New physics searches at ATLAS

Zhijun Liang (梁志均)

Institute of High Energy Physics, Chinese Academy of Science (中国科学院高能物理研究所)

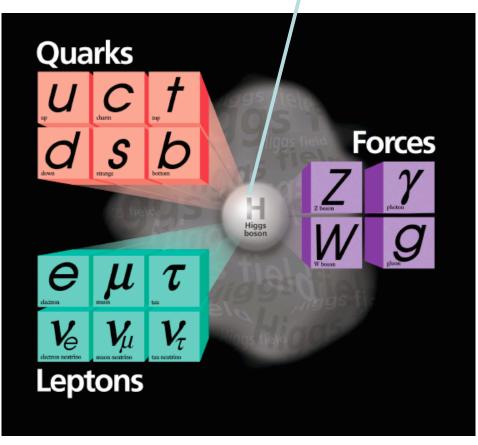
Composite 2019, GuangZhou, Nov 21-23

Motivation

Portal to dark matter or dark sector?

4th generation? Compositness? Lepton quark?

Heavy Leptons ? neutrino mass?



New heavy vector boson (W', Z')?

Dark partners?

ATLAS Exotics search summary

• A final state often probes multiple theories

ATLAS Exotics Searches* - 95% CL Upper Exclusion Limits

Status: May 2019

ATLAS Preliminary

 $\sqrt{s} = 8.13 \text{ TeV}$

 $\int f dt = (3.2 - 139) \text{ fb}^{-1}$

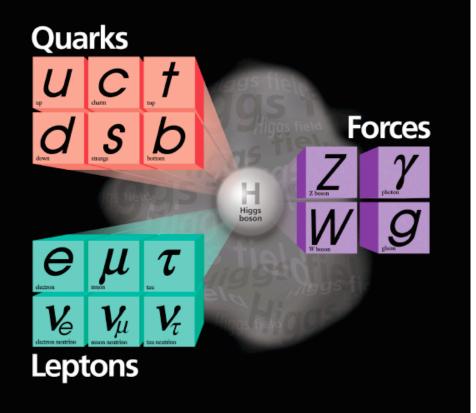
olaloo may 2010						$\int \mathcal{L} dt = (3.2 - 139) \text{ fb}^{-1}$		$v_s = 8, 13 \text{ lev}$
	Model	<i>ℓ</i> ,γ	Jets†	E ^{miss} T	∫£ dt[fb			Reference
Extra dimensions	ADD BH multijet RS1 $G_{KK} \rightarrow \gamma \gamma$	$\begin{array}{c} 0 \ e, \mu \\ 2 \ \gamma \\ \hline \\ 2 \ 1 \ e, \mu \\ \hline \\ 2 \ \gamma \\ \end{array}$ ulti-channel $\begin{array}{c} 0 \ e, \mu \\ 1 \ e, \mu \\ 1 \ e, \mu \\ \hline \\ 1 \ e, \mu \end{array} \geq$	$1 - 4 j$ $- 2j$ $\geq 2 j$ $\geq 3 j$ $- 2J$ $1 b, \geq 1 J/2$ $\geq 2 b, \geq 3 j$		36.1 36.7 37.0 3.2 3.6 36.7 36.1 139 36.1 36.1	M _{th} 8.2 T	$ \begin{array}{l} n = 3 \text{ HLZ NLO} \\ \hline n = 6 \end{array} $	1711.03301 1707.04147 1703.09127 1806.02265 1512.02586 1707.04147 1808.02380 ATLAS-CONF-2019-003 1804.10823 1803.09678
Gauge bosons		$\begin{array}{c} 2 \ e, \mu \\ 2 \ \tau \\ - \\ 1 \ e, \mu \\ 1 \ \tau \\ 0 \ e, \mu \\ \\ ulti-channel \\ 2 \ \mu \end{array}$	- 2b 1b,≥1J/2 - 2J 1J	- - Yes Yes -	139 36.1 36.1 139 36.1 139 36.1 36.1 36.1 80	Z' mass 5.1 TeV Z' mass 2.42 TeV Z' mass 2.1 TeV Z' mass 3.0 TeV W' mass 6.0 TeV W' mass 3.7 TeV V mass 3.6 TeV V' mass 3.5 TeV V' mass 3.29 TeV War mass 3.25 TeV War mass 5.0 TeV	$\Gamma/m = 1\%$ $g_V = 3$ $g_V = 3$ $m(N_R) = 0.5 \text{ TeV}, g_L = g_R$	1903.06248 1709.07242 1805.09299 1804.10823 CERN-EP-2019-100 1801.06992 ATLAS-CONF-2019-003 1712.06518 1807.10473 1904.12679
C	Cl qqqq Cl ℓℓqq Cl tttt	_ 2 e,μ ≥1 e,μ	2 j ≥1 b, ≥1 j	– – Yes	37.0 36.1 36.1	Λ Λ Λ 2.57 TeV	21.8 TeV η_{LL}^- 40.0 TeV η_{LL}^- $ C_{4t} = 4\pi$	1703.09127 1707.02424 1811.02305
MQ	Axial-vector mediator (Dirac DM) Colored scalar mediator (Dirac DM) $VV_{\chi\chi}$ EFT (Dirac DM) Scalar reson. $\phi \rightarrow t\chi$ (Dirac DM)	0 e, µ	1 - 4 j 1 - 4 j $1 J, \le 1 j$ 1 b, 0-1 J	Yes Yes Yes Yes	36.1 36.1 3.2 36.1	m _{mod} 1.55 TeV m _{mod} 1.67 TeV M. 700 GeV m _e 3.4 TeV	$\begin{split} g_q = 0.25, g_z = 1.0, m(\chi) &= 1 \; \text{GeV} \\ g = 1.0, m(\chi) &= 1 \; \text{GeV} \\ m(\chi) < 150 \; \text{GeV} \\ y &= 0.4, \lambda = 0.2, m(\chi) = 10 \; \text{GeV} \end{split}$	1711.03301 1711.03301 1608.02372 1812.09743
