ATLAS Status Report

Peter Onyisi, on behalf of the ATLAS Collaboration

5 June 2019
Recent Physics Results

\[ m_{jj} = 8.02 \text{ TeV} \]
recording eff ~ 94%
good for physics ~ 95%

comparative stability of different lumi measurements in 2018

2018 prelim lumi uncertainty 2.0% (of which stability 0.8%)
Full Run 2 prelim uncertainty 1.7%
Performance

• Studies on object reconstruction, lumi performance to support initial search results using full 139 fb$^{-1}$
• Work ongoing to provide the best possible uncertainties for precision measurements

\[ E_{\text{data}} = (1+\alpha)E_{\text{MC}} \]

electron energy scale correction

[Graphs and plots related to electron energy scale correction and missing transverse energy significance]
Higgs Coupling Combination

- Combine Run 2 results (up to 80 fb\(^{-1}\)) for a global picture of Higgs interactions
- Move beyond simple coupling modifiers in a full combination
  - “Simplified Template Cross Sections” provide constraints on Higgs production as a function of associated objects & kinematic regime – e.g. high \(p_T\) where new physics effects might become important
  - sensitivity to more subtle BSM effects, improve model-independence

6.5\(\sigma\) single-experiment observation of vector boson fusion (5.3 expected)

ATLAS Preliminary

ATLAS-CONF-2019-005
Higgs Coupling Combination: STXS

Modified Stage 1 STXS (see YR4 arxiv:1610.07922) defined by truth bin

\[ gg \rightarrow H \]
- \[ gg \rightarrow H, \text{0-jet} \]
- \[ gg \rightarrow H, 1\text{-jet}, \vec{p}_T^H < 60 \text{ GeV} \]
- \[ gg \rightarrow H, 1\text{-jet}, 60 \leq \vec{p}_T^H < 120 \text{ GeV} \]
- \[ gg \rightarrow H, 1\text{-jet}, 120 \leq \vec{p}_T^H < 200 \text{ GeV} \]

\[ gg \rightarrow H, \geq 1\text{-jet}, \vec{p}_T^H \geq 200 \text{ GeV} \]

\[ qq \rightarrow H qq \]
- \[ qq \rightarrow H qq, \vec{p}_T^j \geq 200 \text{ GeV} \]
- \[ qq \rightarrow H qq, \text{VH topo} \]
- \[ qq \rightarrow H qq, \text{VBF topo + Rest} \]

\[ V(\text{lep})H \]
- \[ qq \rightarrow Hlv, \vec{p}_T^V < 250 \text{ GeV} \]
- \[ qq \rightarrow Hlv, \vec{p}_T^V \geq 250 \text{ GeV} \]
- \[ gg/qq \rightarrow Hll, \vec{p}_T^V < 150 \text{ GeV} \]
- \[ gg/qq \rightarrow Hll, 150 \leq \vec{p}_T^V < 250 \text{ GeV} \]
- \[ gg/qq \rightarrow Hll, \vec{p}_T^V \geq 250 \text{ GeV} \]

\[ \text{compatibility with SM } \rho = 88\% \]
Higgs Couplings Combination, $\kappa$-framework

- Simple scalings $\kappa_i$ of SM couplings
  - include $H \to$ invisible branching fraction limits, width constraints from off-shell measurements to constrain unseen decays
  - SM: $\kappa_i = 1$

"effective couplings" $\kappa_g, \kappa_\gamma$ encapsulate loop effects
**ttH, H → γγ**

- Use high-resolution H → γγ decay to search for ttH production
  - measures top quark Yukawa coupling
  - hadronic and leptonic categories of top pair decays; BDTs used to select bins of various purity
- 4.9σ observed signal (4.2σ exp); $\mu_{t\bar{t}H} = 1.38^{+0.41}_{-0.36} = 1.38^{+0.33}_{-0.31} \text{(stat.)}^{+0.13}_{-0.11} \text{(exp.)}^{+0.22}_{-0.14} \text{(theo.)}$

