Trigger Level Analyses in ATLAS

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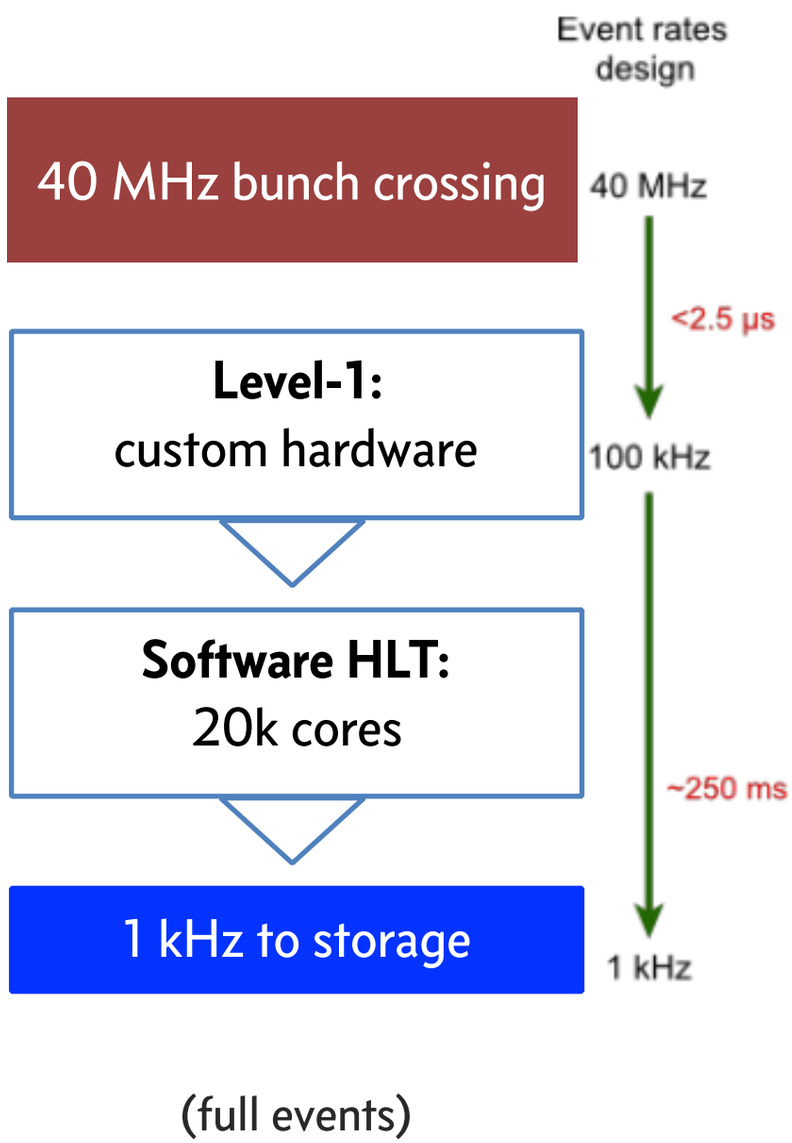
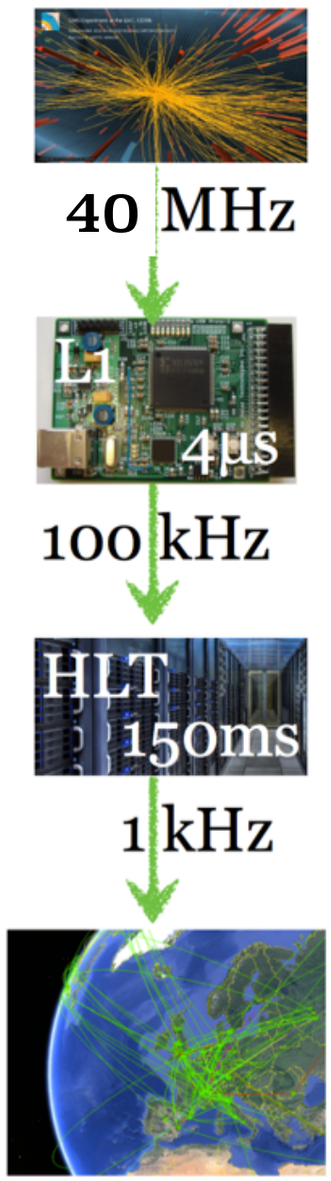
Caterina Doglioni (Lund University)

Trigger systems in ATLAS/CMS

ATLAS



CMS



H. Brun, LP 2015

Limitations to recording all data

Limited by:

fast **read-out** of O(100M) detector channels

computing resources (reconstruction)

disk **storage** (saving for further processing)

finite trigger menu

Bandwidth = Event rate **x** Event size

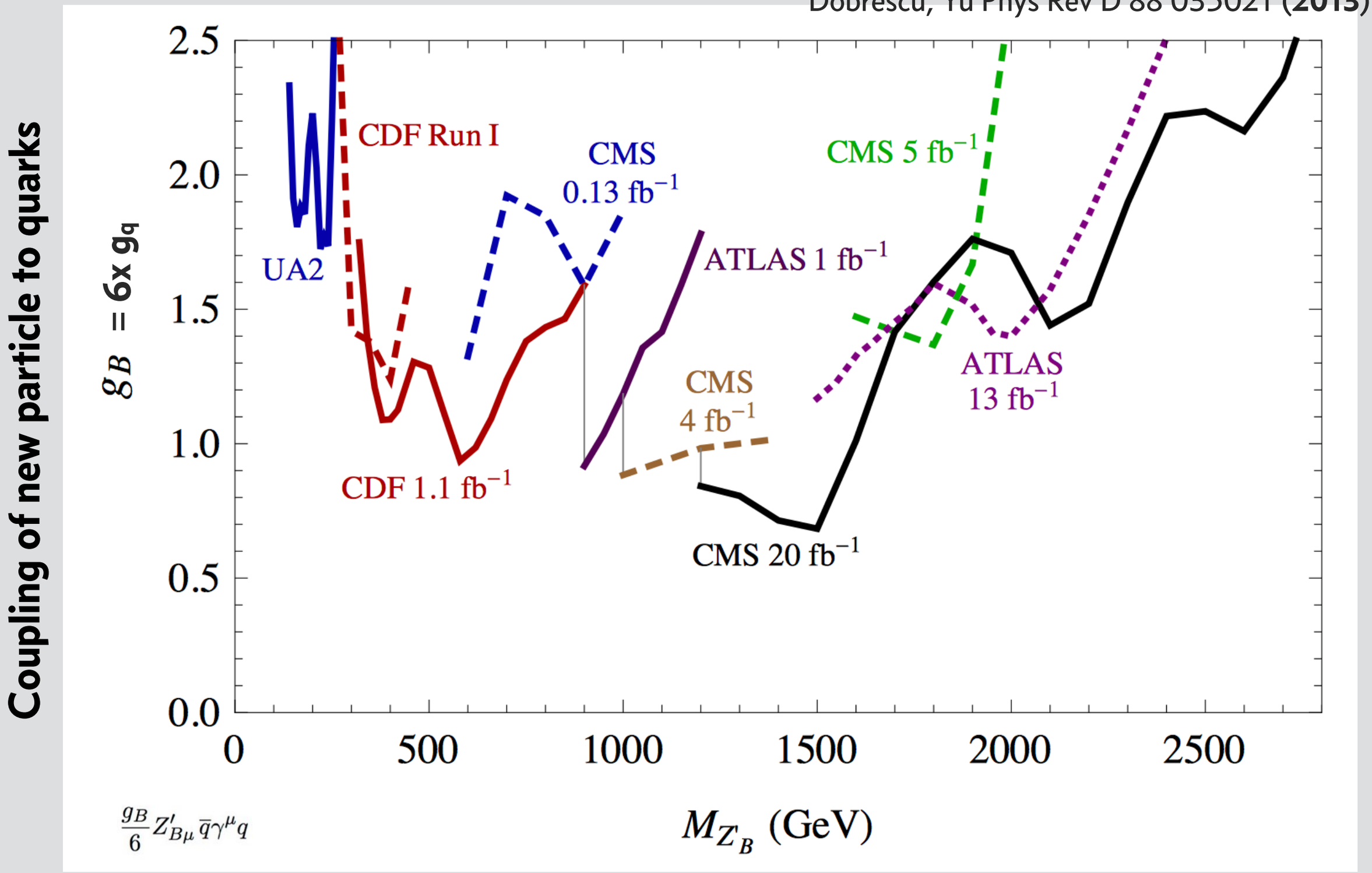
LHC: 40 MHz ATLAS: 1 kHz CMS: 1 kHz	(Reconstructed) ATLAS: o(MB) CMS: o(MB)

Readout bandwidth is an important limitation of searches when backgrounds are large.

Probing for **low-rate** processes is important: LHC **luminosity** will increase but energy will not (anytime soon)

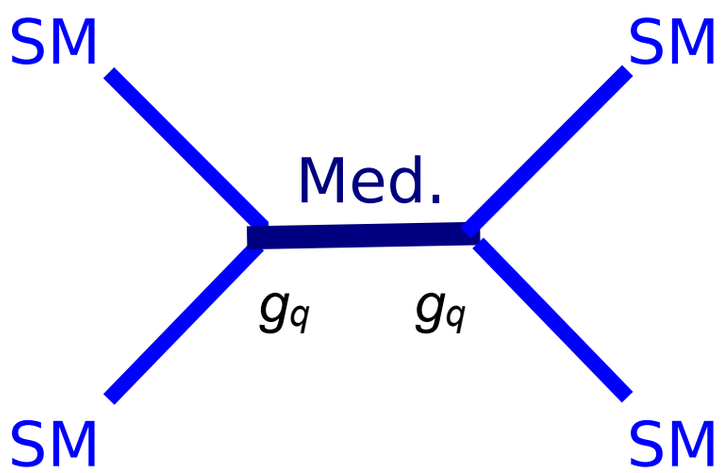
Dijet Resonances: Constraints on Coupling Values vs. Mass, 2013

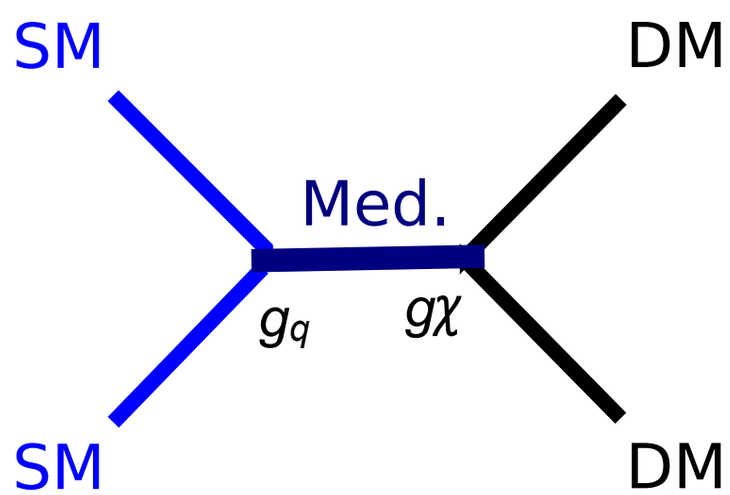
Dobrescu, Yu Phys Rev D 88 035021 (**2013**)



