Searches for High-Energy Neutrino Emission from GRBs with ANTARES

June 23, 2015

Julia Schmid @ SAp, CEA Saclay
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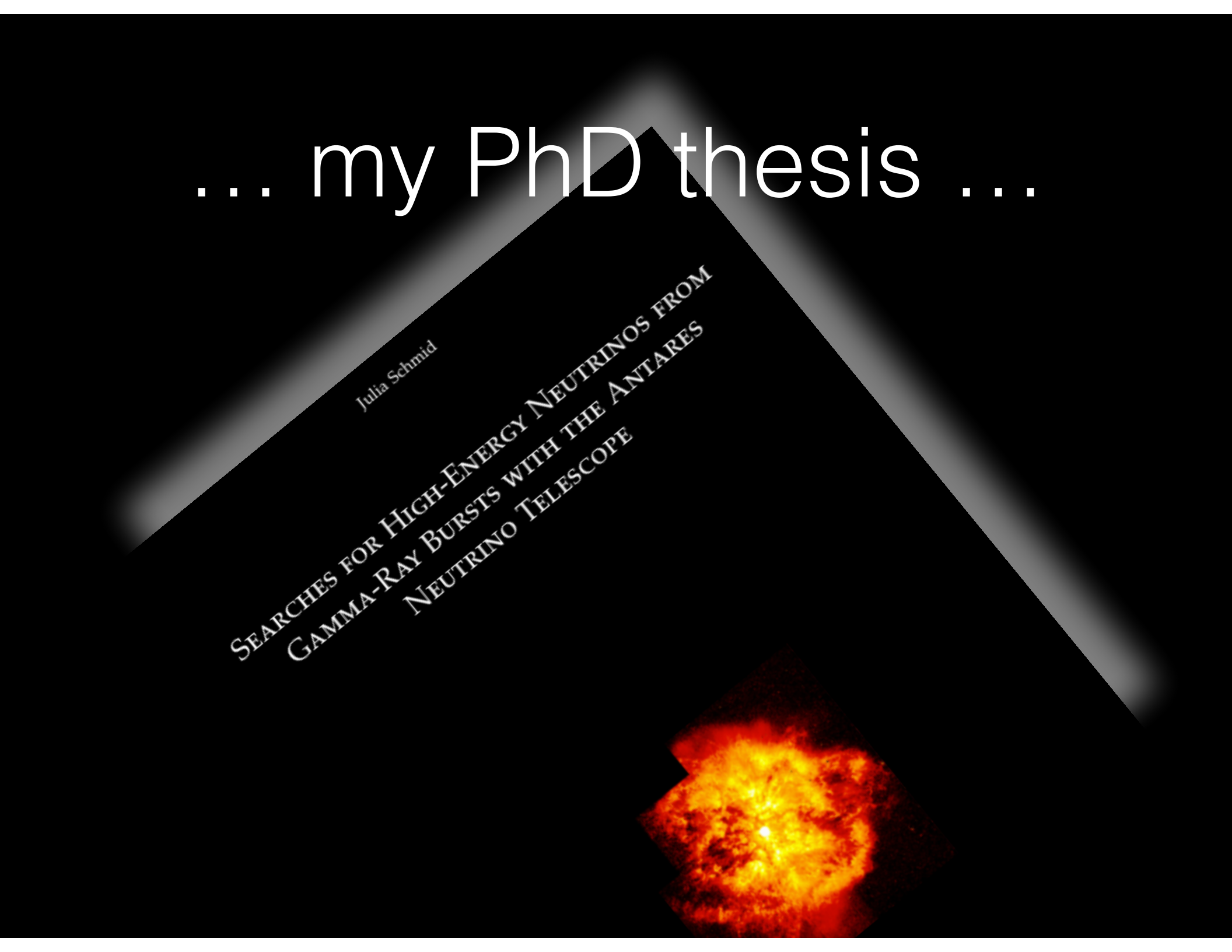
Orme des Merisiers
91191 Gif sur Yvette

At a glance…

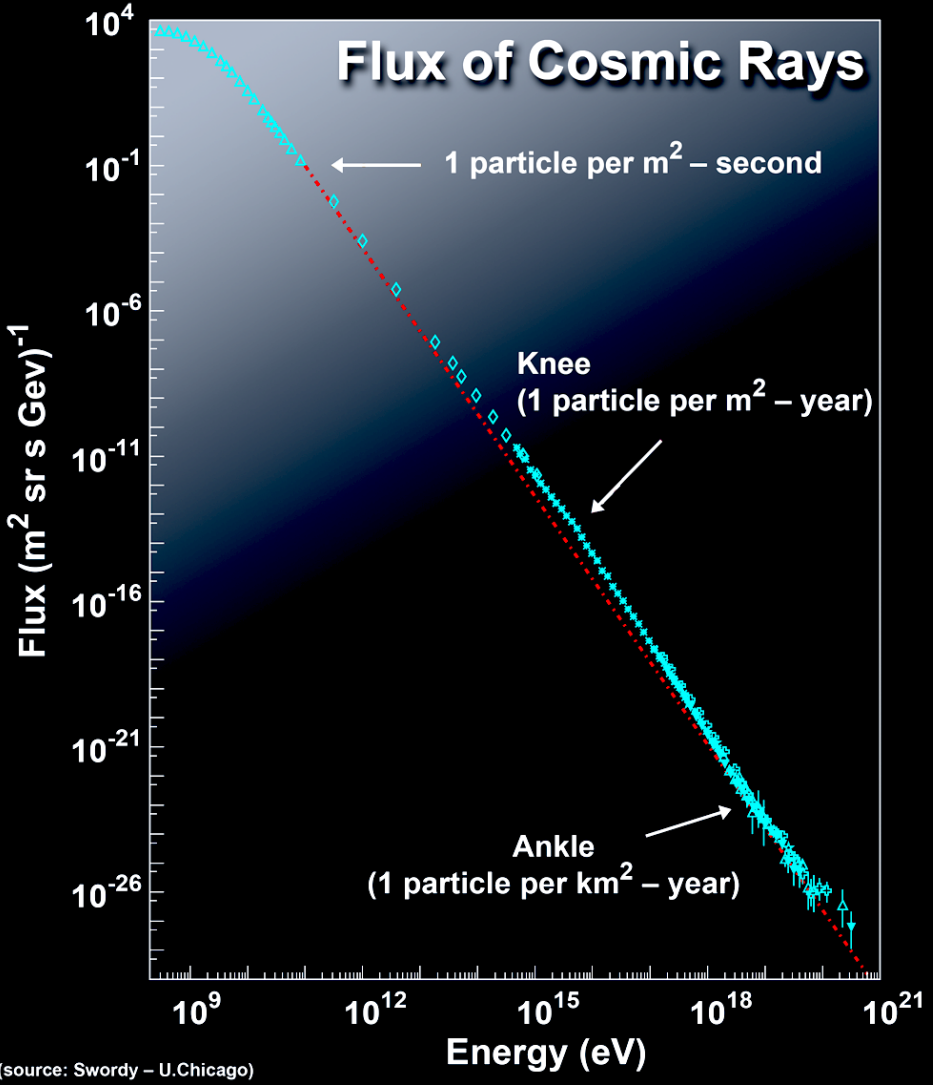
- studies & PhD in Erlangen (ECAP = Erlangen Center for Astroparticle Physics) —> Neutrino Telescope ANTARES
- 1st PostDoc: CEA Saclay w/ Jean Ballet, Fermi-LAT

… my PhD thesis …

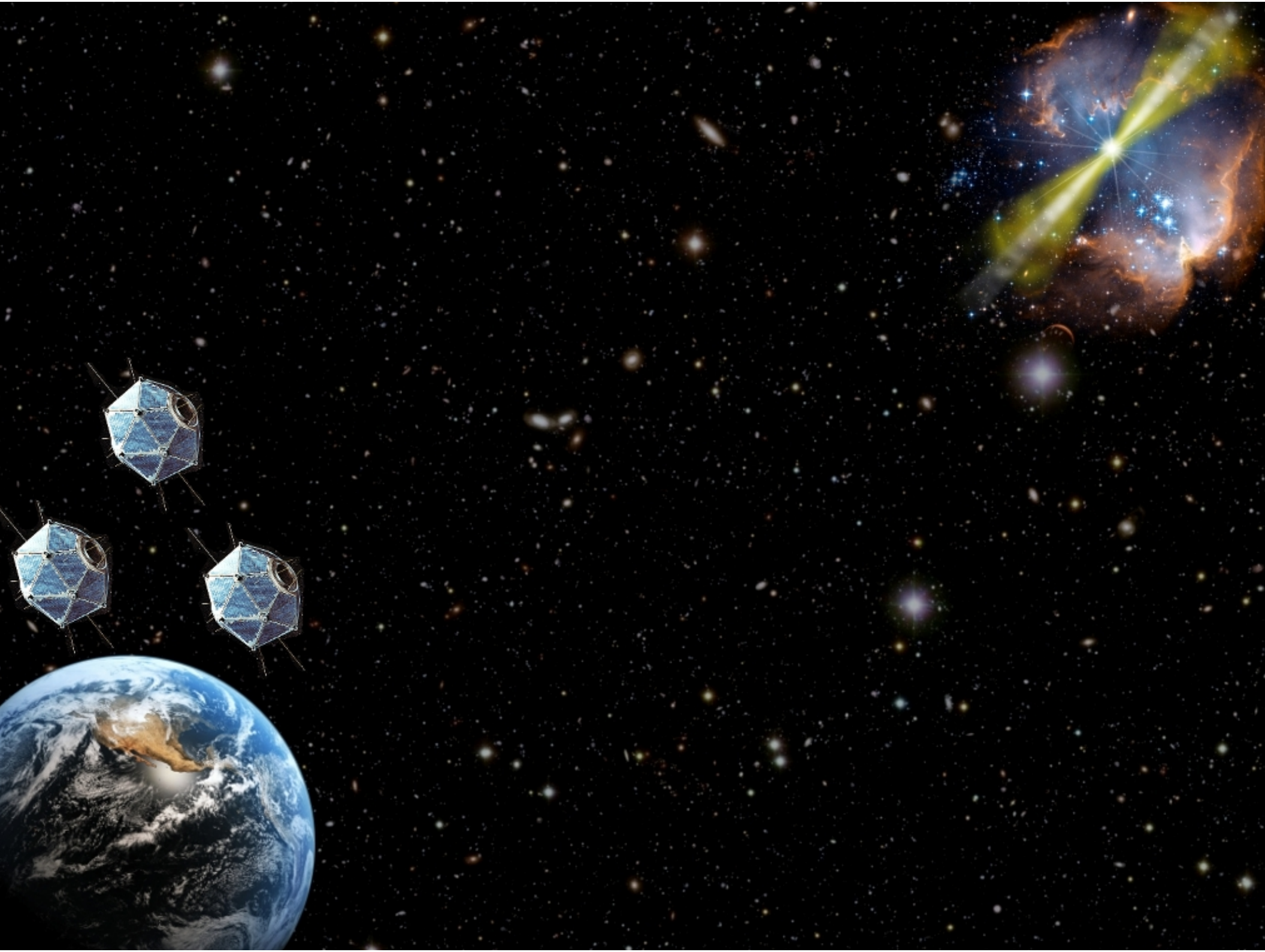


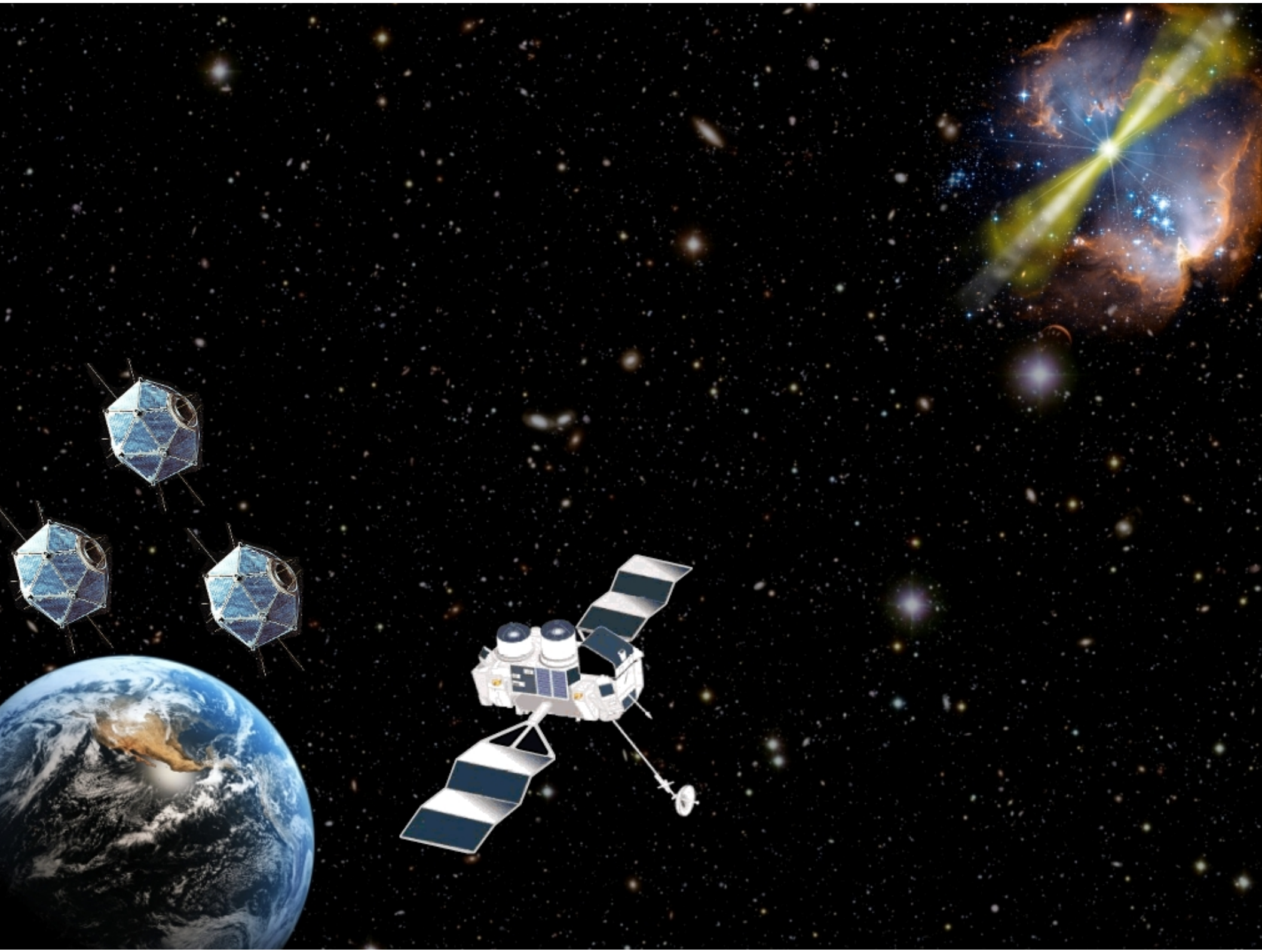
why cosmic neutrinos?

