



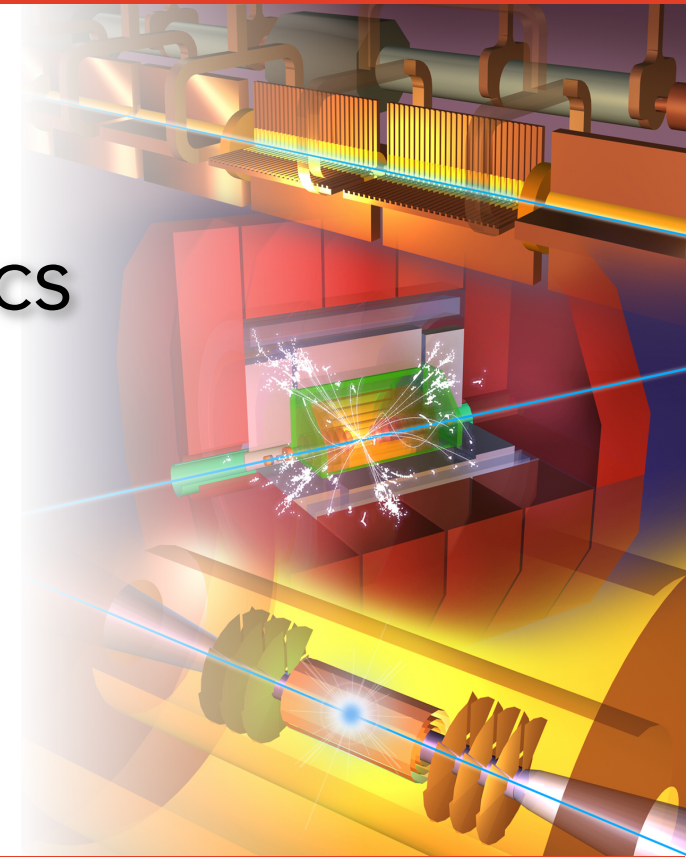
hidden valley  
Higgs  $V_{sr}(\phi) = rg\Lambda^3\phi$   
SMEFT flavour-changing neutral currents  
CLIC search  
Yukawa  
SUSY axion  
dark matter  
BSM  
2HDM  
inert doublet  
mono-photon  
dark matter

$$W = \frac{g^2 C_{WW}^{\text{eff}} m_W^2}{960\pi^2}$$
$$\propto A_{++}^{\text{BSM}} [A_{-+}^{\text{SM}} + A_{+-}^{\text{BSM}}] \cos 2\varphi$$
$$W = 2 \frac{g^2 M_W^2}{g_*^2 M_*^2}$$
$$\theta \lesssim \rho \mu^2 / M^2 \simeq \left(\frac{m_-}{m_+}\right)^2$$

# CLIC Detector & Physics

CLIC Project Meeting  
13 December 2021

Aidan Robson  
University of Glasgow

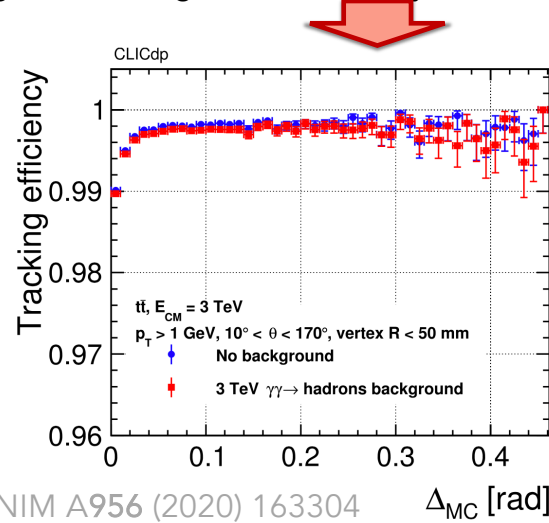
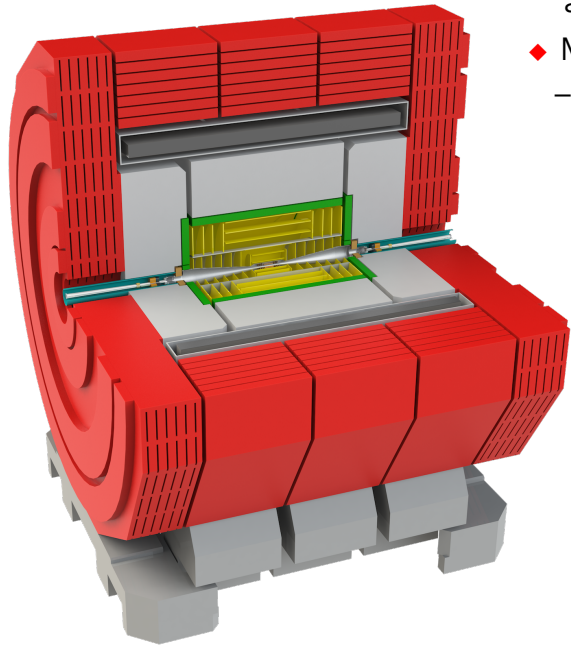




