Detectors and Physics Issues

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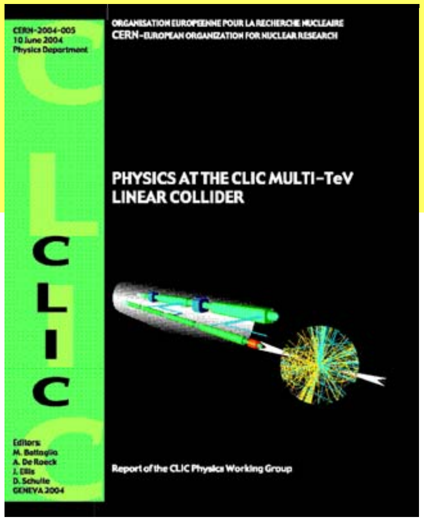
Content

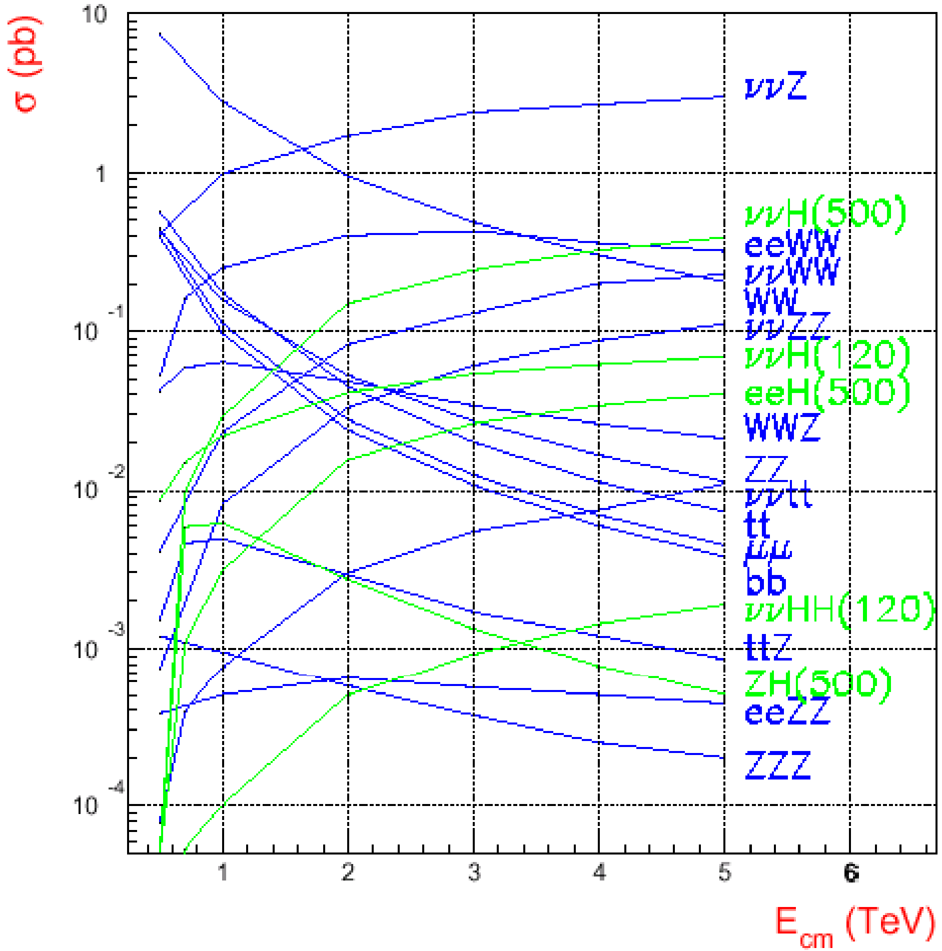
- Introduction
- Experimental issues at CLIC for precision physics: backgrounds, luminosity spectra
- Detector Developments
  - Progress for ILC detectors
  - Ideas/Proposals for CLIC

- Details of physics and backgrounds the report hep-ph/0412251.



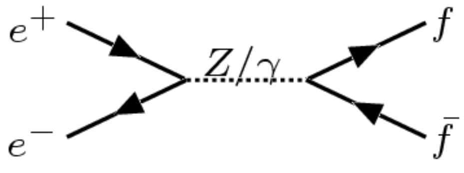
Editors: M. Battaglia, J. Ellis
A. De Roeck, D. Schulte

Cross Sections at CLIC



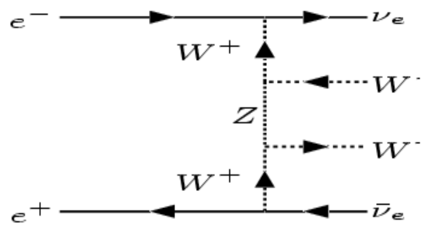
Event Rates/Year (1000 fb^{-1})	3 TeV 10^3 events	5 TeV 10^3 events
$e^+e^- \to t\bar{t}$	20	7.3
$e^+e^- \to b\bar{b}$	11	3.8
$e^+e^- \to ZZ$	27	11
$e^+e^- \to WW$	490	205
$e^+e^- \to hZ/h\nu\nu$ (120 GeV)	1.4/530	0.5/690
$e^+e^- \to H^+H^-$(1 TeV)	1.5	0.95
$e^+e^- \to \tilde{\mu}^+\tilde{\mu}^-$ (1 TeV)	1.3	1.0

s-Channel Production



$\sigma \propto 1/s$

t-Channel Production



$\sigma \propto log(s)$

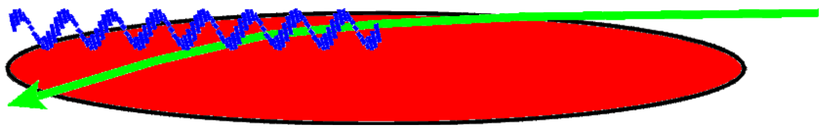
Experimental Issues: Backgrounds

CLIC 3 TeV e+e- collider with a luminosity ~ $10^{35}cm^{-2}s^{-1}$ (1 ab^{-1}/year)

E_{cm}	[TeV]	0.5	3	
$\mathcal{L}$	$[10^{34}cm^{-2}s^{-1}]$	2.1	10.0	5.9
$\mathcal{L}_{0.99}$	$[10^{34}cm^{-2}s^{-1}]$	1.5	3.0	2.0
f_r	[Hz]	200	100	50
N_b		154	154	311
Δ_b	[ns]	0.67	0.67	0.67
N	$[10^{10}]$	0.4	0.4	0.4
σ_z	[μm]	35	30	44
ϵ_x	[μm]	2	0.68	0.66
ϵ_y	[μm]	0.01	0.02	0.02
σ_x^*	[nm]	202	43	53
σ_y^*	[nm]	≈ 1.2	1	1
δ	[%]	4.4	31	31
n_γ		0.7	2.3	2.0
$N_\perp$		7.2	60	45
N_{Hadr}		0.07	4.05	2.7
N_{MJ}		0.003	3.40	

Report → Old values
New values close to those used in the report

To reach this high luminosity: CLIC has to operate in a regime of high beamstrahlung

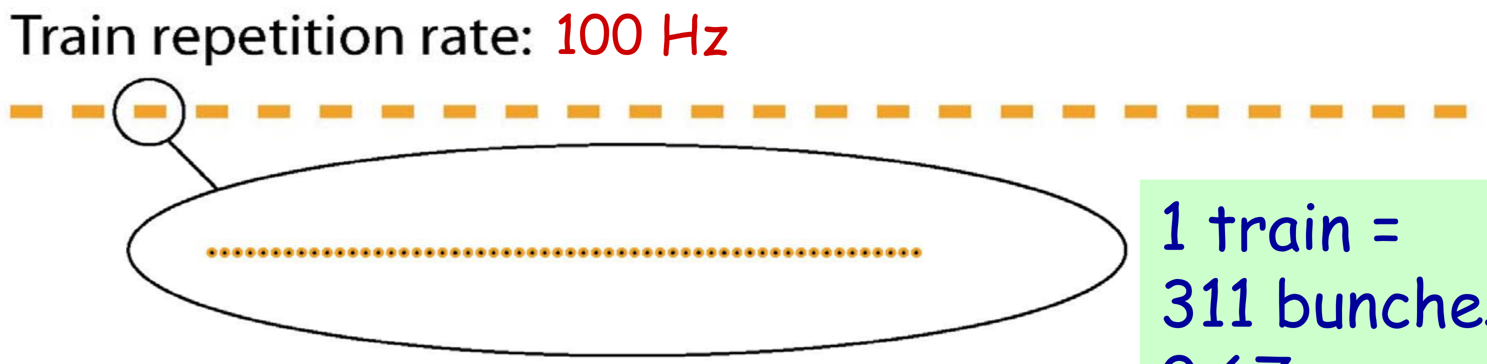


Expect large backgrounds
# of photons/beam particle
- e+e- pair production
- γ γ events
- Muon backgrounds
- Neutrons
- Synchrotron radiation

Expect distorted lumi spectrum

Time Structure of the Beams

CLIC



1 train =
311 bunches
0.67 nsec apart
~ 20 cm

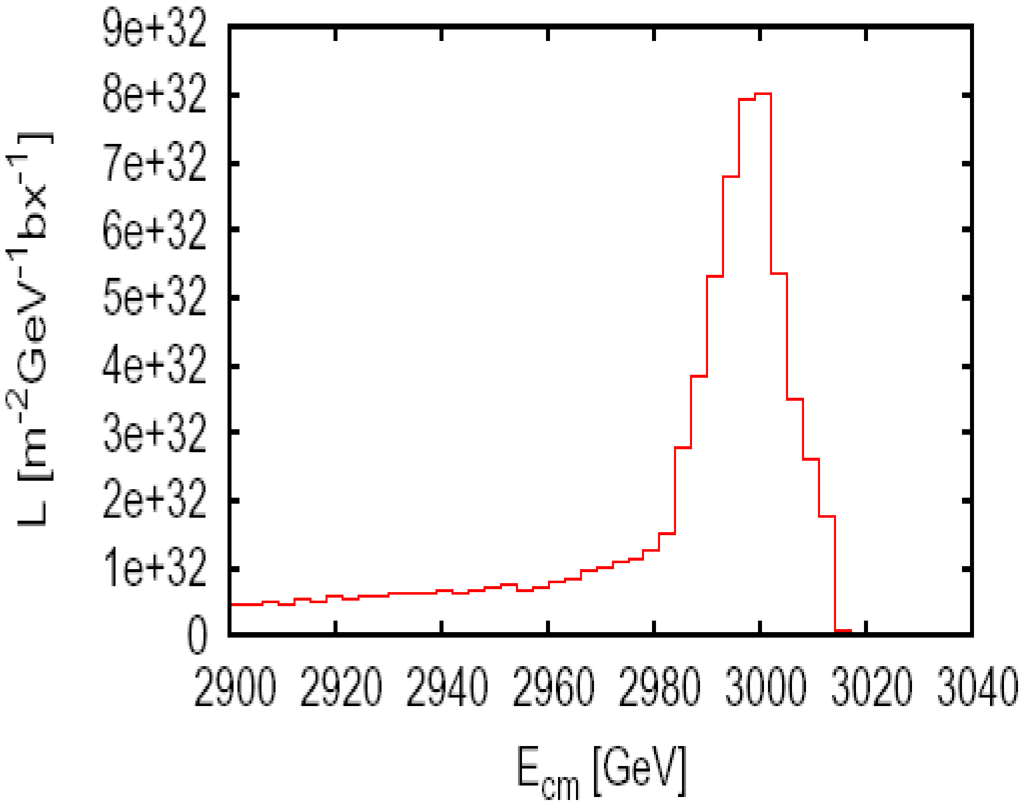
ILC

⇒ 5 Hz 1 train 2625 bunches 369 ns apart

Experimenting at CLIC similar to the "NLC"

Experimental issues: Luminosity Spectrum

RECONSTRUCTED $\sqrt{s'}$ SPECTRUM FROM BHABHA ANGLES



Preliminary Results: expect accuracy $\frac{\delta\sqrt{s'}}{\sqrt{s}} \simeq 10^{-4}$ for 100 fb^{-1}

Luminosity spectrum not as sharply peaked as e.g. at LEP or TESLA/NLC

e+e- Pair Production

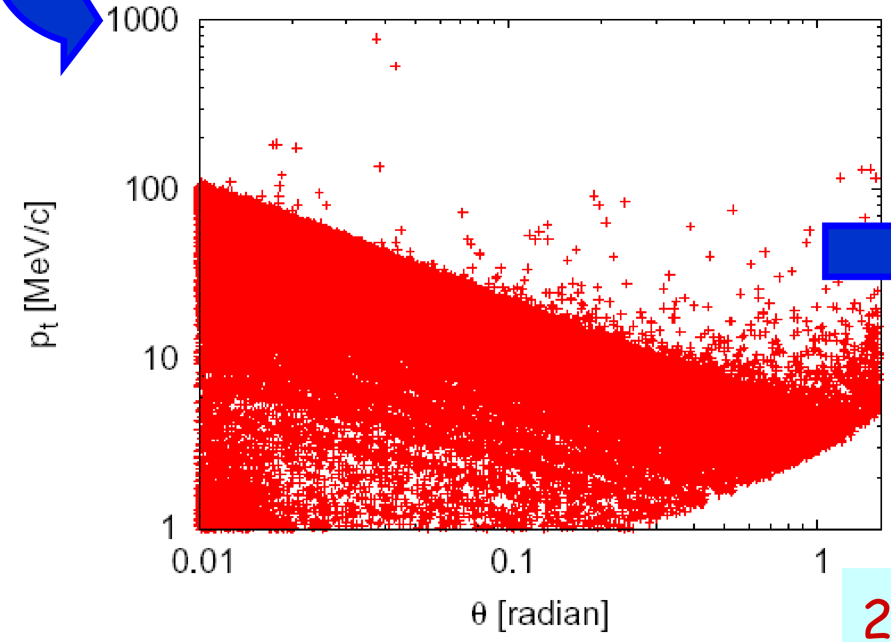
Coherent pair production
- number/BX   3.8 10^8
- energy/BX   2.6 10^8 TeV

