Response of gap/crack scintillators of the Tile Calorimeter of the ATLAS detector to isolated muons from $W \to \mu\nu$ events.

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First Pan-African Astro-Particle and Collider Physics Workshop
March 23, 2022

Institute for Collider Particle Physics
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National Research Foundation
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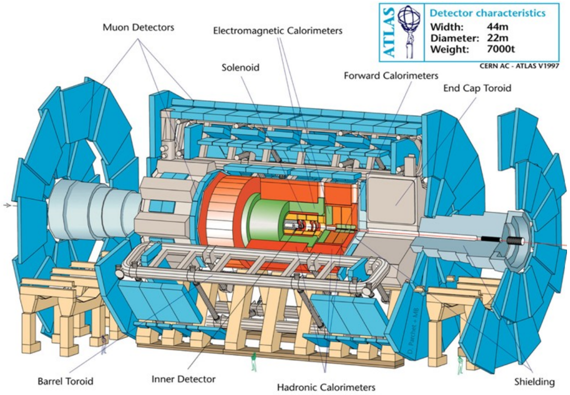
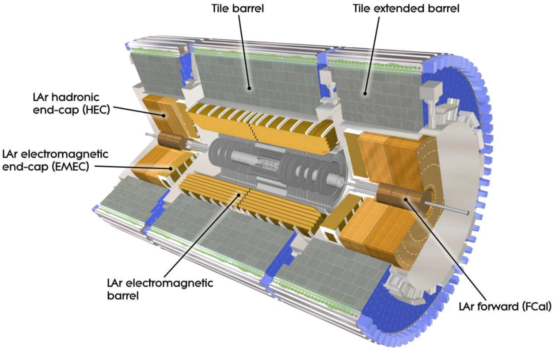
Overview

The ATLAS Detector at the LHC



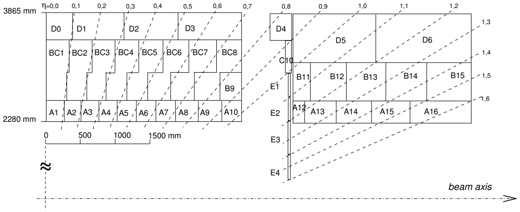
- It is a general purpose detector.
- It is purpose-built for the precise measurement of known physics and for searching for physics Beyond the Standard Model.
- It is made of systems of tracking detectors and calorimeters.

Layout of TileCal Cells.



- The Tile Calorimeter (TileCal) is made of a fixed central barrel and two moveable extended barrels.
- The TileCal is composed of 64 modules, made of alternating layers of iron as an absorbing medium and plastic scintillating tiles as the active medium

The ITC



- The Intermediate Tile Calorimeter (ITC) is a plug detector located gap region, in between the long and the extended barrels.
- It was designed to correct for energy lost in the passive material that fills the gap region.
- The gap/crack region is covered by the E1, E2, E3 and E4 scintillators.
- The gap scintillators are 12.7 mm wide and the crack scintillators are 6 mm wide

Response of gap/crack scintillators to isolated muons

- The energy loss of through matter is a well understood process.
- For high energy muons, the dominant energy loss is through ionisation.
  - This well understood behaviour is used to study the response of the gap/crack scintillators to passing muons.
- The performance is evaluated in three data taking periods

Period	$\int \mathcal{L}dt$ [fb^{-1}]
2015 - 2016	36.2
2017	44.3
2018	58.5

- This study uses muons originating from the $W \to \mu\nu$ events from proton-proton collisions observed the ATLAS detector.

Object Reconstruction and Event Selection

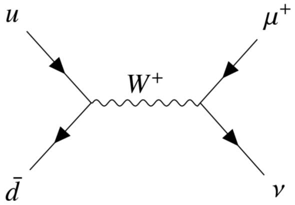
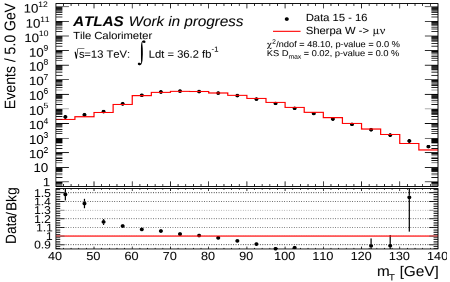


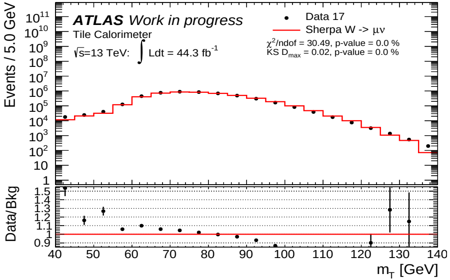
Table: Event selection based on the W decays

