



Cosmic Black Holes and their Vicinity: Research Prospects

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Thinking in terms of the next 20 years of BH research, we should:

- Go beyond post-Newtonian tests of GR.**

- Consider carefully all „exotic“ alternatives to BH (boson or quark stars, ECO, etc., including something totally unknown).**

- Strive for a „full“ (*3D GRMHD + Poynting flux + thermal particles*) description of the BH vicinity (*relativistic jets and accretion disks*).**

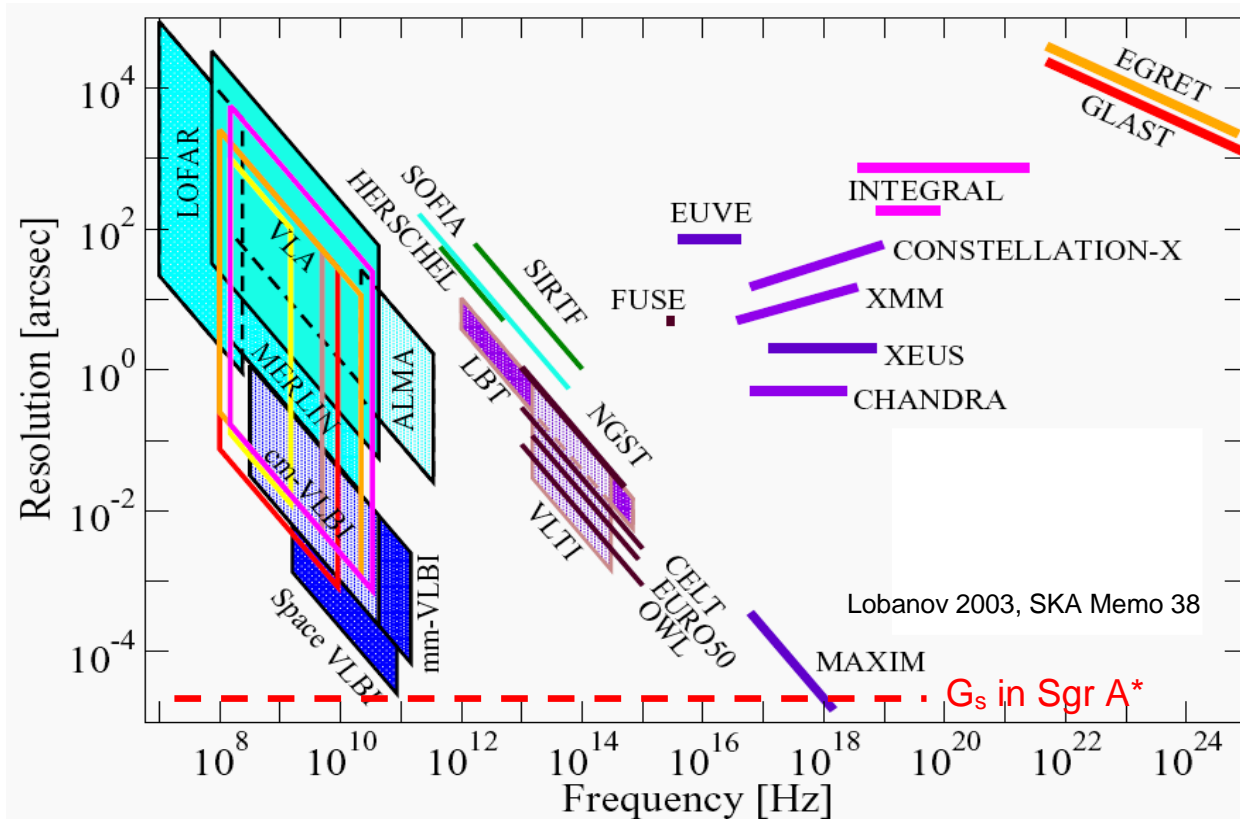
- Look for means to obtain 2D information about the BH vicinity (*true imaging*).**

