Chargino / Neutralino Fully Hadronic Analysis

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SUSY P5: Params, Samples, Software

Input Parameters		m_{bosino} [GeV]		Decays
m_0:	206.0 GeV	neut1	115.7	–
$m_{1/2}$:	293.0 GeV	neut2	216.7	$\widetilde{\chi}_2^0 \to \widetilde{\chi}_1^0 Z$: 96.4 %
$\tan(\beta)$:	10	neut3,4	413, 430	not relevant
Sgn(μ):	1	char1	216.5	$\widetilde{\chi}_1^\pm \to \widetilde{\chi}_1^0 W$: 99.4 %
A_0:	0	char2	430.7	2-body: ≈ 87.0 %

- Processes: $e^+e^- \to \widetilde{\chi}_1^\pm \widetilde{\chi}_1^\pm \to W^+W^- \to u\bar{d}\,d\bar{u}$
  and $e^+e^- \to \widetilde{\chi}_2^0 \widetilde{\chi}_2^0 \to Z^0 Z^0 \to u\bar{u}\,d\bar{d}$
- Software: ILCsoft v01-04, $\sqrt{s} = 500$ GeV, $\mathcal{P}_{e^+} = +1$, $\mathcal{P}_{e^-} = -1$
- Compare different detector models:
  - ▷ LDC (LDC01_06Sc) `DST*_ch1ch1_udud_*LDC01_06Sc_*.slcio`
  - ▷ LDC′ (LDCPrime_02Sc) `DST*_ne2ne2_ddbb_*LDCPrime_02Sc_*.slcio`
  - ▷ LDC-GLD (LDC_GLD_01Sc) `DST*_ch1ch1_cscs_*LDC_GLD_01Sc_*.slcio`

Kinematic Fits (5C,7C) W/Z mass constraints

- Software is based on Kinfit (ILCsoft v01-04)
- Jet Energy Scale (JES) setting: +1% (jet 4-vector× 1.01)
- Assume Gaussian errors for all parameters

5C Fit: E, p conservation & $m(j1,j2) = m(j3,j4)$

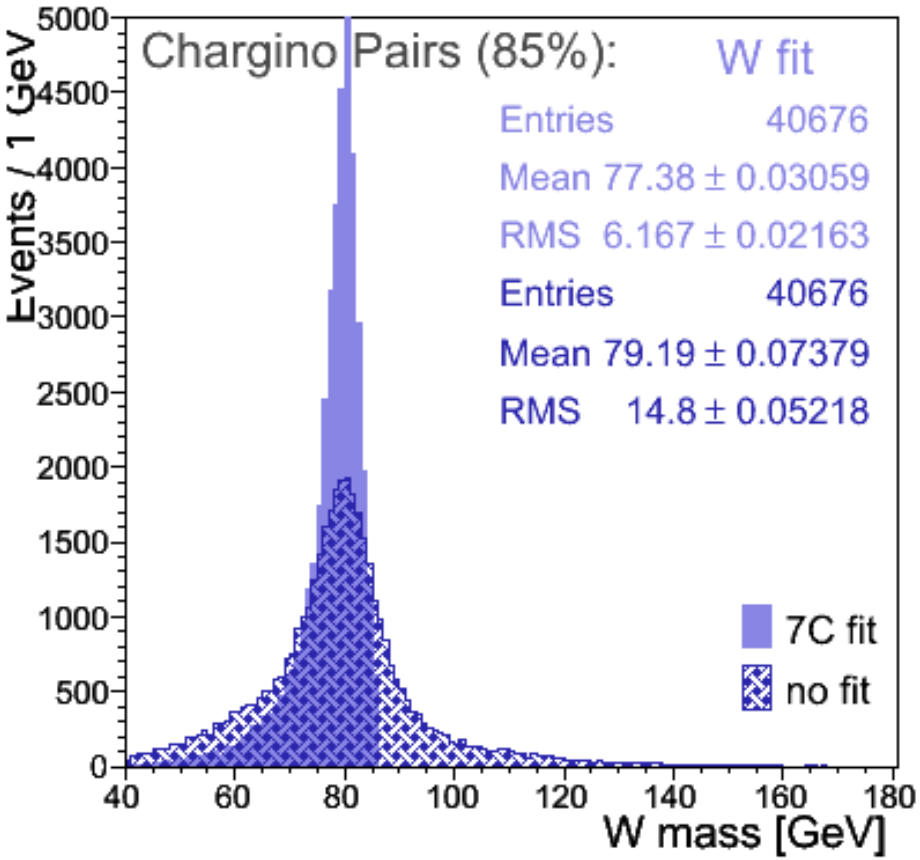
- ▷ E' : $E \pm {}^{50\%}/\sqrt{E}$
- ▷ θ' : $\theta \pm 0.1$ rad (5.7°)
- ▷ ϕ' : $\phi \pm 0.1$ rad (5.7°)

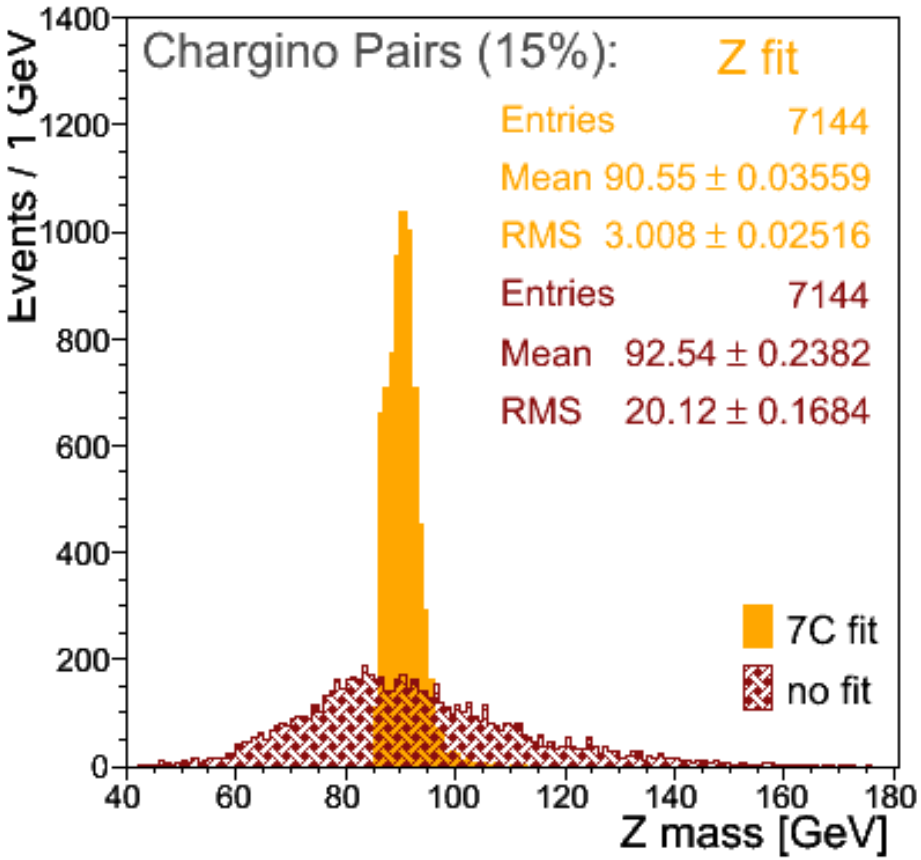
7C Fit: E, p conservation & $m(j1,j2) = m(j3,j4)$

- ▷ same parameters/errors as above
- ▷ and $m(j1,j2) = m_W,\, m_Z$
- ▷ and $m(j3,j4) = m_W,\, m_Z$

Charginos: W/Z Masses

Detector model: LDC (LDC01_06Sc)
nearly the same performance as for LDC′





Charginos: W/Z Masses

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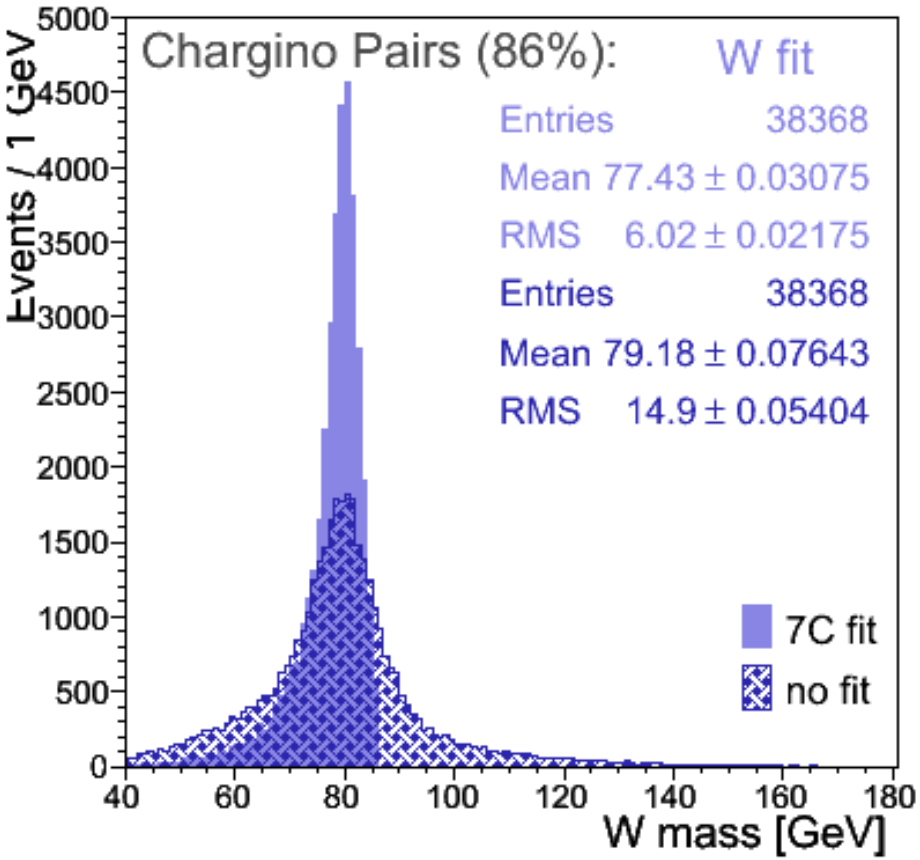
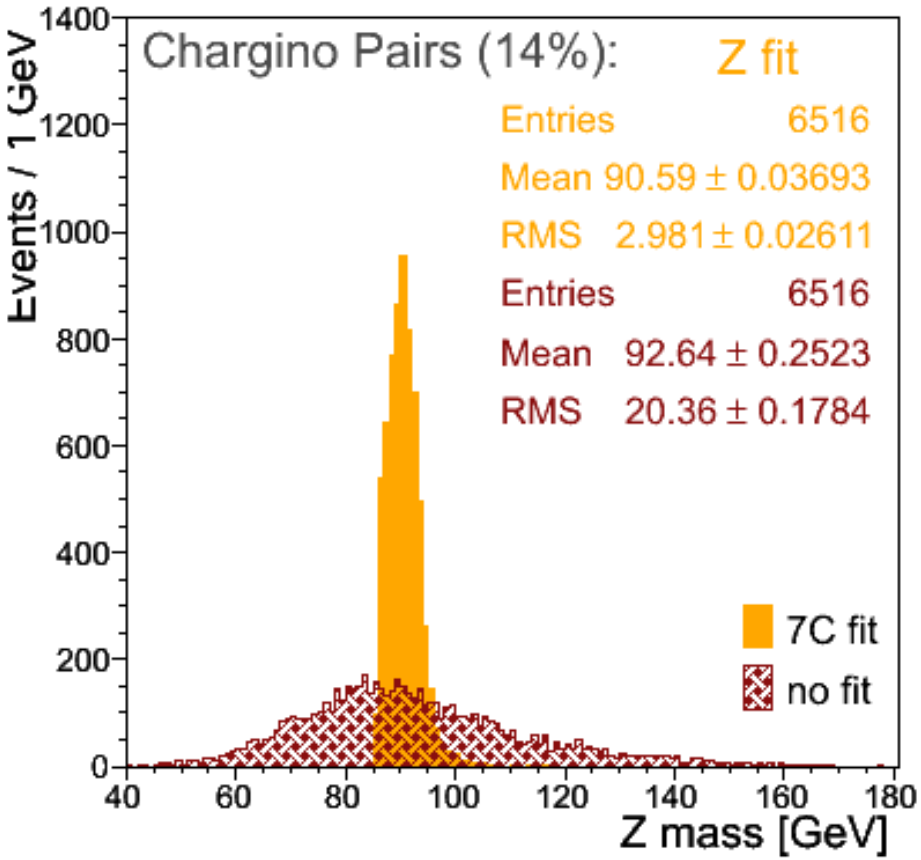
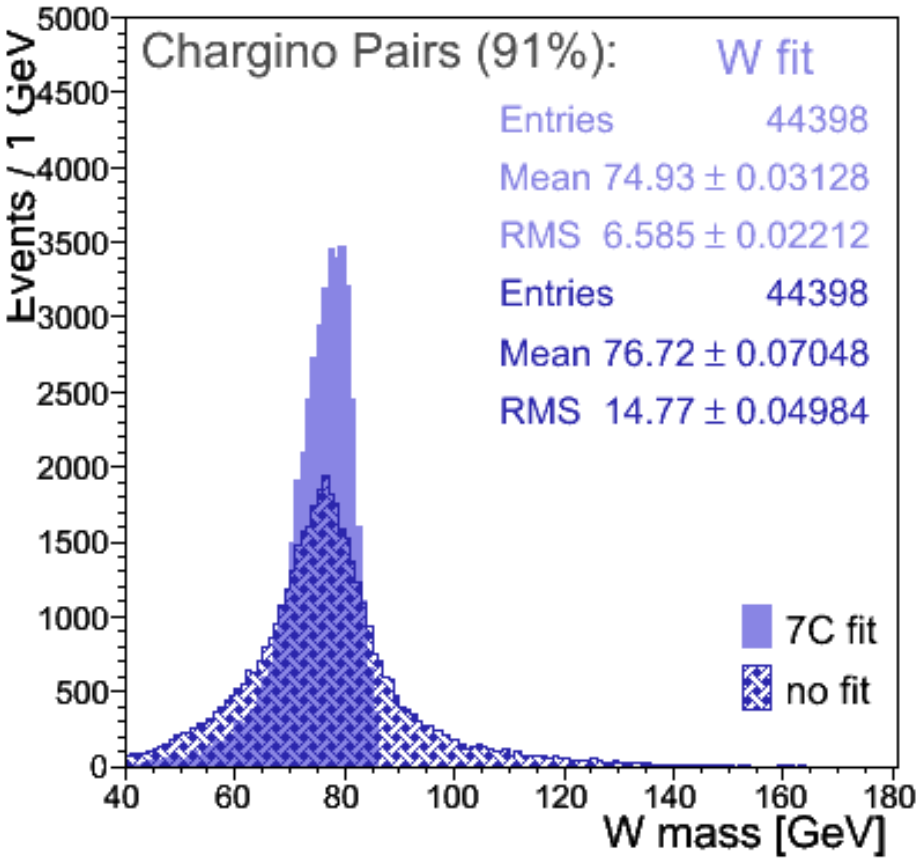


