

Search for beyond the standard model physics with ATLAS



David Brunner
on behalf of ATLAS Sweden

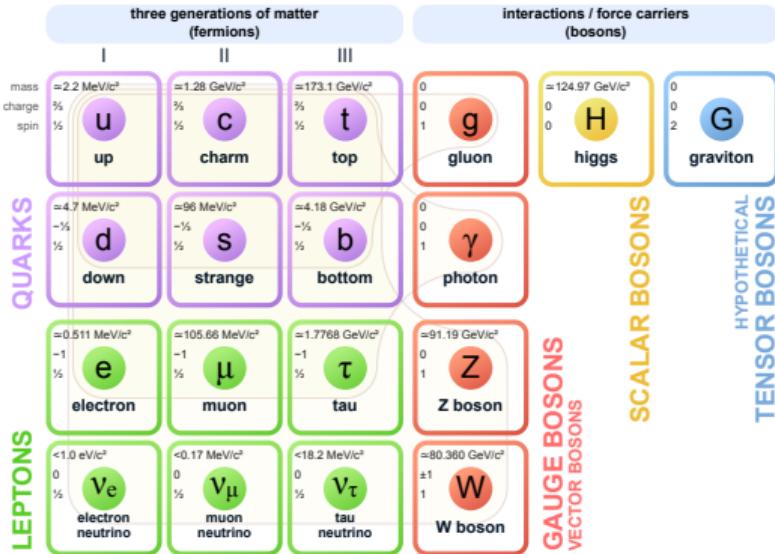


Fysikdagarna 2023 Stockholm
14.6.2023



Standard Model of particle physics

Standard Model of Elementary Particles and Gravity

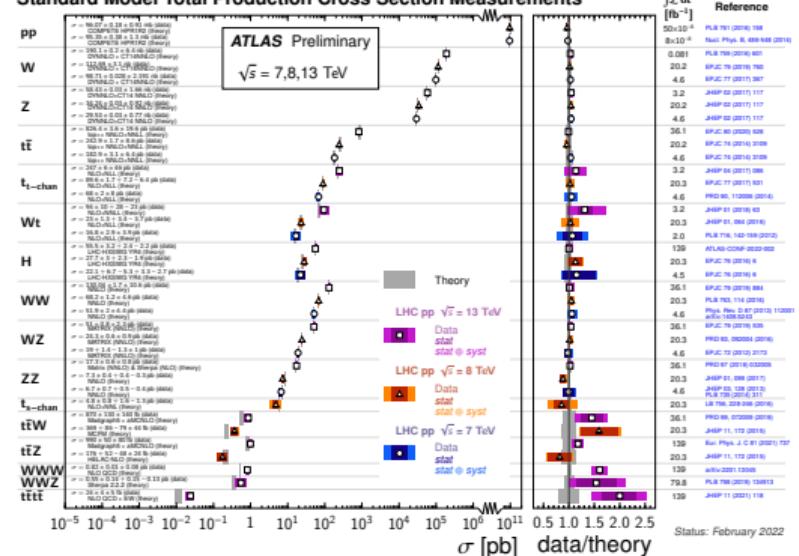


from Wikipedia

- Standard Model (SM) describes known particles and interactions

ATLAS SM measurements

Standard Model Total Production Cross Section Measurements



from ATL-PHYS-PUB-2022-009

- Measurement agrees well with SM in several order of magnitudes

What is missing?

- Gravity not described
- Massive neutrinos (neutrino oscillation)
- Dark matter (gravitational lensing, cosmic microwave background, ...)
- Matter-antimatter symmetry
- ...

What could be beyond?

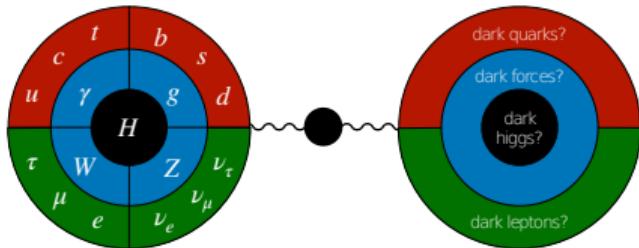
- extended Higgs models
- Supersymmetry (SUSY)
- Seesaw mechanism
- Hidden sectors
- ...

