Looking for dark-sector long-lived particles with ATLAS

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80 years of building new worlds through knowledge

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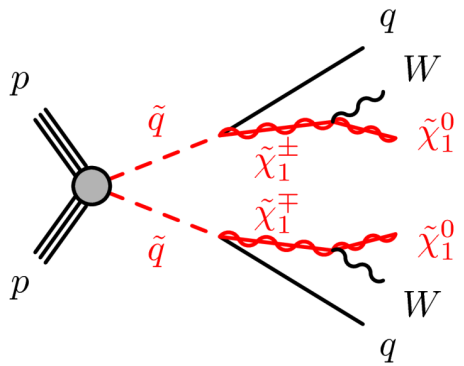
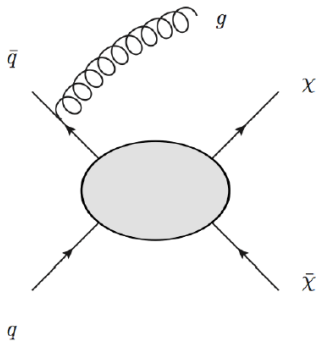
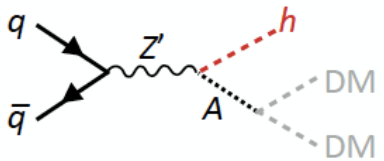
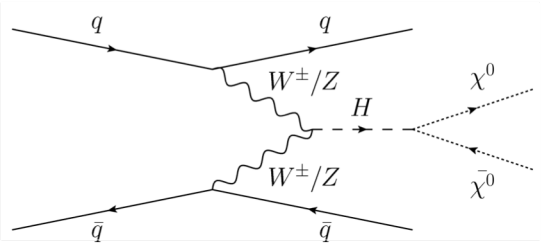
Dark Matter: WIMP-like search status

- DM searches at the LHC have so far focused mainly on SUSY particles (cascade decays down to the neutralinos), direct pair production of DM particles in simplified models of the mono-X type (X=jet, photon, V, H) or the Higgs invisible decay *









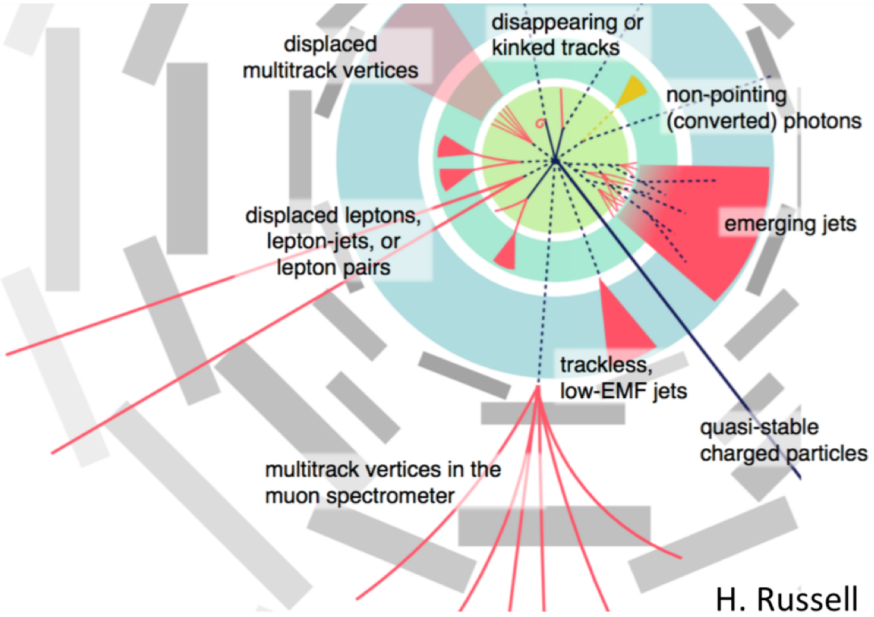
- All these are very interesting searches, but they are rather well covered already – the full run-2 analyses have already started, with some results starting to get out already
- With the start of Run-3 in 2021 and a factor 2 in integrated luminosity by the end of it, it will be possible to strenghten the limits provided by these types of searches**, but the discovery space beyond the already existing limits will be reduced.

