CaptInnov Platform

for new generation sensors and signal processing

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on behalf of Rémi Cornat (LLR)

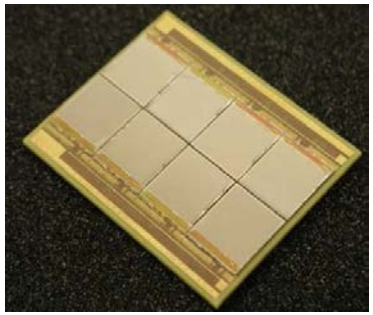
P2IO Scientific Council, December 17th, 2014

Motivations of the CaptInnov Group

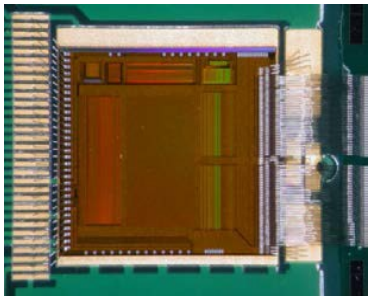
- Expertise for R&D project pre-evaluation before submission to selection committee
  - In the field of semiconductor sensors / circuits
- Develop informal relationship within the instrumentation/electronics community of P2IO labs
  - Share technical information and possibly share hardware, tools, facilities…
- Propose common projects, in particular concerning facilities
  - High quality tools for detector & chip characterization and integration
  - Best performance wrt. existing tools (CERN, Carnot network, …)
  - Tools having no existence in close area institutes
- Answered to P2IO call for platform proposal

Examples of Potential needs

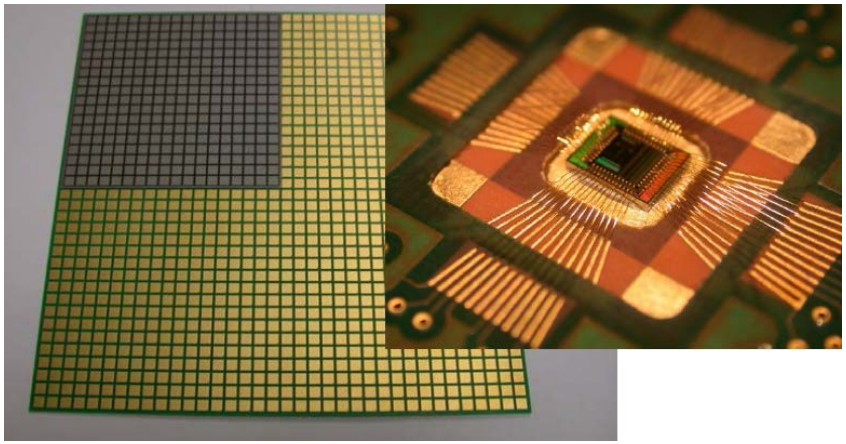
- Characterization of fine pitch, large size components is a key issue
- Can concern semiconductor detector or chips, hybrids, printed circuits
- R&D developments require reactivity, flexibility and home expertise
- Needs are not always affordable for sub-contractors
  - Size
  - Precision
  - R&D cycles

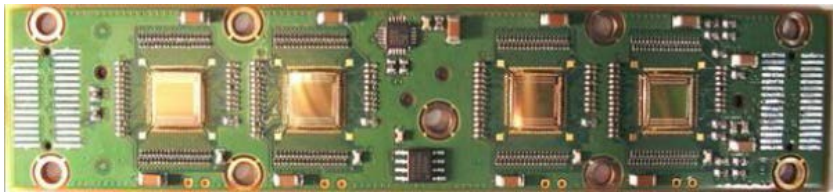


Octopuce board
2x4 matrix of
Timepix chips



APV chip for
COMPASS Double
row bonding





AFTER front end board (ILC TPC), 13x6 cm²

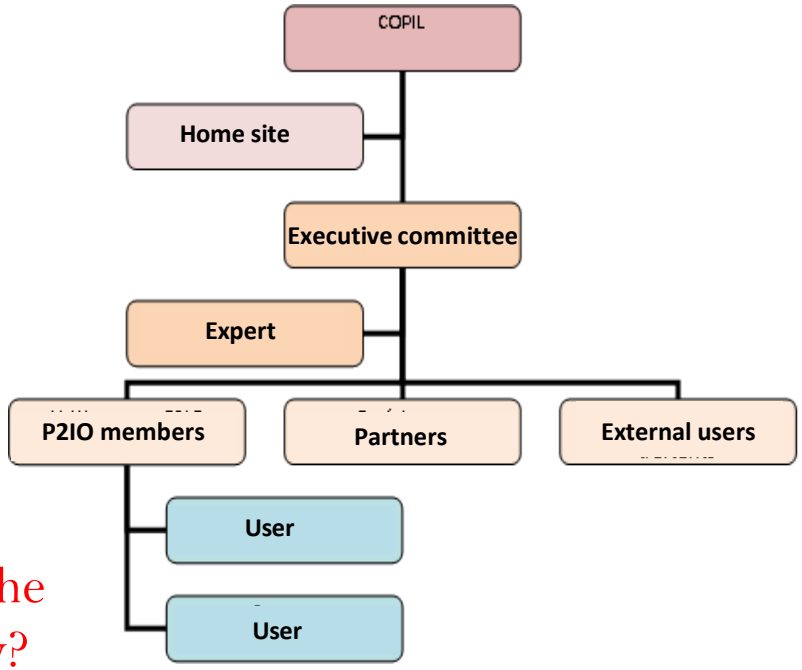
ILC – Si-W ECAL detector module : 18x18 cm, 1024 PIN ASIC bonded within the PCB thickness

CaptInnov Platform

- Proposal for sharing top level equipment
  Intended for electronics/detector integration and high precision testing

- Priorities given to a **probe station** and a **bonding machine** at first: consensus
  Can be extended thanks to next calls for projects ?

