



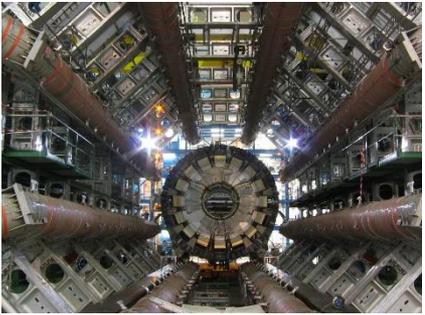
Electronique et détecteurs au LHC Fete de la Science 2019

Christophe de LA TAILLE

OMEGA microelectronics lab
Ecole Polytechnique & CNRS IN2P3

<http://omega.in2p3.fr>

- Laboratoire CNRS/IN2P3 Ecole Polytechnique
- 10 Ingénieurs de Recherche CNRS
- Conception de circuits intégrés (ASICs) pour la physique des particules
- Transfert de technologie via startup WEEROC



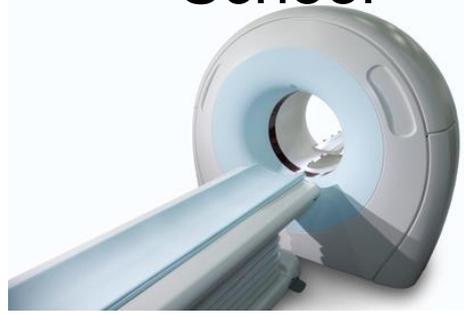
Research,
Institute



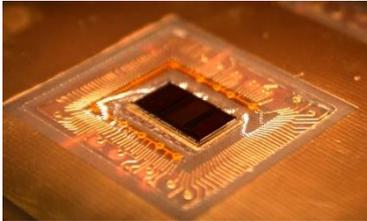
Education,
School



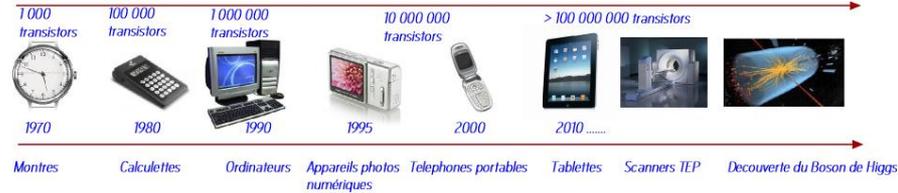
Industry, company



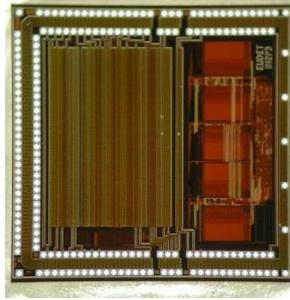
- Circuits intégrés également appelés Chip ou Puce ou ASIC (A Specific Application Integrated Circuit).
- La microelectronique a révolutionné la plupart des équipements qui nous entourent => Objets quotidiens deviennent intelligents et communicants



On les trouve dans les téléphones portables, appareils photos, PC ...

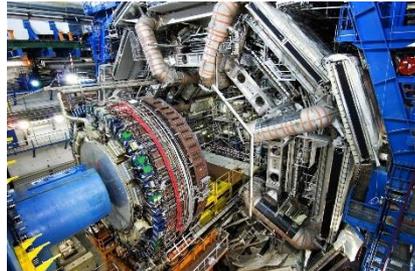
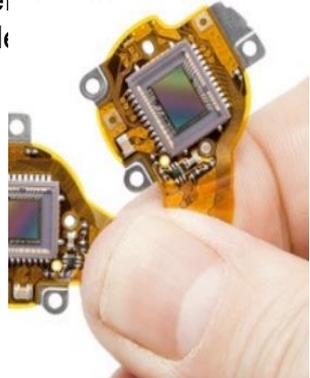


- Leur role:
 - Miniaturisation de fonctions de plus en plus complexes
 - Permettent le traitement des signaux parfois très faibles qui sortent des détecteurs de physique de plus en plus innovants, très « granulaires » (Millions de canaux de détection) tout en restant compacts
 - Performance du circuit de lecture est déterminante dans la performance du détecteur

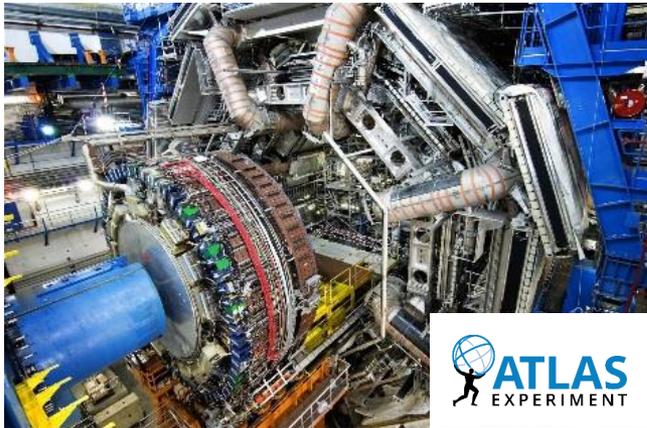


Applications en physique des particules mais aussi en imagerie médicale, spatiale, environnemental, matériaux...

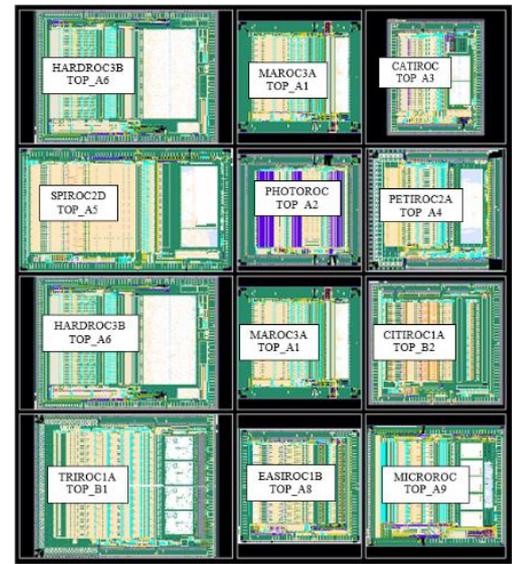
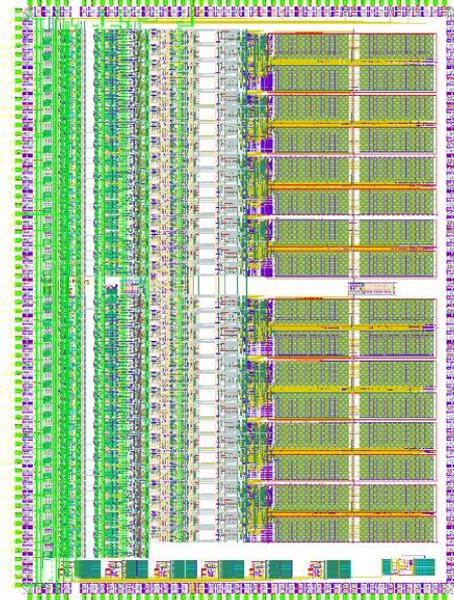
Les circuits intègrent de multiples fonctions électroniques sur quelques mm² de Silicium, permettent de réaliser des détecteurs plus performants et plus compacts, de lire des millions de voies de



