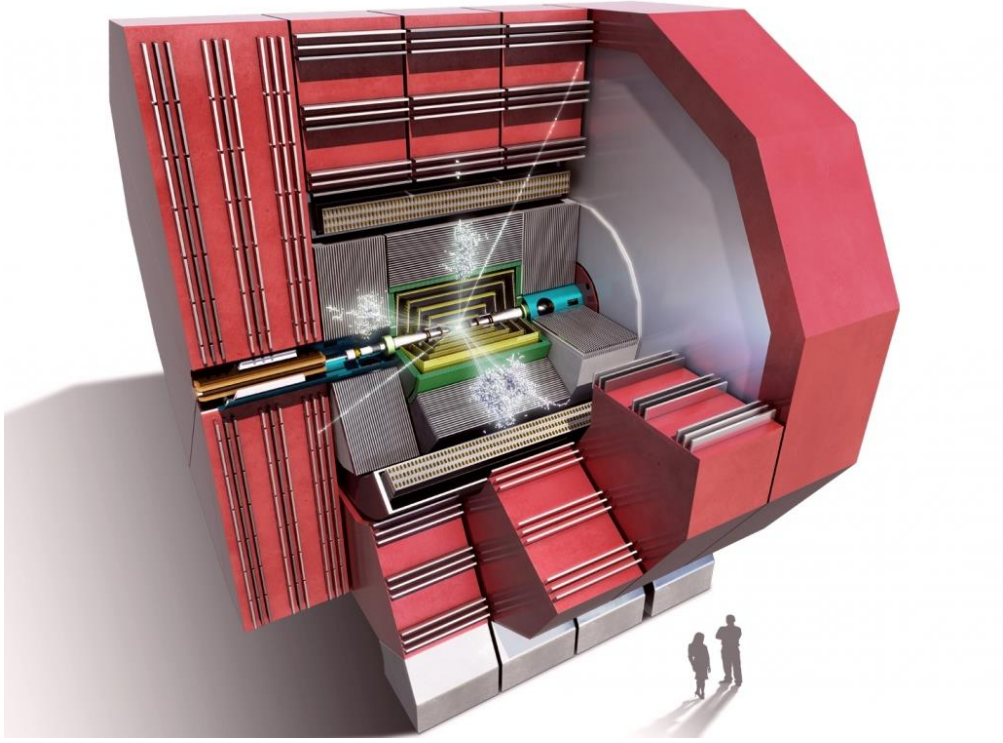
CLICdp
achievements in 2014 and goals for 2015



Lucie Linssen, CERN
on behalf of the CLICdp collaboration

CLIC workshop, January 30th 2015

CLIC detector and physics (CLICdp)

Australia	Australian Collaboration for Accelerator Science (ACAS), University of Melbourne
Belarus	National Scientific and Educational Centre of Particle and High Energy Physics (NC-PHEP), Belarusian State University, Minsk
Chile	Pontificia Universidad Católica de Chile, Santiago
Czech Republic	Institute of Physics of the Academy of Sciences of the Czech Republic, Prague
Denmark	Department of Physics and Astronomy, Aarhus University
France	Laboratoire d'Annecy-le-Vieux de Physique des Particules (LAPP), Annecy
Germany	Karlsruher Institut für Technologie (KIT), Institut für Prozessdatenverarbeitung und Elektronik (IPE), Karlsruhe
Germany	Max-Planck-Institut für Physik, Munich
Israel	Department of Physics, Faculty of Exact Sciences, Tel Aviv University
Norway	Department of Physics and Technology, University of Bergen
Poland	The Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Cracow
Poland	Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Cracow
Romania	Institute of Space Science, Bucharest-Magurele
Serbia	Vinca Institute for Nuclear Sciences, Belgrade
Spain	Spanish Network for Future Linear Colliders
Switzerland	CERN
Switzerland	Département de Physics Nucléaire et Corpusculaire (DPNC), Geneva
United Kingdom	The School of Physics and Astronomy, University of Birmingham
United Kingdom	University of Bristol
United Kingdom	University of Cambridge
United Kingdom	University of Glasgow
United Kingdom	The Department of Physics of the University of Liverpool
United Kingdom	Oxford University
USA	Argonne National Laboratory, High Energy Physics Division
USA	University of Michigan, Physics Department

http://clicdp.web.cern.ch/

Now 25 institutes (**5 new in 2014**)

In 2014:

3 CLICdp working groups:

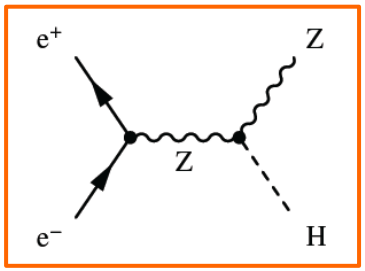
- WG **analysis** (incl. **software**)
- WG **vertex detector** technology
- WG **detector optimisation**

