



Exotic searches with ATLAS

Results and Perspectives in Particle Physics
La Thuile - 01-07 March 2015



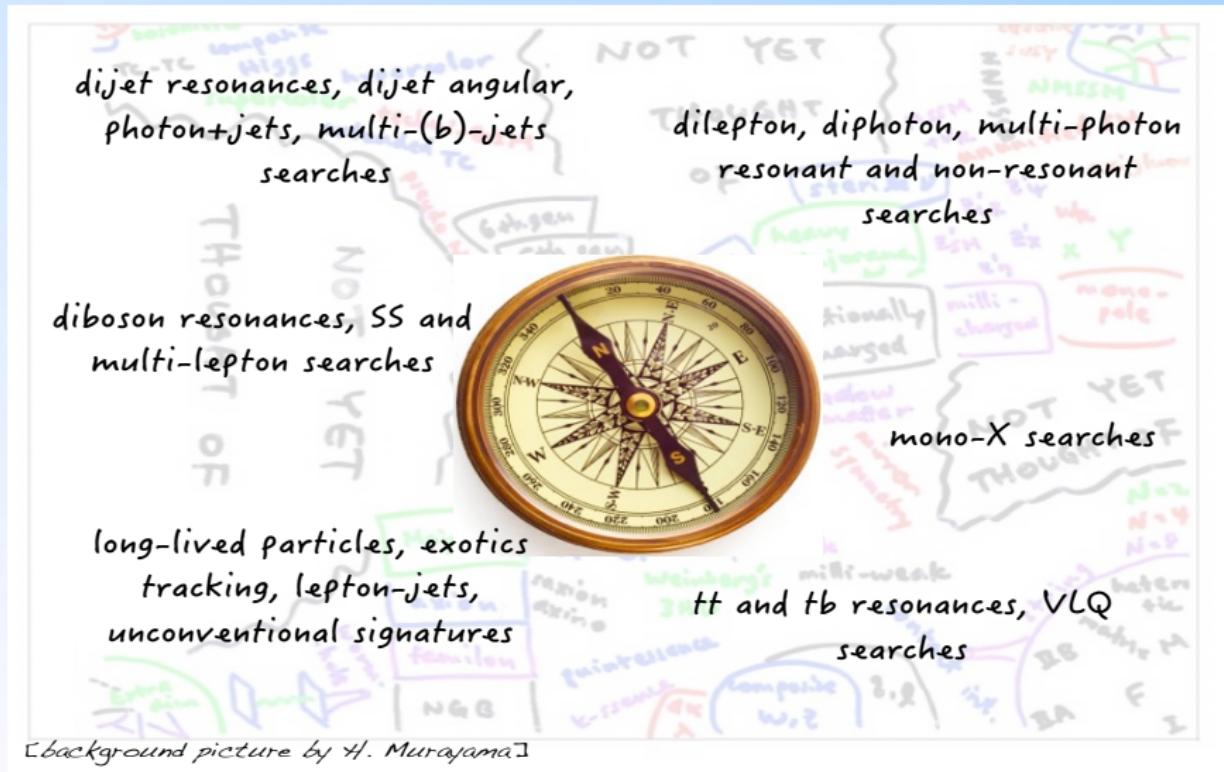
Andrea Coccato
University of Washington
on behalf of the
ATLAS Collaboration



Exotics land



Exotics compass



Outline

1. Mono-jet search
2. High-mass resonance to photon pairs*
3. High-mass resonance to tau pairs*
 4. Charged lepton search
 5. Same-sign lepton search
 6. VLQ search in $Wt+X^*$
7. Multi-charge particle search*
 8. Displaced jets*
 9. Displaced lepton-jets

DISCLAIMER

Impossible to cover the whole spectrum of searches.

Had to make choices, focus on fresh results.

* Searches presented at this conference for the first time!

All ATLAS exotics results can be accessed at [ExoticsPublicResults](#).

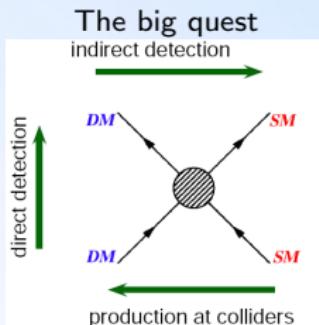
Mono-X searches for dark matter (and not only!)

