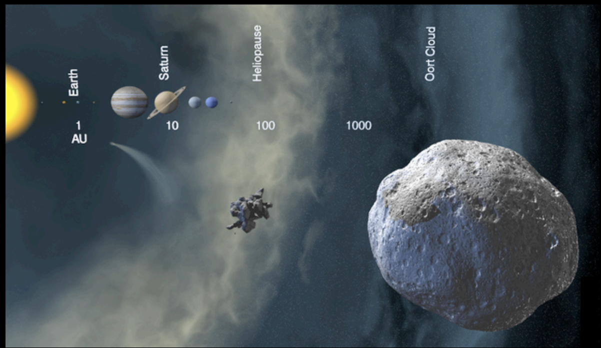
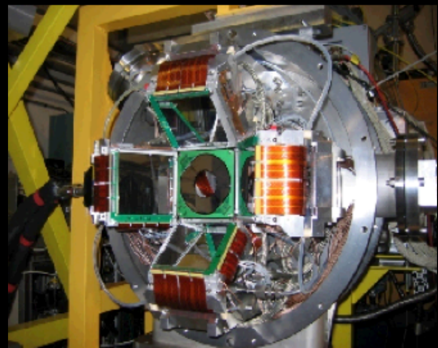
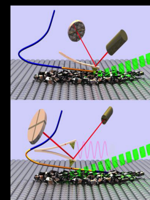
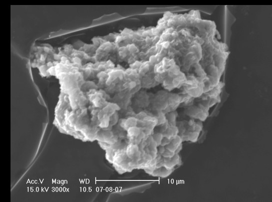
HCERES evaluation of laboratories in the Orsay Valley

CSNSM
IMNC
IPN
LAL
LPT







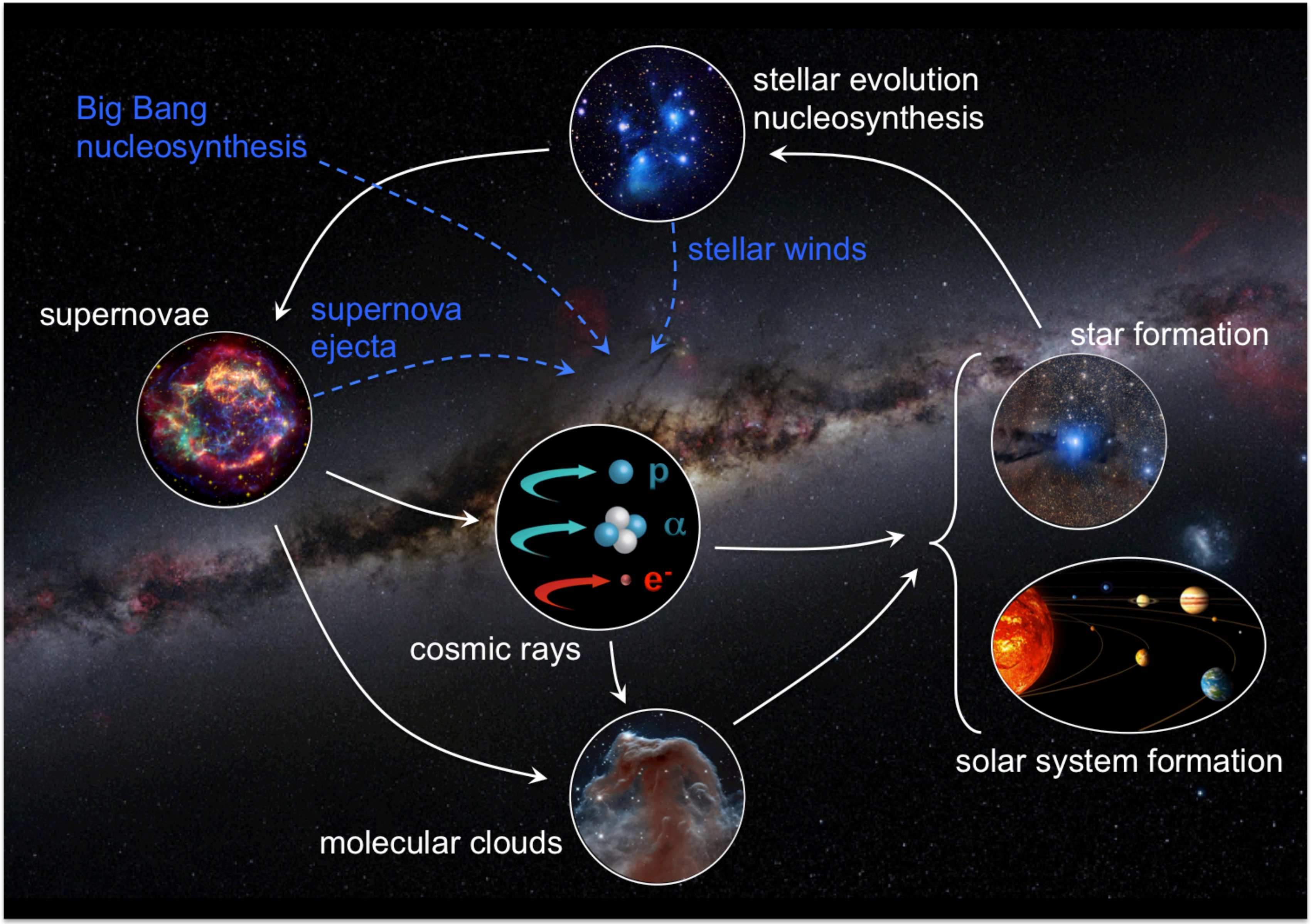


Nuclear Astrophysics & Astro/Cosmochemistry

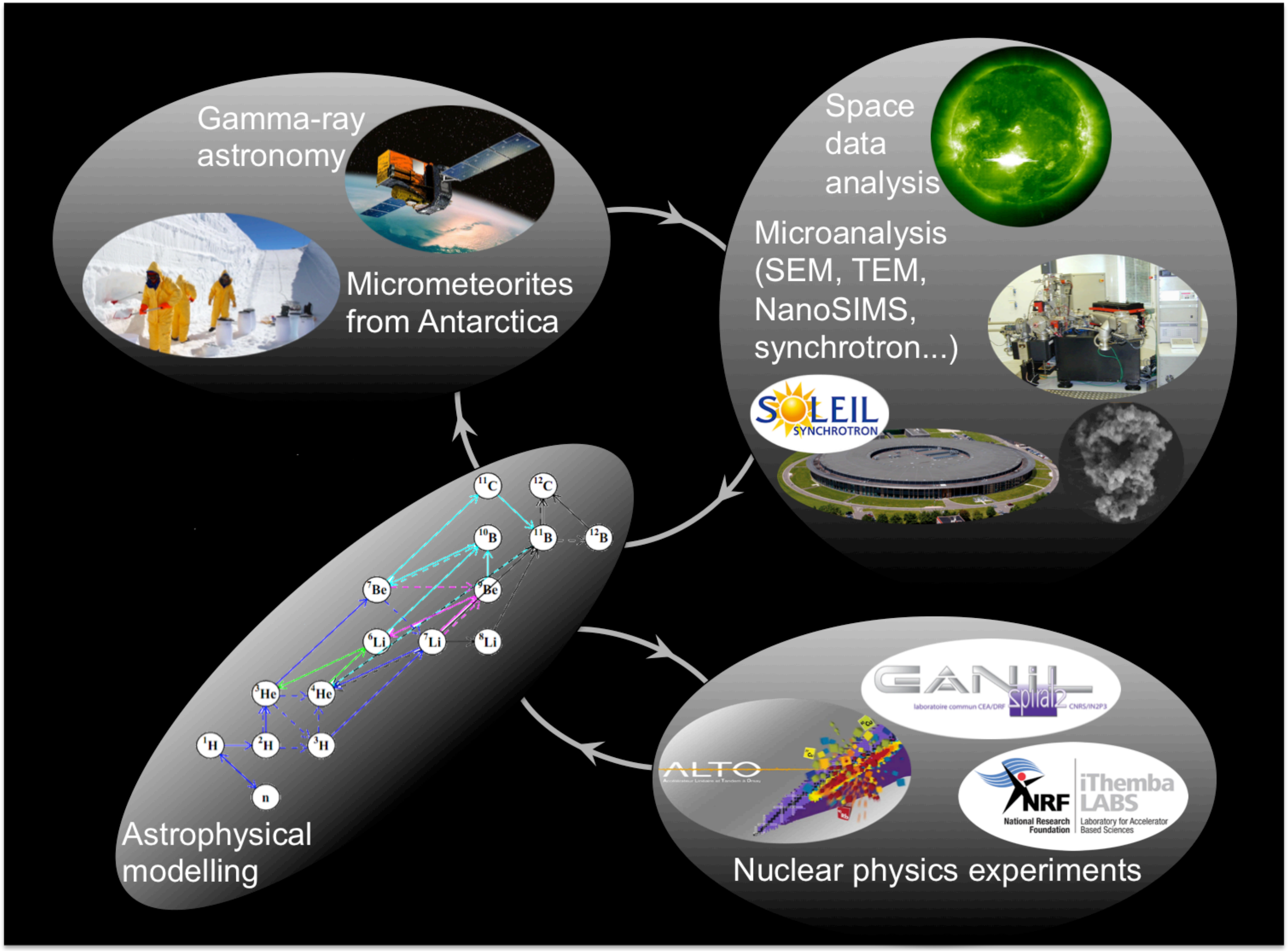
Speaker : V. Tatischeff
on behalf of the Astro teams of IPNO and CSNSM