  "Platform" concept:
  - equipment located in 2 sites (LAL, CEA)
  - free/easy access to site(s)
  - opened to every P2IO members, partners and external structures (fees)
  - Coordination by an executive committee
  - User support thanks to trained expert person



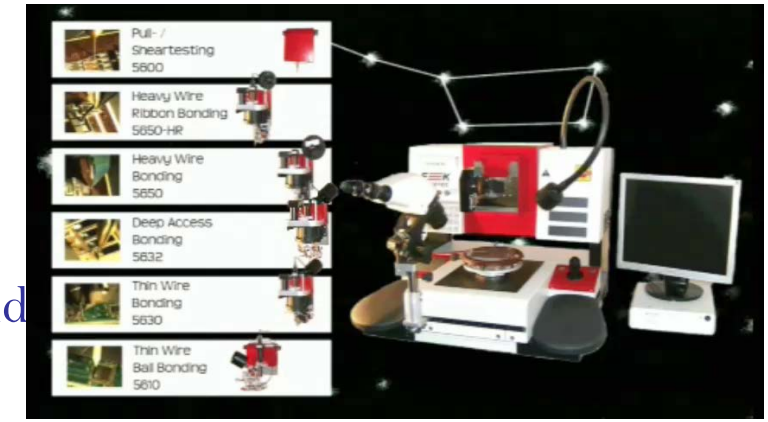
- The platform concept comes essentially from the building of a small (engaged) user community?
  link with existing professional networks (IN2P3)

Achievements of the Project

- Equipments **ordered end of July'13**
- Clean rooms are functional (maintenance on going at LAL)
- **Bonding machine is installed** (October'13) and first training passed
- **Probe station and thermal system installed** (July'14)
  - In qualification phase
  - Equipment accepted (June'15)
- Finalizing a platform convention (management, access rules, terms of use, …) to be agreed at the P2IO level : **long and painful**!
- Training of experts (2 operators @ CEA, 1 CDD @LAL, 1 AI@LLR) opening to the community : ~ 1/2yr.

Bonding machine : DELVOTEK 5632

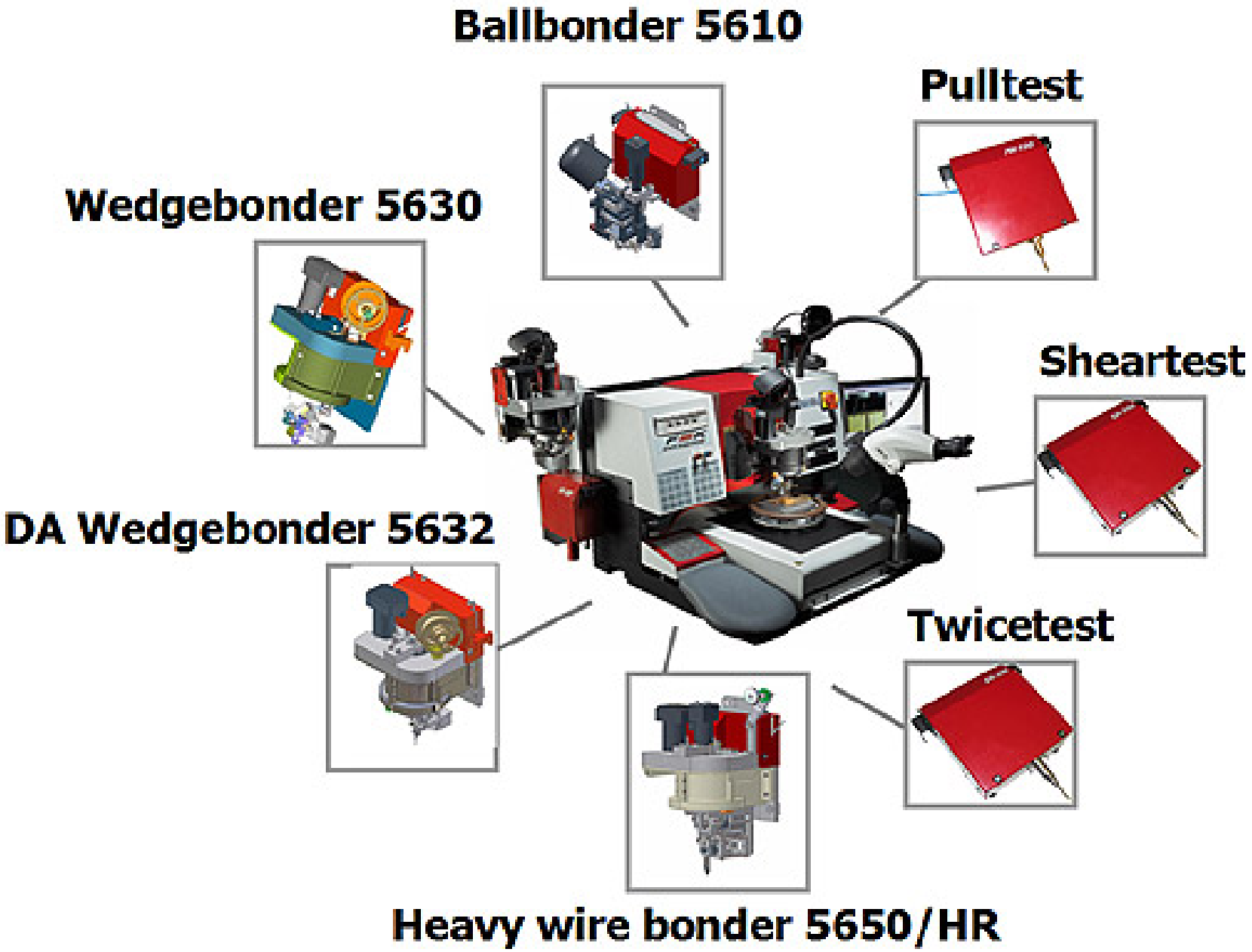
- Semi-automated machine:
  - fully programmable step mode,
  - pattern recognition unit (alignment),
  - controlled z axis positioning,
  - online wire shape control (angle, tense, bend
  - manual operation allowed,
  - 360° operations
  - deep access head allow bonding in cavities or close to components



- Several heads may be ordered in addition for various type of bonding:
  - wedge- or ball-bonding
  - gold or aluminum material
  - wire or ribbon
  - mechanical pull/shear tests
    (require additional head, not ordered)

