



1

Study of The Dijet Mass Spectrum in $pp \rightarrow W(\rightarrow l\nu) + jj$ Final States And Search For an Anomalous Resonance Near 150 GeV in CMS

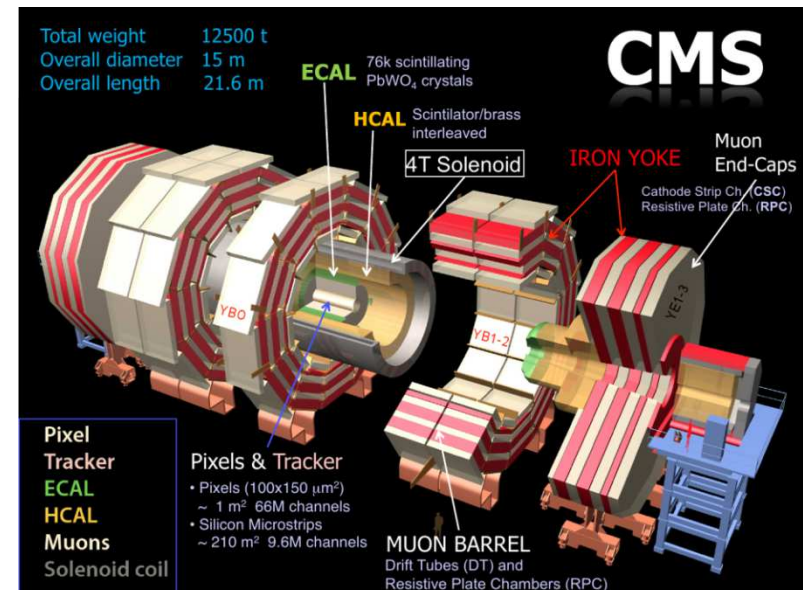
Osipenkov, Ilya (Texas A&M University)

On behalf of the CMS Collaboration

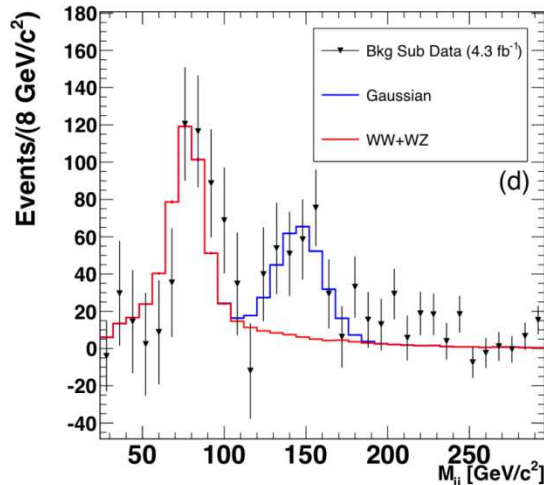
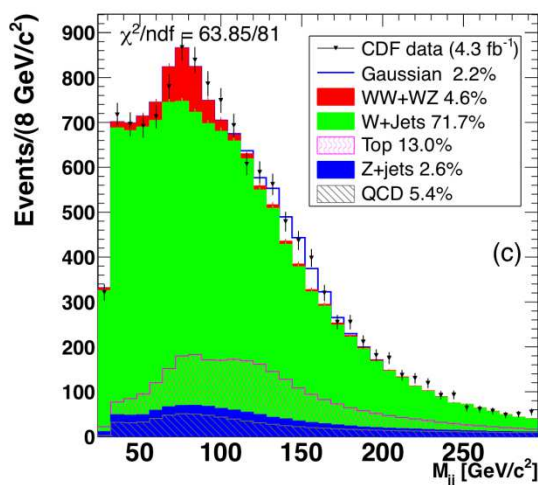
USLUO Meeting

arXiv:1208.3477v1 [hep-ex]

<https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEWK11017>



Motivation : CDF-Resonance



- CDF: an excess of 253 events at 145 GeV, width = 15 GeV
- Significance of 3.2σ at 4.3fb^{-1} and 4.1σ at 7.3fb^{-1}

