



Search of the Higgs boson decay to b quarks and for a new resonance decaying to diphoton in ATLAS

→ *LHC-USTC-LPNHE-ATLAS project review* ←

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Overview of the projects

- ◆ **The two institutes have strong collaboration on physics analysis as well as on detector performance studies in ATLAS experiment:**
 - ❖ Search for a SM Higgs boson produced in association with a vector boson and decaying to a pair of b-quarks; b-jet reconstruction calibration
 - ❖ Search for low mass resonance in diphoton events; photon energy calibration

French Group		
Name	Title	Institute
Giovanni MARCHIORI	CRCN	LPNHE
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Chinese Group		
Name	Title	Institute
LIU Yanwen	Professor	USTC
LI Changqiao	PhD (3 rd year)	USTC
CHEN Cheng	PhD (2 nd year)	USTC
WANG Yufeng	PhD (1 st year)	USTC

Search for VH production in $H \rightarrow bb$ decay channel

- Main source of information for $H \rightarrow bb$ decay and VH production.

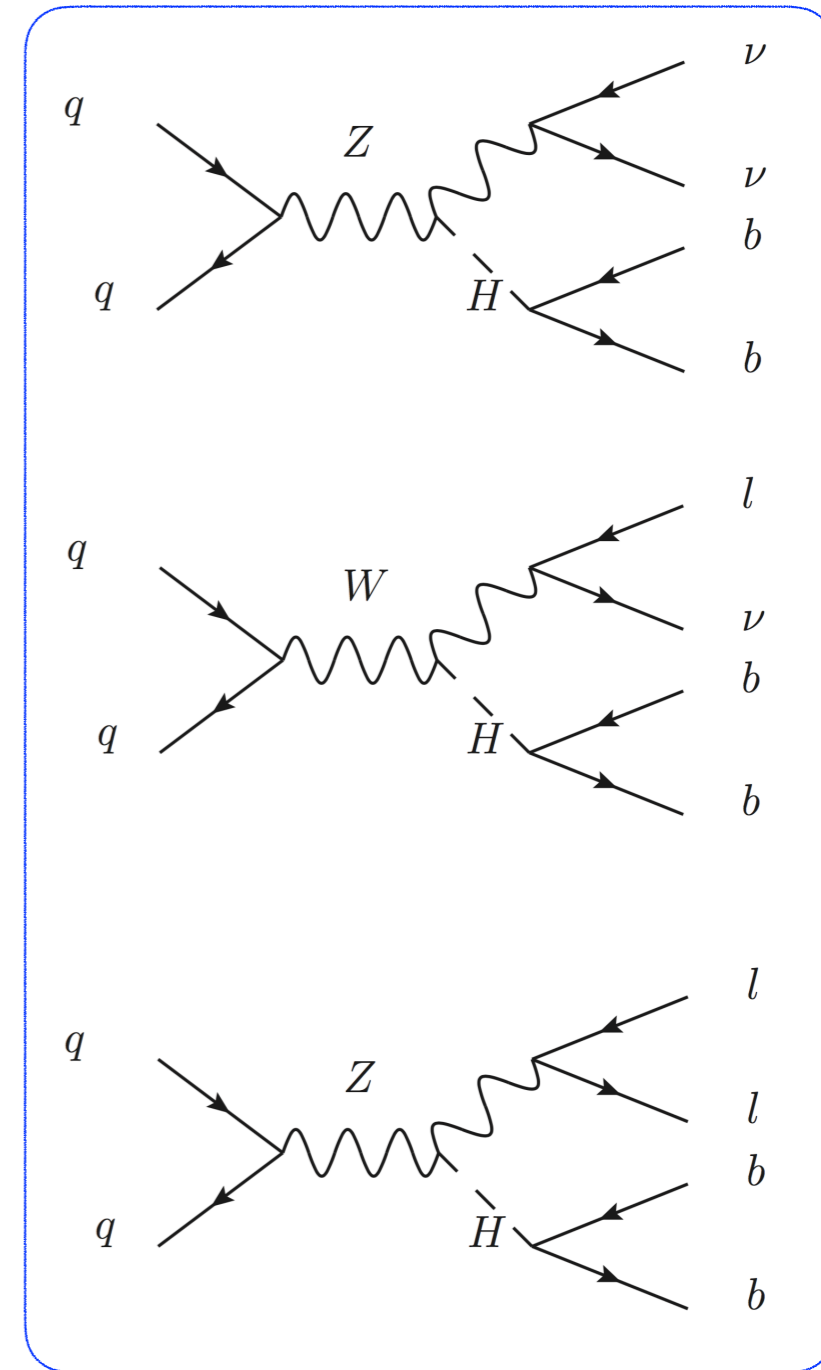
significance	ggH	VBF	VH	ttH
$H \rightarrow bb$ decay	/	0.9σ /	3.0σ 2.6σ	1.6σ ← Run 2 1.1σ ← Run 1

significance	$H \rightarrow \gamma\gamma$	$H \rightarrow ZZ$	$H \rightarrow \tau\tau$	$H \rightarrow WW$	$H \rightarrow bb$
VH (V=W,Z) production	1.4σ $\sim 0.8 \sigma$	/	/	0.2σ 0.9σ	3.0σ ← Run 2 2.6σ ← Run 1

- VH ($H \rightarrow bb$) searches result in publication.

