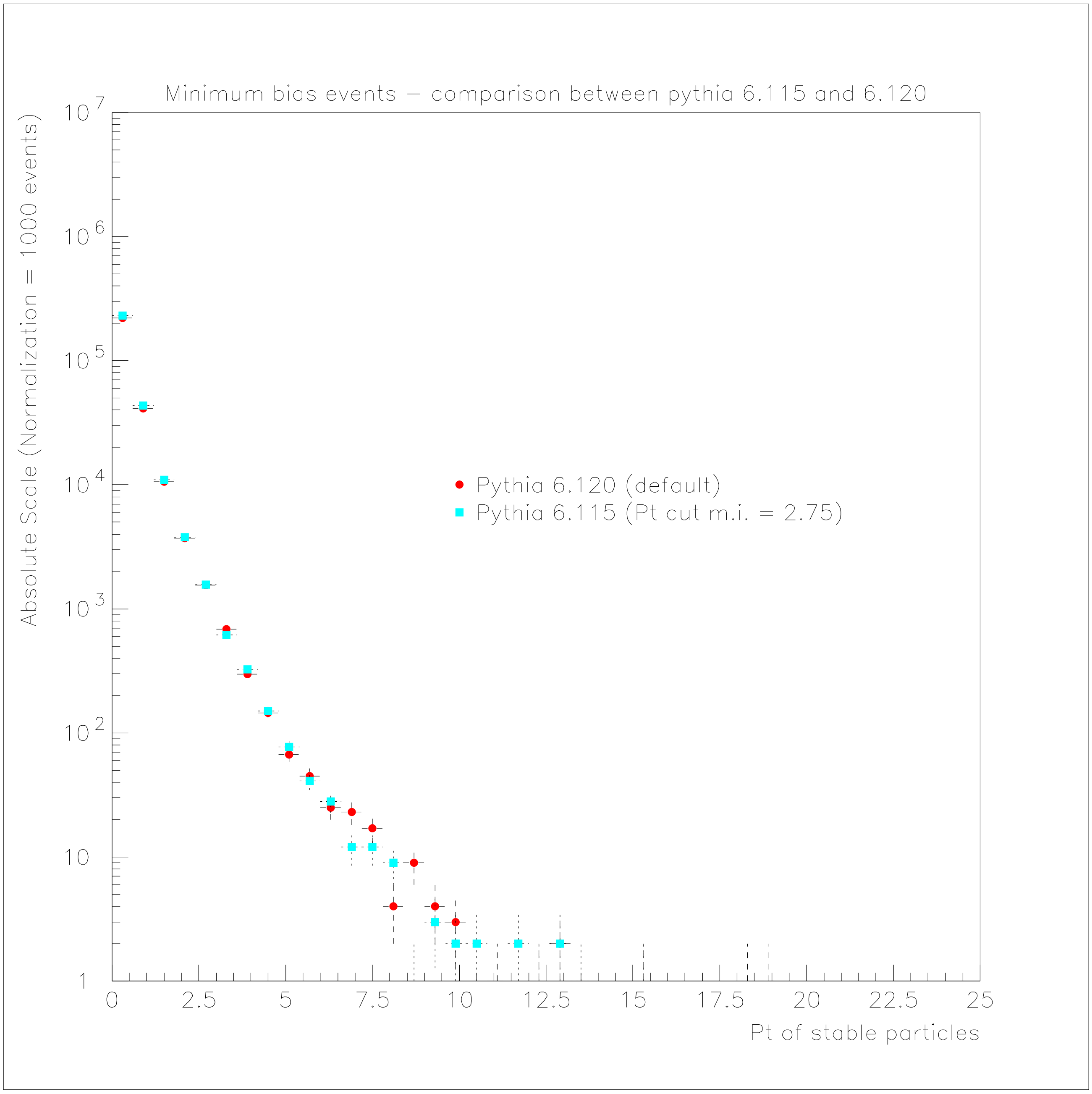

