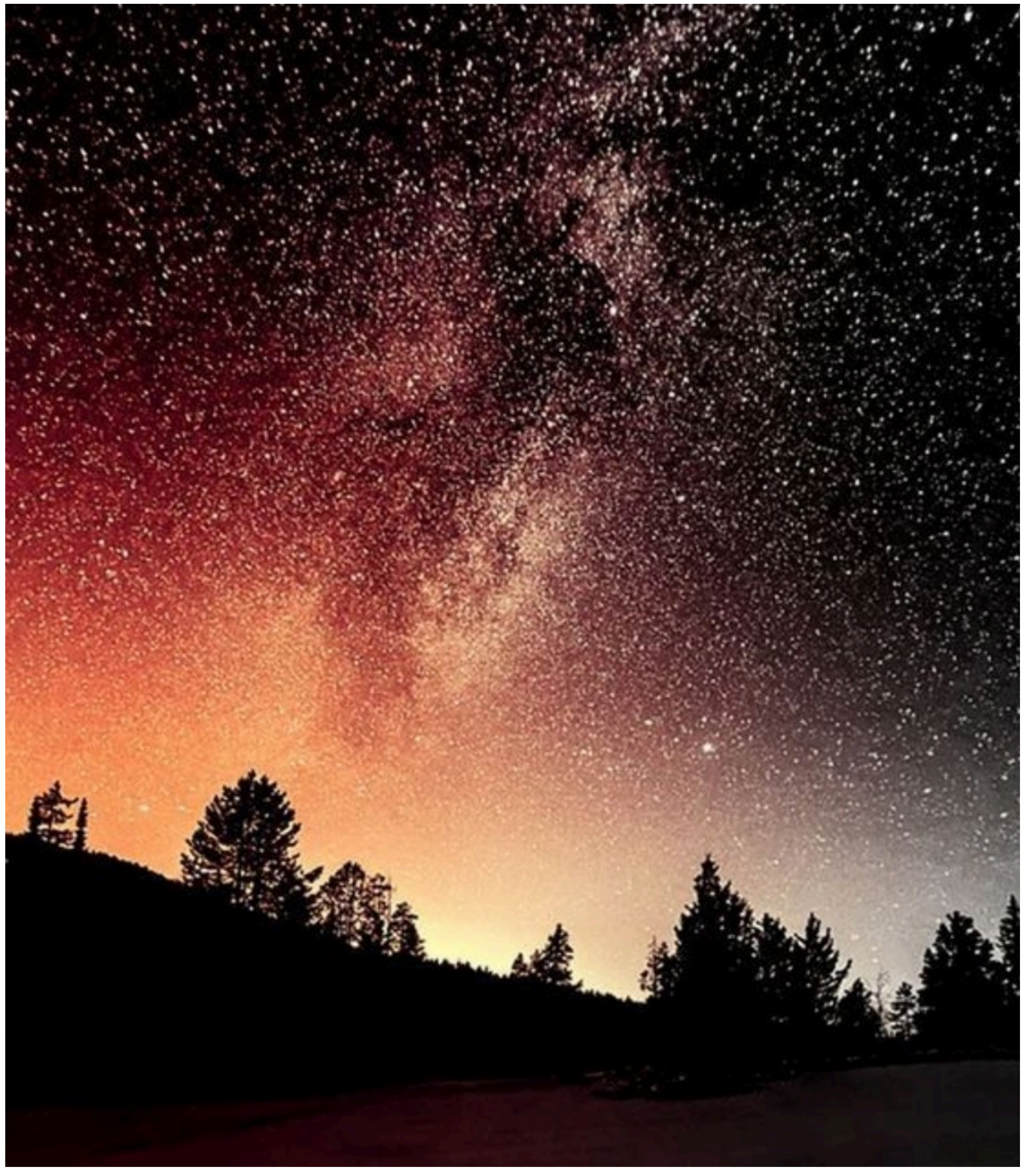
LABx: prove di laboratorio
Radio-Loud AGN

Paola Grandi (INAF-OAS Bologna)



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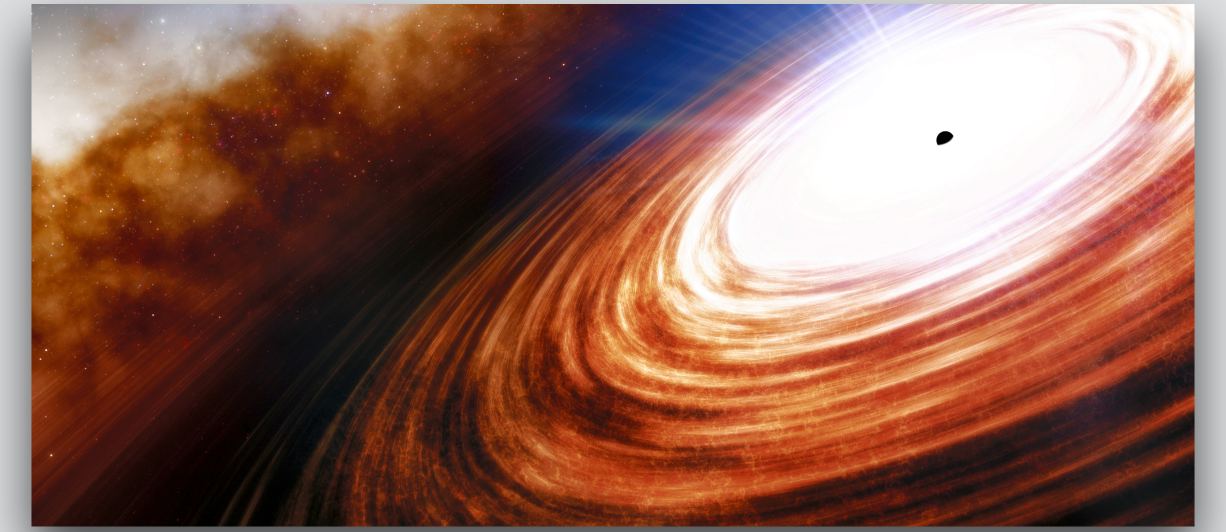
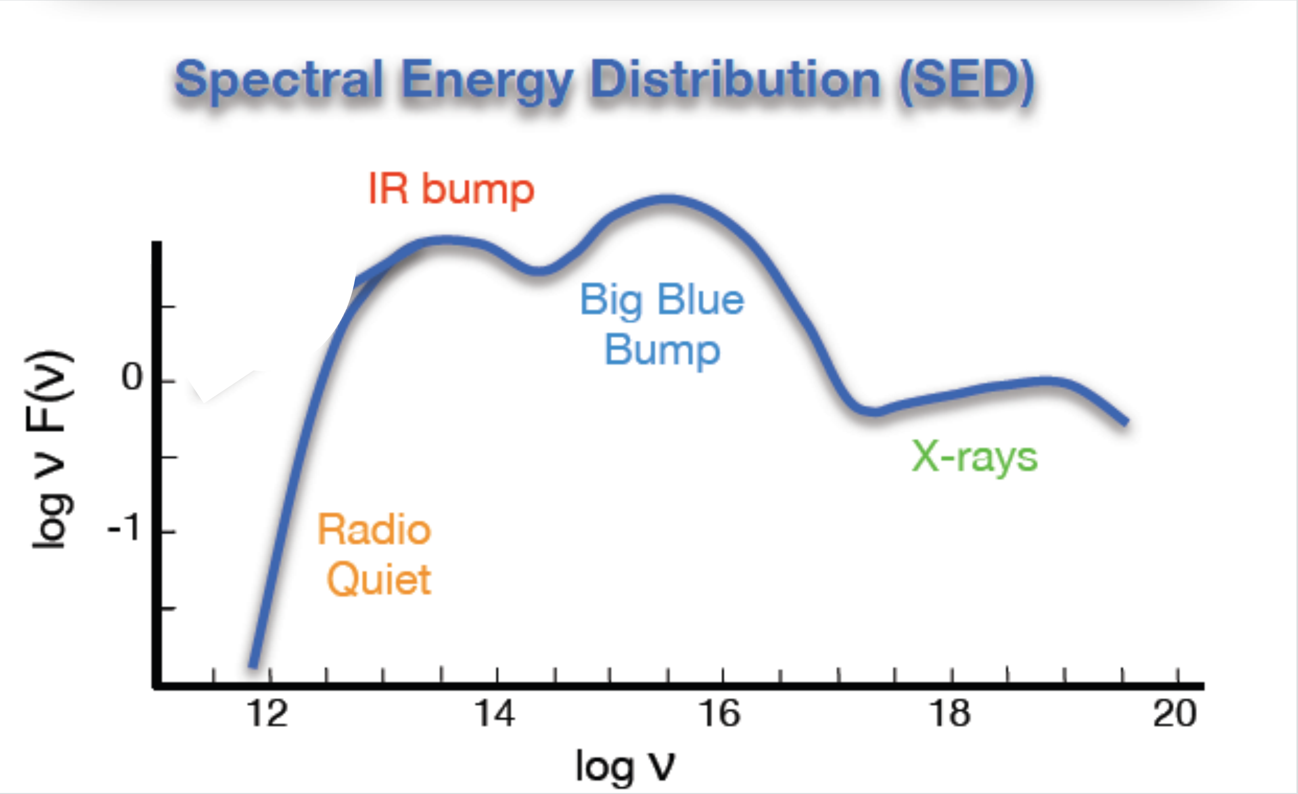
Laboratorio alte energie
24-2-2022

