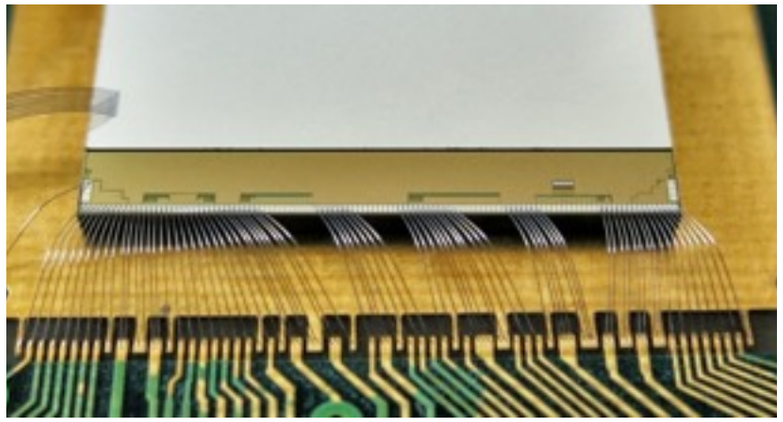
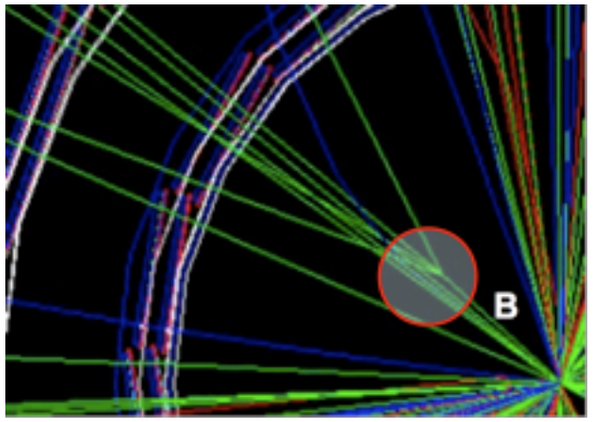
CLICdp Status

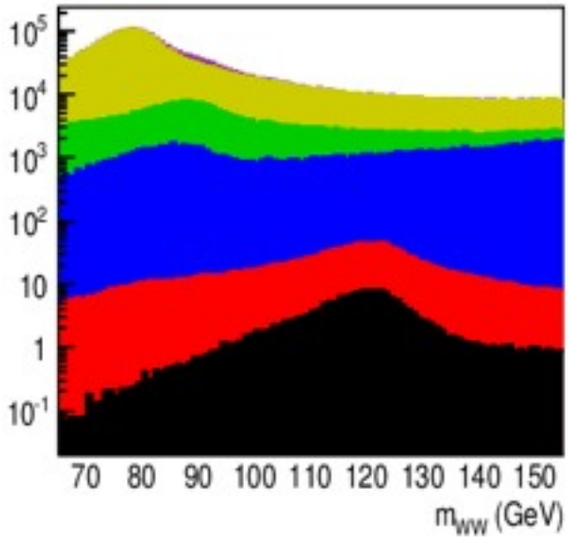
Sophie Redford on behalf of the CLICdp collaboration

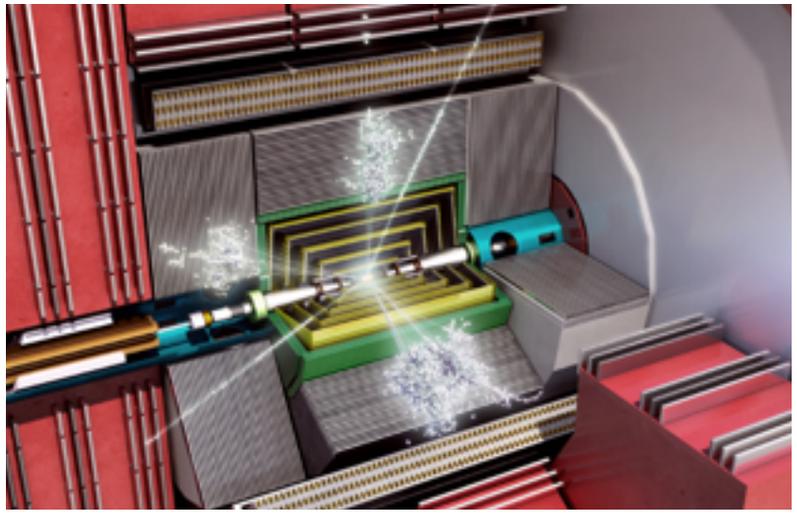
Outline

- CLIC introduction and detector requirements
- Hardware
- Software
- Detector optimisation
- Physics benchmarks
- CLICdp collaboration









Find out more

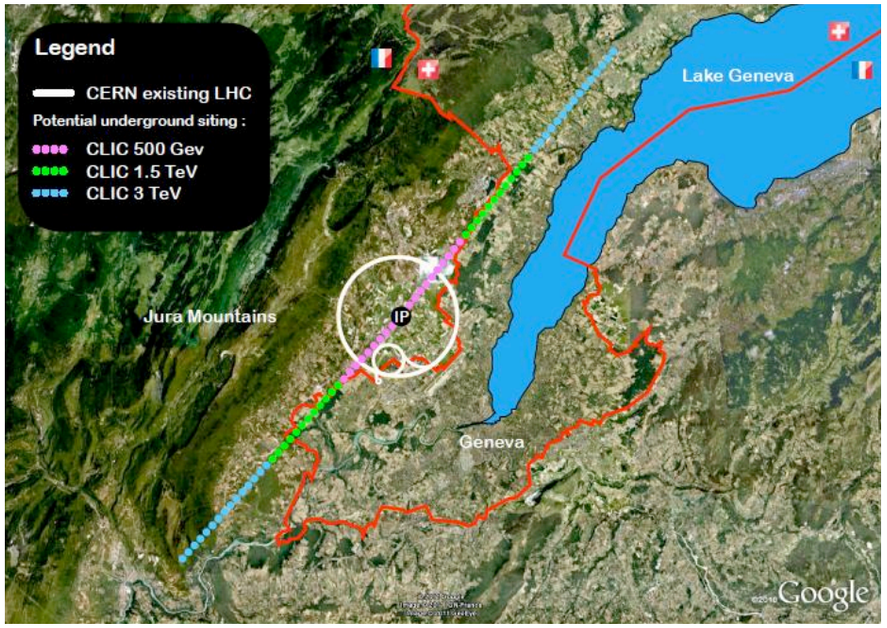
Purple arrows direct you to a whole talk on this topic!

Expert speaker
Day and time

CLIC introduction

S. Stapnes
Monday 3:15pm

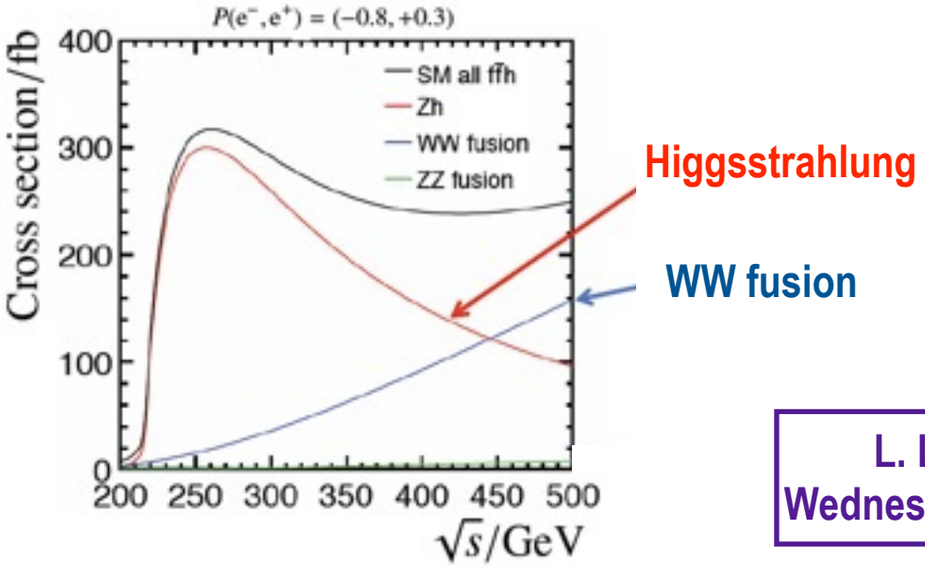
- Linear electron-positron collider
- $\sqrt{s}$ = 3 TeV (staged construction)
- High luminosity: few x 10^{34} $cm^{-2}s^{-1}$
- Small bunch size: σ_{xyz}(40 nm, 1 nm, 44 μm)



News

Update CLIC staging scenario

- accelerator and cost optimisation
- lowest energy stage: $\sqrt{s}$ = 350 - 500 GeV
- trade off between top and Higgs physics
- join the discussion: CLICdp concept session

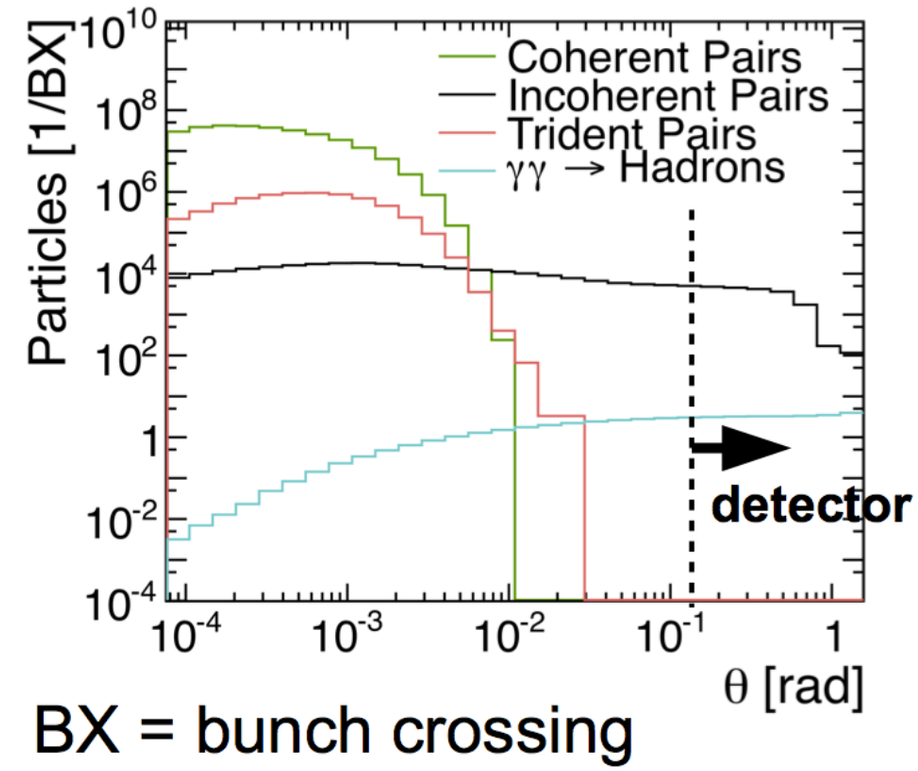


Higgs production cross sections

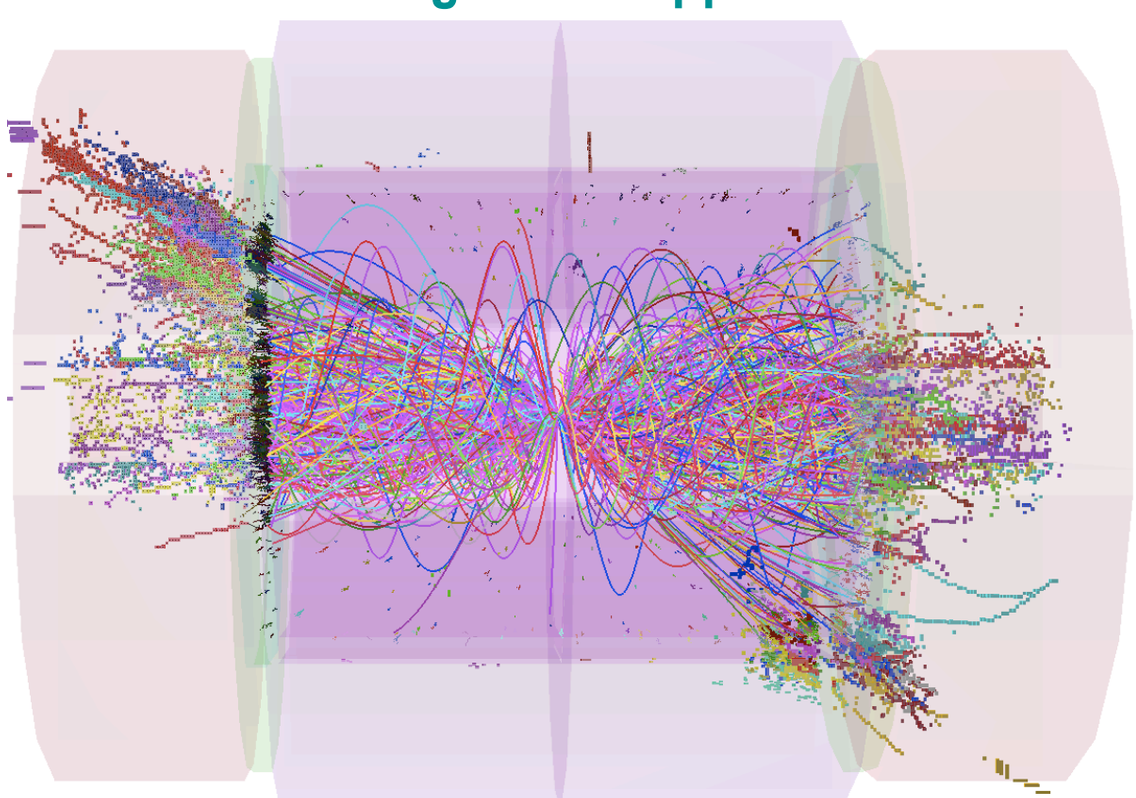
L. Linssen
Wednesday 11:00am

CLIC detector requirements

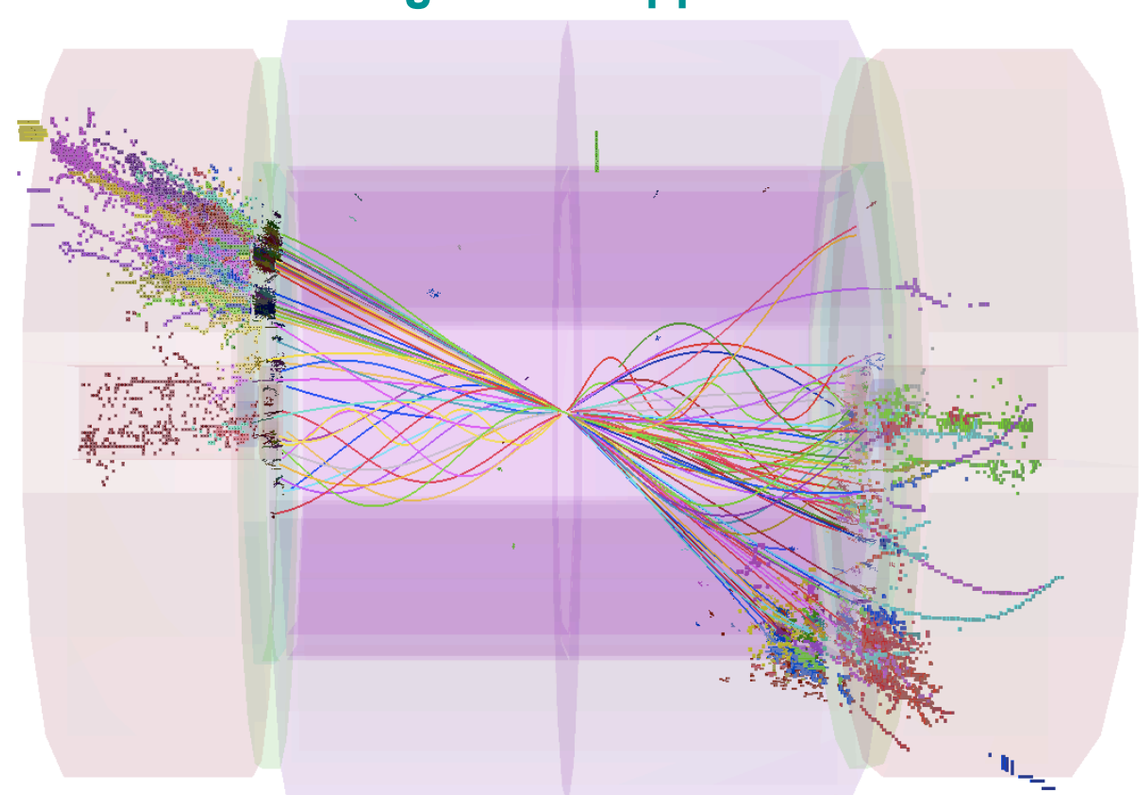
- Small bunch size results in strong beam-beam interactions
- High background levels at low p_T, theta
- Reject beam induced backgrounds with timing and p_T cuts
- Requires high granularity (space and time) detector



