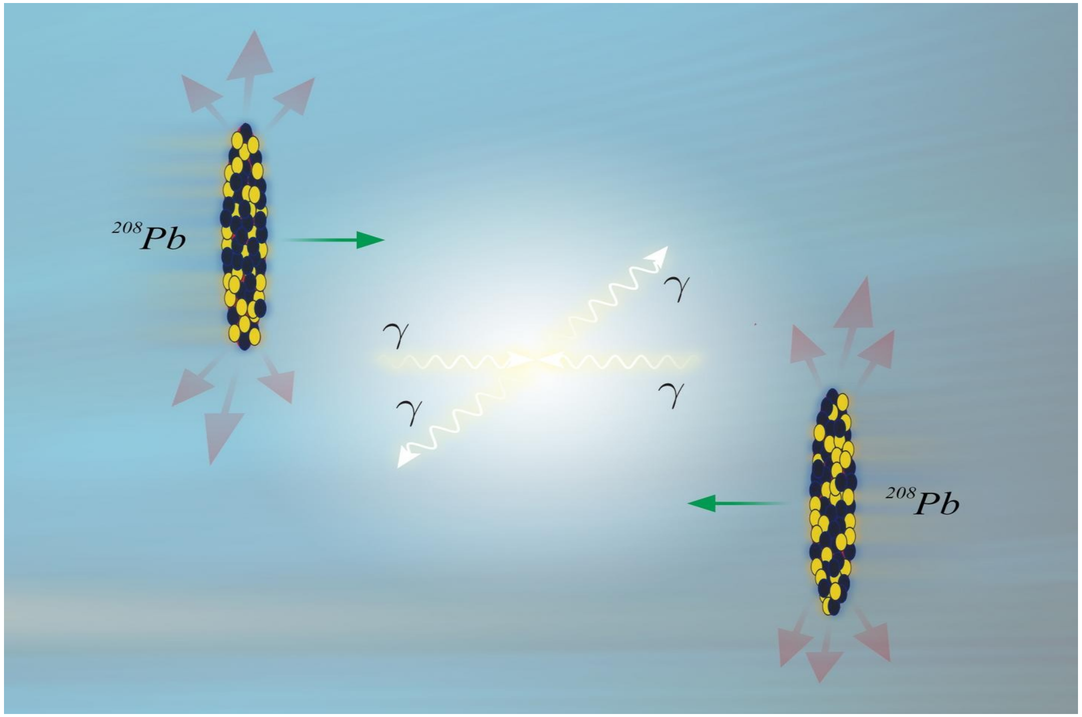


UPC

Rafael Espinosa Castañeda
Dr. Daniel Tapia Takaki
Dr. Arturo Fernández Téllez

July 2 2016

- Work with Dr. Daniel Tapia

  Comparating data with PhD student of Dr. Tapia

  (Photon Flux and average energy W)

  J/Psi MonteCarlo Simulation

  and Comparison with Experimental Data

  Rho Zero MonteCarlo Simulation and Comparison with Experimental Data

- Beam Test

$$n(k,\mathbf{b}) = \frac{\alpha Z^2}{\pi^2 b^2} x^2 \left[K_1^2(x) + \frac{1}{\gamma} K_0^2(x) \right], \tag{3}$$

where k is the photon energy in the nucleus frame with Lorentz factor γ, Z is the electric charge of the emitting heavy nuclei, K_0 and K_1 are Bessel functions and $x = kb/\gamma$. This formula is a good approximation for heavy nuclei and at impact parameters b larger than $b_{\min}$, the sum of the radii of the interacting particles. In this case, the photon flux $n(k) = \int d^2\mathbf{b}\, n(k,\mathbf{b})$ is given by

$$n(k) = \frac{2\alpha Z^2}{\pi} \left[\xi K_0(\xi) K_1(\xi) - \frac{\xi^2}{2} \left(K_1^2(\xi) - K_0^2(\xi) \right) \right], \tag{4}$$

where $\xi = kb_{\min}/\gamma$.

The photon flux from a lead nucleus is then obtained using the corresponding values of Z and γ and using rapidity instead of photon energy as the relevant variable:

$$N_{\gamma/\mathrm{Pb}}(y, M) \equiv k \frac{dn(k)}{dk} \bigg|_{\mathrm{Pb}} . \tag{5}$$

J/Psi Rapidity bin: (-2.3,-1.8) Center-of-mass energy = 2760 GeV kdn/dk_av = 137.214 W_av 328.743

J/Psi Rapidity bin: (1.8,2.3) Center-of-mass energy = 2760 GeV kdn/dk_av = 16.295 W_av 42.804

Upsilon Rapidity bin: (-2,-1.2) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 14.9258 W_av 601.271

Upsilon Rapidity bin: (-1.2,0) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 39.9458 W_av 369.54

Upsilon Rapidity bin: (0,1.2) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 75.7304 W_av 206.665

Upsilon Rapidity bin: (1.2,2) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 106.749 W_av 124.97

Upsilon Rapidity bin: (-2,-1.2) Center-of-mass energy = 8000.33 GeV kdn/dk_av = 25.4664 W_av 766.539

Upsilon Rapidity bin: (-1.2,0) Center-of-mass energy = 8000.33 GeV kdn/dk_av = 53.4382 W_av 470.787

Upsilon Rapidity bin: (0,1.2) Center-of-mass energy = 8000.33 GeV kdn/dk_av= 90.1214 W_av 261.807

Upsilon Rapidity bin: (1.2,2) Center-of-mass energy = 8000.33 GeV kdn/dk_av = 121.266 W_av 157.855

Rho zero Rapidity bin: (-2,-1.2) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 85.0413 W_av 176.821

Rho zero Rapidity bin: (-1.2,0) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 116.169 W_av 108.699

Rho zero Rapidity bin: (0,1.2) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 153.64 W_av 59.8905

Rho zero Rapidity bin: (1.2,2) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 184.883 W_av 35.8871

Rho zero Rapidity bin: (-2,-1.2) Center-of-mass energy = 8000.33 GeV kdn/dk_av = 99.5005 W_av 223.454

Rho zero Rapidity bin: (-1.2,0) Center-of-mass energy = 8000.33 GeV kdn/dk _av= 130.694 W_av 137.421

Rho zero Rapidity bin: (0,1.2) Center-of-mass energy = 8000.33 GeV kdn/dk_av = 168.178 W_av 75.6599

Rho zero Rapidity bin: (1.2,2) Center-of-mass energy = 8000.33 GeV kdn/dk_av = 199.423 W_av 45.3034

J/Psi Rapidity bin: (2.5,4) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 7.30747 W_av 37.6104

J/Psi Rapidity bin: (3.5,4) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 1.68832 W_av 25.1017

J/Psi Rapidity bin: (3,3.5) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 6.04051 W_av 31.8919

J/Psi Rapidity bin: (2.5,3) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 14.1565 W_av 40.669

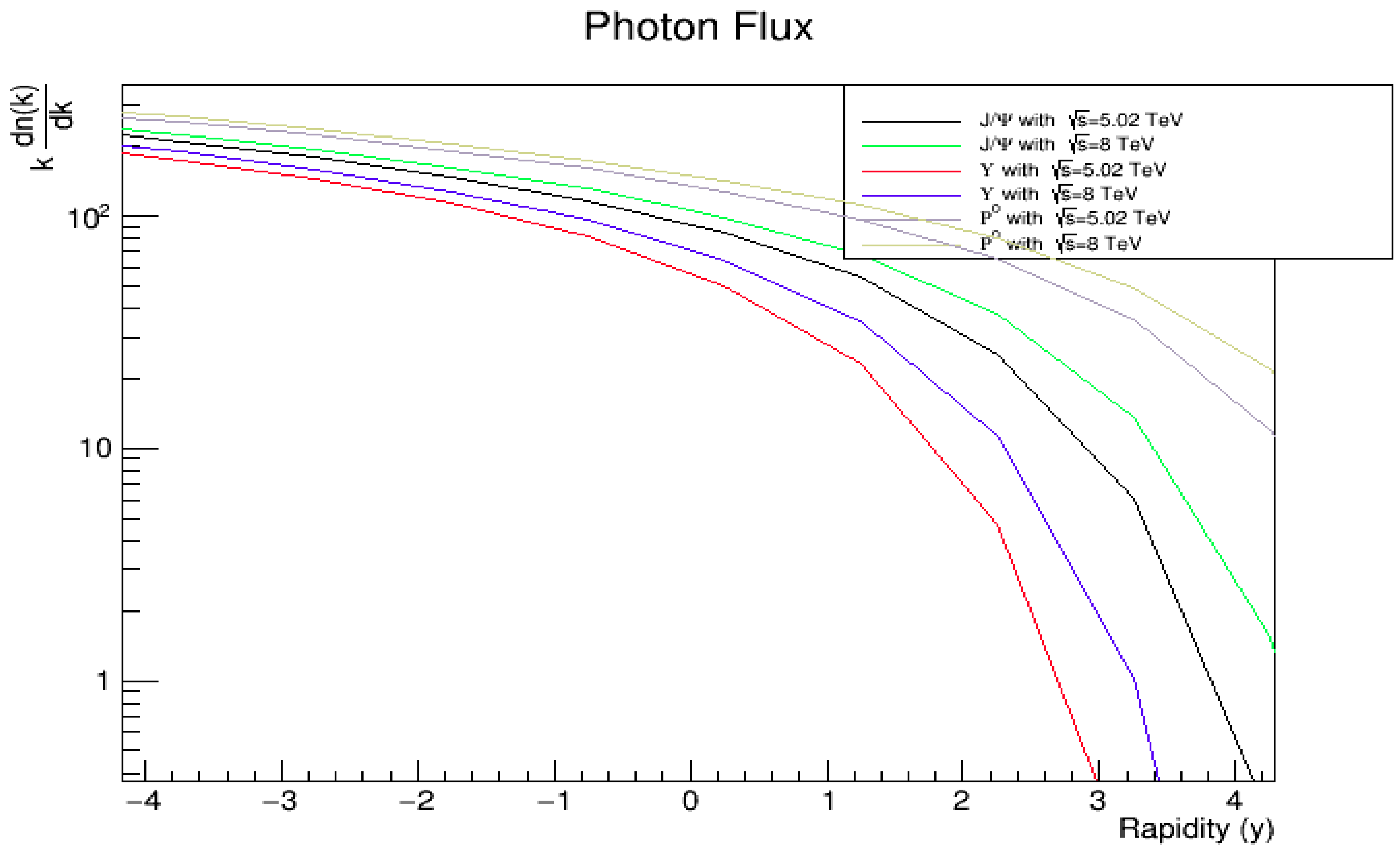
J/Psi Rapidity bin: (-3.6,-2.6) Center-of-mass energy = 5020.01 GeV kdn/dk_av = 188.622 W_av 766.058

J/Psi Rapidity bin: (-2,-1.2) Center-of-mass energy = 8000.33 GeV kdn/dk _av= 156.452 W_av 452.786

