
Searches for extra dimensions in ATLAS



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On behalf of the ATLAS Exotics group

Outlines

- Introduction
- Selection of topics:
 - Gravitational direct production
 - Generic bulk scalar coupling to Higgs
 - Black Holes
- Complete list of Extra dimensions analysis in ATLAS:
<http://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/EXOTICS/ExtraDimensions.htm>

Introduction

- 4D world: $M_P \gg M_{EW} \rightarrow$ Hierarchy problem
- Possible solution: $n+4$ D world:
 - 3+1 dimensions (brane): SM interactions
 - Extra dimensions with new phenomenology:
 - Gravity flows in $n+3$ space dimensions (bulk):
 - $1/r^2$ law does not hold for $r < 0.1$ mm (Black Holes in pp coll.)
 - Fundamental Planck mass M_D can be as low as 1 TeV (TeV scale gravity)
- Most studies performed with 100/fb luminosity and ATLFAST (ATLAS fast simulation program)

Graviscalar production

- LED models with extended Supersymmetry (SLED):
 - Supersymmetric Bulk
 - Natural UV completion in string theory
 - Implications to Λ through quantum corrections
 - Graviton multiplet → **scalar bulk particle**

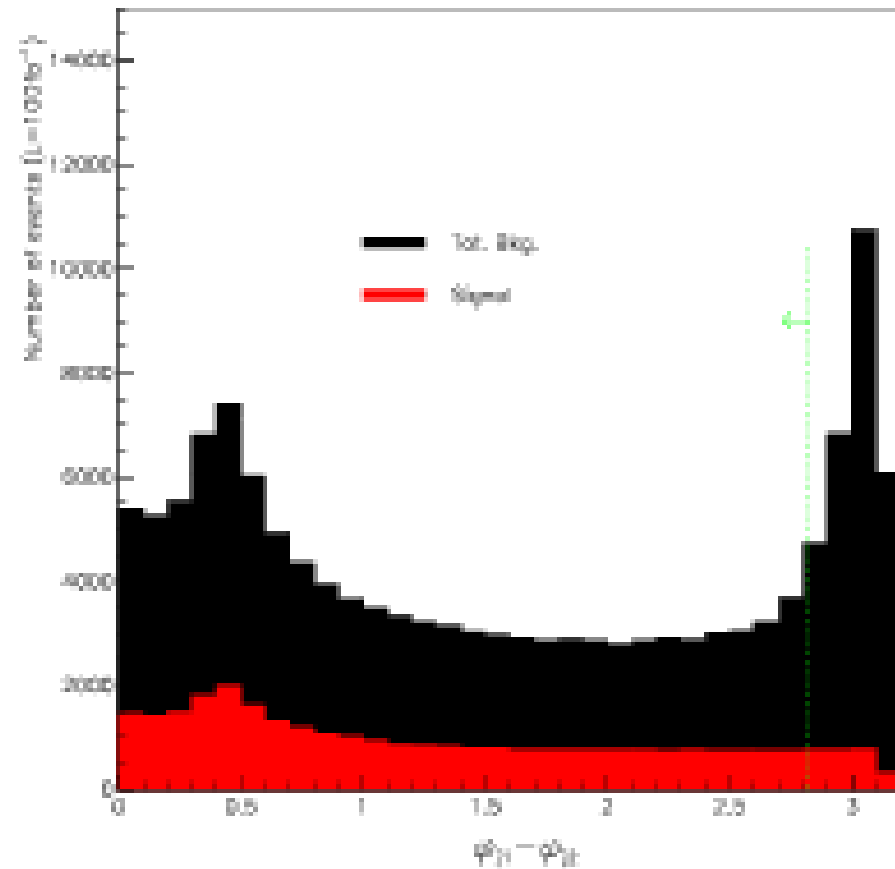
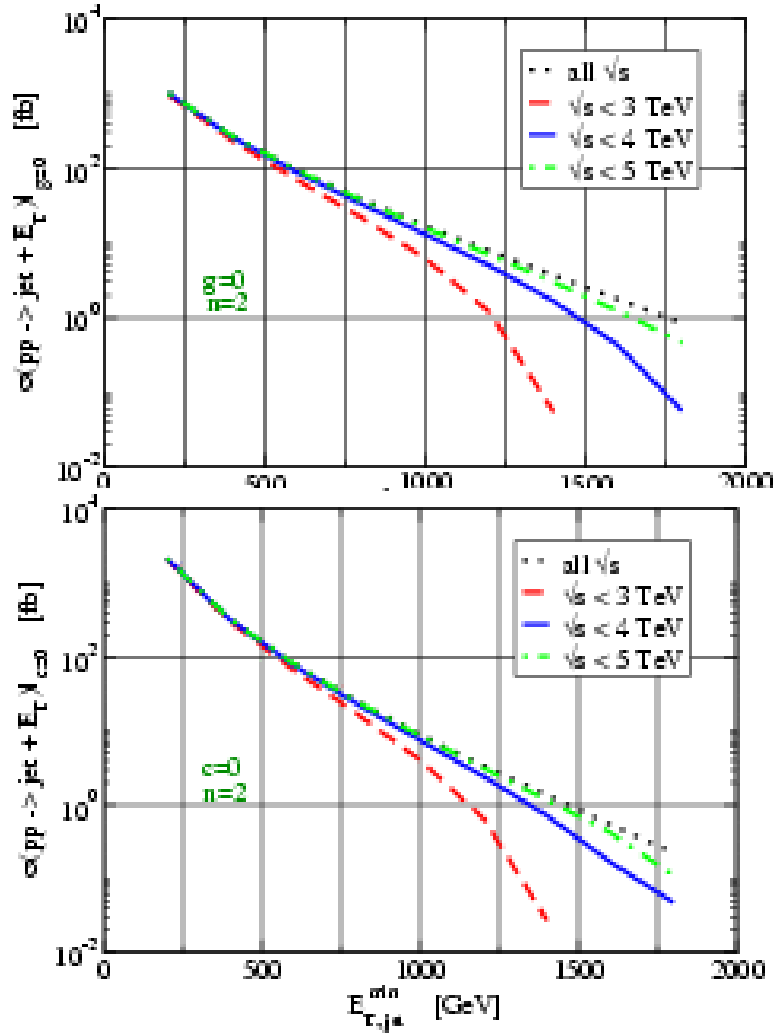
| | |
|-------------------------------|----------------------|
| Graviton (spin2) | Gravitino (spin 3/2) |
| Graviphoton (spin 1) | (spin 1/2) |
| “Graviscalar” (spin 0) | |