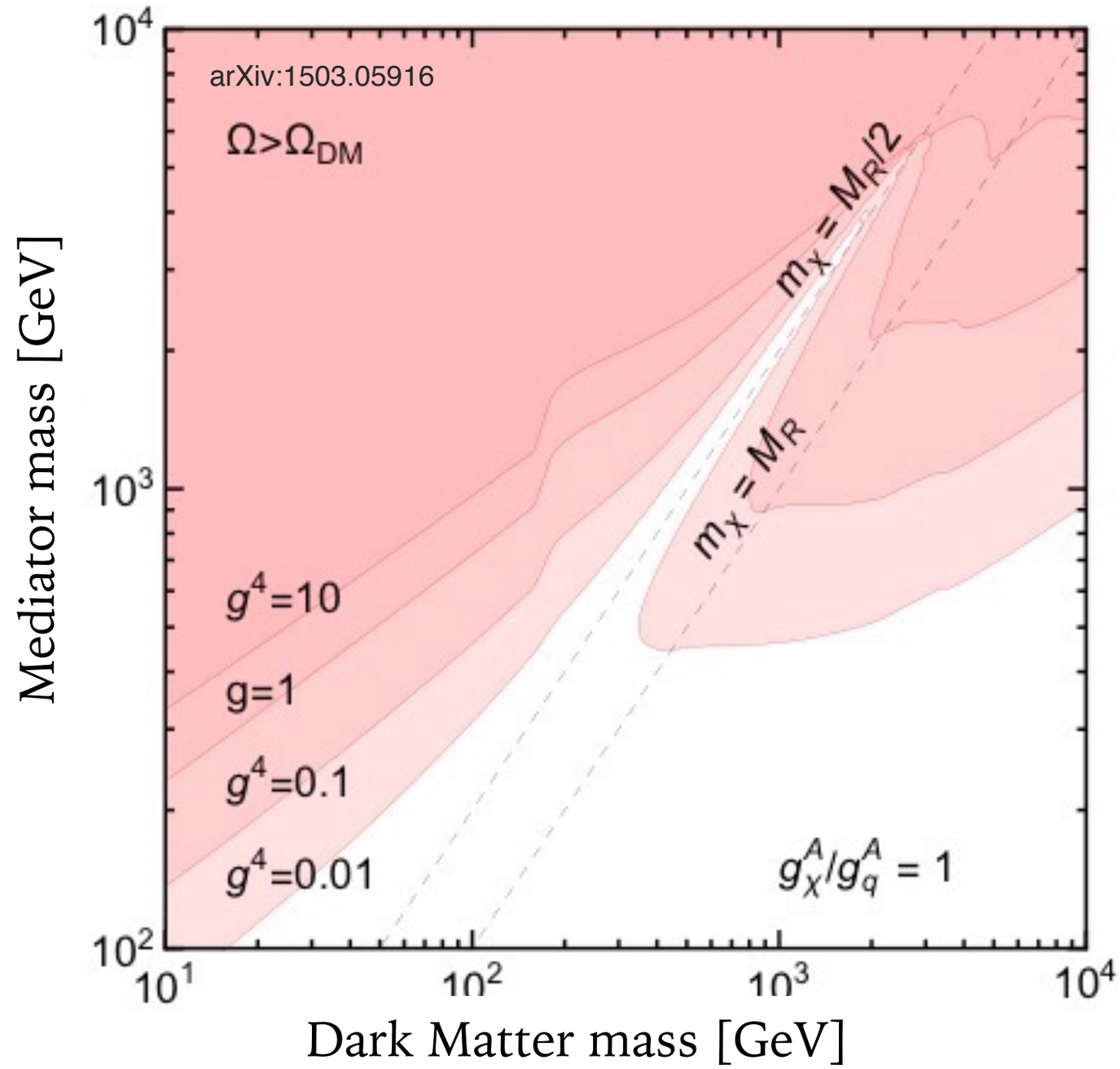
LHC not probing for dijet resonances at the EW scale

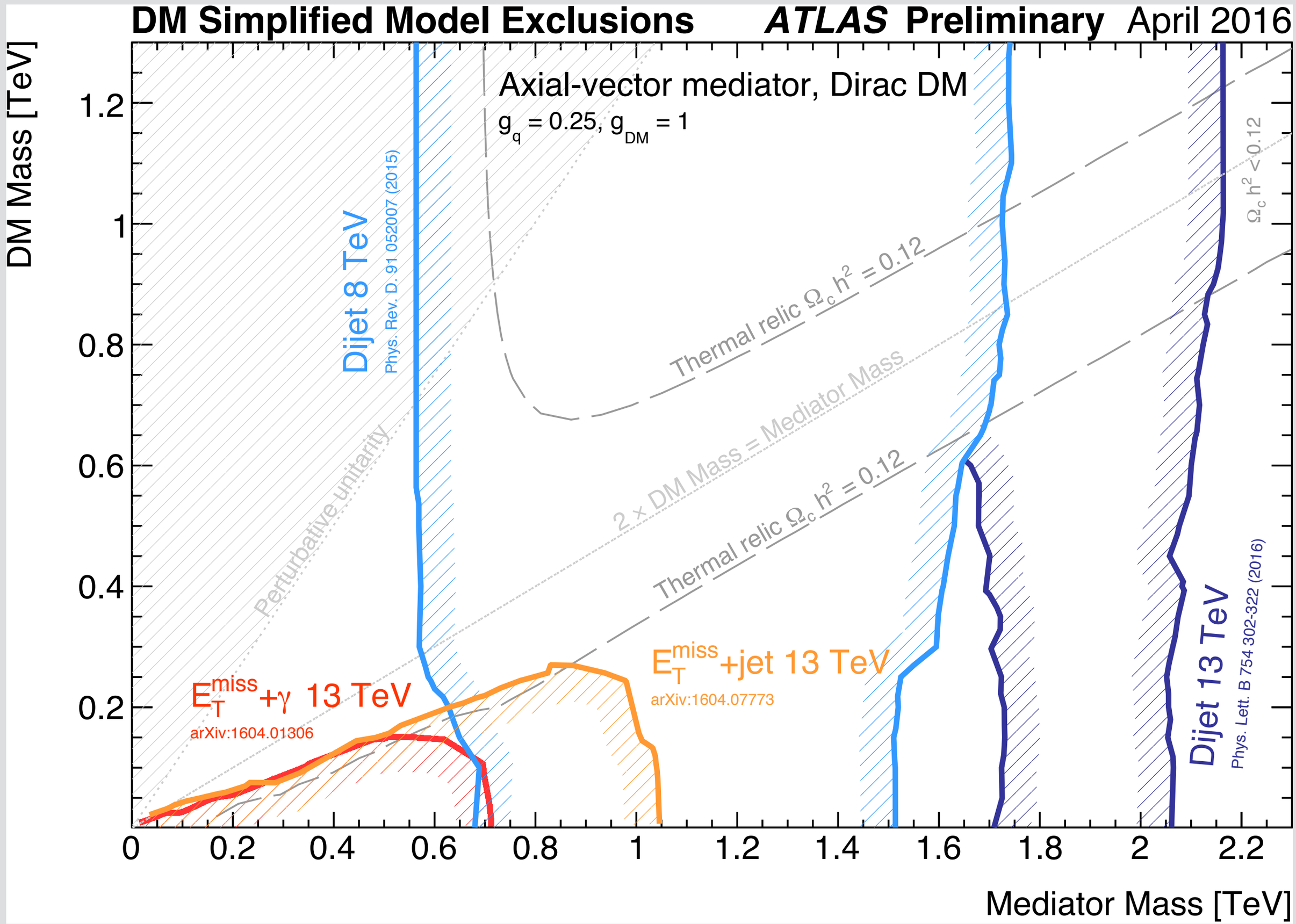
Dark Matter mediators constraints and DM relic density





$$g \equiv (g_q^A \, g_\chi^A)^{1/2}$$




DM Simplified Model Exclusions
ATLAS Preliminary
April 2016
Axial-vector mediator, Dirac DM
g_q = 0.25, g_{DM} = 1
Dijet 8 TeV
Phys. Rev. D. 91 052007 (2015)
Perturbative unitarity
2 × DM Mass = Mediator Mass
Thermal relic $\Omega_c h^2$ = 0.12
Thermal relic $\Omega_c h^2$ = 0.12
$\Omega_c h^2 < 0.12$
E_T^{miss}+γ 13 TeV
arXiv:1604.01306
E_T^{miss}+jet 13 TeV
arXiv:1604.07773
Dijet 13 TeV
Phys. Lett. B 754 302-322 (2016)
DM Mass [TeV]
Mediator Mass [TeV]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2

