SEARCHES FOR NEW PHYSICS IN HADRONIC FINAL STATES WITH THE ATLAS DETECTOR AT THE LHC RUN-I

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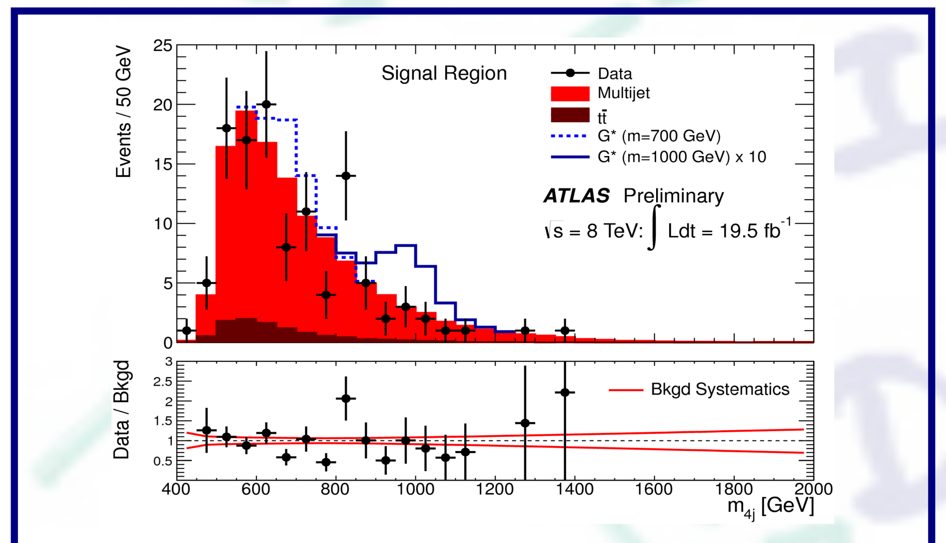
ATLAS EXPERIMENT

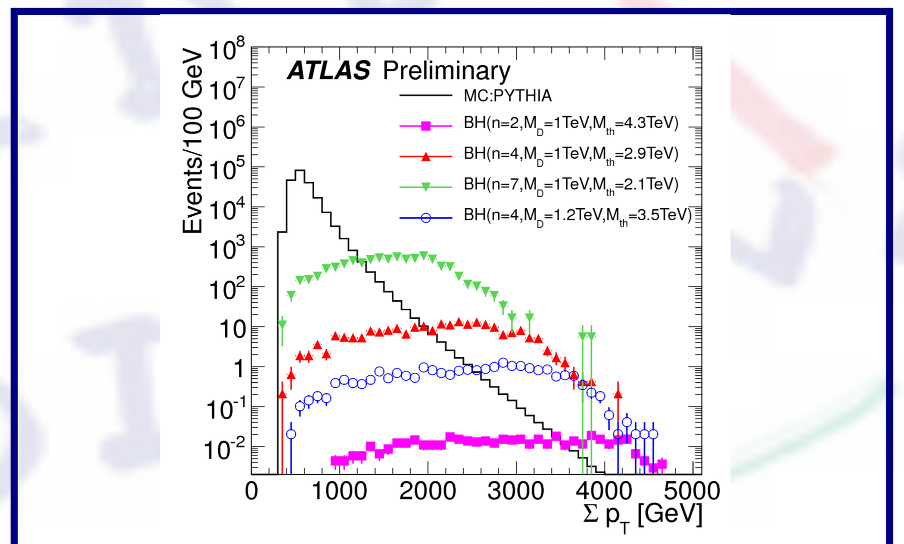
UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES

EXTRA DIMENSIONS

Evidence for **EXTRA DIMENSIONS** would be brought forward by the presence of new **Gravity-mediating particles** (the Graviton) decaying into two of the newly discovered **Higgs bosons, producing** an event containing **4 jets originated by b-quarks** [1]. Another hint would be the observation of an excess of **many-jet events**, produced by the decay of **microscopic black holes** [2].



