

ATLAS Highlights.

87th PRC meeting, Hamburg

Matthias Saimpert, on behalf of the group

DESY

21 May 2019



The ATLAS group at DESY

- Large group promoting a healthy, positive working atmosphere



Outline

- 1 Overview of group activities
- 2 Recent highlights from the ITk strip end-cap
- 3 Improved method to measure b-jet identification performance
- 4 Search for dark matter with b-jets
- 5 Measurement of W^+W^- production (with b-jet veto)

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Detector and computing

- Strong involvement in the **present** and **future** ATLAS detector



Detector operation

- Semi-Conductor Tracker (SCT)
- Luminosity measurements
- Fast TracKer (FTK)
- ALFA forward detectors



Computing and Simulation

- MC production, validation and software
- Inner detector tracking software
- Muon software
- Electron and photon software



Inner Tracker (ITk) upgrade

- Module and sensors
- Mechanics and electronics
- End-cap integration
- Generic R&D

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**Highlighted
today**

Physics object performance and analysis

- Expertise in **physics objects** is a prerequisite to design **high-quality data analyses**



Object Performance

- Jet energy scale and resolution
- Jet flavour-tagging & GPUs
- Track particles
- Electron & photon identification
- Photons energy scale



Data Analysis

- Standard model measurements, PDF
- Top and ttH measurements
- Higgs physics with electrons/ γ
- Search for new phenomena
supersymmetry, dark matter, ...

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Highlighted today

Working together with theorists

- **Many fruitful collaborations with on-site and off-site theorists**
 - interpretation of ATLAS Higgs results (F. Tackmann) [LHCHXSWG-2019-003](#)
 - top quark effective field theory fits (C. Englert, C. White, ..) [arXiv:1901.03164](#)
 - **future of Higgs physics** (C. Grojean, Y. Nir, ..) [arXiv:1905.00382](#), [1905.03764](#)
 - next generation spin-0 dark matter models (F. Kahlhoefer, ..) [CERN-LPCC-2018-02](#)
 - **predictions for $t\bar{t}$ + extra b-jets** (F. Siegert, in progress)

- **Many regular informal discussions at DESY with other groups**
 - “Quantum universe”, monthly “LHC discussions”, “theorist of the month”, ...
 - Higgs *CP* studies at HL-LHC (H. Bahl, T. Stefaniak, G. Weiglein)
 - predictions for diboson (M. Grazzini, F. Tackmann)



Working together with computing

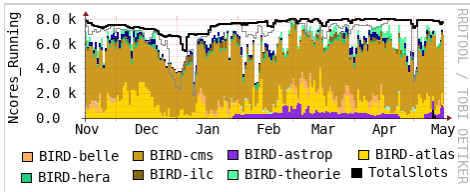
Excellent support and collaboration with the DESY-IT department

– Continuous use of NAF by all groups

- batch system
- local disk storage

– Introduction of GPUs [more later]

- test-bed for state-of-the art machine learning techniques



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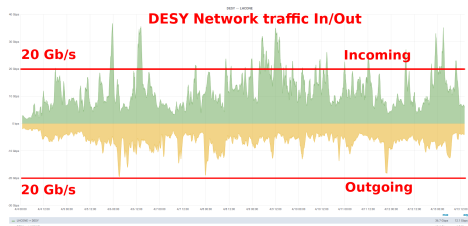
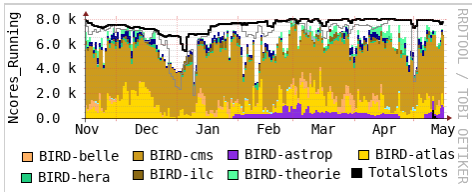
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– Important Tier 2 grid site (ATLAS/CMS)

- all pledges met for the next year
- increased resources required due to LHC luminosity increase

– New 100 Gb/s link in place

- previous WAN links via LHCONE (20 Gb/s) regularly saturated



More in the following talk



ATLAS and the LHC physics programme

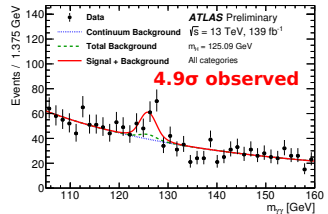


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$ttH(\rightarrow \gamma\gamma)$, ATLAS-CONF-2019-004