(2017 multi-channel combination: 6.5σ obs, 5.1 exp)
### Exotics Summary

ATLAS Exotics Searches* - 95% CL Upper Exclusion Limits

**Status:** May 2019

| Model                          | \(\ell, \gamma\) | Jets | \(E_{T}^{miss}\) | \(|\mathcal{L}|a|b|^{fb^{-1}}\) | Limit          | Reference                  |
|-------------------------------|------------------|------|-----------------|------------------|----------------|----------------------------|
| ADD QCD + g/q            | \(2, 0, 0\)      | 1 - 4 | 7.2 T TeV        | 3.1 T TeV         | Mu            | 1711.023601                |
| ADD non-resonant \(g\gamma\) | \(2, 0, 0\)      | 2    | 8.3 T TeV        | 3.3 T TeV         | Mu            | 1799.02127               |
| ADD QCD + g/q             | \(2, 0, 0\)      | 2    | 8.3 T TeV        | 3.3 T TeV         | Mu            | 1606.021658               |
| ADD QCD + g/q             | \(2, 0, 0\)      | 3    | 3.3 T TeV        | 3.3 T TeV         | Mu            | 1512.021658               |
| RS1 QCD + g/q             | \(2, 0, 0\)      | 2    | 2.3 T TeV        | 2.3 T TeV         | Mu            | 1893.02078               |
| Bulk RS G + g/q → WW/ZZ   | \(2, 0, 0\)      | 2    | 1.8 T TeV        | 1.8 T TeV         | Mu            | 1893.02078               |
| Bulk RS G + g/q → WW/ZZ   | \(2, 0, 0\)      | 2    | 1.8 T TeV        | 1.8 T TeV         | Mu            | 1893.02078               |
| Bulk RS G + g/q → WW/ZZ   | \(2, 0, 0\)      | 2    | 1.8 T TeV        | 1.8 T TeV         | Mu            | 1893.02078               |
| Bulk RS G + g/q → WW/ZZ   | \(2, 0, 0\)      | 2    | 1.8 T TeV        | 1.8 T TeV         | Mu            | 1893.02078               |

**Extra Dimensions**

- \(c\rightarrow t\bar{t}\) (higgsino + higgsino)
- \(c\rightarrow t\bar{t}\) (higgsino + higgsino)
- \(c\rightarrow t\bar{t}\) (higgsino + higgsino)
- \(c\rightarrow t\bar{t}\) (higgsino + higgsino)
- \(c\rightarrow t\bar{t}\) (higgsino + higgsino)

**Gauge bosons**

- **W’** → \(\ell\nu\) EXOT-2018-30
- **Z’** → \(\ell\ell\) arxiv:1903.06248

**Dijet resonances**

ATLAS-CONF-2019-007

**VV resonances**

ATLAS-CONF-2019-003

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

1 Small-radius (large-radius) jets are denoted by the letter \(J\).
W', Z' Searches

- Search for resonances decaying to $\ell\nu$ or $\ell\ell$ ($\ell = e, \mu$)
  - Provide cross section limits as a function of resonance width (and mass limits for some benchmark models, e.g. sequential standard model)

$\mathcal{Z}'$

**arxiv:1903.06248 (sub. to Phys Lett B)**

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ATLAS Preliminary

$\sqrt{s} = 13$ TeV, 139 fb$^{-1}$

$W' \rightarrow \ell\nu$

59% CL

Combined $e\nu$, $\mu\nu$

EXOT-2018-30

139 fb$^{-1}$
**Diboson Resonance Search**

- **WW/WZ/ZZ resonance search**
  - benchmark models: heavy vector triplets; radions; RS gravitons

- **all-hadronic channel**
  - R=1.0 jets: combine calo+track information (“Track-CaloClusters”) for better substructure resolution
  - select jets using \( n_{\text{trk}}, D_2 \) substructure, \( m(\text{jet}) \)

\[ p_{T}^{j_1, j_2} > 600, 200 \text{ GeV}; \text{one tag, one anti-tag} \]
Dijet Resonance Search

- Dijet resonances could arise from e.g. excited quarks ($q' \rightarrow qg$)
  - dijet resonance search a typical probe for compositeness
- Smooth background distribution fit to data
- Bump search algorithm used to search for excesses
### SUSY: Summary

