Searches for New Physics in Multijet Final States with the ATLAS Detector at the LHC

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Introduction

Searches in multijet final states are

- **Challenging. SM background is huge and hard to estimate.**
- **Important and interesting in their own rights.**
- **Complementary to searches in cleaner final states.**

I will discuss two analyses that look for every exciting new physics phenomena using mulitjet events.

Search for production of black hole

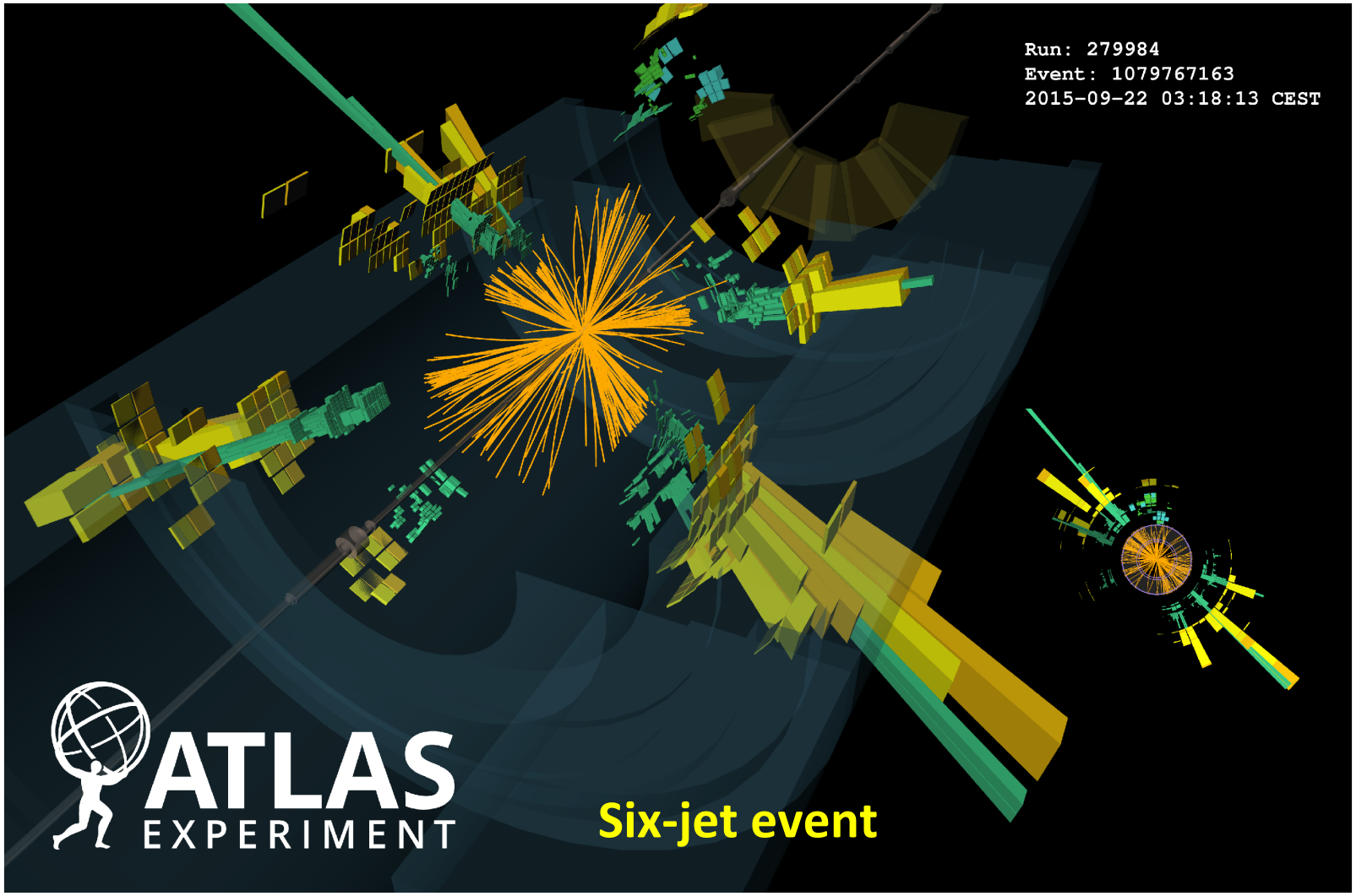
Search for gluino pair production (R-parity violating)

These signals are produced strongly and tend to have large cross sections.

