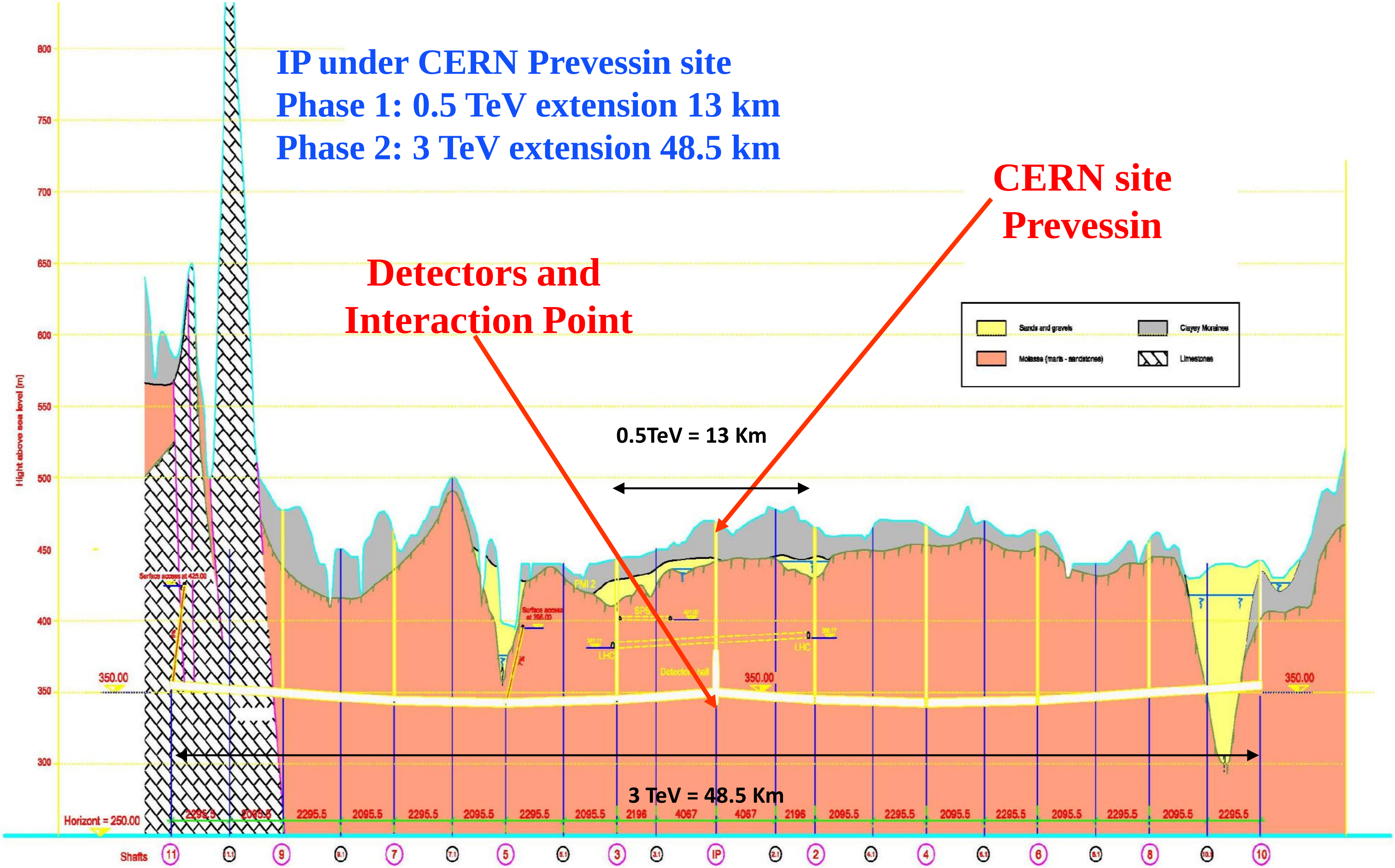
Reserve

CLIC Main Parameters

http://cdsweb.cern.ch/record/1132079?ln=fr http://clic-meeting.web.cern.ch/clic-meeting/clictable2007.html

Center-of-mass energy	CLIC 500 G		CLIC 3 TeV	
Beam parameters	Conservative	Nominal	Conservative	Nominal
Accelerating structure	502		G	
Total (Peak 1%) luminosity	$0.9(0.6)\cdot10^{34}$	$2.3(1.4)\cdot10^{34}$	$1.5(0.73)\cdot10^{34}$	$5.9(2.0)\cdot10^{34}$
Repetition rate (Hz)	50			
Loaded accel. gradient MV/m	80		100	
Main linac RF frequency GHz	12			
Bunch charge 10^9	6.8		3.72	
Bunch separation (ns)	0.5			
Beam pulse duration (ns)	177		156	
Beam power/beam (MWatts)	4.9		14	
Hor./vert. norm. emitt ($10^{-6}/10^{-9}$)	3/40	2.4/25	2.4/20	0.66/20
Hor/Vert FF focusing (mm)	10/0.4	8 / 0.1	8 / 0.3	4 / 0.07
Hor./vert. IP beam size (nm)	248 / 5.7	202 / 2.3	83 / 2.0	40 / 1.0
Hadronic events/crossing at IP	0.07	0.19	0.57	2.7
Coherent pairs at IP	10	100	$5\ 10^7$	$3.8\ 10^8$
BDS length (km)	1.87		2.75	
Total site length km	13.0		48.3	
Wall plug to beam transfer eff	7.5%		6.8%	
Total power consumption MW	129.4		415	

