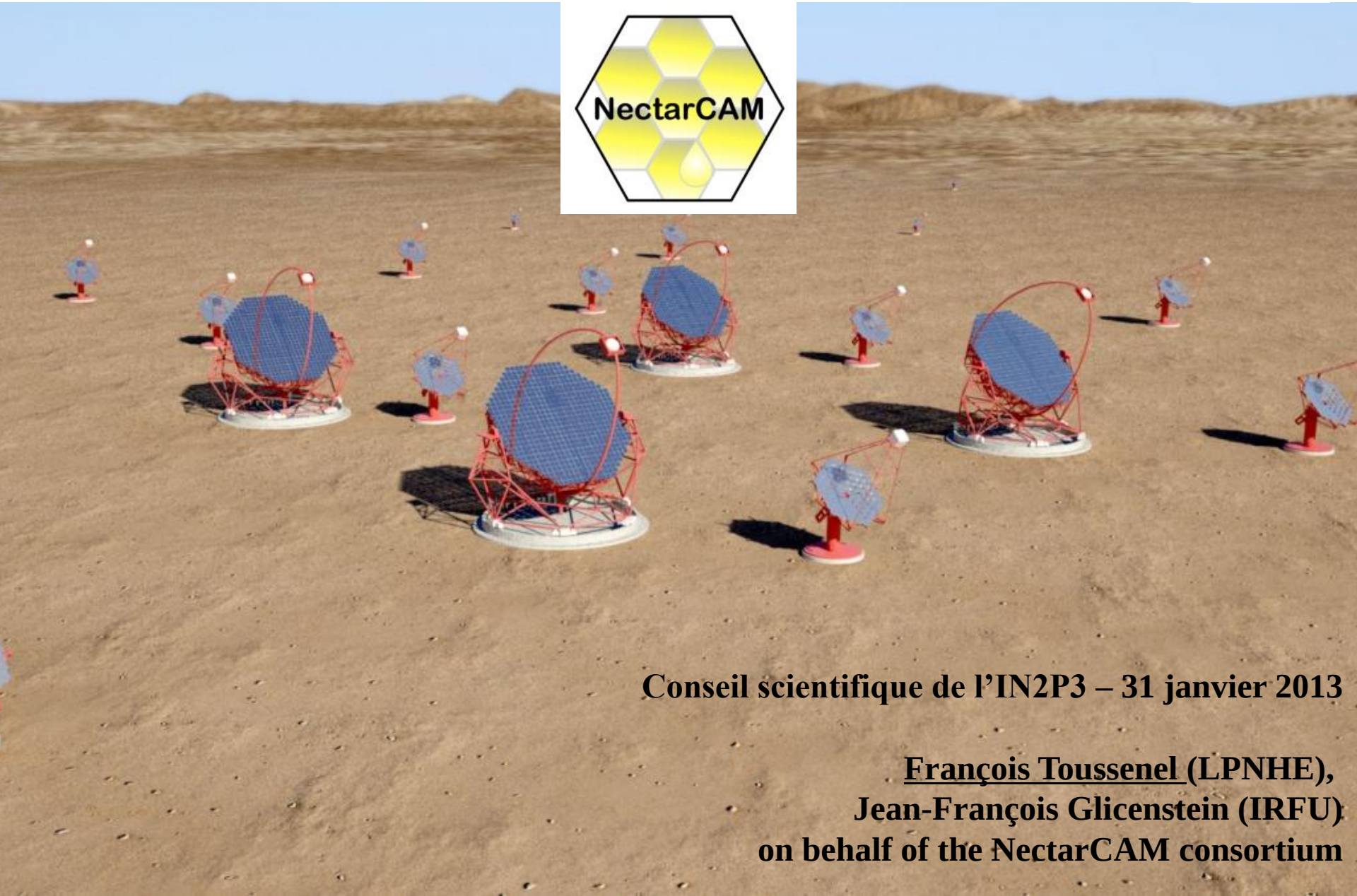
Modular Camera for CTA Medium Size Telescopes

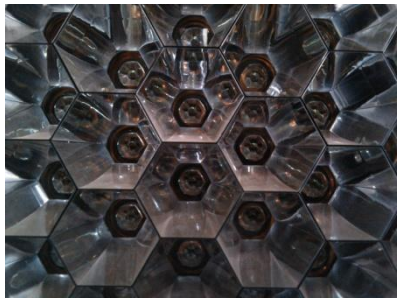


Conseil scientifique de l'IN2P3 – 31 janvier 2013

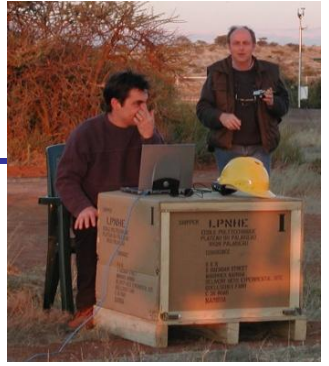
François Toussenel (LPNHE),
Jean-François Glicenstein (IRFU)
on behalf of the NectarCAM consortium

