

Experiments and Modelling in Astroparticle Physics

Team Overview

G. Vasileiadis for the team

AERES committee visit

January 20-22, 2014

Presentation of the team

Scientific quality and outputs

Academic reputation and appeal

Interaction with the social, economic and cultural environment

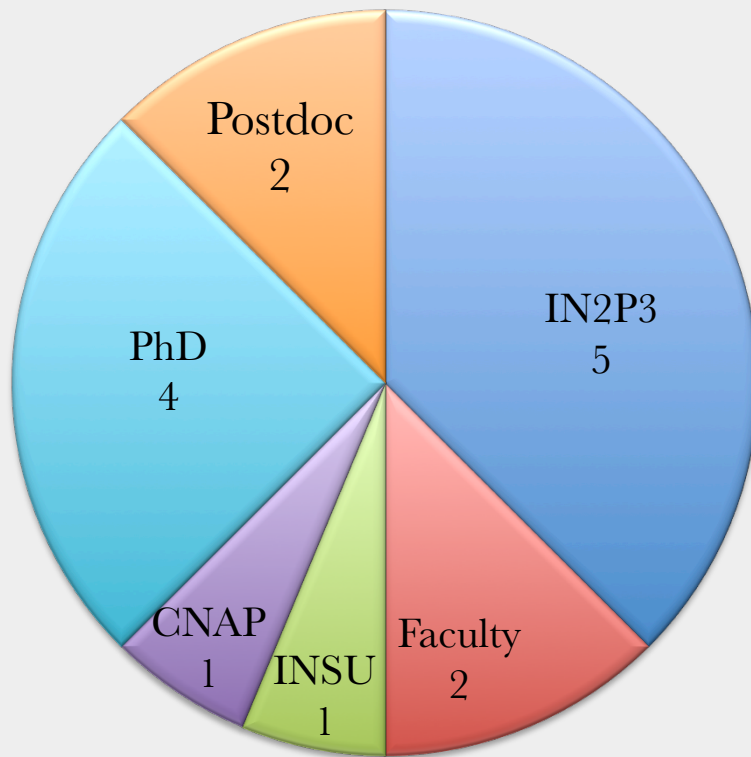
Organization and life

Involvement in training through research

Strategy and the five-year plan

The EMA team (01/2011–06/2013)

As of June 2013

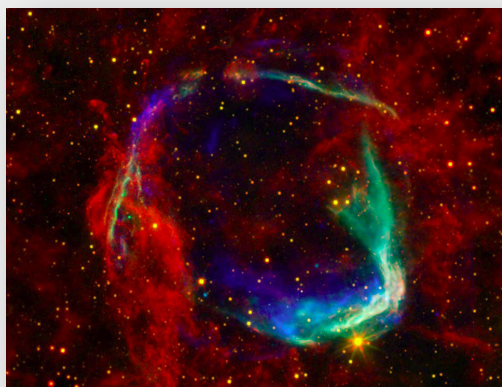


| | |
|--|---|
| N1: Permanent professors and similar positions | 2 |
| N2: Permanent researchers from Institutions | 7 |
| N3: Other permanent staff (no research duties) | |
| N4: Other professors | |
| N5: Other researchers from Institutions (Postdoc, visitors) | 5 |
| N6: Other contractual staff | |

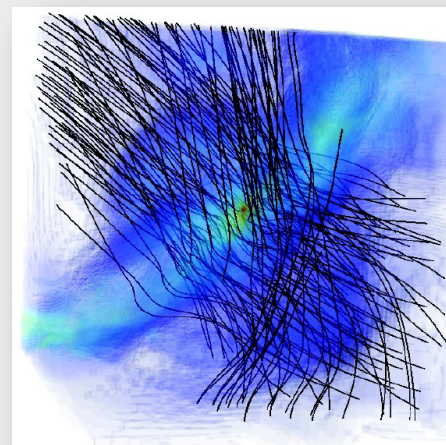
| Unit workforce | Number as at 30/06/2013 | Number as at 01/01/2015 |
|---|--------------------------------|--------------------------------|
| Doctoral students | 4 | 7 |
| Theses defended | 2 | 5 |
| Postdocs > 12 months | 2 | 5 |
| Number of Research Supervisor Qualifications (HDR) taken | 0 | 2 |
| Qualified research supervisors (with an HDR) or similar positions | 5 | 7 |