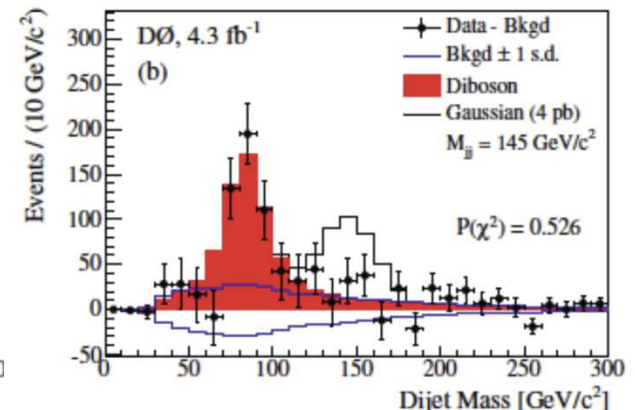
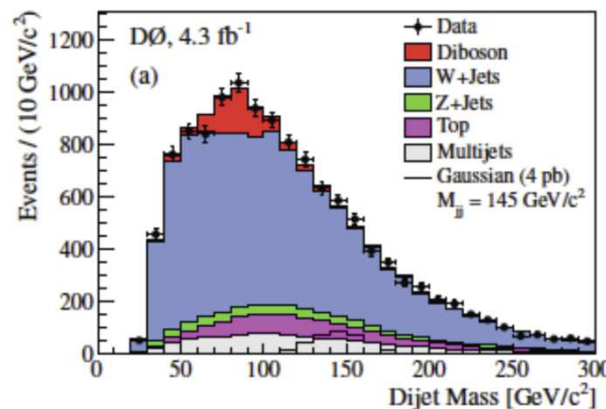
News Coverage:

- NBC: New subatomic particle: real or anomaly?
- NY Times: At Particle Lab, a Tantalizing Glimpse Has Physicists Holding Their Breaths
- Science News: Fermilab data hint at possible new particle
- ...

- D0: Smooth falling spectrum beyond 110 GeV
- Consistent with the Standard Model

News:

- Discovery News: Tevatron's DZero Sees No Evidence of New Particle
- Science News: No new particle from second detector
- NBC: Subatomic mystery leads to standoff

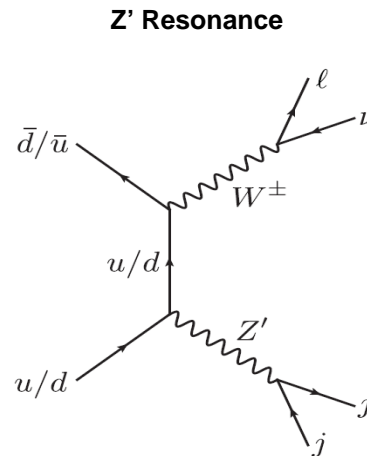
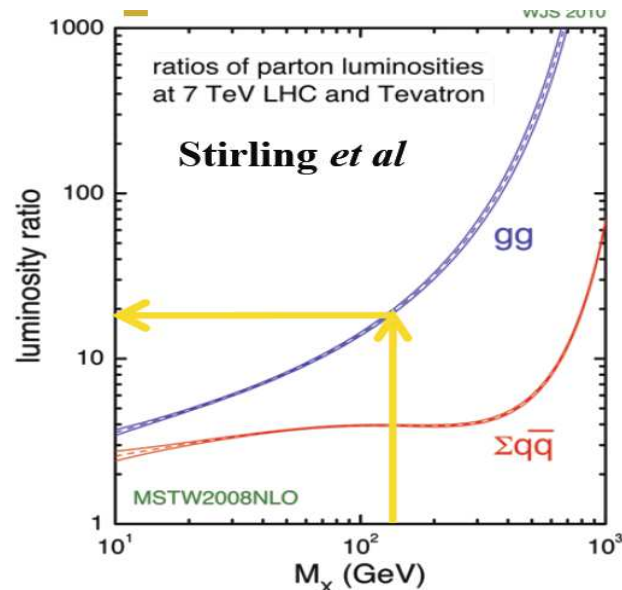


- Up to LHC to address the discrepancy

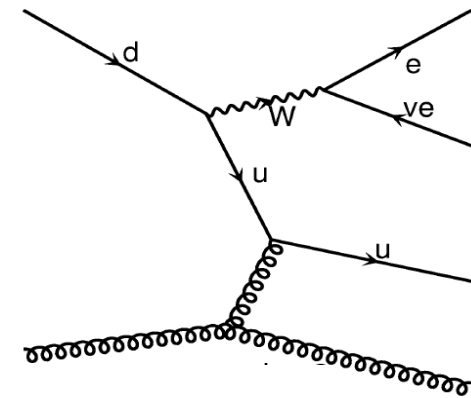
New Physics & Challenges at The LHC

❖ We consider proposed theoretical explanations:

- Leptophobic Z' ($m_{Z'} \approx 150 \text{ GeV}$)
- Technicolor ($\rho_T \rightarrow W\pi_T$, $m_{\pi_T} \approx 150 \text{ GeV}$)
- Can serve as proxies for other theories



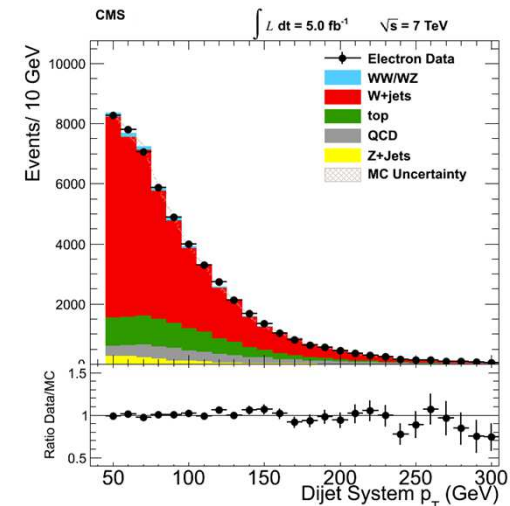
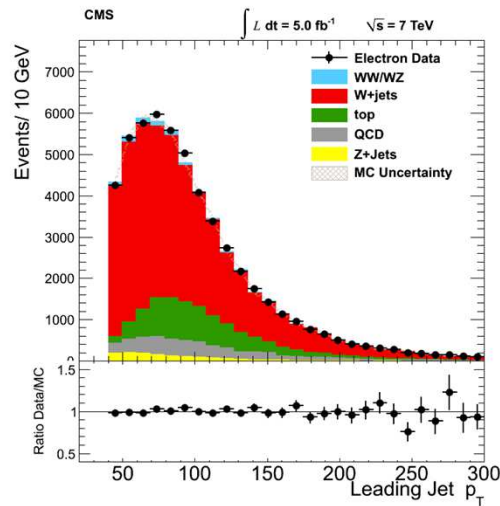
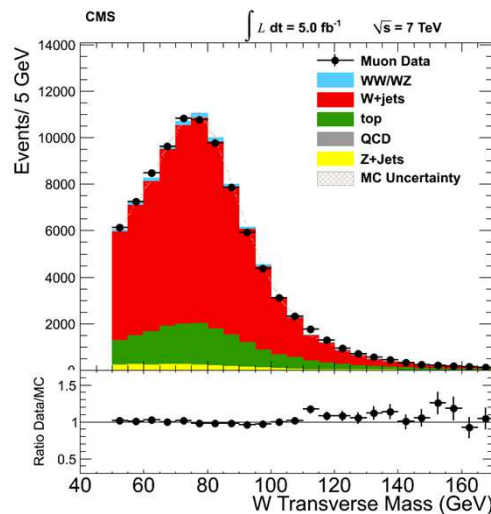
$W+jj$ production via quark-gluon scattering



- The $W+jj$ production is dominated by quark-gluon scattering (vs. $q-q$ at the Tevatron)
 - The potential New Physics can be (and in many theories is) dominated by quark-quark collisions
- ❖ The Signal to Background ratio is much worse: stronger cuts and improved techniques are needed

CMS Selection

- We study $pp \rightarrow W(\rightarrow \ell\nu)jj$ final states at 7TeV
- Apply standard object selection
 - μ, e , MET, two or three PF Jets
 - Cuts on the corresponding values p_T , $|\eta|$, W_{mT} , etc.
- Additional quality Cuts:
 - Designed to enhance S/B and avoid removing potential New Physics
 - Leading Jet $p_T > 40\text{GeV}$, $p_{T^{jj}} > 45\text{GeV}$, $|\Delta\eta_{jj}| < 1.2$, $0.3 < \text{Jet}2 p_T / m_{jj} < 0.7$



Fitting The M_{jj} Spectrum

- Unbinned maximum likelihood for $40 < M_{jj} < 400$ GeV
- Exclude the potential signal region: $123 < M_{jj} < 186$ GeV
- Four Distinct Fits: μ_{2J} , μ_{3J} , e_{2J} and e_{3J} Bins (combine the results when setting exclusion limits)