Search for black hole in the multijet events

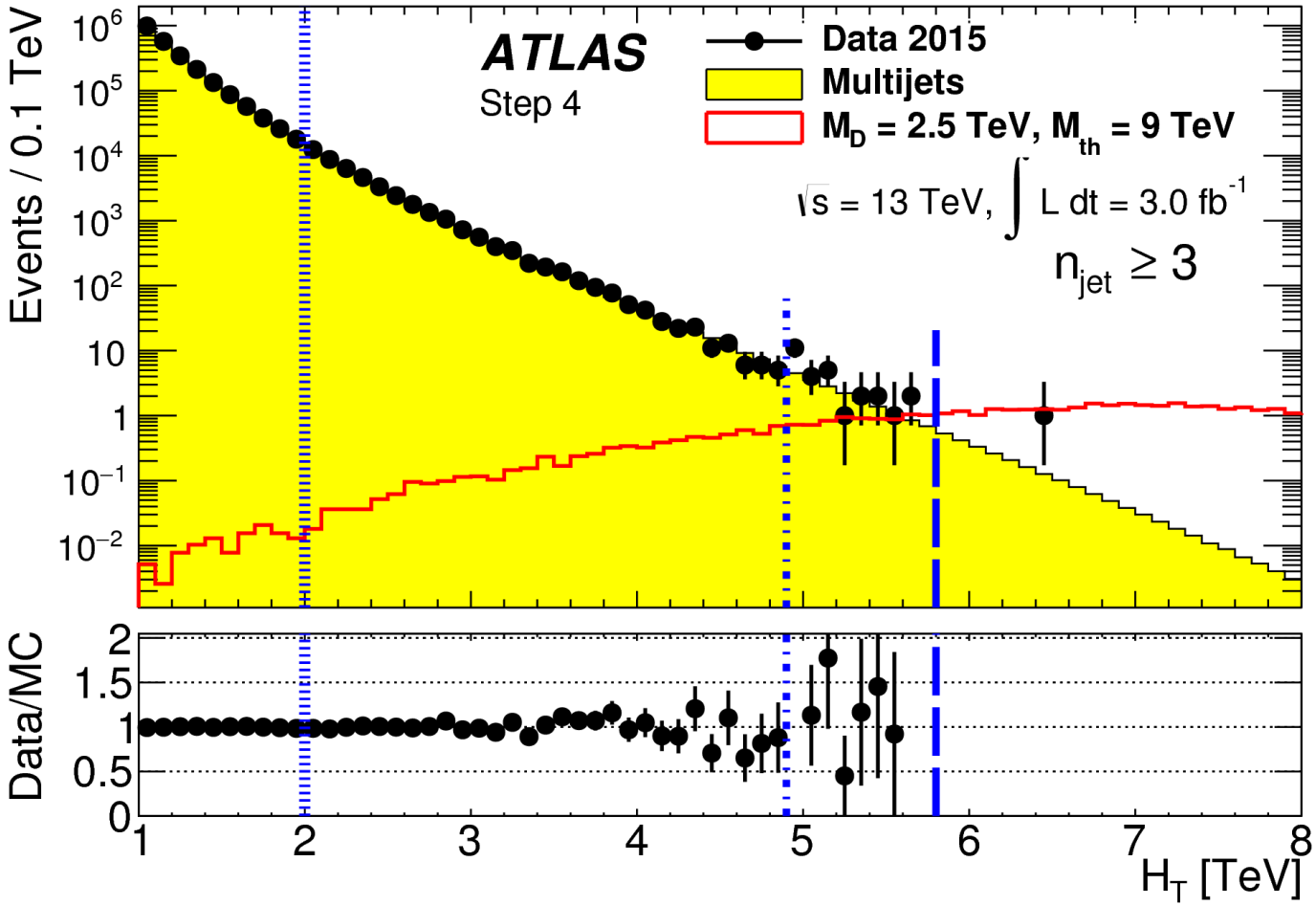
arXiv:1512.02586 published on JHEP

In theories of extra dimensions, a black hole can be produced at the LHC and will decay to many particles. The black hole would have a mass of a few TeV. A final state with a large number of high-p_T jets.



arXiv:1512.02586 published on JHEP

- **Observable: H_T scalar sum of jet p_T.**
  - **pT > 50 GeV, |η| < 2.8, njet >= 3**
- **Black hole signal appear as excess at the tail of H_T.**
- **A fit method method is used to estimate the background.**



