

Istraživački radovi iz astronomije

Gama-astronomija



Agencija za odgoj i obrazovanje
Education and Teacher Training Agency

Istraživački radovi iz
astronomije
22. veljače 2022.

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Sveučilište u Rijeci
Odjel za fiziku
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Antonio Stamerla & SÉPHIR

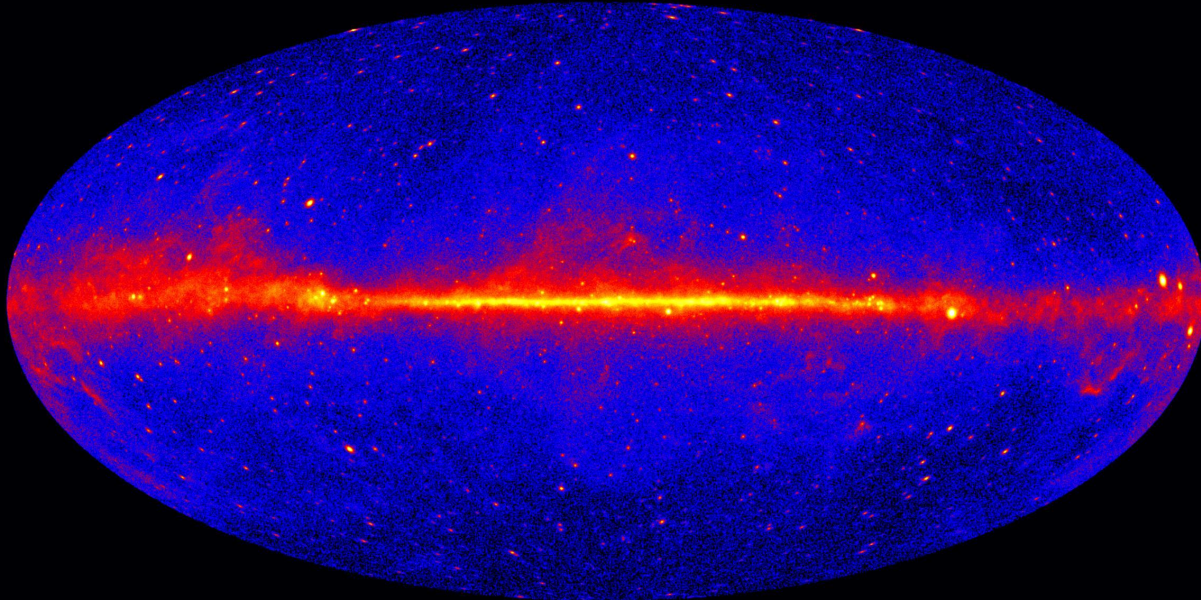
DEPARTMENT OF
PHYSICS



UNIVERSITY OF
RIJEKA

Sadržaj

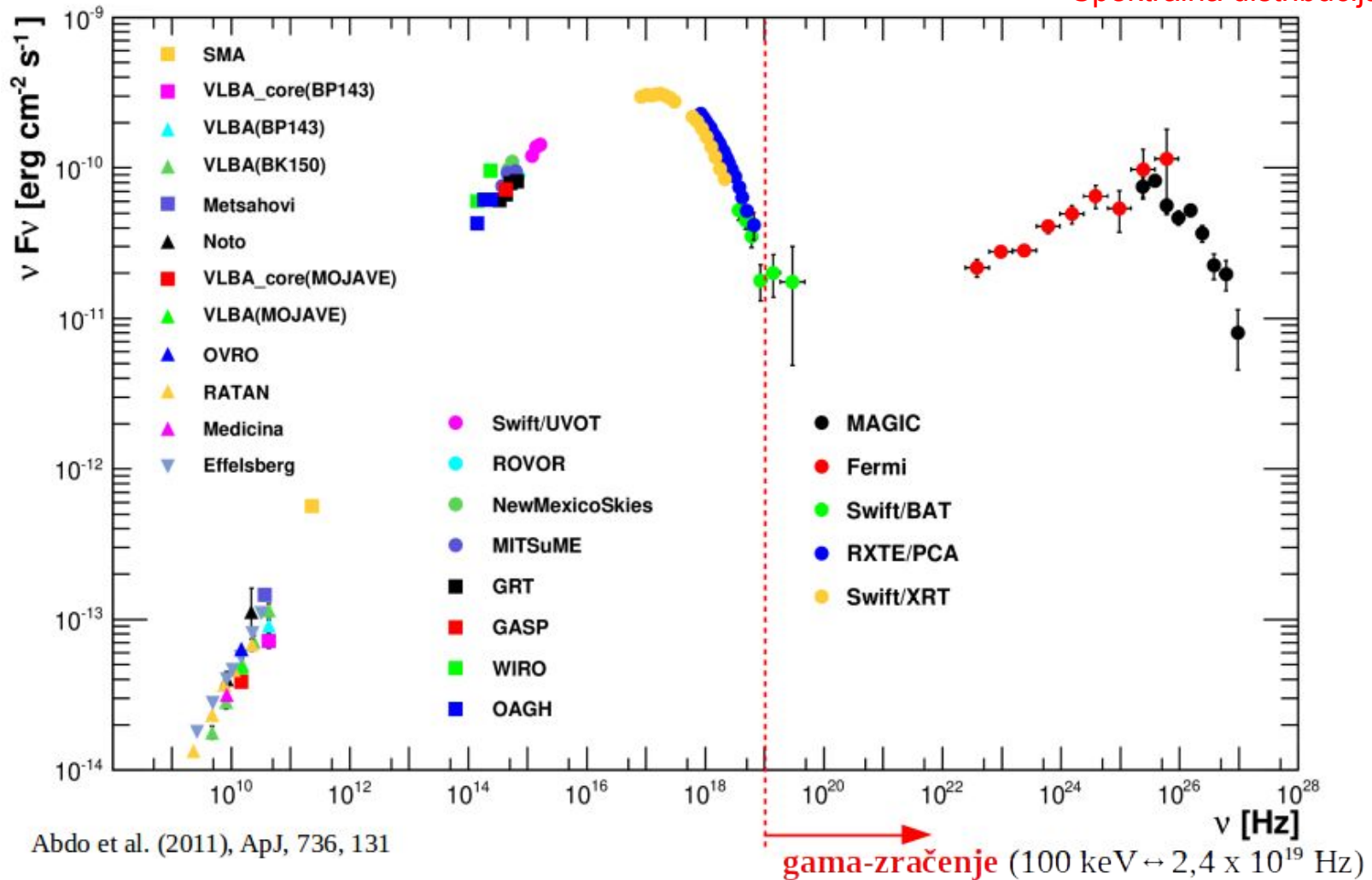
- Što su gama-zrake
- Kako detektiramo gama-zrake iz svemira
- Što proučavamo gama-zrakama



Gama-zračenje u astronomiji

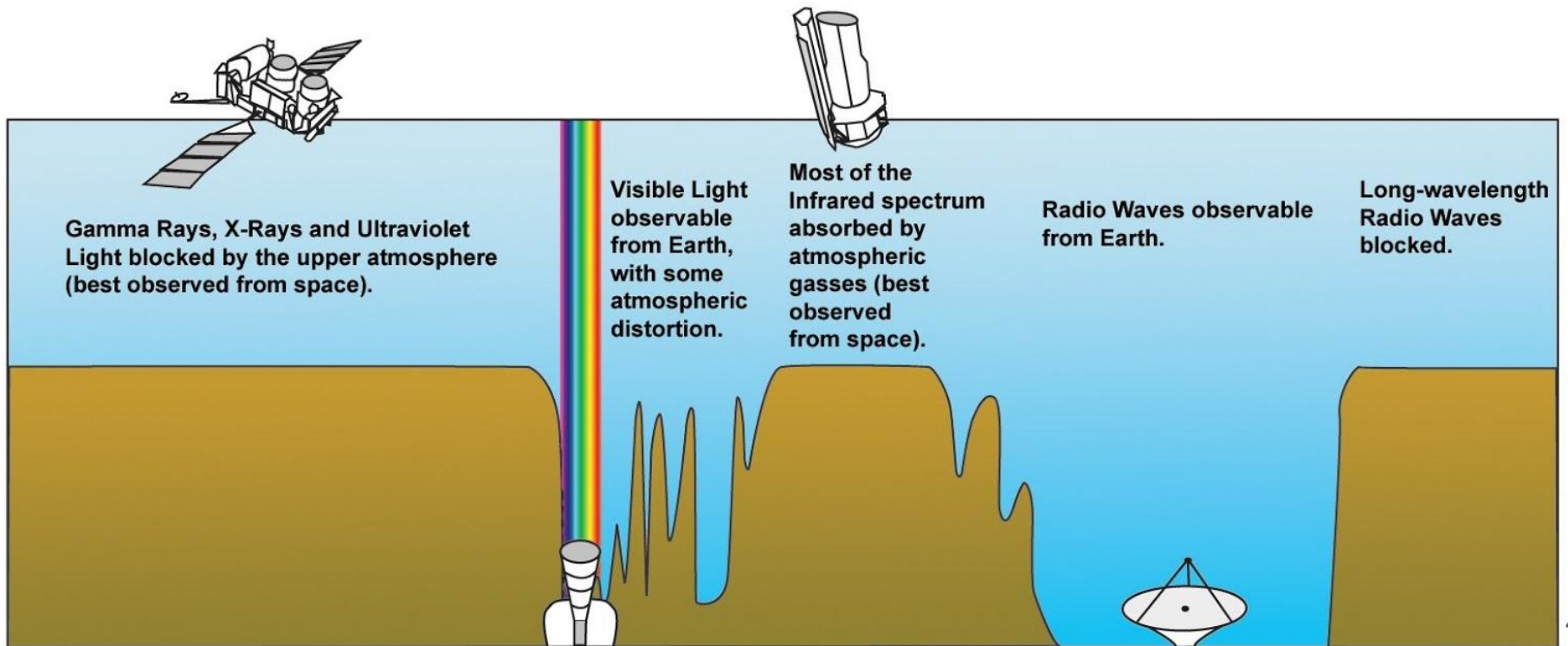
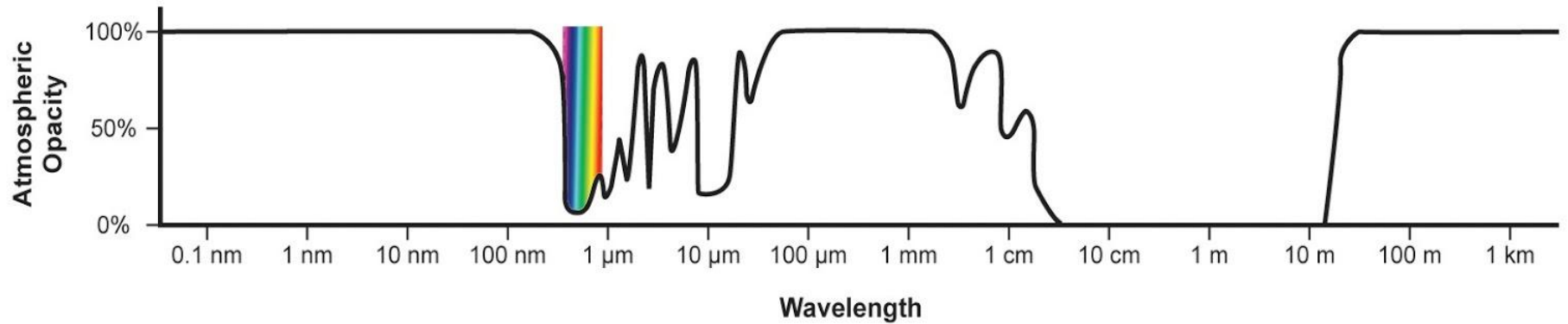
Markarian 421

