

W mass studies

Work in progress

WG1 & WG2 working meeting

Paolo Azzurri, Marina Béguin

Objectives

- Direct (in addition to indirect) W mass measurement at $161 + \epsilon$ GeV (162,3 GeV) ?
- Direct W mass measurement or \sqrt{s} at 240 and 350 GeV ?
 - > Detector parameters for these measurements

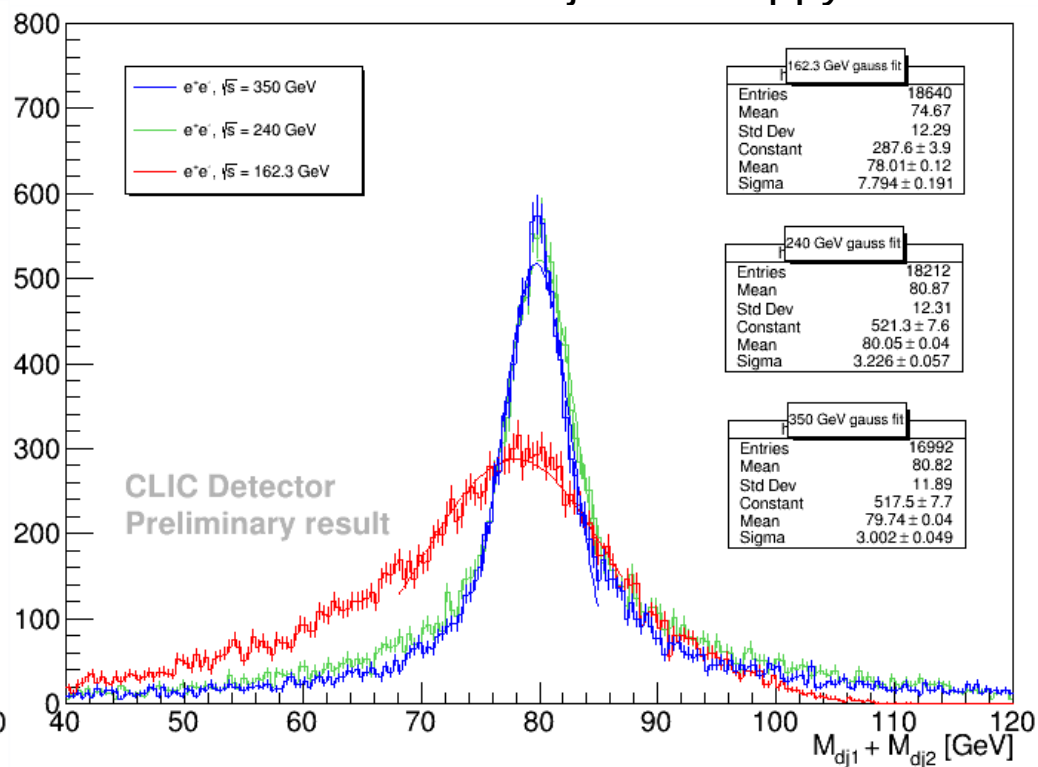
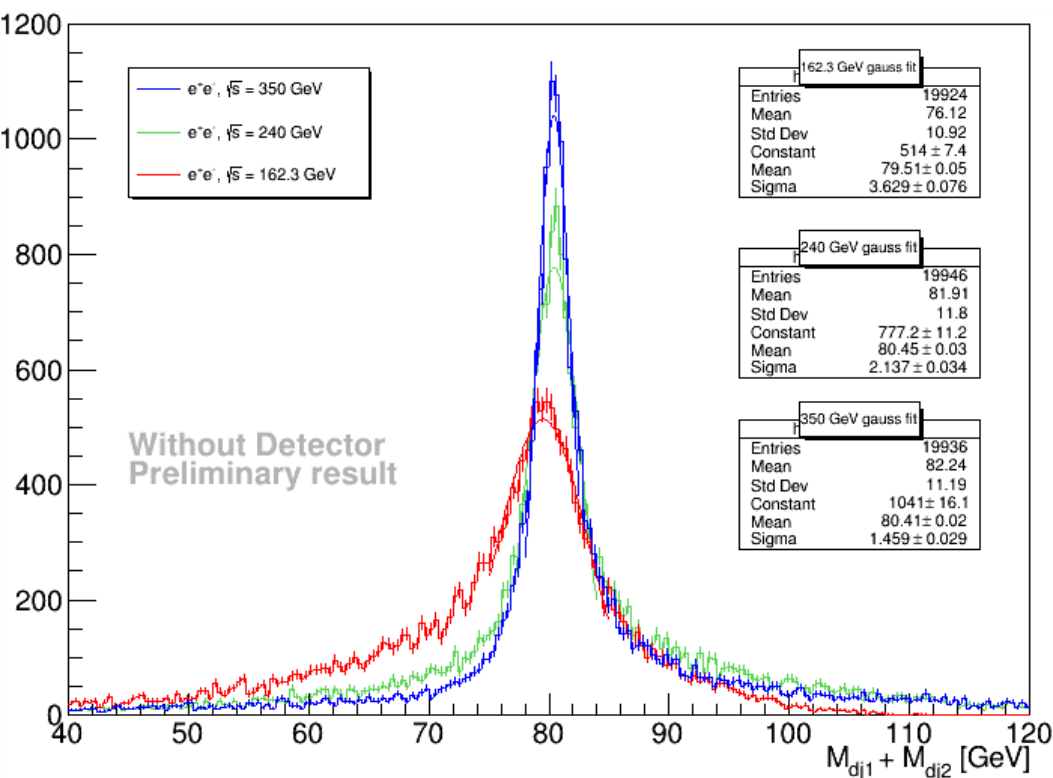
Method

- Study in hadronic and semi-leptonic channels of W decay at $\sqrt{s} = 158, 162.3, 240$ and 350 GeV
Bad reconstruction at 158 GeV (backup slides) -> energy discarded in the following
- Simulation with **Pythia** and reconstruction with **Heppy** (force 4 and 2 jets)
- Several reconstruction algorithms tested : **ee_kt**, **jade** and **Valencia** (plugin developed by CLIC)
- W mass computed **without** (gen_jets) and with (reco_jets) **detector** (CLIC first and IDEA)
- W mass measurement with **kinematic fit** (5C and 2C)

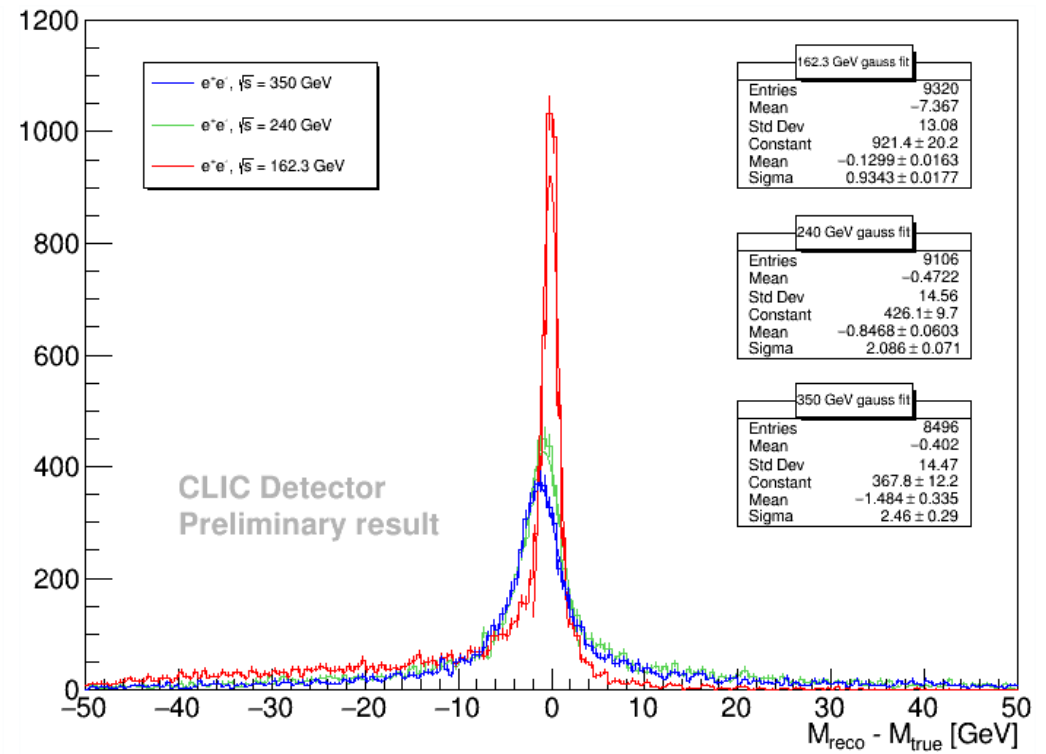
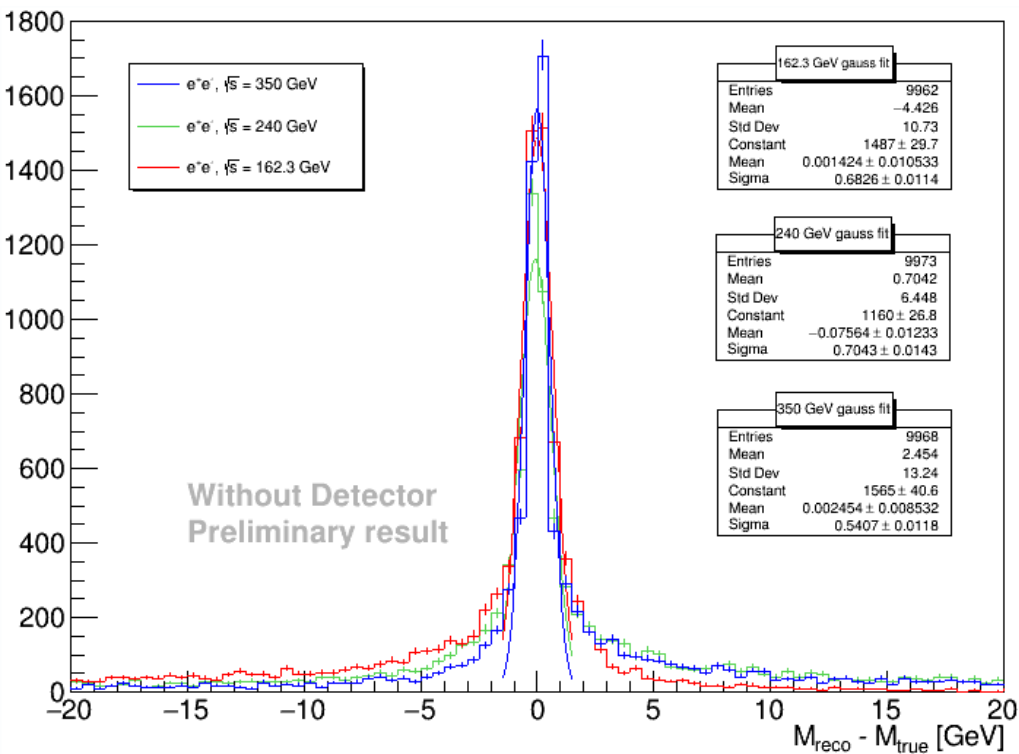
W measurement in hadronic channel

