

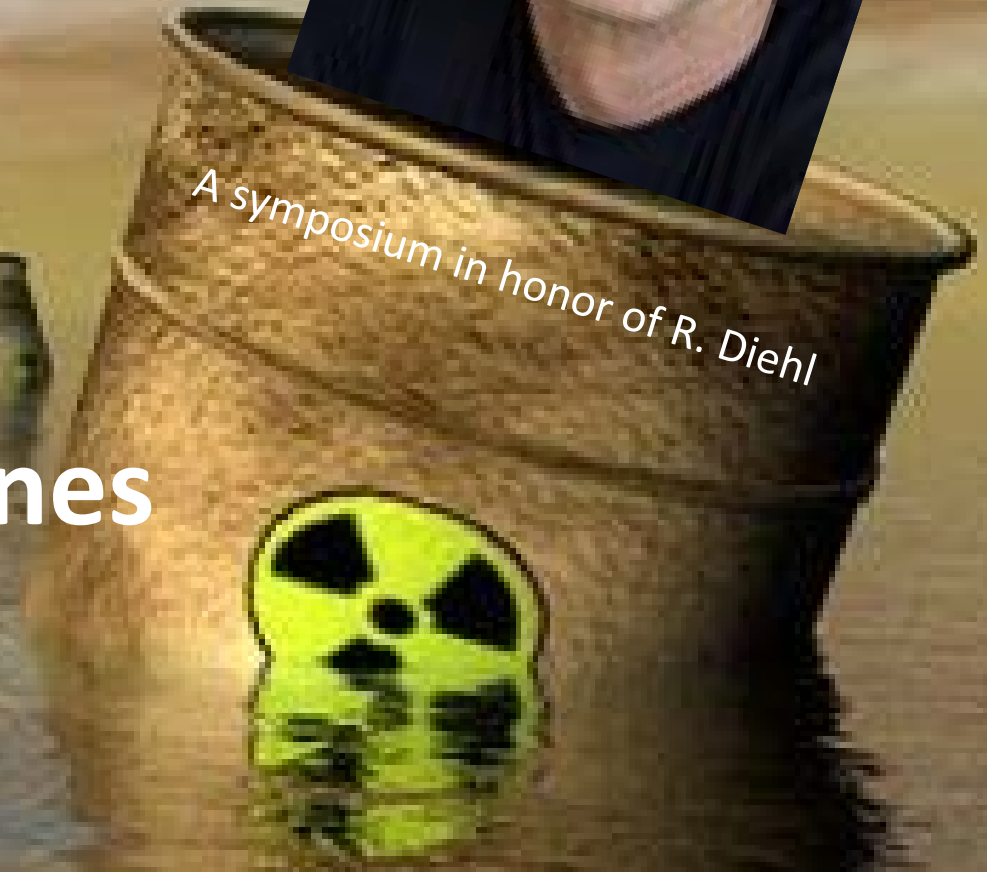
Karl Mannheim
JMU Würzburg

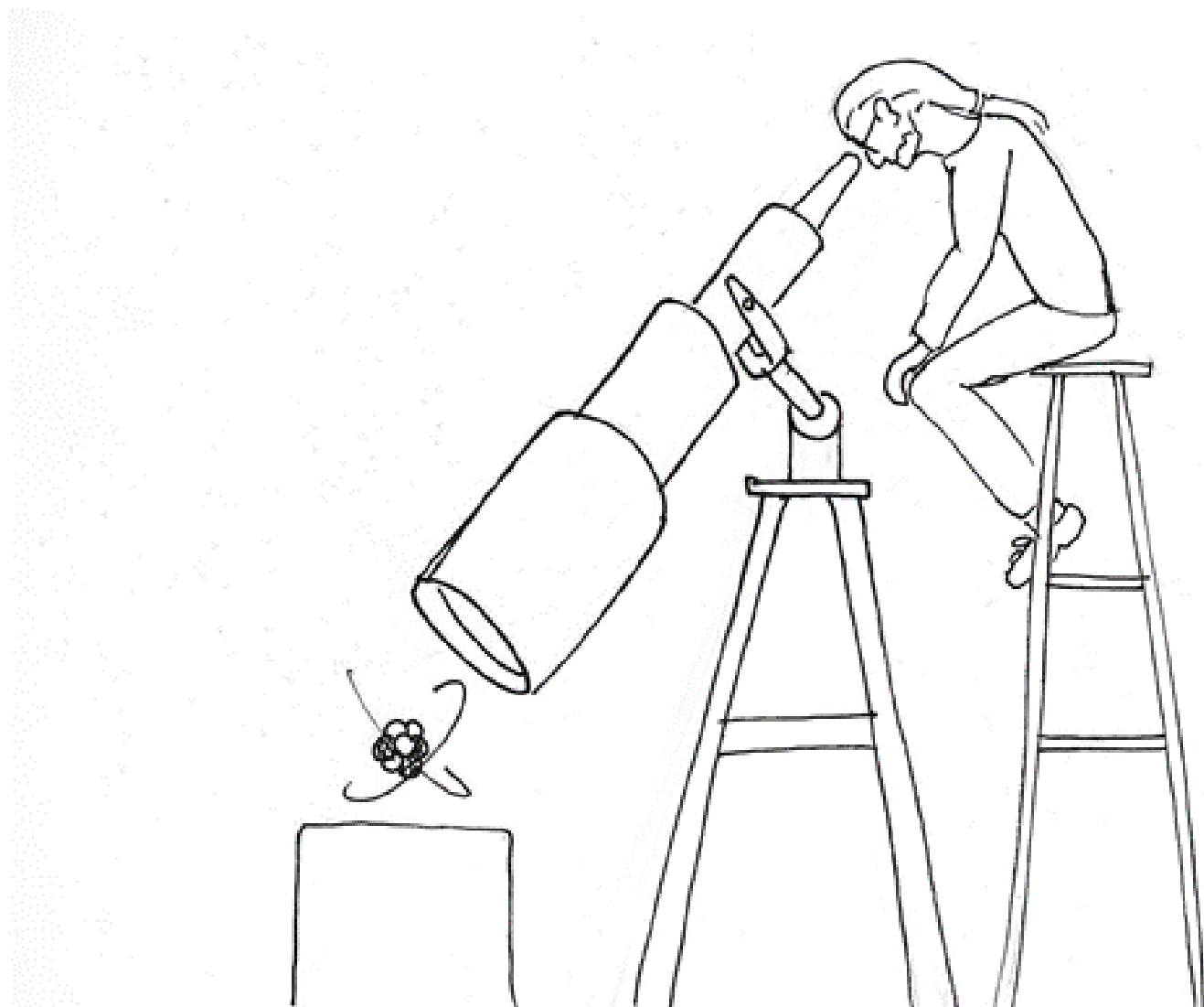
Nucleosynthesis for a Life
Garching, Feb. 08, 2019

