γ-rays from blazars: How and where?

I. Liodakis

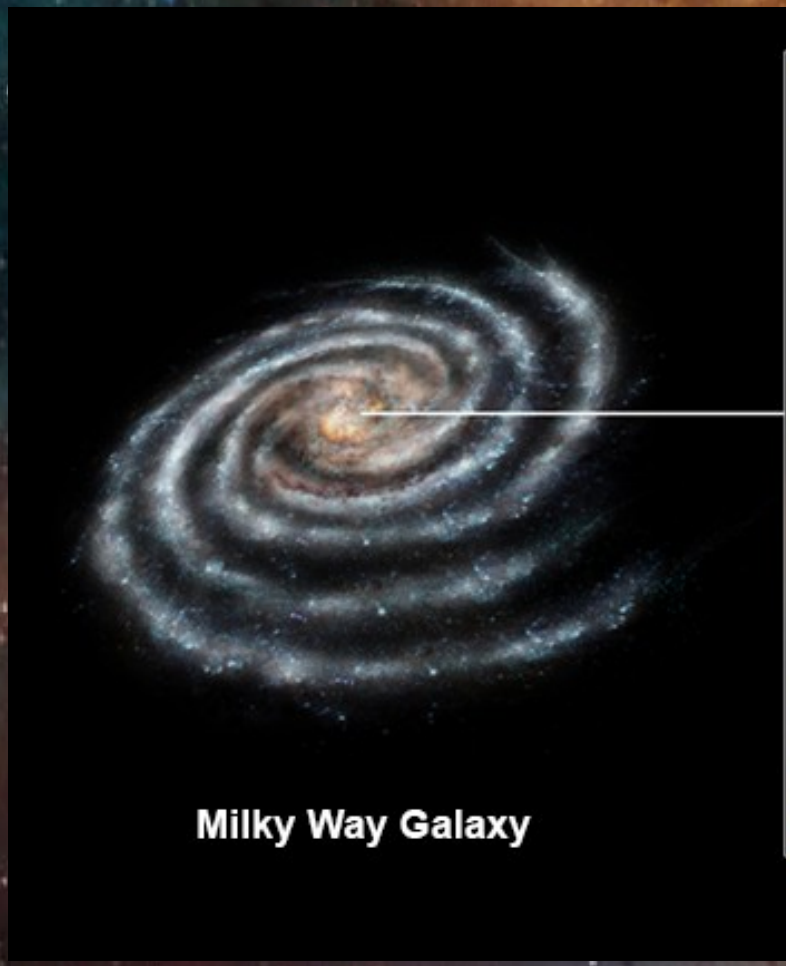
Kavli Institute for Particle Astrophysics and Cosmology

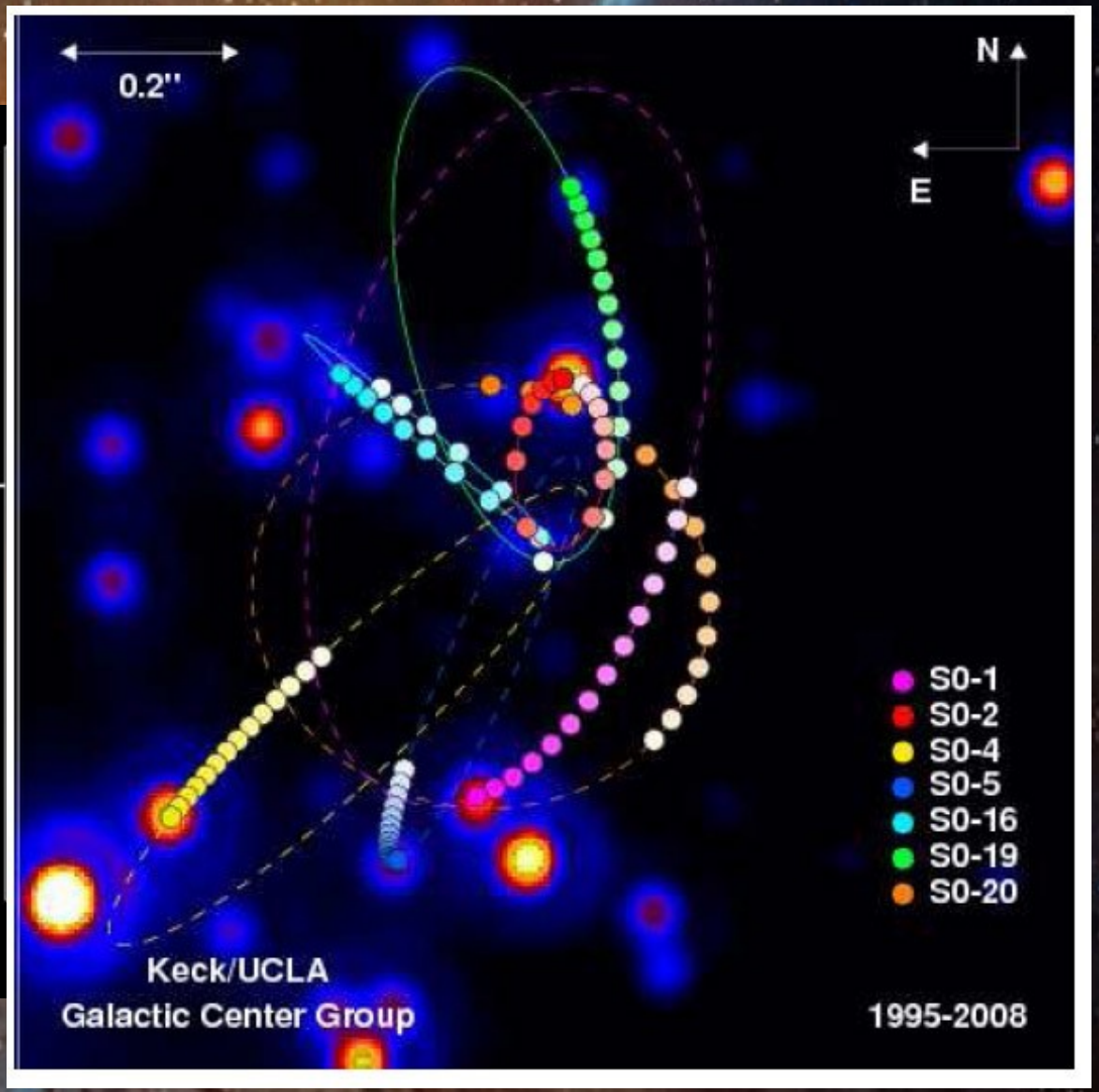
Physics and detector requirements
at zero-degree of colliders
September 2019

KIPAC

Stanford University

Introduction: Radio galaxies and blazars





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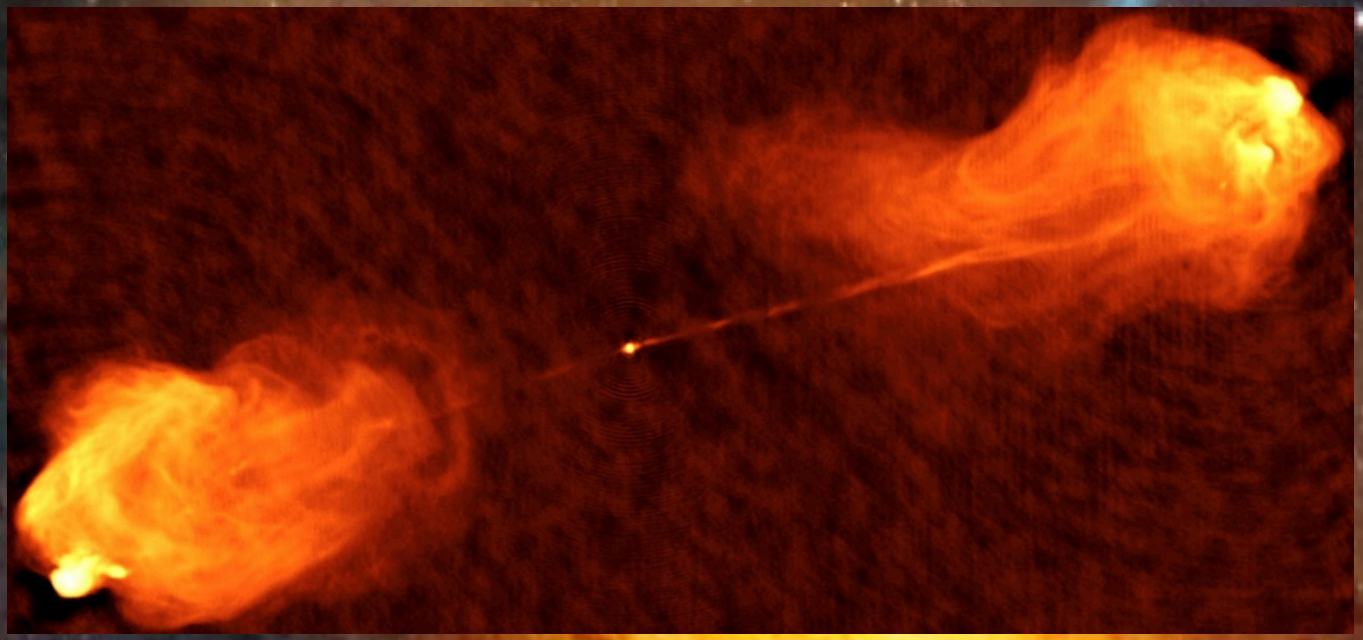

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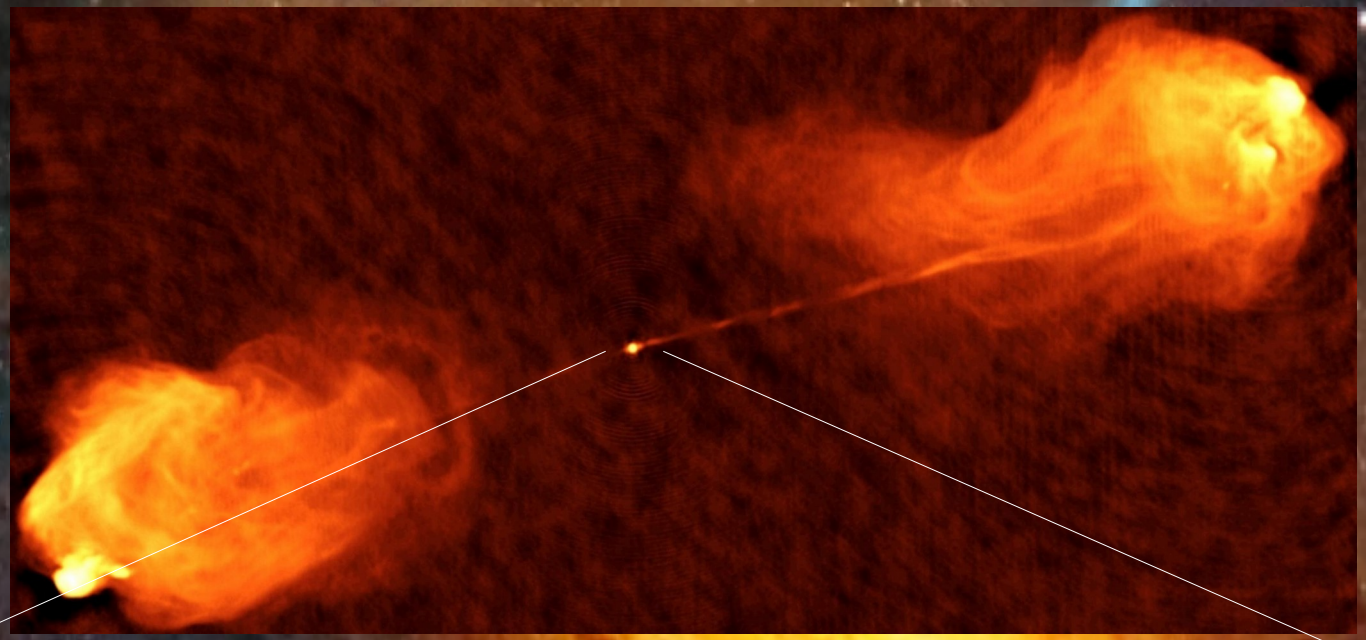

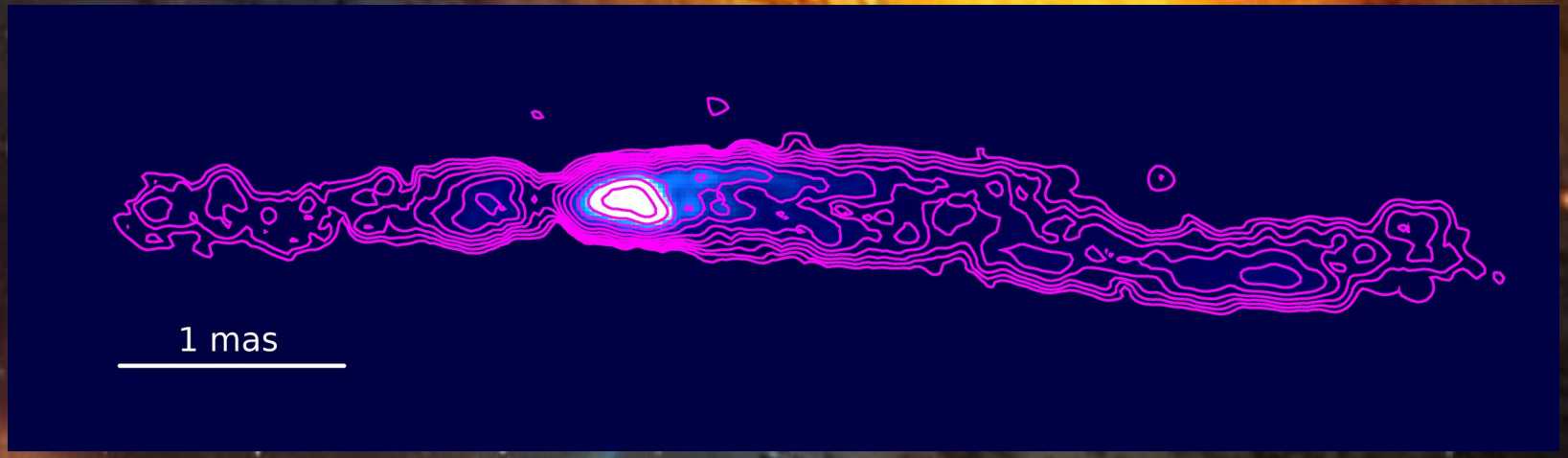

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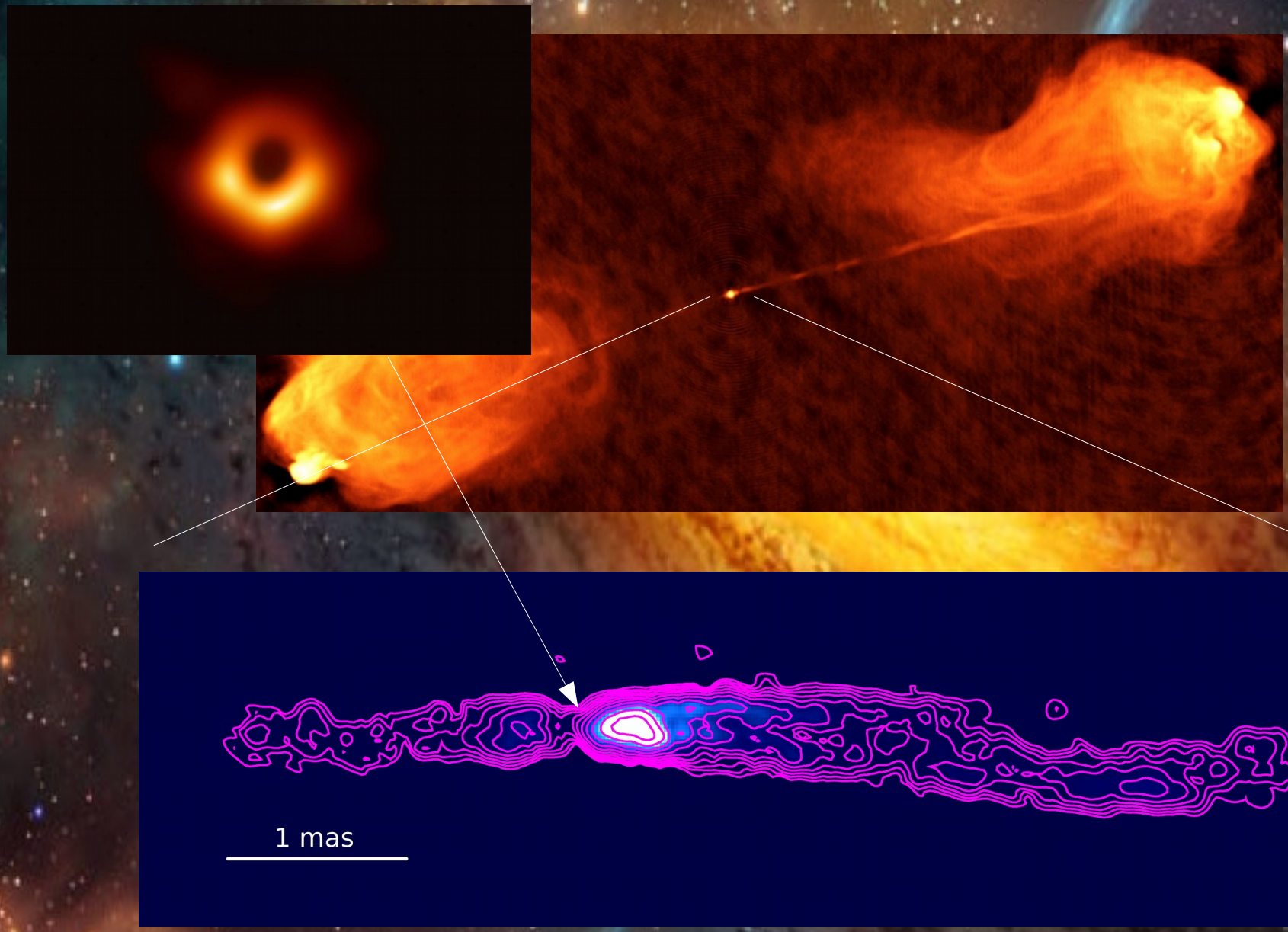

