Vertex and tracking session summary

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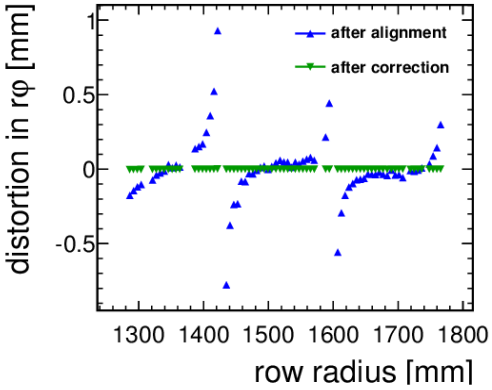
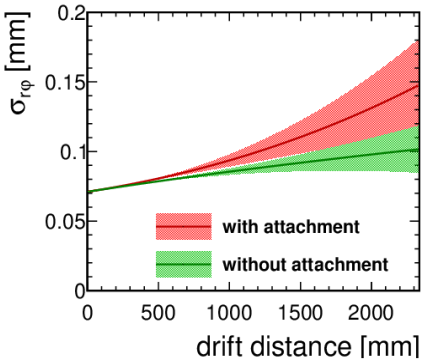
Overview

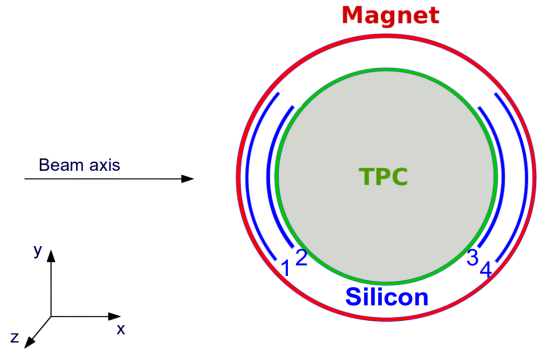
- 3 Sessions + 1 joint session with Performance/Simulation/Reconstruction
- 13 + 4 contributions in total:
  - 3 TPC tracker
  - 8 pixel technology
  - 2 cooling and/or integration
  - 3 simulation studies (silicon sensor response, beam background)
  - 1 track reconstruction and pattern recognition

Studies on GEM modules for a Large Prototype TPC for the ILC

- Successful testbeam campaign
- Ongoing optimisation process for Large Prototype TPC and GEMs
- Silicon tracker to accompany the Large Prototype TPC
- Simulation studies in order to define the characteristics of the system





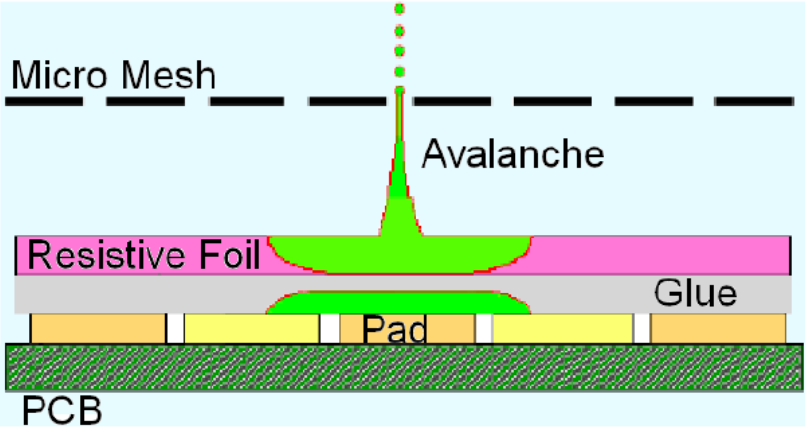


Results driven by limited available space: Sensors with spatial resolution of 10 µm or better are needed

Recent test results from a fully integrated Micromegas TPC prototype

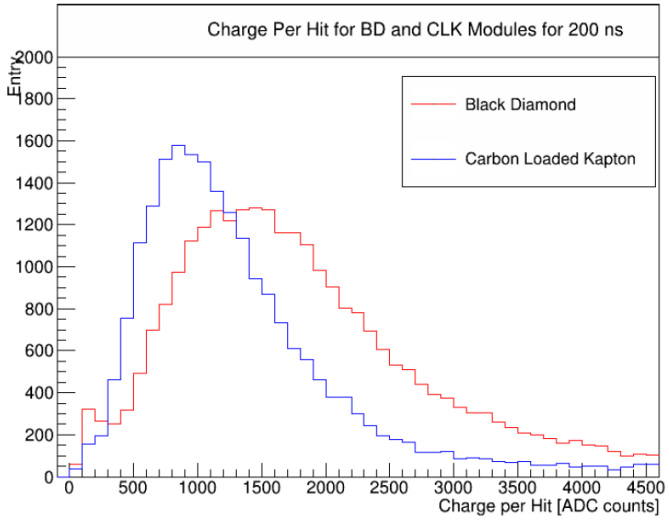
Need to spread the charge to improve resolution

Insulator + resistive coverlay = resistive-capacitive continuous network



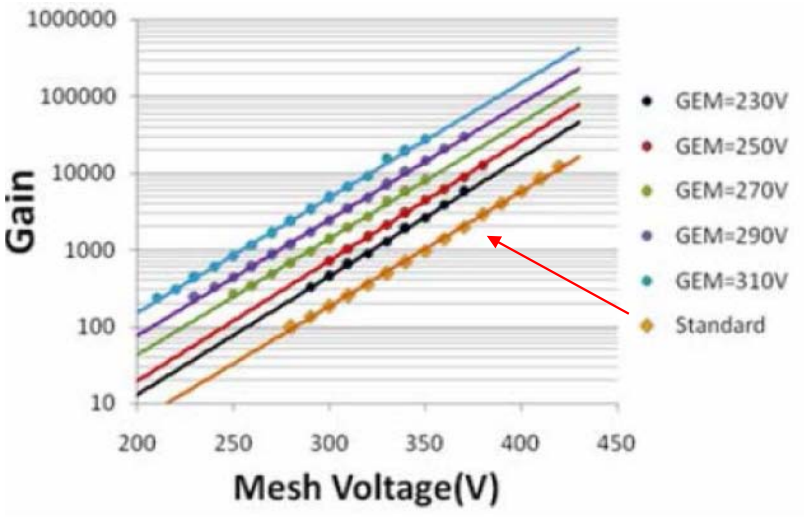
Diamond like carbon: robust, flexible, resistive with a large range of resistivity, precisely tunable, lubricant

Black Diamond (DLC) modules give more charge than Carbon loaded Kapton (CLK)



