Effects of CLIC beam dynamics on physics research potential

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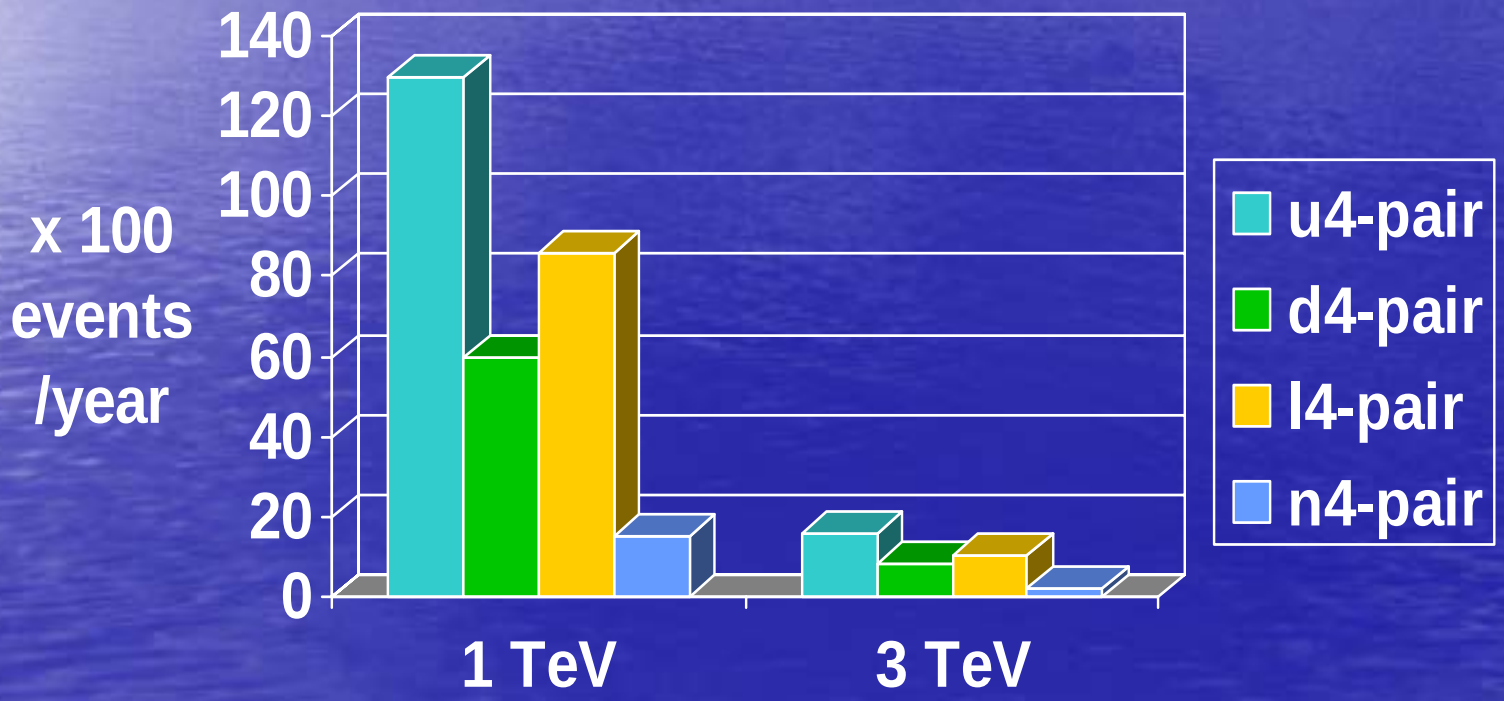
Our contribution to CLIC physics report (CERN-2004-005, p.170-182)

- Production of fourth family quarks (q_4) and leptons (l_4) in e^+e^- and $\gamma\gamma$ collisions, production and decays of fourth family quarkonia (Ψ_4, η_4) [**A. K. Ciftci et al.**] .
- Single production of scalar leptoquarks and resonance production of excited electrons in $e\gamma$ collisions [**O.Cakir et al.**].