р	Scalar LQ 1 st gen Scalar LQ 2 nd gen Scalar LQ 3' ^d gen Scalar LQ 3' ^d gen	1,2 e 1,2 μ 2 τ 0-1 e, μ	≥ 2 j ≥ 2 j 2 b 2 b	Yes Yes - Yes	36.1 36.1 36.1 36.1	LQ mass 1.4 TeV LQ mass 1.56 TeV LQ ^a mass 1.03 TeV LQ ^a mass 970 GeV	$\begin{split} \beta &= 1 \\ \beta &= 1 \\ \mathcal{B}(\mathrm{LQ}_3^u \to b\tau) &= 1 \\ \mathcal{B}(\mathrm{LQ}_3^d \to t\tau) &= 0 \end{split}$	1902.00377 1902.00377 1902.08103 1902.08103
Heavy quarks	$ \begin{array}{ll} VLQ \ \mathcal{BB} \to \mathcal{W}t/\mathcal{Z}b + X & mu \\ VLQ \ \mathcal{T}_{5/3} \ \mathcal{T}_{5/3} \mathcal{T}_{5/3} \to \mathcal{W}t + X & 2(S) \\ VLQ \ Y \to \mathcal{W}b + X & \end{array} $	ulti-channel ulti-channel SS)/ \geq 3 e, μ 1 e, μ 0 e, μ , 2 γ 1 e, μ	≥ 1 b, ≥ 1 j		36.1 36.1 36.1 36.1 79.8 20.3	T mass 1.37 TeV B mass 1.34 TeV T _{Sy1} mass 1.64 TeV Y mass 1.65 TeV B mass 1.21 TeV Q mass 690 GeV	$\begin{array}{l} & \mathrm{SU}(2) \text{ doublet} \\ & \mathrm{SU}(2) \text{ doublet} \\ & \mathcal{B}(T_{5/3} \rightarrow Wt) = 1, \ c\left(T_{5/3} Wt\right) = 1 \\ & \mathcal{B}(Y \rightarrow Wb) = 1, \ c_R(Wb) = 1 \\ & \kappa_B = 0.5 \end{array}$	1808.02343 1808.02343 1807.11883 1812.07343 ATLAS-CONF-2018-024 1509.04261
Excited fermions	Excited quark $q^* \rightarrow qg$ Excited quark $q^* \rightarrow q\gamma$ Excited quark $b^* \rightarrow bg$ Excited lepton ℓ^* Excited lepton ν^*	- 1 γ - 3 e, μ 3 e, μ, τ	2j 1j 1b,1j -		139 36.7 36.1 20.3 20.3	q' mass 6.7 TeV q' mass 5.3 TeV b' mass 2.6 TeV L' mass 3.0 TeV v' mass 1.6 TeV	only u^* and d^* , $A = m(q^*)$ only u^* and d^* , $A = m(q^*)$ A = 3.0 TeV A = 1.6 TeV	ATLAS-CONF-2019-007 1709.10440 1805.09299 1411.2921 1411.2921
Other	Higgs triplet $H^{\pm\pm} \rightarrow \ell \tau$ Multi-charged particles Magnetic monopoles $\sqrt{s} = 8 \text{ TeV}$	1 e, μ 2 μ 8,4 e, μ (SS) 3 e, μ, τ - - 13 TeV	≥ 2 j 2 j - - - - -		79.8 36.1 20.3 36.1 34.4	N ^e mass 560 GeV N _R mass 3.2 TeV H ^{±±} mass 870 GeV H ^{±±} mass 400 GeV molit-charged particle mass 1.22 TeV monopole mass 2.37 TeV	$\begin{split} m(W_R) &= 4.1 \text{ TeV}, g_L = g_R \\ \text{DY production} \\ \text{DY production}, \mathcal{B}(\mathcal{H}_L^{\pm\pm} \to \ell \tau) = 1 \\ \text{DY production}, g &= 5e \\ \text{DY production}, g &= 1g_D, \text{spin } 1/2 \end{split}$	ATLAS-CONF-2018-020 1809.11105 1710.09748 1411.2921 1812.03673 1905.10130
$v_s = o \text{ fev}$ partial data full data 10^{-1} 1 10 Mass scale [TeV]								

*Only a selection of the available mass limits on new states or phenomena is shown.

†Small-radius (large-radius) jets are denoted by the letter j (J).

Di-jet resonance

Compositness? 9*→99



New heavy vector boson (W', Z')?