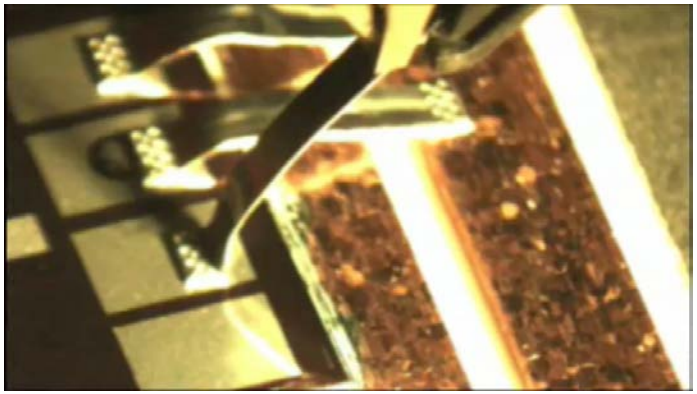
- Current configuration: wedge-bonding with aluminum wire

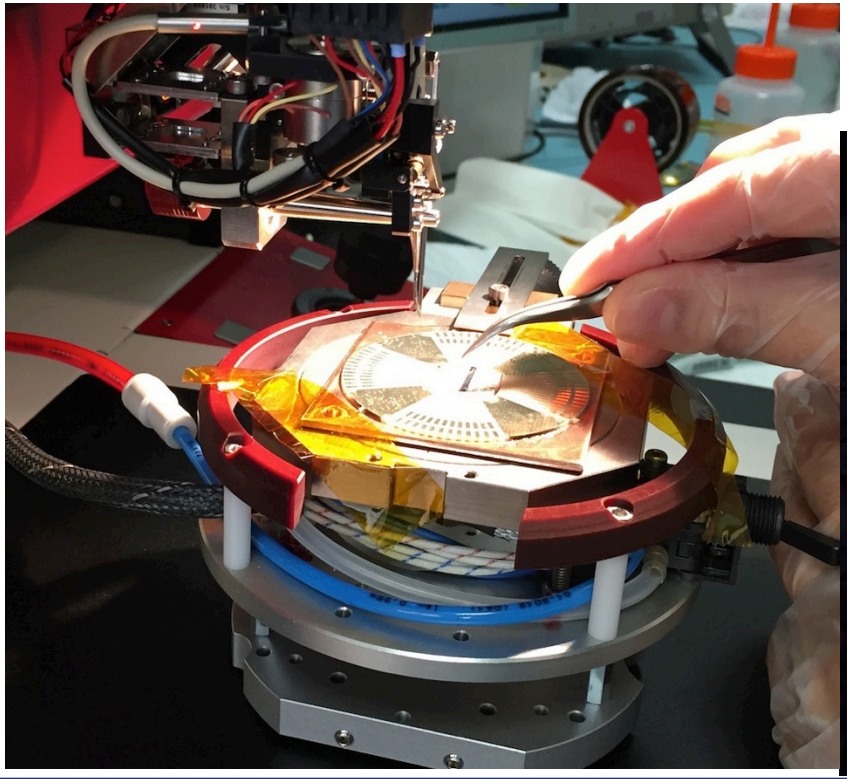
Universal Semi-Automatic Wire Bonders

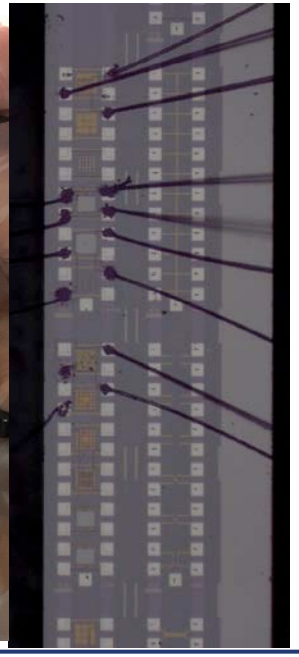


Bonding Machine Status

- 3 people trained since end of September 2014
- First work done for IAS: connection wires of CCD have been repaired
- Need to improve experience before become expert
- Team pending







Probe station: SIGNATONE WL350

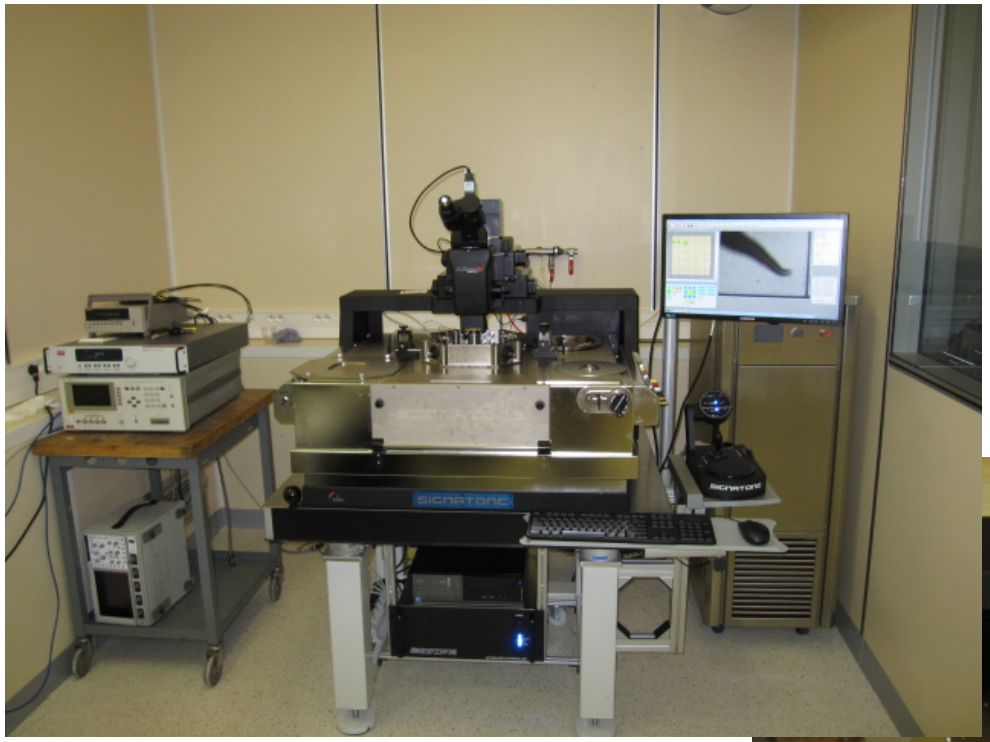
- Have chosen complete thermal system against full automation and performance (<100 fA, 100 fF levels)
- Partly-automated machine: aliment and positioning with vision assisted software
- open software allows any kind of programming (Labview, Python, C…)

