Emulación de detectores:

Reconstrucción de la masa del bosón Z

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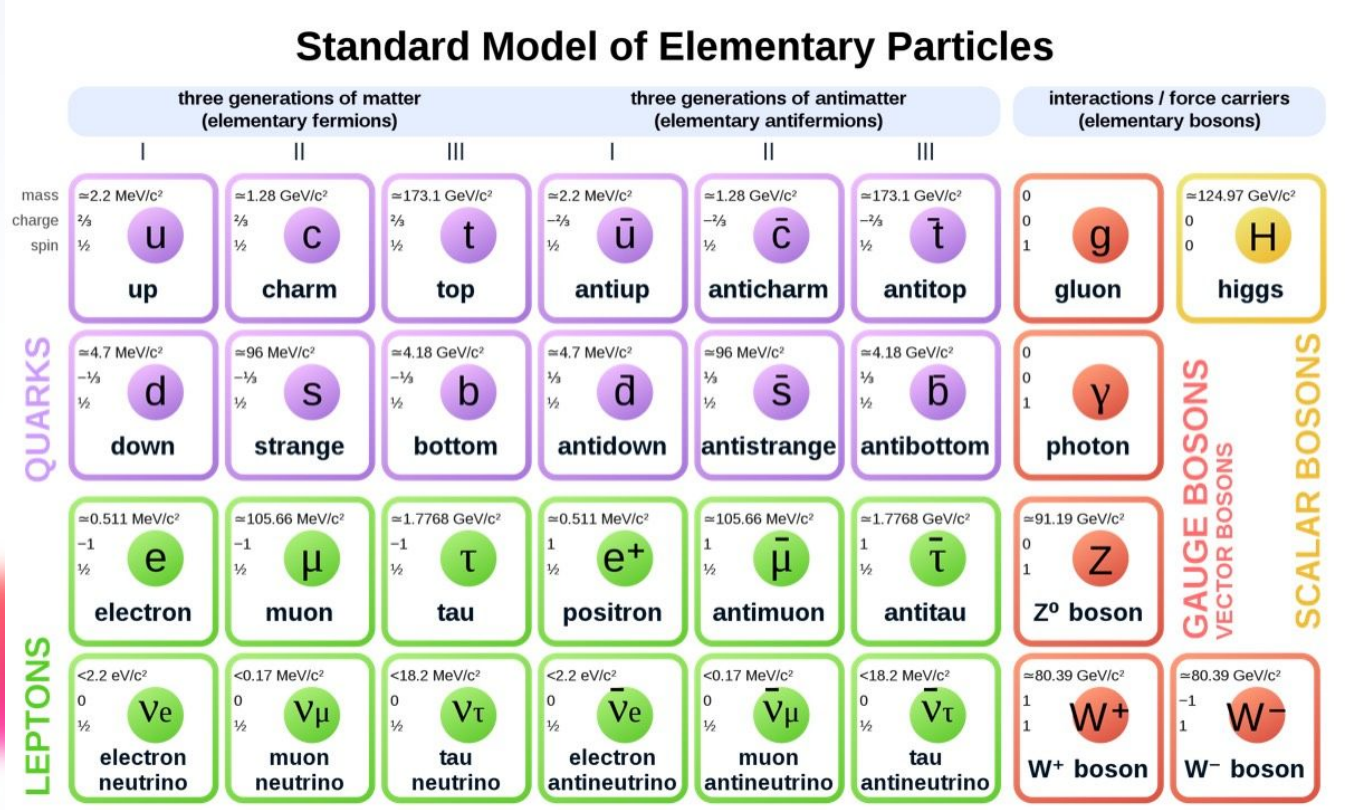
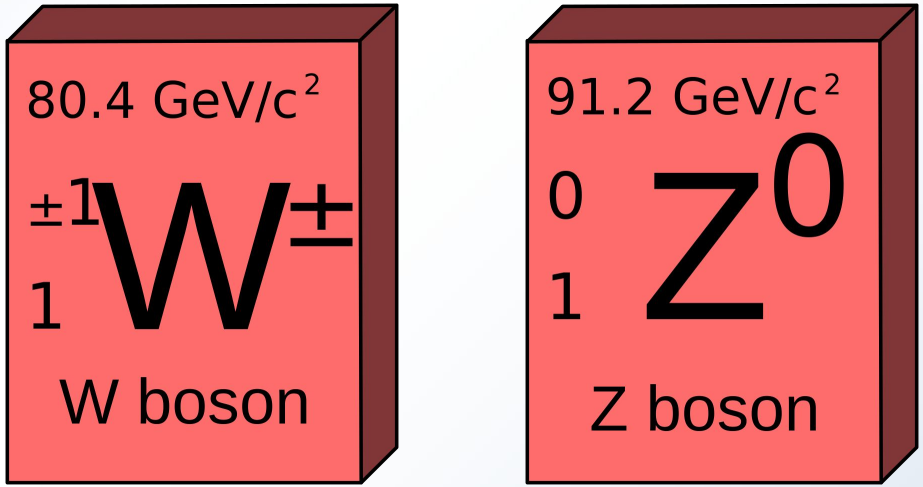
01

