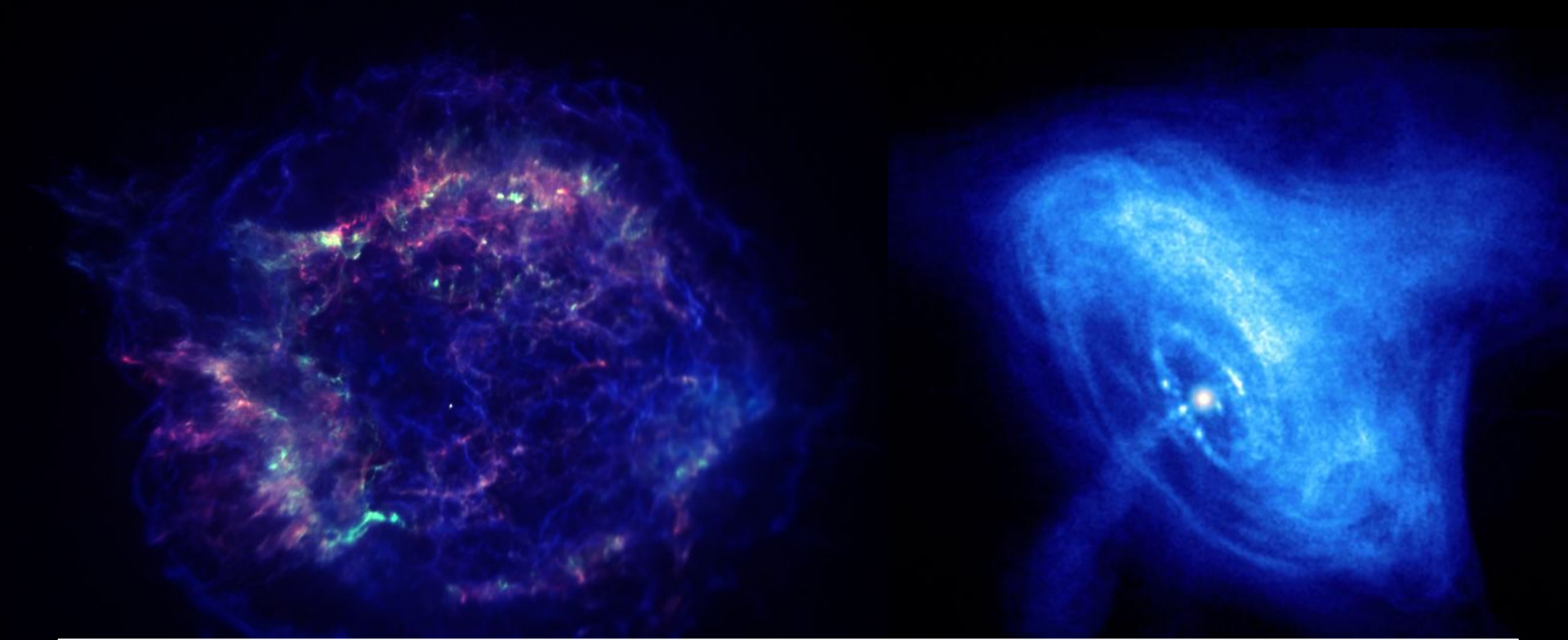
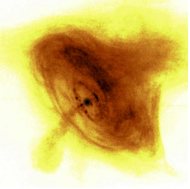


**Analýza Astronomických dát**

Mgr Matúš Kocka

Workshop 0

STU 23.10.2017



# Úvodná prednáška k workshopu o spracovaní astronomických dát

Podobný predmet: 2014, 2015 MUNI
PřF:F9145 Praktikum z astronomie 3

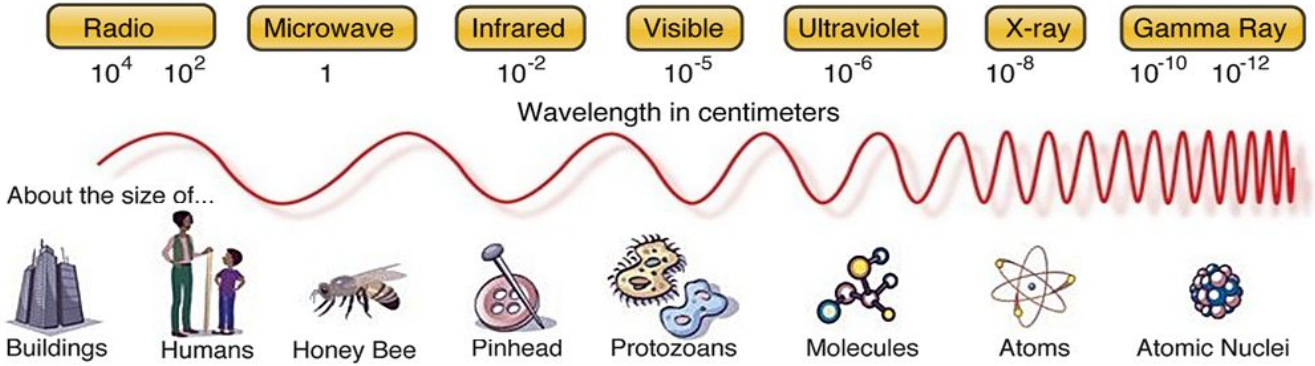
V tejto prezentácií bude veľa **obrázkov** a veľa **rozprávania**. Bude super ak bude aj veľa **otázok**. V nasledujúcich workshop-och to už bude čisto o skriptovaní, grafoch a vizualizácií pomocou: DS9, Fv, Xspec, Astropy, PyFits, etc …

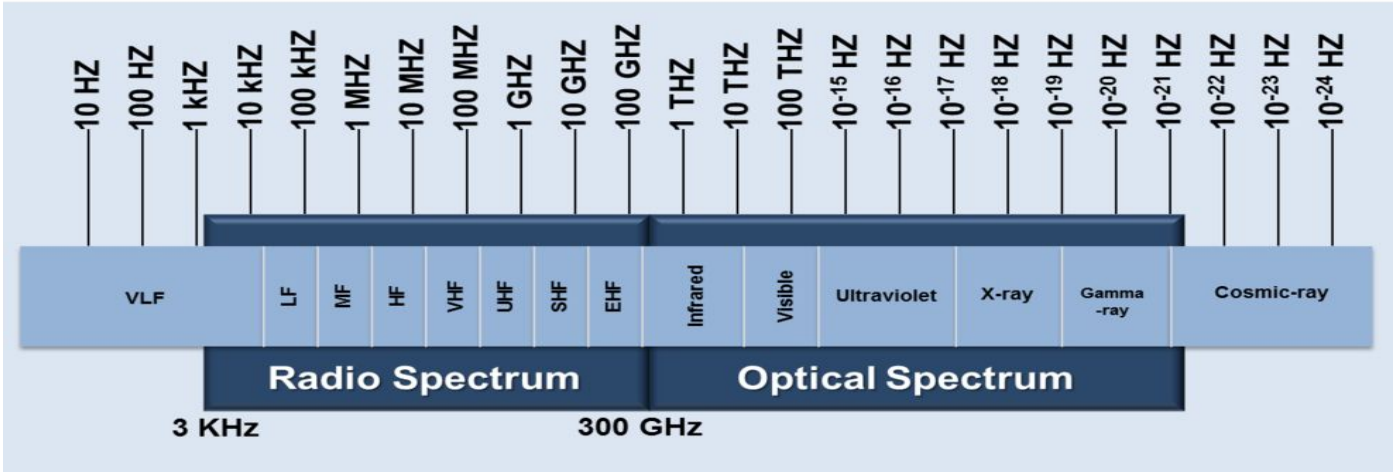
---

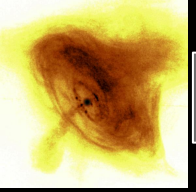
O čom to bude dnes:

- Elmag. Spektrum a astronomické prístroje
- FITS
- HEA
- Chandra (NASA), INTEGRAL (ESA), XMM-Newton (ESA), *[Fermi (NASA)], HST*
- Event detektory, obrázky
- HEA spektrá
- Úlohy na workshop
- Q/A

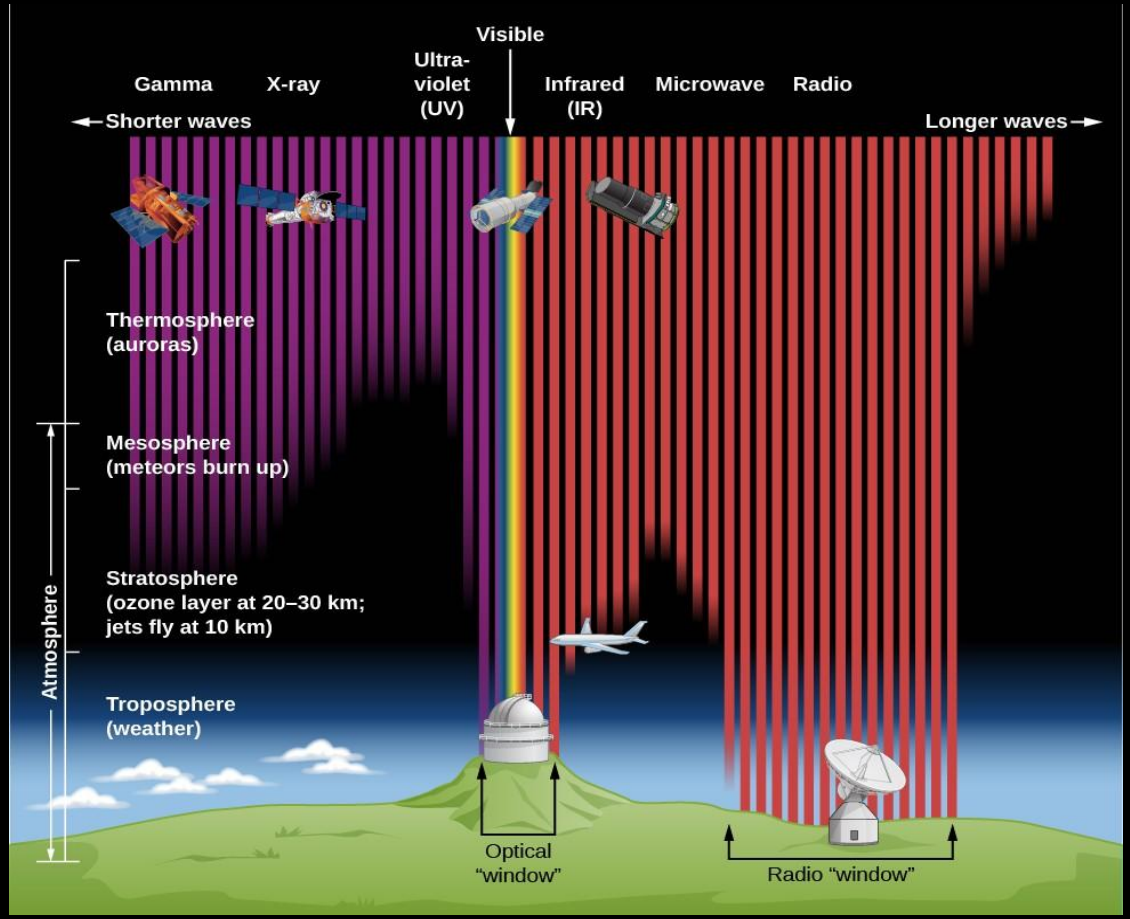
# Vlnové dĺžky a frekvencie elmag. žiarenia v rôznych bandoch.



