Update on WIMP Analysis

Moritz Habermehl

ILD Software / Analysis Meeting

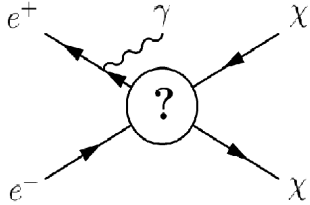
18 October 2017

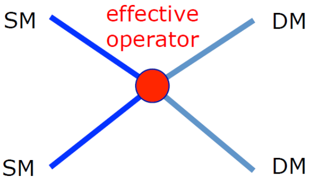
Update on WIMP Analysis

- note: this is not a complete (rehearsal) talk
- I'm just showing new material
- my talk at LCWS: Thursday, BSM session, 11:44, Madrid 2 (remotely)

WIMPs in the mono-photon channel

- **signal**
  - **WIMPs produced in pairs with ISR photon**
    $e^+e^- \rightarrow \chi\chi\gamma$
  - single photon
    in an "empty" detector
  - observables: E_γ, θ_γ
- **main background processes**
  - neutrino pair production
    $e^+e^- \rightarrow \nu\bar{\nu}\gamma$
  - Bhabha scattering
    $e^+e^- \rightarrow e^+e^-\gamma$
- **theory approach**
  - effective operators
  - $\Lambda = M_{mediator}/\sqrt{g_f g_\chi}$



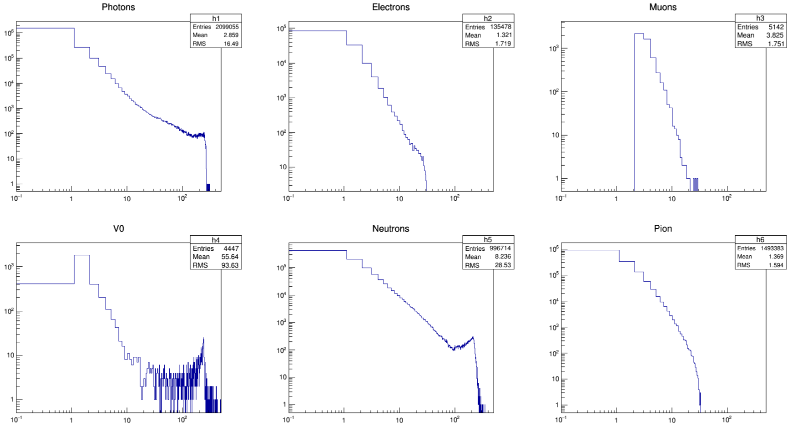


$$\frac{1}{\Lambda^2}(\overline{f}\gamma_\mu f)(\overline{\chi}\gamma^\mu\chi)$$

Updated cuts

- slightly different signal definition
  - 2 GeV $< E_\gamma <$ 220 GeV
  - $\theta_\gamma > 7^\circ$
  - $p_{T,\gamma} > 1.97$ GeV for $\phi_\gamma > 35^\circ$, $p_{T,\gamma} > 5.71$ GeV for $\phi_\gamma \leq 35^\circ$ (BeamCal coordinates)
- as before: veto events
  - with tracks with $p_T > 3$ GeV
  - and with BeamCal clusters
- updated cut on the visible energy
  - add up all PFO energies (also charged particles)
  - only consider particles with $E > 5$ GeV (lower energies probably overlay)
  - allow a maximum energy sum of 10 GeV
  - or 30 GeV, if the extra energy is from reconstructed neutrons or pions

energy distribution of PFOs ($\nu\bar{\nu}$ RL)



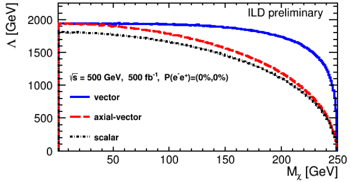
efficiency of background suppression

	sig. def.	p_T GeV	E_{vis} GeV	BCal
$\nu\bar{\nu}$				
unpolarised	4499.6	4334.3	3837.3	3761.0
		96.33%	**85.28%**	83.58%
before the update		96.54%	**78.97%**	78.72%
Bhabhas				
unpolarised				
	50101.2	22300.1	4901.4	186.7
		44.51%	9.78%	0.37%
before the update		49.66%	9.13%	0.32%

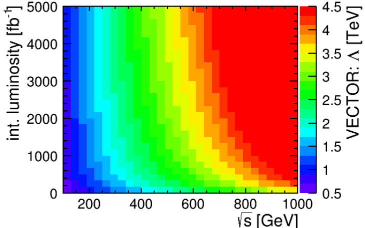
new E_{vis} cut $\Rightarrow$ more signal-like neutrino background kept,
Bhabha background still a lot smaller

