Z Physics Tutorial

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Introductory School to Particle Physics
DESY Hamburg
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Outline

- In the tutorial of today you will learn:

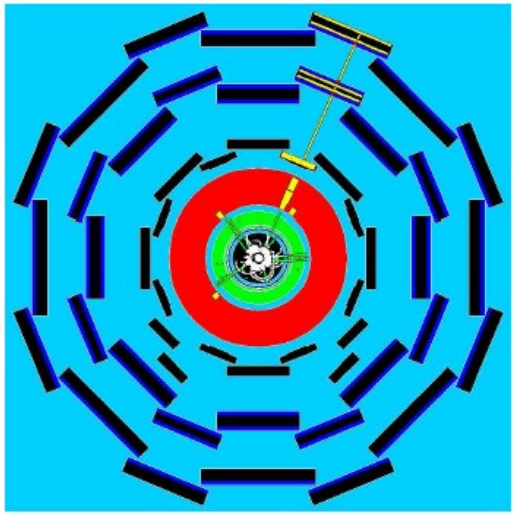
- Part I:
  - how to use the ATLAS event display
  - we will look first at Z bosons produced in simulated pp collisions which decay to a pair of electrons

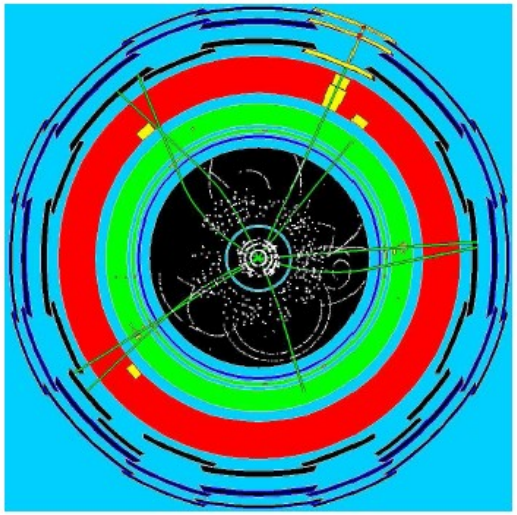
    $$pp \rightarrow Z+X \rightarrow e+e- +X$$
  - how to extract information from the display to calculate kinematic variables
  - you will compare measurements of the mass of Z boson, with different detectors, the calorimeter and the tracking detector
  - use ROOT for the calculation

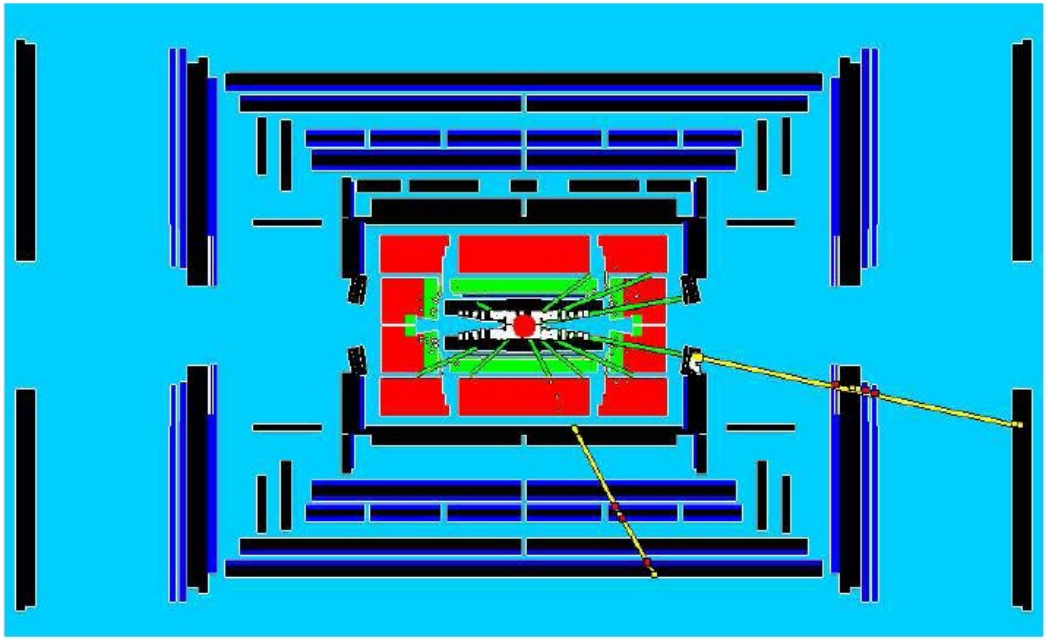
- Part II:
  - determine the Z boson mass in an uncalibrated data set
  - your task is to improve the calibration of the electron energy
  - you learn how to use ROOT for histograms and fitting

