



Recent Activities of ATLAS Group at Shanghai Jiao Tong University

Jun Guo

On behalf of SJTU Group

SJTU-KIT workshop

Sept. 06-08, 2017

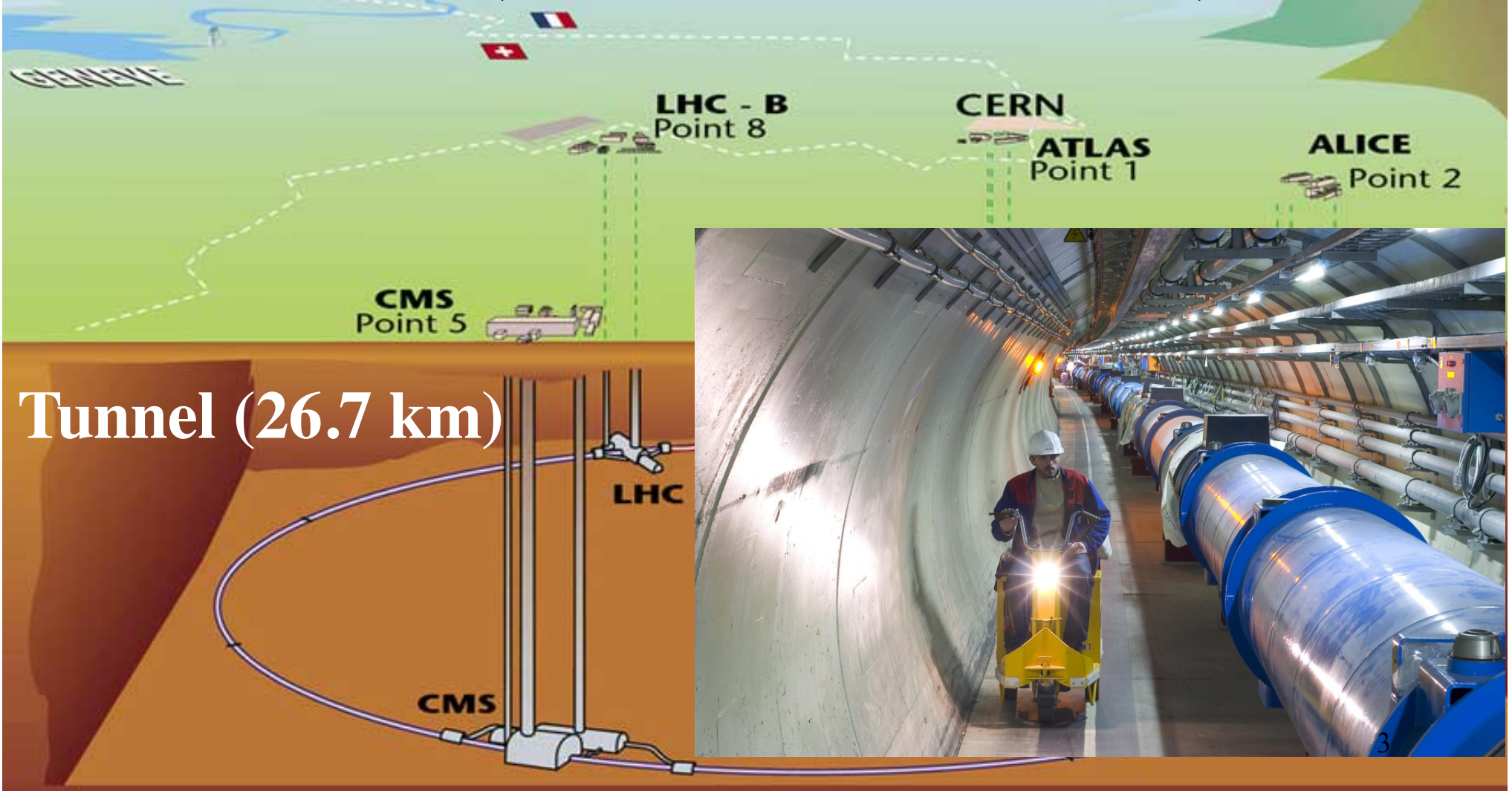
LHC at CERN



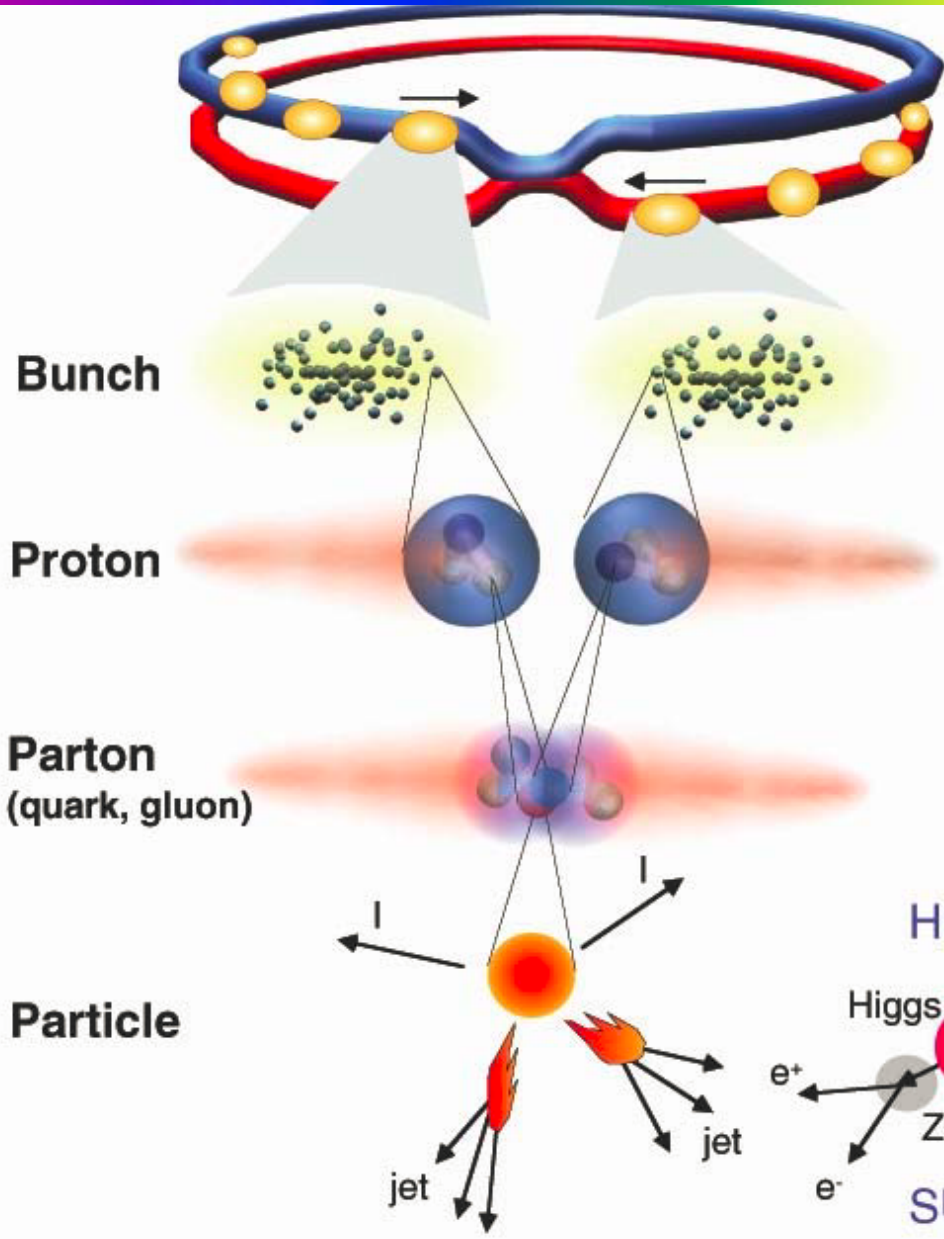
- Proton-proton collider, with design collision energy = 14 TeV
 - Center-of-mass energy: 0.9TeV(2009), 7TeV(2010, 2011), 8TeV(2012), 13TeV(2015-present)
- Two general purpose detectors: ATLAS and CMS
- Goals: Search for SM Higgs boson, probe new physics beyond SM,

LHC

LHC is the largest hadron collider in the world (7-14 TeV)
ATLAS Collaboration (38 countries, 174 institutes, ~ 3000)
CMS Collaboration (41 countries, 179 institutes, ~3300)



LHC Proton-Proton Collisions



Proton-Proton	2835 bunch/beam
Protons/bunch	10^{11}
Beam energy	7 TeV (7×10^{12} eV)
Luminosity	10^{34} cm ⁻² s ⁻¹
Crossing rate	40 MHz
Collisions \approx	$10^7 - 10^9$ Hz

Higgs \rightarrow ZZ* \rightarrow 4l

**Selection of 1 in
10,000,000,000,000**

SUSY.....