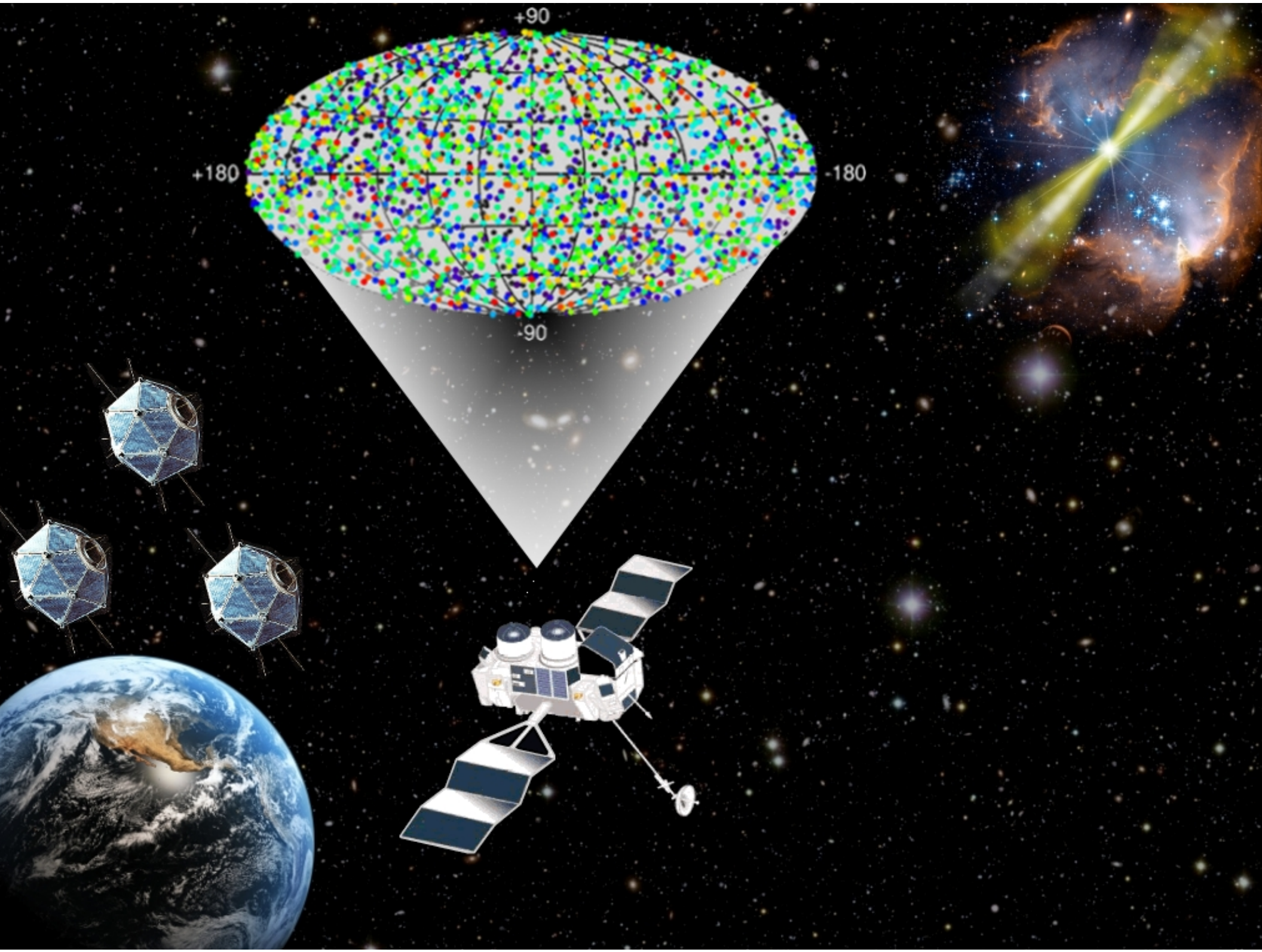
(American Physical Society)

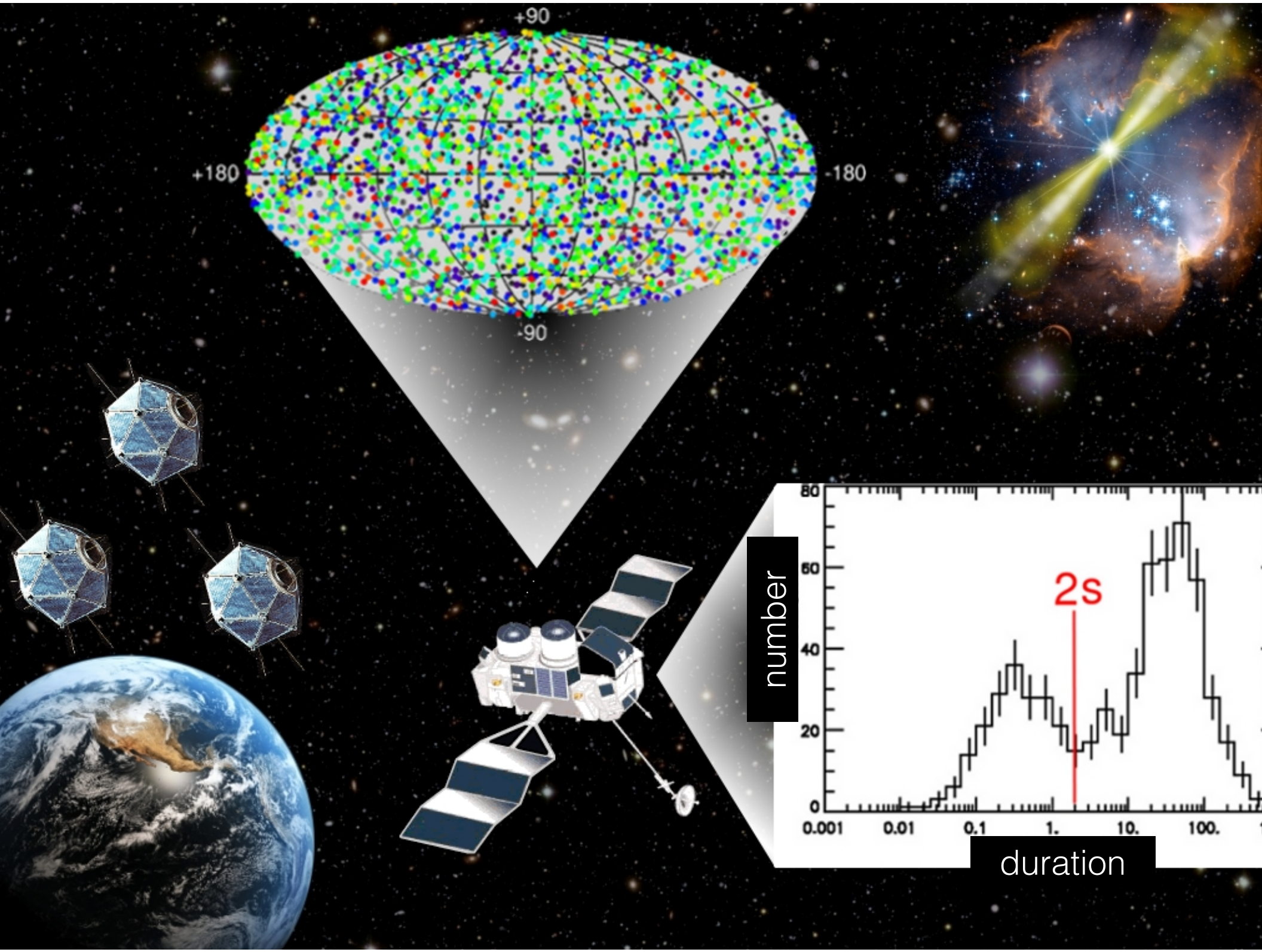


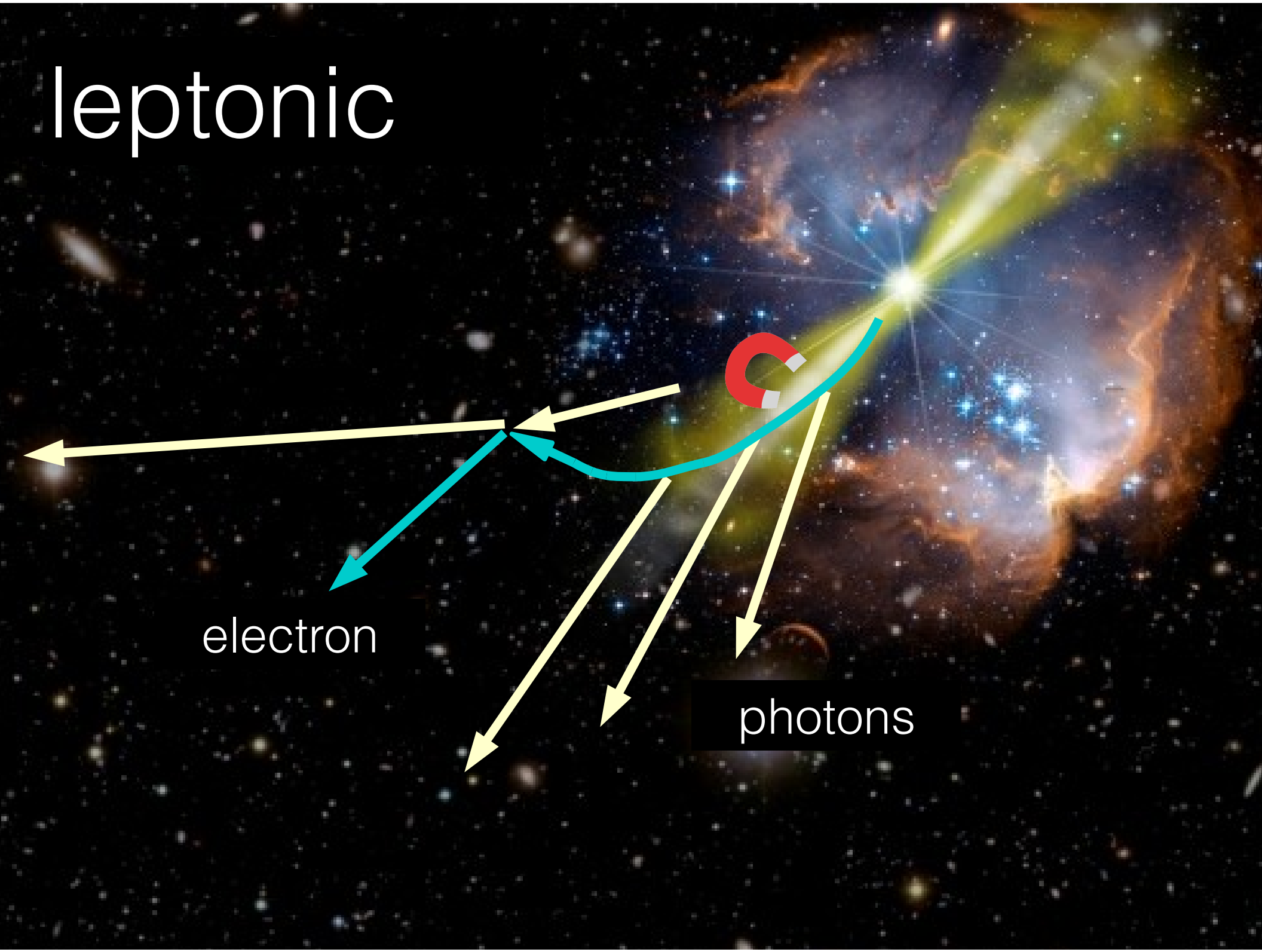
(source: Swordy – U.Chicago)

