Z Physics Tutorial

Felix Friedrich, Arno Straessner – TU Dresden
Jana Kraus, Eckhard v. Törne – Universität Bonn

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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

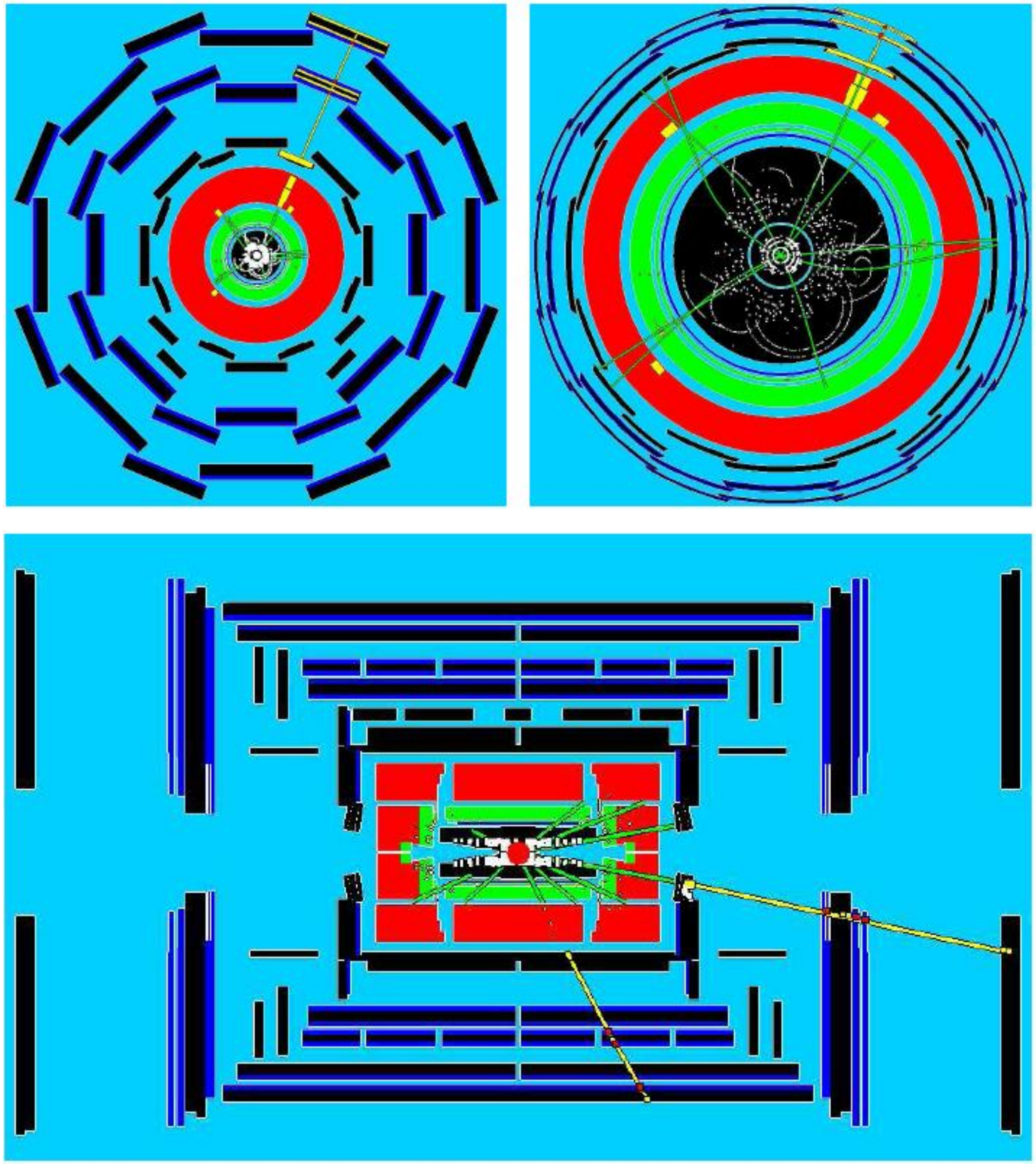
$$pp \rightarrow Z+X \rightarrow e^+e^- +X$$