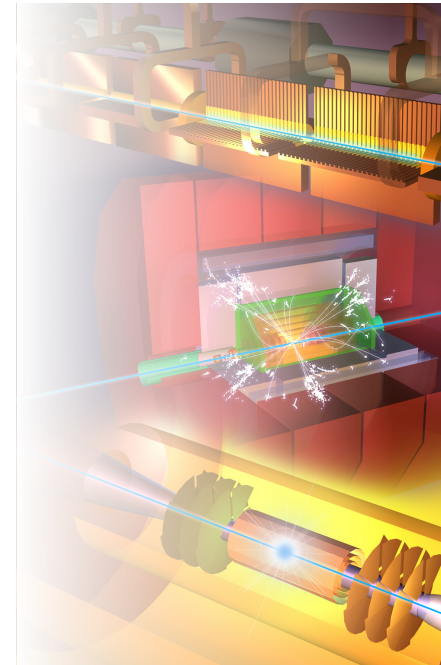
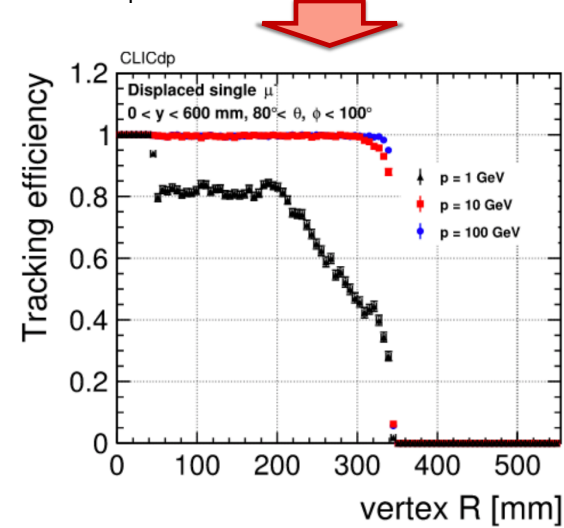
# CLIC Detector



- CLICdet:
- ◆ High-performing detector optimized for CLIC beam environment
  - ◆ Full GEANT-based simulation, including beam-induced backgrounds, available for optimization and physics studies
  - ◆ Mature reconstruction chain allows detailed performance characterisation – e.g. for tracking: effect of busy environment; displaced track reconstruction



NIM A956 (2020) 163304

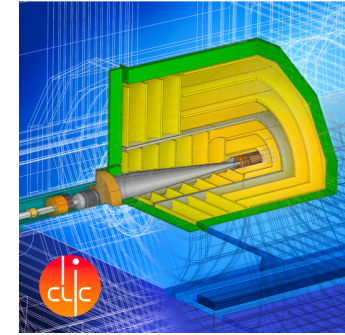


## Software framework:

- ◆ Originally in iLCSoft, the simulation/reconstruction is now fully embedded in the **Key4HEP** ecosystem → a common target for all future collider options
- existing reconstruction algorithms “wrapped” for the new framework



