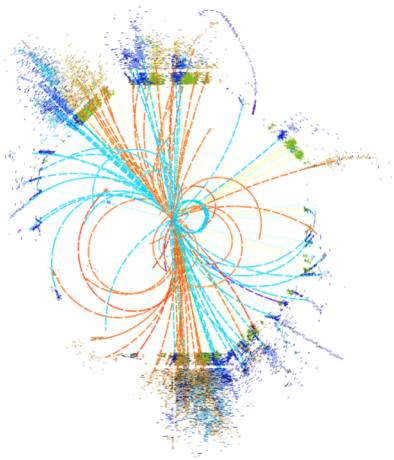
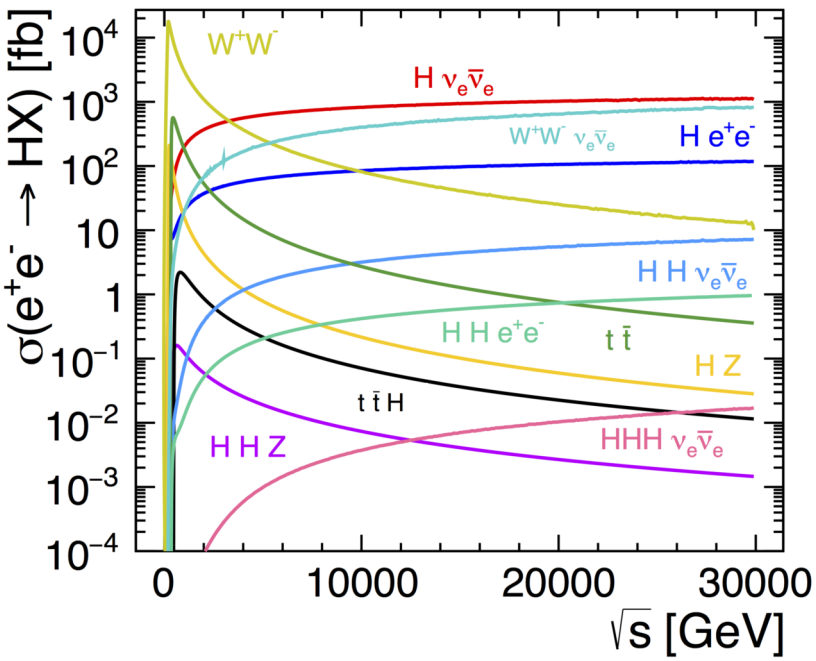
Potential contributions

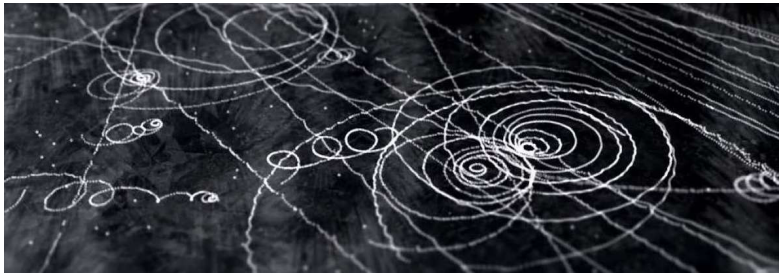
André Sailer (CERN), **Philipp Roloff** (CERN)

bringing also expertise by
Lucie Linssen (CERN), **Eva Sicking** (CERN)





Muon Collider Collaboration Meeting
CERN, 03/07/2020



Introduction

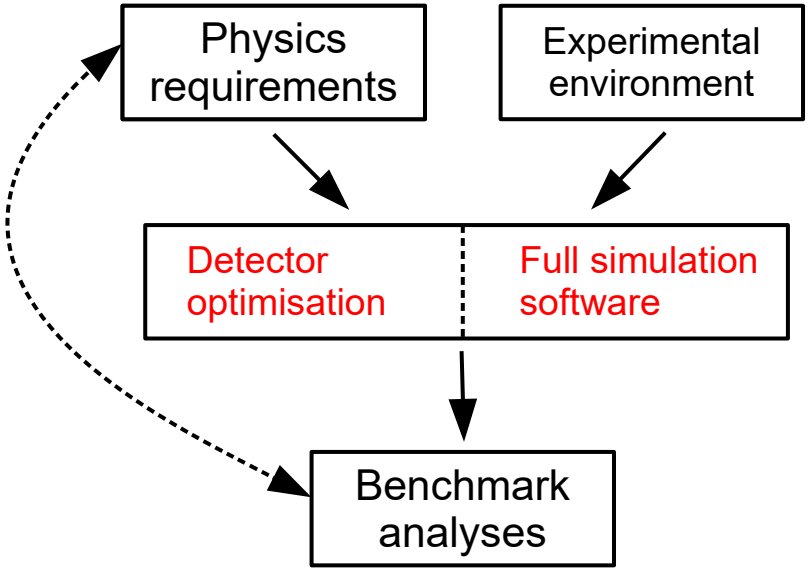
- Detector design is driven by physics requirements and the experimental environment