Thermal emission:

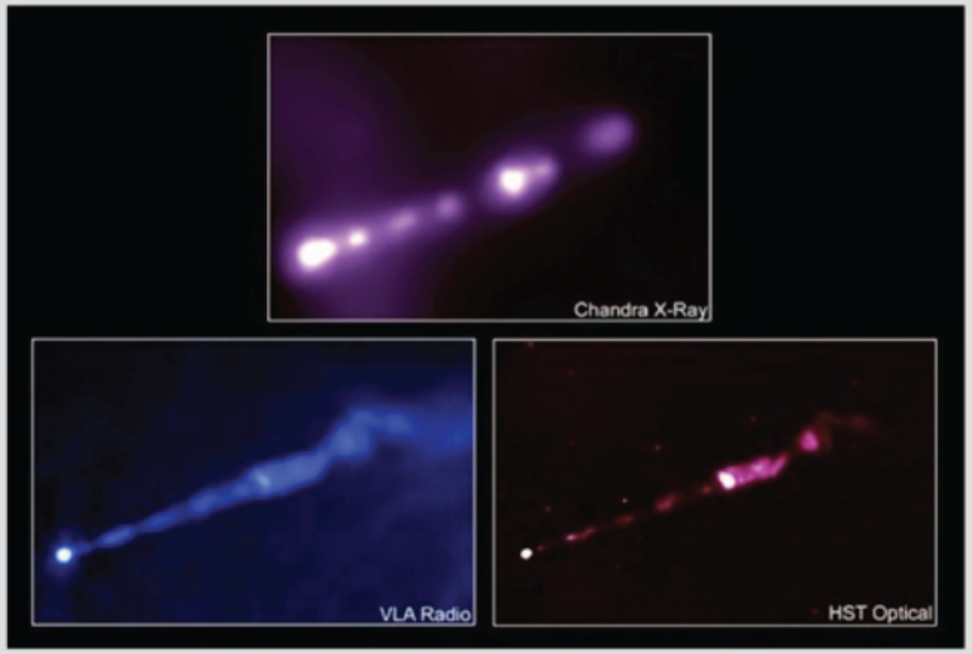
Thermal radiation is dependent on the temperature T of the emitter.

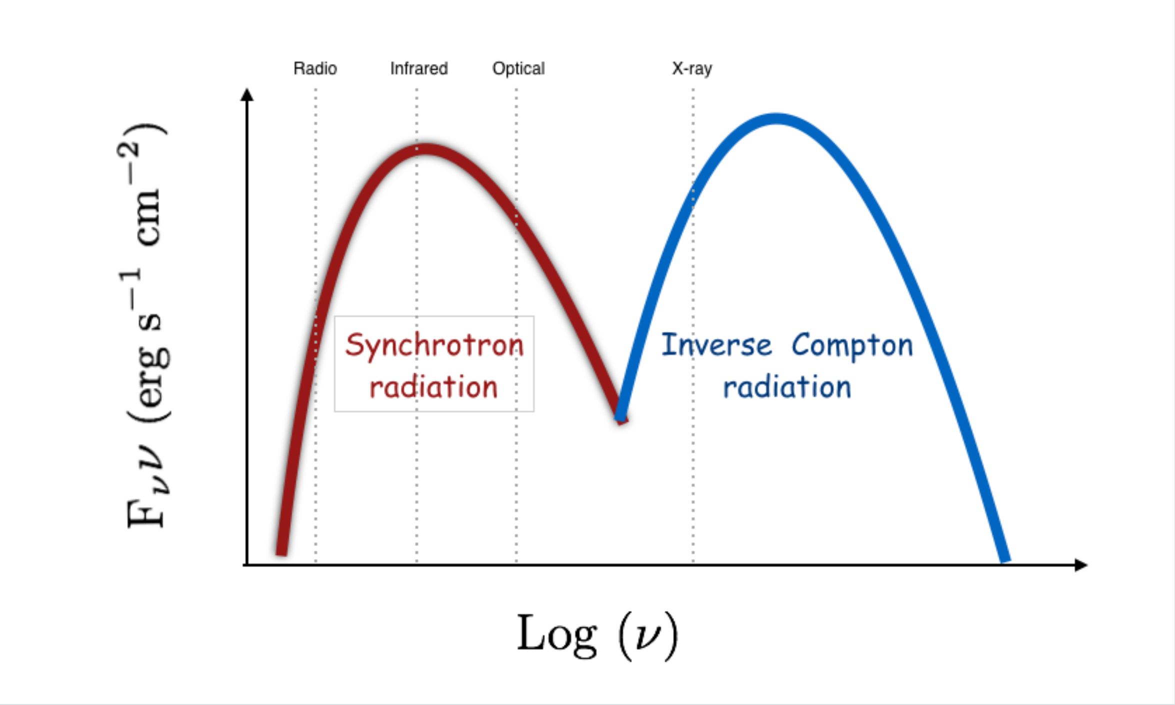




Non-thermal emission

Non-thermal radiation cannot be described by T and requires accelerators





The synchrotron radiation of a power law distribution of electron energies

Synchrotron

$$N(\gamma_e) = K\gamma_e^{-p}, \quad \gamma_{min} < \gamma_e < \gamma_{max}, \; p = 1 + 2\alpha$$

$$\epsilon_{sin}(\nu) \propto K B^{\alpha+1} \nu^{-\alpha} \quad \text{erg cm}^{-3}\,\text{s}^{-1}\,\text{sr}^{-1}$$

Inverse Compton

For a power law distribution of electrons:

$$N(\gamma_e) = K\gamma_e^{-p}\, , \quad \gamma_{min} < \gamma_e < \gamma_{max}\, , p = 1 + 2\alpha$$

Inverse Compton

$$\epsilon_c(\nu_c) \propto K\nu_c^{-\alpha} \int \frac{Ur(\nu)\nu^{\alpha}}{\nu} d\nu \qquad \text{erg cm}^{-3}\ \text{s}^{-1}\ \text{sr}^{-1}$$

U_r is the radiation energy density

$$U_r = \int n(\epsilon)\epsilon d\epsilon$$

- Synchrotron photons in the jet
- Environment photons from Accretion Flow, BLR, NLR, Torus
- Cosmic Microwave Background (CMB) photons