January 14 – 17, 2019

Nuclear Astrophysics & Astrochemistry

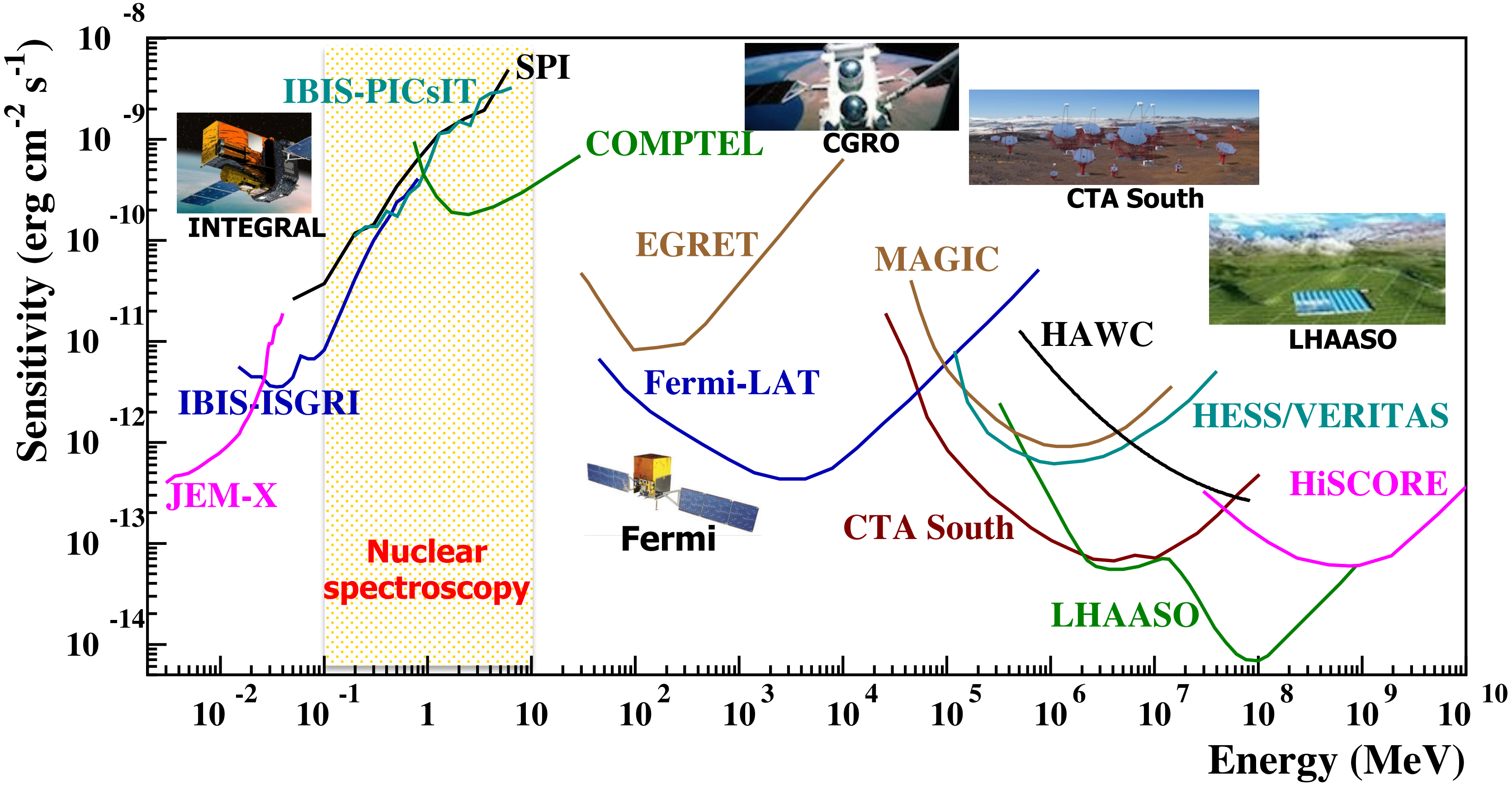


Our research activities



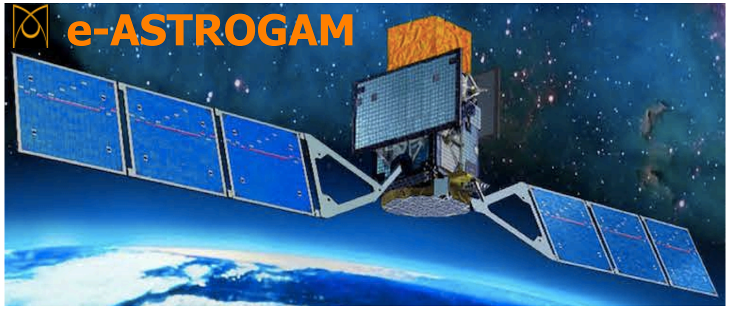
Gamma-ray astronomy

- Gamma-ray astronomy in the **MeV** domain: key tool to study
  - **Supernovae, nucleosynthesis** & Galactic chemical evolution (radioactivities)
  - Origin and impact of **cosmic rays** on Galaxy evolution (nuclear collisions)
  - **Multi-messenger** astrophysics of extreme sources (accelerated particle radiation)
- But one of the **least well covered part of the EM spectrum**

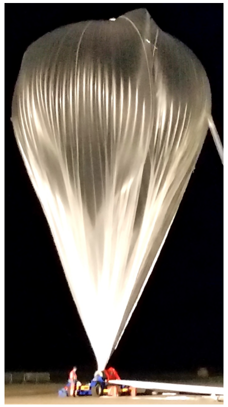


From γ-ray astronomy to nuclear dismantling

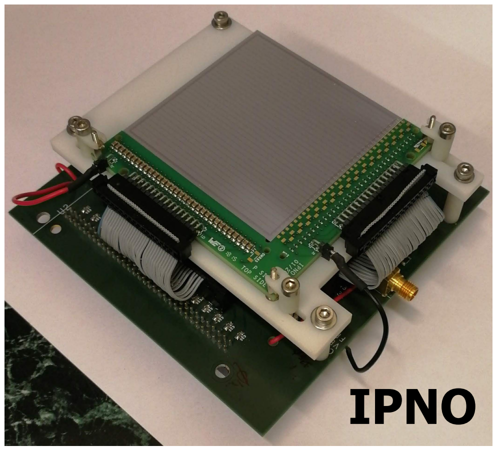
- Co-leadership of the **e-ASTROGAM** collaboration: more than 400 scientists from labs in 29 countries [France: **CSNSM**, **IPNO**, APC, CEA/Irfu, LLR, CENBG, LUPM, IRAP]

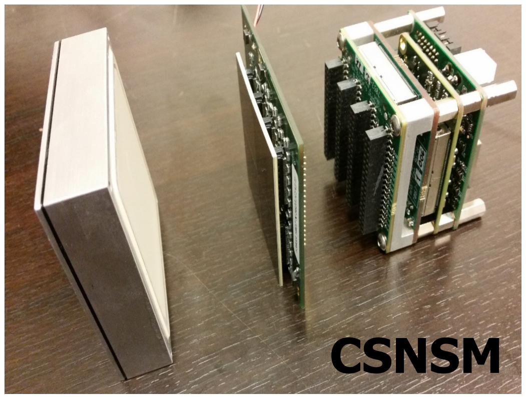


  - Proposals for ESA's M4 (2015) and M5 (2017) missions (e.g. Tatischeff et al. 2016, 2018)
  - Science White Book: De Angelis, Tatischeff et al. (2018) (245 authors, 216 pages)



- R&D **CO**mpact **CO**mpton **TE**lescope (P2IO 2012-2014, DEFI CNRS, CNES) [**CSNSM**, **IPNO**, **LAL**, APC, CEA/Irfu, IRAP]
  - Telescope in double-sided silicon strip detectors & scintillation detectors (de Séréville et al. 2016; Gostojic et al. 2016)
  - **Stratospheric balloon-borne experiment** in 2016

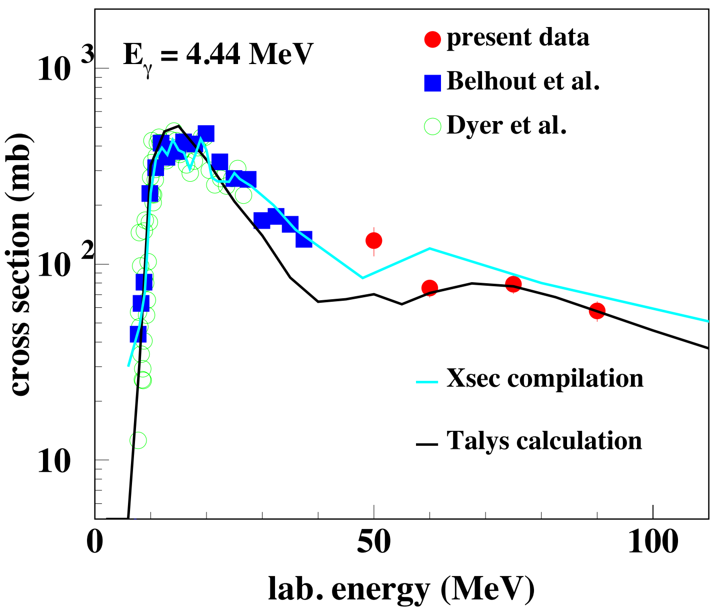


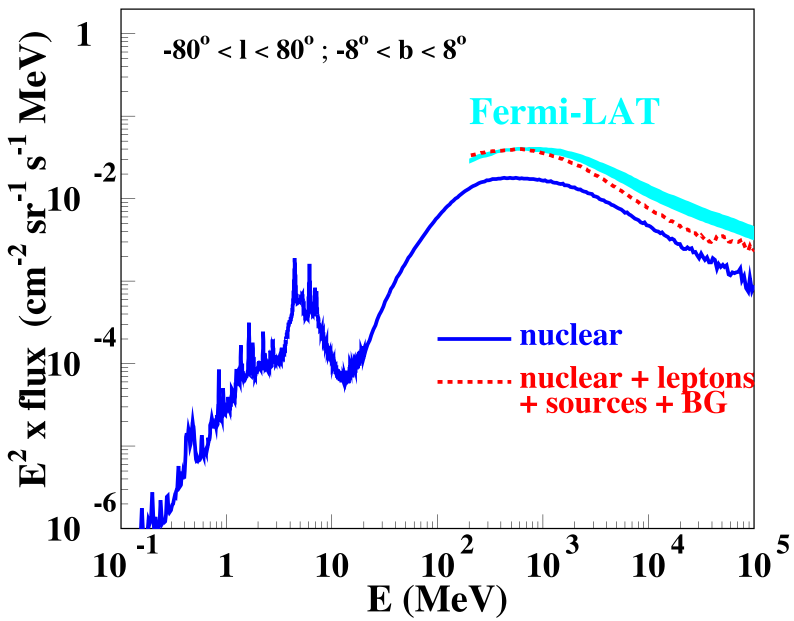


- **ComptonCAM** – Development of an ultra-sensitive **portable gamma camera** to locate and characterise post-dismantling **radioactive waste** (Andra PIA 2017 – 2021, 1.8 M€) [**CSNSM**, **IPNO** + 2 SMEs: SYSTEL Electronics & THEORIS]

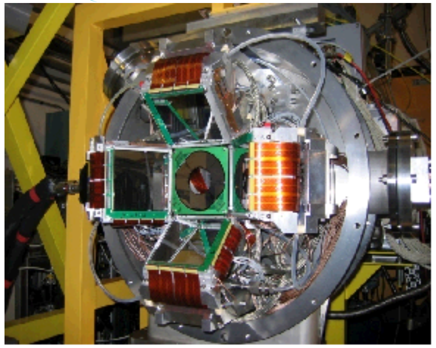
γ-ray signatures of accelerated nuclei in astrophysics

- Gamma-ray emission cross section **measurements** [**CSNSM**, **IPNO**, South Africa, Algeria, Germany]
  - p => C, O, Mg, Al, Si, Ca, Fe E = 30 – 180 MeV 2013-2017 **iThemba LABS**, South Africa
  - α => C, Mg, Si, Fe E = 50 – 90 MeV 2015-2016 **HMI Berlin**, Germany
- **Modelisation/observation** of nuclear γ-ray emission in astrophysical sites
  - Low-energy cosmic rays in the inner Galaxy: perspectives for future γ-ray observatory (e.g. Kiener et al. 2013, 2017)
  - Solar flares, space weather forecasting: **Hesperia** [Horizon 2020; Greece, France, Finland, Spain, Germany, Switzerland] INTEGRAL satellite data analysis (Rodriguez-Gasén et al. 2014)
  - Nova explosions [**CSNSM**, IRAP, IPAG, Spain, Germany] (e.g. Martin et al. 2018)



