Upsilon Status

JaeBeom Park

Fitting Procedure (following the HIN-15-001)

- **Signal function :** Double crystal Ball function

$$\Sigma_{1S}\left(m_{\mu\mu};m_0,n,\alpha,\sigma_0,f,x\right)=f\cdot \mathrm{CB}_1\left(m_{\mu\mu};m_0,n,\alpha,\sigma_0\right)+(1-f)\cdot \mathrm{CB}_2\left(m_{\mu\mu};m_0,n,\alpha,x\cdot\sigma_0\right)$$

$$\Sigma_{nS}\left(m_{\mu\mu};m_0,n,\alpha,\sigma_0,f,x\right)=\Sigma_{1S}\left(m_{\mu\mu};m_0\cdot\frac{m_{PDG}^{nS}}{m_{PDG}^{1S}},n,\alpha,\sigma_0\cdot\frac{m_{PDG}^{nS}}{m_{PDG}^{1S}},f,x\right)$$

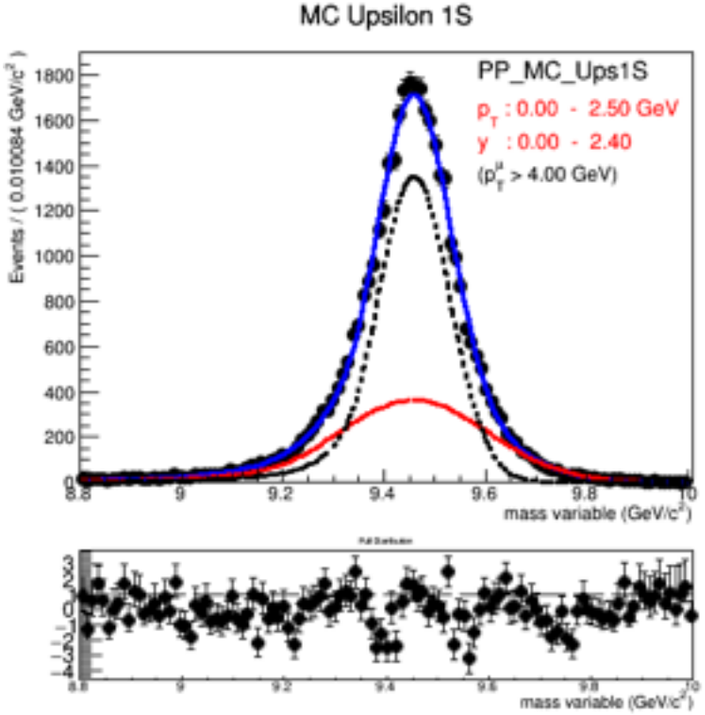
$$\mathcal{S}(m_{\mu\mu};\mathcal{N}_{1S},\mathcal{N}_{2S},\mathcal{N}_{3S},m_0|\,n,\alpha,\sigma_0,f,x)=\mathcal{N}_{1S}\cdot\Sigma_{1S}\left(m_{\mu\mu}\right)+\mathcal{N}_{2S}\cdot\Sigma_{2S}\left(m_{\mu\mu}\right)+\mathcal{N}_{3S}\cdot\Sigma_{3S}\left(m_{\mu\mu}\right)$$

- **Fitting process**
  1. Use pure signals from MC samples in order to set the parameters for both pp & PbPb
  2. Obtain (n,α,σ_0,f,x) for Y(1S) signal
  3. Apply the obtained parameter set to the Y(2S) & Y(3S) signal and fix all signal functions

- **BKG function :** err*exp*N (all free parameters)

- **Cut condition**
  - $p_T(\mu) \geqq 4$ GeV/c
  - $0 \leqq p_T(\mu^+\mu^-) \leqq 30$ GeV/c
  - $0 \leqq |y| \leqq 2.4$

Private MC Fit



Alpha1S = 1.579 ± 0.082

N1S = 3.15 ± 0.57

Sigma1S_1 = 0.1468 ± 0.0030

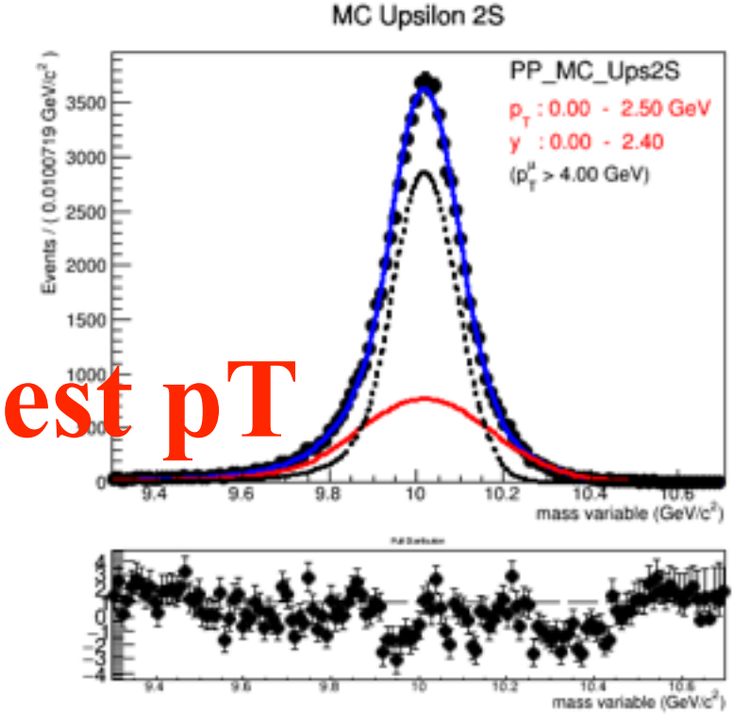
X1S = 0.4833 ± 0.0068

f1S = 0.355 ± 0.025

mass = 9.3 GeV/c^2

mean1s = 9.45898 ± 0.00065

nSig1s = 38621 ± 197

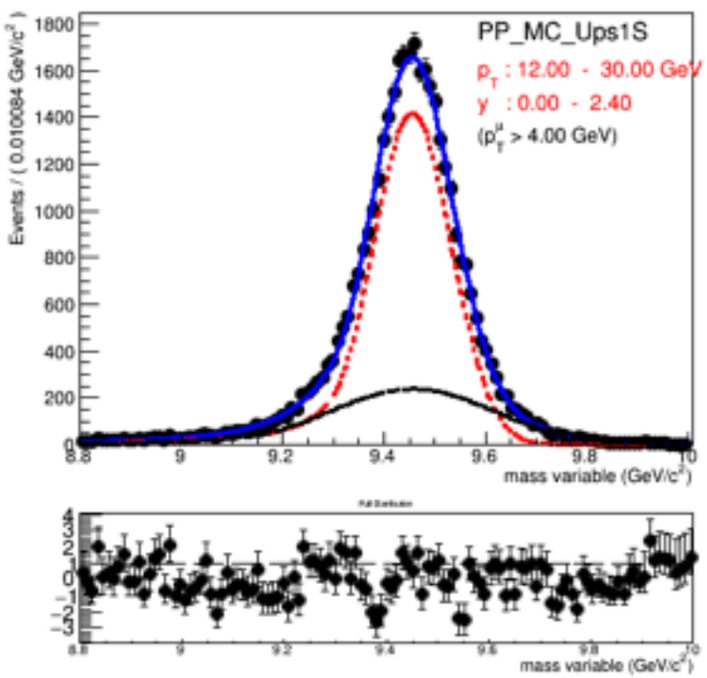


mass = 10 GeV/c^2

mean1s = 9.45516 ± 0.00034

nSig2s = 86891 ± 295

Lowest pT



Alpha1S = 1.670 ± 0.063

N1S = 2.01 ± 0.24

Sigma1S_1 = 0.0769 ± 0.0012

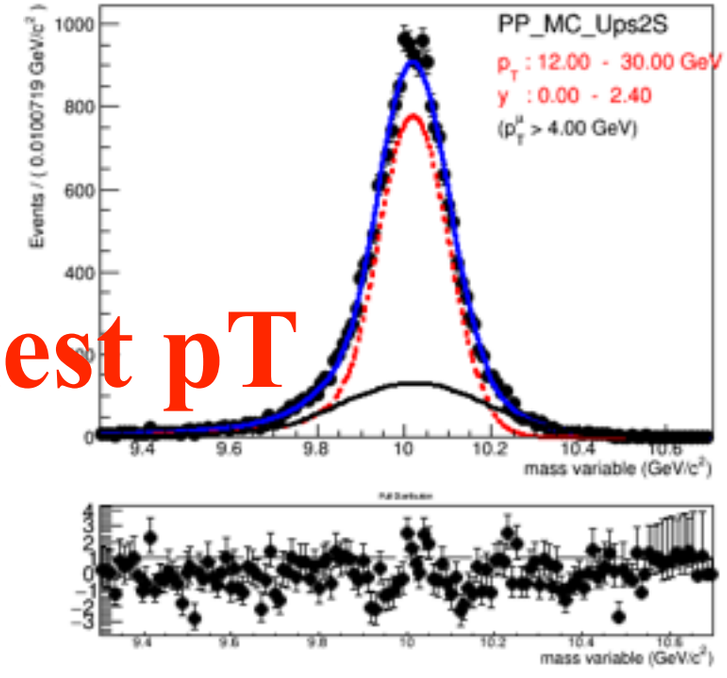
X1S = 2.078 ± 0.036

f1S = 0.744 ± 0.022

mass = 9.3 GeV/c^2

mean1s = 9.45554 ± 0.00061

nSig1s = 38296 ± 196



mass = 10 GeV/c^2

mean1s = 9.45646 ± 0.00068

nSig2s = 22362 ± 150

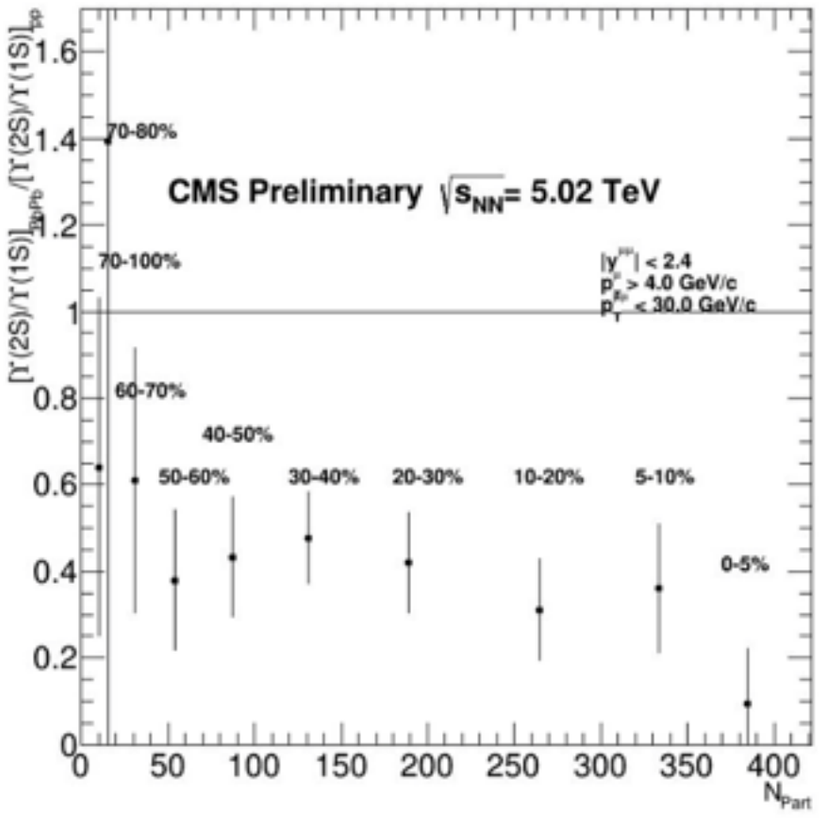
Highest pT

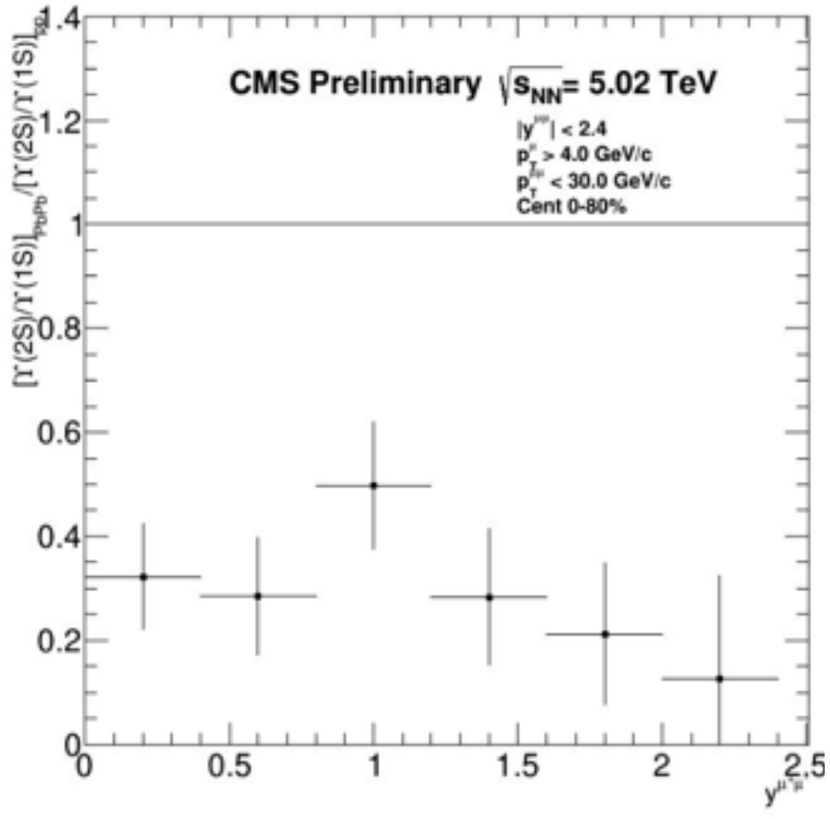
Systematic Uncertainty (following the HIN-15-001)