Disappear in the beampipe

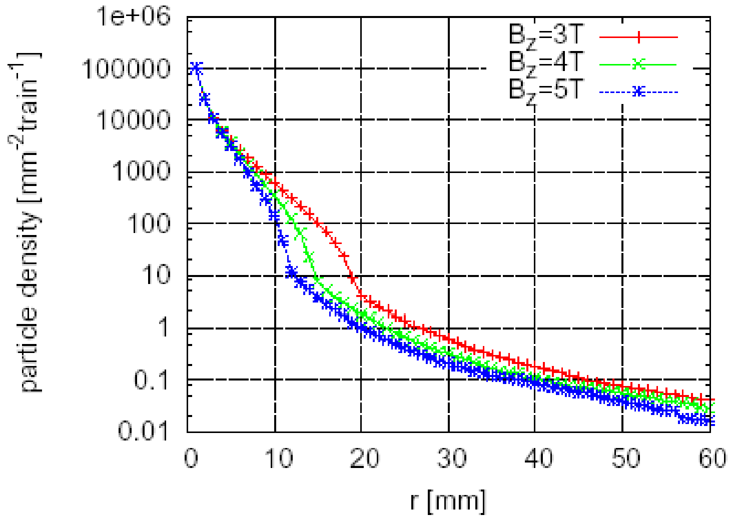
Can backscatter on machine elements
Need to protect detector with mask

Incoherent pair production:
- number/BX   3.0 10^5
- energy/BX   2.2 10^4 TeV

Can be suppressed by strong magnetic field in of the detector



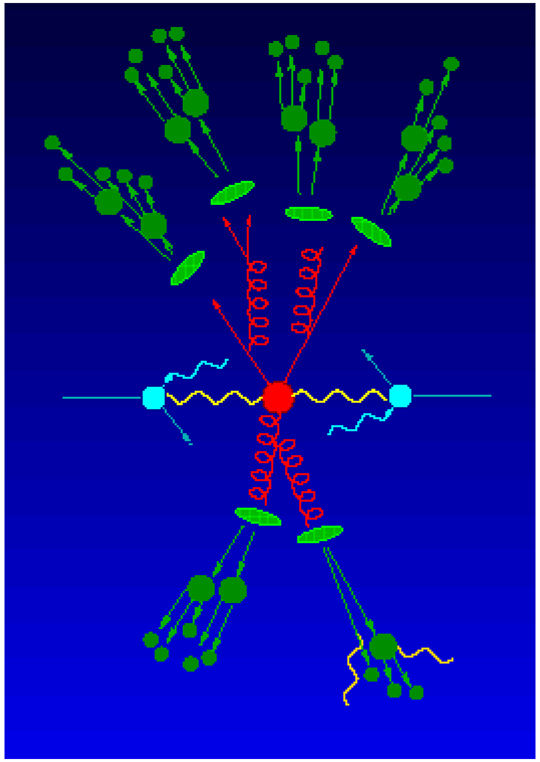
hits/mm²/bunch train



20mm and 4T ⇒O(1) hit/mm²/bunch train 👍

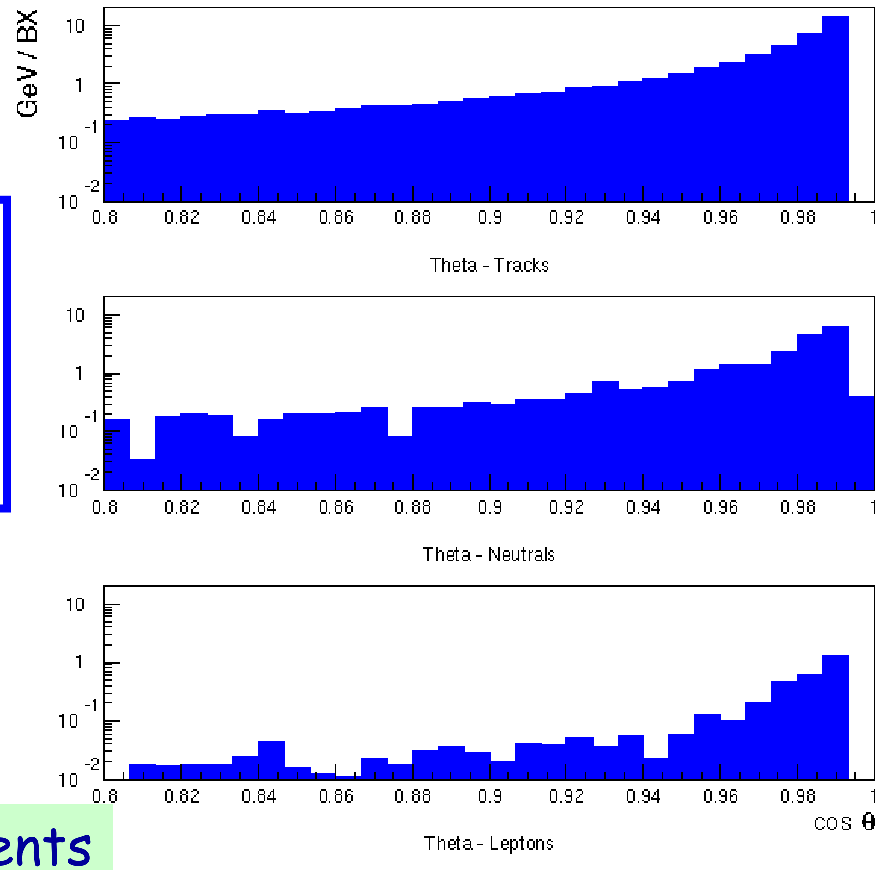
γγ Background

γγ → hadrons: 4 interactions/bx with W_{HAD}>5 GeV



Particles accepted within θ > 120mrad

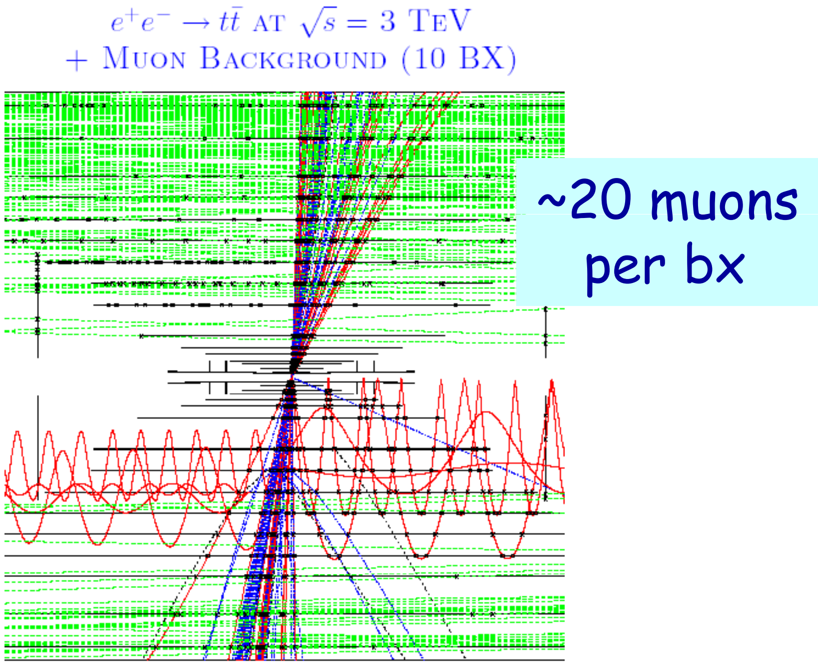
Neutral and charged energy as function of cosθ per bx

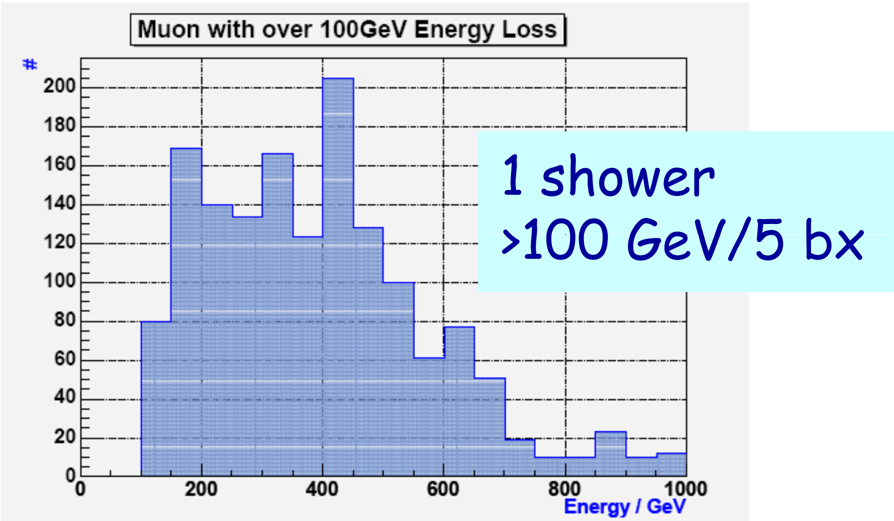


For studies: take 20 bx and overlay events

Most activity at small angles

Muon Background





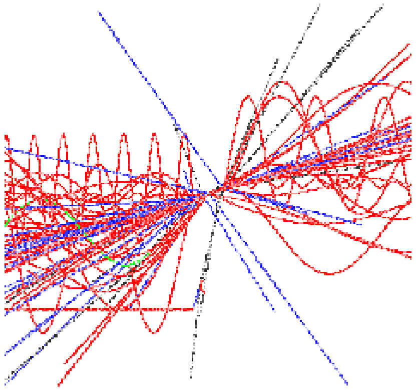
Muon pairs produced in electromagnetic interactions upstream of the IP e.g beam halo scraping on the collimators

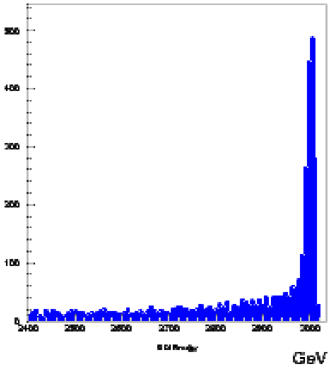
Geant simulation, taking into account the full CLIC beam delivery system

Rate: ~ 20 muons/BX with help of tunnel fillers

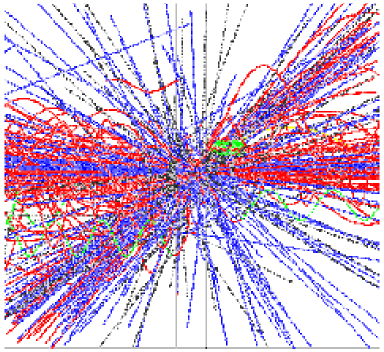
2003 Studies show that:
⇒ OK for (silicon like) tracker
⇒ Calorimeter?

Studies include background, spectra,…

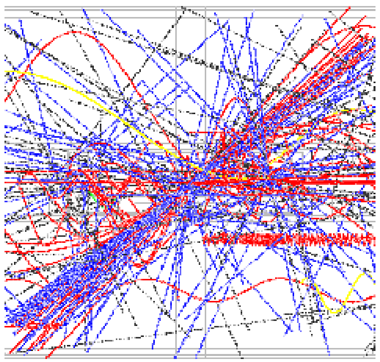




Physics generators (COMPHEP PYTHIA6,…)
+ CLIC lumi spectrum (CALYPSO)



+ $\gamma\gamma \rightarrow$ hadrons background
e.g. overlay 20 bunch crossings
(+ e+e- pair background files…)



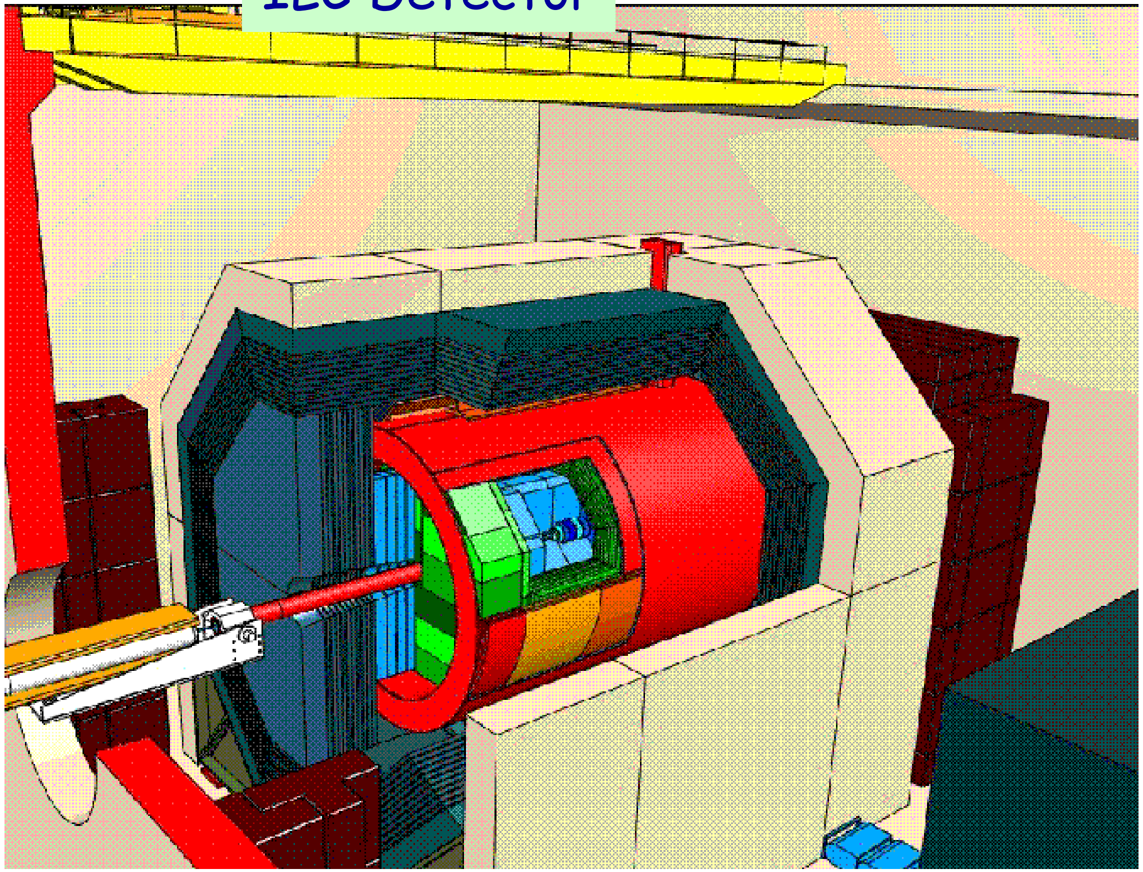
Detector simulation

- SIMDET (fast simulation)
- GEANT3 based program

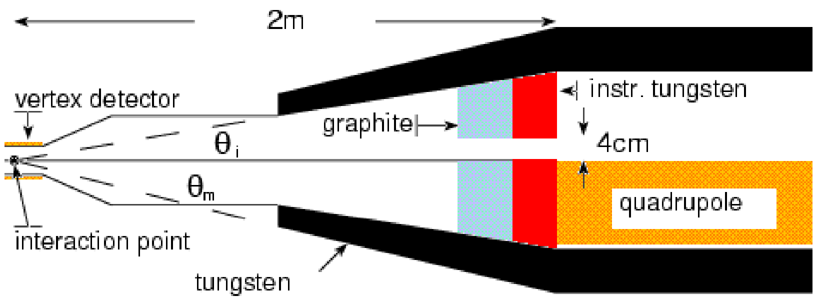
$\Rightarrow$Studies of the benchmark processes include backgrounds, effects of lumi spectrum etc.

