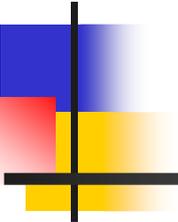
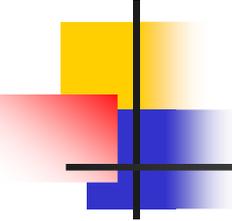


# Detector Cooperation with CLIC



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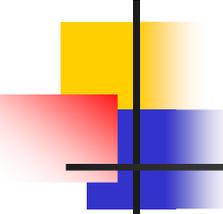
PAC Pohang meeting  
November 3, 2009



# Outline

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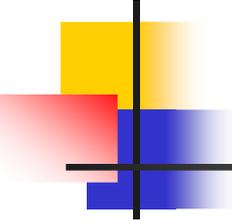
- Introduction
- ILD/SiD for CLIC ?
- Crucial R&D needed
- Political aspects (WG)
- Potential risks
- Conclusions



# Introduction

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- Following the initiative taken by Jean-Pierre Delahaye and Barry Barish, the ILC detector community has increasing technical collaborations with CLIC
- CERN has joined ILD and SiD and the major R&D collaborations and interacts directly with these organizations
- At CERN the DG has launched a 'LC project' beyond the usual technology frontier
- There are 10-12 FTE at CERN
- Will be X2 end of 2010



# Questions

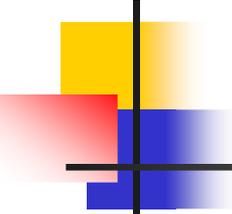
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- Can ILC validated detectors ILD and SiD be used for CLIC at 3 TeV ?
- If not can one define common efforts within the R&D collaborations ? (e.g. calorimetry,  $\mu$ vertex RO, new SC for the coil, push-pull issues, engineering...)
- There is of course a caveat given the different roadmaps: CLIC only foresees a TDR in 2016 but needs to provide a CDR in 2010
- ILC, with limited resources (e.g. in the US), needs to complete a detailed baseline study end of 2012 in conjunction with the ILC TDR
- Any initiative should be considered within the ILC roadmap constraints avoiding diversion in our priorities

# Similar detectors ?

$E_{\text{JET}}$	$\sigma_E/E = \alpha/\sqrt{E_{\text{jj}}}$ $ \cos\theta  < 0.7$	$\sigma_E/E_j$
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 %

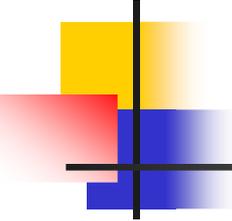
- From studies already reported at PAC (M. Thomson from ILD) PFLOW appears relevant for a multiTeV collider provided that the HCAL is increased to  $\sim 8\Lambda_I$ 
  - CLIC is studying a **W HCAL**, more compact
- Potential benefit for ILC detectors which could reduce the size of the SC coil but costly solution (100€/kg)
- The CALICE collaboration has taken seriously this possibility
- Recall that the PFLOW simulation assumes >99% efficiency on tracking achievable in the ILC environment
- Can this figure be maintained at CLIC at 3 TeV with larger, more energetic  $\gamma\gamma$  background and challenging duty cycle (BX every 0.5 ns) ?



# Challenges with tracking

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- Recall that while SiD assumes perfect time separation (time stamping) of the data recorded at different BX which seems feasible (but challenging) with  $\sim 300$  ns BX separation, ILD assumes  $50 \mu\text{s}$  integration for the  $\mu$ vertex
- For the TPC of ILC  $\gamma\gamma$  events recorded at different BX give well separated vertices which allows topological separation
- CLIC has a 300 BX with 0.5 ns separation