Search for excess in the multijet events

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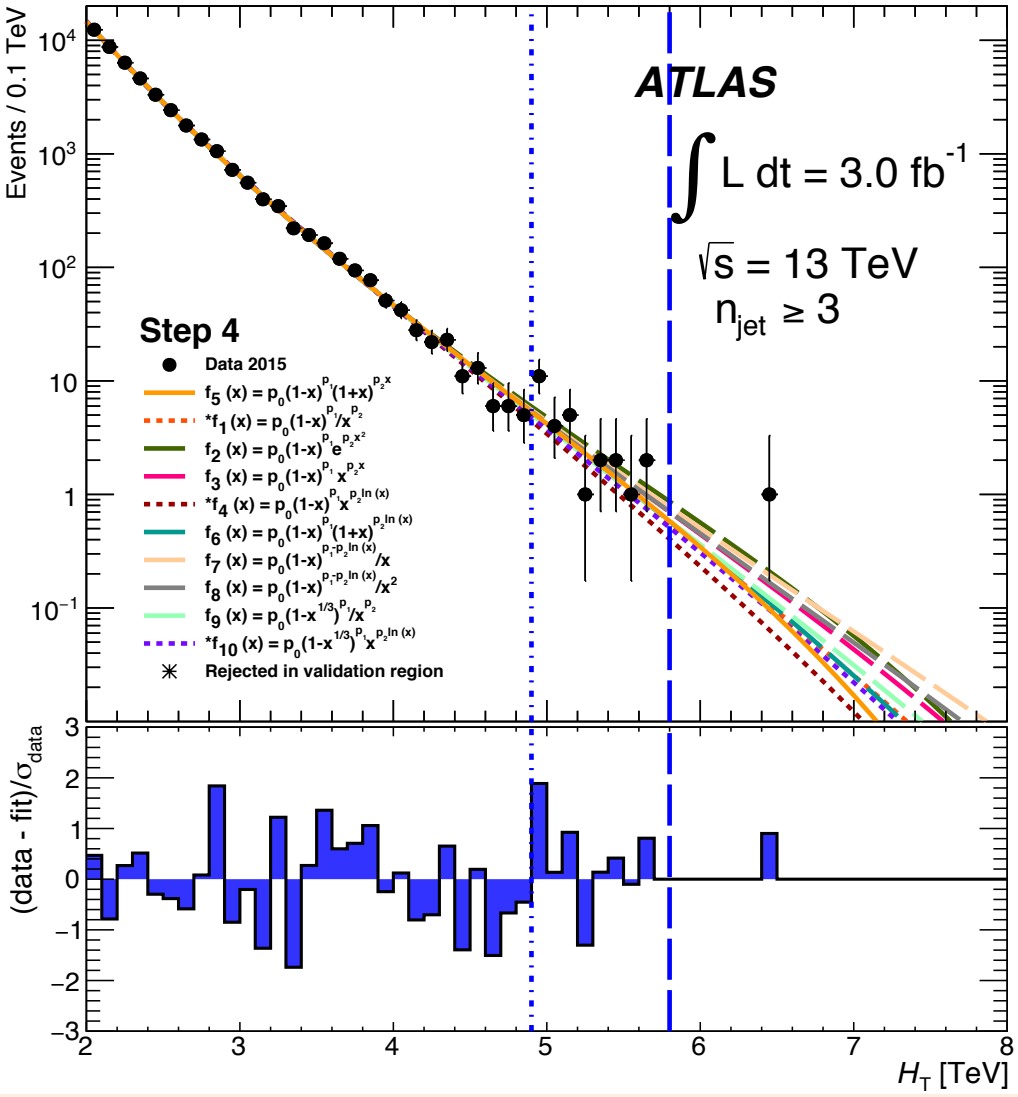
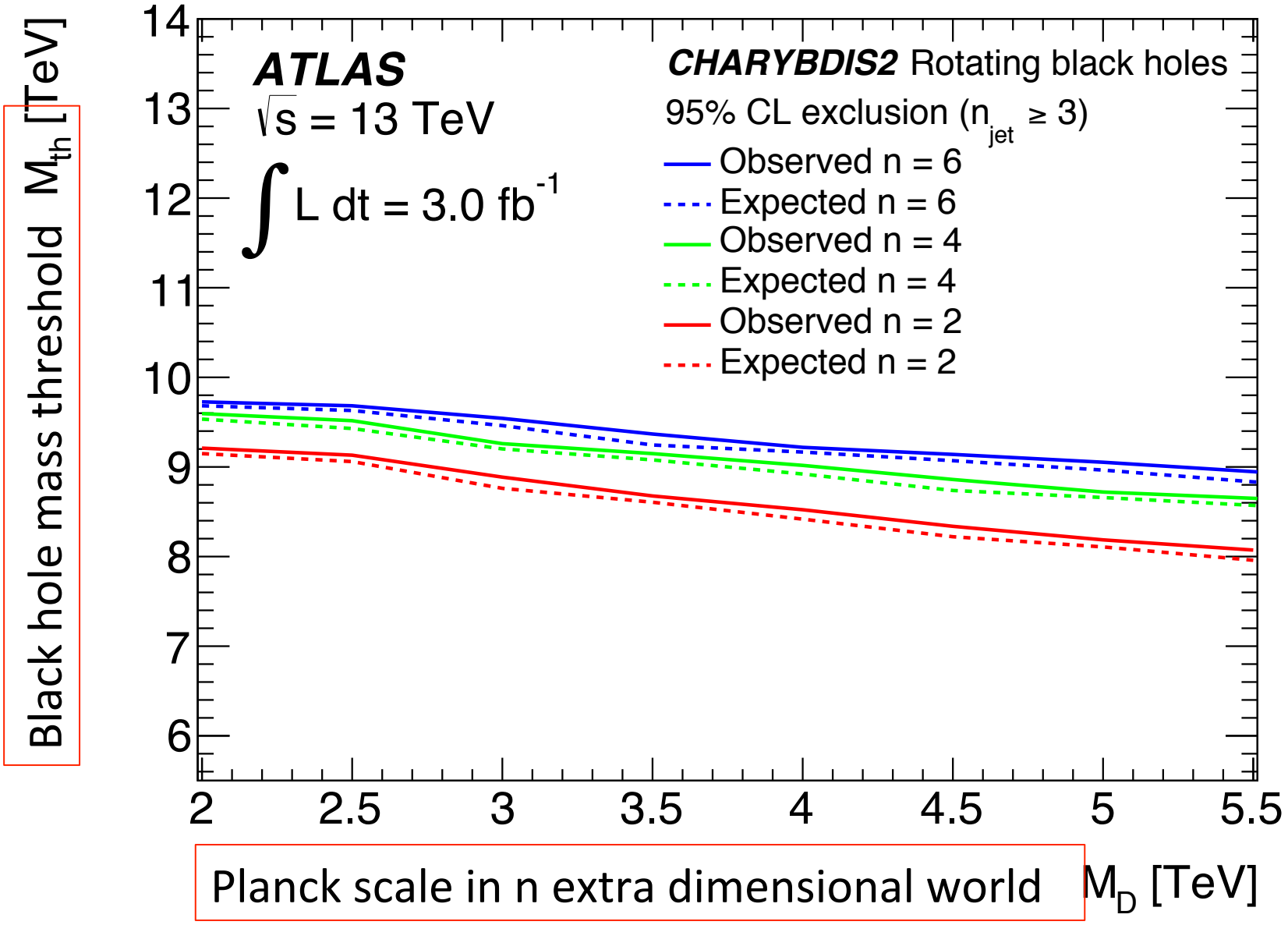
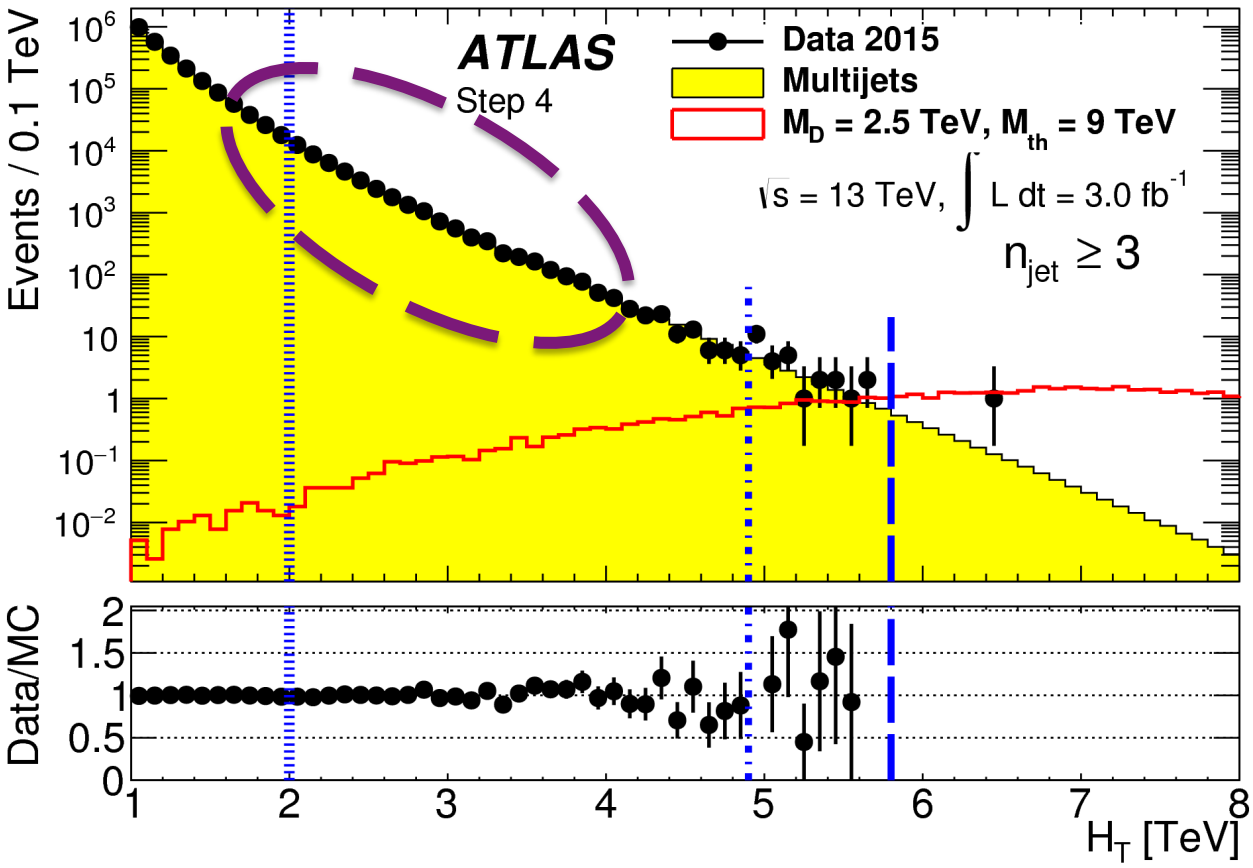