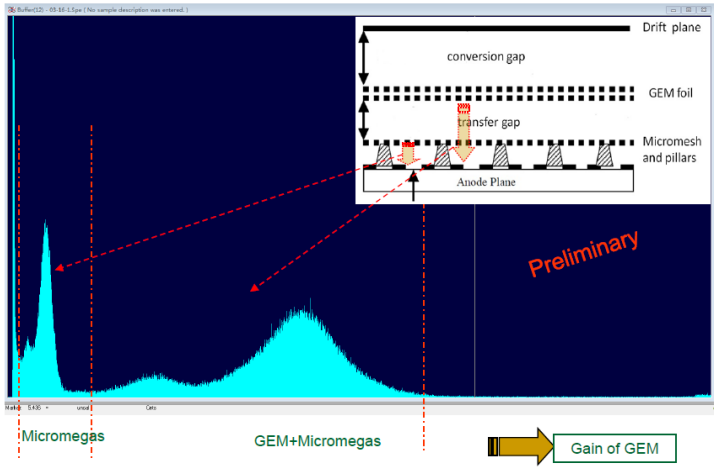
Status and Plan of TPC Hybrid Detector Module for Circular Collider @IHEP

- Towards CEPC TPC– Consideration
  - Optimization of working gas
  - Hybrid Detector Module (GEM + Micromegas)
  - LaserCalibration



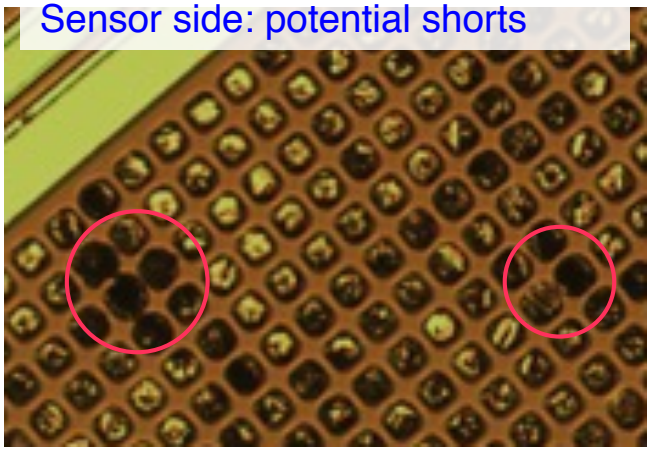
Test with Fe-55 X-ray radiation

- Reach to the higher gain than standard Micromegas
- Similar Energy resolution as the standard Micromegas

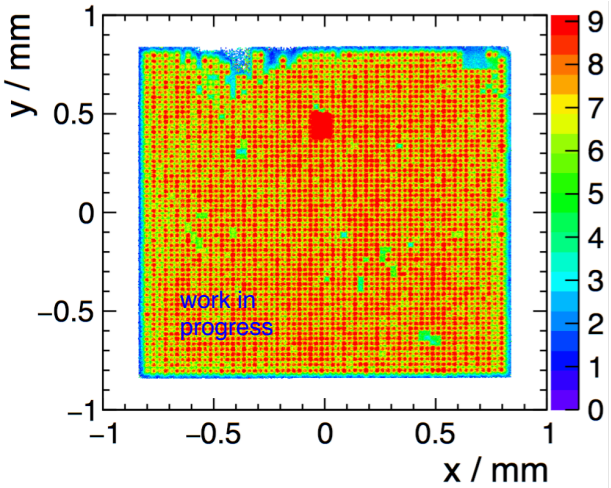


Hybrid Pixel (I): CLICpix planar assemblies

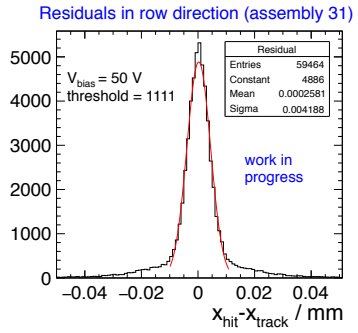
- Single-chip bump-bonding process for 25 µm pitch developed at SLAC
- 3 test assemblies produced with 200 µm sensors
- Improved, bigger version of ASIC to be submitted till end 2015



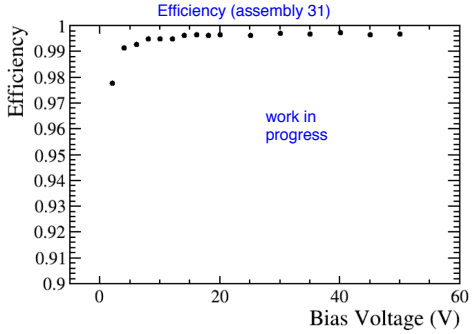
Detailed analysis of interconnect yield in lab and testbeam studies



4µm resolution

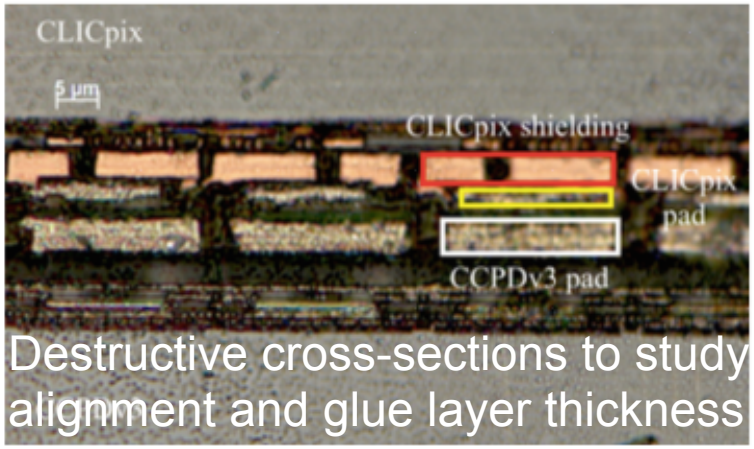


High detection efficiency

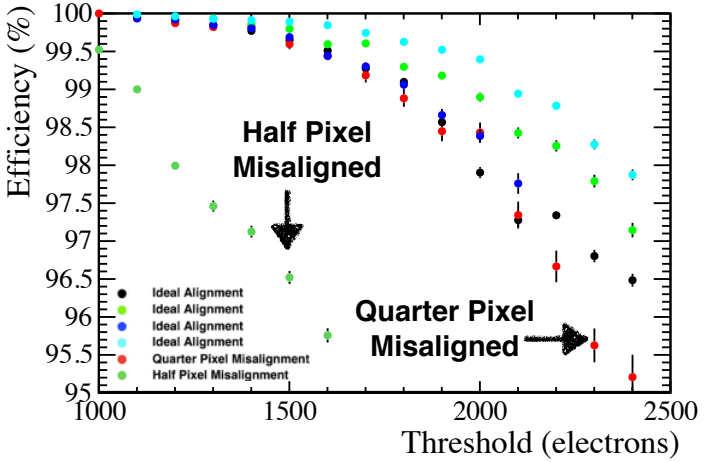


Hybrid Pixel (II): Capacitively coupled pixel detector

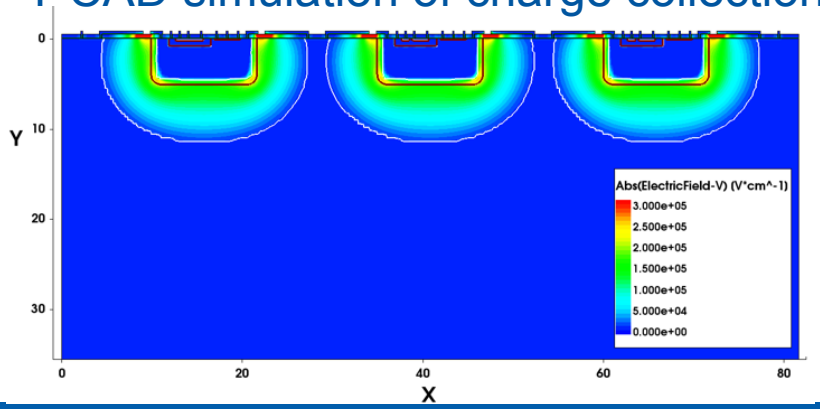
Active HV-CMOS sensor capacitively coupled to CLICpix readout chip via a thin layer of glue

