Pile-up Background

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ATLAS EXPERIMENT

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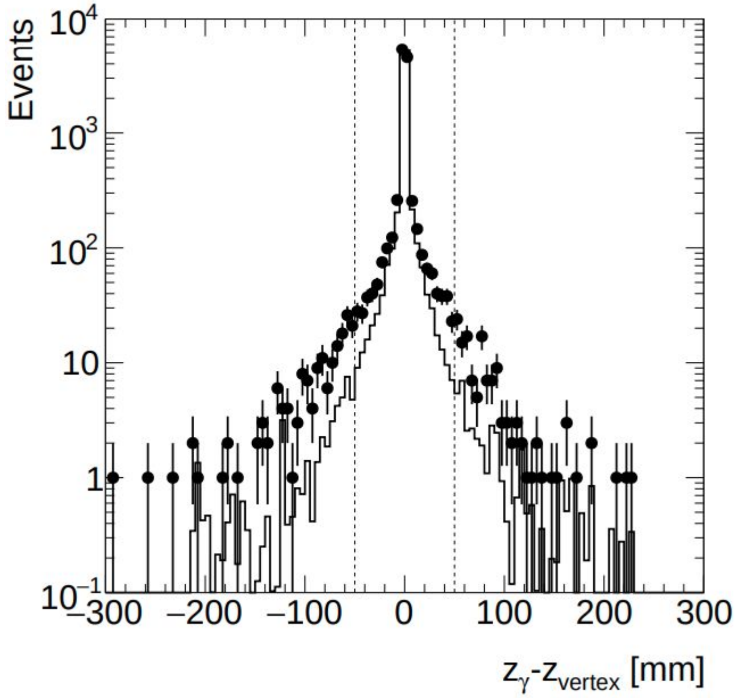
Background source

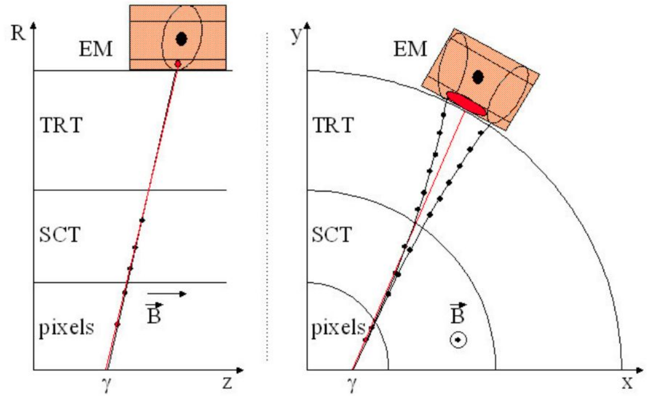
- Z-boson can combine with a photon from a different pp collision in the same bunch crossing.
- Estimation is based on $\Delta z = z_\gamma - z_{vtx}$ distribution, which is broader for the pile-up background.



