Report from Stockholm University ATLAS Group

Xuanhong Lou

Partikeldagarna 2021

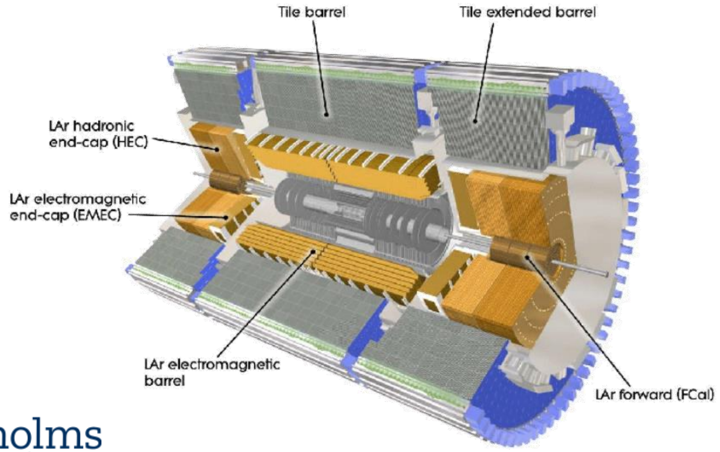
on behalf of Stockholm University ATLAS group

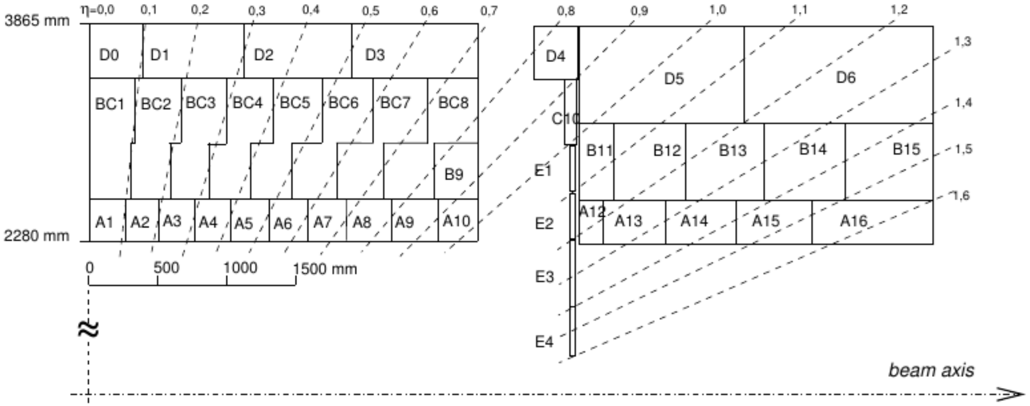
Stockholms universitet

Tile Calorimeter Calibration

Yosse Andrean, Christophe Clement

- The Tile Calorimeter (TileCal) of ATLAS is a calorimeter system in the central region of the detector
- Motivation: Jet energy scale is calibrated assuming calorimeter's uniform response in ϕ
- Muons deposit energy via ionization following the well known Bethe formula, making them ideal for calorimeter response study
- Use muons from $W \rightarrow \mu\nu$ events to measure:
  - cell energy deposit over path length dE/dx data-MC agreement
  - cell response uniformity over azimuthal angle ϕ