BSM physics in Sweden

	public	on going
 UPPSALA UNIVERSITET	Search for dark mesons (see here)	Vector-like quarks in composite Higgs models see PhD thesis from Thomas Mathisen
 LUND UNIVERSITET	Search for type-III seesaw heavy leptons (see here)	Doubly charged Higgs boson search Trigger-level analysis
	Search for long-lived massive particles (see here) (together with Stockholm university)	Search for delayed jets sensitive to longer lifetimes
 Stockholm University	Search for new phenomena with top quark pairs (see here)	Stop analysis with current ATLAS run BSM Di-Higgs search pMSSM global fits

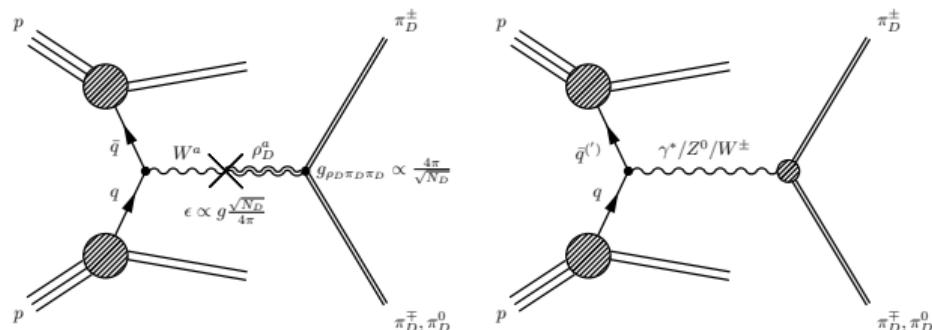
Search for dark mesons

Hidden sector paradigm



from [arXiv:2209.04671](https://arxiv.org/abs/2209.04671)

Production of dark mesons

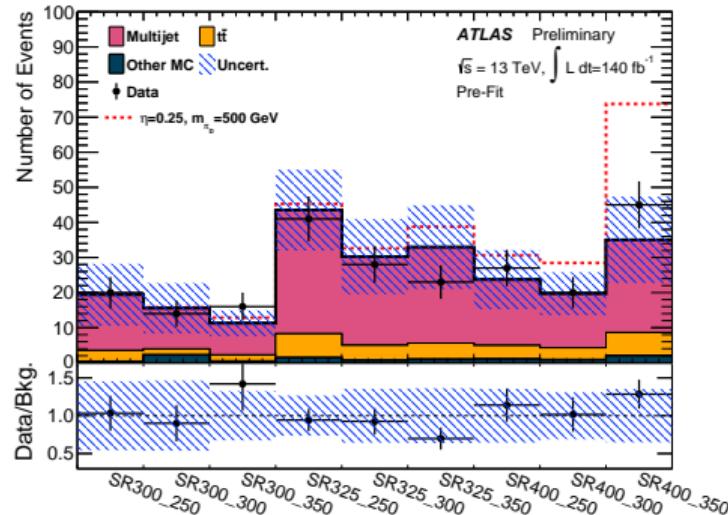
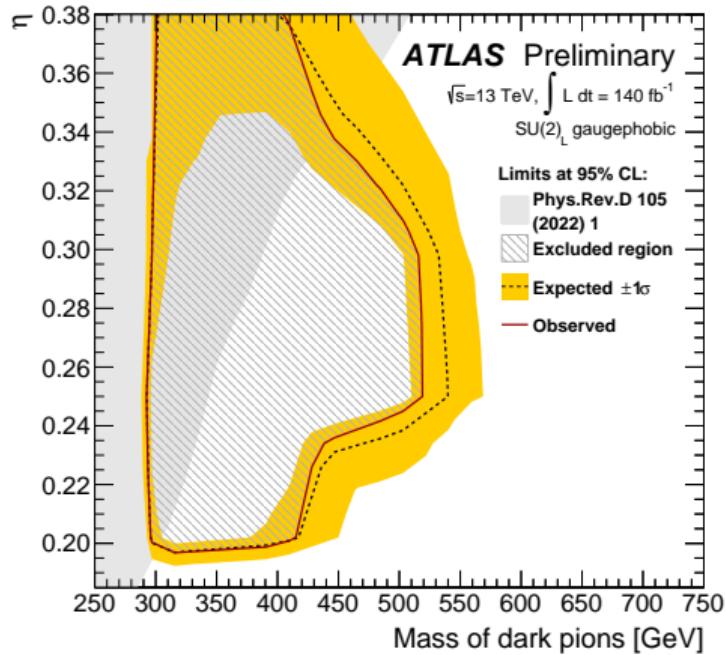