Backgrounds

- The (non W+jets) background contributions are free to float subject to Gaussian constraints.

| Process | Shape | External constraint on normalization |
|---------------------|---------|---|
| W plus jets | MC/data | Unconstrained |
| Diboson | MC | Constrained: (NLO) $61.2 \text{ pb} \pm 10\%$ |
| $t\bar{t}$ | MC | Constrained: (NLO) $163 \text{ pb} \pm 7\%$ |
| Single top | MC | Constrained: (NNLO) $[25-27] \pm 5\%$ |
| Drell-Yan plus jets | MC | Constrained: (NLO, $m_{ll} > 50 \text{ GeV}$) $3048 \text{ pb} \pm 4.3\%$ |
| Multijet | data | Constrained: \mathbb{E}_T fit in data $\pm 50\%$ (100%) for electron (muon) |

❖ W+jets shape is a combination of:

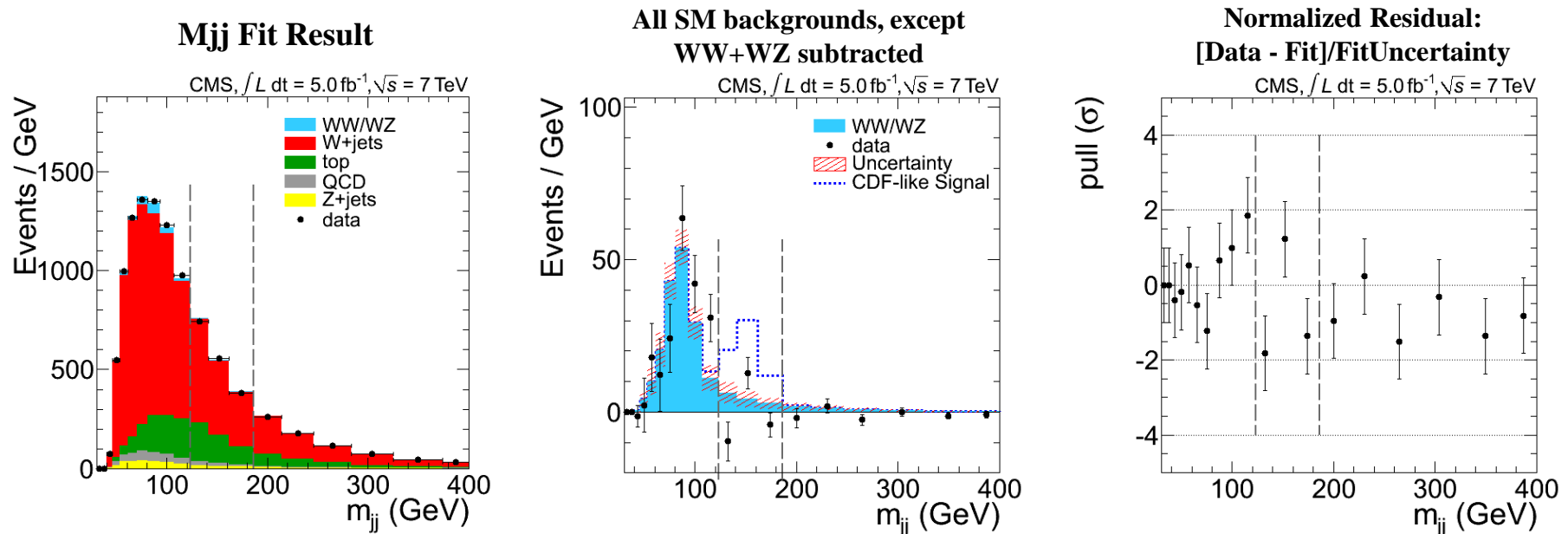
- Default (MADGRAPH) MC
- Either Matrix Element - Parton Shower Matching Up ($\mu=2\mu_0$) or Matching Down ($\mu=0.5\mu_0$) MC
- Either Factorization Scale Up ($q'=2q_0$) or Scale Down ($q'=0.5q_0$) MC

