ATLAS: Recent Results and Future Perspectives

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On behalf of the ATLAS Collaboration

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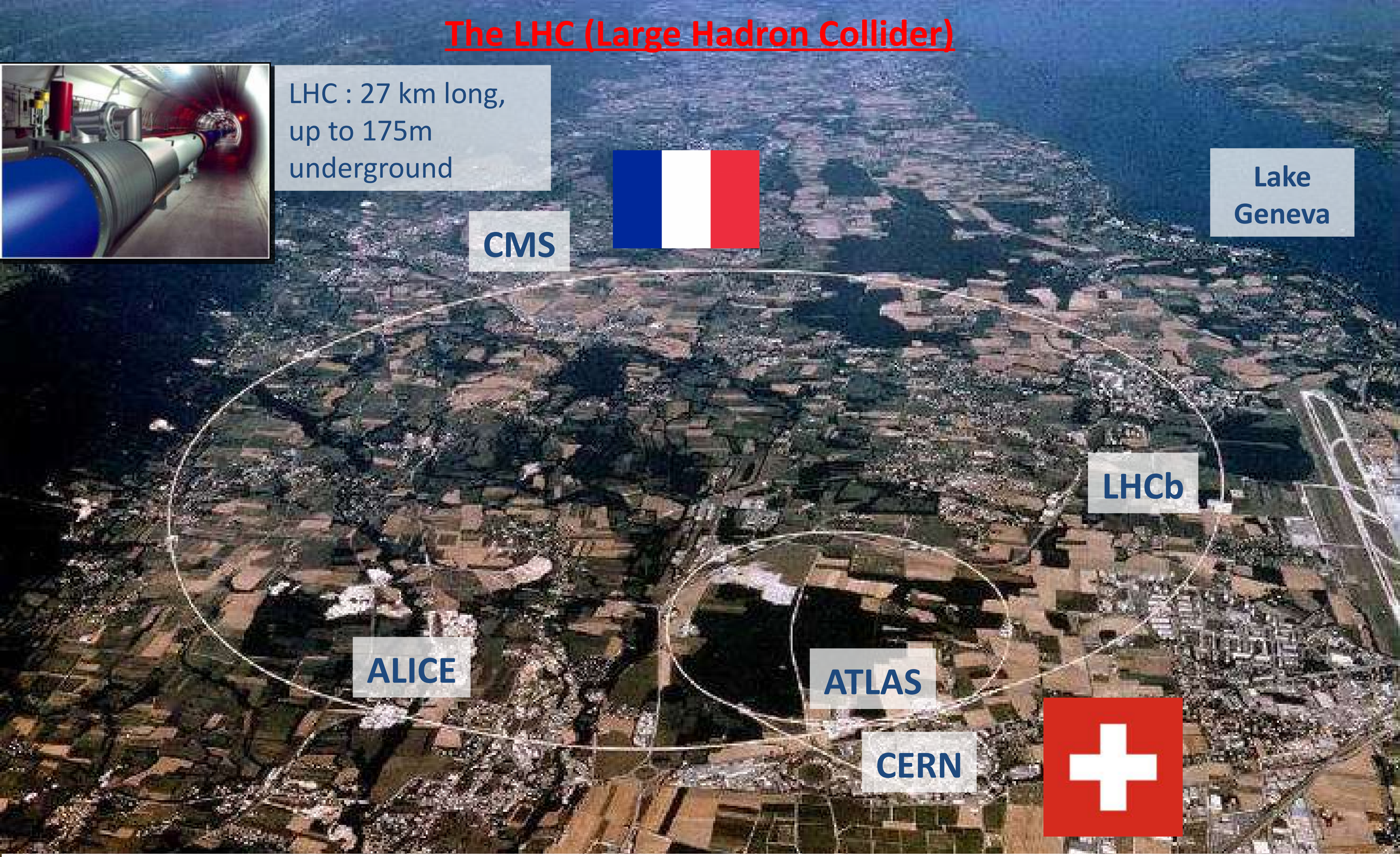
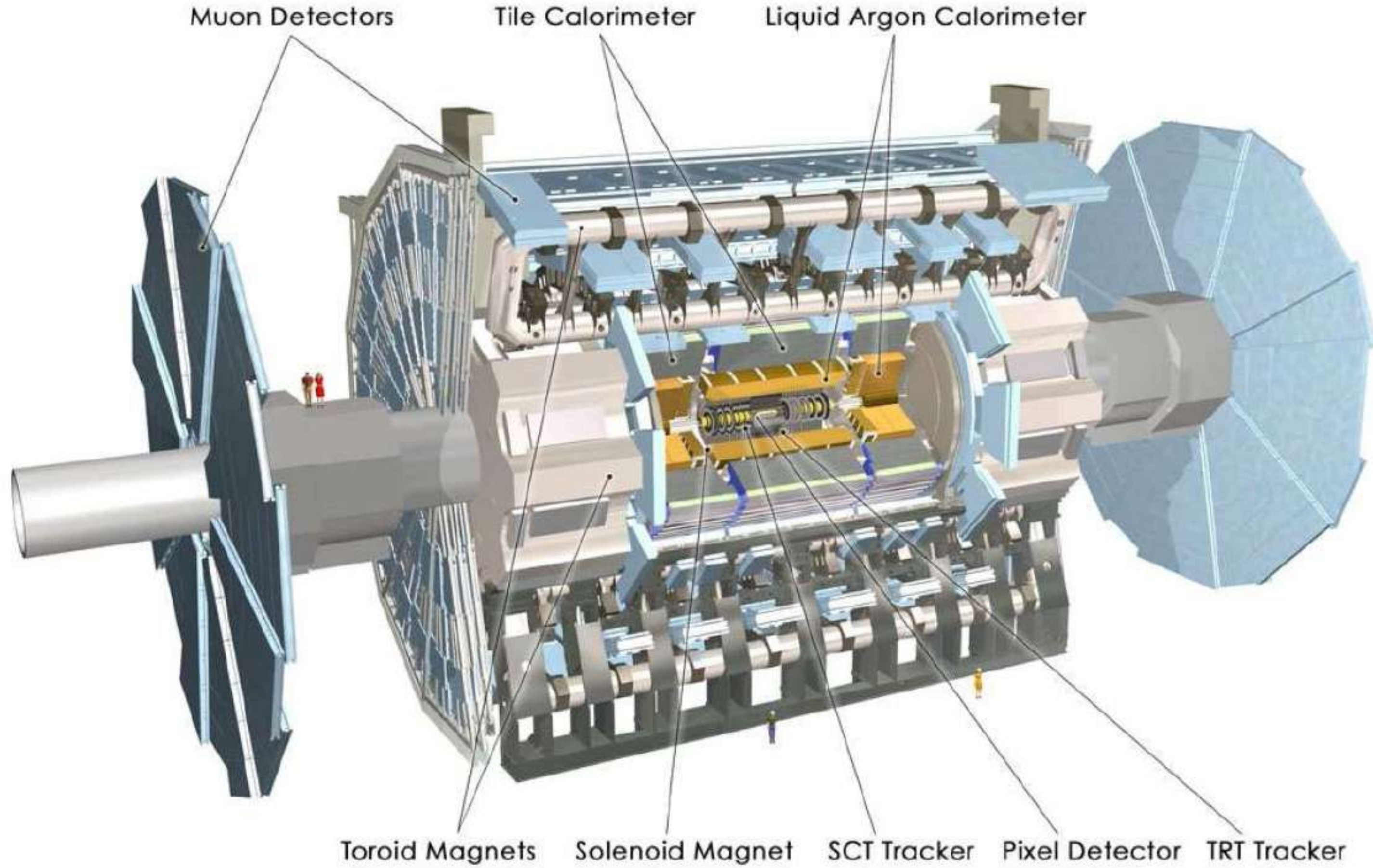
The LHC (Large Hadron Collider)



- p-p collider
- Design parameters:
  - $\sqrt{s}$ = 14 TeV, $L_{inst} = 10^{34}$ cm^{-2} s^{-1}

- Can also collide heavy ion particles
  - Pb, Xe

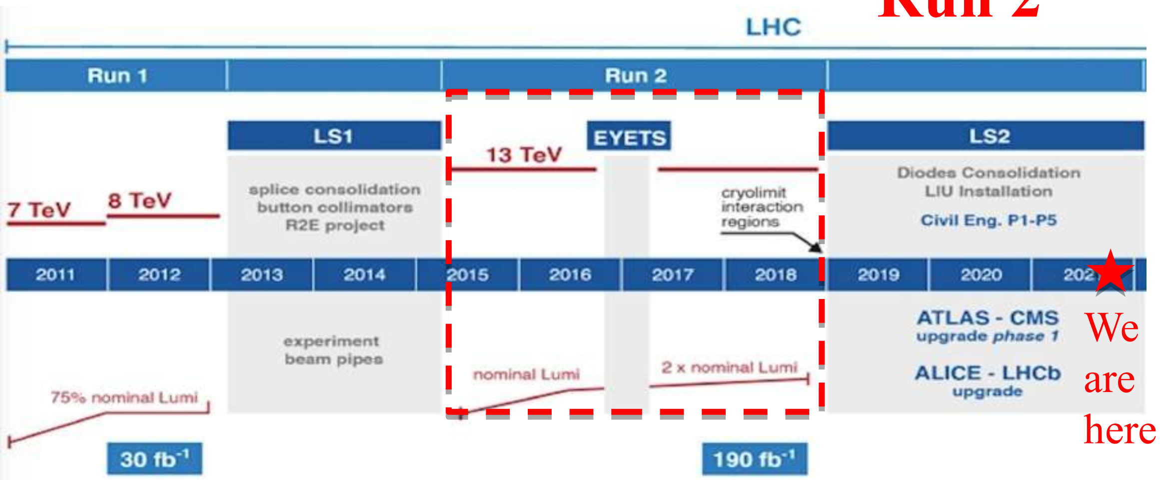
The ATLAS Experiment

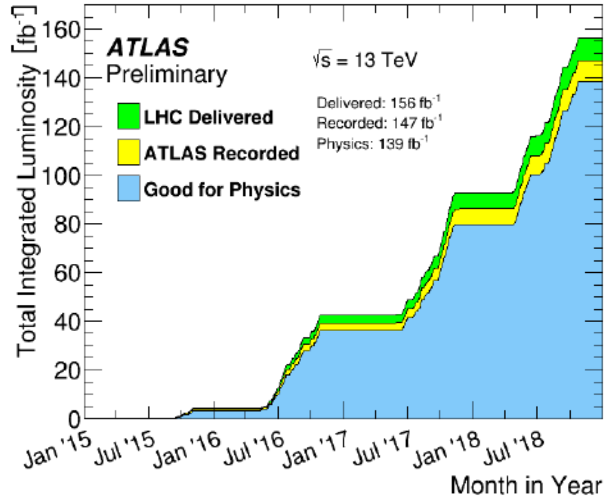


	Weight (tons)	Length (m)	Height (m)
ATLAS	7000	44	25

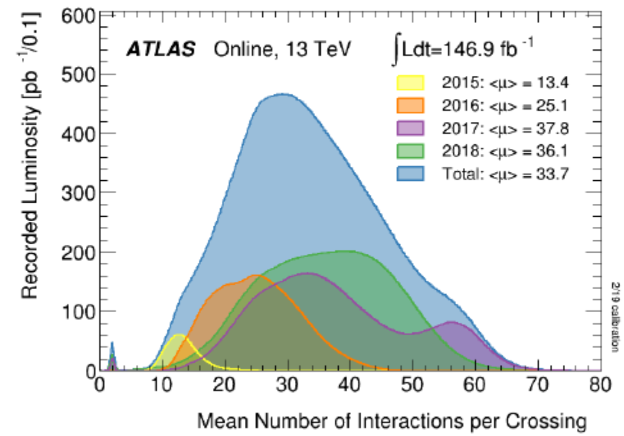
- One of two general purpose experiments

Run 2

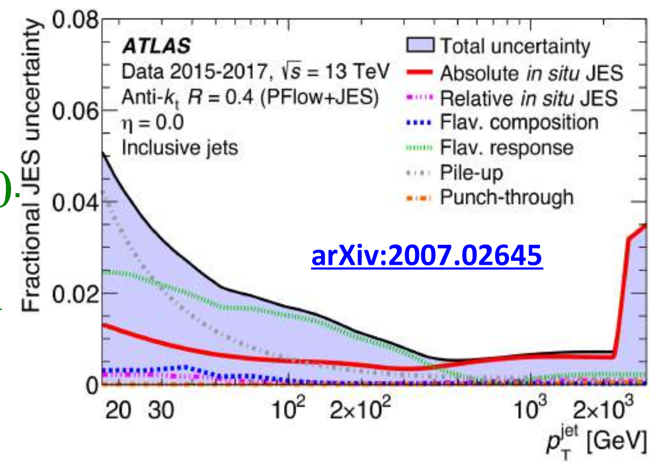




- LHC ran at $\sqrt{s}$=13 TeV from 2015-2018
  - 147 fb^{-1} of pp data recorded
  - 139 fb^{-1} good for physics analysis, data taking efficiency ~95%
  - $L_{max} \sim 2\times10^{34} cm^{-2}s^{-1}$
  - Ave. #of interactions per crossing ~34



- Also heavy-ion collisions (Pb+Pb, p+Pb, Xe+Xe)
- Precision object performance. **Uncertainties :**
  - Electron identification <1% [p_T~30-250 GeV], muon<1% [p_T~10-150 GeV], b-tagging ~1-1.5% [p_T~40-250 GeV @70% working point]
  - Energy scale for central jets ~1% for p_T~250-2000 GeV
- Luminosity uncertainty of 1.7%



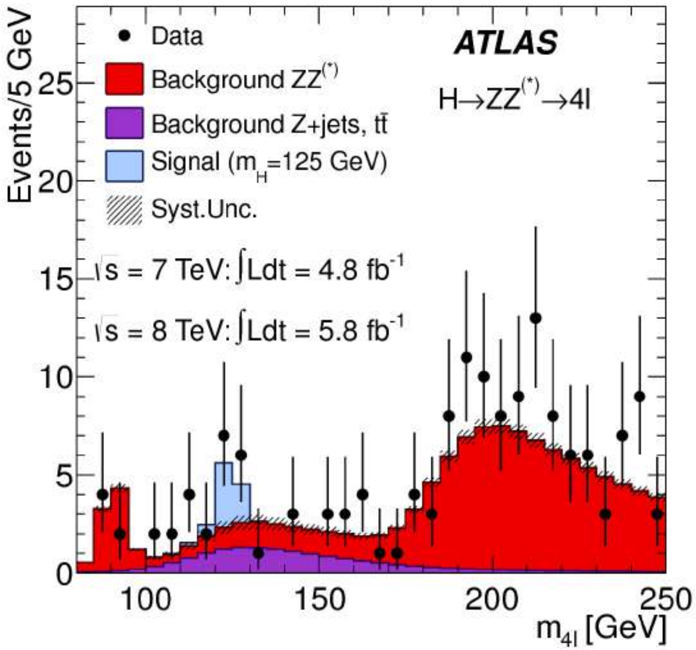
Broad Range of Physics Topics

Standard Model precision measurements	Higgs	Search for Beyond Standard Model
Heavy Flavor Physics	Heavy Ion Physics	Upgrade Physics

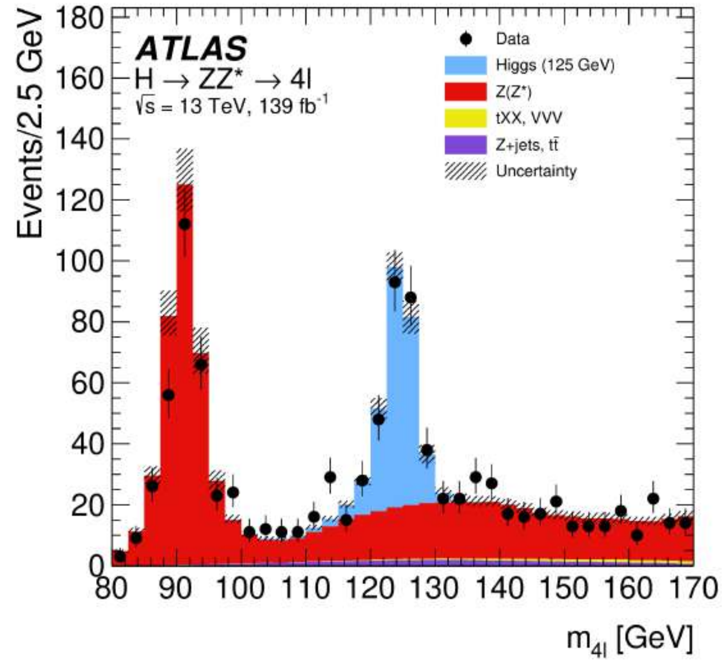
- Can only present short summary of recent results on a few topics and show the future perspectives on some of them.
  - Apologies if some topics are highlighted more than others

Higgs Boson Measurements

Run-1, 2012



Run-2



- Higgs-like boson was discovered at LHC in Run-1
- At Run-2, focus on measuring its properties:
  - Major production channels (ggF, VBF, W/ZH, ttH) and decays modes (H→WW, ZZ, γγ, and 3rd generation fermions bb/ττ) have been observed
  - Now looking for decays to 2nd generation fermions cc/μμ and other rare decays
  - Improving the coupling measurement precision
  - Perform fiducial/differential and simplified template cross section (STXS) measurements
  - Search for signs of New Physics with the Higgs boson

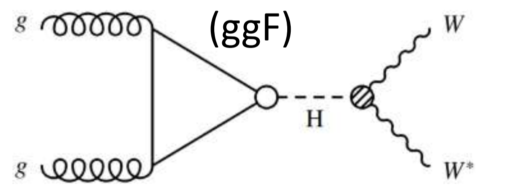
Updates on H→WW*

ATLAS-CONF-2021-014

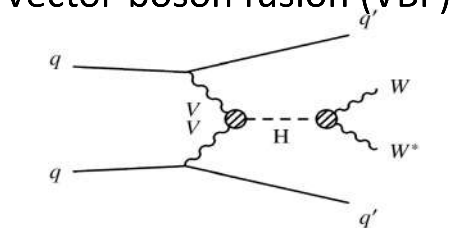
- High statistics of **$H\rightarrow WW^*\rightarrow e\nu\mu\nu$** are used to study different Higgs production modes

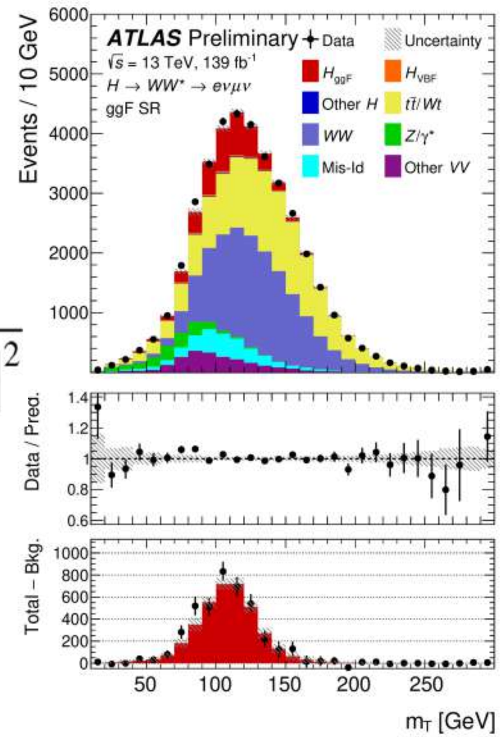
- **ggF** : jets from ISR
- **VBF** : 2 forward jets, large m_{jj} and large $\Delta\eta_{jj}$
- Dominant background from continuum WW^* and ttbar
  - Exploit $\Delta\phi(e, \mu)$, smaller for signal due to spin-0 Higgs
- Categorize selected events into different jet multiplicities
- Final discriminant:
  - ggF : $m_T = \sqrt{\left(E_T^{\ell\ell} + E_T^{\text{miss}}\right)^2 - \left|\boldsymbol{p}_T^{\ell\ell} + \boldsymbol{E}_T^{\text{miss}}\right|^2}$
  - VBF : deep neural net (DNN)