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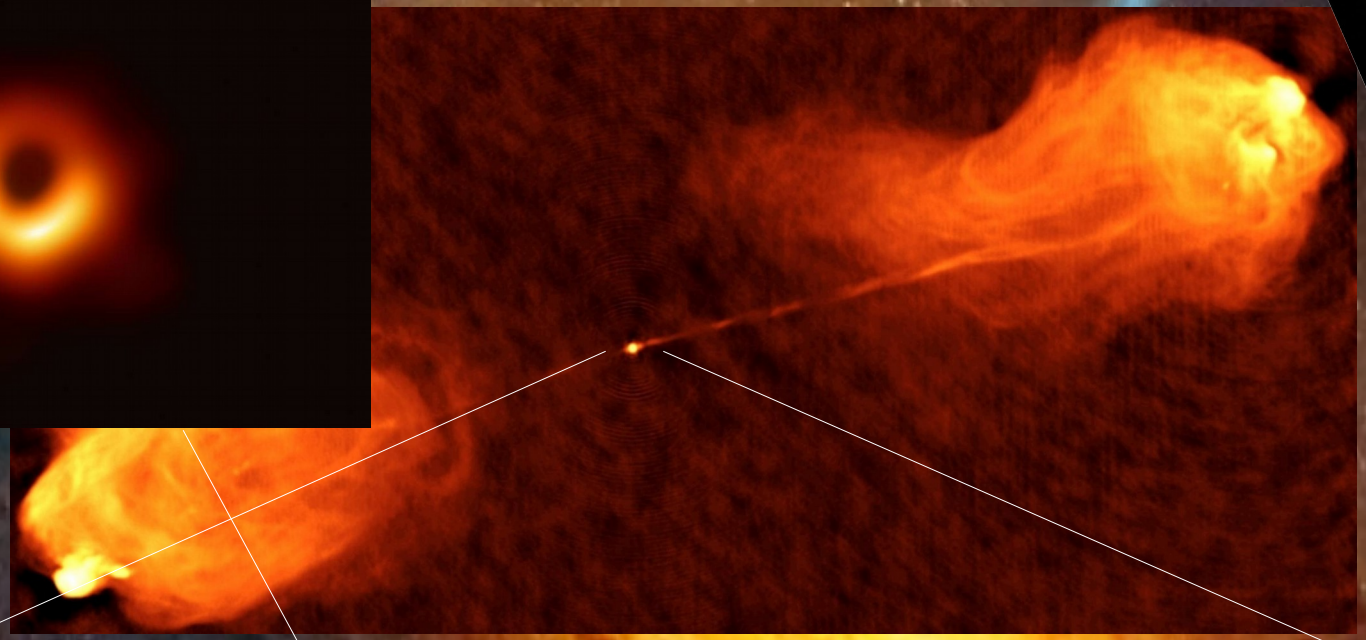

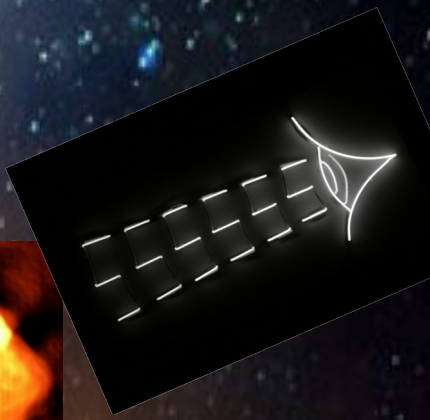

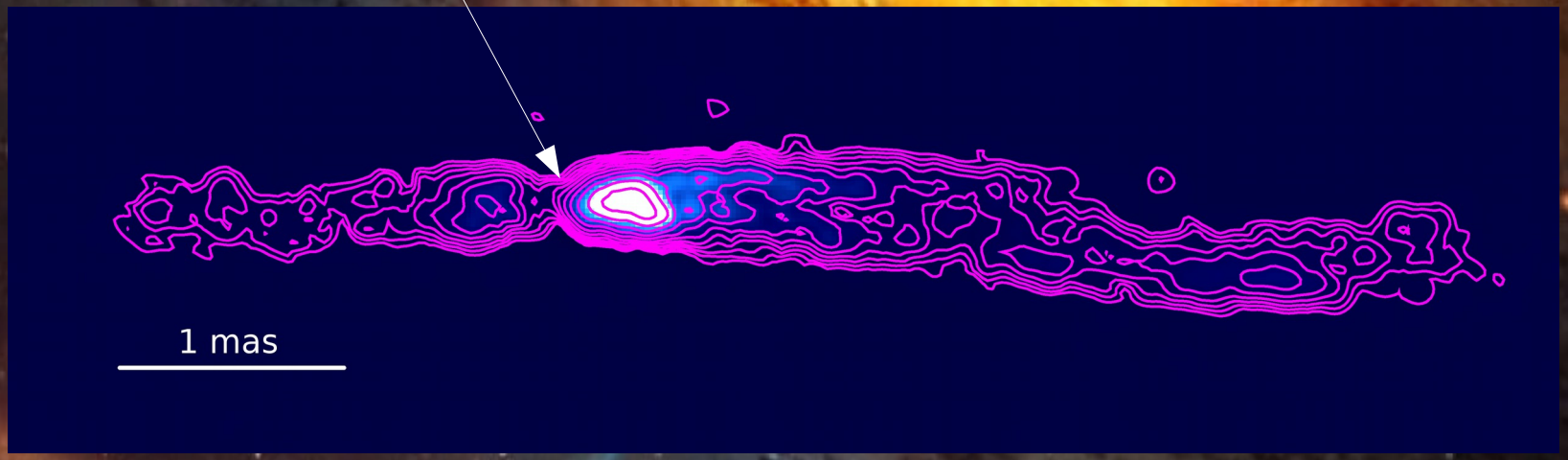

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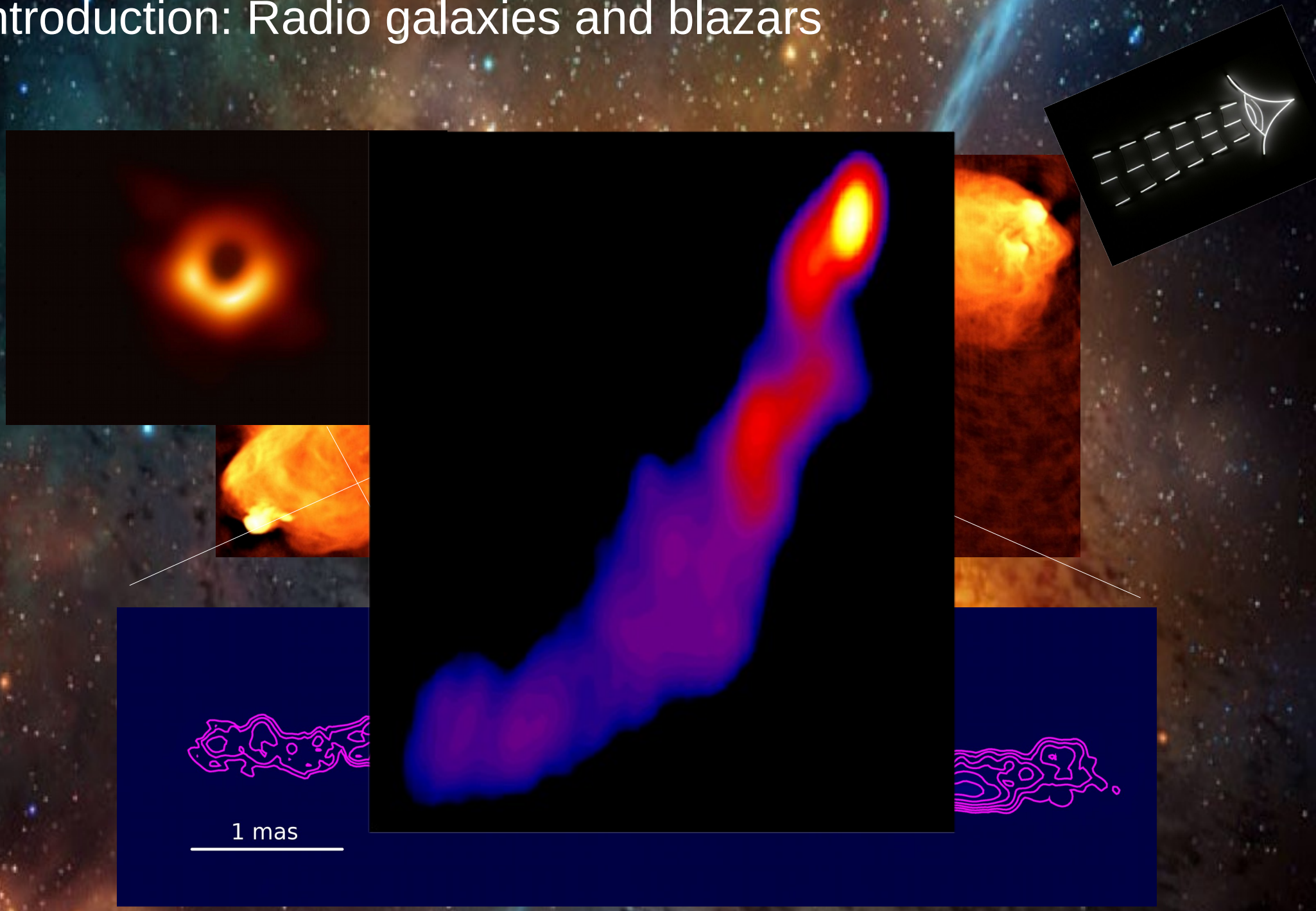
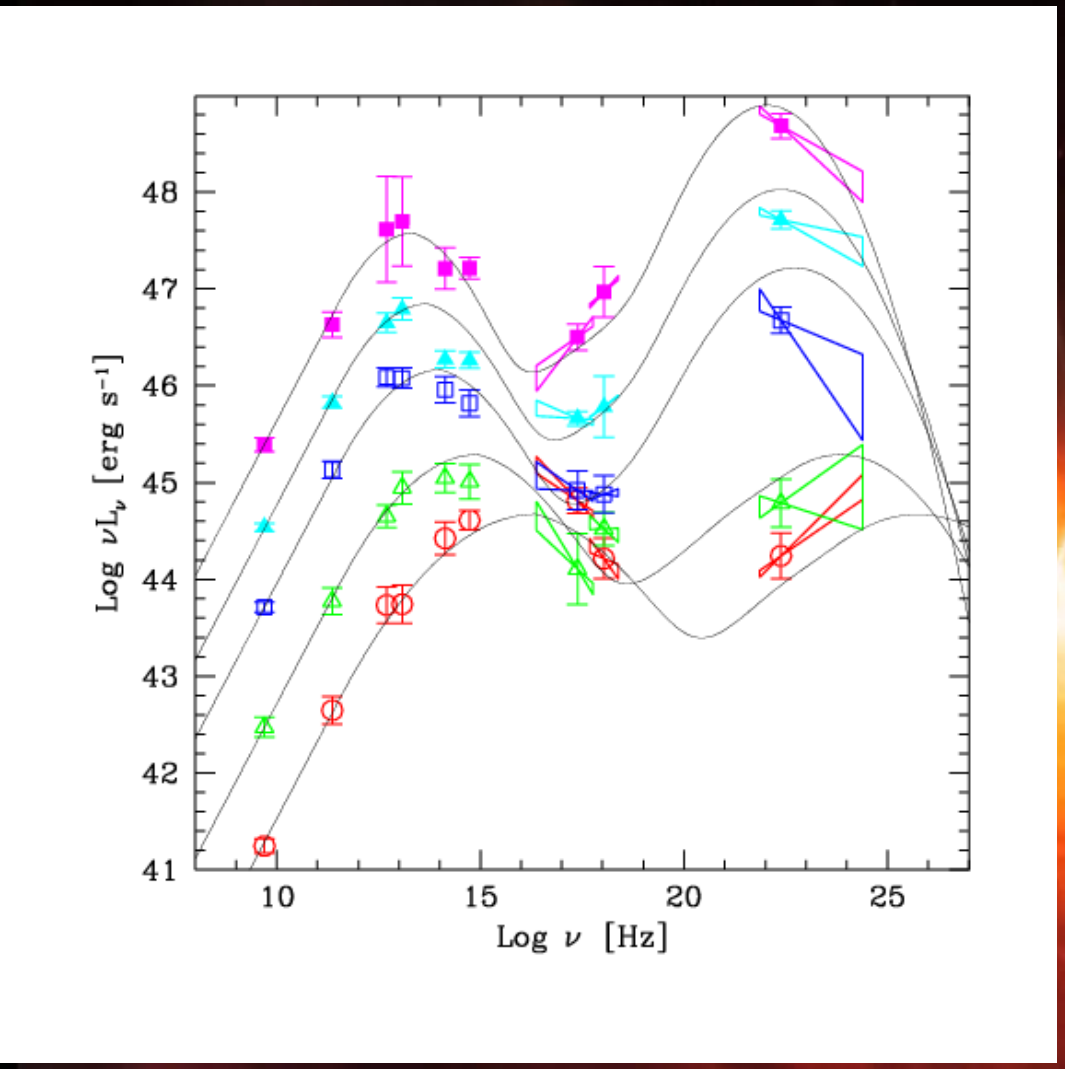


Where is the high-energy emission coming from?



