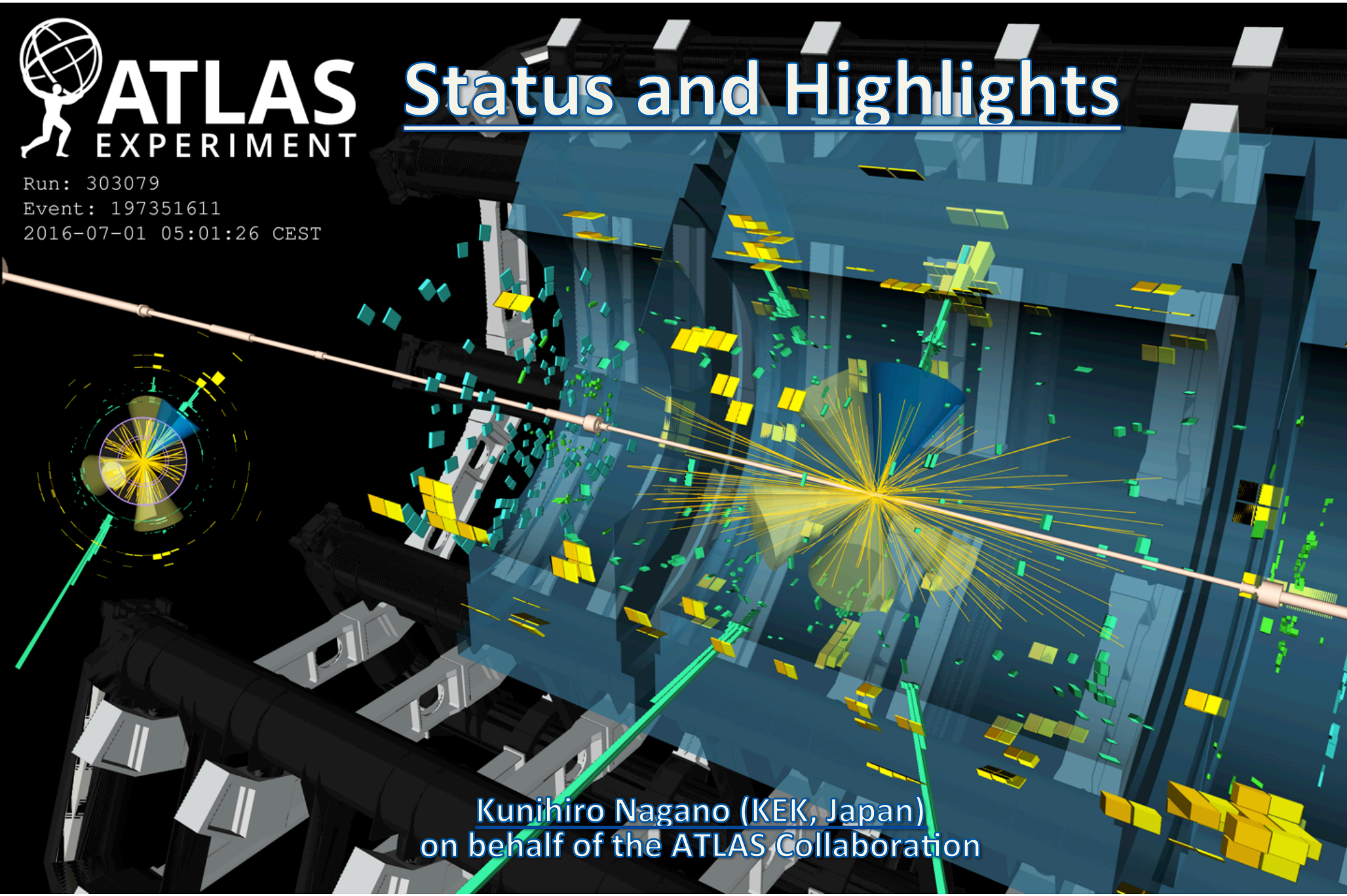
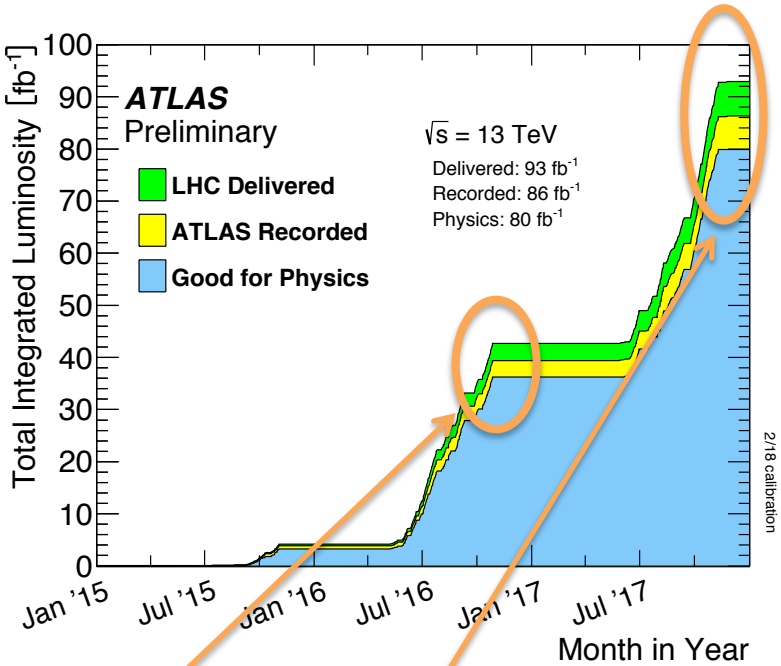


Status and Highlights

Kunihiro Nagano (KEK, Japan)
on behalf of the ATLAS Collaboration

ATLAS @ 13 TeV – in a nutshell

- Excellent data taking efficiency and excellent data quality. Up to 2017:
  - -- Delivered: ~93 fb^{-1}
  - -- Recorded: ~86 fb^{-1}
    - * Reflects DAQ inefficiency as well as HV ramp-up time after stable beam
  - -- Good for physics: ~80 fb^{-1}
    - * All reconstructed physics objects to be of good data quality



- ATLAS strategy on 13 TeV p-p data analysis
  - -- Completing ~36 fb^{-1} analyses (2015-2016 data)
  - -- Update with ~80 fb^{-1} (2015-2017 data) for some high priority analyses, to be followed up (e.g. excesses in ~36 fb^{-1} data), with new method, etc
  - -- Final and legacy papers with full Run-2 data set

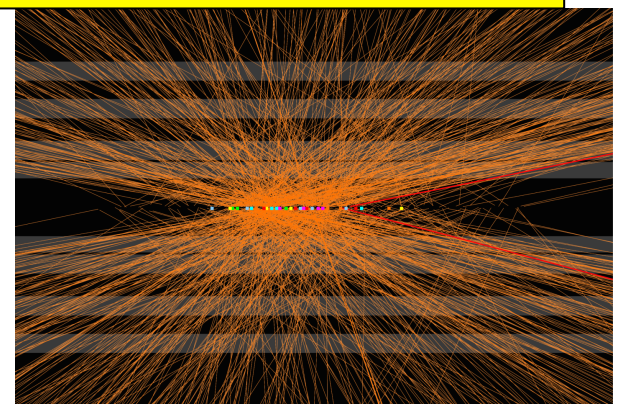
ATLAS expresses deep thanks to the CERN accelerator teams for their tremendous efforts and successes in providing these high statistics data sets!

Challenges

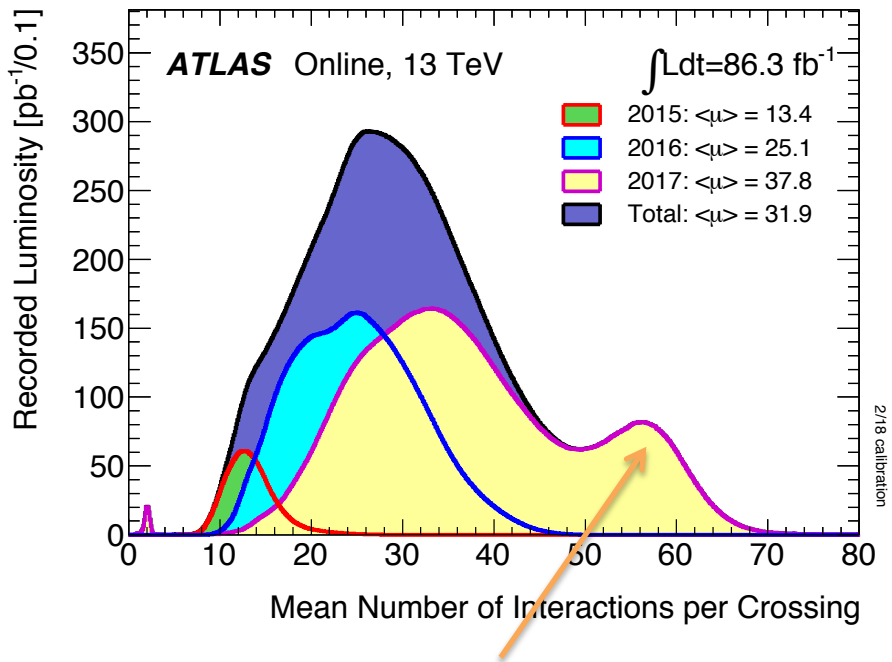
- A big experimental challenge in particular in 2017 data is pileup
  - -- Multiple p-p interactions occur in a same bunch crossing, which cause for instance:
    - * Multiple vertices, many low p_T tracks
    - * Underlying energy deposits in calorimeter
  - -- Detector and data taking challenges
    - * Trigger rates, processing computing power, detector read-out with large occupancy

➔ Continuous efforts in detector sub-systems to improve data taking stability led to a success of smooth operation up to <μ>~60

Z→μμ with 28 vertices (2018 data!)



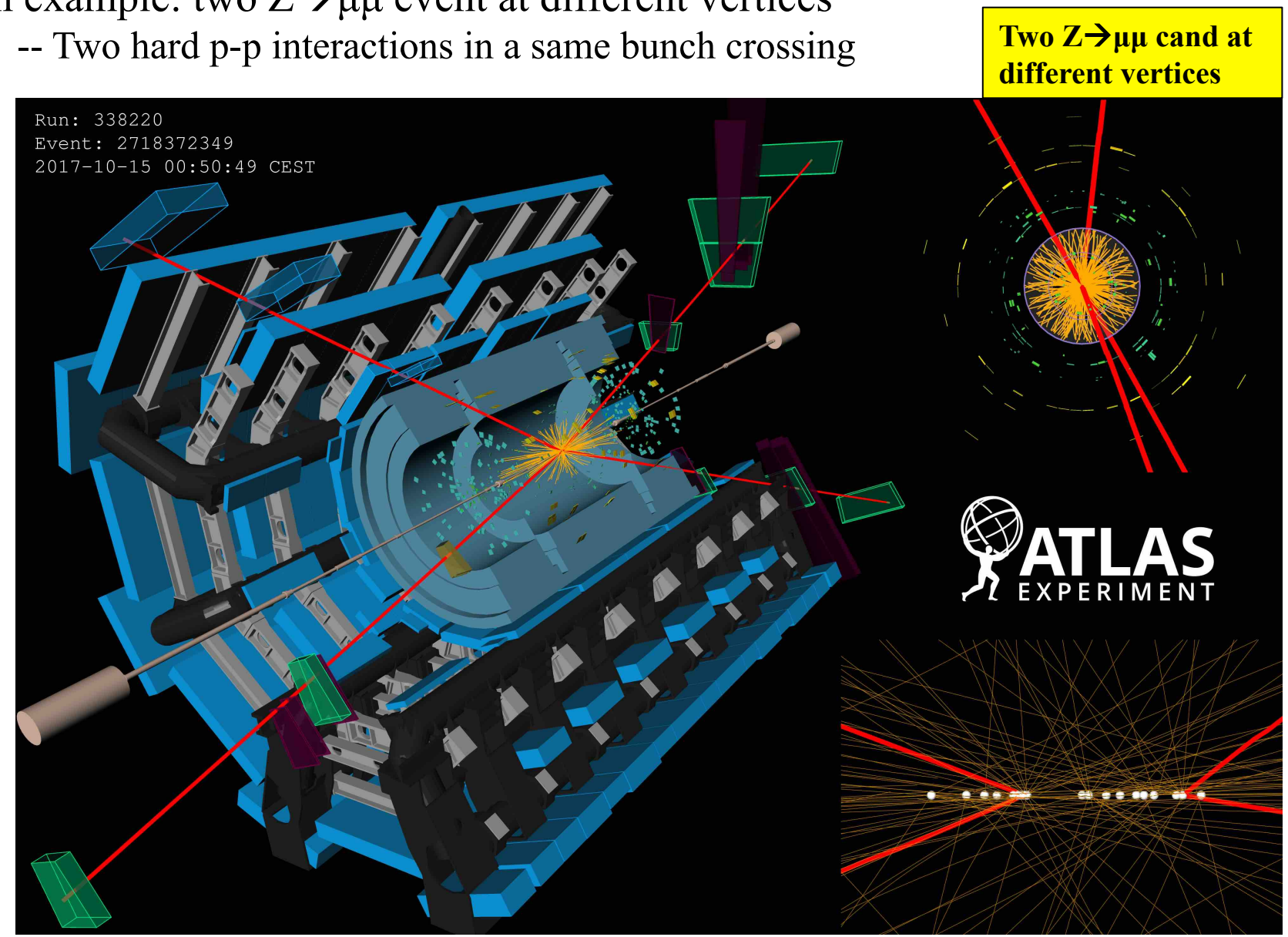
Mean number of interactions per LHC bunch crossing (<μ>)



For 2017 runs, Luminosity leveling requested at <μ>~58 (corresponding to L=1.5x10 ^{34}cm^{-2}s^{-1} with "8b4e" filling scheme) in order to avoid unnecessary impact to data taking and quality

Challenges

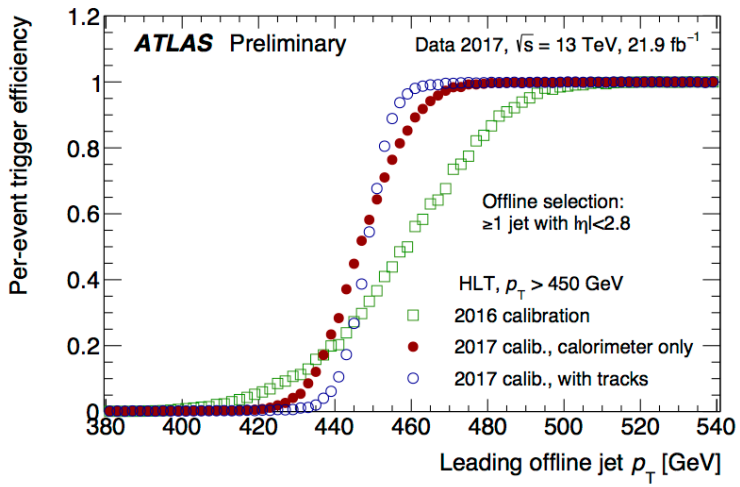
- An example: two Z→μμ event at different vertices
  -- Two hard p-p interactions in a same bunch crossing



Trigger and Trigger-Level Analysis

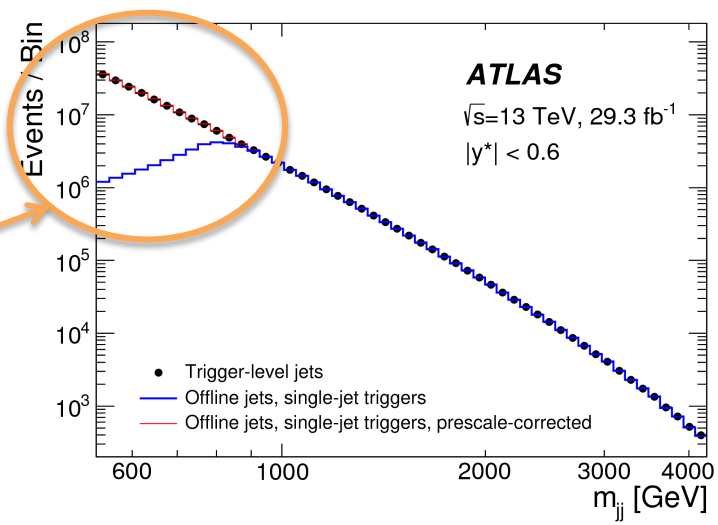
- Trigger
  - -- Hardware topological trigger processor at Level-1 actively used for physics
  - -- Continuous improvements following state-of-the-art offline algorithms
  - -- Menu consists of ~2000 triggers, comprehensively covering the wide physics program
    - * Low threshold inclusive triggers maintained:
      - -- Single e/μ with p_T>26 GeV
      - -- E_T^{miss} > 110 GeV

Jet trigger efficiency



- Physics analysis at trigger level
  - -- Search for di-jet resonances at sub-TeV using trigger-level object
    - * Overcoming bandwidth limitation by recording only trigger jet information

