Multi-wavelength and neutrino emission from blazar PKS 1502+106

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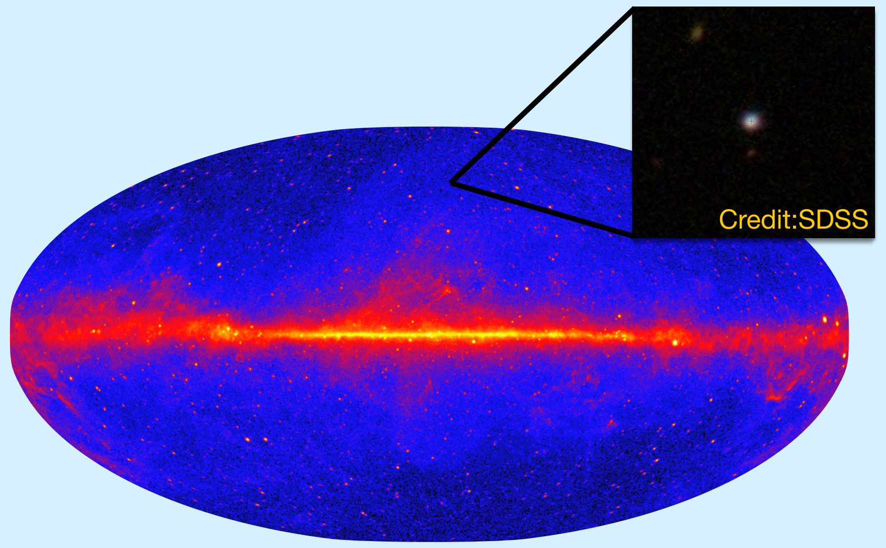


Credit: NASA/DOE/Fermi-LAT

PKS 1502+106 is a flat-spectrum radio quasar (**FSRQ**).

The **supermassive black hole** in its core launches a **relativistic jet** in the direction of Earth, leading to the observation of powerful and highly variable multi-wavelength emission from non-thermal processes

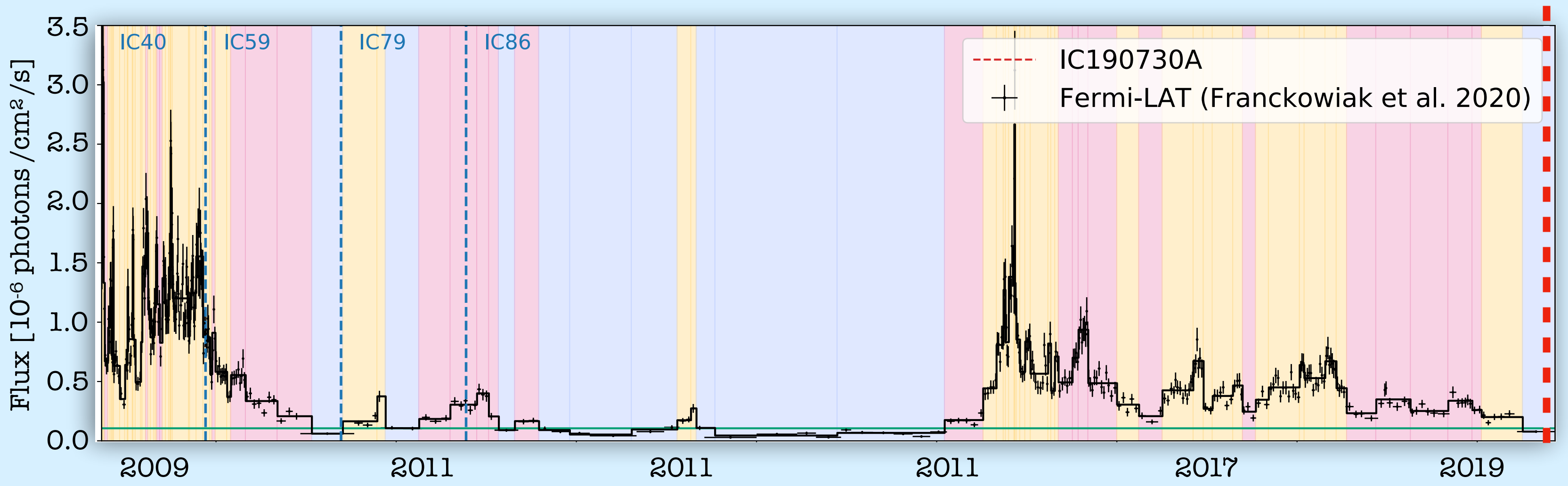
In spite of its high redshift of 1.82, it is **among the 15 brightest** sources in the gamma-ray sky

On July 30, 2019, the **IceCube detector**, located in the South Pole, observed a **neutrino** with an estimated energy of **300 TeV** from the direction of **PKS 1502+106** (IceCube Coll. 2019, GCN#25225)

At the time the source was in a **quiescent state** of weak gamma-ray activity

Neutrino detection (IC-190730A)

Fermi-LAT lightcurve (Franckowiak et al. 2020, ApJ 893,2,162)