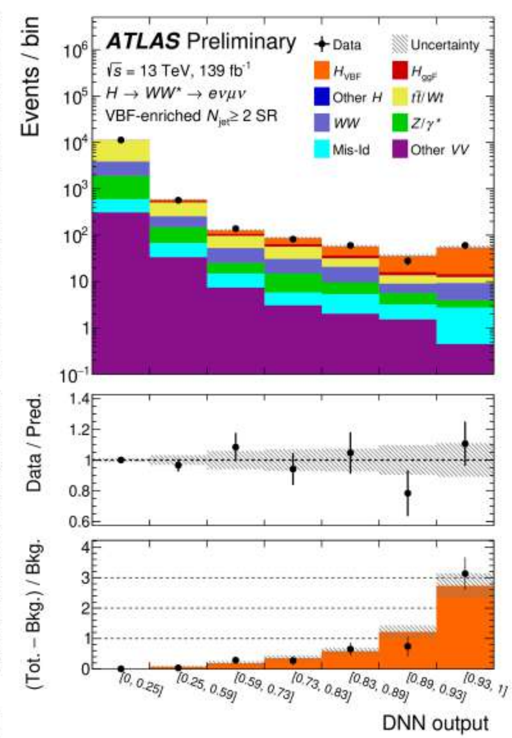
Gluon-gluon fusion (ggF)

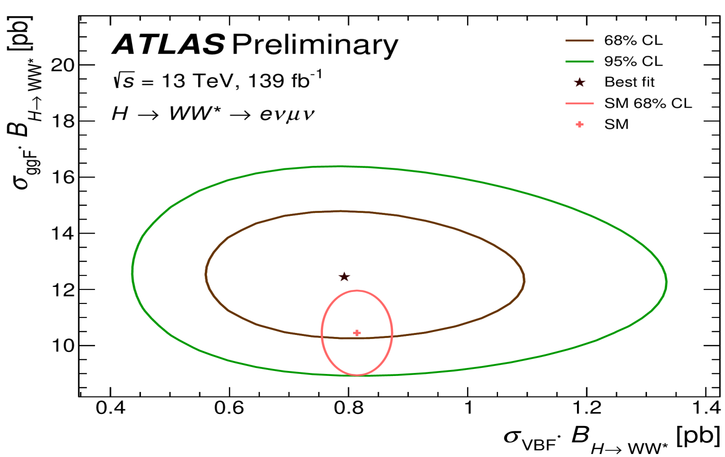


Vector-boson fusion (VBF)







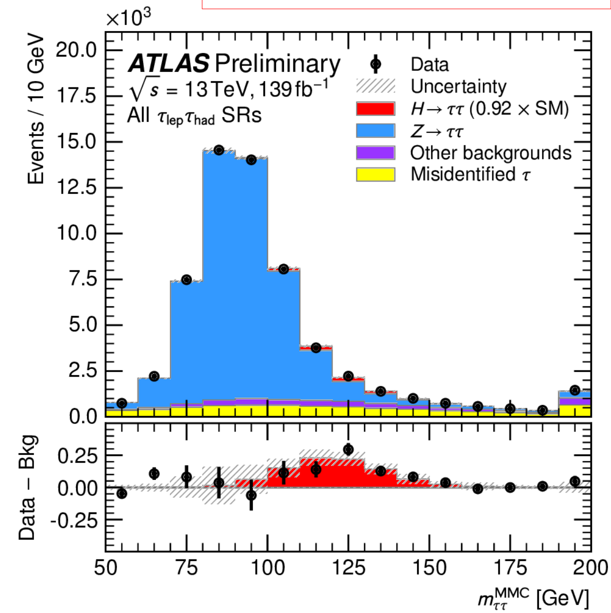


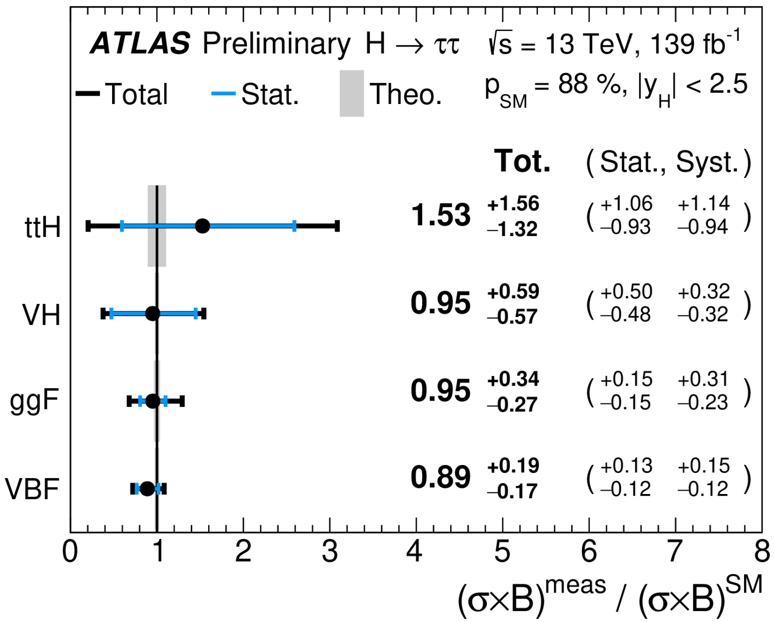
- Measured σ_{ggF} and σ_{VBF} , good agreement with SM
  - $\sigma_{ggF}\times BR$ ($\sigma_{VBF}\times BR$) measures with 12% (22%) precision
  - VBF is observed with 6.6σ significance

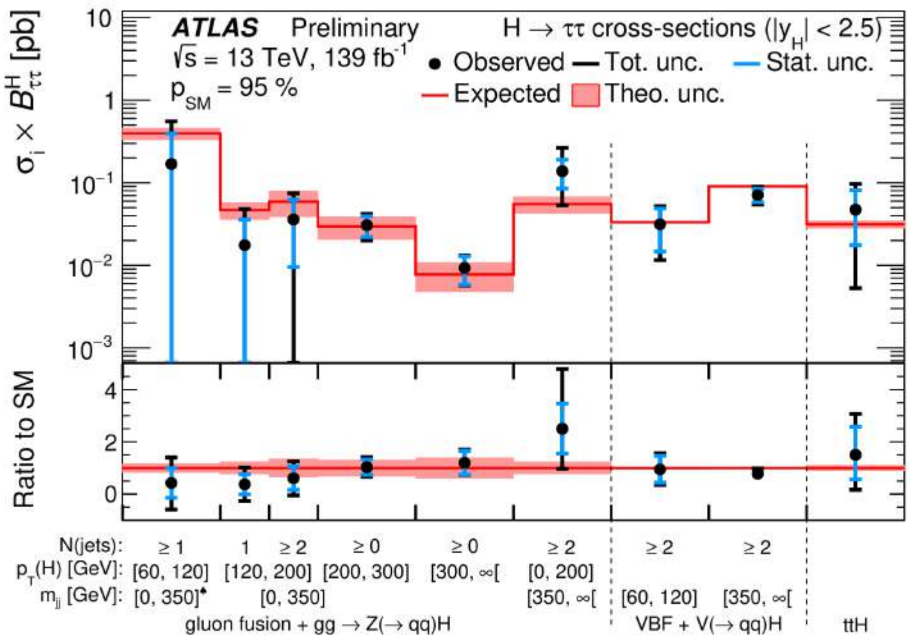
Updates on H→ττ

ATLAS-CONF-2021-044

- Relative high BR H→ττ decay (~6.3%) provides large statistics to study the Yukawa mechanism and the Higgs properties
- Analyzed full Run-2 data to measure:
  - **pp→H→ττ** inclusively in the 4 dominant production modes
  - as function of key production properties (e.g. p_T(H), Njets,…)
- Measured in di-tau decay modes : $\tau_{had}\tau_{had}$, $\tau_{lep}\tau_{had}$, eμ
- Categorize selected events in the dominant production modes
- Main background from Z(→ττ)+jets production





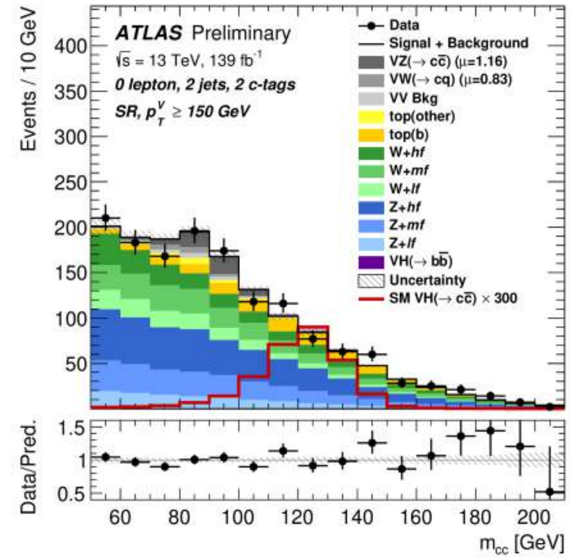


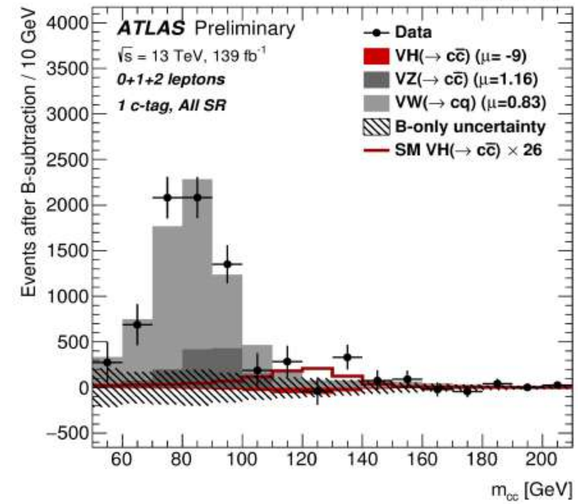
- Inclusive cross section ($|y_H|<2.5$)
  - σ=2.90 ±0.21 (stat) $^{+0.37}_{-0.32}$ (syst) pb (σ^{SM}=3.14 ± 0.08 pb)
- Significance : ggF : 3.9σ obs (4.6σ exp), VBF: 5.3σ obs (6.2σ exp)

Search for Higgs Couplings to Charm Quarks

ATLAS-CONF-2021-021

- Probe Higgs coupling to 2nd gen. fermions
- Difficult at hadron collider
  - Small BR (~2.9% at m_H=125 GeV)
  - Large BG, challenging c-jet identification
- Developed a charm jet tagger, to select "intermediate" lifetime charm hadrons between longer lifetime b and prompt uds/g
  - 27% efficiency for charm, 8% for b, 1.6% light
- Searched in WH→lνcc, ZH→νν/ll cc
  - Select events with large E_t^{miss} or 1,2 leptons
  - Require 1 or 2 c-tagged jets, veto b-tag jets
- m_{cc} is the discriminating variable, simultaneous fit to signal and control regions
- Validate analysis strategy by measuring VW(→cq), VZ(→cc) (V=W or Z)

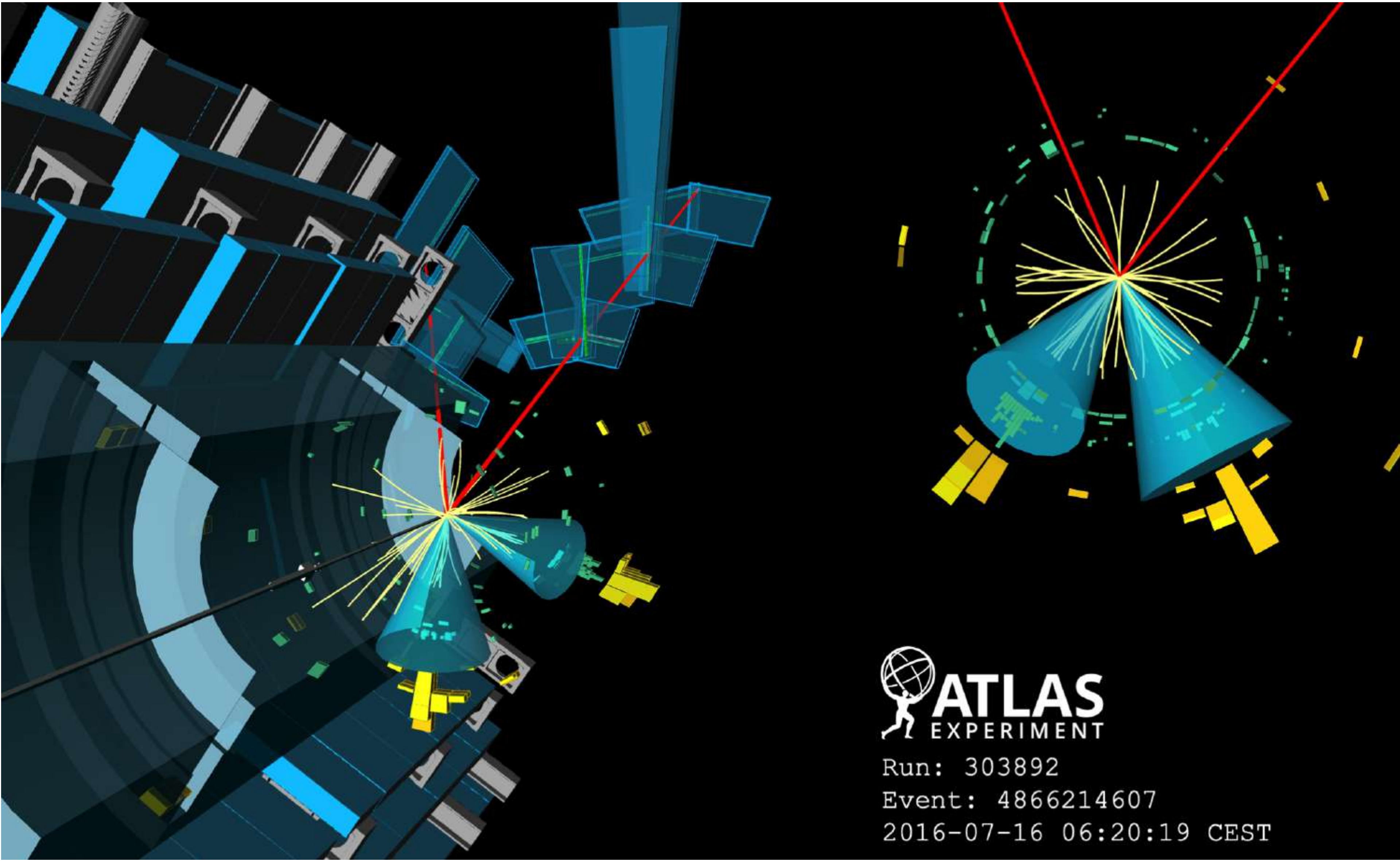




σ×BR / σ×BR(SM)	value	stat	syst
μ (VW(cq))	0.83	0.11	0.21
μ (VZ(cc))	1.16	0.32	0.36
μ (VH(cc))	-9	10	12

- VW(cq) and VZ(cc) are observed with 3.8σ and 2.6σ, consistent with expectation
- Set 95% CL limit on σ(VH(cc))<26×SM (31×SM expected)
- Set limit on H-charm coupling modifier
  - $|\kappa_c|$<8.5 (12.4 exp) at 95%CL (assuming modifier only affect H→cc, not Higgs production)

Search for Higgs Couplings to Charm Quarks



- ZH→μμcc candidate event. m(μμ)=92 GeV, p_T(μμ)=150 GeV
- p_T(c1)=123 GeV, p_T(c2)=71 GeV, m(cc)=123 GeV

Higgs Combination

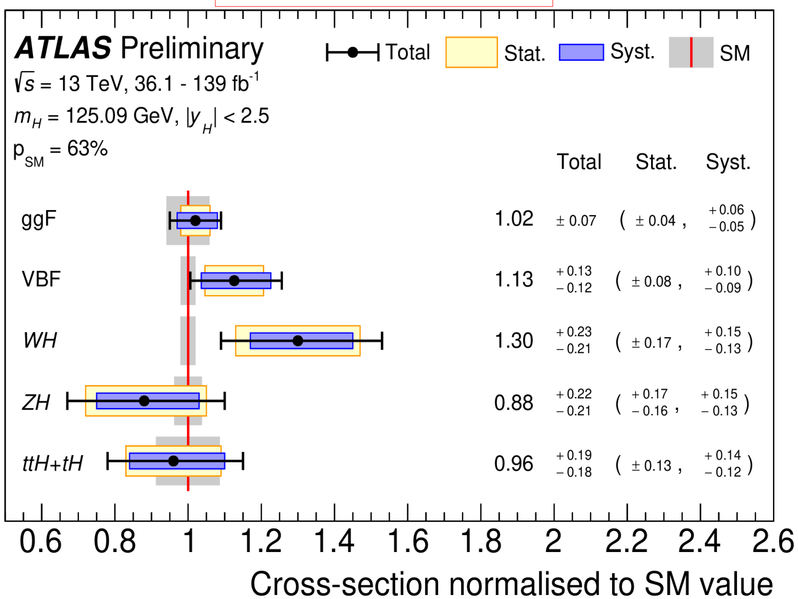
ATLAS-CONF-2021-53

- Combined all major production/decay mode measurements (13 TeV, L~36-139 fb^{-1})
- Global signal strength : $\mu = 1.06 \pm 0.06 = 1.06 \pm 0.03(\text{stat.}) \pm 0.03(\text{exp.}) \pm 0.04(\text{sig. th.}) \pm 0.02(\text{bkg. th.})$

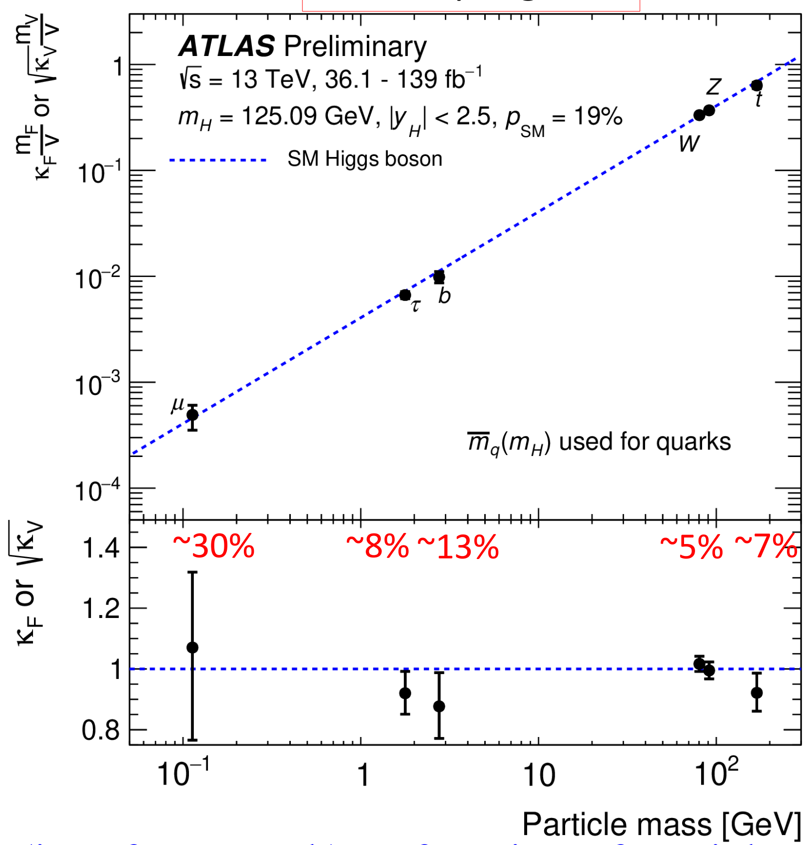
$$\mu_{global} = \frac{\sigma(\exp)}{\sigma(SM)}$$