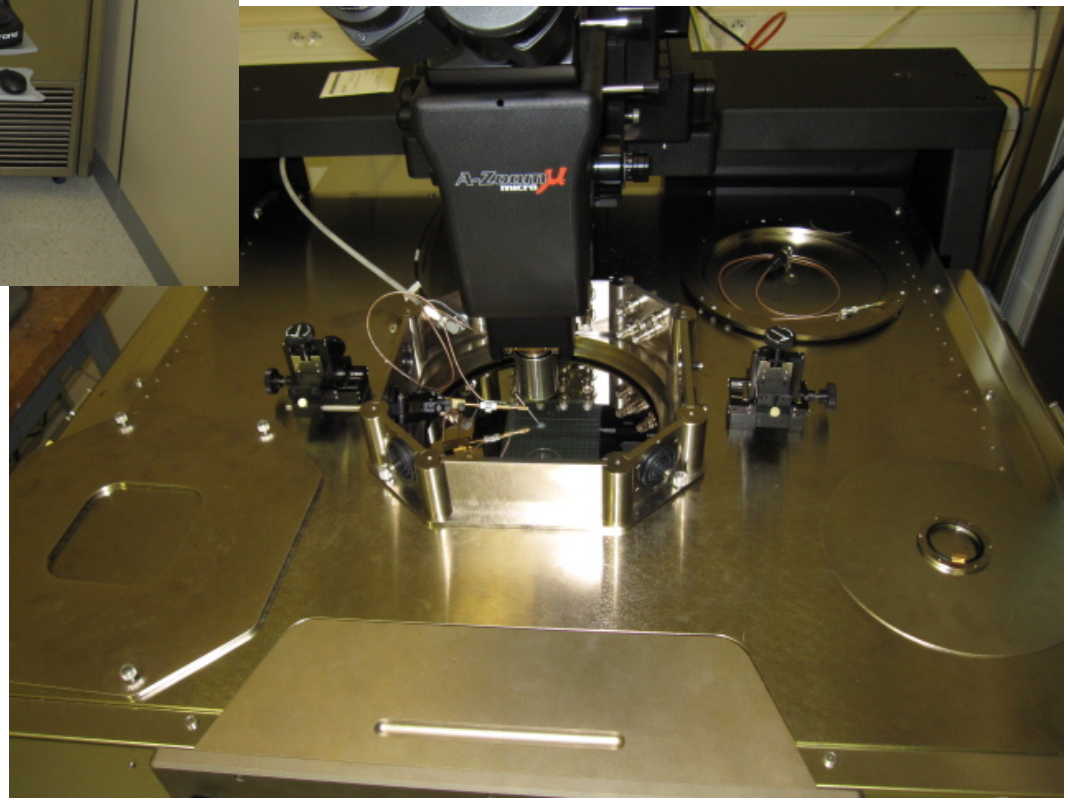
- Features:
  - **30cm** workholder in a **micro chamber**: black box & faraday cage, triaxial connectors Any kind of characterization (DC, AC -50GHz, S, noise, 1/f)
  - Large choice of DC & RF probes

- Wafer level tests or single die
- Probe card holder for specific probe configuration Micrometric resolution
- 12° spin correction

