Update on the extra scalar searches based on recoil mass

Teresa Núñez - DESY

- Motivation and conditions
- Updated analysis flow
- ISR and FSR checks
- Example flow cuts
- Conclusions and outlook

ILD Software and Analysis Meeting (18-12-24)

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Motivation and conditions

- **Reimplementation of previous analysis with current experimental conditions**
- **Redefine cut flow**
- **Use standard Marlin processors if possible**

Full detector simulation and reconstruction procedures of the ILD at the ILC for $\sqrt{s}$ = 250 GeV

Different Z decays modes want to be covered

Samples:

- Background using new SM 250 GeV samples generated with Whizard v.2.8.5, the SetA beam-spectrum, simulation and reconstruction with the ILD_l5_o2_v02 model, and ILCSoft v02-02-01
- Signal generated with Whizard v.2.8.5, the SetA beam-spectrum, detector simulation done by sgv.

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Event selection

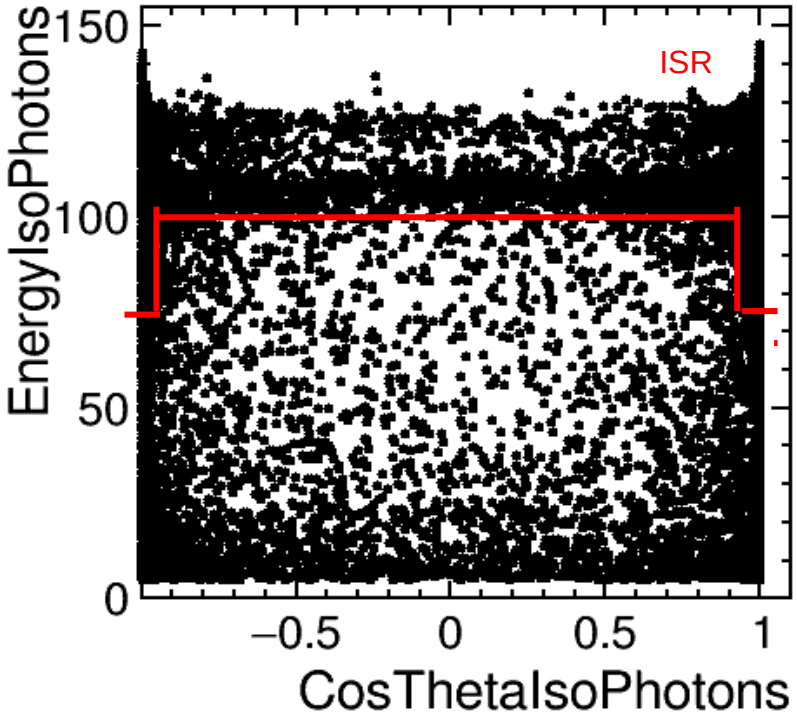
$e^+e^- \rightarrow Z' \rightarrow ZS^0 \rightarrow \mu^+\mu^- S^0$

- Identification of ISR photons (IsolatedPhotonTaggingProcessor)
- Select events without high-energetic ISR photon:
  - none or $E\gamma < 100$ GeV for $|\cos\theta| < 0.95$ or $E\gamma < 75$ GeV for $|\cos\theta| > 0.95$
- Identification of isolated leptons (IsolatedLeptonTaggingProcessor)
- Perform isolated lepton pairing (LeptonPairing)
- Cuts on kinematic variables (FSR corrections applied), accepted if
  - $M_{\mu^+\mu^-} \in [70, 110]$ GeV
  - $P^T_{\mu^+\mu^-} \in [0, 120]$ GeV
- Cuts on output of two BDTGs, 2f-MTVA and 4f-MTVA, trained against 2 fermion and 4 fermion backgrounds, respectively.
  - Input variables: $M_{\mu^+\mu^-}^{FSR}$, $\cos\theta_{\mu^+}^{FSR}$, $\cos\theta_{\mu^-}^{FSR}$, $\cos\theta_{\mu^+\mu^-}^{FSR}$, $\cos\theta\mu - \mu^{FSR}$, $\pi - (\phi_{\mu^+} - \phi_{\mu^-})$
  - cut limits depends on scalar mass
- Limits computed based on fractional event counting using the M_{recoil} histograms

