Looking for leptophilic Z’ at the FCC-ee

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In collaboration with

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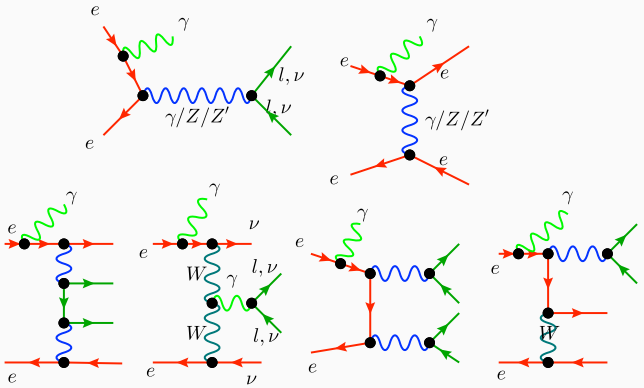
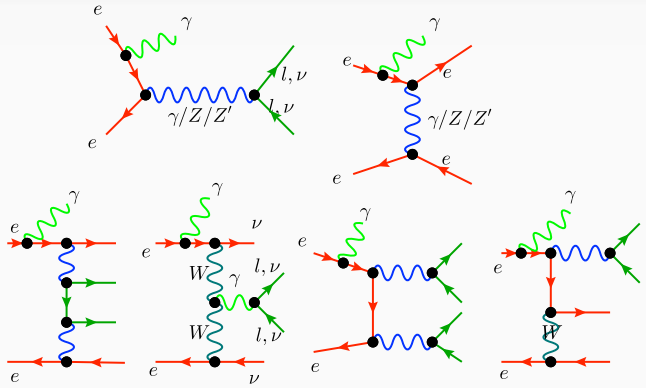
FCC BSM Meeting

- Arises from an additional U(1) symmetry; anomaly free
- Electrically neutral, couples only to SM leptons
- Does not show up at hadron colliders at tree level
- We focus on $L_e - L_\mu$ and $L_e - L_\tau$ models (models where Z’ couples only to electron and muon flavours, and electron and tau flavours respectively)
- Mass range of interest: 10-365 GeV

Recent works: Dasgupta et al (2308.12804), Goudelis et al (2312.14103)



- e+ e- —> Z’ + γ
- Signal: 2 leptons + γ
- Main backgrounds: 2 leptons + γ
  4 leptons + γ
  (final state)



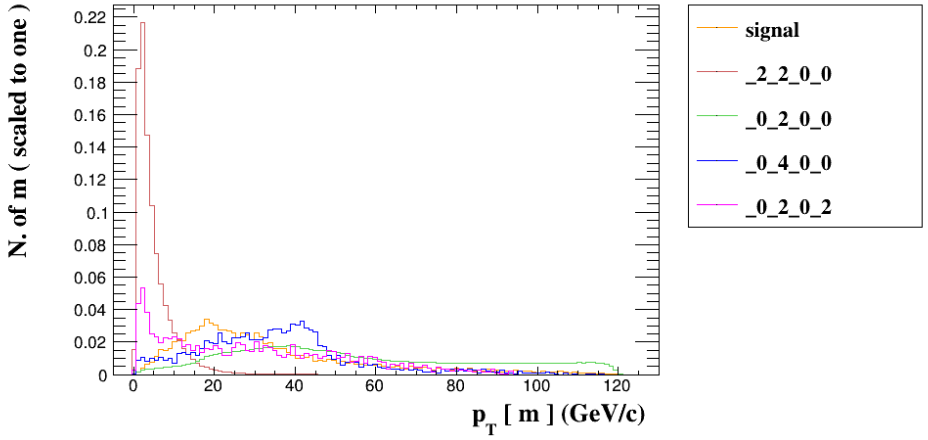
- Calculate signal and background cross-sections on MG5
- Use PYTHIA8 and DELPHES to take showering and detector effects into account
- Cuts taken from DELPHES IDEA card used for parton level analysis:

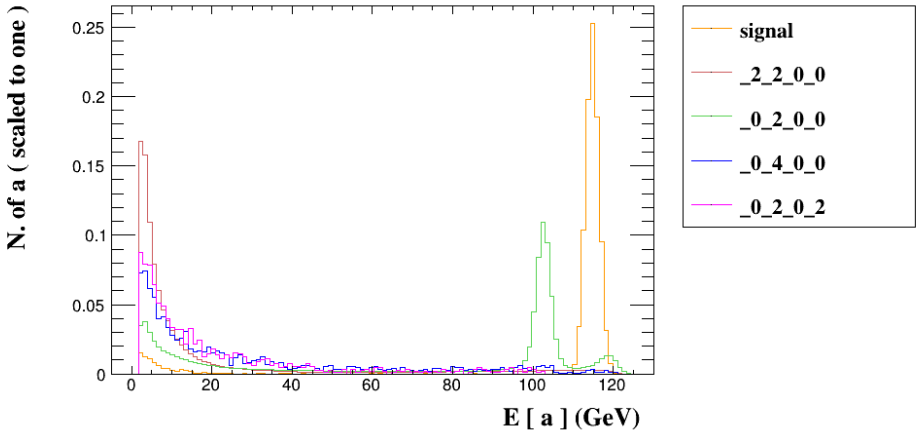
- $l = e, \mu$: $p_T > 0.5$ GeV, $|\eta| \leq 2.56$, $\Delta R(l, X) > 0.5$, $\epsilon_e = 0.99$
- γ: $E > 2$ GeV, $p_T > 0.5$, $|\eta| < 3.0$, $\Delta R(\gamma, X) > 0.5$, $\epsilon_\gamma = 0.99$
- τ: $p_T > 1$ GeV, $|\eta| \lesssim 3.0$, $\Delta R(\tau, X) > 0.5$, $\epsilon_e = 0.85$.

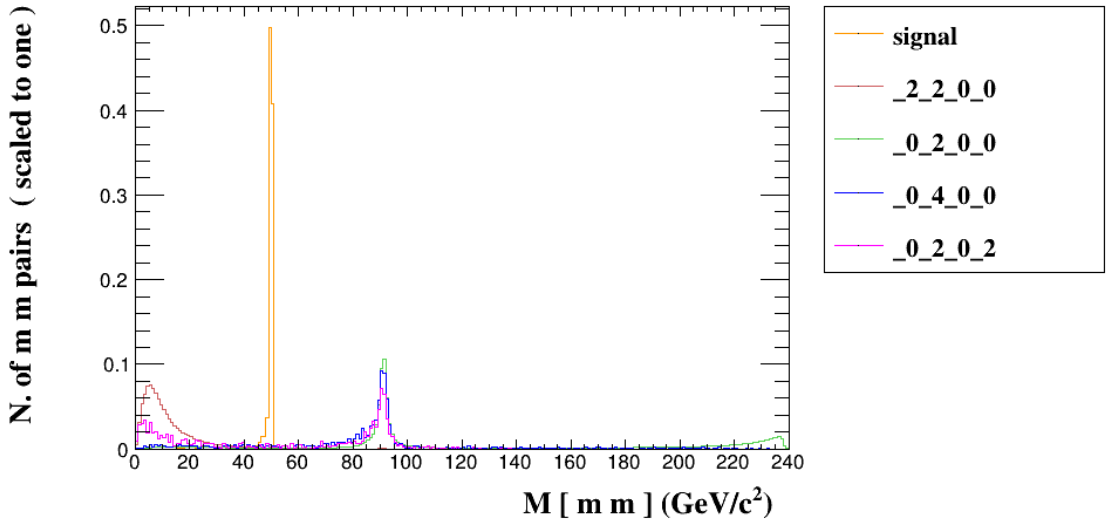
Pipeline (contd.):

Background inclusion

- Calculate signal and background cross-sections on MG5
- Use PYTHIA8 and DELPHES to take showering and detector effects into account
- Final analysis is performed using Madanalysis, additional cuts imposed to improve sensitivity