DM itself invisible to detector

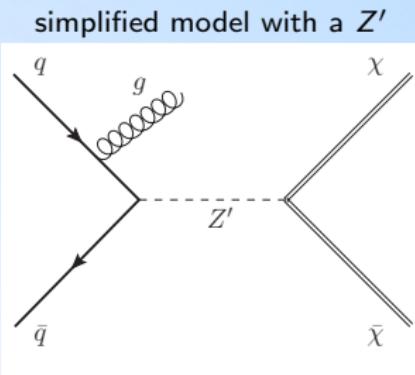
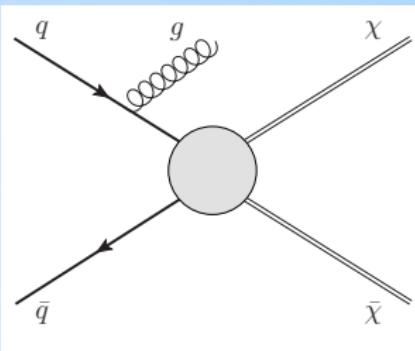
- ▶ need something to tag (and trigger) on
- ▶ MET-based searches

Assumptions:

- ▶ interaction mediated by a new particle too heavy to be produced directly
- ▶ EFT approach



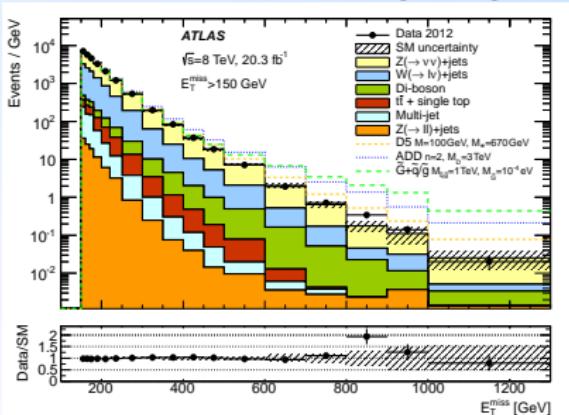
contact interaction described with EFT approach



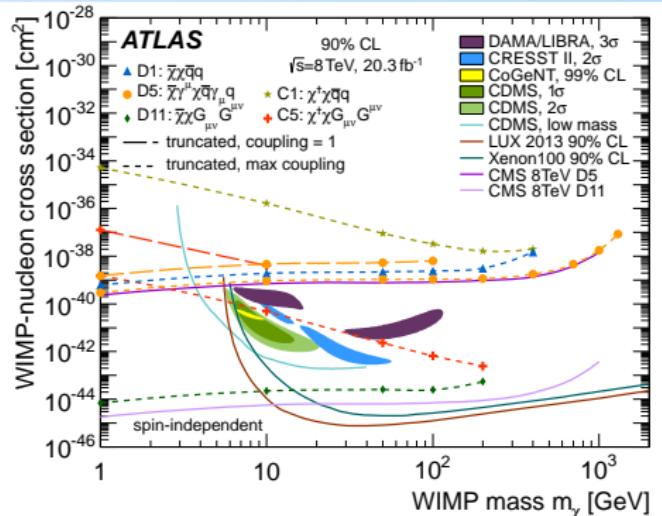
Mono-jet search [arXiv:1502.01518]

- at least one jet with $E_T > 120$ GeV and no leptons
- nine signal regions with increasing MET requirements up to 700 GeV
- SUSY and invisible Higgs interpretations included