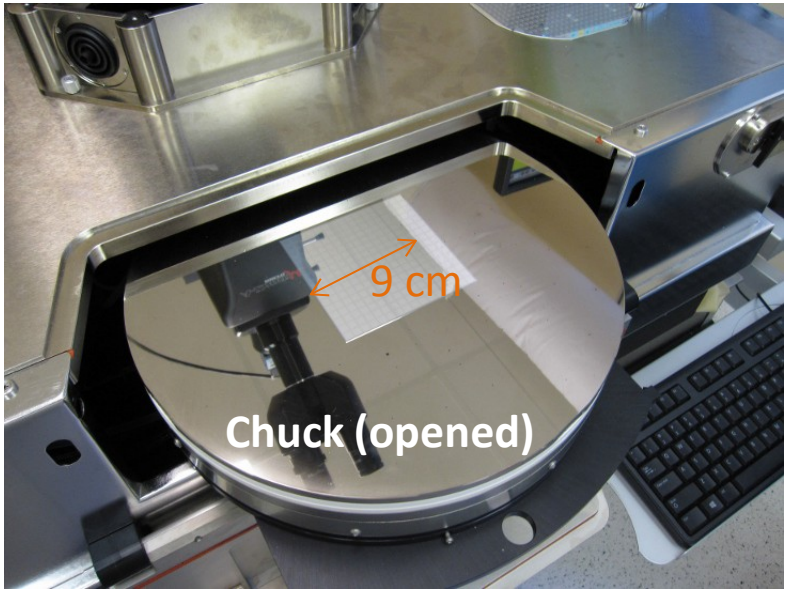
- **Temperature control -60° to 200°**

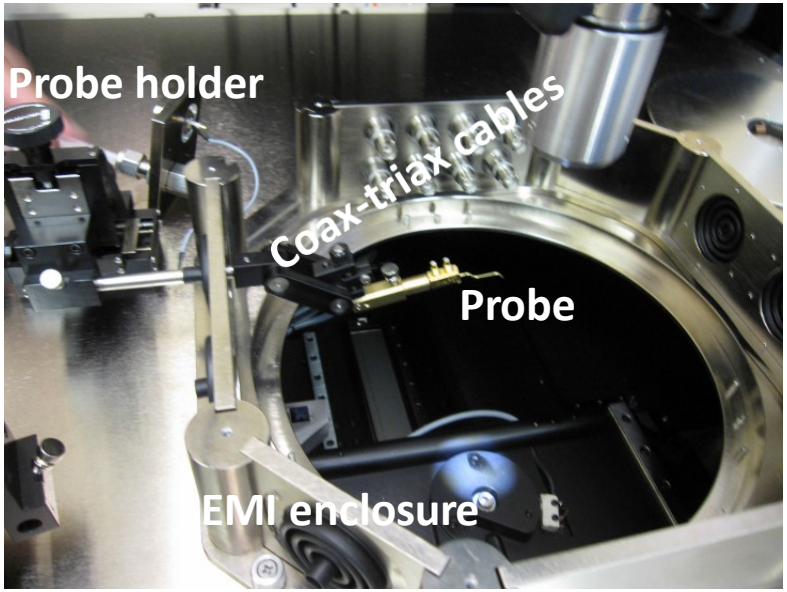
- Installed in a clean room at LAL

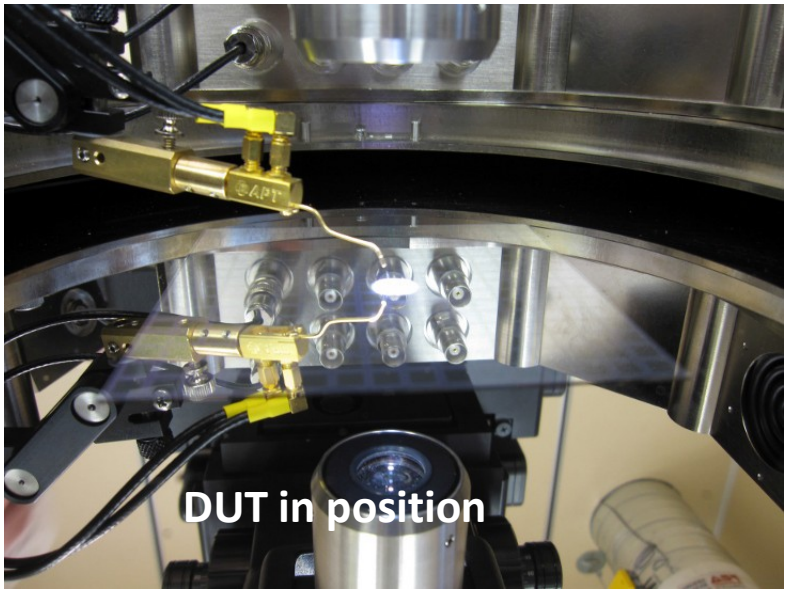

SIGNATONE

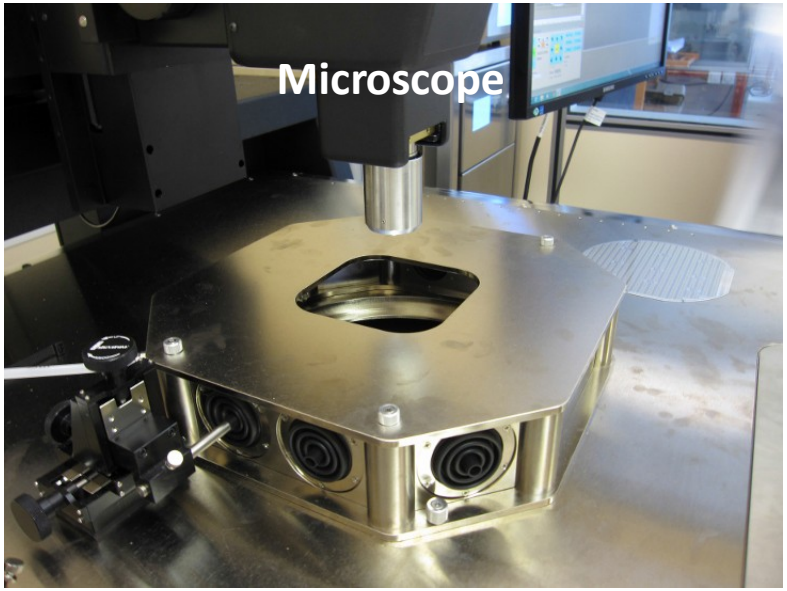

A-ZOOM

First Pictures (installation)