OMEGA projects and products



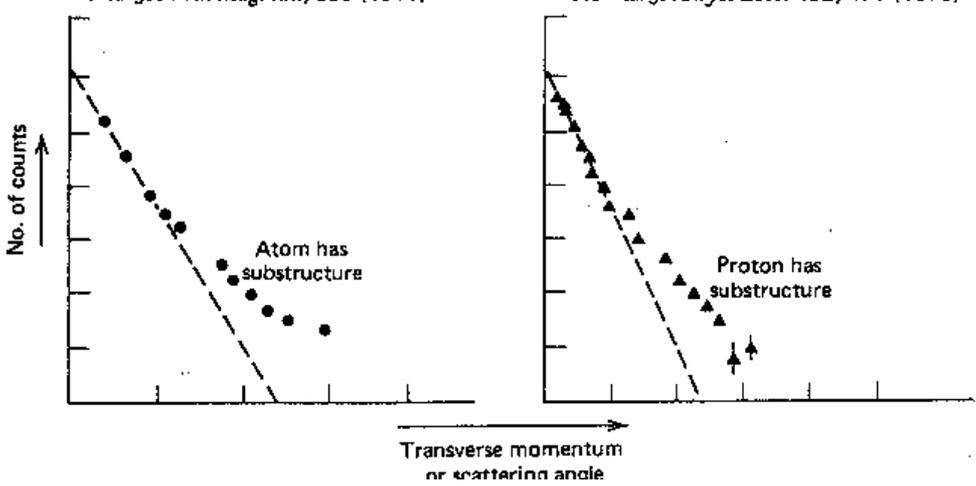
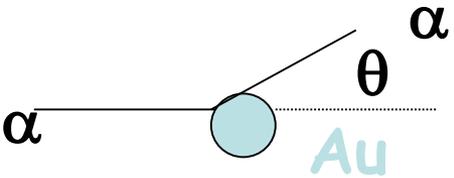
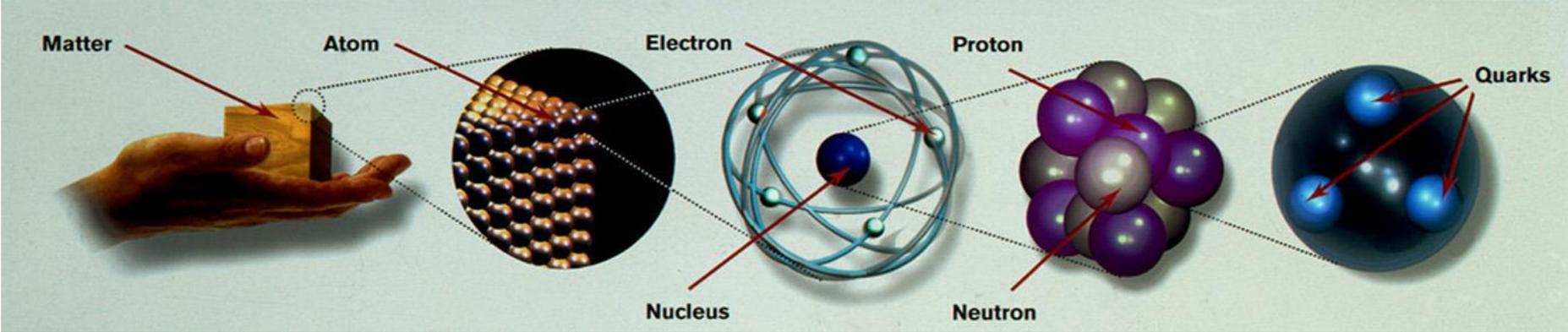
- Large chip productions
 - avg = 4000/yr 200 k€
- Responsibilities in large experiments
 - ATLAS, CMS, EUSO, JUNO
- World-class visibility
 - Strategic domain
 - 6 talks/year in conf.
- Startup company
 - Chips in Ariane



weeroc C. de La Taille fête de la Science 2019

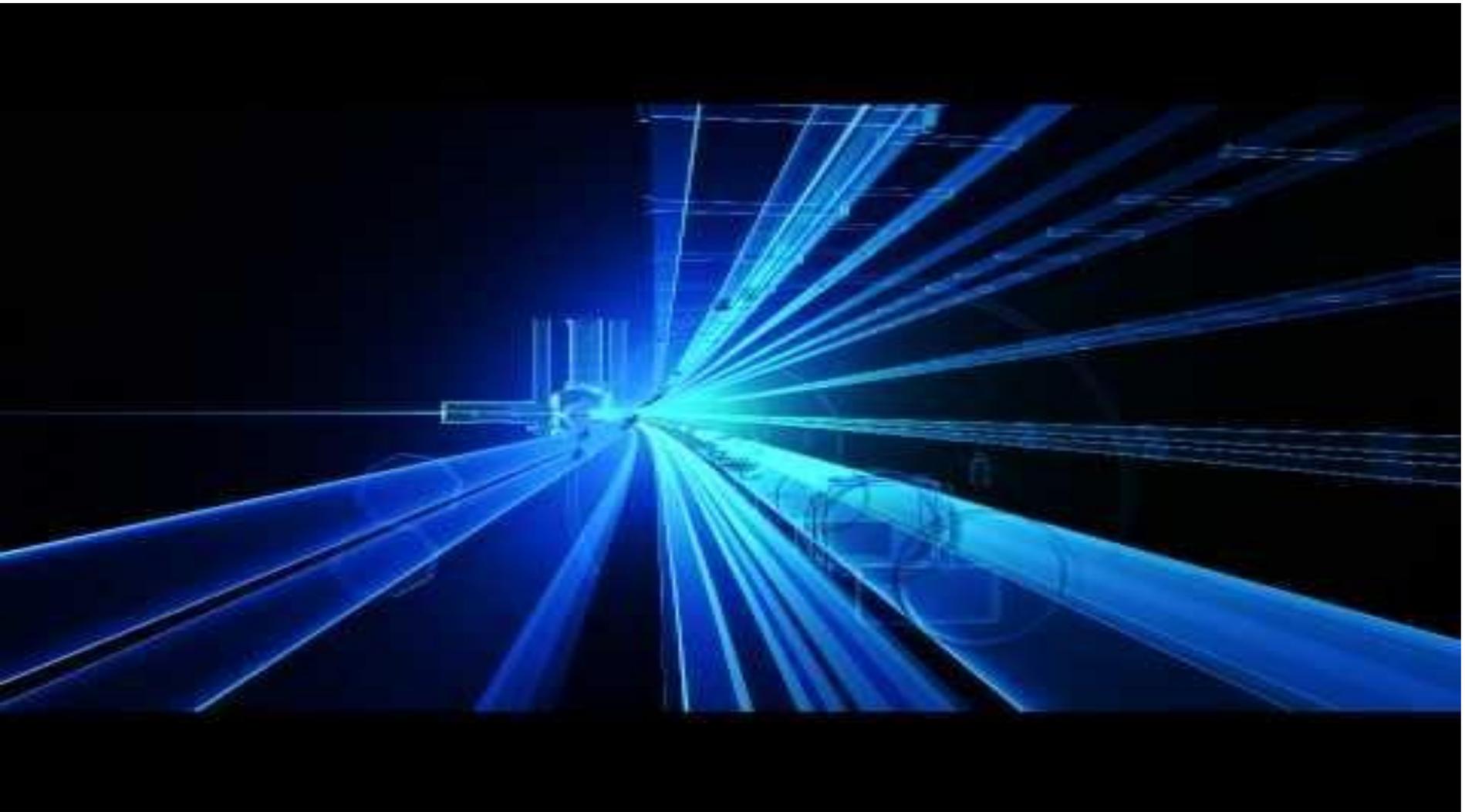
- La matière est constituée de quarks et leptons

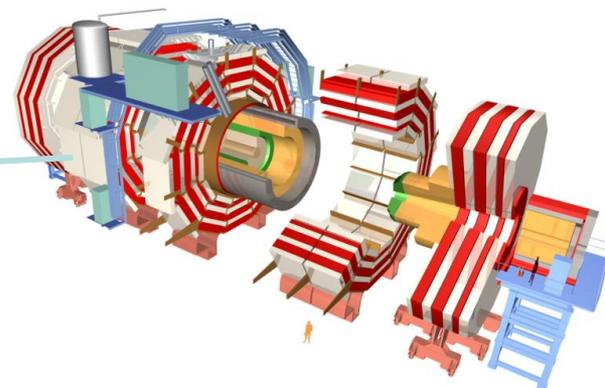
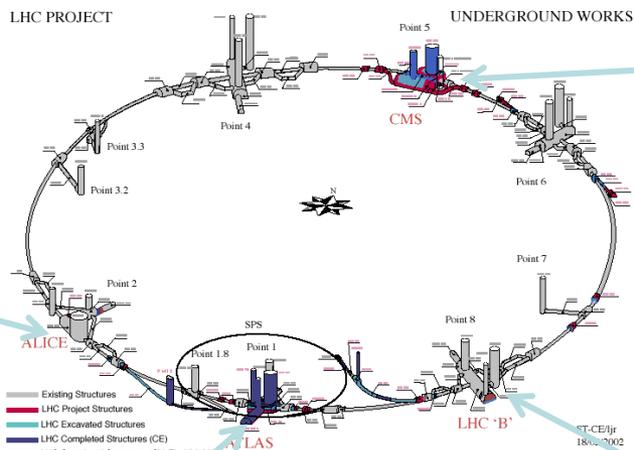
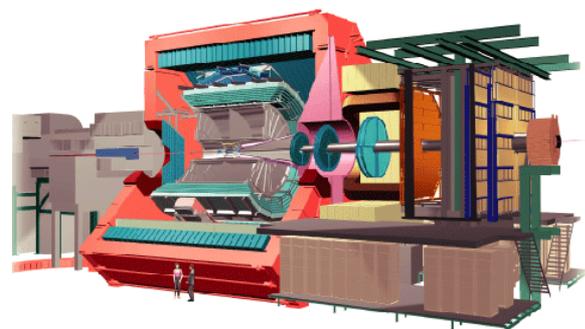
Leptons $\begin{pmatrix} \nu_e \\ e \end{pmatrix}$ Quarks $\begin{pmatrix} u \\ d \end{pmatrix}$