Outlook

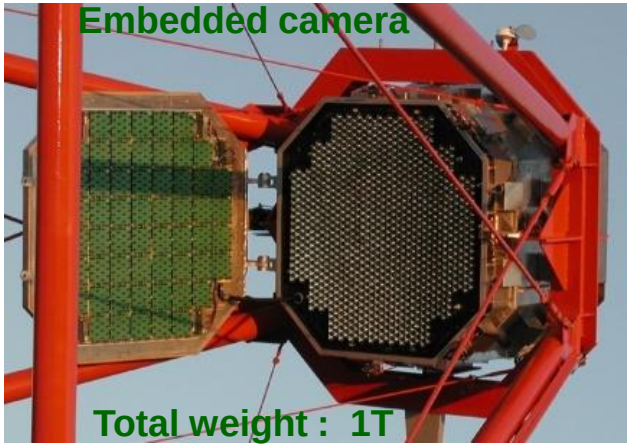
- Background
- EOI, context
- Overview of concept
- Baseline
- Status, next steps
- Conclusion



Background – H.E.S.S. I



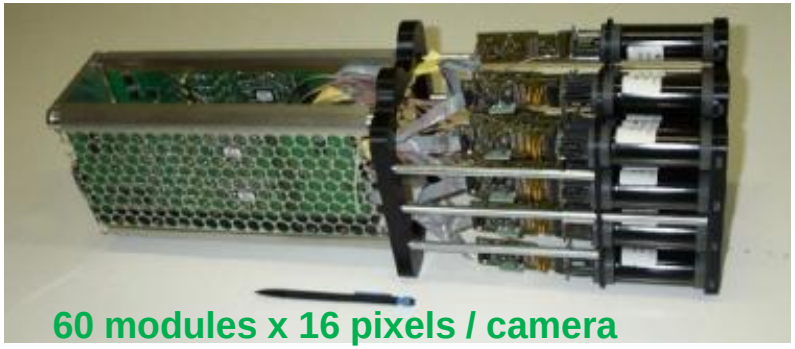
4 modular cameras of 960 pixels with fully embedded electronics
LPNHE, LLR, APC (Camera mechanics and instrumentation), MPIK (PMTs, HV, central trigger interface)

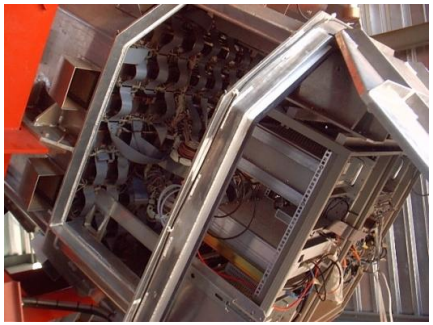


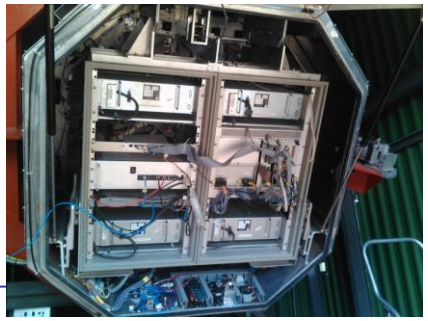
Handcraft Age

Parts production => Industry

Production test => labs
Assembly => labs
Integration and test work => labs



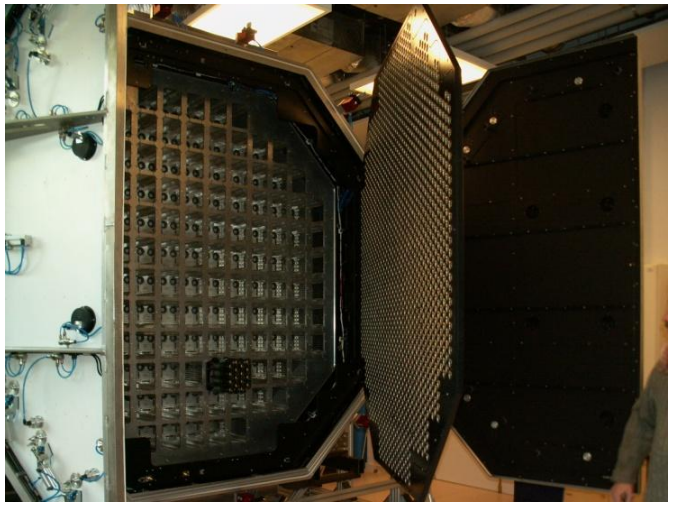




Background – H.E.S.S. II

2048 pixels modular camera (incl. PMTs)

LPNHE, IRFU, LLR, LAPP, LUTH, APC, LUPM

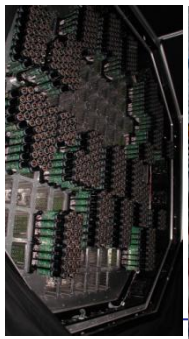


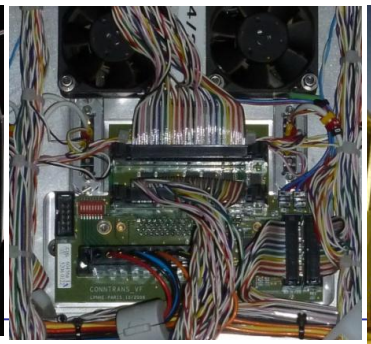
Pre industrial Age

128 modules x 16 pixels camera

Parts production => Industry
Production test => Industry

Integration and test work => labs





4 sub-projects
Autofocus
(un) Loading system
Shelter for maintenance
Outdoor calibration