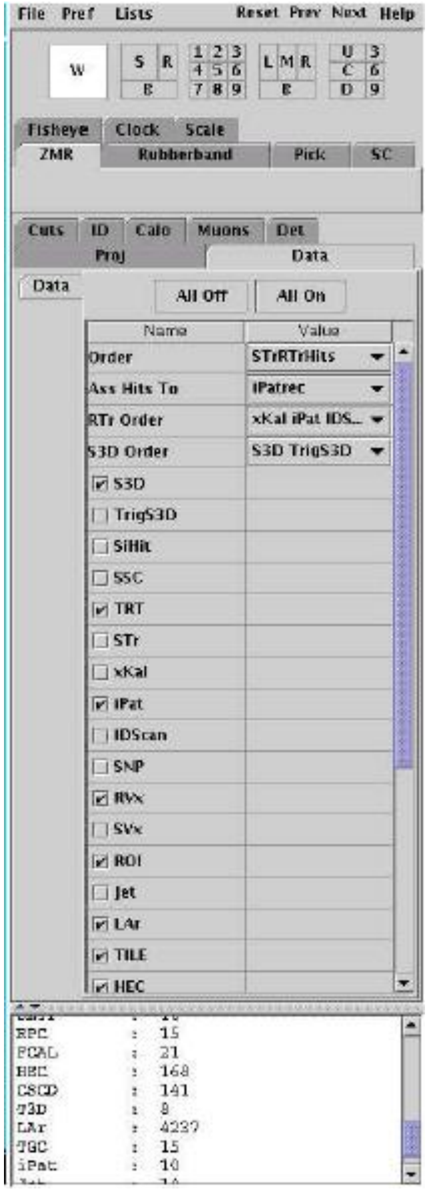
  - how to extract information from the display to calculate kinematic variables
  - you will compare measurements of the mass of Z boson, with different detectors, the calorimeter and the tracking detector
  - use ROOT for the calculation

- 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

- tomorrow: Part III:
  - measurement of the W mass from lepton p_T spectrum

ATLANTIS

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LAr
TILE
HEC
RPC : 15
FCAL : 21
HEC : 168
CSCD : 141
T3D : 8
LAr : 4237
TGC : 15
iPat : 10