Updated exclusion limits

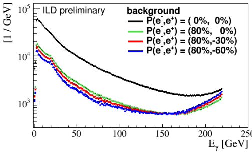
different effective operators

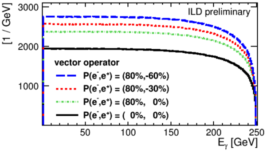


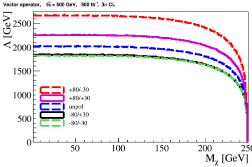
extrapolation to full centre-of-mass energy range



role of polarisation



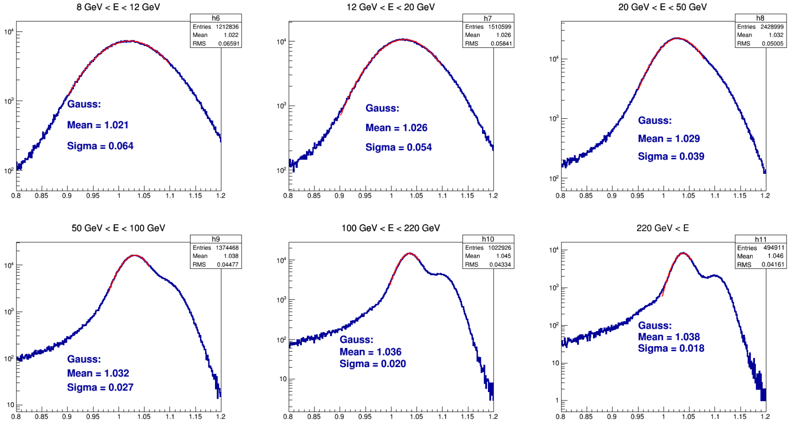




Photon reconstrucion

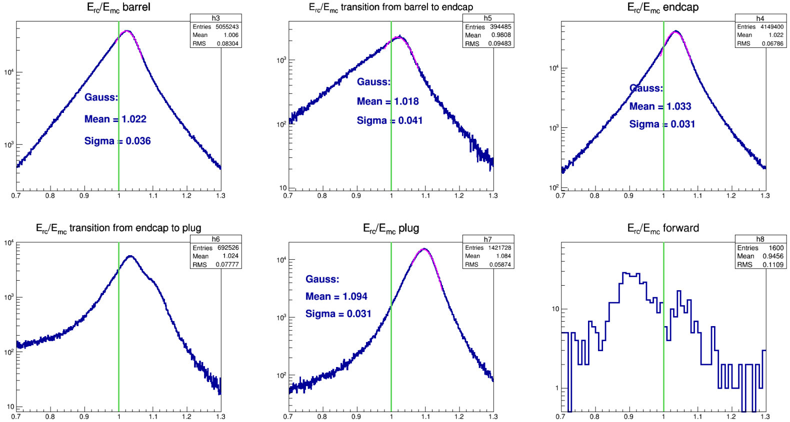
- triggered by the checks of DD4HEP test samples
  I had a closer look at my (Mokka!) $\nu\bar{\nu}$ samples
- photon energy reconstruction
  - reconstructed energy a few percent too high
  - non-linear, rises with energy
  - different ECal parts give different reconstructed energy, especially the ECal plug (aka Ecal ring)
  - reconstruction fails for some photons that hit the transition region from endcap to plug

reco energy as a function of energy



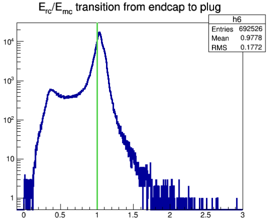
- reconstructed energy too high
- level rises with energy

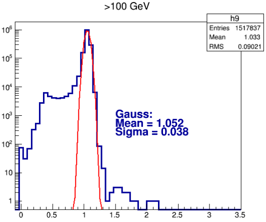
reco energy for different ECal components

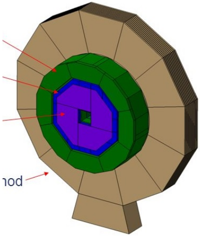


- in plug reconstructed energy 10% too high

Transition region from endcap to plug

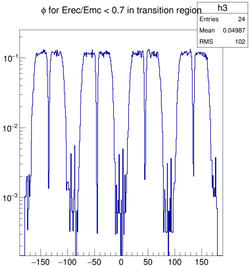


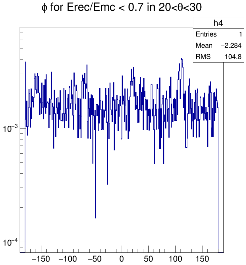




- peak at too low reconstructed energies
- in some cases photon reconstruction fails in the transition region of endcap and plug
- square shape $\rightarrow$ expect ϕ-dependence

ϕ Dependence of Low Reconstructed Energies





number of photons with $E_{reco}/E_{MC} < 0.7$ divided by total number of photons in θ range

- for $9.3^\circ < \theta < 12^\circ$ (transition region): ϕ distribution shows
  - reconstruction fails more often if photon is close to transition
  - fine around 0,90,180,270 degrees (γ fully contained in endcap)
  - fine around 45,135,... degrees (γ fully contained in plug)
- for $20^\circ < \theta < 30^\circ$ (test region in endcap)
  - no ϕ dependence
  - low values $\rightarrow$ "normal" tail to lower reconstructed energies

Using MC information

- How does photon reconstruction deficits influence the WIMP limits
- idea (study is ongoing)
  - MC energies of selected photons
  - smear with detector resolution

    $\Rightarrow$ compare shape of photon spectrum to full simulation