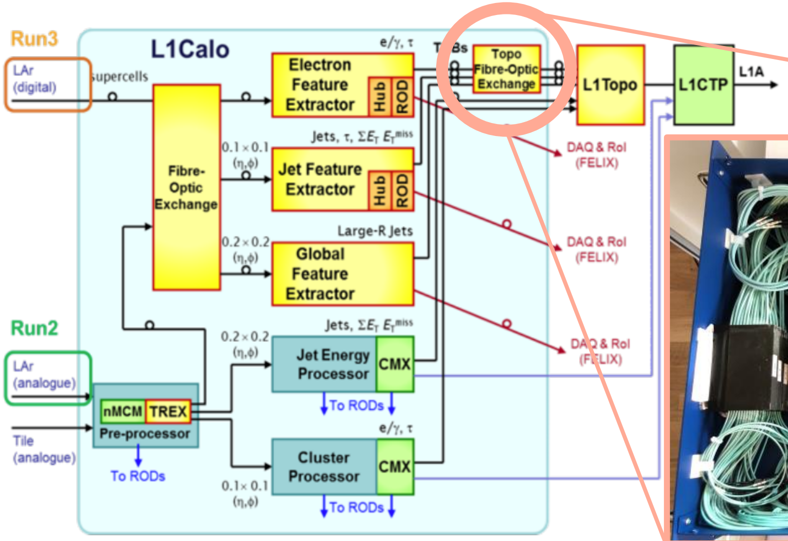


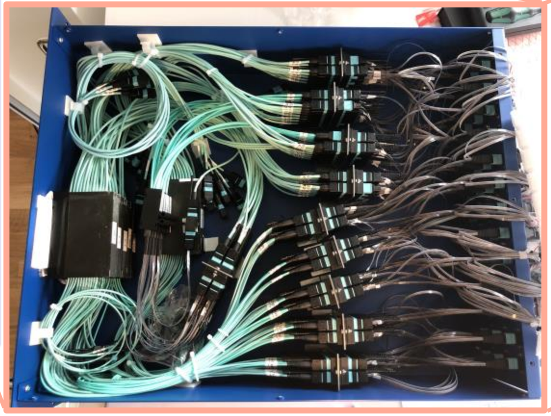


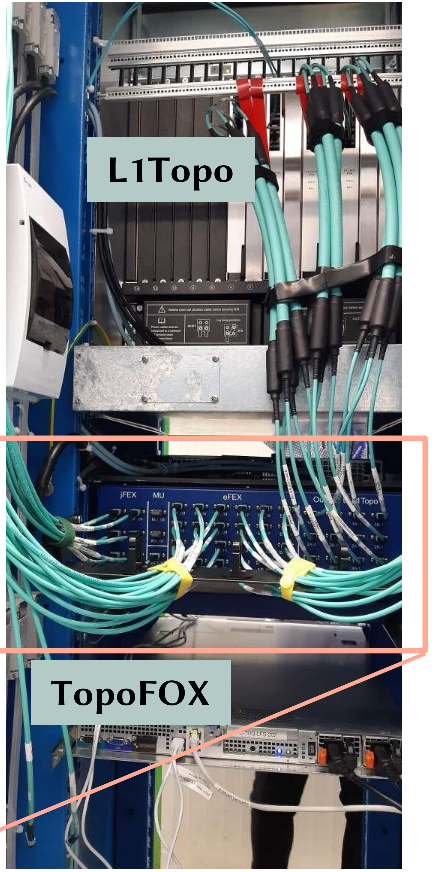
Phase-1 Upgrade of L1Calo (TopoFOX)

Sam Silverstein

- Fiber-optic plant for distributing new Feature Extractor (FEX) outputs to the upgraded topology processor (L1Topo)
- Newly installed and cabled, testing in progress
- The SU group participates in online analyses and is responsible for offline checks of Tile-L1Calo intercalibration







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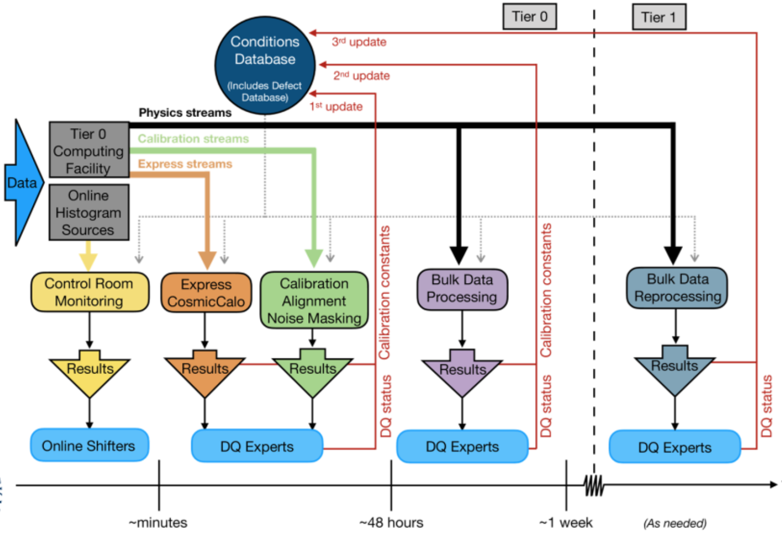
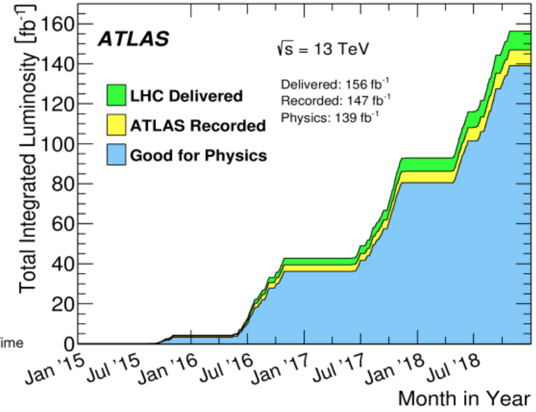
Data Quality

