

IN-KIND CONTRIBUTION TO CERN ALICE EXPERIMENT



HELSINKI
INSTITUTE OF
PHYSICS

Doc. chief engineer Eija Tuominen / IKBEST5 9.4.2019

OUTLOOK

1. Helsinki Detector Laboratory @ HIP In-Kind
2. Collection of HIP In-Kind Experiences
3. In-Kind Contribution to CERN ALICE experiment
 - What we did
 - How we did it
 - What we learnt

Detector Laboratory: The Mission

- Helsinki Detector Laboratory offers premises, equipment and know-how for the **execution of HIP experimental in-kind activities**.
- Detector Laboratory is a **permanent infrastructure** of Helsinki Institute of Physics (HIP) and University of Helsinki / Department of Physics (UH/Physics) with three main tasks:
 1. Support the Finnish **instrumentation** of particle and nuclear physics experiments, such as CERN and FAIR
 2. Support the **education** of experimental particle physics
 3. Participate in externally funded **R&D projects**

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Detector Laboratory: The Team

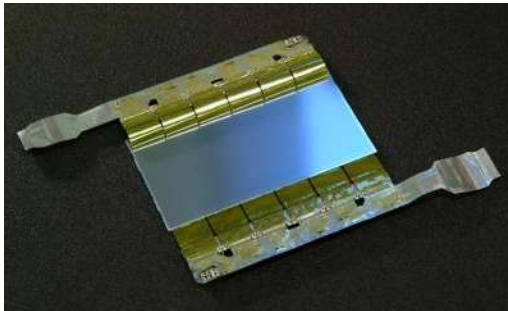
- Permanent laboratory staff:
 - Chief engineer: Doc. Eija Tuominen
 - Laboratory engineers: Mr. Jouni Heino, Ms. Pirkitta Koponen, Dr. Francisco Garcia
 - Laboratory technician: Mr. Raimo Turpeinen
- ~20 research scientists and students
- Collaboration with universities, institutes and companies (e.g. Jyväskylä, Lappeenranta, Aalto, STUK, Micronova, CERN RD50 and RD51)

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History of HIP IK

- HIP / Detector Laboratory has provided in-kind contributions to CERN since 1980's (LEP-DELPHI Hadron Calorimeter).

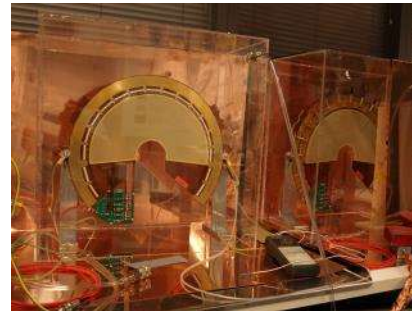


TAB bonding of 715 Silicon Strip Detector (SSD) modules for ALICE Tracker, 2004-2006.

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Manufacture of 700 carbon-fiber support structures for CMS Tracker, 2004-2005.



Assembly of 50 GEM (Gas Electron Multiplier) detectors for TOTEM, 2008-2011.

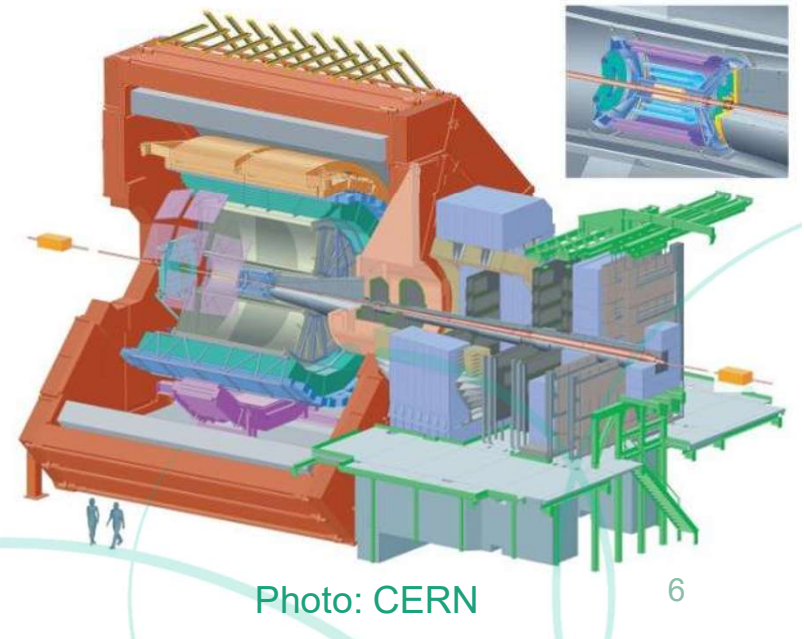


Quality Assurance of 250 silicon pixel detectors for CMS Tracker Upgrade, 2014-2016.

