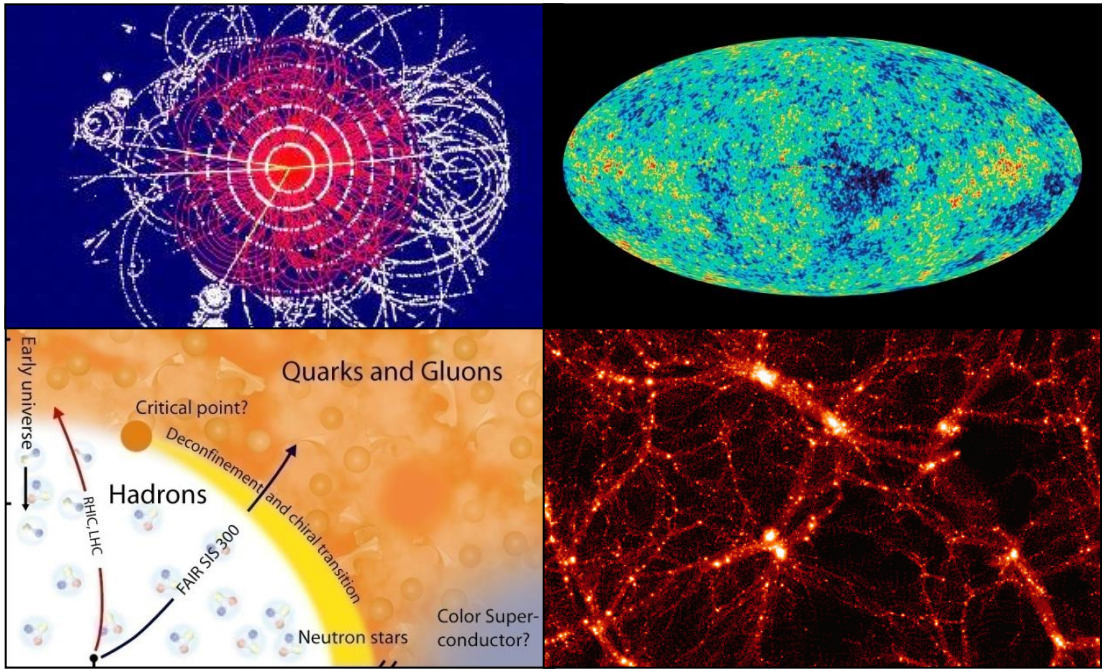
CEA - ***Irfu***: Into the fundamental laws of the universe

Ultimate constituents of the universe

Energy content of the universe

size

Complexity



Extreme states of nuclear matter

Formation and structure of the universe

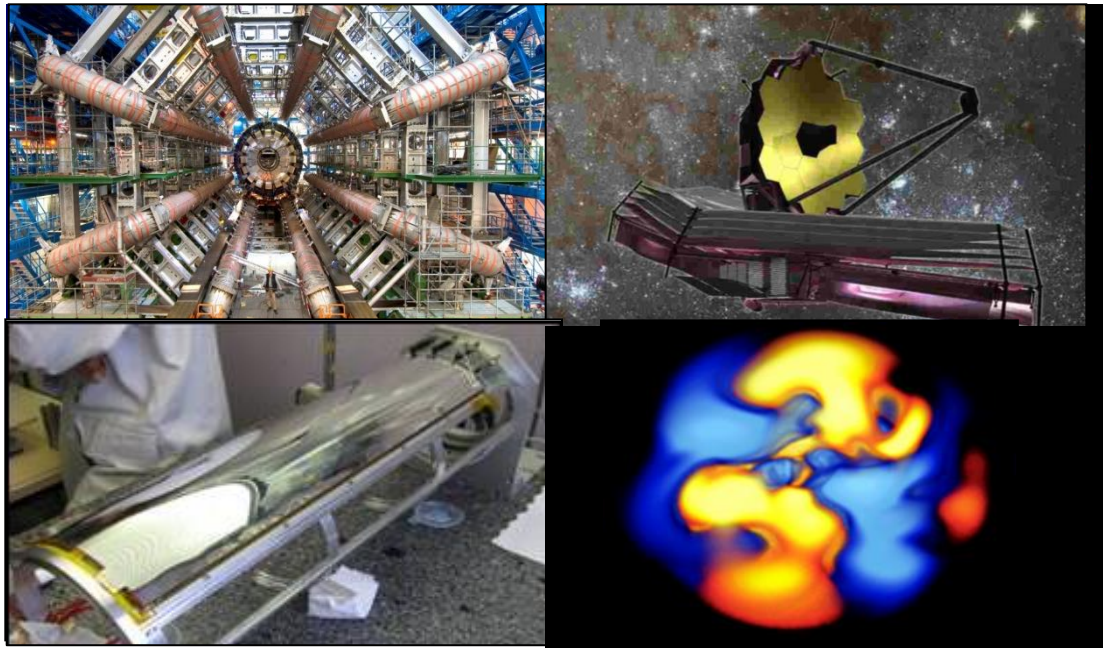
Innovation in instruments

Manipulating radiations

Supraconductor magnets
Particle accelerators

Detecting radiations

Imagers (IR, X, ….)
Satellite payloads



Microstructured detectors
Microelectronics

Observing the universe

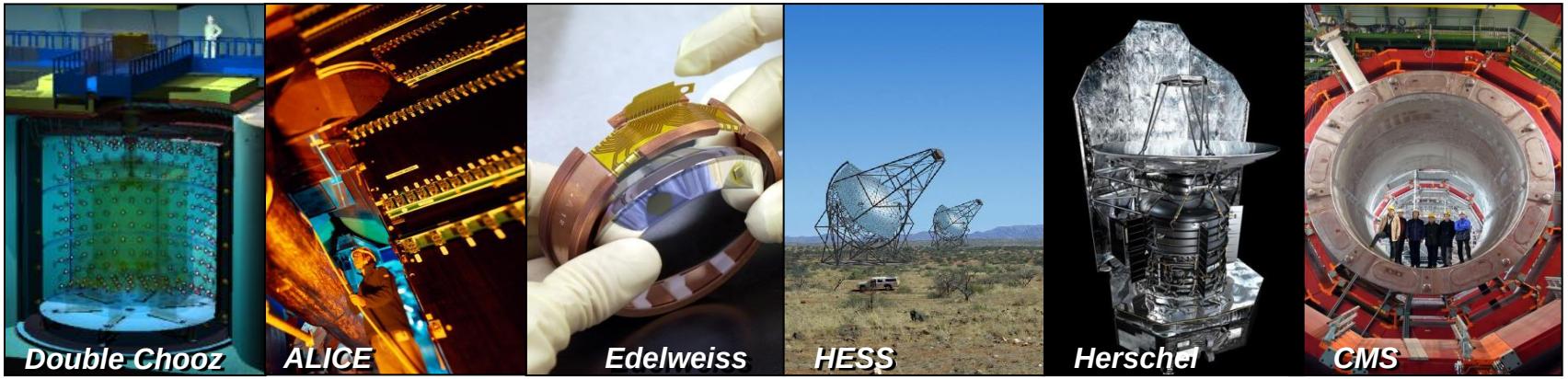
High performance computing
Massive data processing

Simulating the universe

Irfu organisation

Institute of Research into the Fundamental laws of the Universe

SPP	SPhN	Sap	SACM	SIS	Sedi
• Particle Physics	• Nuclear Physics	• Astrophysics	• Accelerator, Cryomagnetism	• System engineering	• Electronics, Detector, Computing