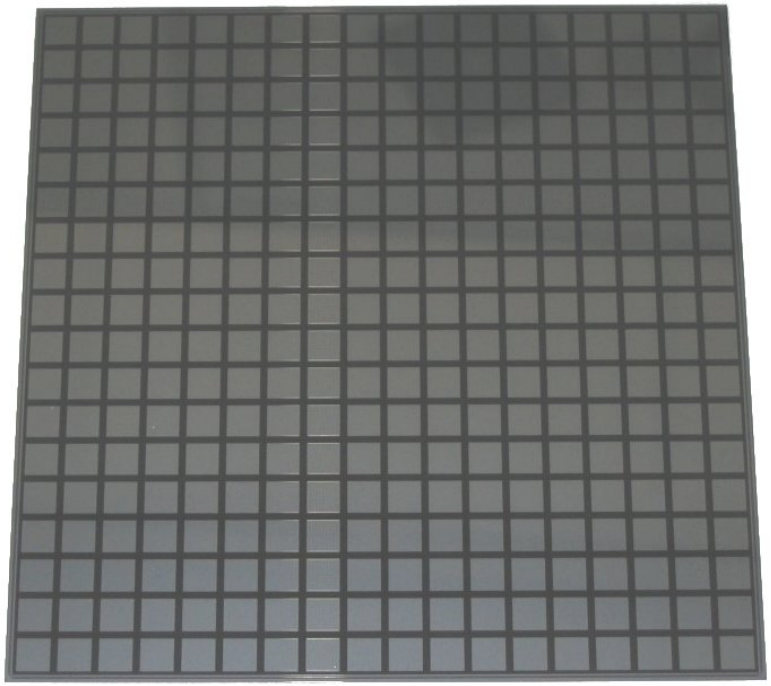


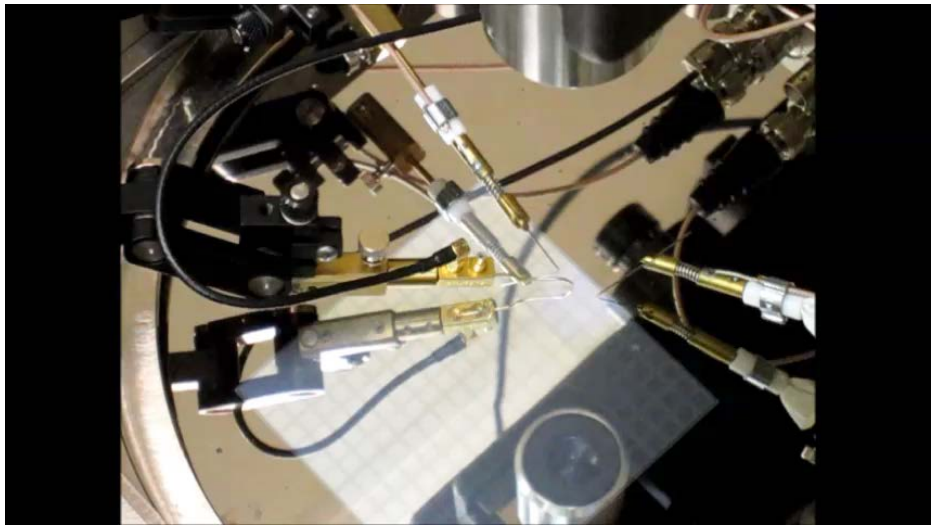




Example of an application

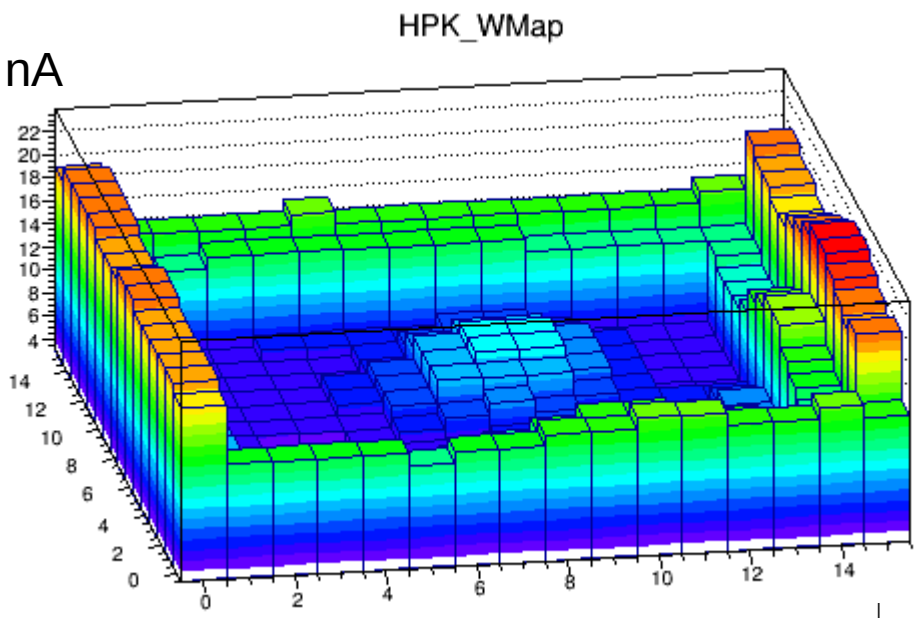
Map of leakage current of the 16 x 16 (9x9 cm^2) PIN diodes detector for the CALICE/ILD Si-W ECAL



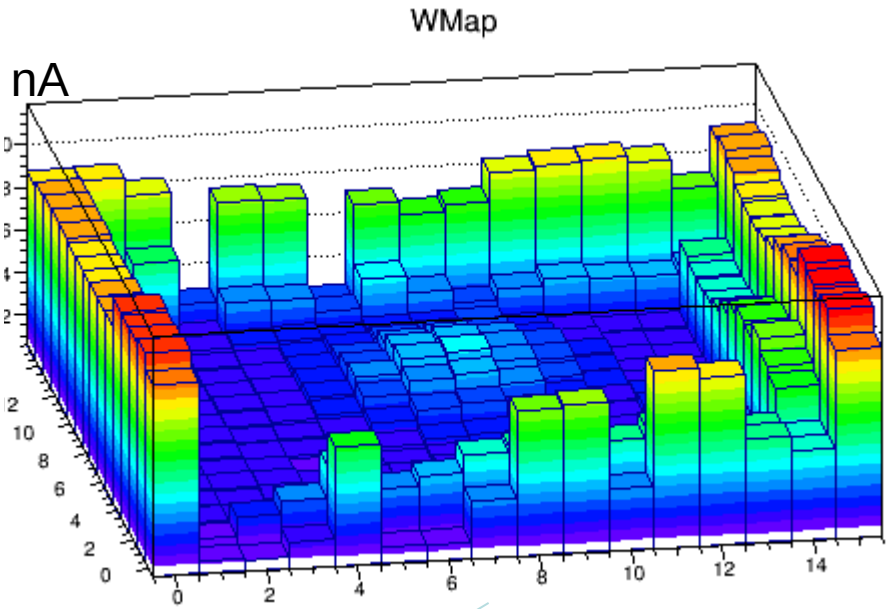


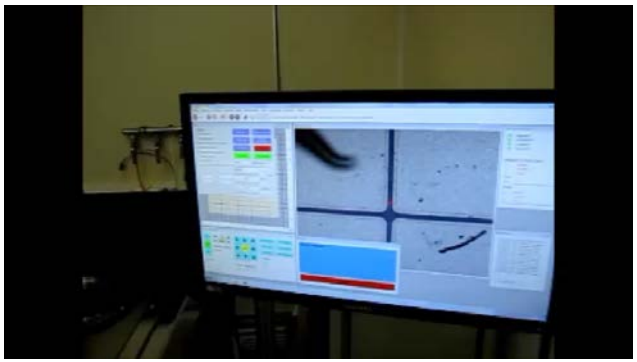
The scan is fully automated and the measurements are synchronized with the machine
Duration of the scan : 30 minutes for 256 diodes.