Signal theory uncertainty becoming the dominant uncertainty source

Production

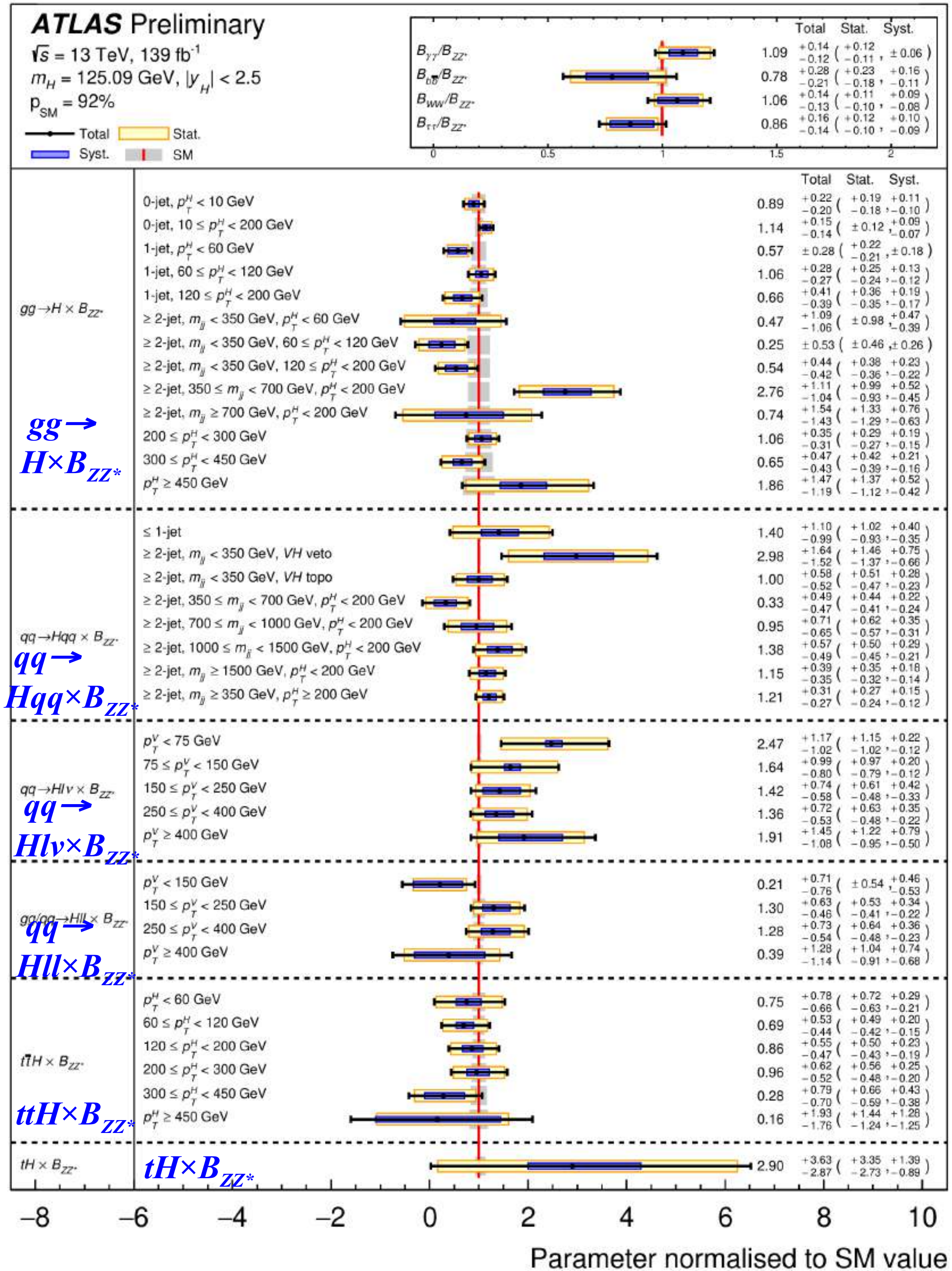


Couplings



- Assume SM branching fractions
- Productions probed to ~7% precision in best channel

- Extract coupling strength modifiers (in κ framework) as function of particle mass
- Assume no BSM contribution to Higgs decay
- Good agreement of couplings through three orders of magnitude of particle mass



Combined STXS Measurements

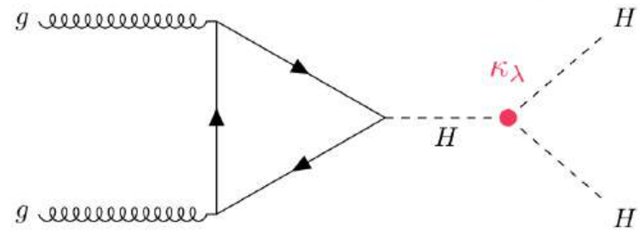
ATLAS-CONF-2021-53

- Extracted best-fit values for cross sections ($\sigma_i \times B_{ZZ}$) of different production processes and in several STXS regions, and the ratios of the branching fractions (B_f/B_{ZZ})
- Good compatibility with the SM predictions

Di-Higgs Production

- HH measurement provides a direct probe of the Higgs boson self-coupling λ_{HHH}
- Searched in ggF + VBF production, and in several different decay modes

NEW

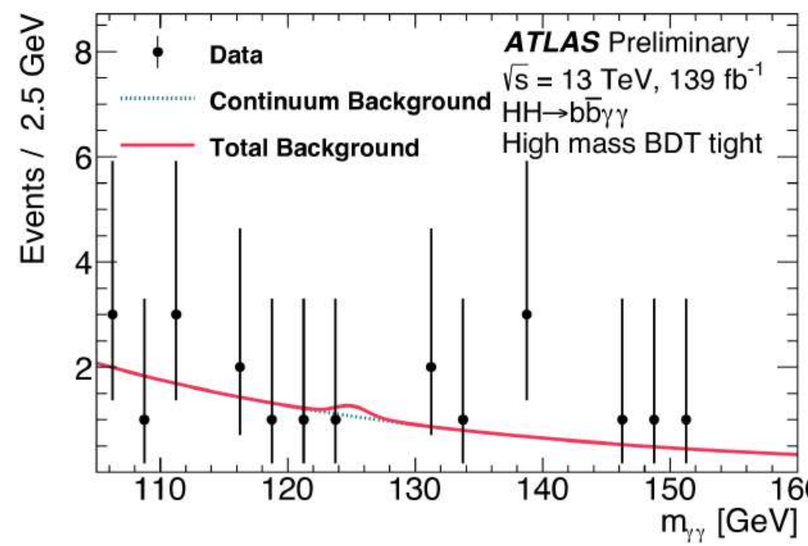


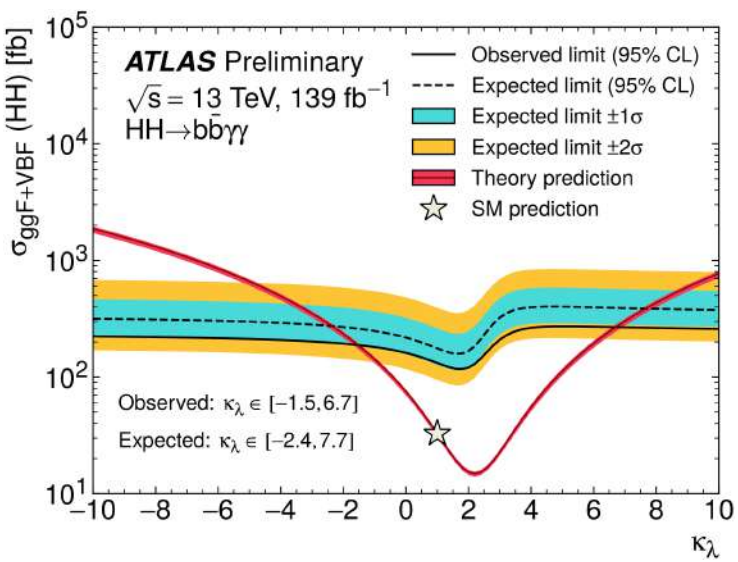
$$\kappa_\lambda = \frac{\lambda_{HHH}}{\lambda_{HHH}^{SM}}$$

(Higgs self-coupling modifier)

$\kappa_\lambda^{SM} = 1$

- **HH→bbγγ :** ATLAS-CONF-2021-016
- One of the most sensitive channels
- Combining high-BR bb and clean low-BR γγ
  - B(HH→bbγγ)=0.26%
- Main background from γγ+jets continuum
- Selected events are categorized by $m_{bb\gamma\gamma}$ and a multivariant discriminant
- Search signal in $m_{\gamma\gamma}$ distribution





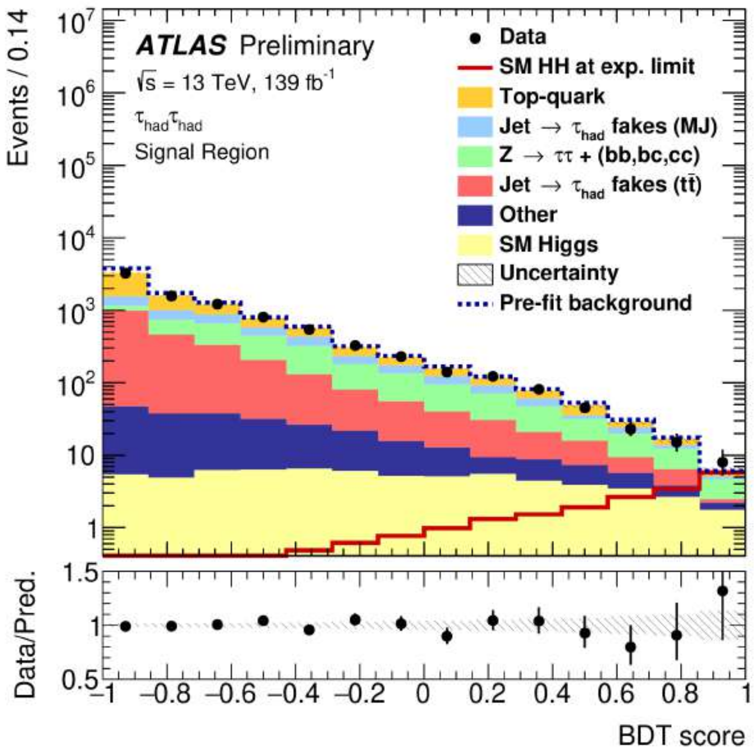
- Set Limit at 95% CL
  - $\sigma(HH)/\sigma^{SM}(HH)<4.1$ (5.5) obs (exp)
    - factor of 5 improvement over 36 fb^{-1} analysis
  - $-1.5<\kappa_\lambda<6.7$ (exp. $-2.4<\kappa_\lambda<7.7$)

Di-Higgs Production

NEW

•HH→bbττ : ATLAS-CONF-2021-030

- Moderate background and branching fraction
  - B(HH→bbττ)=7.3%
- Select events in $\tau_{lep}\tau_{had}$ and $\tau_{had}\tau_{had}$ channels, with improved τ_{had} identification efficiency
- Background mainly from Top, V+jets, VV, single Higgs and fake τ
  - Estimate from simulation and data
- Extract signal from fits to multivariate discriminants



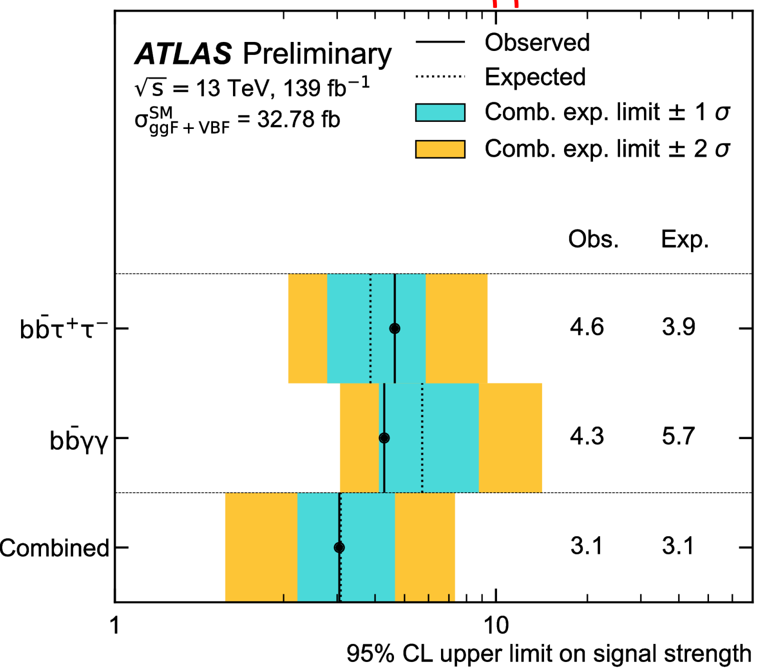
- Set Limit at 95% CL
  - $\sigma(HH)/\sigma^{SM}(HH)<4.7$ (3.9) obs (exp)
    - factor of 4 improvement over 36 fb^{-1} analysis
- Most sensitive single channel to non-resonant HH search at ATLAS

Di-Higgs Production : Combination

ATLAS-CONF-2021-052

NEW

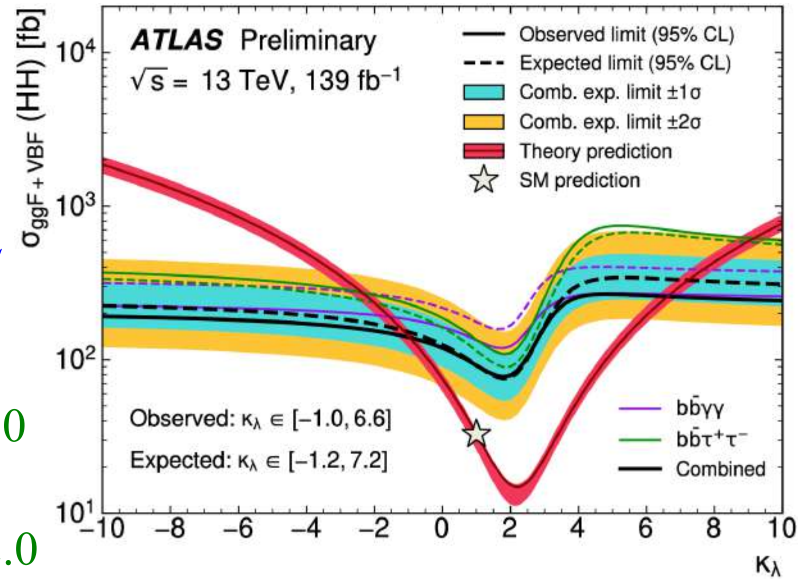
bbγγ+bbττ

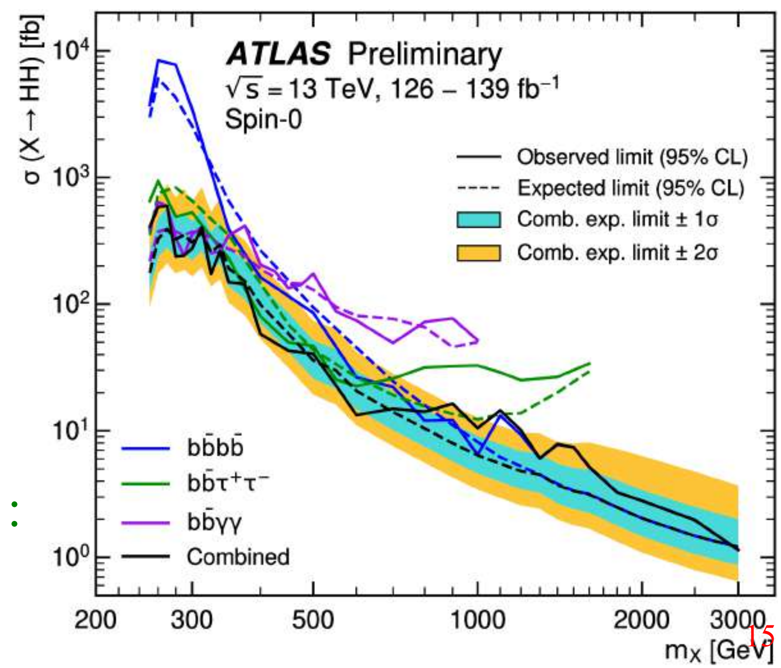


- $\sigma(HH)/\sigma^{SM}(HH)<3.1$ (3.1) obs (exp)
  - <6.9 (10) from 36 fb^{-1} combined analyses

- Obs :
  - $-1.1<\kappa_\lambda<6.6$
- Exp :
  - $-1.2<\kappa_\lambda<7.2$
- From 36 fb^{-1} :
  - Obs :
    - $-5.0<\kappa_\lambda<12.0$
  - Exp :
    - $-5.8<\kappa_\lambda<12.0$

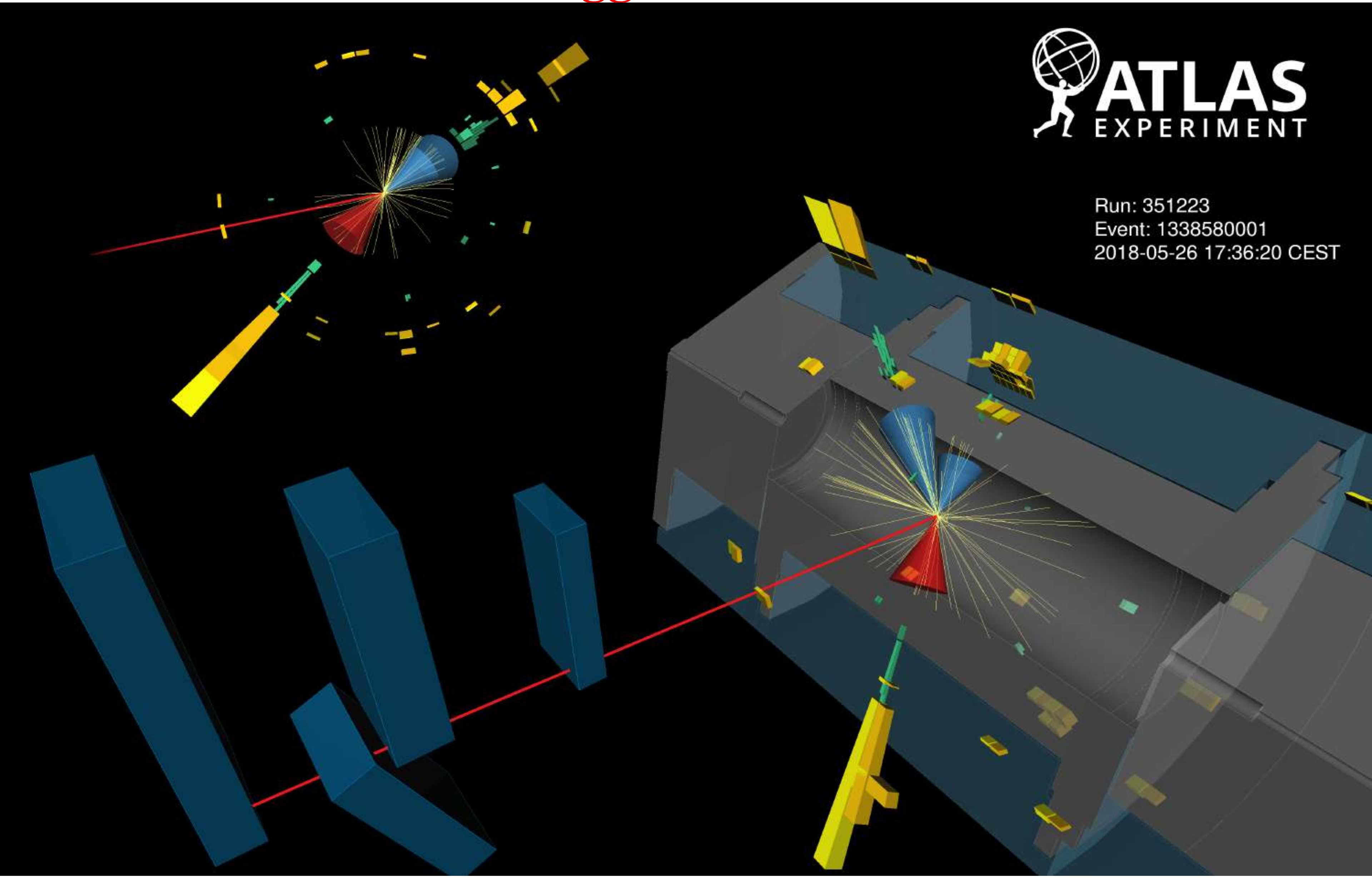
bbγγ+bbττ





- **Search for Spin-0 resonant X→HH** :
- From HH→bbbb, bbγγ, bbττ

Di-Higgs Production



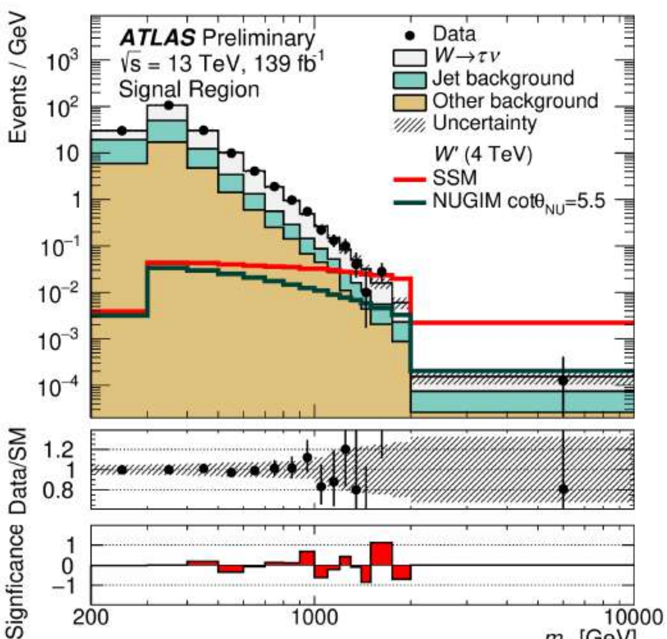
- $HH \rightarrow bb\tau\tau$, $\mu+\tau_{had}$ channel
- $m(bb)$=120 GeV, $m(\tau\tau)^{MMC}$=120 GeV, $m(HH)$=680 GeV