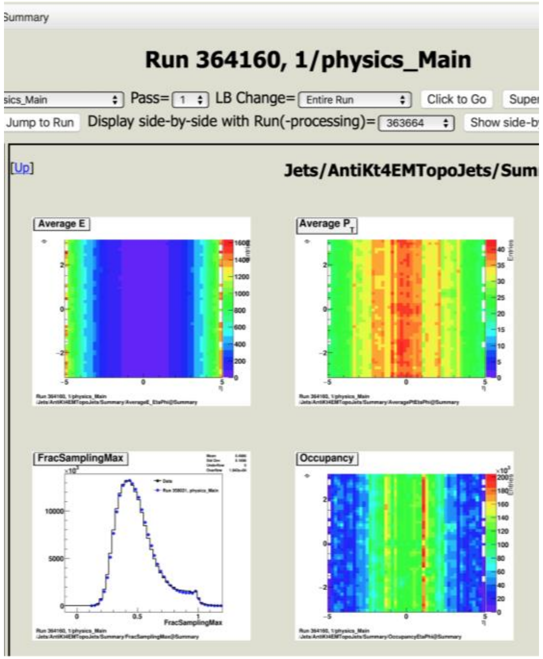
Sara Strandberg

- Currently coordinating the ATLAS Data Quality group
- Responsible for monitoring the quality of the data, both online and offline, and compile the list of data taking periods that are good for physics analyses



[arXiv:1911.04632](https://arxiv.org/abs/1911.04632)



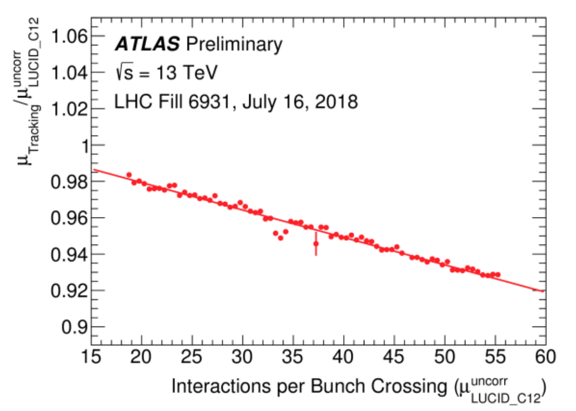


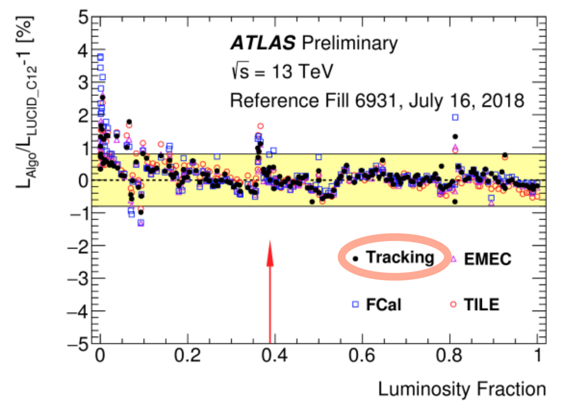
Luminosity Measurements

Karl Gellerstedt, Alex Kastanas, Xuanhong Lou, Patrawan Pasuwan, Sara Strandberg

Track Counting Luminosity

- The number of tracks reconstructed in the Inner Detector is proportional to the number of *pp* collisions in that bunch crossing
  - can be used to measure luminosity
- Together with KTH and DESY, SU is responsible for providing a calibrated luminosity measurement using this method
  - used to correct the linearity of the main method
  - also input to systematic uncertainty estimate





Online

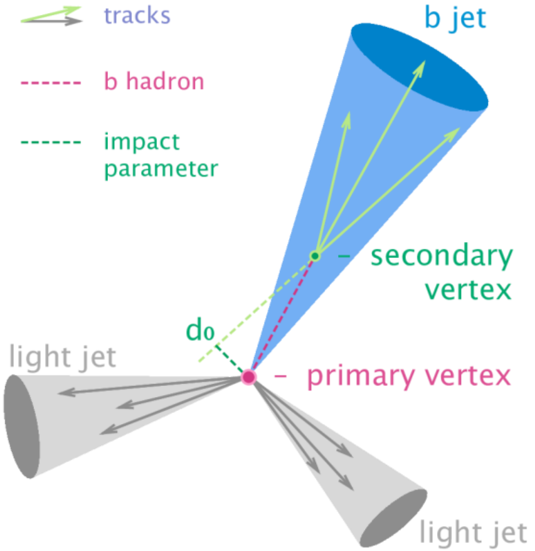
- Responsible (together with KTH) for the online luminosity calculator (OLC), a framework that collects, calibrates and distributes ATLAS online luminosity measurements