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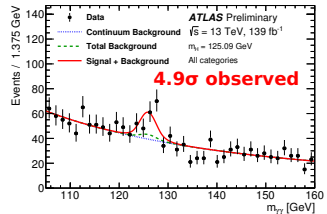


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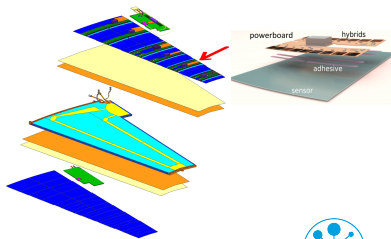
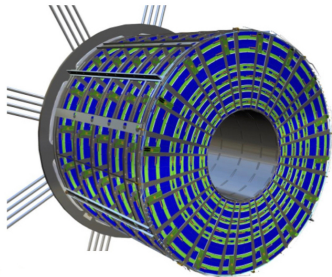
- LHC status presented by CMS this morning
- First releases of ATLAS full Run 2 results, many more to come
- In parallel, on-going work on improving physics object performance and upgrade



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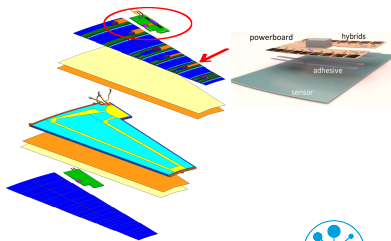
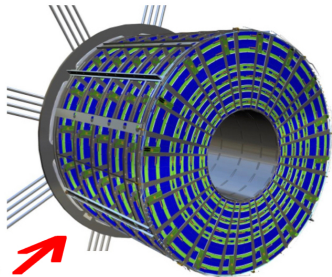
Overview of DESY upgrade activities

- 2019: Preparation of the full construction at DESY of the ITk strip end-cap
 - module building/testing (HH/ZN)
 - precise module loading on petal cores
 - petal core production, incl. bus tape co-curing and Ti pipe welding
 - installation of new robots for petal production
 - petal thermal and mechanical tests
 - end of substructure card
 - frame for full end-cap assembly, integration, transport and insertion into ATLAS
 - upgrade software
 - end-cap thermal models
 - test beam and pixel telescope



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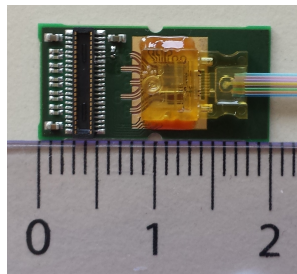
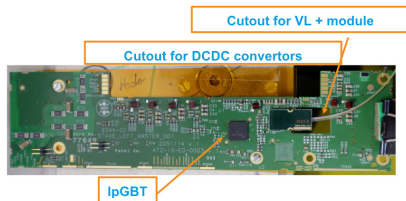
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- Significant progress in all areas!
2 highlighted today:
 - first operation of transceiver chip (IpGBT)
 - successful test of petal insertion tool



End of Substructure (EoS) board

First tests with IpGBT/optoelectronics

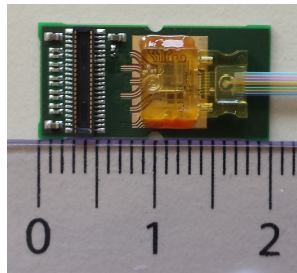
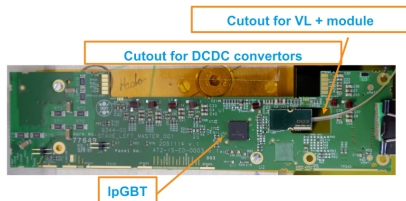
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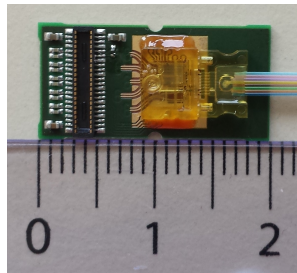
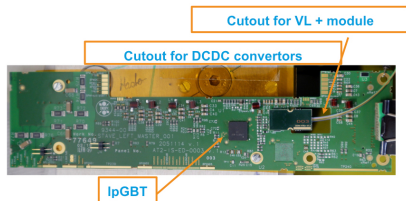
- EoS: gateway between on/off-detector components
- GBTx-based EoS (first prototype, **old chip**)
 - bit error rate tested with full data path ✓
 - integration with full stave prototype ✓
- Design concept with **IpGBT (final chip)** ready
 - based on latest information on IpGBT and optic link (VL+)
 - electronics-mechanics integration ⚠



