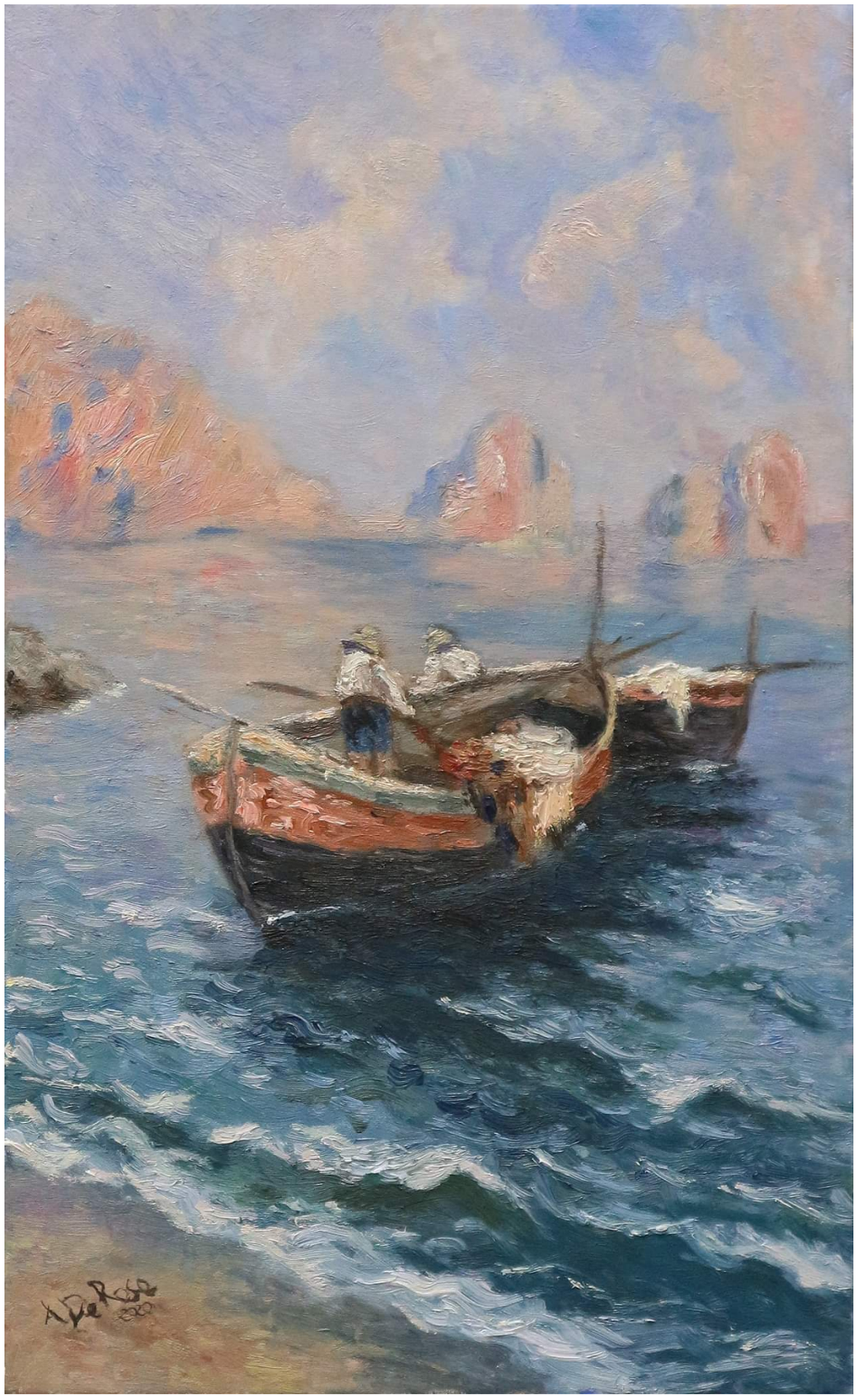


La baia di Napoli, omaggio a Gaetano Esposito

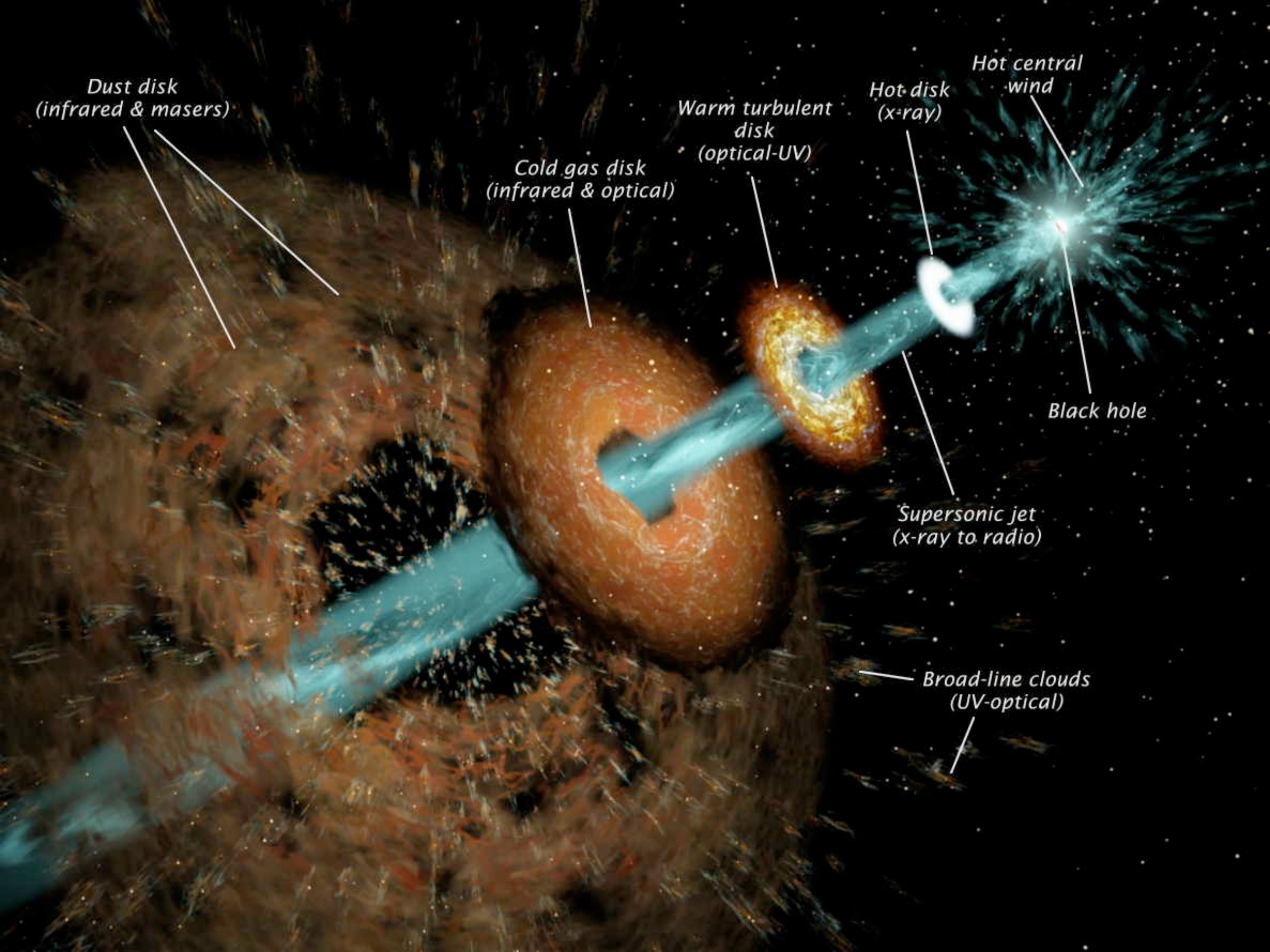
Oggetti compatti extragalattici (AGN)

Alessandra De Rosa (INAF/IAPS)

Giornate INAF del Raggruppamento Scientifico Nazionale 4
Astrofisica Relativistica e Particelle
22-24 Novembre 2022. Napoli

talk overview
(as I thought at glance, and at the end it didn't change)

- AGN: intro, problemi aperti, highlights (a partire dalle schede..)
- cosa si studia, strutture coinvolte, schede coinvolte
- legami con progetti ed infrastrutture
- legami con RSN1, RSN5
- criticità più spesso rilevate
- legami con missioni spaziali (ATHENA, eXTP, HERMES, Theseus, IXPE, AMEGO, ASTROGAM, COSI), telescopi da Terra (ASTRIMini-Array, CTA, SKA, SWGO, VLBI) e rivelatori di onde gravitazionali di terza generazione (Einstein Telescope-LISA).


Dust disk
(infrared & masers)
Cold gas disk
(infrared & optical)
Warm turbulent
disk
(optical-UV)
Hot disk
(x-ray)
Hot central
wind
Black hole
Supersonic jet
(x-ray to radio)
Broad-line clouds
(UV-optical)