EVIDENCE

Year	experiment	exp. sig.	obs. sig.	VHbb signal strength
Run 2 (36 fb ⁻¹)	ATLAS	3.0σ	3.5σ	1.2 ± 0.4
Run 2 (36 fb ⁻¹)	CMS	2.8σ	3.3σ	1.2 ± 0.4
Run 1 + Run 2	ATLAS	4.0σ	3.6σ	0.90 ± 0.27
Run 1 + Run 2	CMS	3.8σ	3.8σ	1.06 ± 0.30



Search for VH production in H→bb decay channel in ATLAS Run 2

JHEP 12 (2017) 024

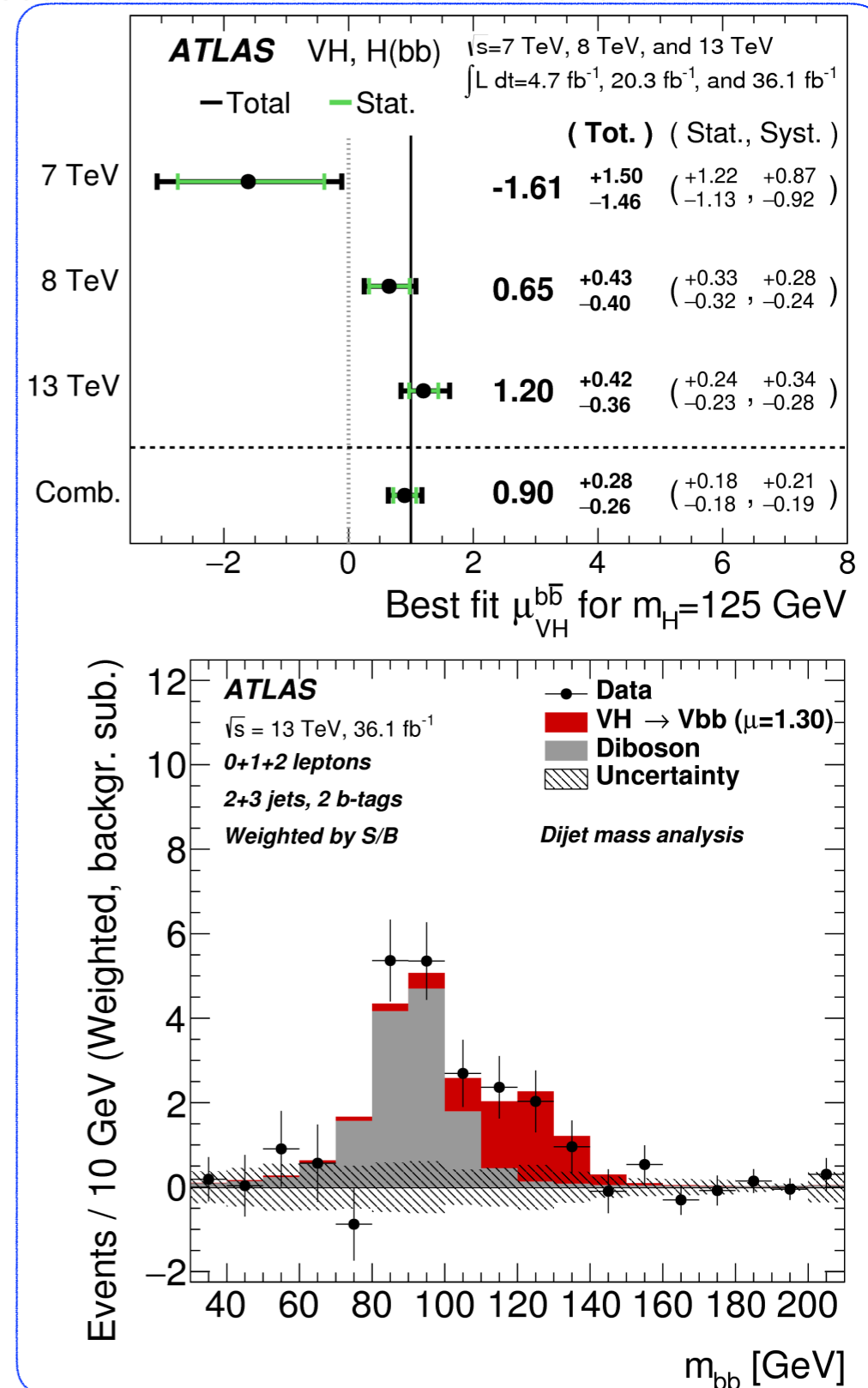
- ◆ The analysis is done in 0/1/2-lepton channels
 - ❖ multivariate technique to separate VH from V+jets/tt/WW bkg.
 - ❖ fitting on BDT output as discriminator
 - ❖ cross check 1: VZ(Z→bb) MVA analysis
 - ❖ cross check 2: VH analysis fitting on m_{bb} as discriminator.