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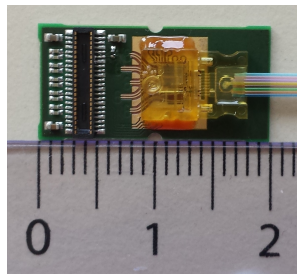
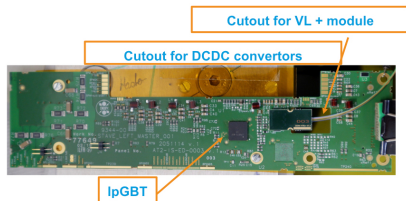
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- **3 IpGBT chips received in April**
 - communication with chip established ✓
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- **Next step started:** test setup for full production ⚠
 - design of special components, firmware/software

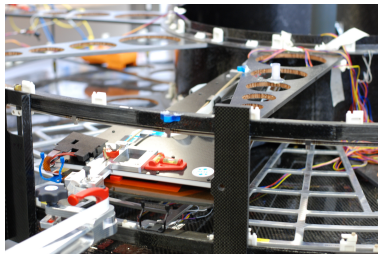


Petal insertion tool

Expansive/fragile petals, restricted space → in-house tool

– Test of the v2 updated design

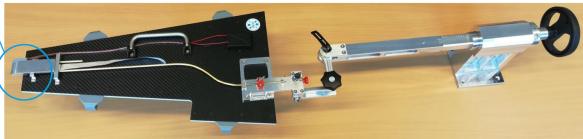
- tilting, rotation and clamping mechanism
outside of the end-cap ✓
→ more space for moving inside
- camera monitoring position
between locator and locking point ✓
- overall handling improved ✓



Tested successfully with end-cap mock-ups at DESY and Nikhef!



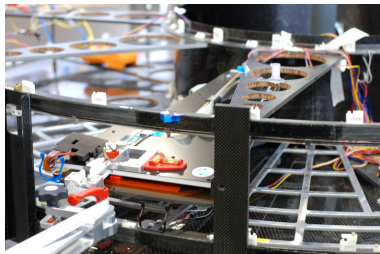
LED + camera



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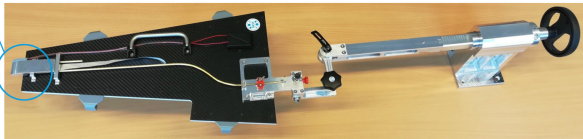
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- only some fine-tuning remains for final version



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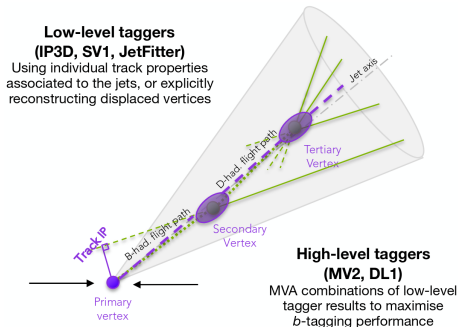
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b-jet identification in ATLAS

