Luminosity Spectrum from collinear events in LumiCal

Oron Rosenblat

Tel Aviv University

FCAL Meeting, Bucharest, May 26 2014

Outline

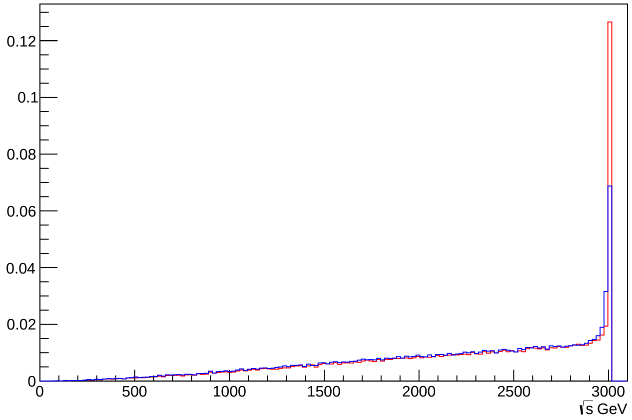
The Problem

- The luminosity spectrum in CLIC has an unknown shape due to Beam-Beam effects (Beamstrahlung)

- Particles reaching the detector are post-interaction (Bhabha scattering) and represent the Beamstrahlung spectrum folded in with the cross-section

The Problem

Due to the Beamstrahlung effects, the spectrum recieved in the detector has a different shape from the original spectrum



*Histograms are normalized to unity

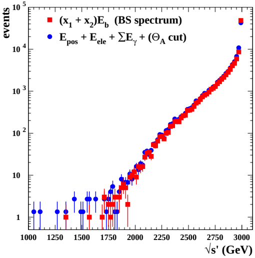
Previous Results


Lumi, Bhabha Scattering, Beamstrahlung...

Sergey Kananov

Tel-Aviv University

FCAL meeting, Zeuthen, May 08, 2012



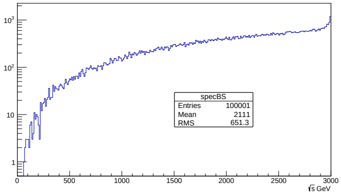
It was shown previously that applying an acollinearity cut on the spectrum received in the detector could help in reconstructing the original generated spectrum (analysis was caried out at the generator level)

Objectives

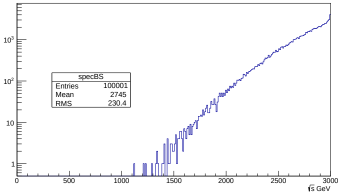
- Reproduce previous results
- Compare different distributions
- Quantify reconstruction effinciency

Samples Used

Used two different samples from Kirke 1.0 (simulate Beamstrahlung spectrum - beta distribution) and Bhwide 1.04 (Bhabha scattering)

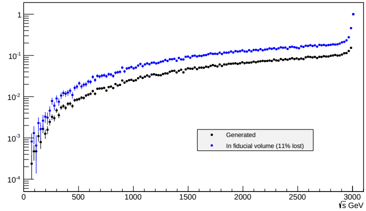


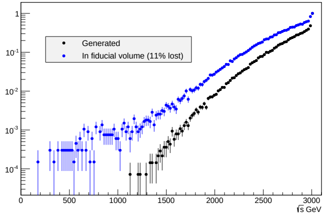
(a) Flat Distribution



(b) Steep Distribution

First introduce a cut on outgoing lepton polar angles accoording to LumiCal angles (42mrad $< \theta_\ell <$ 80mrad). W.r.t the original spectrum, events are lost mainly from the peak.