Fit in CR, validation in VR, prediction in SR

Limit on the production of black hole



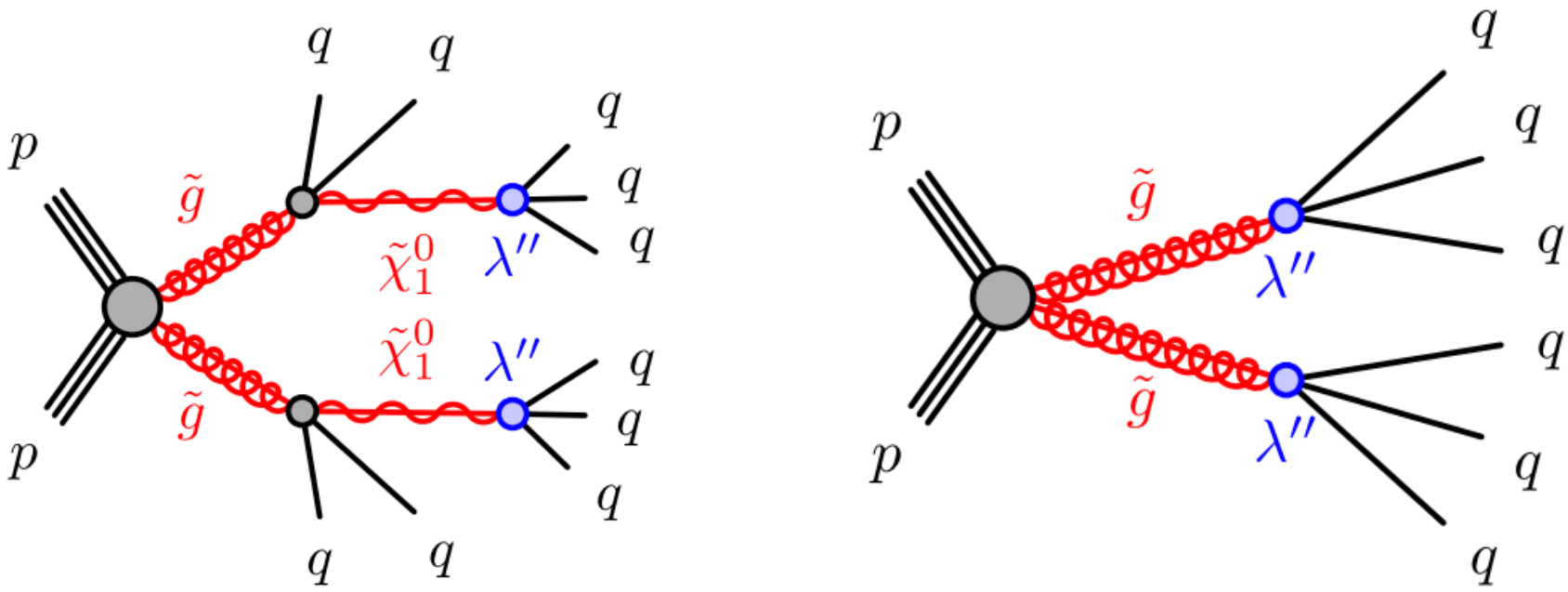
Signatures like high mass black hole are exceptional.



What if signals appear at intermediate H_T ?

This motivates new observable and new background estimation method.

R-parity violating SUSY models



- Gluino pair production, as an example
- **Lightest supersymmetric particles decay to quarks via RPV couplings.**
- **Gluino mass is allowed to be as low as a few hundred GeV.**