No background suppression



Background suppression



Hardware

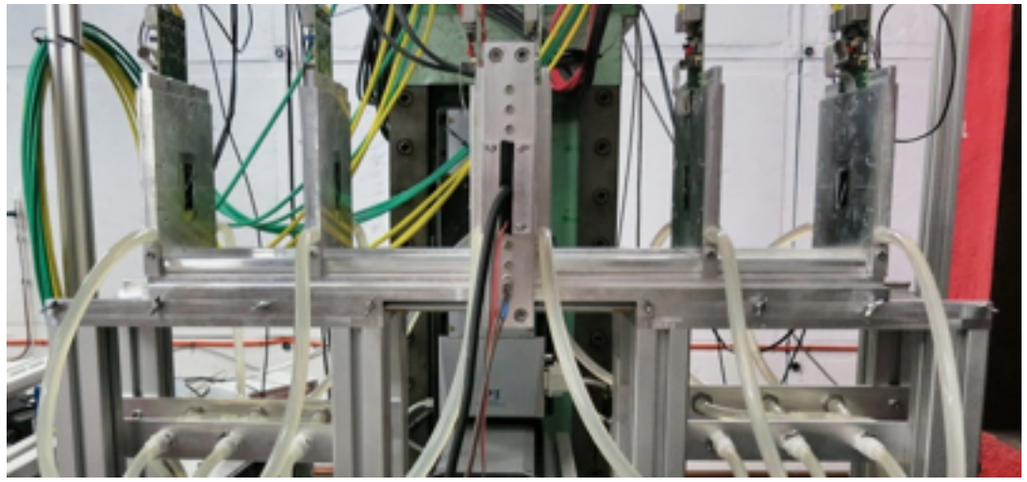
- Vertex detector
  - Timepix1 prototypes
  - Timepix3 first testbeam
  - CLICpix-HVCMOS first assemblies
  - Vertex detector mechanical studies
- HCAL

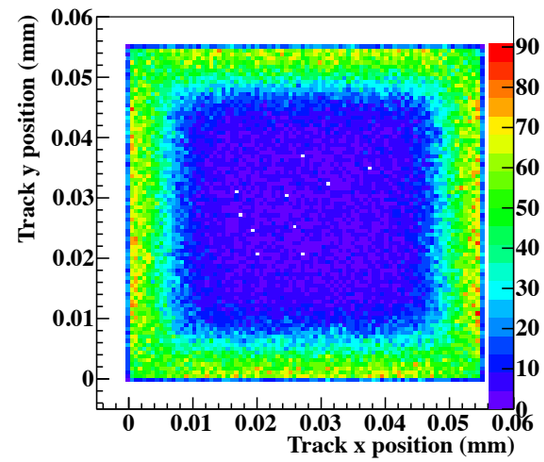
Scale model of CLIC detector
1/15th of the way there?

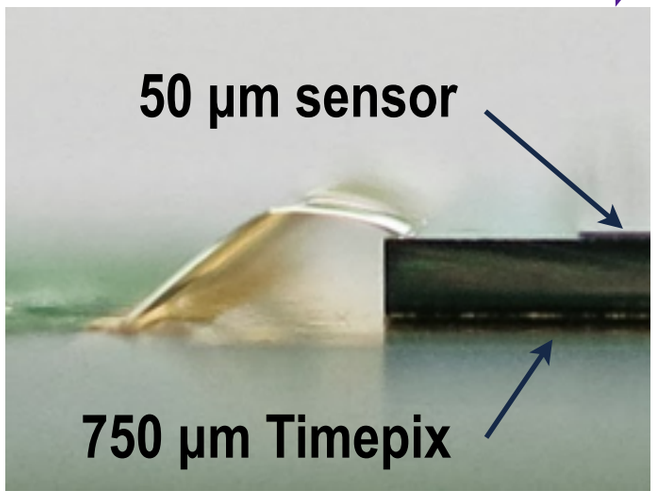
Timepix assembly prototypes

S. Redford
Tuesday 9:44am

- Thin sensors (50 - 300 μm) bump-bonded to Timepix chips
- Data recorded at DESY: 5.6 GeV electron beam, EUDET telescope

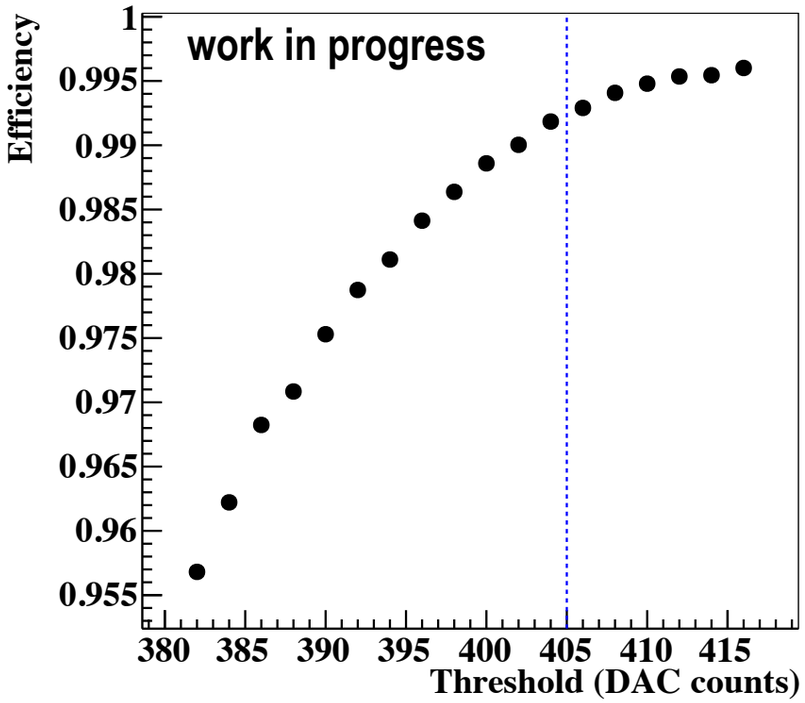




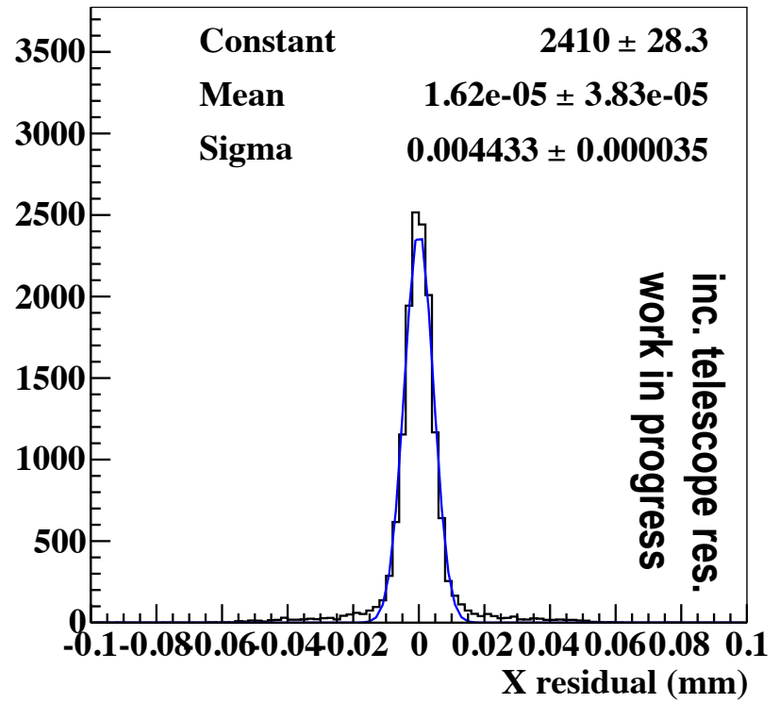


Track position: cluster size 2
low charge sharing

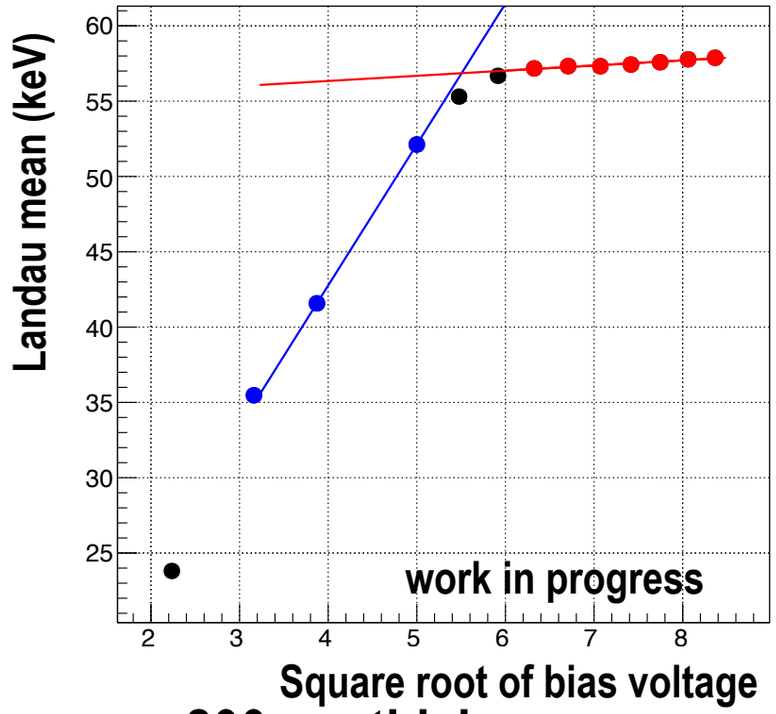
C04-W0110 Oct13 - Work in progress



50 μm thick sensor efficiency
99.2% at operating threshold



100 μm thick sensor two-hit
cluster resolution ~4.5 um



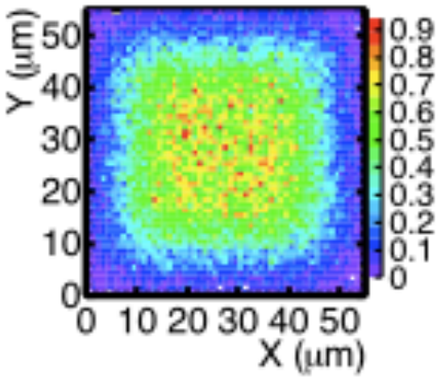
200 μm thick sensor
depletion voltage ~30 V

Timepix3 assembly prototypes

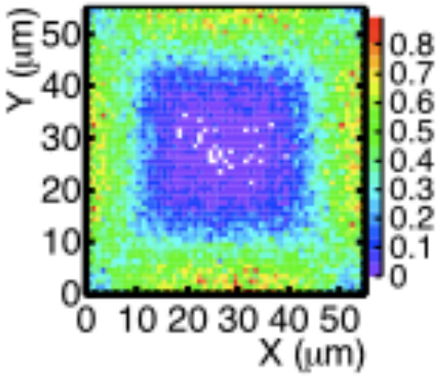
S. Arfaoui
Tuesday 10:06am

- Thin sensors (300 µm) bump-bonded to Timepix3 chips
- Data recorded at CERN PS, using EUDET telescope
- Testing telescope integration and DAQ workflow
- Good efficiency
- Up to 10k tracks / 400ms recorded