ALICE In-Kind: Our Task

- In 2014-2018, Detector Laboratory hosted in-kind contribution to CERN ALICE Upgrade.
- The project was coordinated by University of Jyväskylä / prof. Jan Rak.
- The task: **optical and electrical Quality Assurance of 360 GEM** (Gas Electron Multiplier) foils for the readout of the ALICE TPC (Time Projection Chamber) detector – half of the total GEMs.

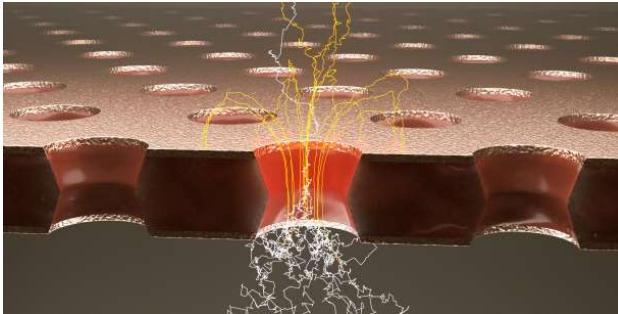
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ALICE In-Kind: What we needed #1

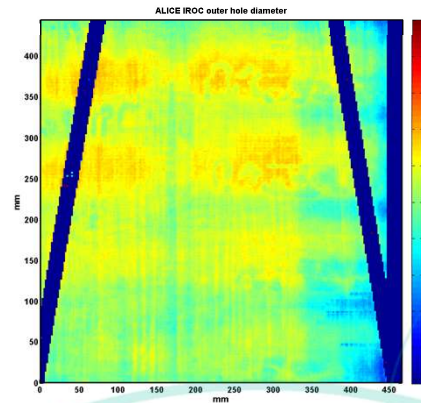
1. Research on GEMs - continuously:

- R&D to predict GEM foil gain uniformity from geometrical hole properties obtained with high definition optical scanning system.



Simulation by Dr. Timo Hilden

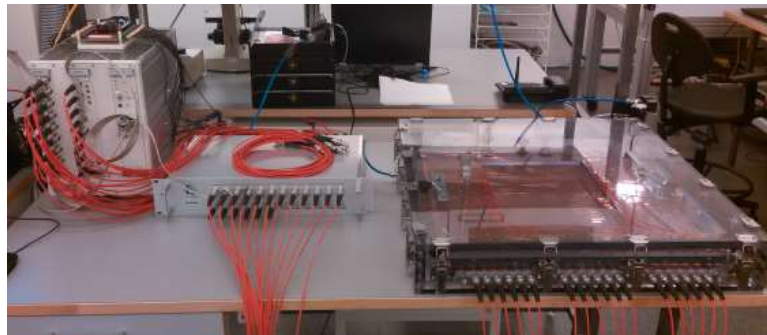
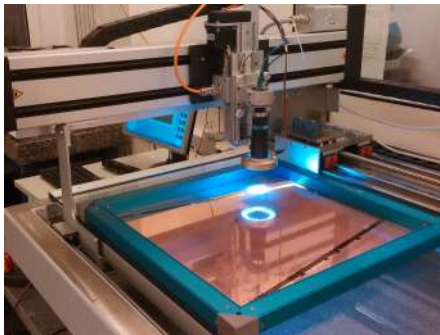
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ALICE In-Kind: What we needed #2

2. Infrastructure – sophisticated & unique

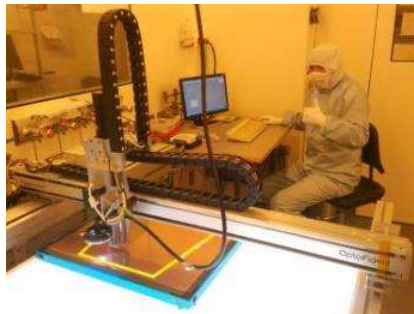
- Properly maintained **clean rooms** and other **laboratories**.
- **Unique equipment** for the optical and electrical QA needed to be designed, constructed and commissioned (bearing in mind EU, Finnish & University purchasing rules).



