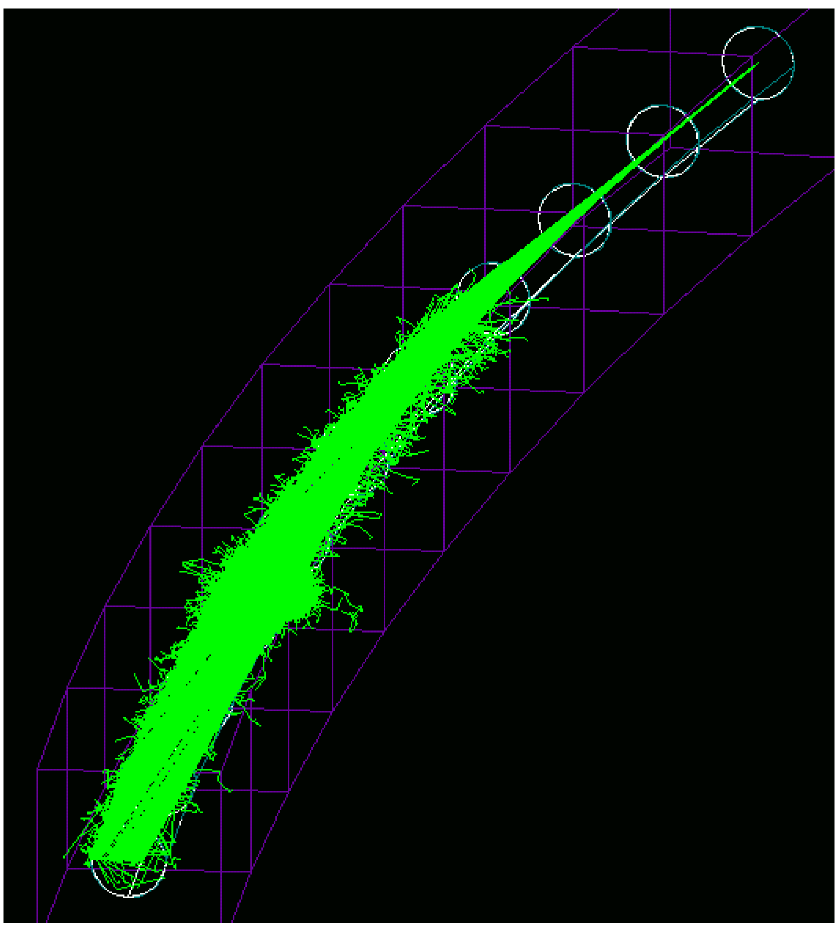
Laserwire Simulation studies for the LC

Grahame A. Blair
Royal Holloway, Univ. of London/DESY
email: g.blair@rhul.ac.uk

- Measuring the emittance in a realistic BDS
- `BDSIM`: a Geant4 Beam Delivery System Simulation Program
- Energy Spectrum of Comptons
- Full simulation of Laserwire with `BDSIM`.
- Measurement Issues
- Extracting the Signal
- Backgrounds from Halo.
- Conclusions + Future Work

BDSIM - a Geant4 BDS Simulation Program

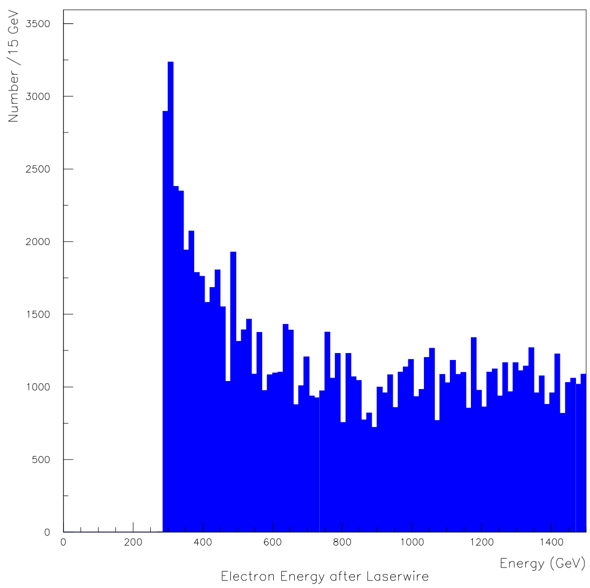
- Project grew out of desire to determine physics backgrounds arising from collimation etc. in the beam delivery system (BDS).
- All usual G4 material interactions are included.
- Synchrotron radiation is included.
- Compton Scattering "Engine" included for scattering off thermal photons and **also Laserwire**.
- Multipole fields up to and including decapoles are incorporated.