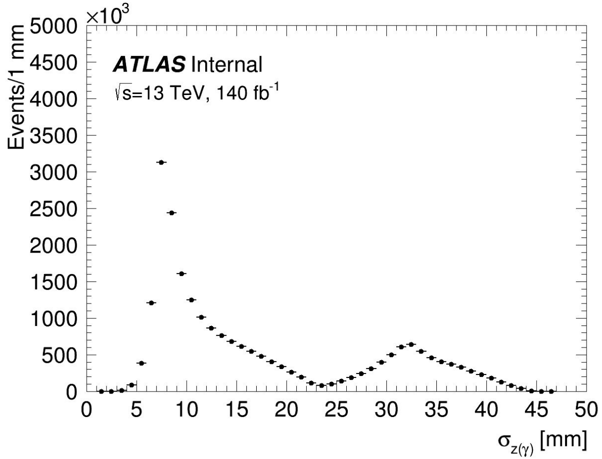
z_γ of the reconstructed photon

Reconstruction of the z vertex and direction of the photon

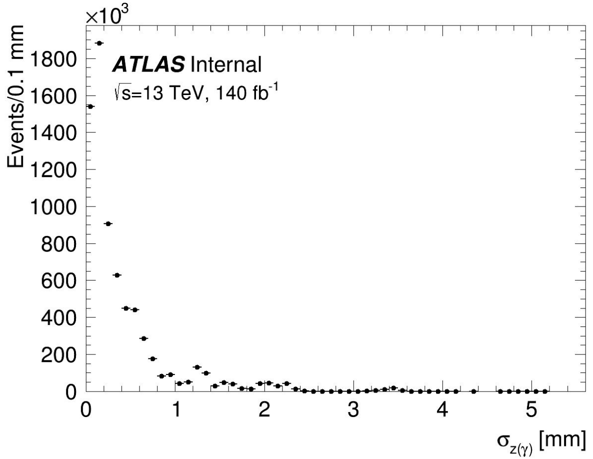
- z_γ is calculated from the longitudinal segmentation using the direction from the electromagnetic cluster **(the calorimeter pointing)**.
- Converted in the silicon detectors photons: information from the ID which is more precise can be used **(the conversion pointing)**.



y_caloPointing_z_err

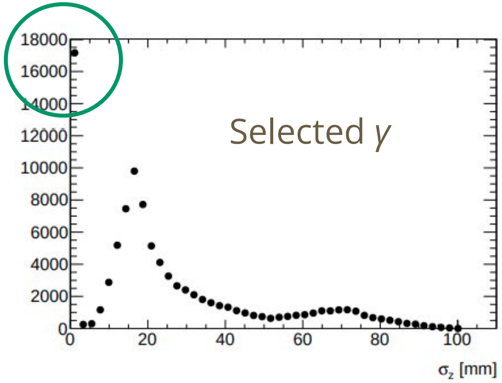


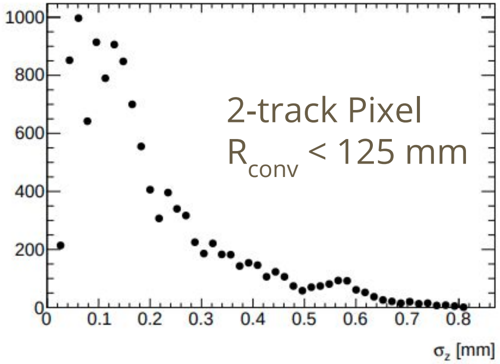
y_convPointing_z_err



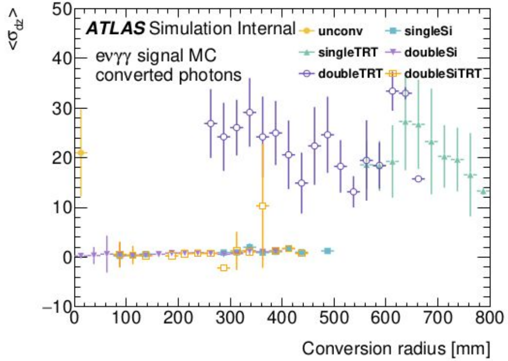
Requirement on photons: other analyses

- Converted photons with hits in the silicon detectors have much better resolution.
- Z(ll)γ analysis: '2-track Pixel' with R_{conv} < 125 mm (σ_z < 1 mm, and typically < 0.2 mm).

