Triggers for photon + MET with machine learning

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Outline

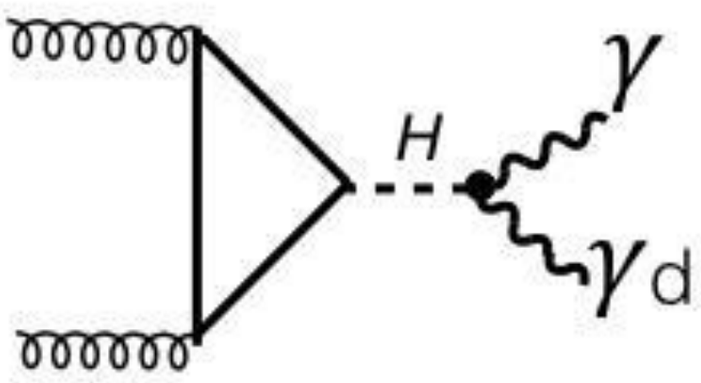
1. Physics motivation
- Dark photons
- What dark photons look like

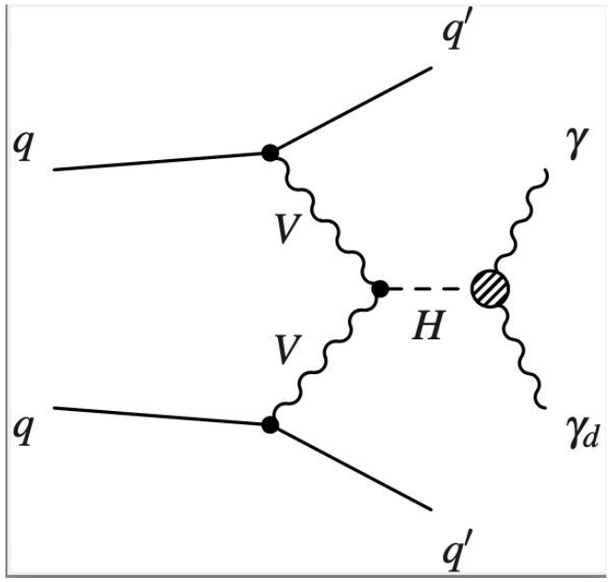
2. MET/Trigger Background
- Two-level trigger
- Trigger strategy
- New for Run 3

3. Resolution & Efficiency Curves
- Resolution
- Efficiency

Why we need new triggers

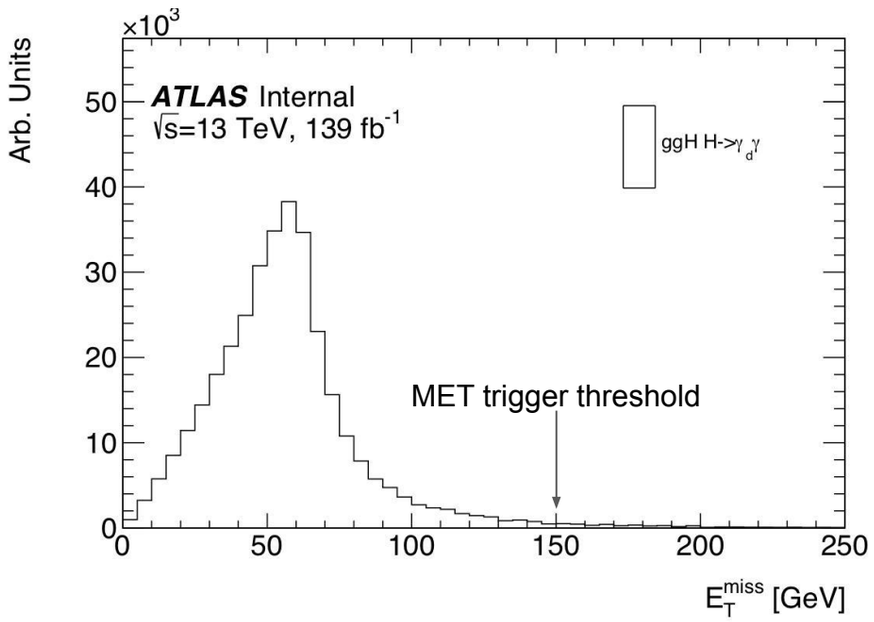
- Dark photons are a bsm model
- VBF search (right) is the most sensitive
- For gluon-gluon fusion (left) requires, a **new trigger**, which we present here





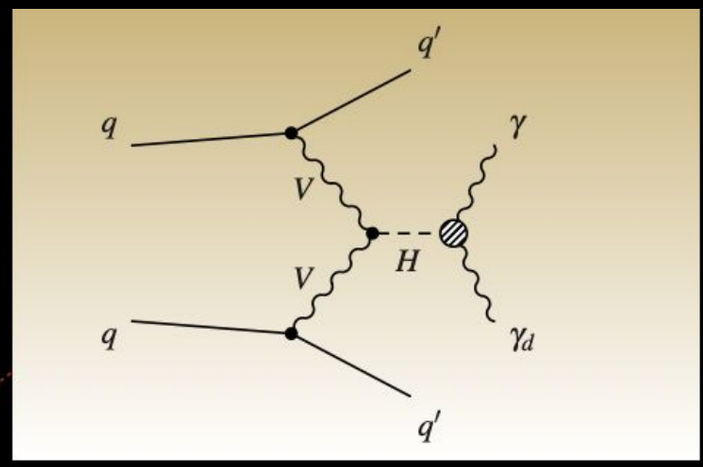
ggF σ = 48.52 pb

VBF σ = 3.78 pb



Result	Expected	Observed
CMS VBF [30]	2.8%	3.5%
CMS ZH [31]	3.6%	4.6%
CMS Combined [30]	2.1%	2.9%
ATLAS VBF [24]	1.7%	1.4%
ATLAS projected ggF (Run 2 trigger)	1.0%	-
ATLAS projected ggF (Run 3 with new trigger)	0.6%	-