N. of m (scaled to one)
p_T [m] (GeV/c)
signal
_2_2_0_0
_0_2_0_0
_0_4_0_0
_0_2_0_2


N. of a (scaled to one)
E [a] (GeV)
signal
_2_2_0_0
_0_2_0_0
_0_4_0_0
_0_2_0_2

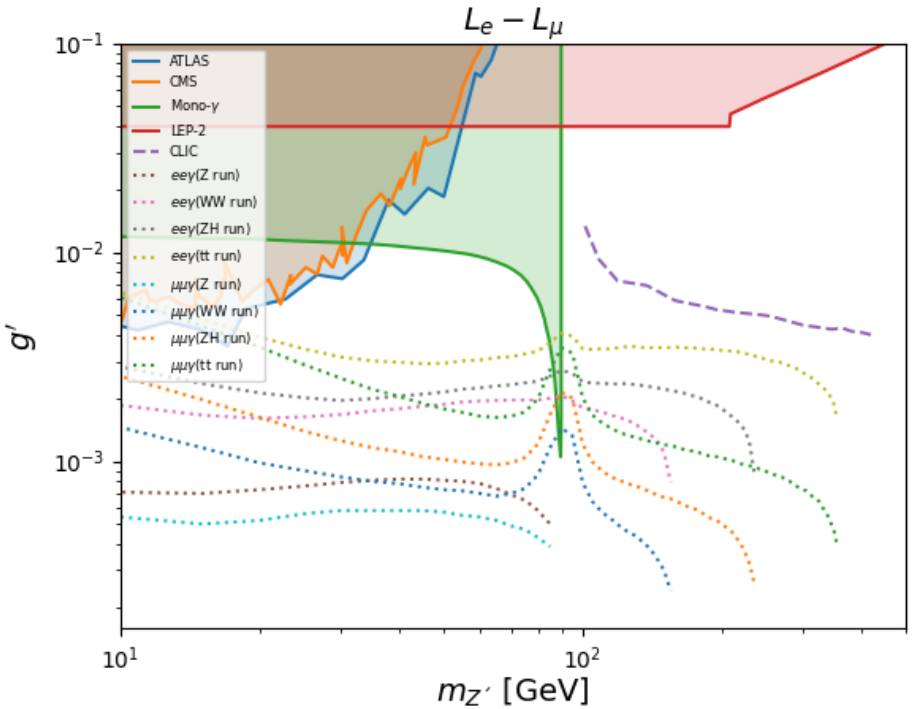

N. of m m pairs (scaled to one)
M [m m] (GeV/c^2)
signal
_2_2_0_0
_0_2_0_0
_0_4_0_0
_0_2_0_2

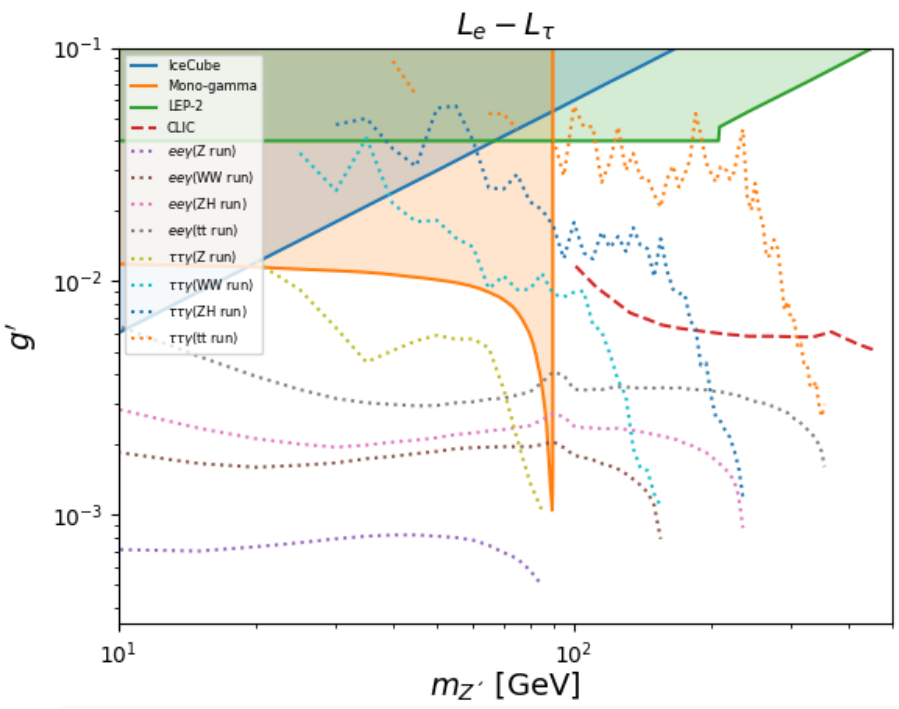
Pipeline (contd.):