- Collisionneur à protons installé au CERN (Genève)
- Anneau de 27 km de circonférence
- 1232 dipôles supraconducteurs LHe 2K, champs 6.3T
- Collisions à 40 MHz : « haute luminosité »
- Energie 13 TeV : « haute énergie »







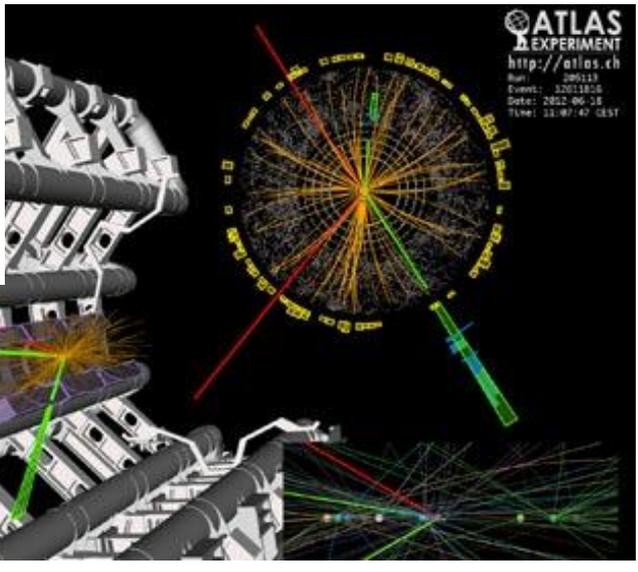
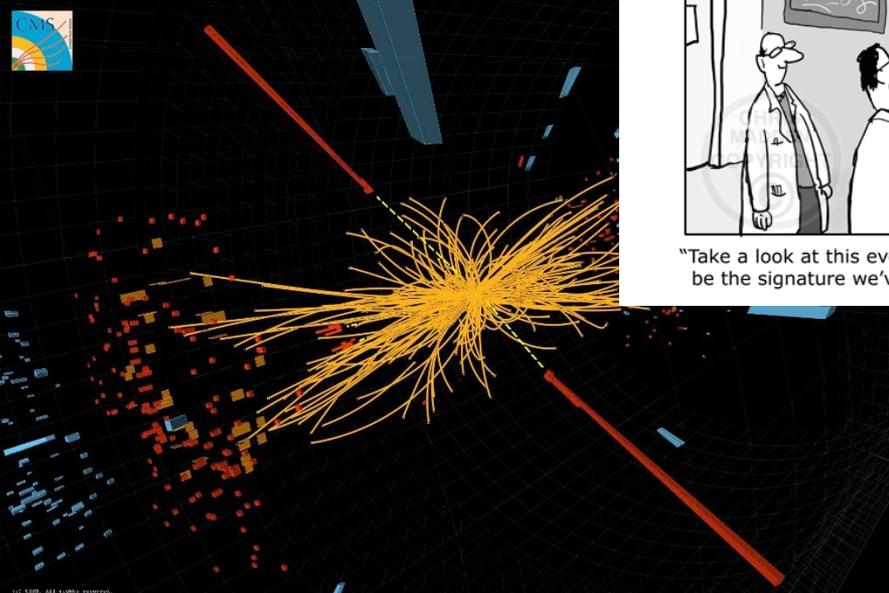
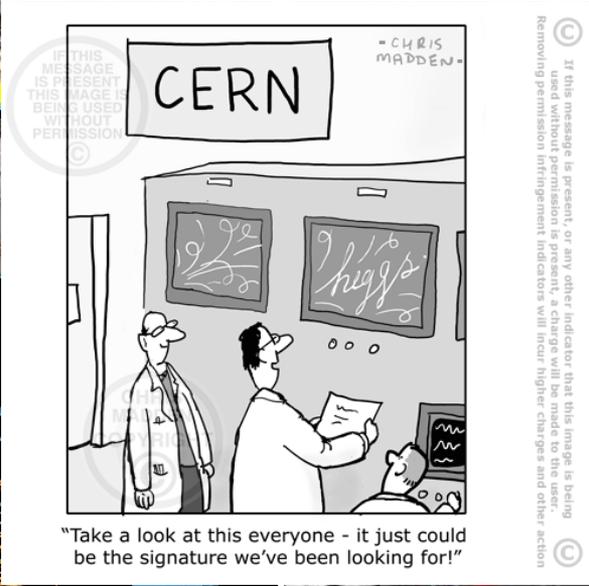
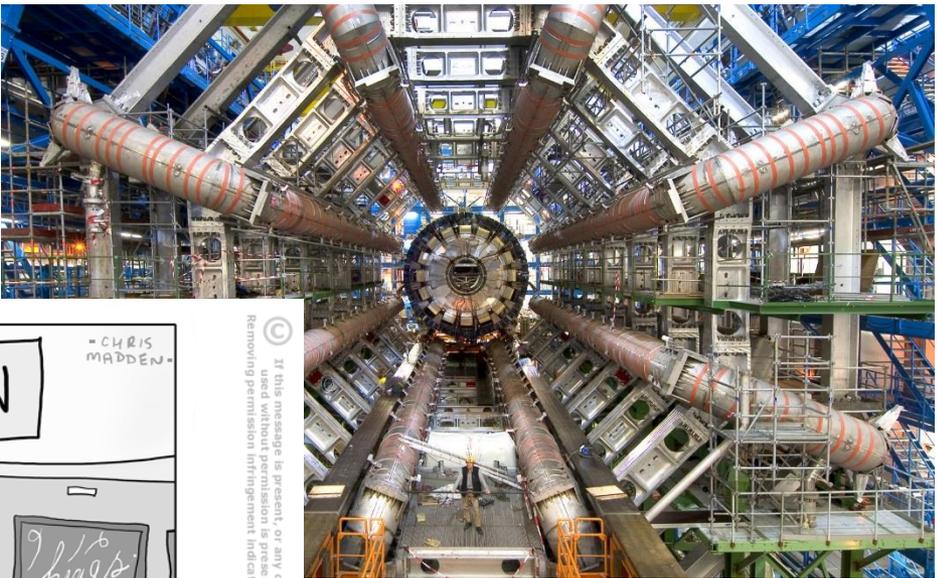
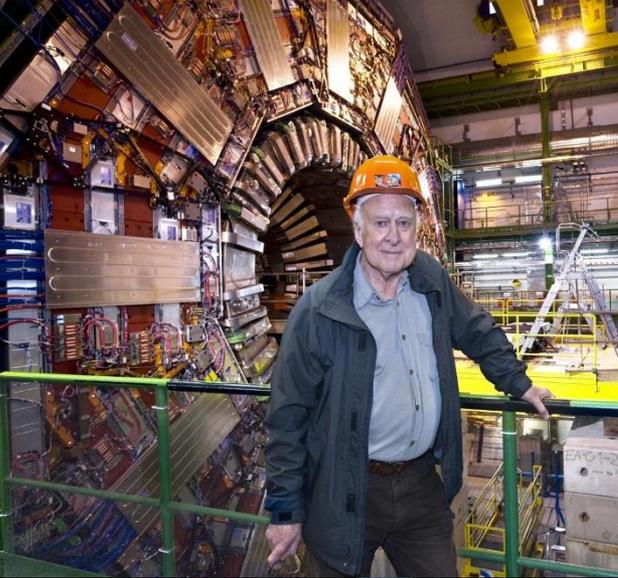
Quarks		Leptons		Bosons
up	down	electron	neutrino e	photon
charm	strange	muon	neutrino μ	gluon
top	beauty	tau	neutrino τ	$Z^0 W^\pm$
				Higgs