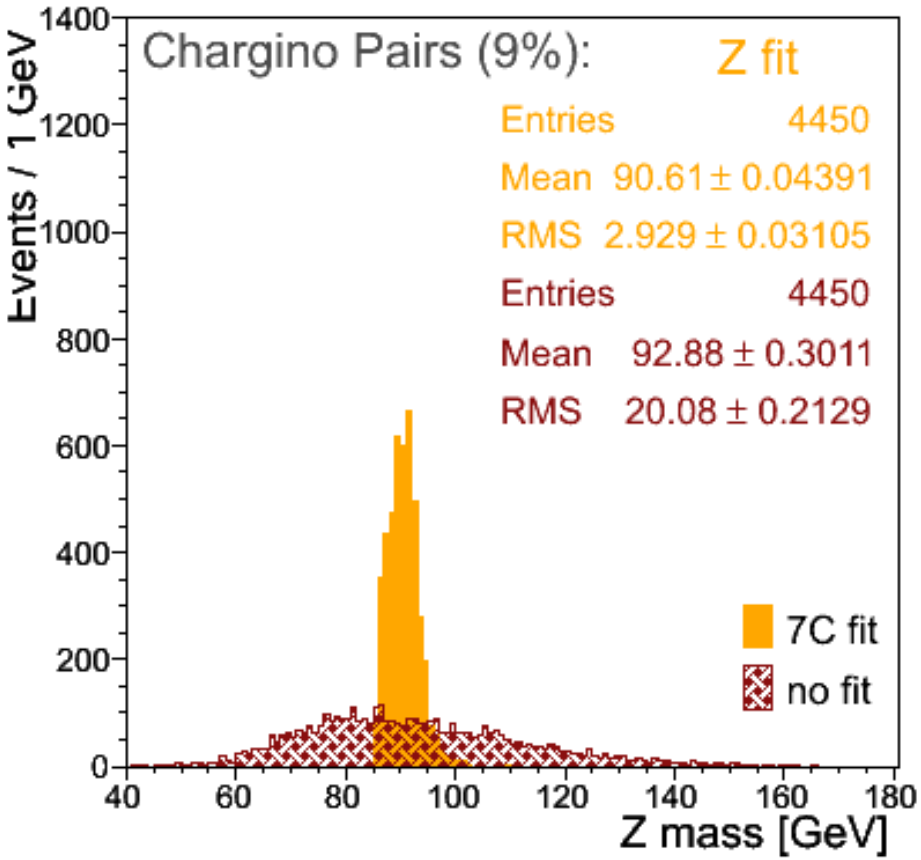


Charginos: W/Z Masses

Detector model: LDC-GLD (LDC_GLD_01Sc)

GLD-sized LDC clearly shows worse performance





Neutralinos: W/Z Masses

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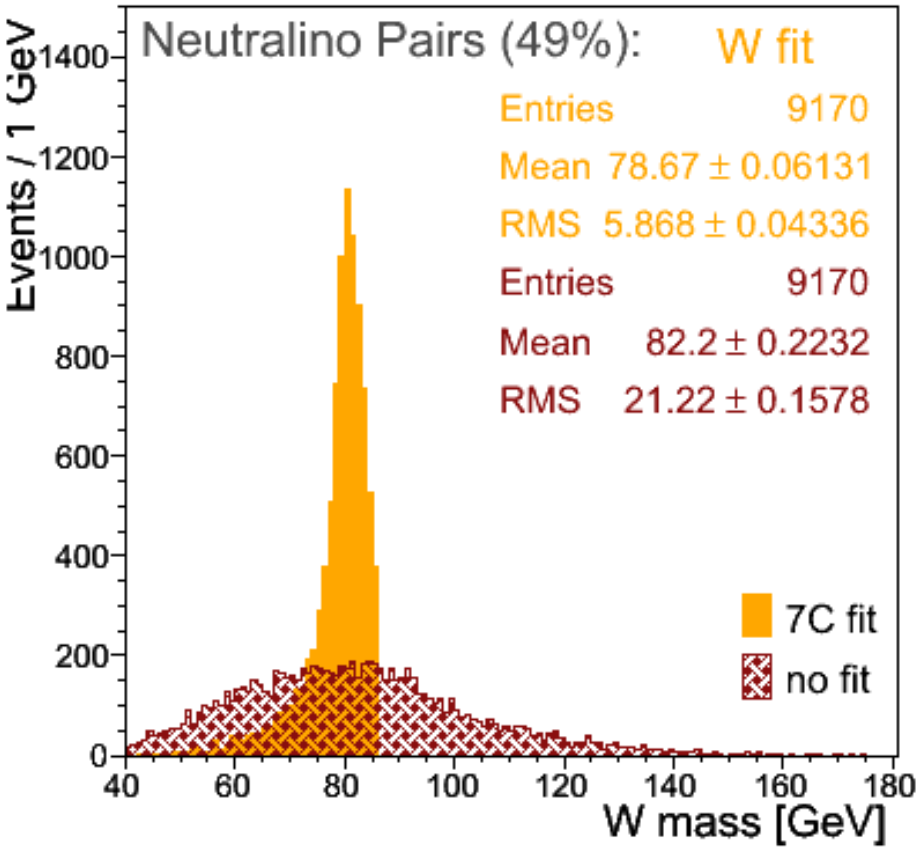

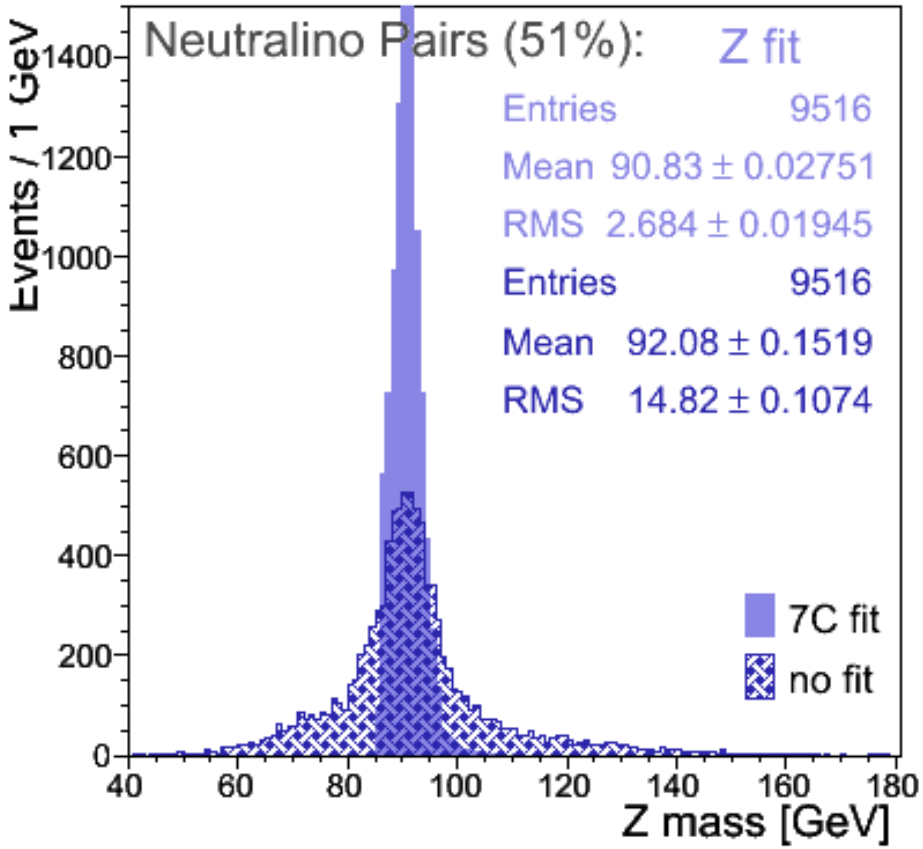

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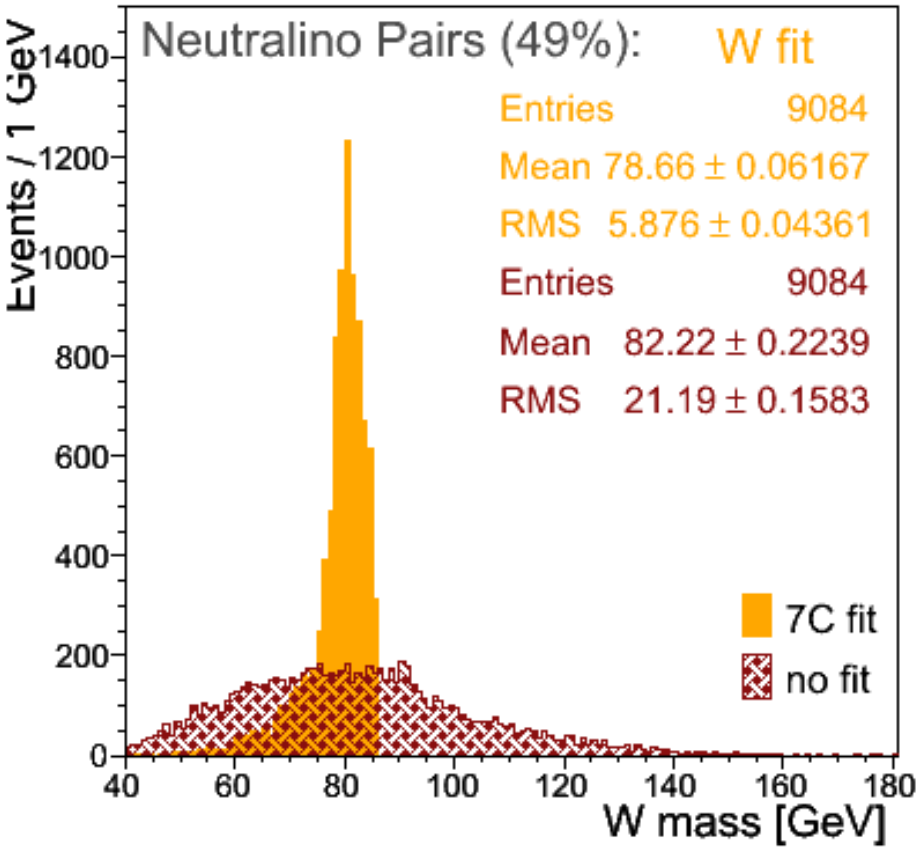

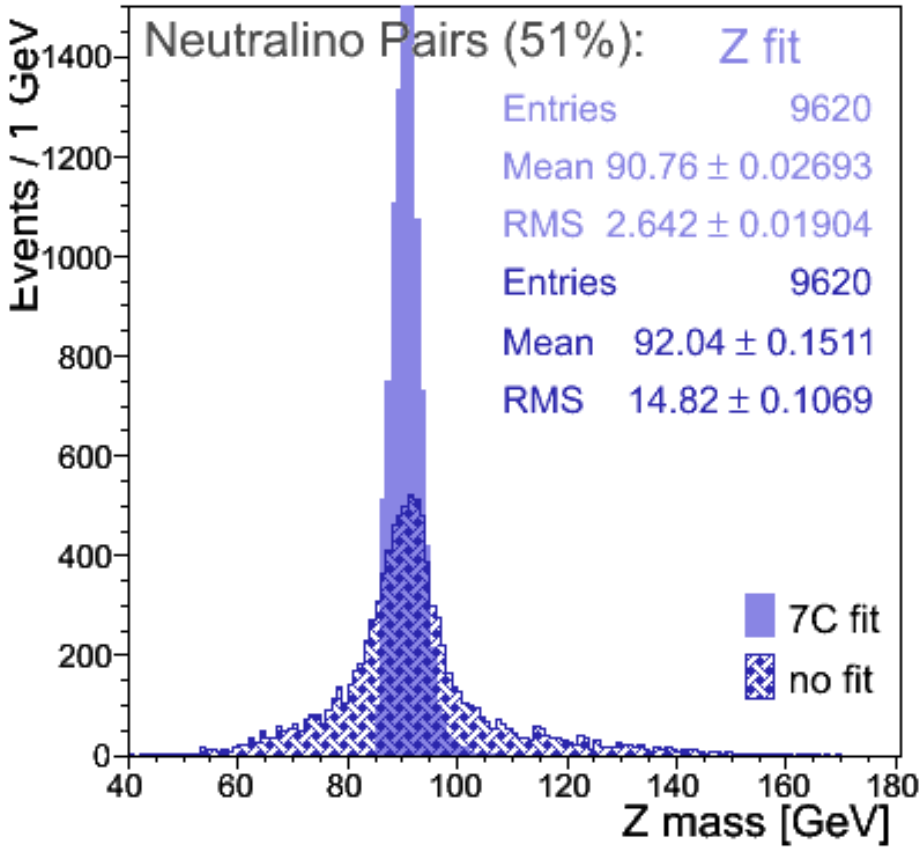

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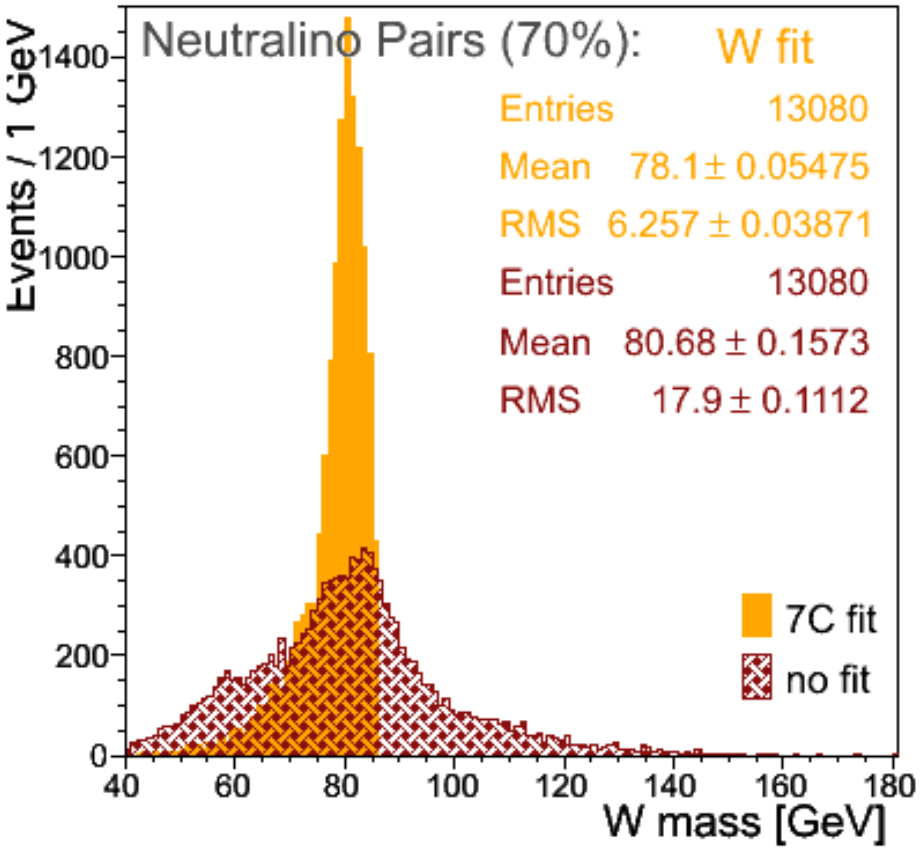