❖ The choice of Up or Down Sample is based on the best fit to the Data

❖ The relative fractions (α, β) and the overall normalization are free to vary in the fit (empirical model):

$$\mathcal{F}_{W+jets} = \alpha \cdot \mathcal{F}_{W+jets}(\mu_0^2, q_0'^2) + \beta \cdot \mathcal{F}_{W+jets}(\mu'^2, q_0^2) + (1 - \alpha - \beta) \cdot \mathcal{F}_{W+jets}(\mu_0^2, q_0^2)$$

Fit Output

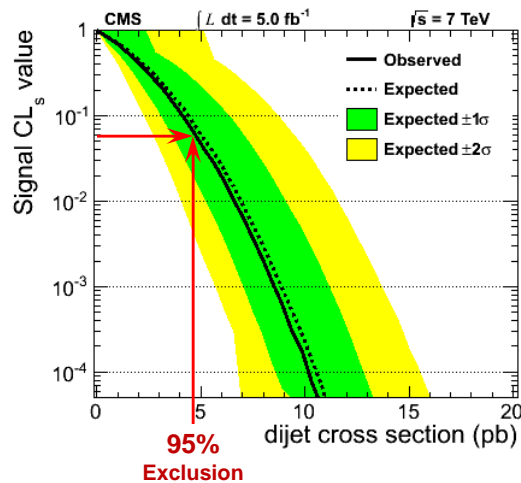


❖ Systematics

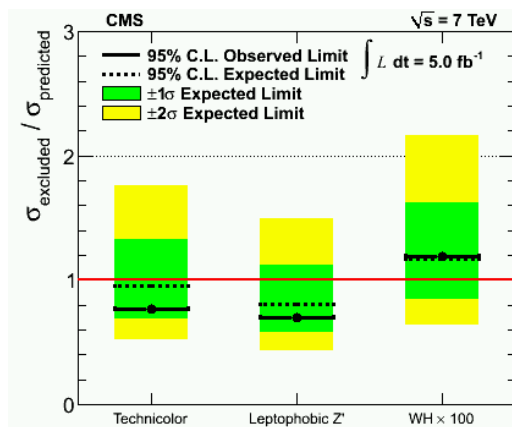
- M_{jj} distribution shape uncertainty for W +jets is covered by the empirical model
- We validate the fitter by performing pseudo-experiments (with correlations taken into account) and correct the yields (errors) based on the resulting (pull) distributions. The procedure also covers the uncertainty due to limited MC.
- Uncertainties due to JES, JER, MET resolution, trigger efficiency, lepton reconstruction & selection efficiency and luminosity are subsequently included.

Results

CL_s statistic for a generic Gaussian signal hypothesis



New Physics Exclusion Limits



- ❖ The analysis produces a high quality model of the data, where the pull distribution consistent with 0, and allows us to extract the diboson peak.
- ❖ We observe no resonant enhancement and set an upper limit of 5pb at 95% CL on the dijet production cross-section.
- ❖ Conservatively, assume the new-physics is generated via $q\bar{q}$ annihilation.
- ❖ $\sigma=4\text{pb}$ at the Tevatron corresponds to 16.7pb at the LHC (estimated using WH production with $M_H=150\text{GeV}$).
- ❖ Two theoretical models that predict a dijet resonance near 150 GeV are excluded at 95% CL.

Submitted To PRL: arXiv:1208.3477v1 [hep-ex]

Public Page: <https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEWK11017>

