The value of exploiting archival data

An example of reducing our dependency on new research infrastructures

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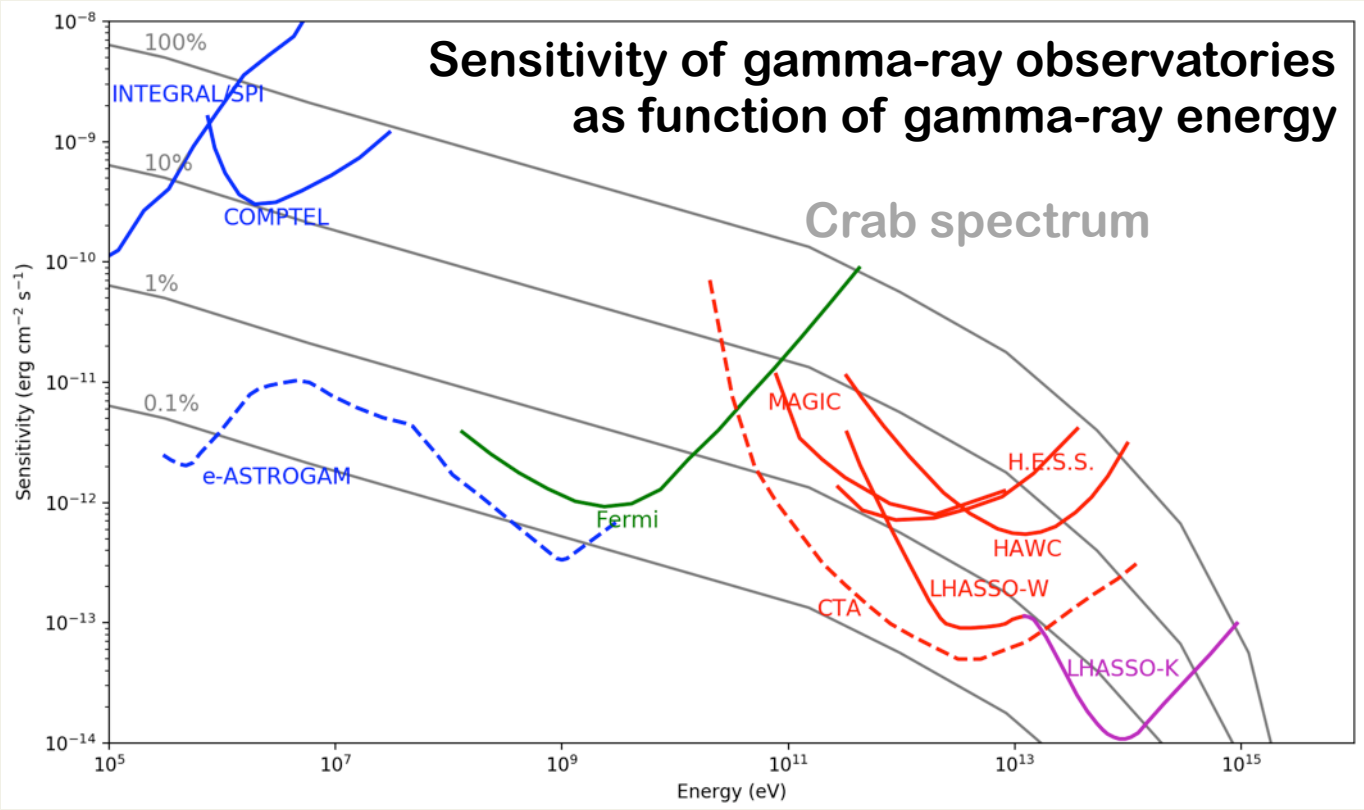
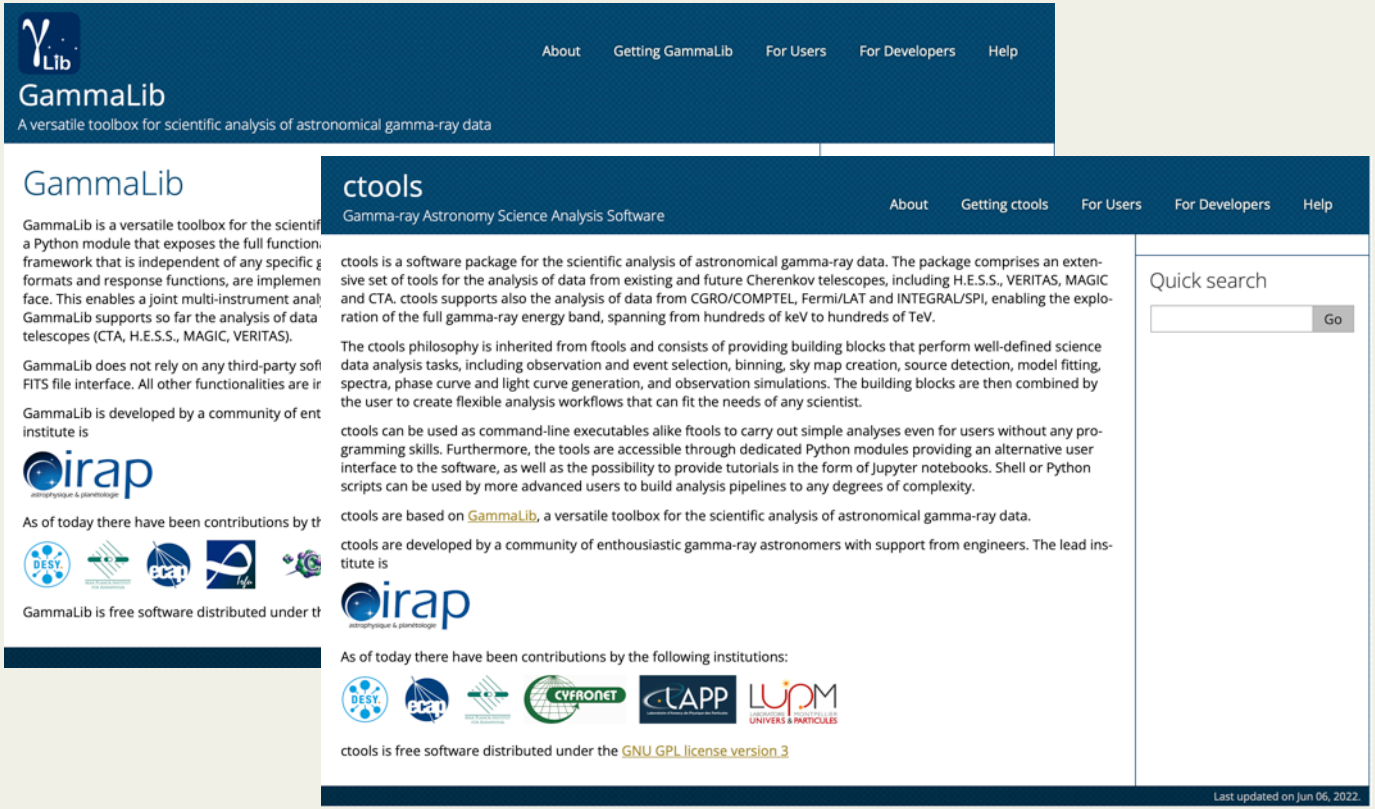
Starting points