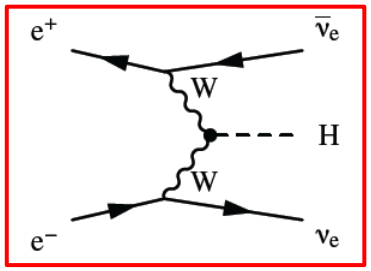
+

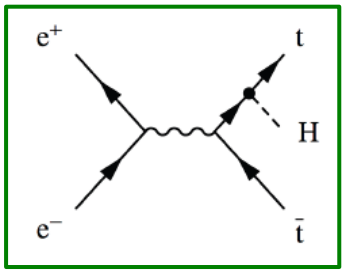
Collaboration with:

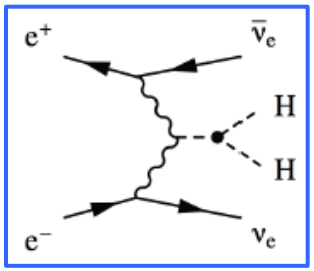
- ILC detector concepts
- **CALICE + FCAL**

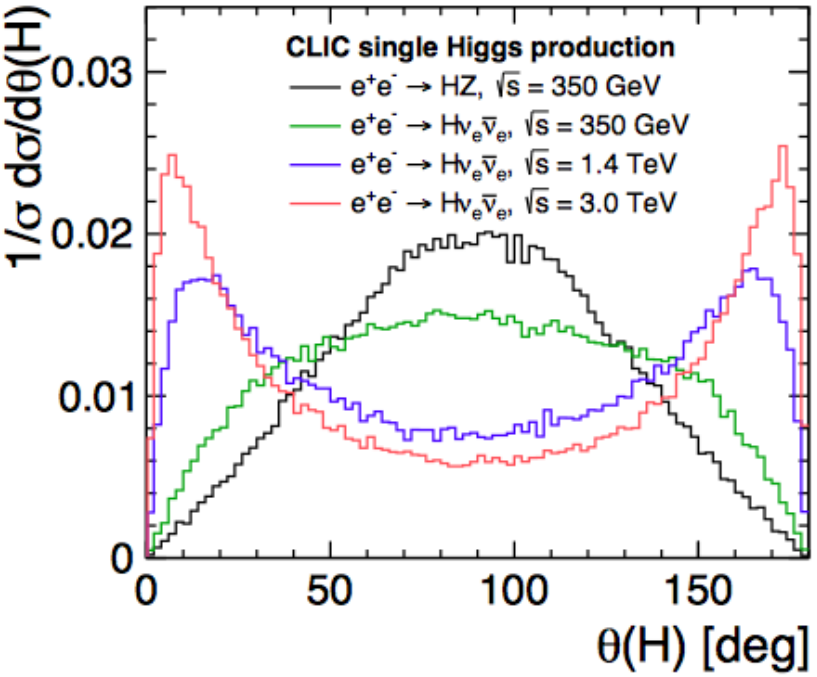
2014 => Higgs benchmark analyses









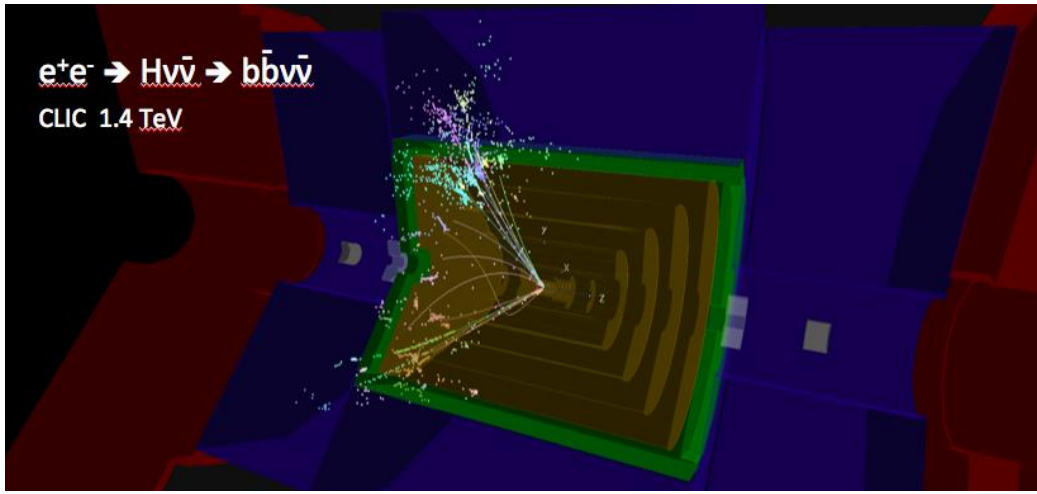


Wealth of production and decay modes addressed at all three CLIC energy stages

A collaboration-wide effort !