- Identification of **jets originating from b quark fragmentation**
 - key ingredient to many physics analyses (ex: ttH) [\[more on this later\]](#)
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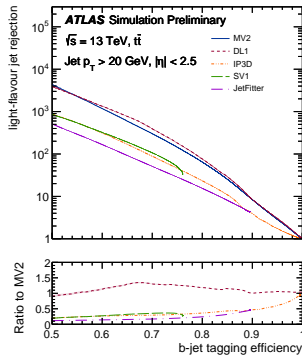
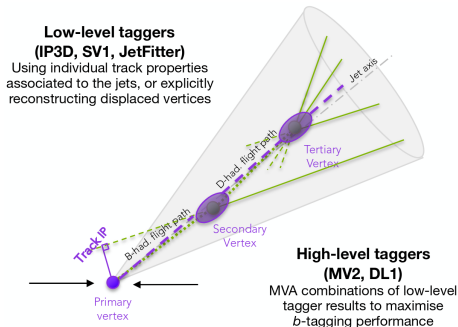
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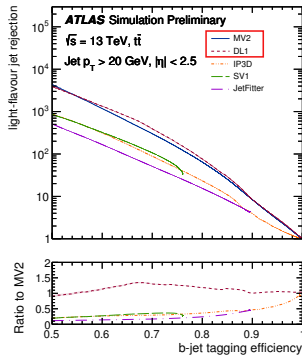
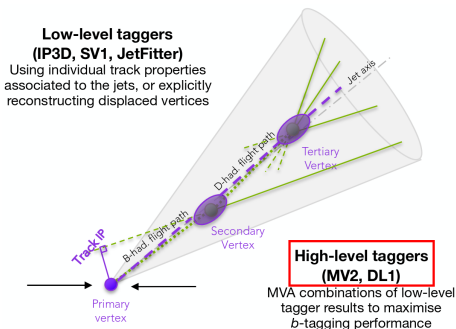
[FTAG-2019-002]



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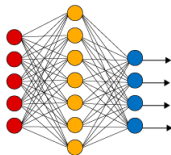


Making the best of the NAF performance

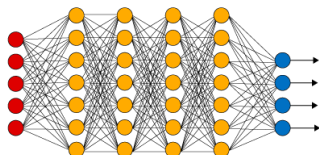
- Collaboration with IT to integrate new software technology
 - building and running of **container images and "notebooks"** on the NAF
 - major step in **code portability** (Ixplus, LHC grid) and **flexibility** (GPUs)
 - ↗ speed/performance, exploration of more complex, better tuned **machine learning architectures** e.g. for *b*-tagging algorithms



Simple Neural Network



Deep Learning Neural Network



● Input Layer

● Hidden Layer

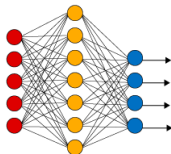
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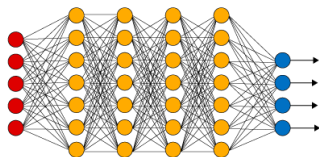


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– Important toolbox for the future

- main work tool of an ATLAS student already
- more users expected soon, e.g. summer-students this year

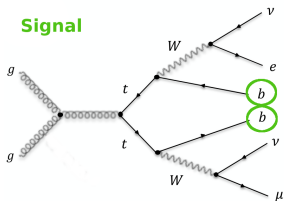


b-jet tagging efficiency in data (80.5 fb^{-1})

- Imperfect detector response and physics modeling in simulation
 - precision measurement in collision data required
 - pure sample of b -jets from $t\bar{t}$ events: $e\mu + \text{exactly 2 jets}$

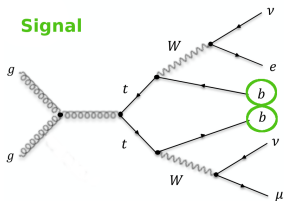
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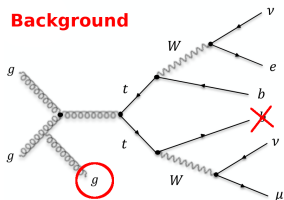
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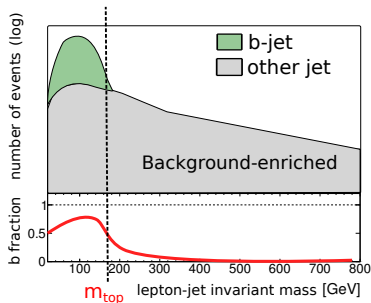
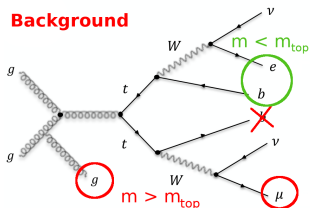
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 - main background from $t\bar{t}$ as well: **extra q/g radiations + lost b -jet(s)**
- New measurement method developed at DESY [FTAG-2019-002]
 - introduction of background (i.e. q/g radiation) enriched regions