# Detector R&D for CLICdet



Calorimeter R&D => within CALICE and FCAL

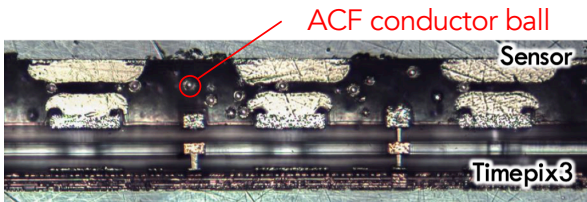
Silicon vertex/tracker R&D:

- [Working Group](#) within CLICdp and strong collaboration with DESY + AIDAInnova
- Now integrated in the [CERN EP detector R&D programme](#)

## A few examples:

### Hybrid assemblies:

- ◆ Development of **bump bonding** process for CLICpix2 hybrid assemblies with 25  $\mu\text{m}$  pitch  
<https://cds.cern.ch/record/2766510>

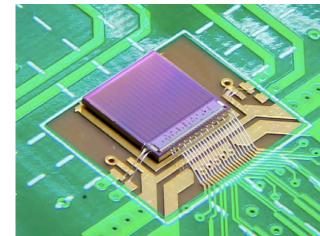


- ◆ Successful sensor+ASIC bonding using **Anisotropic Conductive Film (ACF)**, e.g. with CLICpix2, Timepix3 ASICs. ACF now also used for module integration with monolithic sensors.  
<https://agenda.linearcollider.org/event/9211/contributions/49469/>

### Monolithic sensors:

- ◆ Exploring sub-nanosecond pixel timing with **ATTRACT FASTPIX** demonstrator in 180 nm monolithic CMOS  
<https://agenda.linearcollider.org/event/9211/contributions/49445/>
- ◆ Now performing qualification of modified **65 nm CMOS** imaging process for further improved performance

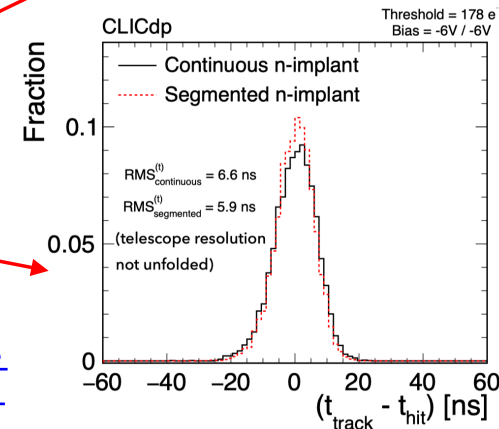
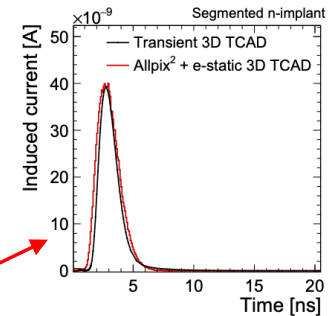
### CLICTD monolithic tracking sensor:



Detailed simulations, Allpix<sup>2</sup> transient Monte Carlo combined with electrostatic 3D TCAD.

Beam tests at DESY, e.g. 5.8 ns CLICTD time resolution achieved

<https://agenda.linearcollider.org/event/9211/contributions/49443/>





# Physics Potential recent highlights

## 1: Initial energy stage



- ◆ Ongoing studies on Higgs and top-quark precision physics potential

Higgs coupling sensitivity:

- ◆ Sensitivities under different integrated luminosity scenarios to complement accelerator luminosity studies