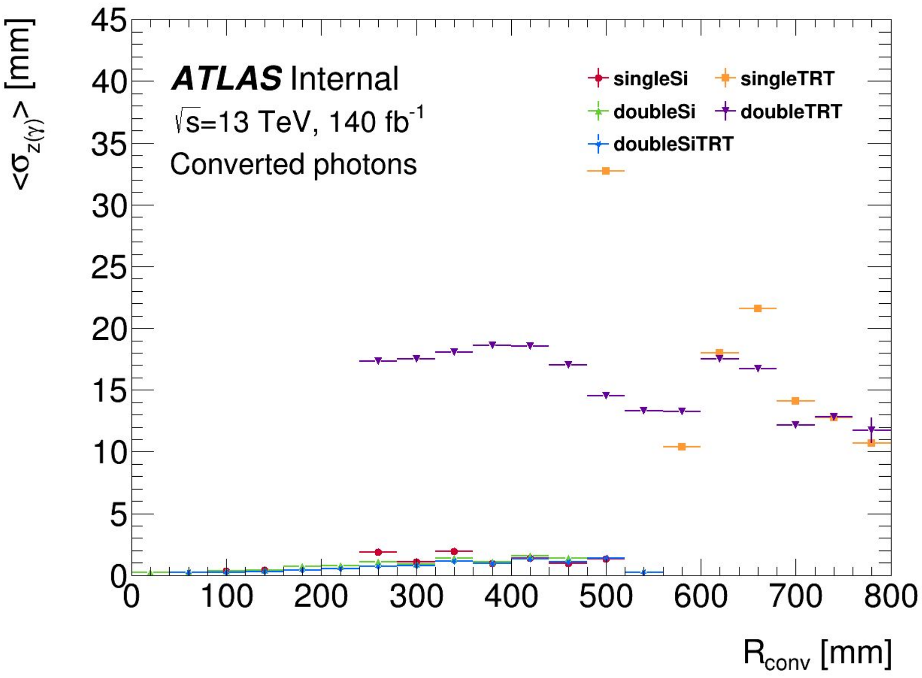


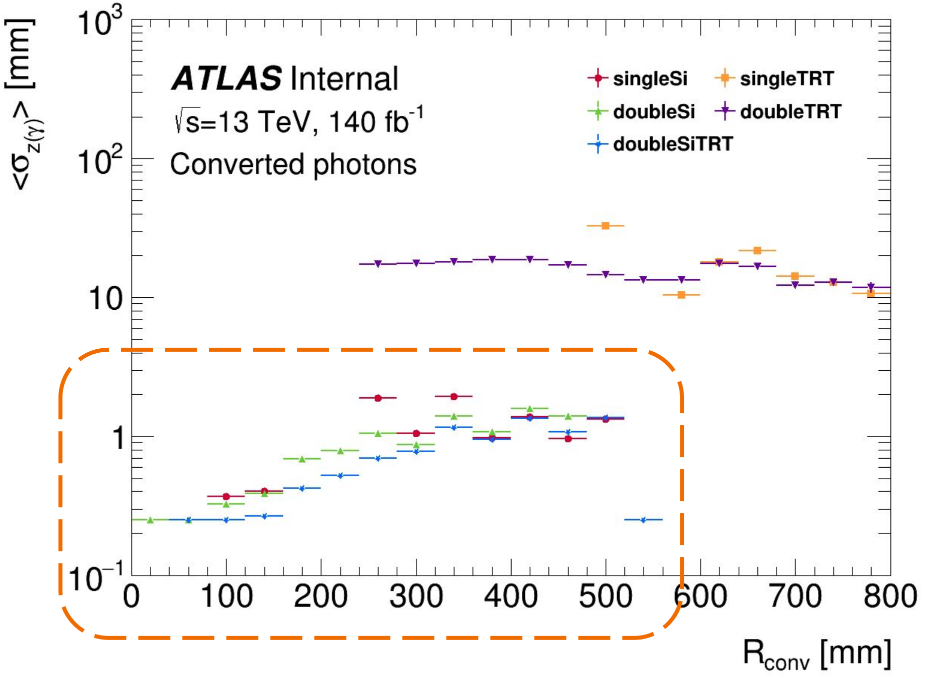


- W(lν)γγ analysis: at least one silicon track and R_{conv} < 400 mm.



