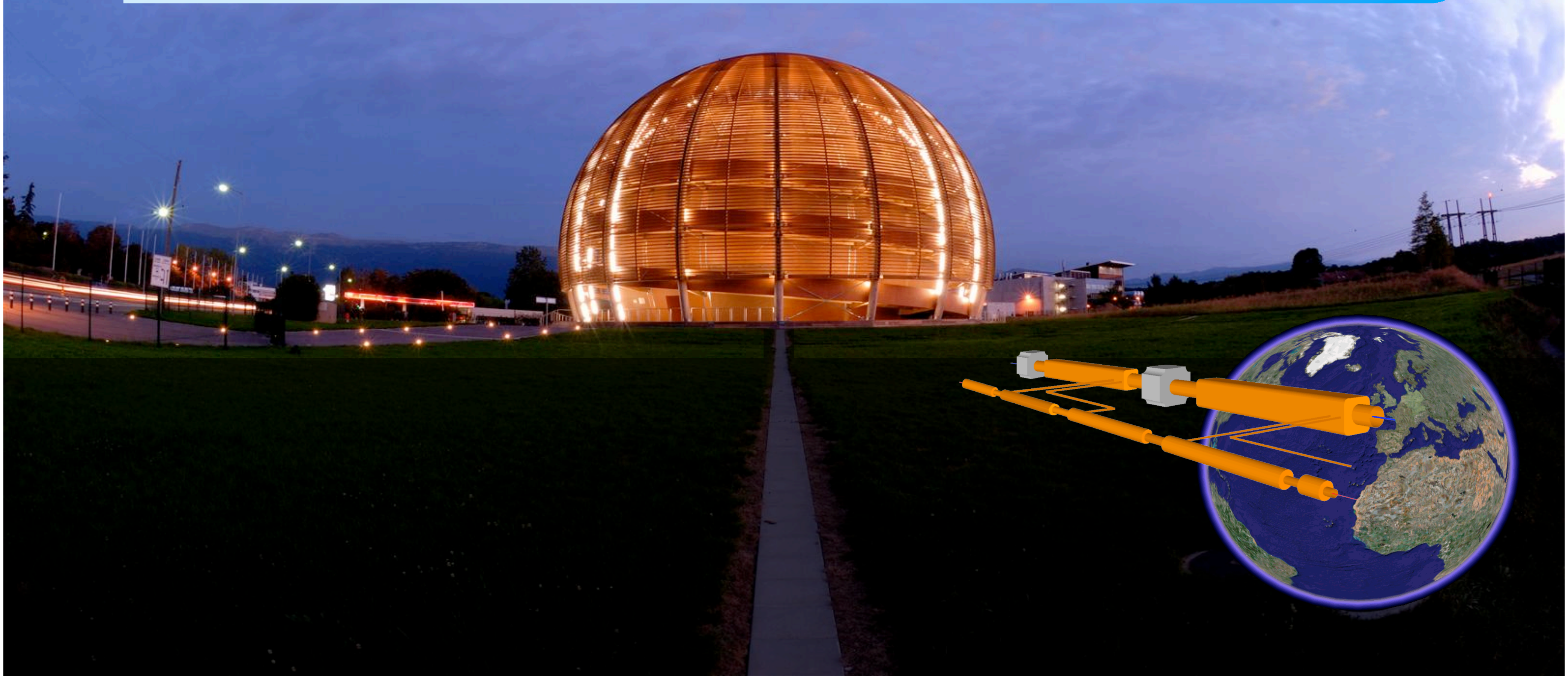
CLIC

ECFA Study
Physics and Detectors for a Linear Collider

CLIC Physics Studies

A. De Roeck / M Battaglia



Physics/Detector studies

- Interests
  - At start: simulation studies to identify critical areas
    - Fast tracking (time stamping), in connection with pixel group
    - TPC studies: usable @CLIC?
    - MDI/FCAL studies. Redesign the MDI area
    - Calorimetry/particle flow, especially for high densities
- Grand plan
  - CLIC CDR by 2010, including a section on detector options
    - TDR for the machine by 2014
  - Capitalize on working with ILC Detector groups
  - Start with some studies with SiD (ILD) detectors
- Since February 08: ILC/CLIC collaboration (machine and detectors)

ILC benchmarks

Compulsory LOI Benchmarking List

At a Dec 7 meeting between Sakue Yamada and representatives of SiD, ILD, 4th Concept, an agreed that the following reactions will be used for LOI Physics Benchmarking:

1. $e^+e^- \to Zh, \to \ell^+\ell^- X, l = e, \mu$; $m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV
2. $e^+e^- \to Zh, Z \to q\bar{q}, \nu\bar{\nu}$; $h \to c\bar{c}, \mu^+\mu^-$; $m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV
3. $e^+e^- \to \tau^+\tau^-$, at $\sqrt{s}$=0.5 TeV
4. $e^+e^- \to t\bar{t}$ at $\sqrt{s}$=0.5 TeV
5. $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- / \tilde{\chi}_2^0\tilde{\chi}_2^0 \to W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ / $ZZ\tilde{\chi}_1^0\tilde{\chi}_1^0$ at $\sqrt{s}$=0.5 TeV

originated from the work of the ILC WWS Benchmark Panel, reported in Battaglia et al, hep-ex/0603010.

…the full list

TABLE III: Table of relations between the benchmark physics processes and parameters of detector subsystems

Process	Vertex	Tracking		Calorimetry		Fwd		Very Fwd	Integration					Pol.
	σ_{IP}	$\delta p/p^2$	ϵ	δE	$\delta\theta$, $\delta\phi$	Trk	Cal	θ^e_{min}	δE_{jet}	M_{jj}	ℓ-Id	V^0-Id	$Q_{jet/vtx}$	
$ee \to Zh \to \ell\ell X$		x									x			
$ee \to Zh \to jjbb$	x	x	x			x				x	x			
$ee \to Zh, h \to bb/cc/\tau\tau$	x		x							x	x			
$ee \to Zh, h \to WW$	x		x		x				x	x	x			
$ee \to Zh,\ h \to \mu\mu$	x	x									x			
$ee \to Zh,\ h \to \gamma\gamma$				x	x		x							
$ee \to Zh, h \to invisible$			x			x	x							
$ee \to \nu\nu h$	x	x	x	x			x			x	x			
$ee \to tth$	x	x	x	x	x		x	x	x		x			
$ee \to Zhh,\ \nu\nu hh$	x	x	x	x	x	x	x		x	x	x	x	x	x
$ee \to WW$										x			x	
$ee \to \nu\nu WW/ZZ$						x	x		x	x	x			
$ee \to \tilde{e}_R\tilde{e}_R$ (Point 1)		x						x			x			x
$ee \to \tilde{\tau}_1\tilde{\tau}_1$	x	x						x						
$ee \to \tilde{t}_1\tilde{t}_1$	x	x							x	x		x		
$ee \to \tilde{\tau}_1\tilde{\tau}_1$ (Point 3)	x	x			x	x	x	x	x					
$ee \to \tilde{\chi}^0_2\tilde{\chi}^0_3$ (Point 5)									x	x				
$ee \to HA \to bbbb$	x	x								x	x			
$ee \to \tilde{\tau}_1\tilde{\tau}_1$			x											
$\tilde{\chi}^0_1 \to \gamma + \not{E}$					x									
$\tilde{\chi}^\pm_1 \to \tilde{\chi}^0_1 + \pi^\pm_{soft}$			x					x						
$ee \to tt \to 6\ jets$	x		x						x	x	x			
$ee \to ff\ [e,\mu,\tau;b,c]$	x		x				x		x		x		x	x
$ee \to \gamma G$ (ADD)				x	x			x						x
$ee \to KK \to f\bar{f}$		x									x			
$ee \to ee_{fwd}$						x	x	x						
$ee \to Z\gamma$		x		x	x	x	x							