- Hidden sector with new particle content indirect/weakly interacting with SM
- BSM or/and SM mediator (portal) particle needed, e.g. Higgs boson

- Strong non-abelian SU(2) symmetry with vector-like fermions
- Analog to QCD mesons: dark rho and dark pion
- Difference to other common dark matter searches: No missing transverse momentum analysis focus
- Decay of dark pions to top/bottom quarks

Search for dark mesons

Results



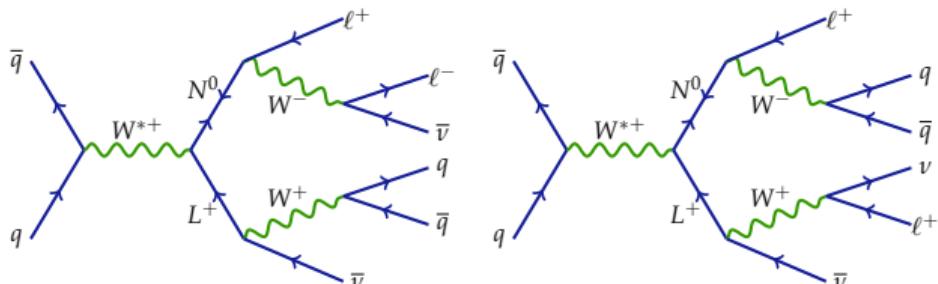
- No deviations from SM observed and strong limits are set
- Paper for one lepton final state analysis on the way
- See more in Olga Sunneborn Gudnadottir [talk](#) and check out the poster session

Search for type-III seesaw heavy leptons

Seesaw mechanism



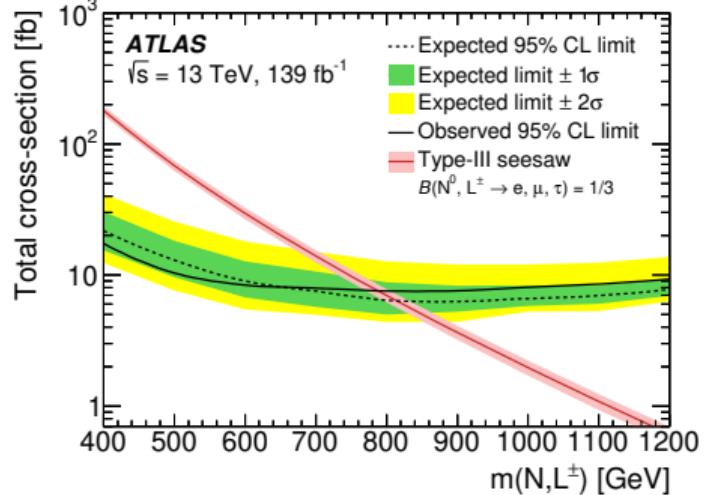
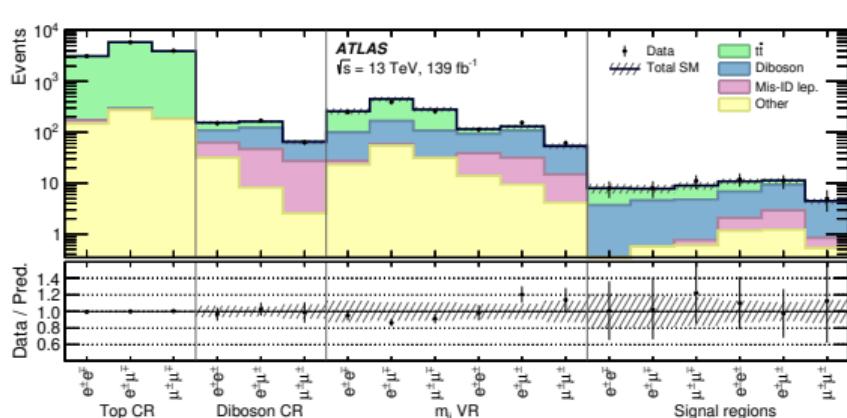
Production of heavy leptons



from [arXiv:1207.1590](https://arxiv.org/abs/1207.1590)