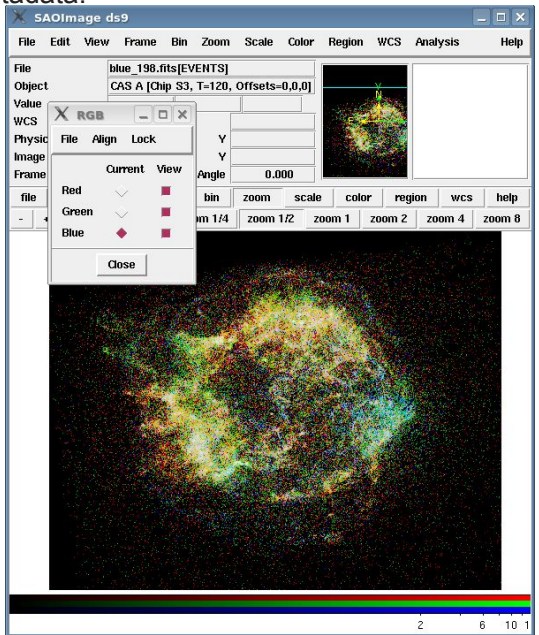


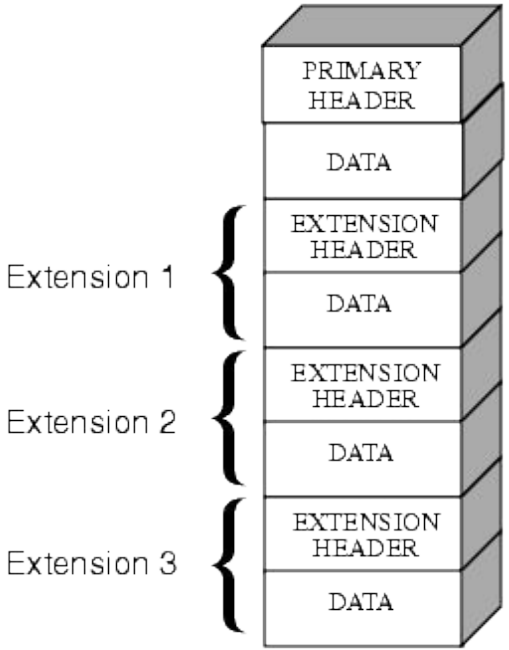
# Vlnové dĺžky a frekvencie elmag. žiarenia v rôznych bandoch.

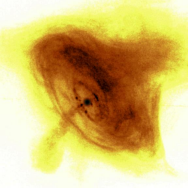


# Flexible Image Transport System (FITS)

**Flexible Image Transport System** (**FITS**) is an open standard[3] defining a digital file format useful for storage, transmission and processing of scientific and other images. FITS is the most commonly used digital file format in astronomy. Unlike many image formats, FITS is designed specifically for scientific data and hence includes many provisions for describing photometric and spatial calibration information, together with image origin metadata.



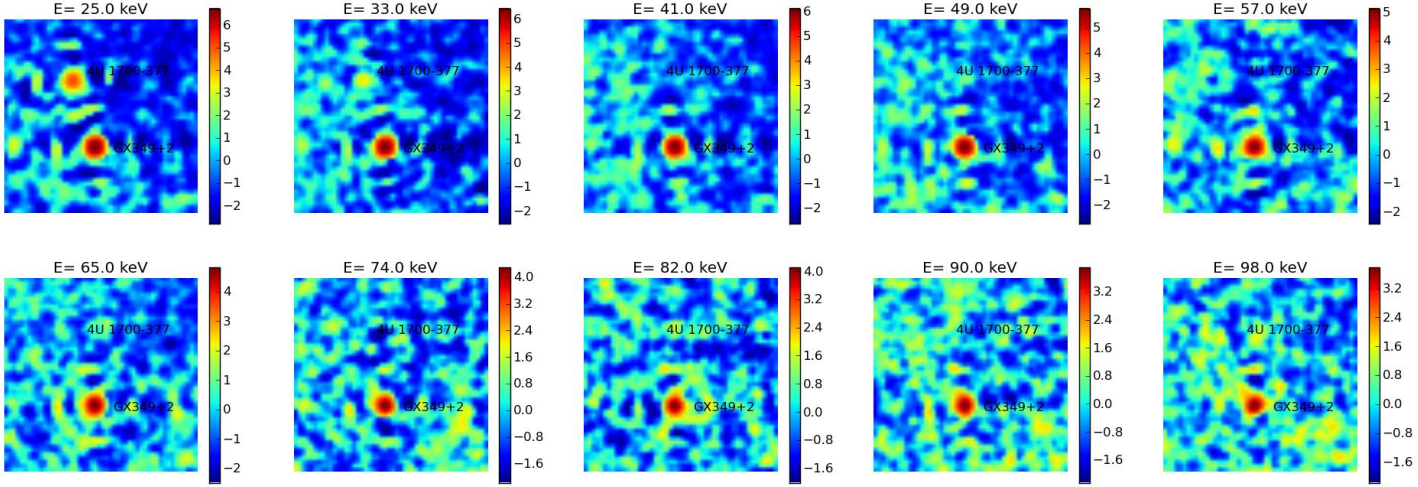


# Flexible Image Transport System (FITS)

https://heasarc.gsfc.nasa.gov/docs/software/fitsio/cexamples.html

S FITS súbormy budeme pracovať buď pomocou BASH utilít alebo v “pythone” pomocou knižníc PyFITS a Astropy.