- **Large number of new 139 fb\(^{-1}\) results**

<table>
<thead>
<tr>
<th>Final State</th>
<th>Probes</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3(\ell) + 0b + MET</td>
<td>chargino+neutralino</td>
<td>ATLAS-CONF-2019-020</td>
</tr>
<tr>
<td>(h \rightarrow \gamma\gamma + (\ell\nu/qq') +) MET</td>
<td>chargino+neutralino</td>
<td>ATLAS-CONF-2019-019</td>
</tr>
<tr>
<td>2(\tau) + MET</td>
<td>staus</td>
<td>ATLAS-CONF-2019-018</td>
</tr>
<tr>
<td>(\ell) + b + jets + MET</td>
<td>stop 3-body</td>
<td>ATLAS-CONF-2019-017</td>
</tr>
<tr>
<td>((Z \rightarrow \ell\ell) + \ell +) jets + MET</td>
<td>stop with Z</td>
<td>ATLAS-CONF-2019-016</td>
</tr>
<tr>
<td>2 same sign (\ell/3\ell) + jets + MET</td>
<td>gluinos/sbottom/stop/gluinos (\rightarrow) RPV stop</td>
<td>ATLAS-CONF-2019-015</td>
</tr>
<tr>
<td>(\ell\ell + j +) MET</td>
<td>compressed spectrum ewkinos, sleptons</td>
<td>ATLAS-CONF-2019-014</td>
</tr>
<tr>
<td>(\geq 3b +) MET</td>
<td>sbottom with Higgs in decays</td>
<td>ATLAS-CONF-2019-011</td>
</tr>
<tr>
<td>2(\ell) + MET</td>
<td>charginos/sleptons</td>
<td>ATLAS-CONF-2019-008</td>
</tr>
<tr>
<td>Displaced (\mu) and vertex</td>
<td>long-lived stop RPV</td>
<td>ATLAS-CONF-2019-006</td>
</tr>
</tbody>
</table>
**SUSY: Stop Production**

- Direct stop production with “unusual” decays
  - three-body decay $\tilde{t}_1 \rightarrow bW\tilde{\chi}_1^0$ in the $\ell + \text{jets} + \text{MET}$ final state
  - $Z + \text{top} \ (\tilde{t} \rightarrow tZ\tilde{\chi}_1^0 \text{ or } \tilde{t}_2 \rightarrow \tilde{t}_1 Z)$
  - long lived stop RPV $\tilde{t} \rightarrow q\mu$ displaced muon + vertex

**ATLAS-CONF-2019-017**

ATLAS Preliminary
\(f_s = 13 \text{ TeV, } 139 \text{ fb}^{-1}\)
Limit at 95% CL

**ATLAS-CONF-2019-006**

ATLAS Preliminary
\(f_s = 13 \text{ TeV, } 136 \text{ fb}^{-1}\)
All limits at 95% CL

**ATLAS-CONF-2019-016**

ATLAS Preliminary
\(f_s = 13 \text{ TeV, } 139 \text{ fb}^{-1}\)
All limits at 95% CL
SUSY: Chargino-Neutralino Production

- **Trilepton**
  - (emulated) recursive jigsaw
  - SRs with and without ISR

- **Higgs**
  - use $h \rightarrow \gamma\gamma$ decay, $W \rightarrow \ell\nu$ or $qq'$ on the other side

Both analyses: excesses in 36 fb$^{-1}$ not seen in full dataset
SUSY: Compressed Spectra

- Small sparticle mass splittings \( \rightarrow \) low \( p_T \) SM particles: hard to trigger and reconstruct
  - use initial state jets (> 50 GeV) to provide a boost to increase MET
  - target electroweakinos and sleptons with same-flavor dilepton analysis
- Use MET trigger
- Recursive jigsaw to isolate ISR
- Sensitivity to mass splittings \( \sim 1 \) GeV

ATLAS-CONF-2019-014
SUSY: Staus

- Potential scenario: colored superpartners very heavy, sleptons accessible at LHC (and staus lightest)
- Search for stau pair production
  - two hadronic taus + MET
  - $m(\tau\tau) > 120$ GeV (remove $Z/H$), events with b-jets (remove $t\bar{t}$), $m_{\tau_2} > 70$ GeV (remove $t\bar{t}$, WW)

validation regions

high mass SR

first sensitivity for $m_\tau > 110$ GeV
New physics can affect mixing in the $B_s$ system
- CP violating phase $\phi_s$ from interference of decays with and without mixing in $B_s \to J/\psi \varphi$ is small in SM ($\sim -0.036$)

Flavor of produced $B_s$ tagged via tagging charge of "opposite side" tracks (opposite side B hadron region identified using lepton or b-tagged jet)

Precision measurement of proper time

Fit includes interference with S-wave $J/\psi$ $K$ $K$
Forward System

- **ALFA** – data during runs with special LHC optics
- **AFP** – data during special runs and also generic high-$\mu$ physics
- ALFA/AFP operation in Run 3 intricately connected to beam optics
- Radiation damage to ALFA fibers → manageable now, but motivates $\sqrt{s} = 14$ TeV ALFA run as early as possible in Run 3