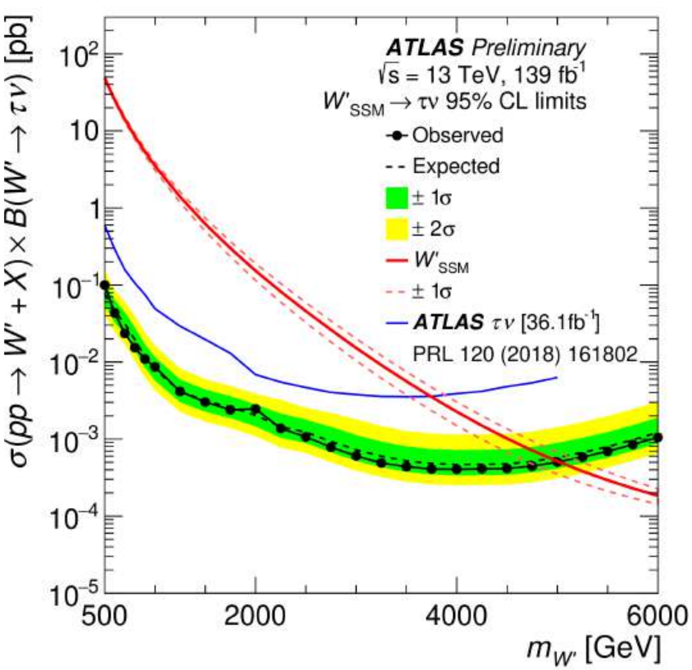
New Heavy Resonances: W’

ATLAS-CONF-2021-025

- Multiple theories beyond SM predict existence of new heavy particles. Example from:
  - Extended Gauge Symmetry for new gauge bosons (e.g. W’, Z’)

- **Heavy W bosons : W’→τν**
- W’→lν, flavour symmetric in Sequential SM (SSM)
  - Coupling to τ could be enhanced for Non-Universal Gauge Interaction Model (NUGIM), if $\cot\theta_{NU}>1$
- 1 τ_{had} candidate and large E_T^{miss}
- Main background from W→τν, Top, Diboson and jets faking τ_{had}
- Transverse mass M_T of τ_{had} and E_T^{miss} used as discriminant





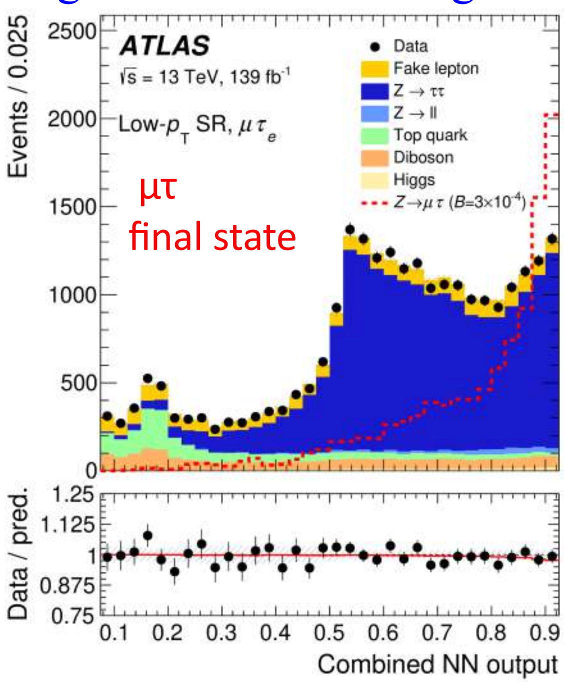
Limits on W’ at 95% CL :
- **SSM**: exclude mass below 5 TeV obs (4.9 TeV exp)
- **NUGIM**: exclude mass up to 3.5-5 TeV (depend on θ_{NU})

Lepton Flavour Violation

- Lepton Flavour is conserved in SM, but not protected by any fundamental principle
  - Violation only observed in neutrino oscillations, negligible for charged leptons in SM
- ***~8 billion Z's produced in ATLAS in Run-2*** => update LFV search in Z decays :

•Z→lτ (l=e,μ) arXiv:2105.12491

- τ→e/μ + 2ν
- **Signature:** e,μ + E_T^{miss}
- **Background :** Z→ττ→eμ+4ν, ttbar, diboson, fake leptons
- NN classifiers trained to discriminate against different background sources

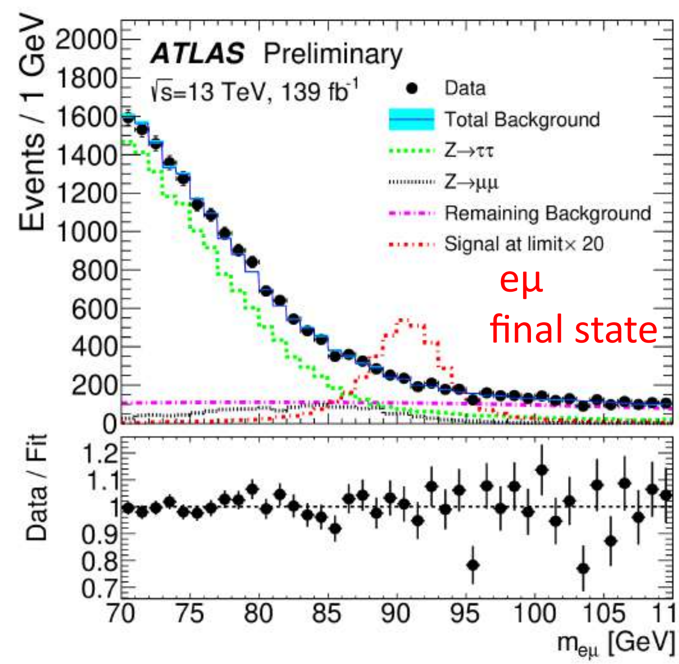


•Z→eμ ATLAS-CONF-2021-042

- **Signature:** e,μ + low E_T^{miss}
- **Background :** Z→ττ→eμ+4ν, Z→μμ, ttbar, diboson
- Search for peak around m_Z in $m_{e\mu}$ distr.

Upper limits @ 95% CL	ATLAS ($\times10^{-6}$)	LEP ($\times10^{-6}$)
B(Z→eμ)	0.34	1.7 (OPAL)
B(Z→eτ)	5.0	9.8 (OPAL)
B(Z→μτ)	6.5	12 (DELPHI)

Combined with Z→e/μ+τ, τ decays hadronically



- ***Surpasses LEP limits !***

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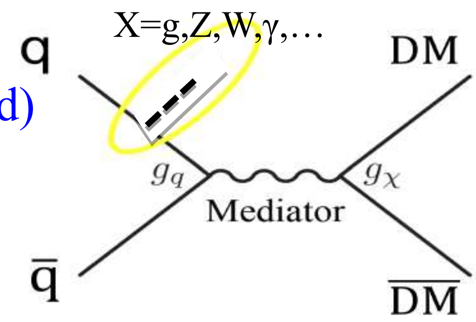
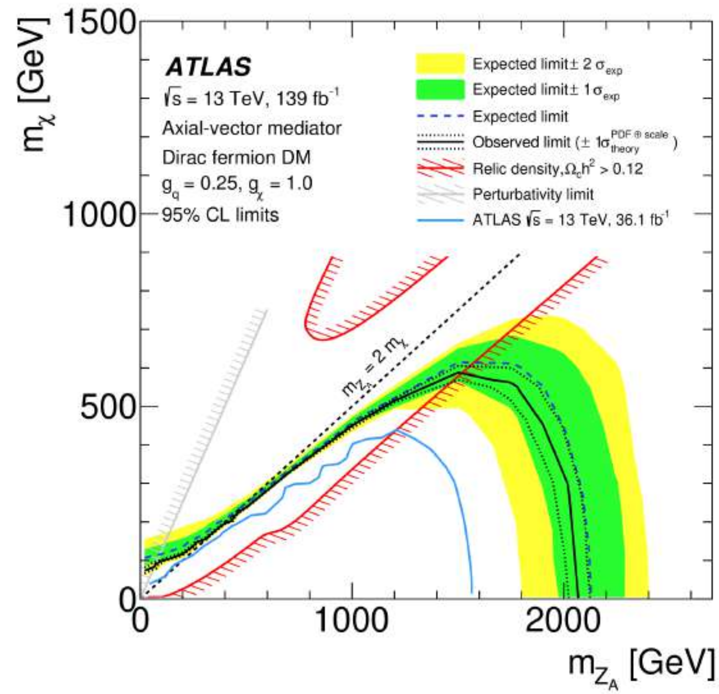
Dark Matter Searches

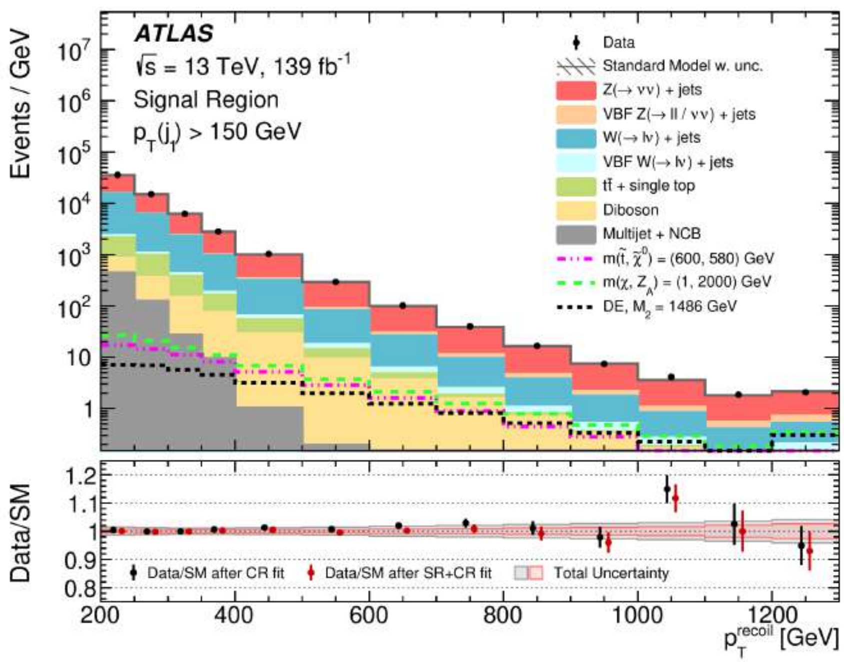


- At LHC dark matter (DM) can be produced via decay of a mediator (med) to the dark sector, and indirectly detected by measuring the SM particles recoiling against it. **Signature : Large E_T^{miss} + X**

Mono-jet (E_T^{miss} + jet) : Golden channel for DM search

- Can interpret results in several models
- Selection :
  - ≥1 jet pT>150 GeV, E_T^{miss}>200 GeV, no lepton/photon
- Background : Z(νν)+jets, W(lν)+jets, ttbar + single top, diboson, multi-jet, non-collision background
- Discriminating variable : E_T^{miss}





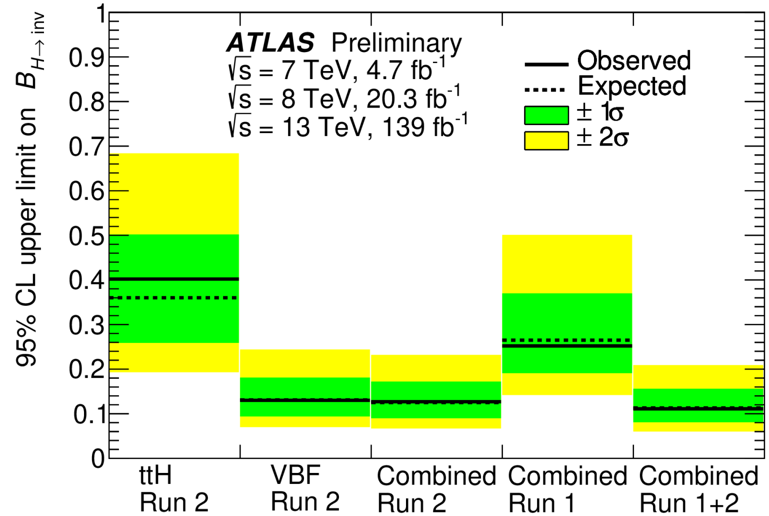
- **Results:**
- Model-independent 95% CL limit on visible cross sections range between 736 fb and 0.3fb.
- Simplified model with axial-vector mediator (Z_A) and Dirac WIMPs (χ)
  - Exclude m_{ZA} up to 2.1 TeV for m_χ=1 GeV (g_q=0.25, g_χ=1)

H→Invisible Decay

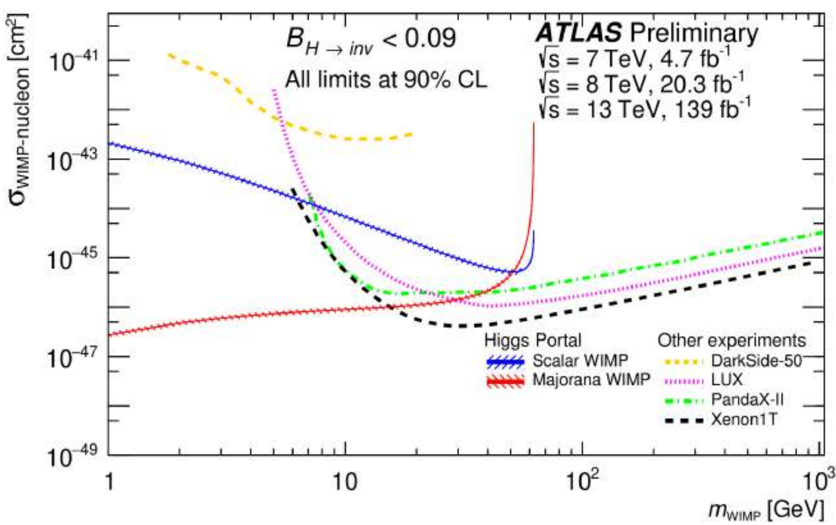
ATLAS-CONF-2020-052

- In SM BR(H→inv) ~0.1% (H→ZZ→4ν)
- Can be enhanced in some BSM where H couples to dark matter
- ATLAS recently updated the H→inv search with full Run-2 data sample and in several different channels

Channel (Run-2)	Limit on BR(H→inv)	Reference
VBF + H	0.13 ($0.13^{+0.05}_{-0.04}$)	ATLAS-CONF-2020-008
tt + H (tt2L + tt0L)	0.40 ($0.36^{0.15}_{-0.10}$)	ATLAS-CONF-2020-052
Z(ll) + H	0.18 (0.18)	ATLAS-CONF-2021-029
VBF + H + photon	0.37 ($0.34^{+0.15}_{-0.10}$)	arXiv:2019.00925



- Run-2 VBF+H and ttH are combined with Run-1
  - BR(H→inv): <0.11 ($0.11^{+0.04}_{-0.03}$ exp) @ 95%CL
- BR limit interpreted as limit on WIMP-nucleon elastic scattering cross section in Higgs portal model (assuming DM particles are either scalar or Majorana fermions)
- A preliminary combination. Final Run-2 combination will include Z(ll)+H and VBF+H+photon

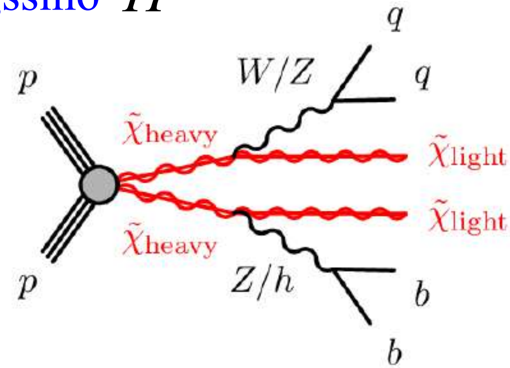


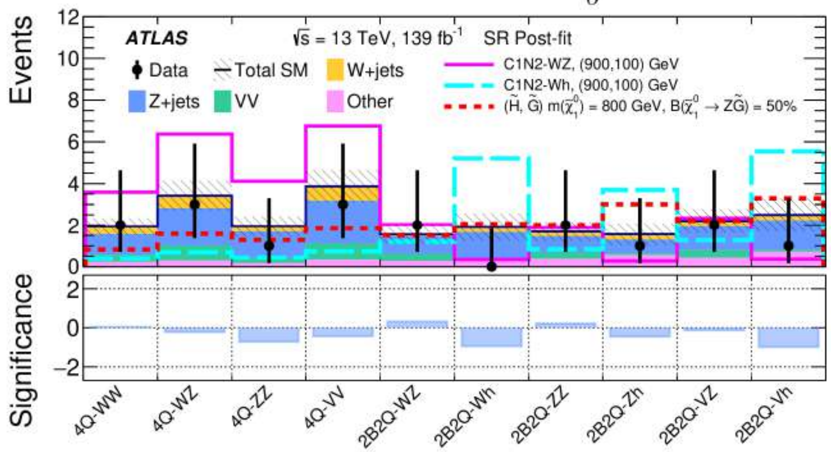
SUSY : All Hadronic Search

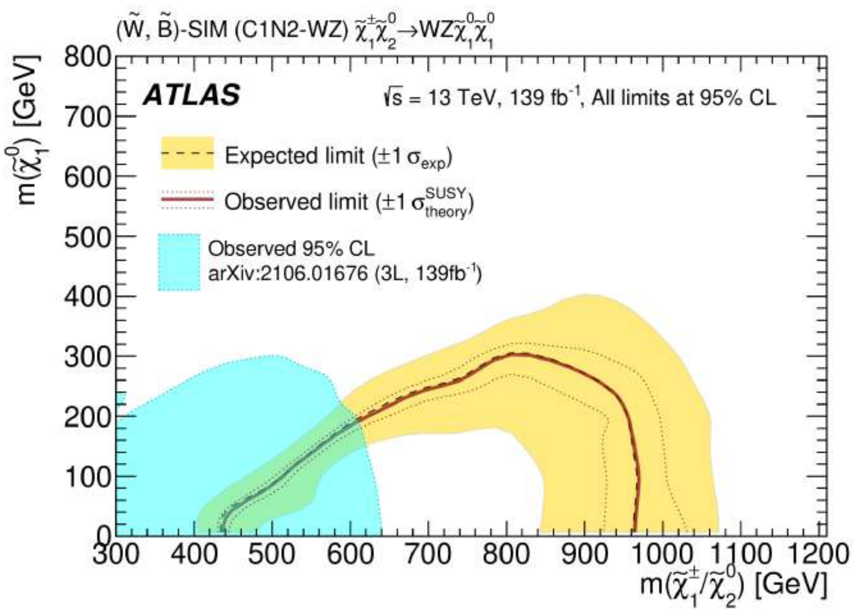
arXiv:2108.07586

- Focus on pair production of heavy "Electroweakinos" decaying into SM bosons (W/Z/H) and LSP
- Exploit the large BR of hadronic decays of W/Z/H to improve the search sensitivity
- **Large radius jet:** to capture collimated energetic jets
- **Jet substructure :** to identify hadronic decays of W/Z/H
- **Orthogonal signal regions :** 4Q, 2B2Q
- **Final state :** large E_T^{miss} , 2 large-R jets, no lepton
- **Dominant background :** Z(νν)+jets, W(lν)+jets and di-boson