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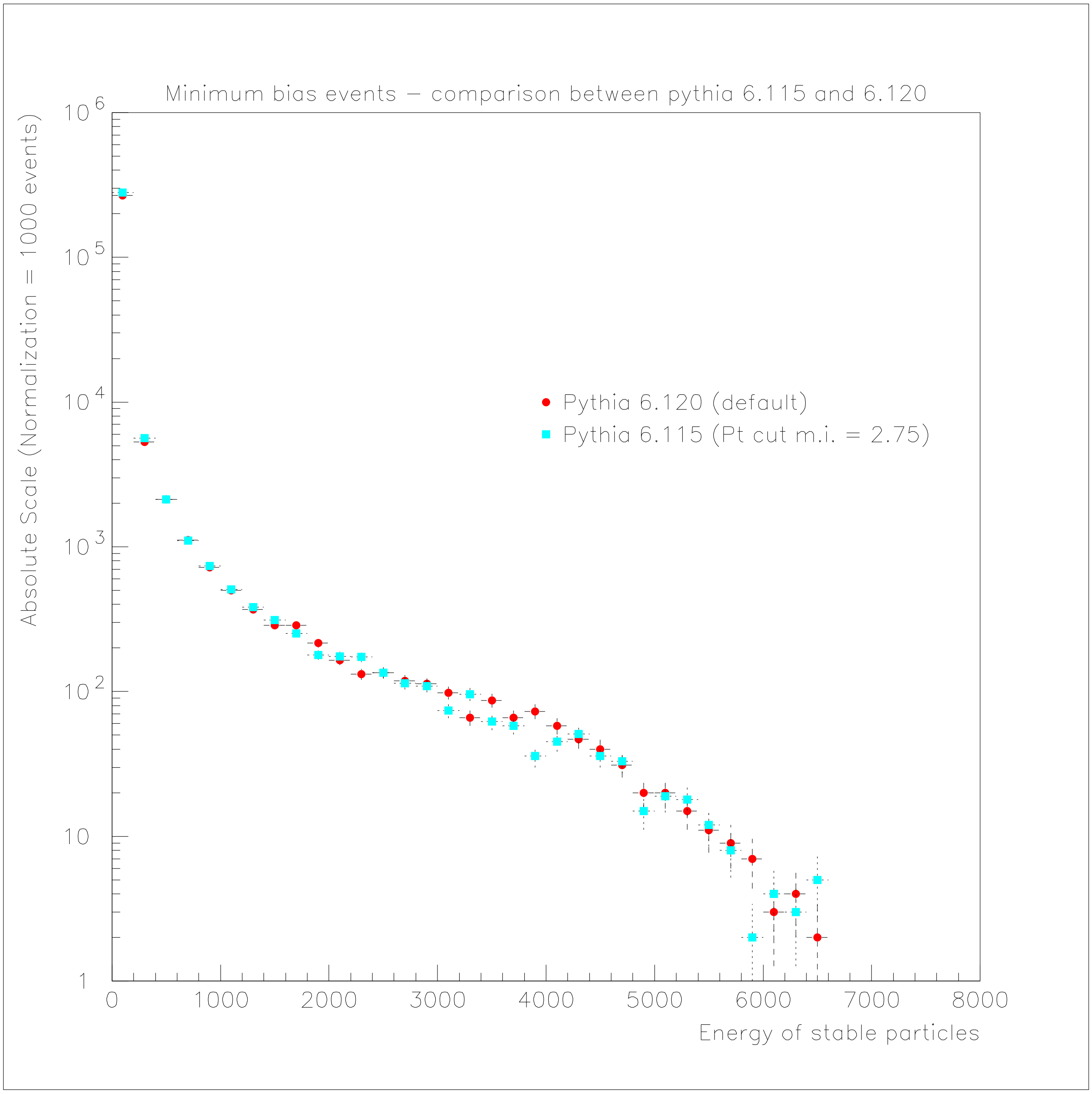