- **Same jet + missing transverse Energy as previous graviton searches** (I Hinchliffe and L Vacavant, J. Phys G:27 (2001) 8)

Search for Gravitiscalars



(Azuelos et al., SN-ATLAS-2004-037)

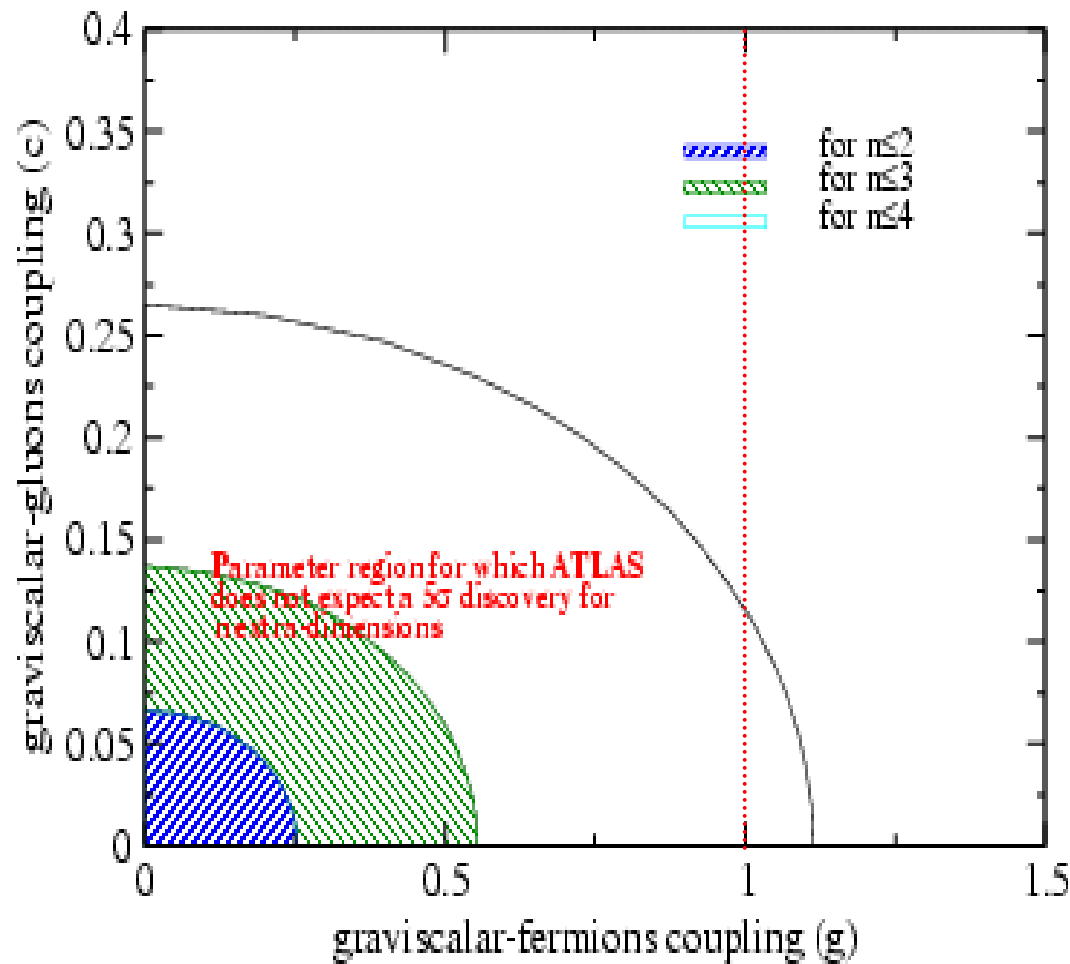


Sensitivity to Graviscalars



| ndim | M_D^{\min} (TeV) | M_D^{\max} (TeV) |
|------|--------------------|--------------------|
| 2 | 3.60 | 14.10 |
| 3 | 4.30 | 9.50 |
| 4 | 4.85 | 7.55 |
| 6 | 5.70 | 5.80 |

$g=0$



x-s reliability

reach

| ndim | M_D^{\min} (TeV) | M_D^{\max} (TeV) |
|------|--------------------|--------------------|
| 2 | 3.2 | 14.00 |
| 3 | 3.8 | 6.45 |
| 4 | 4.4 | 1.45 |