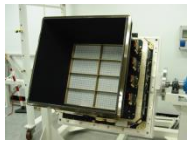


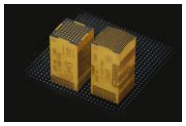
Irfu Detector Roadmap

Past — **Present** — ***Future***

Semiconductor Detectors (Si, CdTe, Ge)

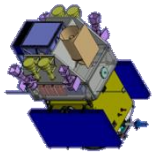
Integral Isgri





X-ray detectors

SVOM Eclairs

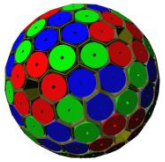


Athena *International X-Ray Observatory*

Spiral

Agata

Musett

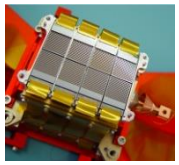


ALICE MFT

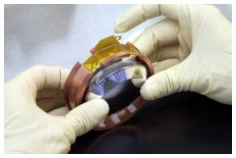
SPIRAL 2

Cryogenic Detectors (Bolometers)

Herschel

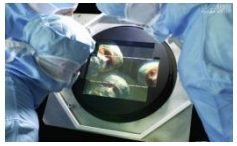


Edelweiss



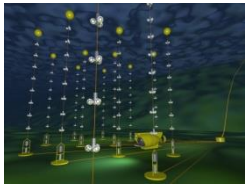
EURECA *Direct Dark Matter Search*

Optical Detectors (CCD, PMT)



Megacam

Antares



Double Chooz

KM3 *Cosmic Neutrino Observatory*

Euclid

Hess, HessII

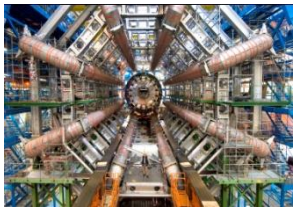
CTA *Cherenkov Telescope Array*

Gaseous and Liquid detectors (Micromegas,...)

Compass

Atlas

Alice



T2K

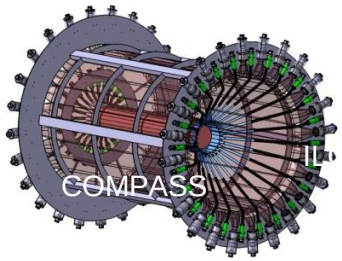
CLAS12

Atlas NSW

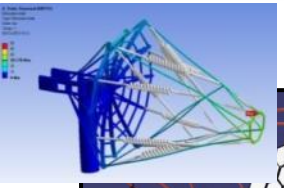
HL-LHC, *Future Linear Colliders*

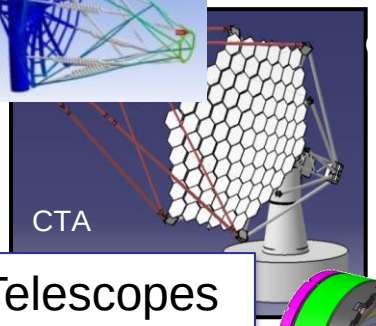
Mechanical Design Office

Mechanical designs of innovative/ challenging systems for IRFU physics applications

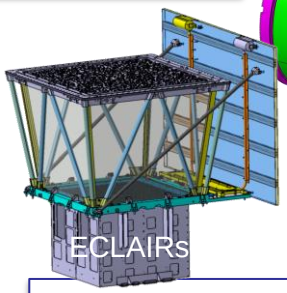


Detectors





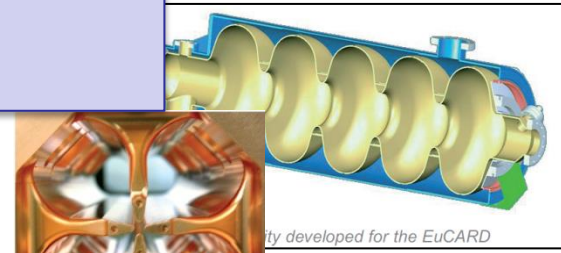
Telescopes



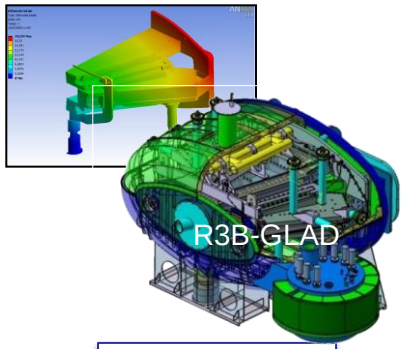
Space instruments

- Centralised organisation based on Iterative processus with project team
- Skills & how-know for :
  - -Simulation, modelisation
  - -Design & integration (CAD)
  - - Definition of technical specification
  - - links with industrial realisations

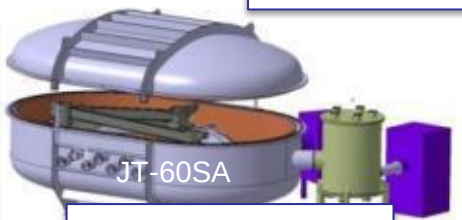
- Efficiency, flexibility and ability to react during preliminary phases
- High level of expertise in the EF structural calculations