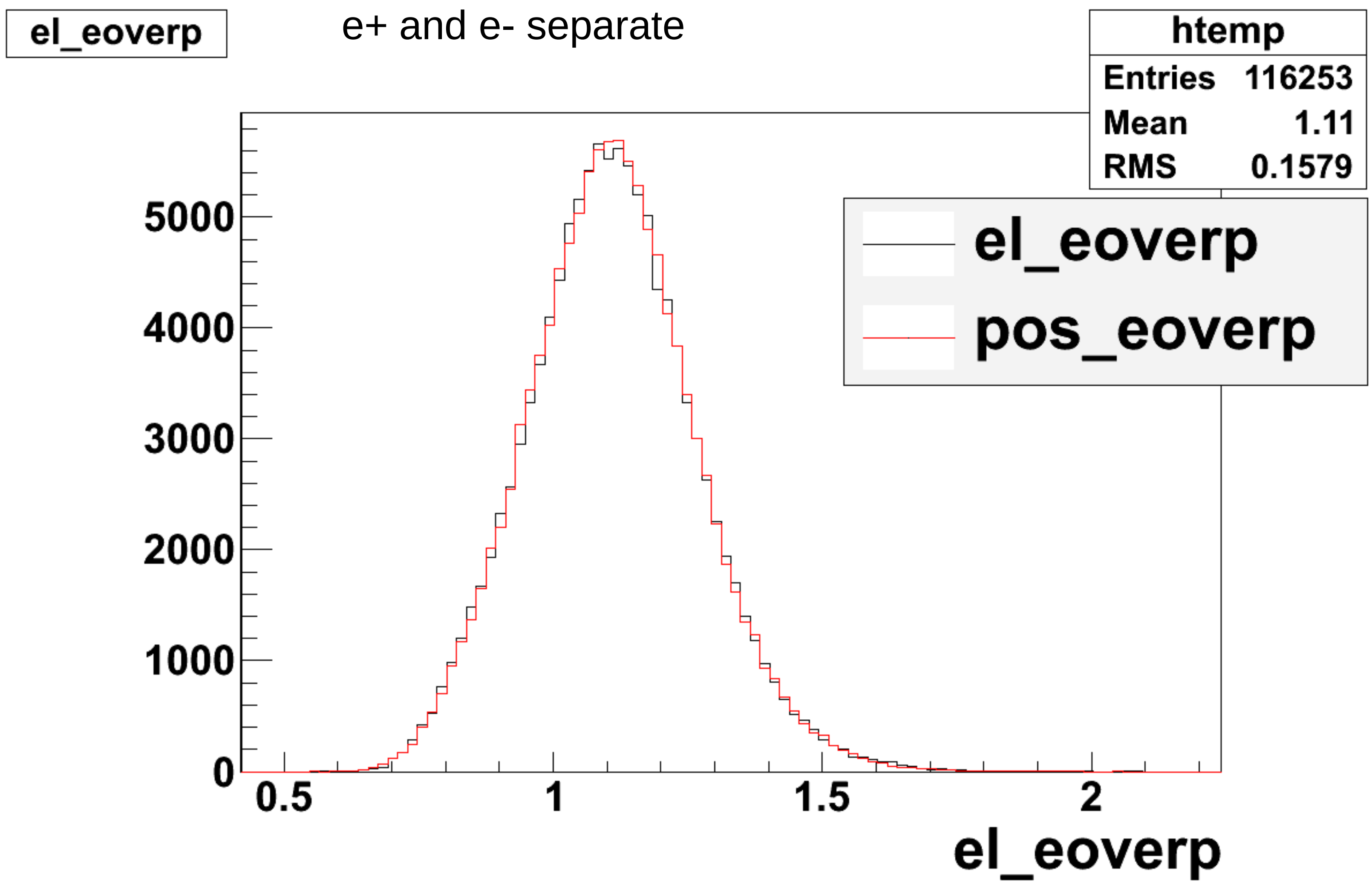
Helpful hints for part I

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

Solutions part I

- Z mass event #3
  - calorimeter m_{ee}= 119.991 GeV
  - tracker m_{ee}= 83.7935 GeV
- Z mass event #7
  - calorimeter m_{ee}= 86.0215 GeV
  - tracker m_{ee}= 68.5353 GeV
- Z mass event #9
  - calorimeter m_{ee}= 87.4466 GeV
  - tracker m_{ee}= 34.5958 GeV