	Variable	Run 2 Requirement
1	Number of Muons	$\mathrm{N}_{\mathrm{muons}} = 1$
2	Transverse invariant mass	$40 < M_T < 140$ GeV
3	Missing transverse energy	$30 < E_T^{\mathrm{miss}} < 120$ GeV
4	Track isolation	$\sum p_T\|_{\Delta R=0.4} < 1$ GeV
5	Calorimeter isolation	$E_{\mathrm{LAr}}\|_{\Delta R=0.4} < 1.5$ GeV
6	Momentum of the muon	$20 < p^{\mu} <= 80$ GeV
7	Transverse momentum of the muon	$p_T^{\mu} > 28$ GeV

- A W^+ boson is created by interaction of up and antidown quarks.
- The interaction creates a single muon a neutrino
- The muon is reconstructed from the hits in the ID and MS
- The mysterious neutrino is reconstructed as the missing transverse energy, E_T^{miss}

Data-MC Comparisons

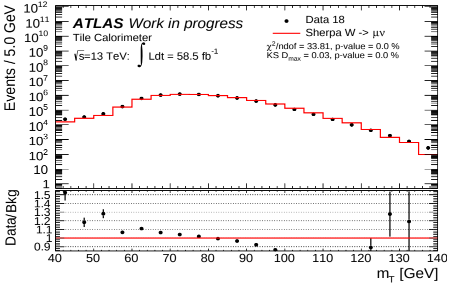




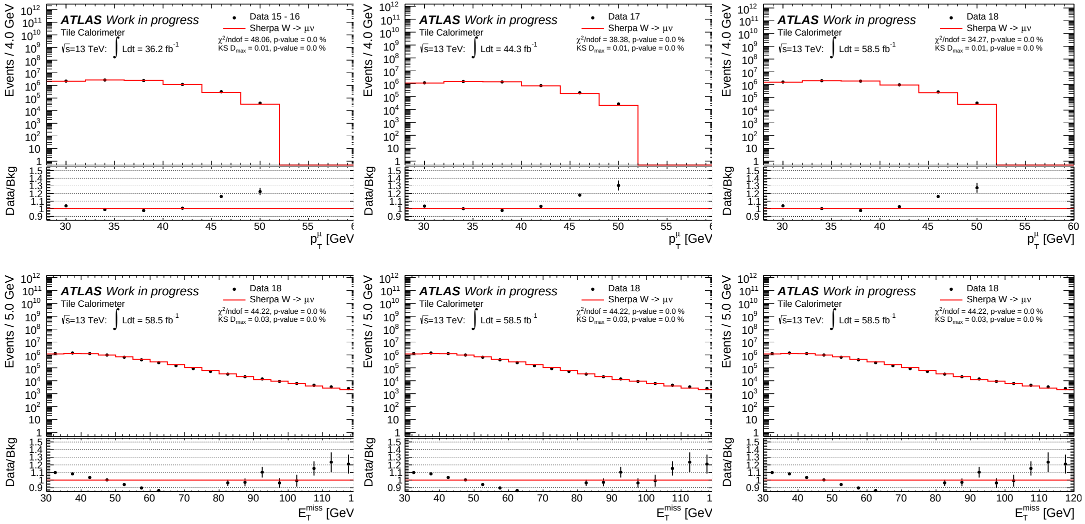
- The transverse mass is defined as:

$$m_T = \sqrt{2p_T^{\mu} E_T^{miss}(1 - \cos[\Delta\phi(\boldsymbol{p_T^{\mu}}, \boldsymbol{p_T^{miss}})])}$$

- The Data-MC mismatch is primarily due to the background from jet production.