- Mechanism for producing light neutrinos
- Several possible realisation of the mechanism
- In general: introduction of heavy neutral Majorana particle
- Seesaw mechanism (type III) with a triplet of heavy fermions (L^\pm, N^0)
- Di-lepton (same and opposite sign) and di-jet final state

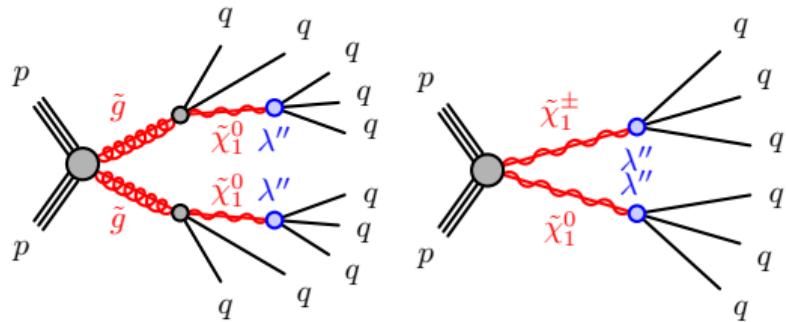
Search for type-III seesaw heavy leptons



- No deviations from SM observed
- Heavy leptons with masses below 790 GeV excluded (mass-degeneracy assumed)

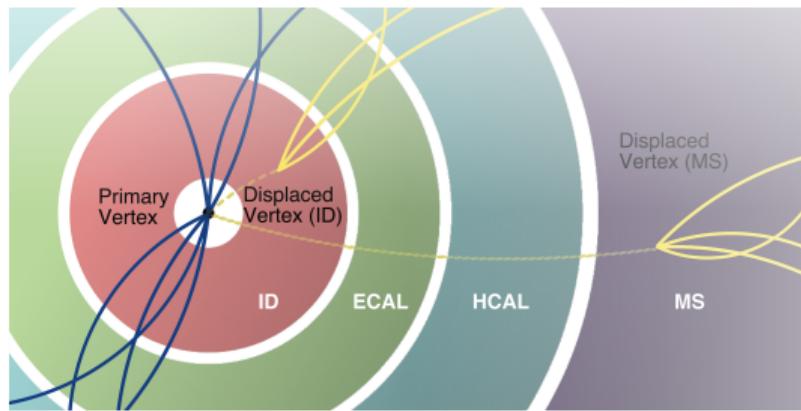
Search for long-lived massive particles

Production of long lived particles



- Super-symmetric model
- Study of long-lived particles (0.01 ns to 1 ns)
- Final state with many jets and displaced vertices (DV)