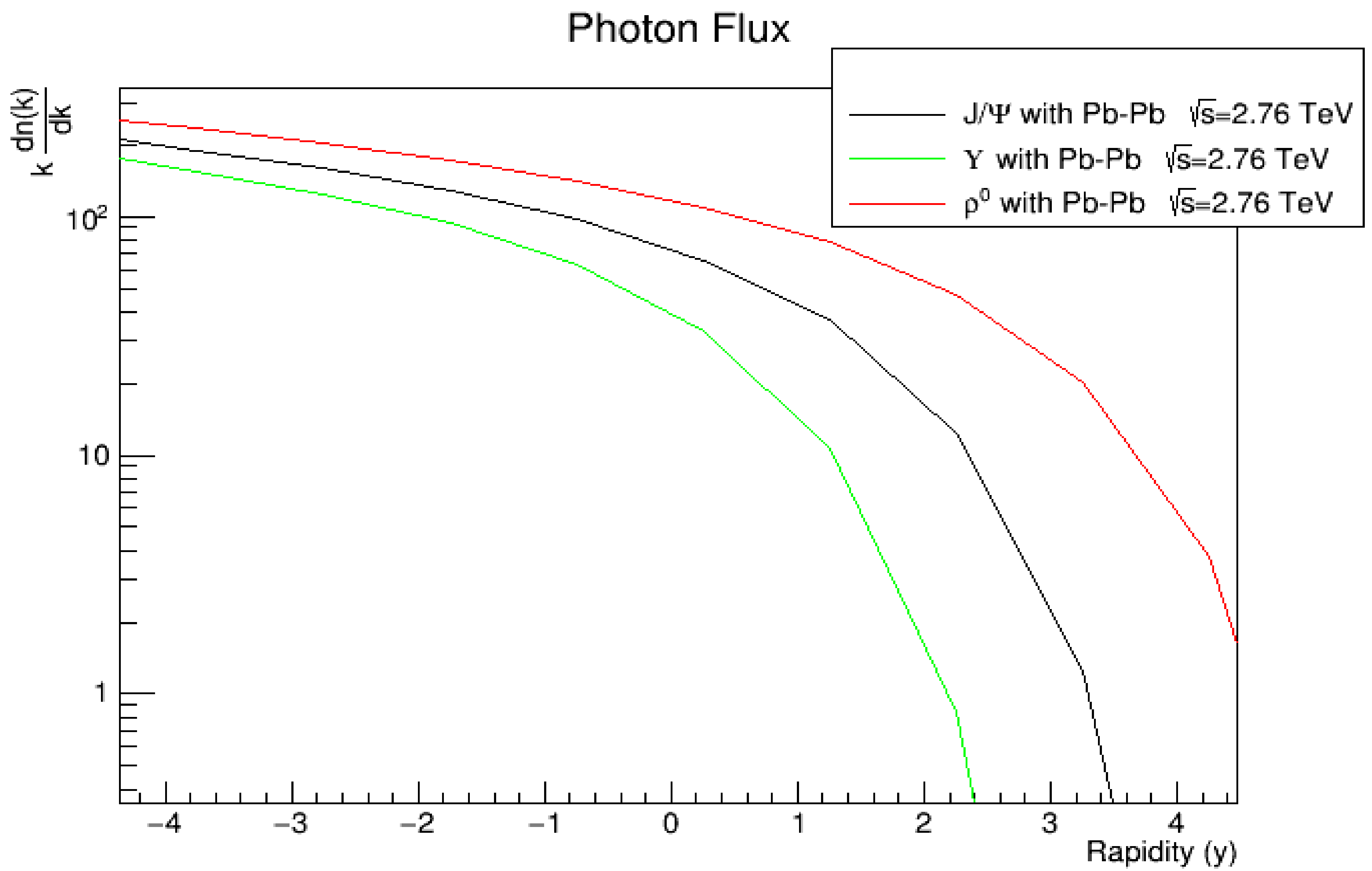
J/Psi Rapidity bin: (-1.2,0) Center-of-mass energy = 8000.33 GeV kdn/dk_av = 125.22 W_av 282.65

J/Psi Rapidity bin: (0,1.2) Center-of-mass energy = 8000.33 GeV kdn/dk _av= 87.8456 W_av 156.027

J/Psi Rapidity bin: (1.2,2) Center-of-mass energy = 8000.33 GeV kdn/dk_av = 57.1559 W_av 92.19



Photon Flux
k dn(k)/dk
Rapidity (y)
J/Ψ with √s=5.02 TeV
J/Ψ with √s=8 TeV
Υ with √s=5.02 TeV
Υ with √s=8 TeV
ρ⁰ with √s=5.02 TeV
ρ⁰ with √s=8 TeV
10²
10
1
−4
−3
−2
−1
0
1
2
3
4



Photon Flux
k dn(k)/dk
10^2
10
1
−4
−3
−2
−1
0
1
2
3
4
Rapidity (y)
J/Ψ with Pb-Pb √s=2.76 TeV
ϒ with Pb-Pb √s=2.76 TeV
ρ^0 with Pb-Pb √s=2.76 TeV

