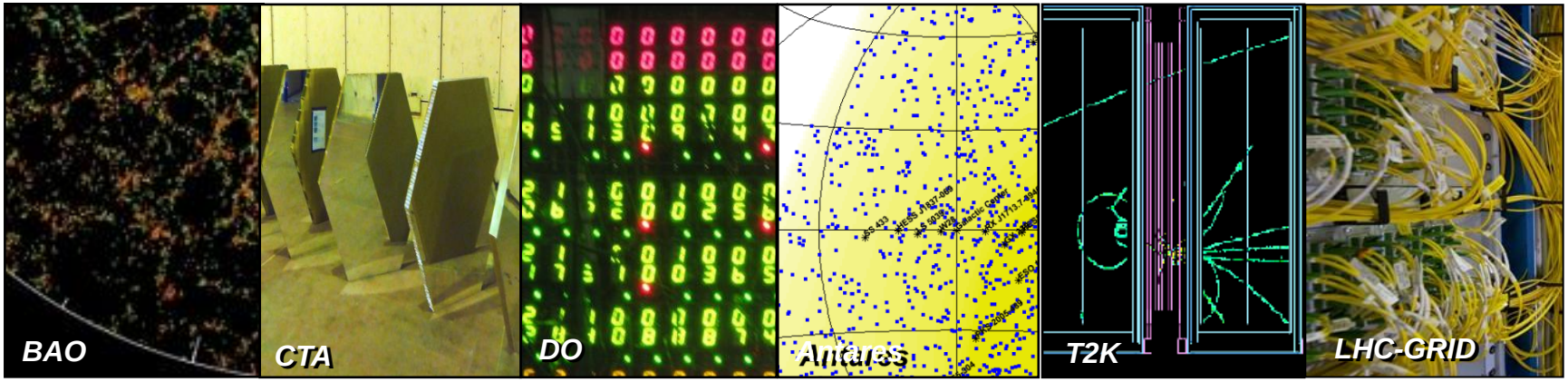
Particles Physics at Irfu

Ursula Bassler
Head of particle physics division

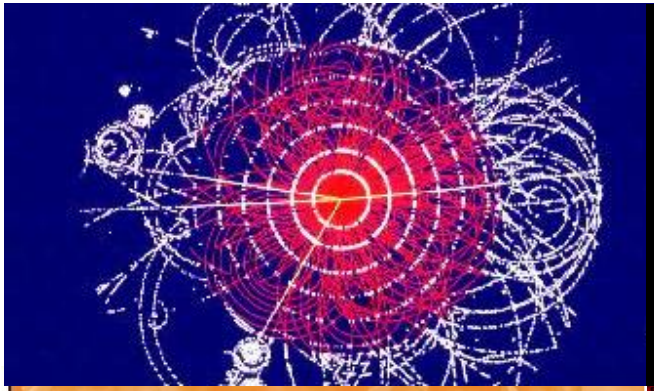


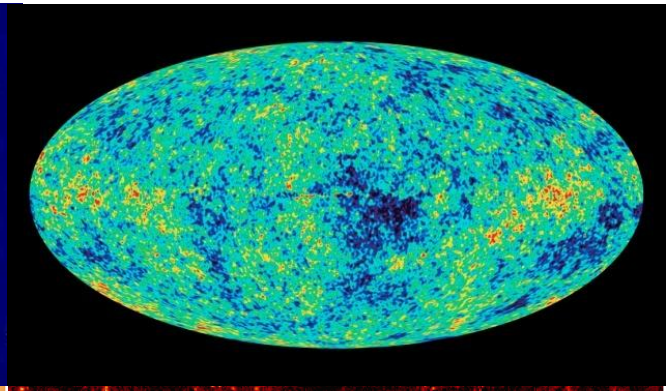
Searching for the Elementary

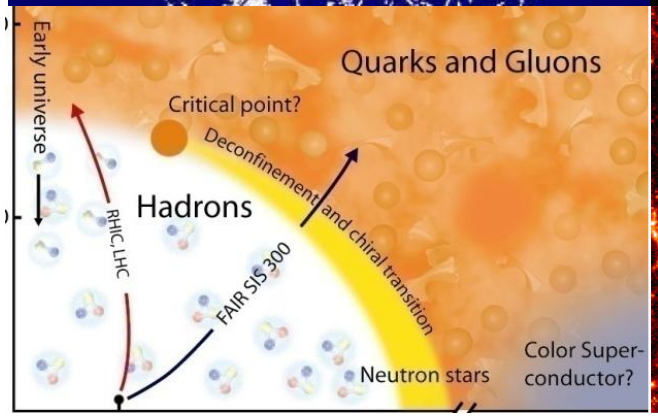
Irfu: 4 fundamental questions

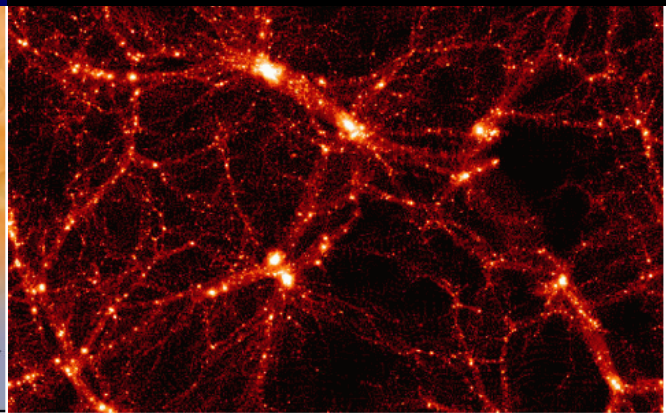
What are the ultimate constituents of matter ?

What is the energy content of the Universe ?





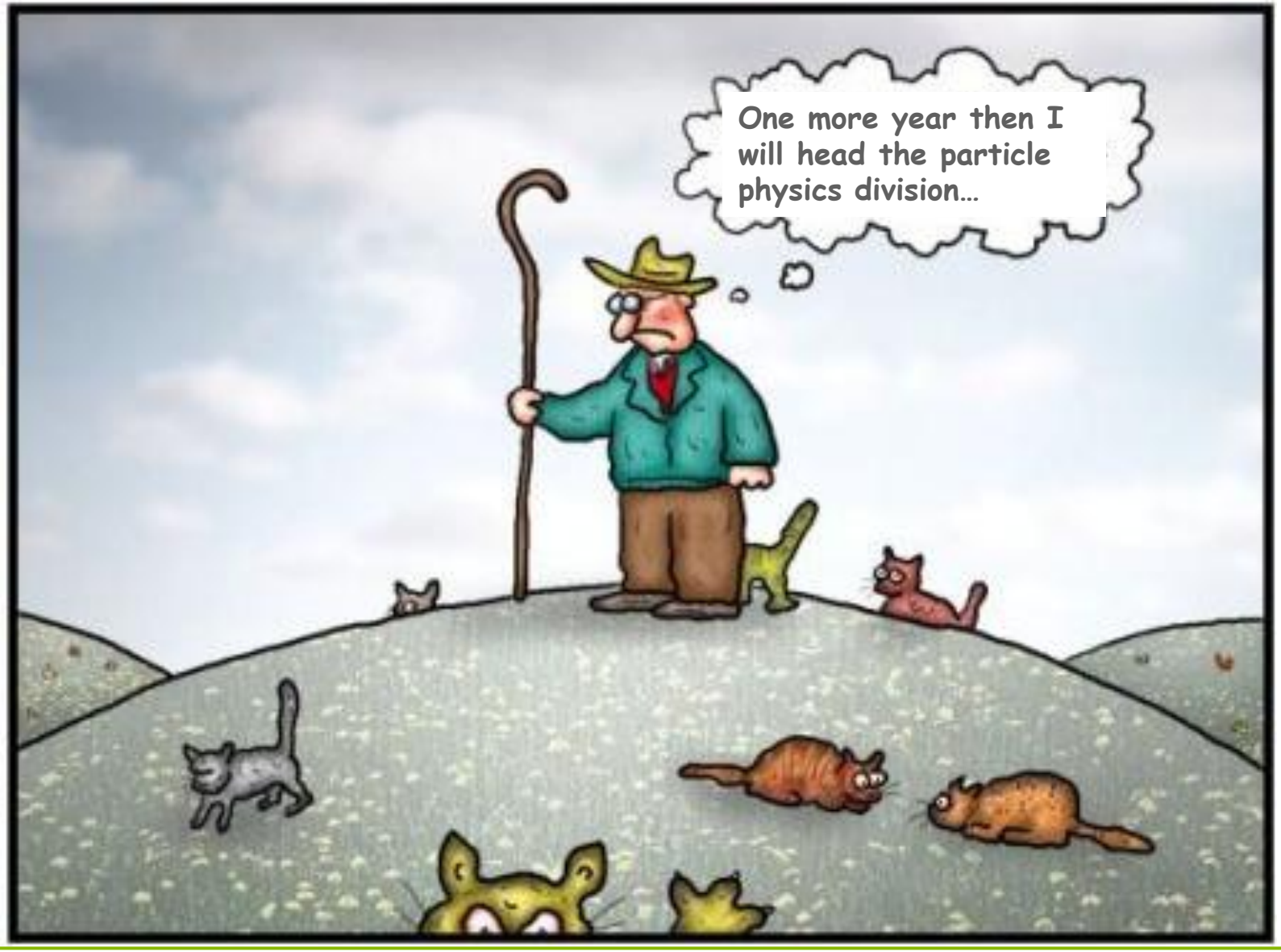




What are the properties of matter under extreme conditions ?

