WIMPs @ ILC

BSM WG Meeting
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An Experiment-Theory Collaboration:
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Signal:

WIMP pair with photon from initial-state radiation (ISR)

   e+ e-   → DM DM **γ**

- Single photon with missing four-momentum
- Observables: E_γ, θ_γ

Main Background:

Neutrino pairs

   e+ e-   → νν**γ**, νν**γγ**, νν**γγγ** …

Irreducible. Control with polarization.

Bhabha scattering

   e+ e-   → e+e-**γ**, e+e-**γγ**, e+e-**γγγ**

Mimics signal if the electron & positron go down the beam pipe undetected. Coverage of forward detectors crucial.
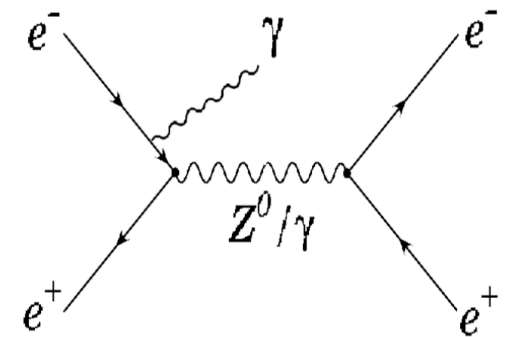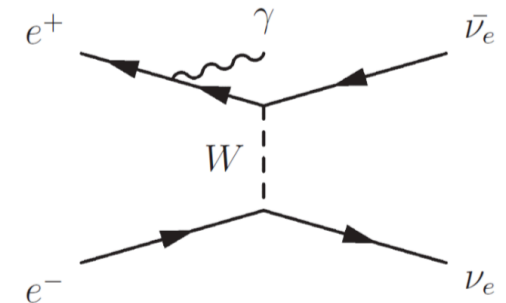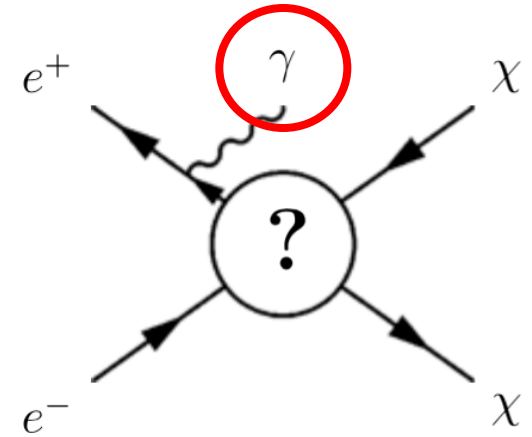
Physics interpretation:
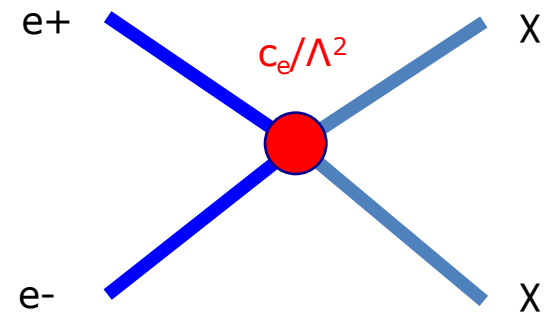
e+   X

g_e mediator g_χ

mass Λ

e-   X

$c_e \sim g_e g_\chi$

e+ c_e/Λ^2 X
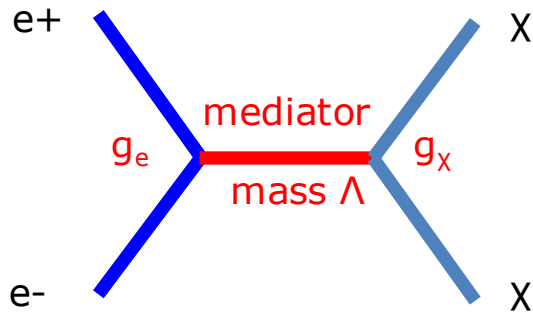
e-   X

Simplified Model (example)
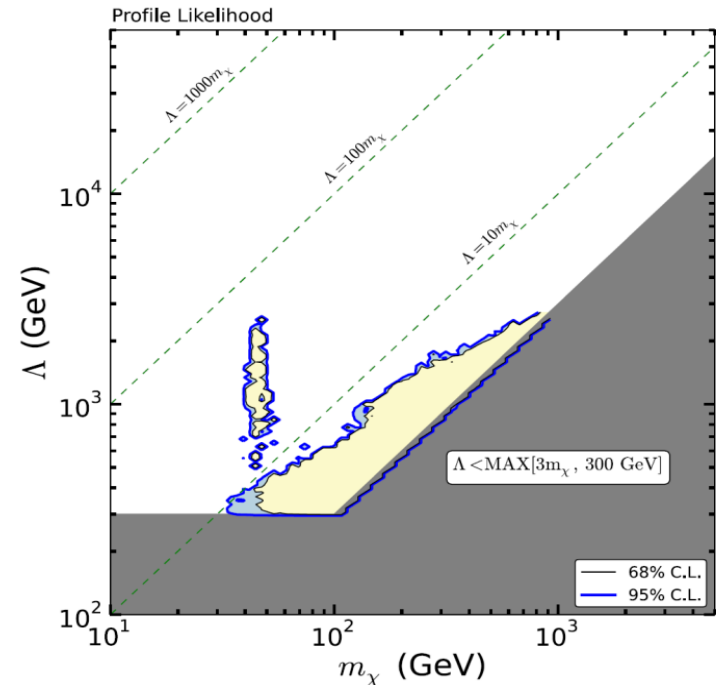→ for collider reach

Effective Field Theory model
→ for direct detection

Perform parameter scan for comparison with other experiments
Expected reach before ILC starts
(see right plot →)
Goal is to include ILC sensitivity

5) Aim to quantitatively compare ILC's sensitivity with other experiments including LHC and direct detection experiments.