Spektralna distribucija energije

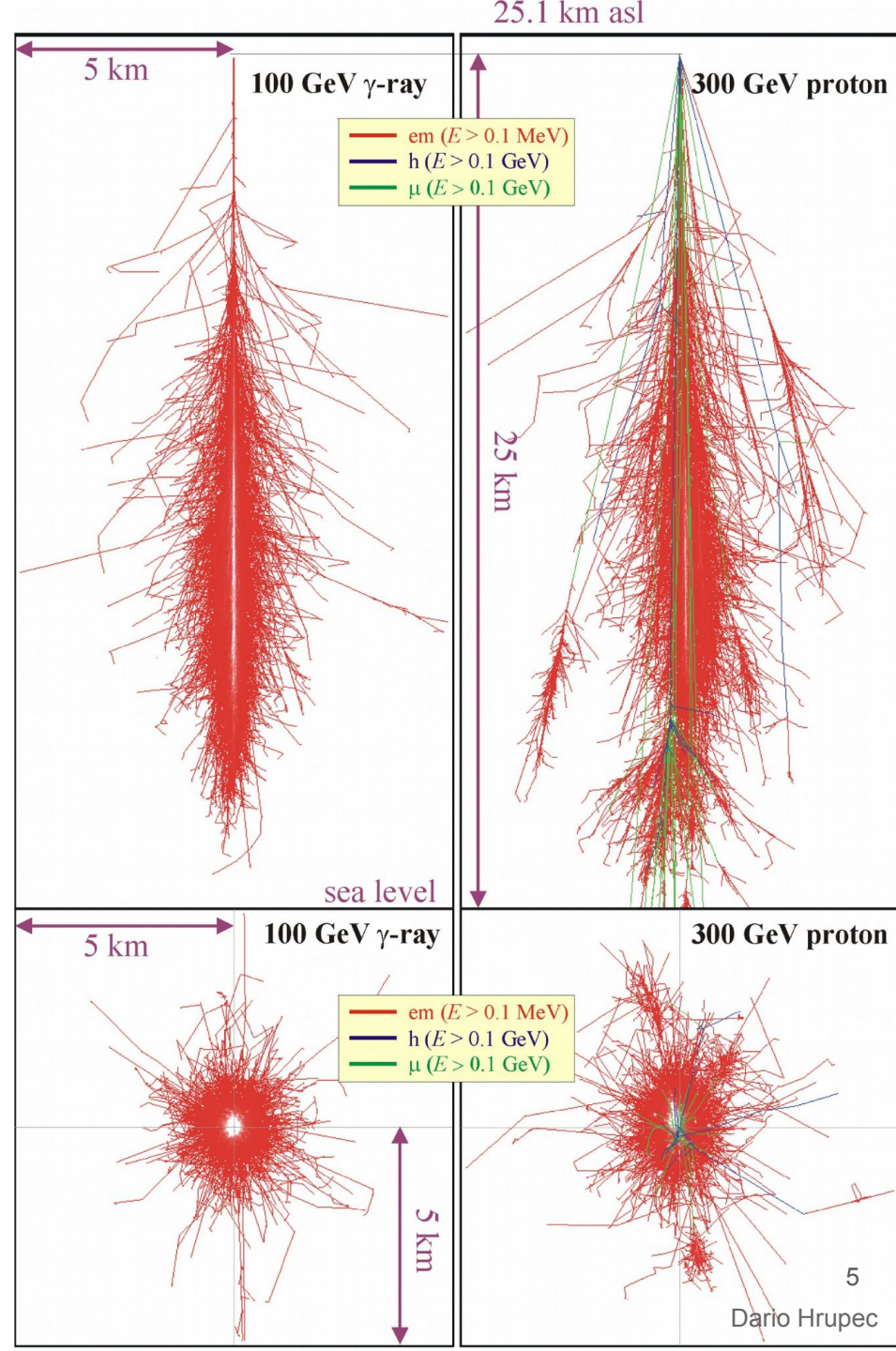
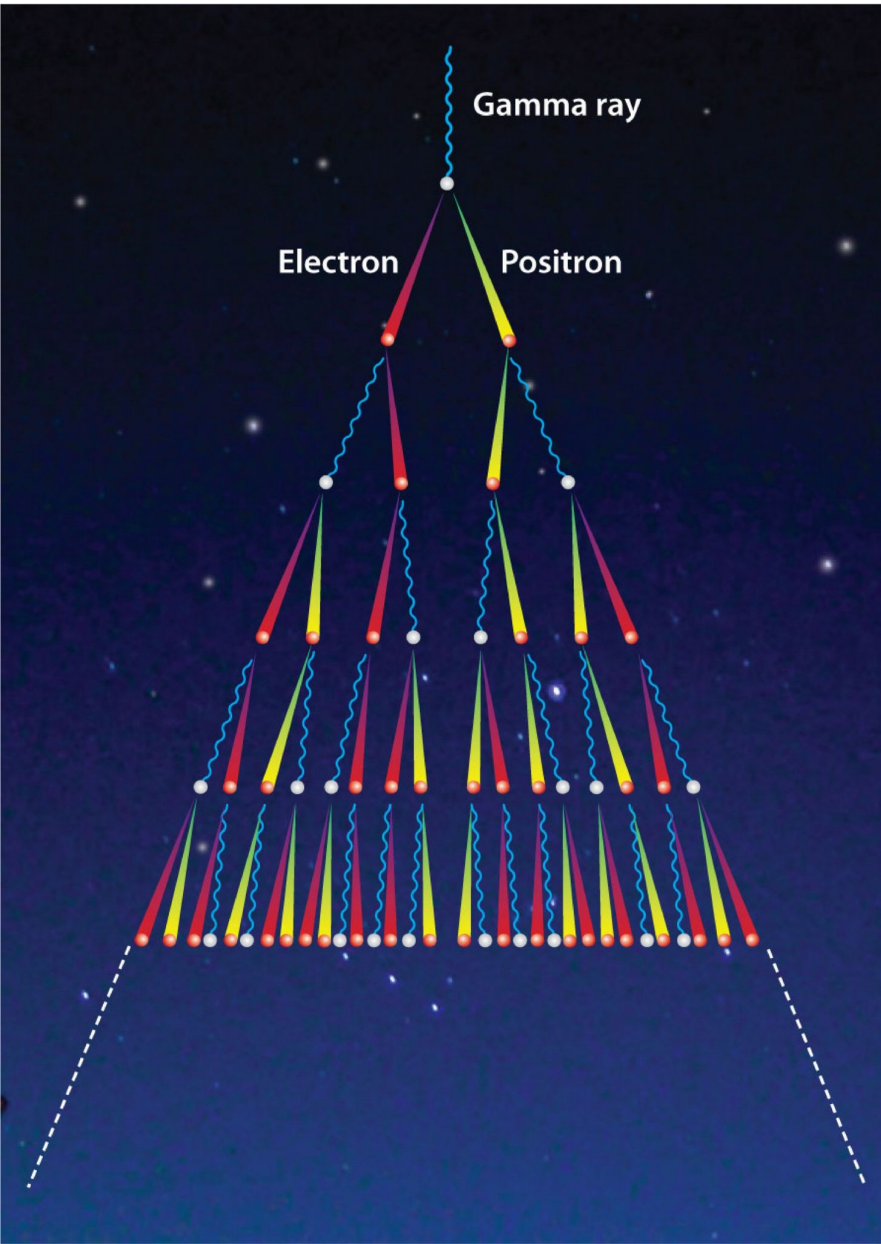


- Elektromagnetsko zračenje energija iznad 100 keV
- Bez obzira na izvor i proces u kojem nastaje

Prozirnost atmosfere

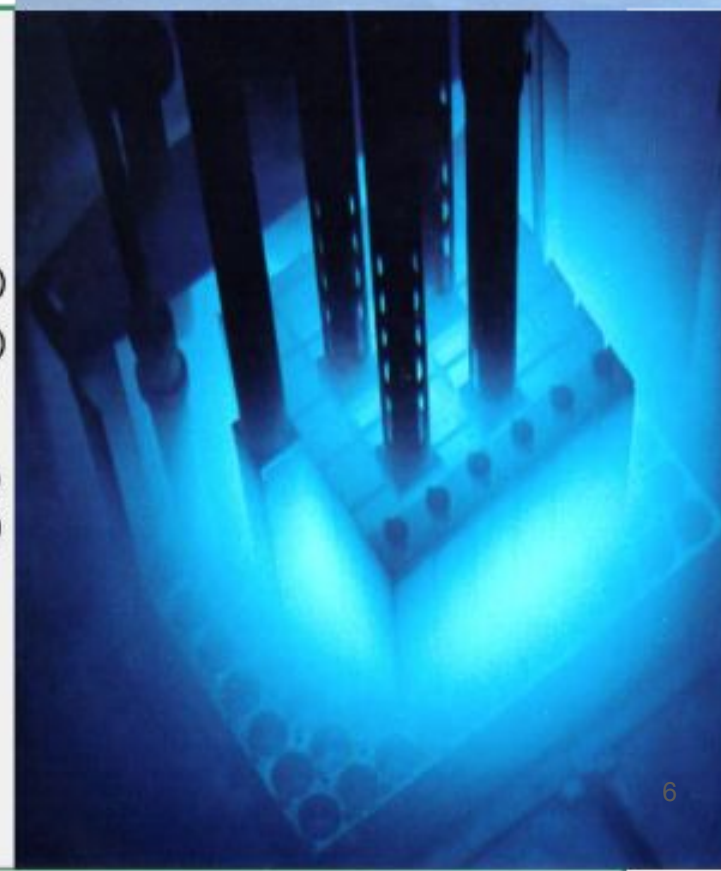
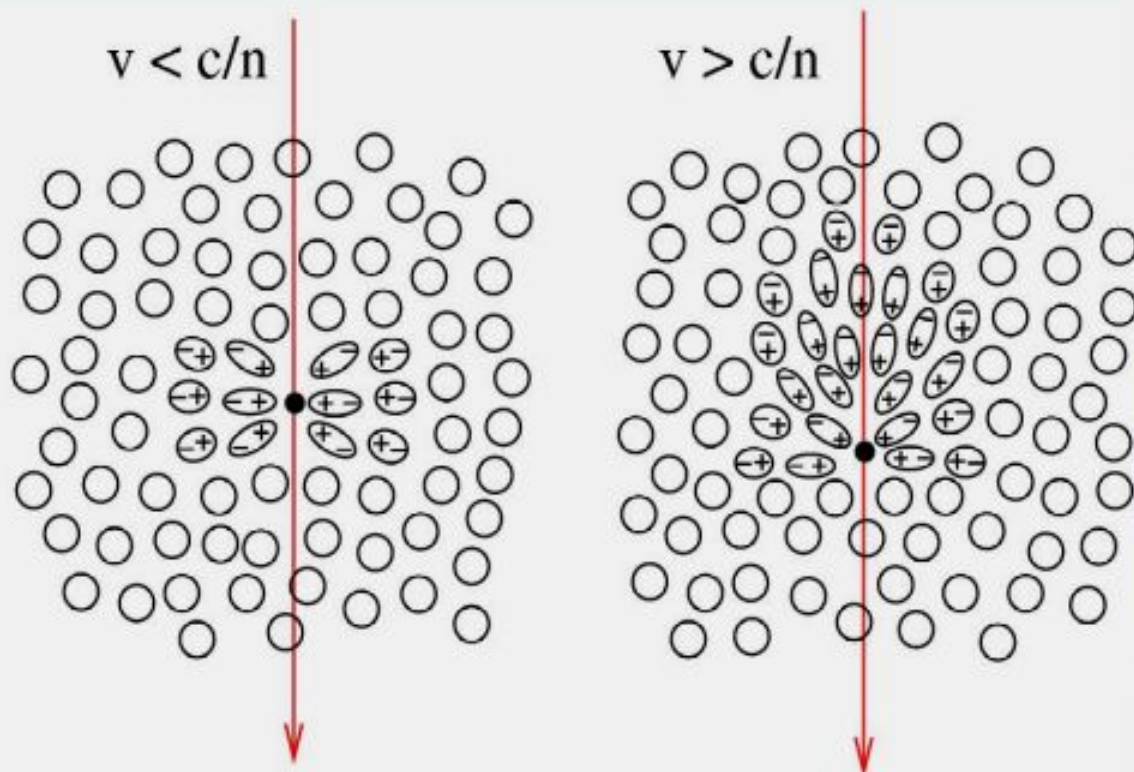


Atmosferski pljuskovi

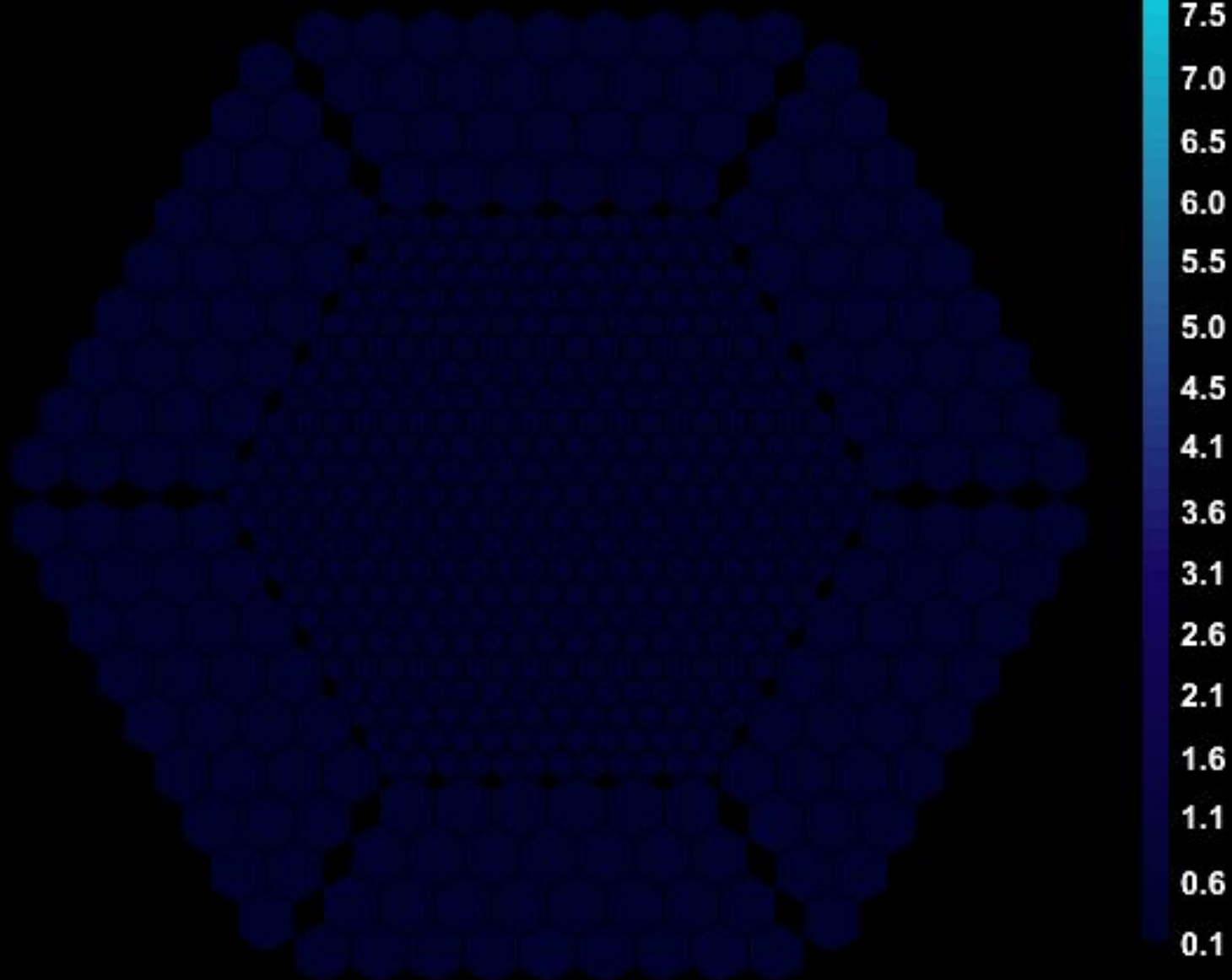


Čerenkovljevo zračenje

Svjetlost koja se emitira kada **nabijena čestica** prolazi kroz **dielektrično sredstvo** brzinom većom od brzine svjetlosti u tom sredstvu