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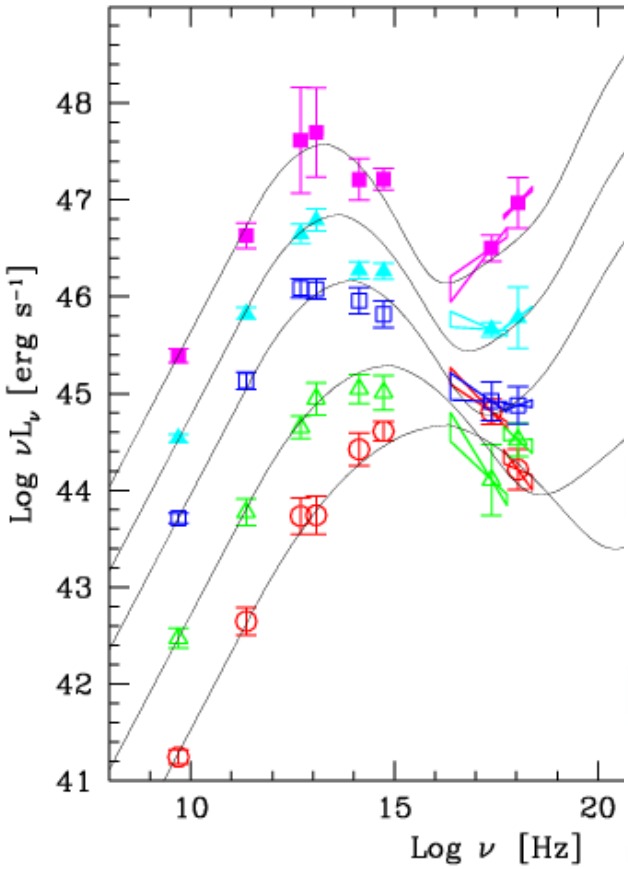

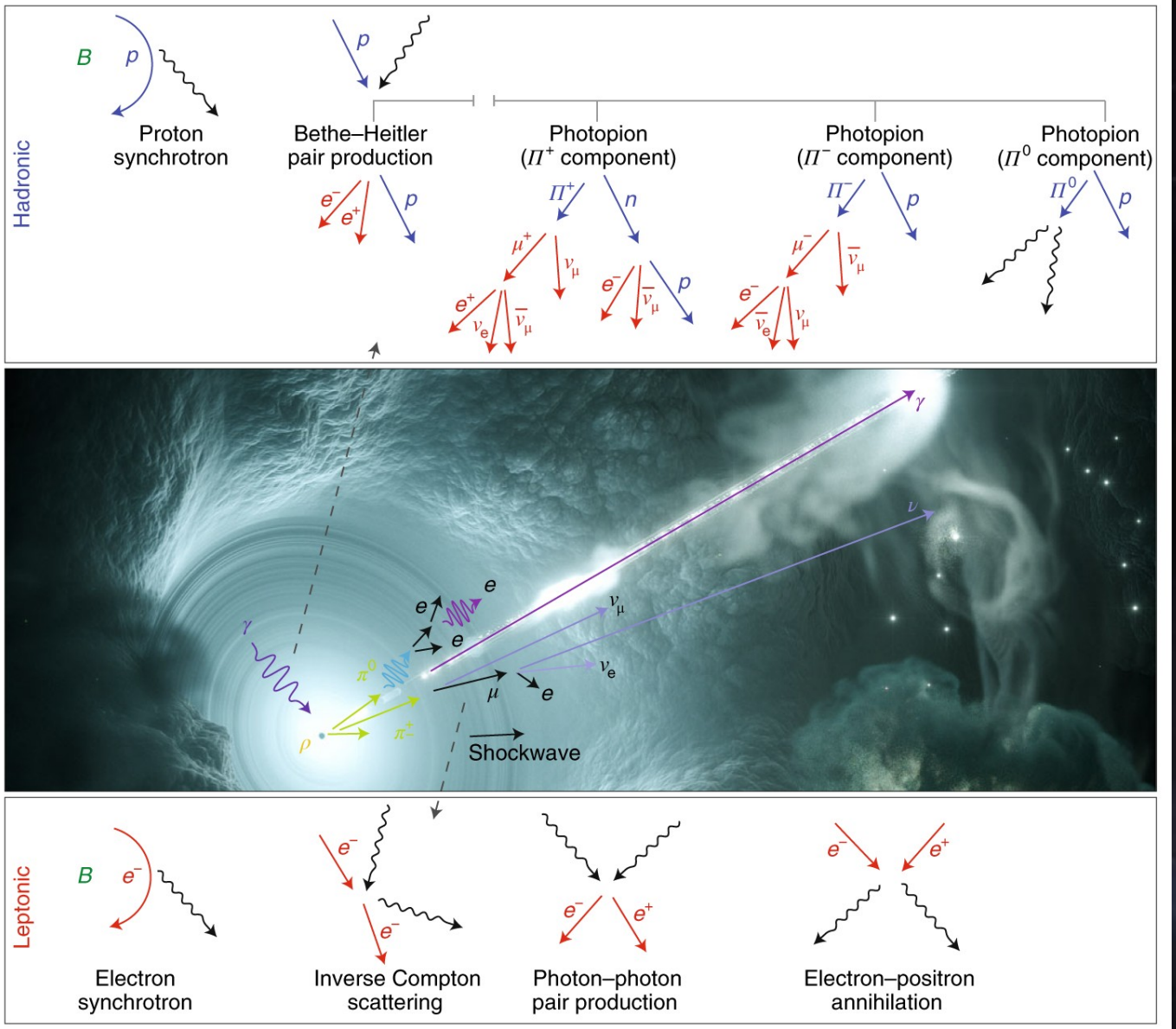

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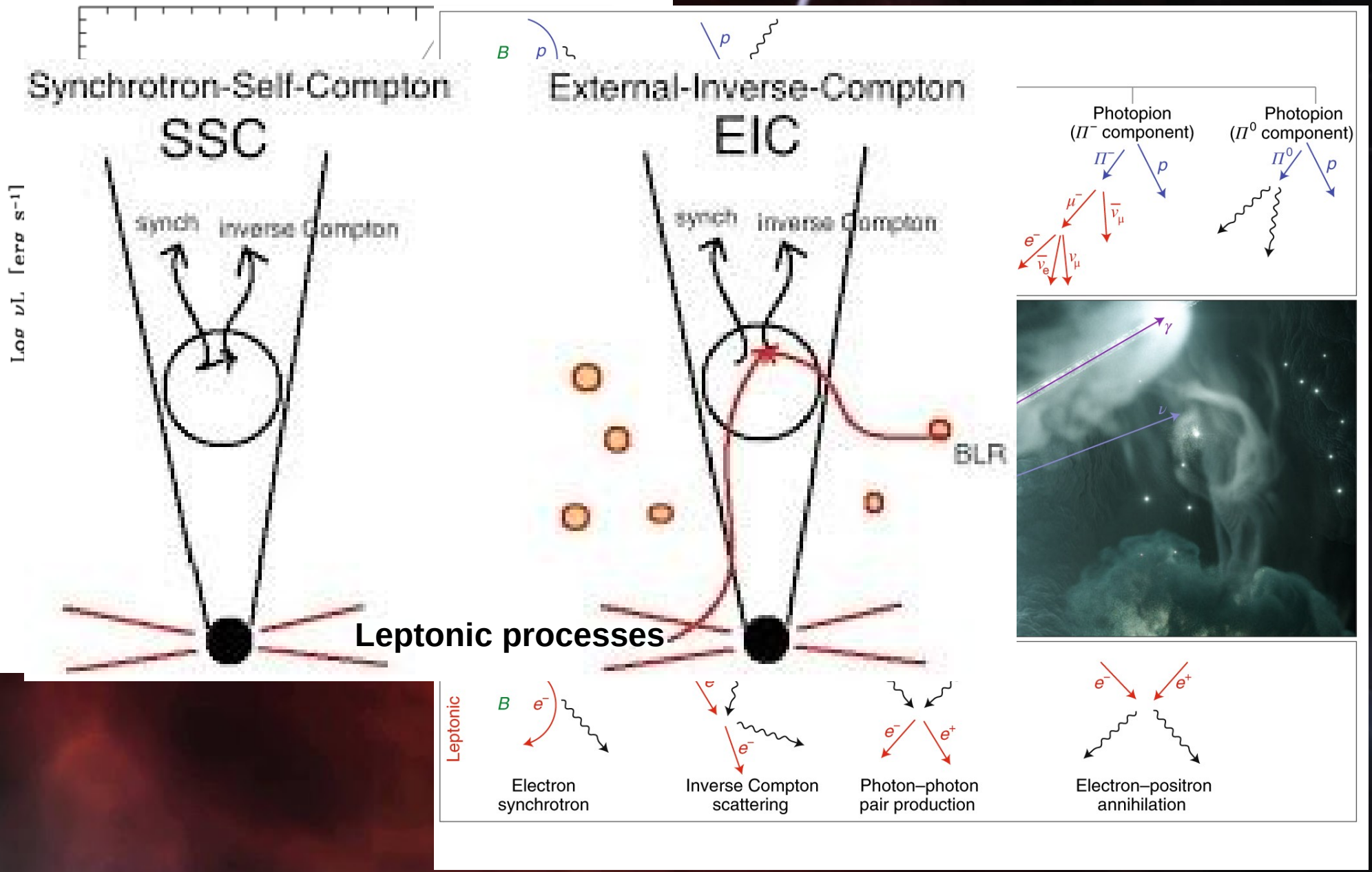
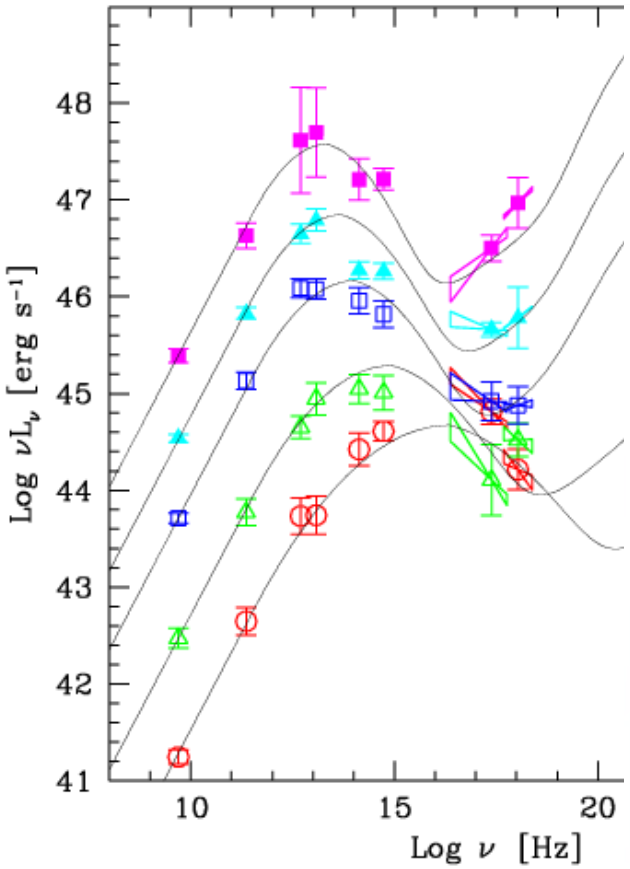
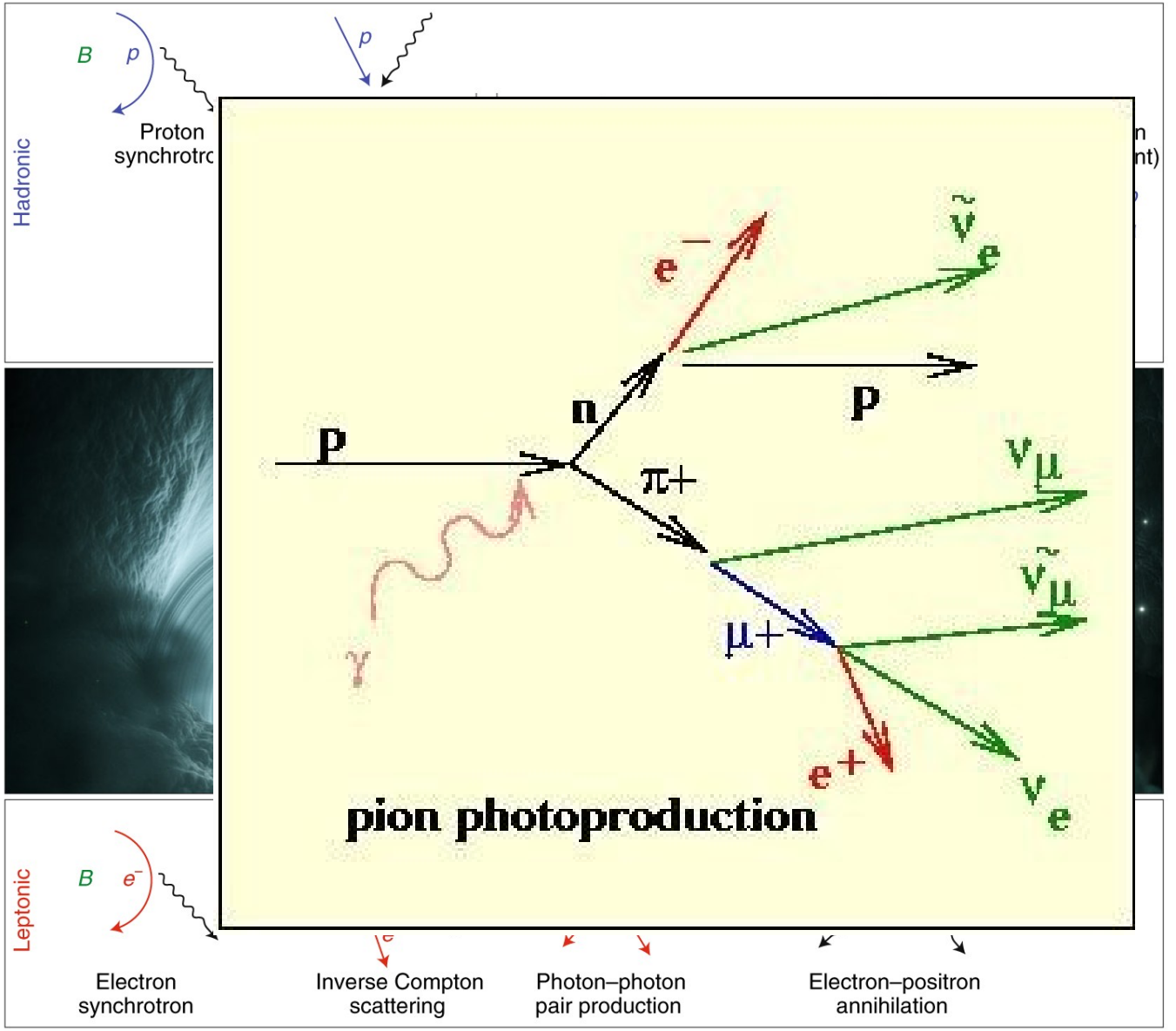


Leptonic processes

Where is the high-energy emission coming from?