El modelo estándar



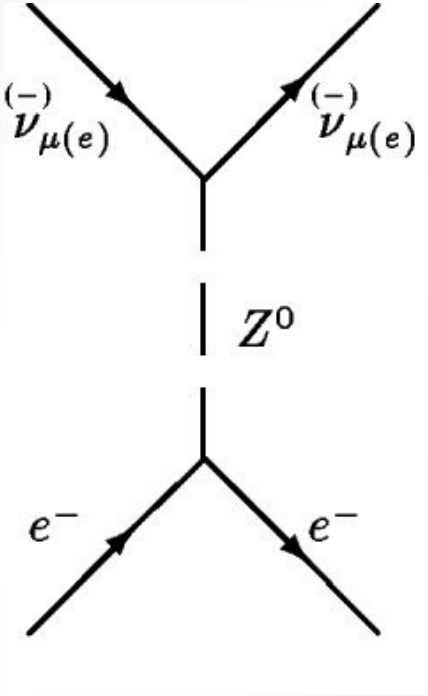
02

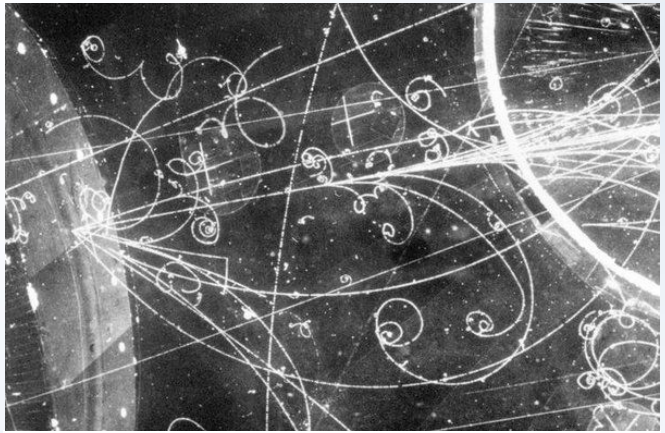
Bosones W y Z



Son los bosones mediadores de la fuerza débil.
La masa del hierro es de 52 GeV aprox

Corriente neutra



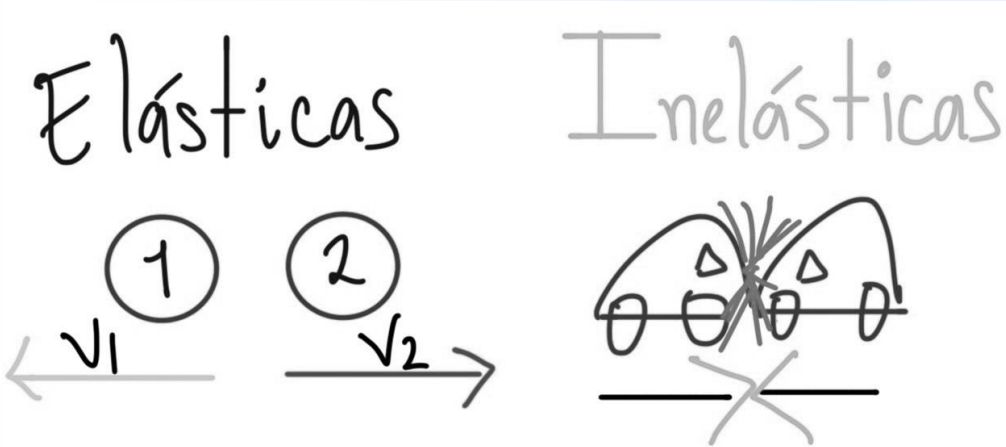


$$\Delta E \cdot \Delta \tau \geq \frac{\hbar}{2}$$

03 Colisiones

Haciendo honor a su nombre, el LHC produce colisiones que son medidas por sus diferentes experimentos.