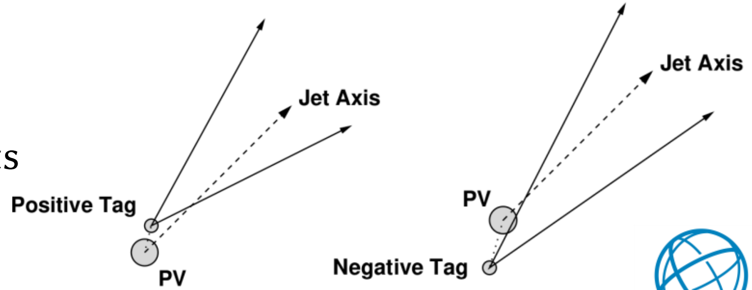
ATLAS-CONF-2019-021

Flavour Tagging

Laura Barranco Navarro, Ellen Riefel, Laura Pereira Sánchez, Sara Strandberg

- b-tagging: identify jets containing b-hadrons
  - important e.g. since Higgs bosons and top quarks have very large branching ratios to b-quarks
  - difficult to get perfect modelling of b-tagging efficiencies and fake rates in simulations
  - therefore the performance of the b-tagging algorithms need to be calibrated with data
- SU is working on calibration of mistag rate (rate at which light-flavour jets are misidentified as b-jets) with the negative tag method
  - b-jets tend to have positive tracks while light-flavour jets have almost as many positive as negative tags
  - measurements currently done with Z+jets events
  - working to extend calibrated jet p_T range using di-jet events





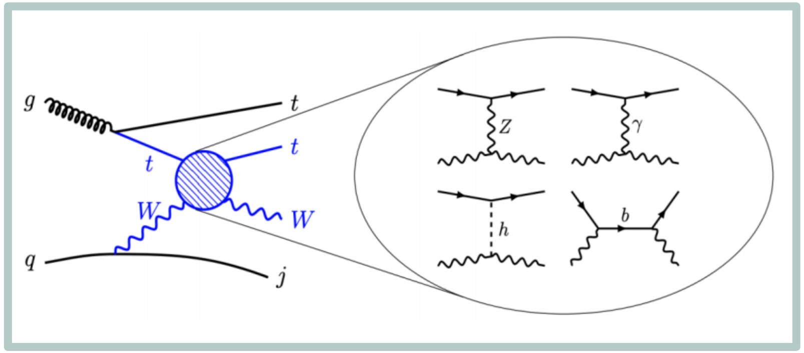
Effective Field Theory (EFT) for Top Physics

Laura Barranco Navarro

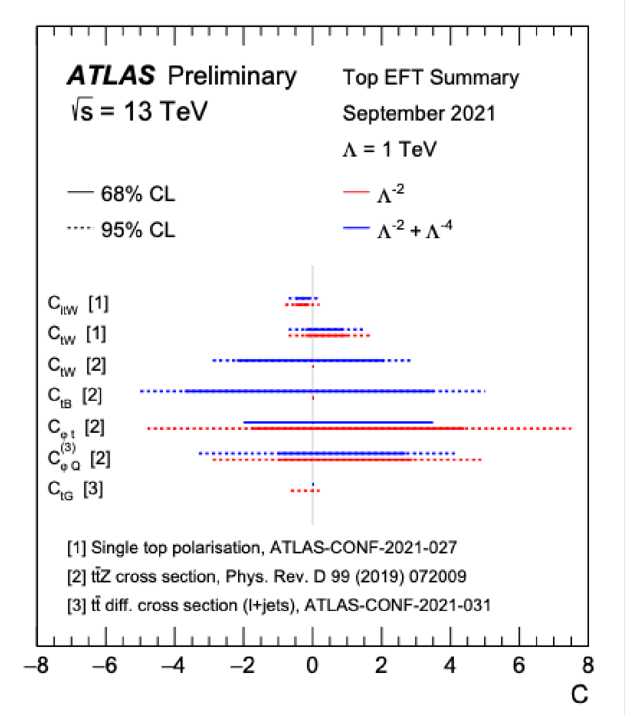
Summary of the limits on SMEFT couplings derived from measurements of the ATLAS Top WG

ttWj measurement: tW → tW scattering

- Challenging but interesting
- Strong dependence in cross section in the presence of SMEFT couplings
- Effective dimension-6 Lagrangian affecting ttZ couplings, which is weakly constrained by standard measurements