- Calculation of jet energy from the directions
- Rescaling p4 with $\alpha = E(\text{computed}) / E(\text{measured})$
- Jet pairing with chi2 minimization
- Mass measurement

Tails due to mixing particles between jets in HepPy

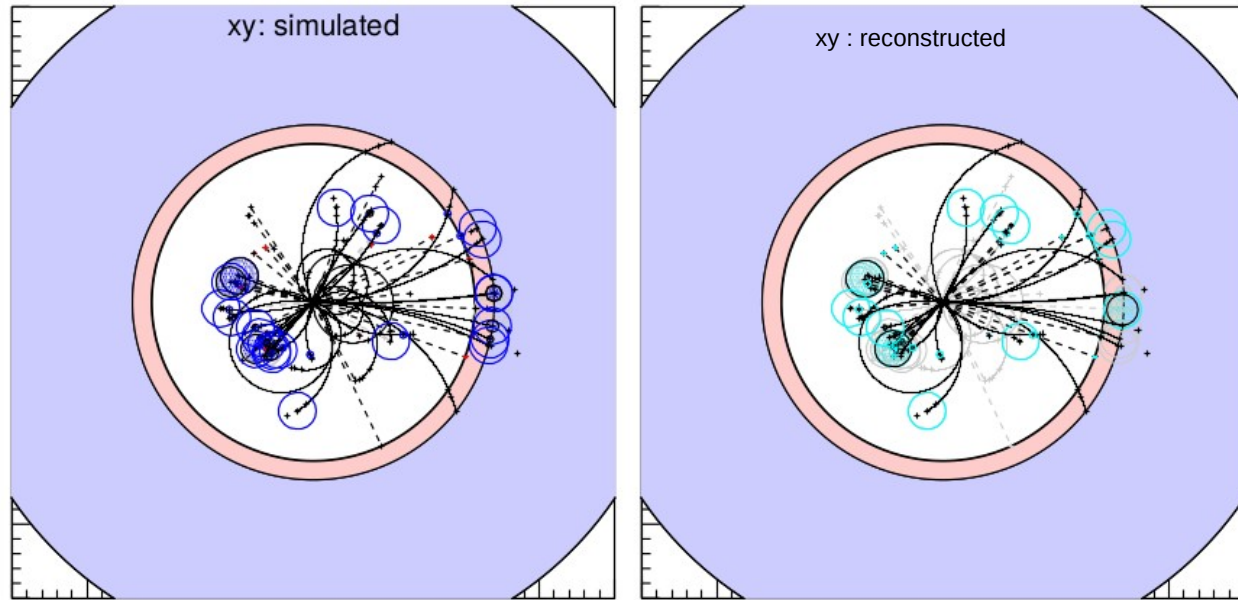


W measurement in hadronic channel



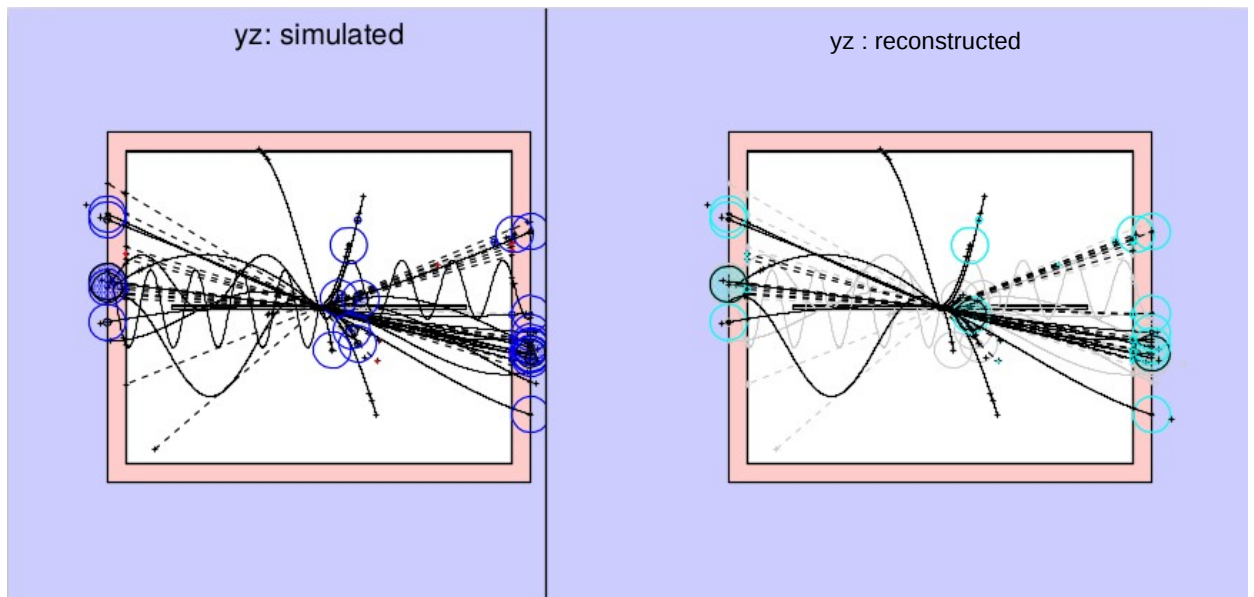
Bad resolution for reco_jets due to lots of particles not reconstructed
-> detector parameters variation