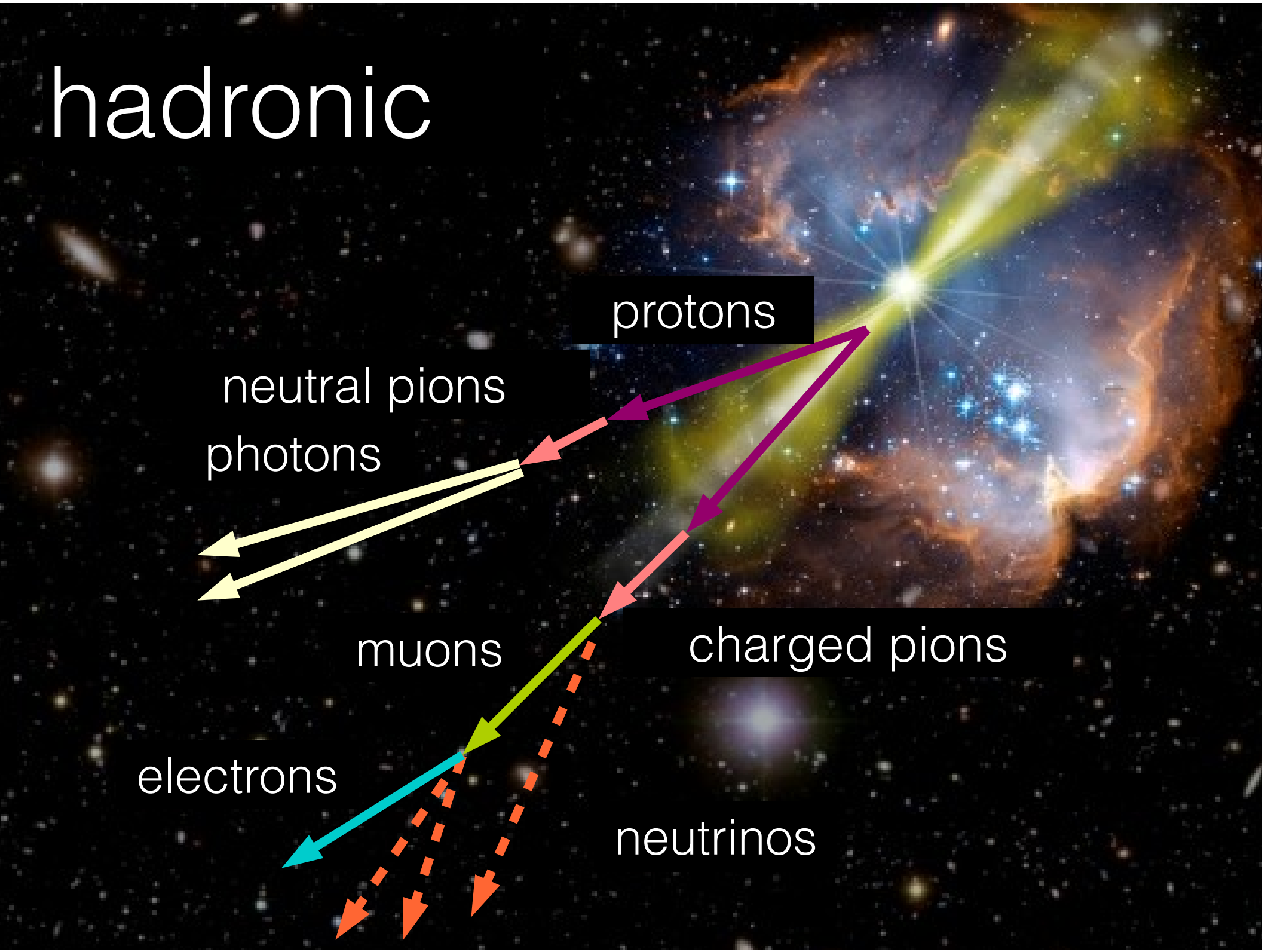


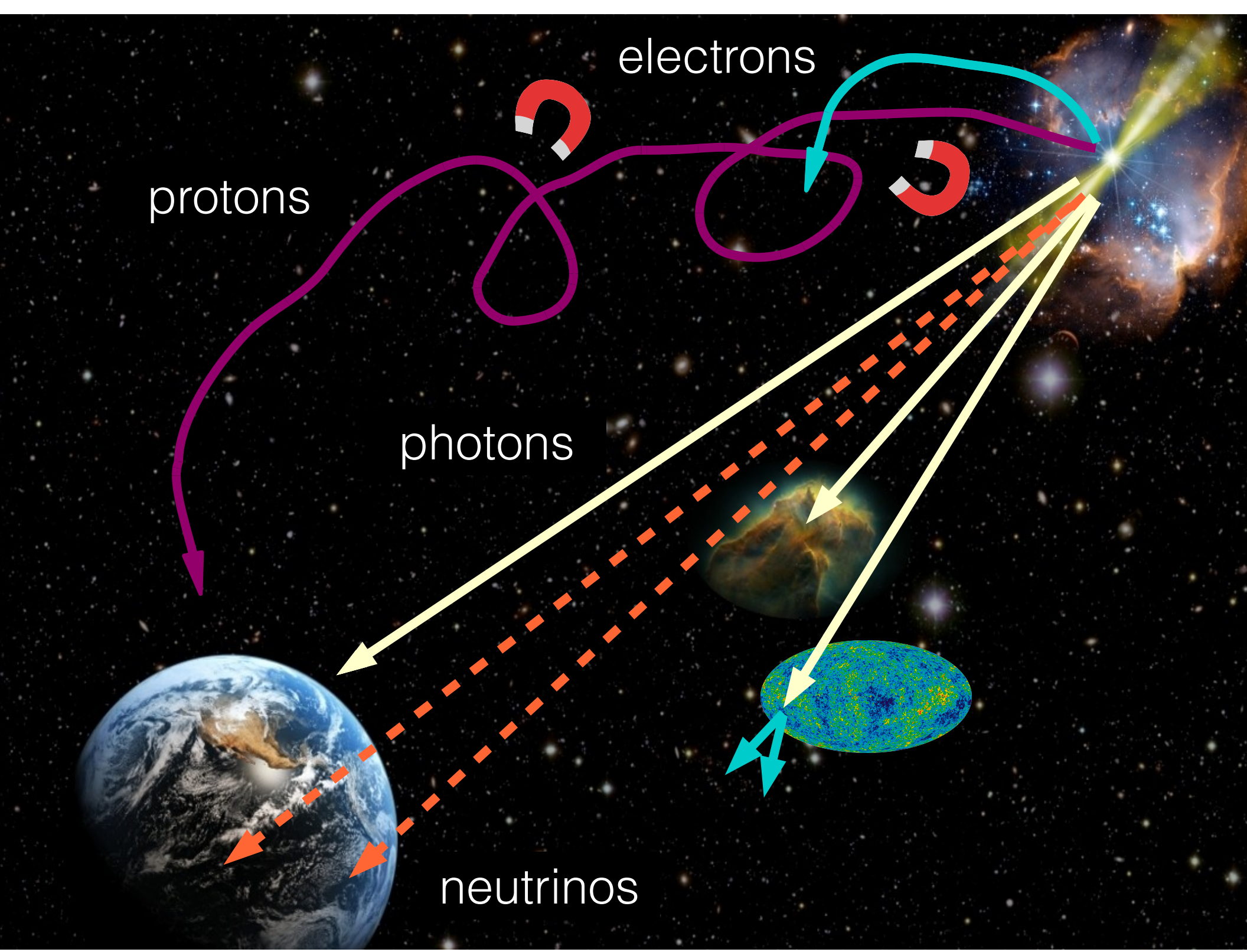


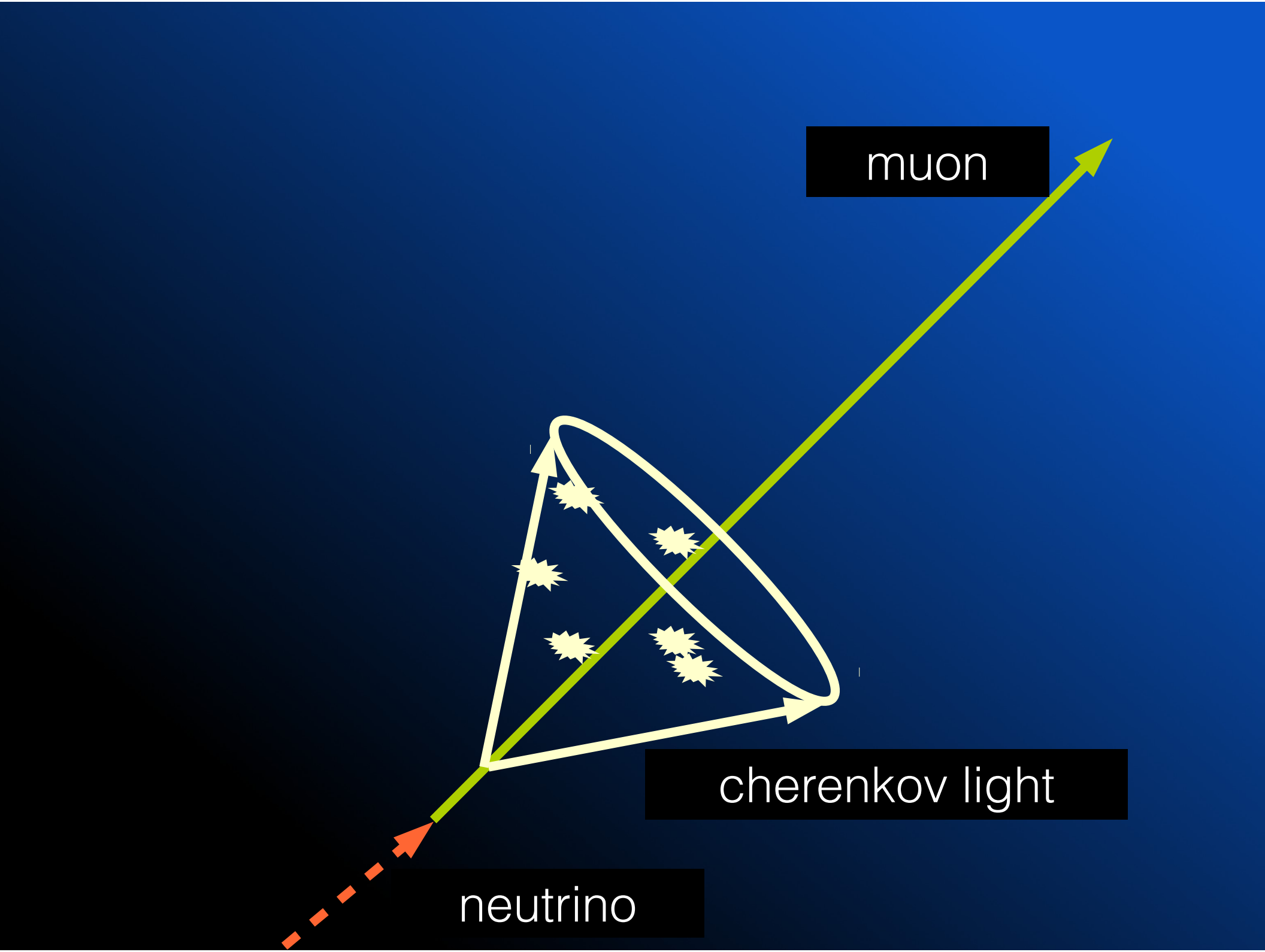

+90
+180
-180
-90

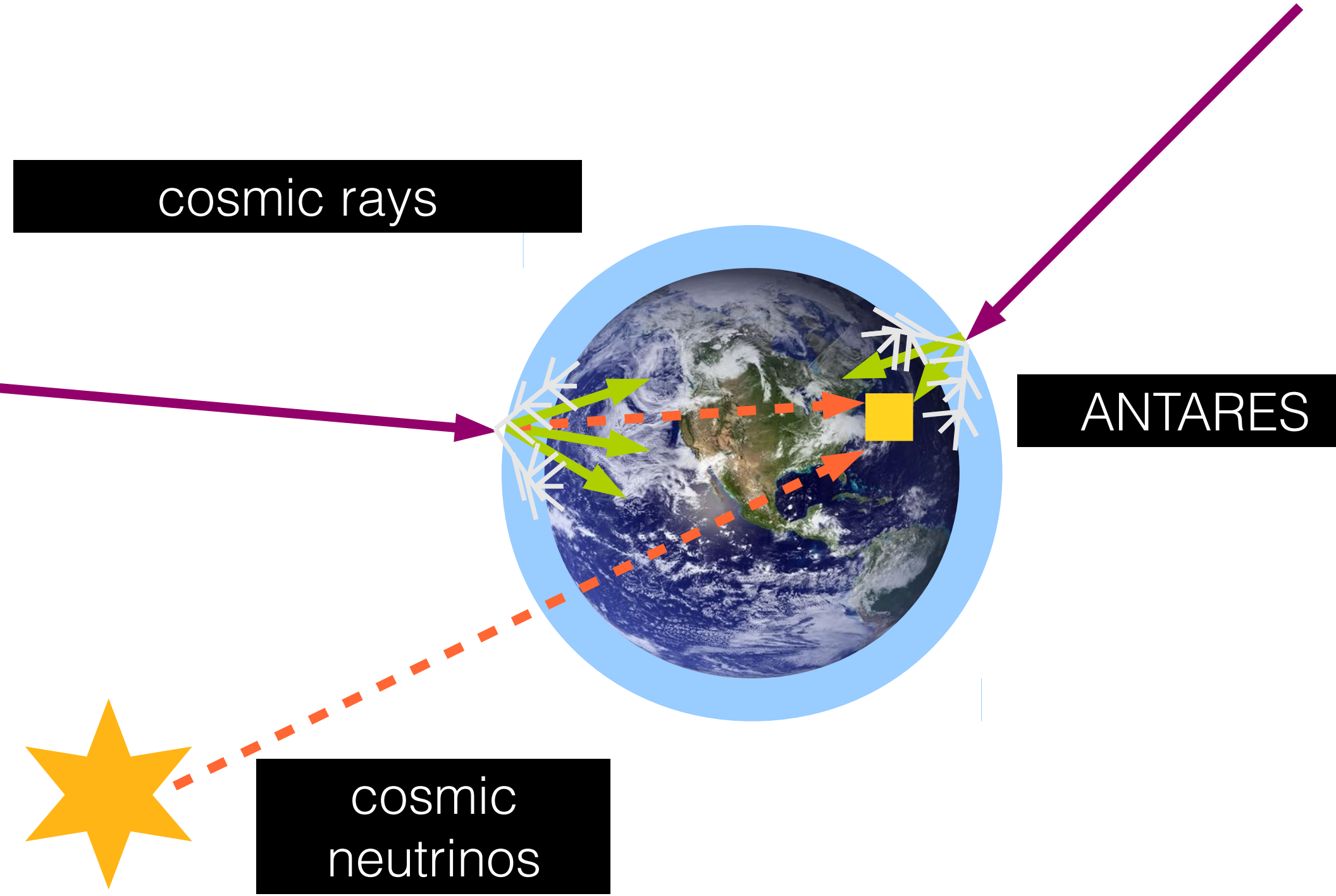

+90
+180
-180
-90
number
2s
80
60
40
20
0
0.001
0.01
0.1
1.
10.
100.
duration

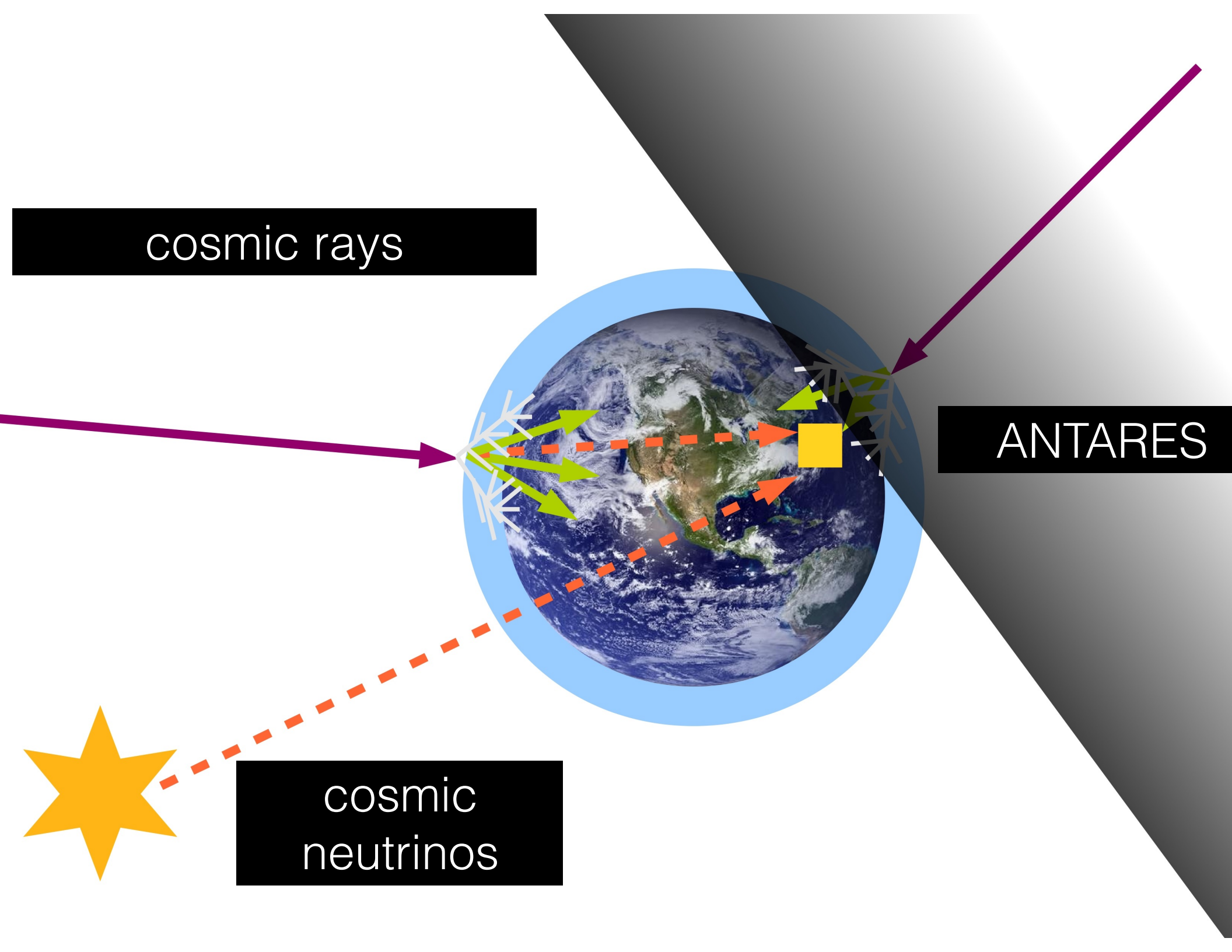

leptonic
electron
photons


hadronic
protons
neutral pions
photons
muons
charged pions
electrons
neutrinos


electrons
protons
photons
neutrinos


muon
cherenkov light
neutrino


cosmic rays
ANTARES
cosmic
neutrinos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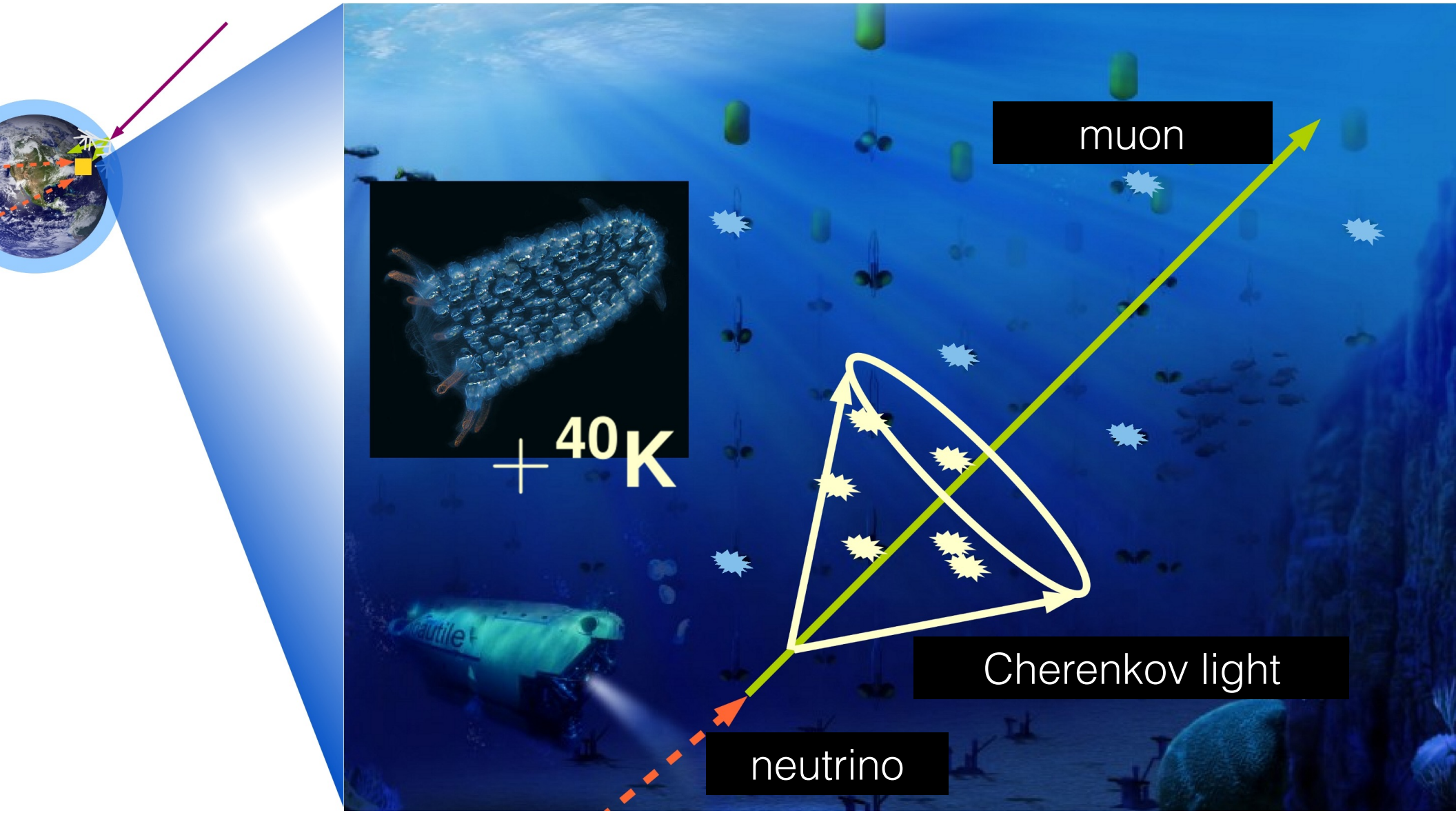
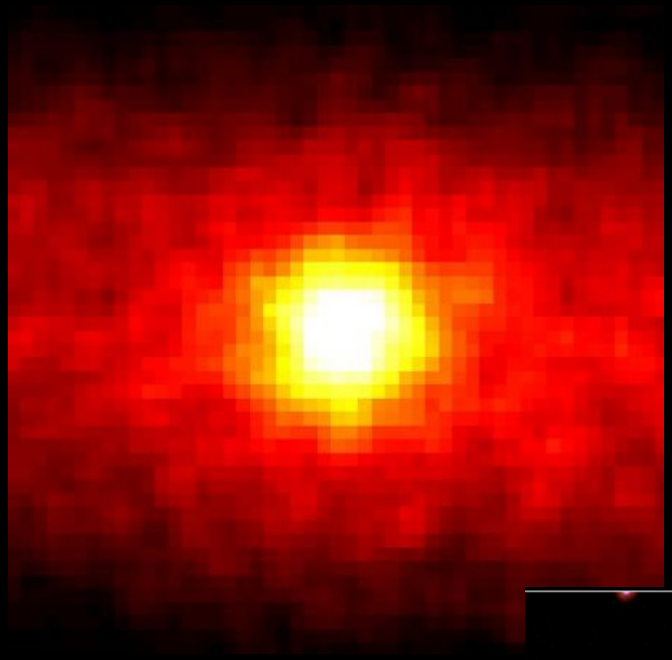
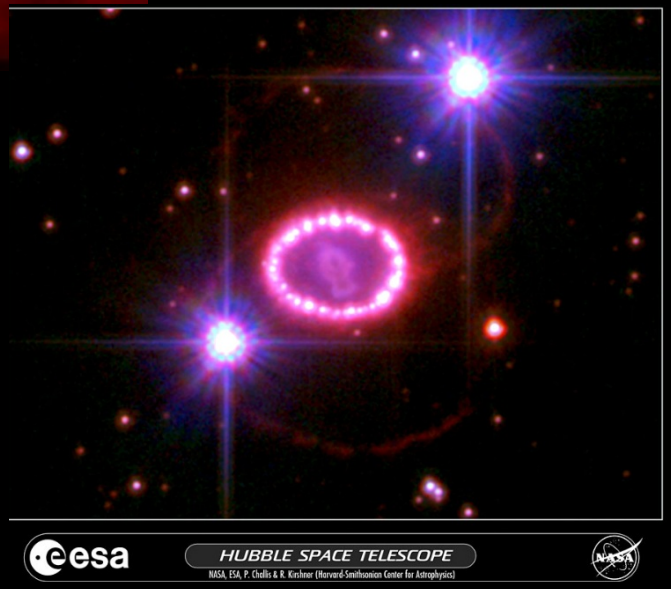
ANTARES
cosmic
neutrinos