Background inclusion

- Calculate signal and background cross-sections on MG5
- Use PYTHIA8 and DELPHES to take showering and detector effects into account
- Final analysis is performed using Madanalysis, additional cuts imposed to improve sensitivity
- Invariant mass (for charged dilepton pair signal) and energy window (for mono-gamma signal) used to calculate signal and background events, and significance: $\mathcal{Z} = \frac{N_s}{\sqrt{N_s + N_b}}$
- Plots shown for $\mathcal{Z}$ = 2

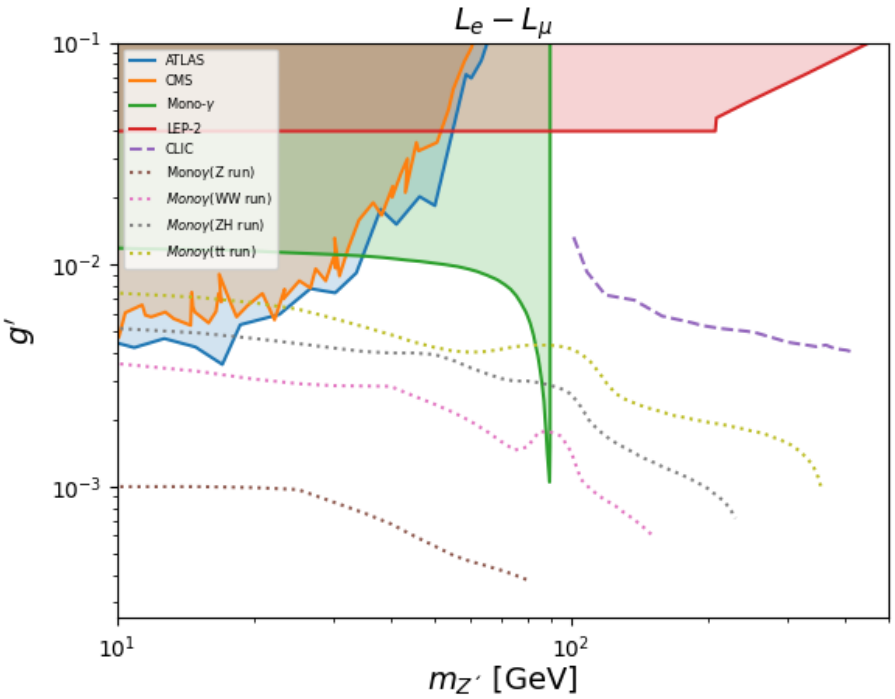
Sensitivity plots

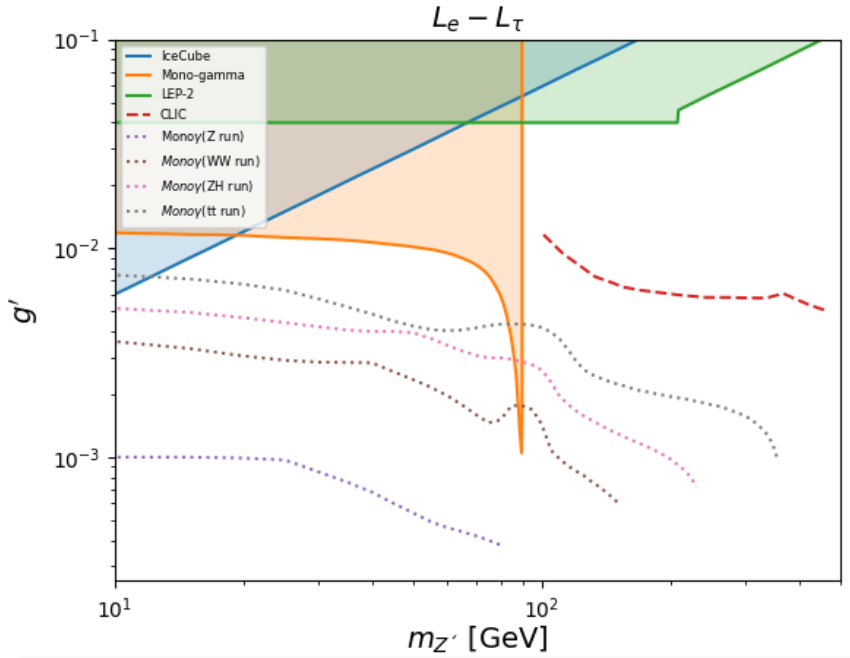




Sensitivity plots with existing constraints (shaded) for the charged dilepton search channel. The plots are shown for an invariant mass window of 5 GeV