French expression of interest (EOI)

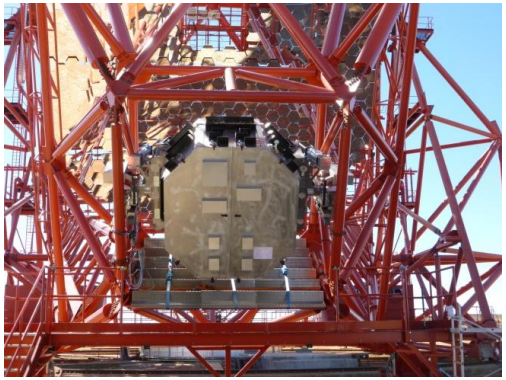
Current French expertise : 4 + 1 cameras for H.E.S.S.
leader in the field and led by IN2P3 labs

+

Historical expertise of IN2P3, IRFU in large Particle Physics experiments
Photodetectors, electronics, mechanics, DAQ and associated software

+

INSU, IRFU know how in space detectors
Project management, methodology, subcontracting, product assurance



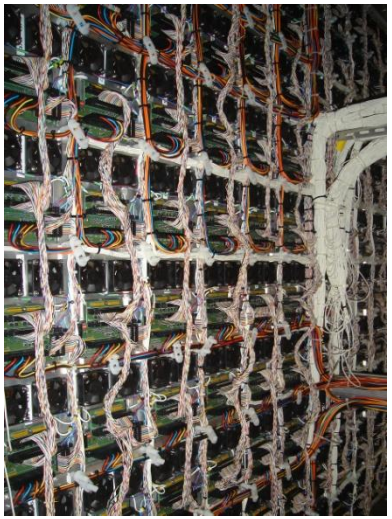
Candidate for delivery of 25 + 14 MST cameras
based on the NectarCAM concept

Initiated jointly by IN2P3, IRFU and INSU

H.E.S.S. to CTA transition

From few cameras (4 +1) to few tens of cameras (39 CTA-MST-CAM)

- 2-4 k channels to 100k channels



What's new/different

- Technical improvements
  - Sealed camera (to prevent aging), timing capabilities.

- Larger scale x10
- Stronger "cost and reliability" constraints

  A-RAMS-0030 The availability of the MST telescopes during observation time must be >97.5 %

  Cost => production, operation and maintenance

- Industrialization

=> Project management and product assurance more critical

NectarCAM consortium

Current situation : international consortium (France, Spain, Germany)

List could be extended depending on

- ➔ Outcome of the ongoing workshop within CTA consortium
  unifying process under discussion : Germany, Japan, France, Spain
- ➔ Expression of interest of other countries

NectarCAM Project

Management team

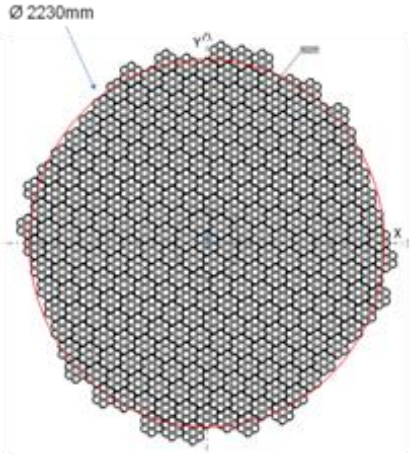
Camera product

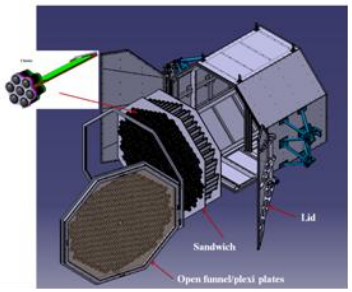
Modular Camera responsibilities

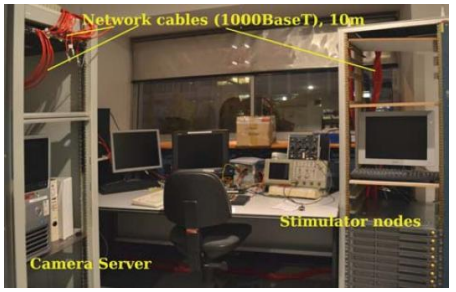
Scientific coordination	Project management	Integration & tests	Focal plane equipments	Camera Mechanics & cooling	Front end electronics	Monitoring & services	Triggering & processing
Principal Investigator : Jean-François Glicenstein (IRFU)	Project manager : François toussenel (LPNHE)	Frédéric Louis (IRFU)	Jürgen Knödlseder (IRAP)	Pascal Manigot (LLR)	Patrick Nayman (LPNHE)	Julie Prast (LAPP)	Dirk Hoffmann (CPPM)
		Detector unit Camera Module	Focal plane optics PMTs & HV Preamplifier	Camera mechanics Cooling Module mechanics	Frontend board Trigger Backplane card	Slowcontrol Safety Power Calibration	Camera DAQ Time stamping Array trigger

System engineering — System engineer : Michel Fesquet (IRFU)

Product Assurance activities — Quality manager : Sandrine Couturier (LLR)







