Kozmičke gama-zrake

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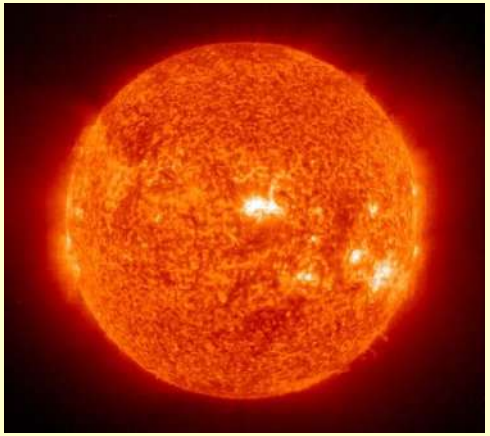
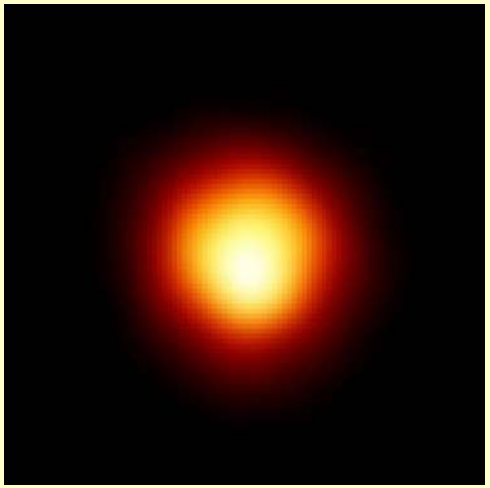
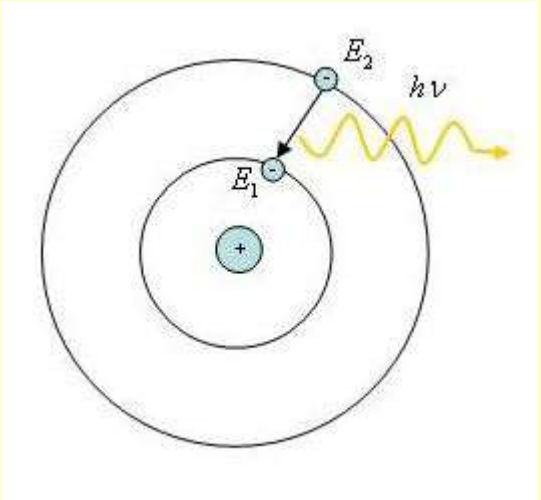
(I) što je svjetlost
(II) što su gama-zrake
(III) izvori kozmičkih gama-zraka
(IV) opažanje kozmičkih gama-zraka

Svjetlost: vidljiva svjetlost

- nastanak: atomski prijelazi...