- Be realistic (or even opportunistic) in the choice of tools.**



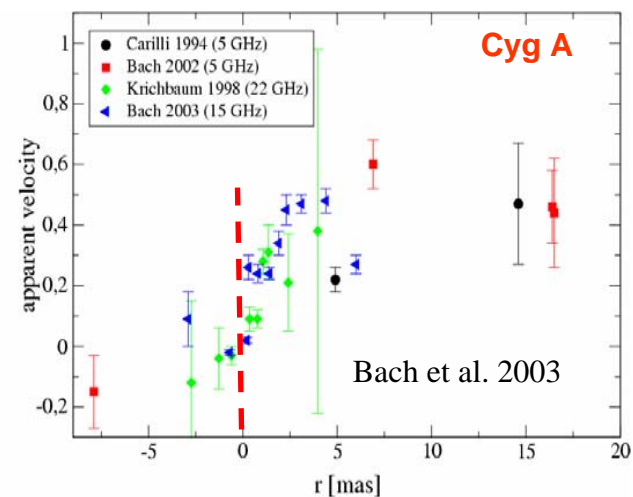
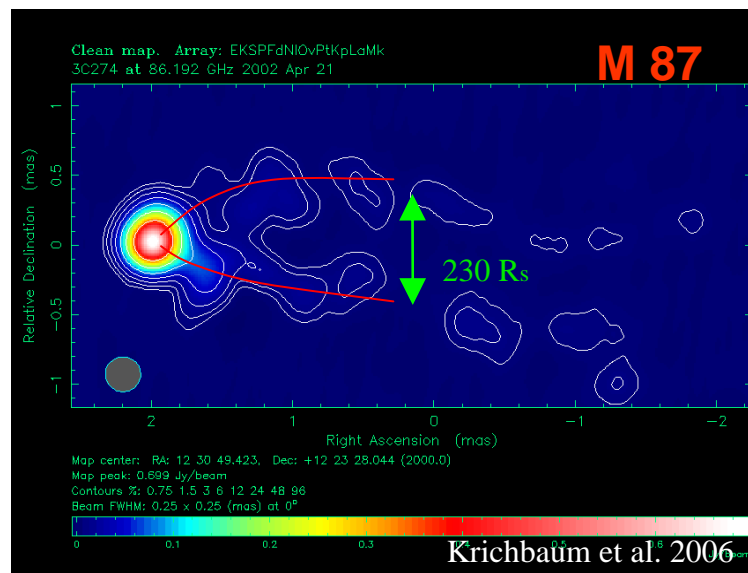
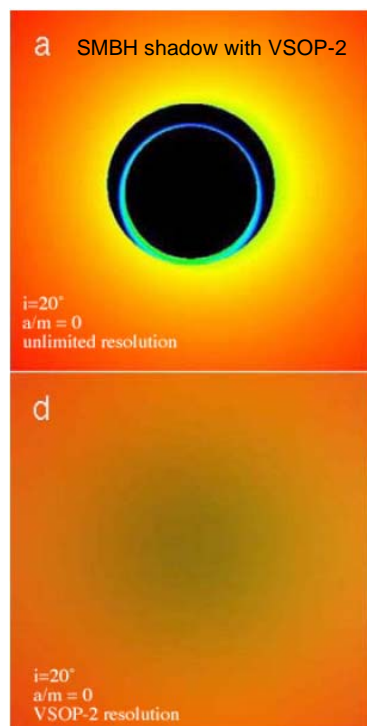
Studying the BH Vicinity

- ❑ **X-ray:** spectroscopy (1D, model dependent); interferometry (not available)
- ❑ **Optical, IR:** interferometry (need good uv-coverage, phase closures)
- ❑ **GWave:** interferometry (detection depends on pre-calculated templates)
- ❑ **Radio:** GVLBI (2D, calibration), SVLBI (2D, orbit determination)



