



# High Energy Astrophysics at APC

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On behalf of the HEA group

Conseil scientifique APC, 20 November 2017

# The HEA group

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## Group Members :

- 24 permanent researchers :
  - 10 CNRS
  - 7 EC (*6 Paris Diderot, 1 Paris Sud*)
  - 4 CEA
  - 2 EMERITES, 1 scientific associate
- 6 Post-docs
- 9 PhDs
- 14 APC members as secondary group
- 9 associated researchers (*CNRS, CEA, Observatoire, ect...*)

# Group evolution

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	2013	2014	2015	2016	2017
Staff researchers	24	25	25	23	22
Post-docs	7	7	7	5	5/3
Phds	8	7	7	8	8

- 2016 : F. Lebrun & V. Beckmann's leave.  
X-gamma spatial missions
- 2016-2017: Lost of several post-docs :  
End of CNES Integral post-docs  
End of CNES Astro-H, Taranis post-docs

	2017	2018	2019	2020	2021	2022
Staff researchers	22	23	22	22	22	21
Post-docs	3	3	3			
Phds	7	?				

- Within next years: 2 emerites + 1 more retirement
- 2018 : arrival of a new MCF P7
- New CDD CNES for TARANIS et SVOM in 2018/19

# High Energy Astrophysics

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Theory  
Model  
Simulations

## Physical processes

Acceleration & Propagation  
Accretion & ejection  
Stellar Explosion  
ISM physics & chemistry

## Astrophysical objects

Supernova remnants & Shocks  
Pulsars & isolated NS  
Active Galactic Nuclei & SMBH  
Gamma-ray burst & Supernovae  
Compact binary systems

## Messenger

### Photons

### UHE CRs

### VHE neutrinos

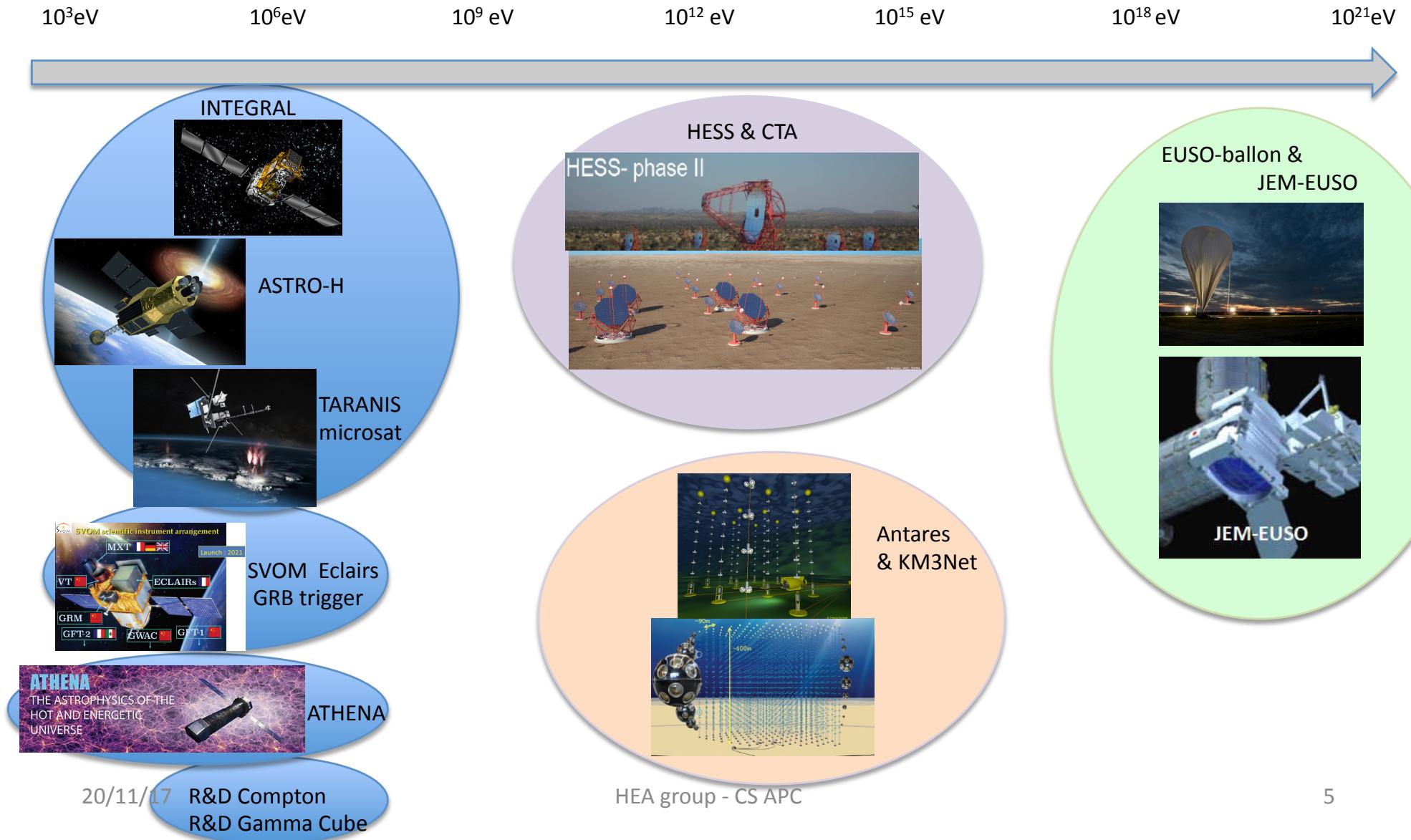
## Experiments

**X-rays:** Athena  
**hard X-rays:**  
INTEGRAL, SVOM,  
Astro-H, Taranis  
**Space Gamma-ray Telescopes:**  
ASTROGAM, Gamma-Cube  
**Tcherenkov Telescopes:**  
HESS-I & -II, CTA

JEM-EUSO,

ANTARES,  
KM3NeT

# Teams & Projets



# Group strategy

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- Balance between projects :

By type:

- Spatial projects (X-rays & soft gamma-rays & UHECRs)
- Ground projects (VHE gamma-rays & neutrinos)

In time:

- Integral --> SVOM, ATHENA, Compton telescope (?)
- HESS --> CTA
- Antares --> KM3Net
- Auger --> JEM-EUSO

- Balance between activities :

- Data analysis (Integral, HESS, Antares, )
- Construction and development (TARANIS, SVOM, ATHENA, CTA, KM3Net)

- Develop complementary activities on tranverse topics :

- Theory (RC, GRBs, SNRS, Pulsars, MC)
- Numerical simulation (AGN, compact objects, GRBs)
- Multi-wavelenght and multi messengers (SMBH, AGNs, GRBs, GW, ect)

# Internal Organization

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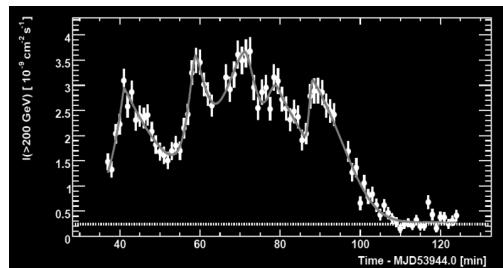
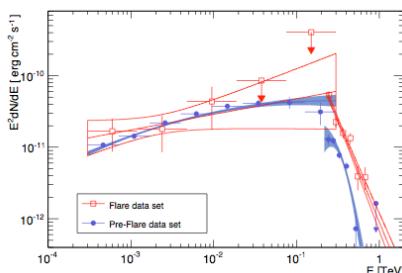
- Group leader-2014: Etienne Parizot
- Group leader since 2015 : Anne Lemière
- Group meeting every week :
  - Informations, administration, news of the group, news from the direction
  - Informal scientific presentation by a group's member or seminar
  - Scientific discussions /prospective /meet other groups
- 2015 : 3 topics discussed during 6 months (RCs in the Galaxy, GRBs, AGNs)
- Agendas statistics :

	Total	discussions HEA	seminar	Talk staff	Talk post-doc	Talk phd
2015	23	4	4	14	1	0
2016	24	4	6	5	3	6
2017	29	8	8	5	6	2

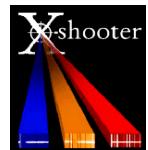
# Transverse AHE activities MWL study of the AGNs

## AGN monitoring : variability studies (HESS,Fermi, X-rays, radio,ect...)

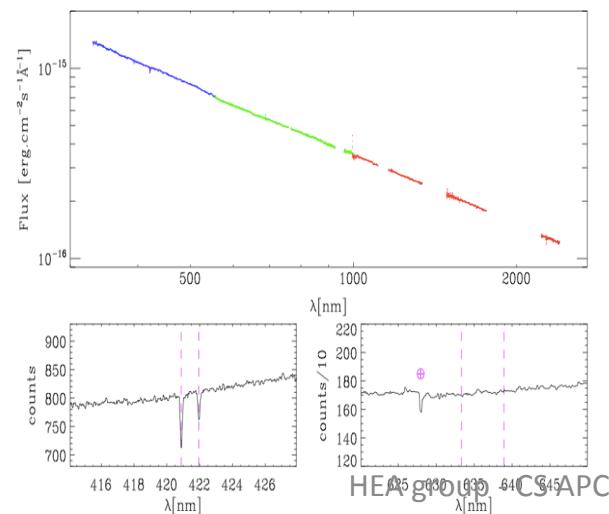
The 2012 flare of PG 1553+113 seen with H.E.S.S. and Fermi -LAT



HESS observations of PKS 2155-304 – Blazar  $z=0.12$   
Exceptionnal variability



X-shooter : Spectrograph : UV- IR for the VLT (O.G)

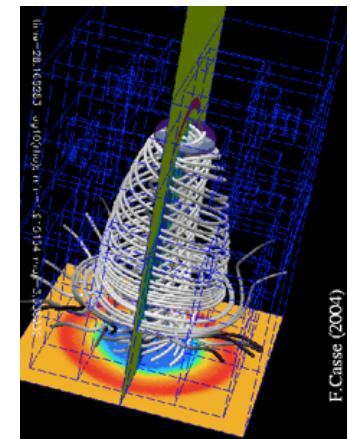
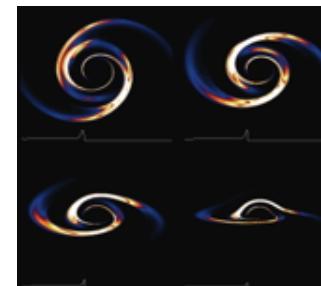


VLT/Shooter observation campaigns for redshift measurement :  
HESS Blazars  
FERMI Blazars : VHE candidates

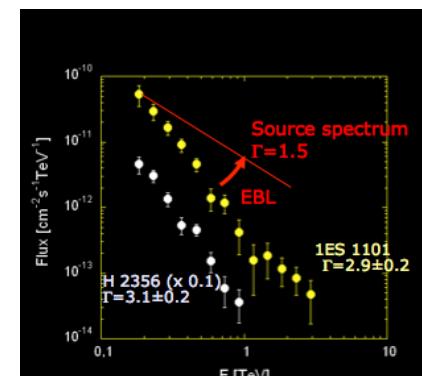
20/11/17

## Simulations :

- Acceleration processes in jets: radio to TeV & UHECR
- Gravity in strong field: timing & spectroscopy