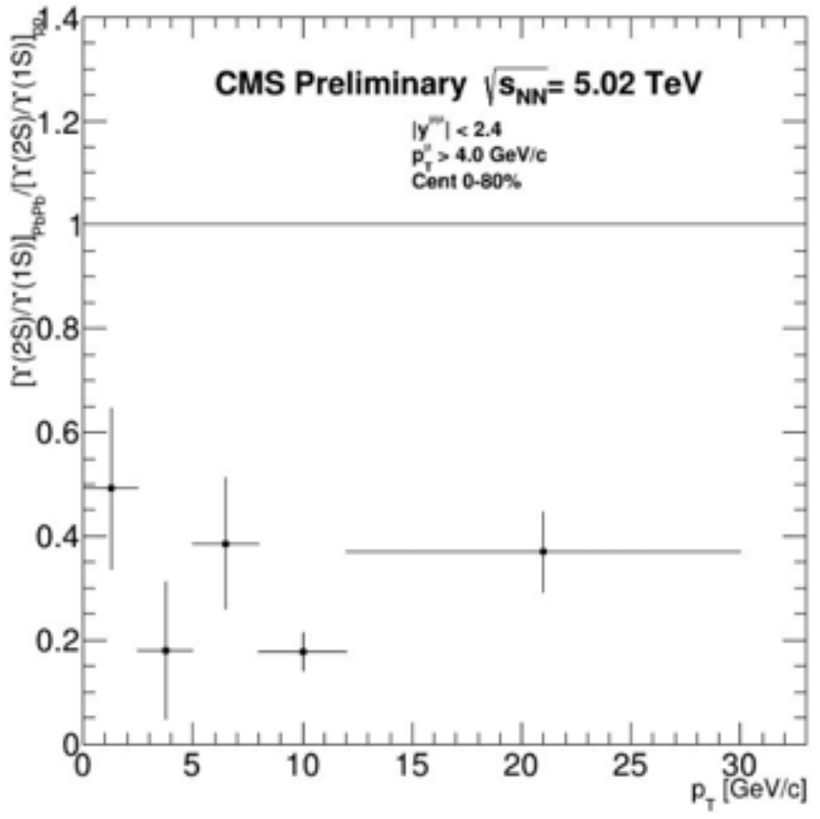
- **Fit Variation**
  - **Signal shape variation** $\Sigma_{nS}\left(m_{\mu\mu}; m_0, n, \alpha, \sigma_0, f, x\right) = \Sigma_{1S}\left(m_{\mu\mu}; m_0 \cdot \frac{m_{PDG}^{nS}}{m_{PDG}^{1S}}, n, \alpha, \sigma_0 \cdot \frac{m_{PDG}^{nS}}{m_{PDG}^{1S}}, f, x\right)$
    - Release fixed parameters (n,α,σ_0,f,x) one by one in the fit to the data, leading 5 fits for each bin
    - The RMS of those variations to the nominal fit is taken to be the systematic uncertainty in the signal
  - **Background shape variation**
    - Add an additional first order Chebychev polynomial function & same operation with a second order Chebychev polynomial
    - The maximum of the two deviations to the nominal fit is the systematic uncertainty in the background

- **New pT & rapidity Binning**
  - **9 Centrality Bin {0, 5, 10, 20, 30, 40, 50, 60, 70, 80}**
  - **3 pT Bin {0, 5, 12, 30} ??**
  - **2 y Bin {0, 1.2, 2.4}**

Current Double Ratio







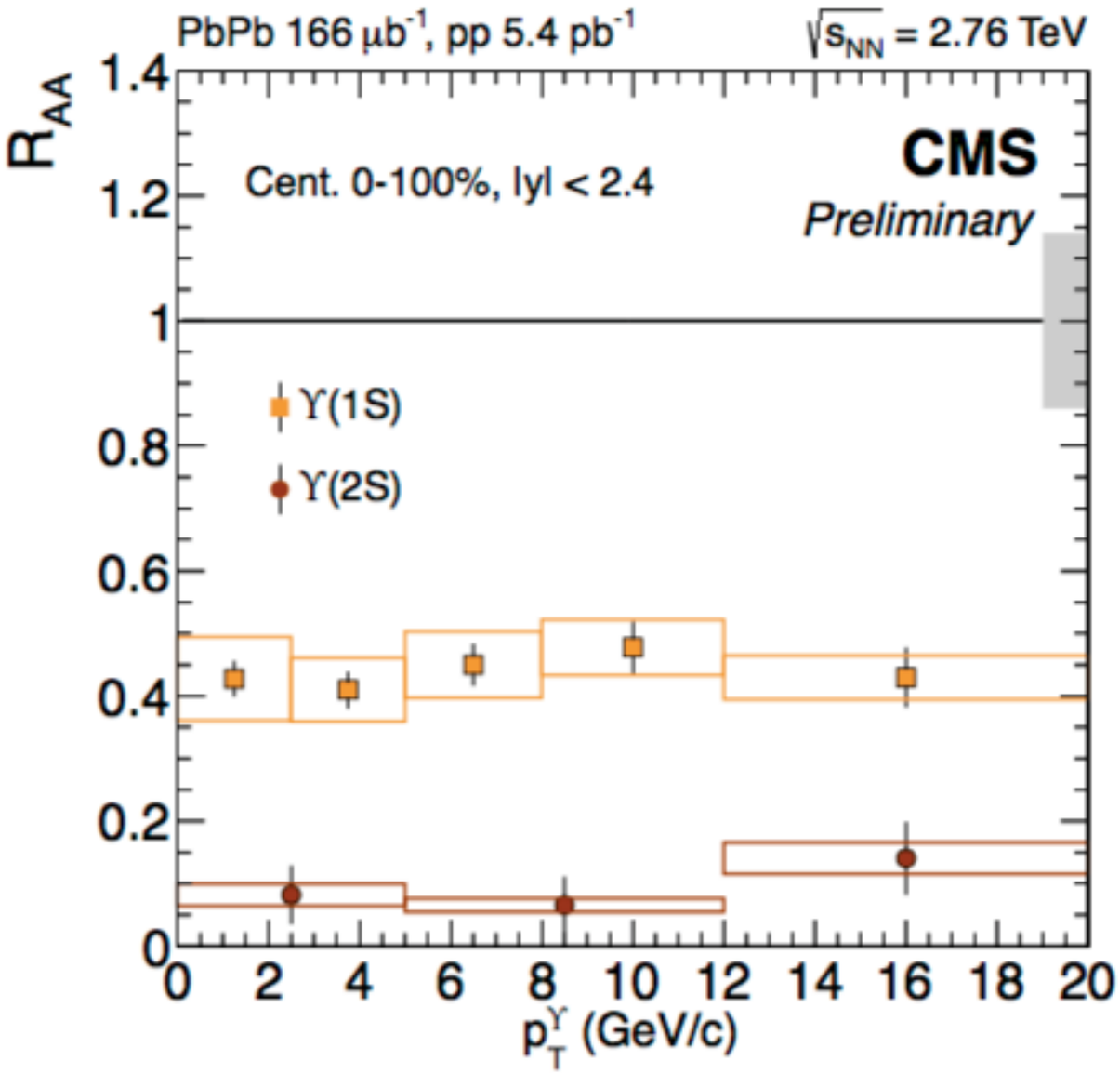
- **Have to change to the new binning**
  - **9 Centrality Bin {0, 5, 10, 20, 30, 40, 50, 60, 70, 80}**
  - **3 pT Bin {0, 5, 12, 30} ??**
  - **2 y Bin {0, 1.2, 2.4}**

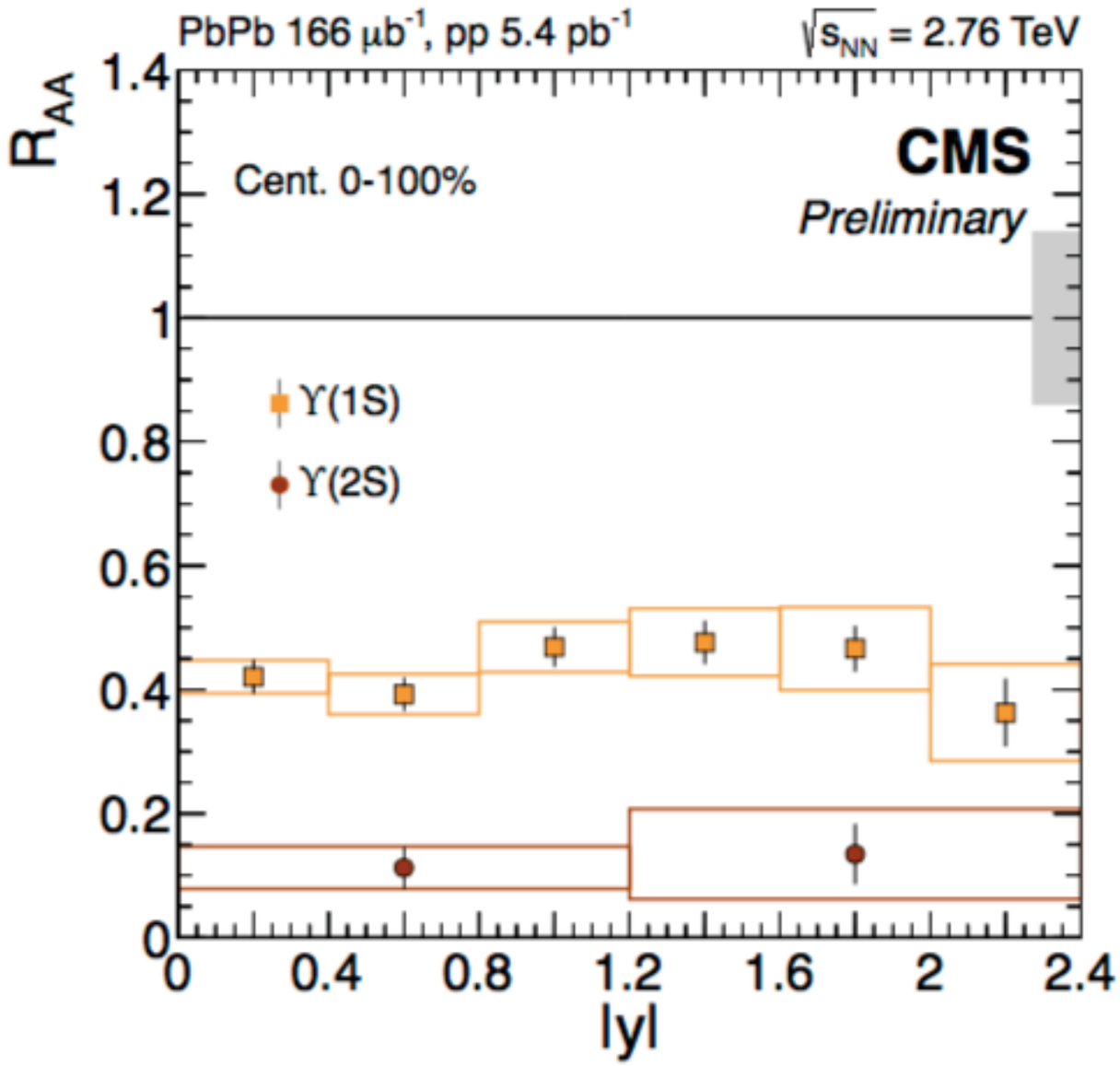
Plan

- **Fitting**
  - Move to official MC for both pp & PbPb (or just get numbers from Chad?)

- **Systematic Uncertainty**
  - Calculate systematic uncertainty for the signal
  - Move on the the background variation

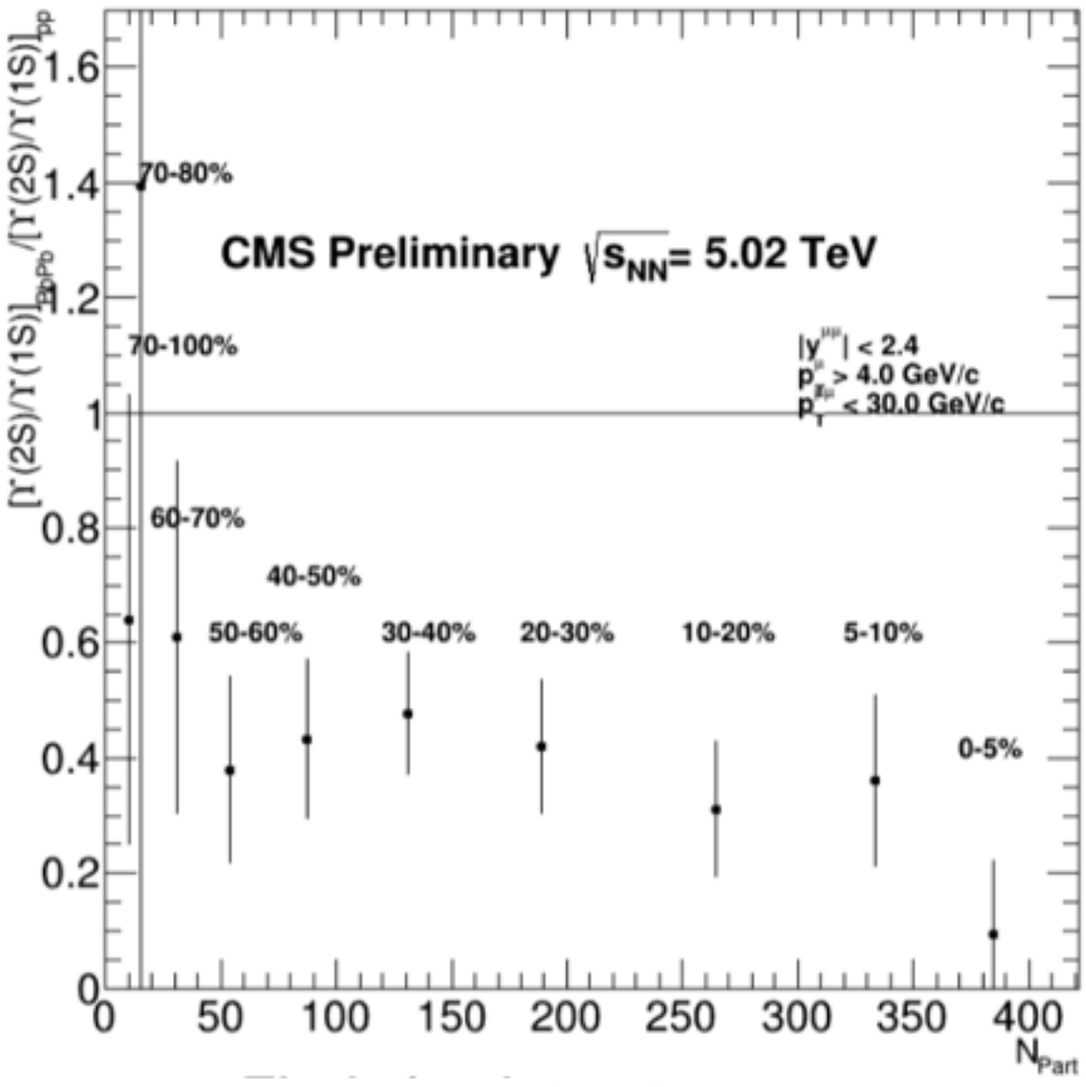
HIN-15-001


PbPb 166 μb-1, pp 5.4 pb-1
√sNN = 2.76 TeV
CMS
Preliminary
Cent. 0-100%, |y| < 2.4
RAA
Υ(1S)
Υ(2S)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0 2 4 6 8 10 12 14 16 18 20
pΥT (GeV/c)


PbPb 166 μb-1, pp 5.4 pb-1
√sNN = 2.76 TeV
CMS
Preliminary
Cent. 0-100%
RAA
Υ(1S)
Υ(2S)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0 0.4 0.8 1.2 1.6 2 2.4
|y|