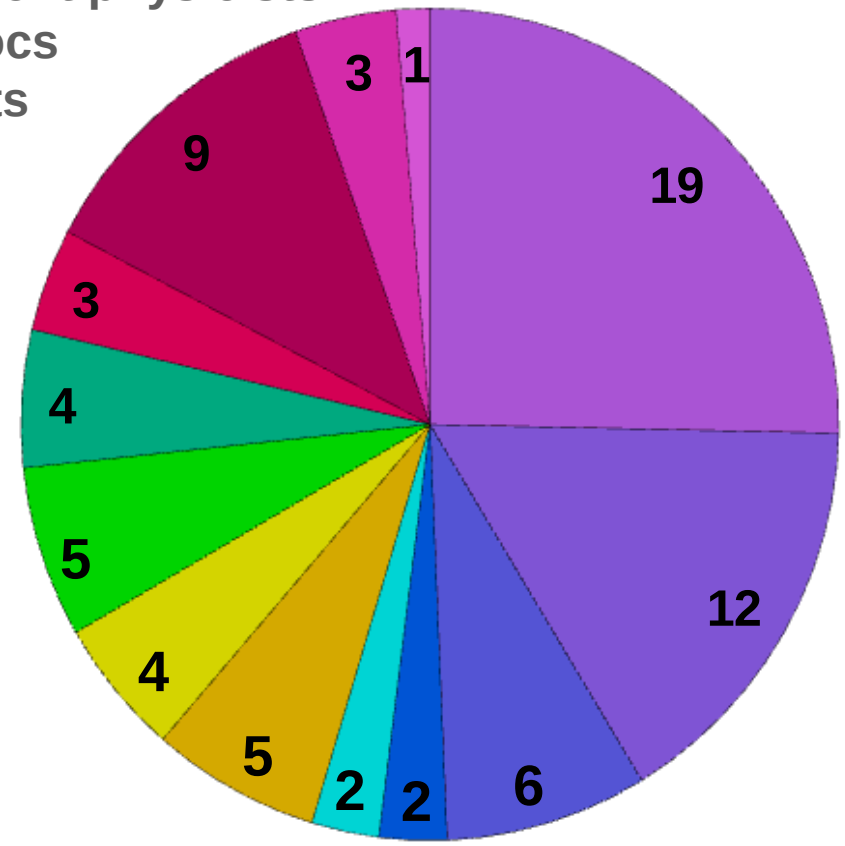
What are the origin and structure of Universe ?

Many ways to answer !



Particle Physics Division

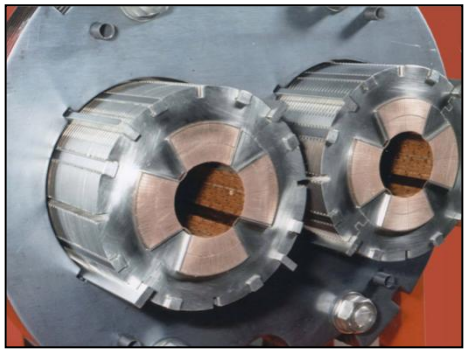
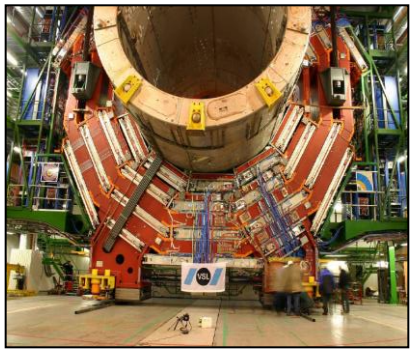
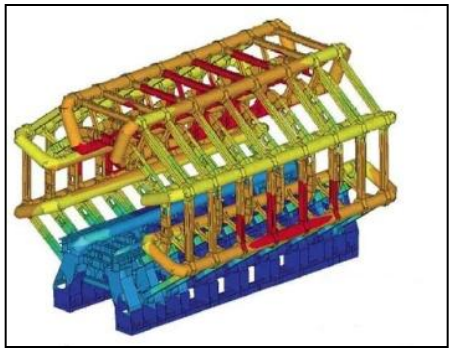
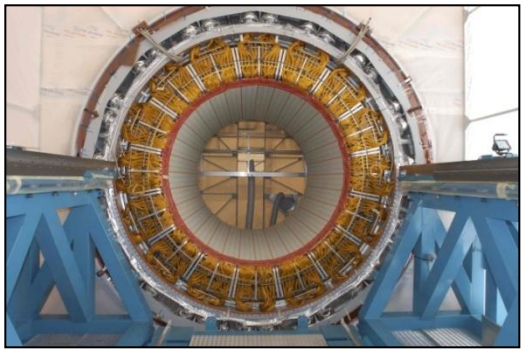
76 permanent physicists
17 post-docs
32 students



- Atlas
- CMS
- D0
- ILC
- Biomed
- T2K/Laguna
- Double-Chooz
- Antares/Km3
- HESS/CTA
- Edelweiss
- Cosmo
- Gbar
- Tiara

In Saclay :
- hardware projects with SACM, SEDI and SIS
- scientific collaborations with SAP, SPhN and IPhT

LHC: major involvement since 20 years!

Contributions from Saclay :

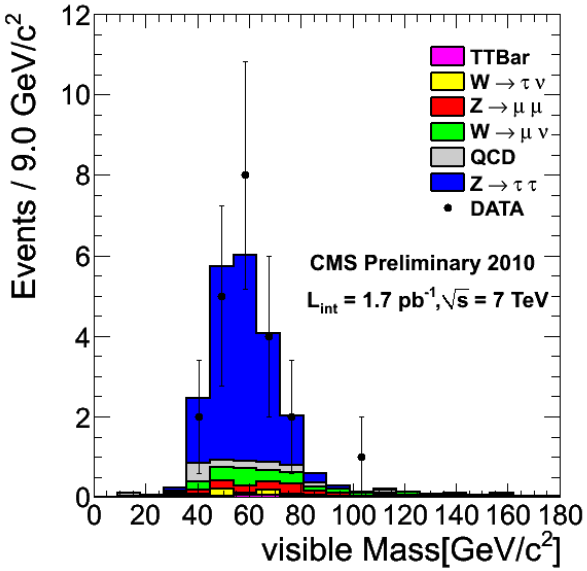
- design, prototyping, follow-up: LHC quadrupoles, CMS magnet, Atlas toroid
- contribution to the Atlas accordion calorimeter assembly
- dedicated electronics: CMS Select Readout Processor, Atlas calorimeter readout and trigger builder
- monitoring systems: CMS laser monitoring, Atlas muon alignment, magnetic field determination
- reconstruction software: CMS em-objects, Atlas muons

➔**More than 1000 man-years**

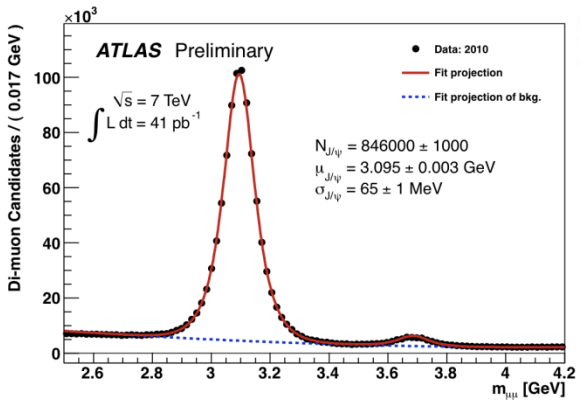
- **detector upgrades:** Atlas muon chambers, CMS calorimeter trigger ???