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ALFA 8 TeV total xsec: $\sigma_{\text{tot}}(pp \rightarrow X) = 96.07 \pm 0.18 \text{ (stat.)} \pm 0.85 \text{ (exp.)} \pm 0.31 \text{ (extr.) \, mb}$

*PLB 761, 158 (2016)*
Forward Physics

- Single diffractive events in ALFA
  - tag intact proton – suppress double diffractive/non-diffractive background
  - study exchanged color-neutral system & characteristics of rapidity gap
  - improve constraints on $\sigma_{\text{inel}}$

- Trigger on min bias trigger scintillators + ALFA coincidence

- Use central tracker to obtain rapidity gap $\Delta \eta$ and fractional proton energy loss $\xi = M_x^2/s$
Light-by-Light Scattering

- $\gamma\gamma \rightarrow \gamma\gamma$ through a loop is a fundamental QED process
  - violates superposition principle of classical electromagnetism
  - $\sigma \propto q^6$
- Ultraperipheral heavy ion collisions are an ideal system to search for $\gamma\gamma \rightarrow \gamma\gamma$
  - colliding the nuclei’s E, B fields – cross section enhanced by a factor $Z^4 = 4.5 \times 10^7$ over proton collisions
  - in-time pileup negligible → look for events with two photons and nothing else
    - $E_T^\gamma > 3$ GeV, back-to-back in $\phi$, low $p_T^\gamma\gamma$
    - Trigger allows a maximum amount of calo energy
- 8.2$\sigma$ observation (6.2 exp)

$\text{arxiv:1904.03536 (sub. to PRL)}$

2018 PbPb data
Planning

- Many activities happening in parallel in cavern
  - potential for conflict between different systems must be managed
Maintenance

• Leak finding/repair
  – comprehensive refurbishment of LAr & Tile cooling circuits (connectors, hoses ...)
  – RPC gas leak repairs progressing well

• Refurbishment of DAQ networks at P1
  – router & switch replacement, bandwidth increase
  – node transition to CentOS 7
  – HLT farm used for MC generation when available

• Replacement of crack scintillators & min bias trigger scintillators (MBTS) in progress
  – crack scintillators significantly improve energy resolution in $|\eta| \sim 1.2-1.6$; replacement will extend coverage to 1.72

• Plans to study pixel depletion depth via program of cosmic runs during LS2
  – ID was warm for only 17 days during endplate opening

new core routers
LAr Trigger Upgrade

- Installation of new trigger data path for liquid argon calorimeter
  - synergistic with “regular” maintenance
- Front-end board rework, crate baseplane replacement proceeding well
  - 50 FEB/wk achieved (1524 total)
- Commissioning of new crates ongoing
  - validate old trigger path first, then new path when possible
Muon New Small Wheel

Assembled sTGC wedges, waiting for services and electronics

New Small Wheel (NSW)

2x 4 layers (Quadruplet) of Micromegas detectors / NSW sector

2x 4 layers (Quadruplet) of sTGC detectors / NSW sector

First complete Micromegas double wedge in cosmic ray test stand for electronics studies

Electronics test on sTGCs
Muon New Small Wheel

- NSW structure ready to receive detector sectors: installation of 1st sector planned in summer
  - Services installation on A-side wheel is complete

- sTGC:
  - Production is progressing according to schedule, 27 chambers shipped to CERN. Wedge assembly ongoing, first 5 wedges completed

- Micromegas:
  - Production is ongoing. Some remaining HV stability issues
  - Wedge assembly PRR was passed in April
  - 1st double wedge assembled successfully, further wedge integration driven by chamber availability

- Electronics:
  - 50% of front end ASIC (VMM) series production wafers received → packaging next
  - All electronics cards are either in pre-production or production, with some delays on the Micromegas frontend board (MMFE8)

- Good progress, but installation of first wheel (A-side) in LS2 remains a challenge
TDAQ Upgrade

L1Calo:
- Prototype boards exist for all feature extractors (FEXs).
- Being tested in Surface Test Facility (STF)@CERN aiming for full FEX-Hub-ROD-FELIX data path.
- Baseline algorithms established for all FEXs.
- Installation Q4-2019 until Q1-2020.

L1Muon:
- Barrel+Endcap Muon Sector Logic (SL) installation planned for July 2019.