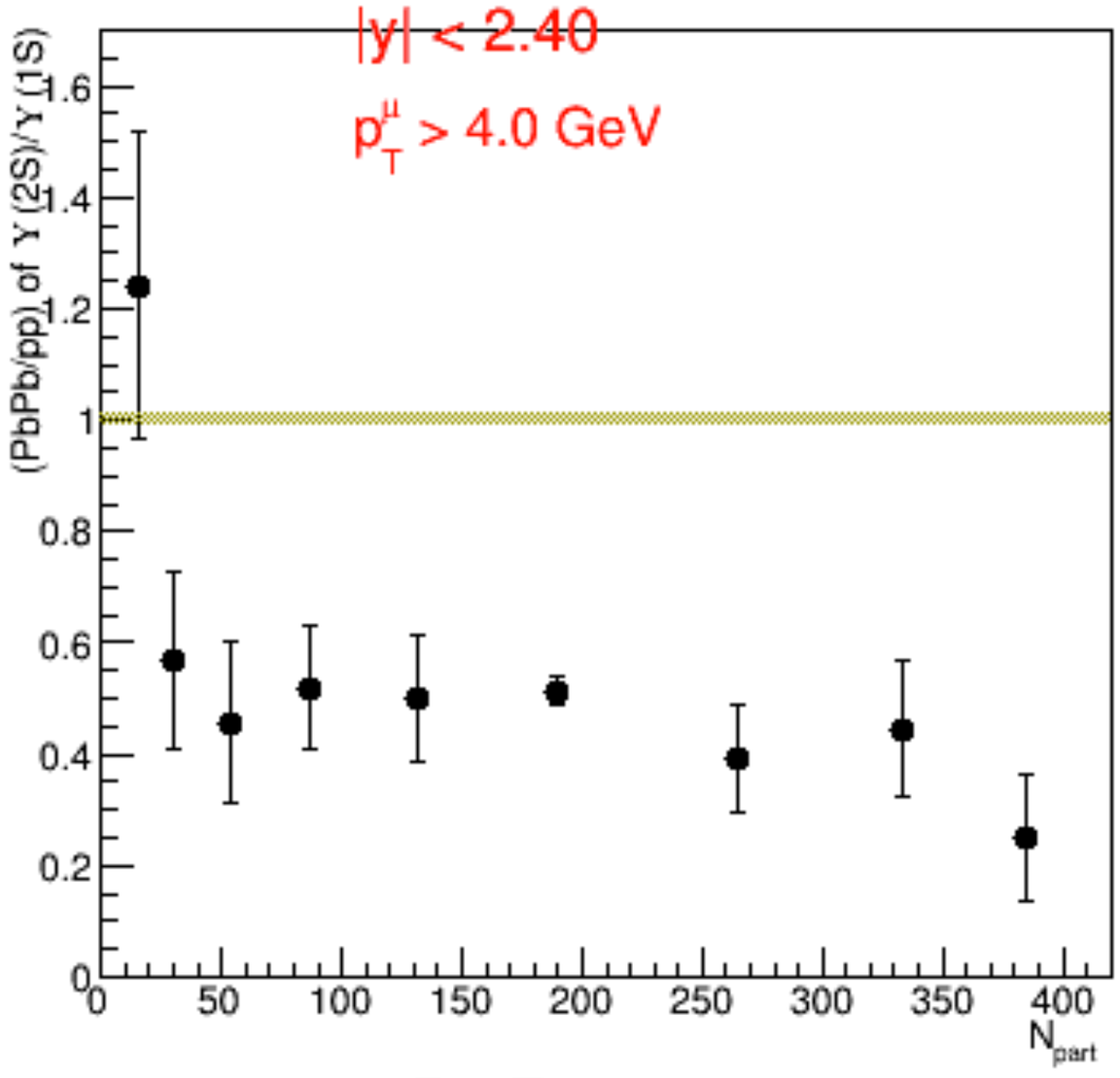
Double Ratio 1S/2S

Double Crystal Ball function



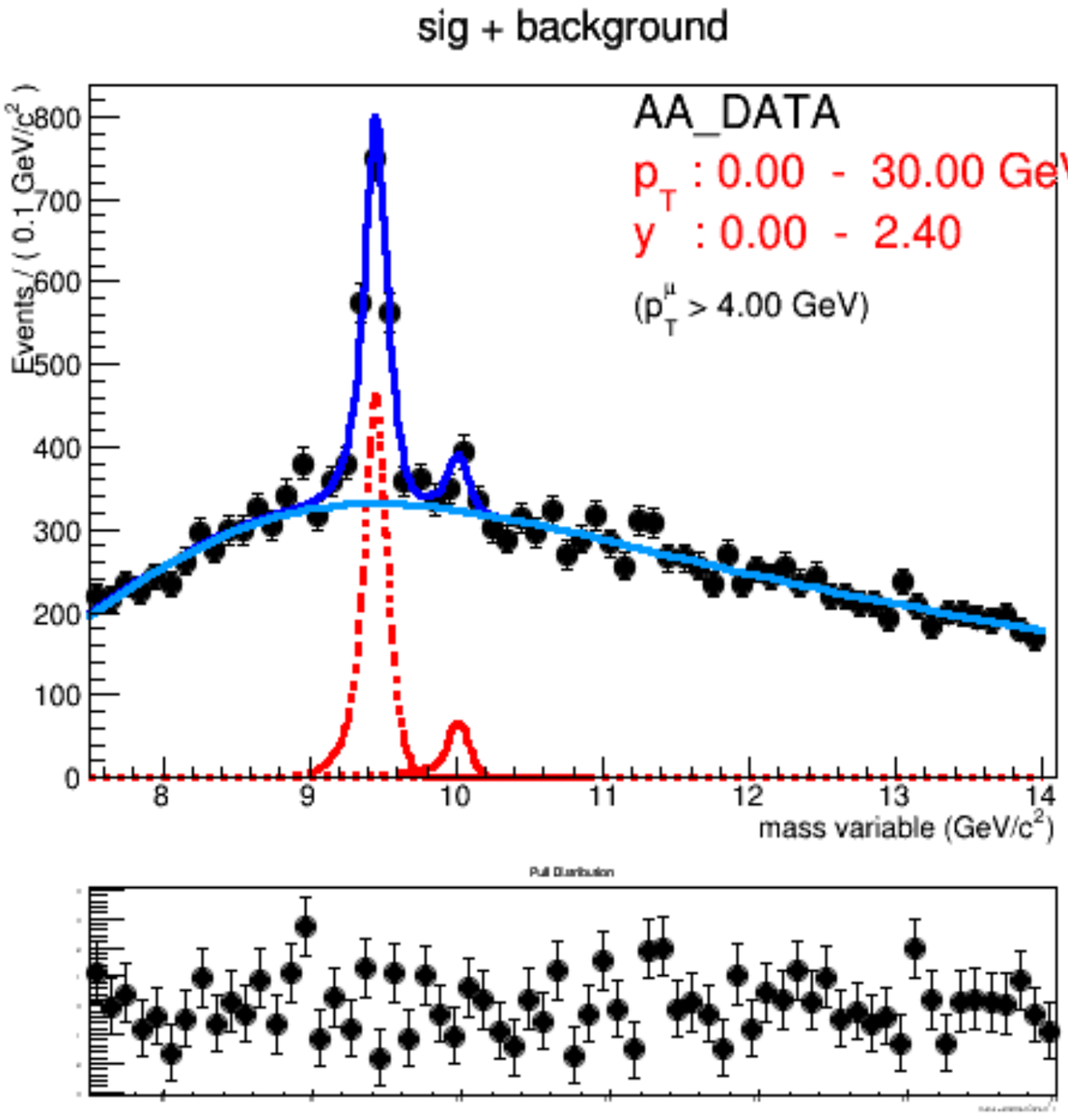
Chad

Double Crystal Ball function



JaeBeom

20~30% Bin Double CB



bkg_N = 4334 ± 29283

err_mu = 7.8733 ± 0.0097

err_sigma = 1.285 ± 0.023

frac1S_12 = 0.744 ± 0.021

frac2S_12 = 0.000 ± 0.014

frac2over1 = 0.1479 ± 0.0076

frac3S_12 = 1.0 ± 3.5

m_decay = 6.181 ± 0.041

mass = 10 GeV/c^2

mean1s = 9.4514 ± 0.0014

nBkg = 17327 ± 38

nSig12s = 1194 ± 14

nSig3s = 0 ± 7232

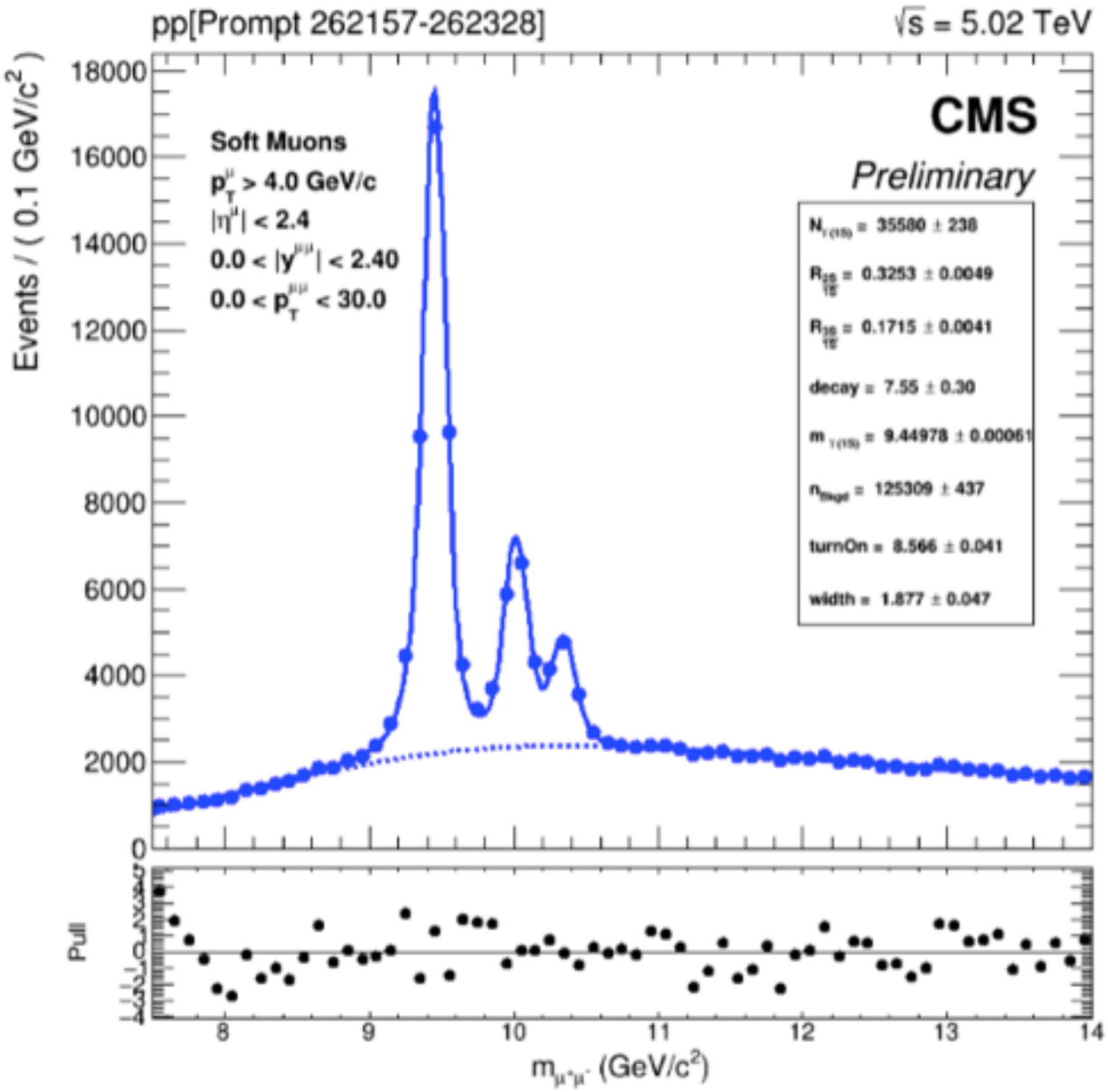
Back - up

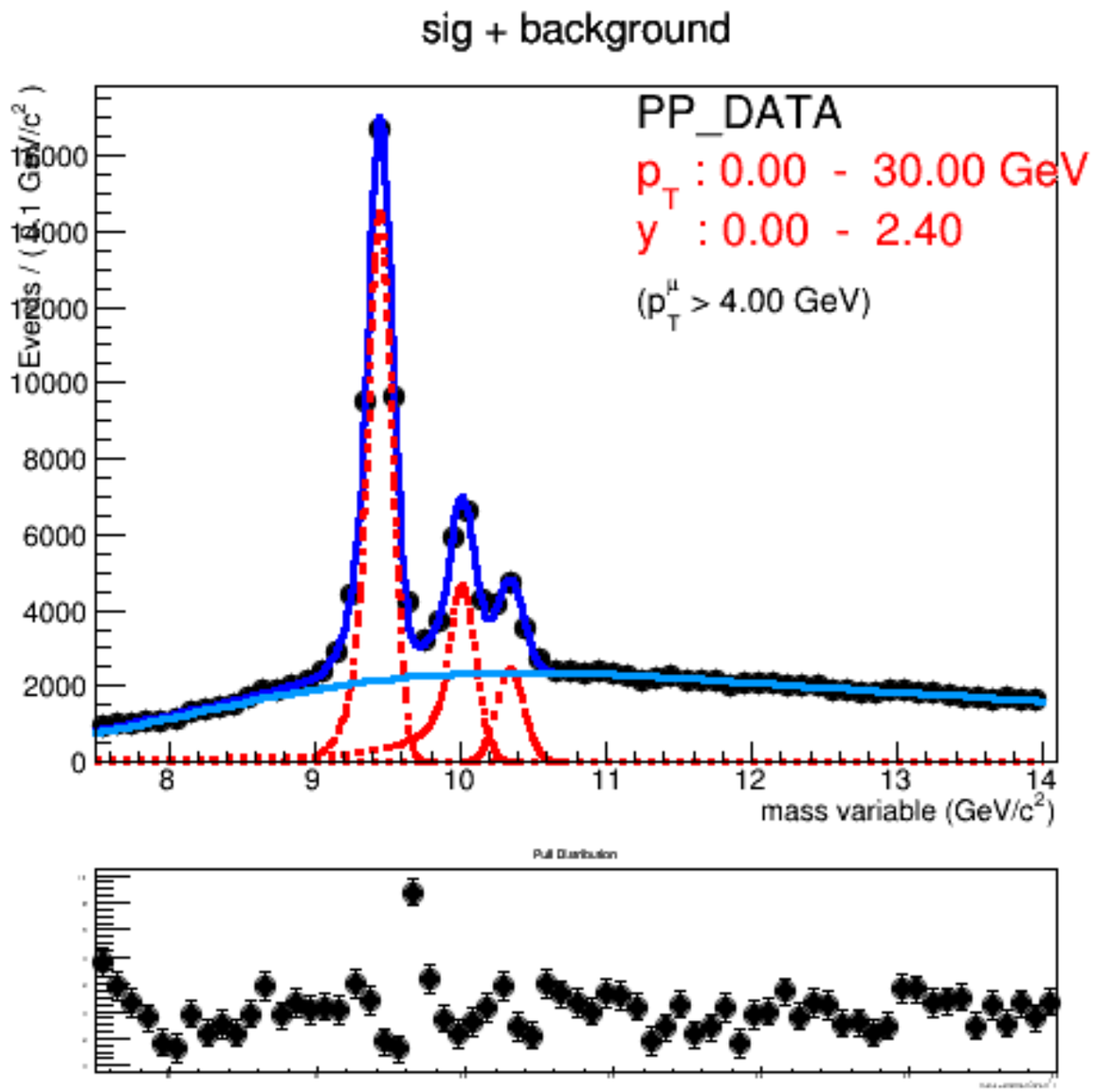
Data samples

- pp : DoubleMu0
- PbPb : DoubleMu0 (0-30%)
  DoubleMu0_Peripheral (30-80%)