W measurement in hadronic channel

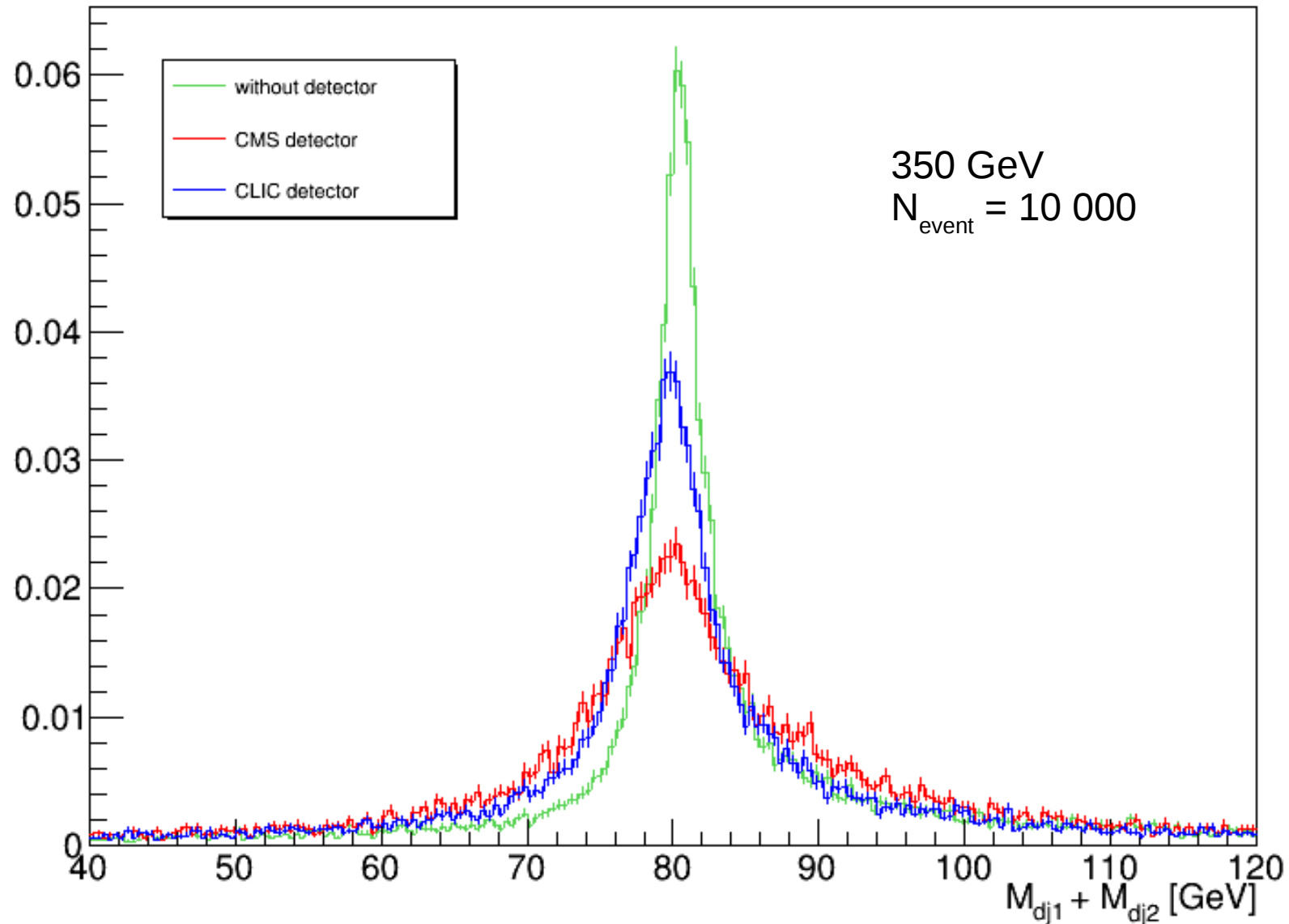


CLIC detector reconstruction
(same for CMS)

240 GeV

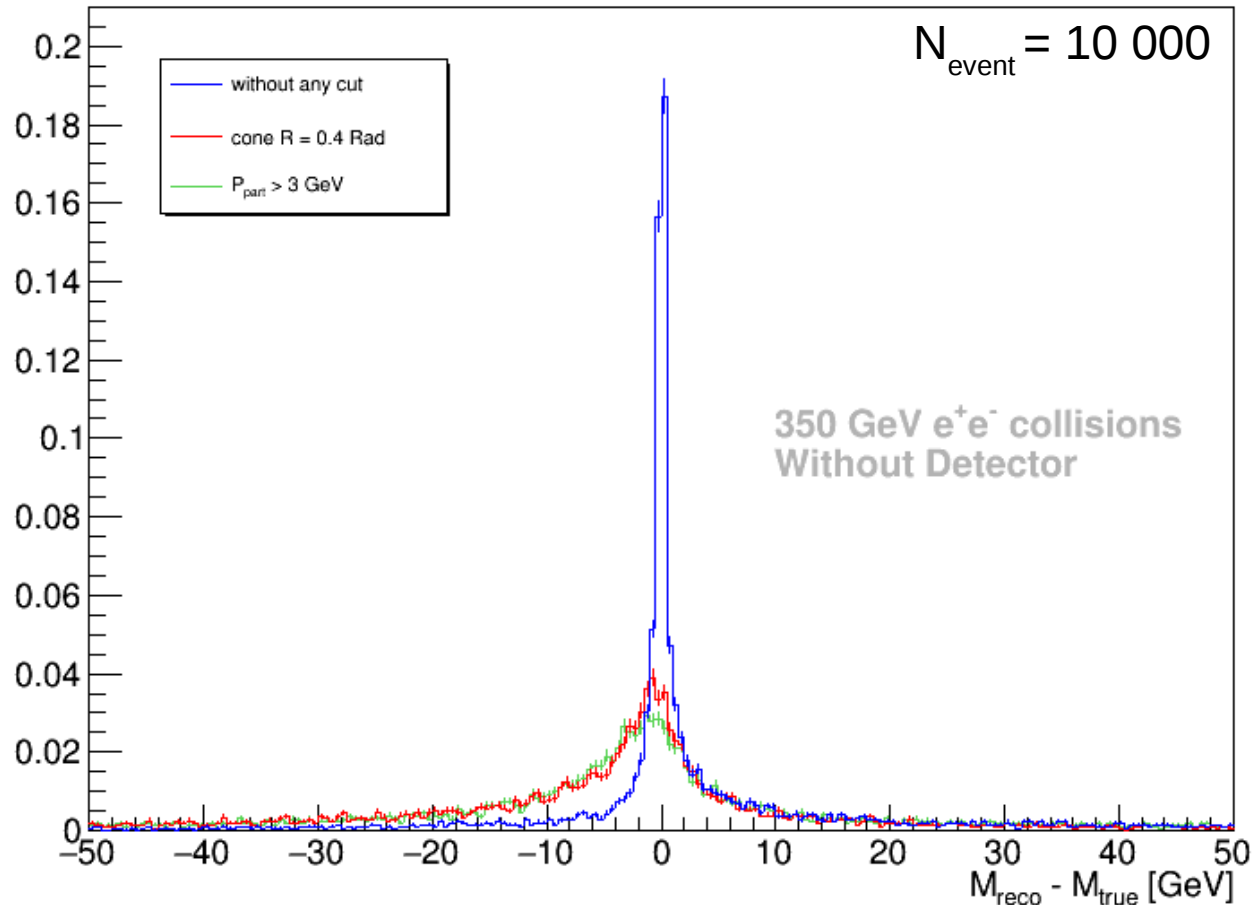


W measurement in hadronic channel



W measurement in hadronic channel

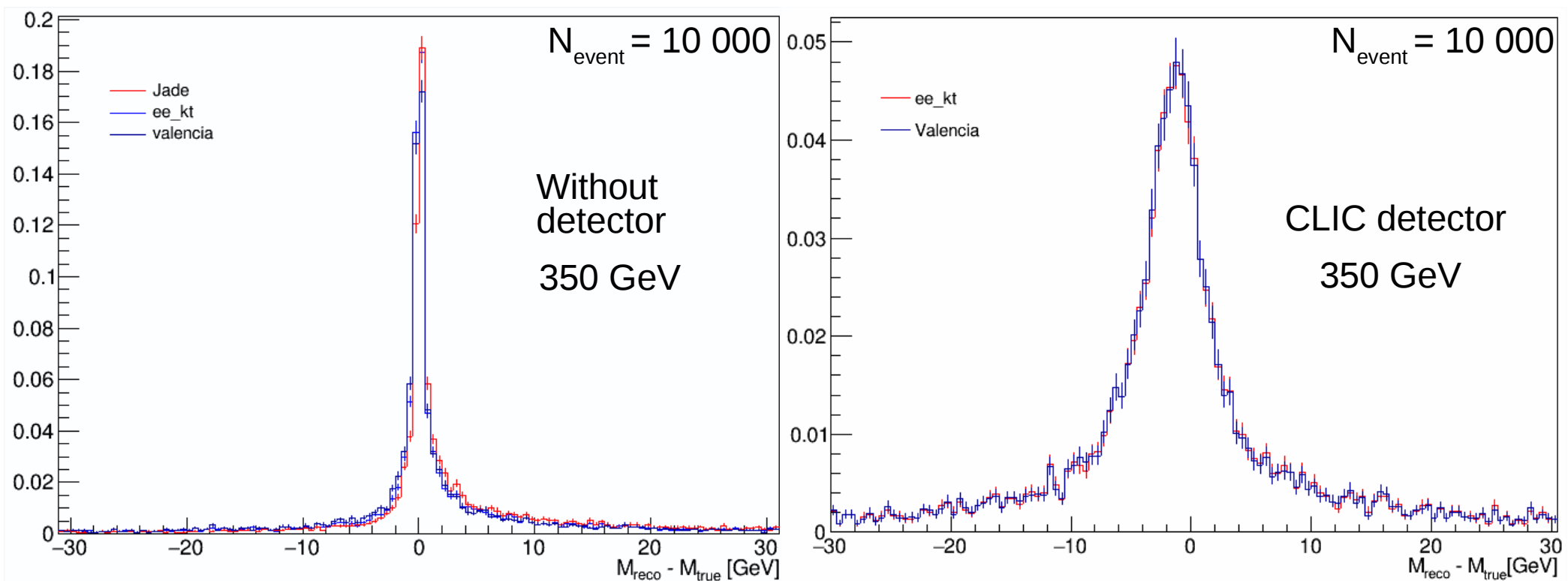
- Application of ALEPH cuts to avoid first state interaction :
 - cone ($R = 0,4$ rad)
 - Particle momentum ($P > 3$ GeV)