 $W' \rightarrow qq$ $qq \rightarrow Z' \rightarrow qq$

Di-jet resonance searches

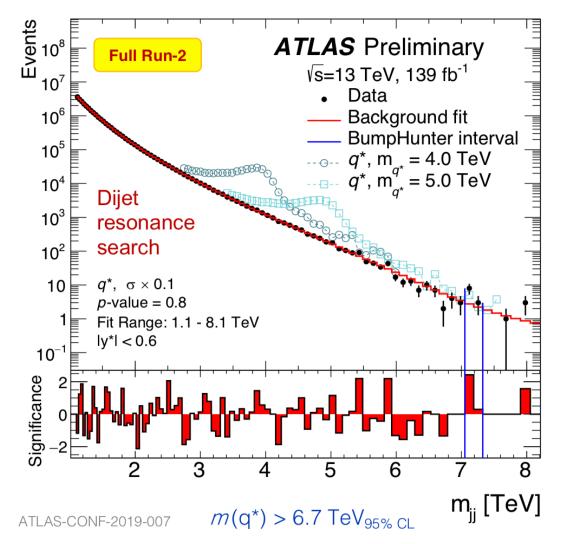
Highest-mass central dijet event of 8.0 TeV selected in resonance search



Run: 305777 Event: 4144227629 2016-08-08 08:51:15 CEST

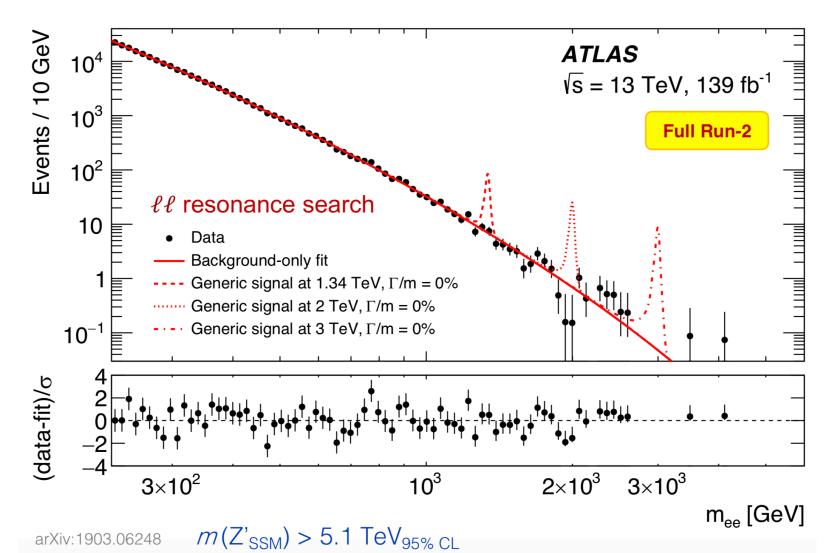
Di-jet resonance searches

- Smoothly-falling background: fit to the data no
- Mass limit at set at 6.7 TeV on a benchmark $q^* \rightarrow gq$.



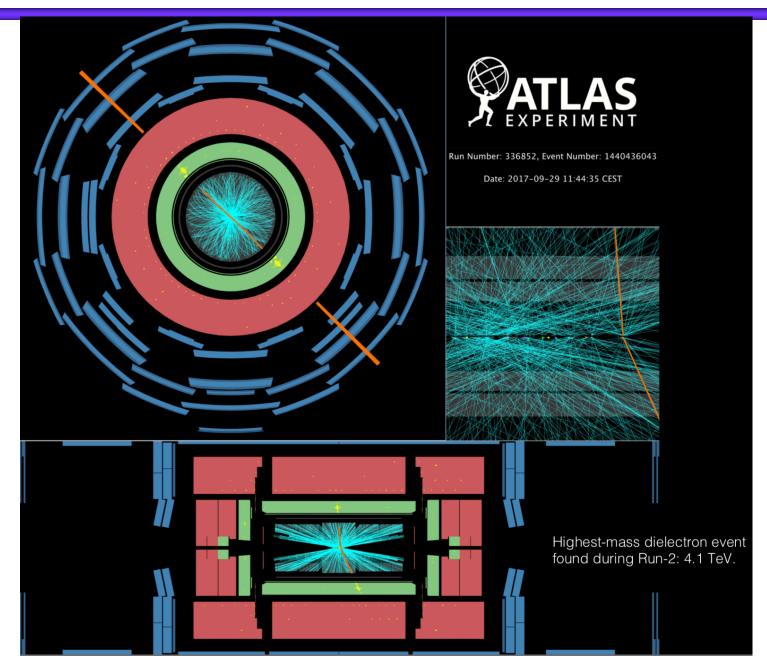
Di-lepton search

- Limits set on benchmarks Z' (for ex. Z'SSM excluded up to 5.1 TeV)
- Dedicated high-pT lepton ID to improve sensitivity

