#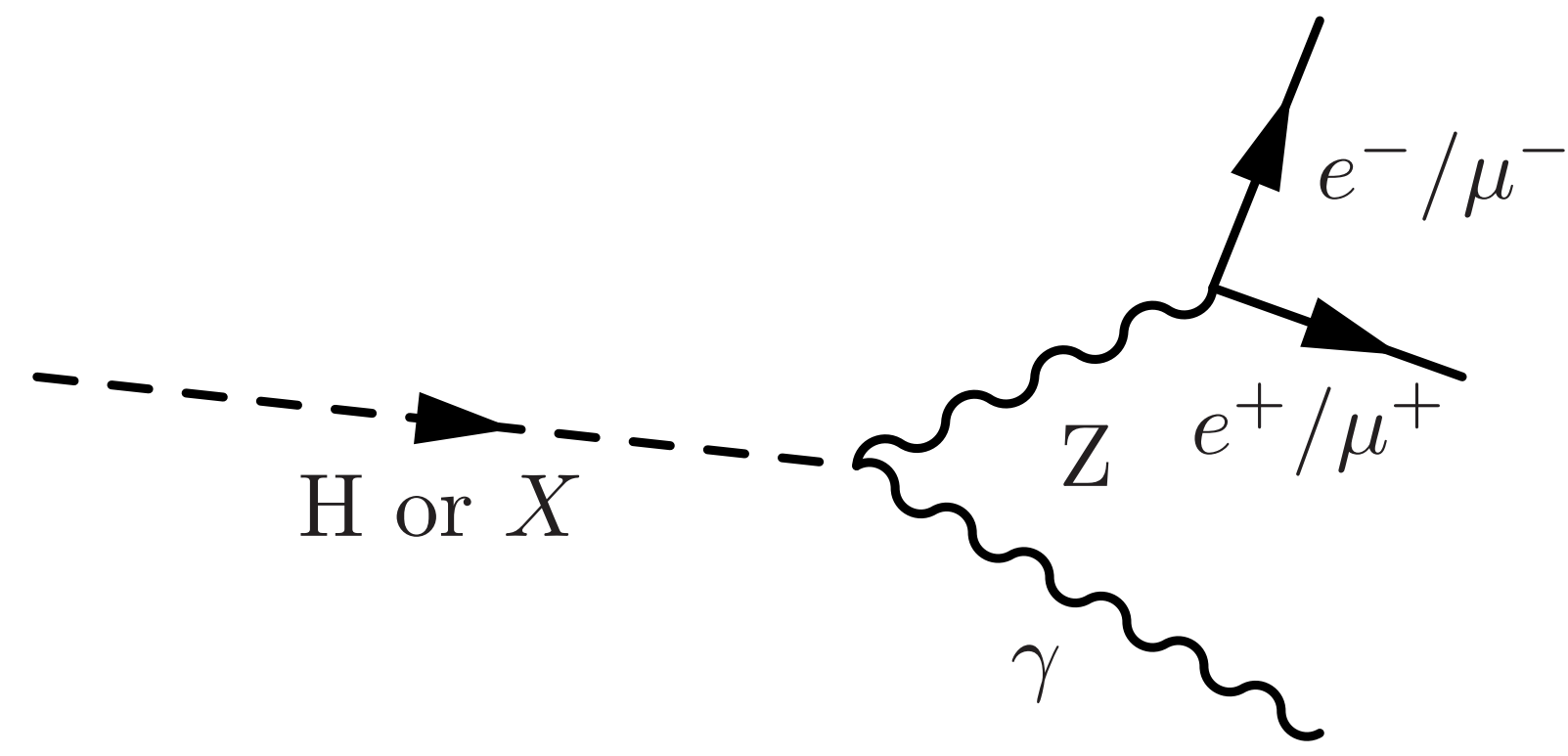 Search for the Standard Model Higgs boson or a new high-mass resonance decaying to $Z\gamma$ in pp collisions at $\sqrt{s}=13$TeV with the ATLAS detector

LHCP Poster Session (No. 143) - Shanghai, 16 May 2017
Shuo Han on behalf of The ATLAS Collaboration

Introduction

- **The $H \to Z\gamma$ decay** is one of the rare decay modes of Standard Model (SM) Higgs boson, whose branching ratios are expected to be modified in some beyond Standard Model (BSM) theories

- **High-mass resonance search** based on many theoretical models introducing a new BSM boson through either an extension of the Higgs sector or additional gauge fields, which can decay to $Z\gamma$