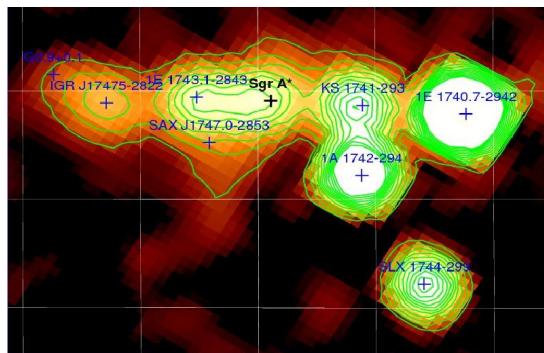


EBL limit using AGNs spectral absorption in HESS VHE gamma-ray data



# Transverse AHE activities MWL study of the Galactic Center

**INTEGRAL detection** of a central source : nature of the source ?  
Not compatible with SgrA\*



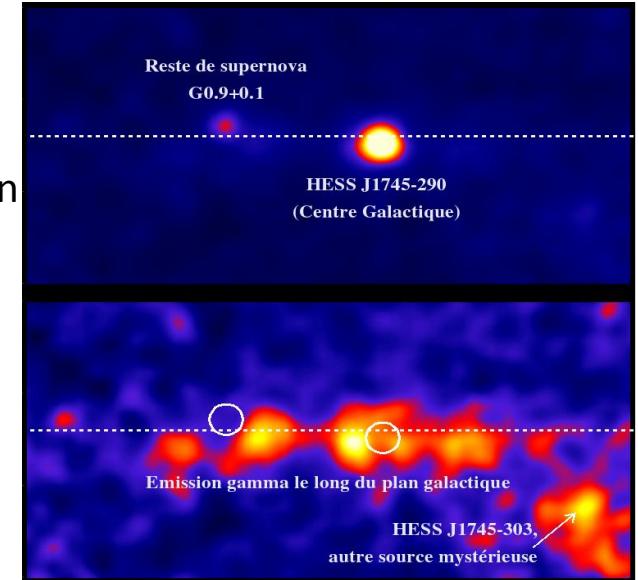
**HESSI GC monitoring (2004-2015):**  
- Point source compatible with SgrA\*  
- Hard diffuse emission spatially correlated with the CMZ gas distribution  
Presence of a Pevatron :  
- SMBH accelerating the CRs ?  
- Connection with Fermi bubble ?  
- Propagation of CRs in the CMZ

Acceleration of Petaelectronvolt protons in the Galactic Centre (Nature 531, 2016)

Characterising the VHE diffuse emission in the central 200 pc of our Galaxy with HESS. Accepted A&A (2017)

CA: Gabici, A. Lelièvre, R. Terrier

L.Jouvin, B. Khélifi



## X-rays study of the CG SMBH past activity with XMM & Chandra

- Propagation of Fe K line emission at 6.4 keV in the GC
- Reflection by Molecular Clouds of past Sgr A\* outbursts

possibility to reconstruct the SMBH light curve of recent past.

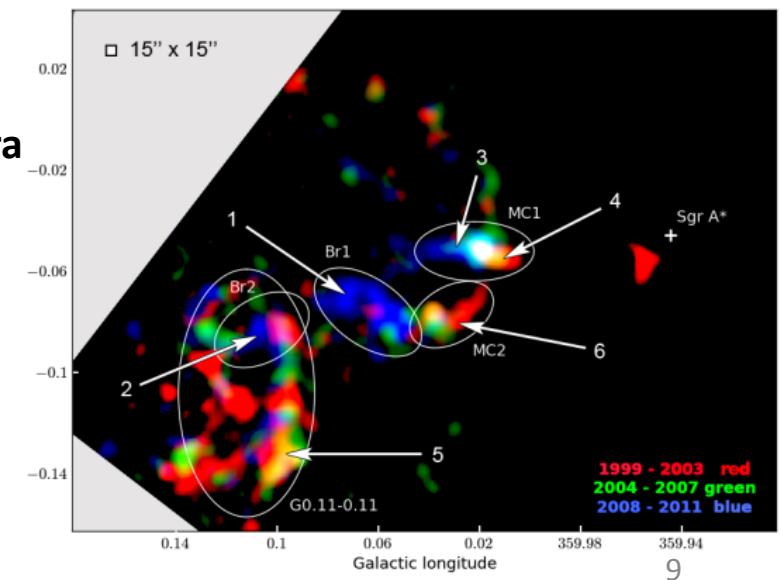
Crucial science linking local SMBH to AGN and galaxy evolution

Terrier et al 2010, Ponti et al. 2010, Clavel et al. 2013, Soldi et al. 2014

“Fait marquant” INSU prospective

20/11/17

HEA group - CS APC

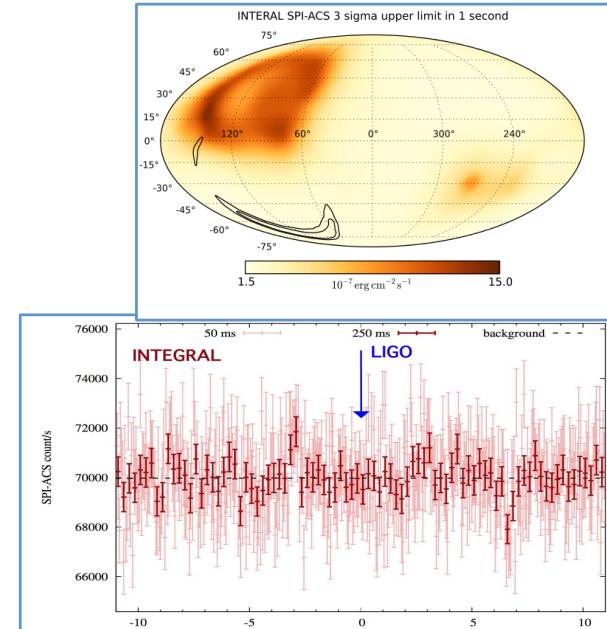


# Transverse AHE activities Multi-messenger strategy for Gravitational Waves(I)

## INTEGRAL upper limits on gamma-ray emission associated with the gravitational wave event GW150914

- Using the INTEGRAL/SPI-ACS (anti-coïncidence system of the SPI telescope)
- Quasi omni-directional view of the sky and is currently used to detect GRBs.
- Constrain the fraction of  $\gamma$ -ray energy for the full high-probability sky region of the LIGO trigger.
- $F \leq 2 \cdot 10^{-8} - 10^{-6}$  erg cm $^{-2}$  between 75 keV and 2 MeV
- $E\gamma/E_{GW} < 10^{-6}$ : Confirmation of the black hole – black hole merging model, not supposed to emit high  $\gamma$ -ray flux

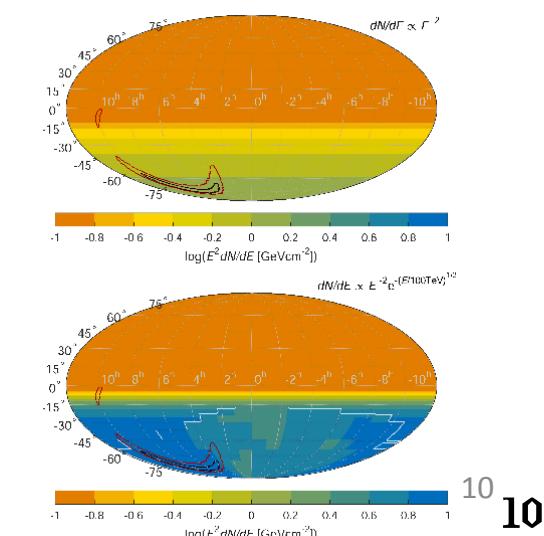
*V. Savchenko et al. (ApJ, 820, L36, 2016)*



## High-energy Neutrino follow-up search of Gravitational Wave Event GW150914 with ANTARES and IceCube

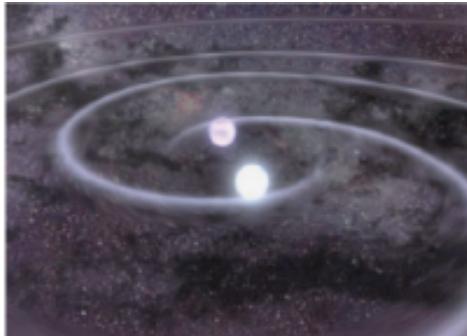
- No Antares neutrino candidate temporally coincident with GW150914.
- For IceCube, none of the three neutrino candidates temporally coincident with GW150914 were compatible with the GW direction at 90% CL.
- Non-detection consistent with the expectation from a binary black hole merger.

*arXiv:1602.05411v2 (3 March 2016 )*



# Transverse AHE activities Multi-messenger strategy for Gravitational Waves (II)

August 2017 :  
First NS/NS merger never detected with  
gravitational waves : GW170817



LIGO Laser Interferometer Gravitational-Wave Observatory Supported by the National Science Foundation Operated by Caltech and MIT

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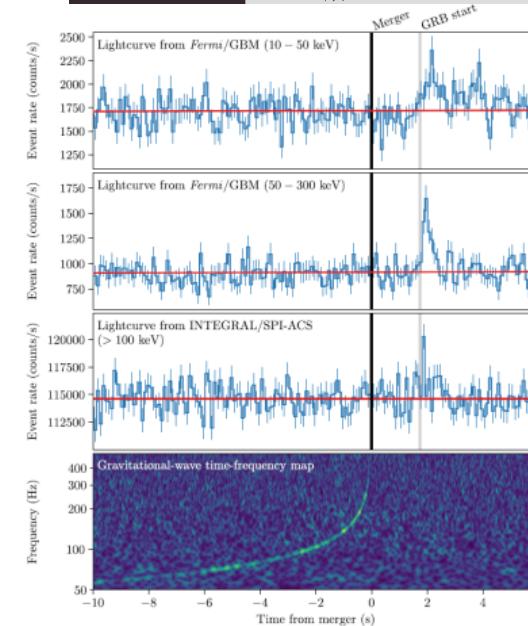
Use LIGO Data LIGO's Impact on Science LIGO R&D Detection Papers Collaborate All Publications

Detection Papers GW170817 Discovery paper

- GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral (open access) Published in *Phys. Rev. Lett.* 119, 161101 (2017)
- GW170817 Data Release

Related papers

- Multi-Messenger Observations of a Binary Neutron Star Merger (open access) Published in *Astrophys. J. Lett.*
- Gravitational Waves and Gamma-Rays from a Binary Neutron Star Merger: GW170817 and GRB170817A (open access) Published in *Astrophys. J. Lett.*
- A Gravitational-Wave Standard Siren Measurement of the Hubble Constant Published in *Nature*
- Estimating the Contribution of Dynamical Ejecta in the Kilonova Associated with GW170817 Accepted by *Astrophys. J. Lett.*
- GW170817: Implications for the Stochastic Gravitational-Wave Background from Compact Binary Coalescences Submitted to *Phys. Rev. Lett.*
- On the Progenitor of the Binary Neutron Star Merger GW170817 Accepted by *Astrophys. J. Lett.*
- Search for High-energy Neutrinos from Binary Neutron Star Merger GW170817 with ANTARES, IceCube, and the Pierre Auger Observatory (authored by the ANTARES, IceCube, Pierre Auger, LIGO Scientific, and Virgo Collaborations) Submitted to *Astrophys. J. Lett.*



