Overview of BSM physics in ATLAS Sweden

Patrawan Pasuwan (Prim)
On behalf of KTH, Lund, Stockholm and Uppsala ATLAS groups

The Standard Model

- The Standard Model (SM) of particle physics is a well-established theory
- There are open questions that the SM does not answer, e.g.
  - Hierarchy problem
  - Dark matter

Beyond the Standard Model

- There are open questions that SM does not answer, e.g.
  - Hierarchy problem —> Supersymmetry (SUSY) and vector-like quarks
  - Dark matter —> SUSY, simplified models and dark sector theories

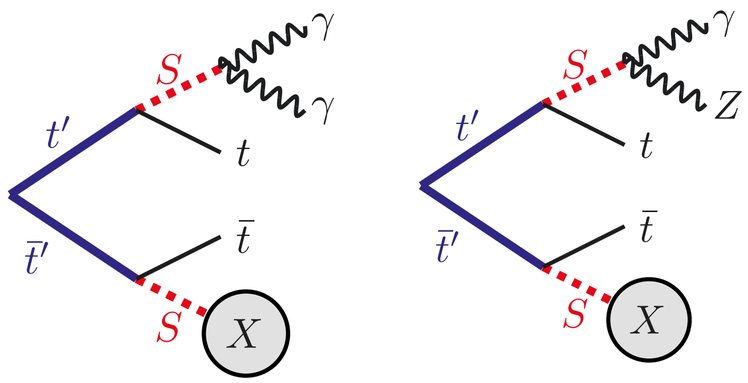
Outline

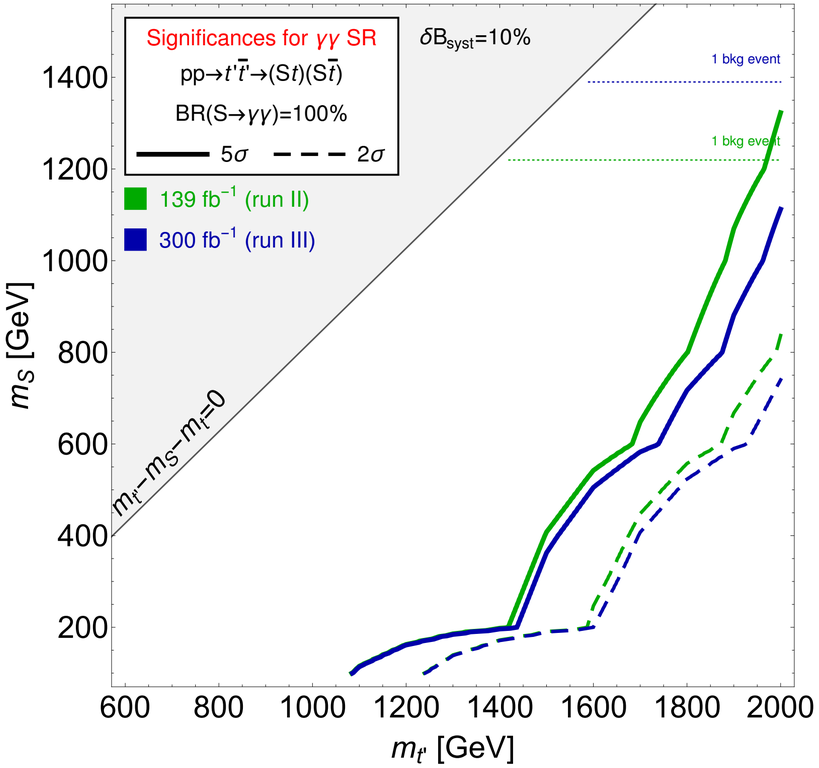
- Highlight recent activities and results in BSM searches by the ATLAS Sweden groups
- Results using the full Run-2 (2015-2018) dataset
  - Vector-like quarks
  - SUSY ttbar resonance
  - Dark matter and dark sector
  - R-parity violating scenarios

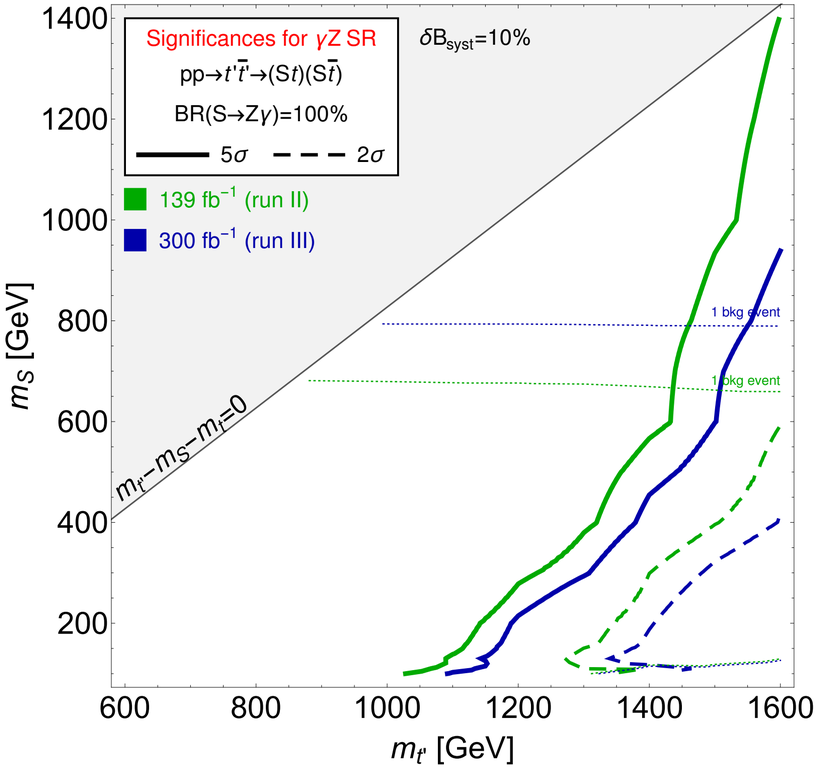
Search for vector-like top partners decaying to an exotic (pseudo) scalar boson