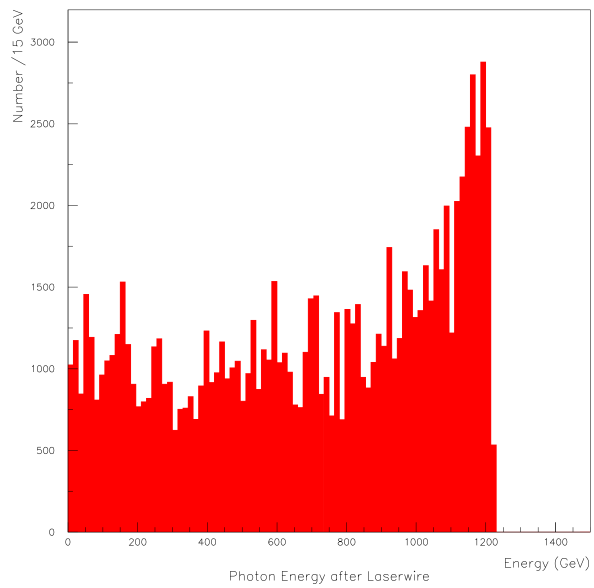


Energy Spectrum of Comptons in CLIC

CLIC Note 509.

Electron and Photon Compton spectra generated using BDSIM:





Requiring a few thousand comptons per bunch sets the minimum pulsed power of laser beam to $\sim$ few $\times$ 10 MW.

e^- Energy (GeV)	Laser λ (nm)	Pulsed Laser Power (MW)	XSec (10^{-25}cm^2)	N_C
250	1064	100	2.73	19200
250	532	50	1.98	3510
250	355	25	1.60	950
250	266	10	1.36	242
1500	1064	100	1.06	7450
1500	532	50	0.668	1186
1500	355	25	0.500	297
1500	266	10	0.404	72

A Full Simulation

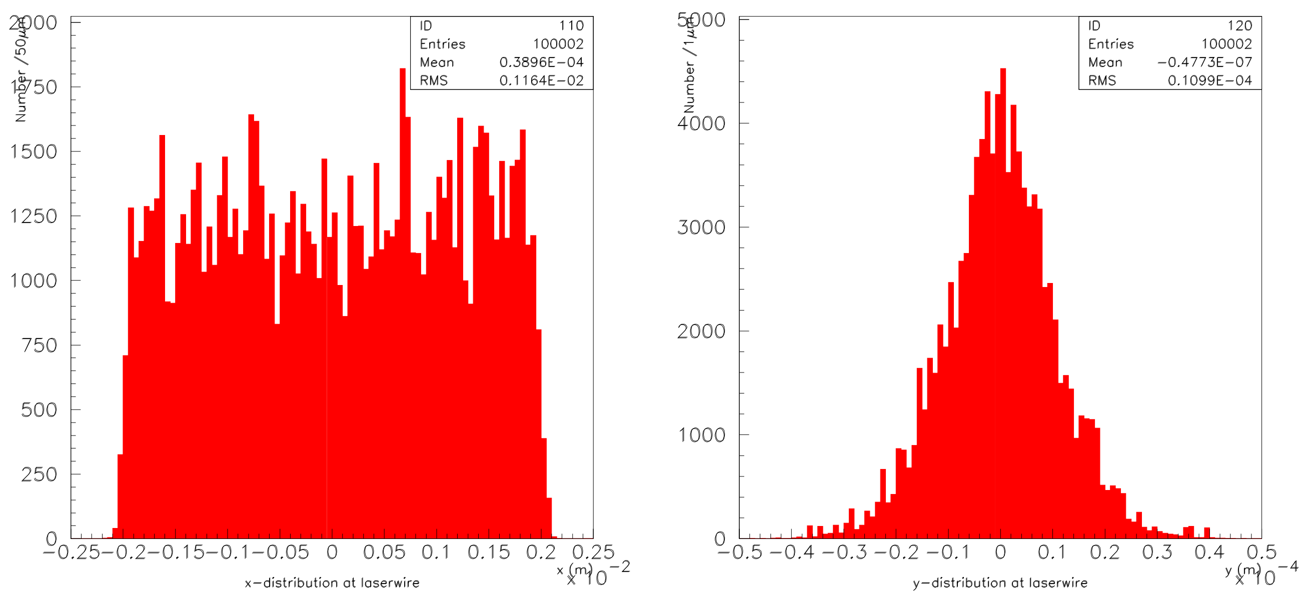
Using CLIC (1.5 TeV) BDS; long option (6186 m).