Multi-Wavelength view of AGN

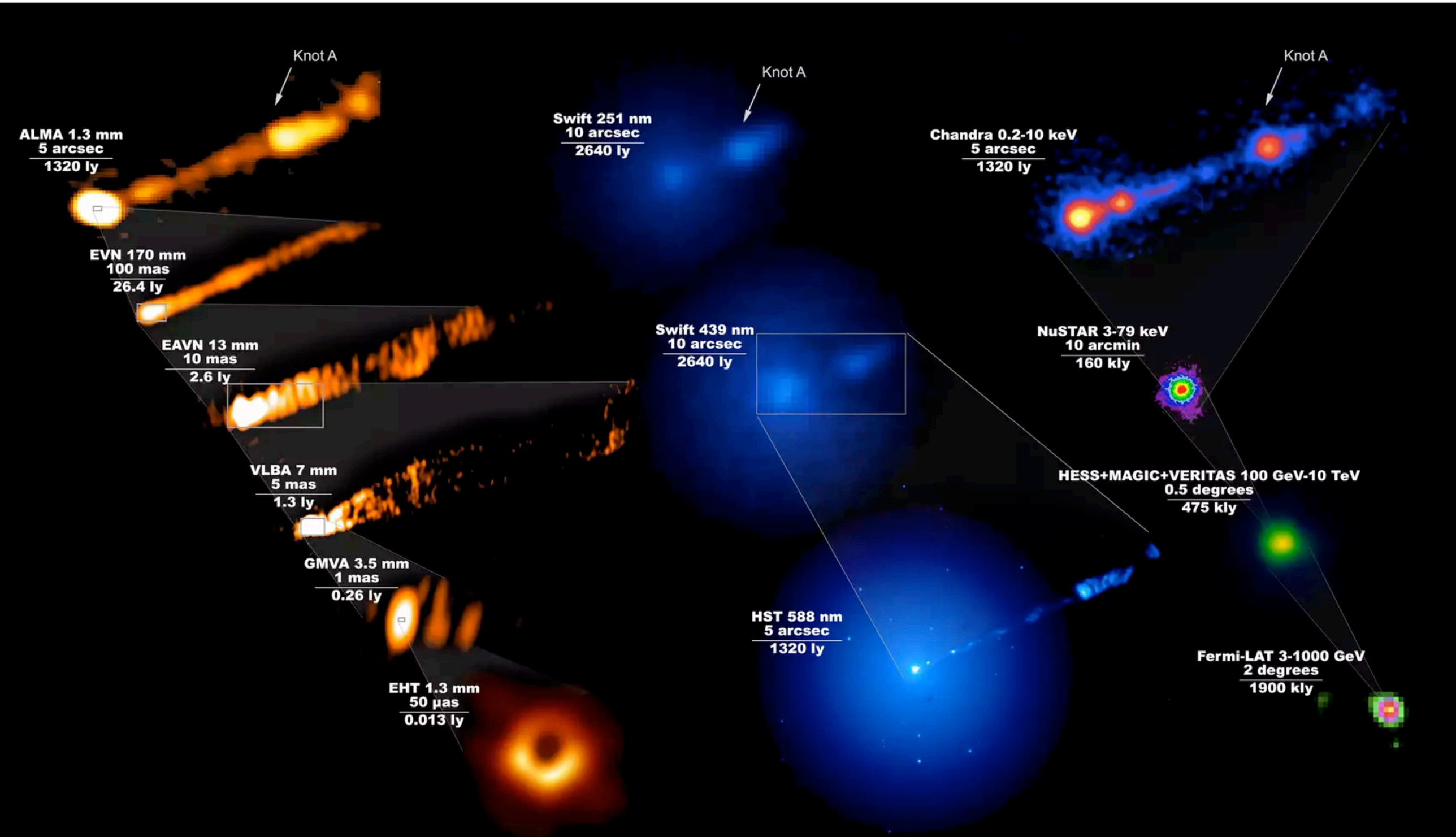
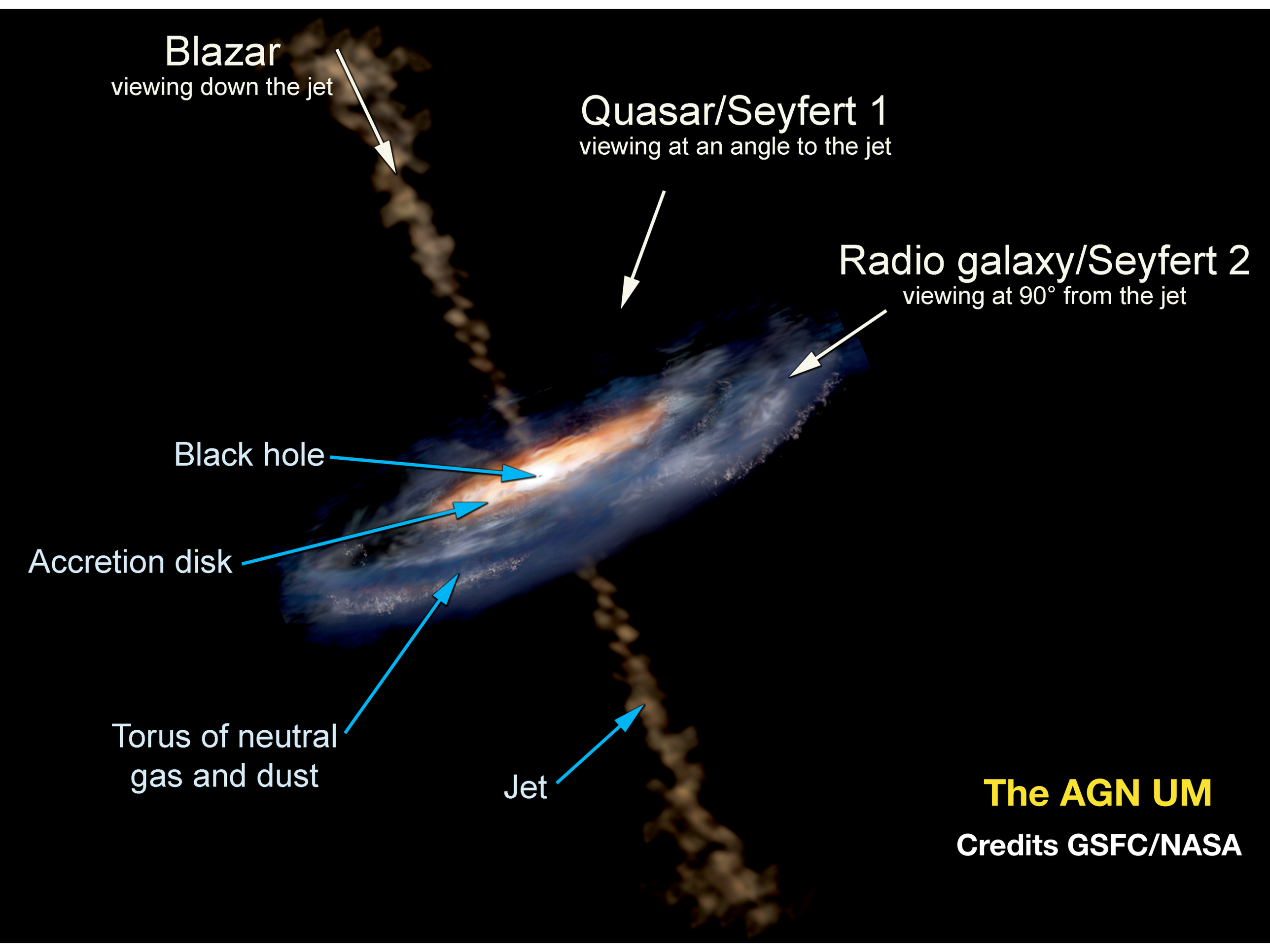
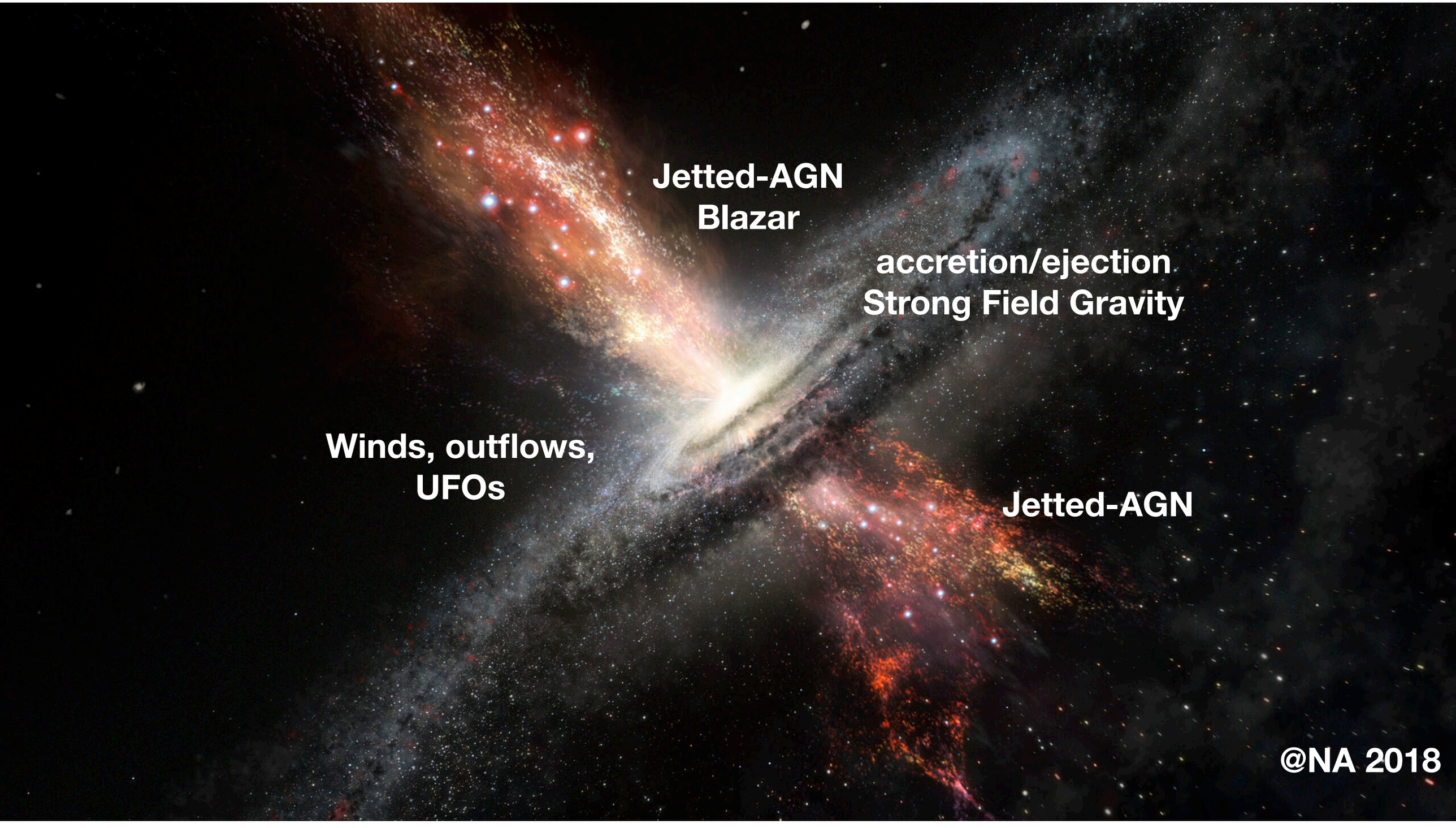


Image Credit: The EHT Multi-wavelength Science Working Group; the EHT Collaboration; ALMA (ESO/NAOJ/NRAO); the EVN; the EAVN Collaboration; VLBA (NRAO); the GMVA; the Hubble Space Telescope; the Neil Gehrels Swift Observatory; the Chandra X-ray Observatory; the Nuclear Spectroscopic Telescope Array; the Fermi-LAT Collaboration; the H.E.S.S collaboration; the MAGIC collaboration; the VERITAS collaboration; NASA and ESA. Composition by J. C. Algaba

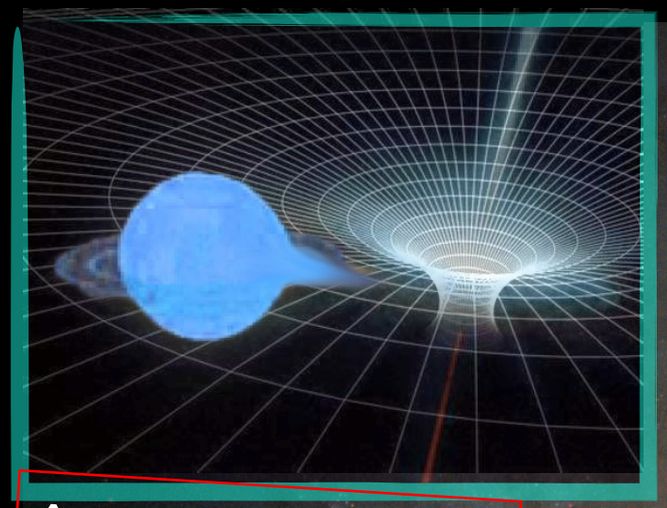

Blazar
viewing down the jet
Quasar/Seyfert 1
viewing at an angle to the jet
Radio galaxy/Seyfert 2
viewing at 90° from the jet
Black hole
Accretion disk
Torus of neutral
gas and dust
Jet
The AGN UM
Credits GSFC/NASA

AGN topics@INAF
roughly from schede + personal (biased) knowledge

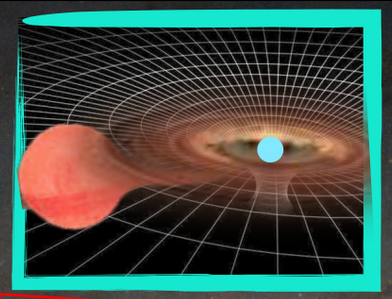


BH inner regions and accretion under SFG regimes

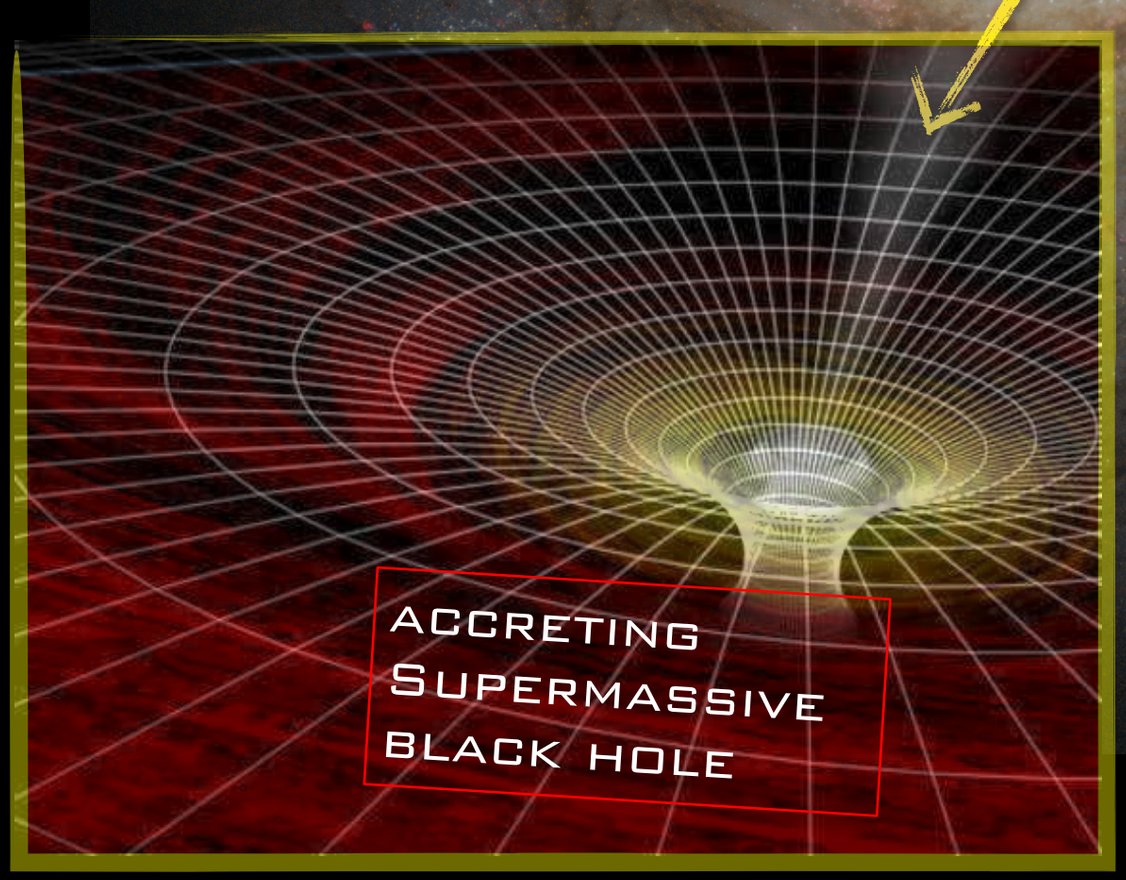
Strong curvature
10^{13} Solar



Accreting
Stellar mass
Black hole



Accreting
Neutron
star



Accreting
Supermassive
Black hole

Weak curvature
~ Solar

stellar mass BHs /NSs scattered in galaxies (X-ray binaries)