ISR efficiency and purity

- Comparison MC true ISR photons with reconstructed isolated photons (IsoPhotonTagging processor)
- Select MC true ISR photons above lower LumiCal edge (31 mrad polar angle) and energy greater than 5 GeV

Efficiency and purity ~ 82%



Region cut by ISR veto

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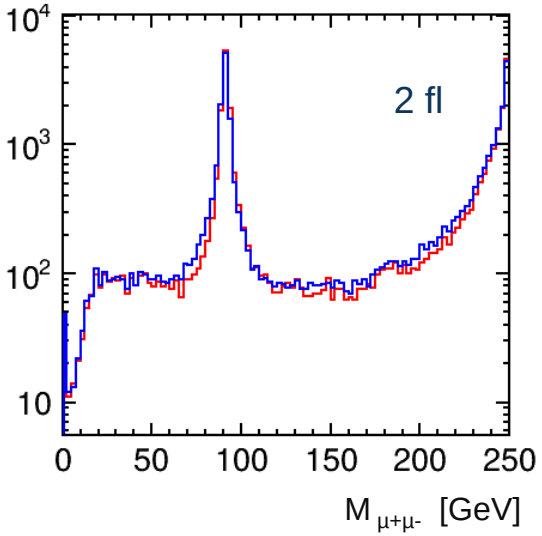
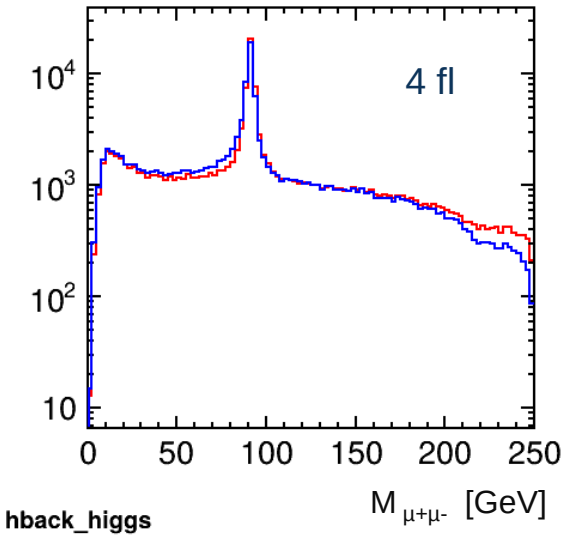
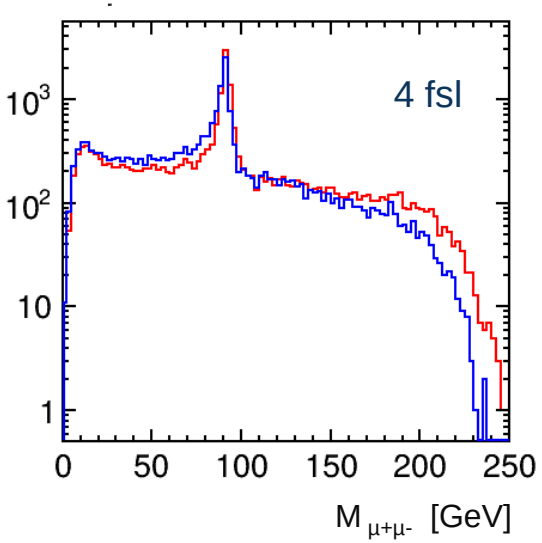
Check FSR correction