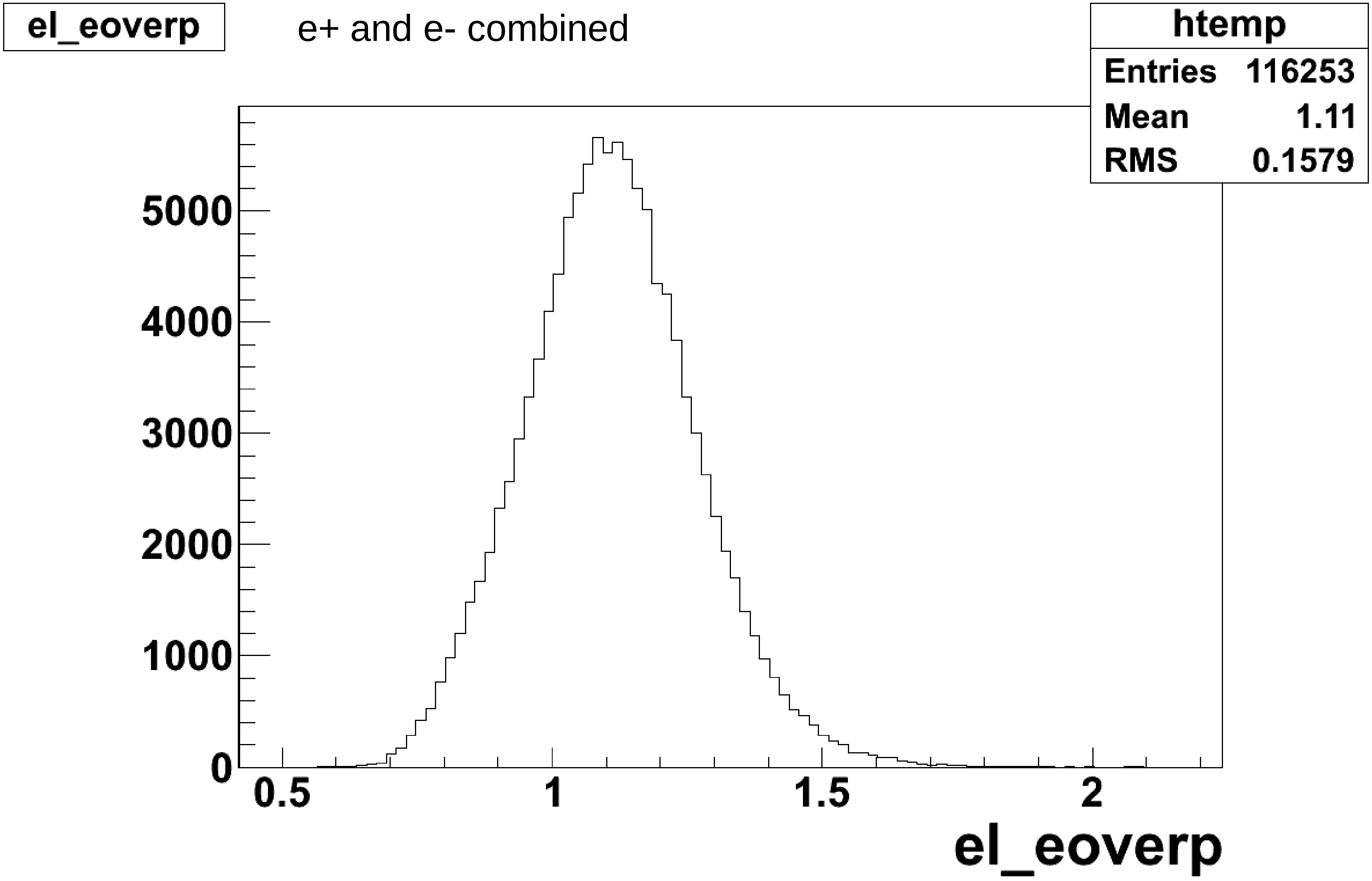
Solutions of part II



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