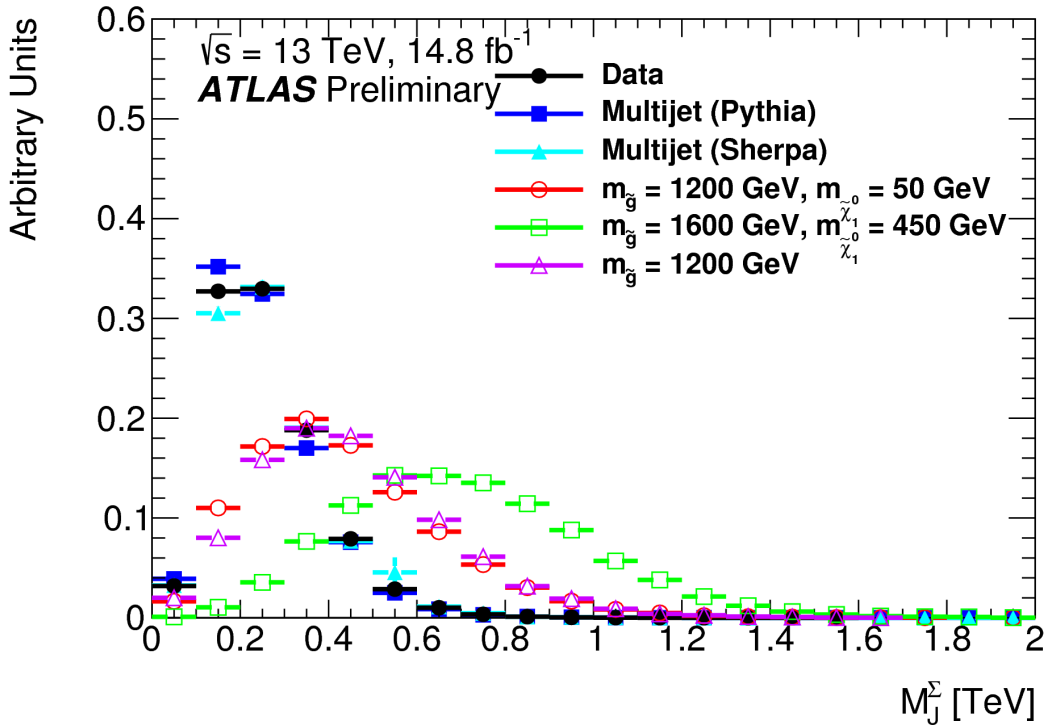
Total jet mass M_J^{Σ}: sum of individual jet mass

parton shower

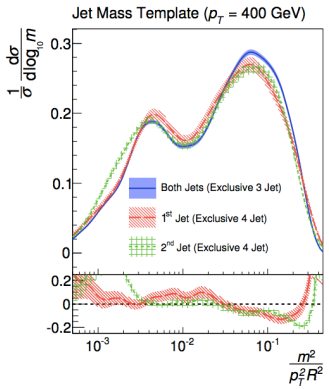
$$\langle m_{j_i}^2 \rangle \propto \alpha_s p_{T,i}^2 R^2$$