J/Psi MonteCarlo Simulation and Comparison with Experimental Data

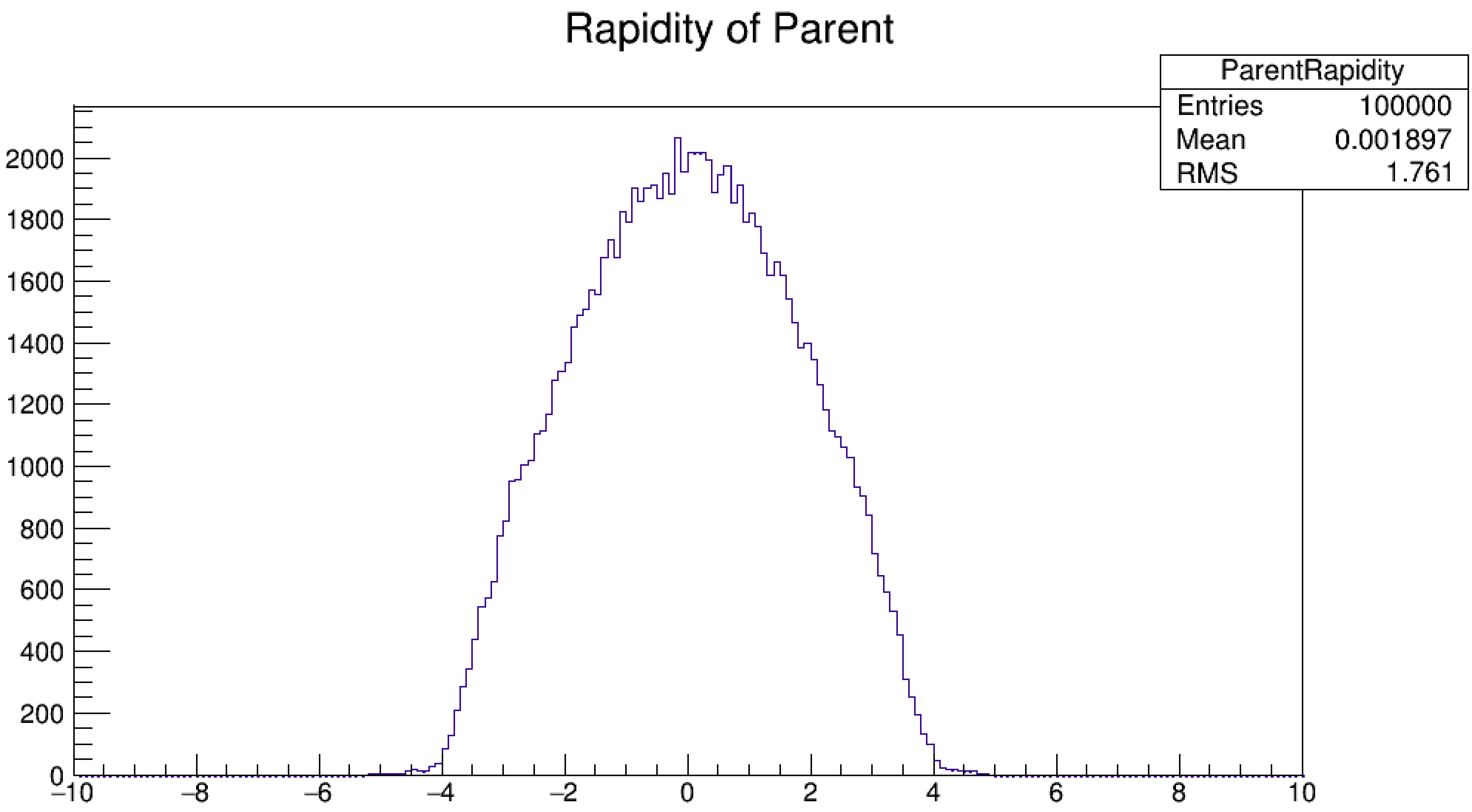
Input slight.in for J/Psi Production

baseFileName = slight

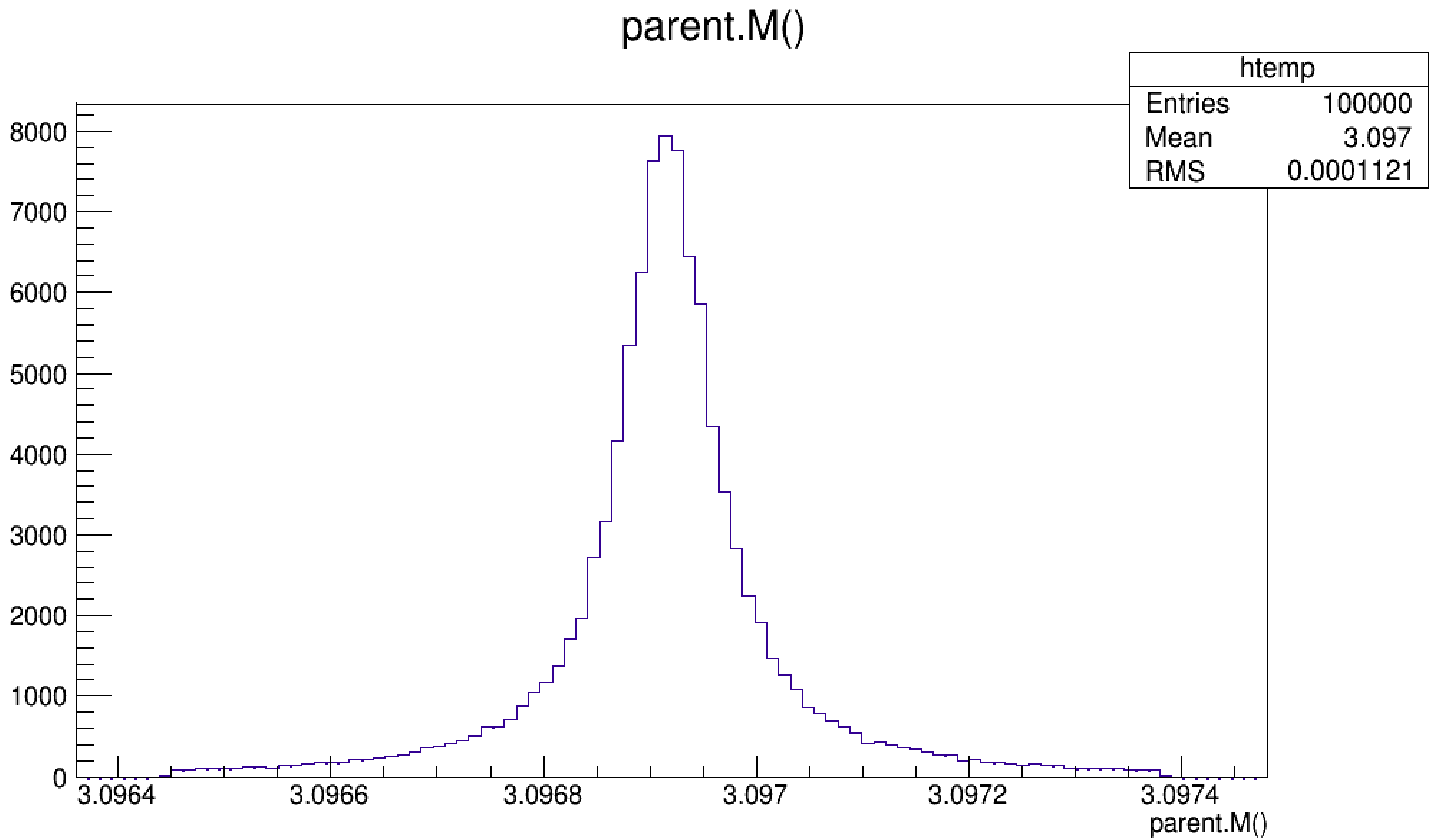
- BEAM_1_Z = 82   #Z of projectile
- BEAM_1_A = 208   #A of projectile
- BEAM_2_Z = 82   #Z of target
- BEAM_2_A = 208   #A of target
- BEAM_1_GAMMA = 1470.0 #Gamma of the colliding ion 1
- BEAM_2_GAMMA = 1470.0 #Gamma of the colliding ion 2
- W_MAX = -1   #Max value of w
- W_MIN = -1   #Min value of w
- W_N_BINS = 50   #Bins i w
- RAP_MAX = 9.   #max y
- RAP_N_BINS = 200   #Bins i y
- CUT_PT = 0 #Cut in pT? 0 = (no, 1 = yes)
- PT_MIN = 1.0 #Minimum pT in GeV
- PT_MAX = 3.0 #Maximum pT in GeV
- CUT_ETA = 0 #Cut in pseudorapidity? (0 = no, 1 = yes)
- ETA_MIN = -10 #Minimum pseudorapidity
- ETA_MAX = 10 #Maximum pseudorapidity
- PROD_MODE = 2   #gg or gP switch (1 = 2-photon, 2 = coherent vector meson (narrow), 3 = coherent vector meson (wide), 4 = incoherent vector mes
- N_EVENTS = 100000   #Number of events
- PROD_PID = 443013   #Channel of interest; this is j/psi --> mu+ mu-
- RND_SEED = 5574533 #Random number seed
- BREAKUP_MODE = 5   #Controls the nuclear breakup; a 5 here makes no requirement on the breakup of the ions
- INTERFERENCE = 0   #Interference (0 = off, 1 = on)
- IF_STRENGTH = 1.   #% of intefernce (0.0 - 0.1)
- INT_PT_MAX = 0.24 #Maximum pt considered, when interference is turned on
- INT_PT_N_BINS =120   #Number of pt bins when interference is turned on
- XSEC_METHOD = 1 # Set to 0 to use old method for calculating gamma-gamma luminosity
- PYTHIA_FULL_EVENTRECORD = 0 # Write full pythia information to output (vertex, parents, daughter etc).

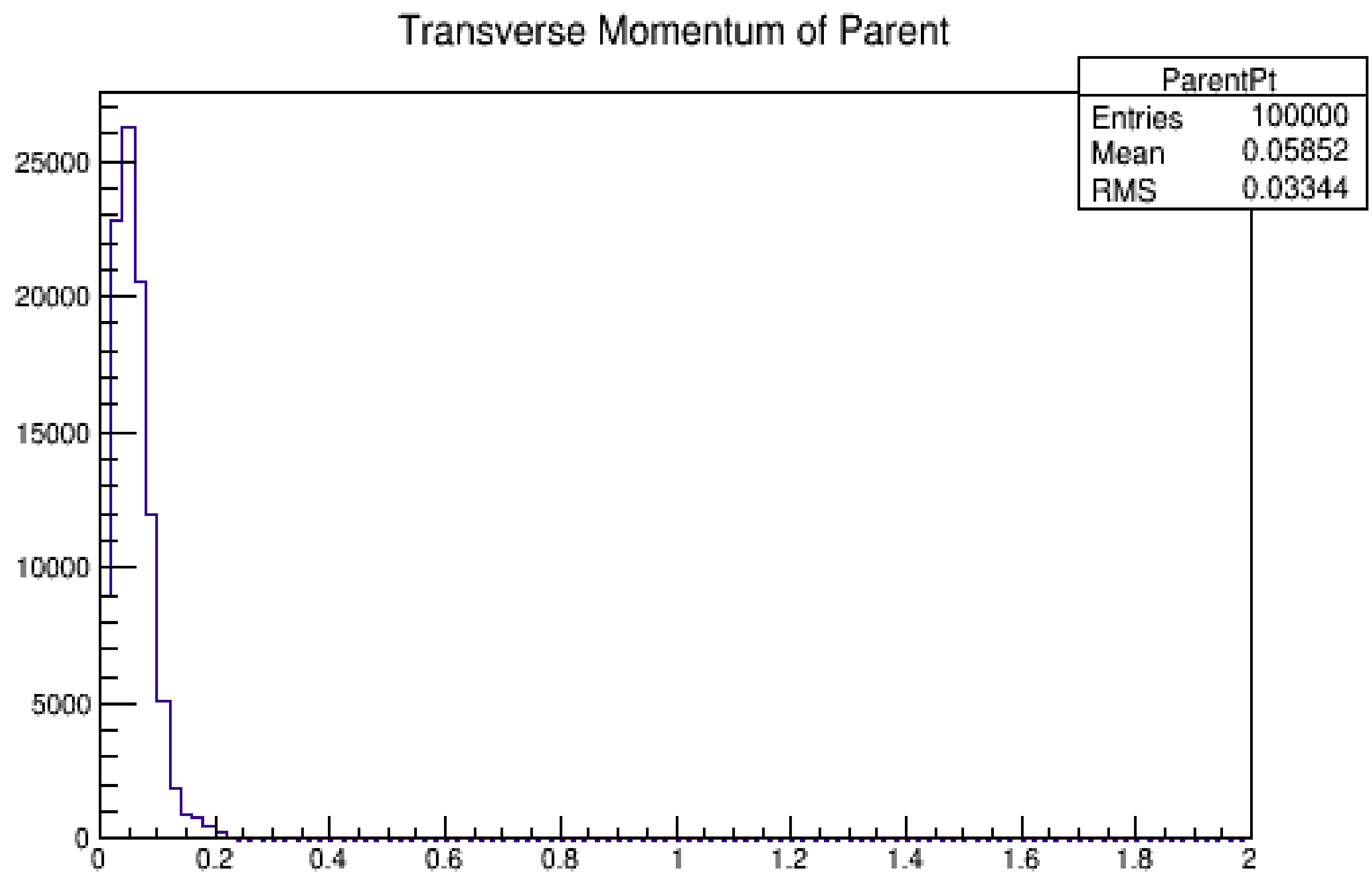
Created a Tree for Data Analysis and

- Plots of :
- Invariant Mass
- Pt
- Rapidity



Rapidity of Parent
ParentRapidity
Entries 100000
Mean 0.001897
RMS 1.761
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−10
−8
−6
−4
−2
0
2
4
6
8
10


parent.M()
htemp
Entries 100000
Mean 3.097
RMS 0.0001121
8000
7000
6000
5000
4000
3000
2000
1000
0
3.0964
3.0966
3.0968
3.097
3.0972
3.0974
parent.M()



Transverse Momentum of Parent
ParentPt
Entries 100000
Mean 0.05852
RMS 0.03344
25000
20000
15000
10000
5000
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2

Information for Plot

We obtain with the formula

dsigma/dy=(NumberofDataInaBin/TotalNumberofData)*sigmagivenbyMontecarlo

sigma(y)=(1/PhotonFlux)*dsigma/dy

- Total Cross section given by MonteCarlo for J/Psi

15.191 mb

Experimental Data of dsimga/dy for J/Psi

- dsigma/dy= 1.0+-0.18(stat)^+0.24_0.26 mb for bin -3.6<y<-2.6

  (obtained from doi:10.1016/j.physletb.2012.11.059)

- dsigma/dy= 2.38^+0.34_-0.24 mb for bin -0.9<y<0.9

  (obtained from 10.1140/epjc/s10052-013-2617-1)

- dsigma/dy=0.36+-0.22(stat)+-0.19(theo) mb or bin 1.8<y<2.3

  (obtained from arXiv:1605.06966)

Code for Cross Section vs Rapidity (MonteCarlo)

```
• yrapidity=D1->Rapidity();
•
•       Double_t j_step=0.05;
•      int counting=0;
• for(Double_t j=-4.0;j<4.0-j_step;j+=j_step)
• {
•        Double_t PbBeamEnergy = pBeamEnergy*IonCharge/IonAtomicNumber;
•         Double_t PbLorentzBoost = PbBeamEnergy/ProtonMass;
•        Double_t k = 0.5*rhozeroMass*TMath::Exp(-yrapidity);
•        W = Wcms(yrapidity,pBeamEnergy,rhozeroMass);
• Flux = HardSphereFlux(PbLorentzBoost,k,BMIN);
•        if(yrapidity>j && yrapidity<j+j_step )
• {
•  bincounting[counting]= bincounting[counting]+1;
•  Wcounter[counting]= Wcounter[counting]+W;//*XS*Flux;
•  FluxCounter[counting]=FluxCounter[counting]+Flux;
•        dividing[counting]=dividing[counting]+XS*Flux;
• break;
• }
• counting=counting+1;
• }
• NUMBER=NUMBER+1;
• dXs_dy=bincounting[i]*sigma/NUMBER;
•        W=Wcounter[i]/bincounting[i];
• Flux=FluxCounter[i]/bincounting[i];
• TSIGMA=dXs_dy*(1/Flux); //mb
•        cout<<TSIGMA<<endl;
• h2->Fill(W,TSIGMA);
```

Code for Cross Section vs Rapidity (Experimental Data)