Gamma Rays, Cosmic Rays, Cosmology & New Physics

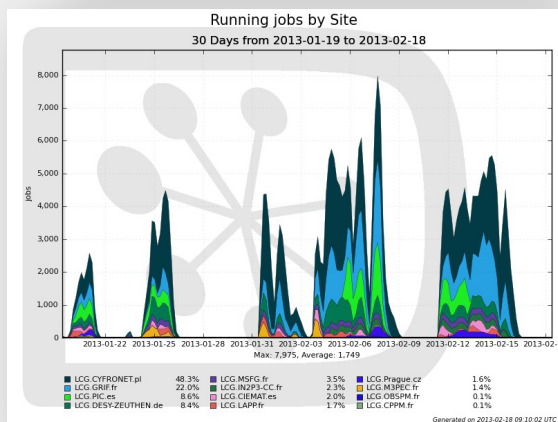
Multi-wavelength (MWL) observations of CR sources
Radio, IR/Optical, X-rays



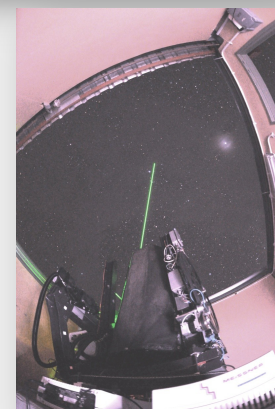
Theory and Modelling
CR acceleration & propagation
Tests on Cold Dark Matter