Heavy particle decay

$$\langle m_{j_i}^2 \rangle \propto p_{T,i}^2 R^2$$



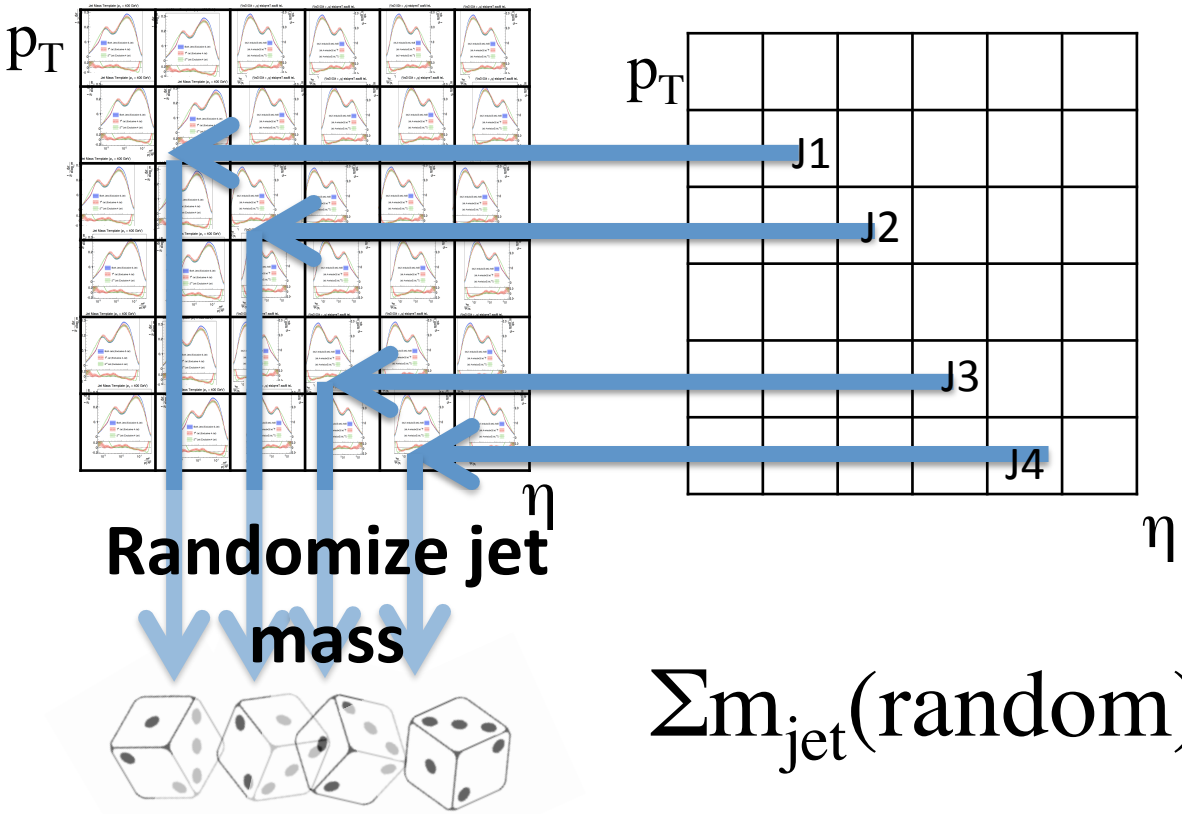
Jet mass PDF



Control region
3-jet events

Signal region
>= 4 jets

(jet1, jet2, jet3, jet4)



$\Sigma m_{jet}(random)$

The distribution of randomized total jet mass will reproduce the background distribution.

Result with 14.8 fb-1 data at √s = 13 TeV.

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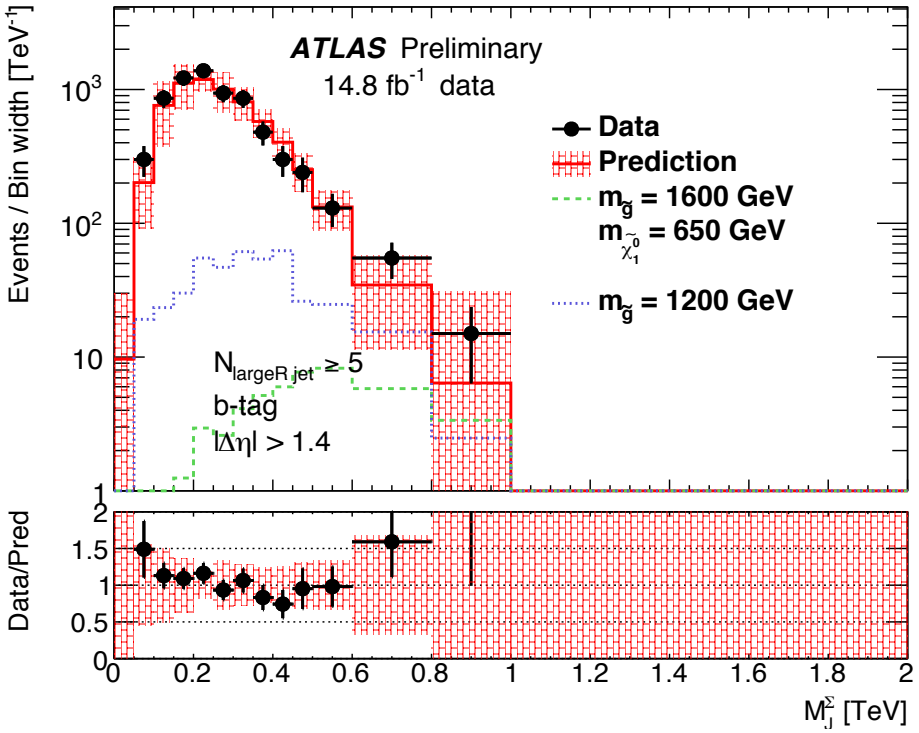
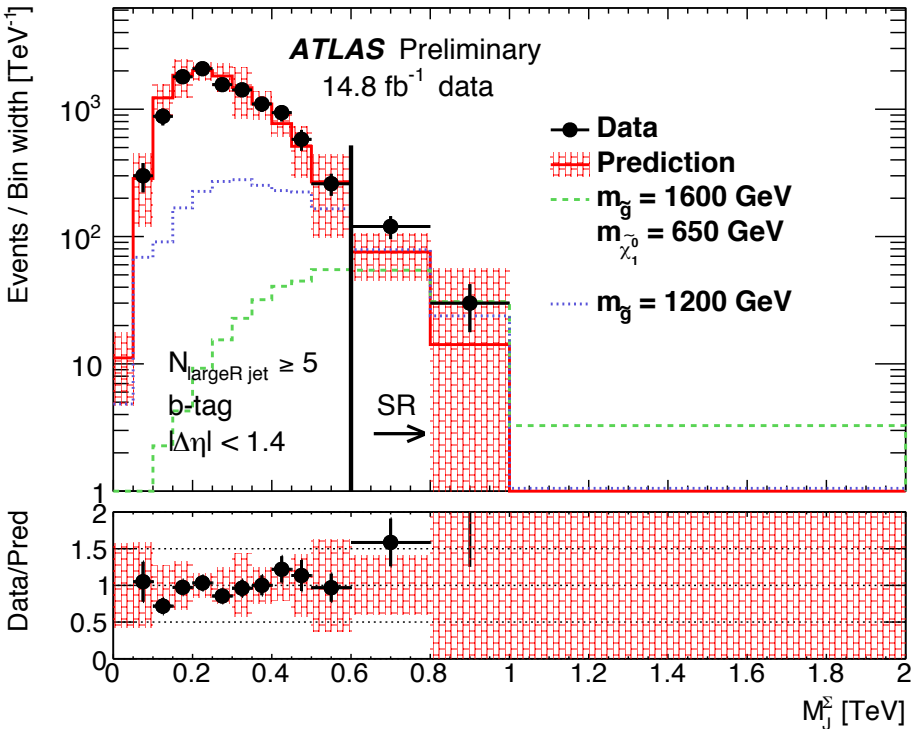
Validation region