## INTEGRAL

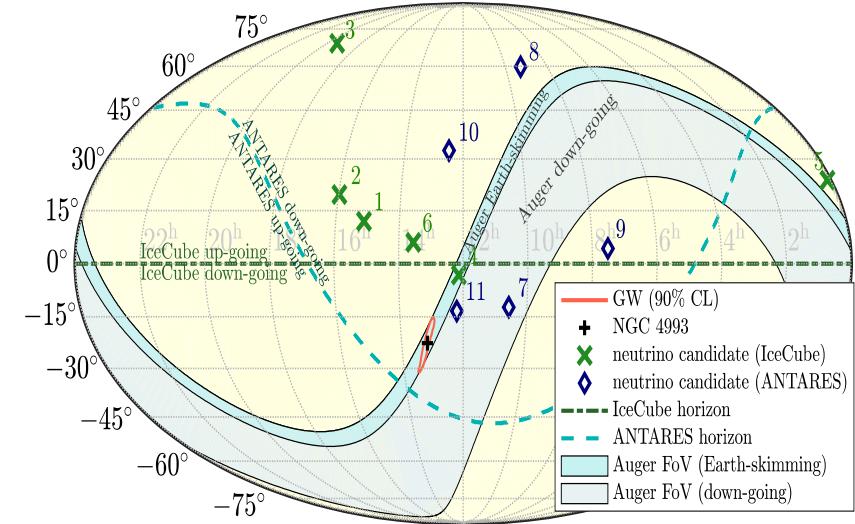
- Detection of the gamma-ray counterpart of GW170817 together with the Fermi GBM (**GRB 170817a, short GRB**).  
(*Savchenko, Laurent et al 2017*)

# Transverse AHE activities Multi-messenger strategy for Gravitational Waves (II)

## ANTARES:

- Dedicated neutrino paper on follow-up ANTARES
- +IceCube + Auger: *APC analysis*

*ANTARES, IceCube, Pierre Auger, LIGO Scientific and Virgo Collaborations, under review ApJL(2017)*

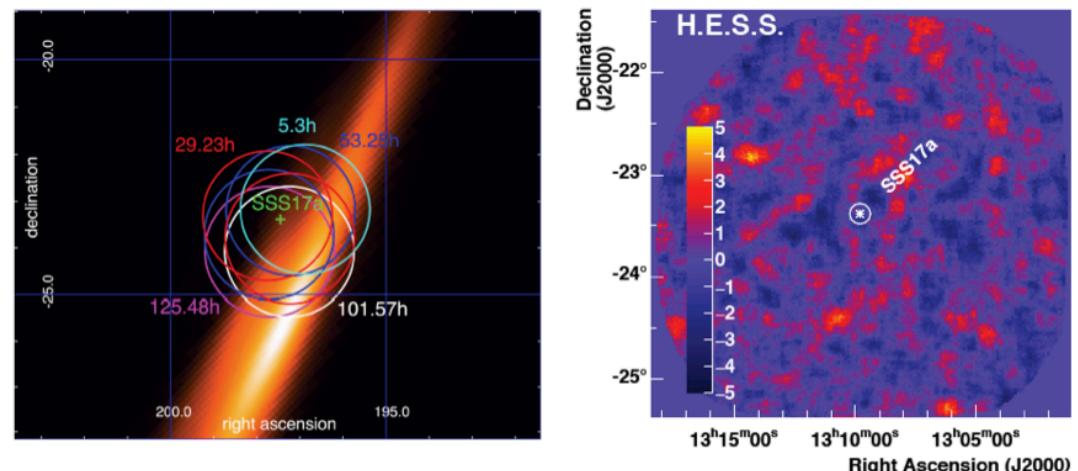


Optimal visibility for Auger Observatory (Earth-Skimming)  
Above horizon for ANTARES and IceCube (down-going events)

## HESS :

- First ground telescope to GW170817 at to+5h. Upper limit for the first night.
- Monitoring during the next days : Total of 5 h of observations

*TeV Gamma-ray Observations of the Binary neutron star merger G170817 with H.E.S.S.. (HESS Collab 2017)*

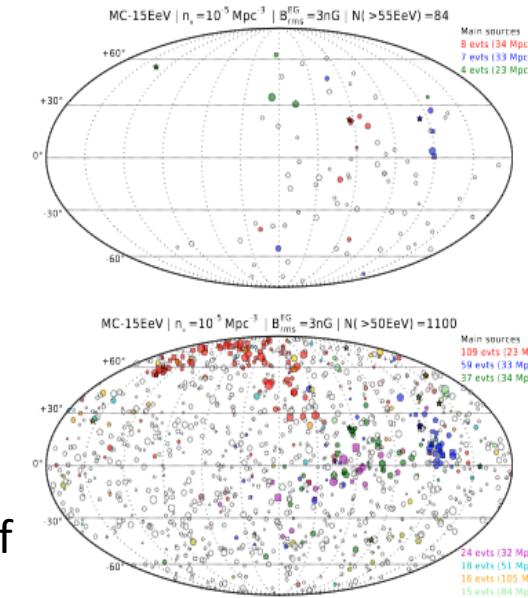


# The AHE theoretical activities

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- **Modeling of UHECR acceleration and propagation :**

- UHECR acceleration at GRB internal shocks  
Including secondary gamma-rays and neutrinos
- Preparation of JEM-EUSO science case  
Collab. with ANTARES groups in APC and within  
Paris-Oxford-Hamburg research training network.



Examples of sky maps corresponding to a given model simulated for the current statistics of Auger and for the expected statistics that JEM-EUSO (Eth=50EeV) would gather with a total exposure of 300000 km<sup>2</sup> sr yr.

- **Galactic sources of cosmic rays.**

Time dependent acceleration and escape, propagation of CR in both turbulent and regular galactic magnetic Field.

- Calculations of secondary gamma-ray and neutrino fluxes.
- Molecular clouds illuminations. Comparison with HESS/CTA obs.
- Low energy cosmic-ray including H3+ results

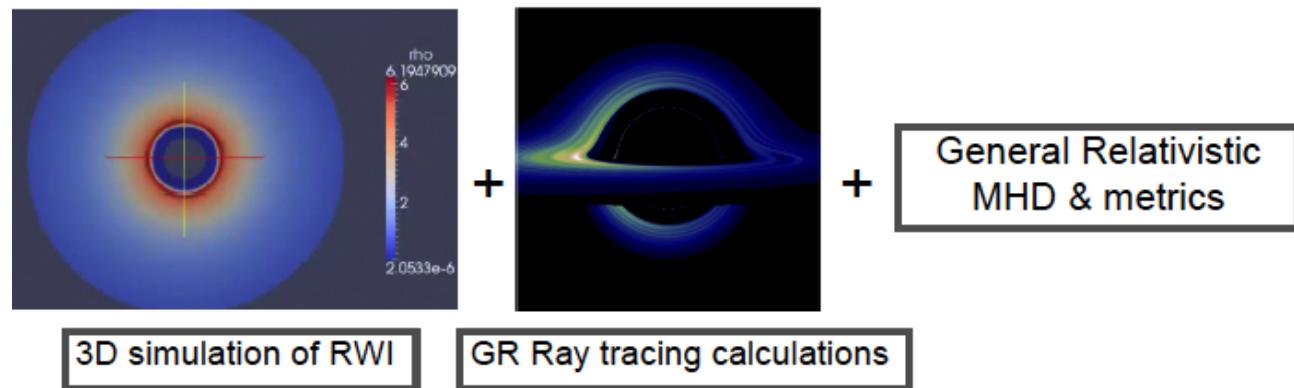
- **Theoretical modeling of gamma-ray sources, using Fermi and HESS data at the same time.**

- Study of the intergalactic magnetic fields and infrared background with gamma-ray data.
- PWN time-dependant modeling

# AHE numerical simulation activities

- **Temporal variability from compact objects**

Development of a toolkit to study compact objects multi-wavelength emission



*microquasars, galactic center, AGN and the iron lines...*

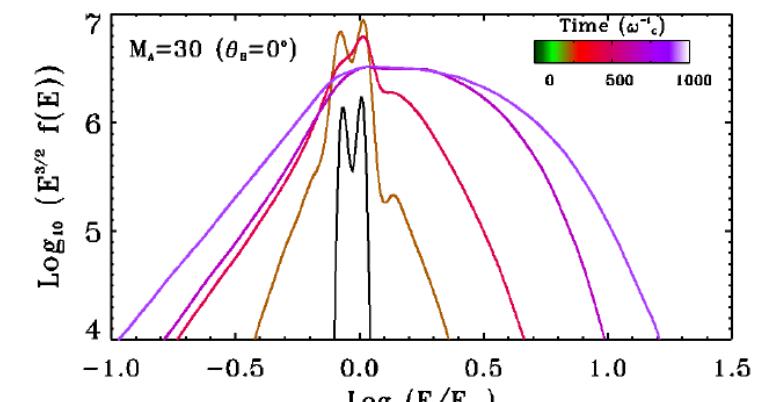
- **GRBs, Cosmic-Rays and HE emission**

Development of a hybrid code (RMHD +PiC) for ultra-relativistic jets (*funded by ANR : 2015-2017*)

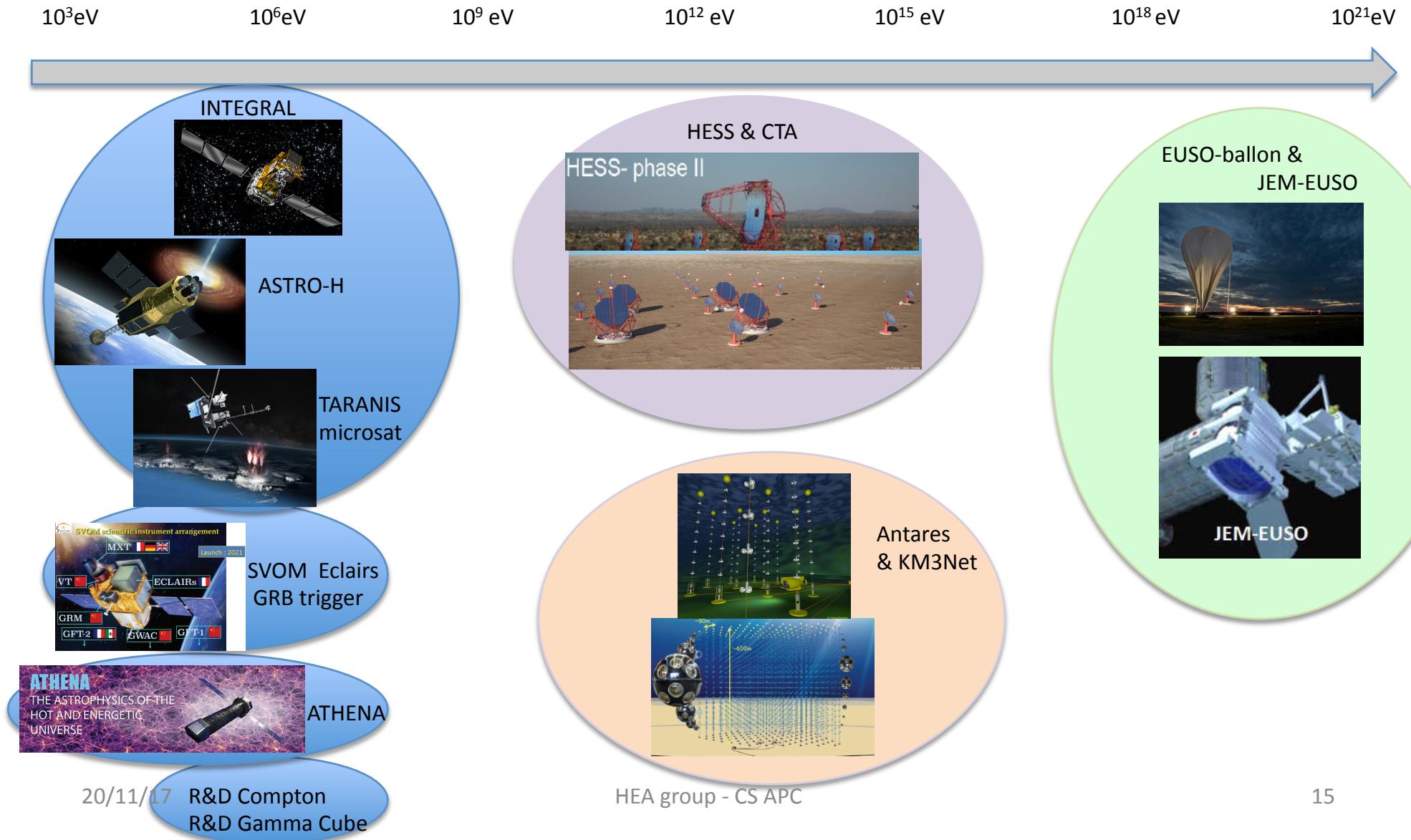
- including description of micro-turbulence in the shocks
- Designed for GRB observations in future X/ $\gamma$  missions