Nuclear deexcitation lines

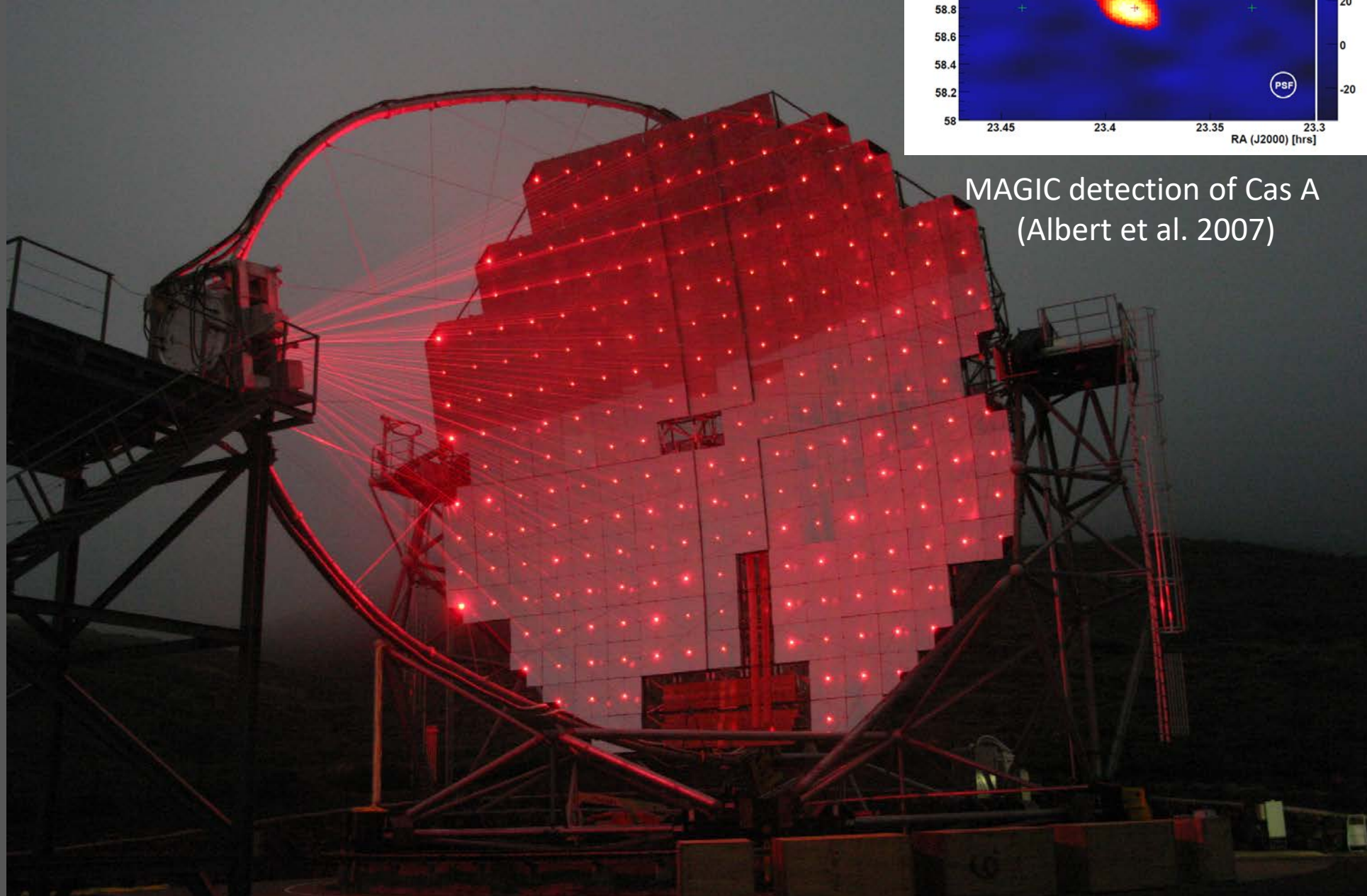


A symposium in honor of R. Diehl





The young SNR Cassiopeia A



MAGIC detection of Cas A
(Albert et al. 2007)





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Advances in Space Research 62 (2018) 2773–2816

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Supernova explosions of massive stars and cosmic rays

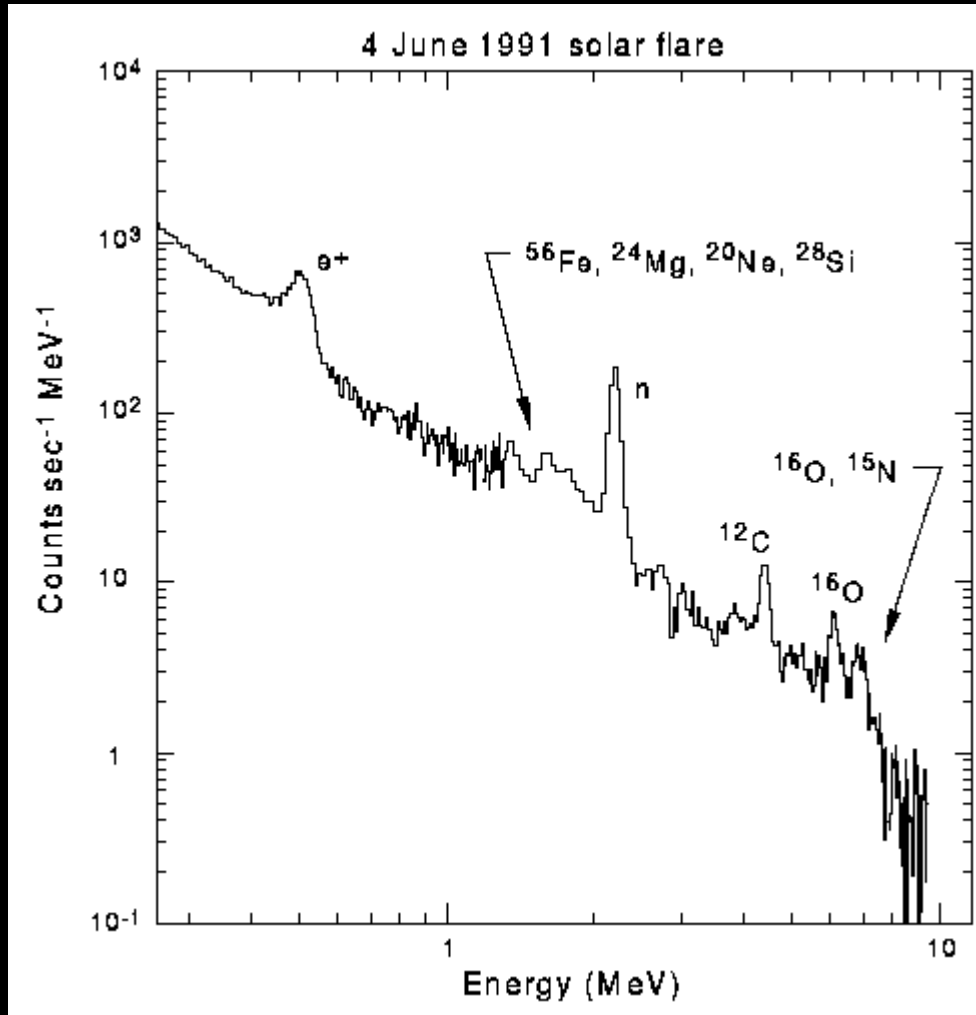
Peter L. Biermann^{a,b,c,d,*}, Julia Becker Tjus^e, Wim de Boer^b, Laurențiu I. Caramete^f,
Alessandro Chieffi^g, Roland Diehl^{h,i}, Iris Gebauer^b, László Á. Gergely^j, Eberhard Haug^k,
Philipp P. Kronberg^{l,1}, Emma Kun^j, Athina Meli^{m,n}, Biman B. Nath^o, Todor Stanev^p