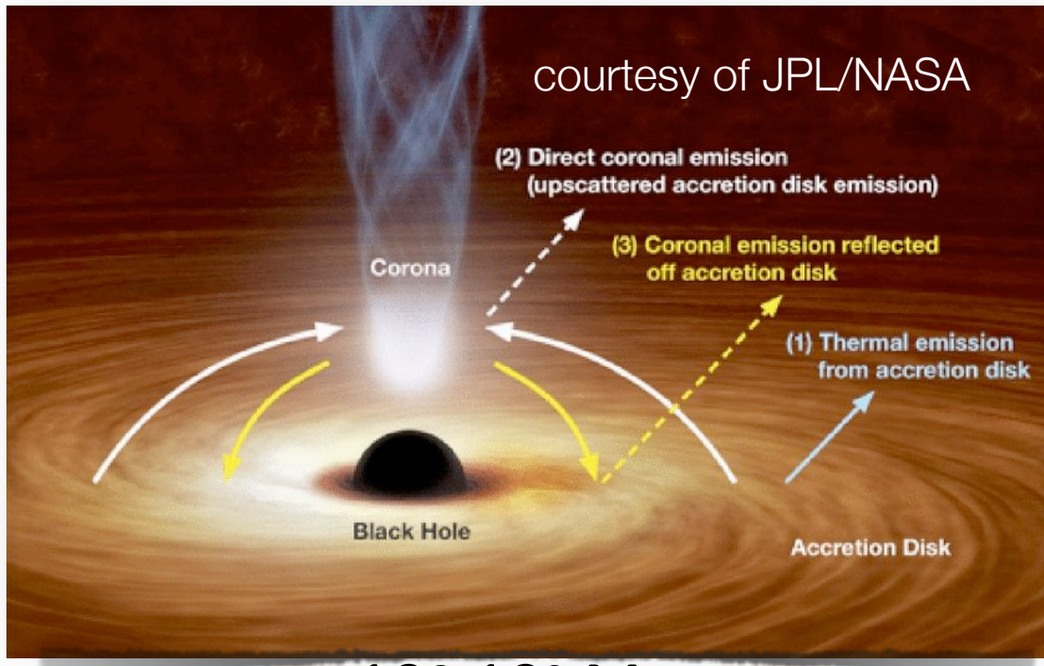
supermassive BHs in the center of galaxies (AGN and quasars)

Close to the BH, most of the physical processes are the same. we can learn a great deal by comparing the two families

What really matters in these studies is the n. of photons (i.e. flux, F_{obs}) per unit of light crossing time scale ~ R_g/c ~ GM/c^3 ~ 500 M_8 s

Accretion flows under SFG regime (X-rays) diagnostics

- Goals: Accretion properties around BHs, through X-ray data. Fe iron line, QPOs. X-ray reverberation. Time lags
- How: spectral-timing; spectral polarimetry Polarimetry
- Mission: XMM, NuStar, IXPE, AThena, eXTP.
- Software development
- Strutture (schede): IAPS, OAR, OAA, IASF-Pa, OACagliari, OACatania (X-Tra, Spectempolar, EXTras, RETHAD)



10^6-10^9 M_{sun}

R_g/c=50s

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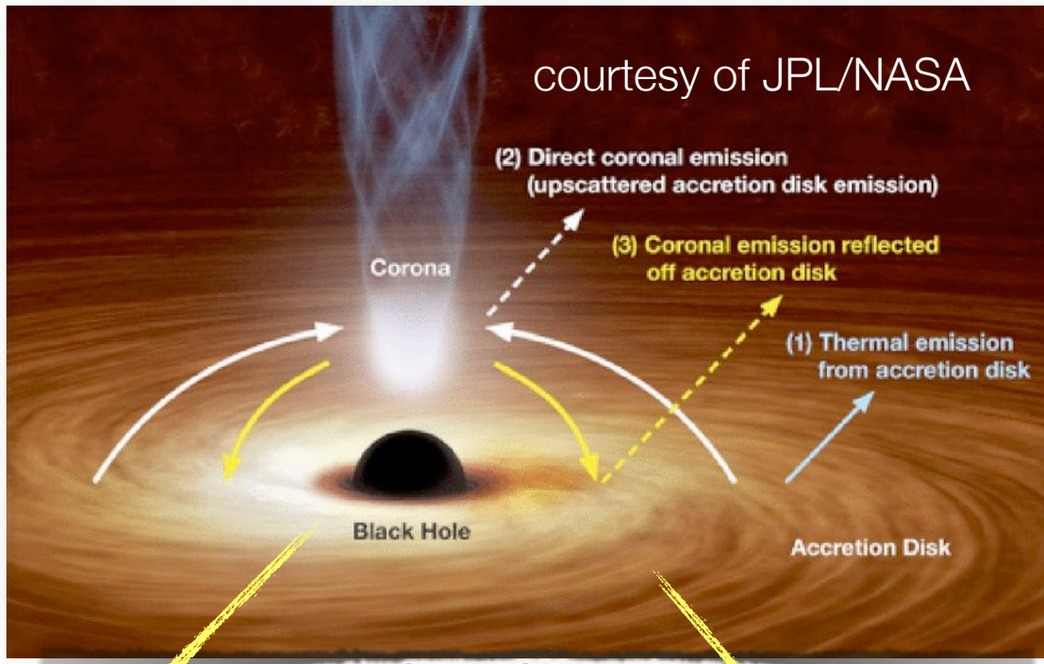

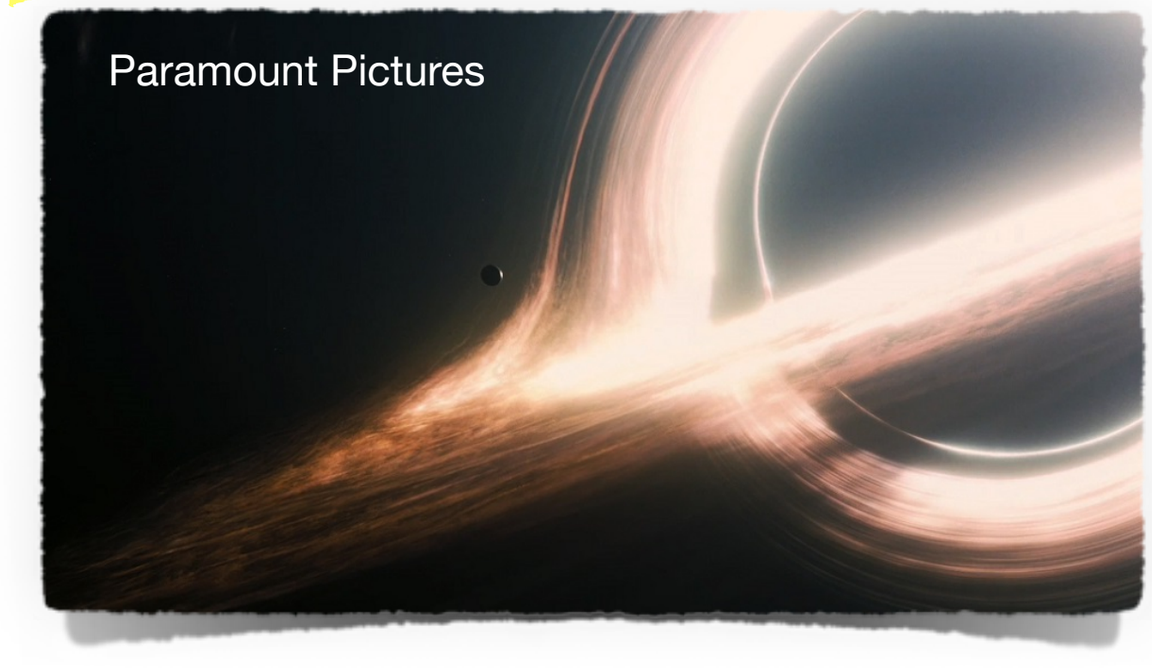

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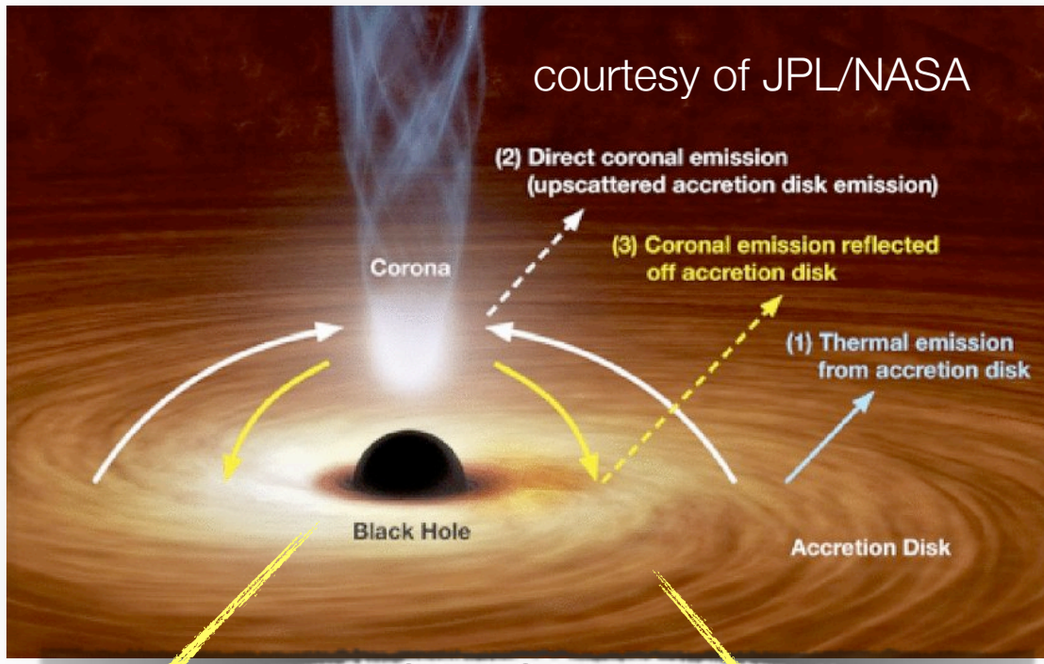

