Title: Search for Universal Extra Dimensions in Diphoton Events with High Transverse Energy with the ATLAS Detector

Date: Dec 07, 2010 02:30 PM

URL: http://pirsa.org/10120036

Abstract: TBA

Search for Universal Extra Dimensions with Gravity Mediated Decays in Diphoton Events with High Missing Transverse Energy

Perimeter Institute December 7, 2010

Xabier Anduaga[e], Bertrand Brelier[f], Marco Delmastro[a], Kamile Dindar[d],
Maria Teresa Dova[e], Yaquan Fang[g], Behi Fatholahzadeh[f], Haleh Hadavand[d],
Robert Kehoe[d], Haifeng Li[g], Lianliang Ma[g], John Parsons[b],
Helenka Przysiezniak[c], Martin Tripiana[e], Haichen Wang[g], Sau Lan Wu[g]

[a] CERN
[b] Columbia University
[c] LAPP, Annecy
[d] Southern Methodist University
[e] Universidad Nacional de la Plata
[f] University of Toronto
[g] University of Wisconsin

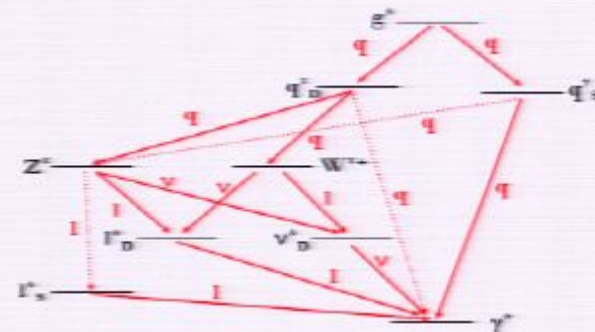# Introduction:

One Universal Extra Dimension (UED)
"Universal" = All SM particles propagate into the extra Dimension (TeV^{-1})

KK quarks/gluons are produced in pairs, which cascade decay down to the LKP γ^*

Gravity mediated decays of the LKP can become possible when N extra dimensions (eV^{-1}) into which only Gravitons can propagate are introduced
$\gamma^* \dashrightarrow \gamma$ + Graviton(*)

***** 2 High P$_T$ photons and Missing Energy ********

Pythia 6.4.20 UED – First level KK mass spectrum [GeV]

$1/R=500GeV$
$\Lambda R \sim 20$
$\alpha_s = 0.118$

R-Compacitification scale of the theory
Λ-cut off scale of the UED model
M$_D$-Planck Scale in 4+N Dim theory
Our choice (preferred theory parameters):
ΛR=20, N=6, M$_D$=5TeV