CLIC Benchmark Processes studied

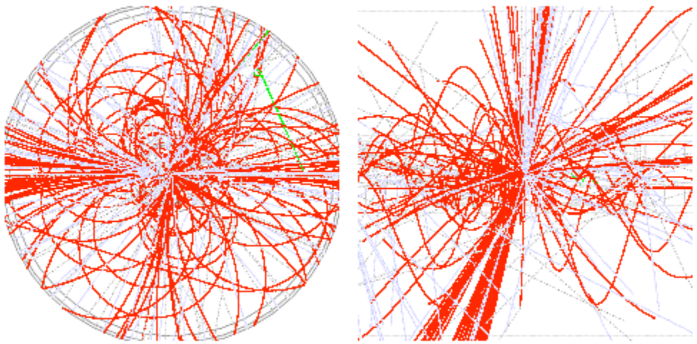
Table 3.1: Physics signatures and CLIC physics programme: matrix of the simulated processes

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

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
$\langle N_{\rm Jets}\rangle$	2.8	4.2	4.8	5.3	6.4	6.7

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



Benchmark

- Similarly: we need to select benchmark processes for the detector performance
  - Single particles, jets,...
  - WW production with structure in the TeV range
  - Top production or heavy charged Higgs (multi-jets)
  - Smuons/SUSY particle reconstruction (neutralino reconstruction? Special DM regions?)
  - Higgs rare decays / Higgs self coupling
  - Resonance (Z') reconstruction/scan
  - B's, Taus related events? ee$\rightarrow$ ff
- Performance studies for the physics case
  - Study of new channels (unparticles, Quirks, ...)
  - Precision cross sections, asymmetries,..
  - Precision of mass determinations
  - Precision of couplings
  - Spin information

Strategy (CDR timescale)

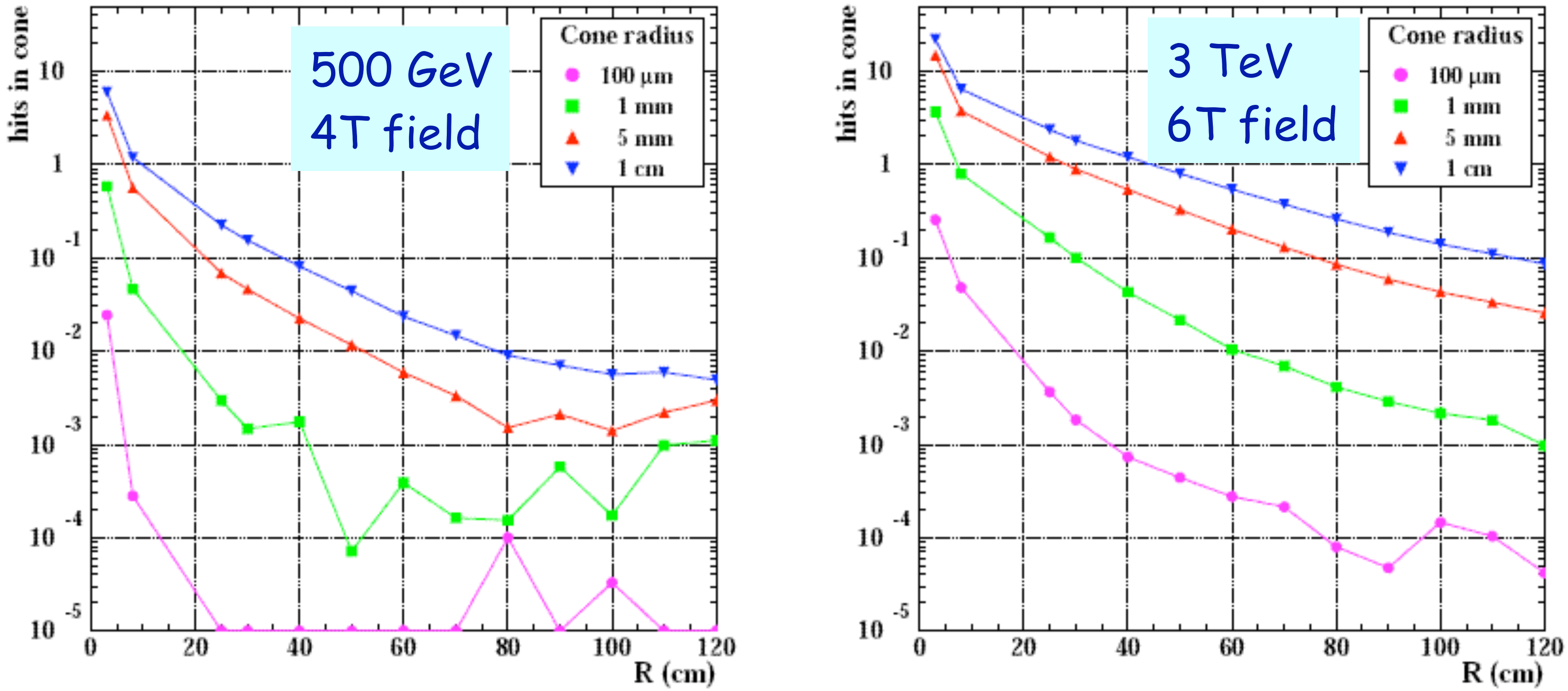
- Take a ILC detector and check performance for CLIC physics program
  - Current choice to take SID for full simulation
  - Keep an eye on ILD
- Modify ILC detector: use fast parametrization?
  - Marlin framework would allow to add CLIC module
- Setting up tools & computing for the CDR studies (~as in 2001)

A few comments

- The detector size (ECal radius and main tracker length). The usual scaling law of 0.15 BR^2/p_T, which gives the distance of a charged particle with p_T wrt a neutral at radius R dictates an increase in radius but much of the CLIC physics will have multi-jet final states, so it requires to be looked into.
- The number of layers in the main tracker. Five, as in the SiD, seems a bit marginal already at 0.5 TeV.
- Forward calorimetry. Spiraling charged particles will give a spatially decorrelated background to neutral detection which needs to be assessed.
- Other issues: machine-related backgrounds and the radius of the innermost Vertex layer (with Daniel).

Issues: 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

CLIC Simulation with SiD

Marco Battaglia, CLIC workshop and follow-up

- Include CLIC $\gamma\gamma$ background (50 bunch crossings)
- Include CLIC luminosity spectrum
- Study $ee \rightarrow \nu\nu H$, $ee \rightarrow H^+H^-$ and $ee \rightarrow$ smuon pair production

	CLIC	SiD DOD
Vertexing	$15+35/p_t$	$5+10/p_t$
$\delta p_t/p_t^2$ (100 GeV)	5.0×10^{-5}	2.5×10^{-5}
B Field (T)	4.0	5.0
ECal	$0.10/\sqrt{E}$	$0.17/\sqrt{E}$

An Example Analysis: $e^+e^- \rightarrow \nu_e\nu_e H \rightarrow \mu^+\mu^-$

$\sigma(e^+e^- \rightarrow H\nu\nu) = 0.51$ pb
for $M_H = 118.8$ GeV, $E_{cm} = 3$ TeV