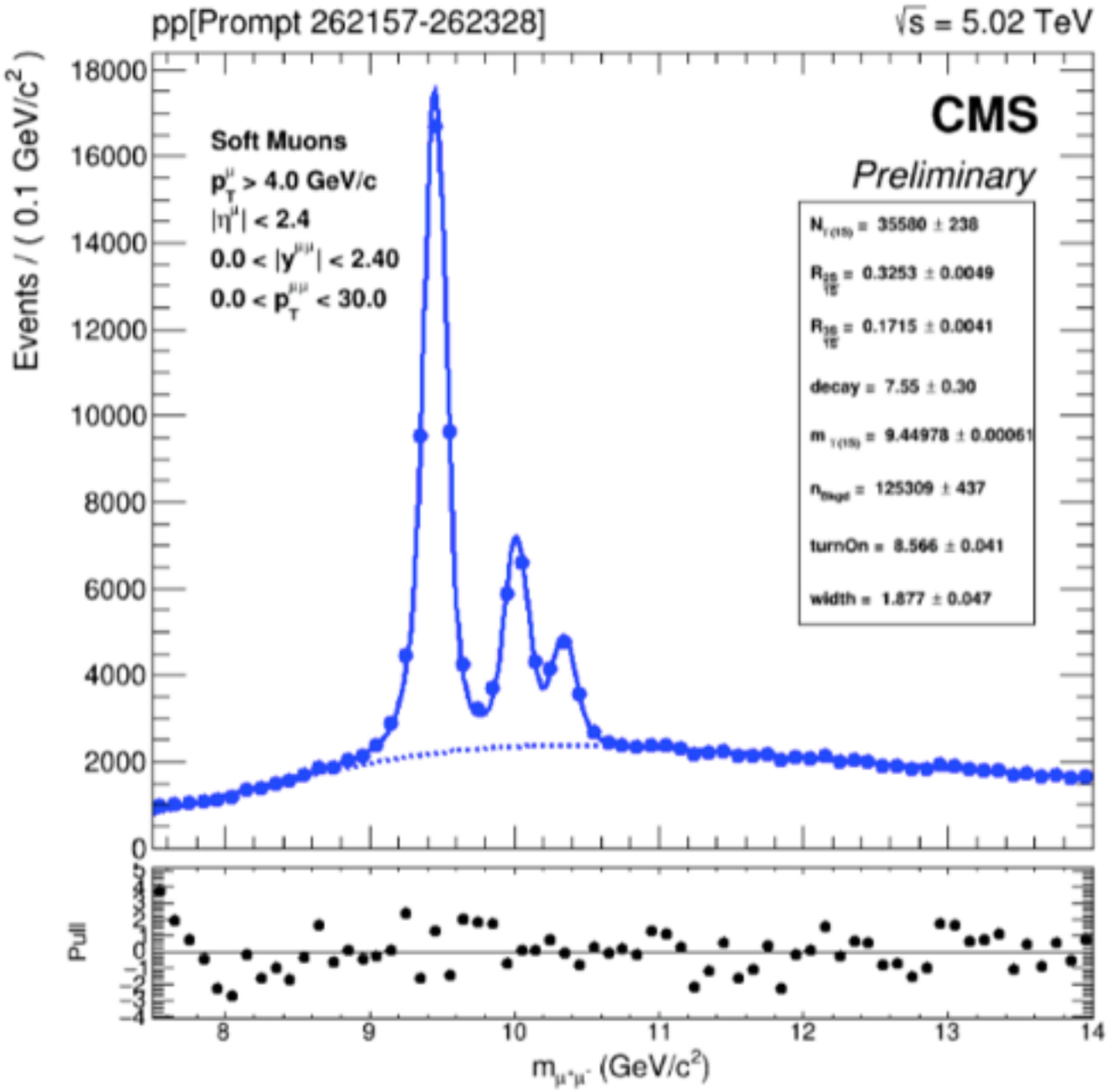
	pp Data	PbPb Data	PbPb Data Peripheral
File Name	OniaTree_DoubleMu_Run2015E-PromptReco-v1_Run_262157_262328.root	OniaTree_HIOniaL1DoubleMu0ABCD_HIRun2015-PromptReco-v1_Run_262620_263757.root	OniaTree_HIOniaPeripheral30100_HIRun2015-PromptReco-v1_Run_262620_263757.root
HLT Trigger	L1DoubleMu0	L1DoubleMu0	L1DoubleMu0Peripheral
PASS 1 : # of events passing HLT	8727725	31531797	3539183
PASS 2 : # of dimuons passing trigger match + PASS 1	3017463	4797051	1036764
PASS 3 : # of dimuons passing muonID cut + PASS 2 + acceptance cut	3017463	4797051	1036764
PASS 4 : # of dimuons in mass range 7.5-14GeV+ PASS 3 + vertex probability cut + opposite sign in all centrality 0-100%)	460724	631612	129904
PASS 4-1 : # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin1 (0-5%)	N/A	135166	0
PASS 4-2 : # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin2 (5-10%)	N/A	121656	0
PASS 4-3 : # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin3 (10-20%)	N/A	184123	0
PASS 4-4 : # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin4 (20-30%)	N/A	107140	23378
PASS 4-5 : # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin5 (30-40%)	N/A	49470	63149
PASS 4-6 : # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin6 (40-50%)	N/A	21228	27028
PASS 4-7 : # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin7 (50-60%)	N/A	8062	10269
PASS 4-8 : # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin8 (60-70%)	N/A	2900	3703
PASS 4-9: # of dimuons in mass range 7.5-14GeV + PASS 4 in centrality bin9 (70-80%)	N/A	1112	1399