A Detector for a LC

ILC Detector



Background at the IP enforces use of a mask



CLIC: Mask covers region up to 120 mrad (2003 design)
Energy flow measurement possible down to 40 mrad
⇒ New ideas from ILC
⇒ Needs to new optimization for CLIC

~TESLA/NLC detector qualities: Excellent tracking and jet energy resolution, jet flavour tagging, lepton identification, hermeticity, small angle detection...
Particle identification?

Detector Parameters

Detector	CLIC
Vertexing	$15\mu m \oplus \frac{35\mu m GeV/c}{p\sin^{3/2}\theta}$ $15\mu m \oplus \frac{35\mu m GeV/c}{p\sin^{5/2}\theta}$
Solenoidal Field	$B = 4\ T$
Tracking	$\frac{\delta p_t}{{p_t}^2} = 5. \times 10^{-5}$
E.m. Calorimeter	$\frac{\delta E}{E(GeV)} = 0.10\frac{1}{\sqrt{E}} \oplus 0.01$
Had. Calorimeter	$\frac{\delta E}{E\ (GeV)} = 0.40\frac{1}{\sqrt{E}} \oplus 0.04$
μ Detector	Instrumented Fe yoke $\frac{\delta p}{p} \simeq 30\%$ at $100\ GeV/c$
Energy Flow	$\frac{\delta E}{E\ (GeV)} \simeq 0.3\frac{1}{\sqrt{E}}$
Acceptance mask beampipe small angle tagger	$\lvert\cos\theta\rvert < 0.98$ 120 mrad 3 cm $\theta_{min} = 40$ mrad

Starting point: the TESLA TDR detector
Adapted to CLIC environment

First ideas:

3–15 cm	VDET
15–80 cm	Silicon/forward disks
80–240 cm	TPC
240–280 cm	ECAL (30 X_0)
280–400 cm	HCAL (6λ)
400–450 cm	Coil (4T)
450–800 cm	Fe/muon

Or an all silicon detector with 5 T field

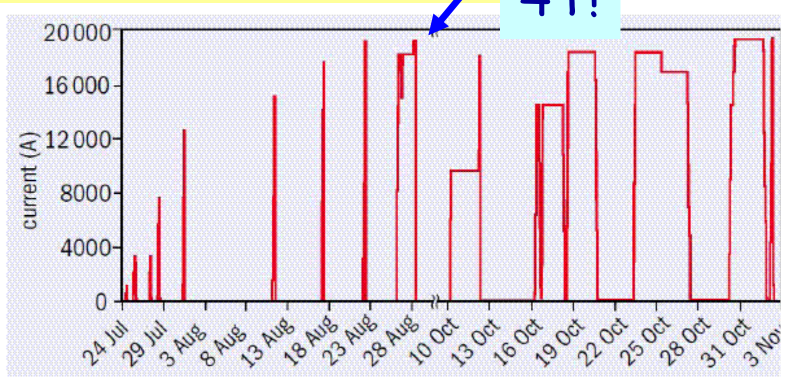
NOTE: CMS Solenoid

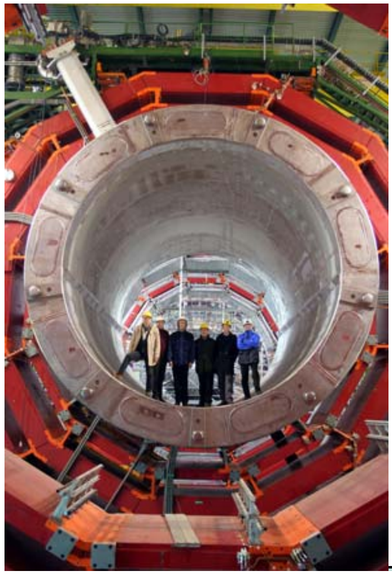
The largest high field solenoid magnet ever build

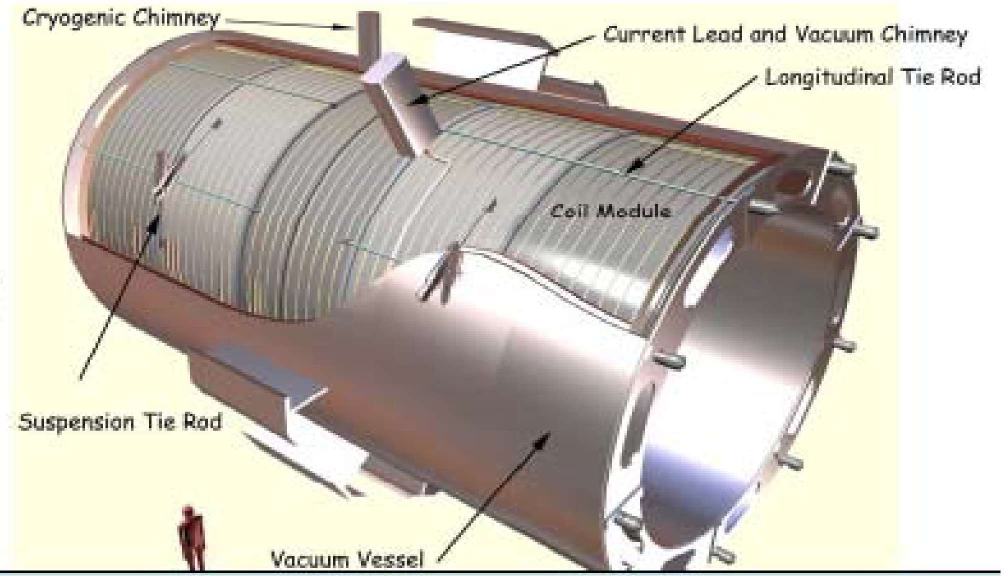
Successfully tested in August ’06!!

Magnetic length	12.5 m
Free bore diameter	6 m
Central magnetic induction	4 T
Temperature	4.2^0 Kelvin
Nominal current	20 kA
Stored energy	2.7 GJ
Magnetic Radial Pressure	64 Atmospheres

4T!







ILC Benchmarks for Detector Optimization

TABLE 2.1
Sub-Detector Performance Needed for Key ILC Physics Measurements.

Physics Process	Measured Quantity	Critical System	Critical Detector Characterstic	Required Performance
ZHH $HZ \to q\bar{q}b\bar{b}$ $ZH \to ZWW^*$ $\nu\bar{\nu}W^+W^-$	Triple Higgs Coupling Higgs Mass $\mathrm{B}(H \to WW^*)$ $\sigma(e^+e^- \to \nu\bar{\nu}W^+W^-)$	Tracker and Calorimeter	Jet Energy Resolution, $\Delta E/E$	3to4%
$ZH \to \ell^+\ell^- X$ $\mu^+\mu^-(\gamma)$ $ZH + H\nu\nu \to \mu^+\mu^- X$	Higgs Recoil Mass Luminosity Weighted $\mathrm{E_{cm}}$ $\mathrm{B}(H \to \mu^+\mu^-)$	Tracker	Charged Particle Momentum Res., $\Delta p_t/p_t^2$	5×10^{-5}
$HZ, H \to b\bar{b}, c\bar{c}, gg$ $b\bar{b}$	Higgs Branching Fractions b quark charge asymmetry	Vertex Detector	Impact Parameter, δ_b	$5\mu\mathrm{m} \oplus 10\mu\mathrm{m}/p(\mathrm{GeV/c})\sin^{3/2}\theta$
SUSY, eg. $\tilde{\mu}$ decay	$\tilde{\mu}$ mass	Tracker, Calorimeter	Momentum Res., hermeticity	

ILC-DCR 2007

Good guidance for CLIC optimization, but additional special features due to higher energy and background: More jets, longer decay distances (b quarks), higher particle densities, short time structure…

CLIC Benchmark Processes studied

Table 3.1: Physics signatures and CLIC physics programme: matrix of the simulated processes

Physics signatures	Higgs sector	SUSY	SSB	New gauge bosons	Extra dimensions
Resonance scan		$\tilde{\mu}$ thresholds	D-BESS	Z'	KK resonances
EW fits				$\sigma_{f\bar{f}}$, $A_{\mathrm{FB}}^{f\bar{f}}$,	$\sigma_{f\bar{f}}$, $A_{\mathrm{FB}}^{f\bar{f}}$,
Multijets	H^+H^- H^0A^0 $H^0H^0\nu\bar{\nu}$				
E_{miss}, Fwd	$H^0e^+e^-$	$\tilde{\ell}$ χ_2^0	WW scattering		

$e^+e^- \to H^+H^-$ $M_H = 900$ GeV

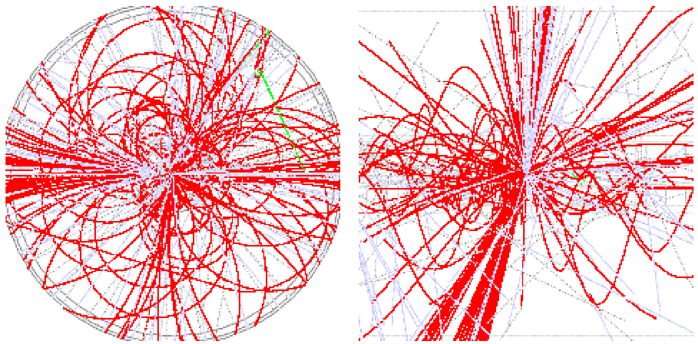


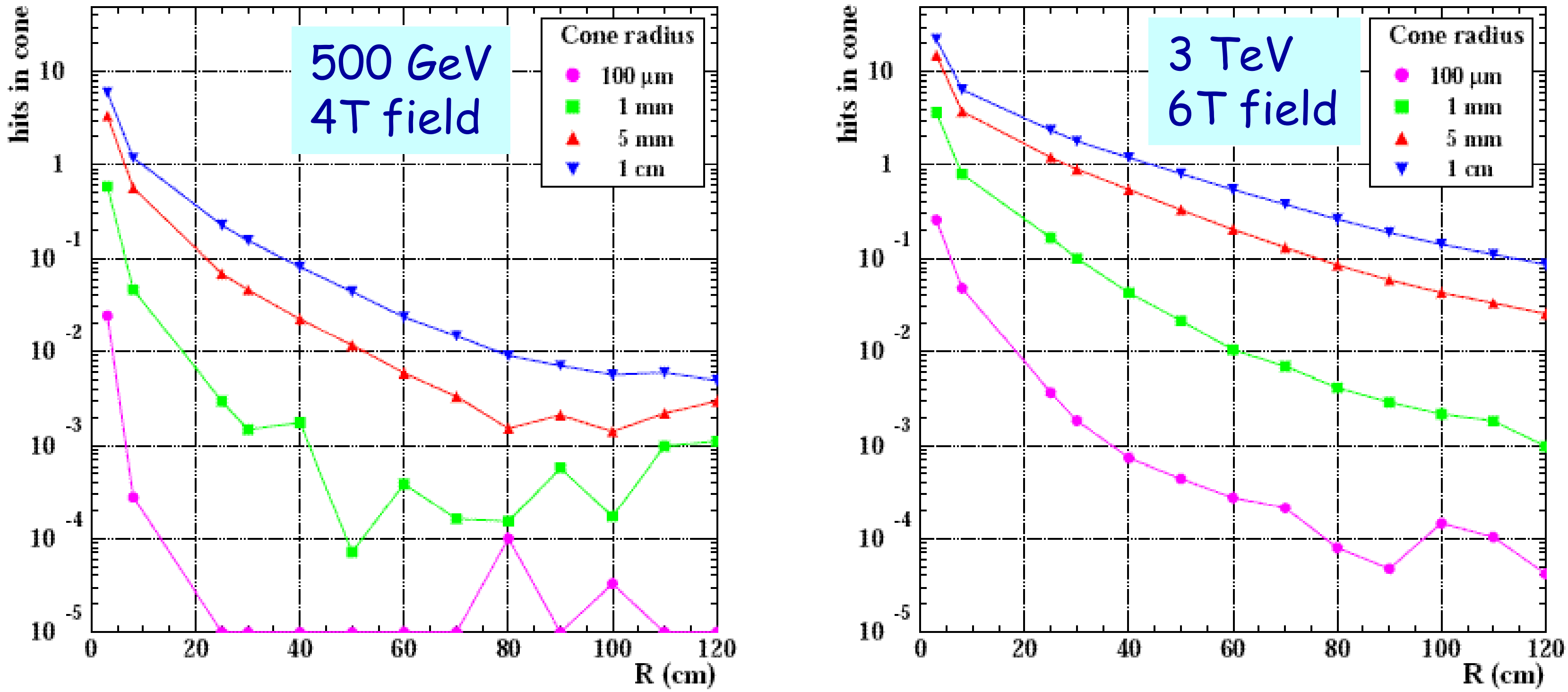
Table 3.7: Average reconstructed jet multiplicity in hadronic events at different $\sqrt{s}$ energies

$\sqrt{s}$ (TeV)	0.09	0.20	0.5	0.8	3.0	5.0
$\langle N_{\mathrm{Jets}} \rangle$	2.8	4.2	4.8	5.3	6.4	6.7