Di-jet mass distribution



Making full use of Trigger and DAQ resources and bandwidths to maintain and improve ATLAS physics sensitivity

arXiv:1804.03496
submitted to PRL
https://arxiv.org/abs/1804.03496

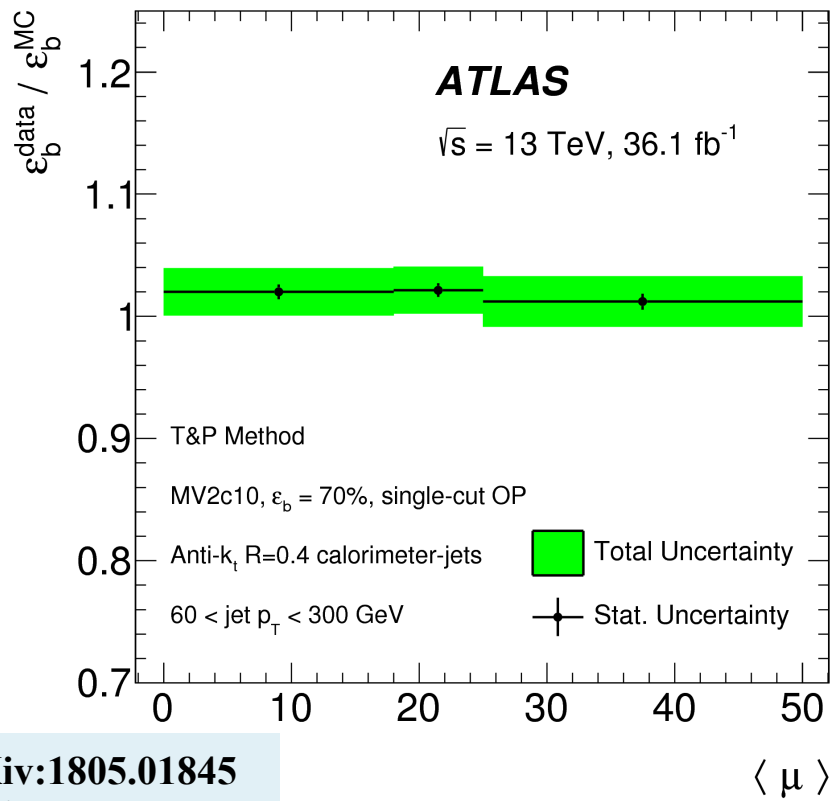
Parallel Talks on Fri:
- S. Souza, K. Pachal,
- N. Styles, C. Gallioni

Reconstruction performance

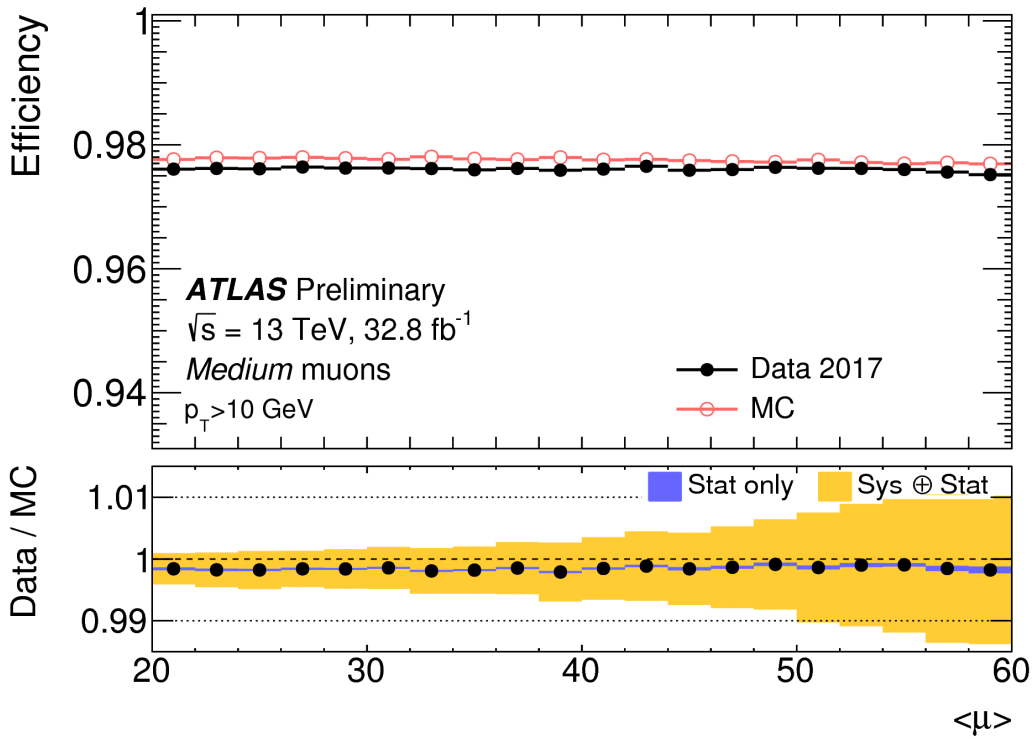
- Converging toward ultimate and final precision Run-2 reconstruction
  -- Improved in-situ calibration (more data and better methods)
  -- Improved tuning/optimizations to mitigate pileup impact on performance
  -- New working points/optimizations for corner phase spaces, e.g. very low and high p_T

NEW

Data / MC for b-tag efficiency vs. <μ>



Muon efficiency vs. <μ>



arXiv:1805.01845
submitted to JHEP
https://arxiv.org/abs/1805.01845

For 2017 specific: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ResultswithData2017

Physics Highlights

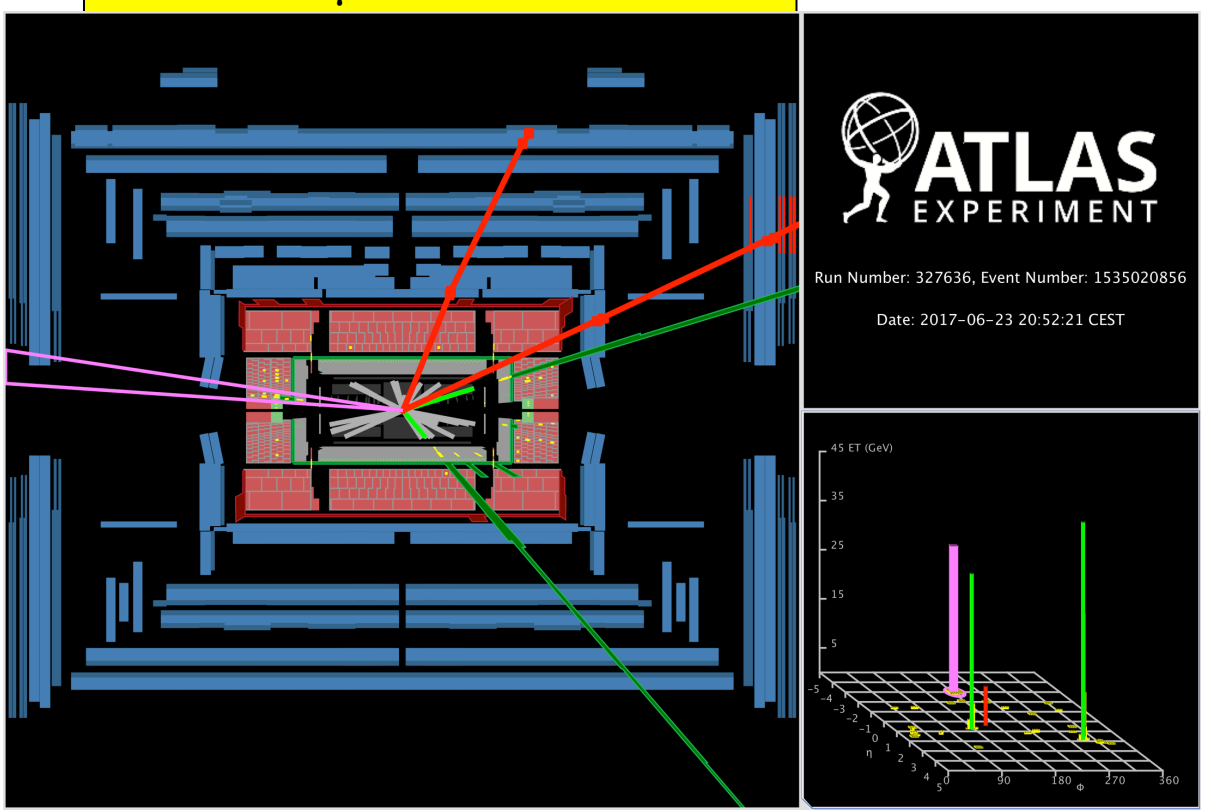
- In this talk: highlights only with focus on
  - -- Final results ~36 fb^{-1} shown new today 

  - -- Brand-new results ~36 fb^{-1} 

  - -- Brand-new results ~80 fb^{-1} 

Most of the results shown today are new for LHCP!

H→ZZ→ 2e2μ candidate in 2017 data

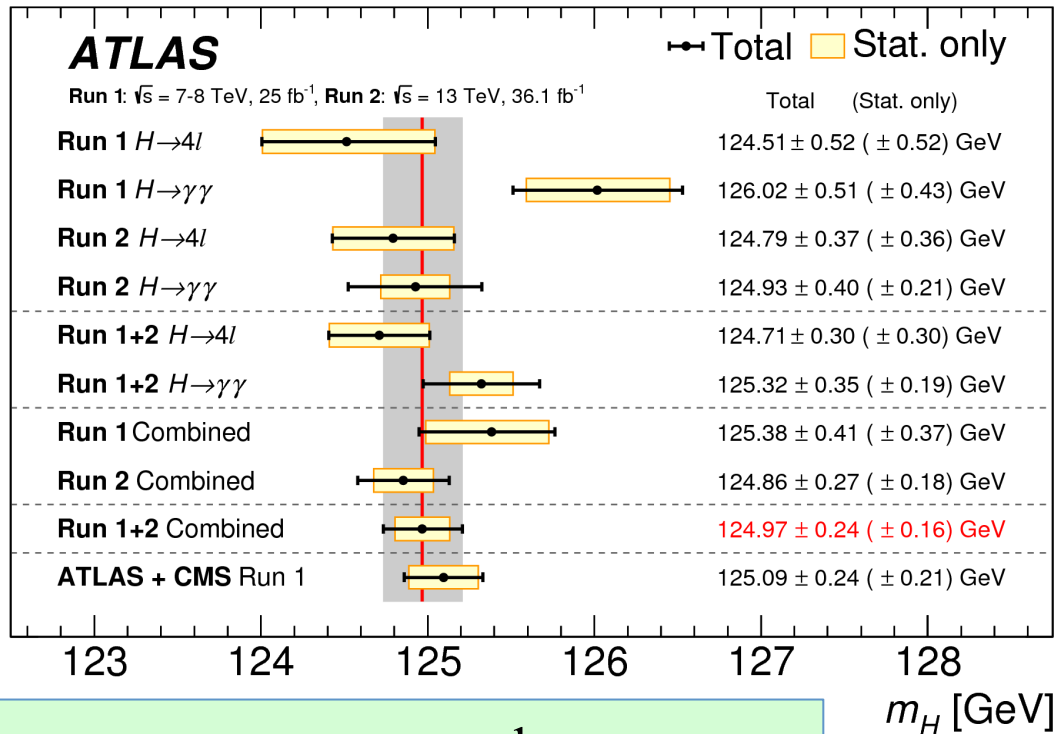


Talk today: Y. Huang

NEW

Higgs boson mass

- Higgs mass measured in H→γγ and ZZ channels
  -- Final 36.1 fb^{-1} result presented



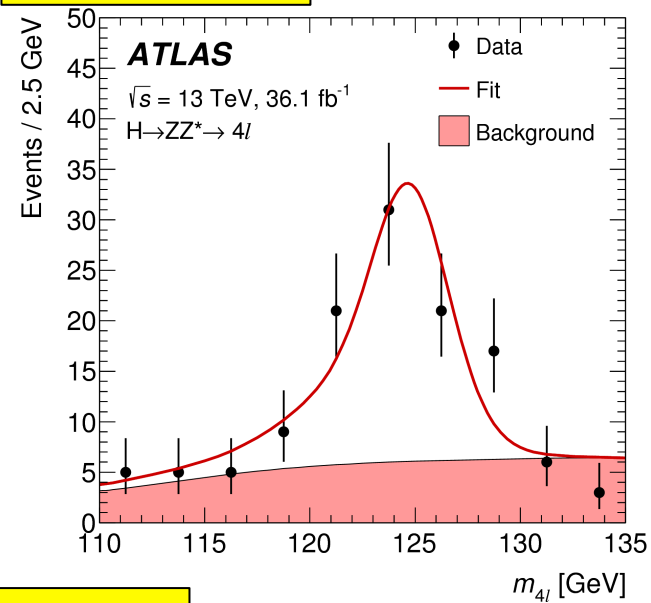
Higgs mass was measured as

$$m_H = 124.97 \pm 0.24 \text{ GeV}.$$

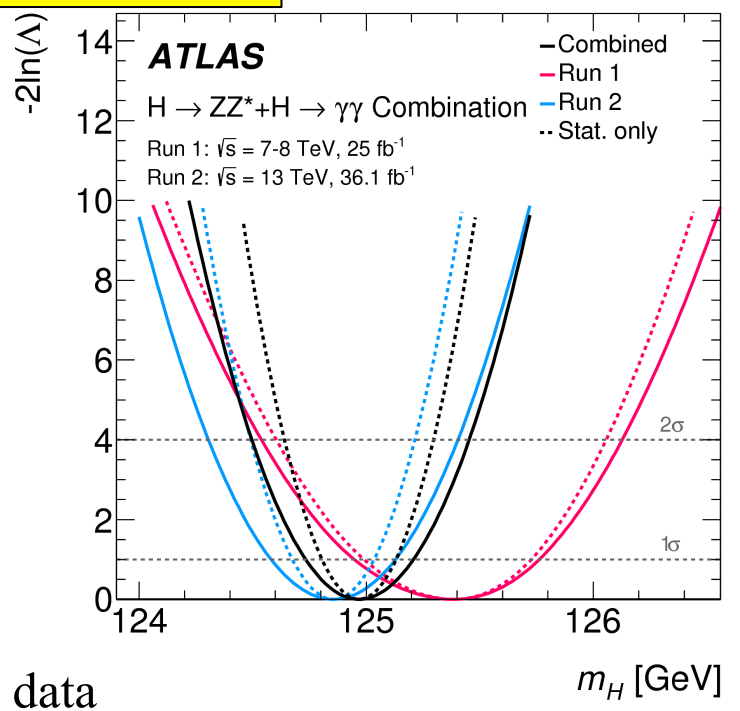
by combining Run-1 and Run-2.

Precision is still limited by statistical uncertainty.
→ Prospect more precise determination with full Run-2 data

4lepton mass



-2ln(λ) Run1/2

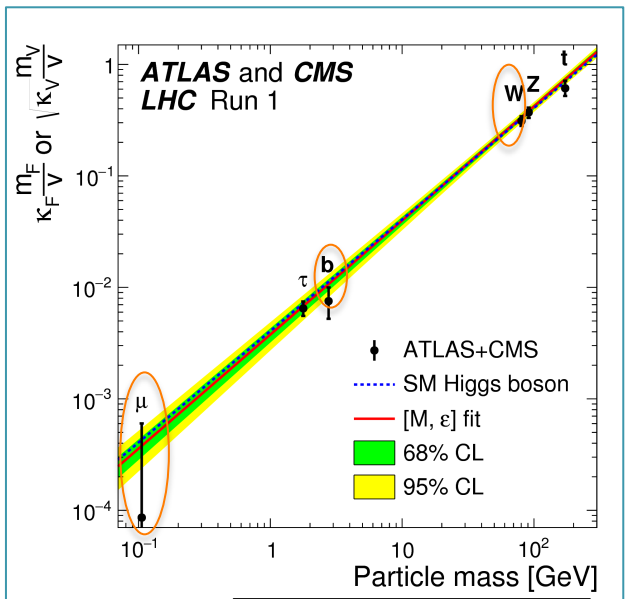


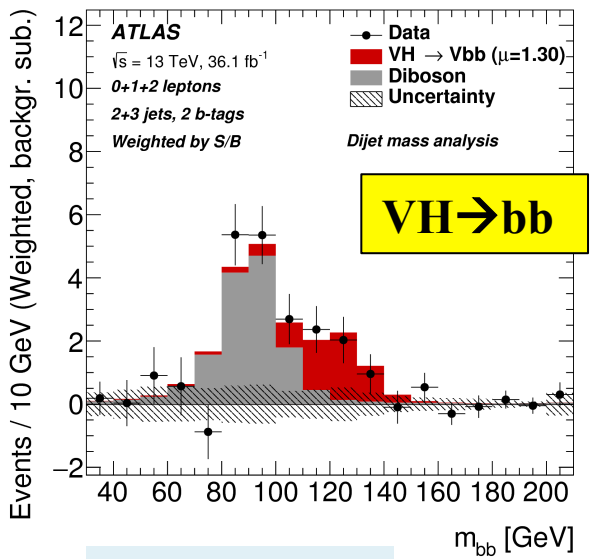
arXiv:1806.00242 https://arxiv.org/abs/1806.00242

Reminder on recent Higgs results

- H→WW, bb, cc, μμ, … results with 36.1 fb^{-1}
  -- H→ WW result first shown at 2018 winter conferences