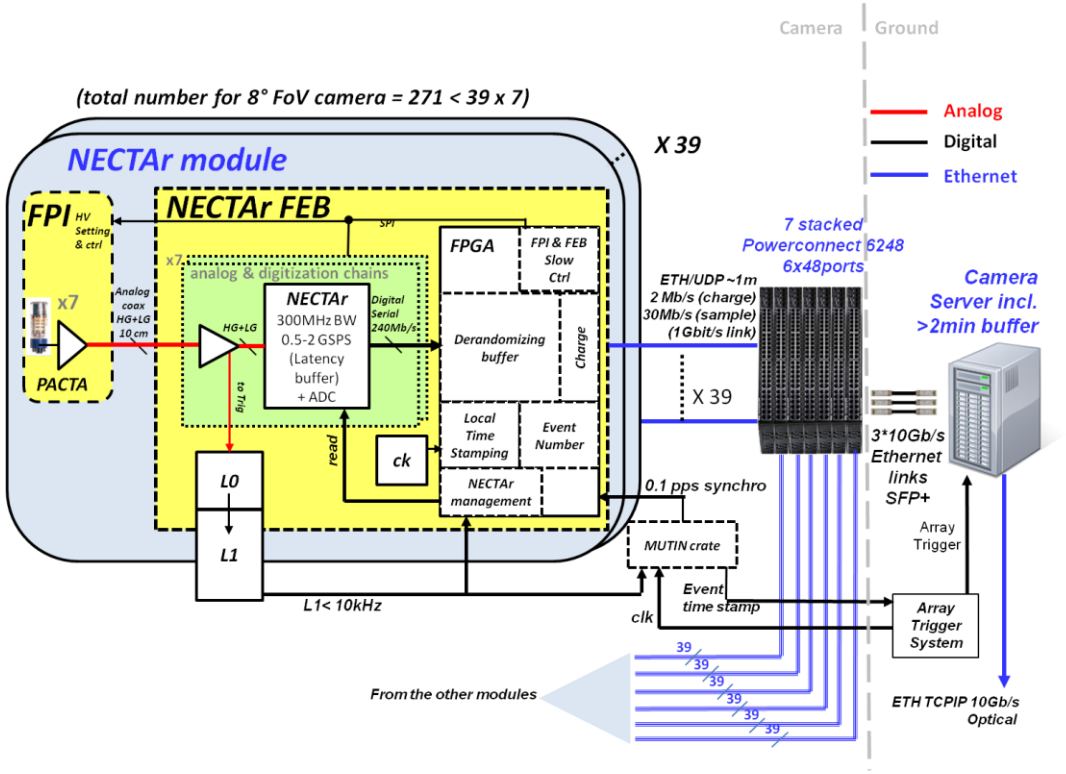
IN2P3

IRFU

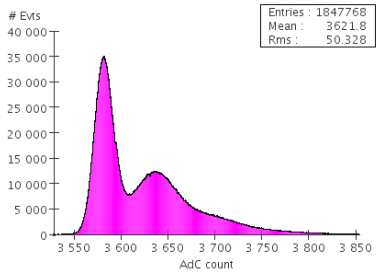
INSU

NectarCAM overview of concept

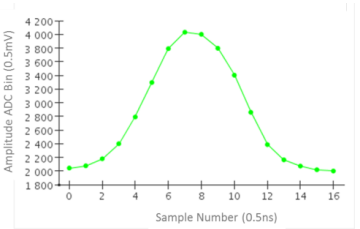
Camera architecture: modular concept



High Gain, charge



High Gain, limit of saturation, 2GS/s



- Output from PMT amplified (PACTA + ACTA) : BW > 300 Mhz
- Separated into a trigger path and data path (HG + LG)
- Signal sampled at 1 GHz, and converted on L1 trigger by NECTAr0
- After camera trigger , 2,7 kbits transferred to FPGA

(10-20 samples read-out window : Charges, T0 calculated in FPGA)

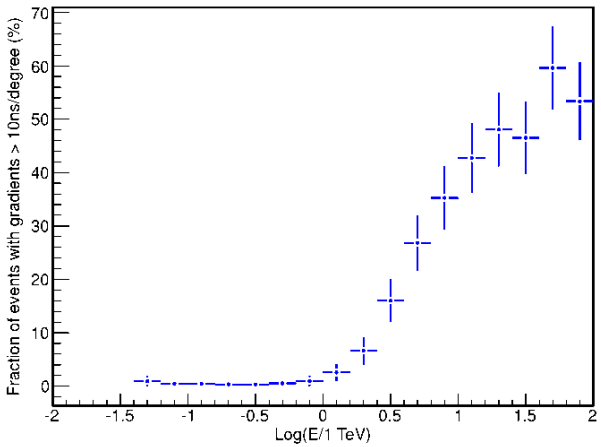
- Data transfer:Camera -> camera server through Eth. switches
- Data rate: FPGA -> switches
  - = 2Mb/s (Charge + arrival time for 16 samples)
  - = 30 Mb/s (all the time samples (for 16 samples)
- Events buffered on camera server waiting for array trigger