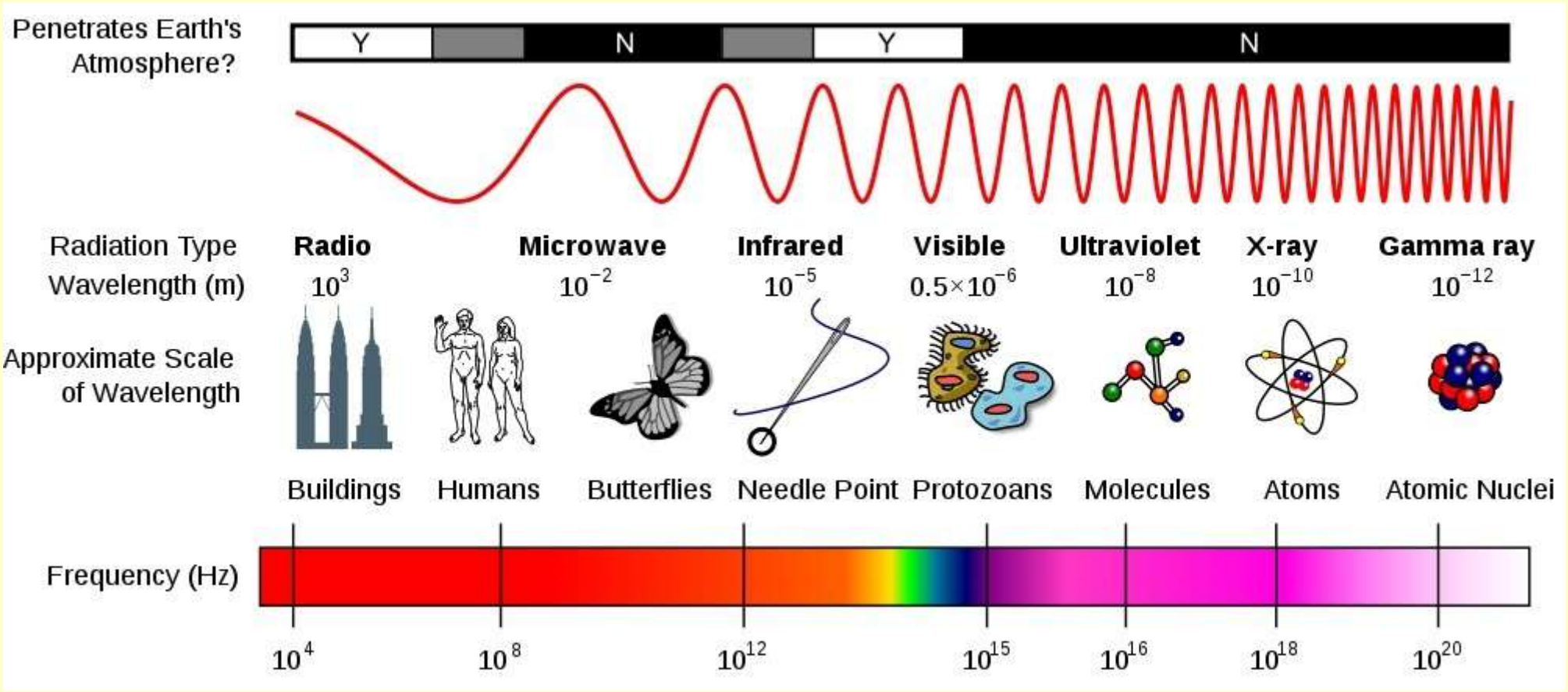






Svjetlost: druge “svjetlosti”

- elektromagnetski spektar
- druge “svjetlosti” nevidljive oku, ali opazive instrumentima