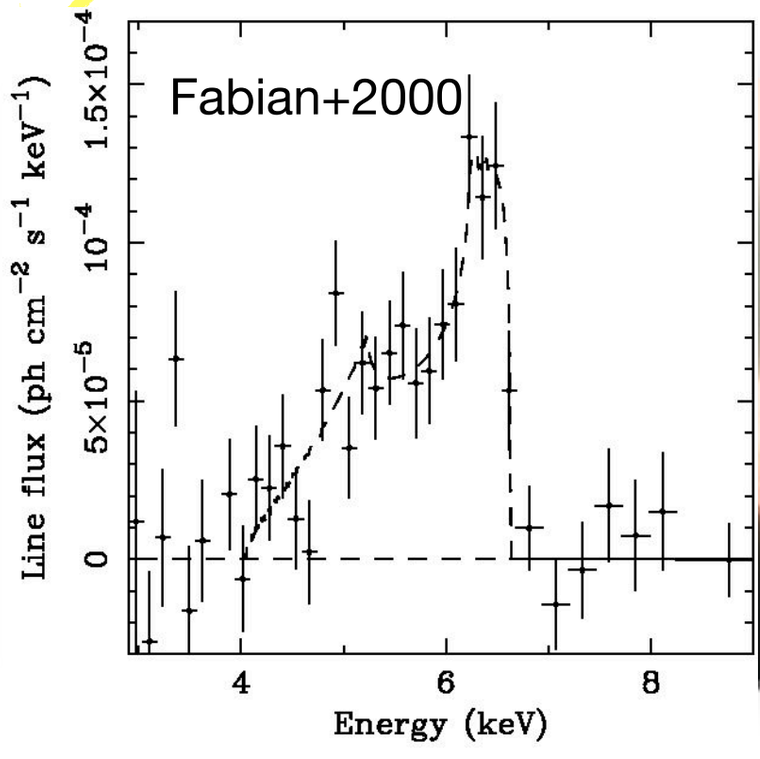

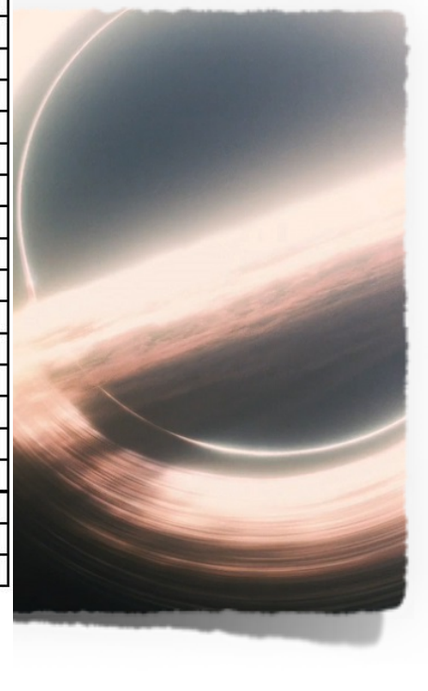

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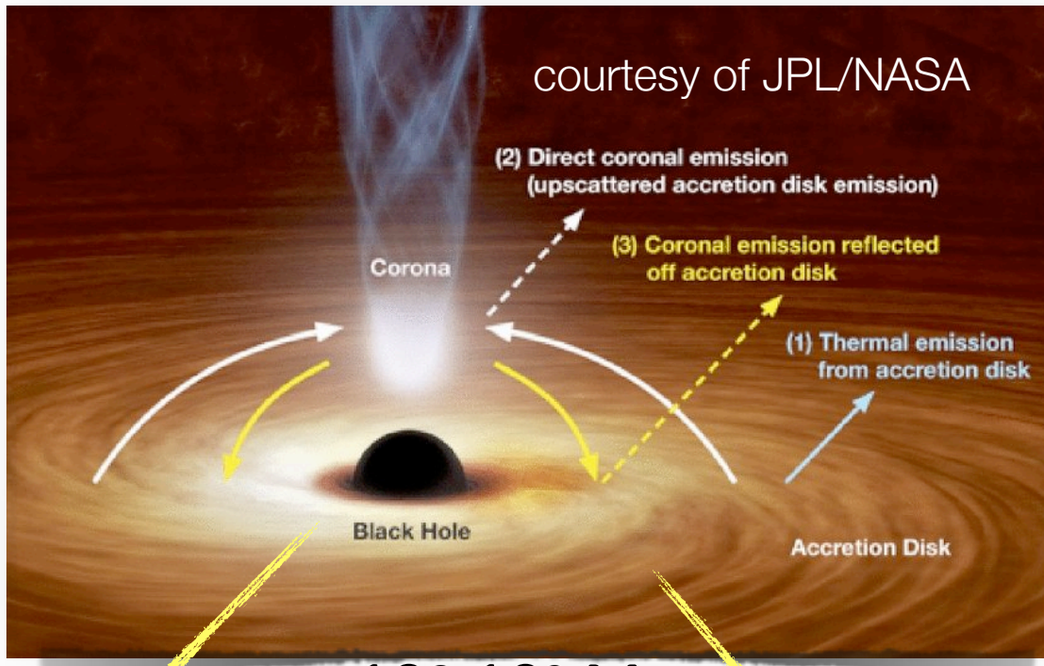
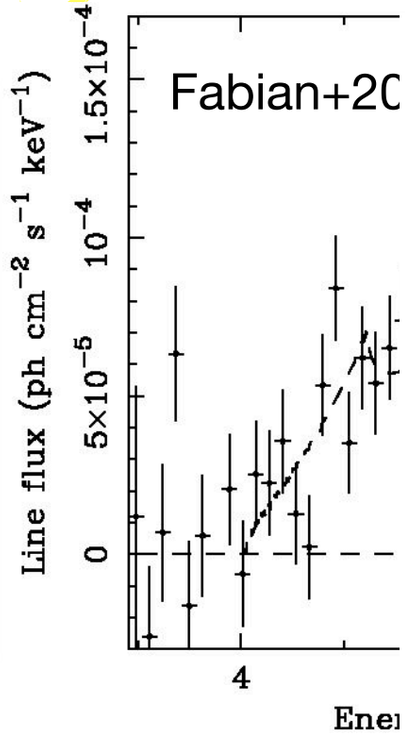
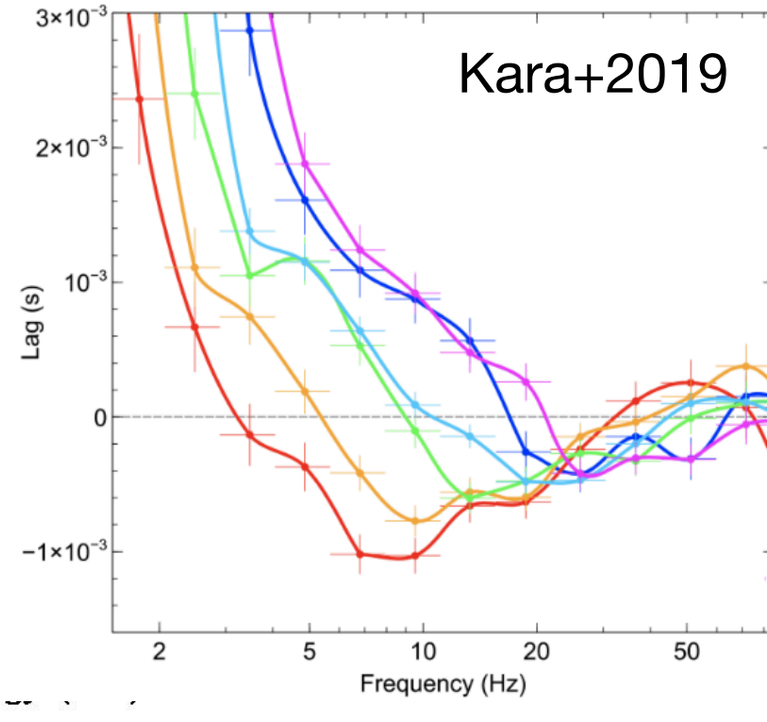
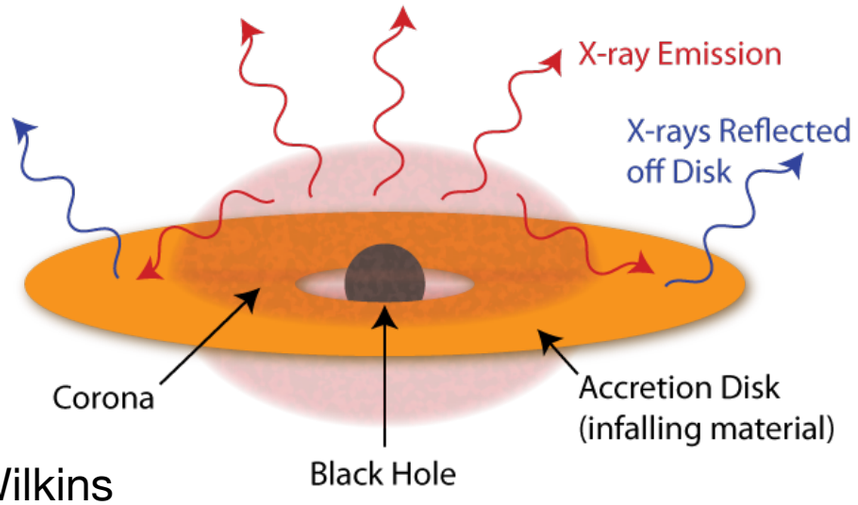
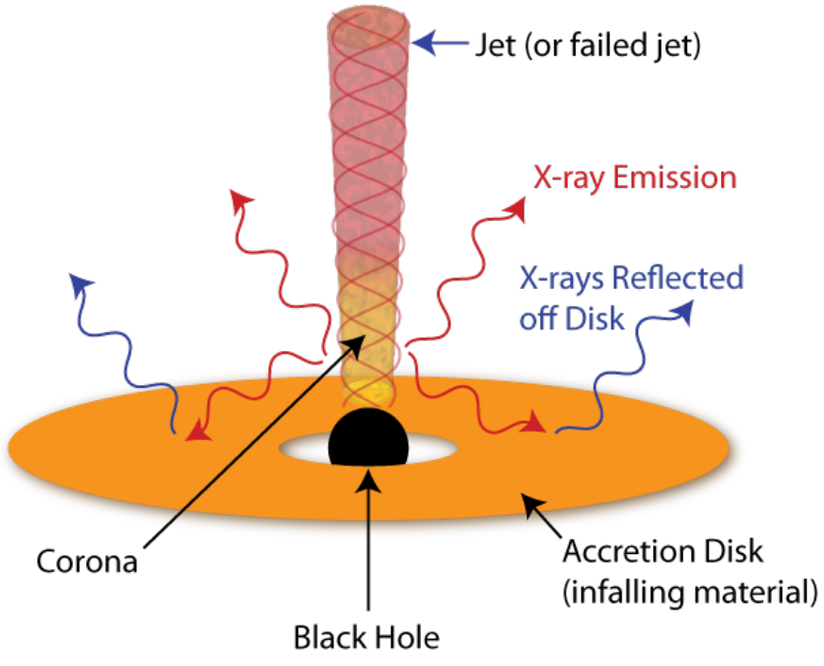






BH inner regions - Accretion Ejection



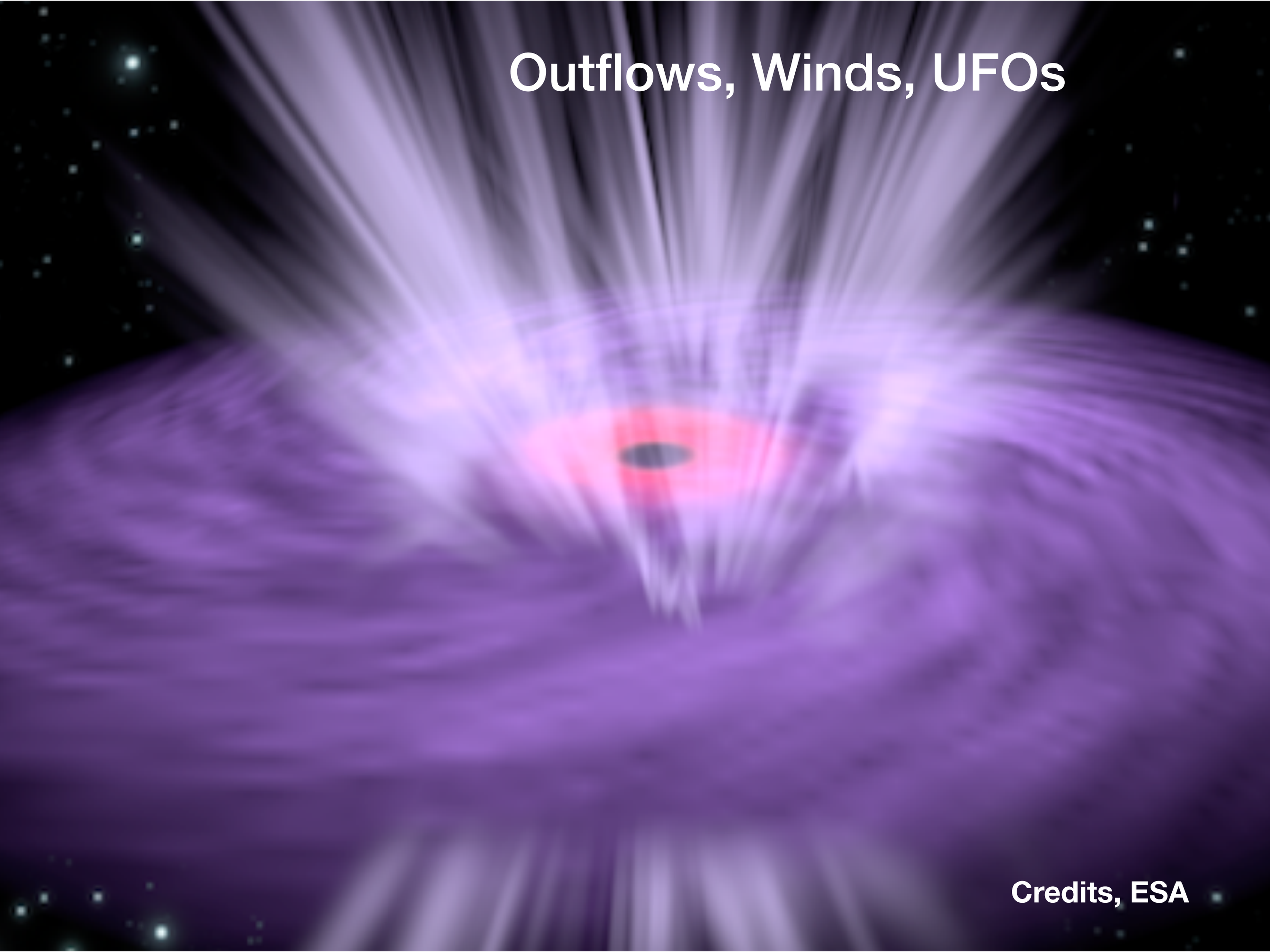


Credit: D. Wilkins

- Goals: Physical (tau and kT) and geometrical properties of the emitting hot corona.
- Coronal activity, interaction with the surrounding medium —> Arcsecond and milli-arcsecond studies of inner regions.
- Accretion/ejection at all scales
- Super-Eddington accretion

- How: X-ray Spectroscopy, X-ray spectral timing, X-ray polarimetry; Radio vs X-rays, Radio variability
- Software timing, spectral/timing.
- Missions: from BeppoSAX to INTEGRAL, XMM+NuStar, Chandra, Swift, IXPE, Athena, eXTP, EVN, VLBA, ATCA, LBA, JVLA, Effelsberg, LOFAR, eMERLIN, AMI
- Strutture (Schede): OAS, OAA, IAPS, IASF-Pa (SEAWIND, TORQUA, HEASS, MIOHECS)