$BR(H \rightarrow \mu\mu) = 0.026$ %

SM Background
$\sigma(e^+e^- \rightarrow \mu\mu\nu\nu) = 4.7$ fb

M. Battaglia, submitted to J. Phys G

For 5 ab^{-1}

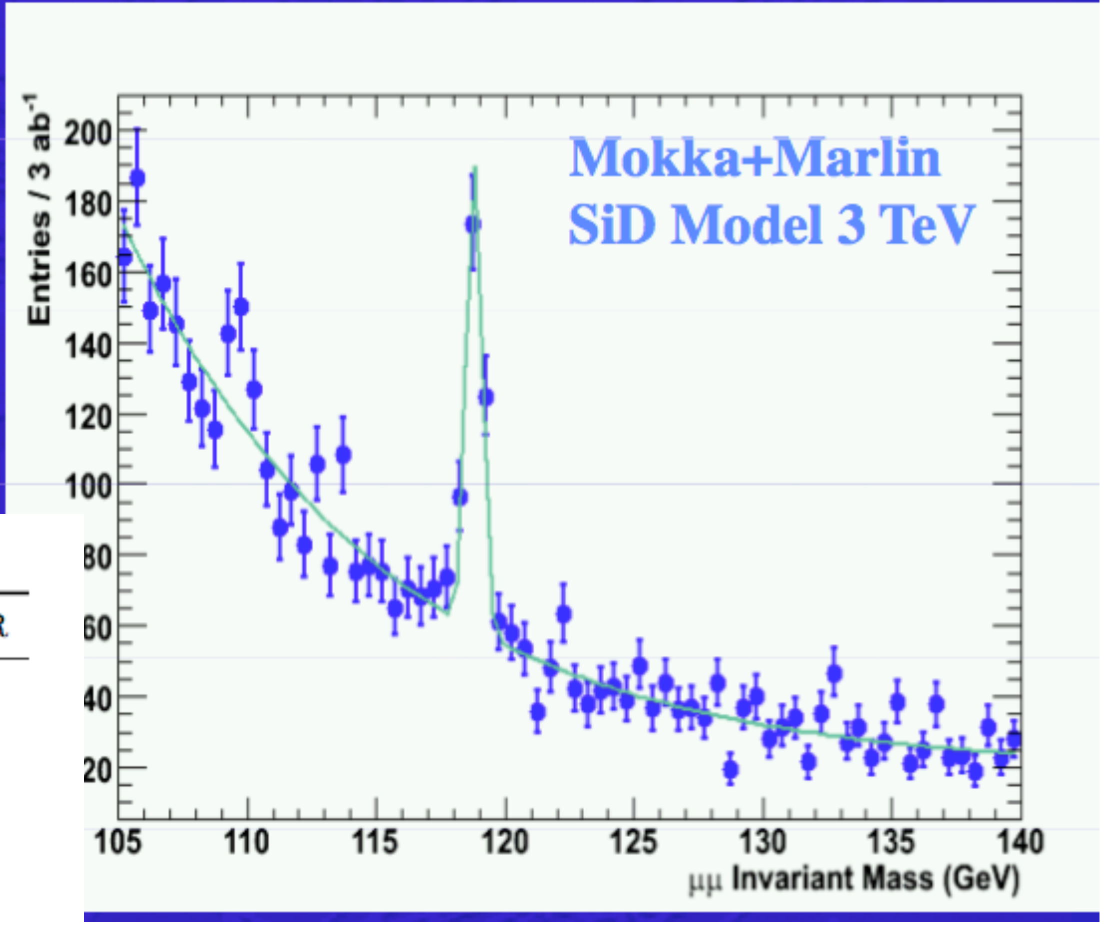


Table 1. Number of selected signal and background events.

M_H (GeV)	Nb. Signal Evts.	Nb. Bkg. Evts.	$S/\sqrt{B}$	$\delta BR/BR$
120	229.6	161.1	18.1	0.086
130	153.1	88.1	16.3	0.101
140	103.2	64.3	12.9	0.125
150	68.1	58.1	9.5	0.160
155	68.1	58.0	5.2	0.253
160	12.1	33.0	2.1	

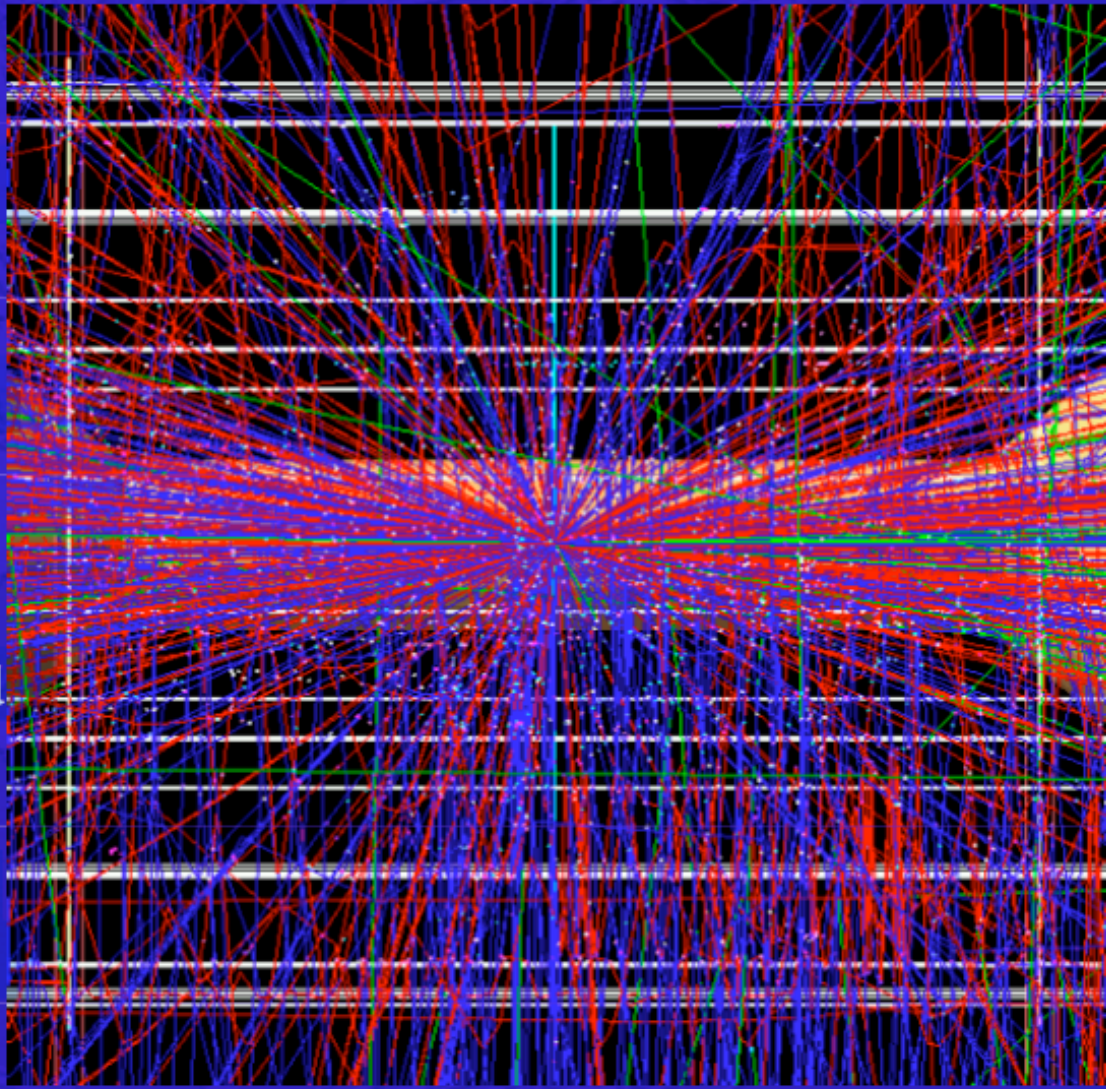
Questions for the Study

B Field strength

B=5 T adequate for $\delta p/p$, main constrain to come from confinement of soft particles from bkgs;