W measurement in hadronic channel

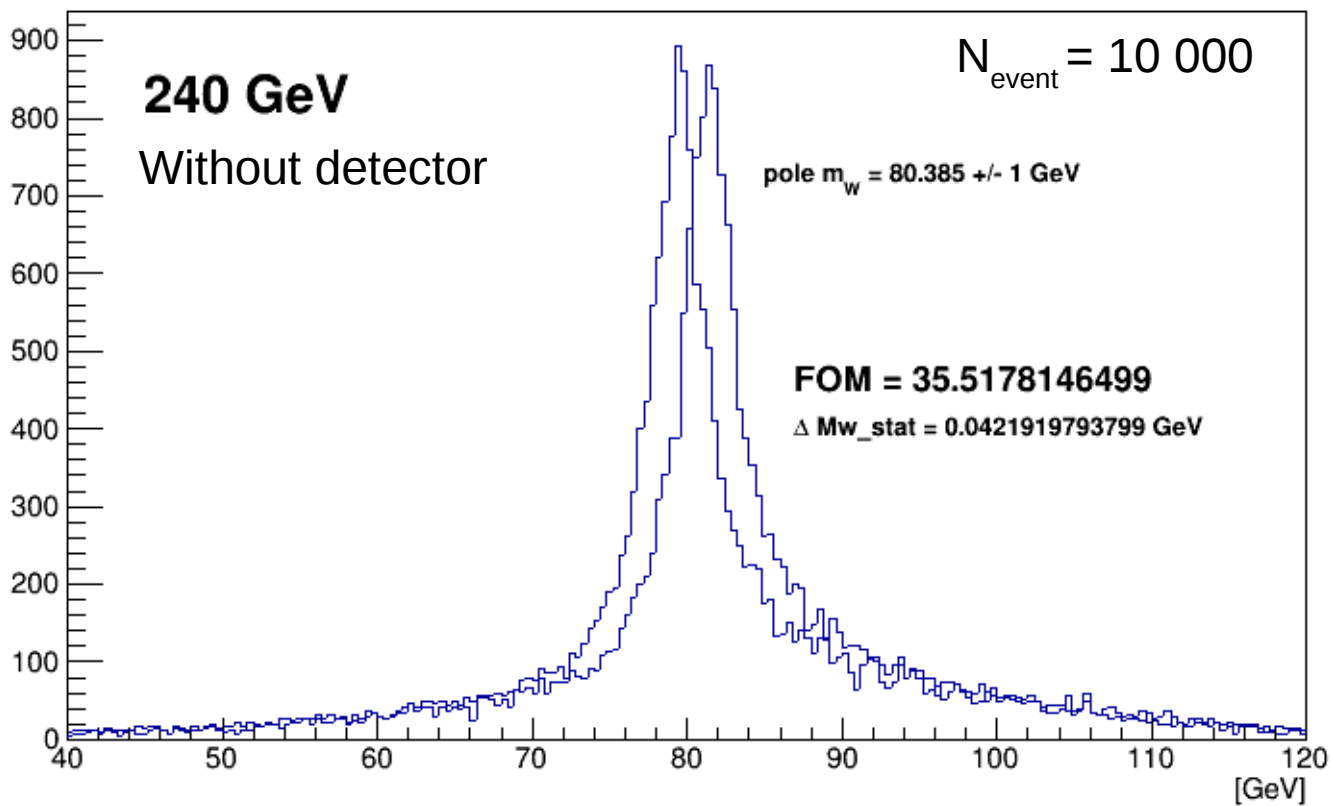
- Test of different reconstruction algorithms :
ee_kt, jade, Valencia

(A robust jet reconstruction algorithm for high-energy lepton colliders, Physics Letters B 750 (2015) 95-99, M. Boronat, J. Fuster, I. García, E. Ros, M. Vos)



W measurement in hadronic channel

- Figure of Merit : W mass reconstructed template with the aim to estimate the statistical mass uncertainty.



Two ways to compute the FOM :

$$\text{FOM} = \text{RMS} * \Delta(m_W) / \Delta(\text{mean})$$

$$\text{FOM} = \Delta M_w * \sum \text{bin_contents} / \sum (\text{diff_bin_content}^2 / \text{bin_contents})$$

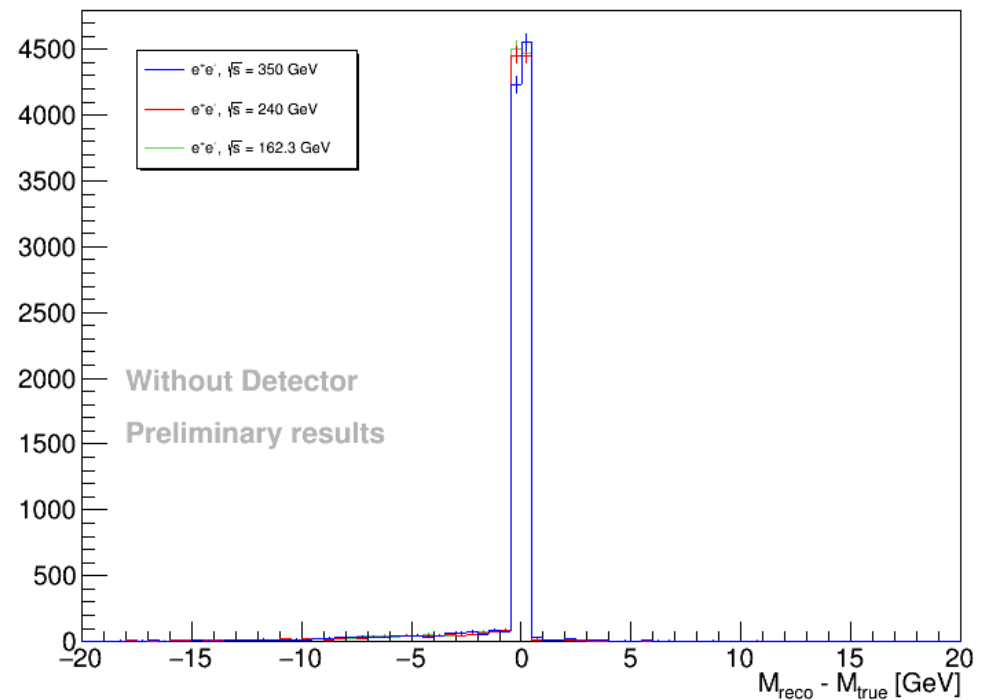
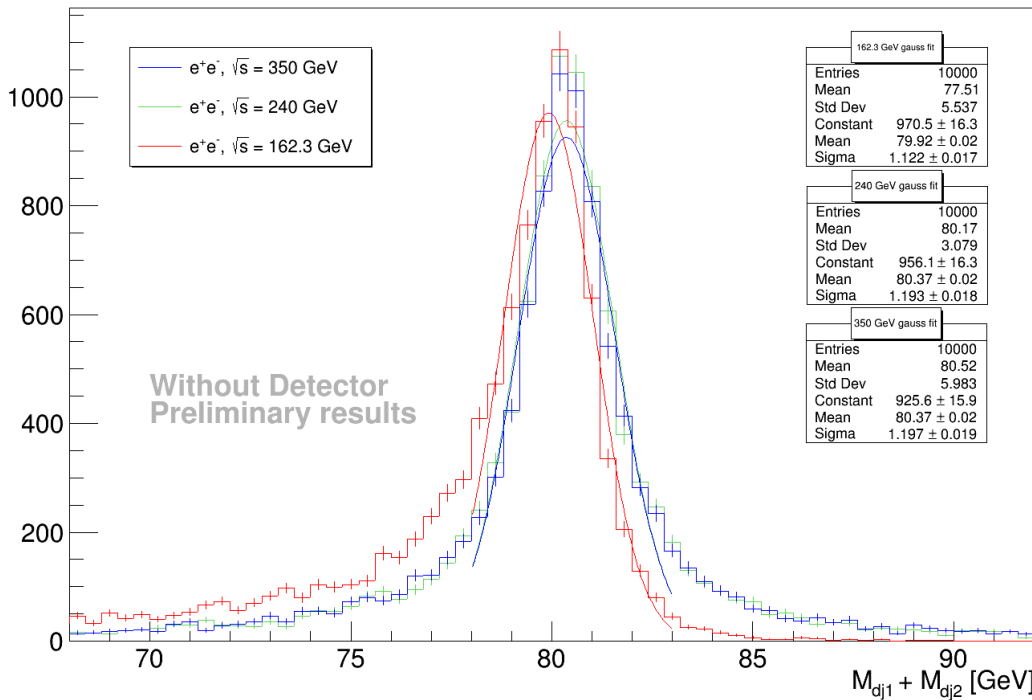
$$\text{Then } \Delta M_{w\text{stat}} = \sqrt{(\text{FOM} / N_{\text{event}})}$$