muon
+ 40K
Cherenkov light
neutrino

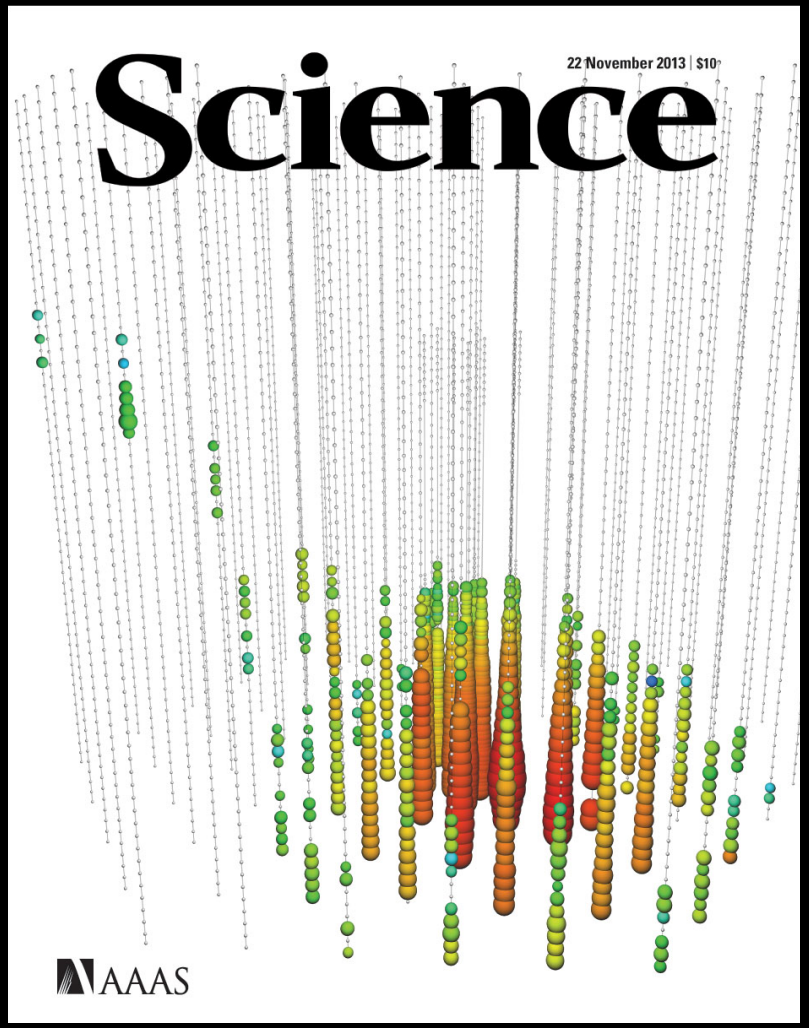


Sun



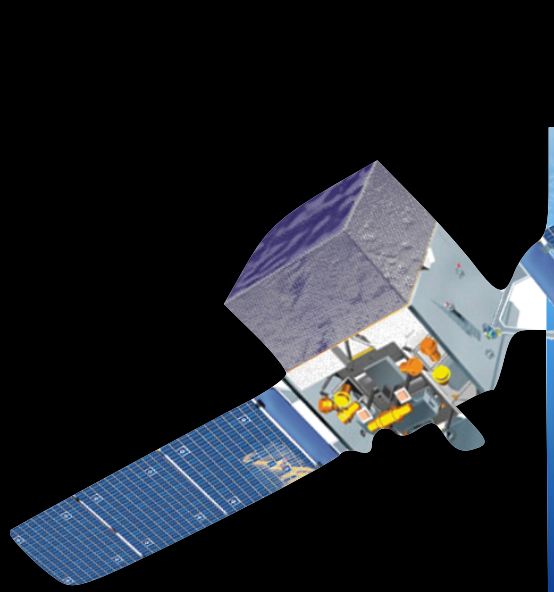
SN 1987 A

Low-Energy
Neutrinos



IceCube:
High-Energy Neutrinos!

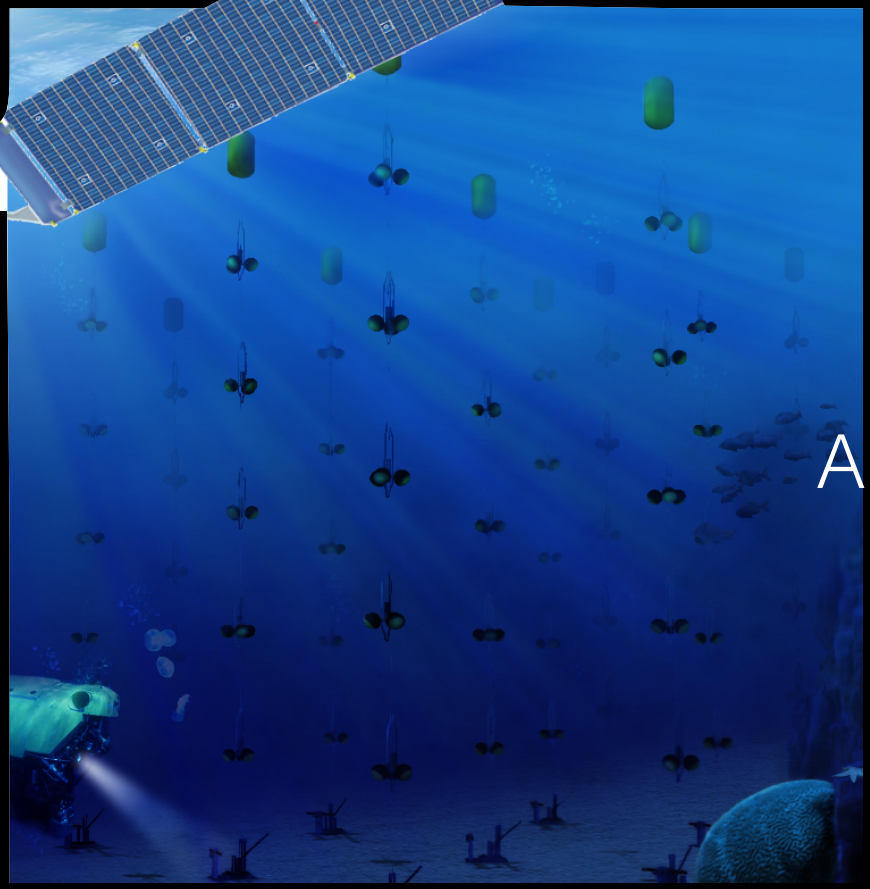
Search for coincident Neutrinos from 297 GRBs (2008-2011)



Fermi

+ Swift

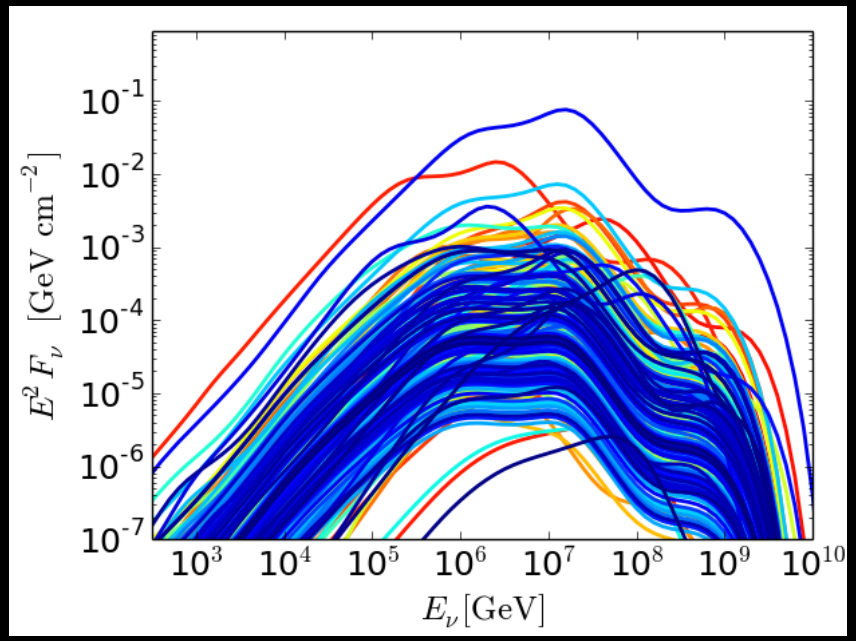
+ Telescopes

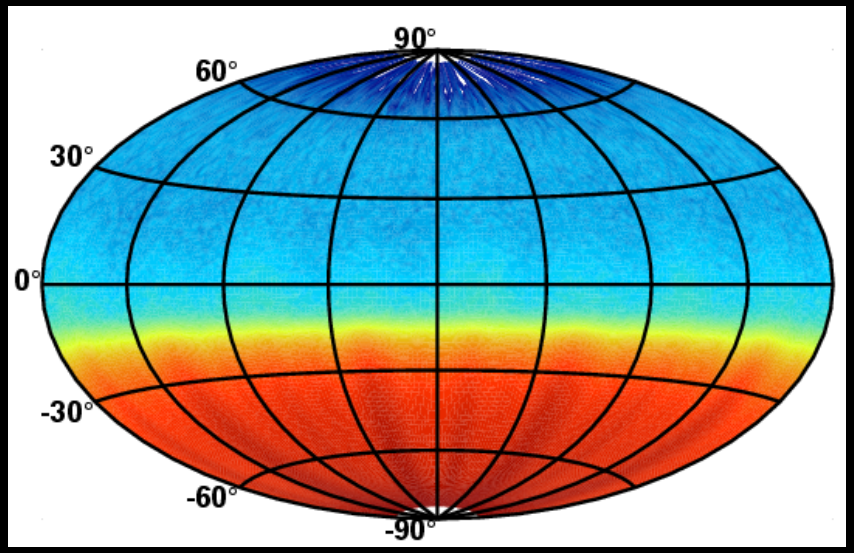


ANTARES data

Search for coincident Neutrinos from 297 GRBs (2008-2011)

[Hümmer+ 2010]

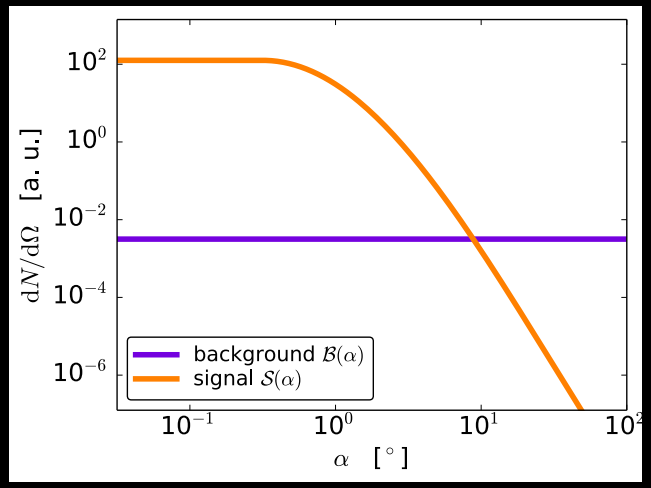




Signal

Background

MC Simulation



extended maximum likelihood ratio

$$Q = \max_{\mu'_s \in [0, n_{tot}]} \left(\sum_{i=1}^{n_{tot}} \log \frac{\mu'_s \cdot \mathcal{S}(\alpha_i) + \mu_b \cdot \mathcal{B}(\alpha_i)}{\mu_b \cdot \mathcal{B}(\alpha_i)} - (\mu'_s + \mu_b) \right)$$

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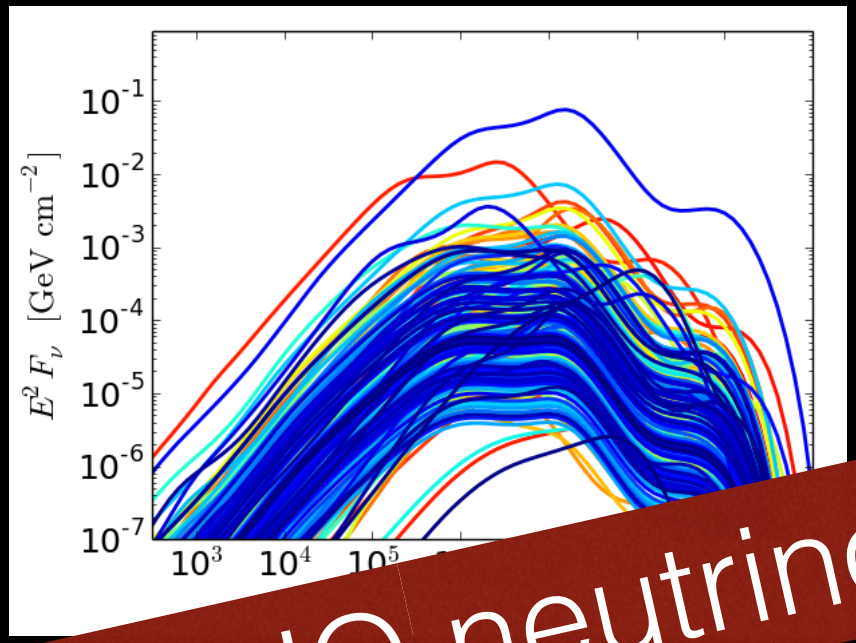

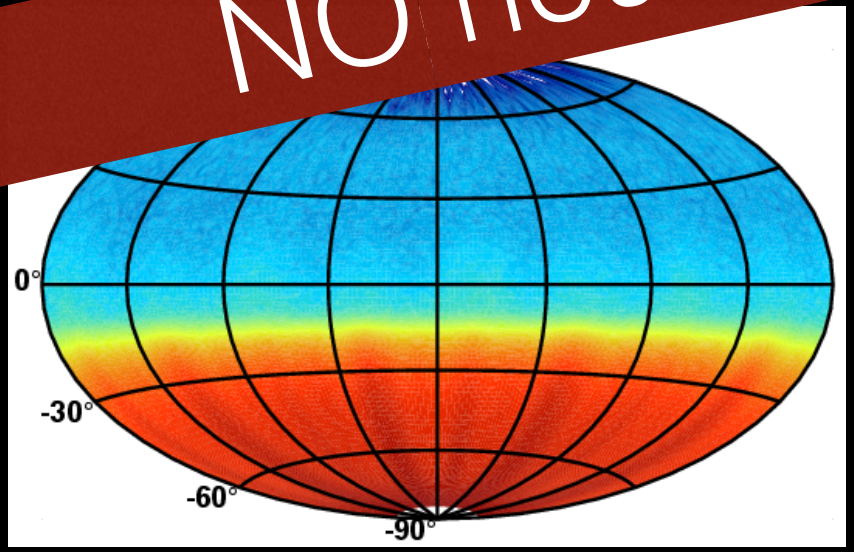

Signal

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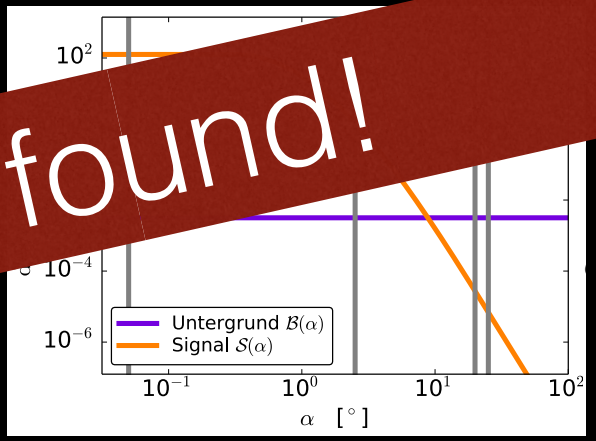

NO neutrino signal found!