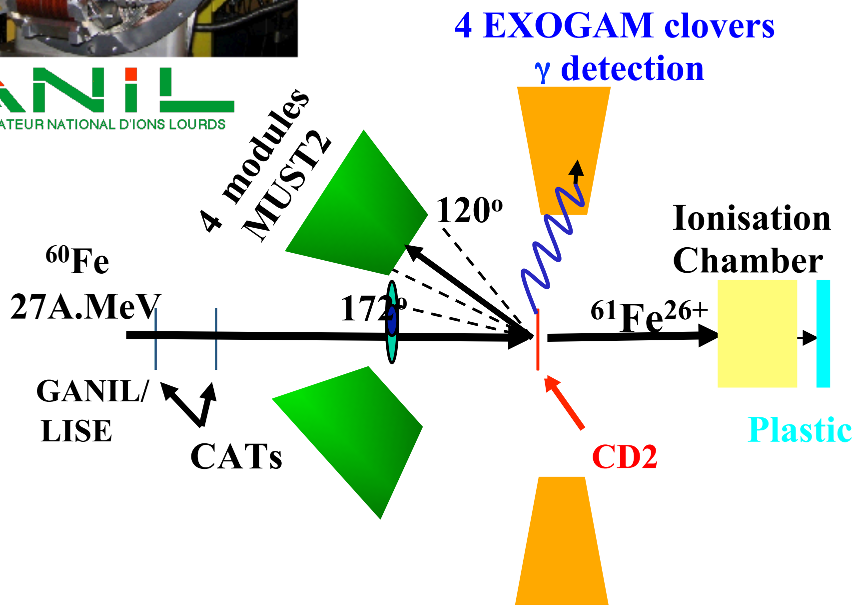


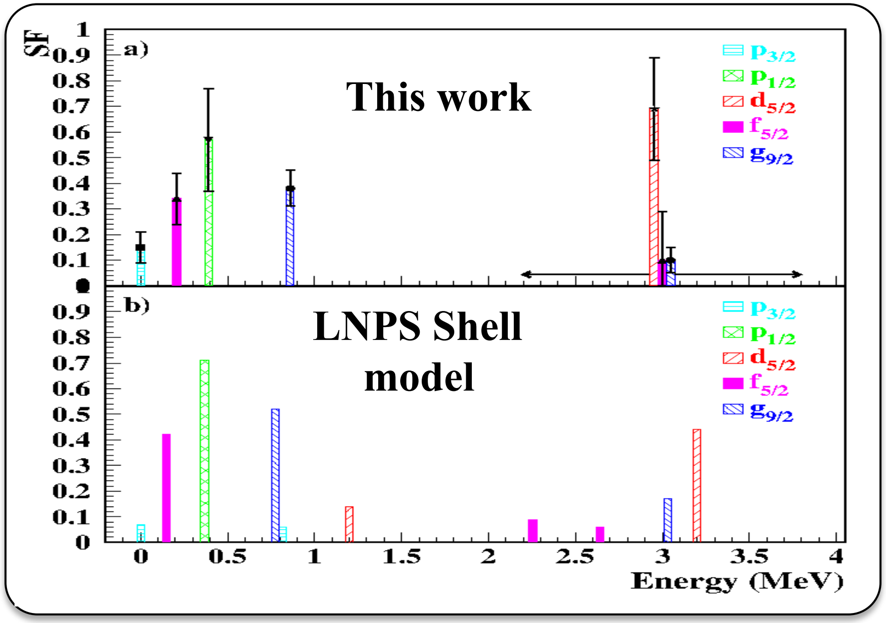
^{60}Fe nucleosynthesis & ^{61}Fe spectroscopy



Collaboration **MUST2**: **IPNO**, GANIL, CEA/SPhN, …

Objective: Determination of the direct component of ^{60}Fe(n,γ)^{61}Fe via the transfer reaction ^{2}H(^{60}Fe,p)^{61}Fe and its impact on the ^{60}Fe nucleosynthesis



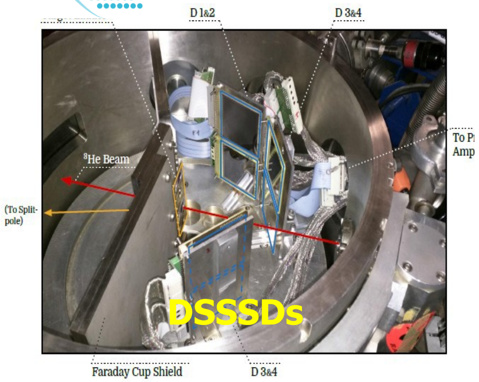


Spectroscopic factors of ^{61}Fe states determined experimentaly for the first time. Very good agreement with LNPS shell model

The direct component deduced from this work is negligible : better constraint on the nucleosynthesis of the radio-isotope ^{60}Fe observed by the satellite INTEGRAL

S.Giron, F.Hammache, N. de Séréville et al., PRC 95, 035806 (2017)

Classical novae & ^{18}F nucleosynthesis

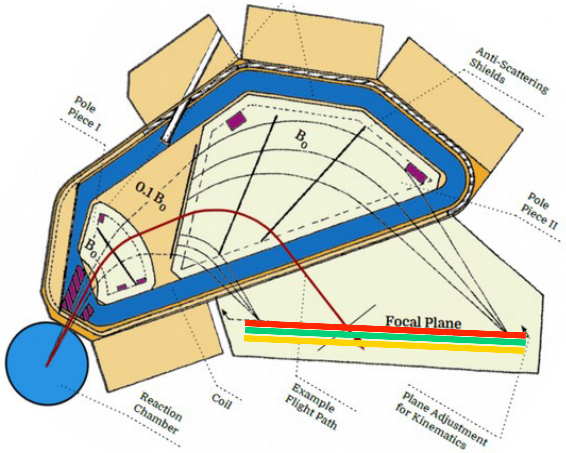


Collaboration: **IPNO**, YORK, **CSNSM**, GANIL,…

Objective: Study of the ^{18}F(p,α)^{15}O reaction and its implication to the <511 keV γ-ray emission: where is the subthreshold ½+ state in ^{19}Ne?

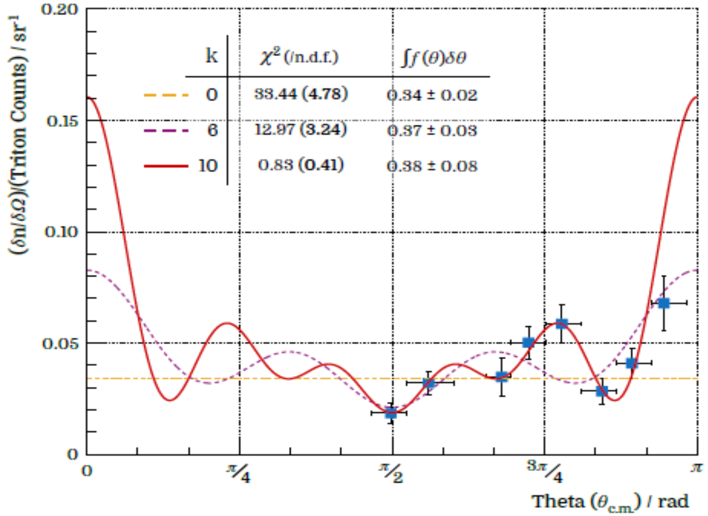
Unique coupling between **Split-Pole magnetic spectrometer** and **DSSSDs array** in coincidence mode with TANDEM accelerator

ALTO
Accélérateur Linéaire et Tandem à Orsay



Indirect measurement: ^{19}F(^{3}He,t)^{19}Ne(α)^{15}O

Angular correlation t+α



E_R = -122 keV

- **Indication of high spin**
- **Rules out previous ½+ assignation**

J. Riley, A. Laird, N. de Séréville et al., to be submitted

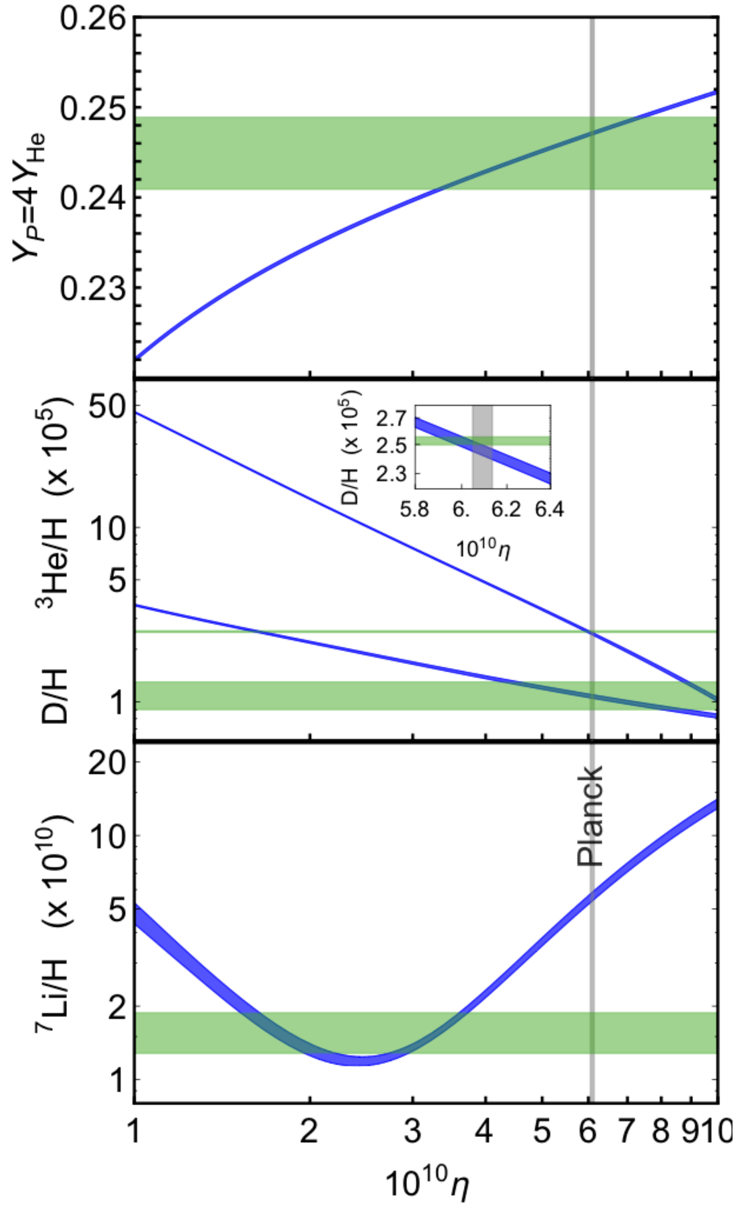
Ongoing work:

- Study of ^{18}F(n,α)^{15}N & ^{18}F(n,p)^{18}O via ^{19}F(p,p')19F*(α|p) and their impact on ^{15}N nucleosynthesis
- Study of ^{26}Al(n,α)^{23}Na & ^{26}Al(n,p)^{26}Mg via ^{27}Al(p,p')^{27}Al*(α|p) and their impact on ^{26}Al nucleosynthesis
- Study of ^{30}P(p,γ)^{31}S in classical novae via ^{31}P(^{3}He,t)^{31}S **A. Meyer thesis**