W measurement in semi-leptonic channel

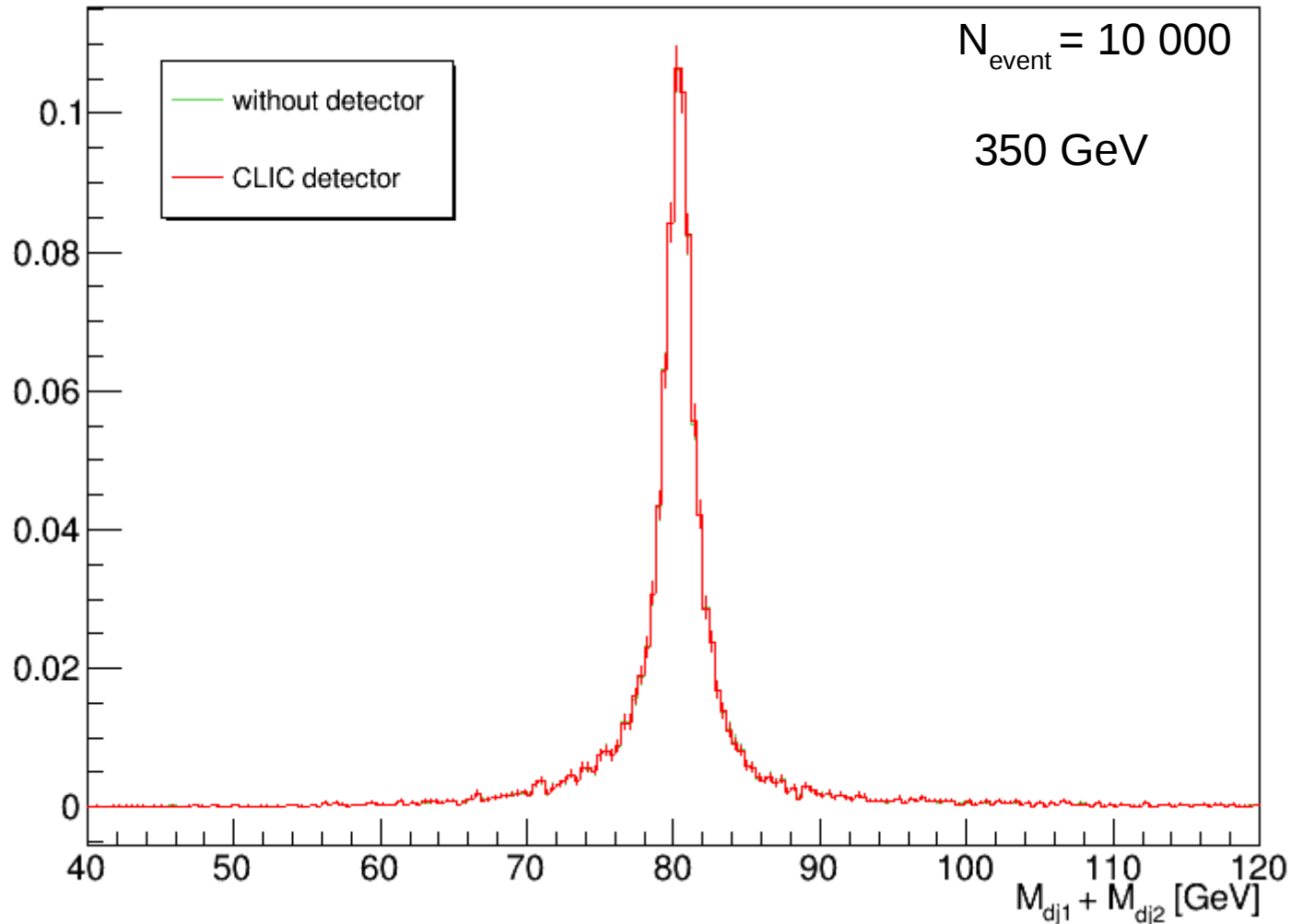
- Mass computed with $M_W = \sqrt{(E^2 + P^2)}$
- Different jet algorithm also tested : similar results for ee_kt and Valencia.

Two jets from the same W

-> remove the mixing particle problem



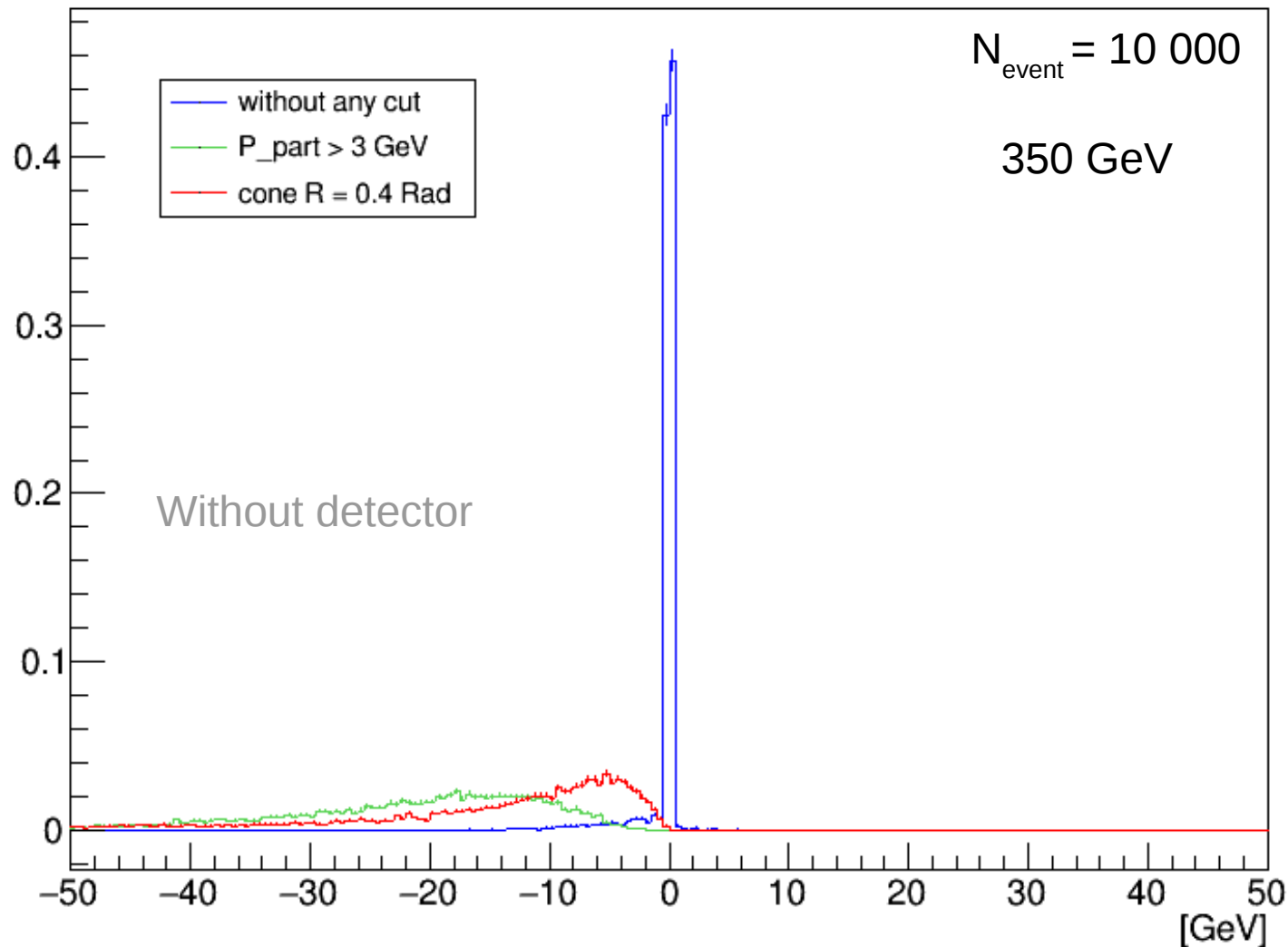
W measurement in semi-leptonic channel



The reconstruction is better in semi-leptonic channel because only few particles are not reconstructed