Processes with up to 14 jets…

Example: Track Density @ CLIC

ee→bb

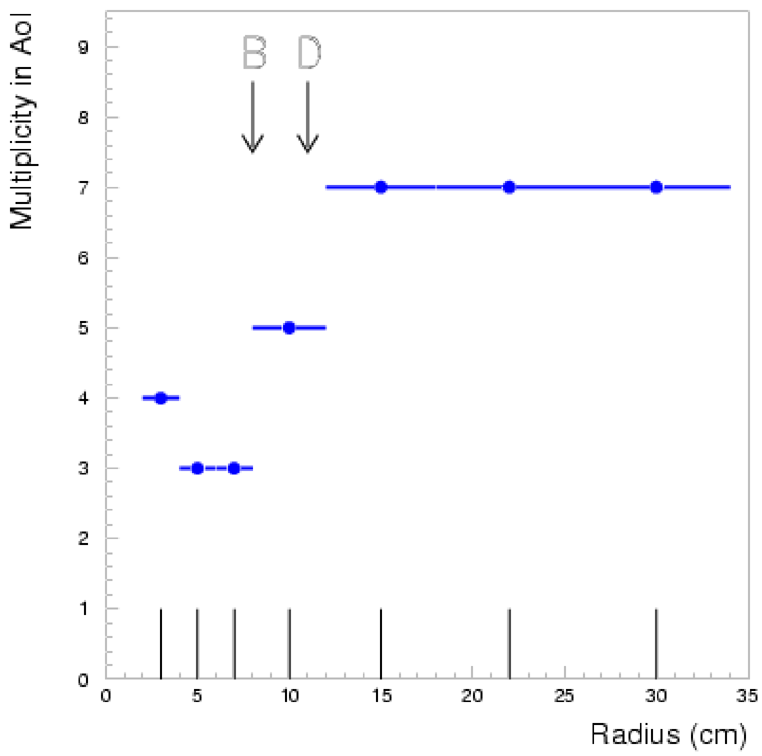


Average number of additional tracks in a cone of given radius
500 GeV : 10% prob. to have 1 extra track within 1cm cone at 40cm radius
3 TeV : 10% prob. to have 1 extra track within 1cm cone at 1 m radius

Example: B-tagging

$B \rightarrow X$ DECAY LENGTH

$\sqrt{s}$ (TeV)	0.09	0.2	0.35	0.5	**3.0**	
	Z^0	HZ	HZ	HZ	H^+H^-	$b\bar{b}$
d_{space} (cm)	0.3	0.3	0.7	0.85	**2.5**	**9.0**

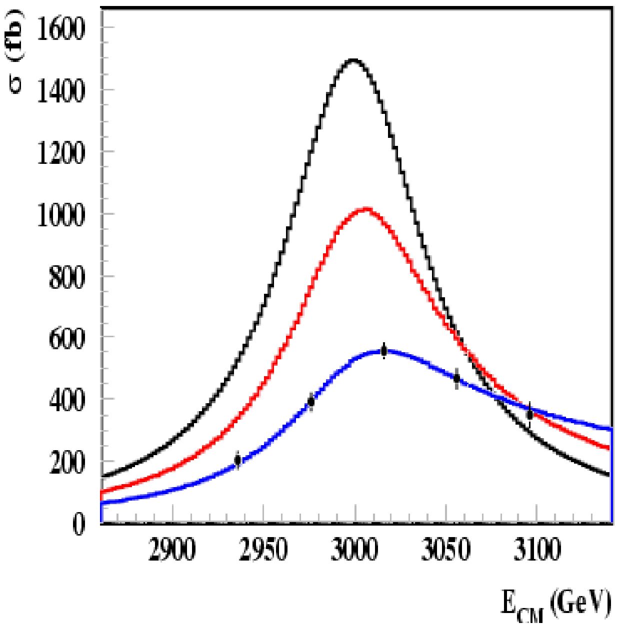


B-Decay length is long!

- Define Area of Interest by $\pm$ 0.04 rad cone around the jet axis
- Count hit multiplicity (or pulse height) in Vertex Track layers
- Tag heavy hadron decay by step in detected multiplicity
- Can reach 50% eff./~80% purity

Example: Resonance Production

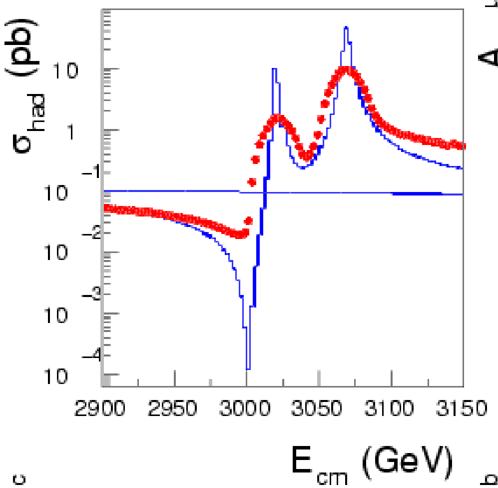
Resonance scans, e.g. a Z′

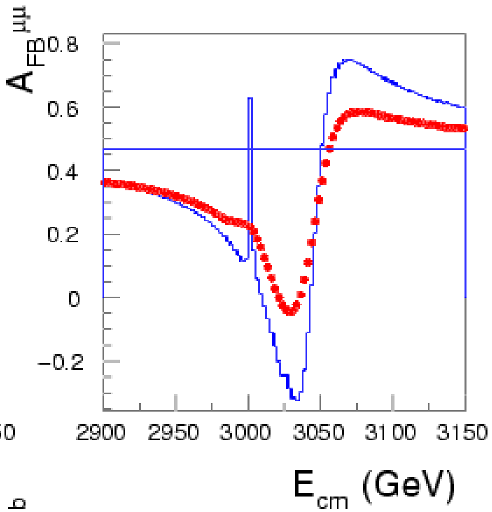


FIT ACCURACY

Observable	Breit Wigner	CLIC.01	CLIC.02
$M_{Z'}$ (GeV)	$3000 \pm .12$	$\pm .15$	$\pm .21$
$\Gamma(Z')/\Gamma_{SM}$	$1. \pm .001$	$\pm .003$	$\pm .004$
σ^{eff}_{peak} (fb)	1493 ± 2.0	564 ± 1.7	669 ± 2.9

$1\ ab^{-1} \Rightarrow \delta M/M \sim 10^{-4}$ & $\delta\Gamma/\Gamma = 3.10^{-3}$



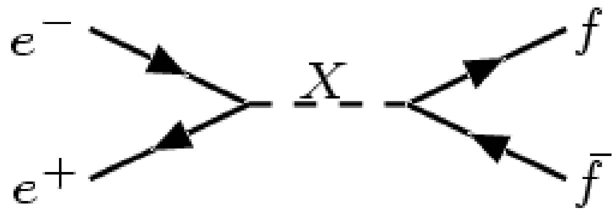


Degenerate resonances
e.g. D-BESS model

Can measure ΔM down to 13 GeV

Smeared lumi spectrum allows still for precision measurements

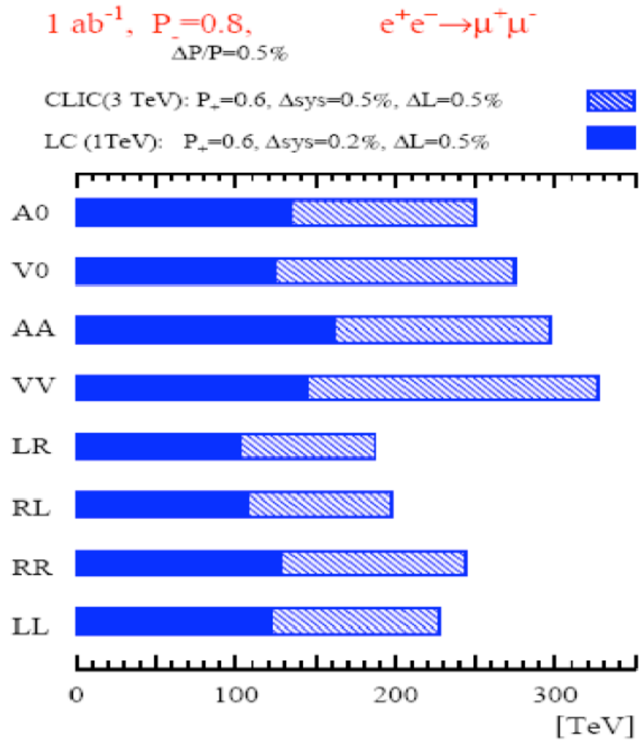
Precision Measurements



Measure $\sigma_{b\bar{b}}$, $A_{FB}^{\mu^+\mu^-}$ and $A_{FB}^{b\bar{b}}$

Examples: $\frac{\delta\sigma_{b\bar{b}}}{\sigma_{b\bar{b}}} = 0.012/\ 1\ \mathrm{ab}^{-1}$

$$\frac{\delta A_{FB}^{\mu^+\mu^-}}{A_{FB}^{\mu^+\mu^-}} = 0.018/\ 1\ \mathrm{ab}^{-1}$$



Observable	Relative Stat. Accuracy $\delta\mathcal{O}/\mathcal{O}$ for 1 ab^{-1}
$\sigma_{\mu^+\mu^-}$	± 0.010
$\sigma_{b\bar{b}}$	± 0.012
$\sigma_{t\bar{t}}$	± 0.014
$A_{FB}^{\mu\mu}$	± 0.018
A_{FB}^{bb}	± 0.055
A_{FB}^{tt}	± 0.040

E.g.: Contact interactions:
Sensitivity to scales up to 100-400 TeV

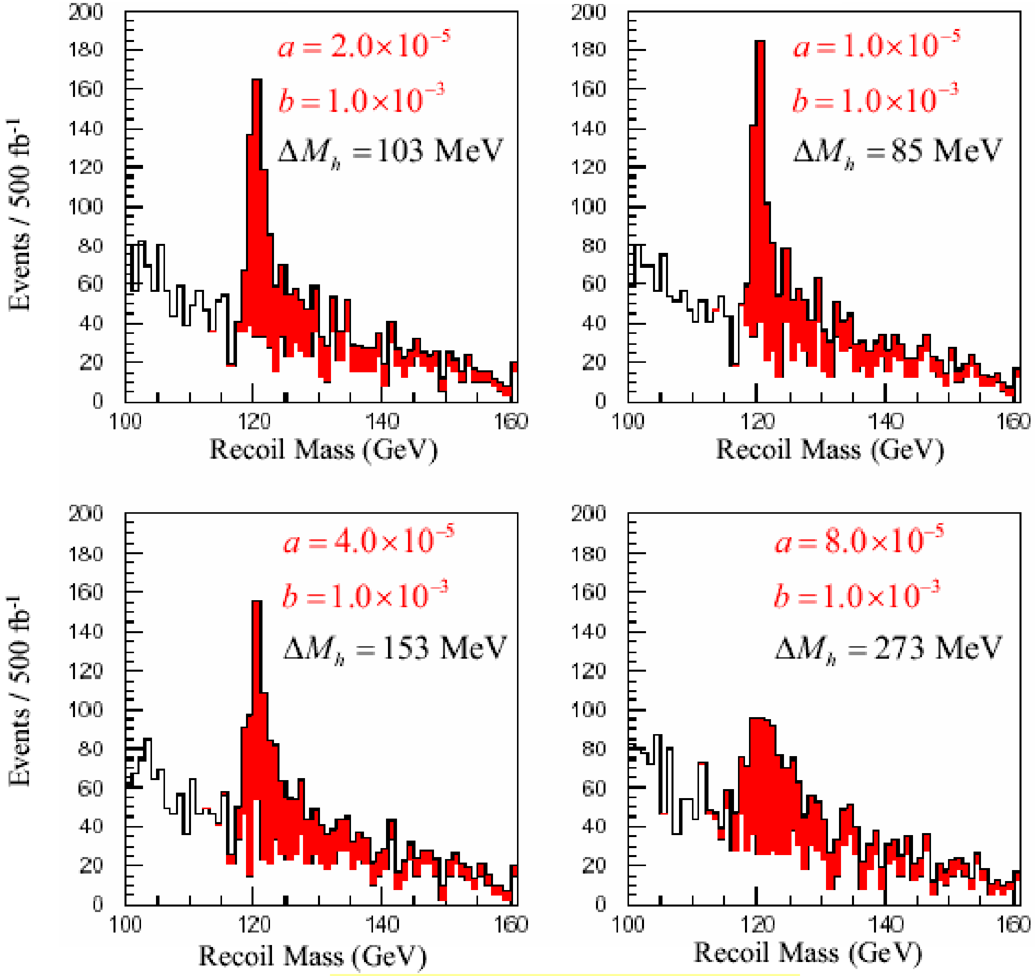
Tracking Detectors

- Silicon detectors/TPC (→K. Dehmelt WG6)
- Many developments for Pixel detectors at the ILC (→M. Winter WG6)
  - To be evaluated for CLIC purpose
  - Dedicated R& D for CLIC, → C. Da Via, M. CampBell WG6
- Remember that for CLIC
  - Time between buch crossings: 0.6 nsec
  - Number of bunches/train: 311
- Time stamping/time slicing of the bunch train?
- Idea (→ P. Jarron WG6): use a coarse pixel planes (300x300 μm) for timing in addition to precision position pixels. Following developments for the NA62 Gigatracker. Aim 100ps or better time resolution
- ALICE TOF proposal (→ C. Williams talk WG6): Large scale TOF with 40ps time resolution

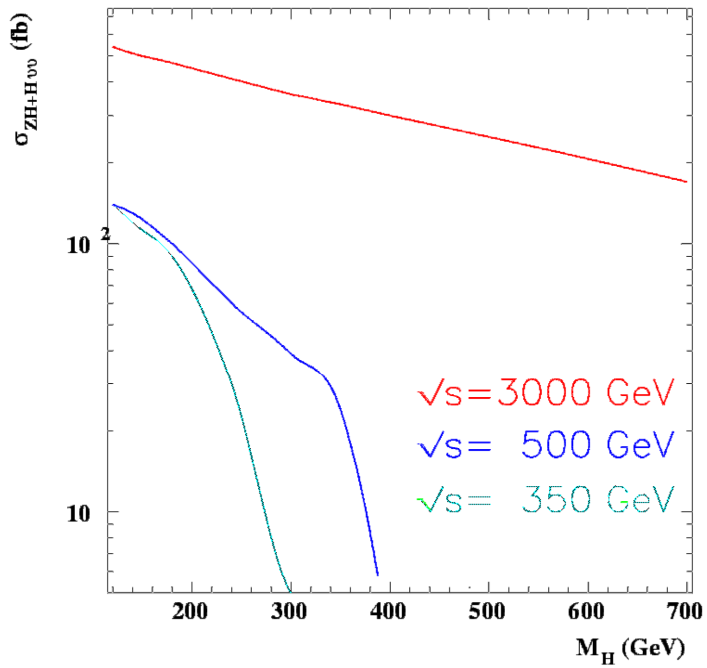
Tracker Resolution

From ILC-DCR document

$$\delta p_t / p_t^2 = a \oplus b/(p_t \sin\theta)$$



Higgs recoil mass



Low mass Higgs:
400 000 Higgses/year @ 3TeV

Susy Mass Measurements

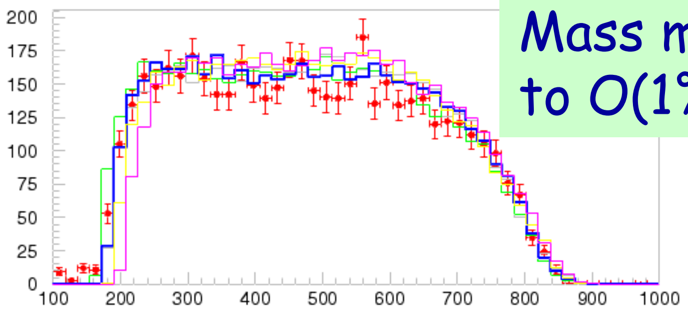
$ee \to \tilde{\mu}\tilde{\mu} \to \mu\mu\chi_0\chi_0$

