IPM @ CMS

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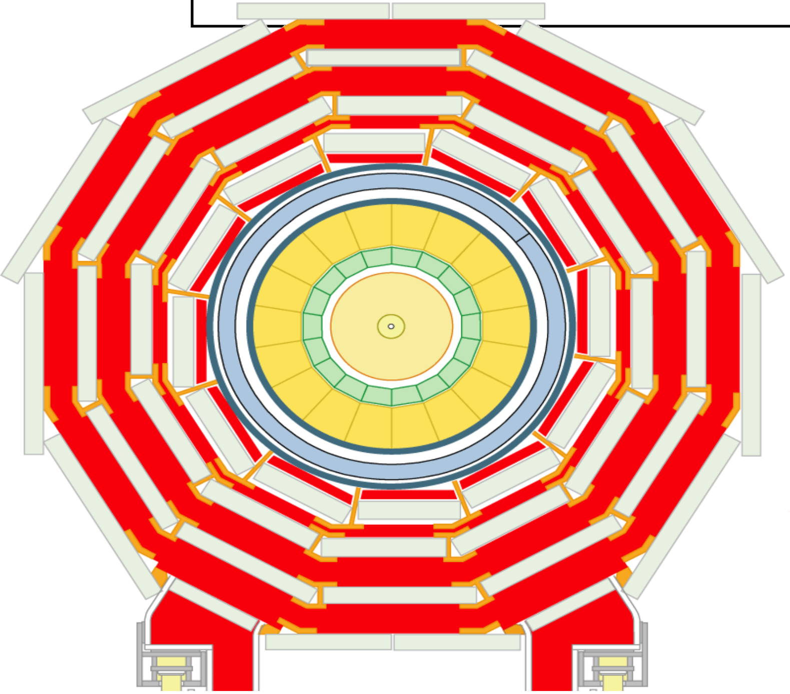
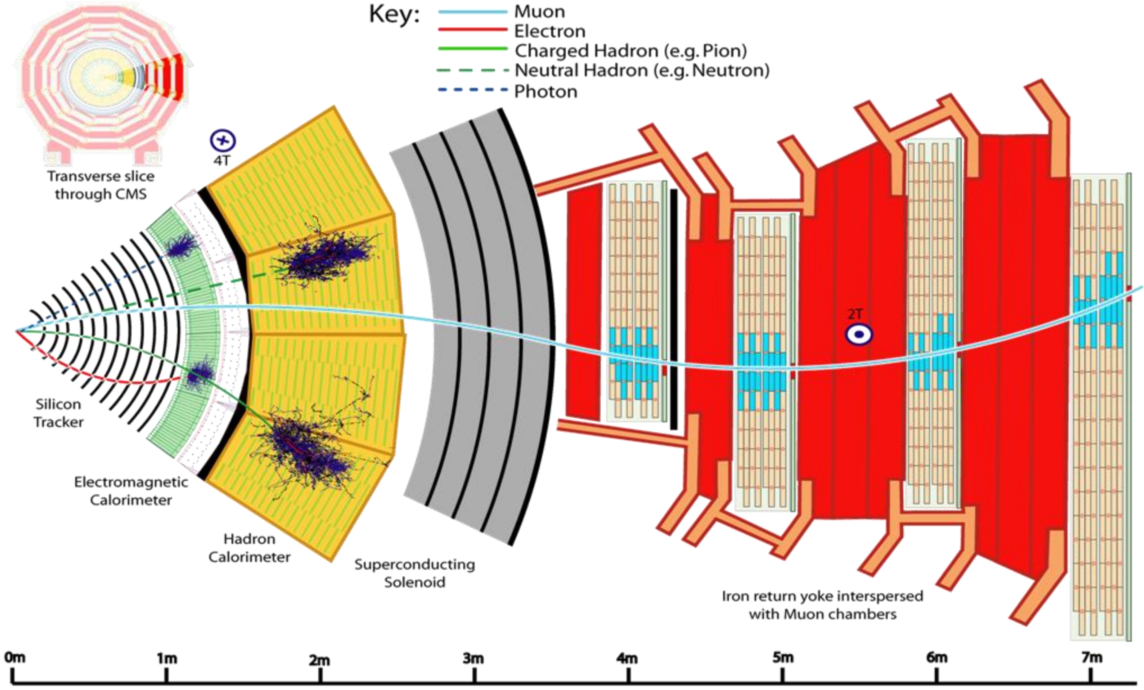
Institute for Studies in Theoretical Physics and Mathematics (IPM)

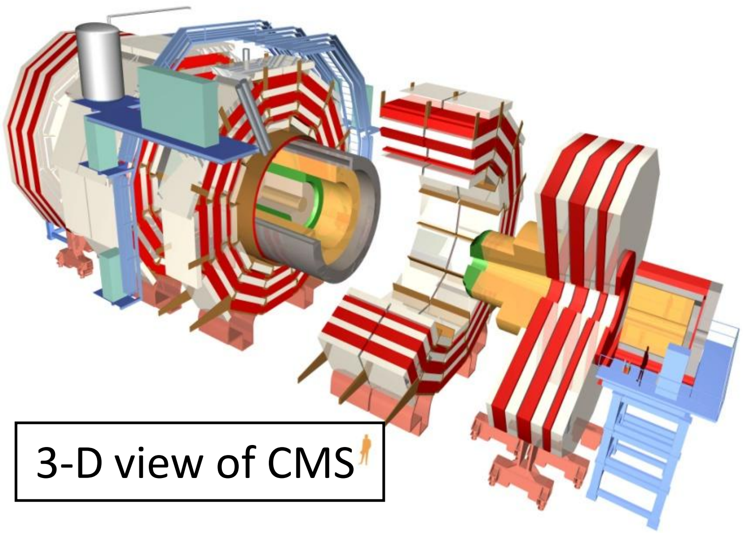
May 23, 2013

The “CMS” detector for LHC



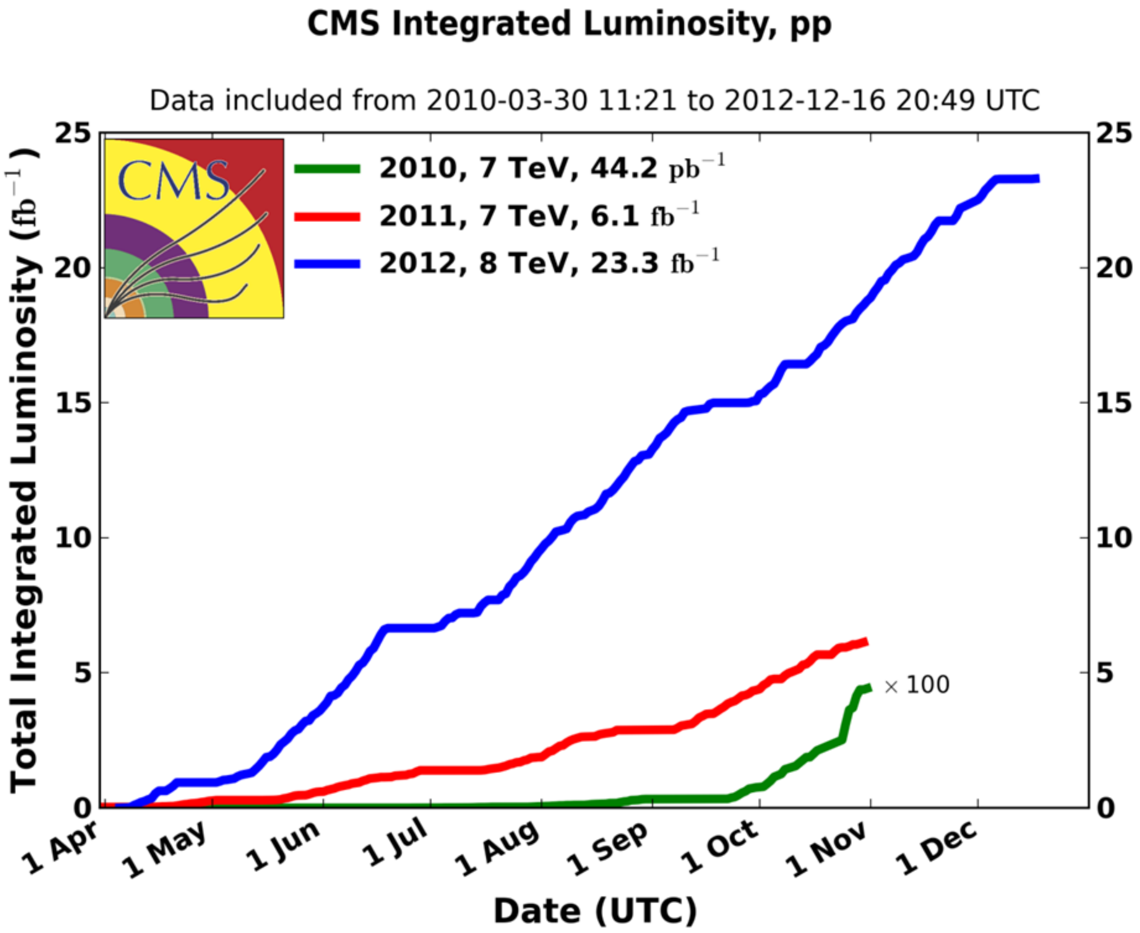
- Each color shows a different layer
- This is the view along the beam direction





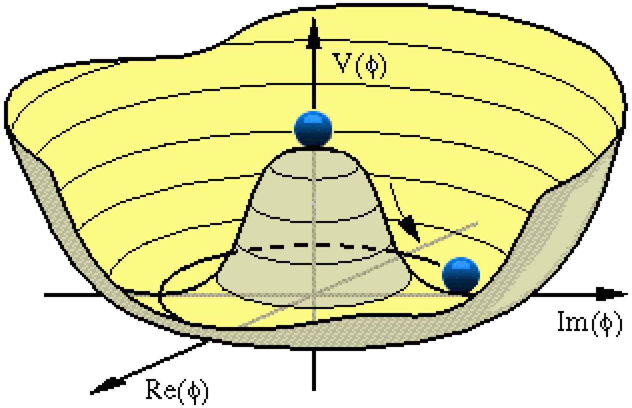
3-D view of CMS

LHC Had an Excellent Performance There are plenty of data to analyze



Higgs was the main goal of LHC from the beginning

- mass terms are not allowed in SM.
- A non zero vev can break the EW symmetry spontaneously.
- Higgs mechanism was introduced in 1960's.