Tracker Optimisation

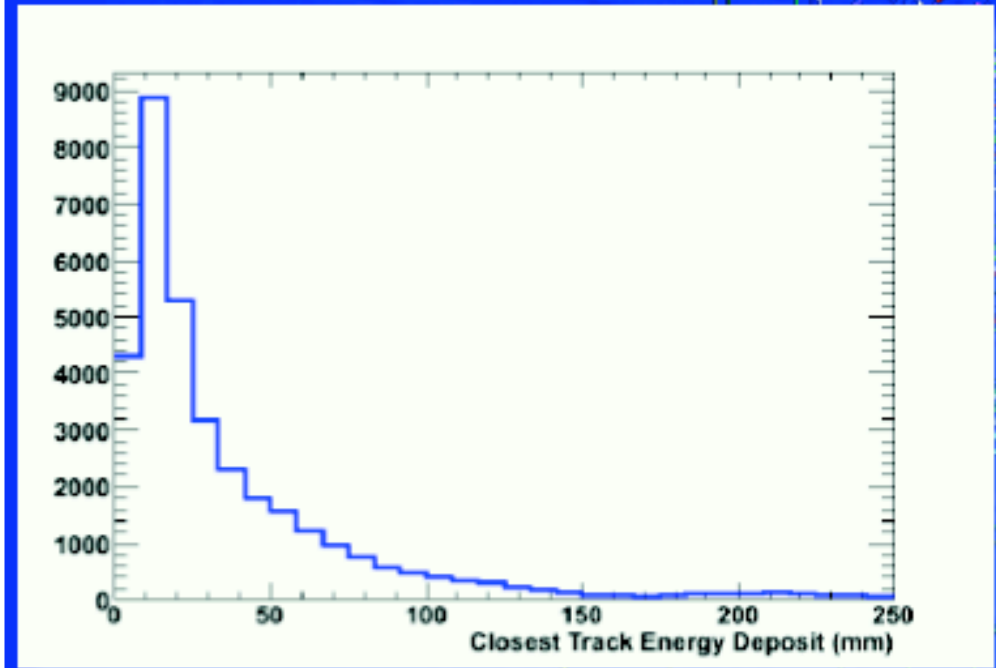
Background and collimated Hadronic jets require to review SiD strategy for track reconstruction and possibly tracker design for CLIC;

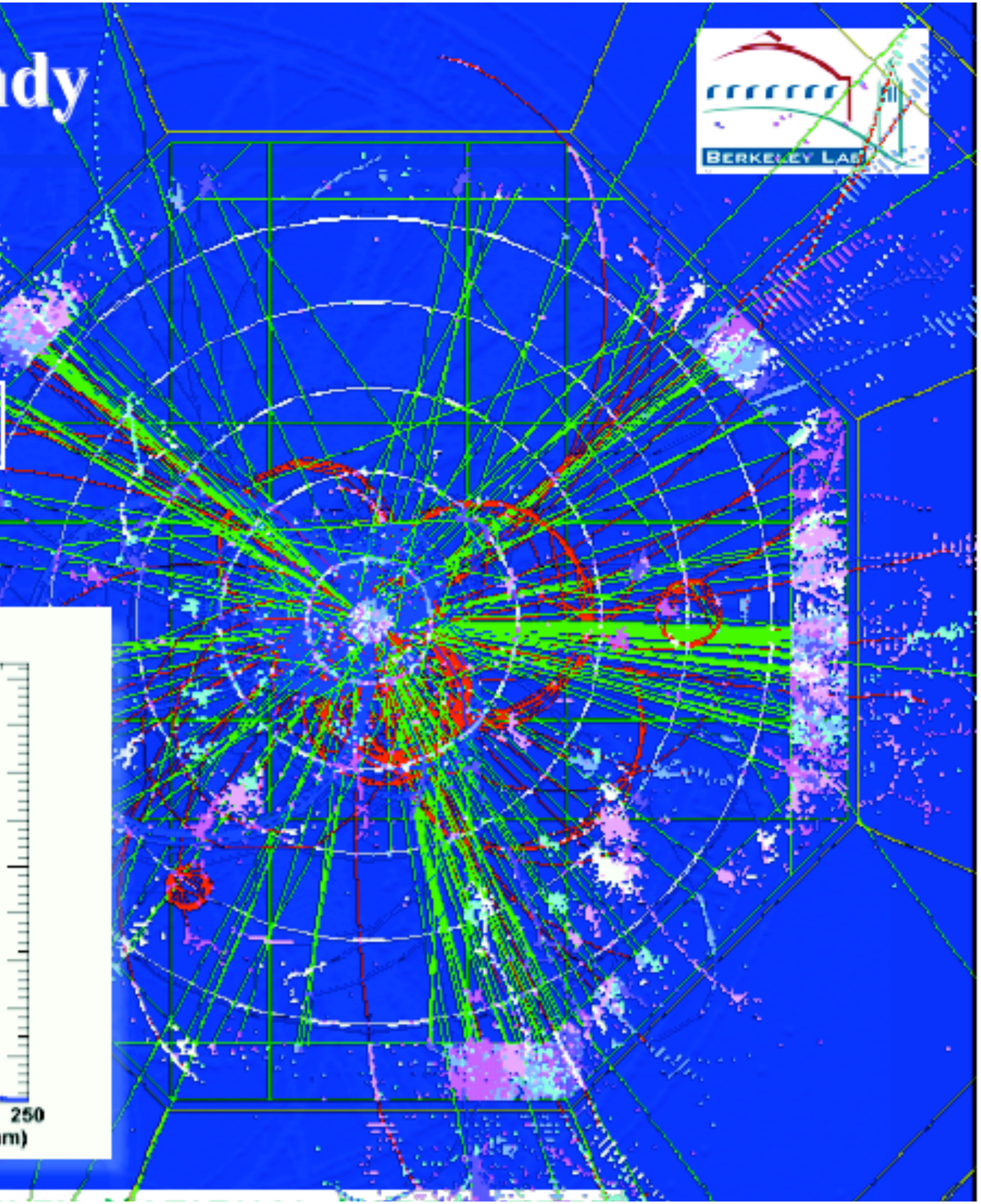


Questions for the Study

Particle Flow Applicability

$e^+e^- \rightarrow H^+H^- \rightarrow tbtb$ at 3 TeV shows limitations in the track-neutral separation in the ECal.