E.G. $m_{1/2} = 1500$ GeV, $m_0 = 420$ GeV, $\tan\beta = 20$, $A = 0$ GeV, $sign(\mu) > 0$ (mSUGRA) (point H)

$\Rightarrow M_{\tilde{\mu}} = 1150$ GeV

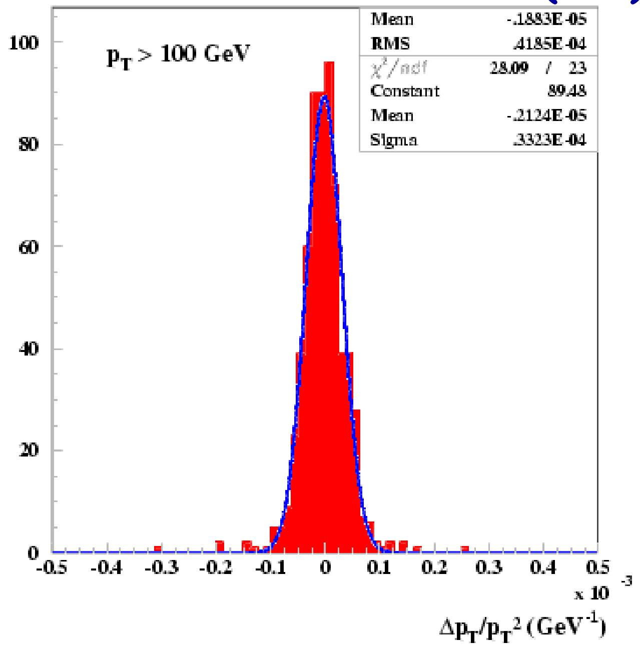
Measure inclusive muon spectrum in $\tilde{\mu} \to \mu\chi^0$

$$\Rightarrow E_{max/min} = \frac{E_{beam}}{2}\left(1 - \frac{M^2_{\chi^0}}{M^2_{tilde\mu}}\right) \times \left(1 \pm \sqrt{1 - \frac{M^2_{\tilde{\mu}}}{E^2_{beam}}}\right)$$



Mass measurements to O(1%)

Momentum resolution (G3)



$\delta p/p^2$	Beamstrahlung	Fit result (GeV)
0	none	1150 ± 10
3.0×10^{-5}	none	1150 ± 12
4.5×10^{-5}	none	1151 ± 12
4.5×10^{-5}	standard	1143 ± 18

Momentum resolution $\delta p_t/p_t^2 \sim 5.10^{-5}$ GeV^{-1} adequate for this measurement

Vertexing

→ P. Jarron

CLIC versus LHC and ILC

	LHC ATLAS VX	ILC	CLIC	NA62 [1]
BX spacing [ns]	25	300	**0.667**	avg 1ns
Nb of BX/train	2808	2820	**311**	$2*10^9$
Bunch train length	70μs	1ms	**207 ns**	2 s
Repetition rate [Hz]	40M	5	50	0.07
Nb of BX/s	36M	11400	15550	10^9
Hit/mm²/BX max	0.05	0.05	?	$6*10^{-4}$
Radiation level fluence	$\sim 10^{15}$/10 y	$\sim 10^{13}$	$\sim 10^{14}$	$\sim 2 \cdot 10^{14}$/y

1) bx = particles; train = spill

Time stamp of CLIC vertex

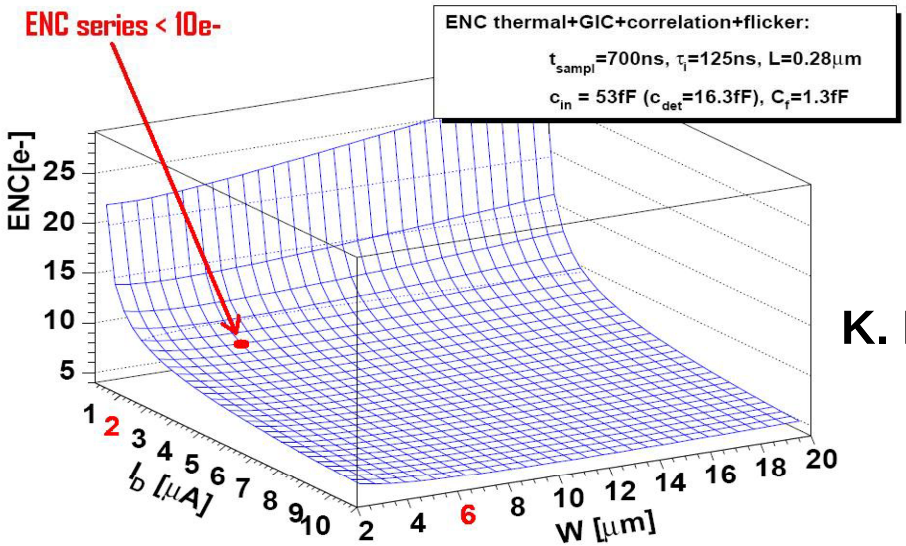
→ P. Jarron WG6

- **Basic concept**
  - A vertex detector complemented by one or 2 time stamp planes
    - **Why?** Hybrid pixel for speed, monolithic is incompatible
      - Too much functionality and power for 20-50μm pixel
    - Vertex is too densely segmented to afford ultra fast processing in each pixel
      - Too much power consumption(ILC), CCD or analog integrating readout
    - With the possibility to estimate pixel multiplicity for jet's
      - Measurement of pixel signal amplitude
- **Goals**
  - Bunch identification
    - Associate hits/tracks of each train with bunch number (1 to 311)
  - Pixel multiplicity
    - Multiplicity estimate, important if one of the inner most layer is a TS pixel plane
  - Background rejection
    - Tracking secondary particles originated tens cm away from the IP contained in highly collimated hadronic jets.
    - Rejection of coherent pairs → hadrons events overlapping e+e- interaction

R&D: Integrating Pixel Detector readout

M. Campbell

- P. Jarron, J. Kaplon, K. Poltorak
- Integrate during pulse train (~200ns) readout during gap (20ms)
- Very low noise (10's e-) possible thanks to soft reset feature
- Pixel dimensions 10's of μm
- Very high spatial resolution – but no timing info

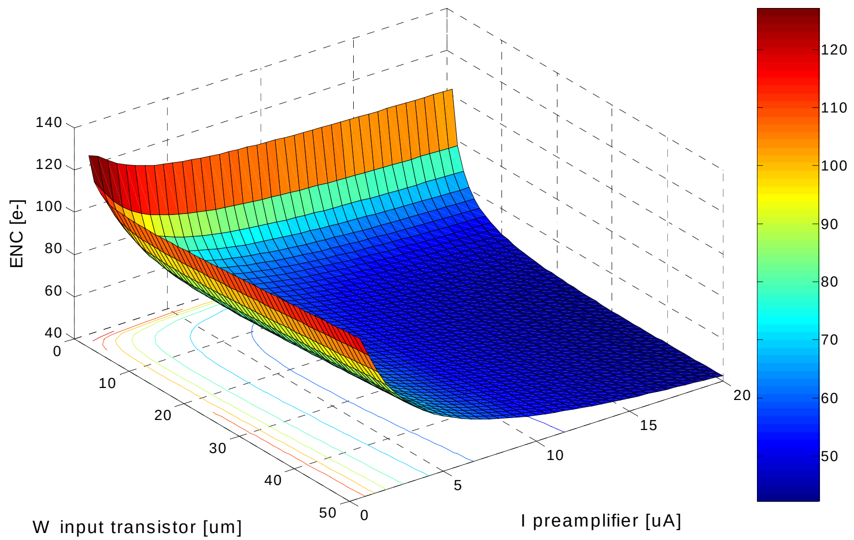


K. Poltorak

R&D: Charge Summing Pixel Detector readout

M. Campbell

- Derived from Medipix3 work
- Pulse processing front-end like LHC
- Clean pattern recognition (noise 100 e^{-}rms, threshold 1500e^{-})
- 10-20ns time tag

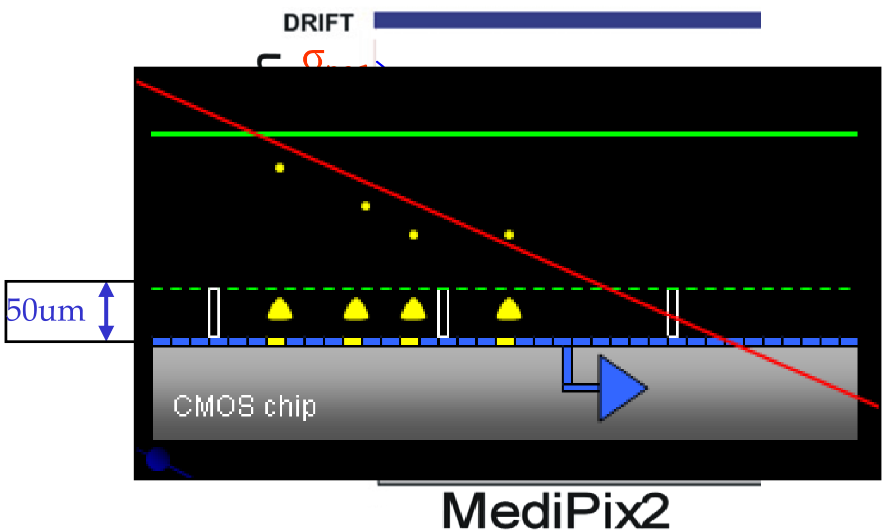


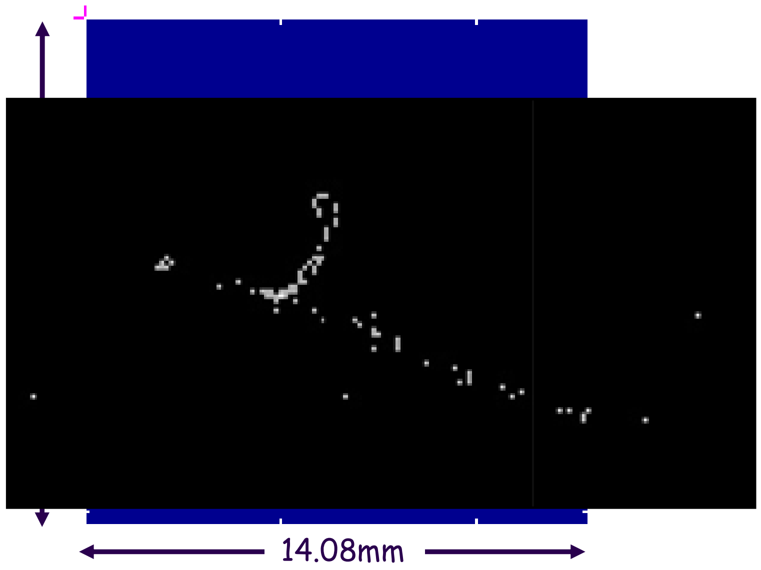
R.Ballabriga

R&D: Timepix-like readout

M. Campbell

A novel approach for the readout of a TPC at the future linear collider is to use a CMOS pixel detector combined with some kind of gas gain grid
Using a *naked* photon counting chip Medipix2 coupled to GEMs or Micromegas demonstrated the feasibility of such approach



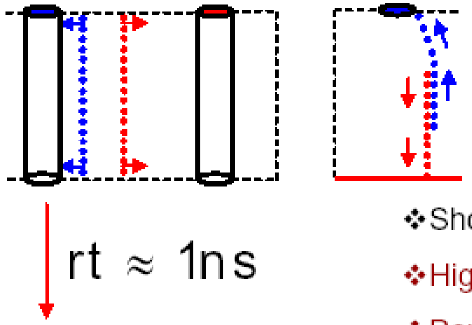


Micromegas
GEM
Michael Campbell

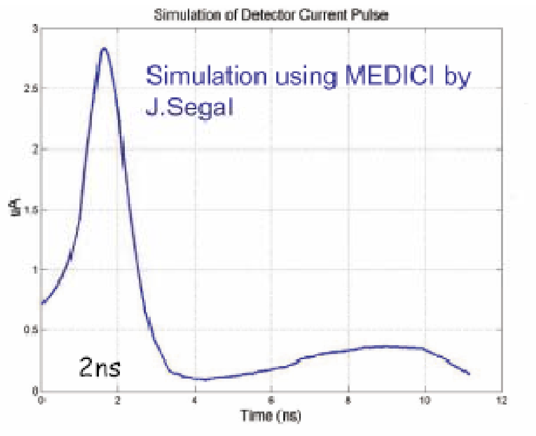
R&D: 3D Detectors

C. Da Via

3D sensor speed



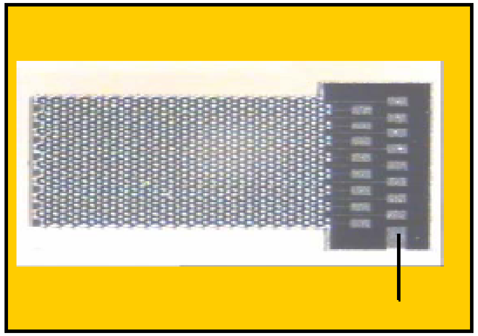
- Short collection distance
- High average e-field at low V_{bias}
- Parallel charge collection