- Electroweakinos : bino $\tilde{B}$, wino $\tilde{W}$, higgssino $\tilde{H}$





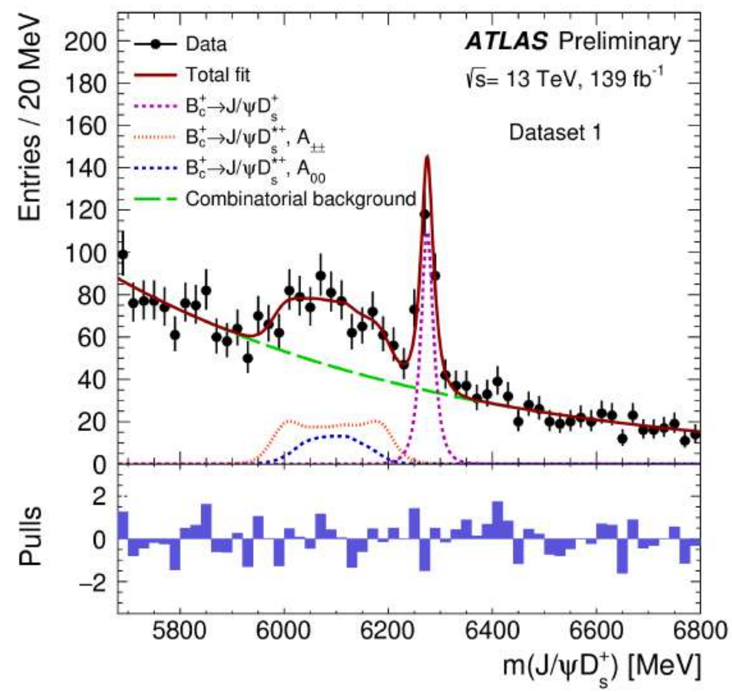


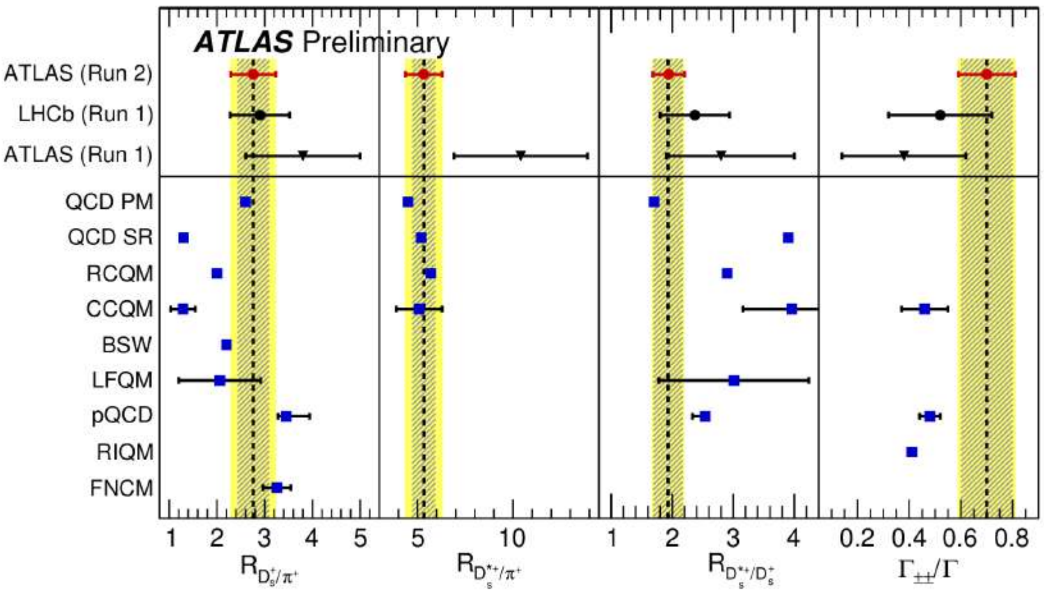
- Many different signal models are considered
- Example: exclusion limits wino pair decaying into bino LSP (C1N2-WZ)
- Limits extending into TeV region, beyond reach of the leptonic analyses

Study of the $B_c^+ \to J/\psi D_s^{(*)+}$

ATLAS-CONF-2021-046

- $B_c^+ \to J/\psi D_s^{(*)+}$ can occur through b decay with c as a spectator, or through annihilation diagram
- These decays were first observed by LHCb and ATLAS using Run-1 data sample
- ATLAS has analyzed full Run-2 data to achieve more precise measurements of the branching fraction and the polarization
- Reference channel : $B_c^+ \to J/\psi\pi^+$
  - Use it for branching fraction ratio measurements





$$R_{D_s^+/\pi^+} = 2.76 \pm 0.33(\text{stat.}) \pm 0.29(\text{syst.}) \pm 0.16(\text{br.f.})$$

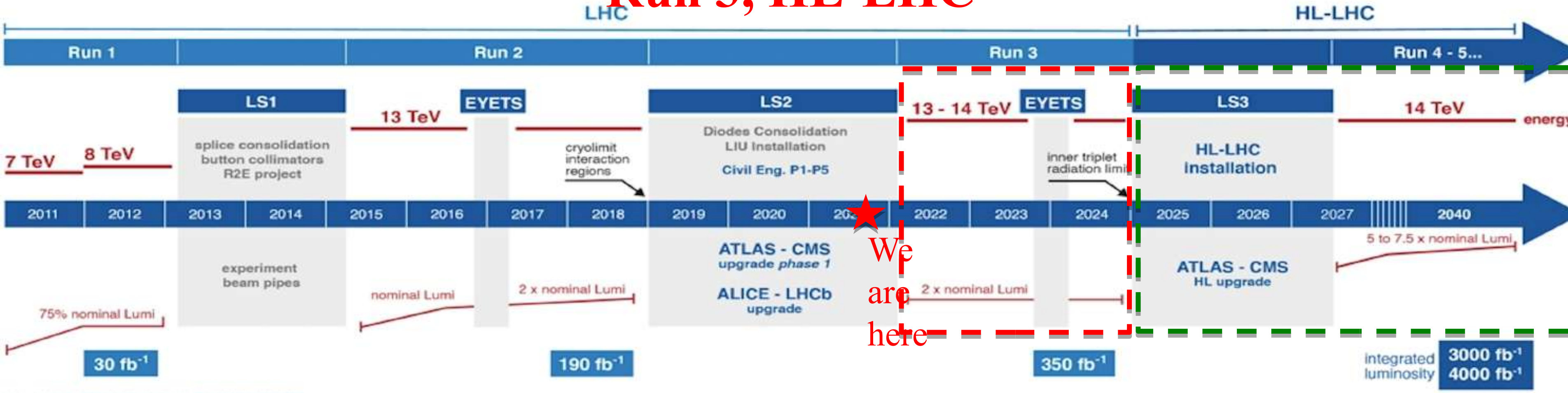
$$R_{D_s^{*+}/\pi^+} = 5.33 \pm 0.61(\text{stat.}) \pm 0.67(\text{syst.}) \pm 0.32(\text{br.f.})$$

$$R_{D_s^{*+}/D_s^+} = 1.93 \pm 0.24(\text{stat.}) \pm 0.10(\text{syst.})$$

$$\Gamma_{\pm\pm}/\Gamma = 0.70 \pm 0.10(\text{stat.}) \pm 0.04(\text{syst.})$$

- New measurements are consistent with earlier measurements of ATLAS and LHCb, and with better precision

Run 3, HL-LHC



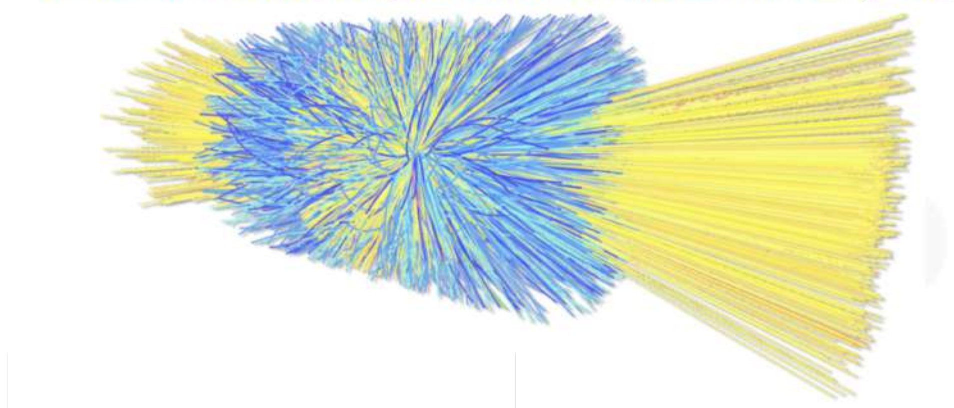
Run 3:

- Will start in 2022, $\sqrt{s}$=13.6 TeV
- $\int L \sim 150\ \mathrm{fb}^{-1}$, will increase the total data sample by factor of 2
- $L_{max} \sim 2\times10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Ave. pileup ~60

HL-LHC:

- $\sqrt{s}$=14 TeV
- $\int L \sim 3000\text{-}4000\ \mathrm{fb}^{-1}$: will be ~15-20 times more data than Run-2
- $L_{max} \sim 5\text{-}7.5\times10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Ave. pileup ~200

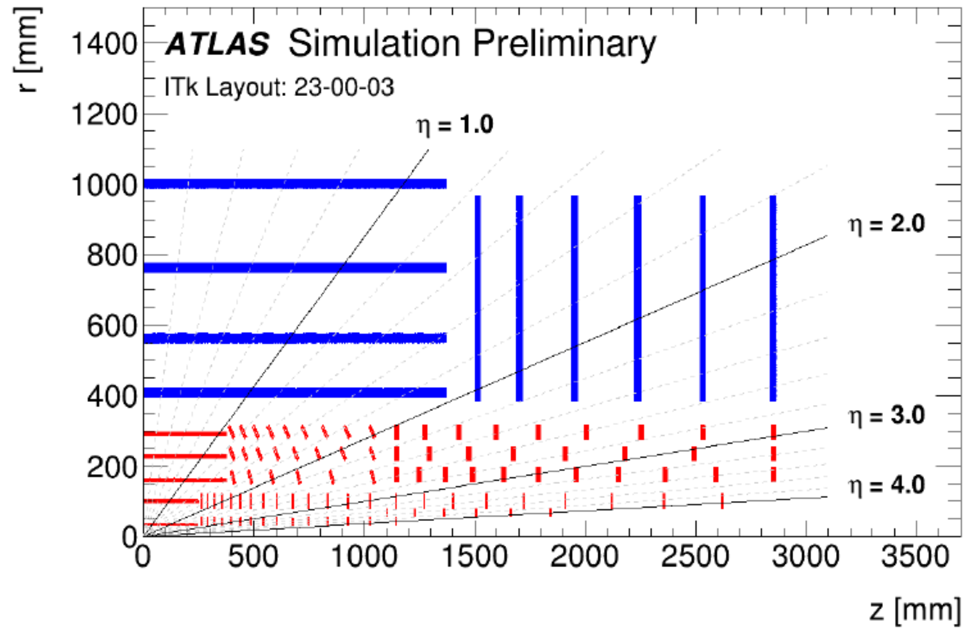
Simulated HL-LHC event, with 200 reconstructed vertices (μ=200)



- A lot of data for
  - QCD and EWK precision measurements
  - Deep understanding of Higgs properties
  - Probe BSM in both direct searches and in precision measurements

ATLAS Upgrades

(ITK: new inner tracking detector for HL-LHC)



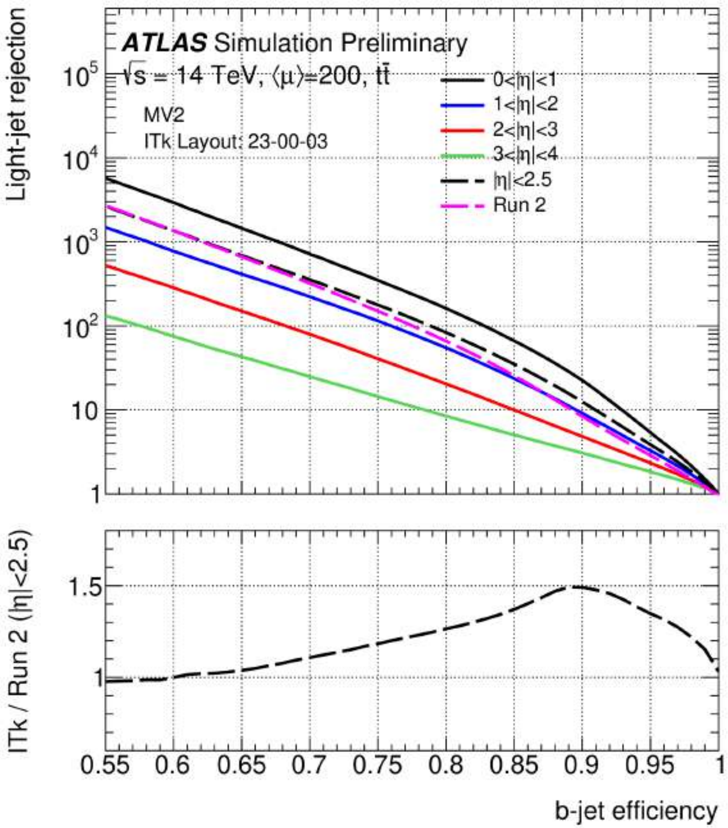
ATLAS Upgrade	Phase-1 (Run-3)	Phase-2 (HL-LHC)
DAQ & Trigger	Trigger hardware : - Higher purity e/γ triggers - Lower forward muon fake rate	Level-1 (L1) rate increase: 1 MHz, High Level Trigger (HLT) increase : ~10 kHz
Inner Tracker		New, up to |η|<4 (ITK)
Calorimeter	L1 trigger electronics for Liquid Argon (LAr)	Electronics upgrade for LAr & Tile
Muon	New Small Wheel (NSW)	Electronics upgrade + new muon chamber
Timing detector		New High Granularity Timing Detector in endcap

Detector Performance (Phase-2)

ATL-PHYS-PUB-2021-024

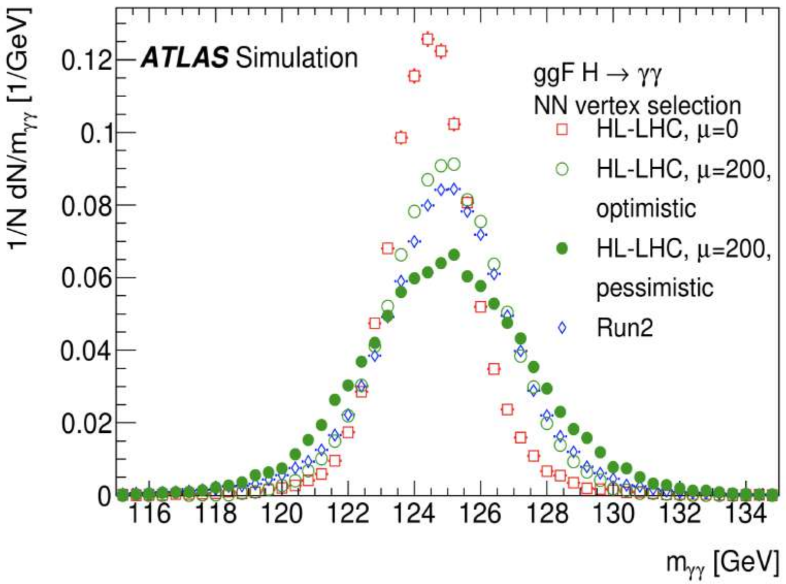
CERN-LHCC-2017-018

Tag b-jets



•Performance at HL-LHC improved by up to 50% in |η|<2.5, and enlarged geometrical coverage

Di-Photon Mass



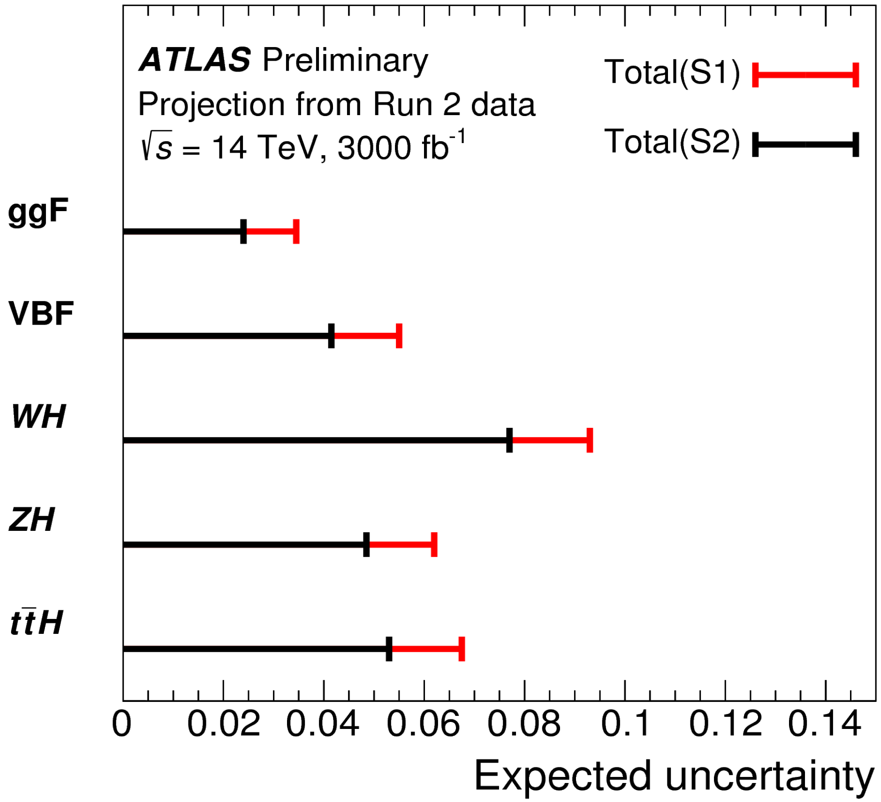
• di-photon mass resolution at HL-LHC, with <μ>~200, is comparable to Run2 for the optimistic scenario

Higgs : Projections for Production / Coupling Measurements

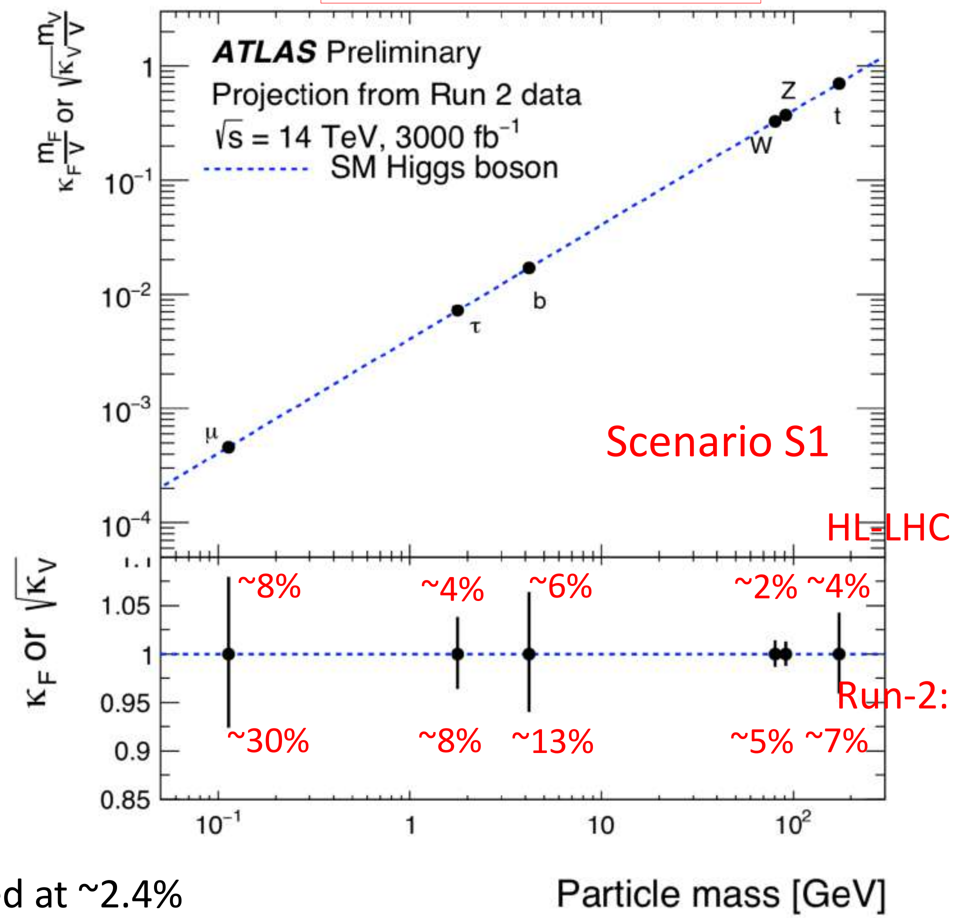
- Combined all major production/decay mode measurements

ATL-PHYS-PUB-2019-006

Production



Couplings



Run-2 :

- ggF measured at ~7%
- WH measured at ~20%

HL-LHC :

- ggF can be measured at ~2.4%
- WH can be measured at ~8%

- Scenario S1: Keep Run2 systematic uncertainties (pessimistic)
- Scenario S2 (baseline): Reduction of syst. uncertainties defined in CERN Yellow Report

Higgs : Projections for VH(→bb), VH(→cc)