- ◆ The result with 36.1 fb⁻¹ luminosity has been released

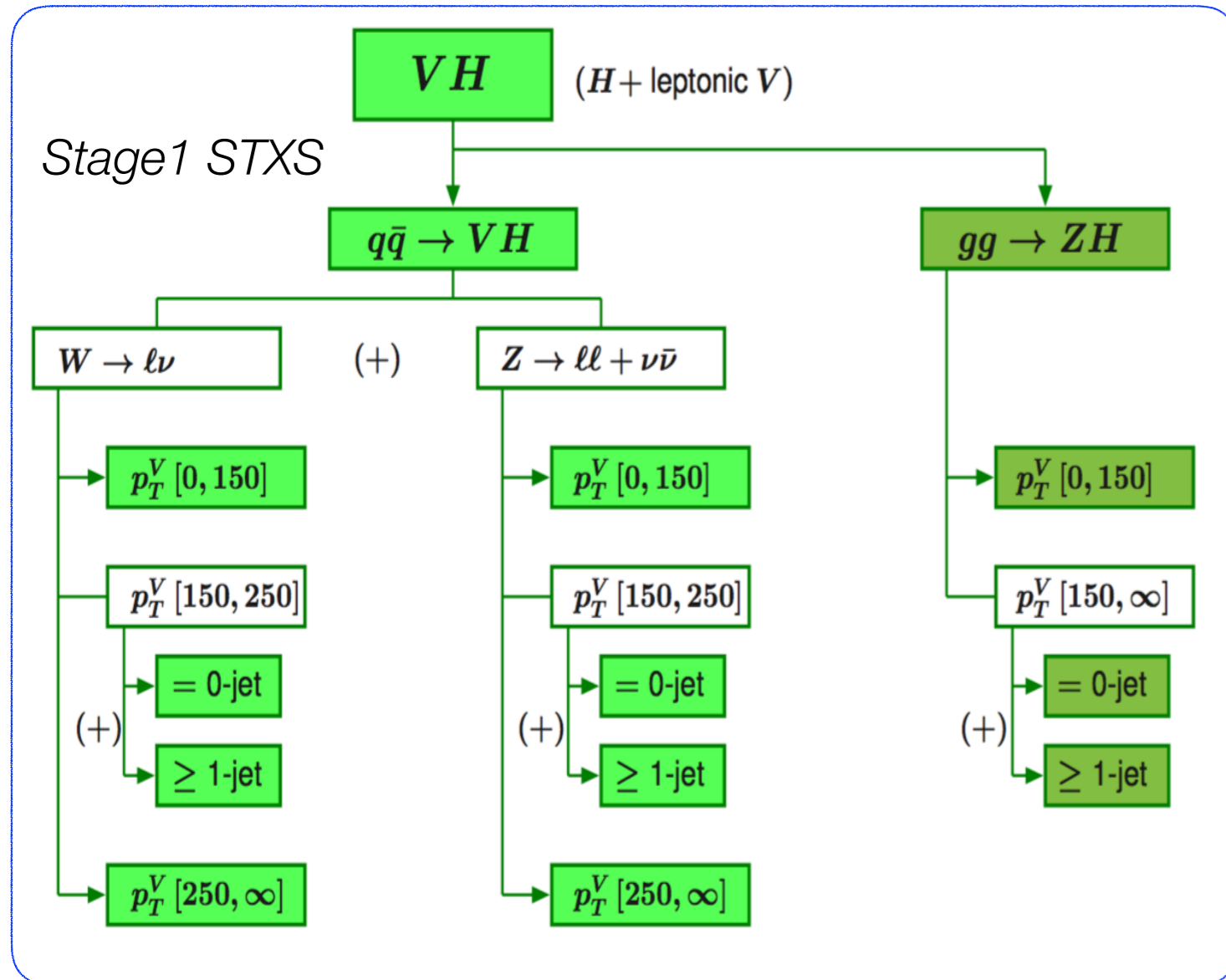
- ❖ 3.5σ (3.0σ) observed (expected) deviation data set w.r.t background-only hypothesis
- ❖ measured signal strength :

$$\mu = 1.20^{+0.24}_{-0.23}(\text{stat.})^{+0.34}_{-0.28}(\text{syst.})$$

- ◆ The analysis using 80 fb⁻¹ dataset is going on.
- ◆ Differential cross section measurement is in preparation
 - in format of “simplified template cross section”.