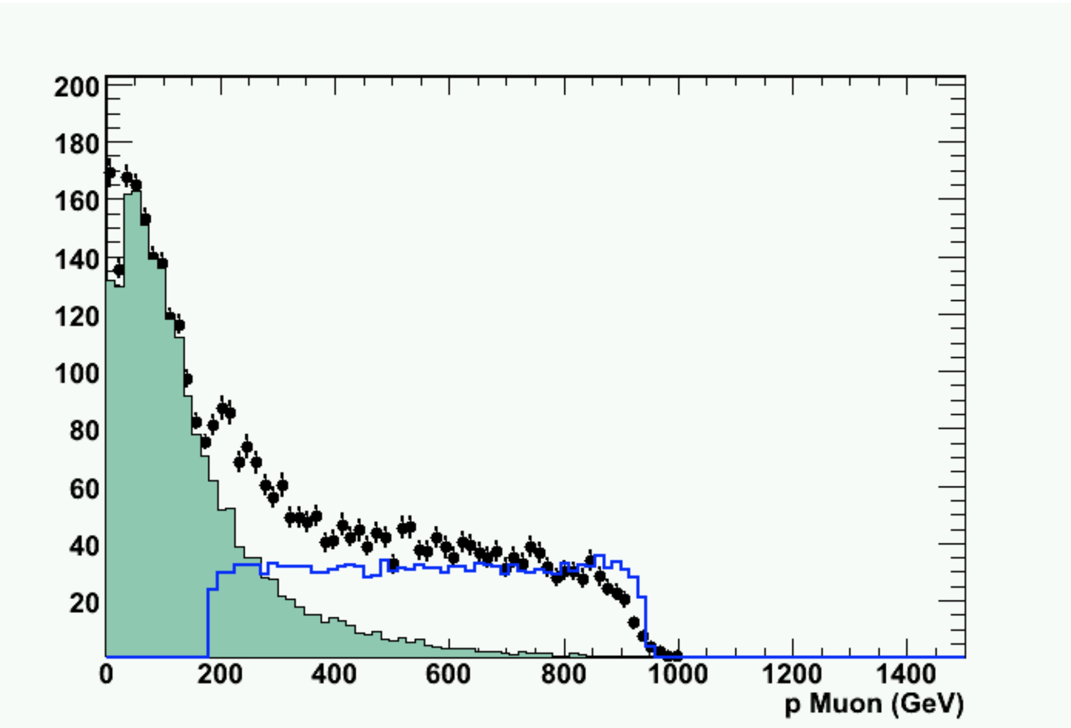


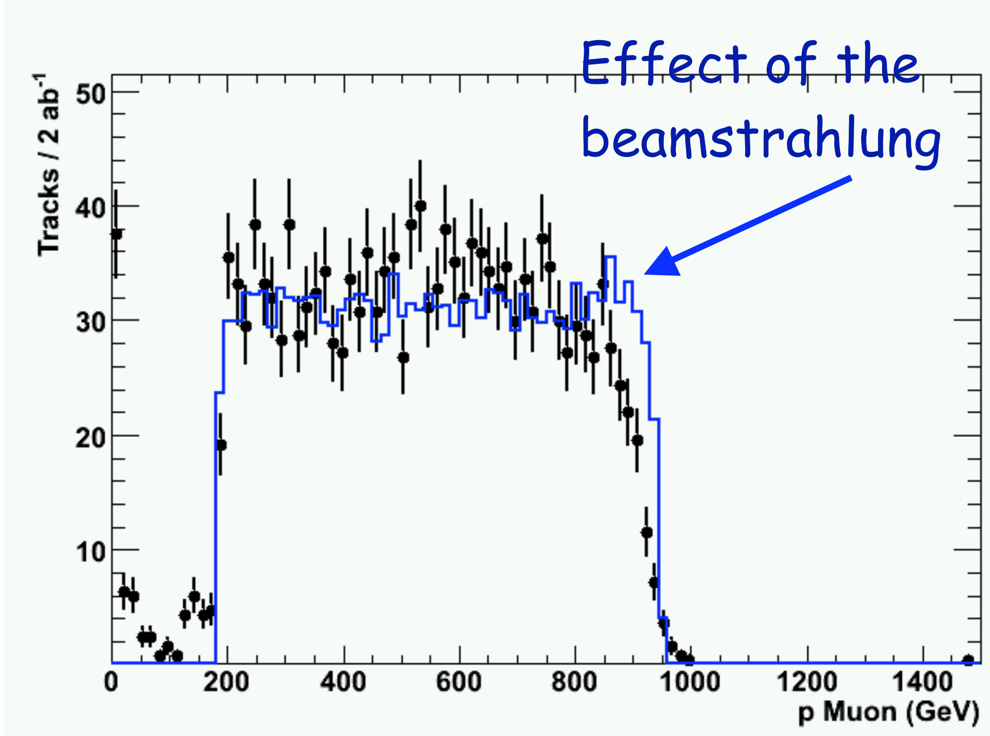


Muons from smuon pair production

Smuon production Benchmark point K, 2 ab^{-1}

M(smuon) = 1100 GeV, M(neutralino) = 550 GeV





Conclusion

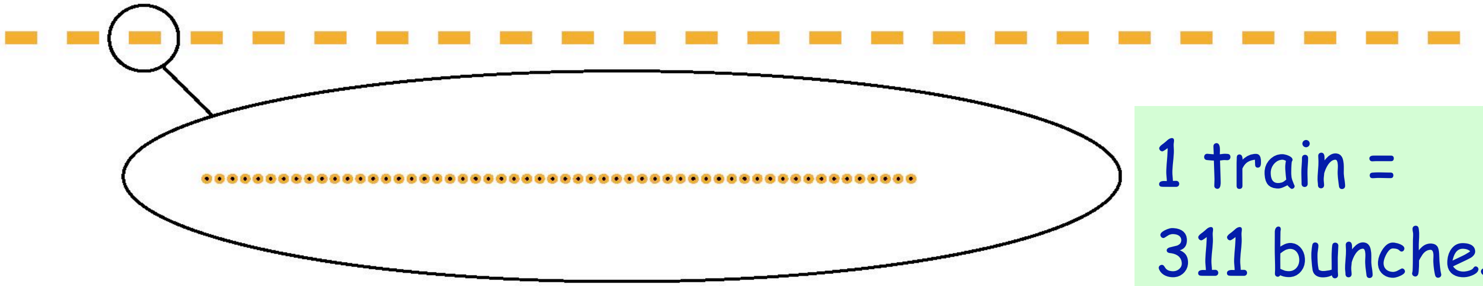
- In order to contribute to the CDR of CLIC in 2010, detector/physics studies need to be performed in the next 2 years
- Some manpower (students, fellow, SA, guests) will become available in the next 2 months @ CERN. But not just CERN! Collaboration with other institutes/groups!!
- Basic tools can be set up centrally (full/fast simulation)
- Regular (bi-weekly) 1 hr meeting planned from September onwards
- We need to select a few benchmark processes to get started
- Additional PH input/manpower will be needed (fraction of time)

Backup

Time Structure of the Beams

Train repetition rate: 100 Hz

CLIC



1 train =
311 bunches
0.5 nsec apart
~ 15 cm

ILC
⇒ 5 Hz 1 train 2625 bunches 369 ns apart

Experimenting at CLIC similar to the "NLC"

Bunch identification?