Insert a laserwire just after the energy absorber (s=1146 m)

Observe the energy downstream:

BDSIM used to:

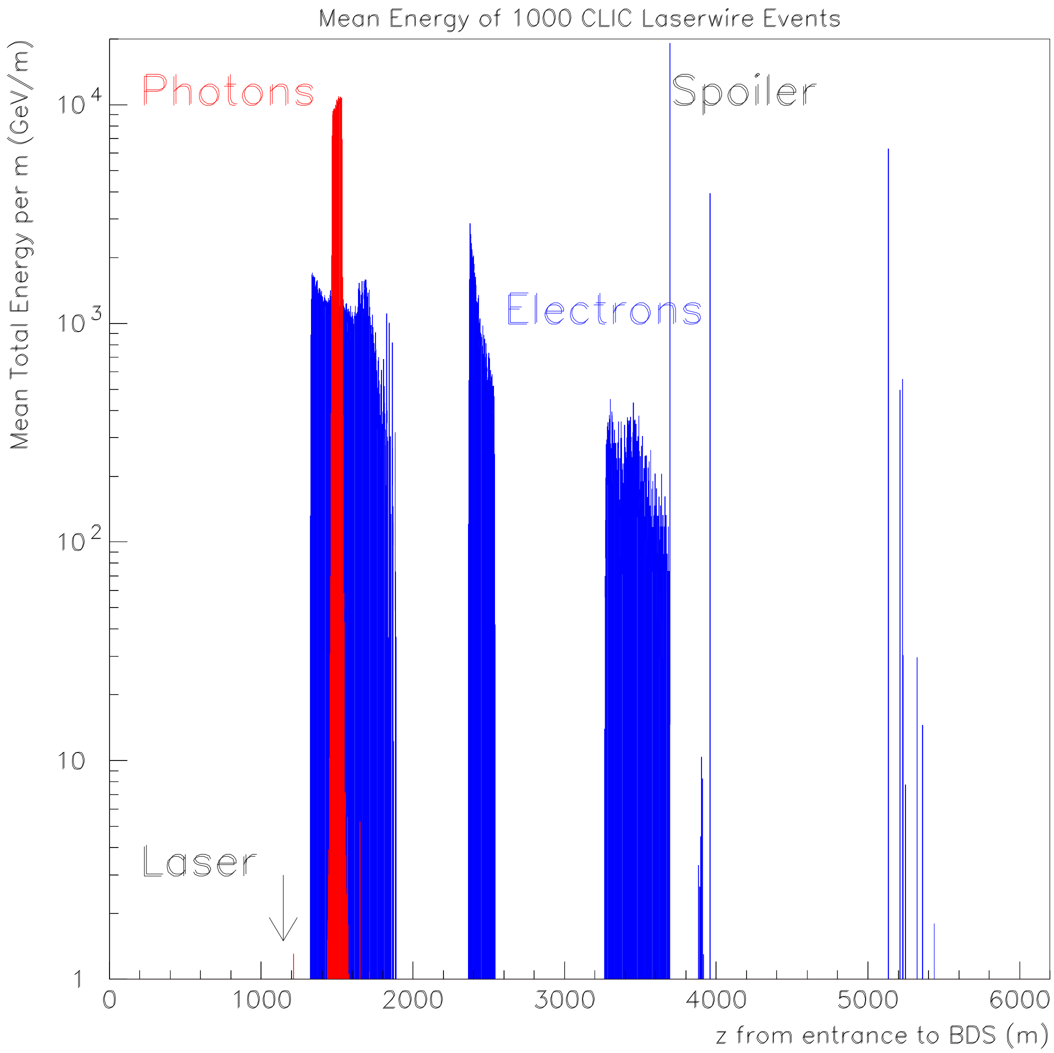
- Track electrons from exit of LINAC to laserwire
- Perform Compton scatter on these electrons at laserwire position
- Track the resulting electron and photon Compton
- Determine where the energy is deposited along the BDS.