Fermi/LAT
H.E.S.S.
CTA

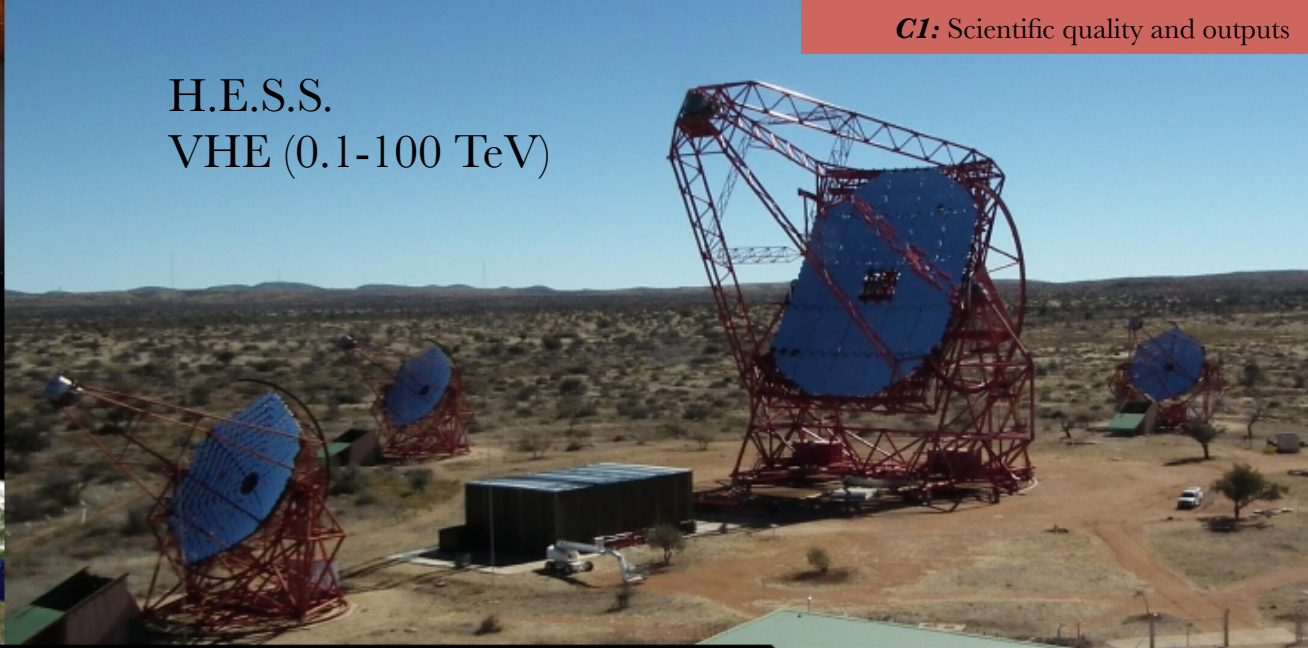


Technical Activities
Calibration (*Fermi*, H.E.S.S., CTA)
Lidar (H.E.S.S., CTA)
Software & Computing (*Fermi*, CTA)



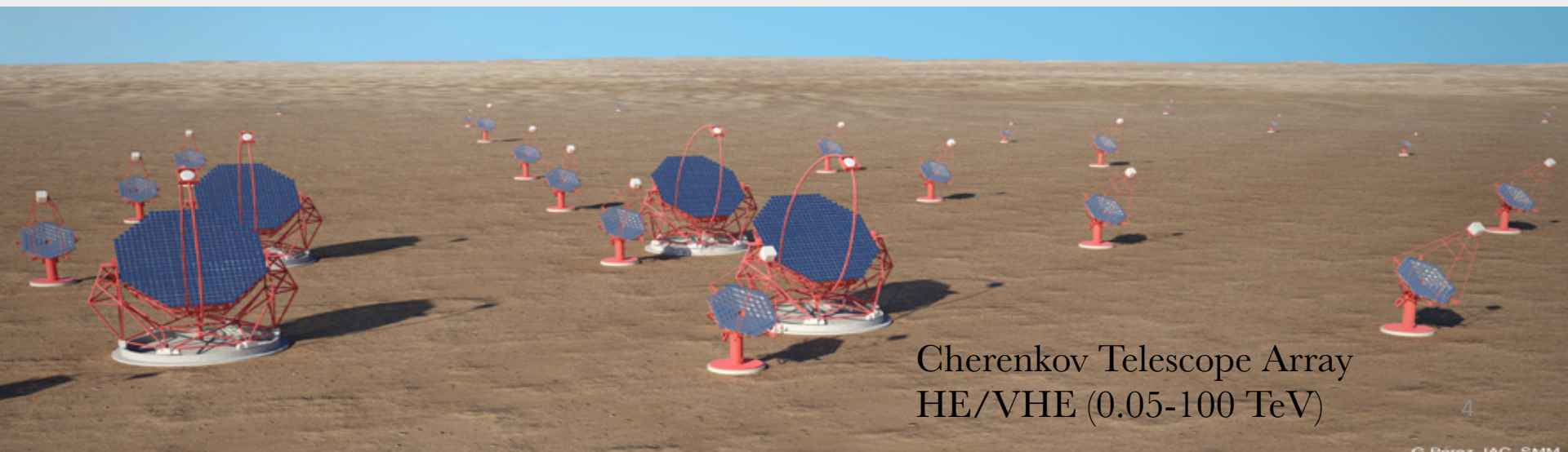


Fermi/LAT
HE (0.02-300 GeV)



H.E.S.S.
VHE (0.1-100 TeV)

Members of the *Fermi/LAT*, H.E.S.S. and CTA collaborations
Amongst the best high-energy gamma-ray telescopes (Descartes & Rossi prizes)



Cherenkov Telescope Array
HE/VHE (0.05-100 TeV)