*See for example https://arxiv.org/abs/1508.06608, https://arxiv.org/abs/1904.05105, https://arxiv.org/abs/1903.01400

** See for example https://arxiv.org/abs/1812.07831

Extending the coverage

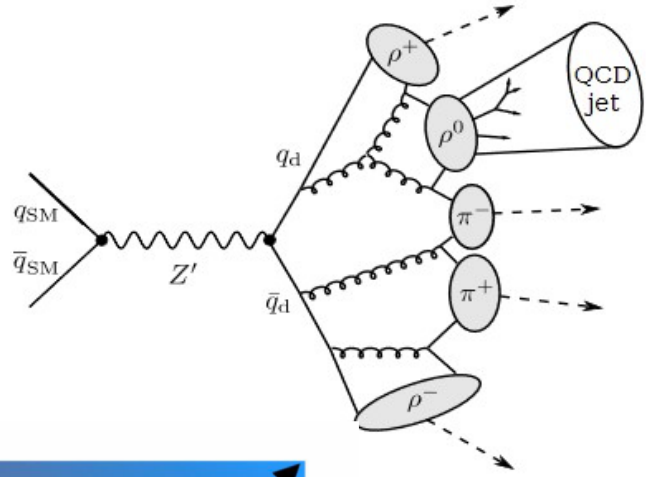
- It is thus important to make sure that less well covered scenarios are also explored
- These scenarios can involve the existence of possibly long-lived particles, such as dark hadrons from a hidden QCD sector or heavy neutral leptons, both of which could lead to signatures involving displaced vertices in the inner detector. The focus of the group is now on these types of searches.



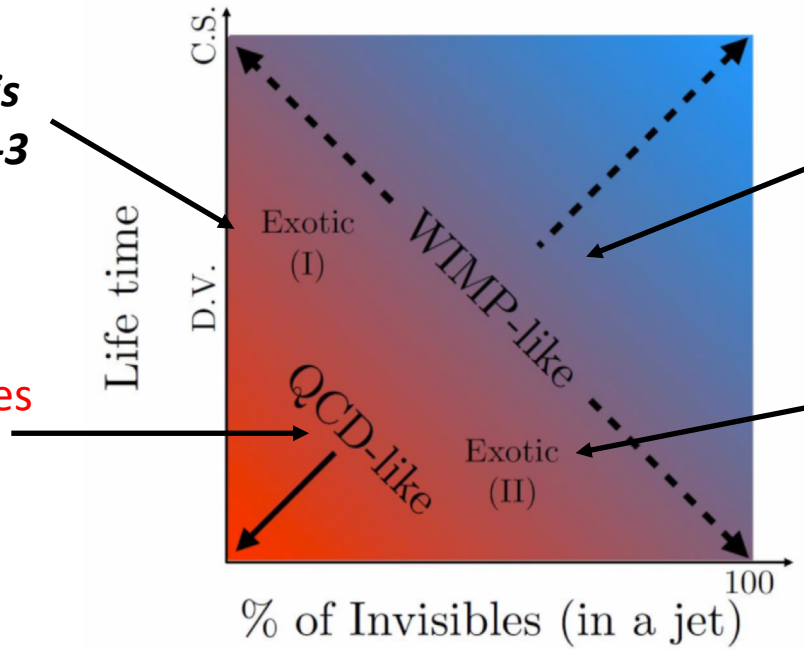
- These require a very good understanding of the objects in the detector, understanding which can now benefit from many years of smooth data taking

Dark QCD scenario

- Can lead to multiple signatures:



Displaced vertices in the jets
Focus of LPSC after the search below is done, possibly in preparation for Run-3
No publication yet from ATLAS