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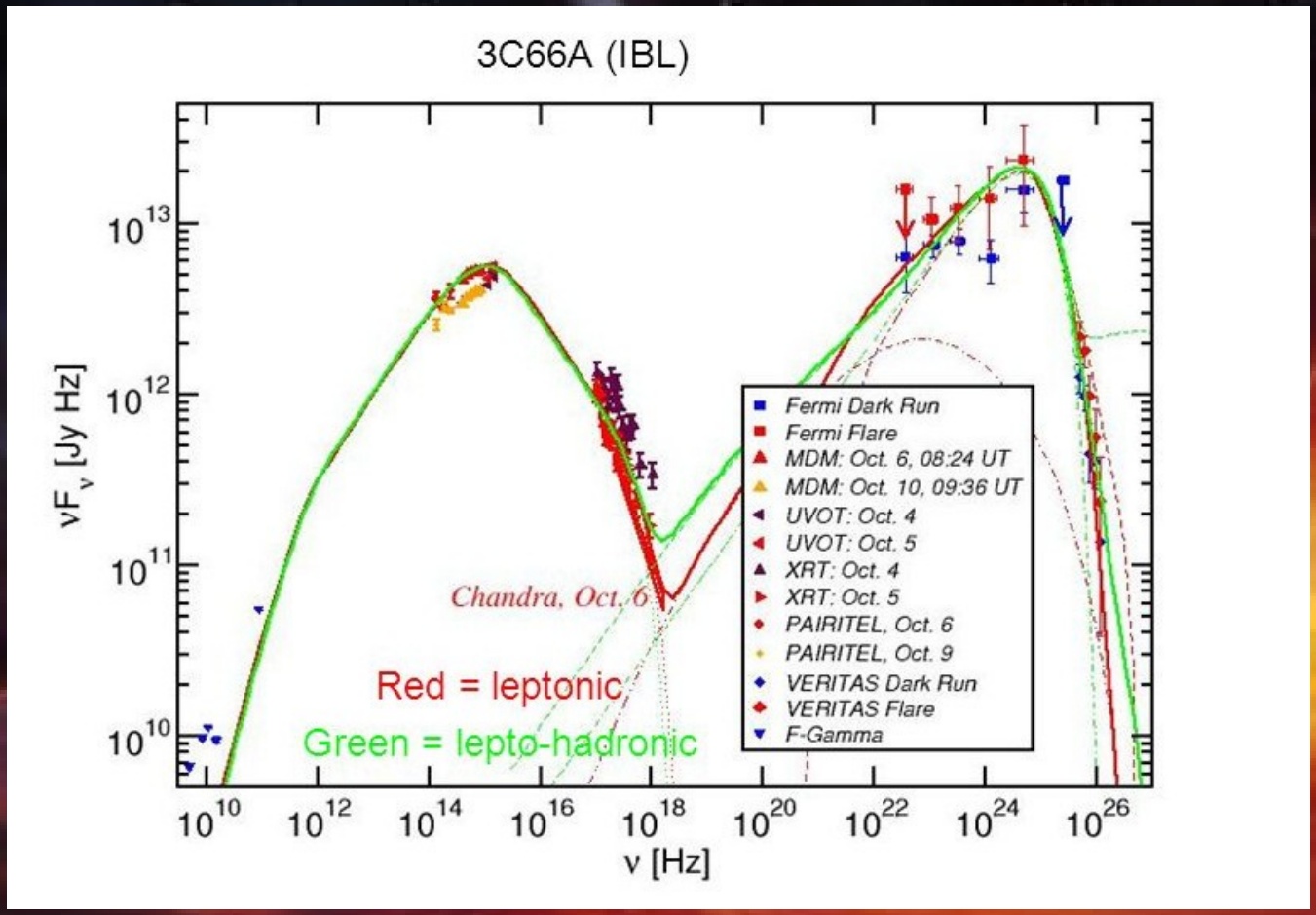

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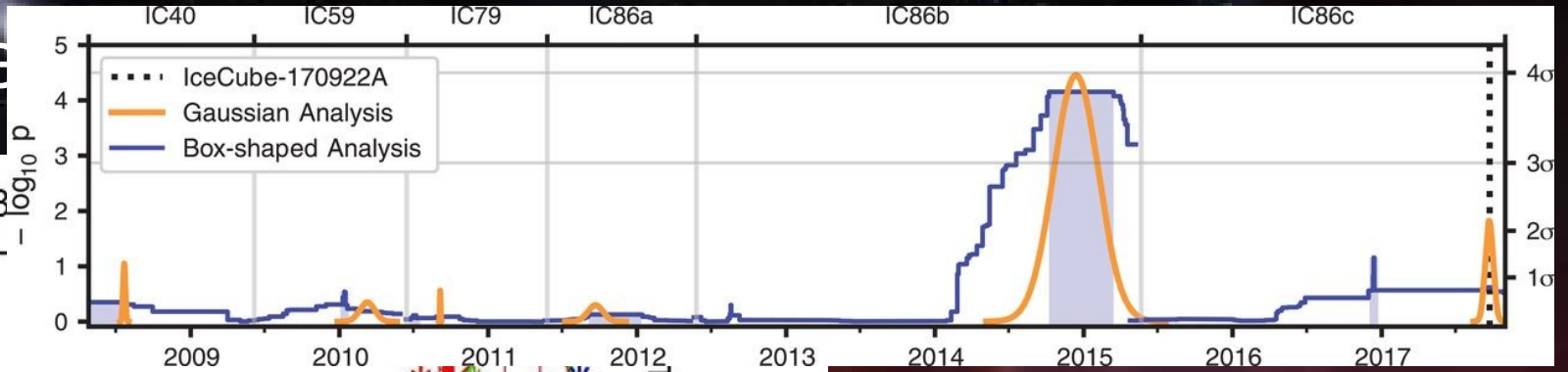
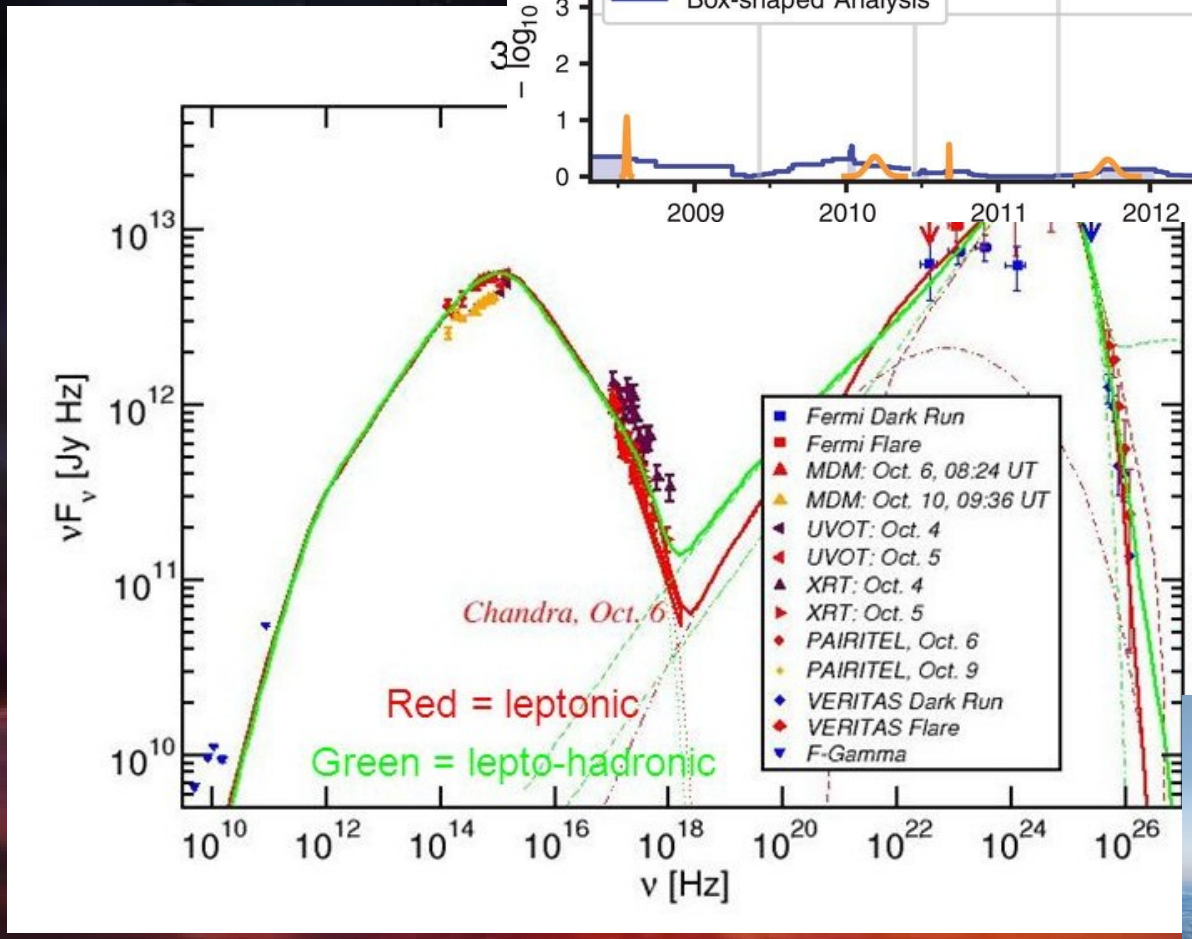
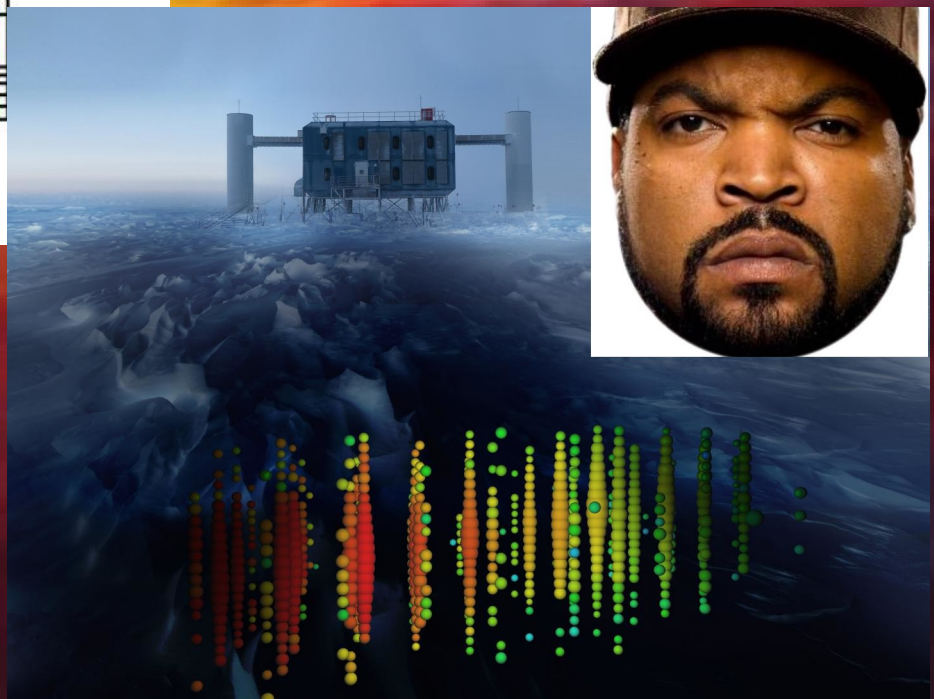




IceCube neutrino observatory



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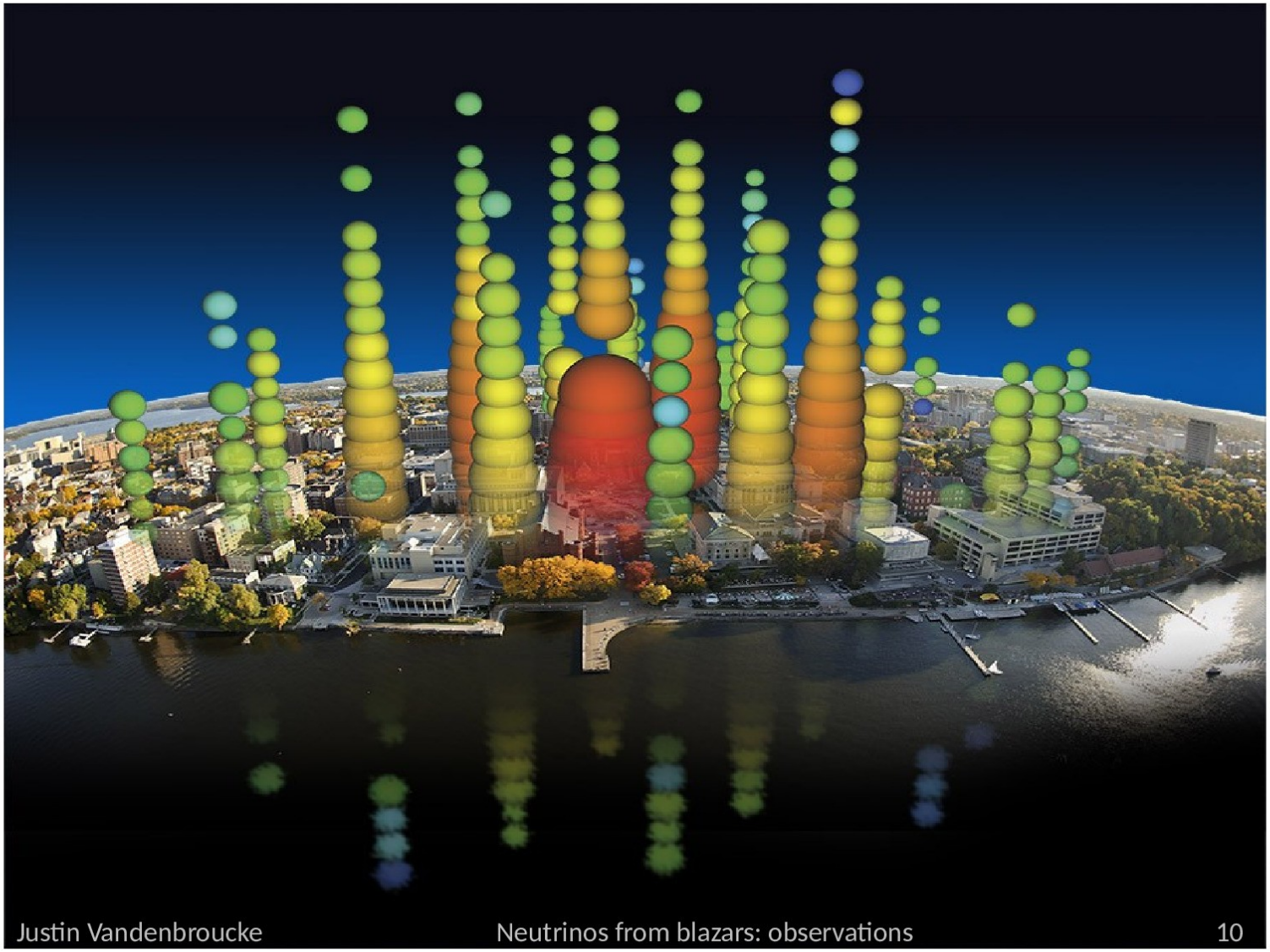
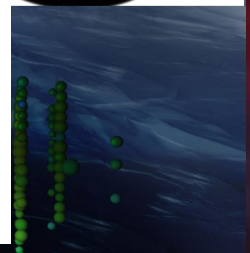


νF_ν [Jy Hz]