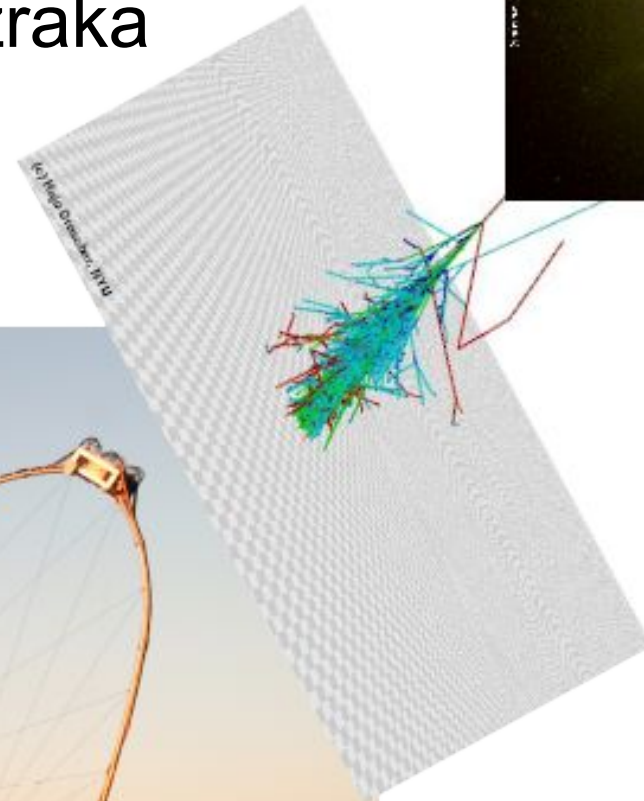


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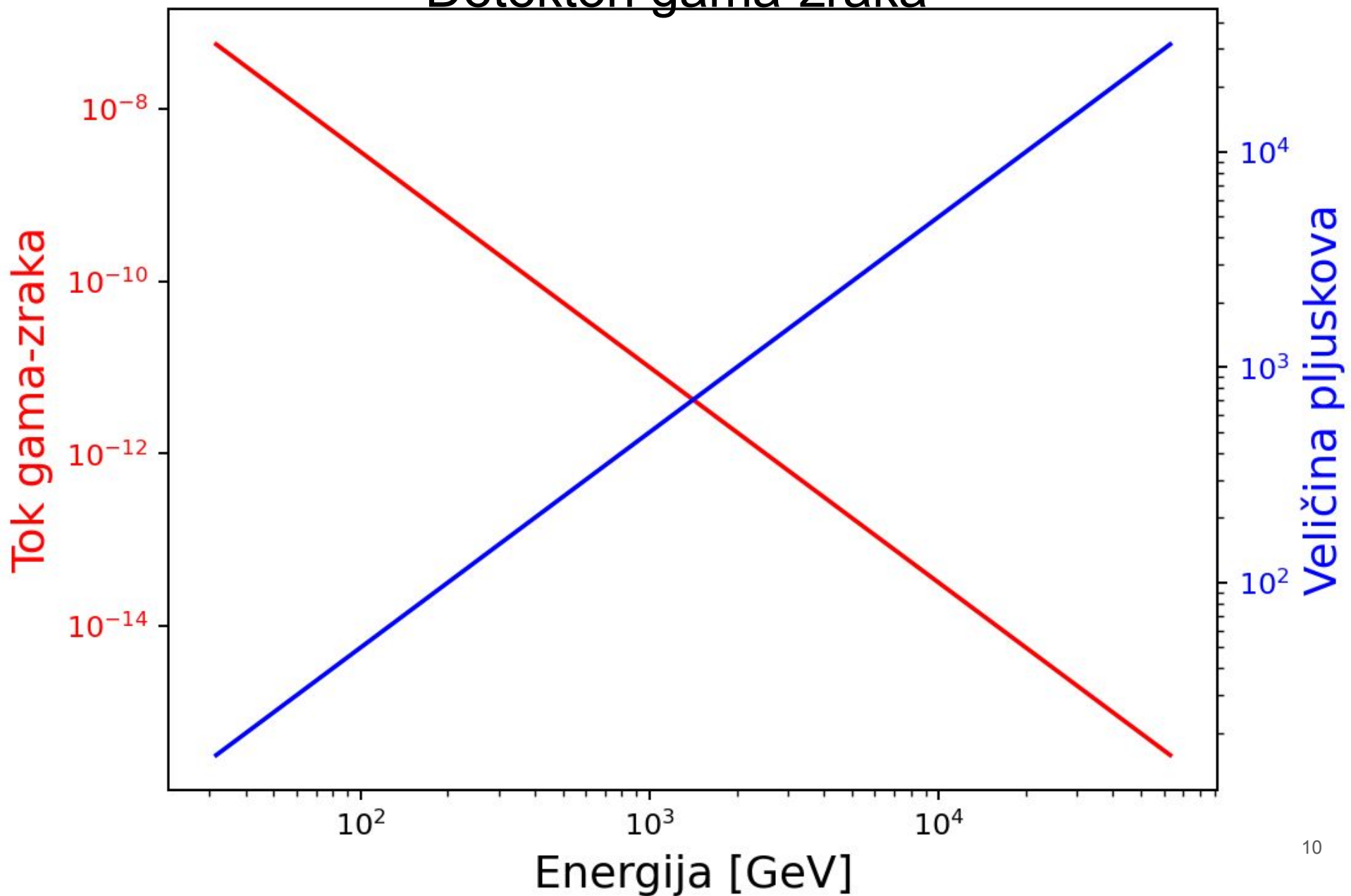