$c=0$

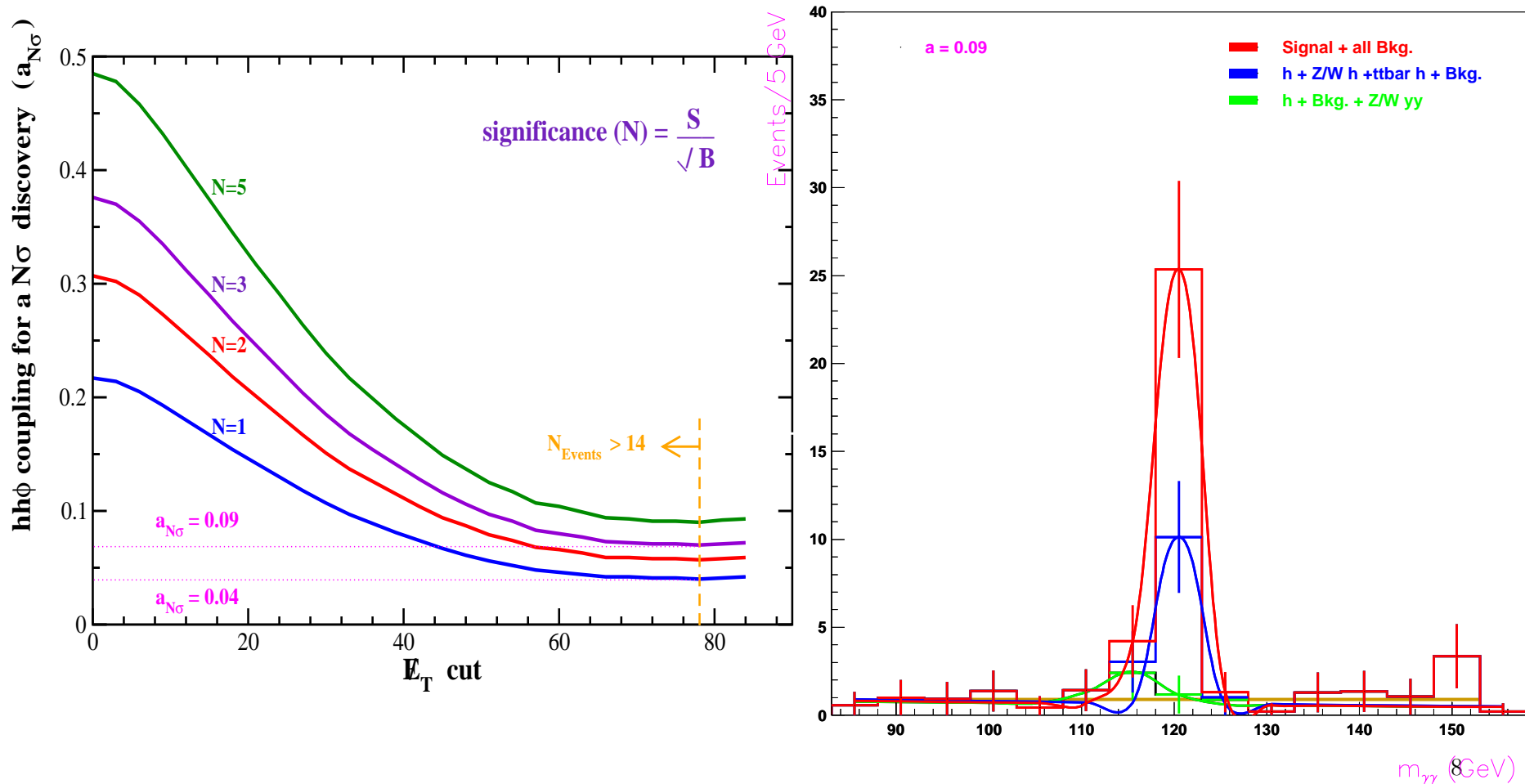
Bulk scalars coupling to Higgs

- 6D SLED model: astrophysical constraints \rightarrow $M_D \sim 10$ TeV
- Higgs sector: **trilinear dimensionless** (unsuppressed) **coupling** between **bulk scalar ϕ and scalar Higgs** \rightarrow **free parameter** in analysis
- Impact on Higgs production and searches.
- **Associated production: $pp \rightarrow H\phi \rightarrow H$ decays (e.g. $\gamma\gamma$) + missing transverse energy. (Beauchemin et al, submitted to JHEP)**

