Smearing output of pythia8 generated file

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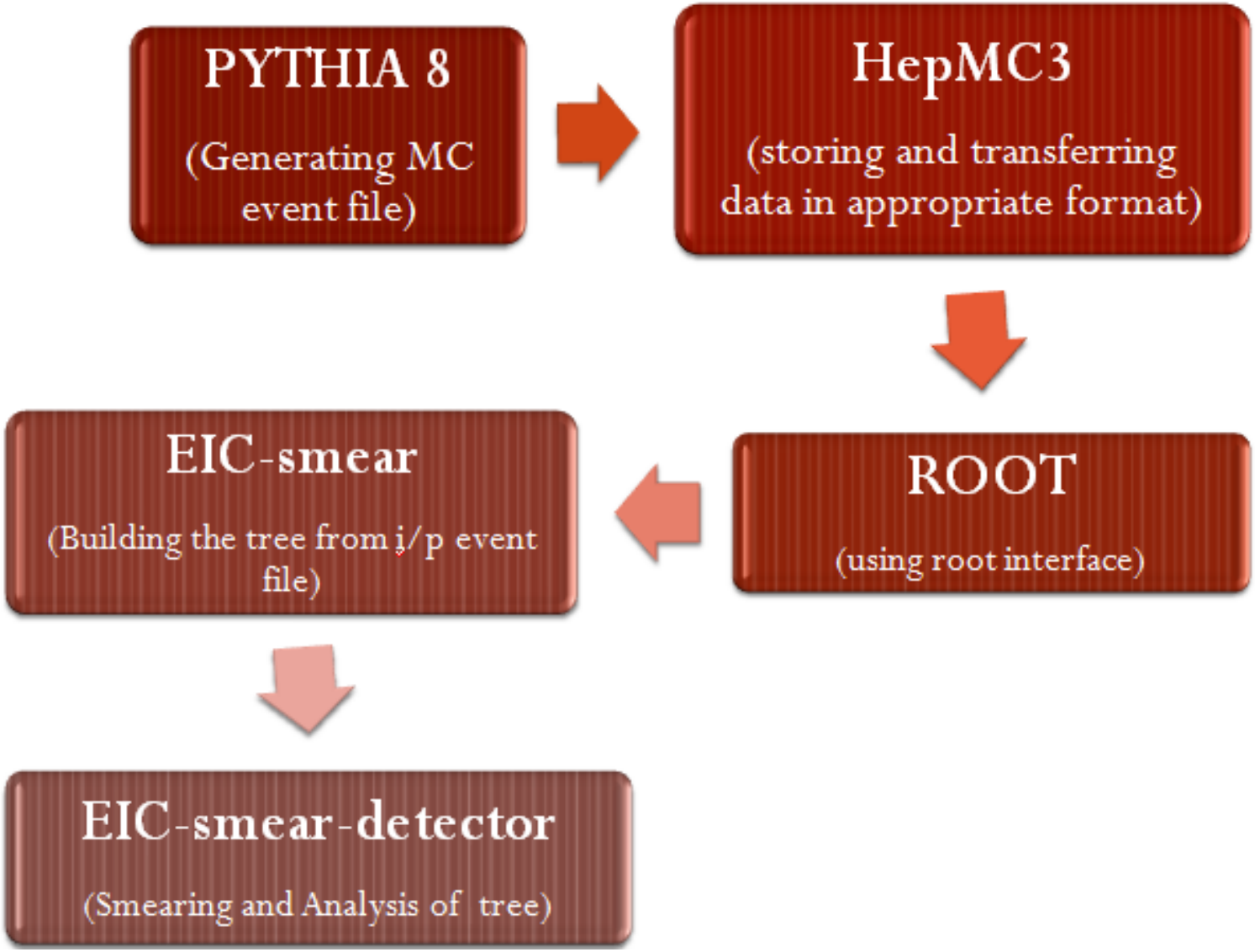
Work flow chart



Installation script for HepMC3

- wget http://hepmc.web.cern.ch/hepmc/releases/HepMC3-3.2.2.tar.gz
- tar -xzf HepMC3-3.2.2.tar.gz
- mkdir hepmc3-build
- cd hepmc3-build
- cmake -DHEPMC3_ENABLE_ROOTIO:BOOL=OFF -DHEPMC3_ENABLE_TEST:BOOL=OFF \
- -DHEPMC3_INSTALL_INTERFACES:BOOL=ON -DHEPMC3_ENABLE_PYTHON:BOOL=ON -DHEPMC3_PYTHON_VERSIONS=2.7 \
- -DHEPMC3_BUILD_STATIC_LIBS:BOOL=OFF -DHEPMC3_BUILD_DOCS:BOOL=OFF \
- -DCMAKE_INSTALL_PREFIX=../hepmc3-install \
- -DHEPMC3_Python_SITEARCH27=../hepmc3-install/lib/python2.7/site-packages \
- ../HepMC3-3.2.2
- make
- make install

Installation script of eic-smear and eic-smeardetectors

FOR EIC

- mkdir EIC
- cd EIC
- git clone https://github.com/eic/eic-smear.git
- cd eic-smear
- mkdir build
- cd build
- cmake ../ -DCMAKE_INSTALL_PREFIX=/home/chitranshi/eic/eic-smear -DHepMC3=/home/chitranshi/Documents/hepmc3-install
- make –j2
- make install

FOR EIC-SMEAR-DETECTORS

- cd EIC
- git clone https://github.com/eic/eicsmeardetectors.git
- mkdir build
- cd build
- cmake ../ -DBUILD_TESTS=ON -DCMAKE_INSTALL_PREFIX=/home/chitranshi/eic/eic-smear
- make –j8
- make install

BASHRC ENVIRONMENT

```
#for EIC

export CMAKE_PREFIX_PATH=/home/chitranshi/eic/eic-smear-master/cmake

export PATH=/home/chitranshi/eic/eic-smear-master/bin/:$PATH
export LD_LIBRARY_PATH=/home/chitranshi/eic/eic-smear-master/lib/:$LD_LIBRARY_PATH
```

1. Generating MC Event data via PYTHIA 8 by using HepMC3 library

Pythia 8 Physics Setup

- Generating 100 number of events of electron and proton beam collision in lab frame , having energies 20 GeV and 250 GeV respectively .
- We are considering Weak Boson exchange physics processes (WeakBosonExchange:ff2ff(t:gmZ)), with kinematics cut PhaseSpace:Q2Min = 25 GeV2 .

  pT max = 2 GeV2

Following settings we are using to generate the event data file in pythia8 .