Simplified template cross section measurement in VHbb channel

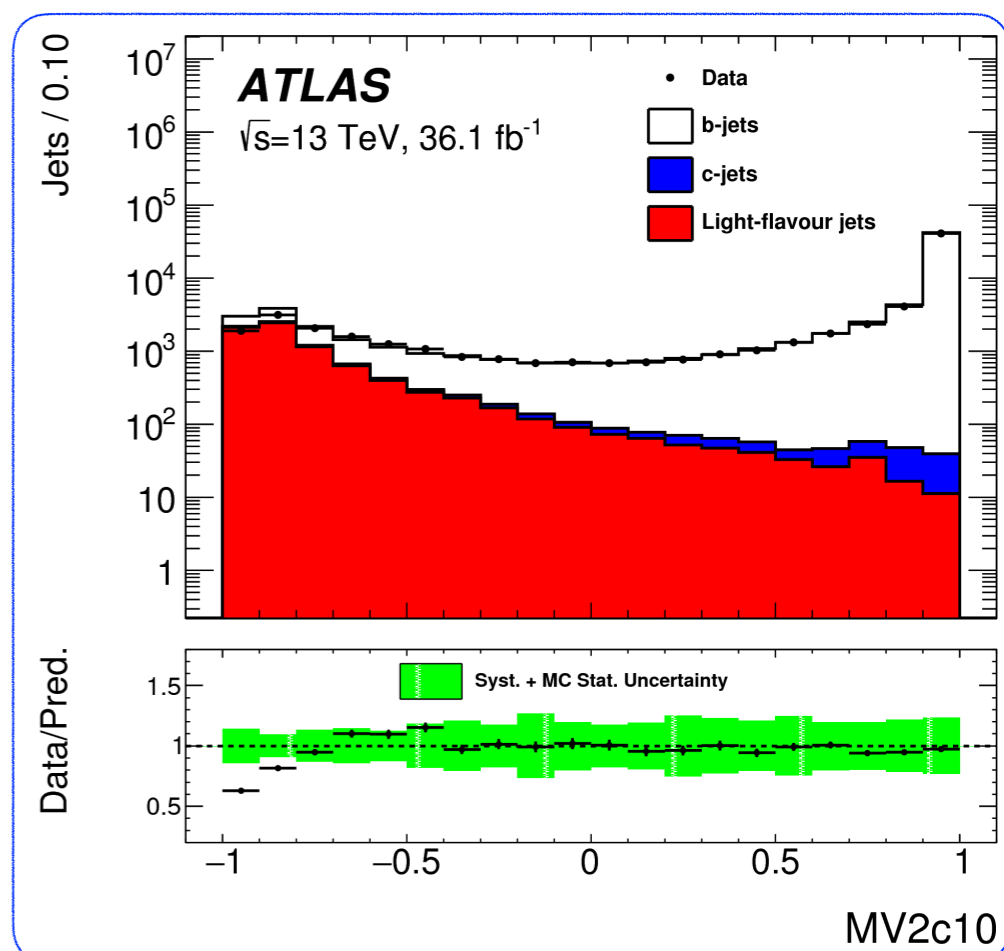
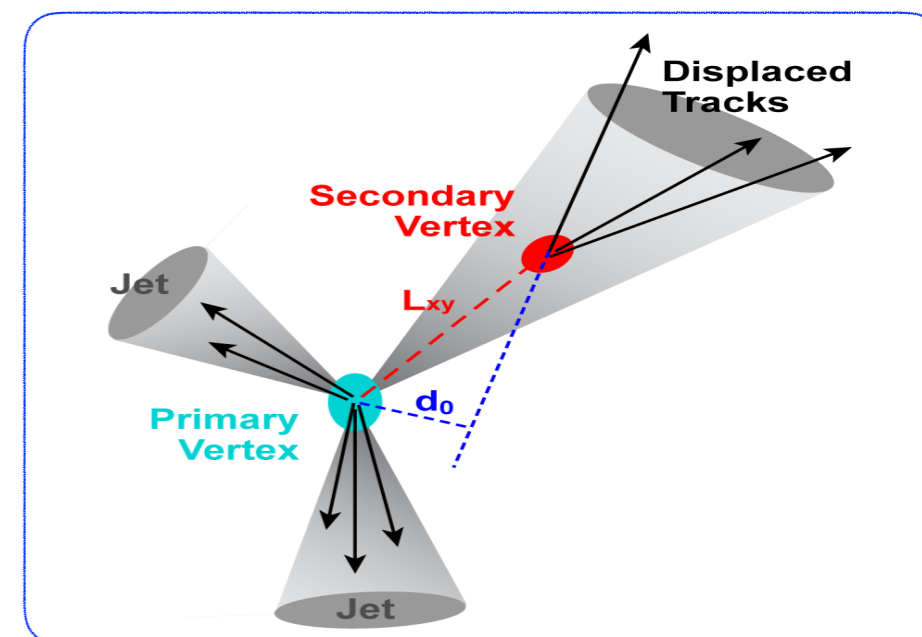


- ◆ Providing more differential information for VH production than simple one signal strength value.
- ◆ Cross section measurement
 - ❖ in different p_T^V range
 - ❖ in different jet multiplicity
 - ❖ in separated in initial processes.
- ◆ VHbb analysis is sensitive to $p_T^V > 150\text{GeV}$ bin.