The jet emission is strongly Doppler boosted

The key parameter is the Doppler Factor $\delta(\beta, \theta)$

Urry & Padovani 1995

$$\delta = [\gamma(1 - \beta cos\theta)]^{-1}$$

$\gamma = \sqrt{(1 - \beta^2)}$ Lorentz factor

β =v/c bulk velocity

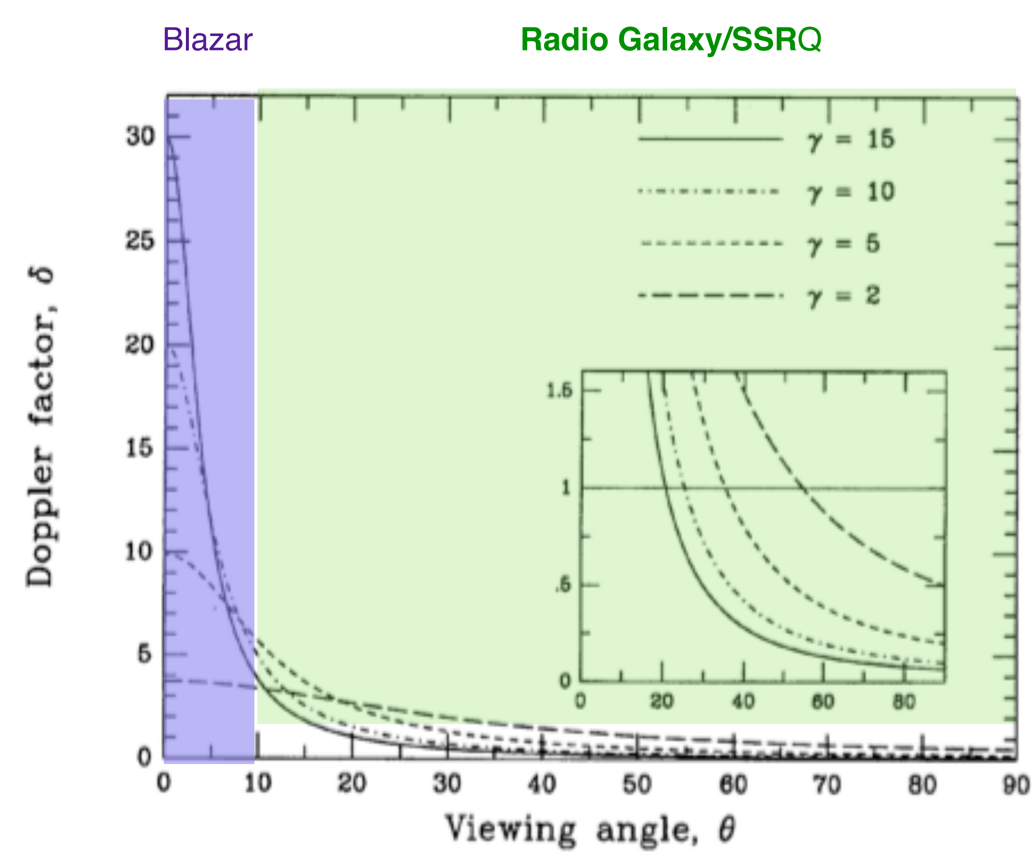
θ angle between the jet axis and the line of sight

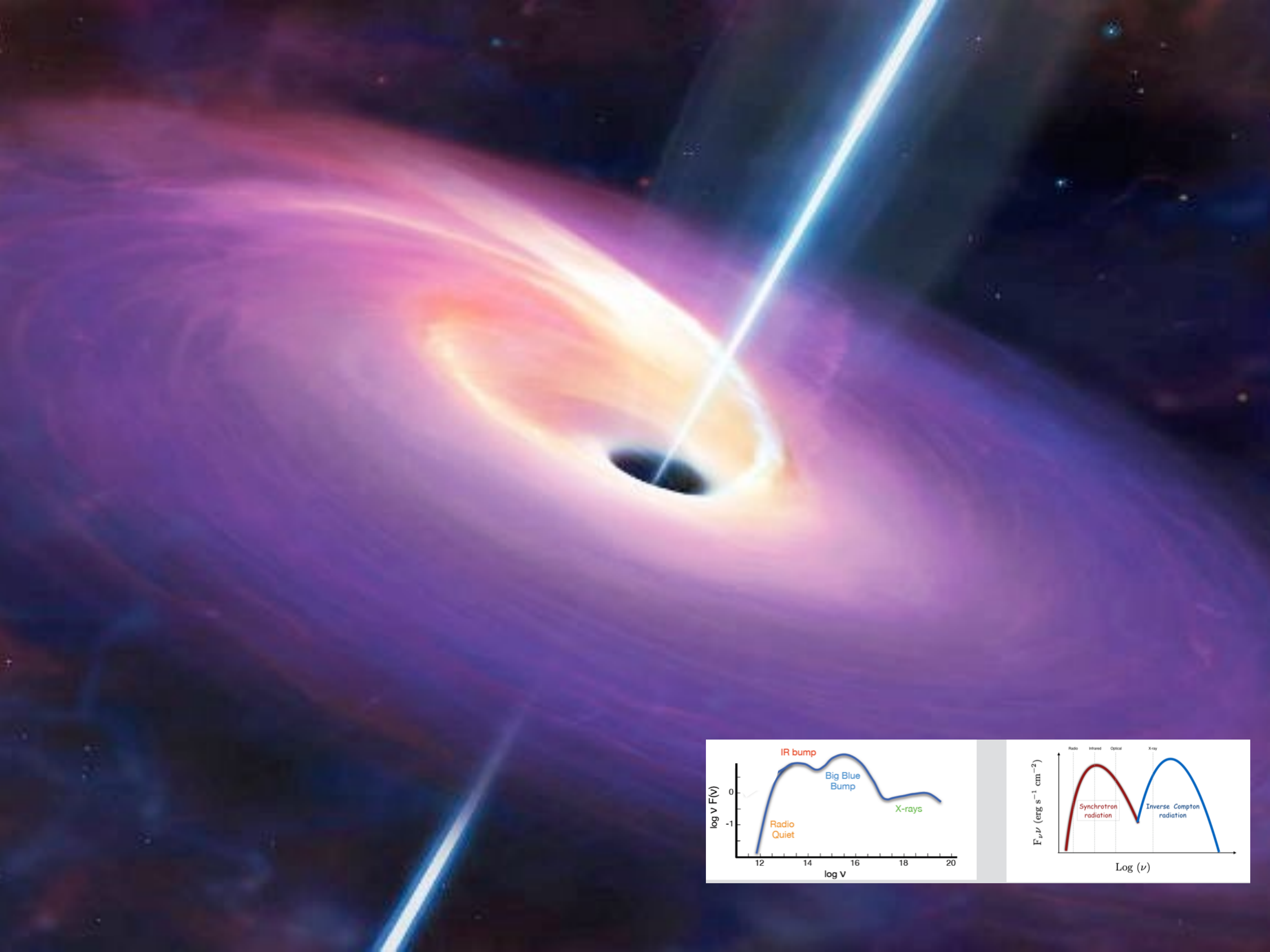
The Doppler factor relates intrinsic and observed flux for a moving source at relativistic speed v=β c.

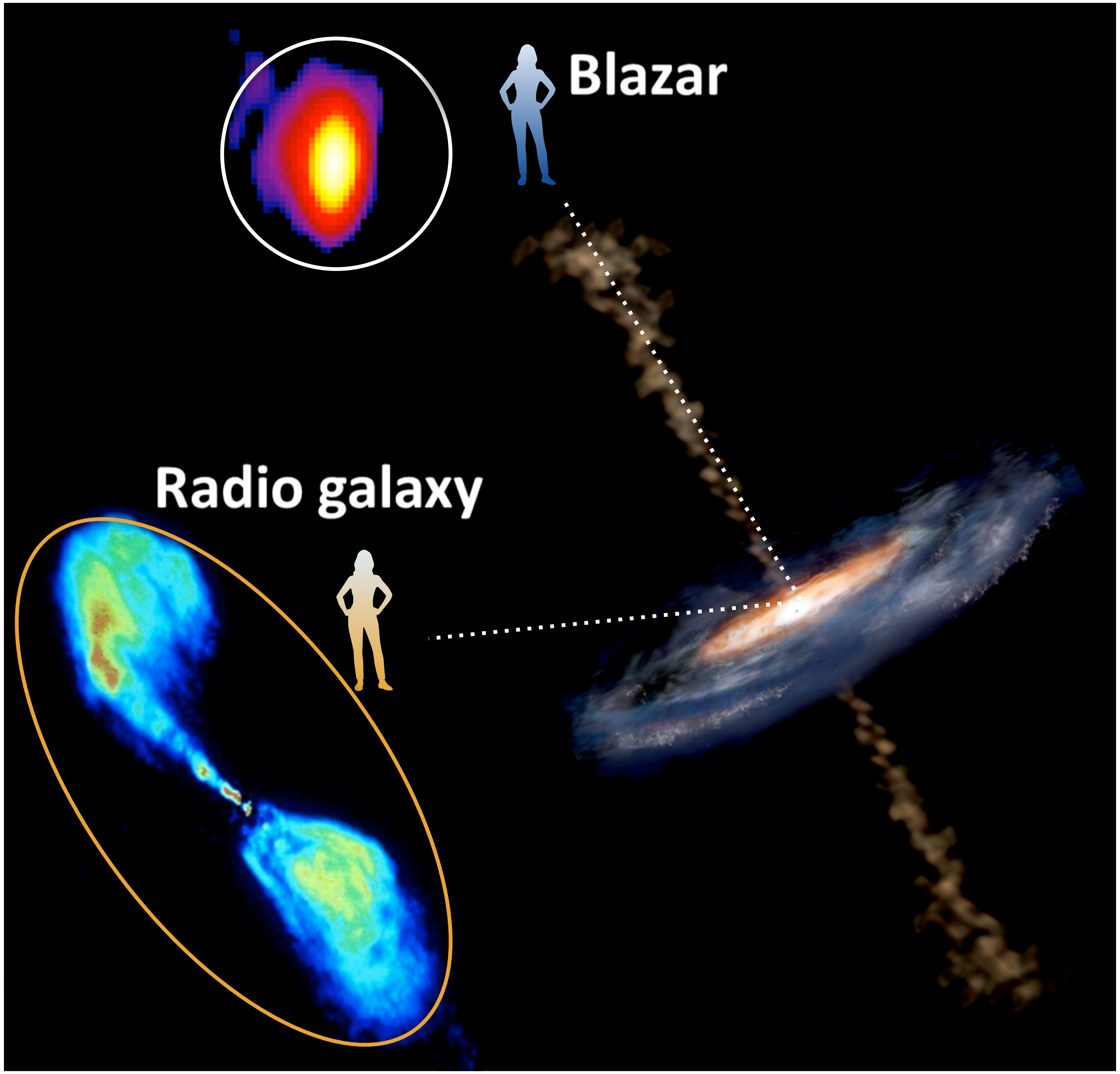
For an **intrinsic** power law spectrum: $F'(\nu') = K (\nu')^{-a}$
the **observed** flux density is