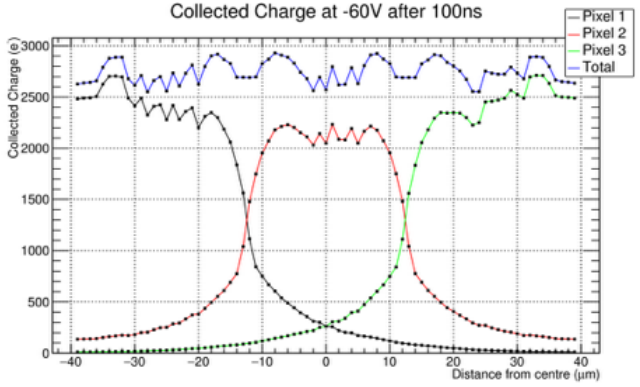


Alignment important for good efficiency



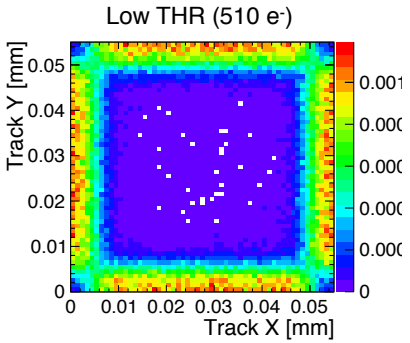
T-CAD simulation of charge collection in HV-CMOS sensor



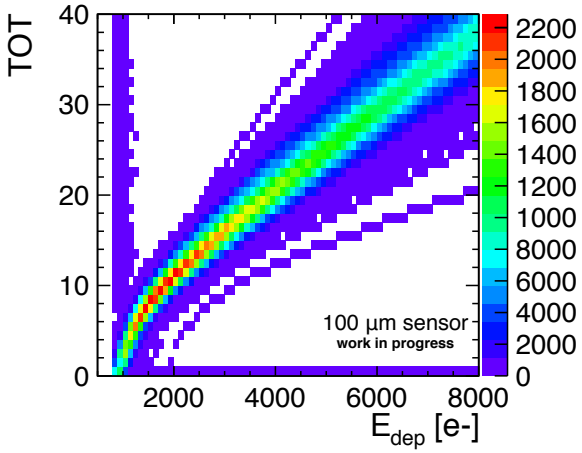


Hybrid Pixel (III): Thin sensor assemblies

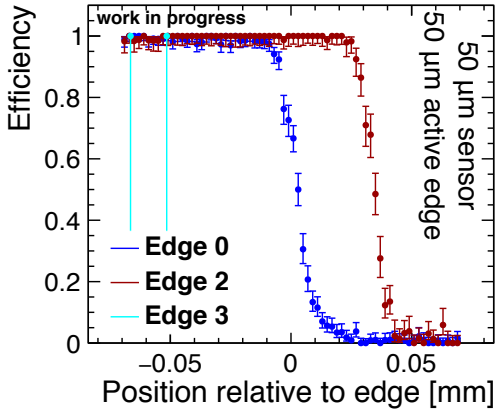
Thin planar sensor assemblies have been successfully studied using Timepix and Timepix3 ASICs



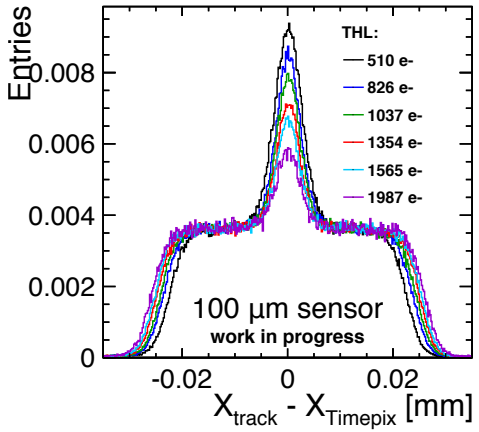
Energy calibration using radioactive sources and x-rays



Excellent detection efficiencies, also in the active edge



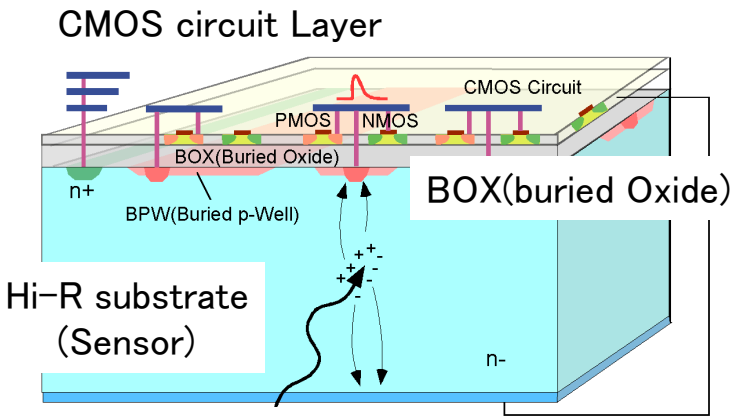
Multi-hit clusters show good resolution, in thin sensors little charge sharing

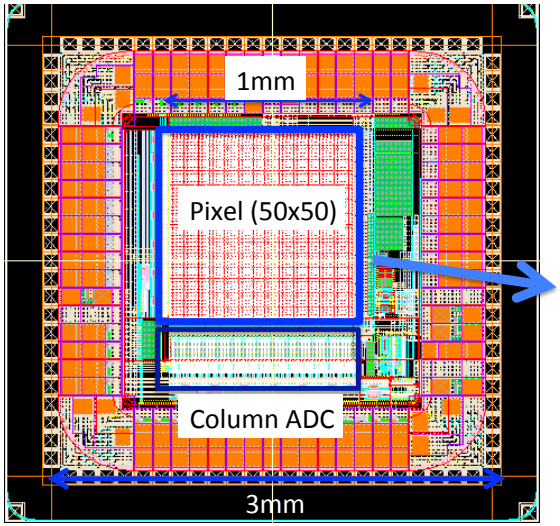


Monolithic (I): Silicon on insulator

- SOI sensor optimized for ILC vertex detector
  - Monolithic
  - Sensor stores both position and timing of the hits in 20x20um pixel
  - < 3 μm resolution
  - 50 μm thickness
- Development of first prototype sensor
- Evaluation of prototypes to start soon