Accelerators



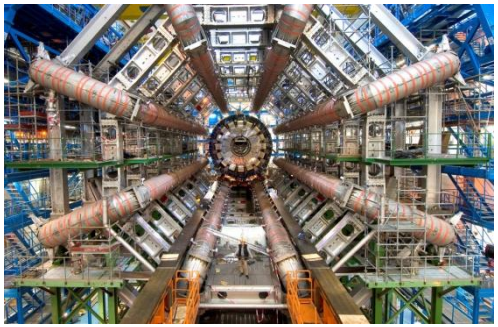
Magnets

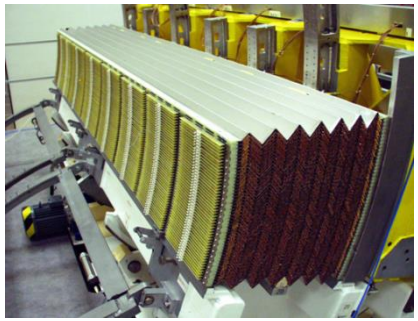


Test facilities

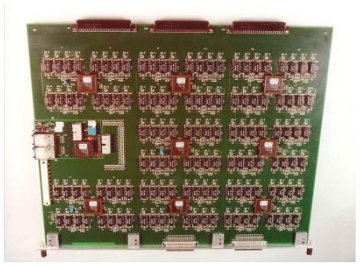
LHC Detectors

Atlas



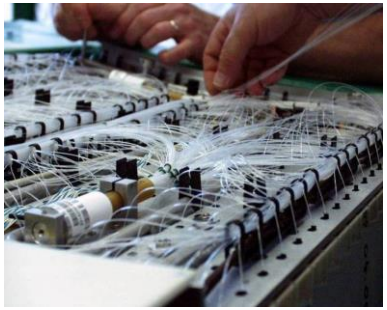


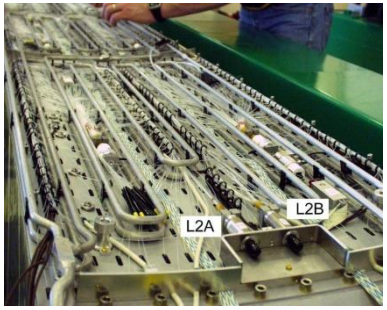
Lar Calorimeter, Asic

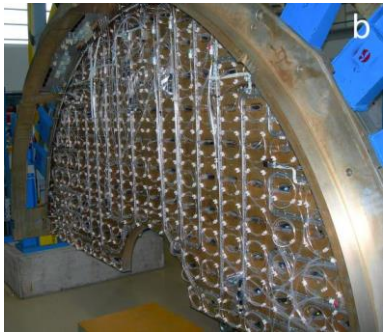


First level trigger electronics

CMS

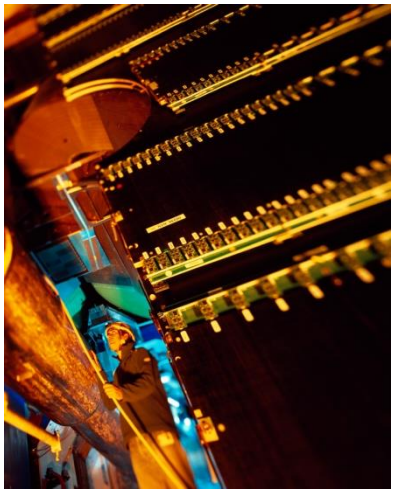






Optoelectronic system to monitor calorimeter crystal transparency

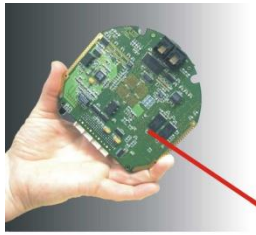
Alice



Dimuon arm tracking chambers

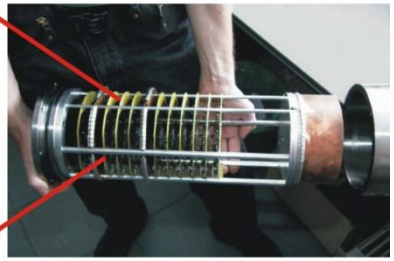
Underwater Neutrino Observatory ANTARES

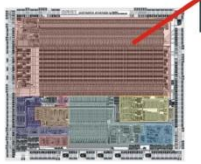
CEA-IN2P3-INFN-NIKHEF Collaboration



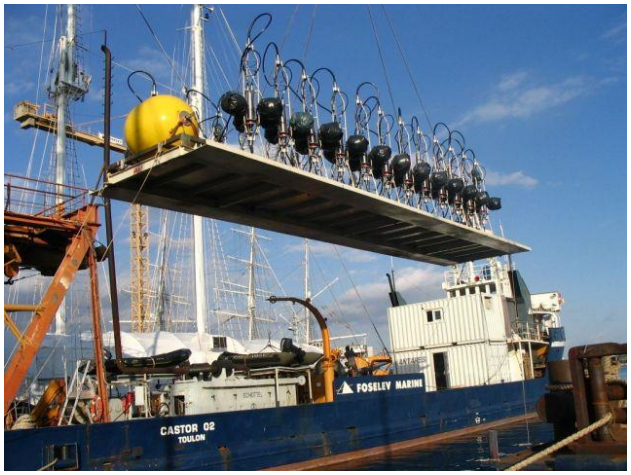
Embedded processor board

Immerged Control Module

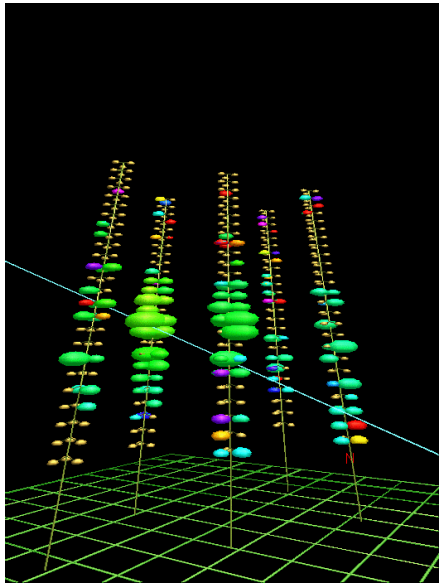




Front-End Asic (Analogue Ring Sampler)



12 lines in operation

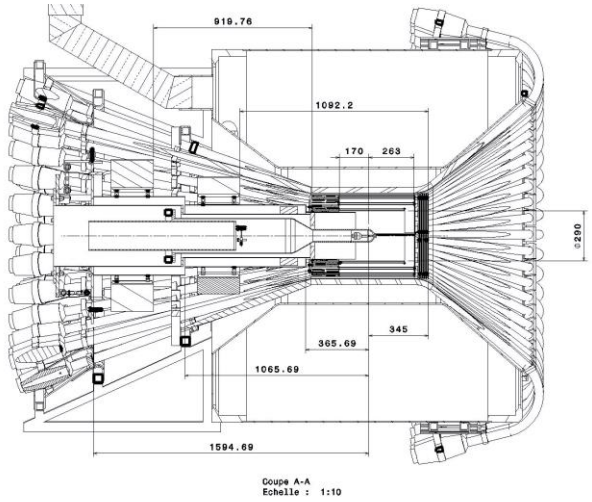


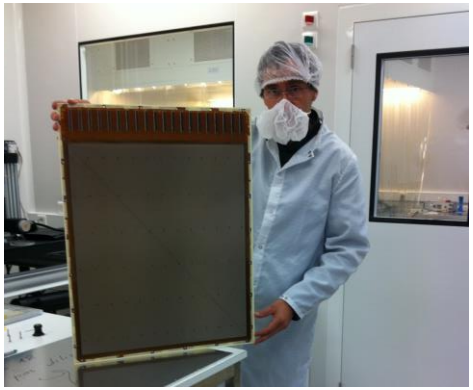
Clas12 Central Tracker (JLab, USA)

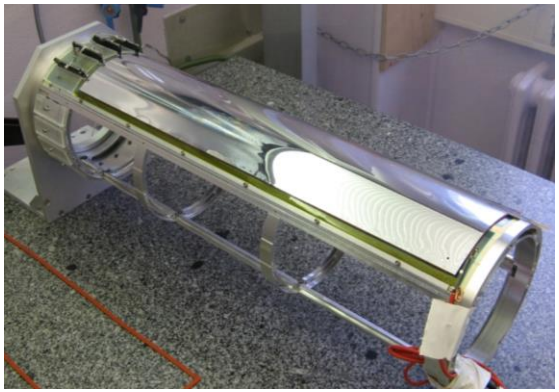
Central detector
- 6 cylindrical layers (X&Y): 3 m^2
- Magnetic field, transparency

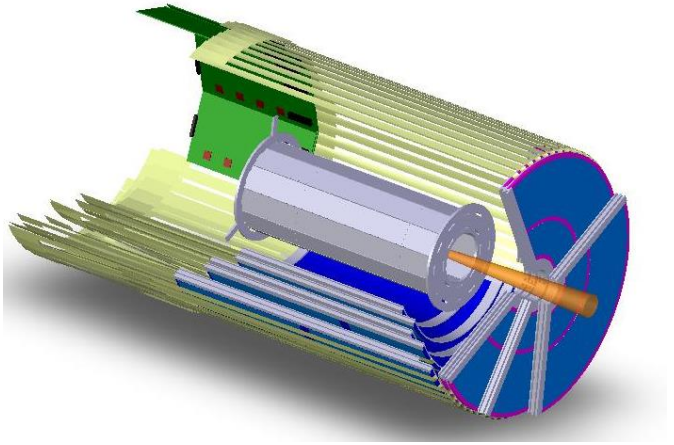
Forward detector
- 6 planar layers (XY): 1.2 m^2
- Density, high flux