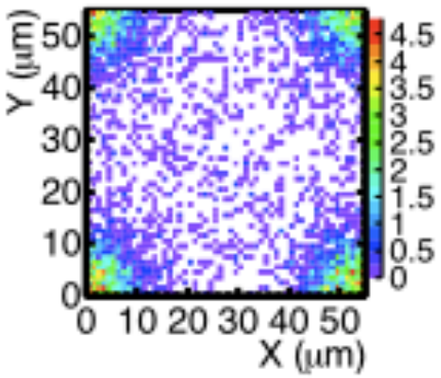
Timepix3 assembly
Cluster size 1

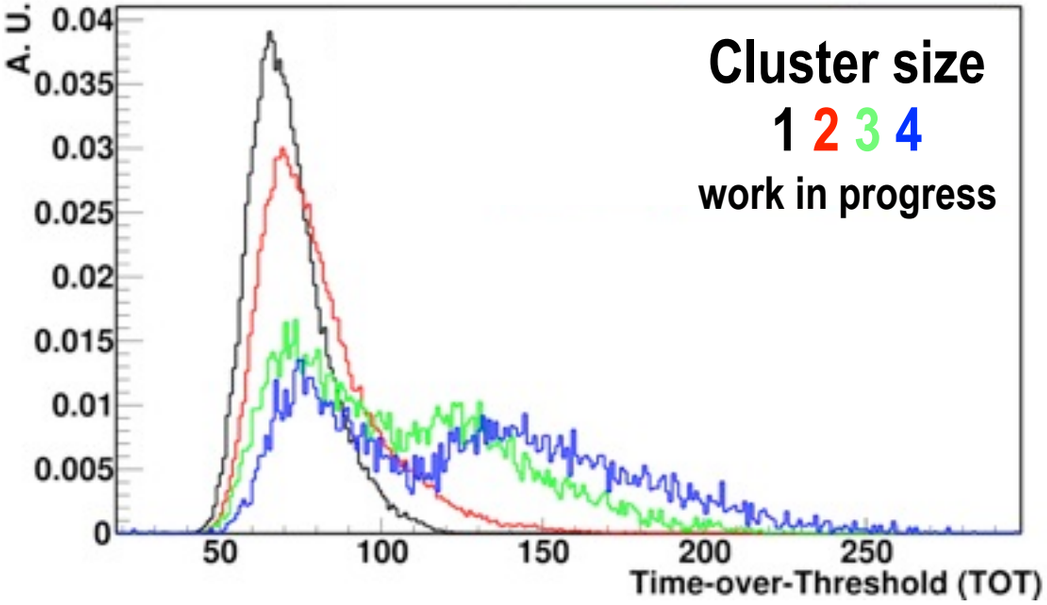


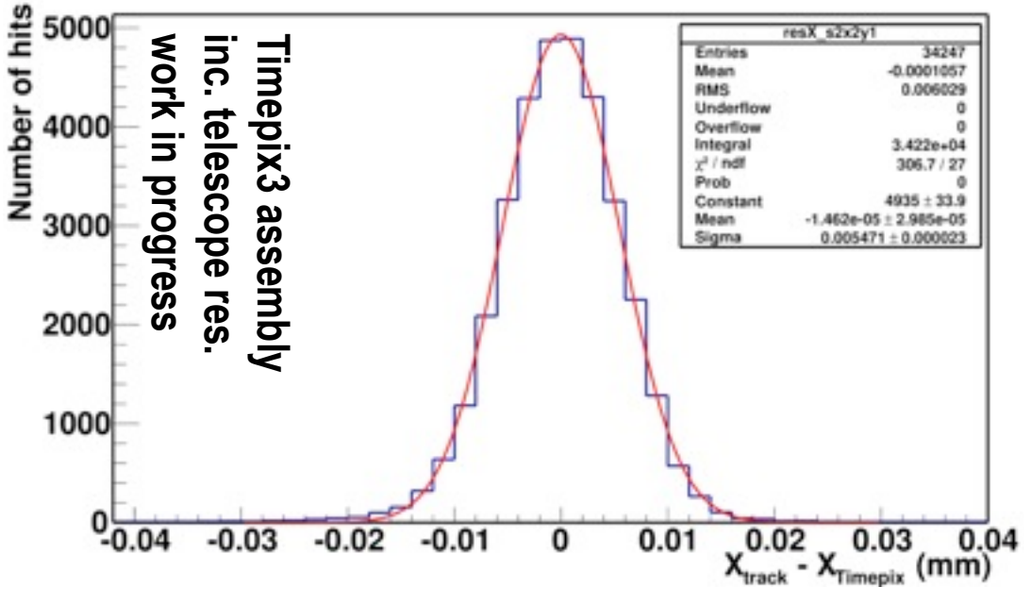
Cluster size 2



Cluster size 4



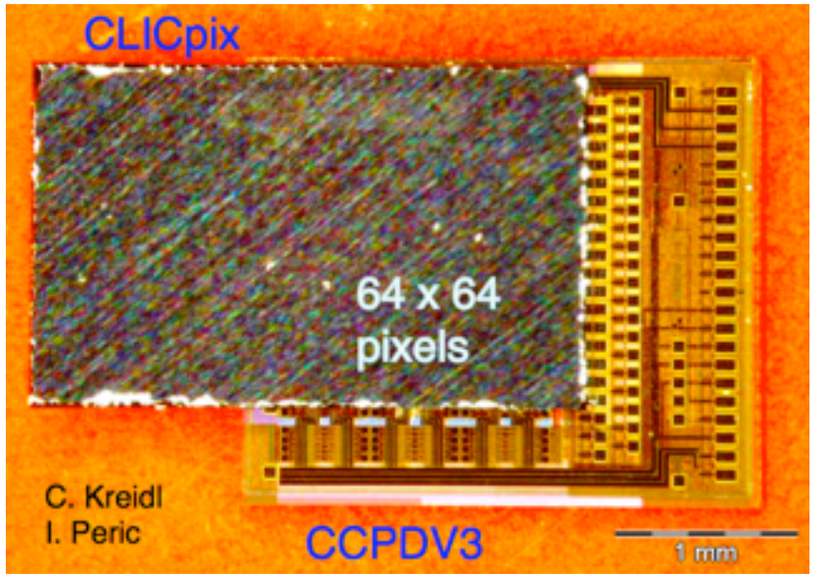


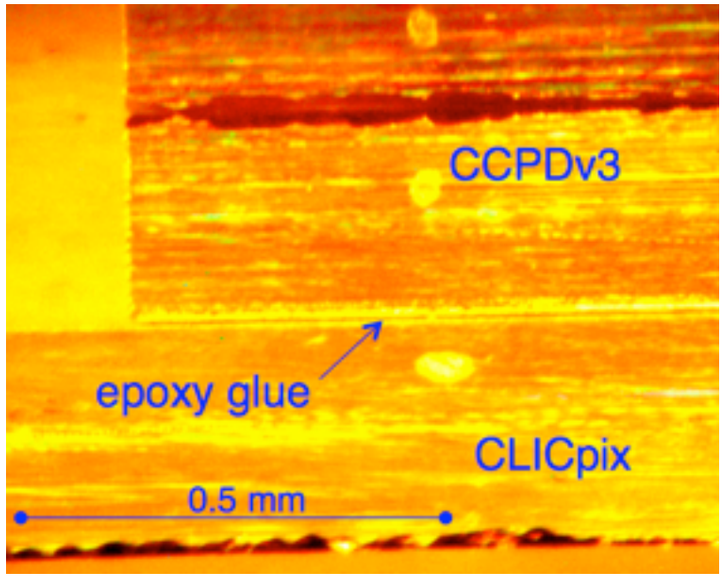


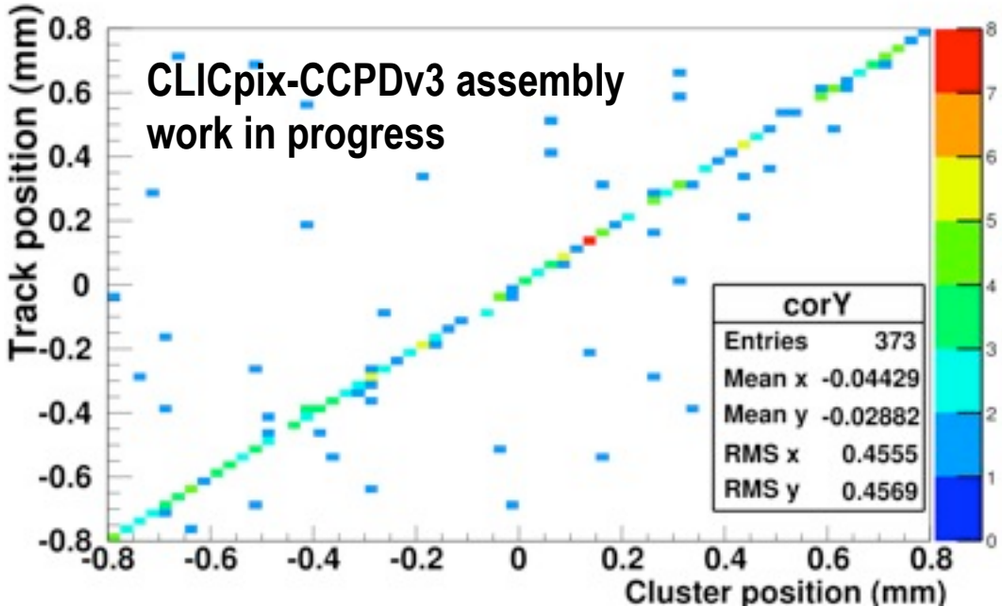
CLICpix assemblies

S. Arfaoui
Tuesday 10:06am

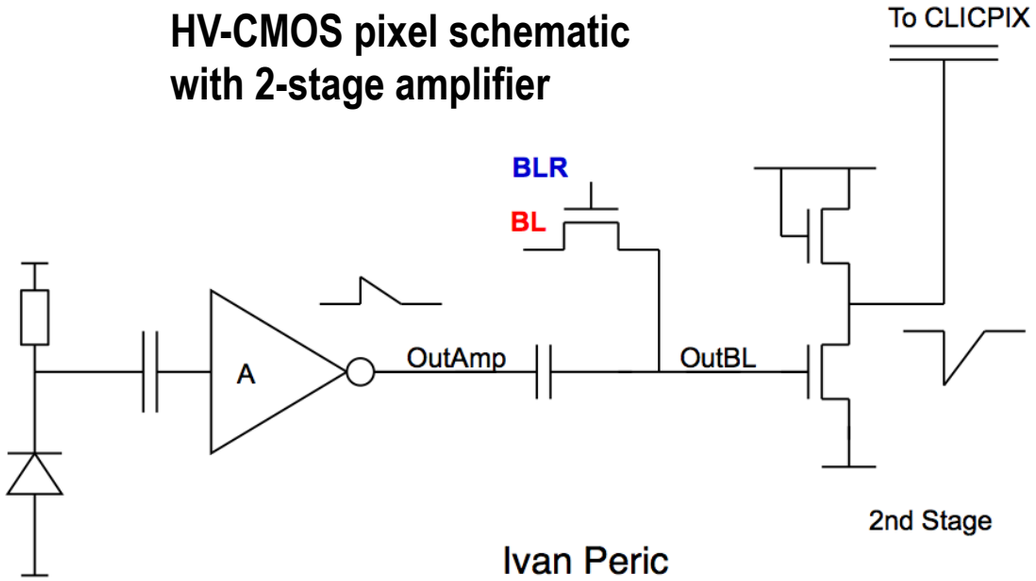
- CLICpix ASIC glued to HV-CMOS sensor: capacitive AC coupling
- CERN PS test beam: successful telescope and DAQ integration, correlation plot achieved
- Next assemblies: bump-bonding trials to Si-sensor at SLAC







HV-CMOS pixel schematic
with 2-stage amplifier

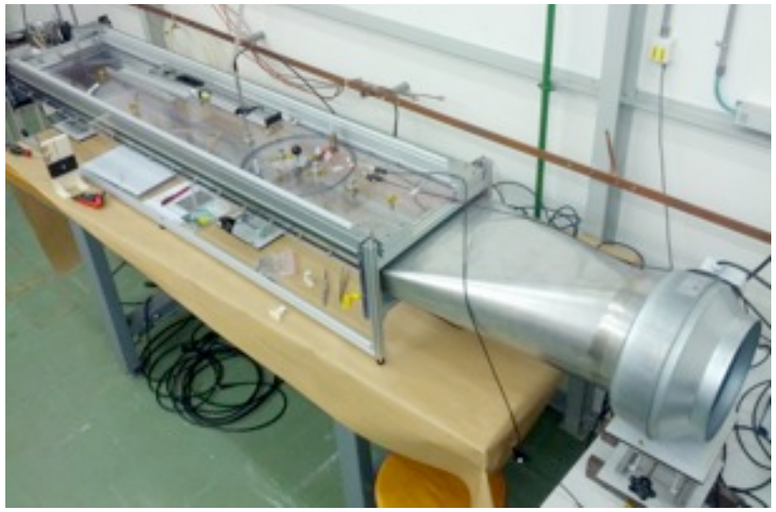


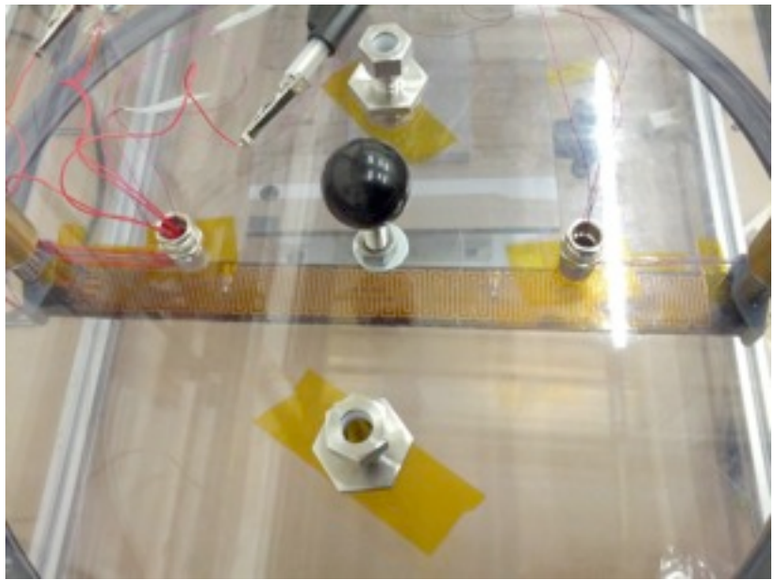
Ivan Peric

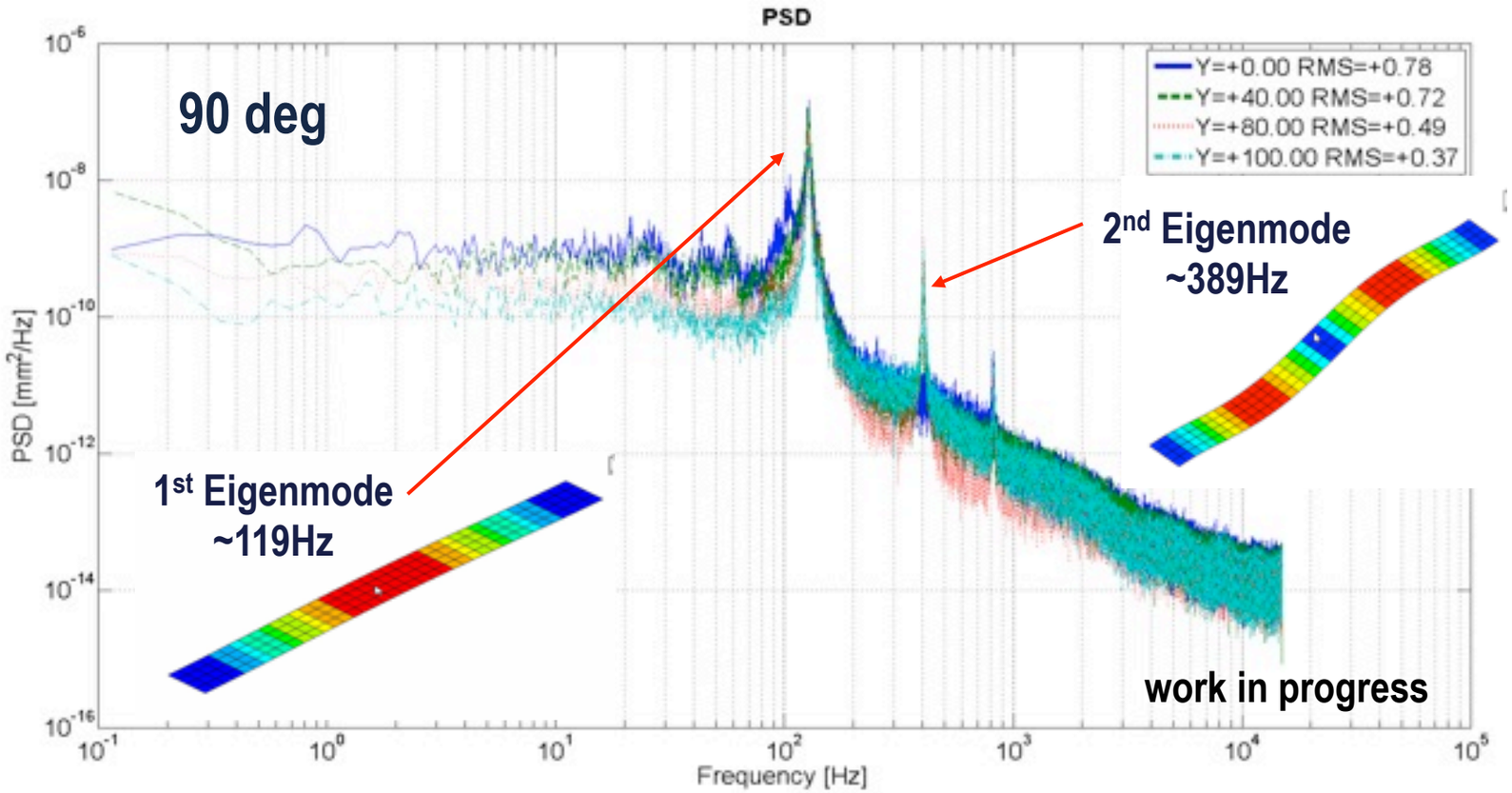
Cooling and vibration studies

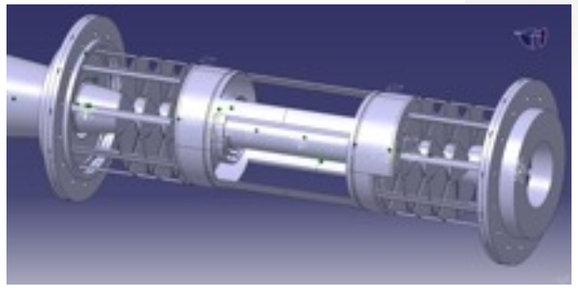
F. Duarte Ramos
Thursday 2:00pm

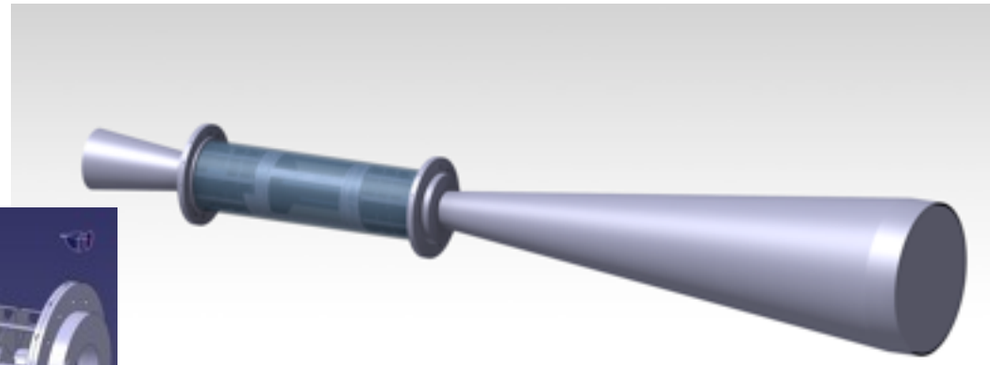
- Thermo-mechanical test bench facilitates temperature and vibration studies of a single stave
- Underway: 3D printing a scale model of the vertex detector for future studies