Example Site at CERN



Detector Reserve

(S)LHC, ILC, CLIC reach

	LHC 100 fb^{-1}	ILC 800 GeV 500 fb^{-1}	SLHC 1000 fb^{-1}	CLIC 3 TeV 1000 fb^{-1}
Squarks [TeV]	2.5	0.4	3	1.5
Sleptons [TeV]	0.34	0.4		1.5
New gauge boson Z′ [TeV]	5	8	6	22
Excited quark q* [TeV]	6.5	0.8	7.5	3
Excited lepton l* [TeV]	3.4	0.8		3
Two extra space dimensions [TeV]	9	5–8.5	12	20-35
Strong $W_L W_L$ scattering	2σ	-	4σ	70σ
Triple-gauge Coupling (95%)	.0014	0.0004	0.0006	0.00013

Gian Giudice CLIC09

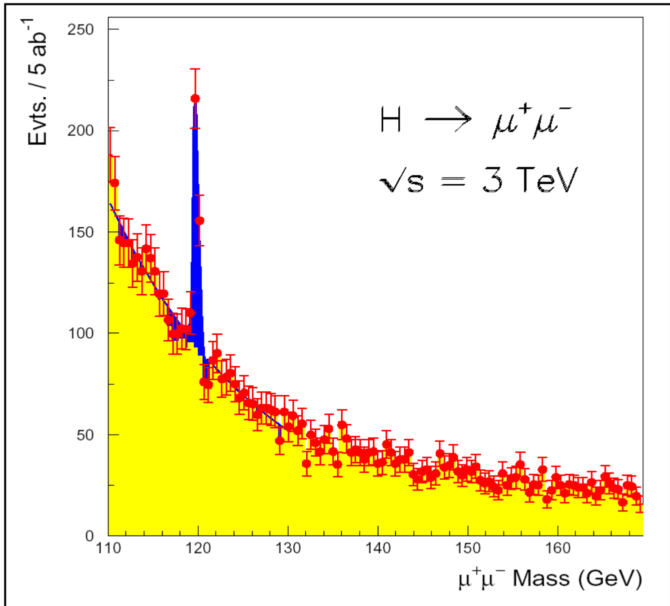
CLIC Physics up to 3 TeV

What can CLIC provide in the 0.5-3 TeV range?
In a nutshell…

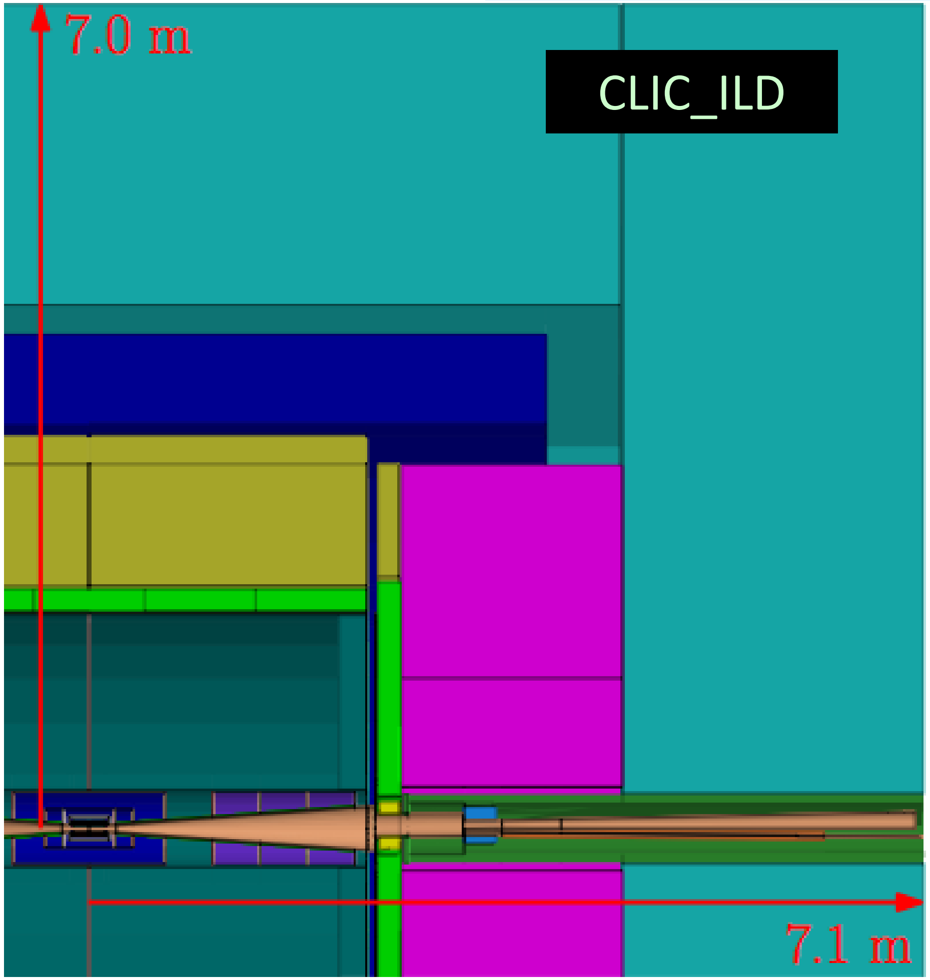
Higgs physics:
•Complete study of the light standard-model Higgs boson, including rare decay modes (rates factor ~5 higher at 3 TeV than at 500 GeV)
 •Higgs coupling to leptons
 •Study of triple Higgs coupling using double Higgs production
•Study of heavy Higgs bosons (supersymmetry models)

Supersymmetry:
•Extensive reach to measure SUSY particles

And in addition:
•Probe for theories of extra dimensions
•New heavy gauge bosons (e.g. Z’)
•Excited quarks or leptons