ASIC + Acq
- S/N ratio, Acq rate
- Density, location, thermal management





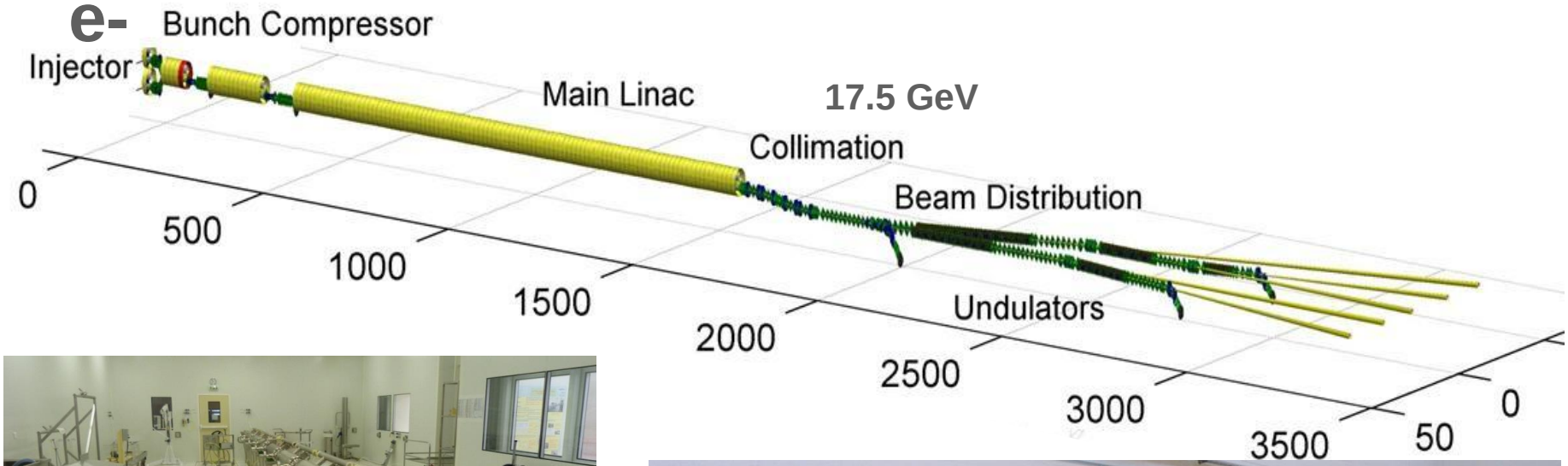




XFEL cryomodules

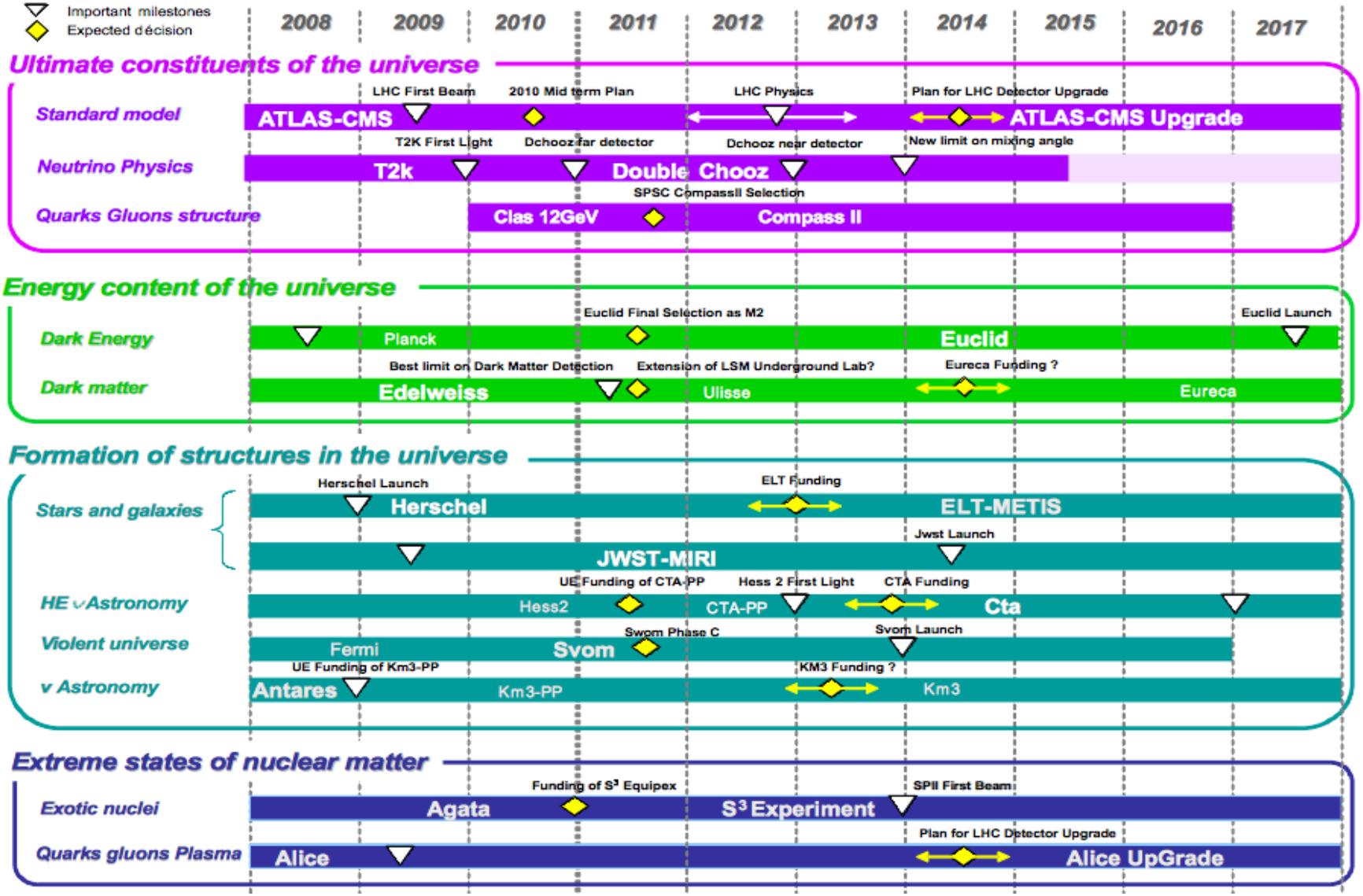
***European X-ray free electron laser* (E-XFel)**

Application : chemistery, biology, material science



103 cryomodules, 1/week.

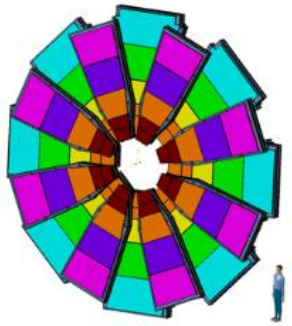
Irfu scientific roadmap



Upgrades LHC: *New Small Wheel* Atlas

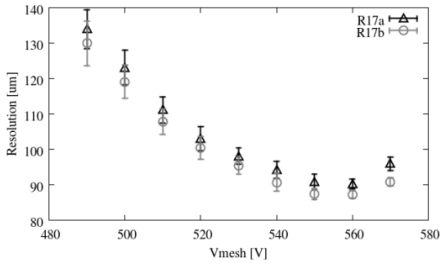
Remplacement détecteurs muons Atlas

- Roues de 12m, ~1000m^2
- Anode résistive, lecture 2D
- Preuve de faisabilité sur 2012/2013