⟹ A point of high dispersion - can we measure the energy spread?

The Tracked Energy Deposits

Assuming 1000 Compton Scatters for one laser pulse:



$\Longrightarrow$ Can we just use the scattered particles plus beam-loss monitors?

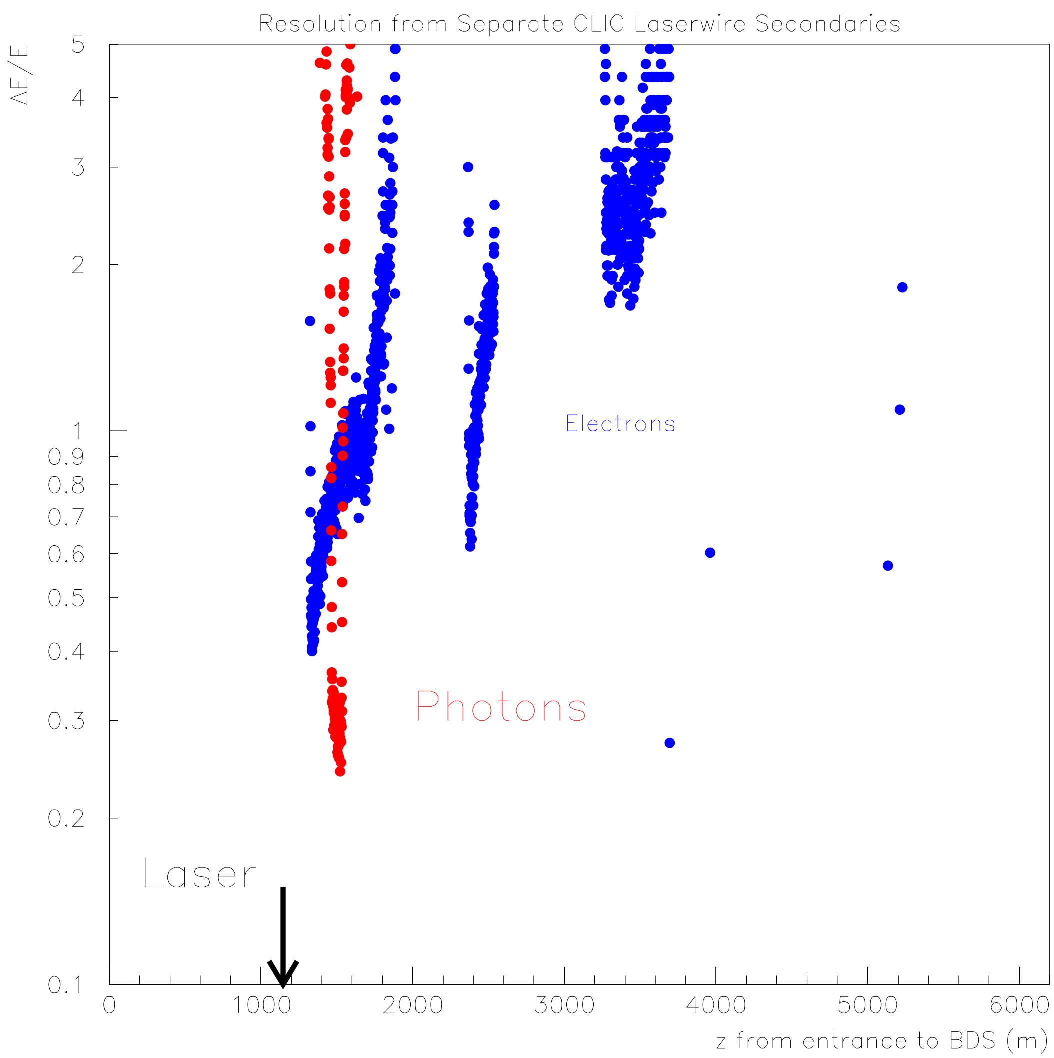
Beware the Fluctuations

The goal is to produce a **fast** and **accurate** measurement $\Longrightarrow$ Statistics are important.