astropy http://www.astropy.org/

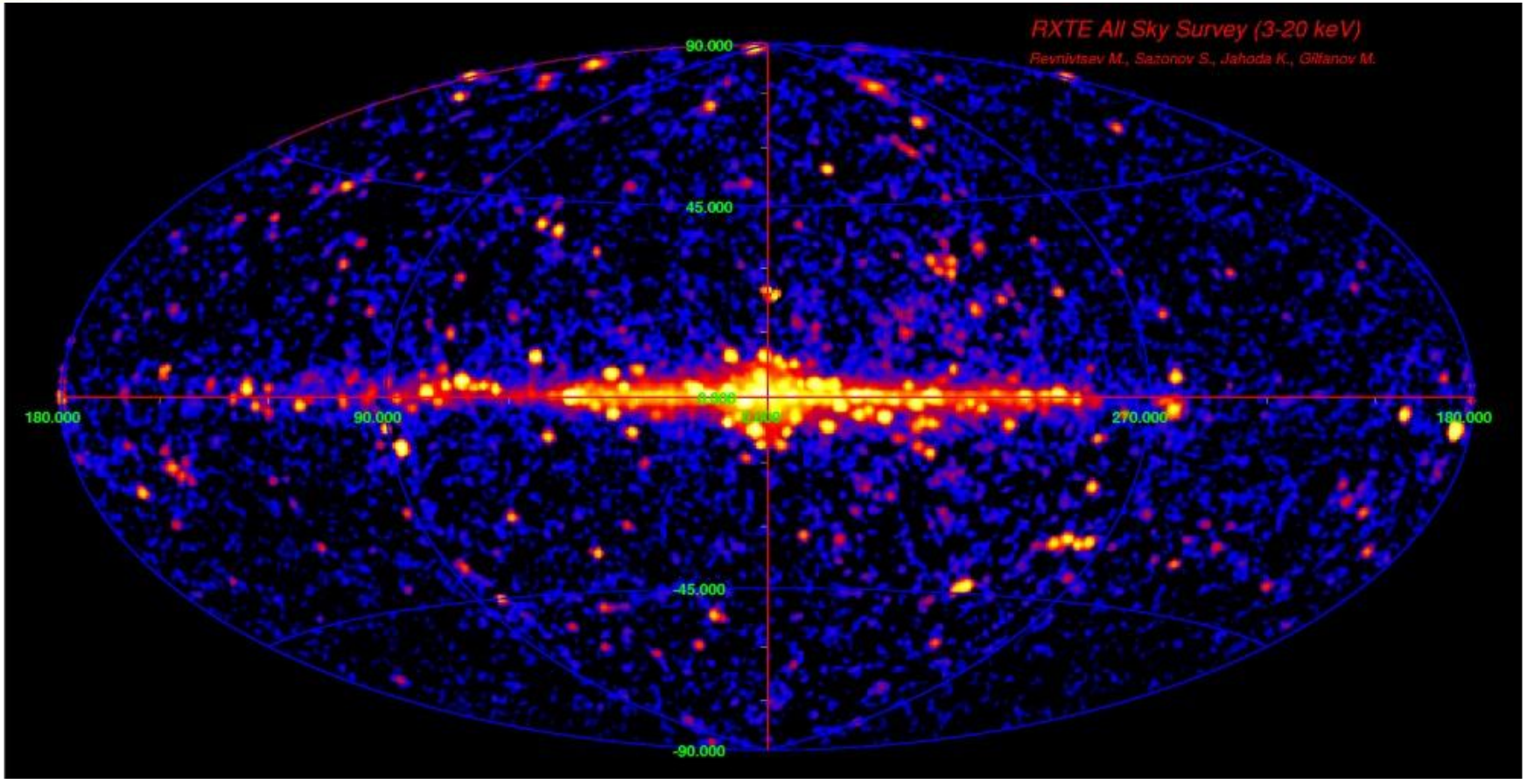



4U 1700-377
HMXB

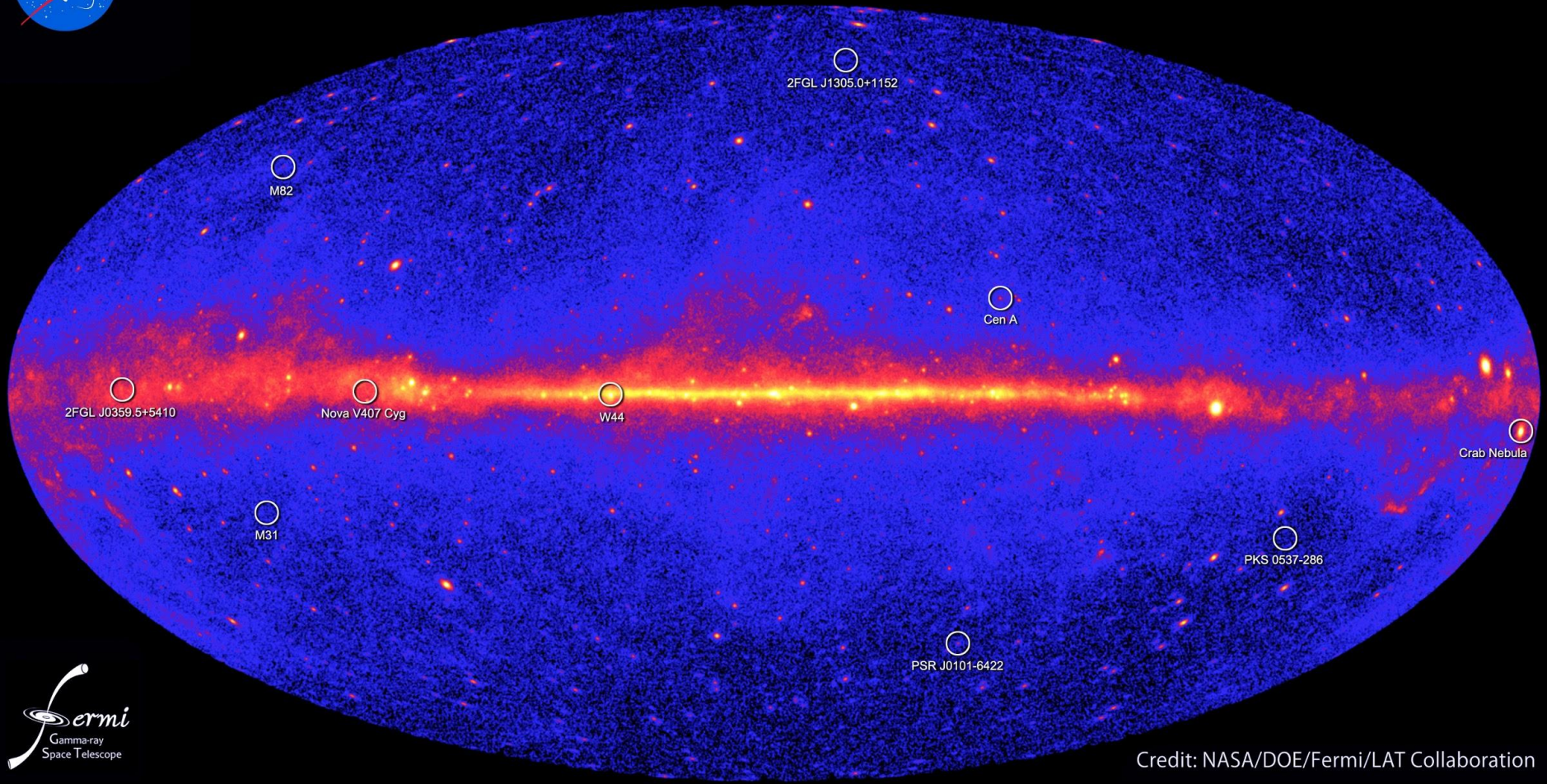
GX349+2
LMXB

INTEGRAL [IBIS]

# HEA High Energy Astrophysics



# Fermi two-year all-sky map

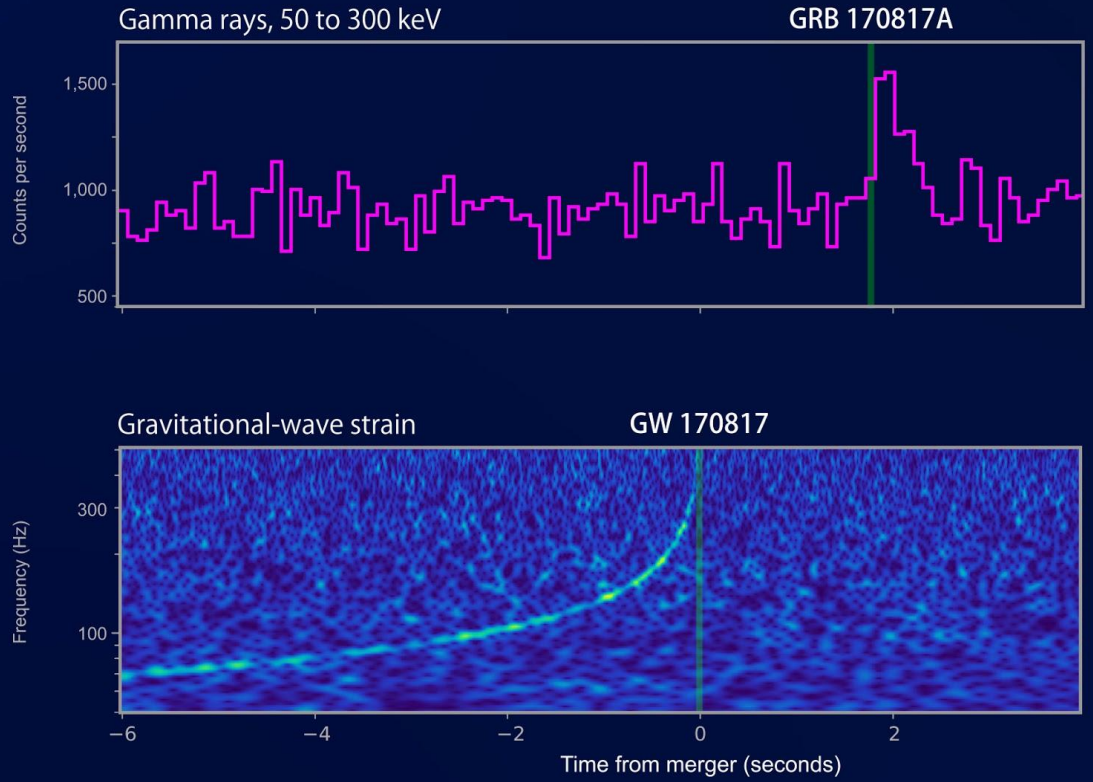



Fermi Gamma-ray Space Telescope

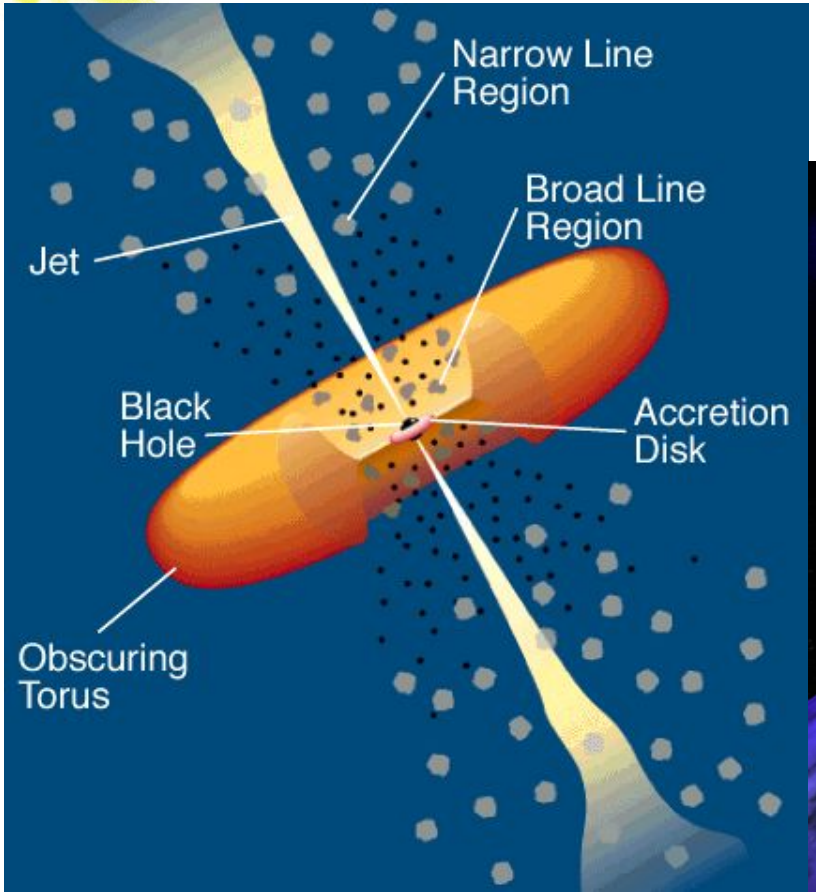
Credit: NASA/DOE/Fermi/LAT Collaboration

Fermi

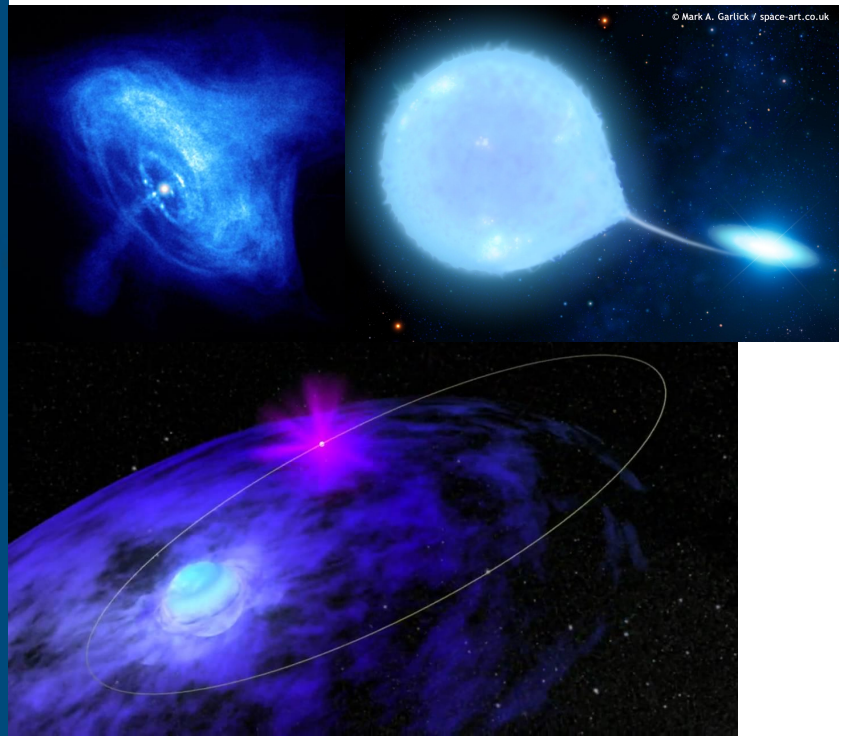
LIGO

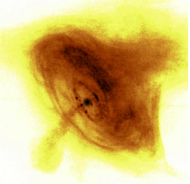

Gamma rays, 50 to 300 keV
GRB 170817A
Counts per second
1,500
1,000
500
Gravitational-wave strain
GW 170817
Frequency (Hz)
300
100
−6
−4
−2
0
2
Time from merger (seconds)