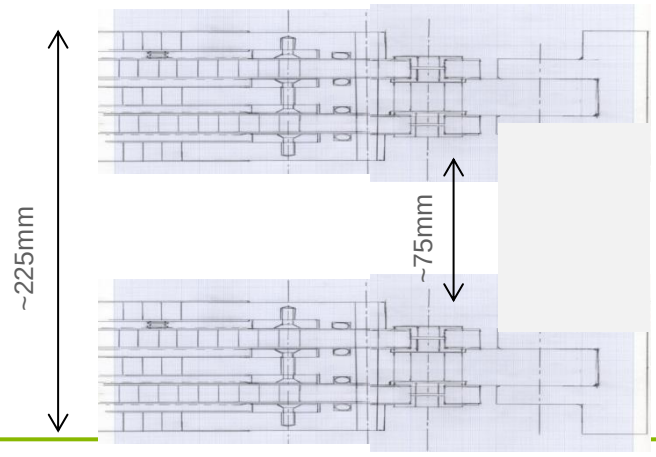
Etudes de vieillissement à Saclay

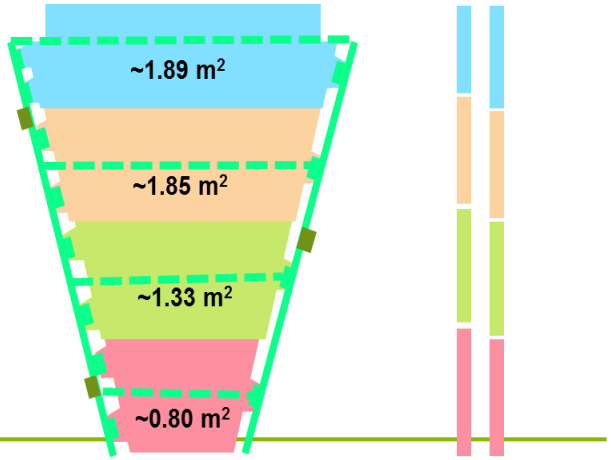
- Irradiations X (5 ans HL-LHC équivalents)
- Irradiations neutrons (Orphée, 10 ans HL-LHC équivalents)
- Irradiations gamma (Cocase, 10 ans HL-LHC équivalents)
- Irradiation alpha (effet particules fortement ionisantes, 500 millions claquages)



Mécanique, production

- Modularité
- Précision spatiale de l'empilement 2*4 détecteurs
- Transfert industriel
- Stratégie d'intégration





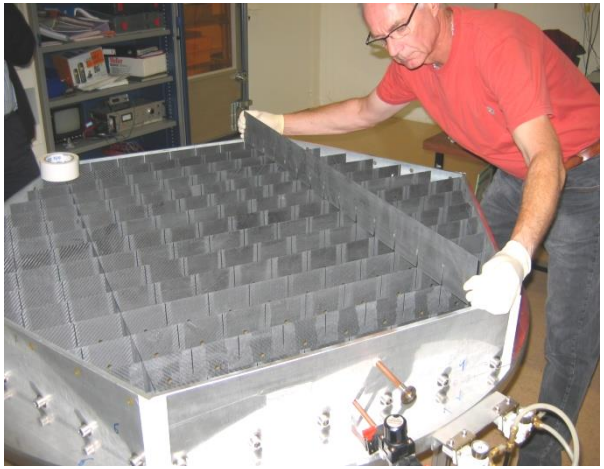
CTA: Mirror studies

2009

- Prototype 50cm*50cm mirrors
- Honeycomb carbon structure

2010/11

- Hexagonal mirror prototypes 1.2m (medium size telescopes)
- Alternate material studies: Al, Carbon, G10, …
- Moulding and assembly procedure validation
- Metrology in dedicated underground hall



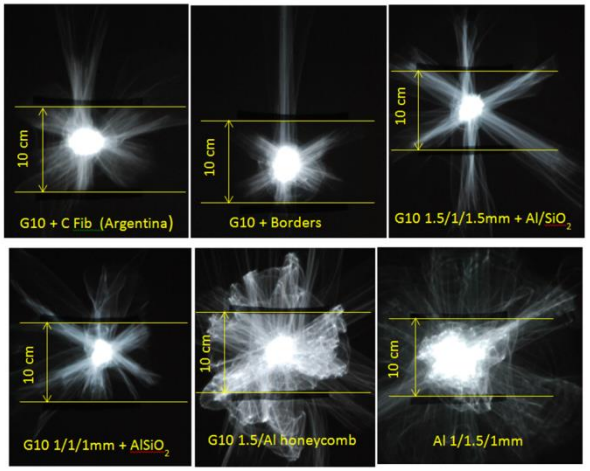


Figure 6: Observation of images at 2F for various mirrors.

Xfel: From prototype to series

Montage du train de cavités en ISO4

Roulage du train de cavités hors salle blanche

Arrimage du train de cavités au cryostat

Alignement des cavités par LaserTacker

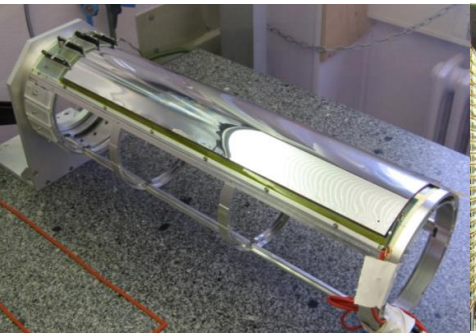
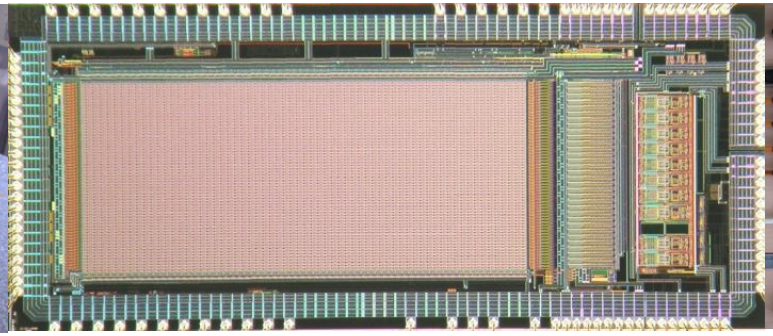
Sedi overview

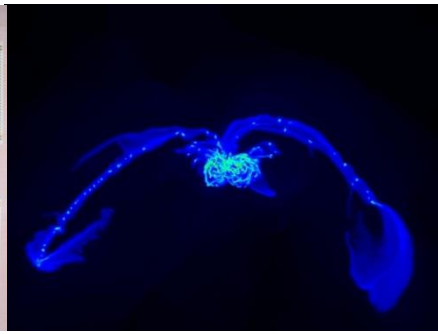
Electronics, Detectors, and Computing Division

Service d'Electronique, des Détecteurs, d'Informatique

LDEF	LID	LSEO	TRAPS	Lilas	CosmoStat	LIS	CERN antenna
• Detector physics • Frontend electronics • Microelectronics	• Detector mechanics and integration	• Electronic and optoelectronic systems	• Digital electronics, • Embedded processors • Real time systems	• Application software for physics • Software engineering	• Signal and image processing for astrophysics	• Computer system operation and administration	• On-site support for Irfu experiments

133 permanent staff (81 engineers/physicists, 52 technicians/administrative), 14 PHD/postdoc/limited contracts