Justin Vandenbroucke Neutrinos from blazars: observations 10

rino
y



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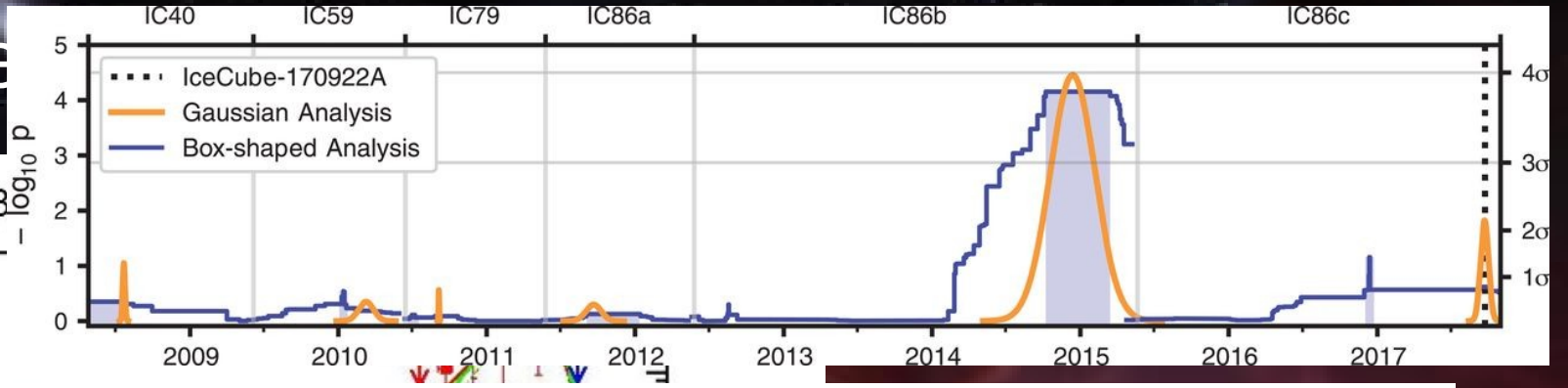
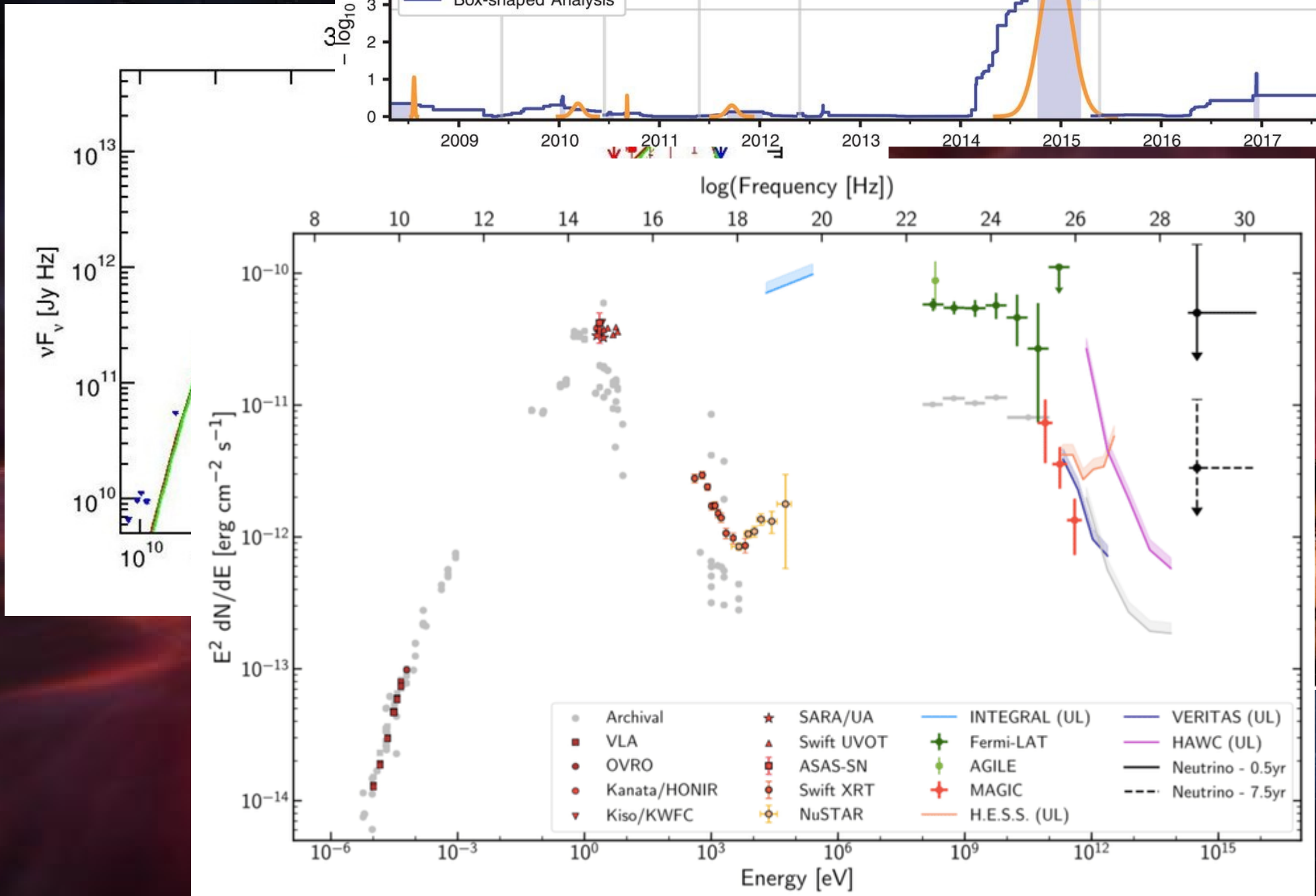
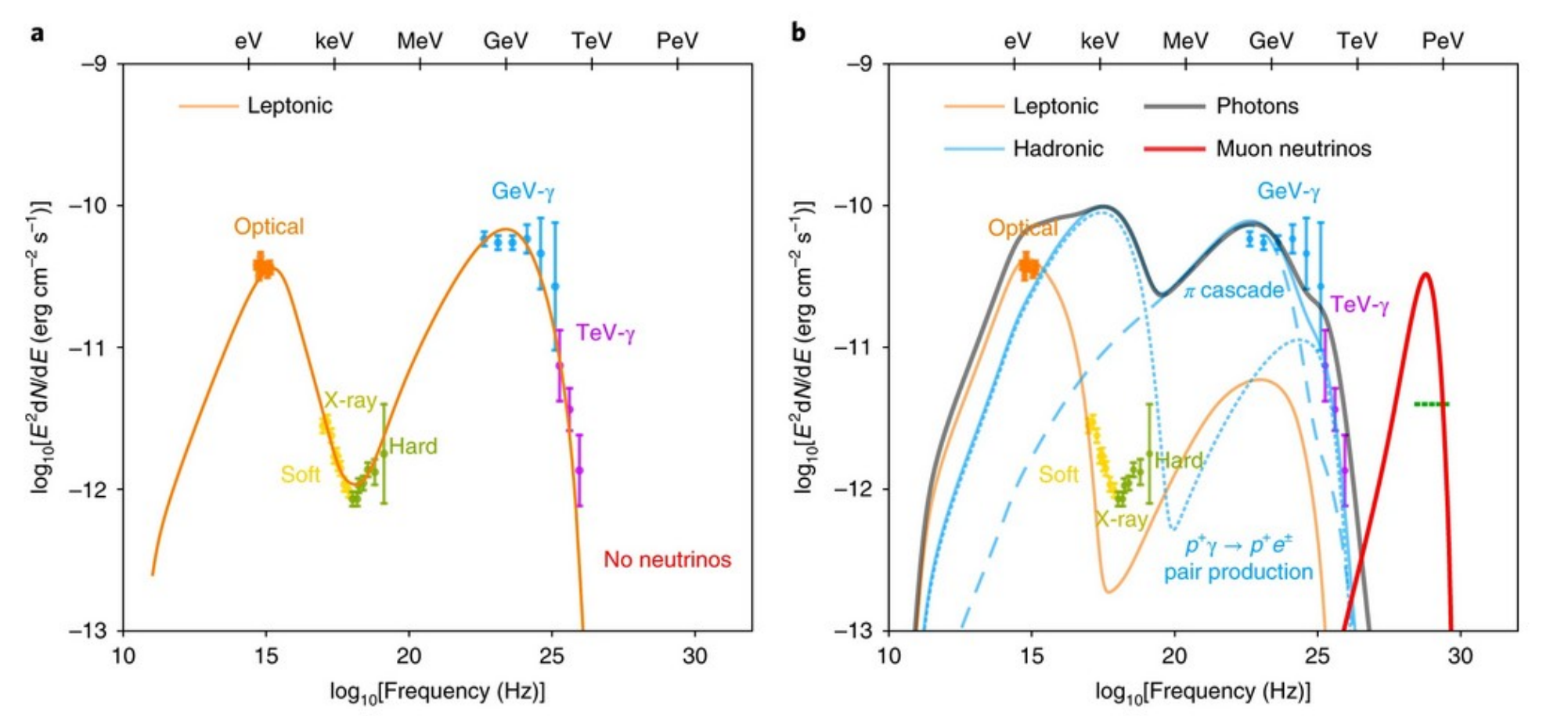

IC40
IC59
IC79
IC86a
IC86b
IC86c
IceCube-170922A
Gaussian Analysis
Box-shaped Analysis
$-\log_{10} p$
2009
2010
2011
2012
2013
2014
2015
2016
2017


log(Frequency [Hz])
νF_ν [Jy Hz]
E^2 dN/dE [erg cm^{-2} s^{-1}]
Energy [eV]
Archival
VLA
OVRO
Kanata/HONIR
Kiso/KWFC
SARA/UA
Swift UVOT
ASAS-SN
Swift XRT
NuSTAR
INTEGRAL (UL)
Fermi-LAT
AGILE
MAGIC
H.E.S.S. (UL)
VERITAS (UL)
HAWC (UL)
Neutrino - 0.5yr
Neutrino - 7.5yr

Where is the neutrinos coming from?



Gao et al., (2019, arXiv: 1807.04275)

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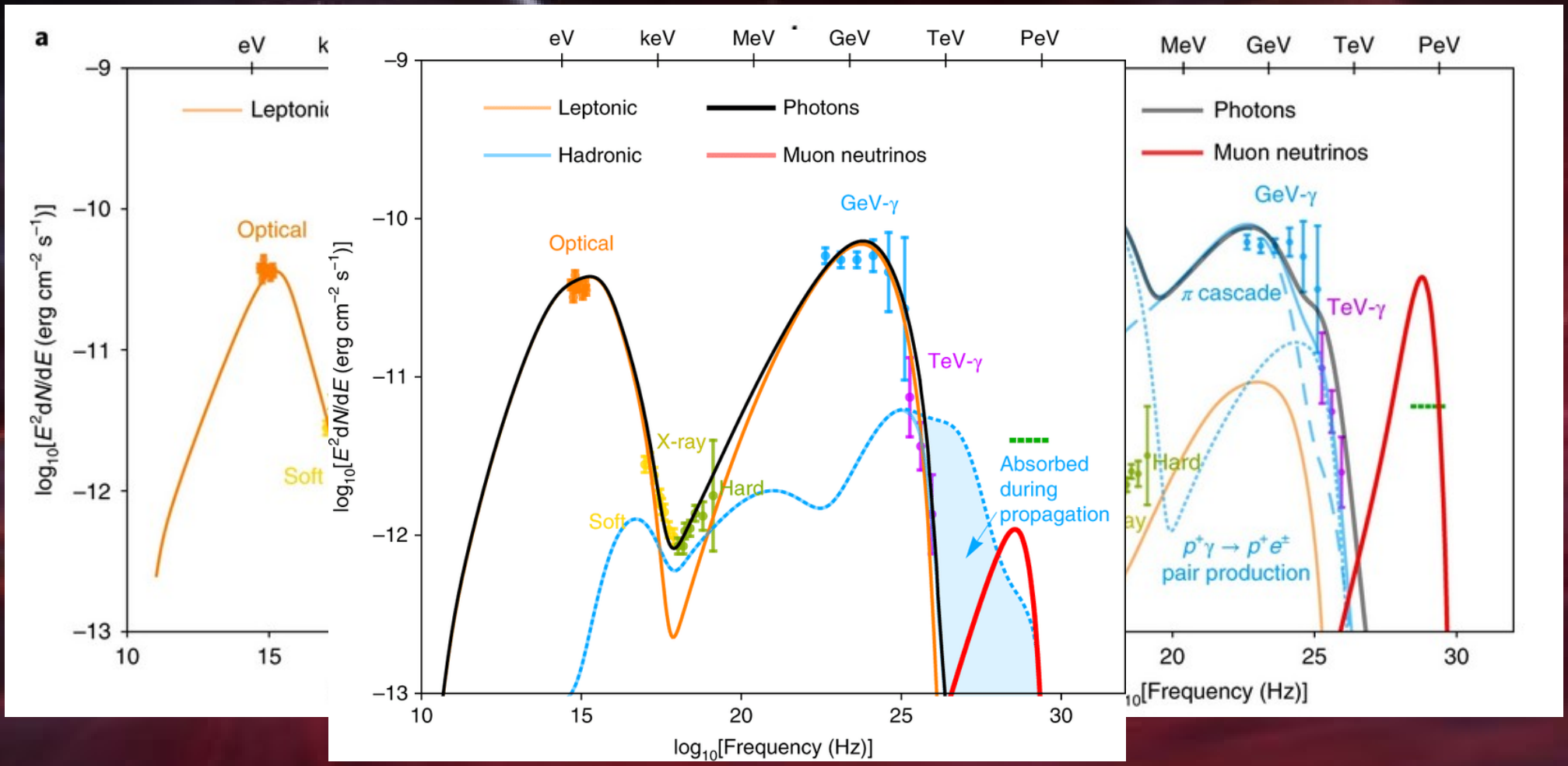

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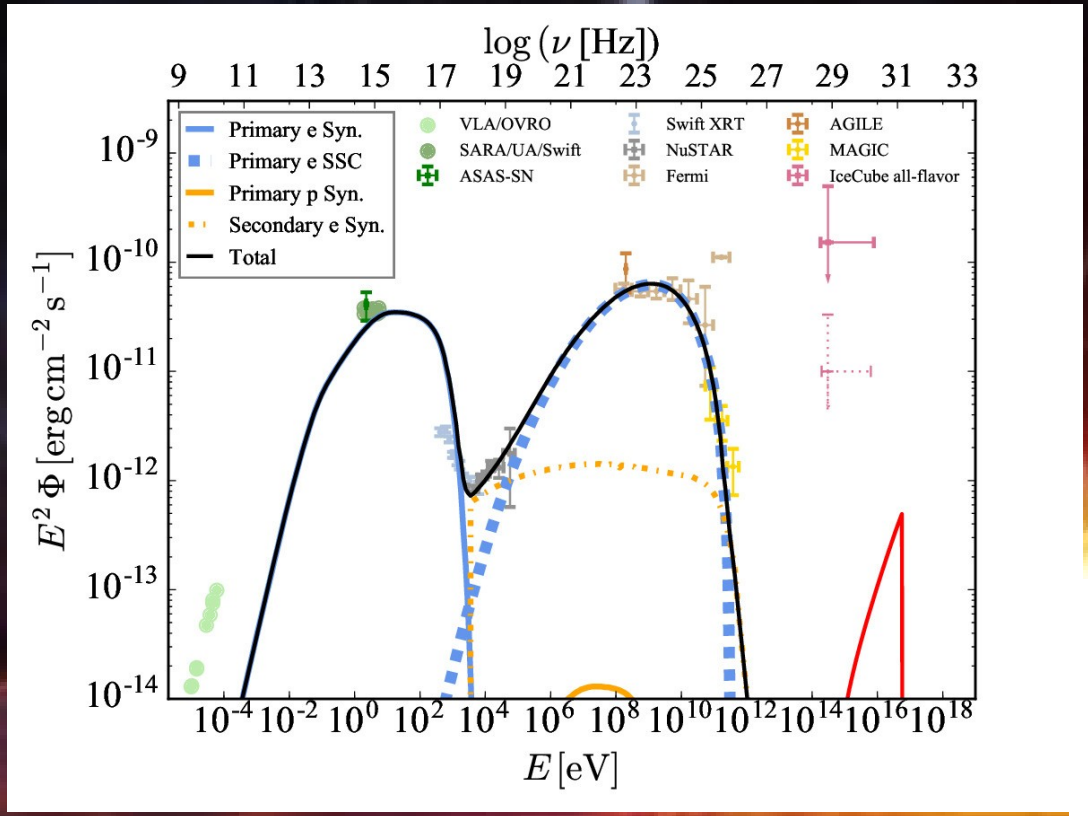
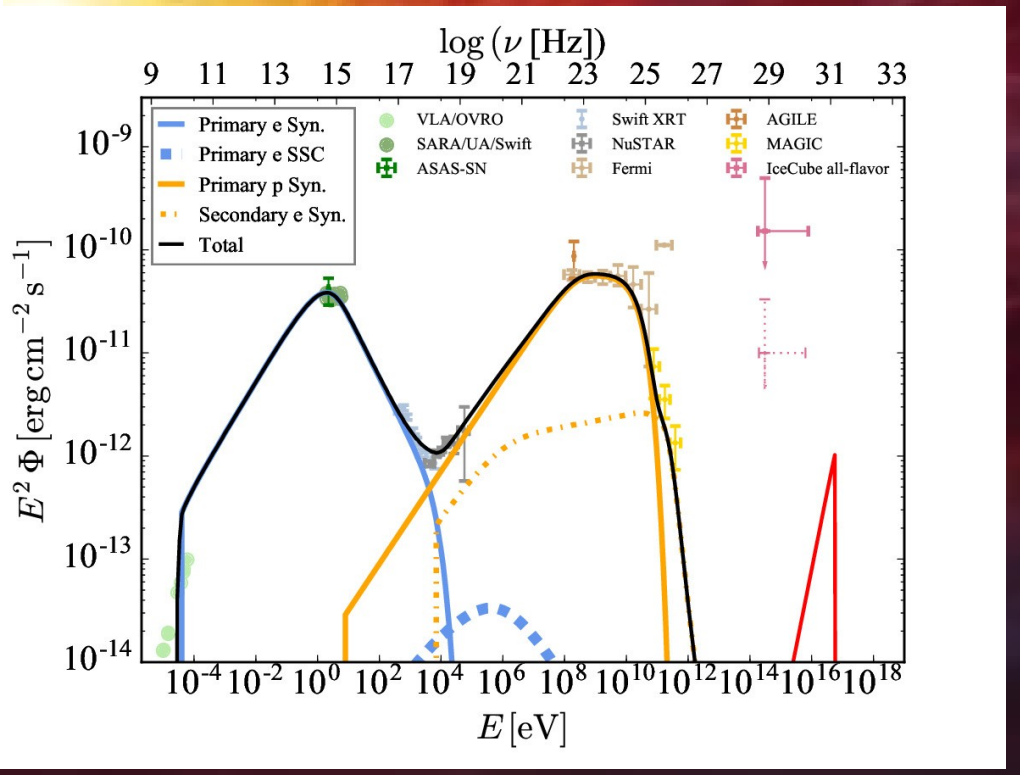