Data - MC

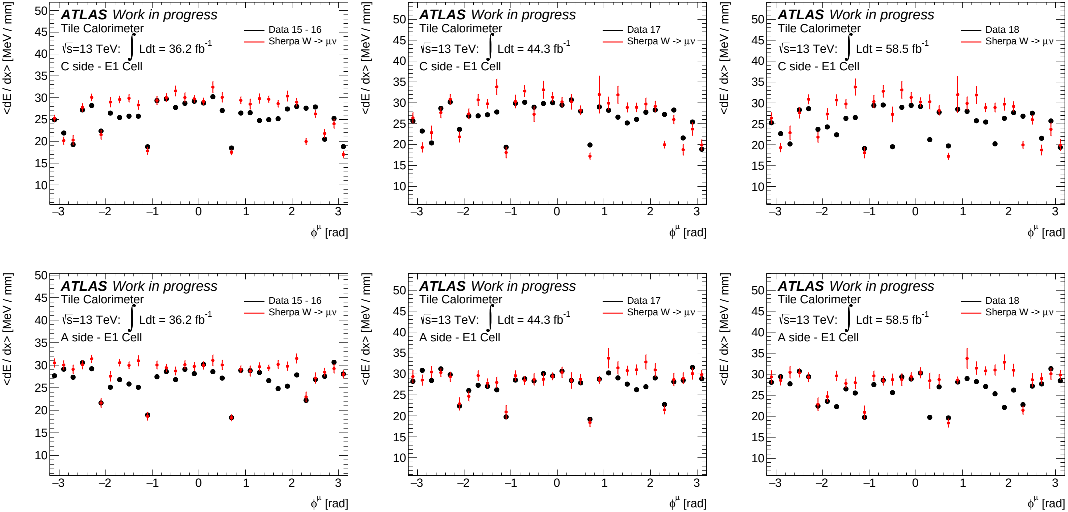


ATLAS Work in progress
Tile Calorimeter
√s=13 TeV: ∫ Ldt = 36.2 fb-1
Data 15 - 16
Sherpa W -> μν
χ2/ndof = 48.06, p-value = 0.0 %
KS Dmax = 0.01, p-value = 0.0 %
ATLAS Work in progress
Tile Calorimeter
√s=13 TeV: ∫ Ldt = 44.3 fb-1
Data 17
Sherpa W -> μν
χ2/ndof = 38.38, p-value = 0.0 %
KS Dmax = 0.01, p-value = 0.0 %
ATLAS Work in progress
Tile Calorimeter
√s=13 TeV: ∫ Ldt = 58.5 fb-1
Data 18
Sherpa W -> μν
χ2/ndof = 34.27, p-value = 0.0 %
KS Dmax = 0.01, p-value = 0.0 %
Events / 4.0 GeV
Data/Bkg
pμT [GeV]
ATLAS Work in progress
Tile Calorimeter
√s=13 TeV: ∫ Ldt = 58.5 fb-1
Data 18
Sherpa W -> μν
χ2/ndof = 44.22, p-value = 0.0 %
KS Dmax = 0.03, p-value = 0.0 %
Events / 5.0 GeV
Data/Bkg
EmissT [GeV]

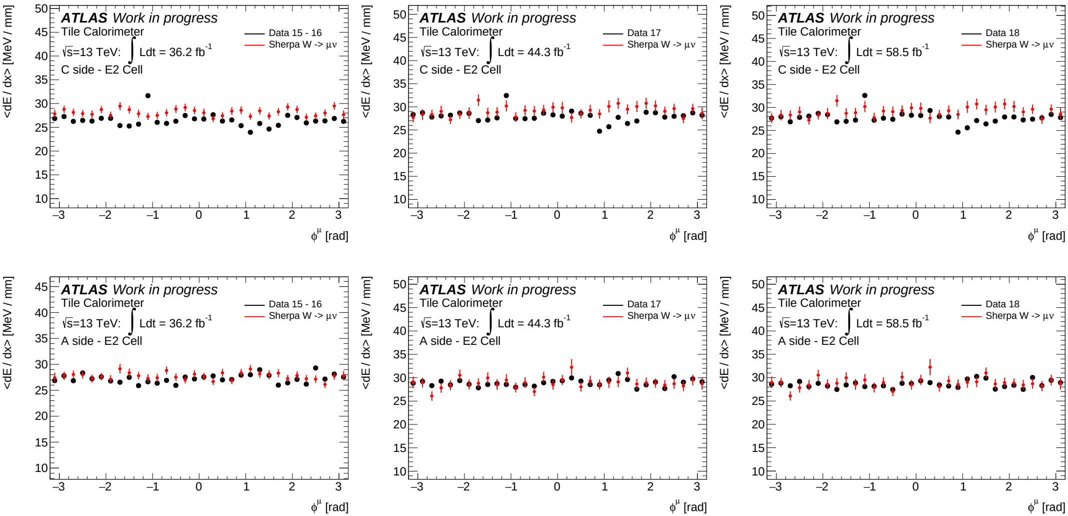
Cell Level Requirements

	Variable	Run 2 Requirement
1	Muon path length	E1, E2: $dx > 11$ mm; E3, E4: $dx > 5$ mm
2	Cell energy	$\Delta E > 60$ MeV
3	Track impact point	$\|\Delta\phi(\mu, \mathrm{cell}\| < 0.046$