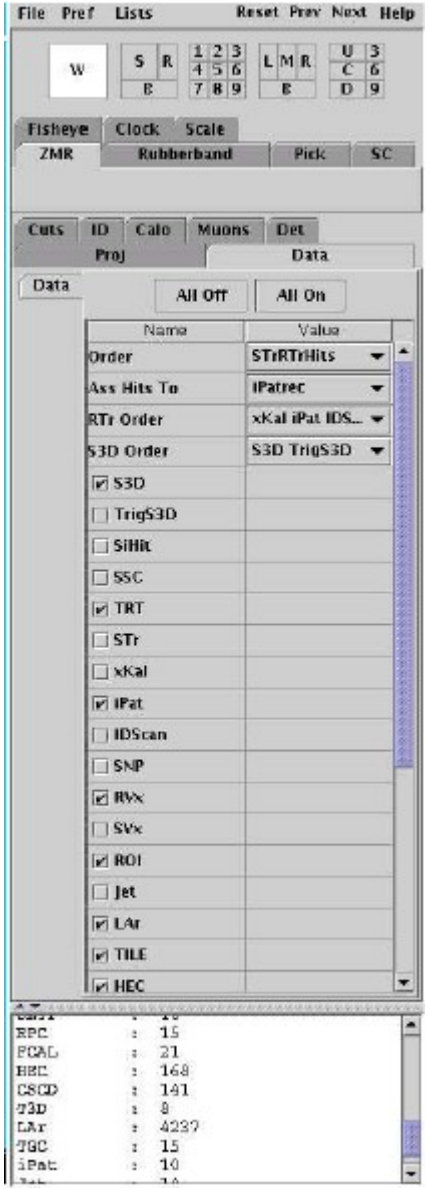
- This afternoon: Part III:
  - measurement of the W mass from lepton pT spectrum

ATLANTIS





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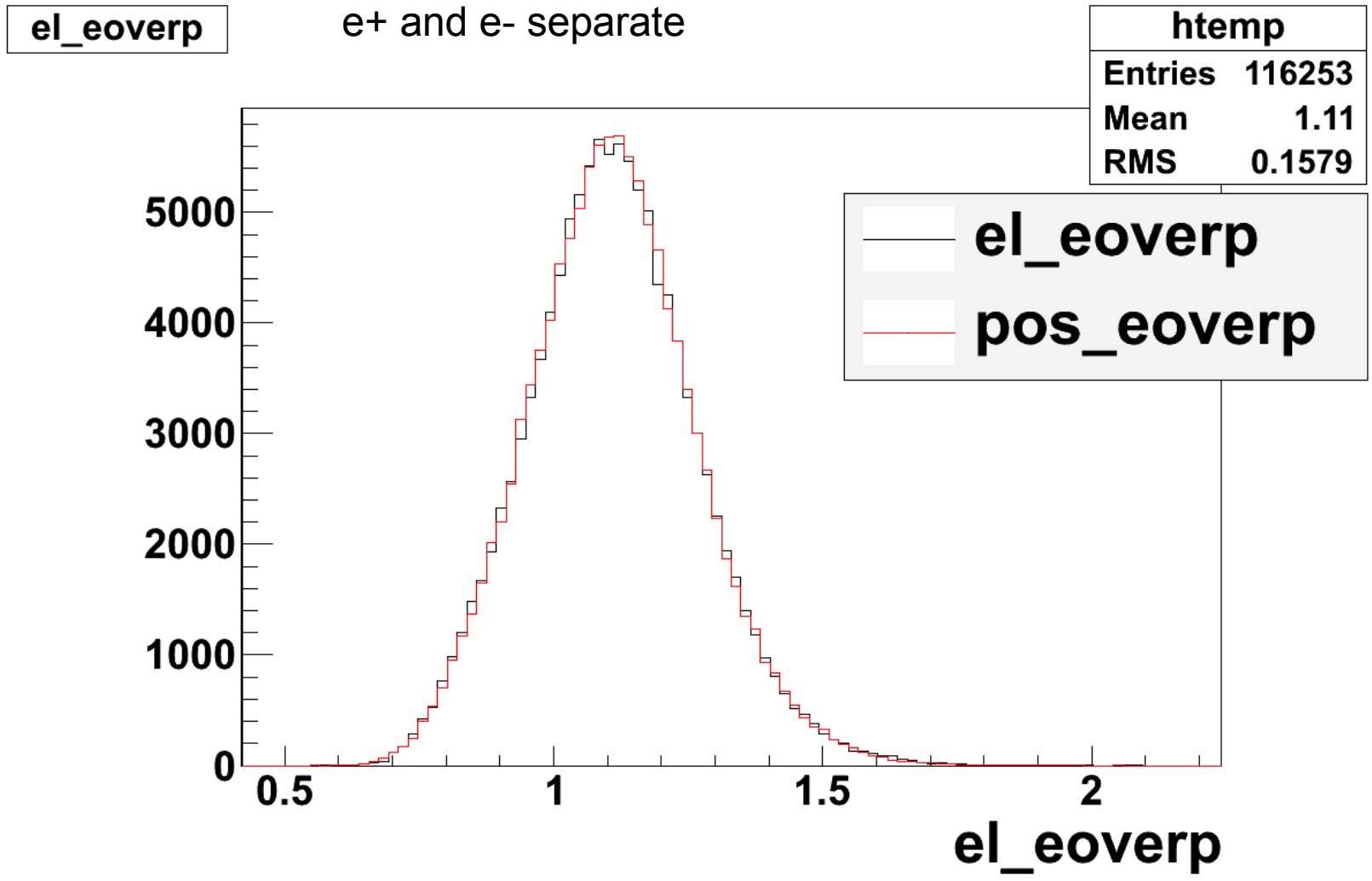
Helpful hints for part I