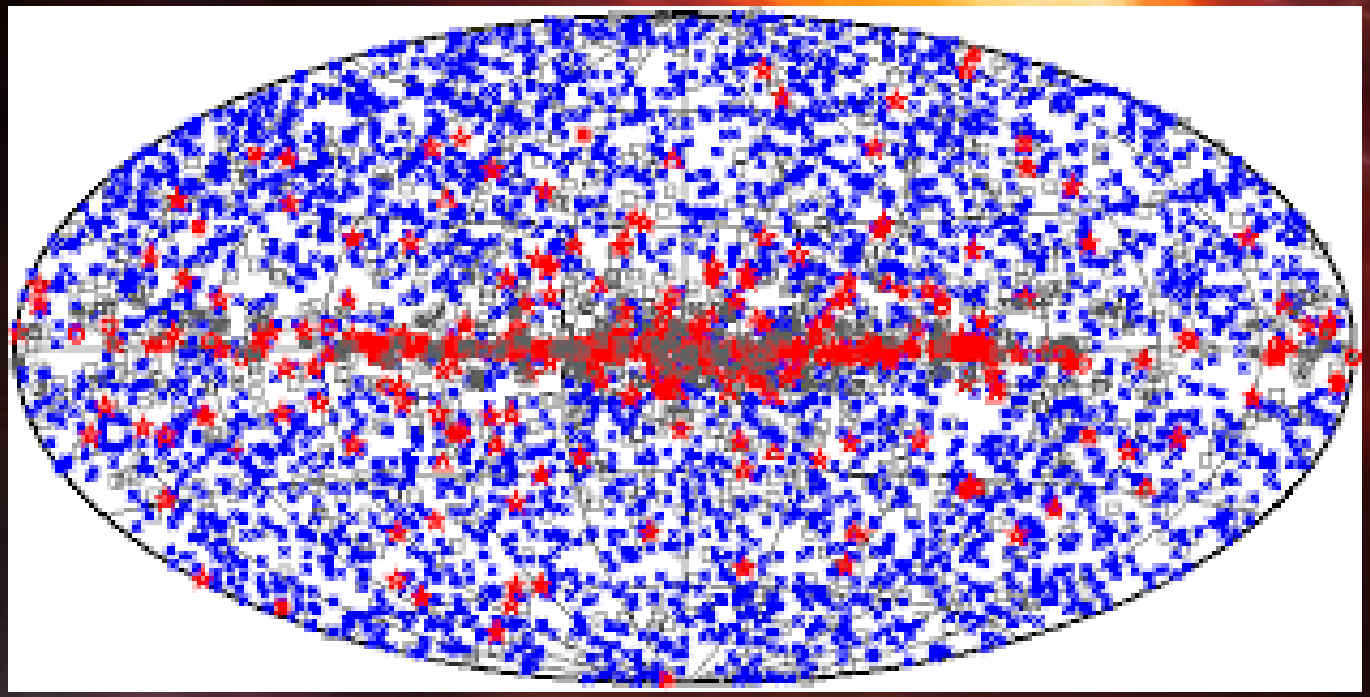
Zhang et al., (2018, arXiv:1807.11069)

Looking for correlated variability

Launched in 2008

Surveying the entire sky in the 0.1-300GeV (up to 1 Tev) range every 3 hours

Fermi



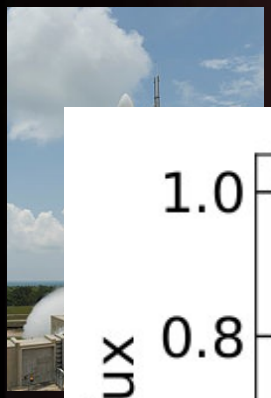
>5000 sources

57% of all detected point sources are blazars

Looking for correlated variability

Fermi

Surveying the entire sky in the



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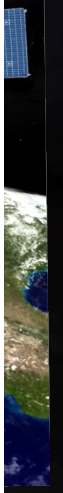
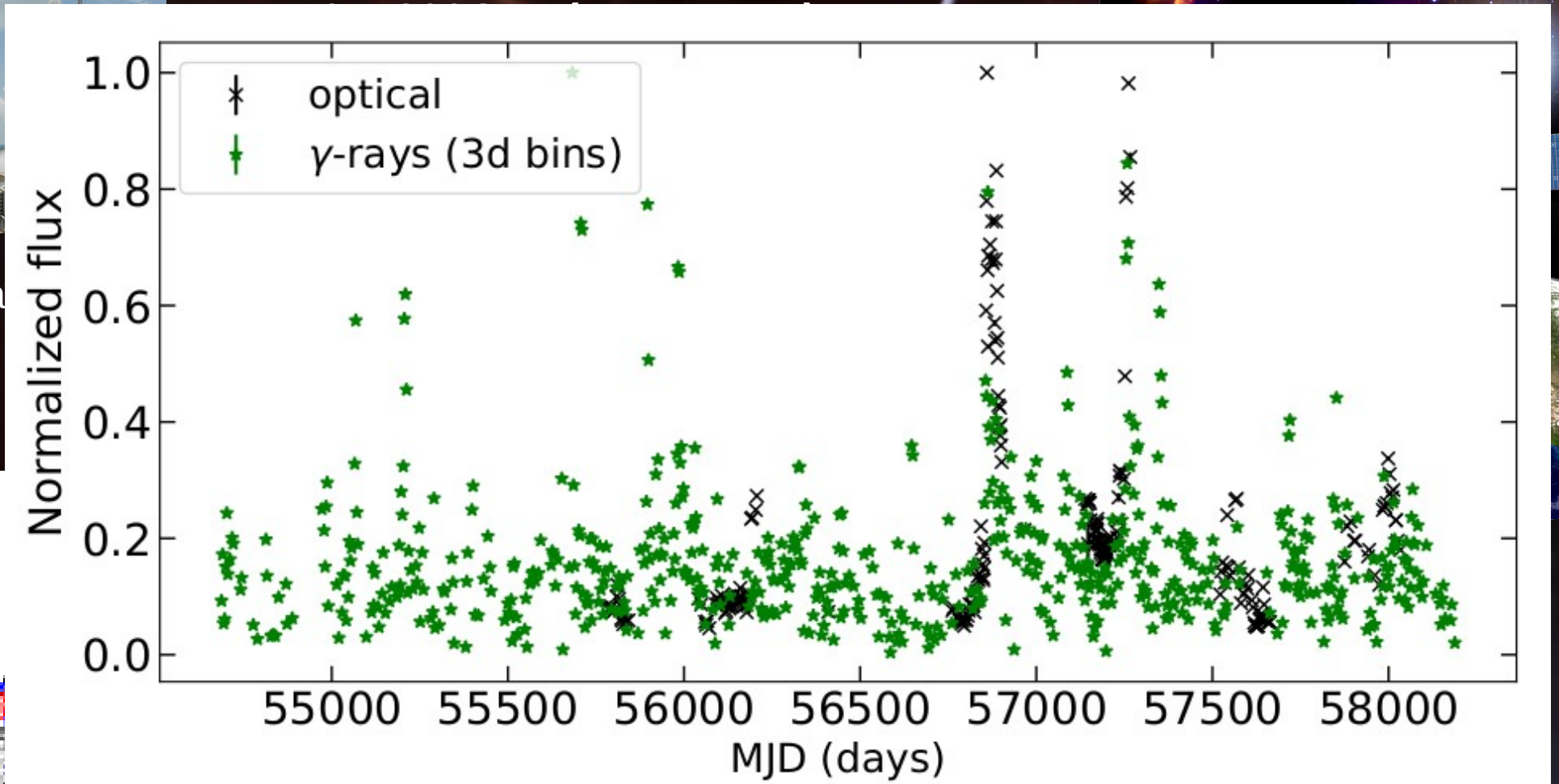
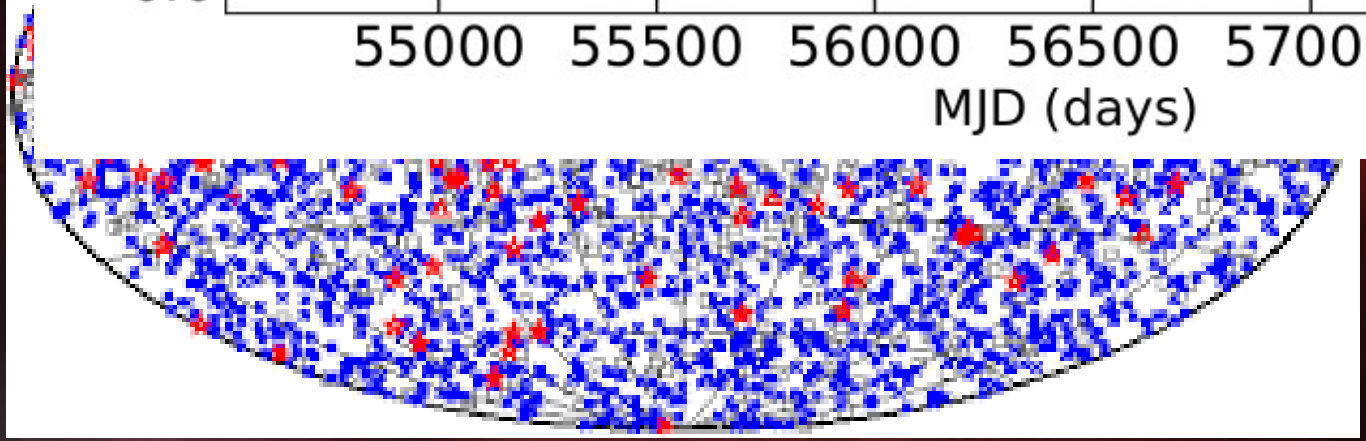
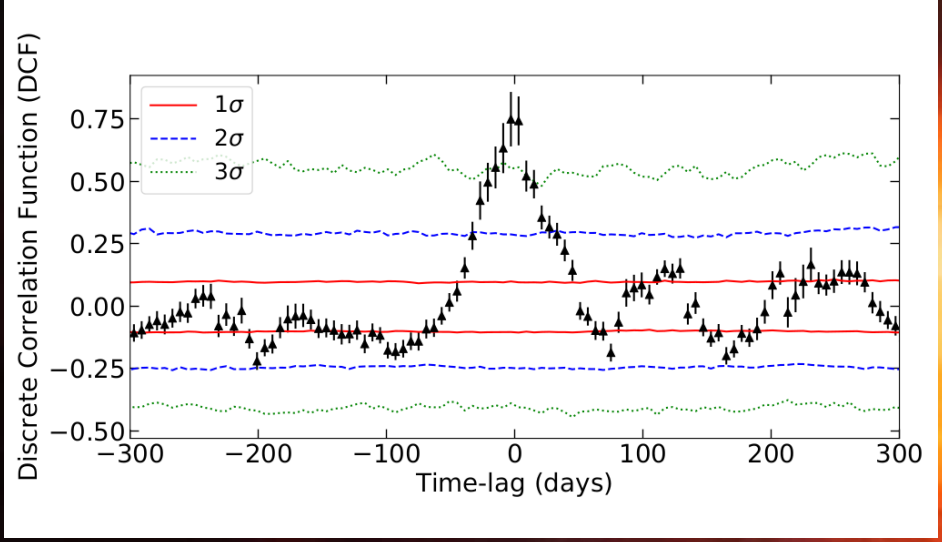






Looking for correlated variability

Time-lags: Discrete correlation function
(Edelson & Krolic 1988)



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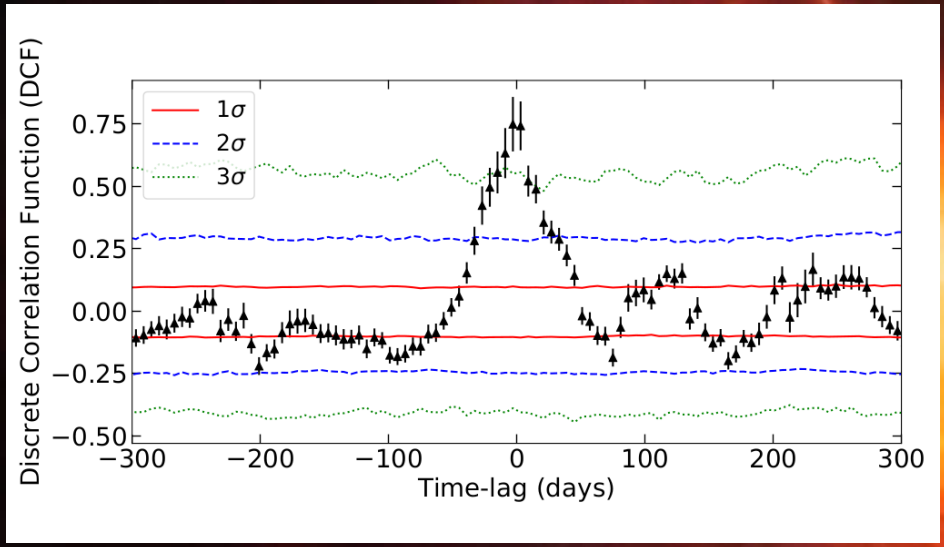
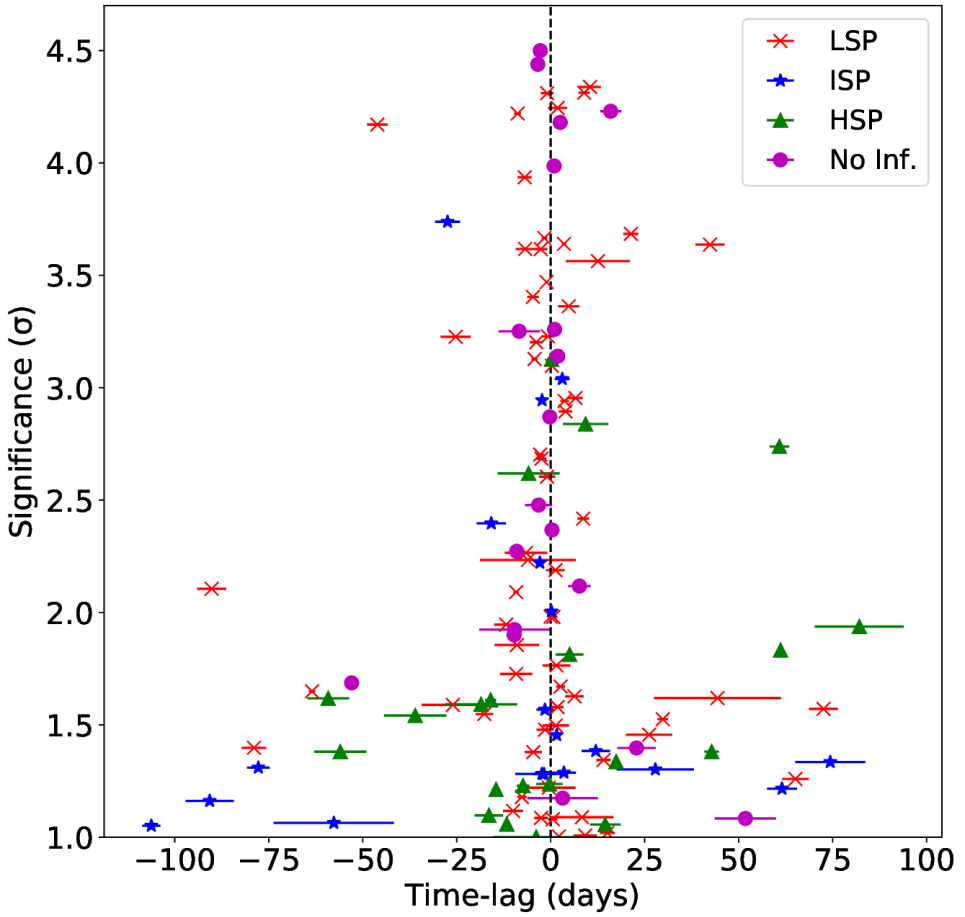


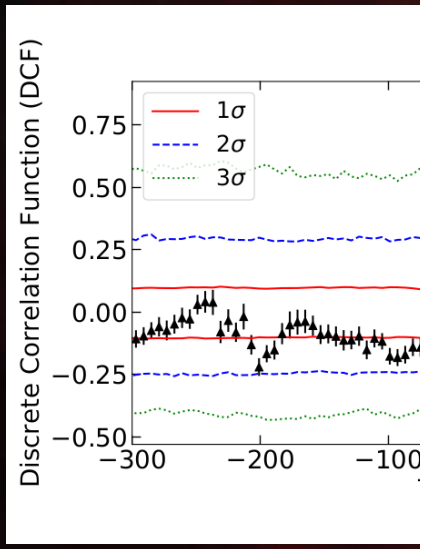
121/178 sources showed a >1σ significant correlation.