The Standard Model

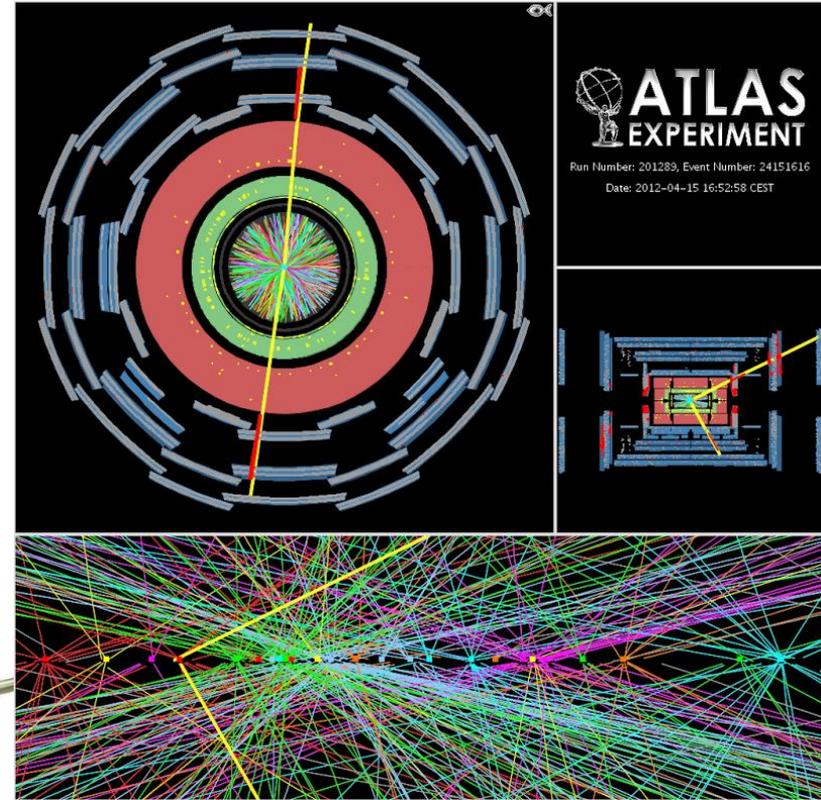
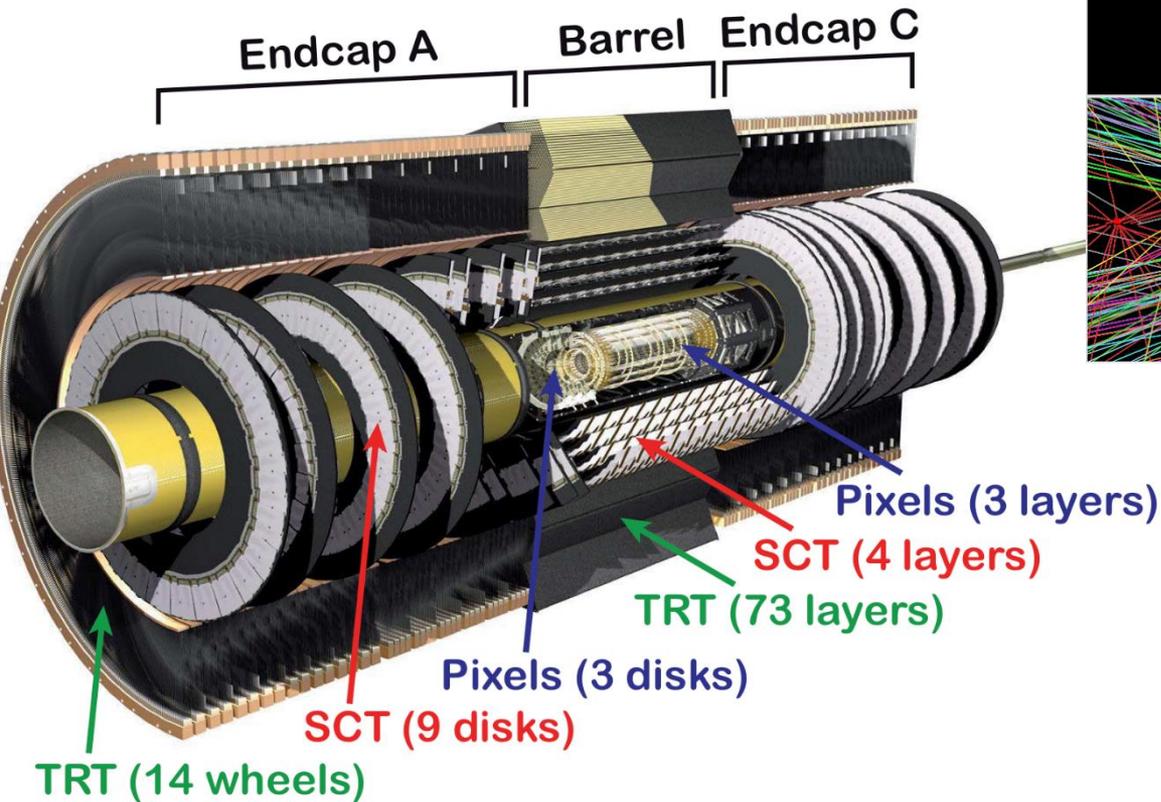
A. Pich - CERN Summer Lectures 2003



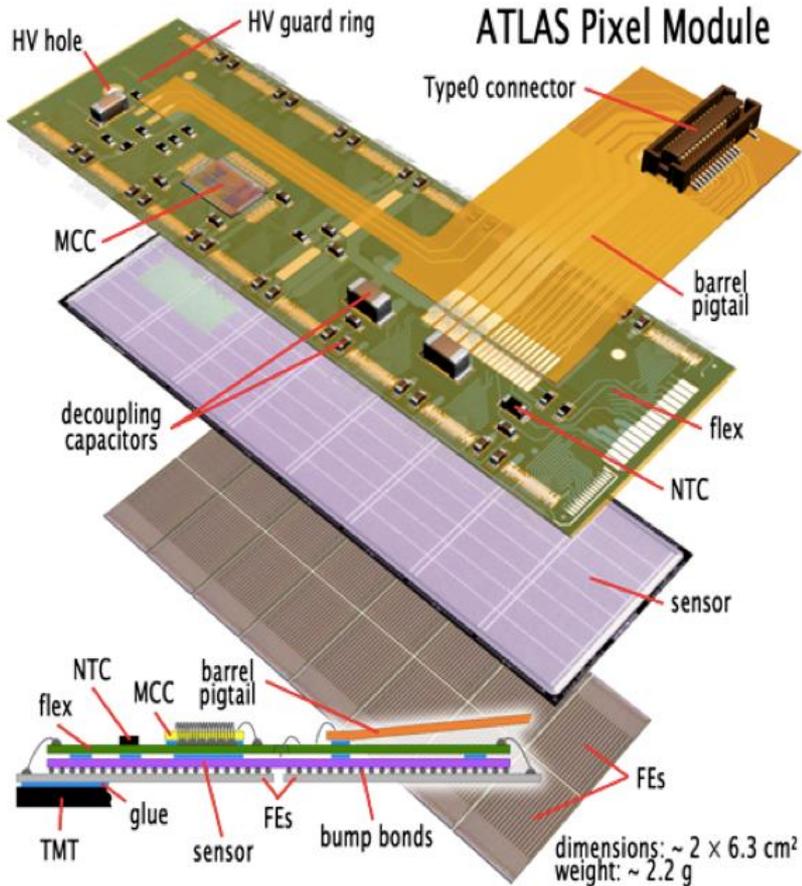
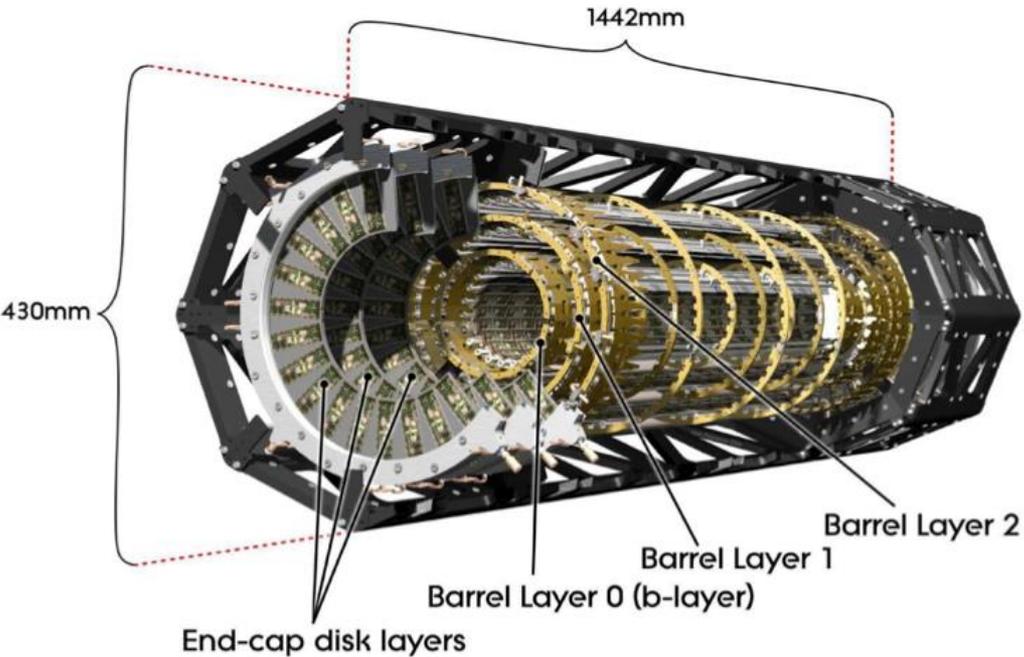
Comment voir le boson ?