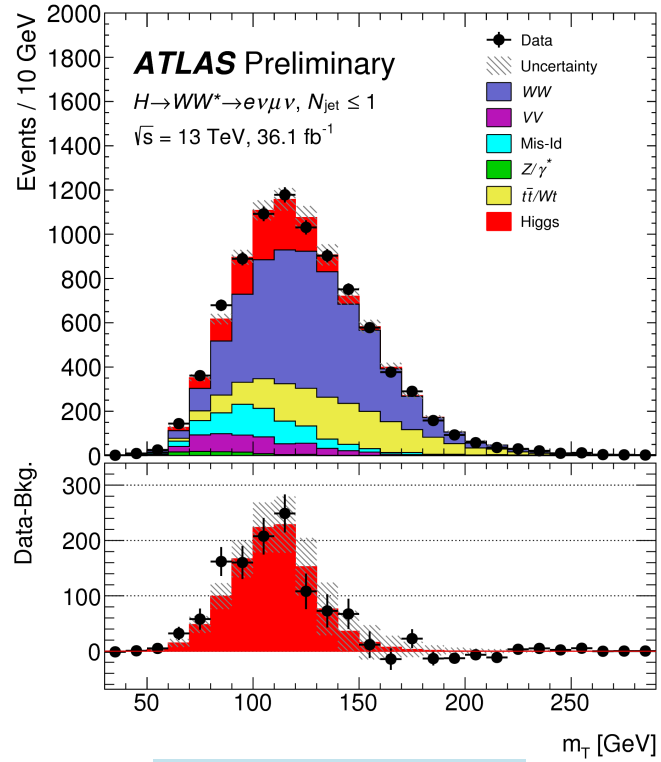
H→WW





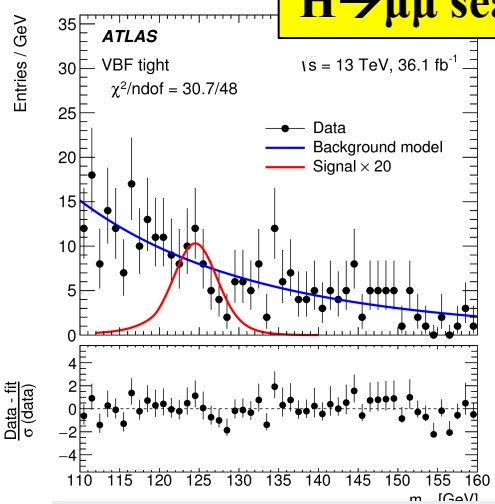
VH→bb

[JHEP 12 (2017) 024]

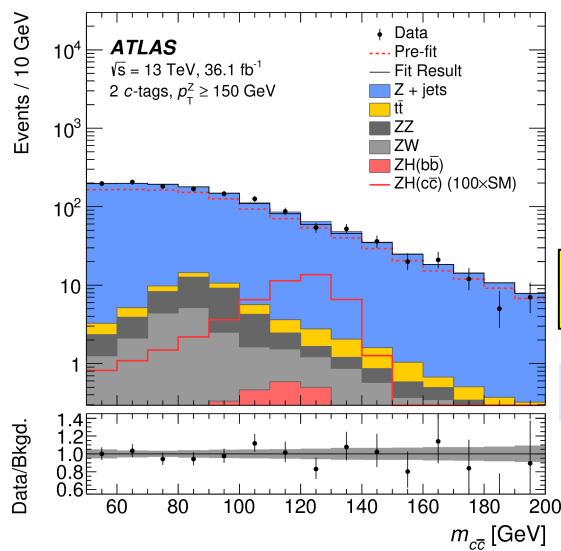


[ATLAS-CONF-2018-004]

H→μμ search



[Phys. Rev. Lett. 119 (2017) 051802]



H→cc search

[Phys. Rev. Lett.120, 211802 (2018)]

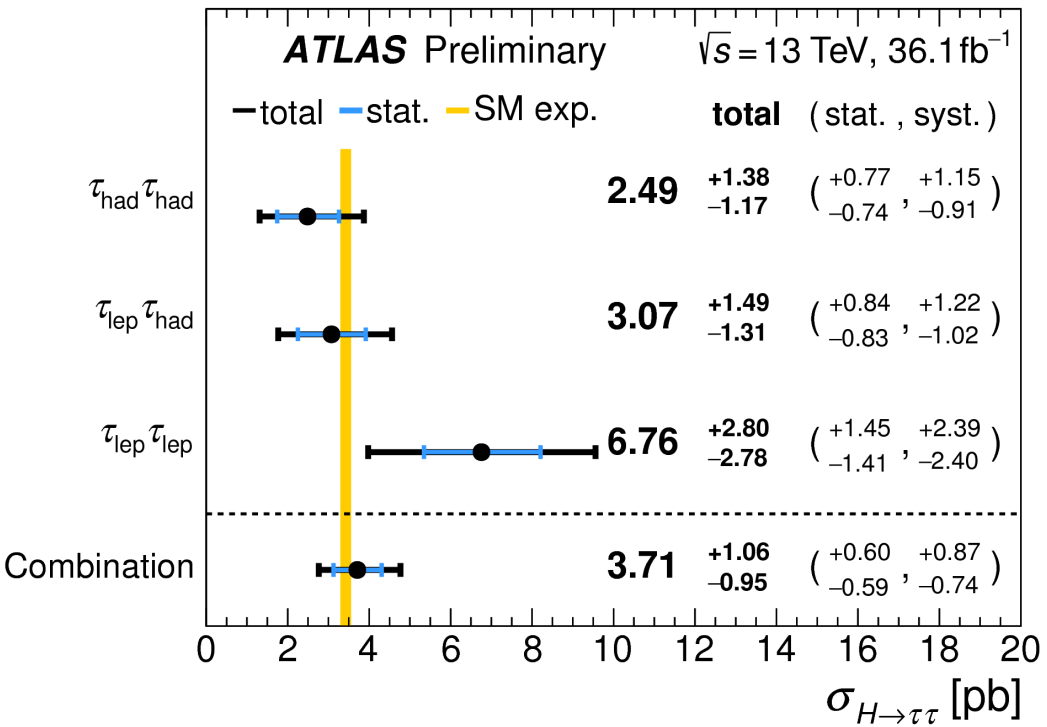
NEW

ATLAS-CONF-2018-021

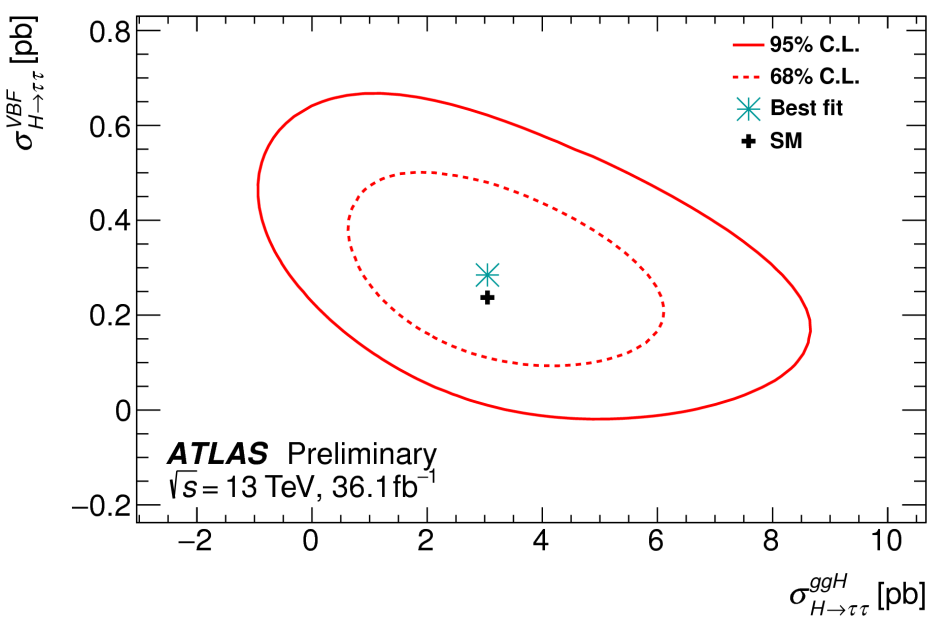
H→ττ @ 13 TeV

- Reminder: Run-1 ATLAS data alone: 4.5 σ significance (3.4 σ expected)
- New today at LHCP: cross section measurement with Run-2 36.1 fb^{-1}
  -- VBF and boosted (mostly ggF) categories with 3 decay channels

Measured / SM cross section



VBF vs. ggF cross section



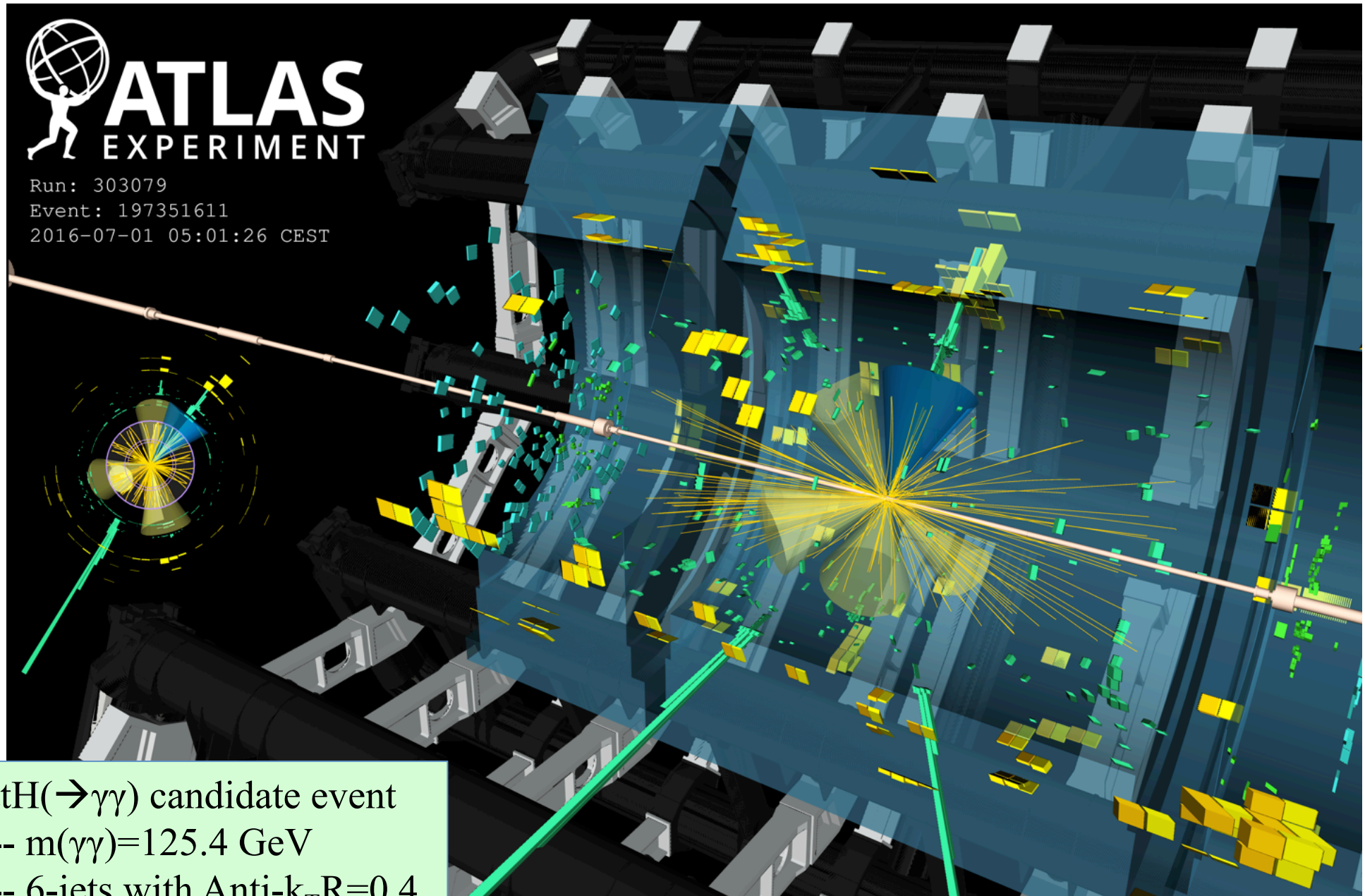
$$\sigma^{\mathrm{ggH}}_{\mathrm{H}\to\tau\tau} = 3.0 \pm 1.0\,(\mathrm{stat.})^{+1.7}_{-1.3}(\mathrm{syst.})\ \mathrm{pb}$$

$$\sigma^{\mathrm{VBF}}_{\mathrm{H}\to\tau\tau} = 0.28 \pm 0.09\,(\mathrm{stat.})^{+0.11}_{-0.09}(\mathrm{syst.})\ \mathrm{pb}$$

The measured cross sections agree with SM prediction

Combined Run-1 and Run-2 significance: 6.4 σ (5.4 σ expected)

Higgs production associated with a top quark pair



ttH(→γγ) candidate event
-- m(γγ)=125.4 GeV
-- 6-jets with Anti-k_TR=0.4,
incl one b-tagged jet

Talk today: C. Grefe
Parallel talk today:
- J. Jovicevic

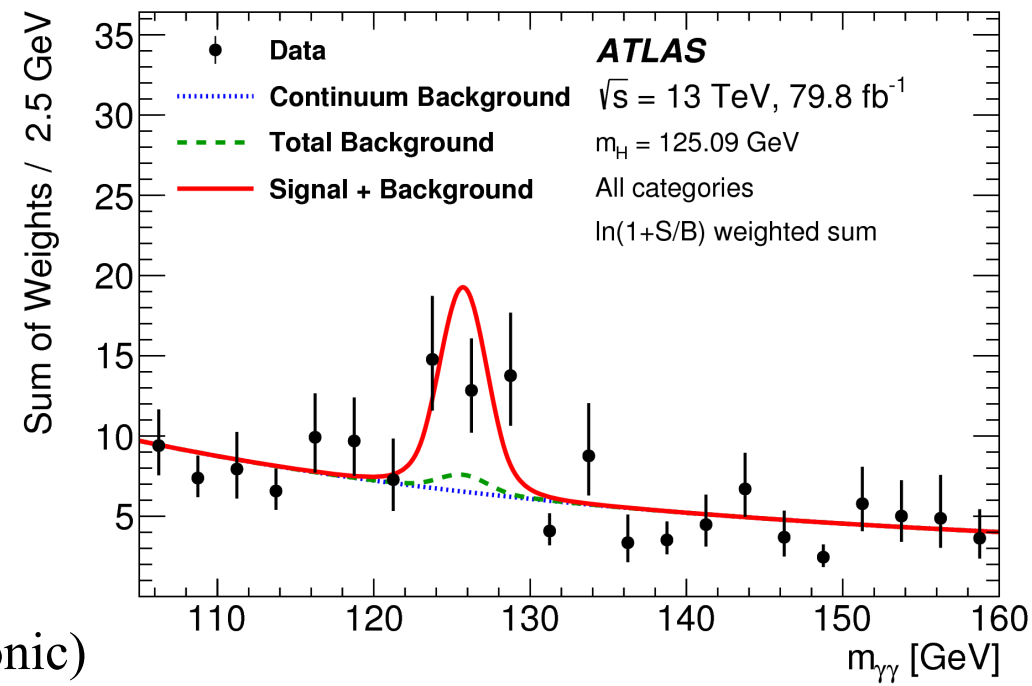
Higgs production associated with a top quark pair

- Reminder -- evidence with 36.1 fb^{-1} in ttH($\tau\tau$, $\gamma\gamma$, bb, VV) released for publication on Dec 24 last year: 4.2 σ observed (3.8 σ expected)
  Phys. Rev. D 97, 072003 (2018) https://doi.org/10.1103/PhysRevD.97.072003
- New today at LHCP: update with 79.8 fb^{-1} for ttH($\gamma\gamma$, ZZ→4l)

- ttH($\gamma\gamma$) with 79.8 fb^{-1} HOT!
  -- Increased sensitivity by analysis improvements e.g:
  * Multi-variate analysis utilizing γ and jet kinematic properties

- ttH(ZZ→4l) with 79.8 fb^{-1} HOT!
  -- Improved sensitivity by analysis improvements e.g.
  * Separate leptonic and hadronic categories with BDT (for hadronic)
  -- No event was observed

$\gamma\gamma$ mass with 79.8 fb^{-1} HOT!