First step archived : particle acceleration and magnetic amplification around parallel chocs at 1D

Next step : Full 3D simulation



# Teams & Projets



# Soft gamma-rays :INTEGRAL

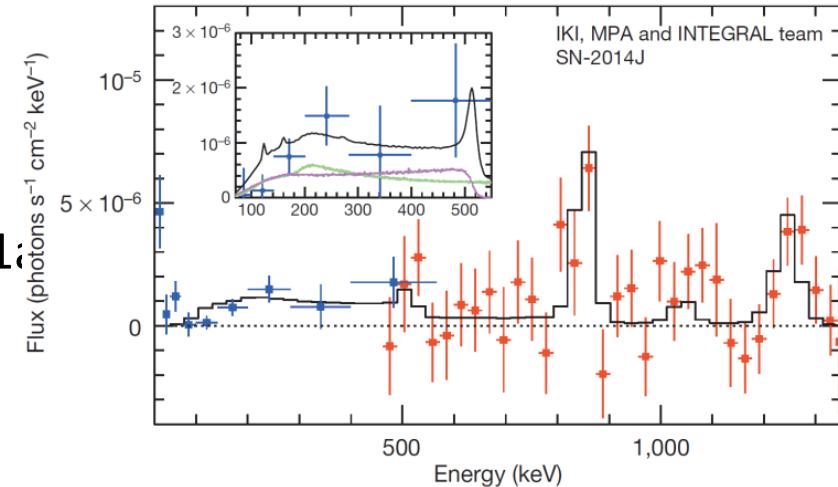
## APC participation and timeline :

- 2<sup>nd</sup> Medium size mission of the ESA horizon 2000 program (*launched 2006*)
- Mission extended to end 2018 (maybe up to 2020)
- Observatory dedicated to gamma-ray astro (3keV-10MeV)
- APC responsible of the in-flight maintenance for the CdTe camera ISGRI, its calibration and its S/W maintenance



## Few science results:

- 2014:  
first detection of the  $^{56}\text{Co}$  lines from a SN1a  
*Churazov et al., 2014, Nature, 512, 406*

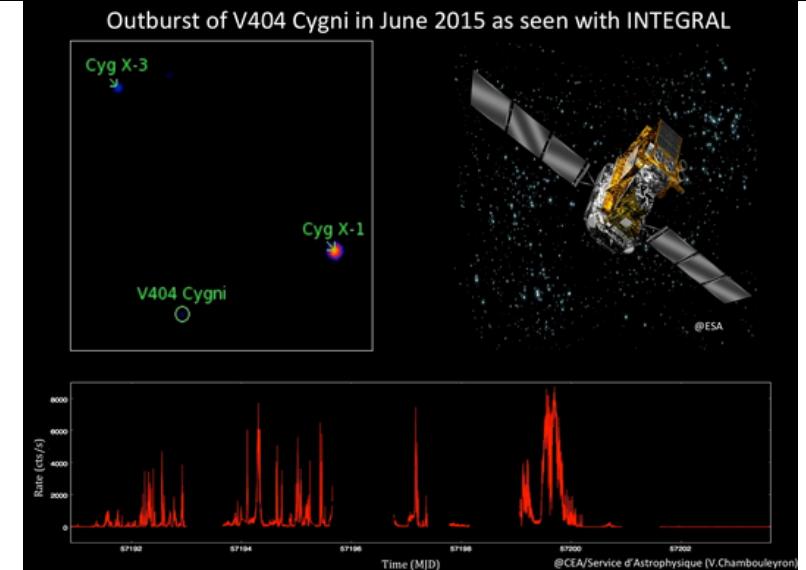


# Soft gamma-rays :INTEGRAL

## Few Science Results:

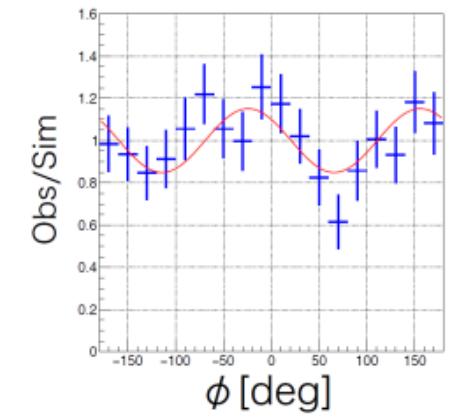
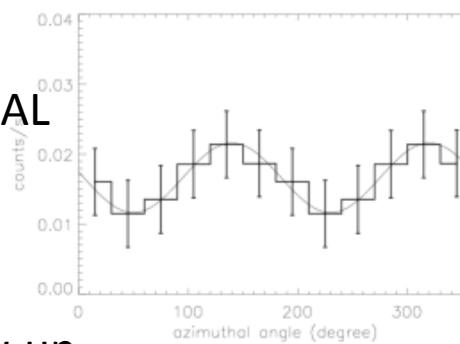
**2015 :**

- Spectral and temporal study of the nova V404 Cygni.
- Emission line detection at 511 keV from V404 Cygni.
- Polarization evolution in Cygnus X-1  $\gamma$  emission with the black hole spectral state.



**2015-2018 :**

- $\gamma$ /optic polarization study of the Crab pulsar and Nebula
- polarization study of the Crab pulsar by INTEGRAL and Hitomi/SGD



**2017 :**

- First short GRB associated with GW, GW follow-up observations.

# Hard X-rays: ASTRO-H

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- Japanese satellite
- Focusing hard X-ray telescope (0.3 to 600 keV)
- 3 French Co-Is : O. Limousin (AIM), F. Lebrun (APC), P. Laurent (APC).
- **Successfully launched the 17 Feb 2016.**
- BUT : Joint Space Operations Center reported that telescope separated into multiple pieces on Saturday 26 March.  
Since then:satellite lost, **project stopped**



## APC participation :

- Procurement, test and delivery to JAXA of BGO detectors for the anticoincidence system of the HXI and SGD instruments of Hitomi
- Supplied the in-flight calibration sources of the ASTRO-H high energy telescopes (HXI and SGD) (jointly with CEA). *Allow to continuously calibrate these detectors.*
  - **Data analysis :** (P. Laurent + D.Maier (post-doc 2015-2017))  
Calibration and Gamma-ray polarization analysis on existing Crab data

# Hard X-rays- Soft gamma: TARANIS

CNES microsatellite dedicated to the study of the transient phenomena in the atmosphere above stormy regions

**XGRE:** X, Gamma-ray and Relativistic Electrons detector

## **APC responsible for the development of XGRE**

- first complete space instrument developed in APC
- fastest space gamma-ray detector (350 ns dead time; 10 times faster than Fermi/GBM)

### • Timeline :

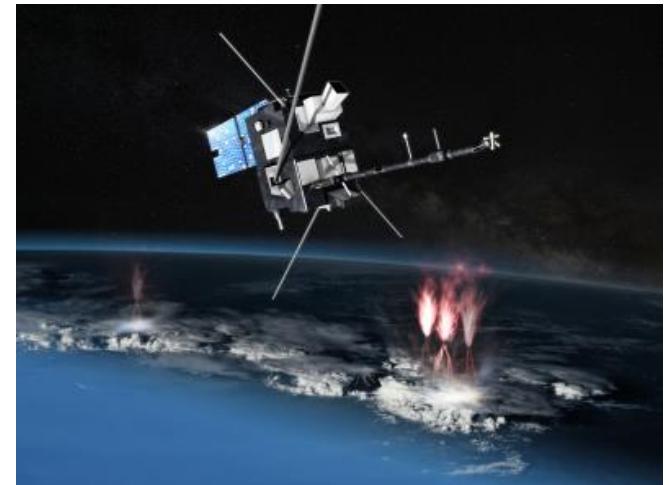
2018 :Fabrication of the UD FM and three XGRE FM

April 2018 : XGRE sensors calibration

July 2018: Delivery to CNES.

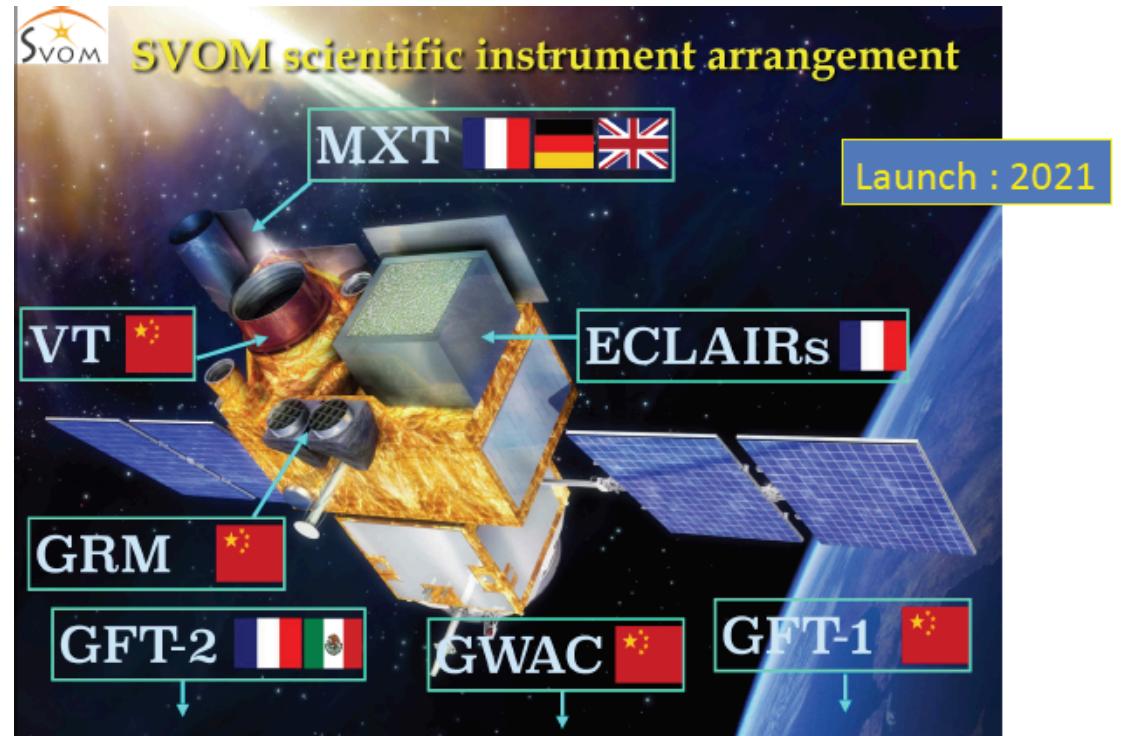
Sept 2019 :launch.