Requirement on photons: *Z(νν)γ* analysis

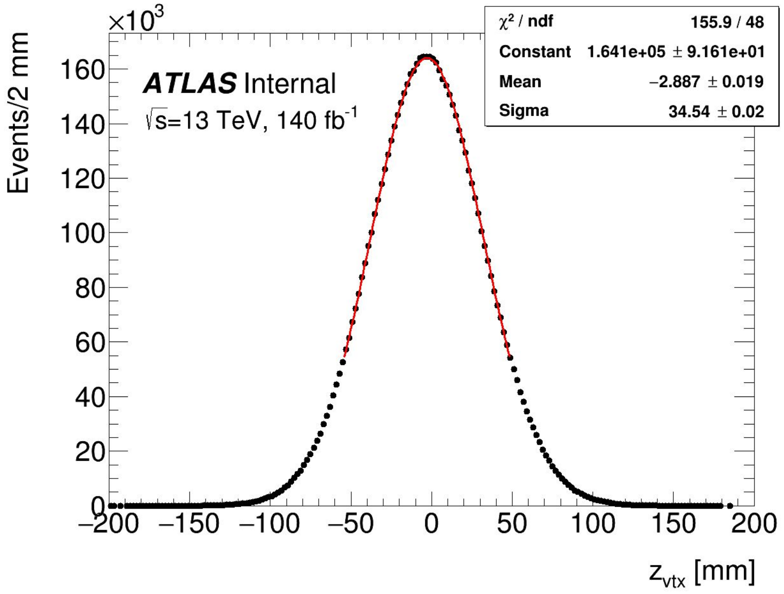




singleSi, doubleSi, doubleSiTRT — at least one silicon track

Gaussian distributions

- Data consists of events produced in **a single *pp*** interaction [$Z(\nu\nu)\gamma$ MC] and **a pile-up component** due to two separate *pp* interactions [the convolution with itself of the z_{vtx}].
- z_{vtx} and z_{γ} distributions: Gaussians of width 35 mm.
- Pile-up: the difference of two Gaussians (also Gaussian) with a width of ~50 mm (35 mm × √2).



Pile-up fraction

- To be insensitive to any MC mismodelling of the *Δz* distribution in simulation for the single *pp* events, the estimation of the pile-up background is performed in the tails of the *Δz* distribution (Gaussian properties: 32% of events have |*Δz*| > 50 mm).
- The fraction of pile-up:

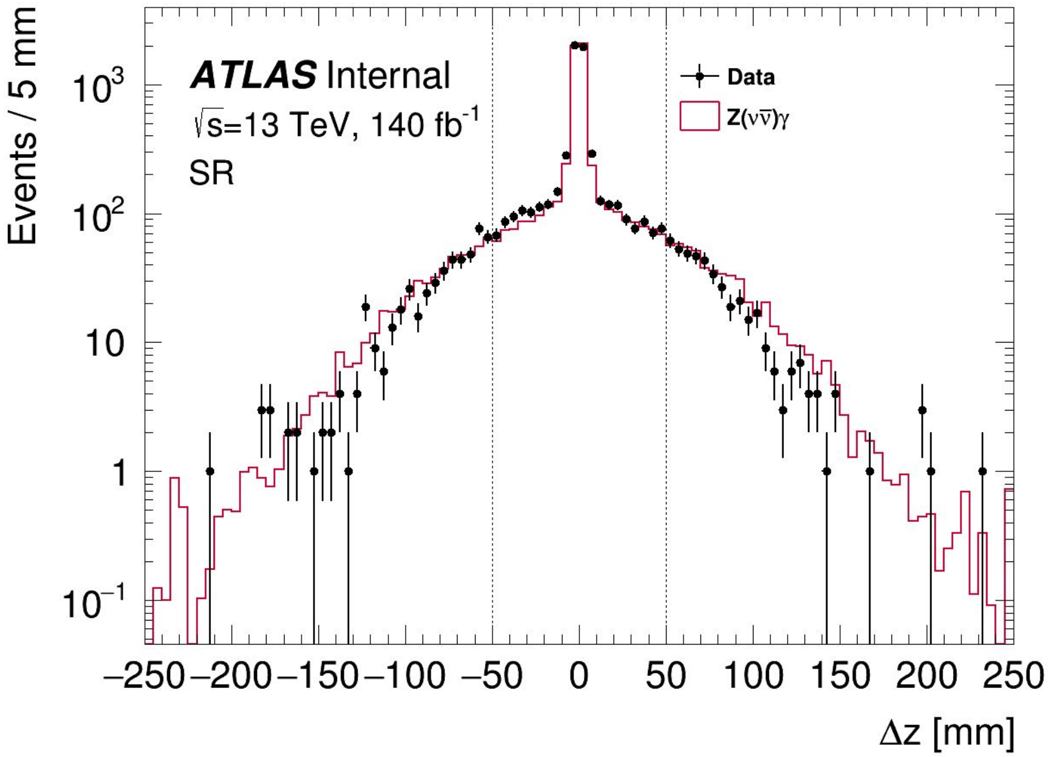
$$f_{\mathrm{PU}} = \frac{N_{\mathrm{data}}^{|\Delta z|>50mm} - N_{\mathrm{single\ pp}}^{|\Delta z|>50mm}}{N_{\mathrm{data}} \times 0.32}$$