VLBI on BH Vicinity

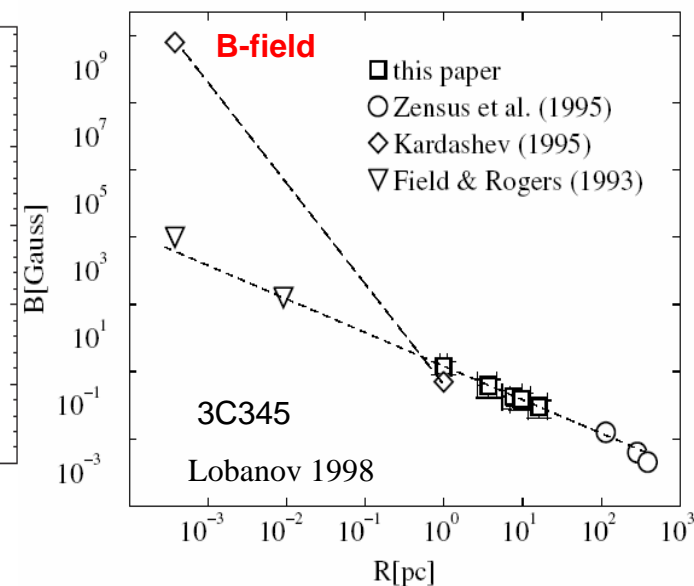
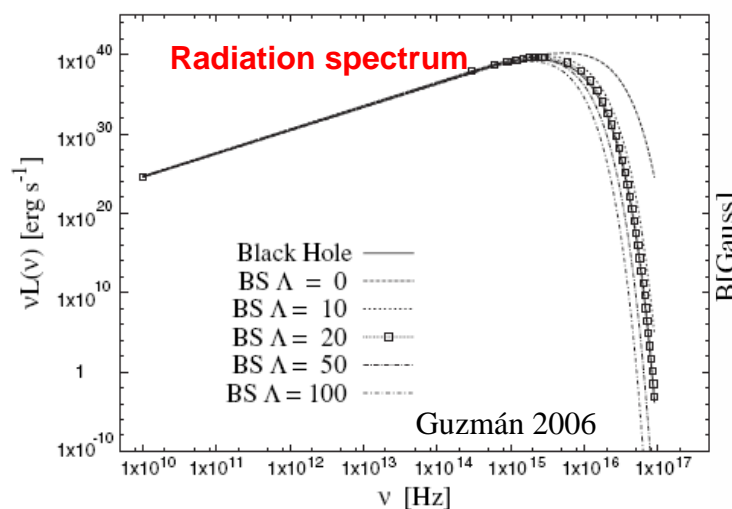
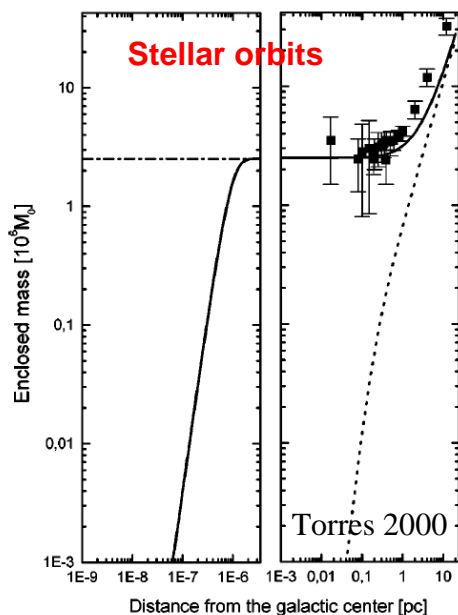
- ❑ Direct imaging of hot (10^9 – 10^{10} K) material in AGN accretion disks in the vicinity of SMBH (M87: a BH “shadow” size $\sim 26 \mu\text{as}$, VSOP-2: $\sim 40 \mu\text{as}$; mm-VLBI: $20 \mu\text{as}$ @ 215 GHz).
- ❑ Formation, acceleration, collimation and internal structure of relativistic jets.





BH or not BH?