b-jet reconstruction (tagging) calibration in ATLAS experiment

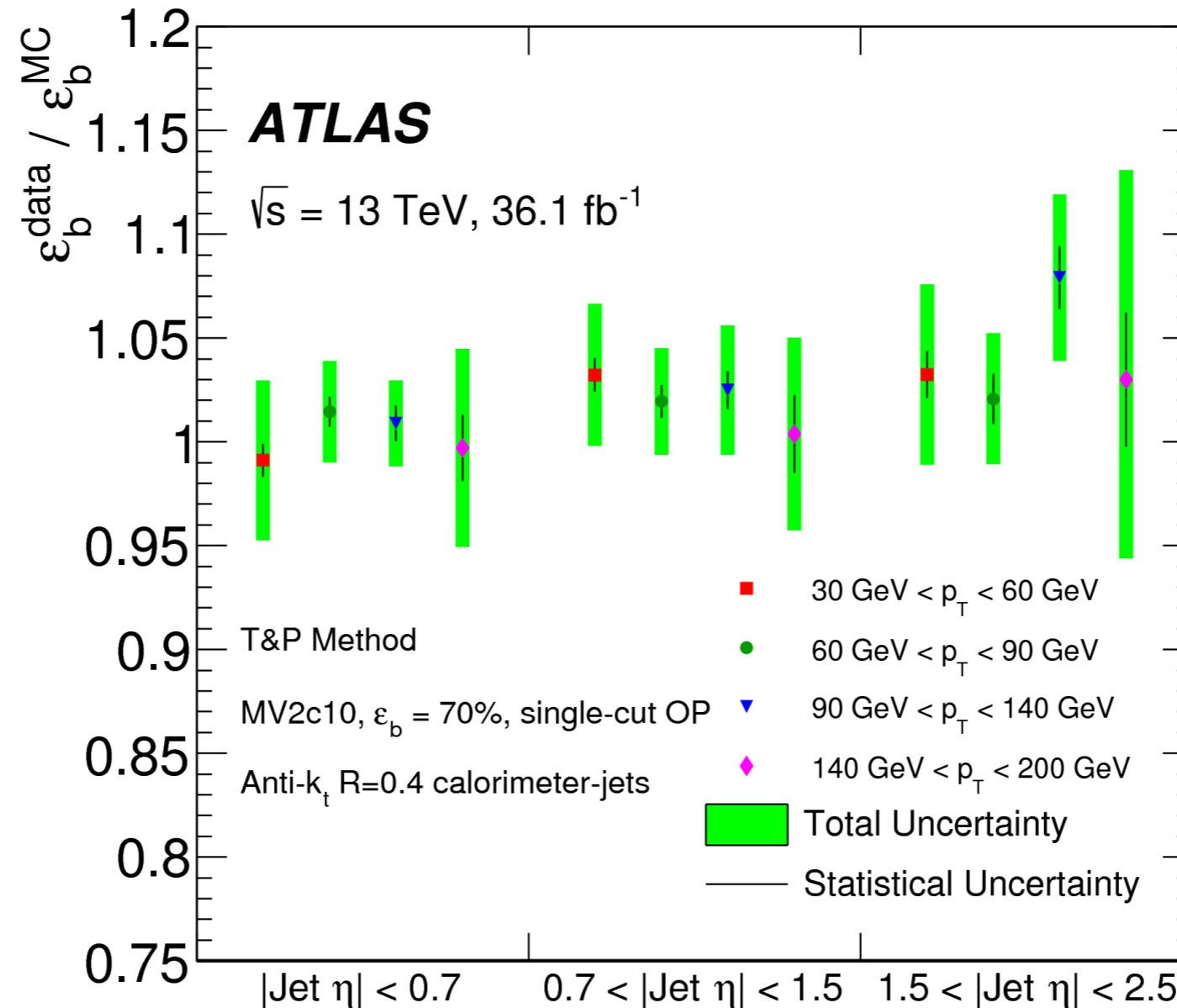
paper submitted to JHEP

- ◆ b-jet tagging calibration is the dominant source of experimental systematic uncertainty in the VHbb analysis.
- ◆ ATLAS b-jet tagging algorithm employs multivariate technique exploiting b-hadron properties
 - ✓ secondary vertex due to long lifetime
 - ✓ large b-hadron mass
 - ✓ large impact parameter (d_0)
 - ✓ semi-leptonic decays of b-hadron.
- ◆ Boosted Decision Tree output 'MV2c10' is the discriminator for b-jet from c-jet and light-flavour jet.
- ◆ b-jet tagging calibration in data uses $t\bar{t}$ events
 - ❖ selecting two opposite-sign leptons and two jets
 - ❖ 90% pure in $t\bar{t}$ events using 'Tag and probe' method
 - ❖ high-purity b-jet sample from $t\bar{t}$ decays.