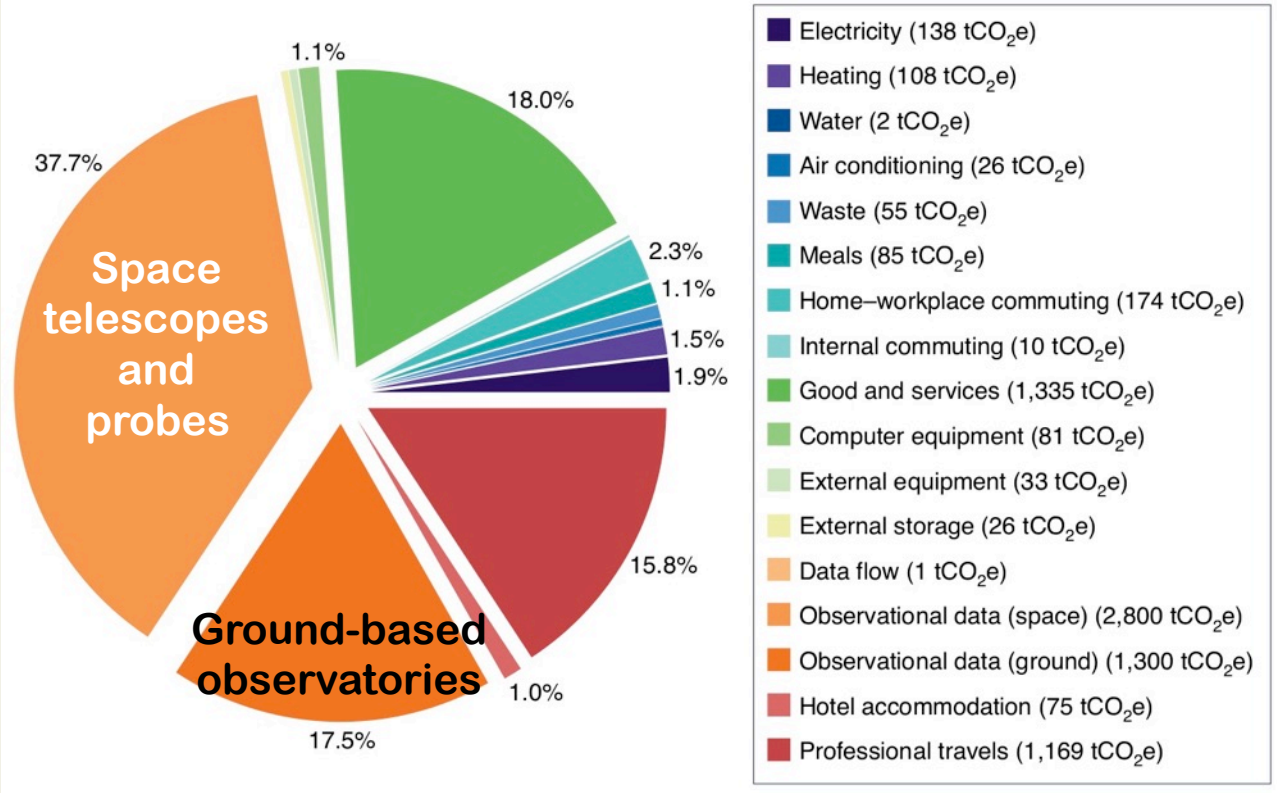
Starting points



Software development driven by CTA needs

(over 15 years of development efforts)

Starting points



A carbon footprint dominated by the use of data from astronomical research infrastructures

Martin et al. 2022, Nature Astronomy, 6, 1219; arXiv:2204.12362

Starting points

nature astronomy

2022, 6, 503 (arXiv:2201.08748)

ARTICLES

https://doi.org/10.1038/s41550-022-01612-3

Check for updates

Estimate of the carbon footprint of astronomical research infrastructures

Jürgen Knödlseder ✉, Sylvie Brau-Nogué, Mickael Coriat, Philippe Garnier, Annie Hughes, Pierrick Martin and Luigi Tibaldo

"We therefore believe that reducing the pace at which we build new astronomical research infrastructures is the only measure that can make our field sustainable in the short run. This does not mean that we must stop developing new observatories or space missions, but we must do so at a (considerably) slower rate. […] The good news is that there is no imperative in science that fixes the rate by which new research infrastructures need to be constructed. Today, the rate is determined by our imagination and, ultimately, by money. Tomorrow, it must be determined by sustainability."

Too many observatories (or too few astronomers)?

The Future of Astronomy and the ALMA Archive

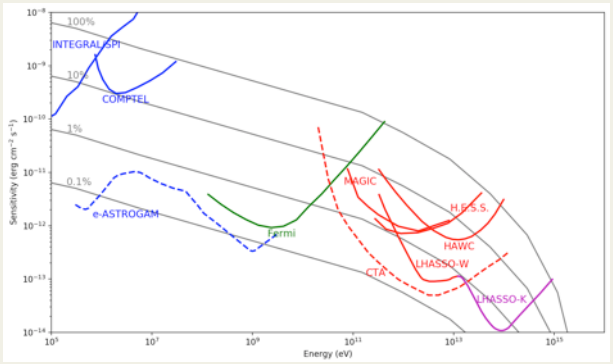
Felix Stoehr,[1] Mark Lacy,[2] Stéphane Leon,[3] Erik Muller,[4] and Akiko Kawamura[4]

ADASS XXIV, 2015, ASP Conference Series, 495, 69

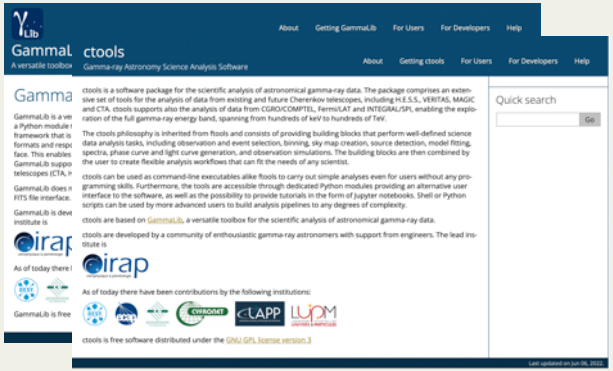
"Astronomy is transformed from being a data-starved science to one where data is overabundant" (Tony Tyson, LSST Chief Scientist)

"Whereas data will scale exponentially, astronomers will not. Therefore the bytes per astronomer do scale exponentially. Our prediction is that whereas now astronomers are competing for observing time, in the future, observatories will be competing for astronomers. [...] Astronomers, not data, will be the rare resource."