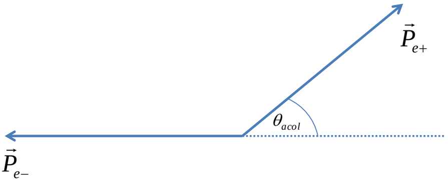


*Histograms are normalized to peak height

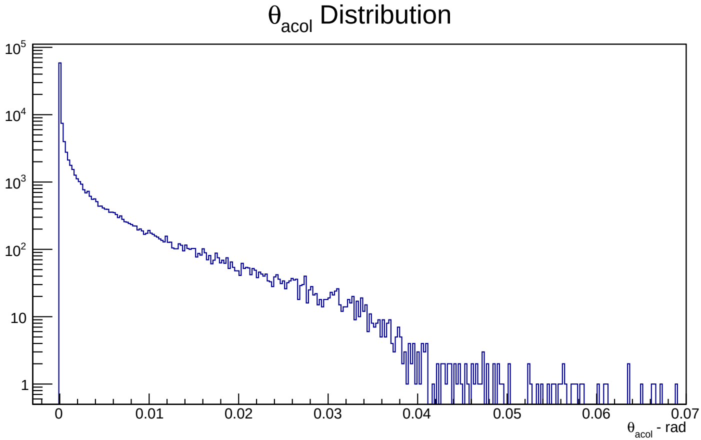
Acollinearity Cut

Choose events which are back-to-back

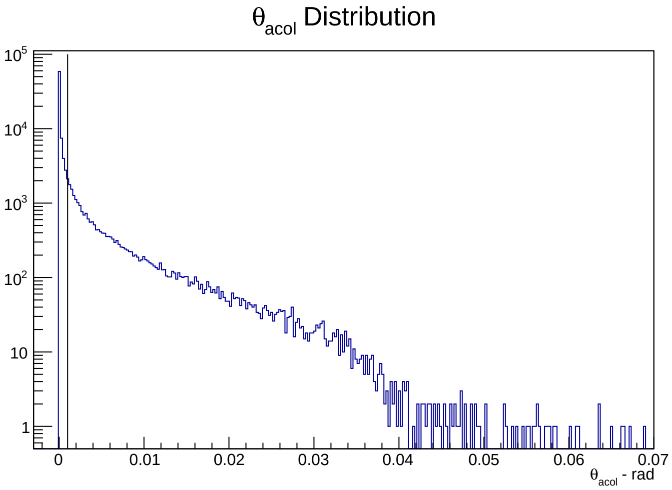
$\theta_{acol} = \pi - (\vec{P}_{e^+}, \vec{P}_{e^-}) < \theta_0$



Acollinearity Cut



Acollinearity Cut



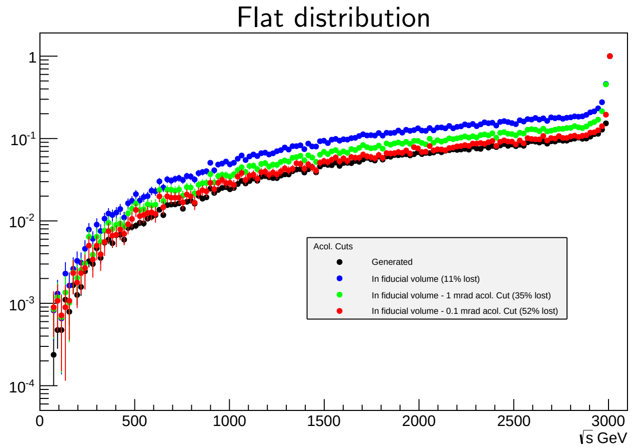
Acollinearity Cut

Apply 2 different cuts:

- $\theta_{acol} < 1mrad$
- $\theta_{acol} < 0.1mrad$ (Not realistic in LumiCal)

And plot reconstructed spectrum vs generated spectrum.

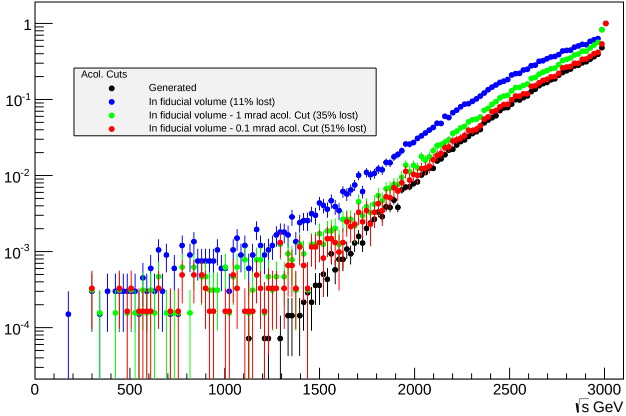
Results



Cut removes events from the tail - reconstructed spectrum approaches generated spectrum