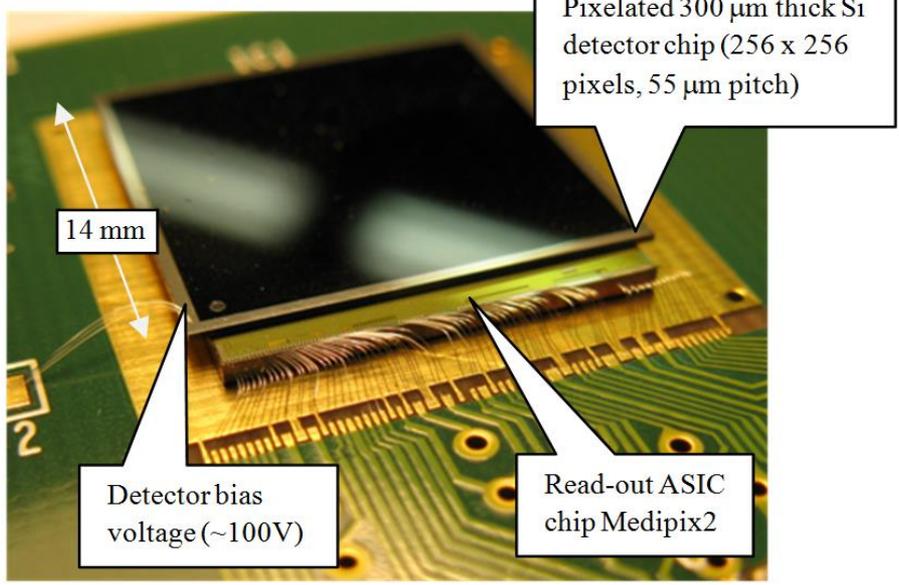
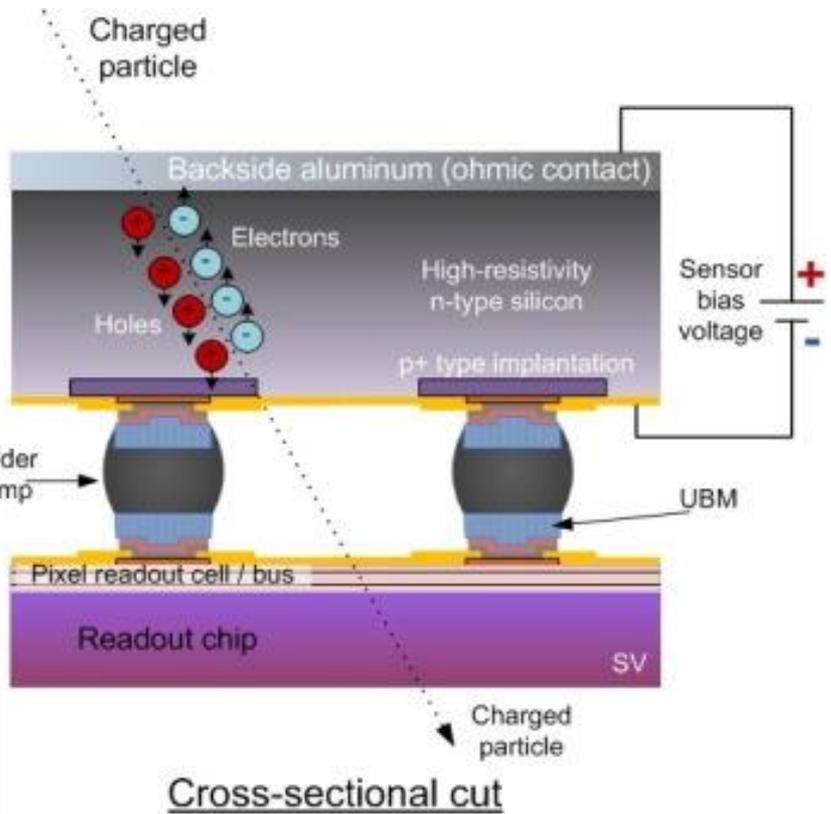
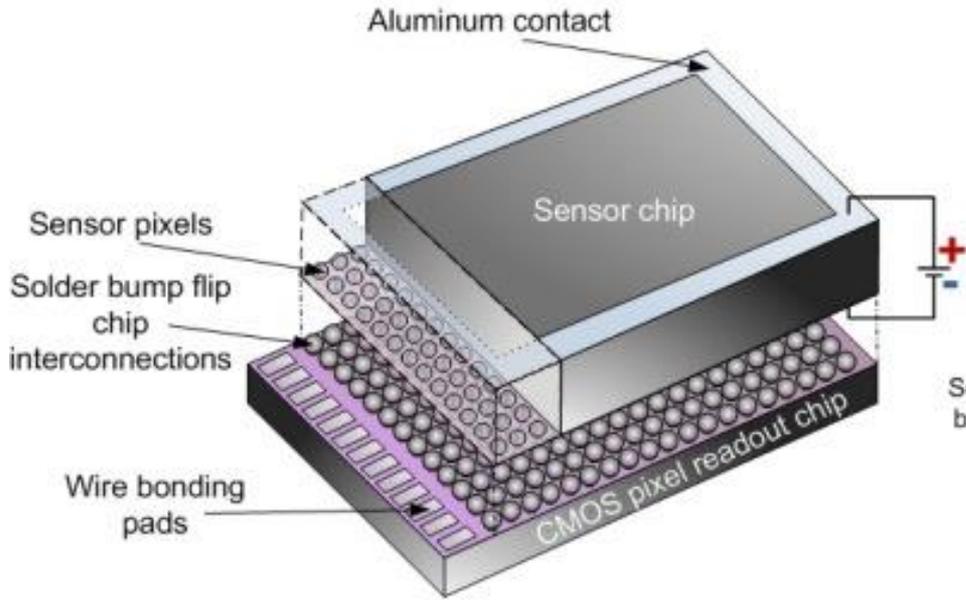


- Reconstruction des traces chargées
 - Détecteurs siliciums (pixels)
 - Précision : quelques dizaines de μm