The Moon

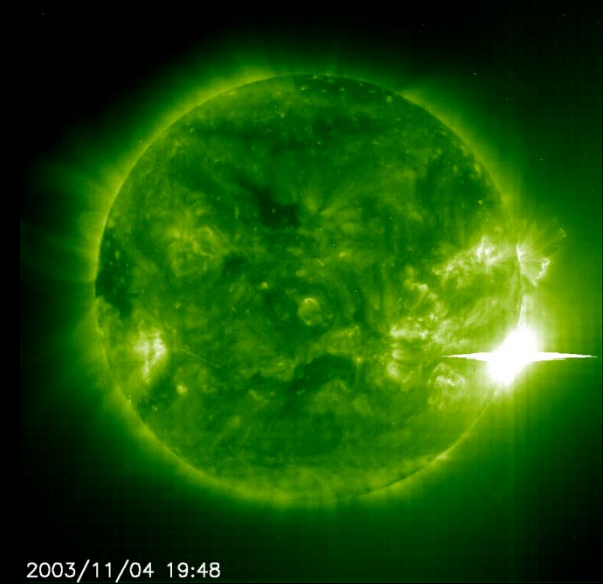


**...as seen by the
Compton GRO at
>20 MeV**

The Sun



Murphy et al., ApJ 1997



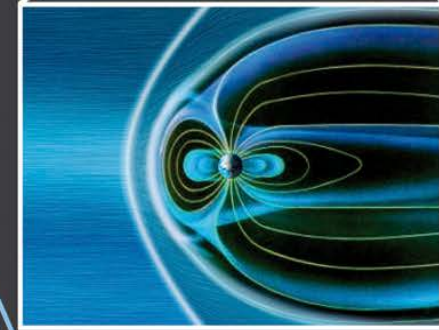
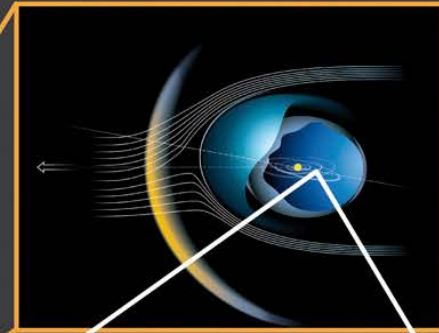
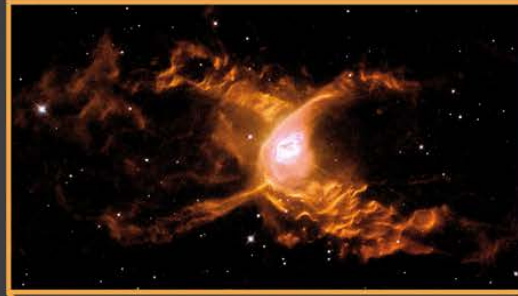
2003/11/04 19:48

... as seen by
OSSE at MeV
energies

LL Ori

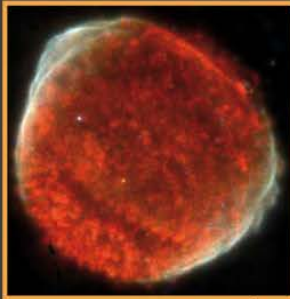


Red Spider Nebula

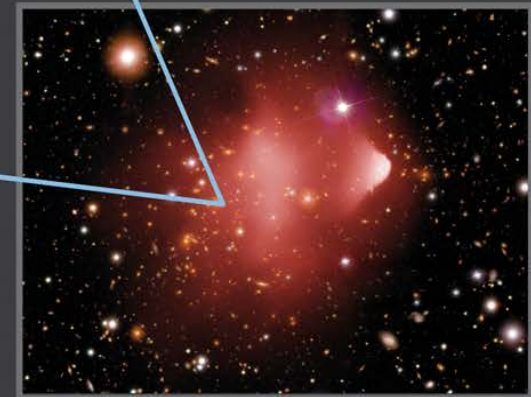
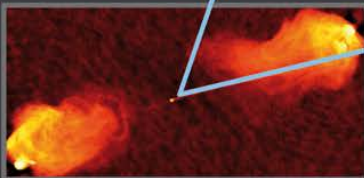