Las colisiones más interesantes son las ***inelásticas***



Detectores del CMS

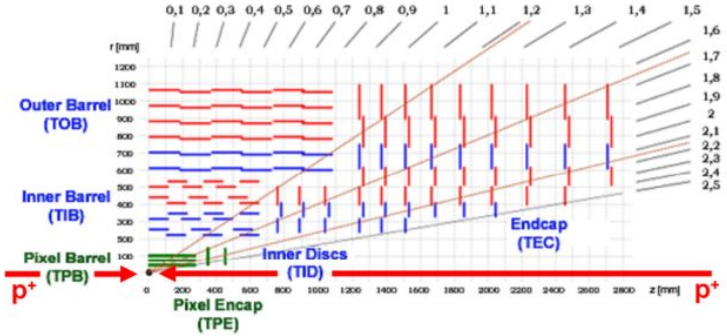


Figure 2.14: Tracker acceptance in η.

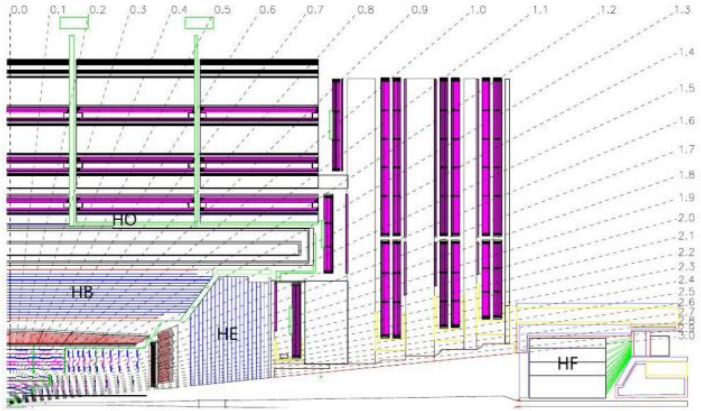


Figure 2.18: CMS HCAL representation.

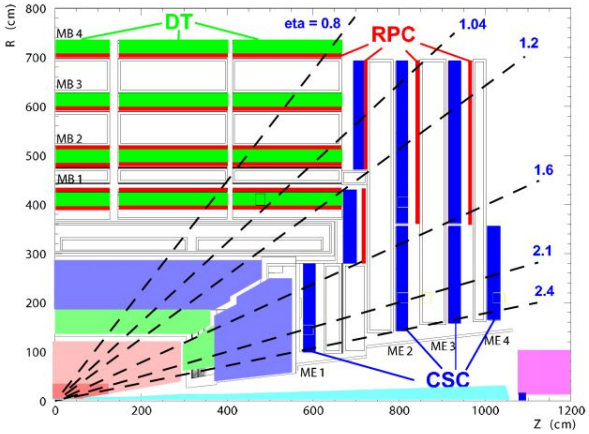


Figure 2.19: CMS muon chambers representation.