# High Energy Astrophysics

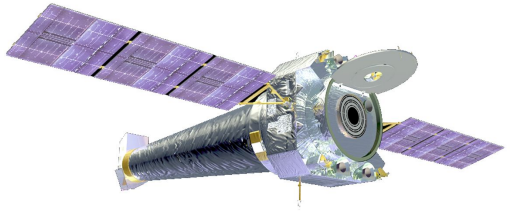



Galaktické vs. extragalaktické objekty
Termálna vs. netermálna emisia





# Vybrané kozmické misie, ktorých dáta budeme používať



## CHANDRA (1999) 0.1 - 10 keV

- High Resolution Camera (HRC)
- Advanced CCD Imaging Spectrometer (ACIS)
- High Energy Transmission Grating Spectrometer (HETGS)
- Low Energy Transmission Grating Spectrometer (LETGS)

## XMM-Newton (1999) 0.1 - 10 keV

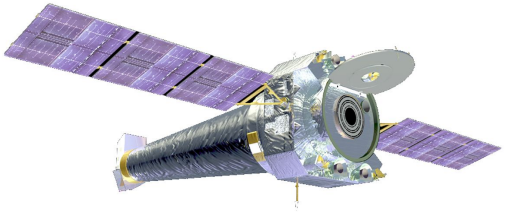
- European Photon Imaging Cameras (EPIC) | 2 x MOS-CCD 1 x pn-CCD
- Reflection Grating Spectrometers (RGS)
- The Optical Monitor (OM)

## INTEGRAL (2002) 15 keV - 10 MeV

- Imager on-Board the INTEGRAL Satellite (IBIS)
- Spectrometer for INTEGRAL (SPI)
- Dual JEM-X soft to hard X-ray
- OMC

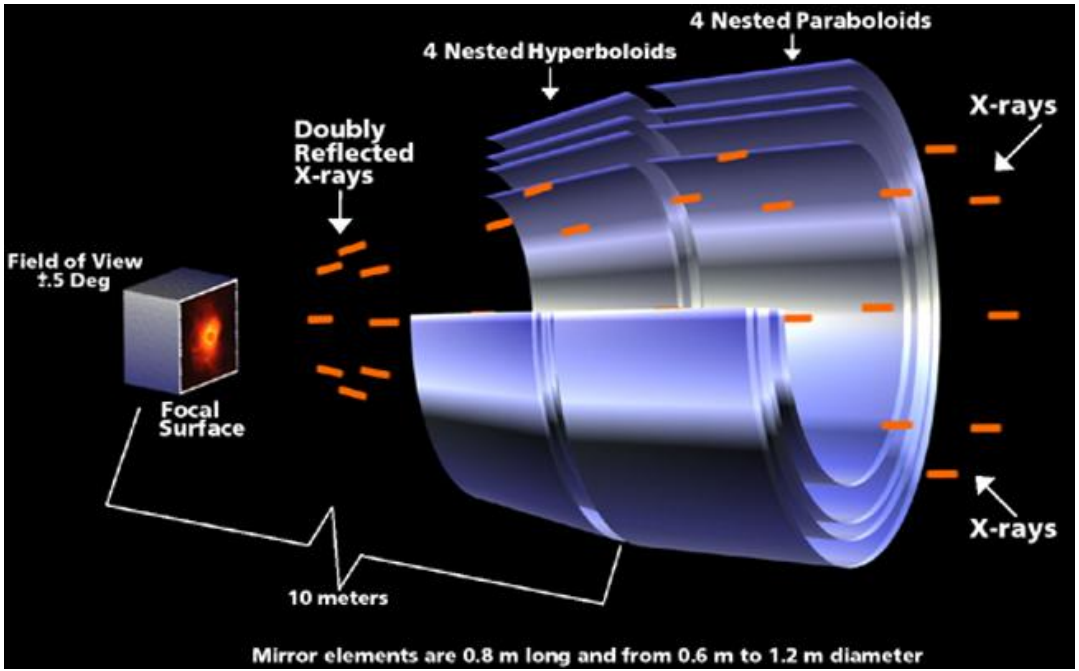
## FERMI (2008)

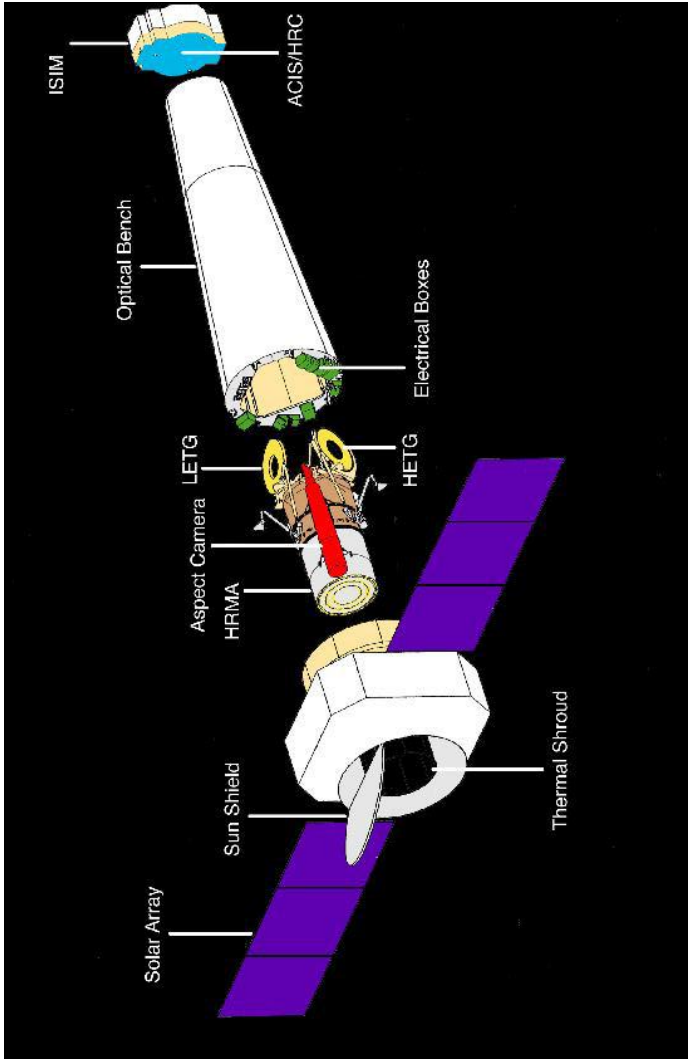
- Large area telescope (LAT) 200 MeV - 300 GeV
- GBM 8 keV - 1 Mev GRB detector



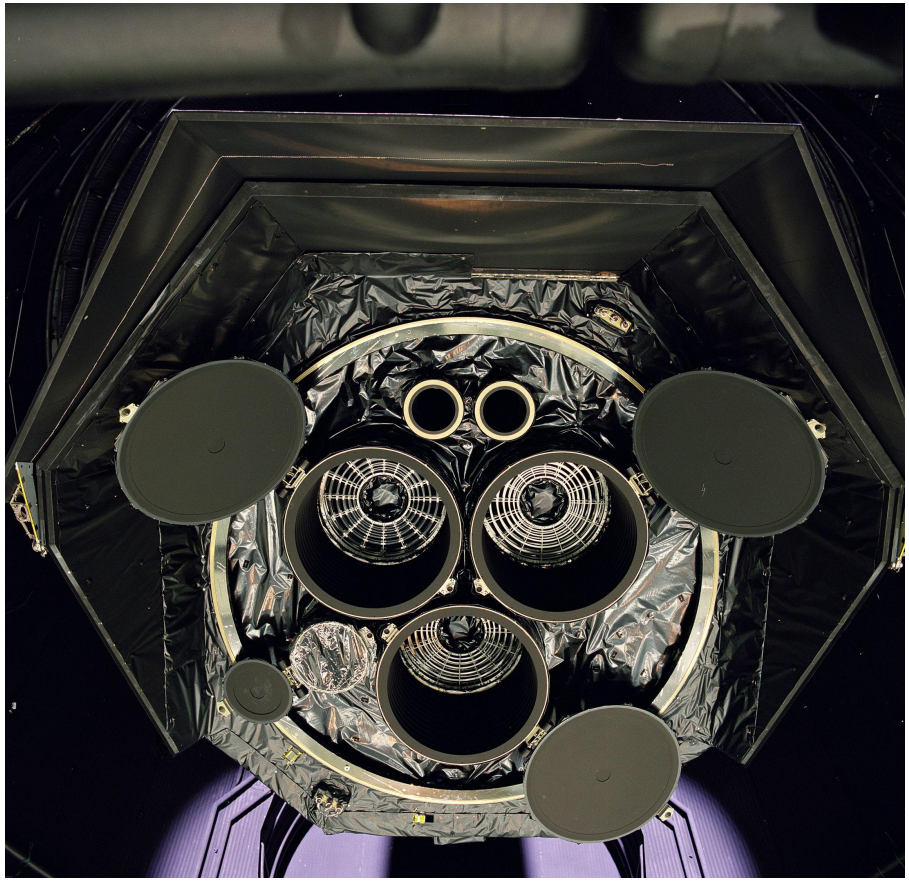
# CHANDRA

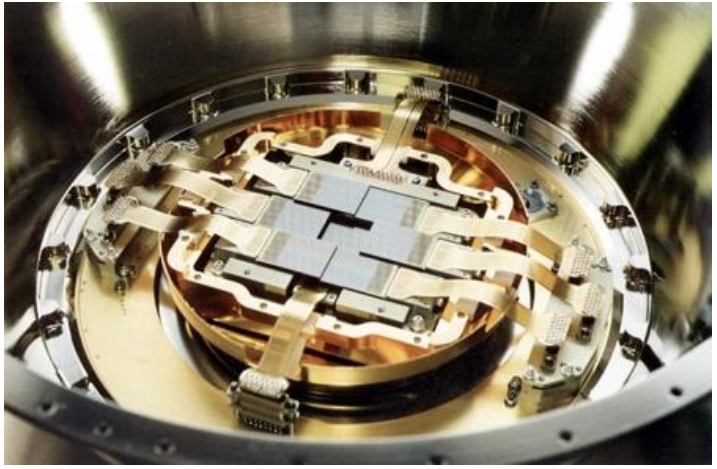
My budeme hlavne používať ACIS, pretože má veľké zorné pole a dobrú citlivosť.