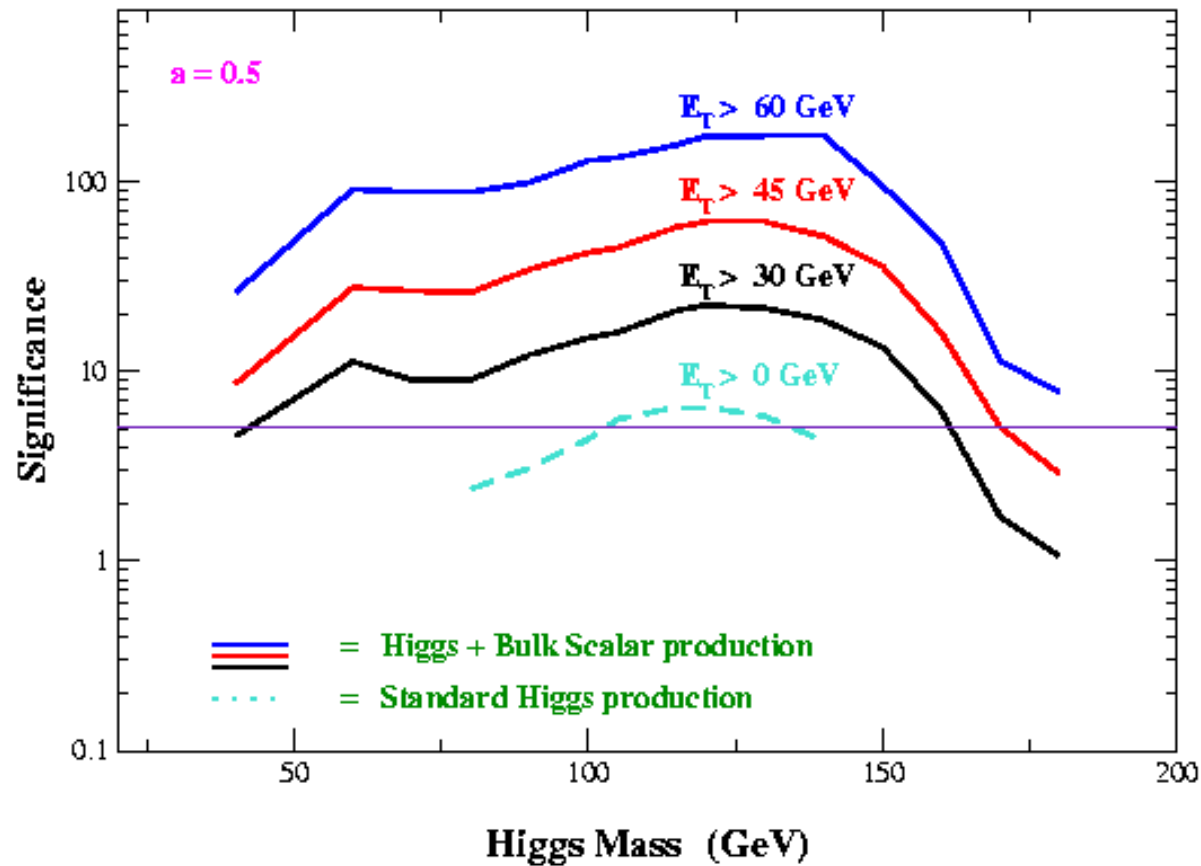
Search for associated production of bulk scalars in ATLAS



Standard Higgs search analysis + missing transverse energy cut



Consequences on Higgs searches



Black hole production and decays

- gravity becomes dominant when $r \sim R_S$:

$$R_S(M_{BH}) = \frac{1}{\sqrt{\pi} M_D} \left[\frac{M_{BH}}{M_D} \left(\frac{8\Gamma(n + 3/2)}{n + 2} \right) \right]^{1/(1+n)}$$

- TeV scale gravity: $M_D, M_{BH} \sim \text{TeV}$, $n > 2 \rightarrow \sigma = \pi R_S^2 = \mathbf{O(100\text{pb})}$
- pp collisions with $b < R_S \rightarrow$ black holes
- Black holes decays, 4 consecutive phases:
 - **Balding**: mass loss up to 16 % in 4D, less known with $n+4$ D
 - **Hawking evaporation** into SM particles:
 - Kerr (spin down)
 - Schwarzschild (radiation)
 - **Planck phase**: non perturbative regime, not well known