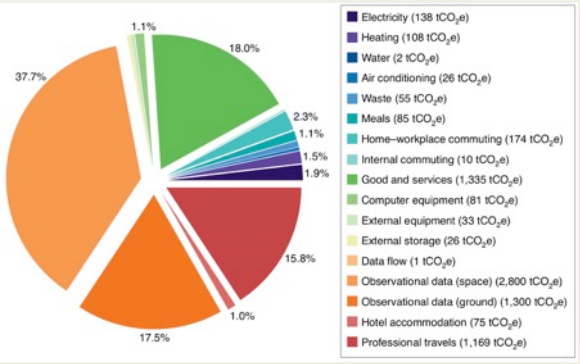
Starting points



Scientific question



Innovative tools

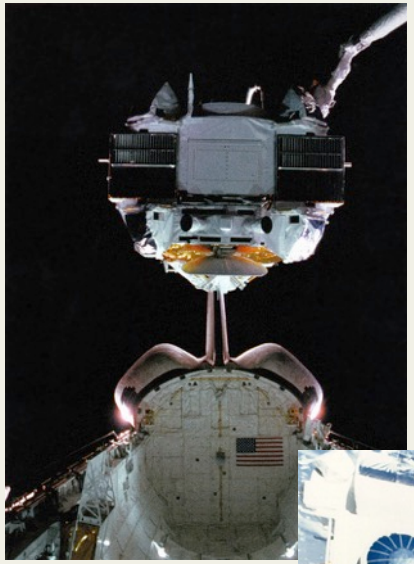


Planetary boundaries

#LowCarbonScience

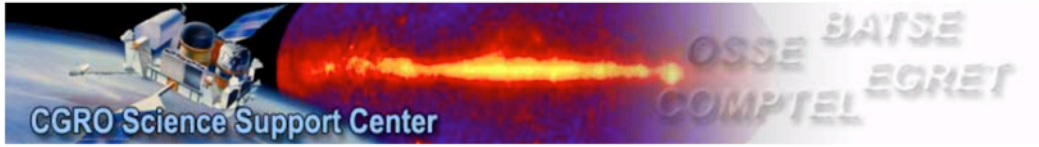
The Compton Gamma-Ray Observatory

April 1991 → May 2000



HEASARC Data Archive

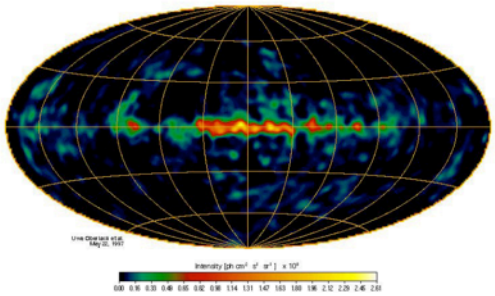
HEASARC HOME | CGRO HOME | ARCHIVE | DATA ANALYSIS | EDUCATION & PUBLIC INFO



ABOUT CGRO | WHAT'S NEW | COMPTEL | BATSE | EGRET | OSSE | RELATED SITES

The Imaging Compton Telescope (COMPTEL)

CGRO / COMPTEL 1.8 MeV, 5 Years Observing Time



Click image for larger view

General Information

- COMPTEL Instrument Description
- In Depth Technical Information on COMPTEL
- COMPTEL Scientific Objectives
- COMPTEL Specifications

Public Data Archive

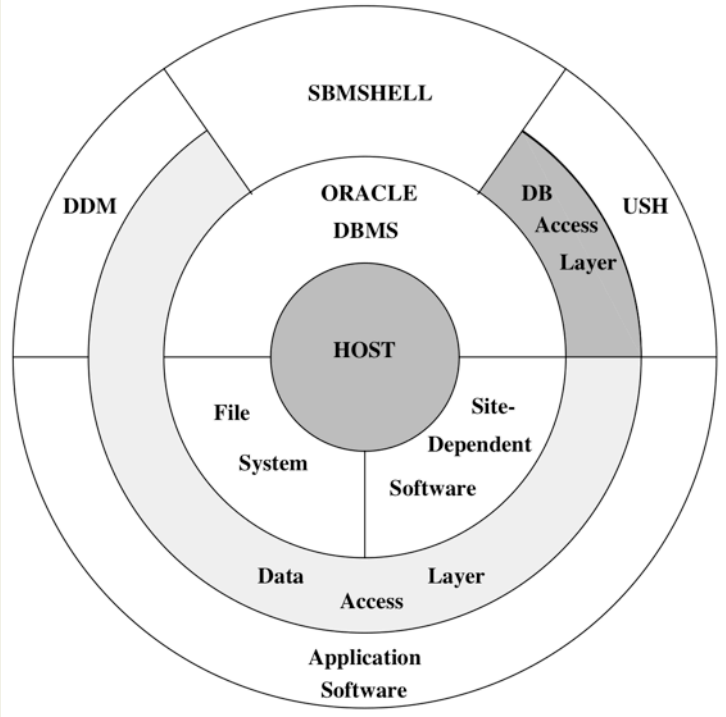
- FTP Access to Public Data Archive
- FTP Access to COMPTEL Software and Documentation
- Summary of Reconfigured CGRO Archive