Data Analysis & Modelling Activity

Acceleration of cosmic rays (CRs) in HE astrophysical sources

- Supernova remnants (SNRs) and the origin of Galactic CRs
- Pulsar wind nebulae (PWNe) and the origin of CR leptons
- Gamma-Ray Bursts (GRBs) studies and the origin of extragalactic CRs
- Compact sources as sources of high energy particles

CR transport in the interstellar medium

- Theory and Modelling
- Diffuse gamma-ray emission observed by *Fermi*

Cosmology and New Physics

- Galaxy clusters and intergalactic medium studies
- Dark Matter
- Large extra dimensions and neutron stars
- Test of Lorentz Invariance Violation (LIV)

Experimental Activities

Lidar developments

- Elastic Lidar developments

H.E.S.S. II Camera Calibration

- Conception, construction & installation of the calibration source

CTA Raman Lidar & Camera Calibration

- Projects similar to the ones developed for H.E.S.S. but adapted to the CTA requirements

INTENS

- Onboard instrumentation: nano-satellites

Computing : massive Monte-Carlo productions

- *Fermi*: extension of the LAT pipeline to the IN2P3 computing center
- CTA & *Fermi*: use of the GRID & DIRAC protocol

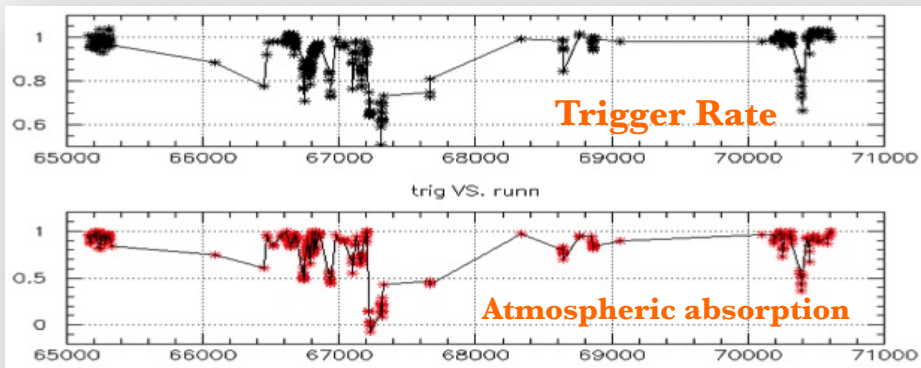
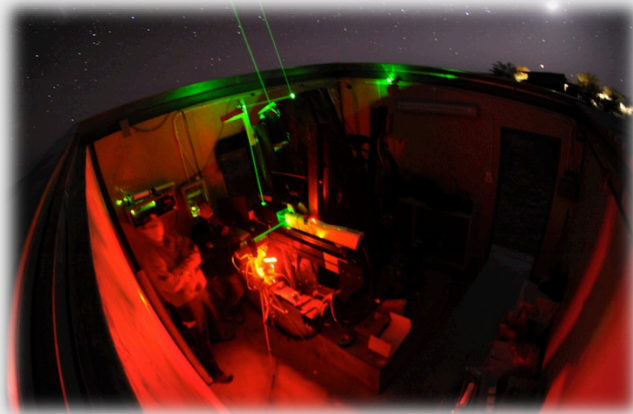
Software developments

- *Fermi*: reconstruction and analysis software
- CTA: data format and associated metadata