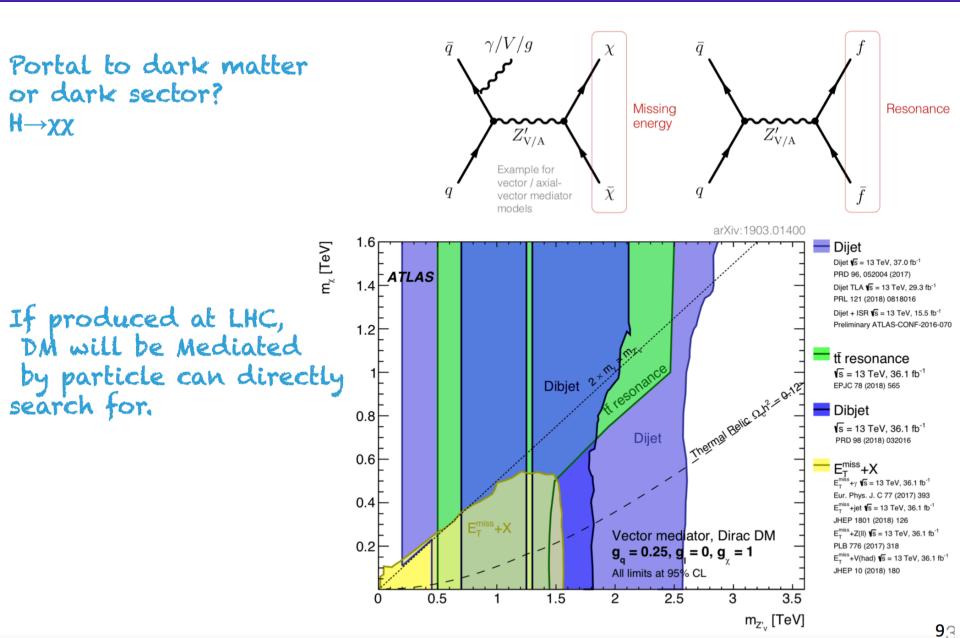


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Di-lepton search

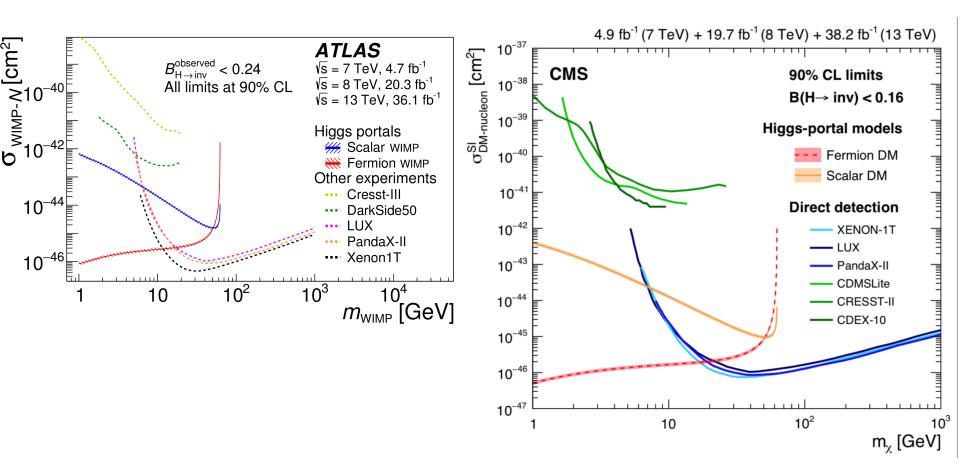


Dark matter search



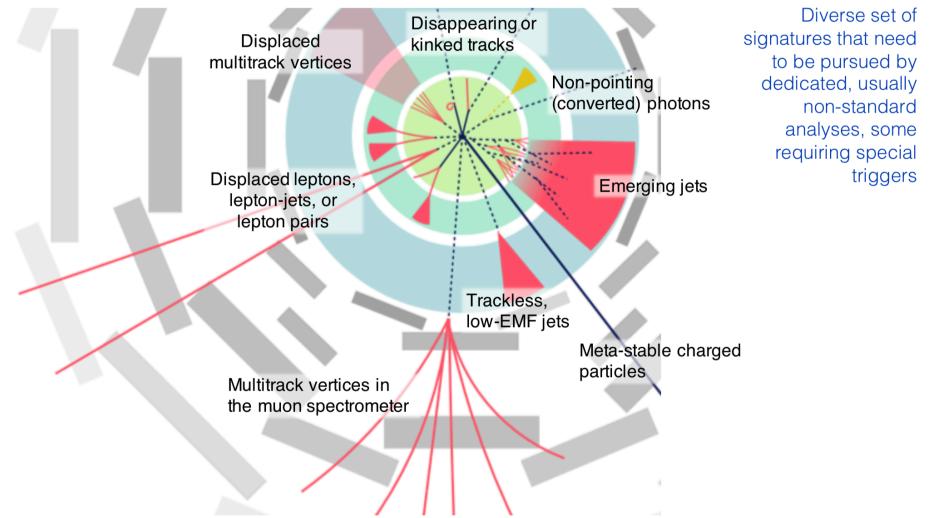
Dark matter searches

- If light enough, Higgs boson can decay to DM (H → invisible)
 - − BR(H \rightarrow inv) < 26% (17% expected) for ATLAS
 - − BR(H \rightarrow inv) <19% (15% expected) for CMS



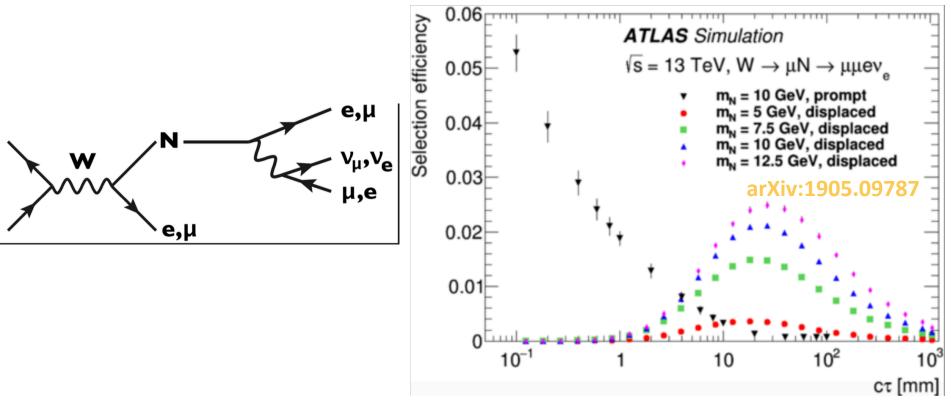
Long-lived particle search

Long-lived particles can occur in case of weak couplings, small phase space (mass degeneracy), high virtuality (scale suppression)