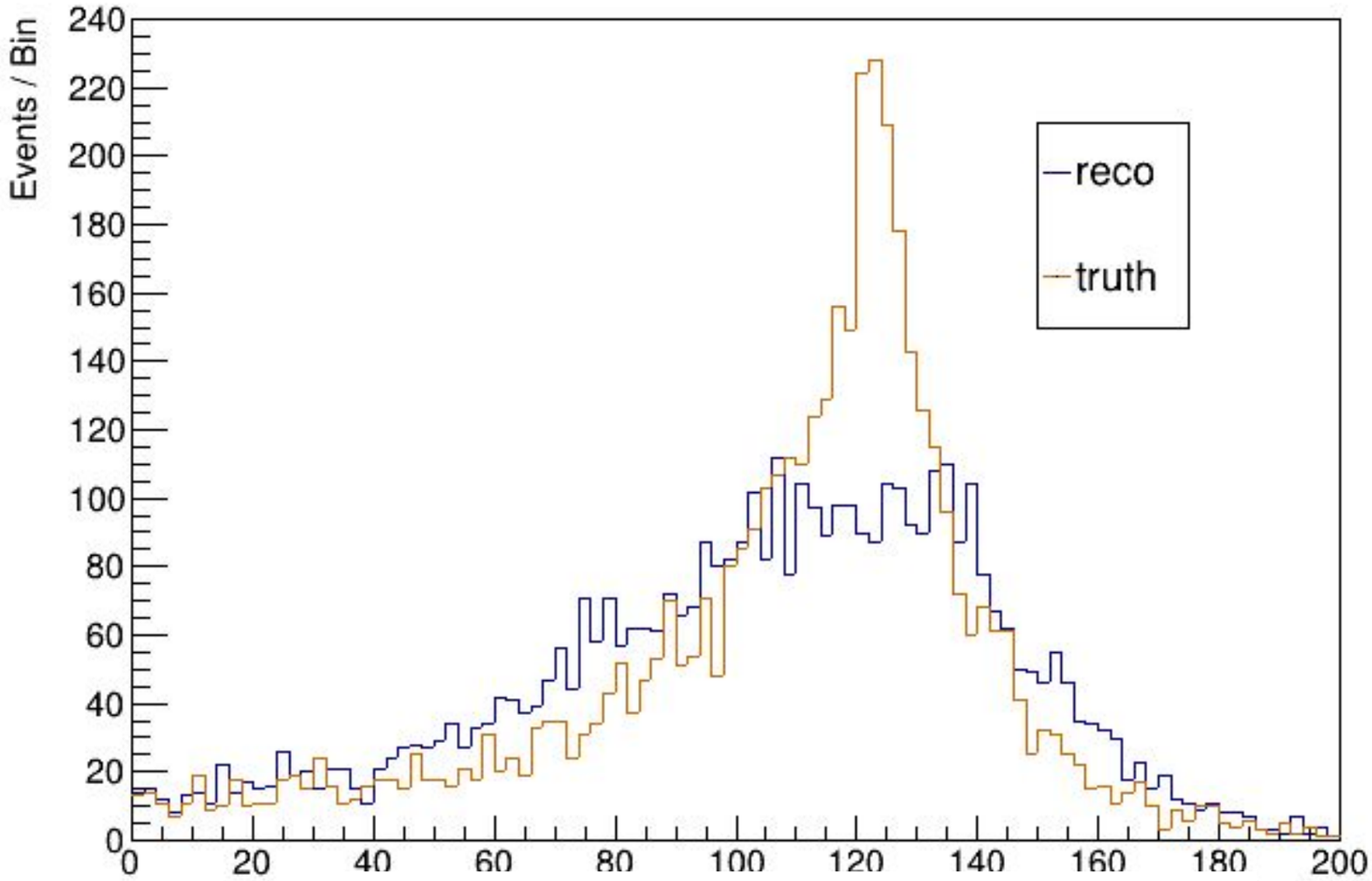
What dark photons look like



MET: conservation of momentum for dark photon momentum

Transverse mass

How we reconstruct Higgs in partially invisible events?
Transverse mass



$$m_T = \sqrt{2P_T^{\gamma} MET[1 - cos(\Delta\varphi)]}$$

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Trigger Overview

Event size · Event rate = 40 Tb/s

1 Mb*

·

40 MHz

Time

2.2μs

O(1s/event)

Partial data

Full data buffer

100 Gb/s

1 Gb/s

Permanent storage

*simplified numbers; actual numbers vary depending on event complexity, and the average event size is 1.5 Mb
**Also true in Run 3