* Zero events found for 0.45 total expected (0.38 ttH) in the purest Lep and Had categories

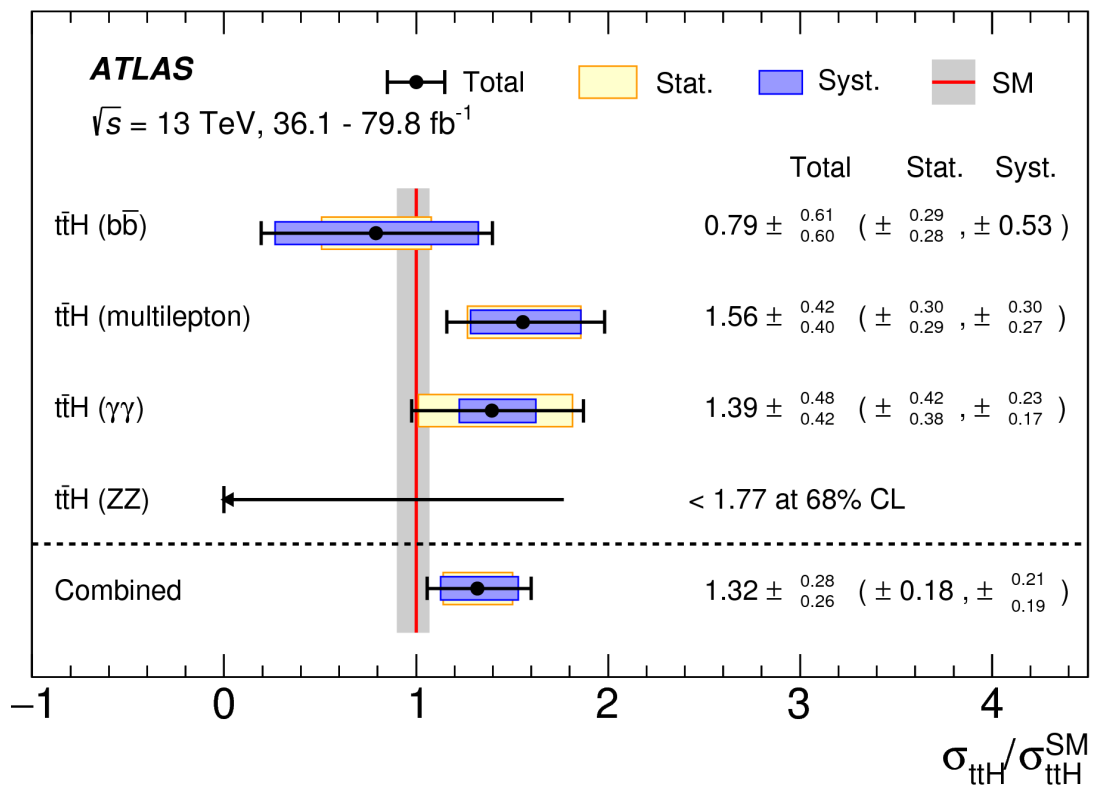
Talk today: C. Grefe
Parallel talk today:
- J. Jovicevic

HOT!

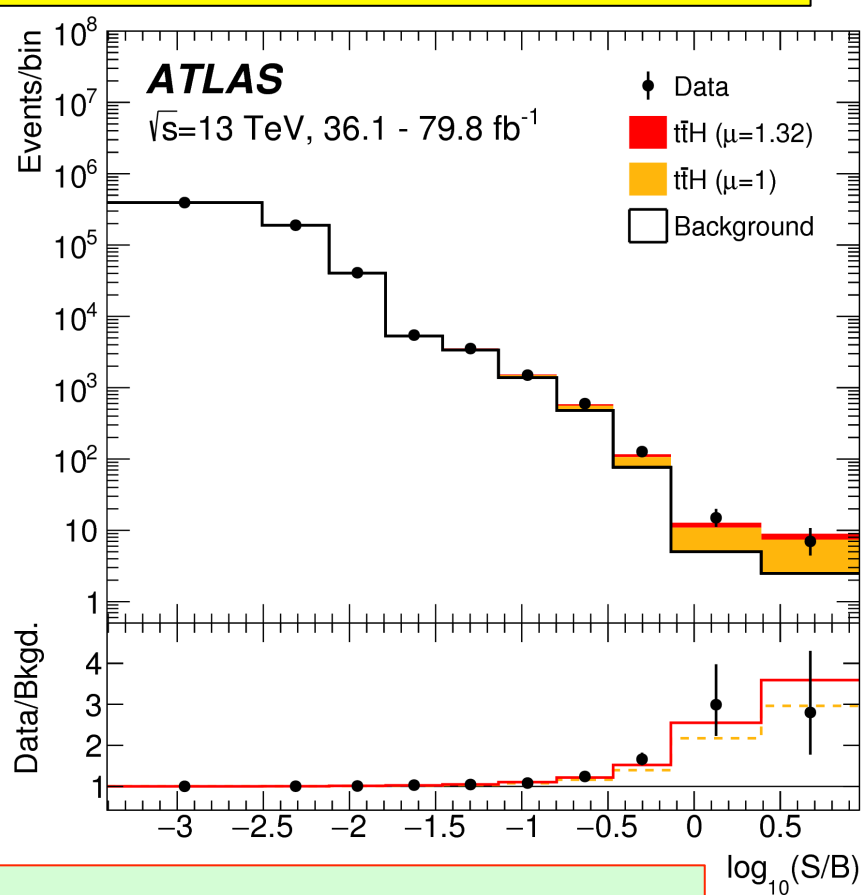
ttH with 36.1-79.7 fb^{-1}

- 79.8 fb^{-1} ttH($\gamma\gamma$,ZZ→4l) result was combined with 36.1 fb^{-1} ttH(bb,multi-lepton), as well as with the Run-1 result

ttH measured / SM cross section



Event yield as a function of log10(S/B)



Observation of ttH production with:
-- Run-2 alone: 5.8 σ significance (4.9 σ expected)
-- Run-1 and Run-2 combined: 6.3 σ significance (5.1 σ expected)

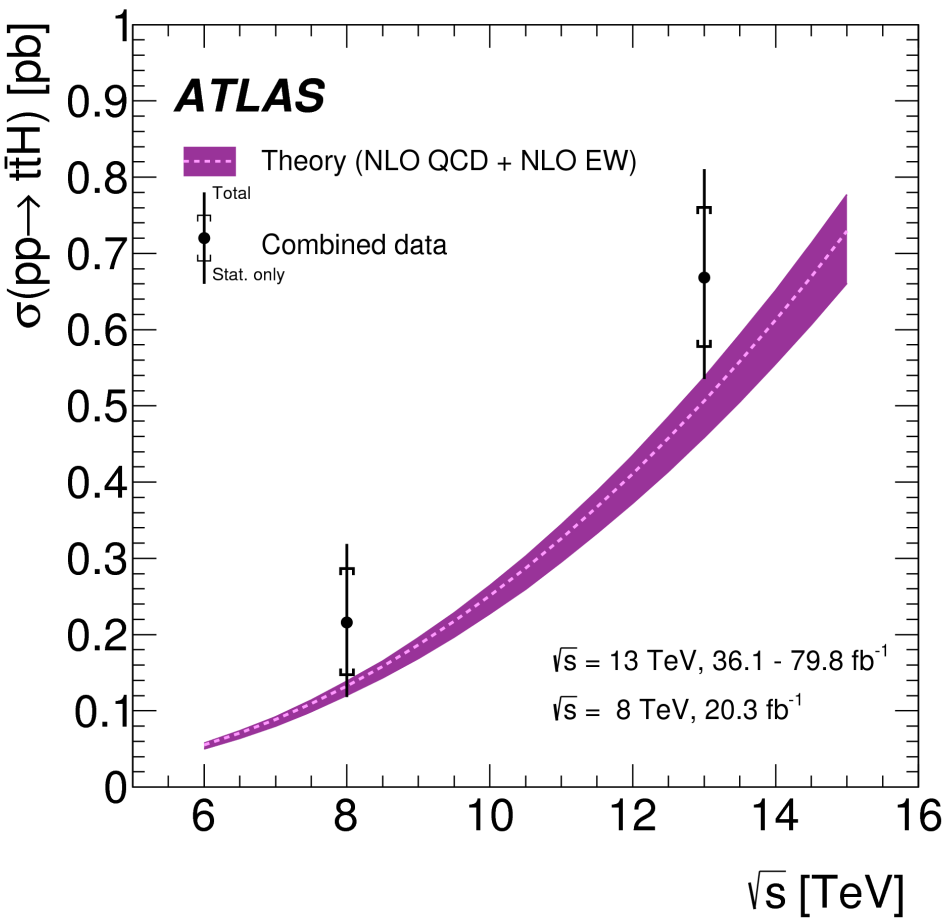
Talk today: C. Grefe
Parallel talk today:
- J. Jovicevic

HOT!

ttH cross section

- The cross section was measured both for 8 TeV and 13 TeV

ttH cross section vs. √s



The measured cross section at 13 TeV is:

$$\sigma_{ttH} = 670 \pm 90(stat)^{+110}_{-100}(sys) \text{ fb}$$

in agreement with SM prediction of 507^{+35}_{-50} fb

The measured cross section at 8 TeV is:

$$\sigma_{ttH} = 220 \pm 100(stat) \pm 70(sys) \text{ fb}$$

in agreement with SM prediction of 133^{+8}_{-13} fb

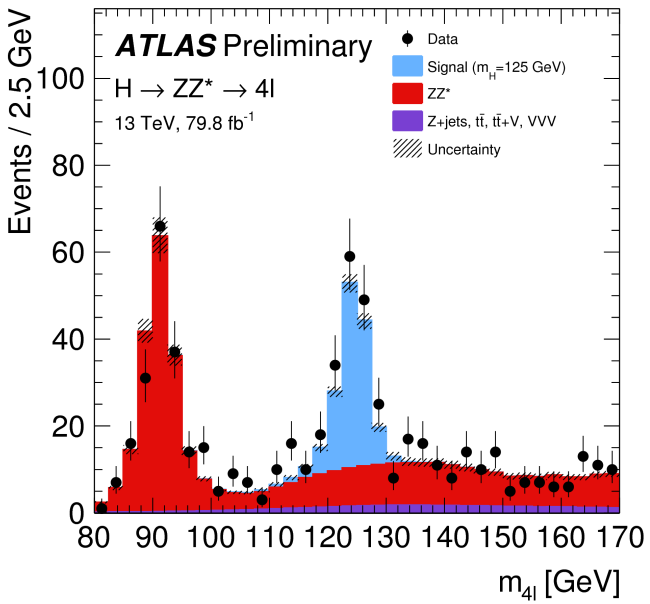
arXiv:1806.00425
https://arxiv.org/abs/1806.00425

HOT!

ATLAS-CONF-2018-018

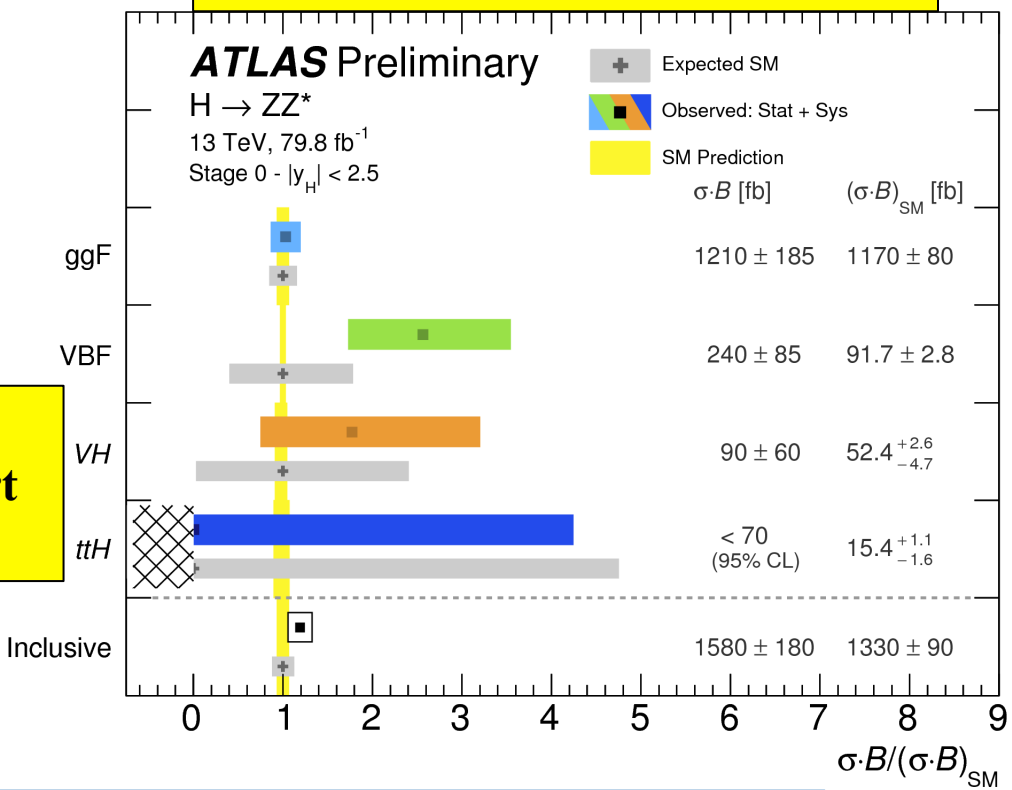
H→ZZ→4l cross section with 79.8 fb^{-1}

4l mass

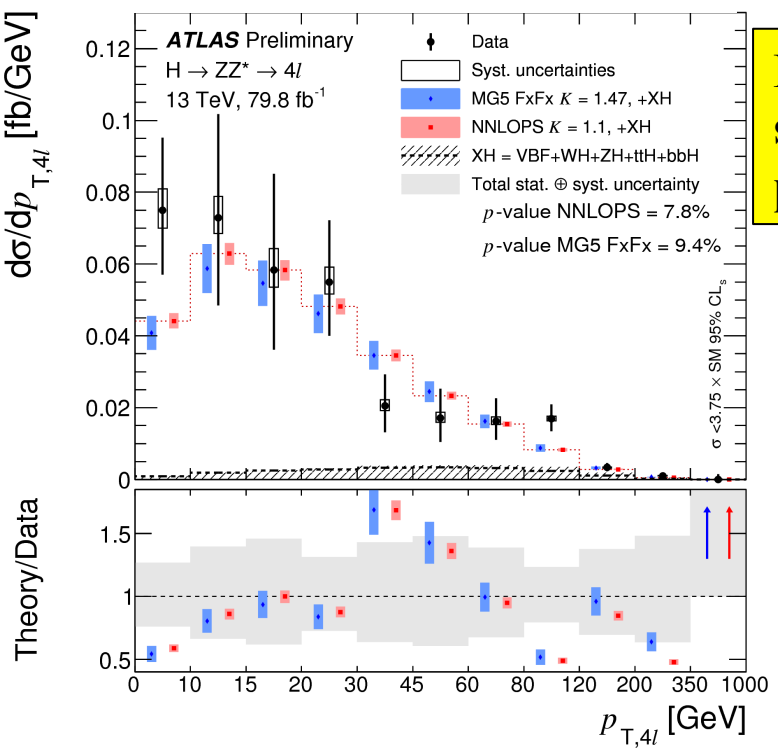


- Measured in the framework of the Simplified Template Cross Sections

Cross section measured / SM



Diff. cross section wrt p_T 4l



The inclusive cross section with $|y_H| < 2.5$ was measured as:

$$\sigma \cdot \mathcal{B}(H \rightarrow ZZ^*) = 1.58 \pm 0.18 \text{ pb}$$

and in agreement with SM (1.33 ± 0.09 pb)

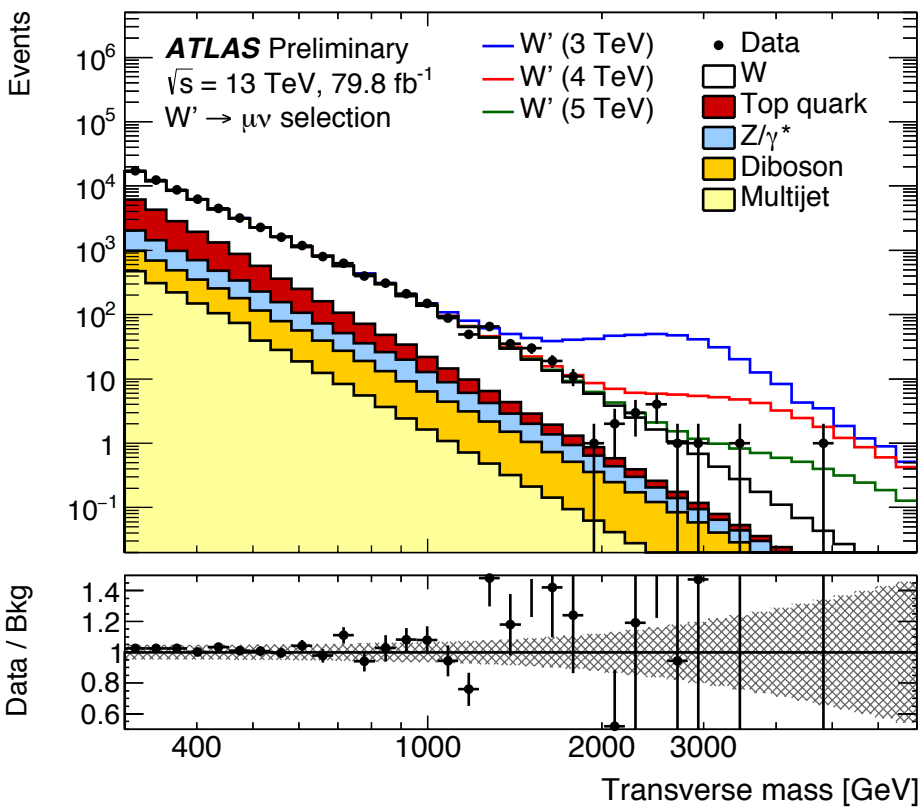
Talk on Thu: G.Facini
Parallel Talk today:
- Y. Okumura

Resonance search with high p_T lepton with 79.8 fb^{-1}

HOT!