FELIX (common readout driver):
- Significant stability improvements in firmware and software; FPGA utilisation under control.
- Pre-production of 20 boards testing found issues, under evaluation, final PRR foreseen May 2019 is delayed.
- Target for installation Q3 2019.
Phase-II Upgrades
Phase-II upgrades

- Six TDR approved (ITk pixel, ITk strips, LAr, Tile, Muon, TDAQ) + one Technical Proposal (HGTD)
  - ATLAS review identified additional R&D steps for HGTD: TDR to be submitted by April 2020
- 5 MoUs released for signature
  - ITk pixel being prepared for summer
- Project baselining process complete
  - Follow-up reviews of ITk pixel and TDAQ planning scheduled by beginning of July
- ITK strips, LAr and Muons passed P2UG in-depth review in May – milestones approved
- In-depth review of ITk pixel and common items, Tile and TDAQ in November
Muons & ITk Strips

Muon upgrade:

- Design of new electronics for MDT/TGC/RPC: new ASICs are either in pre-production or have first prototypes
- BIS7/8, a pilot project for new barrel-inner chambers, on track for installation in LS2

ITk Strips:

- Undergoing the transition from prototyping to pre-production.
- This coming year will have most of the technical reviews allowing for pre-production (final design review)
  - First FDR to allow for sensor preproduction finished this April
  - Next FDR for global mechanics next week

EC Global Support
Demonstrator + Petal Insertion
Conclusion

- Excellent progress in exploiting full 139 fb$^{-1}$ dataset for search analyses
  - 15 public results in SUSY, exotic resonances, Higgs
  - also first result from Nov 2018 heavy ion run!
- Studies in progress to obtain ultimate accuracy for precision analyses
- Long Shutdown activities: detector refurbishment + Phase-I upgrade installation making good progress.
  - Software + TDAQ overhaul for multithreading also proceeding
- Phase-II upgrade activities passing major project milestones – TDR approval, MOUs, baselining

Many thanks to the LHC & computing professionals without whom our results would not be possible!
Extra
# Higgs Combination Categories

<table>
<thead>
<tr>
<th>$H \rightarrow \gamma\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H \rightarrow ZZ^*$</td>
</tr>
<tr>
<td>$H \rightarrow WW^*$</td>
</tr>
<tr>
<td>$H \rightarrow \tau\tau$</td>
</tr>
<tr>
<td>$H \rightarrow bb$</td>
</tr>
</tbody>
</table>

### $ttH$ Leptonic (3 categories)
- $ttH$ leptonic 1 $\ell + 2$ $\tau_{had}$
- $ttH$ leptonic 2 opposite-sign $\ell + 1$ $\tau_{had}$
- $ttH$ leptonic 2 same-sign $\ell$ (categories for 0 or 1 $\tau_{had}$)
- $ttH$ leptonic 3 $\ell$ (categories for 0 or 1 $\tau_{had}$)
- $ttH$ leptonic 4 $\ell$ (except $H \rightarrow ZZ^* \rightarrow 4\ell$)
- $ttH$ hadronic, $H \rightarrow ZZ^* \rightarrow 4\ell$

### $VH$ Leptonic
- $VH$ 2 $\ell$
  - $VH$ 1 $\ell$, $p_T^{\ell+E_T^{miss}} \geq 150$ GeV
  - $VH$ 1 $\ell$, $p_T^{\ell+E_T^{miss}} < 150$ GeV
  - $VH$ $E_T^{miss}$, $E_T^{miss} \geq 150$ GeV
  - $VH$ $E_T^{miss}$, $E_T^{miss} < 150$ GeV
  - $VH + VBF$ $p_T^{3\ell} \geq 200$ GeV
- $VH$ hadronic (2 categories)

### $VBF$
- $VBF$, $p_T^{\gamma\gamma ij} \geq 25$ GeV (2 categories)
- $VBF$, $p_T^{\gamma\gamma ij} < 25$ GeV (2 categories)

### $ggF$
- 2-jet, $p_T^{\gamma\gamma} \geq 200$ GeV
- 2-jet, $120$ GeV $\leq p_T^{\gamma\gamma} \leq 200$ GeV
- 2-jet, $60$ GeV $\leq p_T^{\gamma\gamma} \leq 120$ GeV
- 1-jet, $p_T^{\gamma\gamma} < 60$ GeV
- 1-jet, $p_T^{\gamma\gamma} \geq 200$ GeV
- 1-jet, $p_T^{\gamma\gamma} \leq 120$ GeV
- 1-jet, $p_T^{\gamma\gamma} \leq 60$ GeV
- 1-jet (2 categories)