arXiv:1511.03674v2

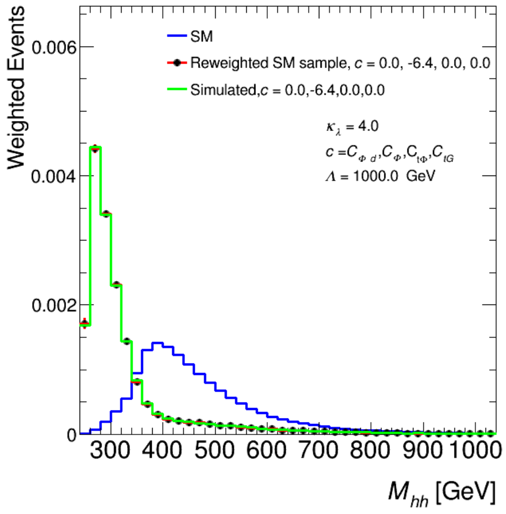


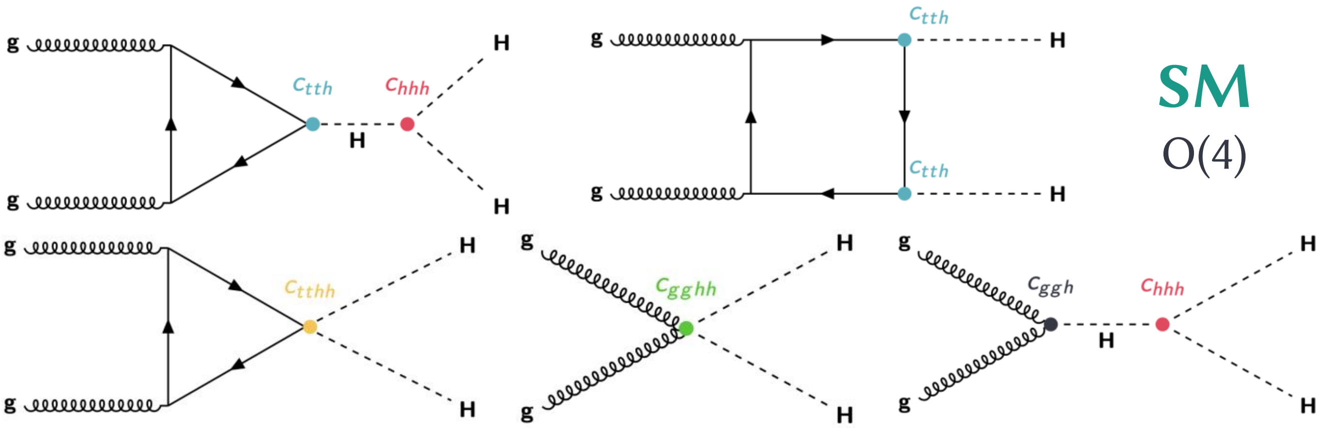
ATL-PHYS-PUB-2021-036

Effective Field Theory (EFT) for Di-Higgs Searches

Tom Ingebretsen Carlson, Laura Pereira Sánchez

- In di-Higgs searches, EFT can be used as a tool to:
  - make a more general measurement of the Higgs self-coupling
  - explore BSM scenarios produced at E > Λ
- EFT interpretations of the published HH → bbγγ search:
  - studying both HEFT and SMEFT interpretations
  - developing SMEFT reweighting





SM
O(4)

BSM
O(6)

HEFT HH feynman diagrams: In SM $c_{hhh} = c_{tth} = 1$ and $c_{ggh} = c_{tthh} = c_{gghh} = 0$

HH → bbγγ

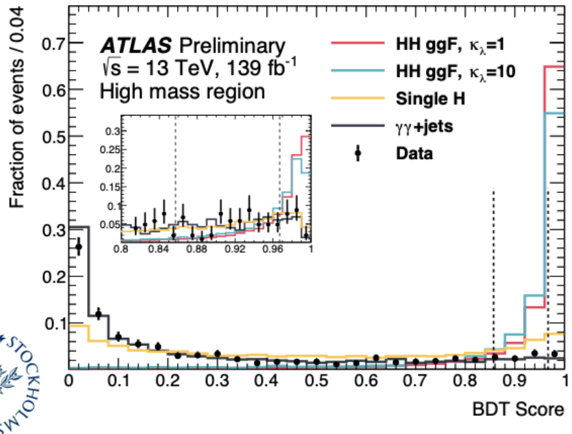
Yosse Andrean, Tom Ingebretsen Carlson, Christophe Clement,
Laura Pereira Sánchez, Jörgen Sjölin, Sara Strandberg

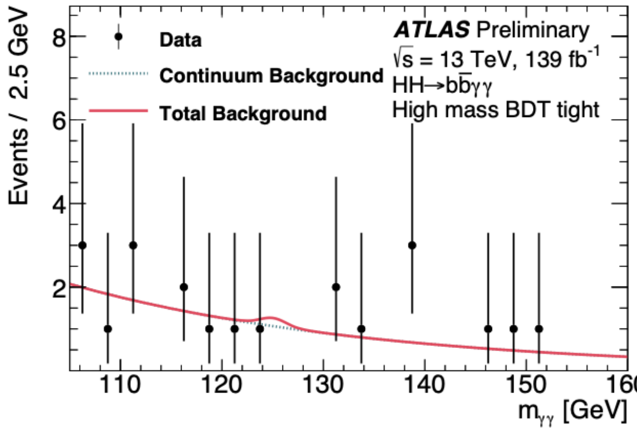
- Two BDTs are trained to separate SM ggF HH (BSM ggF HH) against the backgrounds. A total of 4 SRs are defined from the BDT score and $m_{\gamma\gamma jj}$
- The non-resonant background is obtained from data through a fit of the $m_{\gamma\gamma}$ side bands and limits to cross section and the κ_λs are obtained by fitting the resonant $m_{\gamma\gamma}$ peak ~ m_H