1E 0657-56

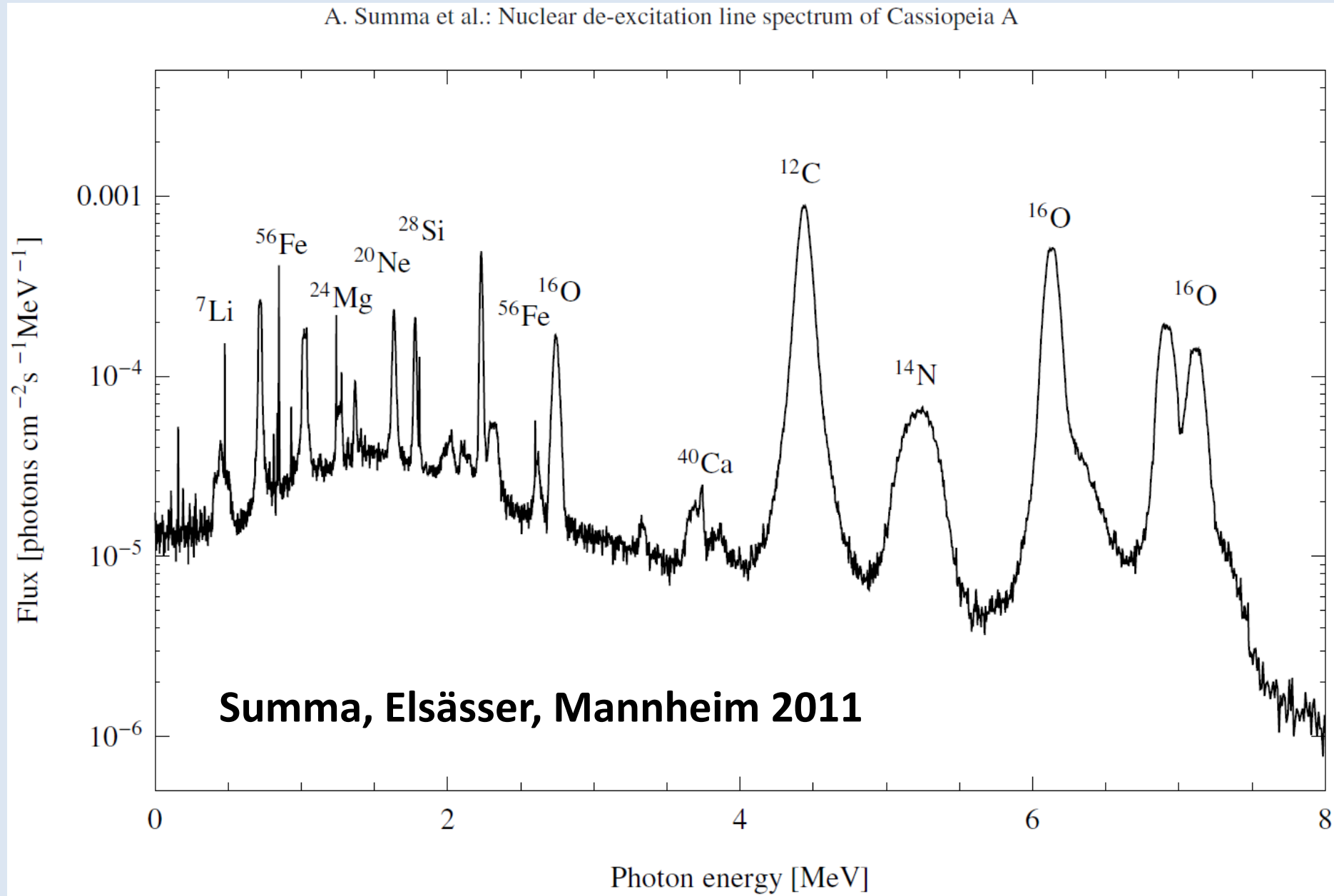
SN1006



Cyg A



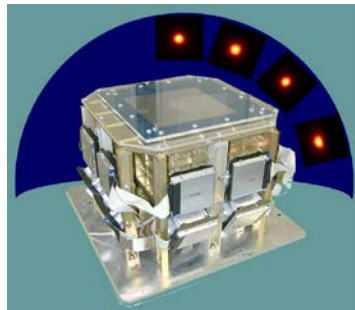
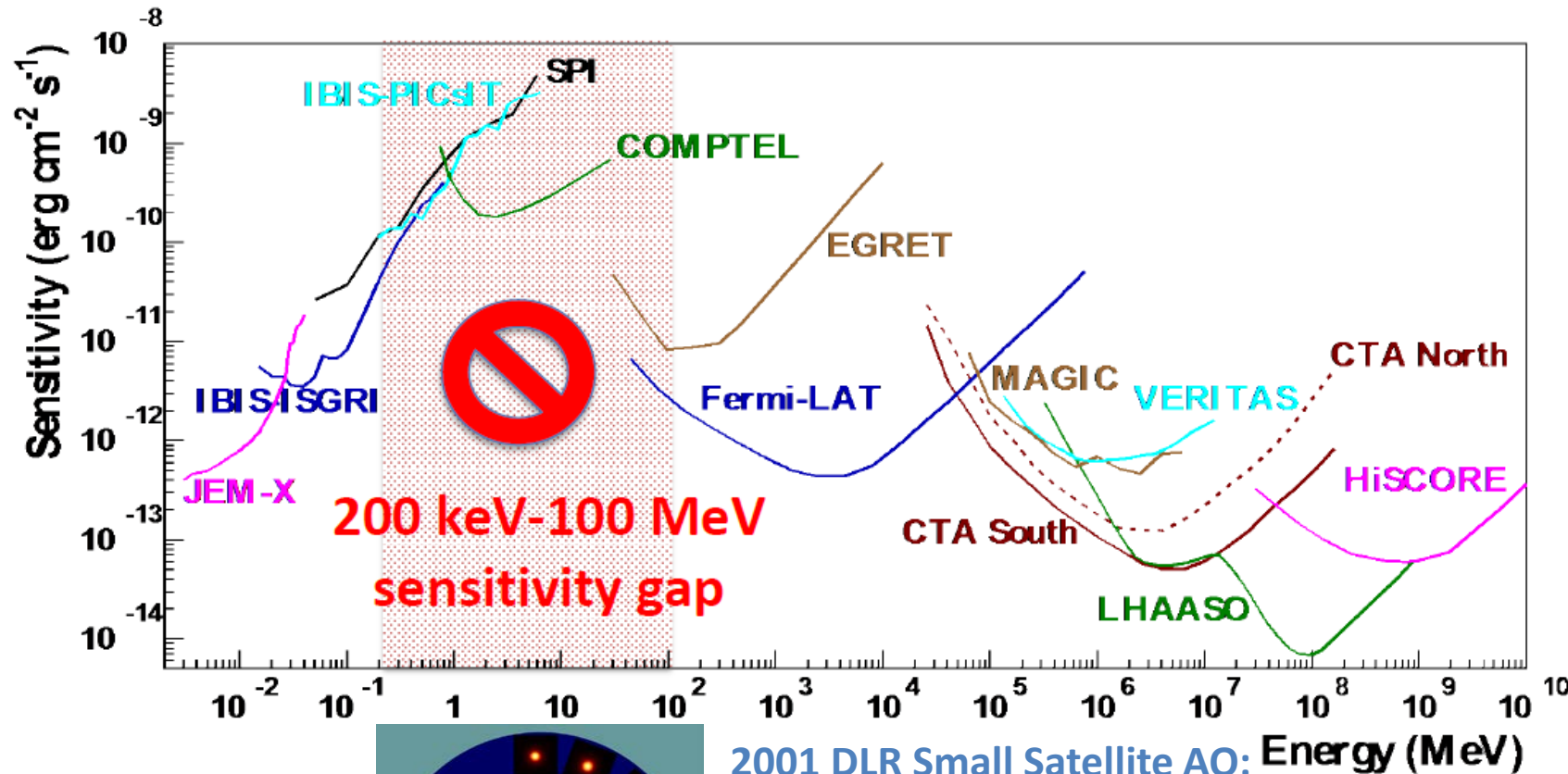
Based on cross-sections from Ramaty 1978; Kozlovsky, Murphy, & Ramaty 2002
Adopting Wolf-Rayet abundances



Nuclear excitations and cosmic rays:

- 1-100 MeV cosmic rays
 - ❑ Ionization inside of molecular clouds: The missing link to star formation
 - ❑ Activation of chemical reactions on icy dust grains: The cradle of life
 - ❑ Chemical composition of cosmic rays and SN ejecta: The injection problem
 - ❑ Spallation yields of light element: The Lithium puzzle
 - ❑ Secondary positrons: The positronium riddle
- Extragalactic cosmic rays?
 - Need MeV detector at least an order of magnitude better than COMPTEL or INTEGRAL or two orders to catch the nearest AGN...

The MeV Gap



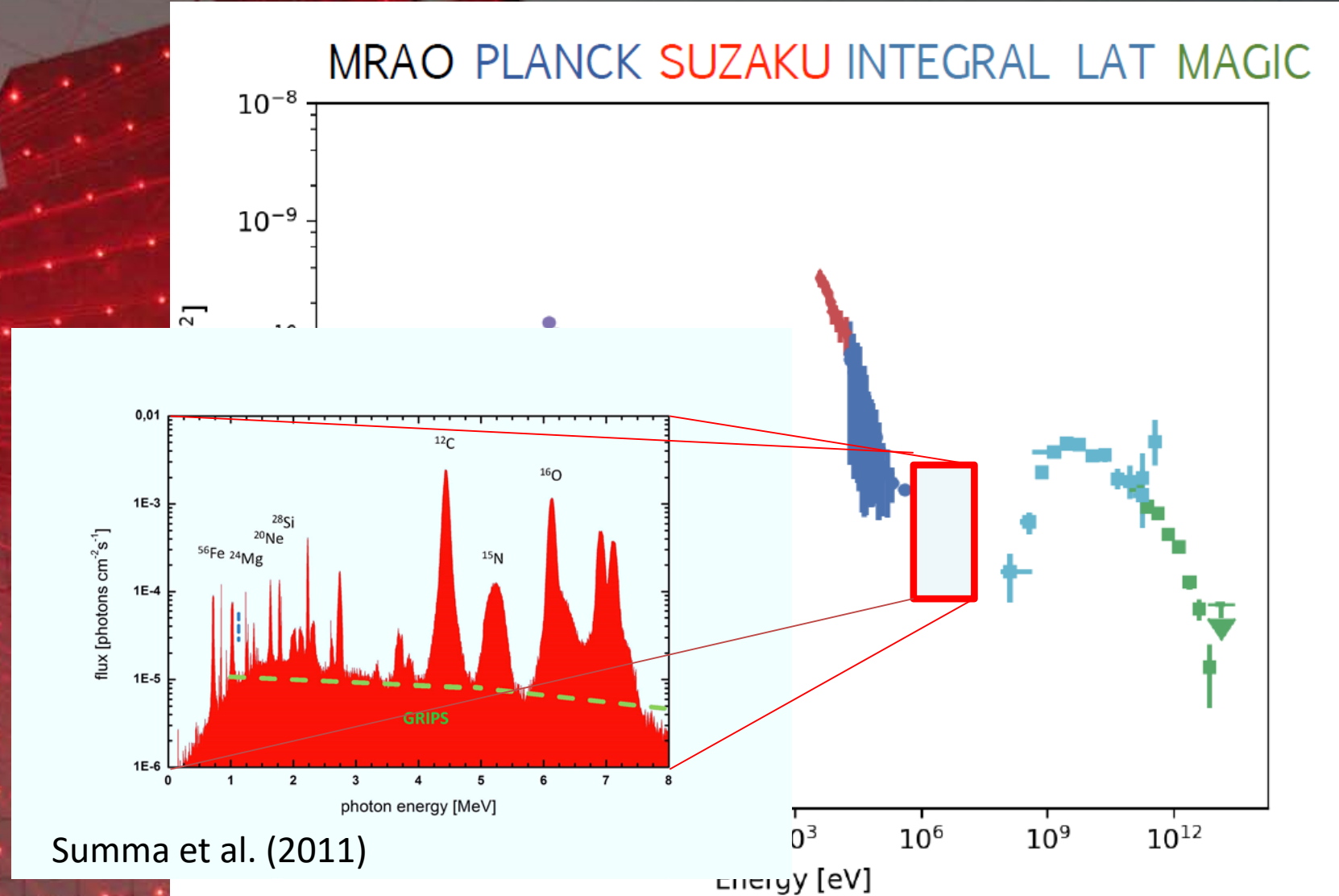
2001 DLR Small Satellite AO: DIVA/MEGA

2003 MEGA activities terminated at MPE

“There’s just one thing I can promise you about the outer space program – your tax dollar will go further.”