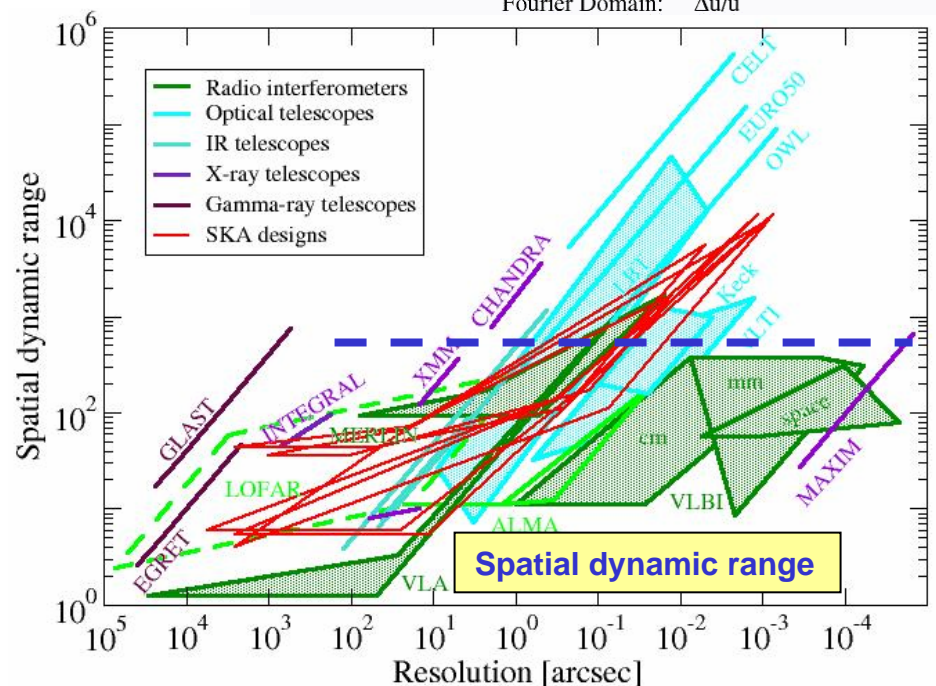
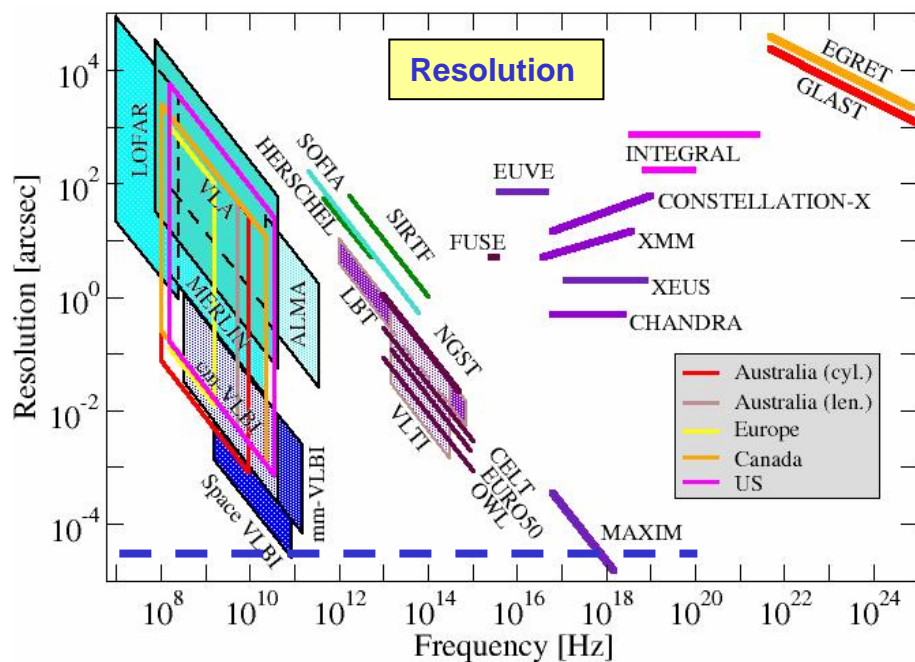
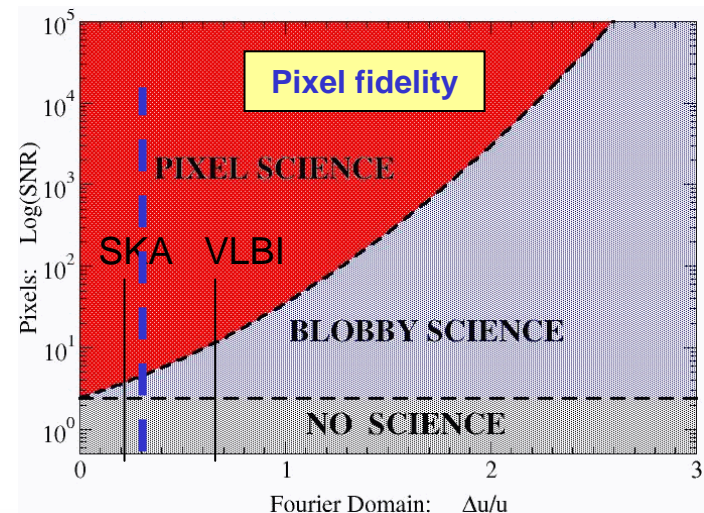
- ❑ Present evidence does not strictly prove existence of BH.
- ❑ Need to devise instruments and experiments to distinguish effectively between BH and their alternatives:
 - **stellar orbits:** (S1, Sgr A*) good enough for BH vs. ν condensate tests
 - **radiation spectrum:** high energies (BH vs. BS), ELF (BH vs. MECO)
 - **gravitation waves:** BH vs. anything (but need accurate templates)
 - **VLBI:** 2D imaging (BH vs. BS/MECO?), B-field (BH vs MECO)