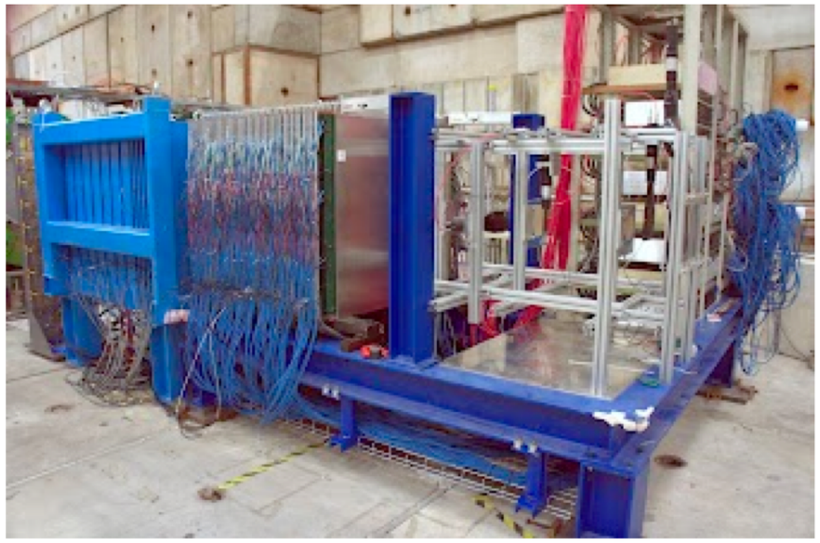






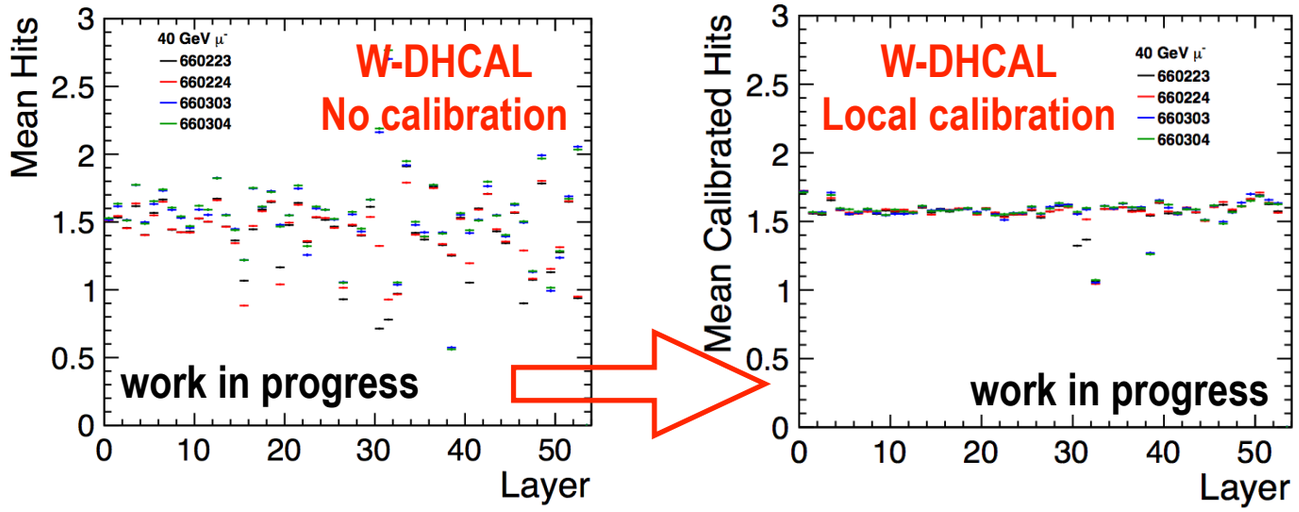


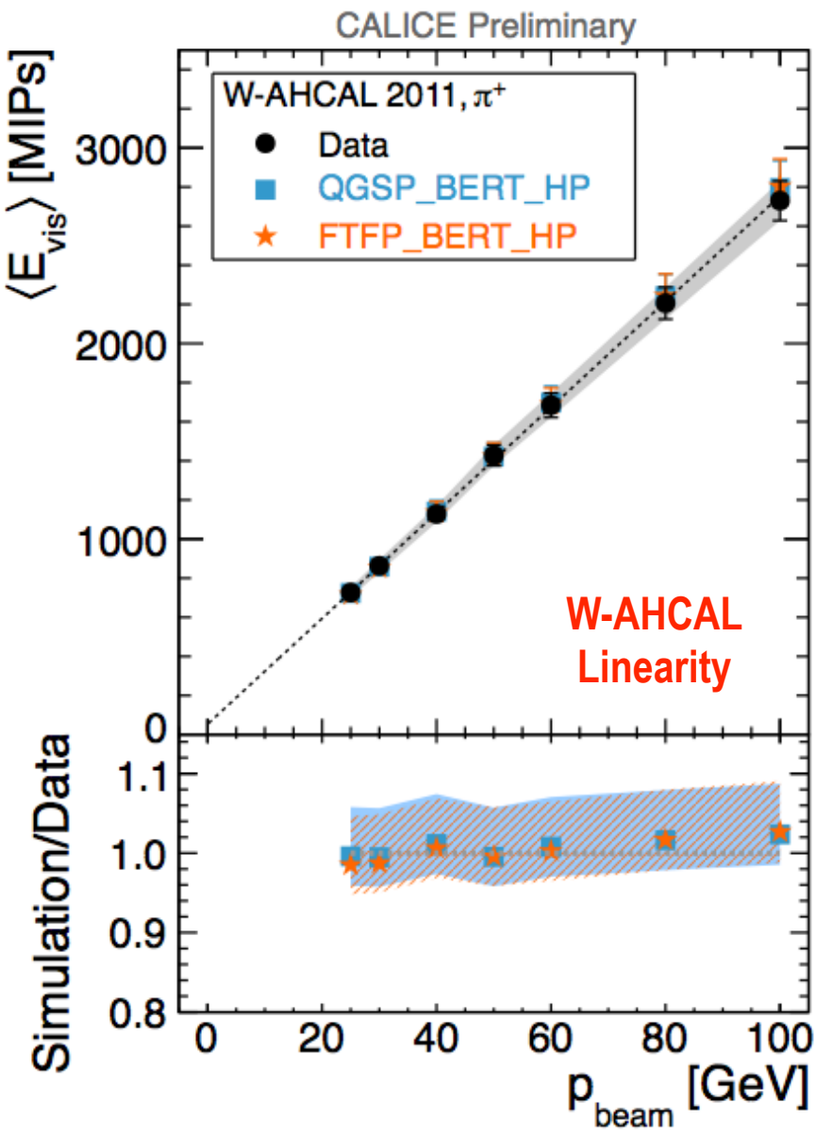
HCAL



Ongoing analysis of W-DHCAL test beam data:

- Improved particle identification
- Better calibration and understanding of efficiencies
- More realistic digitisation simulation





Preparation of W-AHCAL test beam data for publication:

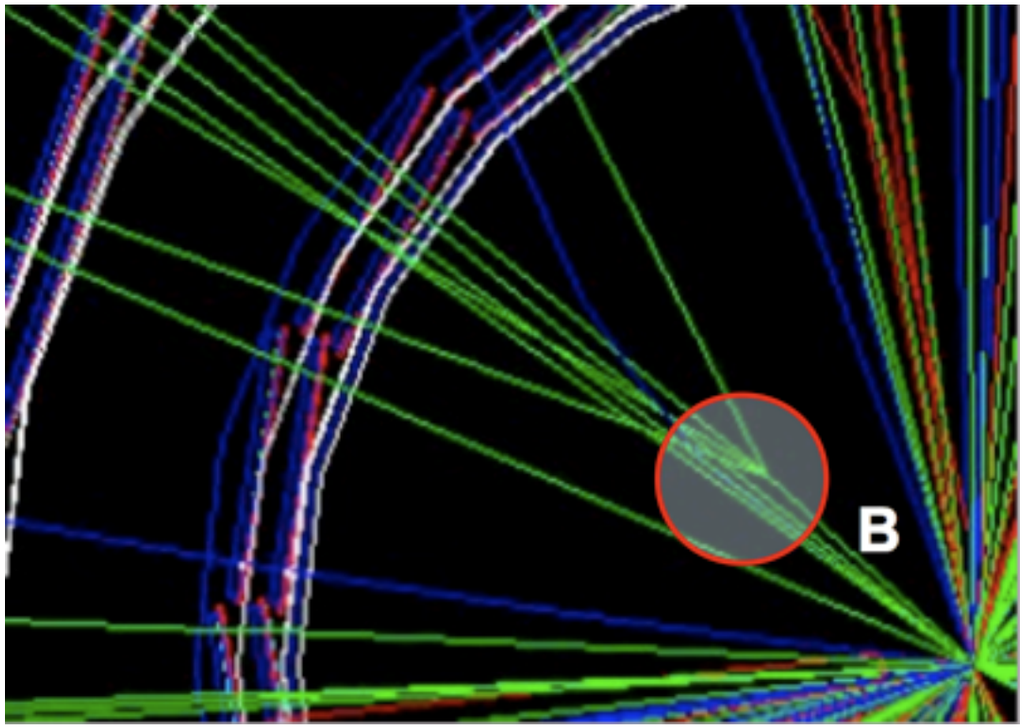
- Linear response for pions up to 100 GeV
- Resolution: fit stochastic term 62%
- Good agreement between data and Monte Carlo

The W-AHCAL paper

coming soon to a journal near you

Software

- DD4HEP
- Tracking
- Flavour tagging
- ILCDIRAC

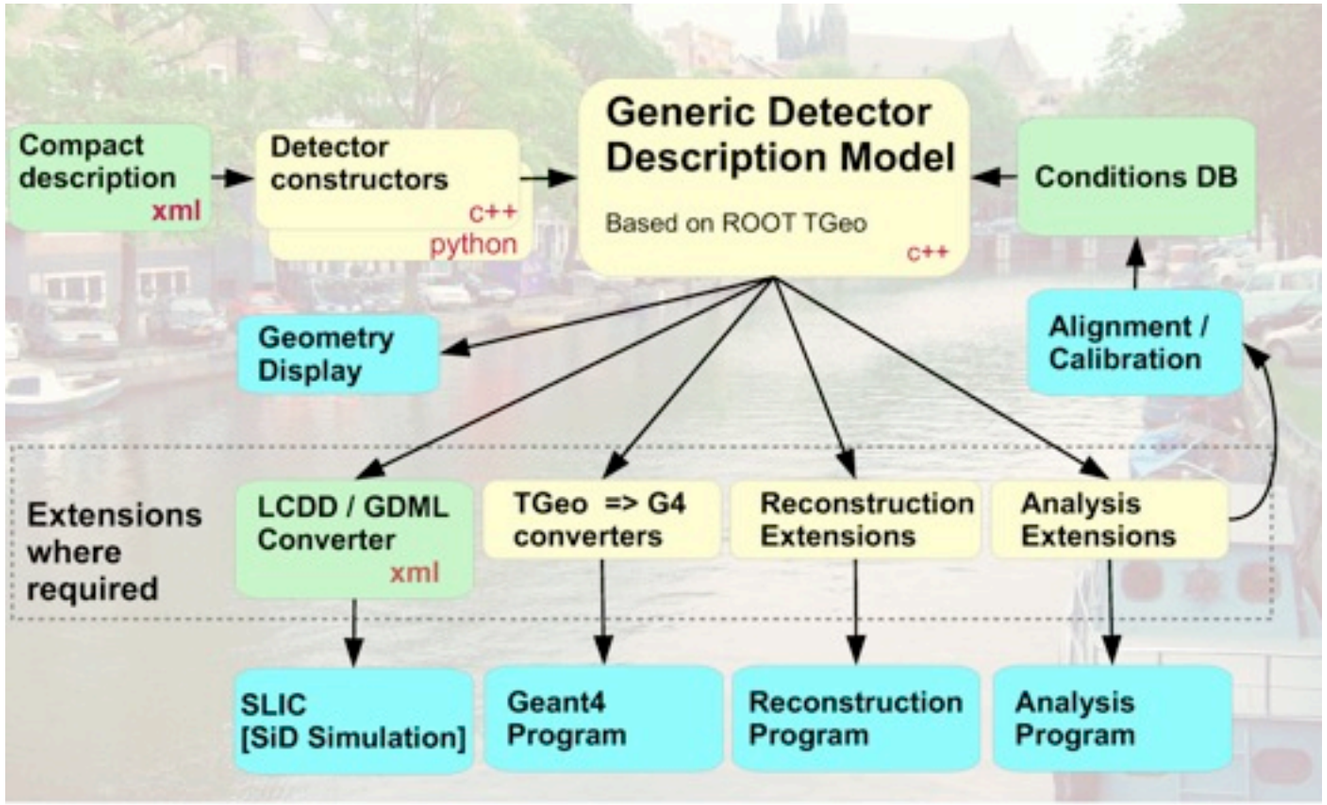


Software reconstructs a displaced vertex
Beta do a good job

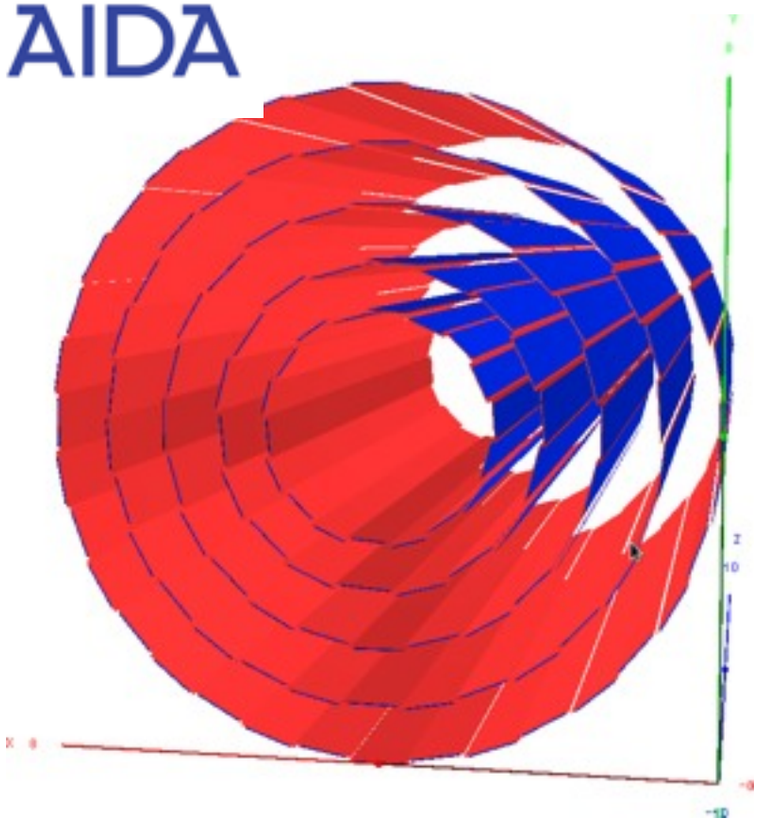
Detector description: DD4HEP

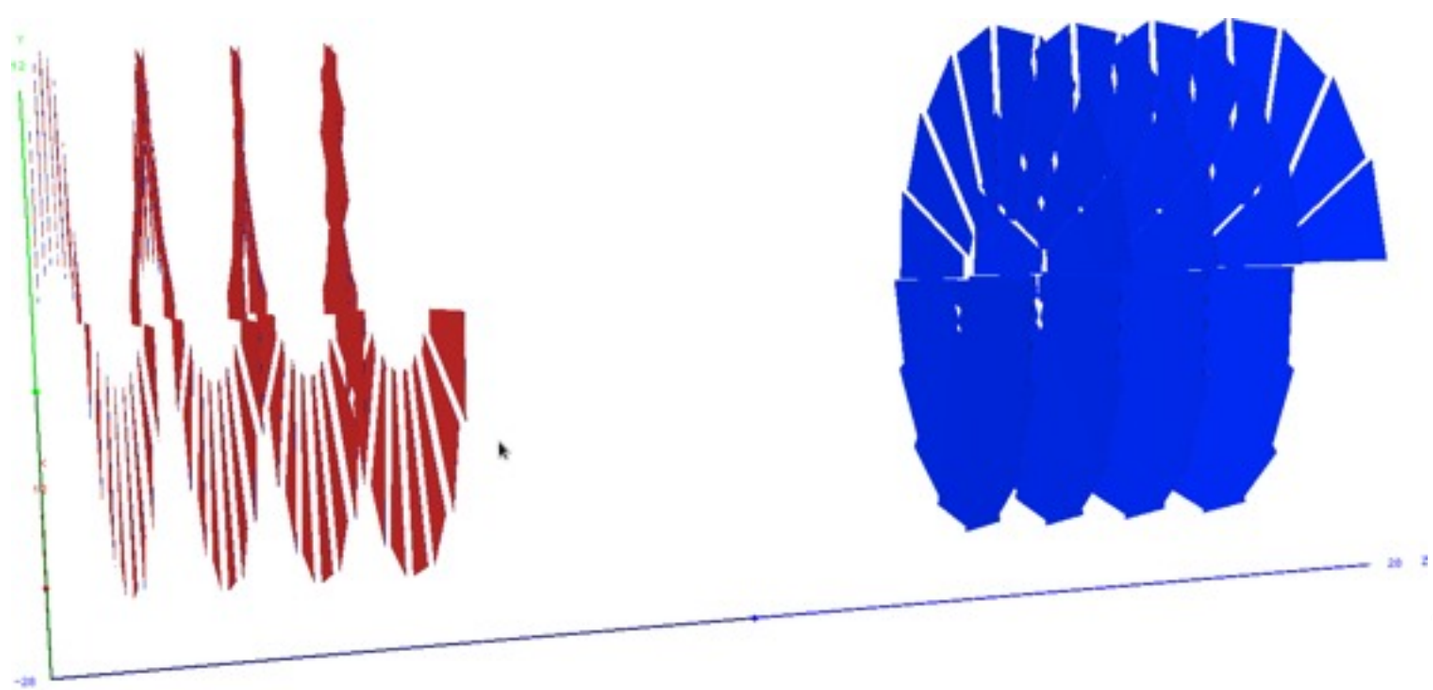
F. Gaede
Wednesday 2:20pm

- Development shared between all LC detector concepts
- A single source of detector information for simulation, reconstruction, visualisation
- Implementation of new CLIC detector model nearing completion



