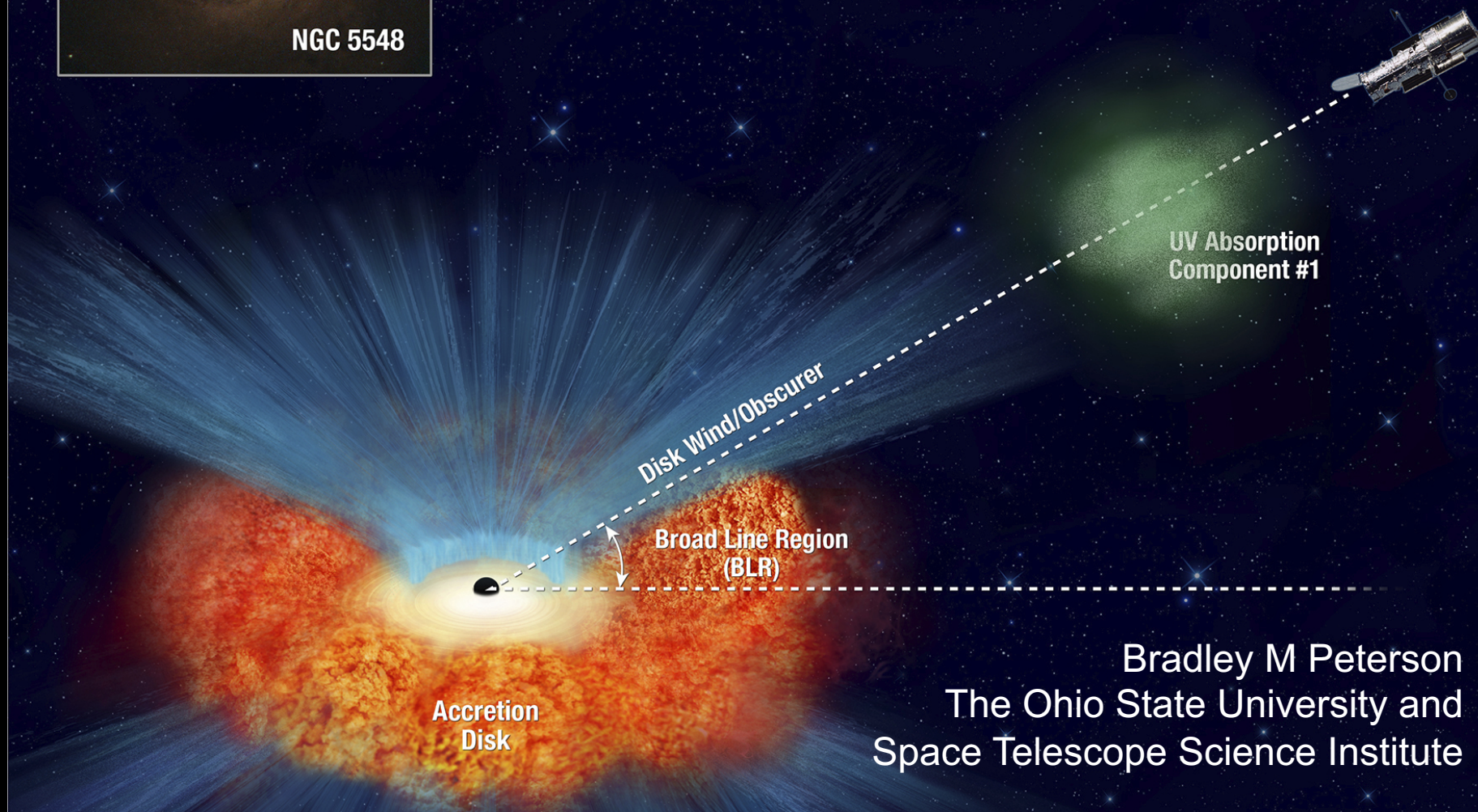
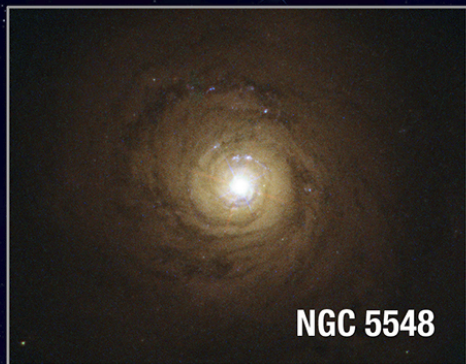


CLOSING REMARKS



Bradley M Peterson
The Ohio State University and
Space Telescope Science Institute

Thanks to the organizers!