P. Adsley analysis

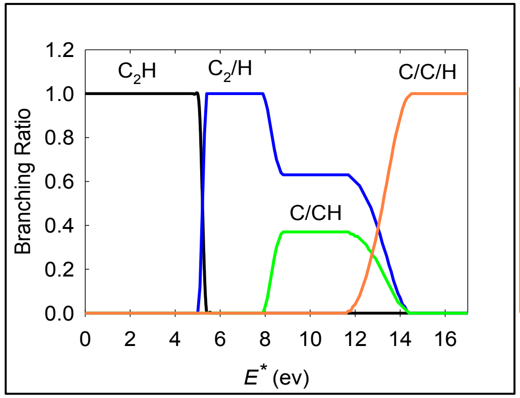
Precision big bang nucleosynthesis

- **Standard BBN** is now in the **percent precision era** for deuterium (D) and ^{4}He
  - Observations: deuterium (1.2%) (Cooke+ 2018), ^{4}He (1.6%) (Aver+ 2015)
  - Evaluation for better precision (≈1%) on D(p, γ)^{3}He, D(d,n)^{3}He and D(d,p)^{3}H reaction rates (Coc+ 2015, Iliadis+ 2016, Gómez Iñesta+2017). [**CSNSM** UNC-Chapel Hill]
  - Theoretical corrections to the weak rates, n↔p: ^{4}He (+1.8%) also affects D/H predictions (+1.5%) (Pitrou + 2018) [**CSNSM**-IAP]
- **Lithium problem** unsolved: predictions/ observations, a factor of 3. [**CSNSM**-IAP-**IPNO**]
  - Exotic solutions e.g. mirror matter (Coc+ 2014) constrained by precision D/H observations (Coc+ 2015)
  - Nuclear solutions excluded by experiments (Hammache+ 2013)
- **Mathematica code** publicly available with ~400 reaction rates library (Pitrou, Coc, Uzan & Vangioni 2018) **adopted by Planck** [**CSNSM**-IAP]



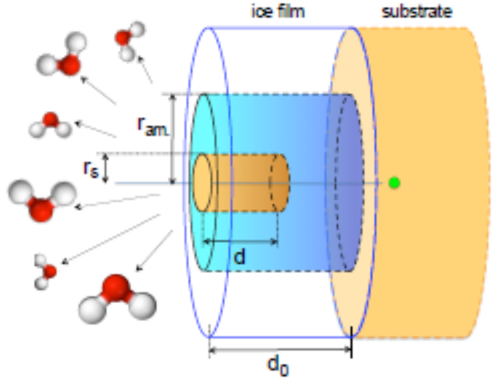
Astrochemistry

- **Branching ratios** of chemical reactions for ISM chemical nets.
  - Surrogate method is applied. Inputs are BRs for all the fragmentation channels following a high velocity collision in an inverse kinetic scheme. (Walemam +15, IdBarkach+18)
  - Experiments are performed with the **AGAT** detector nearby **ALTO** and **ANDROMEDE** [**IPNO**-ISMO]



Chabot+2013

- **On the role of heavy cosmic-rays in the interstellar medium chemistry**
  - Contribution of heavy CRs to the H_2 ionization rates (Chabot14)
  - Rates of molecule injection under heavy CR impact (Dartois&Chabot+17-18) [**IPNO**-ISMO-GANIL-GSI]



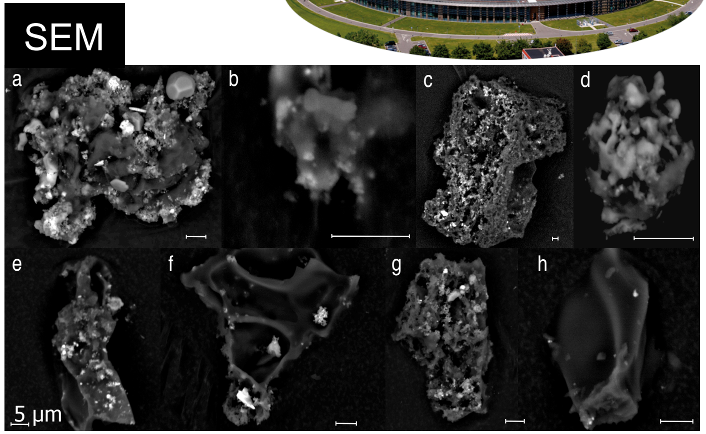
Datois+18

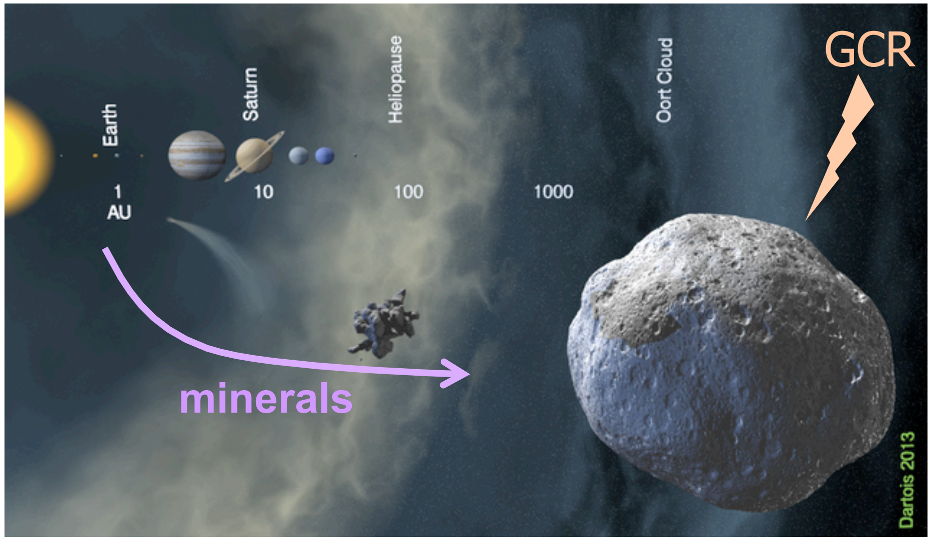
Micrometeorites & interplanetary organic matter

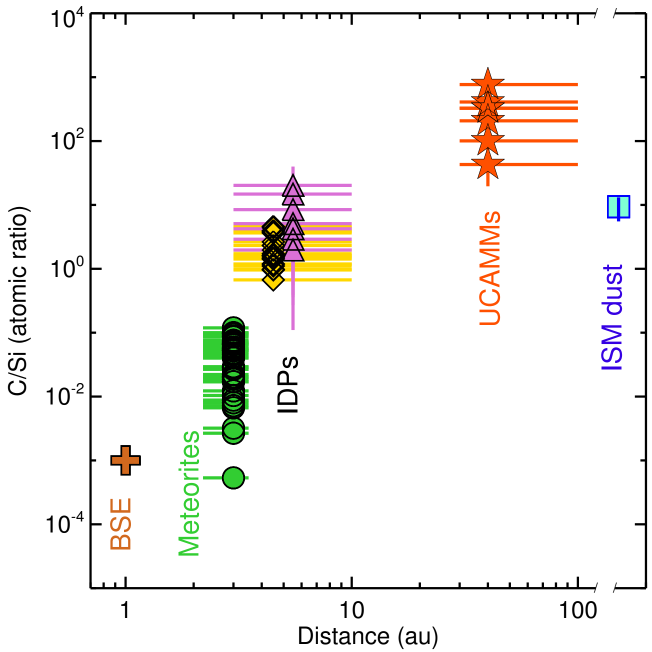
- Ultra-carbonaceous Antarctic micrometeorites (UCAMMs): **a new type of interplanetary matter** (Duprat et al. 2016; Dartois et al. Highlight A&A 2018)
- **Origin of cometary matter**:
  - **Organics**: formation by irradiation of N-rich ices at the surface of trans-neptunian objects => irradiation experiments @ GANIL (Augé et al 2018)
  - **Minerals:** evidence for transport to the outer region of the protoplanetary disk (Engrand et al. 2018)

[**CSNSM**, ISMO, CIMAP/GANIL, LCP, SOLEIL, IMPMC Paris, UMET Lille, IPAG Grenoble]

SOLEIL SYNCHROTRON

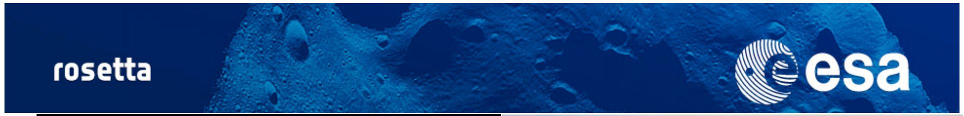


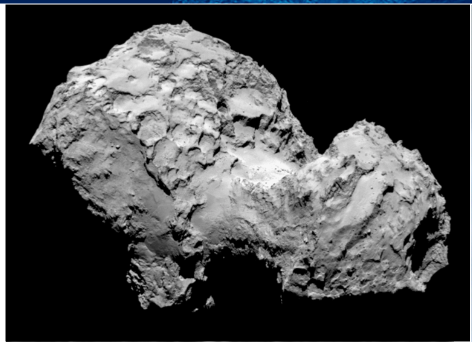


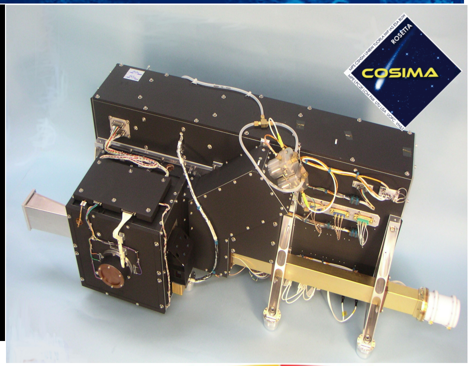


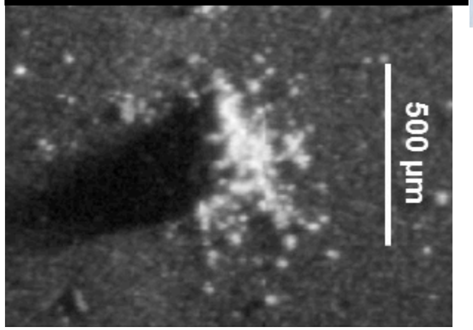
GANIL GRAND ACCELERATEUR NATIONAL D'IONS LOURDS

