

Resultados Recientes del Experimento ATLAS del LHC en el CERN

Isabel Pedraza
(University of Wisconsin)



Facultad de Ciencias Físico-Matemáticas
BUAP

30 de Agosto de 2010

Organización de la Plática

- *Motivación*
- *Descripción del detector*
- *Estatus del LHC*
- *Contribuciones en las conferencias de verano con datos*
 - **W, Z, Z+jets y W'**
 - **Física con Jets**
 - **SUSY**
- *Un poco del trabajo en el CERN*

Motivación

•MODELO ESTÁNDAR

QUARKS

UP QUARK
A teeny little point inside the proton and neutron, it is friends forever with the down quark.

DOWN QUARK
A tiny little point inside the proton and neutron, it is friends forever with the up quark.

CHARM QUARK
A charming second generation quark.

STRANGE QUARK
What's so strange about this second generation quark?

TOP QUARK
This heavyweight champion doesn't live long enough to make friends with anyone.

BOTTOM QUARK
This third generation quark is puttin' on the pounds.

LEPTONS

ELECTRON-NEUTRINO
This minuscule bandit is so light, he is practically massless.

MUON-NEUTRINO
Like the other 2 neutrinos, he's got an identity crisis from oscillation.

TAU-NEUTRINO
He's a tau now, but what type of neutrino will he be next?

ELECTRON
A familiar friend, this negatively charged, busy lil' guy likes to bond.

MUON
A "heavy electron" who lives fast and dies young.

TAU
A "heavy muon" who could stand to lose a little weight.

FORCE CARRIERS

PHOTON
The massless wavicle we know and love.

GLUON
The "glue" of the strong nuclear force.

W BOSON
As the carrier particles of the weak nuclear force, they are downright obese.

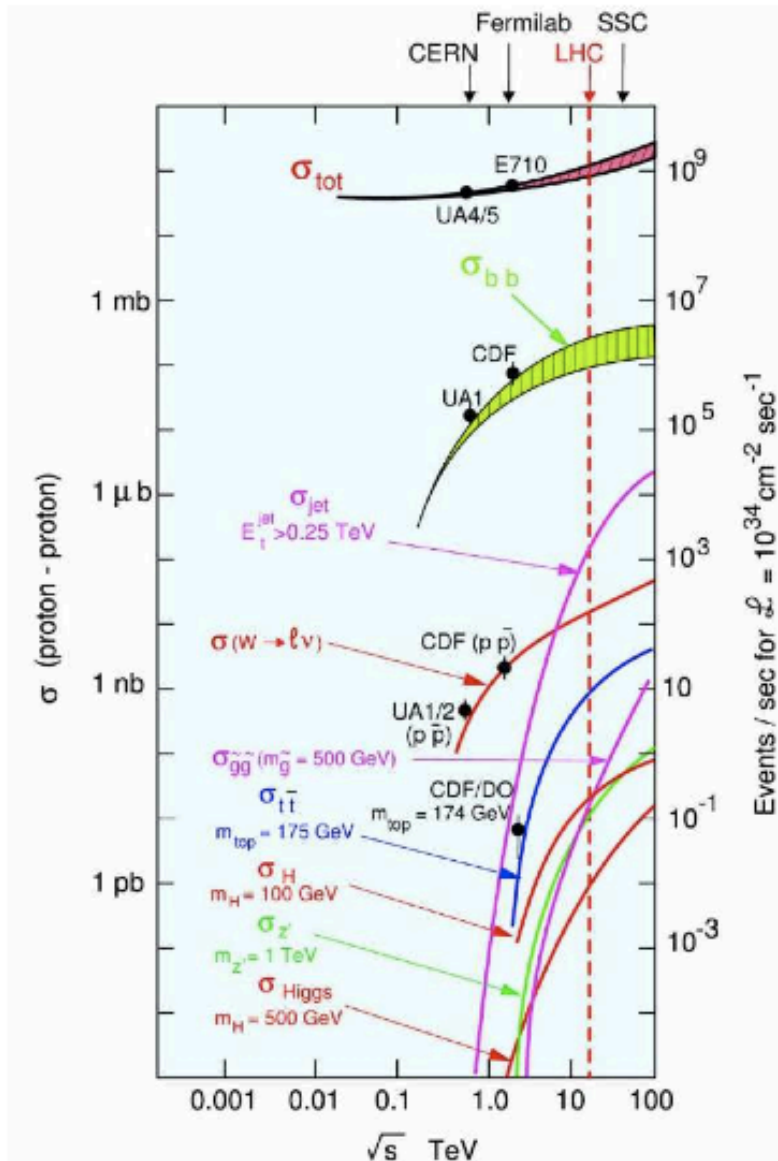
Z BOSON

Motivación

- ¿Cuál es el mecanismo responsable de la masa de las partículas?
- ¿Por qué no es tan fácil incluir la gravedad?
- ¿Cuántas dimensiones existen?
- ¿Por qué tres familias?
- ¿Qué es la materia oscura?



Motivación



¿Cómo encontramos esas respuestas?

Proponiendo modelos y probándolos.

¿Por qué un acelerador más grande?

Porque mientras más energía y/o más colisiones por unidad de tiempo más probabilidad de encontrar física más allá del Modelo Estándar