- you may set a higher cut on the track pT (it is now at 1 GeV)

Solutions part I

- Z mass event #3
  - calorimeter mee = 119.991 GeV
  - tracker mee = 83.7935 GeV
- Z mass event #7
  - calorimeter mee = 86.0215 GeV
  - tracker mee = 68.5353 GeV
- Z mass event #9
  - calorimeter mee = 87.4466 GeV
  - tracker mee = 34.5958 GeV

Solutions of part II

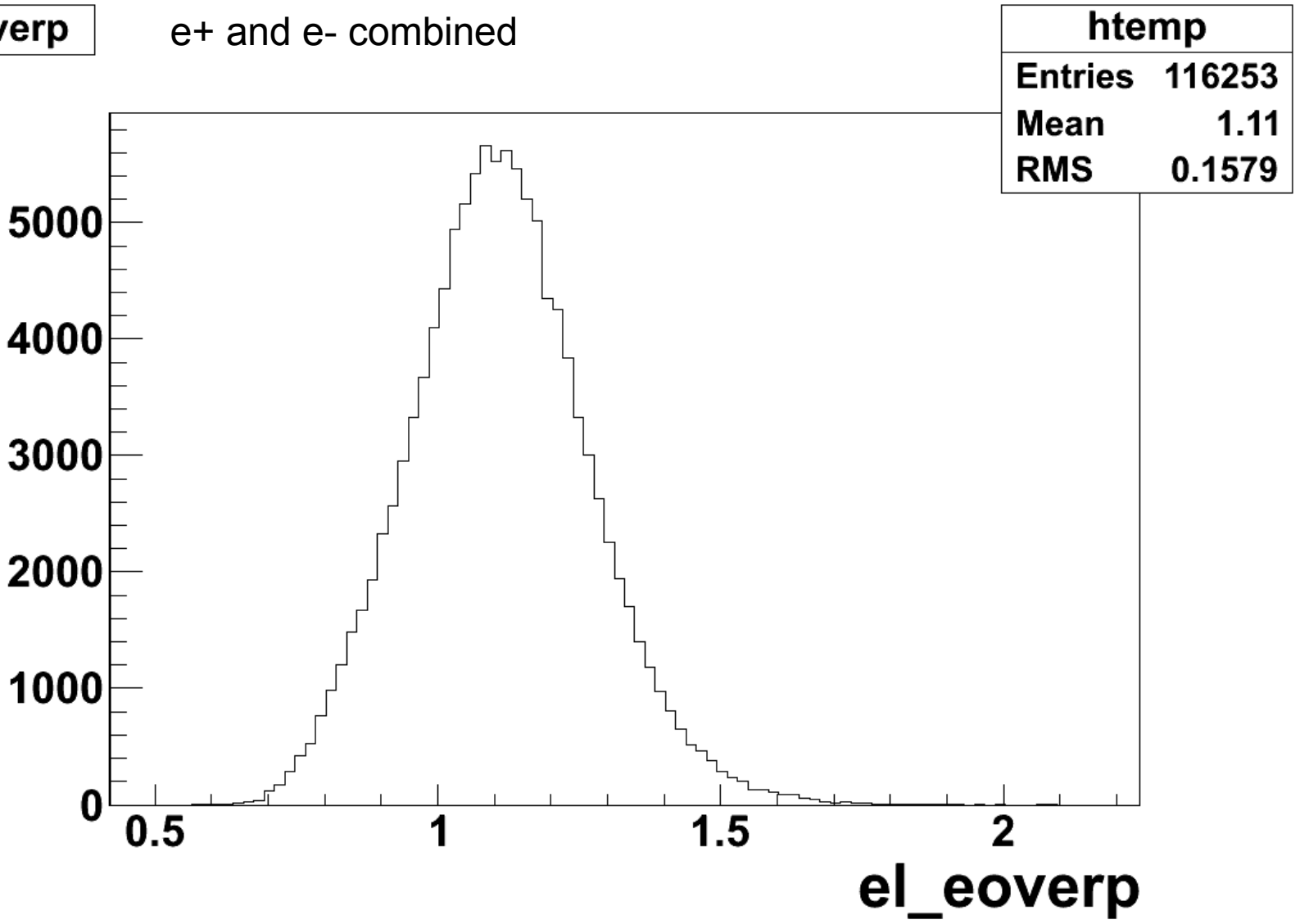


track momentum calibration slightly too low (see calorimeter calibration later)

Solutions of part II

el_eoverp

e+ and e- combined



Solutions of part II

- for njet==0 → pT spectrum peaks at MZ/2 ~ 45 GeV
- for njet>0 → pT spectrum peaks at lower masses

- reason:
  - additional jets balance their pT against Z momentum
  - Z has pT != 0 → ideal "Jacobian peak" approximation is not valid

