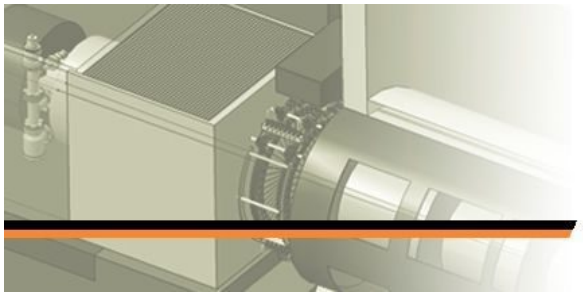
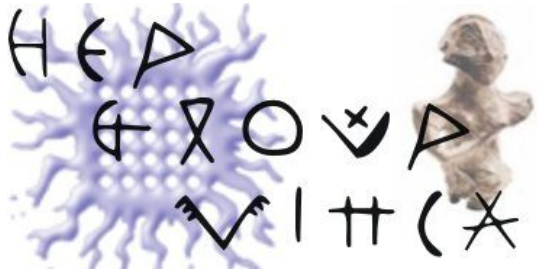
CLIC and the BHSE

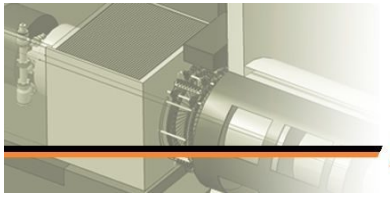
S. Lukić - HEP Group Vinča
CERN meeting, November 2011

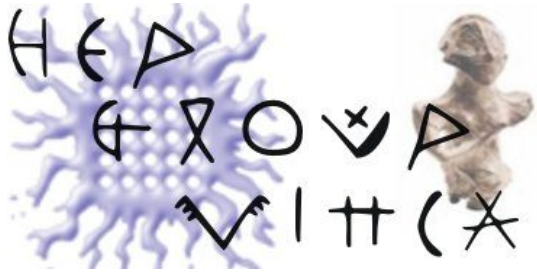


Summary



- Method of analysis
- BHSE at CLIC, difficulties and possibilities





Guinea-PIG (v1.4.1)
e^-e^+ collision pairs –
incoming momenta p_1, p_2
(collision axis, $\sqrt{s'}$, CM frame)

$\mathcal{R} < w\, f(s/s')$?

no

yes

Calculate the collision axis
in the CM frame

BHLUMI / BHWIDE
Bhabha outgoing momenta
fixed $\sqrt{s}$,
fixed collision axis

output

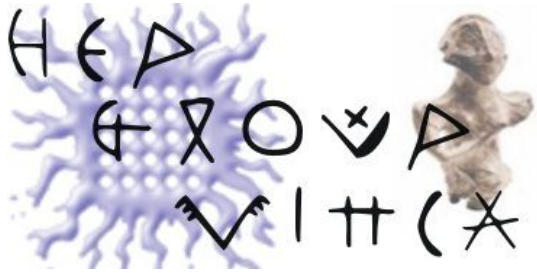
Rotate and scale the outgoing
momenta in the CM frame, then
boost back to the lab frame

output

Track...

output

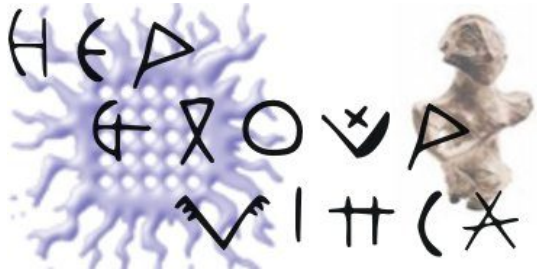
Underlying assumptions



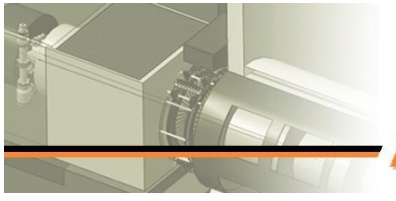
1. $\sigma(\sqrt{s}) \sim f(\sqrt{s})$ (hopefully simple & analytical)
2. $\sigma(\sqrt{s}, \Omega) = \sigma(\sqrt{s})\, g(\Omega)$
3. $\sigma(\sqrt{s}, E_{out}) = \sigma(\sqrt{s})\, h(E_{out}/\sqrt{s})$

- ILC: All valid to a very good approximation (see I. Sadeh webpage: http://alzt.tau.ac.il/~sadeh/bhabhaXs.html)
- CLIC: Tested by I. Smiljanić (http://www.vin.bg.ac.rs/hep/Ivan/x-section_vs_energy_CLIC/Bh_Xsec_E_CLIC.htm)
  1. $\sigma(\sqrt{s}) \sim s^{-0.9891}$; 250 GeV < $\sqrt{s}$ ≤ 3 TeV; excellent fit
  2. Agreement within statistical errors (5×10^5 events at each energy)
  3. Significant differences in $h(E_{out}/\sqrt{s})$ at different $\sqrt{s}$