Experimental Achievements

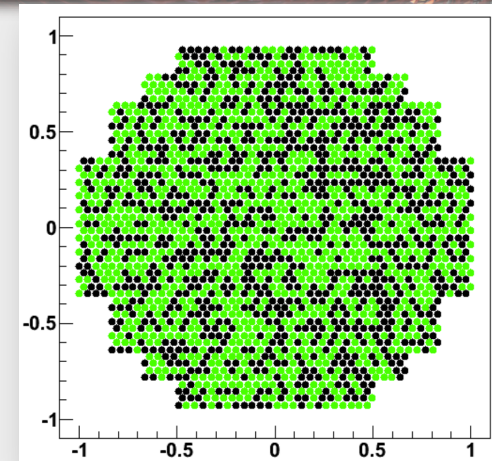
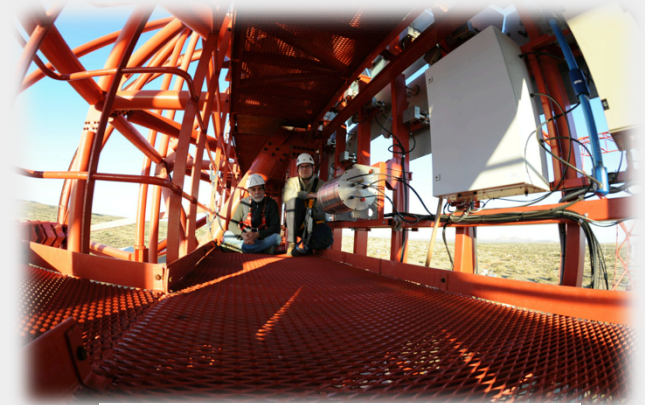
Lidar Atmospheric Calibration

- Clouds can occur around shower maximum and so affect Cherenkov light yield & image shape
- Aerosols act as a filter lowering the Cherenkov light yield



Camera Calibration

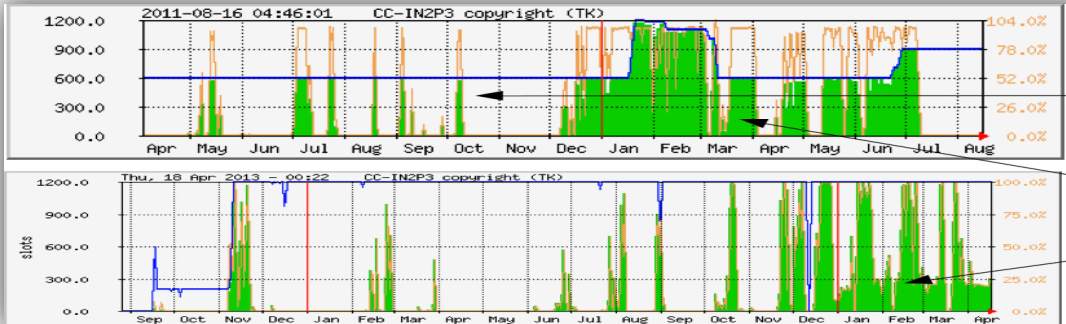
- Flat-Fielding measurements
- Gain measurement using Single Photo-Electron peak



Camera flatness within 10%

Computing for *Fermi* and CTA

- **Fermi MC pipeline** includes 1200 cores at IN2P3 computing center since January 2011 (600 before)
- **2011 MC campaign:** 6th most consuming experiment after LHC and D0 (700 kjobs executed, ~20 million CPU-hours)



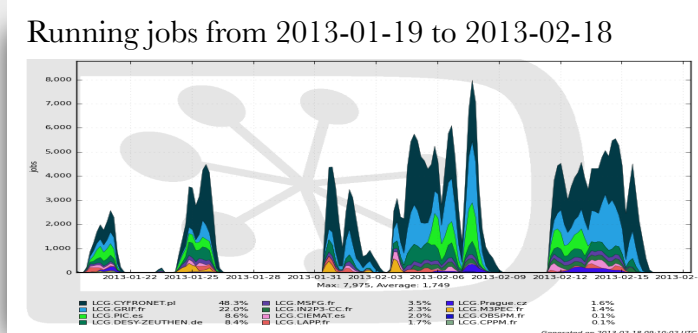
- Time history of running cores since April 2010

LAT Instrument Response Functions

Background (charged cosmic rays)

New s/w developments (Pass 8)

- **CTA MC pipeline** integrated in the DIRAC framework
- **2013 MC campaign:**
 - Stable regime of 4000-5000 jobs
 - ~ 600 TB produced
 - More than 230 kjobs executed
- **EMA team responsibility** (MC production)