$$N_{\mathrm{single\ pp}}^{|\Delta z|>50mm} = SF_1 \times SF_2 \times N_{\mathrm{MC}}^{|\Delta z|>50mm}$$

SF_1 – the ratio of events in data to events in MC for *Δz* around zero.

SF_2 – correction due to the mismodelling of *Δz* in the tails (FSR – *Z(ll)γ* analysis).

Results for $Z(\nu\nu)\gamma$ QCD LO sample



Negligible effect!

$SF_1 = 4.30 \pm 0.07$

(calculated in $|\Delta z| < 10$ mm – peak area)

$|\Delta z|$ > 50 mm results:

$SF_2 = 1.48 \pm 0.26$

$f_{PU} = (-28 \pm 12)\%$

Increased area:

$$f_{\rm PU} = \frac{N_{\rm data}^{|\Delta z|>15mm} - SF_1 \times SF_2 \times N_{\rm MC}^{|\Delta z|>15mm}}{N_{\rm data} \times 0.76}$$

$|\Delta z|$ > 15 mm results:

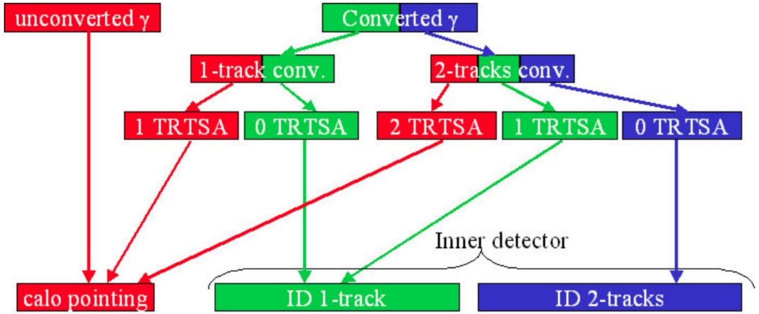
$SF_2 = 1.27 \pm 0.07$

$f_{PU} = (-11 \pm 3)\%$

Back-up slides

Photon conversions

Different types of photon conversions are considered [5]. In the case where the photon converts early enough in the inner detector and the trajectories are separated enough in space by the magnetic field, it is possible to reconstruct the two tracks of the resultant electron and positron as two distinct particles. In this scenario the photon is referred to as a double tracks conversion. If the conversions occurs at a higher radius or if the reconstruction of two separate tracks fails, the photon is referred to as a single track conversion. If the conversion occurs late in the last layer of the inner detector (Transition Radiation Tracker), no tracking information is available on the z measurement in the barrel or for R in the endcap. This means that inner detector can not be used to reconstruct the vertex and direction of the photon, and it is referred to as a TRT standalone (TRTSA) conversion. The strategy used to determine the direction of the photon differs according to the nature of the photon. For the non-converted photons, the one track TRTSA and two tracks TRTSA photon conversions, only the energy deposit in the electromagnetic calorimeter is available. In this scenario, one can use the direction from the electromagnetic cluster by taking into account the longitudinal segmentation. For the case of non-TRTSA conversions, the inner detector, which is more precise than the electromagnetic calorimeter in the absence of pileup, can be used. Figure 1 presents the global strategy and the method to be used as function of the nature of the photon.