Simulation

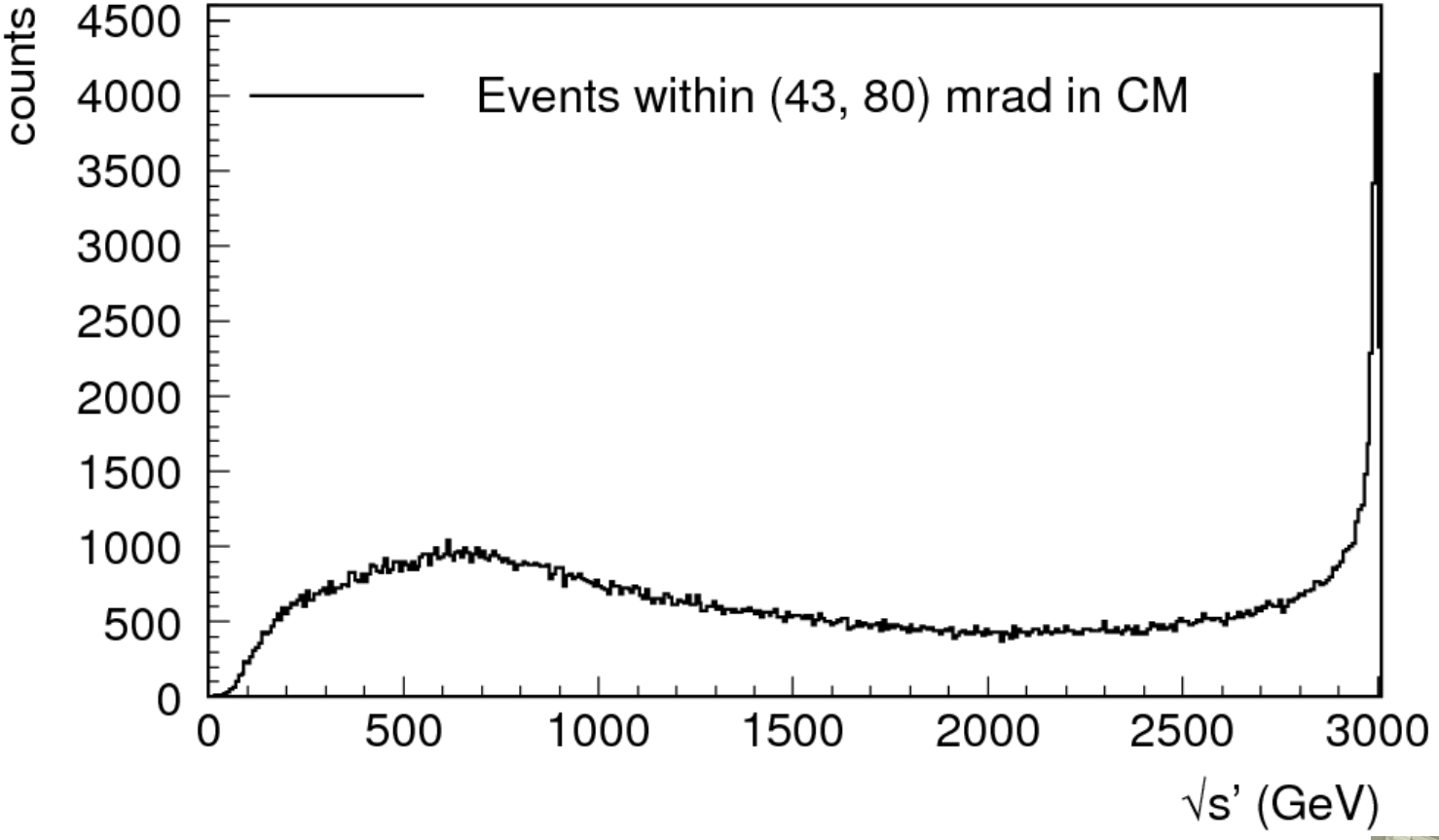


- Realistic beam profiles
- Individual bunches only!
- Scaling of the Bhabha cross section with $(s/s')^{0.9891}$



Beamstrahlung

- √s' spectrum of the Bhabha events (luminosity spectrum times *s/s'*)