D0 has excluded
1/R<477 GeV @ 95% CL
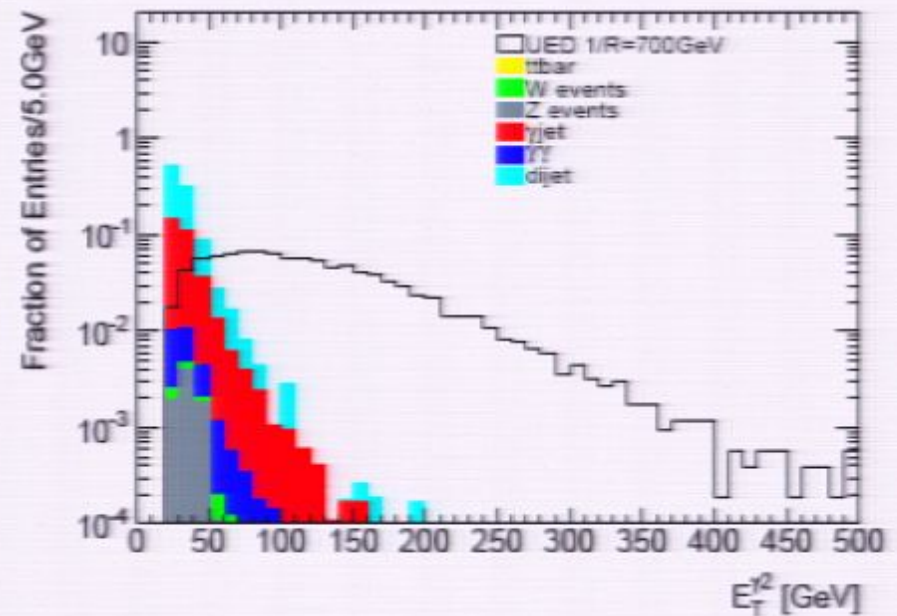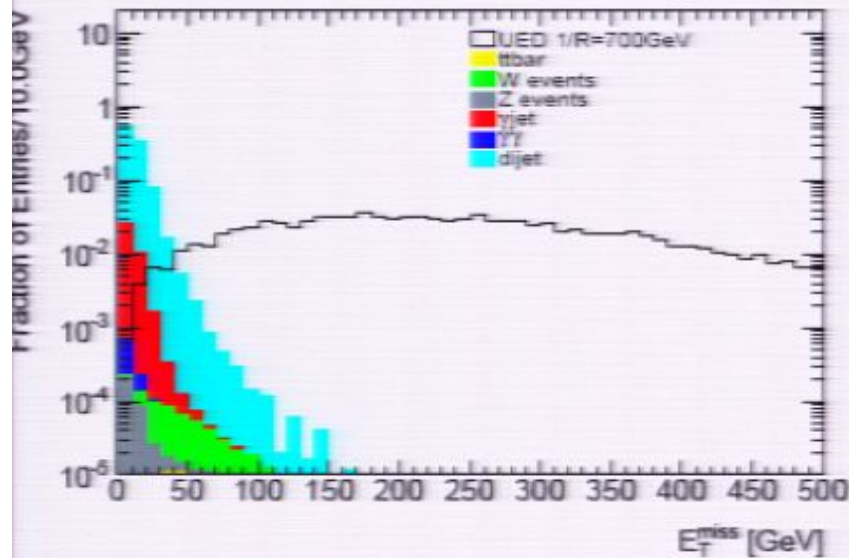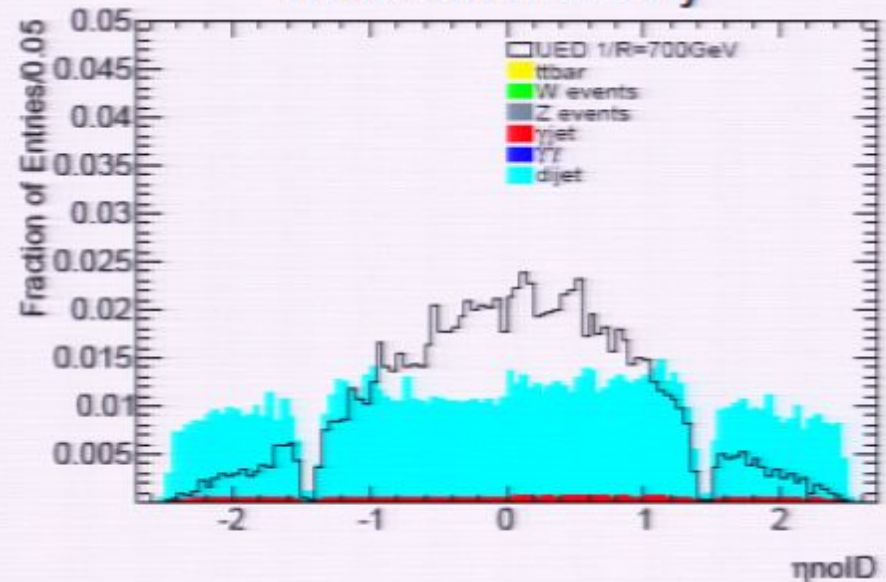**[arXiv:1008.2133]**
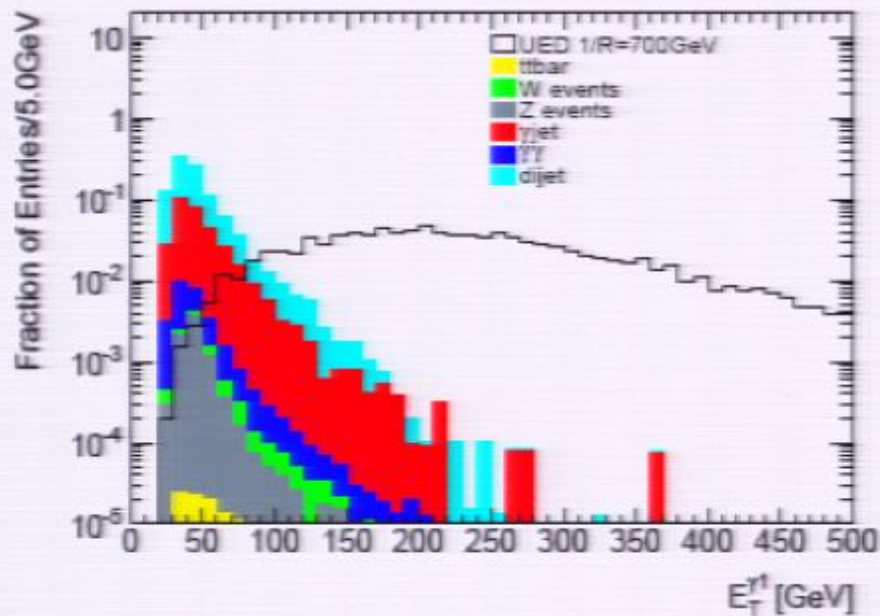
UED Signal Event Topology:

The leading and second leading photons in signal events are significantly harder than the SM background.

UED Signal Event Topology:

The Etmiss distribution has a significantly harder spectrum in signal than SM background (left).

The Leading photons are more central than in SM background (right).

Some Definitions:

Reconstructed Photons:

- A sliding window algorithm is used to find clusters. The window slides in the $\eta \times \phi$ grid of towers to find local energy peaks. The energy in this fixed window is used as the EM cluster energy.
- A very loose cut on the Ratio of E_T in the first sampling of the hadronic Calorimeter to the E_T of the EM cluster < 0.2 is also applied
- If no matching track then this EM cluster is classified as an unconverted photon. If at least one matching track then look for a conversion vertex inside the tracker – If such a vertex is found this EM cluster is classified as a converted photon.
- Corrections for transverse and longitudinal energy loss etc. are then applied

ETCone20:

- [Total ET in a cone of size $\Delta R=0.2$ about centroid)]– [EM Cluster ET]

Loose Photon Identification:

- R_{had} (R_{had1}) – Ratio of E_T in the (first sampling of the) hadronic calorimeter to E_T of the EM cluster.
- R_η – Ratio between the sum of the energies of the cells contained in a 3x7 $\eta \times \phi$ rectangle (measured in cell units), and the sum of the cell energies in a 7x7 rectangle, both centered around the cluster seed
- $\omega_{\eta 2}$ – Lateral width of the shower in the η direction

Event Selection:

BASELINE:

- Trigger requirements and a set of cleaning cuts

- At least 2 **reconstructed photons** with
E_T > 25GeV and $|\eta|$ cuts (within the coverage of the pre-sampler excluding transition region between the barrel and endcap)

FINAL SELECTION:

- Isolation cut on both photons (**ETCone20** < 35 GeV)

- Both Photons pass a **Loose identification** cut (called **Loose-Loose** sample)

OR

- One photon fails the Loose identification cut (used for data-driven bkgd estimation method and referred to as the **misidentified jets** sample)

- Missing Transverse Energy (MET) > 75 GeV (+ Loose-Loose called **Signal region**)

***Defined on previous slide

Event Selection:

BASELINE:

- Trigger requirements and a set of cleaning cuts

- At least 2 **reconstructed photons** with
$E_T > 25$GeV and $|\eta|$ cuts (within the coverage of the pre-sampler excluding transition region between the barrel and endcap)

FINAL SELECTION:

- Isolation cut on both photons (**ETCone20** < 35 GeV)

- Both Photons pass a **Loose identification** cut (called **Loose-Loose** sample)

OR

- One photon fails the Loose identification cut (used for data-driven bkgd estimation method and referred to as the **misidentified jets** sample)

- Missing Transverse Energy (MET) > 75 GeV (+ Loose-Loose called **Signal region**)

6

***Defined on previous slide

Analysis Strategy:

Predict the expected number of background events in the signal region (Loose-Loose with MET>75 GeV) from data (0 events observed in 3.1 pb^{-1}).

MODELLING THE BACKGROUND MET SPECTRUM IN THE LOOSE-LOOSE TOPOLOGY:

"MET from *QCD*"
- Common SM processes with no real MET, but providing events with MET due to MET resolution, tails
- Dominant processes are γγ, γ-jet and multijet events with at least one jet faking a photon
- **Model using data**

"Genuine MET"
- W->eυ events, with e faking a photon and the second photon is either real (Wγ) or a jet faking a photon (W+jet)
- **Measure using data**

"Irreducible γγ + MET"
- Mostly from W/Z + γγ, with W/Z decays to neutrino(s)
- **Negligible**, Cross-sections on the order of a few fb

MET From QCD:

- The **MET** spectrum in the Loose-Loose sample arising from *QCD background* can be modelled using a 'soft MET' topology (to emulate real ɣs or highly EM-like Jets) and a 'harder MET' topology (to emulate the hadronic activity)

- The **MET** spectrum of Z->ee events is used to model the 'soft' component of the Loose-Loose topology and should be dominated by the calorimeter response to 2 genuine EM objects.

- The **MET** spectrum of the misidentified jets sample is used to model the 'harder' component of the Loose-Loose topology.


ATLAS Preliminary
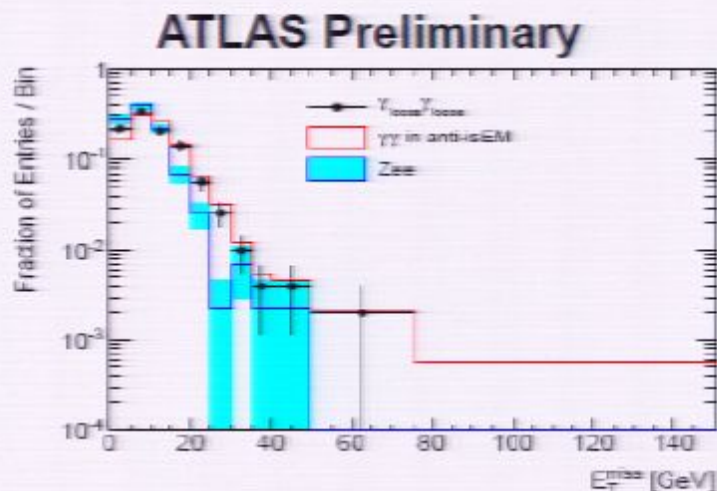
Weighted sum of **Z**ee and misidentifed jets sample is normalized and fitted to MET <20GeV in the Loose-Loose topology. The relative fraction of Zee from the fit is 36±22% (use uncertainty as a systematic error on bkgd).