Open mymain42.cmnd ~/Downloads Save

```
! File: mymain42.cmnd
! This file contains commands to be read in for a Pythia8 run.
! Lines not beginning with a letter or digit are comments.
! Names are case-insensitive  -  but spellings-sensitive!
! The changes here are illustrative, not always physics-motivated.

! 1) Settings that will be used in a main program.
Main:numberOfEvents = 100          ! number of events to generate
Main:timesAllowErrors = 10000          ! abort run after this many flawed events

! 2) Settings related to output in init(), next() and stat().
Init:showChangedSettings = on      ! list changed settings
#Init:showAllSettings = off         ! list all settings
Init:showChangedParticleData = off  ! list changed particle data
#Init:showAllParticleData = off     ! list all particle data
Next:numberCount = 1000            ! print message every n events
#Next:numberShowLHA = 1             ! print LHA information n times
Next:numberShowInfo = 1            ! print event information n times
Next:numberShowProcess = 1         ! print process record n times
Next:numberShowEvent = 5           ! print event record n times
#Stat:showPartonLevel = on          ! additional statistics on MPI

! 3) Beam parameter settings. Values below agree with default ones.
Beams:idA = 2212                   ! first beam, p = 2212, pbar = -2212
Beams:idB = 11                     ! second beam, e- = 11, e+ = -11
#Beams:eCM = 14000.                ! CM energy of collision
```

```
! 3) Beam parameter settings. Values below agree with default ones.
Beams:idA = 2212                    ! first beam, p = 2212, pbar = -2212
Beams:idB = 11                      ! second beam, e- = 11, e+ = -11
#Beams:eCM = 14000.                 ! CM energy of collision
Beams:frameType = 2                 !Beams with different energies
Beams:eA = 250                      !p+ at 250GeV energy
Beams:eB = 20                       !e- at 20GeV energy
PDF:lepton2gamma = on               !Allow for photon from lepton

! 4) PDF settings. Default is to use internal PDFs
! some pdf sets examples: cteq61.LHpdf cteq61.LHgrid MRST2004nlo.LHgrid
#PDF:pSet = LHAPDF5:MRST2001lo.LHgrid
! Allow extrapolation of PDF's beyond x and Q2 boundaries, at own risk.
! Default behaviour is to freeze PDF's at boundaries.
#PDF:extrapolate = on
PDF:lepton = off

! 5a) Pick processes and kinematics cuts.
 WeakBosonExchange:ff2ff(t:gmZ) = on       !Neutral current
 PhaseSpace:Q2Min = 25                      !Minimum Q2 value
 SpaceShower:dipoleRecoil = on              !For DIS + Shower
 SpaceShower:pTmaxMatch = 2                 !To fill the whole space with parton shower
 TimeShower:QEDshowerByL = off              !If it is on then it allow the leptons to radiate photons
```

```
! 5a) Pick processes and kinematics cuts.
 WeakBosonExchange:ff2ff(t:gmZ) = on       !Neutral current
 PhaseSpace:Q2Min = 25                      !Minimum Q2 value
 SpaceShower:dipoleRecoil = on              !For DIS + Shower
 SpaceShower:pTmaxMatch = 2                 !To fill the whole space with
parton shower
 TimeShower:QEDshowerByL = off              !If it is on then it allow the
leptons to radiate photons

 !6)Settings for the event generation process in the pythia8 library.
 HadronLevel:Decay = off       !Hadron decay is off
 HadronLevel:all = on
 PartonLevel:ISR = off         !Initial state showering
 PartonLevel:MPI = off         !Multiparton interaction
 PartonLevel:FSR = off         !Final state showering
 PromptPhoton:all = on

 !7)Random seed settings
 Random:setSeed = on
 Random:seed = 42
```

- The above code run successfully .

The output myymain42Lab.txt file (which contains generated event information) is generated.

2. Feeding Pythia8 generated MC Event file to EIC-smear

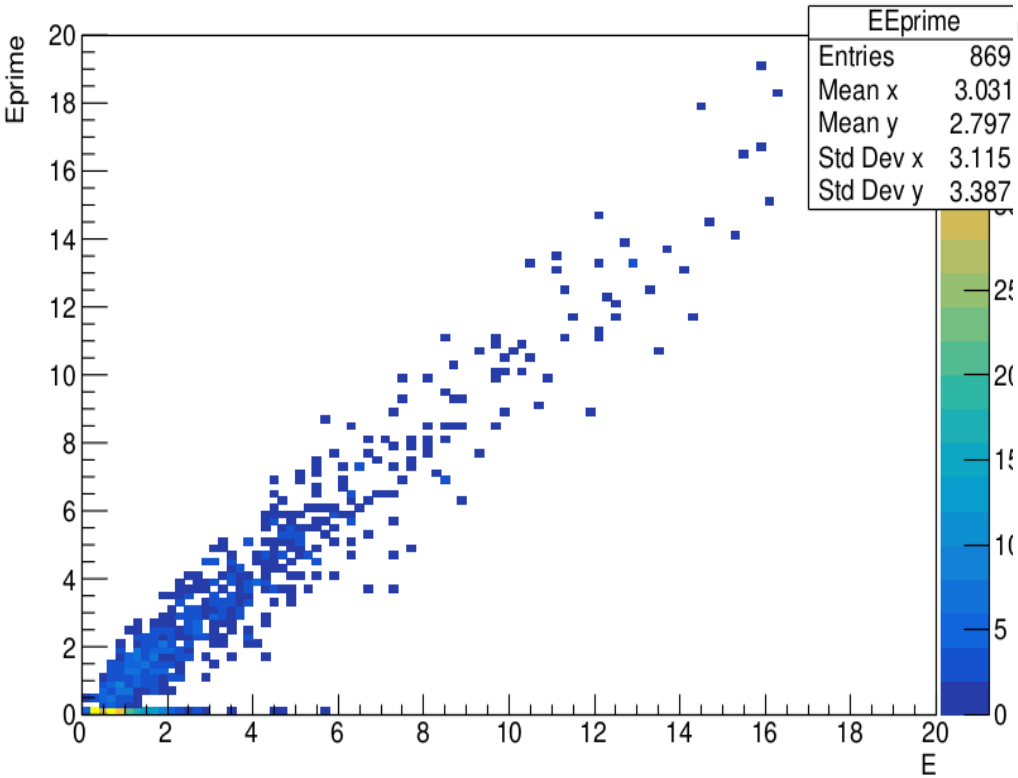
BUILDING TREE IN ROOT INTERFACE AND SMEARING THE TREE

```
/home/chitranshi/eic/eic-smear-master/lib/libeicsmeardetectors.so
   ------------------------------------------------------------------
  | Welcome to ROOT 6.20/06                        https://root.cern |
  | (c) 1995-2020, The ROOT Team; conception: R. Brun, F. Rademakers |
  | Built for linuxx8664gcc on Oct 02 2020, 11:28:00                 |
  | From tag , 10 June 2020                                          |
  | Try '.help', '.demo', '.license', '.credits', '.quit'/'.q'       |
   ------------------------------------------------------------------

eic-smear [0] gSystem->Load("libeicsmear");
eic-smear [1] BuildTree("/home/chitranshi/eic/eicsmeardetectors/tests/myymain42LAB.txt");

Processing /home/chitranshi/eic/eicsmeardetectors/tests/myymain42LAB.txt

Processed /home/chitranshi/eic/eicsmeardetectors/tests/myymain42LAB.txt
TFile**         ./myymain42LAB.root
 TFile*         ./myymain42LAB.root
  OBJ: TTree    EICTree my EIC tree : 0 at: 0x5582b6c9ef90
  KEY: TProcessID       ProcessID0;1    c095778e-7a69-11eb-9345-0f02000abeef
  KEY: TTree    EICTree;1       my EIC tree
  KEY: TObjString       crossSection;1  Collectable string class
  KEY: TObjString       crossSectionError;1     Collectable string class
Began on Mon Mar  1 14:10:31 2021
Ended on Mon Mar  1 14:10:31 2021
Processed 100 events containing 3359 particles in 0.209111 seconds (0.00209111 sec/event)
eic-smear [2] .L SmearMatrixDetector_0_1.cxx
eic-smear [3] SmearTree(BuildMatrixDetector_0_1(),"myymain42LAB.root", "smeared.root",-1)
/-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-/
/  Commencing Smearing of 100 events.
/-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-/
|~~~~~~~~~~~~~~~~~~ Completed Successfully ~~~~~~~~~~~~~~~~~~~~|
(int) 0
eic-smear [4]
```