$$F_\nu(\nu) = \delta^{3+\alpha} F'_{\nu'}(\nu)$$

$$\Delta t = \Delta t' / \delta$$

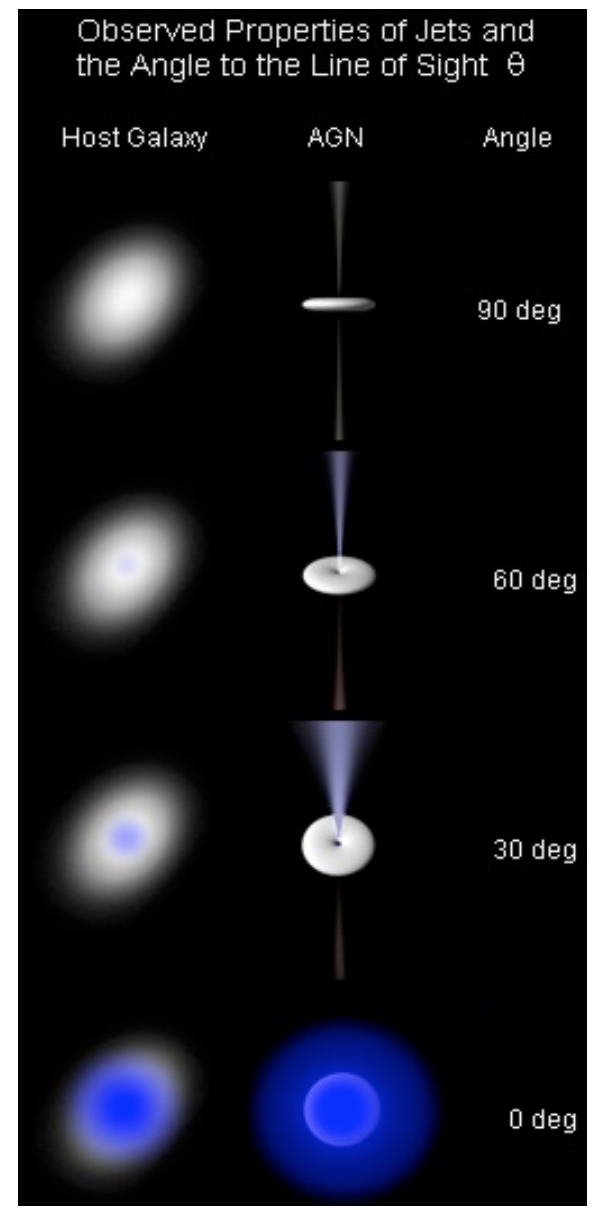



IR bump
Big Blue Bump
X-rays
Radio Quiet
log ν F(ν)
0
-1
12
14
16
18
20
log ν
Radio
Infrared
Optical
X-ray
Synchrotron radiation
Inverse Compton radiation
Fνν (erg s−1 cm−2)
Log (ν)



Non-thermal emission

Thermal nuclear emission

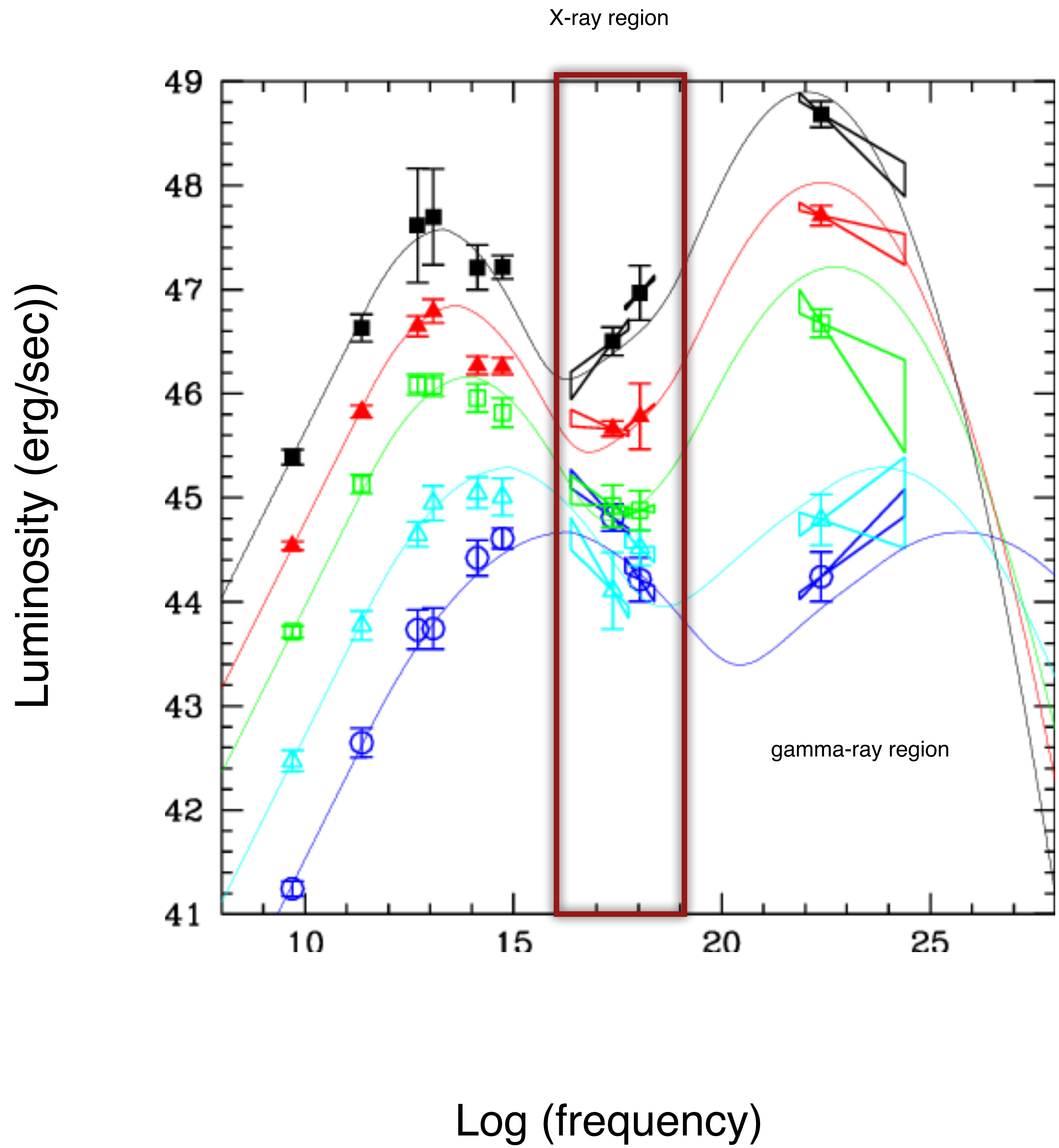


Accretion is dominant

Accretion and jet are in competition

Overwhelmed by the jet

Angle between the jet and the observer ~ 0 deg



double peaked SED

(Fossati et al. 1998)