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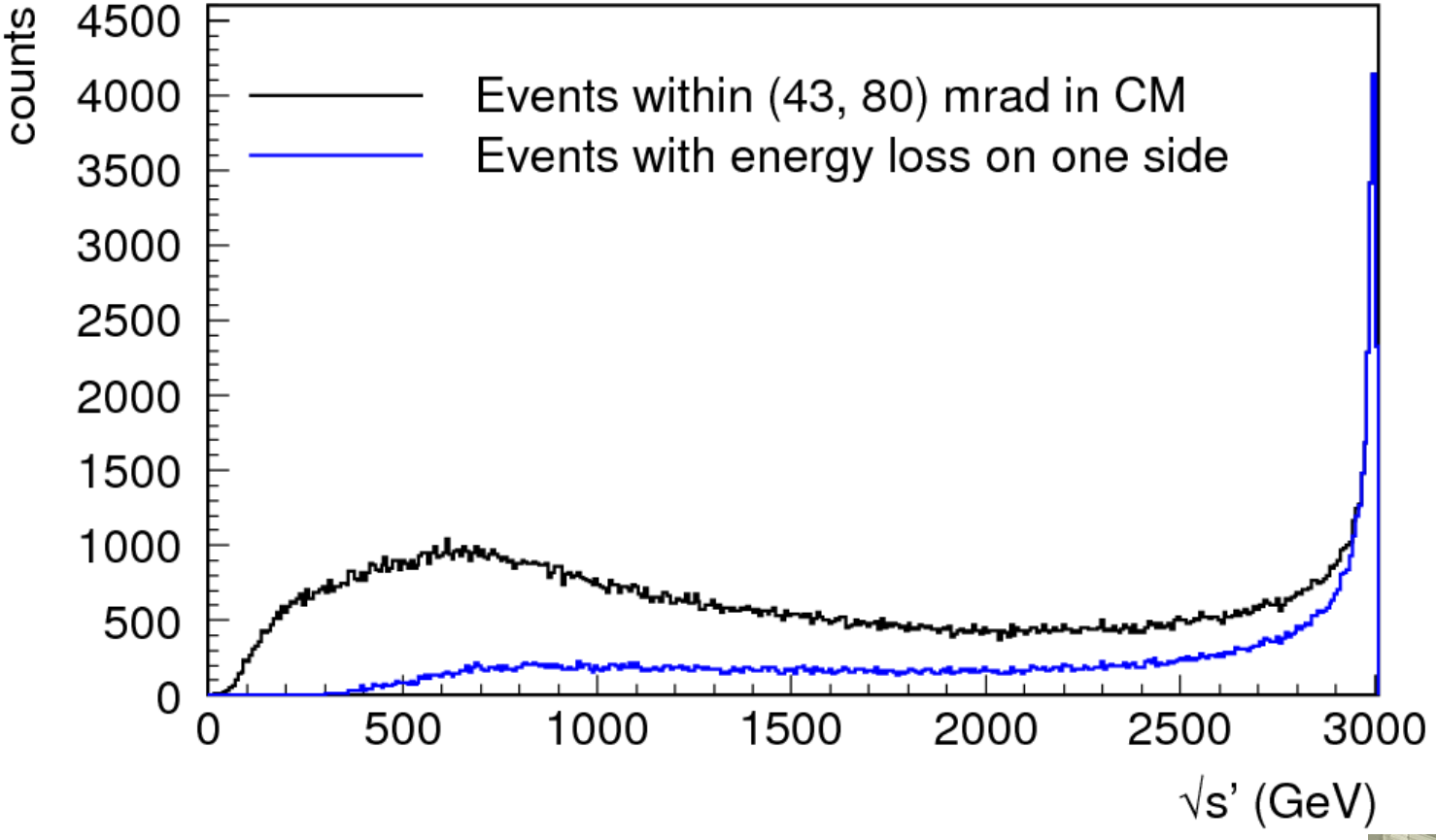
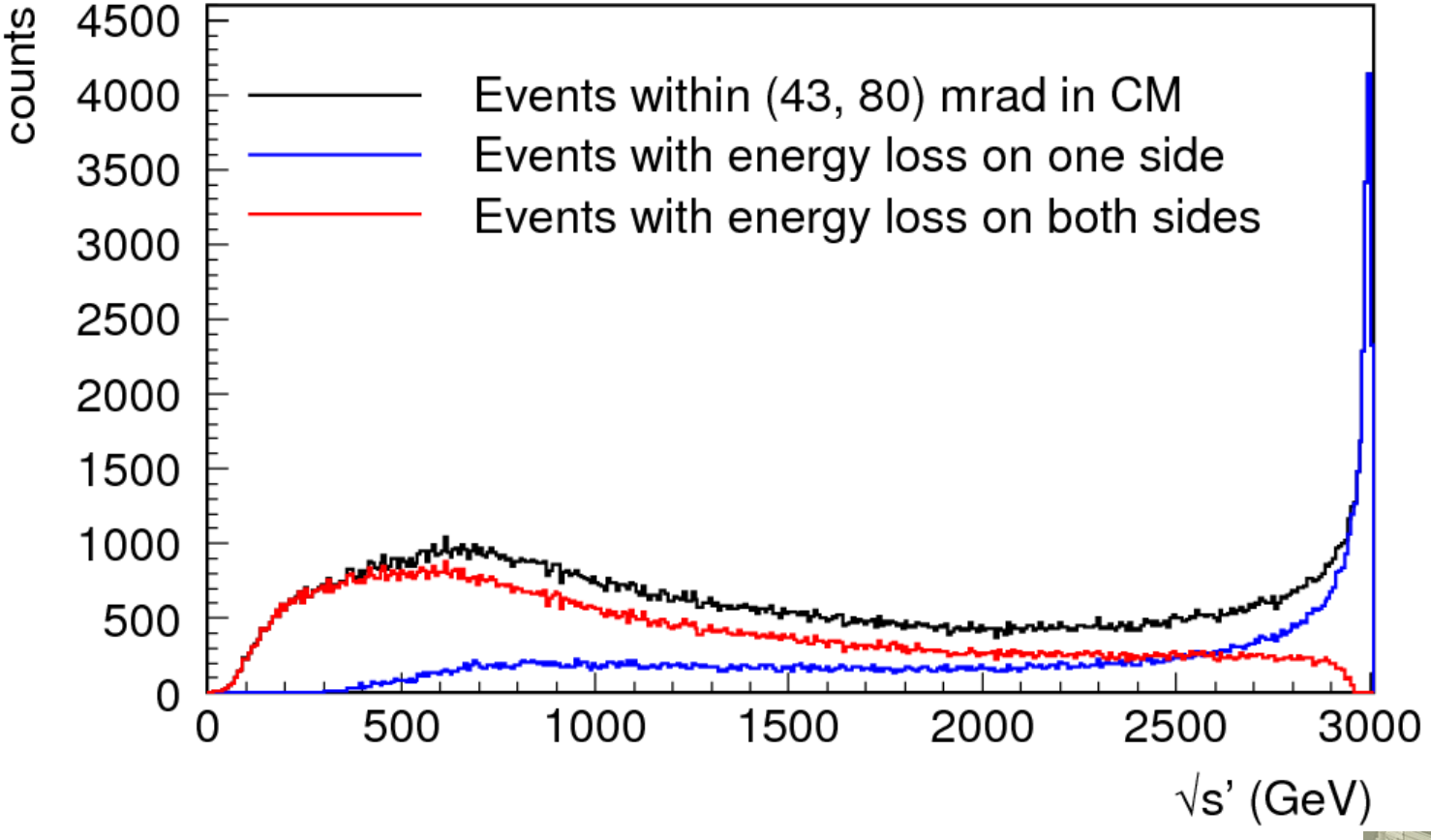