- Double_t dXs_dyExperimental=425; //mb
- Double_t yExpstep=0.05;
- Double_t FluxAveExp;
- Double_t WAveExp;
- Double_t W2;
- Double_t Flux2;
- Double_t countern;
- Double_t sigmaExp;
- countern=0.0;
- WAveExp=0.0;
- for(Double_t yExp=-0.5;yExp<=0.5;yExp+=yExpstep)
- {
- Double_t k2 = 0.5*rhozeroMass*TMath::Exp(-yExp);
- W2 = Wcms(yExp,pBeamEnergy,rhozeroMass);
- Flux2 = HardSphereFlux(PbLorentzBoost,k2,BMIN);
- FluxAveExp=FluxAveExp+Flux;
- WAveExp=WAveExp+W2;
- countern=countern+1;
- }
- WAveExp=WAveExp/countern;
- FluxAveExp=FluxAveExp/countern;
- sigmaExp=(1/FluxAveExp)*dXs_dyExperimental;
- cout<<WAveExp<< "   "<<sigmaExp<<" "<<countern<<endl;
- h3->Fill(WAveExp,sigmaExp);

Data of the Experimental Points to Plot

- dsigma/dy= 1.0+-0.18(stat)^+0.24_0.26 mb   for bin -3.6<y<-2.6

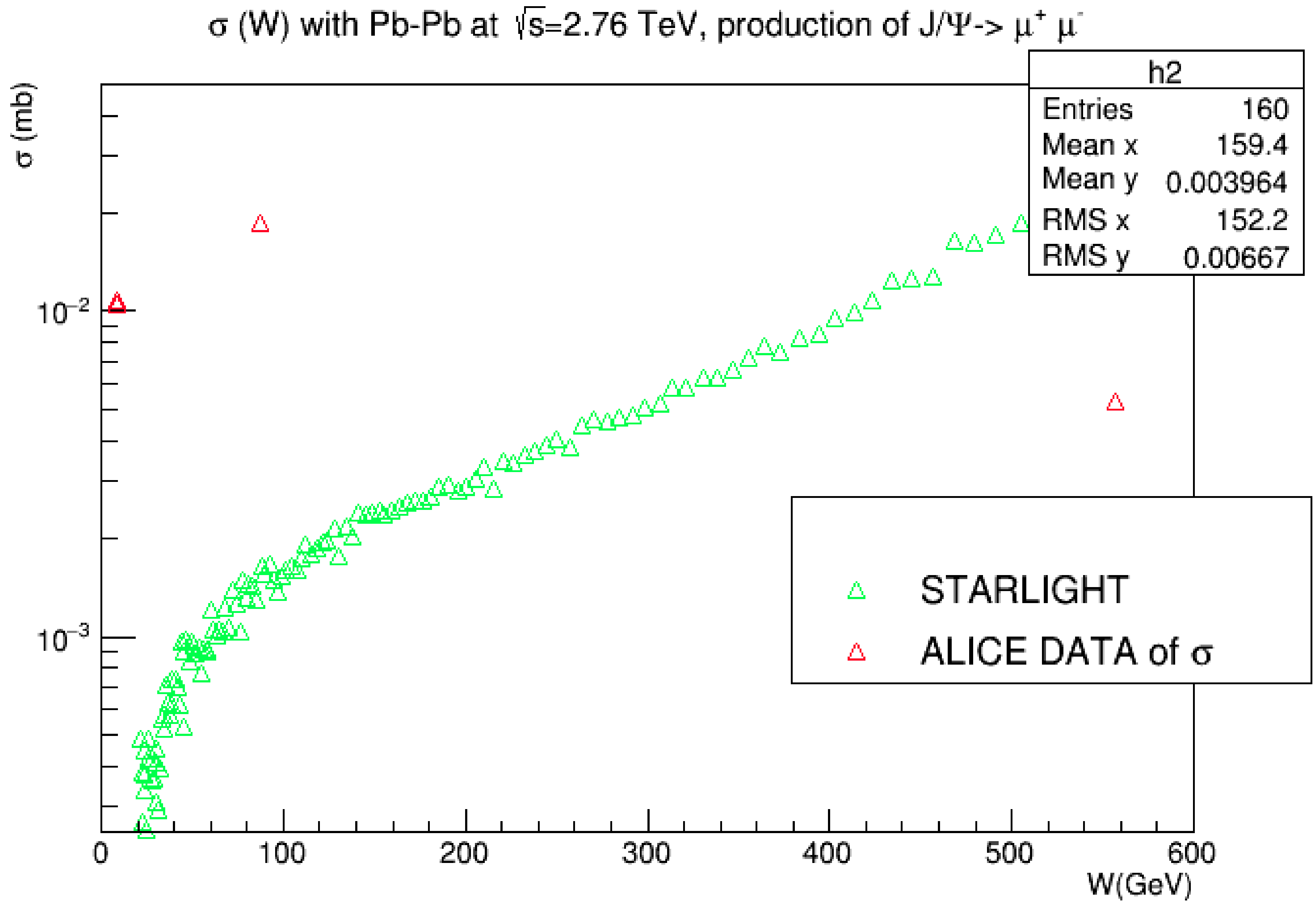
  PhotonFLux 197.357   Wave 557.115 sigmaExp 0.00506696

- dsigma/dy= 2.38^+0.34_-0.24 mb   for bin -0.9<y<0.9

  PhotonFLux 128.109   Wave 87.0827 sigmaExp 0.0185779

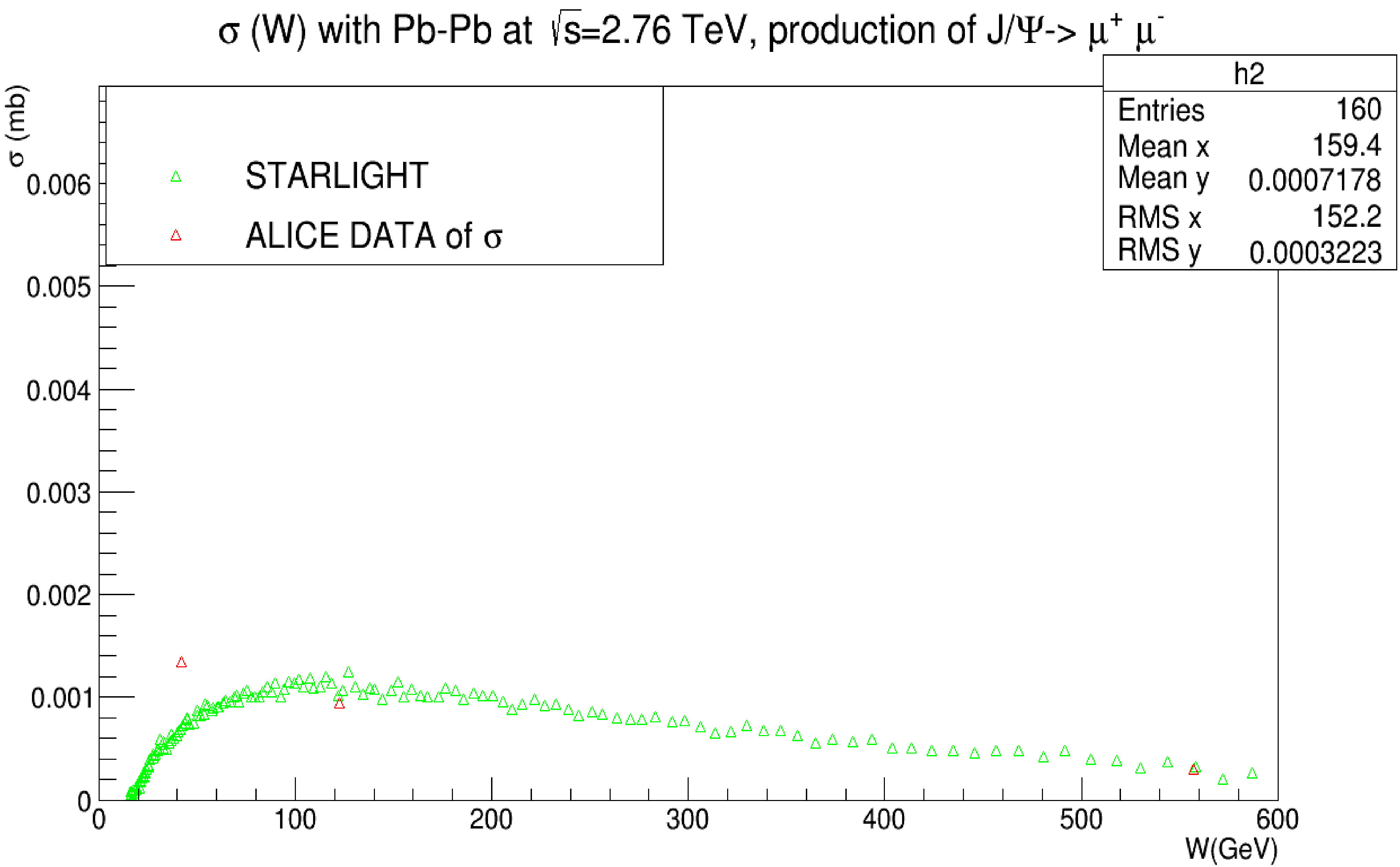
- dsigma/dy=0.36+-0.22(stat)+-0.19(theo) mb or bin 1.8<y<2.3

  PhotonFLux 33.8094   Wave 8.08694 sigmaExp 0.0106479


σ (W) with Pb-Pb at √s=2.76 TeV, production of J/Ψ-> μ+ μ-
h2
Entries 160
Mean x 159.4
Mean y 0.003964
RMS x 152.2
RMS y 0.00667
σ (mb)
10^-2
10^-3
0
100
200
300
400
500
600
W(GeV)
STARLIGHT
ALICE DATA of σ

- With the photon flux contribution of both nuclei the MonteCarlo gives much better values compared to the data.