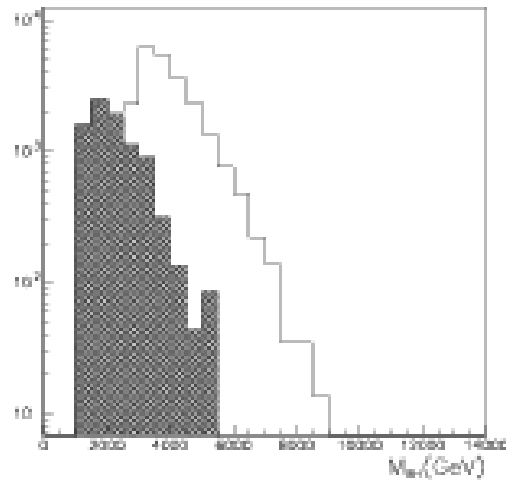
ATLAS search for black holes

- ATLAS analysis (Tanaka et al., ATL-PHYS-2003-037) based on simple assumptions: all decay products from Hawking phase, black body spectrum
- Analysis strategy:
 - Reconstruct M_{BH}
 - Fit T_{H} from the energy spectrum of radiated particles, assuming Black body spectrum
 - Get n from log relationship between T_{H} and M_{BH} , with $ct T_{\text{H}}$.

Black hole searches

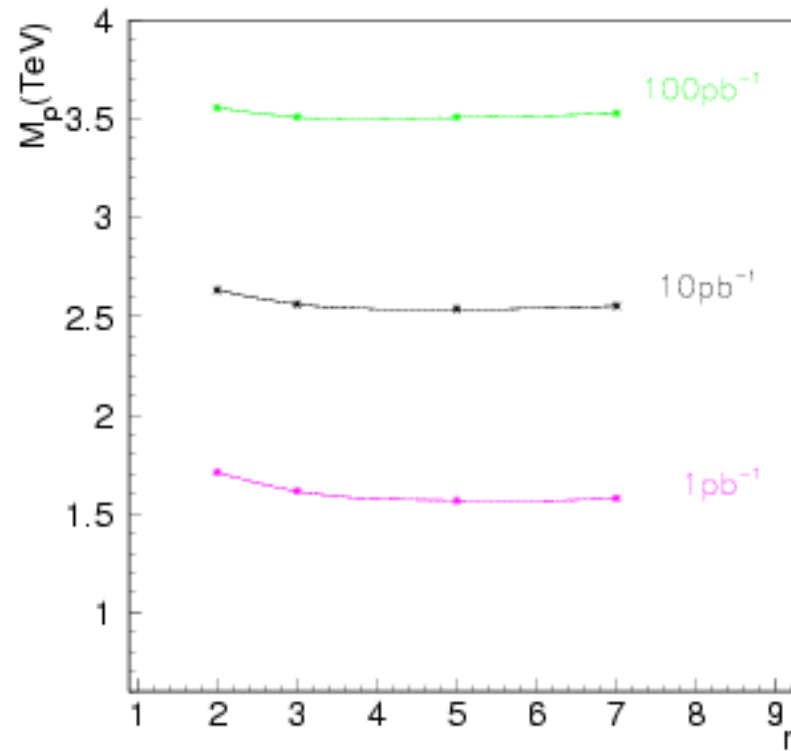
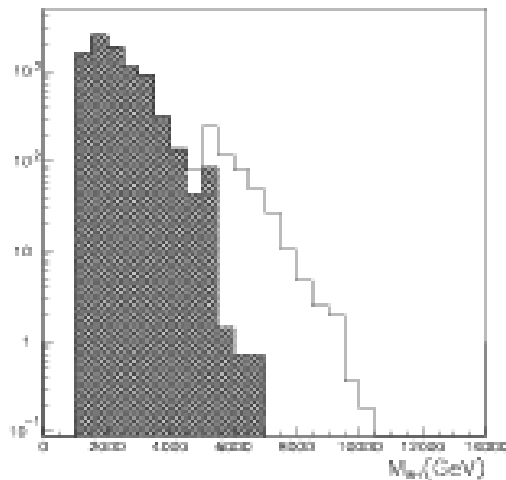


(b) $M_P=3$ TeV



$n = 3$

(d) $M_P=5$ TeV



$$\sigma \propto M_D^{-3} \left(\frac{\Gamma\left(n + \frac{3}{2}\right)}{n + 2} \right)^{\frac{2}{1+n}}$$

Conclusions

- Small selection of most recent topics treated by ATLAS
- Much more to come: new topics (UED, $t\bar{t}$ bar polarization) or updates (Black Holes)
- Stay tuned...