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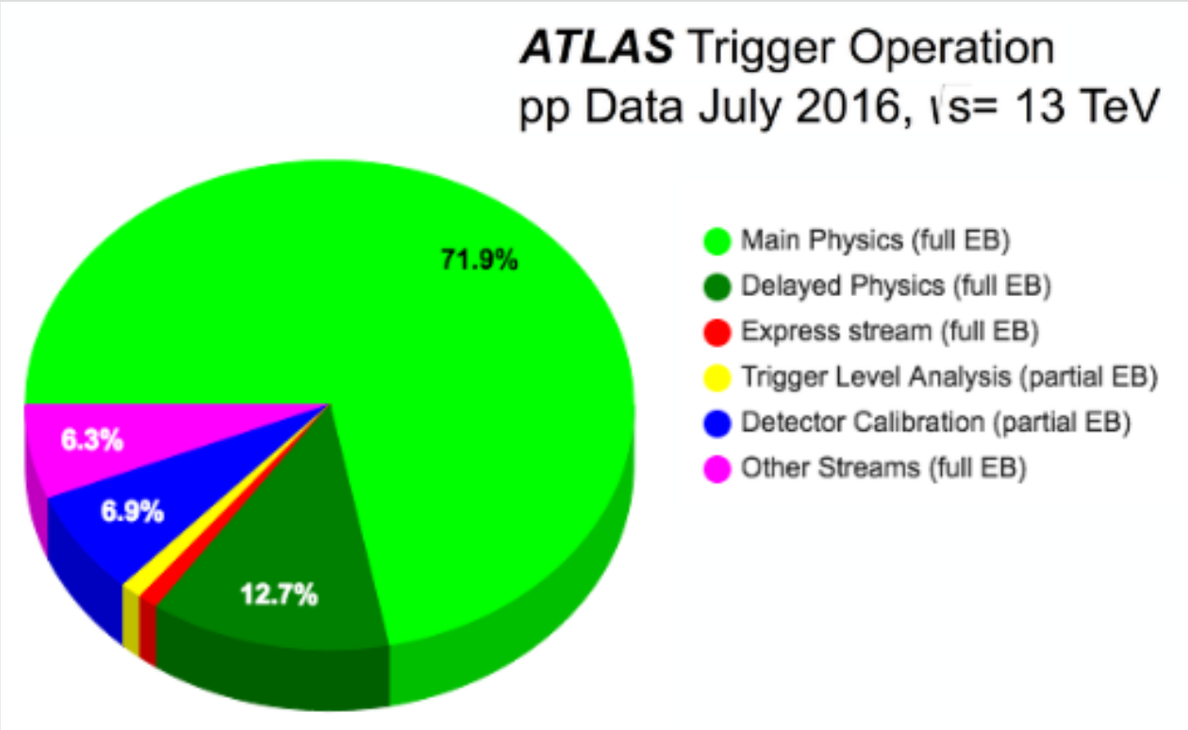
Trigger-Level Analysis technique, applied to dijet resonance search

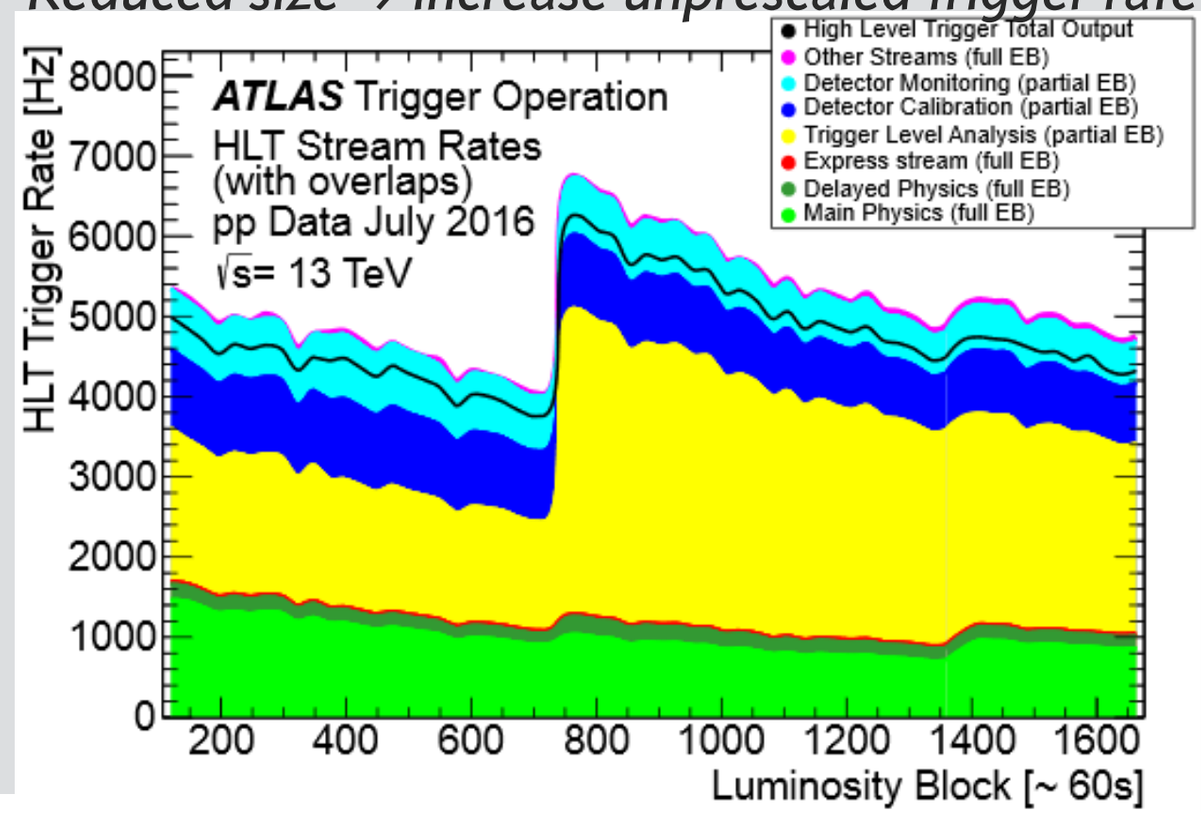
Record only necessary information for jet search: **jets**