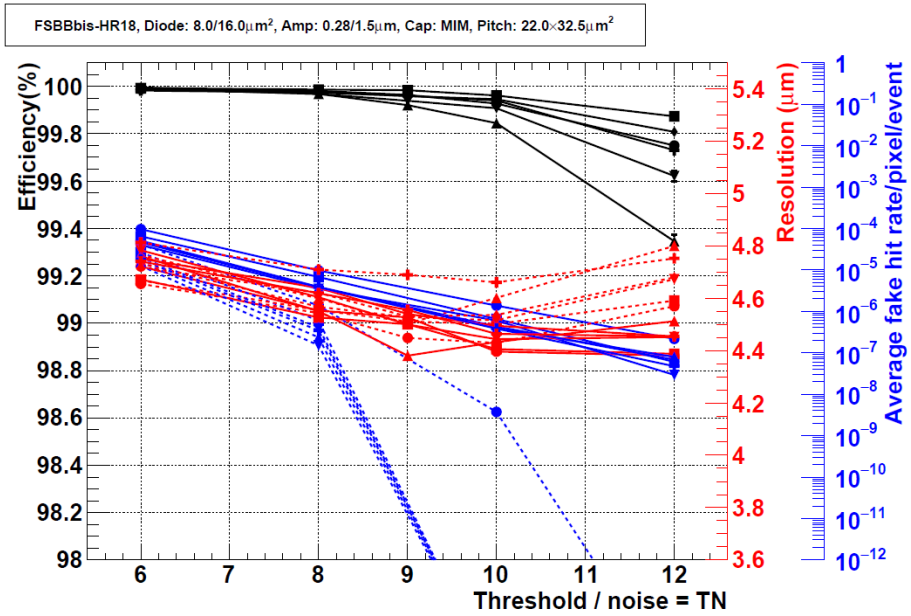
SOI pixel detector



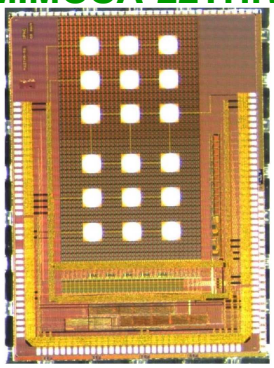


Monolithic (II): CMOS Sensors for ILC

- Successful operation of CMOS pixel detector in the STAR experiment for over 2 years
- Development of CMOS pixel detector for a tracker (ALICE-ITS upgrade) finalised
- Large pixels developed for trackers show good detection efficiency
- 2 chips tested on beam:
  - Mimosa22: small prototype featuring large pixels
  - FSBB: Full scale building block of final sensor



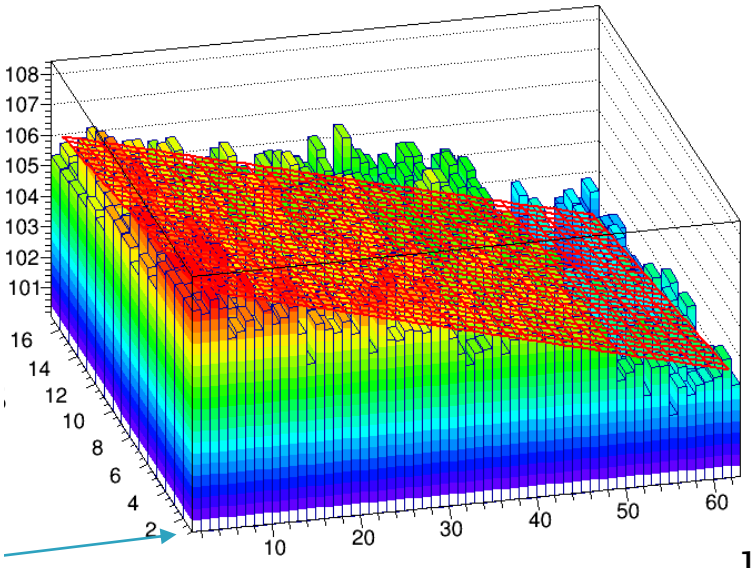
MIMOSA-22THRb

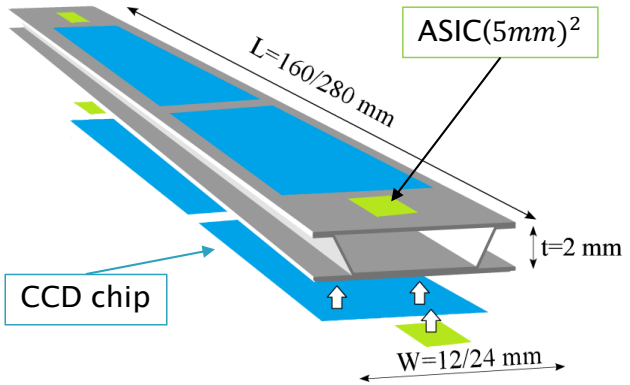


FSBB-M0bis

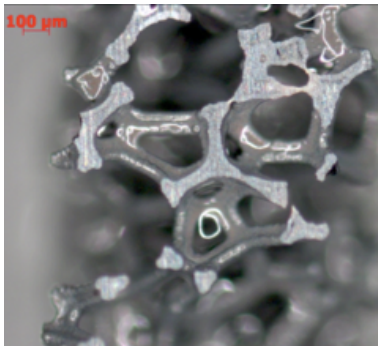
Monolithic (III): Fine-pitch CCD

- 6μm^2 FPCCD prototype has been developed
  - Study of neutron irradiation damage
  - Dark current and hot pixel are not an issue
  - Charge transfer inefficiency (CTI) is at acceptable level
- Start of ladder assembly R&D
- Prototype 2-phase CO_2 cooling system developed

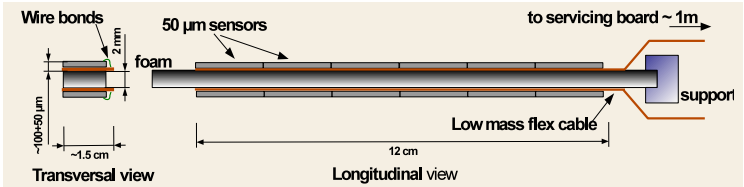


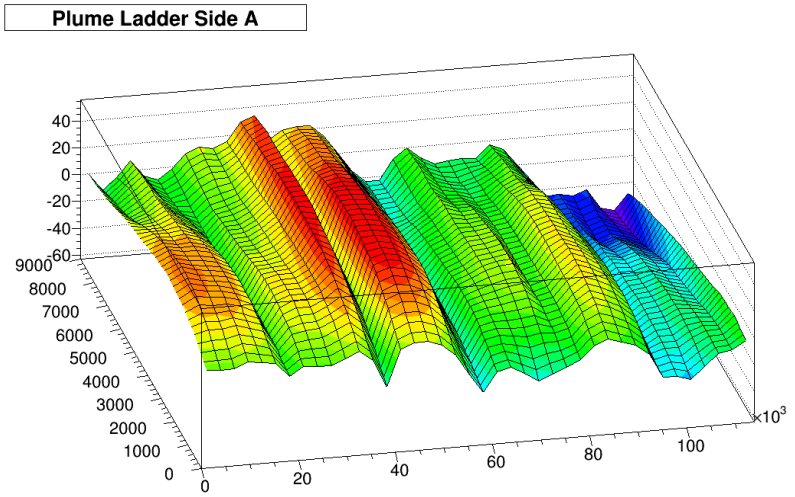


Monolithic (IV): Double-sided pixelated layers studies from the PLUME collaboration