Designing a trigger

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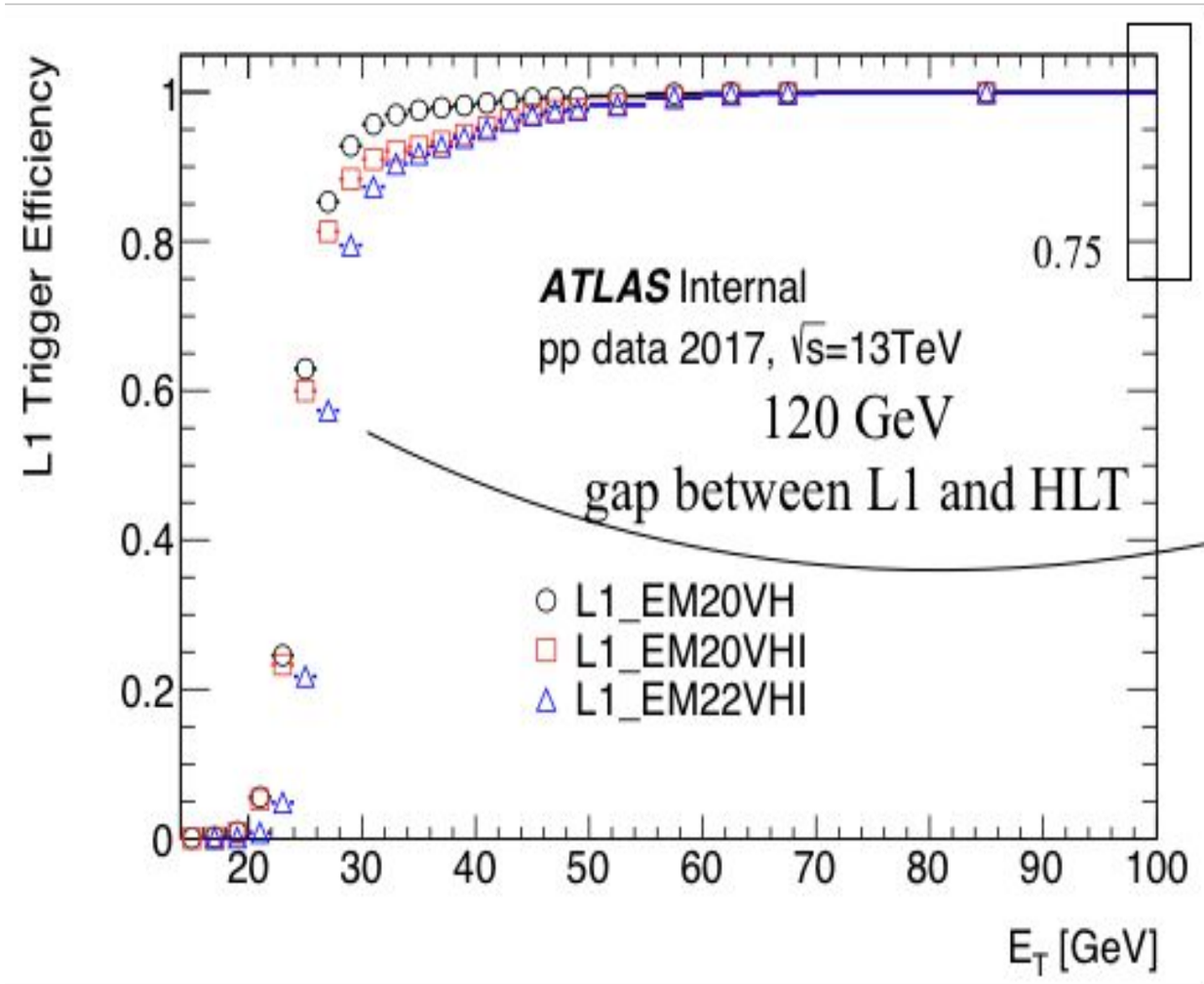
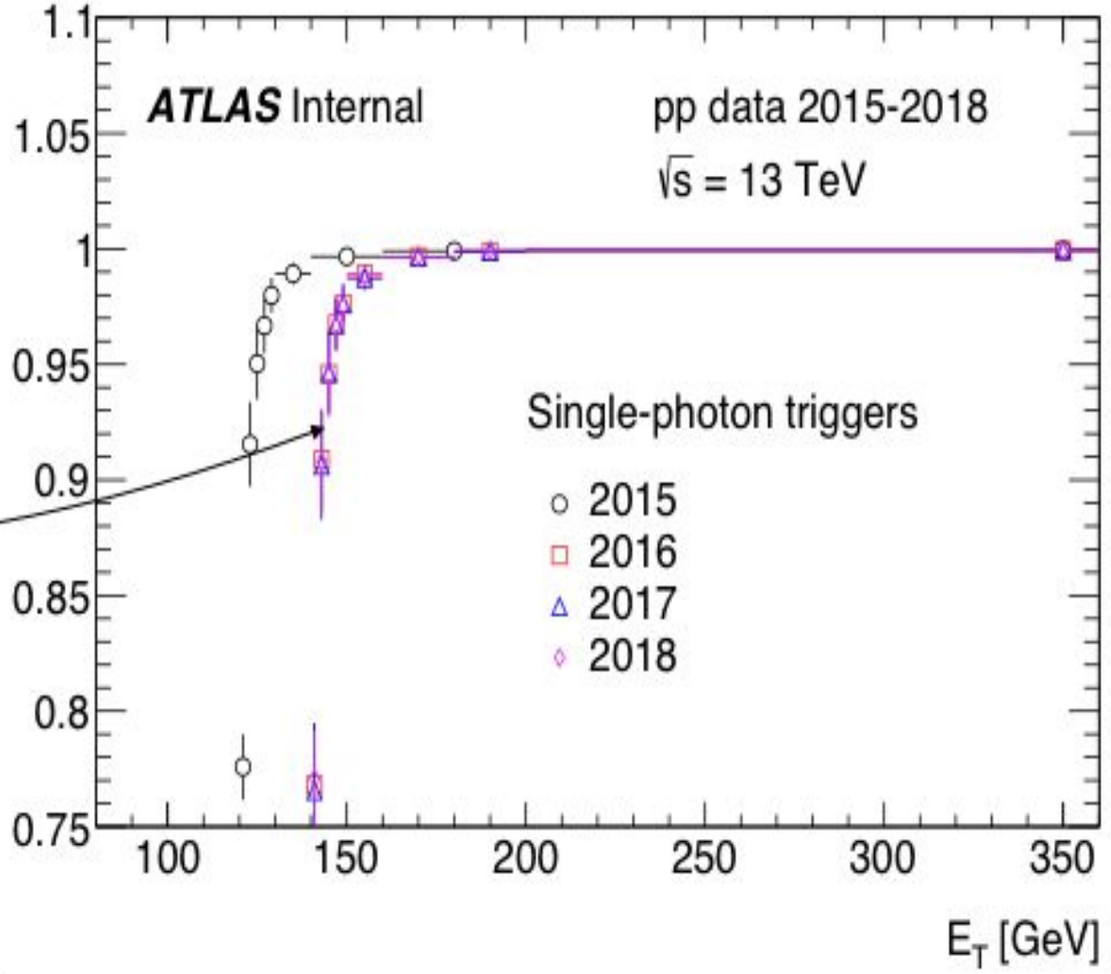
- Large gap between L1 and HLT for photons
- Added new trigger with MET to use events already accepted by L1