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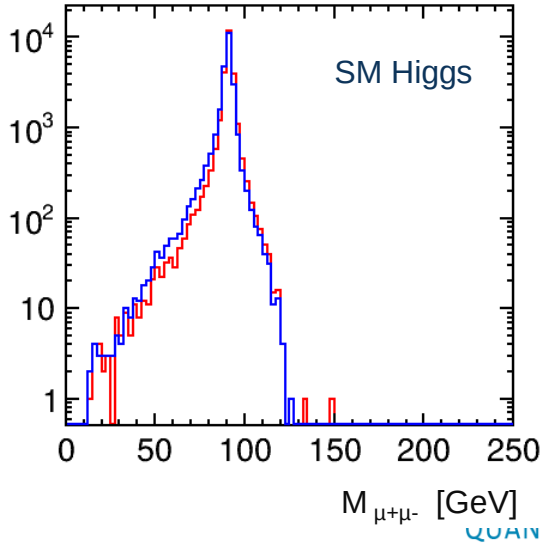

FSR correction

Not corrected

After ISR veto

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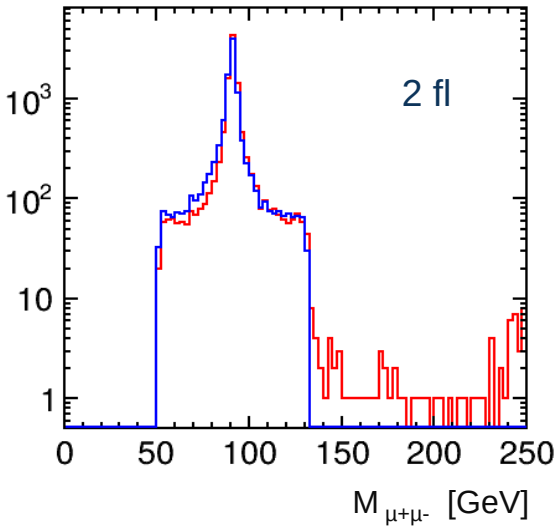
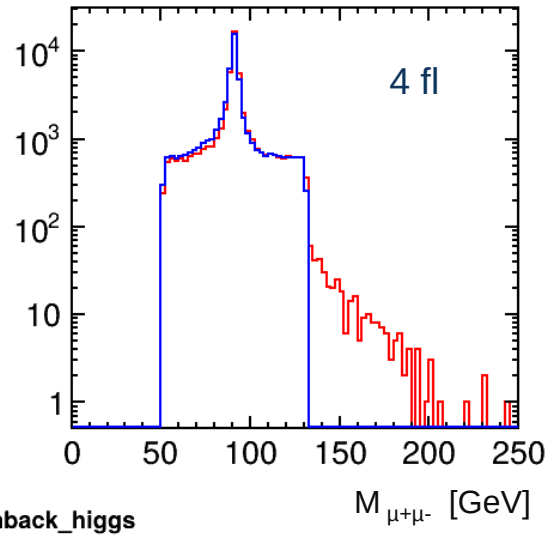
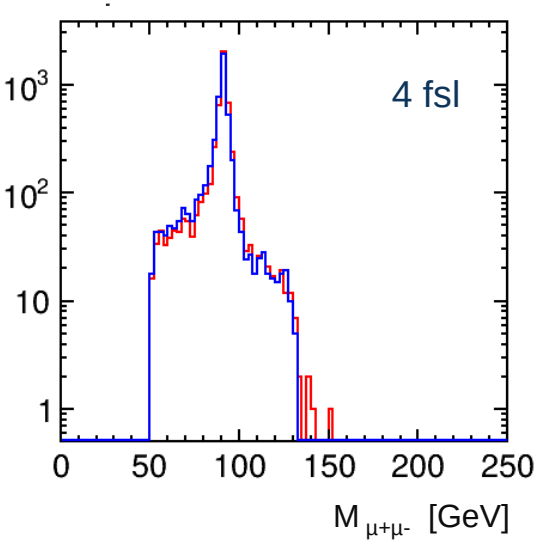
Check FSR correction