Event Selection

Triggers

- Single / di-lepton triggers

Photons

- $H \to Z\gamma$ search: photon transverse momentum $p_T^\gamma > 15$ GeV

- **High-mass resonance search**: $p_T^\gamma > 0.3 \times m_{Z\gamma}$

- photon isolation, photon tight identification, $|\eta| < 1.37$ or $1.52 < |\eta| < 2.37$

Leptons (e^+e^- or $\mu^+\mu^-$)

- lepton transverse momentum cuts corresponding to the triggers

- **electrons**: $|\eta| < 1.37$ or $1.52 < |\eta| < 2.47$, $d_0/\sigma_{d_0} < 5$, electron identification and isolation selections

- **muons**: $|\eta| < 2.7$, $d_0/\sigma_{d_0} < 3$, muon identification and isolation selections

Z boson

- The 2 leptons have opposite sign of charge

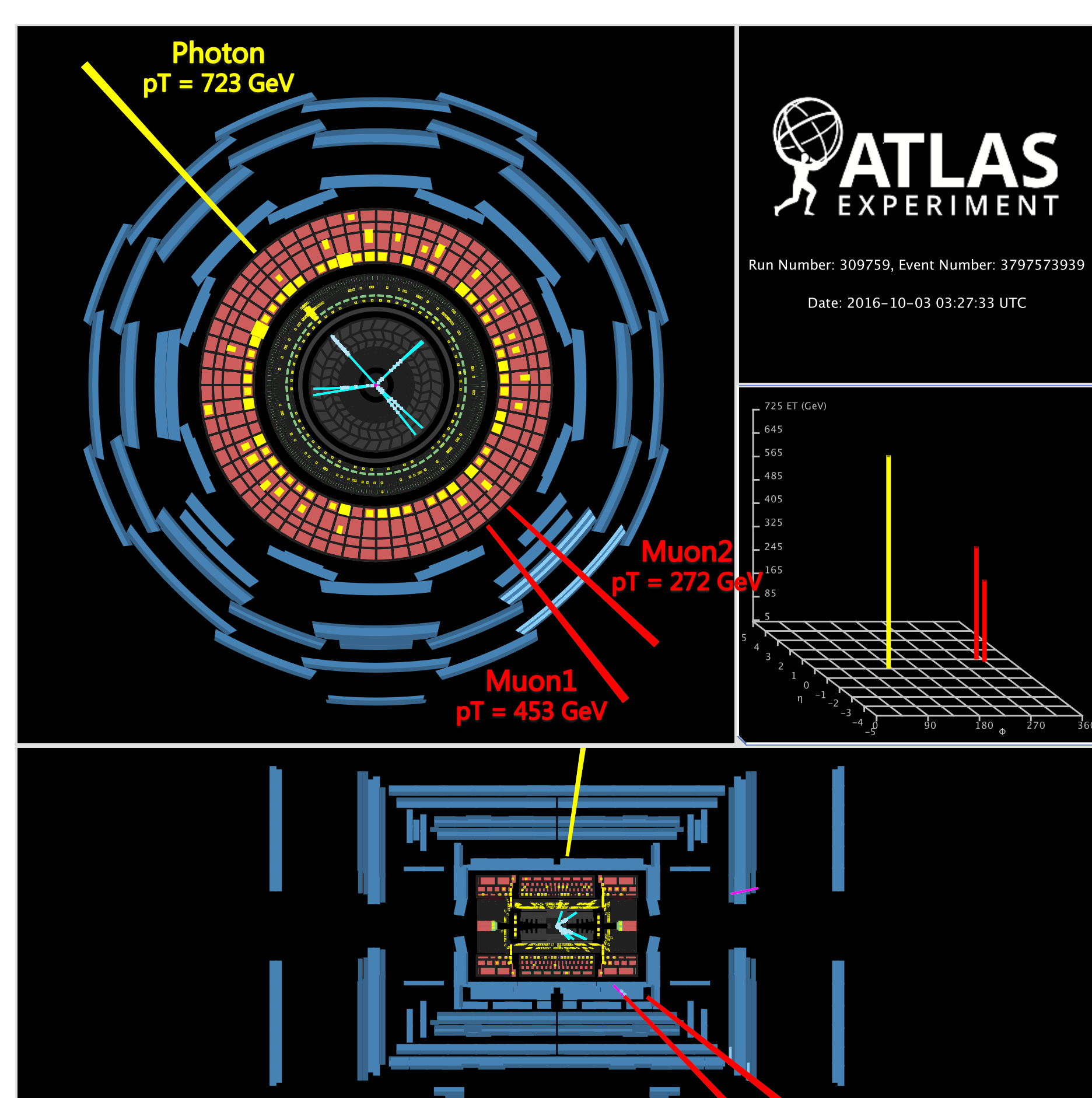- Z mass window of 91.2 ± 15 GeV

Event Display

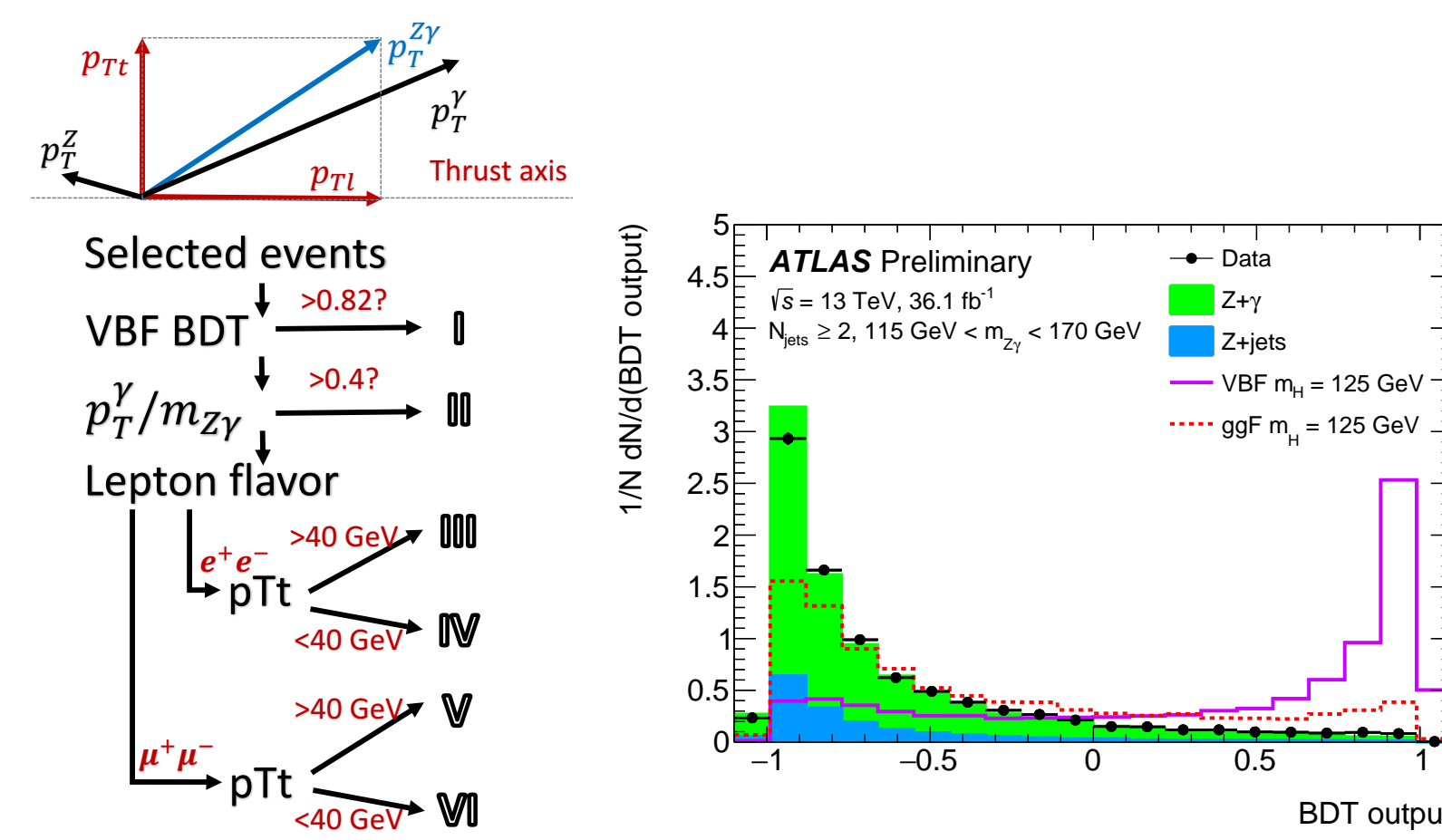**Figure 1:** $\mu\mu\gamma$ candidate with $m_{\mu\mu\gamma} = 1.57$ TeV

Reference

[1] *CERN-EP-2017-095*, May 2017.