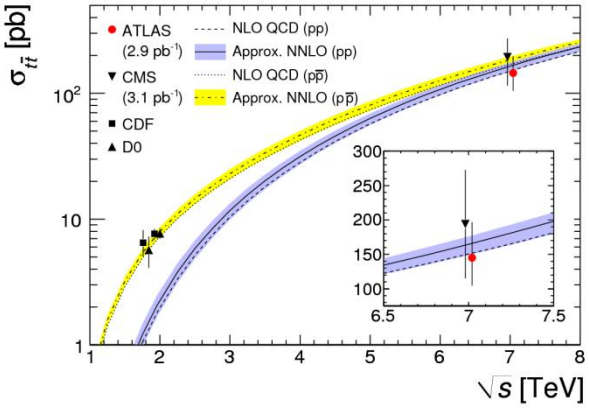
LHC: physics interests

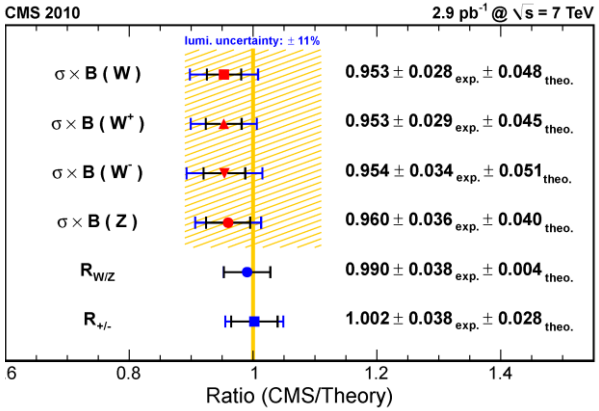
- **Electroweak physics :**
  W-mass, di-bosons, Higgs searches
- **Top physics:** top cross-section and mass
- **QCD:** photo-production, J/Psi production, forward physics
- **SUSY:** Susy Higgs ($\tau\tau$)
- **Exotics:** Z'



➔ **Next milestone: Moriond**





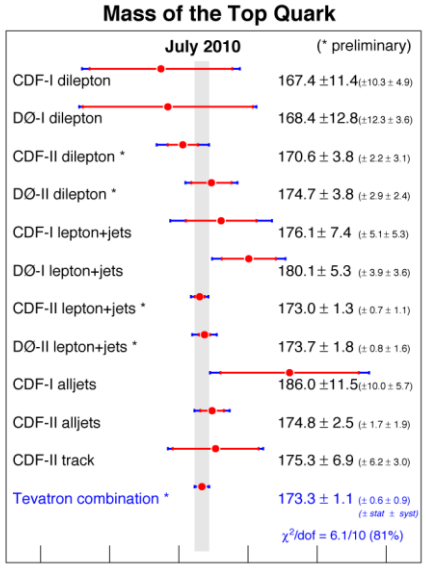


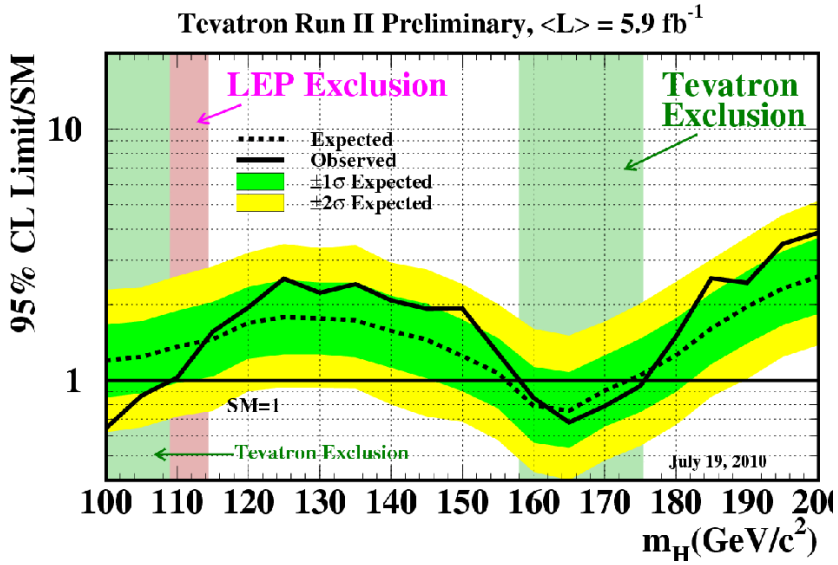
Tevatron: historic member of DØ

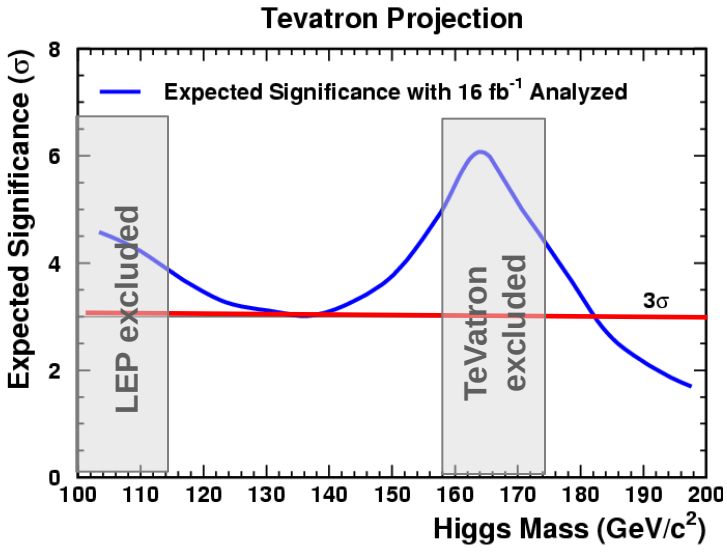
- Strong participation to Tevatron RunII
- Deception about Run End in 2011
- Link to program of LHC groups :
  - Muon reconstruction
  - Top physics
  - Higgs searches
  - QCD

➔ **already common PhD students**

➔ **switch at the end of Tevatron analysis**







R&D for future detectors

Participation to RD 51:

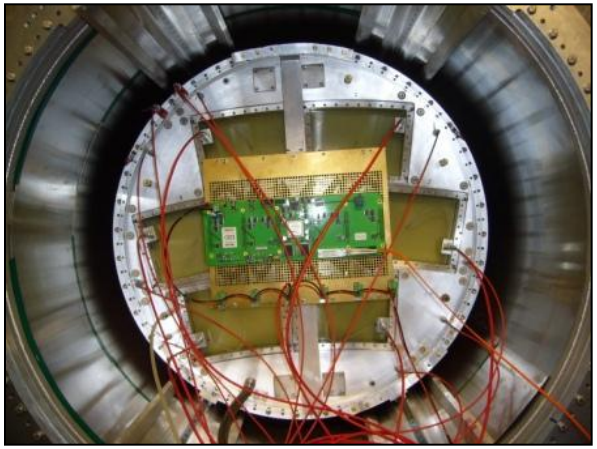
- expertise in micromégas detectors and associated electronics

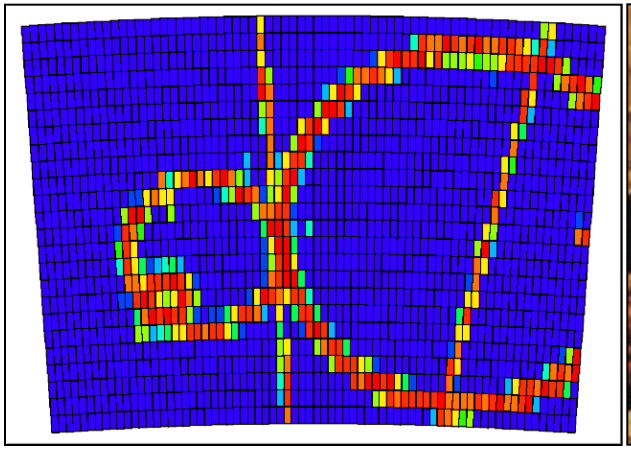
➔ **Proposal of micromégas TPC for LC-detector**