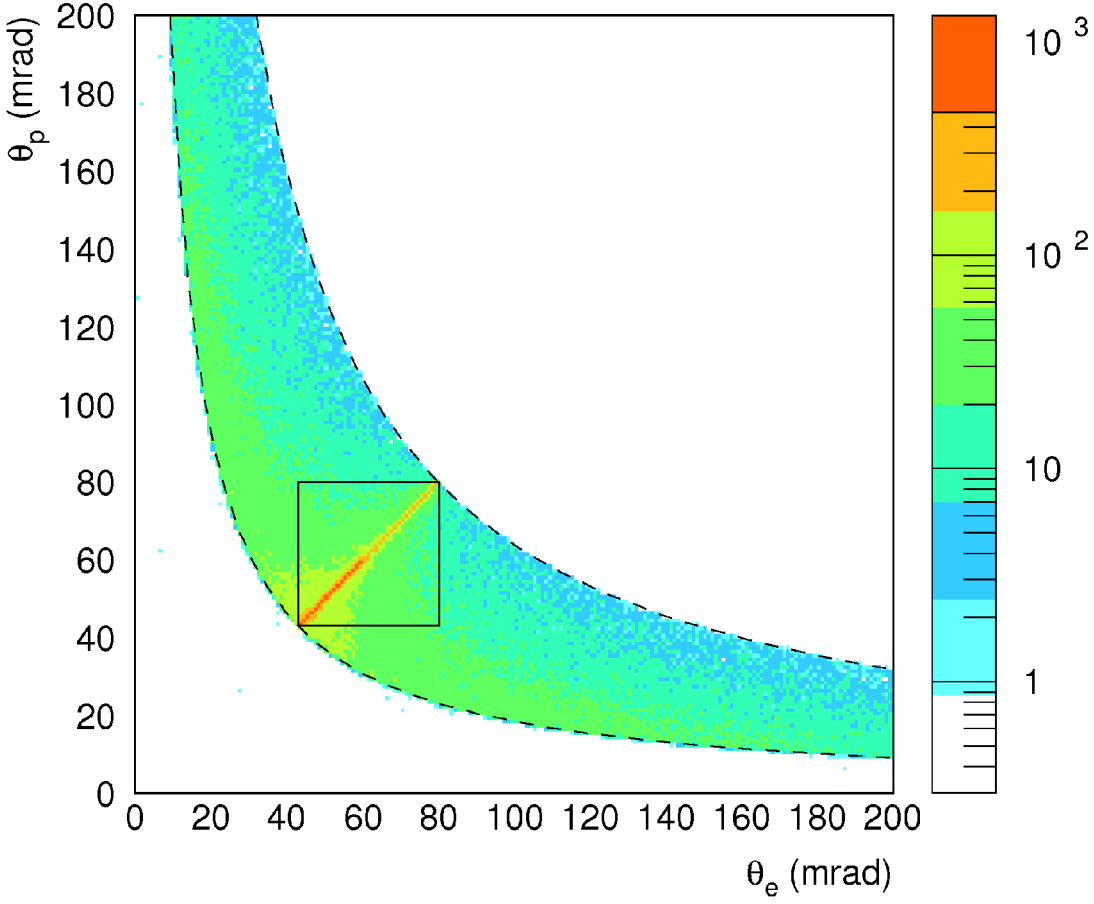
Beamstrahlung

- √s' can not be reconstructed from polar angles only – particle energy reconstruction in LumiCal important!