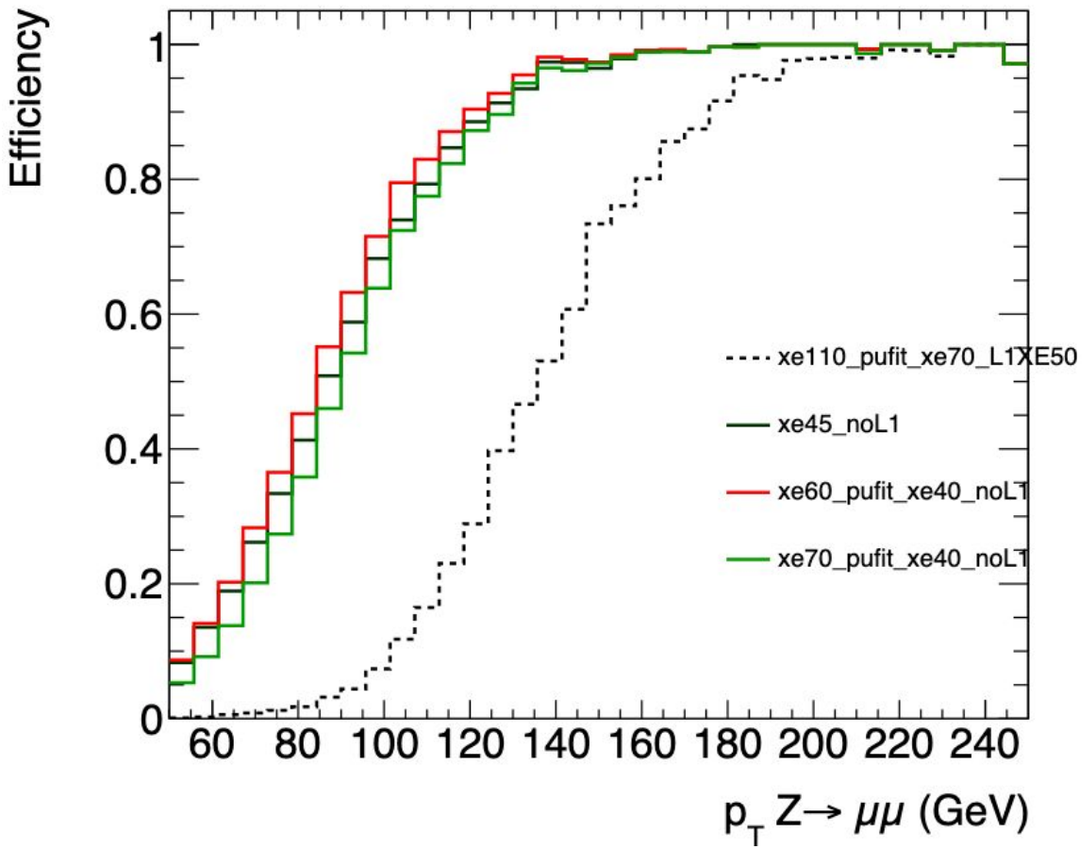


*L1 electrons and photons are the same item

Implemented trigger

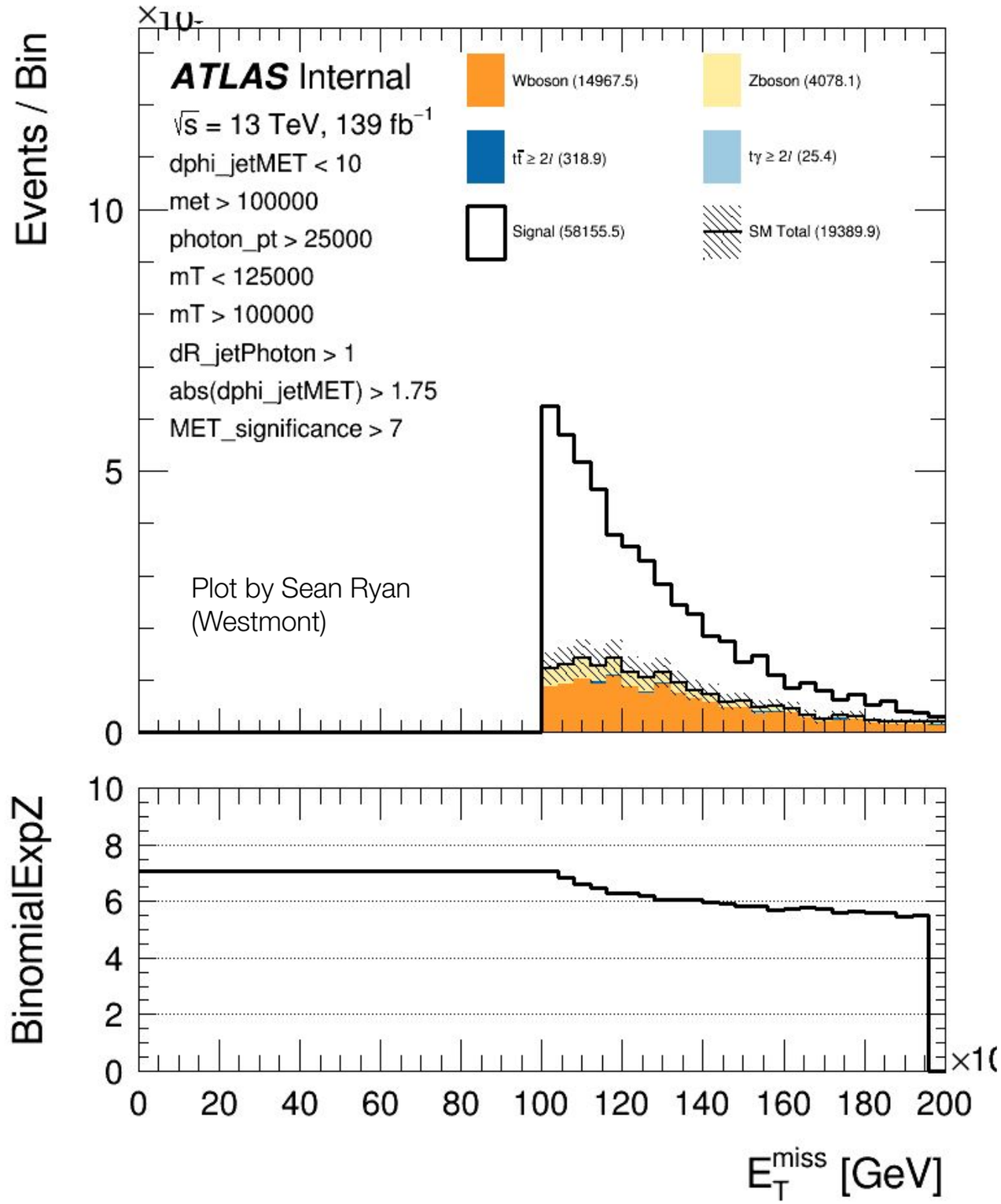
- 25 GeV tight isolated photon
- MET > 60 GeV (pfopufit)
- M_T > 80 GeV
- My goal: measure the efficiency of the trigger in simulation

Example plot from Run 2 data comparing default MET trigger with photon + MET trigger