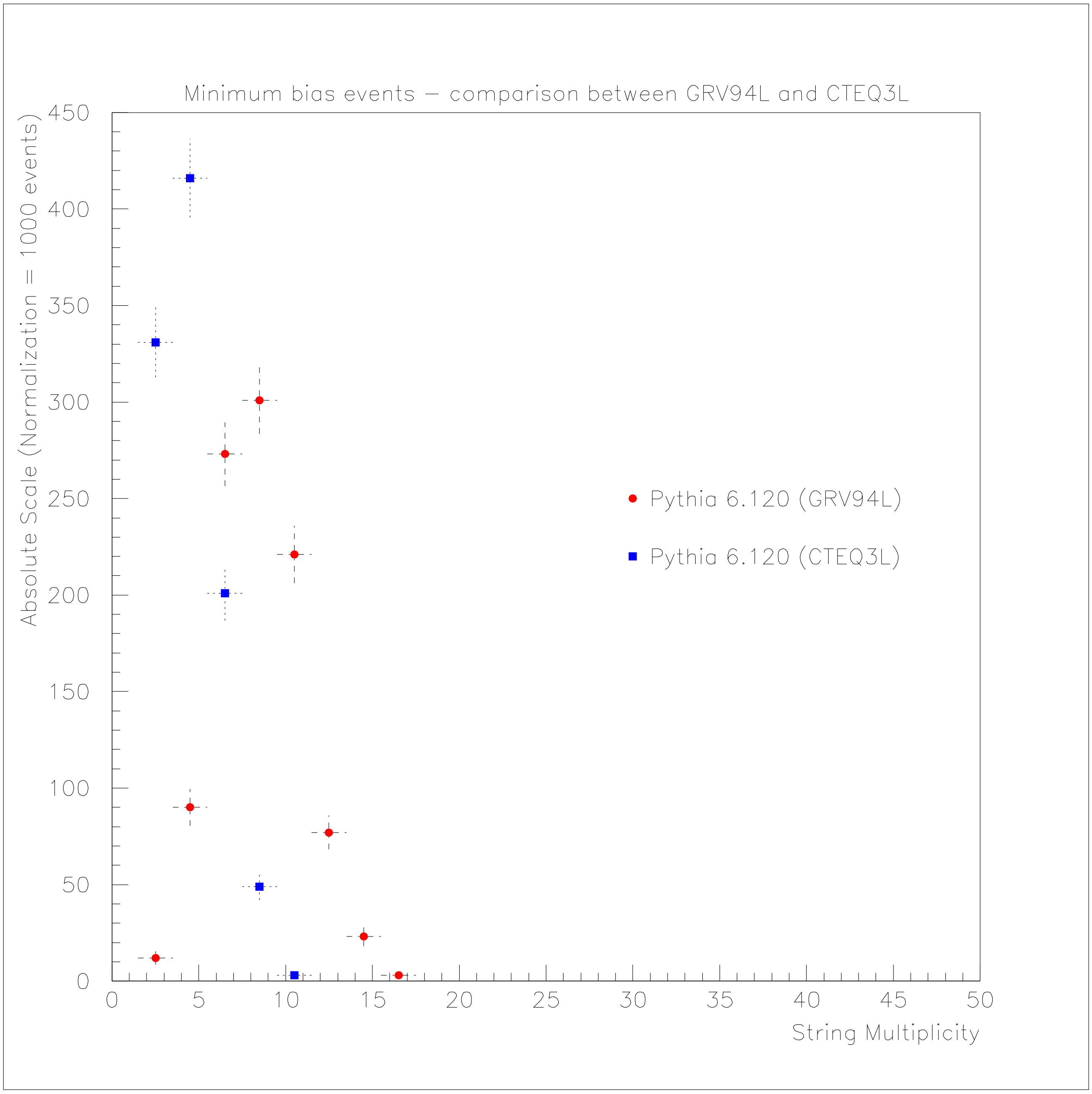