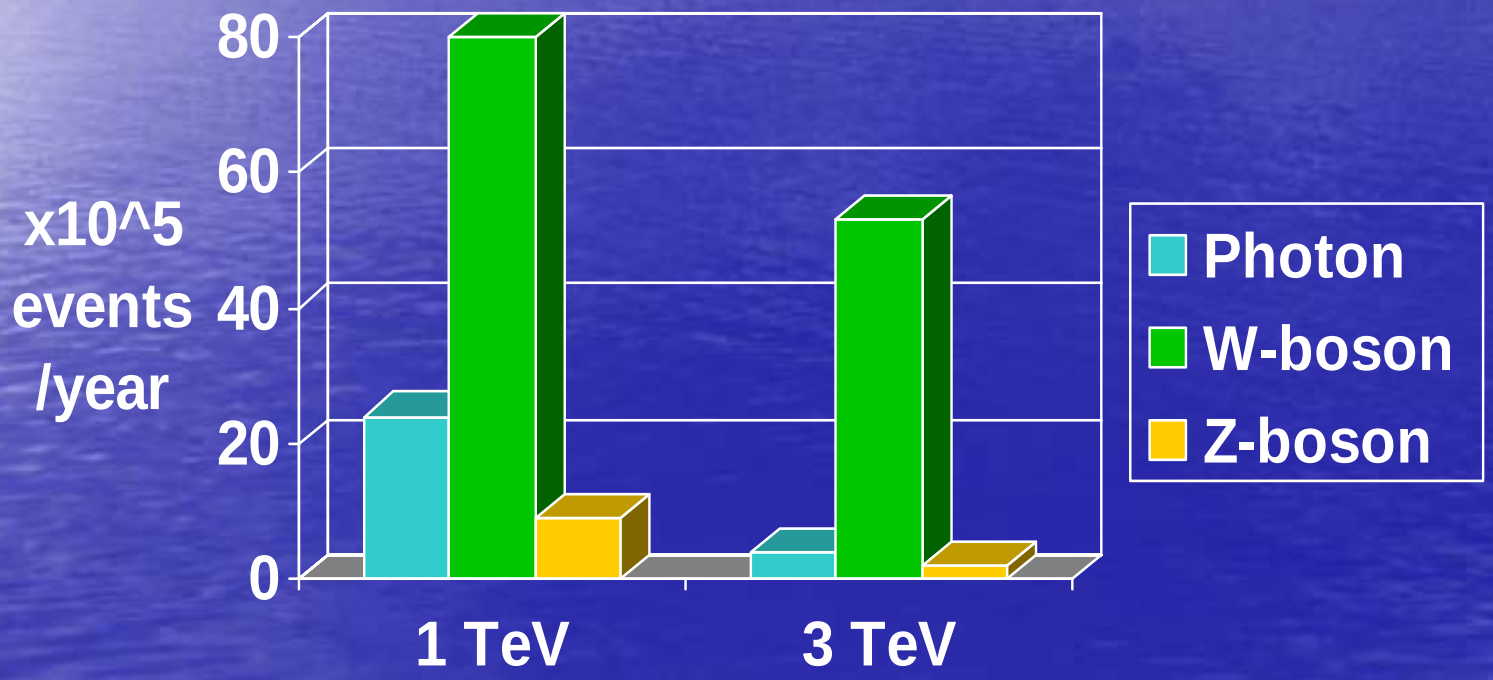
Fourth Family (A. K. Ciftci et al.,)

ee-->f4f4:m4=320 GeV at 1 TeV,
m4=640 GeV at 3 TeV



Excited electrons (O. Cakir et al.)

eγ-->e*-->l V: m*=750 GeV, Λ=m* and f=f'=1



• Combined result: excited electrons can be observed down to the couplings f=f'=0.05 at √s=1 TeV and f=f'=0.1 at √s=3 TeV.