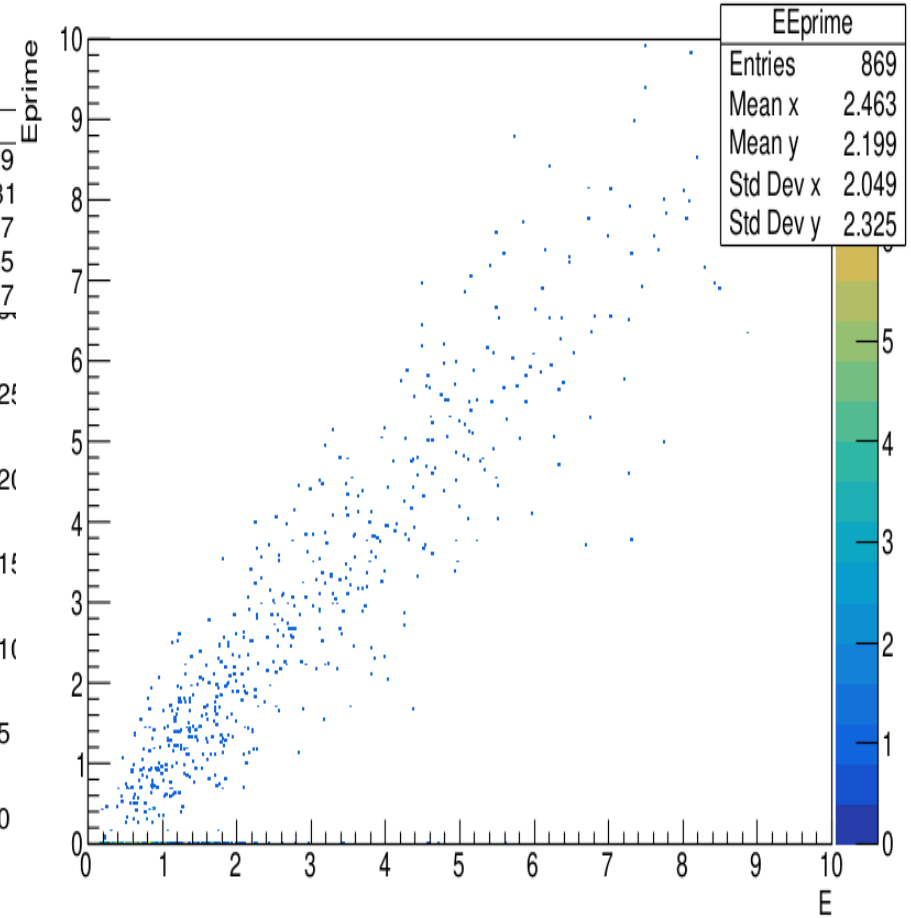
Analyzing the smeared tree

```
root -l
gSystem->Load("libeicsmear");
TFile mcf ("myymain42LAB.root"); // truth
TTree* mc=(TTree*)mcf.Get("EICTree");
mc->AddFriend("Smeared","smeared.root"); // befriend

// Setup Input Event Buffer
erhic::EventMC* inEvent(NULL);
Smear::Event* inEventS(NULL);
mc->SetBranchAddress("event",&inEvent);
mc->SetBranchAddress("eventS",&inEventS);

// histo and event loop
TH2D* EEprime = new TH2D("EEprime", ";E;Eprime", 500, 0, 10, 500, 0, 10);
for(long iEvent=0; iEvent<mc->GetEntries(); iEvent++){
    //Read next Event
    if(mc->GetEntry(iEvent) <=0) break;
    // Loop over Particles
    for(int j=0; j<inEventS->GetNTracks(); j++){
      if ( j<3 ) continue;       // Skip beam
      const Smear::ParticleMCS* inParticleS = inEventS->GetTrack(j); // Smeared Particle
      const Particle* inParticle = inEvent->GetTrack(j); // Unsmeared Particle
      if(inParticleS == NULL) continue;
```

Output plots



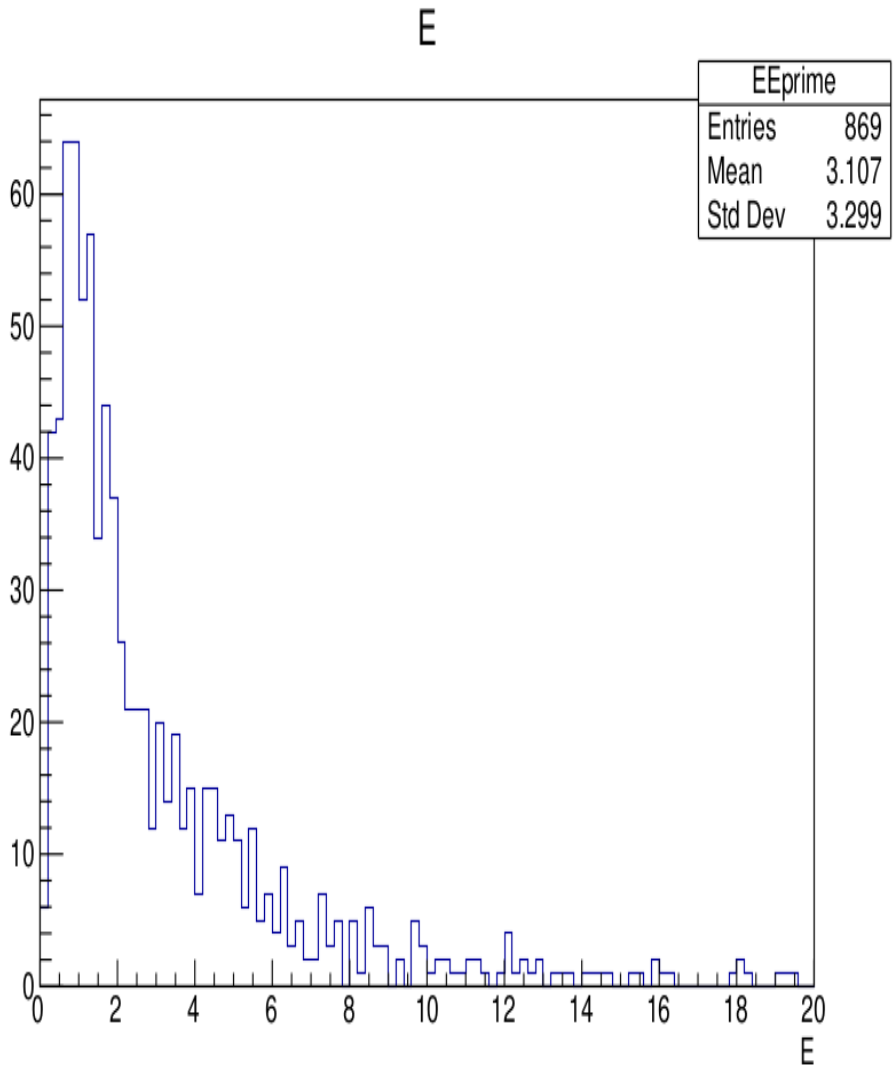
Plot between energy of smeared and unsmeared particle with n =100 bins



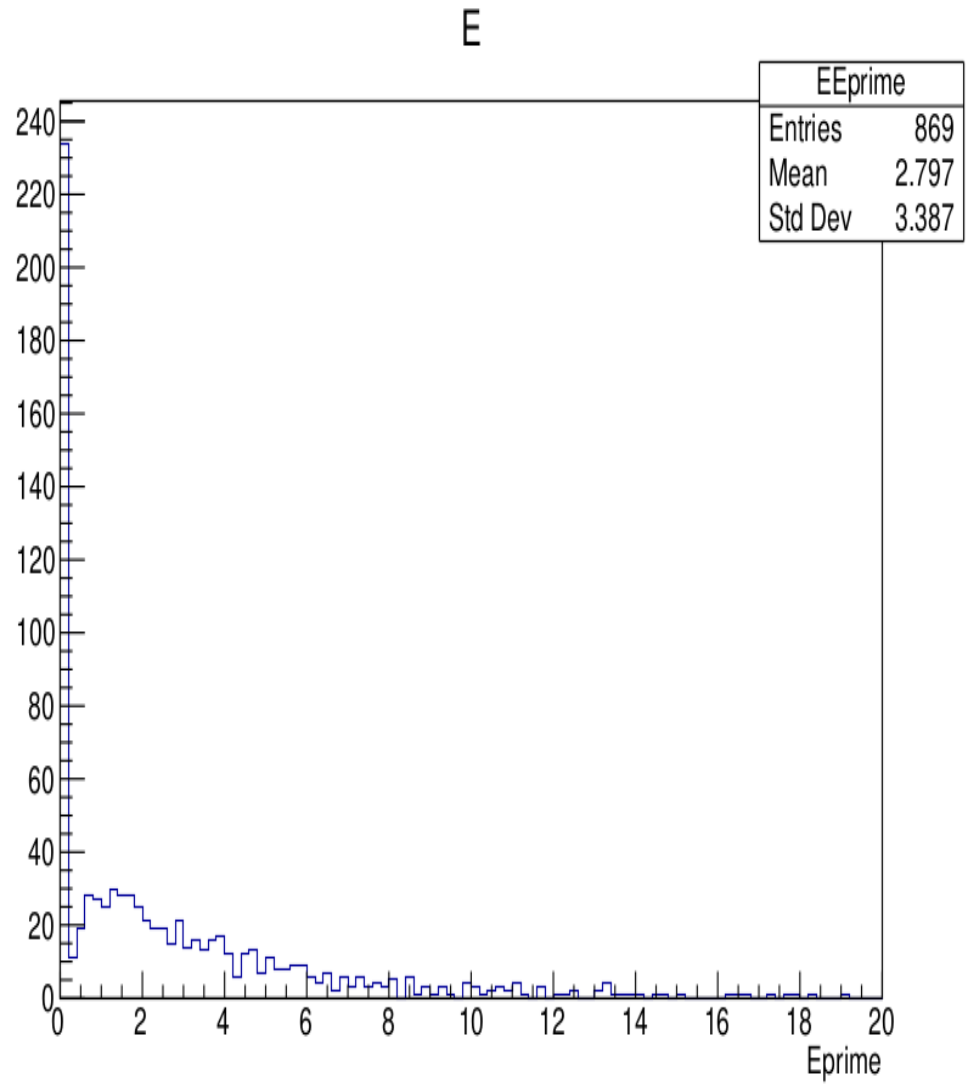
Plot between energy of smeared and unsmeared particle with n =500 bins

- Comparison between output of different parameters for smeared and un-smeared particles.