Solutions of part II

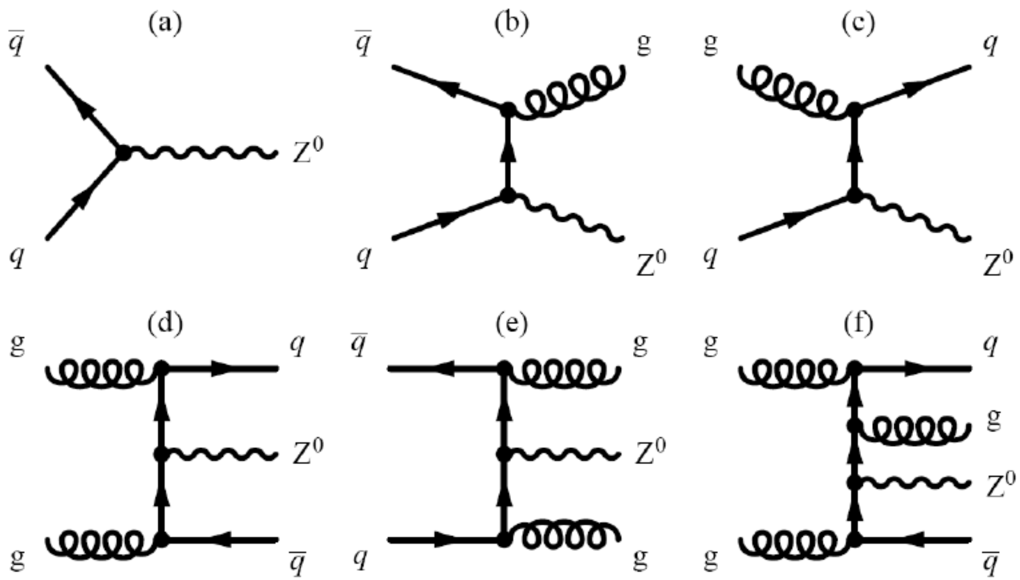
e+ and e- combined



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