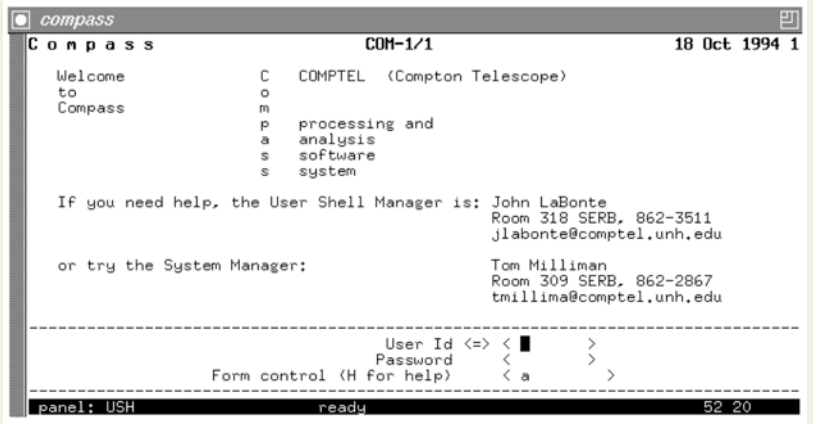
A good fraction of the data is preserved

Analysis software no longer available

COMPASS

The COMPTEL Processing and Analysis Software System





- Built around an ORACLE database
- Only available on four host sites
- Nightly database synchronisation
- Application Software in Fortran
- Decommissioned at end of mission

Two persons who made the project possible

Mark McConnell
University of New Hampshire

Werner Collmar
Max-Planck-Institut für extraterrestrische Physik

Preserved copies of

- Software
- Data
- Documentation

ToDo List

- Implement interface to read/write COMPTEL data
- Implement COMPTEL Instrument Response Computation
- Implement model for instrumental background
- Validate software w/r to literature / COMPASS results

Project started in 2012 …

… and was completed in 2022

Good example of #SlowScience ;-)

A&A 665, A84 (2022)
https://doi.org/10.1051/0004-6361/202243826

Astronomy & Astrophysics

COMPTEL data analysis using GammaLib and ctools

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[4] Southwest Research Institute, Dept. of Earth, Oceans, and Space, Durham, NH 03824, USA

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Acknowledgements. We would like to thank the anonymous referee for the very careful reading of the manuscript and the many constructive suggestions. This research made use of ctools, a community-developed gamma-ray astronomy science analysis software (Knödlseder et al. 2016). ctools is based on GammaLib, a community-developed toolbox for the scientific analysis of astronomical gamma-ray data (Knödlseder et al. 2011). This work has made use of the Python 2D plotting library matplotlib (Hunter 2007). This research has made use of data and/or software provided by the High Energy Astrophysics Science Archive Research Center (HEASARC), which is a service of the Astrophysics Science Division at NASA/GSFC. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France. This research is part of the #LowCarbon-Science initiative that aims in reducing the carbon footprint of scientific research, and has benefitted from discussions held in the context of the GDR Labos 1point5 and the Astro4Earth initiative.

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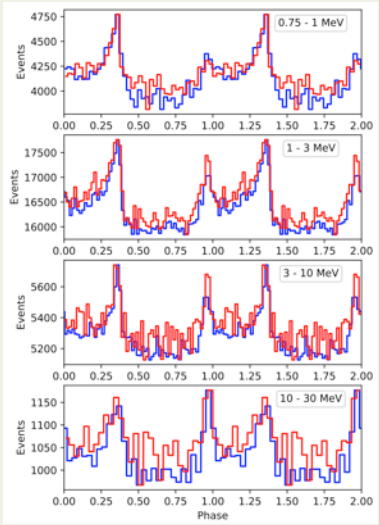
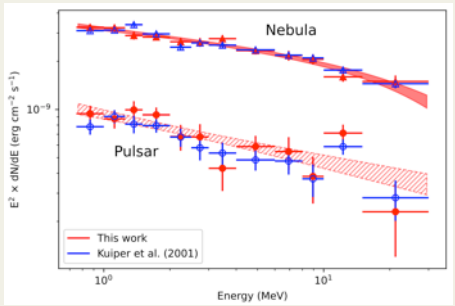
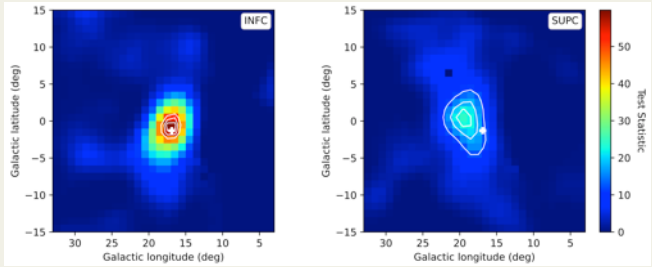
Some validation results