=> ***good overview of CLIC Higgs capabilities***

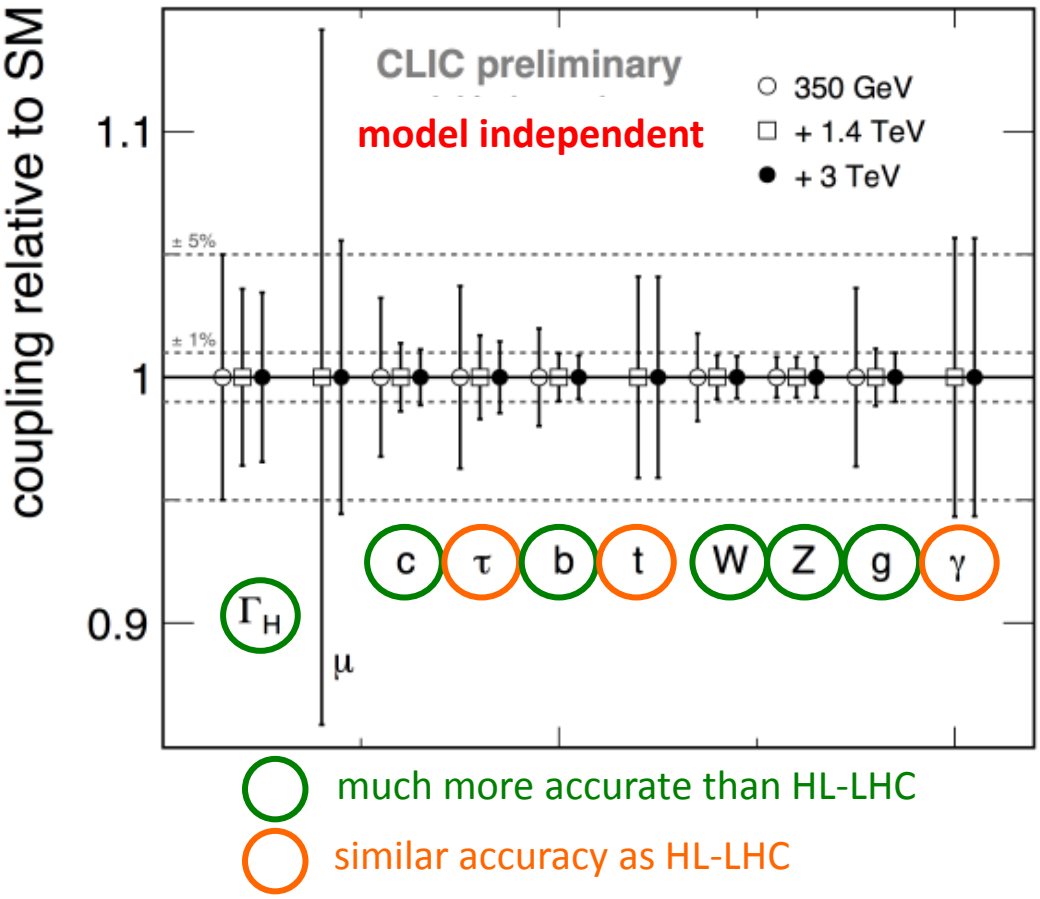
Draft publication is under collaboration review



2014 => Higgs benchmark analyses

★ **Model-independent global fits**

Parameter	Measurement precision		
	350 GeV 500 fb^{-1}	+ 1.4 TeV +1.5 ab^{-1}	+3.0 TeV +2.0 ab^{-1}
g_{HZZ}	0.8 %	0.8 %	0.8 %
g_{HWW}	1.8 %	0.9 %	0.9 %
g_{Hbb}	2.0 %	1.0 %	0.9 %
g_{Hcc}	3.2 %	1.4 %	1.1 %
$g_{H\tau\tau}$	3.7 %	1.7 %	1.5 %
$g_{H\mu\mu}$	–	14.1 %	5.6 %
g_{Htt}	–	4.1 %	$\leq$ 4.1 %
$g^{\dagger}_{Hgg}$	3.6 %	1.2 %	1.0 %
$g^{\dagger}_{H\gamma\gamma}$	–	5.7 %	< 5.7 %
Γ_H	5.0 %	3.6 %	3.4 %