extended maximum likelihood ratio

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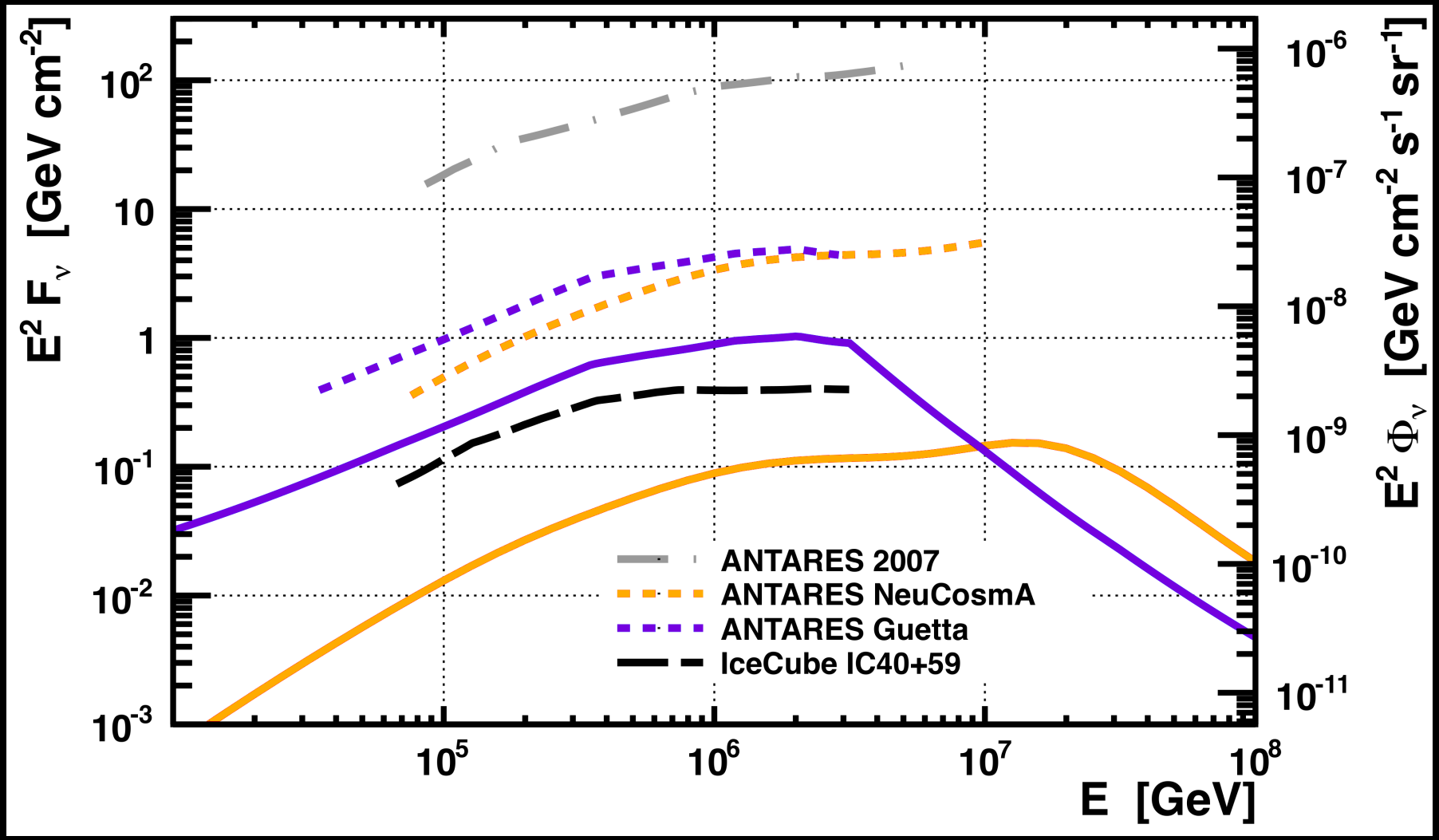
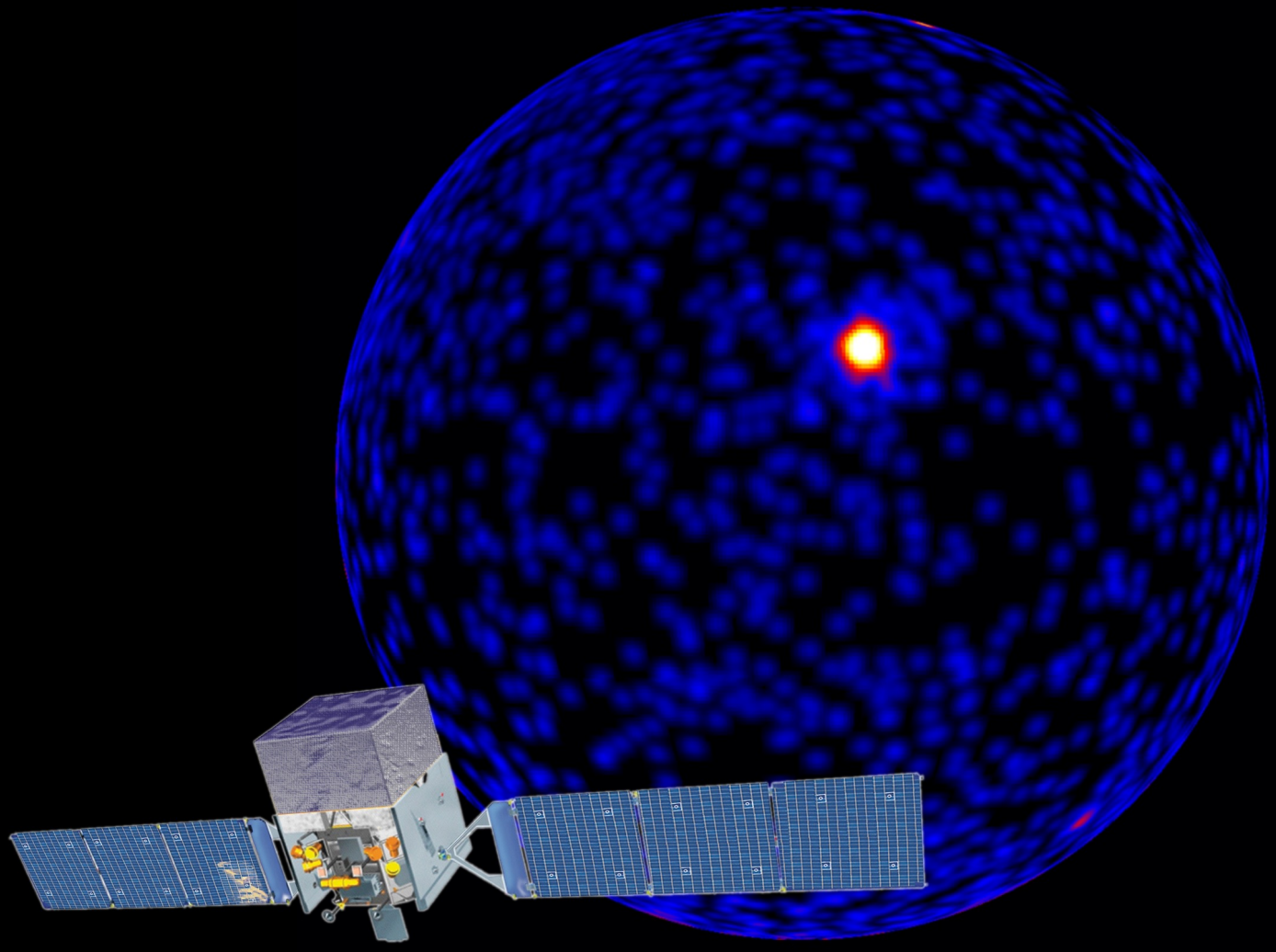
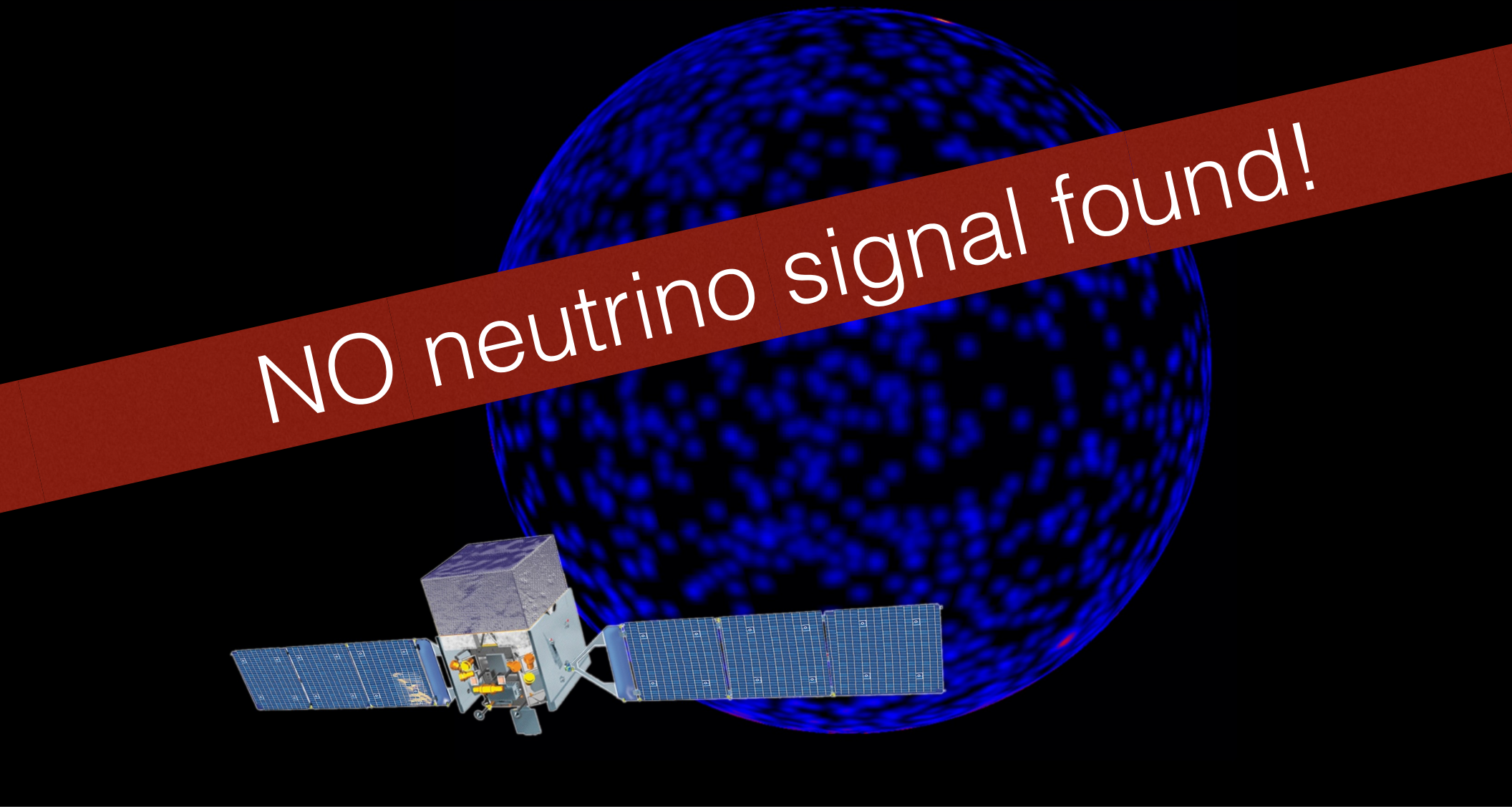


- A&A 559, A9 (2013)

Neutrinos from GRB130427A?



Neutrinos from GRB130427A?



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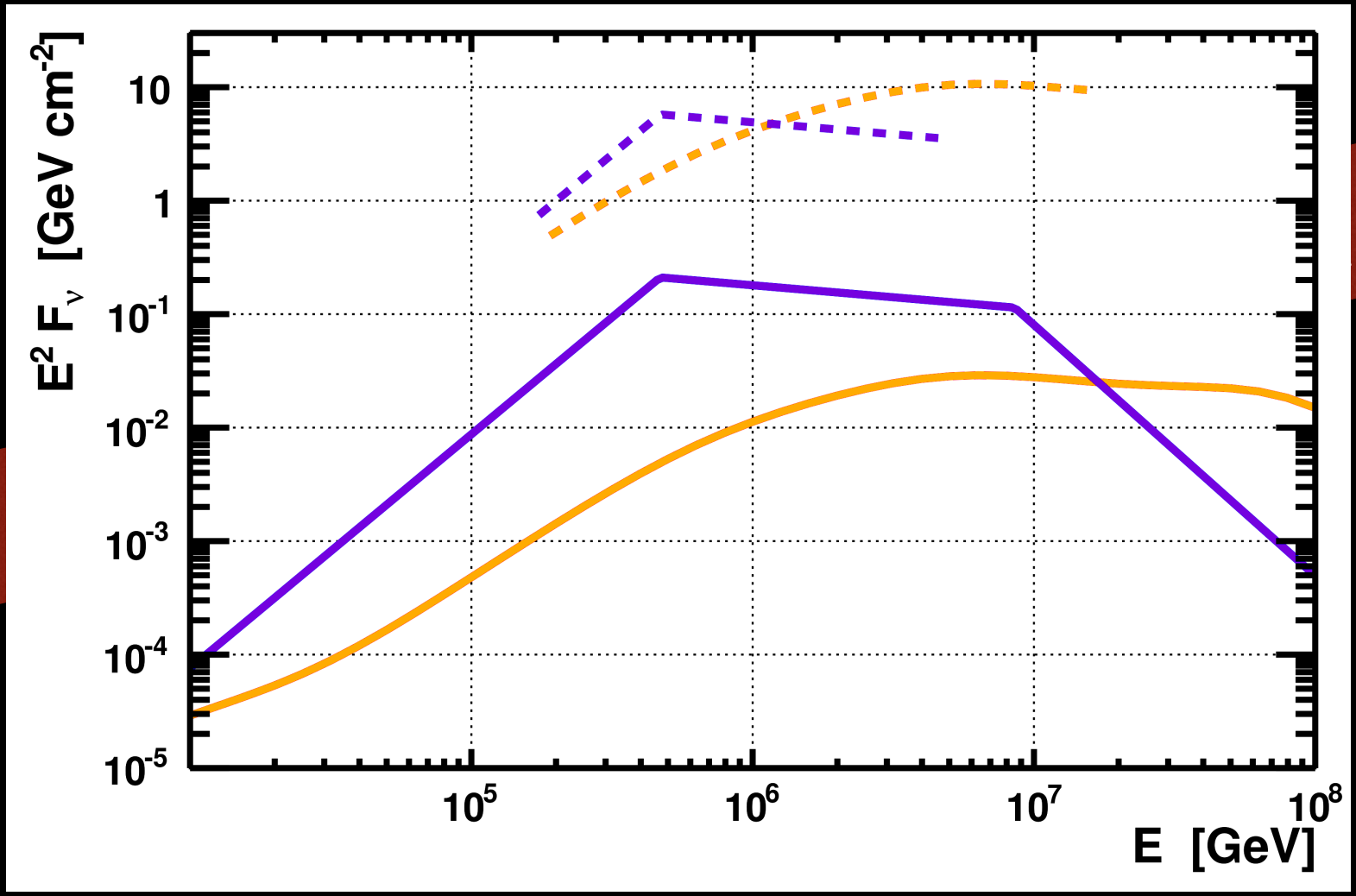
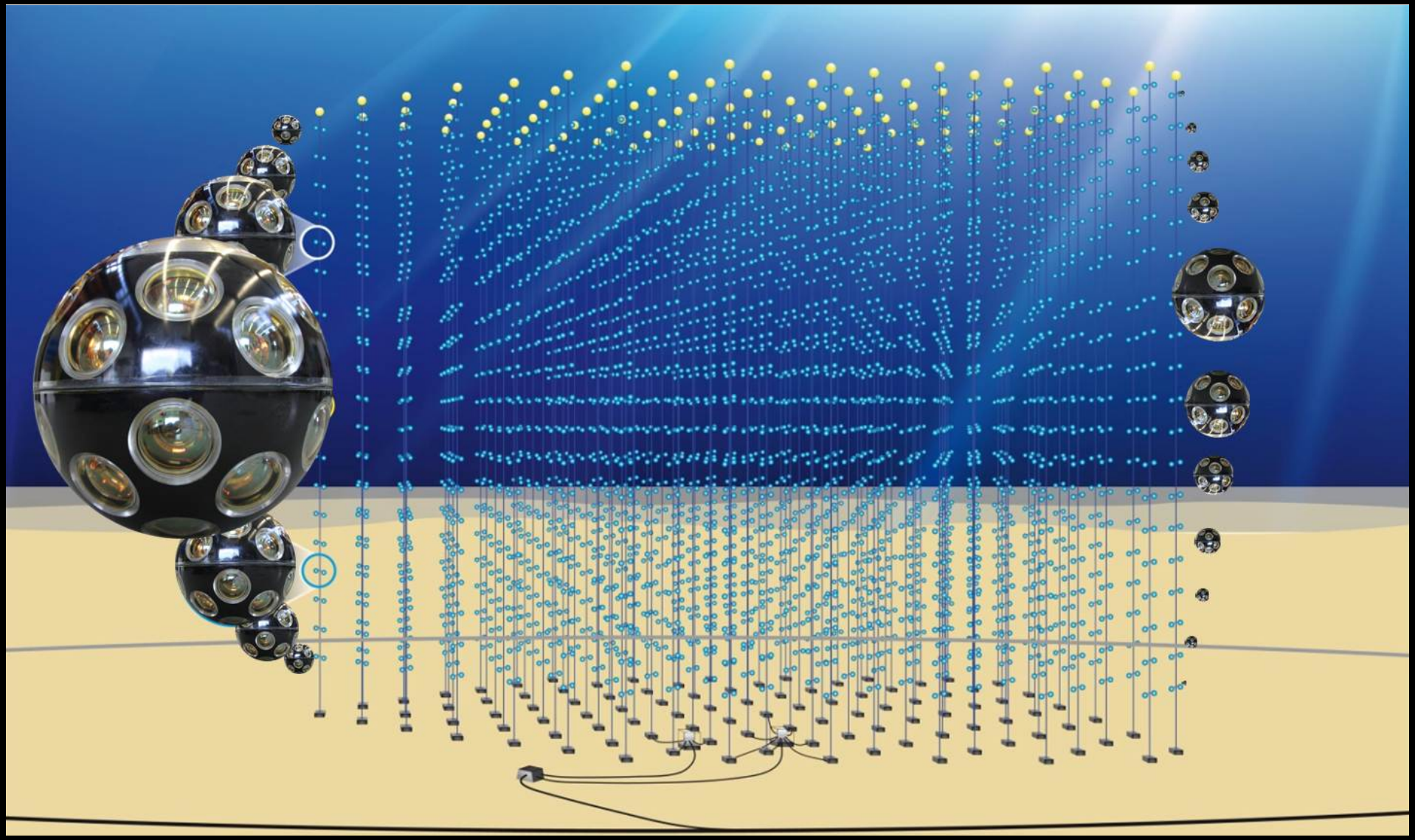