- Detector optimisation and the development of full simulation software are closely connected

- We have experience in these areas from the CLIC (and FCC) detector studies
→ examples on the following slides

- Depending on available resources and structured involvement of the CERN EP department, including dedicated funding for students and fellows, we would be willing to take a role in setting this up for the muon collider

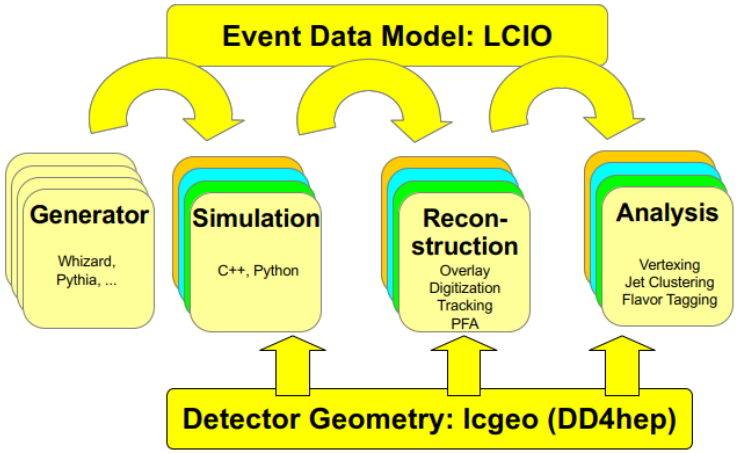
- Too early for dedicated detector R&D (also needs better understanding of specific requirements)



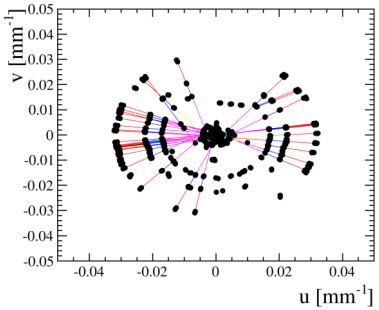
Software and computing

Current CLIC software chain:
- Marlin framework
- LCIO event data model
- Whizard 2 and other MC generators
- DD4hep detector description
- Cellular automaton in conformal space for track finding
- Calorimeter clustering and particle flow analysis: PandoraPFA
- Flavour tagging and optimised jet clustering

→ Already being used for the muon collider studies



Development of Key4hep:
- Low-maintenance common stack for future collider studies
- Gaudi framework
- EDM4hep/PODIO event data model
- CLIC / linear collider reconstruction tools will be ported



$u = x / (x^2 + y^2)$
$v = y / (x^2 + y^2)$

Nucl. Inst. Meth. A 956, 163304 (2020)

Distributed computing with iLCDirac:
- High-level interface between users and distributed resources
- Automated MC production system
- Setup dedicated VO for muon collider studies?

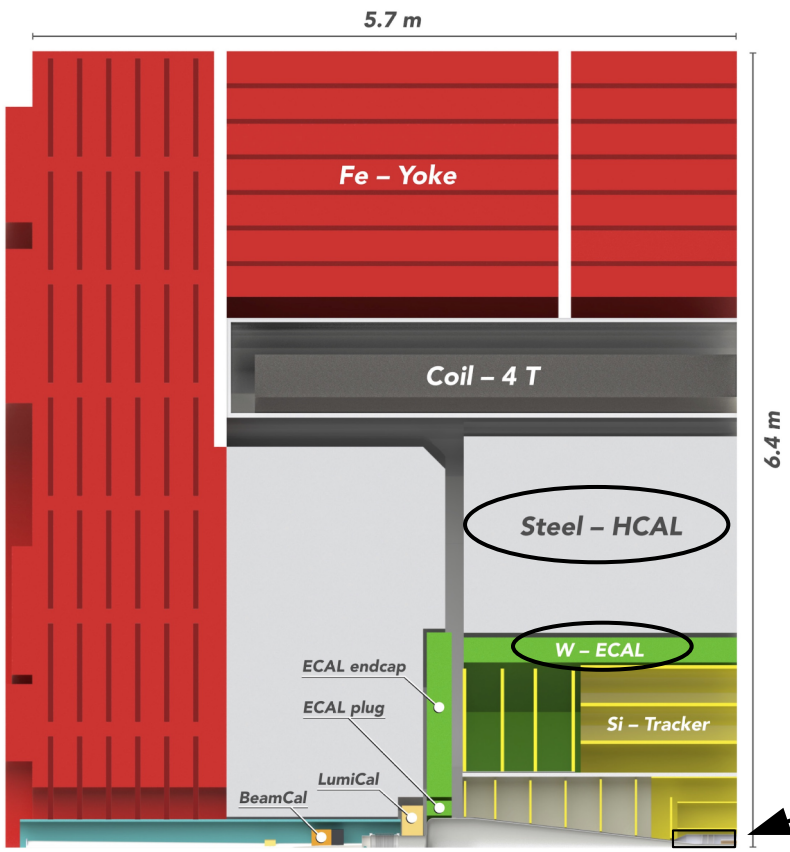
```
from DIRAC.Core.Base import Script
Script.parseCommandLine()
import UserJob, Marlin, DiracILC
d = DiracILC()
j = UserJob()
j.setOutputData("recEvents.slcio")
m = Marlin()
m.setVersion("ILCSoft-01-17-09")
m.setSteeringFile("Steering.xml")
m.setInputFile("SimEvents.slcio")
j.append(m)
j.submit(d)
```