Compact Linear Collider (CLIC) (Basic parameters)

- Center of mass energy, $\sqrt{s}$=0.5, 1, 3 and 5 TeV
- Luminosity (in 1% of energy), L=(1.5, 1.5, 3.2 and 2.4) x 10^{34} $cm^{-2}s^{-1}$
- Collision freq. fcoll=$f_{rep}.k_b$=(200,150,100,50)x154Hz
- Number of particles/bunch, N =(4,4,4,4)x10^9
- Hor. beam size, σ_x=(202,115,60,31)nm
- Vert. beam size, σ_y=(1.2,1.75,0.7,0.78)nm
- Bunch length, σ_z=(35,30,35,25) μm
- Trans. emitt. x-comp., $\gamma\varepsilon_x$=(200,130,68,78)x10^{-8}rad.m
- Trans. emitt. y-comp., $\gamma\varepsilon_y$=(1,2,1,2)x10^{-8} rad.m
- Energy spread, $\Delta E/E$=(0.25,0.7,0.35,0.7)%

Limitations on the parameters from the beam dynamics

- **Luminosity**, $L=H_D N^2 f_{rep} n_b /(4\pi\sigma_x\sigma_y)$ where $\sigma_{x,y}\sim\sqrt{\beta_{x,y}\varepsilon_{x,y}}/\gamma$
  and $Nf_{rep}n_b \sim \eta P$.
  typically transverse emittance $\varepsilon_x >> \varepsilon_y$,
  and β-function $\beta_x >> \beta_y$, $\sigma_x >> \sigma_y$, σ_x=60nm , σ_y =0.7nm for 3 TeV design.

Beam-beam effects:

Beamstrahlung, parameter $\Upsilon=2\hbar\omega_c/3E_0$, for CLIC $<\Upsilon>\sim 8$, the interest $L_1=L(E_{cm} \geq 0.99*E_{cm,0})$,

taking $n_{\gamma/e}$=1.7 and $\delta E/E \approx 20\%$, $L_1 \approx 0.4*L$

Coherent (e^+e^-) pairs from photons, in CLIC $\sim 10^8$ pairs/bunch-crossing--increase backgrounds

Beam delivery system:

due to synchrotron radiation in the bends, quadrupoles and multipoles -- decrease in the luminosity ~1.7 factor