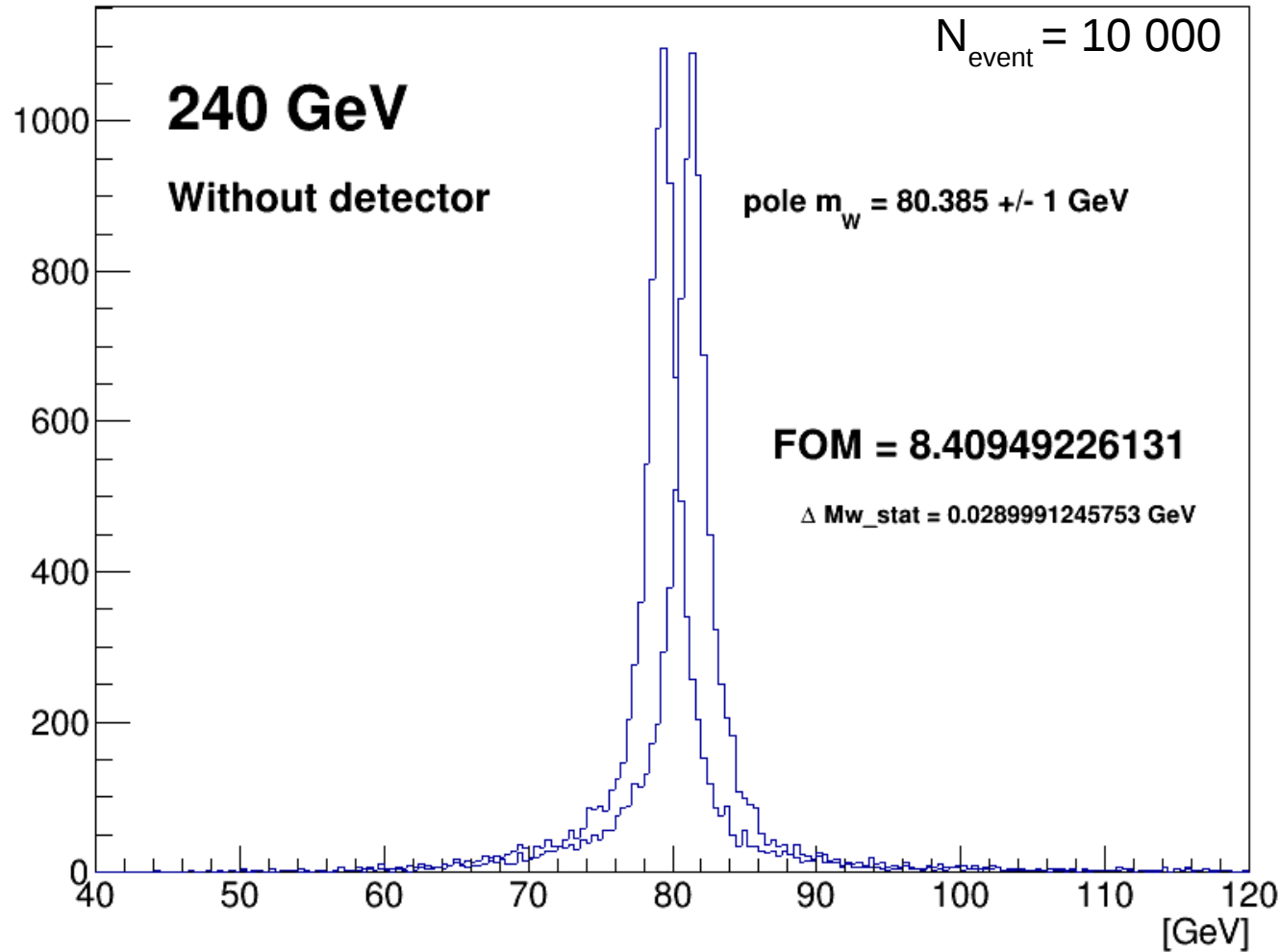
W measurement in semi-leptonic channel

- ALEPH cuts



W measurement in semi-leptonic channel

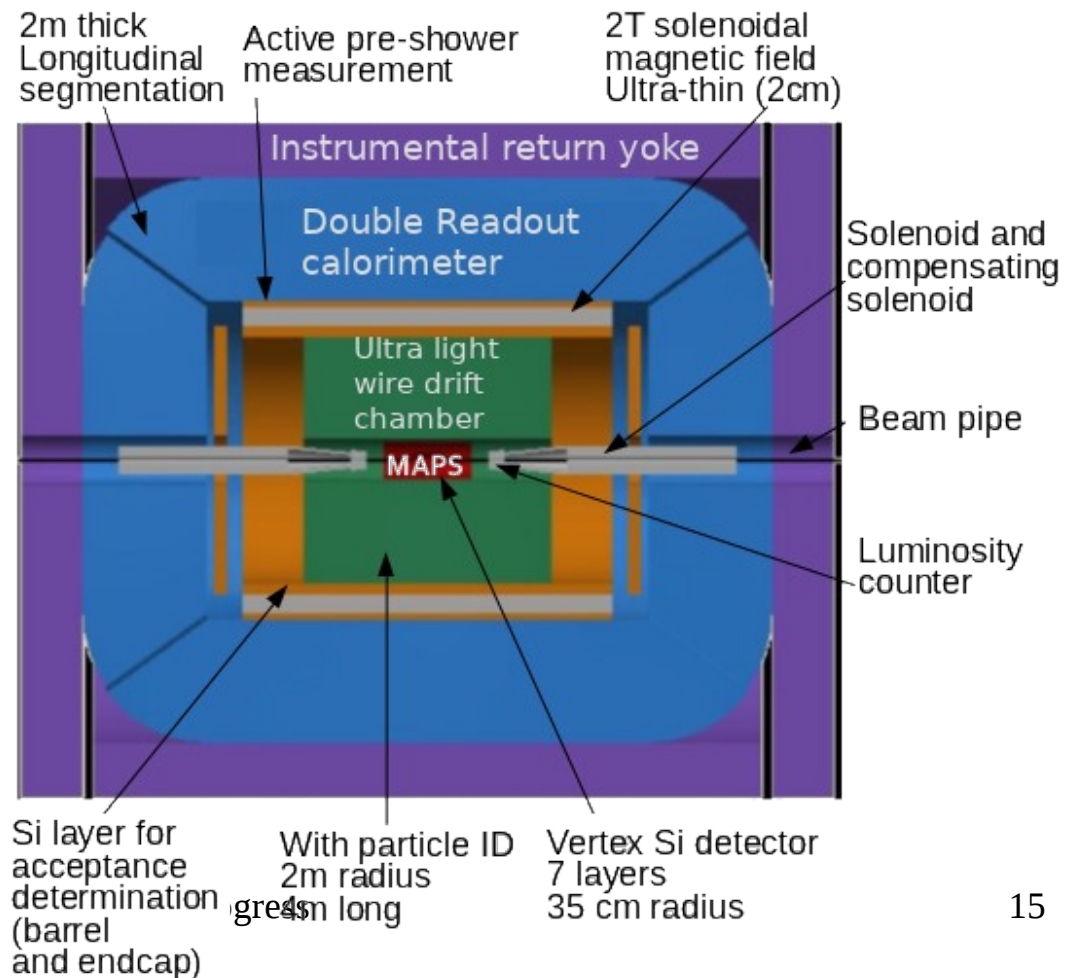
- FOM : same method than hadronic channel



IDEA - Detector implementation

- Study (variation) of CLIC detector parameters
- First draft of IDEA detector implemented in heppy

- What about this detector structure?



Kinematic Fit

$$\chi^2 = \left(\frac{\alpha - 1}{\sigma_\alpha}\right)^2 + \left(\frac{\phi - \phi_0}{\sigma_\phi}\right)^2 + \left(\frac{\theta - \theta_0}{\sigma_\theta}\right)^2 + \left(\frac{v - v_0}{\sigma_v}\right)^2 + 2\lambda f_{constraints} \quad v=p/E$$

$$\chi^2 = \Delta y V \Delta y + 2\lambda B \Delta y - c$$

y = measured parameters

B = dy/d(constraints)