pythia 6.120: CETQ3L vs GRV94L



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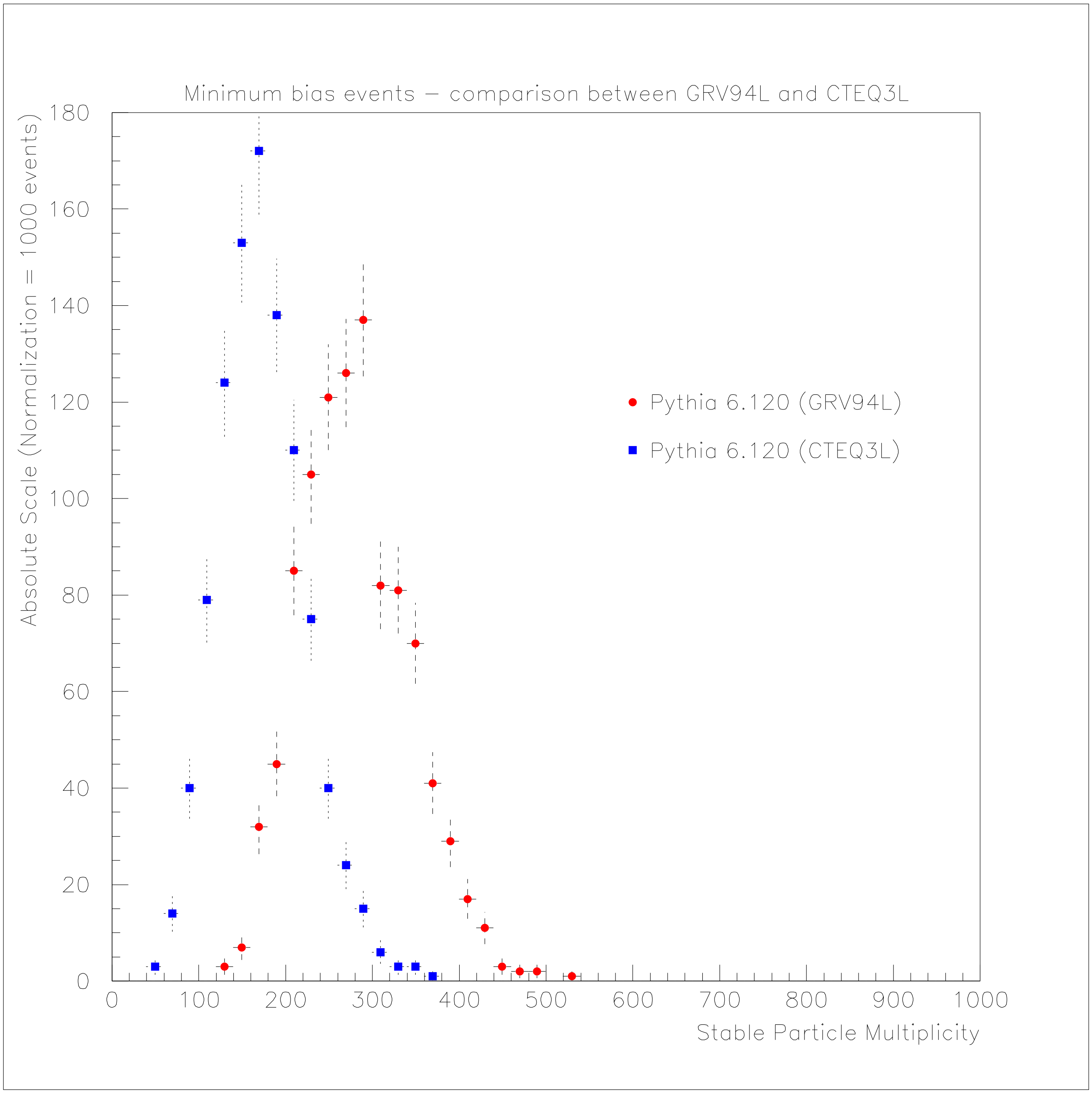