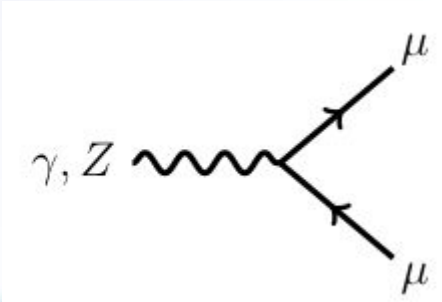
Masa invariante

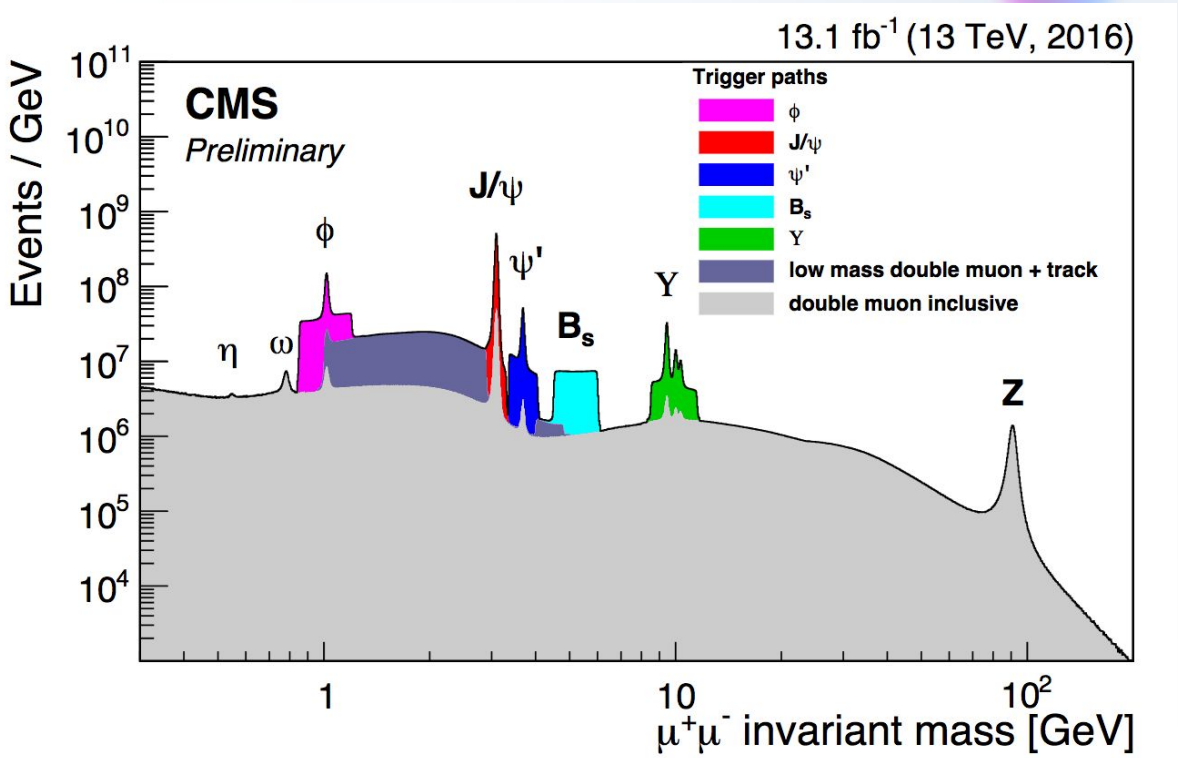
Es la masa que tiene una partícula en reposo.
Es equivalente a la magnitud del cuadrimomento lineal.

$$p = \left(p^0, p^1, p^2, p^3\right) = \left(\frac{E}{c}, p_x, p_y, p_z\right).$$

$$M^2 = 2p_{T1}p_{T2}(\cosh(\eta_1 - \eta_2) - \cos(\phi_1 - \phi_2)).$$

Decaimientos dimuónicos

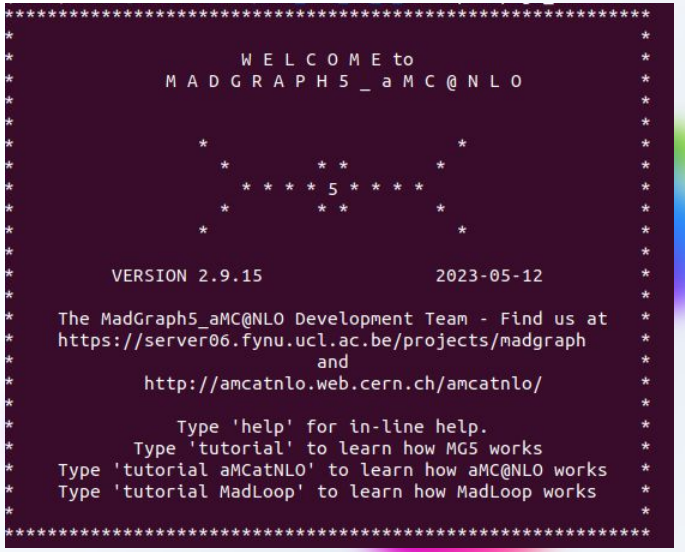




04

Madgraph.