The ATLAS Detector: Huge Camera



Muon Detectors

Tile Calorimeter

Liquid Argon Calorimeter

**46 x 25 x 25 m, 7000 tons
~3000 people**

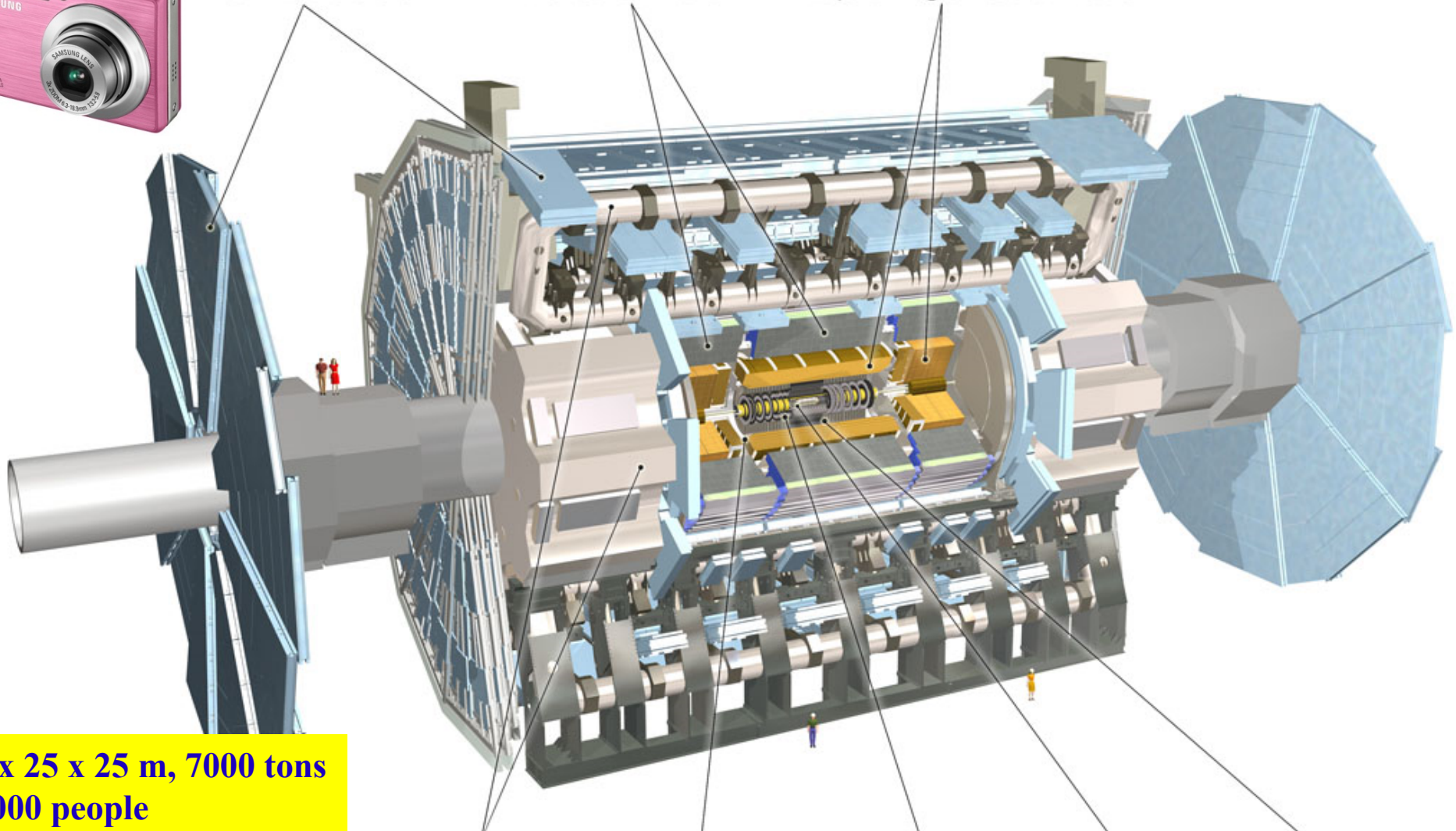
Toroid Magnets

Solenoid Magnet

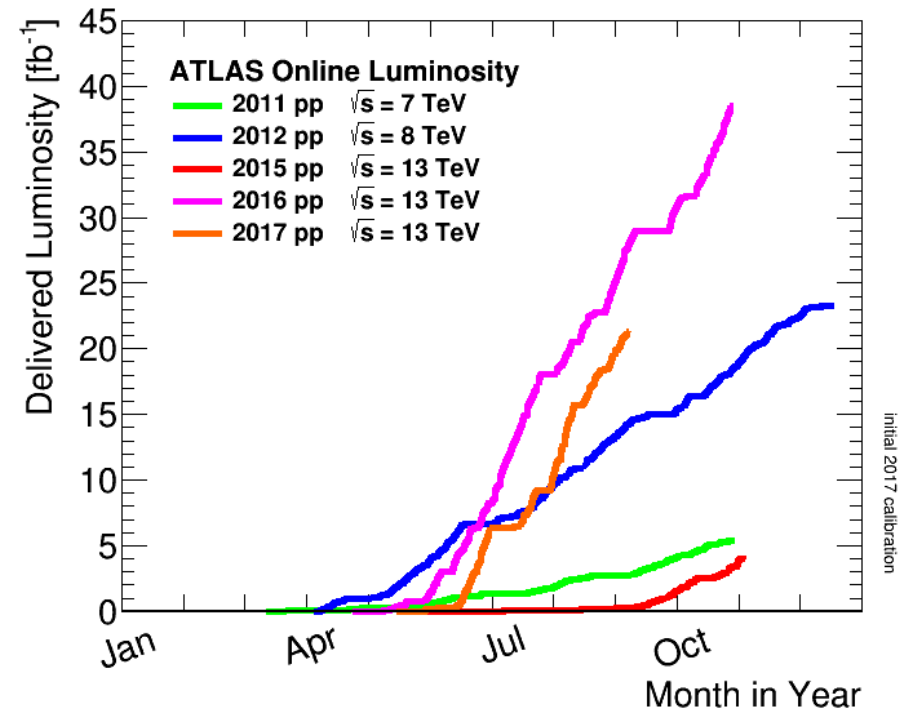
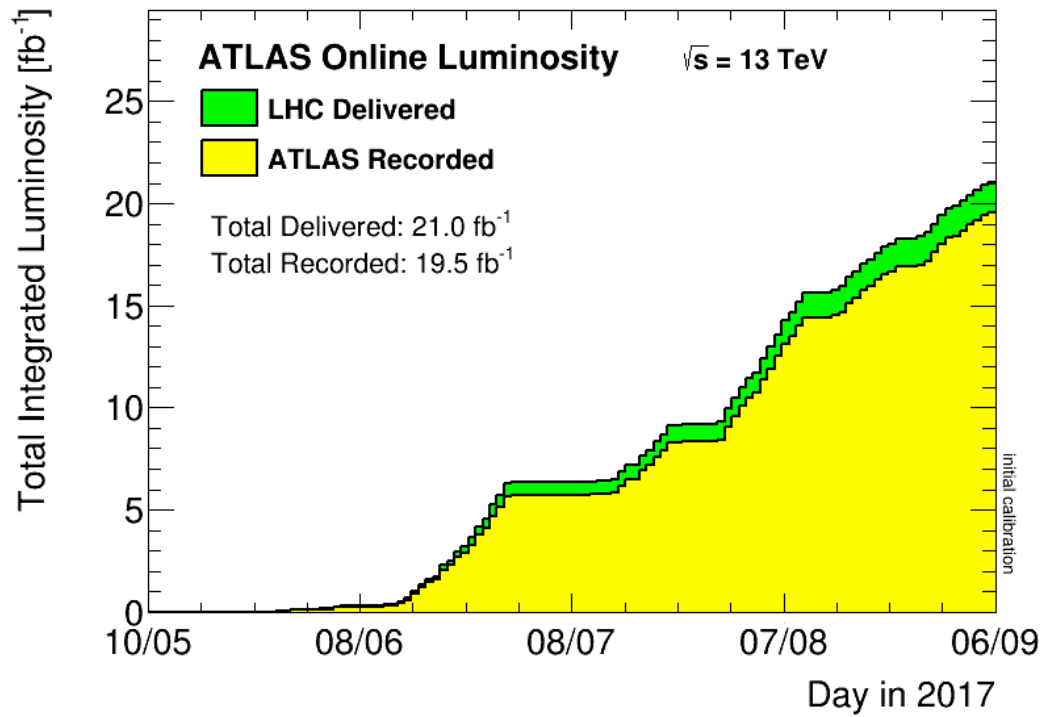
SCT Tracker

Pixel Detector

TRT Tracker



ATLAS Data Accumulation



SJTU Group Members

SJTU group(formed in 2012) working on ATLAS experiment

- **Faculty: 4+1**
 - Haijun Yang, Liang Li, Jun Guo, Ning Zhou, Shu Li(new)
- **Postdocs: 7**
 - Marc Bret, Xingguo Li, Sarah Banes, Nishu Naib, Bibhuti Parida, Nataliia Kondrashova, Monika Mittal
- **Grad Students: 6**
 - Shuyang Hu, Zirui Wang, Jing Li, Wanyun Su, Fan Li, Chenliang Wang



Haijun Yang



Liang Li



Jun Guo



Ning Zhou



Shu Li

ATLAS Activities of SJTU

- **Physics analyses:**

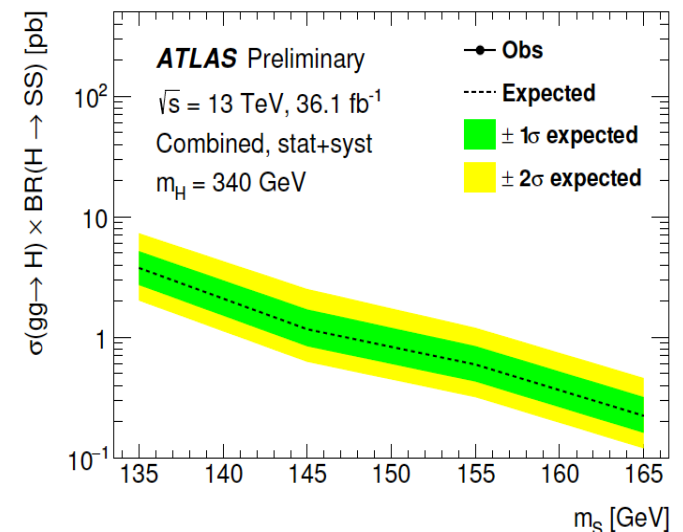
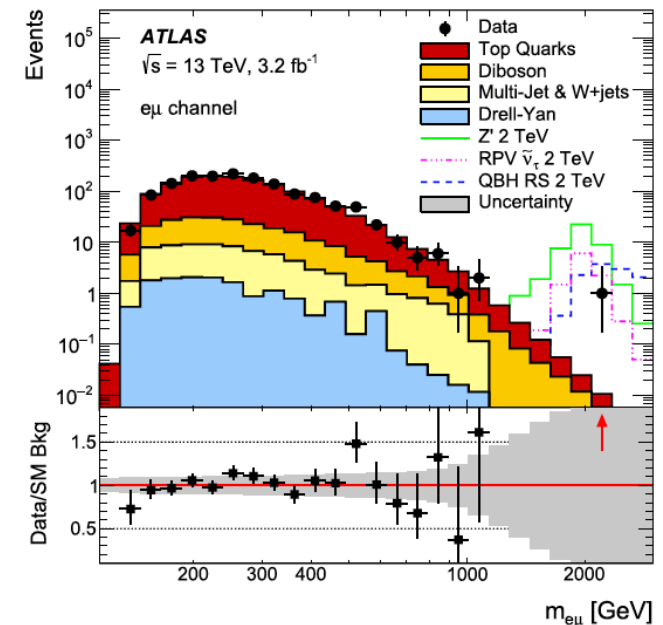
- $H \rightarrow 4l, ZZ^* \rightarrow 4l, H \rightarrow \gamma\gamma$
- ZZ VBS
- $HH \rightarrow WWWW$
- $t\bar{t}H$
- Lepton Flavor Violation
- VH resonance search
- Mono-V, Mono-Z' search
- ...