Genuine MET:

- **Measure (small) W bkgd (with e faking photon) using W->eυ data**

- **Furthermore, if we ask also for a photon with ET>25 GeV in the event, we select out 5 "W+γ" events**

- **Given the rate of e faking a photon (determined from Zee sample), this corresponds to a total background of only ~0.4 events in the Loose-Loose sample**

- **Use MET spectrum of W+jets as template for shape (below) and normalize to 0.4.**
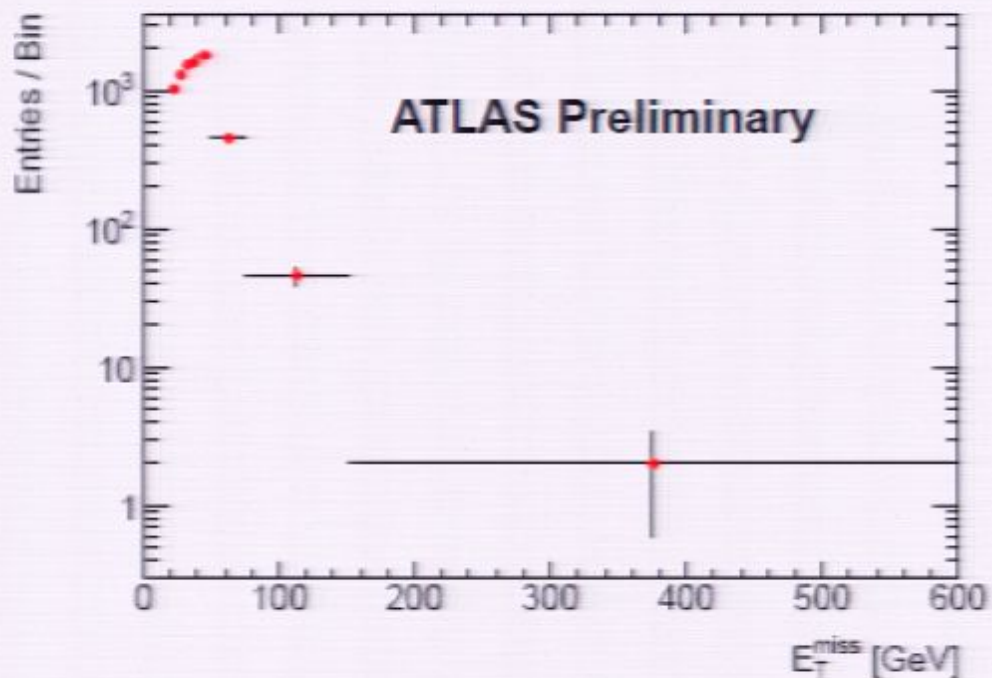
Final MET Spectrum:
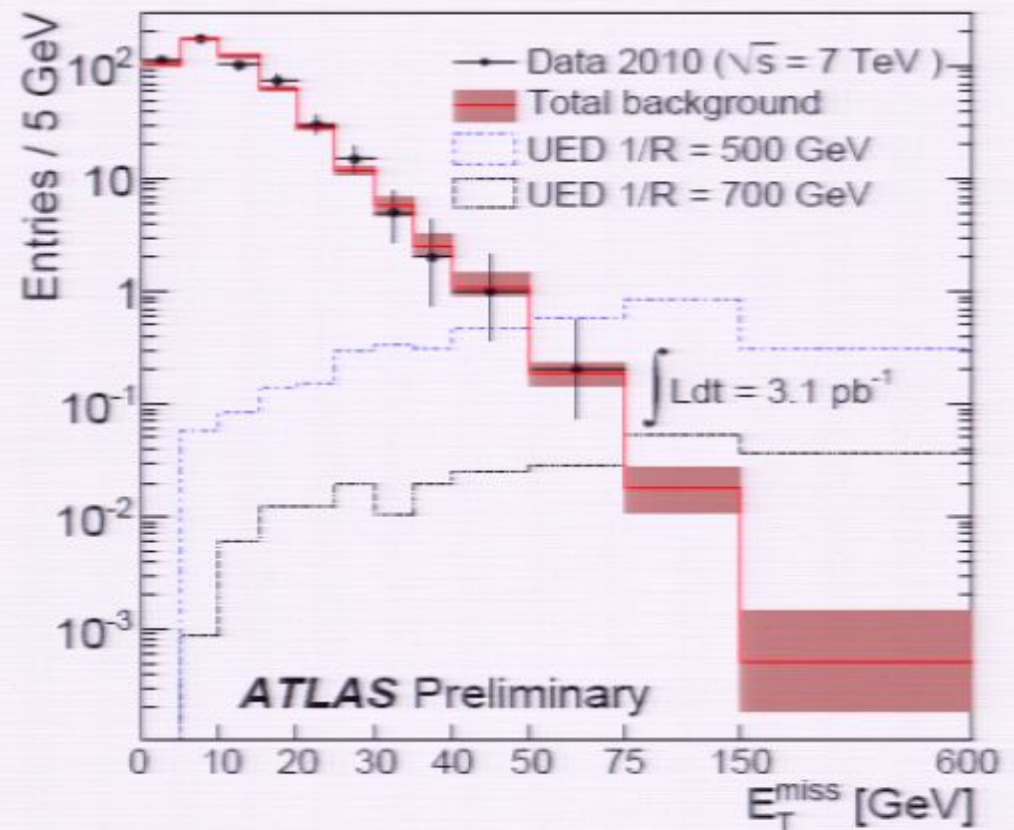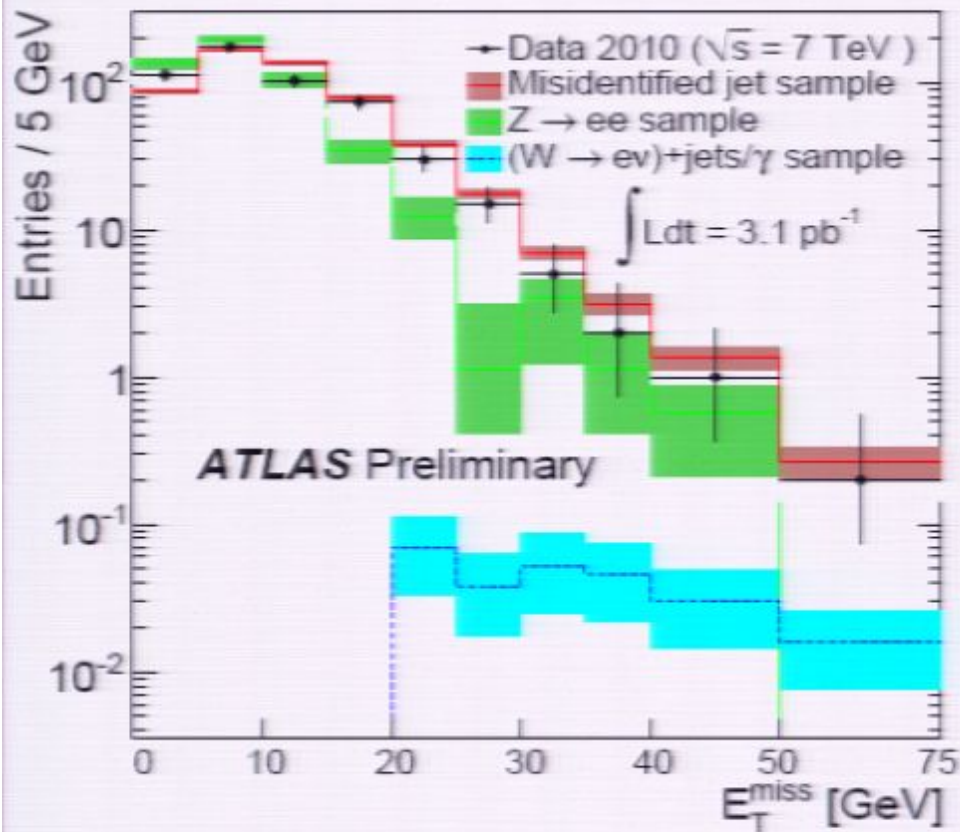
Good agreement between data and predicted background over the whole MET spectrum with no indication of an excess at high MET values.