No statistically significant difference is found between different populations



Looking for correlated variability

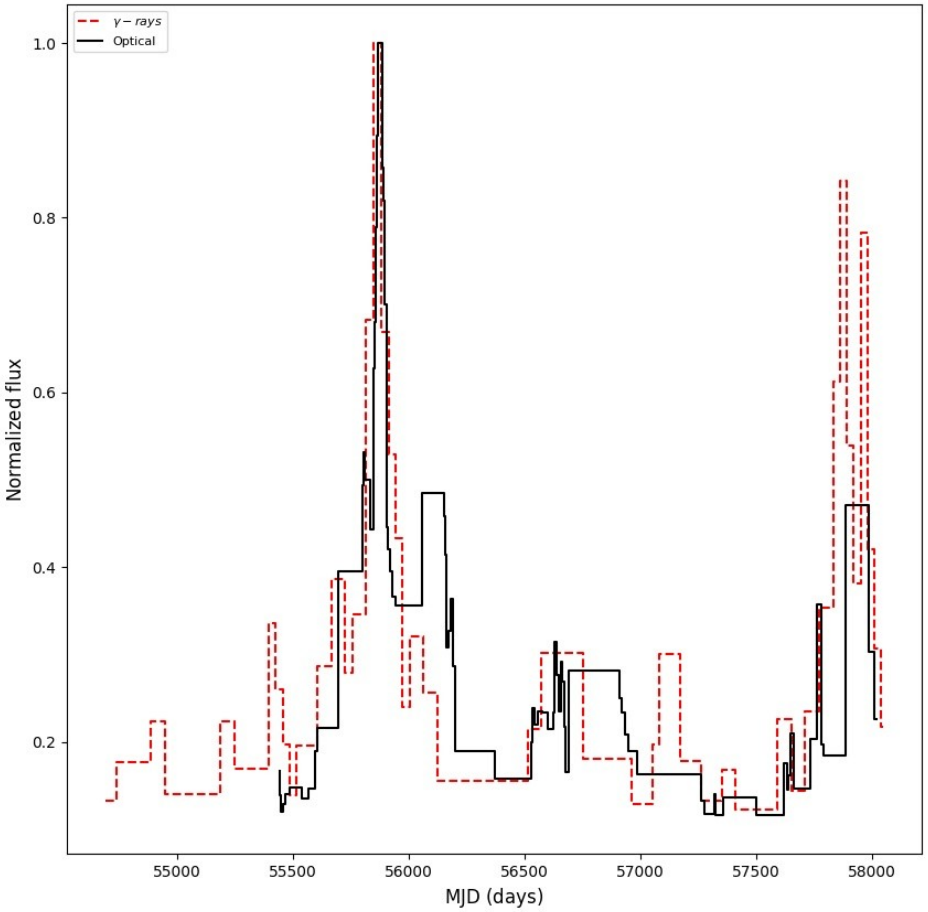
Time-lags: Discre
(Edelson

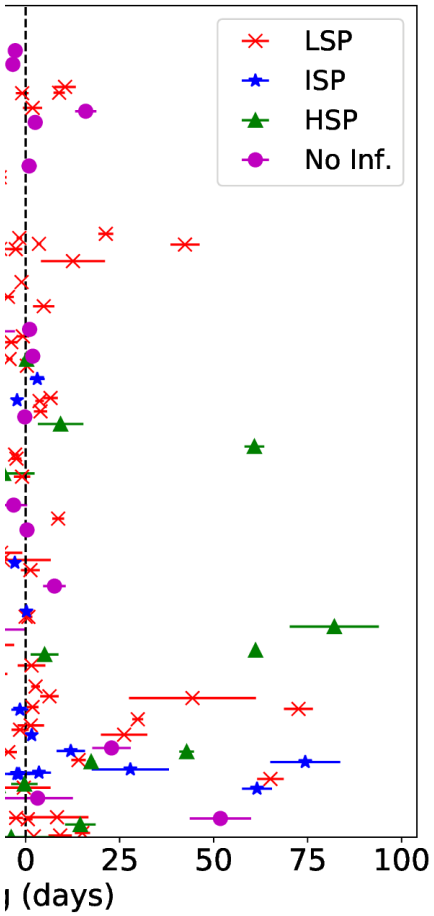


121/178 sou
significa

No statistically
is found between different
populations

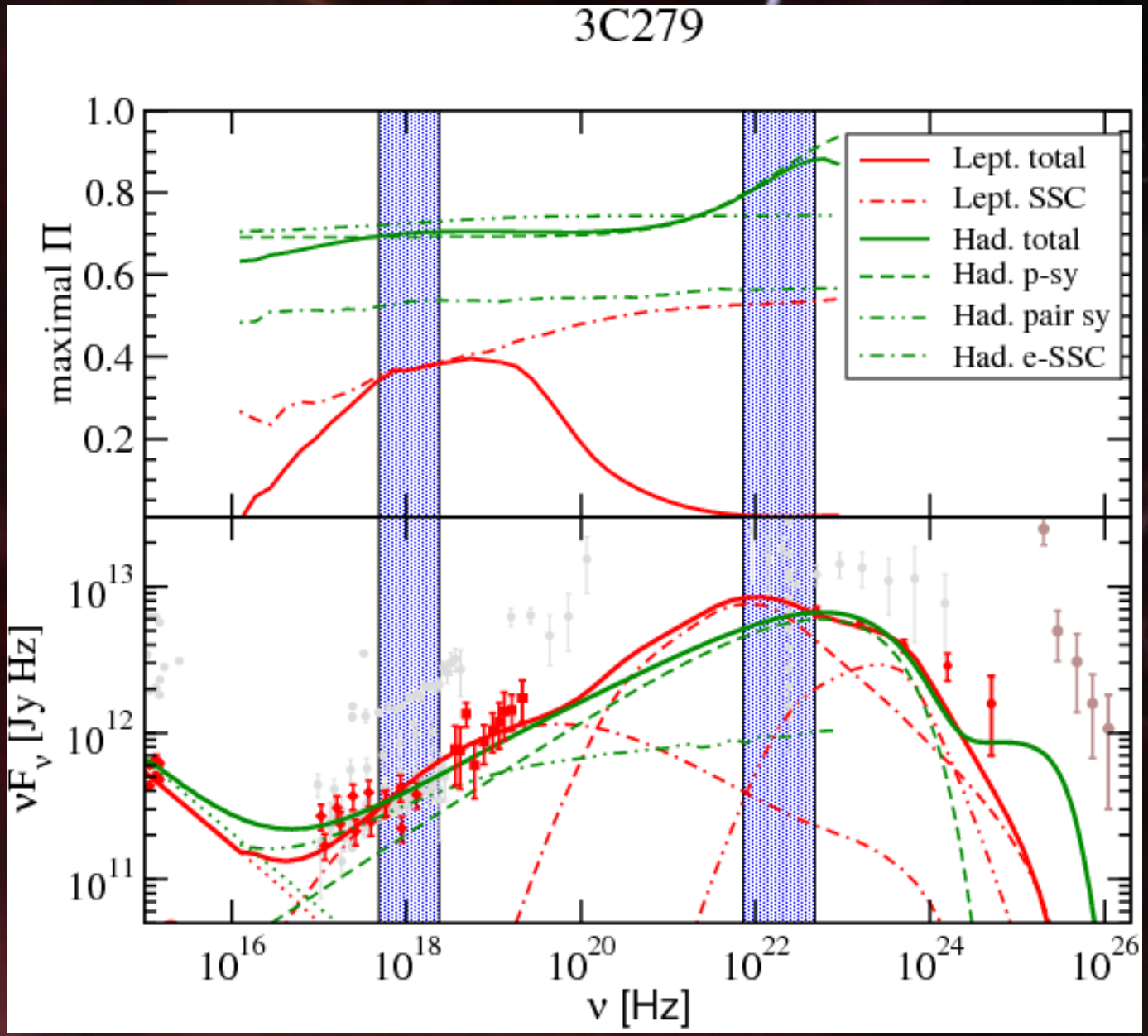
21% of γ-ray events are orphan!





Can high-energy polarization help?

Zhang et al. (2014, arXiv:1401.7138)



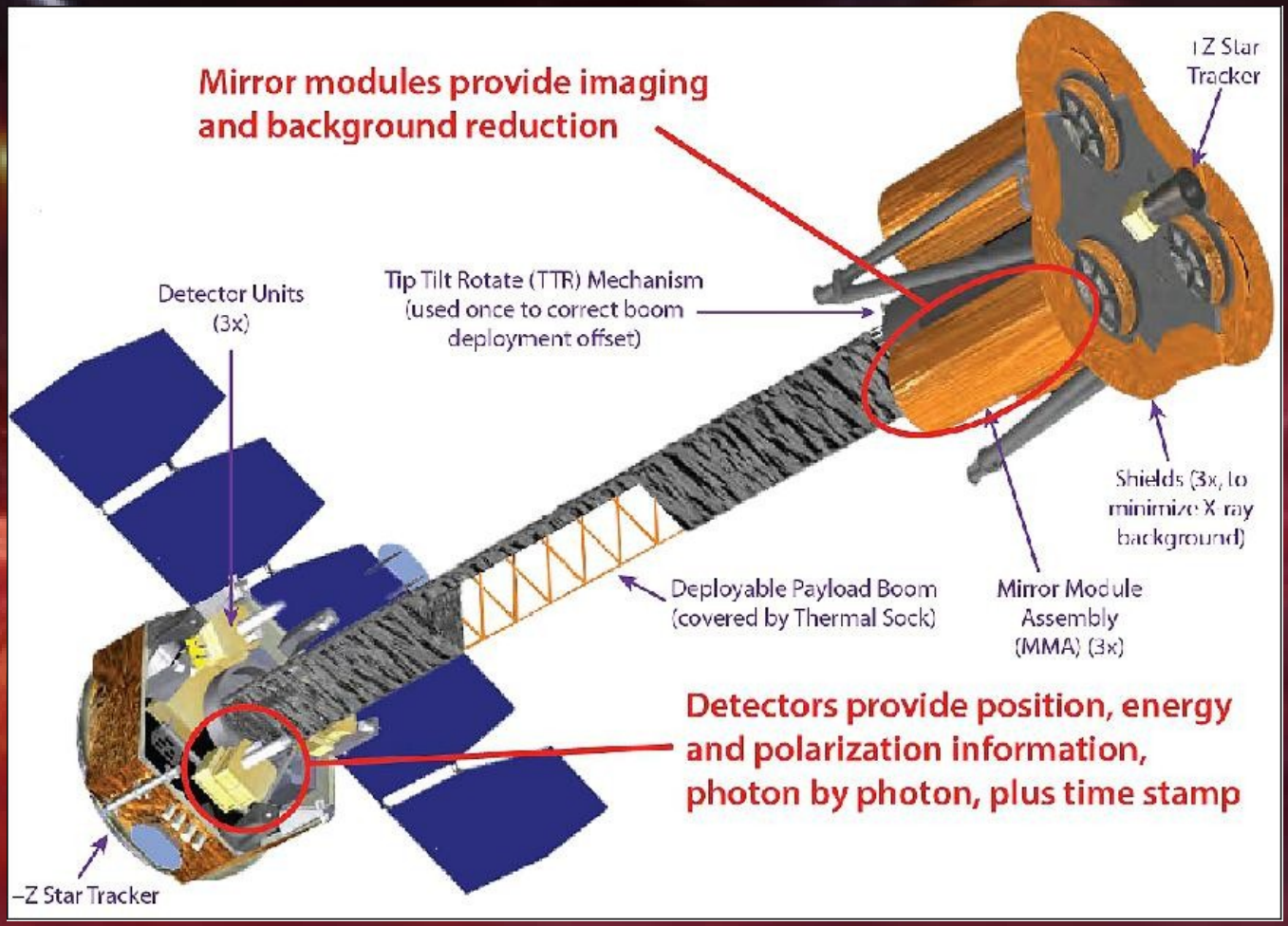
The Imaging X-ray Polarimetry Explorer

Small NASA mission

~2 year lifetime

Launch ~Q1 2021

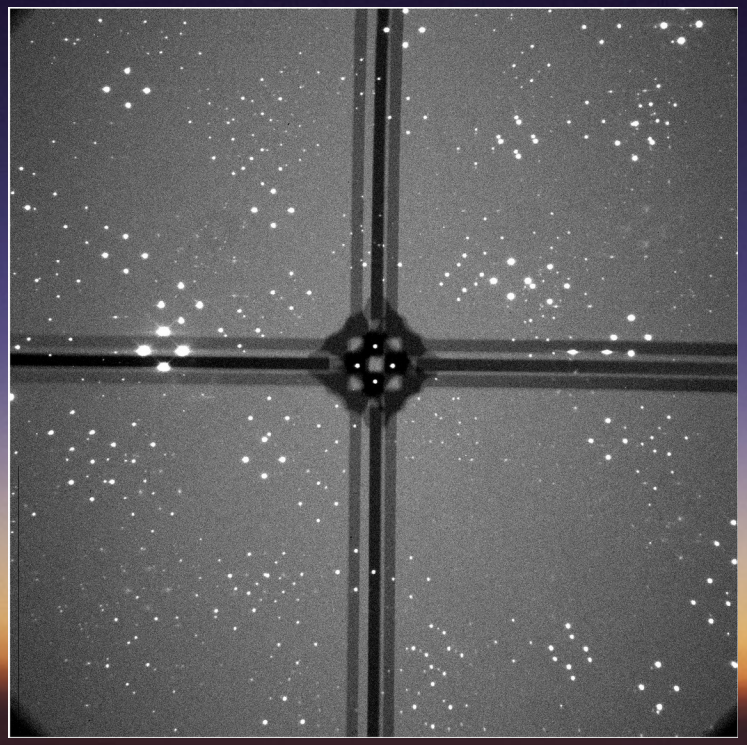
1-10 keV
(2-8 keV sweet spot)

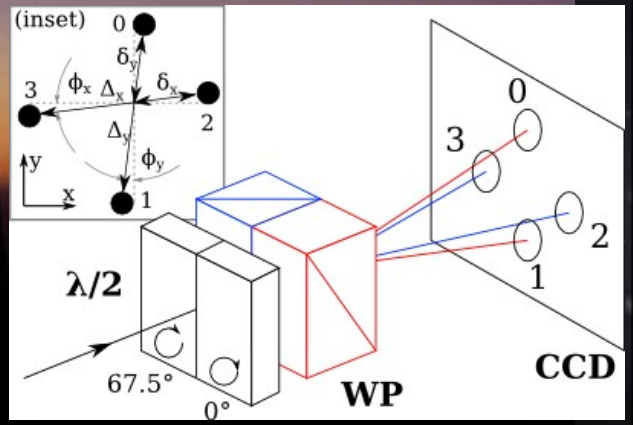


The RoboPol survey

RoboPol observed ~200 blazars over three years.