Descripción del Detector

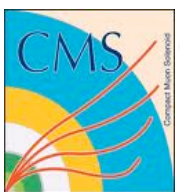
• **LHC**

El Monte Blanco

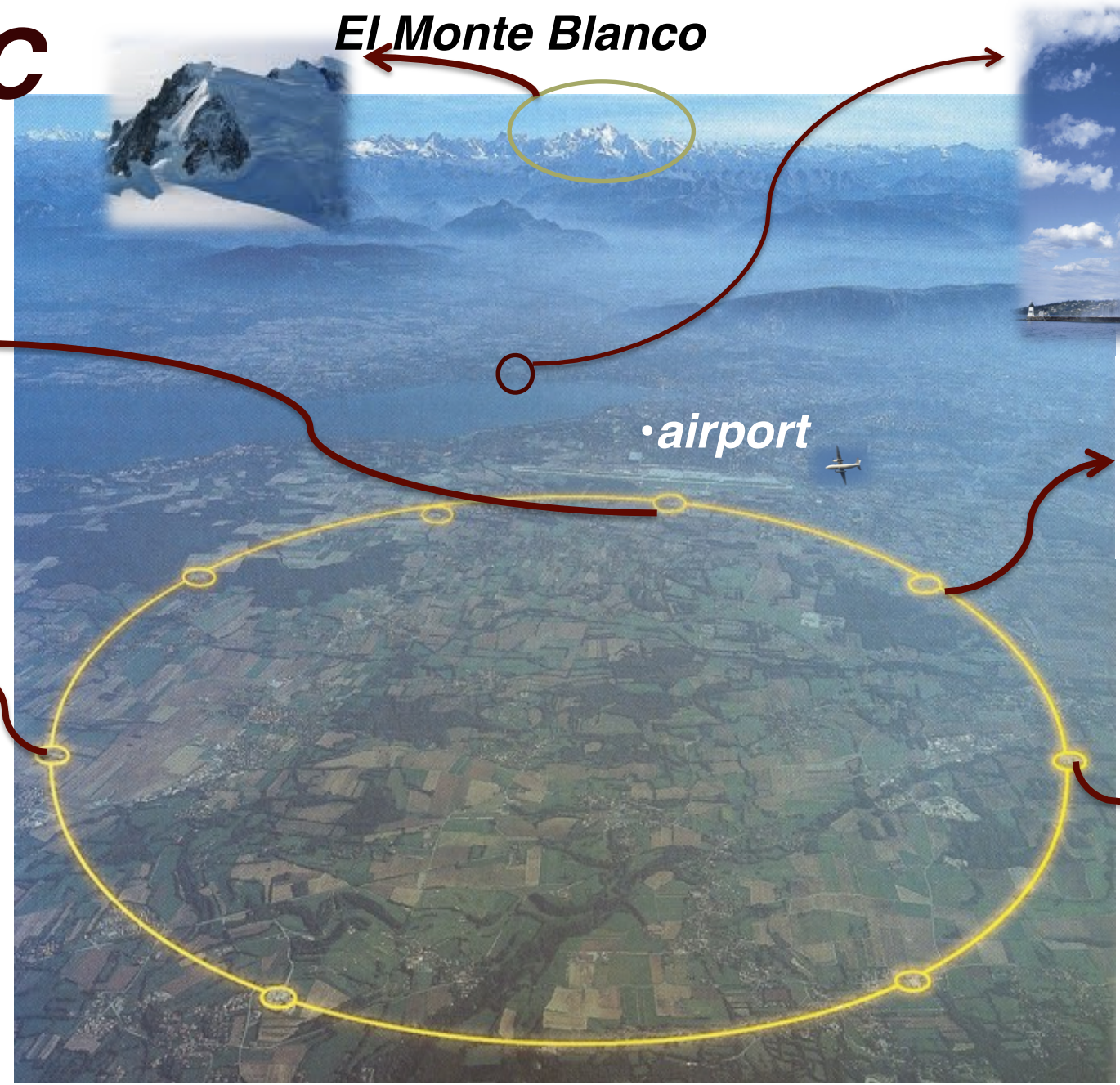
• **Ginebra**

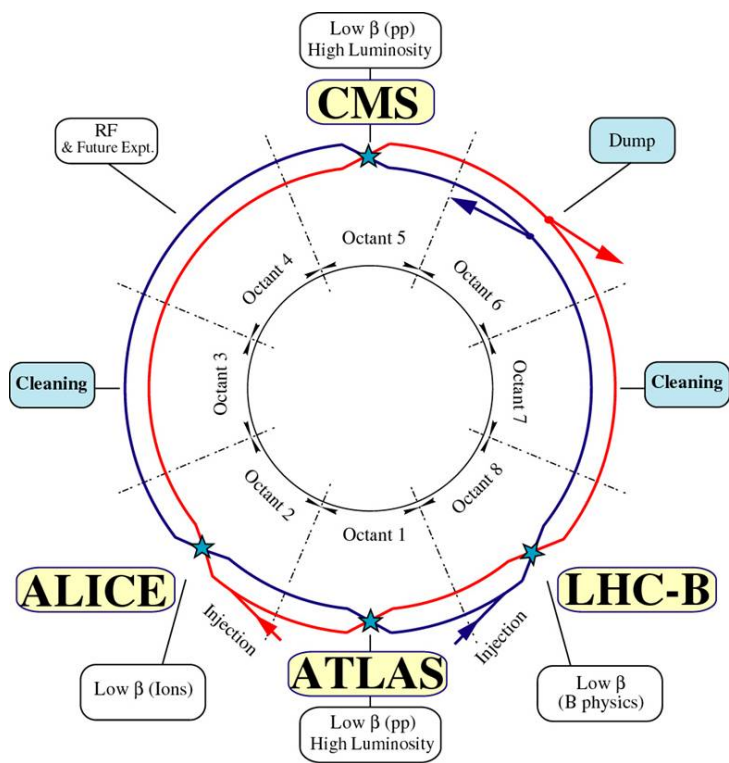
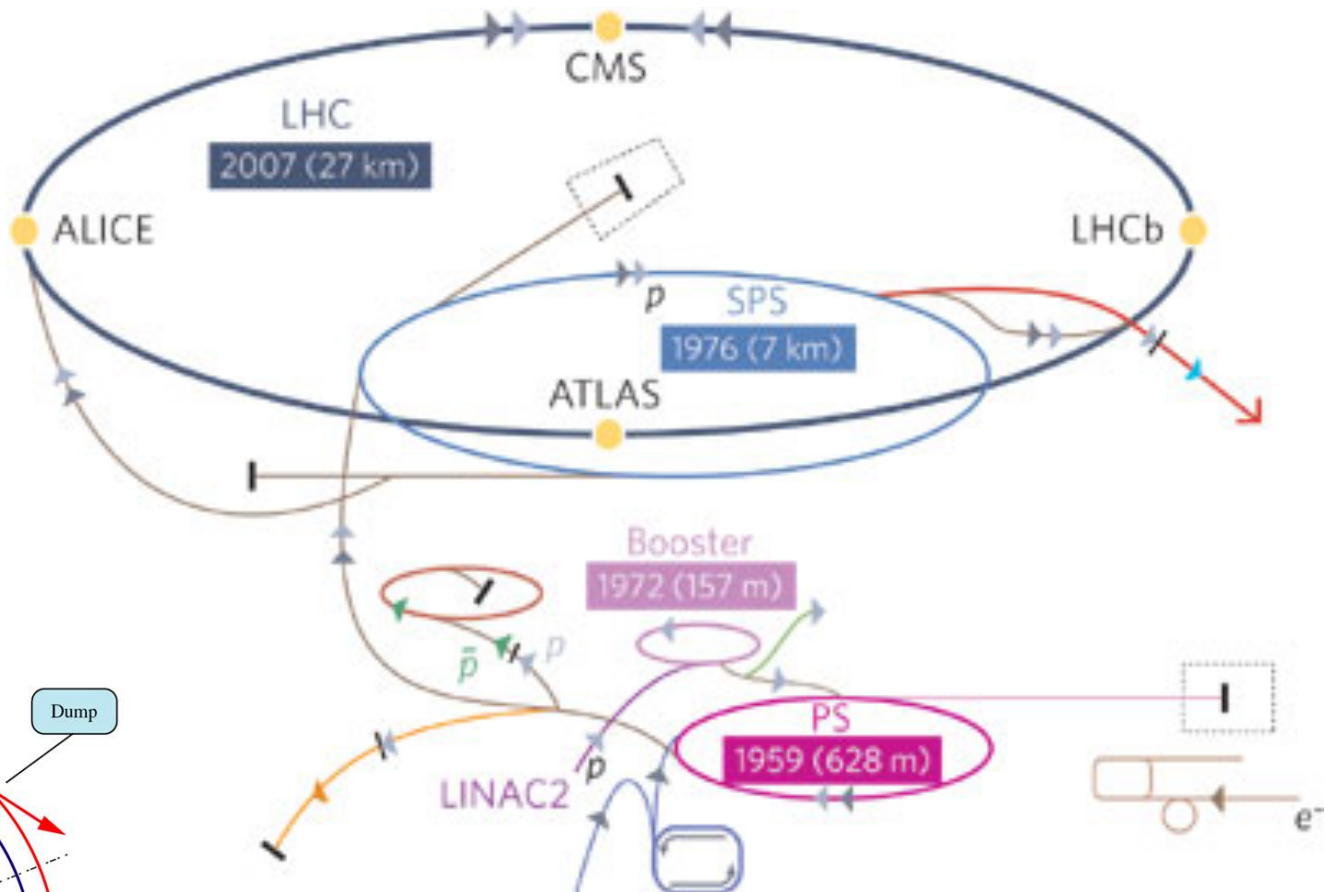
LHCb