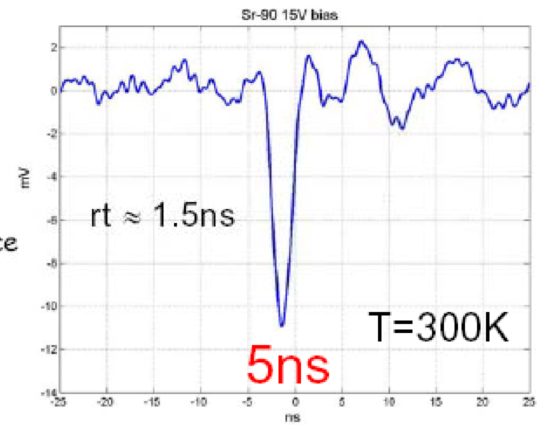
3D simulation

3D Tests 0.13 μm CMOS Amplifier chip

(designed by Depeisse-Anelli-CERN MIC)



oscilloscope trace

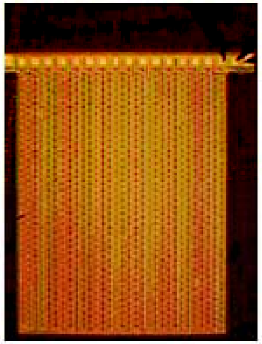


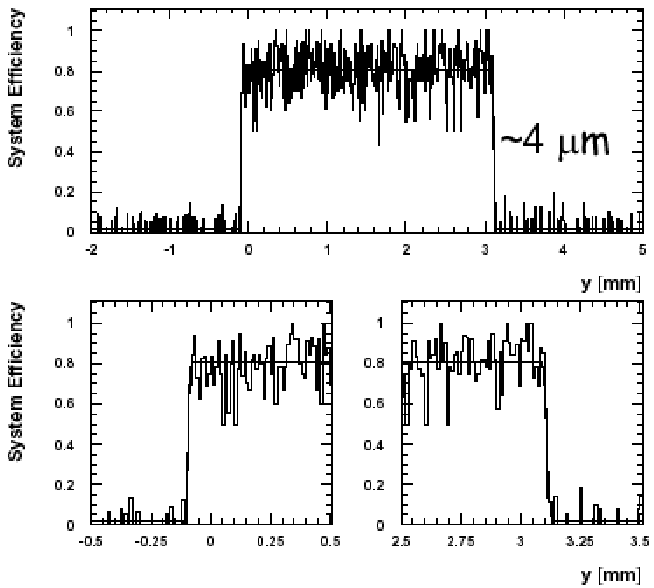
3D Inter-electrode distance = 50 μm

R&D: 3D Detectors

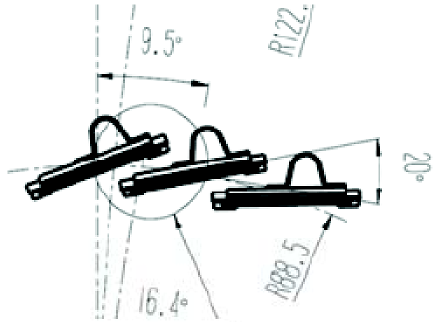
3D active edge
Acceptance and material budget

Cinzia Da Viá - CLIC workshop-25-09-07





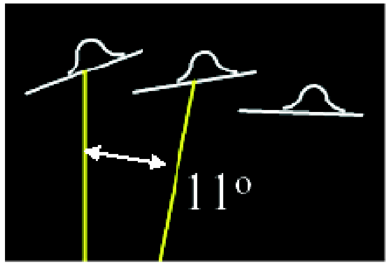
Present design has ~ 500 - 1000 microns dead edge to allow multiple guard rings



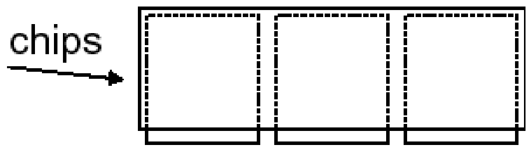
ATLAS Pixel design

Effective Si thickness	680μ	515μ

65%

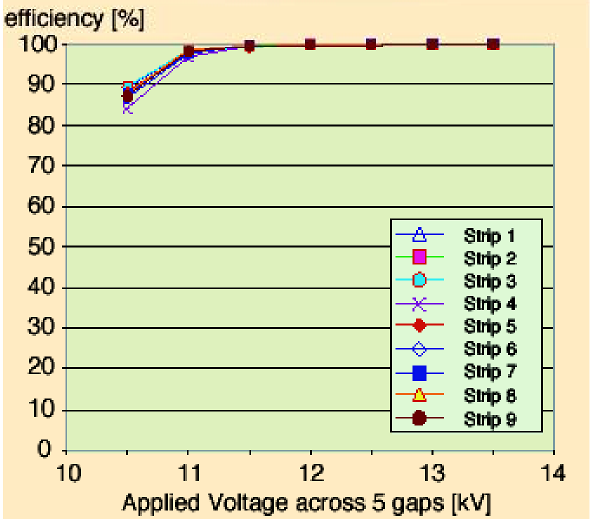


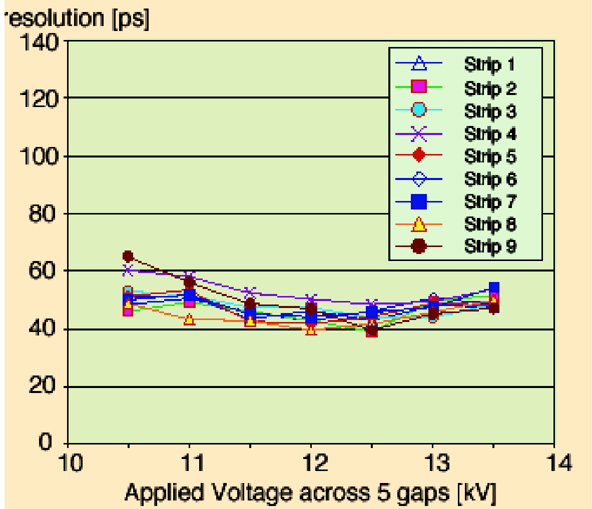
Single chips



Multi-Gap RPC for TOF

ALICE Time-of-Flight array





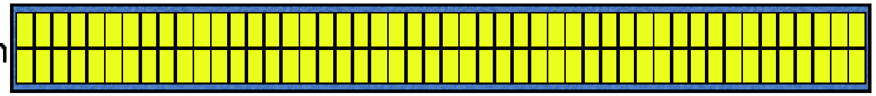
Sunday, 14 October 2007

ALICE TOF strips

→ *C. Williams*

1200 mm

72 mm



96 pads - each 25 x 36 mm^2

(a) long efficiency plateau
(b) time resolution 40-50 ps

n.b. this resolution obtained after correction for slewing. Pulse height measured by time-over-threshold. TDC measures time of both leading and trailing edge. (uncorrected time resolution ~ 100 ps)

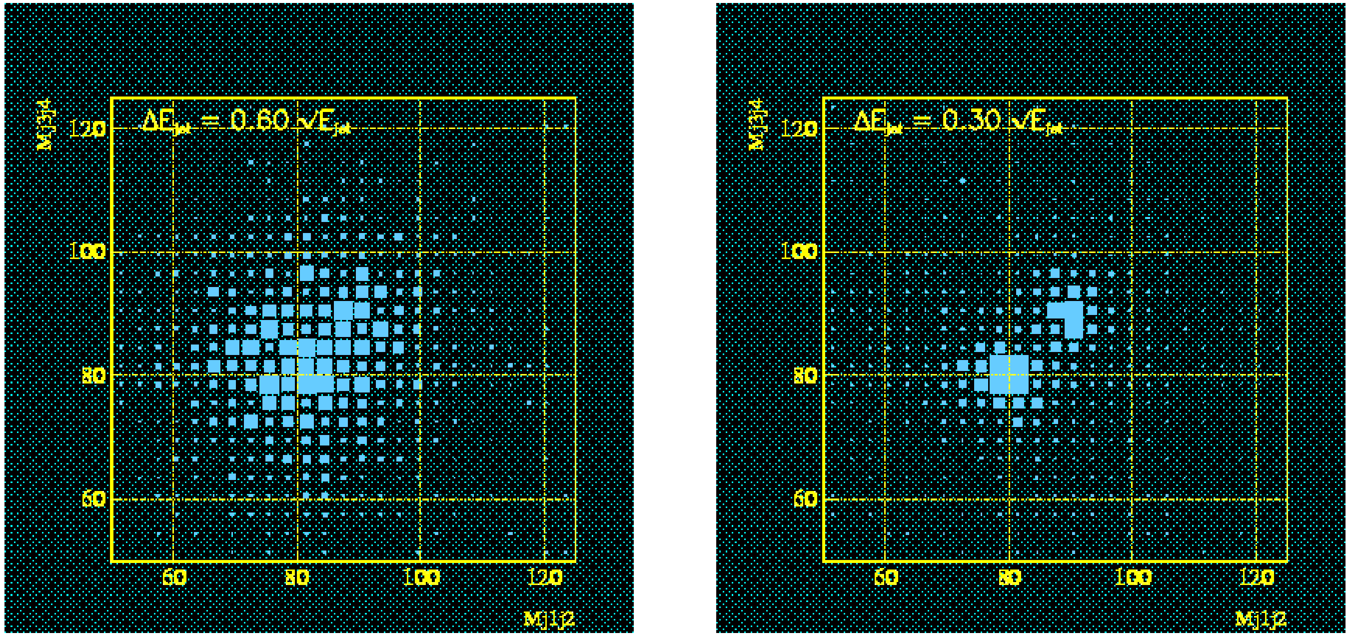
5

Calorimetry

- Lots of developments/studies for ILC (→ Erika Garutti WG6)
- Aim for high jet mass resolution
  - Hermetic and highly segmented calorimeters
    - Optimize for particle flow techniques
  - Dual readout calorimeters for software weighting (DREAM)

- Issues for CLIC that need study:
  - Particle Flow: what is the gain for O(TeV) scale jets?
  - Affordable granularity/size?
  - Effect of detector performance on the Physics?
- Crystal Clear collaboration (→ P. Lecoq WG6): Dual readout calorimeter with heavy scintillating crystalline fibers

Calorimetry: Example



ILC

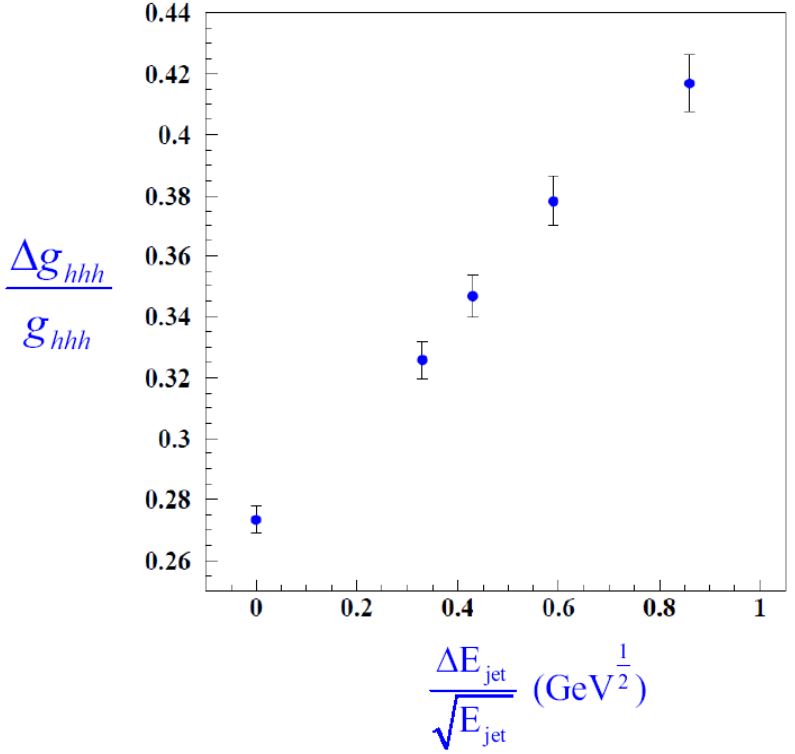
$$e^+e^- \rightarrow \nu\bar{\nu}W^+W^-, \nu\bar{\nu}ZZ\,, \quad W, Z \rightarrow 2\text{jets}$$

Importance of good energy resolution (e.g via energy flow)
Interesting developments and R& D for ILC working groups
e.g. compact 3D EM calorimeters, or "digital" hadronic calorimeters