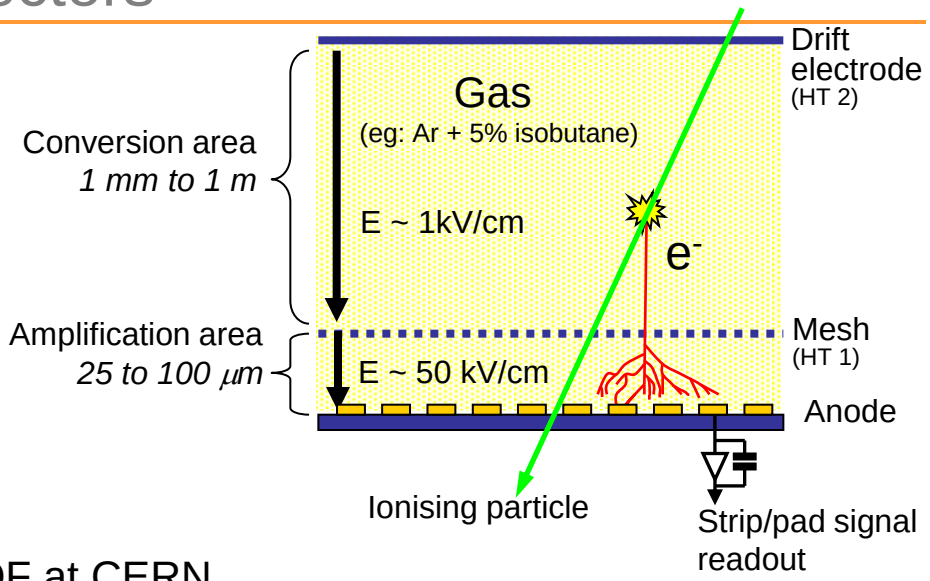


Detectors | Microelectronics | Real time systems | Software engineering and scientific software

Micromegas Gaseous Detectors

A patented CEA invention

MicroMesh GAseous Structure
I. Giomataris, Ph. Rebourgeard, J.P. Robert & G. Charpak,
NIM A376 1996 (29)

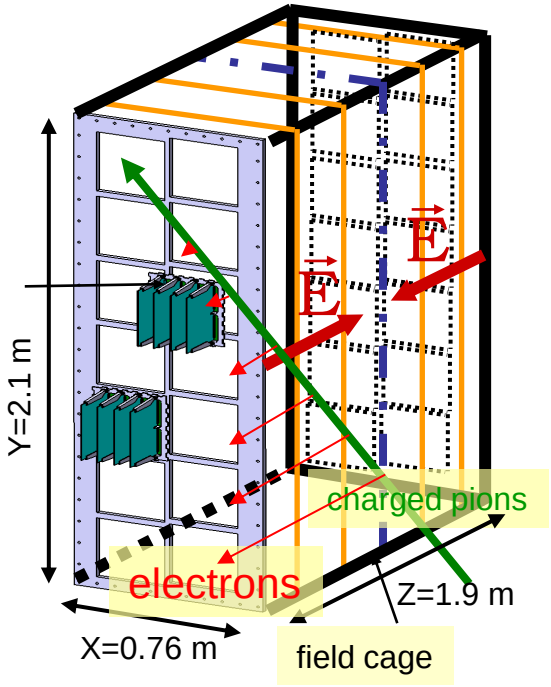


Detectors for COMPASS, KABES, CAST, NTOF at CERN
DEMIN: neutron diagnostics for inertial confinement fusion laser experiments
PICCOLO: Sealed detector for neutron flux measurements in nuclear reactors
ForFire: VUV light detector for early detection of forest fires
Tokaï (JPN): TPCs of the T2K neutrino experiments
Clas12 (JLAB): Cylindrical central tracker

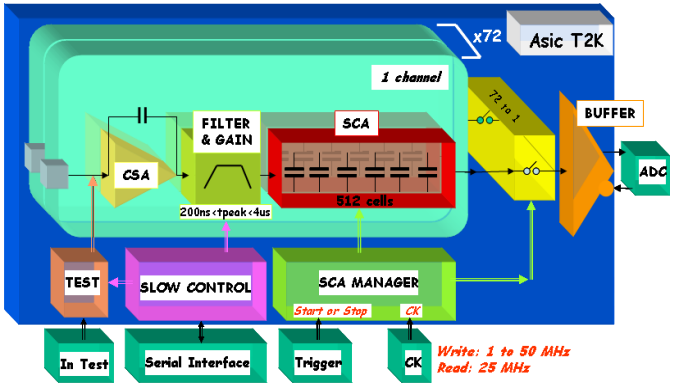
New techniques

Bulk	• Use of proven industrial PCB techniques to fabricate the thin detector amplification area
MicroBulk	• Advanced chemical processing of a dual-sided Kapton sheet

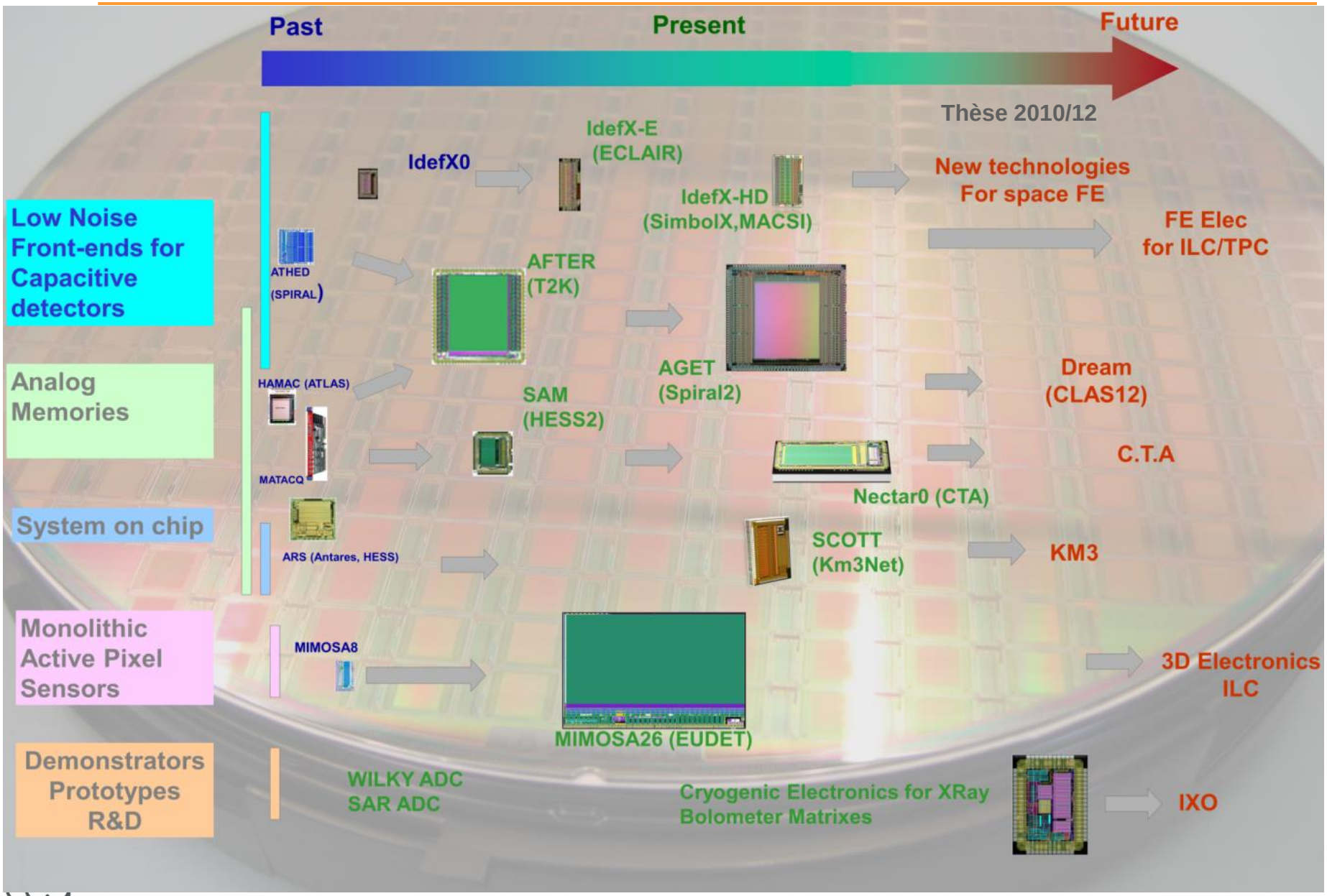
TPC detectors for T2K (Tokaï, JPN)