Svjetlost: fizikalni opis

- dvojna priroda svjetlosti: **čestica** (foton) i EM **val**

$$E = h\nu = \frac{hc}{\lambda}$$

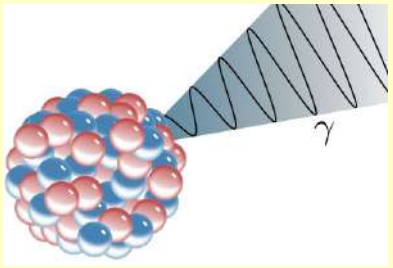
Svjetlost: područja

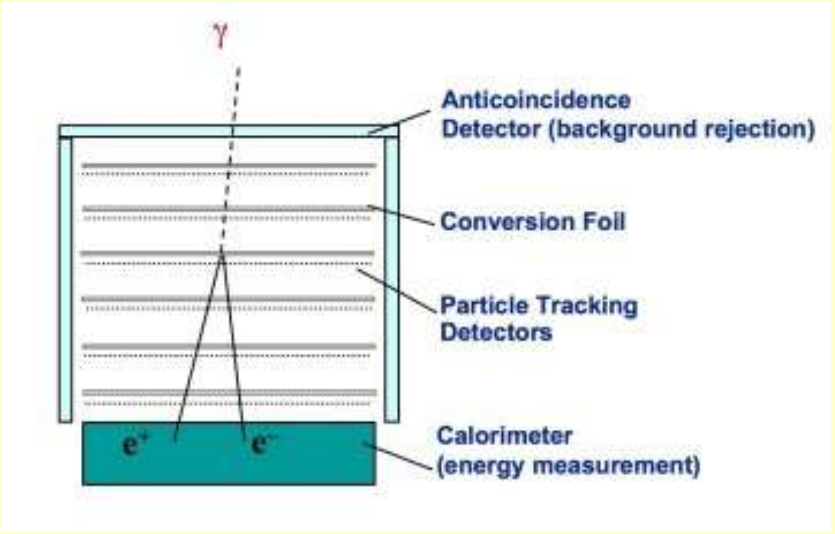
Region	Energy	Wavelength
γ-ray	**$E > 100$ keV** Precisely, $E > m_e c^2 = 511$ keV	**$\lambda < 1$ pm** Precisely, $\lambda < \lambda^e_{\mathrm{COMPTON}} = 2.43$ pm
X-ray	$100\ \mathrm{eV} < E < 100\ \mathrm{keV}$	$1\ \mathrm{pm} < \lambda < 10\ \mathrm{nm}$
ultraviolet	$10\ \mathrm{eV} < E < 100\ \mathrm{eV}$	$10\ \mathrm{nm} < \lambda < 100\ \mathrm{nm}$
visible	$1\ \mathrm{eV} < E < 10\ \mathrm{eV}$ Precisely, $1.7\ \mathrm{eV} < E < 3.2\ \mathrm{eV}$	$100\ \mathrm{nm} < \lambda < 1\ \mu\mathrm{m}$ Precisely, $380\ \mathrm{nm} < \lambda < 750\ \mathrm{nm}$
infrared	$1\ \mathrm{meV} < E < 1\ \mathrm{eV}$	$1\ \mu\mathrm{m} < \lambda < 1\ \mathrm{mm}$
microwave	$0.1\ \mu\mathrm{eV} < E < 1\ \mathrm{meV}$	$1\ \mathrm{mm} < \lambda < 10\ \mathrm{cm}$
radio	$E < 0.1\ \mu\mathrm{eV}$	$\lambda > 10\ \mathrm{cm}$

Region	Energy
LE/ME	$100\ \mathrm{keV} < E < 100\ \mathrm{MeV}$
HE	$100\ \mathrm{MeV} < E < 100\ \mathrm{GeV}$
VHE	**$100\ \mathrm{GeV} < E < 100\ \mathrm{TeV}$**
UHE	$100\ \mathrm{TeV} < E < 100\ \mathrm{PeV}$
EHE	$E > 100\ \mathrm{PeV}$

Gama-zrake: niže energije

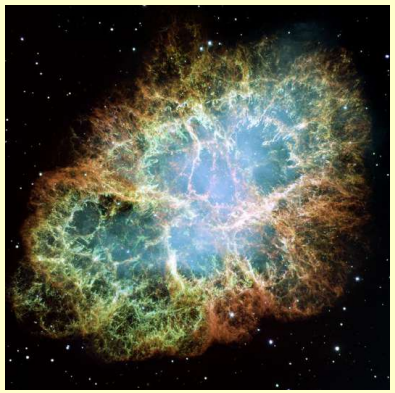
- od 100 keV do 100 MeV
- zemaljski izvori
- laboratorijski detektori