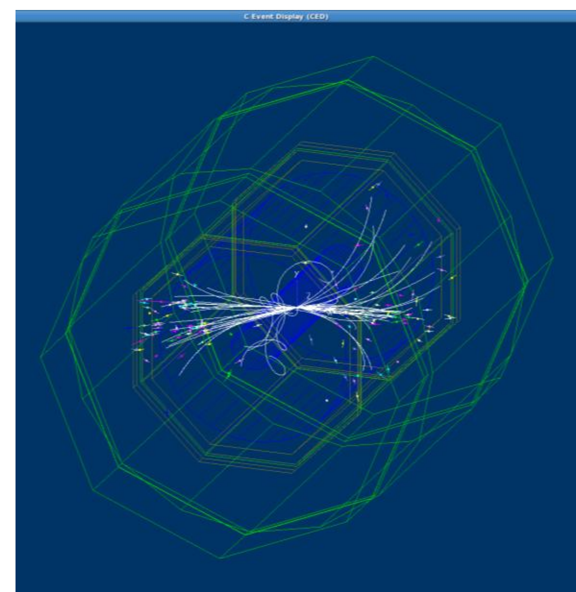
ILD concept adapted to CLIC



Changes to the ILD detector:

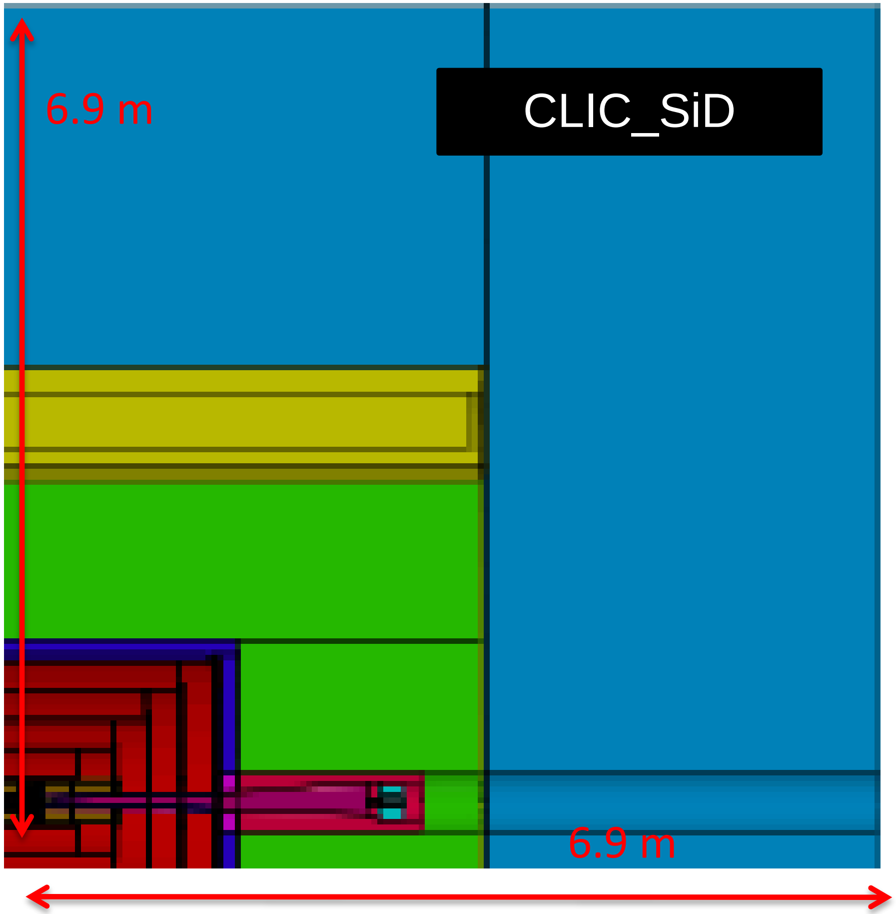
- 20 mrad crossing angle
- Vertex Detector to ~30 mm inner radius, due to Beam-Beam Background
- HCAL barrel with 77 layers of 1 cm tungsten
- HCAL endcap with 70 layers of 2 cm steel plates
- Forward (FCAL) region adaptations

Fully implemented in Mokka/Marlin



Andre Sailer
Berlin Humboldt /CERN

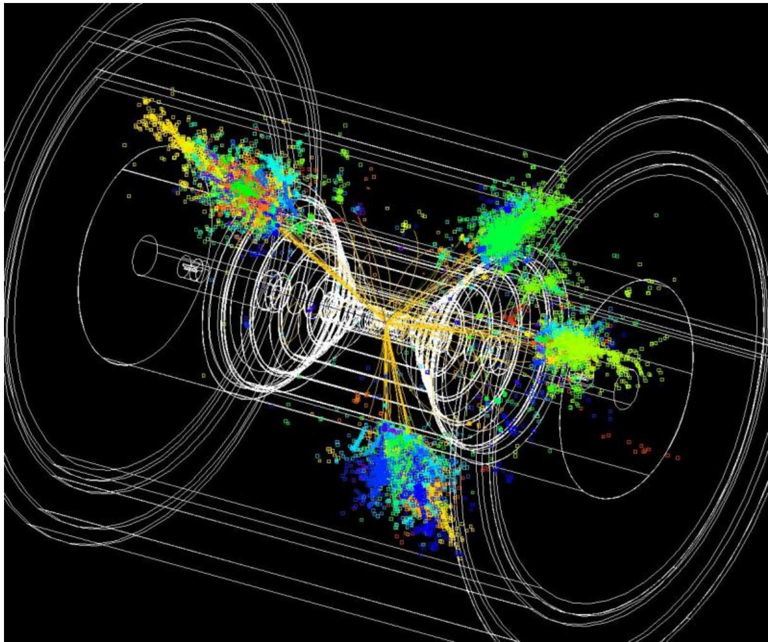
SiD concept adapted to CLIC



Changes to the SiD detector:

- 20 mrad crossing angle
- Vertex Detector to ~30 mm inner radius, due to Beam-Beam Background
- HCAL barrel with 77 layers of 1 cm tungsten
- HCAL endcap with 70 layers of 2 cm steel
- Inner bore of cryostat moved to 2.9 m radius
- Forward (FCAL) region adaptations

Fully implemented in SiD SLiC software



Christian Grefe
Bonn Univ. / CERN

Jet Energy Resolution and PFA

- Is an ILD-sized detector based on PFA suitable for CLIC ?
- Defined modified ILD+ model:
  - B = 4.0 T (ILD = 3.5 T)
  - HCAL = 8 Λ_I (ILD = 6 Λ_I)
- Jet energy resolution
  - using unmodified algorithm

PFA

E_{JET}	$\sigma_E/E = \alpha/\sqrt{E_{jj}}$ $\lvert\cos\theta\rvert<0.7$	σ_E/E_j
45 GeV	25.2 %	3.7 %
100 GeV	28.7 %	2.9 %
180 GeV	37.5 %	2.8 %
250 GeV	44.7 %	2.8 %
375 GeV	71.7 %	3.2 %
500 GeV	78.0 %	3.5 %

Mark Thomson
Cambridge

- Meet "LC jet energy resolution goal [~3.5%]" for 500 GeV jets

Beam-Induced Background and Time–Stamping

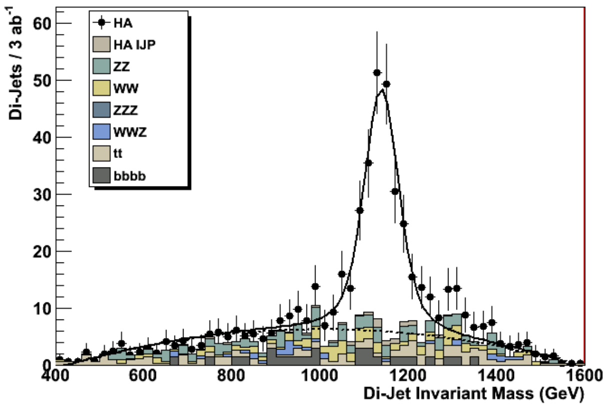
About 3 γγ=> hadron events per bunch crossing

- energy goes mostly in the forward region

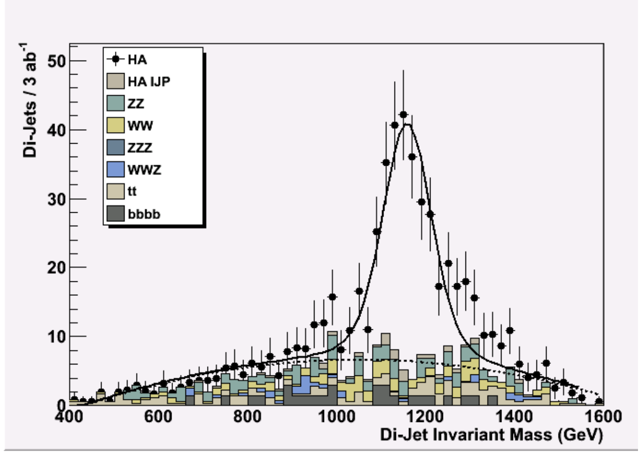
Simulation example of heavy Higgs doublet H^0A^0 at ~1.1 TeV mass (supersymmetry K' point)

$e^+e^- \rightarrow H^0A^0 \rightarrow bbbb$

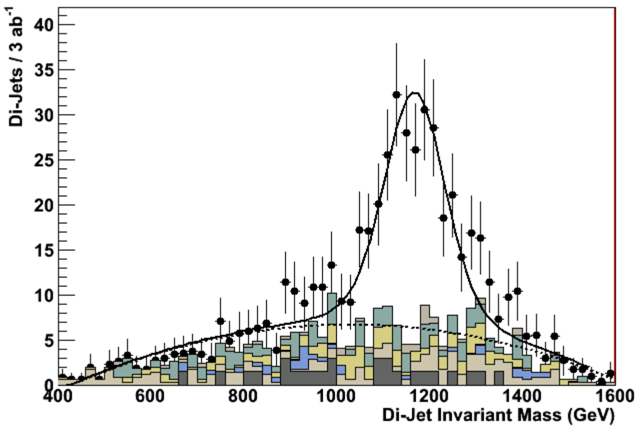
- Signal + full standard model background + γγ=>hadron background
- CLIC-ILD detector: Mokka+Marlin simulation, reconstruction + kinematic fit.



Zero bunch crossings
M_A mass resol. 3.8 GeV



20 bunch crossings
M_A mass resol. 5.6 GeV



40 bunch crossings
M_A mass resol. 8.2 GeV

Feasibility Reserve

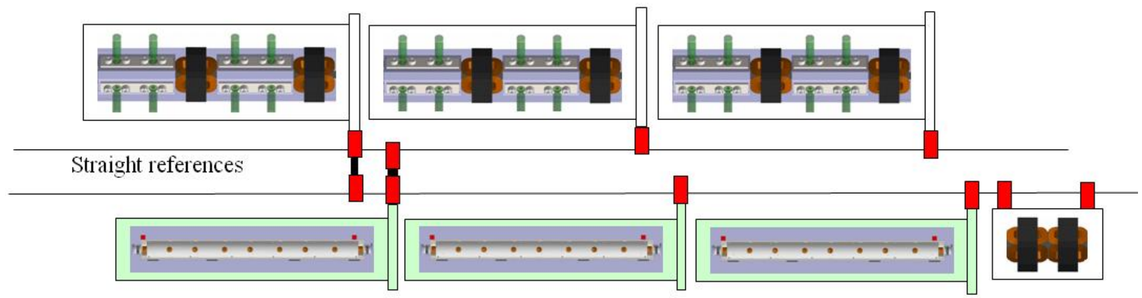
Operation & Machine Protection System

- Basic concept is being developed (M. Jonker et al.)
  - based on LHC experience
- Loss monitoring/control
- Startup scenarios
- Accidental beam losses
  - Slow drifts
    - e.g. temperature
    - Next pulse permit (if pulse is OK next pulse is allowed otherwise safe beam operation)
  - Slow trips
    - e.g. magnet failure
    - interlock 2ms before pulse
  - Fast trips
    - e.g. RF or kickers
    - reduce incidence frequency and impact
    - protective masks