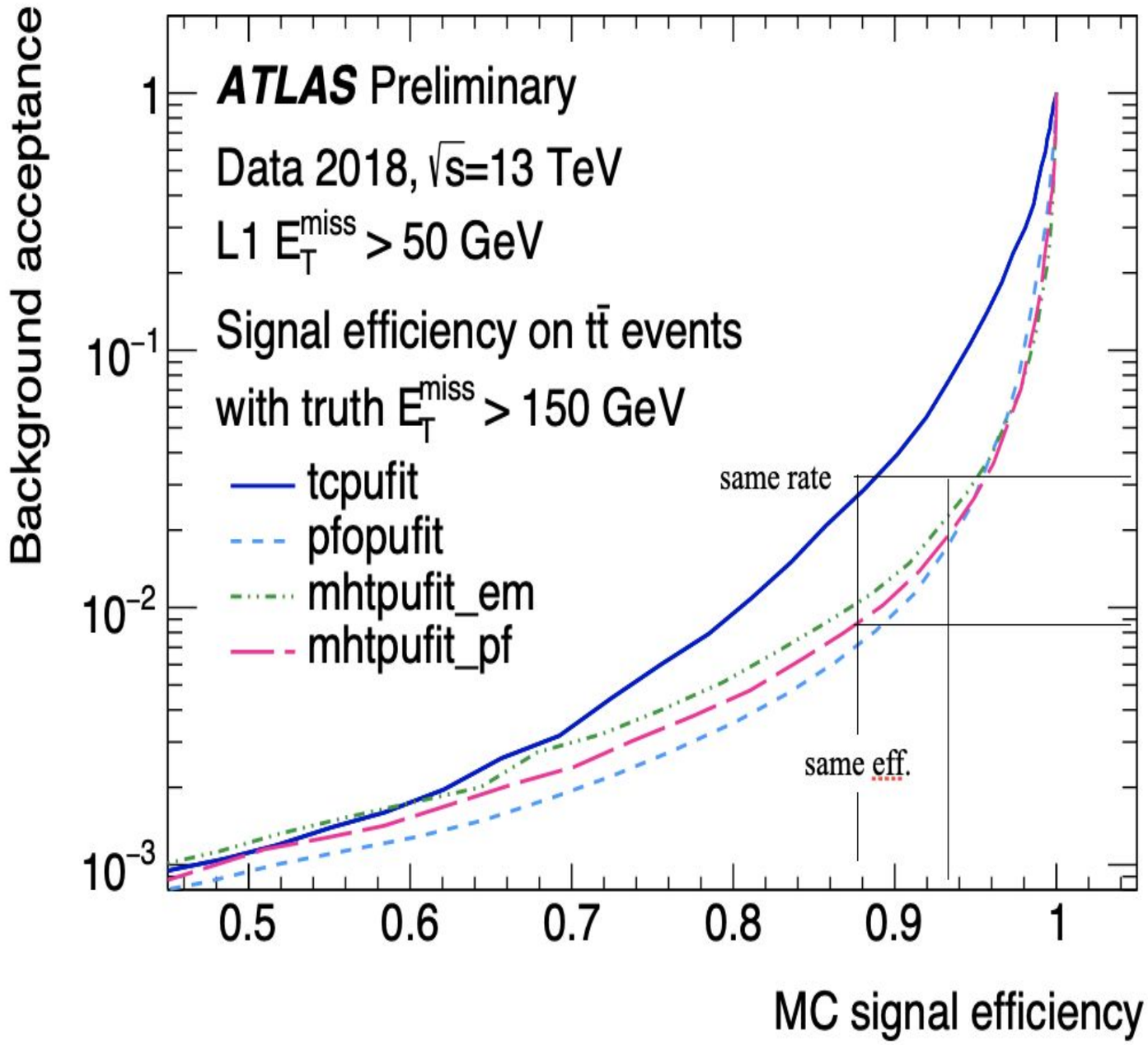
Why low MET?

- Sensitivity drops with MET, aim for 100 GeV threshold



New in Run 3: Tracks

- **Tracking** added into MET trigger for Run 3 (link)
  - Can be incorporated into photon + MET trigger
- Machine learning (neural network) regression that will result in even further background rejection (link)
  - I investigated the performance of the NN algorithm