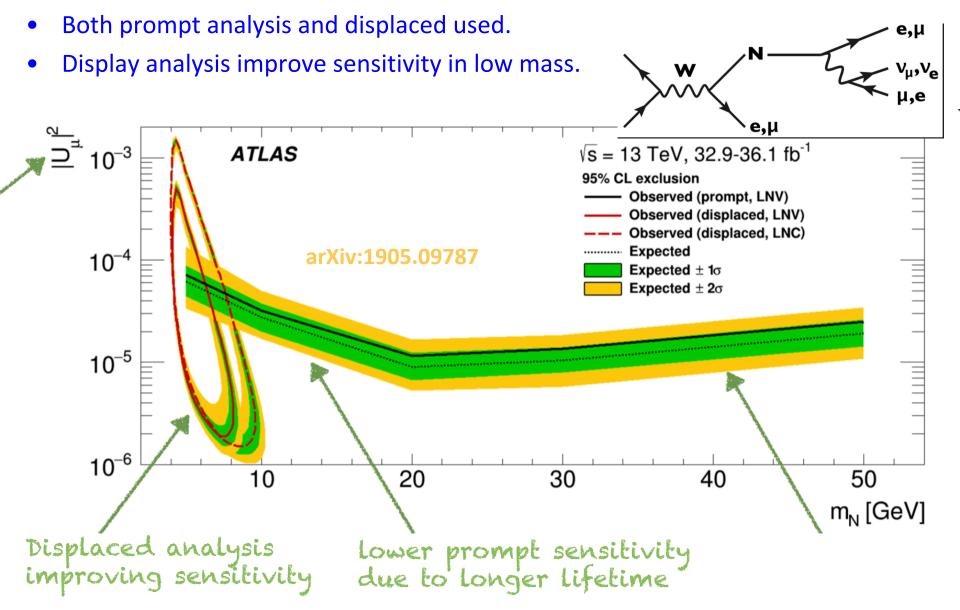


Long-lived particle search: Type-I heavy neutrino

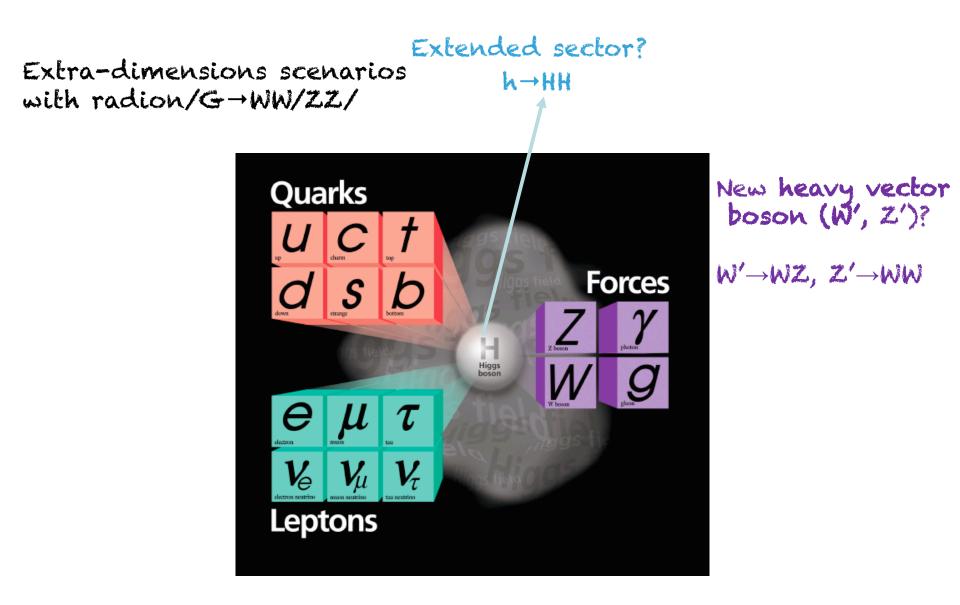
- Displaced analysis Selection:
 - Displaced vertex of two opposite-sign tracks μμ or μe (4-300 mm)
 - One prompt μ
- Mjaor Background : single top and multi-fake displaced tracks