λ = lagrange multiplier

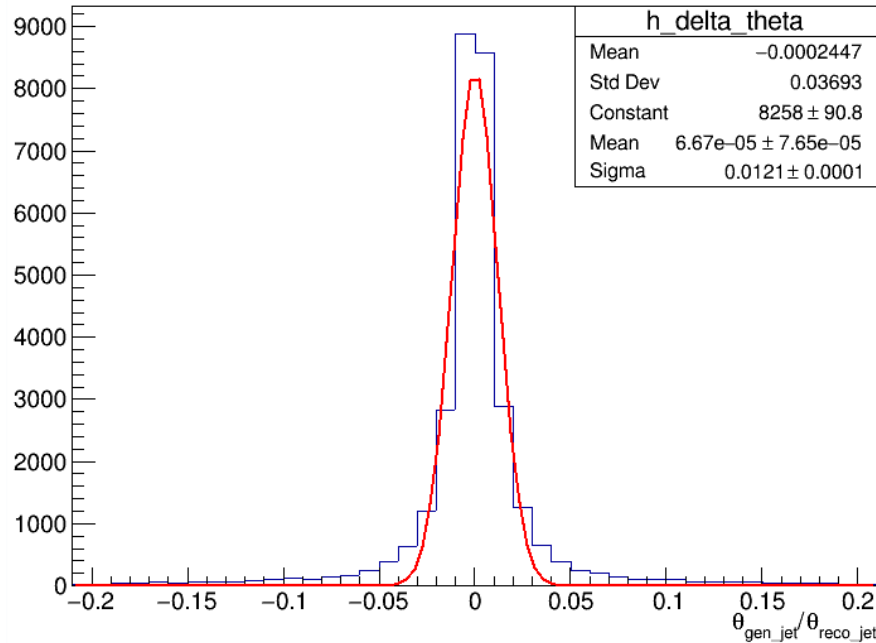
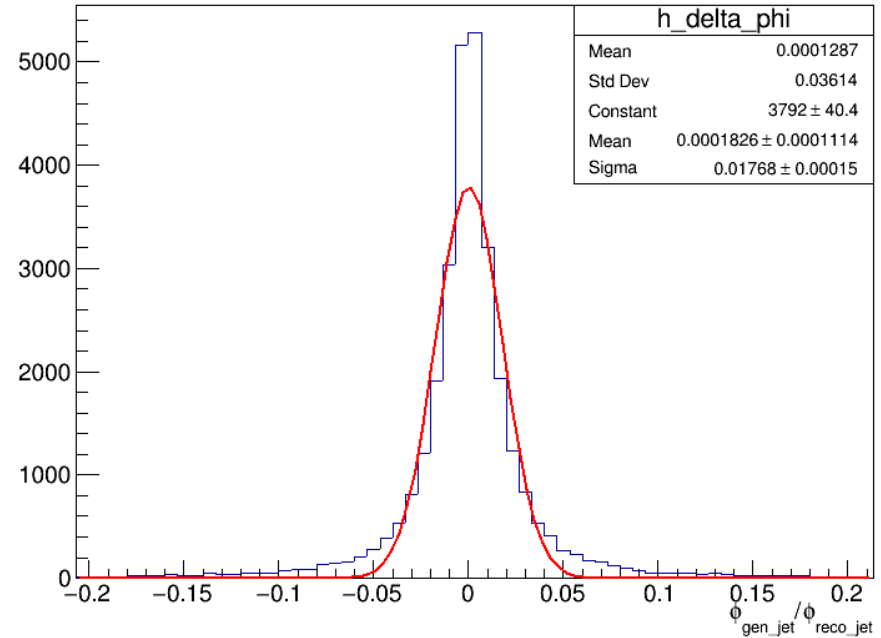
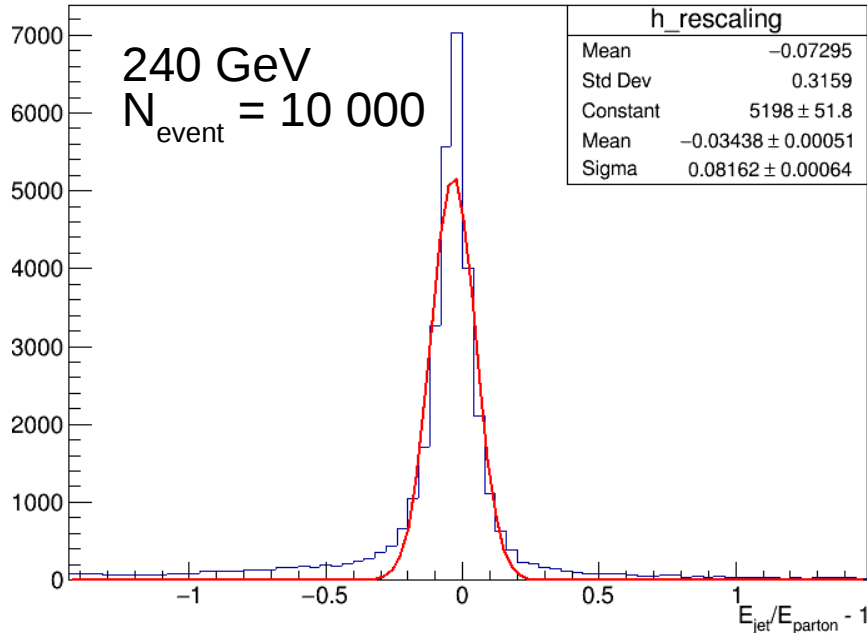
c = constant vector which depends on quantities of n-1 iteration

V = covariance matrix

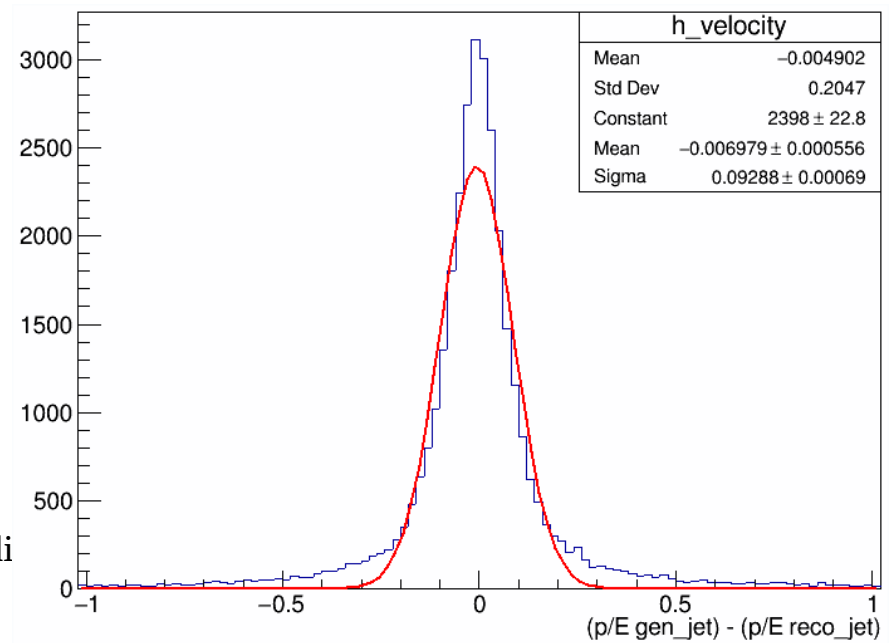
- Constraints used :
 - Hadronic : energy-momentum conservation and W mass equality
 - Semi-leptonic : only mass constraint
- KinFitter tool
- In study : Hadronic channel at 240 GeV for 10 000 events. Reconstruction with CLIC detector