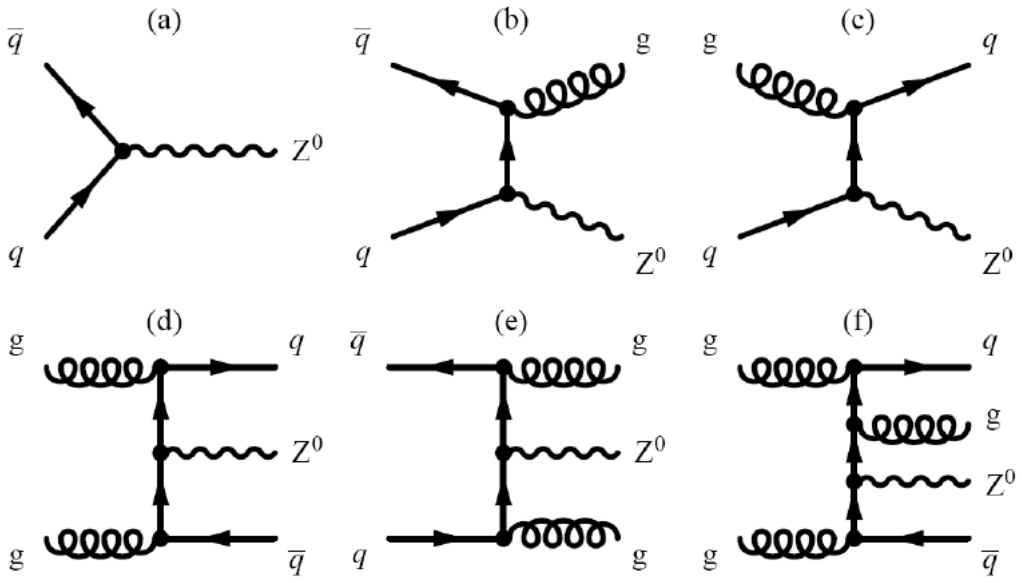
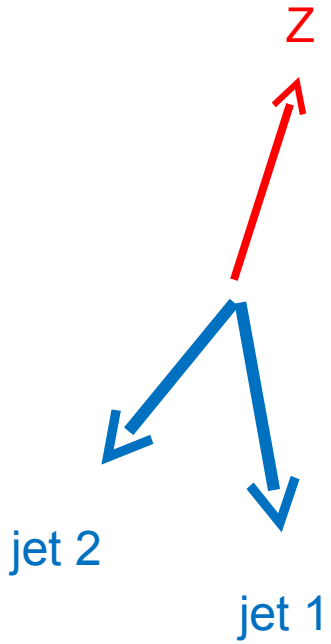