Systematics for Signal (UED 1/R=700 GeV):

Source of Uncertainty	Uncertainty
Integrated Luminosity	11%
Photon Systematics	3.3%
Effect of Pileup	1.6%
Missing ET Resolution and Scale Uncertainties	0.2%
Signal MC statistics	1%
Total:	12%

Systematics for Background Estimation Method:

Expected number of background events in the signal region:

$$0.32 \pm 0.16 \text{ (stat.)} +0.37, -0.10 \text{ (syst.)}$$

Systematics determined by:

- varying within its error the Zee fraction determined in the fit of the QCD background

- Changing the misidentified jet sample definition – both photons fail Loose selection/ exactly one photon fails the loose selection

- Removing the isolation cut

Conclusions:

The UED model with gravity mediated decays (ΛR=20, N=6) has been excluded at 95% CL for 1/R<728 GeV
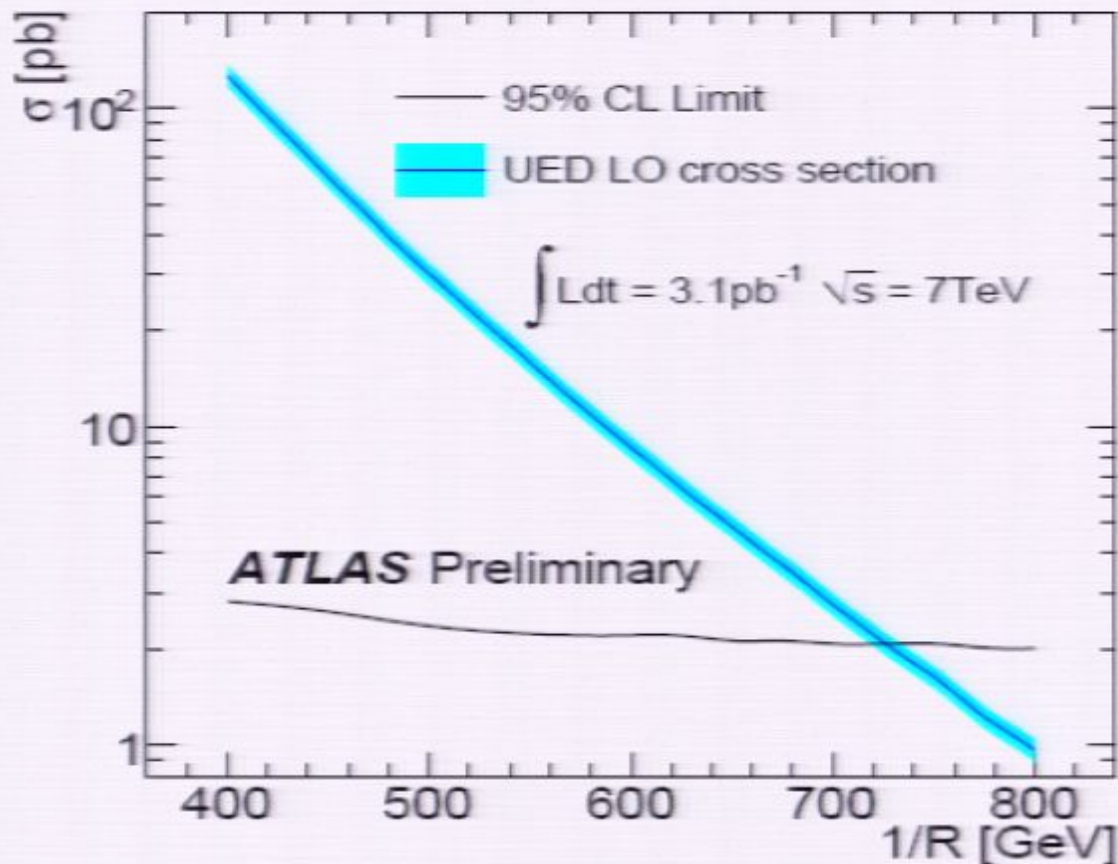
LO cross-section is used in above plot since no higher order corrections have been calculated. The blue band represents the PDF uncertainty on the UED cross-section.