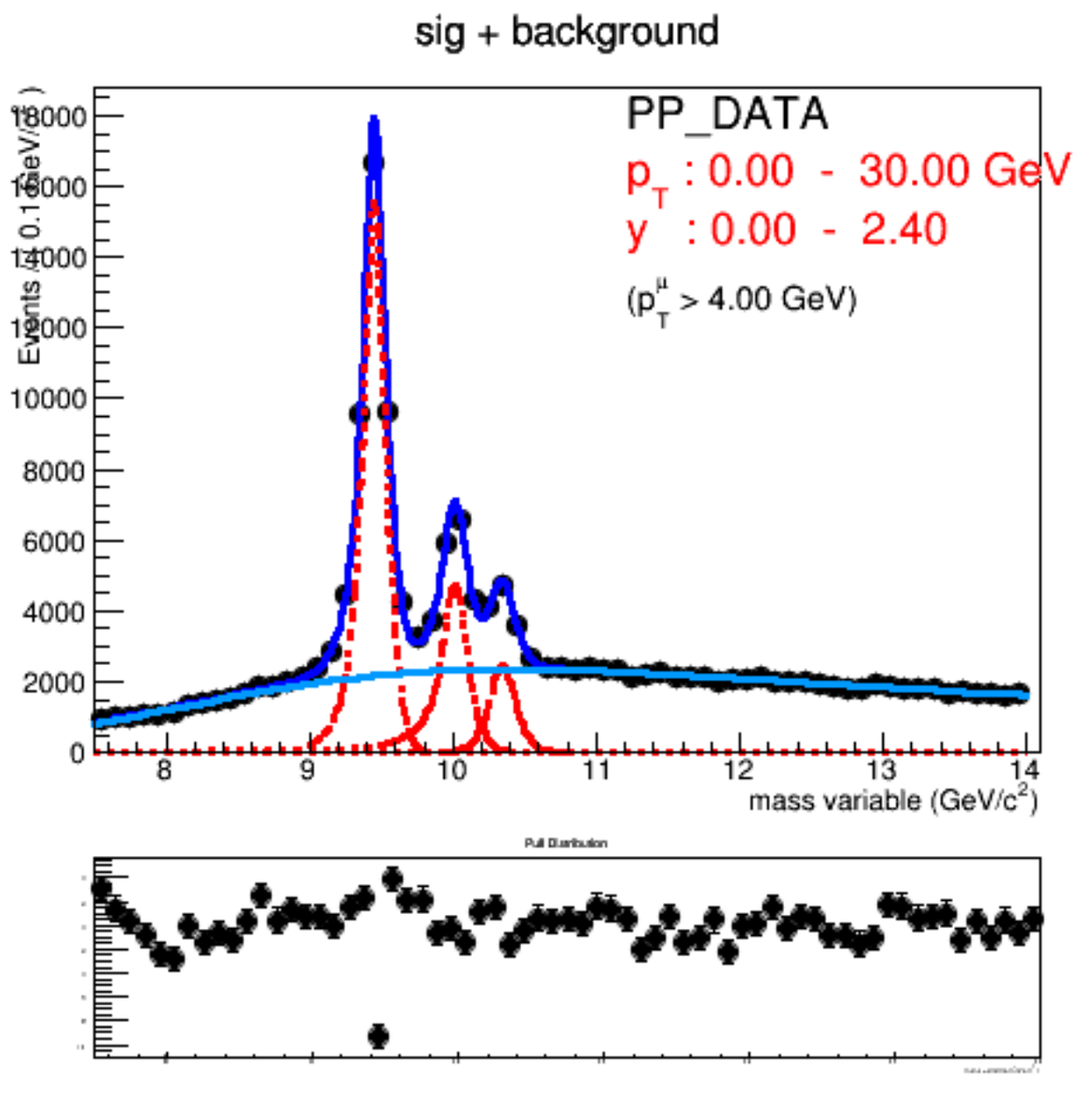
PP Data Single CB





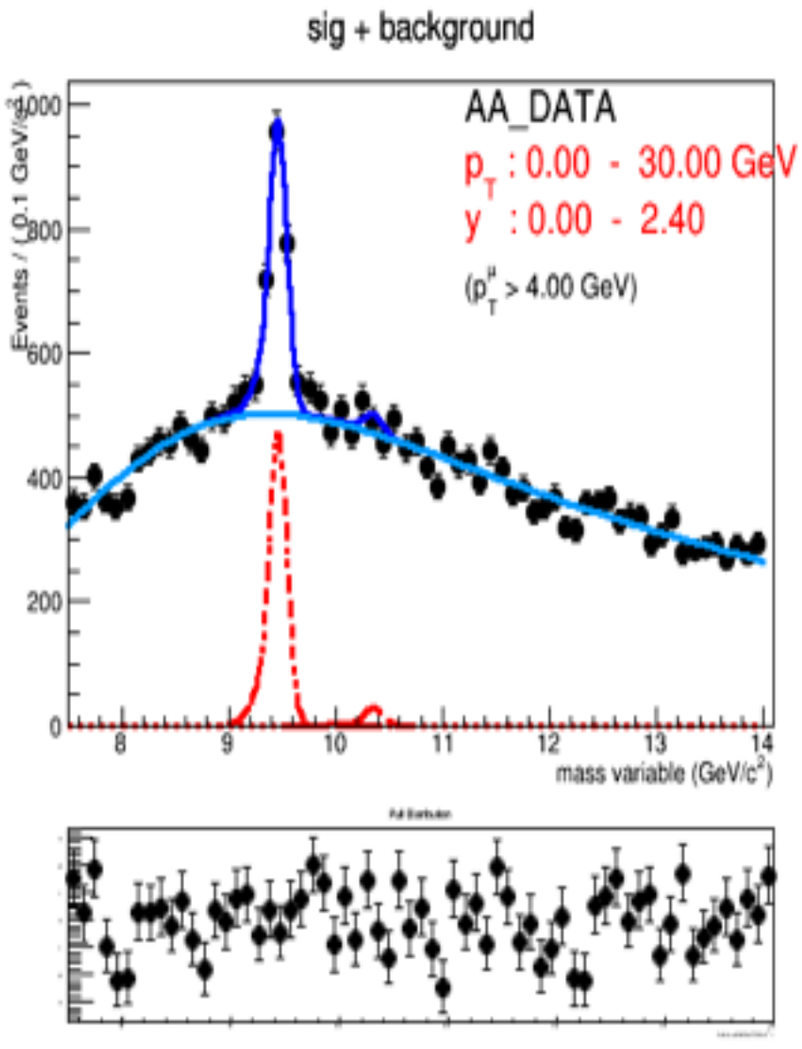
PP Data Double CB





Single CB Fitting

0-5%



bkg_N = 3000 ± 4343

err_mu = 7.785 ± 0.033

err_sigma = 1.347 ± 0.071

frac2over1 = 0.011 ± 0.049

m_decay = 6.05 ± 0.13

mass = 10 GeV/c^2

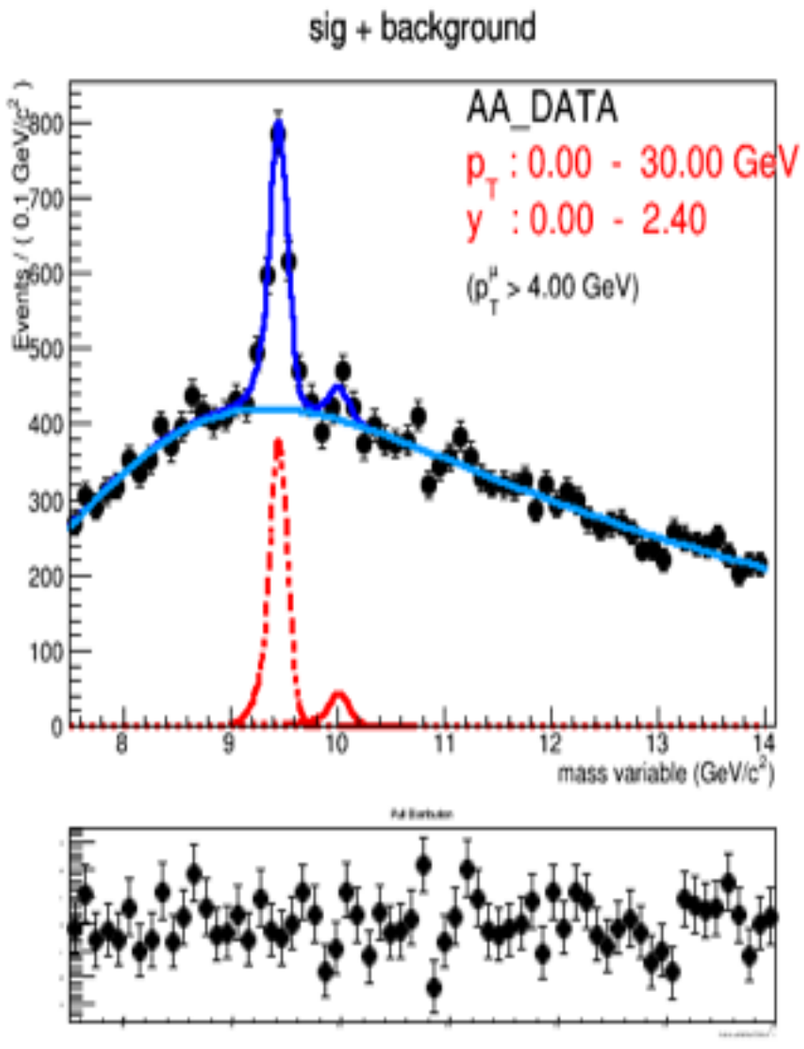
mean1s = 9.4596 ± 0.0059

nBkg = 26305 ± 165

nSig12s = 1083 ± 55

nSig3s = 68 ± 41

5-10%



bkg_N = 3000 ± 4242

err_mu = 7.842 ± 0.034

err_sigma = 1.295 ± 0.076

frac2over1 = 0.146 ± 0.038

m_decay = 5.62 ± 0.12

mass = 10 GeV/c^2

mean1s = 9.4525 ± 0.0068

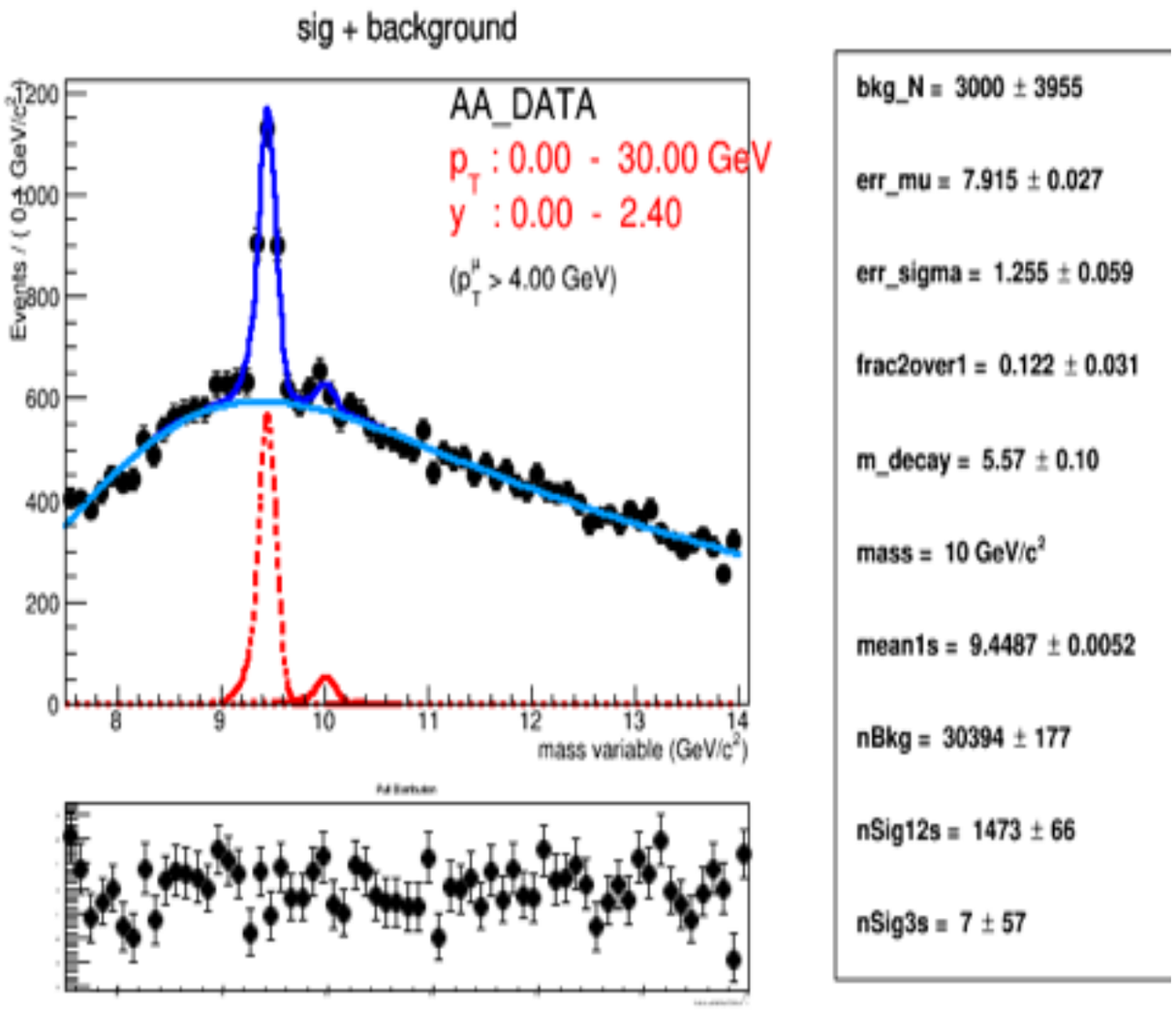
nBkg = 21622 ± 149

nSig12s = 1006 ± 57

nSig3s = 0 ± 47

Single CB Fitting

10-20%



bkg_N = 3000 ± 3955

err_mu = 7.915 ± 0.027

err_sigma = 1.255 ± 0.059

frac2over1 = 0.122 ± 0.031

m_decay = 5.57 ± 0.10

mass = 10 GeV/c^2

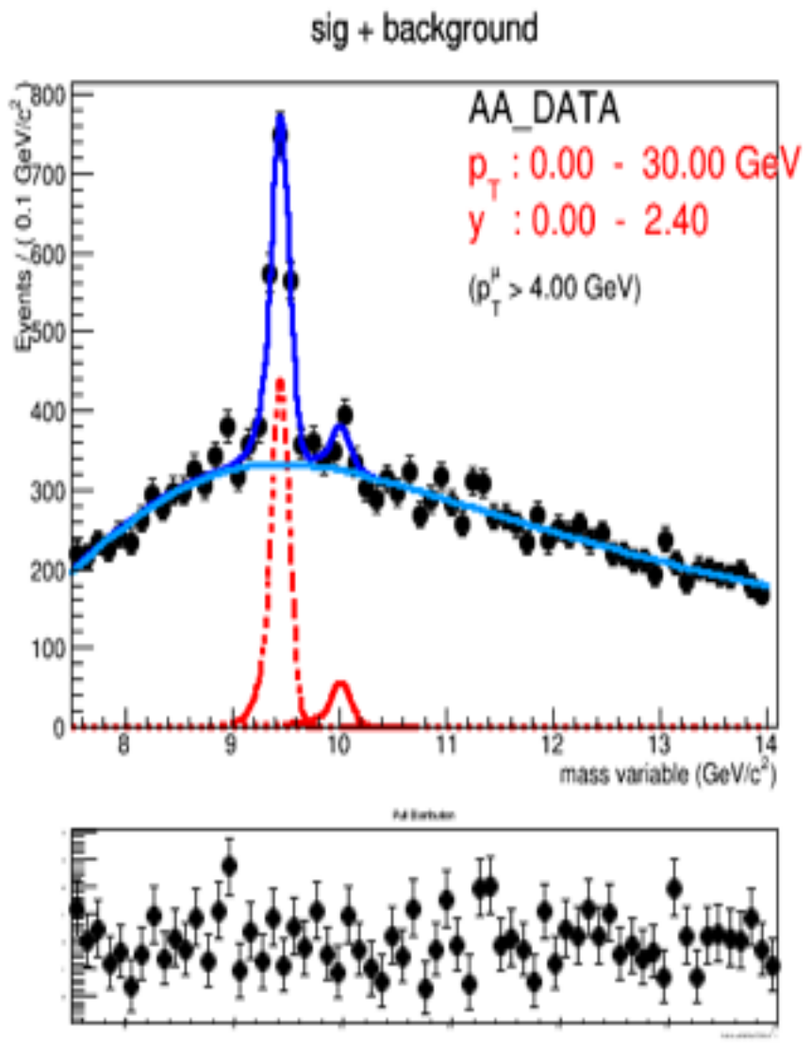
mean1s = 9.4487 ± 0.0052

nBkg = 30394 ± 177

nSig12s = 1473 ± 66

nSig3s = 7 ± 57

20-30%



bkg_N = 2886 ± 4110

err_mu = 7.872 ± 0.037

err_sigma = 1.272 ± 0.084

frac2over1 = 0.162 ± 0.030