ATL-PHYS-PUB-2021-039

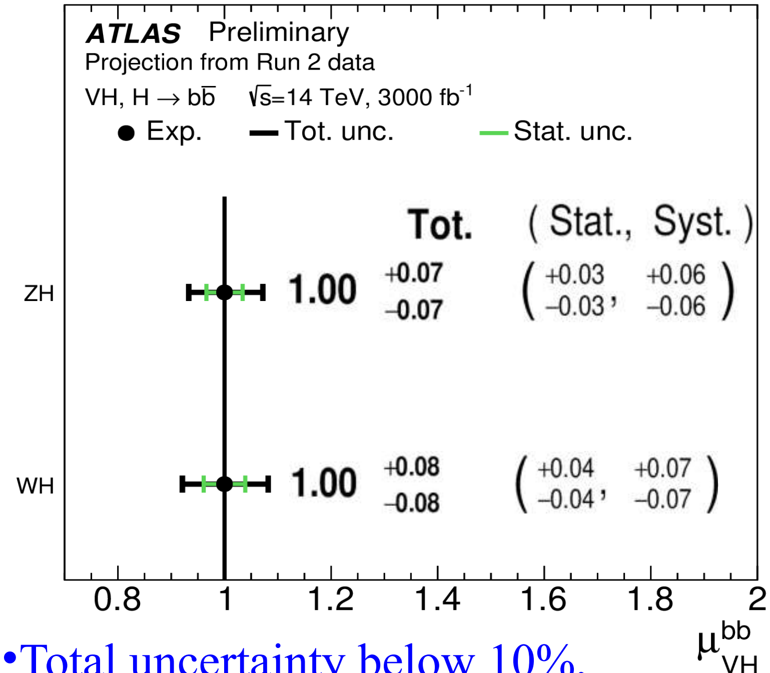
- Both projections based on recent analyses with full Run-2 data and using assumption similar to Scenario S2

VH(→bb)

- Run-2 : measured signal strengths

$$\mu_{WH}^{bb} = 0.95\ ^{+0.18}_{-0.18}(\text{stat})\ ^{+0.19}_{-0.18}(\text{syst})$$

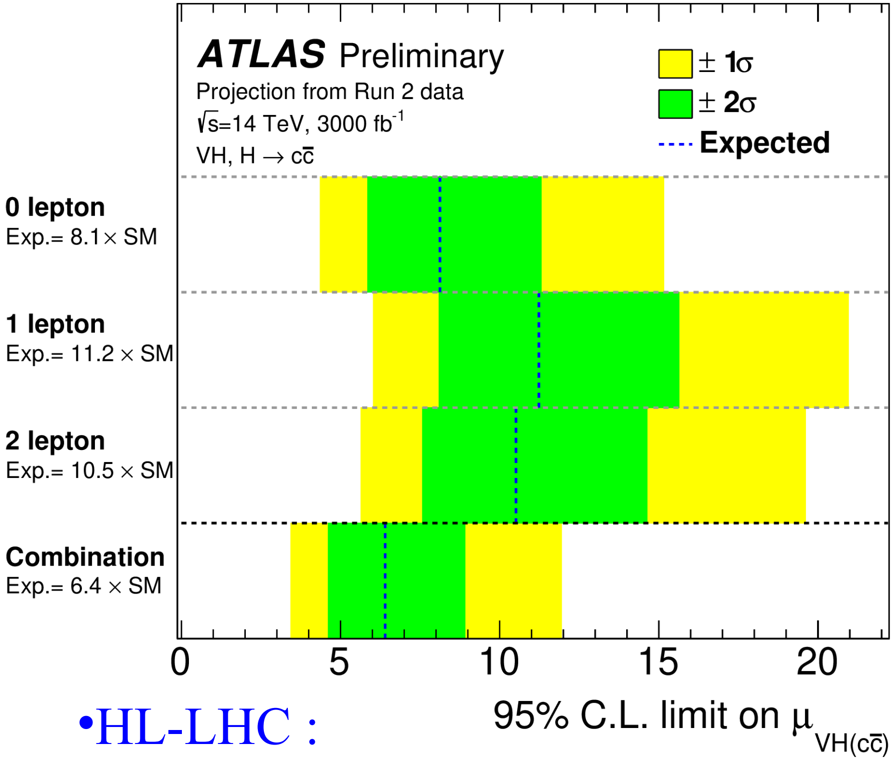
$$\mu_{ZH}^{bb} = 1.08\ ^{+0.17}_{-0.17}(\text{stat})\ ^{+0.18}_{-0.15}(\text{syst})$$



- Total uncertainty below 10%, systematic dominant. Single largest source is signal uncertainty

VH(→cc)

- Run-2 :
  - σ(VH(cc))<31×SM @ 95% CL (exp.)
  - $|\kappa_c|$<12.4 at 95% CL (exp.)



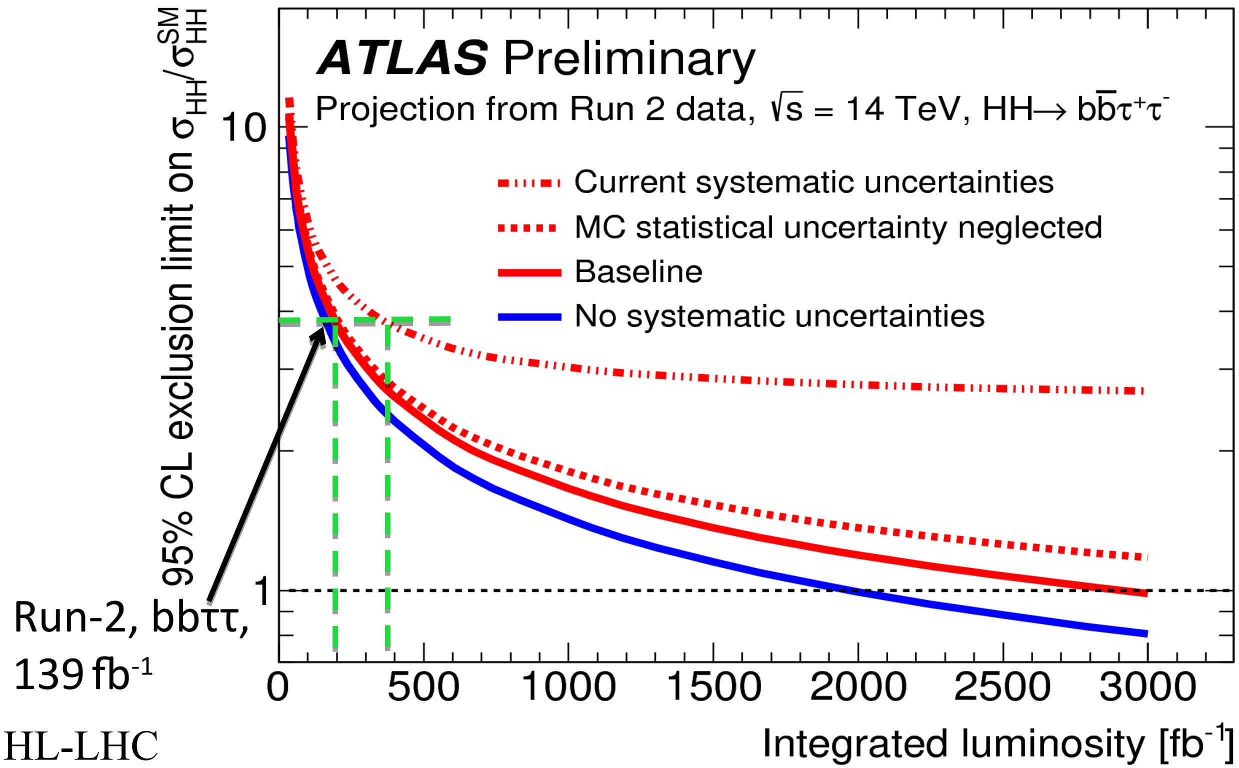
- HL-LHC :
  - σ(VH(cc))<6.4×SM @ 95% CL (exp.)
  - $|\kappa_c|$<3.0 at 95% CL (exp.)

Projection for Di-Higgs Search

ATL-PHYS-PUB-2018-053
arXiv:1902.00134

- Extrapolation based on Run-2 36 fb^{-1} analyses and with the estimate of upgrade detector performance

- Extrapolated sensitivities are sensitive to the scenarios of systematic uncertainties



Significance at HL-LHC

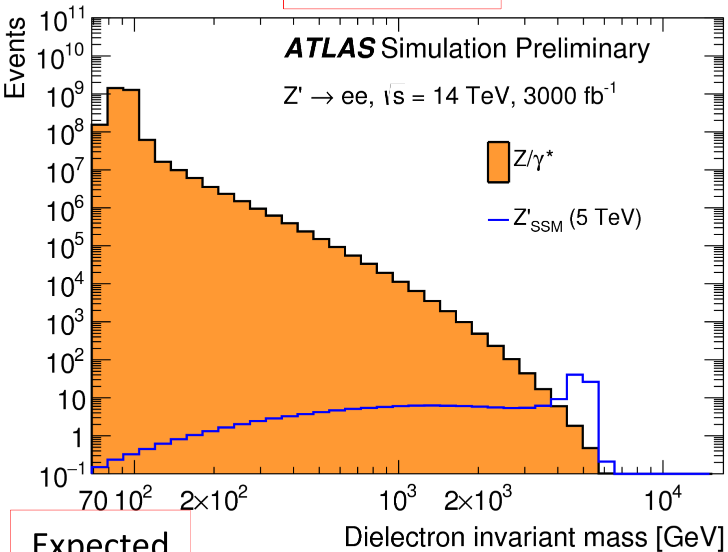
Channel	Statistical-only	Statistical + Systematic
$HH \to b\bar{b}b\bar{b}$	1.4	0.61
$HH \to b\bar{b}\tau^+\tau^-$	2.5	2.1
$HH \to b\bar{b}\gamma\gamma$	2.1	2.0
Combined	3.5	3.0

- Combine ATLAS + CMS : 4.0 σ (stat. +syst.)   (4.5 σ (stat. only))
  - Precision of self-coupling modifier κ_λ can reach ~50%

- Recent full Run-2 HH results improved significantly over the previous 36 fb^{-1} results
- ***May reach the discovery level of di-Higgs production at the end of HL-LHC !***

Projection for *ll* and *lv* Resonance Searches

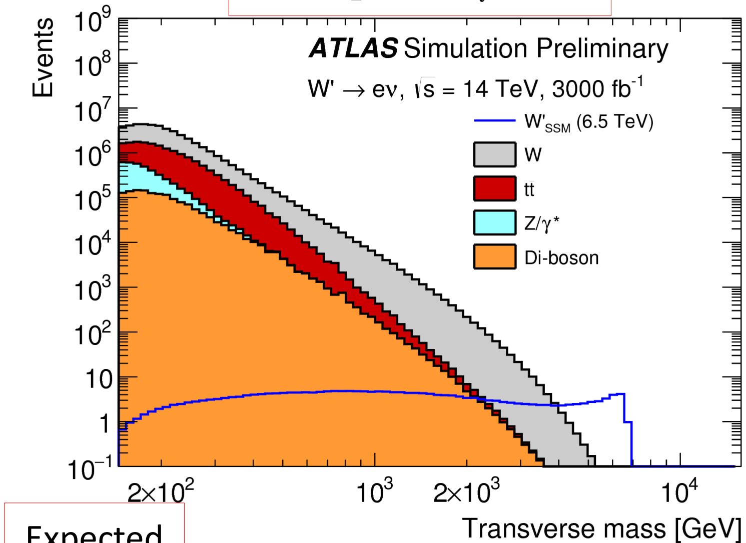
di-lepton



Expected

(ee+μμ)	HL-LHC		Run2 (139 fb^{-1})
Model	Exclusion [TeV]	Discovery [TeV]	Exclusion [TeV]
Z'(SSM)	6.5	6.4	5.1
Z'(ψ)	5.8	5.7	4.5

lepton+E_t^{miss}



Expected

	HL-LHC		Run2 (139 fb^{-1})
W'_{SSM}	Exclusion [TeV]	Discovery [TeV]	Exclusion [TeV]
ATLAS (eν, μν)	7.9	7.7	5.8
ATLAS ($\tau_h\nu$)			4.9

- Extend Z'_{SSM} exclusion limit by ~1.4 TeV
- Overall uncertainty ~6.5%×m_{ll} [TeV]
  - expt. (rec. Id, resolution) : ~2.9%×m_{ll} [TeV]
  - theory (dominated by PDF) : ~5.6%×m_{ll} [TeV]

- Extend exclusion W'_{SSM} mass by ~2 TeV

ATL-PHYS-PUB-2018-044

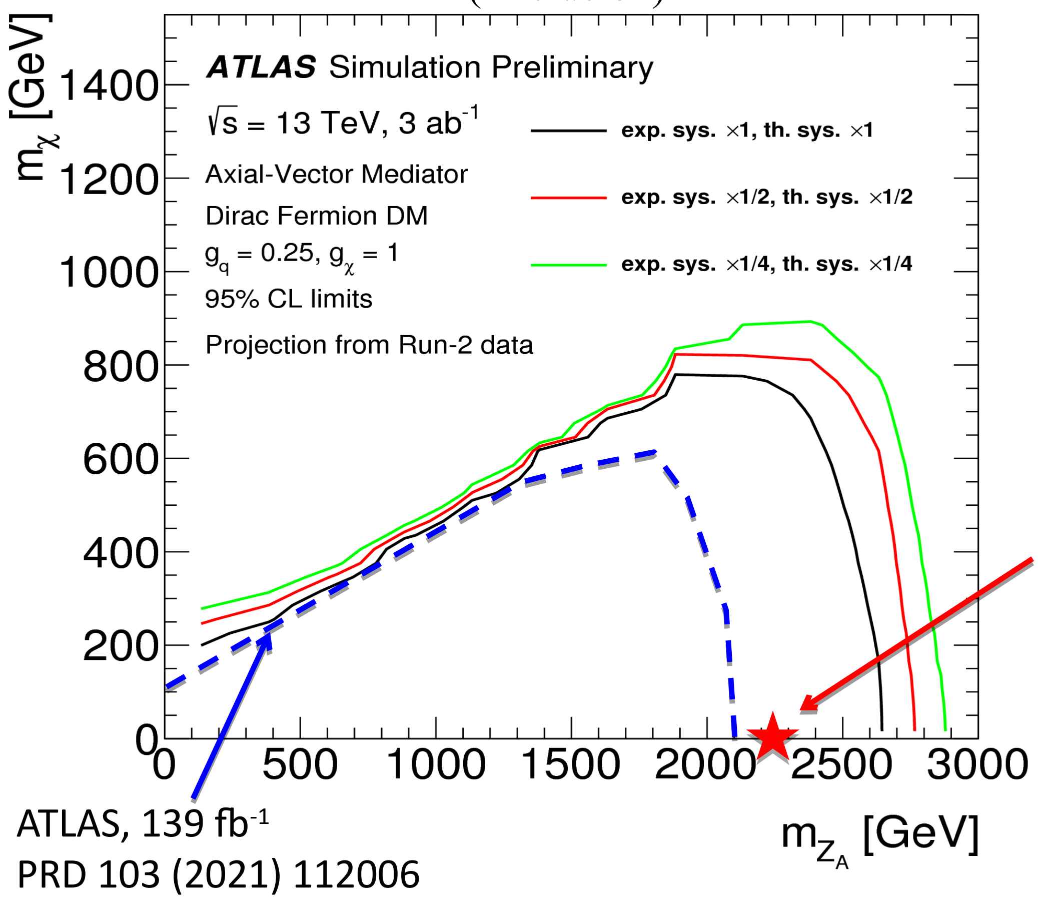
Projection for Dark Matter Searches

• Extrapolate from the Mono-jet (E_T^{miss} + jet) Run-2 analysis with 36 fb^{-1} data

ATL-PHYS-PUB-2018-043

Mono-jet (E_T^{miss} + jet)

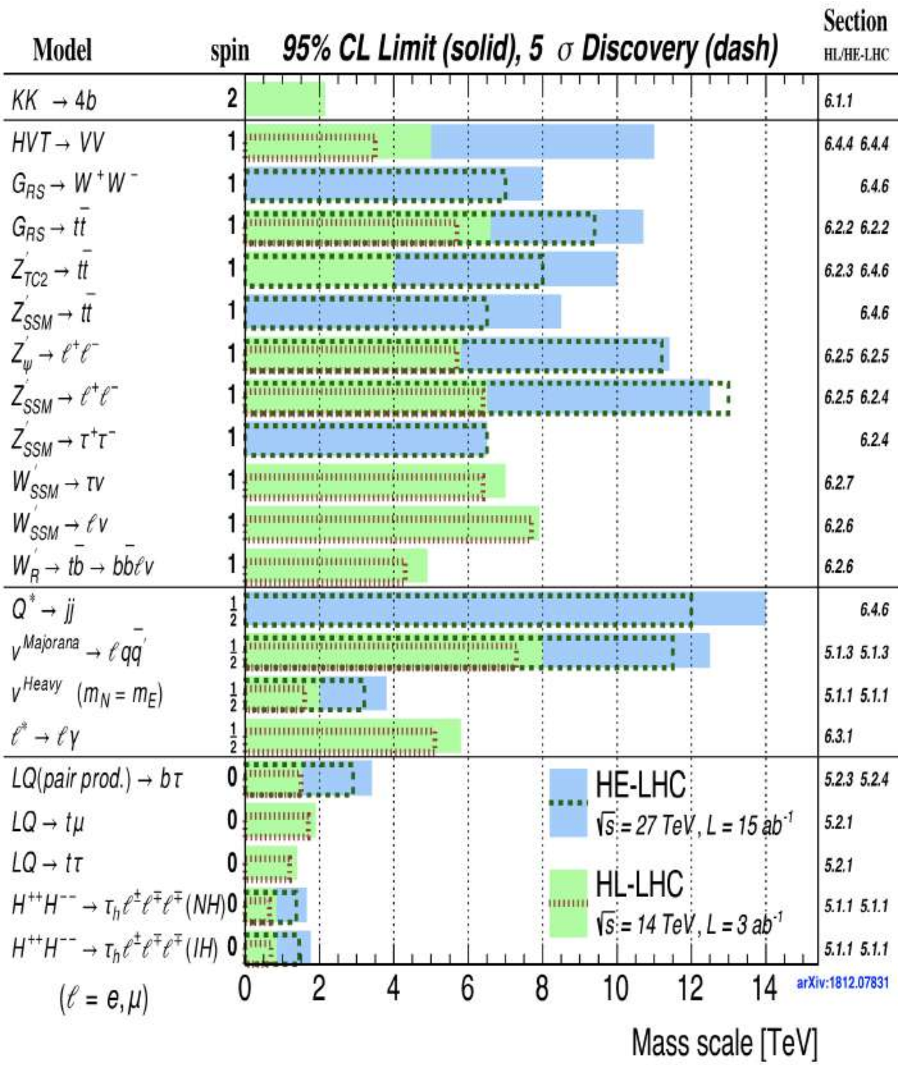
(Exclusion)

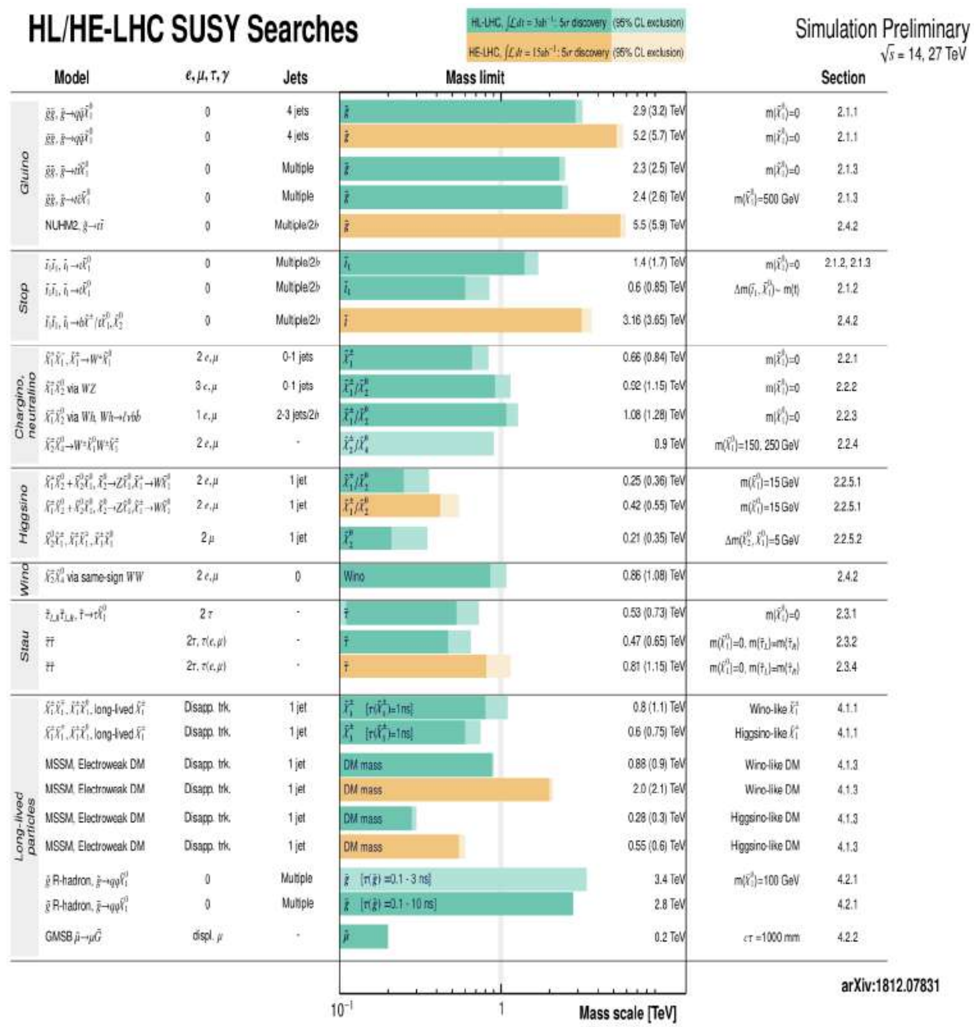


- Searches are sensitive to systematic uncertainties
- Expected exclusion limit on mediator mass can be extended by several hundreds of GeV
- Discovery could be reached for a signal with DM mass of 1 GeV and mediator mass of 2.25 TeV

Large improvement compared to current LHC results !