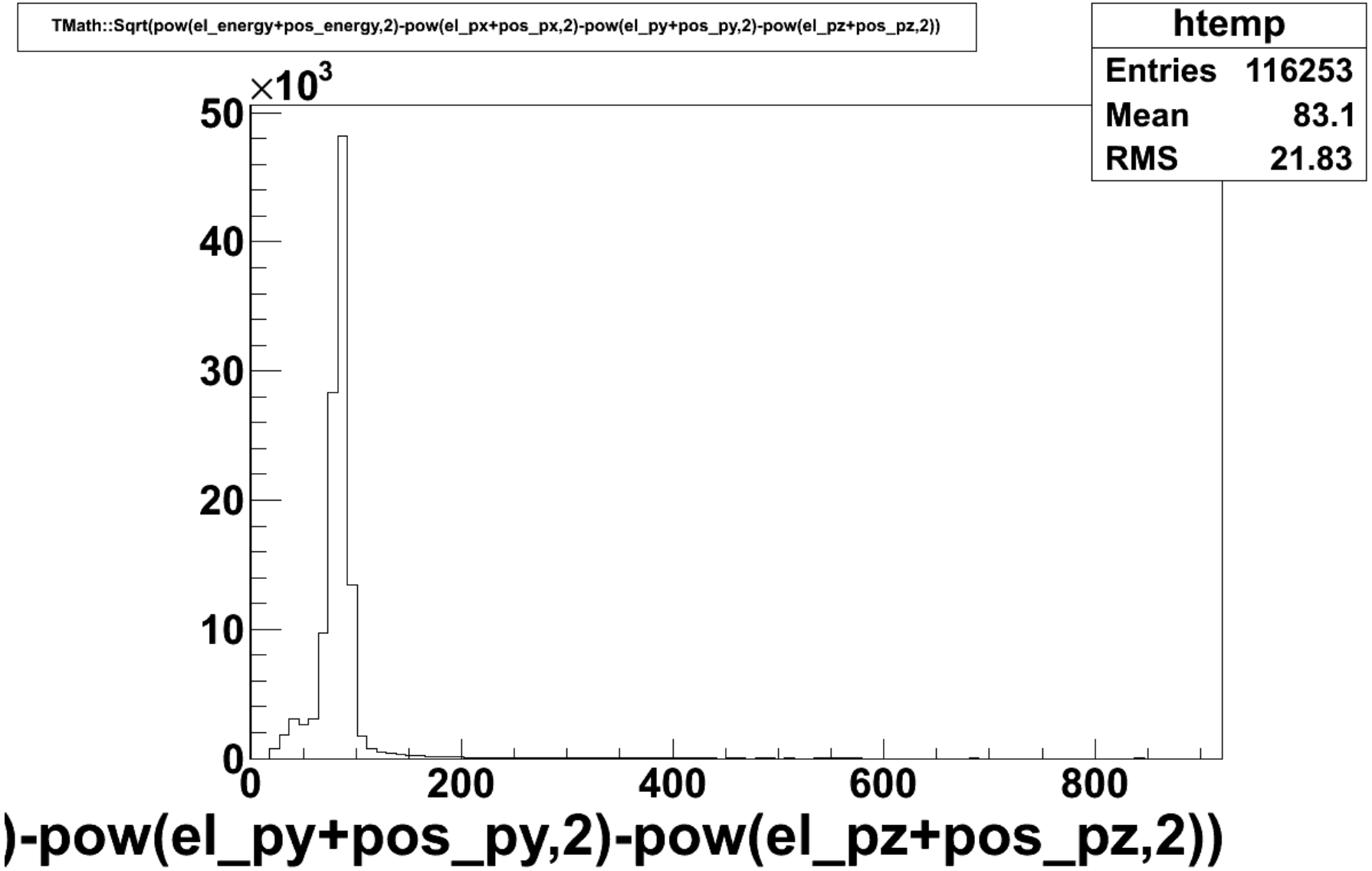