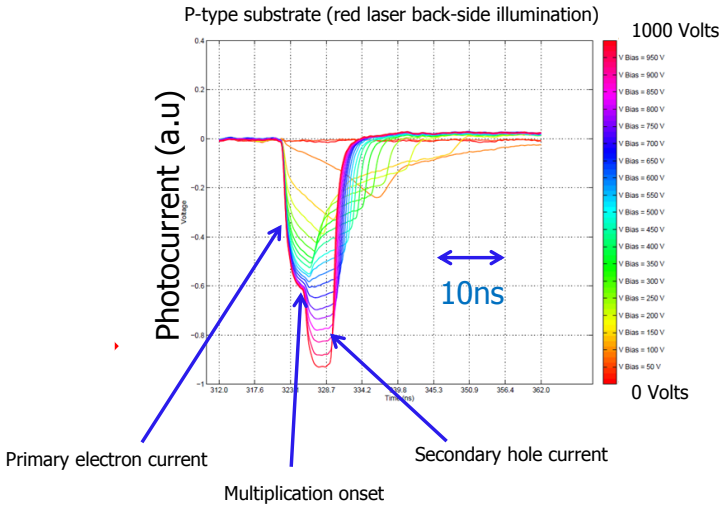
- Test beam studies using double sided layer equipped with Mimosa26 sensors
- 2mm SiC foam as spacer and support
- Deformations can severely impact the resolution
- Can be corrected in software
- New prototype with less material budget will be tested



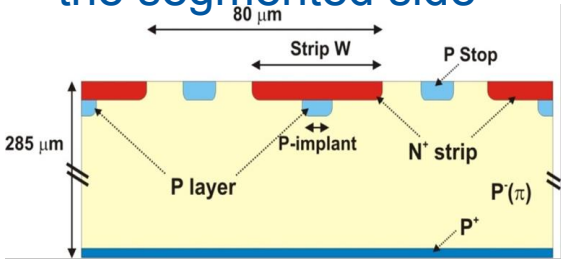


I-LGAD microstrip sensor with amplification

- Multiplication of charge carriers in a small high-field region in order to increase signal
- Demonstrated on pad diodes
- Two options for segmentation:

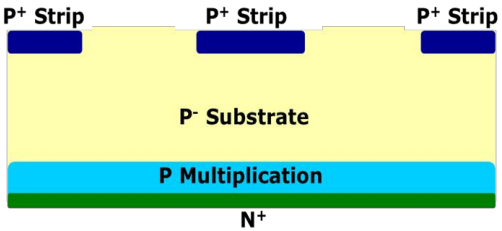


Multiplication layer on the segmented side



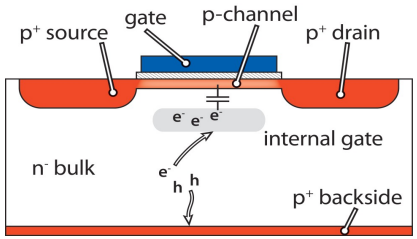
Tested, behaviour understood via T-CAD simulations

Multiplication layer on the backside

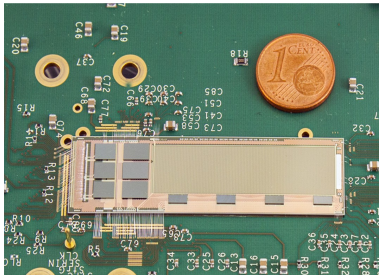


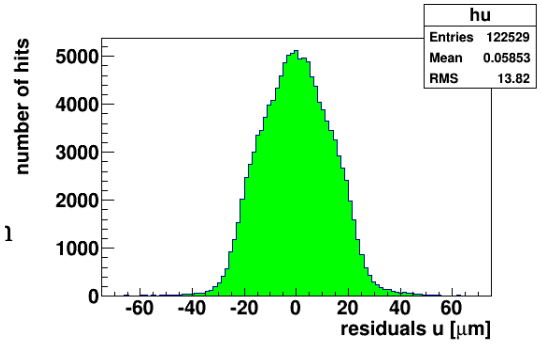
To be processed and tested, T-Cad simulations show promising results

DEPFET vertex detector

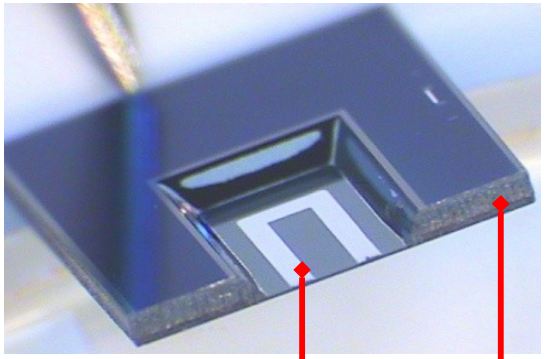


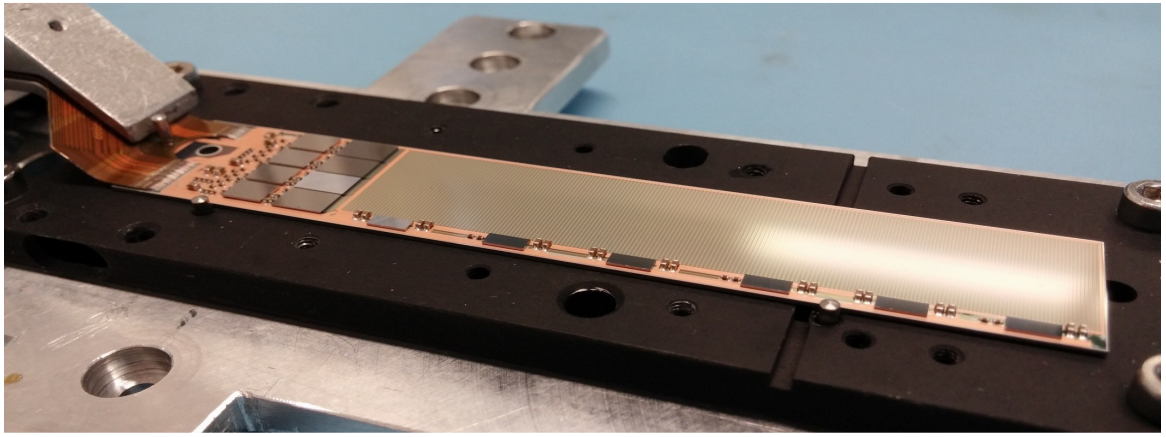
PXD6 – the first multi-chip module Sensor thinned to 50 micron