AIDA





Plans for new tracking software

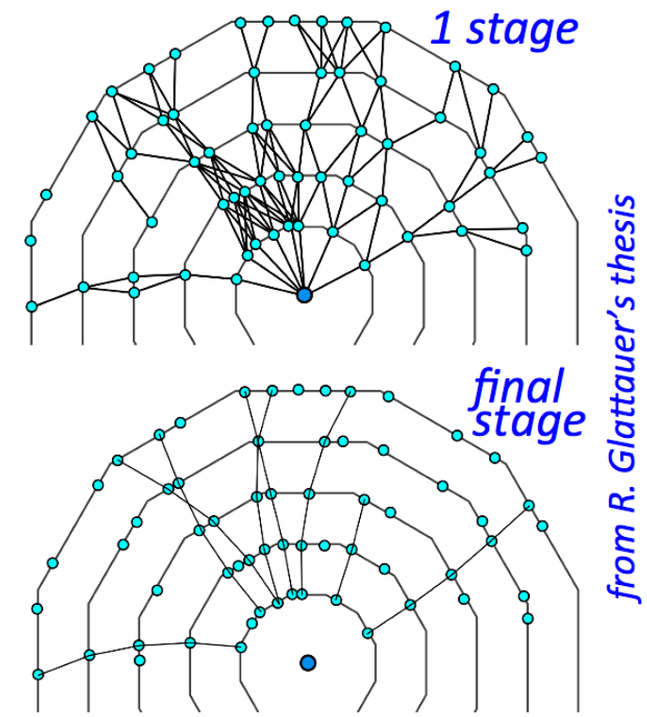
R. Simoniello
Thursday 4:20pm

Current SiD tracking software has no Kalman filter, global helical tracking extrapolation

Plan: extend the ILD vertex tracking software (cellular automaton)

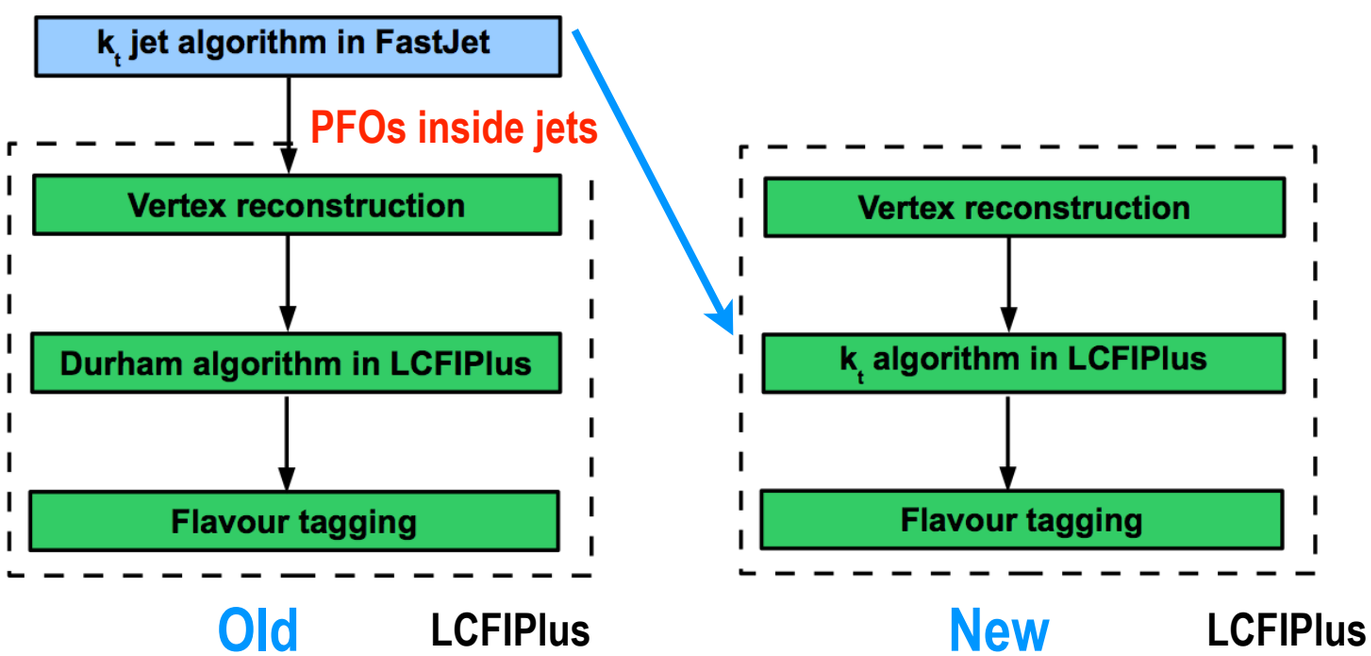
- [x] Kalman filter implemented
- [x] good performance
- [ ] extend to full Si tracker
- [ ] interface to DD4HEP

performance metric: B decays



Flavour tagging using LCFIPlus

P. Roloff
Thursday 11:20am

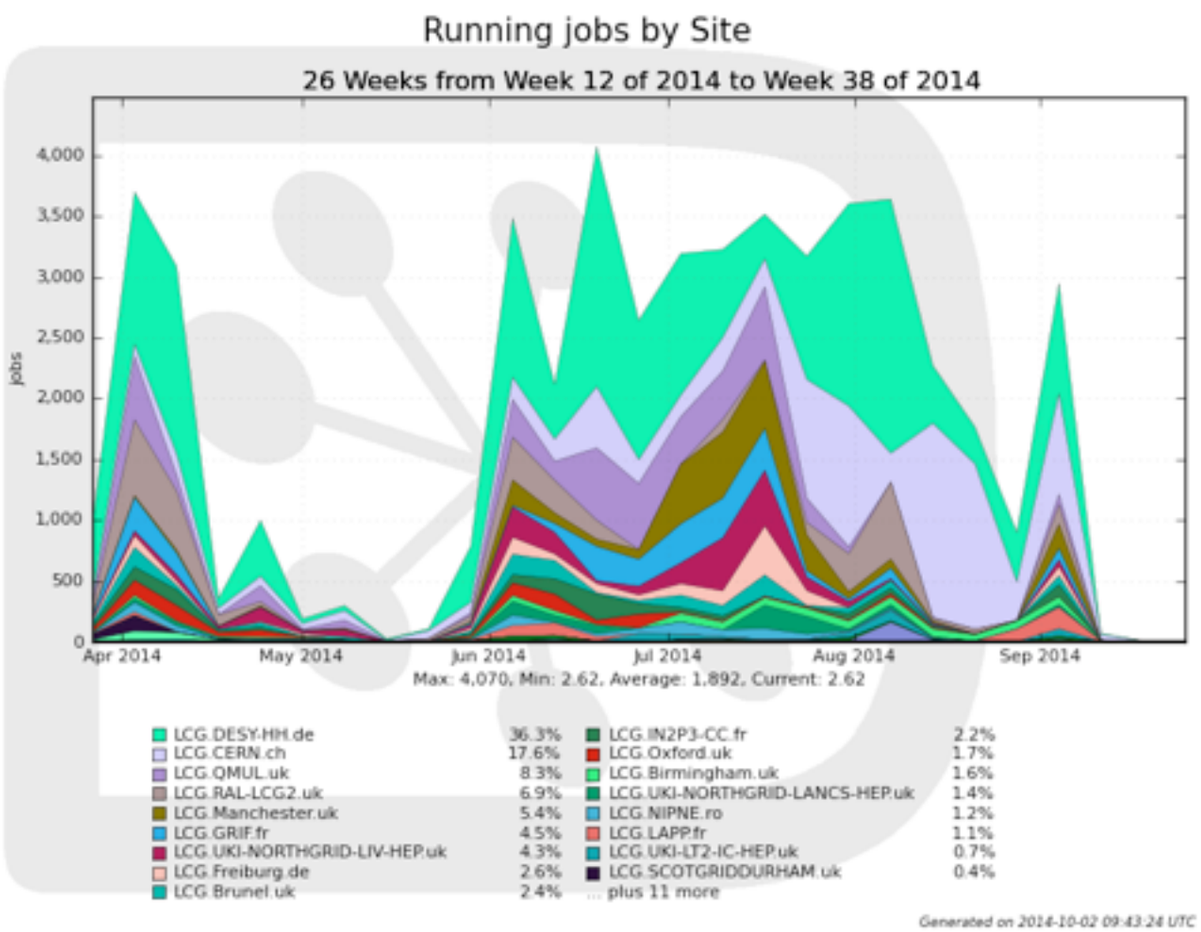


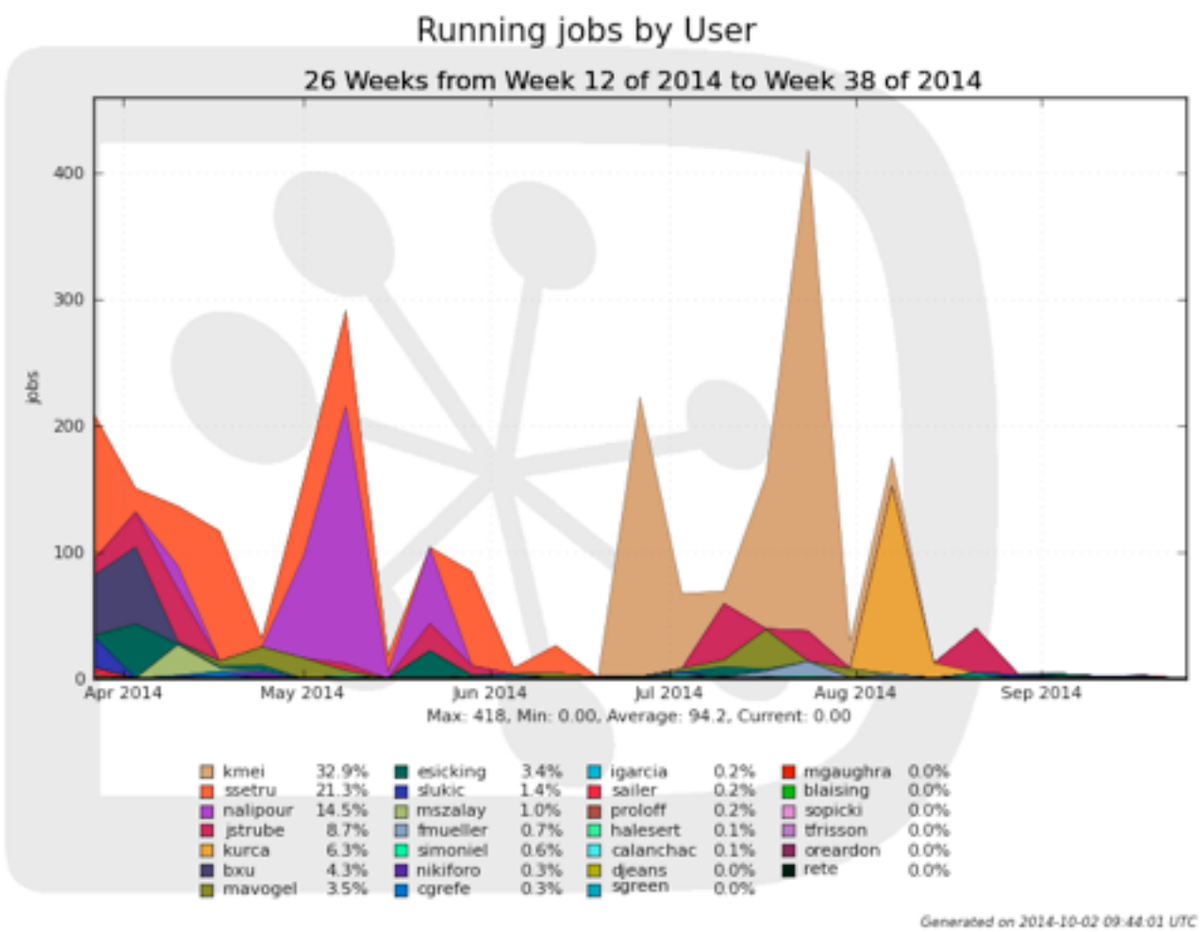
- A hadron collider kT algorithm with beam jets was added to LCFIPlus
- Jet flavour identification shows similar performance to before

ILCDIRAC

A. Sailer
Wednesday 2:00pm

- Grid interface for users and production to run any LC software
- Used by SiD, ILD, CLICdp, CALICE
- All services and databases moved to virtual machine infrastructure at CERN

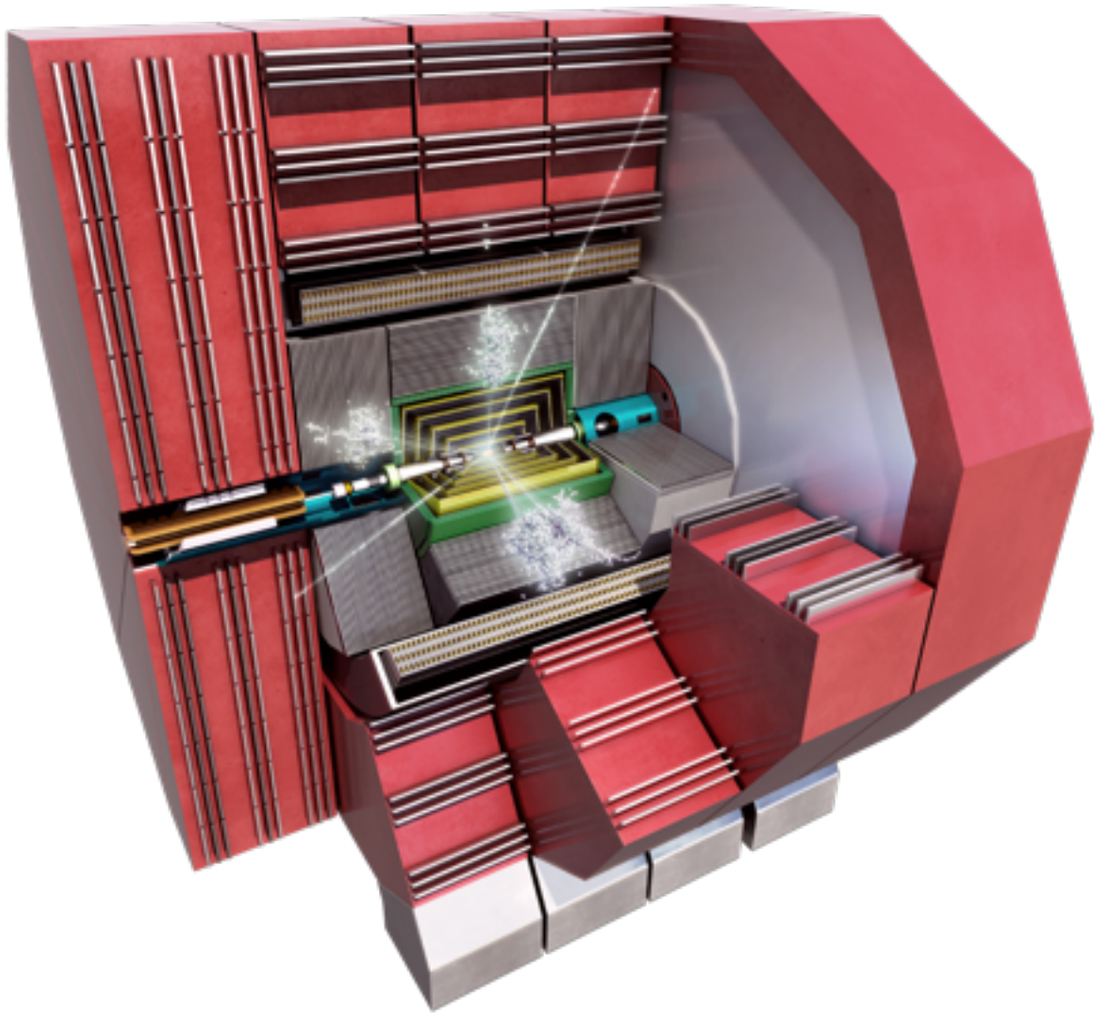




Detector optimisation

R. Simoniello
Thursday 9:00am

- Vertex detector
- Tracker layout
- ECAL layers and active material
- HCAL layers and absorbing material
- Yoke and magnetic field strength