Use information already available to make the decision: **HLT jets**

Event size reduced to 5% of fully recorded event

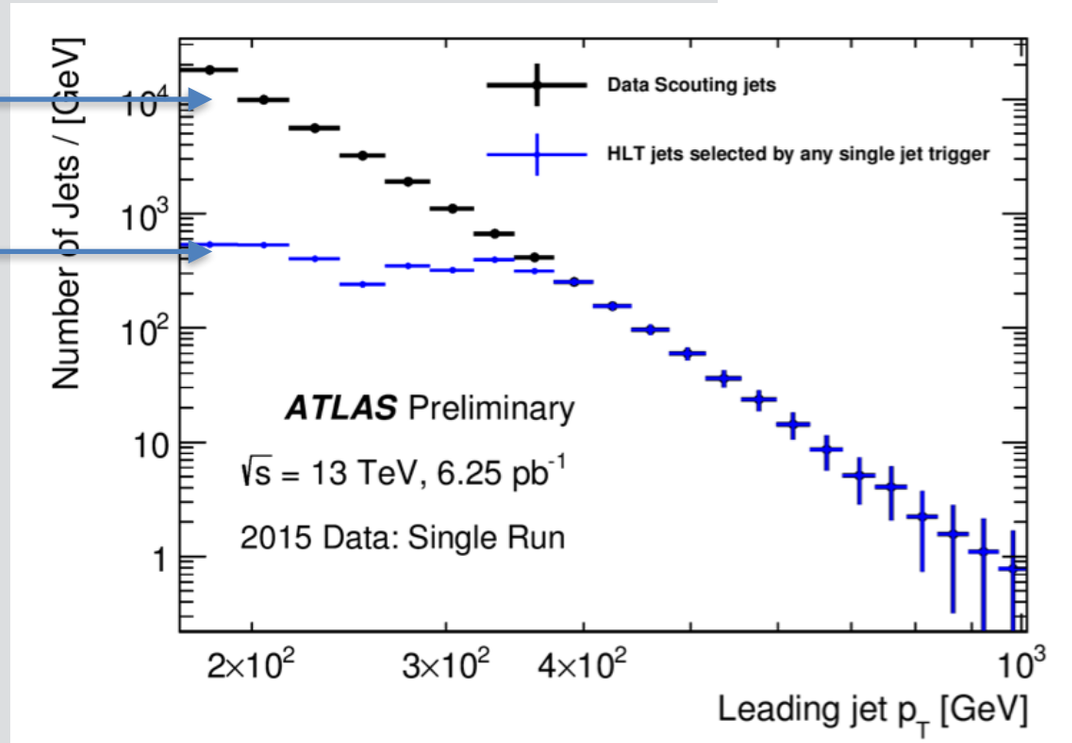


Reduced size → increase unprescaled trigger rate



unprescaled

prescaled

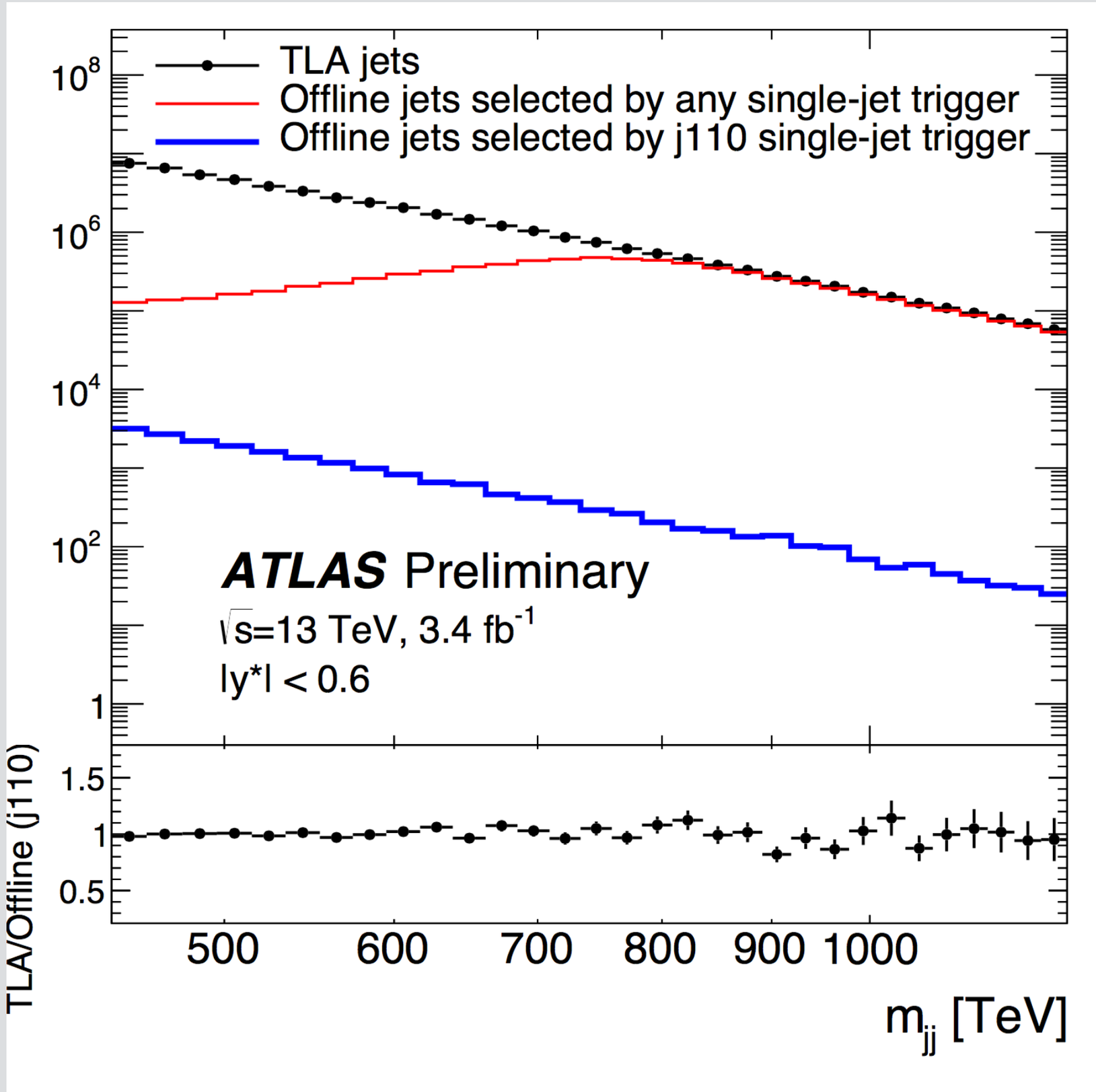


Statistics increase from Trigger-Level Analysis technique: dijet invariant mass

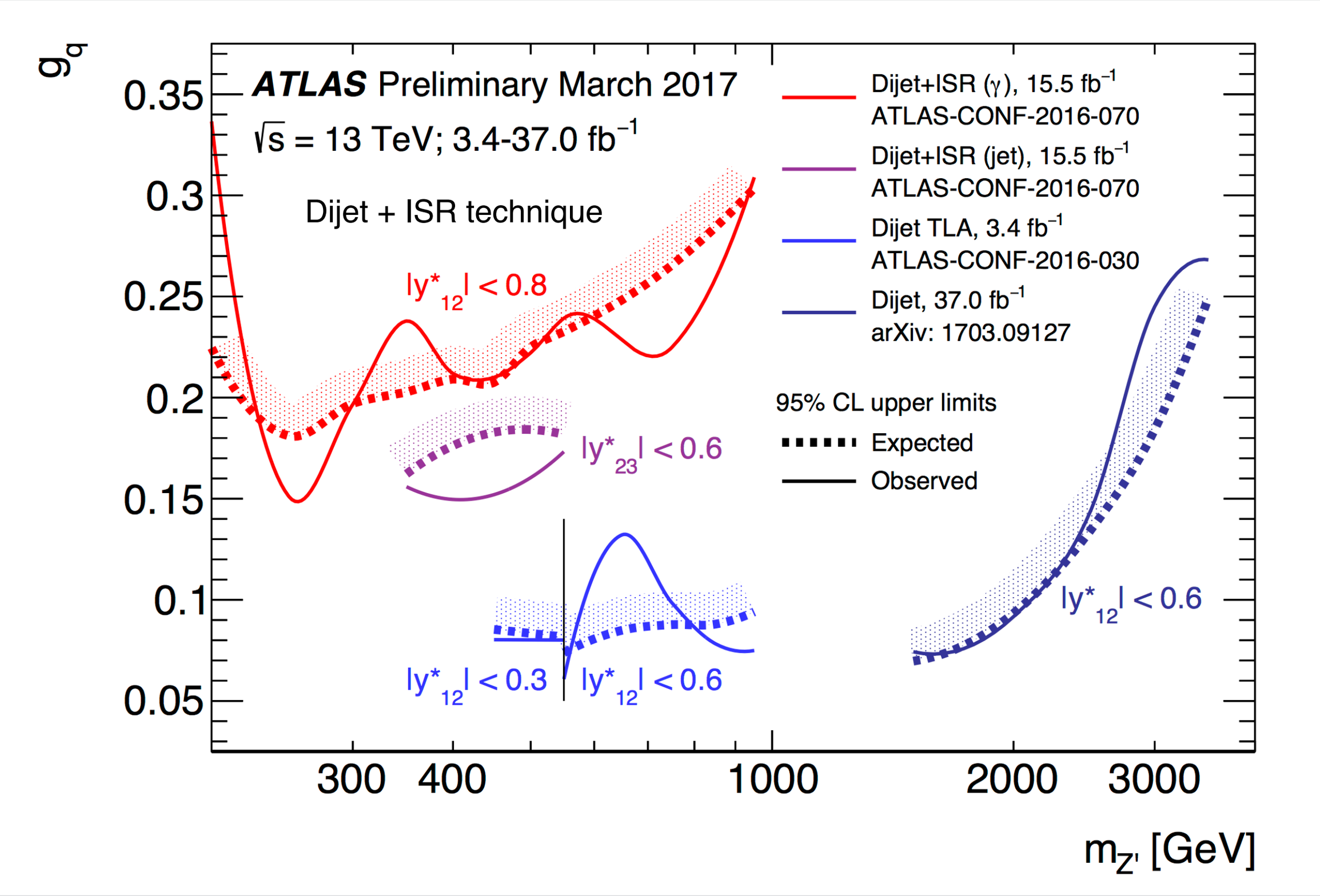
Statistics increase

Performance comparison:

trigger/offline response = unity

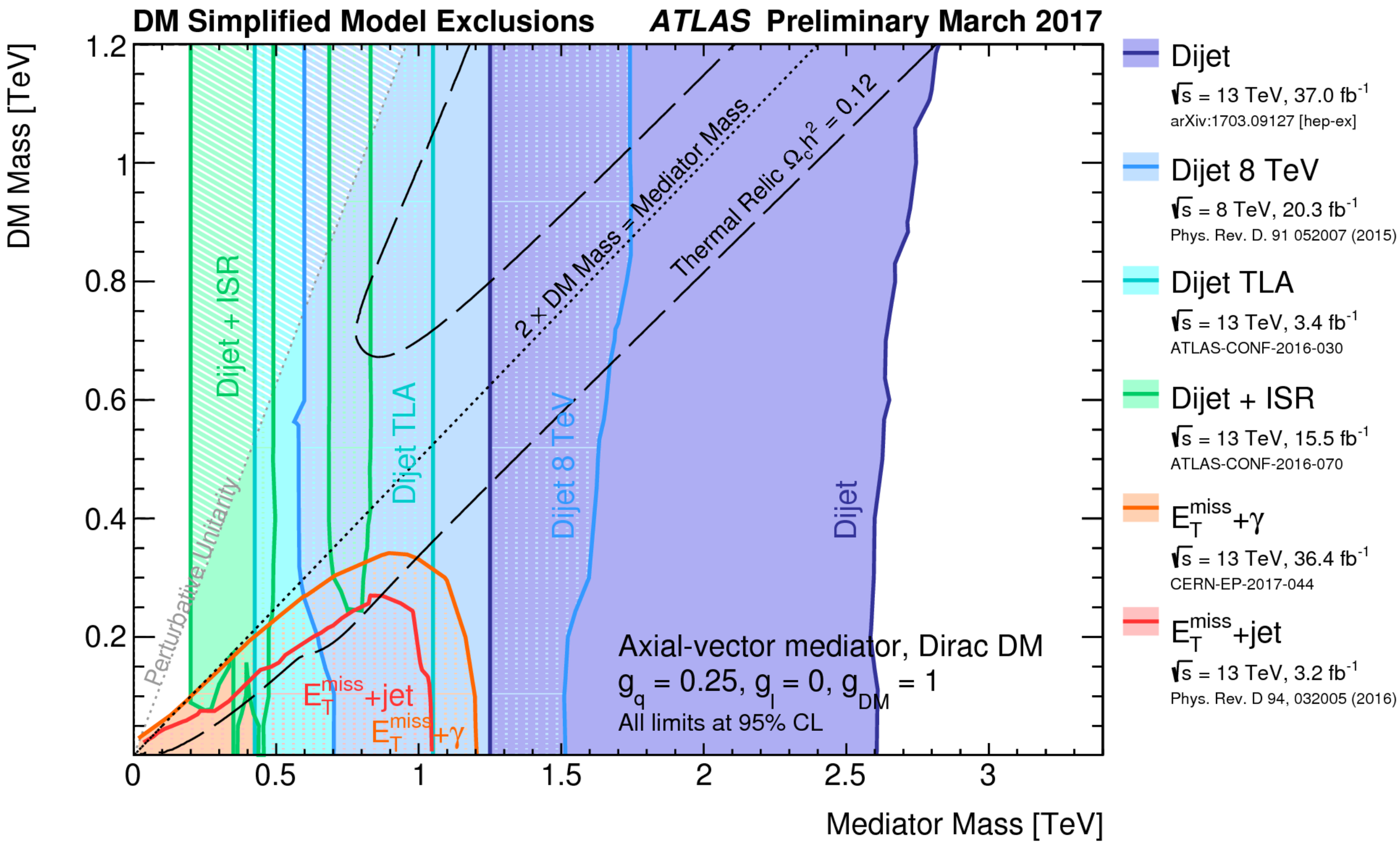


Dijet Resonance Searches



ATLAS MET+X and Dijet Searches

Benchmark model points: LHC DM WG, arXiv:1703.05703



Is this tool useful for long-lived particle searches?

TLA technique powerful to explore regimes where offline analysis is difficult:
- signals are hidden in a large background (e.g. soft) and only revealed by high statistics
  e.g. - particles without known mass, produced in pairs, hidden in a large background
- L1 trigger satisfied
- only a subset of the full detector information is required for the search (HLT rate ~ 1/info)
- object already reconstructed in the trigger and close enough to offline quality

Upgrades such as FTK will make the trigger reconstruction more capable (e.g. Su Dong's talk):
- Track-based pile-up subtraction and calibration, for jet items
- Phase II upgrades to early-level trigger (c.f. exploration of trigger-less analysis with L1Topo)
- Can imagine deriving high-level variables with trigger processors, writing out summary information (real-time analysis)

What long-lived particle signatures could benefit from the TLA technique?
- When we "*need high-energy particles in event to pass trigger*"
- funny (trackless / displaced) low-momentum jets?
  rates high, displaced vertex not currently reconstructed
- low-mass dimuon, diphoton, di-tau, multileptons/multitrack…
- pairs of dijet resonances, but lower lifetimes than reachable offline
- combination of many low-momentum final states (e.g. soft jet + MET + soft tracks)

Quantitative question: can we achieve sensitivity to new parameter space at a manageable rate?