Venugopal Ellajosyula, Thomas Mathisen, Elin Bergeås Kuutmann — Uppsala [collaboration with U. Texas Austin]

See also Venu's talk on "Status of the SHIFT project"



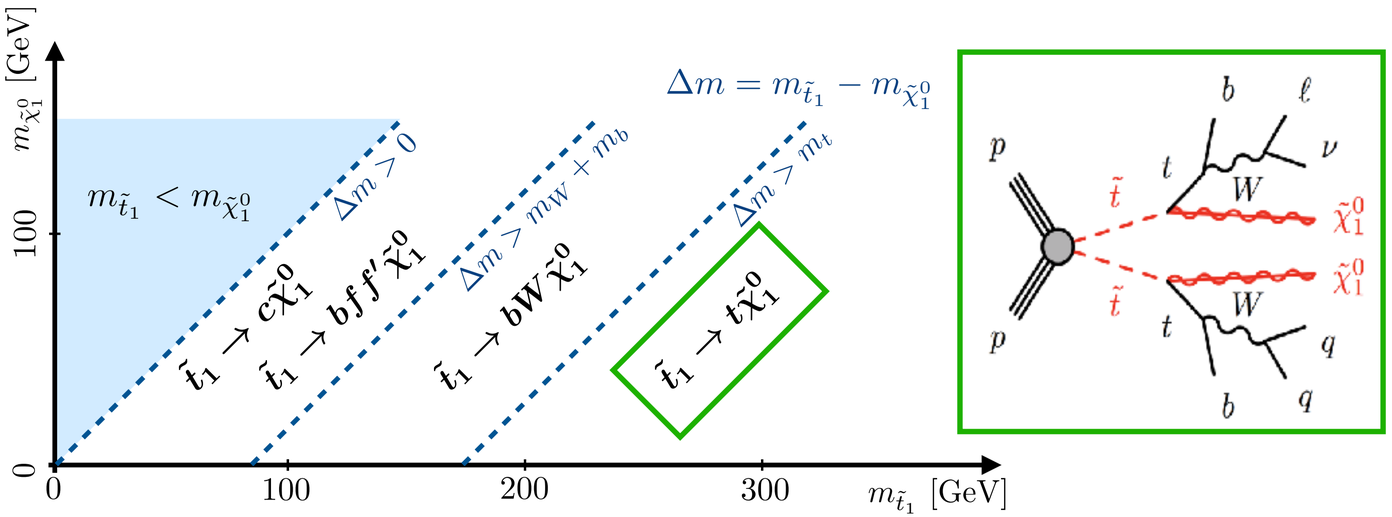


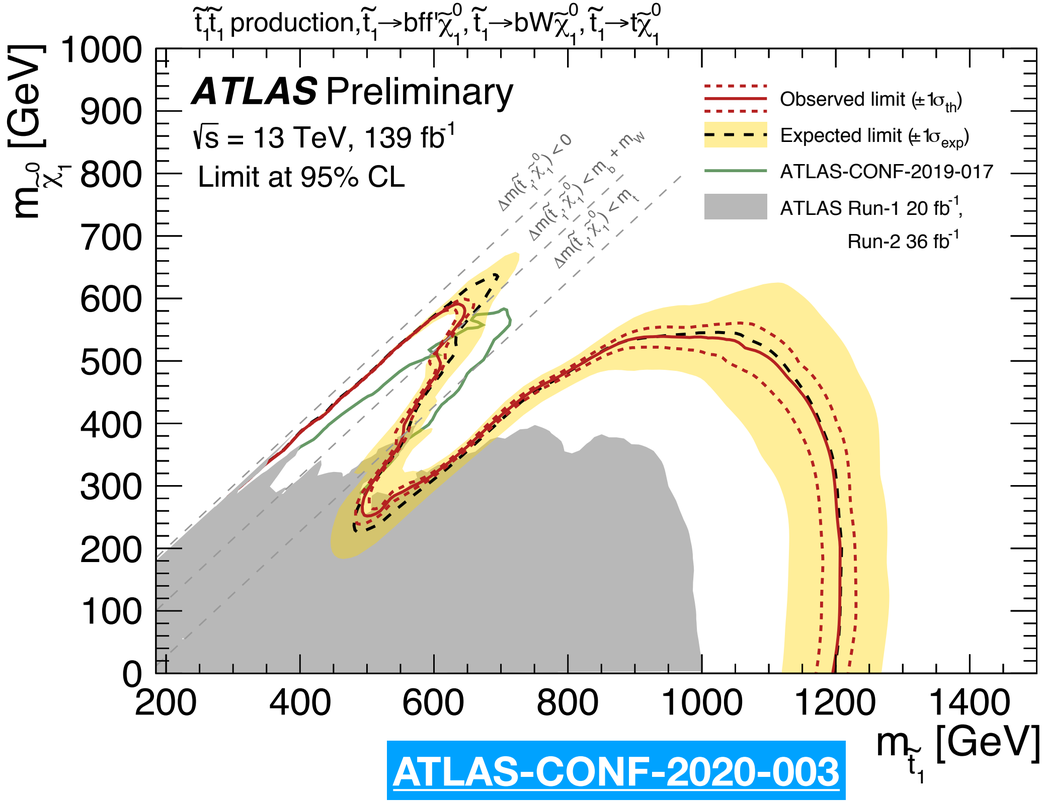


- These exotic decays are possible in Composite Higgs Models as well as 2HDMs with an additional vector-like quark (VLQ)
- Previous analyses that target VLQs decaying only to SM particles not sensitive to such decays
- First VLQ —> BSM analysis in ATLAS
- Optimistic reach in Run 2 and Run 3 evaluated in JHEP05(2020)028 (arXiv:1907.05929), a SHIFT project paper