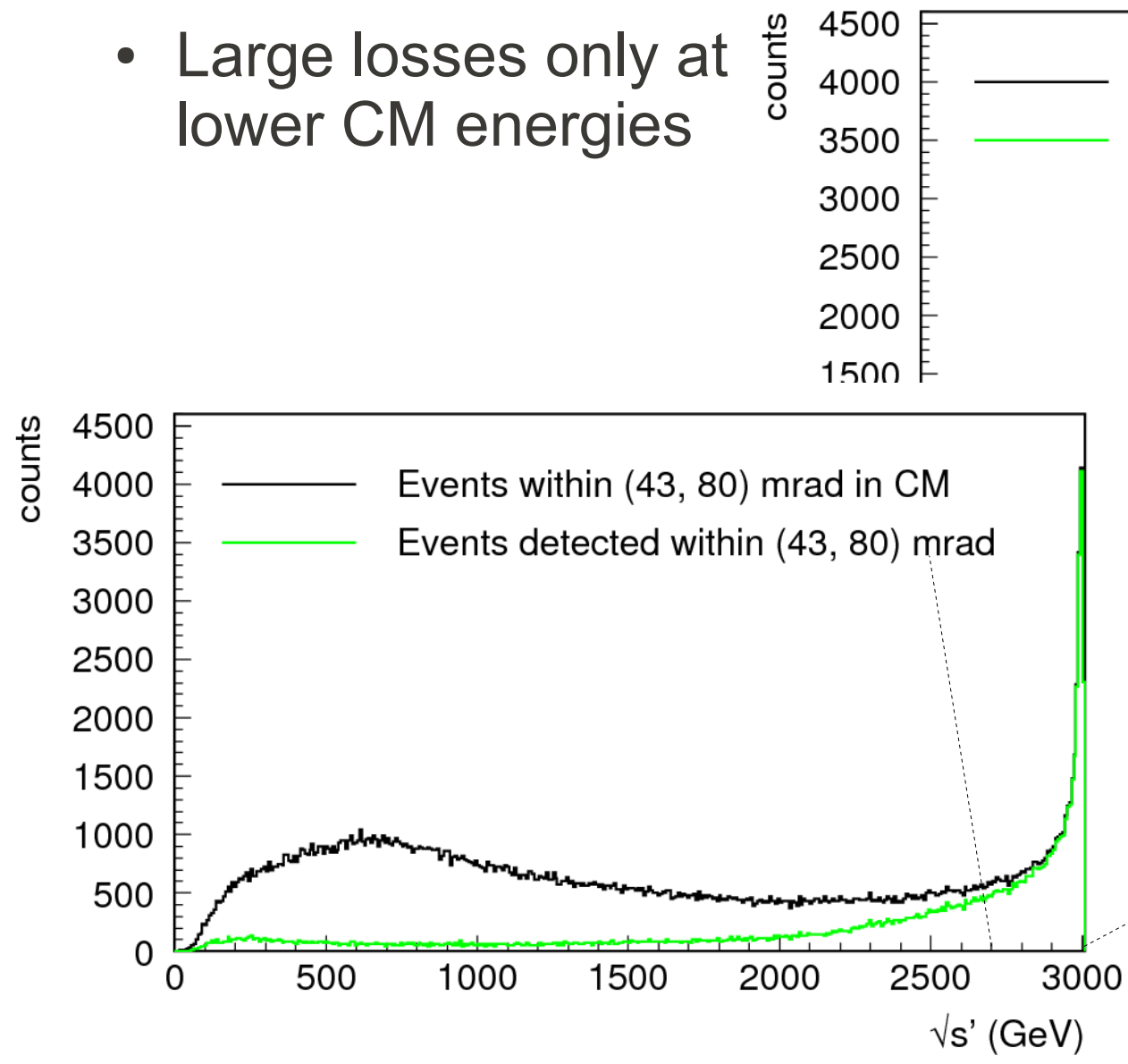
Polar angles

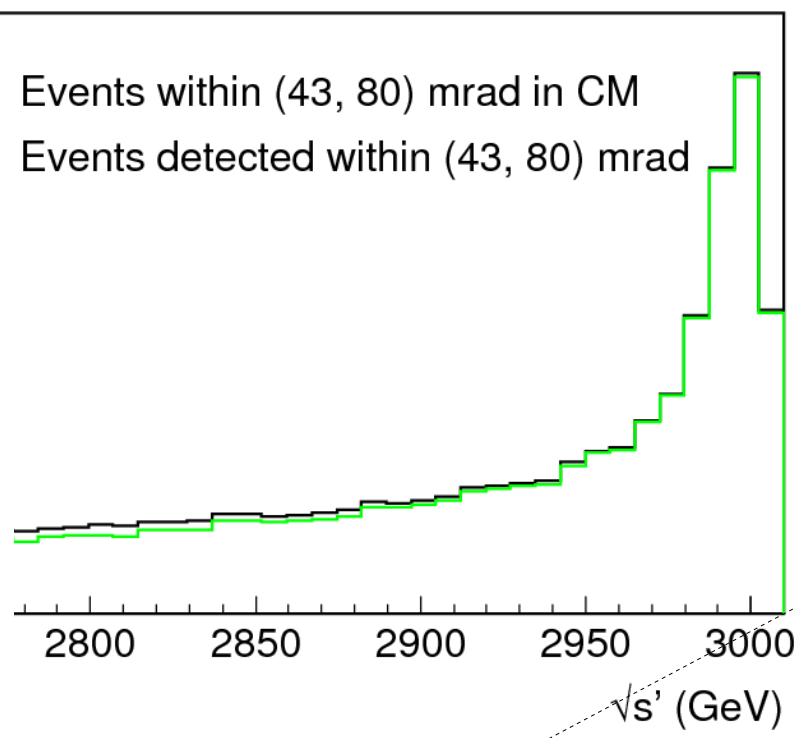
- BHSE 76.4 % (E_{rel} + fiducial volume)
- Needs to be more reliably estimated and corrected
- Energy-differential luminosity essential