### Boosted
- 1-jet, $p_T^{\gamma\gamma} < 30$ GeV, $p_T^{4\ell} < 20$ GeV
- 1-jet, $p_T^{\gamma\gamma} \geq 30$ GeV, $p_T^{4\ell} \geq 20$ GeV
- 0-jet, $p_T^{\gamma\gamma} < 30$ GeV, $p_T^{4\ell} < 20$ GeV
- 0-jet, $p_T^{\gamma\gamma} \geq 30$ GeV, $p_T^{4\ell} \geq 20$ GeV

### Other Conditions
- $2 \ell$, $75 \leq p_T^{V} < 150$ GeV, $N_{jets} = 2$
- $2 \ell$, $75 \leq p_T^{V} < 150$ GeV, $N_{jets} \geq 3$
- $1 \ell$, $p_T^{V} \geq 150$ GeV, $N_{jets} = 2$
- $1 \ell$, $p_T^{V} \geq 150$ GeV, $N_{jets} \geq 3$
- $0 \ell$, $p_T^{V} \geq 150$ GeV, $N_{jets} = 2$
- $0 \ell$, $p_T^{V} \geq 150$ GeV, $N_{jets} = 3$

### Additional Information
- VBF, two central jets
- VBF, four central jets
- VBF $+\gamma$
W’ Efficiency

- Decrease at high mass due to low mass off-shell component becoming dominant.
\[ \mathbf{B}_s \rightarrow J/\psi \phi \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Statistical uncertainty</th>
<th>Systematic uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>[\phi_s[\text{rad}]]</td>
<td>-0.076</td>
<td>0.034</td>
<td>0.019</td>
</tr>
<tr>
<td>[\Delta \Gamma_s[\text{ps}^{-1}]]</td>
<td>0.068</td>
<td>0.004</td>
<td>0.003</td>
</tr>
<tr>
<td>[\Gamma_s[\text{ps}^{-1}]]</td>
<td>0.669</td>
<td>0.001</td>
<td>0.001</td>
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<tr>
<td>[</td>
<td>A_\parallel(0)</td>
<td>^2]</td>
<td>0.220</td>
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<td>A_0(0)</td>
<td>^2]</td>
<td>0.517</td>
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<td>[</td>
<td>A_5</td>
<td>^2]</td>
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<td>[\delta_\perp [\text{rad}]]</td>
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<tr>
<td>[\delta_\parallel [\text{rad}]]</td>
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<td>0.202</td>
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<tr>
<td>[\delta_\perp - \delta_\parallel [\text{rad}]]</td>
<td>-0.216</td>
<td>0.037</td>
<td>0.010</td>
</tr>
</tbody>
</table>

**ATLAS-CONF-2019-009**

<table>
<thead>
<tr>
<th>Tag method</th>
<th>Efficiency [%]</th>
<th>Effective Dilution [%]</th>
<th>Tagging Power [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tight muon</td>
<td>4.50 ± 0.01</td>
<td>43.8 ± 0.2</td>
<td>0.862 ± 0.009</td>
</tr>
<tr>
<td>Electron</td>
<td>1.57 ± 0.01</td>
<td>41.8 ± 0.2</td>
<td>0.274 ± 0.004</td>
</tr>
<tr>
<td>Low-(p_T) muon</td>
<td>3.12 ± 0.01</td>
<td>29.9 ± 0.2</td>
<td>0.278 ± 0.006</td>
</tr>
<tr>
<td>Jet</td>
<td>5.54 ± 0.01</td>
<td>20.4 ± 0.1</td>
<td>0.231 ± 0.005</td>
</tr>
<tr>
<td>Total</td>
<td>14.74 ± 0.02</td>
<td>33.4 ± 0.1</td>
<td>1.65 ± 0.01</td>
</tr>
</tbody>
</table>
SUSY Trilepton Distributions

ATLAS Simulation Preliminary

$\frac{m(\tilde{\chi}_2^0/\tilde{\chi}_1^\pm)}{(200,100) \text{ GeV}}$

$\frac{p_T^{\text{jet}}}{[\text{GeV}]}$
• Chargino/slepton production
  - final state $2\ell$ (e/$\mu$) + MET
  - $m(\ell\ell) > 100$ GeV (e$\mu$) / 121.2 GeV (ee/$\mu\mu$), b-jet veto, MET > 110 GeV, no more than one jet
  - SRs binned in $m_{T2}$, # jets, flavor
ALFA SD: background modeling