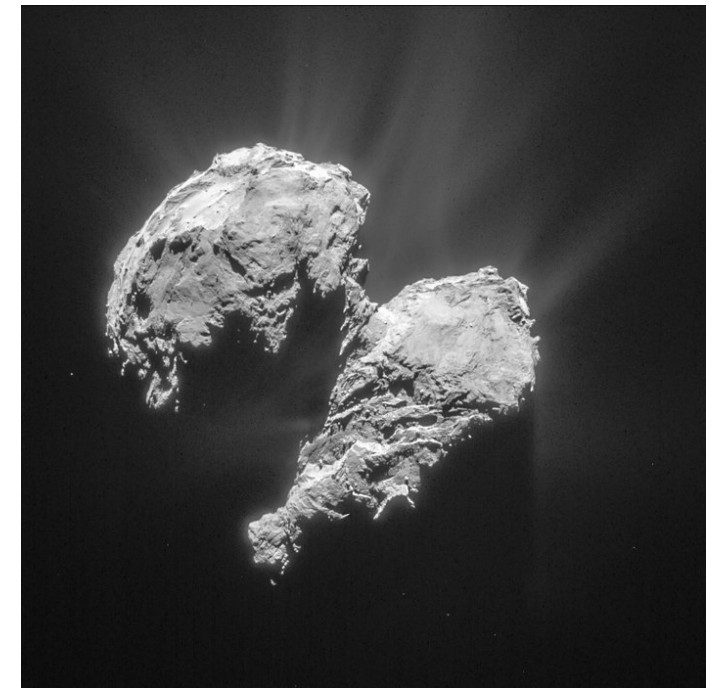
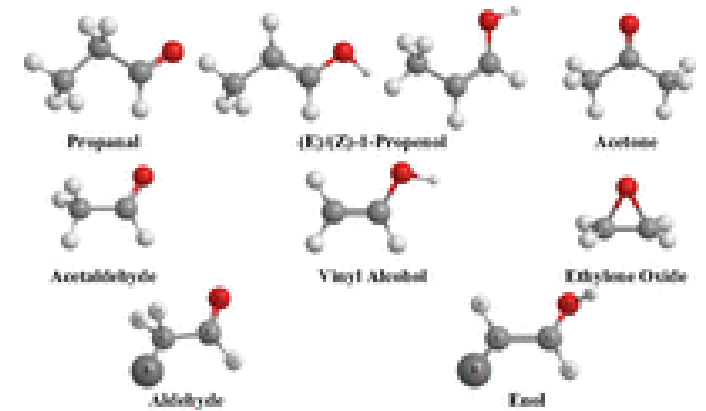
Werner von Braun