- **Service & Detector:**

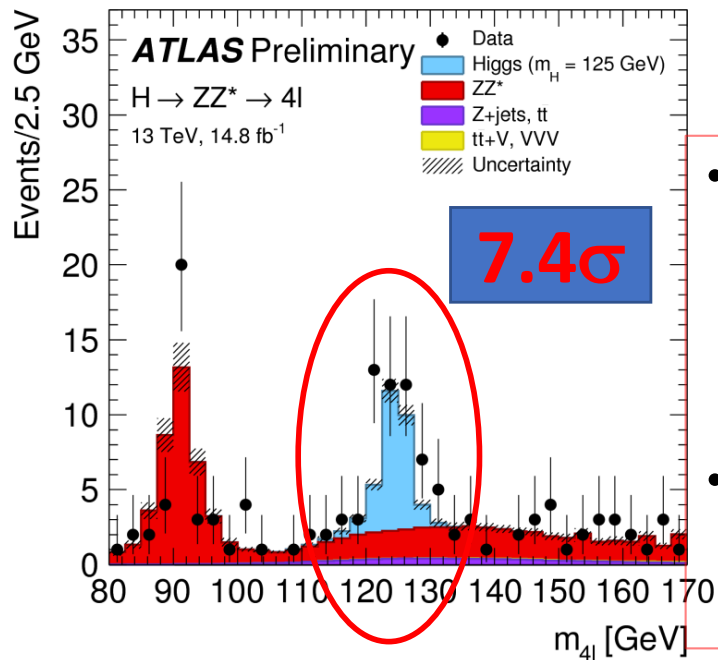
- Muon detector, performance study
- Phase-2 muon RPC upgrade, in collaboration with USTC and SDU

- **Source of grants:**

- NSFC, MOST, SJTU



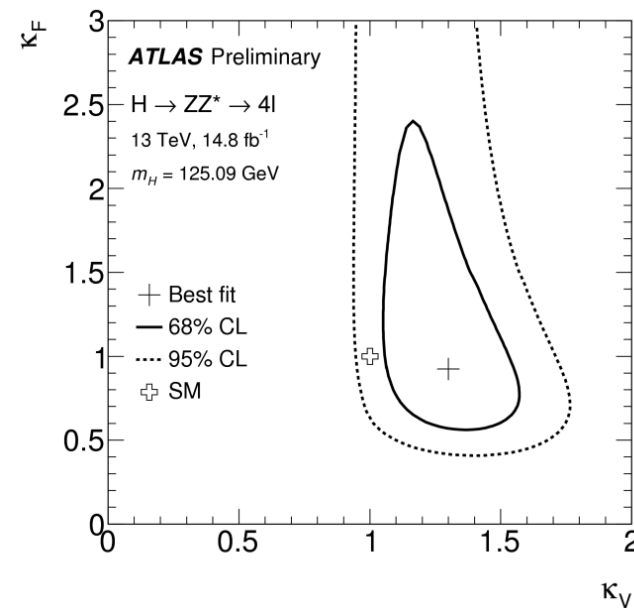
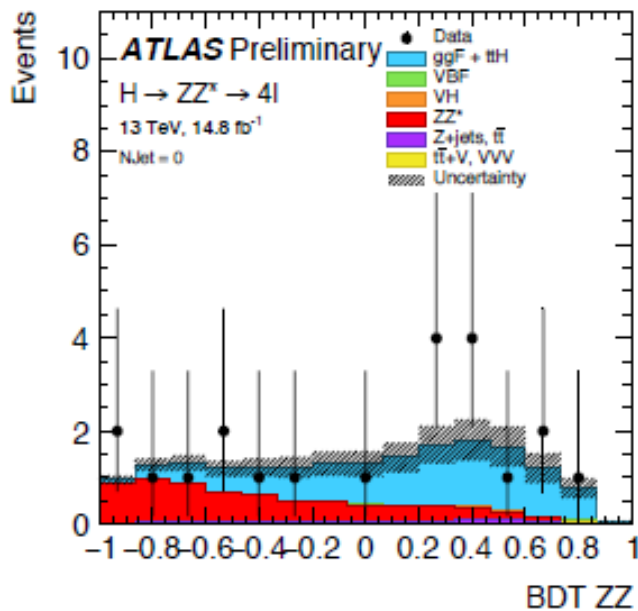
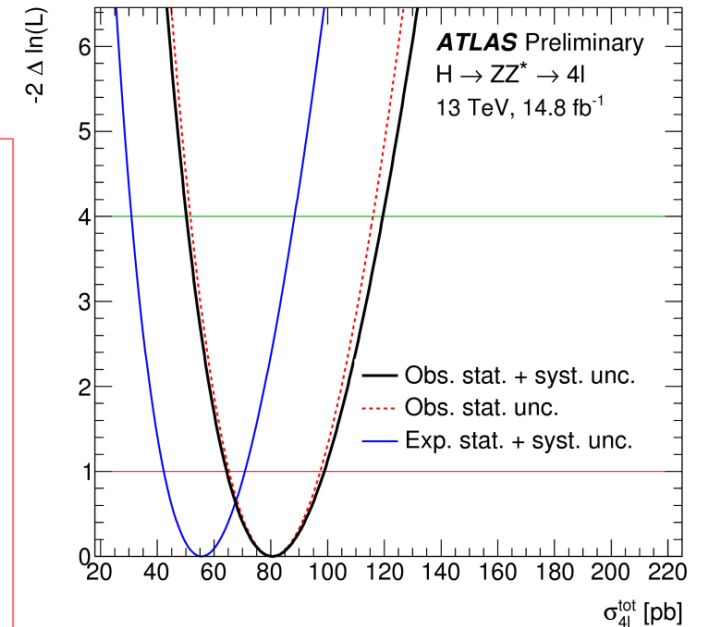
Re-discover Higgs $\rightarrow ZZ^* \rightarrow 4l$



$$\sigma_{\text{tot,SM}} = 55.5^{+3.8}_{-4.4} \text{ pb.}$$

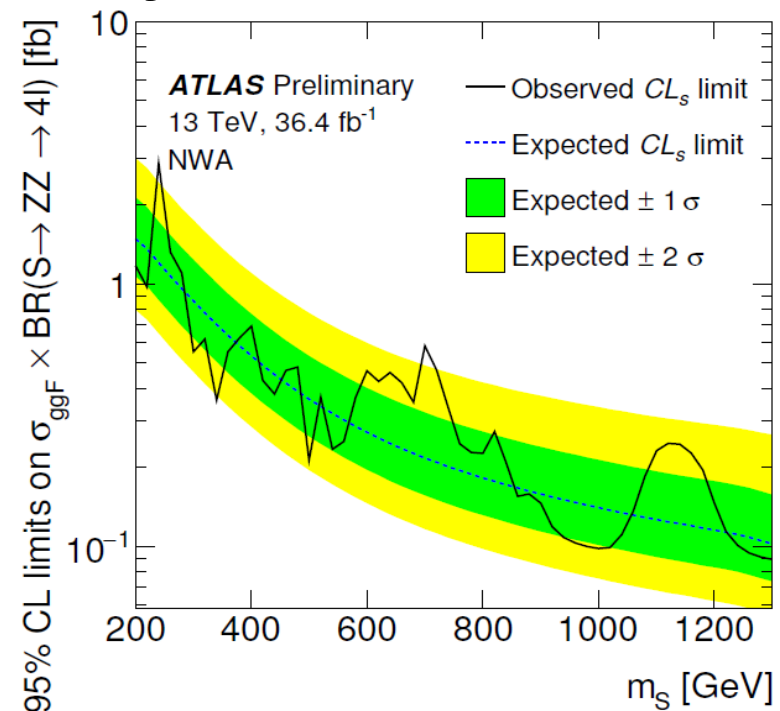
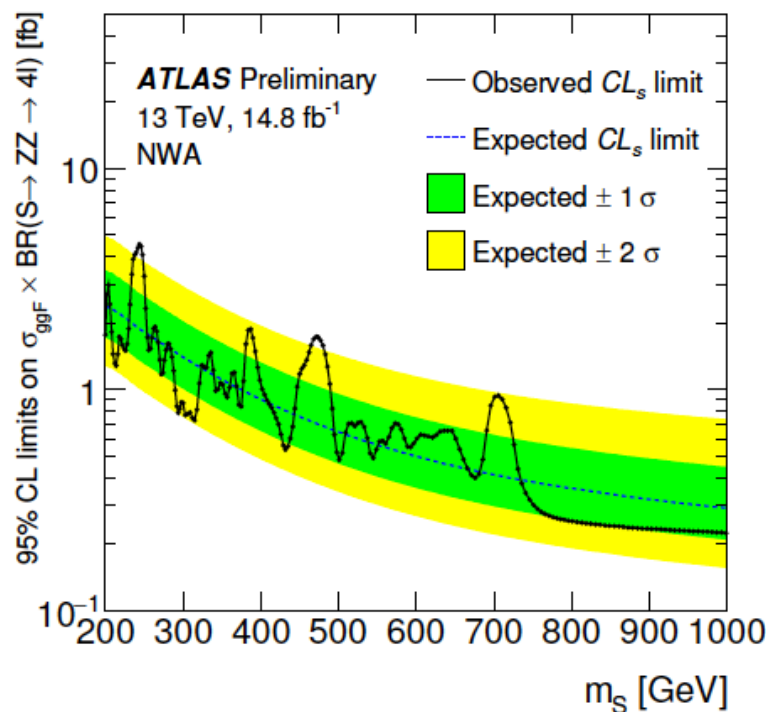
$$\sigma_{\text{tot}} = 81^{+18}_{-16} \text{ pb}$$

- Collaborating with USTC since Run1 at $H \rightarrow ZZ^*$ using BDT to improve S/B, measure Higgs properties: spin & parity
- Run2 involvement: VBF selection & optimization, κ s measurements



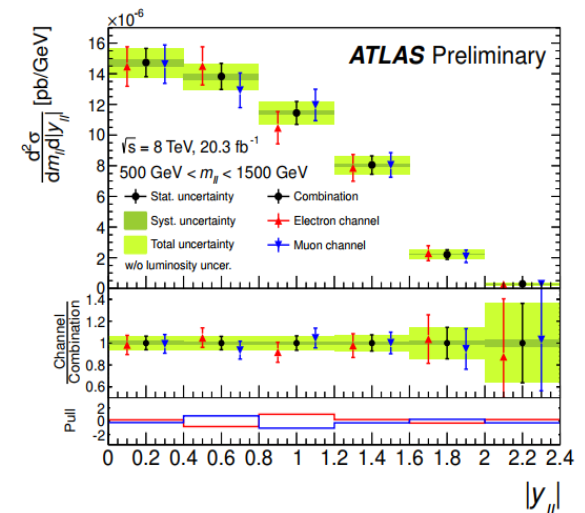
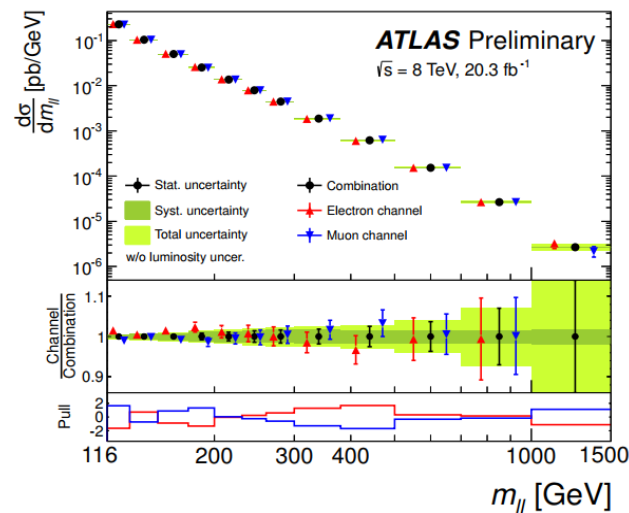
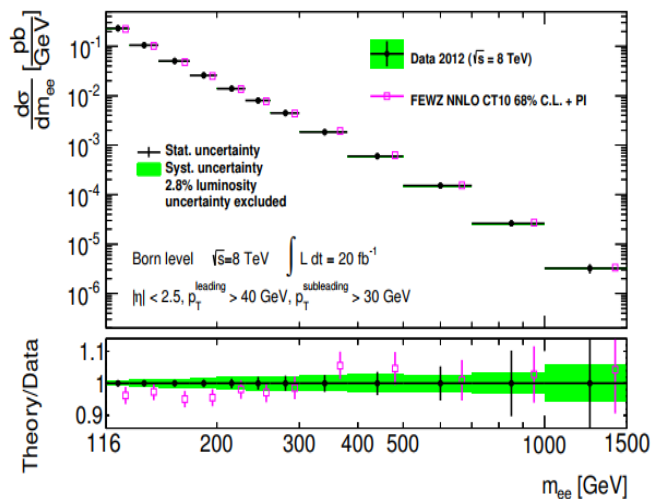
2HDM Search with $H \rightarrow ZZ^* \rightarrow 4l$