"Usual" MET+X searches

« Prompt » dark jet looks like a SM QCD jet – but some tracking and calo variables can be used to discriminate the two
No experimental search published yet
⇒ work ongoing at LPSC :

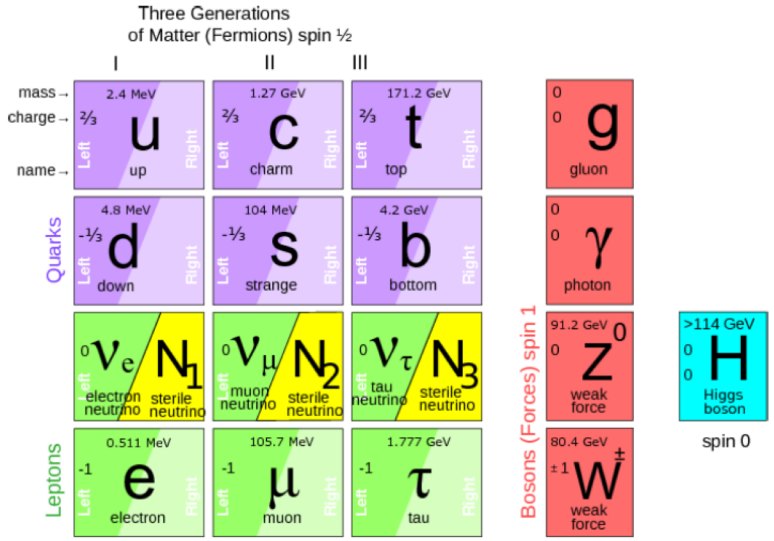
Some stable dark hadrons (dark baryon and also some dark meson) occupy non-negligible portion of a dark jet, which make various kinematic variables useful.

- N. Lalloué (*PhD student*)
- D. Portillo-Quintero (*postdoc, ATLAS jet subgroup convener, dark-jet analysis contact*)
- M-H. Genest (*previous ATLAS Exotics convener*)

(See e.g. https://arxiv.org/abs/1712.09279)

HNL (heavy neutral lepton)