6) Search also relevant at all CM energies of ILC. The expected reach in WIMP mass is roughly half of the CM energy.

Profile Likelihood

Λ (GeV)

$\Lambda = 1000 m_\chi$

$\Lambda = 100 m_\chi$

$\Lambda = 10 m_\chi$

10^4

10^3

$\Lambda < \mathrm{MAX}[3m_\chi, 300\ \mathrm{GeV}]$

68% C.L.
95% C.L.

10^2

10^1 10^2 10^3

m_χ (GeV)

Analysis Status

M. Habermehl

BeamCal Layer 8

2) Current status: "close to final"
3) Level of detail: Full Simulation
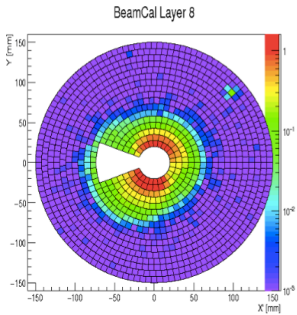
- Event generation with WHIZARD v2
- Simulation with Mokka
- Reconstruction with ilcsoft v01-17 series
  - including improved simulation of forward detectors
- WIMP signal samples will be prepared by reweighting radiative neutrino pairs

NEW

- Updated event selection using photon pT to ensure consistency with Bhabha sample
- Previously missing Bhabha phase space: now lowered invariant mass cuts on all particle pairs (see→)
- Improved ISR treatment to avoid double-counting of photons (with WHIZARD authors)
- Prepared code for calculating differential cross section for the signal, being adapted into limit setting code

Electron Phase Space

Old Bhabha

Electron Phase Space

New Bhabha

4
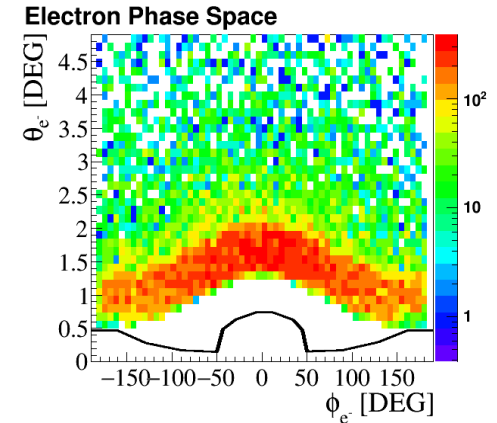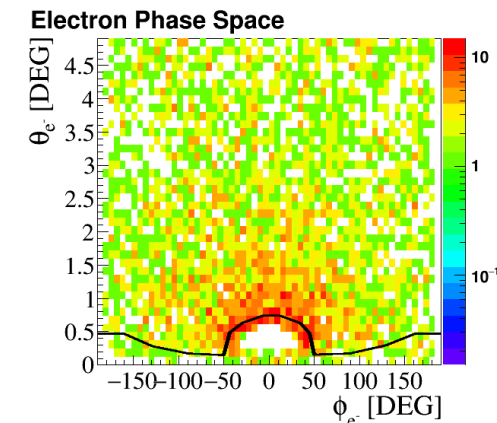
4) Sample request

Analysis setup is close to final.

→ Plan to request generation of background samples

Currently preparing list of processes, cross sections, and #of events.

CM Energy: **500 GeV**

Integrated luminosity: **500 fb^{-1}**

Processes:

- **Neutrino pairs:** $\nu\nu\gamma$, $\nu\nu\gamma\gamma$, $\nu\nu\gamma\gamma\gamma$, ...
- **Bhabha:** $ee\gamma$, $ee\gamma\gamma$, $ee\gamma\gamma\gamma$, ...

Generator-level cuts:
- pT and angular cuts on the hardest photon
- Soft pT cut on the additional photons
- For Bhabha: minimum invariant mass for all particle pairs involving the outgoing e+ or e-

Selections tailored for new event selection:

	Cross section [fb] for P=(0,0)
$\nu\nu\gamma$	6099
$\nu\nu\gamma\gamma$	1270
$\nu\nu\gamma\gamma\gamma$	134

*Final numbers including other beam polarizations will be provided once the event generator setup is finalized

For comparison with existing study:
[Bartels, Berggren, List, EPJ C (2012) 72:2213]

Process	Cross sections [fb] for $(P_{e^-}; P_{e^+}) =$		
	$(-0.8; +0.3)$	$(+0.0; +0.0)$	$(+0.8; -0.3)$
$\nu\bar{\nu}\gamma$	5821	2575	1263
$\nu\bar{\nu}\gamma\gamma$	782.0	355.4	214
$\nu\bar{\nu}\gamma\gamma\gamma$	55.8	26.2	19
$\gamma\gamma$		11.4×10^3	
$\gamma\gamma\gamma$		1.1×10^3	
$\gamma\gamma\gamma\gamma$		0.1×10^3	
e^+e^-		890×10^3	