Exotics/SUSY Search Reach at HL-LHC





•Many more projection studies on Exotic/SUSY searches can be found at :

arXiv:1812.07831

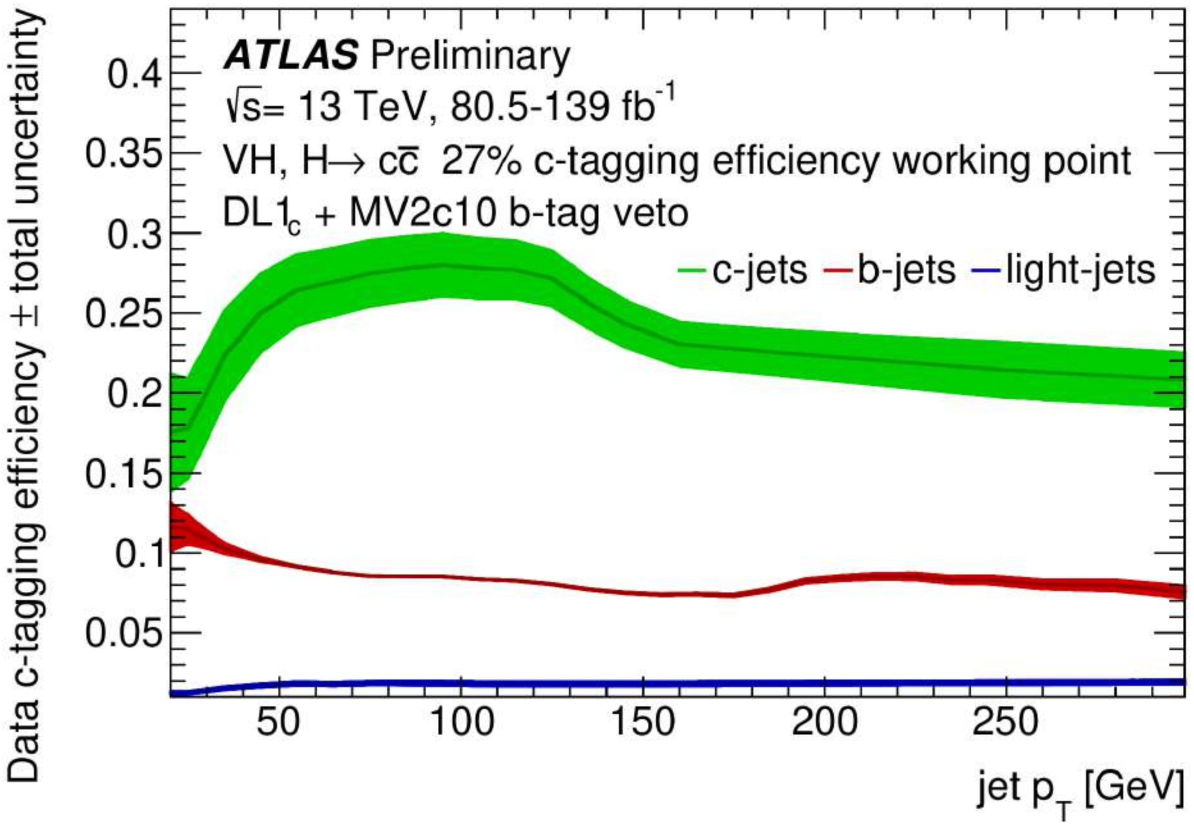
Summary

- Many new results from ATLAS have improved upon not just with more data but also with improvement in the analysis methods
- Tremendous work has been performed by the collaboration to determine the physics potential at the HL-LHC
    - Higgs productions and decays can be measured to a precision of a few percent and we may reach the discovery level of di-Higgs production at the end of HL-LHC
    - Large extensions can be made for Beyond SM searches with more data and with improve detector performance
- However reduction of systematic uncertainties, improvement of theoretical understanding and innovation of advanced techniques will be important for the success of the HL-LHC program.
- Run-3 data taking will start in a few months. More exciting new results will be coming soon.

ATLAS public physics results :
https://twiki.cern.ch/twiki/bin/view/AtlasPublic

Backup

C-jet tagging efficiency



Mono-jet

Table 9: Observed and expected 95% CL upper limits on the number of signal events, S^{95}_{obs} and S^{95}_{exp}, and on the visible cross section, defined as the product of cross section, acceptance and efficiency, $\langle\sigma\rangle^{95}_{\text{obs}}$, for the IM0–IM12 selections.

Selection	$\langle\sigma\rangle^{95}_{\text{obs}}$ [fb]	S^{95}_{obs}	S^{95}_{exp}
$p_T^{\text{recoil}} > 200$ GeV	736	102 274	$83\,000^{+22\,000}_{-23\,000}$
$p_T^{\text{recoil}} > 250$ GeV	296	41 158	$33\,800^{+11\,300}_{-9400}$
$p_T^{\text{recoil}} > 300$ GeV	150	20 893	$15\,400^{+5900}_{-4300}$
$p_T^{\text{recoil}} > 350$ GeV	86	11 937	8300^{+3100}_{-2300}
$p_T^{\text{recoil}} > 400$ GeV	52	7214	4700^{+1800}_{-1300}
$p_T^{\text{recoil}} > 500$ GeV	21	2918	1930^{+730}_{-540}
$p_T^{\text{recoil}} > 600$ GeV	10	1391	940^{+360}_{-260}
$p_T^{\text{recoil}} > 700$ GeV	4.1	574	490^{+190}_{-140}
$p_T^{\text{recoil}} > 800$ GeV	2.1	298	277^{+106}_{-77}
$p_T^{\text{recoil}} > 900$ GeV	1.2	164	168^{+65}_{-47}
$p_T^{\text{recoil}} > 1000$ GeV	1.3	186	119^{+45}_{-33}
$p_T^{\text{recoil}} > 1100$ GeV	0.5	73	75^{+28}_{-21}
$p_T^{\text{recoil}} > 1200$ GeV	0.3	40	49^{+19}_{-14}

Physics Projection at HL-LHC

- Assume center of mass energy at 14 TeV and total integrated luminosity is 3000 fb^{-1}

- Methods for projection:
  - **Detailed simulations** are used to access performance of upgraded detector and HL-LHC condition
  - Existing results are **extrapolated** and take into account of increase in energy and performance of upgraded detector, or **parametric simulations** are used to allow full re-optimization of the analyses

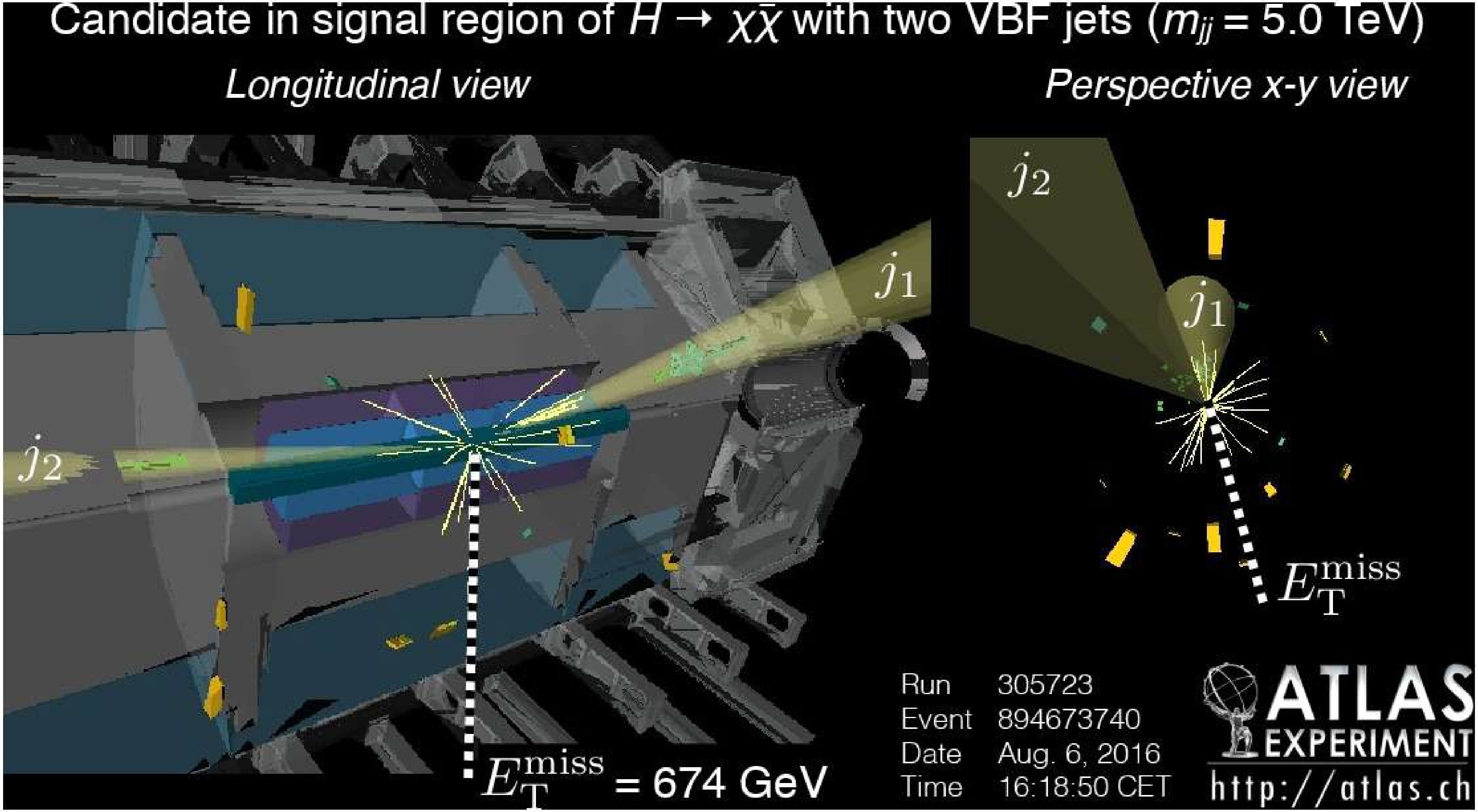
- **Systematic uncertainties :**

- Baseline scenario ("YR18" or "S2") :
  - Theory uncertainties ½ of Run-2
  - No simulation statistical uncertainty
  - luminosity uncertainty ~1%
  - Statistical uncertainty reduced by $1/\sqrt{L}$
  - Uncertainties due to detector limitations remain unchanged or revised according to simulation studies of upgraded detector.

- Conservative scenario ("S1") :
  - Use uncertainties of Run-2 measurements, assuming the higher pile-up effects will be compensated by detector upgrades.

ATL-PHYS-PUB-2018-054
CMS-PAS-FTR-18-011

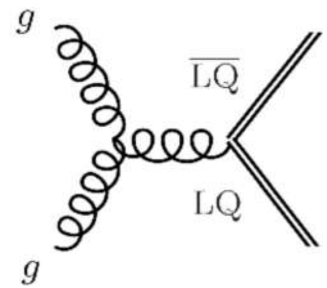
VBF Higgs→Invisible Decay Candidate Event

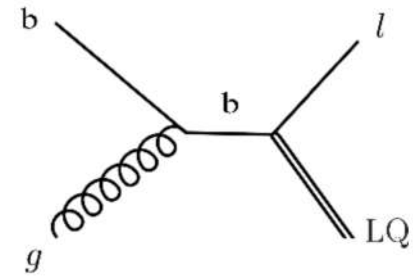


LeptoQuarks

ATLAS-PHYS-PUB-2021-017
arXiv:2018.07665

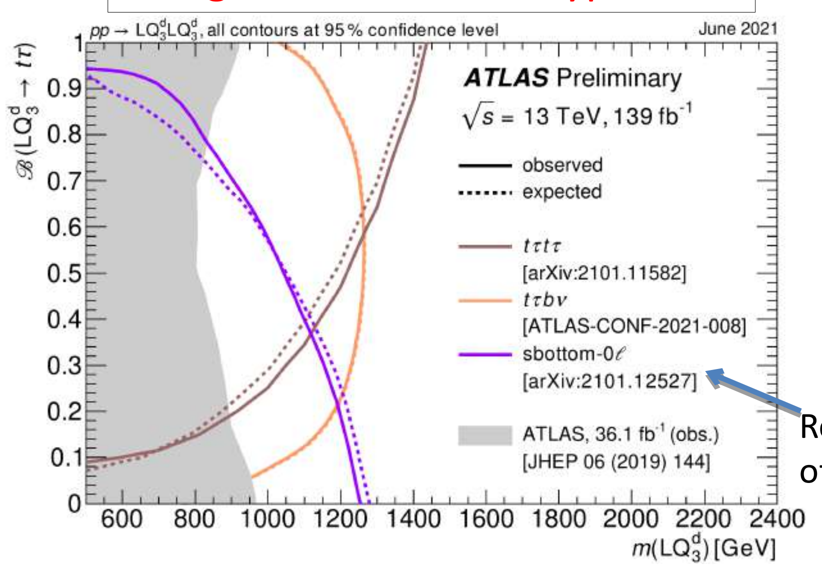
- Leptoquark (LQ), an BSM particle, predicted in GUTs and Composite Higgs models
- At LHC, LQ can be :
  - pair produced : via gg fusion and qq annihilation
  - singly produced : in association with a lepton





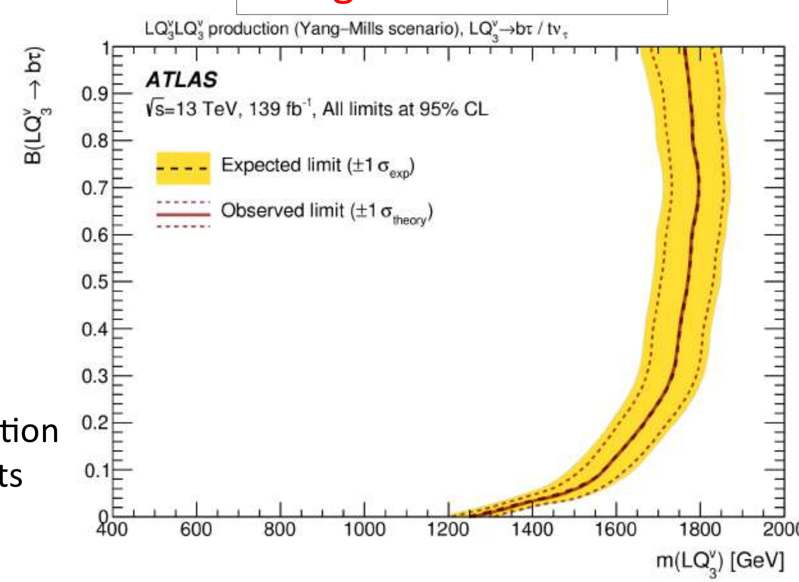
- LQ decay : into a quark and a lepton
- Search for pair-produced 3rd generation scalar LQs
  - Assume LQ decays to 3rd generation quark, and to 3rd generation or 1st/2nd generation lepton
- Also searched for pair-produced 3rd generation vector LQs
- Set 95% CL exclusion region in m(LQ) vs B(LQ decays to a quark and a charged lepton)

3rd gen. scalar down-type LQs



Re-interpretation of SUSY results

3rd gen. vector LQs



Possible HL-LHC Triggers

ATL-PHYS-PUB-2019-005

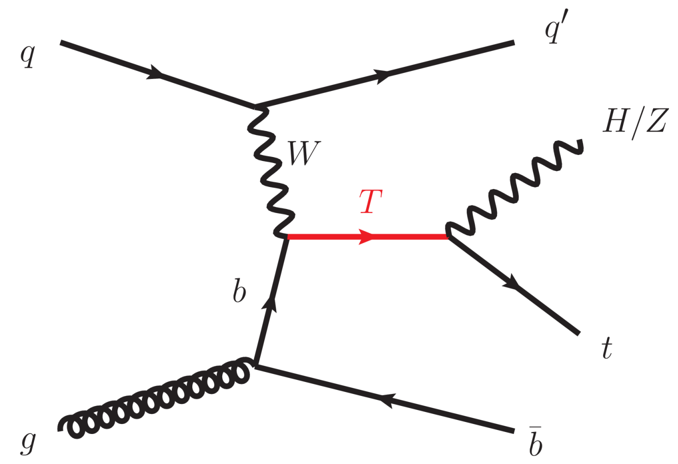
Table 2: Representative trigger menu for ATLAS operations at the HL-LHC. The offline p_T thresholds indicate the momentum above which a typical analysis would use the data. Where multiple object triggers are described only one threshold is given if both objects are required to be at the same p_T; otherwise, each threshold is given with the two values separated by a comma. In the case of the $e-\mu$ trigger in Run 2, two sets of thresholds were used depending on running period, and both are listed. This table is a subset of Table 6.4 from the TDAQ TDR [10].