Energy

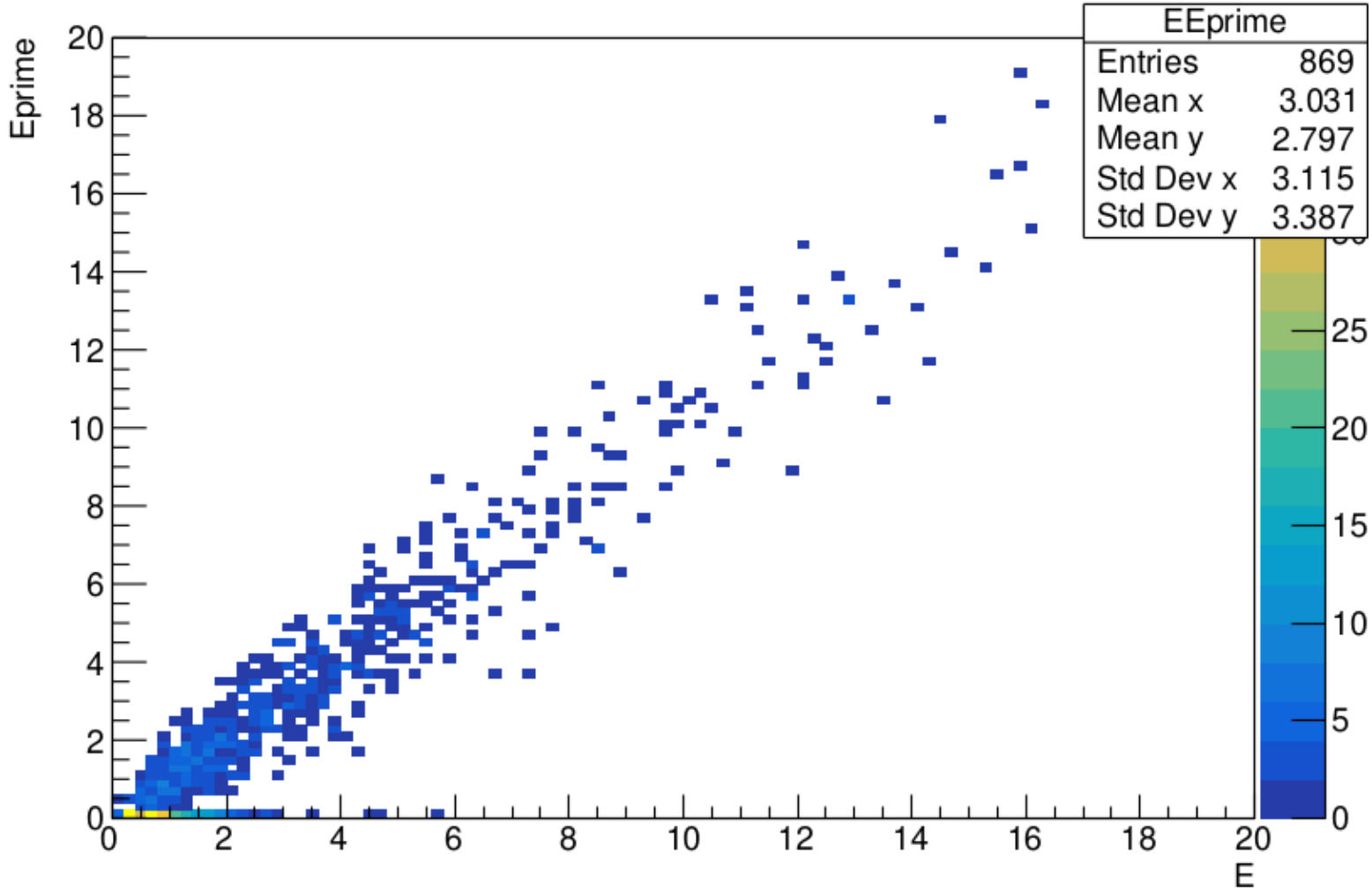


Energy plot for un-smeared particles

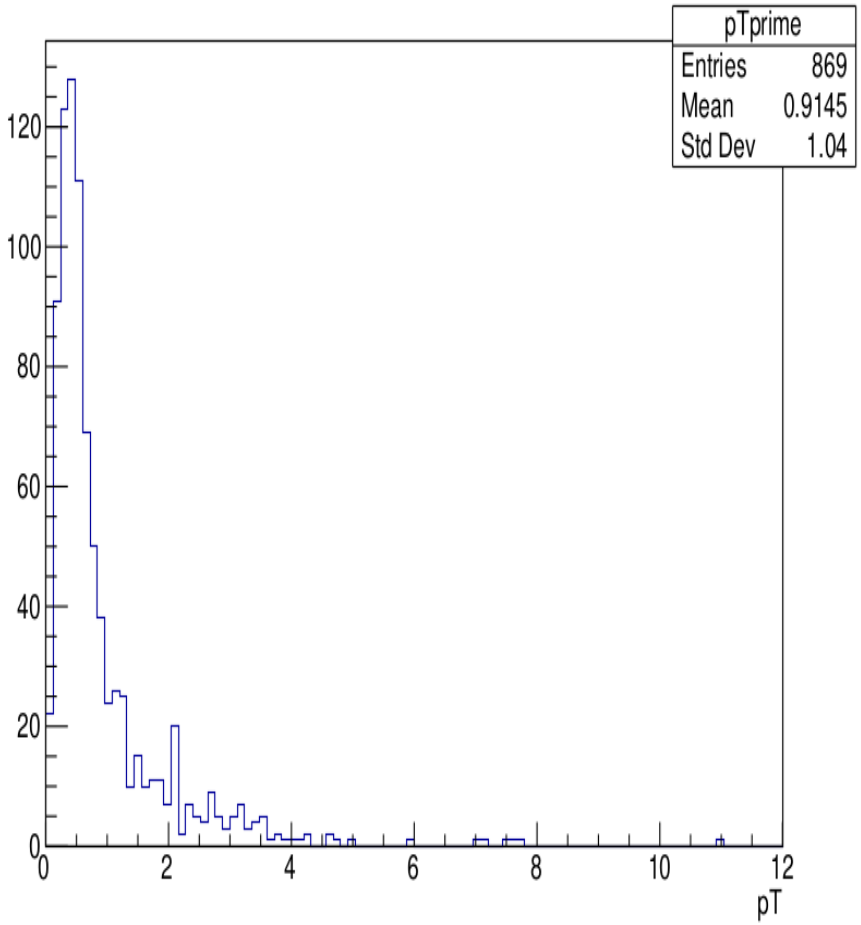


Energy plot for smeared particles

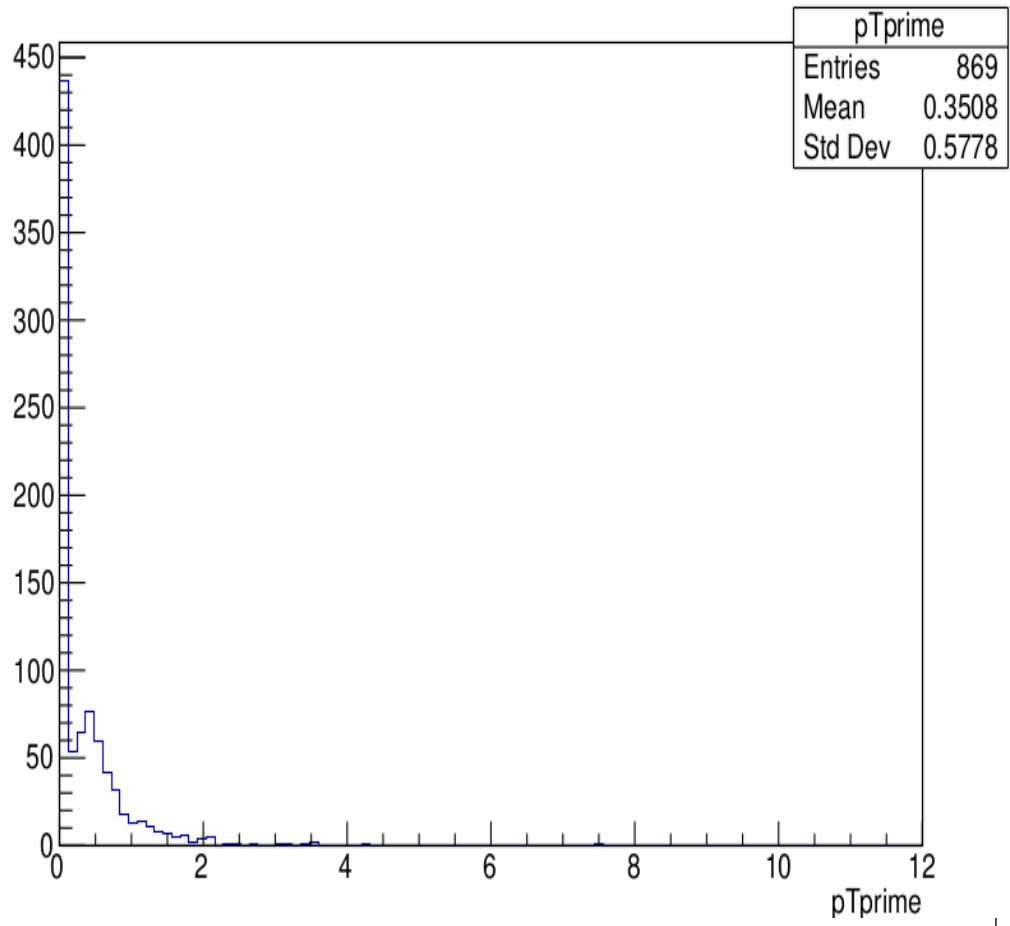
2D energy plots for smeared and un-smeared particles