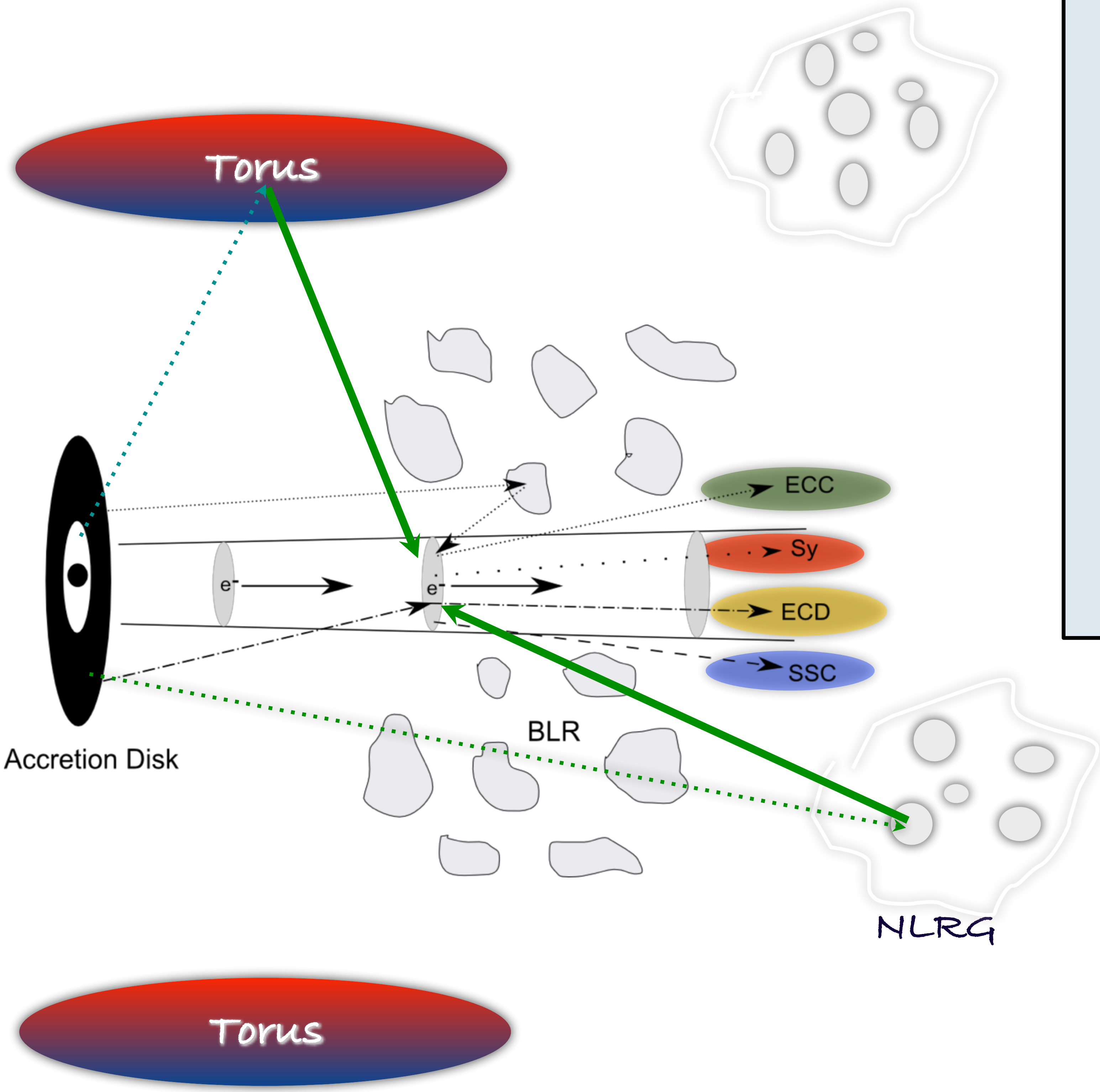
Synchrotron Self–Compton

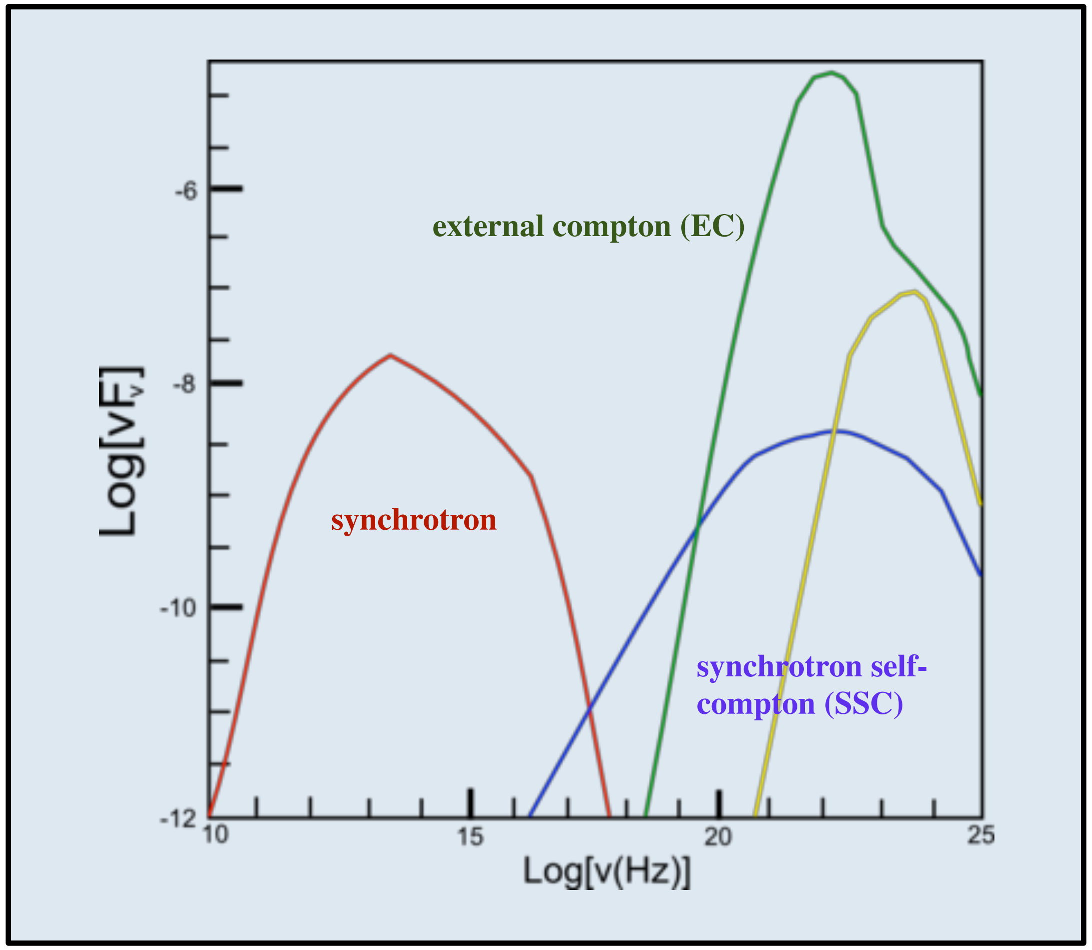
Consider a population of relativistic electrons in a magnetized region. They will produce synchrotron radiation, and therefore they will fill the region with photons. These synchrotron photons will have some probability to interact again with the electrons, by the Inverse Compton process. Since the electron “work twice” (first making synchrotron radiation, then scattering it at higher energies) this particular kind of process is called synchrotron self-Compton, or SSC for short.

External Compton

The population of relativistic electrons in a magnetized region can also interact with photons external to the jet produced in the accretion disk, in the broad/narrow line regions in the torus. This particular kind of process is called External Compton, or EC for short.