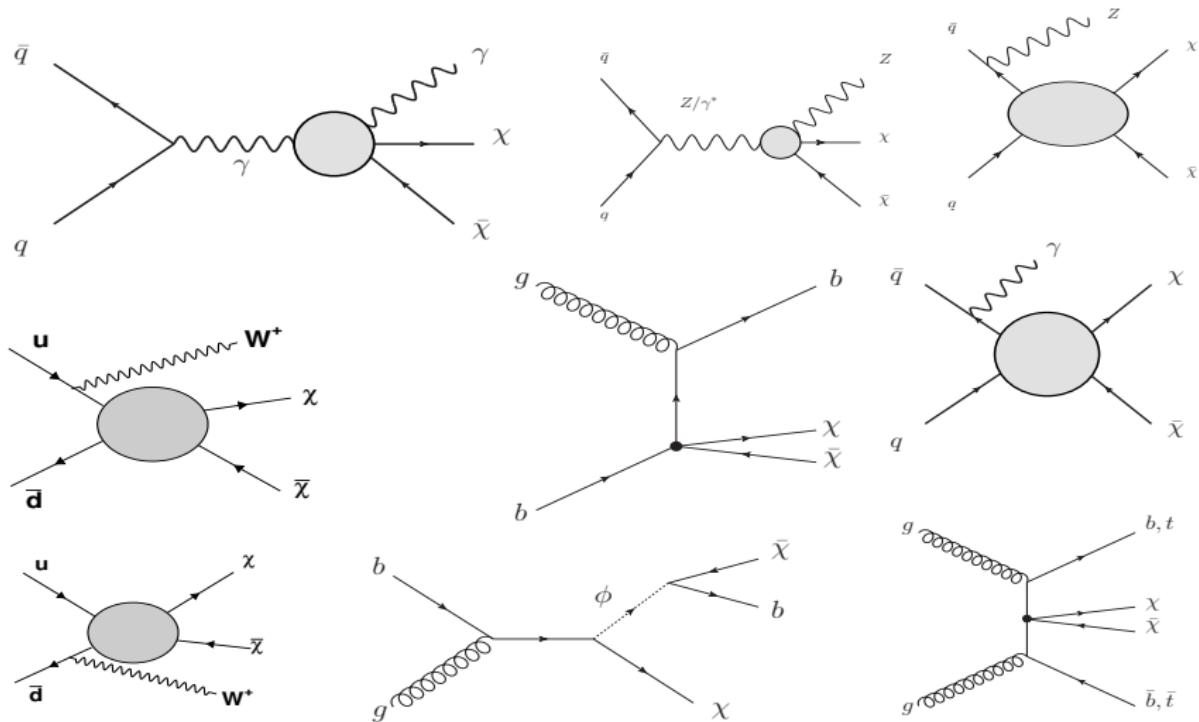
MET distribution in one signal region



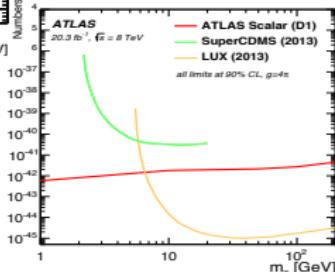
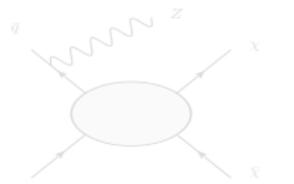
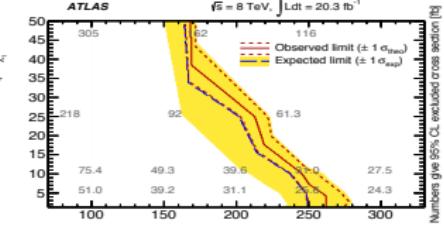
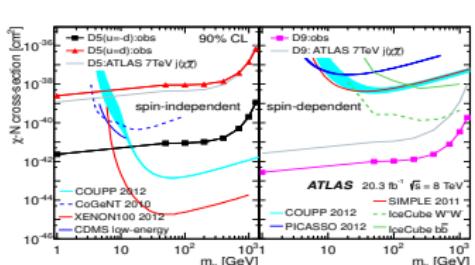
90% CL on the WIMP-nucleon scattering cross section



Extensive search program conducted by ATLAS. The Higgs is also entering in the game.

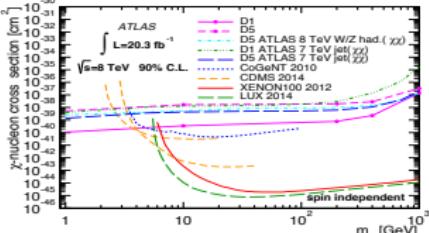
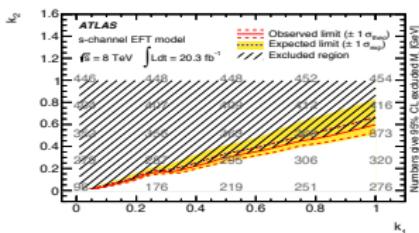


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More details

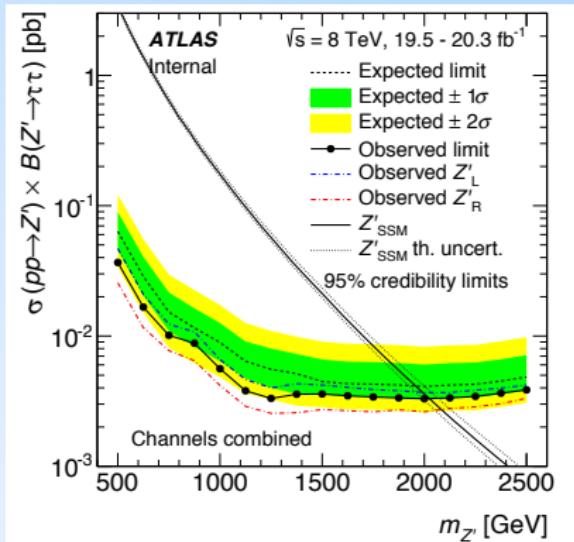
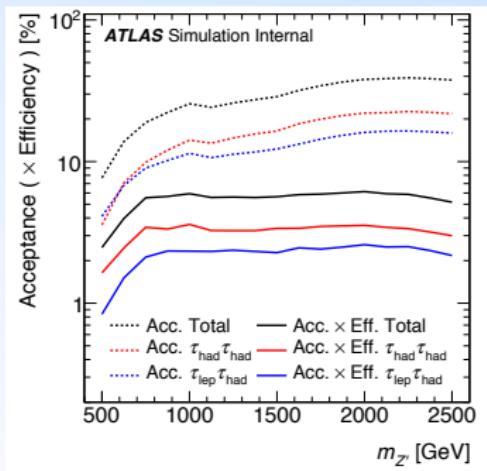
- mono-photon: PRD 91, 012008 (2015)
- mono-b: EPJC 75 (2015) 92
- mono-Z: PRD 90, 012004 (2014)
- mono-Z/W hadronic: PRL 112, 041802 (2014)