Transverse momentum of particles

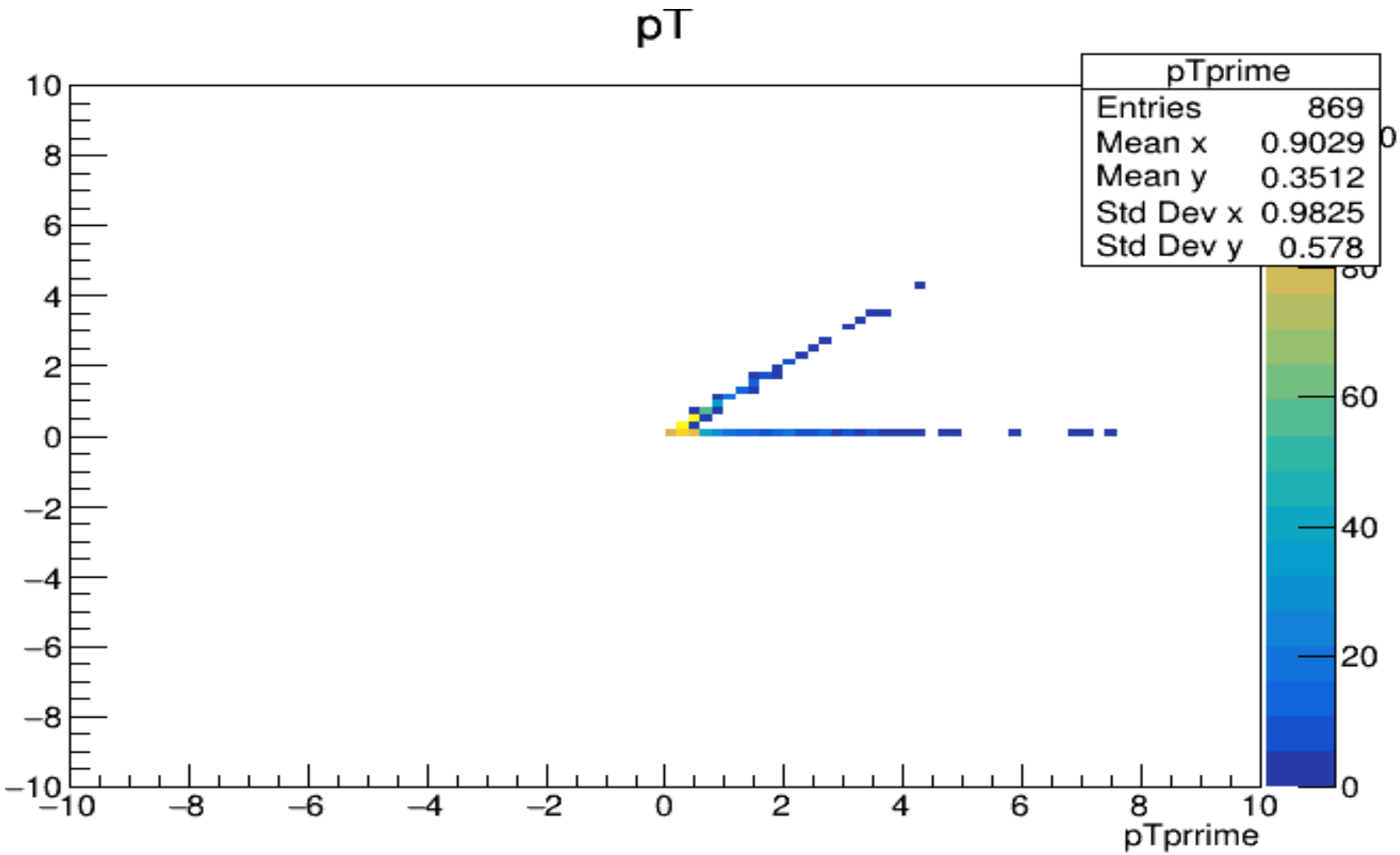


For un-smeared particle

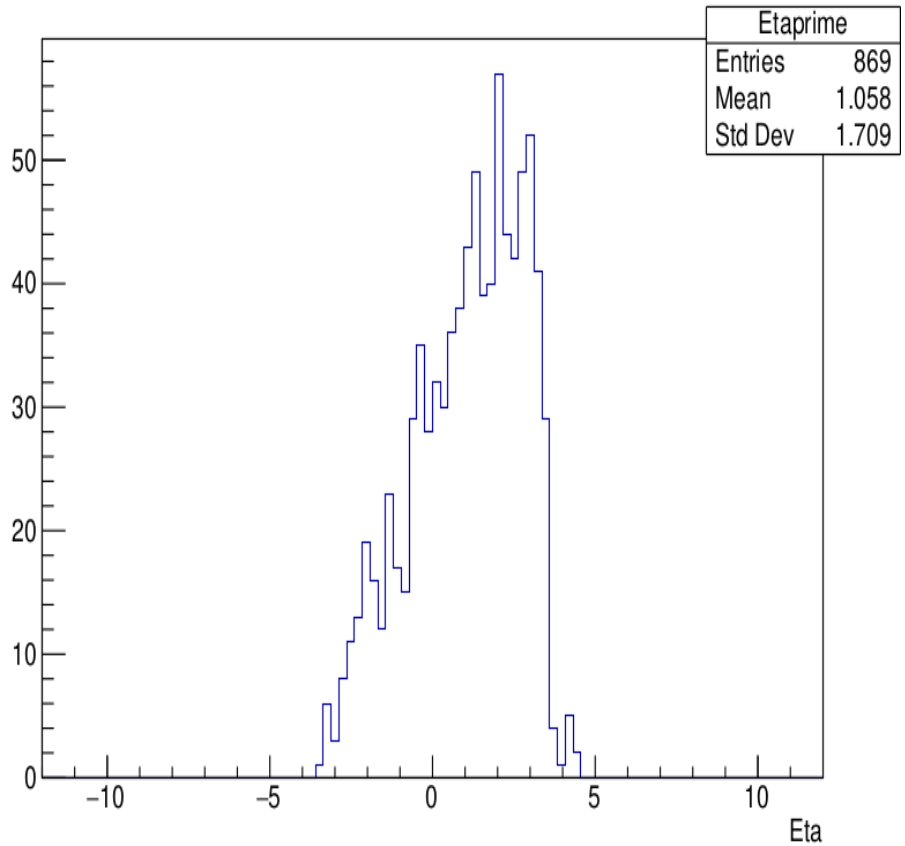


For smeared particle

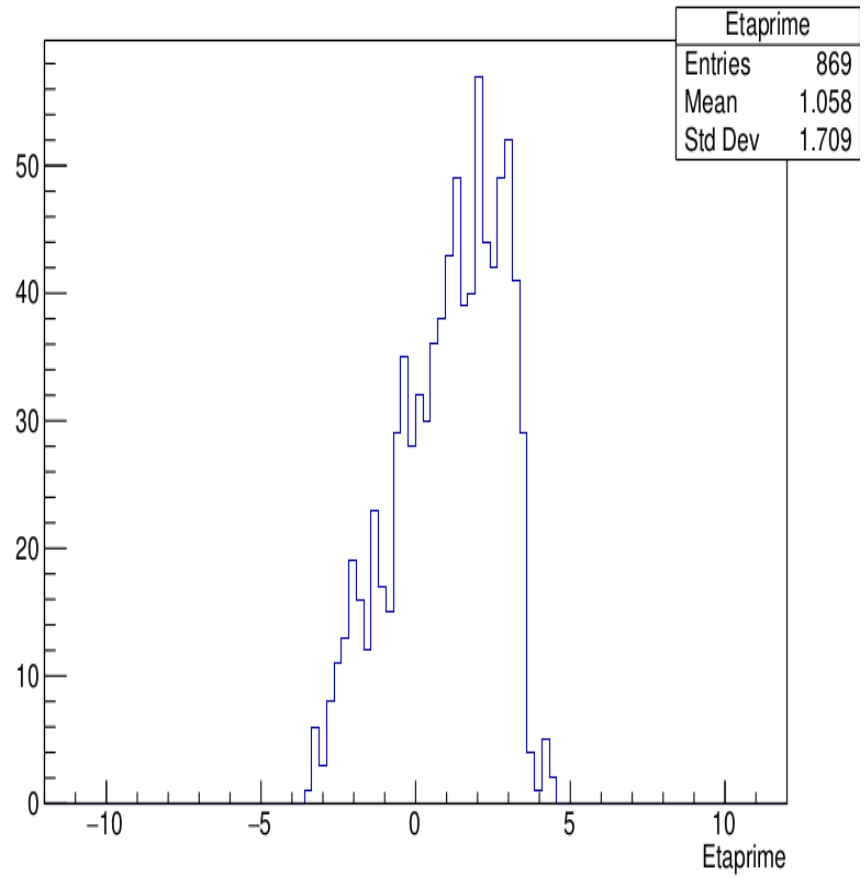
2D transverse momentum plots of smeared (pTprrime) un-smeared (pT) particles