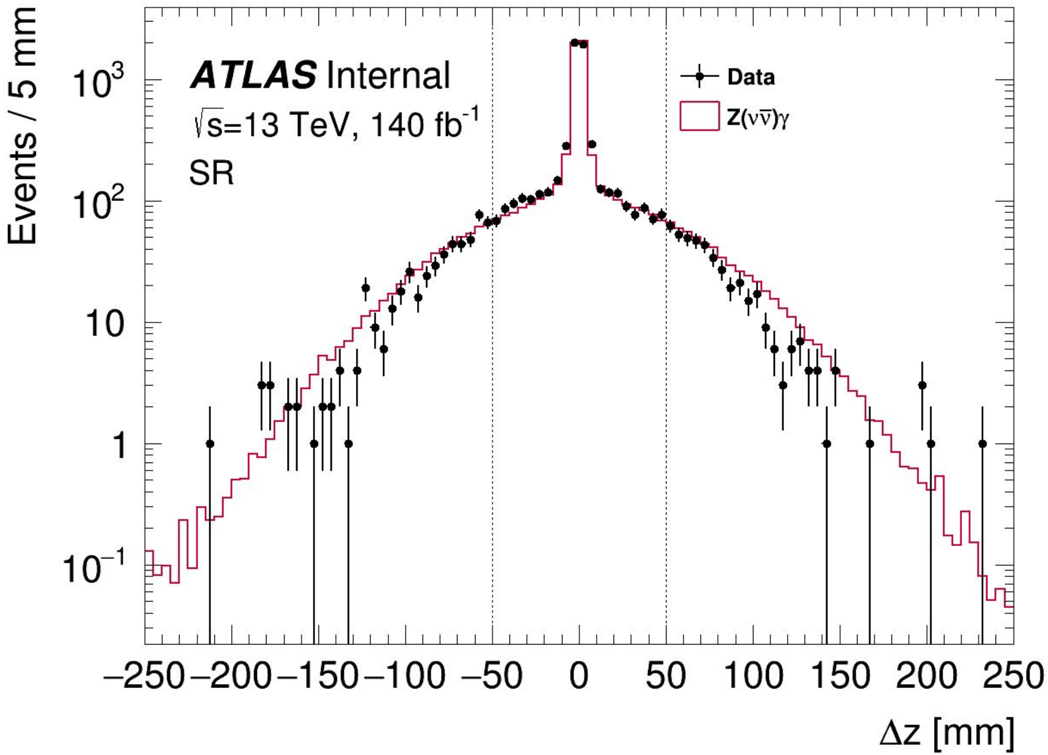
Main parameters of the inner-detector system

Item		Radial extension (mm)	Length (mm)
Overall ID envelope		$0 < R < 1150$	$0 < \|z\| < 3512$
Beam-pipe		$29 < R < 36$	
Pixel	Overall envelope	$45.5 < R < 242$	$0 < \|z\| < 3092$
3 cylindrical layers	Sensitive barrel	$50.5 < R < 122.5$	$0 < \|z\| < 400.5$
2×3 disks	Sensitive end-cap	$88.8 < R < 149.6$	$495 < \|z\| < 650$
SCT	Overall envelope	$255 < R < 549$ (barrel)	$0 < \|z\| < 805$
		$251 < R < 610$ (end-cap)	$810 < \|z\| < 2797$
4 cylindrical layers	Sensitive barrel	$299 < R < 514$	$0 < \|z\| < 749$
2×9 disks	Sensitive end-cap	$275 < R < 560$	$839 < \|z\| < 2735$
TRT	Overall envelope	$554 < R < 1082$ (barrel)	$0 < \|z\| < 780$
		$617 < R < 1106$ (end-cap)	$827 < \|z\| < 2744$
73 straw planes	Sensitive barrel	$563 < R < 1066$	$0 < \|z\| < 712$
160 straw planes	Sensitive end-cap	$644 < R < 1004$	$848 < \|z\| < 2710$