$H \to Z\gamma$ search

Event Categorization

- Six categories including one vector-boson-fusion (VBF) enriched category based on a boosted decision tree (BDT) response using 6 jet kinematic variables, such as m_{jj}, $\Delta\phi_{Zyjj}$...
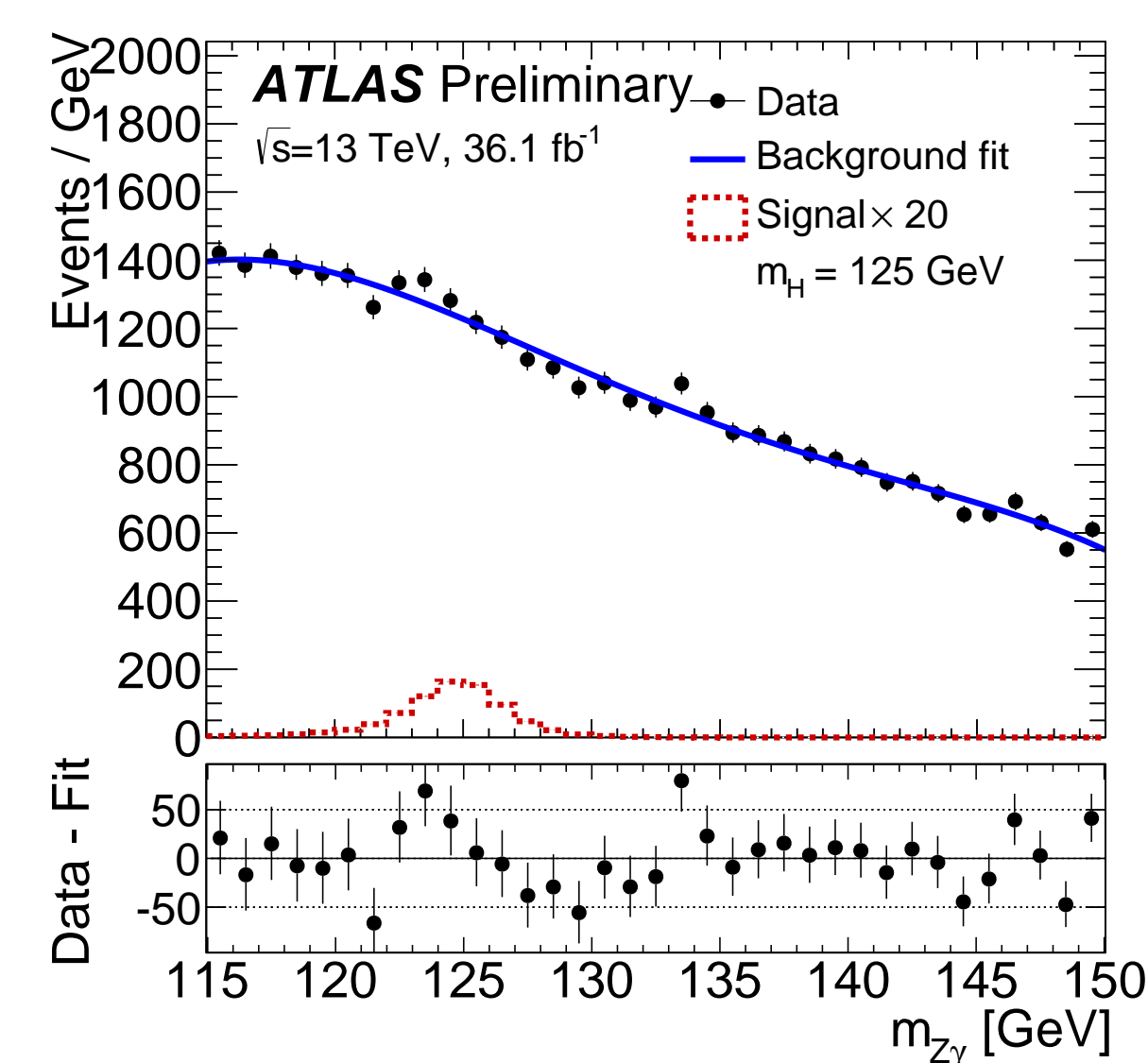

Signal Modeling

- Signal simulation SM Higgs production via gluon-gluon fusion, vector boson fusion, and production in association with a vector boson