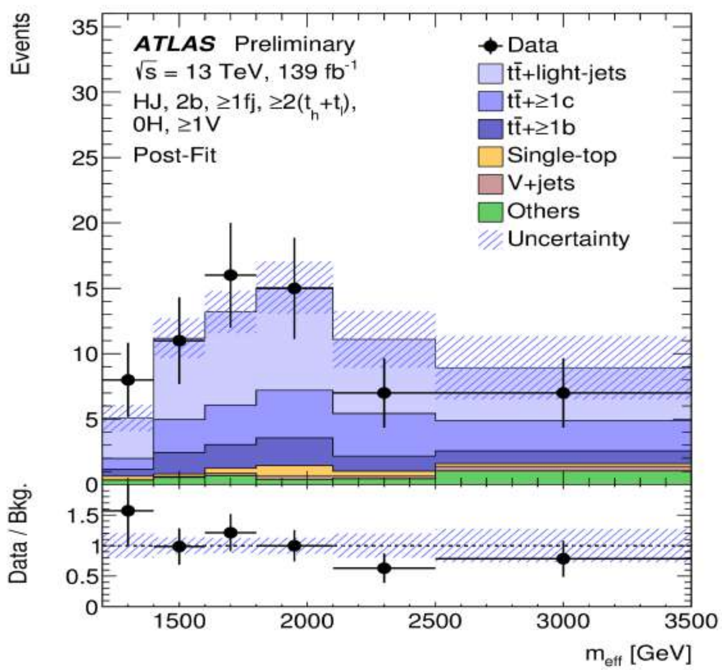
Trigger Selection	Run 1 Offline p_T Threshold [GeV]	Run 2 (2017) Offline p_T Threshold [GeV]	Planned HL-LHC Offline p_T Threshold [GeV]
isolated single e	25	27	22
isolated single μ	25	27	20
single γ	120	145	120
forward e			35
di-γ	25	25	25
di-e	15	18	10
di-μ	15	15	10
$e-\mu$	17,6	8,25 / 18,15	10
single τ	100	170	150
di-τ	40,30	40,30	40,30
single b-jet	200	235	180
single jet	370	460	400
large-R jet	470	500	300
four-jet (w/ b-tags)		45(1-tag)	65(2-tags)
four-jet	85	125	100
H_T	700	700	375
E_T^{miss}	150	200	210
VBF inclusive (di-jets)			2x75 w/ ($\Delta\eta > 2.5$ & $\Delta\phi < 2.5$)

New Heavy Resonances

ATLAS-CONF-2021-040

- **Vector-Like Top quark**
- Search in single production channel
- Probe the universal coupling constant κ
    - Controls the production cross section and resonance width of VLQ
- Search in T→**Zt** , **T→Ht**
- Select events with:
    - e or μ,
    - large-R jet to tag Z / H
    - small-R jets (some b-tagged)
- Main background from ttbar, single top, W+jets





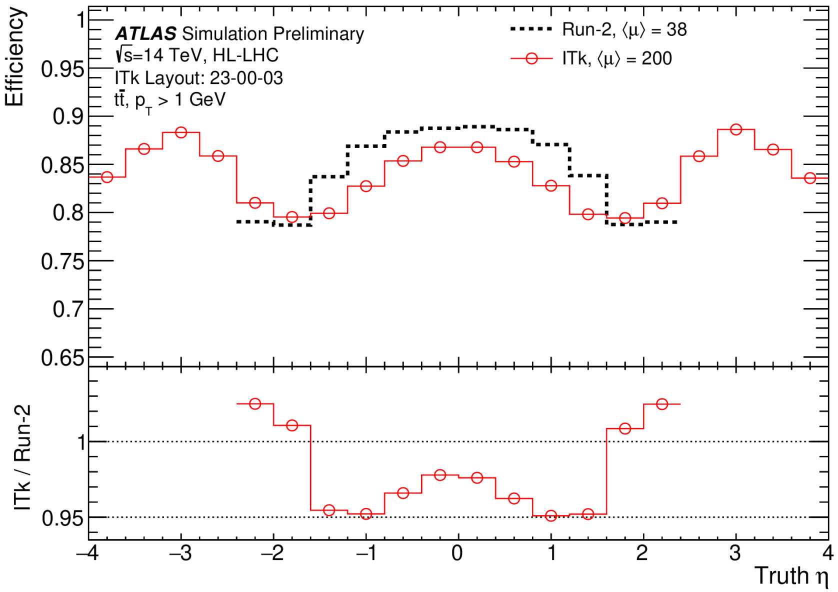
- Discriminating variable:

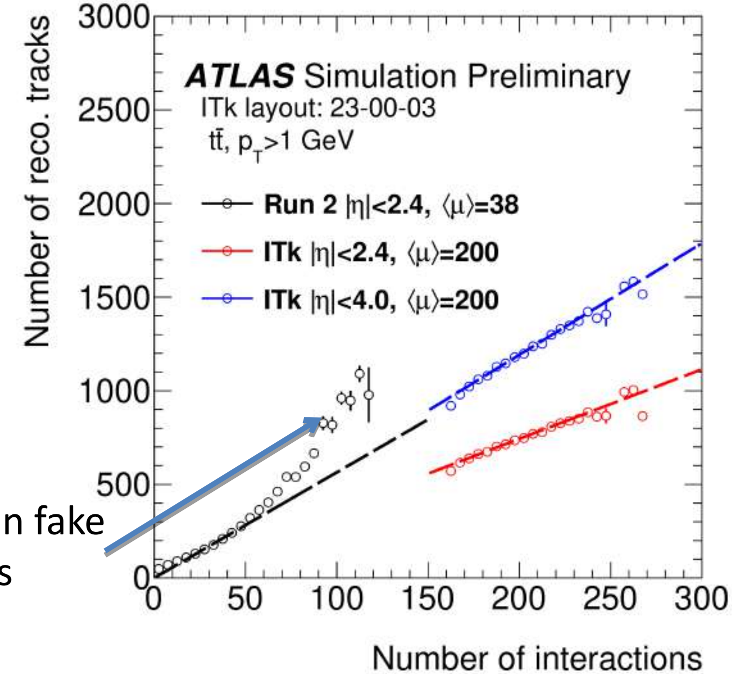
$$m_{eff} = \sum_i p_{T_i}^{(lepton,jets)} + E_T^{miss}$$

- Exclude κ>0.5 for all masses below 1.8 TeV

Run-2 ID vs ITK

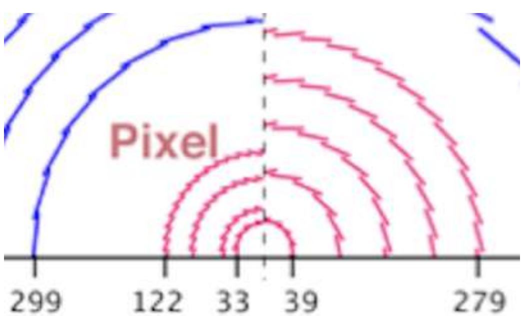
ATL-PHYS-PUB-2021-024



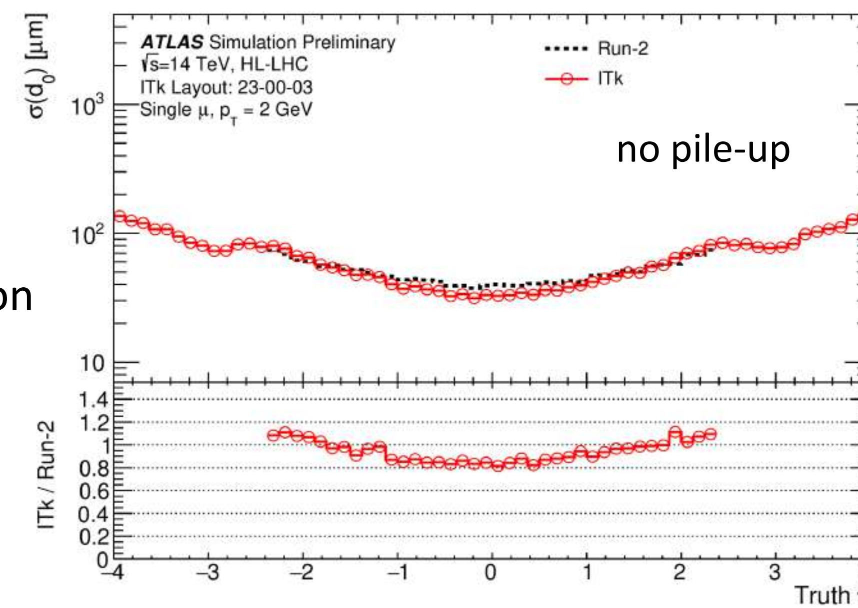


rise in fake tracks

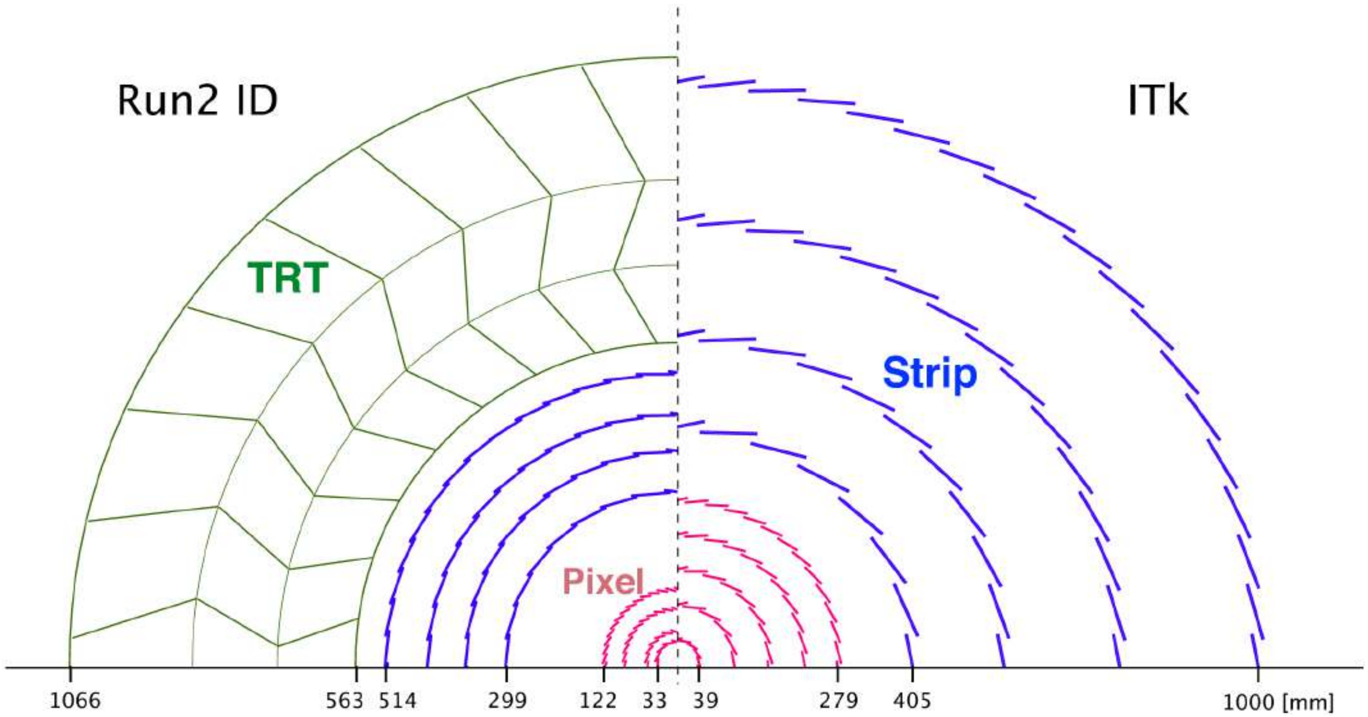
Run2 ID ITK



- Similar d0 resolution due to comparable radius of the inner most pixel layers



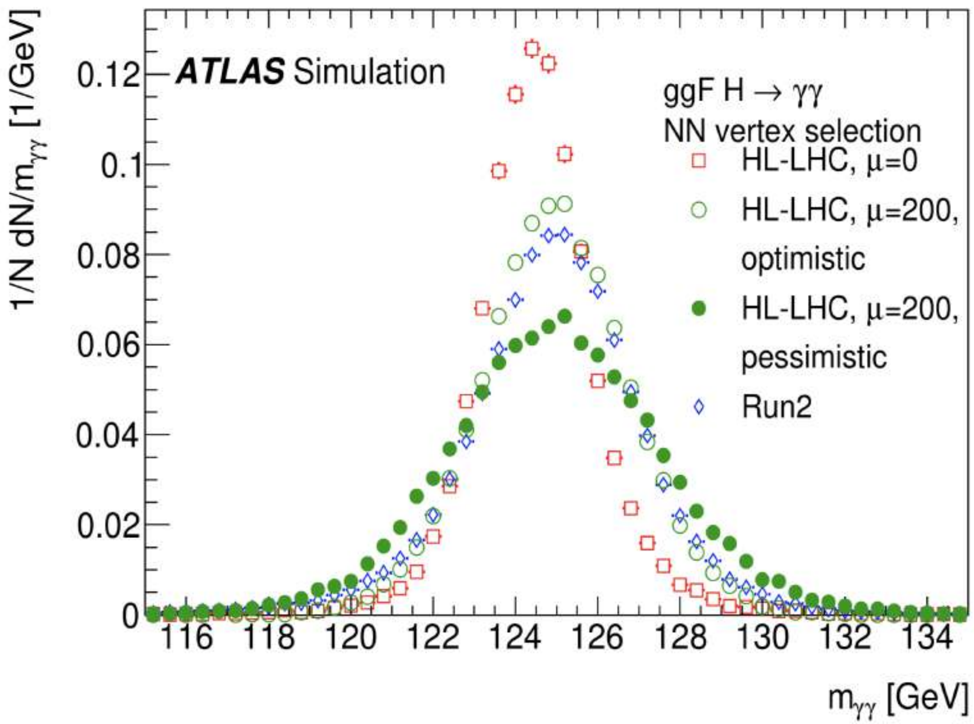
Run-2 ID vs ITK



Detector Performance (Phase-2)

CERN-LHCC-2017-018

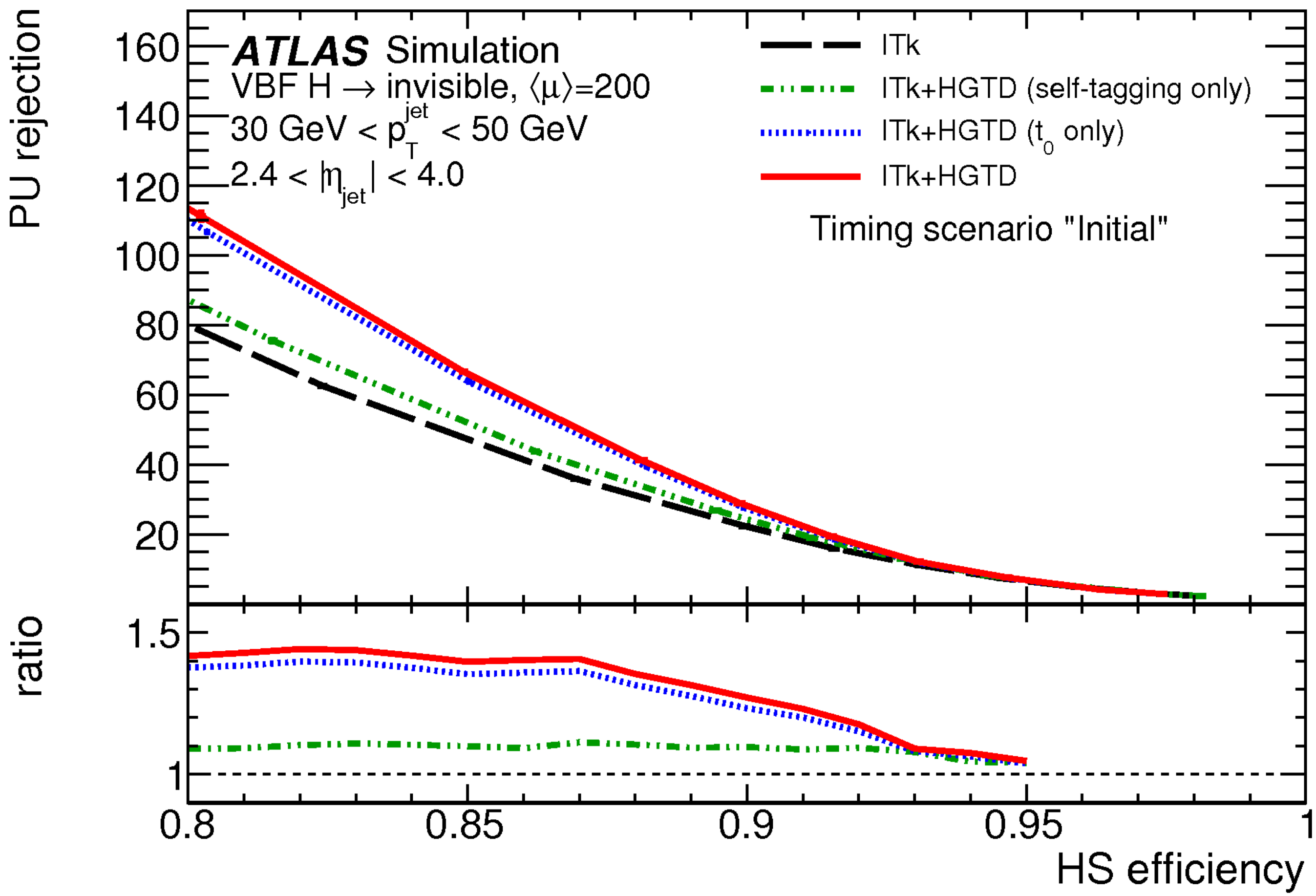
Di-Photon Mass



- di-photon mass resolution at HL-LHC, with <μ>~200, is comparable to Run2 for the optimistic scenario
  - **pessimistic** : same resolution constant term as Run-2, pile-up noise extracted from the full simulation using the Run-2 reconstruction alg.
  - **optimistic** : reduce the resolution constant term to its design value, pile-up noise reduce to level equivalent to <μ>=75

HGTD

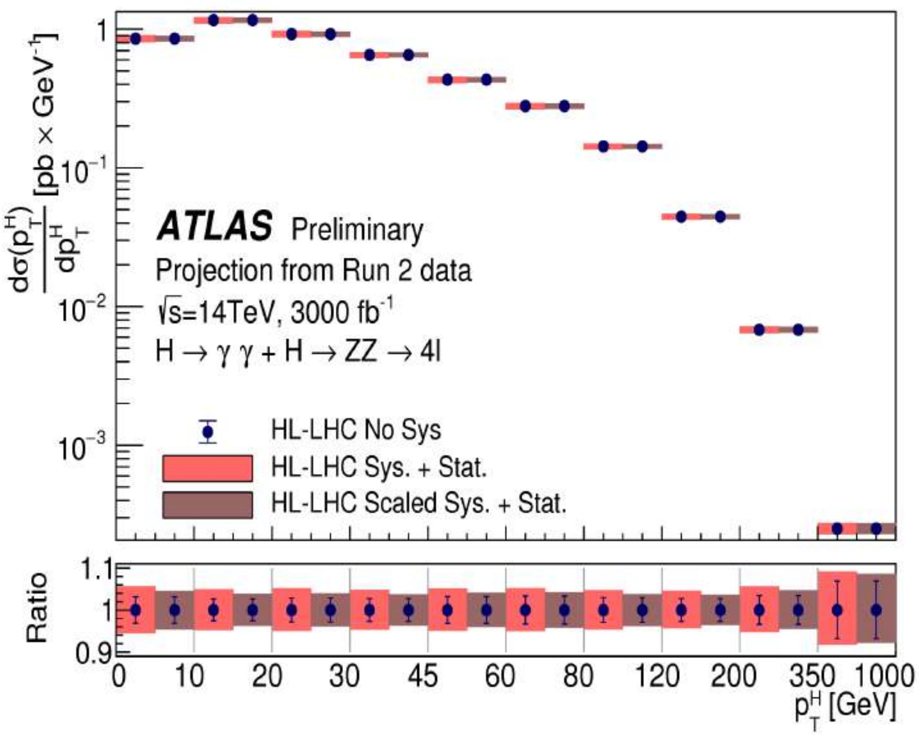
ATLAS-TDR-031

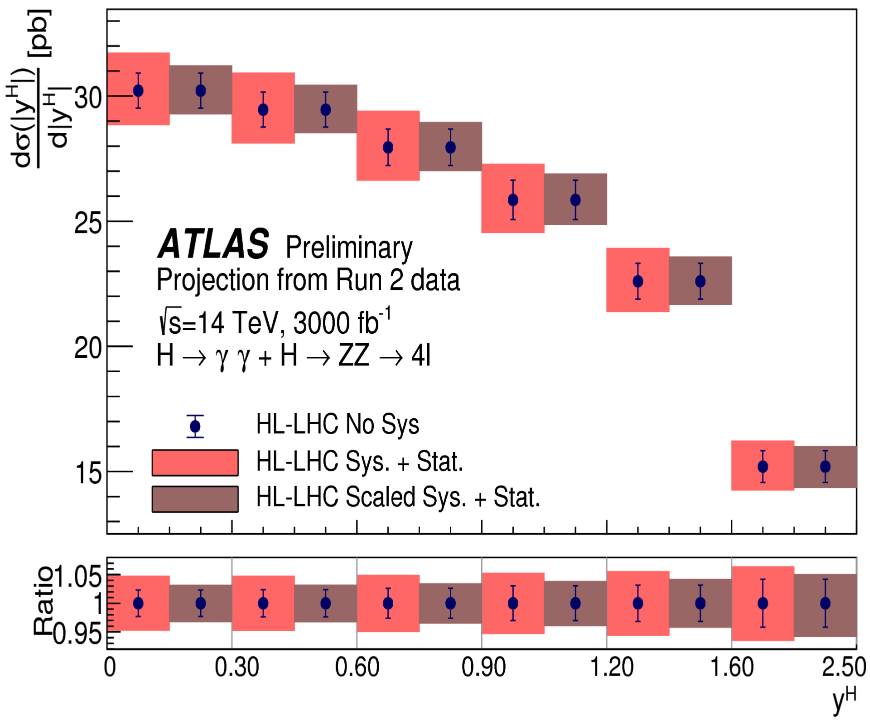


Higgs : Projections for Differential Distributions Measurements

- Important to measure the differential distributions of Higgs production
  - Provide a probe of the SM
  - Constraint effects from beyond the SM
- HL-LHC projections based on Run 2 analyses
- Most precisely measured by $H \to \gamma\gamma$, $H \to ZZ^* \to 4l$ channels

ATL-PHYS-PUB-2018-040





- Expect to probe with precision of ~10% at p_T^H ~350-600 GeV (HL-LHC)
- Run-2 : About ~20% precision at pT(H)~200-350 GeV