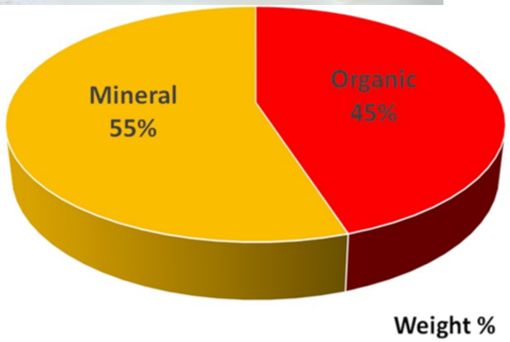
Rosetta, cometary grains & SIMS





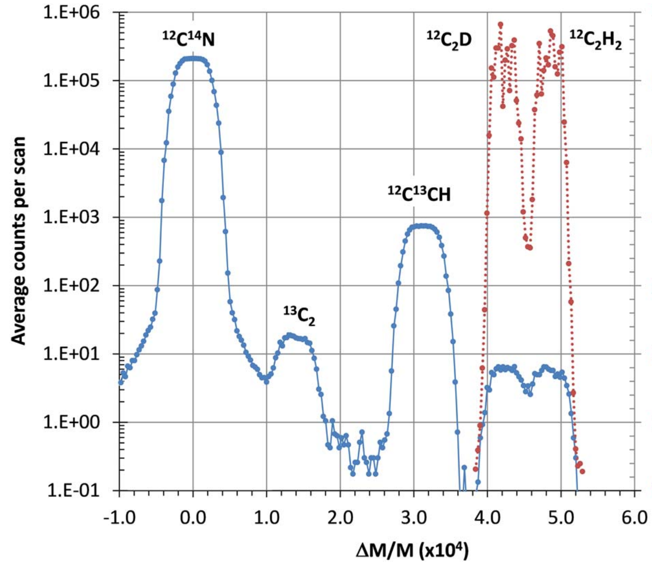


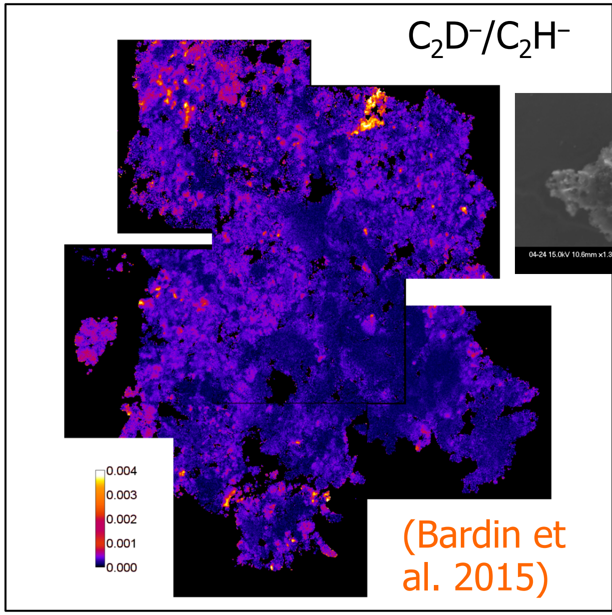




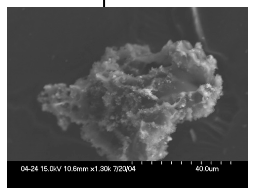
(Fray et al. Nature 2016; Bardyn et al. MNRAS 2017)

SIMS at high resolution (Slodzian et al. 2014)





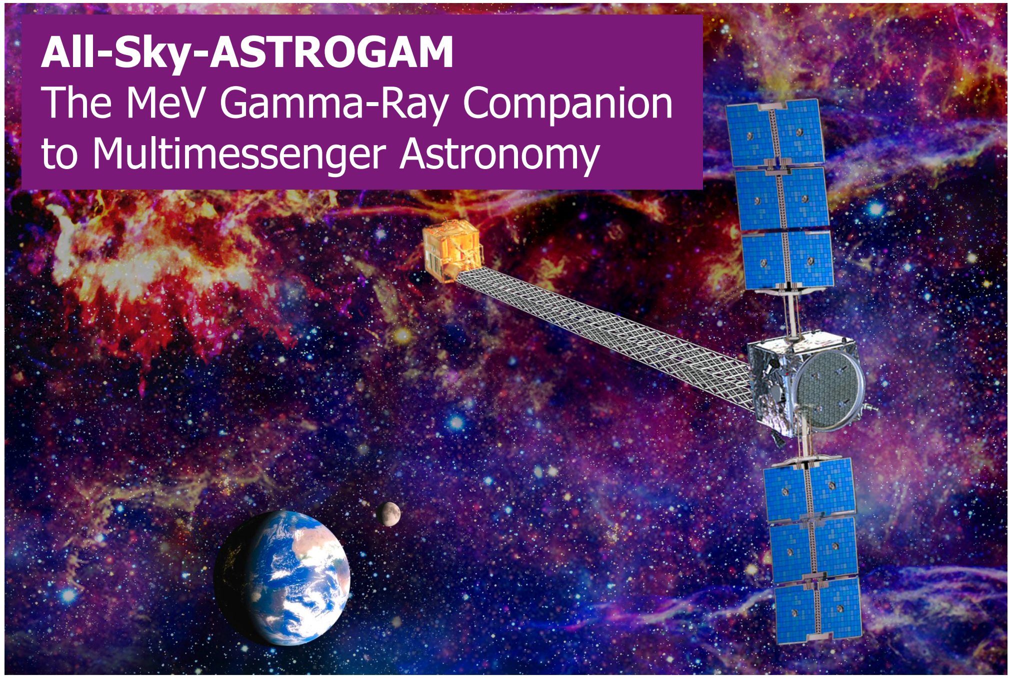
(Bardin et al. 2015)

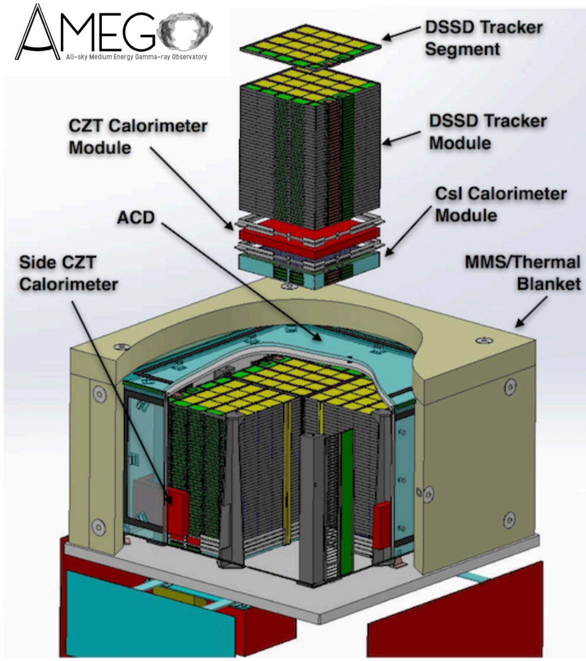


- **Rosetta/COSIMA** => Structure & composition of cometary particles (Engrand et al. 2016)
- **Secondary ion mass spectrometry** at high resolution [**CSNSM**, LPC2E, LISA, MPS Göttingen, Inst. Curie]
  Funding: CNES, **ANR OGRESSE** (PI: J. Duprat 2013-2016, 317 k€) + P2IO, DIM-ACAV, …

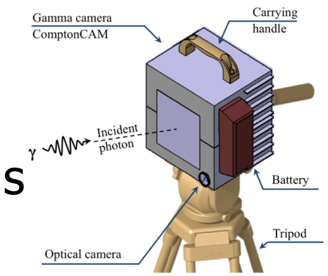
Projects 2019 - 2023
(and beyond)

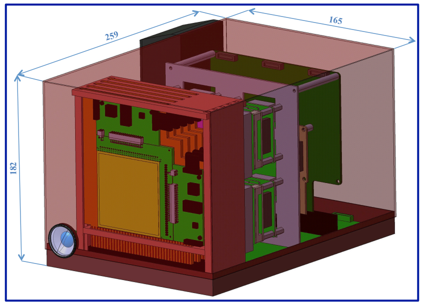
γ-ray astronomy & nuclear dismantling





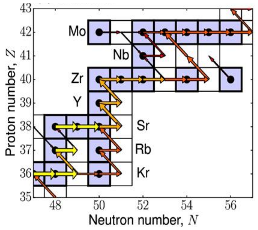
- Towards a future gamma-ray space observatory
  - **All-Sky-ASTROGAM**: proposal (2018) for ESA's "Fast" mission (launch in 2028)
  - **A**ll-sky **M**edium **E**nergy **G**amma-ray **O**bservatory (AMEGO): prop. for a NASA Probe mission
  - Russian (IKI) – e-ASTROGAM collaboration for a dedicated mission
- **ComptonCAM**: industry-ready product available in 2022 for deployment on the market from 2025
- Development of others innovative gamma-ray tools for nuclear dismantling (patent in preparation)





Perspectives in experimental nuclear astrophysics

Accepted experiments & Letters of intent:



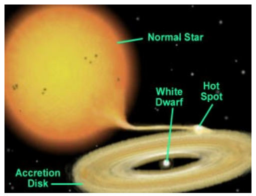
s-process in massive stars

- $^{22}Ne(\alpha,n)\,^{25}Mg$ → ALTO / Split-Pole
- $^{17}O(\alpha,n)\,^{20}Ne$ → MLL (Munich) / Q3D

Nucleosynthesis in Globular Clusters

- $^{30}Si(p,\gamma)^{31}P$ → MLL / Q3D
- $^{30}Si(p,\gamma)^{31}P$ → TRIUMF / DRAGON

Stable beams
High resolution magnetic spectrometers
Need to keep small scale facilities



Explosive nucleosynthesis in classical novae

- $^{30}P(p,\gamma)^{31}S$ → GANIL-SPIRAL1
- $^{25}Al(p,\gamma)^{26}Si$ → GANIL-SPIRAL1

Explosive nucleosynthesis in type I X-ray bursts

- $^{15}O(\alpha,\gamma)^{19}Ne$

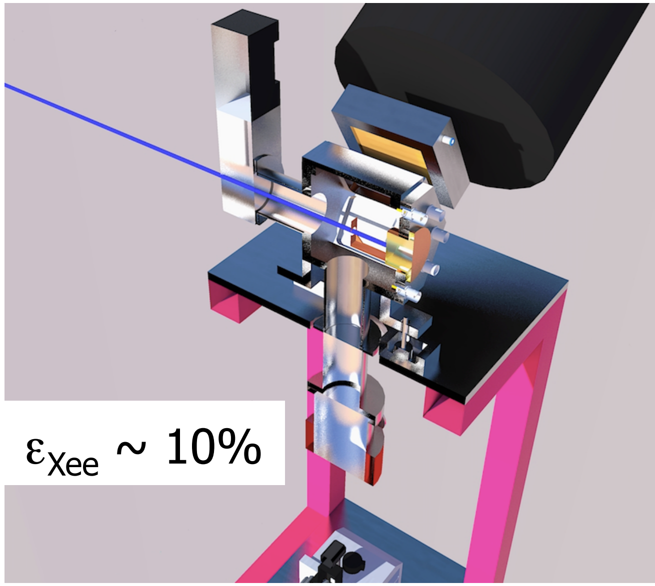
→ GANIL-SPIRAL1 / MUGAST-VAMOS-AGATA

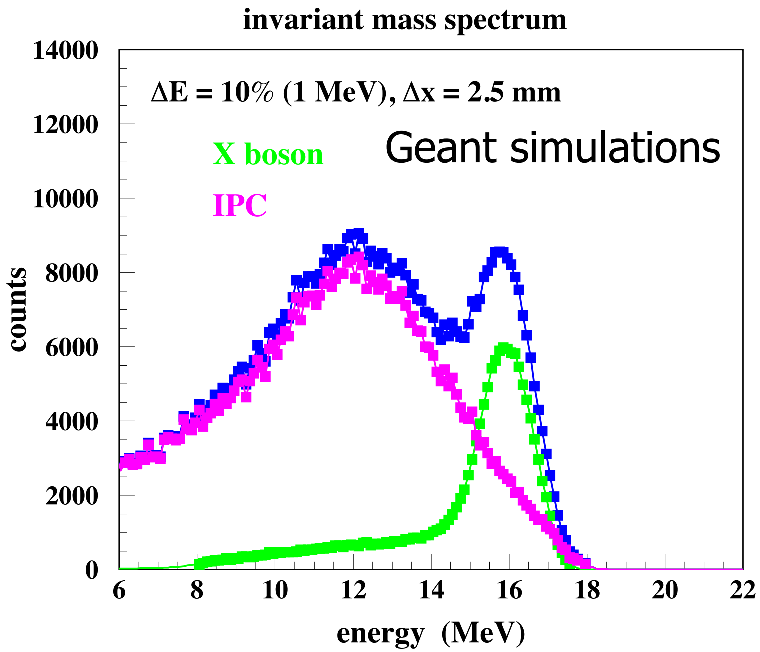
- $^{30}S(\alpha,p)$, $^{22}Mg(\alpha,p)$
- …