- Signal Shape: Double-Sided Crystal Ball function with $m_H = 125.09$ GeV
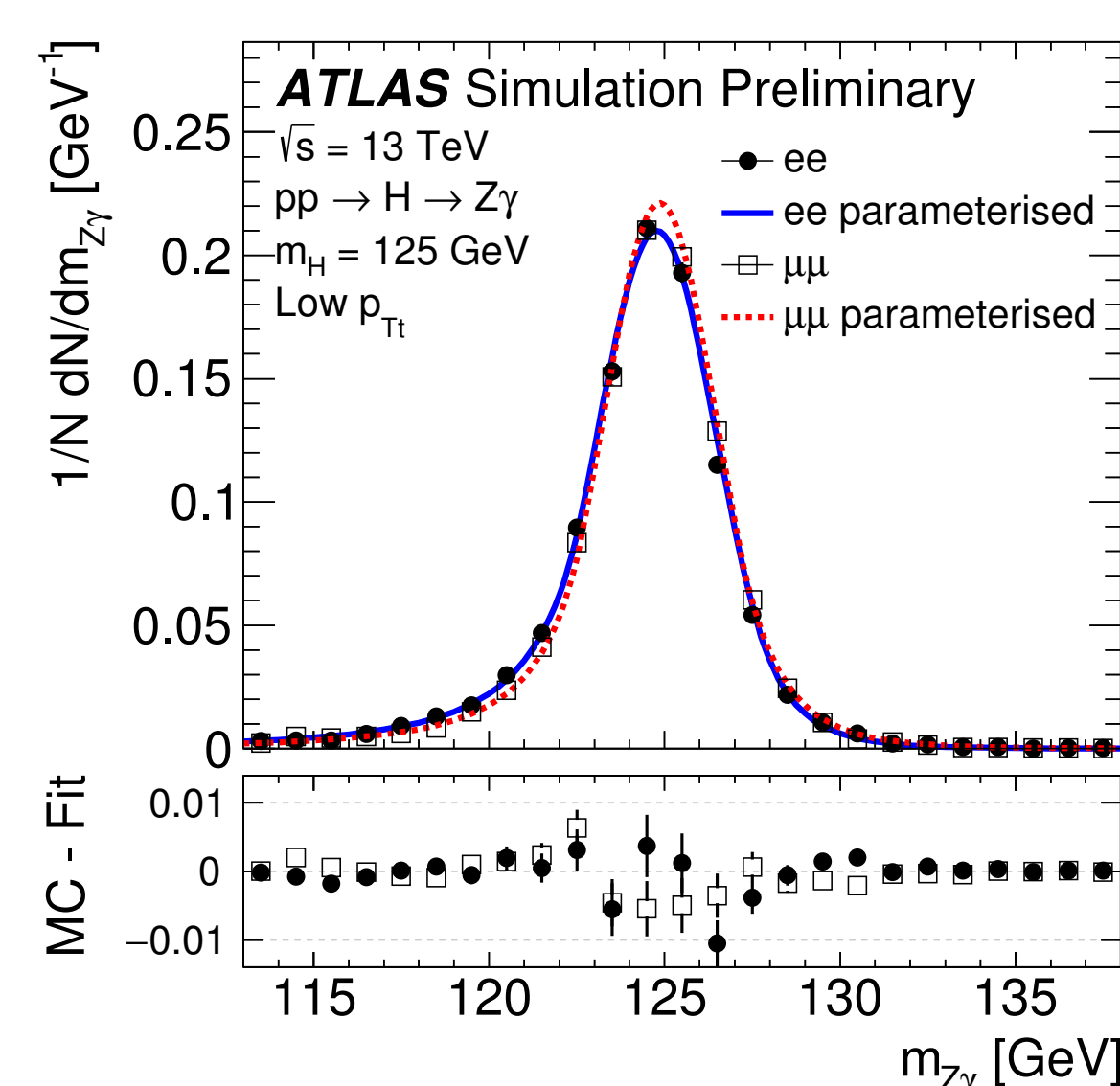
Background modeling

- Main backgrounds $Z + \gamma$ and $Z + $ jet

- Fit $m_{Z\gamma}^{DATA}$ per category with Bernstein polynomial functions, to limit the bias on the estimated signal

Results

- No significant excess beyond background expectation

- Local significance beyond background only (SM) prediction is $1.0(0.5)\sigma$ at 125.09 GeV

- Main uncertainties: background bias (2-25% on signal yield), modeling of the underlying event (3-25% on signal yield)