KM3NeT



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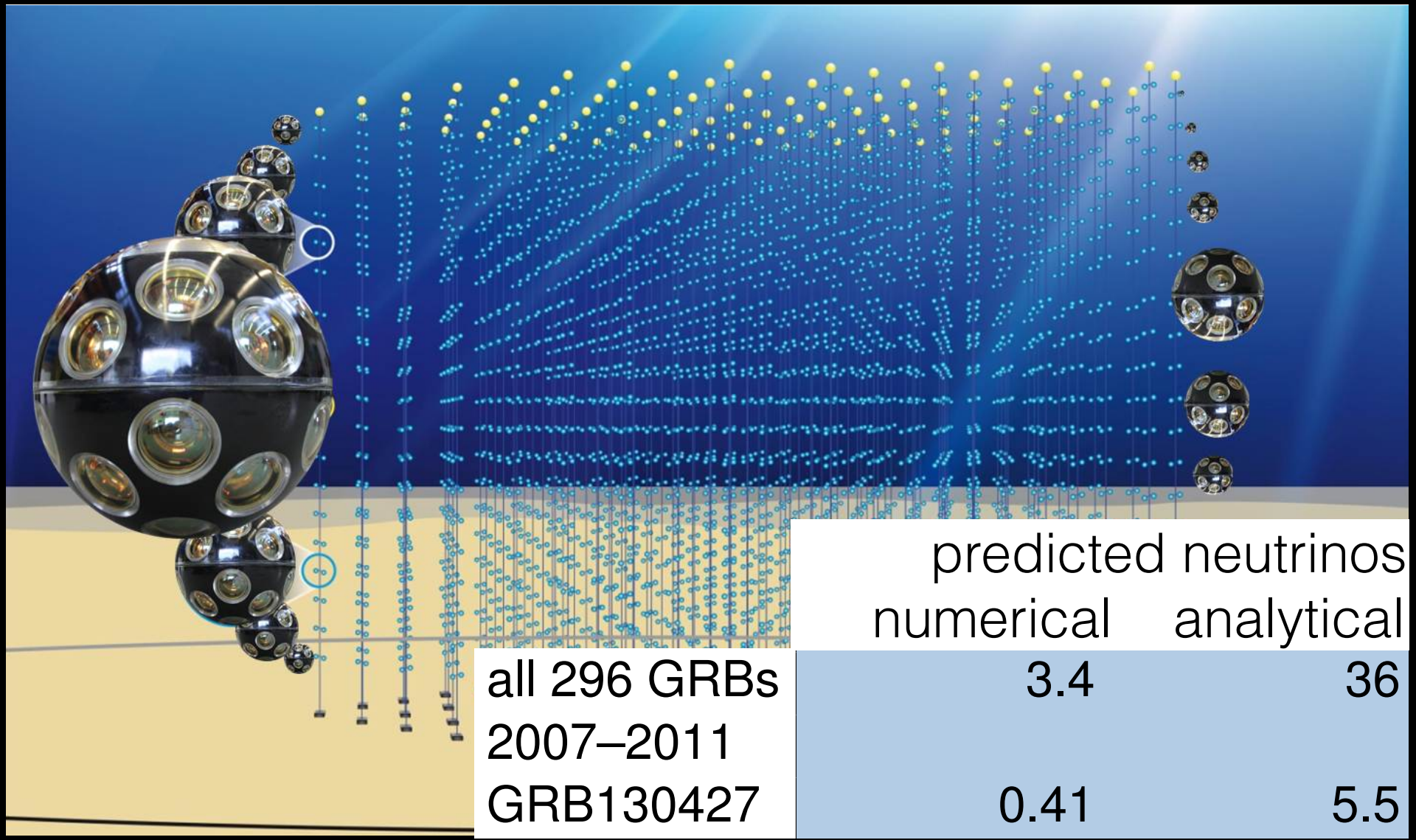
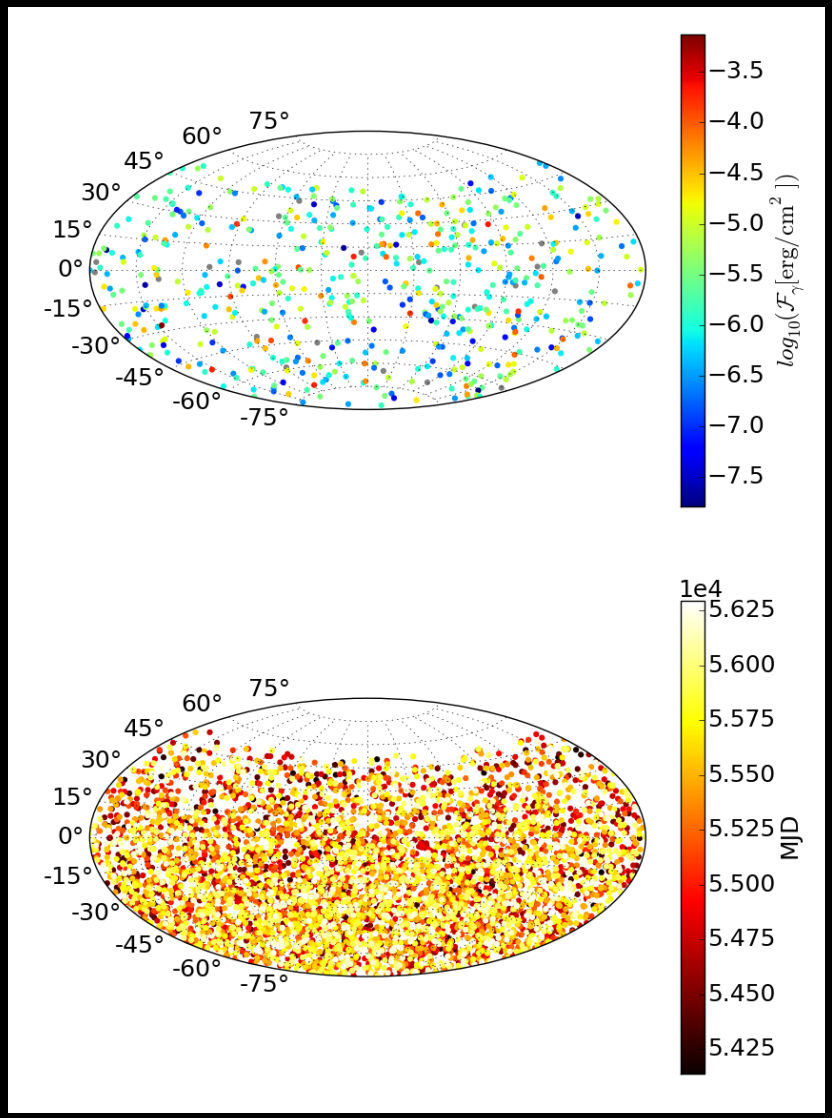


	predicted neutrinos	
	numerical	analytical
all 296 GRBs 2007–2011	3.4	36
GRB130427	0.41	5.5

Neutrinos time-shifted wrt. GRBs?



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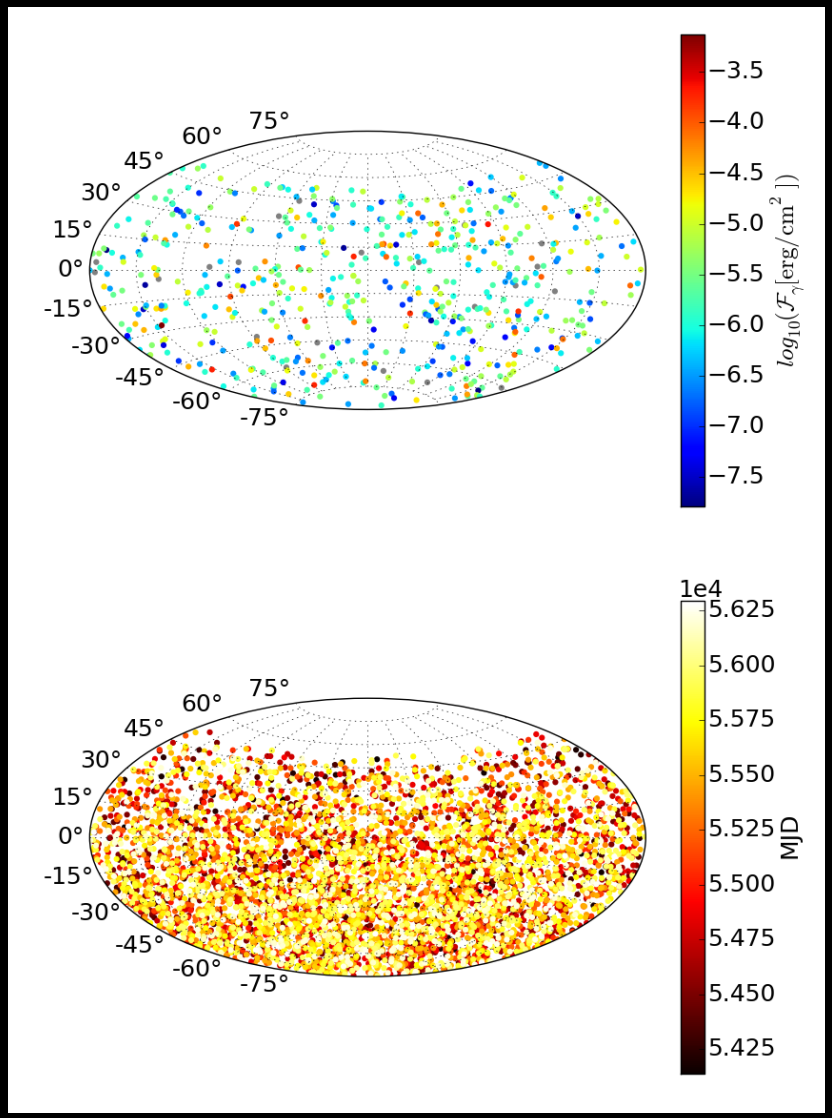

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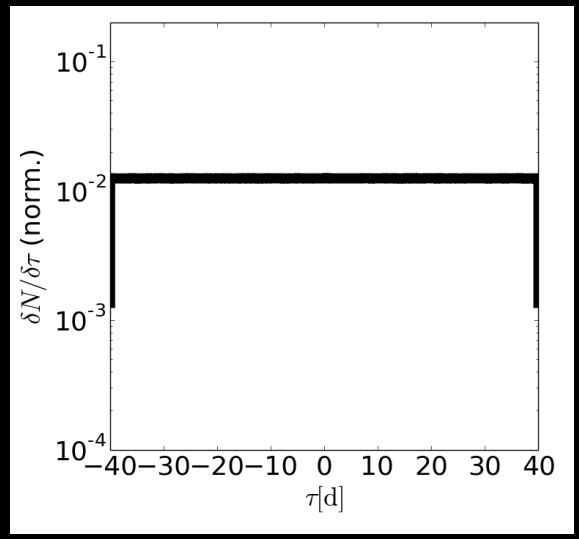

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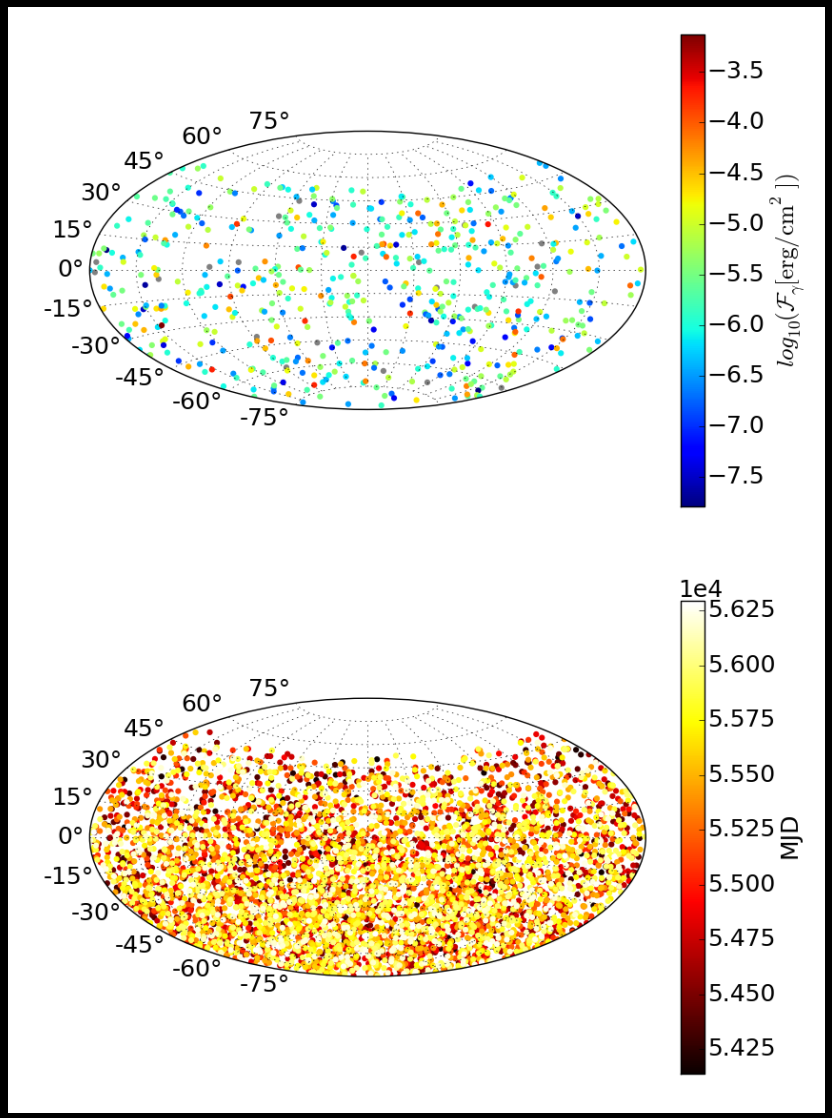
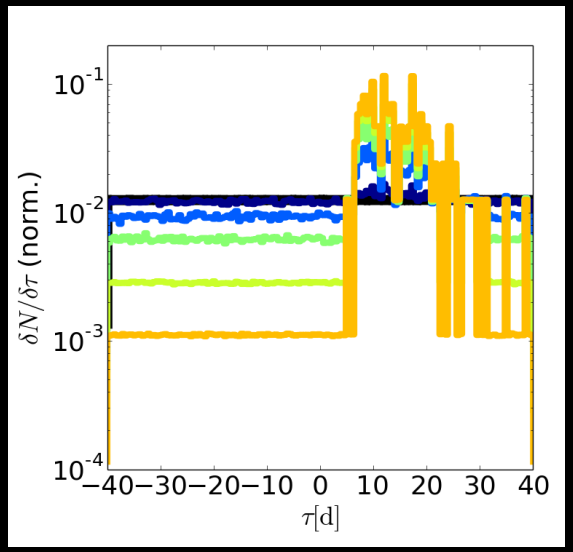
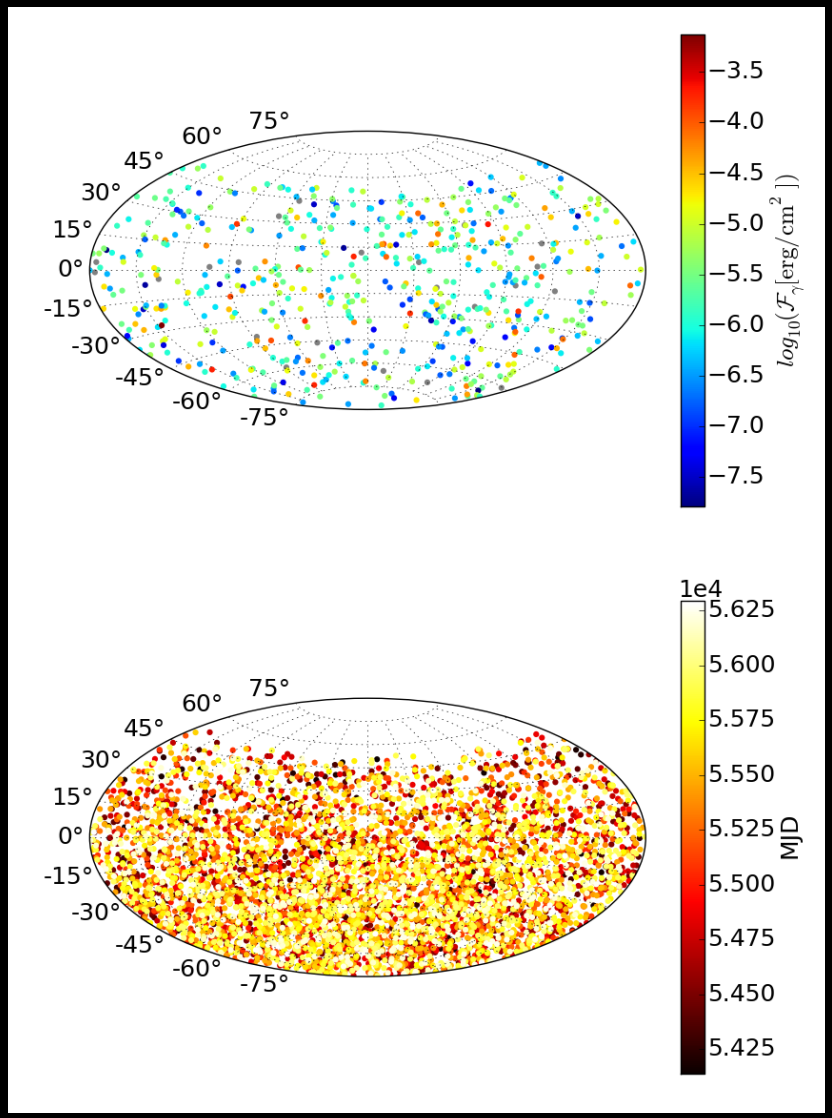