b-jet reconstruction (tagging) calibration in ATLAS experiment

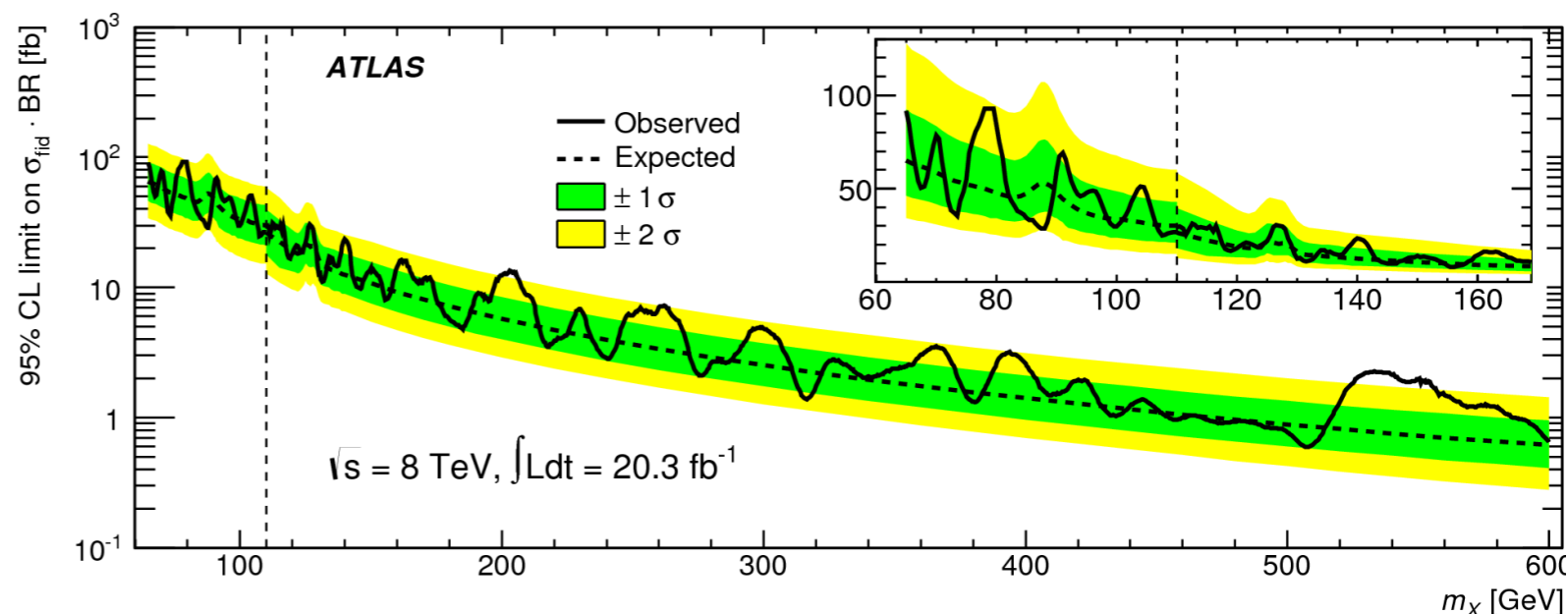
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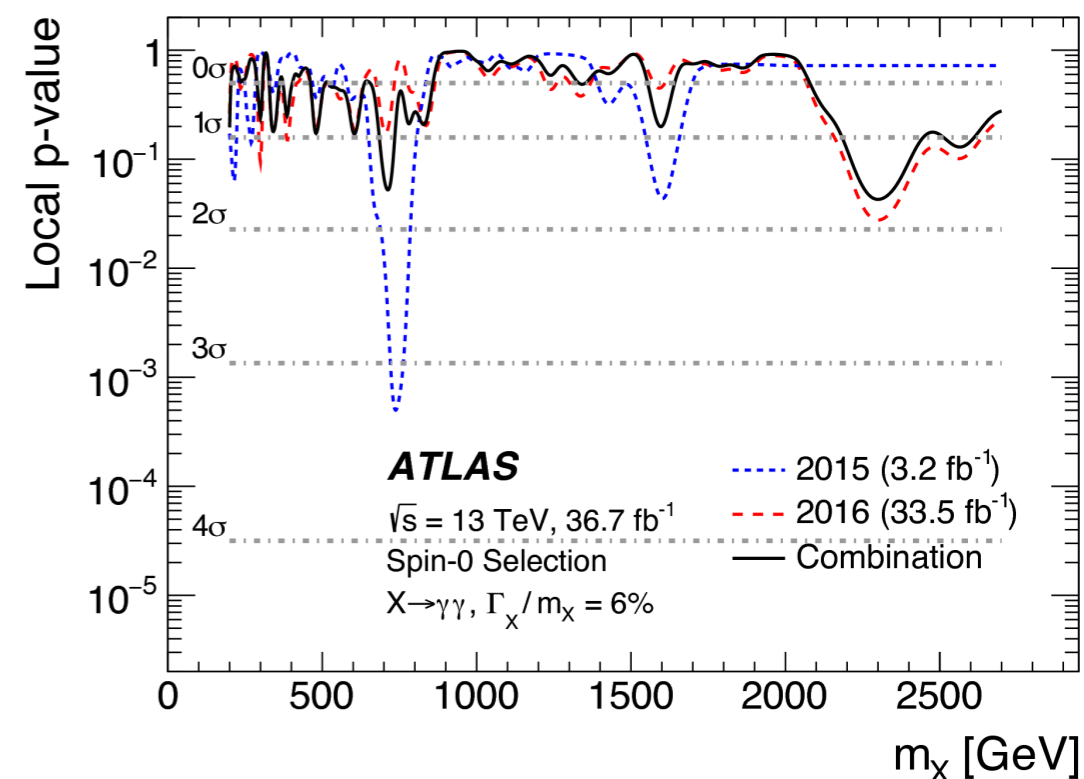
- ◆ Calibration with 36.1 fb^{-1} Run 2 dataset has been done → paper has been submitted to JHEP journal.
- ◆ A new calibration study with 80 fb^{-1} dataset is ongoing → aiming at reducing calibration uncertainty.