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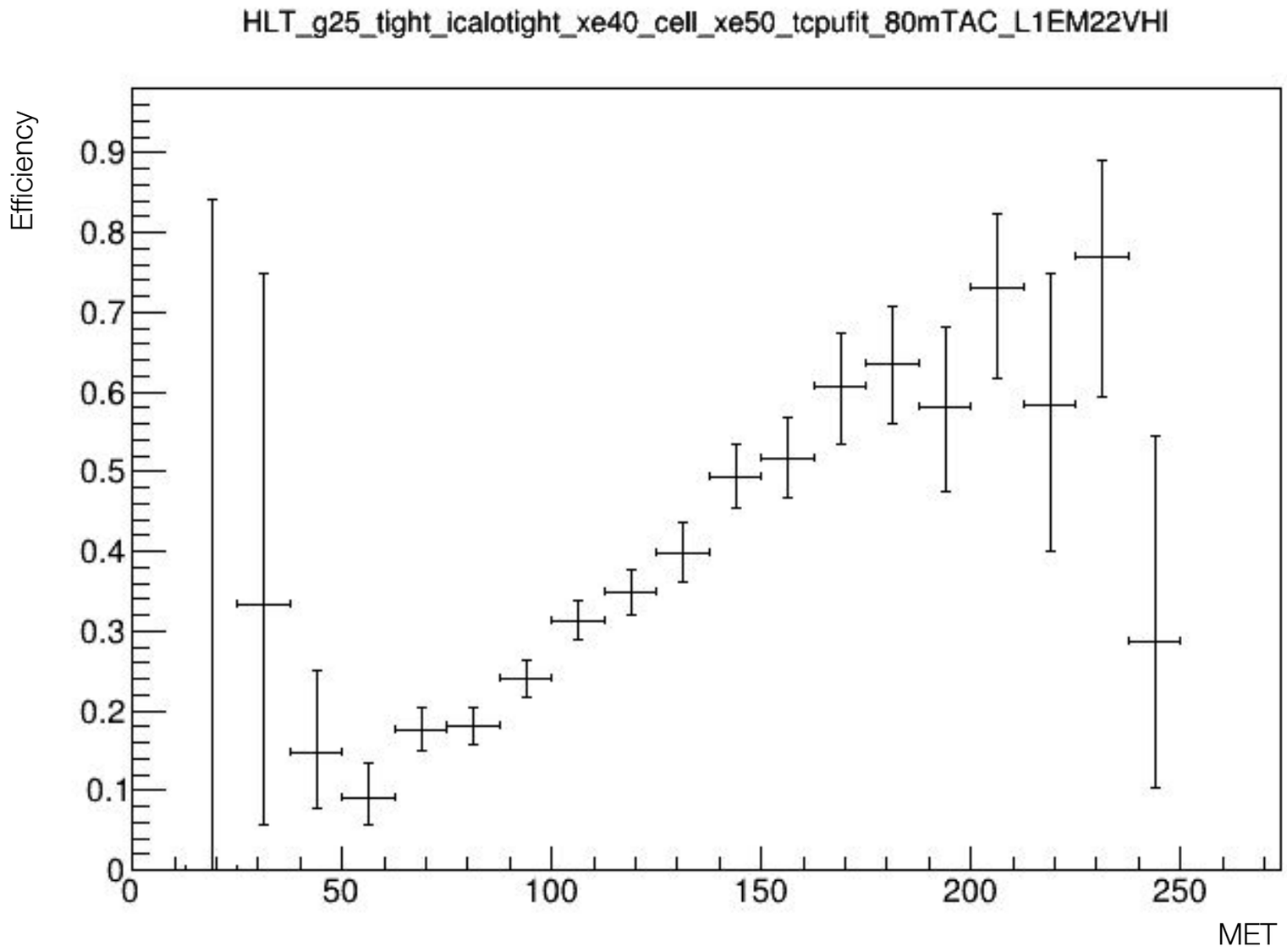