- Search for Higgs doublet in four-lepton invariant mass spectrum
- The Two Higgs Doublet Model (2HDM) is the focus of the search, introducing a high mass Higgs
- In charge of the generation of the workspace used for the statistical interpretation of the results as well as the extraction of exclusion contours for the 2HDM model
- Combination of results between the four leptons final state with the two leptons + two neutrinos analysis



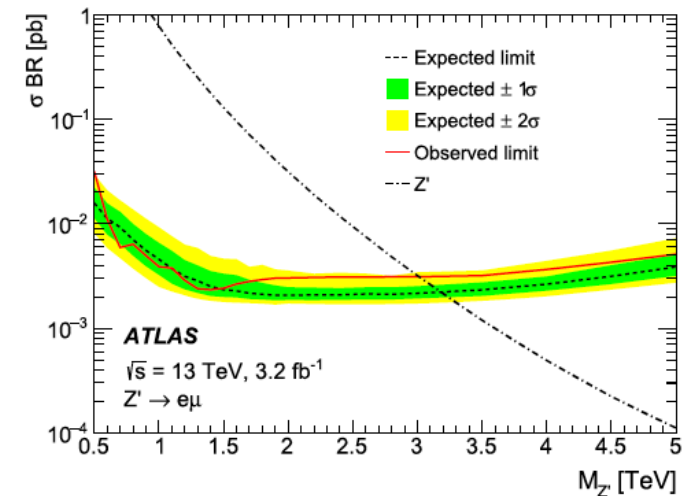
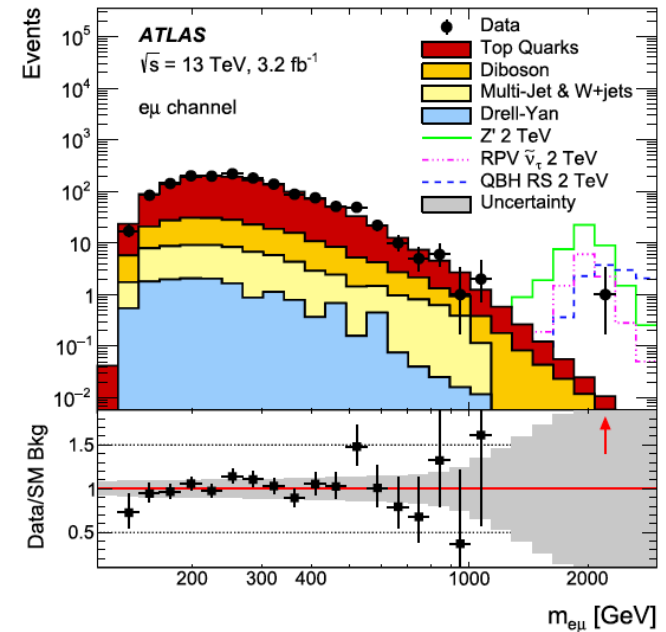
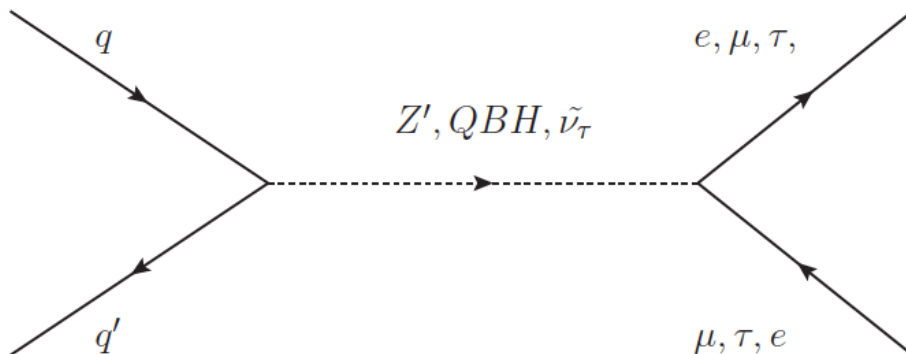
High Mass DY double-differential cross-section measurement

- Follow-up to the 8 TeV measurement: <http://inspirehep.net/record/1467454>
- Differential cross-section measured in both invariant mass and dilepton rapidity
- Use an unfolding method to obtain the fiducial cross-section
- Expect to reach a precision of 1-2% at 500 GeV in dilepton invariant mass and rapidity ≤ 2
- Effort is now getting started
- Long-term effort: aim to publish with the full Run-2 dataset (100-150 fb⁻¹)



Lepton Flavor Violation Search

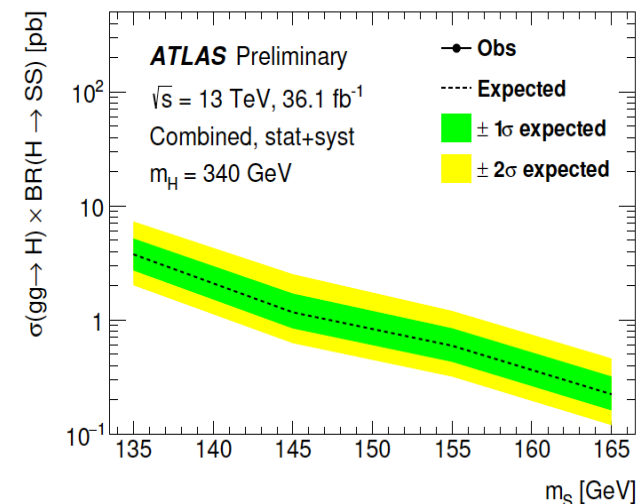
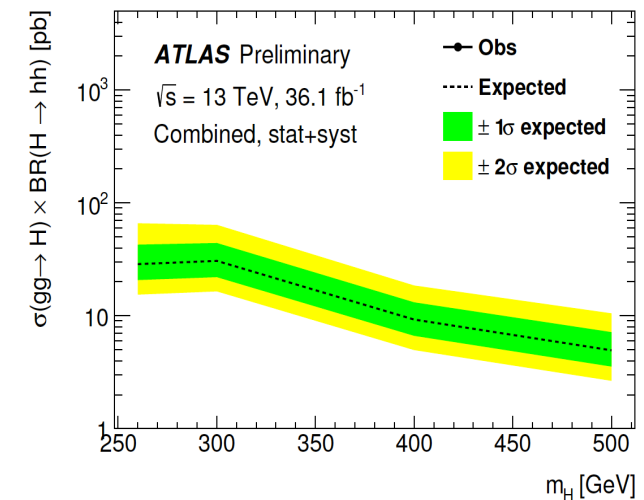
- Search for deviations from the standard in the different flavor di-lepton invariant mass spectrum to probe LFV.
- Results published with the full 2015 data, 2015+2016 dataset results still ongoing.
- Contact editor and contact person of the analysis as well as taking care of the statistical interpretation of the results.



BSM Di-Higgs Search

- First measurement for Di-Higgs to 4W channel at the LHC
- Production rate could be enhanced by BSM models, $H \rightarrow hh$ and $H \rightarrow SS$
- Main analyzer in the 3lepton+ ≥ 2 jets + MET channel, background dominated by WZ+jets
- Analysis in the EB, aiming for publication soon
- Major contributions:
 - 3 lepton channel
 - analysis framework, fake estimation and systematics, signal optimization and other systematic uncertainty evaluation.

ATLAS-COM-PHYS-2016-1577

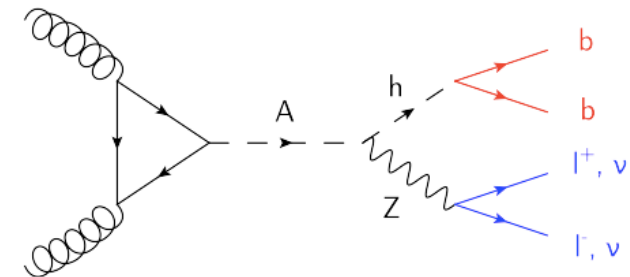


VH Resonances Research

ATL-COM-PHYS-2016-479
To be published soon

➤ VH resonances search @ 13 TeV

- Semi-leptonic final states: $llbb, lvbb, vvbb$
- Two interpretations:
 - Heavy CP-odd A-boson
 - Heavy Vector Triplet resonance

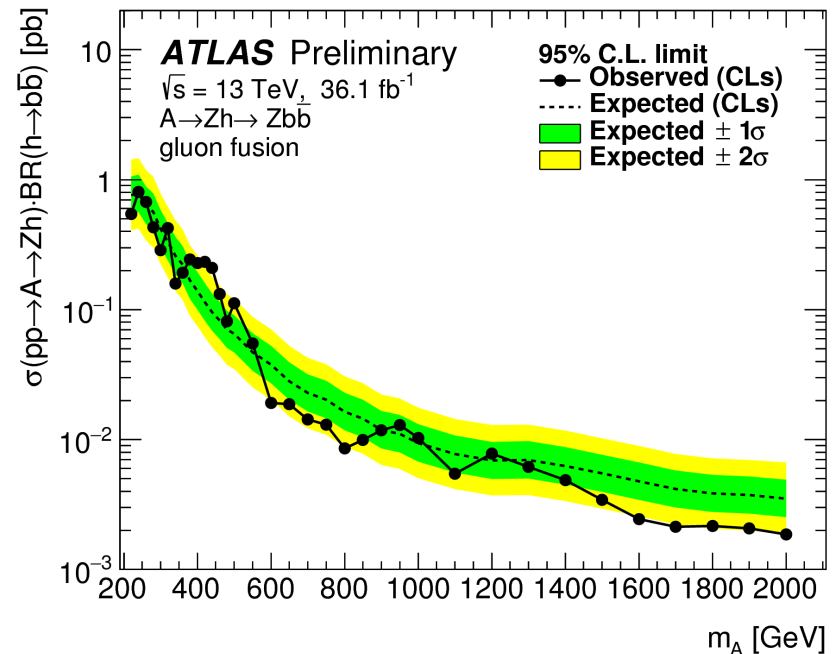


•Discriminating variable: m_{VH}

•Preliminary results in **ATLAS-CONF-2017-055**, paper in review

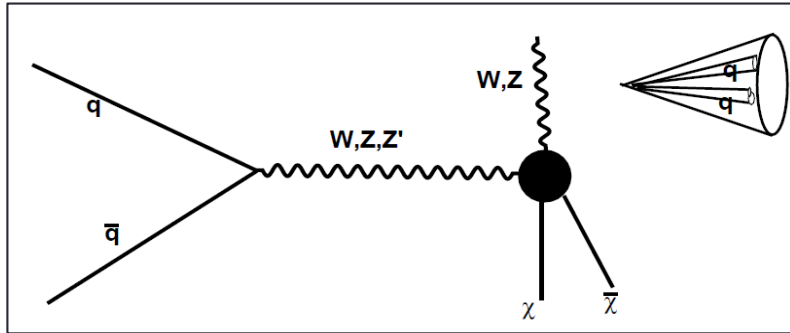
Major contribution:

- 0-lepton code development
- Optimisation of boosted/resolved events recycling
- Production of 0-lepton inputs for the maximum likelihood fit
- 1-lepton checks, systematics implementation

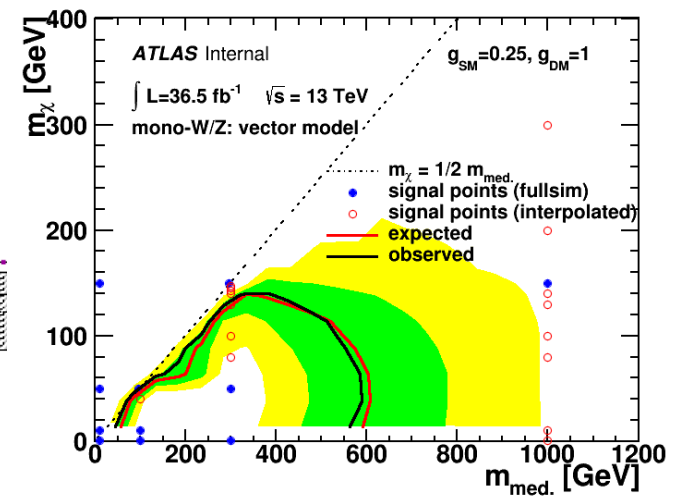
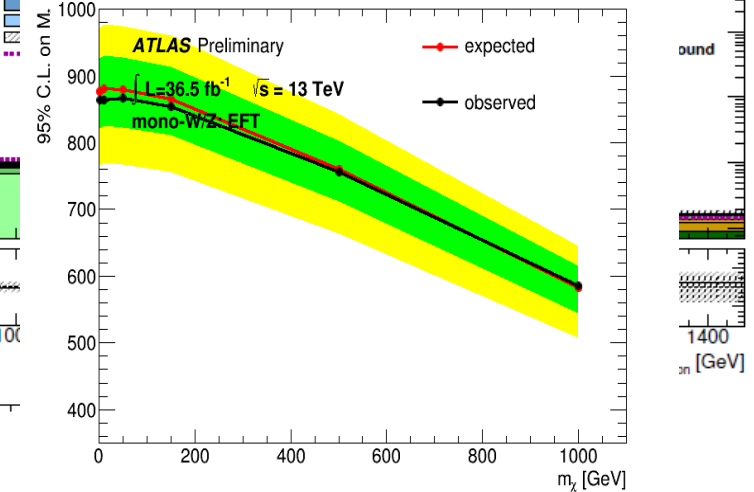
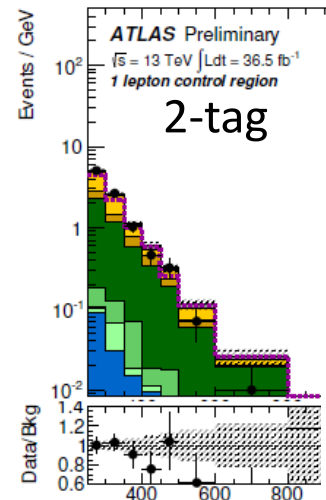
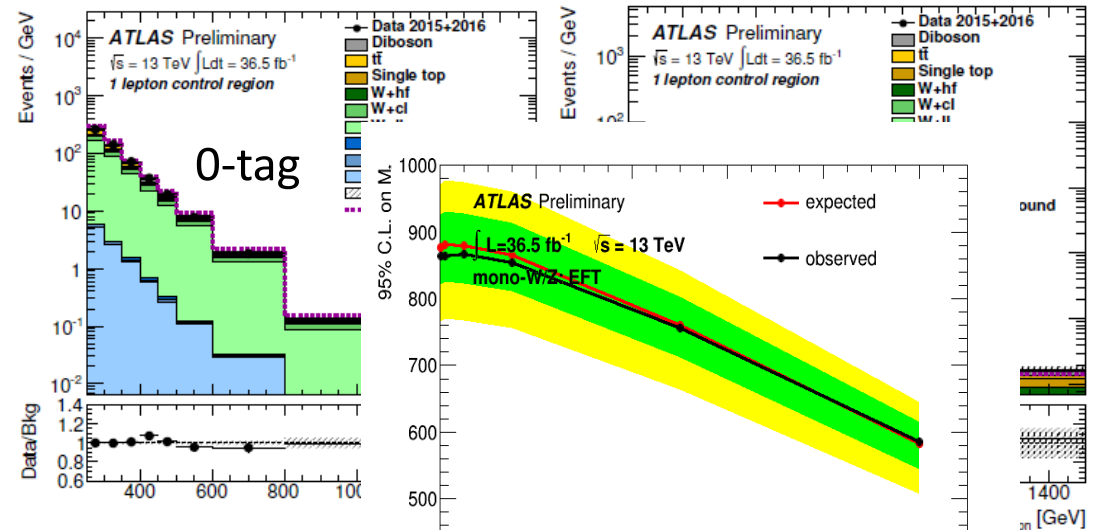


Mono-V Search in Run-II

ATL-COM-PHYS-2016-1499



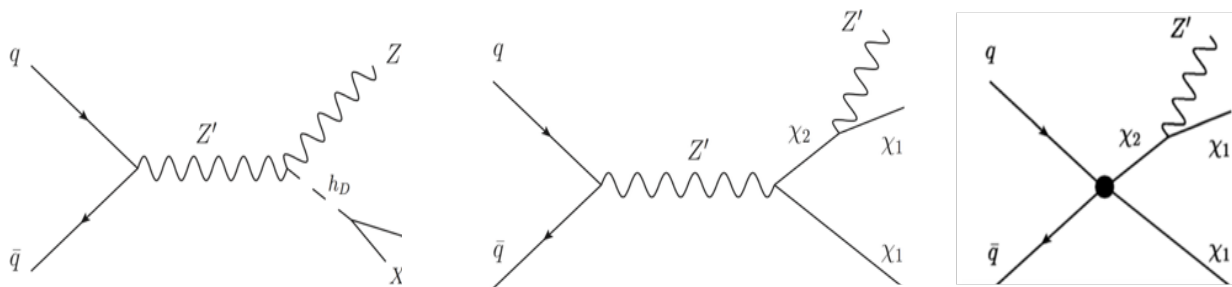
- ▣ **Vector boson recoiling against pair-produced dark matter particles, producing either a large-radius jet or a pair of jets and MET**
 - ▣ **Merged Analysis:** search for events with large MET and identify the boosted boson
 - ▣ **Resolved Analysis:** search for events with MET and dijet
- ▣ **Application of novel jet substructure techniques for merged analysis**



Mono-Z' + DM Search

ATL-COM-PHYS-2017-150

- New previously unstudied model for dark matter production.
- Generalisation of the MonoV analysis.
- Two analysis regions, merged (low mass Z') and resolved (high mass Z').
- Analysis aim is to improve upon previous limits for coupling parameters $gqgx$.
- Three signal models considered : Dark Higgsstrahlung, Light Z' vector, and inelastic EFT.



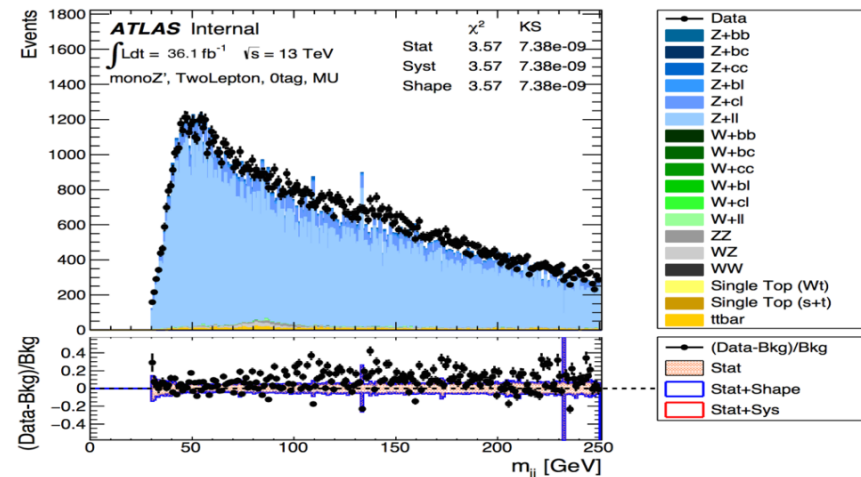
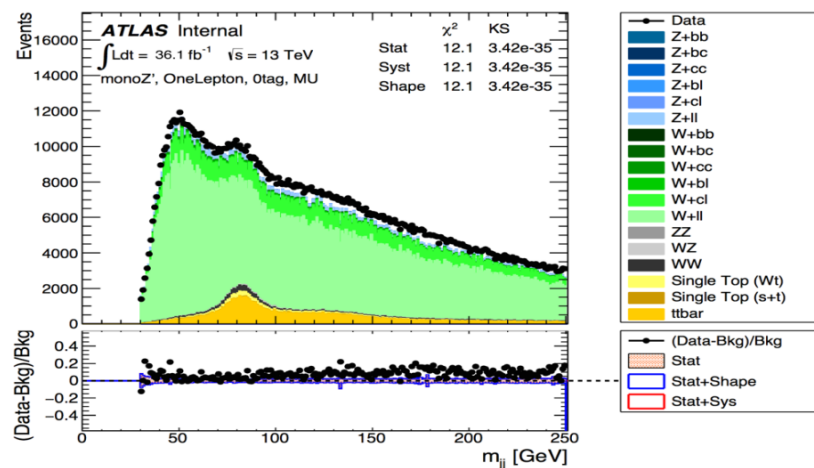
# of leptons	# of b-tagged jets		
	0	1	2
0	SR	SR	SR
1	CR, W+jets	CR, W+jets, $t\bar{t}$	CR, W+jets, $t\bar{t}$
2	CR, Z+jets	CR, Z+jets	CR, Z+jets