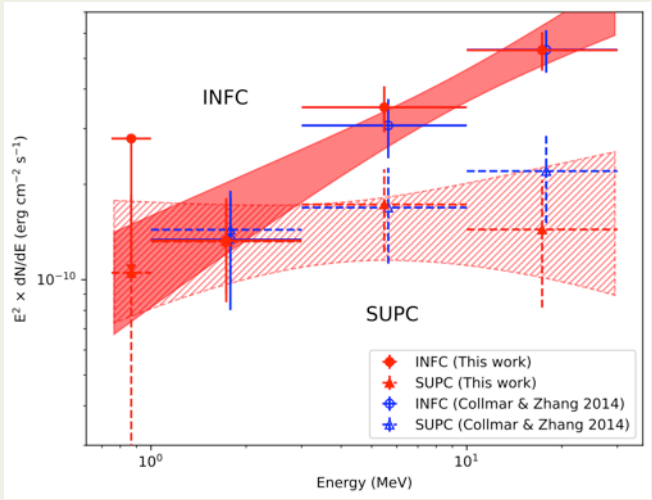
Crab pulsar & nebula



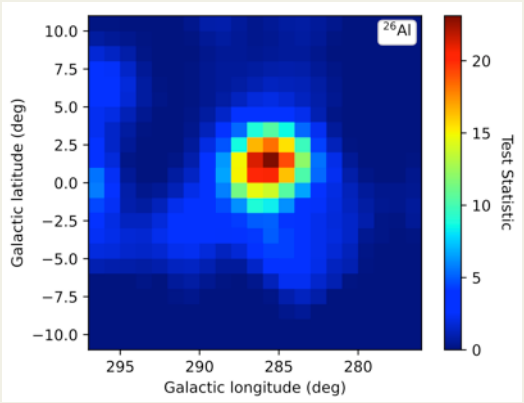


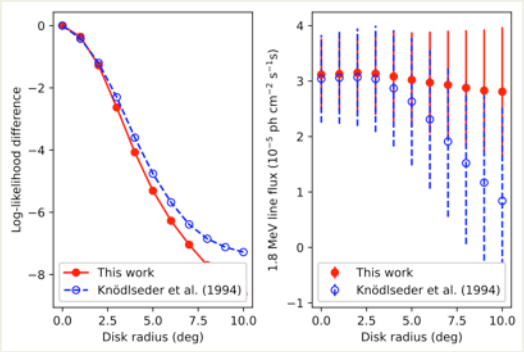
LS 5039



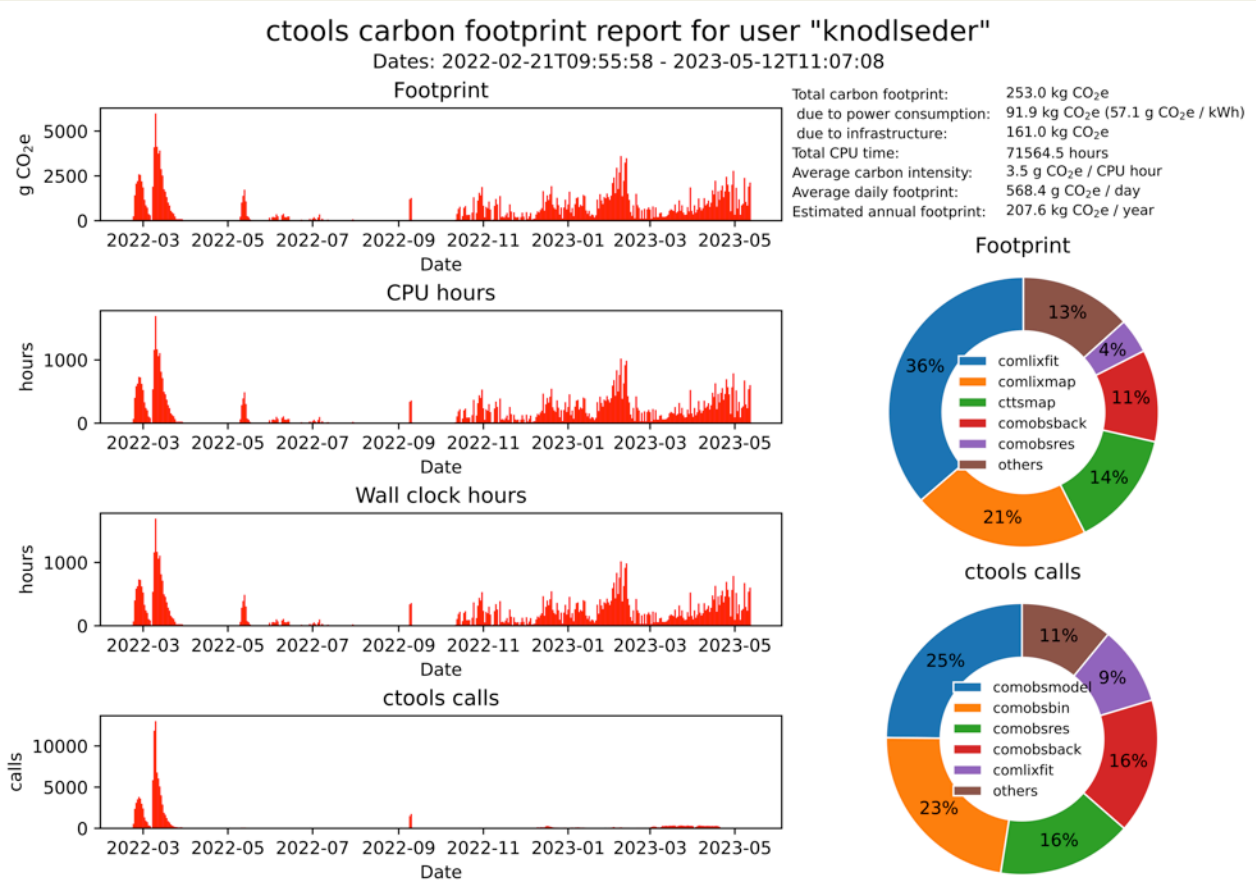


1.809 MeV line (^{26}Al)





ctools carbon tracker



Model based on GRICAD carbon footprint study (Berthoud et al. 2020)

Contributions from infrastructure and power consumption (adapted to carbon intensity of local electricity production)

Estimate of the carbon footprint

Software validation paper

Table H.1. Carbon footprint estimate by emission source of the research work behind this paper.