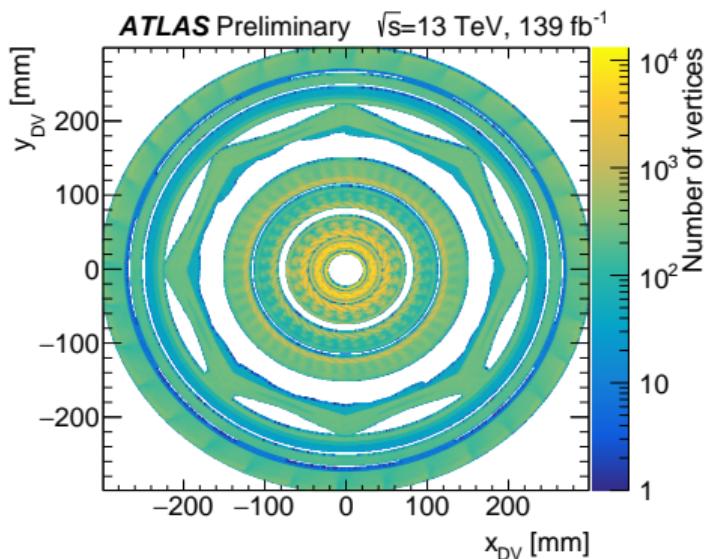
Displaced vertices



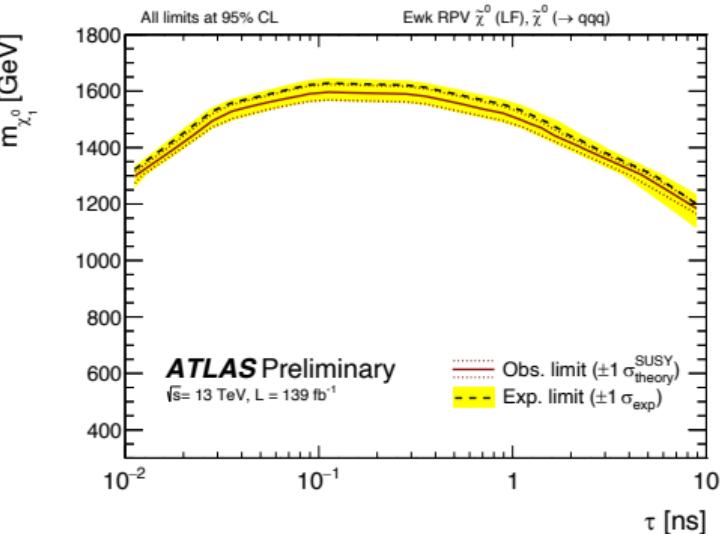
from [arXiv:1810.12602](https://arxiv.org/abs/1810.12602)

Search for long-lived massive particles

Material map of ATLAS tracker



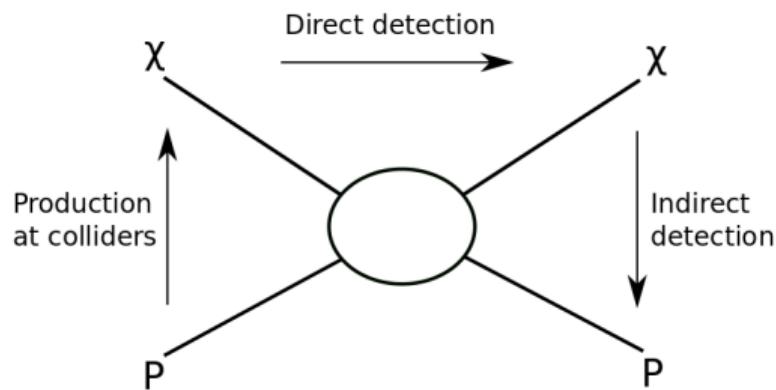
- ⌚ Unique method: data-driven mapping of the ATLAS tracker
- ⌚ Used to for the selection of DV



- ⌚ Limits in terms of the life time and mass of $\tilde{\chi}_1^0$
- ⌚ $m(\tilde{\chi}_1^0)$ values up to 1.58 TeV for $\tau = 0.1$ ns
- ⌚ Results can be interpreted in many different (non-SUSY) models as well!

Search for new phenomena with top quark pairs

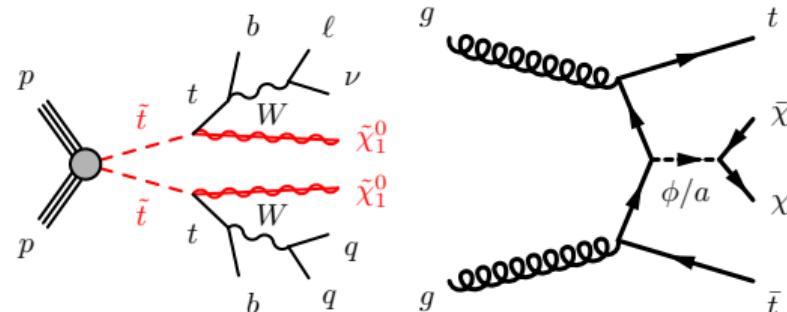
WIMP paradigm



from [arXiv:1509.08767](https://arxiv.org/abs/1509.08767)