Mono-Z' + DM Search

ATL-COM-PHYS-2017-150

- ❑ Select events with large MET (> 150 GeV), and at least 2 central jets.
- ❑ Dijet mass cut optimised for monoZ' analysis for 0-tag (1/2-tag) region
- ❑ Analysis is currently blinded over the full signal region.
- ❑ MonoZ' to be included in MonoV paper, publication end of Sept 2017.

m_{jj} distributions for 1 and 2 lepton CR's :



Di-b-jet Mass Resonances Search

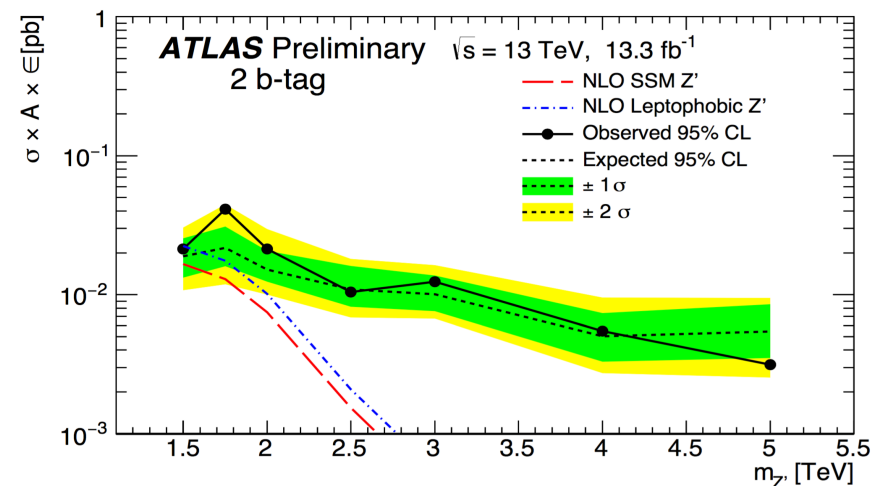
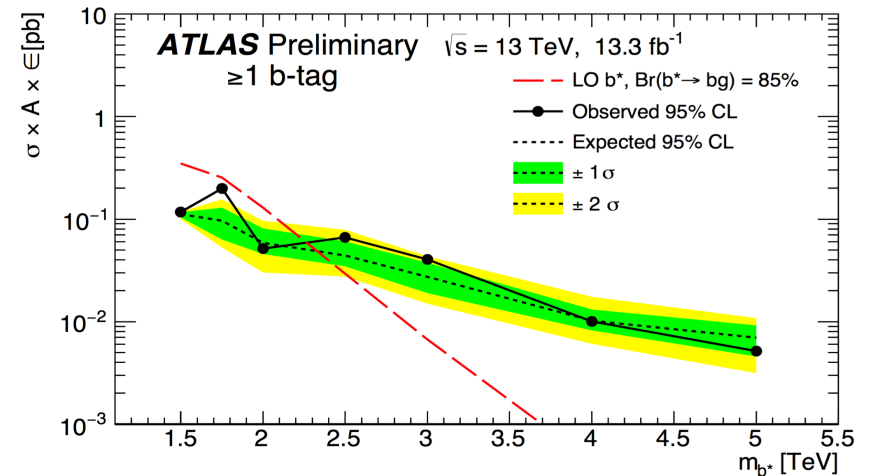
- Di-b-jet High Mass analysis from $M_{jj} > 1.2$ TeV using single jet triggers

PLB 759 (2016) 229-246
ATLAS-CONF-2016-060

- Latest update with 13.3 fb^{-1} of 2015 + 2016 data
- b^* excluded in the mass range 1.38 – 2.3 TeV
- SSM Z' cannot be excluded.
- Observed (expected) limit on the leptophobic Z' model is 1.5 (1.6) TeV

Major Contributions:

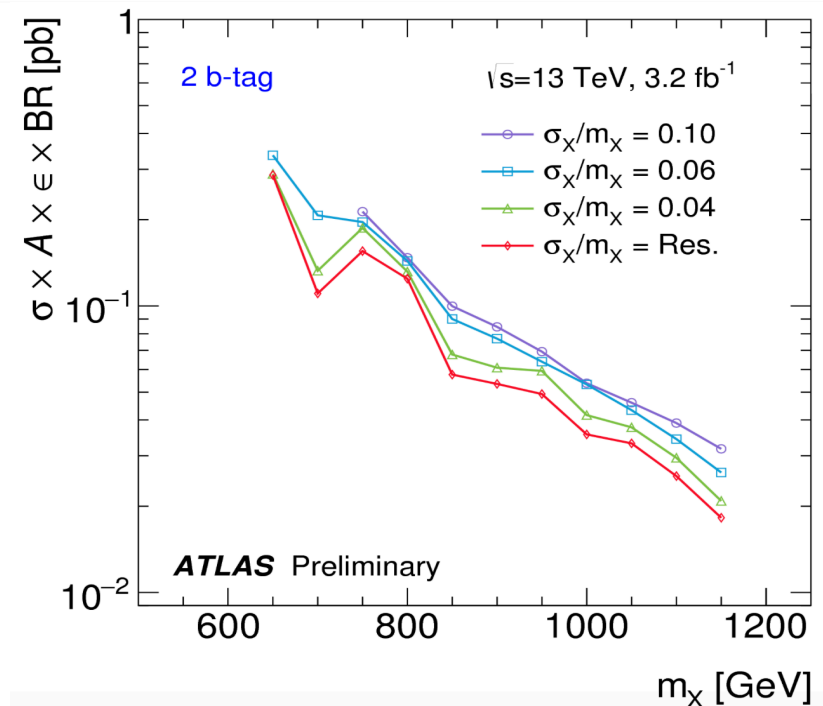
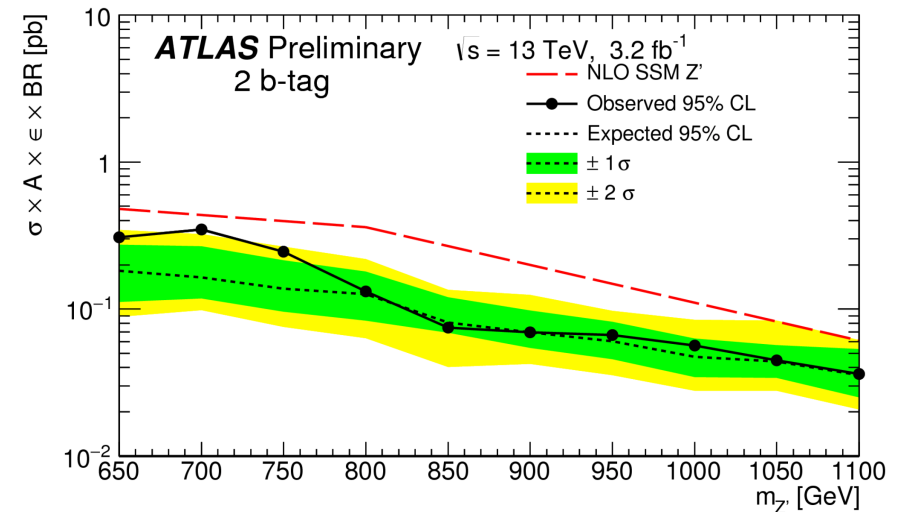
- Event selection & optimization
- b-tagging optimization & calibration
- Data / MC Comparisons
- MC requests
- Signal Model studies
- Support note editor



Di-b-jet Mass Resonances Search

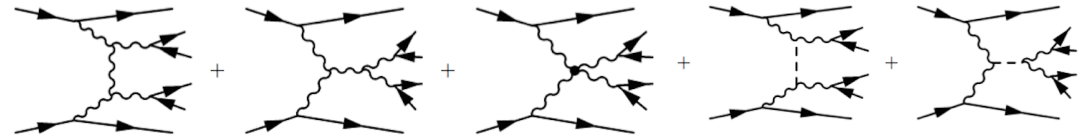
- Di-b-jet Low Mass analysis with $1.2 \text{ TeV} > M_{jj} > 600 \text{ GeV}$ using b-jet triggers.
 - Latest update with 3.2 fb^{-1} of 2015 data
 - Results exclude SSM Z' bosons in the mass range between 0.65 TeV and 1.0 TeV
 - Contributions of a Gaussian signal with cross sections from 0.3 to 0.02 pb also excluded
- Major Contributions:
 - Event selection & optimization
 - b-tagging optimization
 - Data / MC Comparisons
 - MC requests
 - Signal Model studies
 - Support note editor

ATLAS-CONF-2016-031



VBS measurement & aQGC search

➤ VBS measurement & aQGC search @ 13 TeV



- Important test of SM gauge structure
- Involves Higgs-VV couplings
⇒ understanding nature of EWSB
- Involves quartic gauge coupling (QGC)
⇒ anomalous QGC from new physics could enhance cross section significantly

ATLAS VBS WV ($lvqq$) @ 8 TeV:

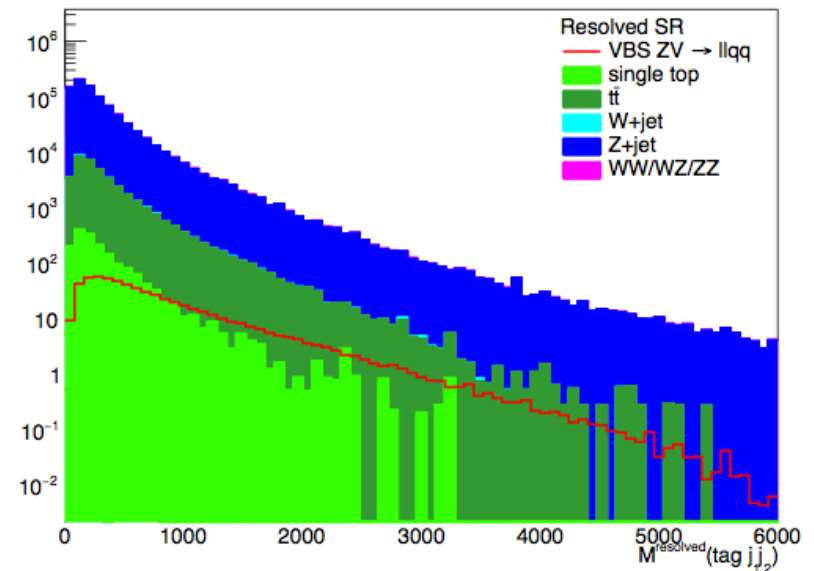
- Not enough sensitivity to VBS @ 8 TeV
- Limits set on aQGC

Semileptonic VBS VV ($vvqq, lvqq, llqq$)jj

- Large branching ratio
- Probe multiple final states (WW, WZ, ZZ)
- Use both resolved/boosted event topologies