Wolf-Rayet SNR Cas A: Nuclear lines as hadronic fingerprint

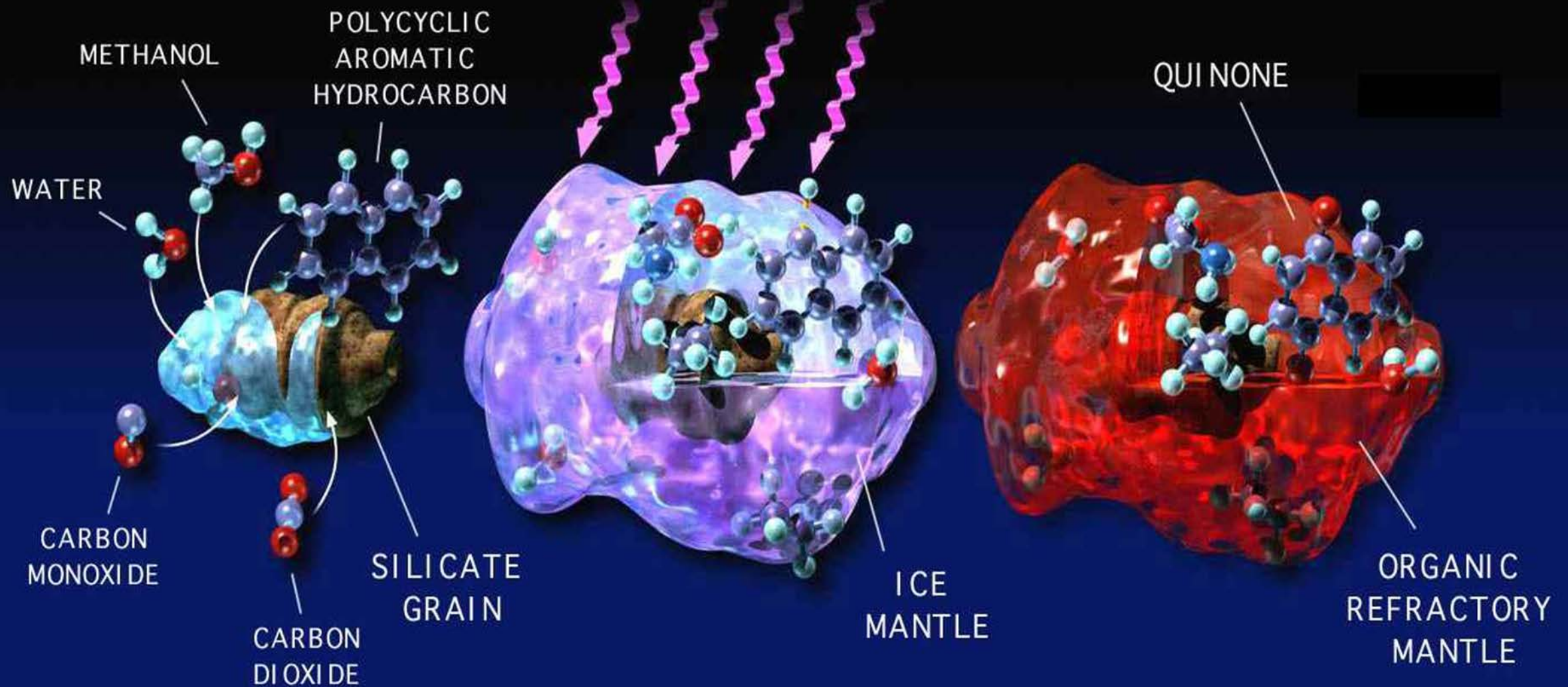


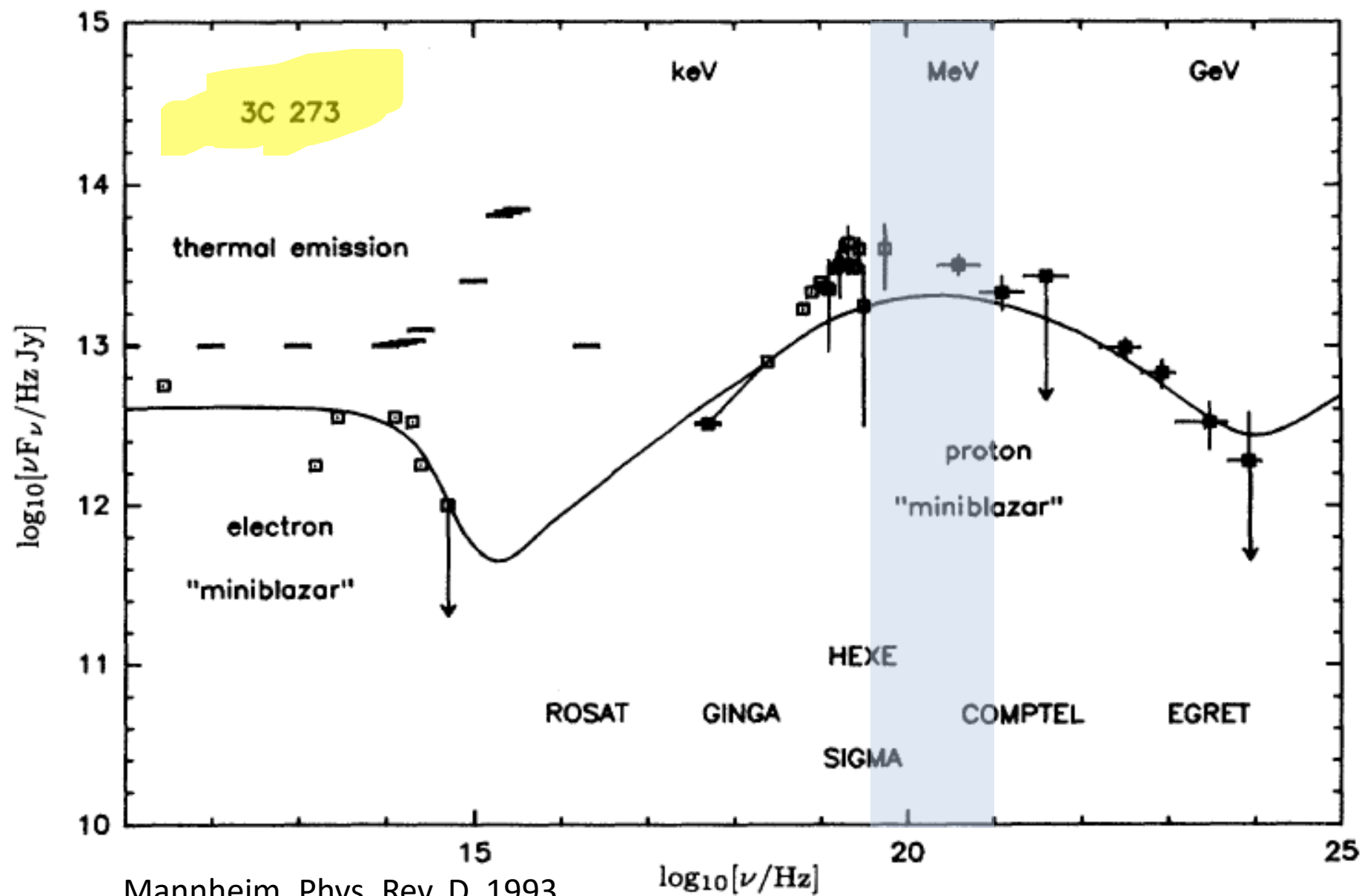
1-100 MeV cosmic rays and the cradle of life: The cold non-equilibrium chemistry in ice

- Interstellar space and in particular molecular clouds are filled with icy grains formed by water sticking on silicate or ferrite cores
- Cosmic rays induce complex molecular reaction networks in these ice grains
- Confirmed in laboratory experiments and simulations (M.J. Abplanalp, PNAS, 2016)
- Rosetta probe contained organic molecules from icy material formed in the Kuiper belt