Results

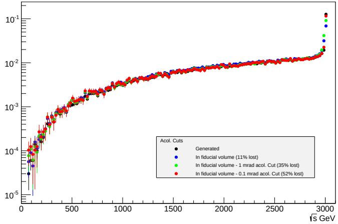
Steep distribution

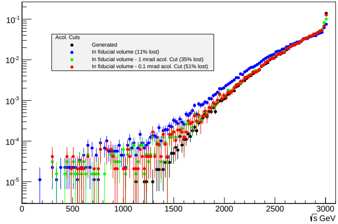


Cut removes events from the tail - reconstructed spectrum approaches generated spectrum

Results

The actual shape of the spectrum:





*Histograms are normalized to unity

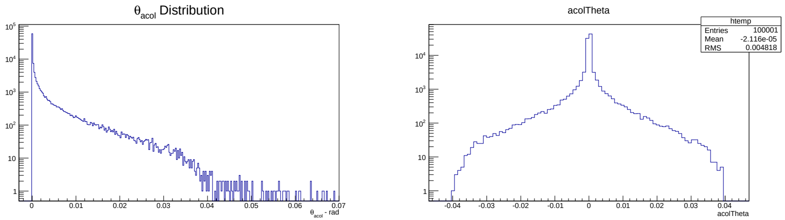
Comparison

	Steep Distribution		Flat Distribution	
	χ^2_{NDF}	Peak Ratio	χ^2_{NDF}	Peak Ratio
No Cut	20	0.54	8.6	0.54
1mrad	3.9	0.72	4.5	0.72
0.1mrad	1.03	0.92	0.38	0.91

What is acollinearity?

θ_{acol} can be taken as:

- $\pi - (\vec{P}_{e^+}, \vec{P}_{e^-})$
- The polar angle difference: $|\theta_{e^+} + \theta_{e^-}| - \pi$



Comparison - polar angle vs full angle

Full angle cut

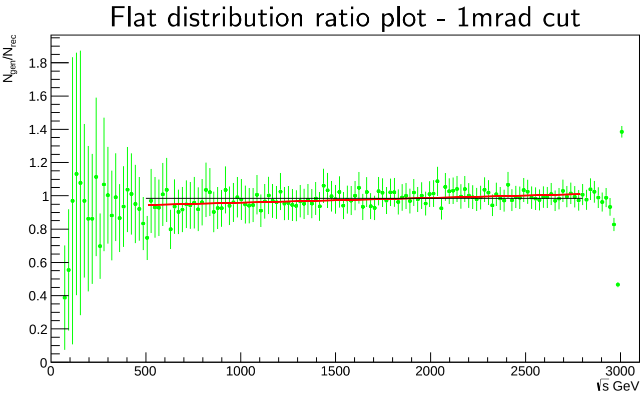
	Steep Distribution		Flat Distribution	
	χ^2_{NDF}	Peak Ratio	χ^2_{NDF}	Peak Ratio
No Cut	20	0.54	8.6	0.54
1mrad	3.9	0.72	4.5	0.72
0.1mrad	1.03	0.92	0.38	0.91

Polar angle cut

	Steep Distribution		Flat Distribution	
	χ^2_{NDF}	Peak Ratio	χ^2_{NDF}	Peak Ratio
No Cut	20	0.54	8.6	0.54
1mrad	4.06	0.71	4.6	0.72
0.1mrad	1.1	0.91	0.4	0.91

Applicability

For what ranges of the spectrum is the reconstruction reliable?