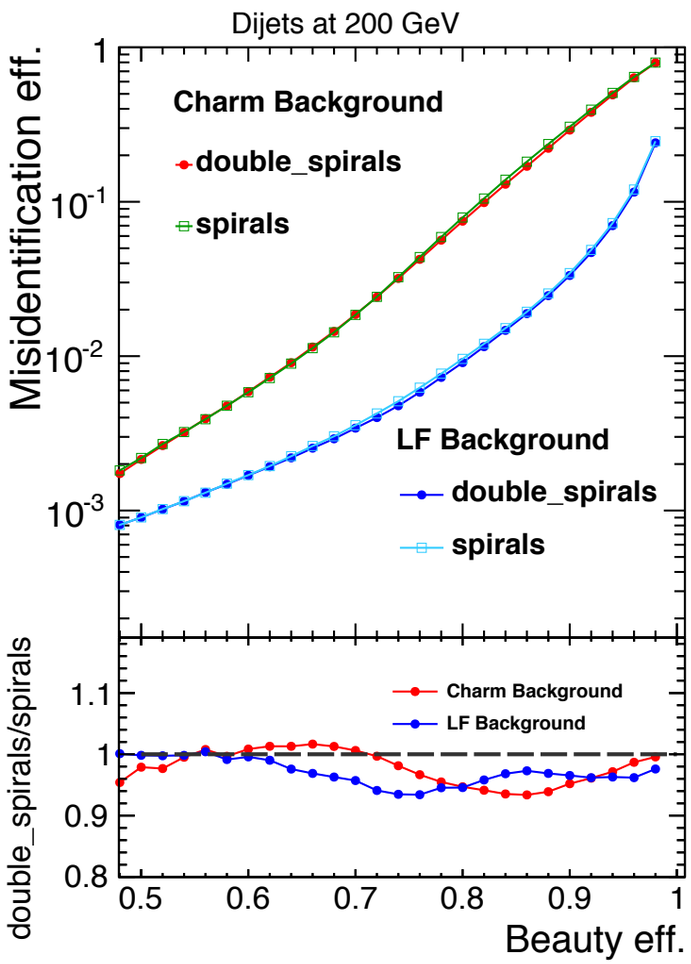
Building the optimal detector
to reconstruct final states like ttHis

Vertex detector

N. Alipour Tehrani
Thursday 4:00pm

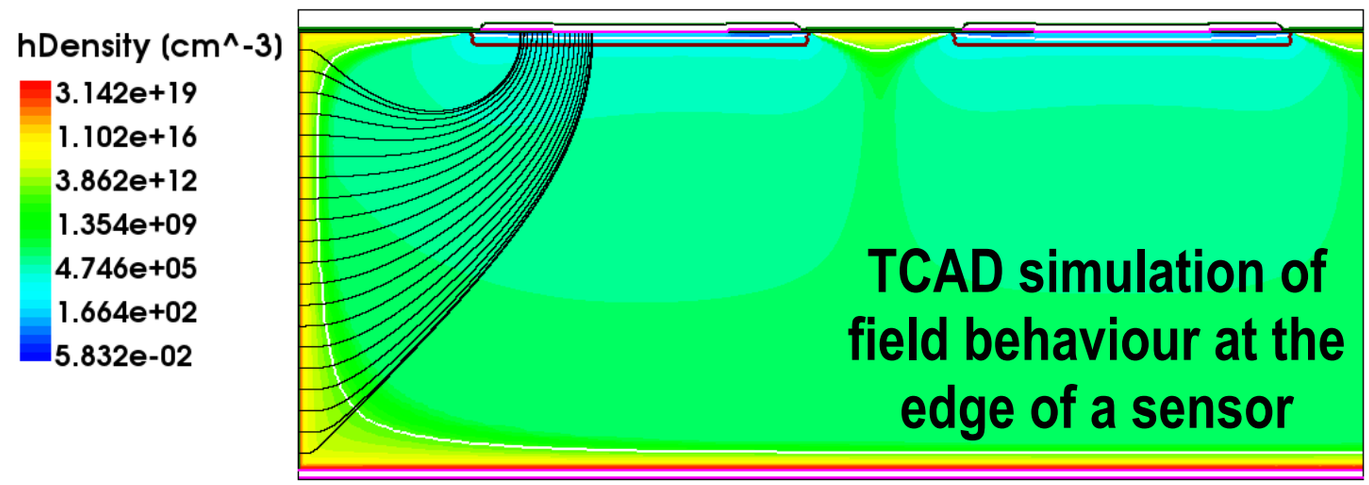
Optimal detector layout - flavour tag metric

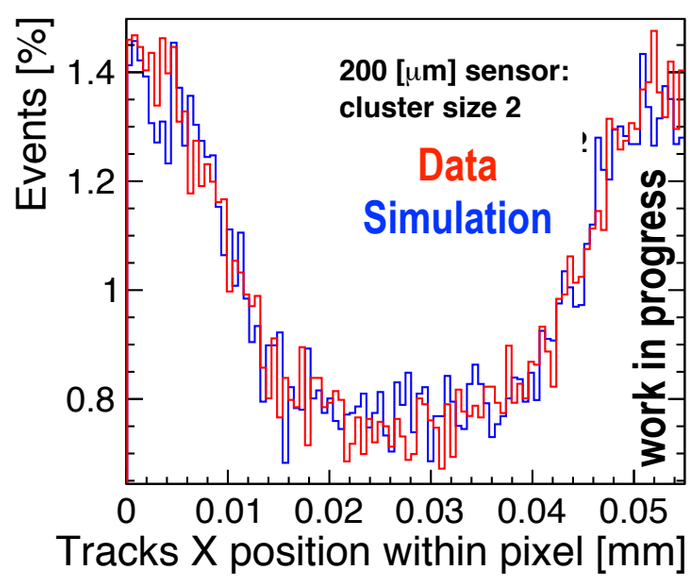
- Single sided vs double sided layers
- Similar flavour tag performance