# Consequences

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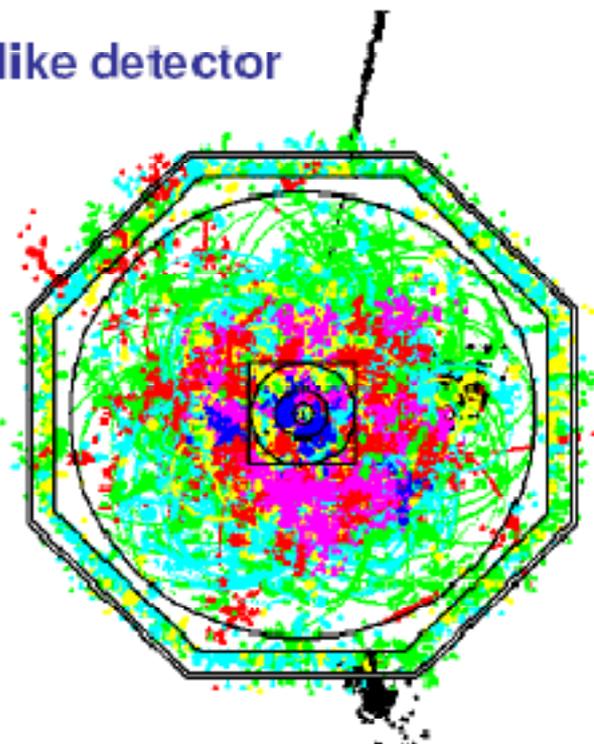
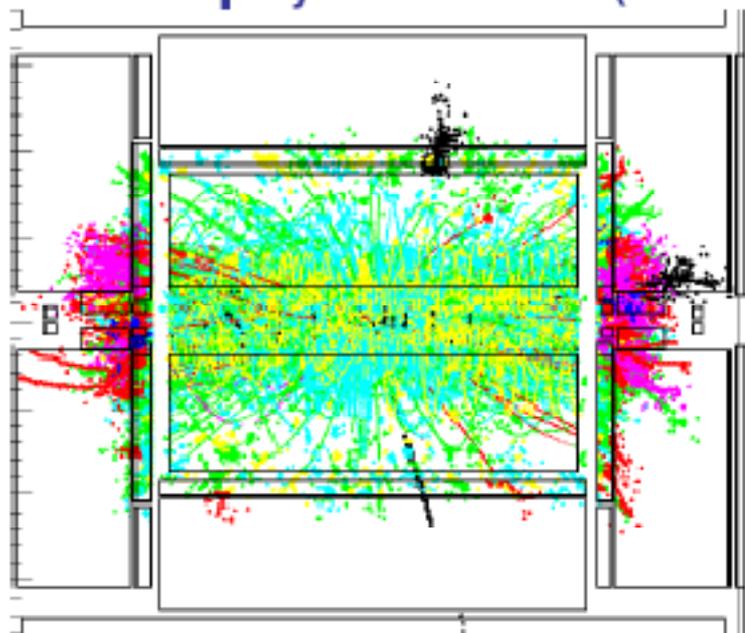
- First simulations were reported by M. Thomson at **CLIC09**
- There are indications of significant loss in performances (HA study) in the absence of stamping
- Criticality of the **FWD region** (e.g. H physics from fusion)
- Need an 'aggressive' R&D to perform **time stamping** on tracking (see 3DIC for vertically integrated Si pixel detectors) and forward calorimetry
- Could be of use for ILD-SiD in particular for what concerns the  **$\mu$ vertex**

★ **Preliminary** studies (Battaglia, Blaising, Quevillon) indicate significant two photon background for 3 TeV CLIC operation

★ Approx 40 particles per BX ( $p_T > 0.15 \text{ GeV}$ ,  $|\cos \theta| < 0.98$ )

➡ ~40 GeV visible energy per event

e.g. Event display for **150 BXs** (75 ns) in ILD-like detector

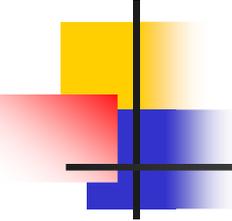


★ Results need checking (**preliminary**)

★ With 0.5 ns BX – will inevitably integrate over multiple BXs, **how many?**

★ **CLIC at 3 TeV may look rather different to the ILC environment**

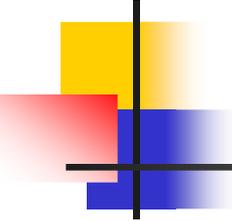
★ In addition, there is also the pair background...



# Political aspects I

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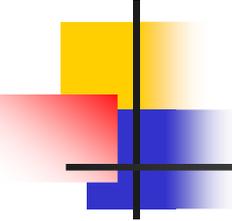
- CLIC needs help from ILC experts to produce a CDR and calls editors from our community
- CLIC wishes to merge its workshops with ILC (note that there is a large overlap between participants at ALCPG09 Albuquerque and CLIC09 at CERN)
- CLIC wishes to intensify work on R&D through the existing collaborations
- ILCSC has encouraged formation of a CLIC/ILC General Issues working group on detectors
- The format of this WG is under discussion with the CLIC partners



# Joint Working Group on General Detector Issues

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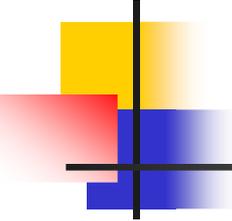
- November 2, 2009 approved version
- ILCSC has encouraged formation of a CLIC/ILC General Issues working group on detectors by the two parties with the following mandate:
  - **Promoting the physics and the detectors of the Linear Collider**
  - **Identifying synergies between the detectors of ILC and CLIC in performance studies, detector R&D, and software tools**
  - **Discussing detailed plans for the ILC and CLIC efforts, in order to explore possible collaborations on issues such as critical R&D on sub-detectors, coil studies, push-pull mechanism and MDI aspects**
  - **Discussing a possible format of collaboration between the ILC validated detector groups and CLIC**
- The conclusions of the working group will be reported to the ILCSC and CLIC Collaboration Board.



