WIMP Study: New Whizard Setup & Request for Simulation

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ILD Software / Analysis Meeting

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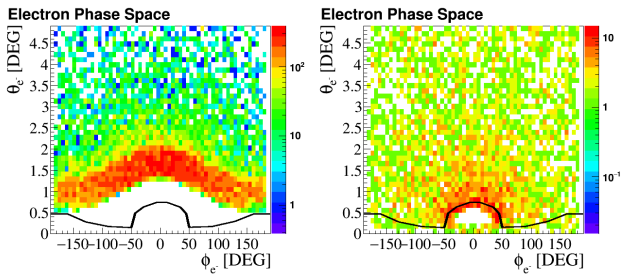
WIMP Search: Involved Processes

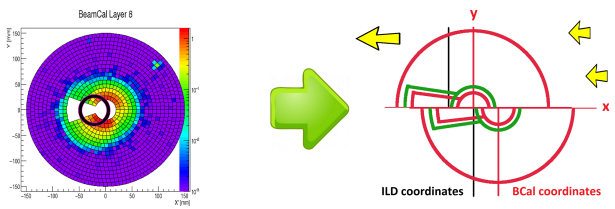
- signal
  - WIMP pair $\Rightarrow$ "empty detector"
  - $+$ ISR photon $\Rightarrow$ "mono-photon channel"
  - not directly generated in Whizard
- dominant background processes
  - $\nu\bar{\nu}\gamma \Rightarrow$ used to produce WIMP events (reweigh)
  - Bhabha scattering
- required Whizard processes (100% polarised)
  - $\nu\bar{\nu}\gamma_{LR}$ $(\nu_e \& \nu_\mu \& \nu_\tau)$
  - $\nu\bar{\nu}\gamma_{RL}$
  - $e^- e^+ \gamma_{LR}$
  - $e^- e^+ \gamma_{RL}$
  - $e^- e^+ \gamma_{LL}$
  - $e^- e^+ \gamma_{RR}$

Why new Samples ?

- gap in Bhabha phase space
  - ever-since → also previous analyses
  - Whizard cut: invariant mass of incoming and outgoing $e^{\pm}$ was too large (4 GeV)
  - now lowered to 1 GeV
  - see talks in phone meetings ▸ 13 July 2016 ▸ 25 Jan 2017



- wrong signal definition
  - Bhabha leptons could escape detector
  - new signal definition
  - see talk in phone meeting ▸ 25 Jan 2017



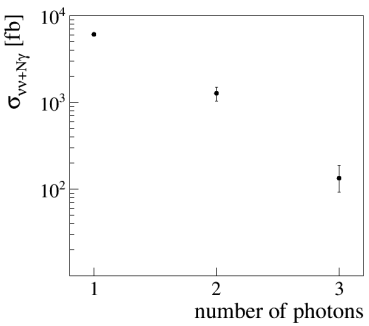
- photon treatment was not correct

⇒ new samples

- generation (Whizard): me
- simulation and reconstruction: request to be done centrally

Photon Treatment in Whizard

- ISR routine
  - best cross-section
  - only collinear photons $\rightarrow$ `circe_recoil=false`
  - generates one "photon" per beam (not physical) $\rightarrow$ no cuts
- in matrix element
  - description of non-collinear photons: correct number, energy, θ
  - separate processes for 1,2,3 photons
  - cuts on photons:
    - $p_T > 0.1\,\text{GeV}$
    - $|\cos(\theta)| < 0.9999755 \leftrightarrow 7\,\text{mrad}$ (outside of outgoing beam pipe)
      $\Rightarrow$ makes them potentially detectable
      $\Rightarrow$ avoid divergencies
    - choice of value is arbitrary $\Rightarrow$ theory error by varying p_T between 0.05 and 2 GeV



Maximum Number of Photons

- include additional photon if cross-section is larger than Whizard uncertainty on process with one photon:
  $\sigma_{XX+n\gamma} > \delta\sigma_{XX+1\gamma}$
- $\nu\bar{\nu}\gamma$, $\nu\bar{\nu}\gamma\gamma$, $\nu\bar{\nu}\gamma\gamma\gamma$, $\nu\bar{\nu}\gamma\gamma\gamma\gamma$
- $e^-e^+\gamma$, $e^-e^+\gamma\gamma$, $e^-e^+\gamma\gamma\gamma$,
  maybe $e^-e^+\gamma\gamma\gamma\gamma$ (still running)

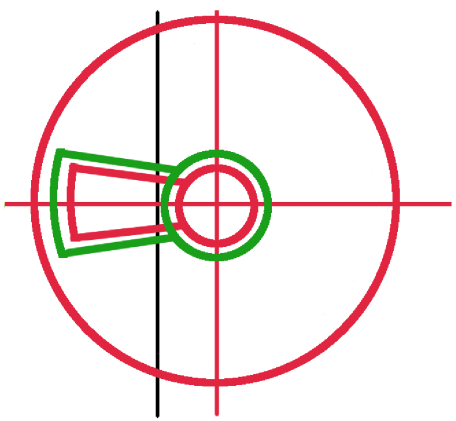
- for now: separate samples
- could be combined to $\nu\bar{\nu}+x\gamma$ and $e^-e^+ + x\gamma$