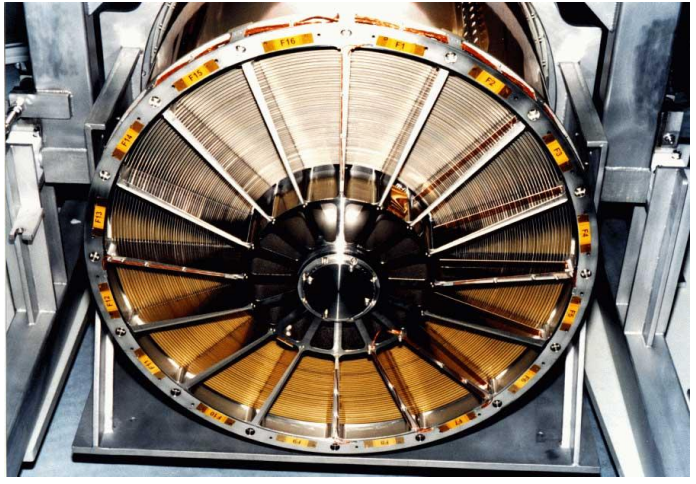


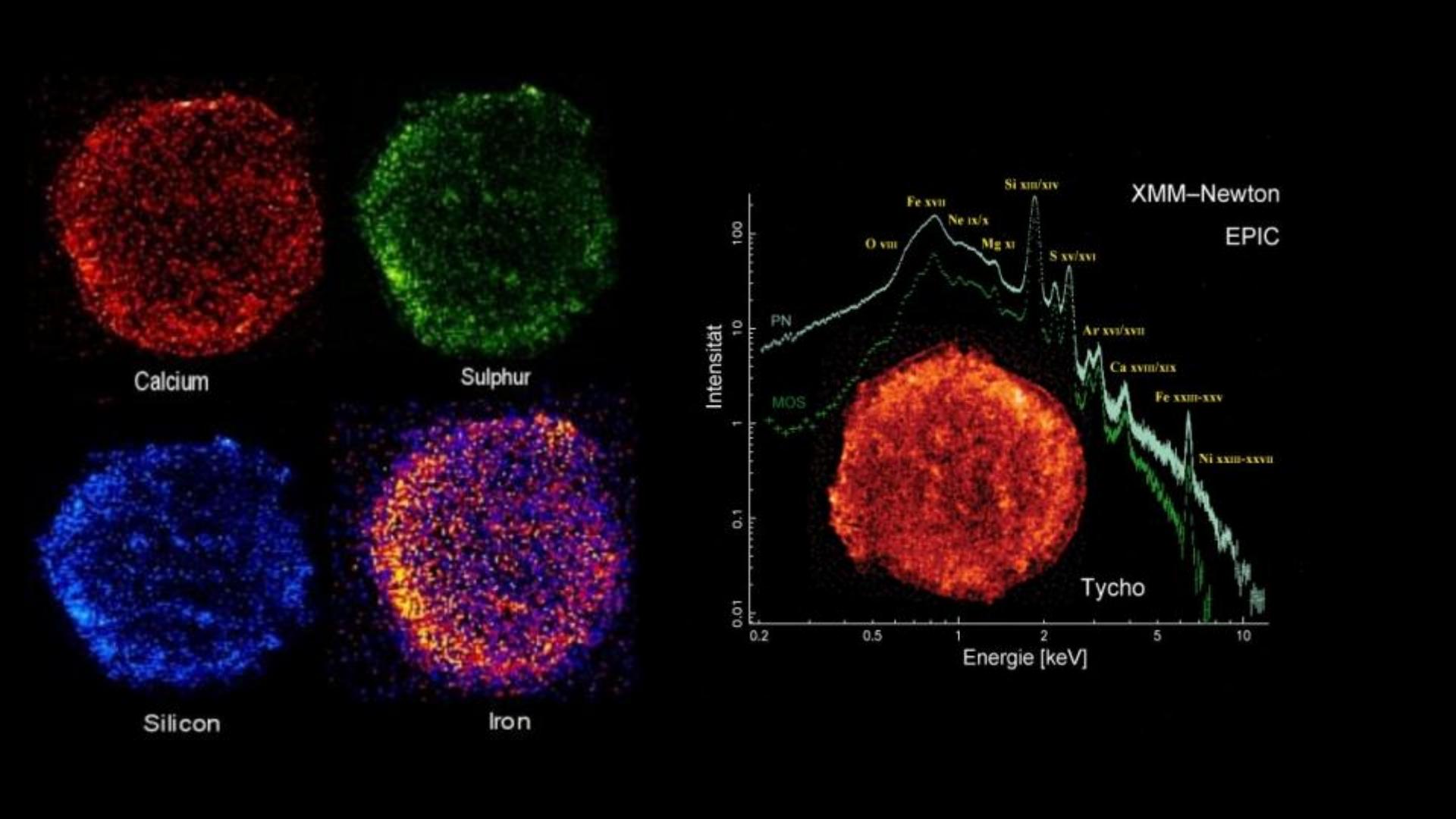



# XMM-Newton





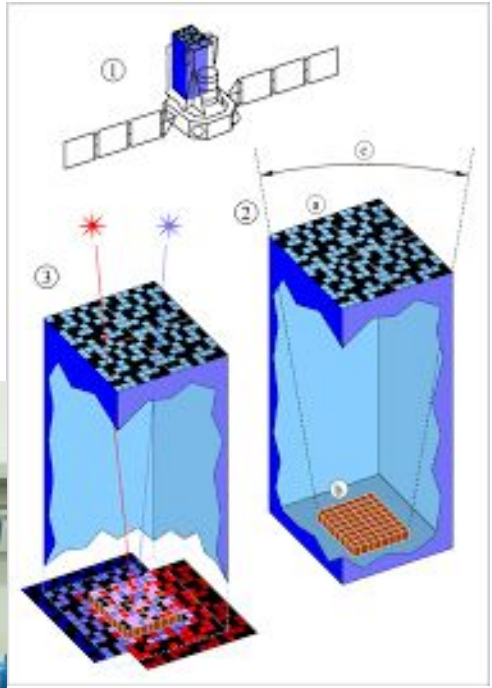


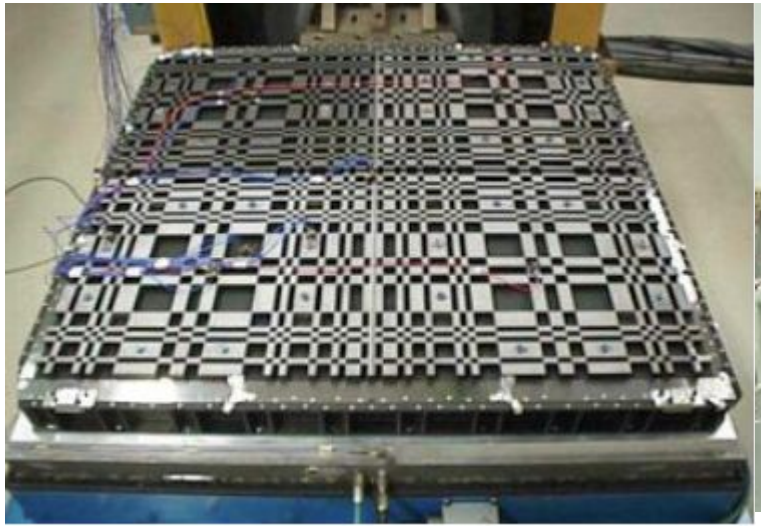

Calcium
Sulphur
Silicon
Iron
XMM–Newton
EPIC
Intensität
Energie [keV]
PN
MOS
Tycho
O viii
Fe xvii
Ne ix/x
Mg xi
Si xiii/xiv
S xv/xvi
Ar xvi/xvii
Ca xviii/xix
Fe xxiii-xxv
Ni xxiii-xxvii
0.01
0.1
1
10
100
0.2
0.5
1
2
5
10