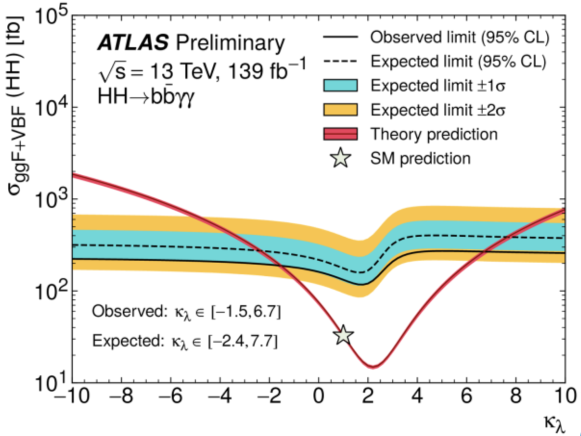
Observed (expected) limits:

- $\sigma^{HH}_{ggF+VBF} < 4.1\ (5.5)\ \times \sigma^{HH\ SM}_{ggF+VBF}$
- $-1.5\ (-2.4) < \kappa_\lambda < 6.7\ (7.7)$

ATLAS-CONF-2021-016

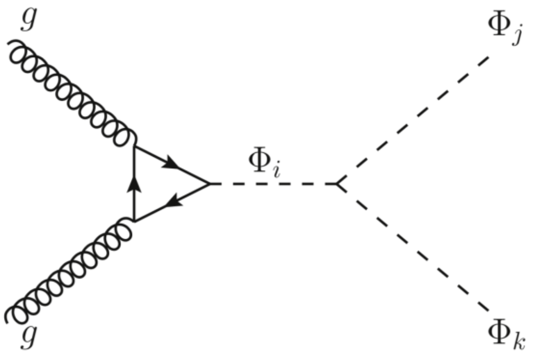






$X \rightarrow SH \rightarrow bb\gamma\gamma$

Yosse Andrean, Tom Ingebretsen Carlson, Christophe Clement, Xuanhong Lou,
Laura Pereira Sánchez, Jörgen Sjölin, Sara Strandberg

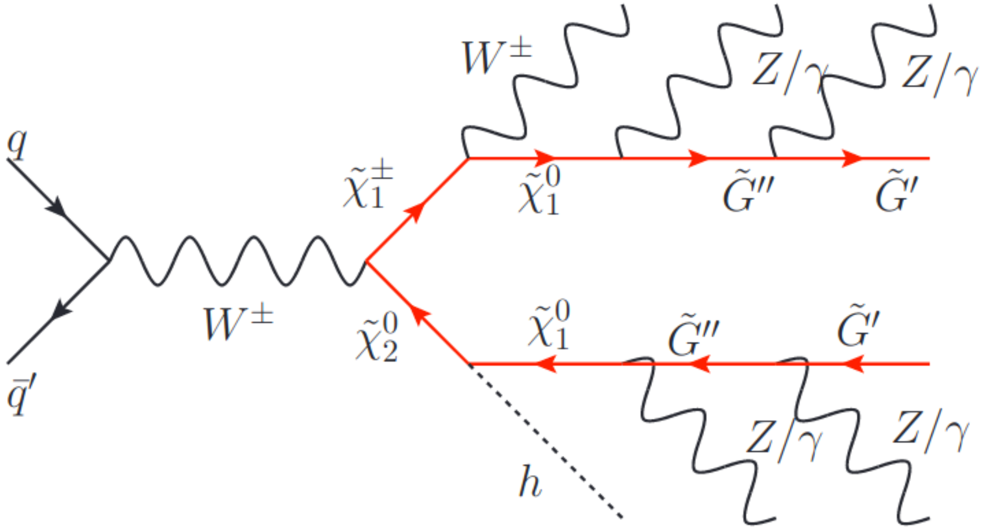


- Most extensions of the Higgs sector that predict enhanced di-Higgs production also predict (pseudo)scalars S, X, allowing a new type of LHC signature "Asymmetric Higgs Decays" $pp \longrightarrow h_a \longrightarrow h_b\, h_c$
- Similar final states as HH production bbbb, bbττ, bbγγ but with different scalar masses and kinematics
- Very poor experimental coverage so far, due to lack of experimental effort!
- Present in the following models:
  - C2HDM [hep-ph/0211371], NMSSM [0910.1785], 2HDMS [1808.02667], N2HDM [1612.01309], TRSM [1908.08554]…
  - models compatible with existing presently measured Higgs properties and BSM Higgses!
  - several of these models used to interpret some experimental excesses [2105.11189, 2109.01128]
- SU kick-started the first search for $pp \longrightarrow h_a \longrightarrow h_b\, h_c$ in bbγγ with ATLAS
  - using full Run-2 data and Run-3
  - sensitivity to a range of NMSSM models expected with already 100 fb^{-1} [1812.03542]

Electroweak SUSY Phenomenology

Ellen Riefel, Sara Strandberg

- Study electroweak signatures of gauge-mediated supersymmetry breaking in multiple hidden sectors
- Paper available on arXiv last week: arXiv:2111.04775
- See Sara Strandberg's SHIFT talk for more information