• **airport**

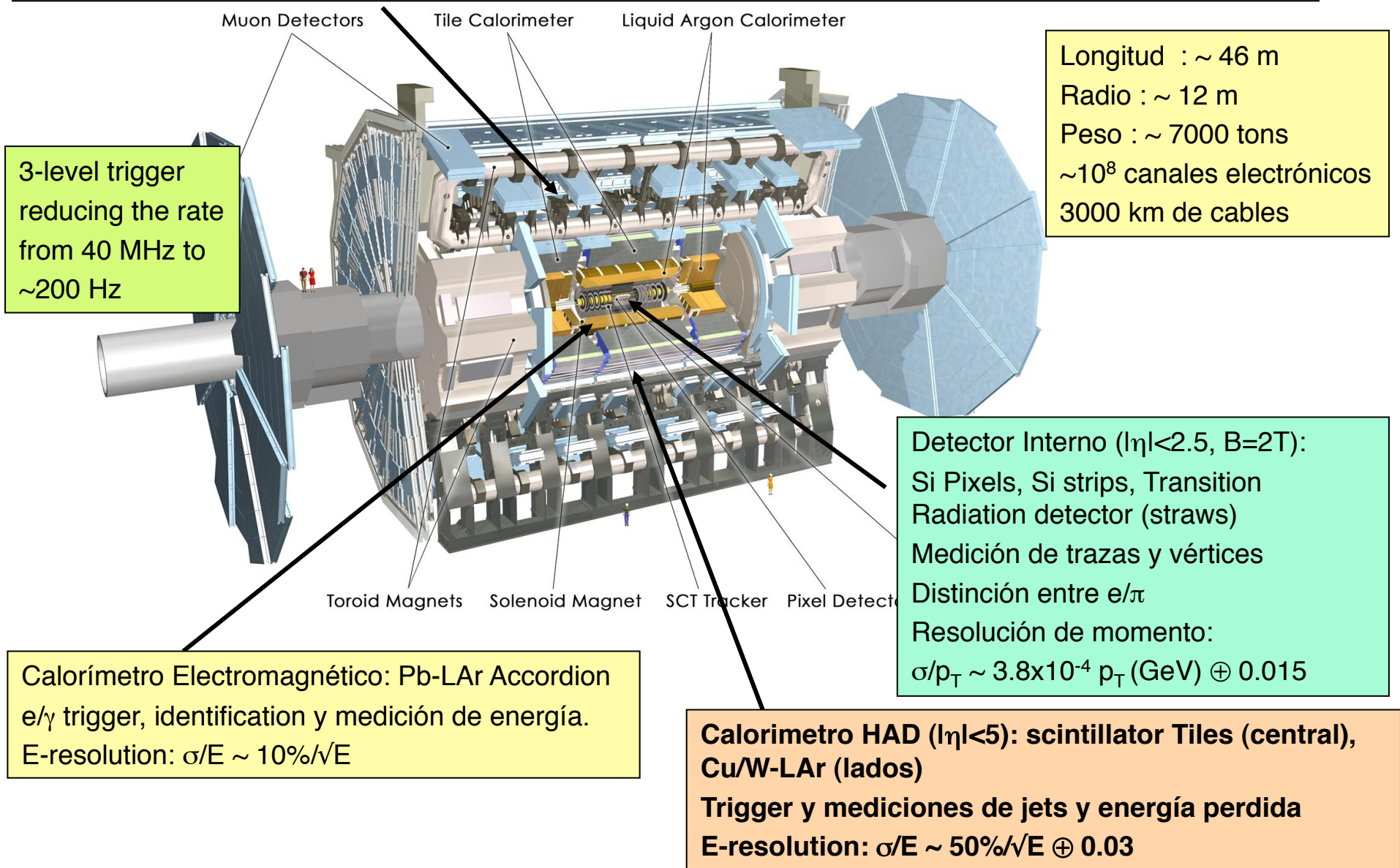


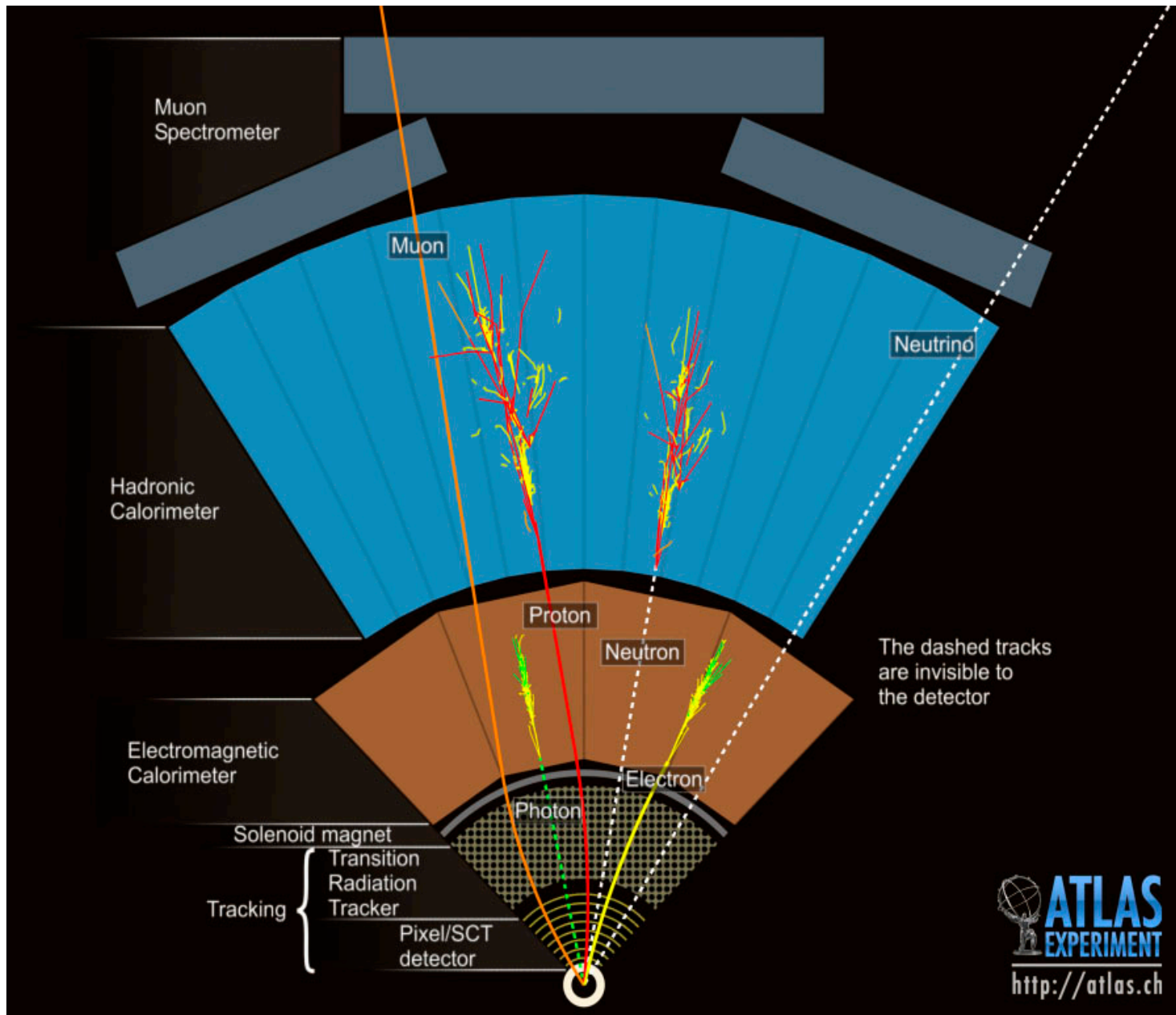
ALICE





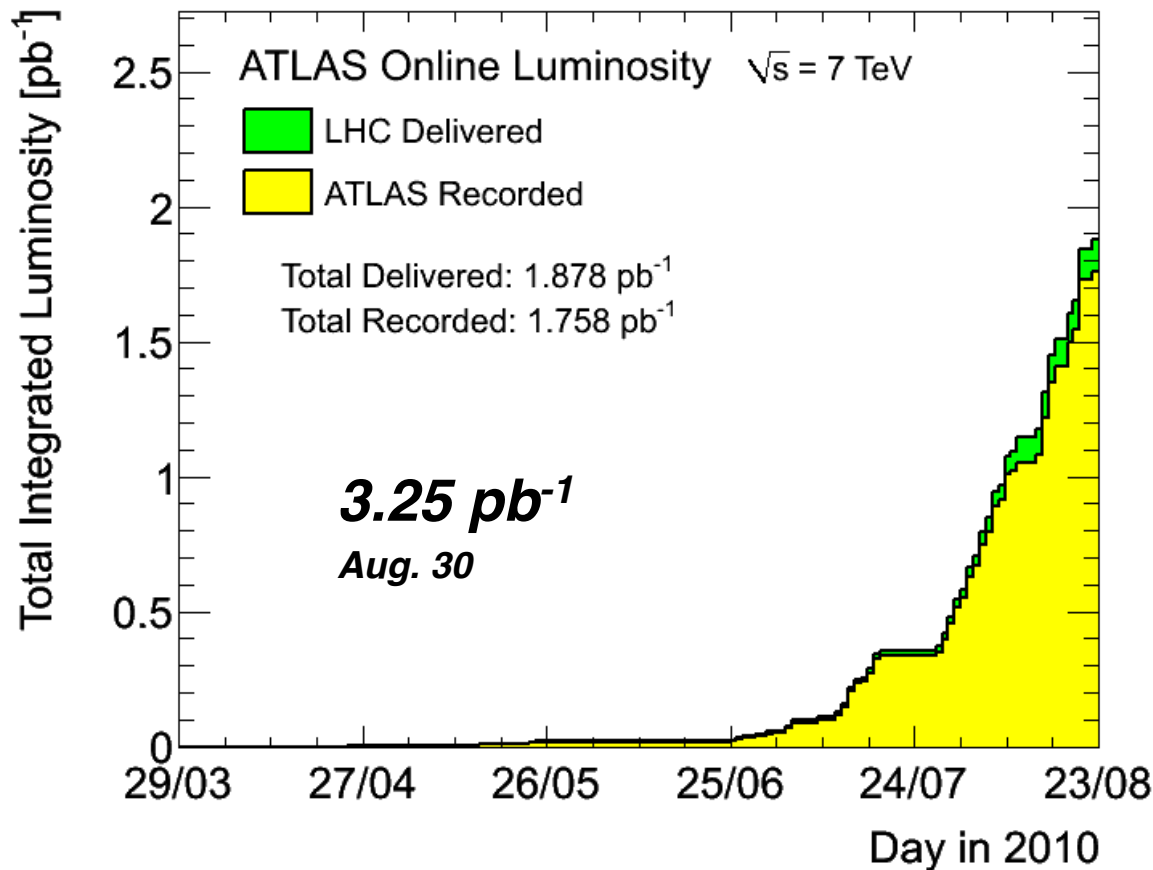
Espectrómetro de muones ($|\eta| < 2.7$) : toroides con cámaras de muones de gas.
 Trigger de muones y medición de momento con una resolución $< 10\%$ hasta una energía de $E_\mu \sim 1$ TeV



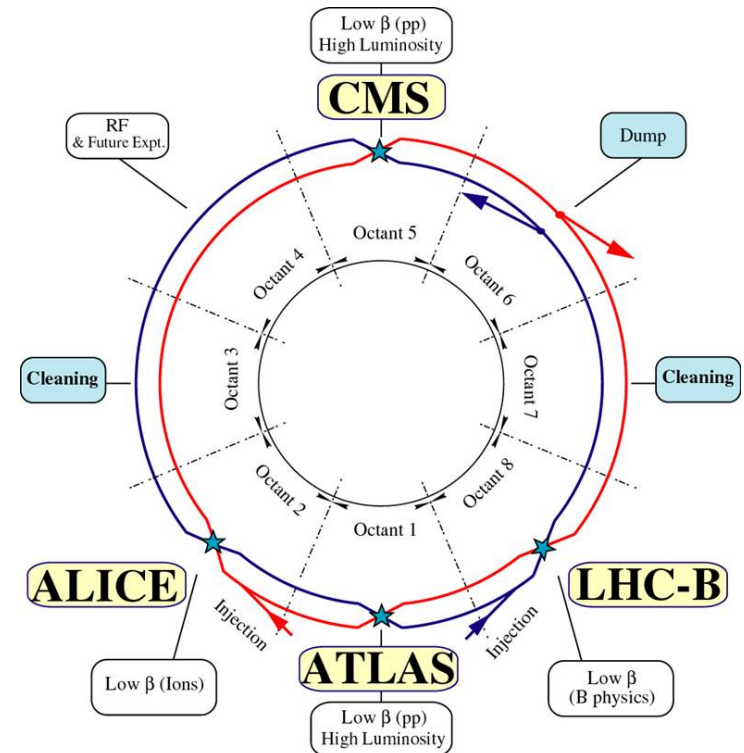


Estatus del LHC

Estatus del LHC



Pico de luminosidad
 $1.03 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

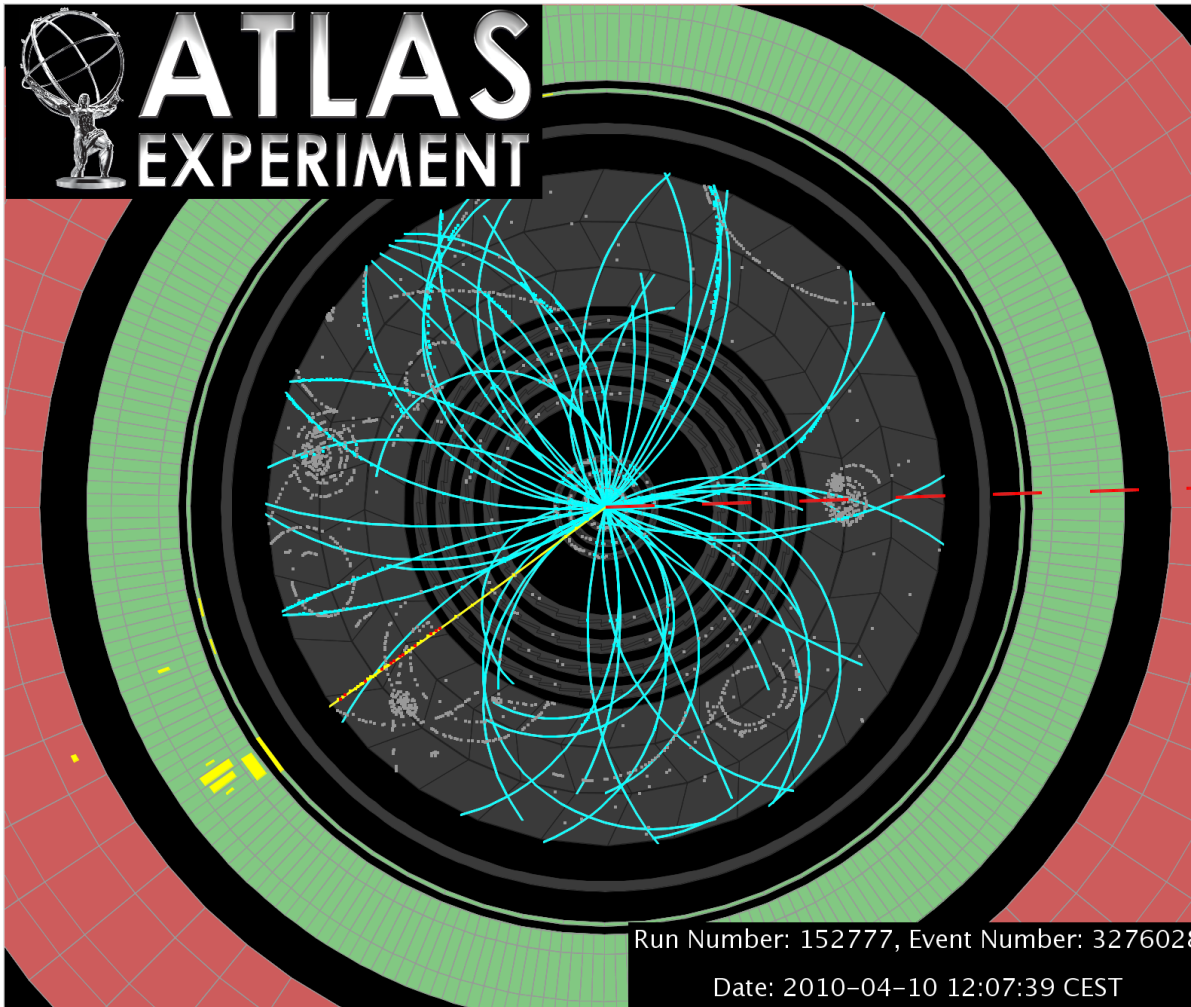


- Primeras colisiones a 7 TeV el 30 de Marzo, 2010
- La luminosidad ha aumentado por 3 órdenes de magnitud en 5 meses.
- 36 bunches in the LHC

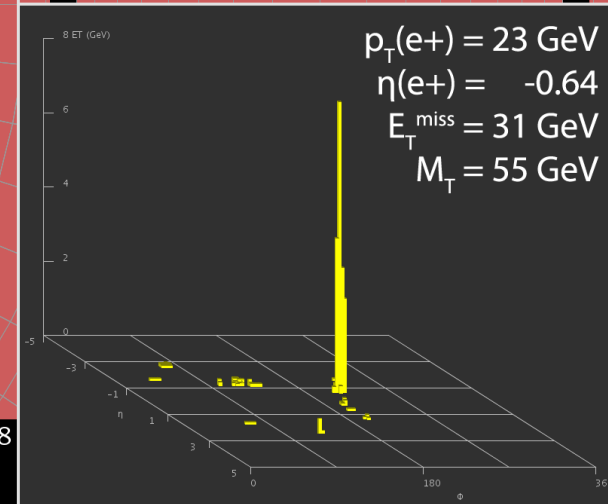
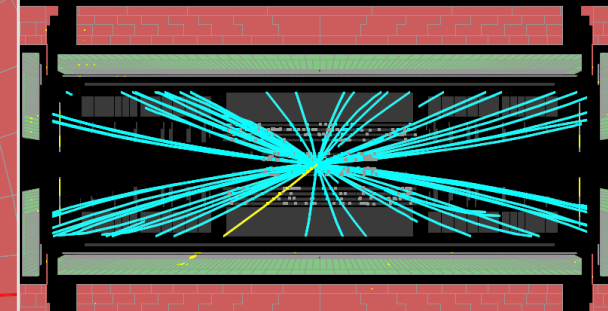
Física en ATLAS con colisiones desde Marzo de 2010

Candidato del W

 **ATLAS**
EXPERIMENT

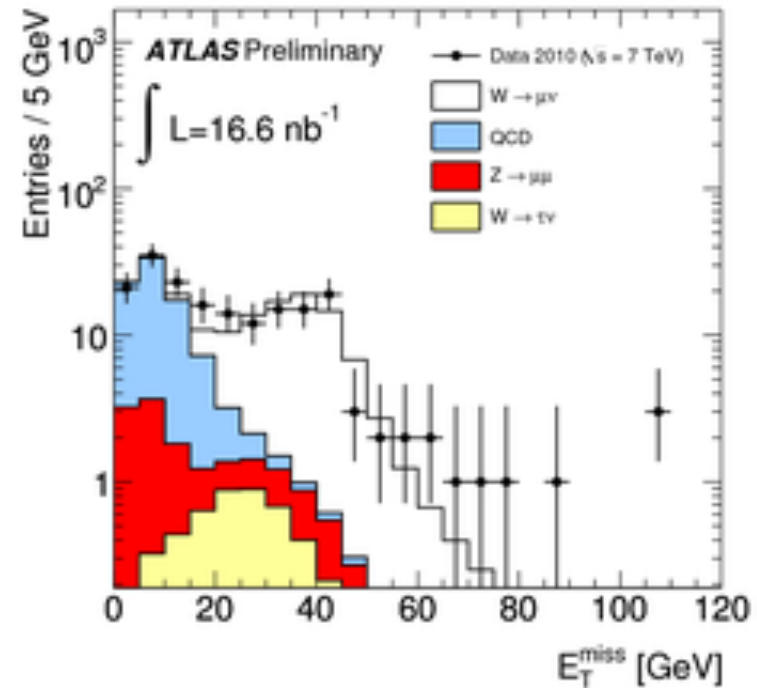
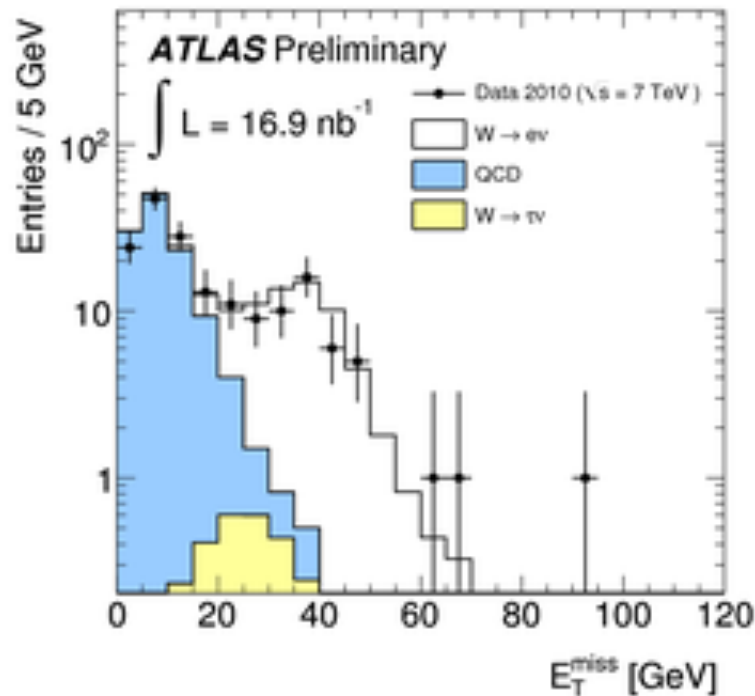