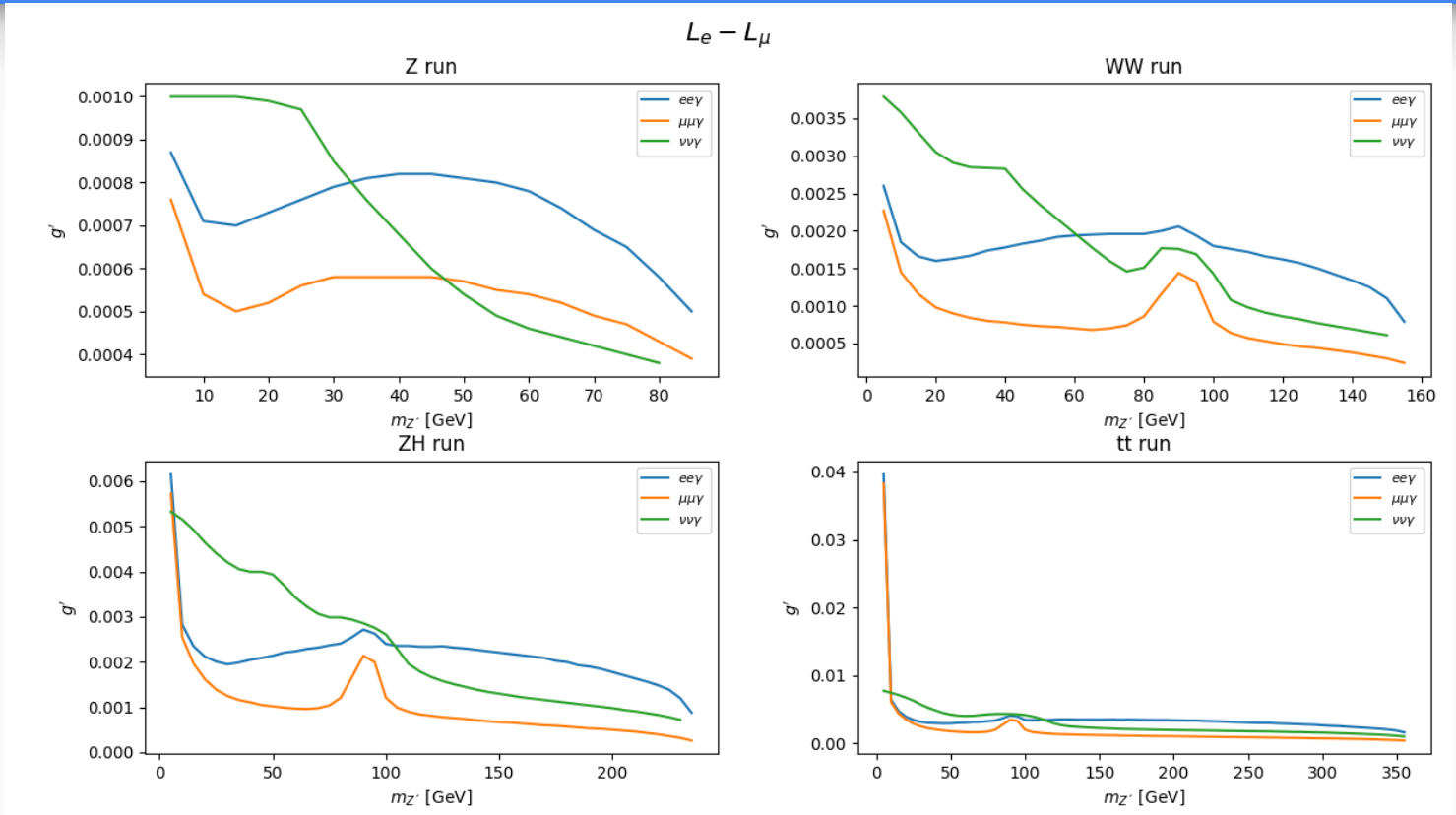
Sensitivity plots



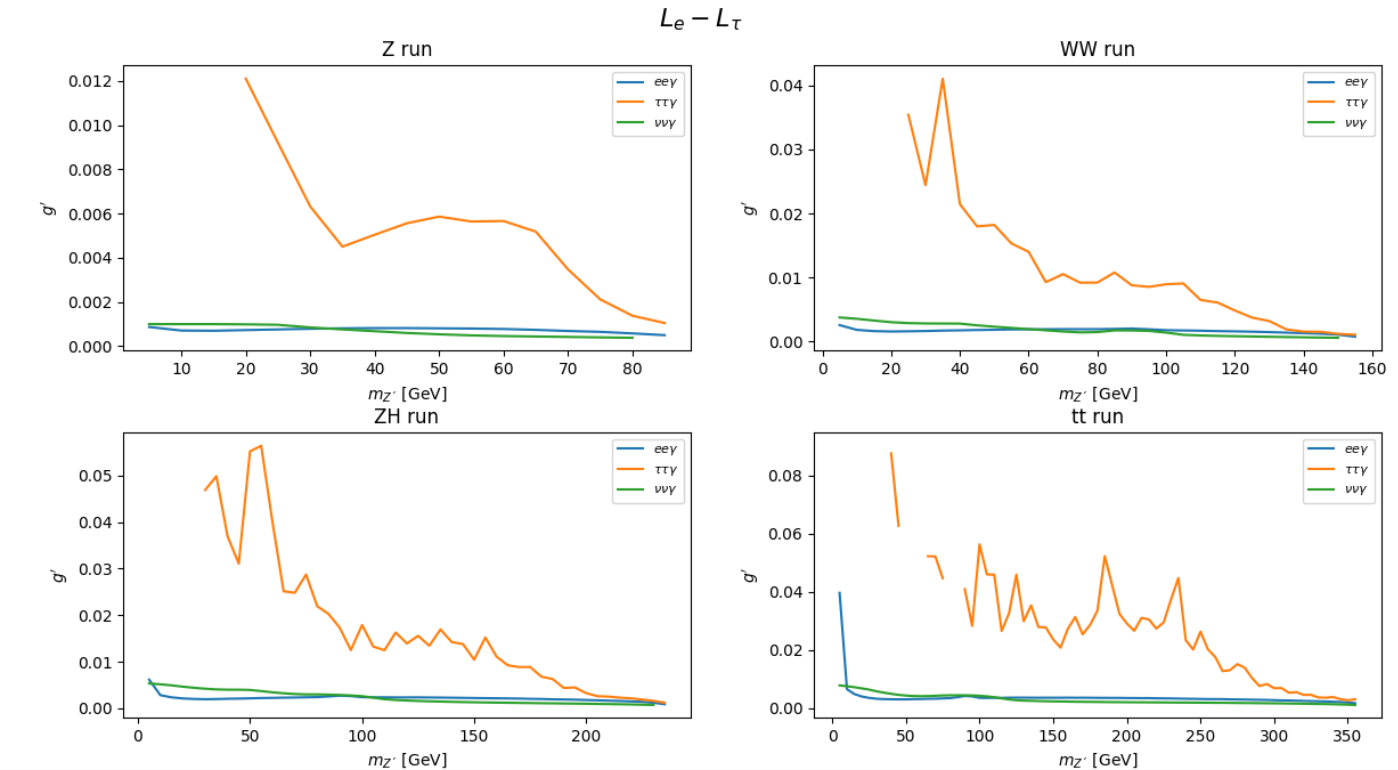


Sensitivity plots with existing constraints (shaded) for the mono photon search channel. The plots are shown for an energy window of 5 GeV