m_decay = 6.19 ± 0.17

mass = 10 GeV/c^2

mean1s = 9.4494 ± 0.0054

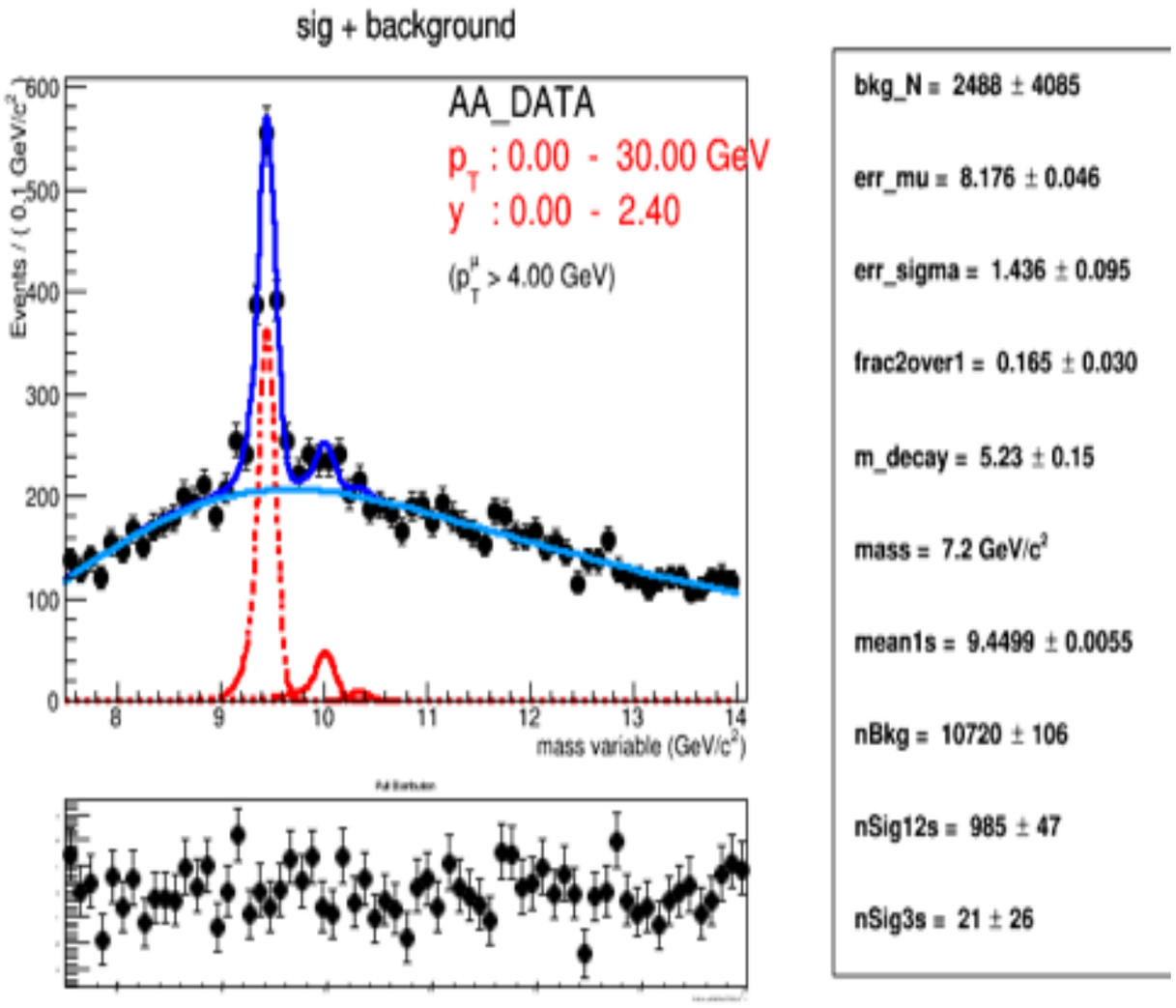
nBkg = 17337 ± 135

nSig12s = 1185 ± 55

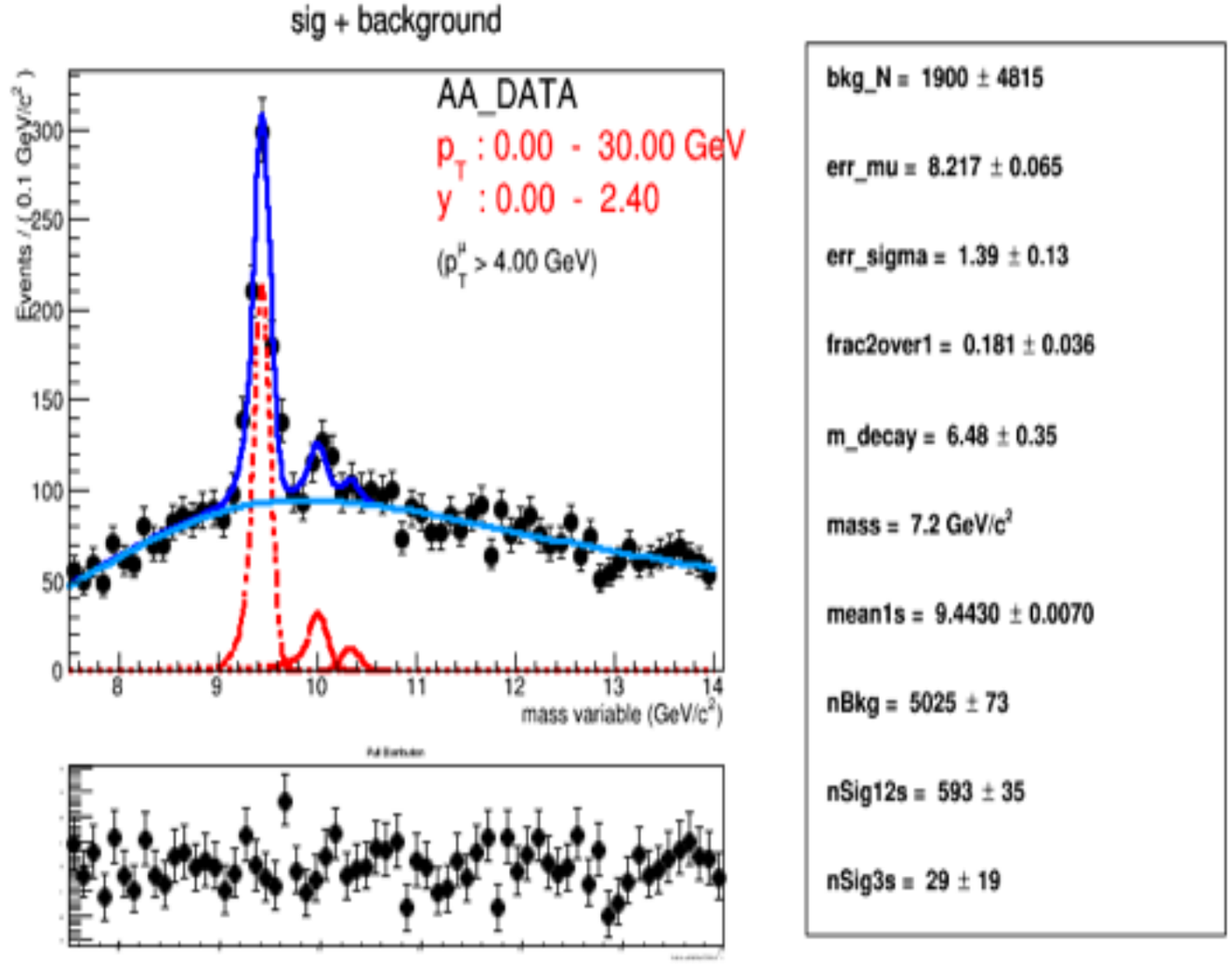
nSig3s = 0.0 ± 9.9

Single CB Fitting

30-40%

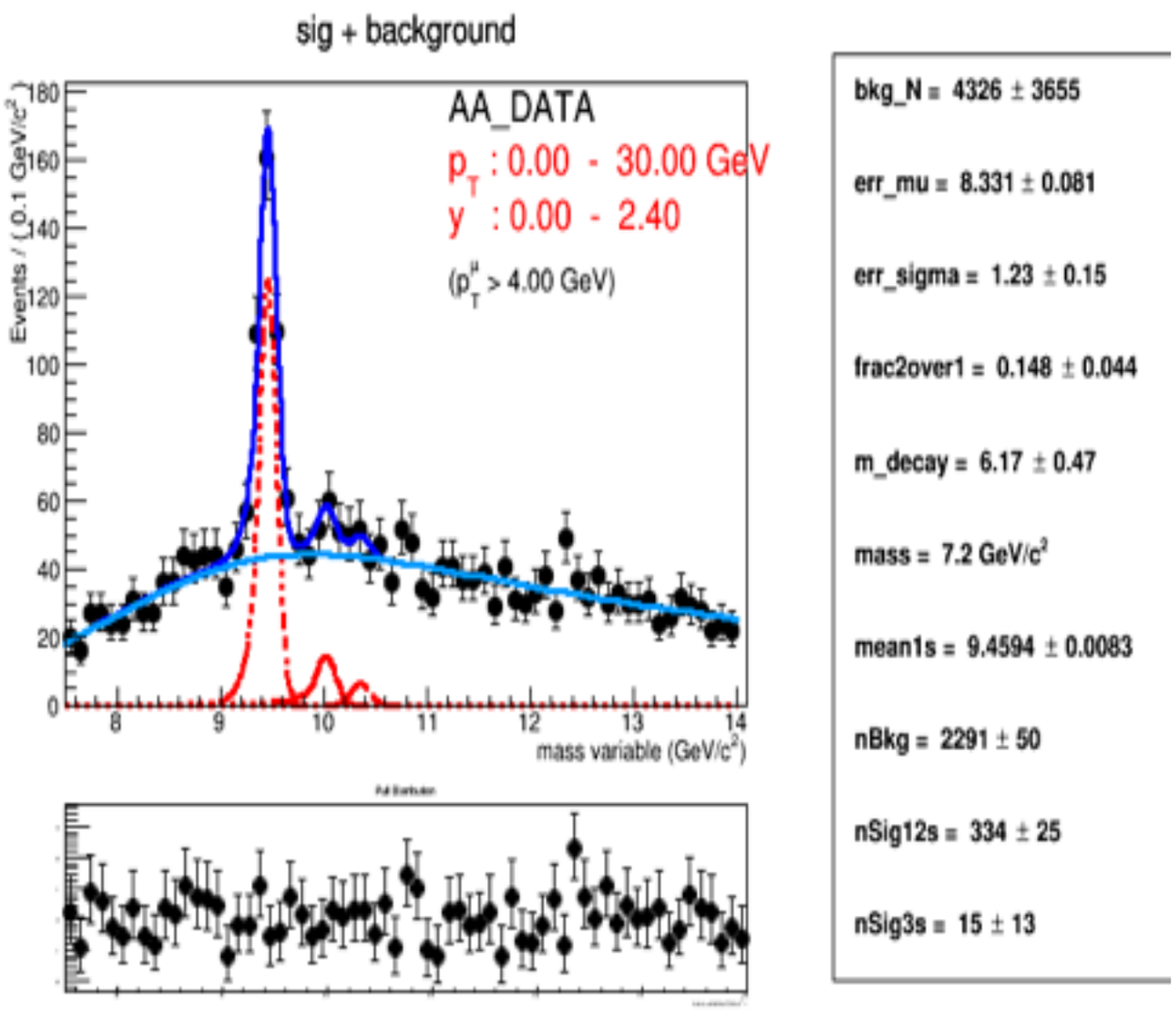


40-50%

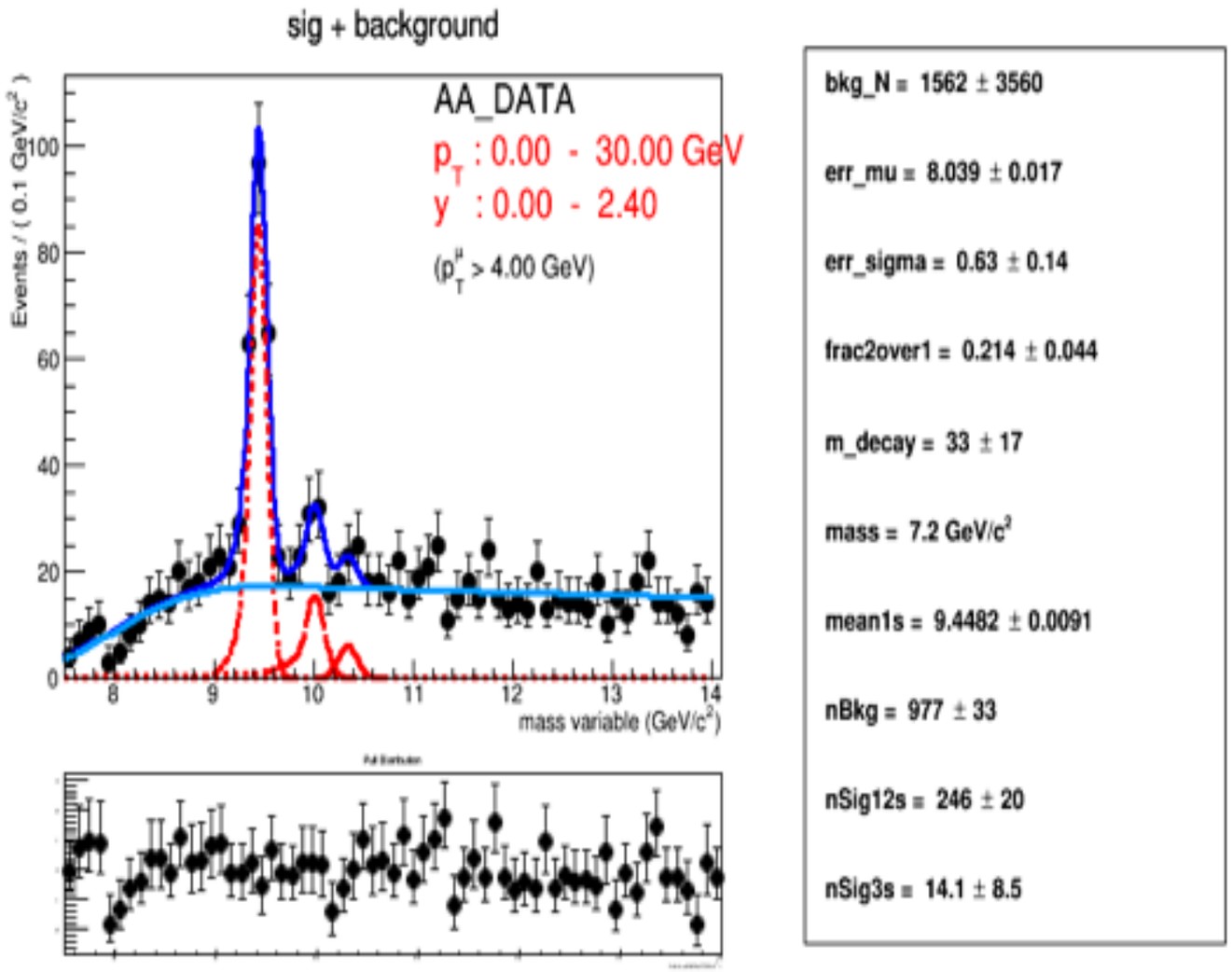


Single CB Fitting

50-60%

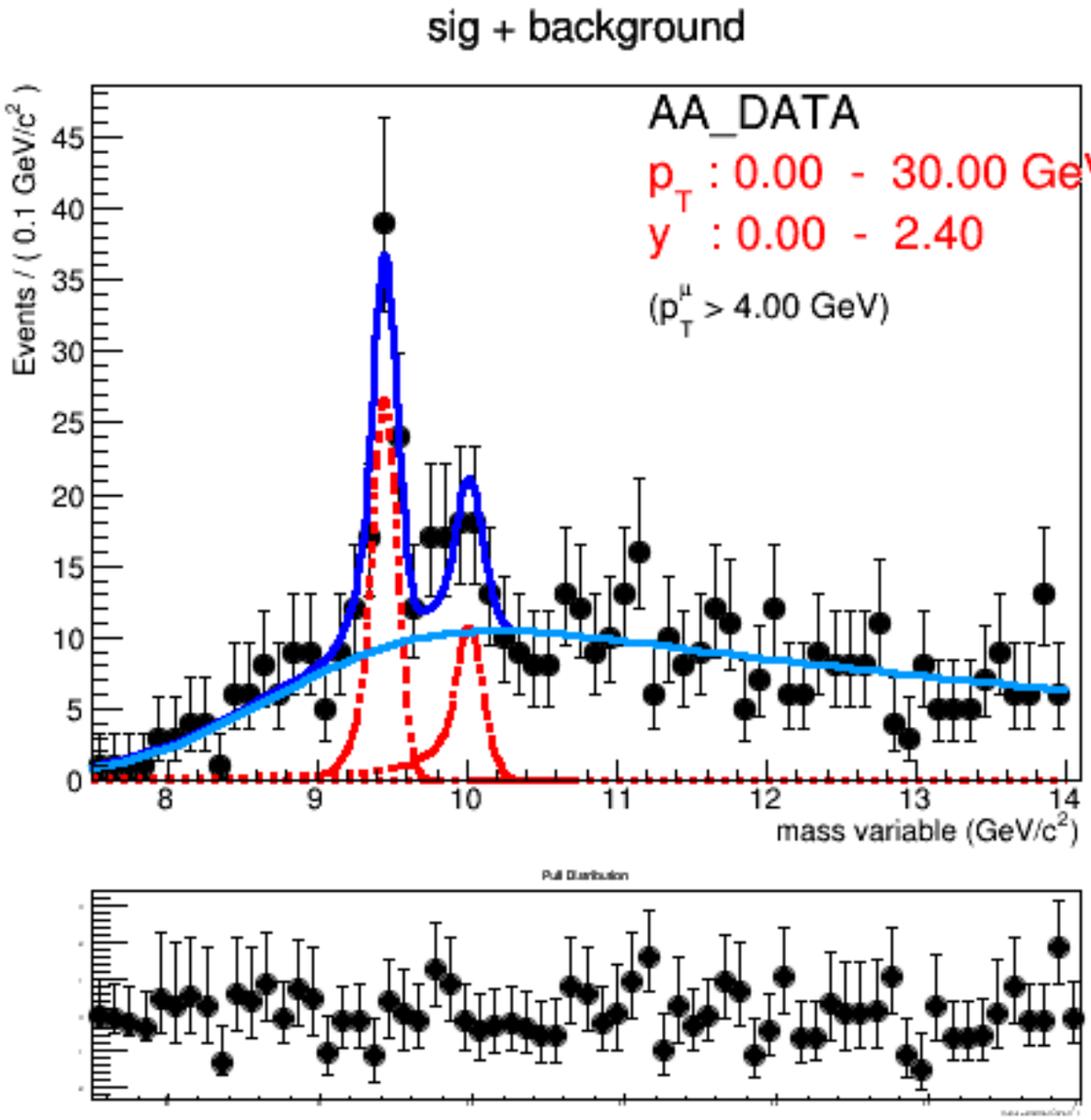


60-70%



Single CB Fitting

70-80%



bkg_N = 3000 ± 2542

err_mu = 8.89 ± 0.32

err_sigma = 0.84 ± 0.23

frac2over1 = 0.376 ± 0.087

m_decay = 6.7 ± 2.8

mass = 7.2 GeV/c^2

mean1s = 9.451 ± 0.016

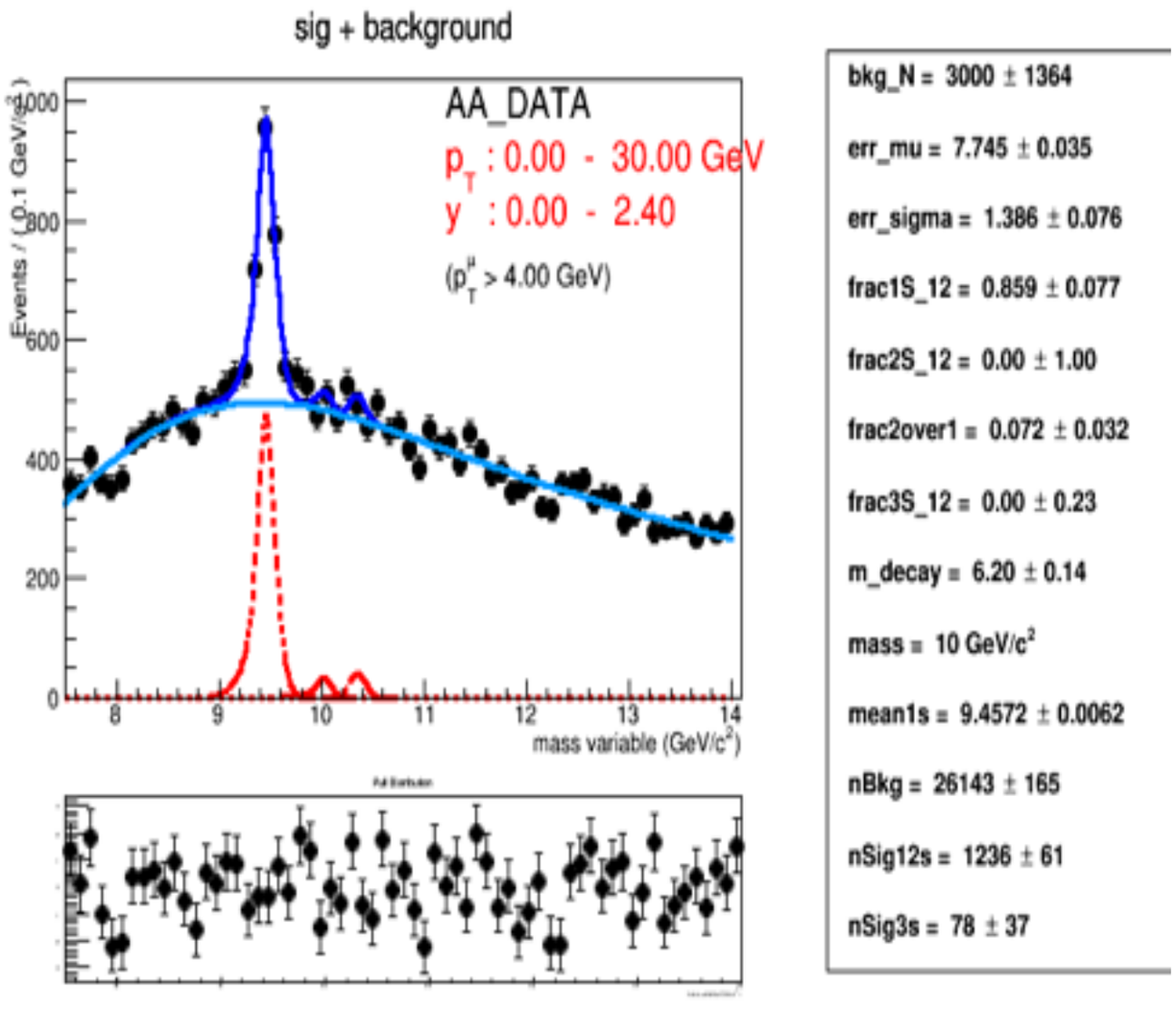
nBkg = 488 ± 26

nSig12s = 97 ± 17

nSig3s = 0.0 ± 2.8

Double CB Fitting

0-5%



bkg_N = 3000 ± 1364

err_mu = 7.745 ± 0.035

err_sigma = 1.386 ± 0.076

frac1S_12 = 0.859 ± 0.077

frac2S_12 = 0.00 ± 1.00

frac2over1 = 0.072 ± 0.032

frac3S_12 = 0.00 ± 0.23

m_decay = 6.20 ± 0.14

mass = 10 GeV/c^2

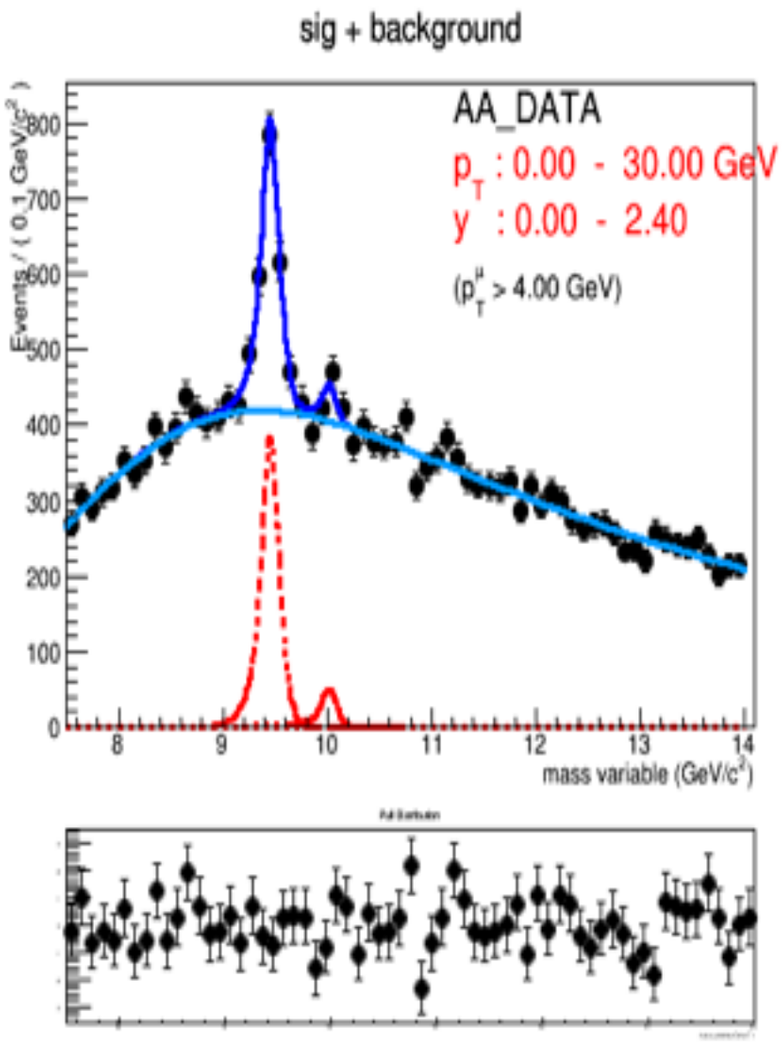
mean1s = 9.4572 ± 0.0062

nBkg = 26143 ± 165

nSig12s = 1236 ± 61

nSig3s = 78 ± 37

5-10%



bkg_N = 3000 ± 1364