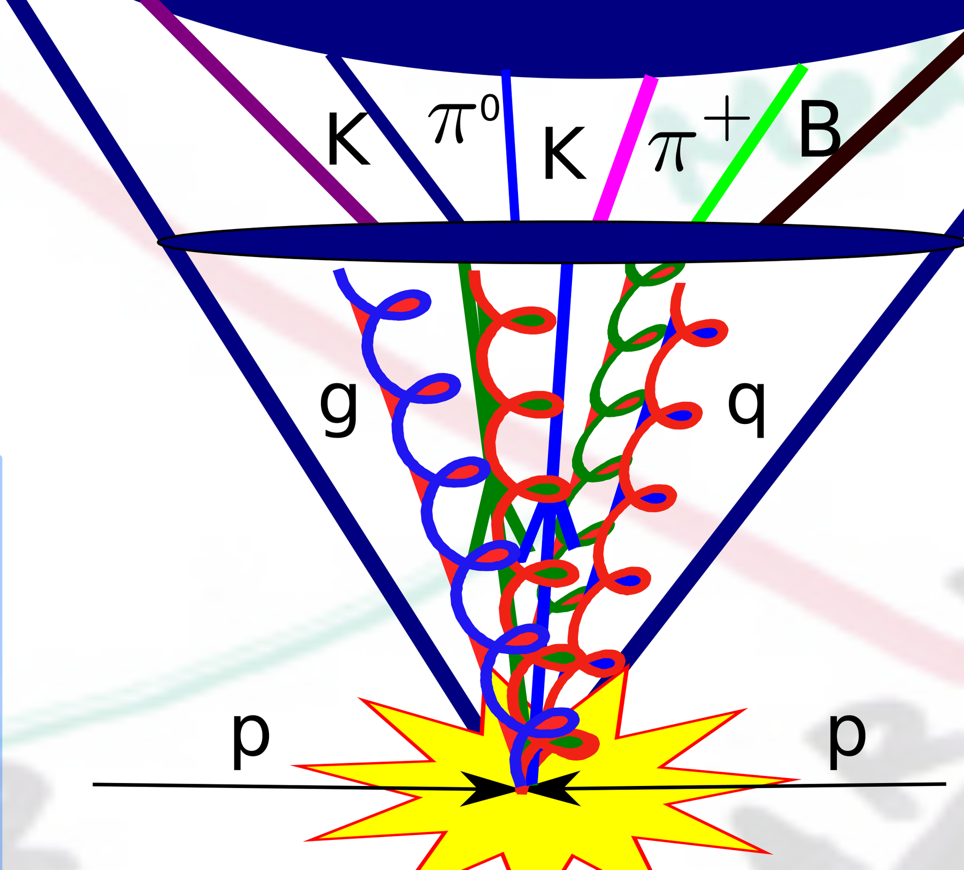
No excess is observed over the background, as shown in the figure depicting the invariant mass of the four-b-jet system. This allows ATLAS to constrain the Graviton mass to be below 590 GeV or above 710 GeV.with this search.



Searches for micro black holes in high jet multiplicities is ongoing. The signature of such a black hole is an excess of many-jet events where the sum of transverse momentum (Σp_T) for all jets in the event is large.

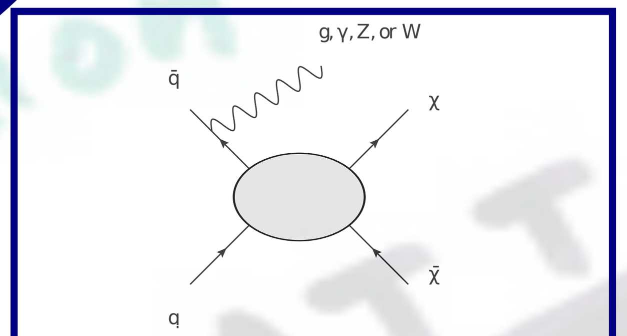
HADRONIC JETS

are the most common object produced at the LHC. Jets are **collimated sprays of particles** resulting from the **scattering of quarks and gluons.**
If **New Physics** processes interact with quarks and gluons, they will manifest as **excesses of highly energetic jets** in data.