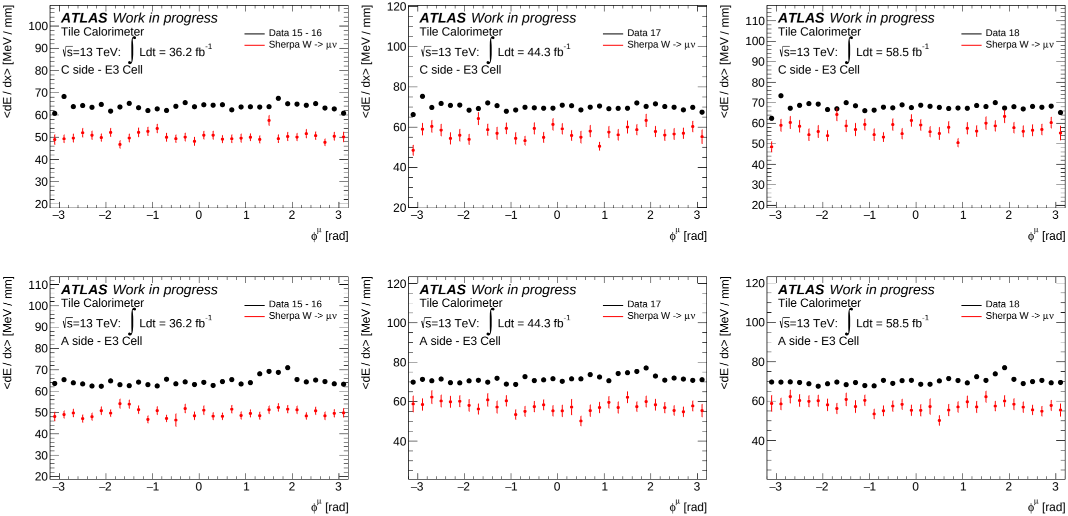
ϕ vs dE/dx in the E1 Cells



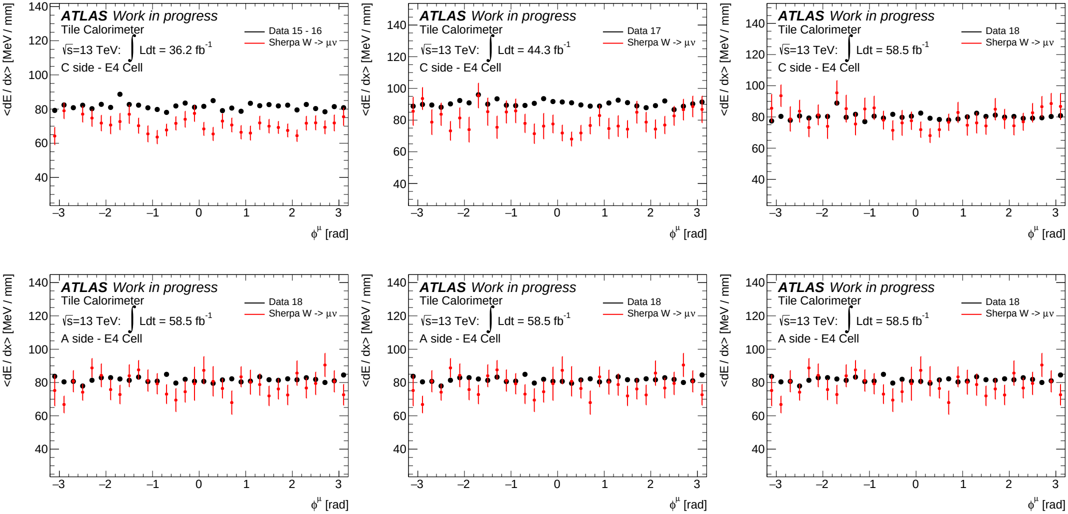
ϕ vs dE/dx in the E2 Cells



ϕ vs dE/dx in the E3 Cells



ϕ vs dE/dx in the E4 Cells



Conclusions

- Isolated muons were used to measure the ϕ uniformity of the response of muons in the gap/crack scintillators using data collected during the 2015 and 2016, 2017 and 2018 periods.
- The E1, E2 and E4 cells show a uniform response.
- Understanding the deviation in E3 cells forms part of the ongoing study