Framework que proporciona los elementos necesarios para la fenomenología de SM y BSM.




```
Loading default model: sm
INFO: Restrict model sm with file models/sm/restrict_default.dat .
INFO: Run "set stdout_level DEBUG" before import for more information
.
INFO: Change particles name to pass to MG5 convention
Defined multiparticle p = g u c d s u~ c~ d~ s~
Defined multiparticle j = g u c d s u~ c~ d~ s~
Defined multiparticle l+ = e+ mu+
Defined multiparticle l- = e- mu-
Defined multiparticle vl = ve vm vt
Defined multiparticle vl~ = ve~ vm~ vt~
Defined multiparticle all = g u c d s u~ c~ d~ s~ a ve vm vt e- mu- v
e~ vm~ vt~ e+ mu+ t b t~ b~ z w+ h w- ta- ta+
MG5_aMC>
```

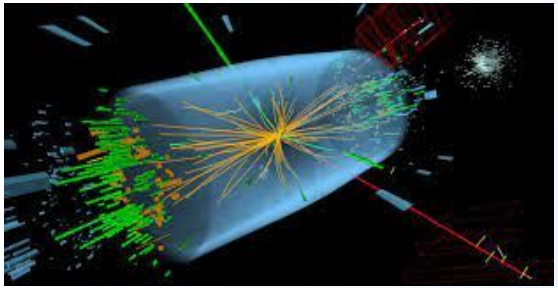
Generar el proceso en madgraph

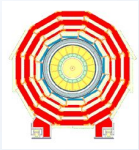
```
MG5_aMC>generate p p > mu+ mu-
INFO: Checking for minimal orders which gives processes.
INFO: Please specify coupling orders to bypass this step.
INFO: Trying process: g g > mu+ mu- WEIGHTED<=4 @1
INFO: Trying process: u u~ > mu+ mu- WEIGHTED<=4 @1
INFO: Process has 2 diagrams
INFO: Trying process: u c~ > mu+ mu- WEIGHTED<=4 @1
INFO: Trying process: c u~ > mu+ mu- WEIGHTED<=4 @1
INFO: Trying process: c c~ > mu+ mu- WEIGHTED<=4 @1
INFO: Process has 2 diagrams
INFO: Trying process: d d~ > mu+ mu- WEIGHTED<=4 @1
INFO: Process has 2 diagrams
INFO: Trying process: d s~ > mu+ mu- WEIGHTED<=4 @1
INFO: Trying process: s d~ > mu+ mu- WEIGHTED<=4 @1
INFO: Trying process: s s~ > mu+ mu- WEIGHTED<=4 @1
INFO: Process has 2 diagrams
INFO: Process u~ u > mu+ mu- added to mirror process u u~ > mu+ mu-
INFO: Process c~ c > mu+ mu- added to mirror process c c~ > mu+ mu-
INFO: Process d~ d > mu+ mu- added to mirror process d d~ > mu+ mu-
INFO: Process s~ s > mu+ mu- added to mirror process s s~ > mu+ mu-
4 processes with 8 diagrams generated in 0.027 s
Total: 4 processes with 8 diagrams
MG5_aMC>
```

Colisiones y detectores en la simulación.

Phytia8

Generación de eventos de física de partículas y las interacciones entre las partículas producidas