High-mass resonance to τ pairs [arXiv:1502.07177]

Heavy Z' search

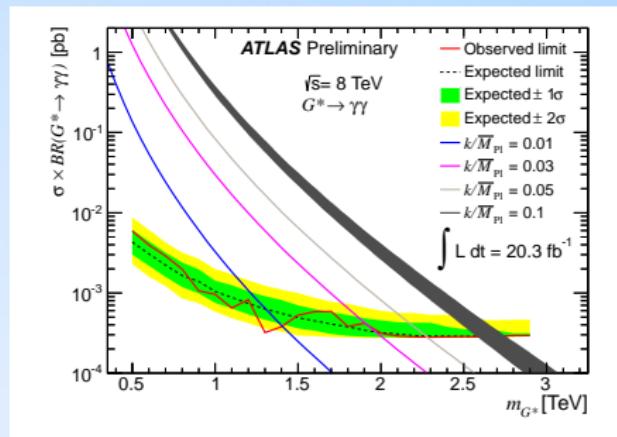
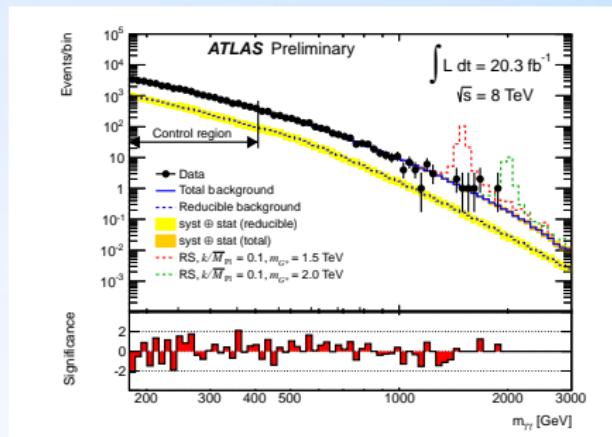
- ▶ both leptonic and hadronic τ decays considered
- ▶ background for the hadronic channel estimated from simulated $Z/\gamma^* \rightarrow \tau\tau$ and validated with data using decays to electrons and muons
- ▶ background at low mass dominated by QCD multi-jet



High-mass resonance to photon pairs [publication coming!]

Looking for high-mass state decaying to photons

- ▶ clean experimental signature with excellent mass resolution
- ▶ irreducible background from prompt di-photon production and photon misidentification
- ▶ looking for excited gravitons assuming different couplings with the SM

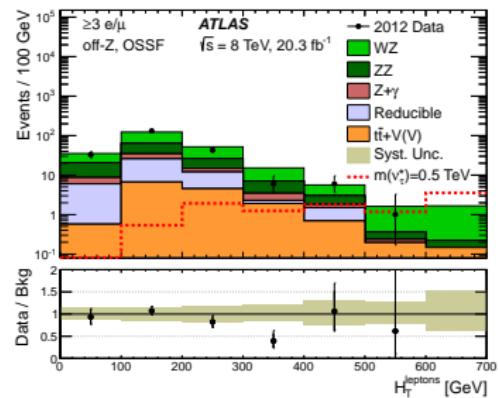


Search with charged leptons [arXiv:1411.2921]

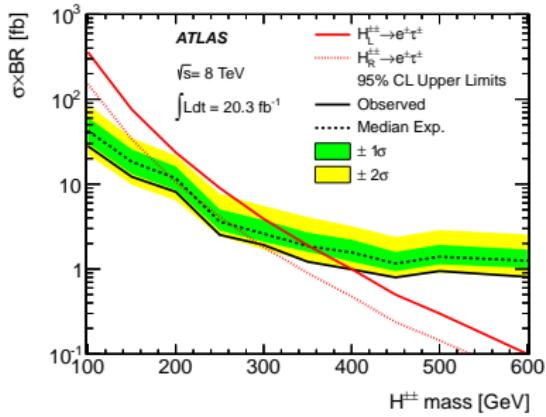
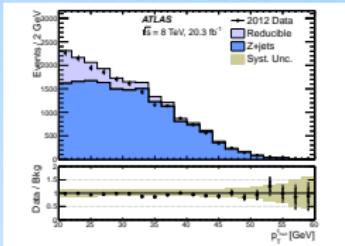
General search

- ▶ at least three charged leptons
- ▶ at least two electrons or muons
- ▶ interpretation for excited leptons and pair-production of doubly charged Higgs bosons (with a focus on LFV)