Run 325446 Event 56

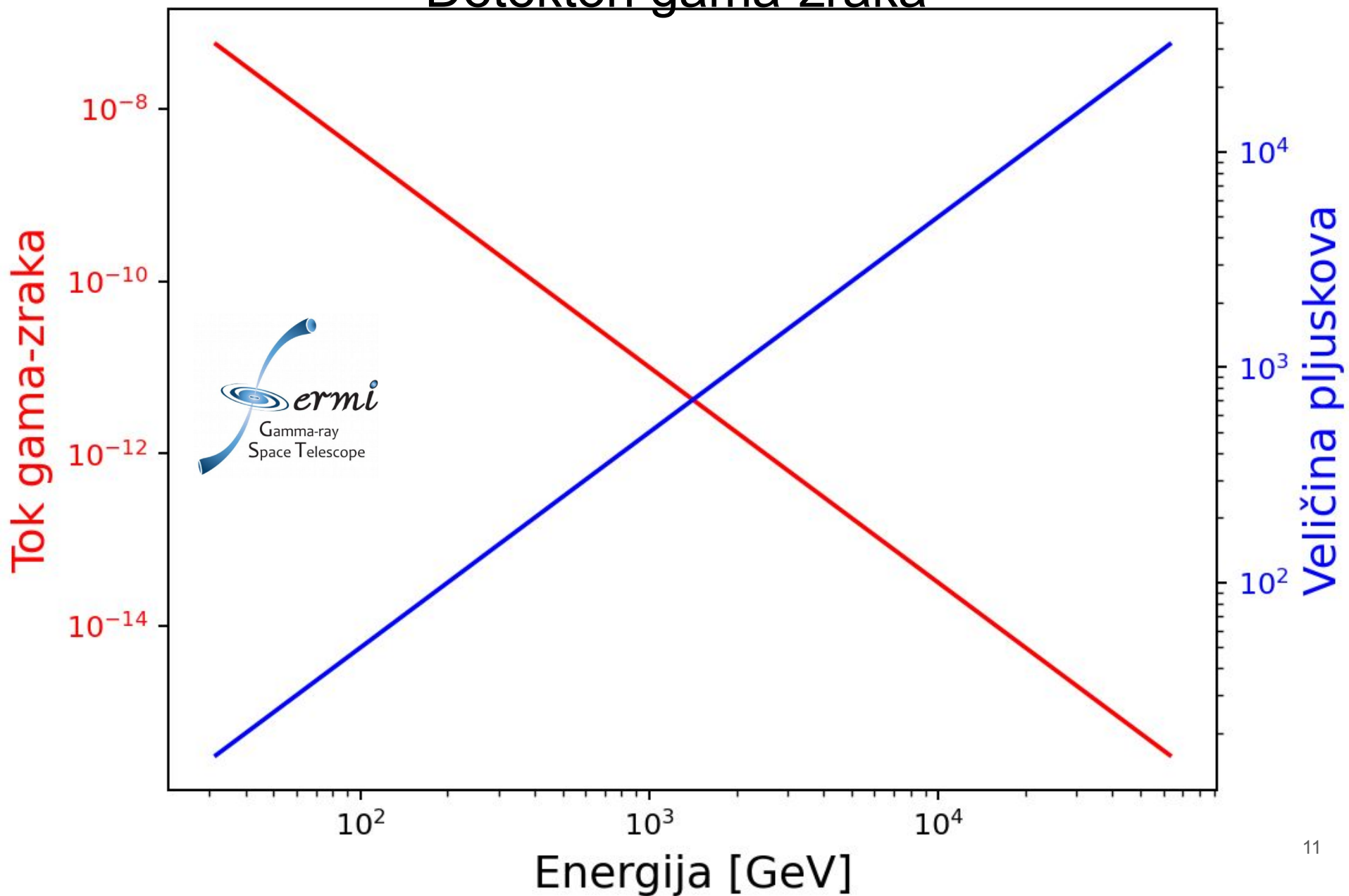
RM



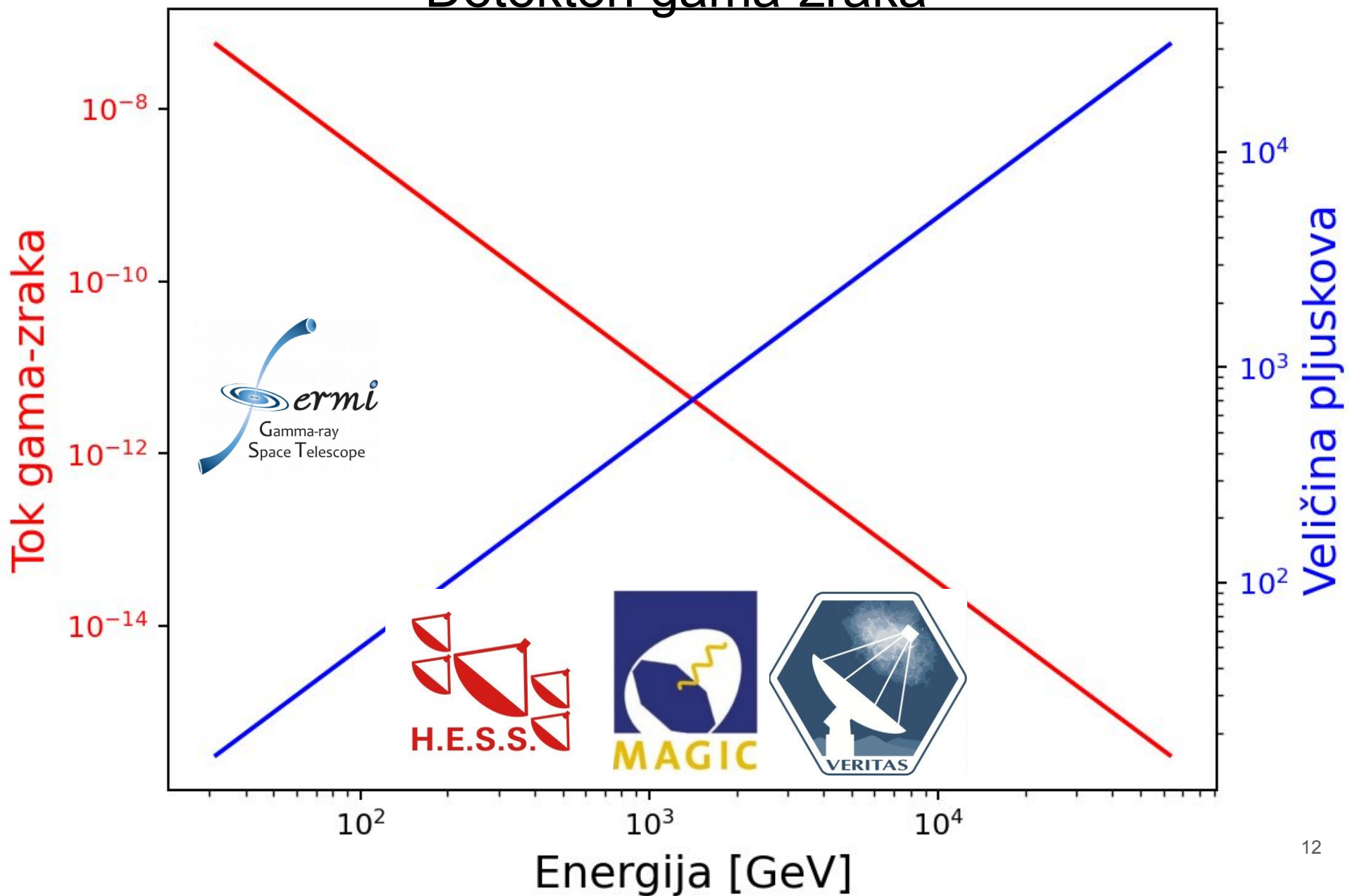
Detektori gama-zraka



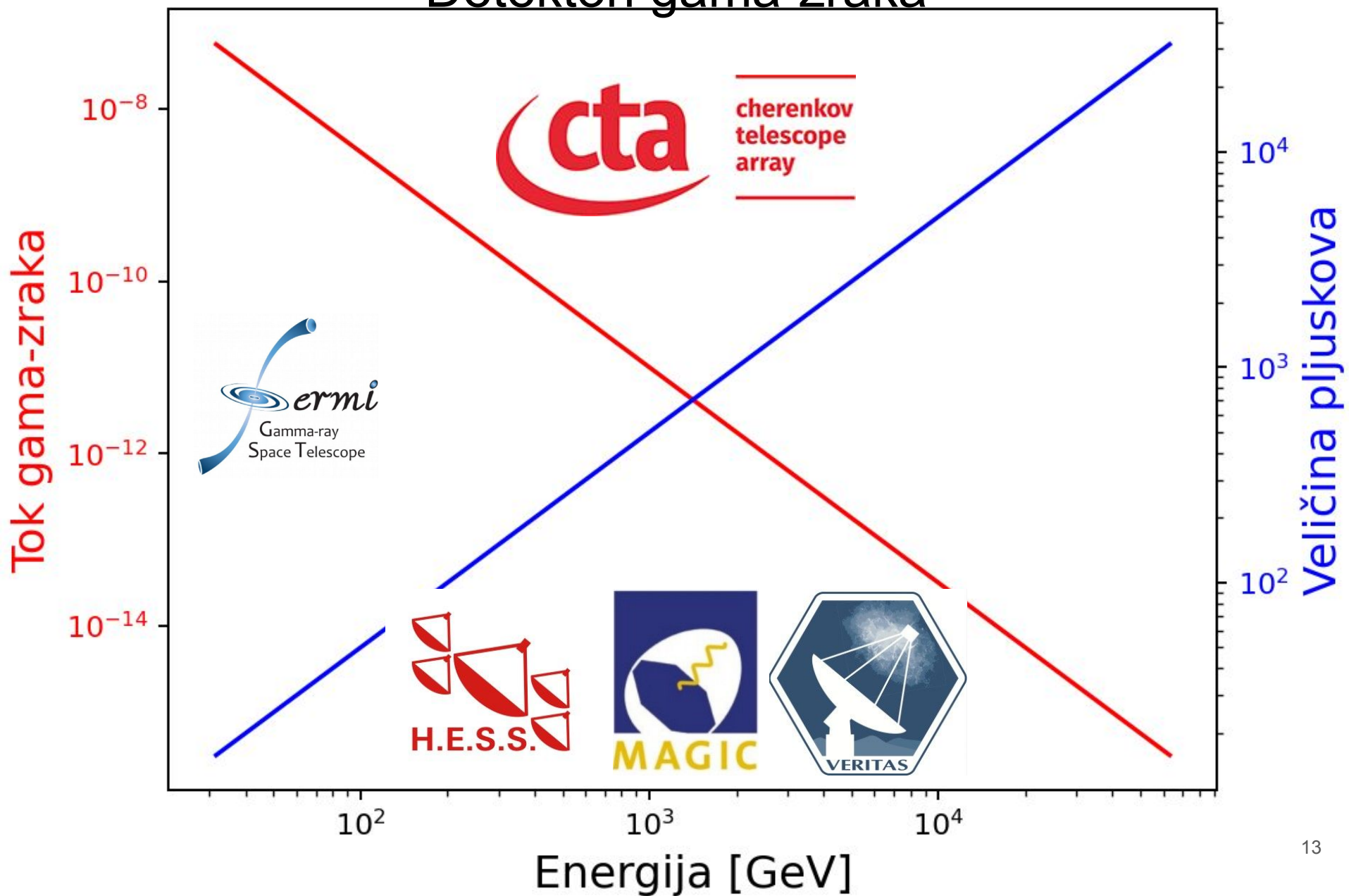
Detektori gama-zraka



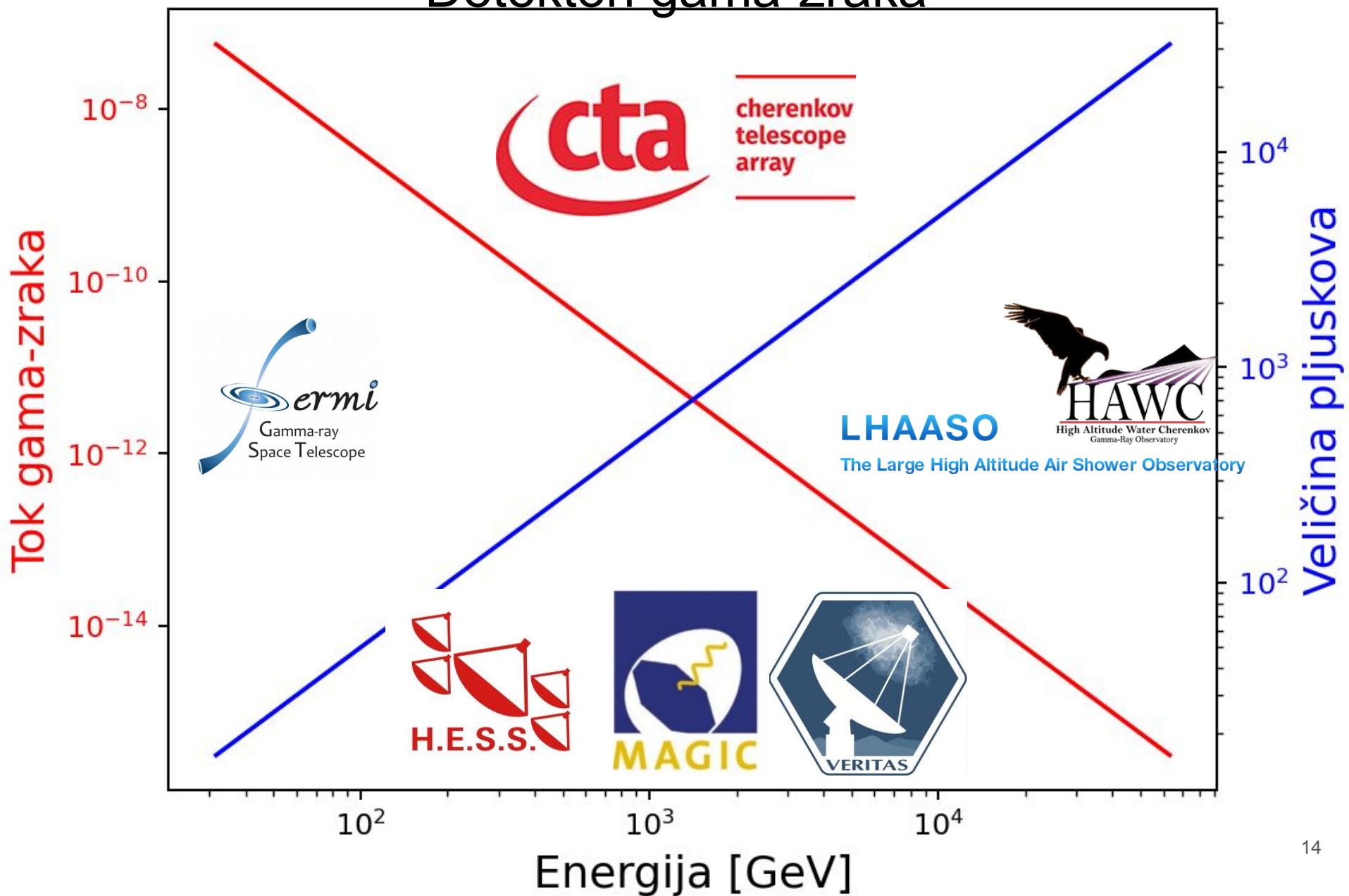
Detektori gama-zraka



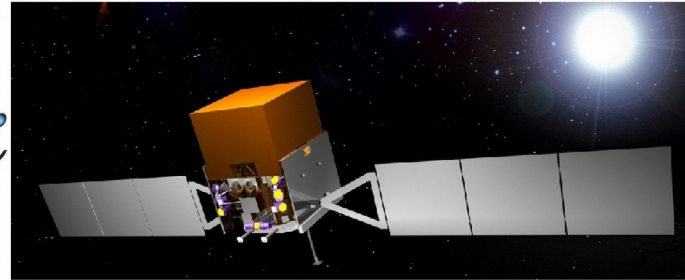
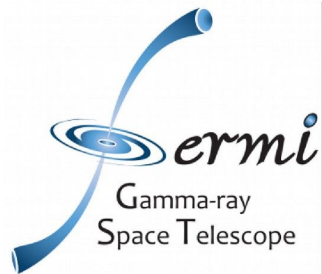
Detektori gama-zraka



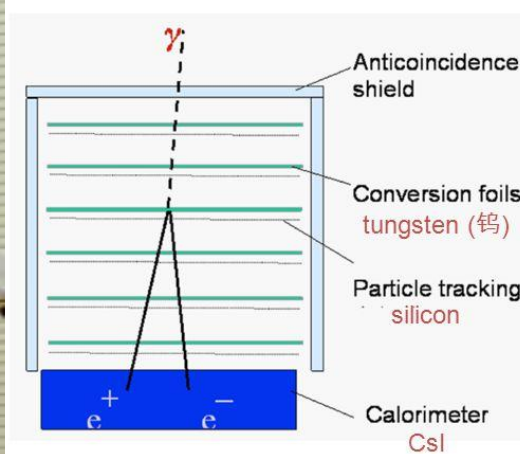
Detektori gama-zraka



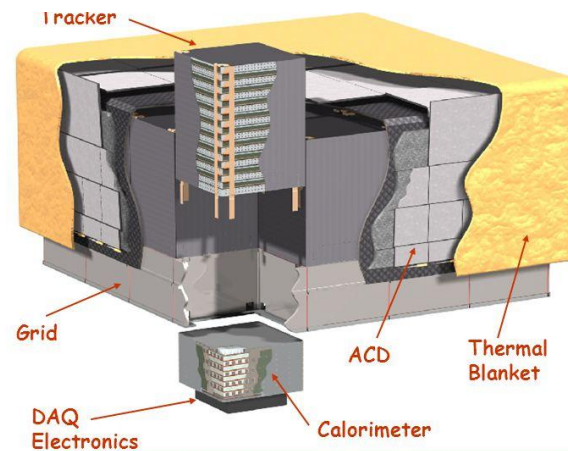
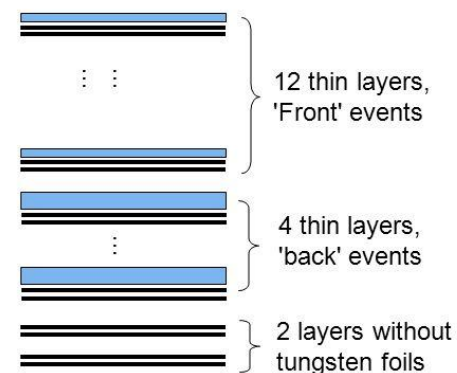
Satelit Fermi



Large Area Telescope (LAT)



Fermi LAT



Gamma-ray Burst Monitor (GBM)¹⁵

Cherenkov Telescope Array (CTA)



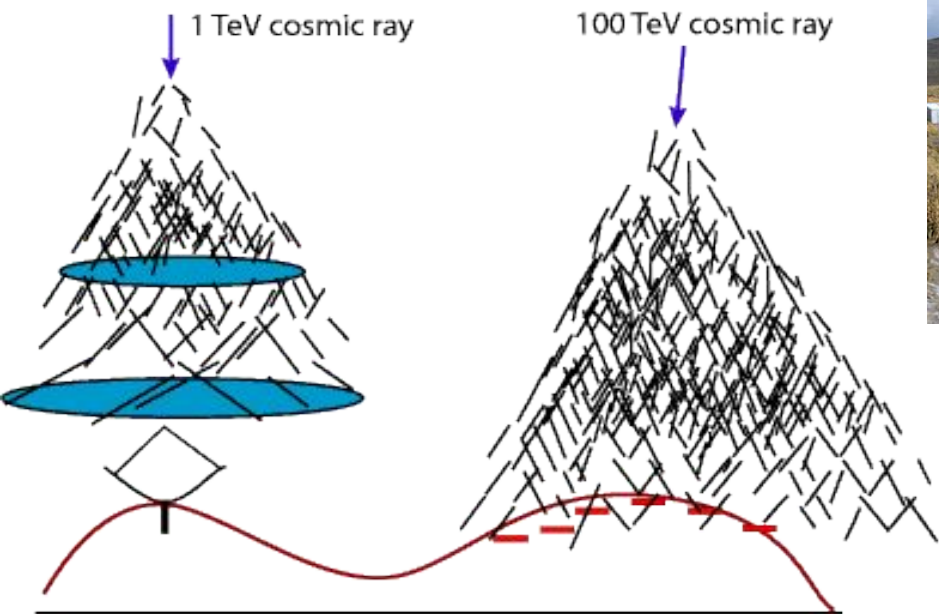
CTA for Educators

(www.cta-observatory.org)

This page provides educational materials and tools to explore the highest-energy Universe in the classroom or at home. All tools are adapted for different educational levels, specified in each case as: elementary, high school, university or “all ages.” We’ll continue to expand, so check back regularly!