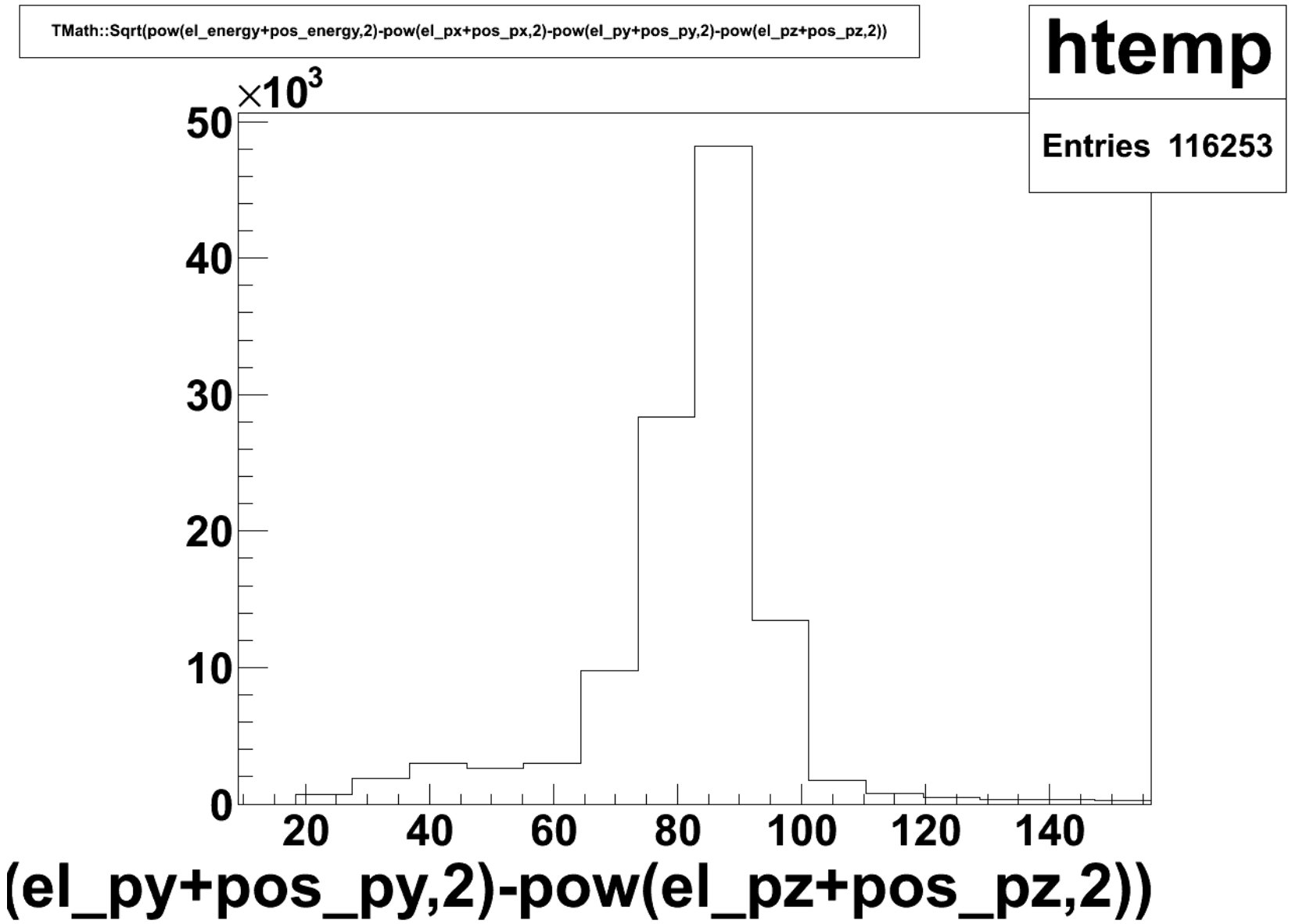
Figure 5.2: Feynman diagrams for the production of Z boson together with 0,1,2,3 jets (from [25, p.120])



Solutions of part I



Solutions of part II



Solutions of part II


```
#include "math.h"

double ElecCalib(double e_raw, double pt, double eta, double phi,
                 double etiso, double eoverp, double drjet)
{
  // useable variables
  //  e_raw = raw energy
  //     pt = transverse momentum
  //    eta = pseudorapidity
  //    phi = azimuthal angle
  //  etiso = transverse energy
  // eoverp = E/p
  //  drjet = minimal delta R of jets


  double energy = e_raw;
  double mZ = 91.2;

  // ============ energy calibration ================================================

  // if      ( fabs(eta) < 1.5 ) energy = e_raw * mZ/mObserved;
  // else if ( fabs(eta) > 2.0 ) energy = e_raw * mZ/mObserved;

  // ================================================================================


  return energy;
}
ElecCalib.C lines 1-28/28 (END)
```