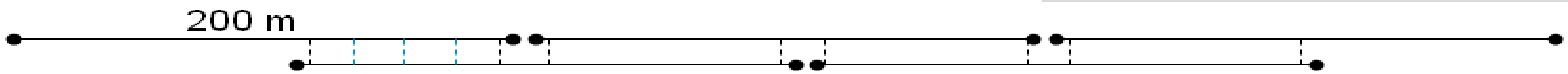
Main Linac Alignment Concept

- Pre-alignment O(10um)
    - with wire system
    - detailed model in simulations
- Dispersion free steering
    - aligns BPMs and quadrupoles
- Move girders onto the beam
    - use wakemonitors
    - removes wakefield effects

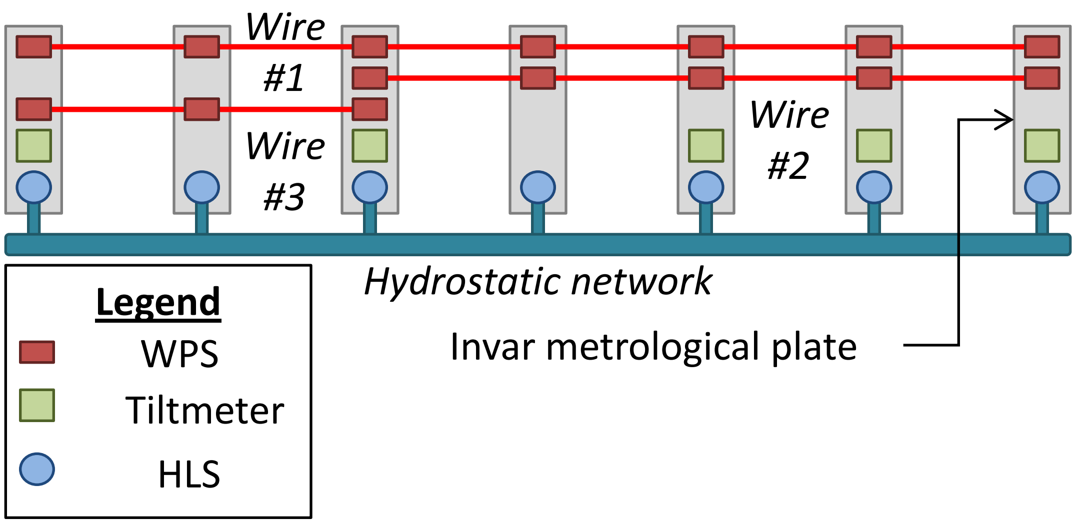
- Straight reference line defined by overlapping wires
- Girders are aligned to these wires
- Detailed work ongoing on module integration, mechanical alignment in module, wire system test, sensor cost reduction, use of laser system