Vodeni i hibridni detektori



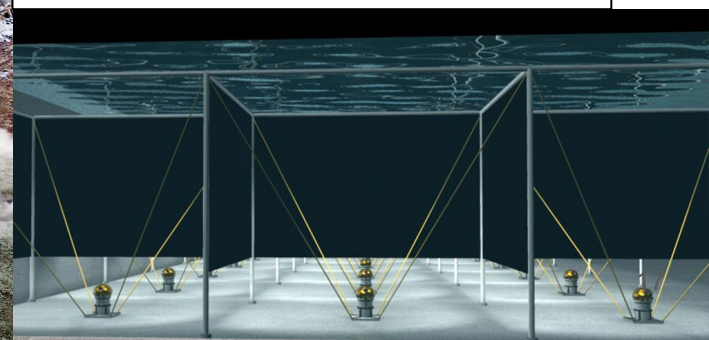
HAWC – High-Altitude Water Cherenkov



LHAASO – Large High Altitude Air Shower Observatory

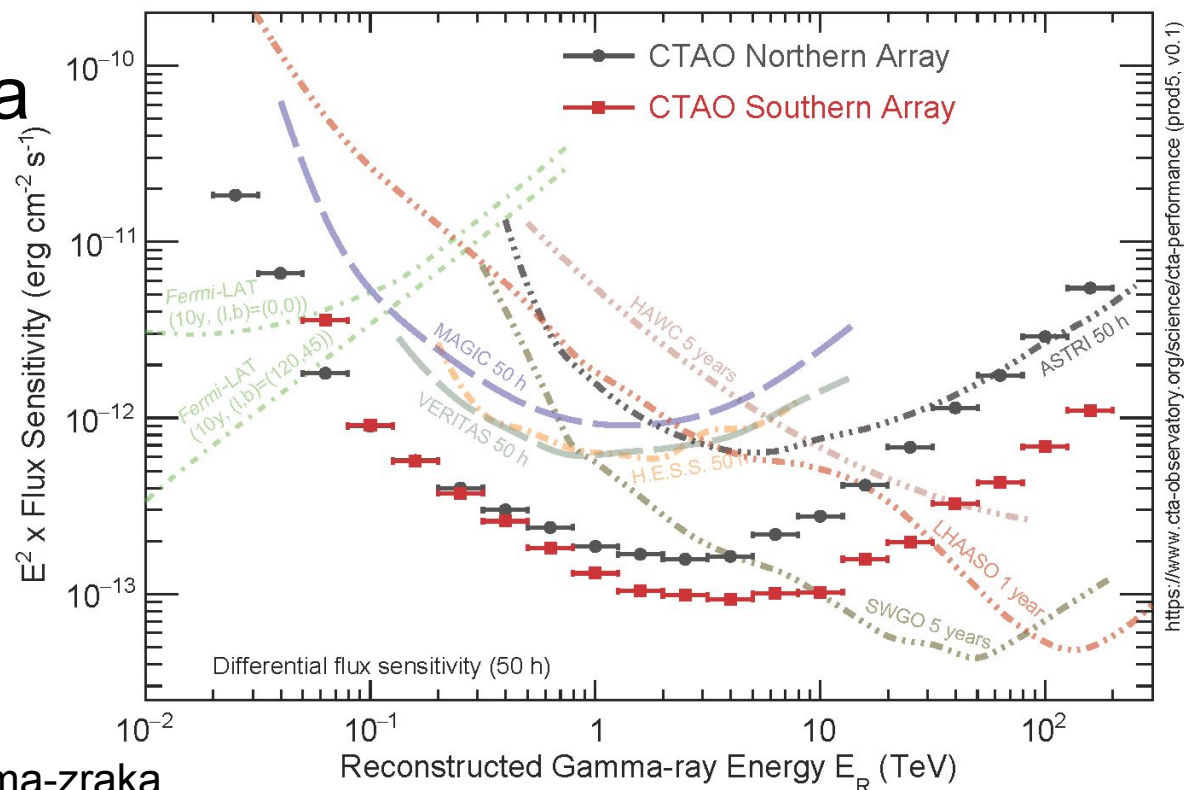


$1,4 \text{ PeV} = 1,4 \times 10^{15} \text{ eV}$
Cao et al. (2021) Nature, 594, 33

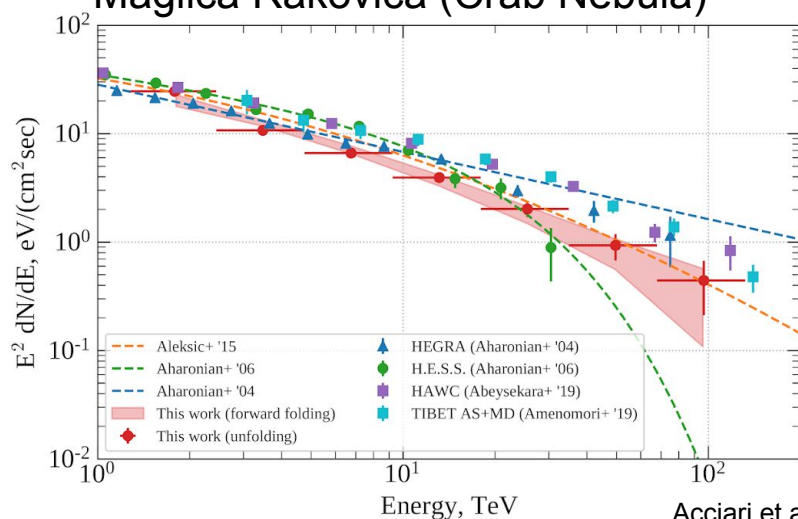


Gama-astronomija

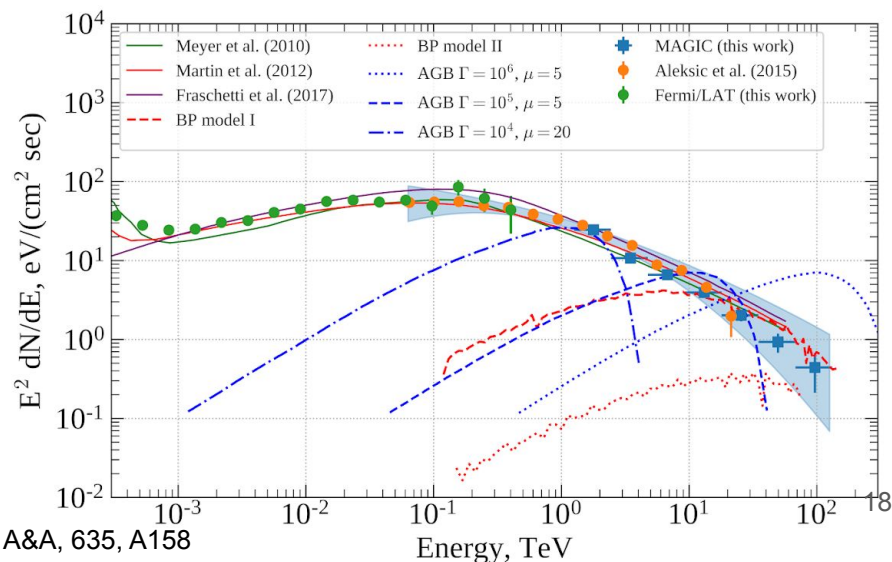
Usporedba osjetljivosti detektora gama-zraka



Suradnja opservatorija gama-zraka Maglica Rakovica (Crab Nebula)



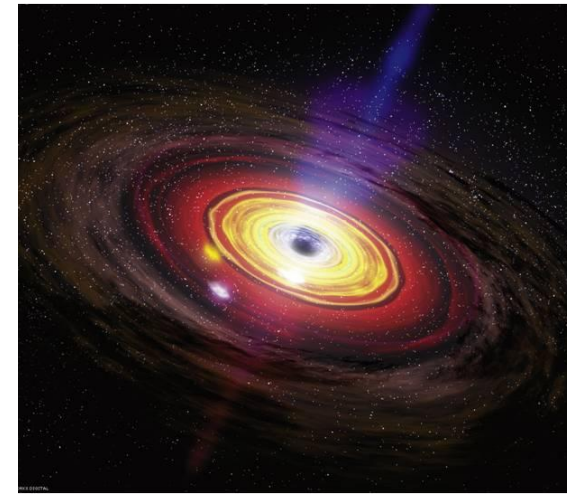
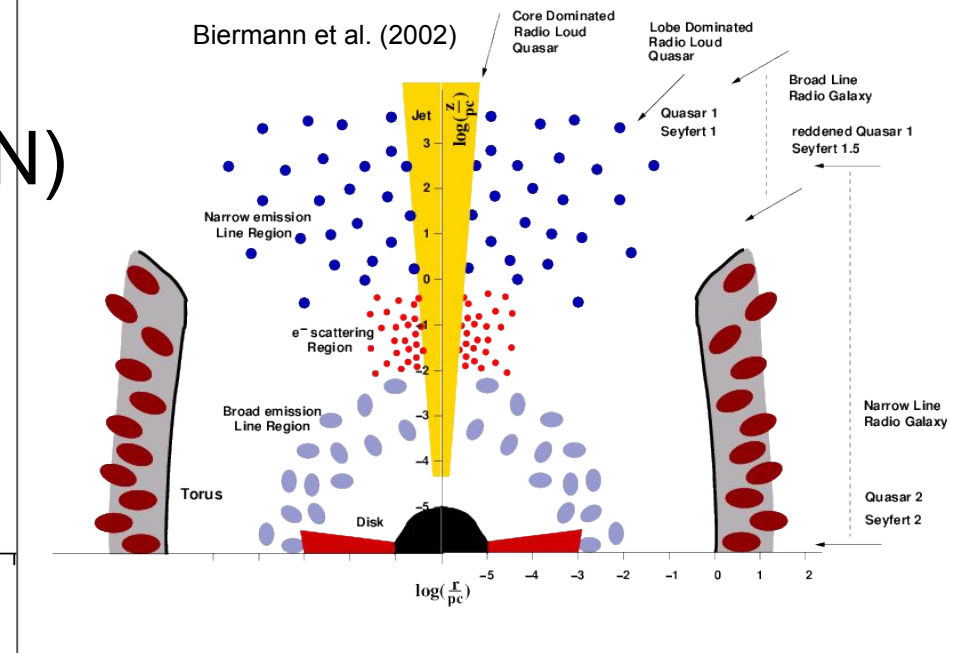
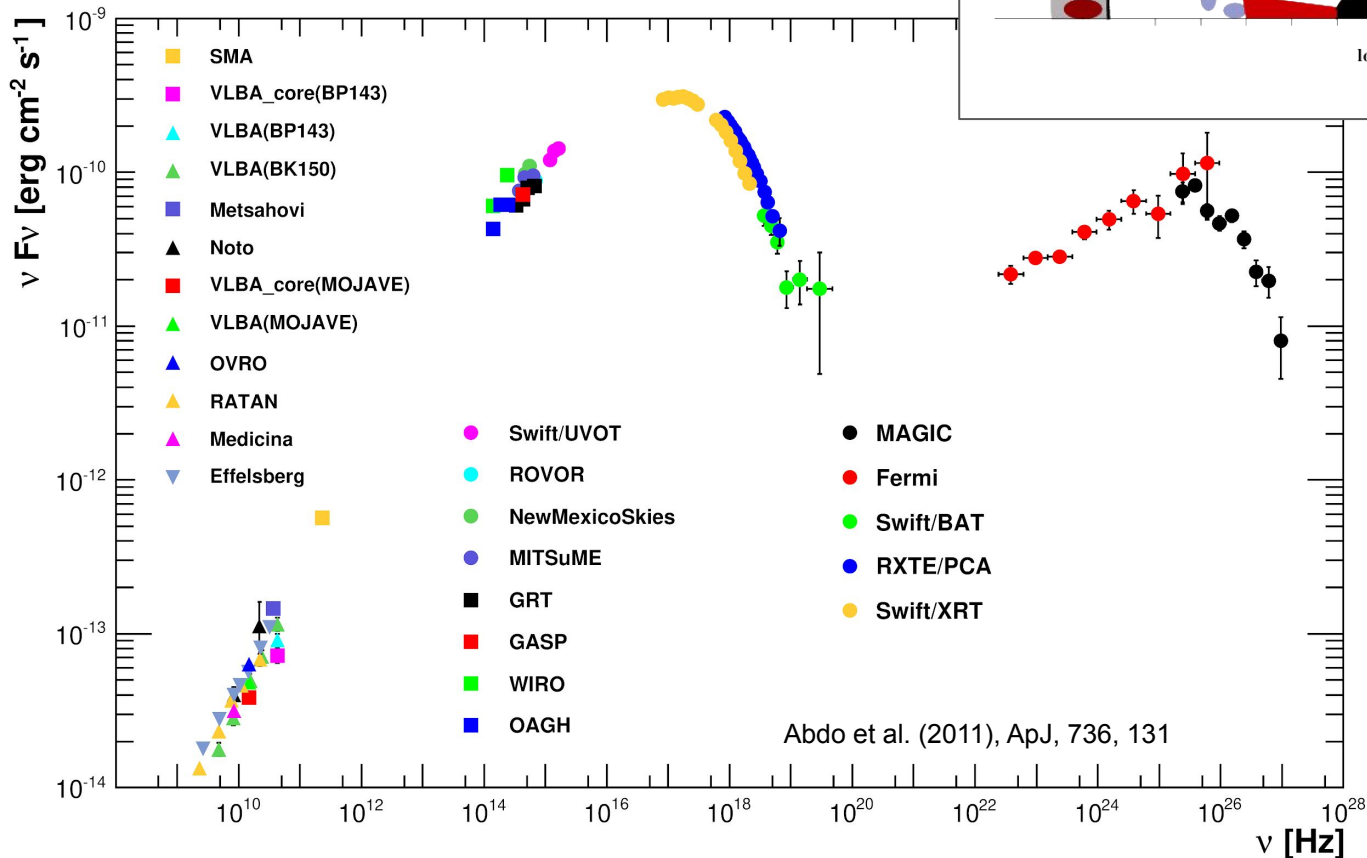
Acciari et al. (2020), A&A, 635, A158