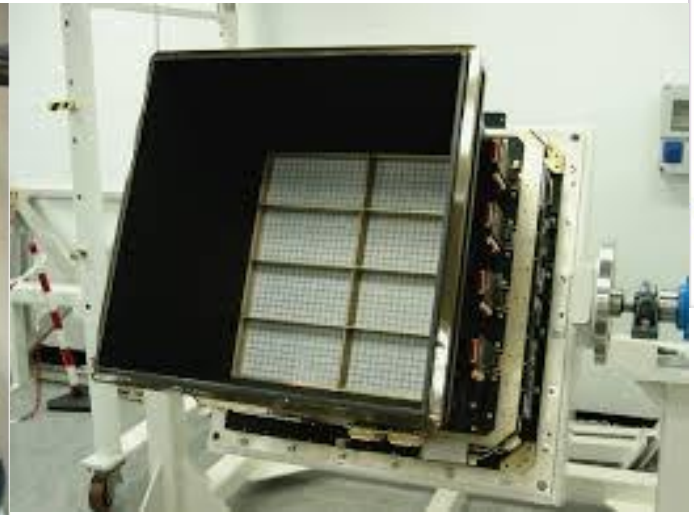
# INTEGRAL

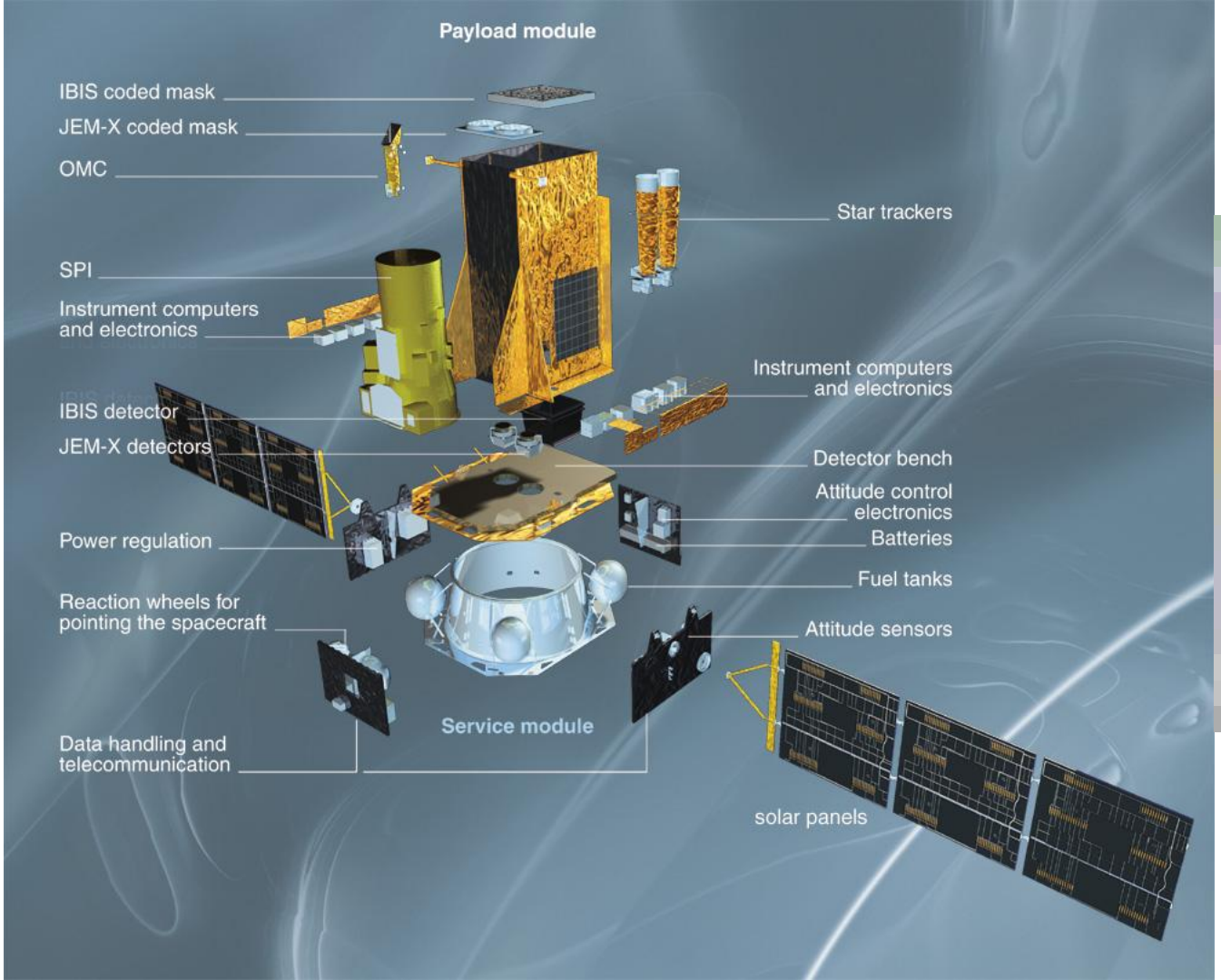
Budeme používať IBIS/ISGRI, detektor tvorený kódovou maskou a dvojitou vrstvou detektorov / kryštálov. Pre nás bude väčšinou zaujímavý od 20 do max 200 KeV.

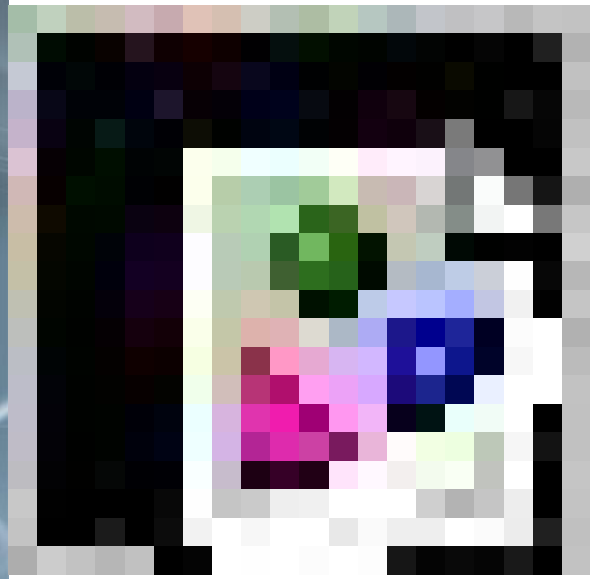
Princíp kódovej masky je princíp tzv. Pin-hole kamery + shadowgram.

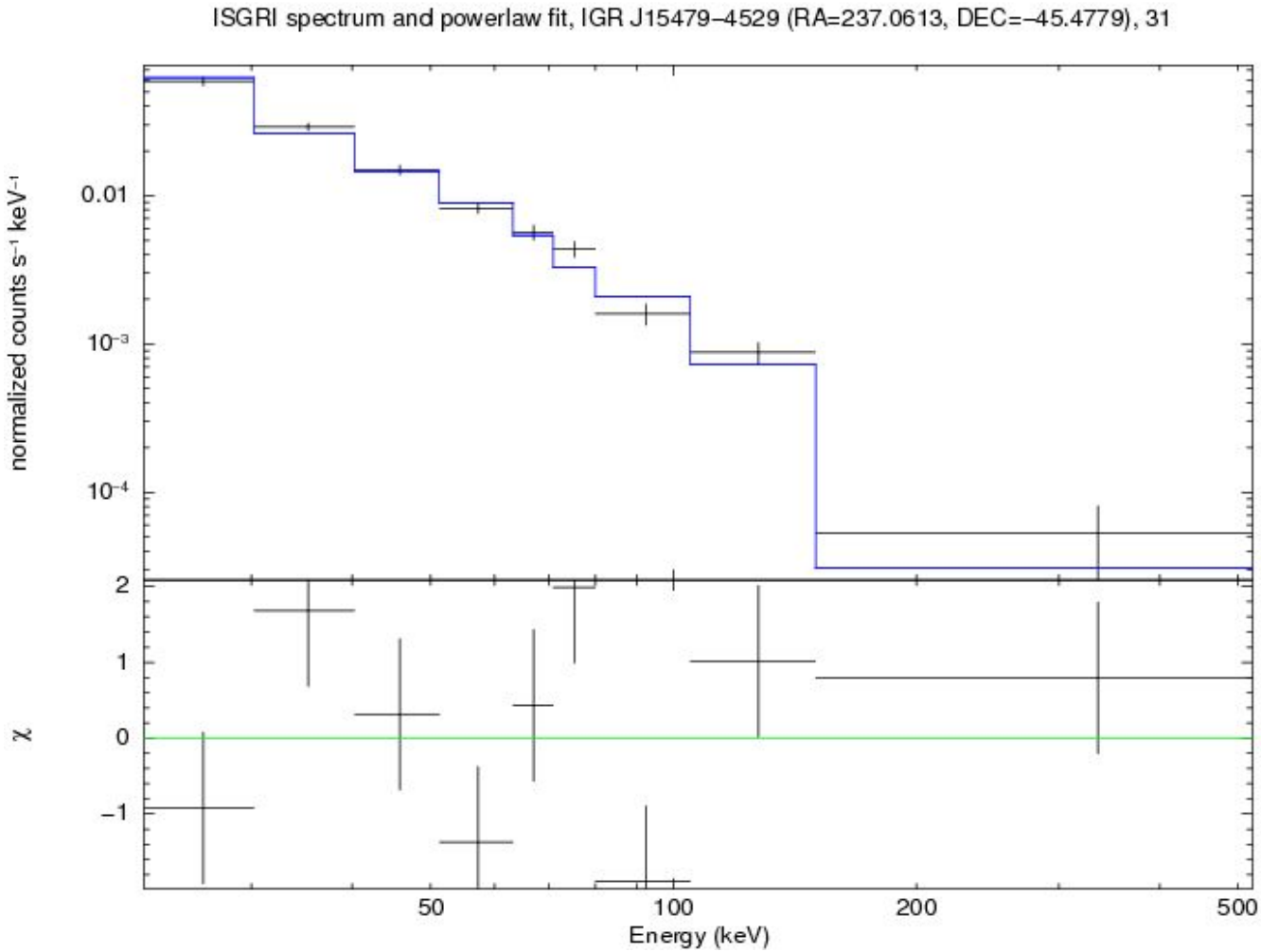




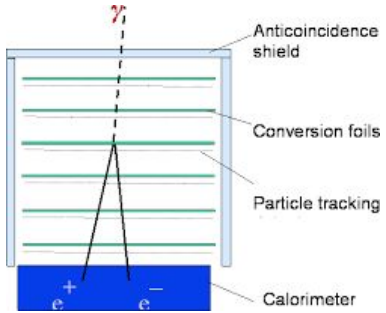


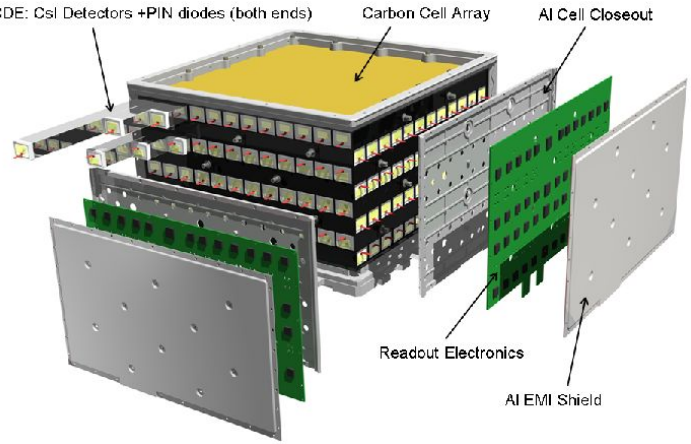

Payload module
IBIS coded mask
JEM-X coded mask
OMC
Star trackers
SPI
Instrument computers and electronics
Instrument computers and electronics
IBIS detector
JEM-X detectors
Detector bench
Attitude control electronics
Power regulation
Batteries
Fuel tanks
Reaction wheels for pointing the spacecraft
Attitude sensors
Service module
Data handling and telecommunication
solar panels