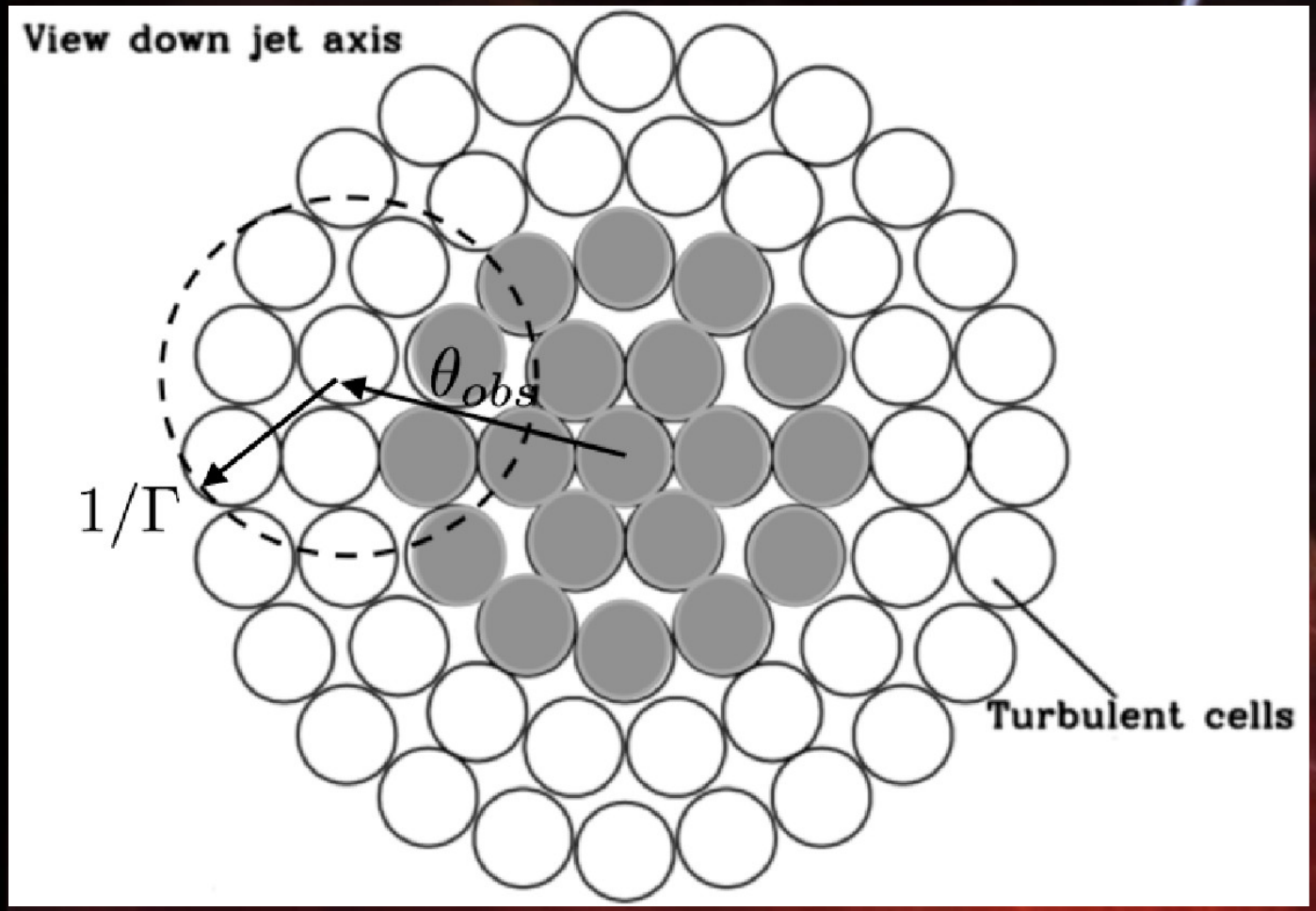
RoboPol also observed stars, White dwarfs, X-ray binaries, GRBs, Gravitational wave candicates...





robopol
robotic polarimeter in crete

Jet model and simulations



Lawrence Peirson

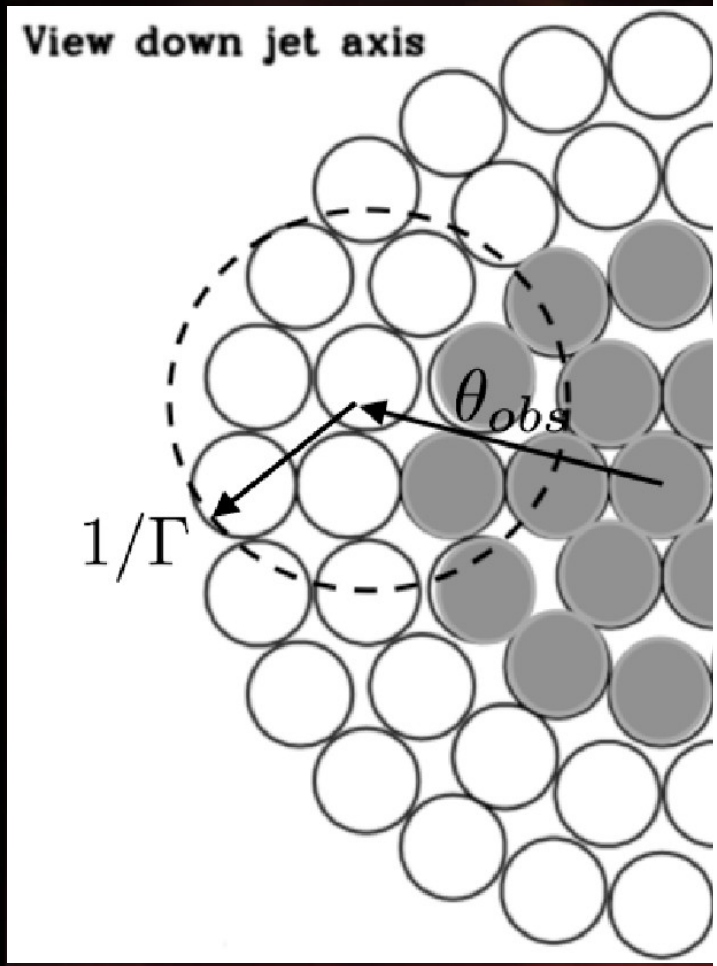
https://www.alpeirson.com/

Marscher (2014,arXiv:1311.7665)
Peirson & Romani (2018,arXiv:1807.10732)

$$\Pi_{obs} = \Pi_{max} / \sqrt{N}$$

Jet model and simulations

Liodakis et al (2019,arXiv:1906.01647)



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Peirson & Romani (2018,arXiv:18

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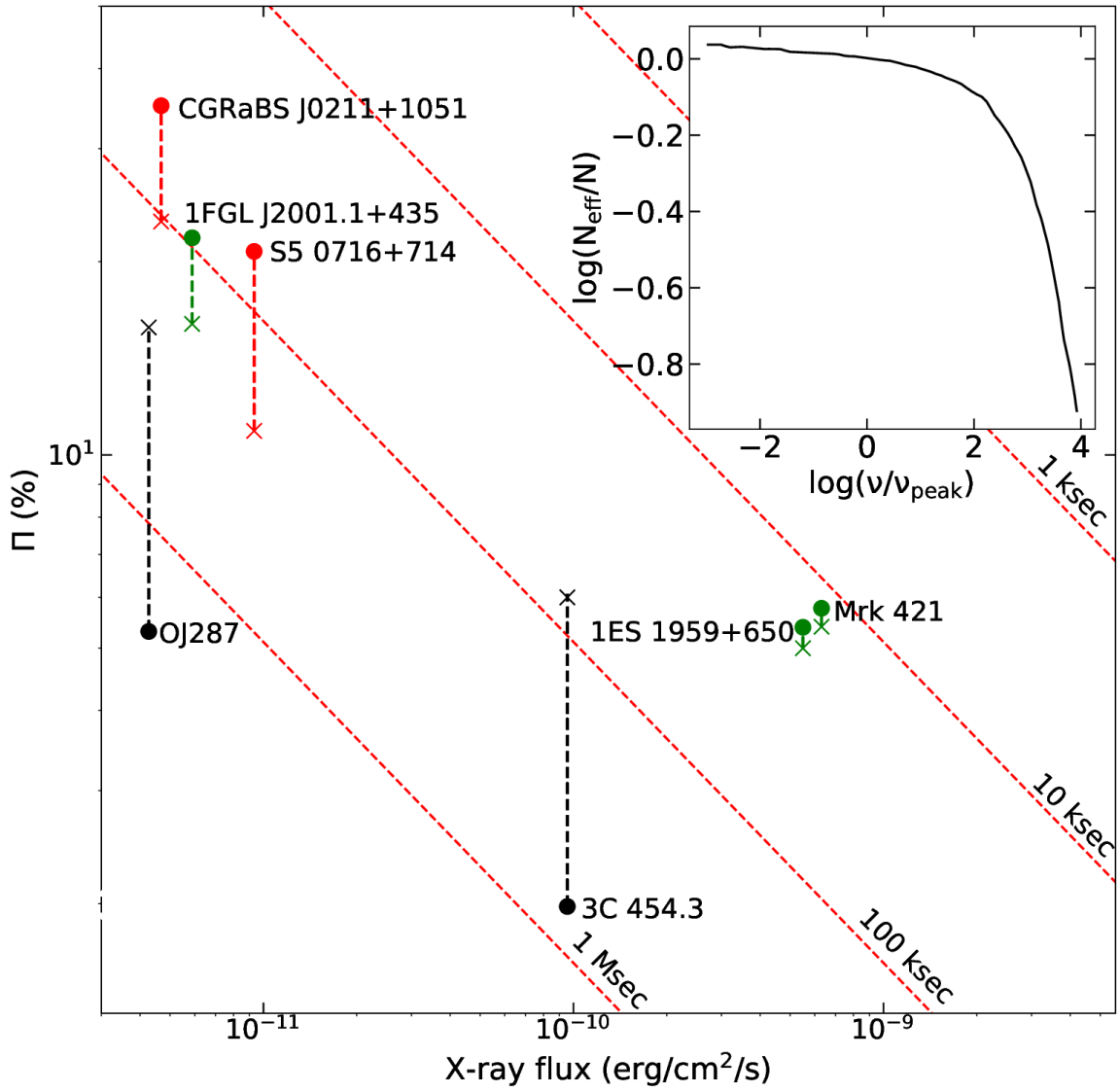
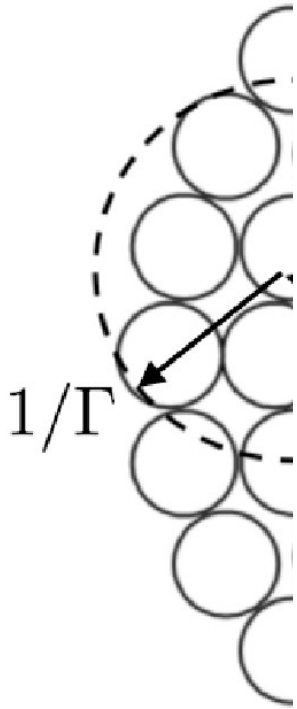


Jet model and simulations

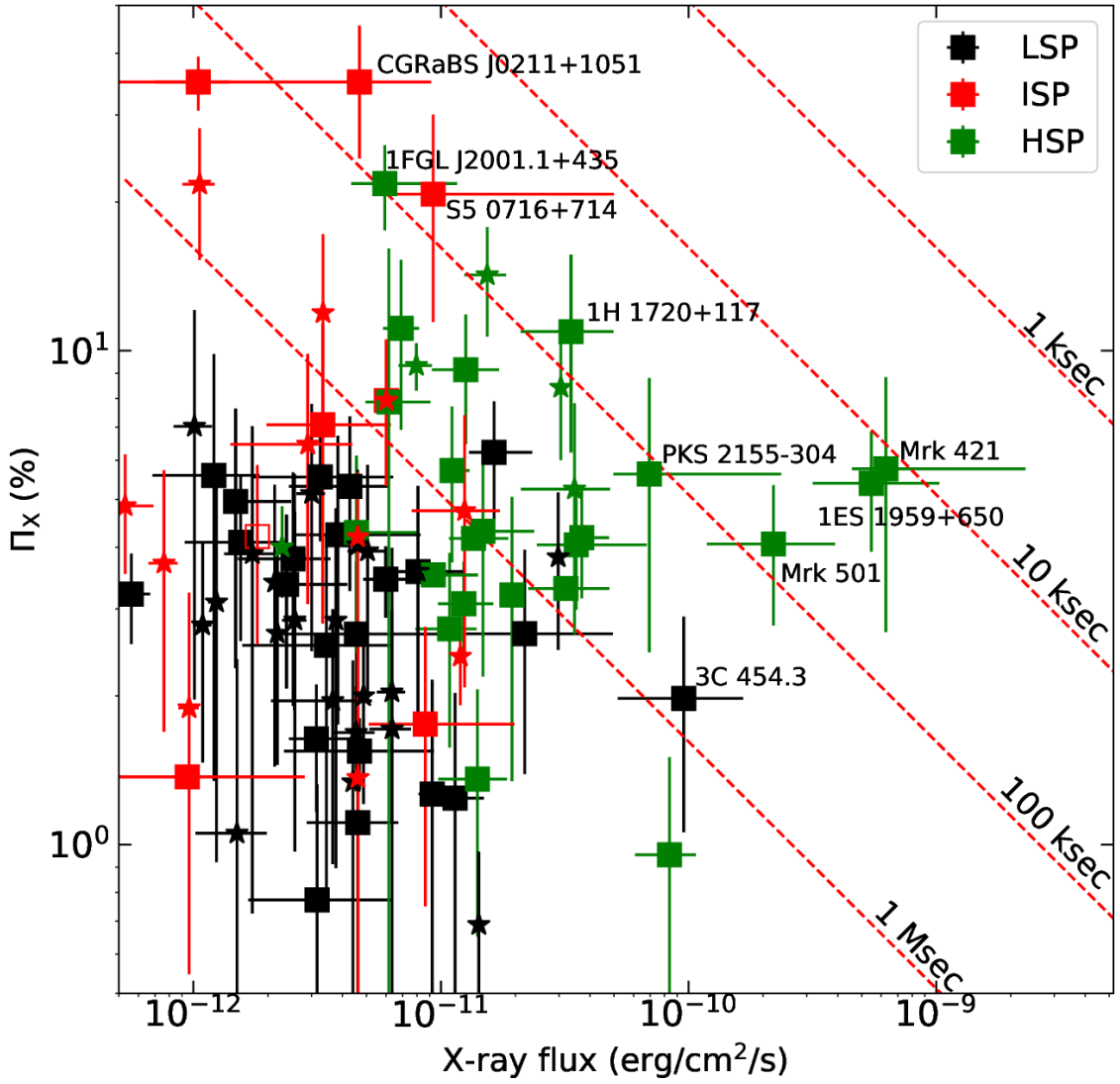
Liodakis et al (2019,arXiv:1906.01647)

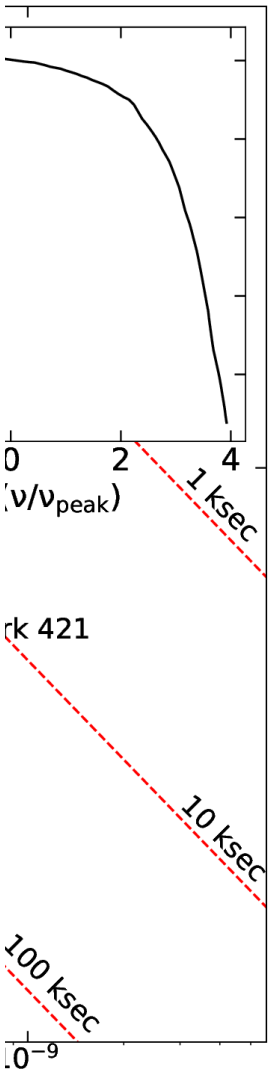
View down jet a



Marscher (2014,
Peirson & Roma

Π_{obs}





Take home message:

Astrophysical jets are exciting cosmic laboratories!

Still a lot of questions on the where and how γ-rays are made….

High-energy polarization will have answers soon!