  dsigma/dy=Photonflux(y)*sigma+Photonflux(-y)*sigma

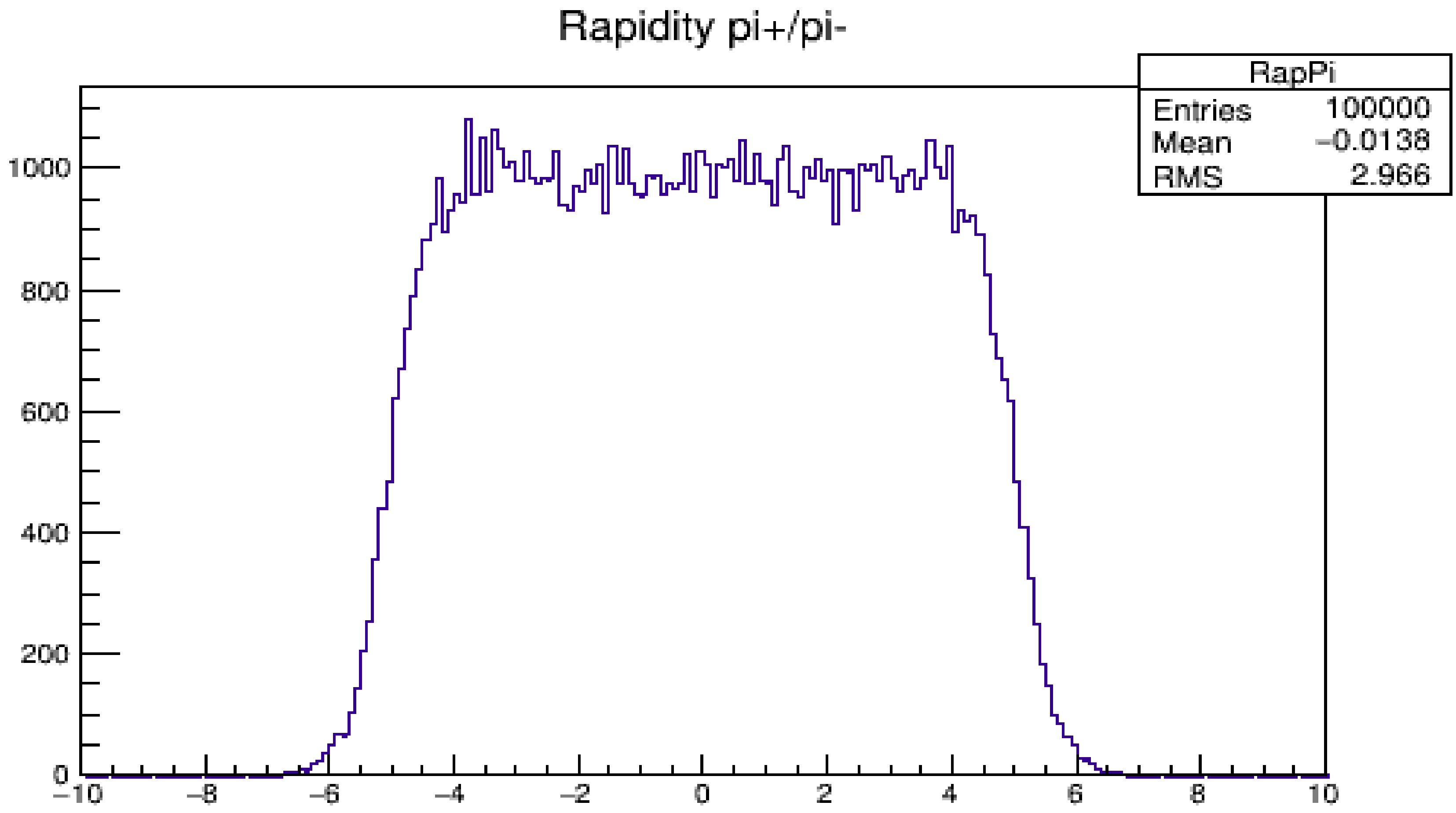

σ (W) with Pb-Pb at √s=2.76 TeV, production of J/Ψ-> μ⁺ μ⁻
h2
Entries 160
Mean x 159.4
Mean y 0.0007178
RMS x 152.2
RMS y 0.0003223
STARLIGHT
ALICE DATA of σ
σ (mb)
0.006
0.005
0.004
0.003
0.002
0.001
0
0
100
200
300
400
500
600
W(GeV)

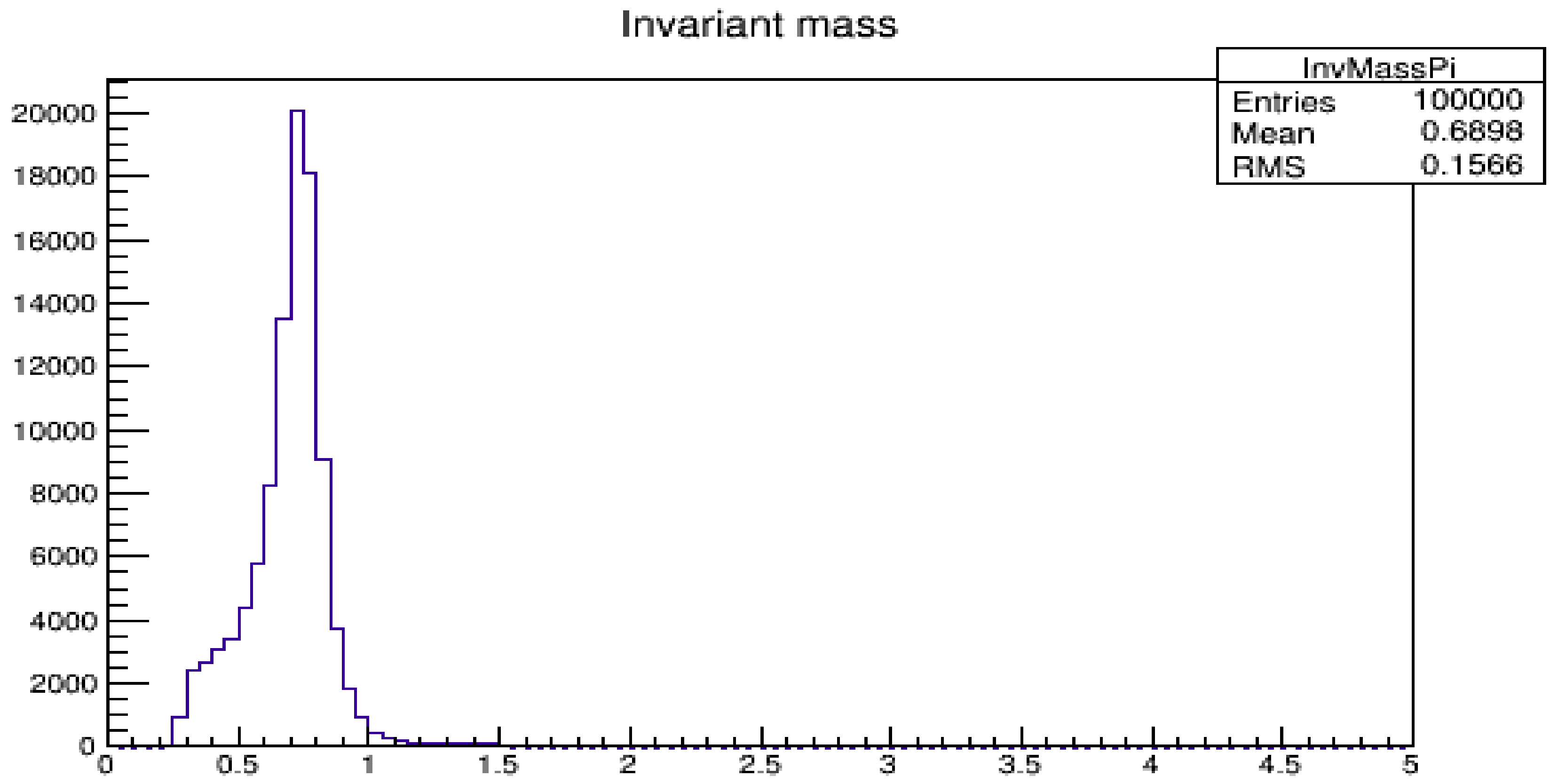
Rho Zero MonteCarlo Simulation and Comparison with Experimental Data

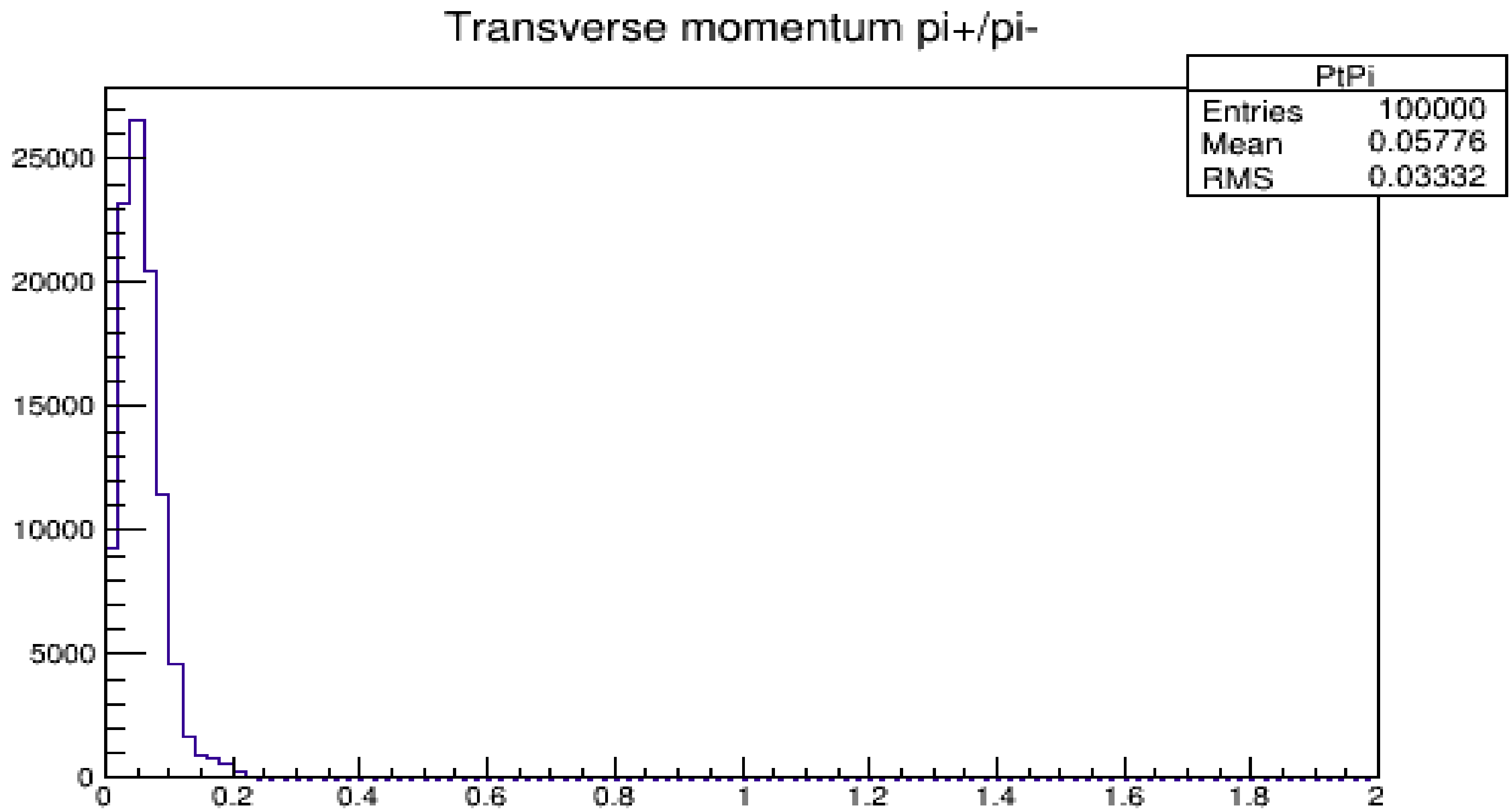
Input slight.in for Rho Zero Production

baseFileName = slight

- BEAM_1_Z = 82 #Z of projectile
- BEAM_1_A = 208 #A of projectile
- BEAM_2_Z = 82 #Z of target
- BEAM_2_A = 208 #A of target
- BEAM_1_GAMMA = 1470.0 #Gamma of the colliding ion 1
- BEAM_2_GAMMA = 1470.0 #Gamma of the colliding ion 2
- W_MAX = -1 #Max value of w
- W_MIN = -1 #Min value of w
- W_N_BINS = 50 #Bins i w
- RAP_MAX = 9. #max y
- RAP_N_BINS = 200 #Bins i y
- CUT_PT = 0 #Cut in pT? 0 = (no, 1 = yes)
- PT_MIN = 1.0 #Minimum pT in GeV
- PT_MAX = 3.0 #Maximum pT in GeV
- CUT_ETA = 0 #Cut in pseudorapidity? (0 = no, 1 = yes)
- ETA_MIN = -10 #Minimum pseudorapidity
- ETA_MAX = 10 #Maximum pseudorapidity
- PROD_MODE = 2 #gg or gP switch (1 = 2-photon, 2 = coherent vector meson (narrow), 3 = coherent vector meson (wide), 4 = incoherent vector mes
- N_EVENTS = 100000 #Number of events
- PROD_PID = 913 #Channel of interest; this is j/psi --> mu+ mu-
- RND_SEED = 5574533 #Random number seed
- BREAKUP_MODE = 5 #Controls the nuclear breakup; a 5 here makes no requirement on the breakup of the ions
- INTERFERENCE = 0 #Interference (0 = off, 1 = on)
- IF_STRENGTH = 1. #% of intefernce (0.0 - 0.1)
- INT_PT_MAX = 0.24 #Maximum pt considered, when interference is turned on
- INT_PT_N_BINS =120 #Number of pt bins when interference is turned on
- XSEC_METHOD = 1 # Set to 0 to use old method for calculating gamma-gamma luminosity
- PYTHIA_FULL_EVENTRECORD = 0 # Write full pythia information to output (vertex, parents, daughter etc).