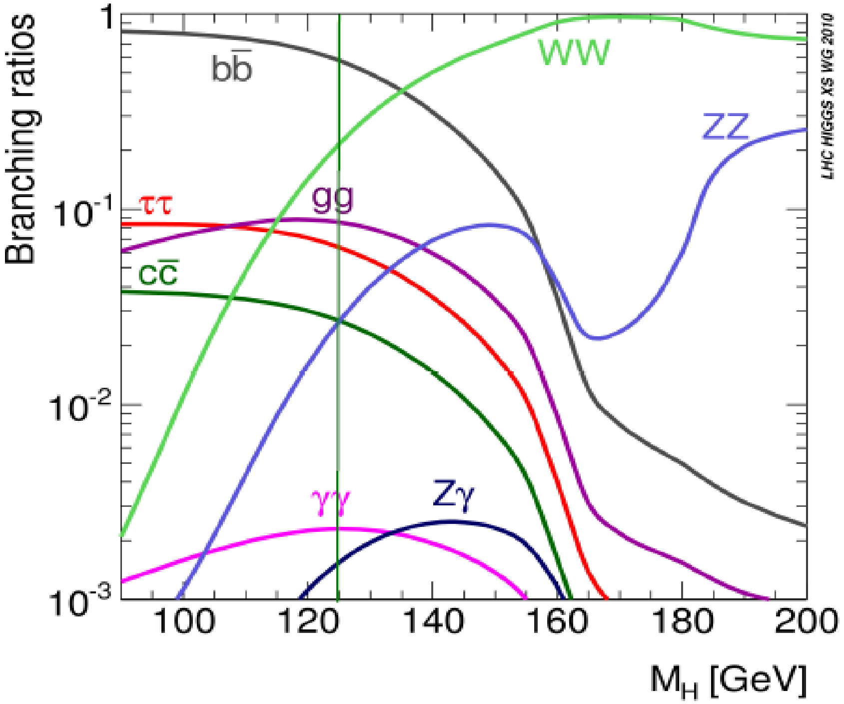
$$\phi = \frac{1}{\sqrt{2}} \begin{pmatrix} \phi^1 + i\phi^2 \\ \phi^0 + i\phi^3 \end{pmatrix} ,$$

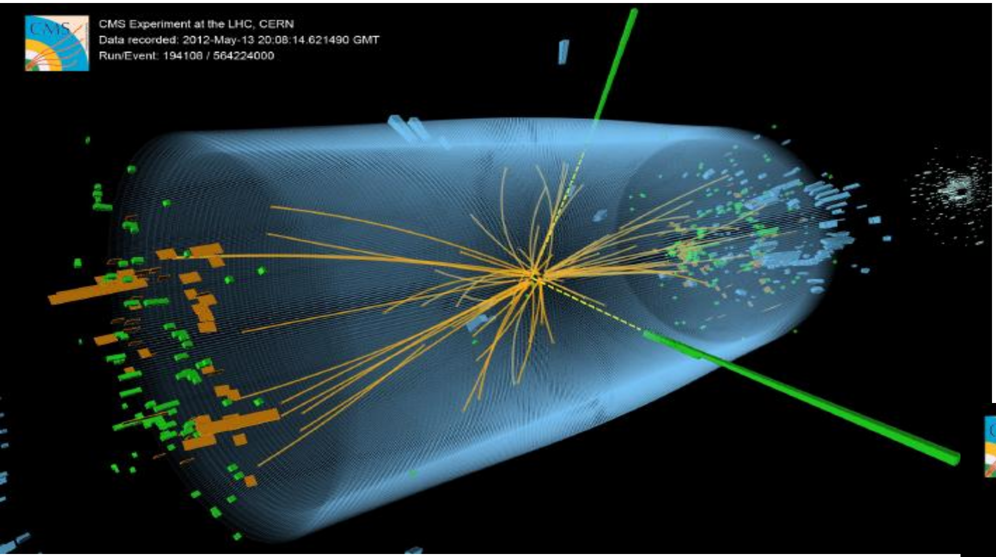
$$\mathcal{L}_H = \left| \left(\partial_\mu - igW_\mu^a \tau^a - i\frac{g'}{2} B_\mu \right) \phi \right|^2 + \mu^2 \phi^\dagger \phi - \lambda (\phi^\dagger \phi)^2,$$

Clean Signatures

$H \rightarrow \gamma\gamma$

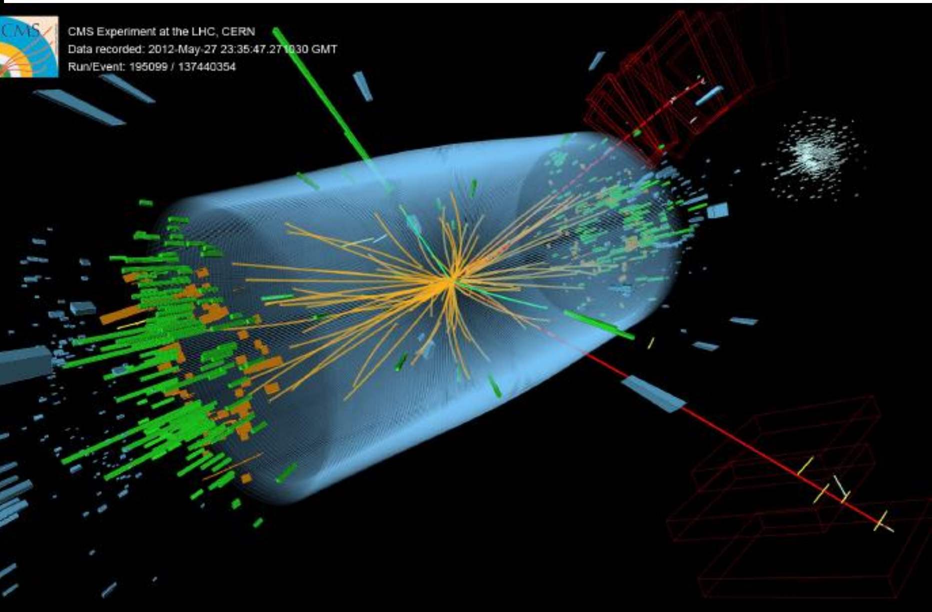
- Controllable bkg.





$H \rightarrow ZZ \rightarrow 4l$

- Low rate

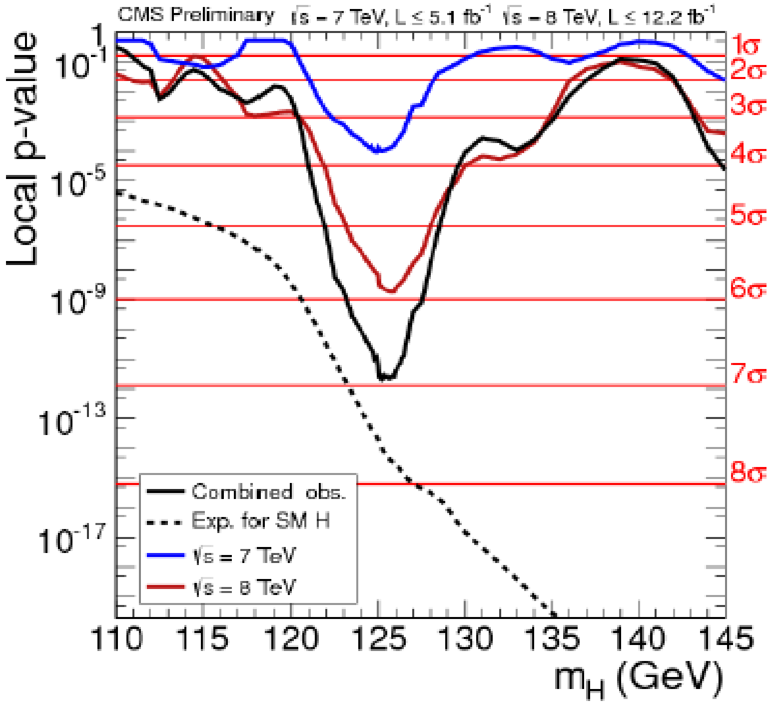


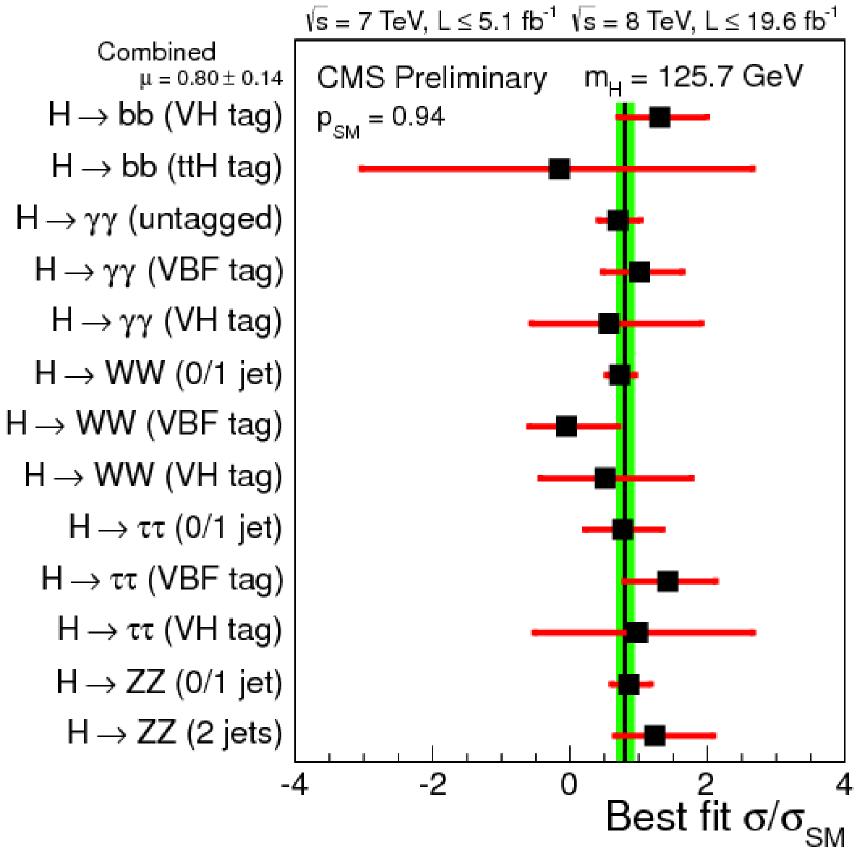
Combination

- Close to 10 channels are combined
- ~7 σ discovery

125.7 +/-0.3(stat) +/-0.3 (syst) GeV

- A little lower cross section!