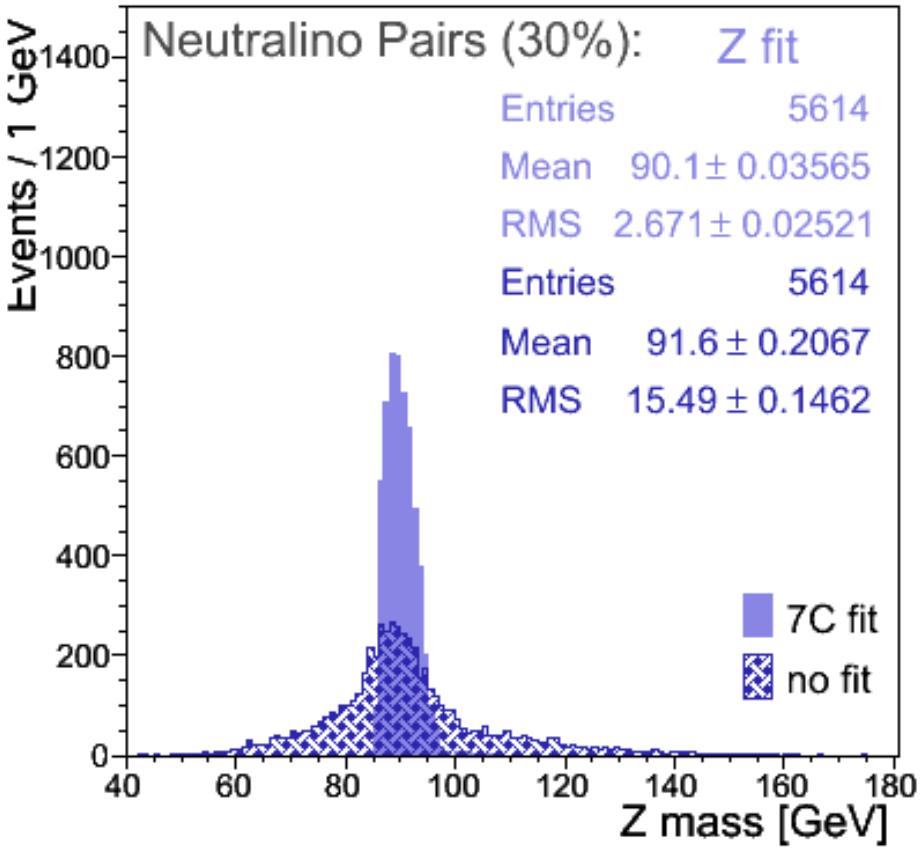

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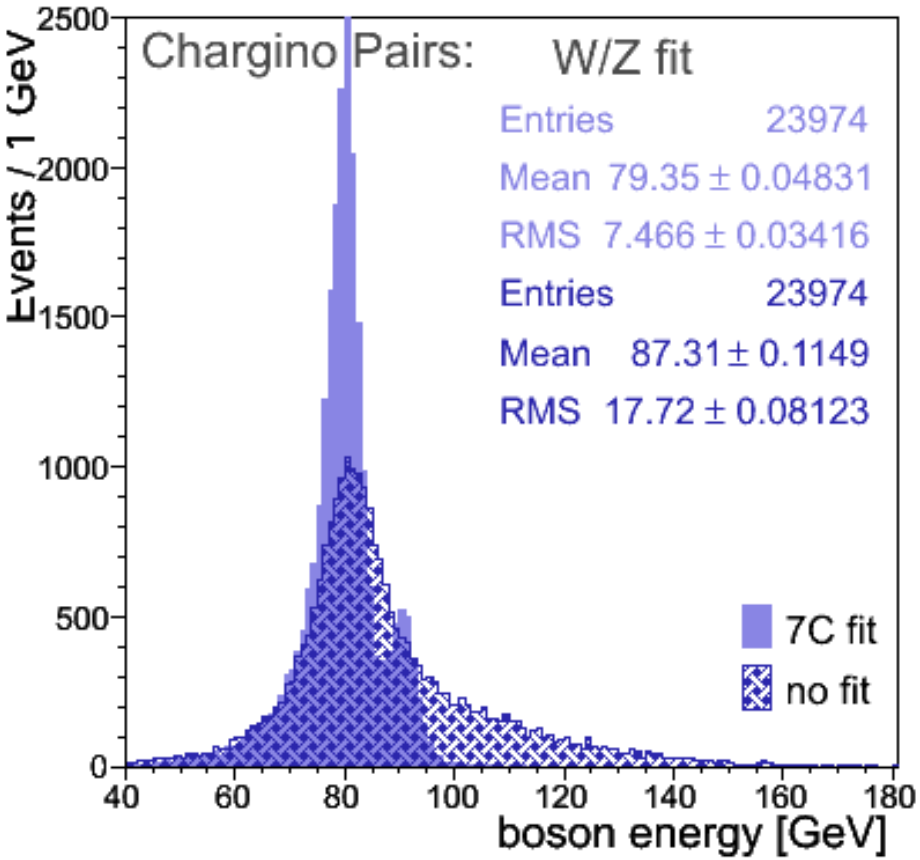

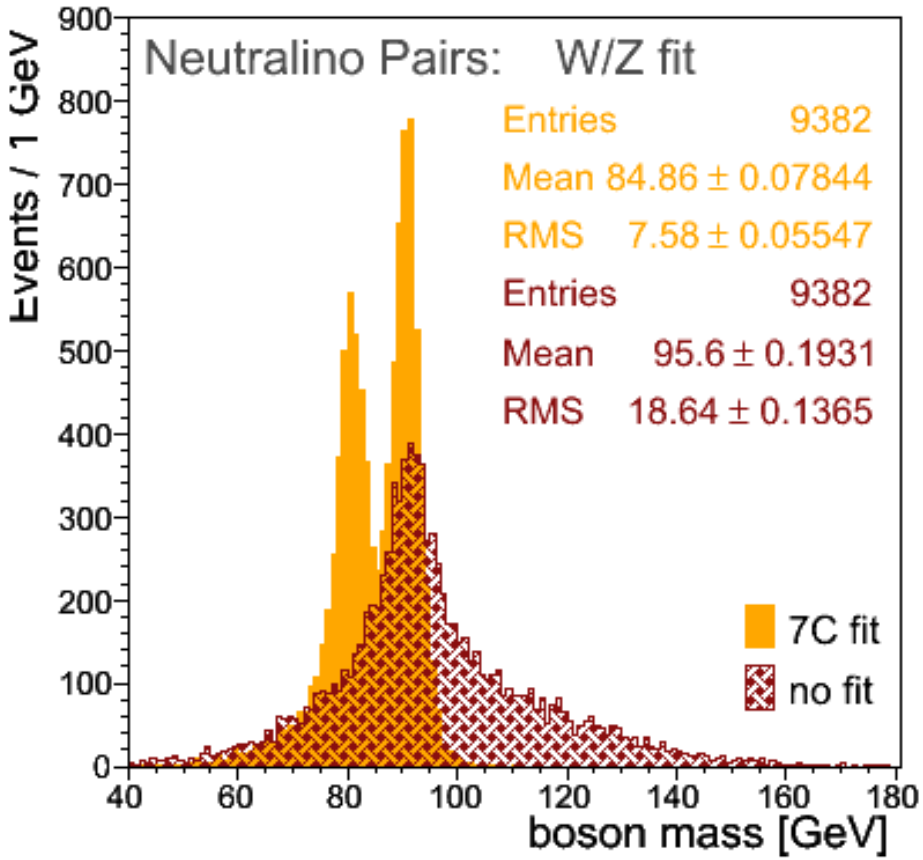

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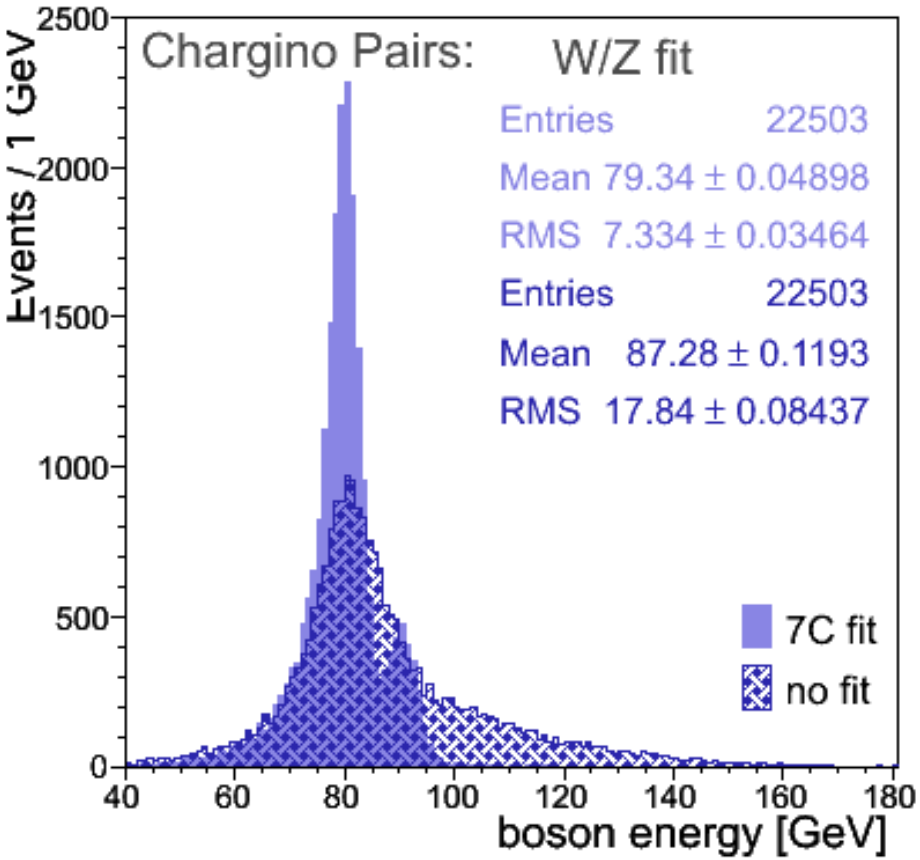

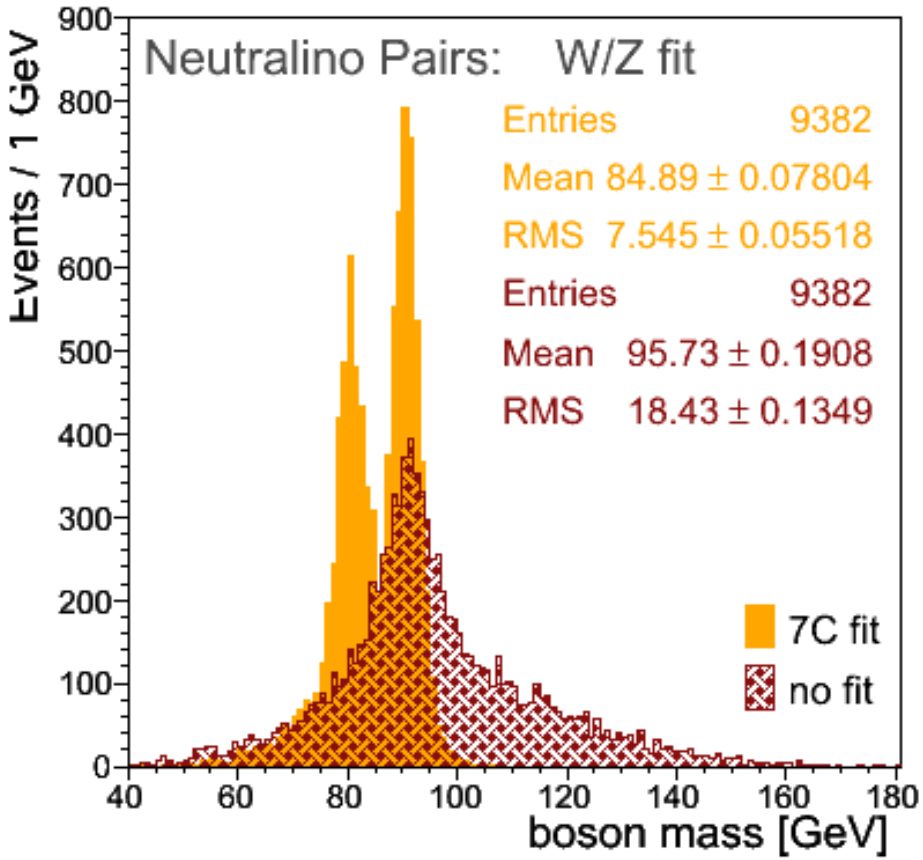

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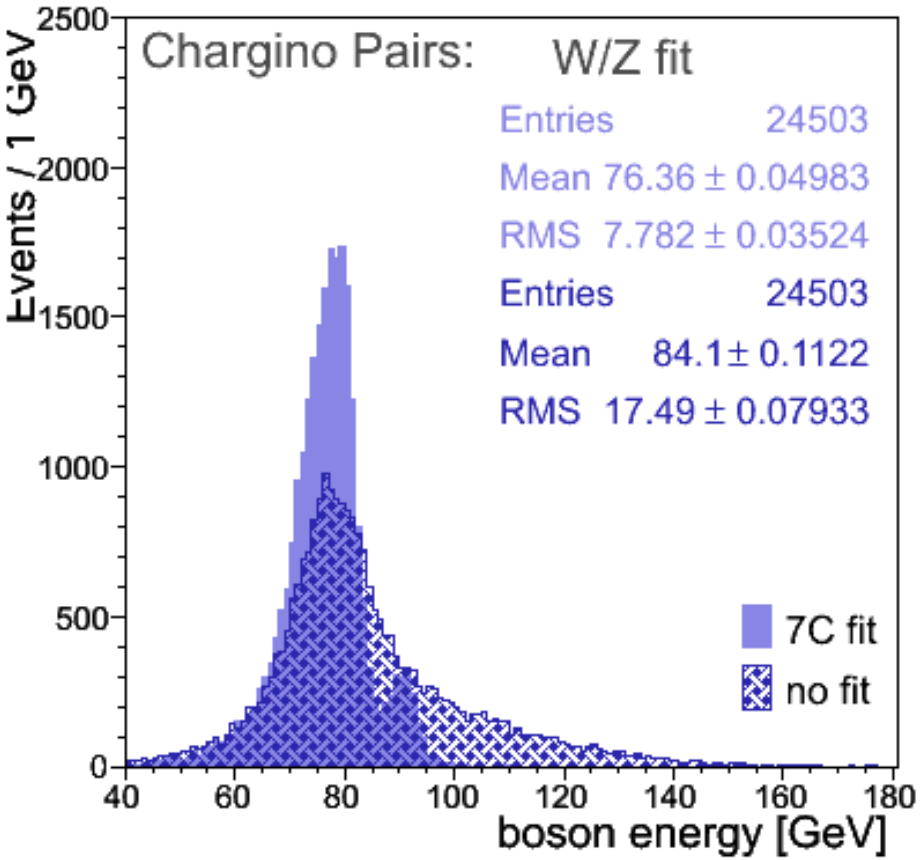
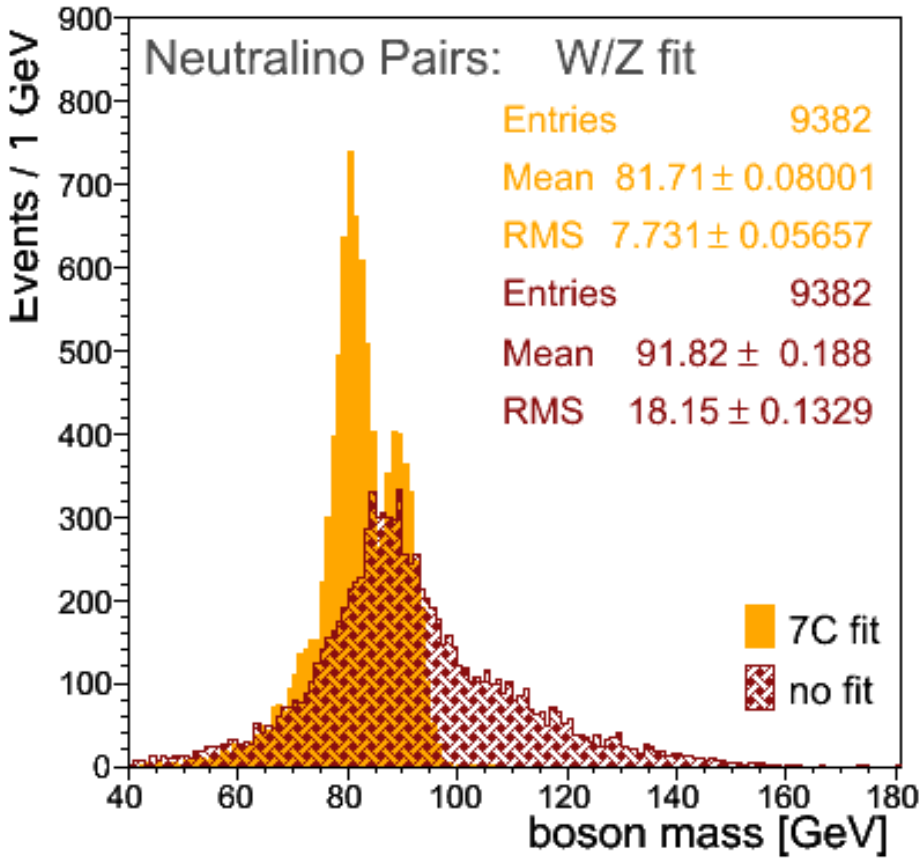
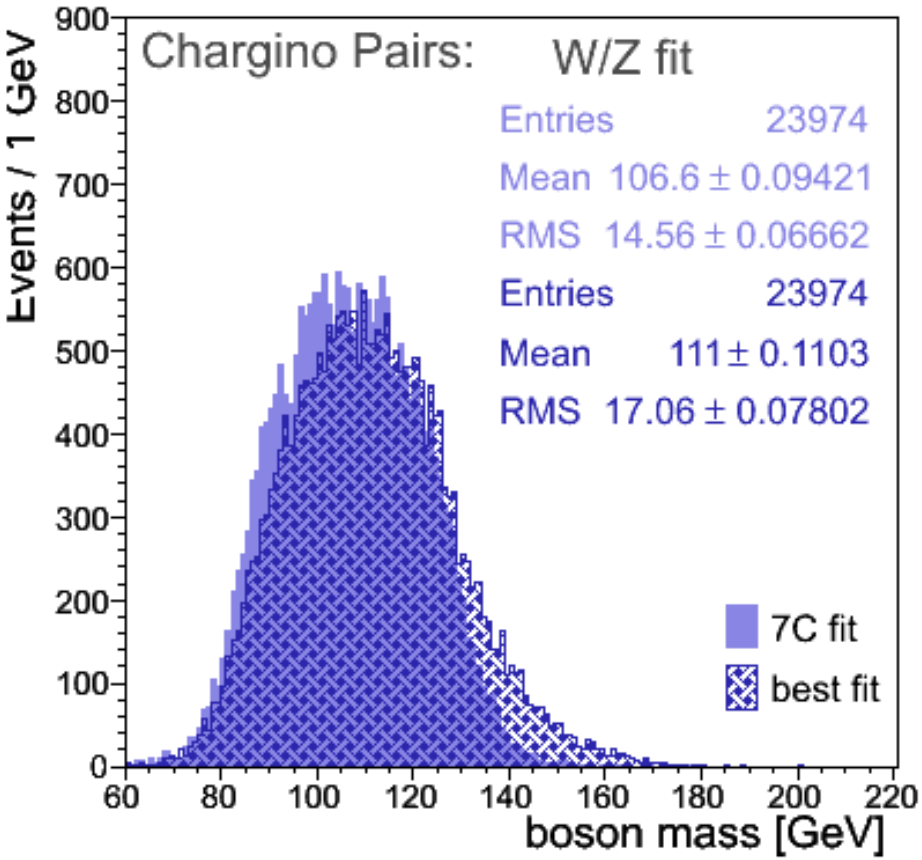
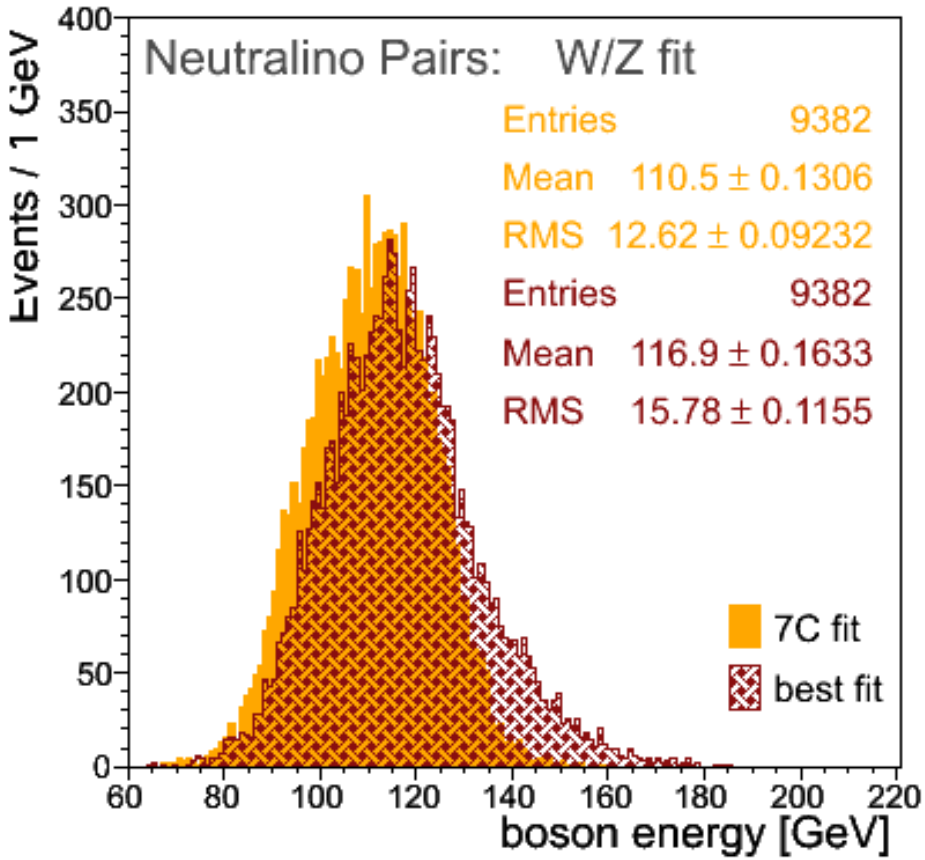