Search for new phenomena with top quark pairs in final states with one lepton, jets, and missing transverse momentum

Antonia Strübig, Christophe Clément, Laura Barranco Navarro, Laura Pereira Sánchez, Prim Pasuwan, Sara Strandberg, Yosse Andrean — Stockholm

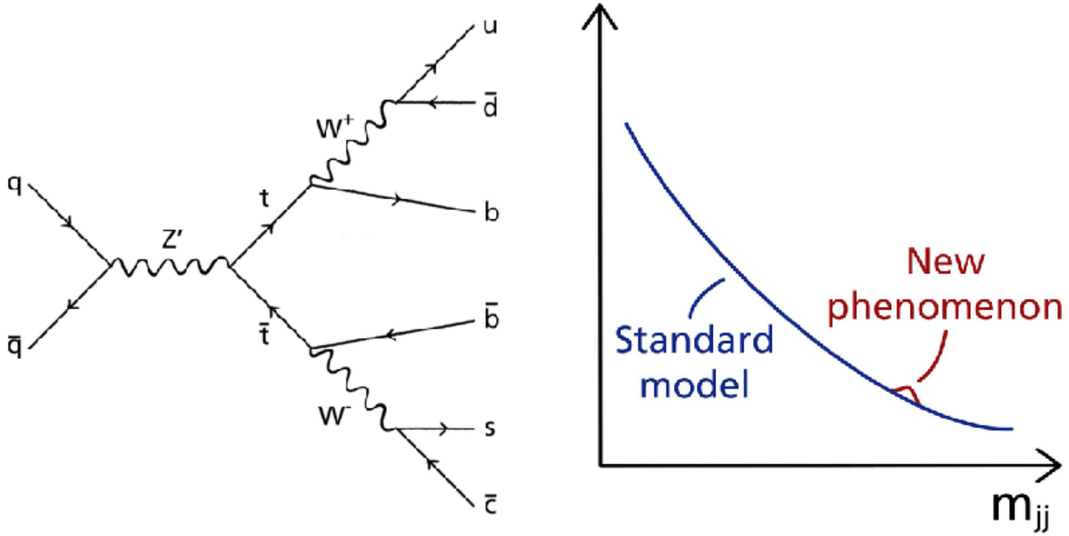


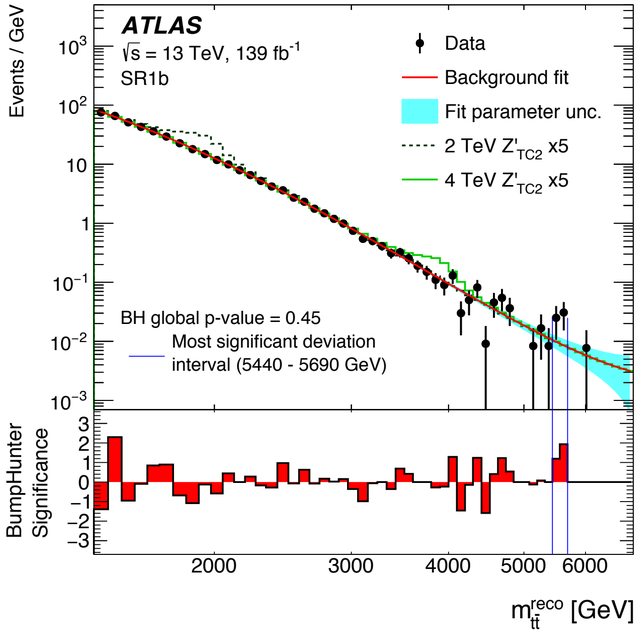


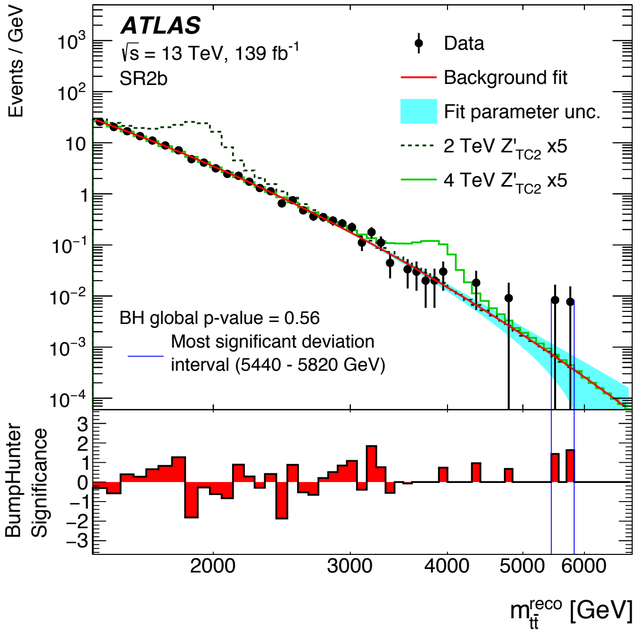
- No significant deviation from the SM background
- Exclude stops up to 1200 GeV in the **two-body** decay scenario
- ATLAS public results for **three-body** and **two- and four-body** scenarios
- Paper in preparation
- Included in the ATLAS Run-2 third-generation pMSSM combination effort