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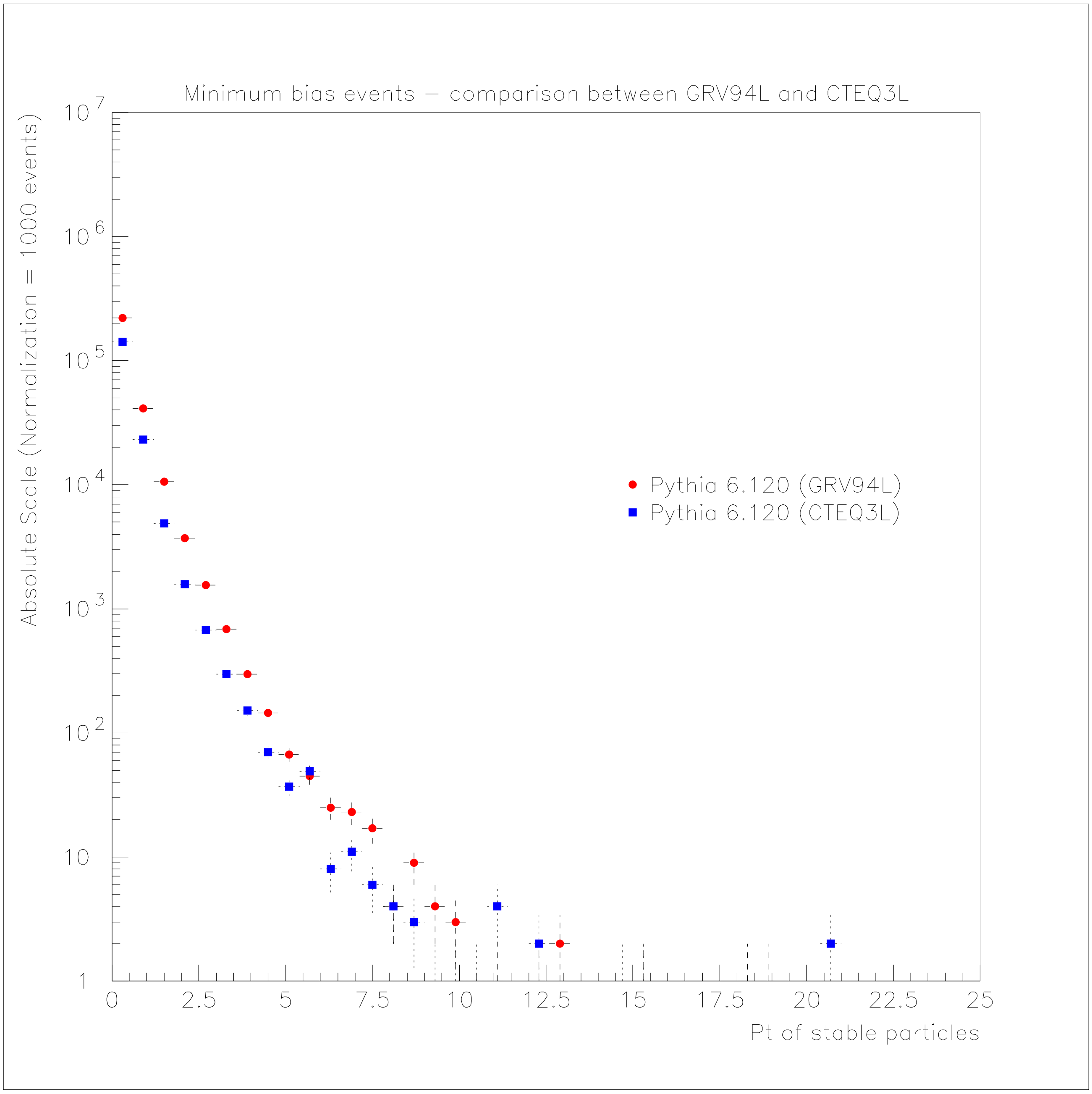