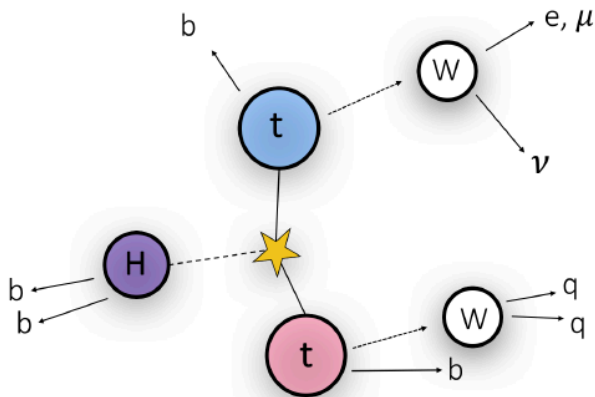
Major contribution:

- analysis code development
- 0/2-lepton event selection optimisation



Other Analyses

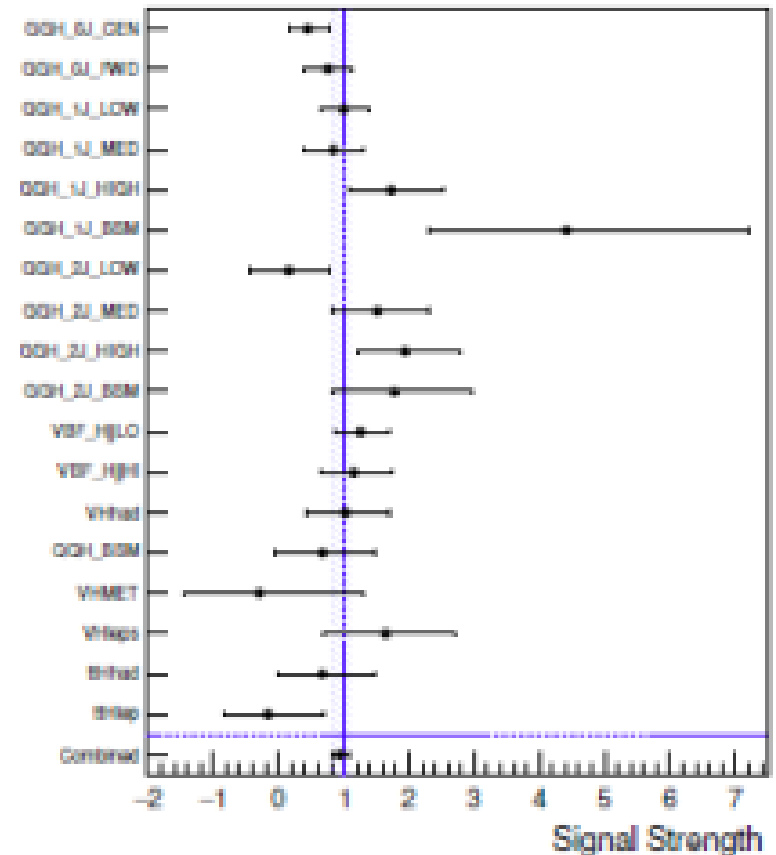
- **H- $\rightarrow\gamma\gamma$ couplings and Simplified Template Cross-Sections:**
 - Working on categorization, signal modeling, systematics and statistical procedure



- **First ttH boosted analysis at ATLAS**
 - Contributed to cutflow, data/MC comparisons & cross checks
 - Planning to work on BDTs, limit setting towards a publication after the summer

ATL-COM-PHYS-2017-445

ATLAS Internal $\sqrt{s}=13$ TeV, 36.1 fb⁻¹
H $\rightarrow\gamma\gamma$, $m_H=125.09$ GeV



Service Work

- **Muon isolation performance in Run 2** **ATL-COM-PHYS-2017-290**
 - **Signal selection for leptons from hard processes using isolation energy, isolation selection optimized centrally**
 - **Study of neutral energy flow isolation variables**
 - **Study of muons close to jets**

- **Flavor tagging calibration** **ATL-COM-PHYS-2016-1513**
 - **Studying Monte Carlo based high pT flavor tagging calibrations**
 - **Estimation of various jet based and track based systematics**

- **Jet energy calibration**
 - **Small-R jets calibration in HL-LHC studies**
 - **Working on to provide JES corrections for small-R jets.**

Service Work

- **L1 Calorimeter**
 - **Software task to improve pre-processor modules functioning**
 - **Primary On-call planned during 2017**

- **Muon Drift Tube Chambers**
 - **Study the performance of 4 new MDT chambers**
 - **Validate the efficiency and resolution**

- **HL-jet Reconstruction**
 - **Investigate an alternative approach to reconstruct and calibrate jets in the forward region, using “calorimeter towers” instead of “topo-clusters” as inputs and compare**

- **Shifts**
 - **Control Room shifts: trigger**
 - **Atlas Distributed Computing Operation Shifts**
 - **Data Quality shifts, MDT calibration shifts**

List of Selected Publications

- **Papers:**
 - **Search for high-mass new phenomena in the di-lepton final state using proton-proton collisions at 13 TeV with the ATLAS detector, [Phys. Lett. B 761 \(2016\) 372-392](#)**
 - **Search for new phenomena in different flavor high-mass dilepton final states in pp collisions at 13 TeV with the ATLAS detector [Eur. Phys. J. C76 \(2016\) 541](#)**
 - **Search for resonances in the mass distribution of jet pairs with one or two jets identified as b-jets in proton – proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector [Physics Letters B 759 \(2016\) 229-246](#)**
- **Conference Notes:**
 - **Study of the Higgs boson properties and search for high-mass scalar resonances in the $H \rightarrow ZZ^* \rightarrow 4\ell$ decay channel at $\sqrt{s}=13$ TeV with the ATLAS detector [ATLAS-CONF-2016-079](#)**

List of Selected Publications

- **Conference Notes:**
 - **Search for new phenomena in the di-lepton final state using proton-proton collisions at 13 TeV with the ATLAS detector**
ATLAS-COM-CONF-2015-093
 - **Search for beyond the Standard Model phenomena in electron-muon final states in pp collisions at 13 TeV with the ATLAS detector**
ATLAS-COM-CONF-2015-082
 - **Search for resonances below 1.2 TeV from the mass distribution of b-jet pairs in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector**
ATLAS-CONF-2016-031
 - **Search for resonances in the mass distribution of jet pairs with one or two jets identified as b-jets with the ATLAS detector with 2015 and 2016 data**
ATLAS-CONF-2016-060
 - **Measurement of fiducial, differential and production cross sections in the $H \rightarrow \gamma\gamma$ decay channel with 13.3 fb⁻¹ of 13 TeV proton-proton collision data with the ATLAS detector**
ATLAS-CONF-2016-067

List of Selected Conference Contributions

- **Measurements of the production of jets in association with a W or Z boson with the ATLAS detector, 25th International Workshop on Deep Inelastic Scattering and Related Topics, Birmingham, April 3-7 2017**
- **Searches in ATLAS, International Conference on High Energy Physics Theory to Experiment, Kuala Lumpur, February 27 – March 1, 2017**
- **Higgs Properties Measurement through the $H \rightarrow ZZ^* \rightarrow 4l$ with the ATLAS detector”, The 2nd China LHCP Workshop, Peking U., December 17-19, 2016**
- **Search for Lepton Flavor Violation in di-lepton channel at ATLAS, The 2nd China LHCP physics workshop, Peking University, Beijing, China, December 17-19, 2016**
- **Search for Higgs Rare Decays at ATLAS and CMS, International Symposium on Higgs Boson and Beyond Standard Model Physics, Weihai, China, August 2016**

List of Selected Conference Contributions

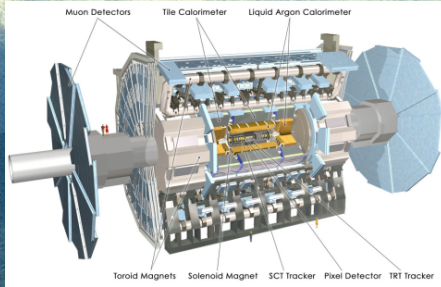
- Searches for Charged Lepton Flavor Violation with the ATLAS detector at the LHC', NuFact2016, Quy Nhon (Vietnam), August 2016
- The 9th French-China Particle Physics Laboratory (FCPPL) workshop, University of Strasbourg, France, invited talk, “Highlights of the ATLAS Run2 Results”, March 30 – April 1, 2016
- Exotics Lepton+X Results, ATLAS Physics Jamboree, CERN, February 12, 2016
- MC based high pT calibrations, ATLAS Flavor Tagging Workshop held in Bonn, Germany, April 2016
- **LHCP 2017**
 - Searches for lepton flavor violation at ATLAS
 - Measurements of integrated and differential cross sections for isolated photon pair production in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector
 - Search for di-jet resonances with one or two jets identified as b-jets in proton-proton collisions at 13 TeV with ATLAS detector

Summary & Plan

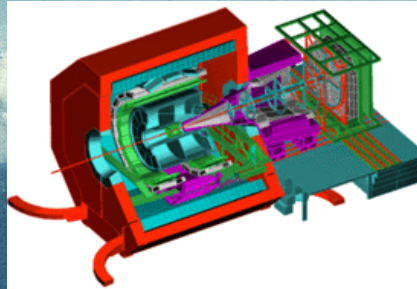
- **Growing group: 5 faculties, 7 postdocs, 6 students**
- **Physics analyses**
 - **SM (precision) measurements**
 - **BSM/Exotics searches**
 - **More publications to come in the fall**
- **Service & Upgrade**
 - **Increasing involvement with various service work**
 - **ATLAS muon RPC upgrade with USTC and SDU**