Radioactive Ion Beams
Need for beamtime & RIBs

Nuclear physics search for a light boson

- Observation of an anomalie in the $^{7}Li(p,e^+e^-)$ reaction (Krasznahorkay et al. PRL 2016)
  - Excess in Θ_{e+e-} at ~140° and in the invariant mass spectrum at ~17 MeV, confirmed in 2018
  - Decay of a **~17 MeV boson**? => ***new physics beyond the standard model***
- New project: independent confirmation in $^{7}Li(p,e^+e^-)$ and other reactions [GANIL, **CSNSM**, **IPNO**, CEA, NPI Rez, U. Victoria]
  - First test at CSNSM/ARAMIS with Micromegas [CEA/Irfu] + EDEN detectors [IPNO]
  - Design of a dedicated reaction chamber and detection setup, end 2018 - beginning of 2019
  - Proposal **ERC consolidator grant in preparation** (Beyhan Bastin, GANIL), February 2019: $^{7}Li + p$ at CSNSM 2019-2020; $d + p$, $n + {}^{3}He$, $n + p$ (+ states in ^{10}B, ^{10}Be?) at NPI Rez (Czech Rep.) 2020+ and GANIL/Spiral 2021+

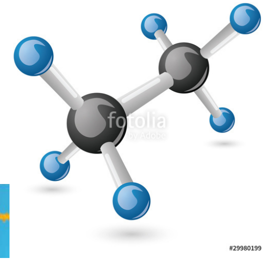




Astrochemistry

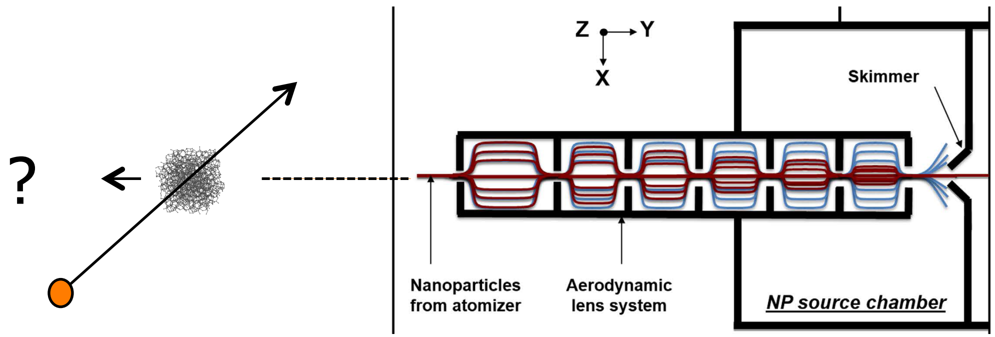
C_2H_m Branching Ratios

- C_2H_m molecules, after CH_m molecules, are very sensitive species for carbon chemistry in the interstellar medium
- Construction of a new molecular ion source at **ALTO / SIMATT** (Source d'Ions Moléculaires Au Terminal d'un Tandem)



NANOCR: ISM grains destruction by heavy CRs [**IPNO-CSNSM**-ISMO-NIMBE/CEA]

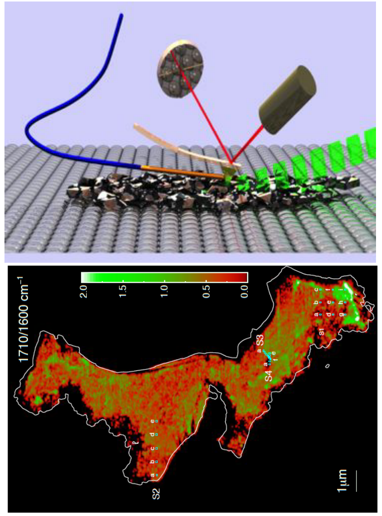
- What is a result of the interaction between a heavy CRs and ISM nano grains? Is there some effects on future observations (James Webb Space Telescope)?
- Production of a nanoparticule beam with an aerodynamic lens system and ion beam crossing at **ANDROMEDE**



Sublemontier+2018

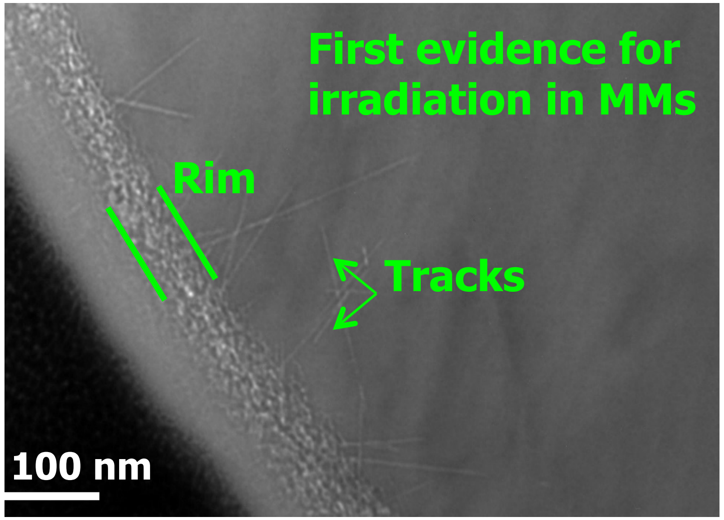
Formation & evolution of organics & minerals in space

AFMIR on UCAMMs

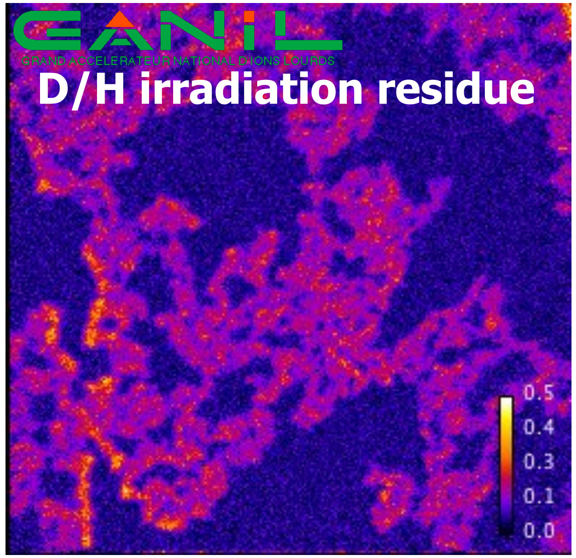


(Mathurin et al. 2019)

Irradiation in interplanetary space



(Charon et al. 2017, Engrand et al. 2018)



(Augé et al. in preparation)

- **Mineral-organic association** in cometary dust (AFMIR) [**CSNSM**, ISMO, LCP, IMPMC, UMET]
- **Heavy ions tracks & amorphous rim** in UCAMM minerals [**CSNSM**, UMET, ISMO]
- **Irradiation experiments** for (i) alteration of minerals & (ii) the origin of organics matter [ISMO, GANIL, **CSNSM/SCALP**]
- **Soluble organics & amino-acids** in UCAMMs: prebiotic input [**CSNSM**, IPAG & NASA Goddard]
- **Hayabusa II** / Preliminary Examination Team
- **2 PhD theses** 2018 - 2021 : B. Guerin, J. Rojas
- **ANR COMETOR** (PI: C. Engrand, 2018-2022, 572 k€)

Who we are

CSNSM Astro team

Astronuc group

Alain COC (DR2)(1)
Clarisse HAMADACHE (MC Univ Paris-Sud)
Jürgen KIENER (DR2)(2)
Vincent TATISCHEFF (DR2)

Rosa RODRIGUEZ-GASEN (Postdoc H2020, 2013)
Paolo CUMANI (Postdoc H2020, 2018-2019)
Valentin GOURLAOUEN (CDD IR PIA, 2017-2020)

Aleksandar GOSTOJIC (PhD, 2013-2016)
Adrien LAVIRON (PhD, 2018+)
Thibaud VIEU (PhD, 2018+)(3)

Astrosol group

Jean DUPRAT (DR2)
Cécile ENGRAND (DR2)
Marie GODARD (MC Univ Paris-Sud)
Georges SLODZIAN (Emeritus Pr)
Lucie DELAUCHE (T Instrumentation)

Yuki KAKAZU (Postdoc ANR, 2013-2015)
Emeline CHARON (Postdoc P2IO, 2016-2017)
Basile AUGÉ (Postdoc P2IO, 2018)

Noémie BARDIN (PhD, 2013-2015)
Baptiste GUÉRIN (PhD, 2018+)
Julien ROJAS (PhD, 2018+)

IPNO Astro team

NESTER astrophysics group

Nicolas DE SÉRÉVILLE (CR1)
Faïrouz HAMMACHE (CR1)

Philip ADSLEY (Postdoc CNRS, 2016-2018)
Nicolas METEYE (CDD IR PIA, 2017-2020)

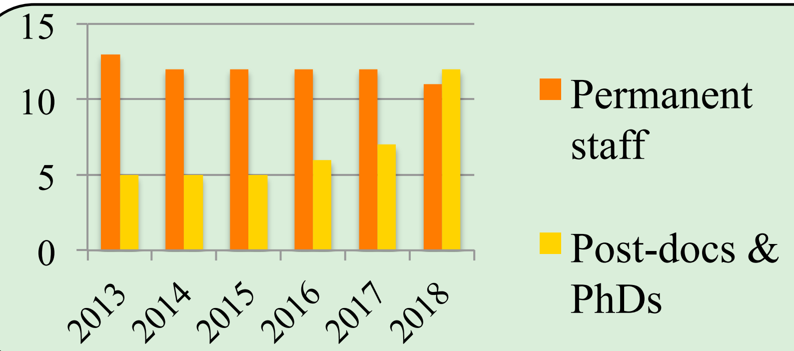
Salem BENAMARA (PhD, 2014-2019)
Anne MEYER (PhD, 2016-2019)

NIM astrophysics group

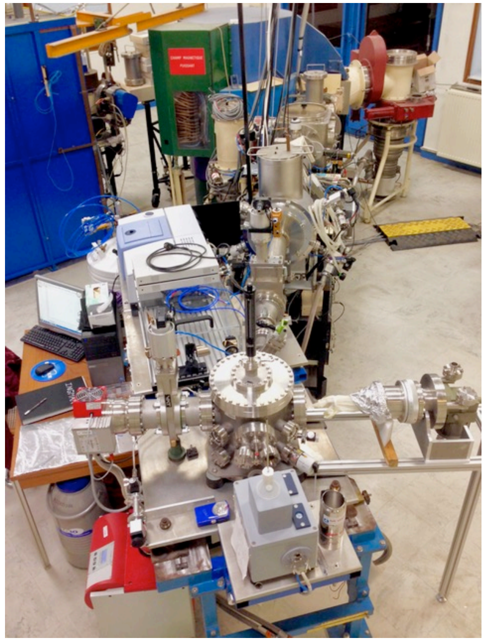
Marin CHABOT (DR2)

Aurélie JALLAT (PhD, 2012-2015)
Tijani IDBARKACH (PhD, 2016-2019)

(1) Retirement at the end of 2019
(2) Retirement from 2022
(3) Co-supervision with Stefano GABICI (APC lab.)