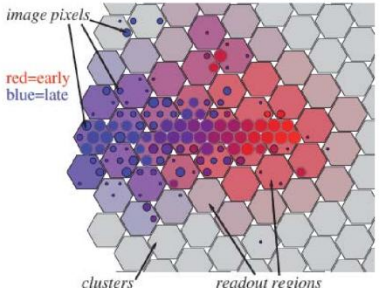
L1 rate > 4500 Hz, Dead time < 5%

NectarCAM overview of concept

Basic measurements & parameters

- Total charge and time of arrival of Cherenkov signal
  (Complete pulse shape analysis also possible)
  - Energy and gamma/hadron separation
- Read out window : 10-20 ns
  - Duration of Cherenkov signal 2-3 ns - NSB : 100-300 Mhz
    - Reduce NSB contribution
- Large FoV for MST : > 7° (>1400 pixels = 200 modules)
  - Survey, extended sources
- Events with time gradient
  - Flexible readout
    - Follow shower development
  - Time of Maximum or waveform analysis
    - Impact parameter, gamma/hadron separation, energy





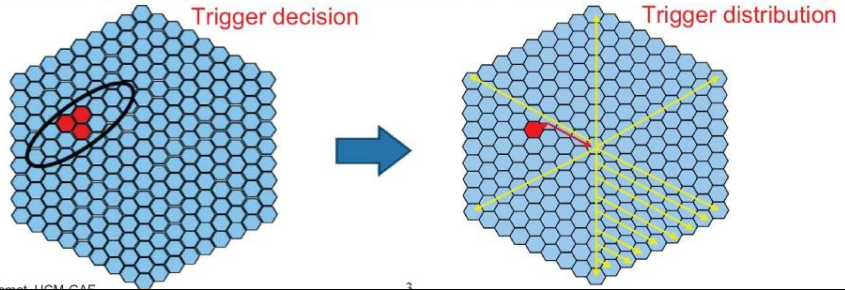
NectarCAM overview of concept

Trigger Concept: 3 levels trigger

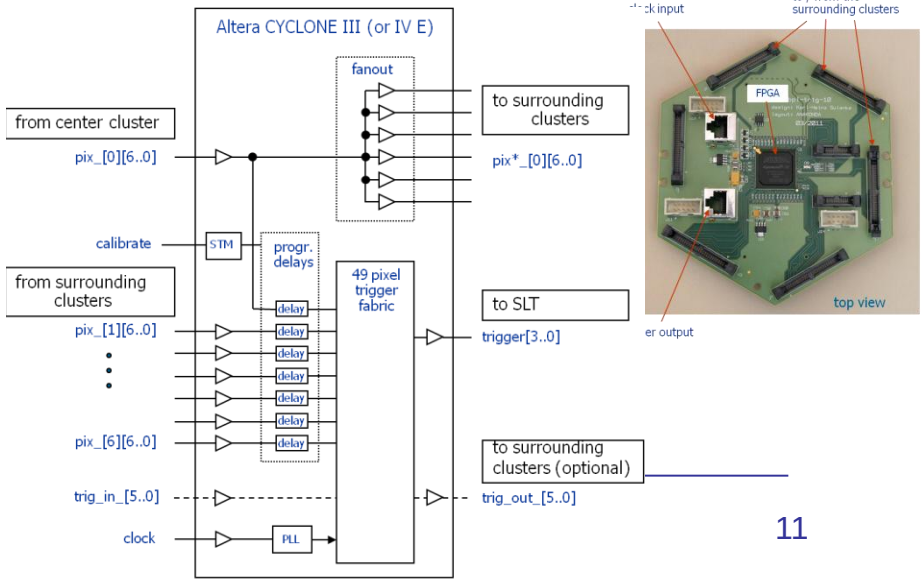
- Module level : Level0 (L0) : calculated in module and sent to neighbors
  - Majority or Sum trigger scheme
- Camera level : Level1 (L1): could be either Analog or Digital
  - calculated in module and sent to the whole camera or Region of Interest :
  - on L1 trigger => event transfer from module to camera server
- Array level : array trigger
  - If array trigger => event stored in the central computer farm

Analog trigger concept

- Each hexagon represents a cluster of 7 pixels
- First combines the signal within a cluster to provide a L0 signal
  - Comes in two flavors: Sum and Majority trigger schemes
- Then combines the L0 among all trigger regions (closed-packet patches of 2, 3 or 4 clusters)
- Camera triggered if the combination exceeds a certain threshold in any trigger region
- The trigger is distributed among all clusters isochronously
  - Both region of interest and colibri trigger are already implemented
- Clock distribution (1PPS, 10MHz) are also distributed with this system.