Measure the energy at a given point in the BDS and use it as a measure of the beam profile intensity.

Generated 100 separate laserwire shots, each of 1000 Comptons.

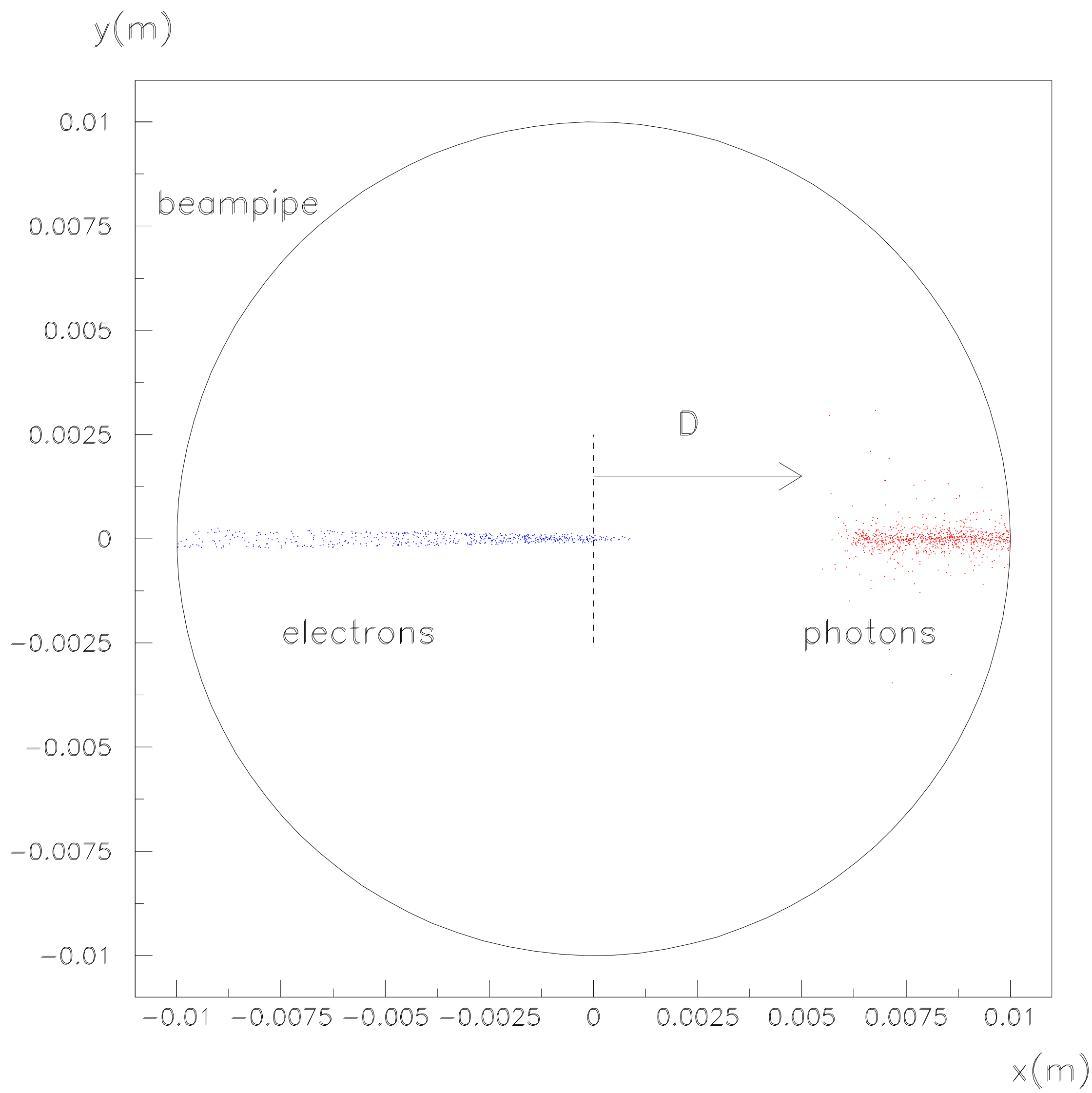
Determine the RMS variation along the BDS at each z-position:



$\Longrightarrow$ **At best** a 25% measurement **using photons**. Electrons are harder because they are more spread out by magnetic fields.