Teaching activities



- Statutory teaching of C. Hamadache & M. Godard (L1 -> M2)
- Since 2015, set up (M. Godard) of **practical works** "*spatial environment, ion irradiation & spectroscopy*" for the Master 2 OSAE (Outils et Systèmes de l'Astronomie et de l'Espace) using the SIDONIE astro-line **INGMAR** (**CSNSM**, IAS, ISMO)
- **Nuclear astrophysics course** of the MASTER 2 NPAC (Noyaux, Particules, Astroparticules & Cosmologie)
  - 2009 - 2013: J. Duprat & V. Tatischeff (CSNSM), E. Parizot (APC)
  - 2014 - 2015: C. Hamadache (CSNSM)
  - 2016 - 2020: F. Hammache (IPNO)
- Contributions to the **MOOCs** *Des particules aux étoiles* (J. Duprat & V. Tatischeff) and *Voyages de l'infiniment grand à l'infiniment petit* (J. Duprat)
- Courses in **thematic schools**: *Santa-Tecla Summer School on Experimental Nuclear Astrophysics 2013 & 2015 & 2017* (A. Coc, F. Hammache, J. Kiener), *Russbach School on Nuclear Astrophysics 2013-2018* (A. Coc, N. de Séréville, J. Duprat, F. Hammache, V. Tatischeff), *Joliot Curie School 2016* (J. Duprat, F. Hammache), *CNT Lectures on Special Topics in Nuclear Astrophysics 2017* (A. Coc, F. Hammache), *Ecole des 2 Infinis 2013-2017* (J. Duprat), *Ecole d'été e2phy 2014* (V. Tatischeff), *Festival d'Astronomie de Fleurance 2015* (V. Tatischeff) etc.

Financial support (1)

European & international contracts

- **H2020** HESPERIA (2015-2017): High Energy Solar Particle Events foRecastIng and Analysis
- **H2020** AHEAD (2015-2019): Activities for the High-Energy Astrophysics Domain
- **H2020 COST Action** ChETEC (2017-2021): Chemical Elements as Tracers of the Evolution of the Cosmos
- **BILATERAL COOPERATION CNRS - Royal Society** (2013-2014, PI: N. de Séréville, 8 k€): High-efficiency coincidence facility dedicated to nuclear astrophysics
- **BILATERAL COOPERATION CNRS - FAPESP** (2017-2018, PI: F. Hammache, 10 k€): Experimental study of nuclear reactions of astrophysical interest

National contracts

- **ANR** VACOUL (2010-2014): Variation des constantes fondamentales de la Physique : Contraintes observationnelles dans l'Univers lointain
- **ANR** COSMISME (2011-2015): COSmoMateriaux du Milieu Insterstellaire au Système solaire: Multi-diagnostics Expérimentaux
- **ANR** COSMIS (2012-2015): Cosmic Rays and Compressible MHD Turbulence in the InterStellar Medium
- **ANR** OGRESSE (2012-2016, PI: J. Duprat, 317 k€): cOmet GRains and Early Solar System Evolution - Isotopic analyses of cometary polar micrometeorites
- **ANR** PECORA (2017-2021): PEV COsmic RAys
- **ANR** COMETOR (2018-2022, PI: C. Engrand, 572 k€): COMETary dust ORigin
- **R&T CNES** Télescope Compton (2011-2014)

Financial support (2)

National contracts (continued)

- **Infrastructure CNRS - Univ Paris Sud** MYRTHO (2013-2016, PI: J. Duprat, 350 k€): Micrométéorites & système solaire primitif
- **AP PNHE** Novae gamma (2014-2015): une nouvelle lumière sur le rayonnement cosmique
- **CNRS DEFI Instrumentation aux limites** DIAGME (2014, PI: V. Tatischeff, 14 k€): Détecteurs Innovants pour l'Astronomie Gamma des Moyennes Energies
- **CNRS DEFI Instrumentation aux limites** WPOL (2016): Réalisation d'un prototype de camera grand champ pour observer les sursauts gamma
- **CNRS DEFI ORIGINE** PrébioMM (2018, PI: C. Engrand, 27 k€): Origine de la matière organique - apport prébiotique
- **CNES** COSIMA (up to 2018, PI: C. Engrand, ~30 k€/yr): Calibration and scientific expertise for the COSIMA dust instrument (Rosetta space mission)
- **AP PNP-INSU** MMs & système solaire primitif (2000-2017, PIs: C. Engrand & J. Duprat, 7 k€/yr)
- **IPEV** Micrometeorite collection in Antarctica (2014 & 2016 & 2018, PI: J. Duprat, 15 K€ + full funding for Antarctica missions)
- **AP IN2P3** Split-Pole (2014-2018, PI: N. de Séréville, 27.5 k€)
- **AP IN2P3** Nucléosynthèse (2014-2018, PI: F. Hammache, 58 k€)
- **AP IN2P3** ASTROMEV (2015-2017, PI: V. Tatischeff, 15 k€)
- **AP IN2P3** GRAPE (2017-2018, PI: J. Kiener, 6 k€): Gamma-Ray emission in Accelerated Particle Environments
- **AP IN2P3** EXTERIOR (2017-2018, PI: J. Duprat & C. Engrand, 23 k€): Caractérisation de micrométéorites de la Collection Concordia

Financial support (3)

Contracts with the Île-de-France region

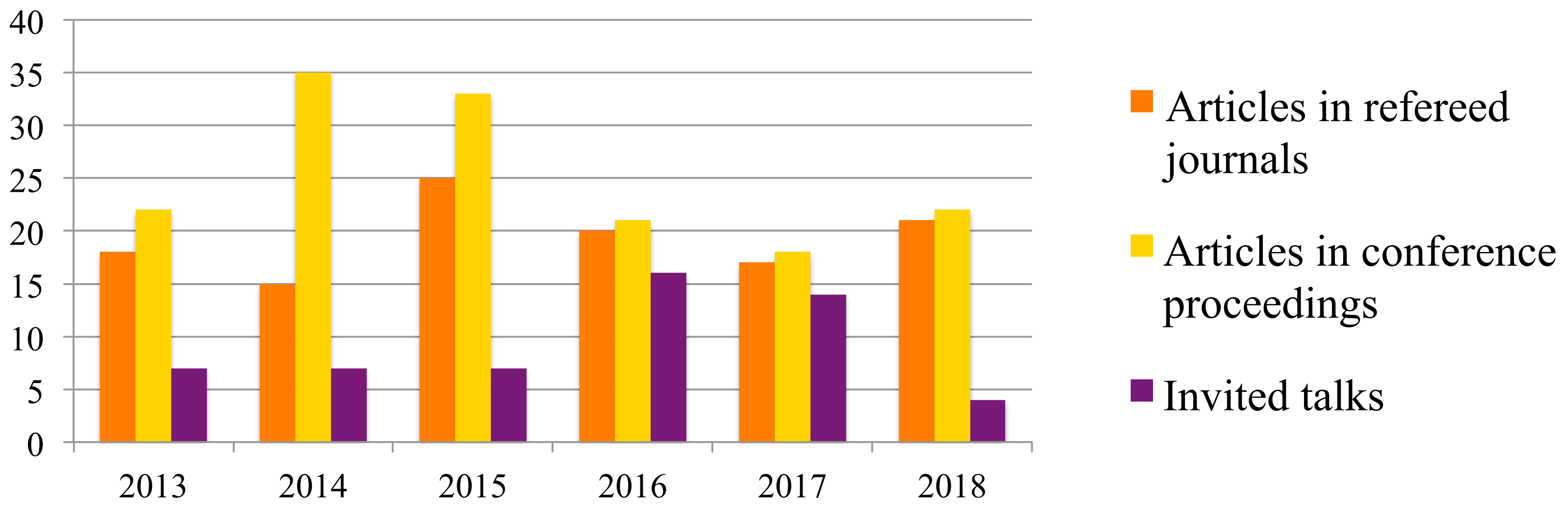
- **DIM-ACAV** MICROMET (2013 - 2020, PI: J. Duprat, 90 k€): Support for the equipment of the MYRTHO cleanroom for the Concordia micrometeorite collection
- **DIM-ACAV** EXTERIOR (2017 - 2020, PI: M. Godard, 120 k€): Multi-analytical characterization of micrometeorites
- **DIM-ACAV** PARADIGME (2017 - 2019, PI: V. Tatischeff, 20 k€): PlAteforme de caRActérisation de Détecteurs Innovants pour l'astronomie Gamma des Moyennes Energies

Contracts funded by the "Investing in the Future Programme" (PIA)

- **LabEx P2IO R&D** COCOTE (2012-2014, PI: V. Tatischeff, 40 k€): Développement d'un petit prototype de télescope Compton à rayons gamma
- **LabEx P2IO Emblematic Project** JWST (2016-2019): Evolution of matter from the interstellar medium to exoplanets with JWST
- **LabEx P2IO Postdoc** (2016-2018, PI: C. Engrand, 100 k€): Origine et évolution de la matière interplanétaire
- **Univ Paris-Saclay - Dept SPU** DISC (2017, PIs: C. Engrand & J. Duprat, 8 K€): Dust Irradiation in Space
- **Univ Paris-Saclay - Dept P2I** NANOCR (2018, PI: M. Chabot, 20 k€): Interstellar grains destruction by heavy cosmic rays
- **ANDRA** ComptonCAM (2017-2021, PI: V. Tatischeff, 1.8 M€) : Development of an ultra-sensitive portable γ camera to locate and characterize post-dismantling radioactive waste

⇒ Total budget of the contracts managed by the team: 3.8 M€

Publications



- **116 articles in refereed journals** (~11 per permanent researcher): Nature, PRL, PRC, PRD, MNRAS, ApJ, A&A, Solar Phys., Icarus, NIM A, NIM B, Phys. Report, Ann. Rev. Nucl. Part. Sci. etc..
- 151 articles in conference proceedings (~14 per permanent researcher)
- **55 invited talks/reviews in conferences** (cometary dust & micrometeorites, Big Bang nucleosynthesis, experimental nuclear astrophysics, γ-ray astronomy...)
- Participation in the **organization of 32 conferences/symposia/schools**

Outreach

- **Popular research topics with the general public**: micrometeorites, origin of life, solar system formation, origin of the elements, black holes & neutron stars, big bang, the extraterrestrials...
  - **14 articles in popular/general newspapers**: Pour la Science, Science & Vie, Astrosurf, Le Monde, Libération, Le Figaro, Les Echos, Charlie Hebdo...
  - **5 radio programs**: France Culture *La méthode scientifique* (x2), Radio France International *Autour de la Question* (x2), France Inter *Maman les P'tits Bateaux*
  - **Book chapters**: (i) C. Engrand in *Impact. Des météores aux cratères*, (ii) J. Duprat in *Où sont-ils? Les extraterrestres et le paradoxe de Fermi*
  - Participation in the **movie** *Atome Sweet Home*

  - **Exhibitions** in La Grande Galerie de l'Evolution MNHN: *La nuit* (Feb - Nov 2014), *Météorites* (Nov 2017 - Jan 2019) & *L'astronomie se la raconte* (DIM-ACAV Région Île-de-France)
  - Presentations/debates in schools, universities (L3 to M1), cultural centers, museums...