Main parameters of the Pixel detector system

Item		Radial Extension [mm]	Length [mm]	Staves / Sectors	Modules	Pixels ($\times 10^6$)
Beam pipe (today)		$29 < R < 36$				
Beam pipe (with IBL)		$25 < R < 29$				
IBL	Envelope	$31.0 < R < 40.0$				
	Sensitive	$< R > = 25.7$	$\|Z\| < 332$	14	224	6.02
Pixel	Envelope	$45.5 < R < 241.0$	$\|Z\| < 3092$			
B-layer	Sensitive	$< R > = 50.5$	$\|Z\| < 400.5$	22	286	13.2
Layer 1	Sensitive	$< R > = 88.5$	$\|Z\| < 400.5$	38	494	22.8
Layer 2	Sensitive	$< R > = 122.5$	$\|Z\| < 400.5$	52	676	31.2
Disk 1	Sensitive	$88.8 < R < 149.6 = 88.5$	$< Z > = 495$	8×2	48×2	4.4
Disk 1	Sensitive	$88.8 < R < 149.6 = 88.5$	$< Z > = 580$	8×2	48×2	4.4
Disk 1	Sensitive	$88.8 < R < 149.6 = 88.5$	$< Z > = 650$	8×2	48×2	4.4
					Pixel Total	*80.4*

Results for *Z(νν)γ* QCD NLO sample



Negligible effect!

SF_1 = 3.23 ± 0.05

(calculated in |*Δz*| < 10 mm – peak area)

|*Δz*| > 50 mm results:

SF_2 = 1.48 ± 0.26

f_{PU} = (-31 ± 13)%

Increased area:

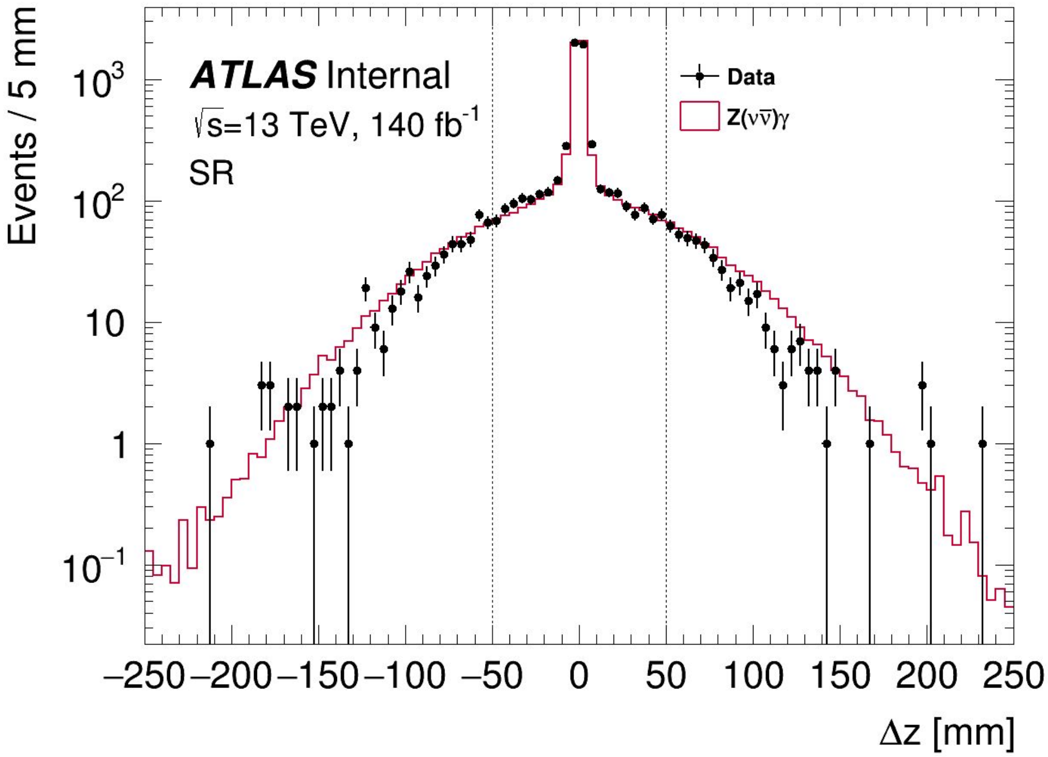
$$f_{\mathrm{PU}} = \frac{N_{\mathrm{data}}^{|\Delta z|>15mm} - SF_1 \times SF_2 \times N_{\mathrm{MC}}^{|\Delta z|>15mm}}{N_{\mathrm{data}} \times 0.76}$$