CLIC detector optimisation

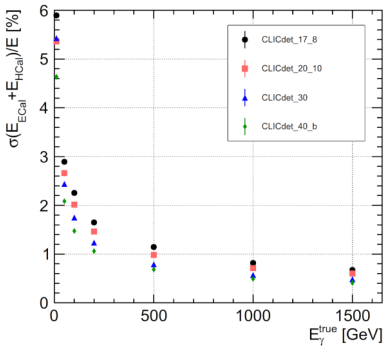
CLICdet: CLICdp-Note-2017-001, arXiv:1812.07337
→ examples on this slide

CLD (variant for FCC-ee): arXiv:1911.12230

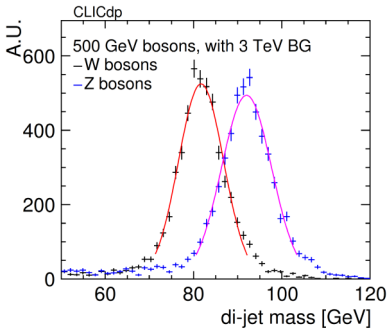
Optimisation of FCC-hh detector using CLIC software:
LCD-Note-2018-001, LCD-Note-2018-002, LCD-2018-003



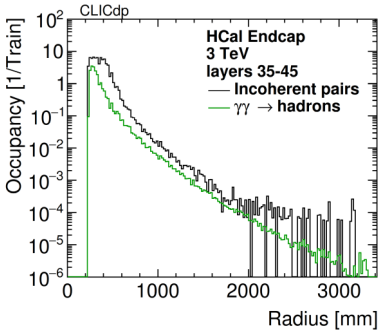
Photon energy resolution



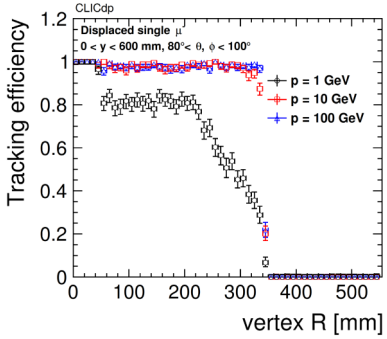
Particle Flow Analysis



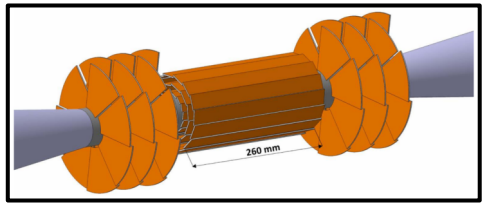
Occupancy studies



Displaced tracks



vertex detector



Particle flow detector with timing capabilities in silicon detectors and calorimeters

Event Reconstruction and benchmark analyses

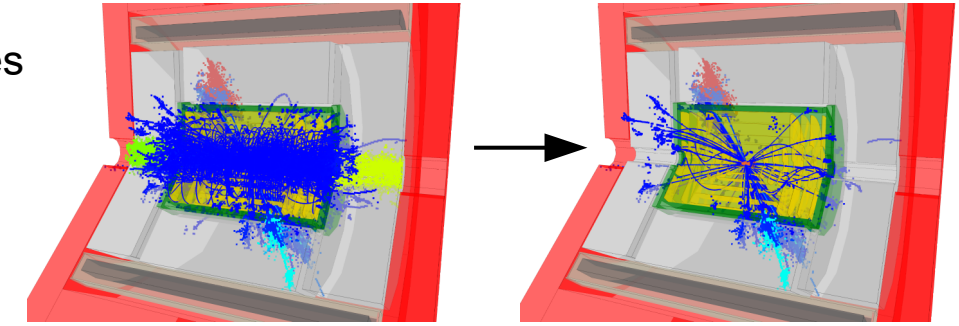
CLIC and the muon collider share a common energy stage at 3 TeV
→ muon collider could benefit from CLIC experience with reconstruction challenges such as:

- Beam-induced backgrounds to be mitigated through combination of detector design and analysis techniques

- The forward direction becomes increasingly important with rising energy

- Hadronic final states are crucial as the EW production cross sections are small
→ needs good jet energy resolution in the presence of backgrounds

- b-jets at high energy (large secondary vertex decay lengths, very collimated b- and c-hadron decay products)



$e^+e^- \to t\bar{t}$ at 3 TeV with background from $\gamma\gamma \to$ hadrons overlaid

Higgs: EPJ **C 77**, 475, 2017
Top-quark: JHEP **11**, 003, 2019
New physics: CERN-2018-009M

Thank you!