★ ~1 % precision on many couplings

- limited by g_{HZZ} precision

-80% electron polarisation assumed above 1 TeV

Note: contrary to (HL-)LHC, CLIC results are model-independent

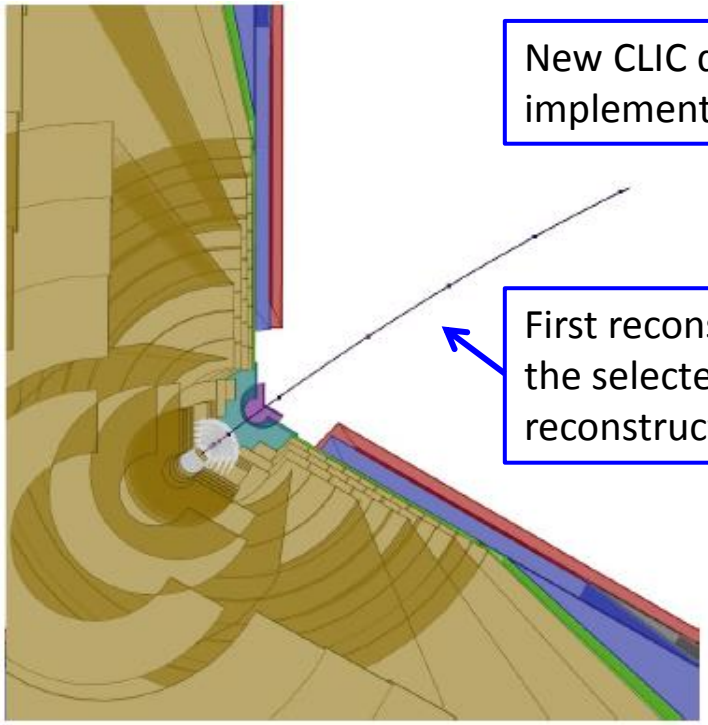
2014 => software development

Major improvements of simulation and reconstruction software

Most important new elements:

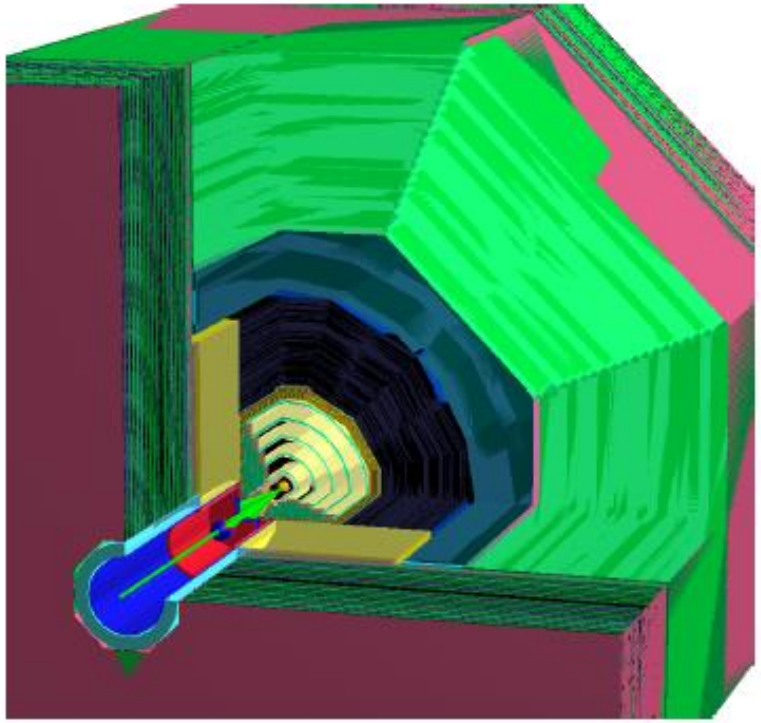
- New geometry description (DD4hep)
  - For simulation, reconstruction, event display, alignment….
  - Generic, developed under AIDA EU project, also for other projects (FCC)
- New/optimised track reconstruction for all-silicon tracker

Excellent progress in 2014 towards the new software framework



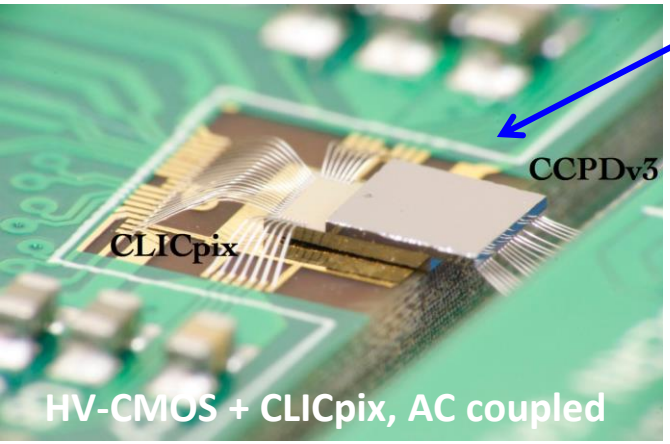
New CLIC detector model implemented in DD4hep

First reconstructed tracks using the selected and adapted reconstruction software