Conclusions

Strengths
- High-visibility and high-impact multidisciplinary research
- World-leading team on various topics
- Financial independence thanks to numerous contracts at all scales
- In depth collaboration with labs from other institutes (INSU, INP)
- Popular research topics with the general public

Weaknesses
- Retirements in the near future: unique expertise could be lost

Opportunities
- New research entity could take a leading role in the development of a future γ-ray space observatory

Threats
- Thematic not identified in the organizational chart in preparation
- Autonomy, flexibility and responsiveness are mandatory for multidisciplinary research
- Responsive local technical services (simple machining, electronics...) and responsive administration are critical for many projects
- Close link with local platforms (ALTO, SCALP, MYRTHO) must be kept and existing instrumentations (e.g. Split-Pole) must be maintained

Nuclear Astrophysics & Astrochemistry

BACKUP

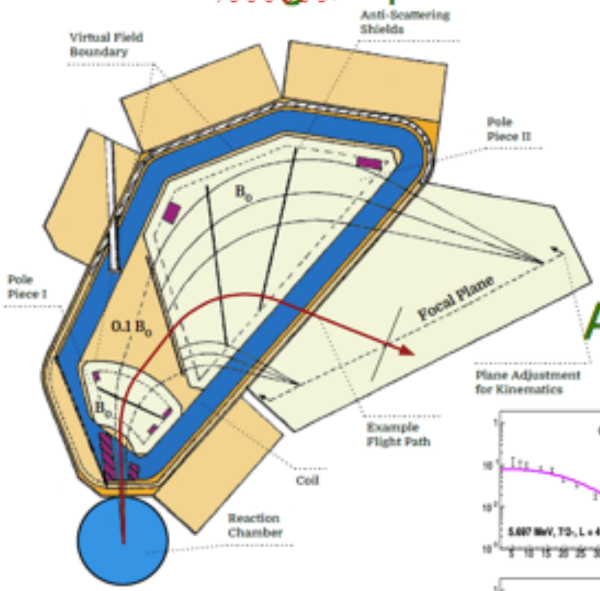
French contribution to e-ASTROGAM

- **e-ASTROGAM PAYLOAD**
  - **SYSTEM**
    - Project Office
      - Management
      - System Engineering
      - PA
    - AIV
    - GSE
      - MGSE
      - EGSE
    - E2E Calibration
  - **PAYLOAD SUB-SYSTEMS**
    - Silicon Tracker
      - Project Office
      - Silicon tiles procurement (esa)
      - ASIC procurement (esa)
      - FEE dev. & manufacturing
      - BEE dev. & manufacturing
      - Detection plane manufacturing
      - AIT
      - Calibration
    - Calorimeter
      - Project Office
      - Crystals procurement (esa)
      - ASIC procurement
      - FEE dev. & manufacturing
      - BEE dev. & manufacturing
      - Detector manufacturing
      - AIT
      - Calibration
    - AC
    - PDHU
    - PSU

Institution	Main activities
APC	Management, manufacturing & AIT of the Calorimeter. P/L calibration activities. Science activities.
CSNSM	Manufacturing of the Calorimeter detectors. P/L calibration activities. Contribution to Science Data Center. Science activities.
CEA/Irfu	Silicon Tracker FEE. Simulations. Science activities.
IPNO	Screening & characterization of the Si Tracker detectors. P/L calibration support.
LLR	Calorimeter mechanical structure. P/L calibration activities. Science activities.
CENBG	Calorimeter mechanical structure. P/L calibration activities. Science activities.
LUPM	Data Handling support. P/L calibration support. Science activities.
IRAP	P/L calibration support. Science activities.

Split-Pole magnetic spectrometer

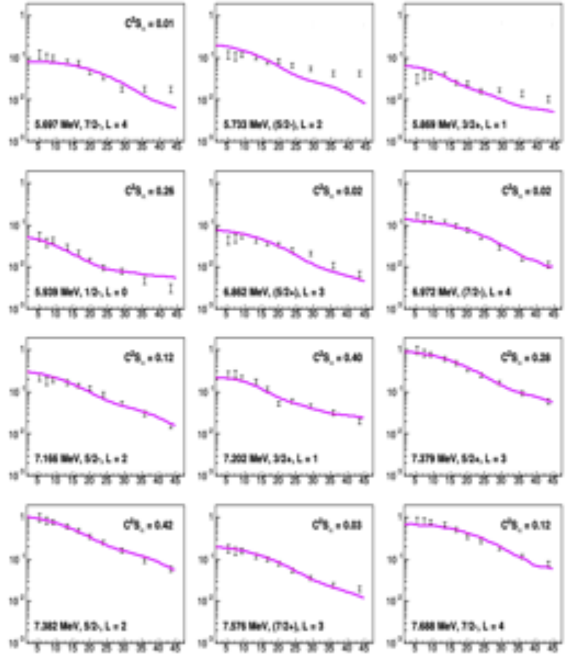
The Enge Split-Pole spectrometer



p/Dp = 2000
DW = 1.7 msr

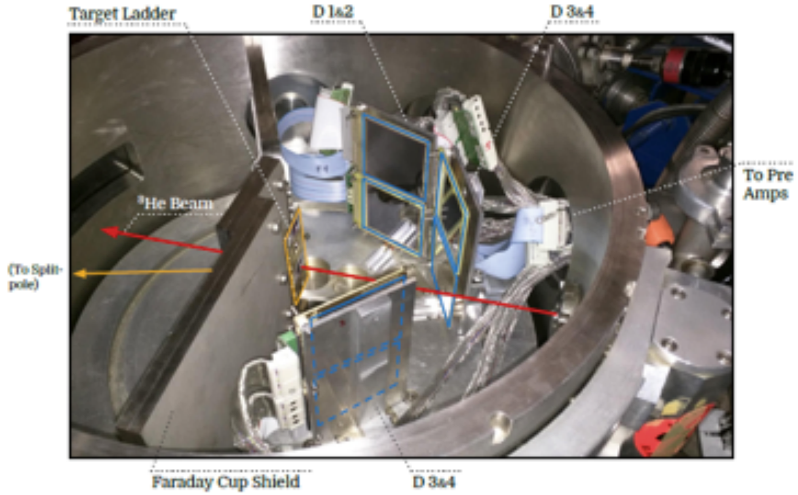
Angular distribution

$^{13}C(7Li,t)^{17}O$

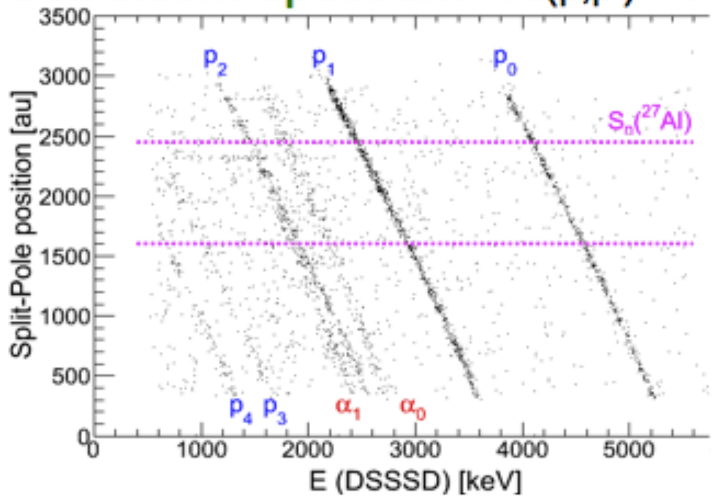


→ sensitivity to transferred orbital momentum
→ determination of spectroscopic factors

Coupling with a DSSSDs array

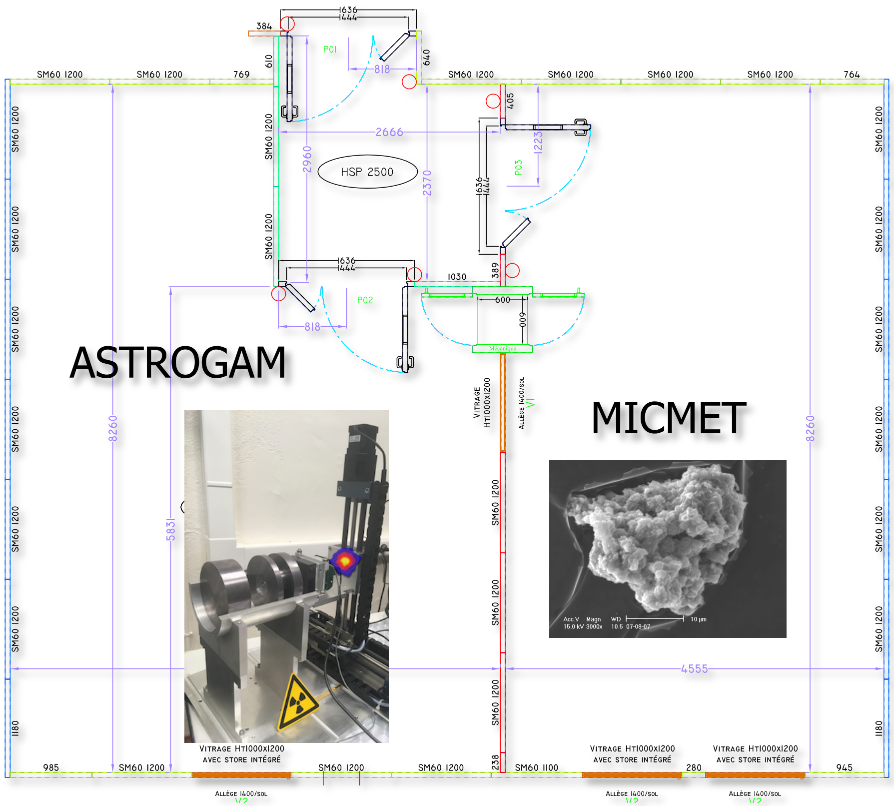


Coincident spectrum $^{27}Al(p,p')^{27}Al^*(p|a)$



→ sensitivity to spin and parity
→ determination of branching ratio

MYRTHO Platform



IR Microscope

Concordia Collection

- Platform **MYRTHO** (100 m^2) of CSNSM:
  - **MICMET** room (ISO 6): Preparation / analysis of micrometeorites (Concordia Collection)
  - **ASTROGAM** room (ISO 7): Development / characterization of gamma-ray detectors

Birth of the solar system

- Astrophysical scenario to explain the origin of the **short-lived radioactivities** present in the early solar system **[CSNSM, IPNO]**

  - The level of ^{10}Be in the protosolar nebula (FUN-CAIs) can be explained by the **explosion of a runaway Wolf-Rayet star** triggering the formation of the solar system (Tatischeff et al. 2014)