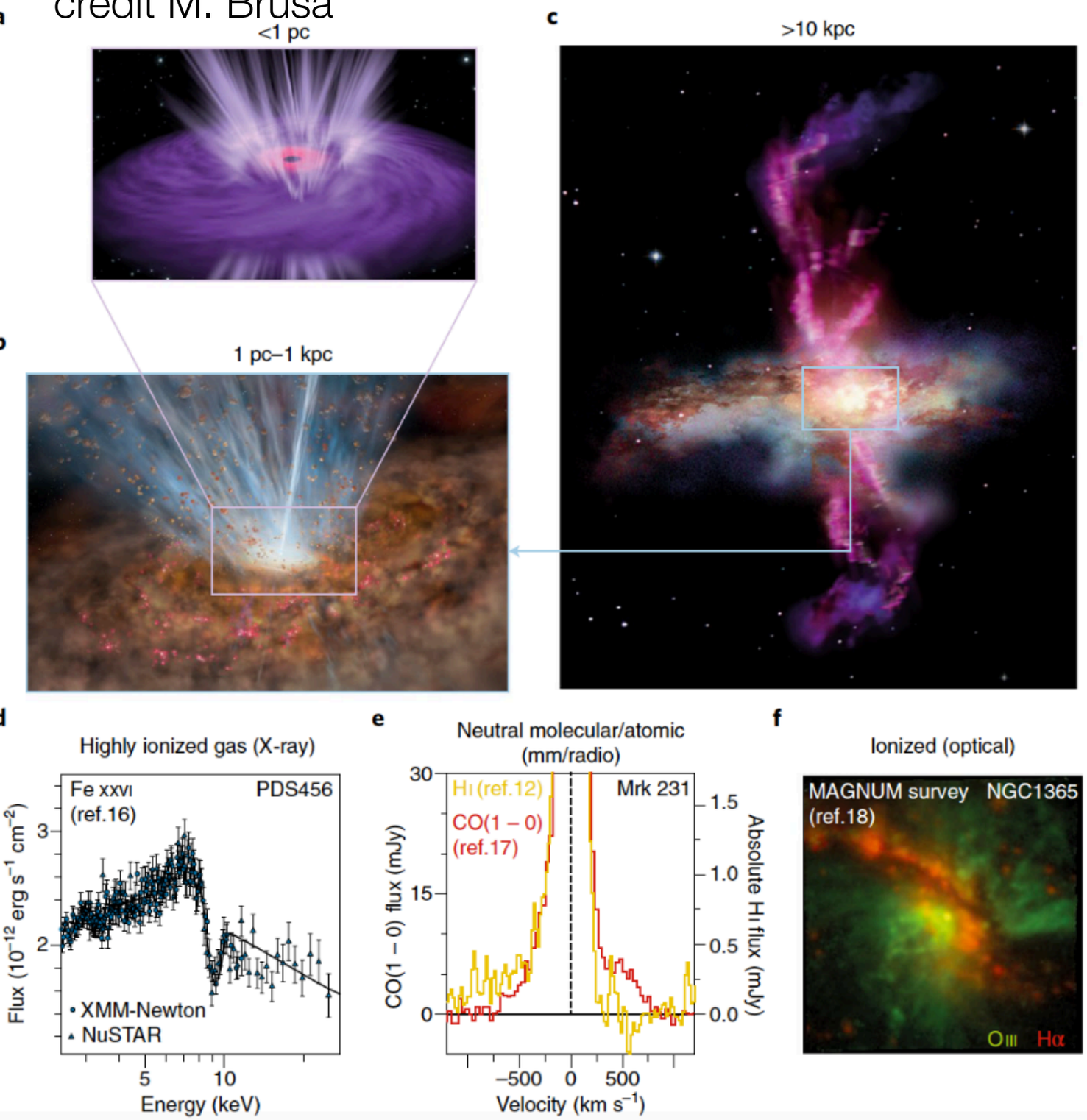
Outflows, Winds, UFOs



Credits, ESA

AGN winds, fast outflows and UFOs

Cicone+2018,
credit M. Brusa



gas flows in the form of energetic winds may play a pivotal role in galaxy evolution [—> RSN1].

These winds are detectable through strongly blue-shifted absorption lines associated with highly ionized iron atoms (Fe xxv and Fe xxvi) observable at energies E>6 keV

The AGN outflows have a multiphase nature, as revealed by observations and expected from simulations: highly ionized in the X-ray to the lower ionized gas traced by the [OIII] and the neutral phase observed in the galaxy-wide molecular outflows.

King 2005, King & Pounds 2015

NALs

$\log[\xi\ (\mathrm{erg\ cm\ s^{-1}})] = 0–1.5$
$\log[N_H\ (\mathrm{cm^{-2}})] = 18–20$
Velocity = 100–1,000 km $\mathrm{s^{-1}}$
Distance scale = ~1 pc–1 kpc

WAs

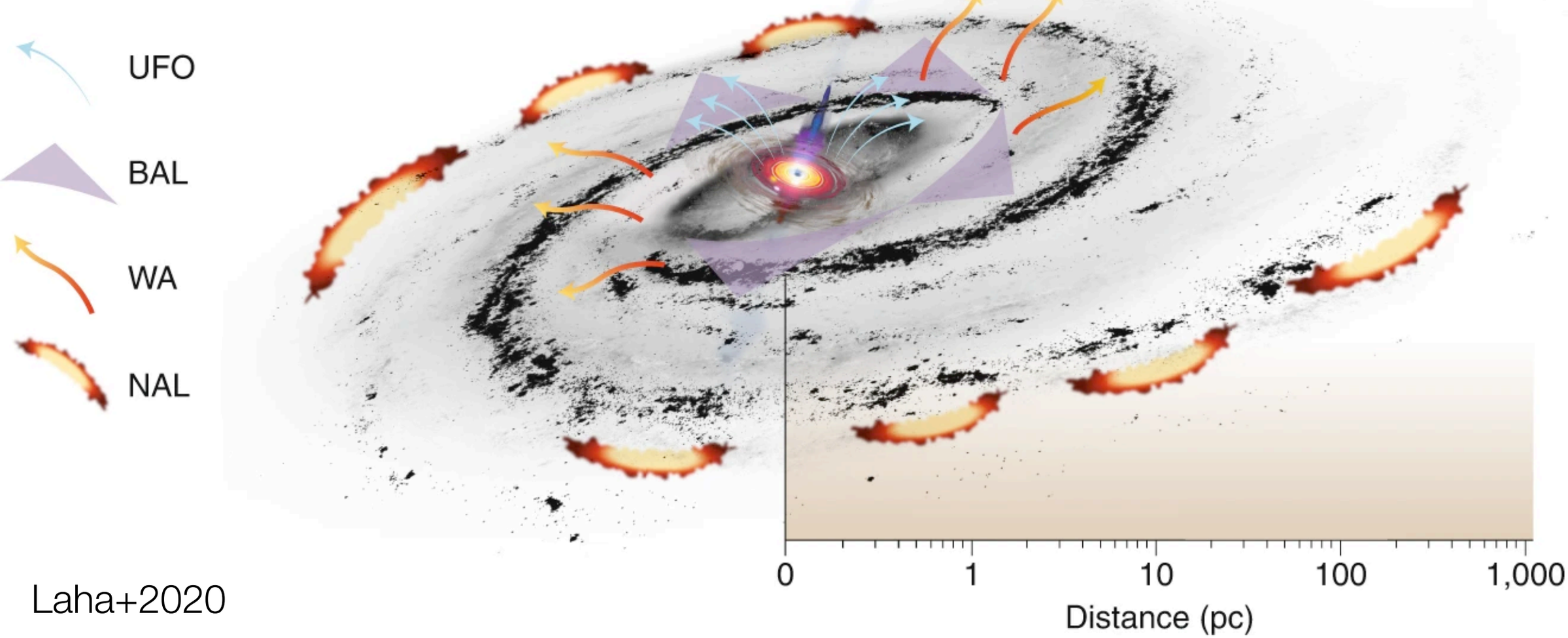
$\log[\xi\ (\mathrm{erg\ cm\ s^{-1}})] = -1–3$
$\log[N_H\ (\mathrm{cm^{-2}})] = 21–22.5$
Velocity = 100–2,000 km $\mathrm{s^{-1}}$
Distance scale = 0.1 pc–1 kpc

BALs

$\log[\xi\ (\mathrm{erg\ cm\ s^{-1}})] = 0.5–2.5$
$\log[N_H\ (\mathrm{cm^{-2}})] = 20–23$
Velocity = 10,000–60,000 km $\mathrm{s^{-1}}$
Distance scale = 0.001 pc–500 pc

UFOs

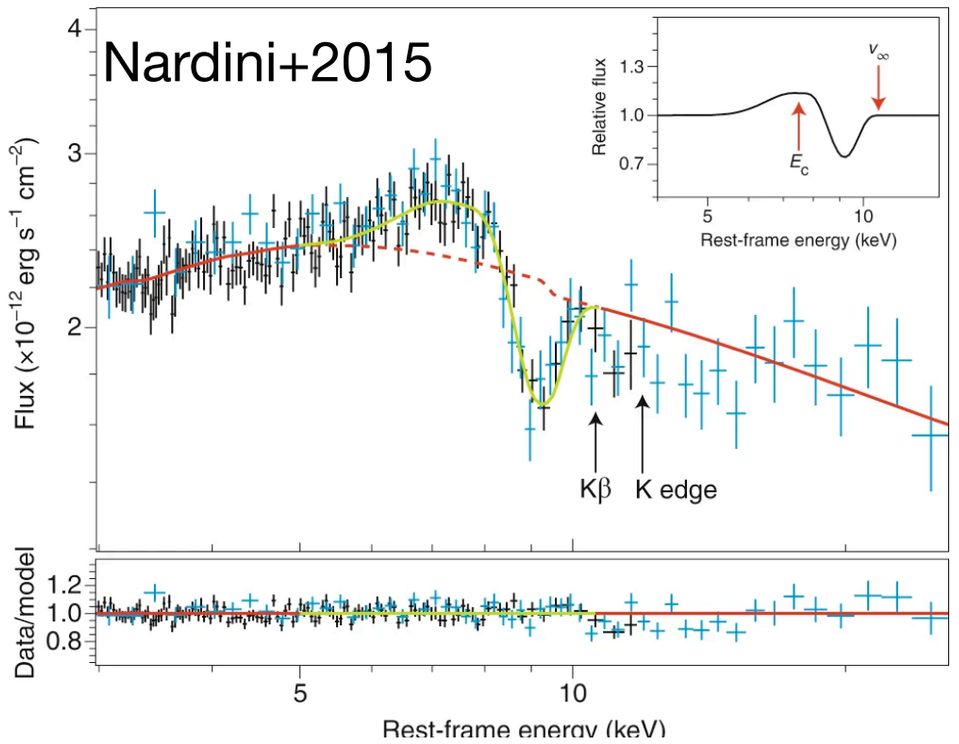
$\log[\xi\ (\mathrm{erg\ cm\ s^{-1}})] = 3–5$
$\log[N_H\ (\mathrm{cm^{-2}})] = 22–23.5$ -24
Velocity = 10,000–70,000 km $\mathrm{s^{-1}}$
Distance scale = 0.001 pc–10 pc



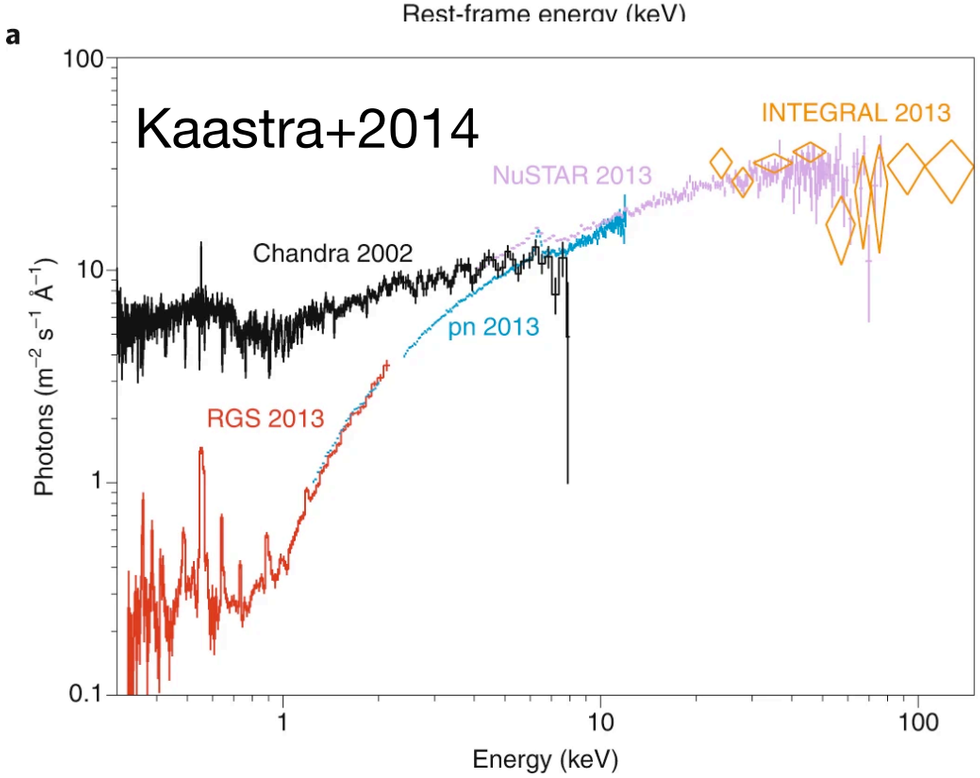
Laha+2020

Outflows, winds, UFOs

- Goals: study the launching mechanism of winds and UFOs, their energetics and if and how they may impact on the evolution history of the host;
- Bubbles: As a prototype for spirals, the Milky Way offers the opportunity to capture the details of feedback from sub-parsec to galactic scales.