Rapidity pi+/pi-
RapPi
Entries 100000
Mean −0.0138
RMS 2.966
1000
800
600
400
200
0
−10
−8
−6
−4
−2
0
2
4
6
8
10


Invariant mass
InvMassPi
Entries 100000
Mean 0.6898
RMS 0.1566
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


Transverse momentum pi+/pi-
PtPi
Entries 100000
Mean 0.05776
RMS 0.03332
25000
20000
15000
10000
5000
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

Information for Plot

We obtain with the formula

dsigma/dy=(NumberofDataInaBin/TotalNumberofData)*sigmagivenbyMontecarlo

sigma(y)=(1/PhotonFlux)*dsigma/dy

- Total Cross section given by MonteCarlo for RhoZero

3195 mb

Experimental Data of dsigma/dy for Rho Zero

- Dsigma/dy =425+-10(stat)^42_50
- for bin -0.5<y<0.5

  taken from

  JHEP09(2015)095

Data of the Experimental Points to Plot

- Dsigma/dy =425+-10(stat)^42_50

  for bin -0.5<y<0.5

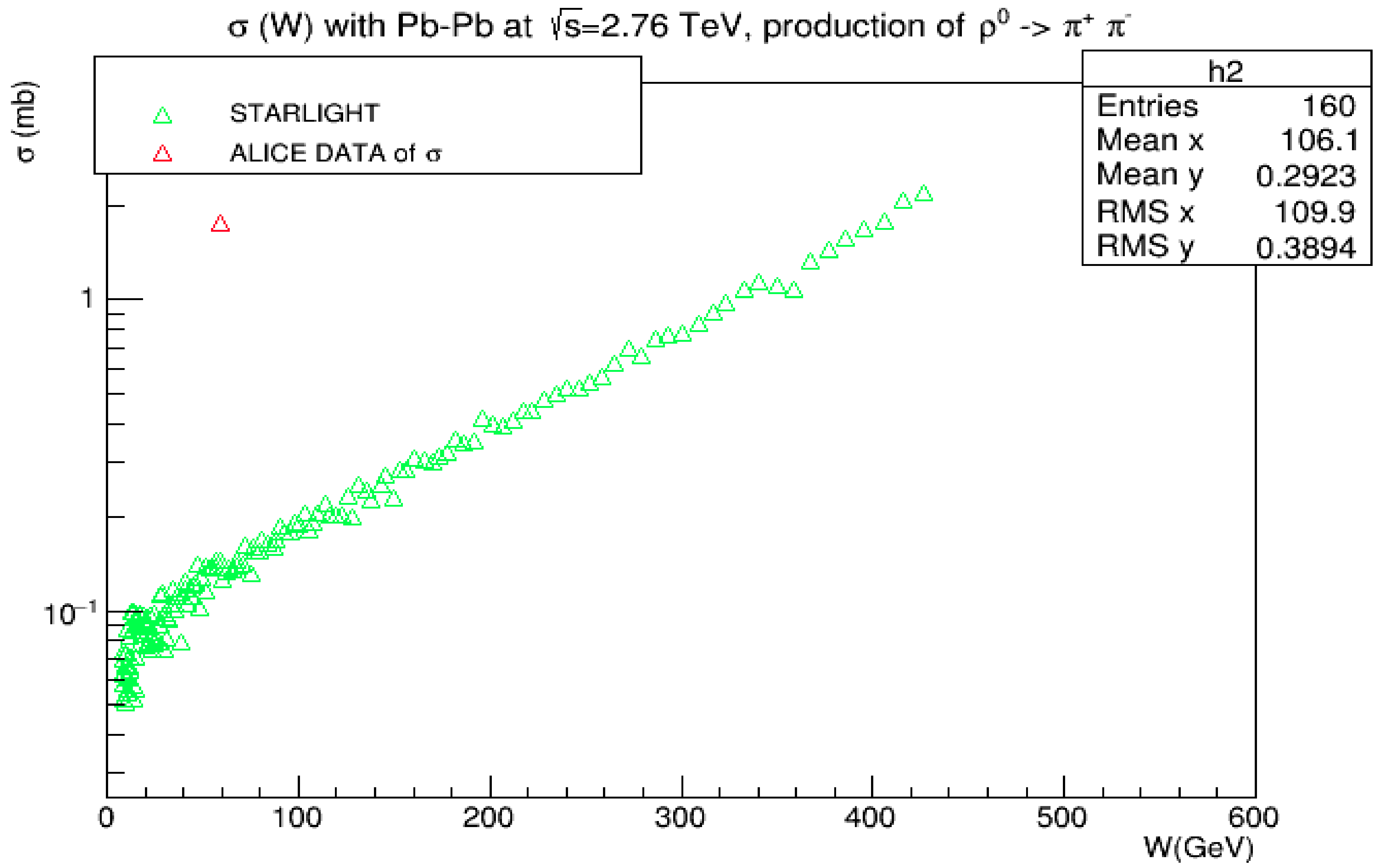
  PhotonFLux 240.614

  Wave 59.1519

  sigmaExp 1.76632

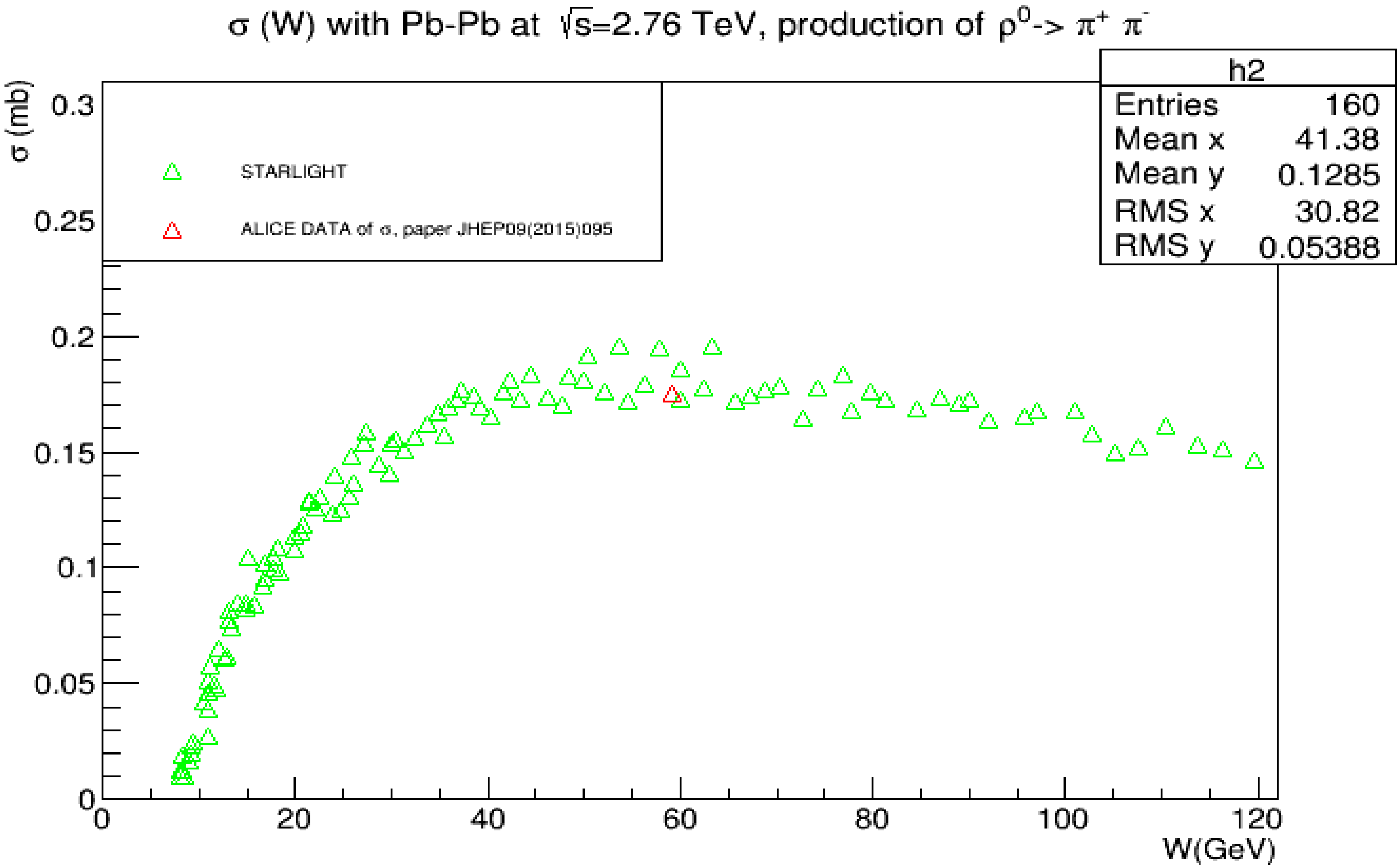
- Rapidity beam 1: 7.52543, rapidity beam 2: -7.52543, rapidity CMS system: 0, beam gamma in C
927.308
- >>> inputParameters::init(): info: using the following starlight parameters:
- base file name .... 'slight'
- beam 1 atomic number 82
- beam 1 atomic mass number 208
- beam 2 atomic number 82
- beam 2 atomic mass number 208
- Lorentz gamma of beams in CM frame 927.308
- mass W of produced hadronic system ..... 0.27914 < W < 1.5275 GeV/c^2
- # of W bins 50
- maximum absolute value for rapidity 9
- # of rapidity bins 200
- cut in pT.............................. no
- cut in eta............................. no
- production mode 2
- number of events to generate 100000
- PDG ID of produced particle 913
- seed for random generator 5574533
- breakup mode for beam particles 5
- interference enabled .... no
- coherent scattering off nucleus .... yes