2014 => WG vertex detector technology

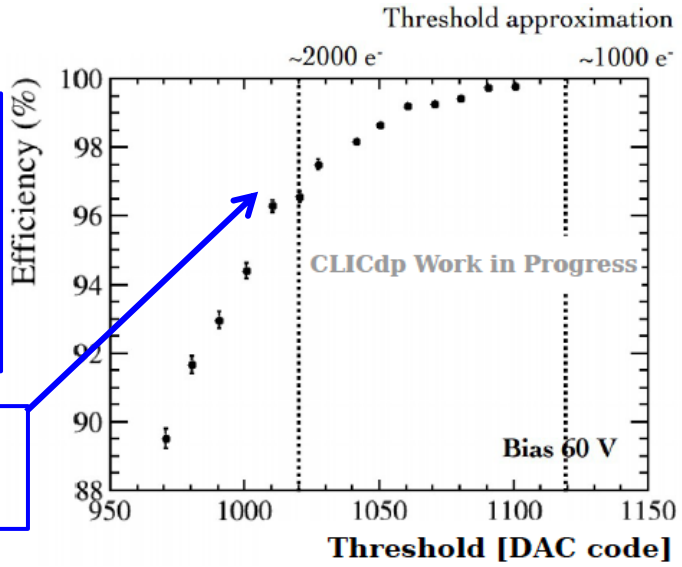
Successful 2014 beam tests with novel HV-CMOS techn



Active HV-CMOS sensor AC-coupled (glue) to complex CLICpix readout chip

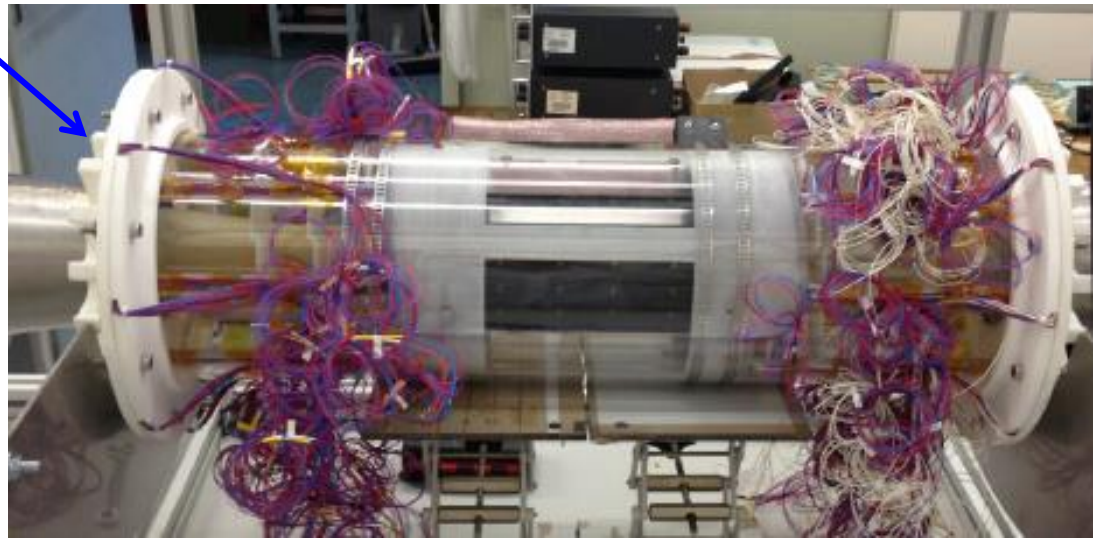
- Fast signal !
- Small pixels

High efficiency achieved at test beam



Engineering studies on support structures and air cooling

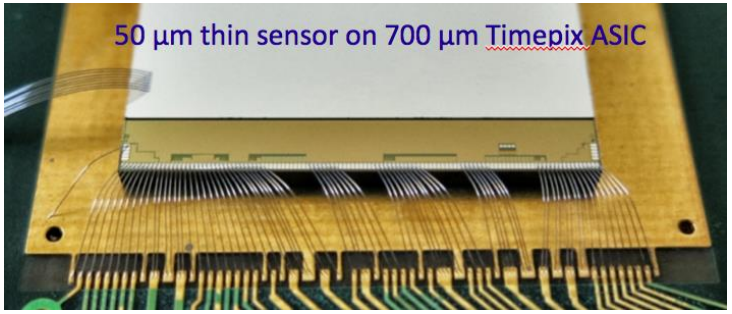
Full-scale thermo-mechanical mock-up of the vertex detector