Kinematic Fit

- Covariance matrix uncertainties

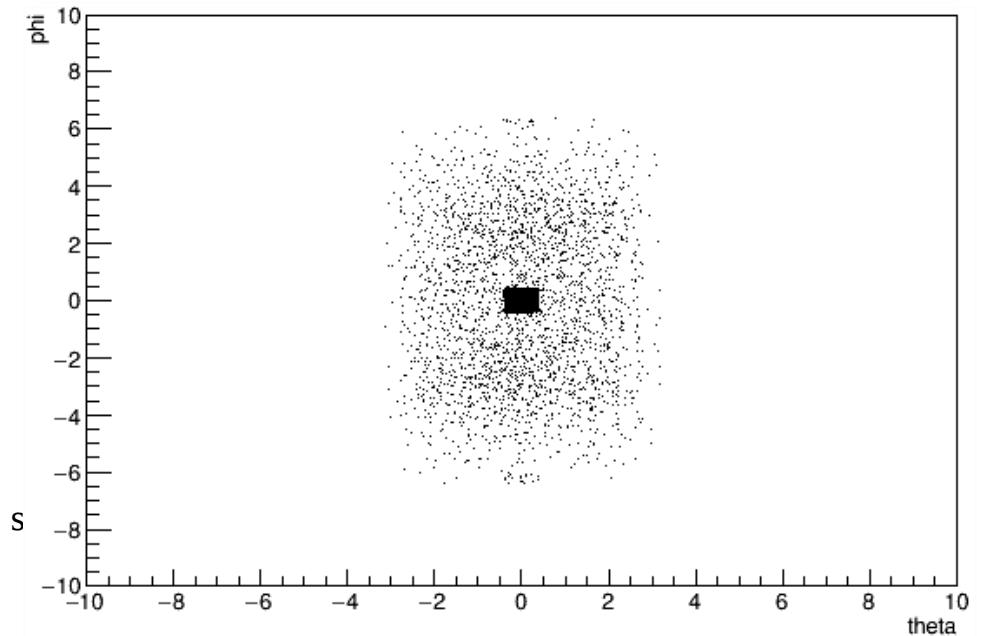
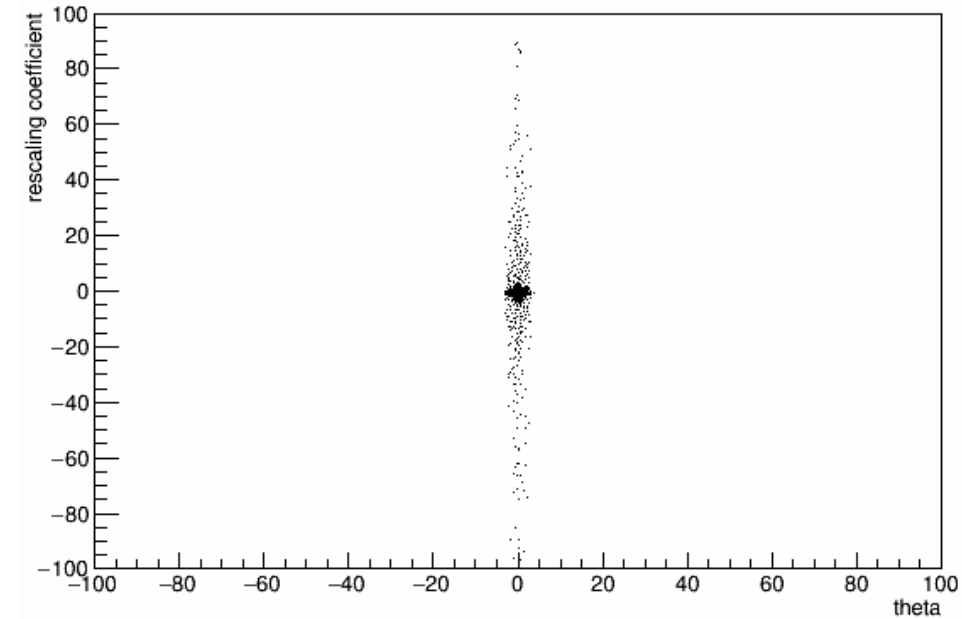
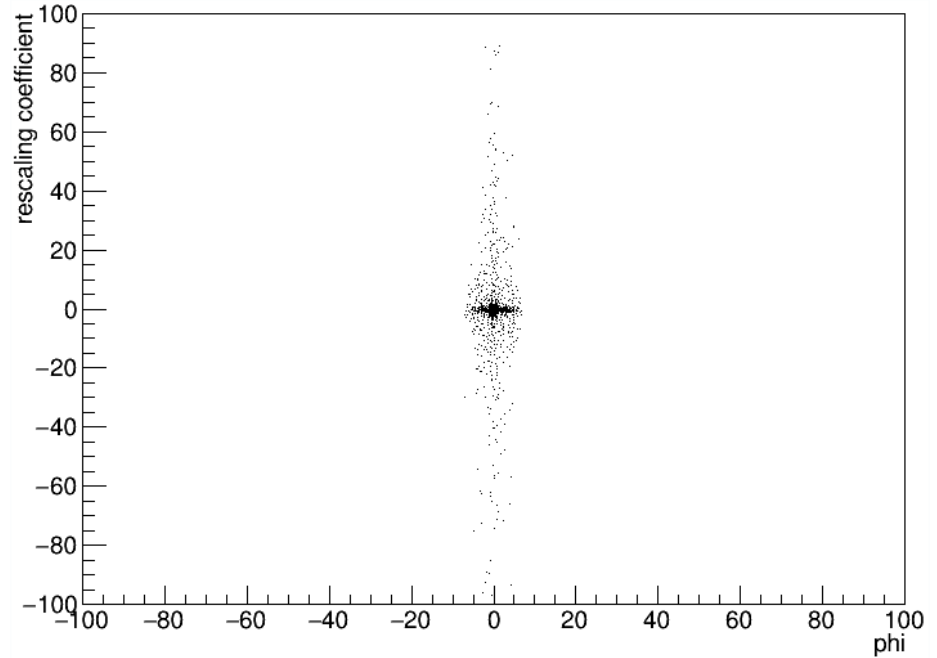
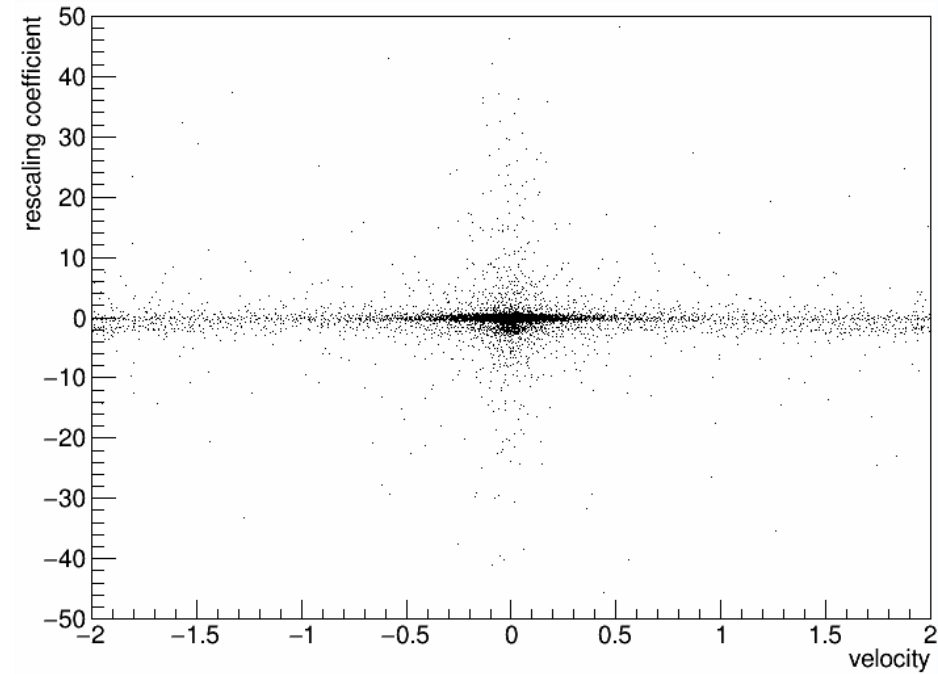


mass studi



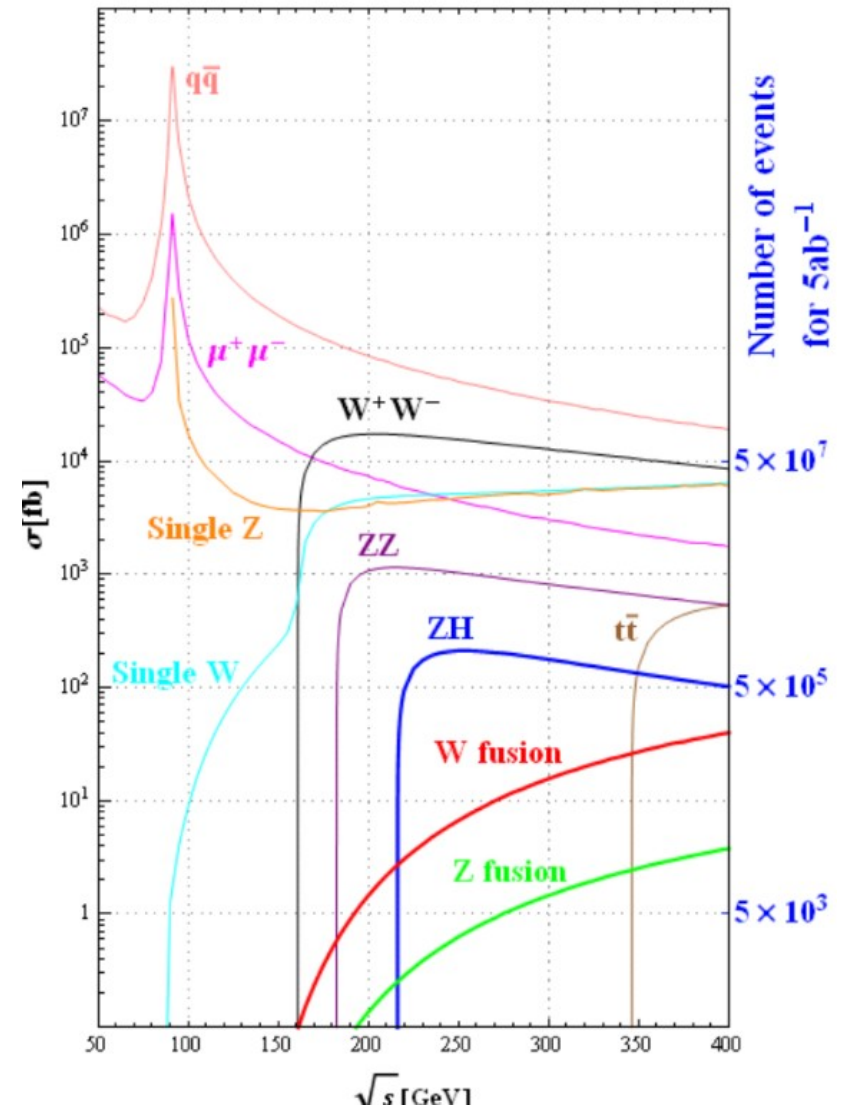
Kinematic Fit

- 0 correlation ! The covariance matrix is diagonal



Background in the W decay

- Hadronic : Only $q\bar{q}$
- Semi-leptonic : $q\bar{q}$ and Z boson decay
- Simulated with Pythia but not introduced in the reconstruction yet



Thanks for your attention

Questions ?

BACK UP

W mass measurement at 158 GeV