- Synchrotron photons in the jet
- Environment photons from DISK, BLR, NLR, Torus

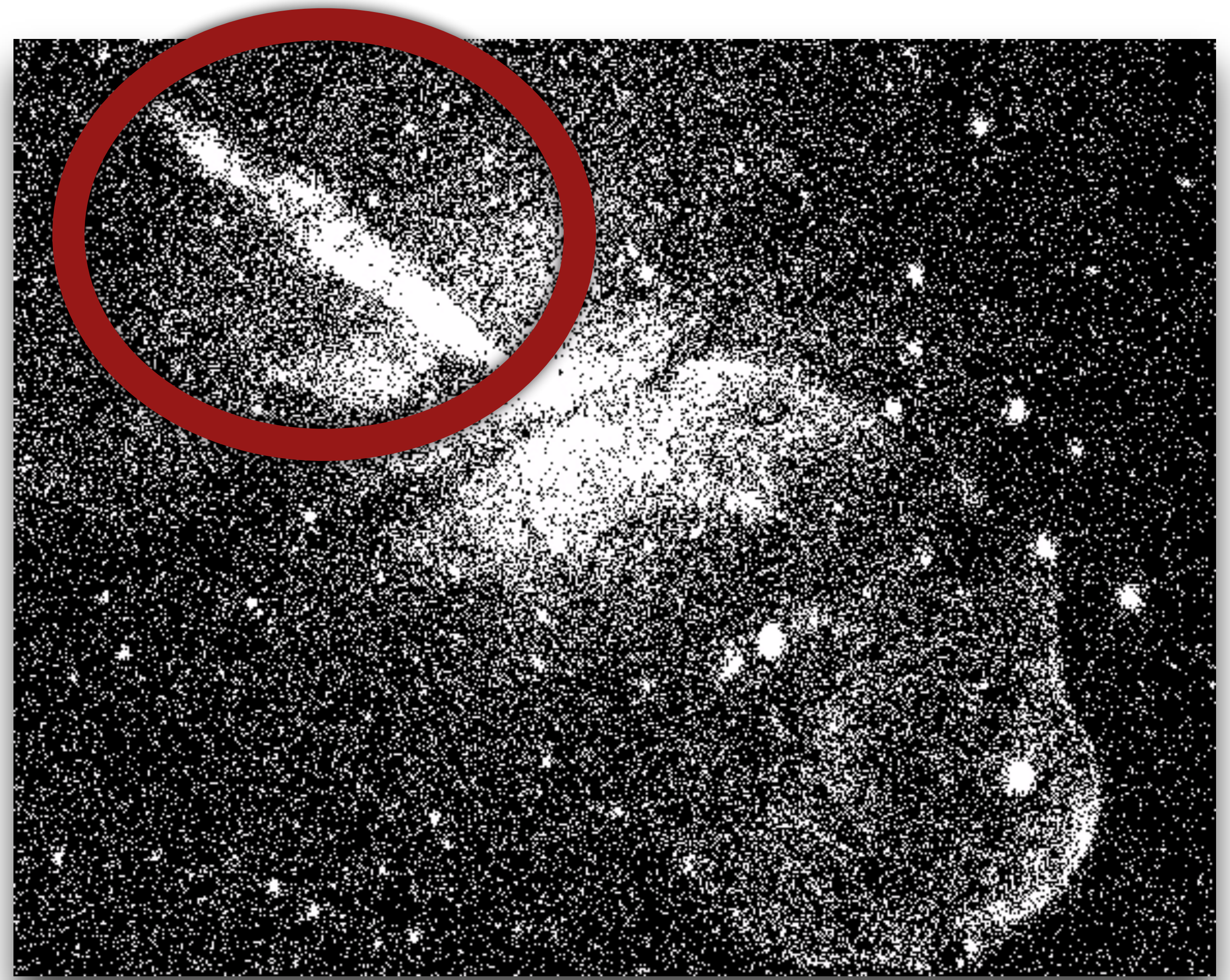


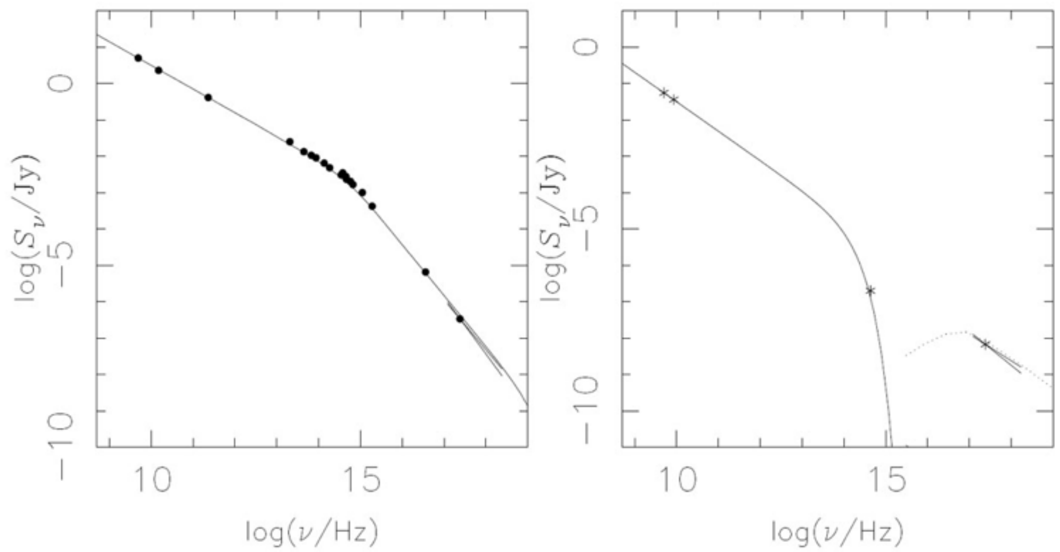


Angle between the jet and the observer ~60-70 deg

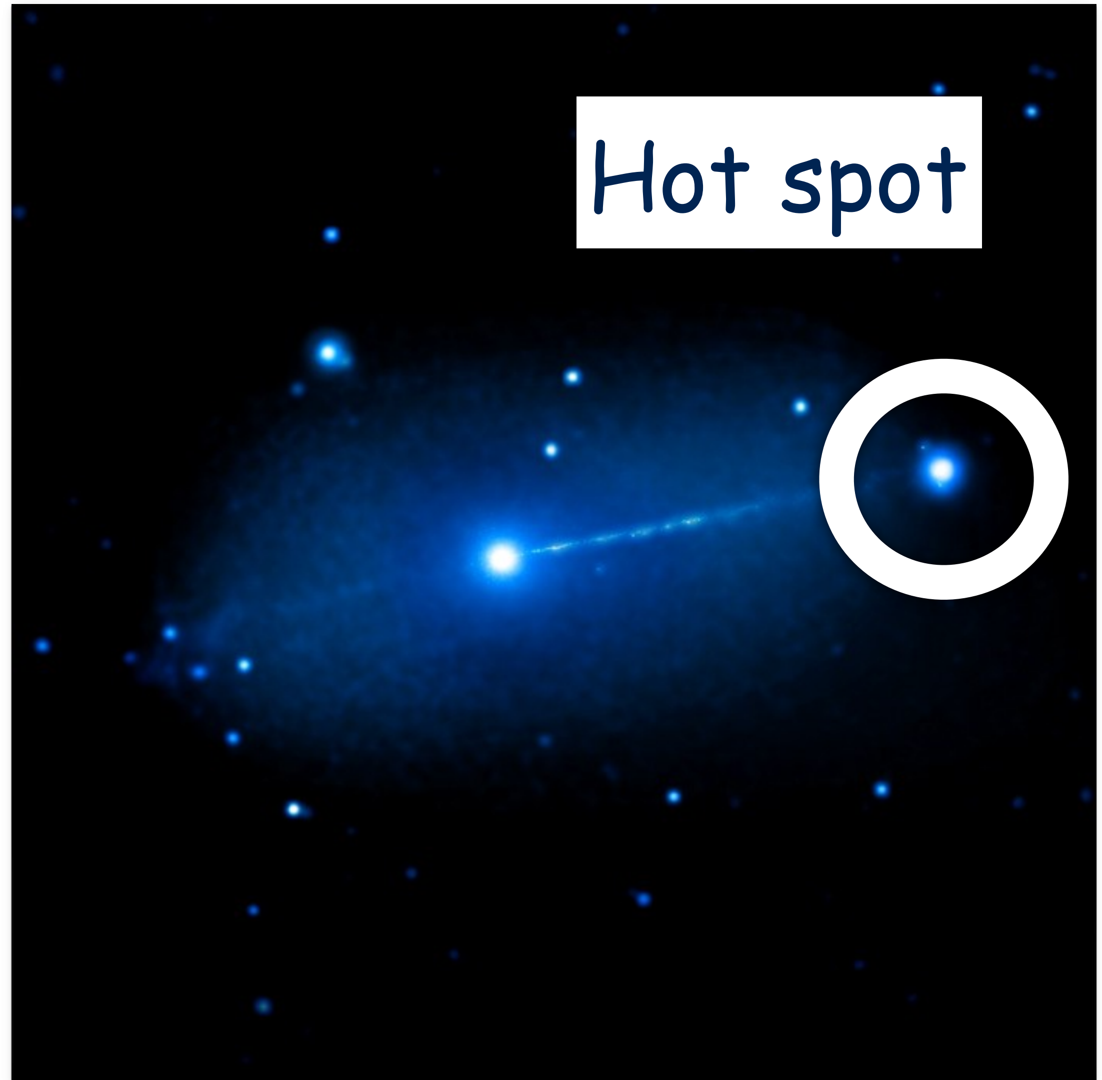
Extended Non-thermal structure can be observed