Backup

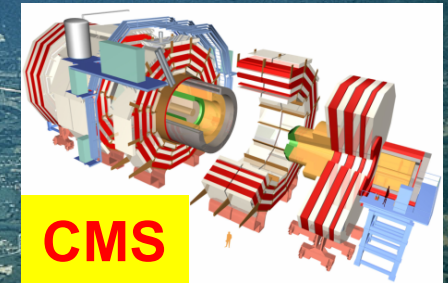
Large Hadron Collider at CERN



ATLAS

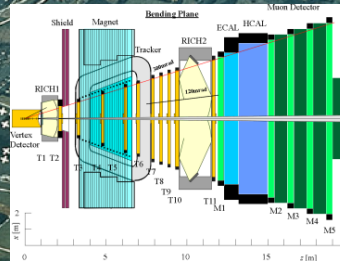


ALICE



CMS

CERN

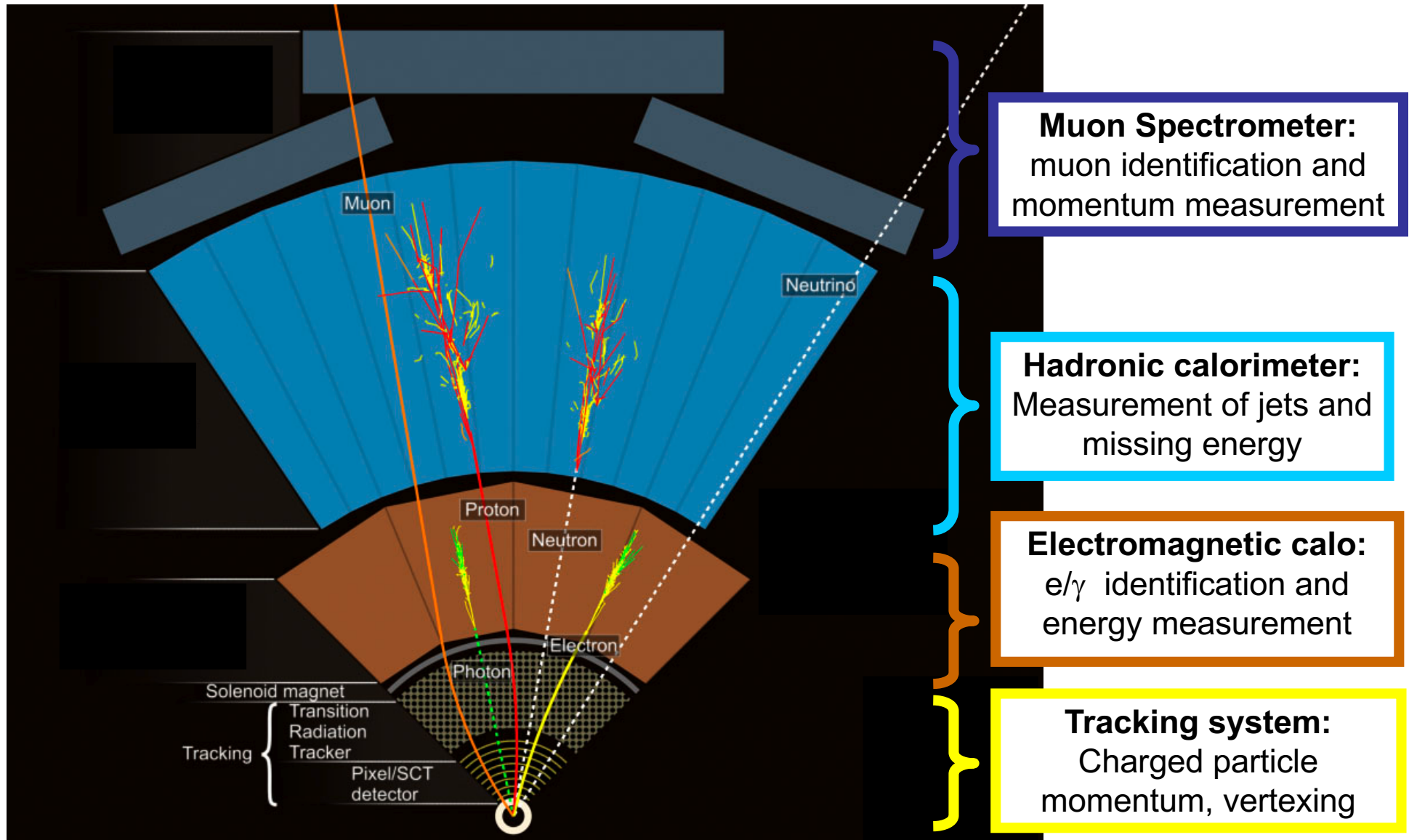


LHCb

LHC: 27 km, the world's largest proton-proton collider (7-14 TeV)

Where the WWW was born ...

Particle Detection



Mono-Z' + DM Search

ATL-COM-PHYS-2017-150

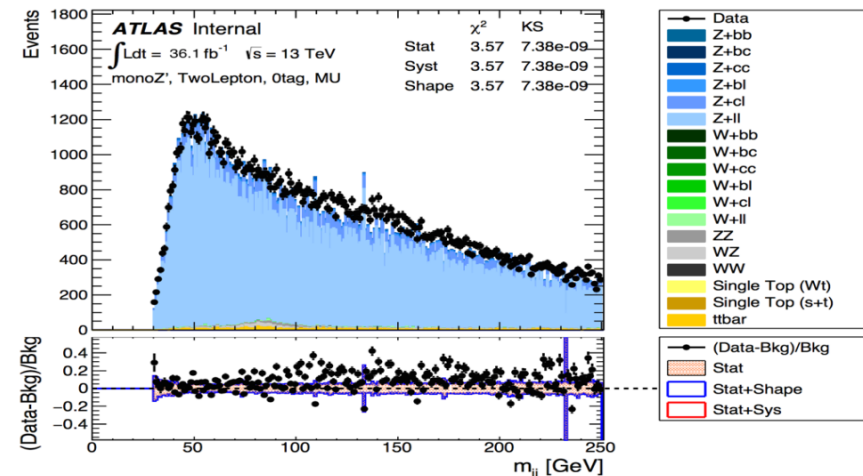
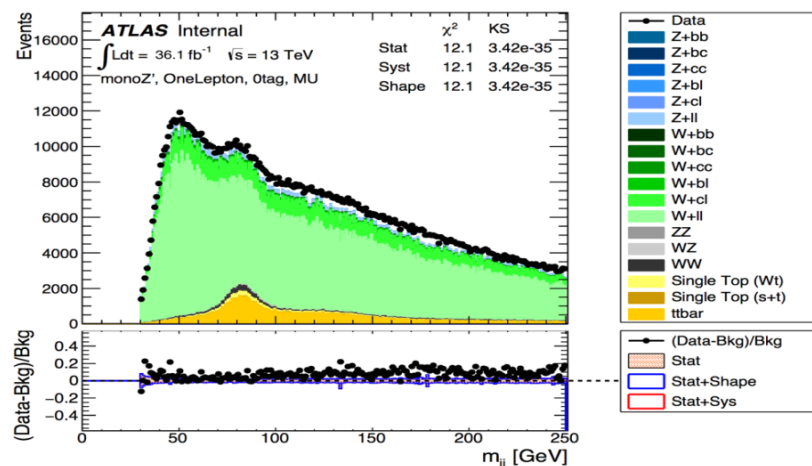
- Select events with large MET (> 150 GeV), and at least 2 central jets.
- Dijet mass cut optimised for monoZ' analysis for 0-tag (1/2-tag) region :

$$m_{Z'} < 200\text{GeV} : [0.85(0.75) \times m_{Z'}, m_{Z'} + 10\text{GeV}]$$

$$m_{Z'} \geq 200\text{GeV} : [0.85(0.8) \times m_{Z'}, m_{Z'} + 20\text{GeV}]$$

- Analysis is currently blinded over the full signal region.

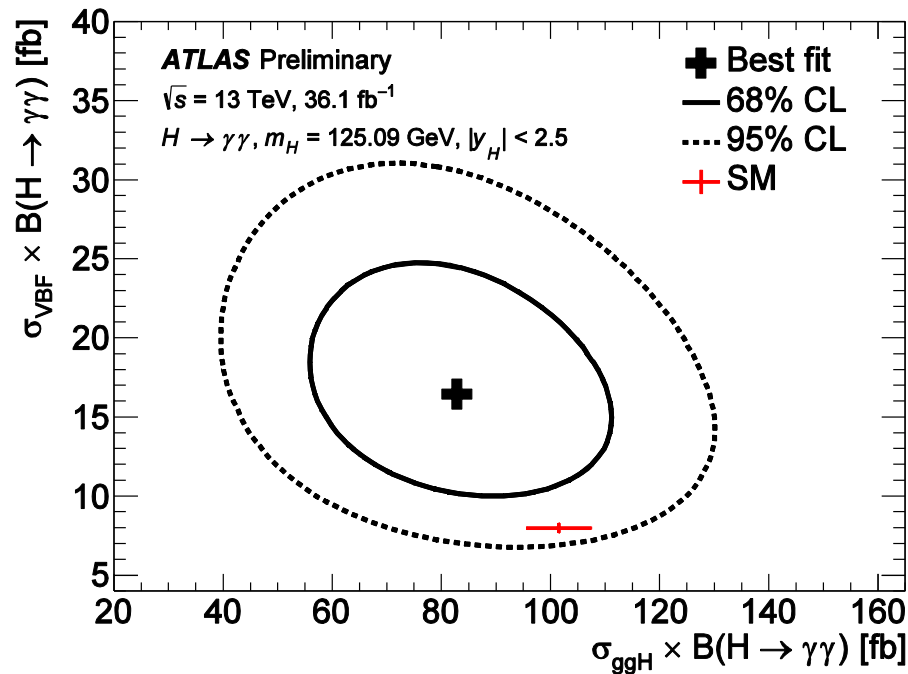
m_{jj} distributions for 1 and 2 lepton CR's :



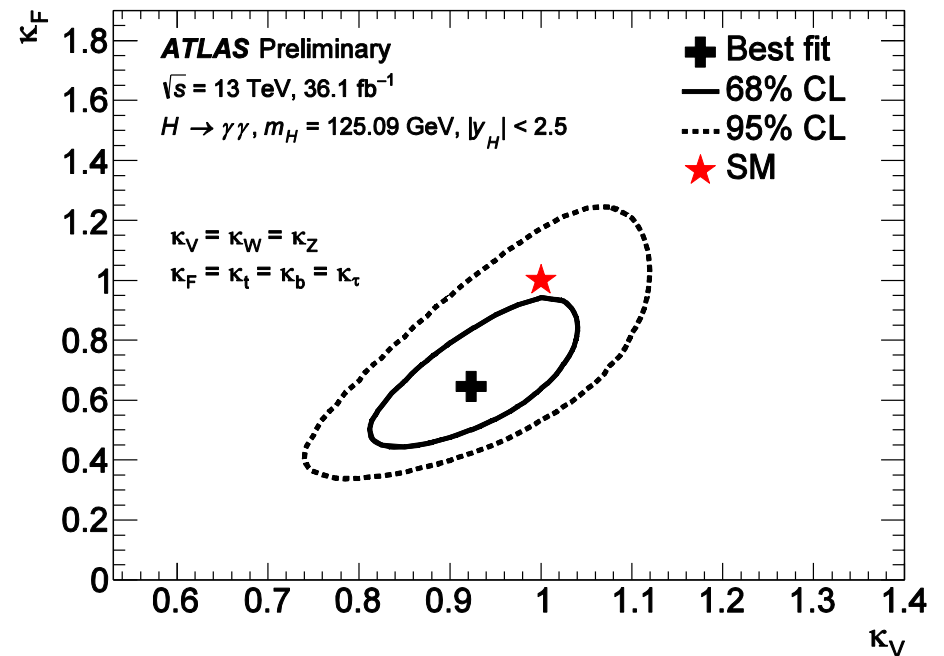
H- $\rightarrow\gamma\gamma$ couplings

H- $\rightarrow\gamma\gamma$ couplings and Simplified Template Cross-Sections:

- Working on categorization, signal modeling, systematics and statistical procedure.



Likelihood contours in the $(\sigma_{ggH}, \sigma_{VBF})$ plane, compared to the Standard Model prediction



Likelihood contours in the (κ_V, κ_F) plane.