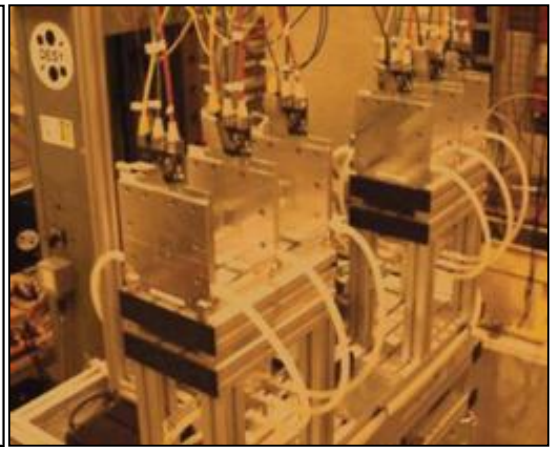
- used in CAST and T2K, currently built for CLAS12
- new workshop in Saclay working with CERN
- contributions to TimePix development

- **Contribution to EUDET beam-telescope based on CMOS pixels**

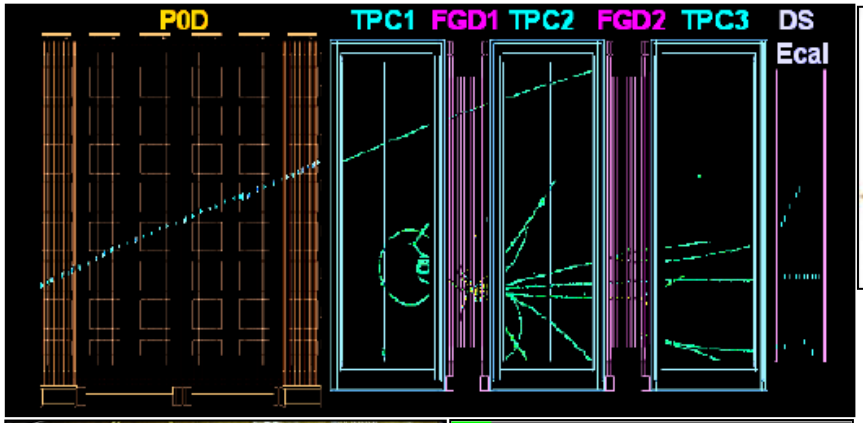
- **Development in warm, liquid calorimeters for medical imaging**

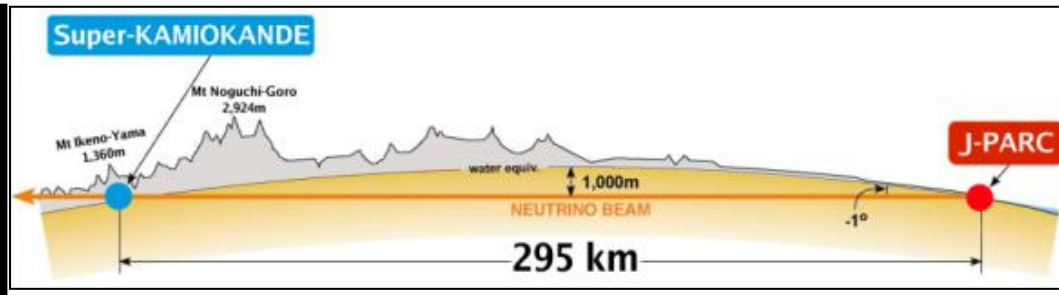


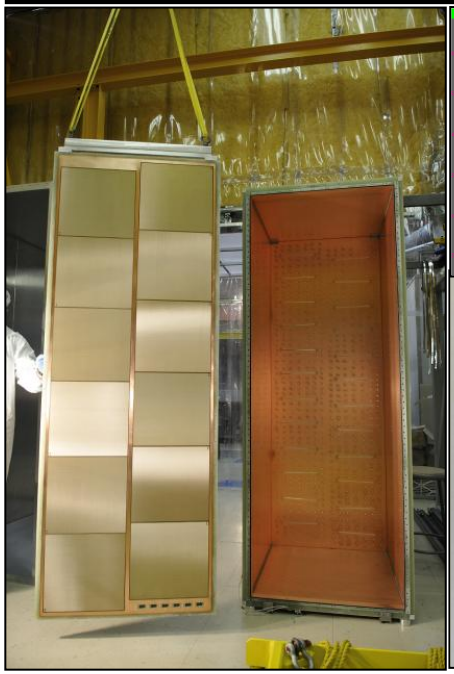


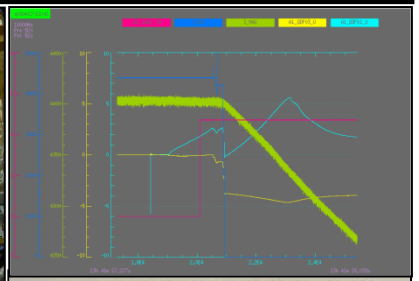


T2K : Θ_{13} from neutrino beam expermient









Measurement of Θ_{13} from ν_e appearance within ν_μ beam between Tsukuba and Kamioka

-Measurement of beam composition with near detector at 280m from beam-target

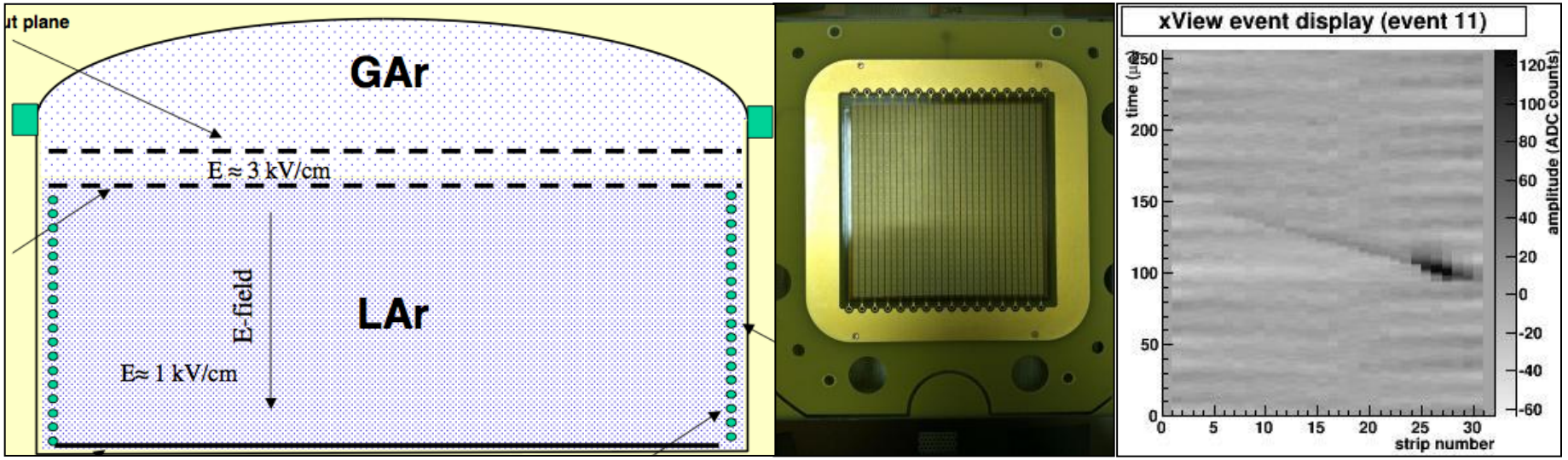
Irfu contribution:

-Magnet safety system for J-Parc p-beam

- large area microMegas TPC for ND-280

- Front end electronics : analog memories

Laguna – Glacier : micromegas getting cold!



Glacier: Concept of a "giant" liquid Argon TPC - up to 100 kton !

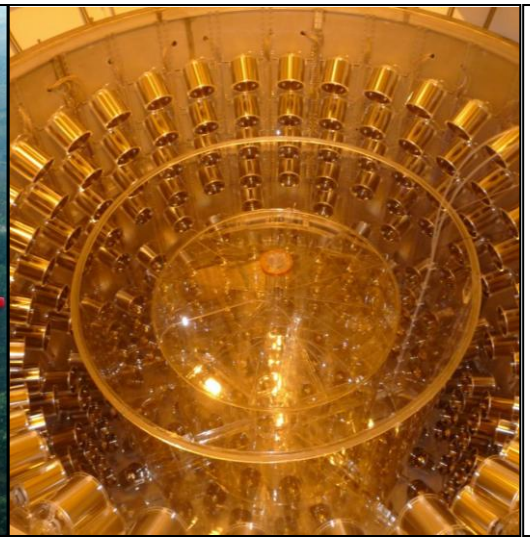
➔Proton decay, neutrino physics (CP-violation?)