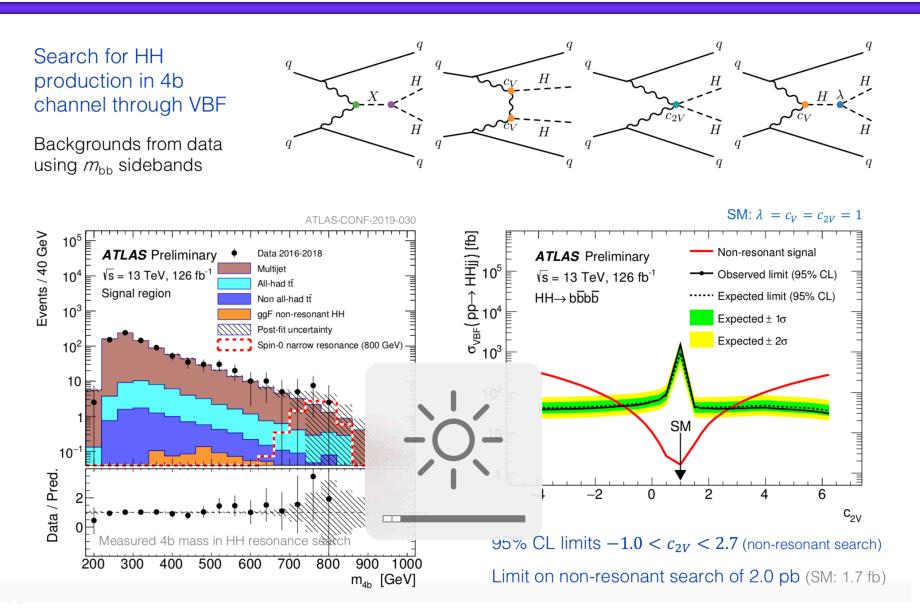
Long live particle search: Type-I heavy neutrino



Di-boson and Di-Higgs search

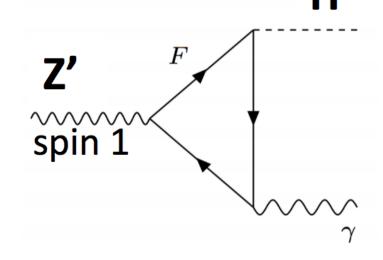


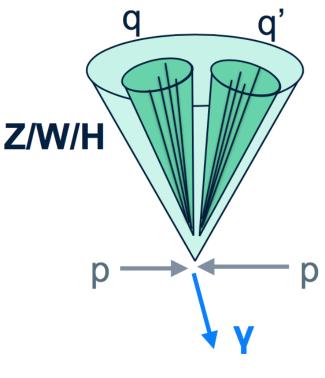
Di-Higgs: Double the Higgs for double the difficulty



Diboson search : X-> H γ

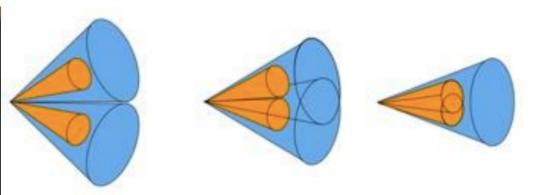
- Motivation
 - Search for anomalous magnetic moments of H (or W/Z)
 - □ More W/Z anomalous coupling will be covered Dr. Shu Li tomorrow
 - Several models predict a new massive scalar decaying into H_{γ}
- Event selection :
 - boosted jet (b tagging) -- from H, W or Z decay
 - high pT γ (pT>250GeV)
- The main background
 - γ +jets
 - $H\gamma$
 - Ηγ

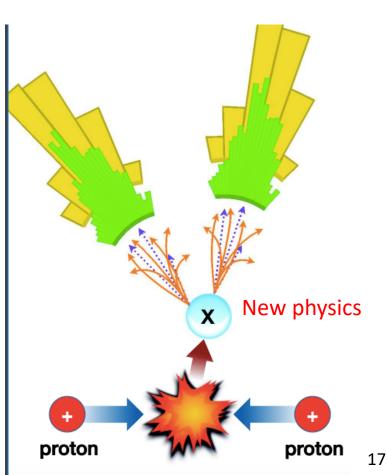




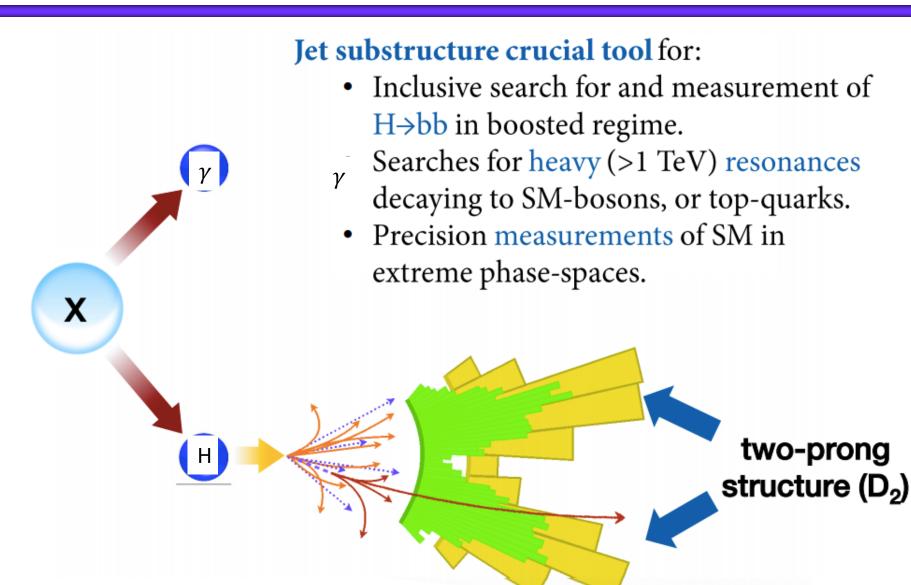
Key issue in search for TeV new physics

- Two b jets from boosted Higgs decay merge into one
- Difficult to reconstruct Higgs boson in jet final state
- Two new analysis technique used in this analysis
 - B tagging on track jets
 - Jet substructure