Energy differential BHSE

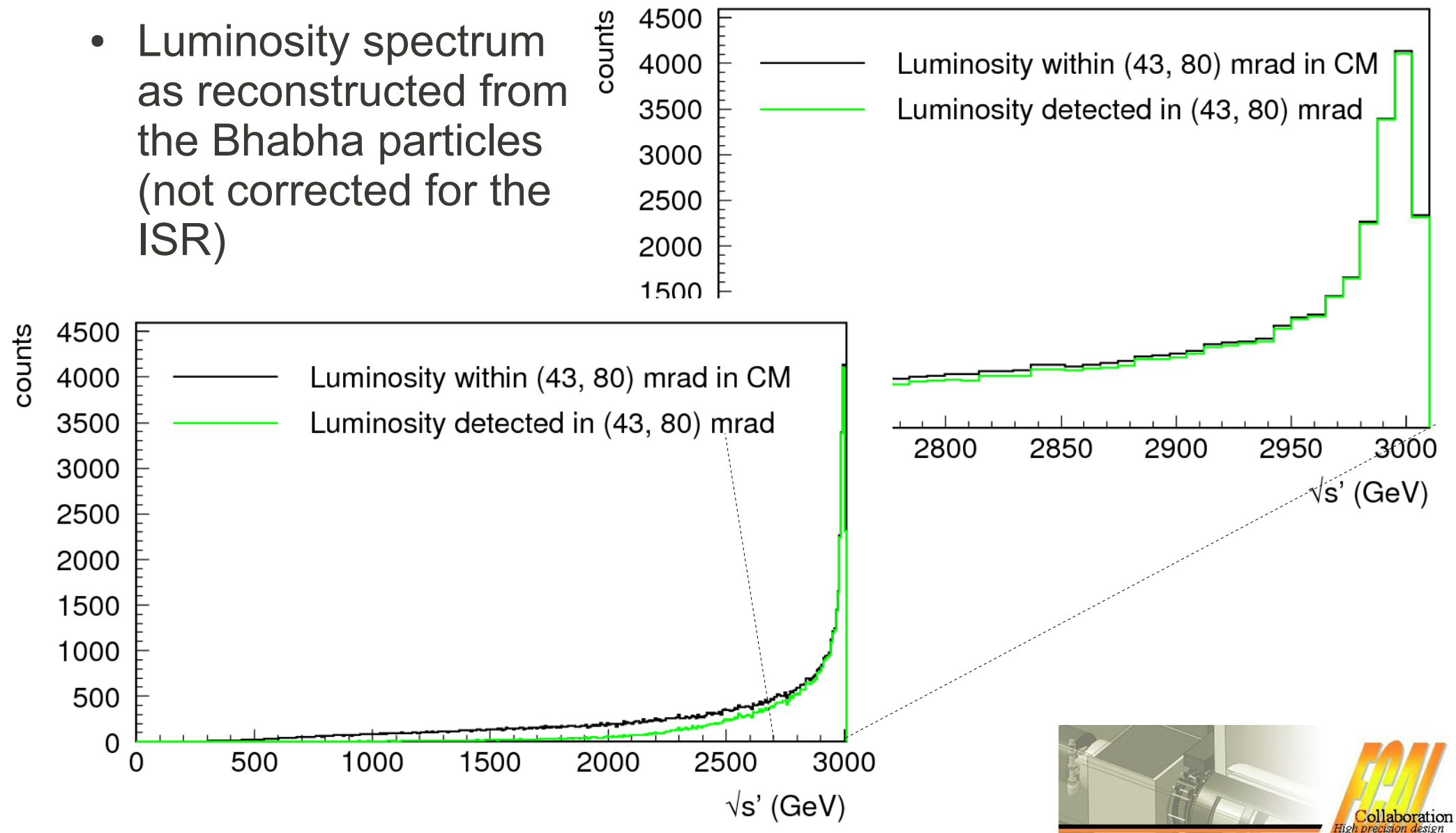
- Large losses only at lower CM energies





Energy differential BHSE

- Luminosity spectrum as reconstructed from the Bhabha particles (not corrected for the ISR)