Gama-zrake: srednje energije

- od 100 MeV do 100 GeV
- kozmički izvori
- satelitski detektori

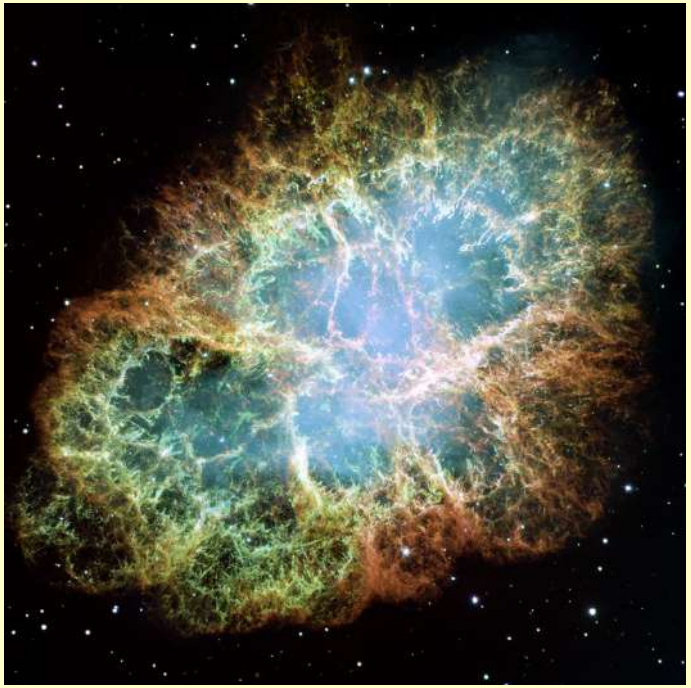


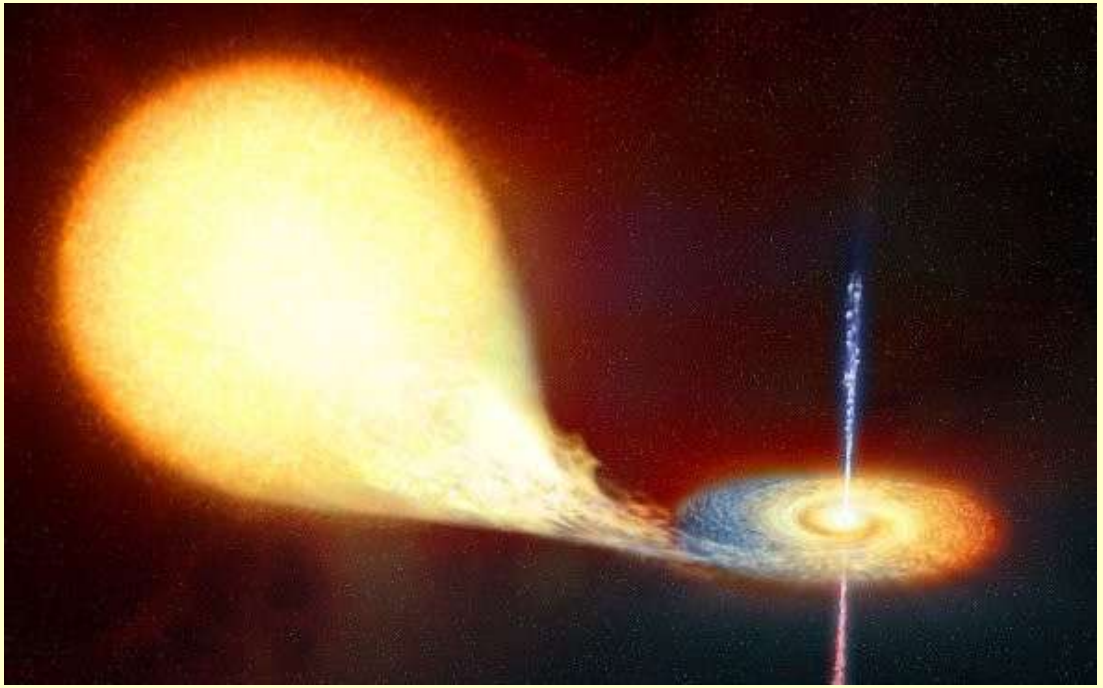
Gama-zrake: više energije

- od 100 GeV do 100 TeV