2019-2021 : Data analysis (P.Laurent + post-docs CNES)



# SVOM: a GRB mission

- GRBs in the distant Universe
- Wide field imager in X/hard X-rays
- Mission approved by CNES/CNSA in summer 2014.
- Tight schedule for a launch in 2021
  - 2015-2016 : preparation
  - 2017-2020 : development
  - 2021- : operation



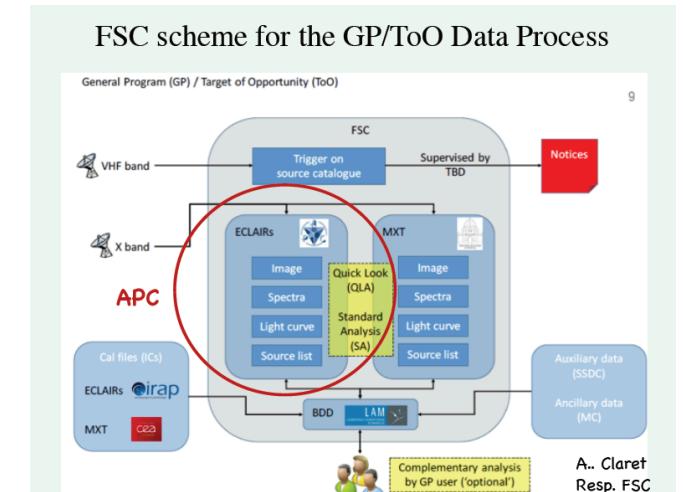
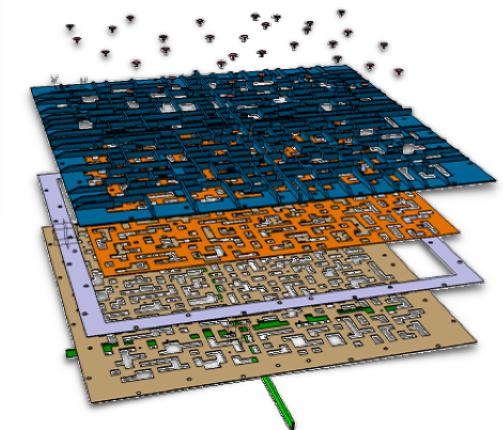
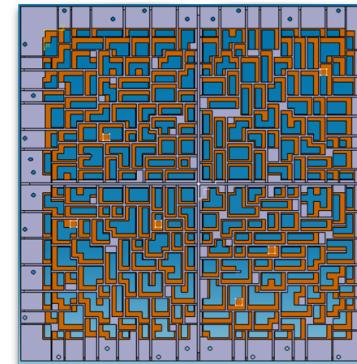
## Science fits well within APC perimeter :

- Non-GRB science group (resp A.Goldwurm) : GP
  - AGNs, Ultra Luminous X-ray sources, Tidal Events, Magnetars, X-ray Binaries
- Multi-messenger science group (resp C.Lachaud) : ToO
  - GW, neutrinos, gamma HE

# SVOM @ APC

**Large involvement of APC technical teams (mechanics & computing)**

- Coded Mask (Givaudan - Lachaud)
  - Responsibility for the development of the Coded mask of the ECLAIR instrument technically challenging
  - Flight model to be delivered in 2019
- Ground Segment (Beckmann - Goldwurm)
  - Responsibility of the ECLAIRs analysis pipeline :  
(A. Goldwurm, C.Lachaud + J.M.Colley, C. Cavet+ 2 CNES FTE  
2017-2019 : Development  
2020 :Delivery
  - Responsible for Mission documents for the SIR (System and Interface Review)



# Future X-rays mission: Athena

- ESA Cosmic Vision Large (L2) Space Mission

- **Large X-ray (0.1 – 12 keV) Observatory :**

~ 2 m<sup>2</sup> effective area, angular res. of 5'', FoV up to 30' and exceptional energy resolution of 2.5 eV,

- **Timeline :**

- APC joined Athena consortium in Feb-Mar 2014
- Athena Concept approved by ESA in June 2014
- Extension de la Phase A jusqu'à 2019
- Lancement 2028 -> 2030

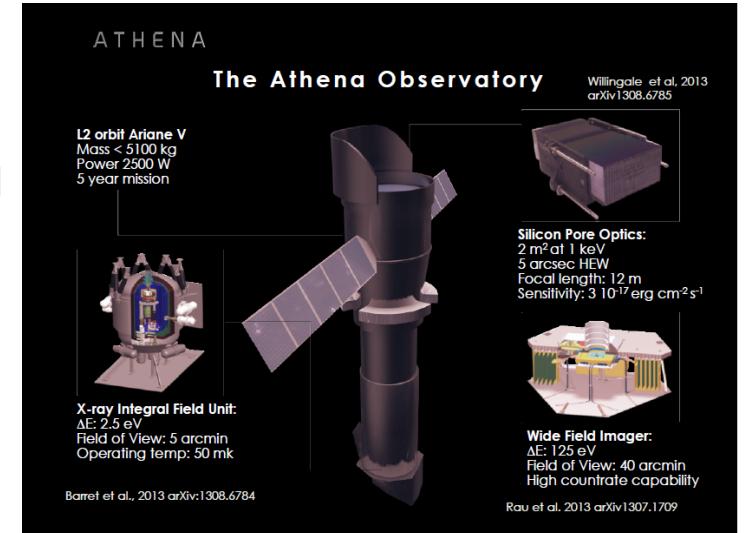
- **APC Participation :** (A. Goldwurm “Referent Physicist”, R.Terrier , S. Gabici , P.Laurent, P. Varniere)

- X-IFU (Spectrometer) Warm Front End Electronics (part of readout electronic chain): provision of the whole system : ASIC realization and tests and interfaces definition in good progress

- X-IFU background Simulation

- Possible futur implication : Athena Science Ground Segment with the FAcCe

**It exploits the H/W & S/W Expertise and Facilities of APC**



# Space Gamma-ray Telescopes (1-100 MeV)

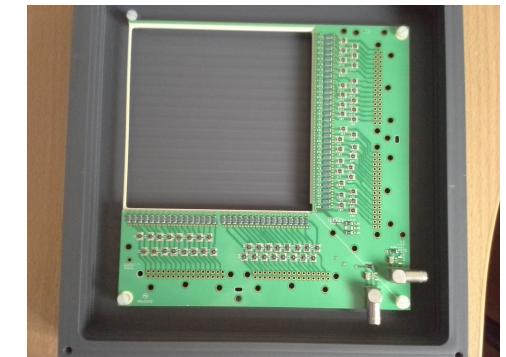
## R&D :

- Si DSSDs (Double Side Stripped Silicon Detectors) tracker

(funded by CNES and Labex UnivEarthS)

2015 :

- Development of test bench MUSSETT at APC
- DSSD integration into hybrid PCB
- Development of numerical readout card for ASIC IDefX



2016 :

- Validation of the DSSDs spectroscopic performances with the ASIC IDefX
- Design and test of first COMPTON mini camera (COCOTE)

- Gamma Cube: 3D imaging scintillating tracks thanks to microlens array

readout on SPAD arrays

- GEANT4 model and reconstruction methods

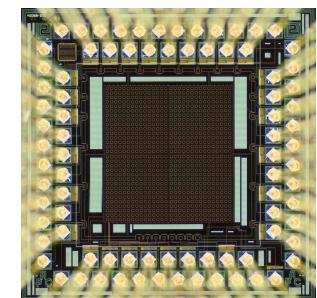
Estimations of localisation performances Lebrun et al. 2014

- Design of a prototype imager in CMOS

2016 : SATT supports the « prematuration program» : (50 k€/ 6 months)

application to a medical gamma camera (convince industrial partners)

2017 : stop of the project because no technical forces available



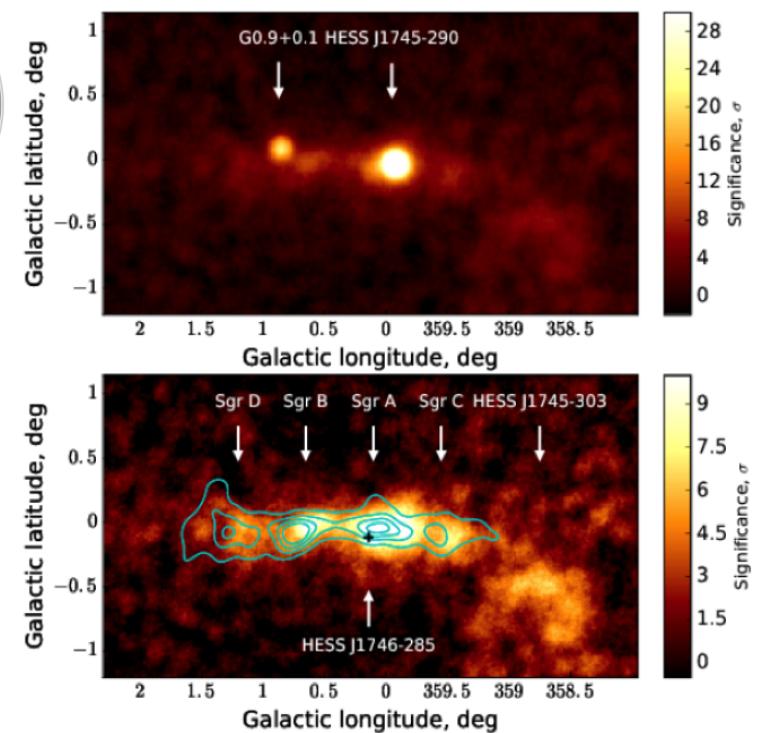
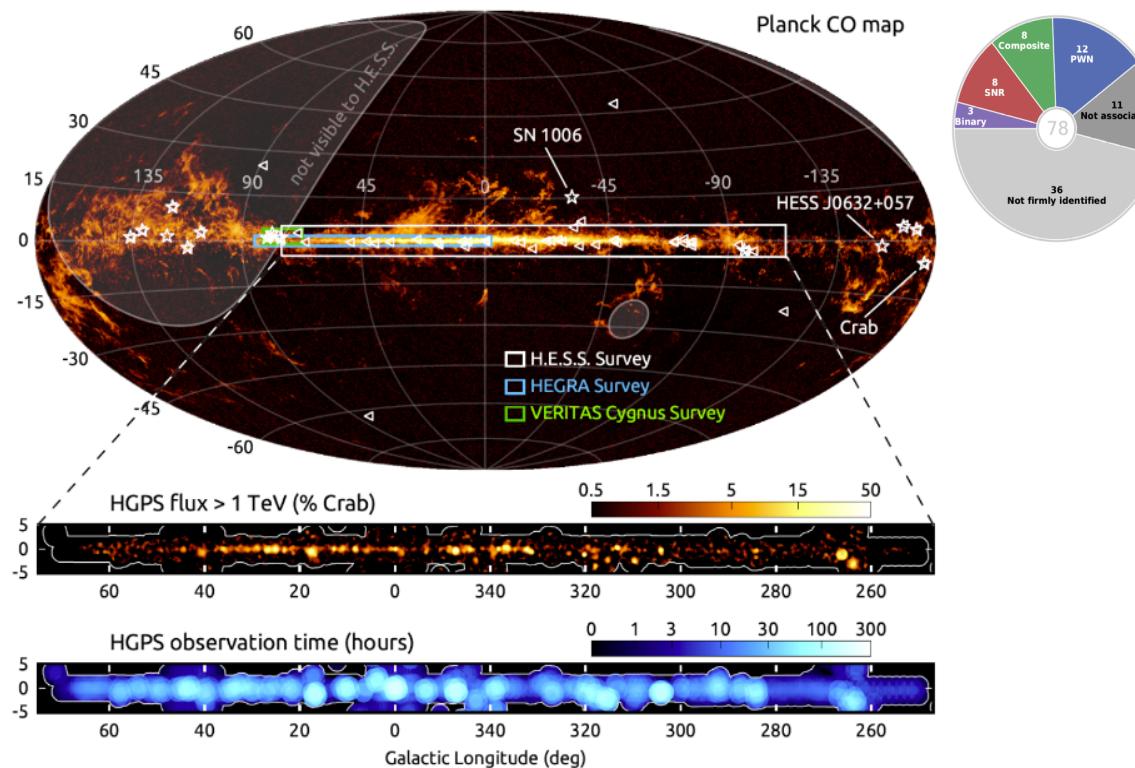
# VHE gamma-rays : HESS-I