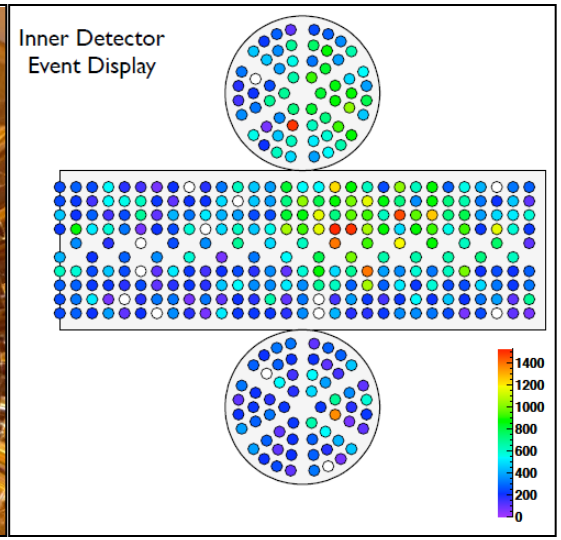
• First successful test using a micromegas detector in "hostile" environment:

➔Ultrapure (without quencher) , dense gas at very low temperatures

➔ observation of cosmic muon tracks

Double Chooz: Θ_{13} from reactor anti-neutrinos





- **measuring disappearance of anti-ν_e from reactor core:**

➔ oscillation effect between near (400m) and far (1km) detector

- almost identical detectors based on Gd doped liquid scintillator
- involvement of Nuclear Physics and Particle Physics Divisions (SPhN and SPP)
- Data taking started in far detector on December 23rd 2010
- Construction of near detector site scheduled from April 2011

➔ **First measurements expected in late summer 2011**

➔ **Measurements from both detectors in 2013**

➔ **Competition with Daya Bay and Reno**

Estimation of anti-ν_e flux from reactor cores

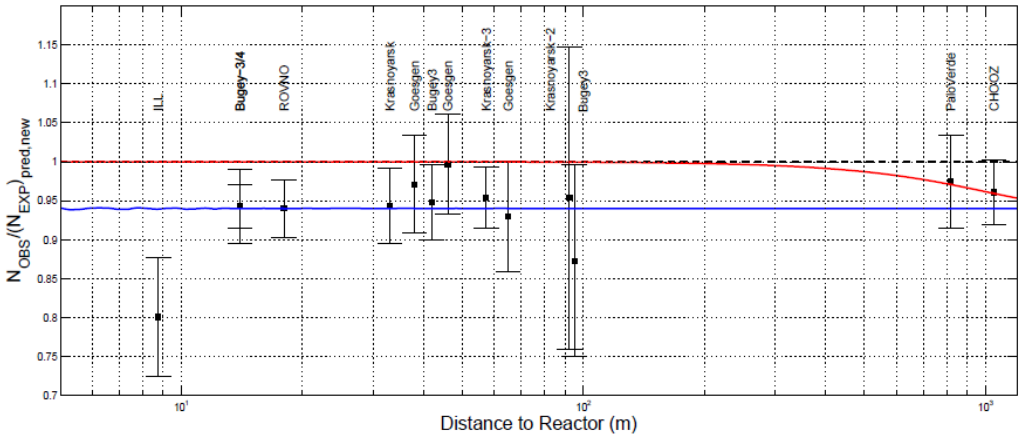
The Reactor Antineutrino Anomaly

G. Mention,[1] M. Fechner,[1] Th. Lasserre,[1,2,*] Th. A. Mueller,[3] D. Lhuillier,[3] M. Cribier,[1,2] and A. Letourneau[3]

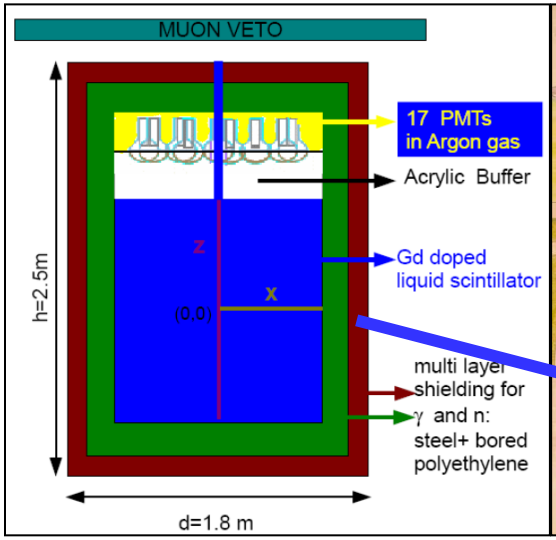
[1] *CEA, Irfu, SPP, Centre de Saclay, F-91191 Gif-sur-Yvette, France*
[2] *Astroparticule et Cosmologie APC, 10 rue Alice Domon et Leonie Duquet, 75205 Paris cedex 13, France*
[3] *CEA, Irfu, SPhN, Centre de Saclay, F-91191 Gif-sur-Yvette, France*

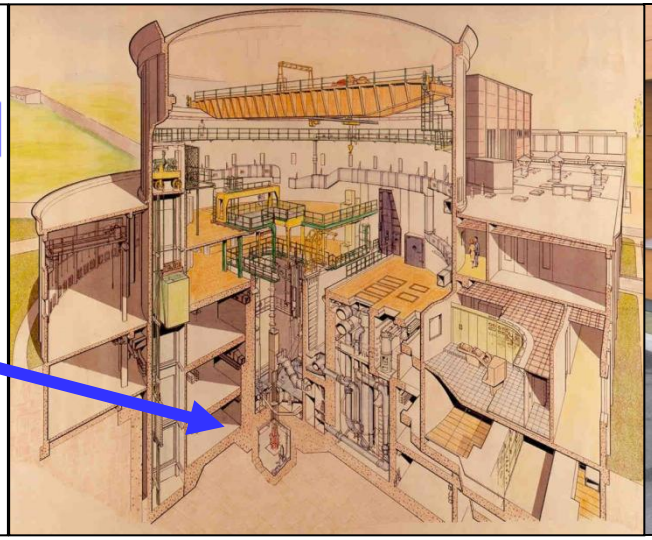
(Dated: January 17, 2011)

Recently, new reactor antineutrino spectra have been provided for ^{235}U, ^{239}Pu, ^{241}Pu, and ^{238}U, increasing the mean flux by about 3 percent. To a good approximation, this reevaluation applies to all reactor neutrino experiments. The synthesis of published experiments at reactor-detector distances <100 m leads to a ratio of observed event rate to predicted rate of 0.979±0.029. With our new flux evaluation, this ratio shifts to 0.937±0.027, leading to a deviation from unity at 98.4% C.L. which we call the reactor antineutrino anomaly. The compatibility of our results with the existence of a fourth non-standard neutrino state driving neutrino oscillations at short distances is discussed. The combined analysis of reactor data, gallium solar neutrino calibration experiments, and MiniBooNE-ν data disfavors the no-oscillation hypothesis at 99.93% C.L. The oscillation parameters are such that $|\Delta m^2_{new}| > 1.5$ eV^2 (99%) and $\sin^2(2\theta_{new}) = 0.17 \pm 0.1$ (95%). Constraints on the θ_{13} neutrino mixing angle are revised.