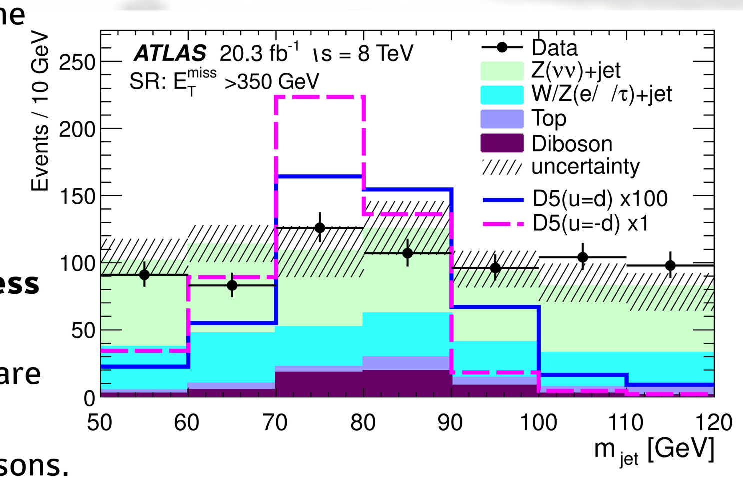
DARK MATTER

If **DARK MATTER** particles interact with quarks and gluons, they can be produced at the LHC. However, they will **not be directly visible in the detectors**: their nature might allow them to interact only weakly (Weakly Interacting Massive Particles, WIMPs), and their signature will be **unbalanced transverse momentum recoiling against one or more objects** that are radiated in the initial state. ATLAS searches target **highly energetic jets** from quarks, **boosted W boson decaying into two quarks** [6], or a **photon** [7]. Other signatures include **W and Z bosons decaying leptonically** [8, 9].