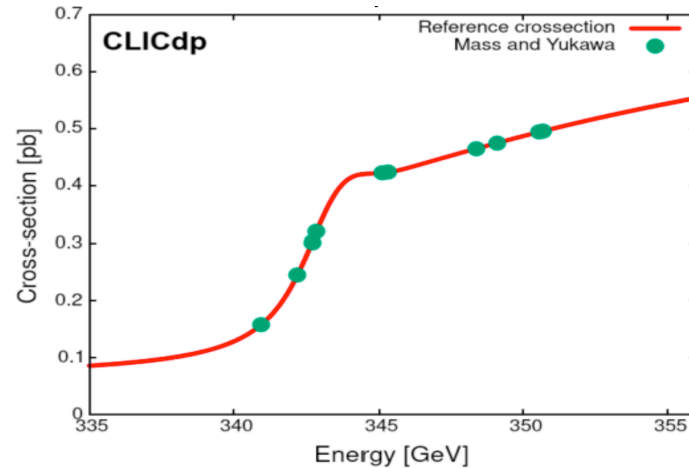
Increased integrated luminosity at 380 GeV (4ab<sup>-1</sup>)

Baseline: 380 GeV (1ab<sup>-1</sup>) + 1.5 TeV

	Benchmark	HL-LHC	HL-LHC + CLIC		HL-LHC + FCC-ee	
			380 (4ab <sup>-1</sup> )	380 (1ab <sup>-1</sup> ) + 1500 (2.5ab <sup>-1</sup> )	240	365
$g_{HZZ}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	3.6	0.3	0.2	0.5	0.3
$g_{HWW}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	3.2	0.3	0.2	0.5	0.3
$g_{H\gamma\gamma}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	3.6	1.3	1.3	1.3	1.2
$g_{HZ\gamma}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	11.	9.3	4.6	9.8	9.3
$g_{Hgg}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	2.3	0.9	1.0	1.0	0.8
$g_{Htt}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	3.5	3.1	2.2	3.1	3.1
$g_{Hcc}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	—	2.1	1.8	1.4	1.2
$g_{Hbb}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	5.3	0.6	0.4	0.7	0.6
$g_{H\tau\tau}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	3.4	1.0	0.9	0.7	0.6
$g_{H\mu\mu}^{\text{eff}} [\%]$	SMEFT <sub>ND</sub>	5.5	4.3	4.1	4.	3.8
$\delta g_{1Z} [\times 10^2]$	SMEFT <sub>ND</sub>	0.66	0.027	0.013	0.085	0.036
$\delta \kappa_\tau [\times 10^2]$	SMEFT <sub>ND</sub>	3.2	0.032	0.044	0.086	0.049
$\lambda_Z [\times 10^2]$	SMEFT <sub>ND</sub>	3.2	0.022	0.005	0.1	0.051

<https://arxiv.org/abs/2001.05278>

other sensitivities from Briefing Book <https://arxiv.org/abs/1910.11775>



Top-quark threshold scan

- ◆ Optimisation of scan points including beam spectrum; here optimising on mass and Yukawa coupling.

- ◆ Expected top-quark mass precision of 25MeV can be improved by 25% without losing precision on width or Yukawa.

<https://arxiv.org/abs/2103.00522>





# Physics Potential recent highlights

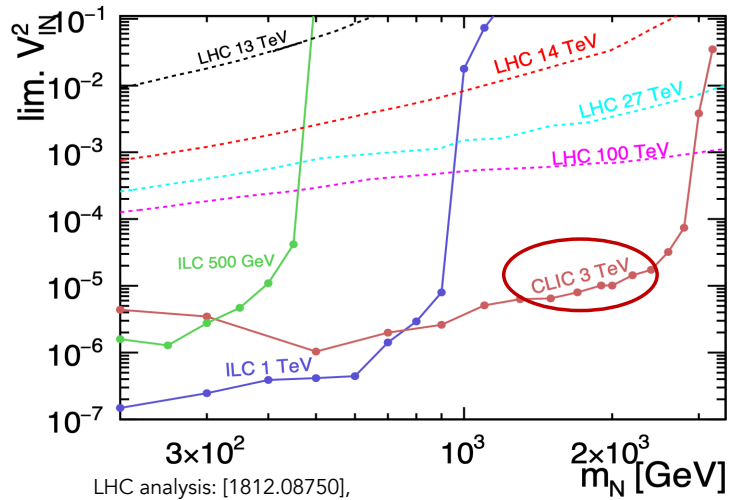
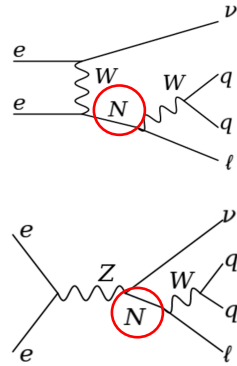
## 2: Multi-TeV stages