Background

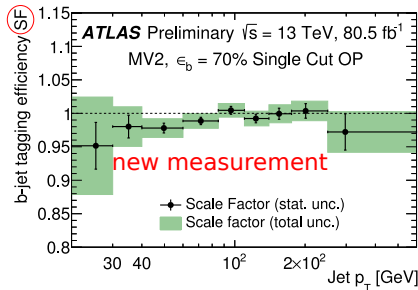
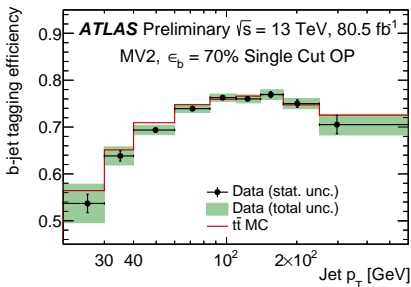


Comparison of data/MC performance

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 - **%-level constraints on sample b-jet composition before tagging**
 - *b*-jet tagging efficiency measurement less dependent on $t\bar{t}$ modeling

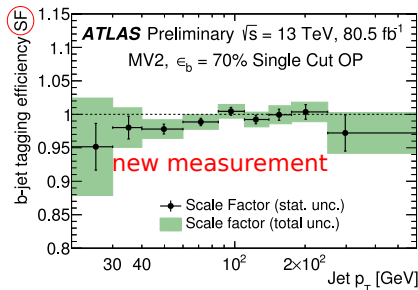
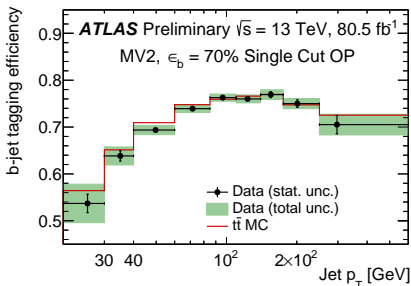
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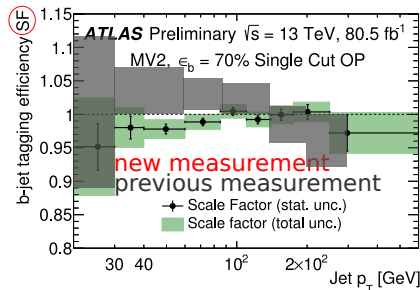
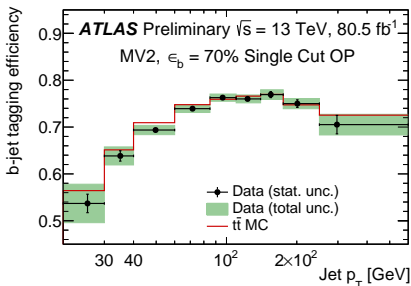
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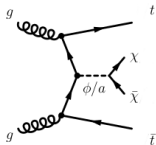
Dark matter and the top quark

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- Higgs-like mediator \rightarrow production in association with $t\bar{t}$: $t\bar{t} + E_T^{\text{miss}}$ search

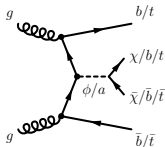
JHEP 06 (2018) 108 Eur. Phys. J. C78 (2018) 18



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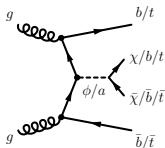


- various complementary channels with (and without) b -jets:
 - $t\bar{t}$ resonances, 4-tops, ...
 - $X + E_T^{\text{miss}}$ (H, V, \dots), VBF, ...

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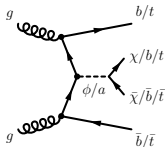


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- **long-term involvement of DESY to draw a consistent picture of LHC sensitivity**

Dark matter and the top quark

- Many dark matter (DM) models involve an **extended Higgs sector**
- Higgs-like mediator \rightarrow production in association with $t\bar{t}$: $t\bar{t} + E_T^{\text{miss}}$ search

JHEP 06 (2018) 108 Eur. Phys. J. C78 (2018) 18 Eur. Phys. J. C78 (2018) 565 JHEP 10 (2018) 180

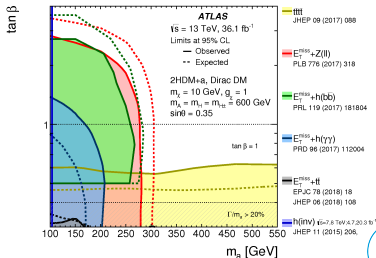


- various complementary channels with (and without) **b -jets**:
 - $t\bar{t}$ resonances, 4-tops, ...
 - $X + E_T^{\text{miss}}$ (H, V, \dots), VBF, ...
- **long-term involvement of DESY to draw a consistent picture of LHC sensitivity**