- kozmički izvori
- zemaljski teleskopi

Izvori kozmičkih gama-zraka: galaktički

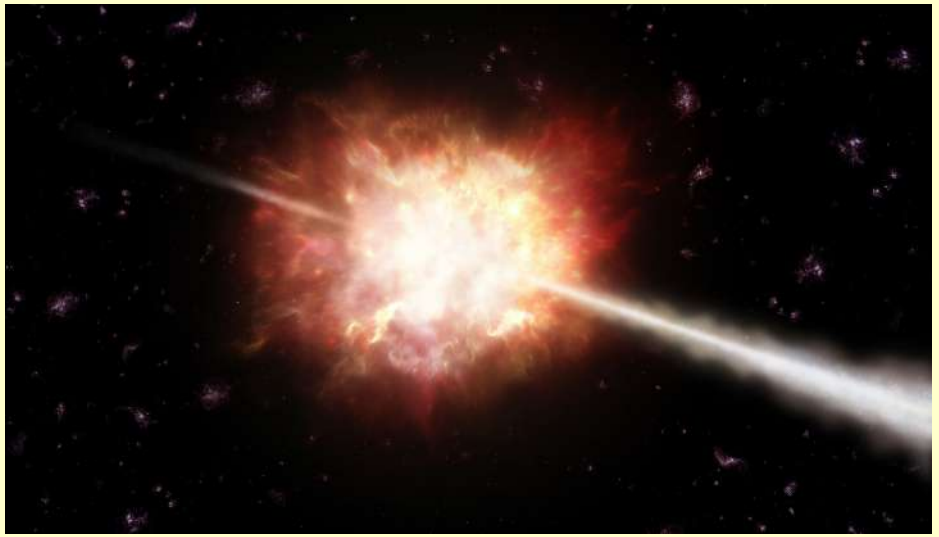
- ostaci supernova
- mikrokvazari





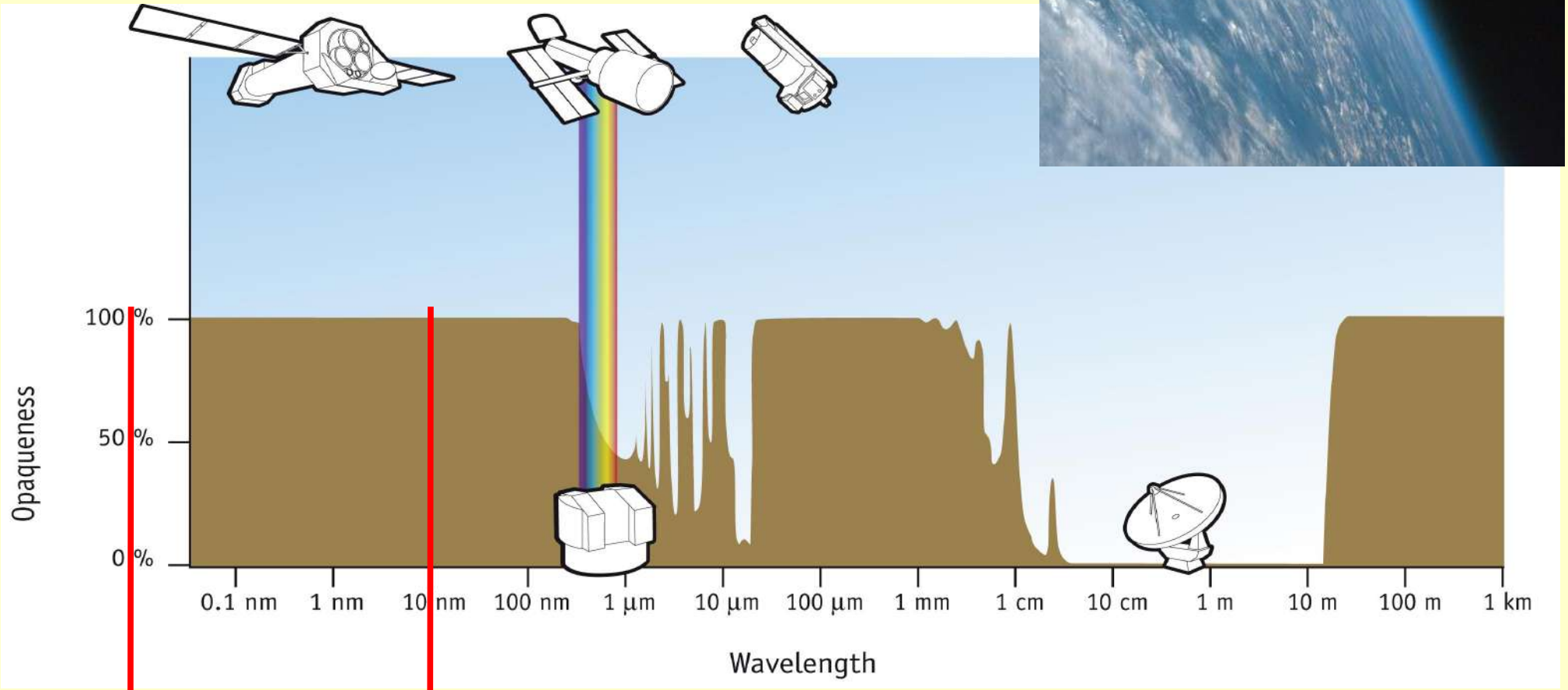
Izvori kozmičkih gama-zraka: izvangalaktički