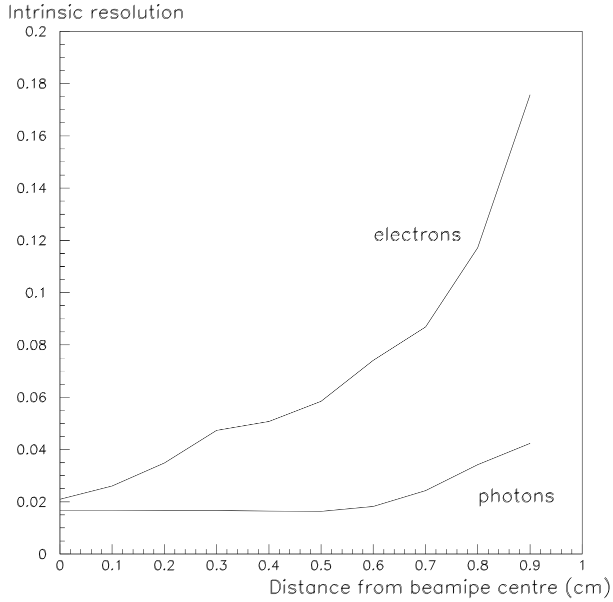
Downstream Picture

Consider a location 325 m downstream of the laserwire, which is also 16 m downstream of the energy collimator:

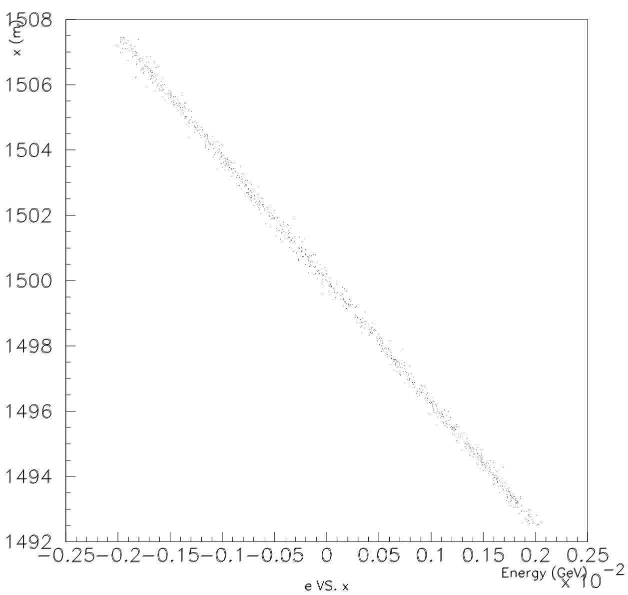


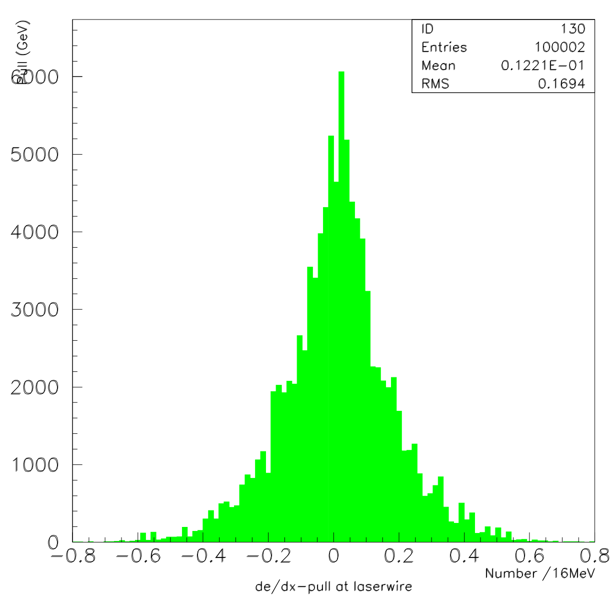
and determine the intrinsic resolution (before calorimeter smearing) for electrons and positrons $\Longrightarrow$