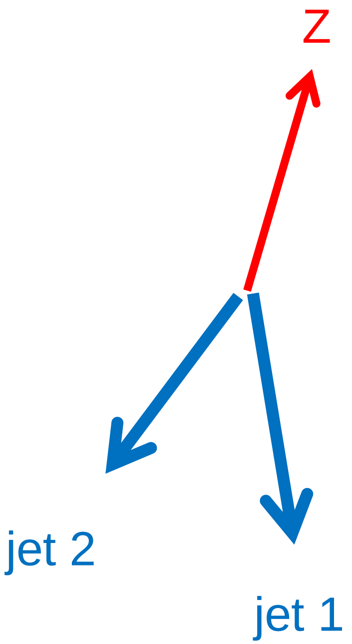
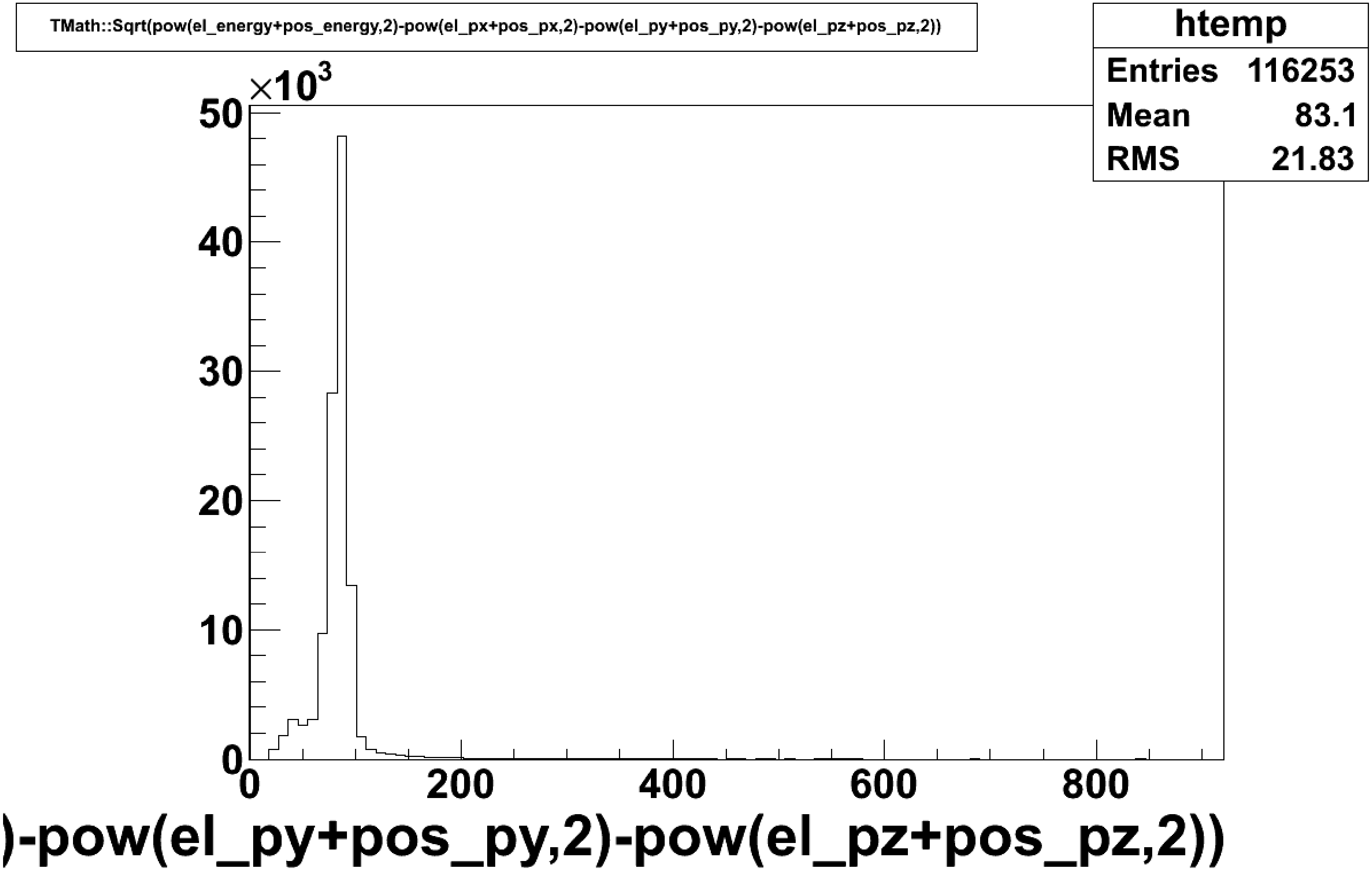
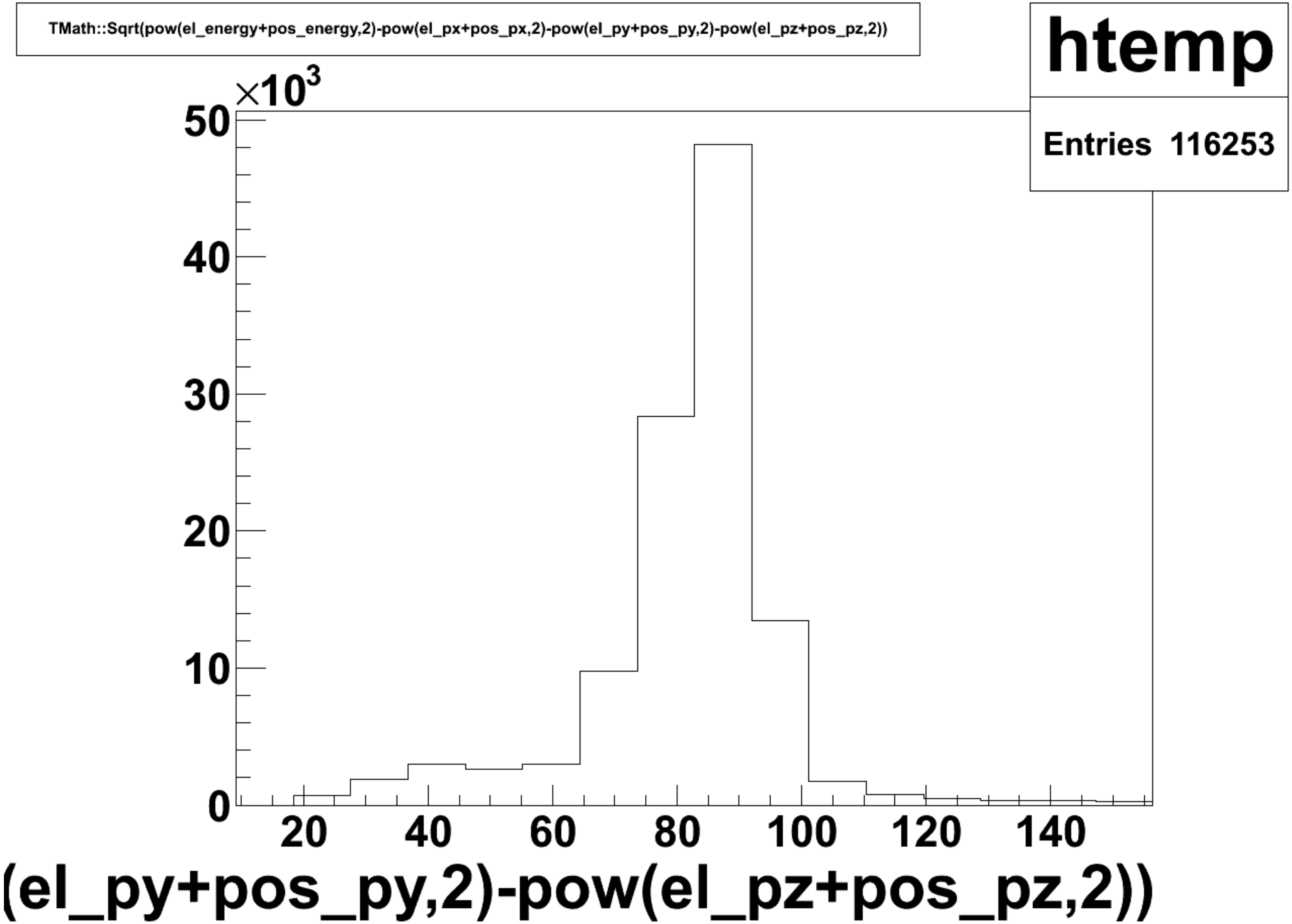