Eta curves

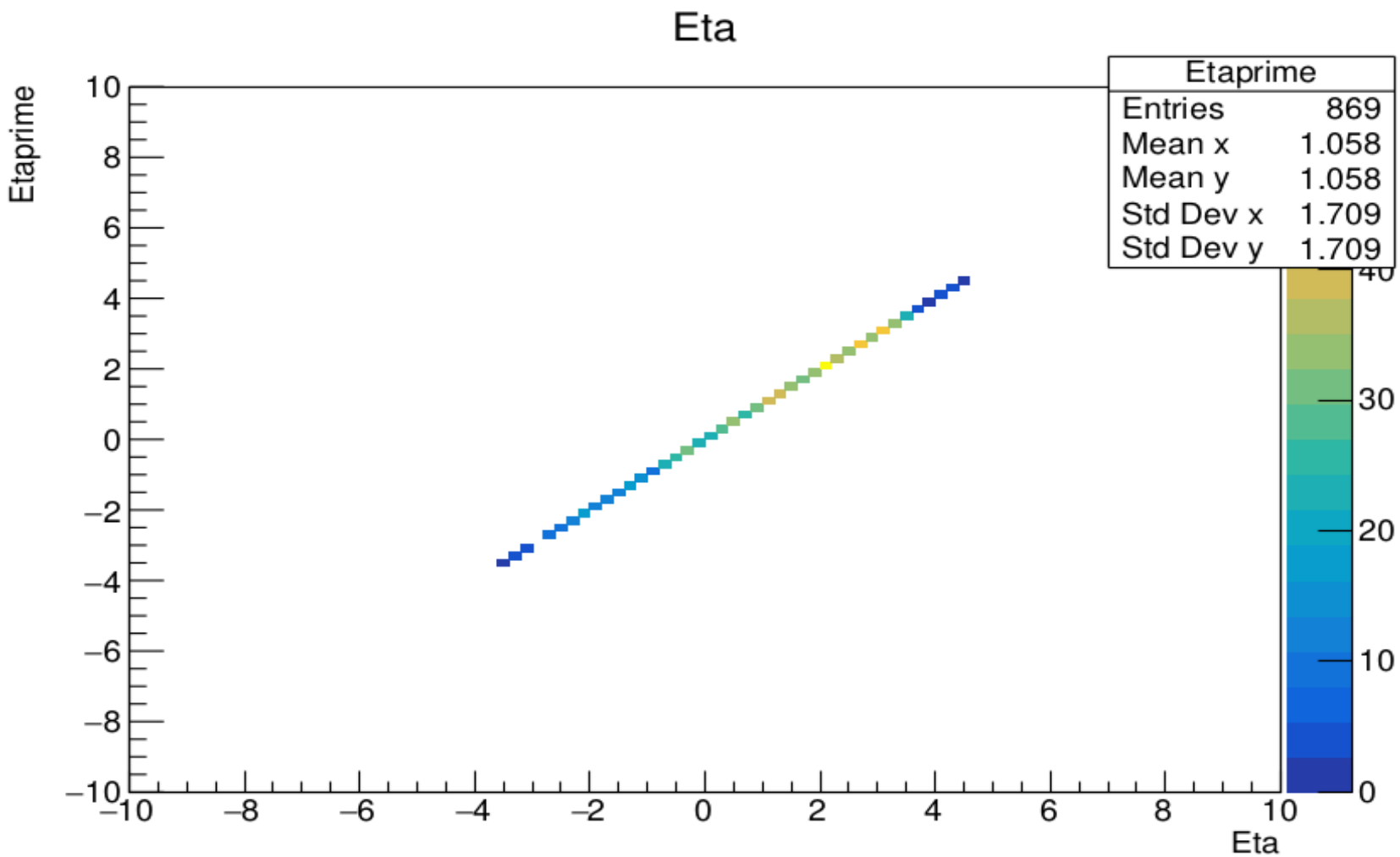


For un-smeared particles

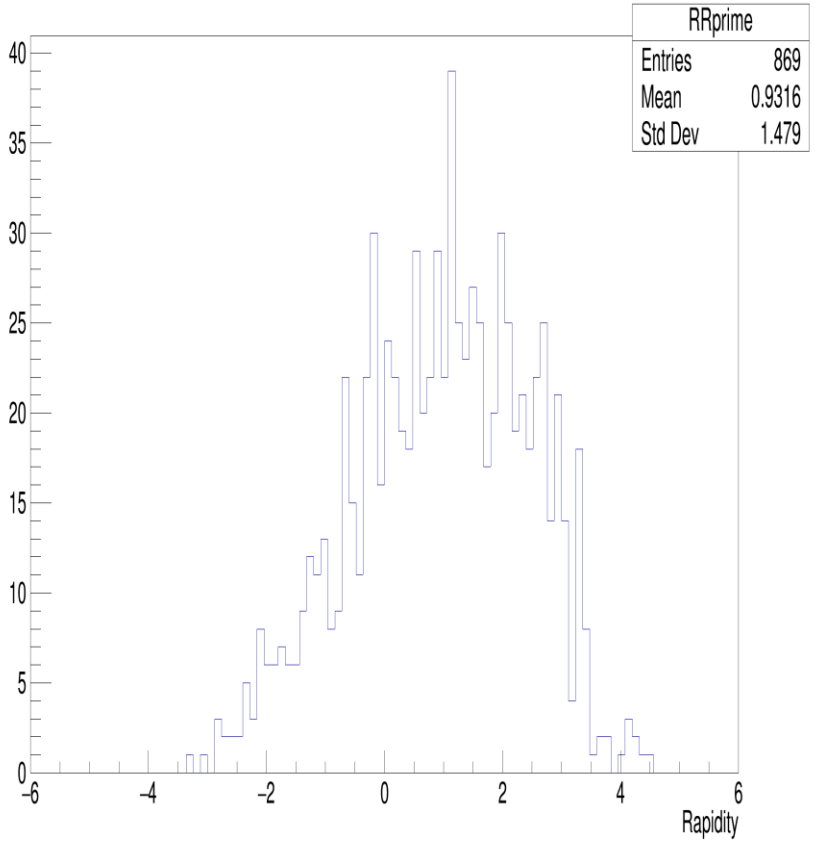


For smeared particles

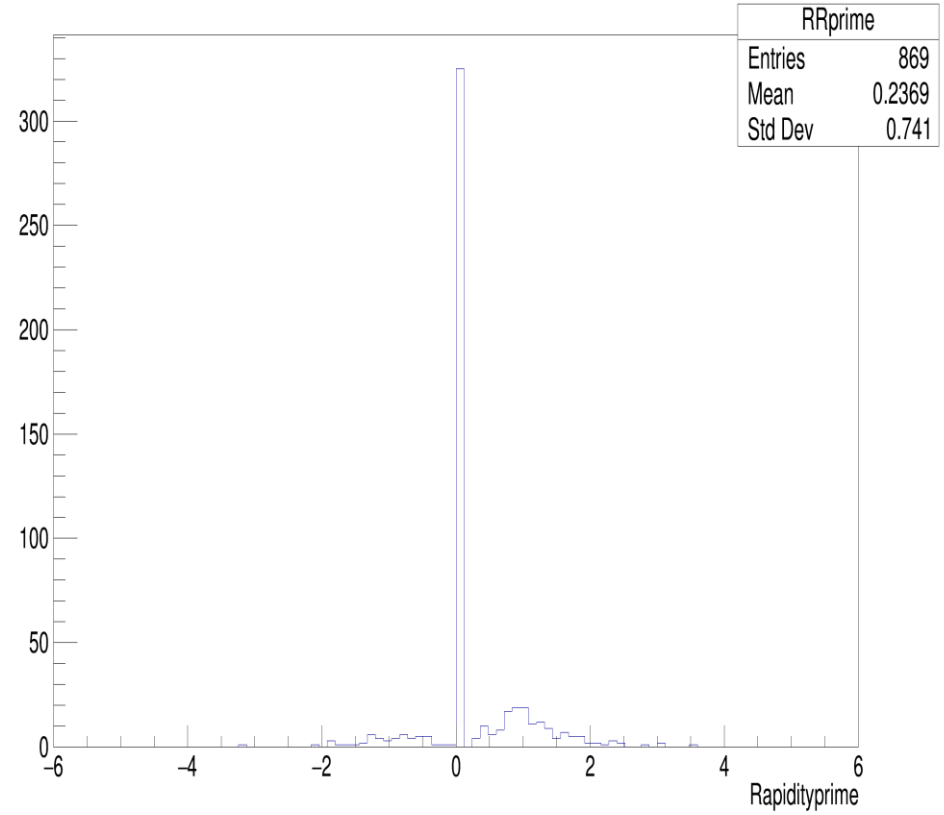
2D Eta plot for smeared(Etaprime) and un-smeared(Eta) particles



Rapidity curve

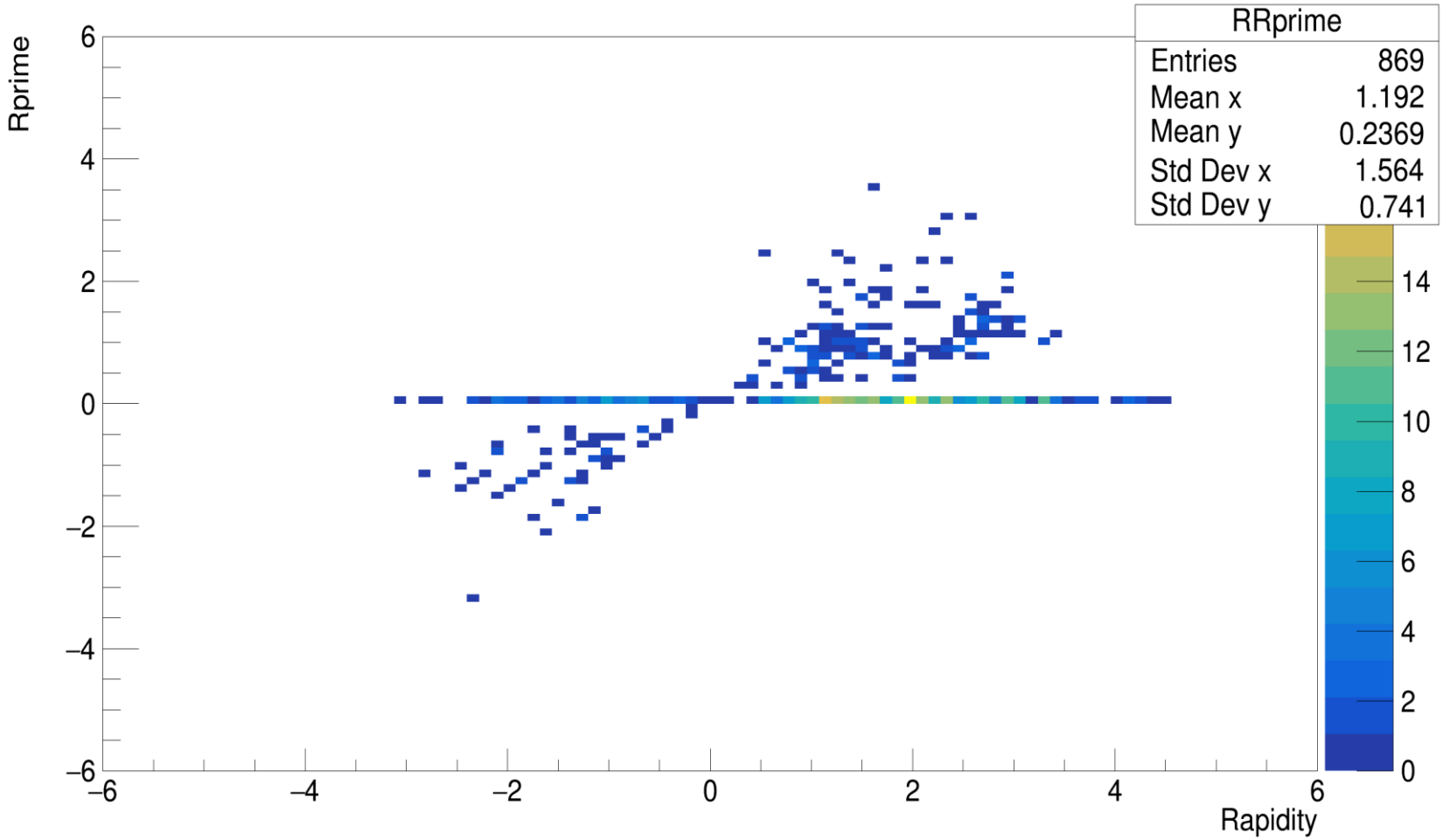


For un-smeared particles



For smeared particles

plot for rapidity for smeared(Rprime) and un-smeared(Rapidity)



Future task

- Create MC event file output for exclusive reactions parameters using Pythia 8.(specifying in next slide)
- Feed this file to eic-smear and eic-smear-detectors(using matrix detector only?)
- Generate plots for the parameters where it needs to be zoomed in.