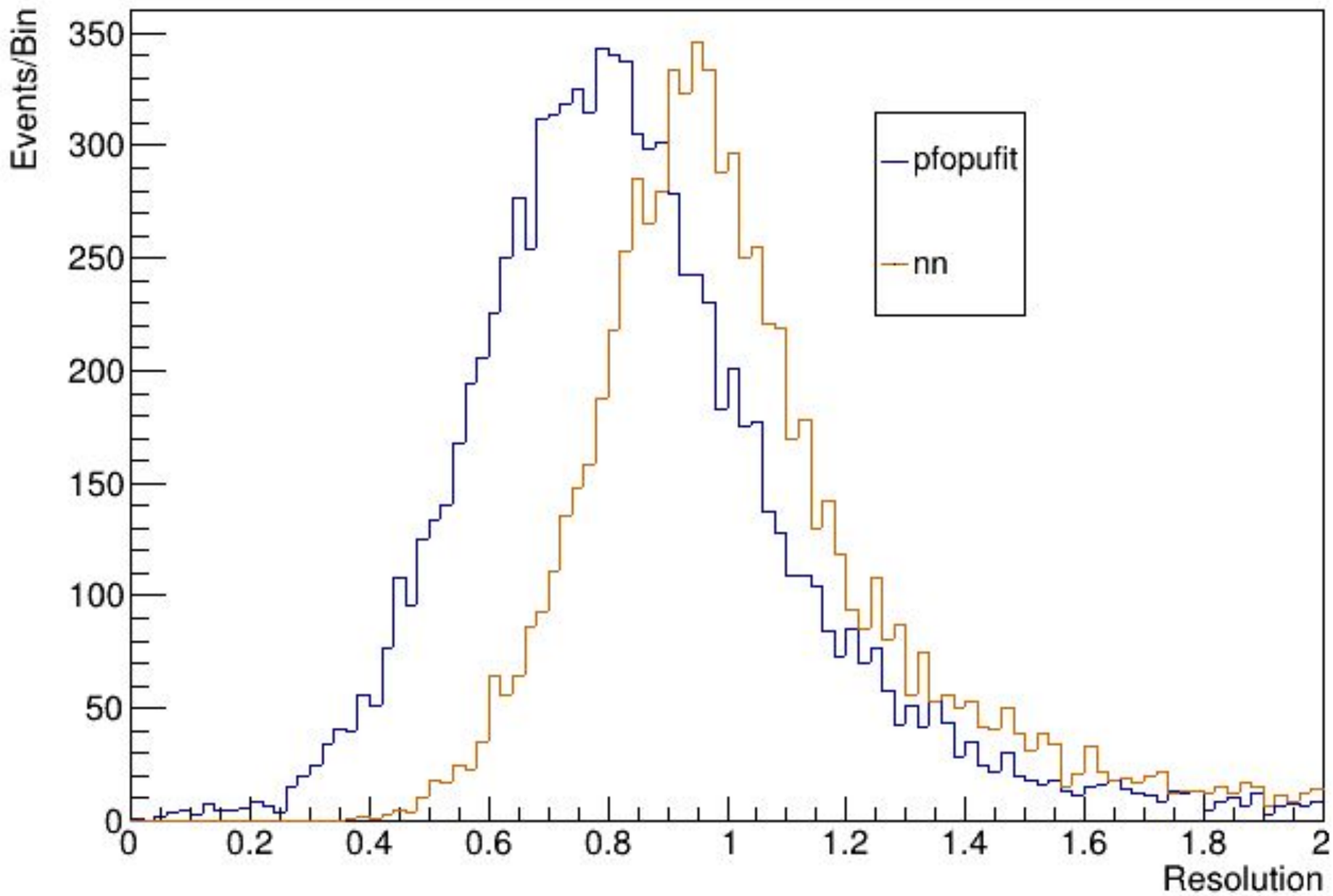
Efficiency Curves