3G pMSSM Summary

Stefio Yosse Andrean, Antonia Strübig

- From Simplified Model to full pMSSM search
- 19 parameters scan constrained by experimental bounds using already published SUSY analyses:
  - ▷ $m_h^{\mathrm{FH}} \pm \Delta m_h^{\mathrm{FH}}$ agrees with 125.10 ± 0.14 GeV [1]
  - ▷ $\Omega_{\tilde{\chi}_1^0}^{\mathrm{MO}} h^2 \leq 0.12$ [2]
  - ▷ $\Delta a_\mu^{\mathrm{GM2}} \pm \Delta(\Delta a_\mu^{\mathrm{GM2}})$ agrees with $(25.1 \pm 5.9) \times 10^{-10}$ [3]
  - ▷ LEP: no charged particles below 90 GeV [4]
  - ▷ $\mathrm{BF}^{\mathrm{SI}}(B_s \to \mu^+\mu^-) \in (3.0 \pm 0.6^{+0.3}_{-0.2}) \times 10^{-9}$ [5]

  FH: FeynHiggs, MO: MicrOMEGAs, GM2: GM2Calc, SI: SuperISO
- Extremely large parameter space!
- Statistical analysis done via simplified likelihood in TRUTH-level [ATL-PHYS-PUB-2021-038] to reduce computational load:
  - merge the different background component to one
  - reduce number of nuisance parameter to one: the total background uncertainty

Parameter	Min value	Max value	Note
$m_{\tilde{L}_1}(= m_{\tilde{L}_2})$	90 GeV	4 TeV	Left-handed slepton (first two gens.) mass
$m_{\tilde{e}_1}(= m_{\tilde{e}_2})$	90 GeV	4 TeV	Right-handed slepton (first two gens.) mass
$m_{\tilde{L}_3}$	90 GeV	4 TeV	Left-handed stau doublet mass
$m_{\tilde{e}_3}$	90 GeV	4 TeV	Right-handed stau mass
$m_{\tilde{Q}_1}(= m_{\tilde{Q}_2})$	200 GeV	4 TeV	Left-handed squark (first two gens.) mass
$m_{\tilde{u}_1}(= m_{\tilde{u}_2})$	200 GeV	4 TeV	Right-handed up-type squark (first two gens.) mass
$m_{\tilde{d}_1}(= m_{\tilde{d}_2})$	200 GeV	4 TeV	Right-handed down-type squark (first two gens.) mass
$m_{\tilde{Q}_3}$	100 GeV	4 TeV	Left-handed squark (third gen.) mass
$m_{\tilde{u}_3}$	100 GeV	4 TeV	Right-handed top squark mass
$m_{\tilde{d}_3}$	100 GeV	4 TeV	Right-handed bottom squark mass
$\lvert M_1 \rvert$	0 GeV	4 TeV	Bino mass parameter
$\lvert M_2 \rvert$	70 GeV	4 TeV	Wino mass parameter
$\lvert \mu \rvert$	80 GeV	4 TeV	Bilinear Higgs mass parameter
M_3	200 GeV	4 TeV	Gluino mass parameter
$\lvert A_t \rvert$	0 GeV	8 TeV	Trilinear top coupling
$\lvert A_b \rvert$	0 GeV	4 TeV	Trilinear bottom coupling
$\lvert A_\tau \rvert$	0 GeV	4 TeV	Trilinear τ lepton coupling
M_A	100 GeV	4 TeV	Pseudoscalar Higgs boson mass
$\tan\beta$	1	60	Ratio of the Higgs vacuum expectation values

arXiv:1508.06608

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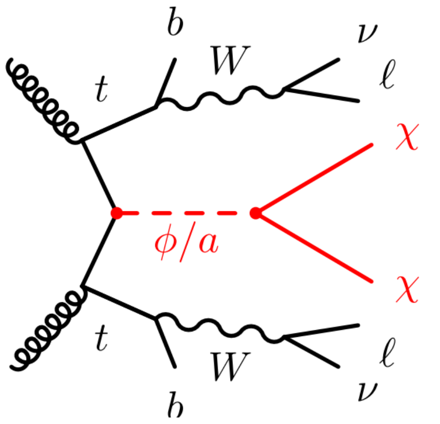
Search for New Phenomena with Top Pair in Final State

Yosse Andrean, Christophe Clement, Xuanhong Lou, Patrawan Pasuwan,
Laura Pereira Sánchez, Sara Strandberg

- Combination of 4 channels: 0L-highMET, 0L-lowMET, 1L and 2L
  - SU largely involved in 0L-lowMET, 1L and the combination effort
- Dark Matter (DM) - simplified tt+DM model
  - scalar/pseudoscalar mediator, g_{SM} = g_{DM} = 1, m_{DM} = 1 GeV
  - upper limit set on $\sigma/\sigma_{g=1}$ as functions of $m_{med.}$