err_mu = 7.842 ± 0.035

err_sigma = 1.319 ± 0.078

frac1S_12 = 0.821 ± 0.089

frac2S_12 = 0.01 ± 0.99

frac2over1 = 0.128 ± 0.035

frac3S_12 = 0.07 ± 0.94

m_decay = 5.61 ± 0.12

mass = 10 GeV/c^2

mean1s = 9.4523 ± 0.0068

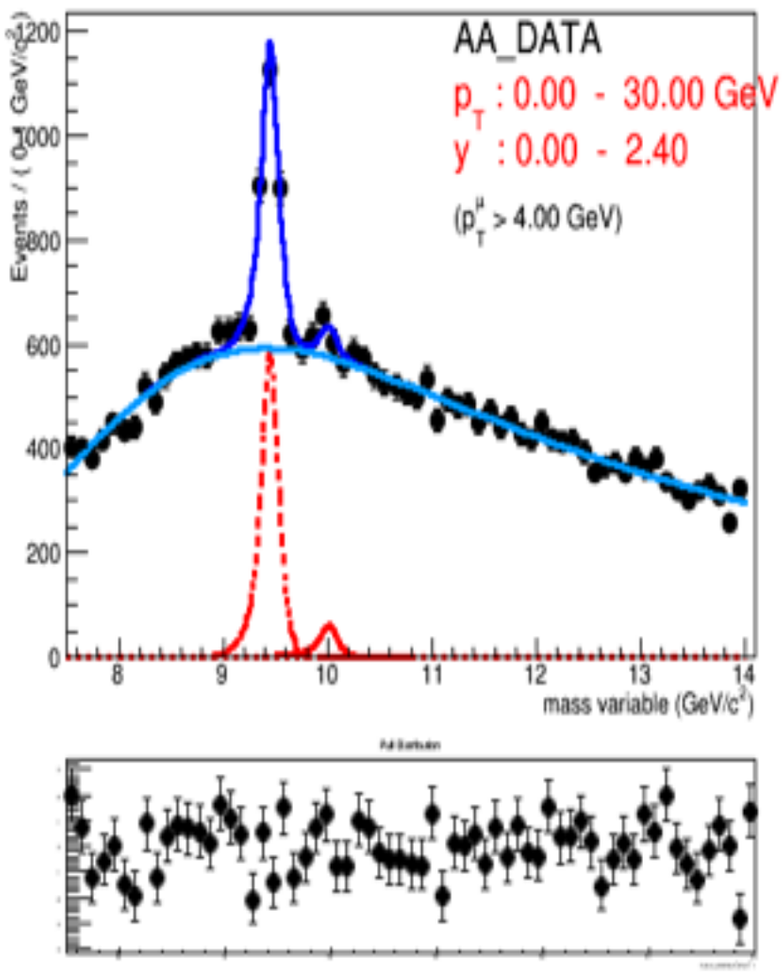
nBkg = 21593 ± 149

nSig12s = 1034 ± 57

nSig3s = 0 ± 87

Double CB Fitting

10-20%



bkg_N = 3000 ± 4340

err_mu = 7.911 ± 0.027

err_sigma = 1.272 ± 0.060

frac1S_12 = 0.801 ± 0.073

frac2S_12 = 0.37 ± 0.58

frac2over1 = 0.113 ± 0.028

frac3S_12 = 0.25 ± 0.37

m_decay = 5.58 ± 0.10

mass = 10 GeV/c^2

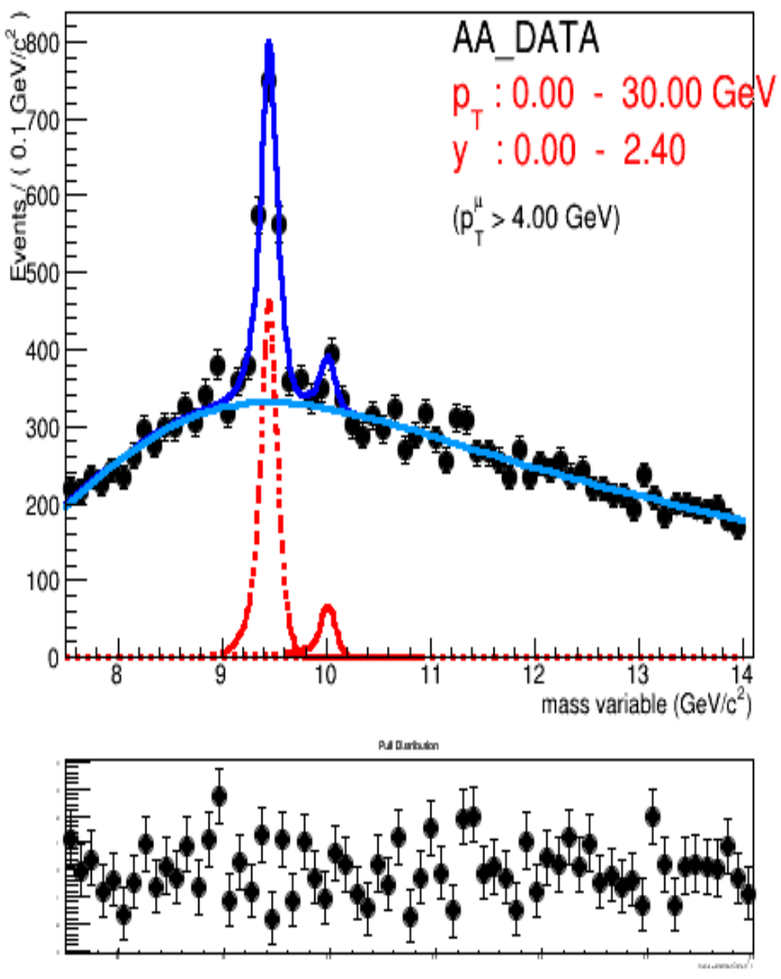
mean1s = 9.4470 ± 0.0054

nBkg = 30355 ± 177

nSig12s = 1514 ± 68

nSig3s = 5 ± 78

20-30%



bkg_N = 4334 ± 29283

err_mu = 7.8733 ± 0.0097

err_sigma = 1.285 ± 0.023

frac1S_12 = 0.744 ± 0.021

frac2S_12 = 0.000 ± 0.014

frac2over1 = 0.1479 ± 0.0076

frac3S_12 = 1.0 ± 3.5

m_decay = 6.181 ± 0.041

mass = 10 GeV/c^2

mean1s = 9.4514 ± 0.0014

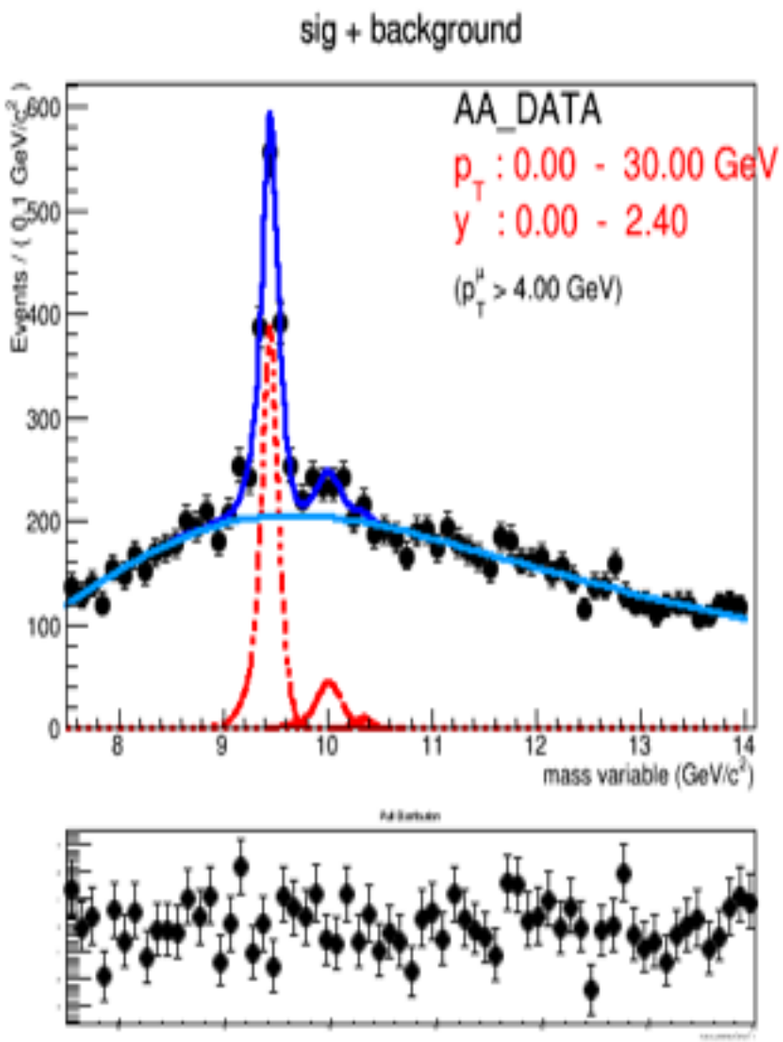
nBkg = 17327 ± 38

nSig12s = 1194 ± 14

nSig3s = 0 ± 7232

Double CB Fitting

30-40%



bkg_N = 3965 ± 2390