- Metadata: internal calibration, reconstruction and analysis pipelines
- International VO Agency (IVOA) interoperability requirements
- **EMA team responsibility** (Archive Model Structure)

Scientific production

59 publications in refereed journals (01/2011-06/2013) (*major contributors*)

- **24** H.E.S.S. publications
 - **2** Nature
- **18** *Fermi*/LAT publications
- **4** CTA publications
- **13** Multiwavelength & Theory publications

6 invited reviews

41 international conference contributions

Expertise & Coordination

International Level

- *Fermi* GRB Science Group: *V. Vasileiou (2011-2012)*
- *Fermi* Diffuse Science Group: *J. CohenTanugi (2012-)*
- H.E.S.S. SNR/PWN/pulsar Working Group: *Y. Gallant (-2012)*
- H.E.S.S. Galactic Working Group: *M. Renaud (deputy convener 2013-)*
- CTA ATAC Work Package: *G. Vasileiadis (2011-2013)*
- CTA EGI VO Technical Administrator: *L. Arrabito (2013-)*
- CTA Archive Model Structure Coordinator: *C. Lavalley (2013-)*
- Referees for A&A, ApJ, Astroparticle Physics, Experimental Astronomy, JCAP, etc

National Level

- CNES Astronomy & Astrophysics group member: *F. Piron (2011-)*
- PCHE Scientific Council: *A. Marcowith (-2012)*
- PNHE SNR research group: *M. Renaud (2009-)*
- Prospective works: IN2P3-Irfu (2012), CNES (2013)
- ANR expert: *E. Nuss (2011)*

Regional Level

- D. Coord. AP Group Labex "Origines Constituants & Evolution de l'Univers": *G. Vasileiadis (2012-)*

Visibility & Attractiveness

Organization of international conferences

- CRISM (2011) “*Cosmic rays and their interstellar medium environment*” (70 participants)
- AtmoHEAD (2013) “*Atmospheric monitoring for high energy astroparticle detectors*” (43 participants)
- AstroMeV (2013) “*Scientific perspectives in the MeV domain*” (60 participants)
- 2013 annual meeting of the French Astronomical and Astrophysical Society SF2A (350 participants)

ANR Participation

- COSMIS (*Cosmic Rays and Compressible MHD Turbulence in the InterStellar Medium*)
- NECTAr (*New Electronics for the Cherenkov Telescope Array*)

Other Collaborations

- IAE/UAB Raman Lidar (Spain-France IN2P3 joint project)
- Armenia (convention d'échanges)
- Arcetri (Italy, PICS CNRS/INAF)
- MPE Garching (Germany, Labex OCEVU)
- etc..

Communication

Public Outreach

- Montpellier Planétarium: cycle “*L’Univers violent*”
 - 3 conferences
- Yearly “Fête de la Science”
- “Bars des Sciences”
- Numerous science popularisation activities in schools, high schools and colleges

Media related activities

- Radio interviews and specialised magazine articles
- Press conferences
 - AMS, H.E.S.S., *Fermi*

Team life organization

Structure, budget

- *Fermi*, H.E.S.S., CTA & Theory groups
- Independent budget
- A lot of common scientific interests

Scientific animation

- Regular group meetings
 - PhD students reports
 - Paper & conference news
- Frequent seminars

Representation in LUPM

- Participation in “Conseil Scientifique” and “Conseil du Laboratoire”
- Budget discussion & attribution
- Recruitment discussions and decisions

Specific infrastructures

- Dedicated technical facilities for R&D developments

Access to shared resources

- Section on the Webpage of LUPM
- LUPM GRID cluster

Training through research

PhD students

- 6 students
- Participate in collaboration meetings, summer schools and conferences
- Contribute to the outreach activities of the team

Master and high school trainee students

- 4 at the M2 level and 6 at the M1 level
- The EMA team welcomes all the high school students visiting every year the LUPM

Summer schools

- “Ecole astroparticules” Cargèse (2013) (*A. Marcowith*)
- “Ecole Gif” Annecy (2013) (*A. Marcowith*)
- Astroparticle Physics OHP (2013) (*F. Piron*)