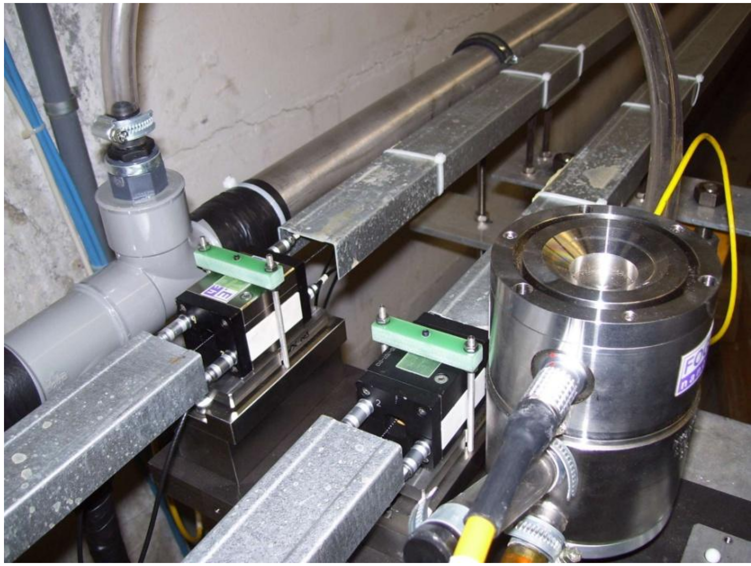


H. Mainaud-Durand et al. CERN

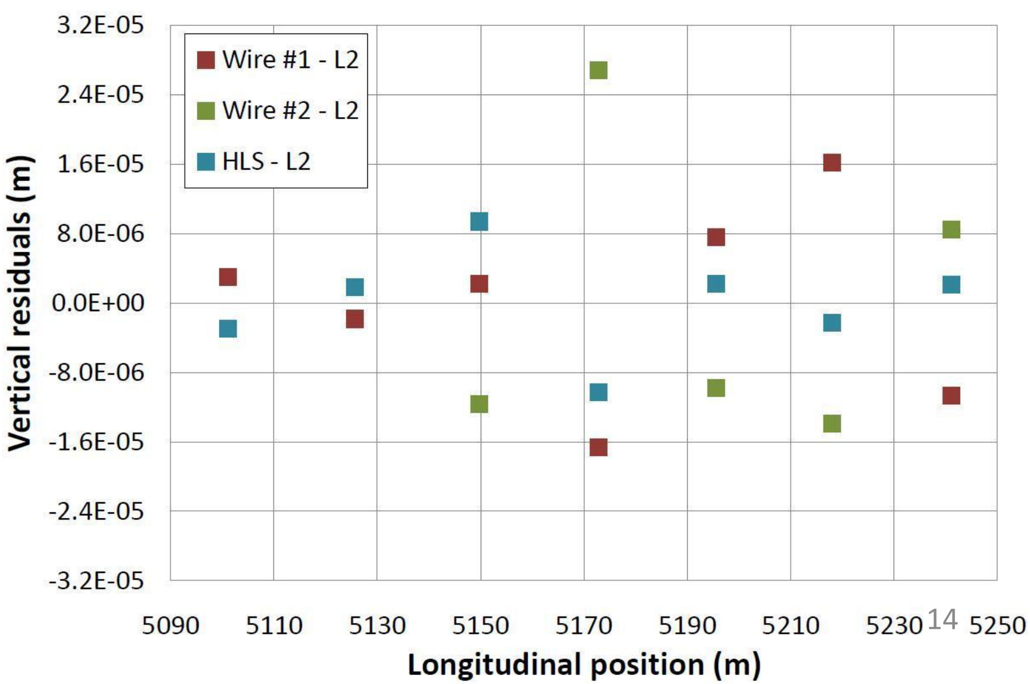


TT1 Alignment Results



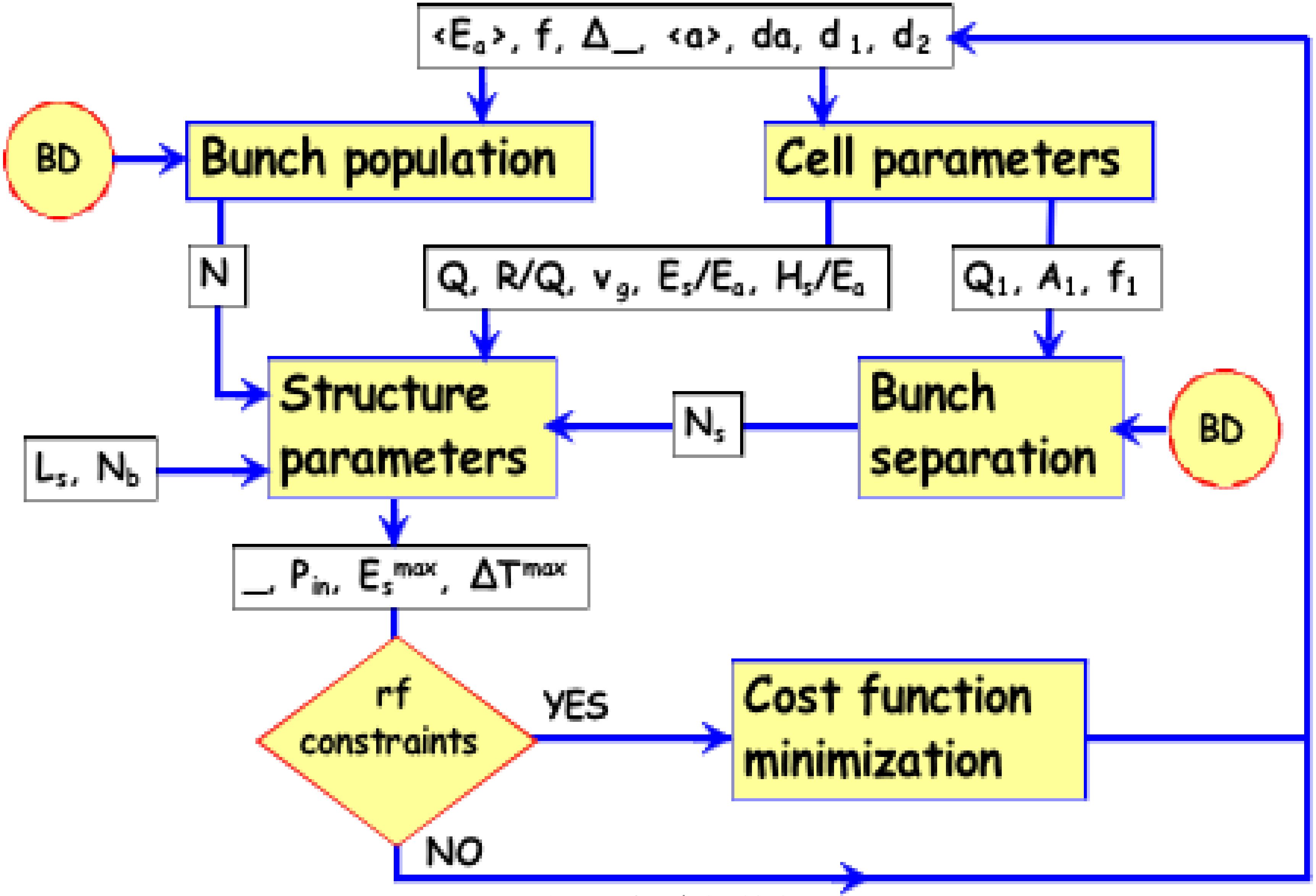


- RMS error of 11µm found
  - Target is 10µm
- More work remains to be done
  - Found two bad points due to mechanical problem
  - Stake-out error needs to be determined