err_mu = 8.16 ± 0.17

err_sigma = 1.45 ± 0.17

frac1S_12 = 0.749 ± 0.086

frac2S_12 = 0.95 ± 0.20

frac2over1 = 0.144 ± 0.033

frac3S_12 = 0.00 ± 0.21

m_decay = 5.27 ± 0.54

mass = 7.2 GeV/c^2

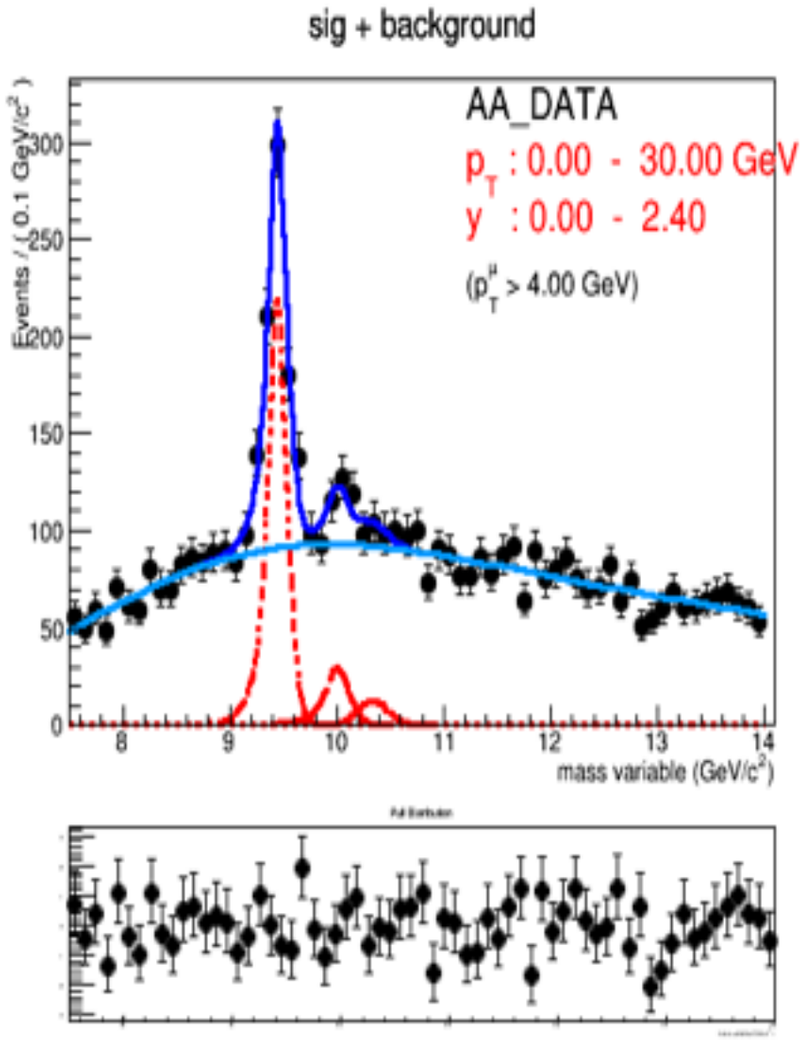
mean1s = 9.4482 ± 0.0054

nBkg = 10709 ± 125

nSig12s = 997 ± 69

nSig3s = 19 ± 25

40-50%



bkg_N = 1855 ± 1444

err_mu = 8.179 ± 0.070

err_sigma = 1.44 ± 0.15

frac1S_12 = 0.832 ± 0.093

frac2S_12 = 0.79 ± 0.55

frac2over1 = 0.149 ± 0.032

frac3S_12 = 1.00 ± 0.96

m_decay = 6.67 ± 0.37

mass = 7.2 GeV/c^2

mean1s = 9.4435 ± 0.0070

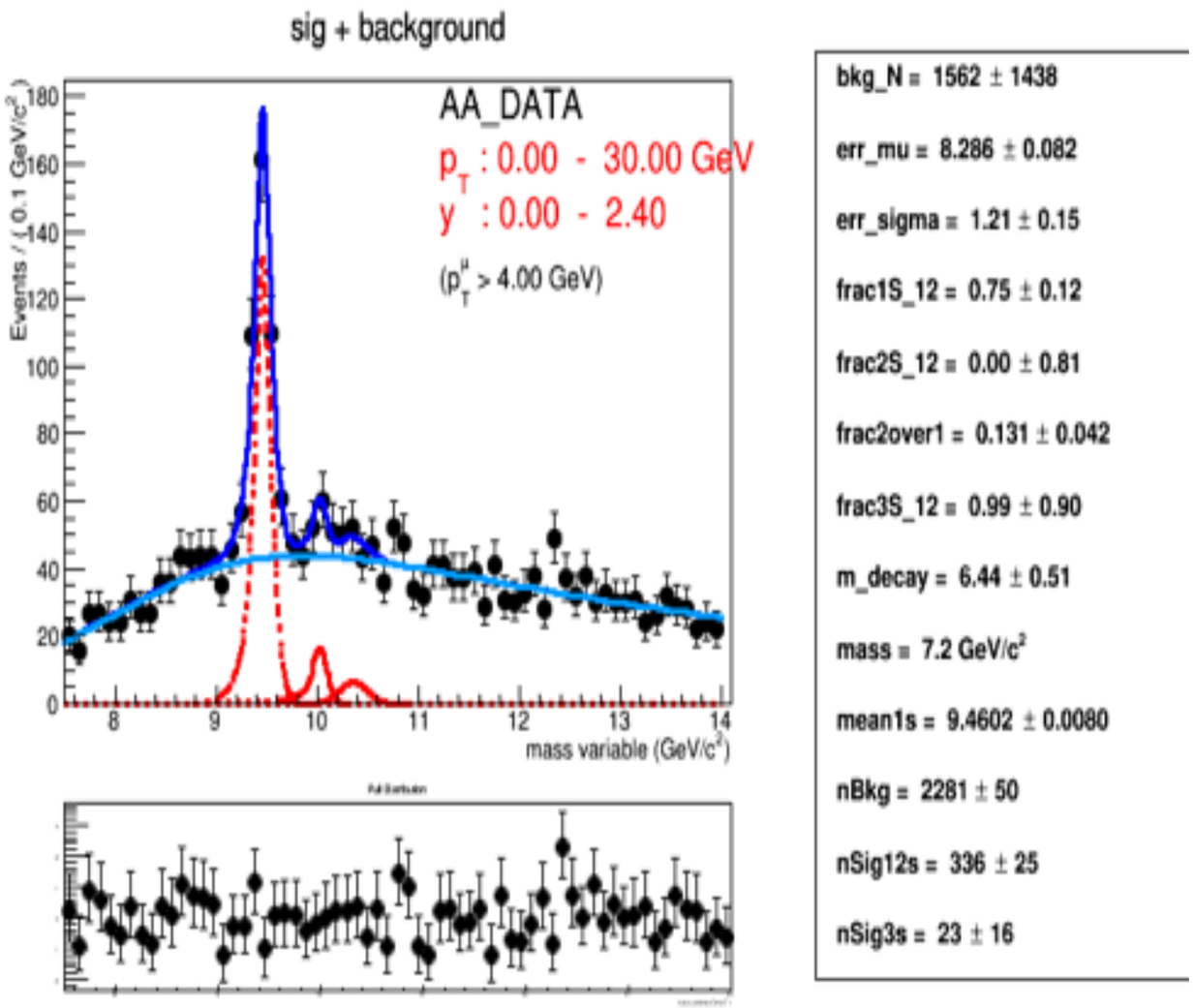
nBkg = 4992 ± 73

nSig12s = 610 ± 35

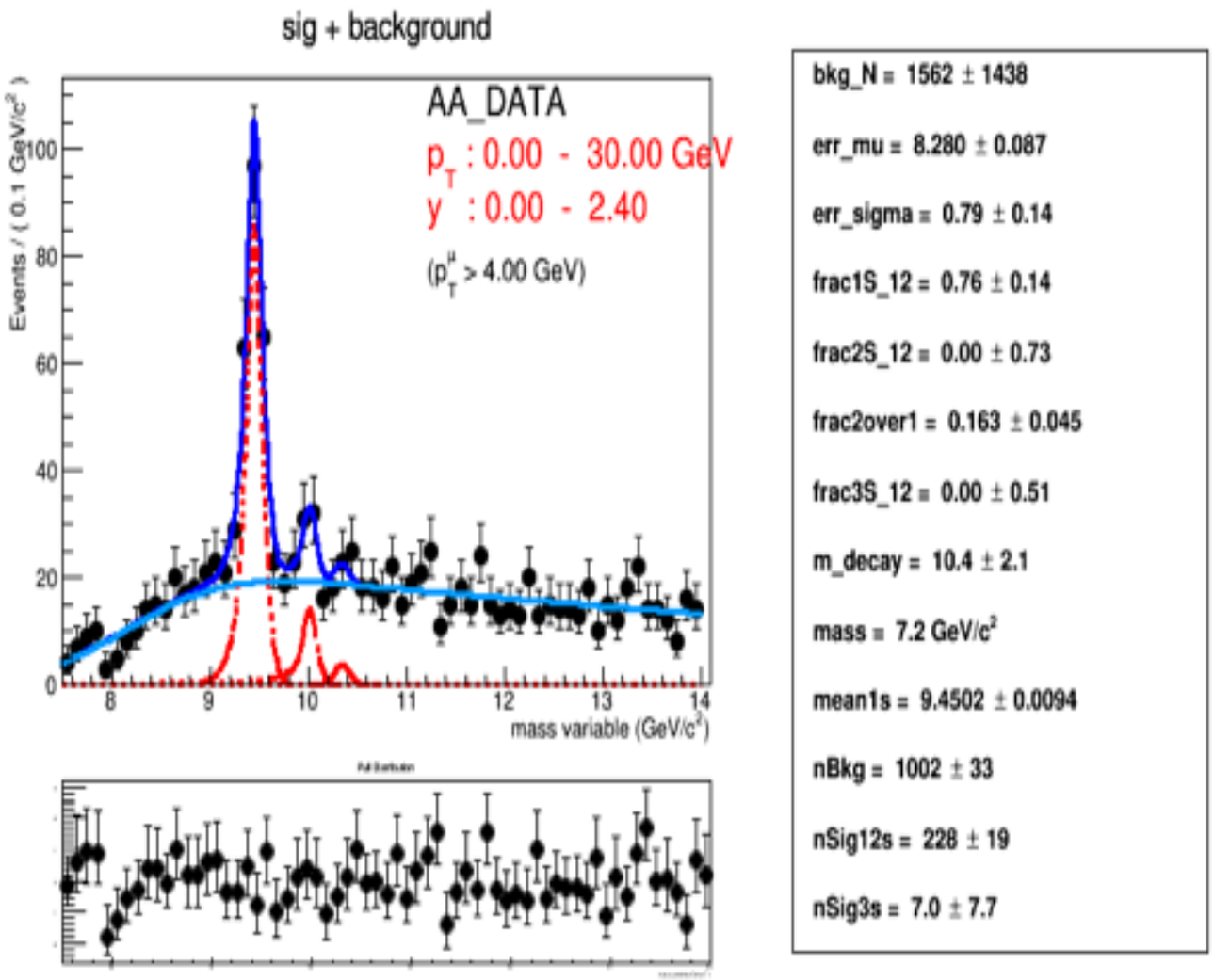
nSig3s = 43 ± 23

Double CB Fitting

50-60%

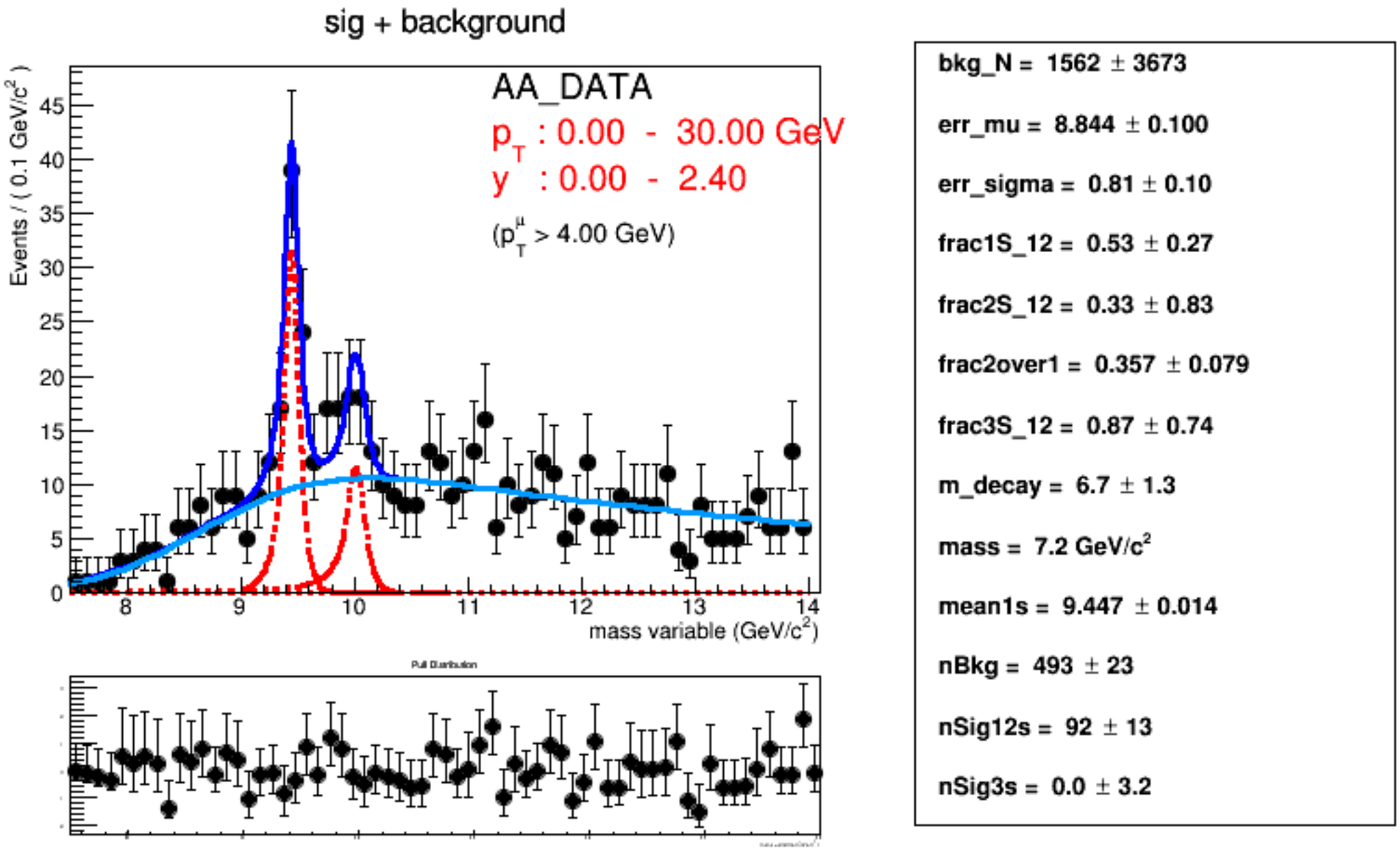


60-70%



Double CB Fitting

70-80%



bkg_N = 1562 ± 3673

err_mu = 8.844 ± 0.100

err_sigma = 0.81 ± 0.10

frac1S_12 = 0.53 ± 0.27

frac2S_12 = 0.33 ± 0.83

frac2over1 = 0.357 ± 0.079

frac3S_12 = 0.87 ± 0.74

m_decay = 6.7 ± 1.3

mass = 7.2 GeV/c^2

mean1s = 9.447 ± 0.014

nBkg = 493 ± 23

nSig12s = 92 ± 13

nSig3s = 0.0 ± 3.2