MC Simulation

+ correlated Signal

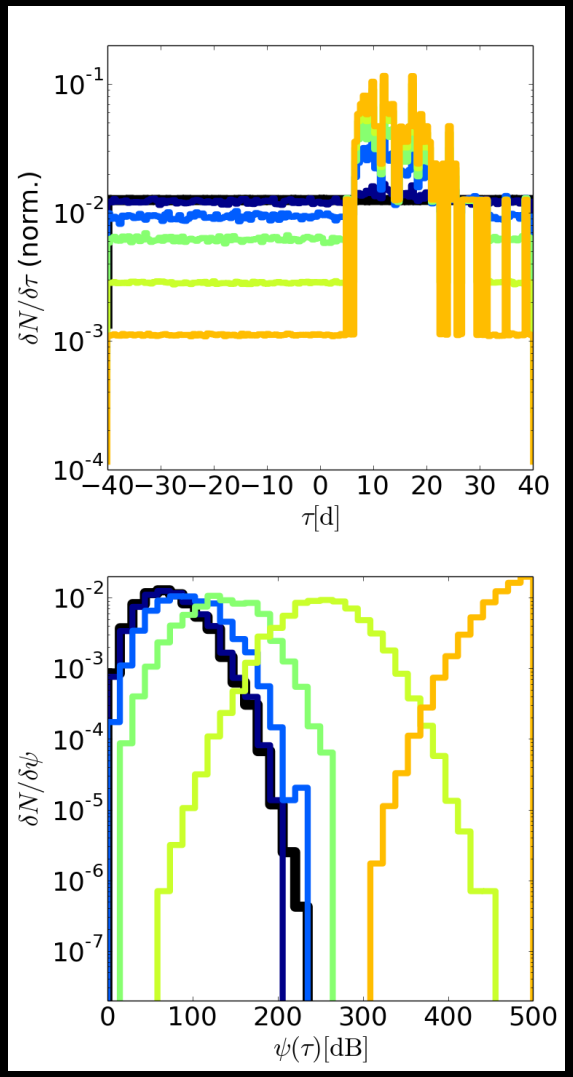


Neutrinos time-shifted wrt. GRBs?



MC Simulation

\+ correlated Signal



Neutrinos time-shifted wrt. GRBs?

ANTARES 2007-2012

under-fluctuation wrt. background expectation

signal < 0.01 detectable neutrino / GRB within +/- 40 days

1 year public IceCube data

slight over-fluctuation above background expectation

—> consistent with random coincidences (5%)

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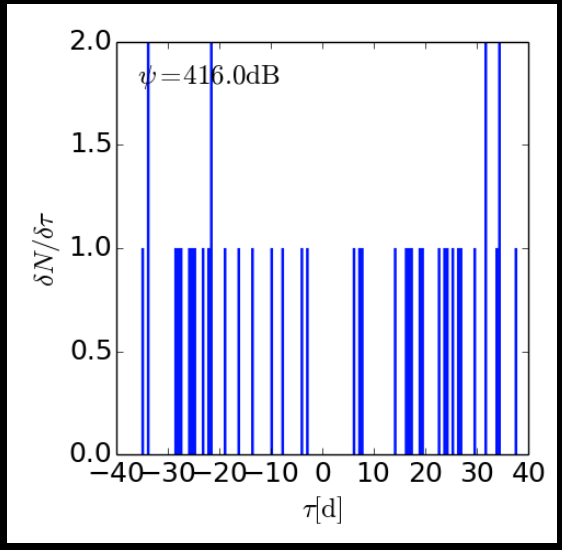

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days

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backgro

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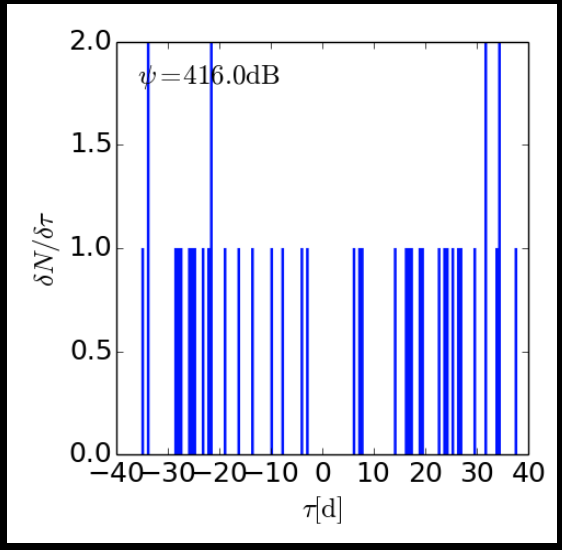


Summary

- Neutrinos: astronomy at highest energies and largest distances
- origin of cosmic rays
- ideal candidates: GRBs

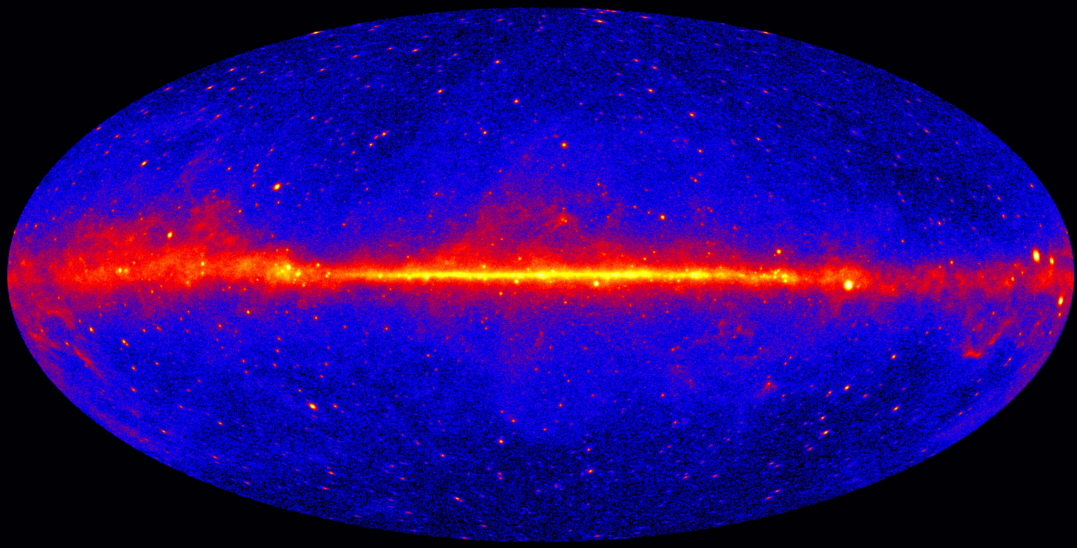
- search for coincident neutrino signal from GRBs, numerical models
- search for time-shifted neutrino signal (+/- 40 days) wrt. GRB alert

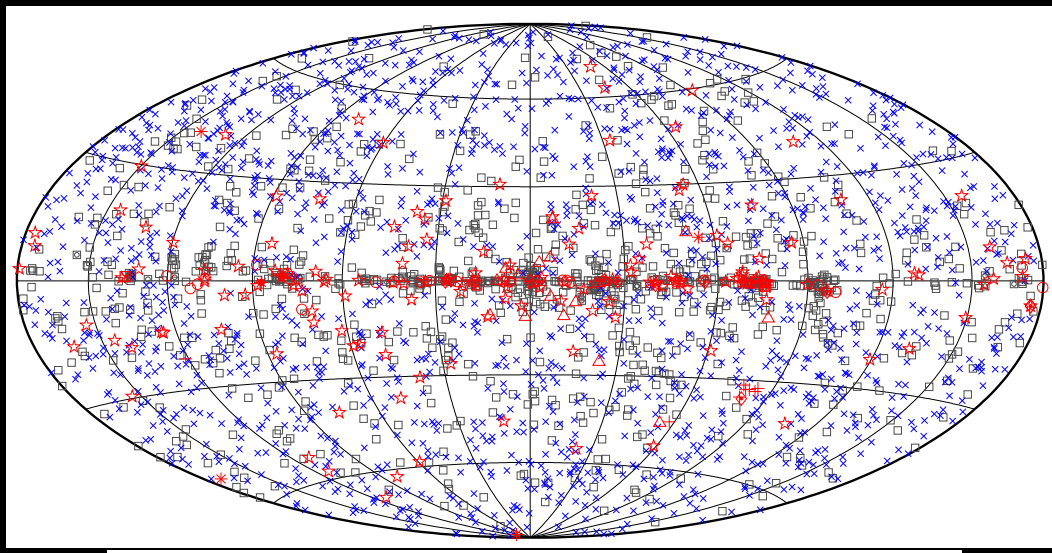
—> fully consistent with background <—

- realistic detection probabilities in near future w/ IceCube & KM3NeT

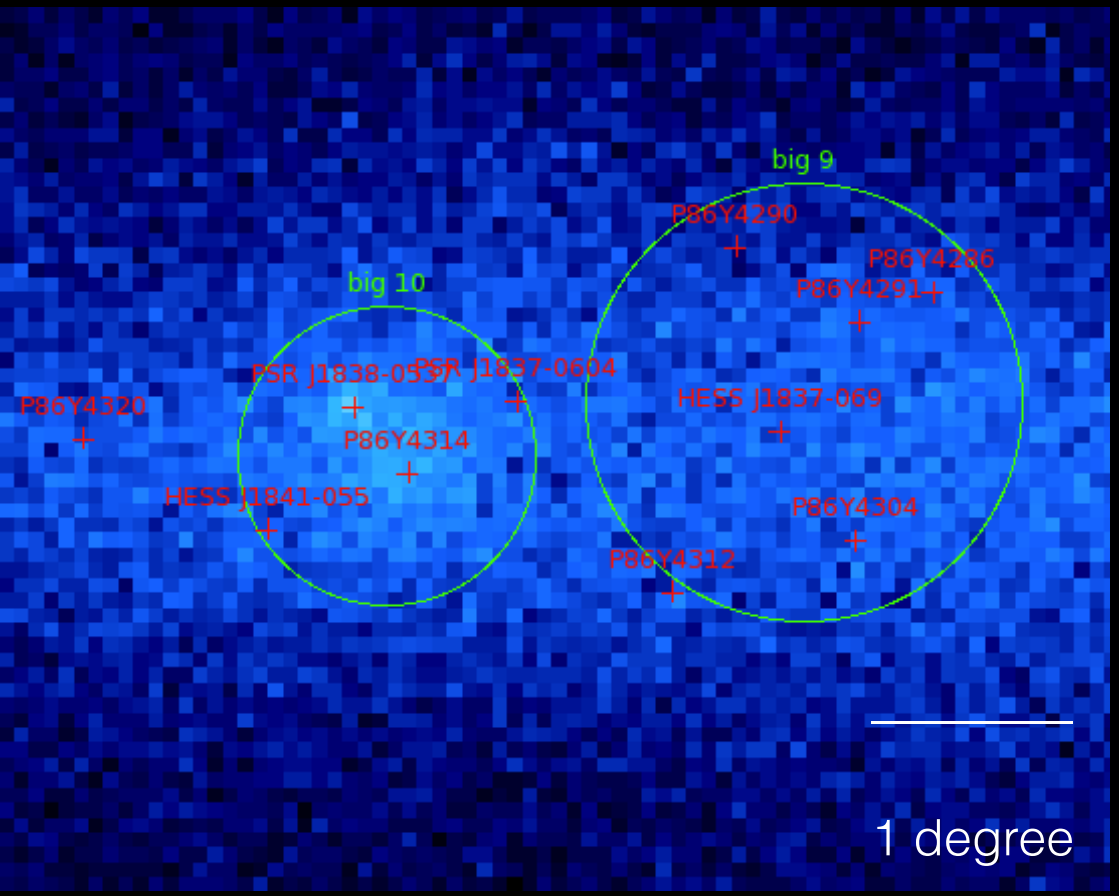
Fermi:LAT source catalog

- 3FGL just released based on 4 years
- now: 6 years of data
- better data reconstruction
- Planck results —> background models





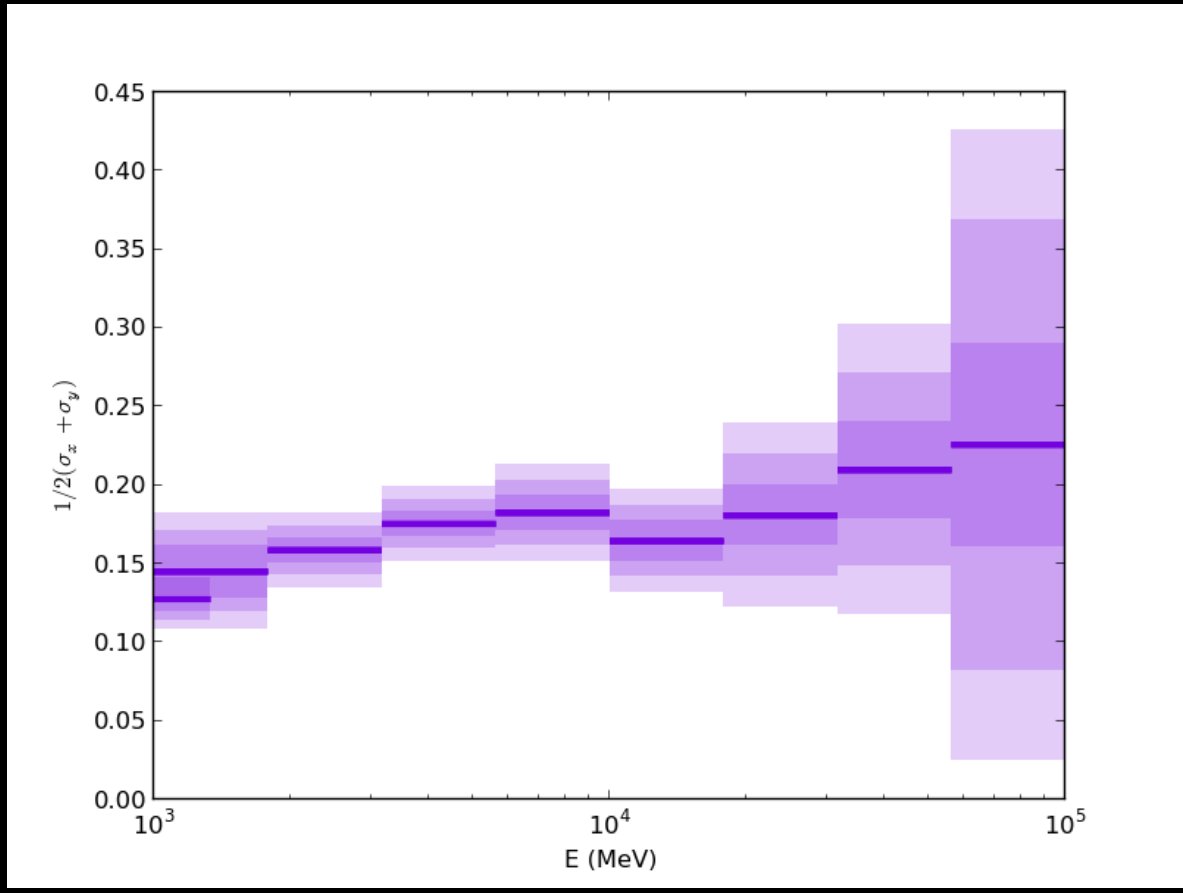
extended sources



- 25 sources in catalog (only previously published)
- systematic search for & fit of extended sources
- clusters of point sources —> extended source?