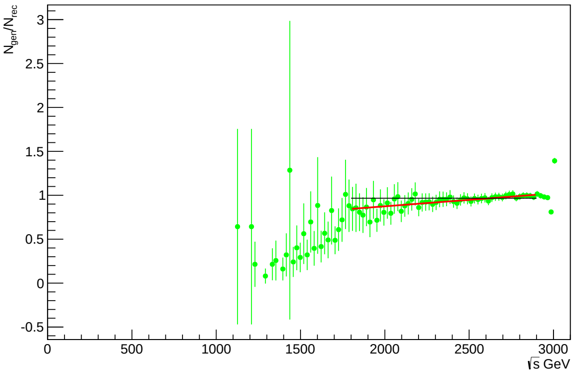


Linear fit	Constant fit
Slope $= (2.8 \pm 1.4) * 10^{-5}$	const $= 0.99$
$\chi^2_{NDF} = 0.19$	$\chi^2_{NDF} = 0.23$

Applicability

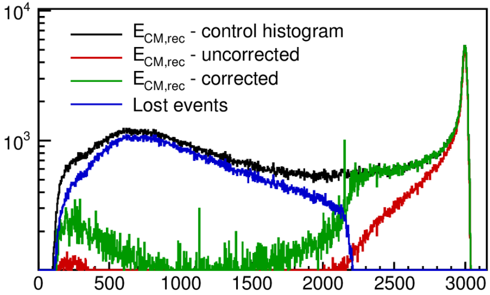
For what ranges of the spectrum is the reconstruction reliable?

Steep distribution ratio plot - 1mrad cut



Linear fit	Constant fit
$\text{Slope} = (1.47 \pm 0.38) * 10^{-5}$	$\text{const} = 0.97$
$\chi^2_{NDF} = 0.18$	$\chi^2_{NDF} = 0.46$

Applicability



Previous work (see S. Lukić - FCAL workshop, CERN, November 2012) has shown that for the peak region the spectrum can be reconstructed with precision better than 1%.
This work may be complementing for the lower energy region.

Conclusion

- The shape of the luminosity spectrum in LumiCal is altered due to beam-beam effects
- Introducing a cut on θ_{acol} allows reconstruction of the spectrum more reliably
- This cut is universal i.e. works for different distributions
- Cutting on the difference in polar angles instead of θ_{acol} suffices
- Resulting reconstruction is reliable for the central area of the spectrum, and breaks down around the edges
- All of the work has been done at the generator level

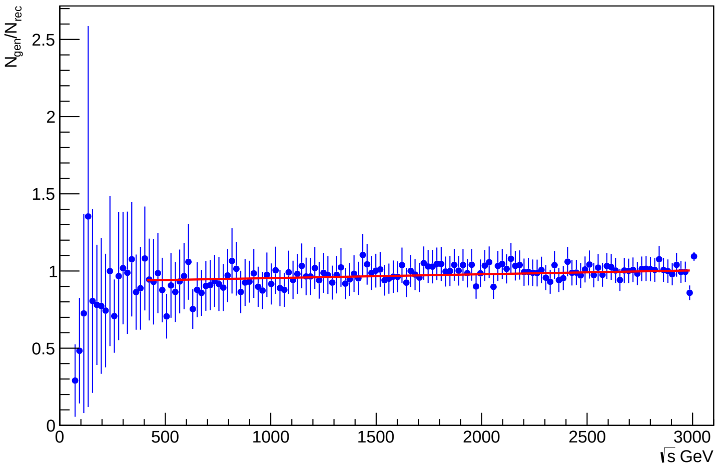
Outlook

- Move on to using this method on GUINEA PIG spectrum
- Apply full detector simulation and try to repeat these results
- If this is successful, explore possibility to combine with previous work in order to reconstruct a larger region of the spectrum

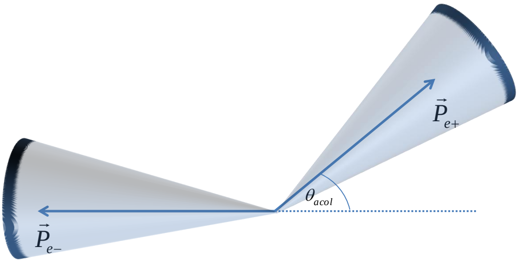
THANK YOU

Extra Slides

Flat distribution - 0.1mrad cut



$$\text{Slope} = (3.8 \pm 1.4) * 10^{-5} \quad \chi^2_{NDF} = 0.21$$


$\vec{P}_{e+}$
θ_{acol}
$\vec{P}_{e-}$