Map from the manufacturer (2011)

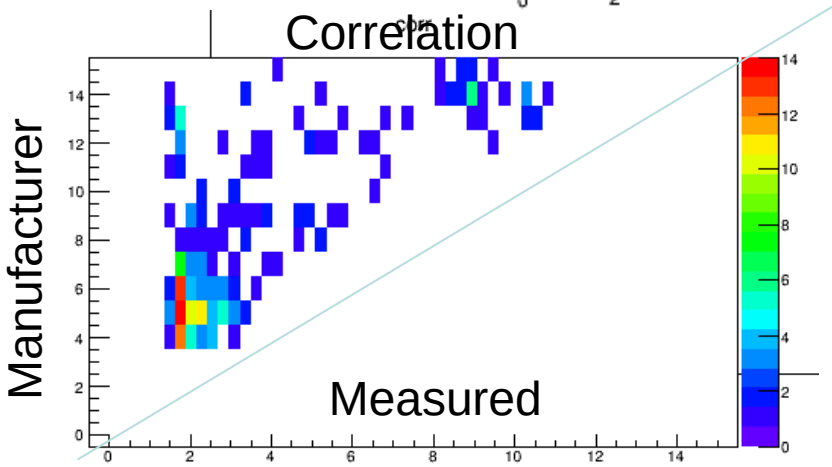


Measured map (09/06/2015 –preliminary–)





Correlation



CaptInnov Extras

The CaptInnov group also take care of:

- Training:
  Some training courses possible + help of experts

- Hardware pool
  Will (try to) share probes and measurement hardware

- Software options
  - Automation capability or user friendly control environment
  - Control of external hardware in NOT included as well as acquistion

- Planning of user access and maintenance operations
  Coordinated by dedicated experts

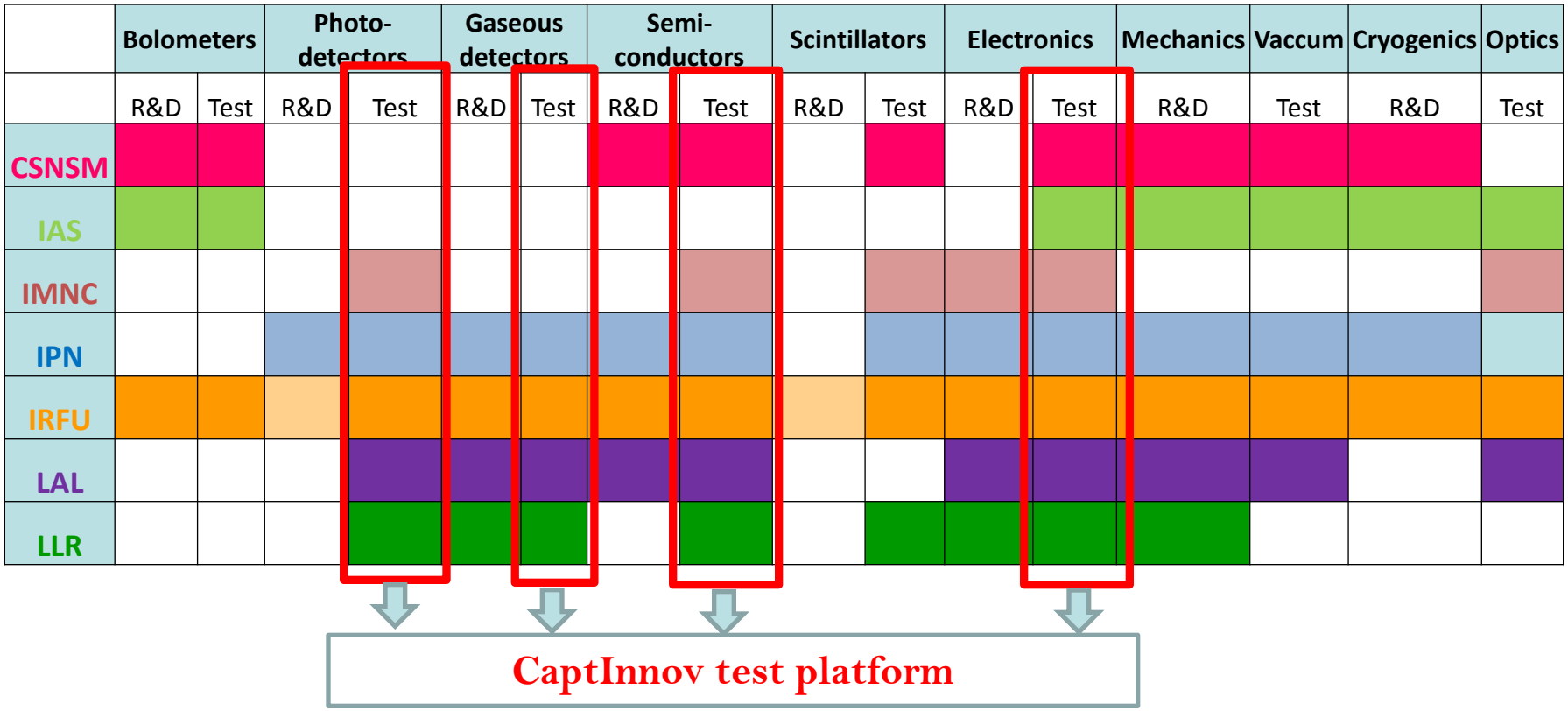
- Forge web site : https://forge.in2p3.fr/projects/P2ioCaptinnov (internal, will be opened within few months)

Conclusions

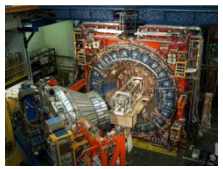
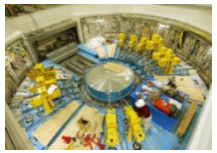
- Two high quality machines have been installed
- High potential for R&D, a large set of project are already interested in:
  - ATLAS pixels (vertex) and 3D electronics
  - TF2 (diamond sensors)
  - ILC TPC & large micromegas R&D
  - Compton telescope (DSSD detector + ASICs)
  - ILC ECAL (large PIN diode matrices, SoC ASICs, big production tests, …,…,….)
- The platform can be completed later on…
- Organization, rules, access and hardware qualification are on-going Should be opended to local community within ~1 yr.
- Future functioning will be based on goodwill and user's contributions