All-hadronic ttbar resonance analysis

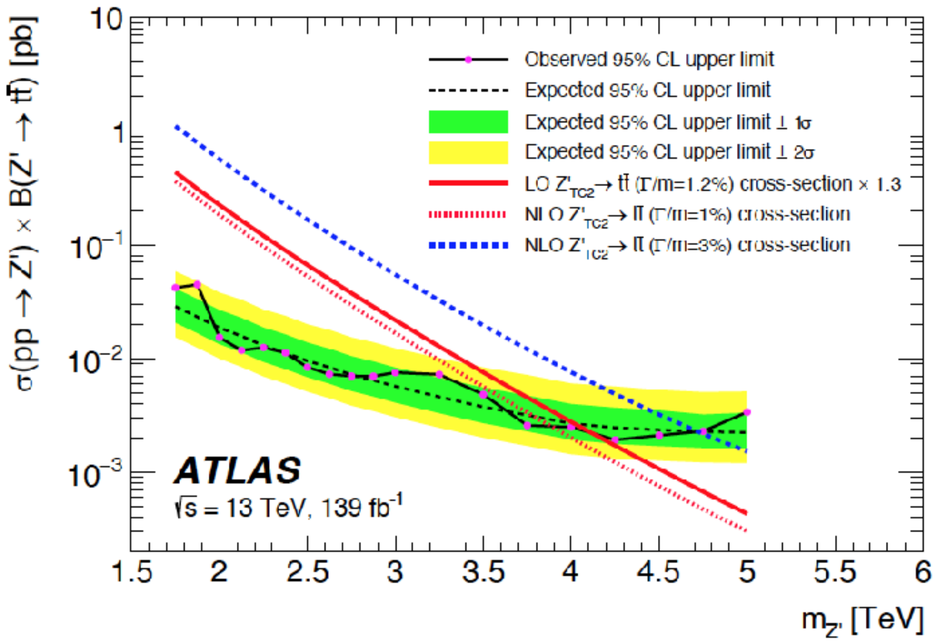
Trine Poulsen, Torsten Åkesson — Lund







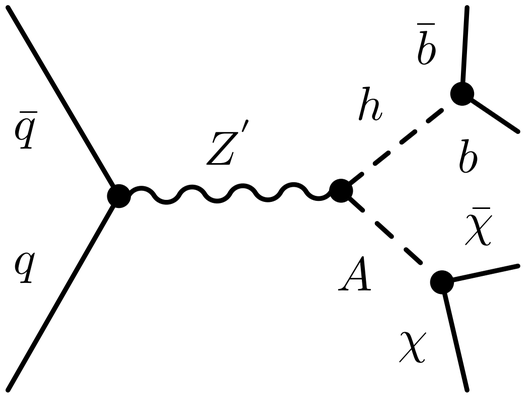
- Search for final states with two hadronically decaying top quarks
- Z' boson, which is predicted from e.g. top-color assisted technicolor, results in a bump in the invariant mass spectrum
- SM background is predicted with global fit
- No significant excess from the SM background
- Upper limits are set on cross section times branching fraction for Z' signal
- Published results on **JHEP10(2020)061** (arXiv:2005.05138)