Aktivne galaktičke jezgre

Active galactic nuclei (AGN)

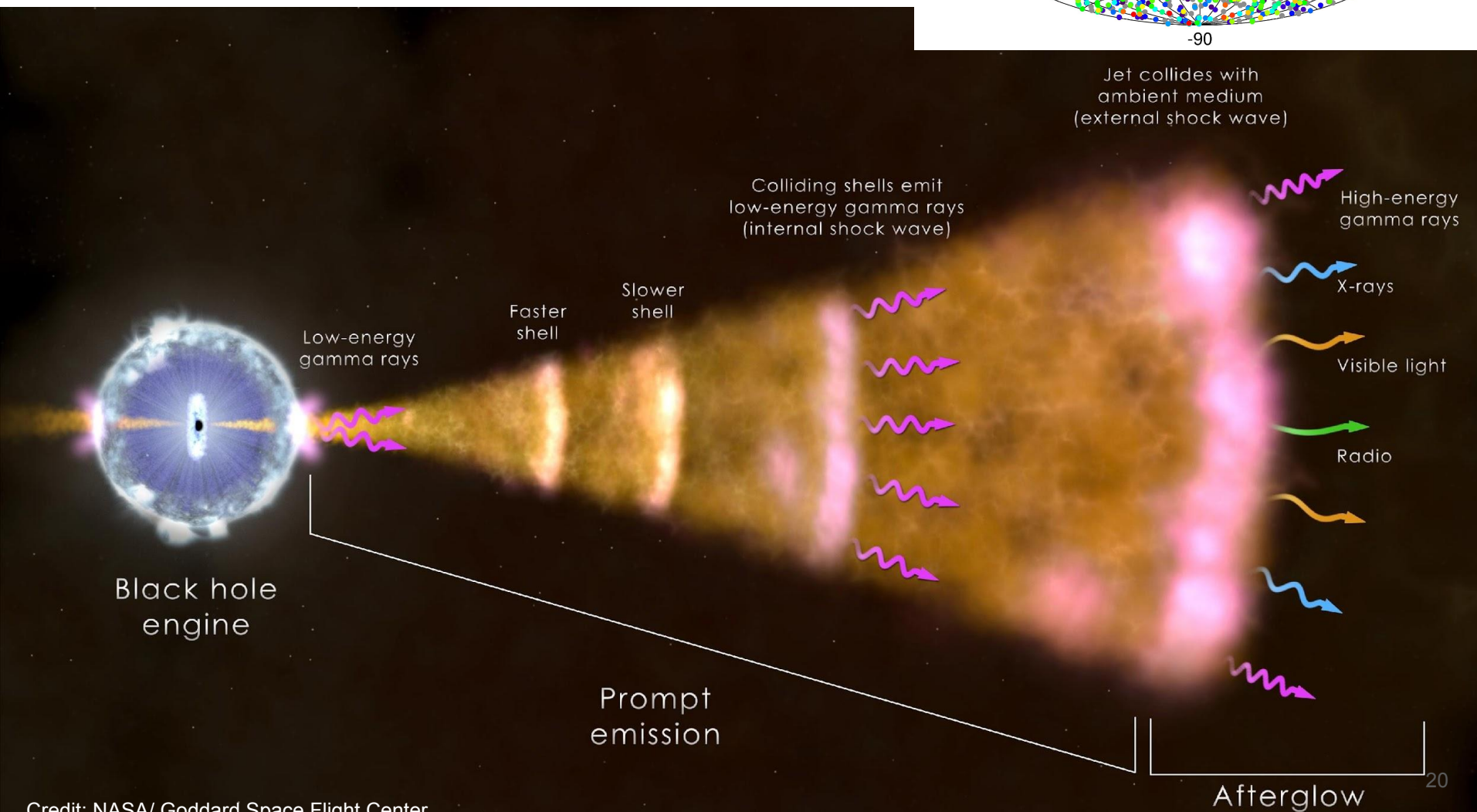
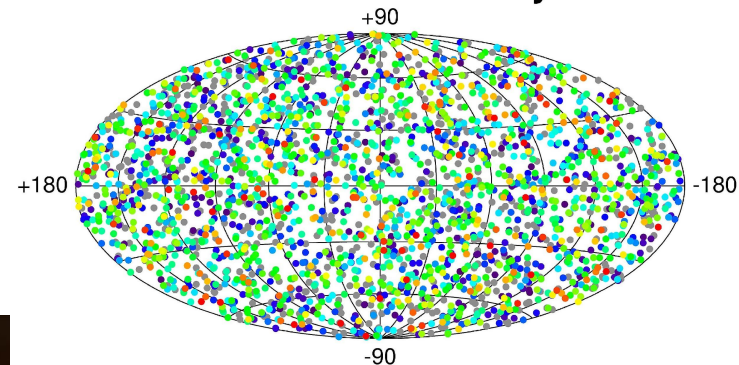
Multiwavelength (MWL) astronomija



Provale gama-zračenja

Gamma-ray bursts (GRB)

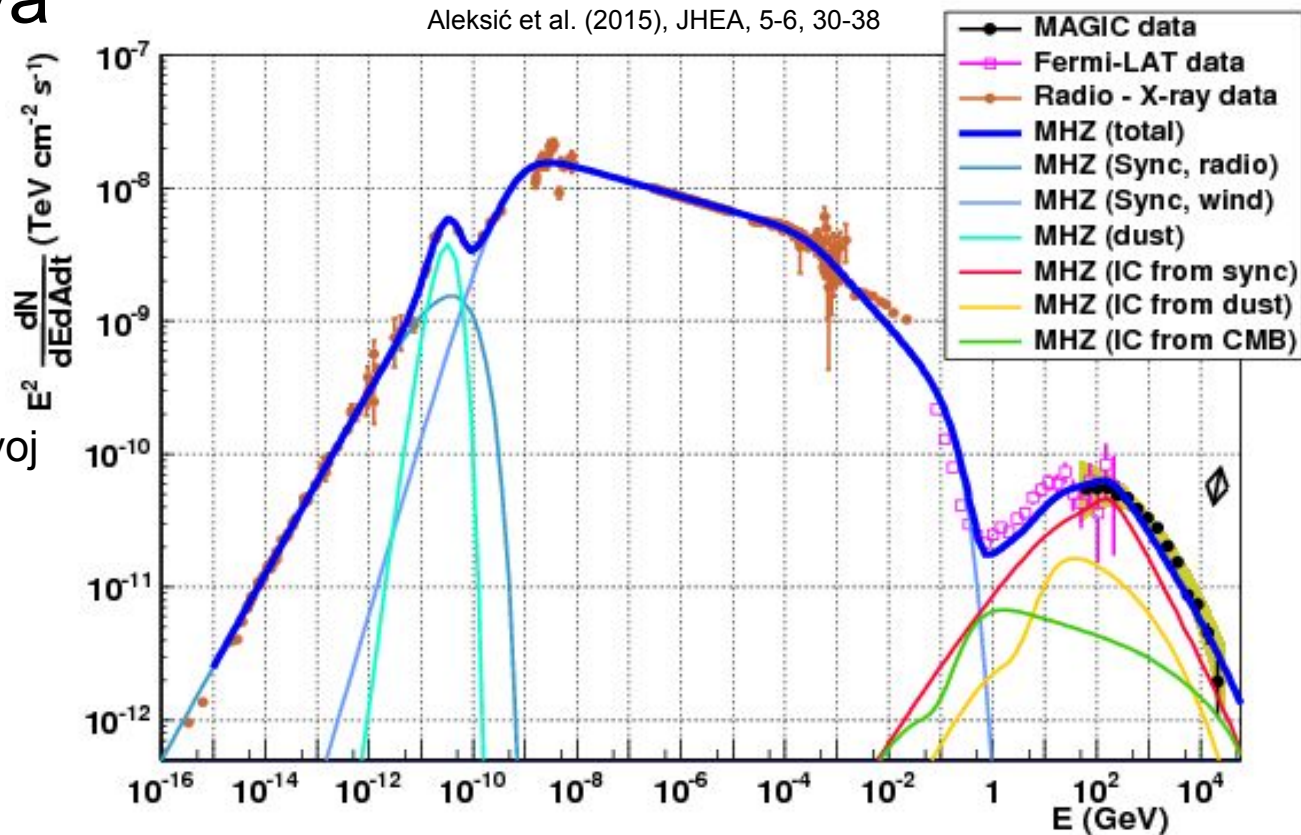
2704 BATSE Gamma-Ray Bursts



Ostaci supernova

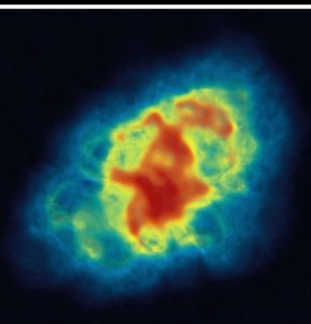
Maglica Rakovica (Crab Nebula)

- Najvažniji objekt za razvoj gama-astronomije
- Standardna svijeća u gama-astronomiji