CaptInnov Inside P2IO

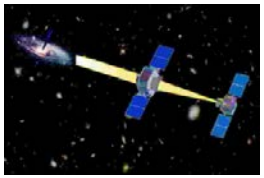
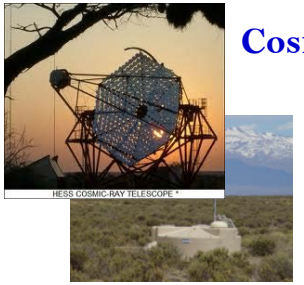
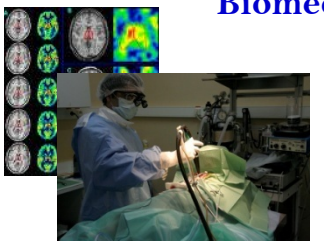
- **P2IO staff involved in CaptInnov**: **193**
- **Many international collaborations**: CERN, FERMILAB, SLAC, INFN, DESY, PSI, KEK, ESA…. and networks: AIDA, RD51, NUPNET, …
- **National collaborations**: Labex Univearth, … technical platforms (PTA, Minerve), Universities and other labs of CNRS
- **Strong involvement of P2IO detection teams in Physics experiments**: (HL-)LHC, ILC, AGATA, Spiral(-2), Auger, Edelweiss(-II/III), Super-B, Planck, T2K, etc.



Detectors studied by the labs of P2IO (1)

Applications	Challenges	Fields of research	Experiments/R&D
 **Calorimetry & Trajectography**	▪ High granularity(10^7channels) ▪ Large size ▪ High B field (→ 4 T) ▪ High rate ▪ Radiative environment ▪ Material « budget »	▪ Semiconductors ▪ Gaseous ▪ Low pressure ▪ Scintillators ▪ Photodetectors ▪ Microelectronics	▪ ATLAS,CMS,ALICE ▪ HL-LHC upgrades ▪ ILC ▪ COMPASS ▪ CLAS12 ▪ Spiral(2) ▪ …
 **Neutrinos**	▪ High number of channels (10^5) ▪ Low background ▪ Single photon sensitivity	▪ Gaseous detectors ▪ Photodetectors ▪ Microelectronics	▪ T2K ▪ Double Chooz ▪ ANTARES ▪ …
 **Particle Id**	▪ Single photon sensitivity ▪ Precise timing ▪ Digital treatment	▪ Semiconductors ▪ Gaseous detectors ▪ Digitization	▪ SuperB ▪ Fazia ▪ …
 **γ spectroscopy Nuclear phys**	▪ High resolution detectors ▪ Low noise → cooling ▪ Digital treatment	▪ Semiconductors ▪ Low noise FE ▪ Digitization	▪ AGATA ▪ S^3 ▪ …
 **Neutron detection**	▪ Large size> 1 m^2 ▪ Precision Mechanics ▪ Spatial resolution < 1 mm ▪ Good S/N ▪ Timing	▪ Photodetectors ▪ Gazeous detectors	▪ CLAS12 ▪ Demin ▪ Sedine ▪ NFS

Detectors studied by the labs of P2IO (2)

Applications	Challenges	Fields of research	Experiments/R&D
 **Spaceborn spectro-imagers**	▪ Low noise ▪ Space environment ▪ Miniaturisation ▪ Low power ▪ Large number of channels	▪ Semiconductors ▪ Microelectronics ▪ Scintillators	▪ MACSI ▪ Solar orbiter ▪ Compton camera
 **Dark matter search**	▪ Low background ▪ Low noise ▪ Ultra low temperature ▪ Material purity	▪ Bolometers ▪ Gaseous detectors ▪ Photodetectors ▪ Low noise electronics	▪ Edelweiss(-II/III) ▪ SuperNemo ▪ Cast ▪ …
 **Cosmic Rays**	▪ Single photon sensitivity ▪ High efficiency ▪ Precise timing ▪ Digital treatment	▪ Photodetectors ▪ Ultrafast digitizers ▪ Antennas	▪ Auger ▪ H.E.S.S.(2) ▪ Codalema
 **Biomedical**	▪ Spatial resolution(mm) ▪ Detection efficiency ▪ B field (IRM PET) ▪ Miniaturization ▪ Ergonomics	▪ Scintillators ▪ Photodetectors ▪ Semiconductors ▪ Microelectronics	▪ ART ▪ CALIPSO ▪ SIPMED ▪ PIXSIC ▪ MONITEP

Supports of P2IO for detection systems

- **No postdoc funded**
- **Support for collaborative R&D on detectors:** **300 k€** funded in 2011 (for 3 years)

Project	Field	CSNSM	IAS	IMNC	IPNO	IRFU	LAL	LLR
New generation of cryogenic detectors	bolometers							
HARPO	Space techno, gaseous detector							
SAMPIC	Fast timing electronics, Photodetectors							
CALIPSO ionisation	biomedical							
COMPTON telescope	Space technologies, semicon, scintillators.							

- **CaptInnov test platform (182 k€):**

- Advanced probe station + bonding machine,
- Usable for large area devices,
- Usable for detectors & (micro-)electronics,
- « Seed » funding of P2IO complemented by application to Univ. Paris-Sud and IdF region

- **Other supports:**
  - Workshops (PhotoDet 2012, …) and schools (*Rencontres de physique de l'infiniment grand à l'infiniment petit 2011/2012*, …)
  - Support for visitors (Pr Savvidis, …)
  - Platform operational supports (~10 k€): Cryogenic, Dalton, Calva

Prospects and conclusions

- **Each year:**

  Yearly status reports for each R&D project

- **Longer term:**

  CaptInnov platform: operational next year (mi-2013)

- Starting point to improve synergy between detector teams of P2IO labs
- P2IO supports are precious for risky and innovative R&D of detector systems
  Initial stage of R&D before asking funding to agencies (Cnes, ESA, ANR, …).
- These platform and R&D projects can be a starting point for partnership with industries
- Platform are also planned to be used for teaching purposes