- S. Wada (*PhD student*)
- K. Hara

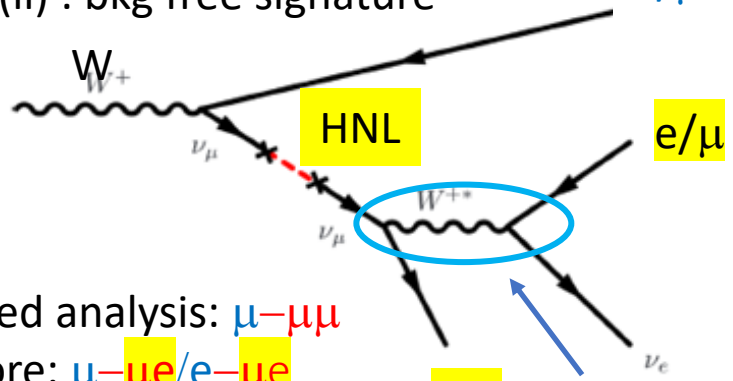


⇒Many of BSMs require additional neutral leptons

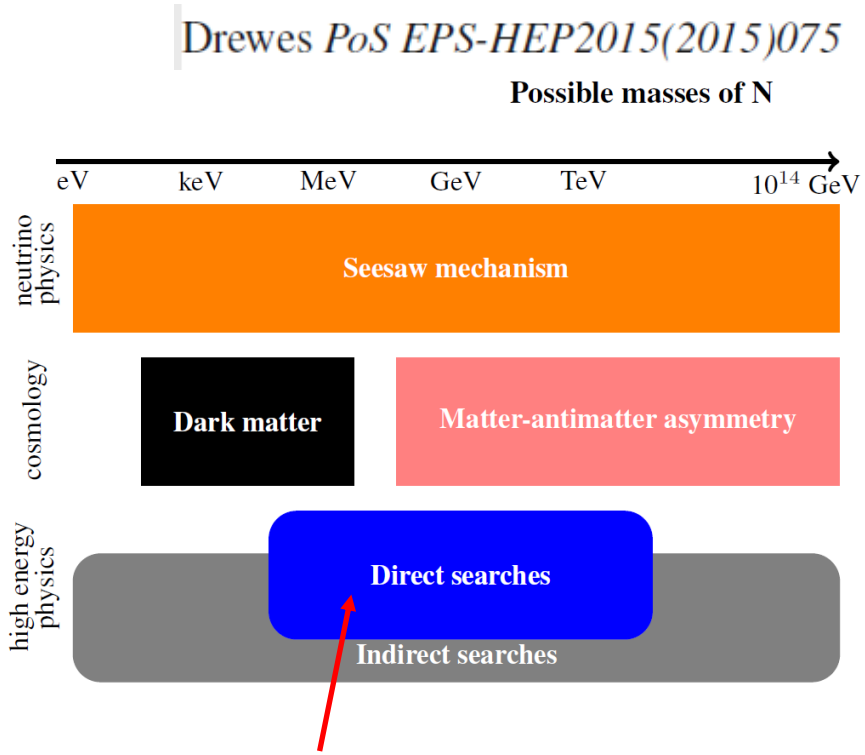
- Right-handed neutrino in type-I SeeSaw
- Left-Right symmetric model

$$\tau_{N_\mu} = (4.49 \cdot 10^{-12}\ \mathrm{s})|U|^{-2}(m_N/1\ \mathrm{GeV})^{-5.19}$$