- W' → e/μ + ν search
  -- lepton + E_T^{miss}

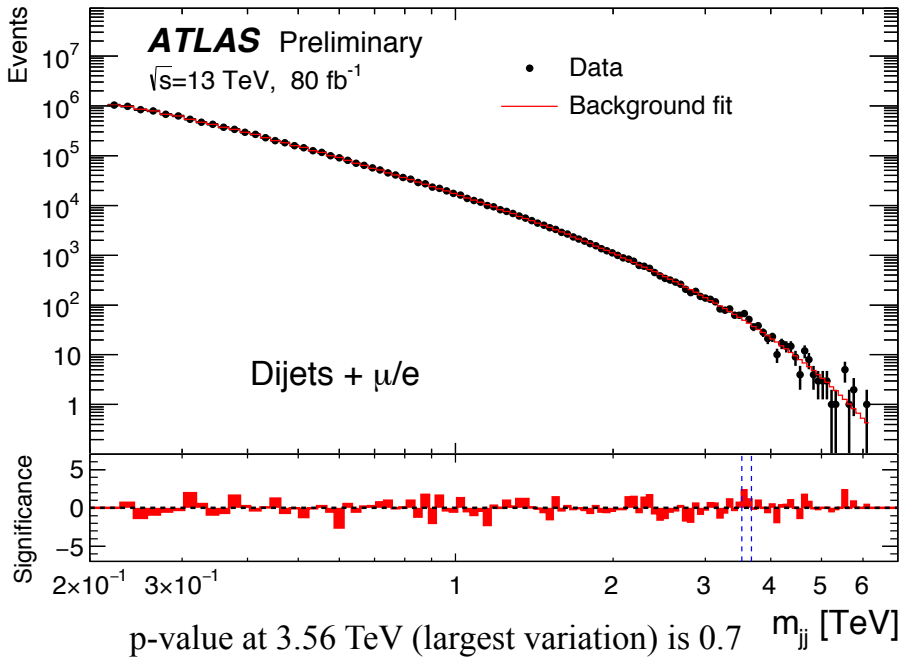
Transverse mass for W'→μν



W' in context of sequential SM excluded up to 5.5 TeV
-- Extended from 5.2 TeV (~36.1 fb^{-1})

- Di-jet resonance pp→WX search
  -- lepton + di-jets
  -- New topology search

m(j,j)



p-value at 3.56 TeV (largest variation) is 0.7 including look-else-where effect

95% CL exclusion of σ x A x ε:
* 50 fb – 0.1 fb, for masses 0.25 – 6 TeV

ATLAS-CONF-2018-015

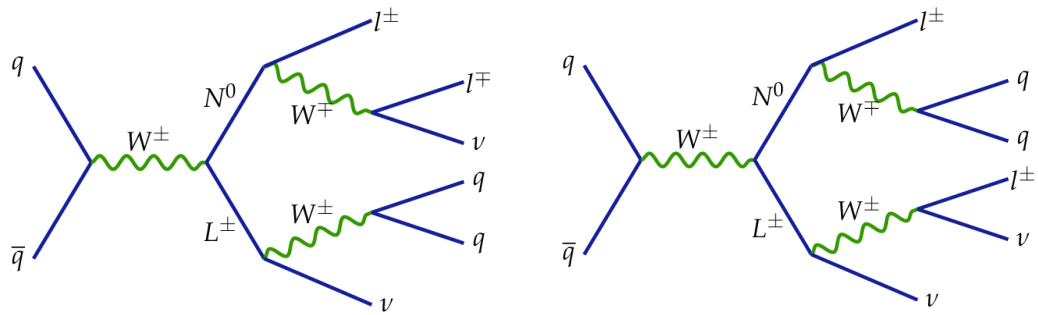
ATLAS-CONF-2018-017

Talk on Thu: G.Facini
Parallel Talk today:
- Y. Okumura

Type-III seasaw heavy lepton search with 79.8 fb^{-1}

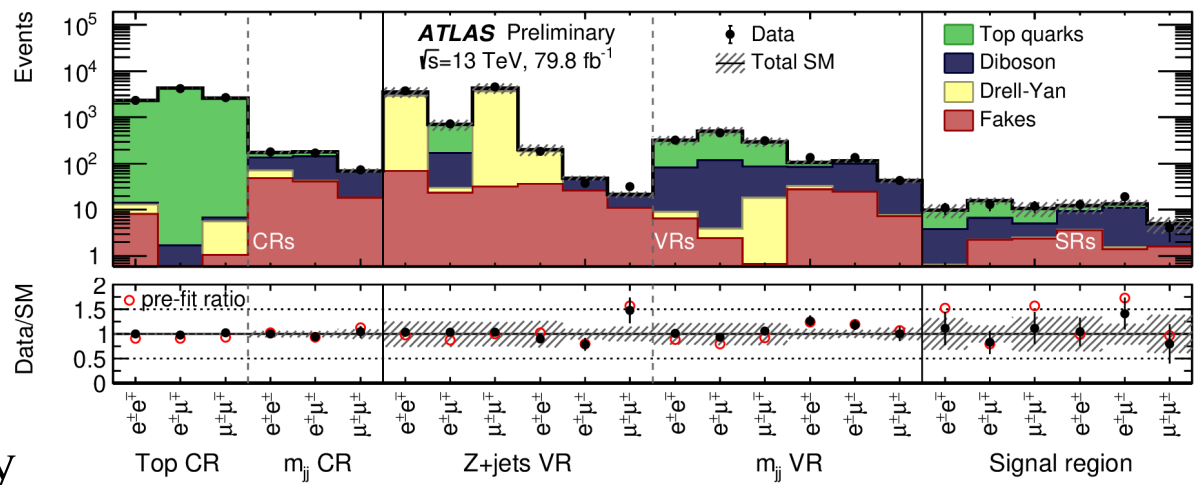
HOT!

- Reminder -- in Run-1 probed 2l+2j(W)+E_T^{miss} and 3l final states
  -- 95% CL exclusion < 330 GeV



- New today at LHCP:
  search in Run-2 data with 79.8 fb^{-1}
  -- Pair production of heavy leptons (N^0, $L^{\pm}$)
  -- 2l+2j(W)+E_T^{miss}, classified into 6 categories (lepton flavour, charge)
  -- Signal region selection optimized for each category

Nr of events in each category



95% CL exclusion up to 560 GeV for mass of heavy lepton
-- Under assumption of equal BRs to all leptons, and that neutral and charged heavy leptons are mass-degenerate

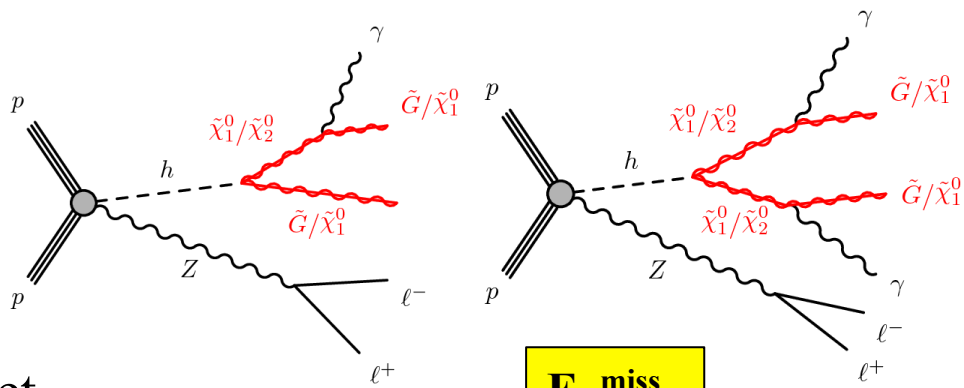
ATLAS-CONF-2018-020

HOT!

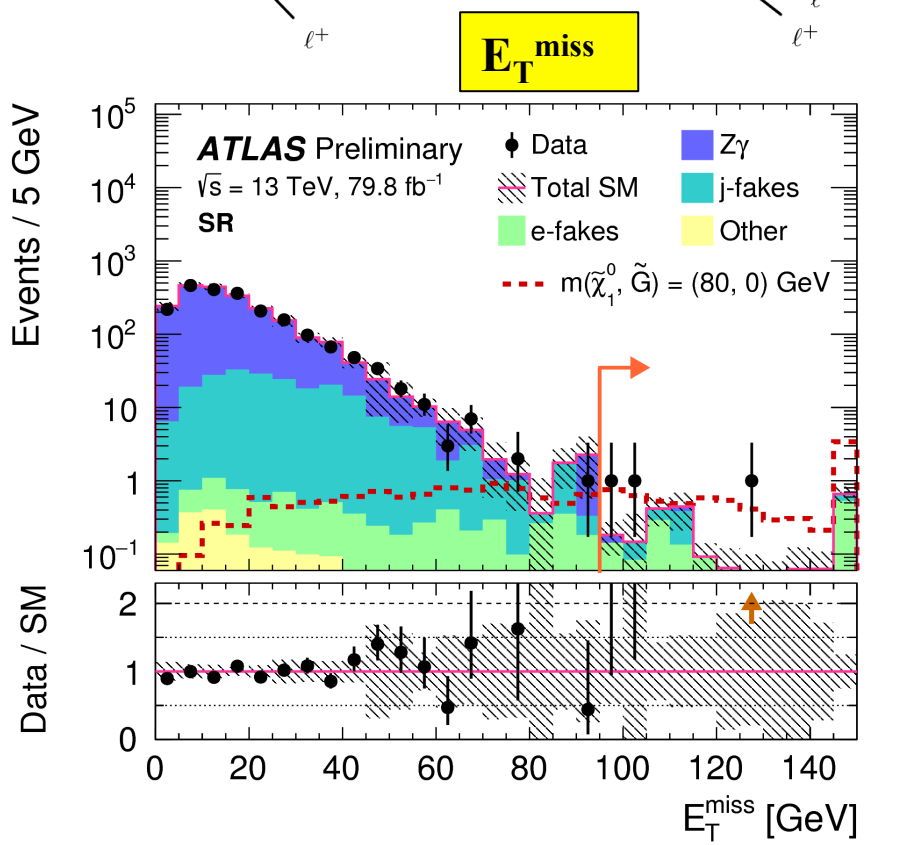
Parallel Talk on Wed: A. Haas

Exotic Higgs decay search: H→γ(γ)+E_T^{miss} with 79.8 fb^{-1}

- A hypothesis to explain such final state SUSY
- Reminder -- in Run-1 probed VBF production (γ+ E_T^{miss}+2j).
  -- Although a slight excess observed, 95% CL exclusion for Higgs BF was set



- <u>New today at LHCP: search in Run-2 data with 79.8 fb^{-1}</u>
  -- Consider associated production with Z, to reduce backgrounds
  -- Backgrounds dominated by photon fakes (e, jets) which are well controlled and validated at CRs



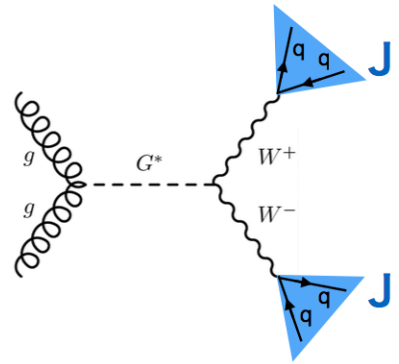
95% CL limit on Higgs BF to γ(γ) +E_T^{miss}
5-18% depending on NLSP and LSP masses
-- 11 (18)% for massless (massive) gravitino

No significant evidence beyond SM observed
-- 3 events observed in SR
(2.1 events expected)

ATLAS-CONF-2018-019
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2018-019/

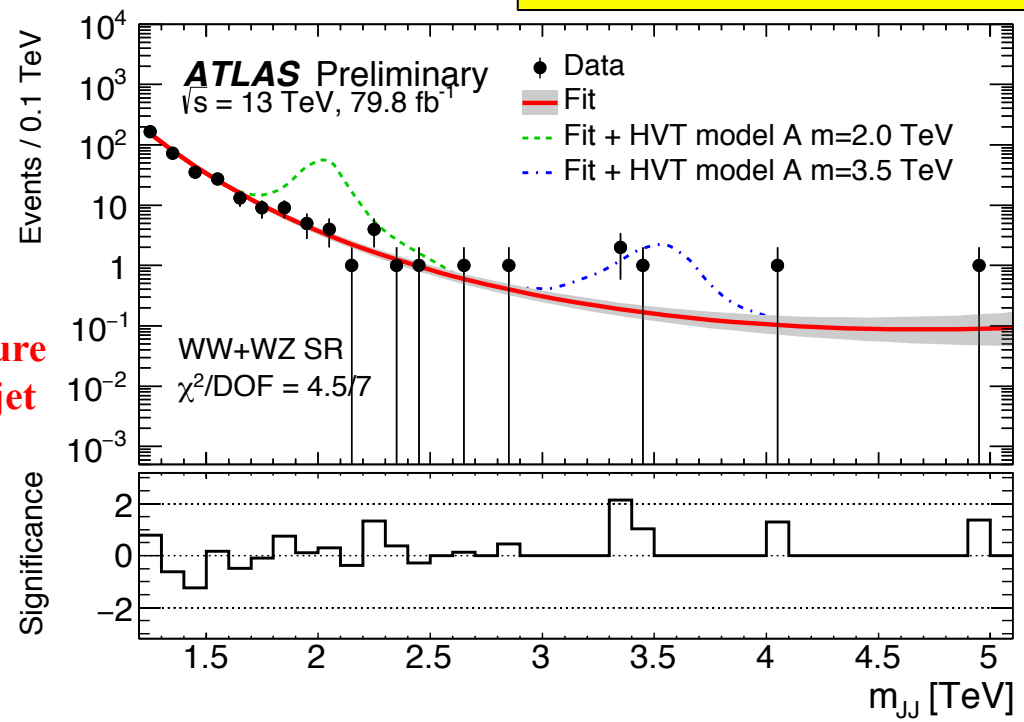
HOT!

Di-boson resonance search with 79.8 fb^{-1}

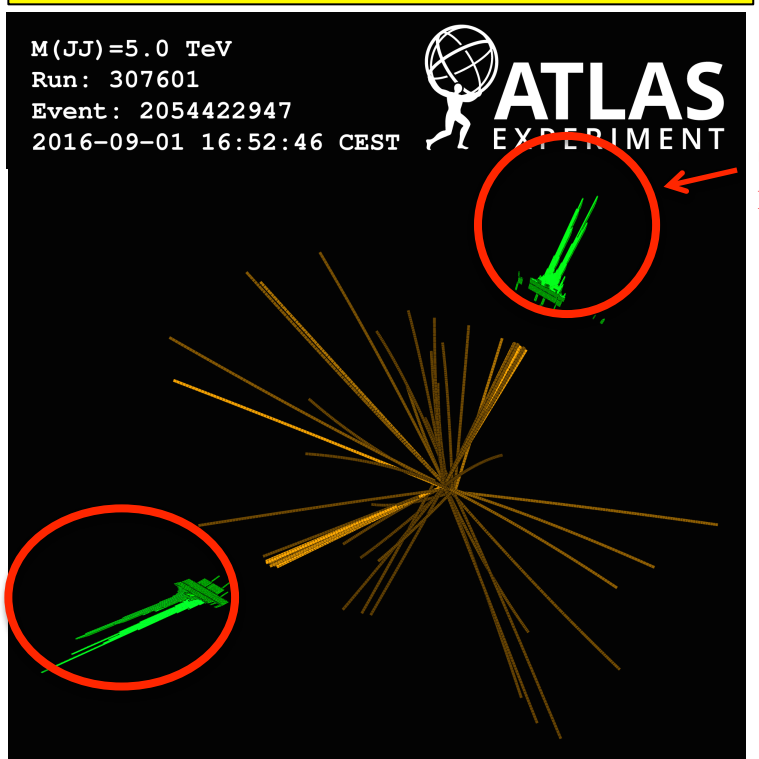


- Di-boson resonance in hadron decays, searched by using boosted object reconstruction with 79.8 fb^{-1}
  - -- Sensitivity improved by factor 2 (4) at mass=3 (5) TeV:
    - * Improved reconstruction by using large-R jet built from new unified object built from both tracking (for angle) and calorimeter (for energy)
    - * Tagger optimization at high p_T

M (J, J) for WW+WZ



Highest M (J, J)=5.0 TeV event



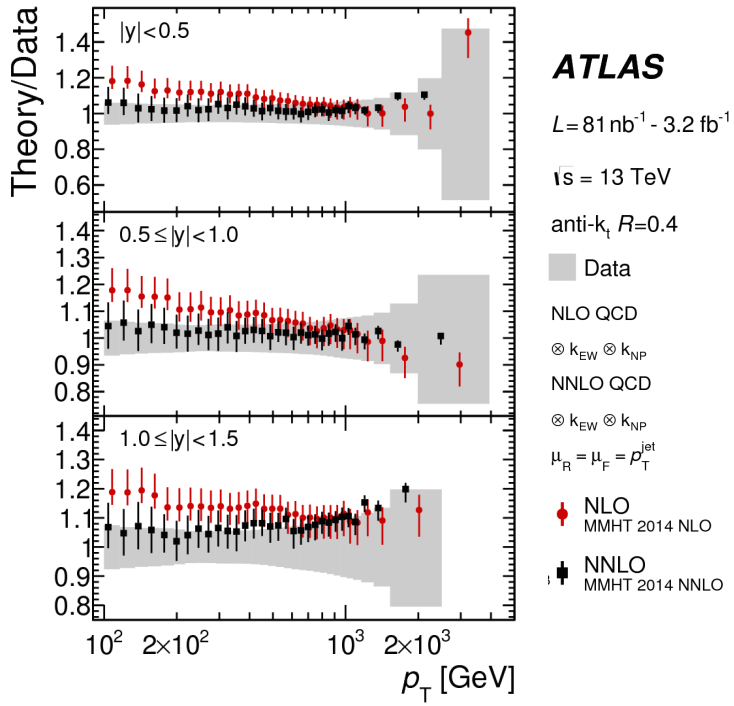
Sub-structure in large-R jet

95% CL limit for a benchmark of Heavy Vector Triplet model with g_v=3:
1.20 TeV < $m(V')$ < 4.15 TeV for WW+WZ