Charginos/Neutralinos: W/Z Energies

Detector model: LDC (LDC01_06Sc)
nearly the same performance as for LDC′





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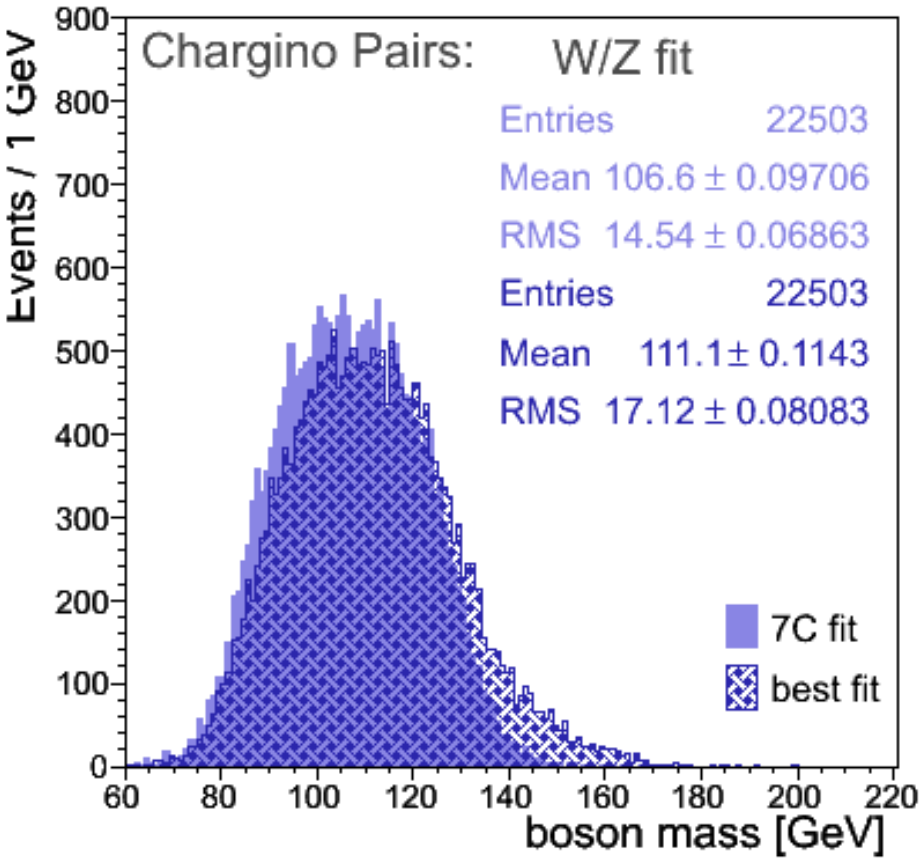

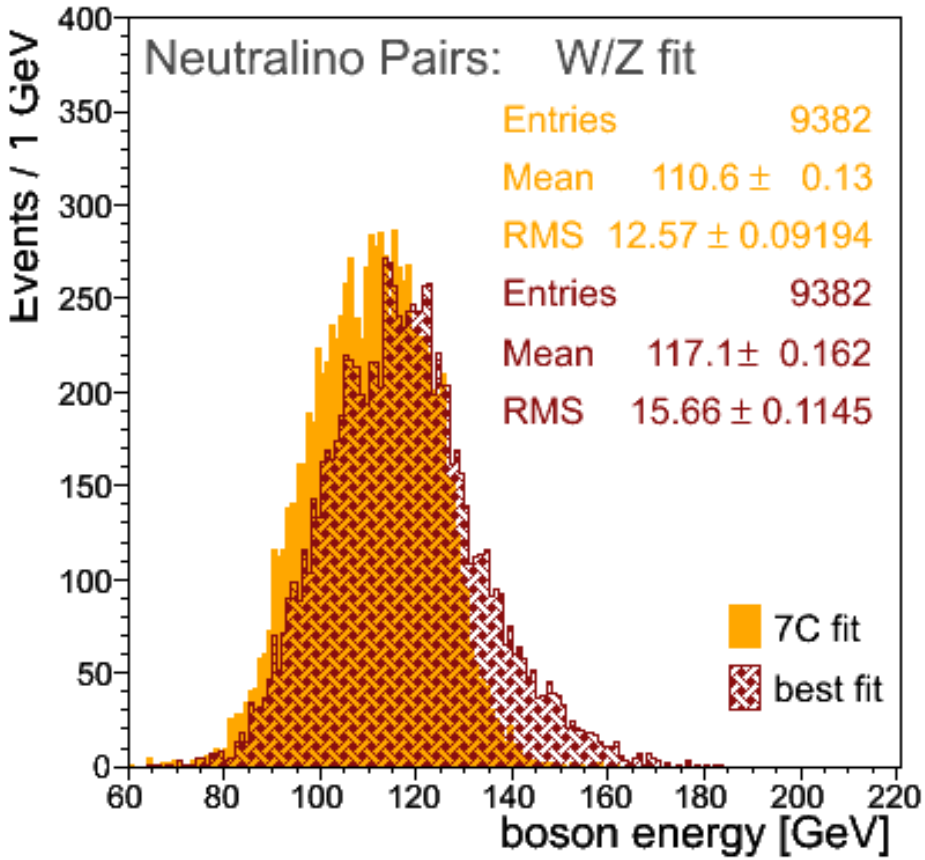

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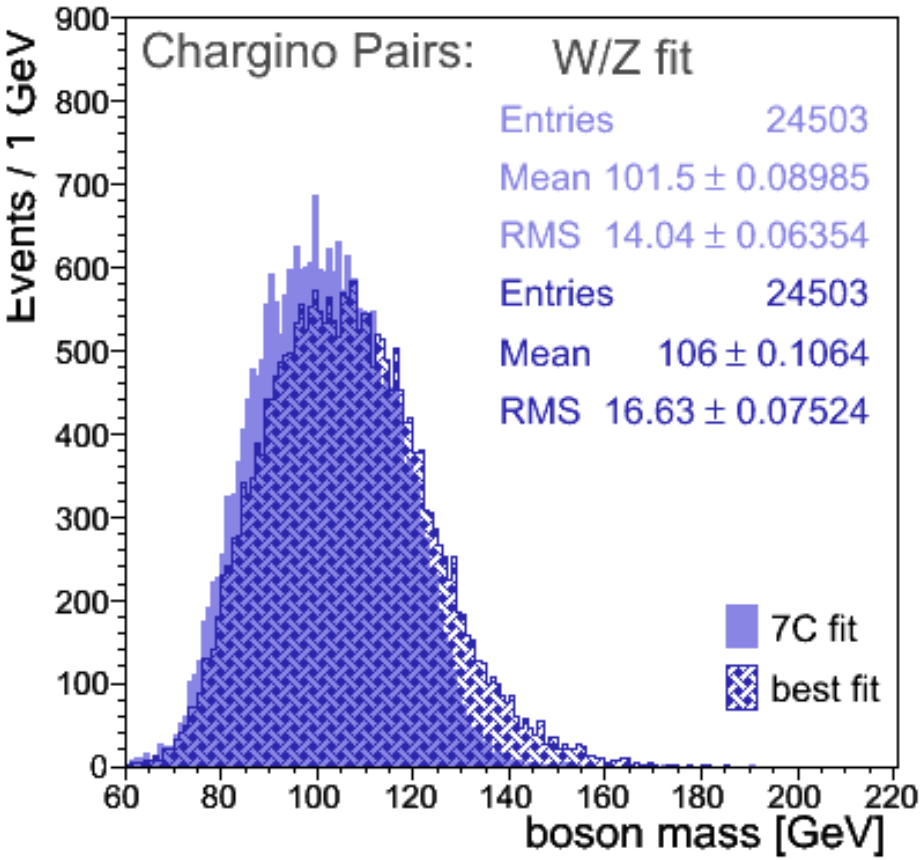

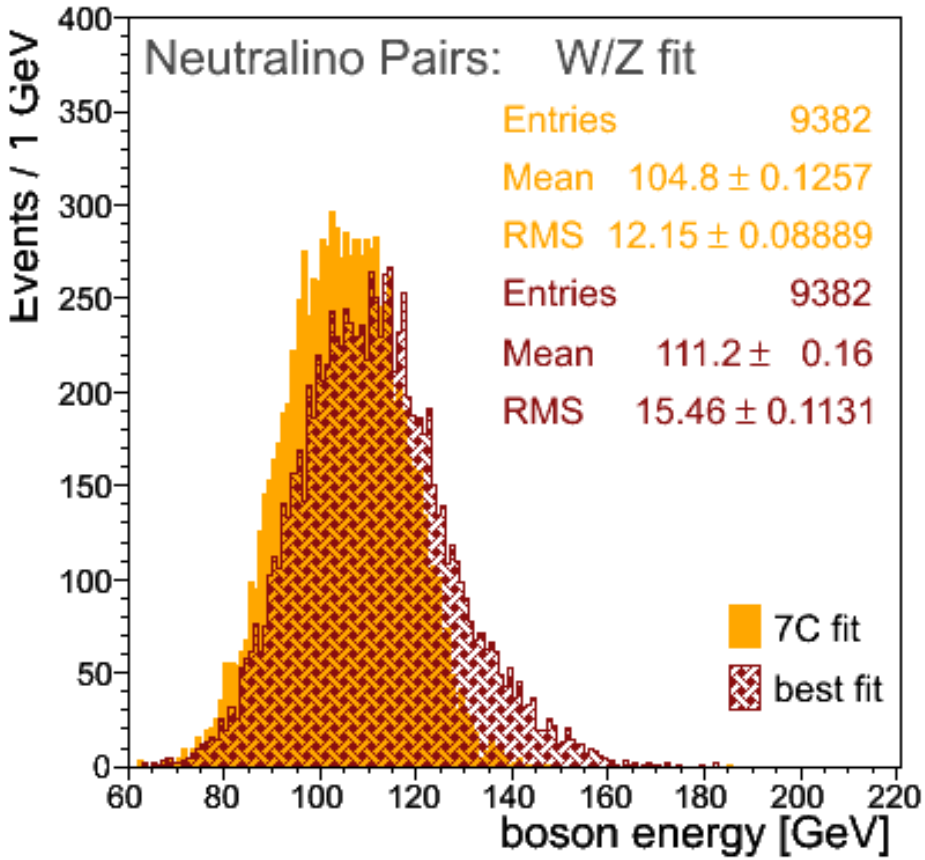

Charginos/Neutralinos: W/Z p_T

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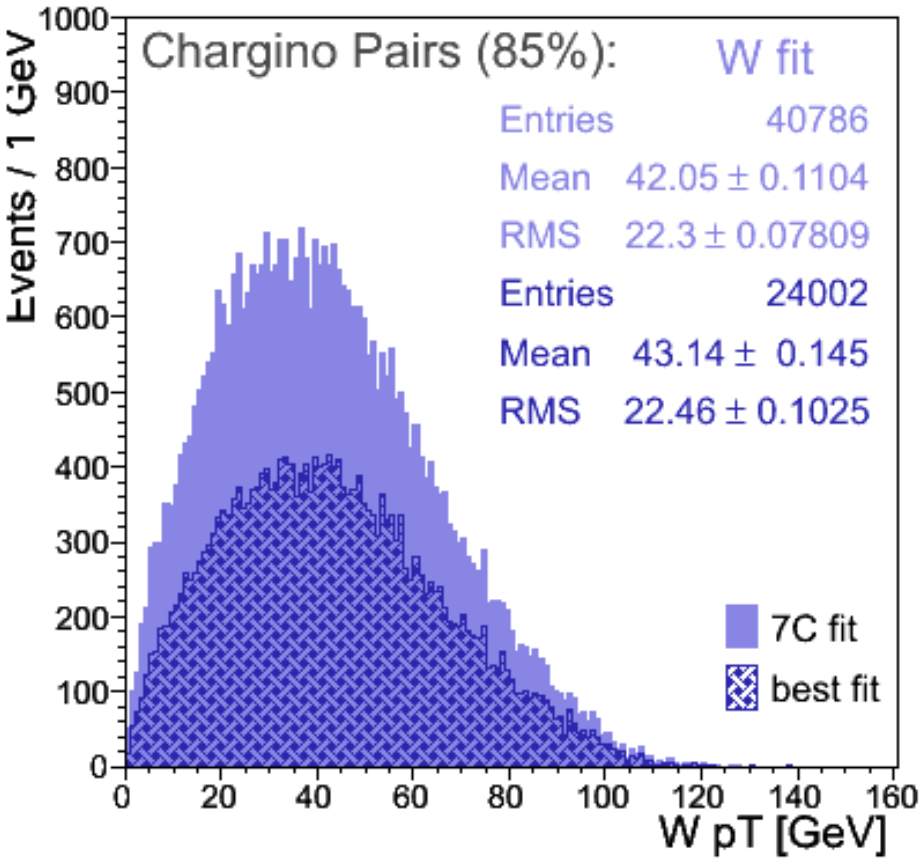