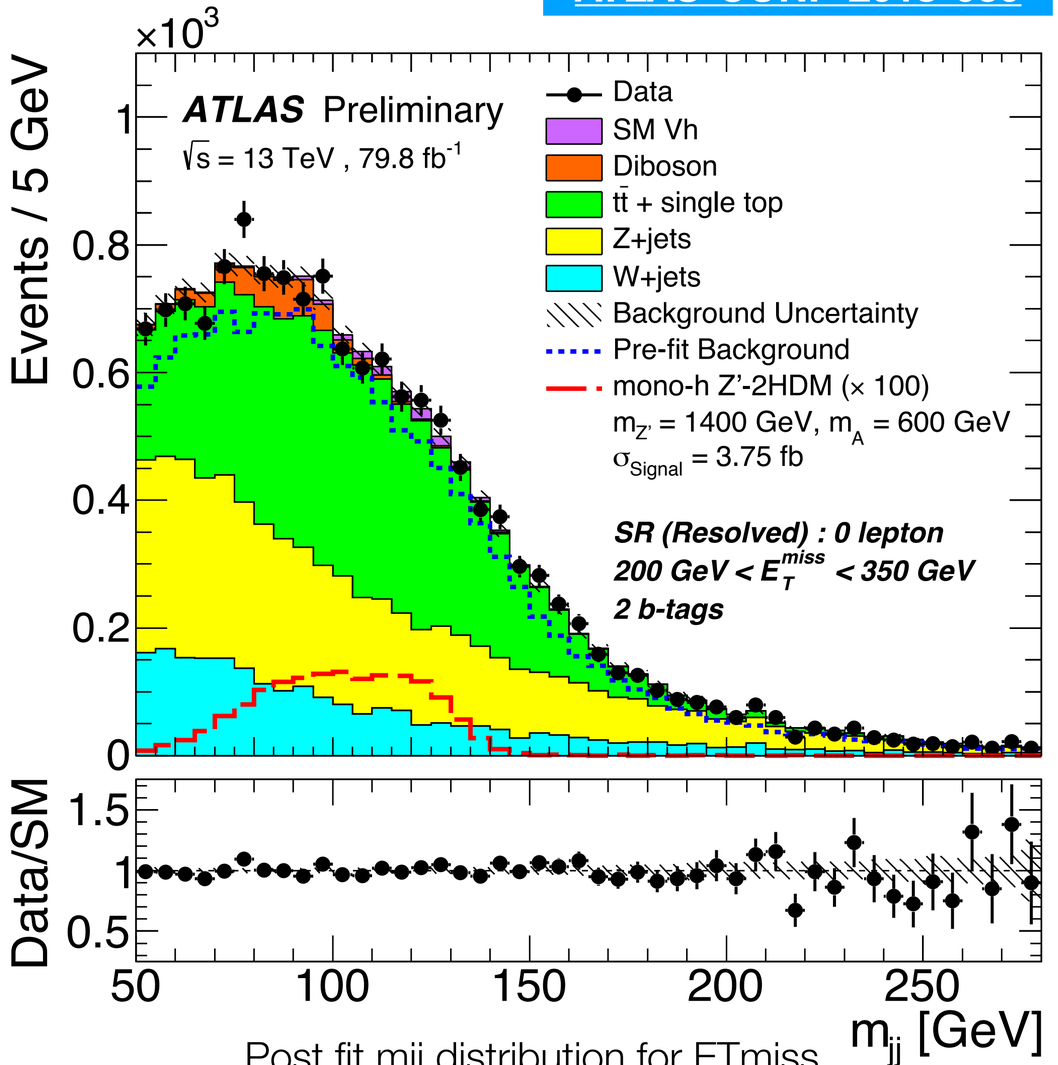
Mono-h search for dark matter

Eleni Skorda, Ruth Poettgen, Else Lytken — Lund

- Dark matter produced in association with a Higgs boson decaying to two b-quarks
- Final state signature: a pair of b quarks and large missing transverse momentum
- Paper in preparation with full Run-2 dataset
- Signal region optimisation to improve sensitivity for 2HDM+pseudoscalar models



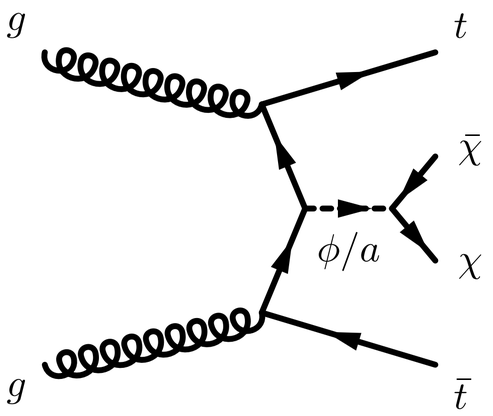
ATLAS-CONF-2018-039

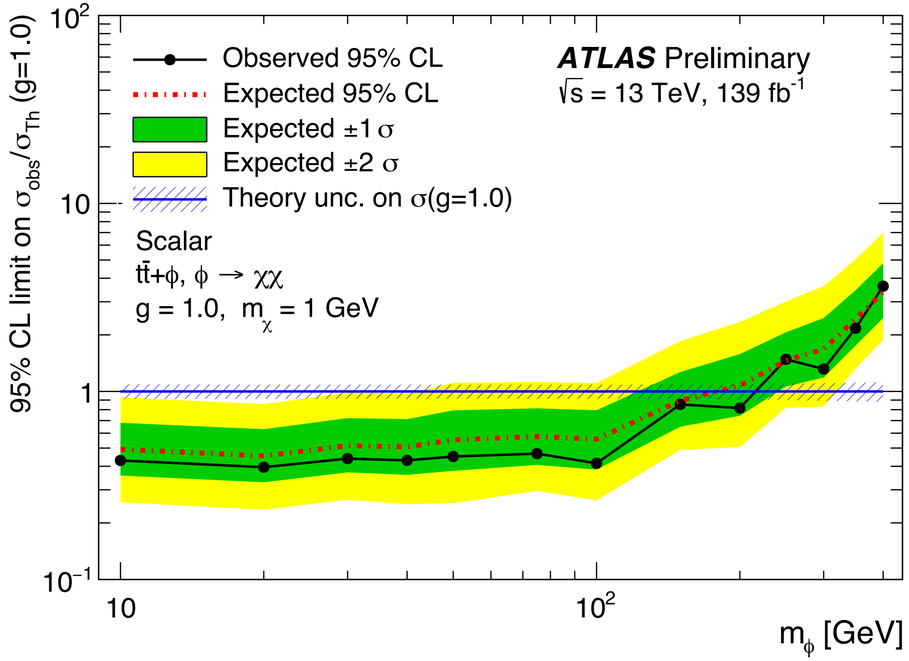


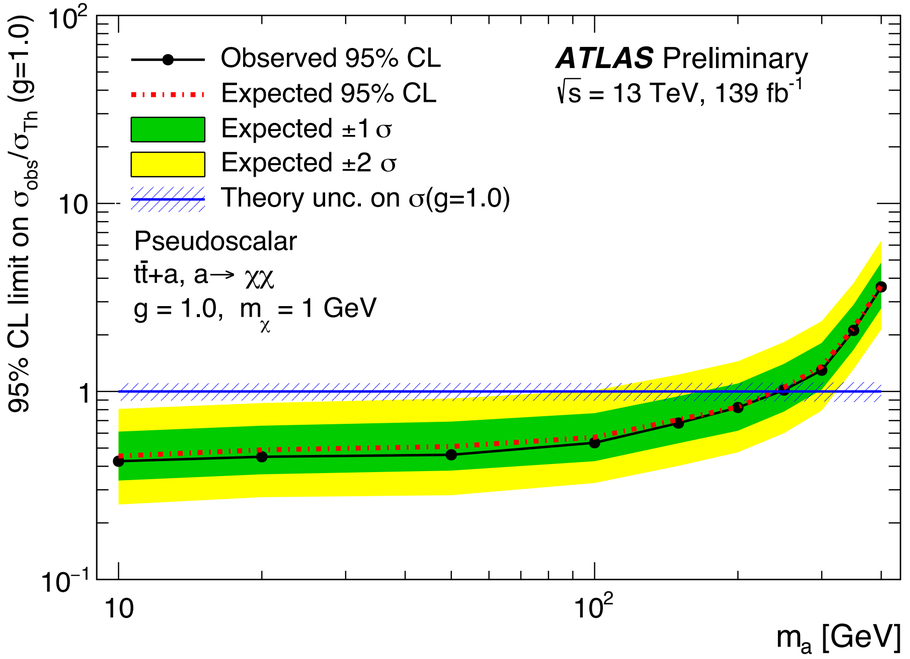
Post fit mjj distribution for ETmiss range of 200-350 GeV