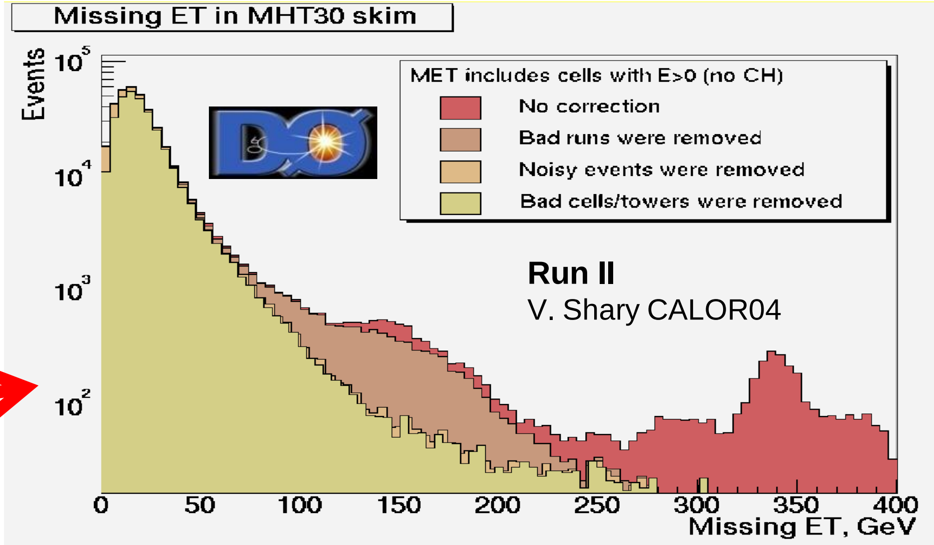


IPM Contribution in CMS

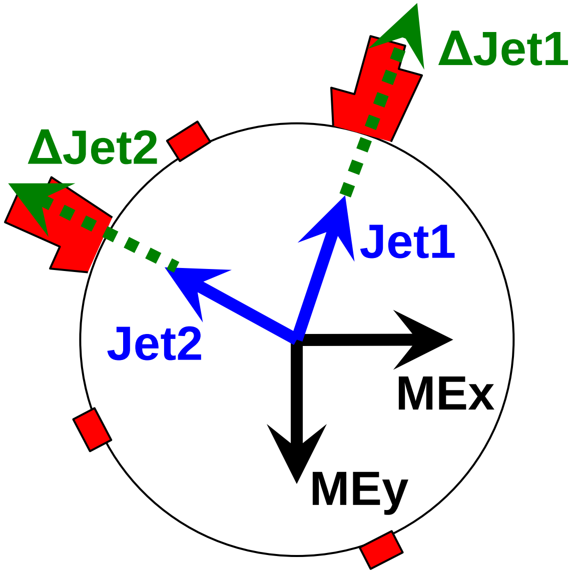
- There is a long way from collision to final plots
  - Online Shifts
  - Data Quality Monitoring
  - Calibration
  - Noise Suppression
- Future Collisions
  - Upgrade Studies
- All parts need manpower/coding
- Every signature on the final papers needs 3 months service for the experiment.

Important MET

- Most of the SUSY searches rely on MET.
- Wrong MET can easily mimic SUSY.



- By definition, wrongly measured jets can make MET.



Short List of the Topics

- SM: W-helicity measurement , FCNC, Single Top
- ADD → ee
- SUSY: stop, sbottom
- Exclusive processes
- HCAL Noise suppression
- DQM framework development
- Trigger development
- Tracker upgrade

CMS-TOP-12-020

W-helicity in single-top

- New interactions at higher energies may manifest themselves in the form of effective couplings of SM fermions.
- Top quark is the heaviest fermion of the Standard Model, decays before hadronization

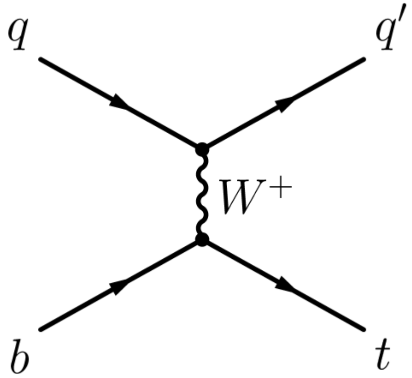
  The quark information, like spin, is not lost, accessible in decay products
- It decays almost all the time to a b-quark and a W-boson

  Provides an interesting area to study the Wtb vertex in search for new interactions

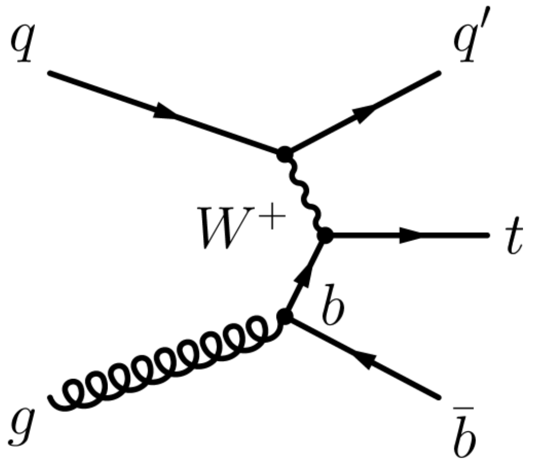
  Wtb can be also involved in the production of top quark, another place to investigate the anomalous couplings

$$L = -\frac{g}{\sqrt{2}}\bar{b}\gamma^{\mu}(V_L P_L + V_R P_R)tW^{-}_{\mu} + -\frac{g}{\sqrt{2}}\bar{b}\frac{i\sigma^{\mu\nu}q_{\nu}}{M_W}(g_L P_L + g_R P_R)tW^{-}_{\mu} + h.c.$$

arXiv:hep-ph/0605190v2



t-channel



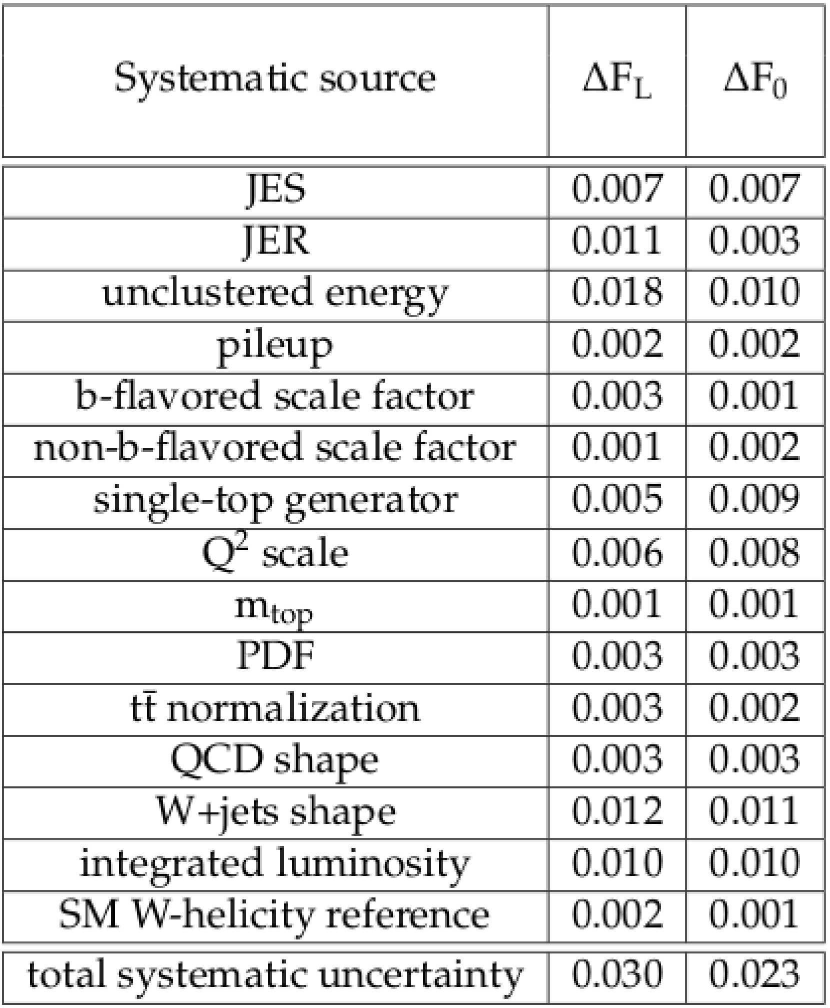
$\cos\theta_\ell^*$ is defined in the top quark rest frame as a the angle between the W-boson 3-momenta and the down type fermion 3-momenta in the W-boson rest frame.