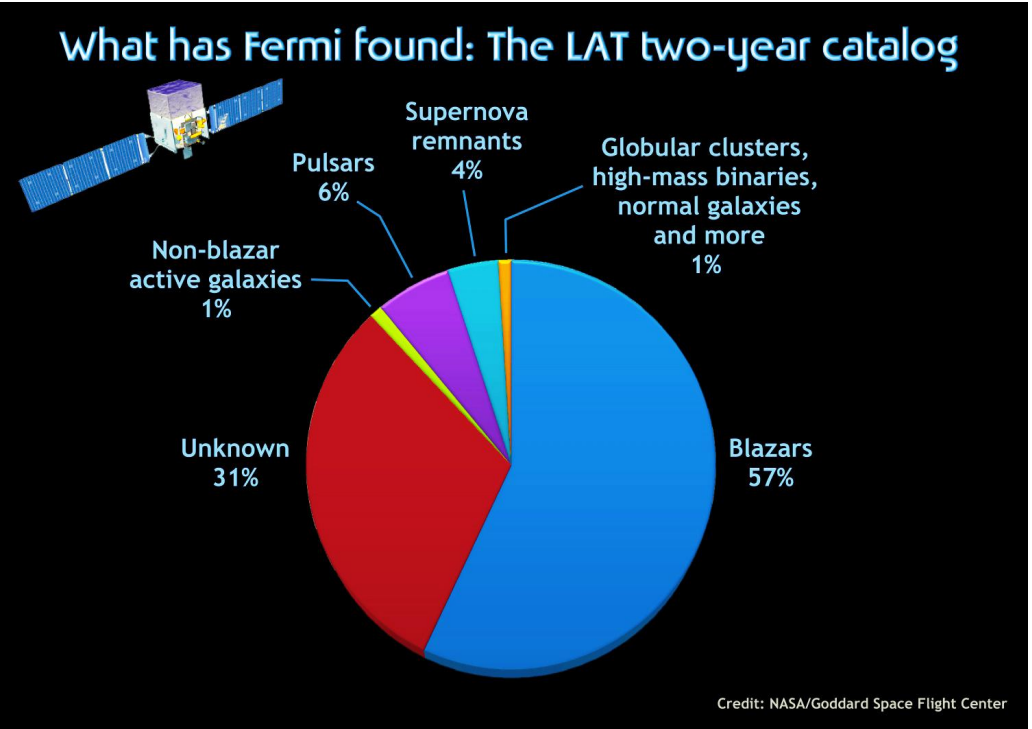


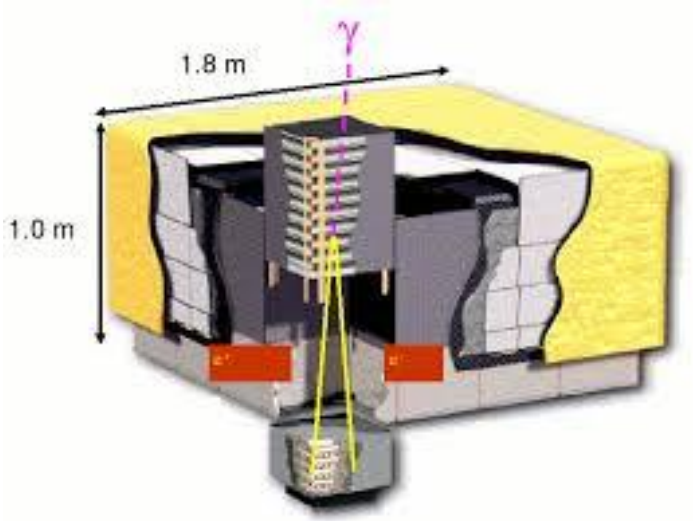

ISGRI spectrum and powerlaw fit, IGR J15479−4529 (RA=237.0613, DEC=−45.4779), 31
normalized counts s⁻¹ keV⁻¹
0.01
10⁻³
10⁻⁴
2
1
0
−1
χ
50
100
200
500
Energy (keV)

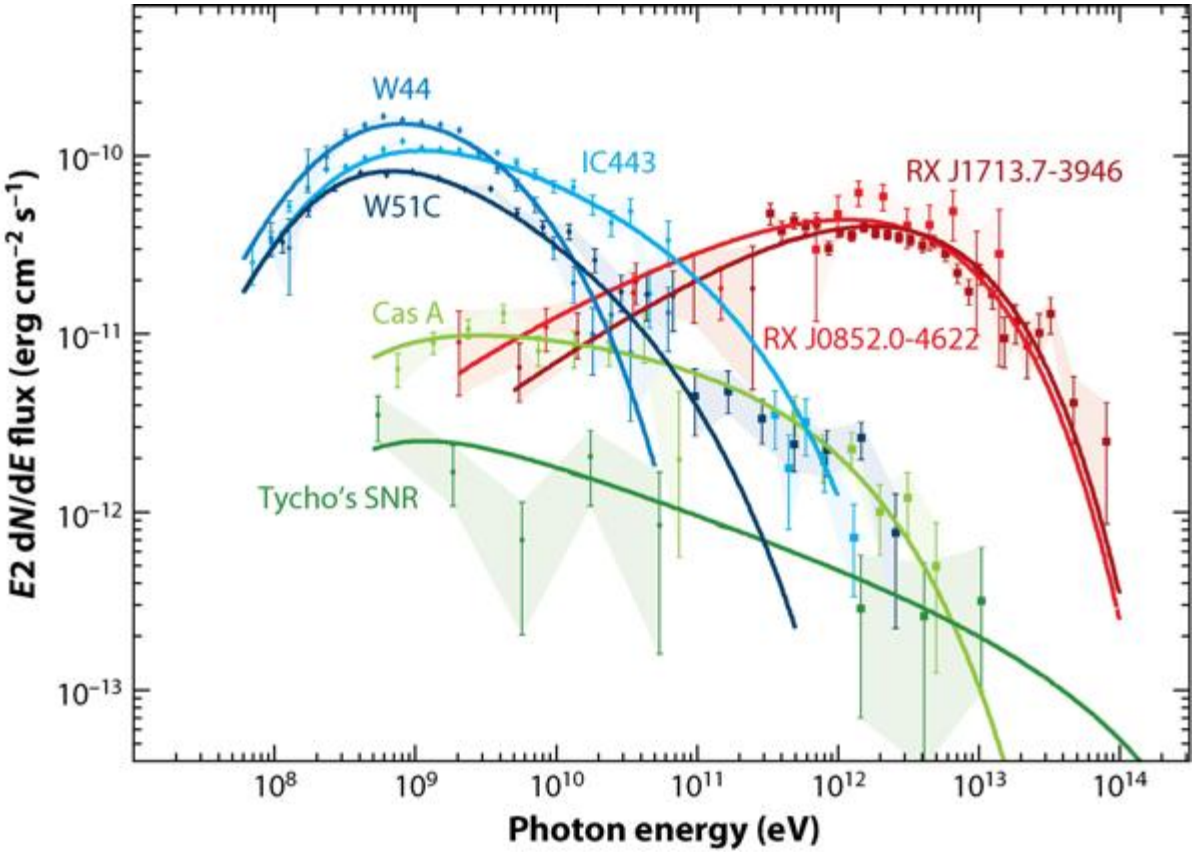
# FERMI


γ
Anticoincidence shield
Conversion foils
Particle tracking
Calorimeter
e+
e−

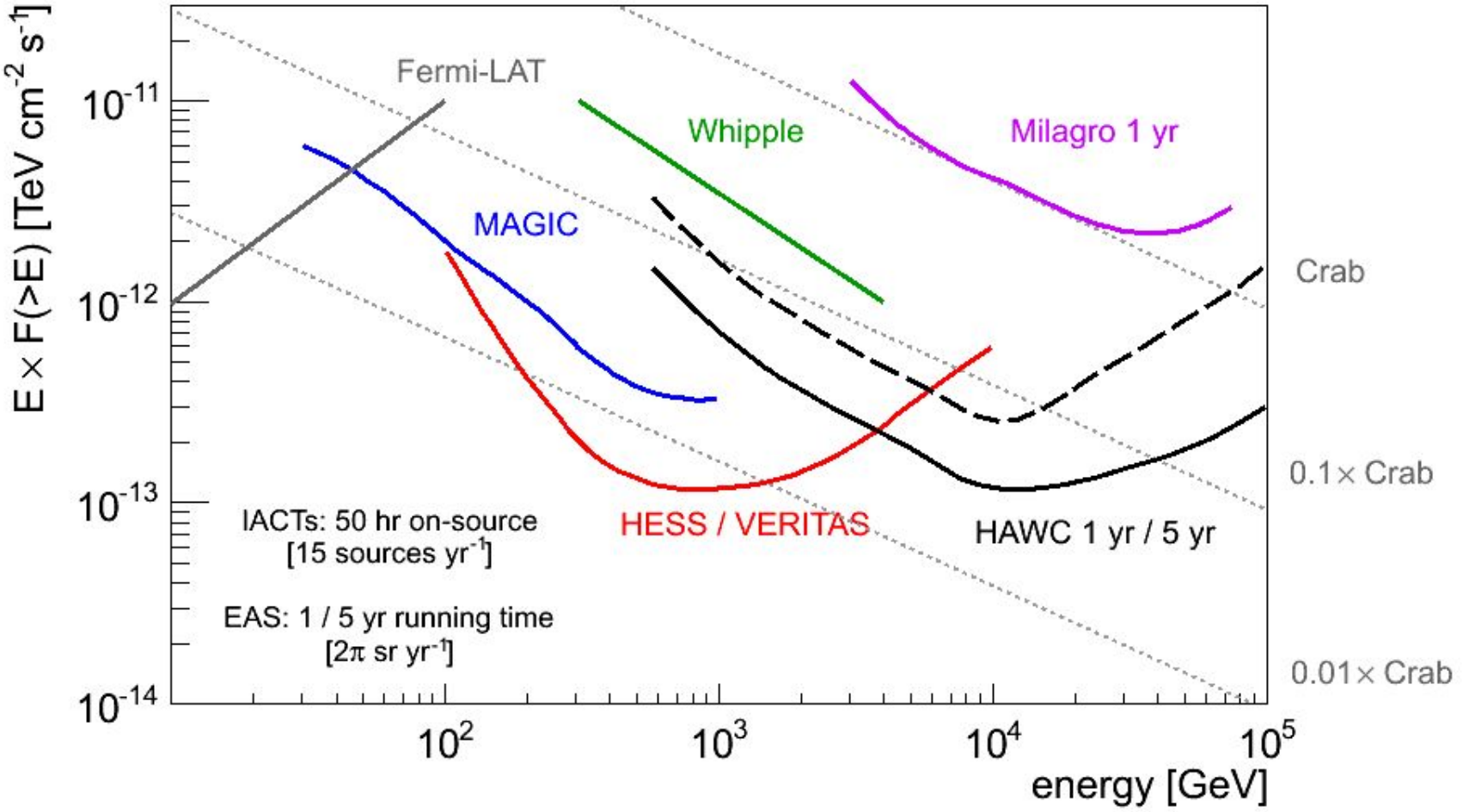

CDE: CsI Detectors +PIN diodes (both ends)
Carbon Cell Array
Al Cell Closeout
Readout Electronics
Al EMI Shield


What has Fermi found: The LAT two-year catalog
Supernova remnants 4%
Pulsars 6%
Globular clusters, high-mass binaries, normal galaxies and more 1%
Non-blazar active galaxies 1%
Unknown 31%
Blazars 57%
Credit: NASA/Goddard Space Flight Center