Search for dark matter with top quarks

Christophe Clément, Laura Barranco Navarro, Laura Pereira Sánchez, Prim Pasuwan, Sara Strandberg, Xuanhong Lou, Yosse Andrean — Stockholm



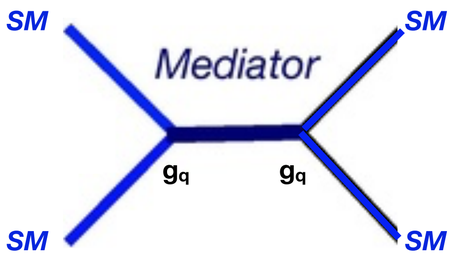


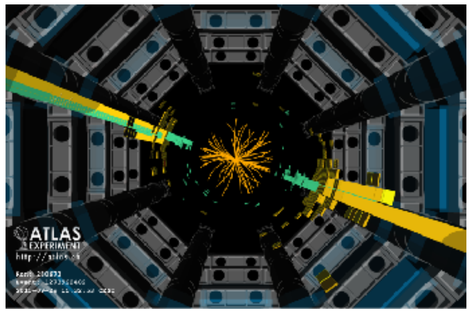


- Final states of 1 lepton, jets and MET
- No significant deviation from the SM background
- Exclude scalar and pseudoscalar mediator up to 200 GeV for dark matter mass of 1 GeV and g=1
- ATLAS public results **ATLAS-CONF-2020-003** ; Paper in preparation
- Included in the ATLAS Run-2 third-generation tt+DM/tt+Hinv combination effort
  - Combine results from tt+MET with 0, 1, 2 leptons included in the final states

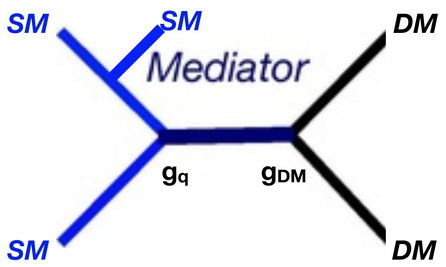
Dark matter mediator searches

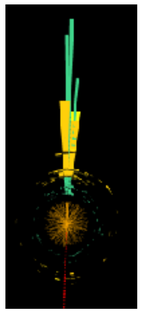
Eric Corrigan, Alexander Ekman, Eva Hansen, Caterina Marcon, Jannik Geisen, Oxana Smirnova, Caterina Doglioni — Lund



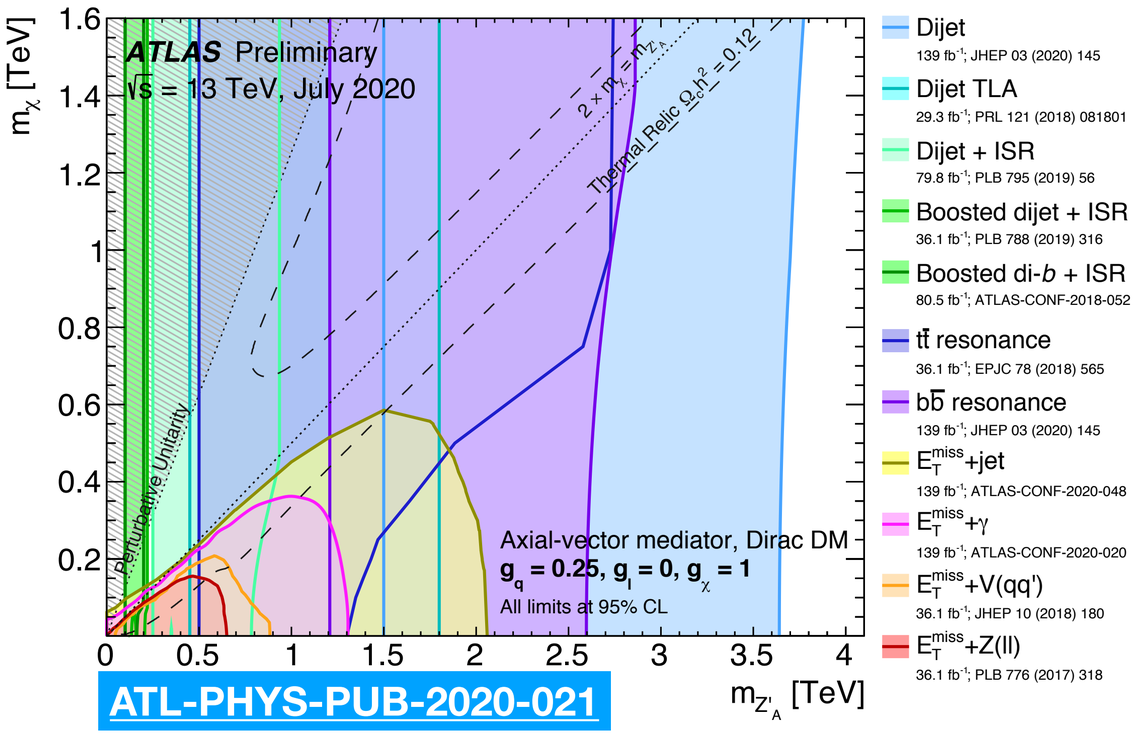


[Dijet event display]





[Monojet event display]