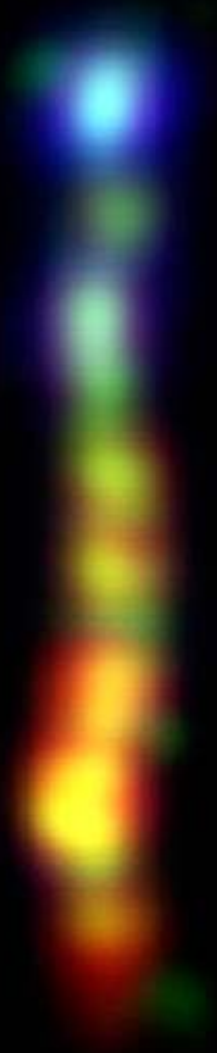


ULTRAVIOLET PHOTONS

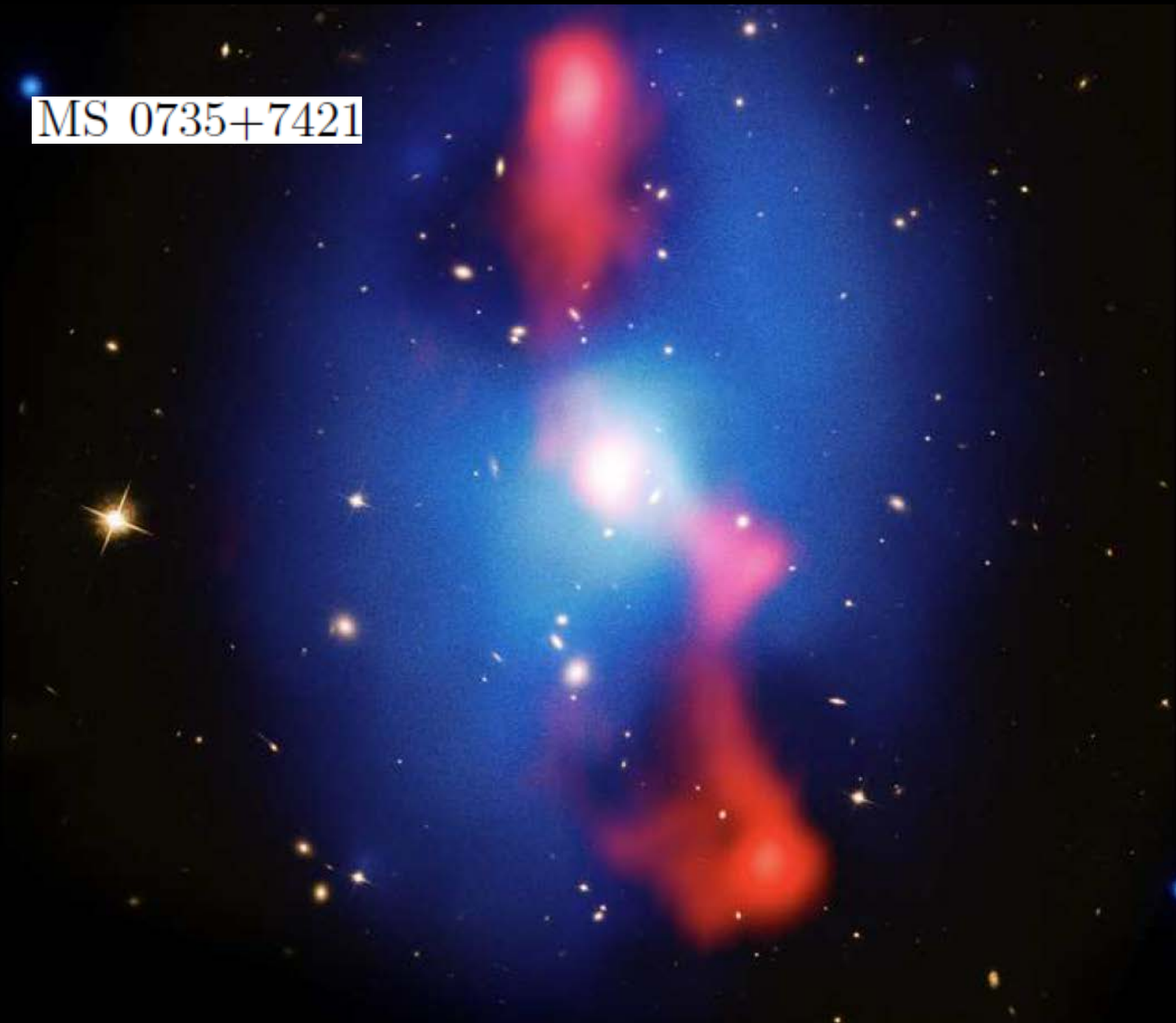




Mannheim, Phys. Rev. D, 1993



MS 0735+7421

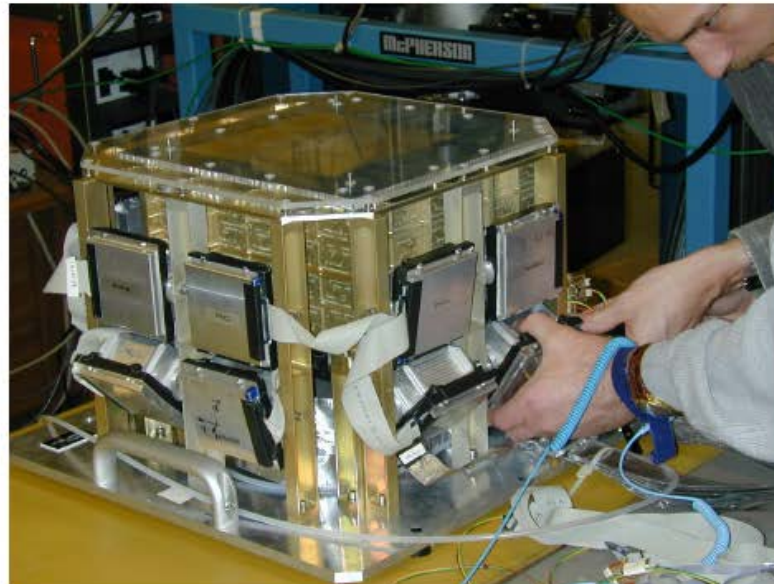


Assembly of the MEGA Prototype

Assembly of
the Tracker



Assembly of
Calorimeter
Modules



Kanbach, 2011

Rolandslied

(1075-1100)



Rolands legendäres Horn Olifant im Museum der Kathedrale von Santiago de Compostela



Heidelberger Liederhandschrift (Cod. Pal. germ. 112, P, fol. 57v),
Ende 12. Jh.

Virtual Institute for Nuclear Astrophysics



EMMI-Workshop
GSI Darmstadt
December 2011

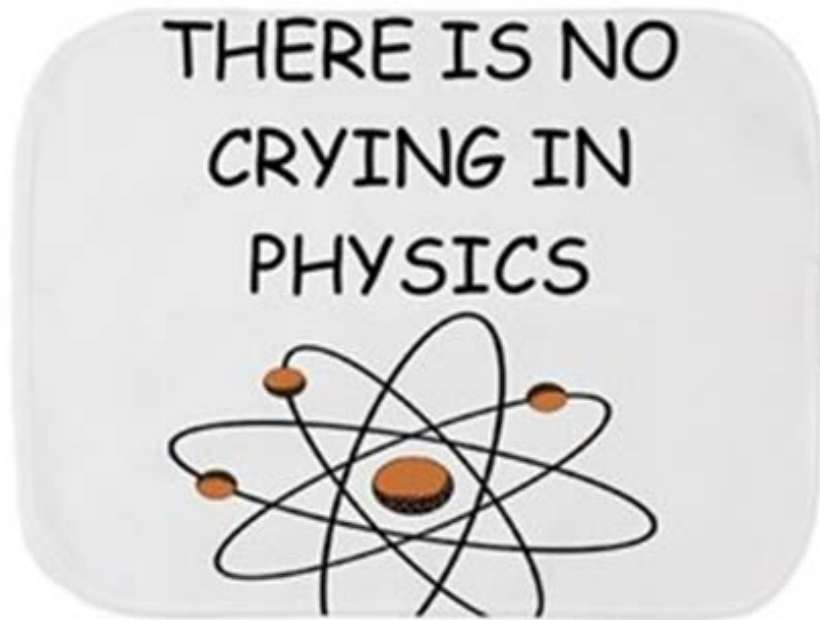


→ MoU with nuclear gamma-ray spectroscopy
collaboration NUSTAR@FAIR ready for signature



- 2007 ESA M1/M2: GRIPS
- 2010 ESA M3: GRIPS
- 2014 ESA M4: ASTROGAM
- 2016 ESA M5: eASTROGAM
- 2018 ESA F-call: all-sky ASTROGAM

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THE ASTROPHYSICAL JOURNAL LETTERS, 848:L12 (59pp), 2017 October 20

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Multimessenger observations of a flaring blazar
coincident with high-energy neutrino IceCube-170922A
The IceCube Collaboration, Fermi-LAT, MAGIC, AGILE, ASAS-SN, HAWC, H.E.S.S., INTEGRAL, Kanata, Kiso, Kapteyn, Liverp...
* See all authors and affiliations
Science 13 Jul 2018;
Vol. 361, Issue 6398, eaat1378
DOI: 10.1126/science.aat1378

<https://doi.org/10.3847/2041-8213/aa91c9>

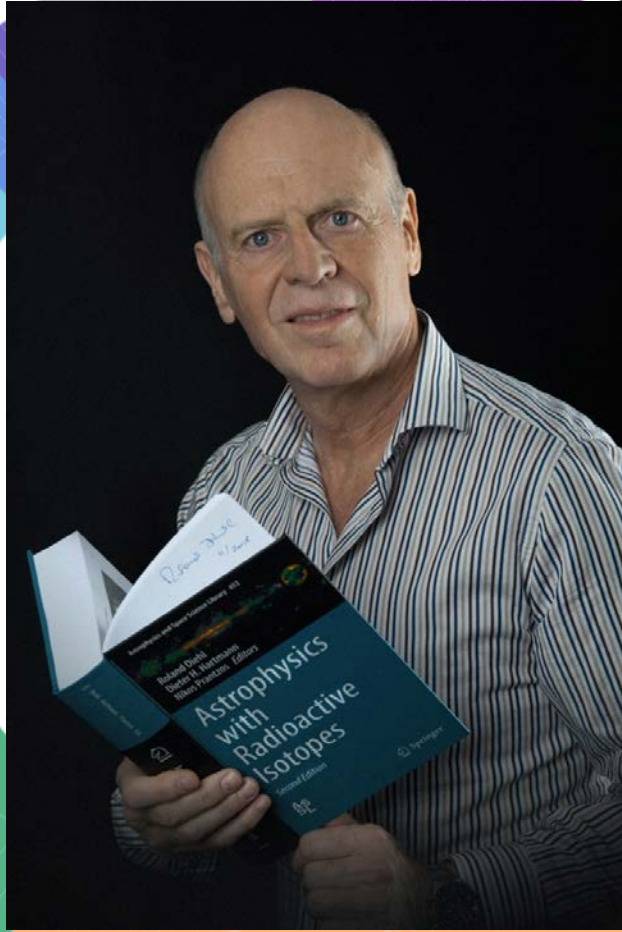


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Multi-messenger Observations of a Binary Neutron Star Merger*