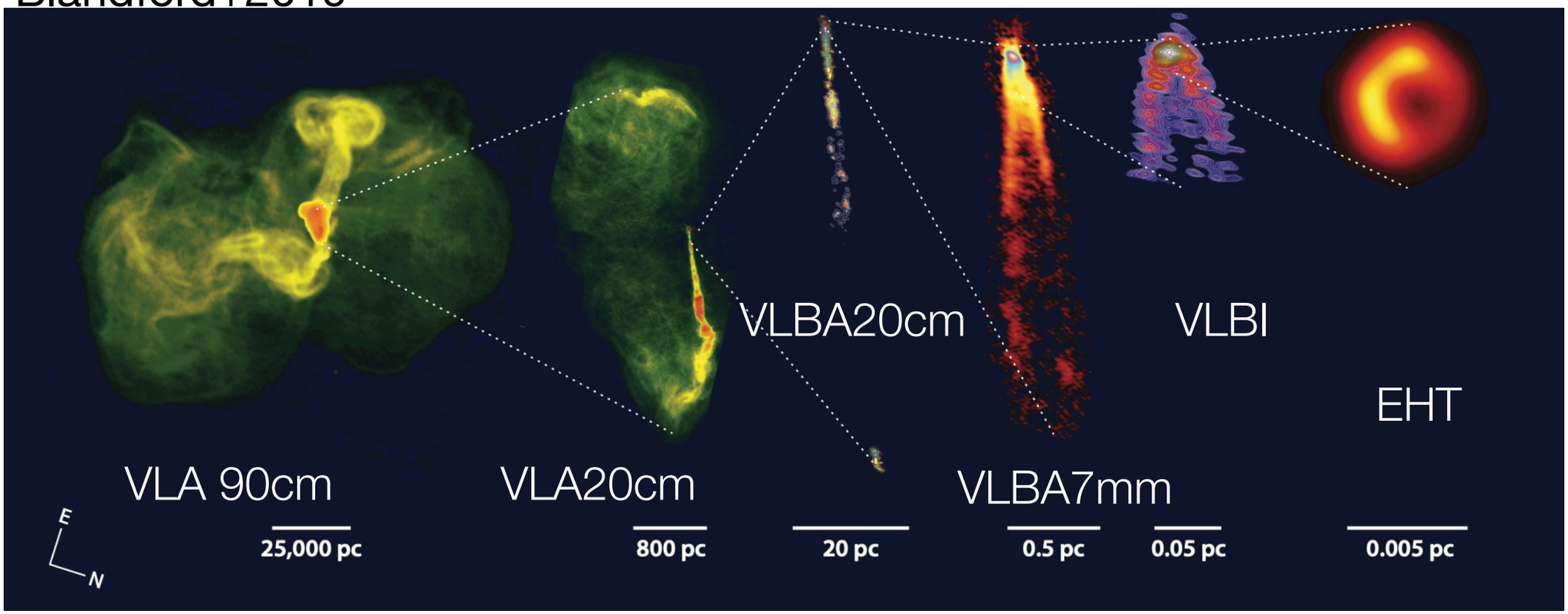


- How: X-ray measurements of winds/UFO both at low-z and High-z, (XMM-Newton, NuSTAR, Chandra) also tacking advantage of gravitational lenses for high-z QSOs. MWL (ALMA, HST) data.
- Theoretical models and development of ML techniques to implement them into standard fitting tools deep usage of computing power
- Missions: Athena, XRISM, HEX-P
- Strutture (Schede): OAS, OAB, [RSN1] (UAGNER, TheExtremeWinds, HotMilk GCHeritage)



jetted-AGN

M87,
Blandford+2019



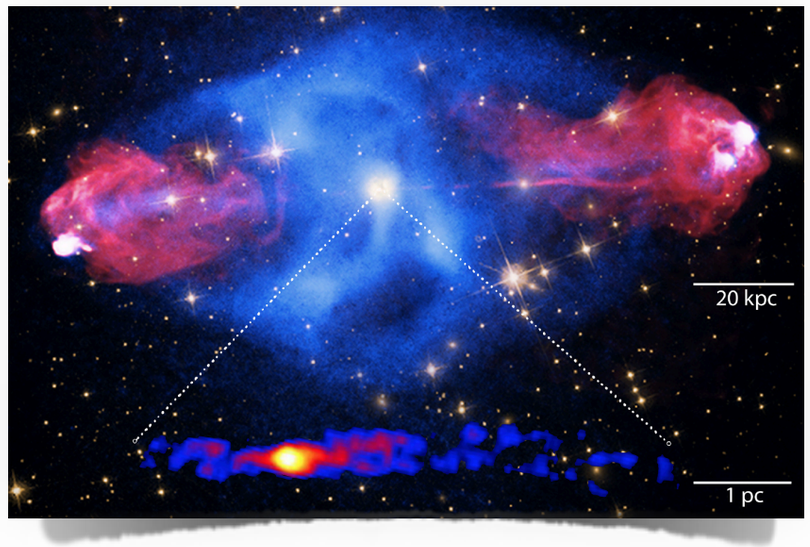
- AGN jets are formed when the black hole spins and the accretion disk is strongly magnetized,
- AGN jets are collimated close to the black hole by magnetic stress associated with a disk wind.
- Higher power jets can emerge in a relativistic state and terminate in strong, hot spot shocks; lower power jets are degraded to plumes and bubbles.
- Jets may accelerate protons to EeV energies which contribute to the cosmic ray spectrum
- Jets can have a major influence on their environments, stimulating and limiting the growth of galaxies

jetted-AGN

- goals: jet formation, structure, particle acceleration & radiative processes; gamma-ray & multi-messenger astrophysics; evolution of the extragalactic radio sources, feeding & feedback.;

- Emerging population of gamma-ray radio galaxies from new radio surveys. Modelling of the broad-band SED, and GeV emission from the lobes;

- Giant radio galaxies and their duty cycle; Addressing jets duty cycle, reorientation, restarting activity; Correlation with high-energy emission and accretion state



Cygnus A. Credits: X-ray: NASA/CXC/SAO; Optical: NASA/STScI; Radio: NSF/NRAO/AUI/VLA; VLBI inset: Boccardi et al. (2017). From Blandford+2019

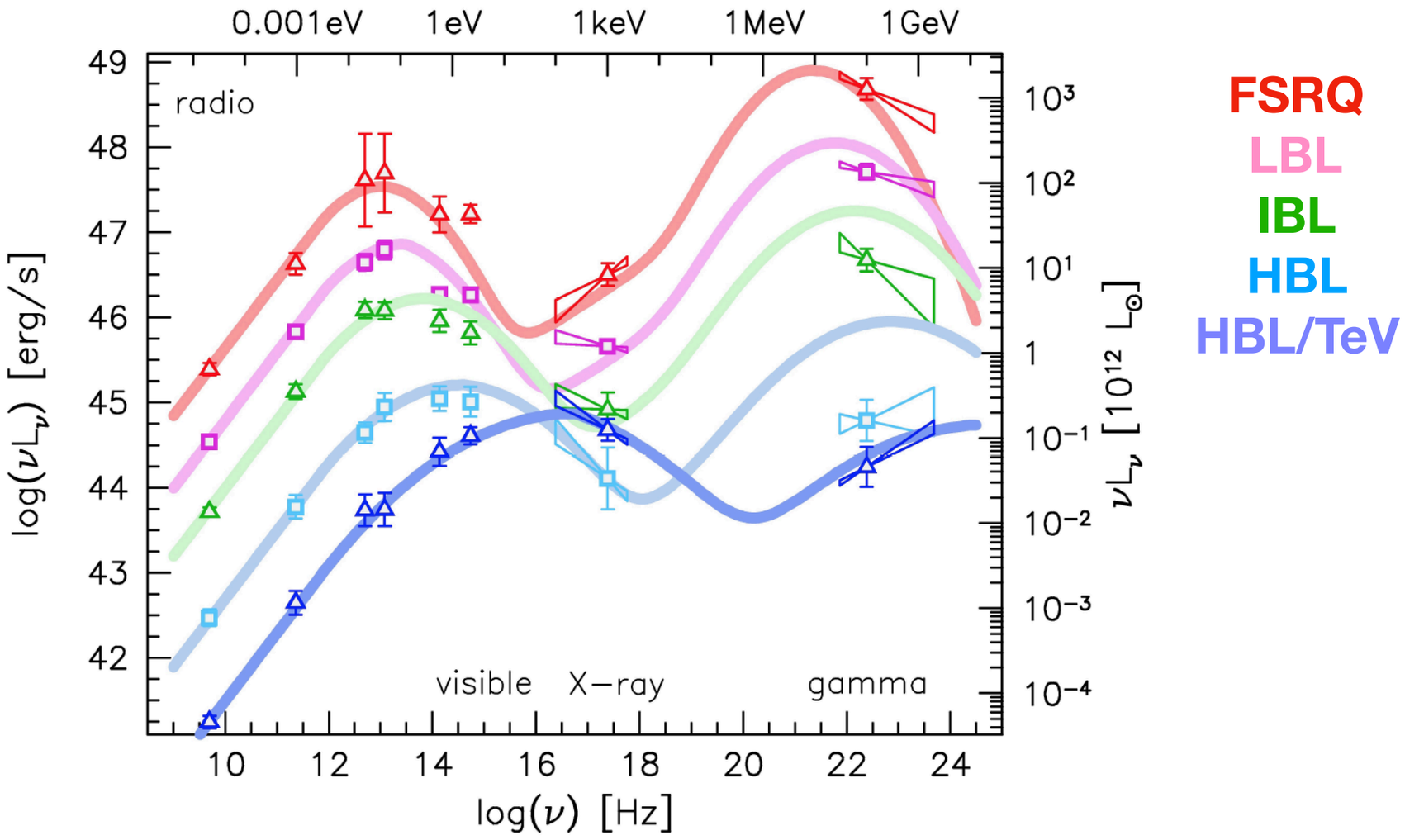
- How: Multi-frequency radio observations & VLBI, neutrino-candidate follow-up campaigns; High-energy (X-to-gamma-ray) analysis; Population studies & multi-wavelength emission modeling.
- EVN, VLBA, ATCA, LBA, JVLA, Effelsberg, LOFAR, eMERLIN, AMI, SKA VLBI Italian VLBI, EVN, Eating VLBI (East-Asia Italy Nearly Global VLBI) & Korea/Japan radioastronomy projects & collaboration. XMM, Chandra, Swift, INTEGRAL, Fermi, NuStar, Athena, CTA ASTRI LSST
- Strutture (schede): OAS, IRA, IAPS, OAB (YRG, DUTYRAGA, MUTE SORCERER, JEAH, gNLS1s)