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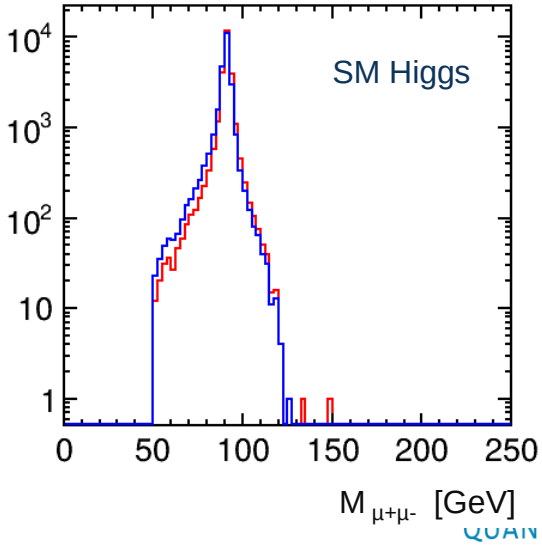

FSR correction

Not corrected

After loose selection of muon pair with mass close to Z

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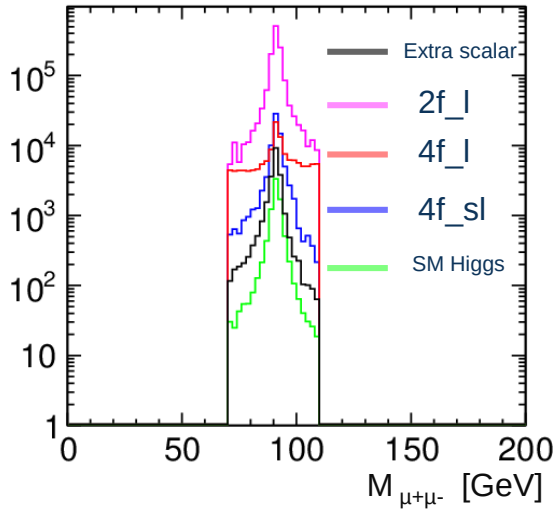
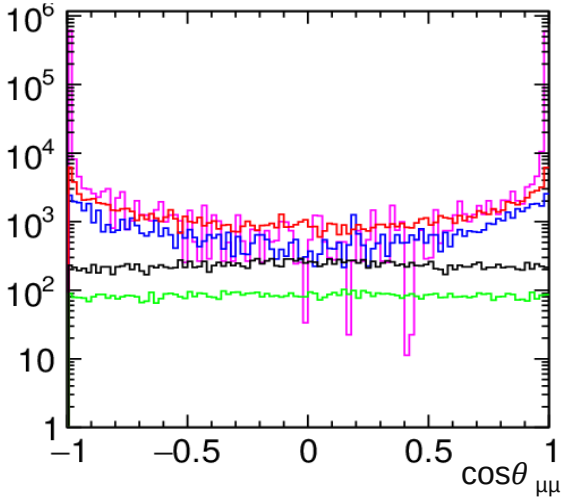
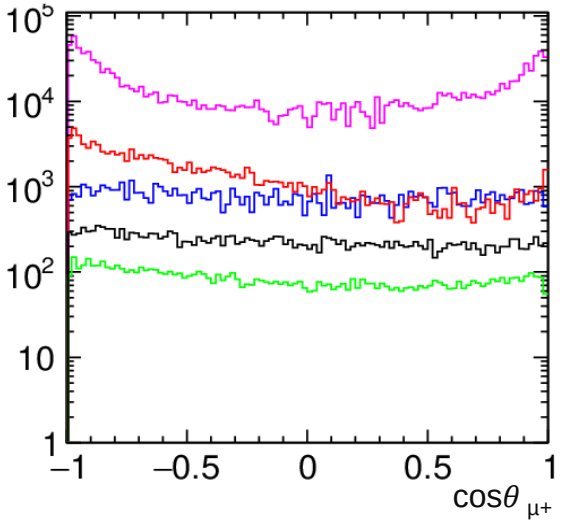
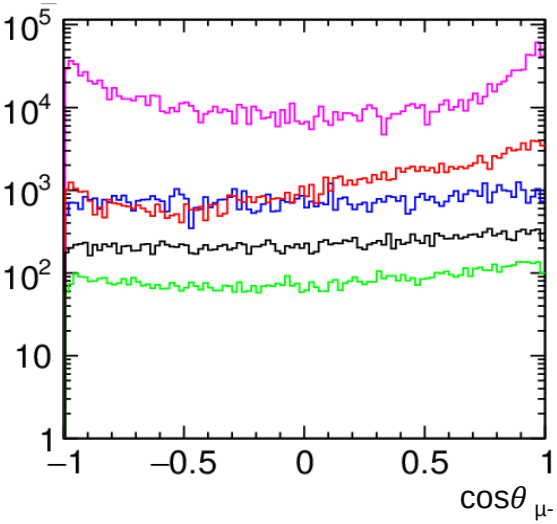
Variables used for the MVA response