…the full table

TABLE II: Benchmark reactions for the evaluation of ILC detectors

	Process and Final states	Energy (TeV)	Observables	Target Accuracy	Detector Challenge	Notes
Higgs	$ee \to Z^0h^0 \to \ell^+\ell^- X$	0.35	M_{recoil}, σ_{Zh}, BR_{bb}	$\delta\sigma_{Zh} = 2.5\%$, $\delta BR_{bb} = 1\%$	T	{1}
	$ee \to Z^0h^0,\ h^0 \to b\bar{b}/c\bar{c}/\tau\tau$	0.35	Jet flavour , jet $(E,\vec{p})$	δM_h=40 MeV, $\delta(\sigma_{Zh} \times BR)$=1%/7%/5%	V	{2}
	$ee \to Z^0h^0, h^0 \to WW^*$	0.35	M_Z, M_W, σ_{qqWW^*}	$\delta(\sigma_{Zh} \times BR_{WW^*})$=5%	C	{3}
	$ee \to Z^0h^0/h^0\nu\bar{\nu},\ h^0 \to \gamma\gamma$	1.0	$M_{\gamma\gamma}$	$\delta(\sigma_{Zh} \times BR_{\gamma\gamma})$=5%	C	{4}
	$ee \to Z^0h^0/h^0\nu\bar{\nu},\ h^0 \to \mu^+\mu^-$	1.0	$M_{\mu\mu}$	5σ Evidence for $M_h = 120$ GeV	T	{5}
	$ee \to Z^0h^0, h^0 \to invisible$	0.35	σ_{qqE}	5σ Evidence for $BR_{invisible}$=2.5%	C	{6}
	$ee \to h^0\nu\bar{\nu}$	0.5	$\sigma_{bb\nu\nu}$, M_{bb}	$\delta(\sigma_{\nu\nu h} \times BR_{bb}) = 1\%$	C	{7}
	$ee \to t\bar{t}h^0$	1.0	σ_{tth}	δg_{tth}=5%	C	{8}
	$ee \to Z^0h^0h^0,\ h^0h^0\nu\bar{\nu}$	0.5/1.0	σ_{Zhh}, $\sigma_{\nu\nu hh}$, M_{hh}	δg_{hhh}=20/10%	C	{9}
SSB	$ee \to W^+W^-$	0.5		$\Delta\kappa_\gamma, \lambda_\gamma = 2 \cdot 10^{-4}$	V	{10}
	$ee \to W^+W^-\nu\bar{\nu}/Z^0Z^0\nu\bar{\nu}$	1.0	σ	$\Lambda_{*4}, \Lambda_{*5} = 3$ TeV	C	{11}
SUSY	$ee \to \tilde{e}^+_R\tilde{e}^-_R$ (Point 1)	0.5	E_e	$\delta M_{\tilde{\chi}^0_1}$=50 MeV	T	{12}
	$ee \to \tilde{\tau}^+_1\tilde{\tau}^-_1,\ \tilde{\chi}^+_1\tilde{\chi}^-_1$ (Point 1)	0.5	E_π, $E_{2\pi}$, $E_{3\pi}$	$\delta(M_{\tilde{\tau}_1} - M_{\tilde{\chi}^0_1})$=200 MeV	T	{13}
	$ee \to \tilde{t}_1\tilde{t}_1$ (Point 1)	1.0		$\delta M_{\tilde{t}_1}$=2 GeV		{14}
-CDM	$ee \to \tilde{\tau}^+_1\tilde{\tau}^-_1,\ \tilde{\chi}^+_1\tilde{\chi}^-_1$ (Point 3)	0.5		$\delta M_{\tilde{\tau}_1}$=1 GeV, $\delta M_{\tilde{\chi}^0_1}$=500 MeV,	F	{15}
	$ee \to \tilde{\chi}^0_2\tilde{\chi}^0_3,\ \tilde{\chi}^+_1\tilde{\chi}^-_1$ (Point 2)	0.5	M_{jj} in $jj\not{E}$, $M_{\ell\ell}$ in $jj\ell\ell\not{E}$	$\delta\sigma_{\tilde{\chi}_2\tilde{\chi}_3} = 4\%$, $\delta(M_{\tilde{\chi}^0_2} - M_{\tilde{\chi}^0_1})$= 500 MeV	C	{16}
	$ee \to \tilde{\chi}^+_1\tilde{\chi}^-_1/\tilde{\chi}^0_i\tilde{\chi}^0_j$ (Point 5)	0.5/1.0	$ZZ\not{E}$, $WW\not{E}$	$\delta\sigma_{\tilde{\chi}\tilde{\chi}}$=10%, $\delta(M_{\tilde{\chi}^0_3} - M_{\tilde{\chi}^0_1})$ =2 GeV	C	{17}
	$ee \to H^0A^0 \to b\bar{b}b\bar{b}$ (Point 4)	1.0	Mass constrained M_{bb}	δM_A=1 GeV	C	{18}
-alternative SUSY breaking	$ee \to \tilde{\tau}^+_1\tilde{\tau}^-_1$ (Point 6)	0.5	Heavy stable particle	$\delta M_{\tilde{\tau}_1}$	T	{19}
	$\tilde{\chi}^0_1 \to \gamma + \not{E}$ (Point 7)	0.5	Non-pointing γ	$\delta c\tau$=10%	C	{20}
	$\tilde{\chi}^\pm_1 \to \tilde{\chi}^0_1 + \pi^\pm_{soft}$ (Point 8)	0.5	Soft $\pi^\pm$ above $\gamma\gamma$ bkgd	5σ Evidence for $\Delta\tilde{m}$=0.2-2 GeV	F	{21}
Precision SM	$ee \to t\bar{t} \to 6$ *jets*	1.0		5σ Sensitivity for $(g-2)_t/2 \leq 10^{-3}$	V	{22}
	$ee \to f\bar{f}$ $(f = e, \mu, \tau; b, c)$	1.0	$\sigma_{f\bar{f}}$, A_{FB}, A_{LR}	5σ Sensitivity to $M_{Z_{LR}} = 7$ TeV	V	{23}
New Physics	$ee \to \gamma G$ (ADD)	1.0	$\sigma(\gamma + \not{E})$	5σ Sensitivity	C	{24}
	$ee \to KK \to f\bar{f}$ (RS)	1.0			T	{25}
Energy/Lumi Meas.	$ee \to ee_{fwd}$	0.3/1.0		δM_{top}=50 MeV	T	{26}
	$ee \to Z^0\gamma$	0.5/1.0			T	{27}

Priorities

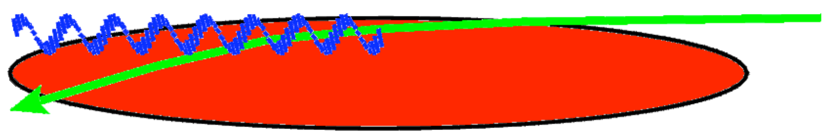
0. Single $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, π^0, $K^{\pm}$, K_S^0, γ, $0 < |\cos\theta| < 1$, $0 < p < 500$ GeV
1. $e^+e^- \to f\bar{f}$, $f = e, \tau, u, s, c, b$ at $\sqrt{s}$=0.091, 0.35, 0.5 and 1.0 TeV;
2. $e^+e^- \to Z^0h^0 \to \ell^+\ell^- X$, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;
3. $e^+e^- \to Z^0h^0$, $h^0 \to c\bar{c}, \tau^+\tau^-, WW^*$, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;
4. $e^+e^- \to Z^0h^0h^0$, $M_h = 120$ GeV at $\sqrt{s}$=0.5 TeV;
5. $e^+e^- \to \tilde{e}_R^+\tilde{e}_R^-$ at Point 1 at $\sqrt{s}$=0.5 TeV;
6. $e^+e^- \to \tilde{\tau}_1^+\tilde{\tau}_1^-$, at Point 3 at $\sqrt{s}$=0.5 TeV;
7. $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- / \tilde{\chi}_2^0\tilde{\chi}_2^0$ at Point 5 at $\sqrt{s}$=0.5 TeV;

Experimental Issues: Backgrounds

CLIC 3 TeV e+e- collider with a luminosity 5.10^{34}-$10^{35}cm^{-2}s^{-1}$ (>0.5 ab^{-1}/year)

E_{cm}	[TeV]	0.5	3	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	0.5
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]	$\approx$ 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	

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

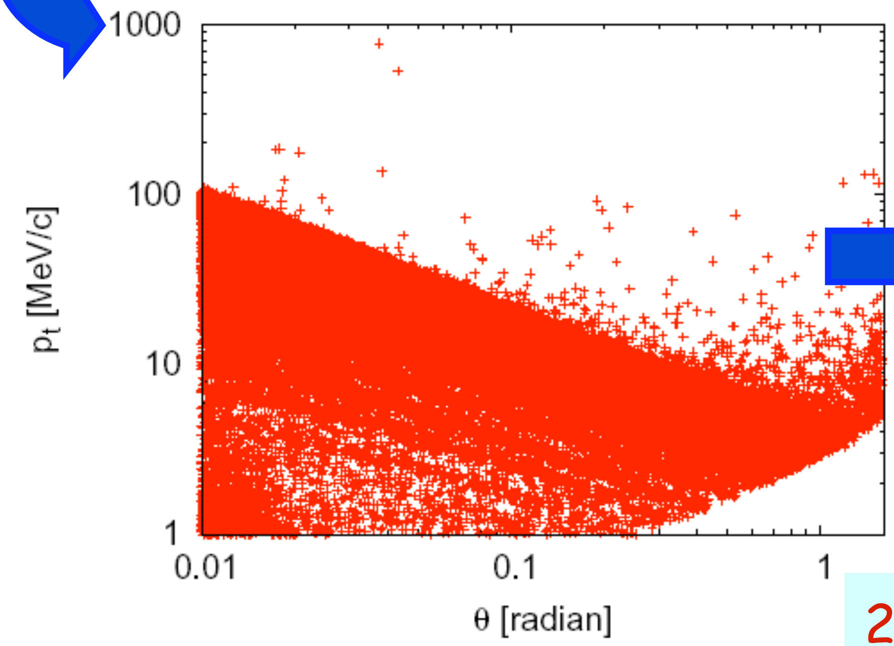
Report →Old values

New values close to those used in the report

e+e- Pair Production

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

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

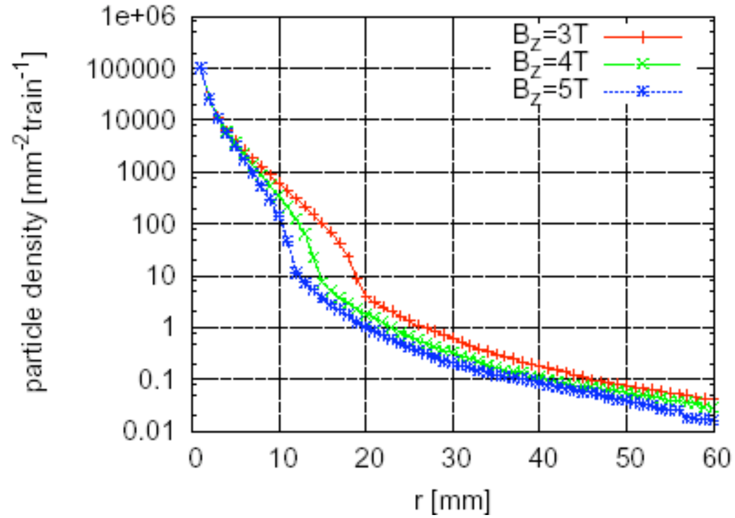


Disappear in the beampipe

Can backscatter on machine elements
Need to protect detector with mask

Can be suppressed by strong magnetic field in of the detector

hits/mm²/bunch train



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

Topics for CLIC/ILC Detector R&D

1) Define a CLIC detector concept at 3 TeV.
(update of 2004 CLIC Study) based on ILC detector concepts.