Source	Emissions $kgCO_2e$	Comments
Electricity to power office building	525 ± 53	
Heating of office building	422 ± 118	
Water usage in office building	8 ± 2	
Air conditioning in office building	80 ± 23	
Waste management	209 ± 106	
Computing infrastructure	400 ± 200	Evaluated using `csfootprint`
Data flow	8 ± 8	Includes videoconferencing
Lunch meals	171 ± 103	10% classical, 10% flexitarian, 80% vegetarian
Home-to-office commuting	89 ± 36	90% cycling, 5% public transport, 5% car
Total	1911 ± 284	

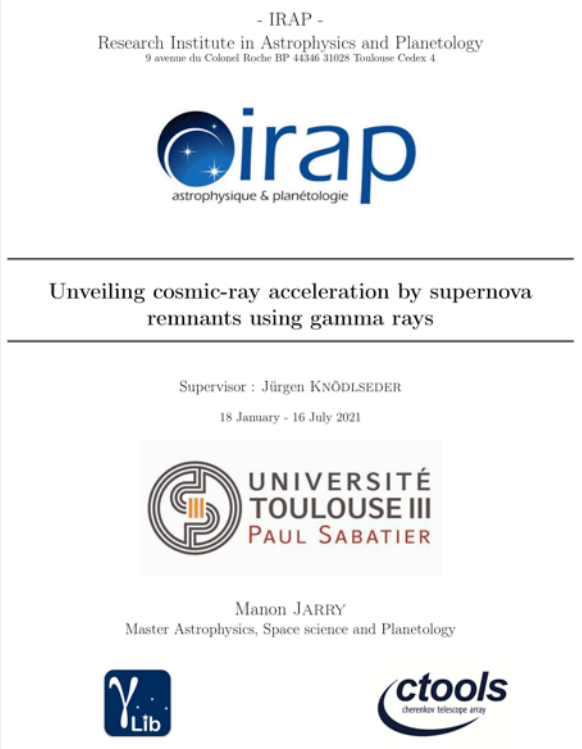
Notes. The footprint is based on a total work time estimate of one FTE or 220 working days.