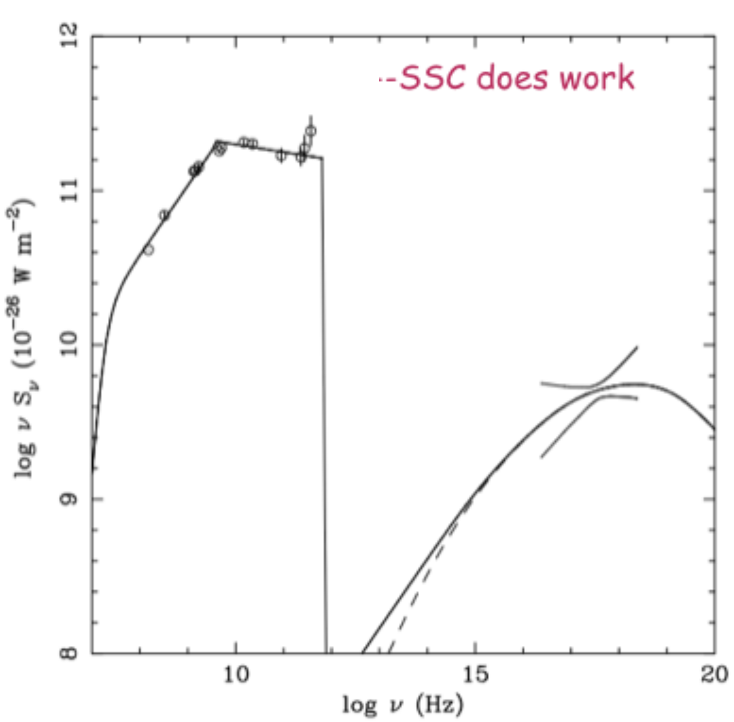
Jet at kpc scales

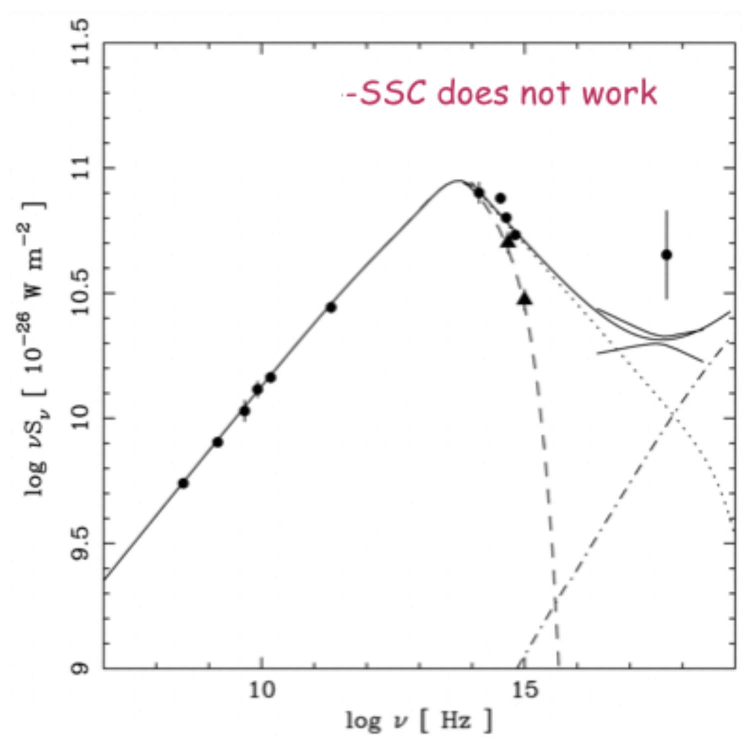




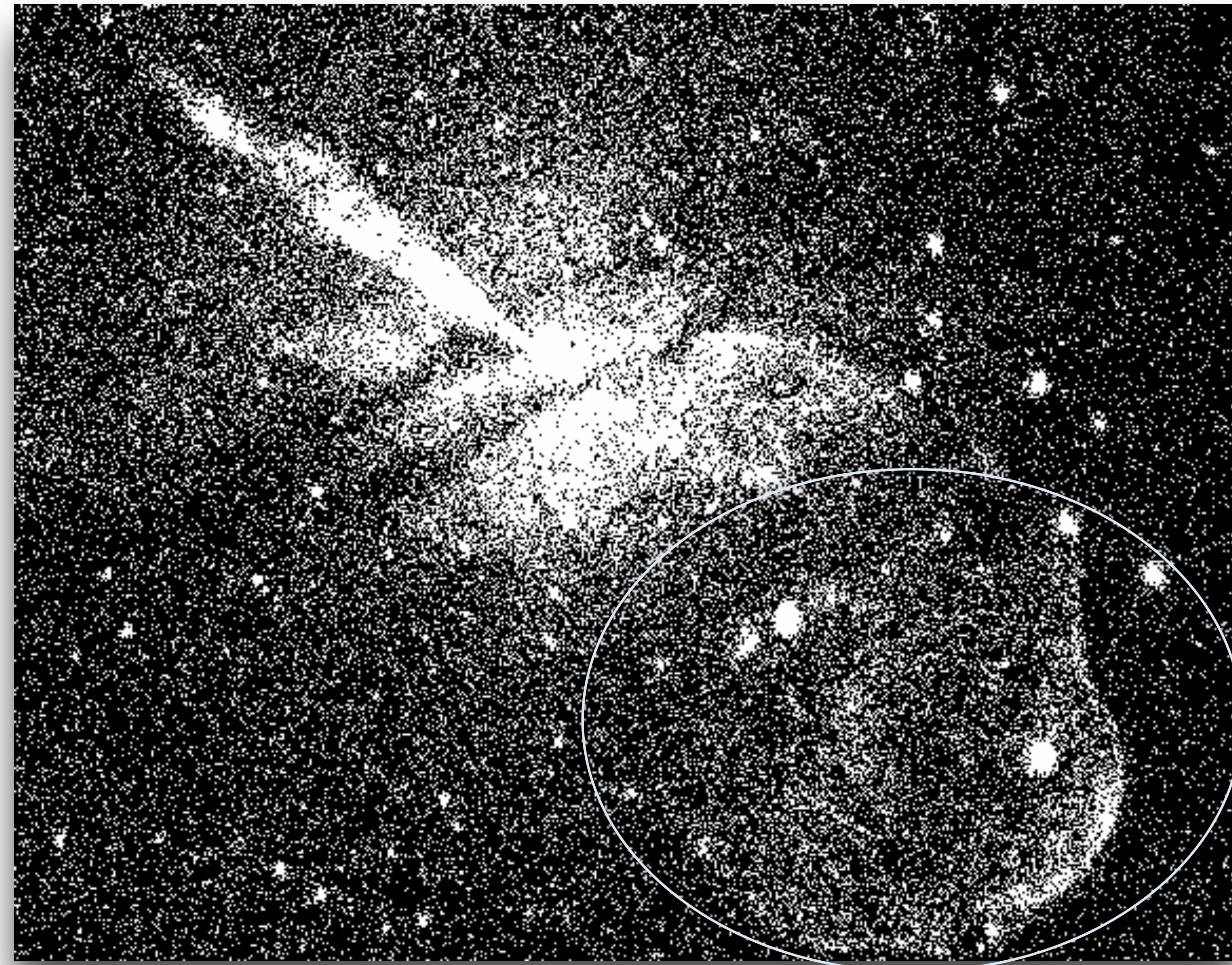
hot spots

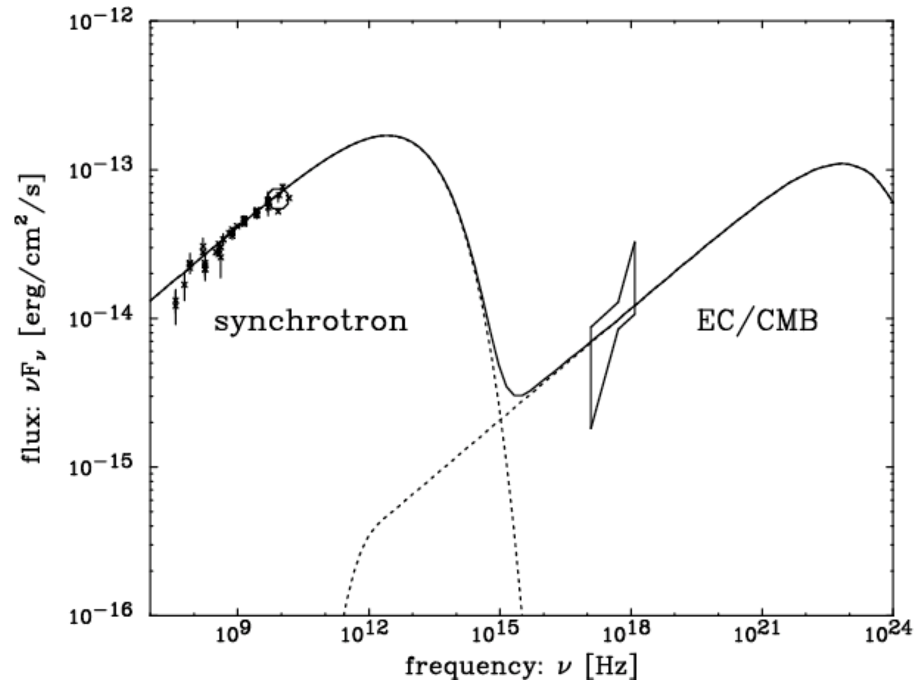

Hot spot

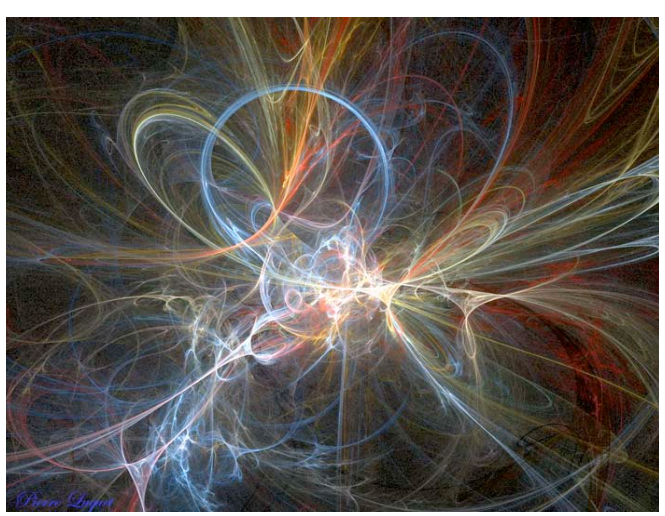

-SSC does work
log ν S_ν (10^-26 W m^-2)
log ν (Hz)
8
9
10
11
12
10
15
20


-SSC does not work
log νS_ν [10^-26 W m^-2]
log ν [Hz]
9
9.5
10
10.5
11
11.5
10
15

and Lobes







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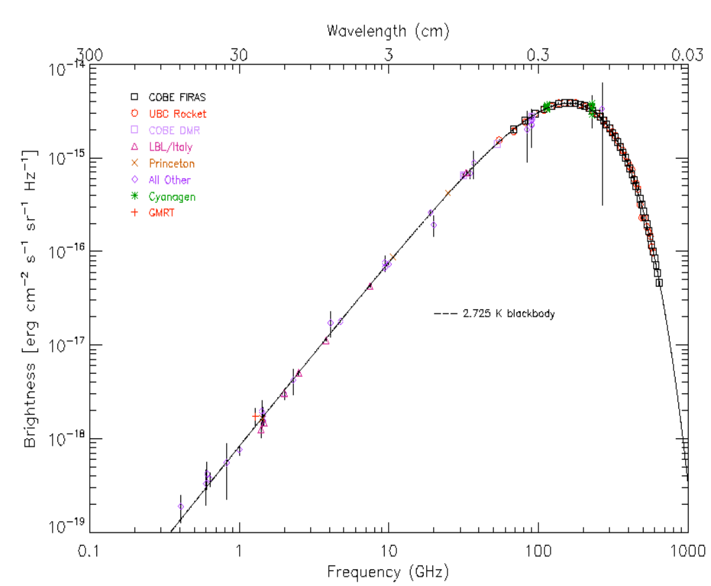

relativistic electrons

CMB

Prove di laboratorio: AGN radio emittenti LabX

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X-RAY LABORATORY 2022

February 21, 2022 to March 11, 2022
Europe/Rome timezone

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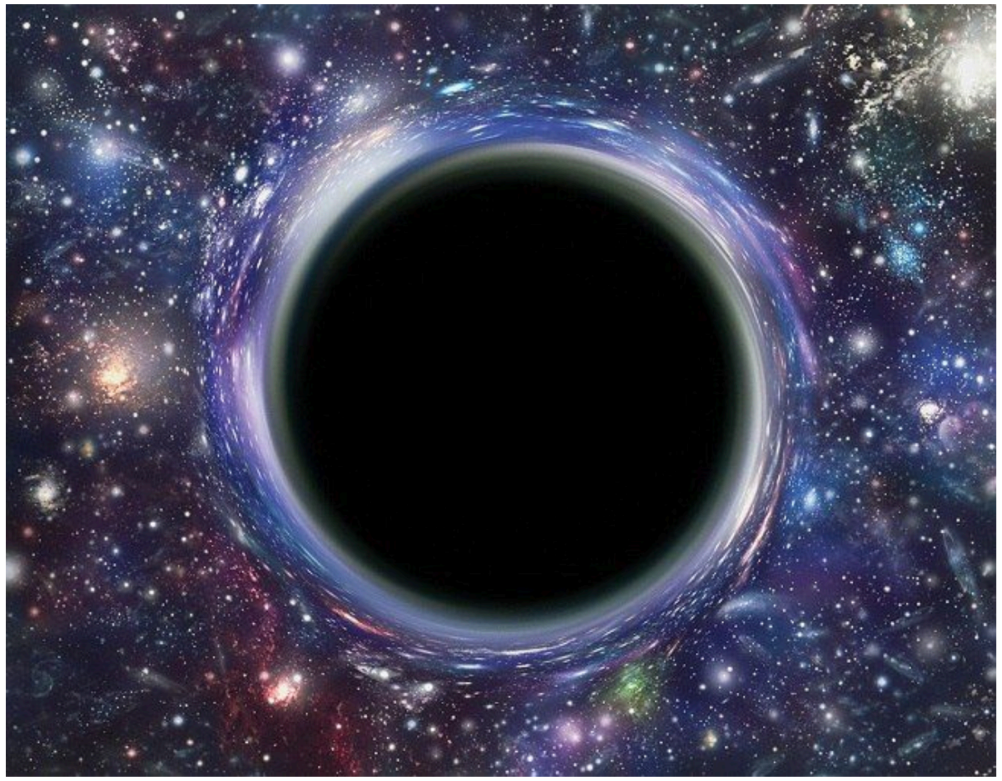
** WELCOME TO THE *X-RAY LABORATORY 2022* **

In collaboration with the Department of Physics and Astronomy of the University of Bologna (DIFA), OAS-Bologna organizes combined seminars/laboratories, investigating a broad range of astronomical systems through detection and analysis of their X-ray emission and other radiation they emit.

The laboratory runs for three weeks (21 February-11 March 2022).



Students working in small groups are introduced to the current problematics of supermassive black holes in order to contextualize their X-ray data analysis exercises. In addition, the X-ray laboratory offers the opportunity to gain first-hand experience with the essential instrumentation tools of modern X-ray astronomy. At the end of the tutorial, students summarize the laboratory experience in a power-point presentation organized as a professional communication to an Astrophysical Conference.

X-ray Lab is part of the Astrophysics Laboratory course of DIFA Bologna.

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