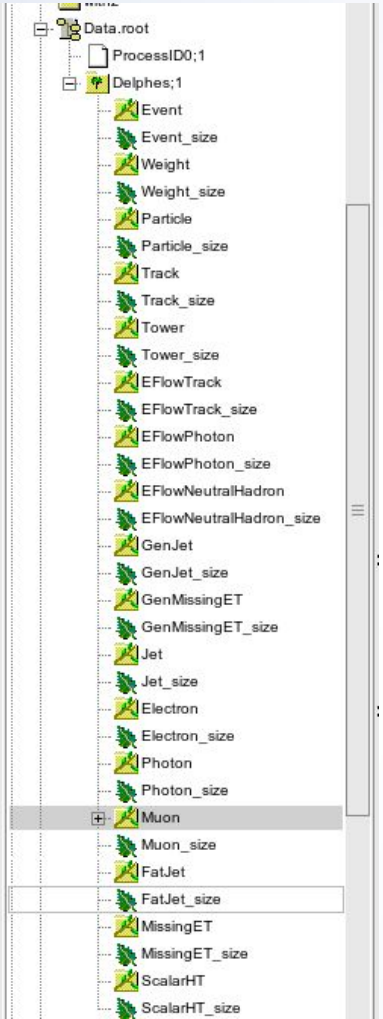


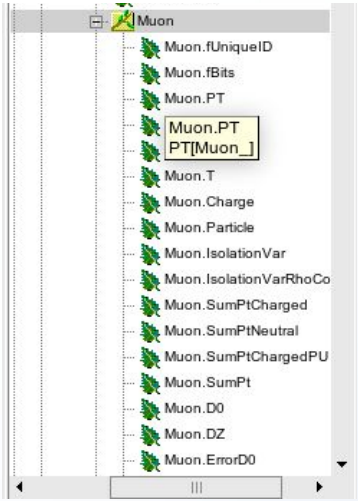


Delphes

Se utiliza para simular la respuesta de un detector de partículas y generar datos simulados que se asemejan a los datos experimentales.

```
The following switches determine which programs are run:
/============================================================\
1. Choose the shower/hadronization program      shower = Pythia8
2. Choose the detector simulation program     detector = Delphes
3. Choose an analysis package (plot/convert) analysis = Not Avail.
4. Decay onshell particles                     madspin = OFF
5. Add weights to events for new hypp.        reweight = OFF
\============================================================/
Either type the switch number (1 to 5) to change its setting,
Set any switch explicitly (e.g. type 'shower=OFF' at the prompt)
Type 'help' for the list of all valid option
Type '0', 'auto', 'done' or just press enter when you are done.[60s t
o answer]
>
```





05

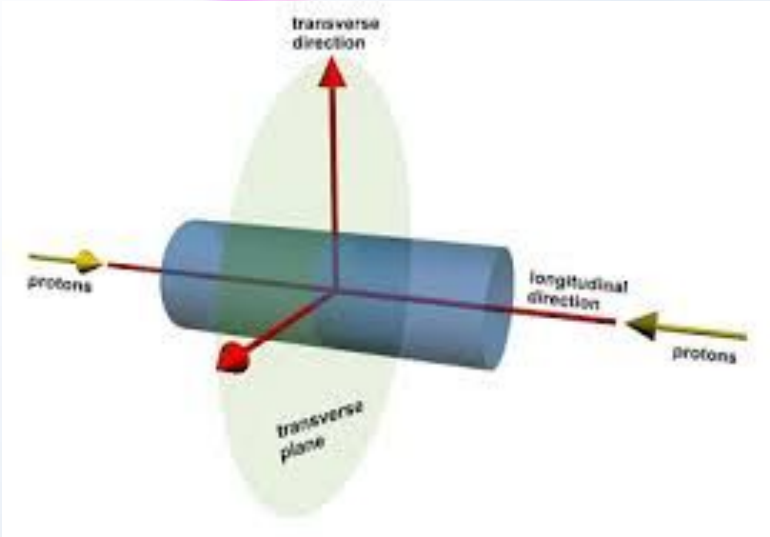
Lectura de datos.

Recolectar la información arrojada por Delphes (10.000 eventos)