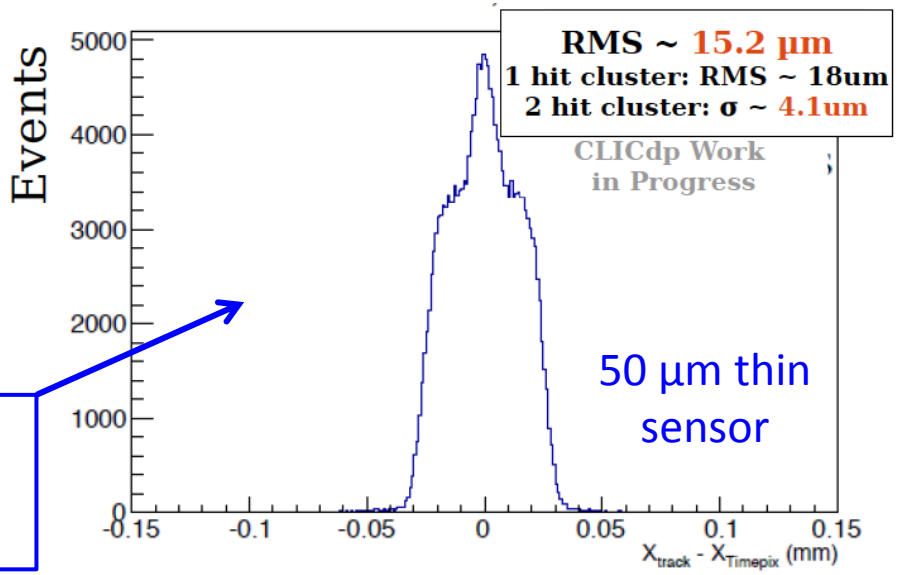


Ultra-light supports tested for vibration stability in air flow

2014 => WG vertex detector technology

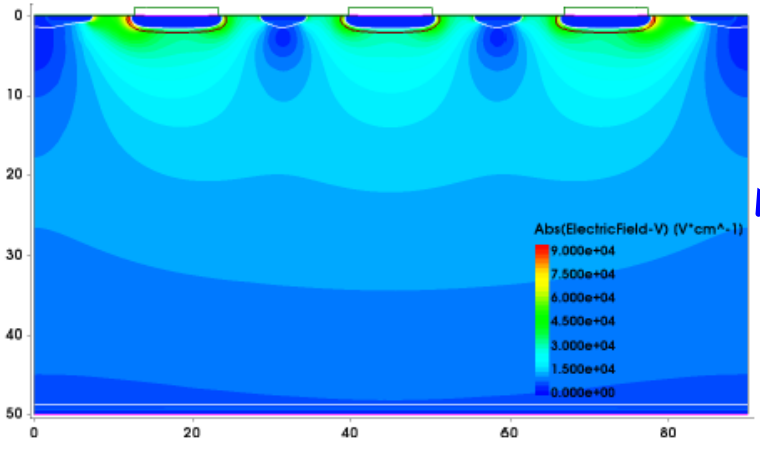
Analysis of 2013 test beam data





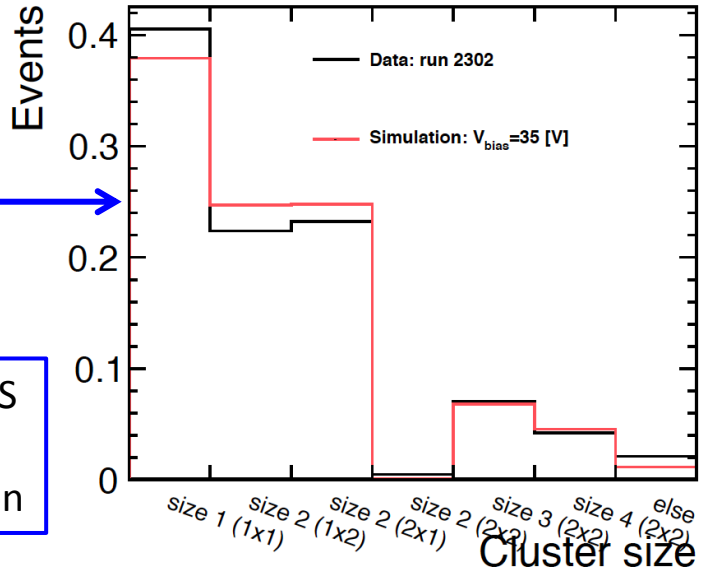
Required position resolution (~3 µm) can be achieved with charge sharing between neighbouring pixels.
But, how to get charge sharing for all hits ?

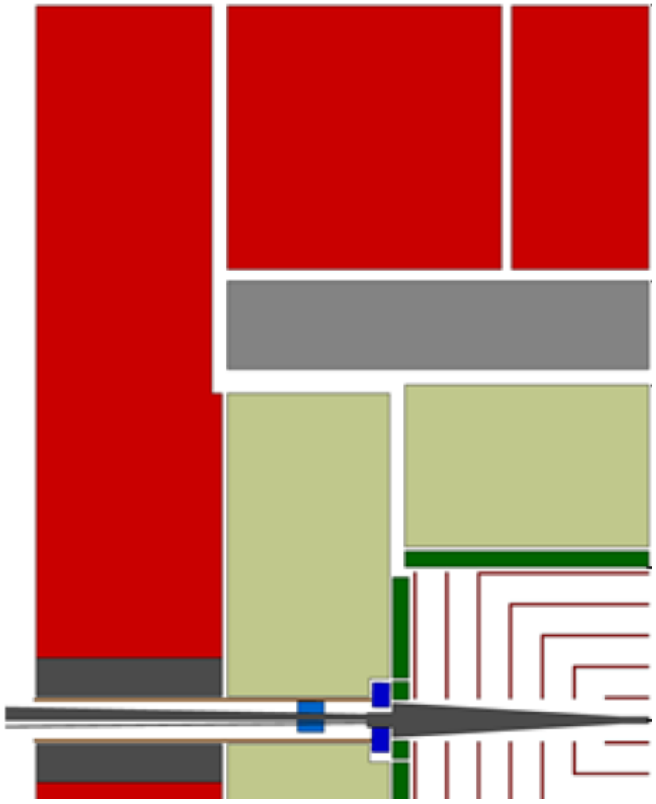
Better understanding through detailed simulations