$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_l^*} = \frac{3}{8}(1+\cos\theta_l^*)^2 F_R + \frac{3}{8}(1-\cos\theta_l^*)^2 F_L + \frac{3}{4}\sin^2\theta_l^* F_0$$

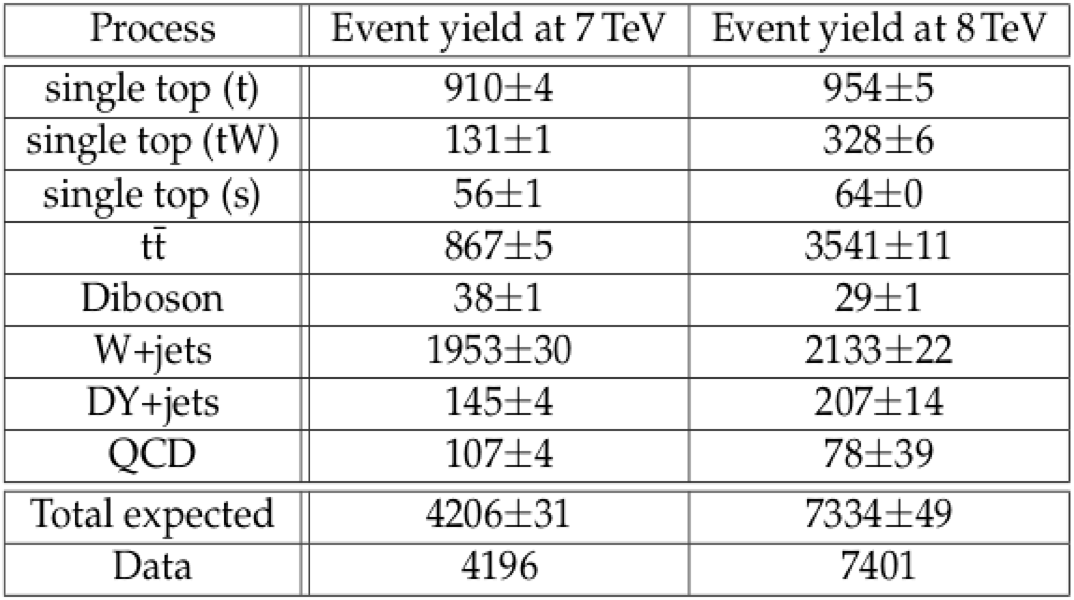
$$F_x \equiv \frac{\Gamma_x}{\Gamma}$$

Event Yield and Systematic

- Full top reconstruction.
- Every event with μ b and ν can enter the analysis.
- Different systematics can affect the measurement.



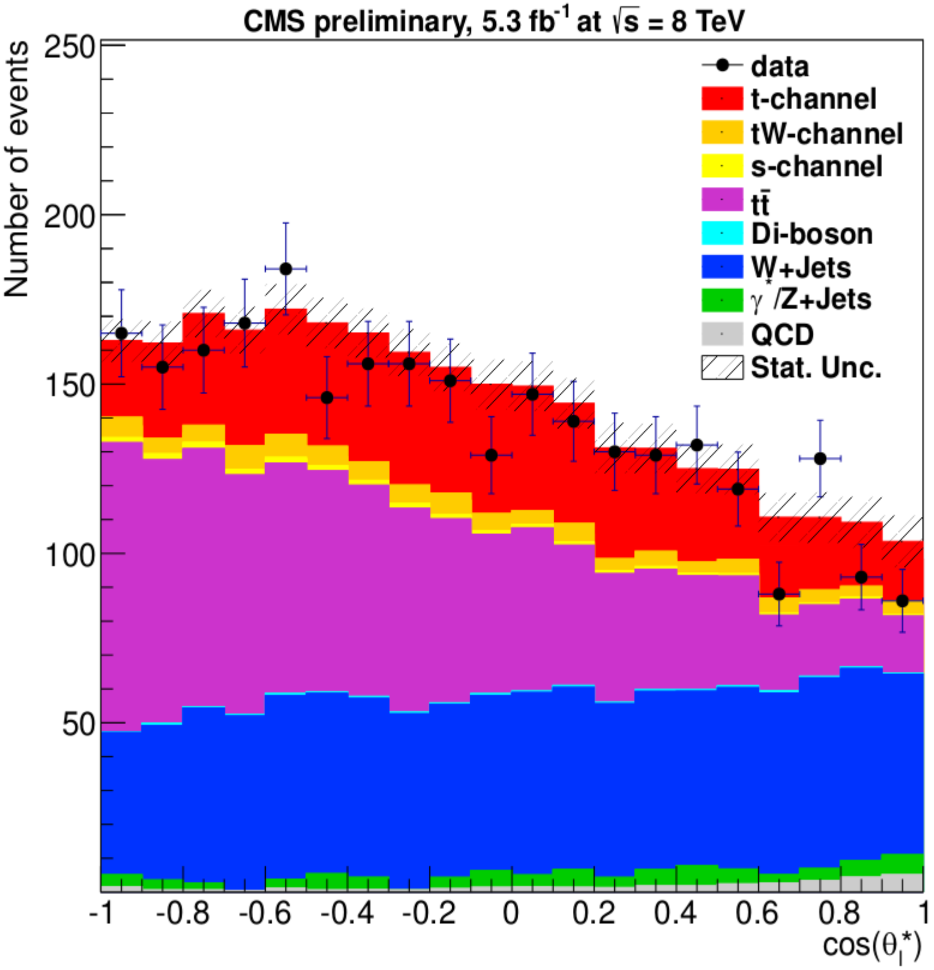
Systematic source	ΔF_L	ΔF_0
JES	0.007	0.007
JER	0.011	0.003
unclustered energy	0.018	0.010
pileup	0.002	0.002
b-flavored scale factor	0.003	0.001
non-b-flavored scale factor	0.001	0.002
single-top generator	0.005	0.009
Q^2 scale	0.006	0.008
m_{top}	0.001	0.001
PDF	0.003	0.003
$t\bar{t}$ normalization	0.003	0.002
QCD shape	0.003	0.003
W+jets shape	0.012	0.011
integrated luminosity	0.010	0.010
SM W-helicity reference	0.002	0.001
total systematic uncertainty	0.030	0.023

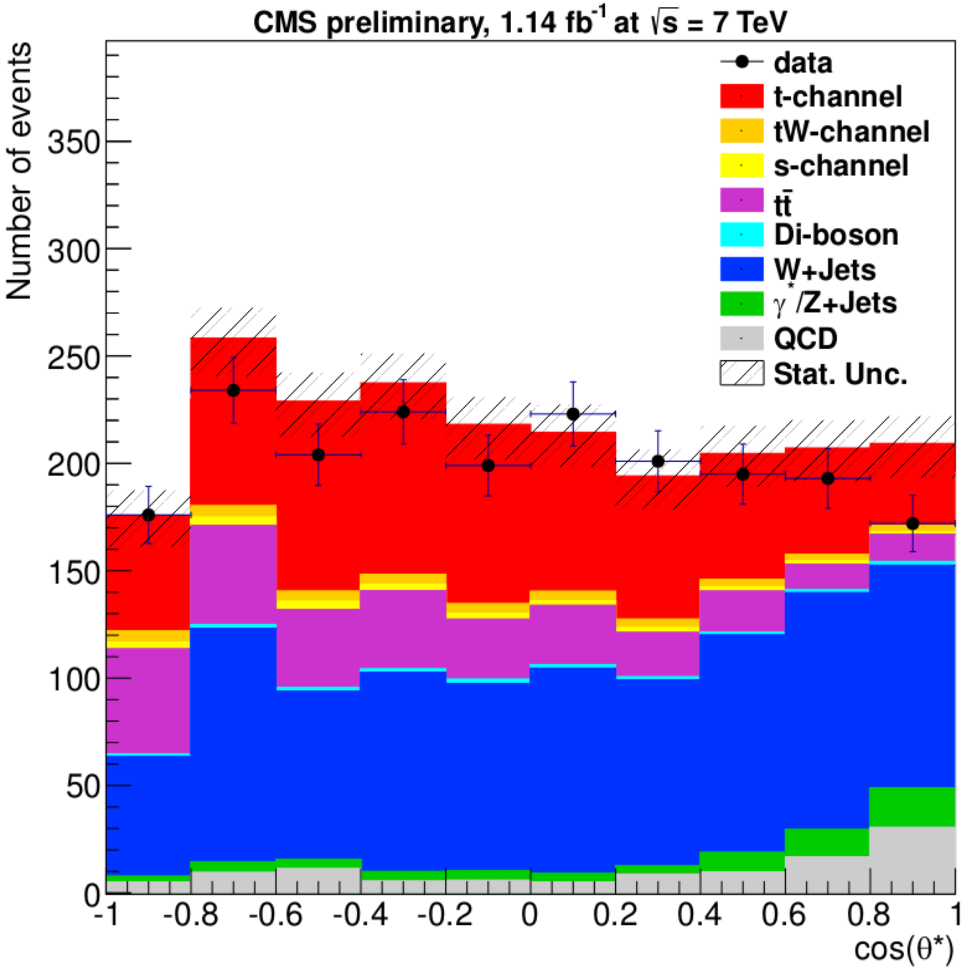


Process	Event yield at 7 TeV	Event yield at 8 TeV
single top (t)	910±4	954±5
single top (tW)	131±1	328±6
single top (s)	56±1	64±0
$t\bar{t}$	867±5	3541±11
Diboson	38±1	29±1
W+jets	1953±30	2133±22
DY+jets	145±4	207±14
QCD	107±4	78±39
Total expected	4206±31	7334±49
Data	4196	7401

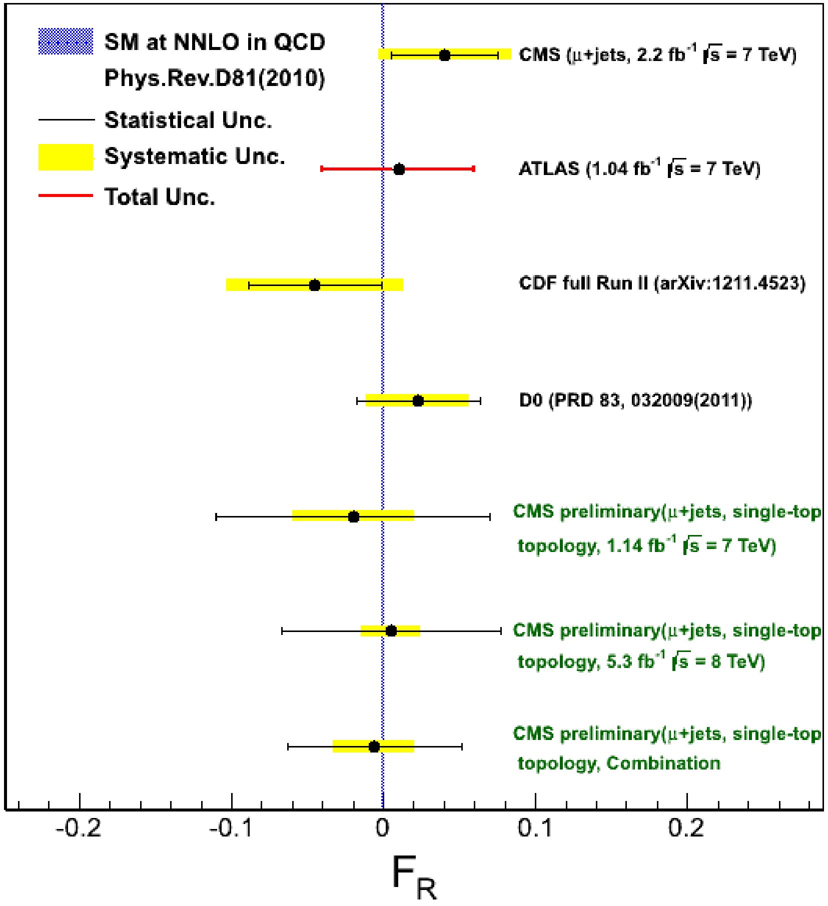
Backgrounds are more than signal!