- aktivne galaktičke jezgre (AGN)
- provale gama-zraka (GRB)



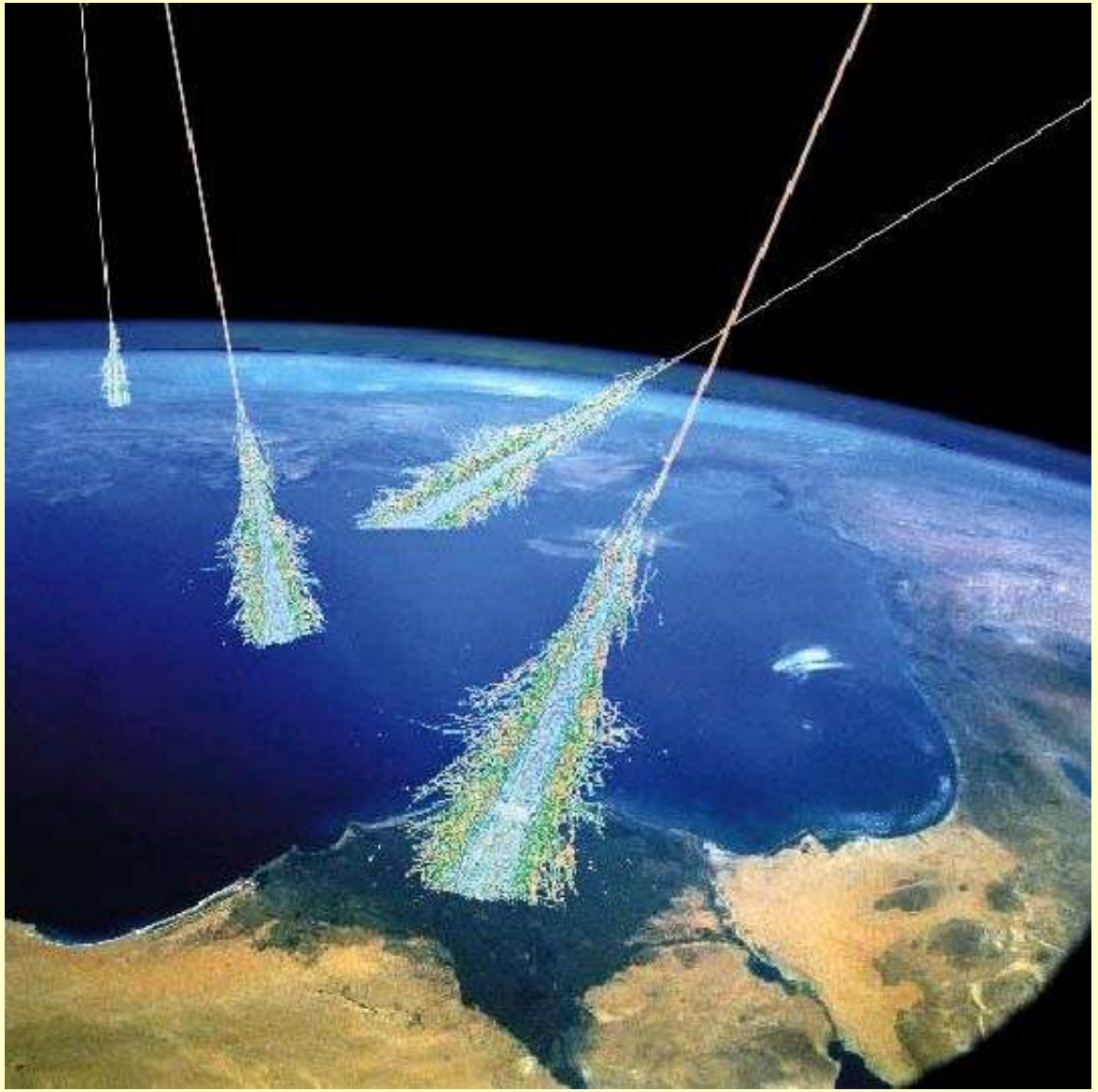
Opažanje: problem transparentnosti

- selektivna transparentnost atmosfere
- različiti detektori za različita područja