**W \rightarrow ev candidate in
7 TeV collisions**



W, Z Observation

$$m_T = \sqrt{2p_T^\ell p_T^\nu (1 - \cos(\phi^\ell - \phi^\nu))}$$

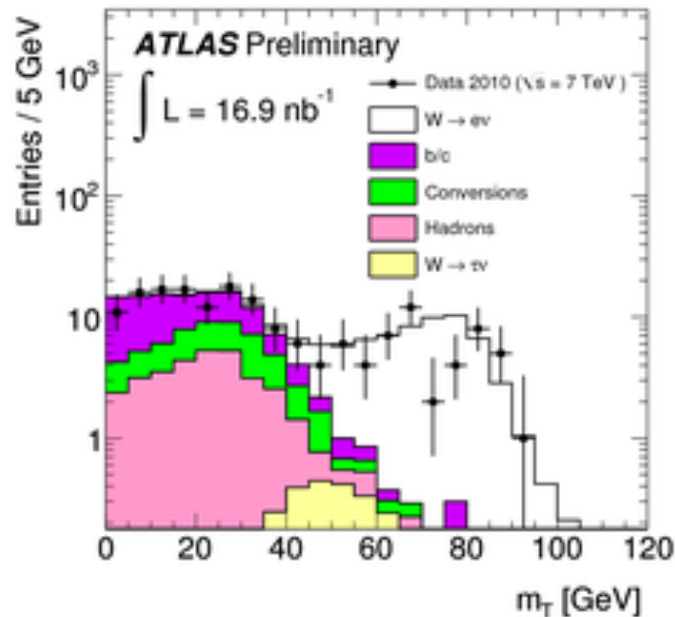


Primera observación de W y Z en ATLAS (6.7 nb^{-1})

- $W \rightarrow \ell\nu$: 57 eventos
- $Z \rightarrow \ell\ell$: 3 eventos

Sección transversal de la W

$$m_T = \sqrt{2p_T^\ell p_T^\nu (1 - \cos(\phi^\ell - \phi^\nu))}$$



Asimetría (resultados ICHEP 17 nb⁻¹)

$$A = \frac{\sigma(W \rightarrow \ell^+ \nu) - \sigma(W \rightarrow \ell^- \nu)}{\sigma(W \rightarrow \ell^+ \nu) + \sigma(W \rightarrow \ell^- \nu)}$$

- $A(W \rightarrow e \nu) = 0.21 \pm 0.18 \pm 0.01(\text{syst})$
- $A(W \rightarrow \mu \nu) = 0.33 \pm 0.12 \pm 0.01(\text{syst})$
(NNLO prediction: $A=0.2$)

$$P = uud$$

$$W^+ = u\bar{d}$$

$$W^- = d\bar{u}$$

Resultados ICHEP (17 nb⁻¹)

$$\sigma(W \rightarrow \ell \nu) = 9.3 \pm 0.9(\text{stat}) \pm 0.6(\text{syst}) \pm 1.0(\text{lumi}) \text{ nb}$$

119 eventos:

47 W → eν

72 W → μν

$$\sigma(W \rightarrow e \nu) = 8.5 \pm 1.3(\text{stat}) \pm 0.7(\text{syst}) \pm 0.9(\text{lumi}) \text{ nb}$$

$$\sigma(W \rightarrow \mu \nu) = 10.3 \pm 1.3(\text{stat}) \pm 0.8(\text{syst}) \pm 1.1(\text{lumi}) \text{ nb}$$

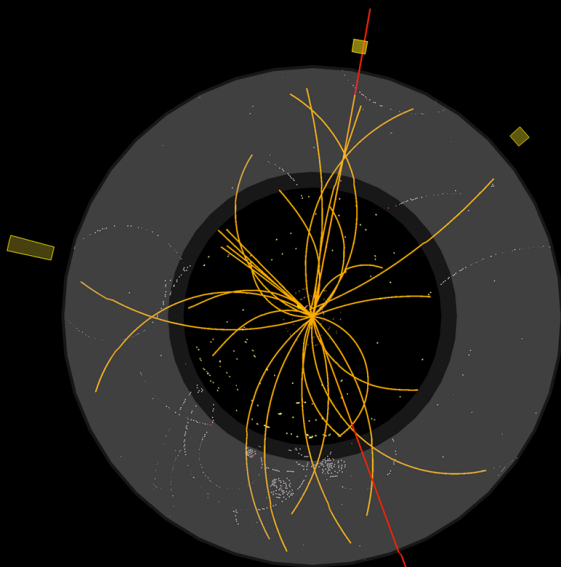
NNLO: 10.46 nb

Candidato del Z



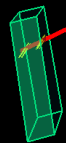
ATLAS EXPERIMENT

Run: 154822, Event: 14321500
Date: 2010-05-10 02:07:22 CEST

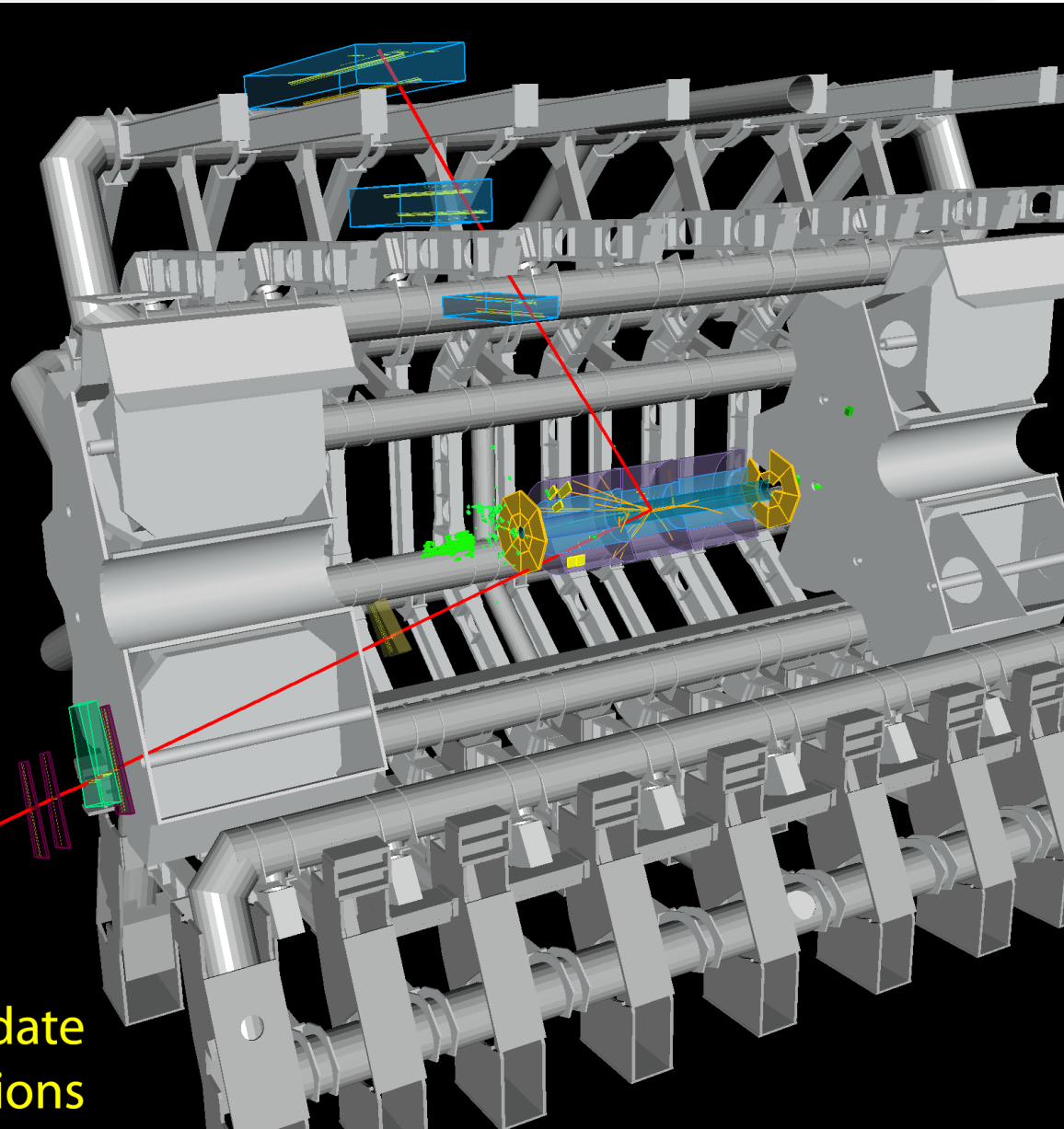


$p_T(\mu^-) = 27 \text{ GeV}$ $\eta(\mu^-) = 0.7$
 $p_T(\mu^+) = 45 \text{ GeV}$ $\eta(\mu^+) = 2.2$