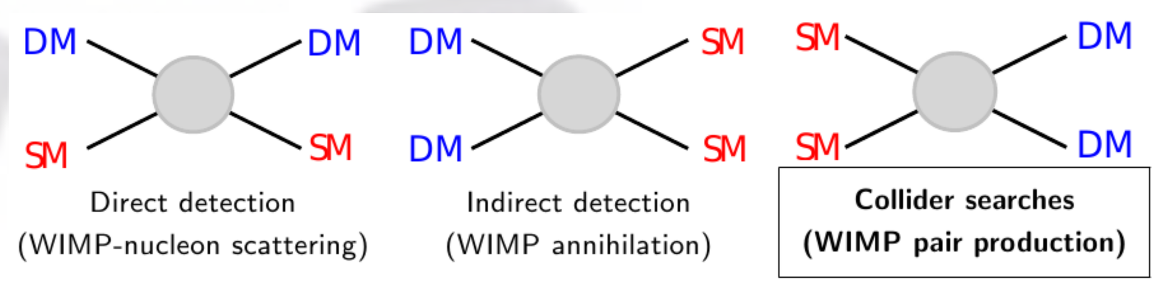


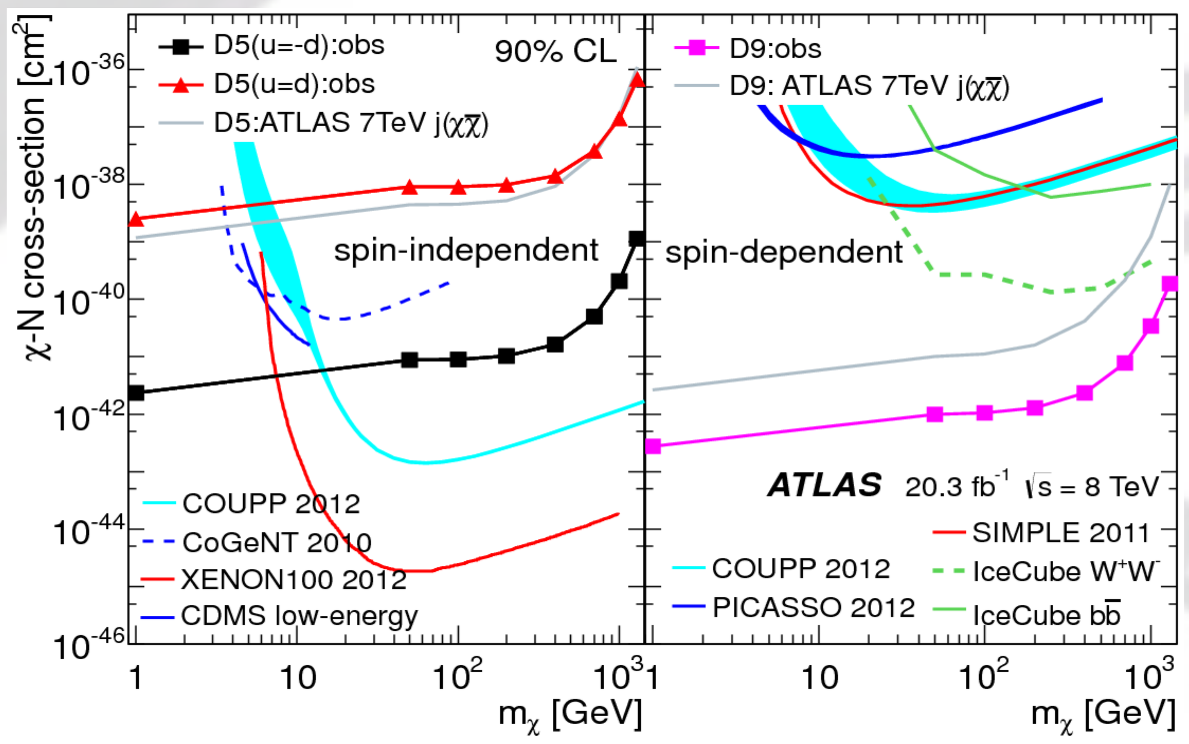
Schematic diagram of the production of DM particles at a collider. **DM particles** are produced together with a **recoiling object**, whose presence is exploited for the search.

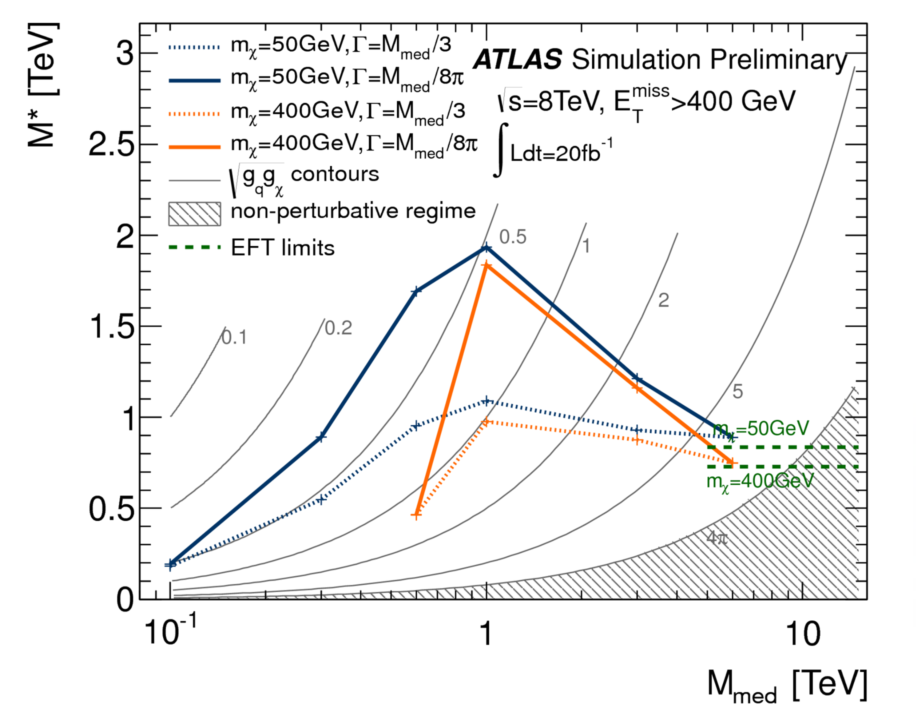
The main discriminant variable for the search exploiting hadronic decays of the W boson is the **jet mass**, given that all W decay products will be reconstructed in a single jet whose mass will correspond to the mass of the W boson itself. **No excess** is observed above the background. The **strongest constraints to date** are set on **Dark Matter particles** that would preferentially couple to W bosons.