Upper 95% CL limits on
$$\mu = \frac{(\sigma_{pp\to H} \times Br_{H\to Z\gamma})}{(\sigma_{pp\to H} \times Br_{H\to Z\gamma})_{SM}} \text{ at } 125.09 \text{ GeV}$$

Observed	6.5 (547 fb)
SM expected	5.2
bkg-only expected	4.4

## High-mass resonances search

Event Categorization

- Two categories: $Z \to e^+e^-$ or $Z \to \mu^+\mu^-$, with different mass resolution and systematic uncertainties

Signal Modeling

- Signal simulation narrow spin-0 resonance via gluon-gluon fusion, or narrow spin-2 resonance from gluon-gluon / quark-antiquark initial states with mass points between 300-2500 GeV

- Signal Shape: Double-Sided Crystal Ball function signal shape and efficiency parametrized with mass
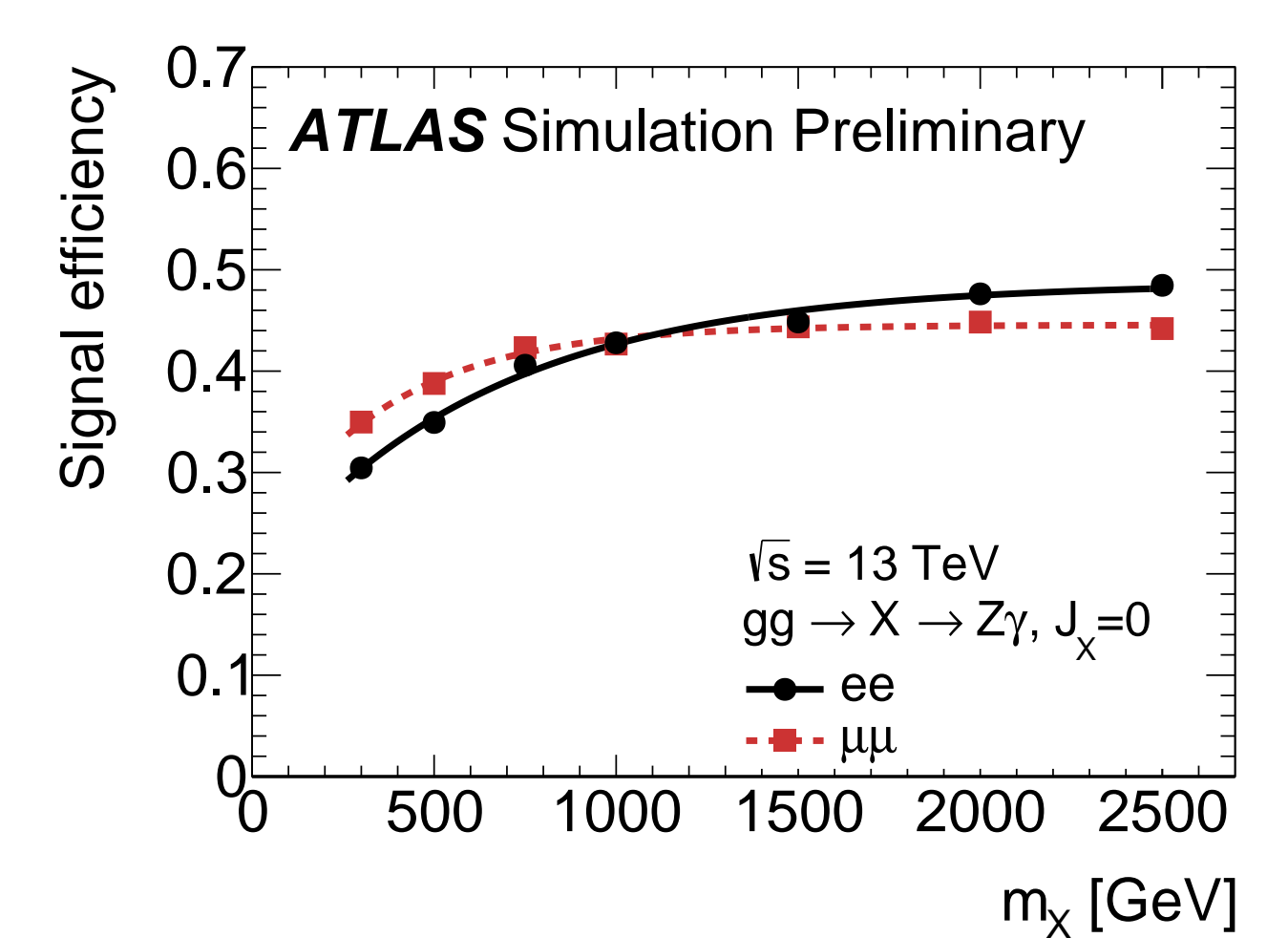
Background modeling