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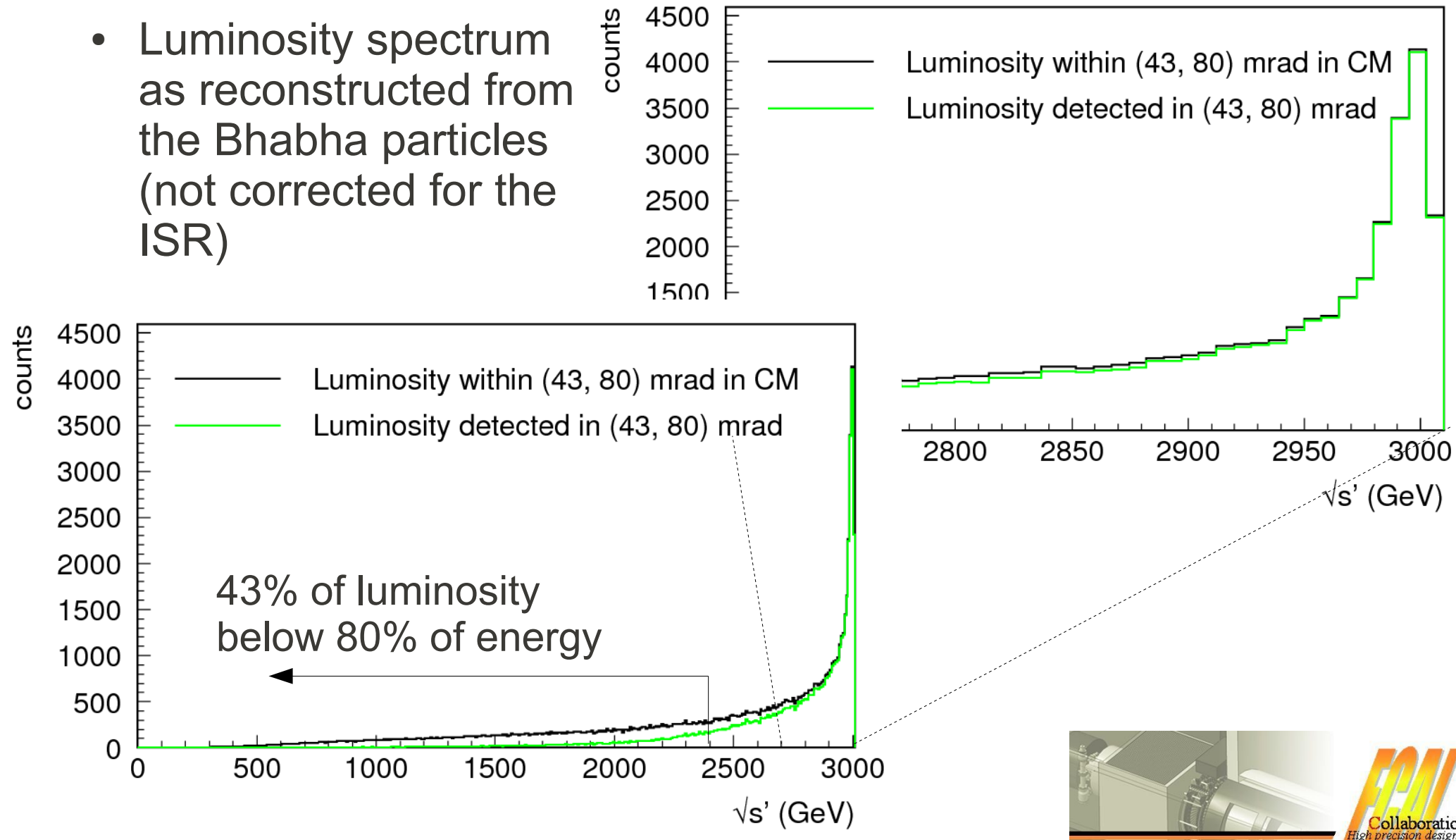
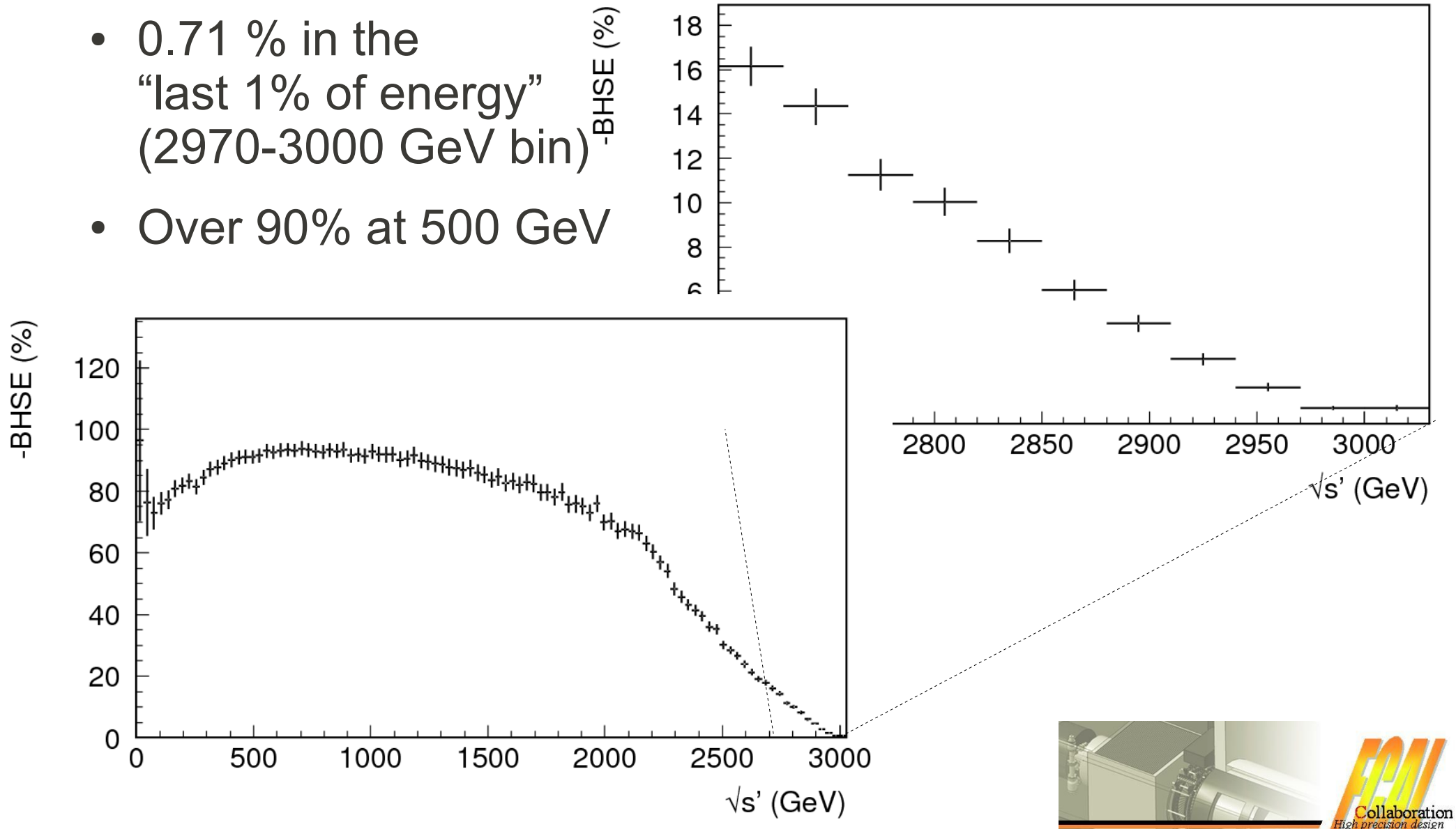
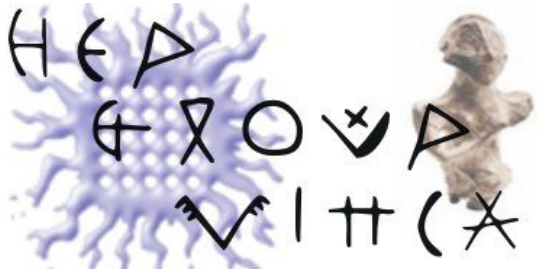