Results of searches for dark matter at **colliders** are **complementary** to **direct and indirect detection experiments** within the Effective Field Theory framework. If combined with results from other experiments, colliders are crucial to cover the mass phase space available to WIMP dark matter particles, especially at low masses. The plot below shows the **constraints on the nucleon-WIMP cross section** from LHC and direct detecton experiments, showing their complementarity.



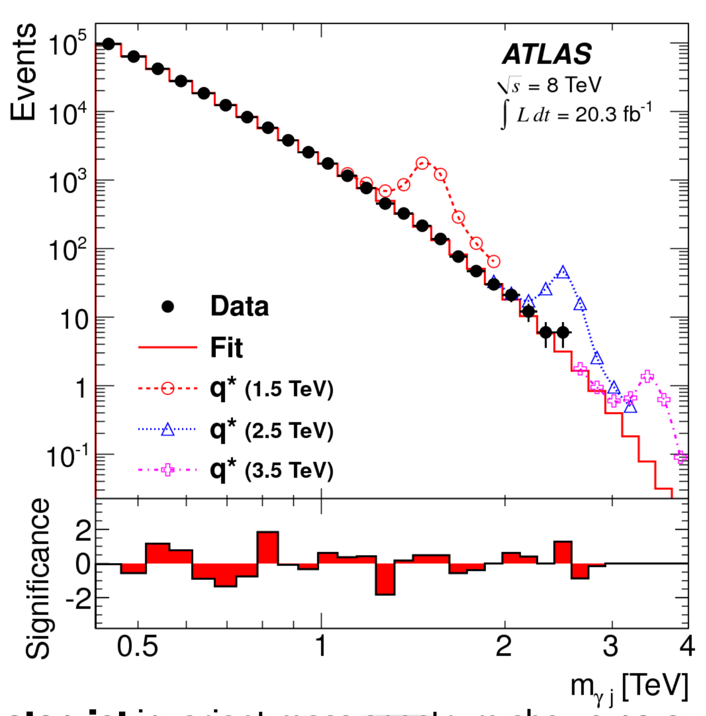




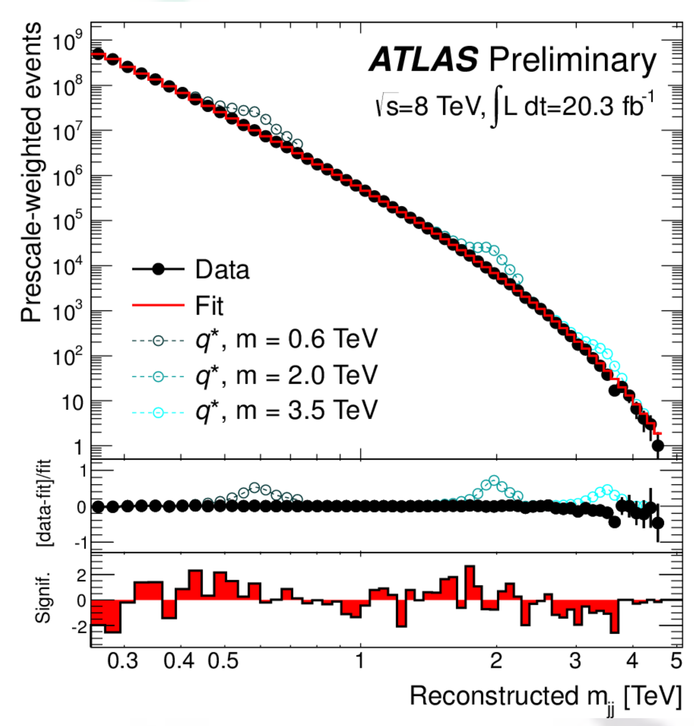
The **validity** of this **theoretical framework** needs to be **considered carefully**, since it makes the stringent assumption that the particle mediating the interaction between SM and dark sector is heavier than the momentum transferred in the collision. Collider searches from both ATLAS and CMS are considering this constraint carefully before comparing to other experiments, by moving to theoretical benchmarks where the mediator particle appears explicitly (**simplified models**) [10]. An example is in the right-hand plot above where expected limits on the scale of the interaction between DM and SM particles (Λ) are set as a function of the mass of the mediating particle (M_{med}).