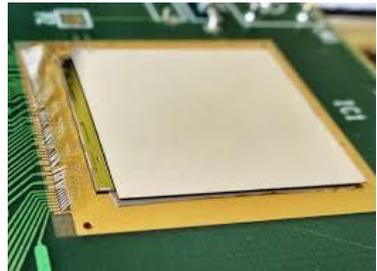
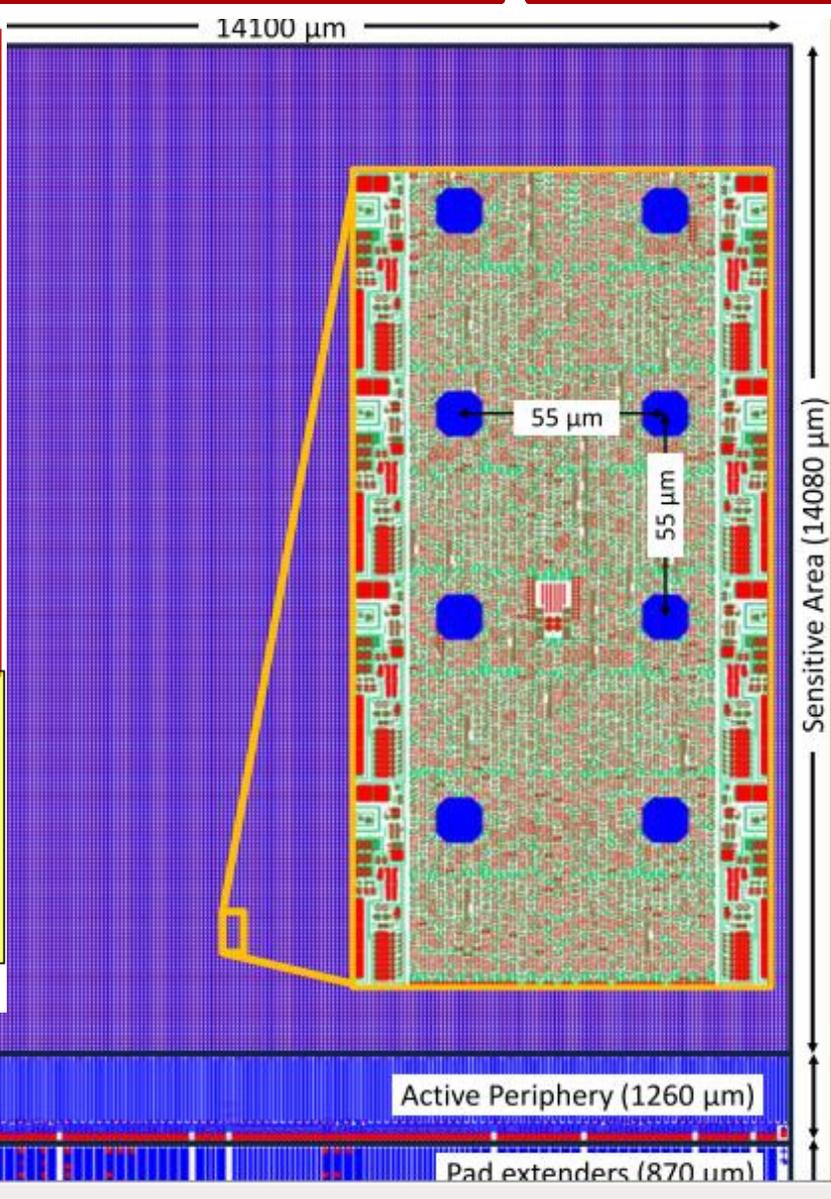
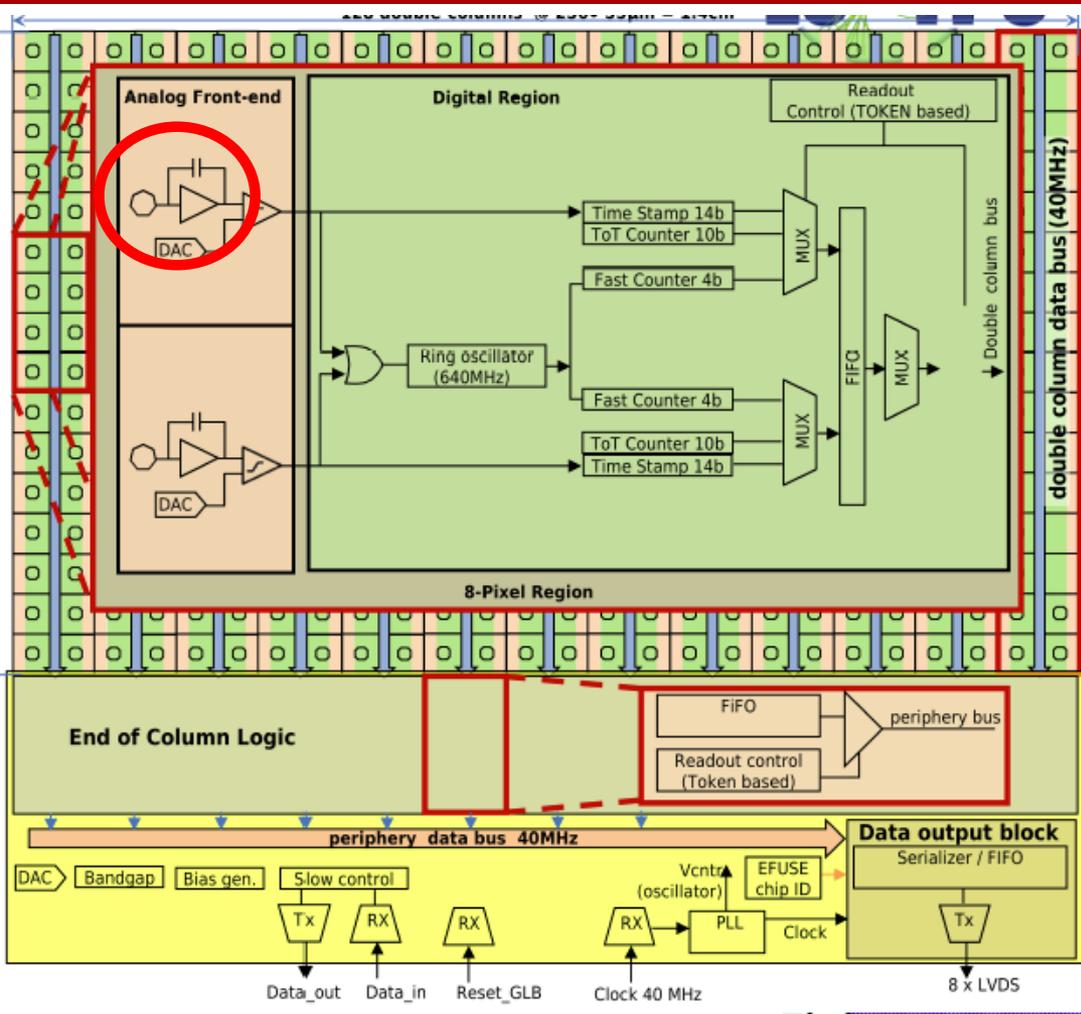


- 1600 modules Pixels = 80 Mpix
- Pixels $100\ \mu\text{m} \times 350\ \mu\text{m}$





Du préampli au chip ...



Partenariat CAEN pour distribution ASIC et systèmes



Construction du PET/IRM
Trimage



Premiers évènements Cerenkov –
ASTRI
appel d'offre pour 10 télescopes



C. de La Taille

Démarrage
partenariat IP

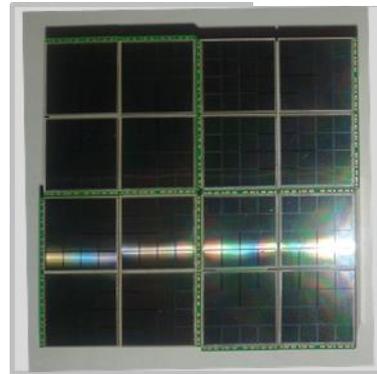
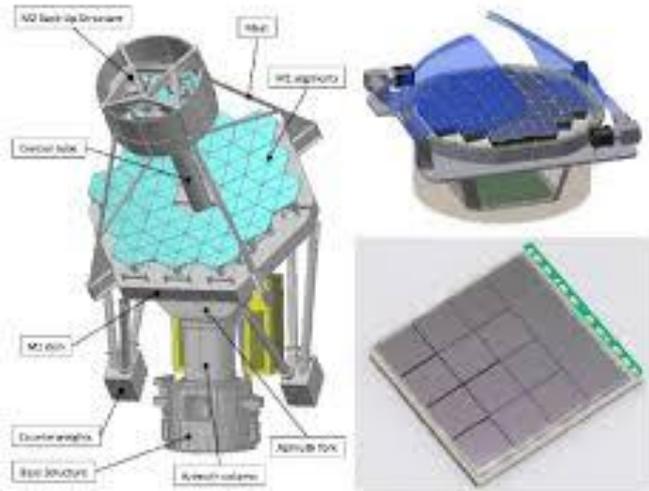
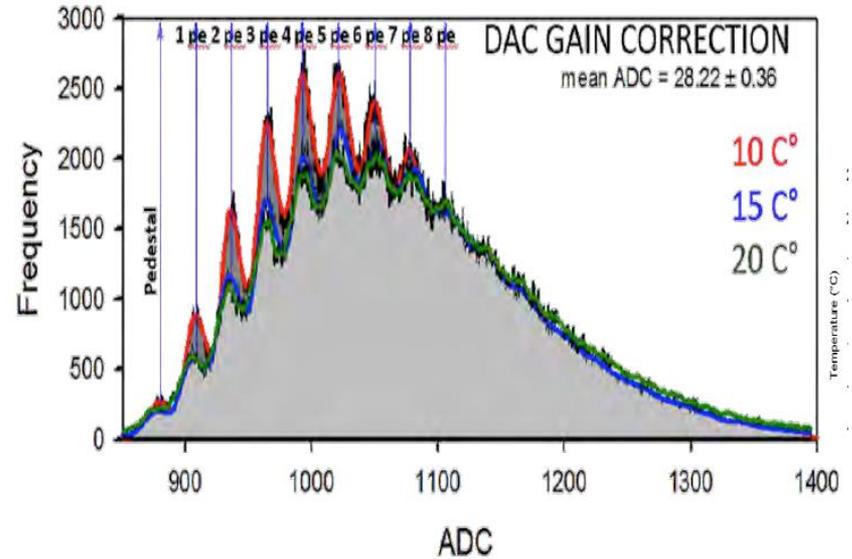