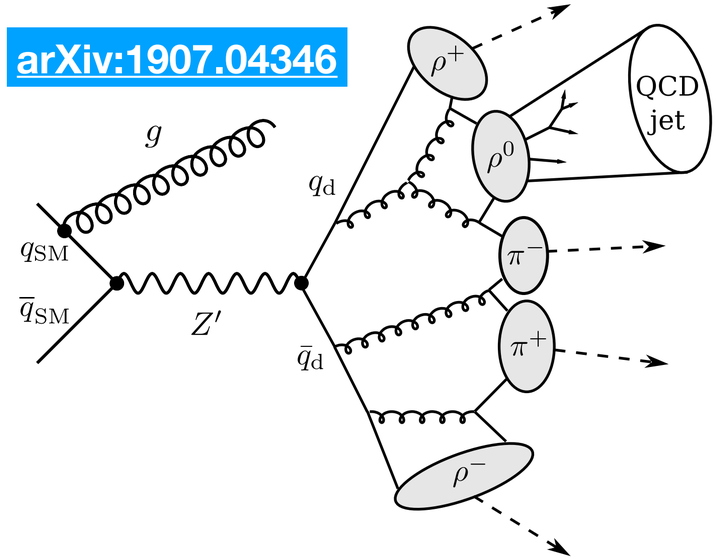


ATL-PHYS-PUB-2020-021

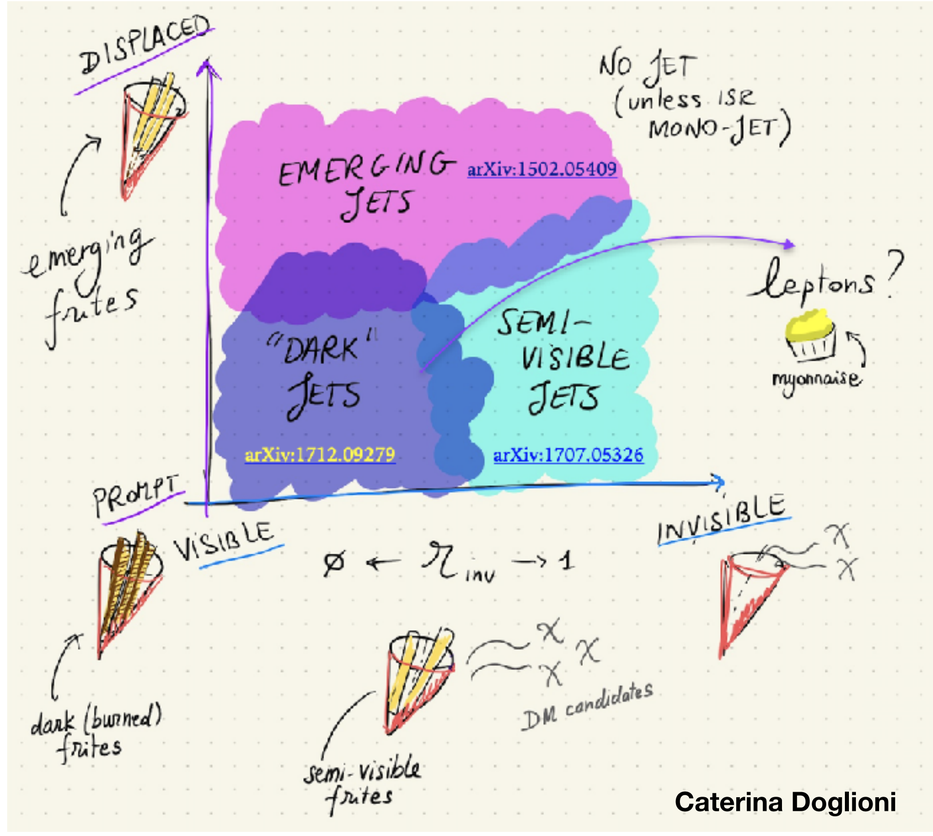
- Searches for the decays of the particles mediating dark matter, complement those for the dark matter particles themselves
- Additions to the ATLAS low-mass resonance search program by the ATLAS Lund team:
  - Trigger Level Analysis (TLA): use reduced collision event information to collect more events and increase sensitivity, see Caterina M.'s flash talk
  - Dijet+ISR search: use initial state radiation (ISR) to reduce backgrounds and increase search range
- Work ongoing on more advanced techniques (+ machine learning) for discovery of dark matter and dark sector processes in LHC Run-3 data

Dark sector searches

Eva Hansen, Jannik Geisen, Caterina Doglioni — Lund



- Looking for heavy mediator in “dark sector” decaying to two dark quarks which:
  - promptly decay to SM particles → two *QCD-like* “dark jets” → bump in mjj
  - only decay partly to SM particles → two *semi-visible* jets → different MET behaviour
- Simulate dark shower via Pythia Hidden Valley module
- New searches using full Run-2 dataset, signatures not yet studied
- Strong collaboration ongoing with U. Witwatersrand (SA) and U. Grenoble (FR)
- Lund Workshop in November 2019 together with Witwatersrand, Grenoble and Lund theorists
- STINT grant application for further Sweden-Africa collaborations submitted



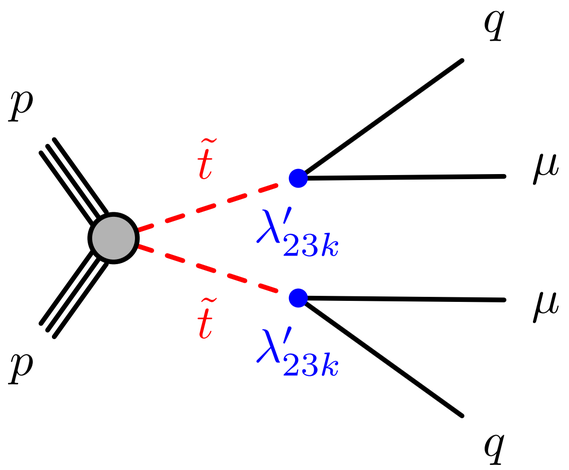
- **Search for dark mesons decaying to top quarks**, see Olga's flash talk
- New search that has never been done before in ATLAS