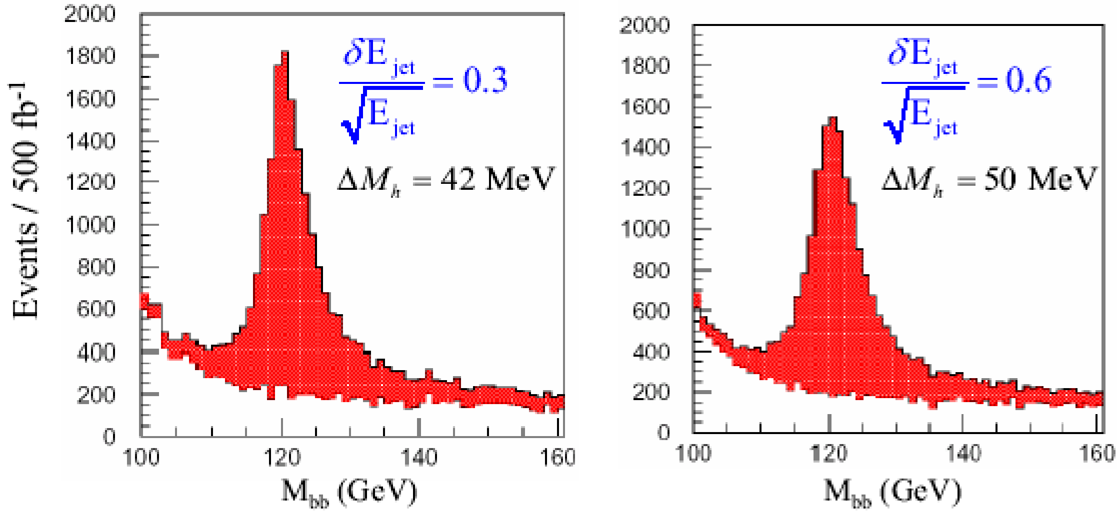
Calorimeter Resolution: Examples

From ILC-DCR document

Triple Higgs coupling



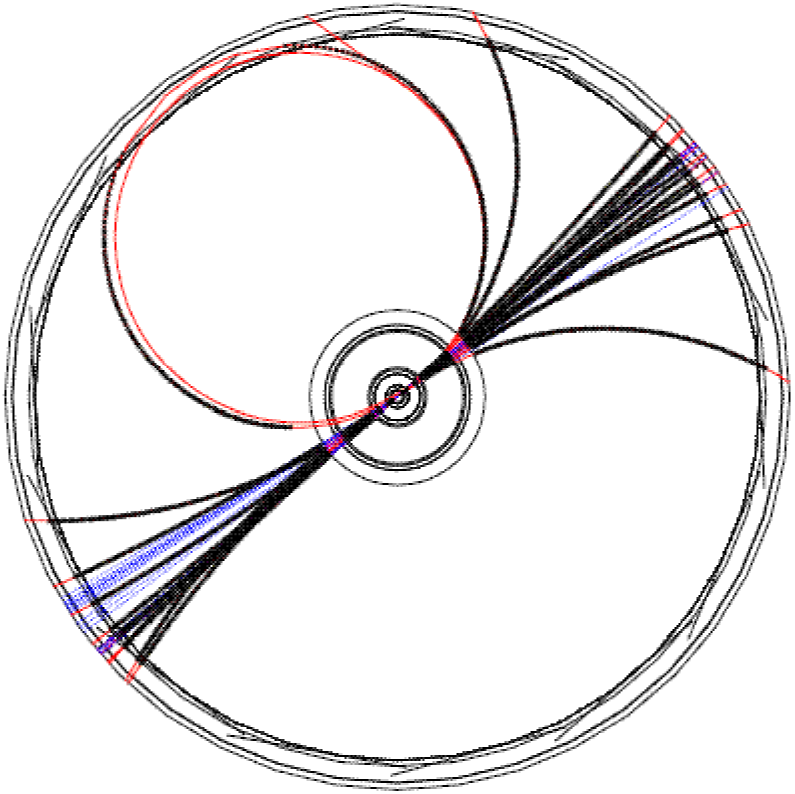
Reconstructed Higgs Di-jet mass



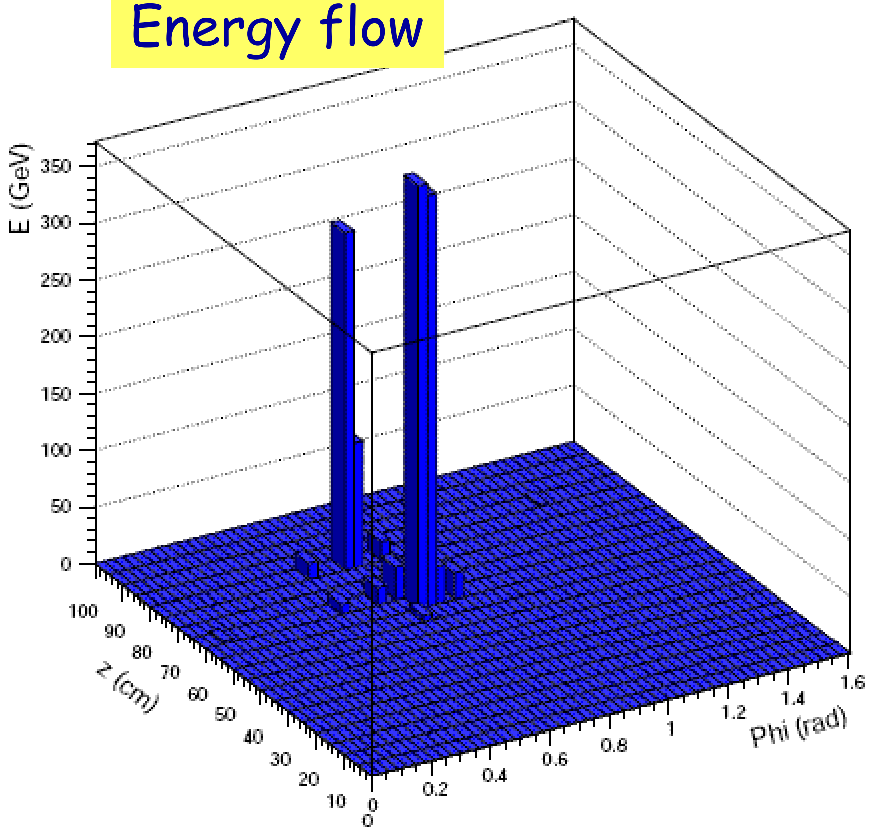
DCR: 2x worse resolution ⇒ Needs ~40% more of luminosity for same precision

Calorimetry

ee→WW at 3 TeV



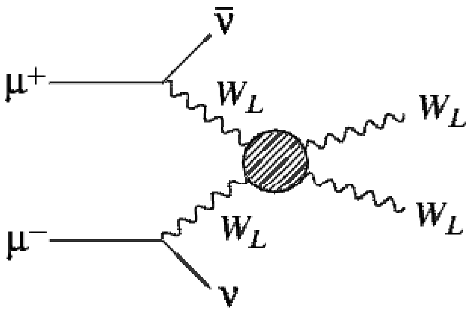
Energy flow

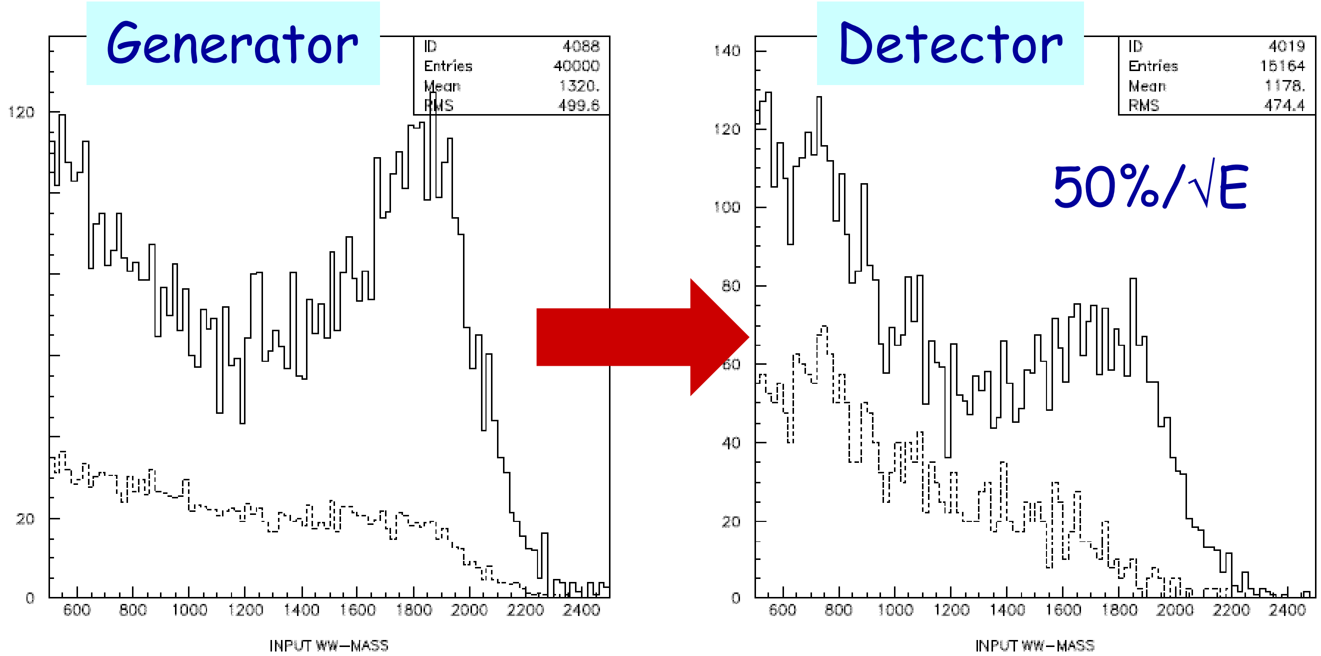


5x5 cm cell size

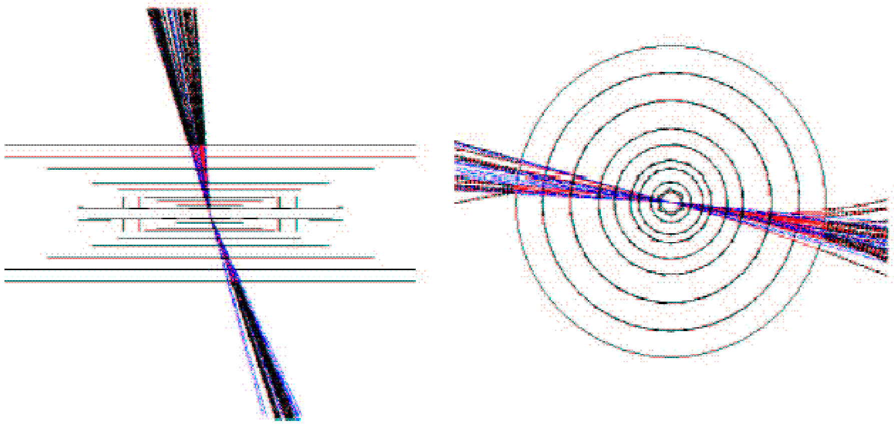
Performance of particle flow at 3 TeV?

WW Scattering: High Energy Jets





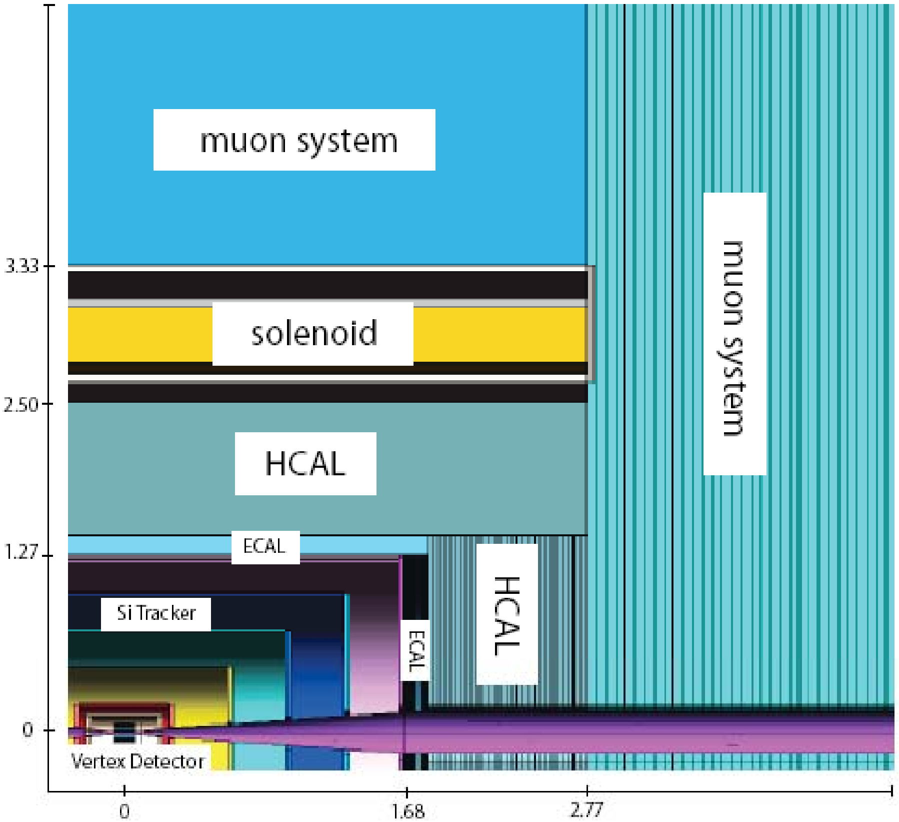
e.g. a high mass resonance
ee→ννWW (ZZ)
Strongly boosted WW (ZZ) pairs.



SiD @ CLIC

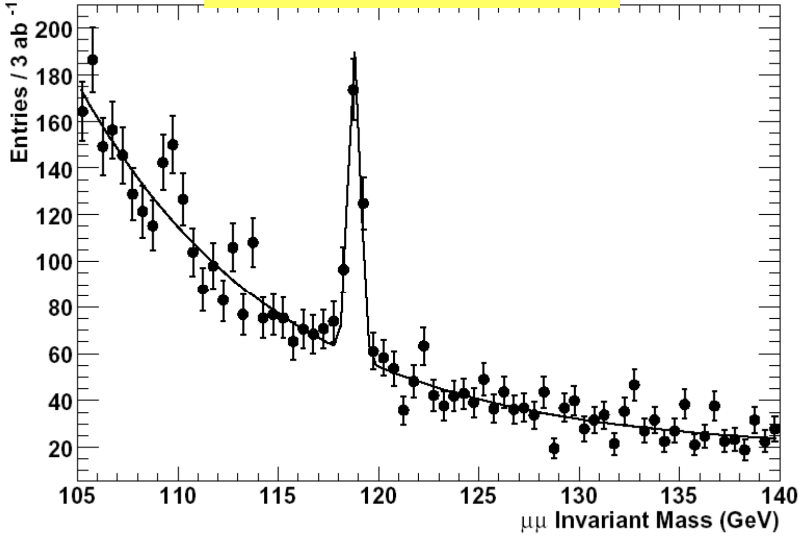
ILC Detector concepts at CLIC?
→Use MOKKA for SiD with 5T