ALICE In-Kind: What we needed #3

3. People – plenty & skillful

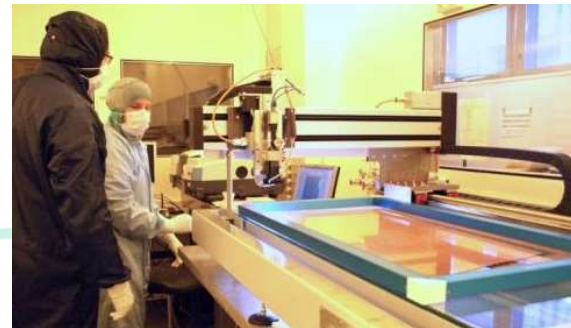
- **Laboratory staff** to maintain infrastructure & organize logistics.
- Project **scientists** to coordinate activities.
- Academically educated **technicians** to do the QA.
- Doctoral **students** to participate in service work.



ALICE In-Kind: What we needed #4

4. Money – a lot of it

- National funding agency, **Academy of Finland**, supported the in-kind contribution during 2014-2017 with two consequent FIRI (Funding Instrument for Research Infrastructures) projects.
- The price tag of the in-kind contribution including specific equipment and technical people - not lab staff, students or premises: ~1 M€.



ALICE In-Kind: What next

- GEM foils will be installed to ALICE TPC detector.



- Helsinki Detector Laboratory has proceeded to CERN CMS & TOTEM in-kind contribution - & later to FAIR in-kind contribution.

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Photos: CERN

ALICE In-Kind: Lesson Learned

1. Positive: Yes we can!
2. Negative: There is always something unexpected (especially with the timetables).
3. Lesson learned: Do not underestimate the logistics.
4. Stress-saving: “Well planned is half done” – but prepare top improvise..
5. Learning objective for IKB5: “Together we are strong” - let us learn from each others’ experiences.

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Our dream team: Dr. Erik Brucken, lab.eng. Pirkitta Koponen, lab.eng. Jouni Heino, student Tiina Naaranoja, technician Essi Kangasaho, student Tomas Snellman, Eetteri the dog, lab.tech. Raimo Turpeinen, chief eng. Eija Tuominen, Dr. Timo Hilden, technician Vladyslav Litichevskyi

The background is a solid teal color. It features several abstract geometric elements: a large, faint white circle on the left side; a smaller, faint light teal circle on the right side; and several thin, curved white lines and dots scattered across the surface, some resembling orbital paths or stylized orbits.

Thank You.



Backup: More info about Helsinki Detector Laboratory



Helsinki Detector Laboratory: Premises

- Two research **laboratories** (122 m² + share of 86 m²) and three **clean rooms** (class 1000: 105 m² + class 100: 20 m²)
- Premises contain fume hoods, gas pipelines with outlets, central vacuum, deionized water, chemical storages, gas alarms, laser chamber, radiation room, access to mechanical workshop
- Emphasis on **quality management, laboratory safety and risk management**



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Instrumentation is great fun!

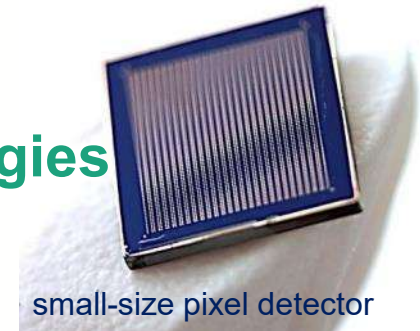
Helsinki Detector Laboratory: Equipment

- **Assembly and prototyping:**
 - wire bonder (for semiconductor strip detectors)
 - flip-chip bonder (for semiconductor pixel detectors)
- **R&D and QA**
 - germanium gamma-ray imaging spectrometer GeGI
 - environmental chamber (for long-term reliability testing)
 - probe stations (for semiconductor on-chip testing)
 - scanning camera systems (for optical QA)
 - profilometer (for surface morphology testing)
 - NIM-electronics, oscilloscopes, microscopes, source-meter-units, laser, microstandards, radiation sources, X-ray source, 3D-printer, ultrasonic baths, stone tables, programmable ovens, desiccators, radiation/temperature/humidity/dust monitors