SNR IC 443

- size energy-dependent?
- ellipse w/ constant intensity
- individual fit in energy bands
- ~ constant



Thank You!

- my PhD thesis (English):
  http://www.ecap.nat.uni-erlangen.de/members/schmid/Doktorarbeit/JuliaSchmidDissertation.pdf

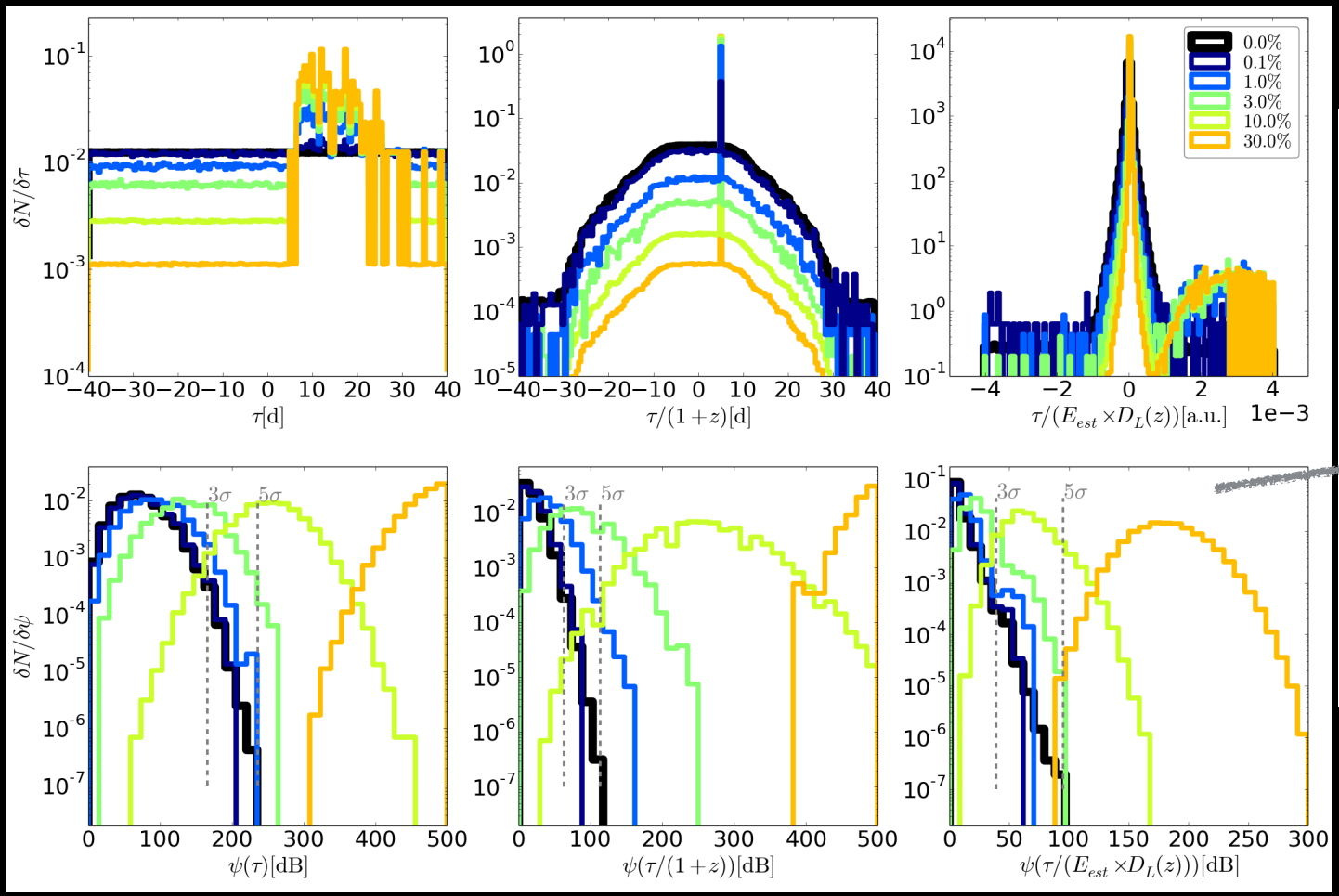
- published results: A&A 559, A9 (2013)
  http://www.aanda.org/articles/aa/full_html/2013/11/aa22169-13/aa22169-13.html

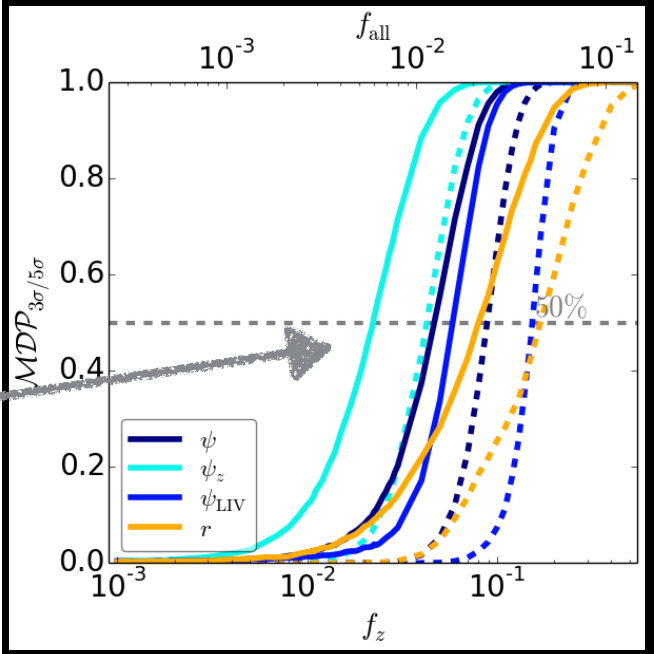
- talks, diploma thesis, …:
  http://www.ecap.physik.uni-erlangen.de/members/schmid/

ANTARES = Astronomy with a Neutrino Telescope and Abyss environmental RESearch

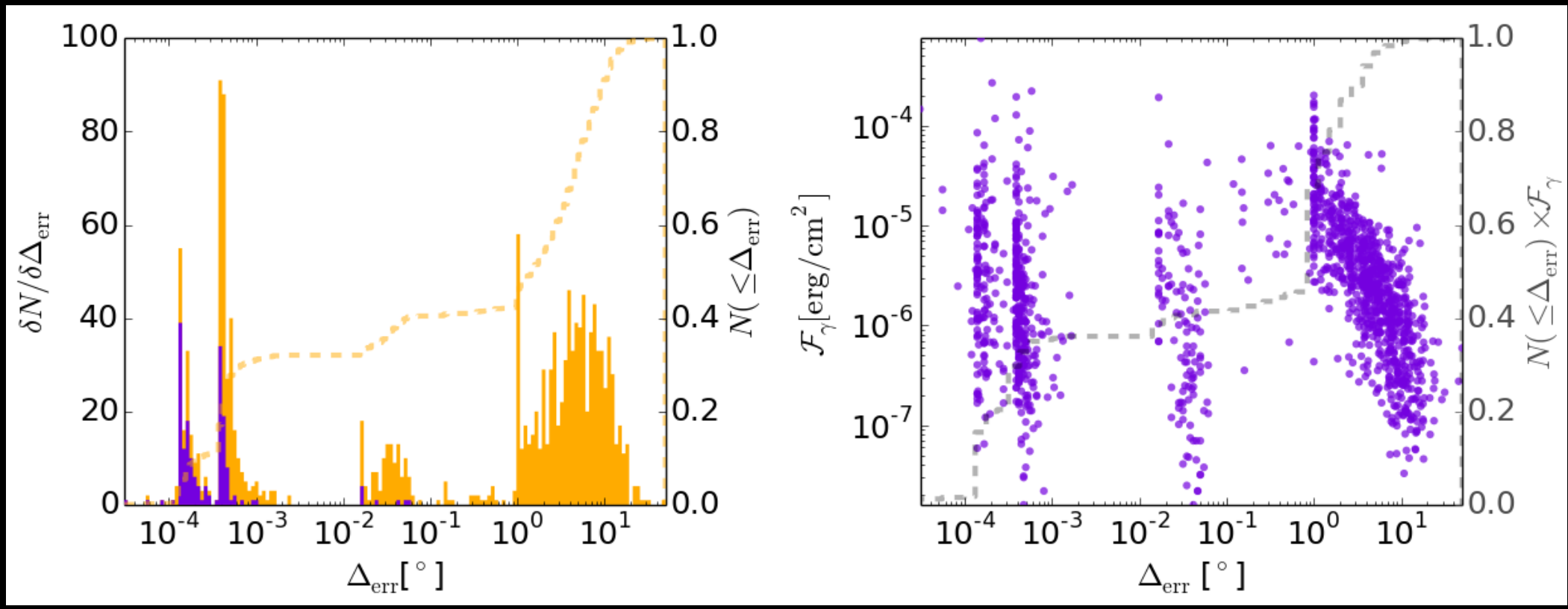
a bit more complicated…

$$\tau = t_\nu - t_{\mathrm{GRB}} \qquad \tau_z = \tau/(1+z) \qquad \tau_{\mathrm{LIV}} = \frac{\tau}{E_{\mathrm{est}} \cdot D(z)} \propto \pm \frac{E}{E_{\mathrm{est}}} \cdot \frac{1}{M_{\mathrm{LIV}} \cdot c}$$





Neutrinos time-shifted wrt. GRBs?



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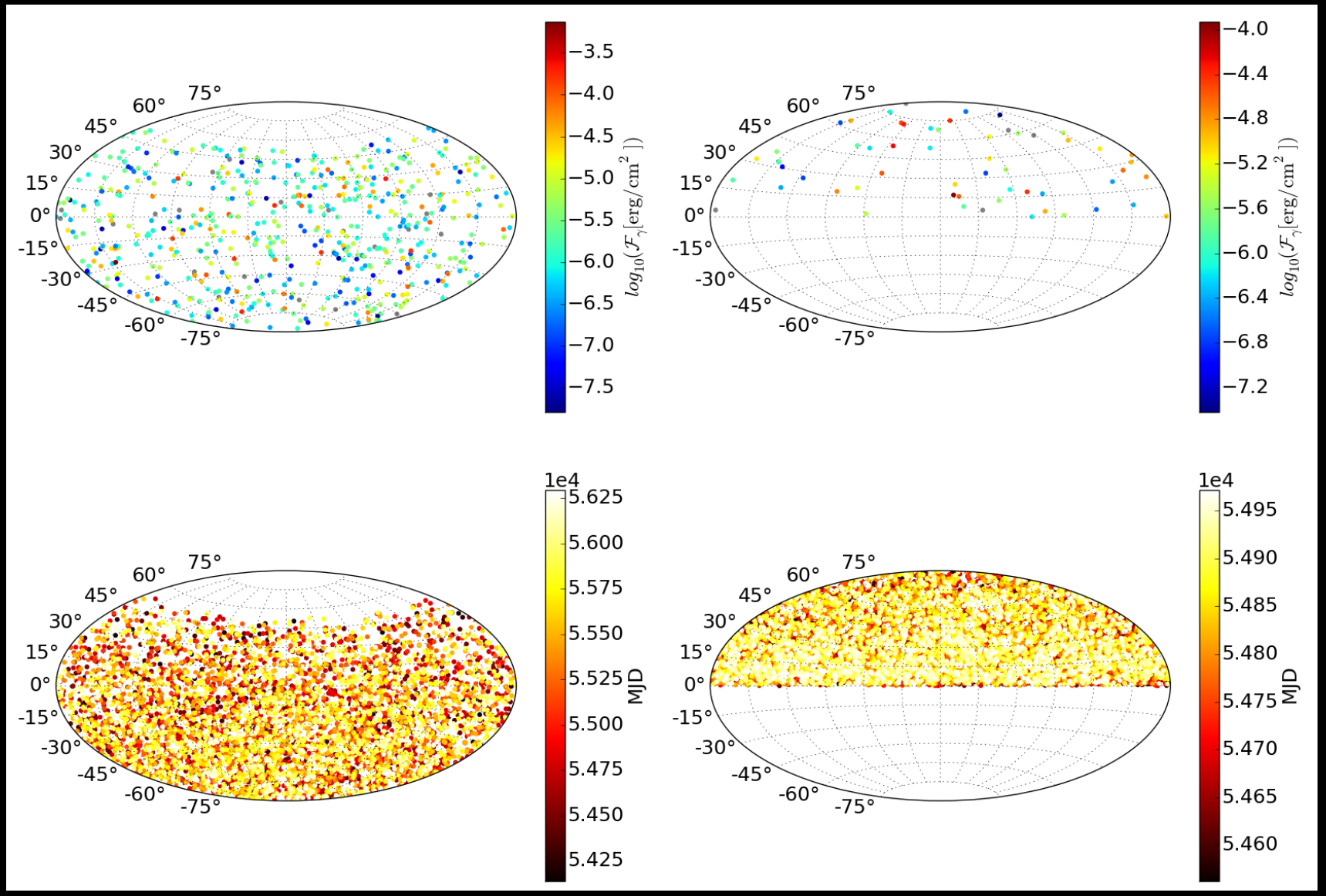

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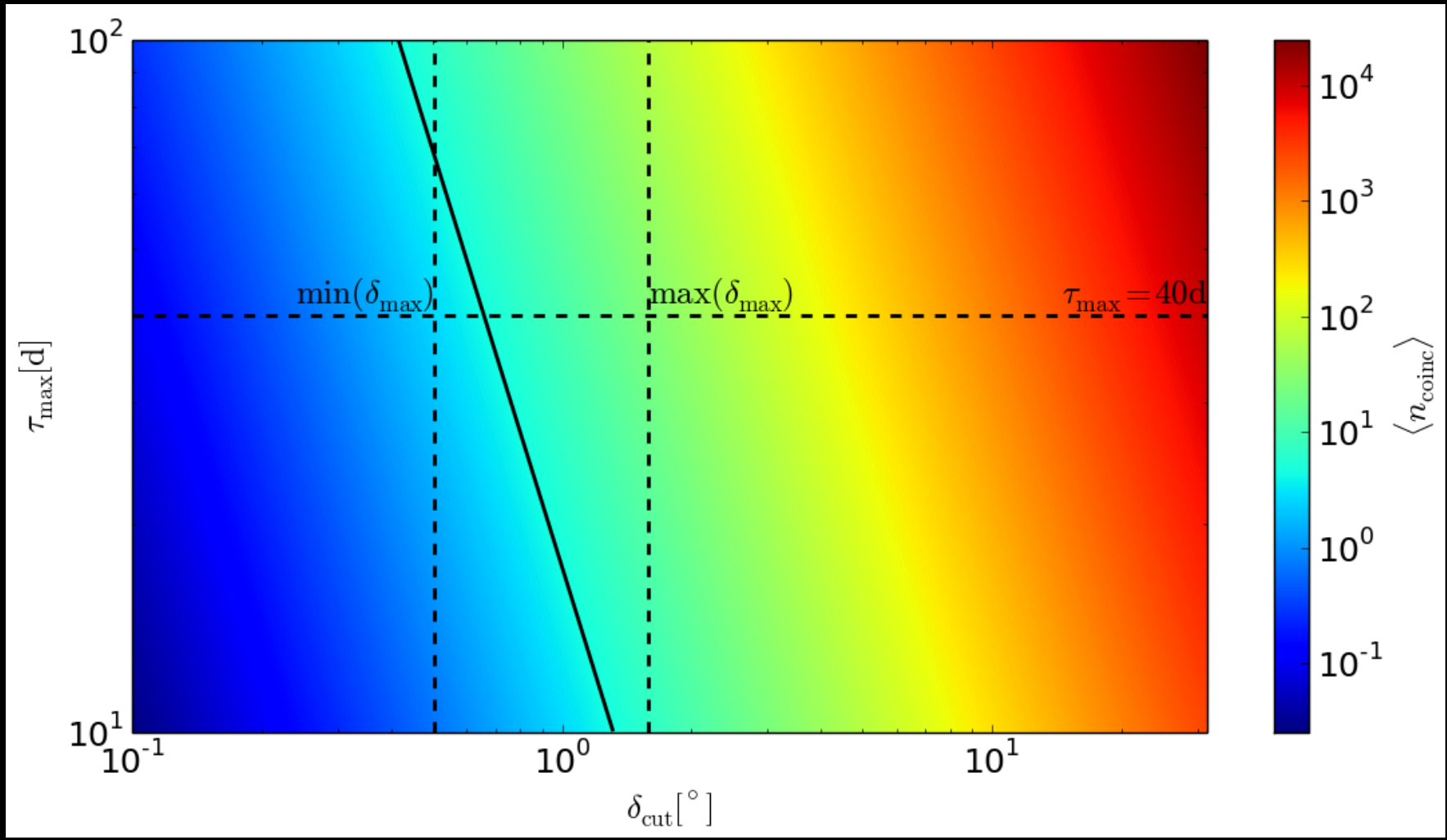

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