Additional Slides

Other ideas from KITP workshop last year

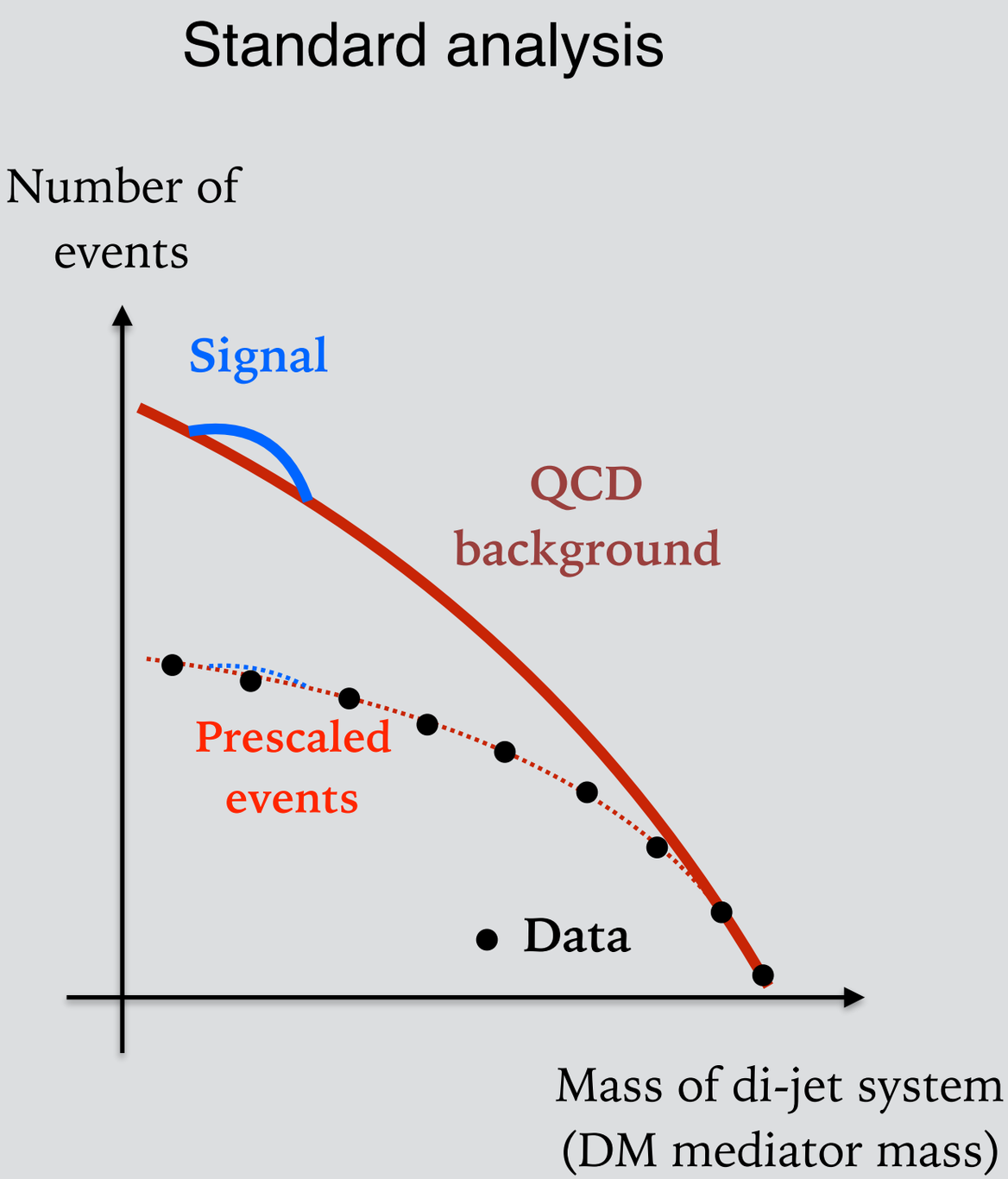
http://experlhc16.wikispaces.com/Exotica+Session

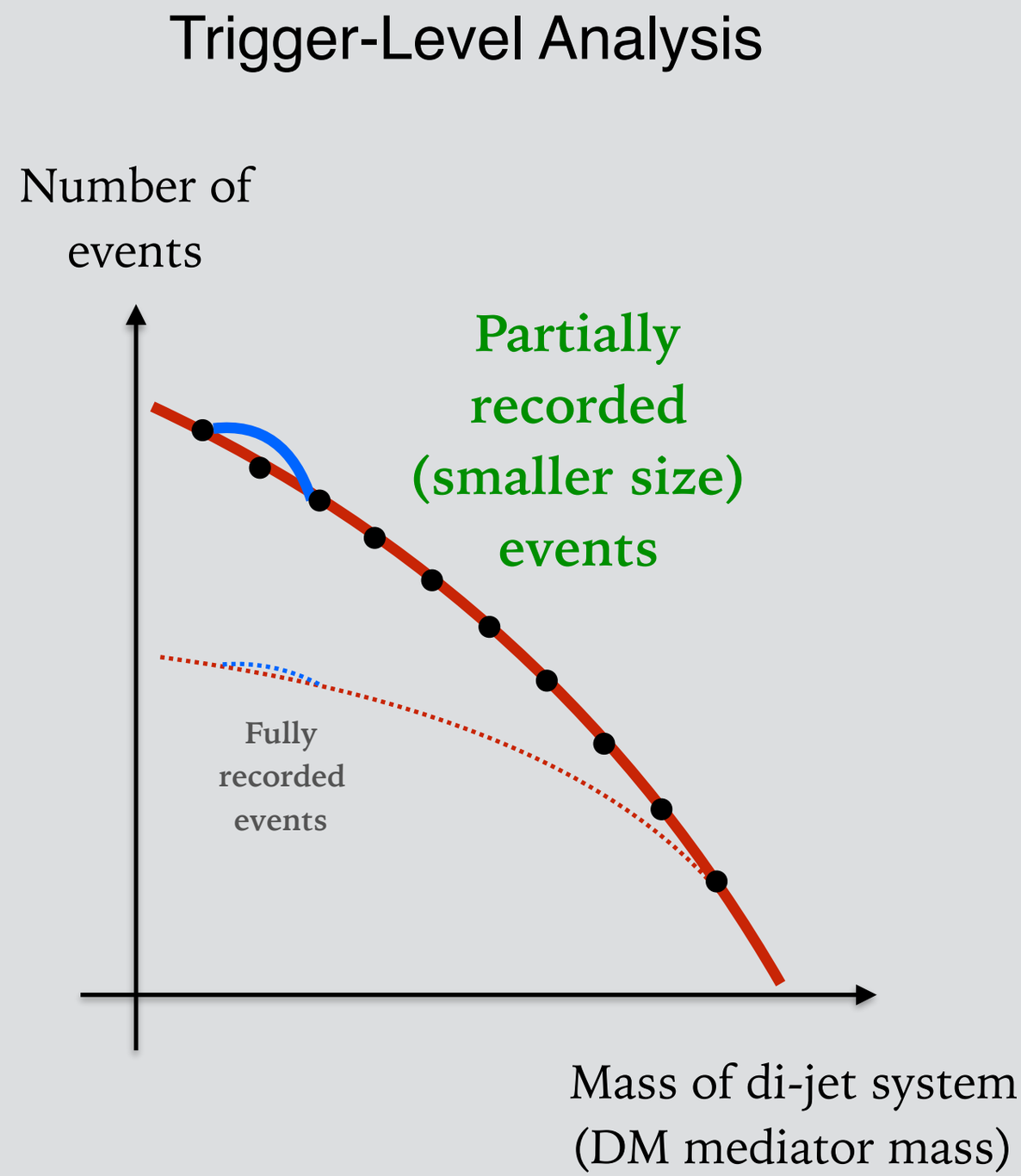
- VBF + displaced/trackless jets

- VBF + MET + pair of leptons or photons, with kinematic structure, but too soft to trigger on their own

etc.

Statistics increase from Trigger-Level Analysis technique





High Energy Physics - Experiment

Dark Matter Benchmark Models for Early LHC Run-2 Searches: Report of the ATLAS/CMS Dark Matter Forum

Daniel Abercrombie, Nural Akchurin, Ece Akilli, Juan Alcaraz Maestre, Brandon Allen, Barbara Alvarez Gonzalez, Jeremy Andrea, Alexandre Arbey, Georges Azuelos, Patrizia Azzi, Mihailo Backović, Yang Bai, Swagato Banerjee, James Beacham, Alexander Belyaev, Antonio Boveia, Amelia Jean Brennan, Oliver Buchmueller, Matthew R. Buckley, Giorgio Busoni, Michael Buttignol, Giacomo Cacciapaglia, Regina Caputo, Linda Carpenter, Nuno Filipe Castro, Guillelmo Gomez Ceballos, Yangyang Cheng, John Paul Chou, Arely Cortes Gonzalez, Chris Cowden, Francesco D'Eramo, Annapaola De Cosa, Michele De Gruttola, Albert De Roeck, Andrea De Simone, Aldo Deandrea, Zeynep Demiragli, Anthony DiFranzo, Caterina Doglioni, Tristan du Pree, Robin Erbacher, Johannes Erdmann, Cora Fischer, Henning Flaecher, Patrick J. Fox, et al. (94 additional authors not shown)

(Submitted on 3 Jul 2015)

This document is the final report of the ATLAS-CMS Dark Matter Forum, a forum organized by the ATLAS and CMS collaborations with the participation of experts on theories of Dark Matter, to select a minimal basis set of dark matter simplified models that should support the design of the early LHC Run-2 searches. A prioritized, compact set of benchmark models is proposed, accompanied by studies of the parameter space of these models and a repository of generator implementations. This report also addresses how to apply the Effective Field Theory formalism for collider searches and present the results of such interpretations.