|*Δz*| > 15 mm results:

SF_2 = 1.27 ± 0.07

f_{PU} = (-13 ± 4)%

Results for *Z(νν)γ* QCD NLO sample



Negligible effect!

$SF_1 = 3.23 \pm 0.05$

(calculated in $|\Delta z| < 10$ mm – peak area)

$|\Delta z| > 50$ mm results:

$SF_2 = 1$

$f_{PU} = (6.0 \pm 1.6)\%$

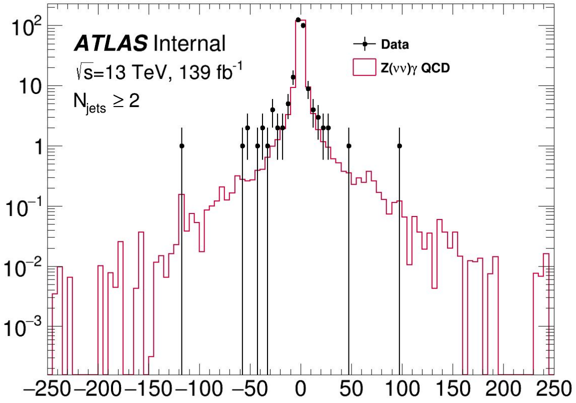
$SF_2 = 0.5$

$f_{PU} = (23.7 \pm 1.4)\%$

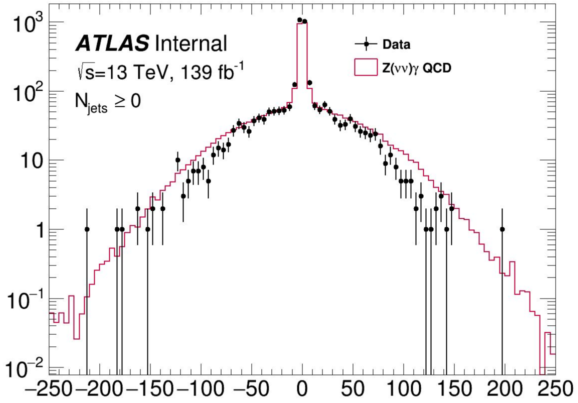
$SF_2 = 2$

$f_{PU} = (-29 \pm 2)\%$

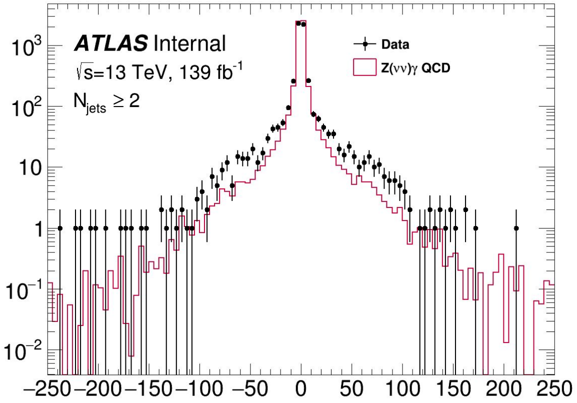
Z(νν)γjj VBS pile-up study



inclusive selection



$N_{jets} \geq 0$



without E_T^{miss} cuts

For Z(νν)γ QCD LO sample, $f_{PU} = -5 \pm 3\%$ ($SF_1 = 4.2 \pm 0.3$, $SF_2 = 1.5 \pm 0.3$)