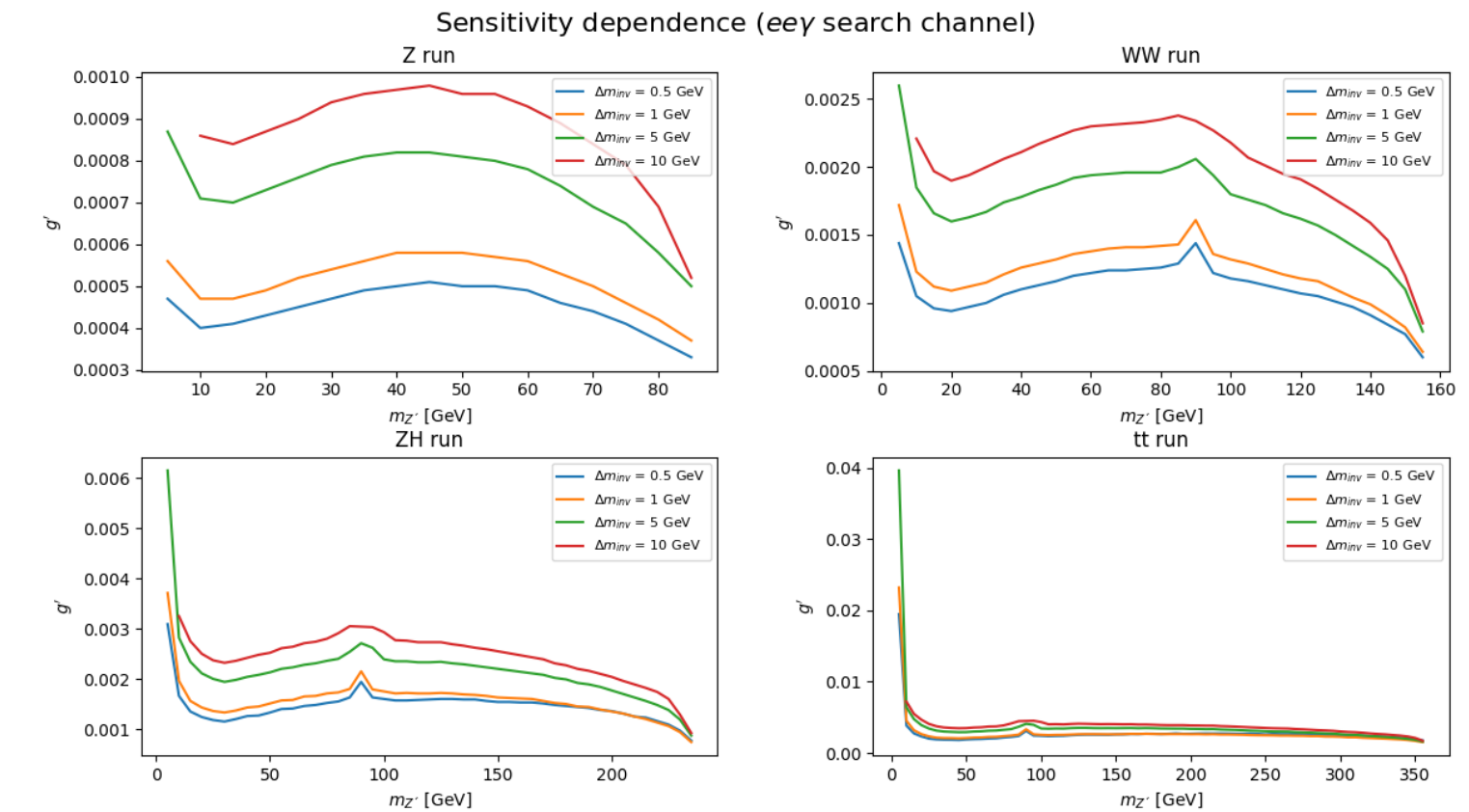
Combined search channels



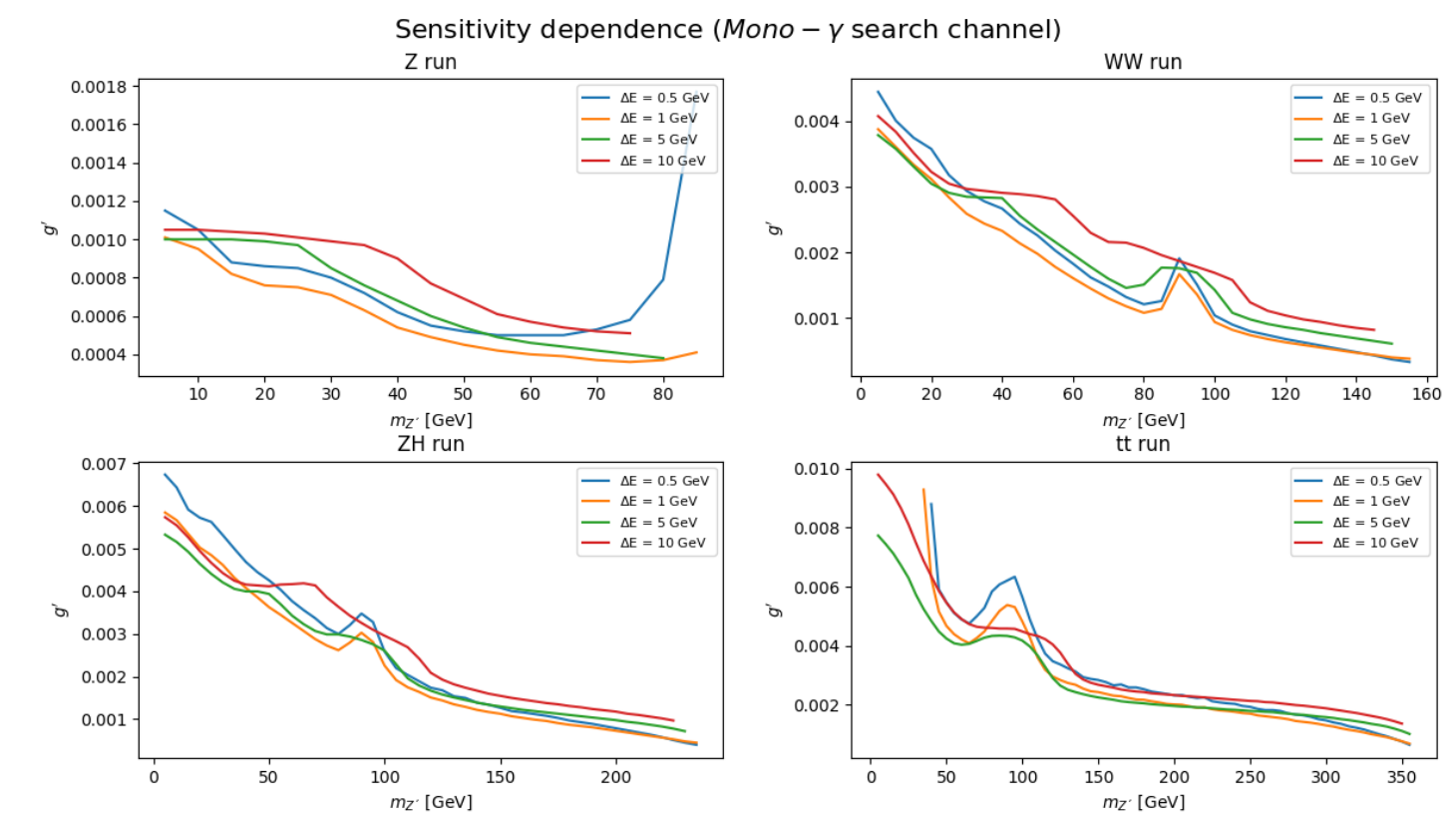
Combined search channels



Sensitivity dependence on invariant mass window resolution



Sensitivity dependence on energy window resolution



Thank you!

Backups:

Process $e^+e^- \to \gamma + ...$	N_{ev}, Z run	N_{ev}, WW run	N_{ev}, ZH run	N_{ev}, $t\bar{t}$ run
$\mu\mu$	2.3×10^7	2.1×10^4	5.5×10^3	844
ee	8.63×10^7	1.26×10^6	4.5×10^5	7.9×10^4
$\tau\tau$	2.3×10^7	2.1×10^4	5.7×10^3	882
$\nu\nu$	2.2×10^6	5.9×10^4	3.3×10^4	1.35×10^4
$\mu\mu\mu\mu$	1.2×10^3	14	6.3	1.4
$\mu\mu ee$	8×10^4	5.03×10^3	4.16×10^3	1.73×10^3
$\mu\mu\nu\nu$	8	18	15.6	6.7
$eeee$	7.6×10^4	4.86×10^3	4.04×10^3	1783
$ee\tau\tau$	3×10^4	1.1×10^3	890	382
$ee\nu\nu$	12.8	20	25	11.6
$\tau\tau\tau\tau$	500	6.3	4.5	1
$\tau\tau\nu\nu$	4	23	160	40
$\nu\nu\nu\nu$	5×10^{-2}	11.2	8.1	4.6

Table 2: Expected number of events for our background processes