H_T for opposite-sign, same-flavor leptons in events with at least three leptons



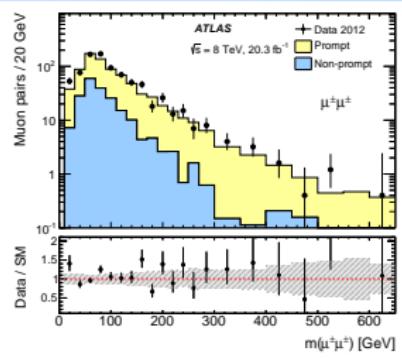
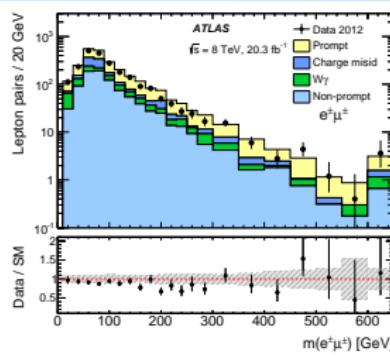
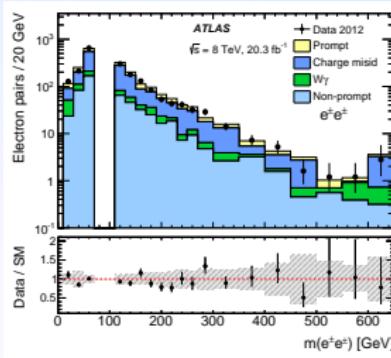
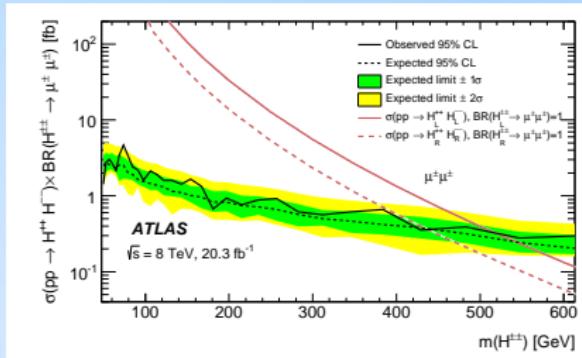
p_T distribution for hadronic tau candidates



Search with same-sign leptons [arXiv:1412.0237]

Generic search

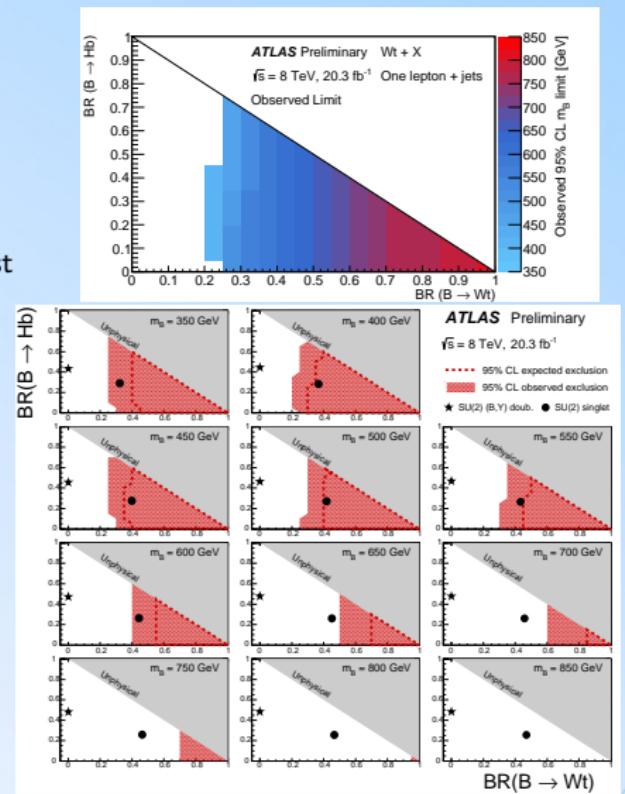
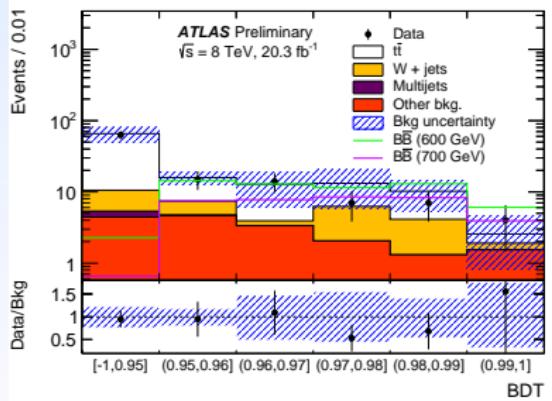
- ▶ isolated lepton pairs with the same electric charge
- ▶ invariant mass distributions inspected
- ▶ charge misidentification probability in electrons is studied in data with Z decays
- ▶ charge misidentification in muons is found negligible
- ▶ constraints on doubly charged Higgs bosons