- **Spread in the c.m. energy**,

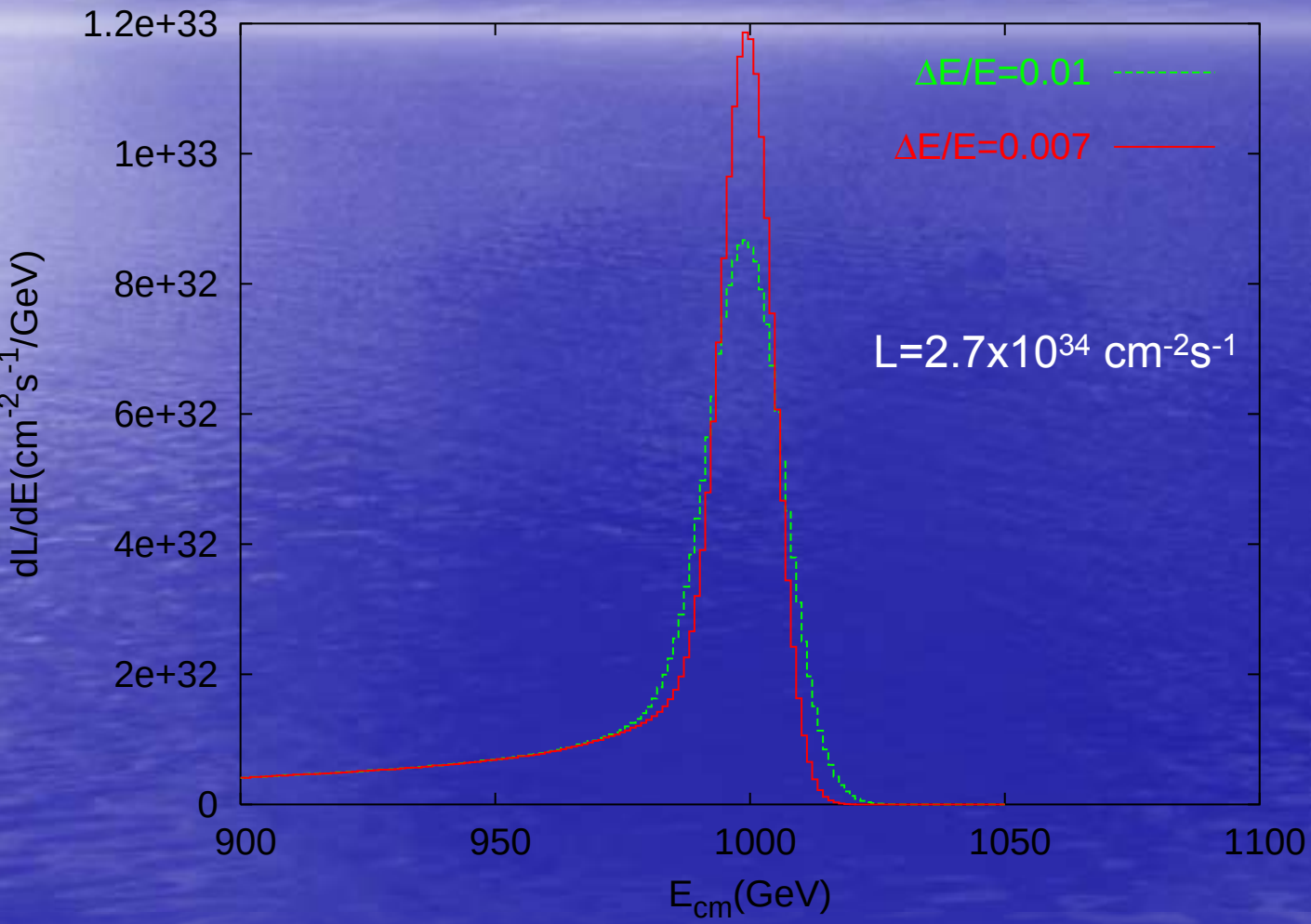
  intrinsic beam energy spread (Gaussian),

  ~0.7%--1%

  ISR and beamstrahlung (long tail down to large energy losses).

- Another issue is due to error in the calibration of the beam energy

Luminosity spectrum obtained from GUINEA-PIG for two values of beam energy spread ΔE/E



Possible options for physics studies: sample resonances

- $e^+e^- \rightarrow Z'$ (new neutral vector boson)
- $e^-e^- \rightarrow L^{--}$ (scalar and vector bileptons)
- $e^-\gamma \rightarrow e^*$ (excited electron)
- $\gamma\gamma \rightarrow Z$ (anomalous TGC)

As an example Z' Production

- If the Z' boson decays only into the SM particles, $\Gamma'/m_{Z'} \sim \Gamma/m_Z = 2.49/91.18 = 2.7\%$ taking the current lower limit for $m_{Z'} > 690$ GeV we obtain $\Gamma' > 18$ GeV.
- $Z' \rightarrow t\ \bar{t}$ accessibility
- Less beamstrahlung effect, but large beam energy spread effect.

L^{--} production

- Scalar and vector bilepton production via process $e^-e^- \rightarrow L^{--} \rightarrow l^- l^-$
- If the ratio $\Gamma/m<1\%$ beam energy spread can effect its observation directly.
- Implementation of the vertices into an event generator such as COMPHEP, PYTHIA, etc.
- Luminosity spectrum for ee by using GUINEA-PIG
- Fast simulation of signal and background using SIMDET
- Search for the effects of parameter limitations from the beam dynamics

Conclusion

- We need to simulate the beam-beam interaction using GUINEA-PIG to get luminosity spectrum depending on the energy.
- Interface with the event generators (PYTHIA) and detector simulation (SIMDET or GEANT4) using CALYPSO and HADES.
- Resonances are being studied to see the effects of the parameter limitations from the beam dynamics.