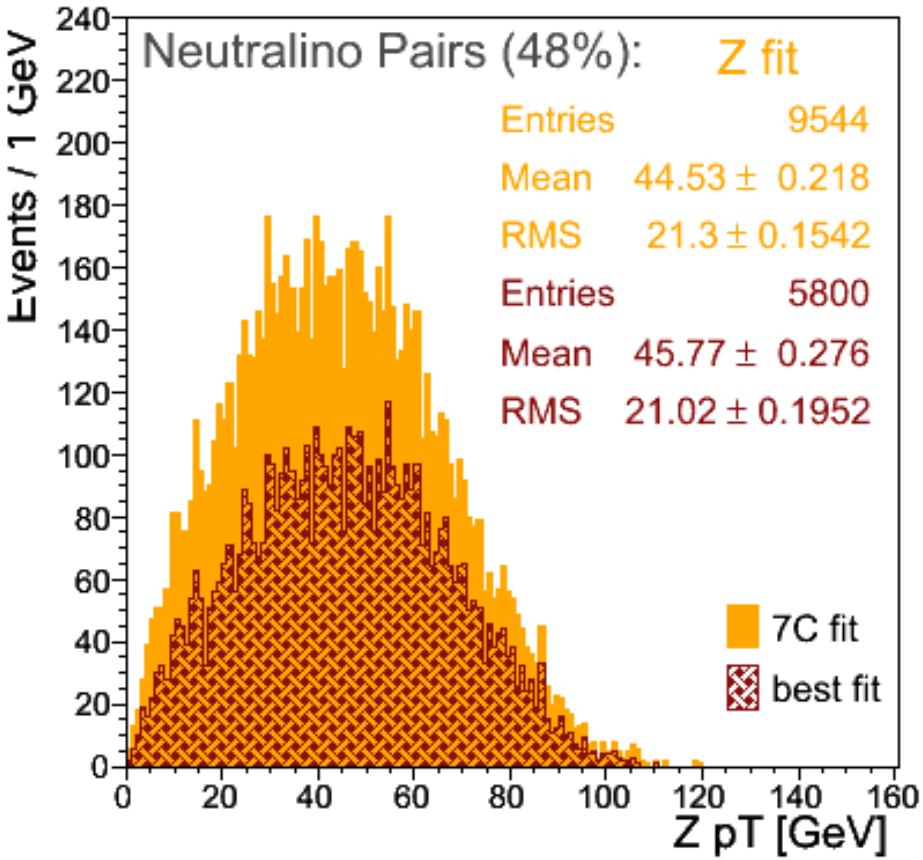

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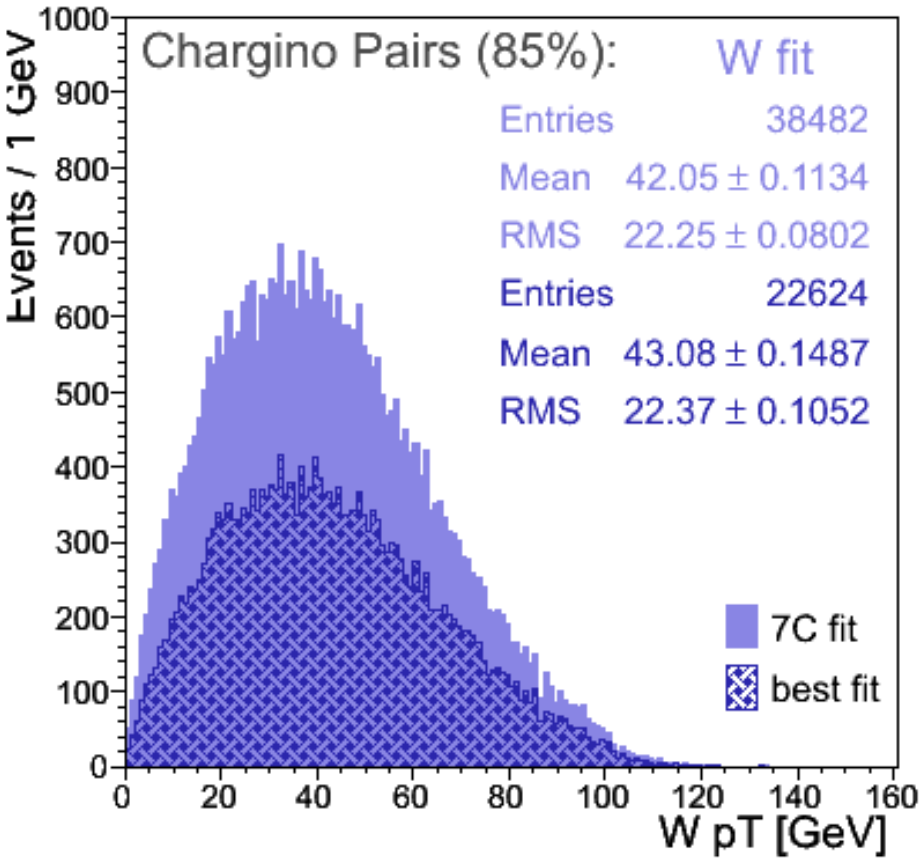

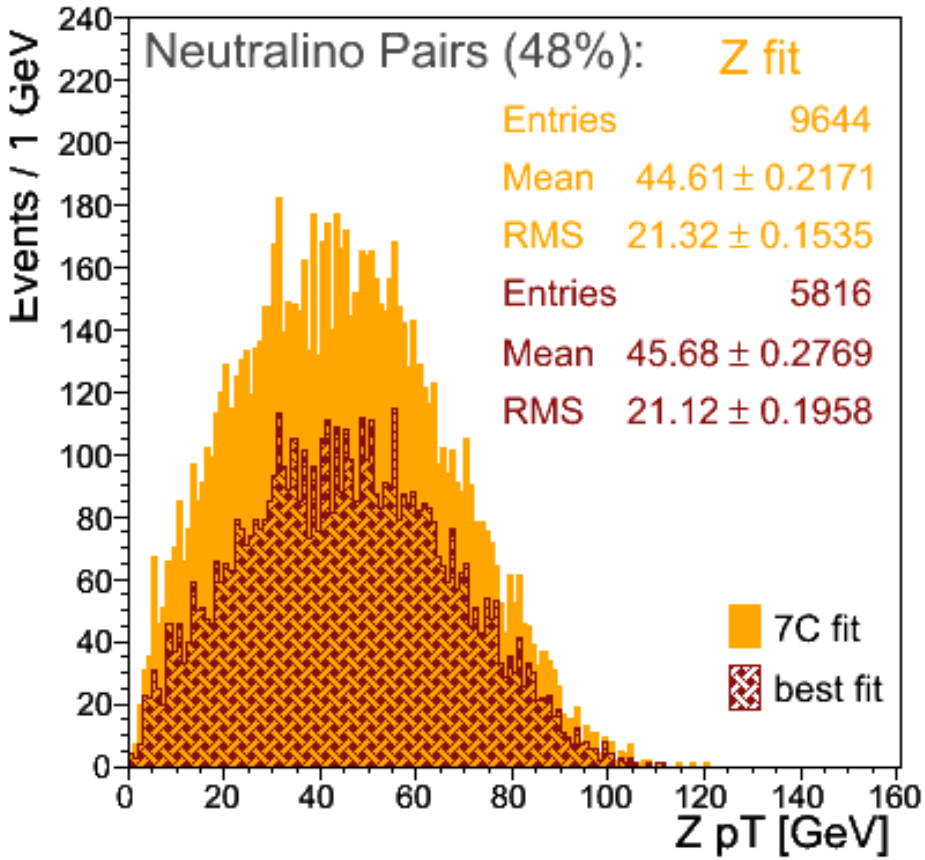

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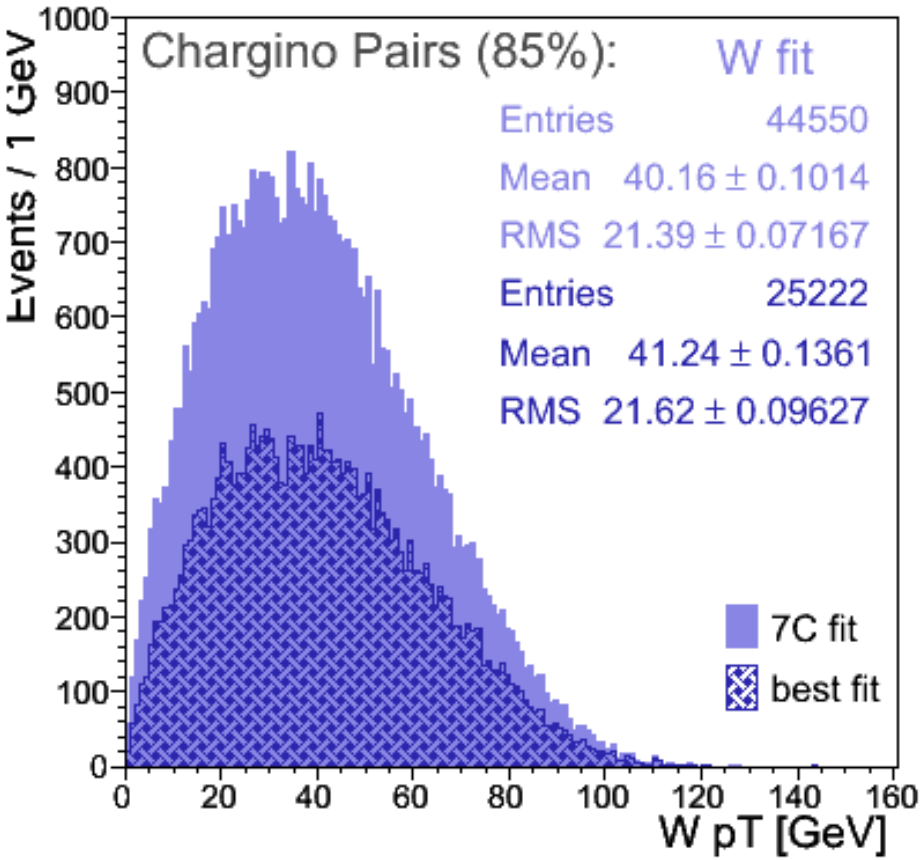
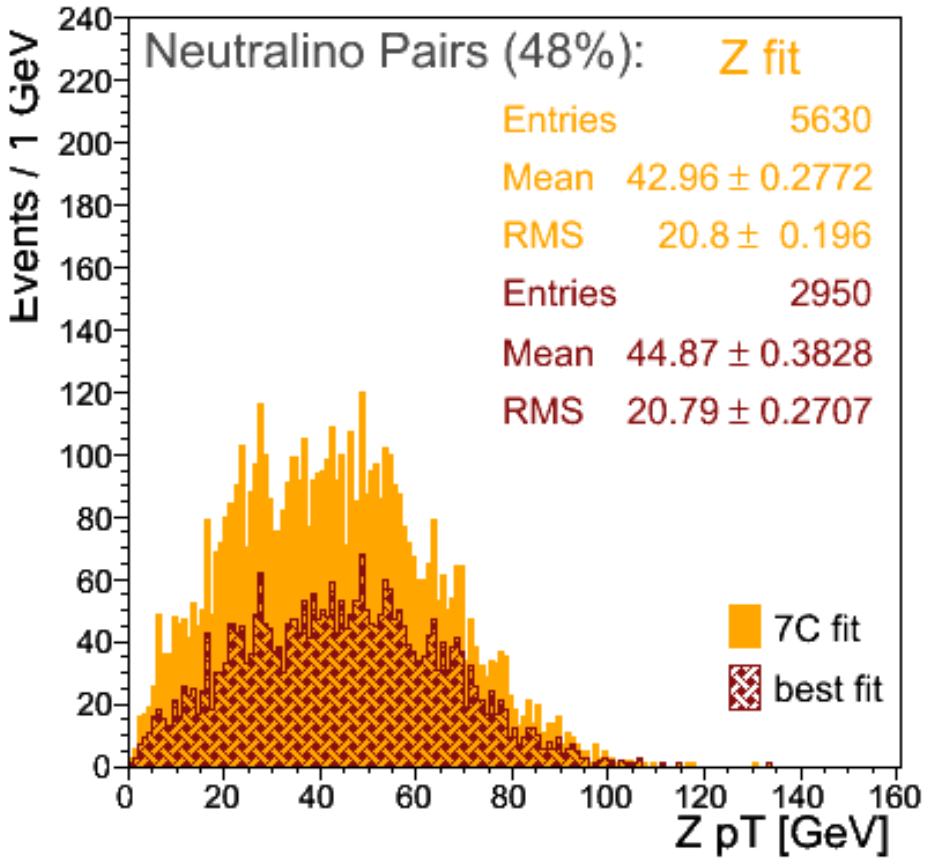




Extracting the $\widetilde{\chi}_1^{\pm}$ ($\widetilde{\chi}_2^0$) Mass I (first try)

Perform a "bloody" complicated fit to the E_W (E_Z) Spectrum:

- express E_V and $|\vec{p}_V|$ in terms of the 3 relevant masses:
  $m_2 = m(\widetilde{\chi}_1^{\pm}, \widetilde{\chi}_2^0)$, $m_1 = m(\widetilde{\chi}_1^0) = m_{\text{LSP}}$, $m_V = m_{W,Z}$:

$$E_V = \frac{1}{m_2}\left(m_1^2 - m_2^2 - m_V^2\right) = \frac{1}{m_2}\lambda\left(m_1, m_2, m_V\right)$$

$$|\vec{p}_V| = \frac{1}{m_2}\sqrt{\left(m_2^2 - m_1^2 - m_V^2\right)^2 - 4\,m_1^2\,m_V^2}$$

- then find the inverse expression for chargino mass or neutralino mass
- add the effect of a finite boson mass width via integrating over a Breit-Wigner distribution
- add Gaussian smearing to the boson energy spectrum ...