For small |U|, m_N
=> DV(ll) : bkg free signature

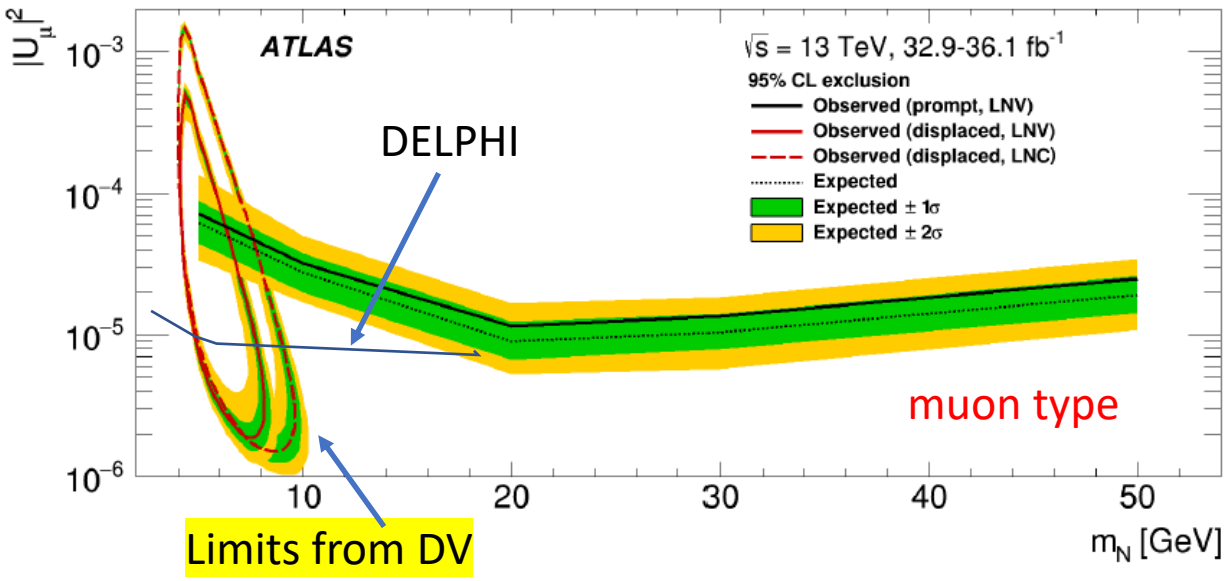


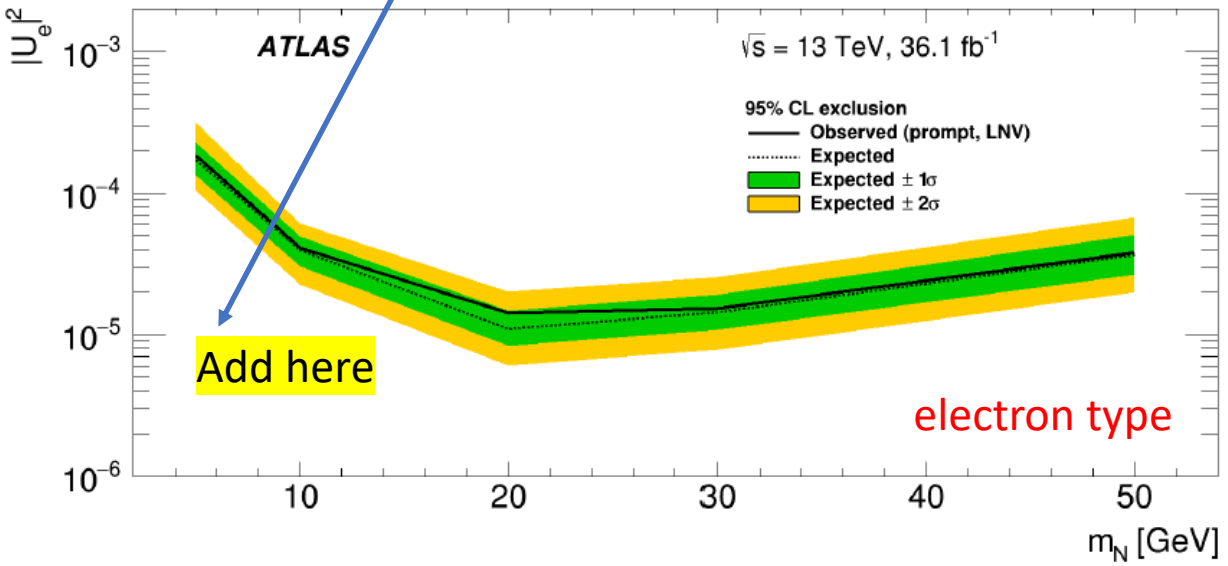
published analysis: μ–μμ
in explore: μ–μe/e–μe
Adding: e-ee



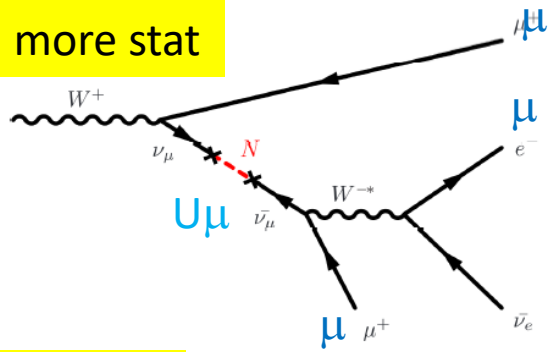
Direct search @LHC ATLAS

Current ATLAS coupling limits on HNL

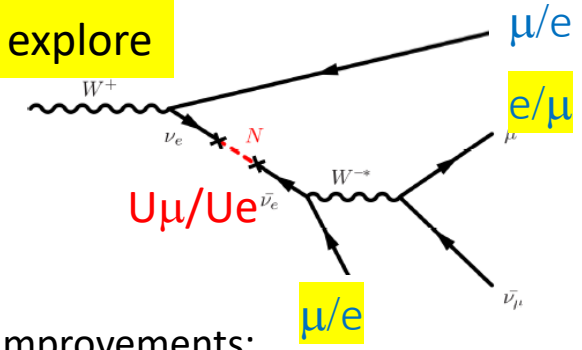




more stat



explore



Improvements:

- luminosity (high mass region)
- electron prompt + DV
- DV(ee) – to cover low-mass Ue

add