SM Physics

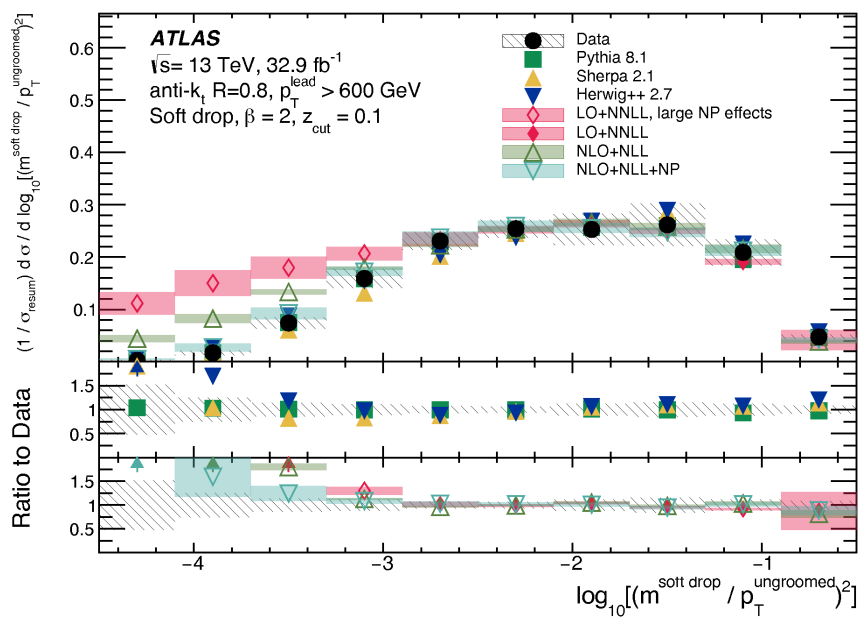
- High precision validation of SM
  - -- Inclusive jet production cross section is now compared with NNLO
    - * NNLO describes data if p_t^{jet} as QCD scale

arXiv:1711.02692
accepted by JHEP
https://arxiv.org/abs/1711.02692



- Jet-substructure validation: "soft-drop mass"
  - -- First jet substructure quantity at hadron colliders to be calculated beyond leading log (LL)
  - -- Measured with 32.9 fb^{-1} at 13 TeV

Calculations agree with data except for regions where non-pert. effect is large (where MC generators are better)



arXiv:1711.08341
submitted to PRL
https://arxiv.org/abs/1711.08341

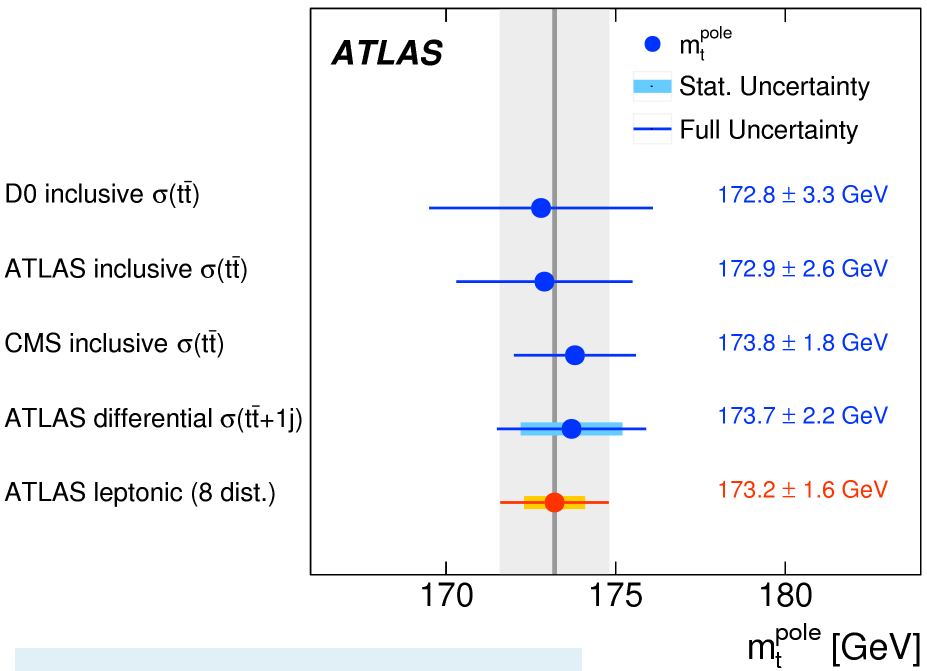
Talk on Fri: M. Vos
Parallel Talk on Thu:
- A. Knue, R. Sipio

Top Physics

- LHC is a top factory → precision cross section, mass measurements
  -- Rich variety of processes to study
    * tZ – evidence (4.2σ observed, 5.4 expected) with 36.1 fb^{-1}

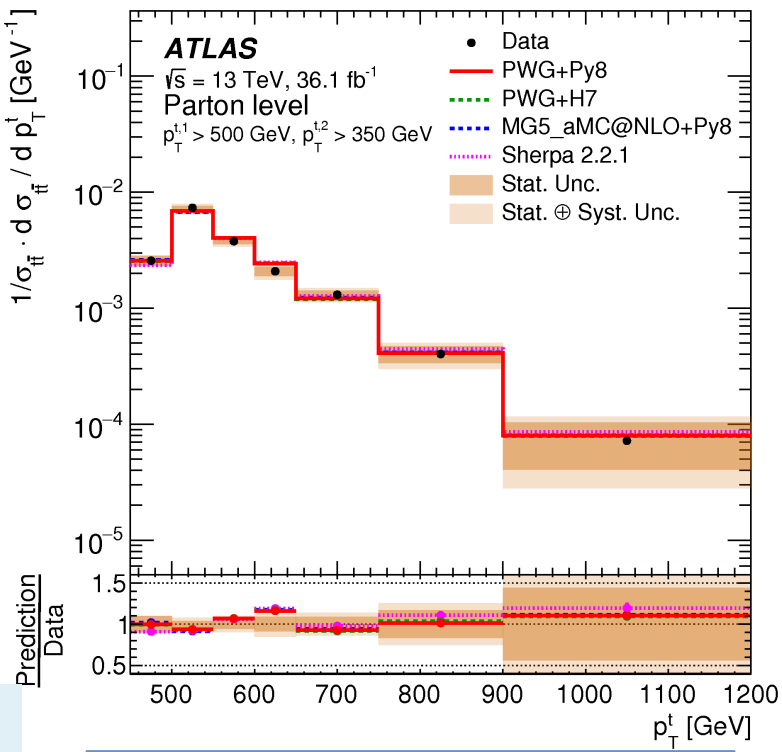
Phys. Lett. B 780 (2018) 557 https://doi.org/10.1016/j.physletb.2018.03.023

- Differential di-lepton and pole-mass



Eur. Phys. J. C 77 (2017) 804
https://doi.org/10.1140/epjc/s10052-017-5349-9

- Boosted top production



arXiv:1801.02052
submitted to PRD
https://arxiv.org/abs/1801.02052

Precise cross section measurement, leading to a precise pole-mass determination

Top production measured up to ~1 TeV of top p_T

Talk on Thu: Y. Nakahama, B. Petersen
Parallel Talks: S. Chien, S. Griso,
- J. Long, Miguens

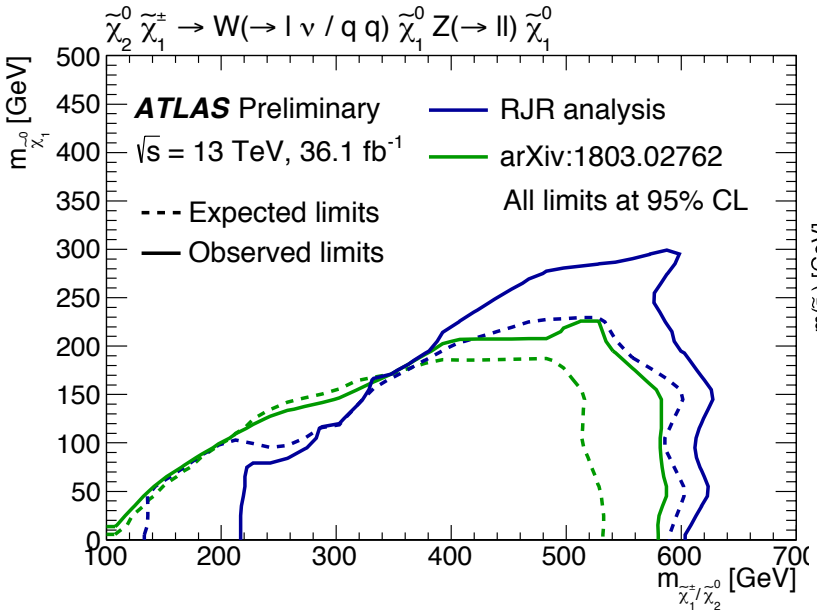
SUSY searches

- Getting important to improve and/or invent analysis techniques to survey:
  -- Uncovered phase space, e.g. small mass difference
  -- Small production cross section, e.g. EW, 3rd generation
  -- Unconventional topology, e.g. long-lived, R-parity violating (RPV)

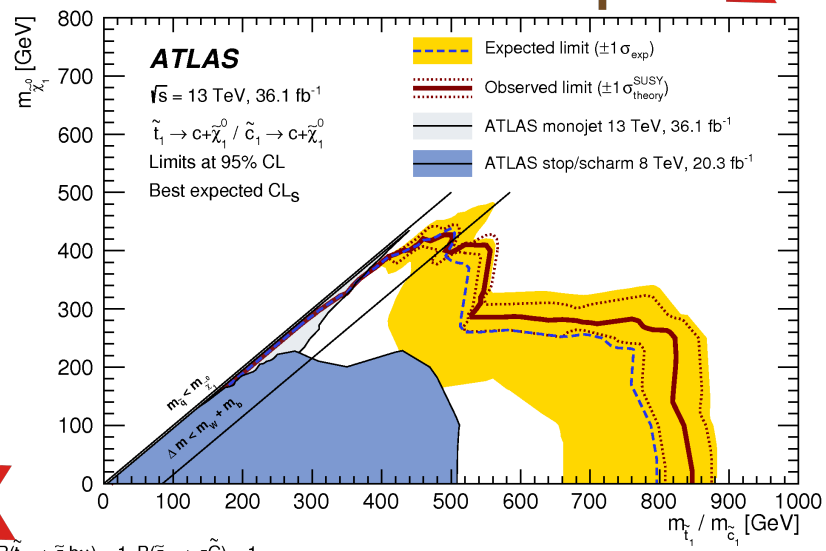
NEW

- EW 2/3 leptons search
  -- By using the recursive jigsaw reconstruction (RJR)

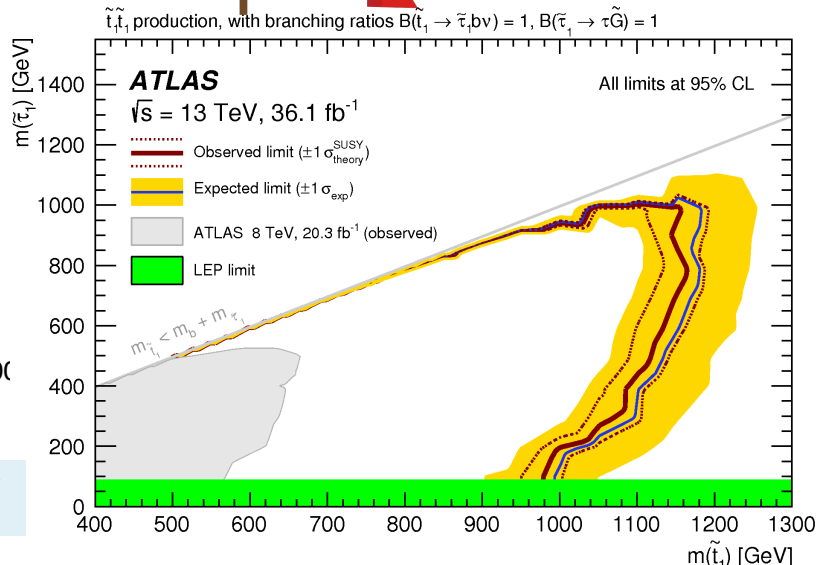
NEW



- Stop search with exclusive final states:
  -- Charm
  -- Tau



NEW



arXiv:1805.01649
submitted to JHEP
https://arxiv.org/abs/1805.01649

arXiv:1803.10178
accepted by PRD
https://arxiv.org/abs/1803.10178

https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PAPERS/SUSY-2017-03/

Talk on Wed: M. Dyndal
Parallel Talk on Fri: R. Slovak

Heavy Ion Physics

- Data sets in Run-2

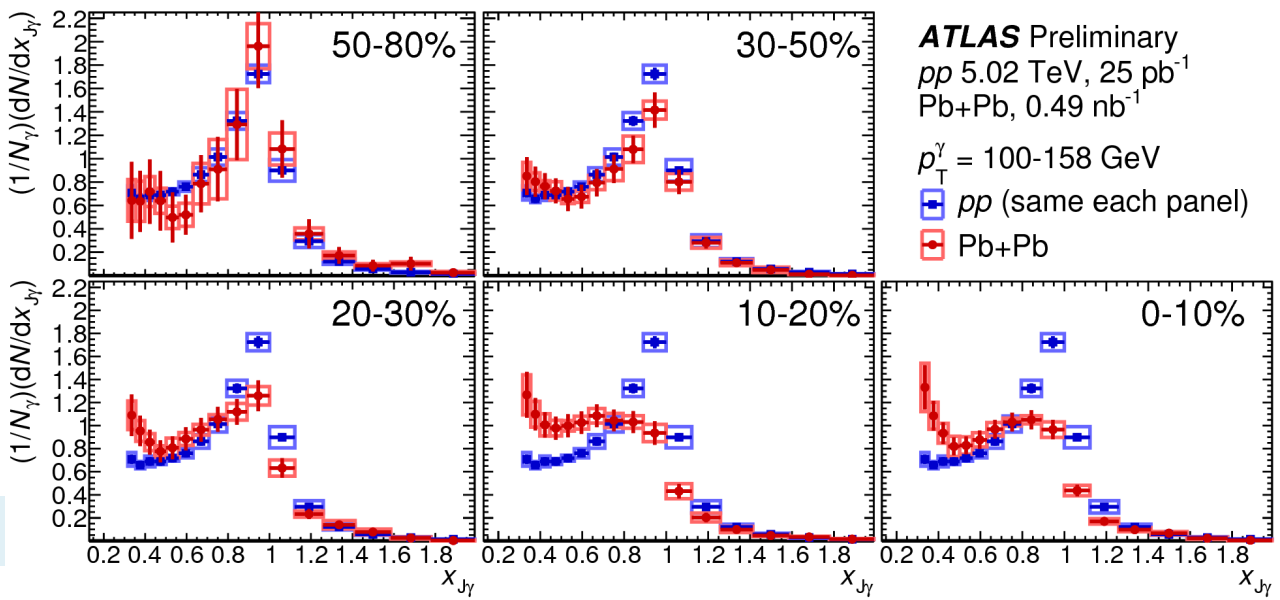
	$\sqrt{s_{NN}}$	Luminosity
-- Pb-Pb	5.02 TeV	~0.5 nb^{-1}
-- p-Pb	5.02 TeV	~0.5 nb^{-1}
-- p-Pb	8.16 TeV	~180 nb^{-1}
-- Xe-Xe	5.44 TeV	~3 μb^{-1}

(Xe-Xe – just one night fill in 2017)