Extracting the $\widetilde{\chi}_1^{\pm}$ ($\widetilde{\chi}_2^0$) Mass II (first try)

. . . finally, the fit function looks like this - allowed region: $|\text{reg}| < 1$

$$\text{bin}_i = \frac{1 - a \cdot \text{reg}}{2} \qquad \text{(no Gaussian smearing)}$$

$$\cdot \left[\Theta\left(\frac{\text{reg}+1}{\sigma_{jes}\, b}\right) - \Theta\left(\frac{\text{reg}-1}{\sigma_{jes}\, b}\right) + a \cdot \frac{b}{2\pi} \left(e^{-\frac{(\text{reg}_{-1})^2}{2\,(\sigma_{jes}\, b)^2}} - e^{-\frac{(\text{reg}_{+1})^2}{2\,(\sigma_{jes}\, b)^2}} \right) \right]$$

$$\text{spect} = \text{bin}_i \cdot \text{BW}\left(m_V^0,\, \gamma,\, m_V - \frac{\Delta m}{2},\, m_V + \frac{\Delta m}{2} \right) + \text{spect}$$

with the boson E_V and $|\vec{p}_W|$ in the bosino rest-frame:

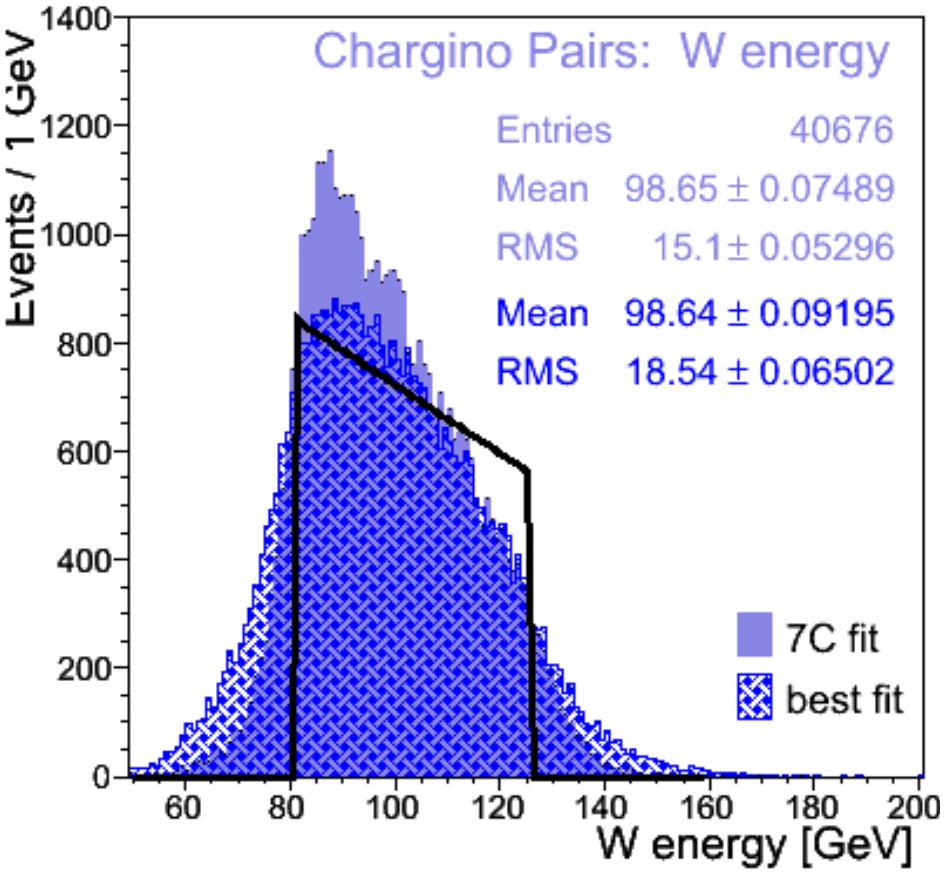
$$p_V = \frac{\lambda}{2\, m_2} \qquad b = \frac{m_2}{\sqrt{E_{beam}^2 - m_2^2} \cdot p_V}$$

$$E_V = \left| \frac{m_1^2 - m_2^2 - m_V^2}{2\, m_2} \right| \qquad \text{reg} = \frac{x\, m_2 - E_{beam}\, E_V}{\sqrt{E_{beam}^2 - m_2^2} \cdot p_V}$$

Fit: E_W Spectrum $\rightarrow$ $m(\widetilde{\chi}_1^{\pm})$ (first try)

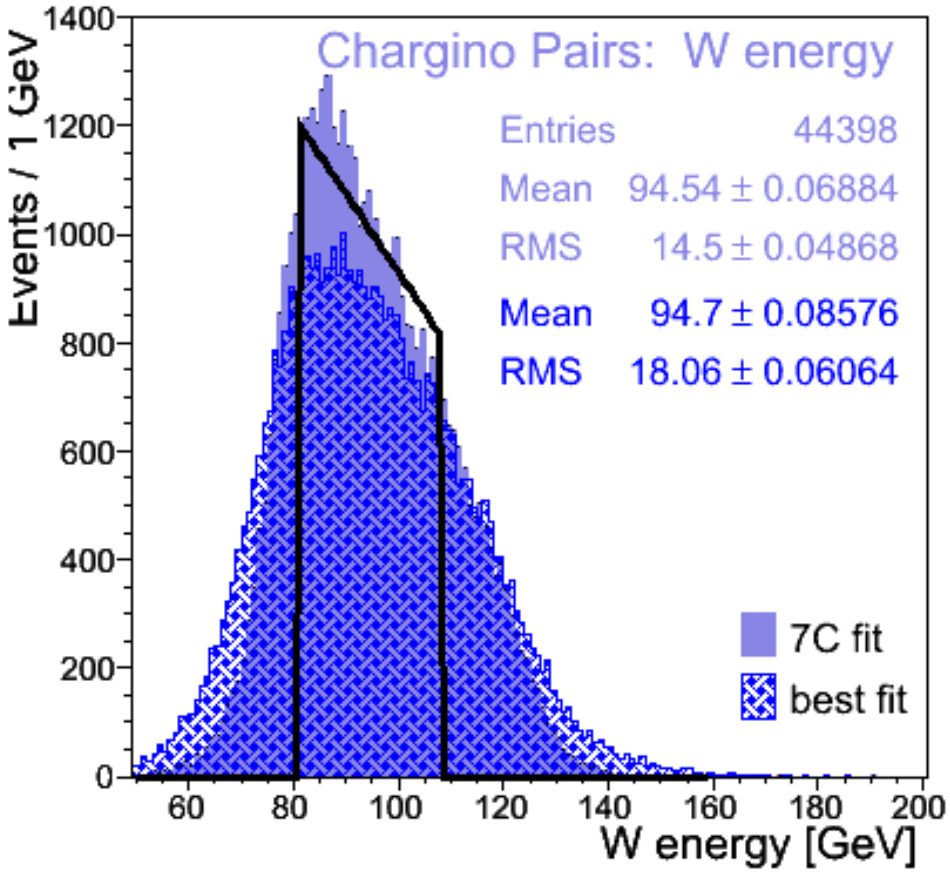
LDC (LDC01_06Sc)

very, very, very preliminary!



LDC (LDC_GLD_01Sc)

very, very, very preliminary!



Fit: E_W Spectrum $\rightarrow$ $m(\widetilde{\chi}_1^{\pm})$ (first try)

LDC (LDCPrime_02Sc)

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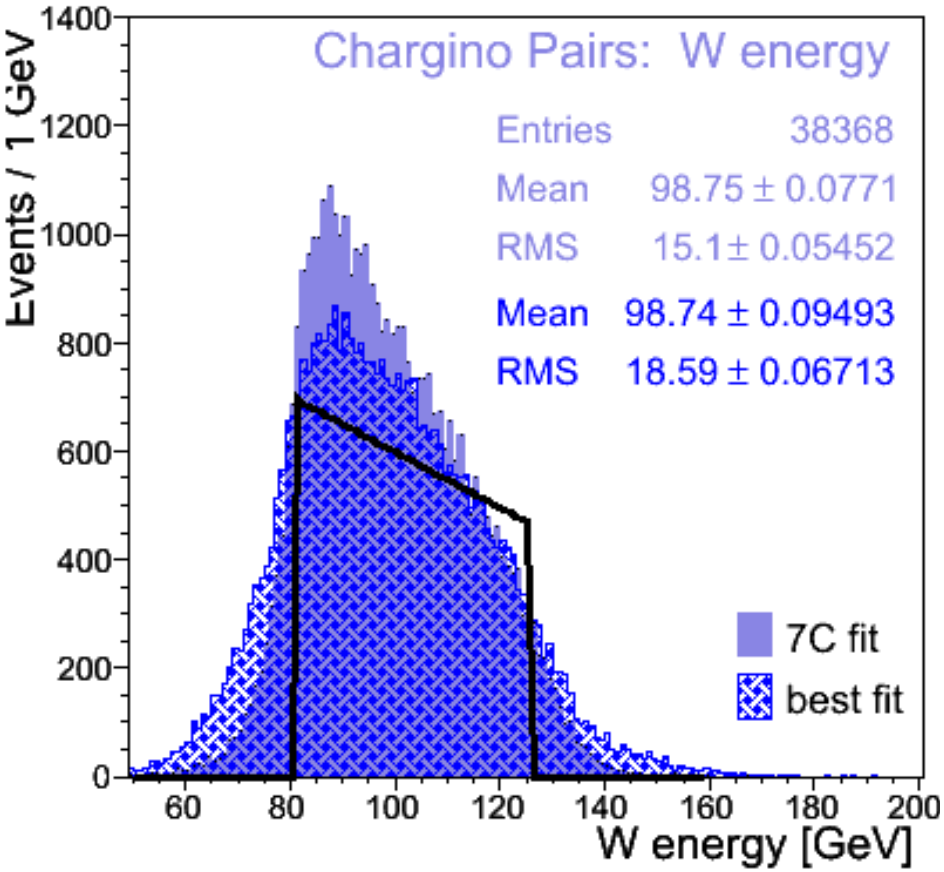
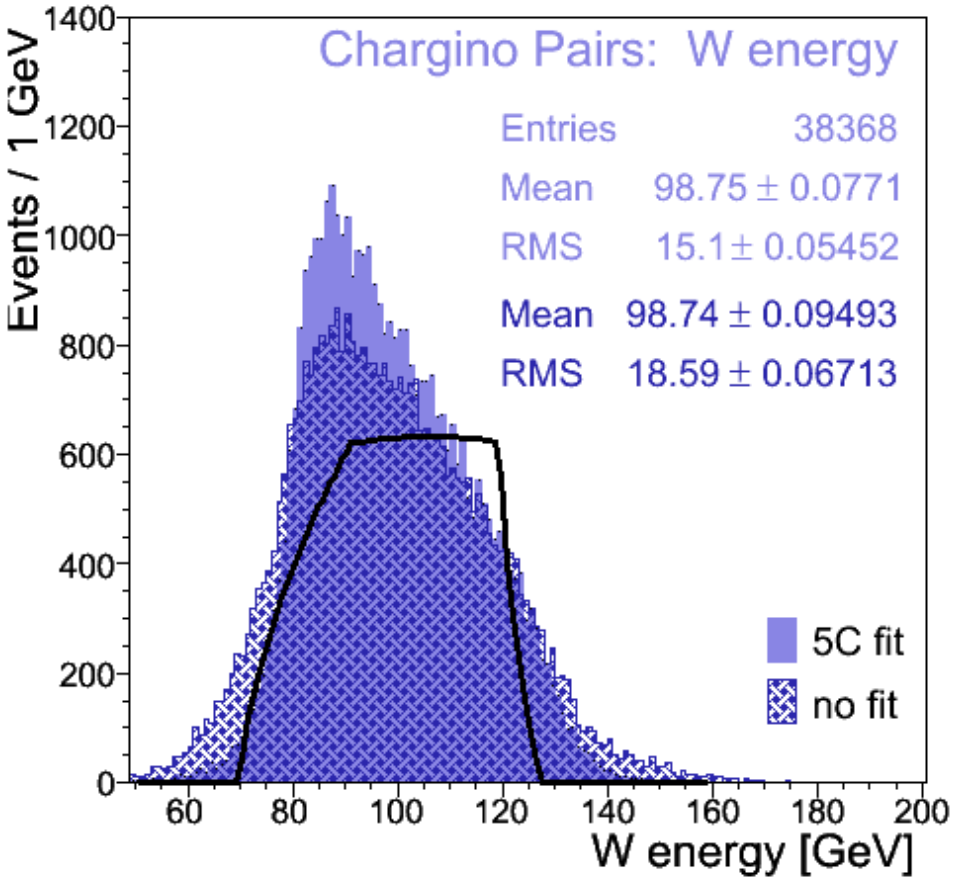


LDC′ (LDCPrime_02Sc)

This is even less than

very, very, very preliminary!

no time to check thoroughly



SM Analysis: WW(ZZ) $\rightarrow$ qqqq

by: Moritz Beckmann

4 Jet Final States: MC Sample & Selection

- Processes: $e^+e^- \to W^+W^- \to u\bar{d}d\bar{u}$, $(e^+e^- \to ZZ \to u\bar{u}d\bar{d})$
- Detector Model: LDC′, CM-Energy: 500 GeV

- Software: ILCsoft v01-04
- Total number of events: 52490 in files:

`DST01-04_ppr002_uddu_w11903_500_LDCPrime_02Sc_LCP_ep+1.0_em-1.0_Slac_SM_00??.slcio`

Some simple requirements:

- ▷ $E_{jet} > 5$ GeV and $|\cos(\theta_{jet})| < 0.995$ $(\theta_{jet} > 5.73°)$
- ▷ Number of tracks per jet > 3 → 31492 Ev

- ▷ No MC-photon in the detector:
  $|\cos(\theta_\gamma)| < 0.995$ $(\theta_\gamma < 5.73°)$ for $E_\gamma > 5$ GeV → 29999 Ev

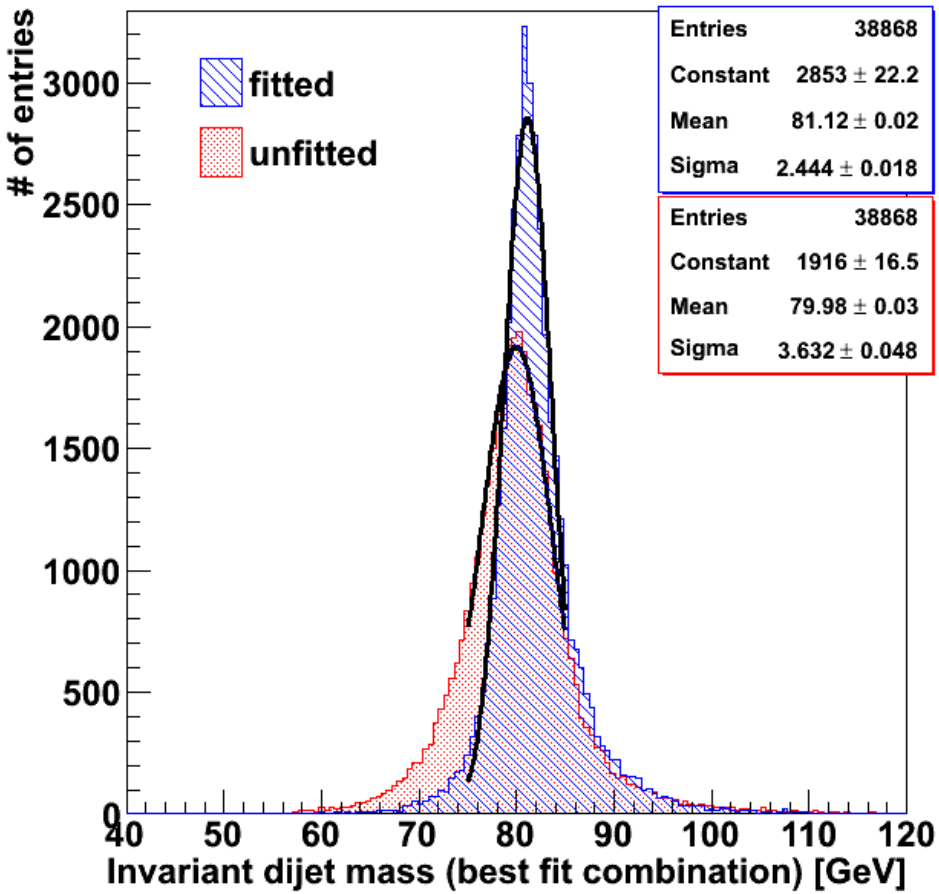
  No visible change in the shape of distributions → no plots here