Teaching responsibilities in the Physics Department

- Responsible of the M2 “Physique des particules et techniques exp.” teaching unit (*E. Nuss*)
- Responsible of the M1 “Physique des hautes énergies” teaching unit (*E. Nuss*)
- Coordination (Montpellier) of the master “Space and Applications” Hanoi (*E. Nuss*)
- Director of the Physics Department of UM2 (-March 2011) (*F. Feinsein*)

International teaching contributions

- Responsible of the “Particle Physics & Detectors” teaching unit of the Ms S&A, Hanoi (*E. Nuss*)

Strategy and future projects

Gamma Rays, Cosmic Rays, Cosmology & New Physics

Open questions we plan to contribute to:

- Cosmic ray origin, acceleration mechanisms and transport to the Earth
- Very high energy violent phenomena around compact sources
- Indirect search for Dark Matter
- Tests of fundamental laws of Physics

Better precision, more statistics, better sensitivity

- Need to master HE astrophysics “backgrounds” in order to claim signal from New Physics

Experimental Tools

- Continuing with existing experiments upgrades (*Fermi*, H.E.S.S.) and future ones (CTA)

Looking beyond

- Time domain astronomy
- Cosmology
- Exploration of the MeV domain

Future projects (1 / 3)

Ground based projects

- H.E.S.S.
 - Galactic PWNe and SNRs in interaction with molecular clouds
 - SNR catalog from Galactic plane survey data
 - Observation proposals & analysis for sources of interest using CT5
- CTA
 - Source simulations
 - Calibration (Raman Lidar & camera calibration)
 - DIRAC-GRID activities
 - Data Model & Virtual Observatory aspects
- LSST
 - A wide field synoptic optical surveyor in 6 bands
 - First light ~2020
 - Primary cosmological science, stellar science & Galactic dynamics
 - LUPM team currently investigating scientific opportunities (e.g., BAO, DM) & possible technical contributions (computing)

Future projects (2/3)

Space based projects

- *Fermi*
 - New LAT event reconstruction (Pass 8)
 - Pipeline development, maintenance & exploitation (CC-IN2P3 and GRID workers)
 - GRB population studies
 - Galactic sources and diffuse emission
 - Dark matter and New Physics
- SVOM
 - Next generation observatory dedicated to GRB science
 - Expected to be launched by ~2020
 - Rich non-GRB science case (e.g., young SNRs)
 - Approved by the LUPM “Conseil Scientifique” (2013)

Future projects (3/3)

Theory and modelling

- Modelling of CR sources
 - Particle acceleration in SNe
 - Lepton production in PSRs and SNRs
 - H.E.S.S. sources in the Galaxy
 - Particle acceleration in PWNe/SNRs
- Modelling of CR propagation in the ISM
 - MHD simulations (*COSMIS ANR*)
 - CR/molecular cloud interaction (*Labex OCEVU*)
 - Low energy CR propagation in different environments (*Labex OCEVU*)
- Hydrodynamic and magneto-hydrodynamic simulations (MHD)
 - Massive star environment (small scale: winds, large scale: HII regions)
 - CNRS recruitment priority & link with AS team

S.W.O.T.

Strengths & Weaknesses

- Strong participation in the state of the art experiments in the field
 - *Fermi*/LAT, H.E.S.S., CTA
 - Well identified contributions and responsibilities in these collaborations
- The LUPM EMA group is very visible
 - Expertise recognized by CERN, CNES, NASA, SLAC
- Wide scientific expertise
 - From detector R&D to analysis and modelling
 - Unusual breadth for an astroparticle team (in France certainly)
- Good coordination needed to maintain strong synergies within the team

Opportunities & Threats

- *Fermi*/LAT (Pass 8), H.E.S.S. II & CTA expected possible new & interesting physics results
- Future project schedule & finance (CTA, SVOM, LSST)