CMS: EWK-11-017/AN-11-266/AN-11-484

References

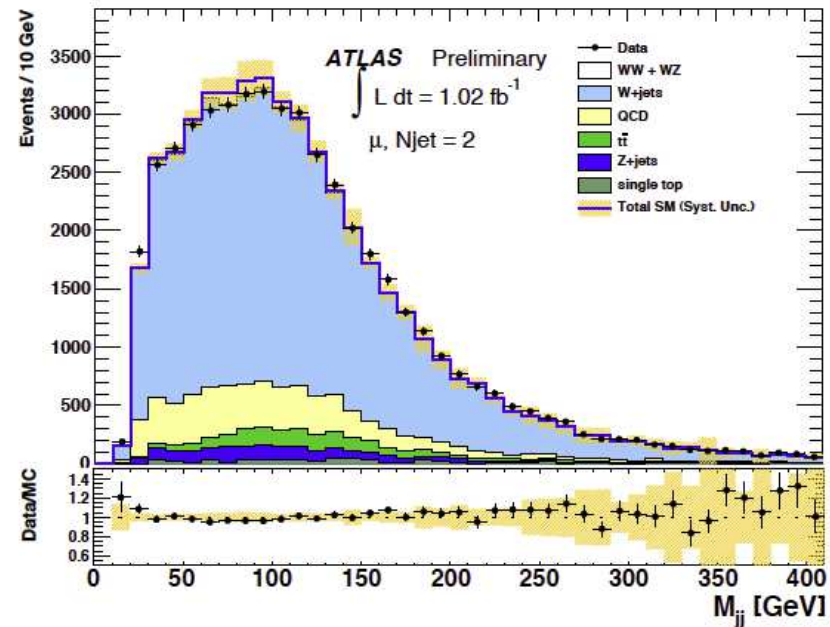
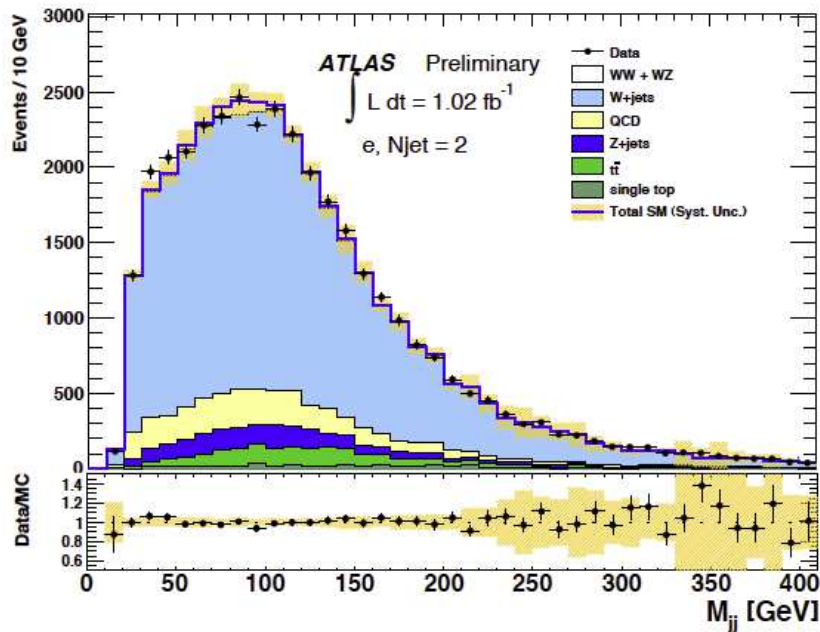
- CDF Search - arXiv: 1101.6079, Phys. Rev. Lett. 106:171801 (2011)
- D0 Search - arXiv: 1106.1921, Phys. Rev. Lett. 107:011804 (2011)
- In The News:
 - NBC: New subatomic particle: real or anomaly? - http://www.msnbc.msn.com/id/42497555/ns/technology_and_science-science/t/new-subatomic-particle-real-or-anomaly
 - Science News: Fermilab data hint at possible new particle - http://www.sciencenews.org/view/generic/id/72302/title/Fermilab_data_hint_at_possible_new_particle
 - NY Times: At Particle Lab, a Tantalizing Glimpse Has Physicists Holding Their Breaths - http://www.nytimes.com/2011/04/06/science/06particle.html?_r=0
 - Science News: No new particle from second detector - http://www.sciencenews.org/view/generic/id/331050/title/No_new_particle_from_second_detector
 - Discovery News: Tevatron's DZero Sees No Evidence of New Particle - <http://news.discovery.com/space/dzero-puts-the-brakes-on-possible-new-particle-110610.html>
 - NBC: Subatomic mystery leads to standoff - <http://cosmiclog.nbcnews.com/news/2011/06/10/6831067-subatomic-mystery-leads-to-standoff>
- Technicolor - E. J. Eichten, K. Lane, and A. Martin, “Technicolor Explanation for the CDF Wjj Excess”, 191 Phys. Rev. Lett. 106 (Jun, 2011) 251803.
- Leptophobic Z' - M. R. Buckley, D. Hooper, J. Kopp et al., “Light Z' Bosons at the Tevatron”, Phys. Rev. D 193 83 (2011) 115013, arXiv:1103.6035.



Backup

ATLAS Search

➤ Presented at EPS : ATLAS-CONF-2011-097 (1.02fb⁻¹)



❖ “The measured dijet mass spectrum shows no significant excess over the Standard Model expectation”