Figure 5.2: Feynman diagrams for the production of Z boson together with 0,1,2,3 jets (from [25, p.120])

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
#include "math.h"

double ElecCalib(double e_raw, double pt, double eta, double phi,
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  double energy = e_raw;
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  // ============ energy calibration ===================================================================

  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;
  else if ( fabs(eta) < 2.5 ) energy = e_raw * mZ/80.39 * mZ/86.49 * mZ/89.40 * mZ/90.50 * mZ/90.86;

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


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Solutions of part II

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


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```

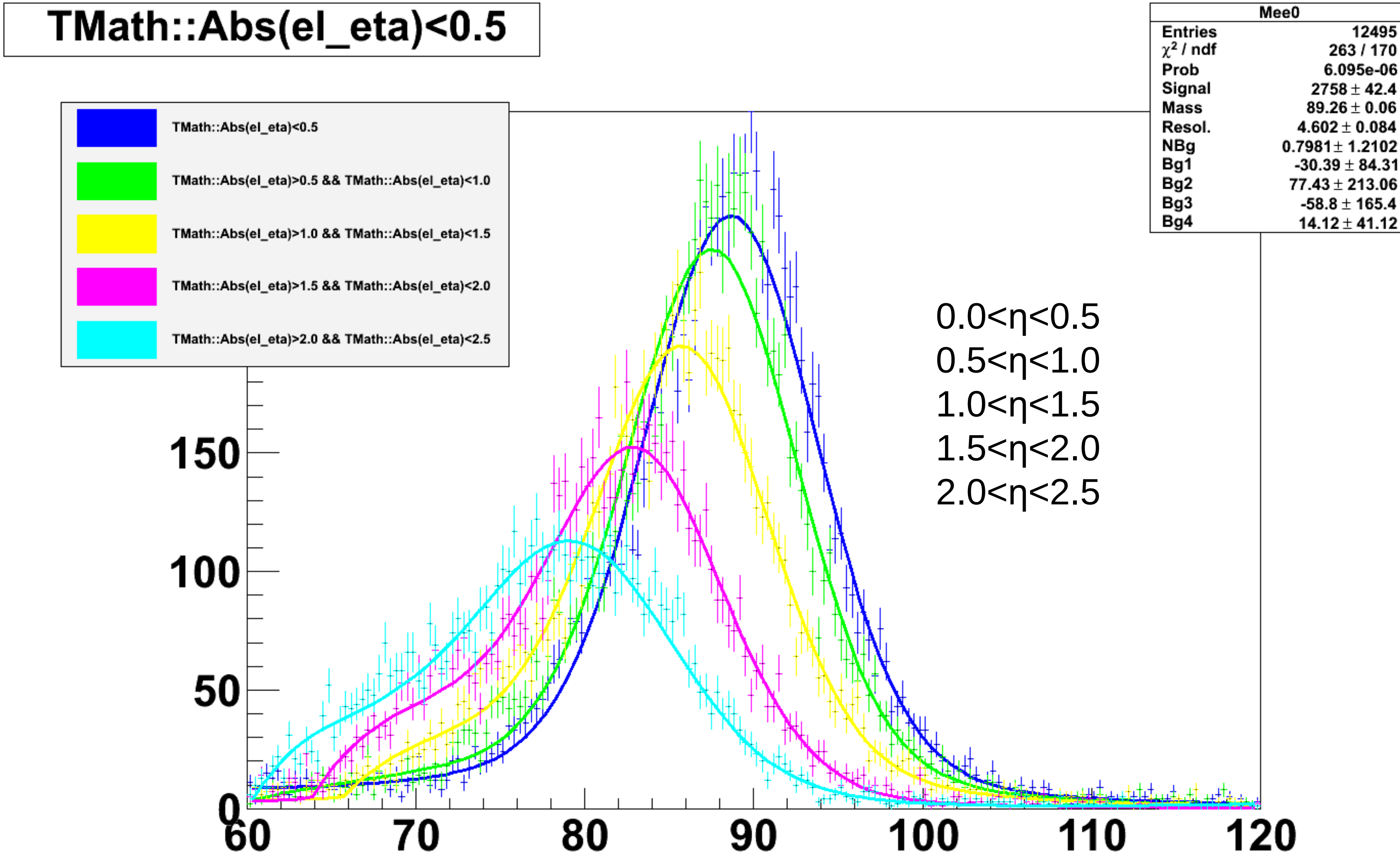
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TMath::Abs(el_eta)<0.5
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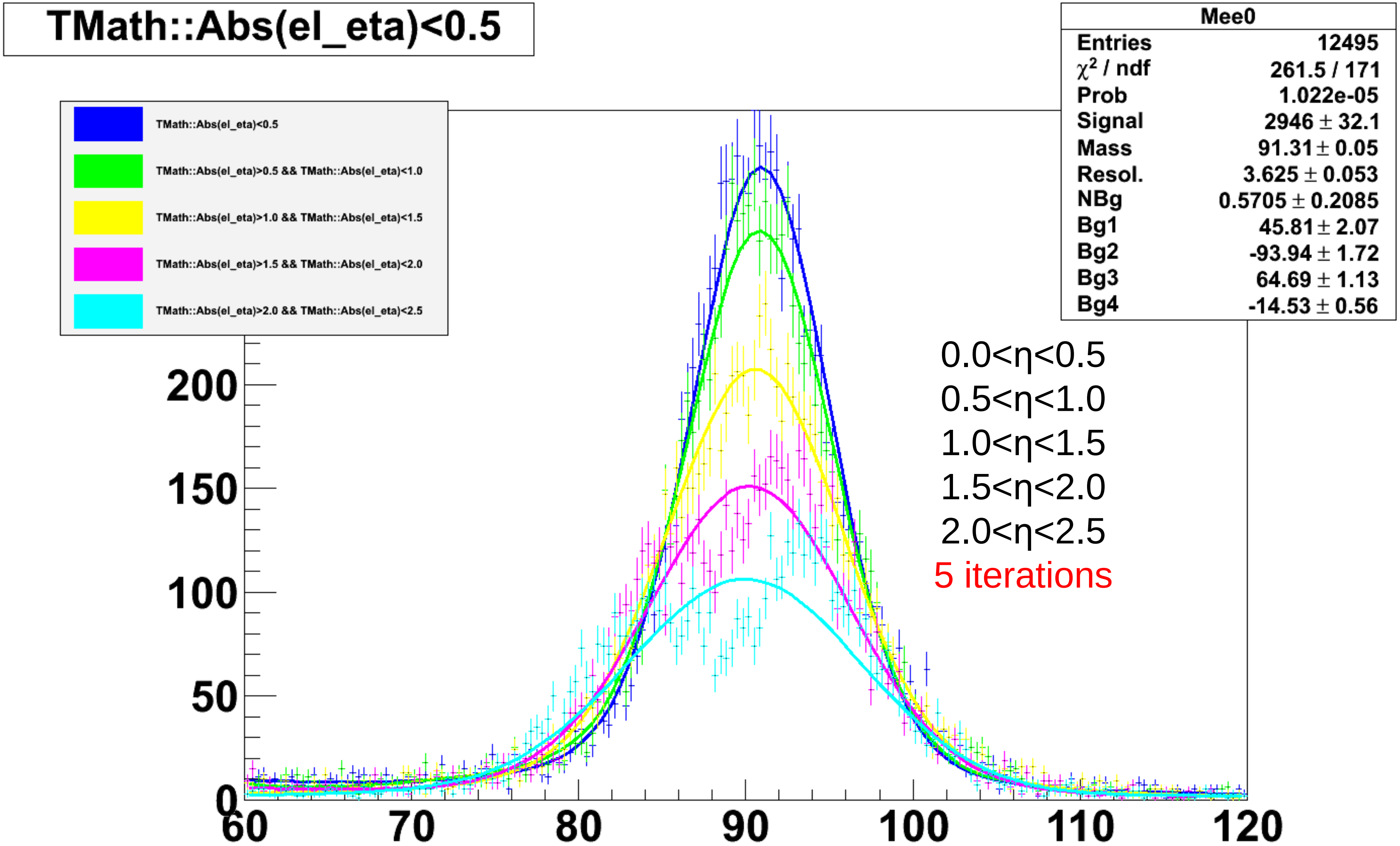
TMath::Abs(el_eta)>1.5 && TMath::Abs(el_eta)<2.0
TMath::Abs(el_eta)>2.0 && TMath::Abs(el_eta)<2.5
Mee0
Entries 12495
χ² / ndf 263 / 170
Prob 6.095e-06
Signal 2758 ± 42.4
Mass 89.26 ± 0.06
Resol. 4.602 ± 0.084
NBg 0.7981 ± 1.2102
Bg1 -30.39 ± 84.31
Bg2 77.43 ± 213.06
Bg3 -58.8 ± 165.4
Bg4 14.12 ± 41.12
0.0<η<0.5
0.5<η<1.0
1.0<η<1.5
1.5<η<2.0
2.0<η<2.5
0
50
100
150
60
70
80
90
100
110
120

Solutions of part II



Solutions of part II