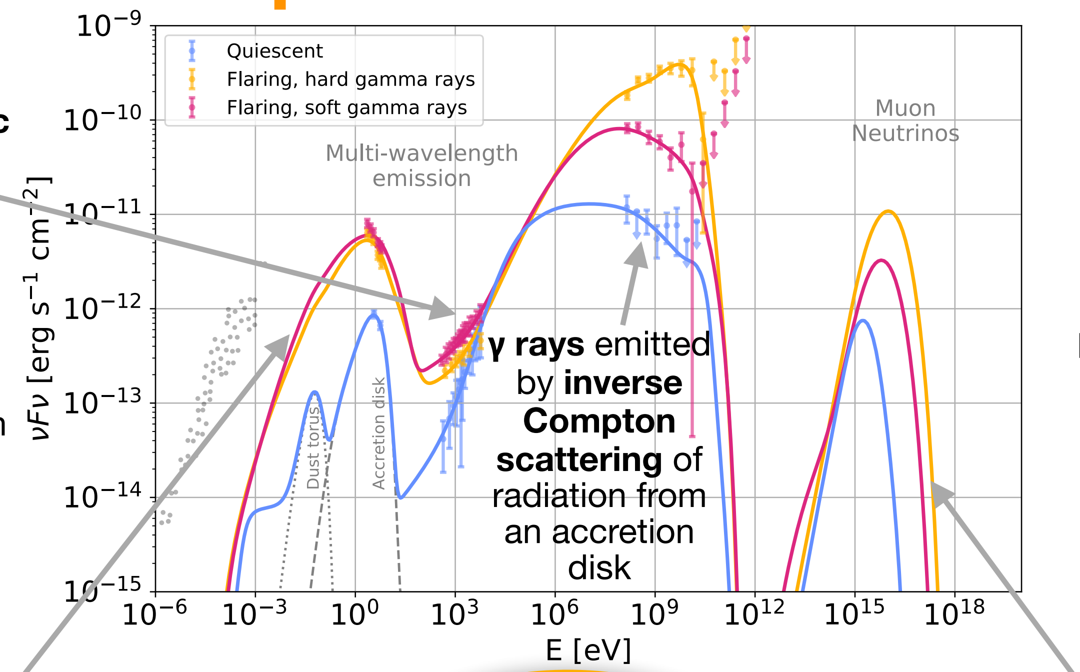
We identify three activity states:

	Total duration
Quiescent state (low gamma-ray flux)	3.8 years
Flaring, hard gamma-ray spectrum	3.7 years
Flaring, soft gamma-ray spectrum	3.5 years

Leptohadronic model

X-ray emission originates in **electromagnetic cascades** initiated by protons.

Broad line and thermal emission are the main target photons



γ rays emitted by **inverse Compton scattering** of radiation from an accretion disk

Neutrino spectra peak around **1-10 PeV**

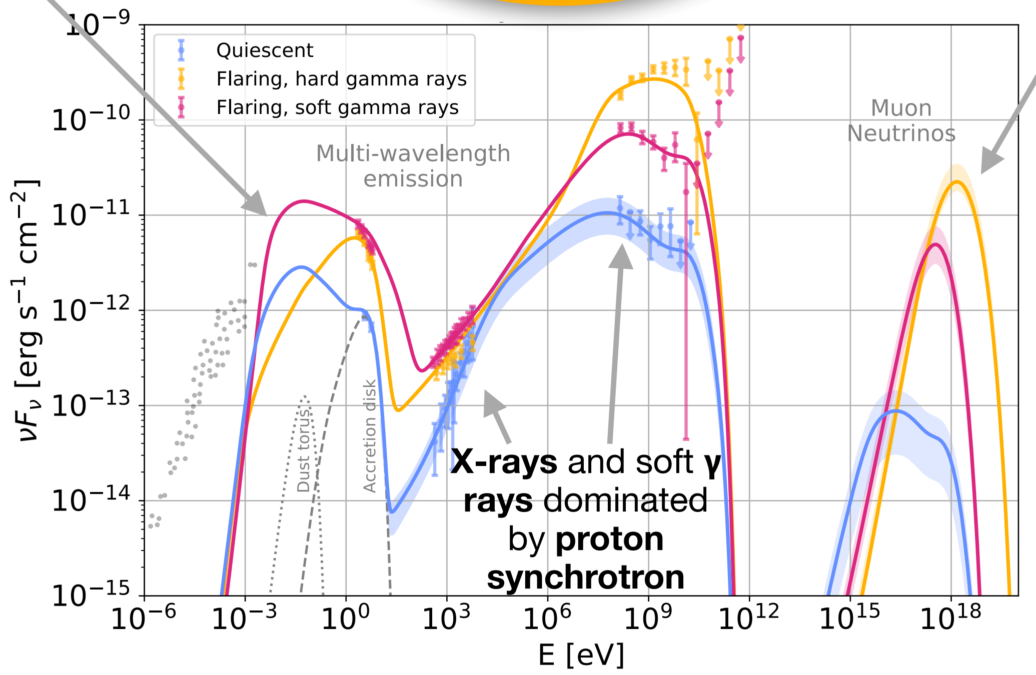
Variable **optical** emission originates in **synchrotron radiation** by electrons