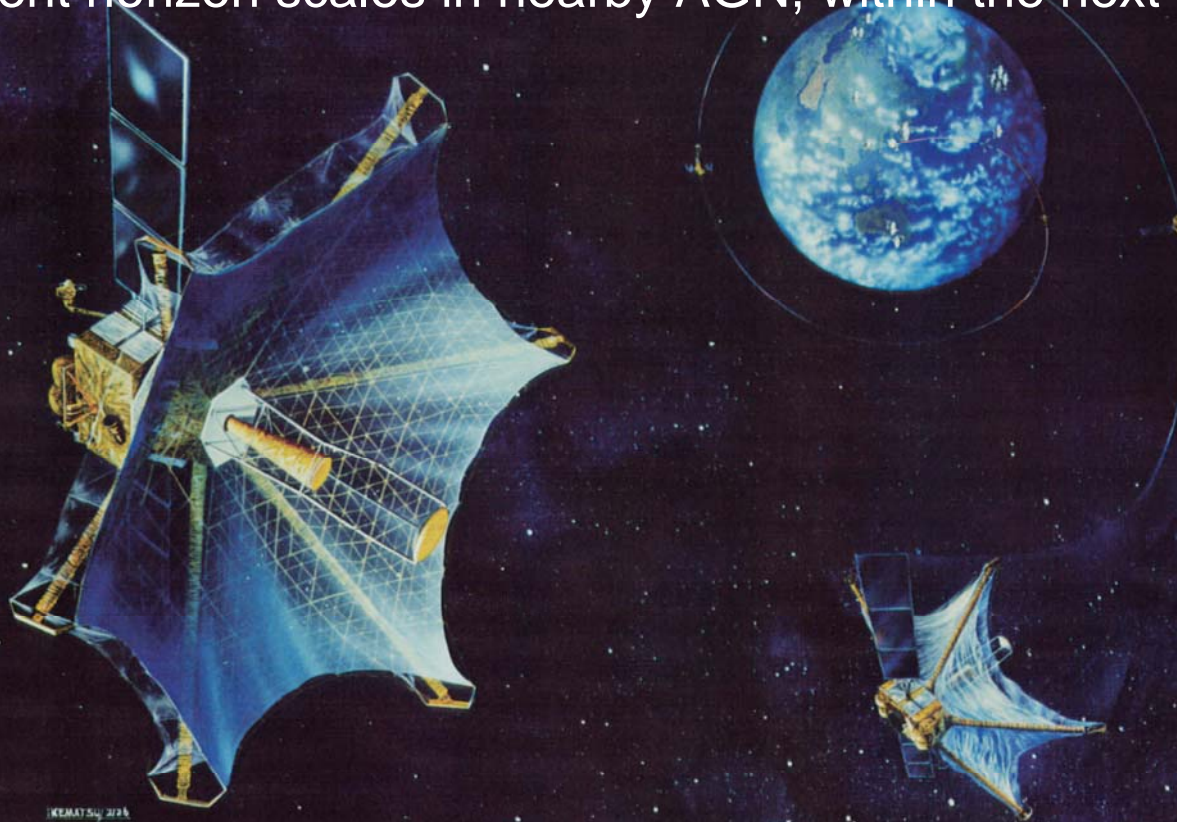


Observational requirements

- Effective studies of SMBH and their vicinity will require imaging with:
 - $\sim 10 \mu\text{as}$ resolution;
 - spatial dynamic range of >500
 - pixel fidelity down to $\text{SNR} \sim 5$



- ❑ Opting for a two-spacecraft SVLBI mission with ~ 25 meter antennas at a $\sim 40,000$ km orbit offers a viable way to approach true imaging of the event horizon scales in nearby AGN, within the next two decades.



- ❑ Determining the true physical nature of black holes is fundamental for astronomy and physics.
- ❑ Jets may have a substantial EM component arising from an extreme vicinity of BH and affecting their formation and propagation. A 3D GRMHD description and high resolution imaging are essential for future studies.
- ❑ High-sensitivity VLBI from the ground (mm-VLBI) and space (VSOP-2 and beyond) is one of the primary (and affordable) tools for studies of BH and relativistic jets.