- Next generation spin-0 models : 2 Higgs Doublet + pseudoscalar

CERN-LPCC-2018-02

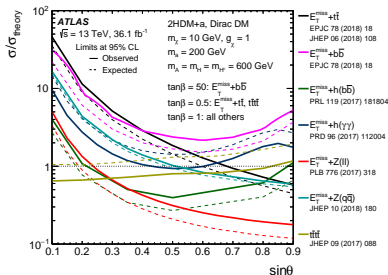
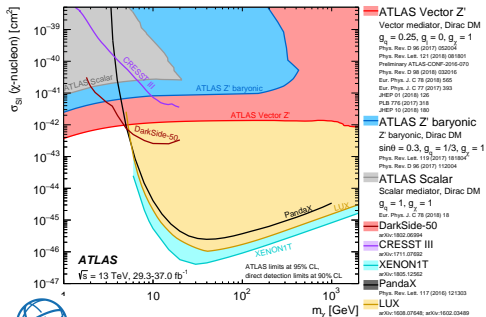
- **minimal SM extension** beyond simplified model
- more consistent and **richer phenomenology**
- ex: resonantly enhanced mono- H/Z production



Gathering all the pieces together

arXiv:1903.01400 (2019), BMBF newsflash (May 2019)

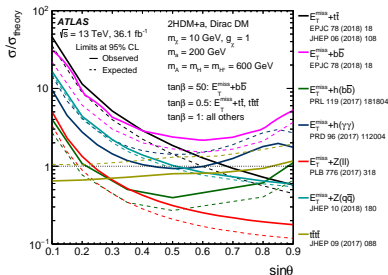
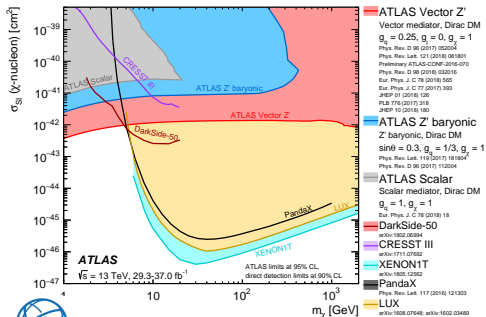
- Comprehensive summary of mediator-based DM searches at 36.1 fb^{-1}
 - ~ 20 ATLAS search analyses, including first limits on $2\text{HDM} + a$
 - DESY strongly involved in 6 analyses and coordination**
 - inclusion of first collider limits on scalar dark energy (effective model)



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 - high potential of stat.-limited channel for full Run 2 (e.g. $t\bar{t} + E_{\text{T}}^{\text{miss}}$)

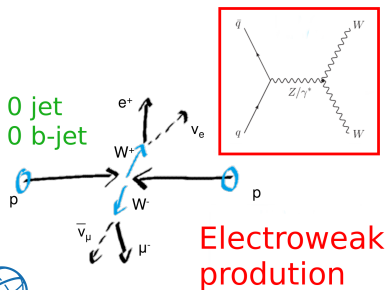


- 1 Overview of group activities
- 2 Recent highlights from the ITk strip end-cap
- 3 Improved method to measure b-jet identification performance
- 4 Search for dark matter with b-jets
- 5 **Measurement of W^+W^- production (with b-jet veto)**