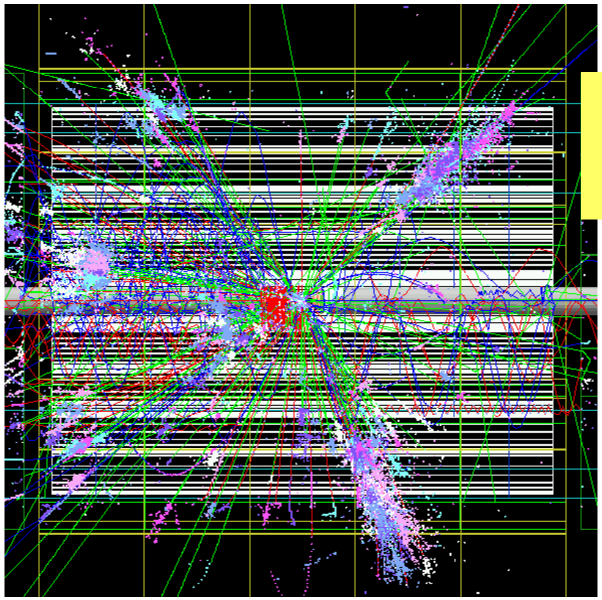
M. Battaglia, WG6



H. Videau → Next talk

$ee \to H\nu\nu \to \mu\mu\nu\nu$

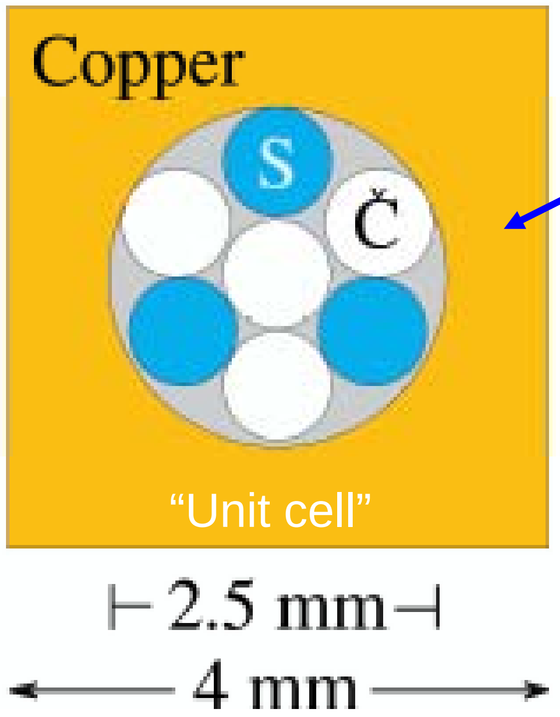




H→tbtb
M_H=890 GeV

Proposal for a Novel Calorimeter

P. Lecoq et al.

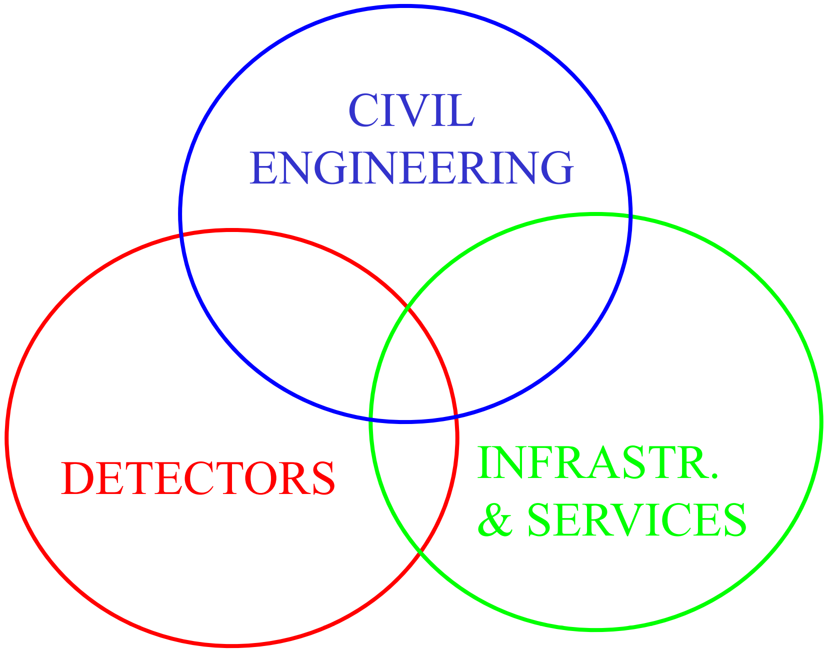


- Detected both total and EM component of shower via detection of scintillating light and cerenkov light, ie the approach of the DREAM concept
- Use instead quasi-homogeneous (scintillating and Cerenkov) fibres of the same heavy material to suppress sampling fluctuations. Adequate metamaterials exist
- Additional neutron sensitive fibers can be incorporated
- Simulation studies needed!

Experiment Integration Desigg and Infrastructures

→A. Gaddi, A. Herve WG6

The choice made by ILC to have two detectors on the same interaction region has led to the push-pull concept. This has a great impact on the layout of detectors infrastructures, because they have to be designed for a "moving" detector. Consequently, the design of services must be integrated with the design of the detector and the civil engineering plans from the beginning.



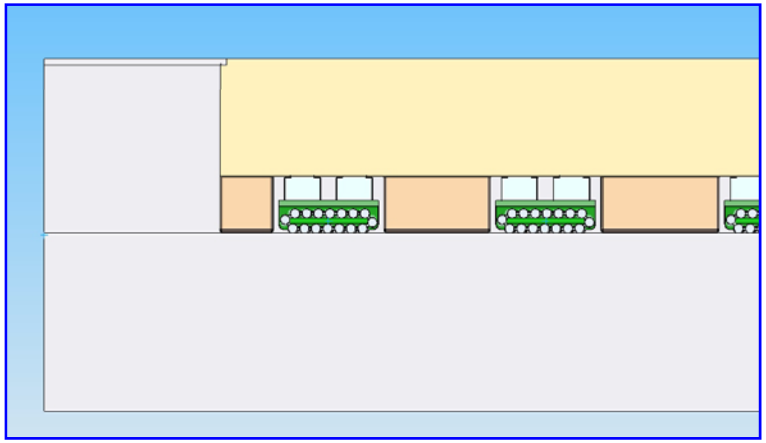
CLIC: >1 experiment! 1 interaction region? ⇒has consequences on layout/design…

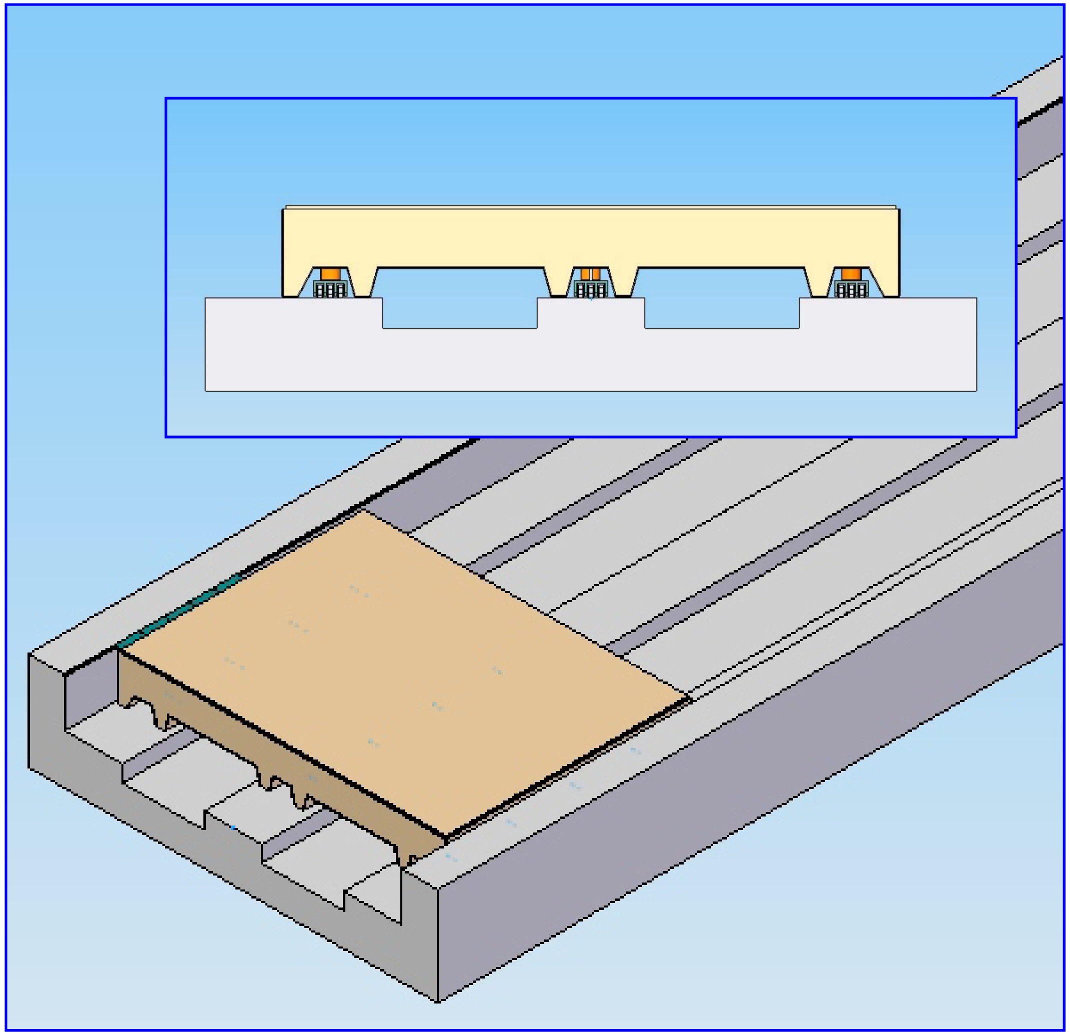
ILC Sliding Platform Design Concept

Concept developed by J. Amann

Platform details:

- 20x15x2m
- 5m wide trenches for cable chain and roller access.
- Steel reinforced concrete or steel plate construction.



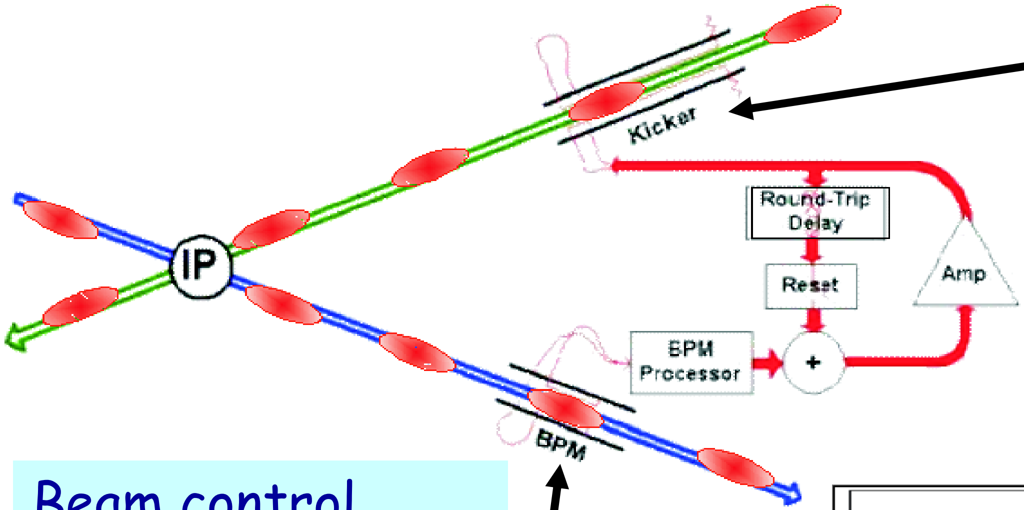


Is this an option for CLIC?   Learn from ILC study

Finally: We need Luminosity

P. Burrows, ILC

We collide nm beams!

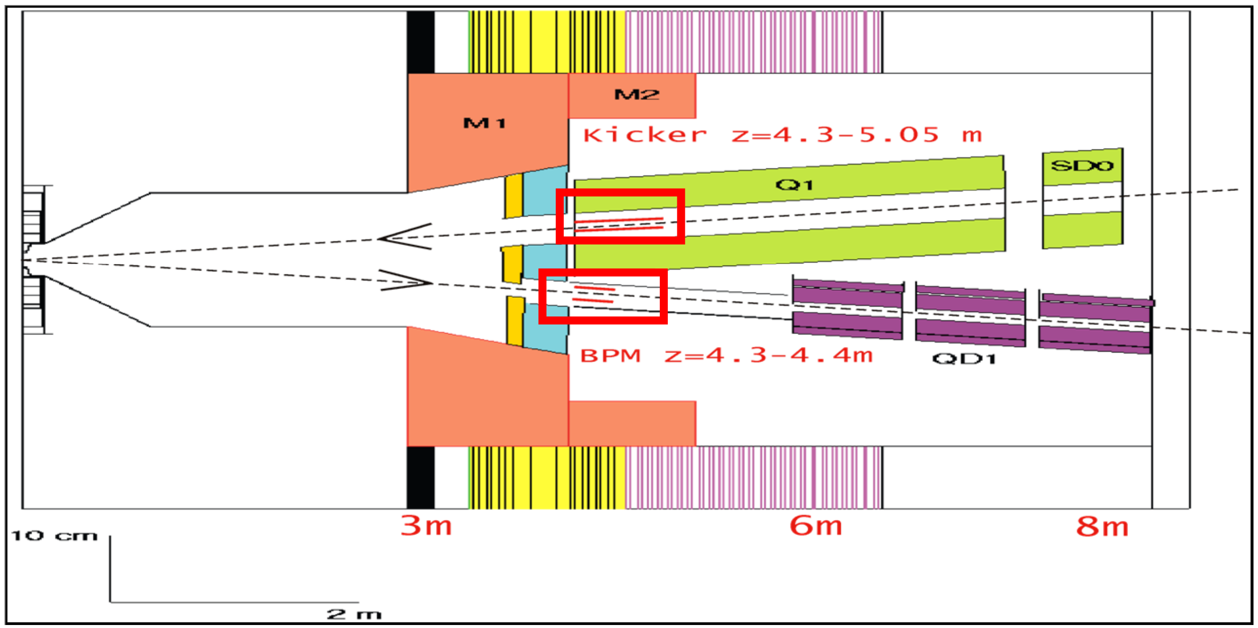


Steer incoming bunches into collision

Very important to get to good/high luminosity!
⇒ Involves experimentalists at ILC

Beam control and fast feedback very important!!!

Measure deflection of outgoing beam



Conclusions

- Experimental conditions at CLIC are more challenging than e.g at LEP, or even a TeV class collider. The CLIC physics study (2004) showed via benchmark studies that CLIC will allow for precision measurements in the TeV range. Little "detector optimization" in that study…
- The backgrounds with the new parametes are close to the old ones. No significant change to the precision is expected
- 'State of the art' detector R&D for detectors for precision measurements ongoing for the ILC. CLIC detector R&D studies should be in close contact (collaboration) with these studies.
- Specific needs for CLIC need to be addressed: E.g. Fast time stamping, particle density, forward region…
- Physics benchmark studies have to be carried out to detector performance (e.g optimized calorimetry, pixle-size,…)
- R&D project proposals are in the pipeline (vertexing, tracking, calorimeter). More details in WG6 this afternoon.

Backup

Proposal

- New technologies in the production of heavy scintillators open interesting perspectives in:
  - Design flexibility: detector granularity
  - Functionality: extract more information than simple energy deposit

- The underlying concept of this proposal is based on metamaterials, and can be derived in eg via scintillating cables made of scintillating fibers of different composition (semi global approach)

Concept

See P. Lecoq in WG6

- Select a non-intrinsic scintillating material (unlike BGO or PWO) with high bandgap for low UV absorption
- The undoped host will behave as an efficient Cerenkov: heavy material, high refraction index n, high UV transmission
- Cerium or Praesodinum doped host will act as an efficient and fast scintillator
  - ≈ 40ns decay for Ce
  - ≈ 20ns decay for Pr
- If needed fibers from neutron sensitive materials can be added:
- All these fibers can be twisted in a cable behaving as an pseudo-homogeneous absorber with good energy resolution and particle identification capability
- Readout on both sides by SiPMT's