- Main backgrounds: $Z + \gamma$ and $Z + $ jet

- Fit $m_{Z\gamma}^{DATA}$ with $F_{bkg}(x) = N(1-x^{1/3})^{p_1} x^{p_2}$
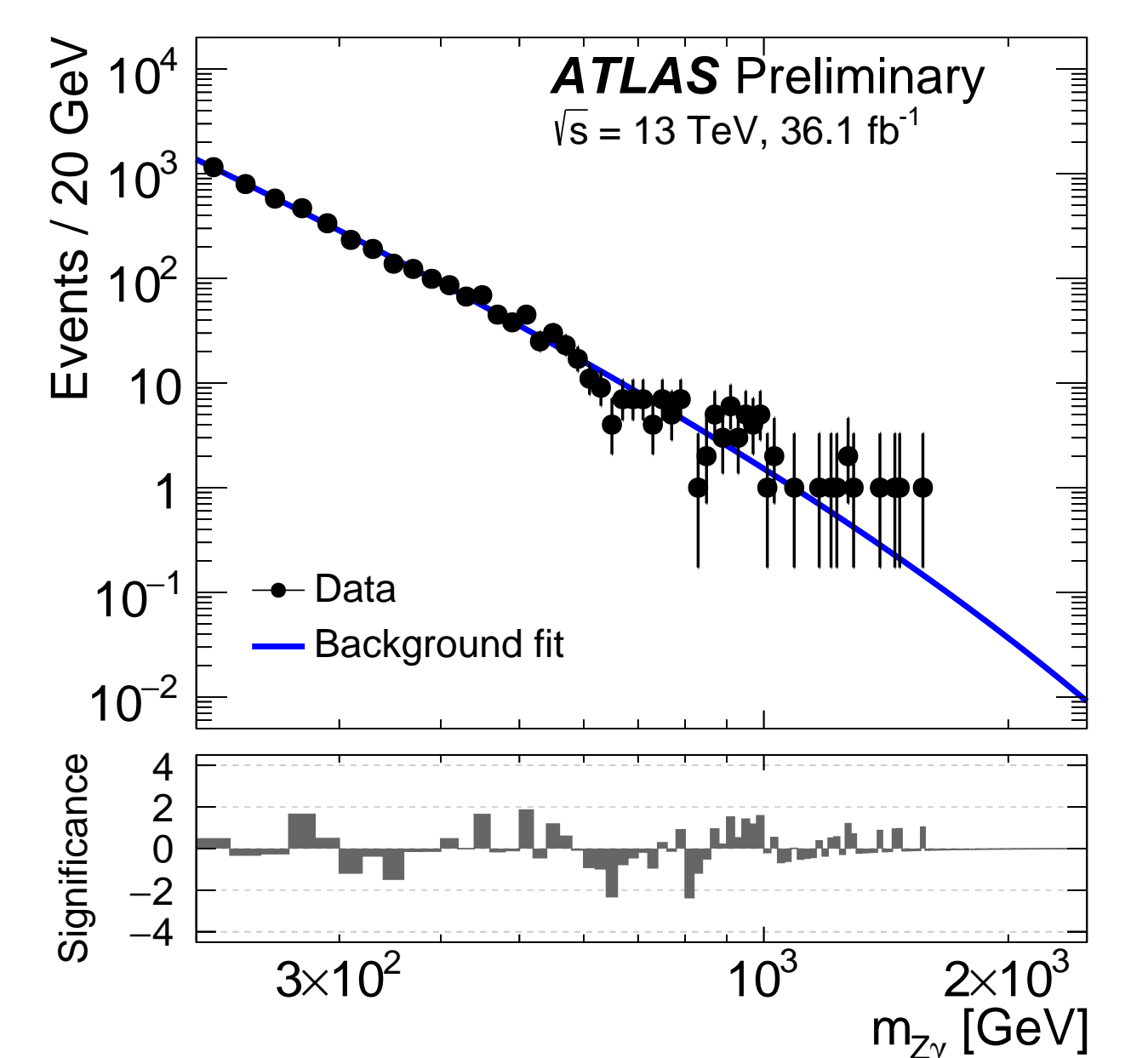
Results