Exclusive Reaction parameters

- For $1 < Q^2 < 10 GeV^2$, $-1 < \eta < 1$ sufficient for **J**/ ψ decay
- And $Q^2 < 0.01$, $-3.5 < \eta < -2.5$ sufficient for **J**/ ψ decay
- pT range 0.5 – 1.5 for $1 < Q^2 < 10 GeV^2$, pT range -2 - -6 for $Q^2 < 0.01$
- for $1 < Q^2 < 10 GeV^2$, $|t| < 0.1$
- -3.5 – 3.5 (η range detected in central detector)
- Q^2 range less than 100 GeV^2 (10^{-4} to 100)
- Low Q^2 tagger at $-6.9 < \eta < -5.6$ (top panels)

Setting used for energy 5x41 GeV (ep collision)

```
! 3) Beam parameter settings. Values below agree with default ones.
Beams:idA = 2212                    ! first beam, p = 2212, pbar = -2212
Beams:idB = 11                      ! second beam, e- = 11, e+ = -11
#Beams:eCM = 14000.                 ! CM energy of collision
Beams:frameType = 2                 !Beams with different energies
Beams:eA = 41                      !p+ at 250GeV energy
Beams:eB = 5                       !e- at 20GeV energy
PDF:lepton2gamma = on               !Allow for photon from lepton

! 4) PDF settings. Default is to use internal PDFs
! some pdf sets examples: cteq61.LHpdf cteq61.LHgrid MRST2004nlo.LHgrid
#PDF:pSet = LHAPDF5:MRST2001lo.LHgrid
! Allow extrapolation of PDF's beyond x and Q2 boundaries, at own risk.
! Default behaviour is to freeze PDF's at boundaries.
#PDF:extrapolate = on
PDF:lepton = off

! 5a) Pick processes and kinematics cuts.
 WeakBosonExchange:ff2ff(t:gmZ) = on       !Neutral current
 PhaseSpace:Q2Min = 1                      !Minimum Q2 value
 SpaceShower:dipoleRecoil = on              !For DIS + Shower
 SpaceShower:pTmaxMatch = 1.5                 !To fill the whole space with parton shower
 TimeShower:QEDshowerByL = off              !If it is on then it allow the leptons to radiate photons

 !6)Settings for the event generation process in the pythia8 library.
 HadronLevel:Decay = off       !Hadron decay is off
 HadronLevel:all = on
 PartonLevel:ISR = off         !Initial state showering
 PartonLevel:MPI = off         !Multiparton interaction
 PartonLevel:FSR = off         !Final state showering
 PromptPhoton:all = on

 !7)Random seed settings
 Random:setSeed = on
 Random:seed = 42
```

Error with above settings

```
PYTHIA Error in BeamRemnants::setKinematics: kinematics construction failed
PYTHIA Error in Pythia::next: partonLevel failed; try again
PYTHIA Abort from Pythia::next: parton+hadronLevel failed; giving up

*-------  PYTHIA Event and Cross Section Statistics  -------------------------------------------------------------*
|                                                                                                                  |
| Subprocess                                    Code |            Number of events       |      sigma +- delta    |
|                                                    |       Tried   Selected   Accepted |     (estimated) (mb)   |
|                                                    |                                   |                        |
|------------------------------------------------------------------------------------------------------------------|
|                                                    |                                   |                        |
| q g -> q gamma (udscb)                         201 |         605        47        46 |   3.415e-08  1.842e-09 |
| q qbar -> g gamma                              202 |         448        35        35 |   2.333e-08  1.290e-09 |
| g g -> g gamma                                 203 |           1         0         0 |   0.000e+00  0.000e+00 |
| f fbar -> gamma gamma                          204 |           1         0         0 |   0.000e+00  0.000e+00 |
| g g -> gamma gamma                             205 |           0         0         0 |   0.000e+00  0.000e+00 |
| f f' -> f f' (t-channel gamma*/Z0)             211 |         378        18        18 |   1.389e-08  1.084e-09 |
|                                                    |                                   |                        |
| sum                                                |        1433       100        99 |   7.137e-08  2.497e-09 |
|                                                                                                                  |
*-------  End PYTHIA Event and Cross Section Statistics -----------------------------------------------------------*

*-------  PYTHIA Error and Warning Messages Statistics  ----------------------------------------------------------*
|                                                                                                                  |
|  times   message                                                                                                 |
|                                                                                                                  |
|      1   Abort from Pythia::next: parton+hadronLevel failed; giving up                                           |
|    106   Error in BeamRemnants::setKinematics: kinematics construction failed                                    |
|     10   Error in Pythia::next: partonLevel failed; try again                                                    |
|                                                                                                                  |
*-------  End PYTHIA Error and Warning Messages Statistics  ------------------------------------------------------*
```

Settings used for energy 18x275 GeV (ep Collision)

```
! 3) Beam parameter settings. Values below agree with default ones.
Beams:idA = 2212                    ! first beam, p = 2212, pbar = -2212
Beams:idB = 11                      ! second beam, e- = 11, e+ = -11
#Beams:eCM = 14000.                 ! CM energy of collision
Beams:frameType = 2                 !Beams with different energies
Beams:eA = 275                      !p+ at 250GeV energy
Beams:eB = 18                       !e- at 20GeV energy
PDF:lepton2gamma = on               !Allow for photon from lepton

! 4) PDF settings. Default is to use internal PDFs
! some pdf sets examples: cteq61.LHpdf cteq61.LHgrid MRST2004nlo.LHgrid
#PDF:pSet = LHAPDF5:MRST2001lo.LHgrid
! Allow extrapolation of PDF's beyond x and Q2 boundaries, at own risk.
! Default behaviour is to freeze PDF's at boundaries.
#PDF:extrapolate = on
PDF:lepton = off

! 5a) Pick processes and kinematics cuts.
 WeakBosonExchange:ff2ff(t:gmZ) = on       !Neutral current
 PhaseSpace:Q2Min = 1                      !Minimum Q2 value
 SpaceShower:dipoleRecoil = on              !For DIS + Shower
 SpaceShower:pTmaxMatch = 1.5                 !To fill the whole space with parton shower
 TimeShower:QEDshowerByL = off              !If it is on then it allow the leptons to radiate photons

 !6)Settings for the event generation process in the pythia8 library.
 HadronLevel:Decay = off       !Hadron decay is off
 HadronLevel:all = on
 PartonLevel:ISR = off         !Initial state showering
 PartonLevel:MPI = off         !Multiparton interaction
 PartonLevel:FSR = off         !Final state showering
 PromptPhoton:all = on

 !7)Random seed settings
 Random:setSeed = on
 Random:seed = 42
```

Error with above settings

```
*-------  End PYTHIA Event Listing  ----------------------------------------------------------------------------------*
PYTHIA Error in BeamRemnants::setKinematics: kinematics construction failed
PYTHIA Error in Pythia::next: partonLevel failed; try again

*-------  PYTHIA Event and Cross Section Statistics  -------------------------------------------------------------*
|                                                                                                                  |
| Subprocess                                    Code |            Number of events       |      sigma +- delta    |
|                                                    |       Tried   Selected   Accepted |     (estimated) (mb)   |
|                                                    |                                   |                        |
|------------------------------------------------------------------------------------------------------------------|
|                                                    |                                   |                        |
| q g -> q gamma (udscb)                         201 |         657        62        62 |   6.111e-07  3.125e-08 |
| q qbar -> g gamma                              202 |         206        16        16 |   1.996e-07  1.522e-08 |
| g g -> g gamma                                 203 |           0         0         0 |   0.000e+00  0.000e+00 |
| f fbar -> gamma gamma                          204 |           0         0         0 |   0.000e+00  0.000e+00 |
| g g -> gamma gamma                             205 |           0         0         0 |   0.000e+00  0.000e+00 |
| f f' -> f f' (t-channel gamma*/Z0)             211 |         219        22        22 |   1.816e-07  1.781e-08 |
|                                                    |                                   |                        |
| sum                                                |        1082       100       100 |   9.923e-07  3.906e-08 |
|                                                                                                                  |
*-------  End PYTHIA Event and Cross Section Statistics -----------------------------------------------------------*

*-------  PYTHIA Error and Warning Messages Statistics  ----------------------------------------------------------*
|                                                                                                                  |
|  times   message                                                                                                 |
|                                                                                                                  |
|     82   Error in BeamRemnants::setKinematics: kinematics construction failed                                    |
|      8   Error in Pythia::next: partonLevel failed; try again                                                    |
|                                                                                                                  |
*-------  End PYTHIA Error and Warning Messages Statistics  ------------------------------------------------------*
```

Queries:-

- We are trying to resolve the above errors .Can you suggest us what major errors should we consider first here.
- To overcome these errors is there any specific physics processes that is required and we are missing it here.