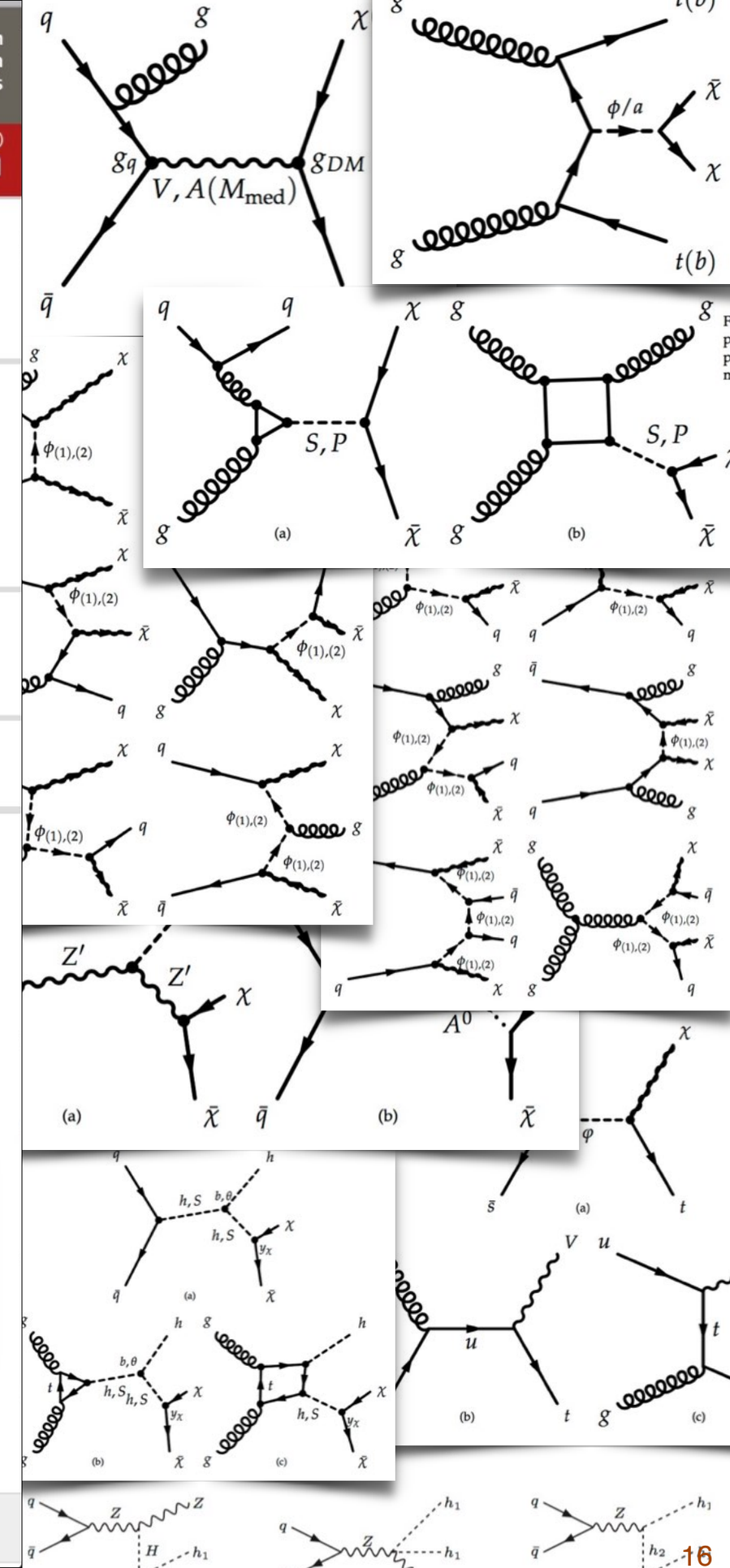
Subjects: **High Energy Physics - Experiment (hep-ex)**; High E (hep-ph)
Cite as: **arXiv:1507.00966 [hep-ex]**
(or **arXiv:1507.00966v1 [hep-ex]** for this version)

Submission history

From: Antonio Boveia [view email]
[v1] Fri, 3 Jul 2015 16:54:32 GMT (3860kb,D)

Which authors of this paper are endorsers? | Disable MathJax (What is MathJax?)

Dirac WIMP mediators:
s- and t-channel
vector/axial-vector/scalar/pseudo-scalar
MET+heavy flavor, W, Z, and Higgs



Trigger Level Analysis: search

ATLAS-CONF-2016-030

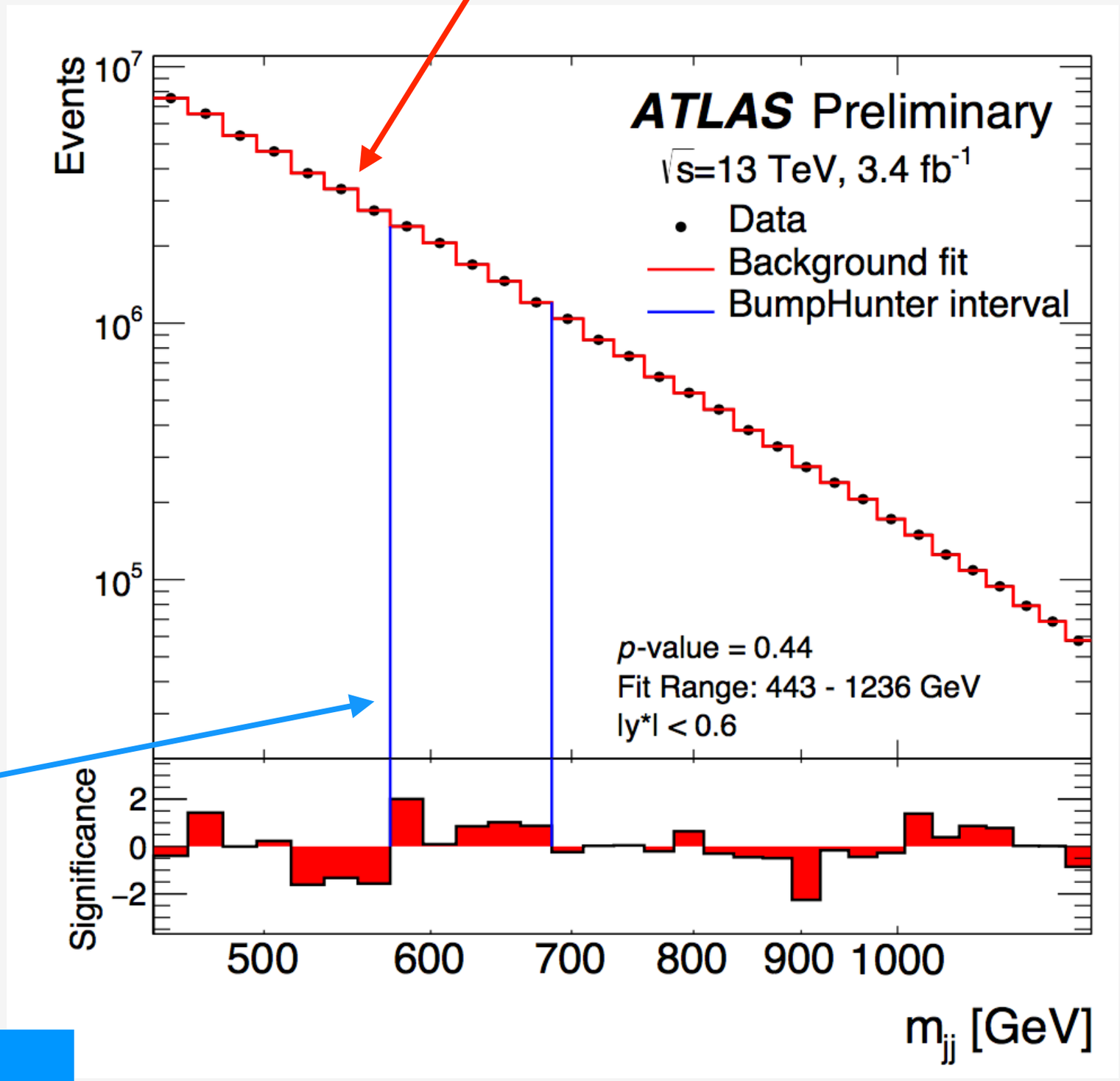
Data-driven background fit (UA2 fcn)

$$f(z) = p_1(1-z)^{p_2} z^{p_3+p_4 \log z}$$

Jet p_T > 185, 85 GeV

$|y^*| = |y_1-y_2|/2 < 0.6$
(rejects forward-peaking t-channel QCD processes)
m_{jj} > 460 GeV

$|y^*| = |y_1-y_2|/2 < 0.3$
(reaches lower in mass due to forcing more central, higher pT jets)
m_{jj} > 396 GeV



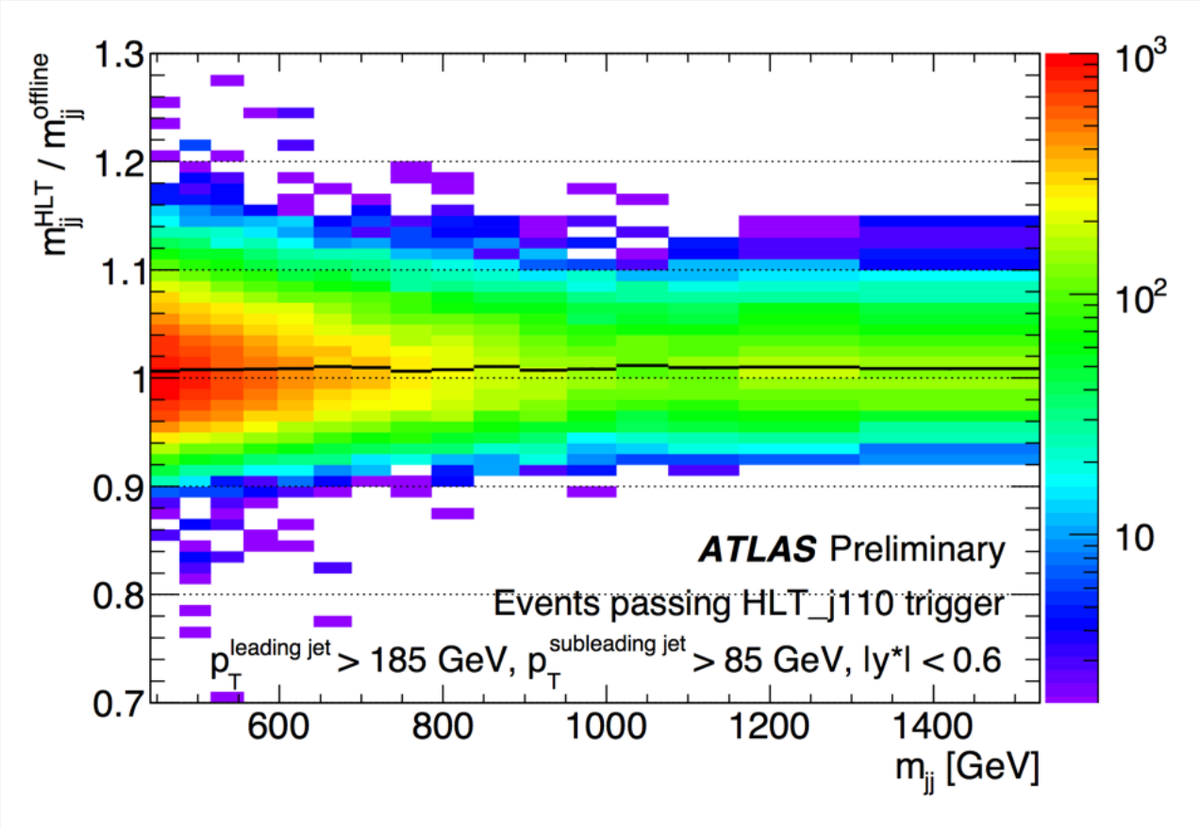
Most discrepant region (p-value 0.44)