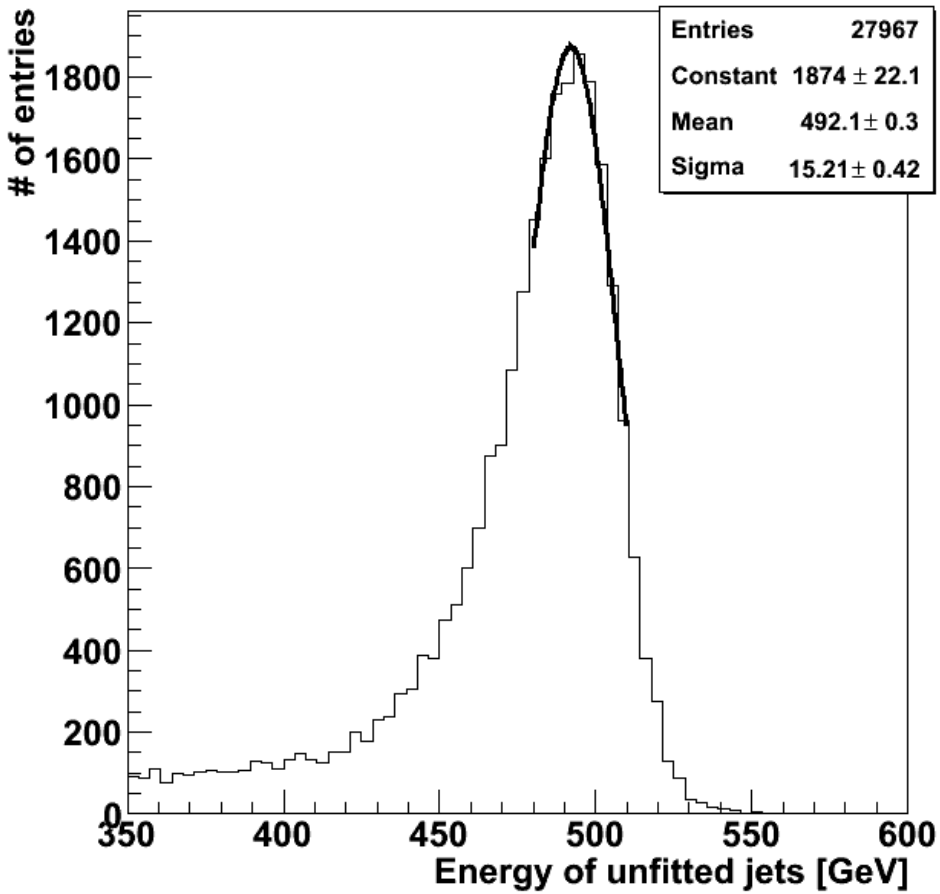
The Problem with ISR / beam-Strahlung

Events with no (or little) ISR are selected: 27967 Ev

require MC-photon(s) to have $E_\gamma < 5$ GeV

best fit: highest fit probability and $50 < m_W < 110$ GeV



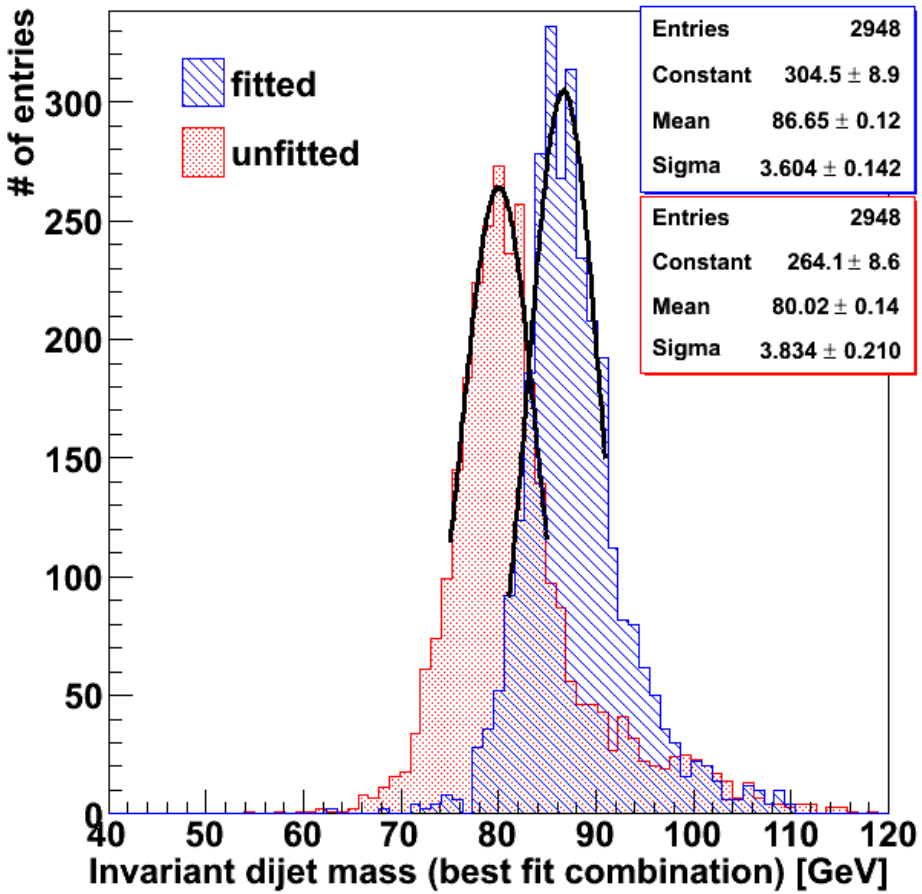


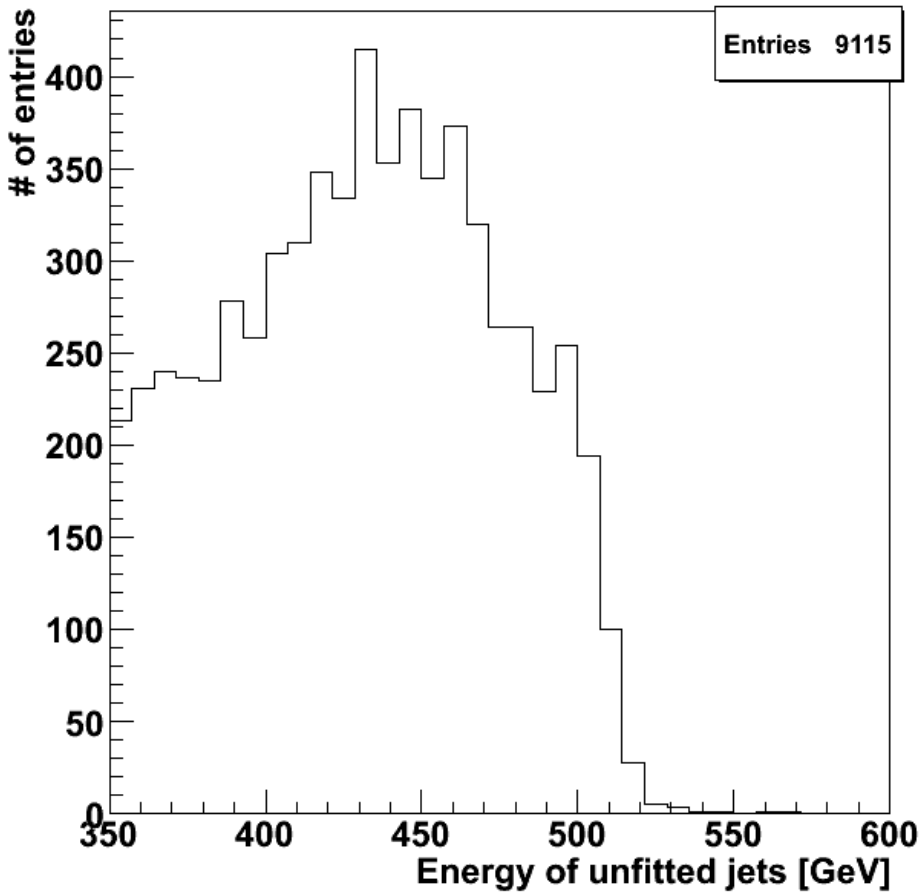
The Problem with ISR / beam-Strahlung

Events with ISR are selected: 9115 Ev

require at least one MC-photon with $E_\gamma > 25$ GeV

best fit: highest fit probability and $50 < m_W < 110$ GeV





Kinematic Fit Including ISR-Photons

- Software is based on Kinfit (ILCSoft v01-04) + bug fixes
- Jet Energy Scale (JES) setting: +1% (jet 4-vector× 1.01)
- Assume Gaussian errors for all parameters

4C Fit (4 jets): energy & momentum conservation

- ▷ E' : $E \pm {}^{22.67\%}/_{\sqrt{E}} + {}^{1.696\%}/_{E}$
- ▷ θ' : $\theta \pm 0.01$ rad (0.57°)
- ▷ ϕ' : $\phi \pm 0.01$ rad (0.57°)

4C Fit (4 jet + 1 γ): energy & momentum conservation

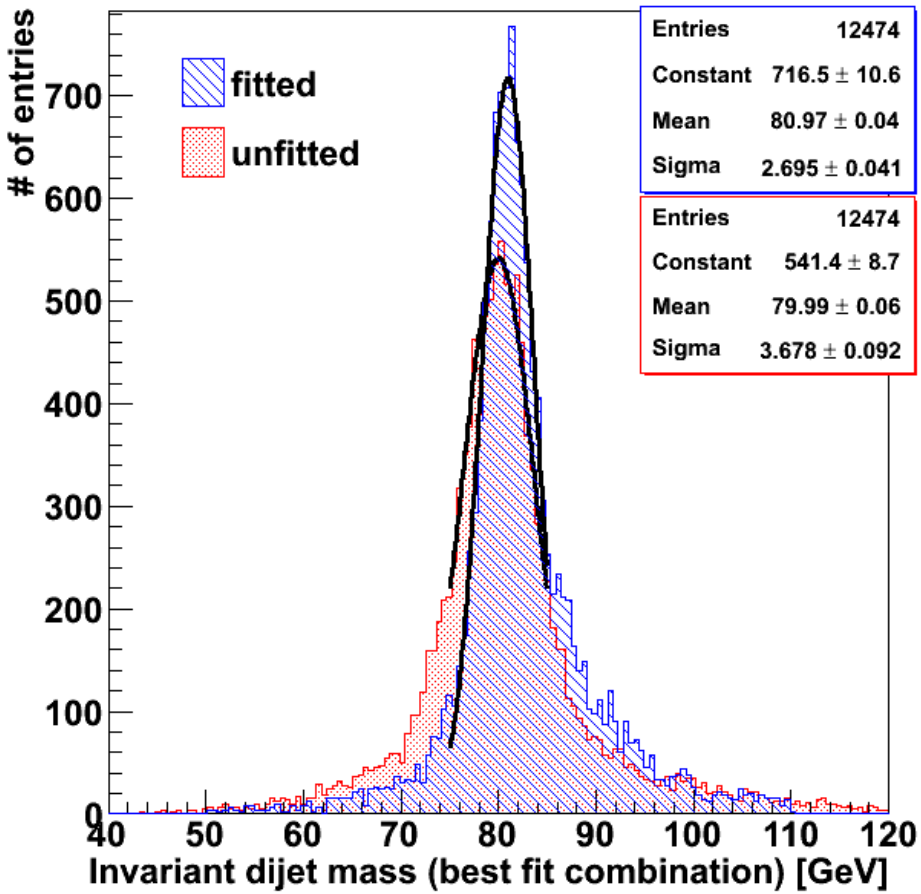
- ▷ Jets: same parameters/errors as above
- ▷ Photon-Object (in addition):
- ▷ p'_x, p'_y: $p_x, p_y \pm 5$ GeV, p'_z: $p_z \pm 100$ GeV

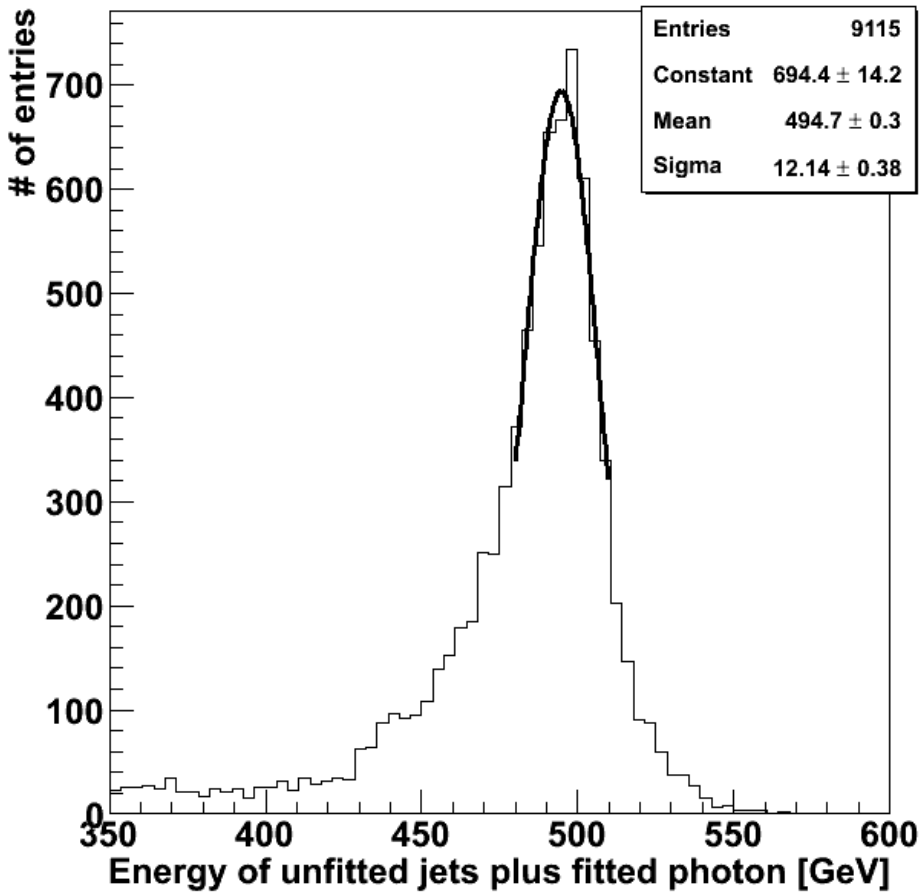
Taking Care of ISR-Photons I

Events with ISR are treated separately: 9115 Ev

an additional photon object is taken into account in the fit

best fit: highest fit probability and $50 < m_W < 110$ GeV





Taking Care of ISR-Photons II

Events with ISR:

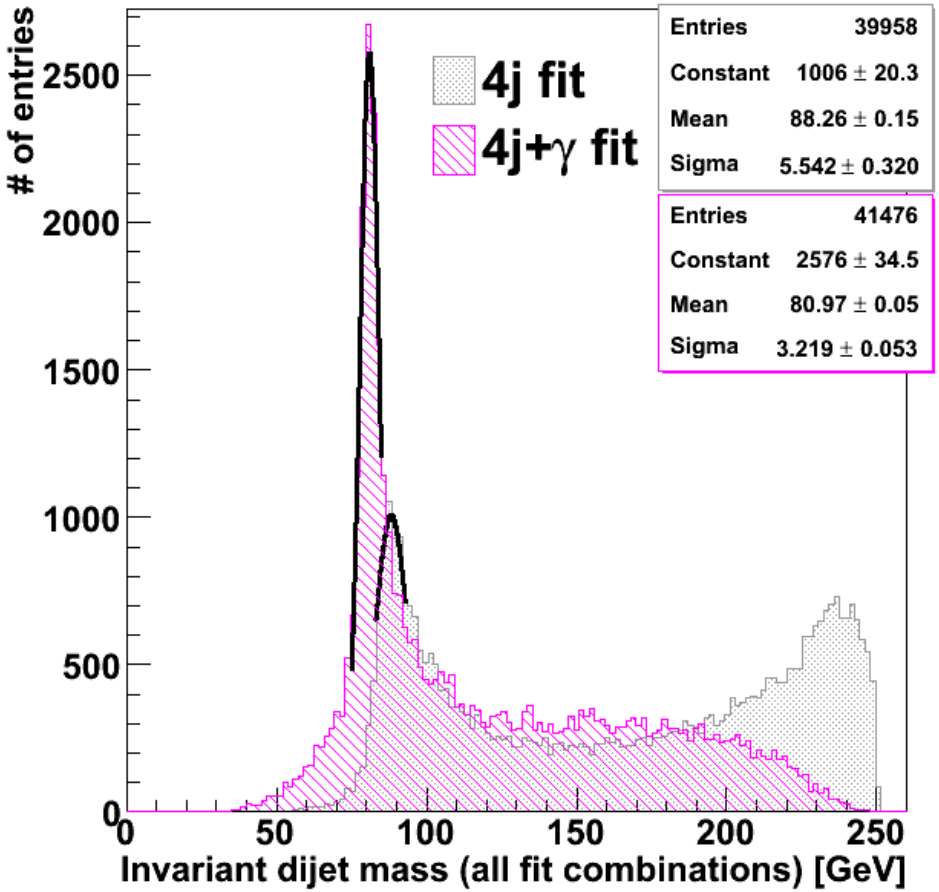
4C fit: 4 jets only

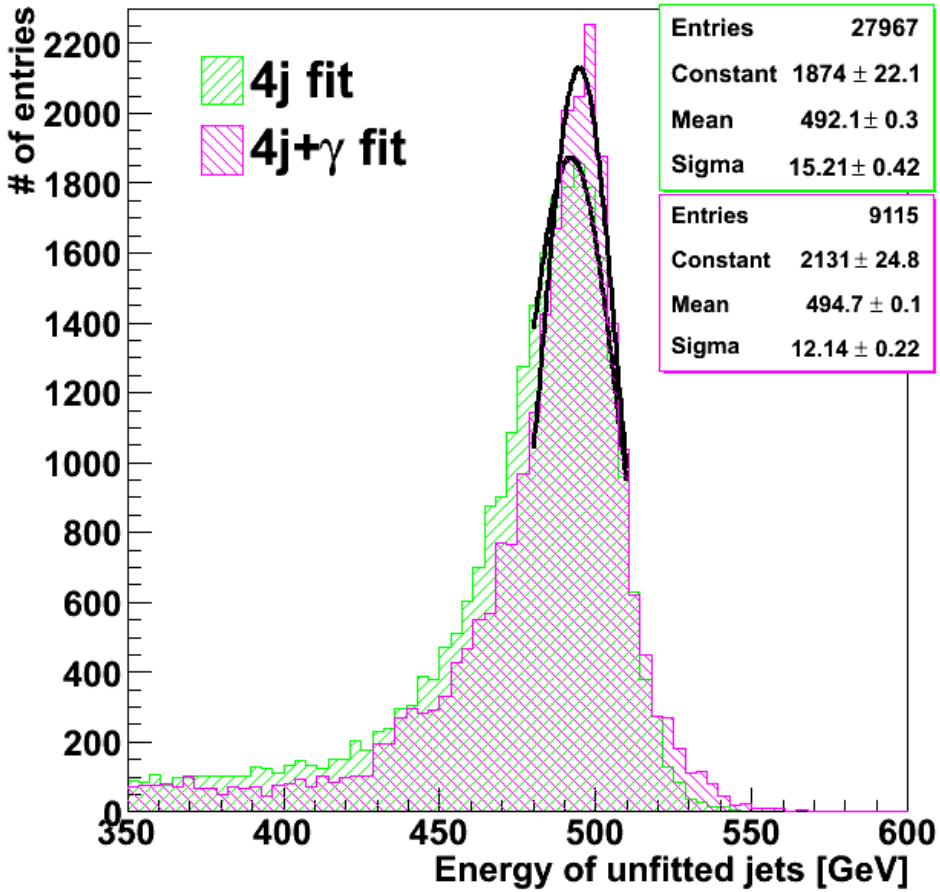
4C fit: 4 jets + photon object

Events: no ISR and with ISR

4j fit: E (unfit-jets)