Helsinki Detector Laboratory: Technologies

- **Detector materials:**
 - semiconductors: silicon, diamond, CdTe, CdZnTe
 - gaseous: Gas Electron Multiplier (GEM), proportional chambers, Micromegas
 - scintillators
- **Detector assembly:**
 - micromechanics & prototyping
 - wire bonding & flip-chip bonding
- **Detector quality assurance (QA):**
 - electrical (on-chip measurements, laser-TCT)
 - optical (large-area flat-bed optoscanning, microscopy)
 - long-term reliability (environmental testing)
 - morphological (profilometry)
 - radiation safety (Compton imaging with GeGI)



Helsinki Detector Laboratory: Teaching

- **UH Master's Program for Particle Physics and Astrophysical Sciences (ParAs)** – module of instrumentation:
 1. Laboratory course on instrumentation
 2. Physics of semiconductor devices
 3. Semiconductor radiation detectors
 4. Gaseous radiation detectors and scintillators
- **Nordic laboratory course** in detector technology for particle physics
- **Doctoral theses, master's theses**

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Helsinki Detector Laboratory: Outreach

- **Encouraging** young generation to the fascinating world of physics
- **Disseminating** information about instrumentation to general public
- E.g. visits to schools, hosting school visits, UH outreach events

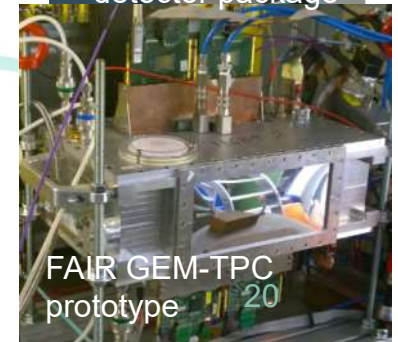
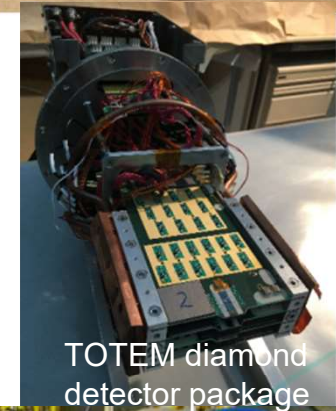
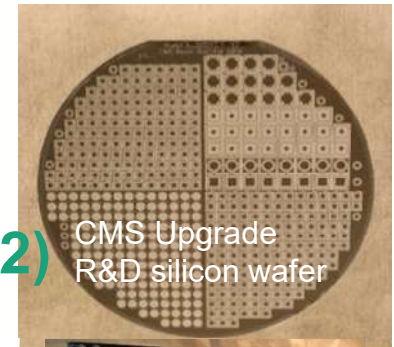


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Helsinki Detector Laboratory: Projects (1/2)

- CMS / **CMS Upgrade** (Dr. Panja Luukka):
 - R&D and manufacture of CMS LGAD Silicon Timing Detectors
 - Pixel detector module production
- CMS / **TOTEM** (Prof. Kenneth Österberg):
 - T2 Telescope Upgrade
 - R&D and package assembly of Diamond Timing Detectors
- Nuclear Physics / **FAIR** (Dr. Tuomas Grahn):
 - GEM-TPC (Gaseous Electron Multiplier – Time Projection Chamber) for NuSTAR Super-FRS

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Helsinki Detector Laboratory: Projects (2/2)

- **RADDESS** - Radiation Detectors for Health, Safety and Security
(Dr. Panja Luukka):
 - multispectral photon-counting for medical imaging and beam characterization - with Aalto, LUT, STUK
- **NINS3** - Novel Instrumentation for Nuclear Safety Security and Safeguards
(Prof. Peter Dendooven):
- **DEFACTO** – DEtector for Fallout and Air Concentration moniTOring
(Dr. Sakari Ihantola / STUK)