### ◆ Ongoing studies on new physics searches

#### Search for heavy neutrinos

- ◆  $e+e- \rightarrow N\nu \rightarrow qq\ell\nu$  signature allows full reconstruction of N
- ◆ BDT separates signal from SM; beam backgrounds included.
- ◆ cross-section limits converted to mass ( $m_N$ ) coupling ( $V_{IN}$ ) plane

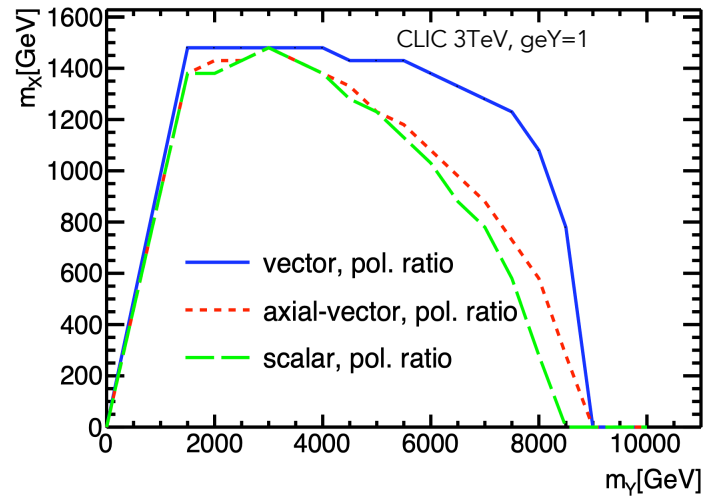


LHC analysis: [1812.08750],  
different assumption  $V_{eN} = V_{mN} \neq V_{\tau N} = 0$

#### Dark matter using mono-photon signature at 3TeV, $e+e- \rightarrow XX\gamma$

- ◆ New study using ratio of electron beam polarisations to reduce systematics
- ◆ Exclusions for simplified model with mediator Y and DM particle X
- ◆ For benchmark mediator of 3.5TeV, photon energy spectrum discriminates different DM mediators & allows 1TeV DM particle mass measurement to ~1%

<https://arxiv.org/abs/2103.06006>





# Collaboration



◆ Wolfgang Kilian elected for a second term as chair of Institute Board



◆ Roma Tre admitted to the Collaboration

◆ Roberto Franceschini (Roma Tre) joins Publications Committee  
(also new: Lucie Linssen, Aidan Robson)



◆ Katharina Dort (CERN) joins Speakers Committee





# Related Initiatives



## ◆ ECFA Higgs factory initiative

<https://indico.cern.ch/event/1044297/page/22657-programme>

WG1 (Physics Programme)

– 5 working units under construction: Precision, EFT, Higgs/top/EWK, Flavour, Search

WG2 (Physics Analysis Tools)

– first topical meeting held (generators)

– follow-up on beam spectrum January; Simulation topical meeting February

'WG3' (Detector) under discussion

First workshop being planned for October 2022 ; second expected in autumn 2023 followed by reports in 2024

## ◆ ILC International Development Team

Monthly open physics meetings inclusive of all  $e+e-$  projects (common physics case)

<https://linearcollider.org/team/wg3/physics/>

## ◆ Snowmass planning exercise

Continuing interest from them

◆ **CERN Future Collider Unit** aiming to maintain some diversity at CERN

Everyone encouraged to bring CLIC physics & detectors to all of these forums



# Outlook



- ◆ CLICdp collaboration remains active
- ◆ Resources very limited, but targeted activities maintained in context of wider efforts
- ◆ Higgs factory is community priority, but continued interest in physics reach of TeV-scale  $e^+e^-$