For comparison:

Median per paper carbon footprint of a space mission: ~ 23000 $kgCO_2e$

(Knödlseder et al. 2022, Nature Astronomy, 6, 503)

Searching for MeV emission from GeV SNR



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astrophysique & planétologie

Unveiling cosmic-ray acceleration by supernova remnants using gamma rays

Supervisor : Jürgen KNÖDLSEDER

18 January - 16 July 2021

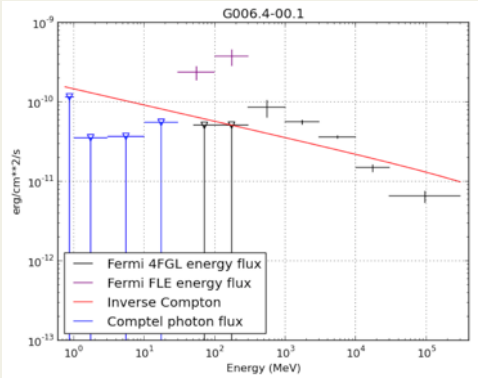
UNIVERSITÉ TOULOUSE III PAUL SABATIER

Manon JARRY
Master Astrophysics, Space science and Planetology

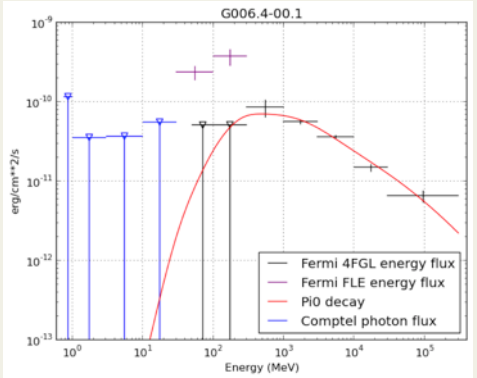
Lib

ctools
cherenkov telescope array

- **Supernova remnants were not known to emit gamma rays at the COMPTEL epoch**
- **Today GeV (Fermi, Agile) and TeV (HESS, MAGIC, VERITAS) is detected from many SNRs**
- **COMPTEL data can be crucial to discriminate between leptonic and hadronic models**

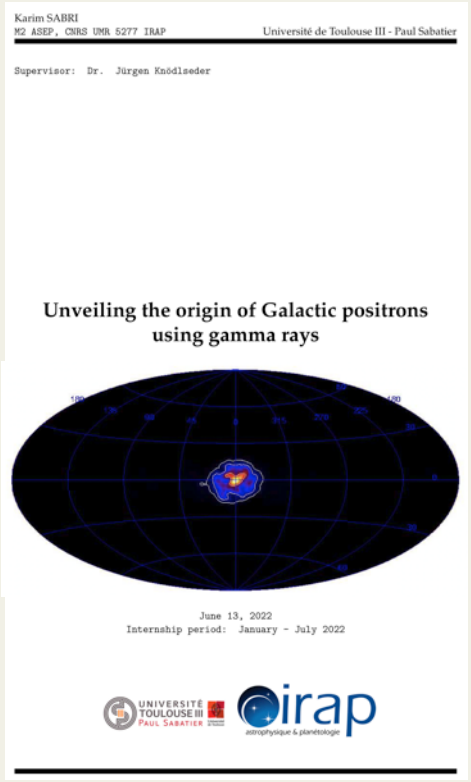


leptonic

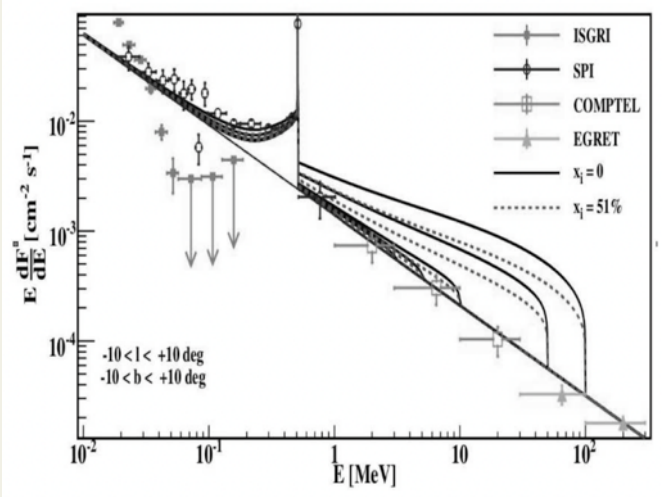


hadronic

Searching for positron inflight annihilation



- Bright 511 keV positron annihilation emission of unknown origin observed towards Galactic centre (most precise results so far from INTEGRAL/SPI)



- Continuum MeV emission predicted from positron inflight annihilation
- Embodies information of positron kinetic energies
- Nobody ever looked whether signal is in COMPTEL data :-o

Conclusions

- A highly rewarding experience
  - No competition
  - No pressure (#SlowScience)
  - One great discovery (so far…)
  - No need for new infrastructure (#LowCarbonScience)
  - Satisfaction of servicing the community (#OpenSource software)

- A long list of research ideas using COMPTEL data will keep me busy for many years :-)