- ##
- Initialising Starlight version: trunk...
- ##
-
- >>> beamBeamSystem::generateBreakupProbabilities(): info: Requiring no hadronic interactions.
- >>> starlight::luminosityTableIsValid(): info: using random seed = 5574533
- >>> starlight::init(): info: creating luminosity table for coherent photon-Pomeron channel
- Creating Luminosity Tables.
- Calculating photon flux from Emin = 1.000000e-05 GeV to Emax = 1.657454e+02 GeV (CM frame) for source with Z = 82
- Luminosity Tables created.
- Reading in luminosity tables. Gammaanarrowvm()
- Creating and calculating crosssection. Gammaanarrowvm()
- Using Narrow Resonance ...
- gamma+nucleon threshold: 5.845594e-04 GeV
- Total cross section: 3.195 barn.
- >>> starlightStandalone::run(): info: generating events:
- 0 of 100000
- 10000 of 100000
- 20000 of 100000
- 30000 of 100000
- 40000 of 100000
- 50000 of 100000
- 60000 of 100000
- 70000 of 100000
- 80000 of 100000
- 90000 of 100000
- >>> starlightStandalone::run(): info: number of attempts = 100000, number of accepted events = 100000
- The cross section of the generated sample is 3.195 barn.
-

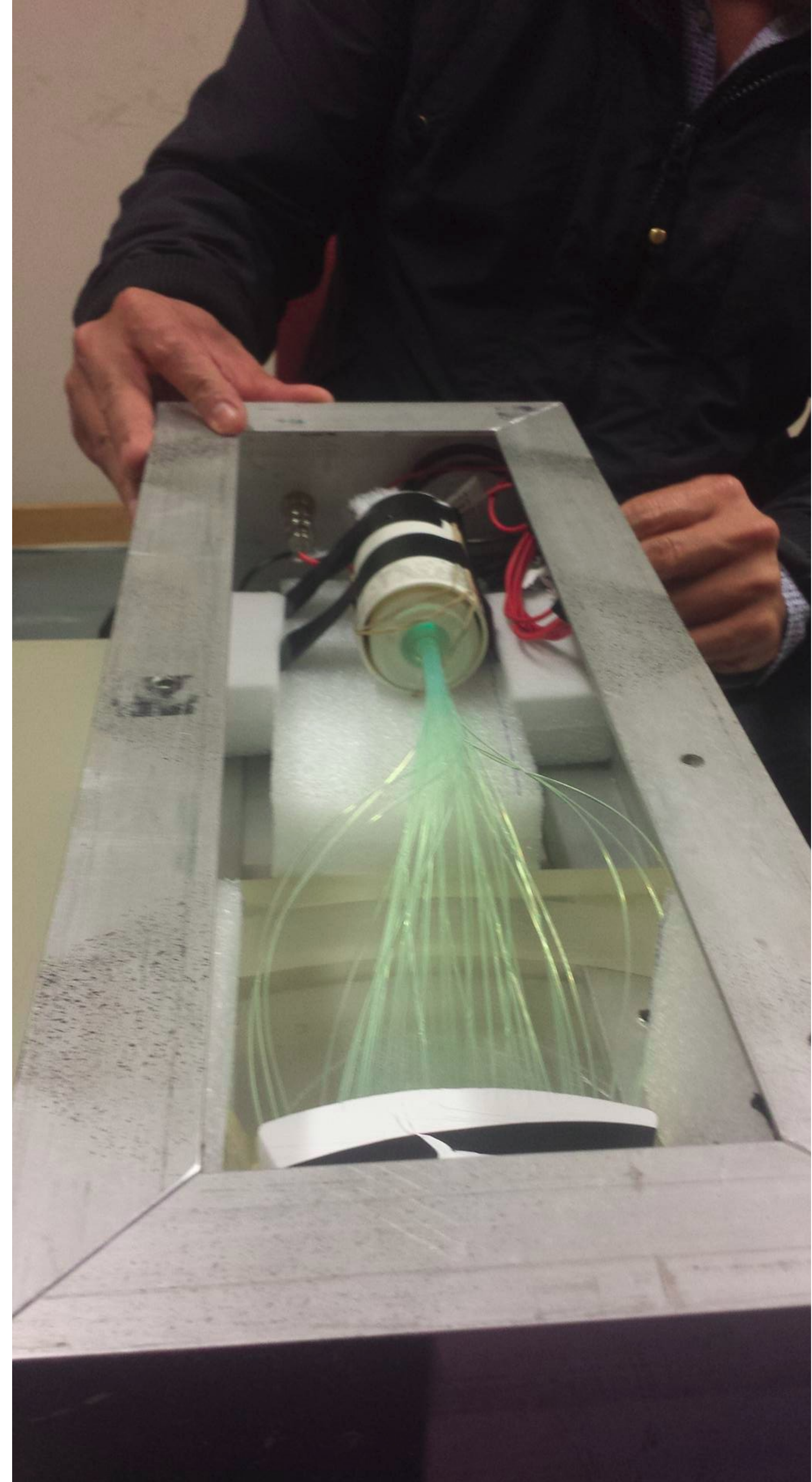

σ (W) with Pb-Pb at √s=2.76 TeV, production of ρ0 -> π+ π-
STARLIGHT
ALICE DATA of σ
h2
Entries 160
Mean x 106.1
Mean y 0.2923
RMS x 109.9
RMS y 0.3894
σ (mb)
1
10−1
0
100
200
300
400
500
600
W(GeV)

- With the photon flux contribution of both nuclei the MonteCarlo gives much better values compared to the data.

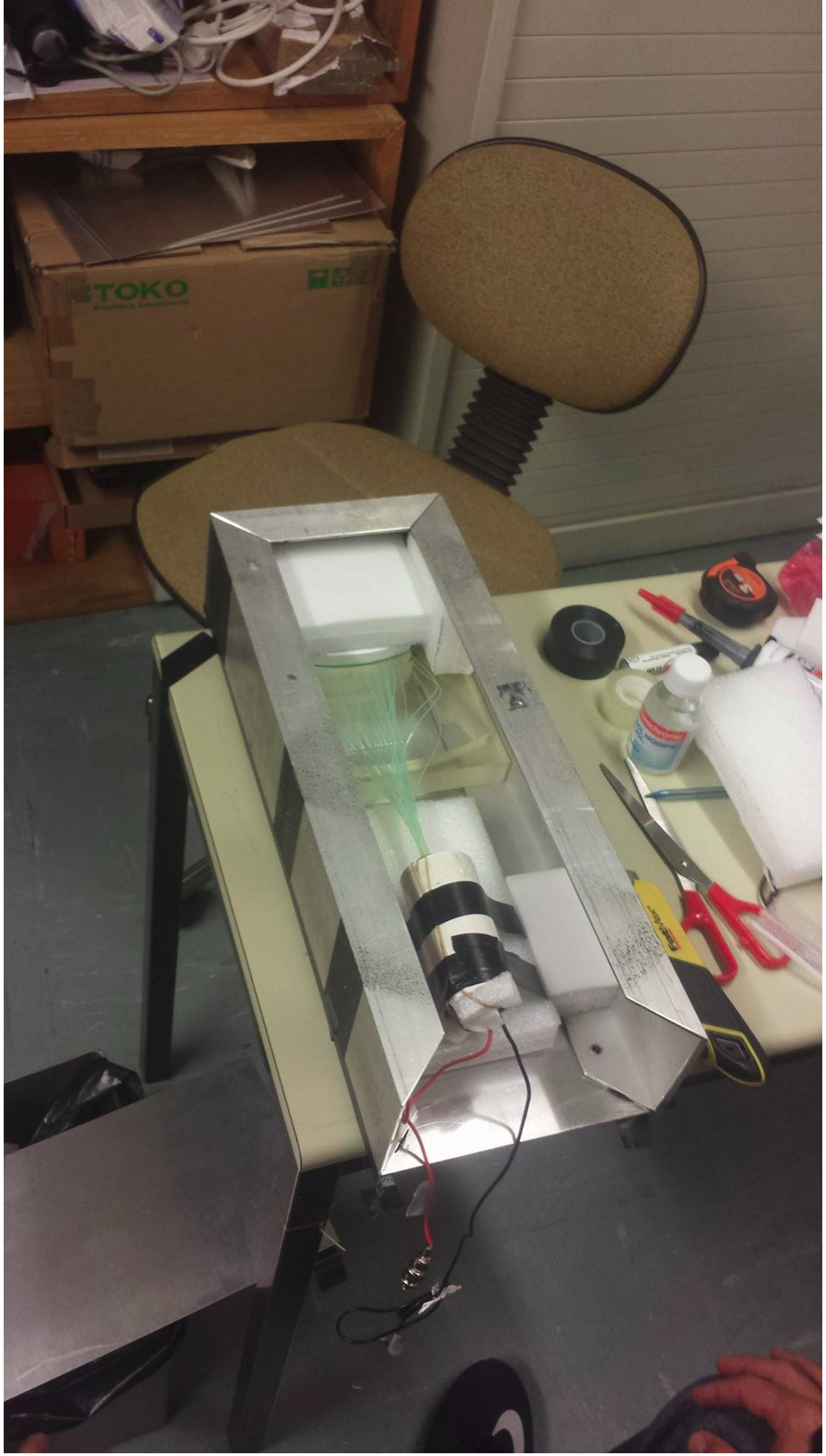
dsigma/dy=Photonflux(y)*sigma+Photonflux(-y)*sigma