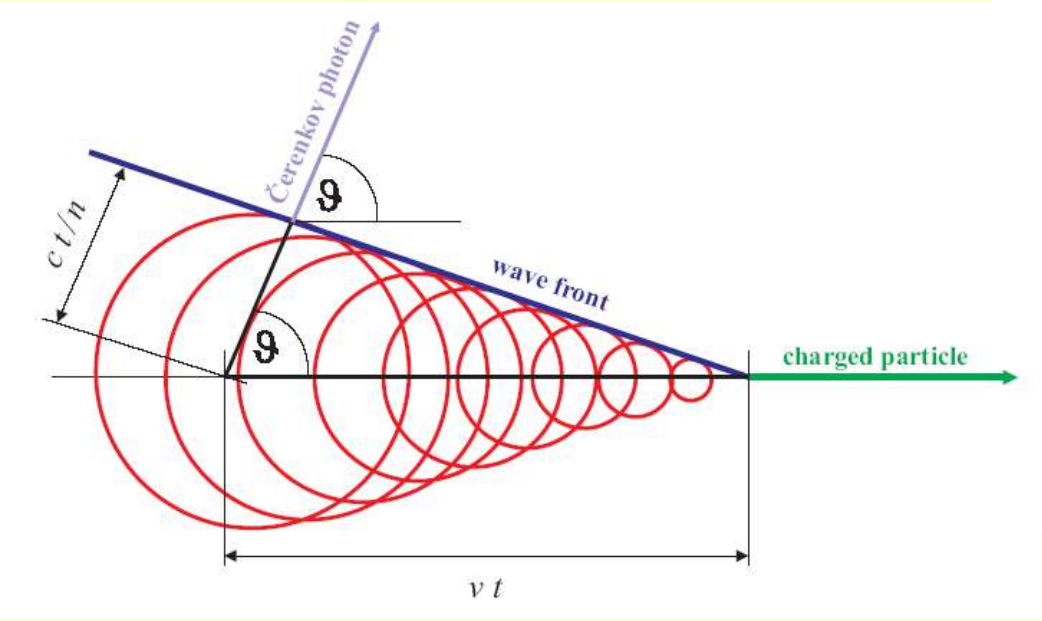


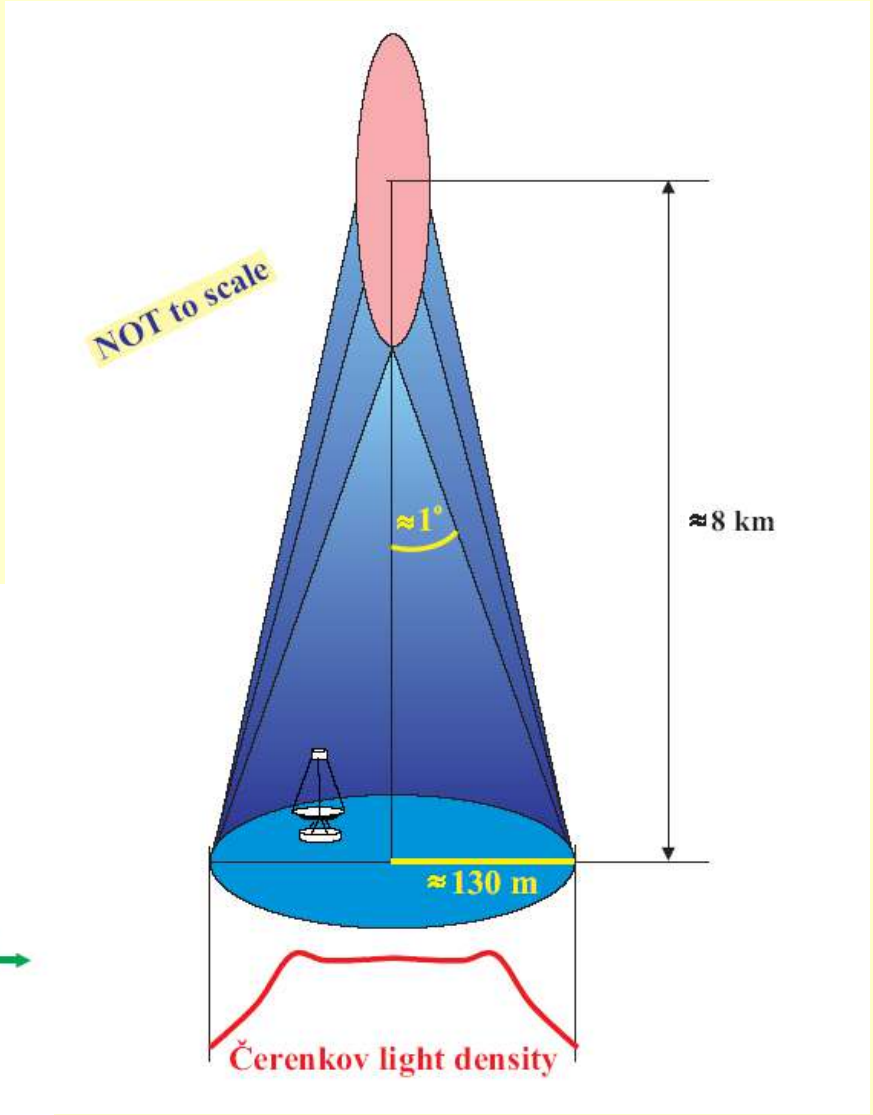
γ X UV

Opažanje: pljuskovi čestica u atmosferi



Opažanje: Čerenkovljeva tehnika





Opažanje: Čerenkovljevi teleskopi

- MAGIC, VERITAS, H.E.S.S.

Opažanje: teleskopi MAGIC

- Major Atmospheric Gamma-ray Imaging Cherenkov Telescope
- La Palma, Kanarski otoci
- promjer 17 m
- 40 t
- 10 M€
- 50 GeV do 30 TeV