- Photon-jet correlations
  -- To control over initial jet kinematics to see energy loss in jets
    * xJγ: transverse momentum balance between jet and γ

$$x_{j\gamma} = \frac{p_T^{jet}}{p_T^{\gamma}}$$

NEW



ATLAS-CONF-2018-009

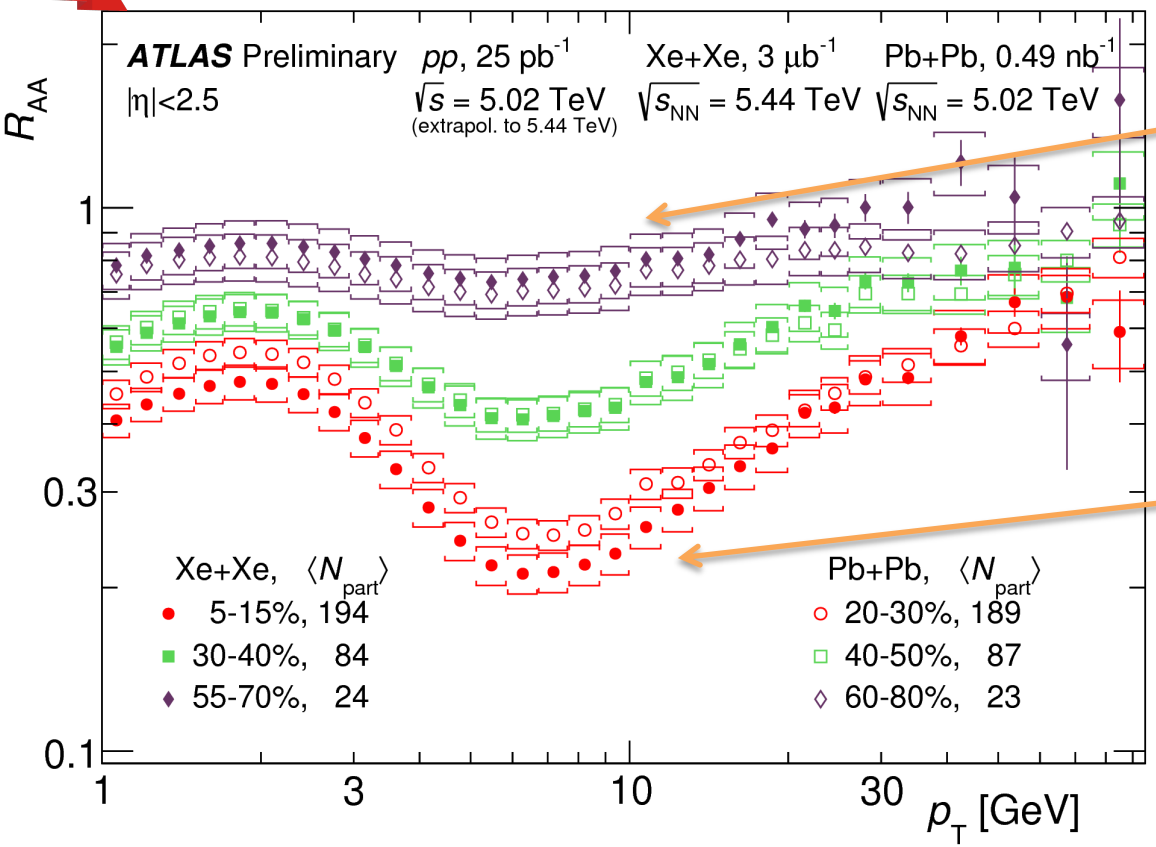
For Pb+Pb collisions, the *x*Jγ distribution is modified with increasing centrality, consistent with the picture of parton-energy loss in the hot nuclear medium.

Talk on Wed: M. Dyndal
Parallel Talk on Fri: R. Slovak

Heavy Ion Physics

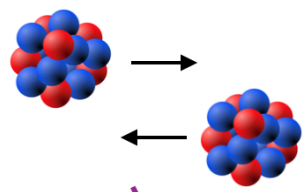
- Charged particle suppression in Pb-Pb and Xe-Xe
  -- Nuclear modification factor, R_{AA}, vs p_T, for different centrality

NEW

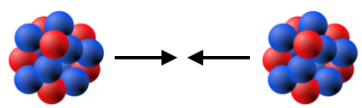


-- Peripheral collisions
→ Milder suppression in Xe-Xe

<Npart> ~ 24



<Npart> ~ 190



-- Central collisions
→ Stronger suppression in Xe-Xe than Pb-Pb

ATLAS-CONF-2018-007
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2018-007/

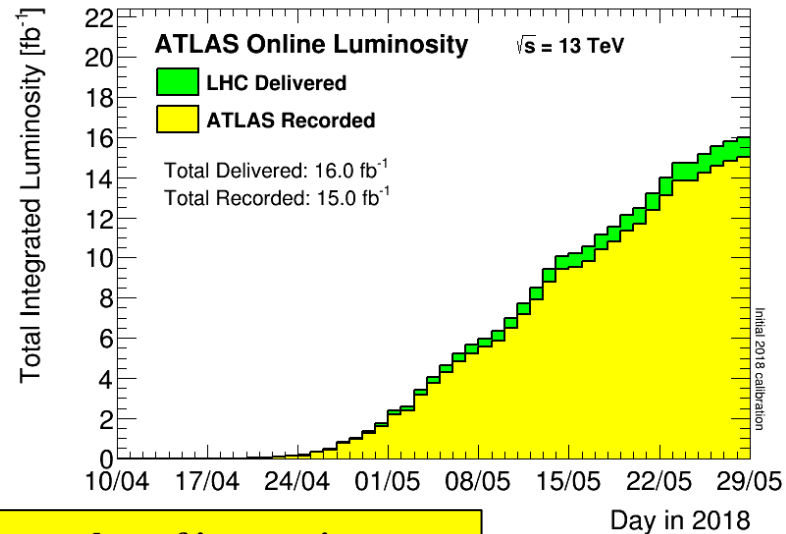
ATLAS in 2018 – in a nutshell

- LHC has already broken records
  -- L(max)=2.1 x 10^{34} $cm^{-2}s^{-1}$
  -- intL/week(max)= 4.1 fb^{-1}

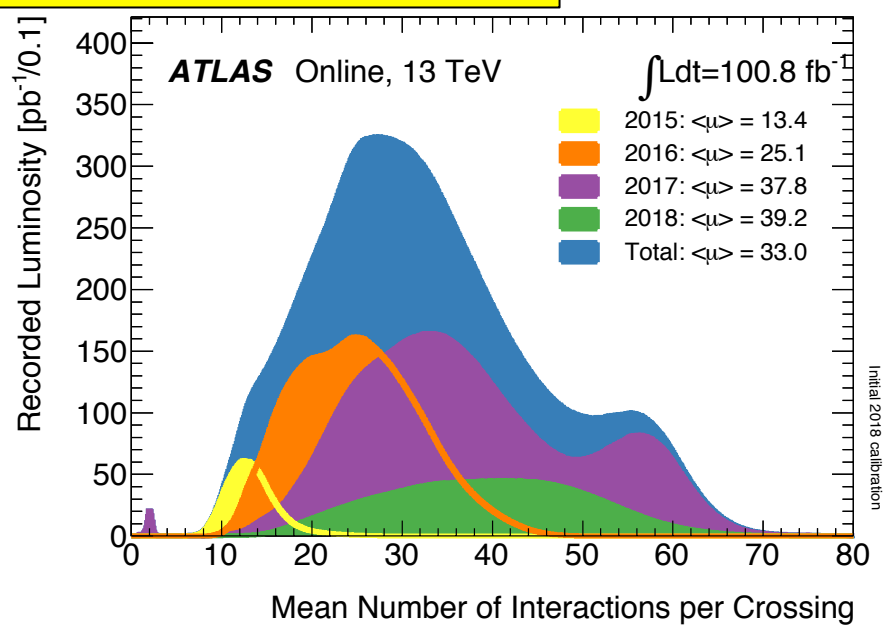
- ATLAS was able to cope with this record-high luminosity of 2.1x10^{34} $cm^{-2}s^{-1}$ without need of luminosity leveling
  -- Pileup is less thanks to the "BCMS" bunch scheme

- ATLAS is smoothly collecting data!
  -- Data taking efficiency > 93%,
  > 15 fb^{-1} already recorded
  -- Trigger menu same as 2017
  -- No "luminosity leveling" necessary with the 2018 beam condition so far

2018 luminosity



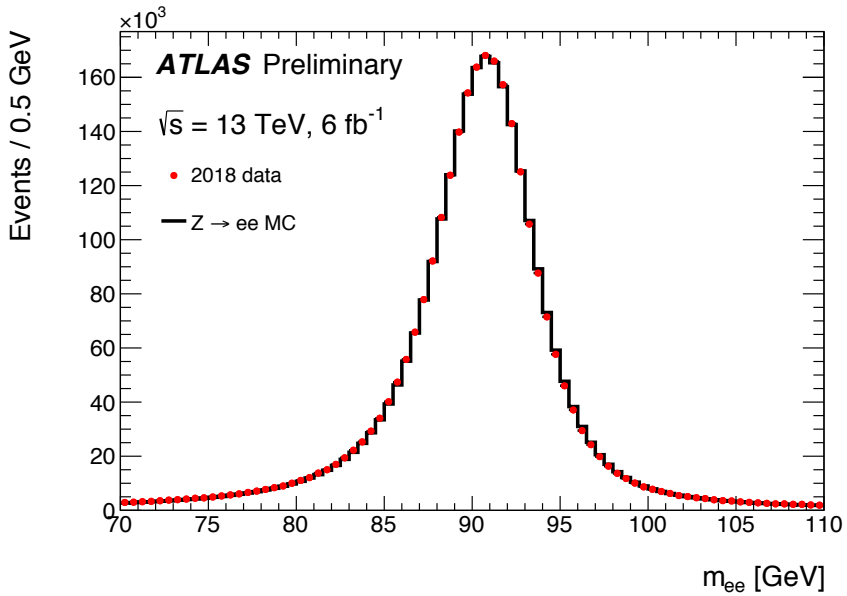
Mean number of interactions per LHC bunch crossing



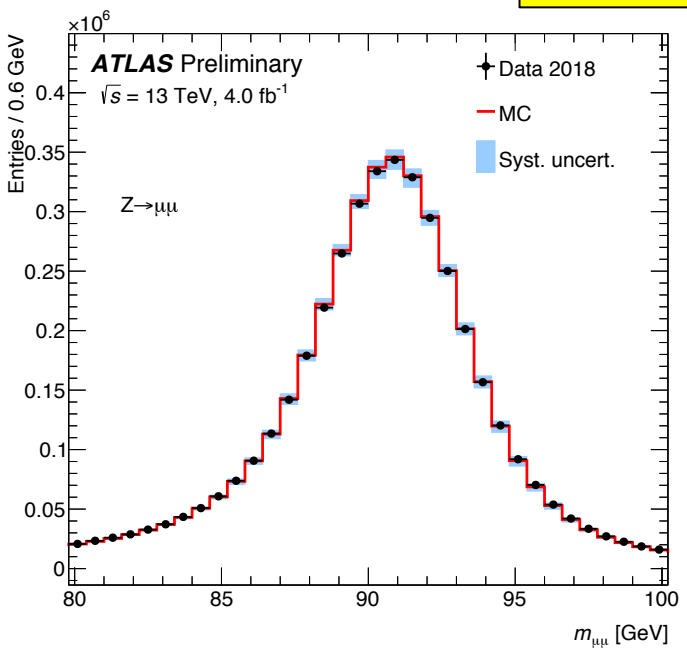
~100 fb^{-1} 13 TeV p-p data recorded!

Already, 2018 performance plots!

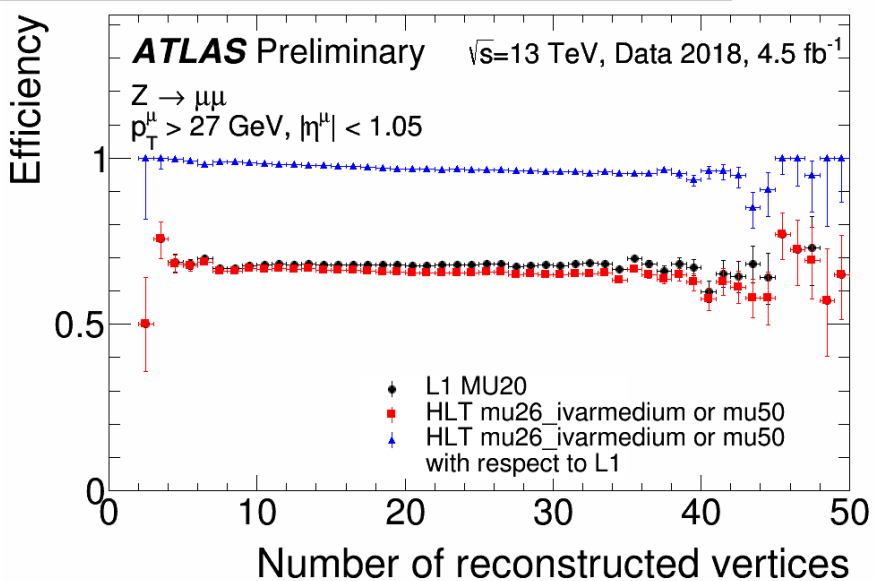
Z→ee mass



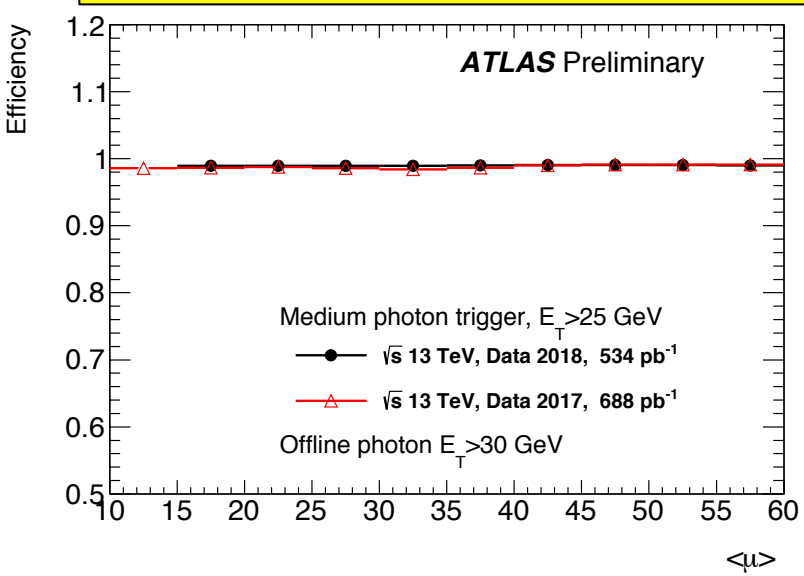
Z→μμ mass



Muon trigger efficiency vs. n_{vtx}

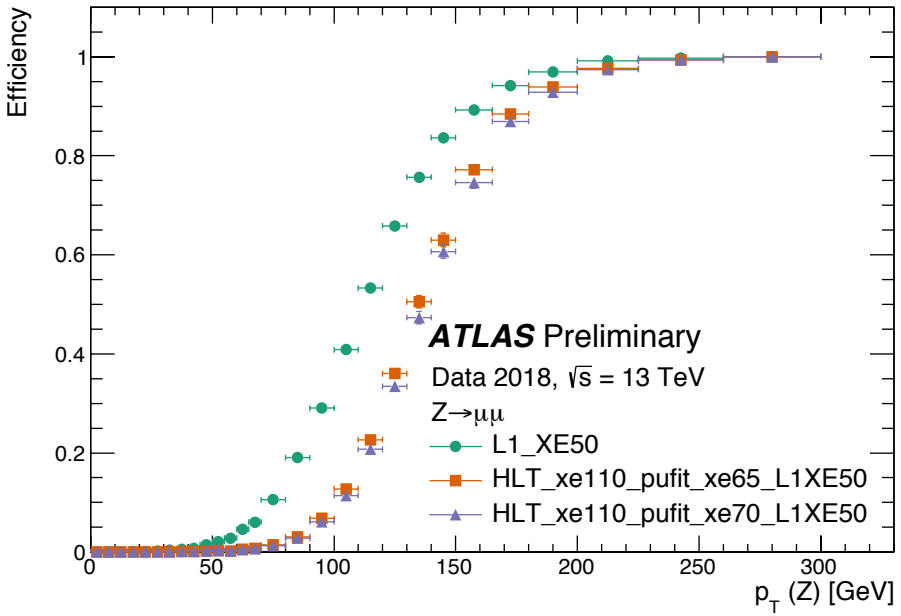


Photon trigger efficiency vs. <μ>

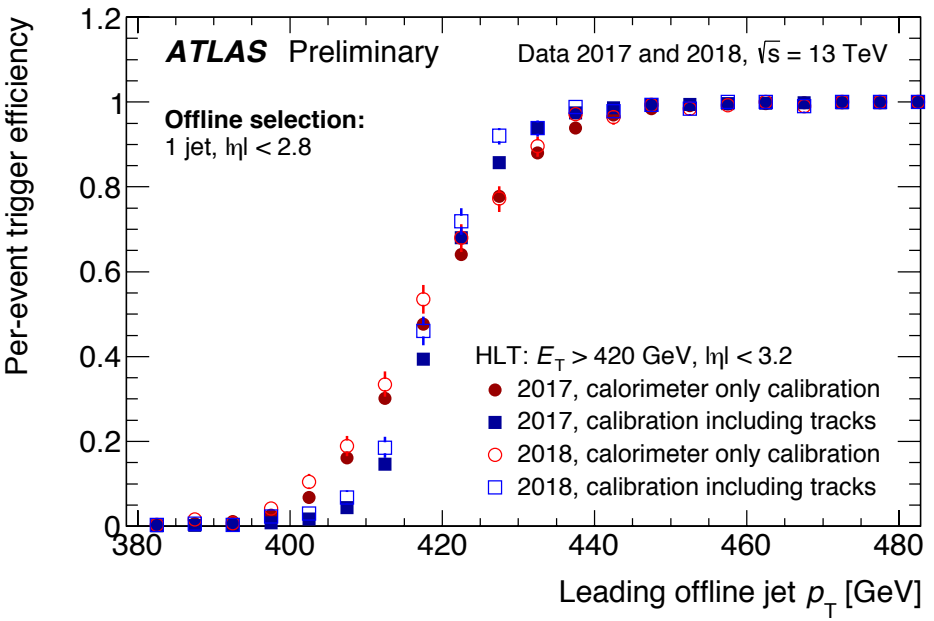


Already, 2018 performance plots!