CRAB NEBULA

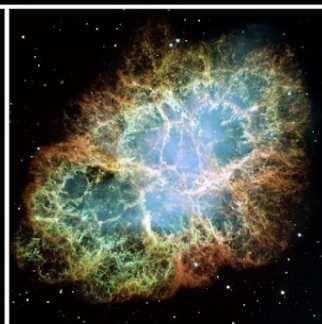
Wikipedia: Torres997



RADIO



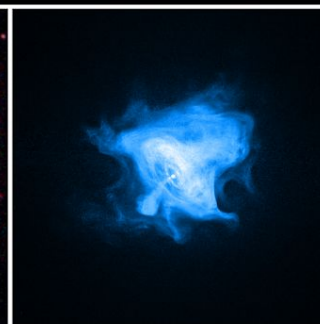
INFRARED



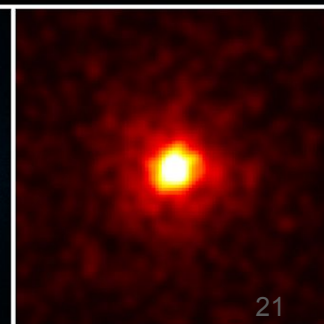
VISIBLE LIGHT



ULTRAVIOLET

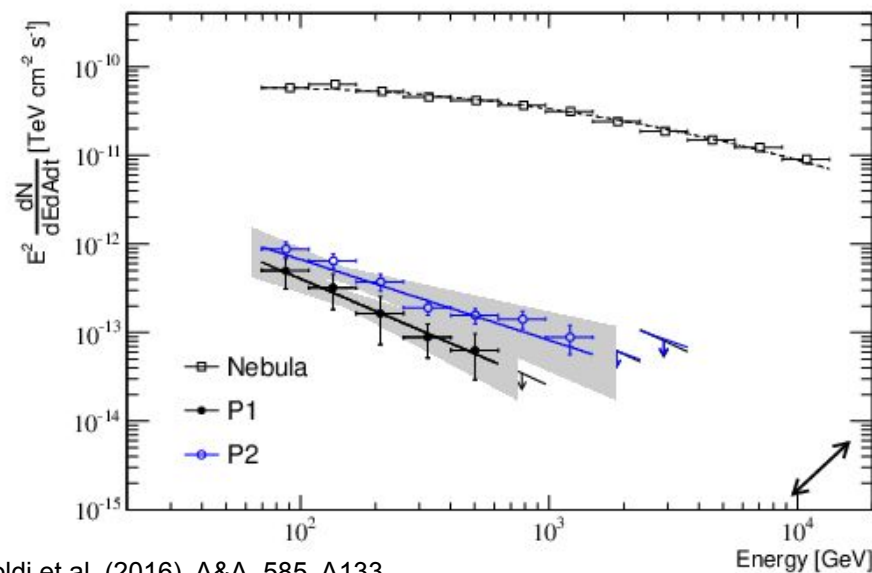
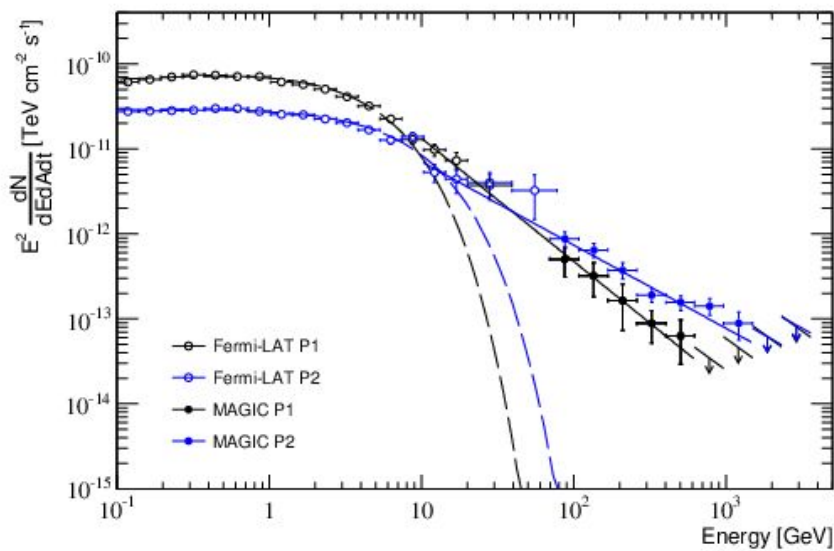
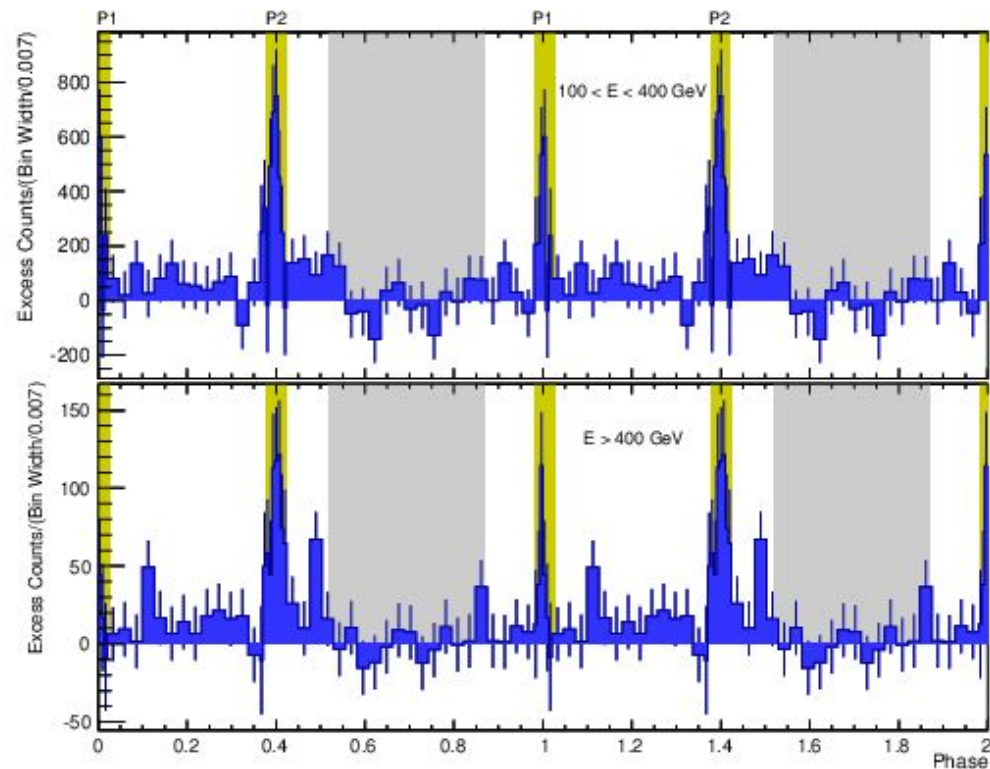
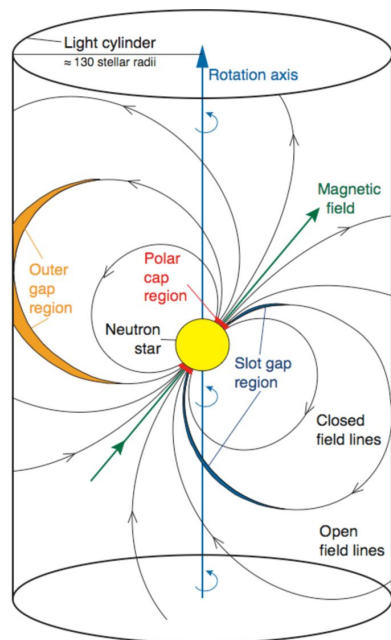


X-RAYS



GAMMA RAYS

Pulsari



Katalog TeV izvora

TeVCat 2.0

tevcat2.uchicago.edu

axion like particles

Settings Login

TeVCat

Home

Recently Viewed 0

TeV Astrophysics

Tools 3FGL

About TeVCat

TeVcat Labs

Home

RESET - + VIEW LEGEND

Source Name: PSR B1706-44
Source Type: Gal | PSR
Distance: 2.3 kpc
GLON: 33.1117
GLAT: 28.1868

RegExp Search

Filter by Type

Filter by Observer

☐ AND

☐ AND

Sync To Map

Filter Selected

Reset

Table Columns

Name	RA	Dec	Type Tags	Distance	Catalog
GRB 180720B	00 02 06.87	-02 55 05.2	XGal,GRB,JGRB	z=0.654	Default Catalog
CTA 1	00 06 26	+72 59 01.0	Gal,SNR,PWN	1.4 kpc	Default Catalog
SHBL J001355.9-185406	00 13 52.0	-18 53 29	XGal,AGN,Bltr,BLLa...	z=0.095	Default Catalog
Tycho	00 25 21.6	+64 07 48	Gal,SNR,Shell	3.5 kpc	Default Catalog
KUV 00311-1938	00 33 36	-19 21 00	XGal,AGN,Bltr,BLLa...		Default Catalog
1ES 0033+595	00 35 16.8	+59 47 24.0	XGal,AGN,Bltr,BLLa...	z=0.467	Default Catalog
NGC 253	00 47 32.54	-25 17 25.4	XGal,*B1st	2500.0 kpc	Default Catalog
GRB 201216C	01 05 28.88	+16 30 58.0	XGal,GRB,JGRB	z=1.1	Newly Announced
S2 0109+22	01 12 05.8	+22 44 39	XGal,AGN,Bltr,BLLa...		Default Catalog
RGB J0136+391	01 36 32.5	+39 06 00	XGal,AGN,Bltr,BLLa...		Newly Announced
RGB J0152+017	01 52 33.5	+01 46 40.3	XGal,AGN,Bltr,BLLa...	z=0.08	Default Catalog
3C 58	02 05 31	+64 51 00	Gal,SNR,PWN	2.0 kpc	Default Catalog
TXS 0210+515	02 14 17.9	+51 44 52	XGal,AGN,Bltr,BLLa...	z=0.049	Default Catalog
S3 0218+35	02 21 05.5	+35 56 14	XGal,AGN,Bltr,FSRQ	z=0.954	Default Catalog
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MAGIC J0223+403	02 23 12	+43 00 42	UNID		Default Catalog
1ES 0229+200	02 32 53.2	+20 16 21	XGal,AGN,Bltr,BLLa...	z=0.1396	Default Catalog
1RXS J023832.6-311658	02 38 32.5	-31 16 58	XGal,AGN,Bltr,BLLa...	z=0.232	Newly Announced
LS I +61 303	02 40 34	+61 15 25	Gal,BIN	2.0 kpc	Default Catalog
GRB 190829A	02 58 10.51	-08 57 28.1	XGal,GRB,JGRB	z=0.0785	Default Catalog
PKS 0301-243	03 03 23.49	-24 07 35.86	XGal,AGN,Bltr,BLLa...	z=0.2657	Default Catalog
IC 310	03 16 43.0	+41 19 29	XGal,AGN	z=0.0189	Default Catalog
RBS 0413	03 19 47	+18 45 42	XGal,AGN,Bltr,BLLa...	z=0.19	Default Catalog

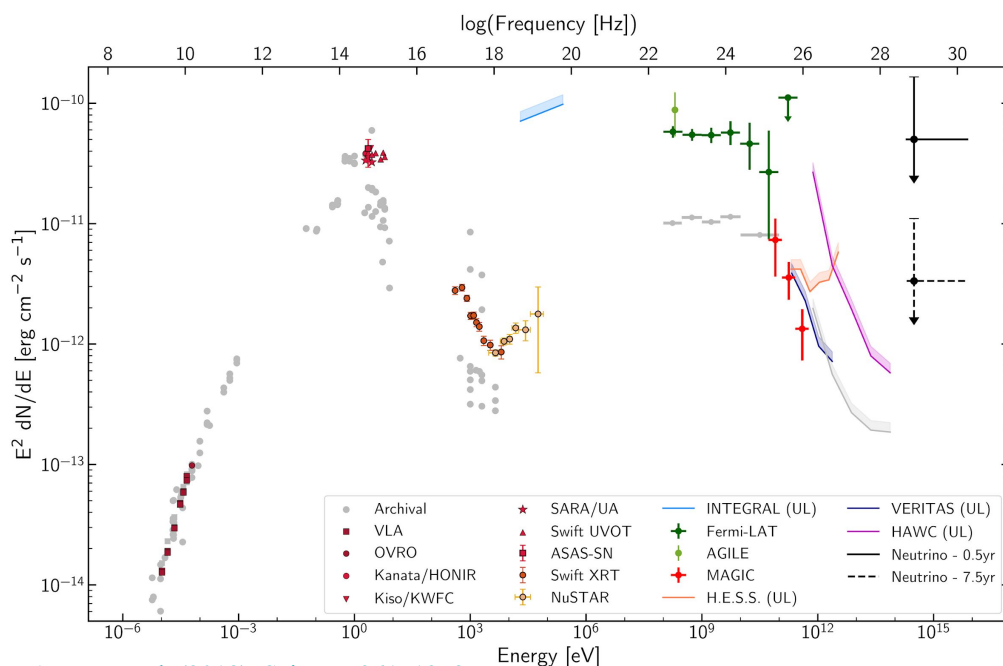
Sources Listed: 251

2014-2022 © Scott Wakely and Deirdre Horan

Multimessenger astronomija

TXS 0506+056 (blazar)

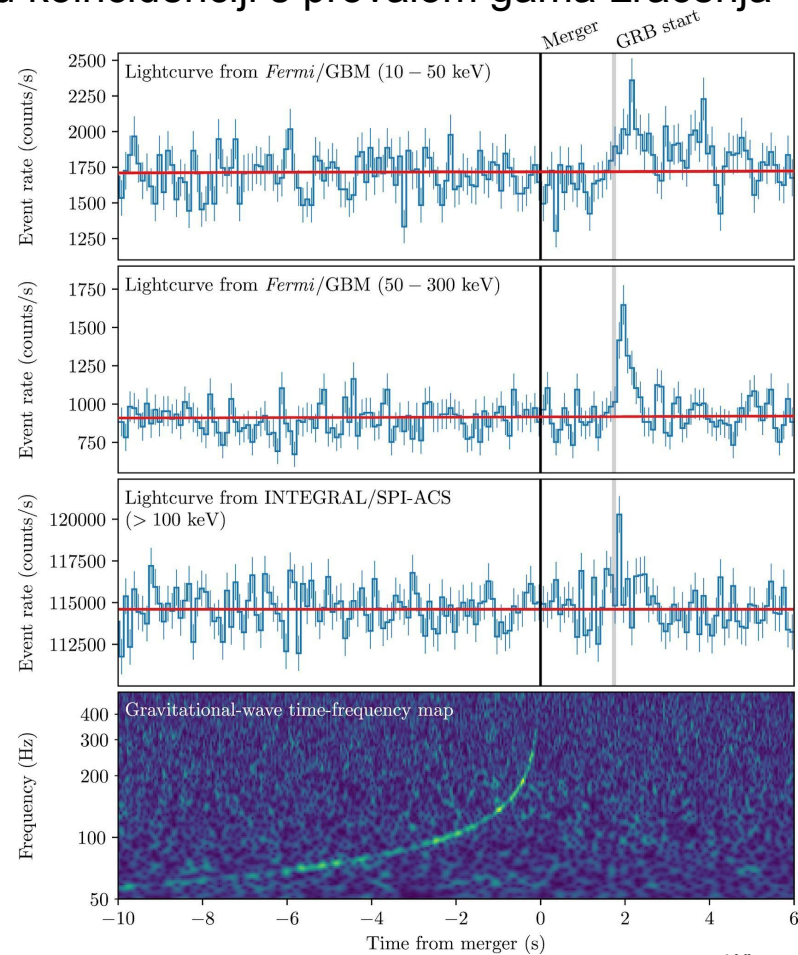
Prvo opažanje pojačanog toka gama-zračenja u koincidenciji s emisijom neutrina



[Aartsen et al. \(2018\), Science, 361, 1378](#)