- Large detection surface ~10m2
- 72 Micromegas modules in operation
- Dedicated Asic, 124000 electronic channels
- Remote Acquisition
- A number of re-uses and spin-offs in other applications



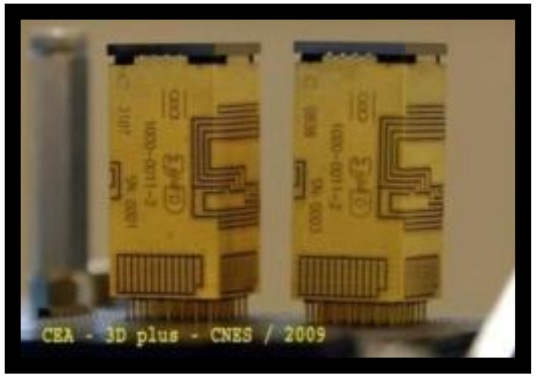
ASIC roadmap

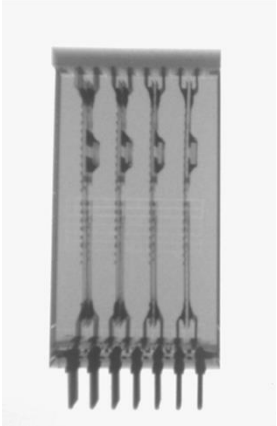


IdefX-HD for Caliste256 CdTe modules (SimbolX, MACSI)

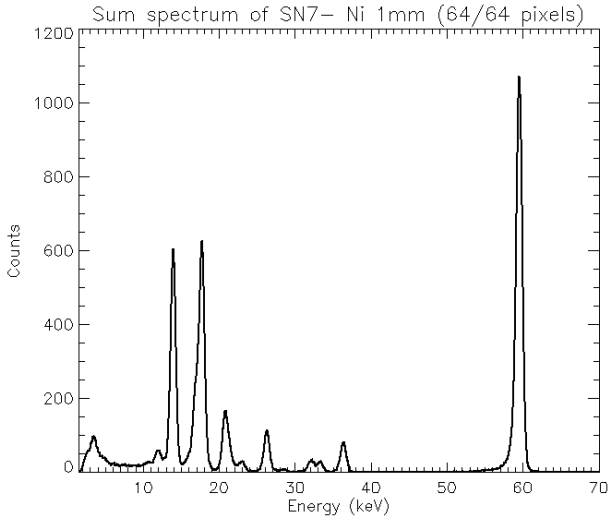
Caliste module houses 8 x 32-channel ASICs + pixelated CdTe (500µm pitch) inside a 1x1x2 cm^2 module

Significative power reduction in Idef-X HD: < 250mW/Caliste





Xray Photography of the 64-pixel version of Caliste



Sum spectrum of ^{241}Am.

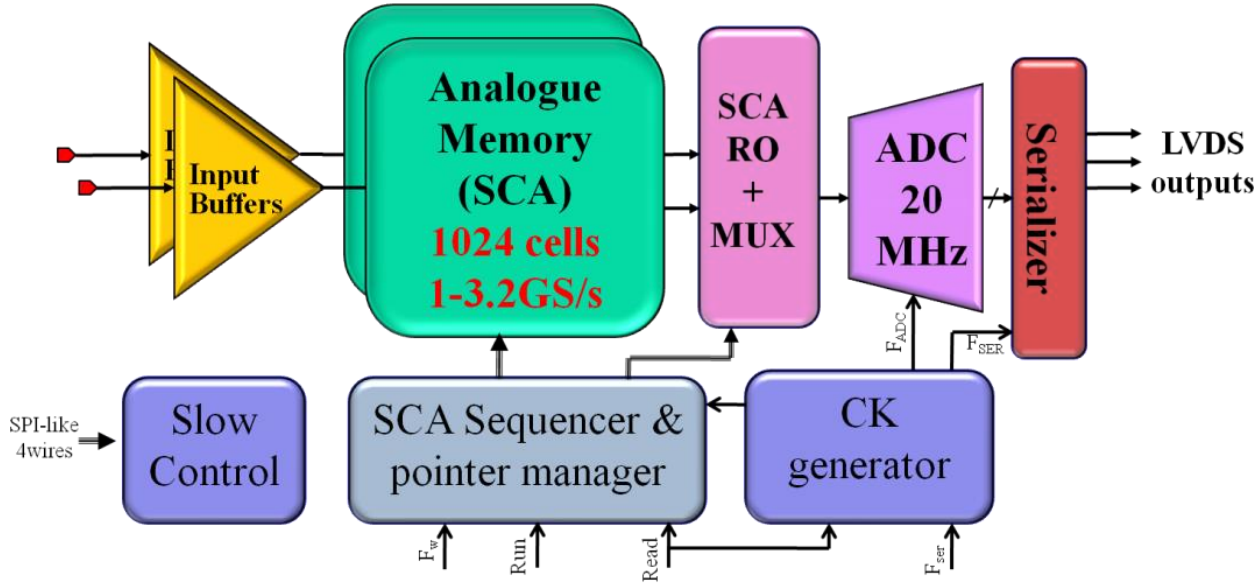
Resolution:

800 eV FWHM@ 60keV

700 eV FWHM à 13keV

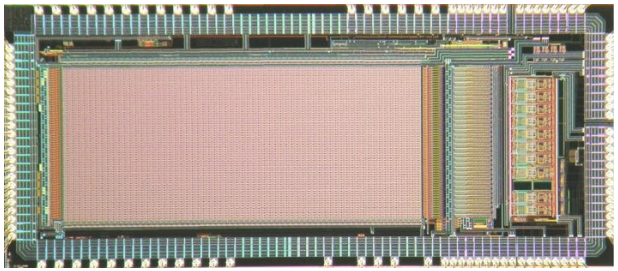
Threshold = 2keV

NECTAR: Advanced ASIC for Cerenkov Telescope Array



Innovative architecture

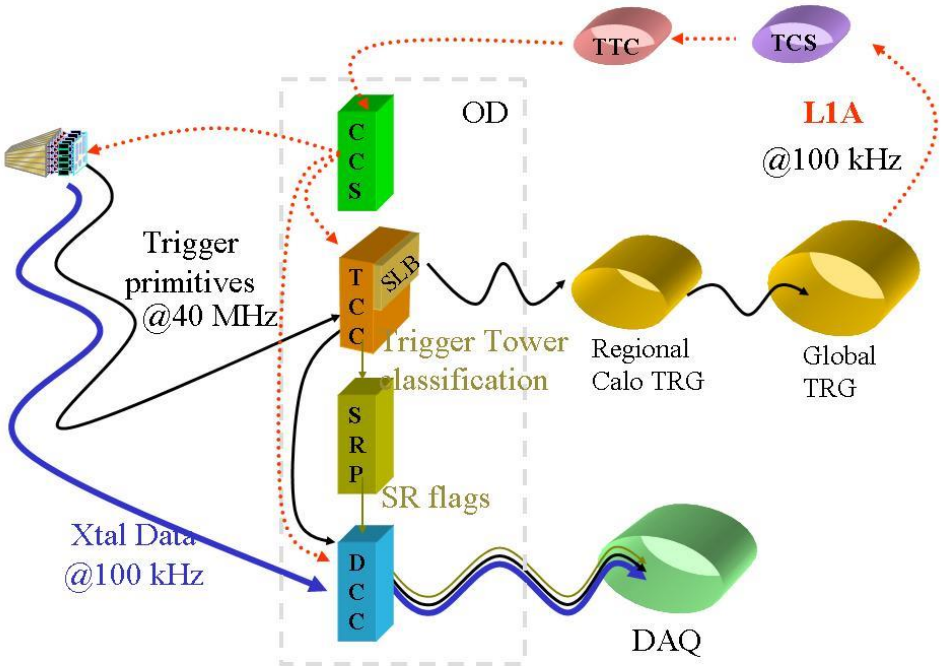
- Fast analog memory sampler
- High performance ADC (IN2P3/LPSC IP block)
- Serializer and digital output transmitter