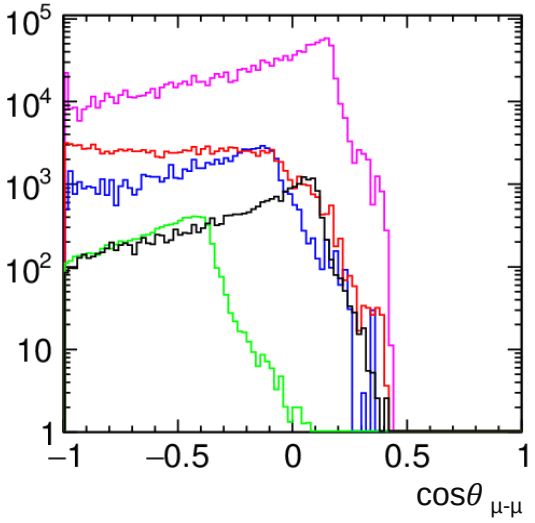
Exotic Scalar mass 50 GeV

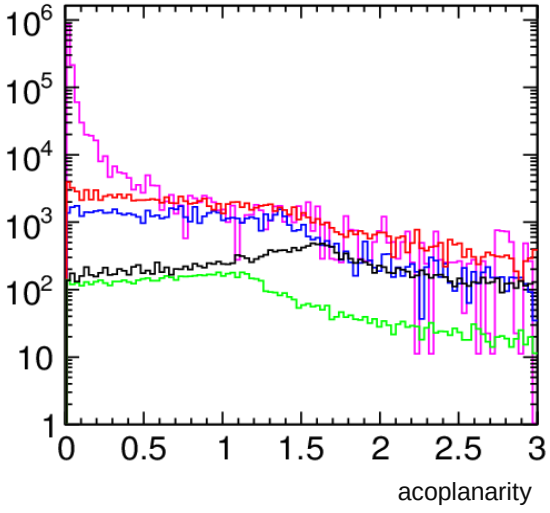






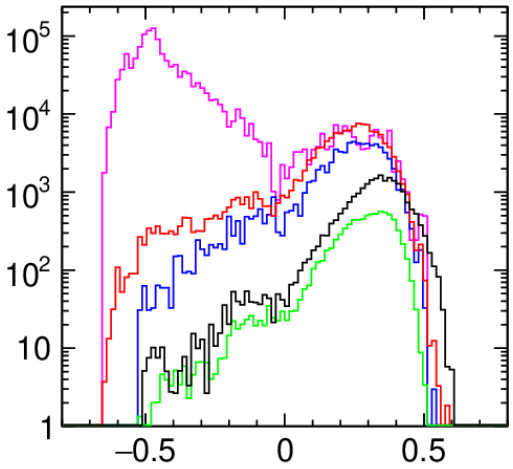




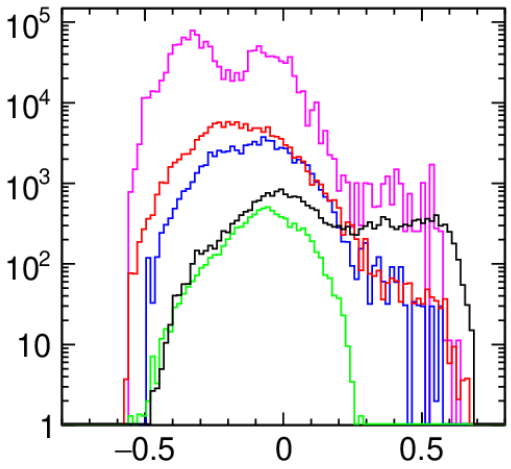


Variables used for the MVA response

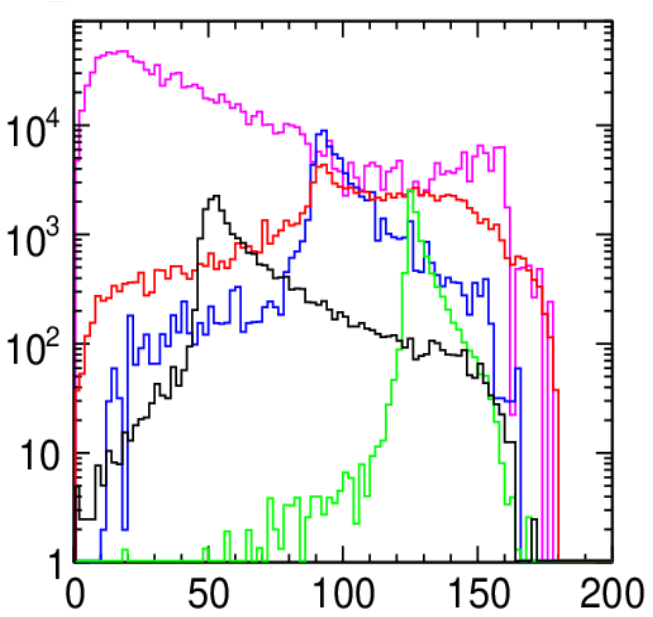
MVA-2f response



MVA-4f response



Exotic Scalar mass 50 GeV



Recoil mass before MVA cuts

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New exotic scalars: cut flow (m_{extra_scalar} = 50 GeV)

Polarisation LR

	Signal	mumuHiggs	4f leptonic	4f semileptonic	2f leptonic	Others	Total background	Significance
Total	25673.8	9277.43	5.24819e+06	1.67591e+07	1.16846e+07	3.14992e+08	3.48693e+08	0
ISR veto	25574.6	9277.40	3.58982e+06	1.65261e+07	1.00969e+07	2.72015e+08	3.02237e+08	1.47
Kinematic cuts	23243.3	8368.12	132412	76915.5	1.35870e+06	0	1.5764e+06	18.8
MVA 2f	22460.0	7922.28	113034	68241.4	110683	0	299881	39.6
MVA 4f	8680.21	20.78	3276.87	2628.59	18199.3	0	24125.5	47.9

Polarisation RL

	Signal	mumuHiggs	4f leptonic	4f semileptonic	2f leptonic	Others	Total background	Significance
Total	17312.0	6257.16	2.05509e+06	2.33915e+06	9.28338e+06	2.56734e+08	2.70418e+08	0
ISR veto	17219.3	6256.73	1.16572e+06	2.0274e+06	8.0073e+06	2.20701e+08	2.31907e+08	1.13
Kinematic cuts	15645.8	5663.22	32143.1	37916.8	917513	0	993236	15.6
MVA 2f	15123.6	5429.19	25240	34152.9	76423.8	0	141246	38.2
MVA 4f	5139.9	13.73	816.57	894.0	10235.9	0	11960.2	39.3

$$significance = \frac{s}{\sqrt{s+B}}$$

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Conclusions and outlook

- The model independent search for new scalars is reimplemented based on newest MC production and ILD software
- Cut flow is modified with respect to the previous analysis
- Review of the cuts is being performed
- Possible optimisation of current cuts is under study
- Calculation of the limits using fractional counting will be done after previous checks/changes
- Extension of the searches to other Z mode decays is forseen