Digital trigger concept



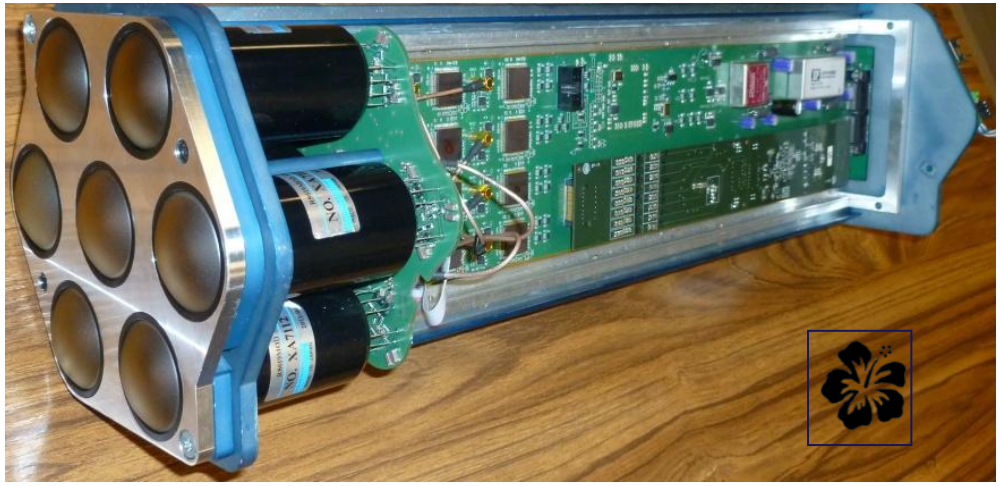
Baseline for the NectarCAM

1. NECTAr module developed within the NECTAr ANR project (2009- 2012) - **IRFU,LPNHE,LUPM + ICC-UB**

- Low power Nectar0 ASIC with integrated ADC
- Reduced number of parts, connectors and more integrated Electronics

To lower the cost
Facilitate industrialization
Increase reliabilility

&

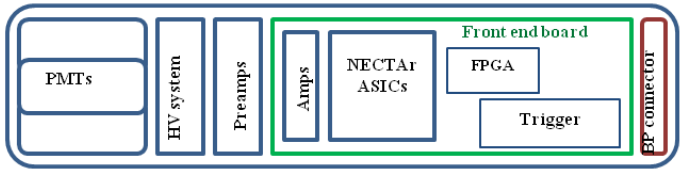


2. Outcome of CTA design study phase => 2008 – 2010

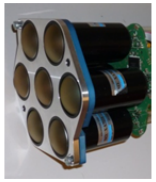
French groups involved in different CTA work packages : ELEC/FPI*, ACTL*, DATA, MC

* ELEC / FPI => all camera activities (PMTs, Mechanics, cooling, electronics) - ACTL => Array control

From module to camera

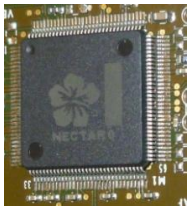


Module

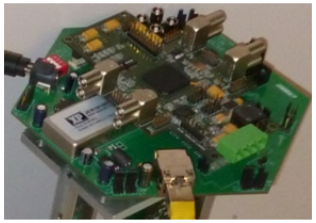


PMTs

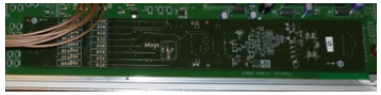
HV card



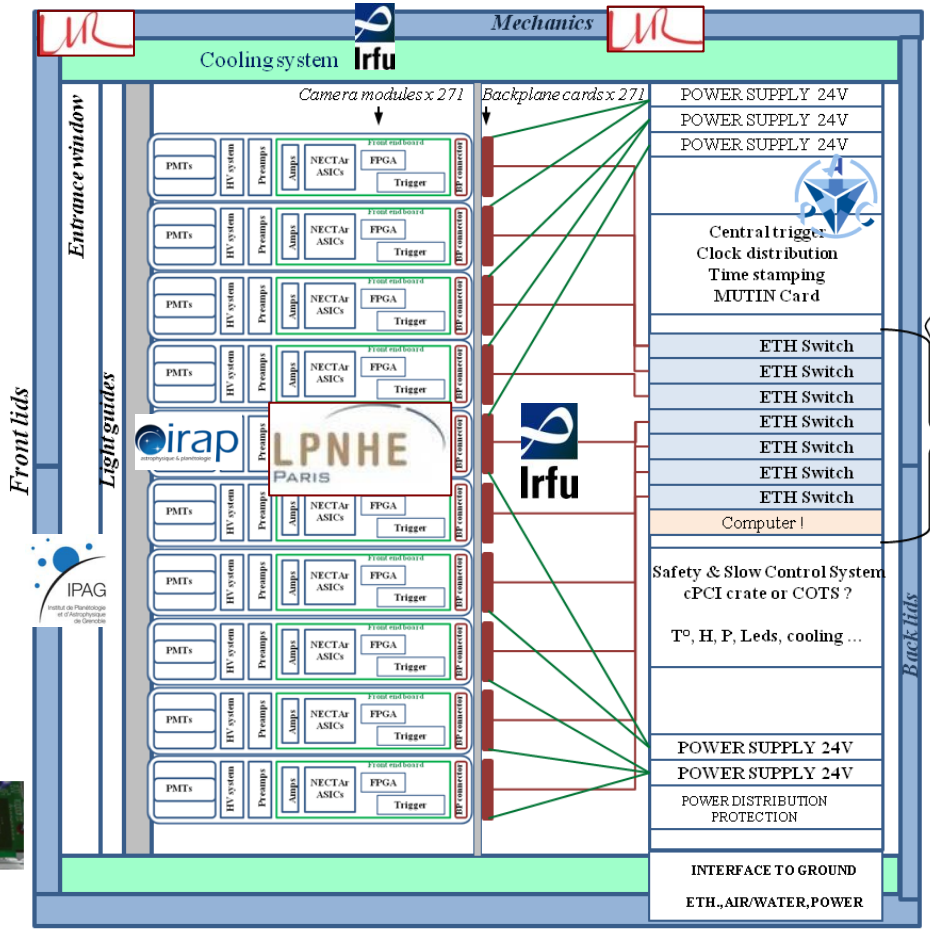
NECTAr ASICs



Backplane & L1 dist
(Analogue Trigger scheme)



L0, L1
Analogue Trigger scheme



e.g. POWER SUPPLY 24V

ETH Switch

Camera server

Computer
Should be on the ground

cPCI crate

NectarCAM Status within CTA collab.