We can explain the photon emission from the source by numerically modeling the **photo-interactions** of **electrons** and **protons** accelerated in a single zone in the relativistic jet (see also Rodrigues et al. 2019, ApJ 874 L29)

Neutrinos are produced through **photo-pion** interactions by high-energy **protons**

In this model, the acceleration zone is located **outside** the broad line region

(no external fields)

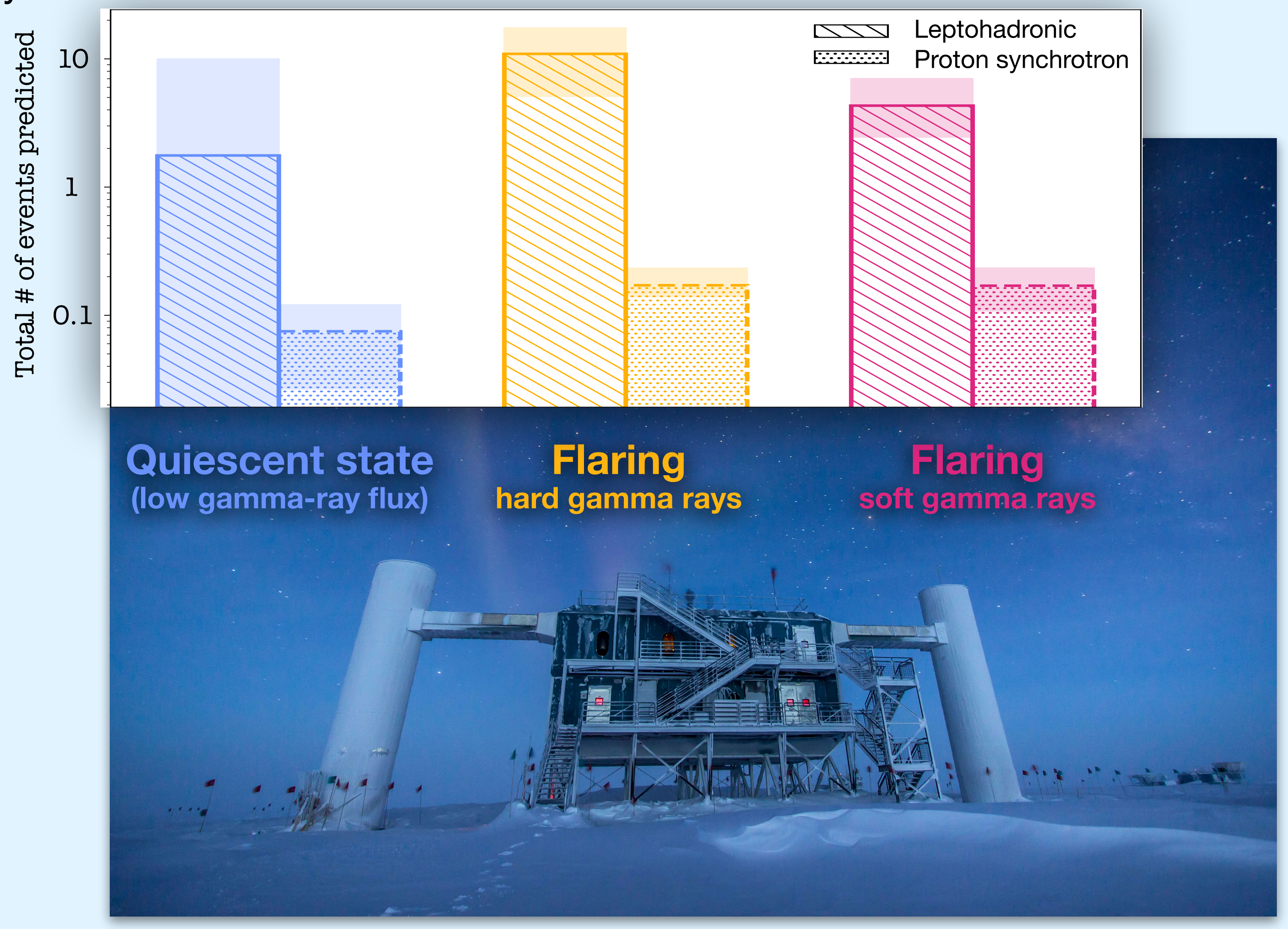


X-rays and soft **γ rays** dominated by **proton synchrotron**

Neutrino spectra peak around **10-1000 PeV** due to high maximum energies of the accelerated protons

Proton synchrotron model

The models can be used to predict the expected number of neutrino events detected by IceCube from this source over the course of 11 years



In both models **high-energy protons** can help explain the multi-wavelength emission from PKS 1502+106, leading to the **co-production of high-energy neutrinos**.

While neither model favours the emission of neutrinos during the quiescent state, they both **support the hadronic nature** of the emission of PKS 1502+106 and its **potential as a neutrino source**.

The results suggest that with increasing statistics of observed neutrinos, **more correlations** should be expected with sources of this kind.

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