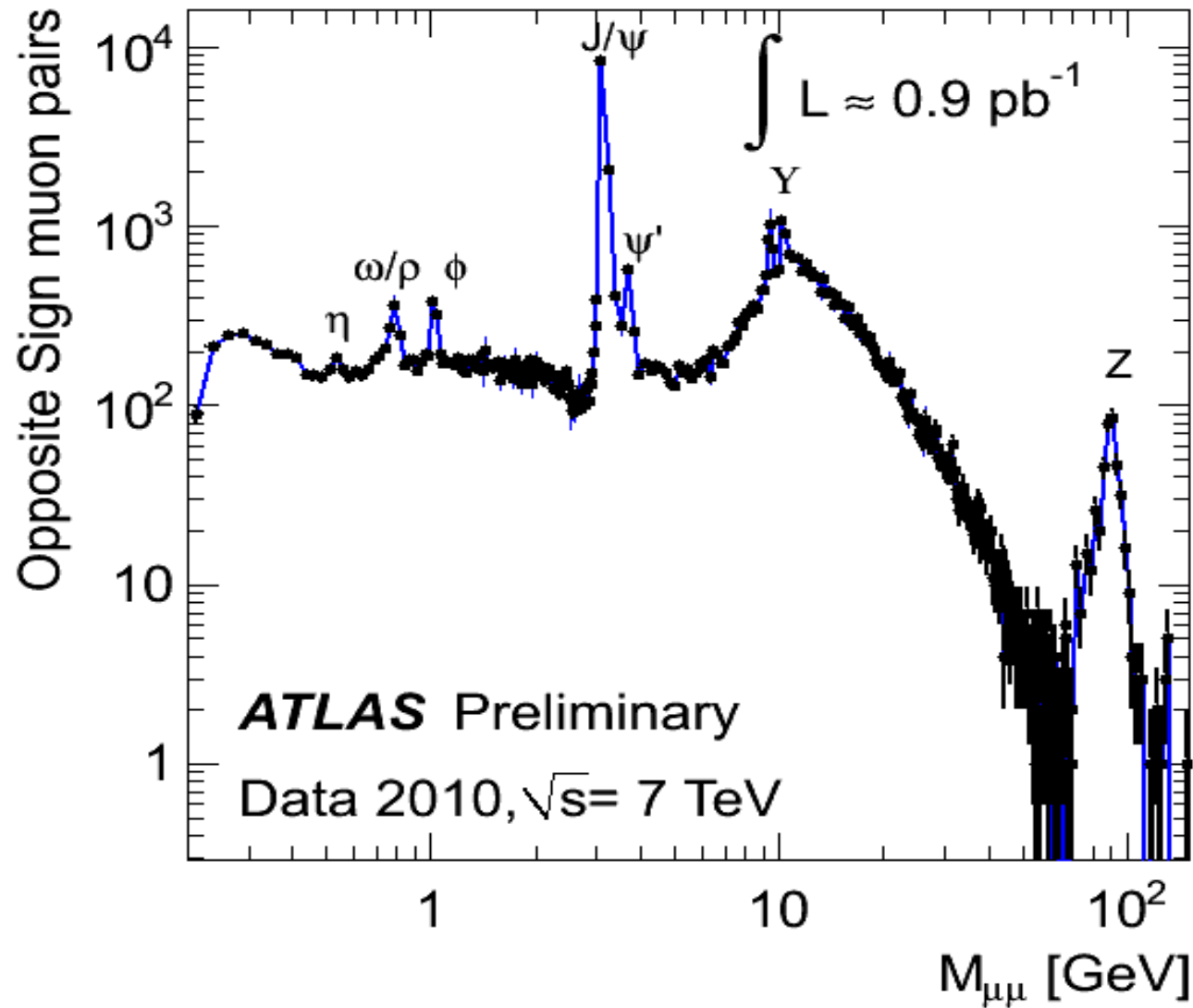
$M_{\mu\mu} = 87 \text{ GeV}$



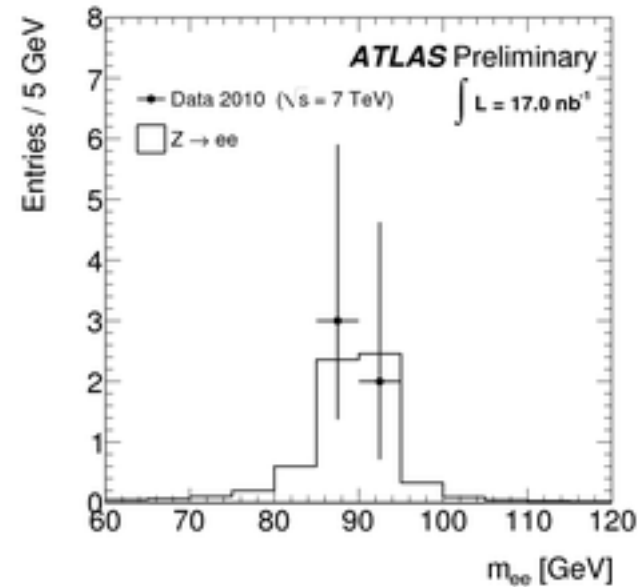
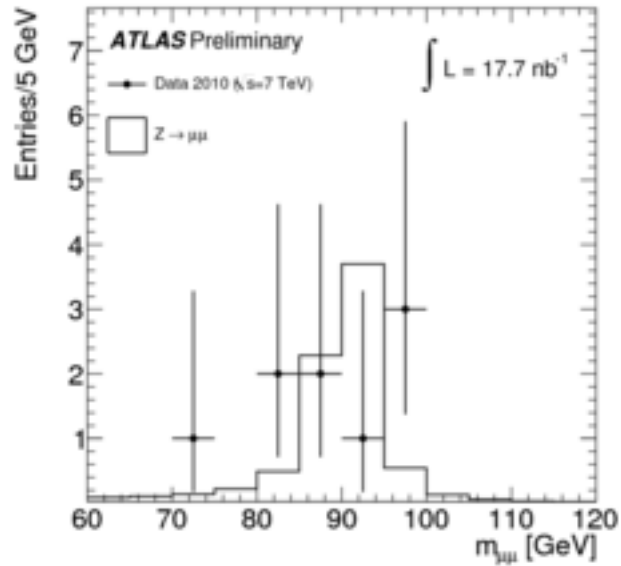
**Z \rightarrow $\mu\mu$ candidate
in 7 TeV collisions**



Estados finales en dos leptones



Z cross section



Resultados ICHEP 225 nb⁻¹

$$\sigma(Z \rightarrow \mu\mu) = 0.83 \pm 0.07(\text{stat}) \pm 0.06(\text{syst}) \pm 0.09(\text{lumi}) \text{ nb}$$

NNLO: 0.99 nb por familia para $m_{ll} > 60 \text{ GeV}$

$$\sigma(Z \rightarrow ee) = 0.72 \pm 0.11(\text{stat}) \pm 0.10(\text{syst}) \pm 0.08(\text{lumi}) \text{ nb}$$

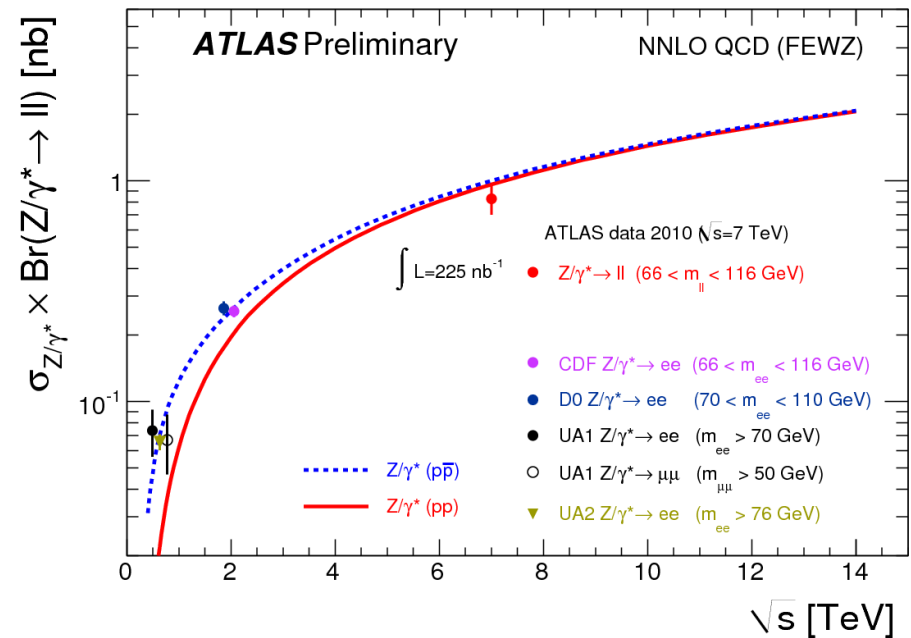
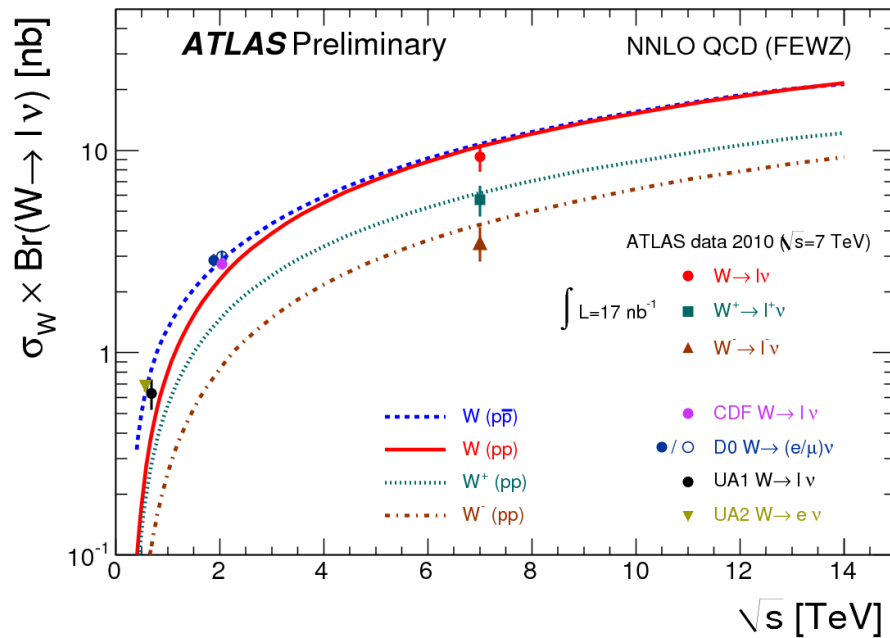
$$\sigma(Z \rightarrow \mu\mu) = 0.89 \pm 0.10(\text{stat}) \pm 0.07(\text{syst}) \pm 0.10(\text{lumi}) \text{ nb}$$

125 events:

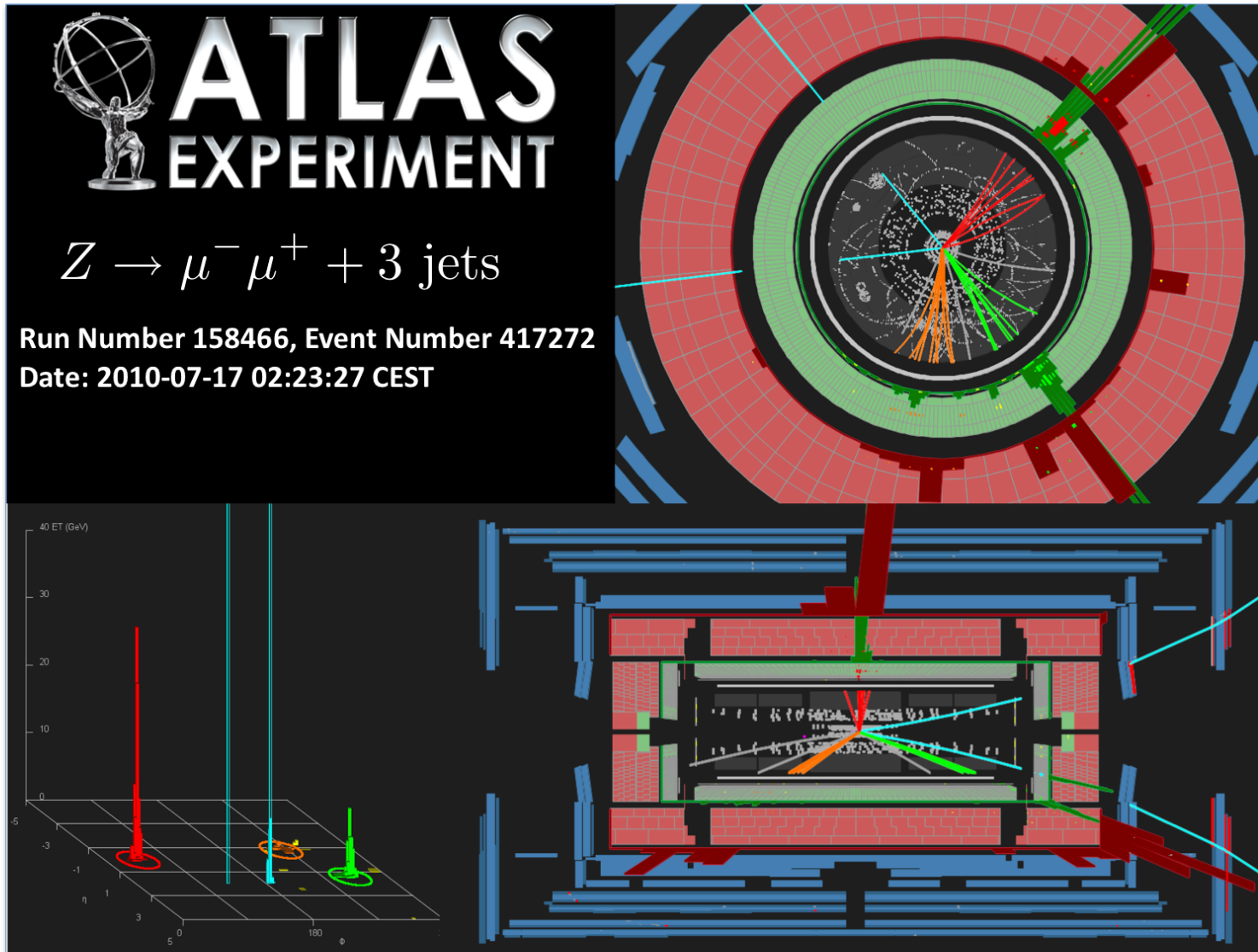
46 Z → ee

79 Z → μμ

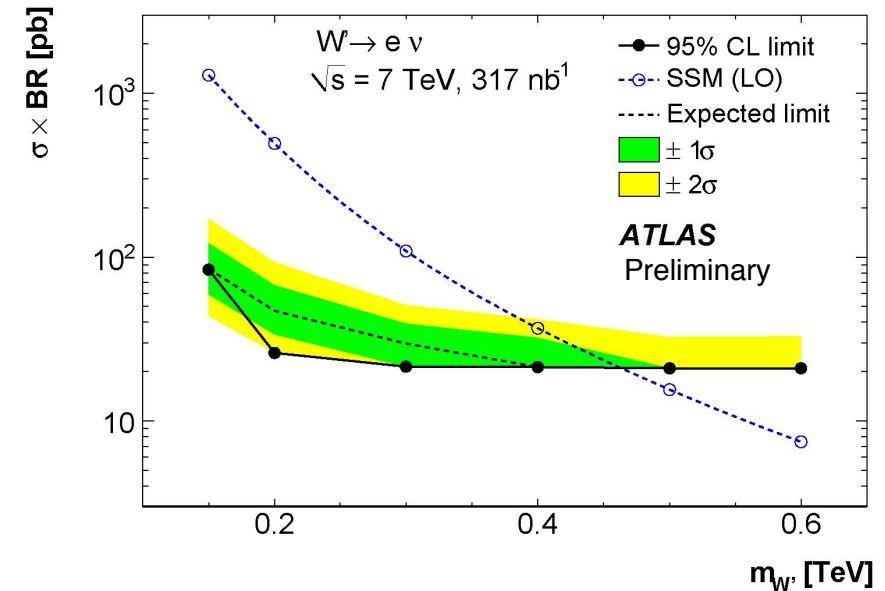
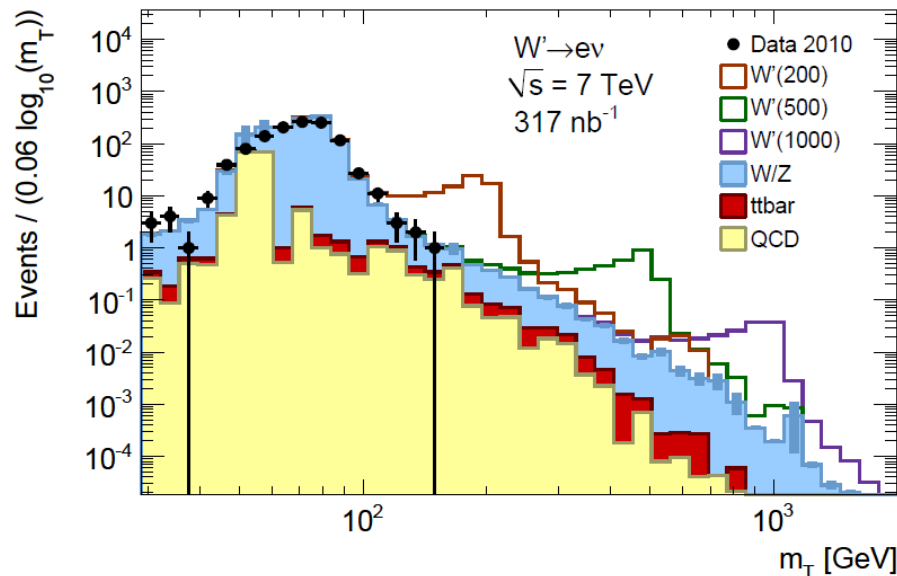
Secciones transversales de la W y la Z



Candidato a Z + Jets

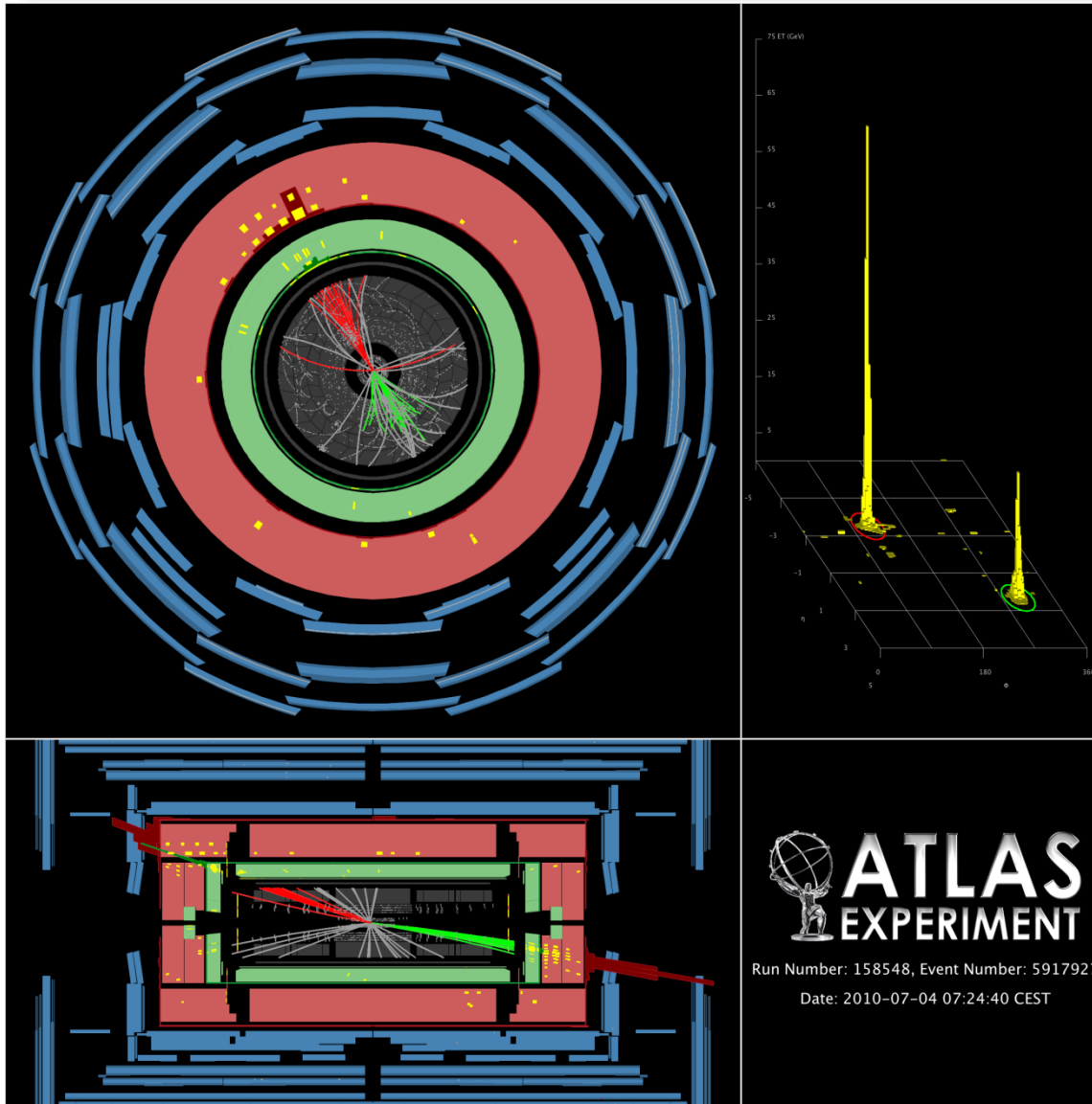


Búsqueda de la W'



- Búsqueda de un Bosón Cargado Pesado en el contexto del Sequential Standard Model, hasta ahora se han obtenido los límites para **cross section** \times **BR** como función de $m_{W'}$
- 95% C.L. exclusion: **$m_{W'} > 460 \text{ GeV}$**
 - Límite Tevatron: **$m_{W'} > 1 \text{ TeV}$**
- ATLAS puede competir con los resultados del Tevatron with $\sim 5 \text{ pb}^{-1}$

Física con jets



Evento de dos
jets más
masivo
reportado en
ICHEP

$$m_{jj}=2.55\text{TeV.}$$
$$p_T^{j1}=420\text{GeV,}$$
$$p_T^{j2}=320\text{GeV}$$

Búsqueda de resonancias con Dijets

Estado final de un quark excitado:

Aceptación :

Desde

$\sim 36\%$ for $m_{q^*} = 400 \text{ GeV}$

$(\sigma_{mjj}/m_{jj} \sim 11\%)$

hasta

$\sim 49\%$ for $m_{q^*} = 1.5 \text{ TeV}$

$(\sigma_{mjj}/m_{jj} \sim 7\%)$

Modelo de referencia: Excited quark q^*

• U. Baur, I. Hinchliffe, and D. Zeppenfeld, *Int. J. Mod. Phys., A2*, 1285 (1987)

• U. Baur, M. Spira, and P. M. Zerwas, *Phys. Rev., D42*, 815 (1990)

Dijet resonance search

Limites para la producción de q^*

Excluido a 95% CL:

Con MRST PDF:

(Martin, Roberts, Stirling, Thorne)

$400 < m_{q^*} < 1260$ GeV

con 315 nb^{-1}

Limite Actual:

$260 < m_{q^*} < 870$ GeV

con 1.1 fb^{-1}

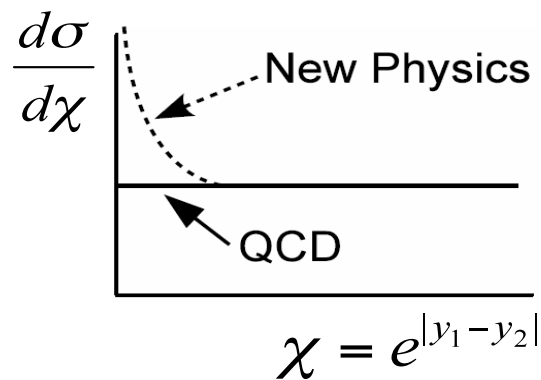
CDF Collaboration,

Phys.Rev.D 79(2009)112002

Distribución angular de Dijets

- Búsqueda de desviaciones en la distribución angular de Dijets respecto a la predicción de QCD.