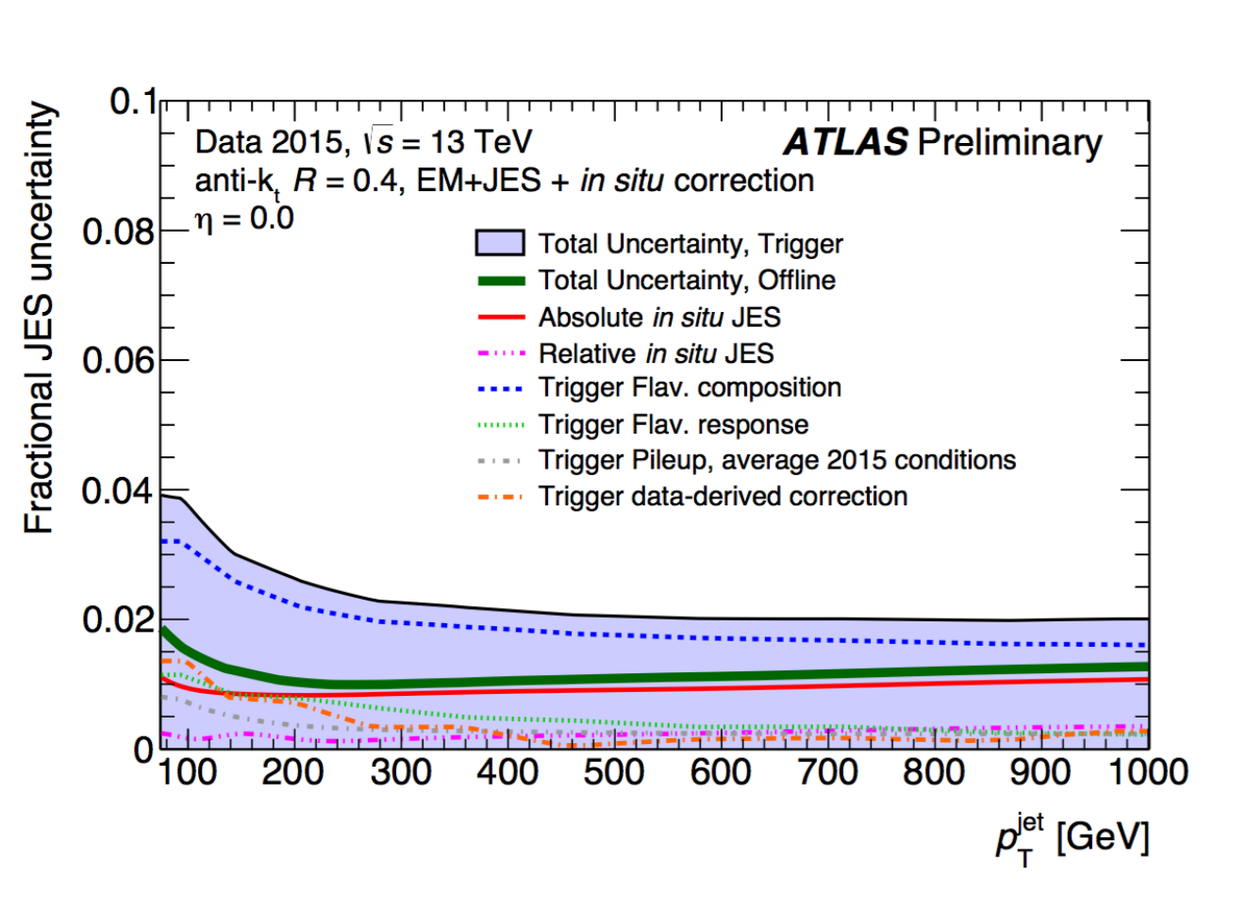
Only probing below M ~ 1.2 TeV (high-mass analysis takes over)

Jet performance for TLA

Performance of trigger jets comparable to that of offline jets

Improvements benefit jet trigger as a whole

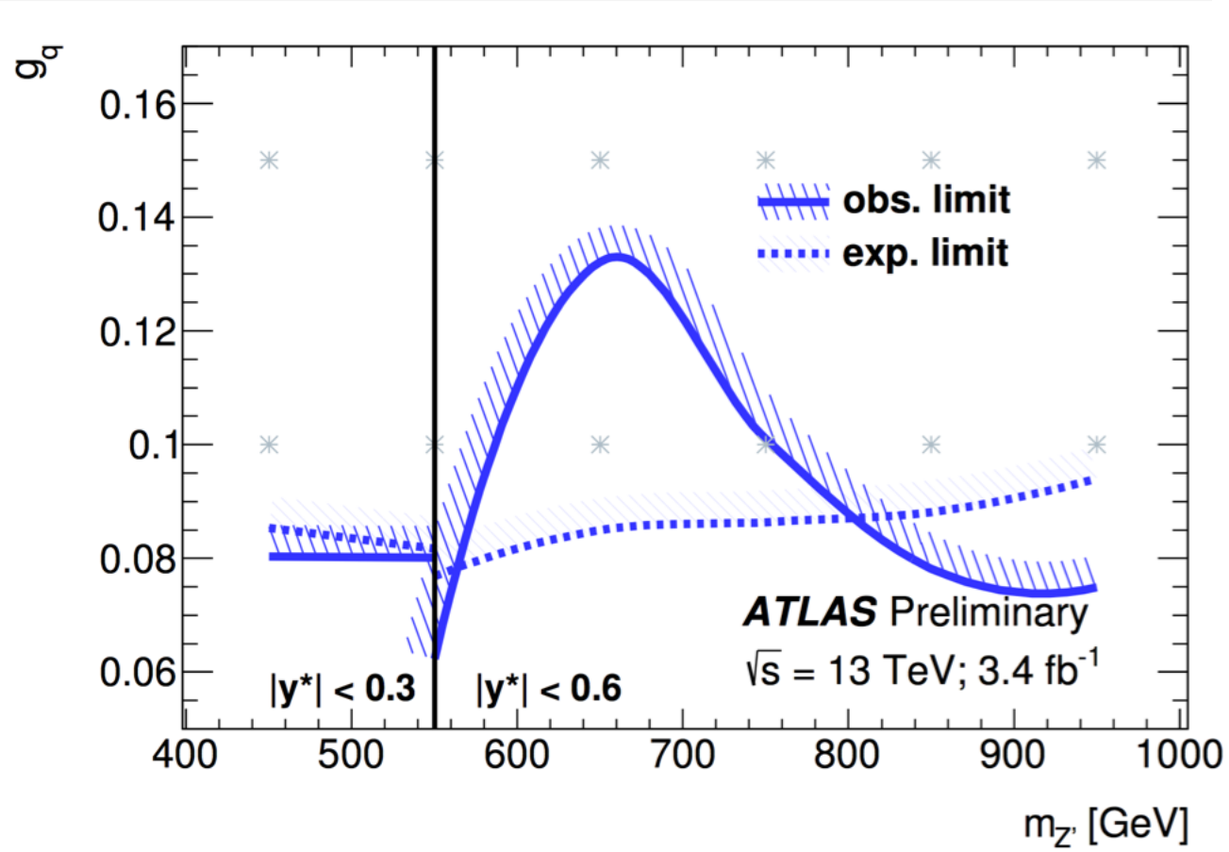




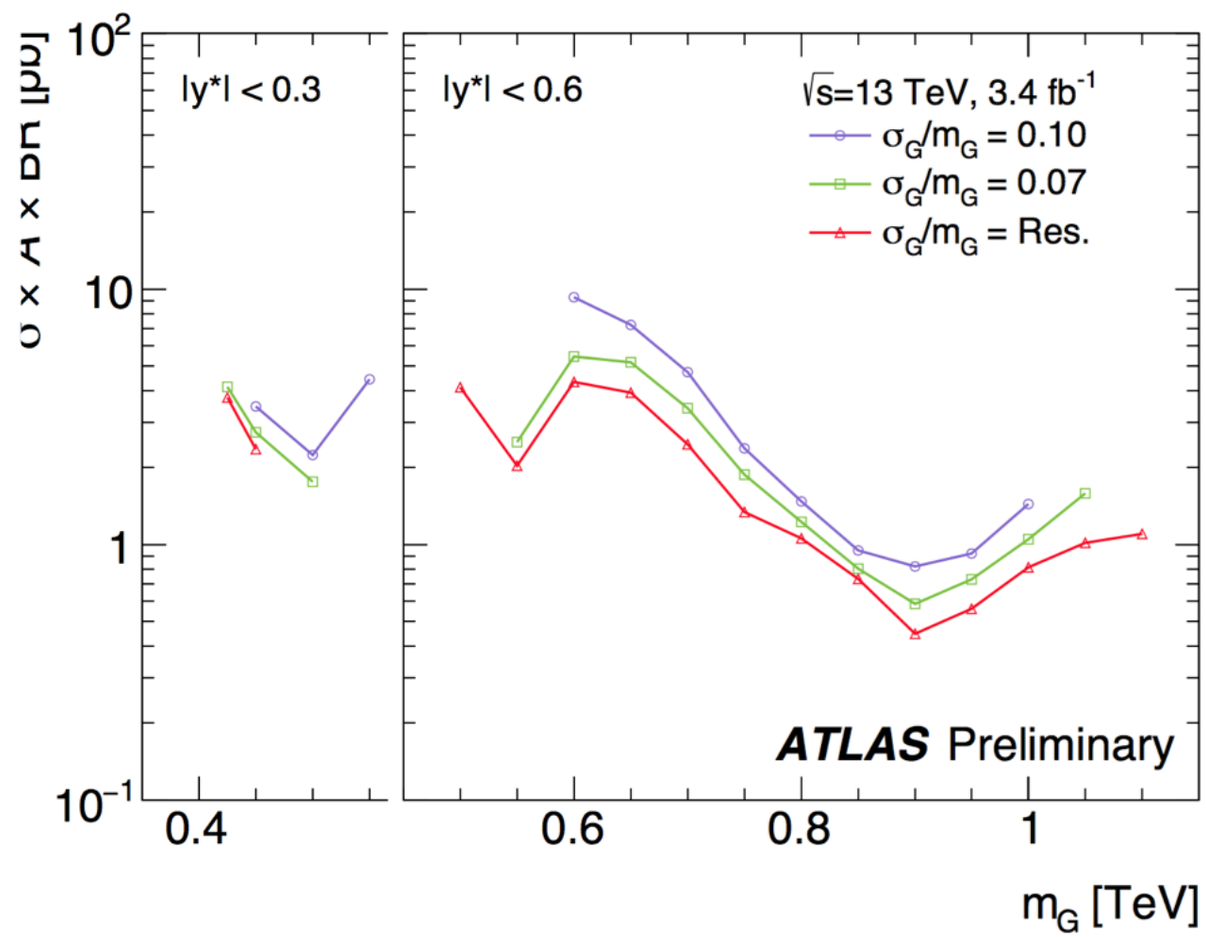
Trigger Level Analysis: results

ATLAS-CONF-2016-030

Constraints on DM mediator couplings



Limits on Gaussian-shape resonances (for reinterpretation)



