Object reconstruction and event selection

- **Object reconstruction**
  - **Working points efficiency:**
    - Loose muon: highly efficient
    - Medium electron: 80% 
    - Medium photon: 80% 
    - Medium jet: 95%

- **Good Muon selection**
  - Tight muon
  - Relative Particle-Flow isolation < 0.15
  - $p_T > 20$ GeV, $|\eta| < 2.4$

- **Good Electron selection**
  - Medium electron
  - $p_T > 25$ GeV, $|\eta| < 2.5$

- **Good Photon selection**
  - Medium photon
  - Conversion-safe electron veto
  - $p_T > 20$ GeV and $|\eta| < 1.442$ or $1.56 < |\eta| < 2.3$

- **Event selection**
  - Two or only two same-flavor good leptons
  - Three leptons veto
  - One good photon with $p_T > 20$ GeV
  - Two jets with $p_T > 30$ GeV
  - $70$ GeV < $M_{jj}$ < $180$ GeV
  - $M_{jj} > 100$ GeV

- **Signal regions**
  - $500$ GeV $< M_{jj} < 400$ GeV
  - $M_{jj} > 500$ GeV
  - $|\Delta p_T| > 0.25$

- **Optimization selection**
  - $|\Delta \eta| < 0.9$
  - $|\Delta \phi| > 1.9$

Background estimation

- Background processes estimated from simulation are normalized to the best theoretical cross section prediction and all of them are reweighted to correct pileup, lepton, photon and trigger efficiencies.
- Irreducible background QCD Zγ normalization is significantly constrained by data in a low $M_{jj}$ control region.
- A data-driven method is used to estimate non-prompt photon contribution.

- A fit was performed using the shape of $\sigma_{\text{data}}$ (the shower shape variable) for data, true and fake photons.

- Build non-prompt sample by inverting one of medium cut-based photon variable with corresponding loose cut-based value while keep others invariant.
- For each event in this non-prompt sample, a photon $p_T$ dependent weight is applied

**Fiducial cross section**

- $\sigma_{\text{fiducial}} = \sigma_{\text{generator}} \cdot H_{\text{signal}} - \sigma_{\text{generator-to-fiducial}}$
  - $H_{\text{signal}}$ is the best fit signal strength which is 0.65 ± 0.24 for EWK and 0.91 ± 0.19 for EWK+QCD.
  - $\sigma_{\text{generator-to-fiducial}}$ is the cross section computed by the generator (MadGraph & aMC@NLO) which is 4.97 ± 0.25 (scale) ± 0.14 (PDF) for EWK and 15.7 ± 1.7 (scale) ± 0.2 (PDF) for EWK+QCD within the fiducial region acceptance.
  - Expected to fail bias is the efficiency to go from the generator cuts to the fiducial cuts.

**Limits on anomalous quartic gauge couplings**

SM Lagrangian can be extended with higher dimensional operators maintaining SU(2)×U(1) gauge symmetry.

$\mathcal{L}_{\text{new}} = \mathcal{L}_{\text{SM}} + \sum_i \frac{\lambda_i}{\Lambda^4}$

- Operator $\mathcal{L}_{\text{new}}$, $\mathcal{L}_{\text{SM}}$, and $\mathcal{L}_{\text{SM}}$ were considered.
- For each $\lambda_i$ value, the ratio of $\lambda_i$ at SM was computed for every $m_{3/2}$ bin and a fit was performed.
- Considering a test statistics test: $\chi^2_{\text{expected}} = -2 \ln (\mathcal{L}_{\text{expected}}/\mathcal{L}_{\text{SM}})$
- Extract the limits directly using the delta log-likelihood function $\DeltaLL = \chi^2_{\text{expected}}/2$.
- The 95% CL limit on a one dimensional aQGC parameter corresponds to a value of 3.84.