Differential W^+W^- xsec measurement

arXiv:1905.04242 (2019), coordinated by DESY

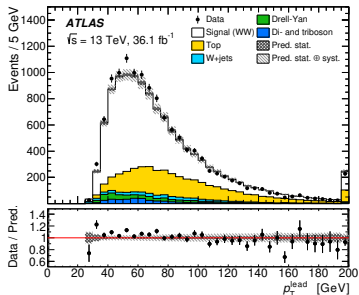
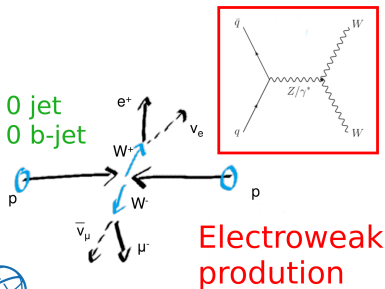
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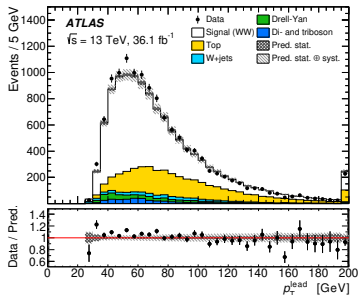
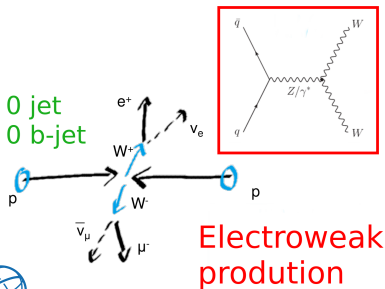
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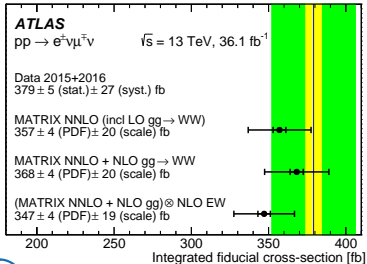
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- Dominant uncertainty ($\sim 5\%$): **b-jet identification and jet calibration**
 - direct benefit from **new b-jet tagging efficiency measurement** for full Run 2



Selection of results (36.1 fb^{-1})

- Overall good agreement with NNLO QCD predictions
 - getting closer to probe NLO QCD gg production and EW corrections

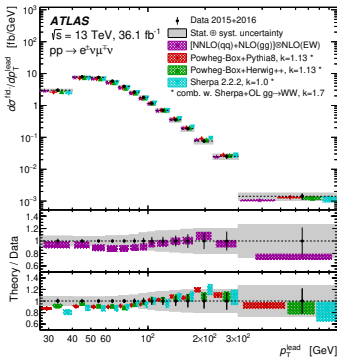
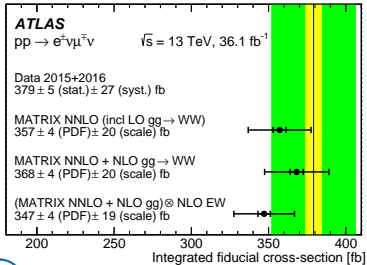
$$\text{Fiducial cross section: } \sigma = \frac{N^{\text{data}} - N^{\text{bkg}}}{L \cdot C_{\text{WW}}}$$



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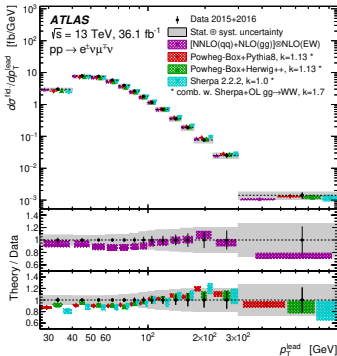
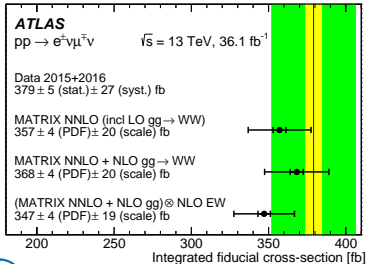
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 - good prospects for full Run 2 analysis!

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Outlook

other activities

important role of DESY in detector operation, upgrade projects, computing, simulation, measurements and searches for new phenomena

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- About **20 journal papers** and **15 preliminary publications** with a strong DESY contribution released since the last PRC
- Highlights presented today illustrating:
 - Continuous, fruitful collaboration with **on-site/off-site theorists** and **DESY IT**
 - Excellent progress toward **the construction of an ITk strip end-cap** for the HL-LHC
 - Strong DESY presence in a wide array of **performance measurements** to maximize the **physics output of the Run 2 LHC data**
 - DESY leading role in **on-going physics measurements and searches** connected with this expertise

ATLAS Highlights.

Additional material

Matthias Saimpert

87th PRC, ATLAS highlights

21 May 2019



2 Higgs Doublet + pseudoscalar Model

JHEP 1705 (2017)