LIGO Scientific Collaboration and Virgo Collaboration, Fermi GBM, INTEGRAL, IceCube Collaboration, AstroSat Cadmium Zinc Telluride Imager Team, IPN Collaboration, The Insight-HXMT Collaboration, ANTARES Collaboration, The Swift Collaboration, AGILE Team, The IM2H Team, The Dark Energy Camera GW-EM Collaboration and the DES Collaboration, The DLT40 Collaboration, GRAWITA: GRAVitational Wave Inaf TeAm, The Fermi Large Area Telescope Collaboration, ATCA: Australia Telescope Compact Array, ASKAP: Australian SKA Pathfinder, Las Cumbres Observatory Group, OzGrav, DWF (Deeper, Wider, Faster Program), AST3, and CAASTRO Collaborations, The VINROUGE Collaboration, MASTER Collaboration, J-GEM, GROWTH, JAGWAR, Caltech-NRAO, TTU-NRAO, and NuSTAR Collaborations, Pan-STARRS, The MAXI Team, TZAC Consortium, KU Collaboration, Nordic Optical Telescope, ePESSTO, GROND, Texas Tech University, SALT Group, TOROS: Transient Robotic Observatory of the South Collaboration, The BOOTES Collaboration, MWA: Murchison Widefield Array, The CALET Collaboration, IKI-GW Follow-up Collaboration, H.E.S.S. Collaboration, LOFAR Collaboration, LWA: Long Wavelength Array, HAWC Collaboration, The Pierre Auger Collaboration, ALMA Collaboration, Euro VLBI Team, Pi of the Sky Collaboration, The Chandra Team at McGill University, DFN: Desert Fireball Network, ATLAS, High Time Resolution Universe Survey, RIMAS and RATIR, and SKA South Africa/MeerKAT
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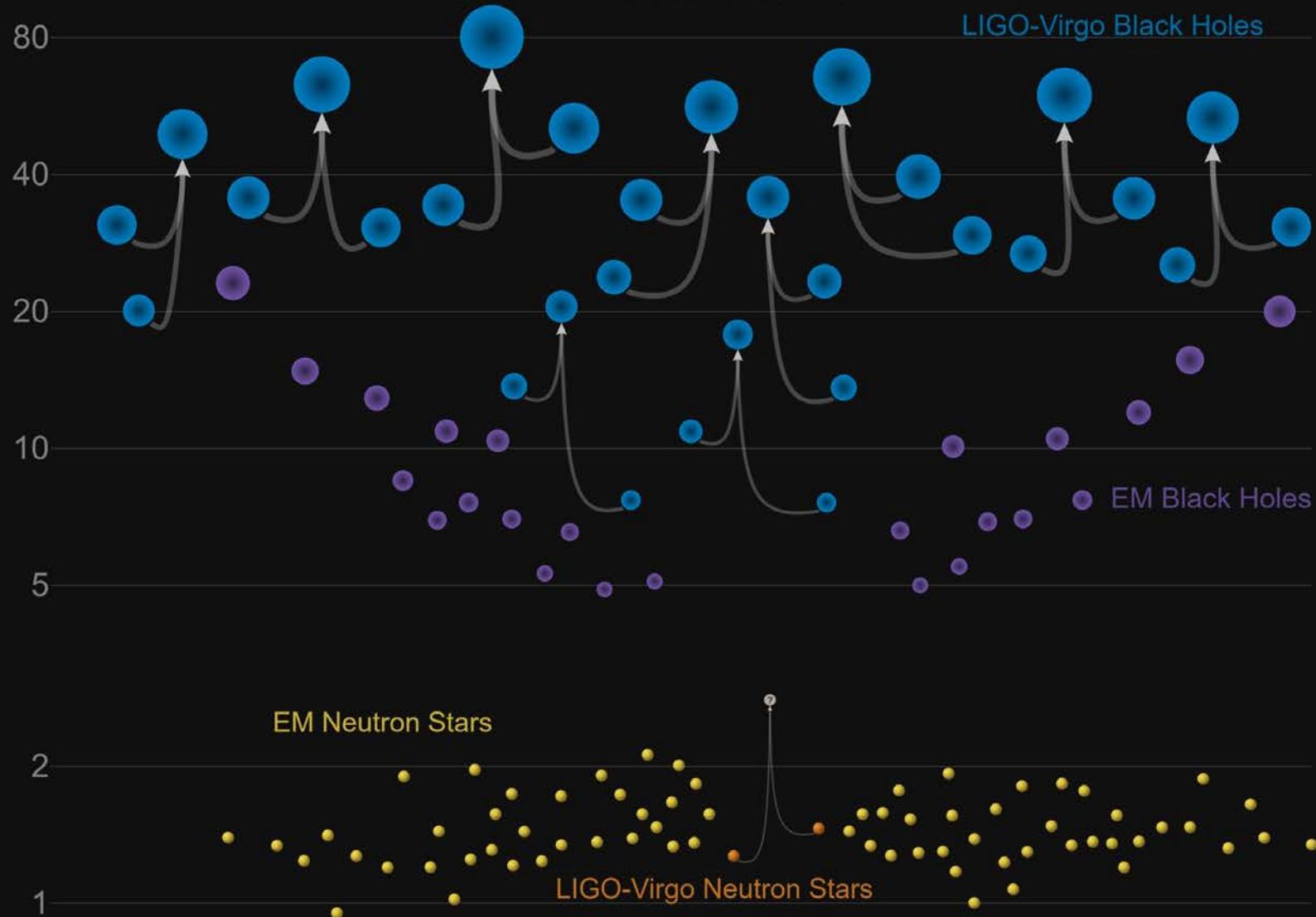
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Science with e-ASTROGAM. A space mission for MeV-GeV gamma-ray astrophysics													
2	☐ 2018SPIE10699E..2JT Tatischeff, V.; De Angelis, A.; Tavani, M.; Grenier, I.; Oberlack, U.; Hanlon, L.; Walter, R.; Argan, A.; von Ballmoos, P.; Bulgarelli, A.; and 67 coauthors	1.000	07/2018	A	E	X		R	C	U			
The e-ASTROGAM gamma-ray space observatory for the multimessenger astronomy of the 2030s													
3	☐ 2018Sci...361.1378I IceCube Collaboration; Aartsen, M. G.; Ackermann, M.; Adams, J.; Aguilar, J. A.; Ahlers, M.; Ahrens, M.; Al Samarai, I.; Altmann, D.; Andeen, K.; and 1001 coauthors	1.000	07/2018	A	E	X	D	R	C	S	U		
Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A													
4	☐ 2017ExA....44...25D De Angelis, A.; Tatischeff, V.; Tavani, M.; Oberlack, U.; Grenier, I.; Hanlon, L.; Walter, R.; Argan, A.; von Ballmoos, P.; Bulgarelli, A.; and 64 coauthors	1.000	10/2017	A	E	X		R	C	U			
The e-ASTROGAM mission. Exploring the extreme Universe with gamma rays in the MeV - GeV range													
5	☐ 2015MNRAS.447.1484S Seitenzahl, I. R.; Summa, A.; Krauß, F.; Sim, S. A.; Diehl, R.; Elsässer, D.; Fink, M.; Hillebrandt, W.; Kromer, M.; Maeda, K.; and 5 coauthors	1.000	02/2015	A	E	F	X		R	C	S	N	U
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7	☐ 2012ExA....34..551G Greiner, Jochen; Mannheim, Karl; Aharonian, Felix; Ajello, Marco; Balasz, Lajos G.; Barbiellini, Guido; Bellazzini, Ronaldo; Bishop, Shawn; Bisnovatij- Kogan, Gennady S.; Boggs, Steven; and 58 coauthors	1.000	10/2012	A	E	X		R	C	U			
GRIPS - Gamma-Ray Imaging, Polarimetry and Spectroscopy													
8	☐ 2009ExA....23...91G Greiner, J.; Iyudin, A.; Kanbach, G.; Zoglauer, A.; Diehl, R.; Ryde, F.; Hartmann, D.; Kienlin, A. V.; McBreen, S.; Ajello, M.; and 49 coauthors	1.000	03/2009	A	E			R	C	U			
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