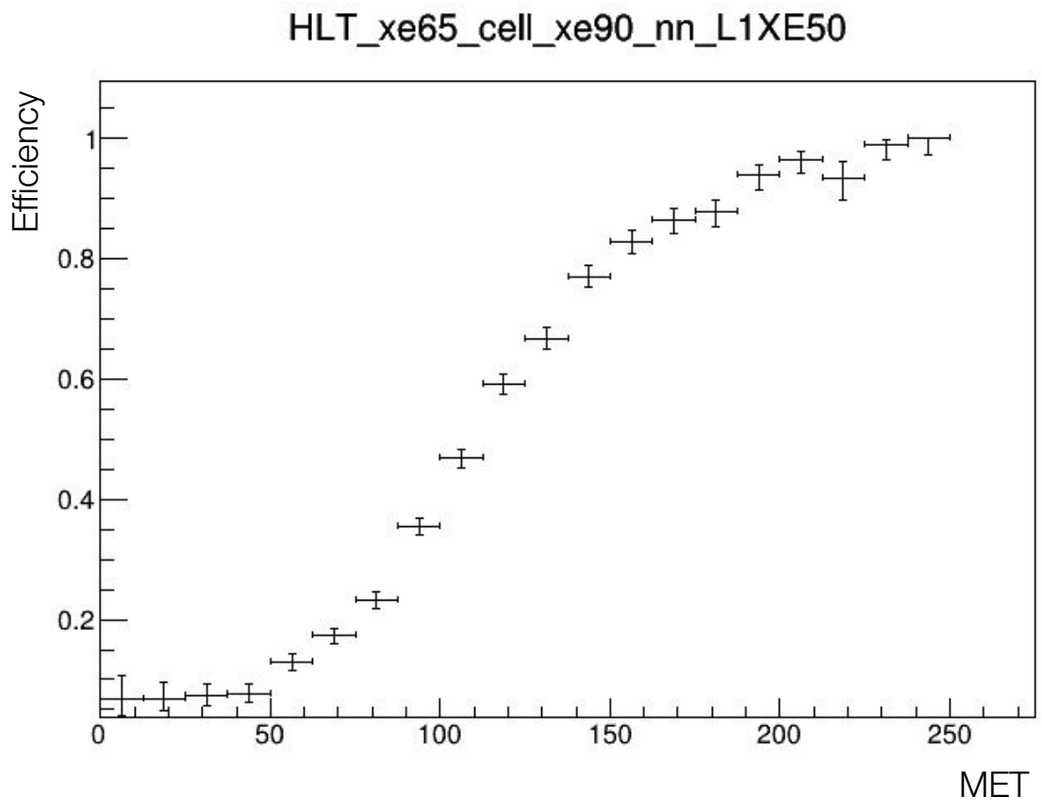


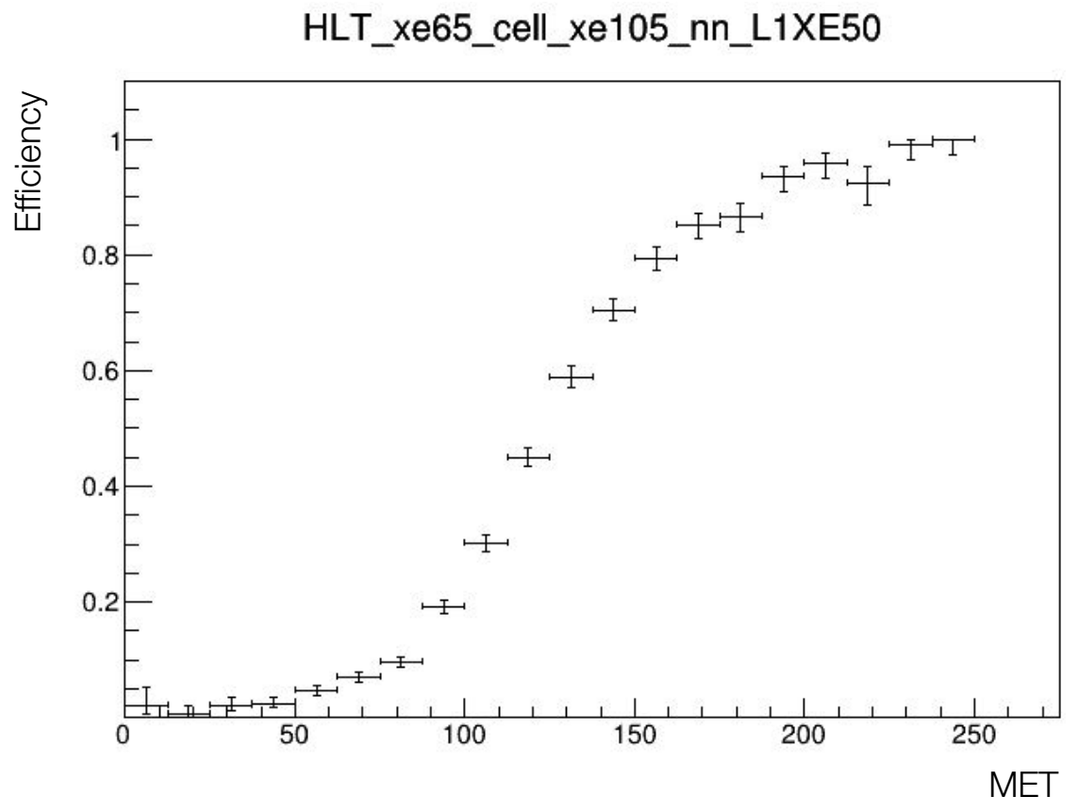
Resolution of NN

- Better resolution for NN compared to track-based algorithm on dark photon sample
  - The resolution improved from 33% to 25% compared to best single algorithm



Efficiency of NN





Conclusions for trigger

- Shown that photon isolation is not working correctly (with E/gamma)
- Raise threshold for photon to ~50 GeV (see plot)
- Add NN MET to lower rate