4j+γ fit: E (unfit-jets) + E (fit-γ)

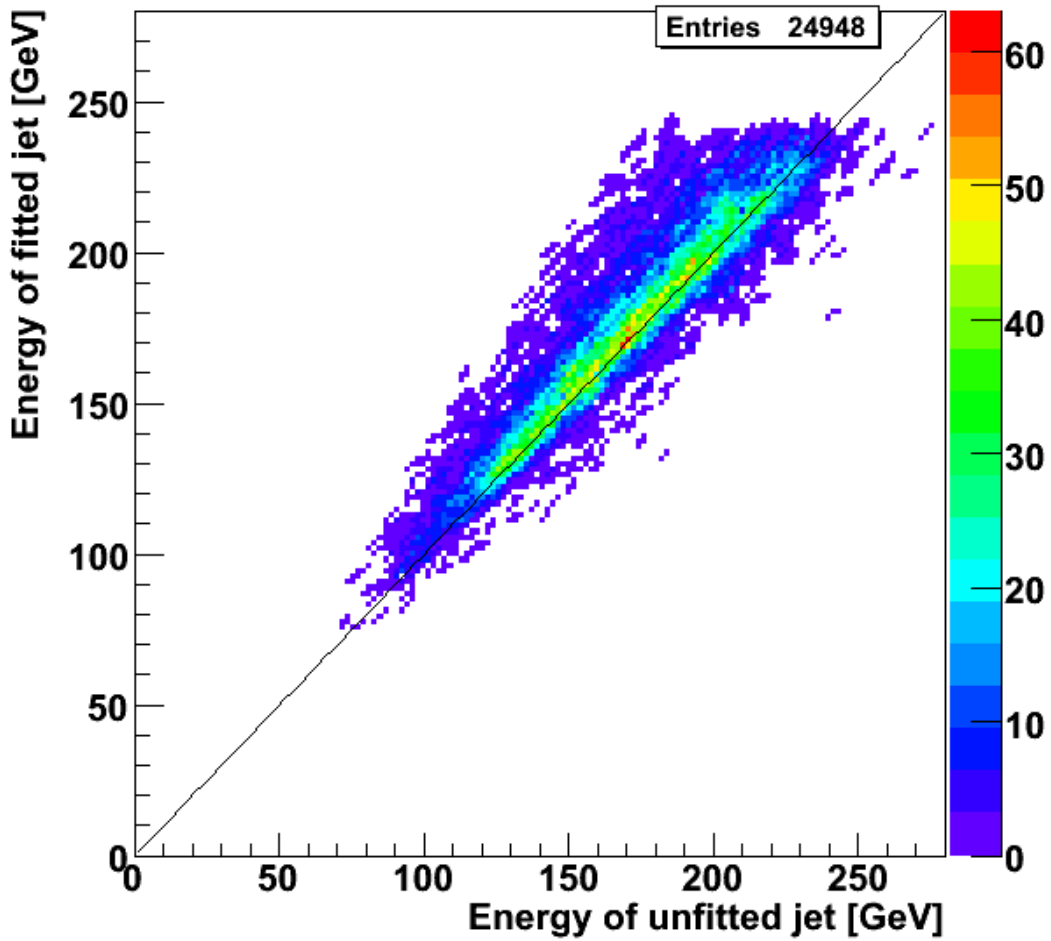




Checking the Fit

Jet energy: before and after the fit, assuming Gaussian errors

E' : $E \pm {}^{22.67\%}/_{\sqrt{E}} + {}^{1.696\%}/_{E}$, θ', ϕ' : $\theta, \phi \pm$ 0.01 rad, JES: +1%



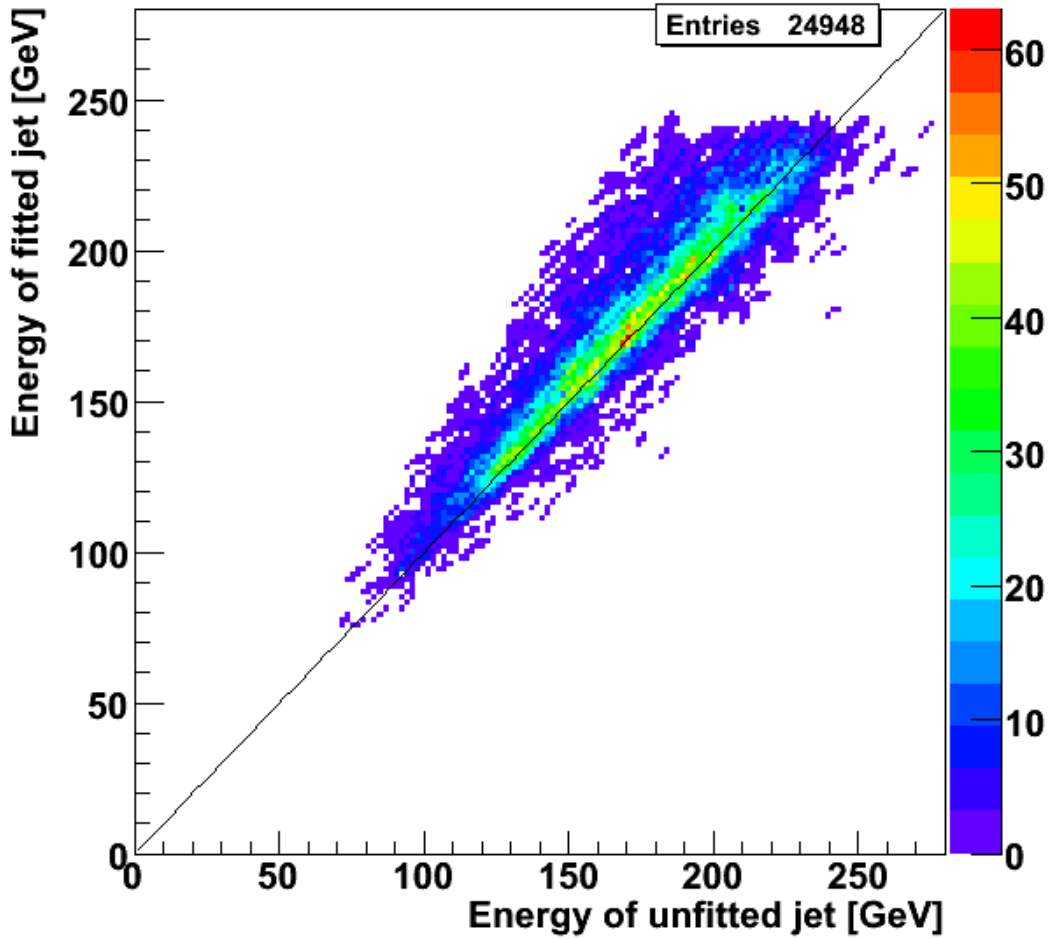
THANK YOU !

BACKUP

Checking the Fit

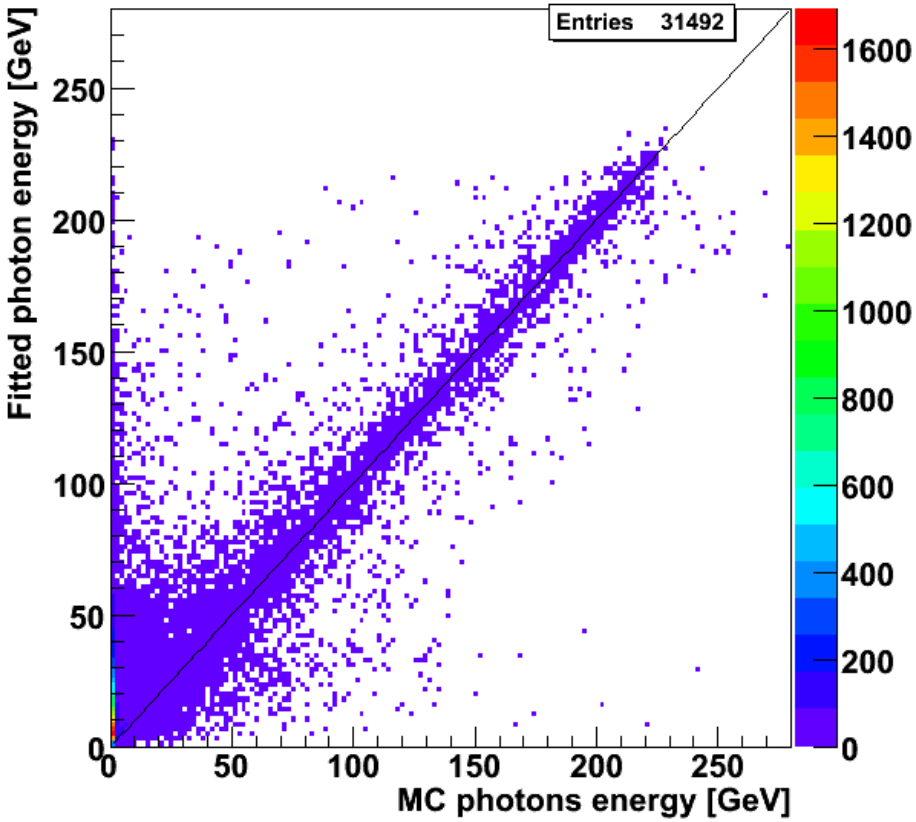
Jet energy: before and after the fit, assuming Gaussian errors

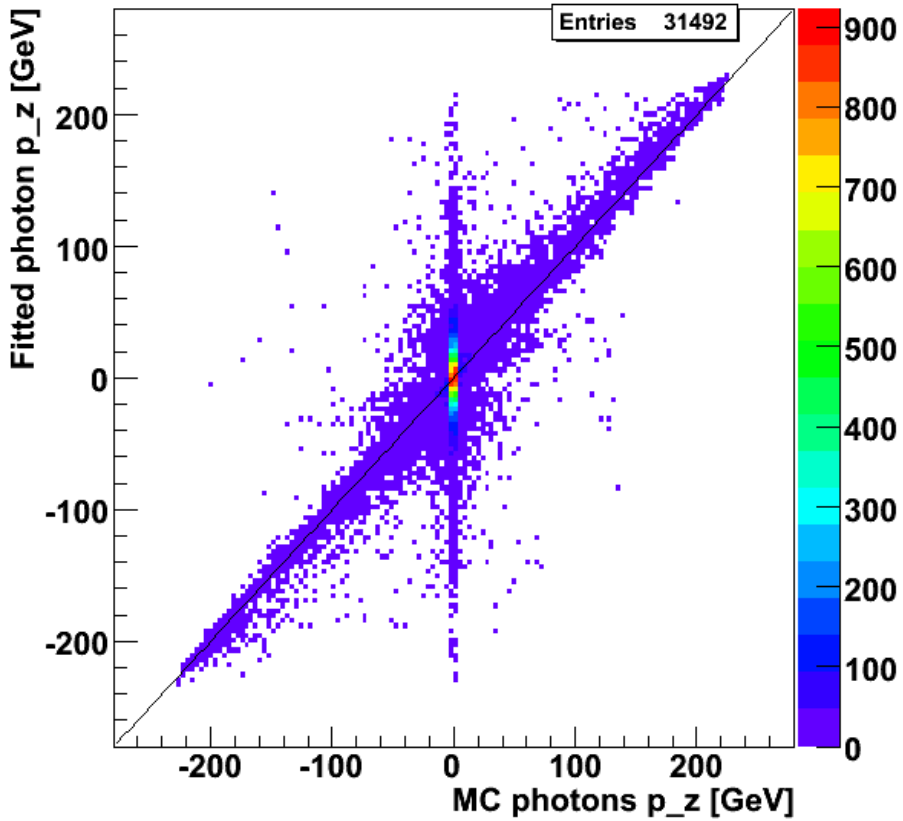
E' : $E \pm {}^{22.67\%}/_{\sqrt{E}} + {}^{1.696\%}/_{E}$, (θ', ϕ') : $(\theta, \phi) \pm$ 0.01 rad, JES: +1



Checking the Fit

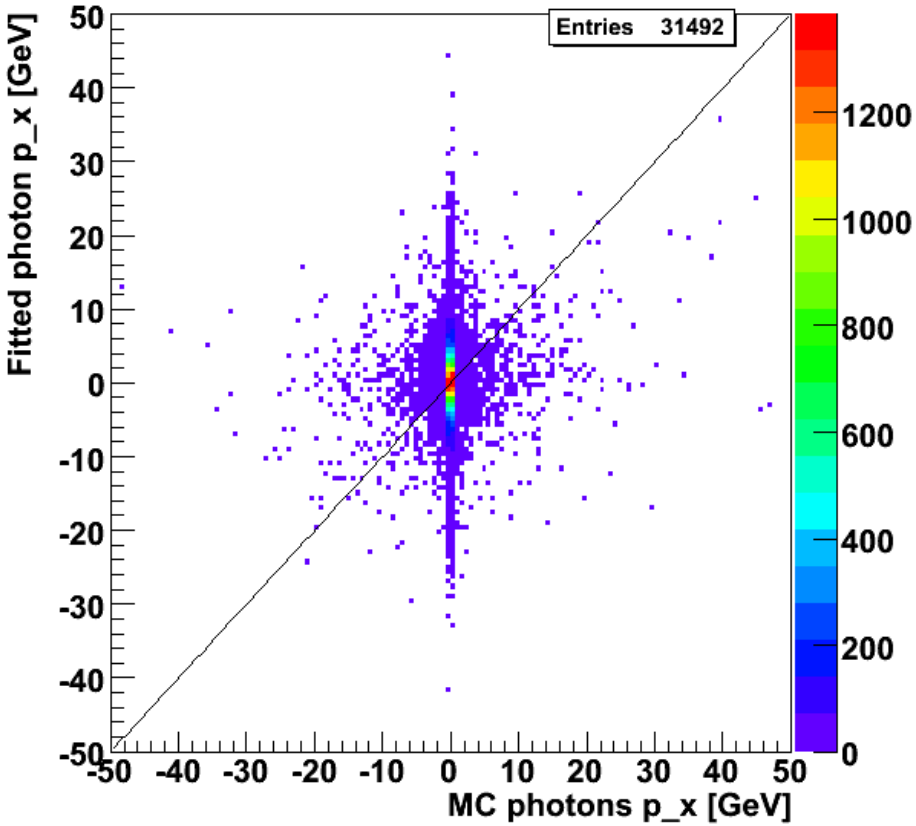
p_z: 0 ± 100 GeV





Checking the Fit

p_x: 0 ± 5 GeV



p_y: 0 ± 5 GeV