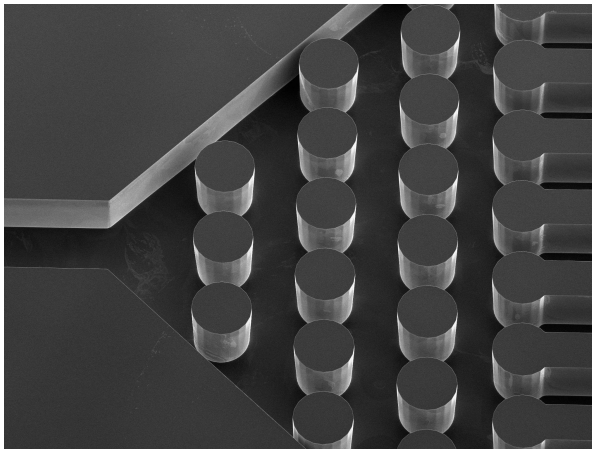
The first complete all-silicon ladder with integrated support, read-out and steering has been built



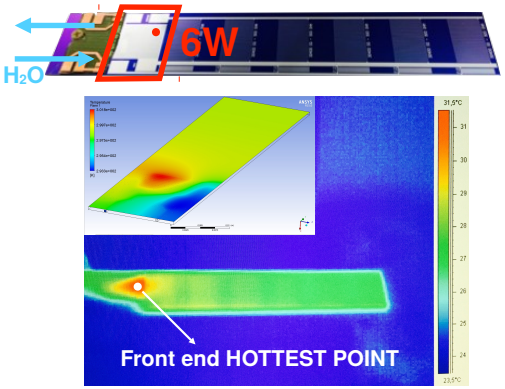


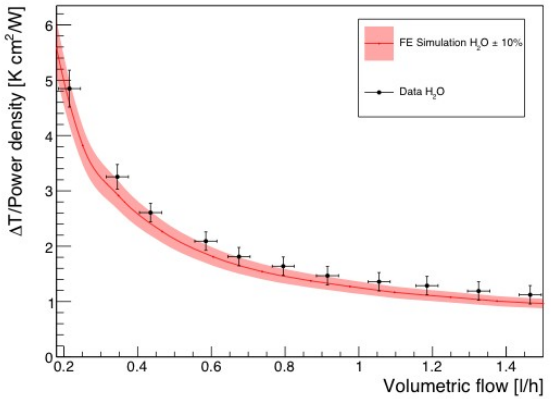
Advanced cooling

Integrate cooling channels directly into the silicon bulk

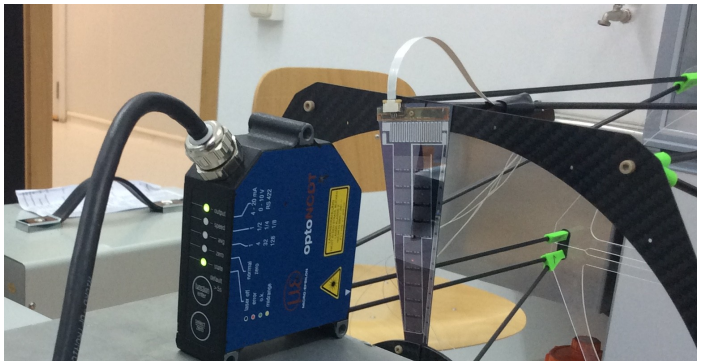


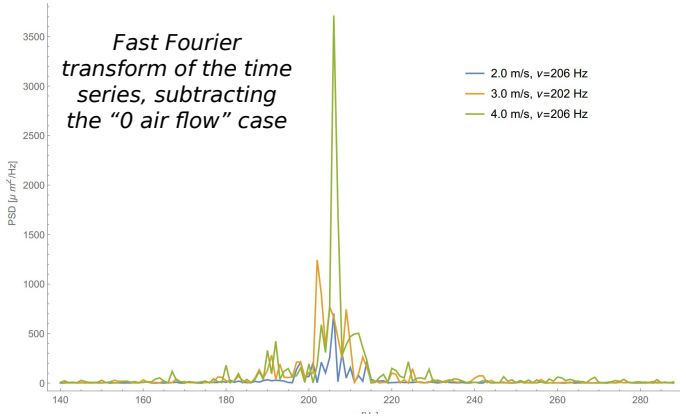
FEA simulation in good agreement to measurements





Additional air flow cooling induces vibrations:

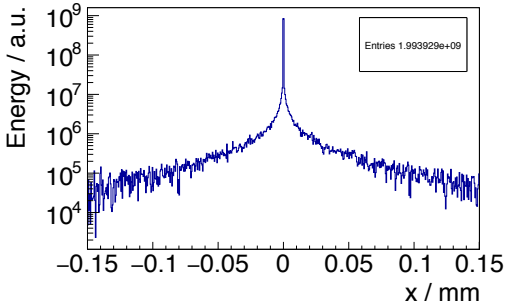




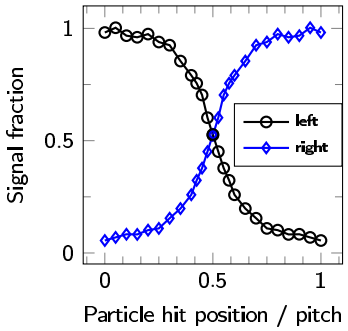
Simulation (I): CLIC Tracker R&D

- Simulation study of silicon sensor response

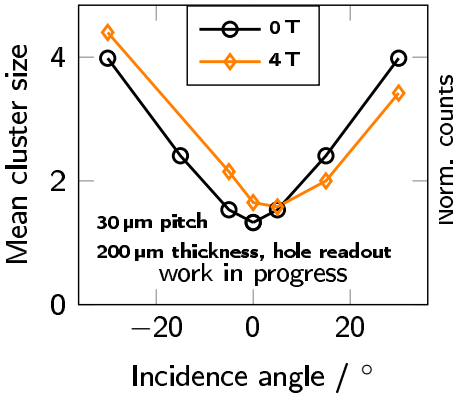
Energy deposit from Geant4



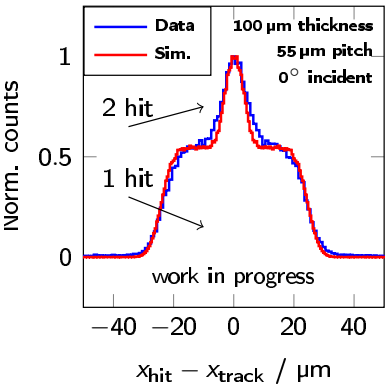
T-CAD simulation of signal formation



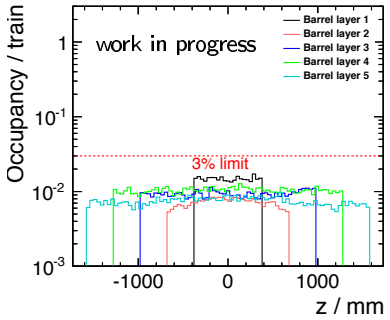
Magnetic field can be included



Validation



- Beam-induced background in CLIC limits maximal strip length to 1-10mm:

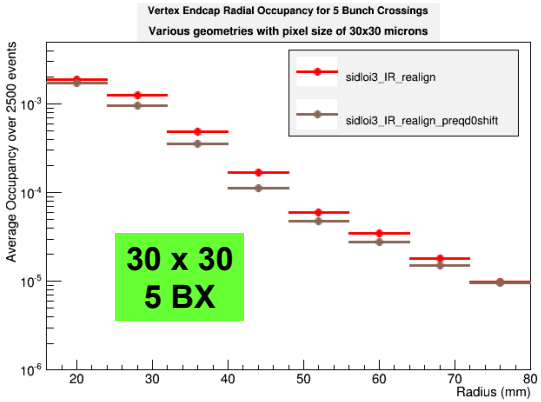


Simulation (II): Geometric and L* changes on SiD Vertex Detector

In interest of a common ILD/SiD L*, SiD has explored the effect of increasing this to 4.1m

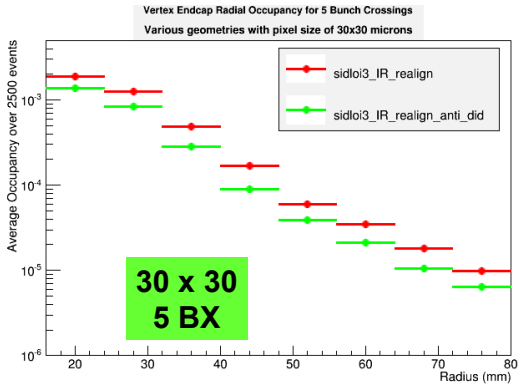
Study of vertex detector occupancy:

Dependence on L*



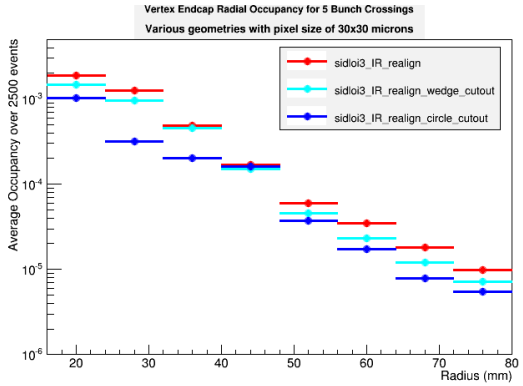
Occupancy differences appear to depend on backscatter deflection angle

Dependence on Anti-did field



Anti-did field generally improves occupancy in barrel and thoroughly improves occupancy in endcap

Dependence on plug geometry

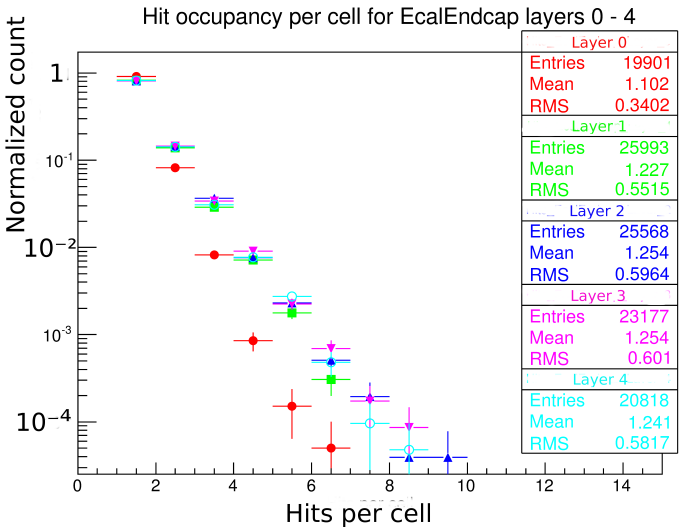


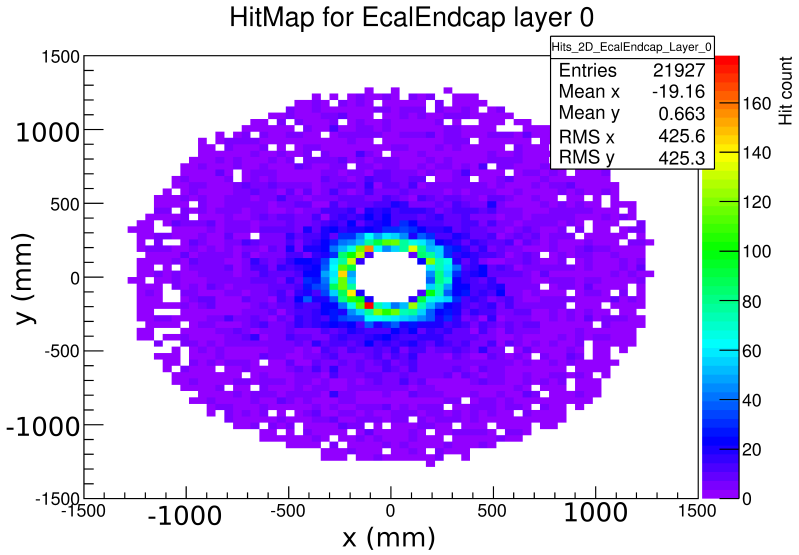
As expected, occupancy gets progressively lower as more of the BeamCal plug is cut away

Simulation (III): Background studies for SiD

- Guinea-Pig pair background files for the ILC are created
- Files for two full trains of the ILC-500GeV available

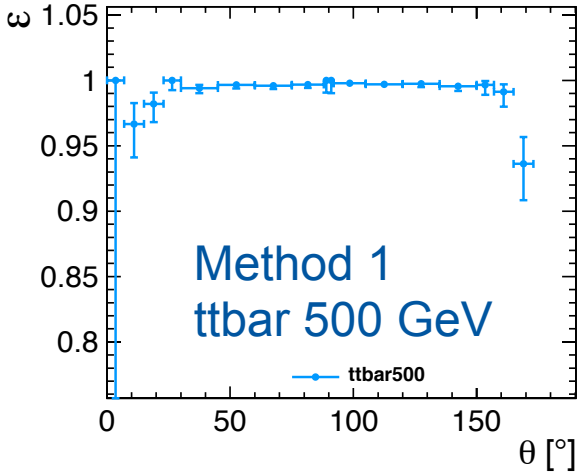
Studying the pair background in the SiD detector in respect to hit maps and occupancy of the calorimeter cells