# Political aspects II

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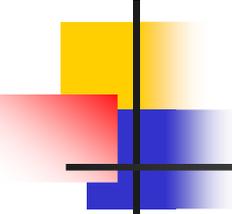
- The actual content of these various CLIC-ILC collaborations to be decided directly by the interested parties (mostly CERN and the ILC groups)
- For what concerns the participation of members of SiD and ILD to the CLIC CDR we feel that it should be done in agreement with these collaborations
- For what concerns the workshops we are already organizing the next European WS (**ECFA WS at CERN** in Sept 2010) with an OC comprising CLIC+ILC representatives
- These various initiatives should further improve the good relationships between the two communities



# Potential risks

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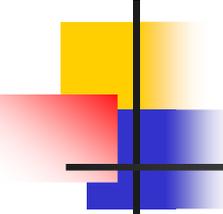
- ILC is an international organization under ICFA/ILCSC with a well defined roadmap
- While CLIC-ILC collaboration appears very natural in Europe we need to make sure that it is agreed upon in the two other regions
- CLIC needs an international R&D oriented towards a multiTeV collider not necessarily overlapping with ILC priorities



# Which Scenario ?

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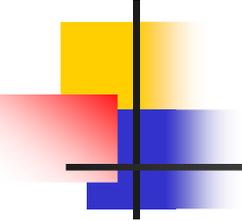
- The scenario proposed by the CERN DG at LCWS08 in Chicago is that LHC should provide the scientific input for a final choice (through a process which needs to be carefully defined) recalling that ILC is  $\sim$ ready for construction while CLIC at 3 TeV remote in time
- CLIC500 however appears in direct competition with ILC and the community would like to see clear rules of the game for the assessment of this technology (new ITRP ?)
- While we fully appreciate the usefulness of the ongoing process to avoid damaging competition the community needs to be well informed on the overall scenario



# Conclusions

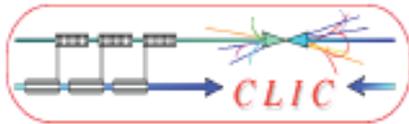
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- CLIC/CERN can bring tremendous help in improving the ILC detectors
- One should therefore encourage the ongoing collaborations but insuring mutual benefits and avoiding distraction of efforts on the main goal
- The proposed CLIC-ILC WG on detectors should allow better communication
- Common CLIC-ILC workshops will be tried at the next ECFA workshop at CERN
- There are clear specific needs for CLIC which may require marked differences between the detectors and the R&D needs but one can foresee important overlaps
- Political risks cannot be minimized and one needs ICFA/ILCSC/PAC guidance



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# **BACK UP SLIDES**



## Time stamping requirements (2)

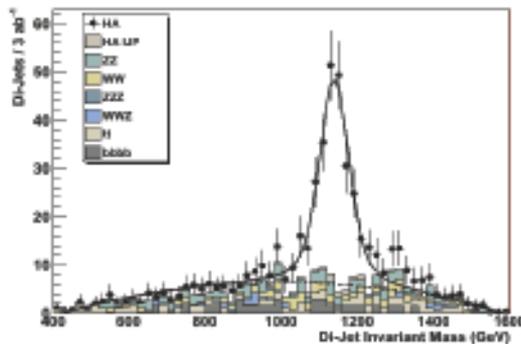


Simulation example of heavy Higgs doublet  $H^0A^0$  at  $\sim 1.1$  TeV mass  
(supersymmetry K' point)

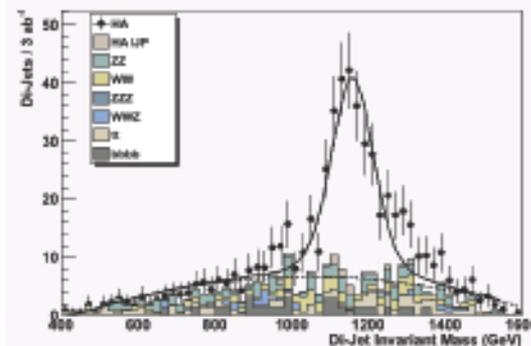
$$e^+e^- \rightarrow H^0A^0 \rightarrow bbbb$$

Signal + full standard model background +  $\gamma\gamma \Rightarrow$  hadron background

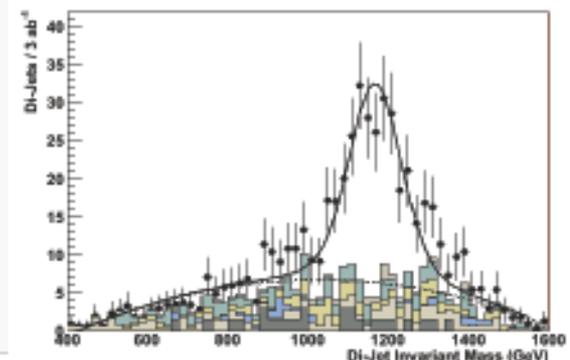
CLIC-ILD detector: Mokka+Marlin simulation, reconstruction +  
kinematic fit.



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