jetted-AGN BLAZAR

Credits: NASA/JPL-Caltech/GSFC

jetted-AGN Blazars

Blandford+19
Fossati+1998

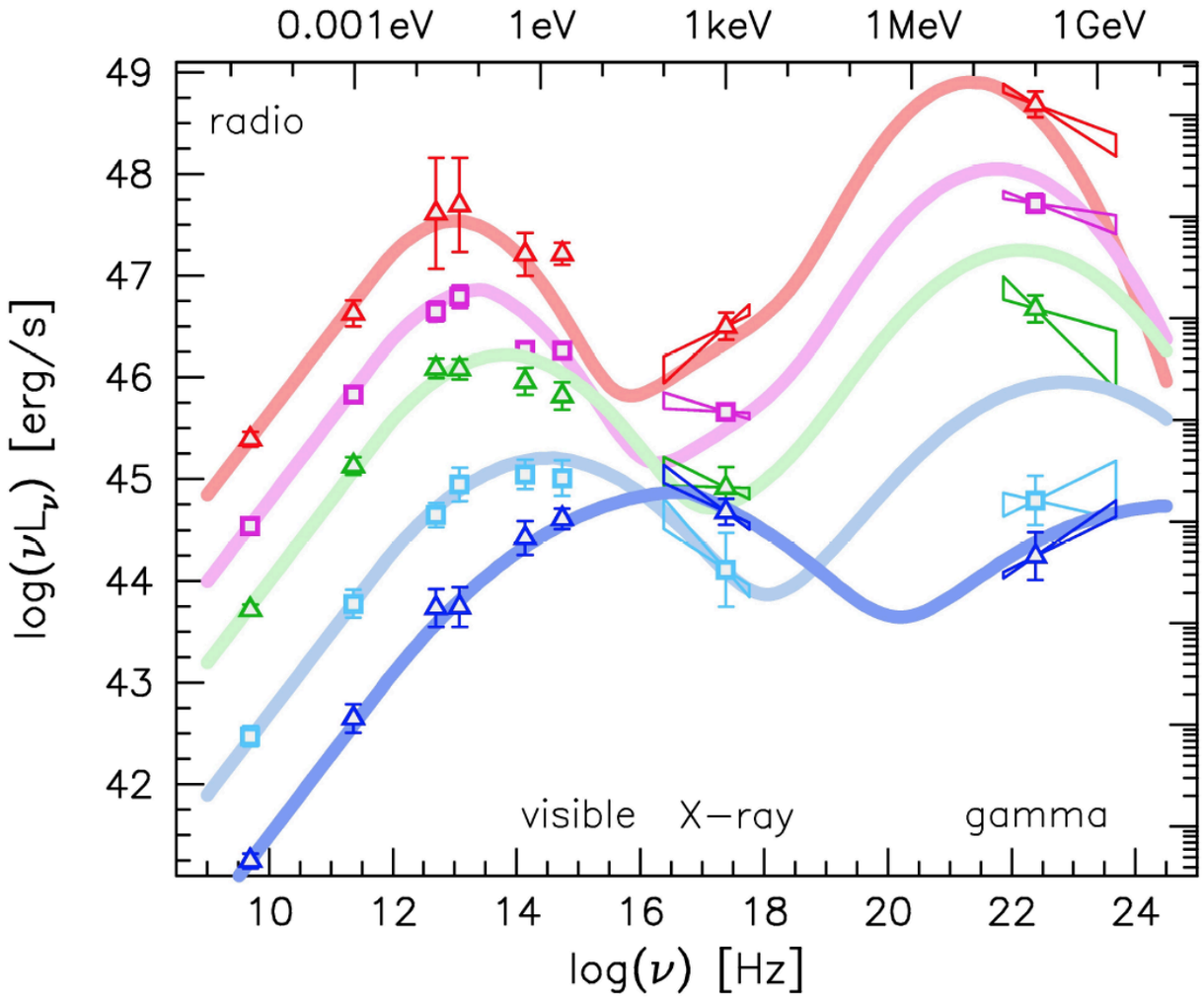


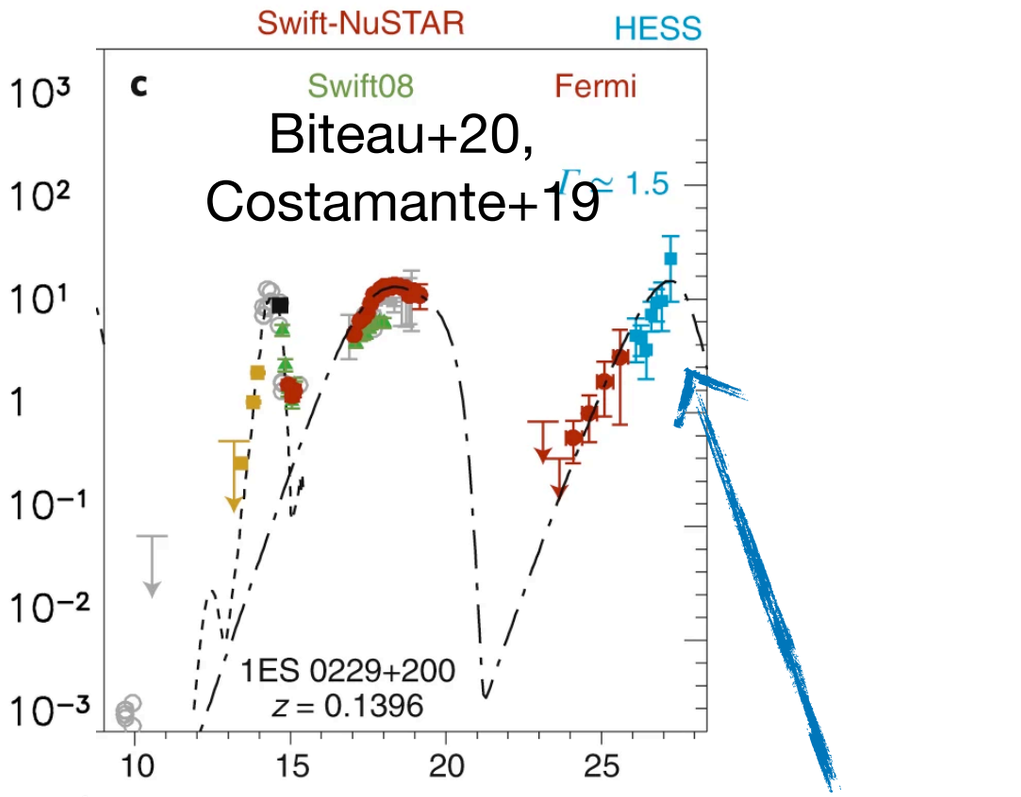
- Typical double peaked SED
- Infrared to X-ray peak associated to synchrotron emission from jet electrons;
- The second hump, peaking above MeV energies IC scattering, possibly of the same electrons on their own synchrotron emission (SSC) or external field (EC).

- The peak frequency tell about the spectrum of the emitting particles, probing the comparative strength of acceleration, cooling and escape mechanisms

jetted-AGN Blazars

Blandford+19
Fossati+1998





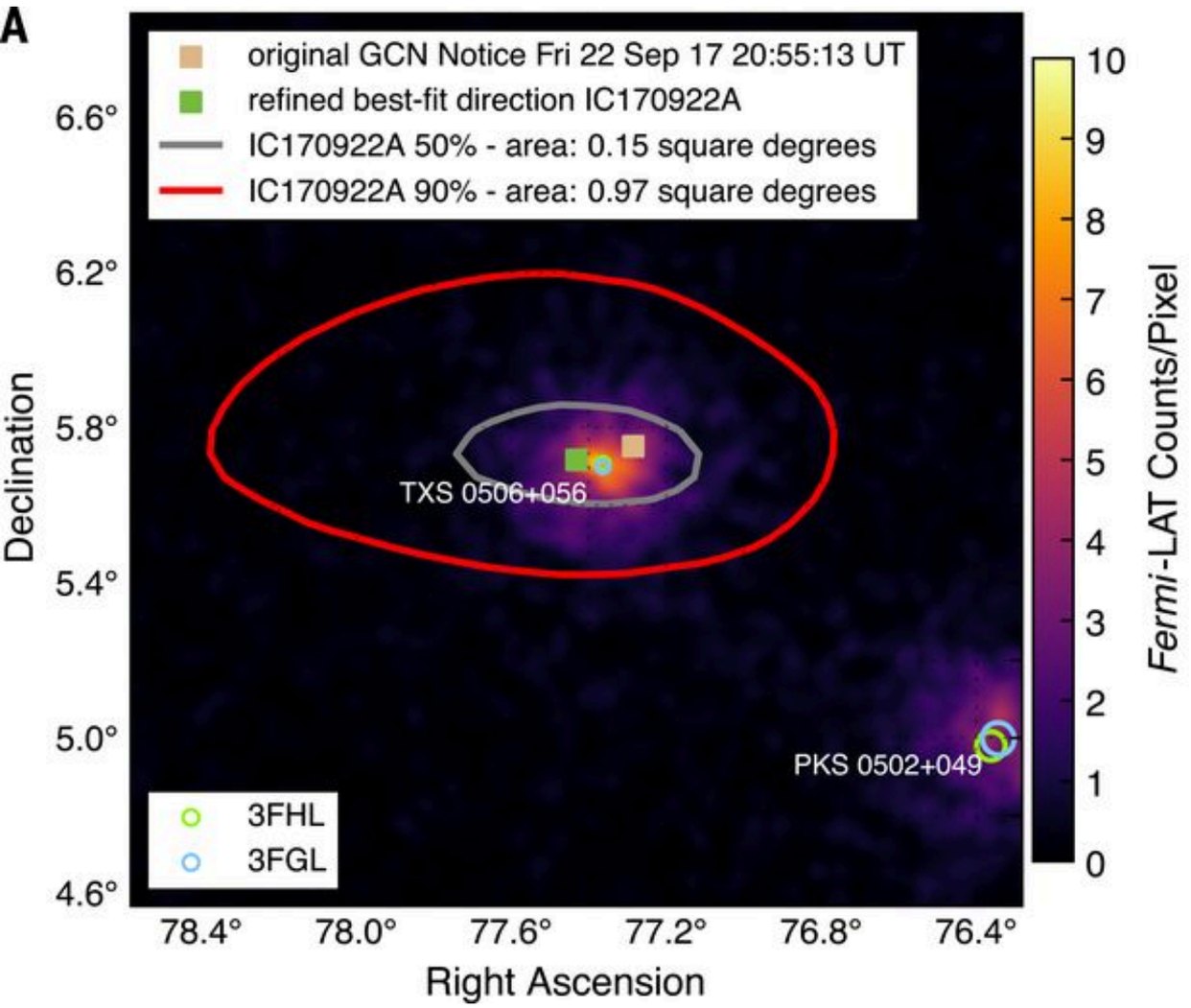
10 TeV Peak!

- Typical double peaked SED
- Infrared to X-ray peak associated to synchrotron emission from jet electrons;
- The second hump, peaking above MeV energies IC scattering, possibly of the same electrons on their own synchrotron emission (SSC) or external field (EC).

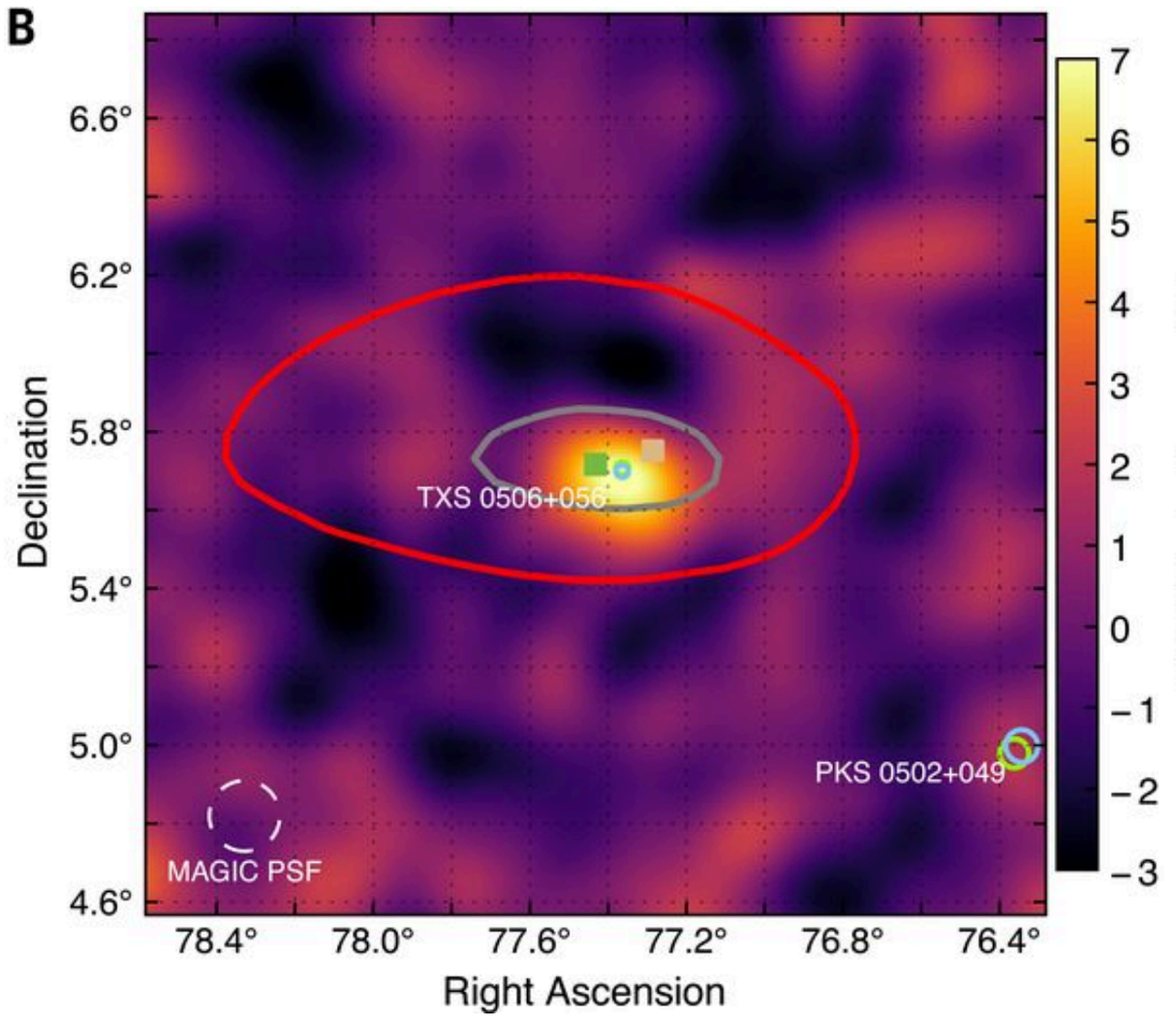
- The peak frequency tell about the spectrum of the emitting particles, probing the comparative strength of acceleration, cooling and escape mechanisms