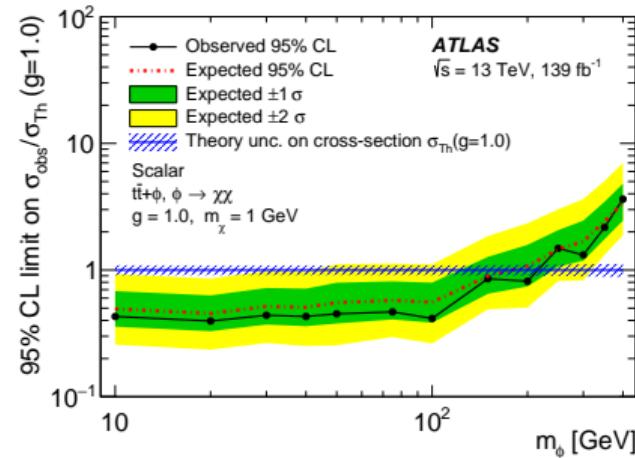
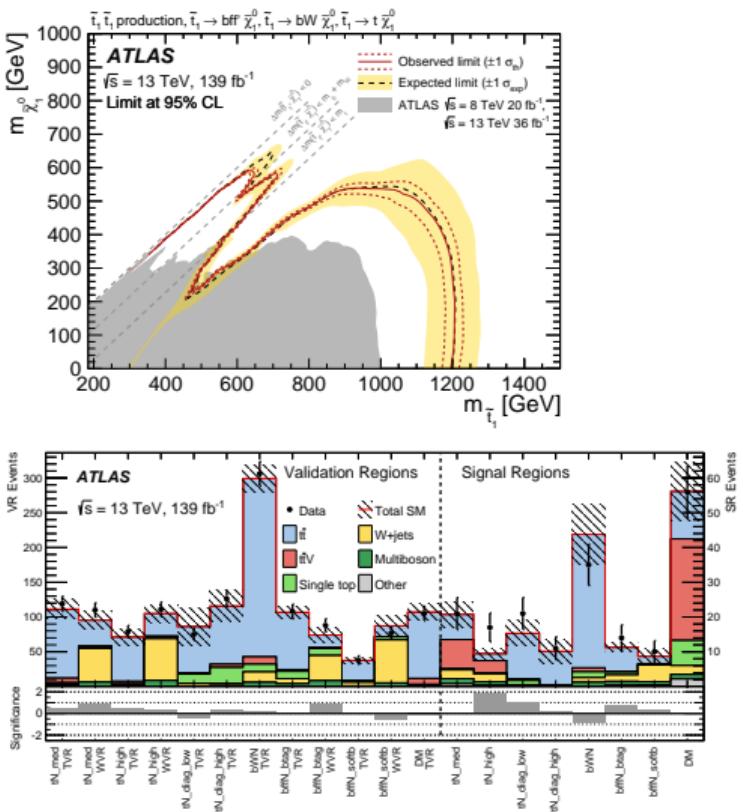
- Existence of a stable weakly interacting massive particle (WIMP)
- Natural candidate for dark matter
- In high energy frontier: SUSY standard approach

Top-quark pair and missing transverse momentum



- Super-symmetric model and generic DM model with scalar mediator
- Classic approach with high missing transverse momentum
- Analyzed in a single lepton and multi-jet final state

Search for new phenomena with top quark pairs



- No deviations from SM observed
- Limits in terms of SUSY parameters and generic DM model
- Dark matter result mentioned in Christina Dimitriad [talk](#)

Conclusion

- Many interesting public results produced in Sweden
- Several BSM areas covered with SUSY, dark matter, hidden sectors, seesaw mechanism
- With the current data taking of ATLAS new results are expected
- BSM models are pushed to their "limits"



LUND
UNIVERSITET



UPPSALA
UNIVERSITET



Stockholm
University



■ Search for beyond the standard model physics with ATLAS ■

■ David Brunner ■ Fysikdagarna 2023 Stockholm ■ 14.6.2023 ■



Tack för er uppmärksamhet!
(Thanks for your attention!)

Contact

David Brunner

david.brunner@cern.ch

david.brunner@fysik.su.se