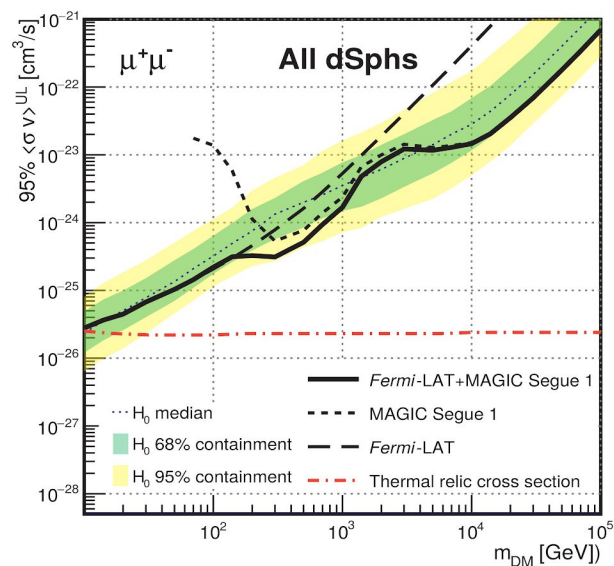
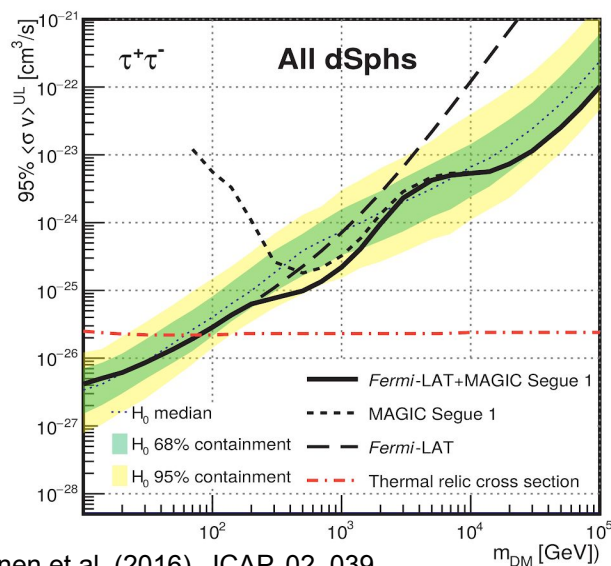
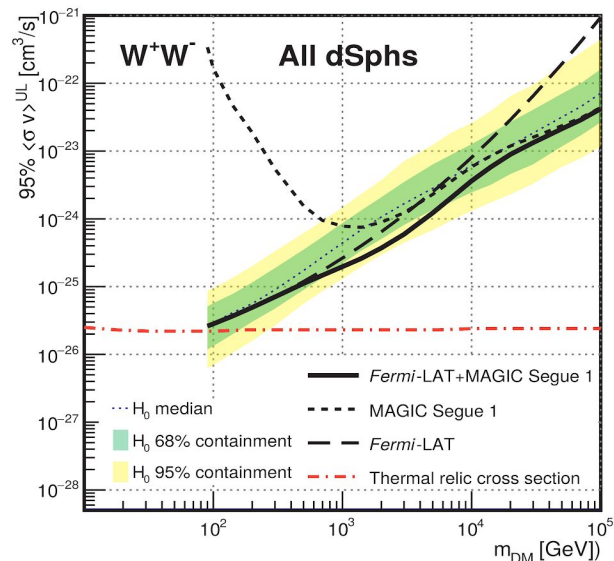
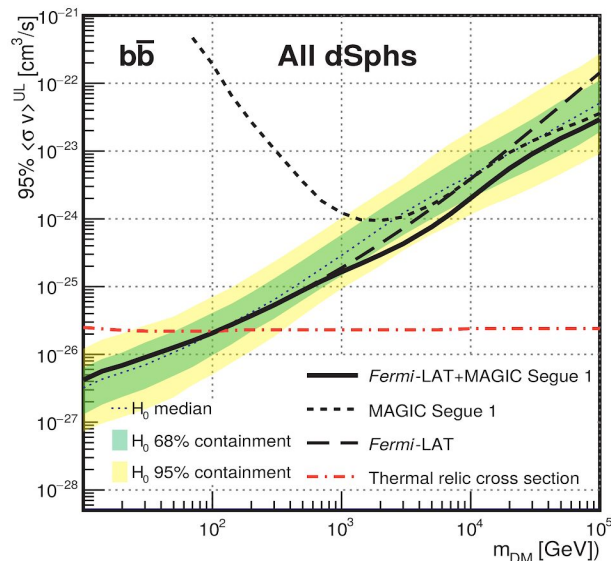
GW170817 & GRB 170817A

Spajanje neutronskih zvijezda
Prvo opažanje gravitacijskih valova u koincidenciji s provalom gama-zračenja

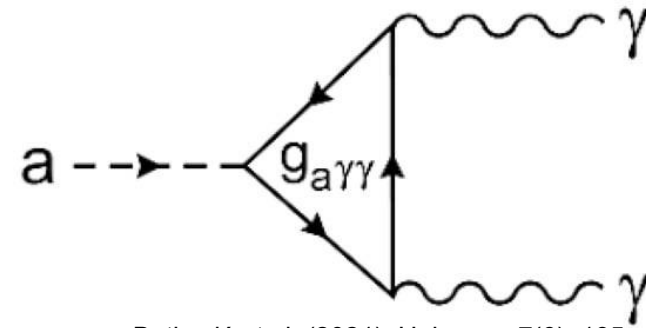
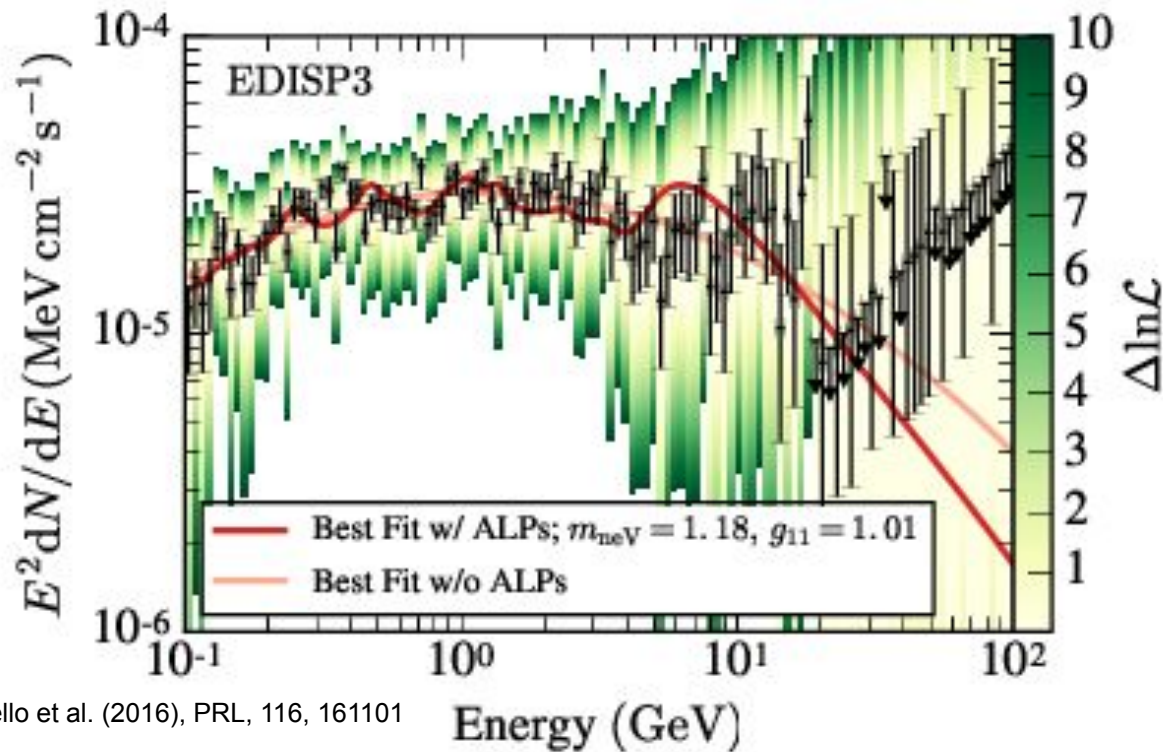
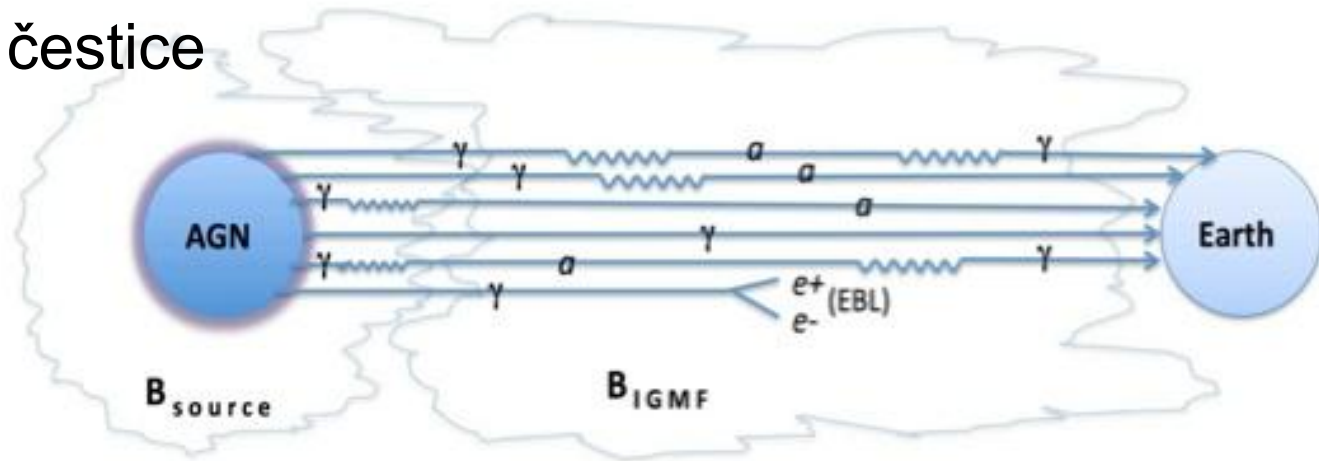


Abbott et al. (2017) ApJL, 848, L13

Tamna materija



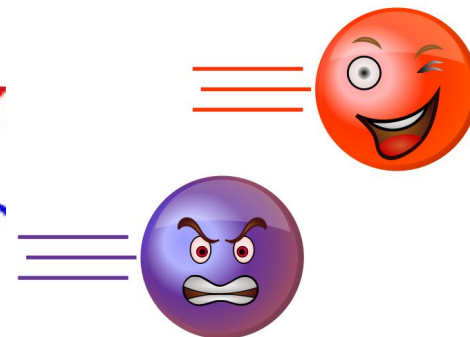
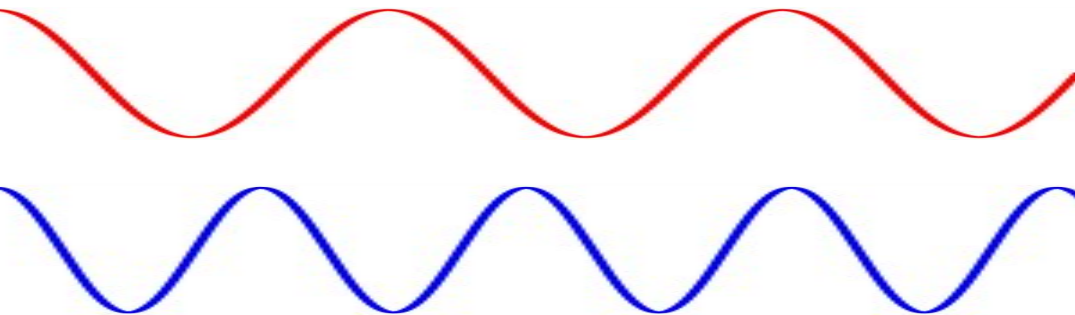
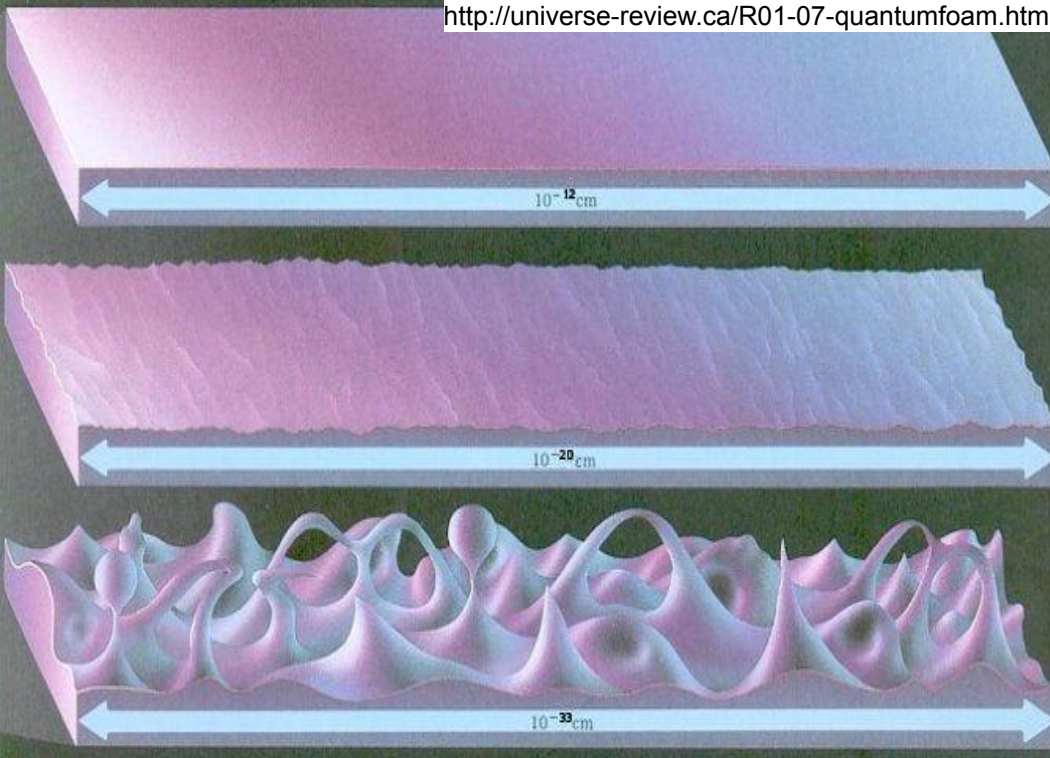
Axioni i axionske čestice



Batković et al. (2021), Universe, 7(6), 185

Kvantna gravitacija

<http://universe-review.ca/R01-07-quantumfoam.htm>



Gama-astronomija – zaključak

- Elektromagnetsko zračenje najviših energija
- Značajan udio snage zračenja iz astronomskih objekata
- Nosi važnu informaciju o procesima u raznim vrstama astronomskih objekata
- Alternativni pristup fundamentalnim istraživanjima

Astročestična
fizika