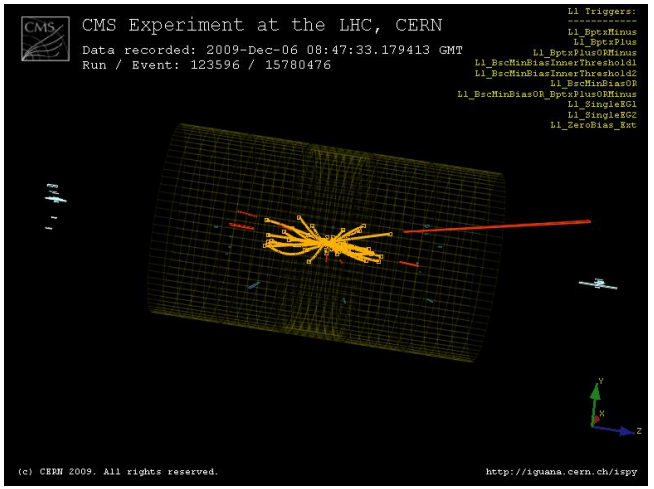


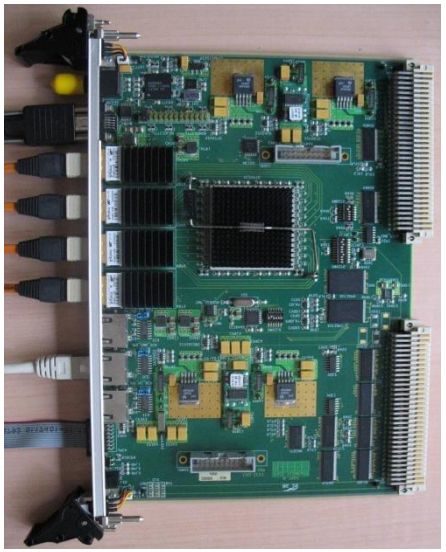
Real time systems

CMS	• Real time *Selective Readout Processor* for data compression in the calorimeter readout
Clas12	• Architecture, data collection and reduction
Eclairs	• Real time embedded system for the SVOM/Eclairs Gamma Ray Burst alert satellite • Electronics, algorithms and on-flight decision software
Hess2	• Level 2 processing system based on camera image analysis
km3Net	• Compact embedded system for optical module data collection

CMS: ECal Selective Readout Processor (SRP)







- Aanalysis of the calorimeter activity (80000 channels) at 100 Hz
- Massively parallel image convolution
- Advanced technologies : FPGA, multi-Gb/s communications

Software Engineering

SVOM

- Ground software for Gamma Ray Burst alert dissemination
- Scientific Ground Segment

GET

- Acquisition software for the *Generic Electronics for TPCs* project

km3Net

- Framework/architecture studies for next underwater neutrino experiment

COAST

- Computational astrophysics
- Software support for large simulations
- Code optimisation, GPU computation, post-simulation graphics

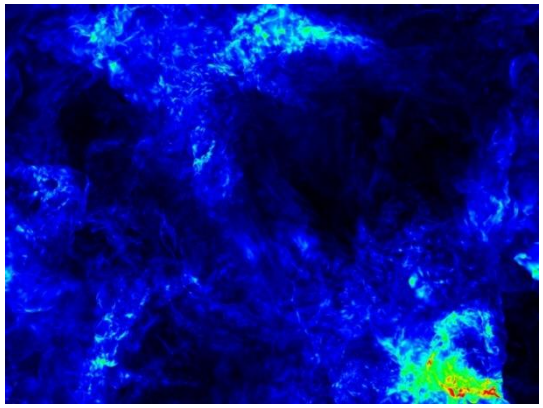
PhoCEA

- Web Technologies for scientific sites
- Deployed in several CEA research units, Herschel scientific site

COAST: Computational Astrophysics

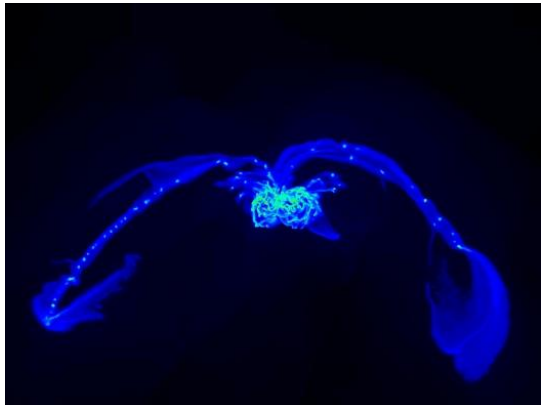
Code development

- MagnetoHydroDynamics on GPU
- Hybrid CUDA/OpenMP/MPI courses (ENSTA)



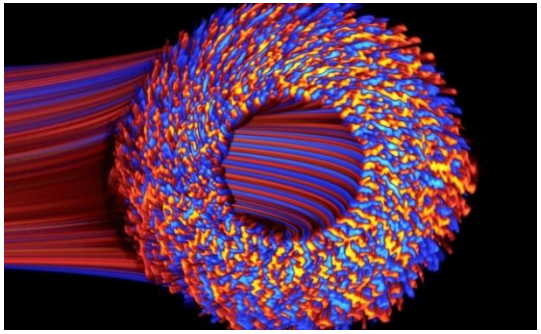
SDVision visualization tools

- Sap simulation programme
- Simulations of ITER plasma (GYSELA)
- Simulations executed on GPU clusters
- Real data from satellite surveys (XMM)



Outreach

- ‘GALAXY3D’ 3D film, Cité des Sciences
- Video production for large CEA 3D high resolution wall displays (res. 4970*2730)



Signal and image processing: CosmoStat

CosmoStat lab (2010+)

- Innovative methods for astrophysics data analysis
- Connected to Sedi & Sap
- Multiresolution, sparse decomposition, compressed sensing
- SparseAstro, Natimage, AstroNet, CS-Orion, industry contracts
- 3 CEA, 4 PHD students, 6 postdocs

SparseAstro

- European Research Council senior grant (2009-14)
- Application to data analysis for Planck, Fermi, Herschel, Euclid

CS-Orion

- FP7 2010+
- Application of original *compressed sensing* methods to video streams

Industry contracts

- Sagem: Application of *inpainting methods* to real time video streams

Scientific computations: Infrastructure

Computing Grid

- 1st year of LHC operation
- Saclay LHC T2/T3 computing & storage node
- Collaborative *Ile De France Grid* effort
- 4h response time (data taking → analysis)
- Network evolution with Renater french research network entity

High Performance Computing

- DAPHPC: intermediate machine for preparation of large simulations
- 384 processor machine at Irfu in 2011
- Development through Equip@Meso french Equipex funding