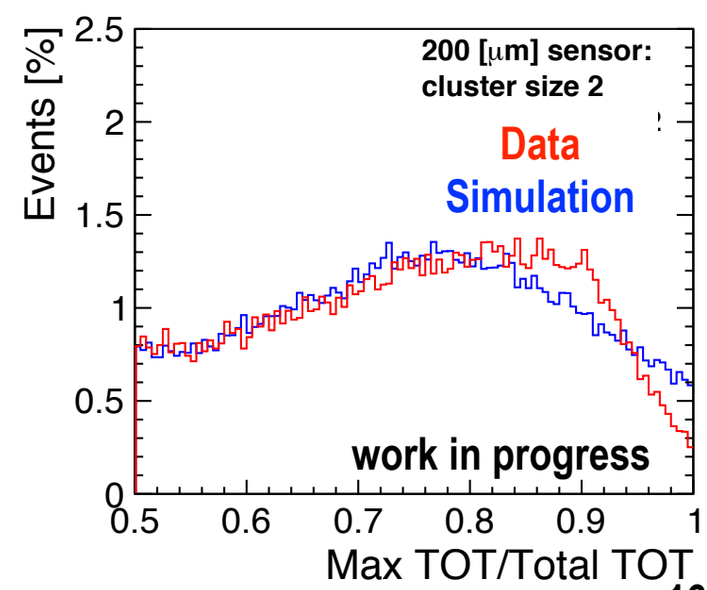


Optimal technology choice - sensor and ASIC design

- TCAD + GEANT4 simulation
- Under validation using test beam data

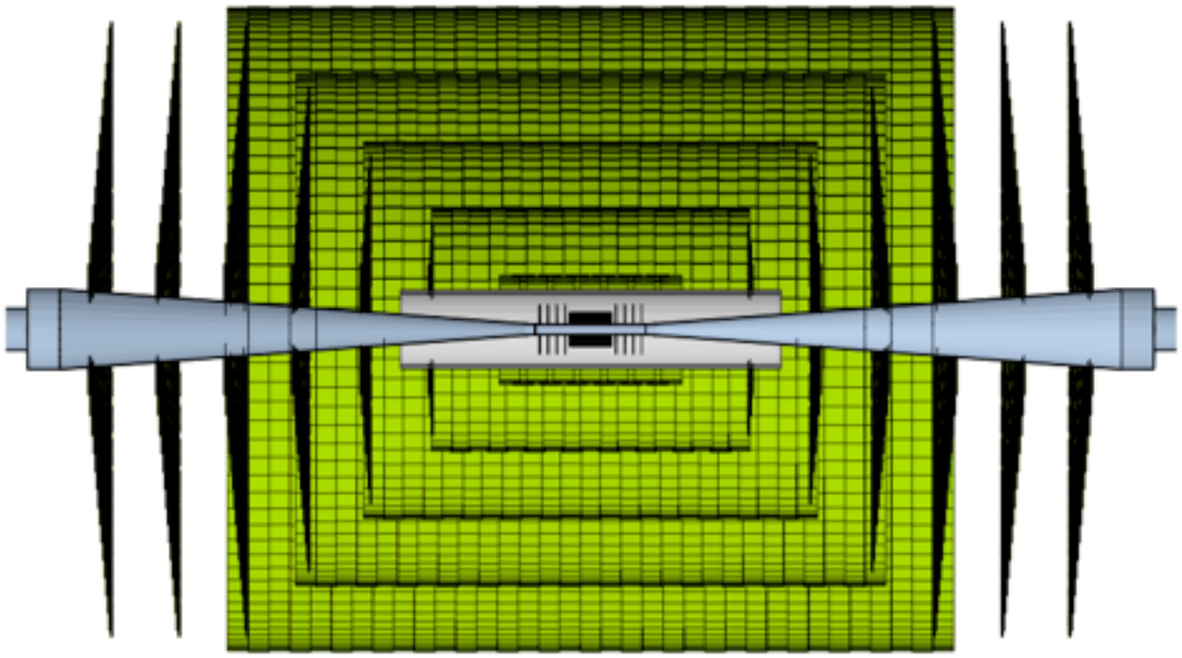


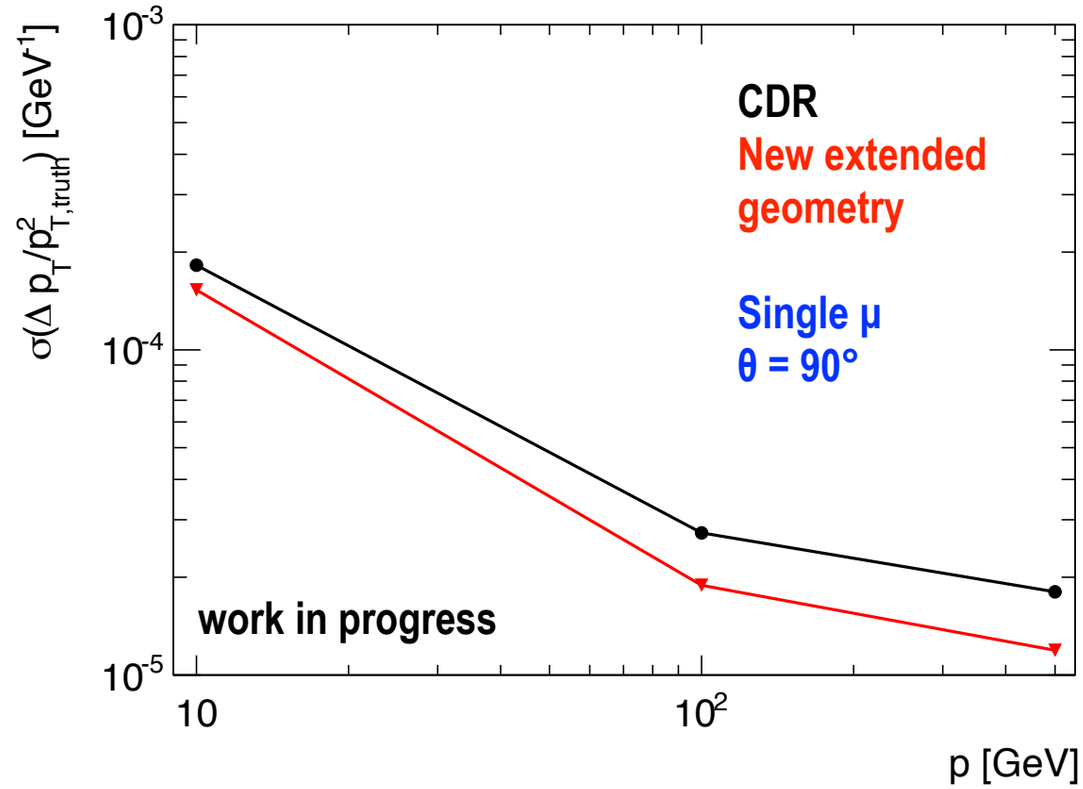




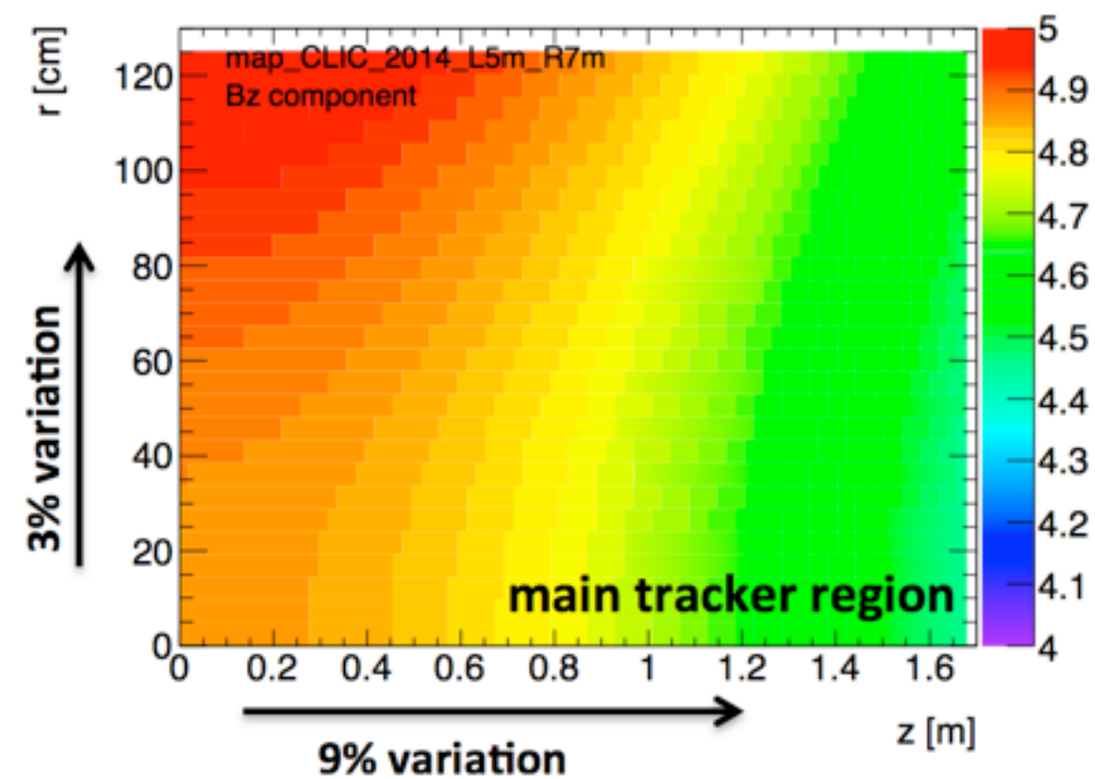
Main tracker

R. Simoniello
Thursday 4:20pm



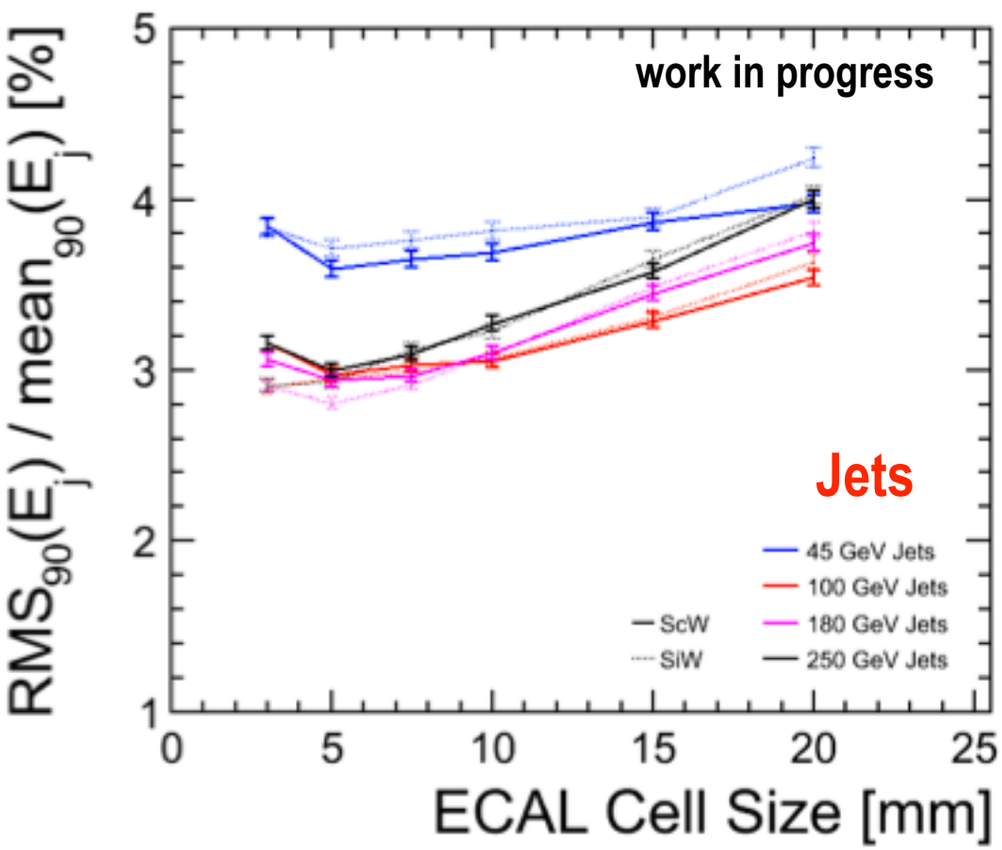


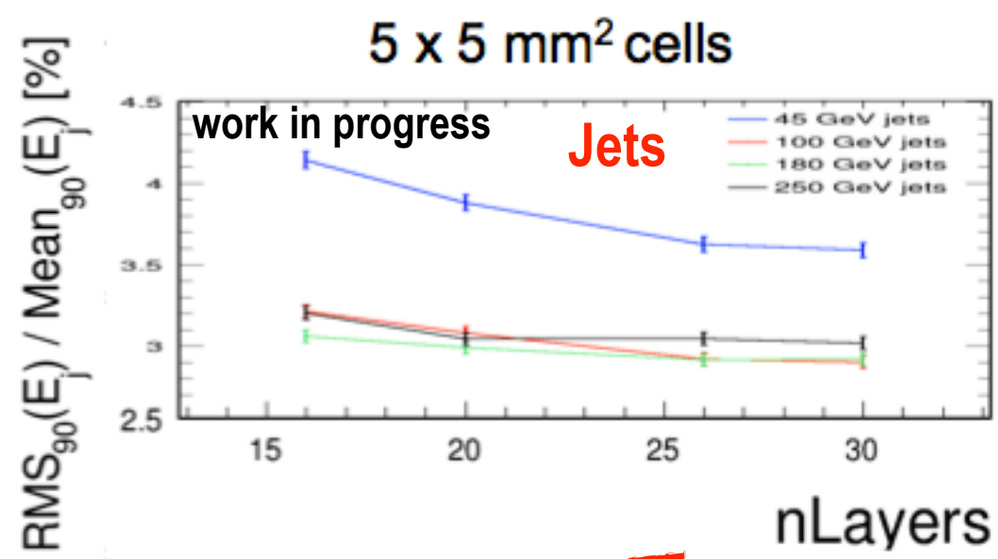
- [x] Extended tracker geometry: two additional endcap discs, outer radius 1.5m (from 1.25m)
- [x] Performance remains good
- [ ] Implementation of more realistic non-homogeneous B field in simulation
- [ ] Reconstruction (helical global fit) uses homogeneous field, will be improved in new tracking software



ECAL

- Considering: the number of layers, active material (silicon / scintillator), cell size
- Particle flow reconstruction: tracking single particles through the calorimeters
- High energy jet resolution: cell size is more important than number of layers (confusion dominates)
- Next: study impact of cell size in hadronic tau decays

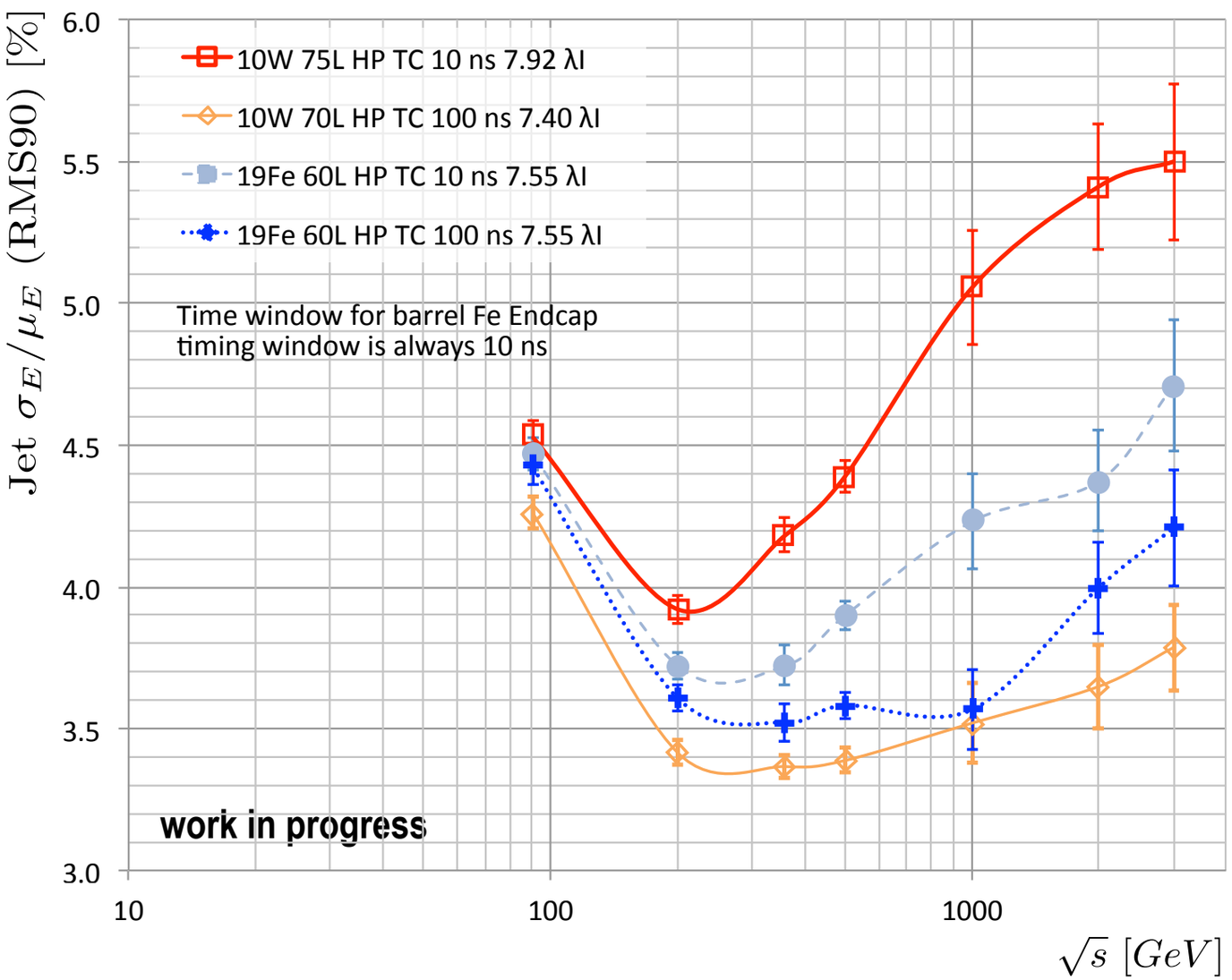


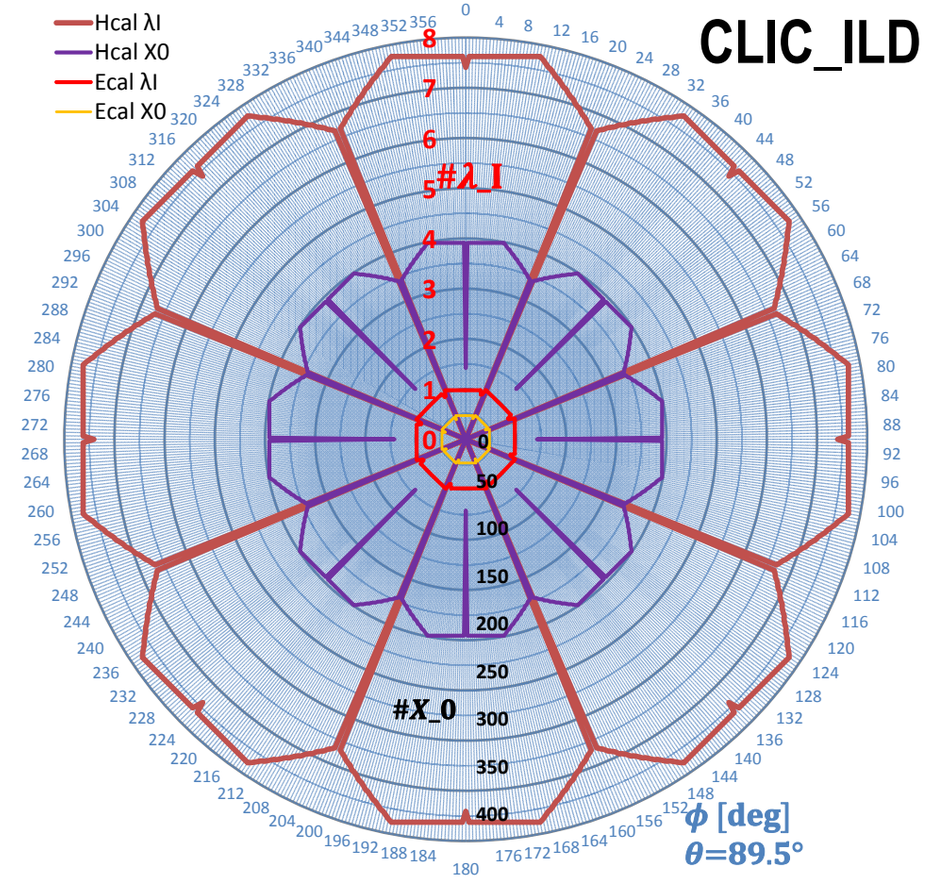


Decision: reduce number of layers from 29 to 25

HCAL barrel

- Verification of existing detector description and material budget
- Absorber material (tungsten vs steel)
- Number of layers and absorber thickness for a total ~7.5 interaction lengths





- Physics performance similar
- Other considerations:
  - material + construction cost
  - outer radius (solenoid cost)

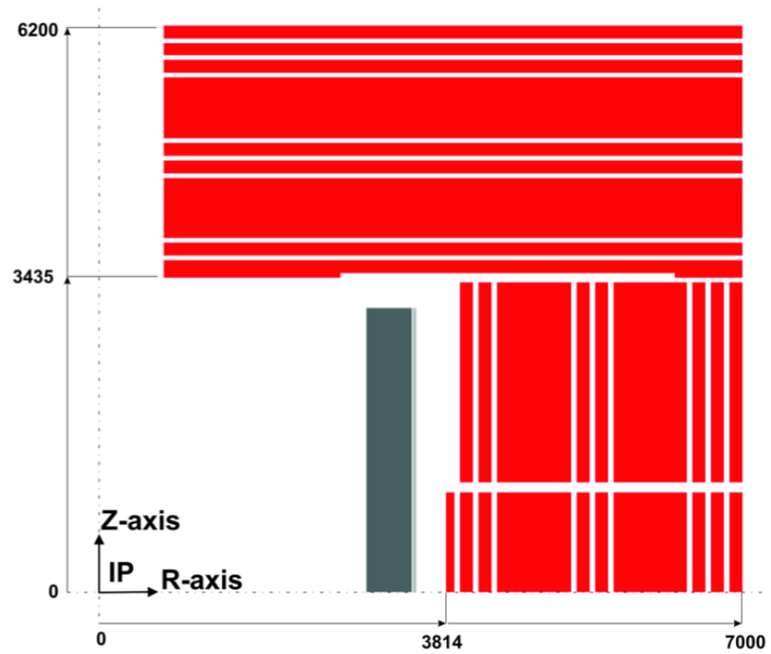
Tungsten / steel decision 5th November

Magnetic field

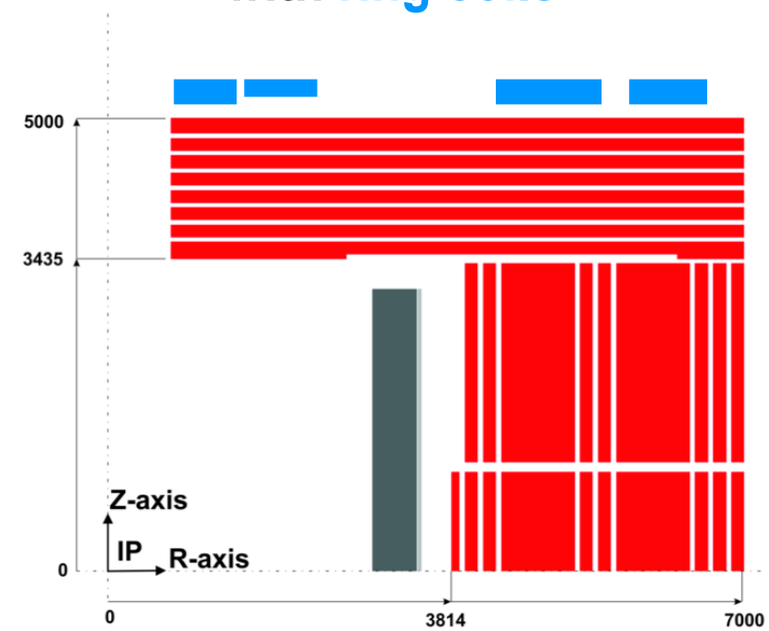
B. Cure
Tuesday 2:35pm

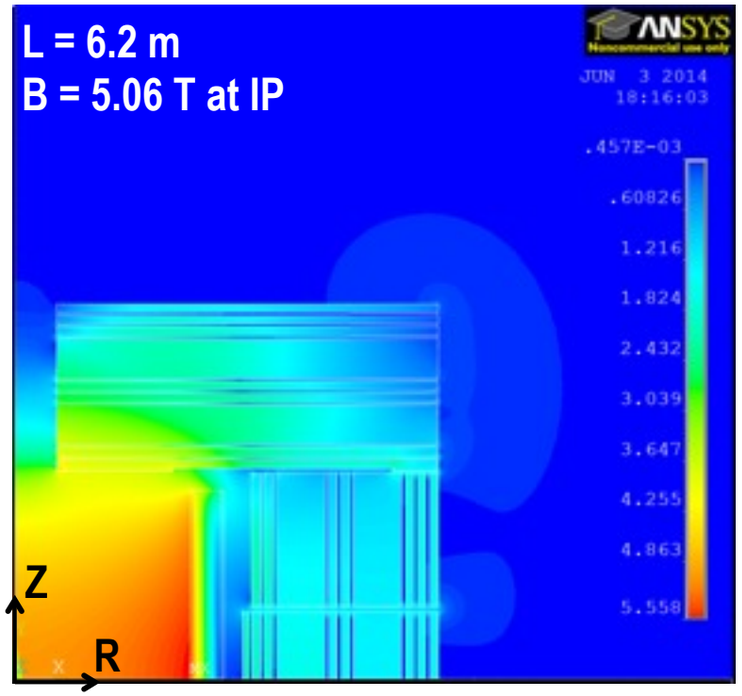
- Shorten endcap yoke
- Possibility to move QD0 magnet outside
- Considerations:
  - stray field
  - homogeneity
  - ring coils
  - cost
- Field strength to be decided after HCAL absorber decision