2) Detector simulations
- Simulation tools to be used by ILC and CLIC (WWS software panel)
- Validation ILC detector options for CLIC at high energy, different time structure, higher densities and different backgrounds
- 1 TeV benchmark studies to provide overlap
- compare performance using defined benchmark physics processes (e.g. WW/ZZ separation)

Topics for CLIC/ILC Detector R&D

3) EUDET /DEVDET (infrastructure for LC detector R&D, with associated non-EU groups)
- microelectronic tools
- 3D interconnect technologies (for integrated solid state detectors)
- simulation and reconstruction tools
- combined test with magnet and LC sub-detectors

4) TPC
- TPC performance at high energies (>500 GeV).
- TPC read out electronics

5) Calorimetry
- Dual Readout Calorimetry (feasible at LC?)

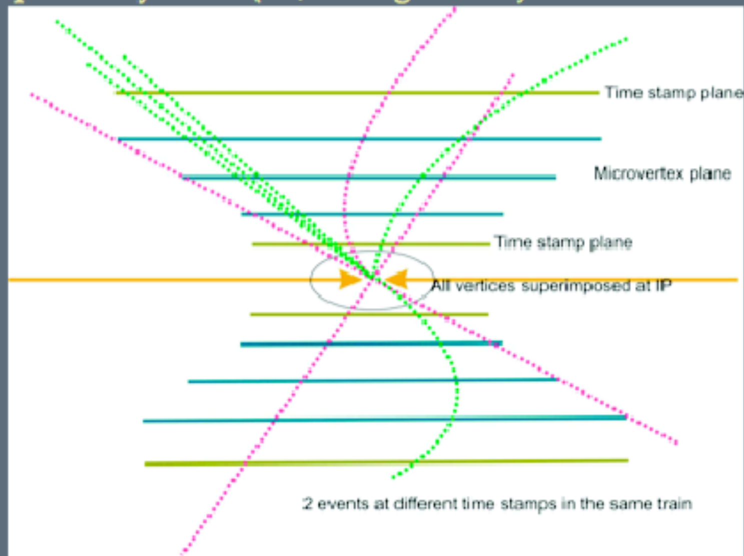
6) General
- increased CLIC participation in future ECFA workshops on LC detectors

Vertex Detector/Tracker at CLIC

P. Jarron
LCW07

Timing Issue at CLIC

- Time tagging of vertices
  - 331 BX's piled up in detector/electronics
- Issue of track reconstruction ambiguities
  - No longitudinal spread of BX interactions
  - Bunch identification by time stamp
    - Ideal time stamp precision 1/6 of bunch separation, 100 ps rms
    - Interaction point very stable (10 µm longitudinal)



CLIC workshop 16-18 Oct. 07 time stamp pixel P. Jarron CERN-PH

Idea: use a coarse pixel planes (300x300 µm) for timing in addition to precision position pixels. Following developments for the NA62 Gigatracker.
Aim for 100ps or better time resolution. Based on 0.13µm CMOS.

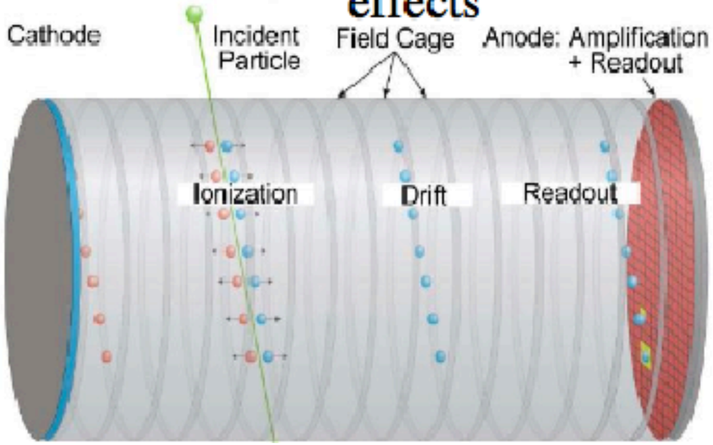
Tracking for CLIC

Silicon tracking… TPC?

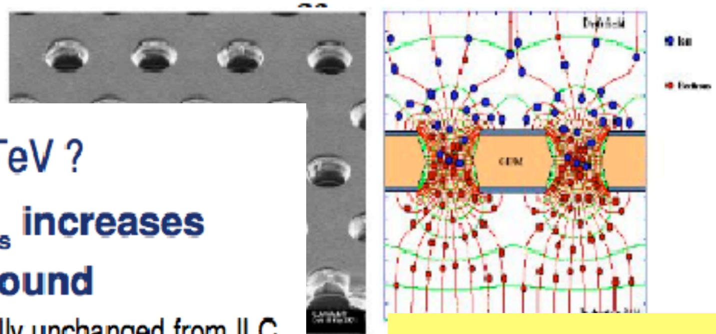
TPC with MPGD

K. Dehmelt
CLIC '07

TPC with
MultiWireProportionalChamber MWPC
has been ruled out: limited by **E x B** effects



MicroPatternGasDetector
MPGD
not limited by **E x B**



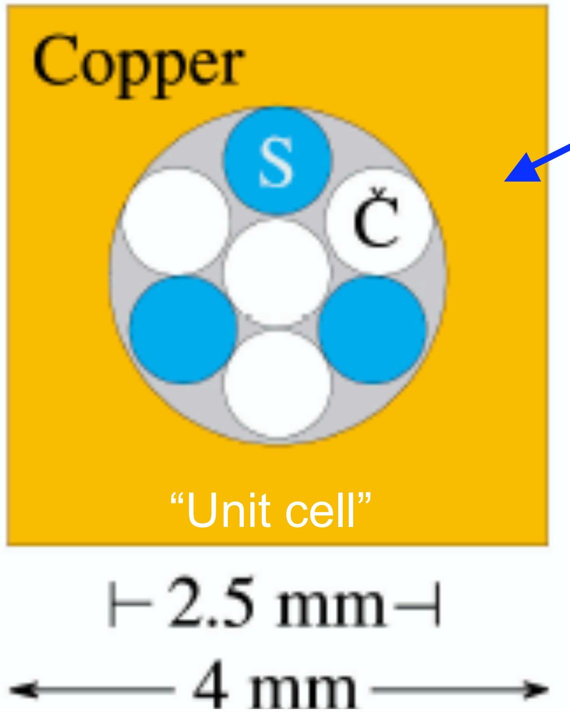
- Is a gaseous tracker viable for E_{cms} = 3 TeV ?
  - **background will be higher as E_{cms} increases**
  - **CLIC: large coherent-pair background**
    → at small polar angle θ, at large angles essentially unchanged from ILC
  - **time stamping: 0.667 ns vs 337 ns ?**
  - **dense jet environment ?**