fête de la Science 2019

Vol des circuits Weeroc
sur Ariane 5 et satellites



© O. Cataneo INAF Palermo



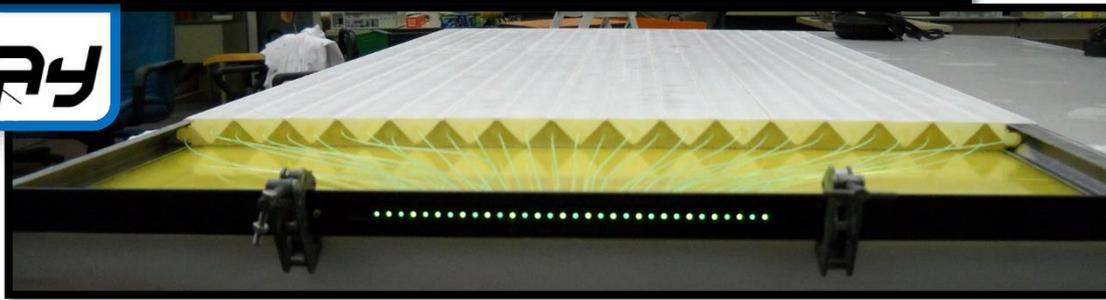
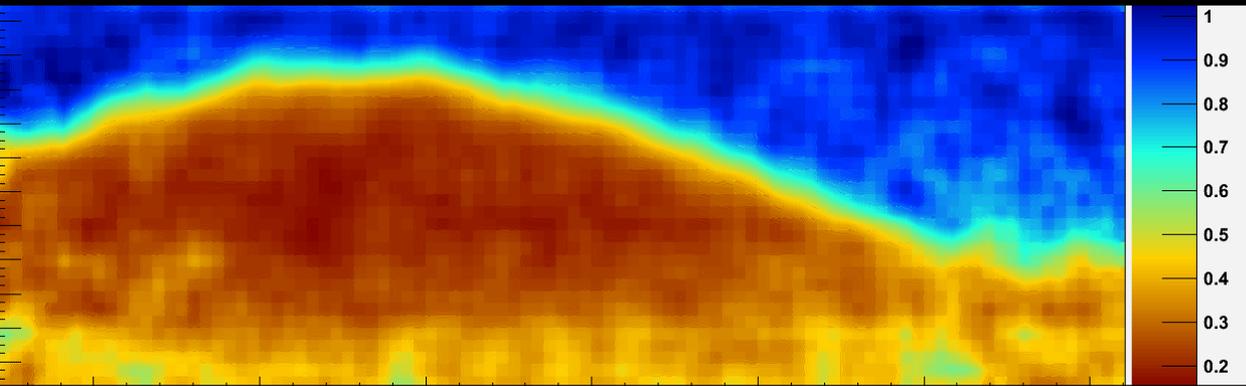
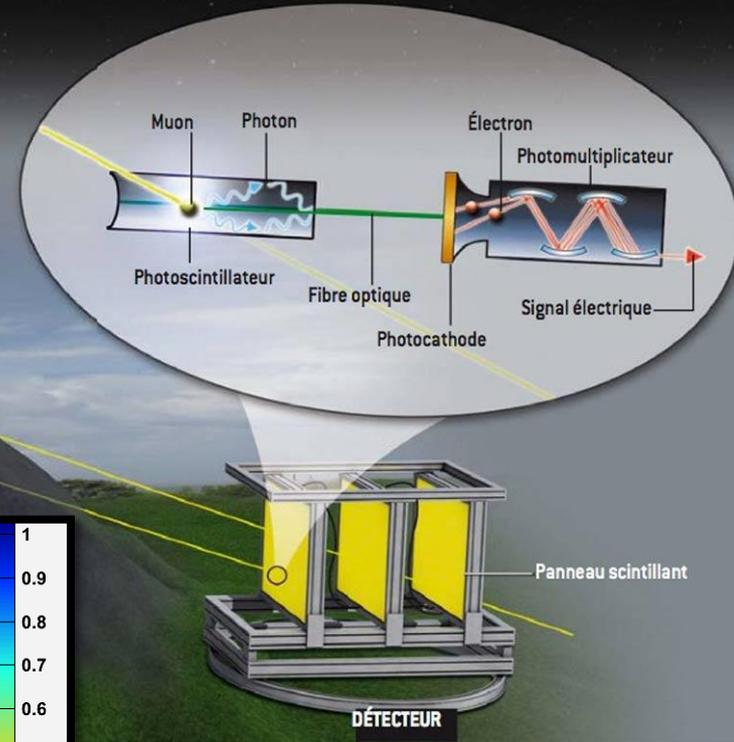
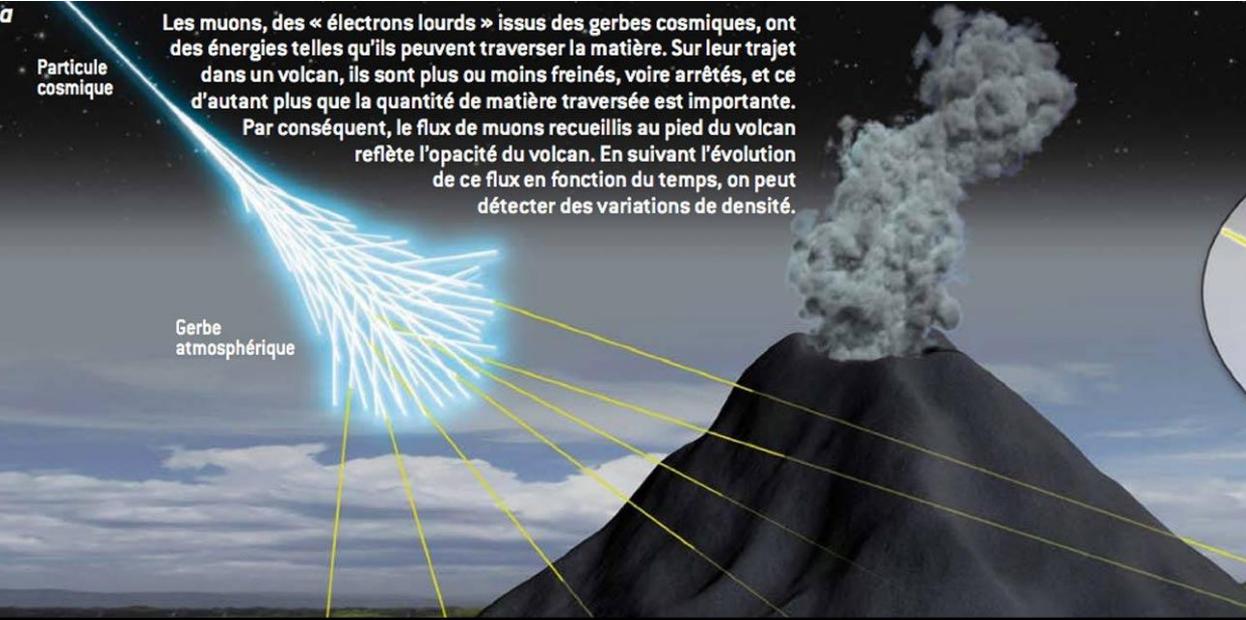
SiPM board
(9 +1 temperature sensors embedded)



Front-End board
(2 CITIROC ASIC)