1. Review on camera activities => June 2011 => front end , trigger , HV & PMTs.

2. Camera concept review => April 2012 => NectarCAM , DragonCAM, FlashCAM

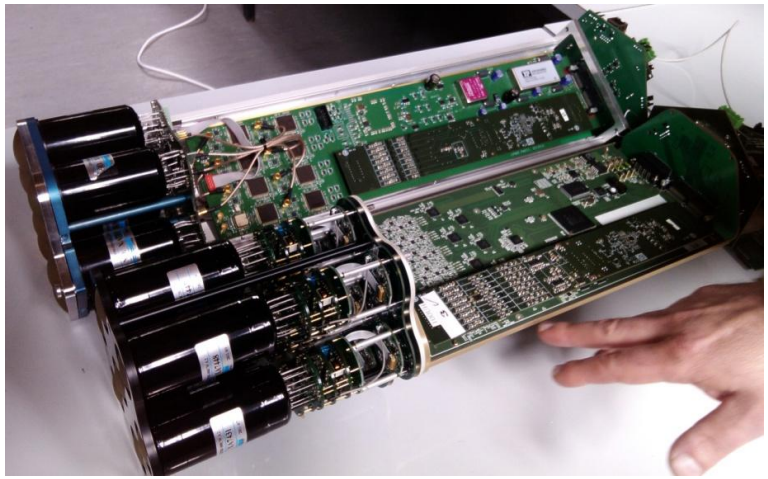
Main recommendation : work on common components for CTA cameras

3. Dedicated FPI ELEC meeting: Oct 2012 – LPNHE

Outcome : Working groups to develop common components for CTA cameras

Study option to merge Nectar & Dragon camera designs keeping the 2 different readout boards

- Kind of guarantee for CTA
- Optimize & share ressources
- Optimize spare parts for the Observatory
- facilitate maintenance, debugging



4. PDR (Preliminary design review) and **Camera decision** : July 2013

Prototyping strategy – Time schedule

1. Validate readout concept from Photodetectors to camera server

   To be done with currents prototypes (7 modules) before summer 2013

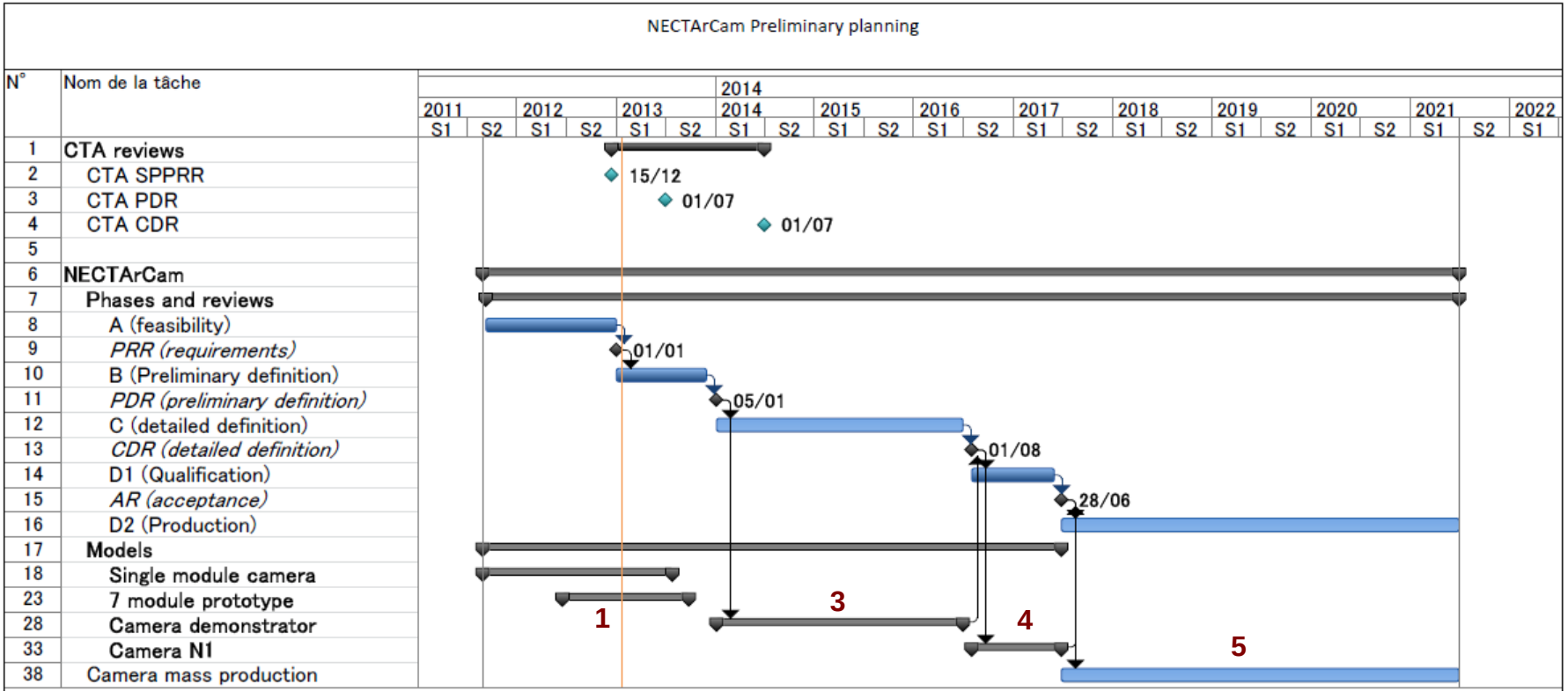
2. Pursue activity within camera designs unifying process