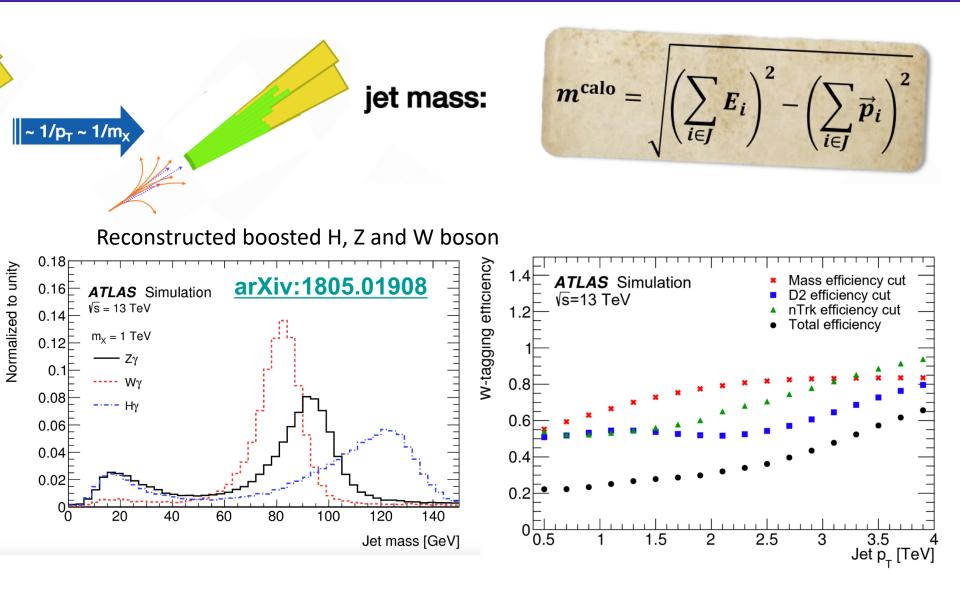




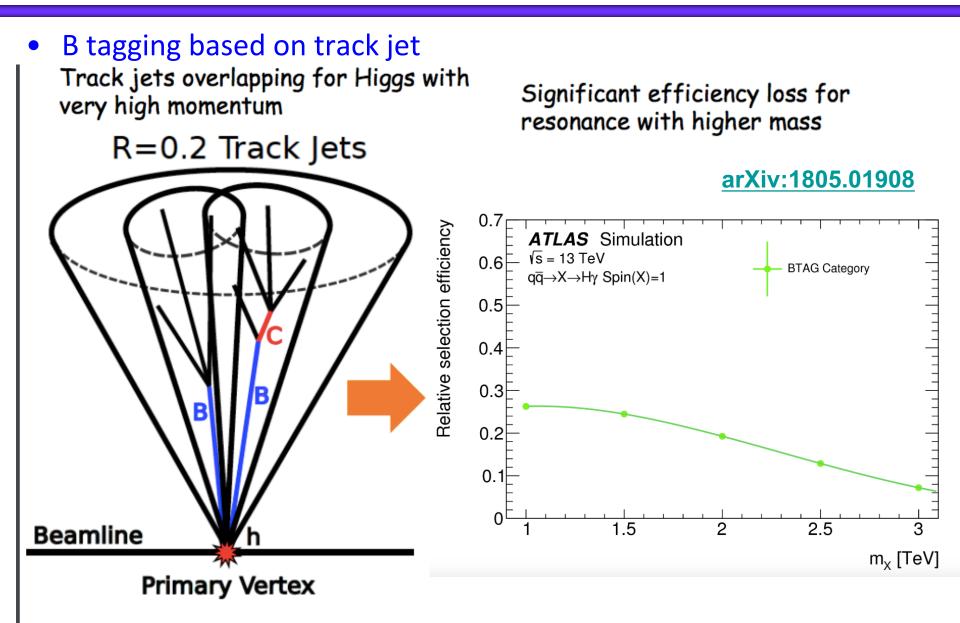
Jet Substruture



Jet mass



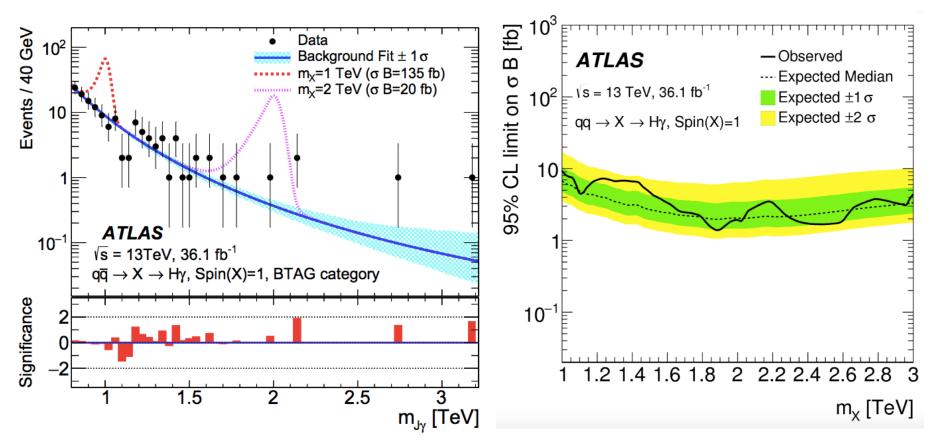
B tagging on track jet



Limit setting of X-> H γ search

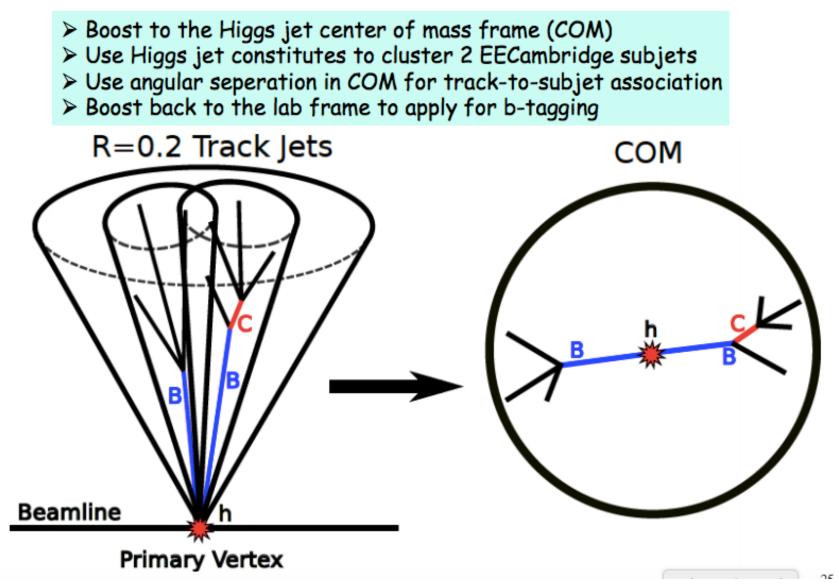
- Use analytic function to fit fast falling background from
 - γ jets, Z γ , SM VBF H γ
- The first X-> Hγ limits (from 1TeV to 3TeV)

arXiv:1805.01908



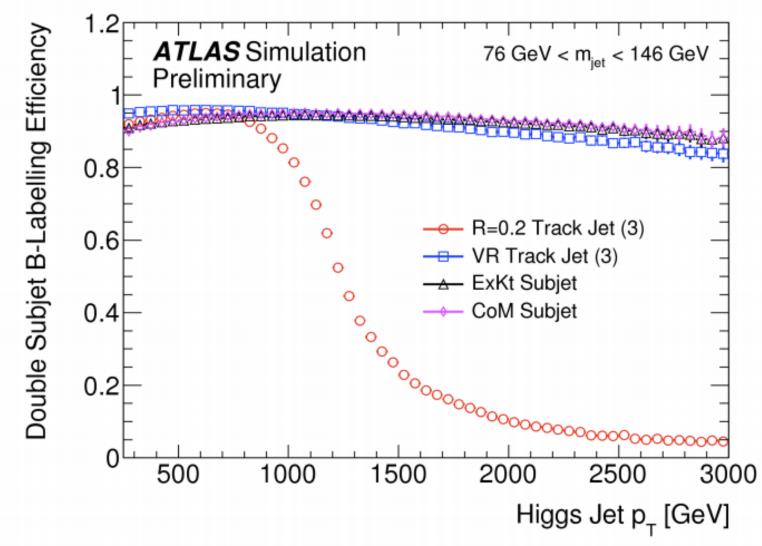
Prospect of X->H+ γ and di-higgs search

Development in advanced double b jet tagger



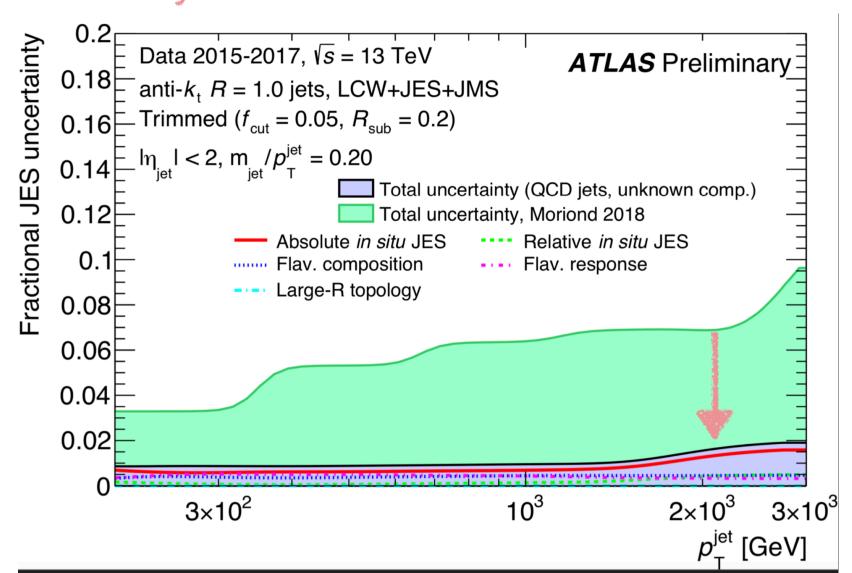
Prospect of future X->H+ γ search

Expect significant improvement in full run-2 dataset In double b tagging efficiency



Prospect of X->H+ γ and di-higgs search

Very recent large improvement on large-R jet energy scale uncertainty, which will benefit future searches!



Summary

- Short review (incomplete) review of ATLAS Exotics search
- Good progress in Di-Higgs and Di-boson search
 - Better Large-R jets jet energy calibration
 - More Advanced double b taggers
- Long-lived/challenging signatures to become a more important focus

B jet energy corrections

• Using ATLAS default jet energy calibrations

- Higgs mass resolution is not great
- Asymmetry in mass, long tail in low mass region
- Dedicated B jet calibration
 - Muon-in-jets corrections
 - Kinematic likelihood