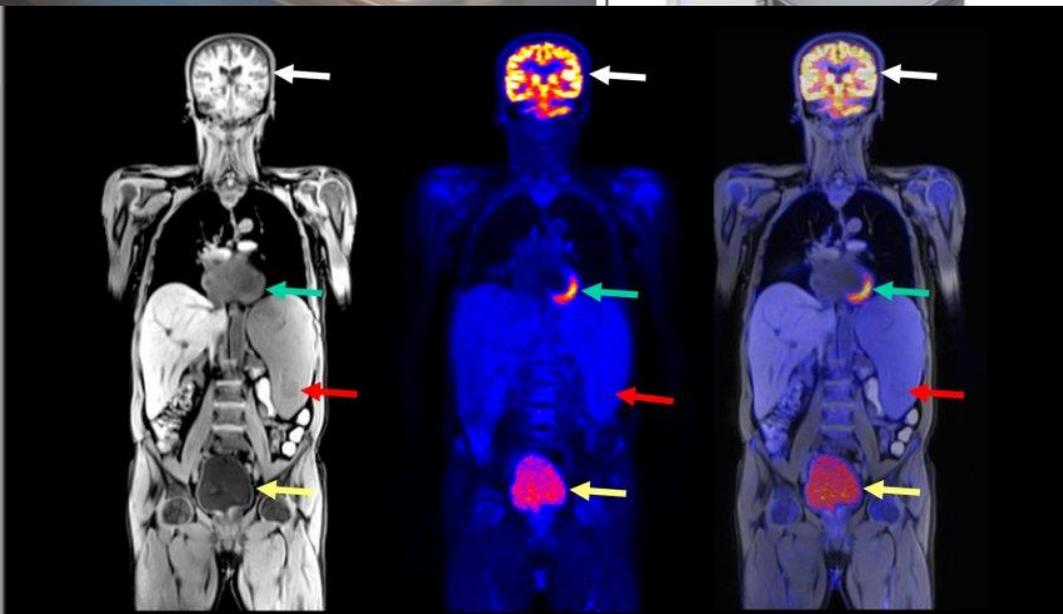
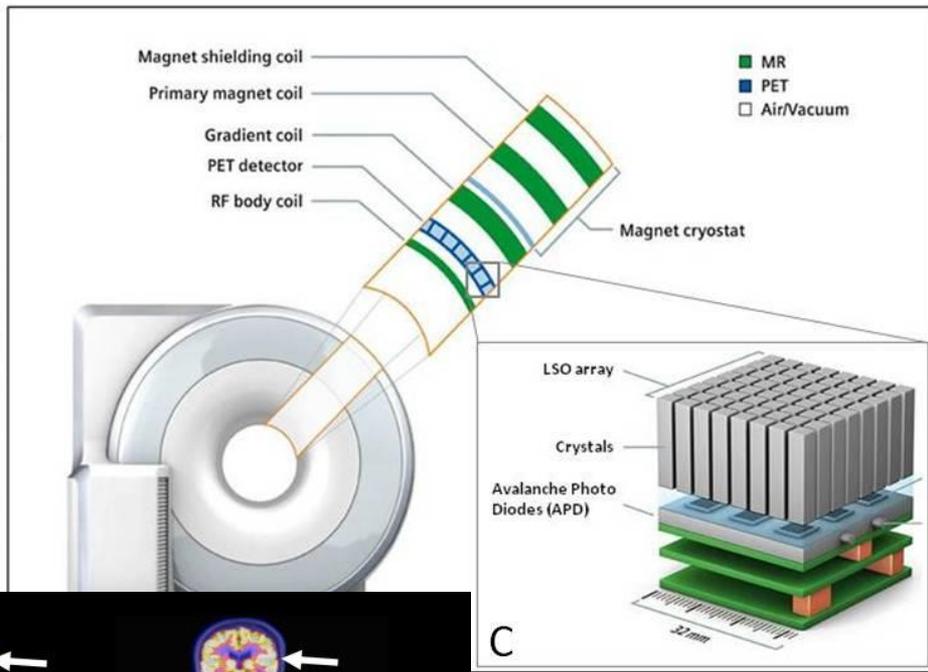


PDM FPGA Board
(XILINX ARTIX 7)





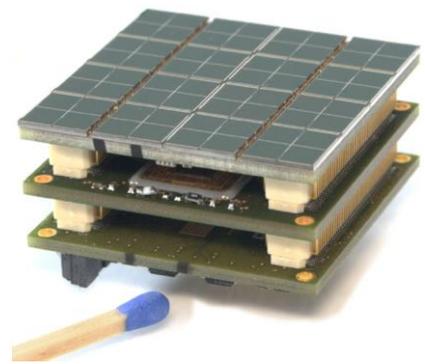
A



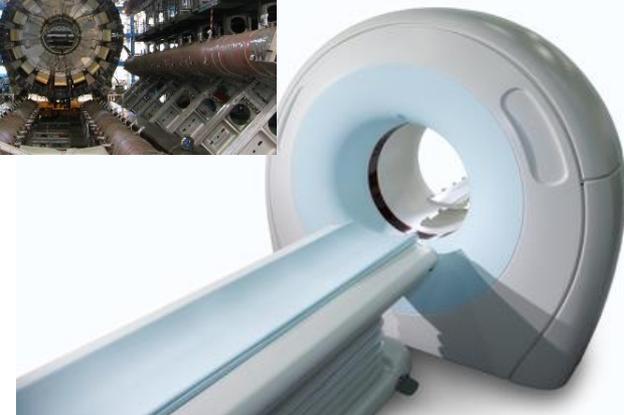
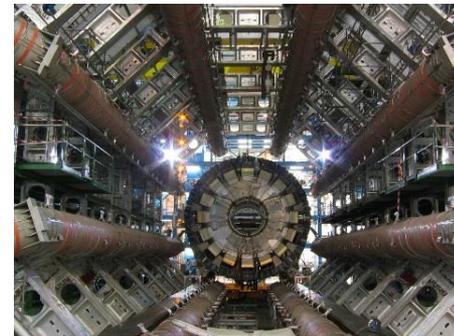
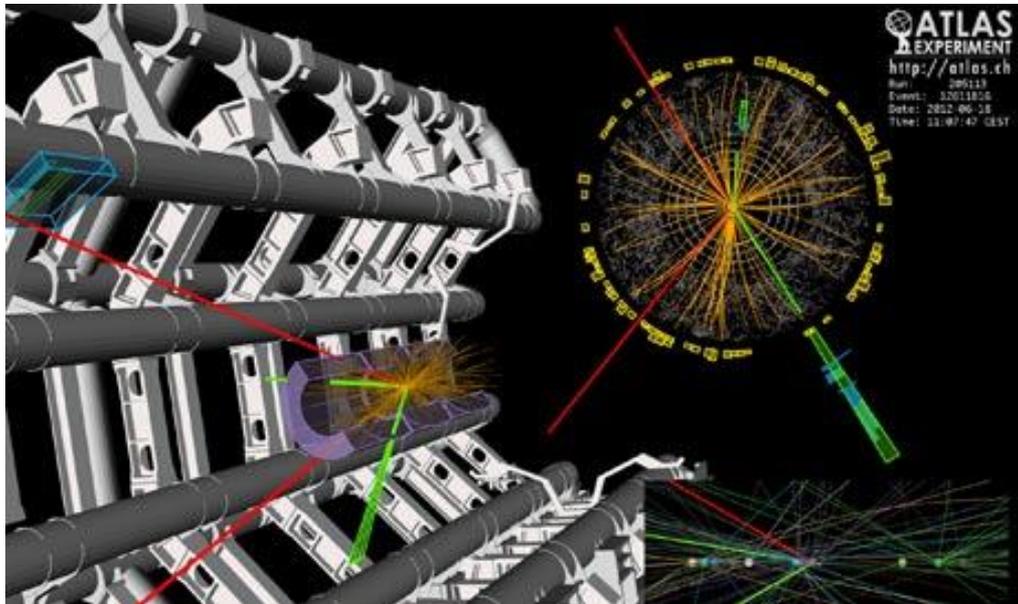
MRT (Struktur)

FDG-PET (Stoffwechsel)

Fusion FDG-PET & MRT



- Importance des détecteurs et de l'électronique pour la performance de physique : un véritable axe de recherche
- Grandes collaborations internationales
- Applications sociétales et industrielles



- EUSO : SPACIROC3 = high speed photon counting for UHECR
- WA105 : PARISROC for fluorescence light measurement
- JUNO : MAROC3 for Target Tracker as veto wall : 2500 chips produced in 2018
 - CATIROC as liquid scintillator small PMTs readout : 2500 chips also produced in 2018