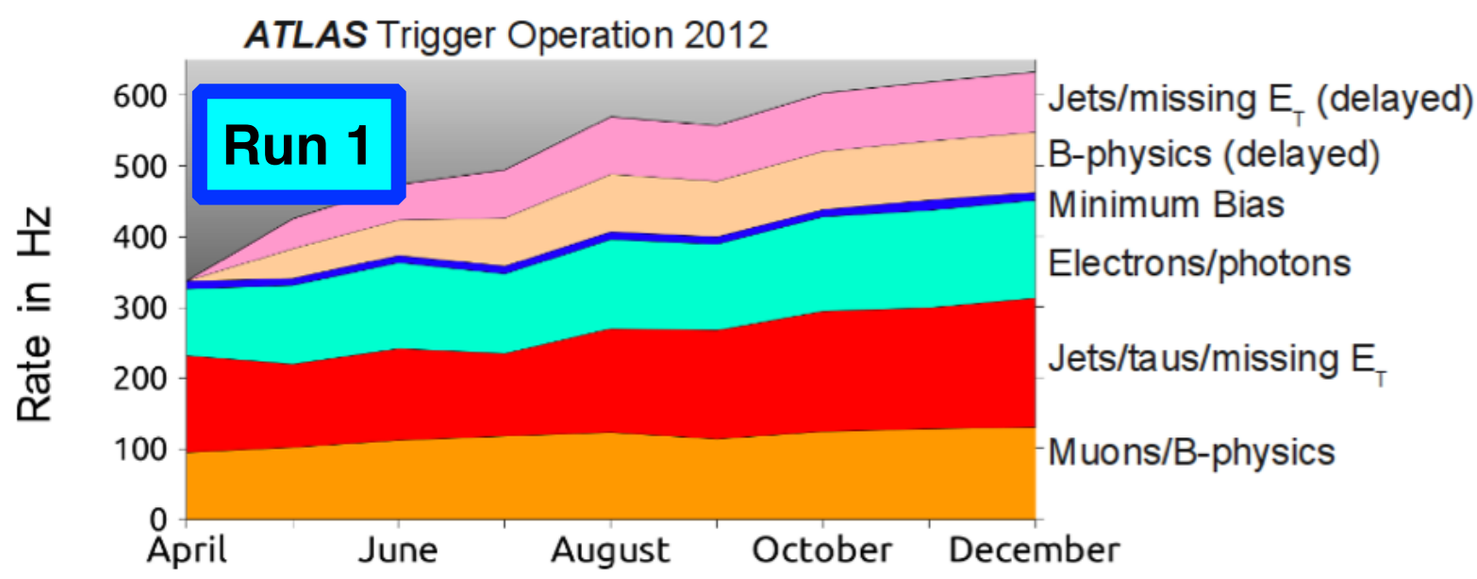
Data parking / delayed stream

Bandwidth = Event rate **x** Event size

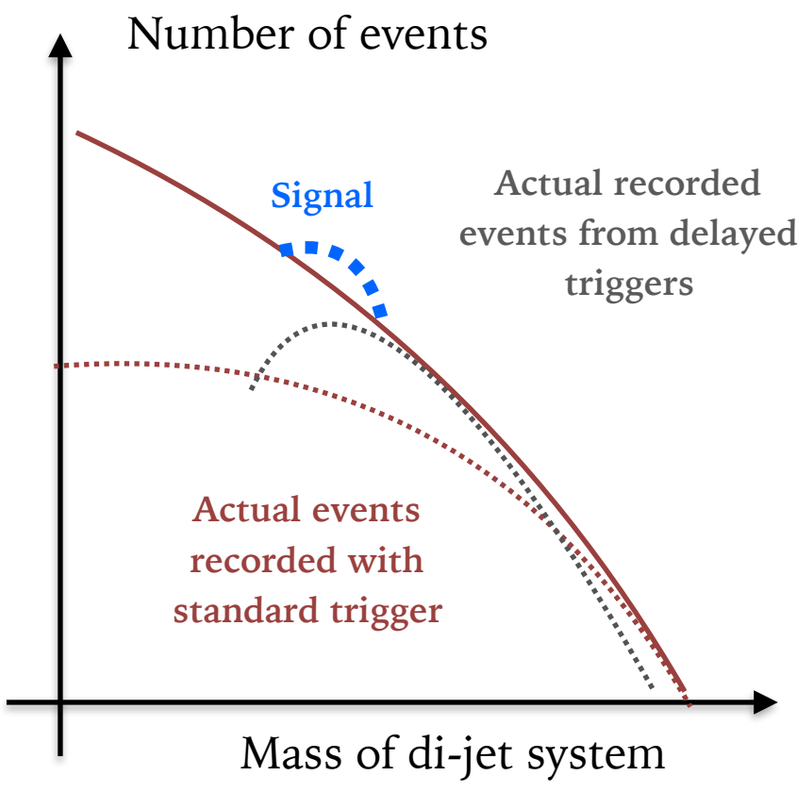
Extra bandwidth = Event rate **x** Event size

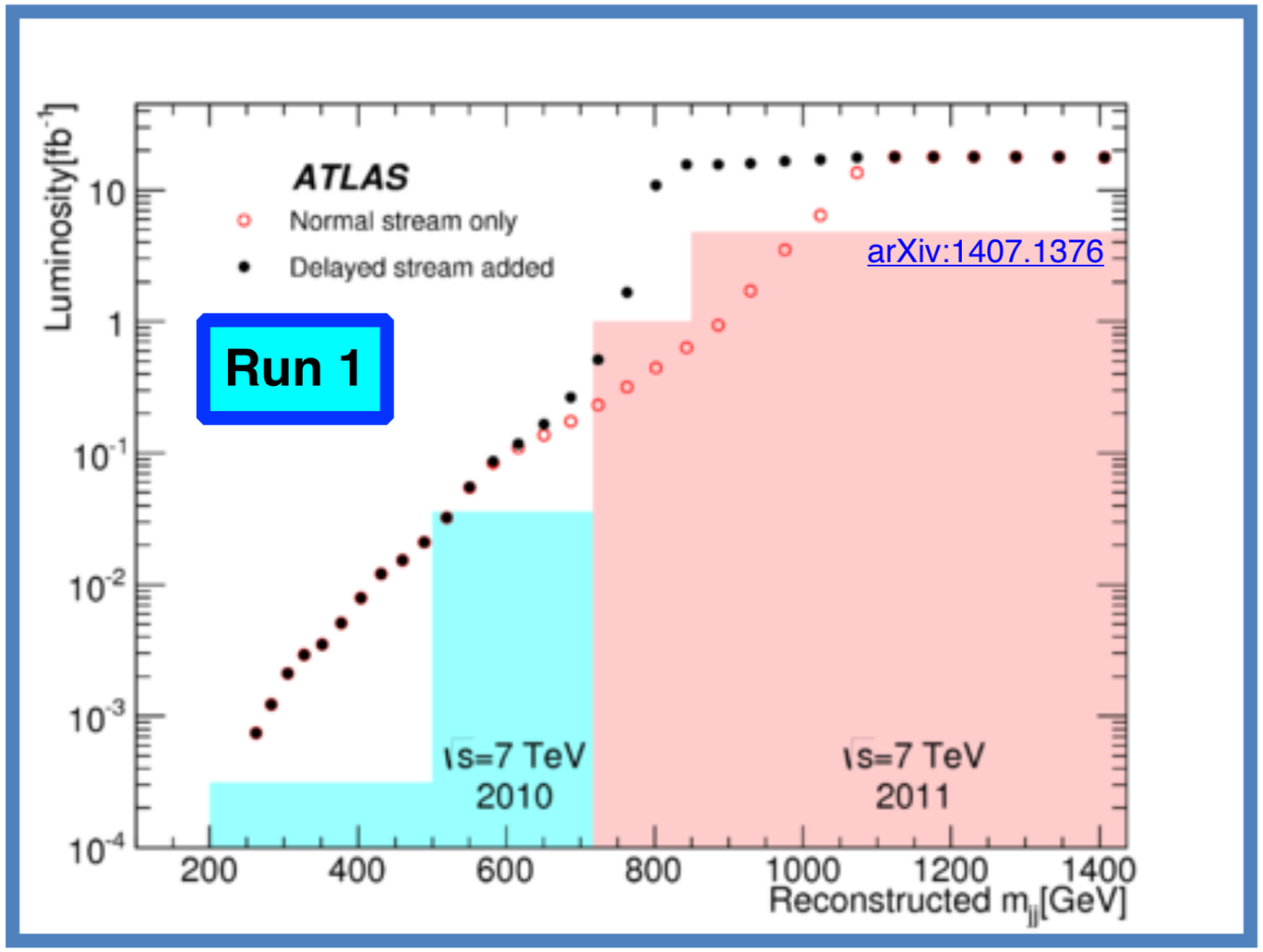
processed later

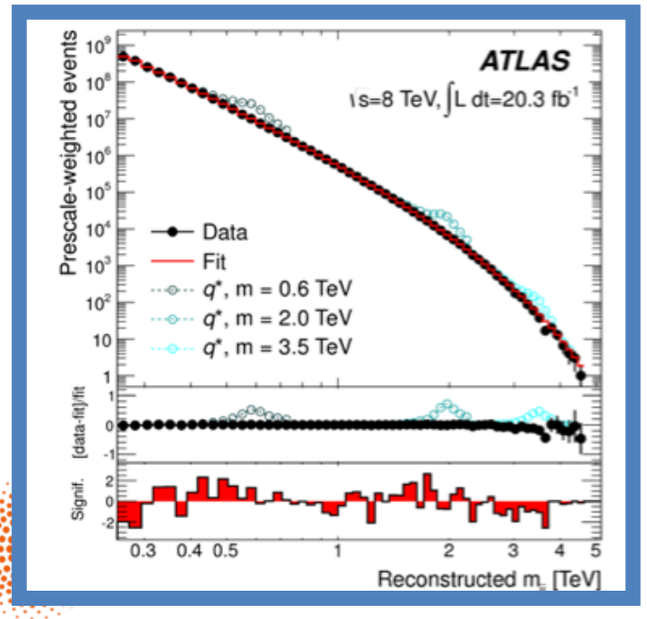
If computing resources for reconstruction limited:
park the raw data and wait (delay) until everything else is processed



ATLAS delayed stream results







Other analyses using delayed stream in ATLAS/CMS:
SUSY search for RPV stops
Dijet angular analysis…
Higgs → bbar
Fully hadronic top
DM searches…