Prediction of hit cluster sizes in a pixel detector

E-field in a HV-CMOS sensor for a given integrated irradiation





2014 => WG detector optimisation

towards one CLIC detector model

include lessons learnt so far

include experience from hardware R&D

2014 achievements

Already agreed working hypotheses:

- Vertex: 0.2%X_0/layer
- Vertex: double layer geometry
- Vertex: spiraling disks
- Tracker: all silicon
- Tracker: radius 1.5 m, half-length 2.3 m
- ECAL: 25 layers, 5×5 mm^2 cell sizes
- HCAL: steel absorbers
- Solenoid field: 4 Tesla

Ongoing assessments:

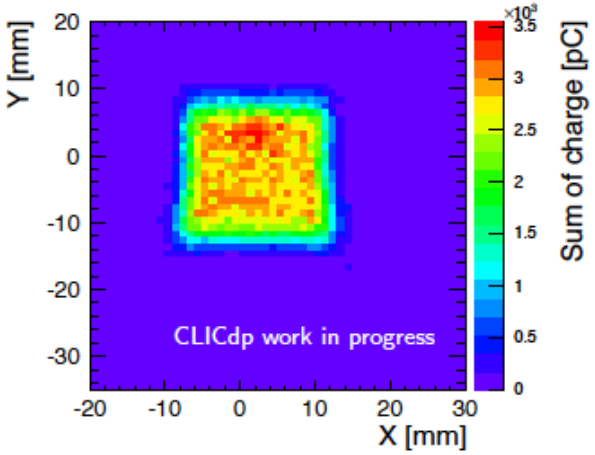
- Tracker layout and technology options
- HCAL: cells sizes
- Enhancement of forward calo coverage
- QD0 in detector or in tunnel
- Luminosity for a long L*
- ……..

2014 R&D calorimetry CALICE / FCAL

FCAL front-end development

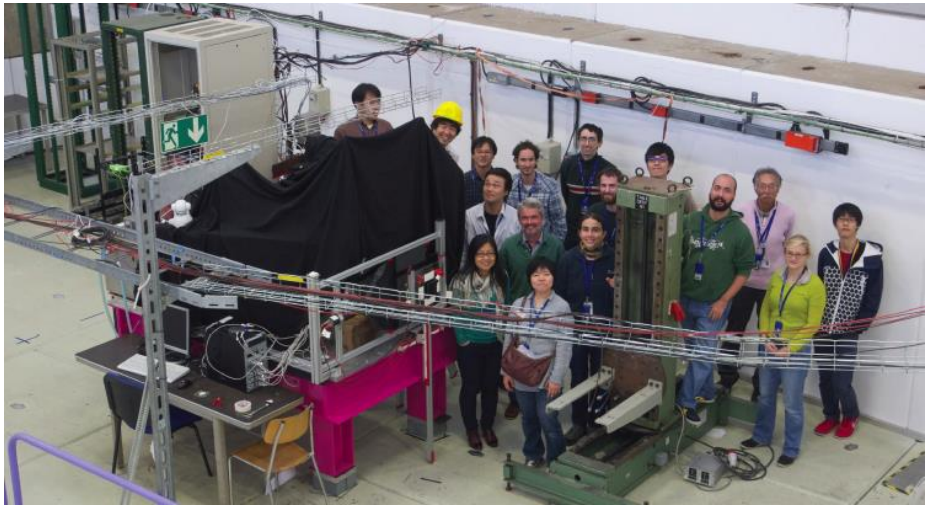
Progress in many areas in parallel

- Hardware development
- Laboratory tests
- Beam tests @ CERN PS
- Data analysis



CALICE scintillator lab test

FCAL multi-layer test beam module



CALICE scintillator (+ silicon) calorimeter beam test

2015, some of the main objectives

New CLIC detector concept

- Continued studies, …. => *new track reconstruction will be important*
- Increase forward acceptance
  - Re-enforced MDI involvement !
  - Assess Luminosity performance for long L*