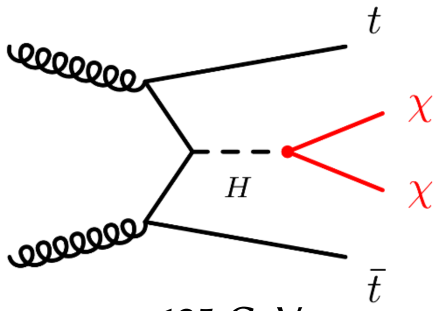


for pseudo-scalar,
greatly suppressed at non-relativistic limit
~ O(10^{-12}) in direct detection

DM-nucleon scattering XS

$$\tilde{\sigma}_n^{\mathrm{SD}} = \frac{9}{16\pi} \boxed{\frac{q^4}{m_{\mathrm{DM}}^2 m_{\mathrm{N}}^2}} \frac{g_{nna}^2\, g_{\mathrm{DM}}^2\, \mu_n^2}{m_a^4}$$

arXiv:1401.6458



- Higgs to invisible decay
  - ttH production corresponding roughly to simplified tt+DM model with $m_{med.}$ = 125 GeV
  - upper limit set on BR(H ⟶ inv.)

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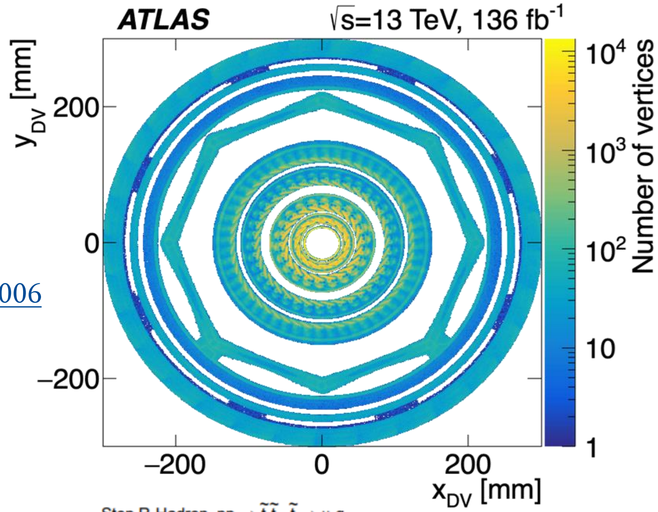
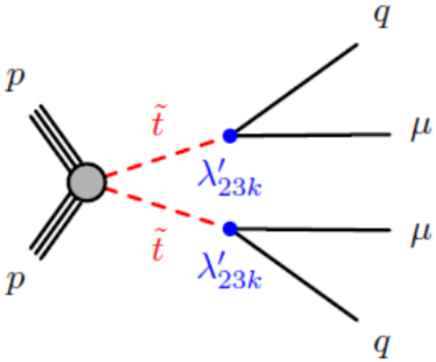
Displaced Vertex (DV) Searches

Filip Backman, Suhyun Lee, David Milstead, Stefan Richter

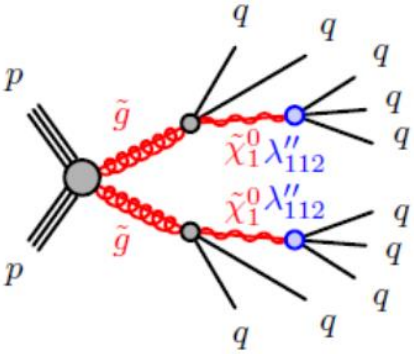
- Exotic long-lived decaying particles (LLPs)
- DV+muons material map used to veto hadronic interactions
- Ongoing DV+jets:
  - Material map
  - Track selections
  - Pile-up
  - Limit setting

Phys.Rev.D 102 (2020) 3, 032006

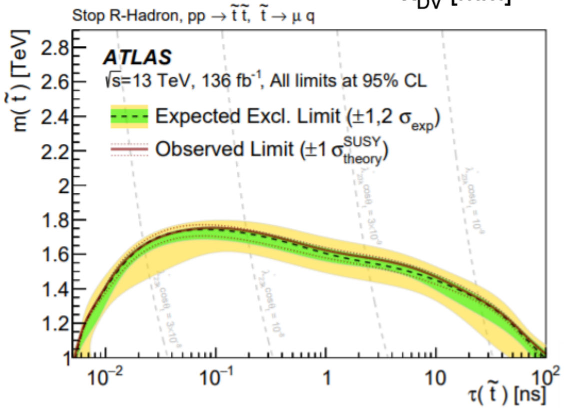




DV+muon



DV+jets



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Summary and Outlook

- SU group has been contributing significantly to various ATLAS activities:
  - TileCal calibration and trigger upgrade…
  - Data Quality, luminosity and flavour tagging…
  - EFT, phenomenology…
  - HH measurement…
  - BSM searches: SH, SUSY, DM, Higgs to invisible decay and LLPs…
- Many interesting studies and results since Partikeldagarna 2020
- Several analyses expected to be public early 2022 :)

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