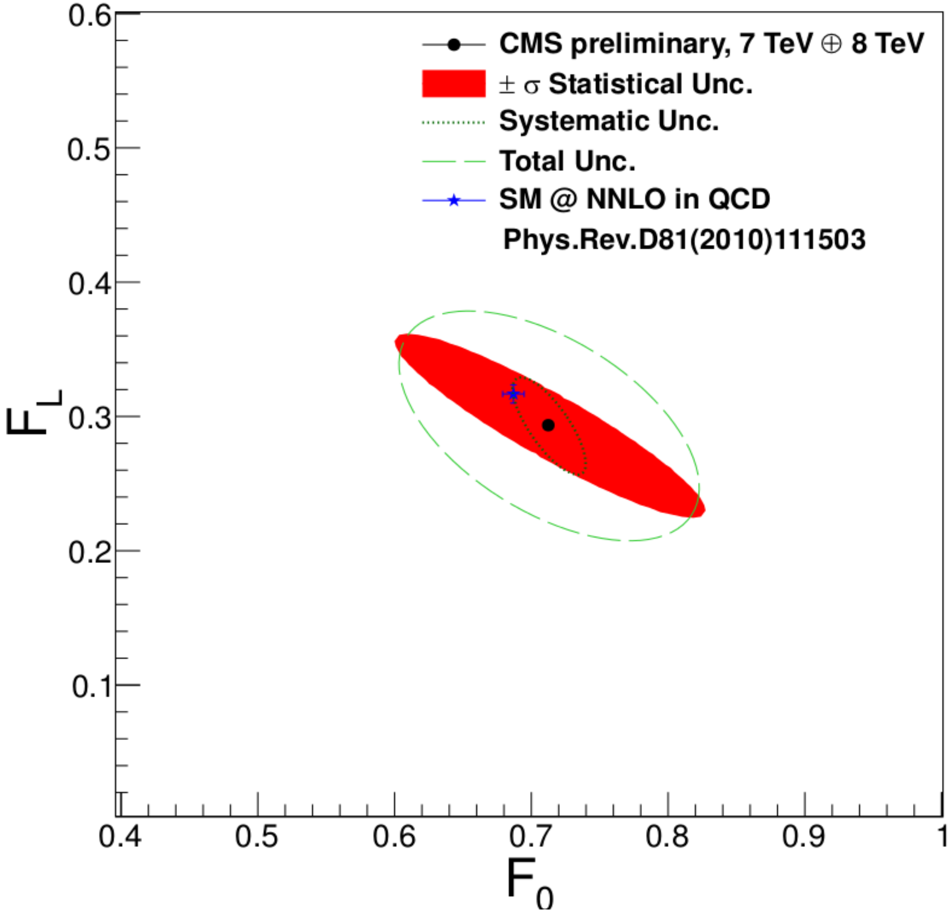
A sophisticated statistical method is used to extract the helicity fractions.





Results, a small room for new physics!

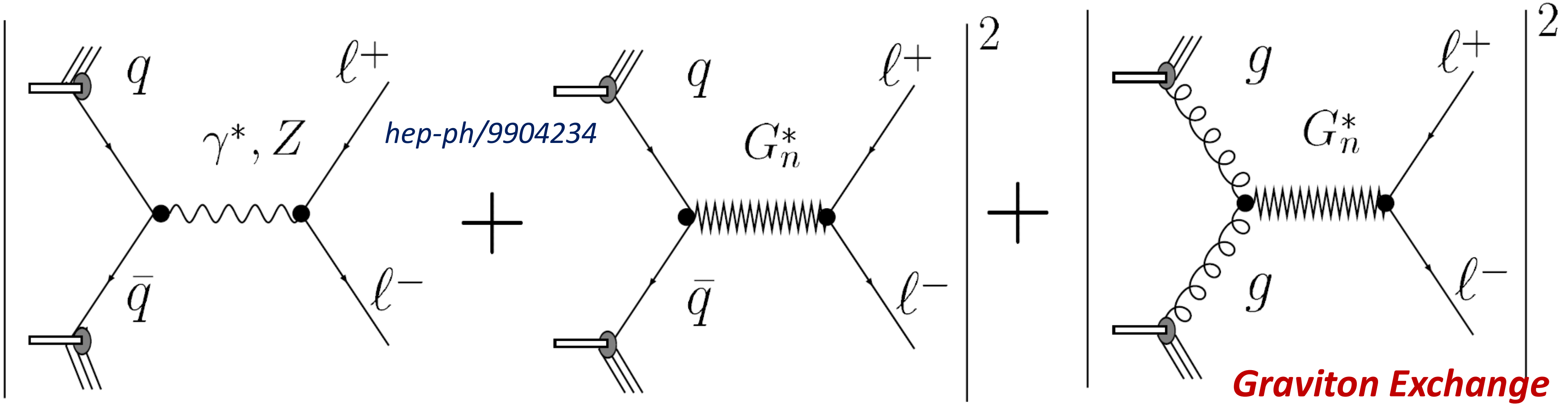




CMS-EXO-12-031

Search for Extra Dimensions

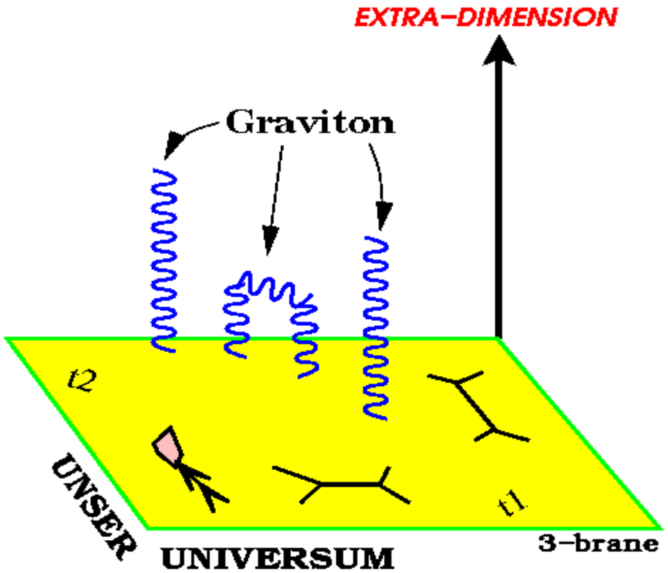
Feynman diagrams for dilepton production in the presence of large extra dimensions.



Graviton Exchange

SM Drell-Yan

$$\sigma_{total} = \sigma_{DY} + \underbrace{A\times\eta}_{\text{Interference term}} + \underbrace{B\times\eta^2}_{\text{ED term}}$$

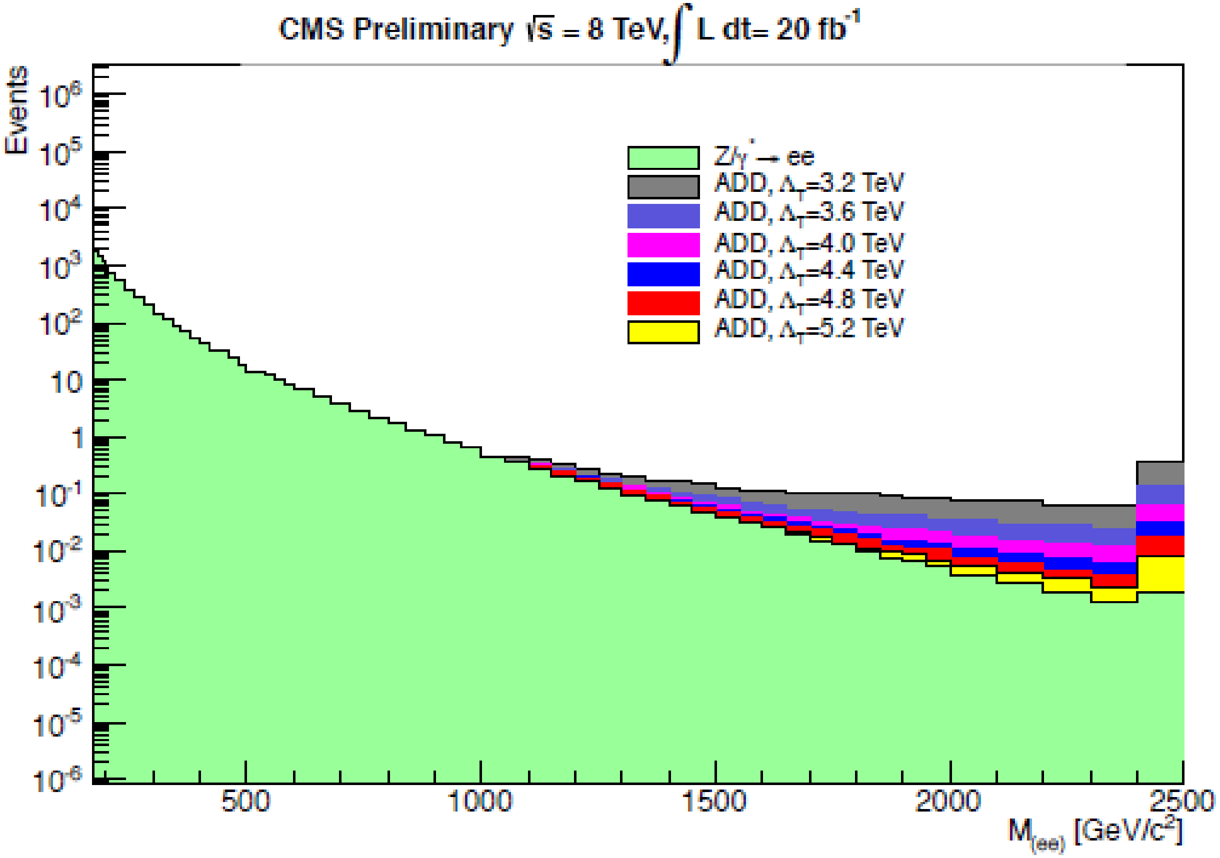


ADD Signal

GRW Convention:

There is one parameter: Effective Planck Scale

$$\eta = \frac{1}{\Lambda_T^4}$$



The Signal invariant mass distribution tends to the Drell–Yan shape as $\Lambda_T \rightarrow$ Infinity .