Discussion indicates that it seems possible

Ideas for Calorimetery

P. Lecoq et al.

DREAM

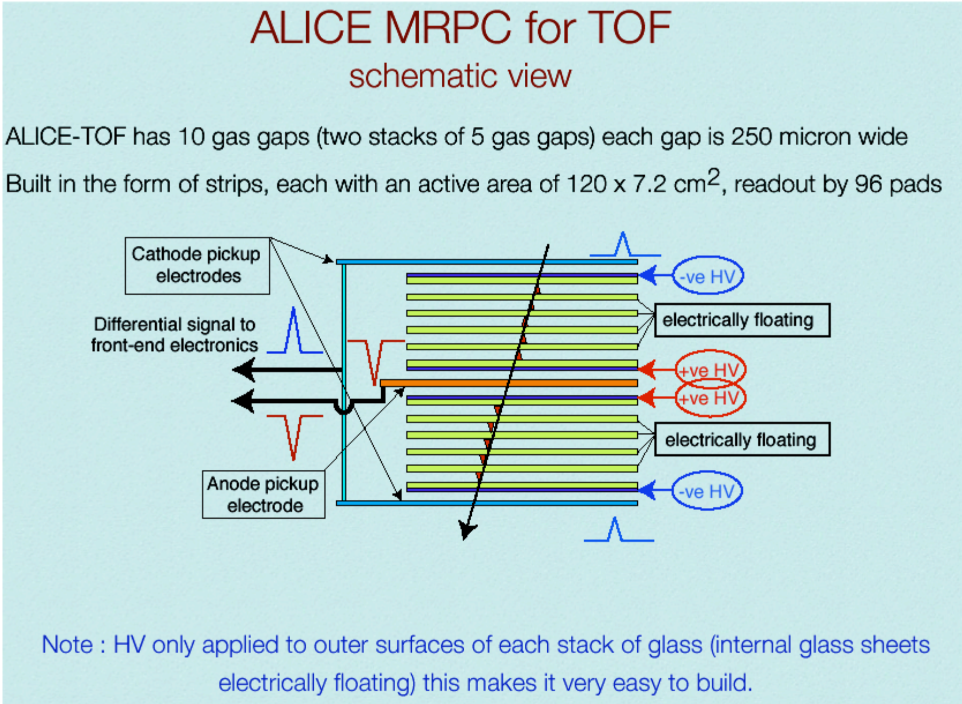


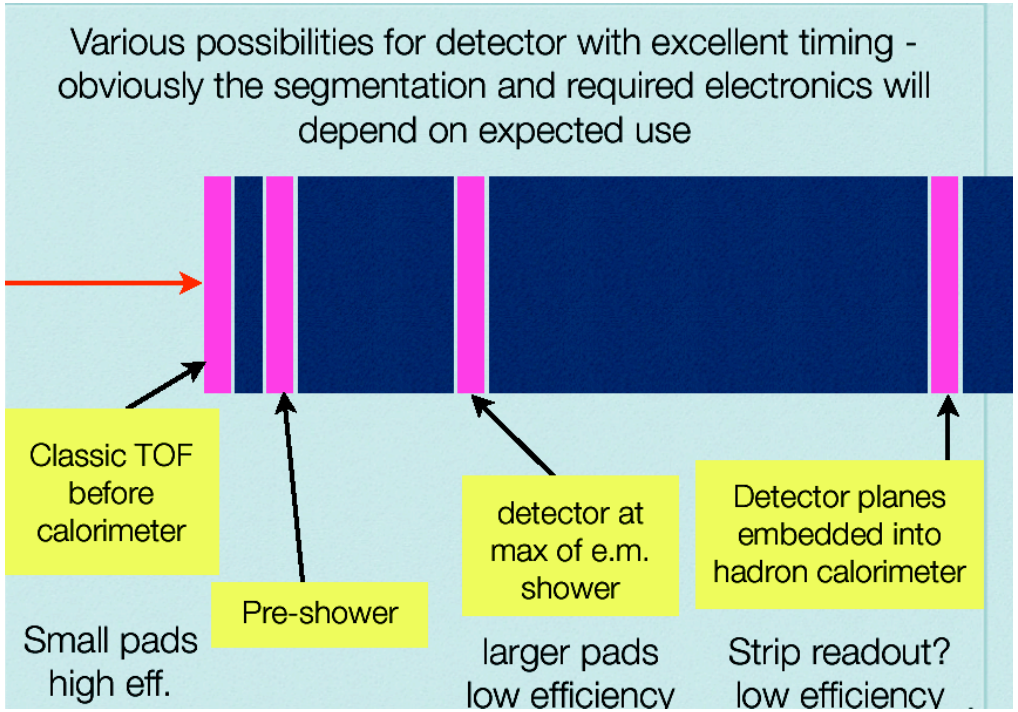
- Detected both total and EM component of shower via detection of scintillating light and cerenkov light, ie the approach of the DREAM concept
- Use instead quasi-homogeneous (scintillating and Cerenkov) fibres of the same heavy material to suppress sampling fluctuations ⇒ fibres are at the same time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

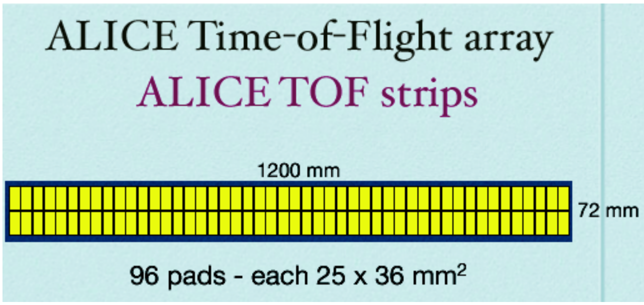
Interested groups from Crystal Clear, DREAM and a growing number institutes

ALICE Time of Flight (MRPCs)

C. Williams CLIC'07







Multigap-RPC→ 150 m^2 with 160000 channels

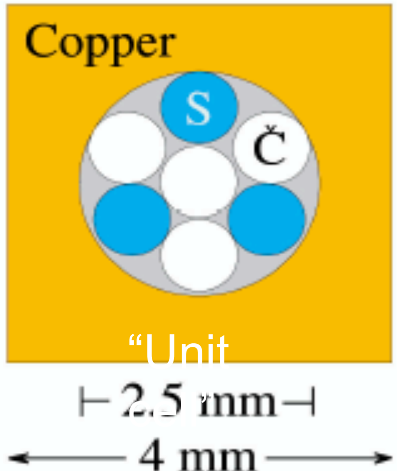
Timing better than 100 ps

Calorimetery: Multi-readout proposal

P. Lecoq et al.

- This approach is based on the DREAM concept
- Added value: quasi-homogeneous calorimeter
  - scintillating and Cerenkov fibres of the same heavy material allowing to suppress sampling fluctuations
- Additional neutron sensitive fibers can be incorporated
- Very flexible fiber arrangement for any lateral or longitudinal segmentation: for instance twisted fibers in "mono-crystalline cables"
- em part only coupled to a "standard" DREAM HCAL or full calorimeter with this technology? Simulations needed

DREAM



Here: use Meta-materials

Interested groups from Crystal Clear, DREAM and a number of growing institutes

Tracking Detectors

- Silicon detectors/TPC (→K. Dehmelt WG6)
- Many developments for Pixel detectors at the ILC (→M. Winter WG6) e.g. new sensor technologies.
  - 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?

  ⇒ fast sensors and electronics

  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. Based on 0.13μm CMOS.
- ALICE TOF proposal (→ C. Williams talk WG6): Large scale TOF with 40ps time resolution

What has happened in the last 8 months

- CLIC 07 workshop (October 07)
  - Important milestone: We had ~200 registered participants, of which ~100 from 54 external institutions
  - Large interest from both CERN and outside
  - Several ideas on detector R&D being presented/ contact with the ILC detector community. Recognized that CLIC needs stronger detector R&D involvement
- Since February: Startup engagement in PH department for LC detector studies (available from September '08 onwards)
  - 2 PhD students
  - 1 Fellow
  - 1 Scientific associate
  - (+ ≥4 part time PH staff)
  - Some resources available for visitors for LC detector studies
  - Collaboration with several other institutes
- Note: CERN involved in EUDET and DEVDET proposal