NEW PARTICLES

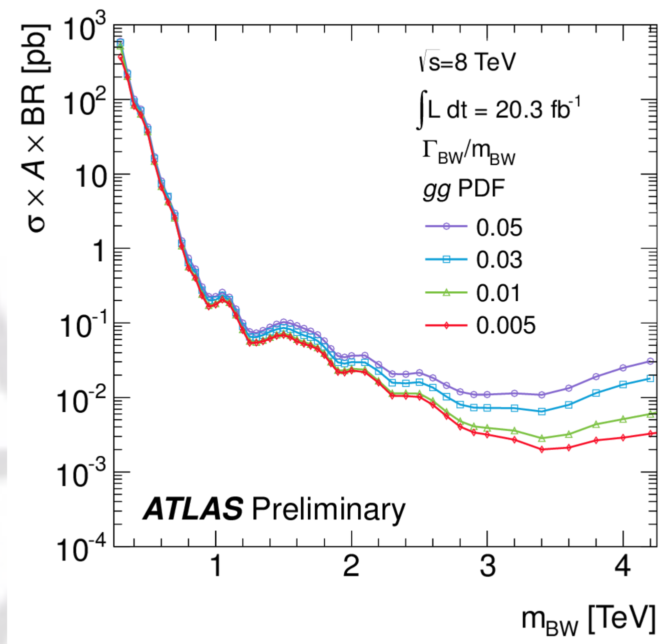
NEW PARTICLES could be produced at the LHC by a variety of models. ATLAS searches for resonances in the **photon-jet** [3] and **dijet** [4] final states, in a wide invariant mass range: the photon-jet invariant mass spectrum spans from 0.5 TeV to 4 TeV, while the dijet invariant mass spectrum starts as low as 250 GeV and reaches 4.5 TeV. New resonances would produce a '**bump**' over the smooth QCD background.



The **photon-jet** invariant mass spectrum shows **no excesses** over the data-driven background. This search constrains the mass of **excited quarks** decaying to a jet and a photon to be above 3.5 TeV at the 95% CL, while the mass of **Quantum Black Holes** is constrained to be above 4.6 TeV



The **dijet** invariant mass spectrum shows **no excesses** over the data-driven background either. Constraints on the lower limits of the masses of resonances from various New Physics models are set at 95% CL.



Parton Distribution Functions (PDF) influence the shape of the mass peak of the new resonance and therefore the constraints one can put on NP models in this search. Limits on the cross-section times acceptance times branching ratio are set separately depending on the production and decay of **generic Breit-Wigner resonances** with various intrinsic widths.

Background image: H. Murayama, ICFA seminar (2011)
[1] ATLAS Graviton -> 2 Higgs -> 4b search: **ATLAS-CONF-2014-005**
[2] ATLAS Multijet Black Hole search: **ATLAS-CONF-2011-068**
[3] ATLAS Dijet resonance search: **to appear**
[4] ATLAS Gamma-jet resonance search: **arXiv:1309.3230; PLB 728, 562 (2013)**
[5] ATLAS Monojet Dark Matter search: **ATL-COM-PHYS-2013-1578**
[6] ATLAS Hadronic Mono-W/Z Dark Matter search: **arXiv:1309.4017; PRL 112, 041802 (2014)**
[7] ATLAS Monophoton Dark Matter search: **arXiv:1209.4625; PRL 110, 011802 (2013)**
[8] ATLAS W'->lv search: **ATLAS-CONF-2013-017**
[9] ATLAS leptonic mono-Z DM search: **arXiv:1404.0051, submitted to PRD**
Collider/DD/ID complementarity image: S. Schramm, DarkInt Workshop (2014)
[10] ATLAS Monojet Sensitivity to DM in Run-II: **ATL-PHYS-PUB-2014-007**