Th Touze et al., CERN

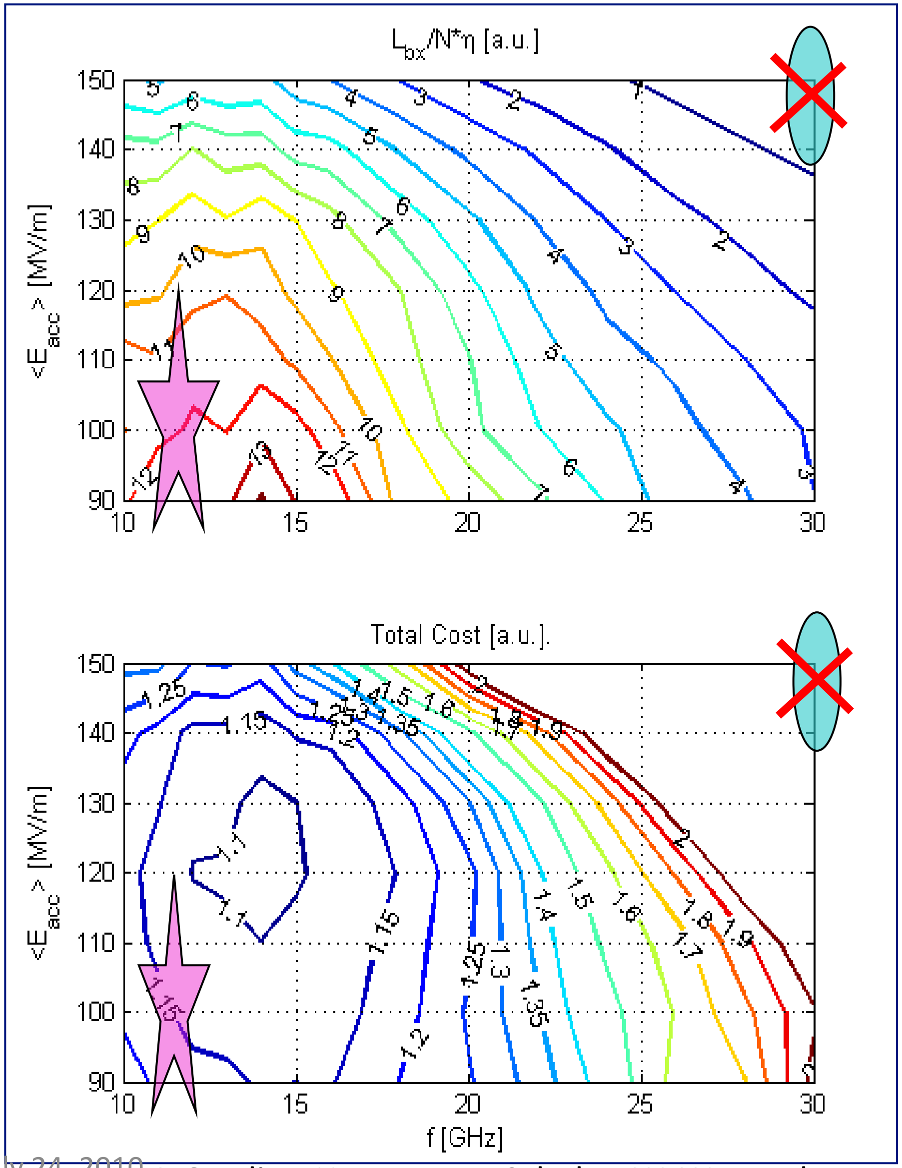
Parameter Optimisation



A. Grudiev et al.

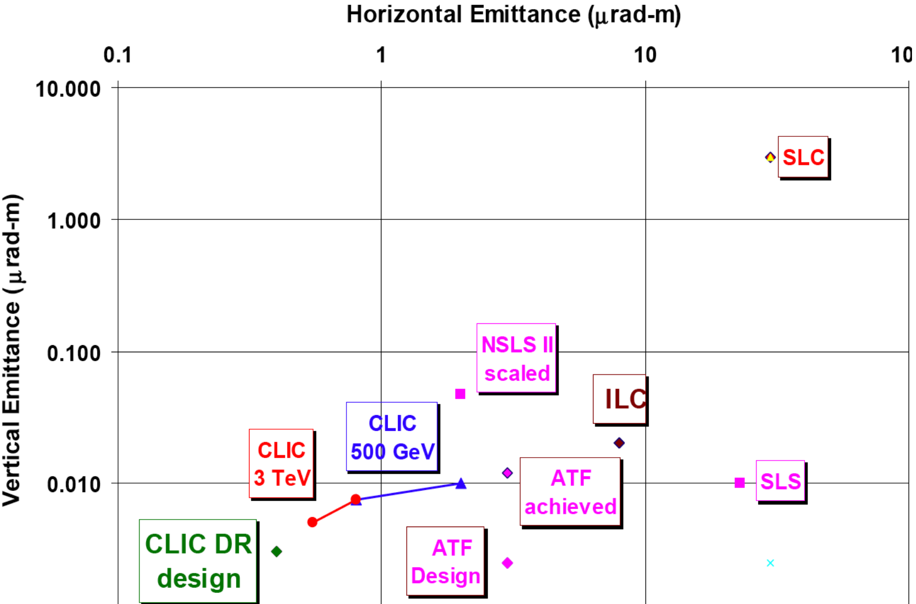
Optimisation Results

- Optimisation - figure of merit:
  - Minimum project cost for 3TeV with $L_{0.01}$=2 $10^{34}cm^{-2}s^{-1}$
- Structure limits
  - RF breakdown – scaling (E_{surf}<260MV/m , $P/C\tau^{1/3}$ limited)
  - RF pulse heating (ΔT<56°K)
- Beam dynamics
  - Beam-beam effects
  - Damping rings, BDS
  - Main linac emittance preservation – wake fields
- Cost model
- Merged into one big model
- Chose 100MV/m and 12GHz



A.Grudiev, H. Braun, D. Schulte, W. Wuensch.