Nucifer: neutrinos for non-proliferation





Based on Double Chooz detector :

produce a 1T detector to be placed close to reactor cores

➔ monitor reactor cycles and fuel replacements

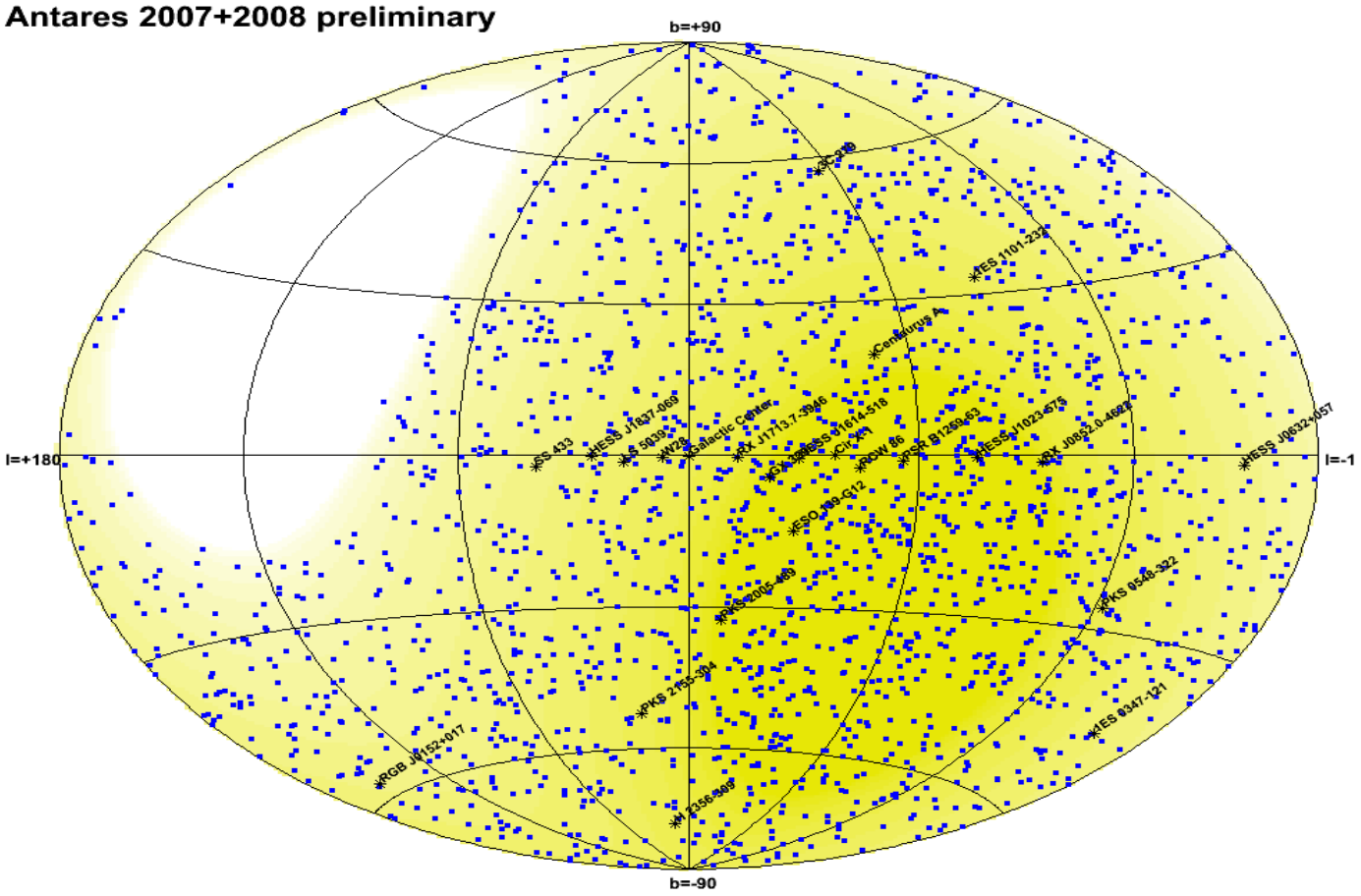
• Detector tested – to be installed at Osiris research reactor in Saclay

• Measurements foreseen at ILL

➔ **Interesting also for an additional reactor flux measurement !**

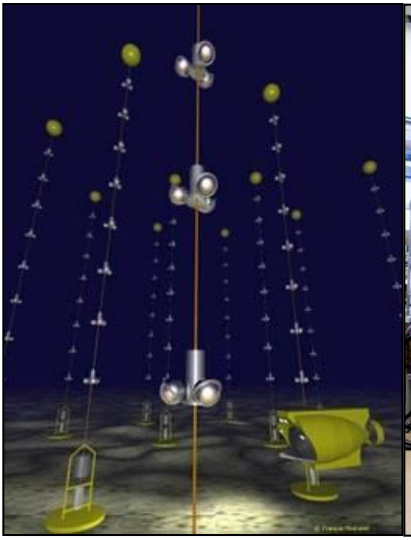
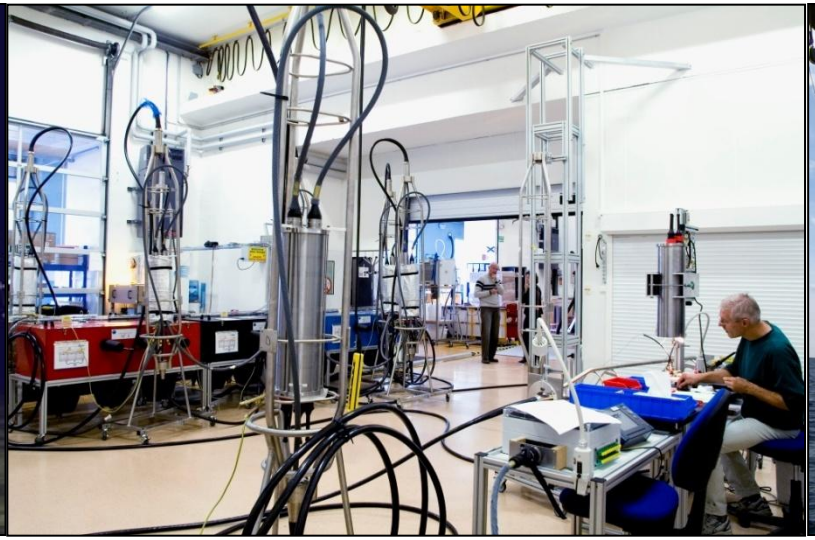
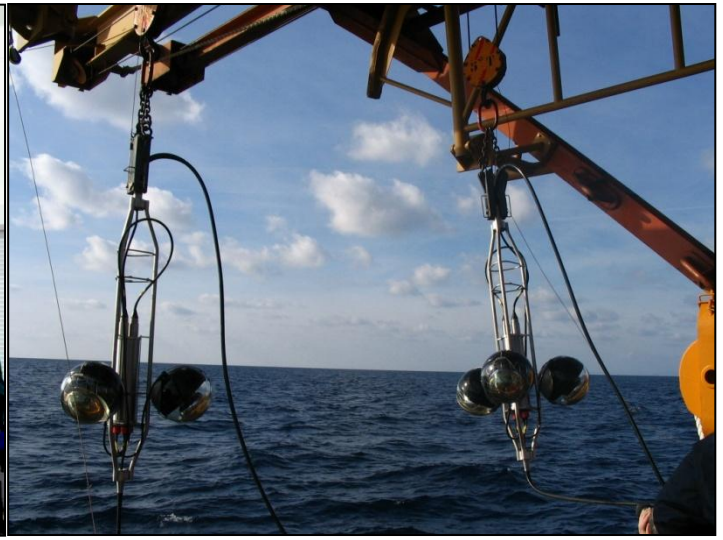
Antares: neutrinos as messengers

- **Unblinding of neutrino sky-map:** 2400 neutrinos



- No anisotropy - sign of a neutrino source - observed yet
- Increase of statistics with 2009 and 2010 data and improvement of calibration
- 5 physics publications so far: best published limit on diffuse ν-flux

Antares: design, construction and deployment

Deployment of full detector in 2008:

- 12 strings with optical modules at 2500 m depth close to Toulon
- 10 year for development, assembly and deployment

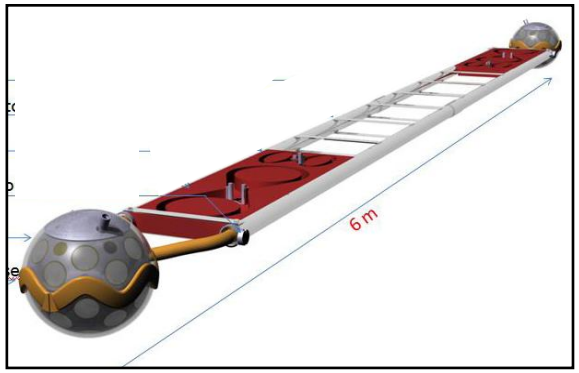
New links established with environmental sciences:

- oceanography, geologist, marin biology

➔Paper on bioluminescence submitted to Nature !