Consolidation of new software tools

ambitious mid 2015 goal

CLIC physics benchmark studies

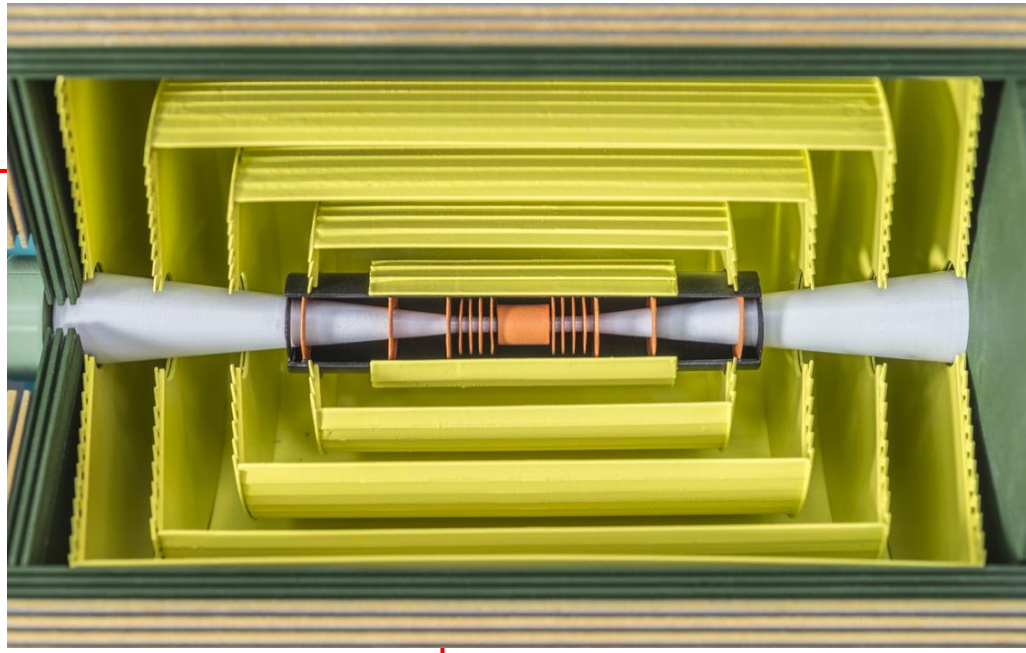
Shift focus from Higgs to Beyond Standard Model (BSM)physics and top physics

- Precision top physics as tool for New Physics (first CLIC stage + higher energies)
- Precision Electroweak physics as tool for New Physics
- BSM searches (dark matter, SUSY, compositeness, etc....)

R&D activities:

- CLIC vertex detector technology
- Fine-grained calorimetry (CALICE, FCAL)
- *New silicon tracking hardware activity*

Main silicon tracker technology



Tracker requirements

- 7 µm single point accuracy
- time-stamping 10 ns

- ~5-6 tracking layers
- Radius ~1.5 m, half-length ~2.3 m

High occupancies in certain regions:

⇒ Calls for large pixels and/or short-strips

Very light => ~1%X_0 per layer

- Requires very thin materials/sensors
  => is this compatible with charge sharing and 7µm accuracy?
- Can we use power pulsing ?
- Air cooling probably not possible….

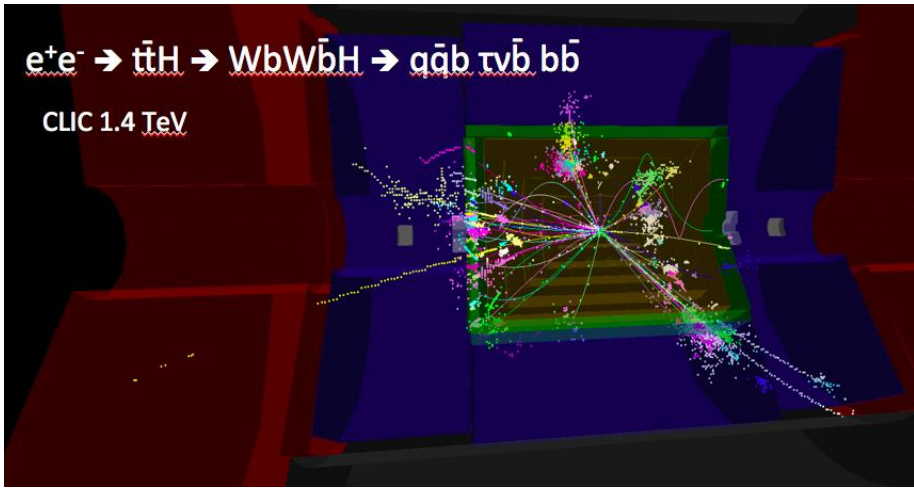
=> new CLIC tracker technology working group

Summary

Good technical progress in 2014, in many domains:

- Higgs benchmarking studies !
- Detector optimisation towards a new CLIC detector concept
- Development towards improved software tools
- Vertex technology R&D
- Fine-grained calorimeter R&D (CALICE, FCAL)

Possible thanks to many contributors !



Objectives for 2015 will focus on:

- A new CLIC detector concept !
- Consolidation of the new software tools
- Physics => focus more on Beyond Standard Model capabilities
- Continuation of vertex technology R&D
- Continuation of fine-grained calorimeter R&D (CALICE, FCAL
- Start of main silicon tracker R&D