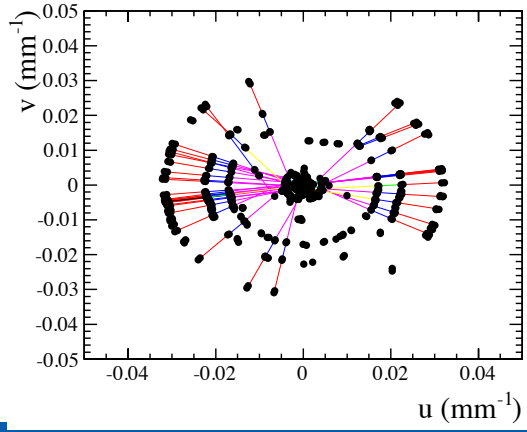
Track reconstruction for the CLIC full silicon tracker

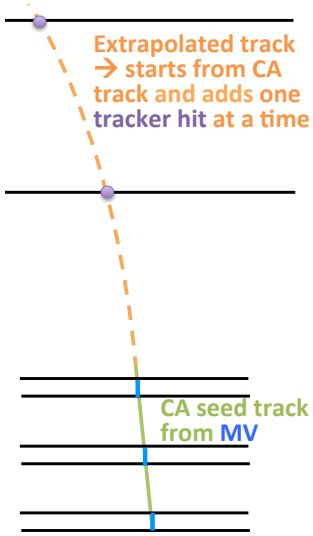
Intense activity on the implementation of the simulation model and in the reconstruction code for the CLIC full silicon tracker



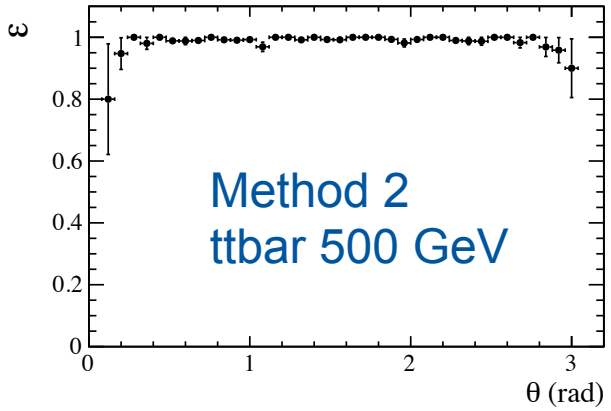
Two algorithms for pattern recognition in silicon tracker:

- Cellular automaton and MV
- Conformal mapping





Work on-going but already encouraging performance



Thanks to all the speakers and audiences!

Thank you for your attention!

Backup

Tuesday morning

08:30 - 10:15 Vertex/tracking

Conveners: Timothy Nelson (SLAC), Alain Bellerive (Carleton University (CA)), Dr. Jan Strube (PNNL), Jerome Baudot (IPHC - Strasbourg), Andreas Nuernberg (CERN)

Location: Empress A

08:30 **Studies on Gas Electron Multiplier (GEM) modules for a Large Prototype TPC for the ILC** *20'*

Speaker: Dimitra Tsionou (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))

Material: **Slides**

08:55 **Recent test results from a fully integrated Micromegas TPC prototype** *20'*

Speakers: Paul Colas (DAPNIA - Centre d'Etudes de Saclay (CEN Saclay)), Paul Colas (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))

Material: **Slides**

09:20 **Status of CEPC-TPC Detector and Plans of Critical R&D** *20'*

Speaker: Dr. Huirong Qi (Institute of High Energy Physics, CAS)

Material: **Slides**

09:45 **Advanced vertex detector cooling concepts: from air flow to micro-channel cooling** *20'*

Speakers: Marcel Vos (Instituto de Fisica Corpuscular (ES)), Miguel-Angel Villarejo Bermudez (Instituto de Fisica Corpuscular (ES)), Mr. Ignacio Garcia Garcia (IFIC Valencia)

Material: **Slides** **Video**

Tuesday afternoon

13:30 - 15:30 **Vertex/tracking: Vertex/Tracking**

Conveners: Timothy Nelson (SLAC), Alain Bellerive (Carleton University (CA)), Takeshi Matsuda (KEK), Dr. Jan Strube (PNNL), Jerome Baudot (IPHC - Strasbourg), Andreas Nuernberg (CERN)

Location: Algonquin

13:30 **CLICpix planar-sensor assemblies** *20'*
- Speaker: Dominik Dannheim (CERN)
- Material: **Slides**

13:55 **Capacitively coupled pixel detectors for the CLIC vertex detector** *25'*
- Speaker: Steven Green (University of Cambridge (GB))
- Material: **Slides**

14:25 **Development of the pixel sensor based on SOI technology for the ILC vertex detector** *20'*
- Speaker: Shun Ono
- Material: **Slides**

14:50 **CMOS Pixel Sensors for vertexing and tracking devices at the ILC** *25'*
- Speaker: Marc Winter (Institut de Recherches Subatomiques (IReS))
- Material: **Slides**

Wednesday afternoon

13:30 - 15:30 **Vertex/tracking**

Conveners: Timothy Nelson (SLAC), Alain Bellerive (Carleton University (CA)), Dr. Jan Strube (PNNL), Jerome Baudot (IPHC - Strasbourg), Andreas Matthias Nurnberg (CERN)

Location: Algonquin

13:30 **DEPFET active pixel detectors: status report of the project** *20'*
- Speaker: Marcel Vos (Instituto de Fisica Corpuscular (ES))
- Material: **Slides**

13:54 **Thin-sensor studies for the CLIC vertex detector** *25'*
- Speaker: Sophie Redford (CERN)
- Material: **Slides**

14:23 **Double-sided pixelated layers studies from the PLUME collaboration** *20'*
- Speaker: Benjamin Boitrelle
- Material: **Transparents**

14:47 **Recent status of ILC vertex detector R&D in Japan** *20'*
- Speaker: Shunsuke Murai (Tohoku University)
- Material: **Slides**

15:10 **LGAD a thin microstrip sensors with integrated charge amplification** *20'*
- Speaker: Dr. Ivan Vila (IFCA (CSIC-UC))
- Material: **Slides**

Thursday afternoon

13:30 - 16:00 **Vertex/tracking: joint with Simulation/Performance/Reco**

Conveners: Timothy Nelson (SLAC), Alain Bellerive (Carleton University (CA)), Dr. Jan Strube (PNNL), Jerome Baudot (IPHC - Strasbourg), Andreas Matthias Nurnberg (CERN)

Location: Empress B

13:30 **Tracker-technology R&D for CLIC** *20'*
- Speaker: Andreas Matthias Nurnberg (CERN)
- Material: Slides

13:55 **Vertex Detector Occupancy Studies** *20'*
- Speakers: Bruce Schumm, Mr. Christopher Milke (UCSC.SCIPP)
- Material: Slides

14:20 **Background studies for the SiD concept** *20'*
- Speaker: Ms. Anne Schuetz (DESY)
- Material: Slides, gif

14:45 **All Silicon Tracking + Conf. Mapping PatRec** *25'*
- Speaker: Rosa Simoniello (CERN)
- Material: Slides