Signal and Backgrounds

The ADD Signal consists of 2-Opposite Sign Electrons in the final state.

Backgrounds can be divided into 3 categories:

-The irreducible Standard Model Drell-Yan with 2 electrons in the final state.
It is estimated using Monte Carlo Simulated events.

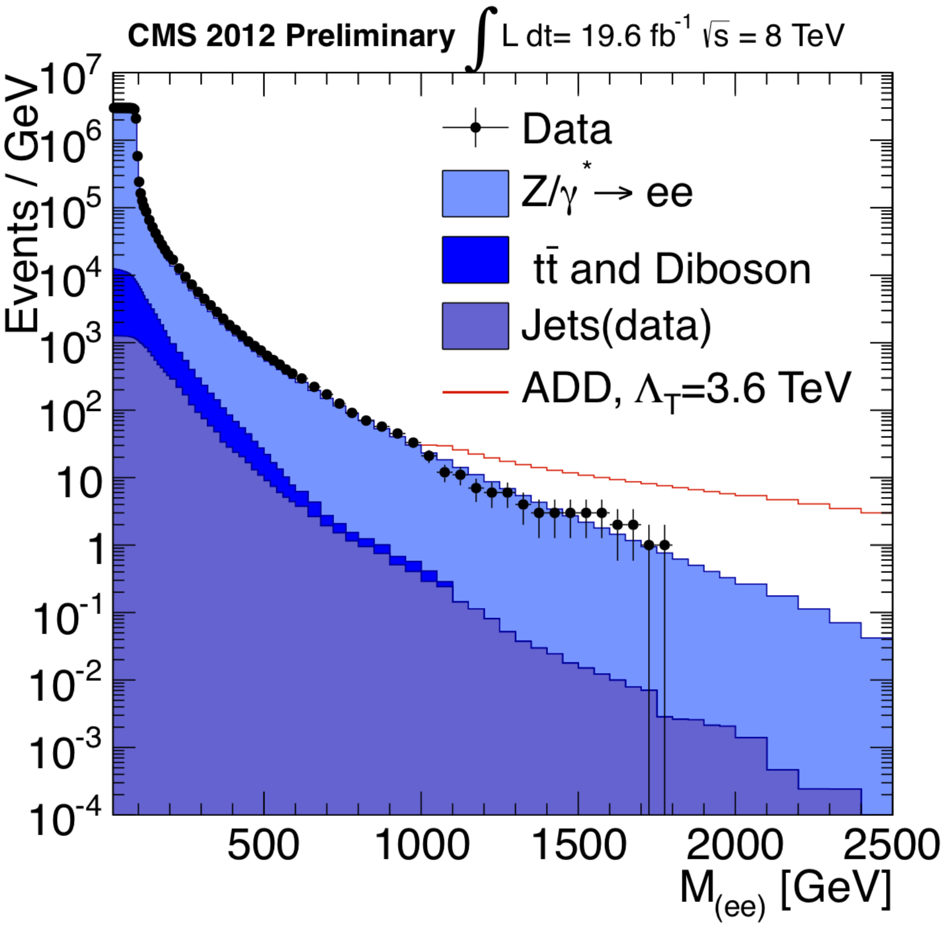
- **Jet Backgrounds (QCD, W+Jets)** : jets can be miss-reconstructed as electrons
It is not possible to estimate it from MC due to lack of enough statistics. Accordingly, it is estimated from data using "fake rate" method.

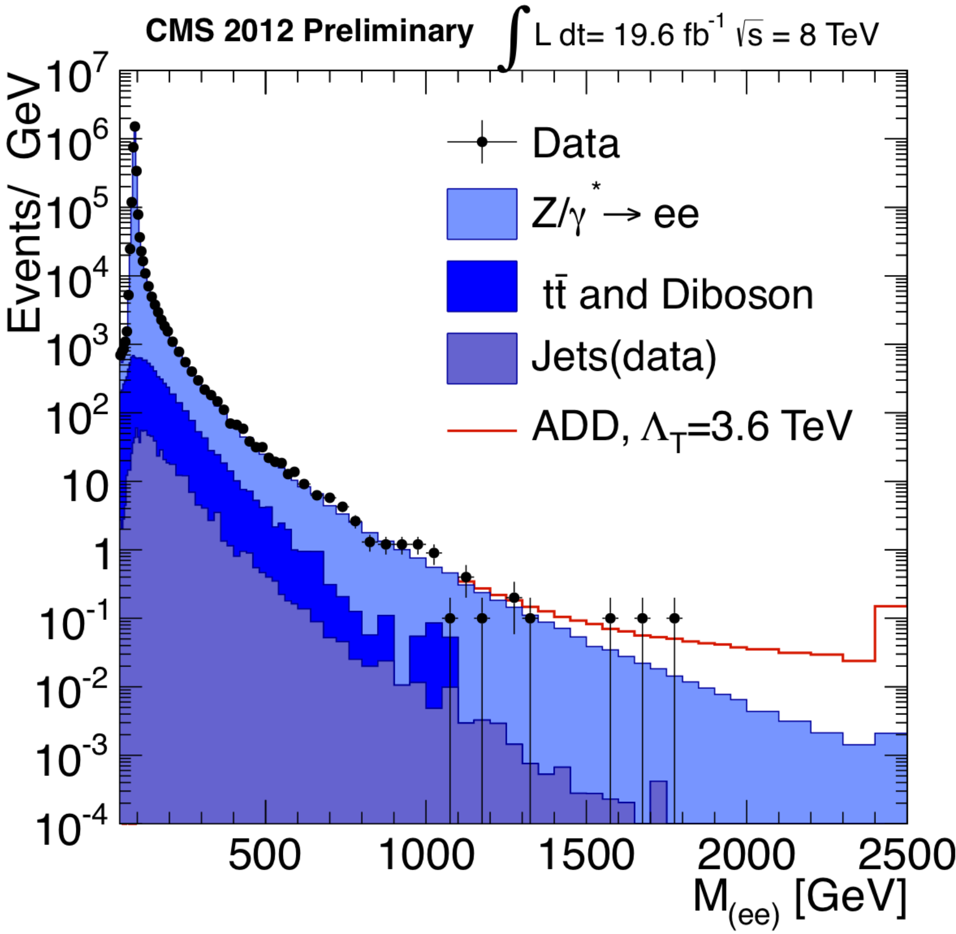
- **The so-called "Top-Like or Flavor Symmetric" backgrounds:** Consists of all events with two real electrons in the final state:
  - Di-Leptonic TTBar and Single Top tW-channel
  - Di-Boson (WW,WZ,ZZ)
  - Z→tau+tau

This type of background is estimated by using e-mu method.

$$\left(\frac{N_{e^{\pm}e^{\mp}}}{N_{e^{\pm}\mu^{\mp}}}\right)_{DATA} = \frac{1}{2}\frac{(\varepsilon_{id}\varepsilon_{rec}A)_{e}}{(\varepsilon_{id}\varepsilon_{rec}A)_{\mu}}$$

Invariant Mass Distribution

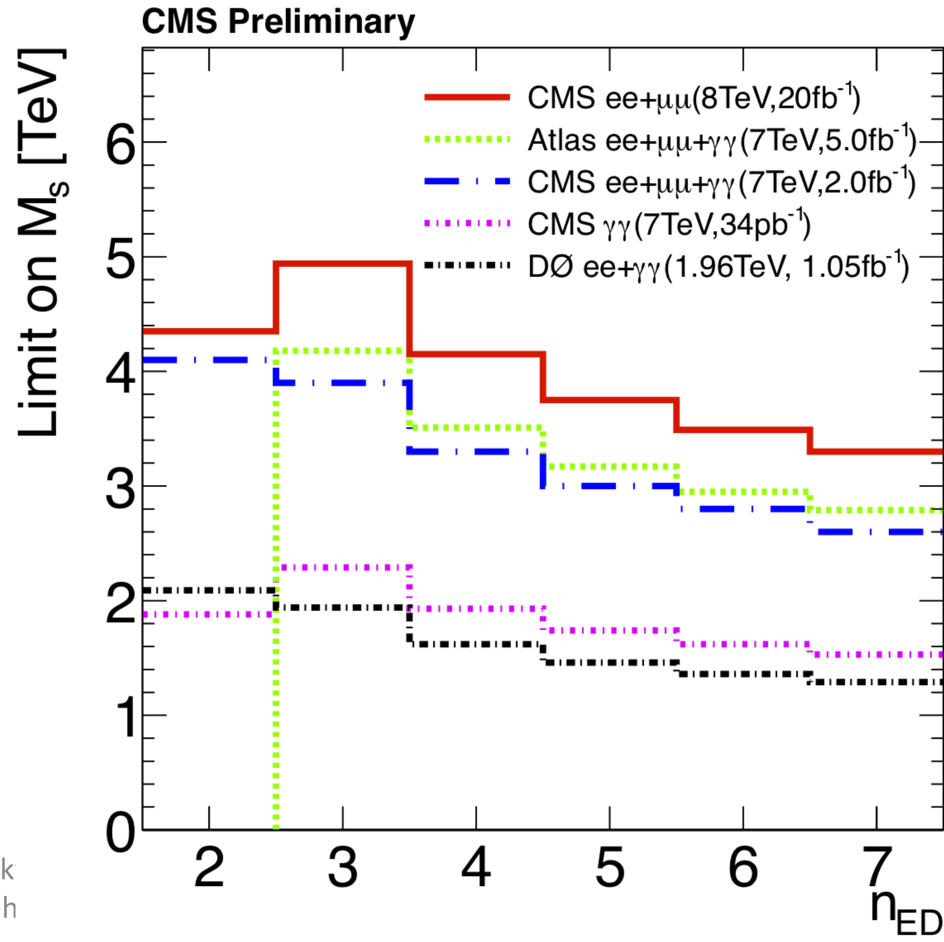




Yields, Systematics & Result

ee, $\mathcal{L} = 19.6\ \text{fb}^{-1}$			
Mass region [TeV]	N_{obs}	Background expectation	Signal exp. $\Lambda_T = 3.6\,\text{TeV}$
Control regions			
0.12–0.40	85851	82497 ±12374	
0.40–0.60	1251	1131±169	
0.60–0.90	249	232 ±35	
0.90–1.30	41	36 ±6	
1.30–1.80	4	4.75 ±0.70	3.70
Signal region			
> 1.80	0	0.64±0.10	6.90