➔ Interest in real-time observation of sea ground

Km3NET: large sea-based neutrino telescope



ESFRI-roadmap: km3 neutrino telescope in the Mediterranean

-Sea based technique has better angular resolution than ice-based
- sky coverage complementary to ICEcube

TDR published with sensitivity studies and cost estimate

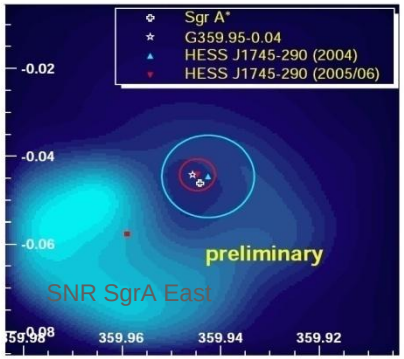
- **towards a technical convergence**

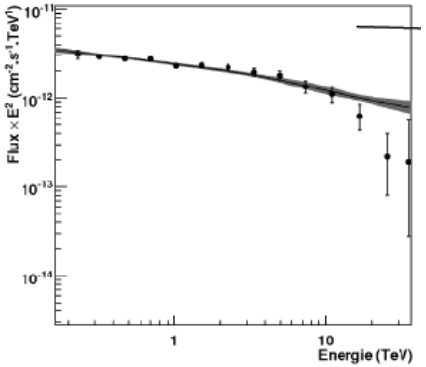
➔Construction of a prototype

➔ Scenarios for site choices and possible financial planning

γ-astronomy : indirect dark matter searches

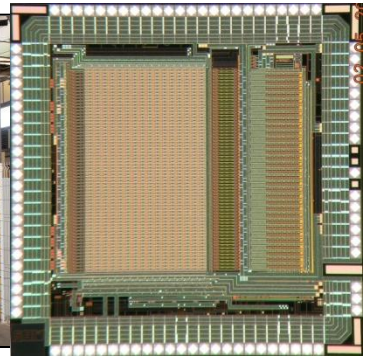
Sensitivity to possible galactic and extragalactic dark matter signals: observation of annihilation products by Cherenkov telescopes





Search of deviations in source spectra: Meticulous disentanglement of astrophysical contribution and possible dark matter signals

➔ **New collaboration of physicists from HESS, Atlas and IPhT**



HESS: array of 4 Cherenkov telescopes in Namibia

HESS-2: additional 25m telescope under construction (until mid-2012)

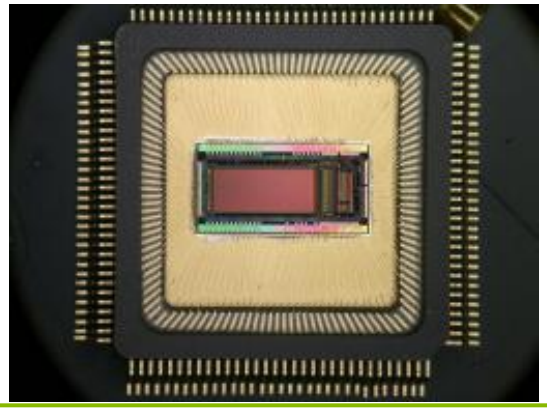
➔ contribution to L2 trigger electronics

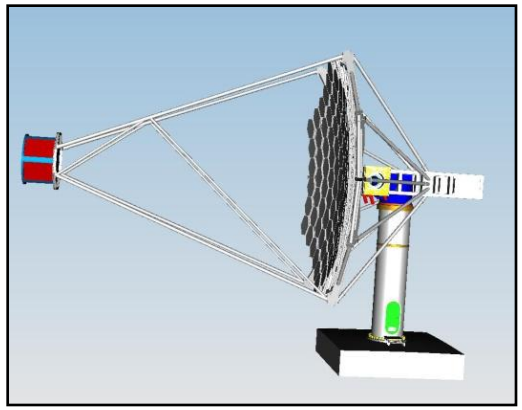
➔ camera succesful tested in France

CTA: a hundred Cherenkov telescopes!

Array of ~100 Cherenkov telescope
➔higher sensitivity, larger energy range
➔ high interest also from astrophysics community

R&D for cost effective solutions:
• Readout Electronics with integrated analog memories
• Carbon-fiber quadrupode for prototype construction with Desy-Zeuthen
• Development of “molded” mirrors on a web structure of carbon fiber
• Conception of solar energy modules





Dark Matter : Direct searches with Edelweiss

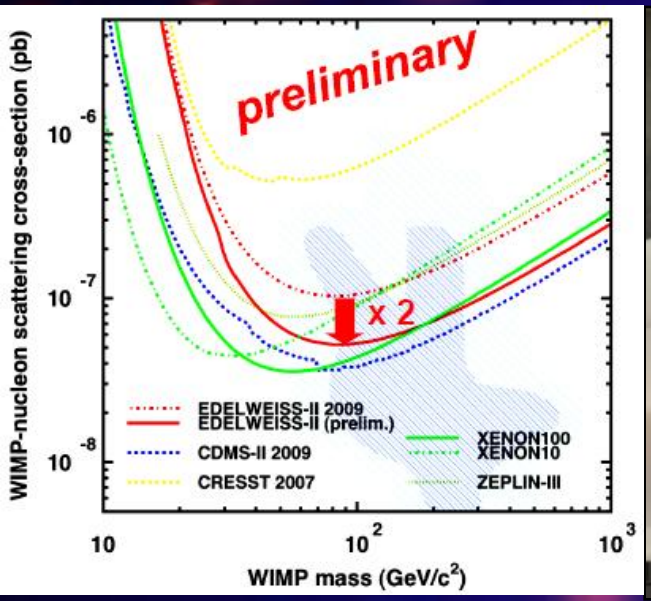
Edelweiss analysis of 2010 data ongoing:
- 415 kg/days up to May 2010
- ➔ Edelweiss close to the level of CDMS!

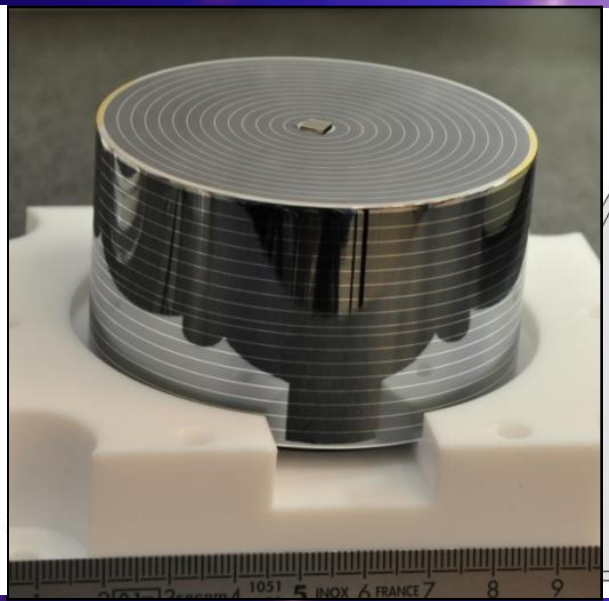
2 new FullID 800 g Ge detectors functioning
➔Preparing Edelweiss-III run in 2011

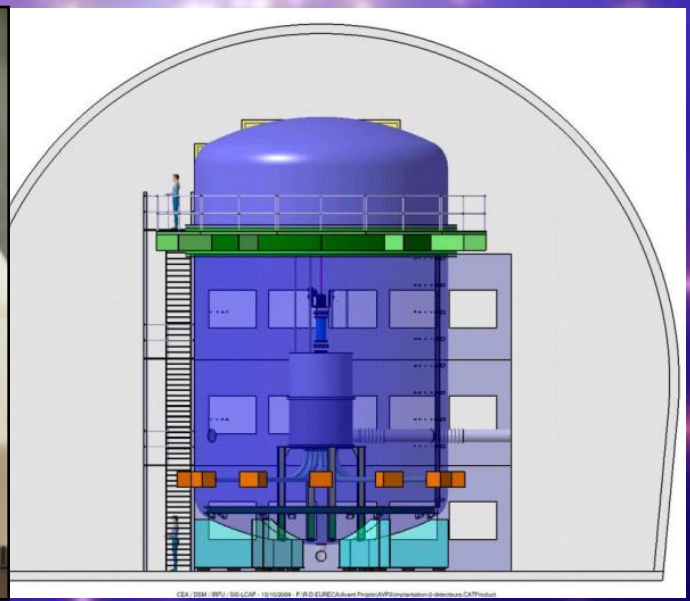
EURECA collaboration:
- members from CREST and Edelweiss
- ULISSE, extension of LSM under discussion for finances within French stimulus package

Collaboration with CDMS (US) :
- Use of interleaf electrodes by CDMS
- First common data analysis

➔ Hopeful close collaboration between EURECA and superCDMS







Dark energy : Supernovae standard candels

SuperNovae - SNLS:

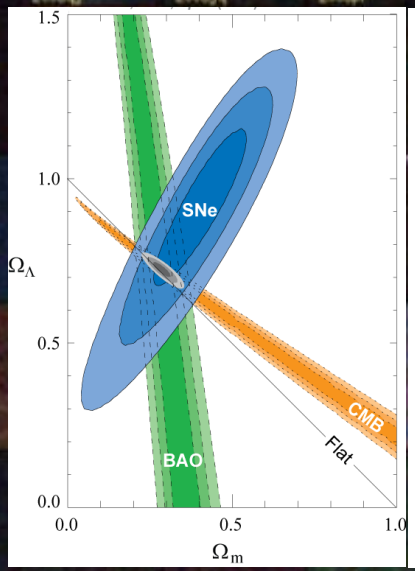
Magnitude of Type Ia Supernovae as a function of their distance

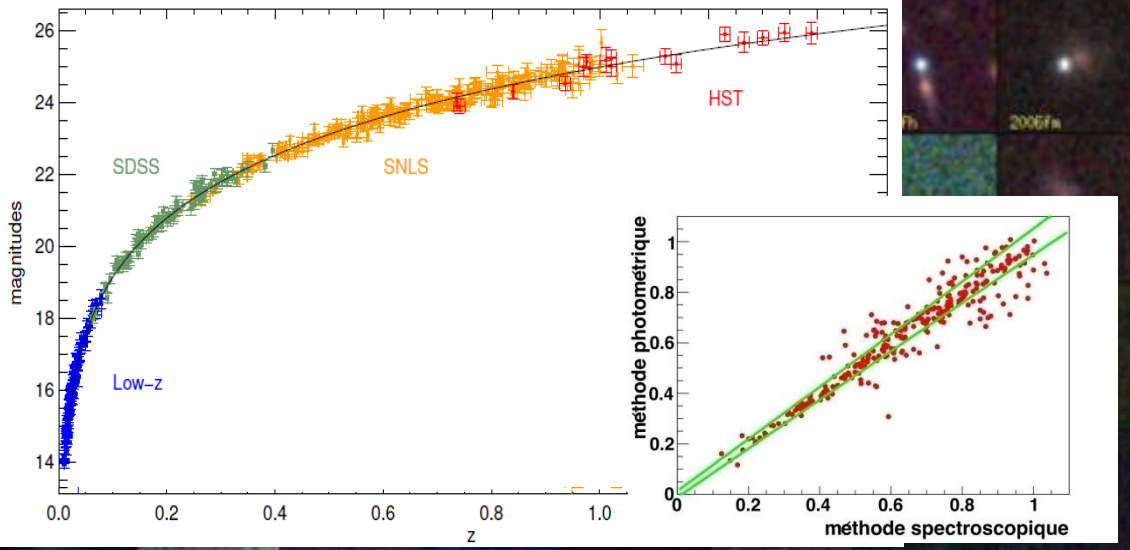
➔ extraction of Ω_m, Ω_λ.

➔ New Hubble diagram with data sample SNLS-3 years : 242 SNIa

➔ Photometric analysis : increase in statistics (x 3.5) , determination of systematics, only method for LSST data

➔ Joint PhD project: SNLS/D0-CMS – Higgs searches and consequences on cosmological models





Dark Energy: standard rulers

Baryon acoustic oscillations

➔Distribution of the galaxies at a standard distance (15MPs)

SDSS-3/BOSS:

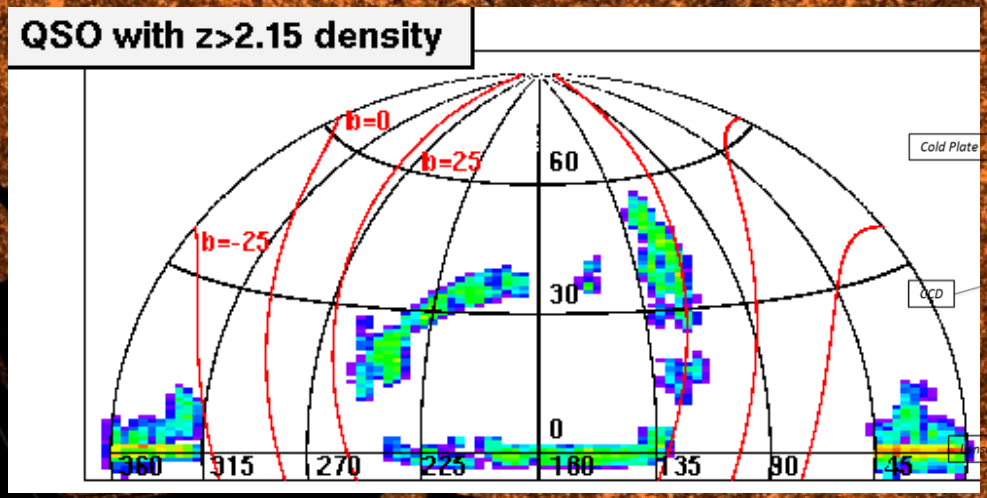
• selection of objects at a large distance to extract cosmological parameters

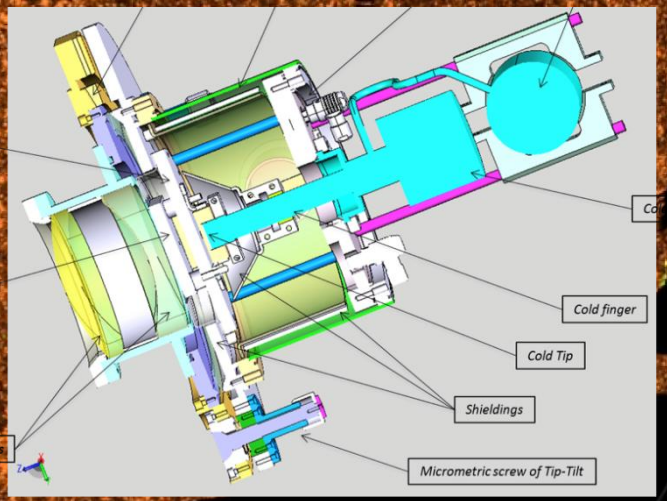
• at largest depths: 50 000 QSO expected by end 2011

BigBOSS project: observation of 2x years starting in 2017

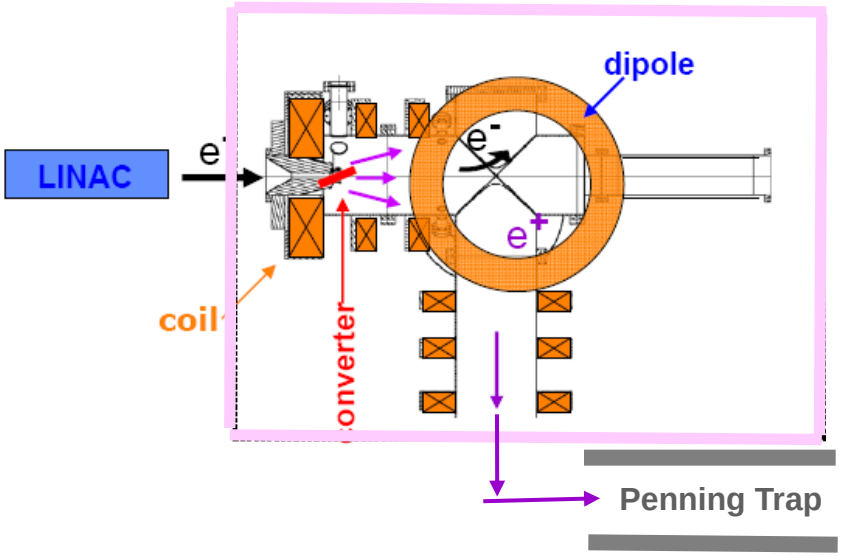
➔ 2-3 better sensitivity, 15x more statistics

• collaboration with Berkeley and Marseille (LAM) for the development of spectrographs





G-bar :anti-gravitation and anti-matter?



Measurement of gravitation on slow anti-hydrogen :
1000 events ➔2% error on g

- Development of a high intensity accelerator based positron source at Saclay

➔ **Possible use for material sciences**

- Final experiment to be installed at the CERN –AD, if possible ELENA?
- Proposal in preparation by 9 laboratories (France, Japan, Suisse, UK)

Particle Physics at Irfu

- Dedication:

LHC physics is the priority !

- Diversity:

a large span of activities and experiments

- Coherence:

embedded in the Irfu strategy

- Collaboration:

the national and international community