**SR**

**CR1**

**CR2**
TDAQ Phase-I Upgrade

**FELIX:**
- Significant stability improvements in firmware and software.
- FPGA utilisation under control.
- Pre-production of 20 boards testing found issues, under evaluation, final PRR foreseen May-19 is delayed.
- Target for installation Q3 2019

**L1Calo:**
- Prototype boards exist for all FEXs.
- Being tested in Surface Test Facility (STF)@CERN aiming for full FEX-Hub-ROD-FELIX data path.
- Baseline algorithms established for all FEXs.
- Results from latency tests are within envelopes.
- System Testing integration of modules in STF at CERN until October 2019.
- some Production Readiness Reviews, depending on inter-module tests and FW readiness have delays.
- No technical problems found so far.
- Installation Q4-2019 until Q1-2020.

**L1Muon**
- Barrel+Endcap Muon Sector Logic (SL) installation planned for July 2019. Then cabling to MuCTPi.
- MuCTPi: final tests to make choice between two Prototypes ongoing (different SoC).
- Tests of connection between BW Trigger Processor (TP) and SL successful.
- Installation from Q4 2019 onwards.

**L1Calo Module**

<table>
<thead>
<tr>
<th>L1Calo Module</th>
<th>Review</th>
<th>Planned/HELD</th>
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<tr>
<td>gFEX</td>
<td>PRR</td>
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<tr>
<td>eFEX</td>
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<td>jFEX</td>
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<tr>
<td>Topo</td>
<td>PRR</td>
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<tr>
<td>Hub</td>
<td>PRR</td>
<td>Dec-18</td>
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<tr>
<td>ROD</td>
<td>PRR</td>
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<td>TREX</td>
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<td>FOX</td>
<td>PRR</td>
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<tr>
<td>TopoFOX</td>
<td>FDR</td>
<td>Apr-19</td>
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High Granularity Timing Detector (HGTD) for HL-LHC

- $\sigma_{t}/\text{track} \sim 30-50 \text{ ps} \text{ up to end HL-LHC}$
- $2.4 < |\eta| < 4.0; Z \sim +3.5 \text{ m from IP}$
- < 10% occupancy
- $1.3 \times 1.3 \text{ mm}^2$ LGAD pixels (6.4 m$^2$)
- $3.6 \times 10^6$ channels
- Luminosity (hit counting) detector
- $< (3-5) \times 10^{15} \text{n}_{eq}/\text{cm}^2$

TP approved in June 2018: (CERN-LHCC-2018-023)

Deliver TDR to LHCC by April 2020
Recent Developments in the ITk Strip Sub-system (WBS 2.2)

- ITk Strip System consists of 4 barrel cylinders and 2 end-cap with 6 disks each
  - 165 m$^2$ of silicon (61 m$^2$: ID), ~18 k modules (~4k modules ID)
- Adopted multi-modular approach (staves/petals)
  - Designed manufacturability and mass production into components from the start
- The ITk Strip project is undergoing the transition from prototyping to pre-production
- Some highlights:
  - Last prototype readout ASIC (ABCstar) and Hybrid Control Chip (HCCstar) have >90% grade A yield
  - Excellent module performance matches expectations
  - First End of Substructure (EoS) cards with lpGBT and VTRX+ working well
  - First double sided (ABC130-based) stave completed and tested
- This coming year will have most of our technical reviews allowing for pre-production (FDR)
  - First FDR to allow for sensor preproduction finished this April

EC Global Support
Demonstrator + Petal Insertion
Barrel Mechanics
Thermal Studies
The Muon Phase-II Upgrade

- The design of new electronics for MDT / TGC / RPC is progressing: New ASICs are either in pre-production phase (MDT ASD, TGC PP ASIC) or we have first prototypes (MDT TDC, RPC FE).

- BIS78, a pilot project for Barrel-Inner (BI) chambers (<10% of total), is on track for installation in LS2: first RPC production module has very good quality. Half of sMDT chambers.

- The design of the new BI chambers is progressing well. New baseline for RPCs includes two-sided h-h strip readout (instead of h-j) and staggered chambers in the large sectors, to improve acceptance and simplify layout and services.