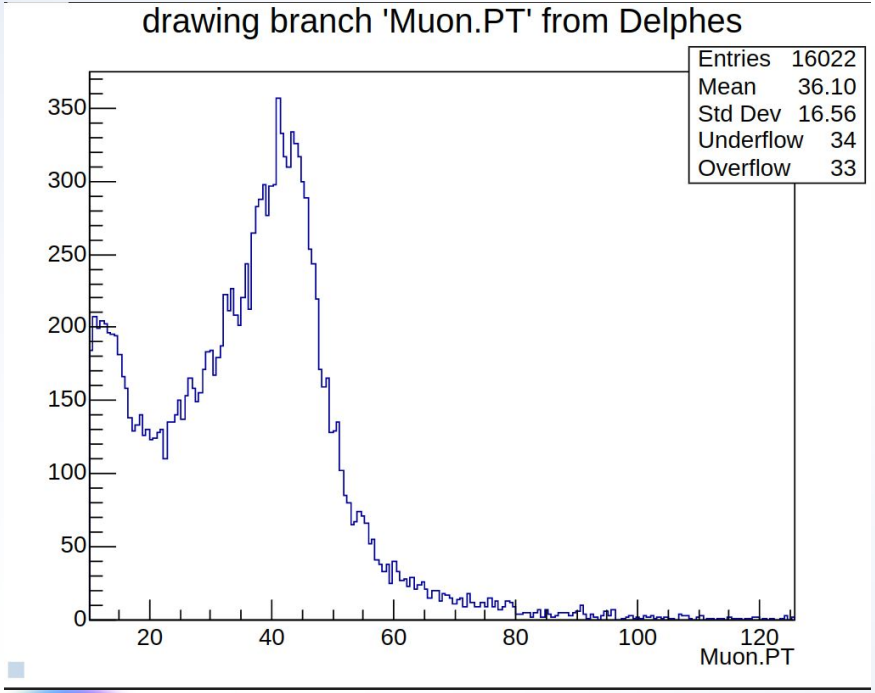
Cortes.

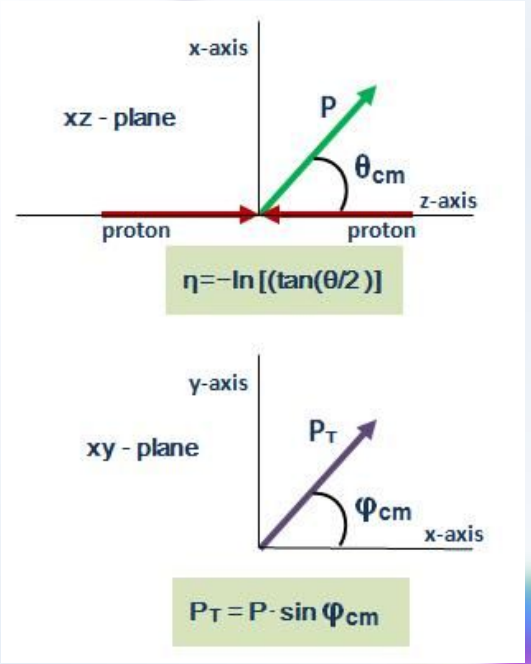
Dada la física del problema se trata de disminuir la cantidad de background en los datos obtenidos.

```
if (mu_size < 2) continue;
if (fabs(Mu_pt[0]<30)) continue;
if (fabs(Mu_pt[1]<30)) continue;
if (fabs(Mu_eta[0])>2.4) continue;
if (fabs(Mu_eta[1])>2.4) continue;
```



PT


drawing branch 'Muon.PT' from Delphes
Entries 16022
Mean 36.10
Std Dev 16.56
Underflow 34
Overflow 33
350
300
250
200
150
100
50
0
20
40
60
80
100
120
Muon.PT


x-axis
xz - plane
P
θcm
z-axis
proton
proton
η=−ln[(tan(θ/2)]
y-axis
xy - plane
PT
φcm
x-axis
PT = P· sin φcm