Systematic Uncert.	Background Uncert.
Energy Scale	1%
Reconstruction and Identification Eff per electron	5%
Drell–Yan NLO Corrections	6%
Choice of PDF	12%
Luminosity	4.4%

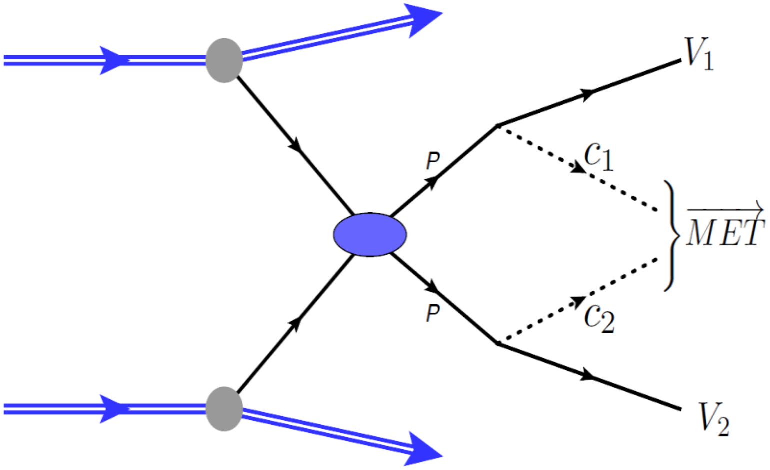


QCD Safe Distributions in search for SUSY

CMS-SUS-12-002

- MT2: stransverse mass, an extension of MT in case of 2 decay chain with “missing particles”:

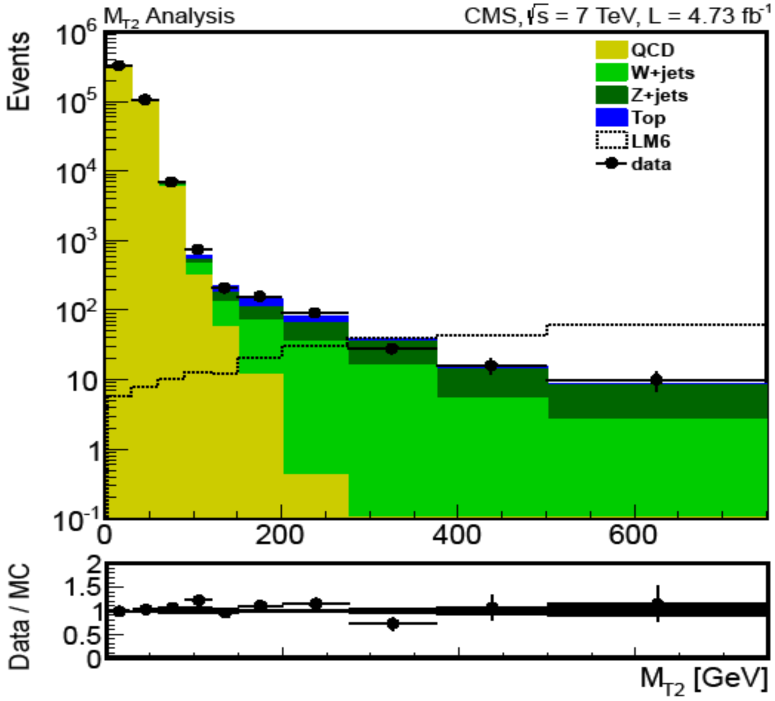
$$M_{T2} = \min_{p_T^{c1}+p_T^{c2}=\not{p}_T} \left[\max\left(m_T^{(1)}, m_T^{(2)}\right)\right]$$



- For massless particles:

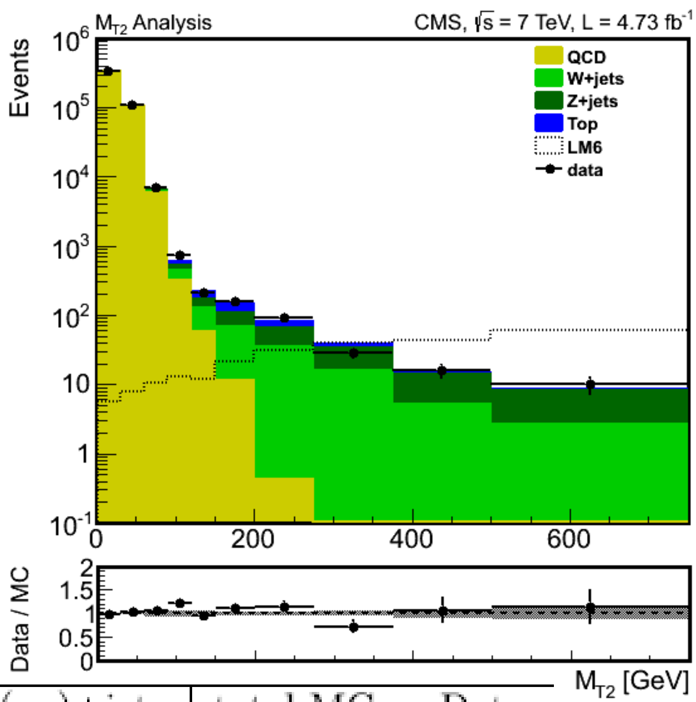
$$M_{T2}^2 = 2p_T^{(1)} p_T^{(2)} (1 + \cos\phi_{1,2})$$

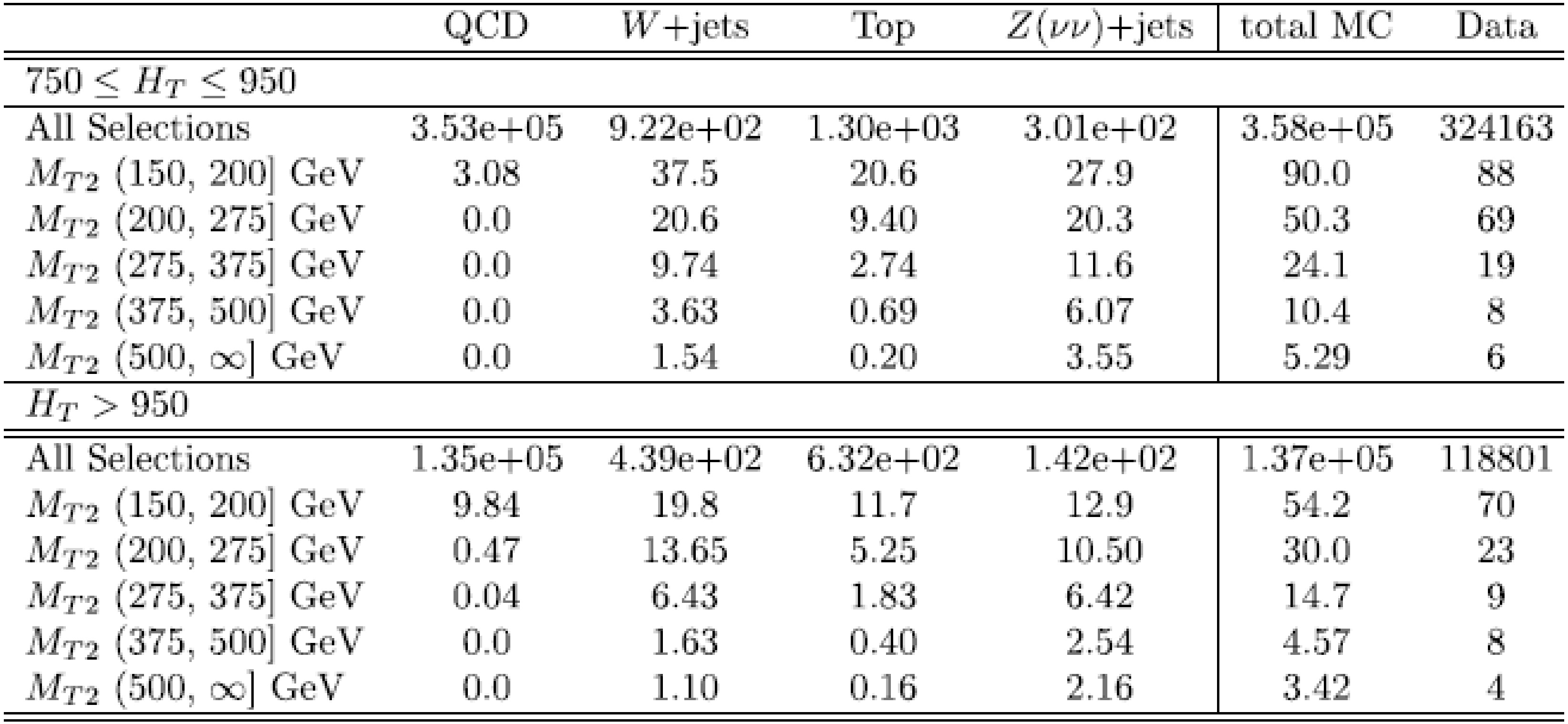
- QCD does not enter the search region,



MT2, Event yield

- There is a good agreement between data and MC predictions.
- W+jets and Invisible Z are the dominant backgrounds.