Potential of the Laserwire



If we used the laserwire then as an energy spectrometer:





$\Longrightarrow$ Intrinsic resolution $\sim$ 170 MeV. Matching this to the spotsize measurement requires endpoints of x-distribution to be determined to within 45 μm. $\Longrightarrow$ Should be possible to obtain energy-spread measurement to $\sim 10^{-4}$

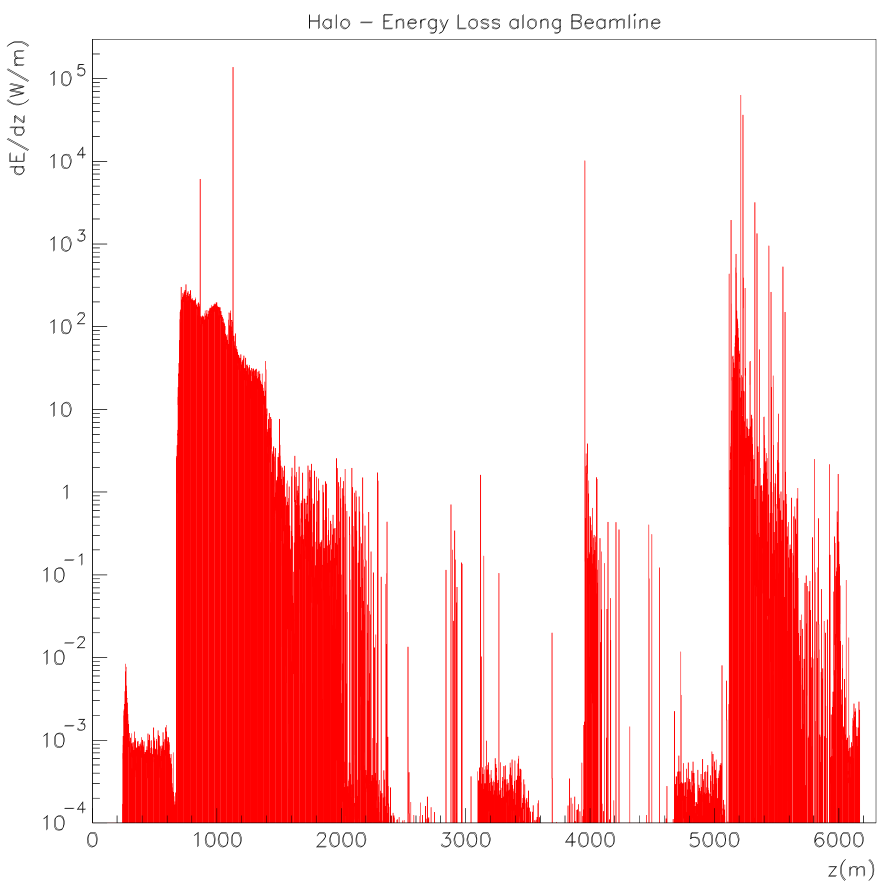
Excellent potential.... **BUT ...**

Beware the Halo

Assuming a halo for CLIC with uniform distribution of electrons leaving the linac with widths:

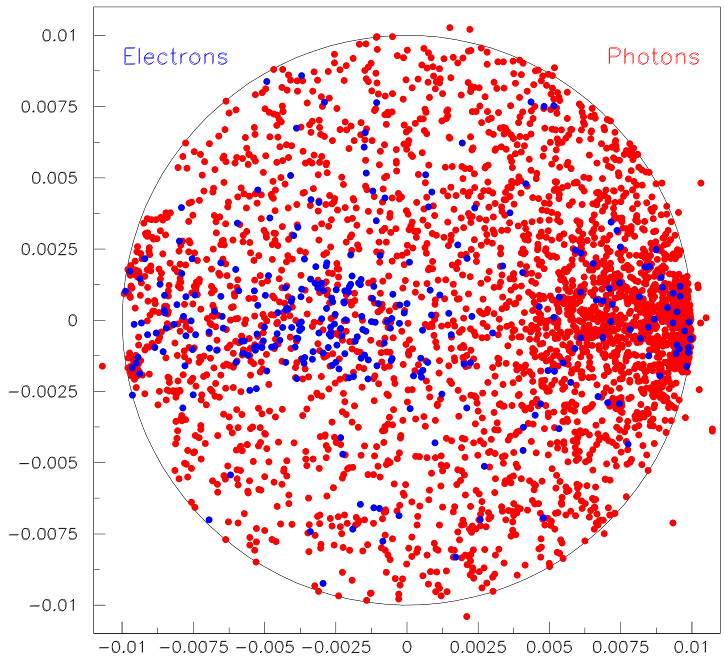
Bunch parameter	Range
x	10.× 1.25 $\times \sigma_x$
y	70.× 1.25 $\times \sigma_y$
x′	10.× 1.25 $\times \sigma_x$
y′	70.× 1.25 $\times \sigma_y$
E	(0.98 - 1.02)$\times E_0$