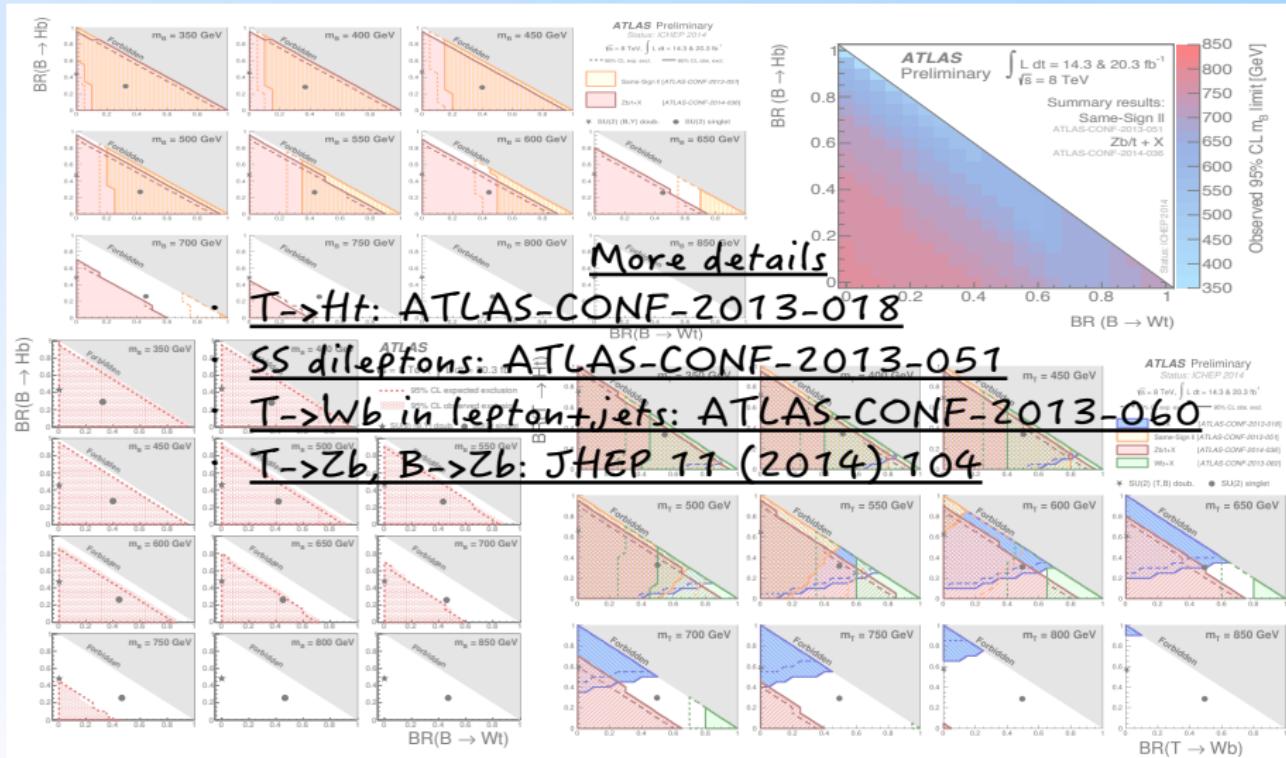
VLQ search in $Wt + X$ [publication coming!]

Searching for pair production of heavy vector-like down-time quarks (B quarks)

- ▶ events with one lepton, MET and jets are considered
- ▶ tagging of b -jets and W/Z hadronic decays
- ▶ signal region defined as at least 6 jets, at least 1 b -jet, at least one hadronic W/Z and $H_T > 500$ GeV



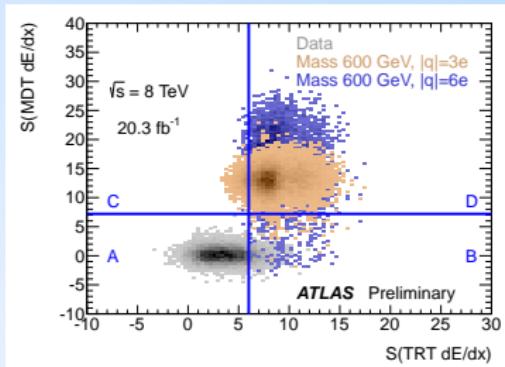
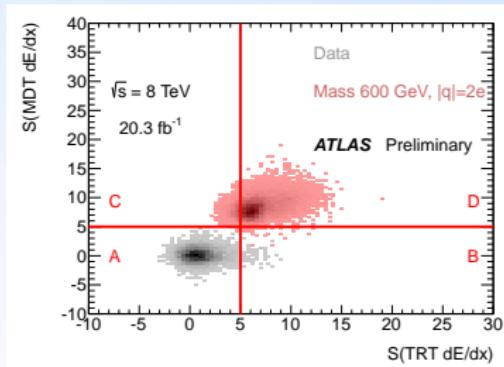
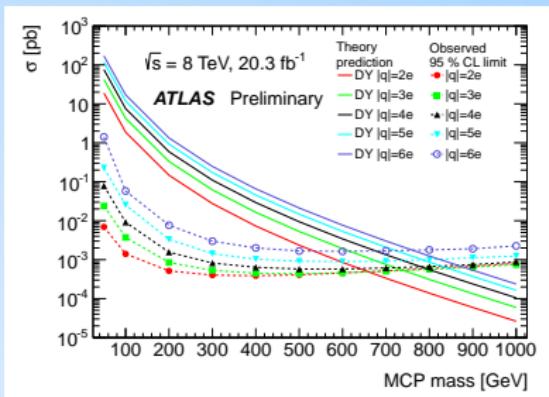
Extensive search program conducted by ATLAS. More signatures being planned for Run-II.