Search for low mass resonance in diphoton final states

- ◆ Several models predict new resonances below the Higgs mass (125 GeV)
 - ❖ additional scalar in 2HDM
 - ❖ axion-like particles.
- ◆ Decay to diphoton final states has high discovery potential
 - ❖ excellent mass resolution
 - ❖ smooth background (except from Z).



- ◆ **ATLAS has released results on:**
 - ❖ **Run 1:** [65,600] GeV mass range
 - ❖ **Run 2** (2015-2016): high-mass range only, [200,2700] GeV.
- ◆ **Ongoing:** low-mass analysis in [65,120] GeV mass range using 80 fb⁻¹ of Run 2 dataset (2015-2017).



CMS has observed 2.9 σ significance at 95.3 GeV mass in 13 TeV dataset.

Photon lateral energy leakage correction

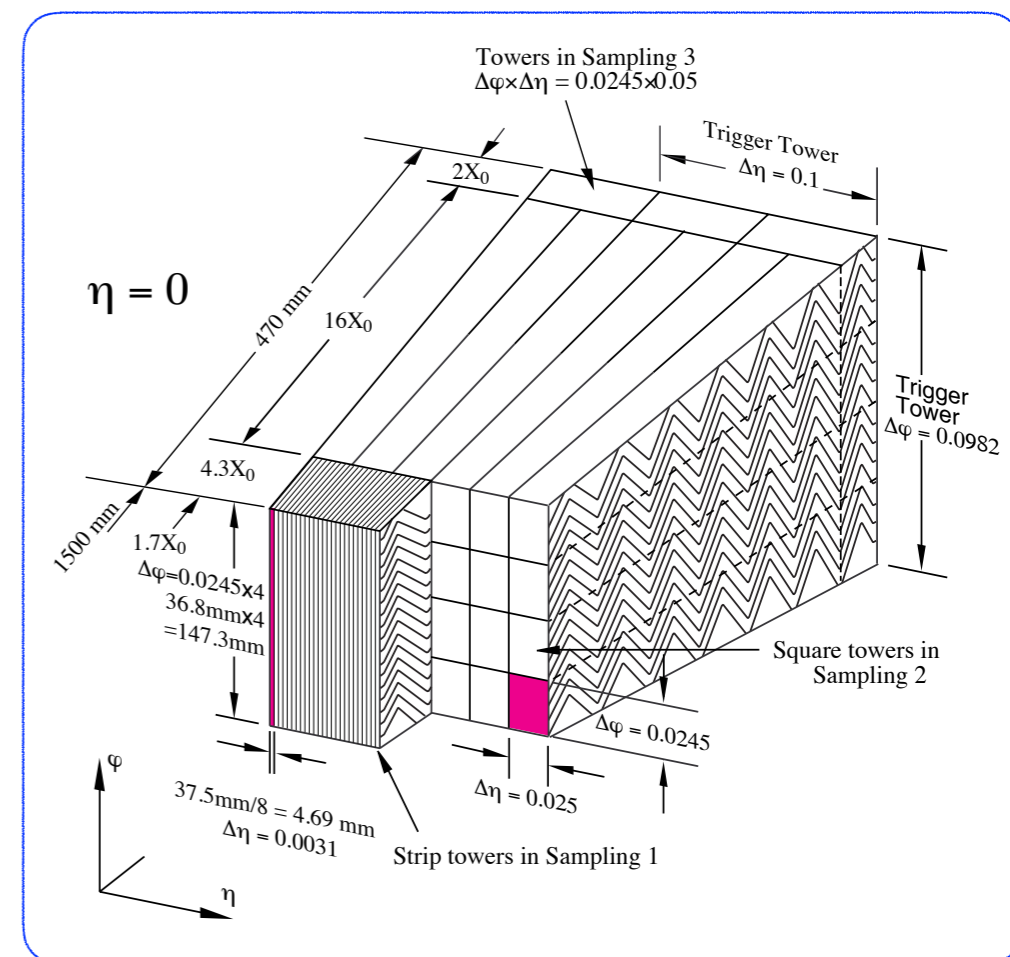
◆ ATLAS photon energy calibration in three steps:

1. energy reconstruction: sum of the energy of all cells in the three layers of the ECAL belonging to a cluster of fixed size.
2. energy calibration: using **simulated** electron from $Z \rightarrow ee$.
3. an overall (“in-situ”) calibration to correct for data-MC discrepancy using electrons from $Z \rightarrow ee$ events.

◆ The lateral energy leakage difference between photon and electron is studied for potential difference of their responses to ECAL

- ❖ photon from $Z \rightarrow \mu\mu\gamma$ decays and di-photon process
- ❖ electron from $Z \rightarrow ee$ decays.

The difference is taken as one source of photon energy calibration systematics.