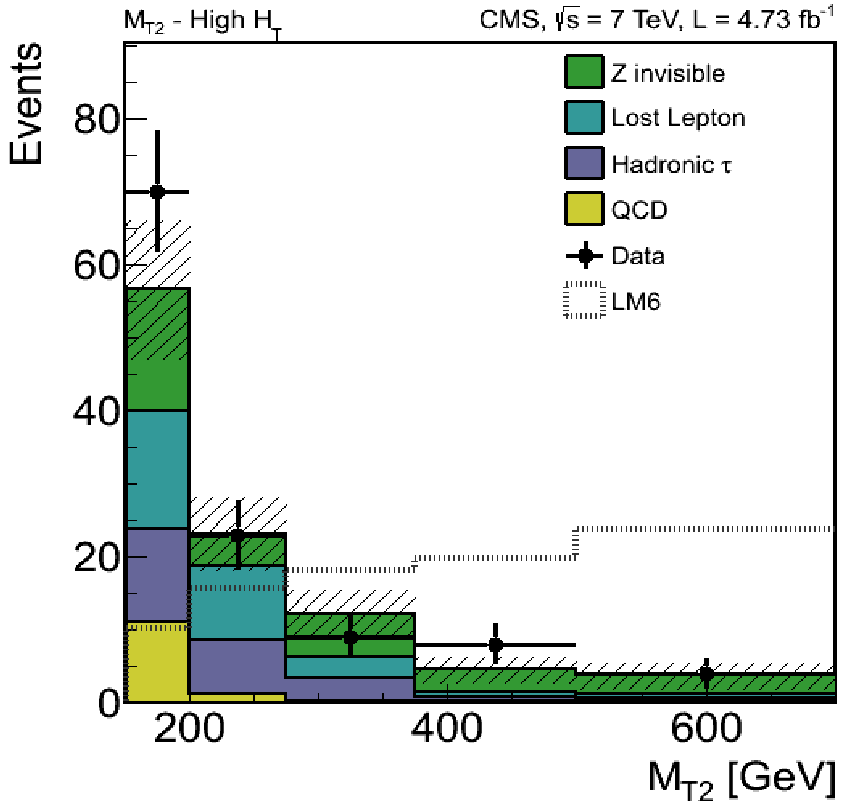


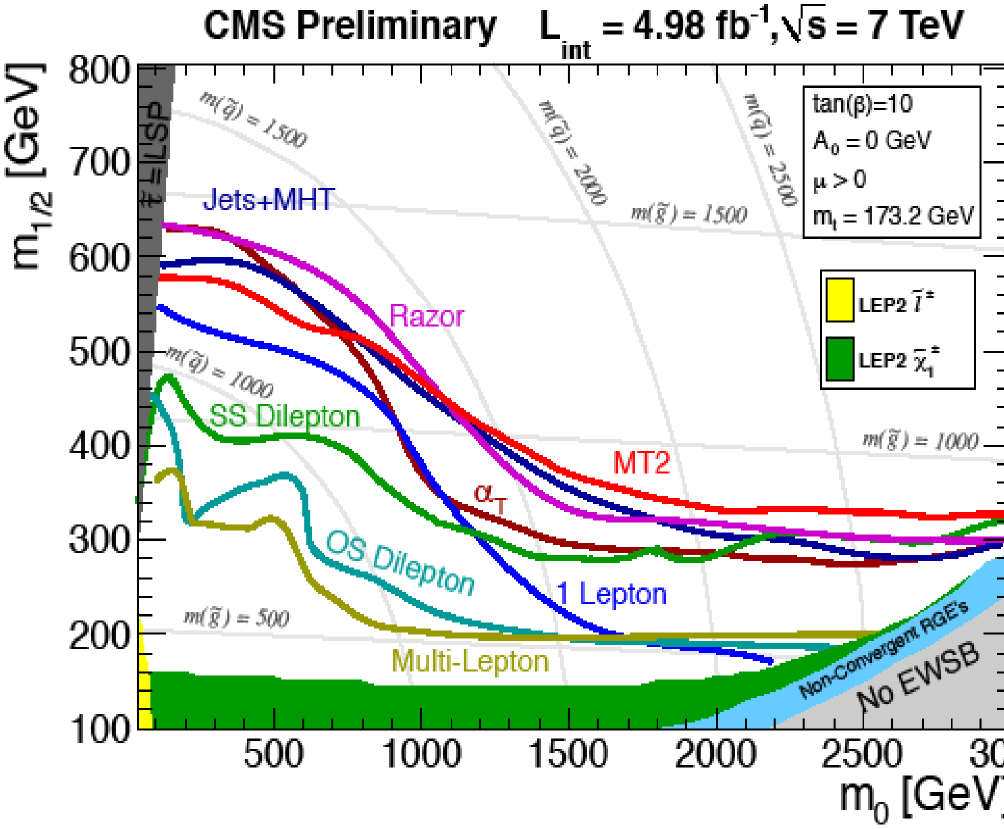


	QCD	W+jets	Top	$Z(\nu\nu)$+jets	total MC	Data
$750 \leq H_T \leq 950$						
All Selections	3.53e+05	9.22e+02	1.30e+03	3.01e+02	3.58e+05	324163
M_{T2} (150, 200] GeV	3.08	37.5	20.6	27.9	90.0	88
M_{T2} (200, 275] GeV	0.0	20.6	9.40	20.3	50.3	69
M_{T2} (275, 375] GeV	0.0	9.74	2.74	11.6	24.1	19
M_{T2} (375, 500] GeV	0.0	3.63	0.69	6.07	10.4	8
M_{T2} (500, ∞] GeV	0.0	1.54	0.20	3.55	5.29	6
$H_T > 950$						
All Selections	1.35e+05	4.39e+02	6.32e+02	1.42e+02	1.37e+05	118801
M_{T2} (150, 200] GeV	9.84	19.8	11.7	12.9	54.2	70
M_{T2} (200, 275] GeV	0.47	13.65	5.25	10.50	30.0	23
M_{T2} (275, 375] GeV	0.04	6.43	1.83	6.42	14.7	9
M_{T2} (375, 500] GeV	0.0	1.63	0.40	2.54	4.57	8
M_{T2} (500, ∞] GeV	0.0	1.10	0.16	2.16	3.42	4

Predictions vs Data

No significant excess is seen in data!





Summary

- The long awaited LHC becomes reality!
- IPM is involved in different activities from instrumentation to analysis.
- Higgs is there, but what about other exotics?
- Wait for at least 2 years!

???

۲۱

شوک

ایران

- یکشنبه
- ۱۸ تیر ۱۳۹۱
- ۱۸ شعبان ۱۴۳۳
- ۸ جولای ۲۰۱۲
- سال هجدهم
- شماره ۵۱۲۰

شماره شوک ۱۸۴

شوک روز

کشف آثار جدید حیات در مریخ

گروه شوک: دانشمندان اعلام کردند کاوشگر جدید سازمان فضایی «ناسا» در پی آخرین سفر فضایی خود به مریخ در ماه آکتبر به یافته‌های جدیدی دست خواهد یافت. این کاوشگر که سعی دارد لایه‌هایی از زیر سطح کره مریخ را بردارد و برای وجود حیات روی این کره سرخ مورد آزمایش قرار دهد، این بار به شکل مجهزتری در مریخ به کاوش خواهد پرداخت.

ادامه در همین صفحه

تحلیل شوک

تبهکاری در نوجوانان لذت یا بیماری

| دکتر داوود شیخاوندی | جرم‌شناس |

شاید ریشه بسیاری از تبهکاری‌ها در بزرگسالان نشأت گرفته از زمان کودکی و نوجوانی باشد. موقعیت‌های حساسی که تبدیل به یک عادت یا شغل و پیشه شده باشند. بسیاری از سارقان حرفه‌ای، دزدی را هنر و پیشه خود می‌دانند که نگاه به آن مستلزم کارشناسی ریشه‌ای در زندگی افراد تبهکار بویژه سنین کودکی آنها است.

بعضی از دزدی‌ها یک نوع بیماری است که هم در دختران و هم در پسران در سنین مختلف دیده می‌شود که با عوامل هوس، حسادت و شجاعت در آنان دیده می‌شود. دخترهایی که دست به دزدی‌های کوچک می‌زنند یا پسرهای تبهکاری که قاچاقچی گری می‌کنند و به سوی مصرف مواد مخدر می‌روند کسانی هستند که احساس مسئولیت خود را از دست داده‌اند.

اما دسته‌ای دیگر از نوجوانان و جوانان هستند

سوداگران بخت و اقبال

دختر بدشانسی بودم و نمی‌دانم چرا مدام بد می‌آوردم. دست به هر ... لای موهایت بگذار، یکی از آنها را داخل زعفران و گلاب بگذار و مقداری از

گزارش و گفت‌وگوی اختصاصی شوک از حضور ۱۷ دانشمند و دانشجوی هسته‌ای در بزرگ‌ترین کشف تاریخ

ناگفته‌های کاشفان ایرانی «ذره بوزون هیگز»

گروه شوک: دانشمندان جوان ایرانی که سهمی بزرگ در کشف «ذره بوزون

حوادث امروز

- درخواست پلیس آگاهی از مردم برای شناسایی و دستگیری متهم فراری/۲۴
- جسد دختربچه گمشده از آب‌های هراز گرفته شد/۲۴
- عکس‌های اینترنتی یک زن برای همکاری‌های جاسوسی/۲۴

معمای مرد دست و پا شکسته در زندان مهریه

گروه شوک: یک زندانی مهریه ادعا می‌کند همسرش برای قتل وی دست به اقدام عجیبی زده است. این مرد که دست و پایش شکسته خواستار تحت تعقیب قرار گرفتن همسرش به اتهام اقدام به قتل شد.

ادامه در صفحه ۲۴