Signal Definition and Preselection Cuts

- preselection cuts on generator level
  - reduce phase space
  - safety margin

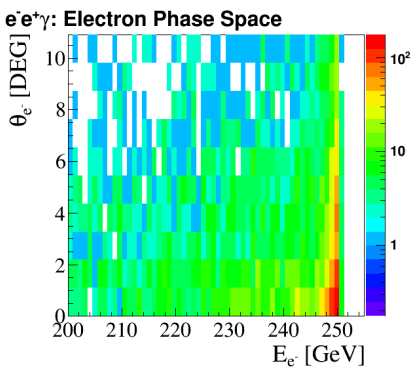
	signal definition	**preselection**
avoid Z return	$E_\gamma < 220\,\text{GeV}$	-
tracking	$\lvert\cos(\theta_\gamma)\rvert < 0.996$ ($\theta > 5.13\,\text{DEG}$)	$\lvert\cos(\theta_\gamma)\rvert < 0.9975$ ($\theta > 4.05\,\text{DEG}$)
distinguish from noise, ensure Bhabha detection	$p_{T,\gamma} > 2$ or $> 5\,\text{GeV}$ (in BCal coordinates)	$1\,\text{GeV}$

- θ in preselection: just inside beam pipe
- p_T cut is ϕ-dependent:
  - $|\phi_\gamma| < 35$: $p_T > 5.71\,\text{GeV}$ (corresponding $e^\pm$ on "incoming" side)
  - $|\phi_\gamma| > 35$: $p_T > 1.97\,\text{GeV}$ (corresponding $e^\pm$ on "outgoing" side)

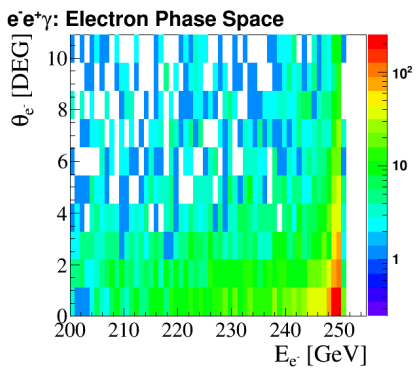


Bhabhas: Invariant Mass Cuts

- Bhabhas need additional cuts to avoid divergencies
- invariant mass of all possible pairs of particles was set to 4 GeV previously
- $M_{e^-_{out},e^-_{out}} > 1\,\text{GeV}$
- $M_{e^\pm_{in},e^\pm_{out}} > 1\,\text{GeV}$: closed the gap
- $M_{e^\pm_{out},\gamma} > 1\,\text{GeV}$
- $M_{e^\pm_{out},\gamma_{signal}} > 4\,\text{GeV}$: $e^\pm$ with high θ would be detected anyway



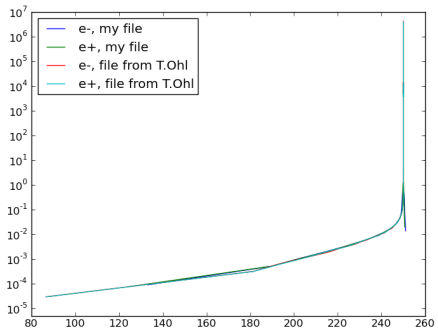
$M_{e^\pm_{out},\gamma_{signal}} > 1\,\text{GeV}$

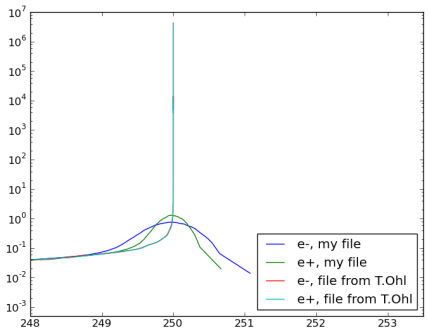


$M_{e^\pm_{out},\gamma_{signal}} > 4\,\text{GeV}$

Versions and Preferences

- Whizard
  - latest version: 2.4.0
  - luminosity spectrum: using circe2 implementation with my input file





- simulation
  - Mokka
  - DBD detector (old L*)
- reconstruction
  - using BeamCalClusterReco (as in /v01-17-11/StandardConfig/current/bbudsc_3evt_stdreco.xml)

Processes for Request: Neutrino Pairs

$\nu\bar{\nu}\gamma$	σ	t_{10000}	ϵ(sig)	ϵ(cuts)	Mokka_{1000}	Marlin_{1000}
1γ,LR	23034	few sec	62.3%	61.7%	40 min 18M	12 min 34M
1γ,RL	1435	few sec	36.1%	34.9%	2h 41M	23 min 77M
2γ,LR	4642	1 min	67.4%	51.5%	2h 28M	15 min 53M
2γ,RL	438	1 min	50.7%	22.8%	4h 50M	30 min 95M
3γ,LR	475	few min	72.0%	41.0%	1h 36M	20 min 69M
3γ,RL	62	few min	60.5%	13.9%	3h 58M	30 min 112M
4γ,LR	33	1h:38	tbd	tbd	tbd	tbd
4γ,RL	6	1h	tbd	tbd	tbd	tbd

Processes for Request: Bhabha Scattering

e^-e^+	σ	t_{10000}	ϵ(sig)	ϵ(cuts)	Mokka_{1000}	Marlin_{1000}
1γ	117188	1 min	46.3%	0.3%	10h 100M	1h:30 180M
2γ	11054	few min	56%	0.04%	11h 110M	1h:30 220M
3γ	627	45 min	65%	0.03%	11h 125M	2h 250M
4γ	?	?	?	?	?	?

- averaged over polarisations
- Mokka and Marlin: CPU time and output files for 1000 events

Summary

- requested event numbers
  - neutrinos:
    $500\,\mathrm{fb}^{-1} = 15{,}062{,}500$ events
  - Bhabhas:
    10,000 events after cuts $\rightarrow$ 4,000,000 - 10,000,000 events
- status
  - generation of events is ready
  - samples with many photons still need to be checked