Signal region



Constraint on gluino production

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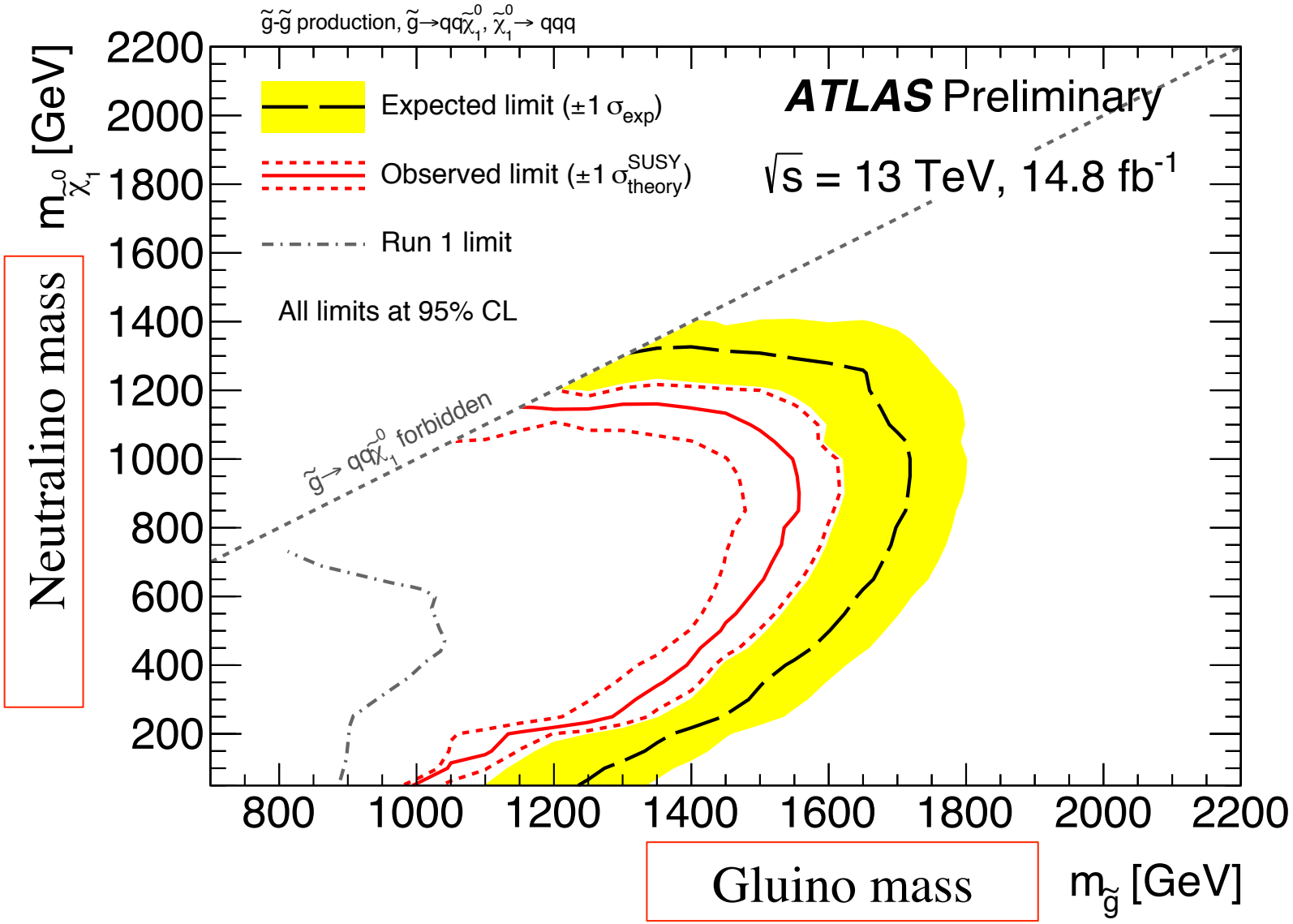

Summary

ATLAS-CONF-2016-057

Two searches were discussed.

- **Black hole search, a conventional fit method (CERN-PH-EP-2015-066)**
- **RPV SUSY search, a jet substructure method (ATLAS-CONF-2016-057)**

These searches look for different multijet signatures with different background estimation approaches. Although no signal was seen, they provide strong constraint on production of new physics in the multijet final state, and are complementary to other searches at the LHC.