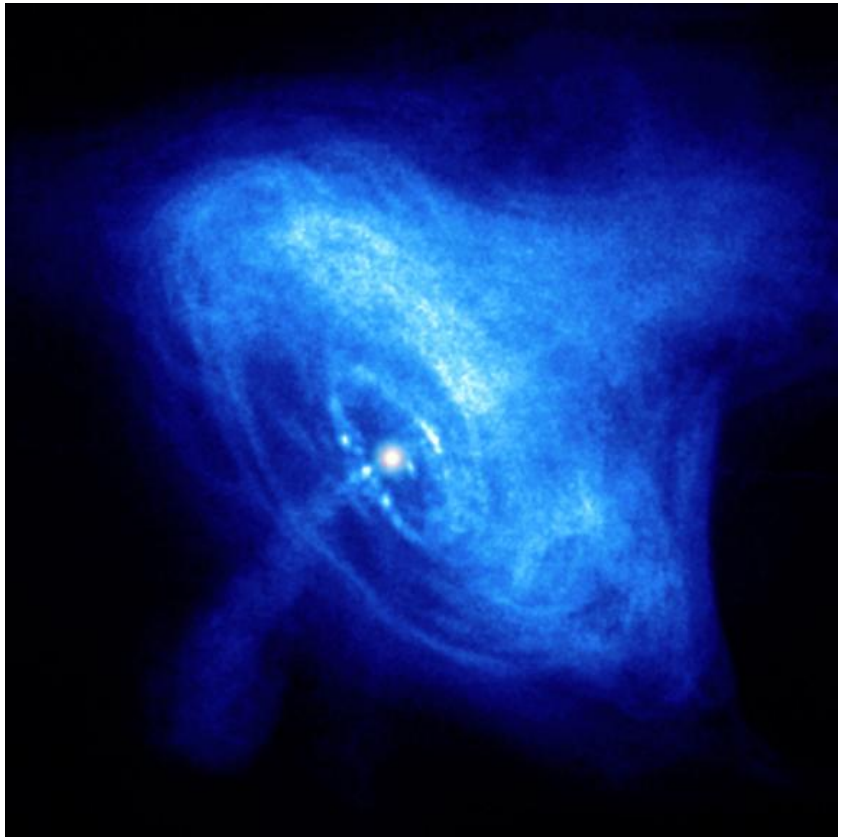

γ
1.8 m
1.0 m



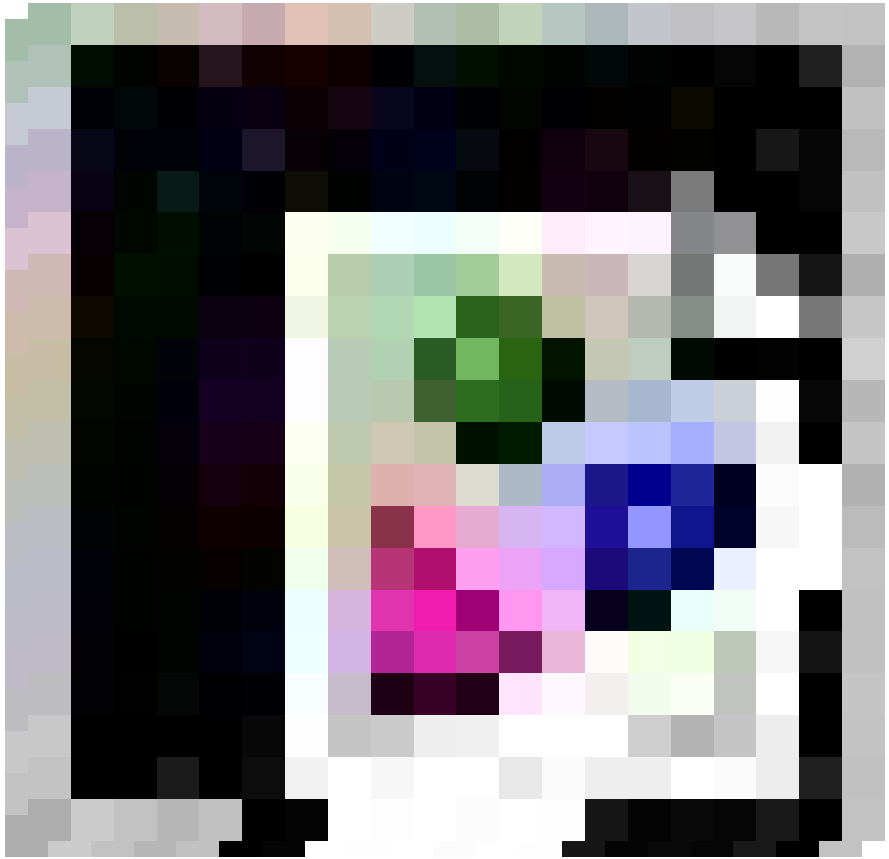

Funk S. 2015.
Annu. Rev. Nucl. Part. Sci. 65:245–77

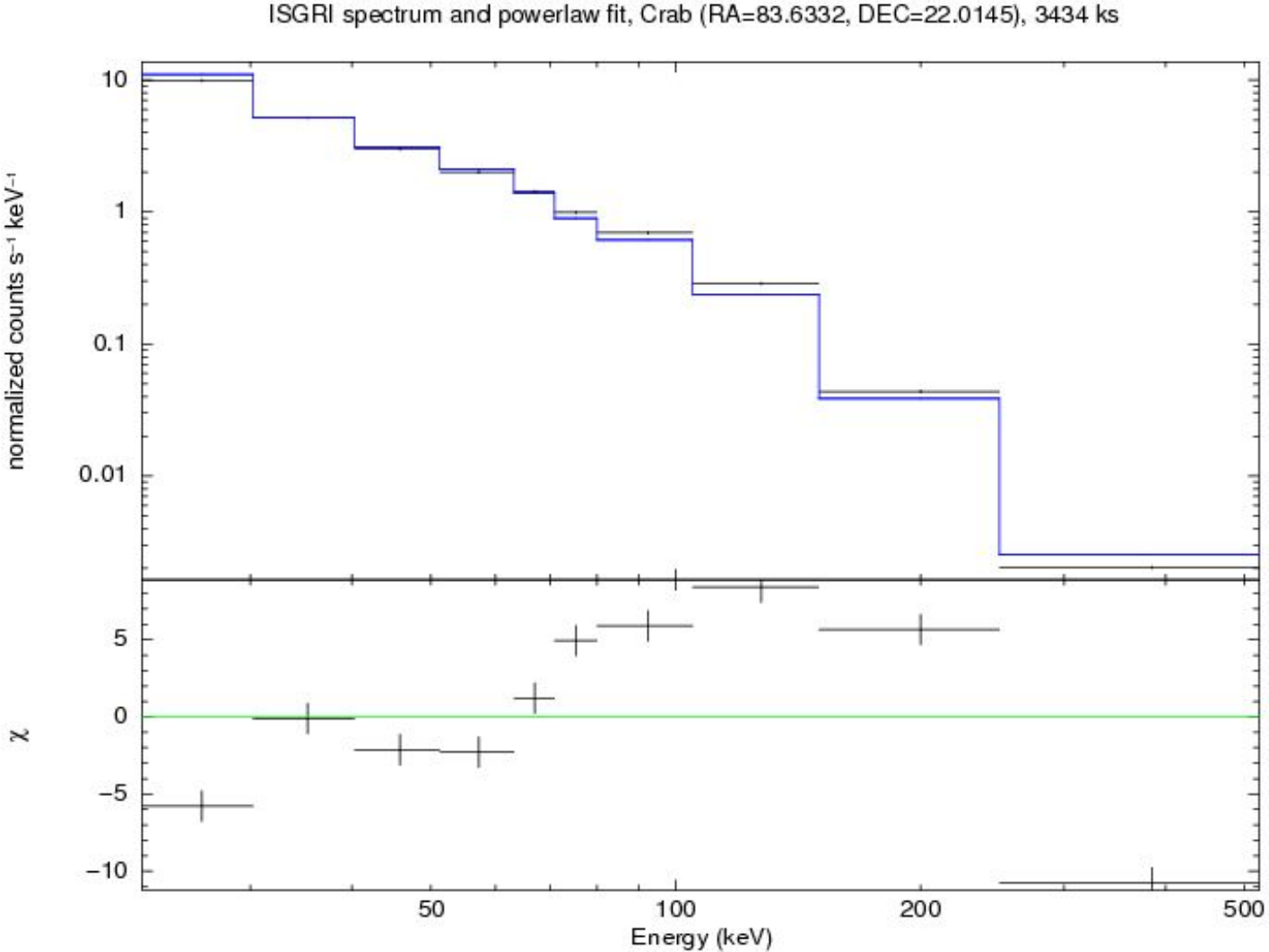

Fermi-LAT
Whipple
Milagro 1 yr
MAGIC
Crab
0.1× Crab
0.01× Crab
IACTs: 50 hr on-source
[15 sources yr⁻¹]
HESS / VERITAS
HAWC 1 yr / 5 yr
EAS: 1 / 5 yr running time
[2π sr yr⁻¹]
E × F(>E) [TeV cm⁻² s⁻¹]
10⁻¹¹
10⁻¹²
10⁻¹³
10⁻¹⁴
10²
10³
10⁴
10⁵
energy [GeV]

CHANDRA



INTEGRAL / IBIS




ISGRI spectrum and powerlaw fit, Crab (RA=83.6332, DEC=22.0145), 3434 ks
normalized counts s⁻¹ keV⁻¹
10
1
0.1
0.01
χ
5
0
−5
−10
50
100
200
500
Energy (keV)

# Úlohy na workshop

Táto prednáška -> Workshop 0
**Workshop 1 -- 3 hod**
Chandra: CIAO, DS9, Fv: zložíme si pár “farebných” obrázkov
Crab, Cas A, M82, Centaurus A

**Workshop 2 -- 3 hod**
XMM-Newton: SAS, DS9: zložíme si zase obrázky a budeme robiť spektrá
Crab, Centaurus A, M82, BL-Lac

**Workshop 3 -- 3 hod**
INTEGRAL IBIS: OSA, zložíme obrázky a spektrá, Python (astropy)
Crab, BL-Lac, Cygnus X-1

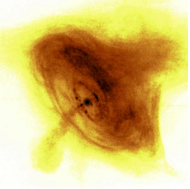
**Workshop 4 -- 3 hod**
Fermi, skúsime analýzu pár jasných zdrojov a spraviť spektrum, toto je žial dosť výpočetne náročne.

**Workshop 5++**
**……...**

# Workshop 5++

Vyriešiť zložitejší problém, buď zopakovať jednu z už existujúcich prác a napasovať na iný objekt, alebo urobiť niečo úplne nové …

- **Super-Eddington Mechanical Power of an Accreting Black Hole in M83**
  Soria et. al. Science Vol 343 2014
- **Klasifikácia X-ray zdrojov v M82, alebo Centaurus A**
- **Pulsary v 47 Tuc**
- **Hmotnosť kompaktných objektov v HMXB alebo LMXB ?**
- **Čokoľvek iné čo nás napadne … a bude to zaujímavé.**



# Na záver, alebo Q/A session

Čo vám účasť na workshop-och prinesie:

- Nové poznatky a zbehlosť v redukcií dát
- Linux skills, bash, python, git
- Prácu s reálnymi dátami a reálnymi nástrojmi
- FUN

Podmienky účasti:

- Schopnosť odpísať na email
- Linux na notebooku (virtuálka je ok)

Postup:

- Napíšte na:

**kocka.mat@gmail.com**

- **Predmet: STU astro workshop**
- Raz za ~2 týždne sa stretneme, dátum upresníme pomocou Doodle.

**Ďakujem za pozornosť ...**