Energy differential BHSE

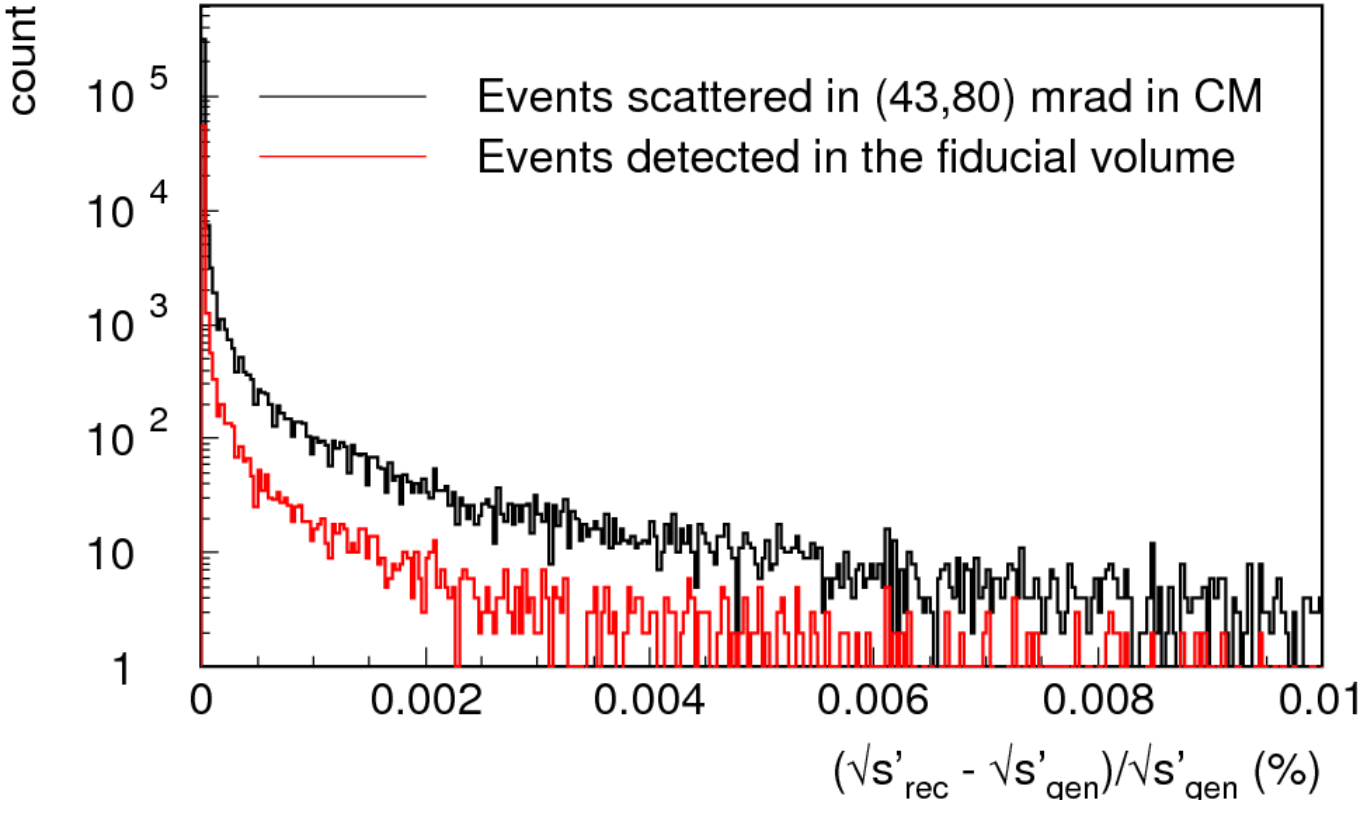
- 0.71 % in the "last 1% of energy" (2970-3000 GeV bin)
- Over 90% at 500 GeV



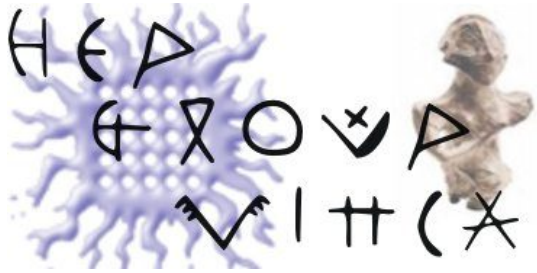
Reconstruction of s'



- $s' = (E_1 + E_2)^2 - (p_1 + p_2)^2 \approx 2E_1E_2(1 - \cos\alpha_{1,2})$
  $= 2E_1E_2(1 + \cos(\varphi_1 - \varphi_2)\sin\theta_1 \sin\theta_2 + \cos\theta_1 \cos\theta_2)$
  $\approx 2E_1E_2(1 + \cos(\theta_1 - \theta_2))$
  (θ_2, φ_2 defined in the mirror-inverted frame)

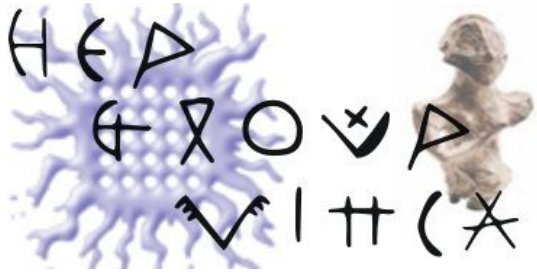


Reconstruction of *s*



- Precise information on $\varphi_{1,2}$ inaccessible to the measurement, but with $\cos(\varphi_1 - \varphi_2) = 1$ the approximation error is negligible
- Influence of θ resolution negligible
- $\sqrt{s}$ uncertainty is of the order of the resolution of the final particle energy (1% - 1.5%, depending on the energy - see talk by **J. Aguilar at TIPP 2011**)
- $\sqrt{s}$ spectrum distortion by the ISR in the Bhabha scattering
- Which level of detail in the description of the luminosity spectrum do we need (energy binning)?

Conclusions



- The luminosity spectrum at CLIC extends down to almost zero CM energy
- The differential luminosity at lower energies difficult to precisely measure because of the high BHSE (and the background spectrum)
- BHSE at energies close to $2E_{beam}$ is rather low
- Energy reconstruction capability of the LumiCal is crucial for the $\sqrt{s}$ reconstruction at CLIC
- Integration of BHWIDE or BHLUMI necessary in order to make Guinea-PIG a precision tool for the analysis of Luminosity measurement at CLIC
- CLIC train structure should be simulated