Multi-charge particle search [publication coming!]

Looking for anomalously high ionisation loss consistent with stable massive particles

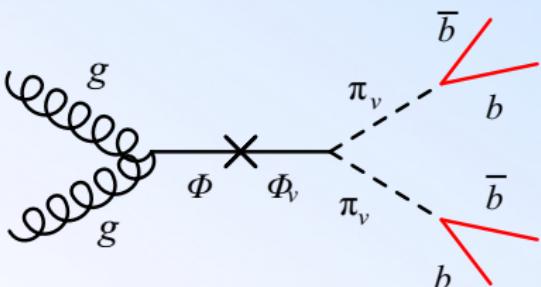
- ▶ single muon and *MET* triggers
- ▶ ionisation estimators defined using pixel dE/dx , TRT dE/dx , MDT dE/dx and fraction of high threshold TRT hits
- ▶ charges from 2e to 6e
- ▶ DY production mode



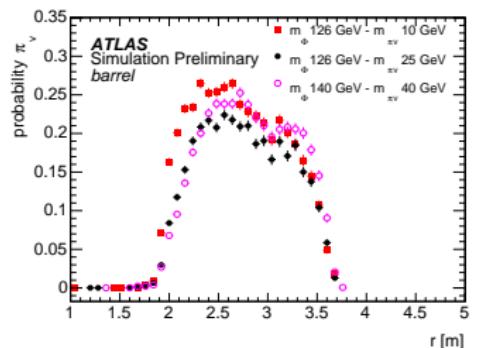
Displaced jets [PLB 743 (2015) 15-34]

Unique analysis, signature never explored before

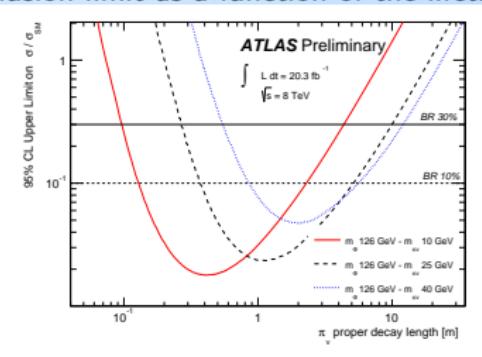
- ▶ signature-driven trigger
[JINST 8 (2013) P07015]
- ▶ two object strategy looking for displaced hadronic jets (unbalanced energy deposit in the calorimeters)
- ▶ background dominated by QCD jets and estimated with a data-driven technique



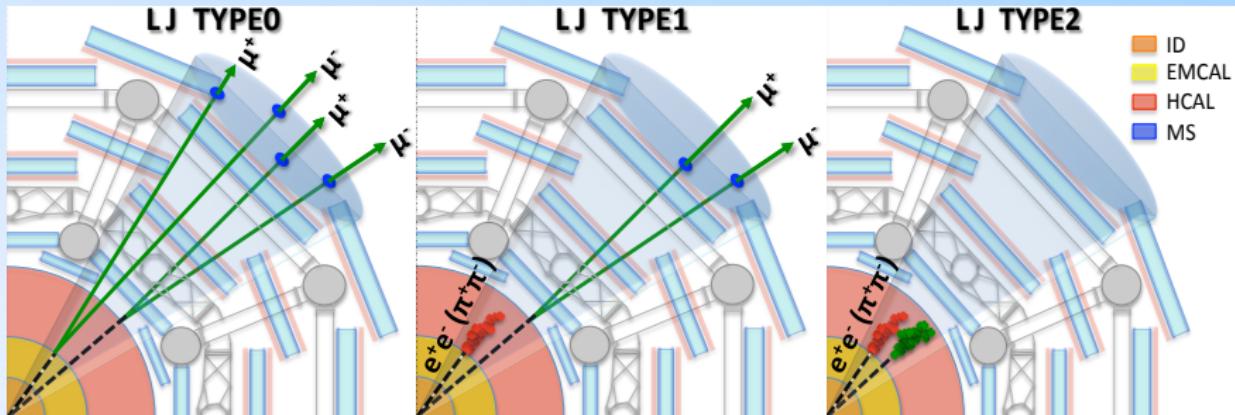
trigger efficiency vs decay position



exclusion limit as a function of the lifetime

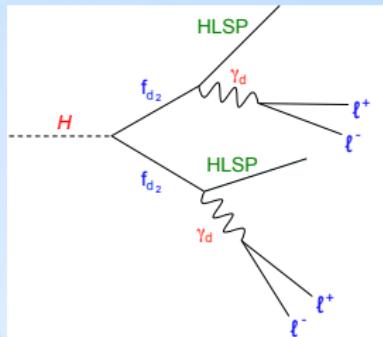


Displaced lepton-jets [JHEP 11 (2014) 088]