Photon lateral energy leakage correction

- ◆ Photon lateral energy leakage

$$leakage = \frac{E_{S2}(7 \times 11) - E_{S2}(cluster\ size)}{E_{S2}(cluster\ size)}$$

- ◆ Double difference of electron and photon leakage is derived

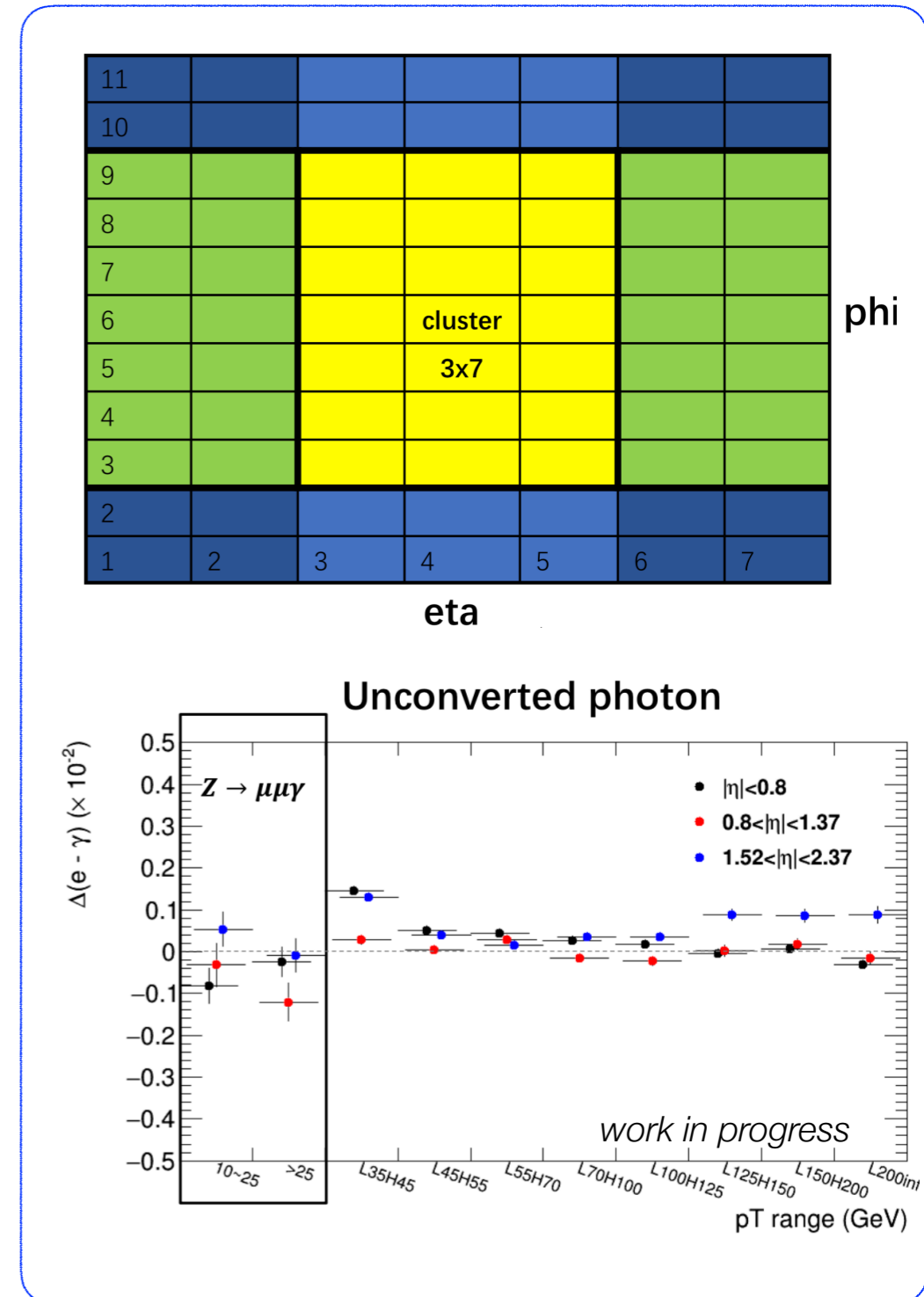
$$(leakage^{el} - leakage^{ph})^{data} - (leakage^{el} - leakage^{ph})^{MC}$$

- ◆ Pure photon samples are selected for this study

- ❖ photons from radiative Z decays → low p_T (10-35 GeV)
- ❖ isolated photon candidate pair → high p_T (> 35 GeV)

- ◆ The study using 36.1 fb⁻¹ Run 2 dataset has been done by Yufeng Wang as her qualification task for authorship

→ paper is in preparation.



Summary

- ◆ **The two institutes have strong collaboration on both physics analysis and detector performance studies in ATLAS experiment, with leading roles in**
 - ❖ **Search for a SM Higgs boson produced in association with a vector boson and decaying to a pair of b-quarks; b-jet reconstruction calibration**
 - ↻ 2 papers in 2017, 1 paper/conference-note in preparation for the 2nd half of 2018.
 - ❖ **Search for low mass resonance in diphoton events; photon energy calibration**
 - ↻ 2 papers in preparation in 2018.