## APC activities on HESS I :

Préparation of the HESSLegacy :

- HESS-I Legacy Survey : 3000h of data, 78 sources + diffuse emission
- SNR pop studies, PWN pop studies
- Galactic center

*Special Edition A&A End 2017 (14 articles submitted, 10 accepted, 4 en review, Public Data Release in prep)*



# VHE gamma-rays : HESS-II

**HESS-II** : add 5th telescope

(28 m diameter, camera 2000 pixels)

- Reduce E threshold :  $100\text{GeV} \rightarrow 30\text{ GeV}$
- In operation since 09/2012



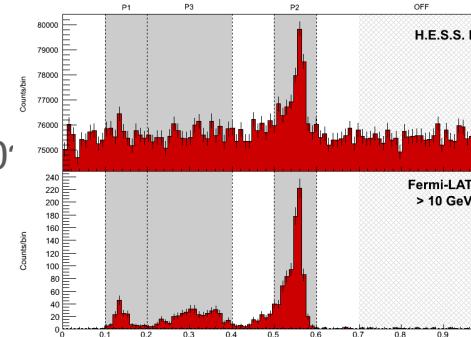
**APC implication in HESS II** : Data analysis on mono-telescope mode and stereo-telescopes mode :

- Spectral analysis of AGNs:

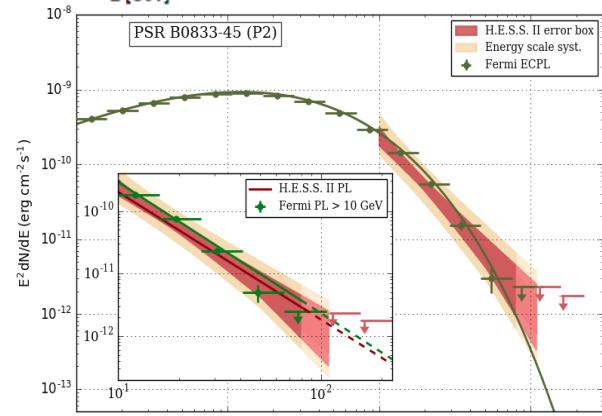
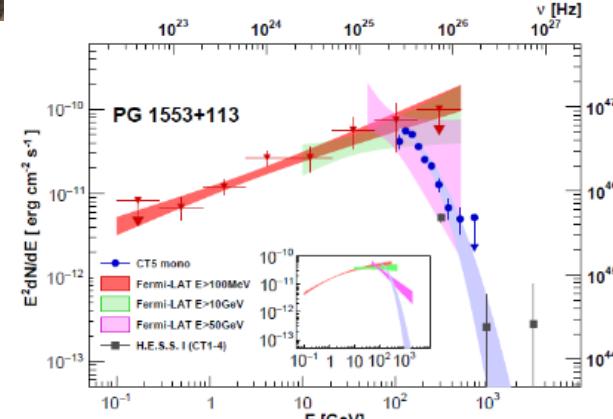
First Analysis of HE-VHE Blazar Spectra with H.E.S.S.  
II: PKS 2155-304 and PG 1553+113 (*published*)

- Discovery of the pulsed HE emission of the Vela pulsar:

First Ground-based Measurement of Sub-20' gamma-rays from the Vela Pulsar with H.E.S.S. II (*submitted*)



HEA group - CS APC



25

# VHE gamma-rays: CTA

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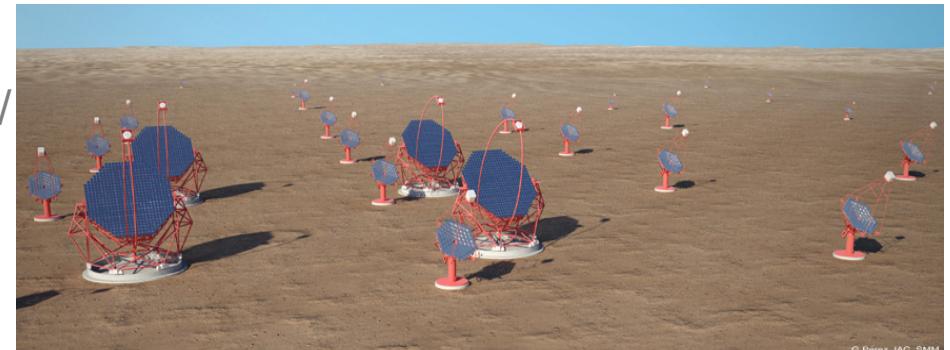
- Next generation high sensitivity Cerenkov telescope array :

- **Timeline:**

2016: CDR CTA International/ TGIR CTA /  
« Founding agreement »

2019: production phase

2023 : ~ full array



## APC implications :

- **Central Trigger/Clock distribution (TDC): Simulation and design optimization :**

- MUTIN system developed at APC (P2I & GATE (IN2P3+région) funding)
- CTA choice defaulted: "White Rabbit" (WR) protocol from CERN (open hardware):
- Successfull reorientation GATE -> White Rabbit

Competition with White Rabbit ZEN (GRAPPA)

More flexibility but more expensive

# VHE gamma-rays: CTA

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- **Data WP:**

- Conception (contribution to the Use Cases)
- Former participation to reconstruction
- Now strong participation to the high level data analysis :
  - First 3D analysis with bkg model within gammaPy (L.Jouvin pdh)
  - Participation to the data challenge, development of physics simulation tools
  - Taking responsibilities on high level analysis for CTA(gammaPy)
- Proposal handling platform accessible via the CTA web portal (resp B.Khelifi)
  - Contribution in-kind from APC to CTA. Most of the effort in IT (~65%)

- **Science WP:**

- Co-coordination of the preparatory phase, contribution to the key science projects: done
- Continue science and analysis preparation :
  - Catalog Gal/Extra-Gal (BK,PG,RT,AL,AD,SP)
  - GC (RT, AL)
  - Pulsars (AD)
  - Galactic physics, Diffuse Emission, SNRS, PWNe, Pevatrons (BK,RT,AL,DS)
  - AGN : Pop, Redshift détermination, EBL (S.Pita, P.Goldoni, D. Semikoz)

# AHE neutrinos : Antares

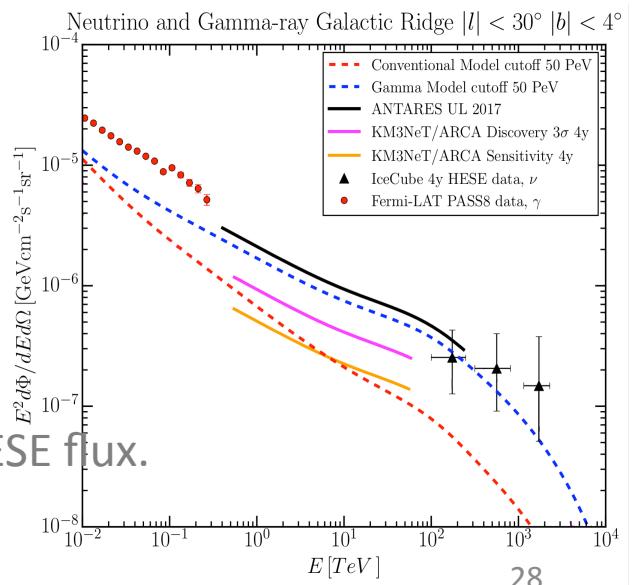
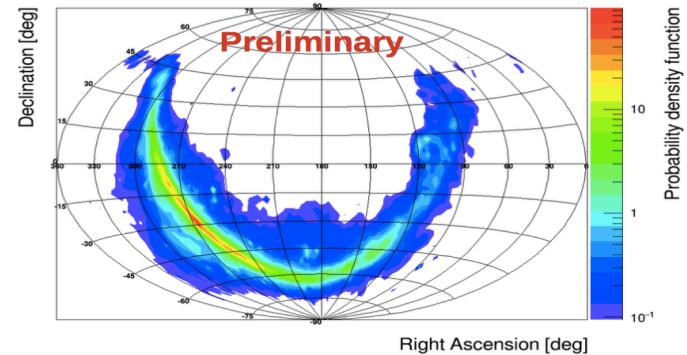
- Deep-sea VHE neutrino telescope
- Timeline: Complete since 2008, running until end 2018
- APC Activities : (*A.K spokesman since 2014*)

## Hardware :

- Front-End electronics calibration, Data Quality monitoring,
- Optical sensor measurements :  
(responsabilities : Data quality(V.VE),CalibrationB.B)

## Analysis : (B. Baret,T. Grégoire, A. Kouchner, V. Van Elewyck)

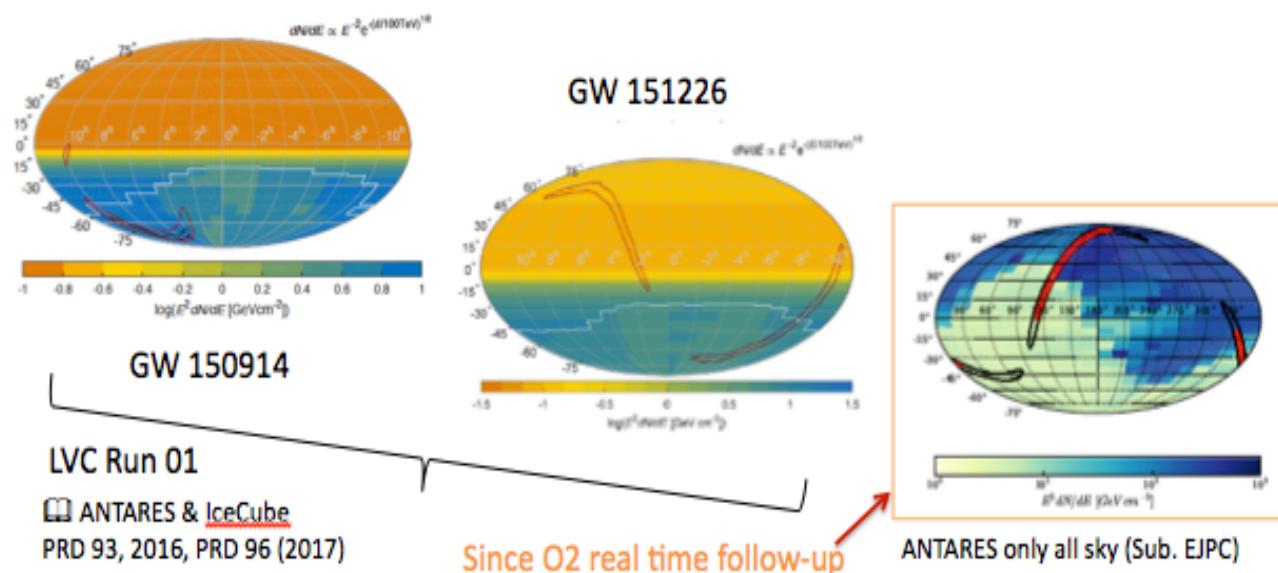
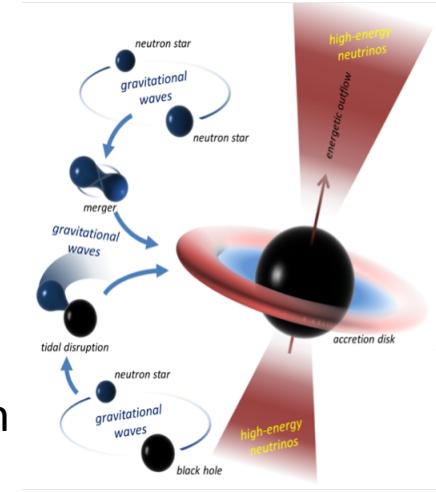
- Search for Cosmic neutrinos in the Galaxy :
  - Limit on Fermi Bubbles and Galactic center signal
  - Emission from the Galactic Plane Ridge:  
Galactic emission contributes max 18% of IceCube HESE flux.