The energy loss along the entire beam delivery system, including spoilers and absorbers gives, for 50k electrons:

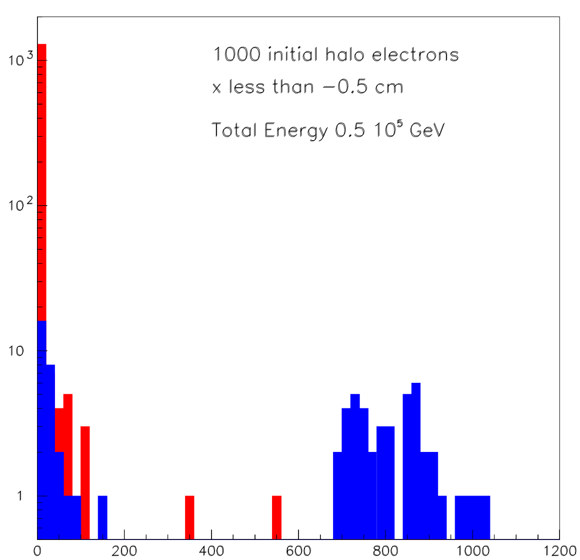


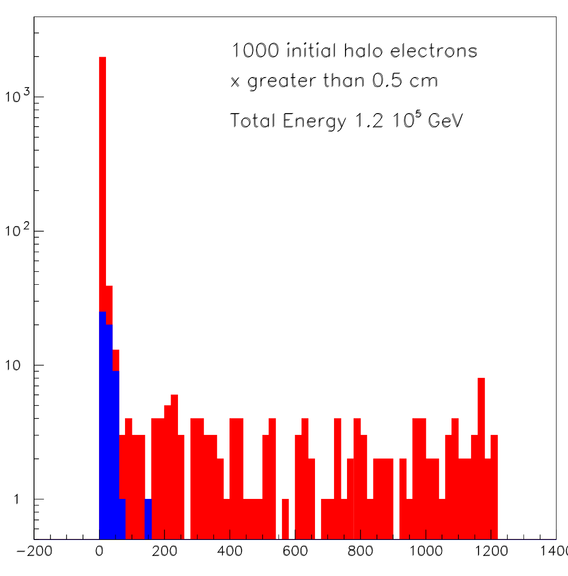
Downstream Picture - Halo

A quick run of 1000 halo events ($\sim 1.6 \cdot 10^{-9}$ of the halo of one pulse train) gives:



With energy distributions:





For photons: signal $\sim 7 \cdot 10^{5}$ GeV compared to halo $\sim 7 \cdot 10^{13}$ GeV.

Conclusions + Future Work

Conclusions

- The potential of laserwires for excellent measurements is clear.
- The problem of backgrounds is most probably very large.
- Need to choose a very low background location with high β-function.
- A first look at full-simulation of a laserwire in a collimation region looks very difficult.
- **The position and layout of laserwire should thus be integral to the design of the BDS from the beginning.**

Future Work

- Continue to optimise layout of laserwire system in existing BDS designs.
- Explore the possibility of dedicated laserwire diagnostics sections that are not located in collimation regions.
- Investigate realistic detectors for extracting the signal.

Summary

Much progress has now been made through full simulation.

The need to design the diagnostics integrally into the BDS is becoming very apparent.