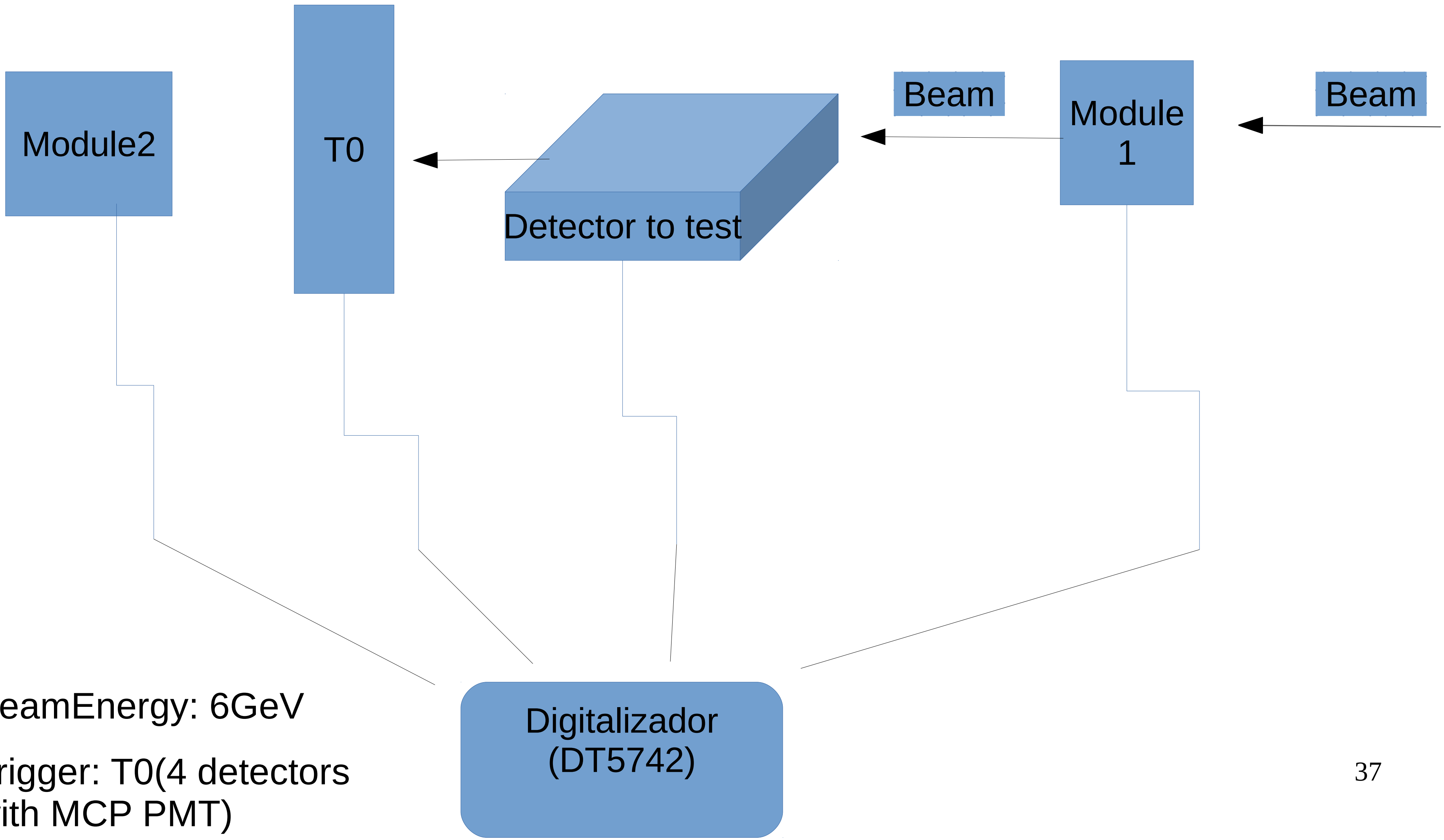

σ (W) with Pb-Pb at √s=2.76 TeV, production of ρ0-> π+ π-
h2
Entries 160
Mean x 41.38
Mean y 0.1285
RMS x 30.82
RMS y 0.05388
STARLIGHT
ALICE DATA of σ, paper JHEP09(2015)095
σ (mb)
W(GeV)
0
0.05
0.1
0.15
0.2
0.25
0.3
20
40
60
80
100
120

BEAM TEST



The detector is constituted of:
1)Photomultiplier tube
2) 38 Optical Fibers(17cm)
3)Scintillator Plastic
All inside of alluminum box of 52cmX19cm

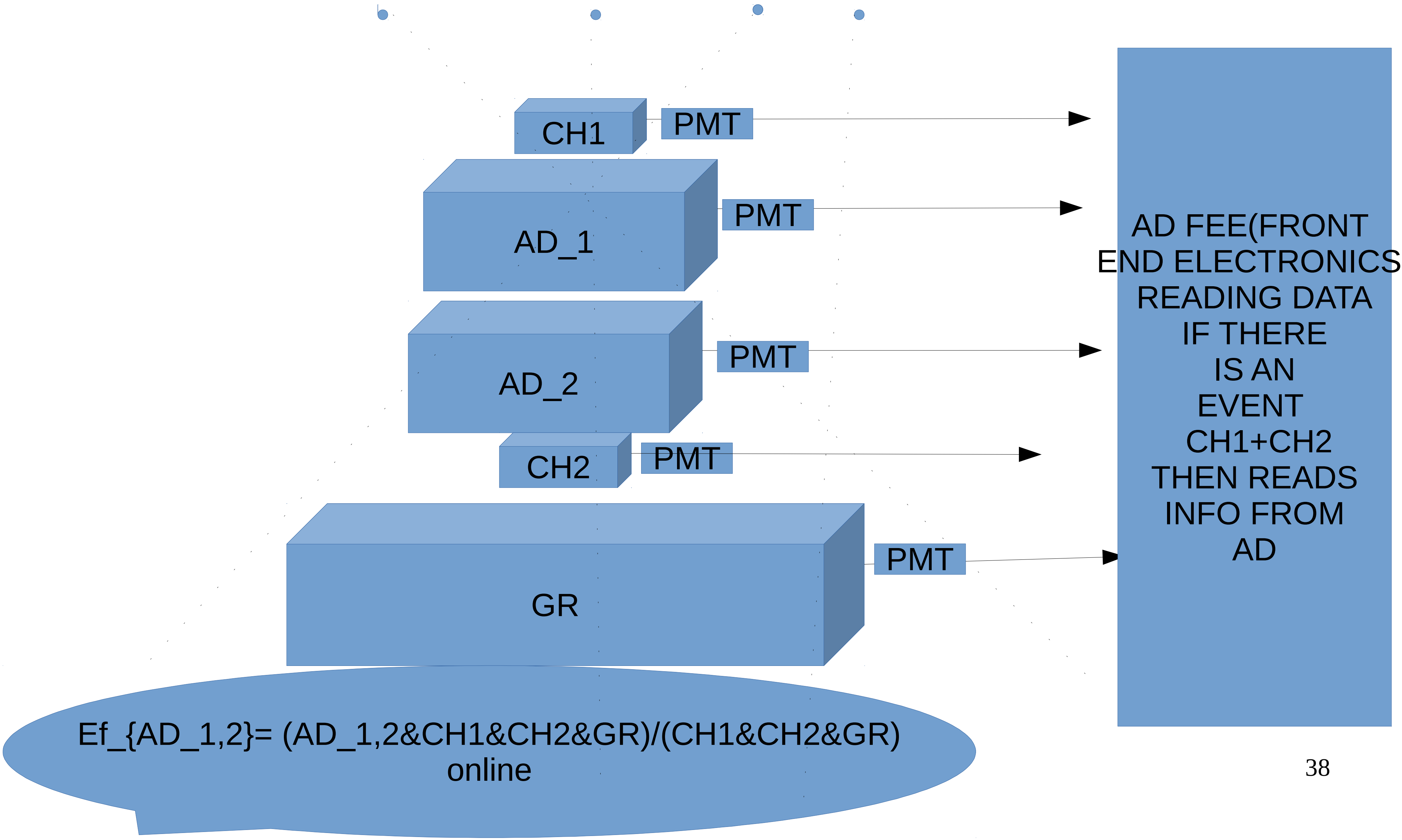

TOKO

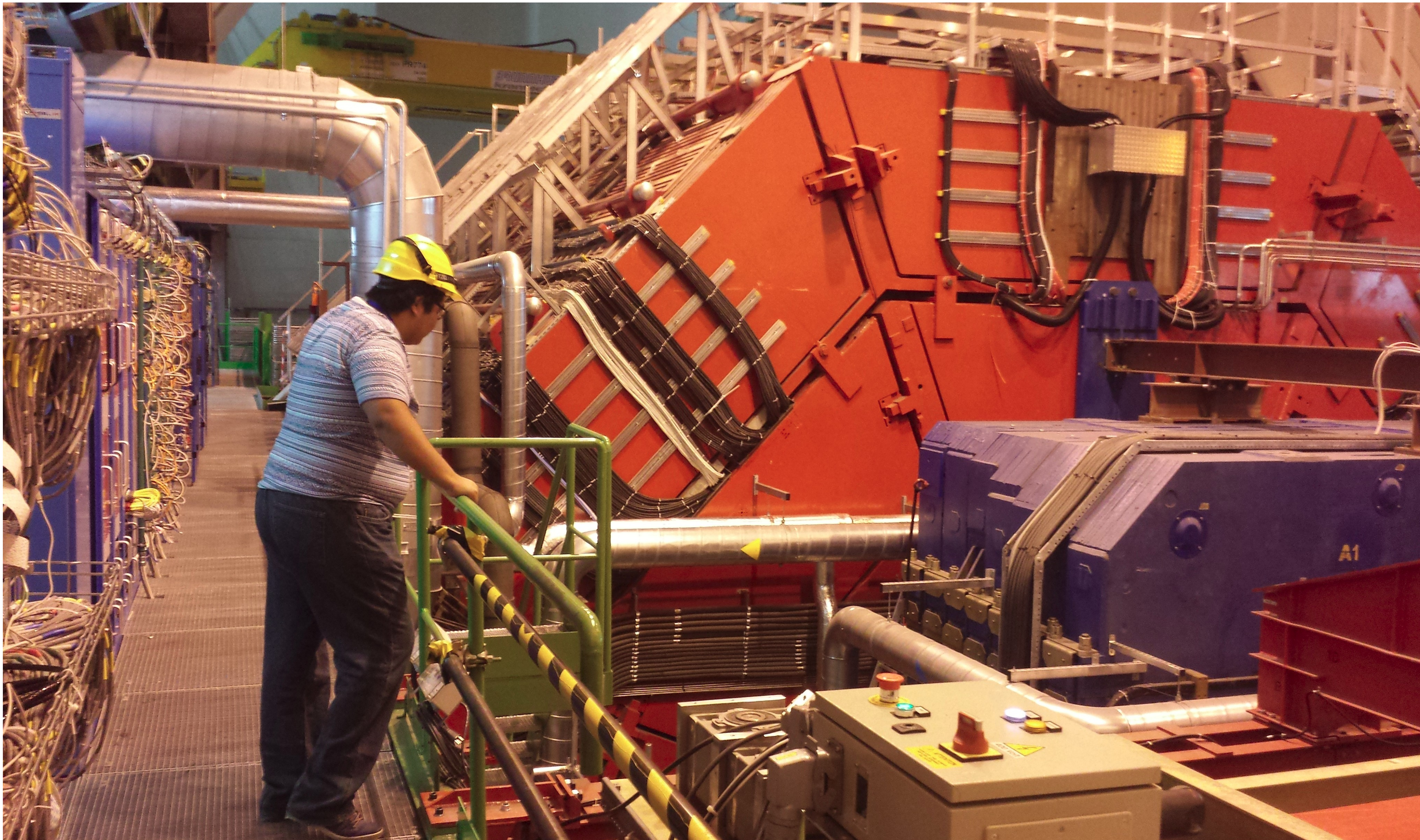


BeamEnergy: 6GeV

Trigger: T0(4 detectors with MCP PMT)

Clean Room


CH1
PMT
AD_1
PMT
AD_2
PMT
CH2
PMT
GR
PMT
AD FEE(FRONT
END ELECTRONICS
READING DATA
IF THERE
IS AN
EVENT
CH1+CH2
THEN READS
INFO FROM
AD
Ef_{AD_1,2}= (AD_1,2&CH1&CH2&GR)/(CH1&CH2&GR)
online


A1