   Freeze the whole design before the end of the year 2013 (Trigger, FEB, cooling)

3. Develop reduced scale camera demonstrator (19 modules) to validate overall concept

   Prepare industrialization, documentation, product assurance

4. Production of the first camera
5. Large production



Production scheme

Current assumptions for the production of 39 MST Cam

Cameras production site : IRFU , other sites ?

<u>Subsystems</u>

Production	=> industry
Assembly & first level test	=> lab/Industry
Integration test	=> labs

<u>Detector unit</u> (272 x 39 = 10608)

Production and assembly	=> industry
Final test of performances	=> lab or lab in partnership with industry

<u>Camera module</u> (10608)

Assembly	=> lab or lab in partnership with industry
Integrated Test	=> lab or lab in partnership with industry

<u>Cameras</u>

Assembly	=> lab or lab in partnership with industry
Integrated test	=> lab or lab in partnership with industry

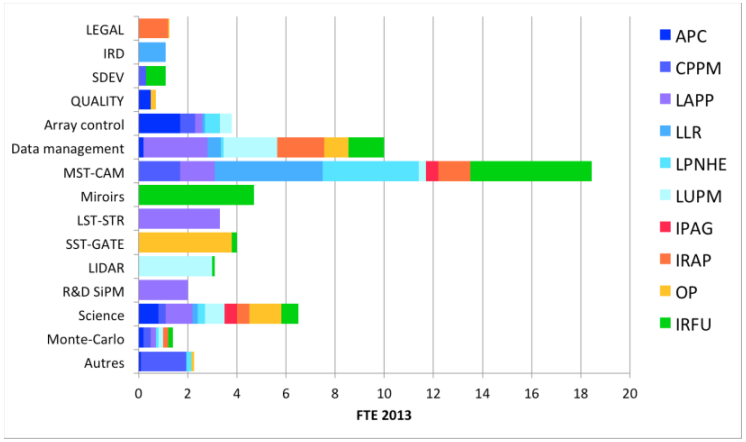
Risks assessment

Funding

Critical to prepare properly a possible large production

Production considered only when demonstrator performances available and concept validated

Manpower



used to be insufficient ~ 18 FTE expected in 2013

> need to be consolidated on some aspects of engineering

> Share of knowledge on critical items
to avoid loss of “time & knowledge”

Technical

No high level risk => well known technologies

Strong Reliability constraint

=> Project management and product assurance

=> Prepare industrialization

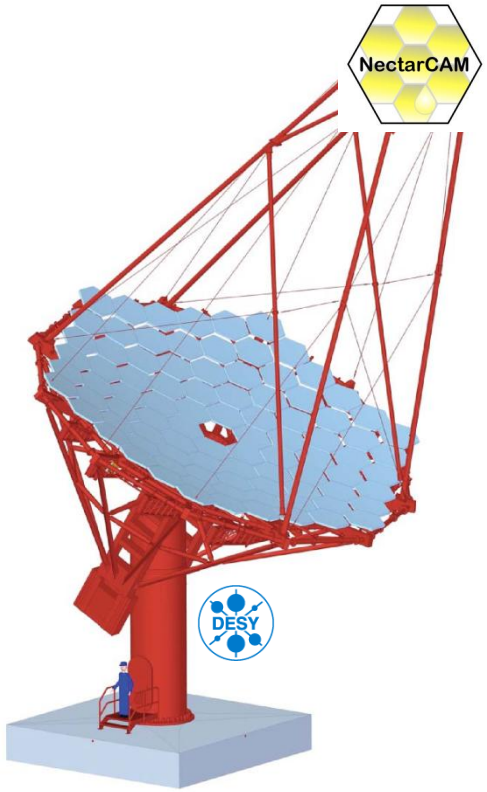
Time schedule

Current CTA time scale => strong constraint for NectarCAM

NectarCAM for CTA MST - Conclusion

Federating project for French teams (3 institutes involved)

- IN2P3 : technical expertise (H.E.S.S.) -> strongly involved in the design
  => huge project in Gamma astronomy field
- IRFU : technical expertise + large structure
  => able to build several cameras per year
- INSU : used to build large detectors in severe environments



EOI

- Candidate for delivery of 25 + 14 MST cameras

Next Steps

- Demonstrate the full concept
- Prepare industrialization process
  Consequent part of the budget should go to industry

Objectives

Lead the MST cam project > heart of the array