Observable (a alta m_{jj})

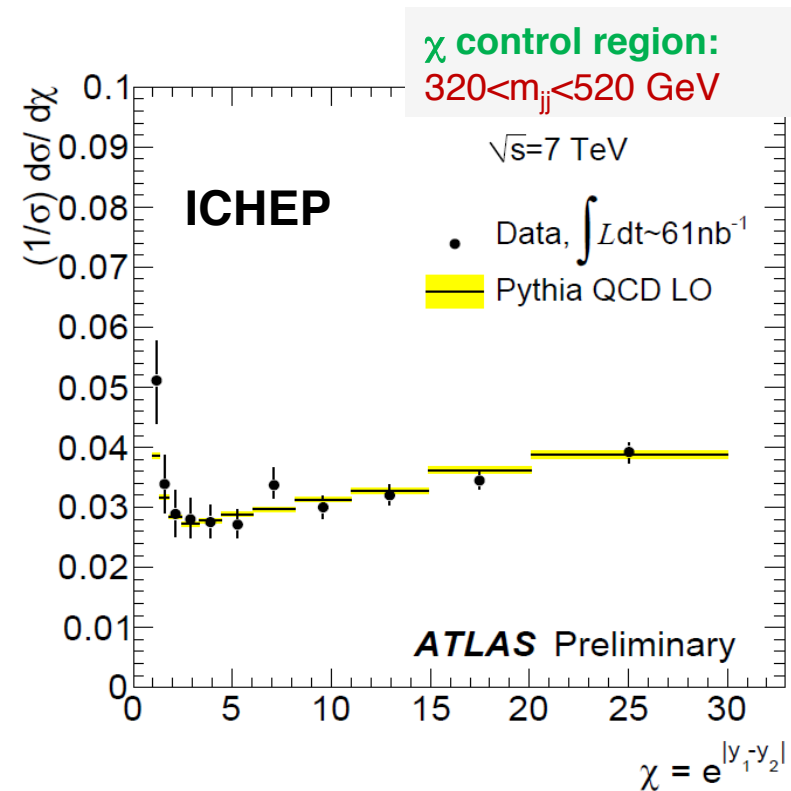


Limite en “quark contact interaction” :
 $\Lambda > 875 \text{ GeV}$ (61 nb⁻¹) para ICHEP 2010

Último límite publicado (DØ Collaboration) :

$\Lambda > 2.8 \text{ TeV}$ (0.7 fb⁻¹)

Phys.Rev.Lett.103:191803,2009



Estado final con componentes múltiples

Motivación : Búsqueda de eventos con gran multiplicidad, alta energía transversal y grandes valores de masa invariante.

Inspirado en : *Black Hole and String Ball signatures.*

Región de control:

$$\Sigma|p_T| > 300 \text{ GeV}$$

Región de la señal:

$$\Sigma|p_T| > 700 \text{ GeV}$$

Observados

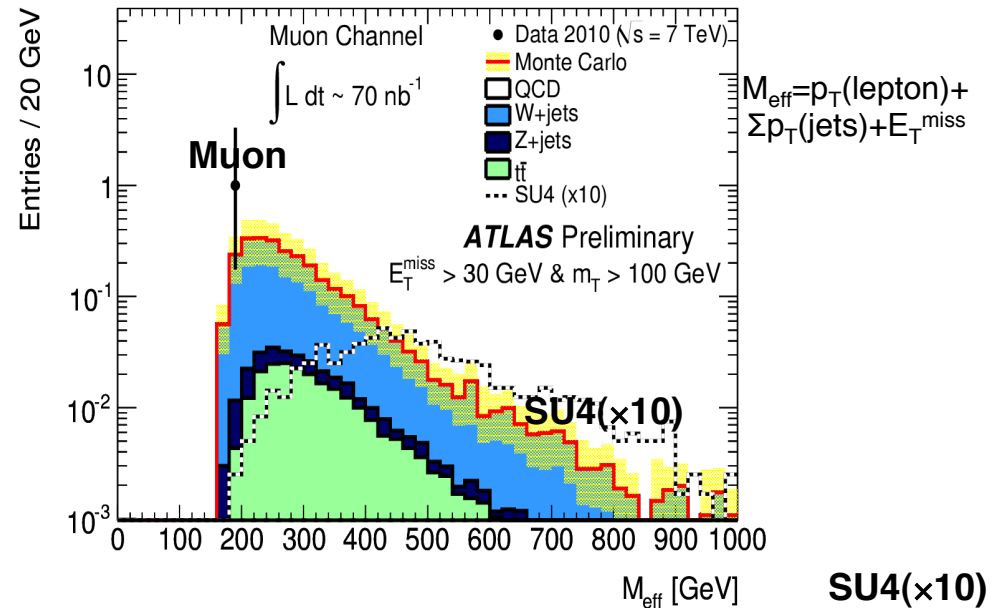
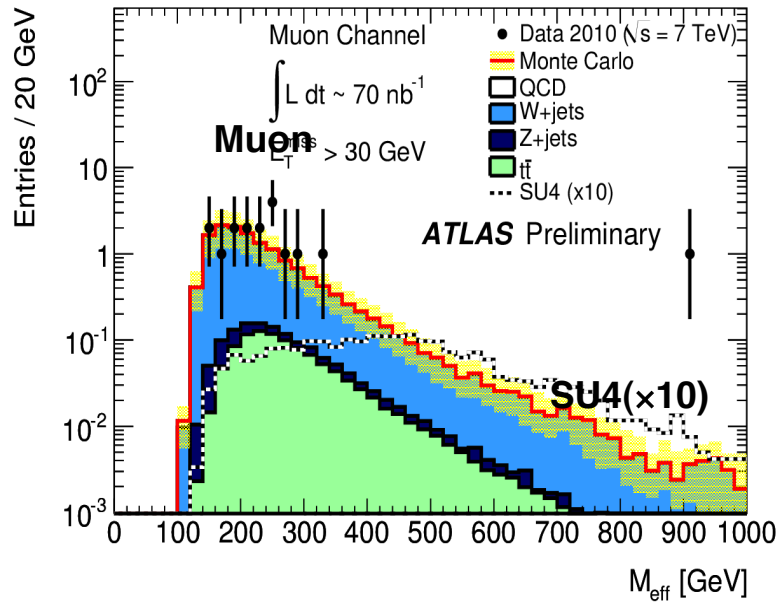
= 193 eventos

Esperados

= $253 \pm 18 \pm 84$

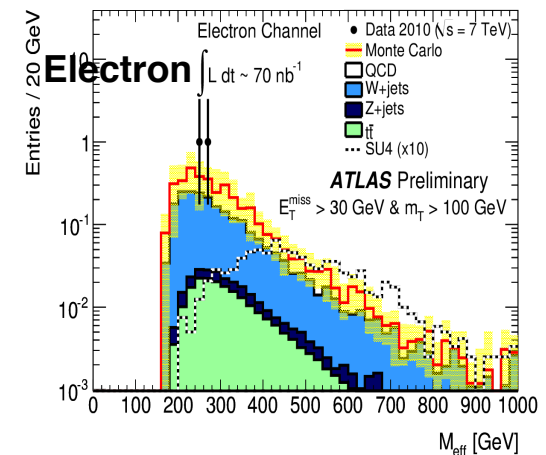
- 95%CL upper limit of **0.34 nb** límites en la sección transversal para estados finales con al menos 3 objetos, masa invariante arriba de **800 GeV** y $\Sigma|p_T| > 700 \text{ GeV}$
- Este resultado es relevante para modelos de low-scale gravity y weakly-coupled string theory.
- **Es la primera búsqueda de este tipo**

SUSY



Resultados ICHE

- Analisis con cortes ligeros: 1 lepton aislado, 2 jets con 30 GeV, $E_T^{\text{miss}} > 30 \text{ GeV}$ y $M_T > 100 \text{ GeV}$
- Typical low-mass SUSY point included in the plots as a reference (“SU4”: point with squark and gluino masses around 410 GeV)



Mi participación

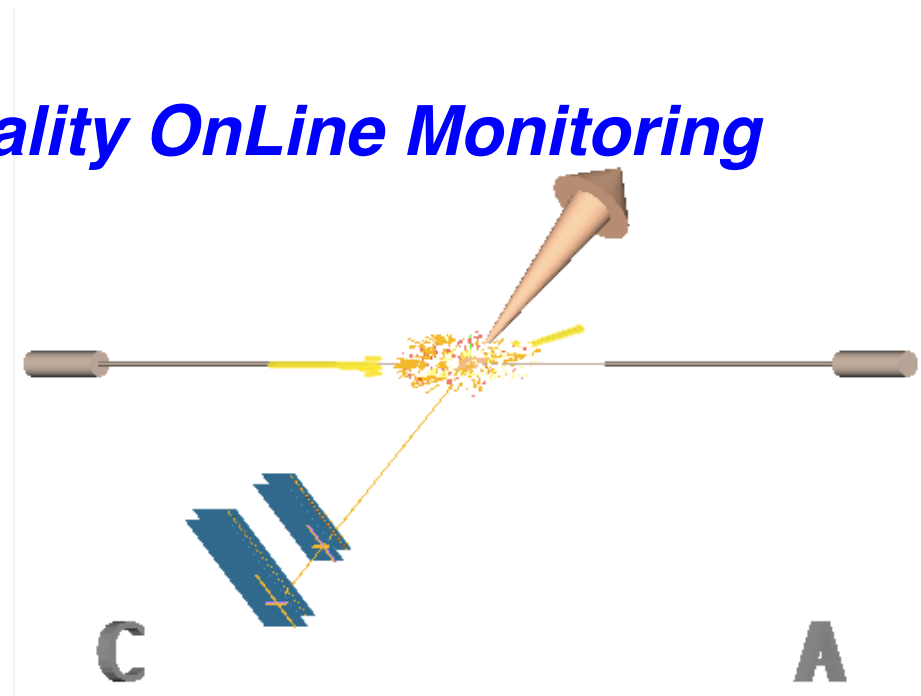
Como ilustración y a petición del Dr. Arturo Fernández

- ***Lepton+MET final states***

 - ***W y W'***

- ***Experto a cargo del Monitorio de la Calidad de Energía perdida.***

- ***SCT, Tier0 and Data Quality OnLine Monitoring Shifter***

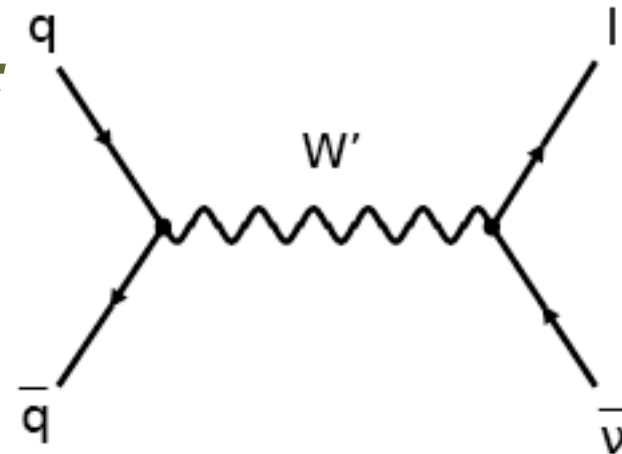


W'

- W' in the Sequential Standard Model:
 - W' is an additional heavy gauge boson
 - W' has the same couplings as W to left-handed fermions; no interaction with other heavy gauge bosons (W, Z, Z')
 - Lower bound on W' mass (direct searches): $\sim 1\text{TeV}$