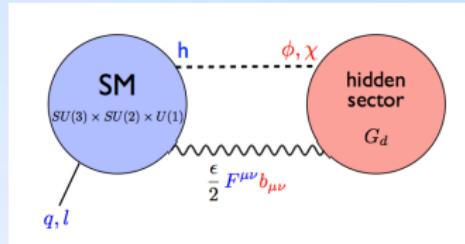


Analysis optimized for looking into displaced lepton-jets in a model-independent way

- ▶ QCD multi-jet background calculated with ABCD method
- ▶ cosmics background estimated analysis the empty bunches
- ▶ benchmarks targeting dark photon production through exotic Higgs decay

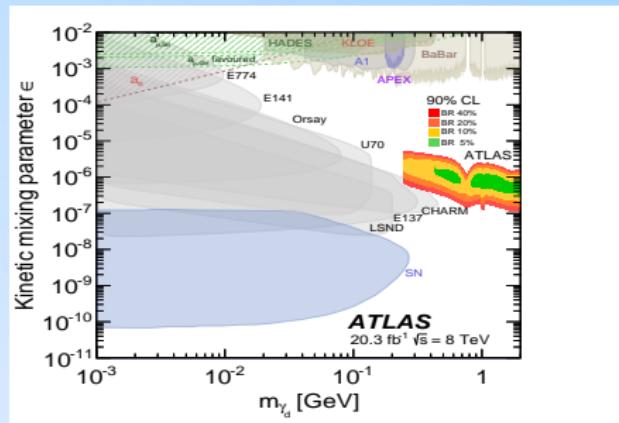


Vector portal model interpretation [JHEP 11 (2014) 088]



$U_d(1)$ gauge invariance resulting in a kinetic mixing between the SM hypercharge and the dark photon

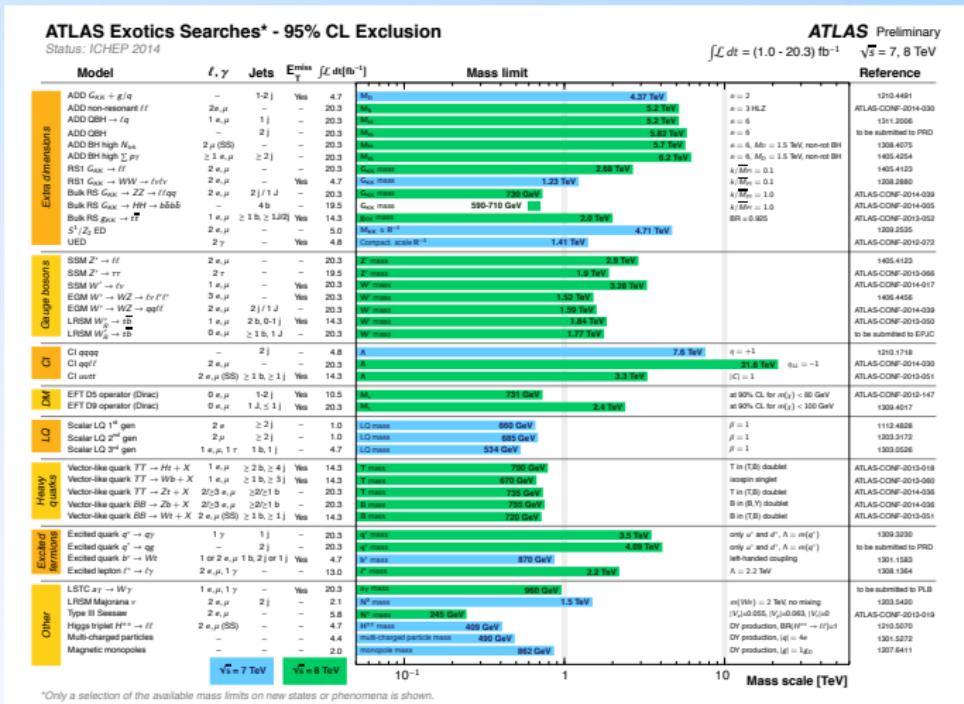
- ▶ the strength of the interaction by the ϵ parameter
- ▶ production of prompt/displaced collimated/nearly-collimated leptons



Hadron-collider experiment entering into the mass vs ϵ plot of the vector-portal interpretation.

Previously unexplored region is now constrained by ATLAS.

Impressive Run-I legacy results - and more to come in the coming weeks/months! Energy increase in Run-II is a tremendously exciting opportunity for finding new physics and it's just around the corner!



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