Multi-messenger observations of the flaring blazar TXS 0506+056 coincident with IceCube-170922A neutrino event

IceCube Collaboration: *Science* 361, 147 (2018).
IceCube & MW collaboration: *Science*, 361, 1378 (2018)

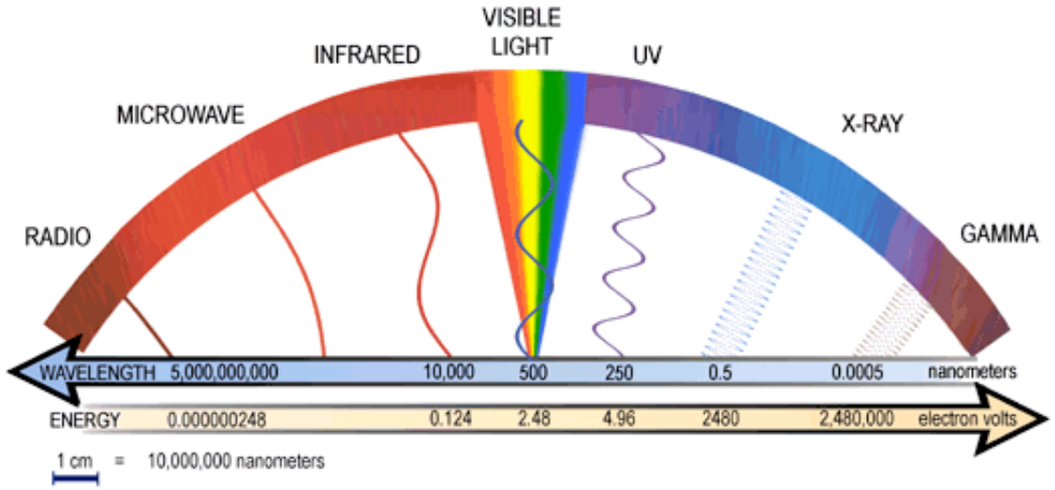


Fermi LAT counts map 1-300 GeV



MAGIC significance map > 90 GeV

Multi-messenger observations of the flaring blazar TXS 0506+056 coincident with high-energy neutrino



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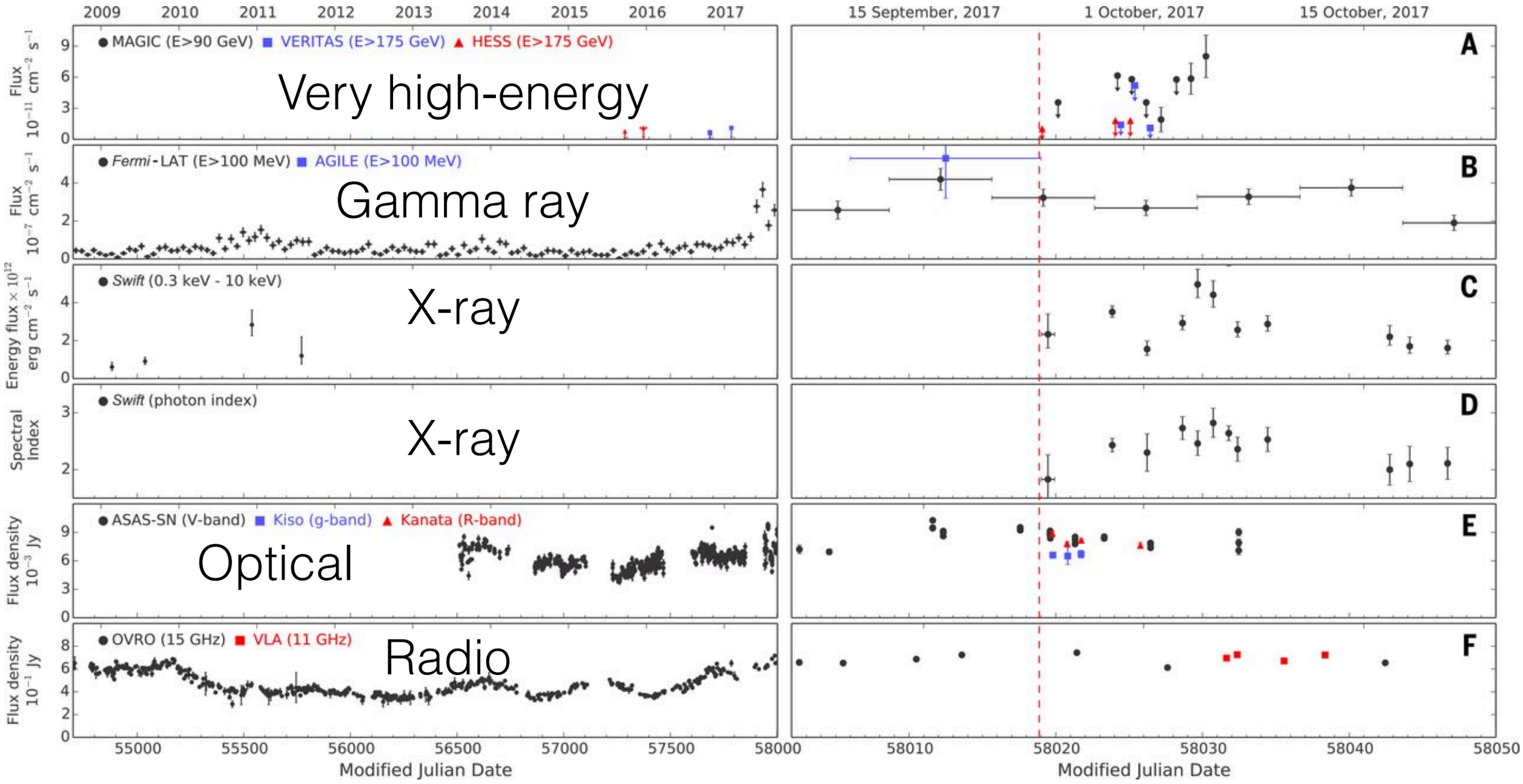


jetted-AGN Blazars

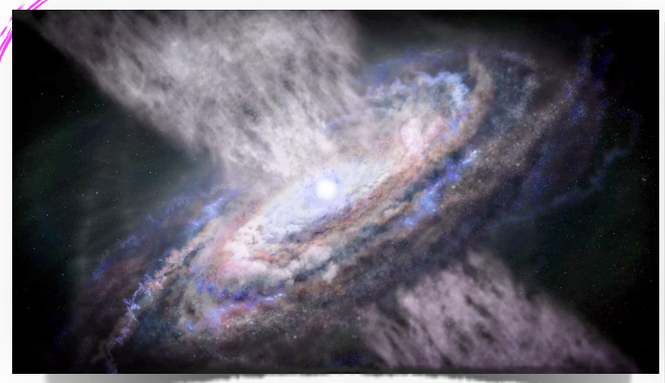
- Goals: Temporal and spectral evolution of the radio-to-very-high-energy emission, the jet structural properties, the connection between neutrino and electromagnetic emission, and the acceleration processes;
- Theory: Leptonic vs hadronic models; jet acceleration plasma physics
- How: Multiwavelength campaigns on blazars providing photometry + polarimetry + spectroscopy; Many tens of observers in optical, radio and near-IR; Archive, with data available
- Missions: Swift, AGILE, Fermi, CTA, ASTRI-Horn, ASTRI Mini-Array, ground-based telescopes
- Strutture (schede): IAPS, OAB, IRA, OA-To, OA-Ts (WEBT, RELJETS, PROGRESS, GAMMA2, RELOUT, PLUTO, PILLAR, BLAZARS, PEACE, PLASMI, ENTGAL)

raised critical points

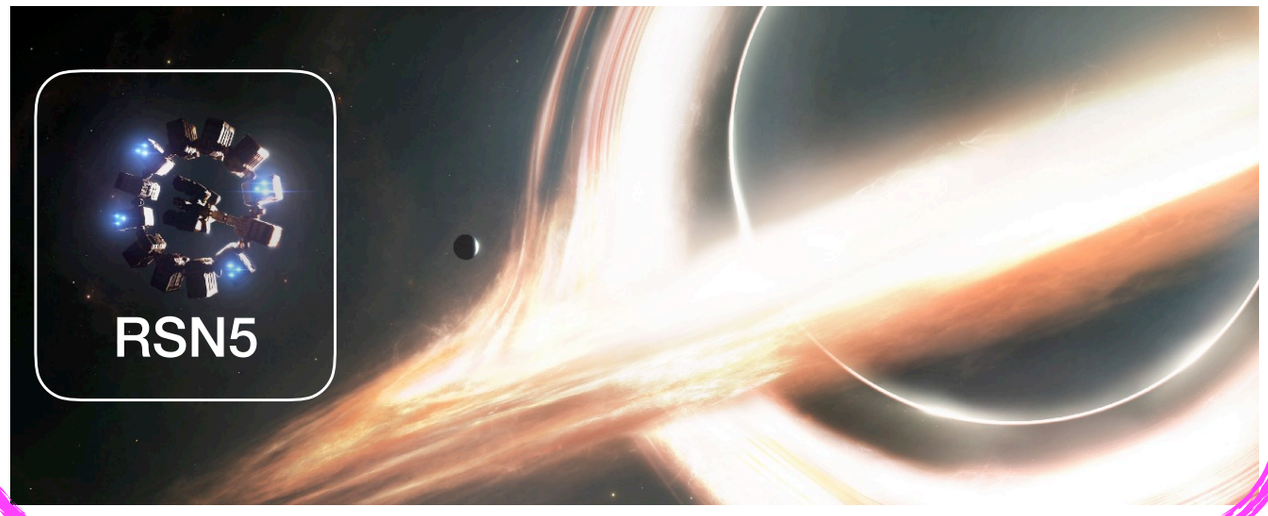
- No dedicated funds, no post-docs, very few students. In some case this is extreme (no funds for invited conference or new pc)
- Difficult to find post-doc level staff: 1-yr appointments are not sufficiently competitive;
- In view of new data/projects in the near term more young researchers to be consolidated to staff;
- Loosing expertise without groups turnover;
- Data handling: need for technological improvement to face the increasingly large datasets in all wavebands;
- Need for IT expert to maintain and develop the IT facilities;
- Timeline for the INAF grants to be defined at the time of the call for all grants (LG, miniG,..)
- exploiting huge archival datasets, but then how to move on and attract students towards high-energy domain without the solid prospective of a European-lead X-ray mission?

points for discussion

RSN1

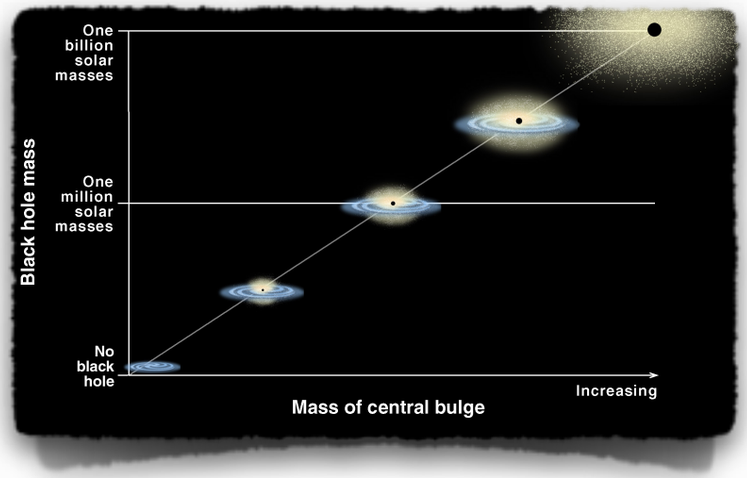


RSN4: Accretion under strong field gravity regime. Accretion/ejection



BH formation and evolution

BH and galaxy coevolution



- RSN4 and our link/synergies with RSN1/RSN5
- RSN4: stellar vs supermassive-BHs: links, synergies and possible “structured interactions” (e.g. AGN and CNOC)

Credits Images: K. Cordes, S. Brown (STScI); Credit: MARK GARLICK; John Paice; Paramount Pictures

cosa ho imparato preparando questo talk

- se dovessi scegliere l'argomento della mia tesi oggi (dopo ~25 anni) valutando interesse personale, impatto, prospettive future, link con sviluppi tecnologici e progetti a leadership italiana, sceglierei di nuovo la scienza degli AGN e chiederei alle ricercatrici e ai ricercatori dell'INAF.

- 15 giorni di anticipo per chiedere input alla comunità AGN… non sono abbastanza!

Grazie!