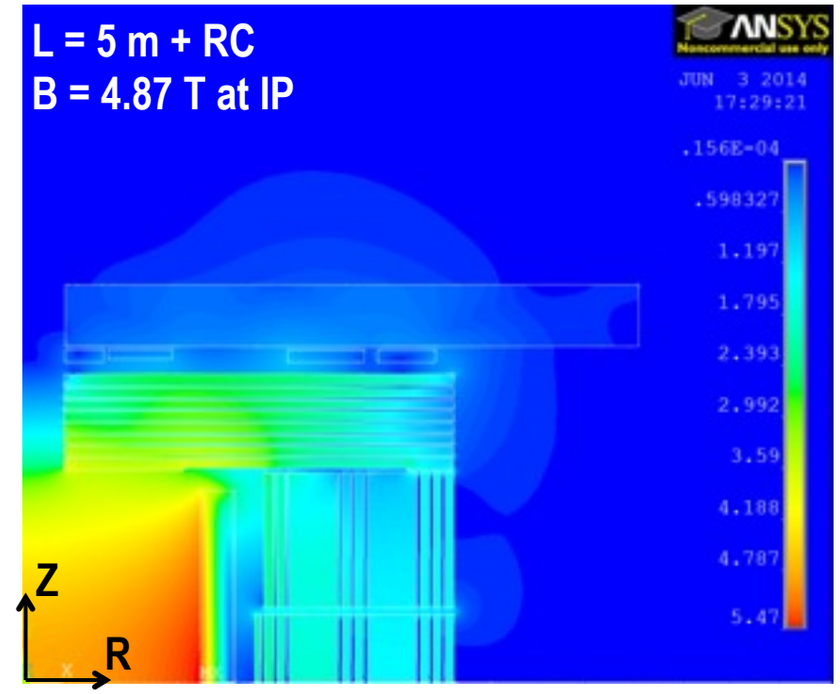
Old long endcap



New short endcap with ring coils





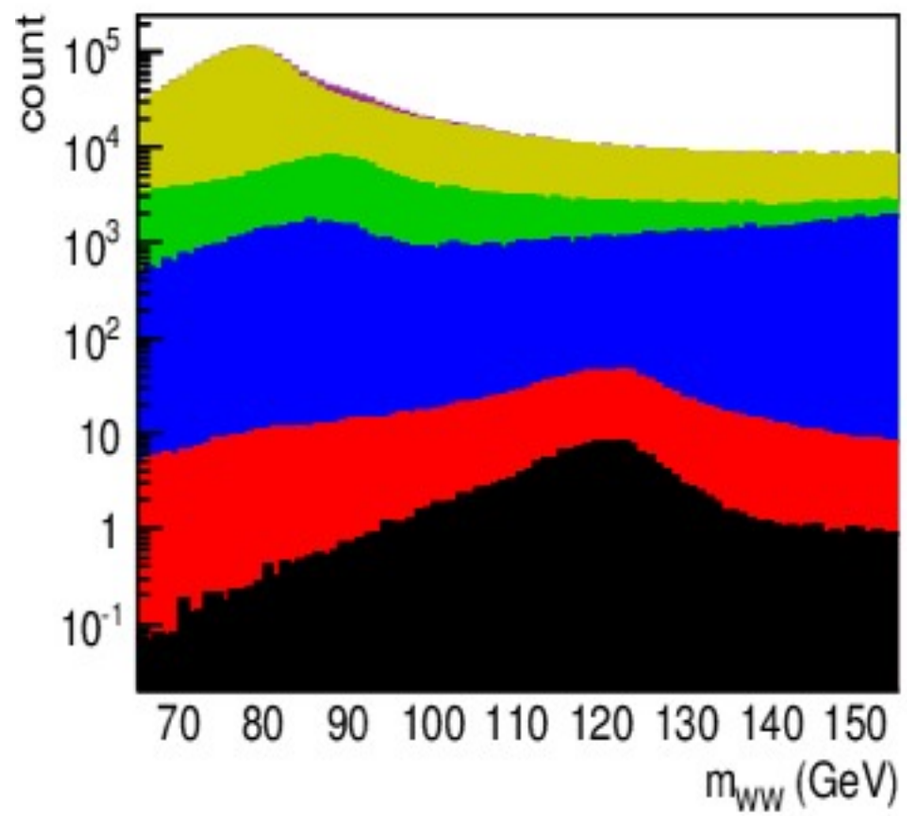


Physics benchmarks

P. Roloff
Monday 2:40pm

Highlights at LCWS14

- Two-body Higgs decays
- Top Yukawa coupling
- Higgs production in ZZ fusion
- Combined fits of Higgs couplings



Finding the signal in the noise
to benchmark detector performance

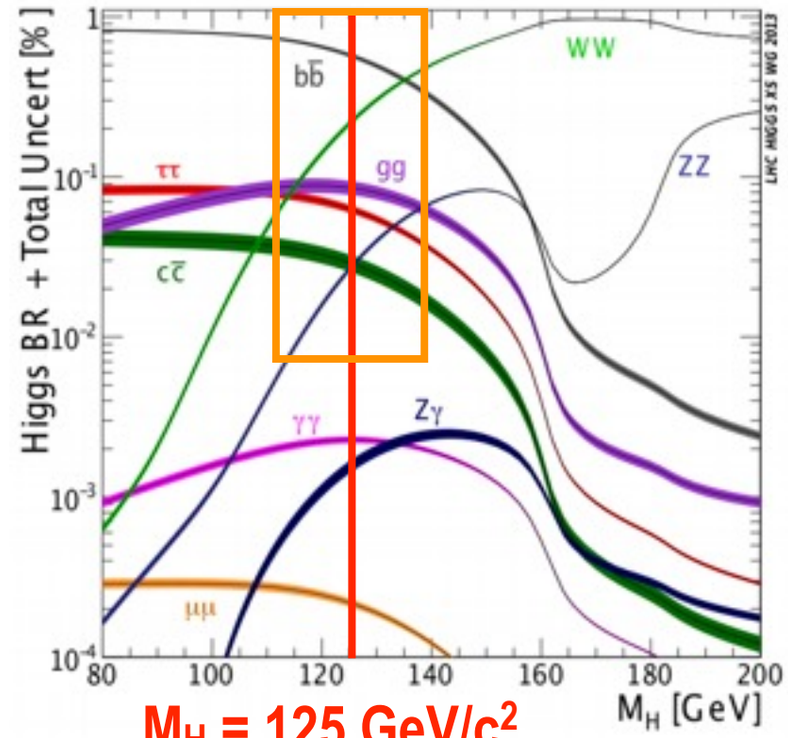
Higgs physics

- Higgs to two body decays
- Top Yukawa coupling
- Higgs production in ZZ fusion
- Full range of centre of mass energies
- Detector benchmarking:

  jet clustering, lepton identification, missing energy, flavour tagging

- Analysis chain:

  simulation, reconstruction, multivariate selection, fits / templates



M_H = 125 GeV/c^2

M. Szalay
Tuesday 4:17pm

G. Milutinovic-Dumbelovic
Tuesday 4:51pm

P. Roloff
Tuesday 3:15pm

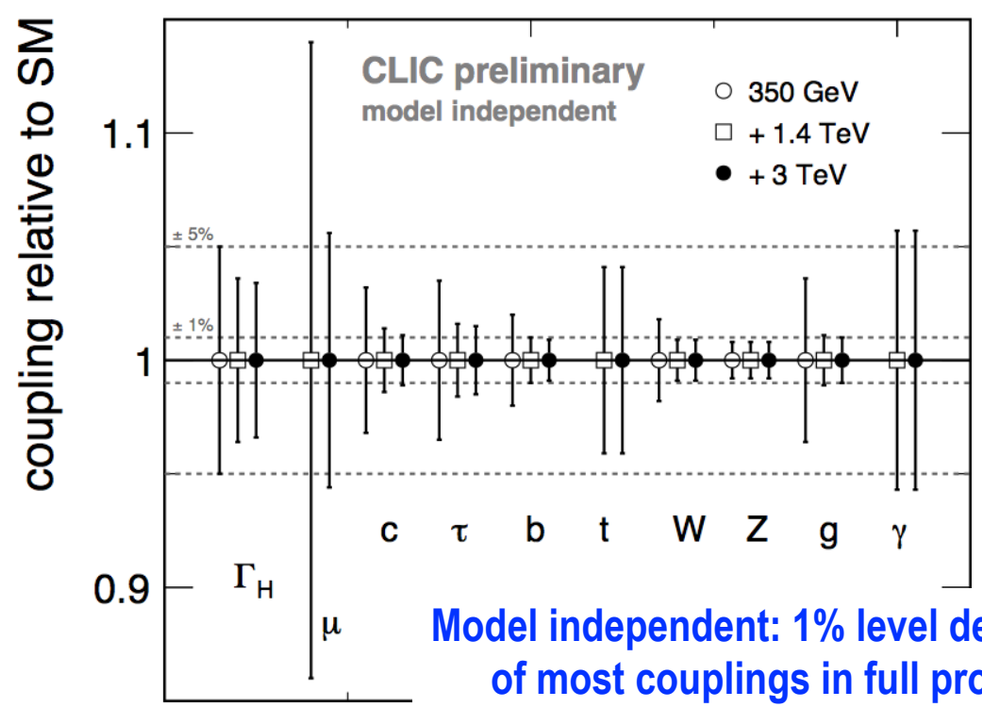
M. Pandurovic
Tuesday 5:08pm

S. Redford
Tuesday 11:41am

F. Simon
Tuesday 11:58am

Combined fit of Higgs couplings

Assume each measurement gives the SM value, use uncertainties in a global χ^2 fit using MINUIT



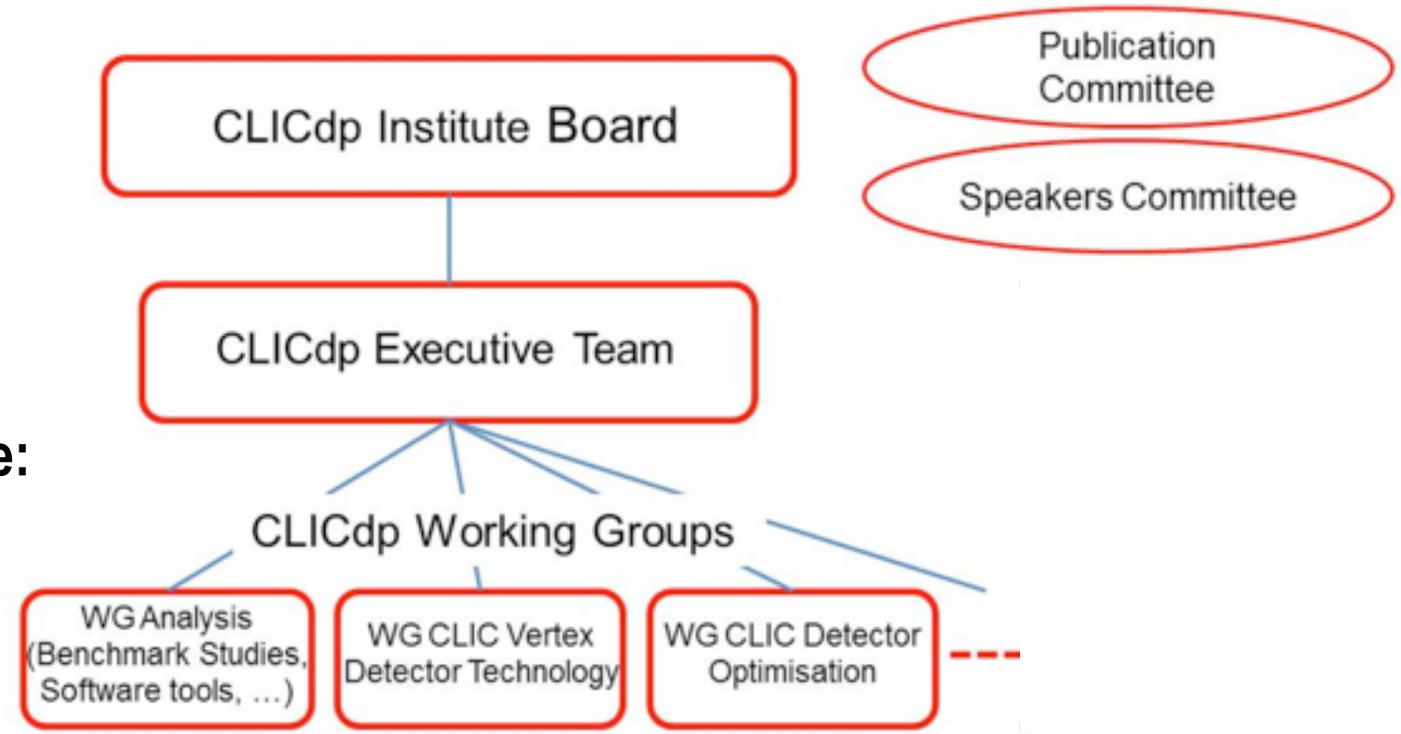
Model independent: 1% level determination of most couplings in full programme

The CLICdp Higgs paper

coming soon to a journal near you

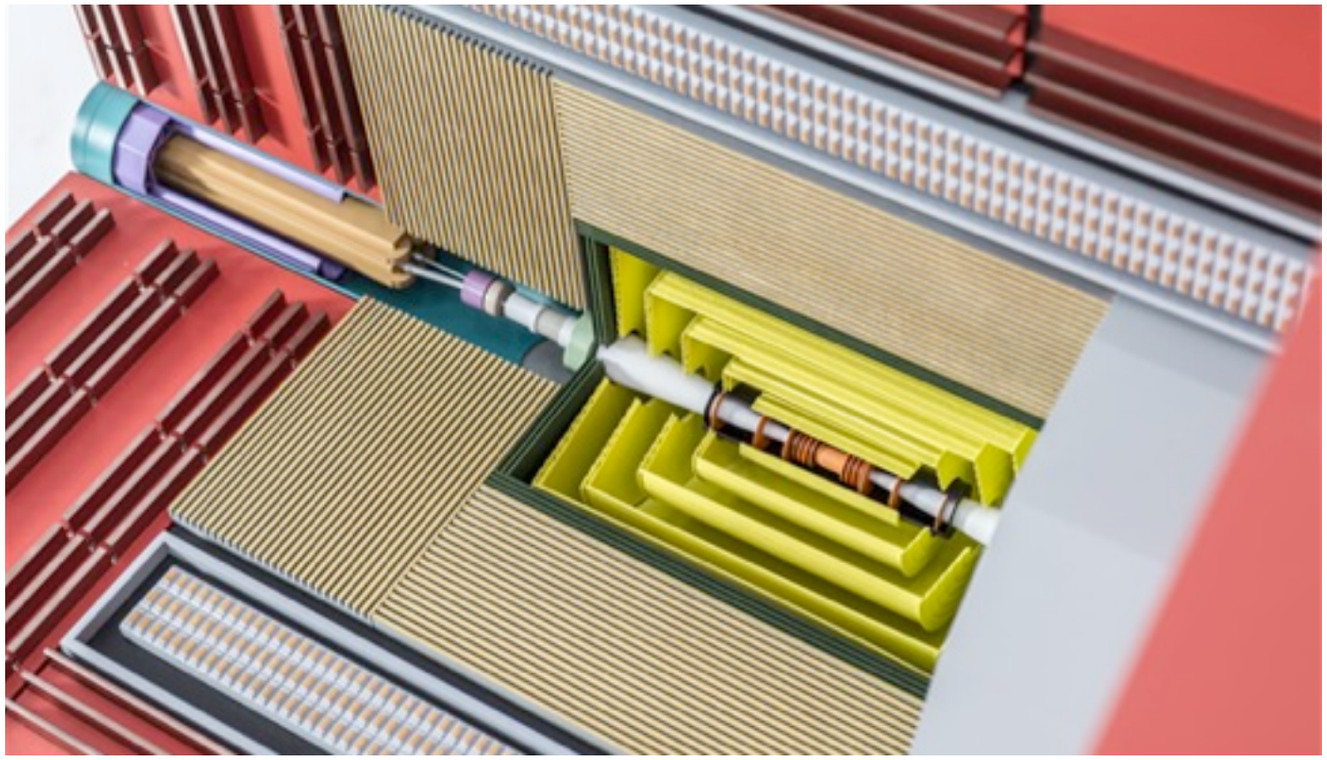
CLICdp collaboration

- 131 members from 23 institutes
- Stable, diverse collaboration
- More information on our website: http://clicdp.web.cern.ch/



Summary

- ☑ Hardware R&D for vertex detector and tungsten calorimeter progressing well
- ☑ Software tools facilitating progress in detector optimisation, physics analyses
- ☑ Single optimised CLIC detector concept coming together
- ☑ Physics studies with full simulation continue to show excellent detector performance



Thanks for your attention!