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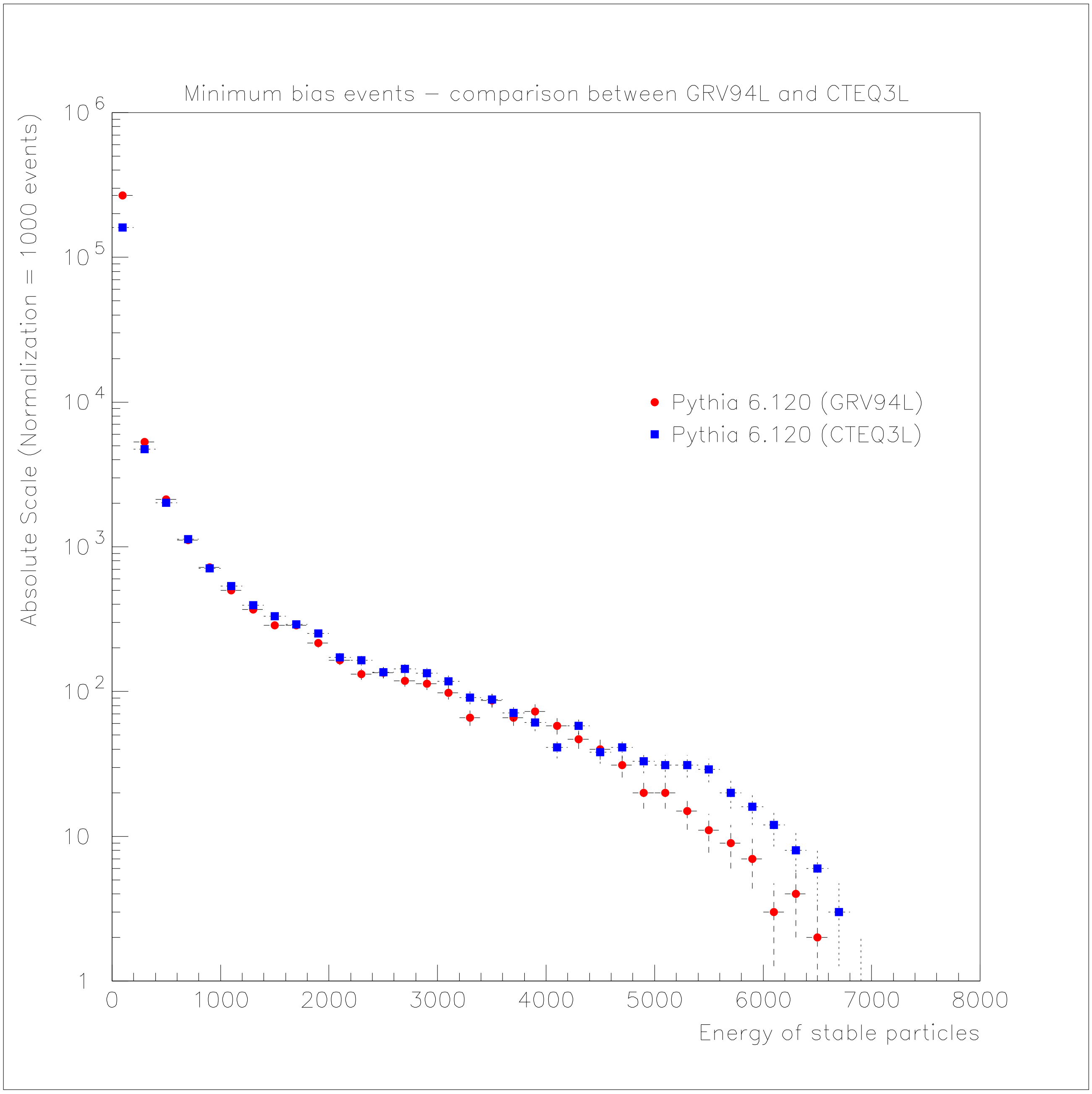

Sjöstrand answer

Dear Dr. Bartalini,

Your point is entirely correct. This is a messy area, unfortunately, and there are no simple answers. HERA has furthered the understanding of small-x physics much, but not given the definitive solution to it all. The first thing we can agree is that the physics landscape HAS changed compared to what structure function people used, say, a few years ago . Now, this has consequences also e.g. for the bottom or charm cross sections. You might easily find those values changed by a factor of four from this alone, but this is taken in stride without people making much fuss over it. However, when the same structure function change also implies a change in the charged multiplicity by a factor of three, this is more sensational. Now, I agree, it should be more worrisome, but I am just trying to say it all hangs together. Ideally, for each set of parton distributions, one should go through a full-blown tuning procedure to some (large) set of collider data (CERN and Tevatron, at a few energies) to provide a reliable lever-arm to extrapolate to LHC . [...] For instance, a reasonable extrapolation form for multiplicity data itself, e.g. in some rapidity bin, should give a reasonably reliable reference for what to expect at LHC.

Now, your first question: no, as you yourself point out, even now different parton distributions do not quite agree, so you will not find perfect agreement. Maybe one approach to take is to tune pT min for each distribution so they all give the same average multiplicity. That way at least you can factorize the production cross section dependence on parton distributions from that of the underlying event.

Your second one: the 6.115 answer is definitely unreasonably high, and I already told a few people there is a problem. However, to pretend there is no uncertainty at all would be unrealistic. The optimist might take a $\pm 20\%$ spread around a "best bet" based either on the older "consistent choice" in Pythia 5.7 or the new one in 6.120, and disregard results based on inconsistent combinations. However, at best, this would be a kind of 1 sigma error estimate, i.e. a $\pm 50\%$ error would not be excluded, but be less likely.

Best regards, Torbjorn