- No excess beyond background expectation

- Largest deviation: local (global) significance of $2.7(0.8)\sigma$ at 960 GeV

- Main uncertainties: e/γ resolution (4-30% on signal width), background bias (0-6% on signal yield)
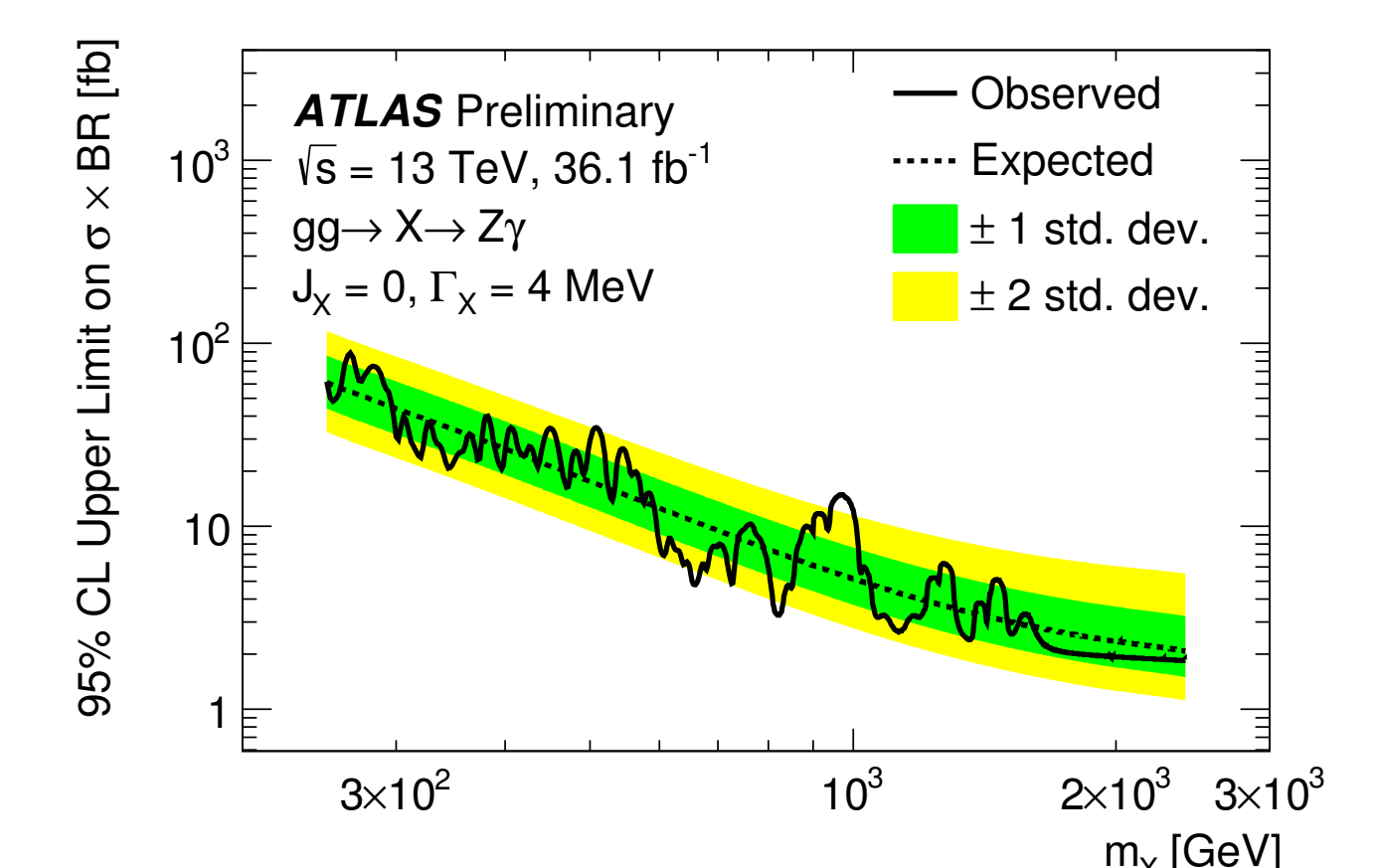
Upper 95% CL limits on $\sigma_{pp\to H} \times Br_{H\to Z\gamma}$

	$gg \to X$ **spin-0**	$gg \to X$ **spin-2**	$qq \to X$ **spin-2**
Exp. high	61 fb	82 fb	66 fb
Exp. low	2.1 fb	2.7 fb	1.7 fb
Obs. high	88 fb	117 fb	94 fb
Obs. low	1.8 fb	2.4 fb	1.5 fb