- ***Standard Model backgrounds:***

- $W \rightarrow l\nu$ ($l: e, \mu, \tau$)
- QCD (dijets processes)
- $t\bar{t}$

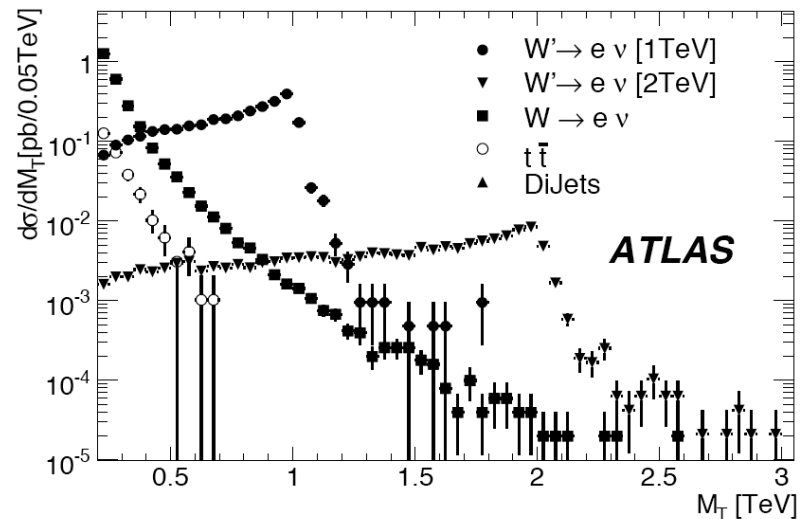
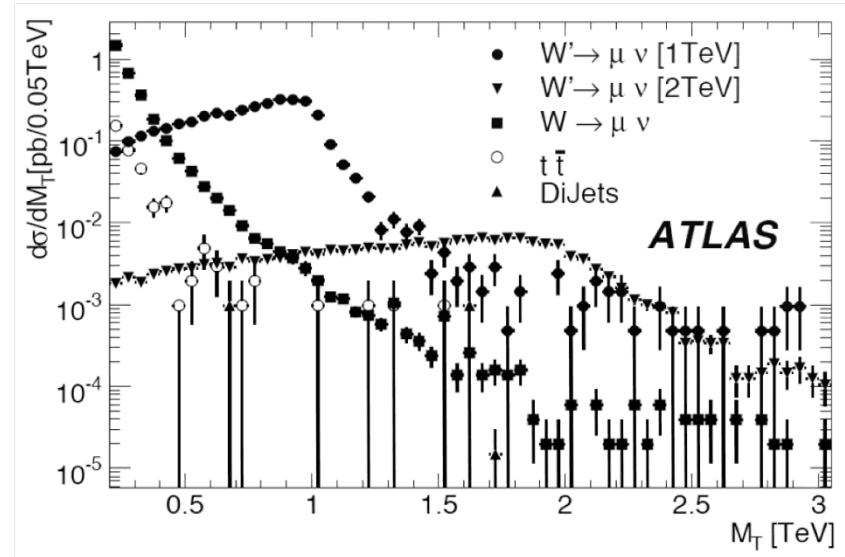


- ***W' signature:***

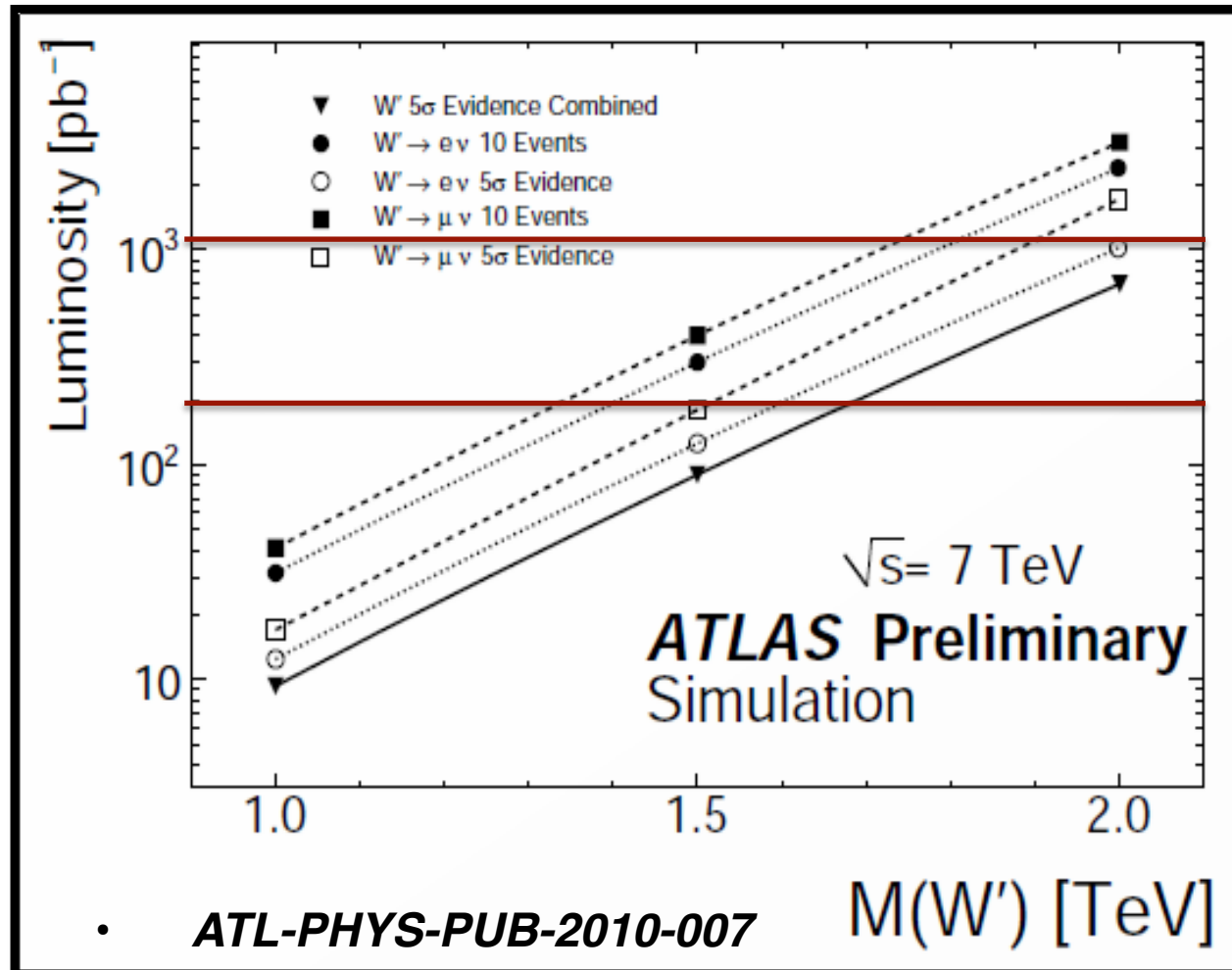
- ***High energy lepton accompanied by missing energy coming from the undetected neutrino.***

W'

- 1. No cuts.
- 2. Good Run List.
- 3. L1_EM2 trigger.
- 4. PV with at least 3 tracks.
- 5. $|PVz| < 150$.
- 6. MET Cleaning.
- 7. el author 1 or 3.
- 8. $|\eta^{cluster}| < 2.47$.
- 9. $1.37 < |\eta_2^{cluster}| < 1.52$.
- 10. isEMMedium.
- 11. $ClusterPt > 20 GeV$.
- 12. OTX cleaning.
- 13. $d0vtx < 1 mm$.
- 14. $z0vtx < 5 mm$. (Up to here: Quality Cuts)
- 15. Just one Lepton.
- 16. Normalized Isolation (EtCone30).
- 17. $MET > 25 GeV$.



Discovery Potential for W'



Monitoreo de Energía Perdida y Jets

- 6 RUNS:160387,160472,160479, 160530,160613,160736

Run	Links	#LB	Start and endtime (CEST)	#Events	Project tag	JETB (SHIFTOFL)	JETE (SHIFTOFL)	JETEC (SHIFTOFL)	JETFA (SHIFTOFL)	JETFC (SHIFTOFL)	METCALO (SHIFTOFL)	METMUON (SHIFTOFL)
160736 (in collb loop)	DS, RS, BS, ANI, DQ, ELOG, DCS:SoR/ EoR	268 (117 s)	Tue Aug 03 2010 22:02:39 – Wed Aug 04, 06:46:33	2,245,454 (71.4 Hz)	data10_7TeV	G	G	G	G	G	G	G
160613 (in collb loop)	DS, RS, BS, ANI, DQ, ELOG, DCS:SoR/ EoR	327 (117 s)	Mon Aug 02 2010 21:07:37 – Tue Aug 03, 07:45:25	6,050,579 (158.1 Hz)	data10_7TeV	G	G	G	G	G	G	G
160530	DS, RS, BS, ANI, DQ, NEMO, ELOG, DCS:SoR/ EoR	628 (118 s)	Sun Aug 01 2010 15:58:01 – Mon Aug 02, 12:41:26	15,036,667 (201.5 Hz)	data10_7TeV	G	G	G	G	G	G	G
160479	DS, RS, BS, ANI, DQ, NEMO, ELOG, DCS:SoR/ EoR	328 (115 s)	Sat Jul 31 2010 18:32:48 – Sun Aug 01, 05:03:12	979,142 (25.9 Hz)	data10_7TeV	G	G	G	G	G	G	G
160472	DS, RS, BS, ANI, DQ, NEMO, ELOG, DCS:SoR/ EoR	533 (117 s)	Fri Jul 30 2010 18:52:35 – Sat Jul 31, 12:20:39	11,833,774 (188.2 Hz)	data10_7TeV	G	G	G	G	G	G	G
160387	DS, RS, BS, ANI, DQ, NEMO, ELOG, DCS:SoR/ EoR	401 (115 s)	Thu Jul 29 2010 18:43:50 – Fri Jul 30, 07:38:36	8,375,715 (180.2 Hz)	data10_7TeV	G	G	G	G	G	G	G

COMMENTS

New Missing Energy reference plots working.
No mayor problems for these runs.

Participación en Notas Recientes

1. **Observation of $W \rightarrow l\nu$ and $Z \rightarrow ll$ production in proton-proton collisions at $\sqrt{s}=7$ TeV with the ATLAS detector (ICHEP)**
2. **Measurement of $W \rightarrow l\nu$ production cross section and observation of $Z \rightarrow ll$ production in proton-proton collisions at $\sqrt{s}=7$ TeV with the ATLAS Detector (ICHEP)**
3. **Search for high-mass states with lepton plus missing transverse energy using the ATLAS Detector at $\sqrt{s}=7$ TeV (ICHEP)**
4. ***ATLAS sensitivity prospects to W' and Z' in the decay channels $W' \rightarrow l\nu$ and $Z' \rightarrow l+l-$ at $\sqrt{s}=7$ TeV***
ATL-PHYS-PUB-2010-007, Jul 2010

Resumen y Conclusiones

- ATLAS esta listo para la física de TeV's.
- Muy pronto tendremos resultados de nueva física y nuestro entendimiento de la naturaleza cambiará ahora y para siempre.
- Es un tiempo magnífico para que nuevos estudiantes se unan al esfuerzo con nuevas ideas y entusiasmo.

Diapositivas de Respaldo

Parámetros del Diseño del LHC

$$L = \frac{N_b^2 n_b f_{rev} \gamma_r F}{4\pi \epsilon_n \beta^*}$$

N_b = number of proton per bunch

n_b = number of bunches

f_{rev} = rotation frequency (~ 11Hz)

F = crossing angle factor

Rms transverse beam size = $\sqrt{\epsilon\beta/\gamma}$

ϵ_n = renorm. transverse emittance

β^* = optics at beam crossing (m)

γ_r = relativistic factor

Cost 3 G€

IP1: Atlas
 IP5: CMS
 IP2: Alice
 IP8: LHCb

Nominal settings	
Beam energy (TeV)	7.0
Number of particles per bunch	1.15 10 ¹¹
Number of bunches per beam	2808
Crossing angle (μrad)	285
Norm transverse emittance (μm rad)	3.75
Bunch length (cm)	7.55
Beta function at IP 1, 2, 5, 8 (m)	0.55,10,0.55,10

**3.2 x 10¹⁴ p/
beam**



**25 ns between
crossing**

Derived parameters	
Luminosity in IP 1 & 5 (cm ⁻² s ⁻¹)	10 ³⁴
Luminosity in IP 2 & 8 (cm ⁻² s ⁻¹)*	~5 10 ³²
Transverse beam size at IP 1 & 5 (μm)	16.7
Transverse beam size at IP 2 & 8 (μm)	70.9
Stored energy per beam (MJ)	362