06

FIT y MC

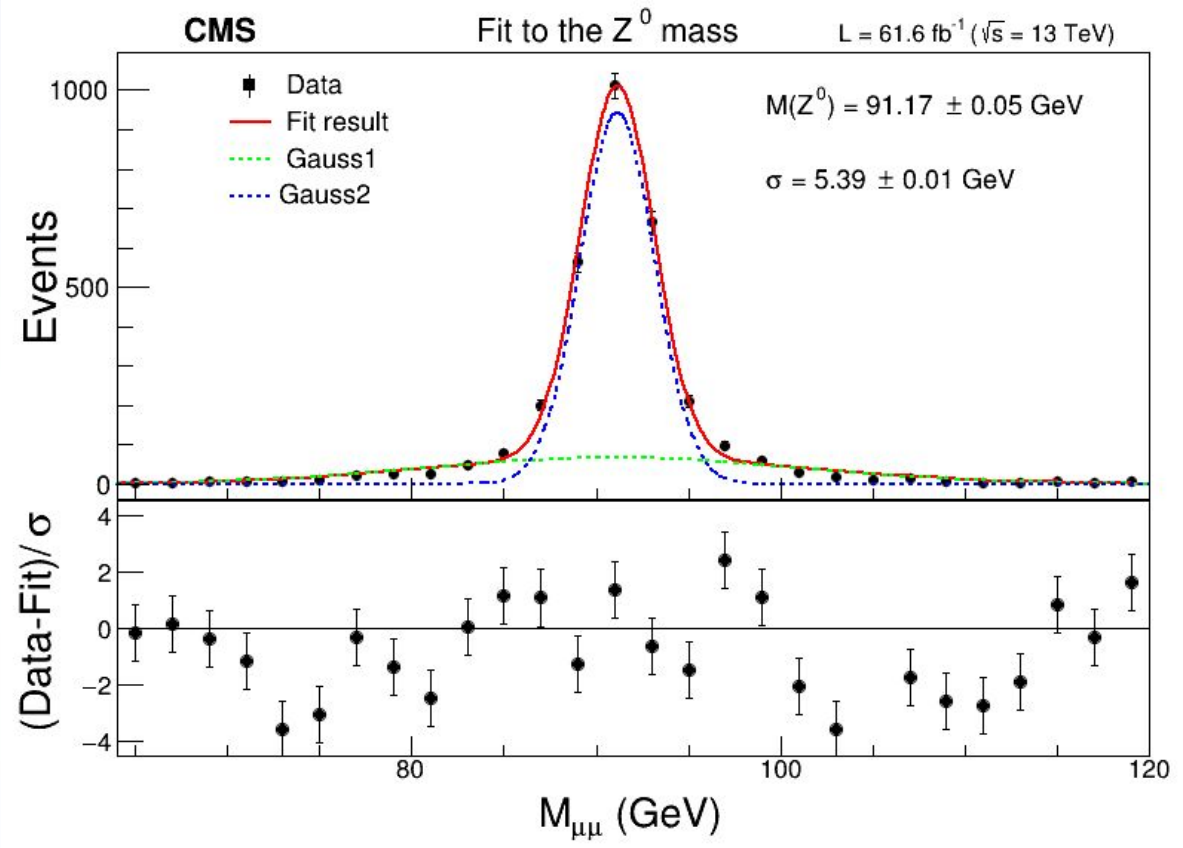
Ajuste a los datos filtrados y verificación del modelo con MC.

Cálculo de la masa invariante.

```
// Calcular la masa invariante utilizando la fórmula
Double_t delta_eta = eta1 - eta2;
Double_t delta_phi = TMath::Abs(phi1 - phi2);
if (delta_phi > TMath::Pi())
{
    delta_phi = 2 * TMath::Pi() - delta_phi;
}
Double_t invariant_pt = pt1 * pt2 * (TMath::CosH(delta_eta) - TMath::Cos(delta_phi));
if (invariant_pt > 0)
{
h->Fill(TMath::Sqrt(2 * invariant_pt));
}
M = TMath::Sqrt(2 * invariant_pt);
```

```
muon1.SetPtEtaPhiE(Mu_pt[0], Mu_eta[0], Mu_phi[0], Mu_E[0]);
muon2.SetPtEtaPhiE(Mu_pt[1], Mu_eta[1], Mu_phi[1], Mu_E[1]);
```

Resultado del Fit



Verificación del modelo con generación MC.

```
COVARIANCE MATRIX CALCULATED SUCCESSFULLY
FCN=14.4251 FROM HESSE     STATUS=OK              10 CALLS          69 TOTAL
                    EDM=7.71045e-05    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   INTERNAL      INTERNAL
 NO.   NAME      VALUE            ERROR          STEP SIZE       VALUE
  1  meanMu       1.78073e+00   5.38924e+00   7.50366e-03   6.35496e-01
  2  widthMu      4.99951e+00   4.78069e+00   6.15559e-03   1.55101e+00
                               ERR DEF= 0.5
```

Bibliografía.

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- https://launchpad.net/mg5amcnlo#:~:text=MadGraph5_aMC%40NLO%20is%20a%20framework,to%20event%20manipulation%20and%20analysis.
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- https://en.wikipedia.org/wiki/Neutral_current
- https://en.wikipedia.org/wiki/Invariant_mass
- https://en.wikipedia.org/wiki/Four-momentum
- https://m.bergauer.org/friedl/diss/html/node8.html