# AHE neutrinos : Antares

## Search for Cosmic neutrinos outside of the Galaxy : mulit-messengers studies

- GWHEN : *first joint search for HE neutrinos and gravitational waves(LIGO/VIRGO)*
- Search for *neutrinos and UHERCs from GRBs*
- *Gravitational lenses, time/space correlations ...*
- Follow-up observations of Gravitational waves Events recently seen by LIGO/VIRGO



# VHE neutrinos: KM3NeT

- KM3Net : infrastructure with 2 main physics topics :

Low -Energy studies of atmospheric neutrinos : **ORCA**

High-Energy search for cosmic neutrinos: **ARCA**

- **Futur and perspectives :**

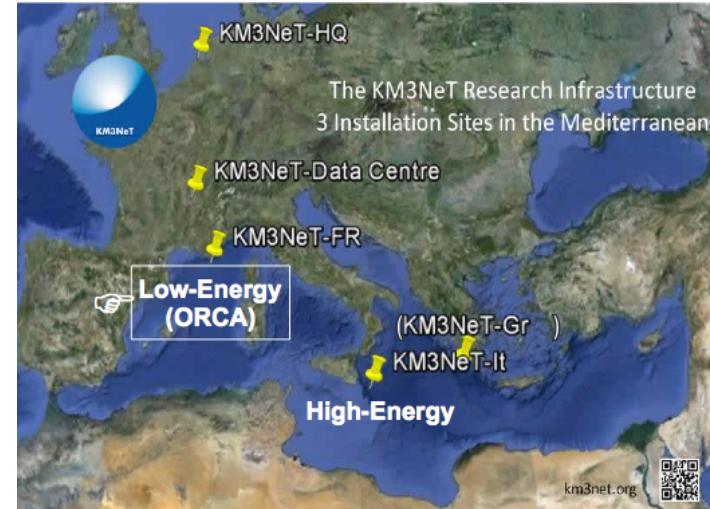
Keep an activity on both ARCA / ORCA

- **Technical implication in ORCA:**

- Design and construction of the first calibration unit
- Test benches for characterization of Digital Optical modules
- Possible involvement in container assembly

- **Data analysis ARCA/ORCA**

- Galactic Plane , GC , Fermi Bulles de Fermi
- Neutrino oscillation tomography of the Earth (see *A.Kouchner talk*)
- Sensitivity to supernovae detection
- multi-messengers analysis and GW and GRBs follow-up



September: Deployment of first ORCA line @ Toulon site.  
Data taking ongoing... first neutrinos seen  
<sub>30</sub>

# UHECR: Euso-Ballon & X-EUSO

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- **Definition and goal of the mission:**

- Wide field UV telescope operating from the ISS
- Space based detection of UHECRs, through the fluorescence light of the induced showers



- **Main highlight :**

- successful flight of the EUSO-Balloon pathfinder, funded by CNES (Aug. 2014): 1 PDM (photo-detection module) on a stratospheric balloon
- EUSO SPB : APC responsible for the development, integration tests and calibration of the instrument focal surface  
Launched in April 2017, data analysis in progress



- **APC activities :**

- R&D Photodetection, calibration
- Science case preparation, modelling
- Simulations & data analysis
- French PI at APC & EUSO-balloon project manager at APC/ Member of the speaker's bureau

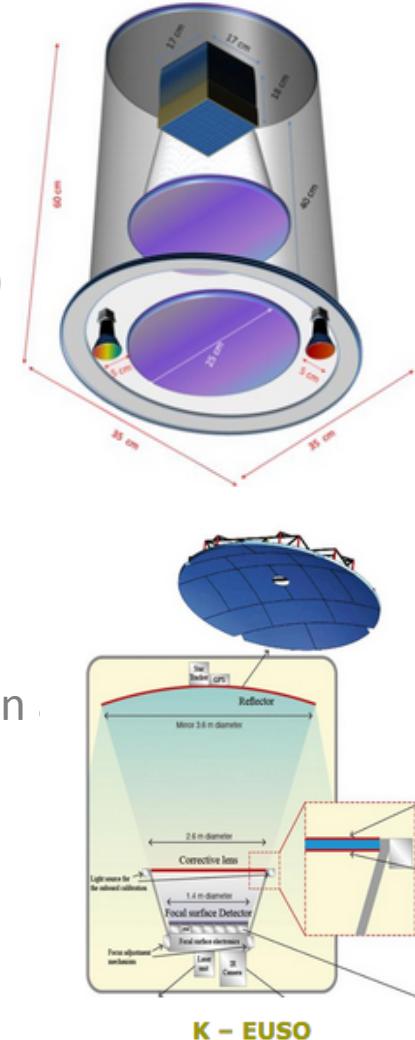
# UHECR: Euso-Ballon & X-EUSO

- Future Timeline:

**mini EUSO (ASI +ROSCOSMOS):**

Launch end 2018/ data in 2019

1 PDM onboard the ISS (*approved by ROSCOSMOS and ASI, 2017*)



**-SPB2 (NASA) le pathfinder of POEMMA & K-EUSO :**

August 2017 : sélection & founding by NASA (2018-2022)

2021/2022 : long flight

**- K-EUSO : projet Russe sur l'ISS (équivalent à 4 X AUGER)**

Launch 2022 (electronic similar to mini EUSO but with ASICs integration)

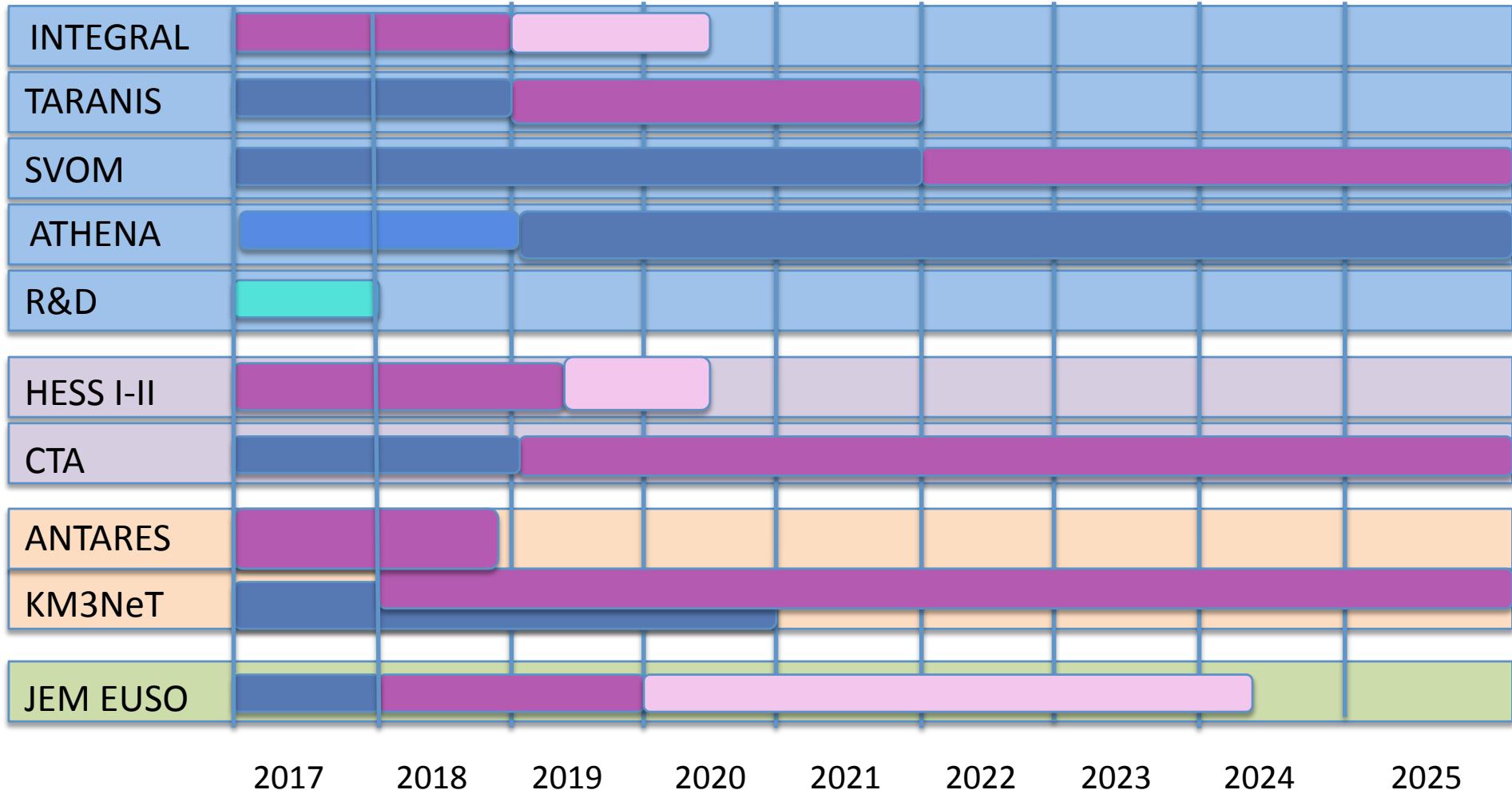
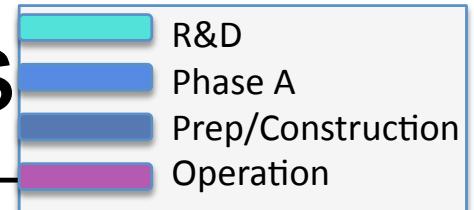
**- POEMMA (NASA):**