E_T^{miss} trigger efficiency



Jet trigger efficiency



Excellent performance also in 2018!
-- Efficiency of good for physics / recorded: 96% (with first 7 fb^{-1})

Summary

- Tremendous amounts of hot-off-the-press and important physics results will be presented first time at this conference from the ATLAS experiment, for instance:
  - -- Cross section measurements of $H \rightarrow \tau\tau$
  - -- Observation of ttH production
  - -- New limits from searches with ~80 fb^{-1} data

Stay tuned, and enjoy our reports!

- ATLAS has been and is being collecting data with high efficiency and high quality
  - -- 100 fb^{-1} 13 TeV p-p data already collected in Run-2
  - -- Heavy-ion runs as well as special runs

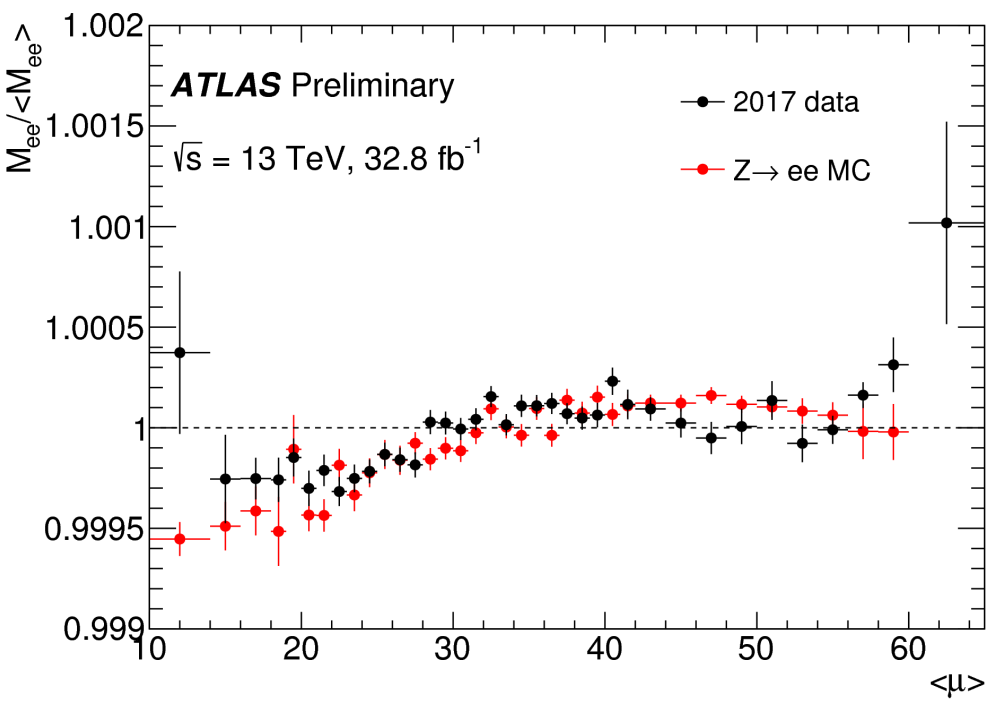
Thanks to the CERN accelerator teams!

Backup Slides

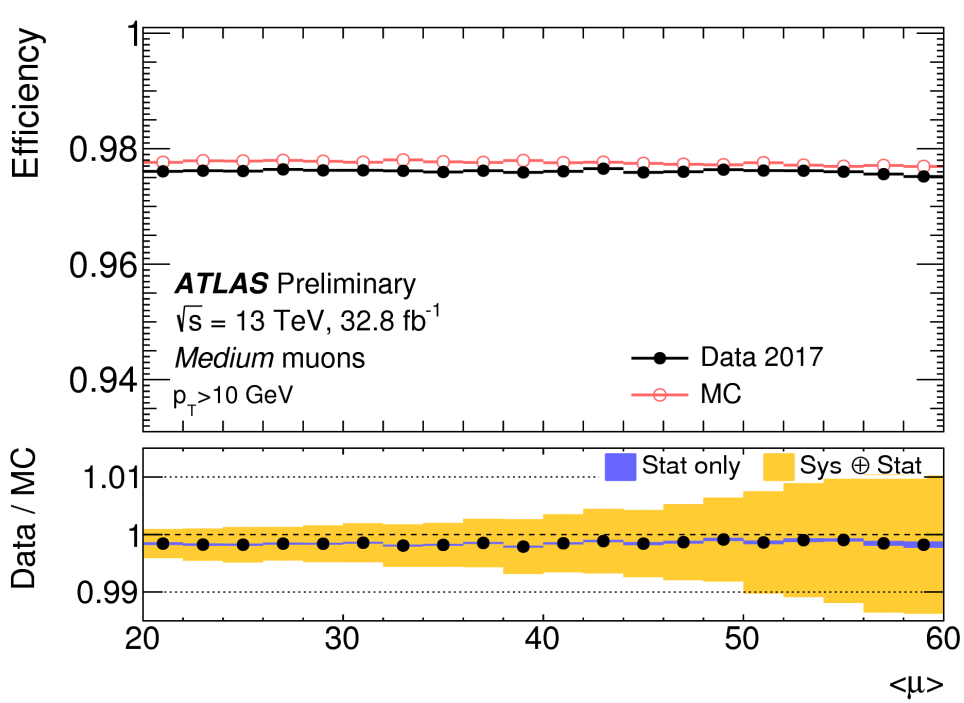
Reconstruction performance

- Converging toward ultimate and final precision Run-2 reconstruction
  - -- Improved in-situ calibration (more data and better methods)
  - -- Improved tuning/optimizations to reduce pileup dependence
  - -- New working points/optimizations for corner phase spaces, e.g. very low and high p_T

Electron energy response at Zmass vs. <μ>



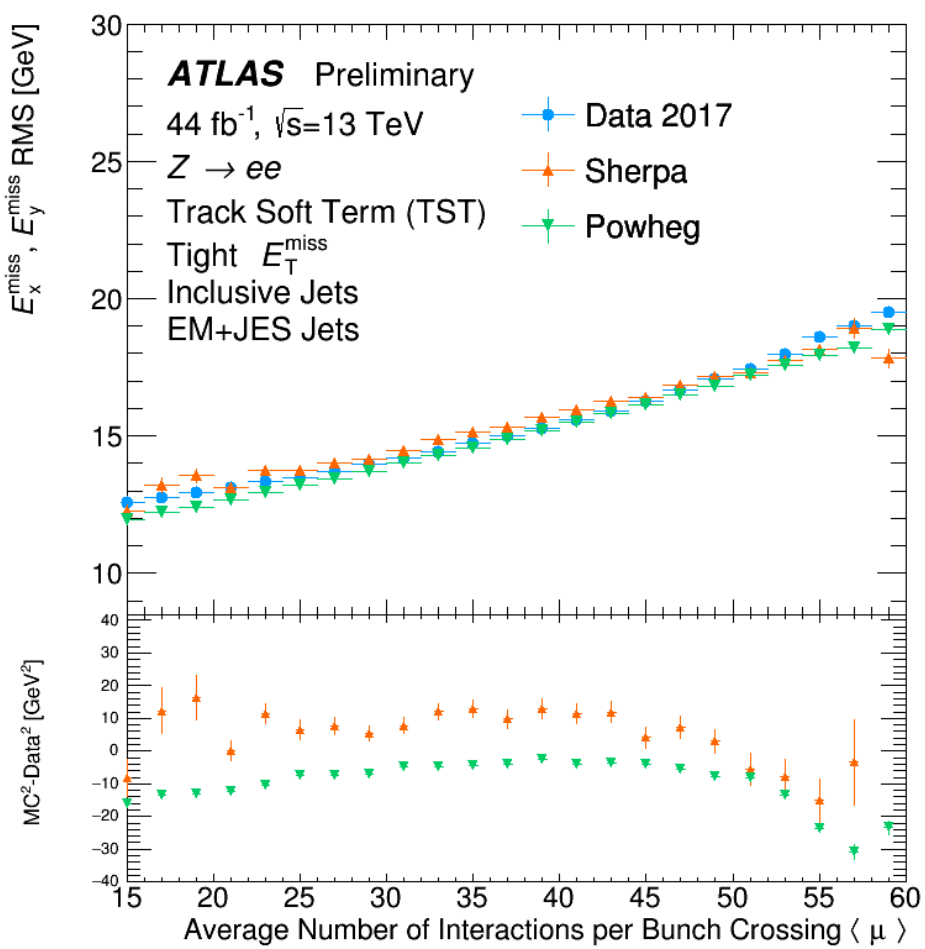
Muon efficiency vs. <μ>



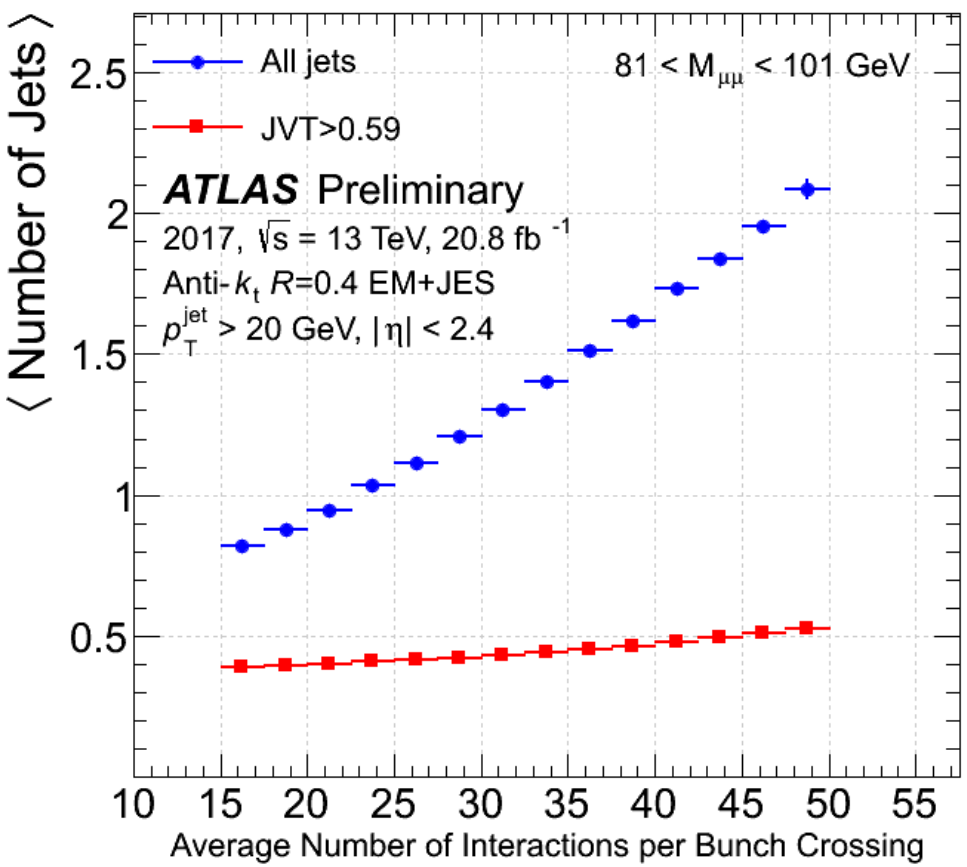
Reconstruction performance

- Pileup mitigation techniques e.g. subtraction, correction continuously improving and getting mature
  -- E_T^{miss} reconstruction improved with track soft term (TST)

E_T^{miss} x, y RMS vs. <μ>



Number of Jets vs. <μ>

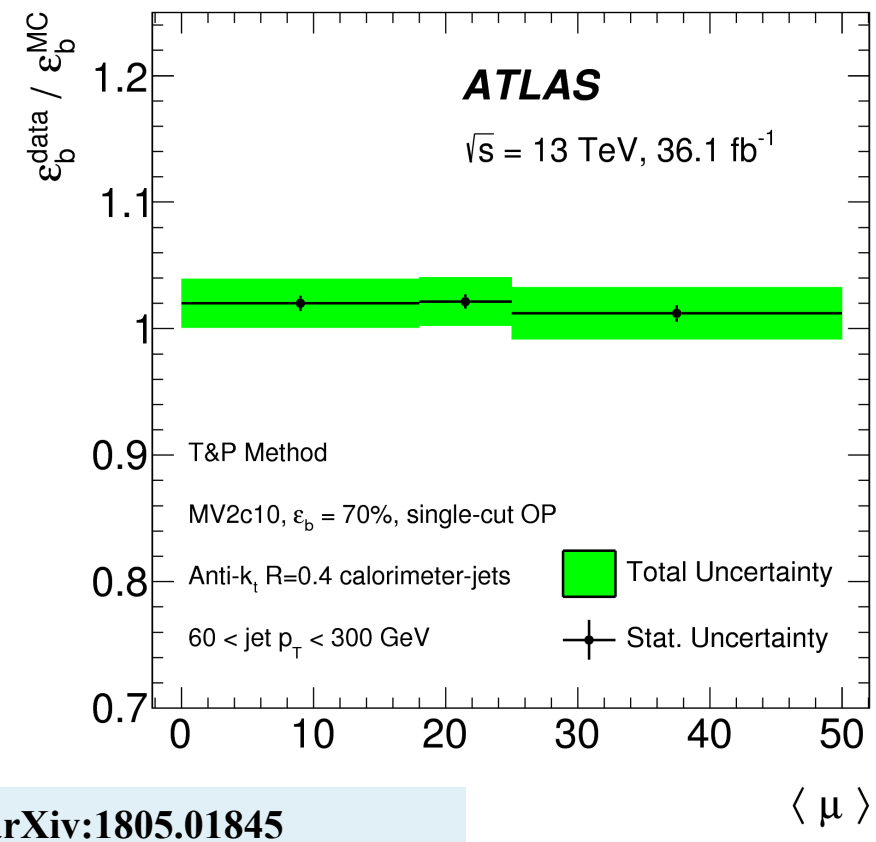


Reconstruction performance

- b-jet and tau reconstructions are often key of particular analyses
  -- Improved calibrations often directly improves sensitivity of such analyses
  -- Pursuing sophisticated algorithms and technologies (e.g. deep learning)
  -- Optimization of corner phase spaces e.g. very high p_T

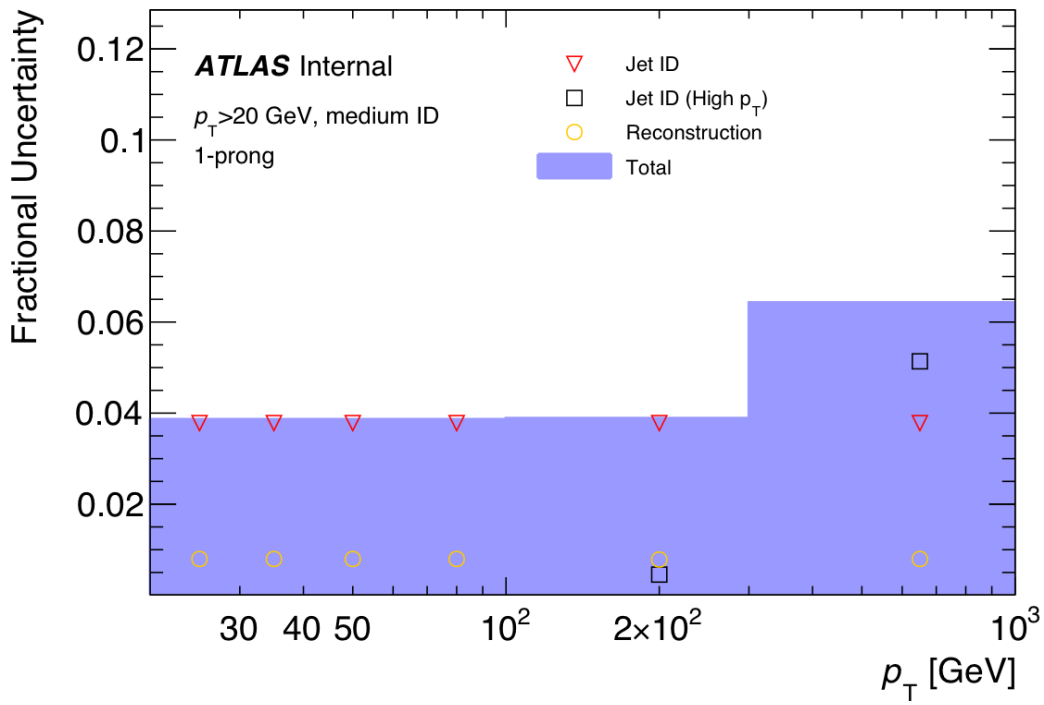
NEW

Data / MC for b-tag efficiency vs. <μ>



NEW

Tau (1-prong) identification efficiency uncertainty



arXiv:1805.01845
submitted to JHEP
https://arxiv.org/abs/1805.01845