Solutions of part II


```
File Edit Options Buffers Tools C++ Help
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  double energy = e_raw;
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  if      ( fabs(eta) < 0.5 ) energy = e_raw * mZ/89.26 * mZ/92.40 * mZ/92.07 * mZ/91.67 * mZ/91.47;
  else if ( fabs(eta) < 1.0 ) energy = e_raw * mZ/88.13 * mZ/91.68 * mZ/91.63 * mZ/91.32 * mZ/91.37;
  else if ( fabs(eta) < 1.5 ) energy = e_raw * mZ/86.45 * mZ/90.29 * mZ/90.97 * mZ/91.09 * mZ/91.15;
  else if ( fabs(eta) < 2.0 ) energy = e_raw * mZ/83.95 * mZ/88.12 * mZ/89.86 * mZ/90.57 * mZ/90.89;
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Solutions of part II

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Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe

http://iktp.tu-dresden.de/~felix/IntroSchool/ElecCalib.C

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  // ================================================================================================


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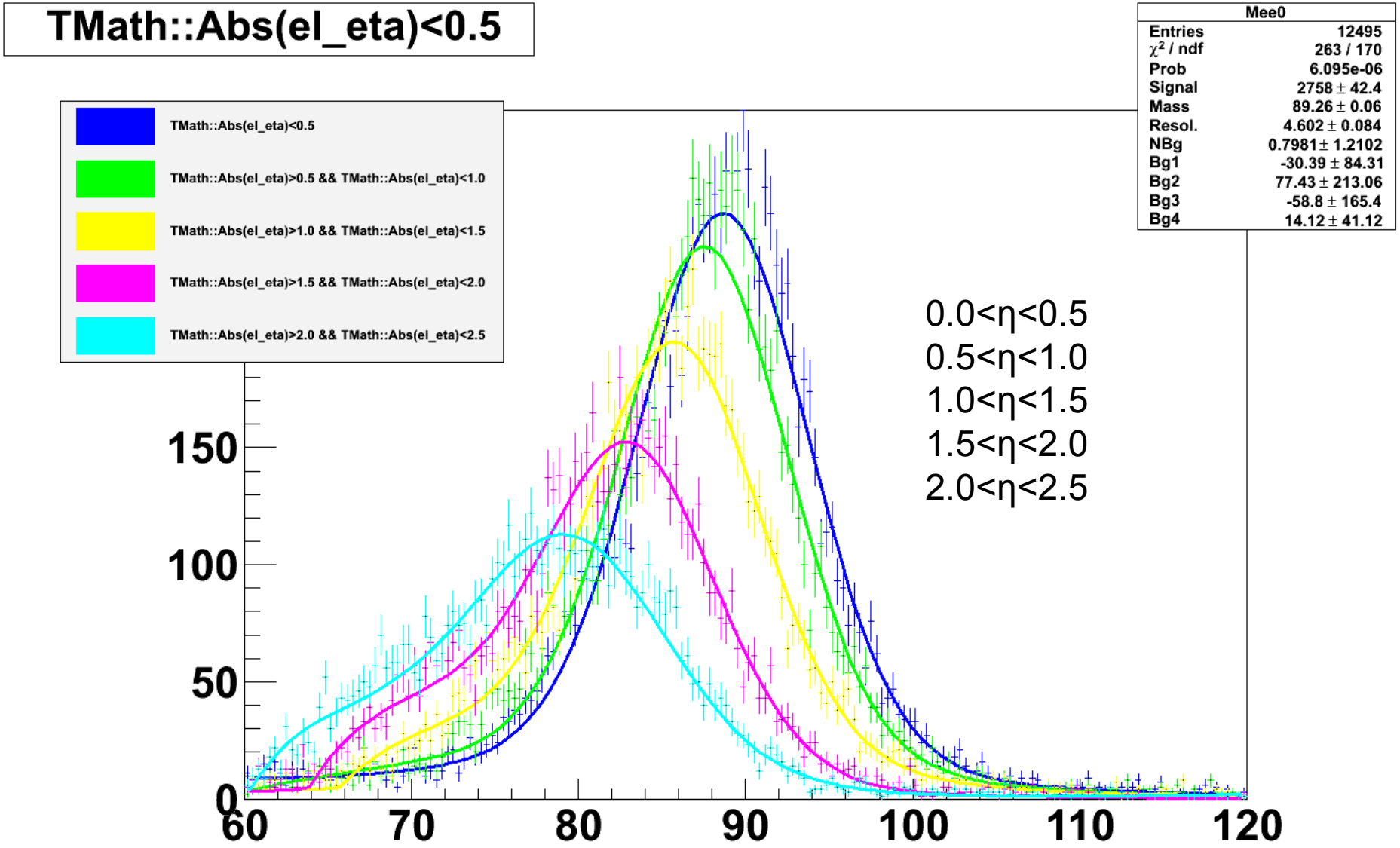
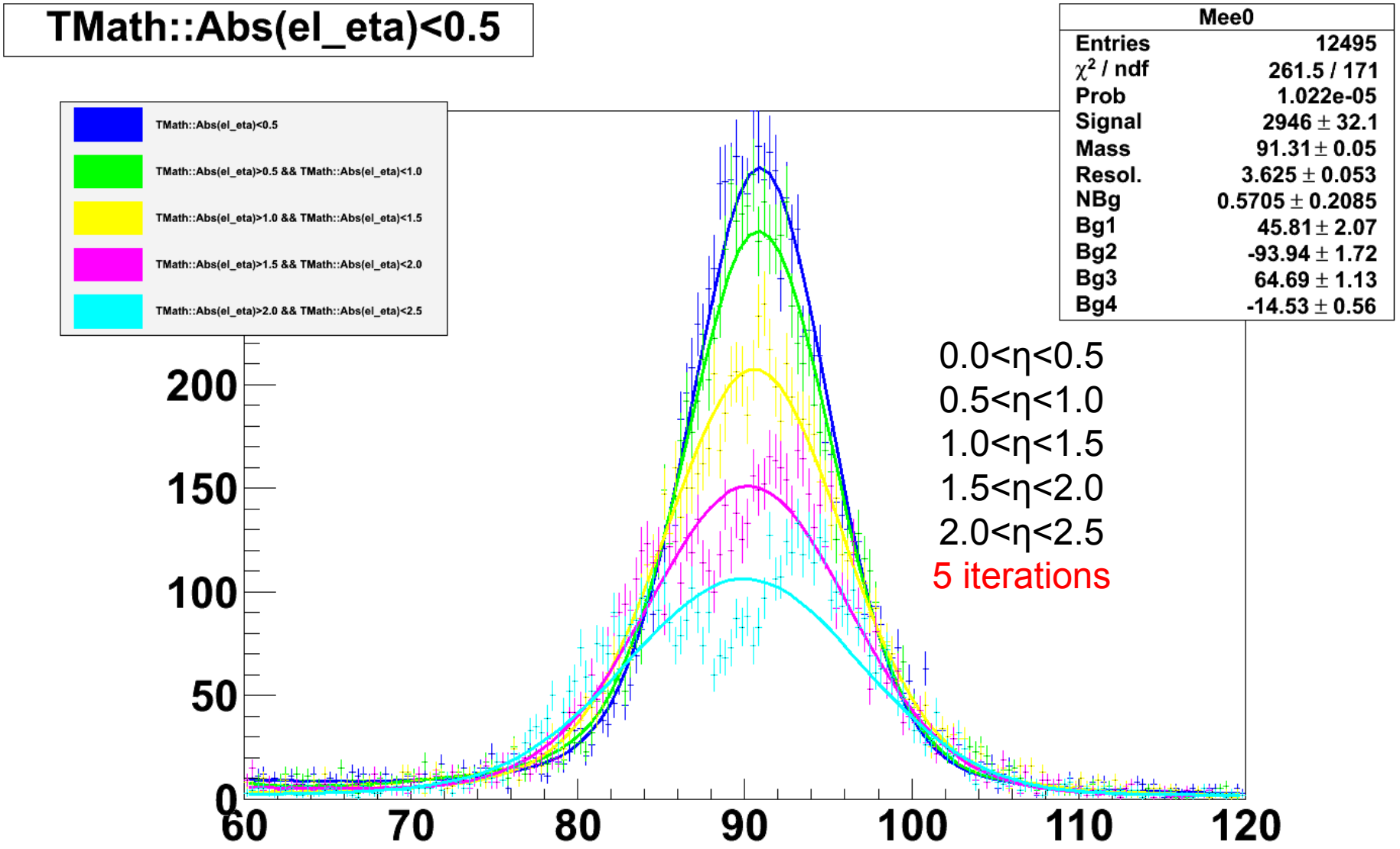
Solutions of part II



Solutions of part II



Solutions of part II