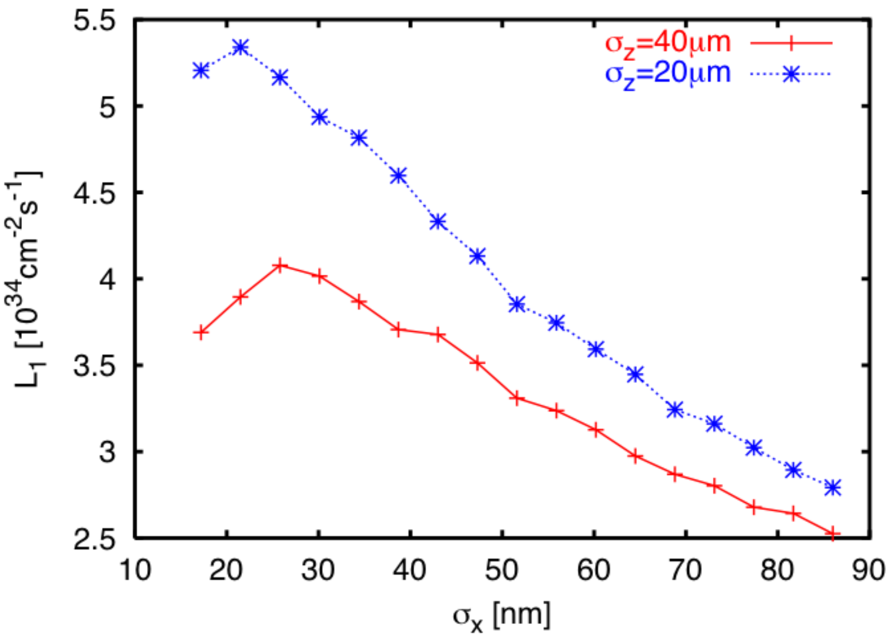
Damping Ring Design

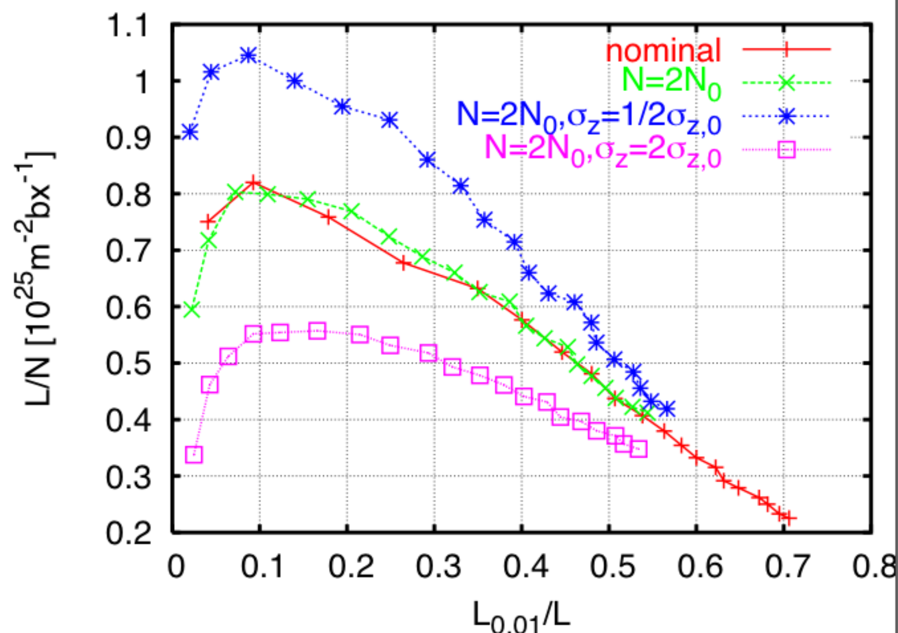


PARAMETER	NLC	CLIC (3TeV)
bunch population (10^9)	7.5	4.1
bunch spacing [ns]	1.4	0.5
number of bunches/train	192	316
number of trains	3	1
Repetition rate [Hz]	120	50
Extracted hor. normalized emittance [nm]	2370	<500
Extracted ver. normalized emittance [nm]	<30	<5
Extracted long. normalized emittance [keV.m]	10.9	<5
Injected hor. normalized emittance [μm]	150	63
Injected ver. normalized emittance [μm]	150	1.5
Injected long. normalized emittance [keV.m]	13.18	1240

- Present CLIC DR design for 3TeV achieves goals for transverse emittances with a 20%-30% margin (380nm horizontal and 4.1nm vertical)
- Conservative DR output emittances (2.4μm horizontal, 10nm vertical) for CLIC @ 500GeV scaled from operational or approved light source projects (NSLSII, SLS)
- Route to lower emittances to be defined

Horizontal Beam Size Optimisation





Total luminosity for $\Upsilon \gg 1$

$$\mathcal{L} \propto \frac{N}{\sigma_x}\frac{\eta}{\sigma_y} \propto \frac{n_\gamma^{3/2}}{\sqrt{\sigma_z}}\frac{\eta}{\sigma_y}$$

large n_γ ⇒ higher $\mathcal{L}$ ⇒ degraded spectrum

chose n_γ, e.g. maximum $L_{0.01}$ or $L_{0.01}/L = 0.4$ or ...

$$\mathcal{L}_{0.01} \propto \frac{\eta}{\sqrt{\sigma_z}\sigma_y}$$

Project Preparation

Project cost, schedule, site, integration aspects and many technical details are critical part of a project

- Analytic cost estimate is being prepared (Ph. Lebrun et al.)
  - To verify previous synthetic cost estimate
  - To identify cost drivers
  - In collaboration with ILC to exploit synergy and provided comparable basis for cost estimate
- Schedule is being developed (K. Foraz et al.)
- Other technical issues are being addressed
  - To provide base line for conceptual design
    - A number of changes have been implemented
  - To make sure that we did not overlook an issue
  - To prepare for the TDR phase
- Potential sites are being explored (-> J. Osborn et al.)
  - Strong synergy with ILC site studies and common ILC-CLIC working group
- Close collaboration with ILC