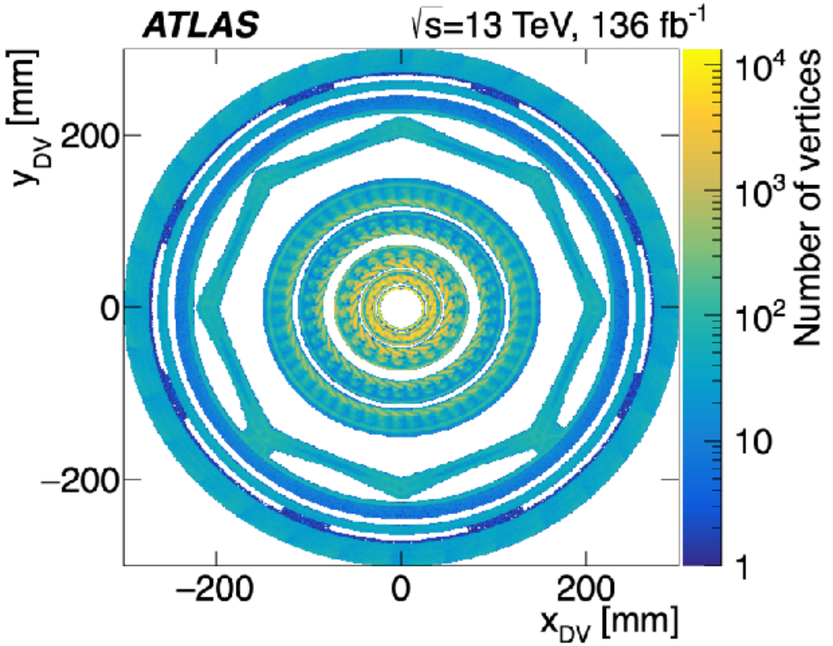
Olga Sunneborn Gudnadottir, Rebeca Gonzalez Suarez— Uppsala

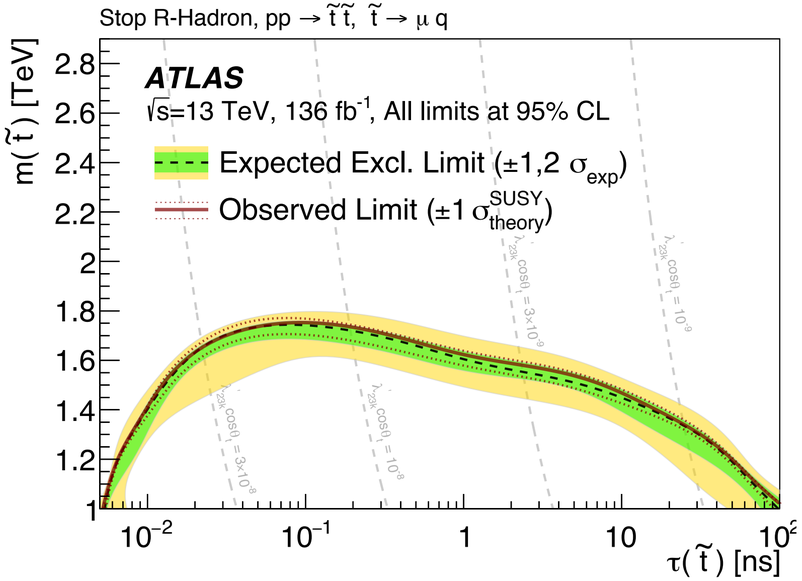
Searches for long-lived particles (LLPs) with displaced vertices

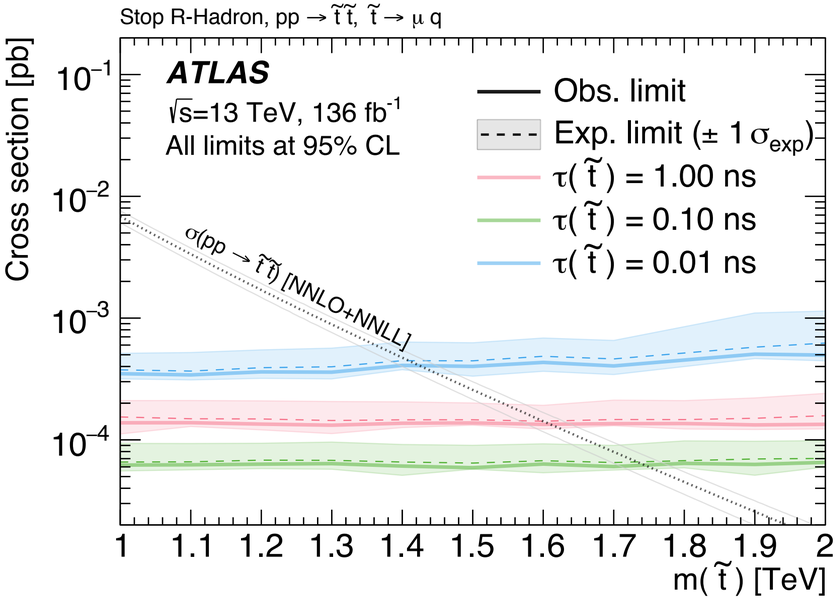
Christian Ohm, Giulia Ripellino — KTH; David Milstead, Filip Backman — Stockholm

- Strong bounds in mass on stops decaying to q+mu vertices via R-parity violation (λ'_{23k} coupling)
- Uses dedicated data processing with special tracking capable of reconstructing tracks not pointing back to the primary vertex, and dedicated vertexing algorithm
- Results published in [PhysRevD.102.032006]
- Comprehensive materials allowing reinterpretation available as [HepDATA] (with instructions [here])









Summary and outlook

- The Swedish ATLAS groups have contributed to various BSM physics
- Many interesting studies, results and papers since Partikeldagarna 2019
- Several combination efforts and new BSM search strategies to look forward to