2017: selection as « Probe study »for the next NASA decadal survey

Science case multi-messengers directe

2017-2030 if final selection

# Timeline of the Projects



# SWOT

## SWOT analysis

Strengths	Weaknesses
<ul style="list-style-type: none"><li>• Unique multi-wavelength and multi-messengers environment allowing to:<ul style="list-style-type: none"><li>◦ build a strategy for coordinate follow up observations of transient objects and gravitational waves.</li><li>◦ lead joint analysis between several projects</li><li>◦ have a global view of the astrophysical processes and objects.</li></ul></li><li>• Strong scientific recognition and high visibility</li><li>• Guaranteed funding of most of the futur projects in which the group is involved (CTA, KM3Net, SVOM, ATHENA, TARANIS).</li></ul>	<ul style="list-style-type: none"><li>• Given the limited ressources, it is difficult to conciliate a strong participation in key experiments and a significative involvement in multi-messenger programs at the same time.</li></ul>
Opportunities	Threats
<ul style="list-style-type: none"><li>• The large discovery potential of the new generation of large Observatory (CTA,KM3Net) and Space projects (SVOM, TARANIS, ATHENA, JEM-EUSO) in which the HEA team is involved.</li><li>• The maturity of the next generation of gravitational waves and cosmic neutrinos detectors that makes possible a real multi-messenger astrophysics.</li></ul>	<ul style="list-style-type: none"><li>• Recent departure or retirement of several group members involved in the field of X-ray and MeV photons have not been replaced yet. It fragilizes this axis even though is plays a central role in our multi-messenger strategy.</li><li>• The prevalence of Astrophysical questions in our field places the HEA team in a marginal position within the IN2P3, while we are neither sufficiently recognized within the INSU.</li><li>• The large Observatory CTA and KM3Net are funded for the construction phase but not for the operation phase : it represents a real threat of a lack of support for our analysis and scientific activities within the next years.</li></ul>

# Summary (I)

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- **X-rays :**
  - Large program of GC data analysis: perspectives linked to the futur of X-ray missions.
  - Involvement in ATHENA (since spring 2014) : launch ~ 2028-2030  
Strong H/w and S/w involvement
  - ASTRO-H : Small contribution, few months of operation in 2016.
  - TARANIS : PI-ship involvement, launch in 2019, data analysis 2019-2012
- **$\gamma$ -rays:**
  - SVOM mission start operation in 2021  
Strong technical involvement at APC : hardware & software (strategic responsibilities)  
Physics preparation : responsibility of multi-messengers and GP programs  
*Involvement in data analysis and exploitation will be strategic for the group*
  - Preparation of a future MeV telescope mission (>2025)  
R&D on Si DSSDs and scintillation trackers  
*Effort to gather community on a common proposal/design (AstroMeV)*

# Summary (II)

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- **VHE  $\gamma$ -rays:**

**Strong involvement in software developments and data analysis of HESS data**

**CTA major high-energy observatory in the next decade**

Hardware : APC proposal within White Rabbit: successful reorientation GATE->WR

Software : Proposal handling : large visibility for moderate effort

*First test of the platform March 2018. Tight schedule*

Analysis : Strong involvement in high level tools (gamma-Py)

Physics : strong involvement in Galactic and extra-Galactic groups

- **VHE cosmic neutrinos :**

**Technical and software developments of ANTARES & strong implication in data analysis.**

**KM3Net major neutrino detector in the next decade**

Hardware : implication in ORCA (calibration units, characterization of DOM)

Analysis : strong implication in ORCA/ARCA data analysis

Physics : Supernovae detection, GC, Diffuse emission, multi-messengers and GW.

# Summary (III)

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- **UHECR: JEM-Euso for  $>10^{19}$  eV CR**  
**Strong APC technical involvement**
  - Successful flight of the EUSO-Balloon pathfinder in 2014
  - flight of EUSO SPD in spring 2017 : data analysis in progress
  - Two new flight: SPB2 and mini-EUSO onboard ISS in 2018-2019
  - Future uncertain after 2019 for the field of UHECRs, balance with theoretical activities

# Annex

# Teaching and scientific animation

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- **Teaching:**

- MCF et Professeurs enseignent à l'université P7
- Responsabilité du cours « Astroparticules» au M2 NPAC & MHD au M2 A&A  
R. Terrier(2010-2014), D.Allard (2014-2017), S. Gabicci (2017) / F.Casse
- Chercheurs CNRs : cours en M1 et L1-2-3 à l'université P7
- Nanosatellite (outil pédagogique universitaire et EIDD)

- **Within the laboratory :**

- 2013-2016 : organisation des Colloquium (B. Baret)
- 2016 : organisation conjointe avec le groupe gravitation d'un atelier GW & multi-messagers
- 2017 : organisation conjointe avec le groupe gravitation d'un séminaire général GW & multi-messagers

- **Implication in University life:**

- 4 membres du conseil scientifique de l'UFR (2016)
- 1 membre du conseil des enseignements de l'UFR (2016)
- 4 membres du conseil d'UFR (2016 )
- V. Van elewick : responsabilité L1-L2 de 2012 à 2015.
- Participation à la journée du l'UFR 2017

# Teaching & outreach

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- Outreach:

- Fête de la science avec la participation de R.Terrier, B. Barret, P.Laurent,, A. Lemiere, M.Punch,B.Khelifi
- Bar des Sciences avec la participation de M. Punch
- L'émission autour de la question sur RFI : «pourquoi le neutrino ?» (couplée à un séminaire grand-public au musée des arts et métiers) avec la participation de D. Allard
- A. Kouchner:
  - Relecteur scientifique du livre sur les neutrinos (Auteur : Juan Antonio Caballero – parution le 8 février 2016) dans la collection Cosmologie du Journal Le Monde.
  - Article paru dans « Pour La Science », Février 2016. Un télescope à neutrinos dans la Mer Méditerranée
  - Conférence grand public au Lions Club Paris Concorde, Paris, 26 mars 2015. Les nouveaux messagers de l'Univers
  - Interview pour « Sciences et Avenir » (A. Khalatbari). 25 nov. 201. Des neutrinos cosmiques piégés pour la première fois
  - Interview pour « La Recherche» (J. Bourdet). N° 484, février 2014
- P. Laurent:
  - participation à une vidéo sur Internet simulant la chute d'une capsule spatiale dans le trou noir supergéant situé au centre de la VoieLactée : "Bons baisers de Sagittarius A\*": <https://www.youtube.com/watch?v=wE8HGFg8CIA>
- A. Lemiere:
  - Project "Ballons Cosmiques": 2012-2013. Université P7 / APC/CNRS/CNES: Coaching of seven high school students during one year: building a detector, launching a ballon, analysing data and presenting results.
  - Science & History: Séminaire/débat sur la physique au siècle des lumières Mai 2014 et 2015 Université Paris 7
  - How to teach high energy astrophysics in high school: Palais de la découverte (Mai 2013) Université Paris 7
- S. Loucacos: Un article de vulgarisation dans le magazine allemand Helmholtz Alliance for Astroparticle Physics (HAP)
- E. Parizot:
  - Intervention à la conférence TEDx (Paris 2011): <http://tinyurl.com/tedx-ep>
  - Invité à donner la conférence de vulgarisation annuelle du Dublin Institute for Advanced Studies en 2014 (au Trinity College, Dublin)
  - Multiples interventions dans les médias: Hebdomadaire « Le Point », L'Obs (Le Plus), France TV info , Le Point .

# Scientific responsibilities

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## ANTARES, KM3Net

- Spokesperson (A. Kouchner) ANTARES
- Responsible of the Astronomy working group (~60 people, largest of the collaboration, divided into 4 subgroups): since 2008 (A. Kouchner)
- Responsible of the data quality (V. van Elewyck)
- Responsible of the working groups "Charge and Energy Calibration" and "Point-like sources" (up to 2008) (A. Kouchner)
- Coordination of the DAQ Front End Electronics Calibration group (since 2006) (A. Kouchner, then B. Barret)
- Member of the Steering Committee of the collaboration (since 2008) (A. Kouchner, B. Barret)
- Member of the collaboration's Publication Committee (since 2011) (A. Kouchner, B. Barret)

## HESS, HESS-2, CTA

- Deputy-spokesman of the HESS collaboration (M. Punch)
- Coordination of the HESS AGN working group (M. Punch)
- Responsibility of the Quality workpackage of CTA (HEA team, M. Punch)
- Participation to the CTA Science workpackage:  
Responsibility of the SNR and Molecular Clouds working group (S. Gabici)  
Responsibility of the reconstruction in the Data working group (A. Djannati-Atai)  
Co-responsibility of the advanced analysis methods working group (A. Djannati-Atai)

## INTEGRAL

- Co-PI of the IBIS instrument and permanent member of the INTEGRAL User Group (F. Lebrun)
- Participation to the INTEGRAL User Group (→ 2009) (A. Goldwurm)
- Member of the Time Allocation Committee (2009-2010) (R. Terrier)

## JEM-EUSO and EUSO-Balloon

- Initiator of the French participation to the mission and National PI of JEM-EUSO (E. Parizot)
- Member of the Executive Committee of JEM-EUSO (E. Parizot)
- Deputy European Coordinator of JEM-EUSO (E. Parizot)
- International Project manager of the EUSO-Balloon mission (funded by CNES) (G. Prévôt, physicien référent: E. Parizot)
- Responsible of the calibration workpackage for JEM-EUSO and EUSO-Ballon (P. Gorodetzky)

## SVOM/ECLAIRs

- Responsibility of the coded mask of the main instrument (ECLAIRs) (C. Lachaud)
- Responsibility of the General program (A. Goldwurm)
- Responsibility of the Too program and multi-messengers (C. Lachaud)

## TARANIS/XGRE

- Co-PI of the XGRE instrument (F. Lebrun, P. Laurent)
- Project manager (C. Olivetto)

# The HEA group

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- **24 staff researchers**

Allard Denis (CR1)

Baret Bruny (CR1)

Djannati-Atai Arache (DR) (HDR)

Gabici Stefano (CR1) (HDR)

Khélifi Bruno (CR1)

Lemière Anne (CR1)

Pita Santiago (CR1)

Punch Michael (CR1)

Terrier Régis (CR1) (HDR en cours)

Varniere Peggy (CR1)

Capdevielle Jean-Noel (EMERIT)

Gorodetzky Philippe(EMERIT)

Casse Fabien (MCF)(HDR)

Creusot Alexandre (MCF)

Donzaud Corinne (MCF P11)

Kouchner Antoine (PR) (HDR)

Lachaud Cyril (MCF)

Parizot Etienne (PR) (HDR)

Van Elewick Véronique (MCF)

Goldoni Paolo (CEA)

Goldwurm Andrea (CEA) (HDR)

Laurent Philippe (CEA) (HDR)

Loucatos Sotiris (CEA) (HDR)

Lebrun Francois (CEA, retraité et associé APC)

- **3-6 Post-doc**

Maier Daniel (CDD CNES jusqu'en Avril 2017)

Sarria David (CDD CNES jusqu'en nov 2016)

Volodymyr Savchenko (CDD CNES jusque fin 2016)

Van Marie Allard (ANR)

Reccia Sarah (CDD DIM ACAV)

Atreyee Sinha (CDD in2p3, depuis 10/2017)

- **7-9 phd**

Jung Aera (thèse soutenue en 2017)

Jouvin Léa (thèse soutenue en 2017)

Chuard Dimitri(soutenance en 2018)

Grégoire Timothée (soutenance en 2018)

Sen Chi (soutenance en 2018)

Phan Thanh-Hien (soutenance en 2019)

Demidem Camilia (soutenance en 2019)

Jacob Marion (soutenance en 2019)

Phan Vo Hong Minh (soutenance en 2020)