- SOC

- Jian-Min Wang (chair)
- Keith Horne (co-chair)
- Brad Peterson (co-chair)
- Bozena Czerny
- Andy Fabian
- Fred Hamann
- Luis Ho
- Sarah Gallagher
- Ari Laor
- Ian McHardy

- LOC

- Ning Wang (chair)
- Ming Xiao
- Pu Du
- Yue Sun
- Qiao-Li Mo

Current state of affairs

- It's been an exciting week, seeing all the progress that has been made in studying active nuclei.
 - Development of Chinese astronomy, notably in AGN studies, has been truly remarkable.
- Thanks to Hagai Netzer for an excellent and introspective summary.

Current state of affairs

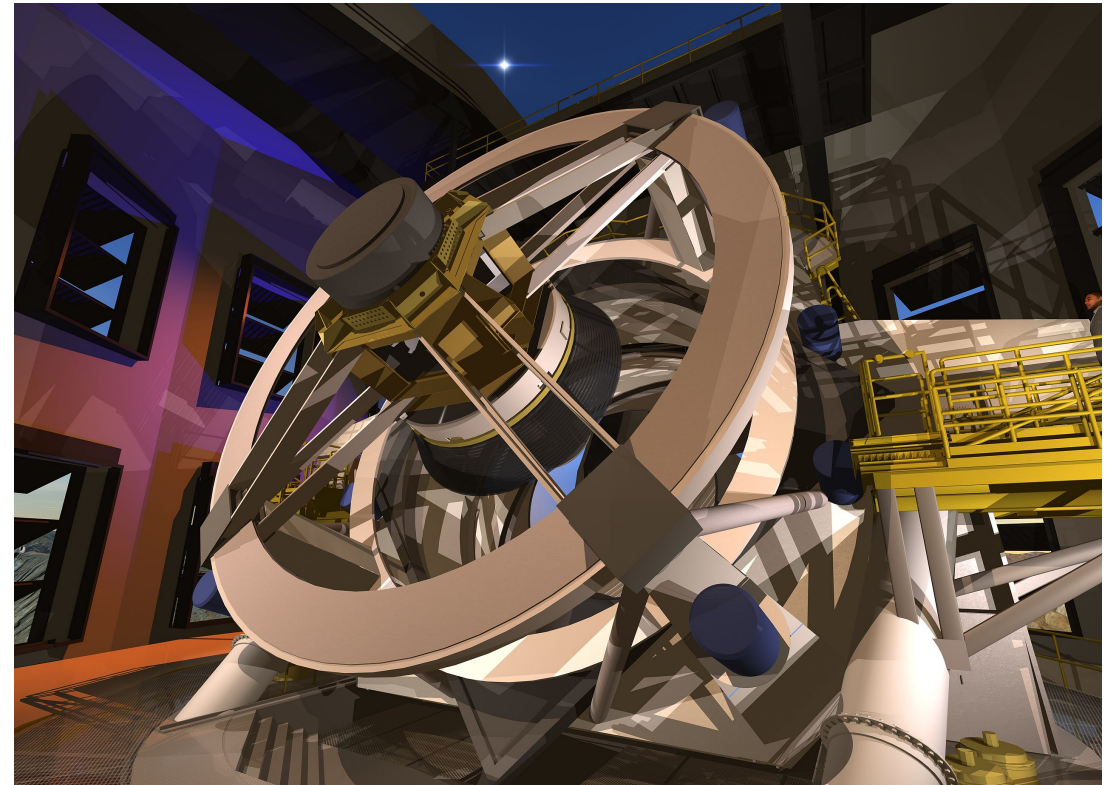
- Two personal opinions:
 - Advances in quasar astronomy are usually tied to new technology.
 - Quasar research drove the development of multiwavelength astrophysics.
 - With certain exceptions, RM programs are largely carried out by groups with either guaranteed or preferential telescope access.
 - It's difficult to get time for large programs on shared (public) facilities.

Enabling Technologies

- Optical RM was enabled by proliferation of CCDs on small/medium-sized telescopes.
- High cadence RM was enabled by robotic ground-based telescopes and SWIFT.
- Interferometric measurement of the BLR size has been enabled by VLTI and GRAVITY.
- Characterization of feeding and fueling on torus-scales is enabled by ALMA.
- Transient studies have been enabled by wide-field monitoring (e.g., ASAS-SN).

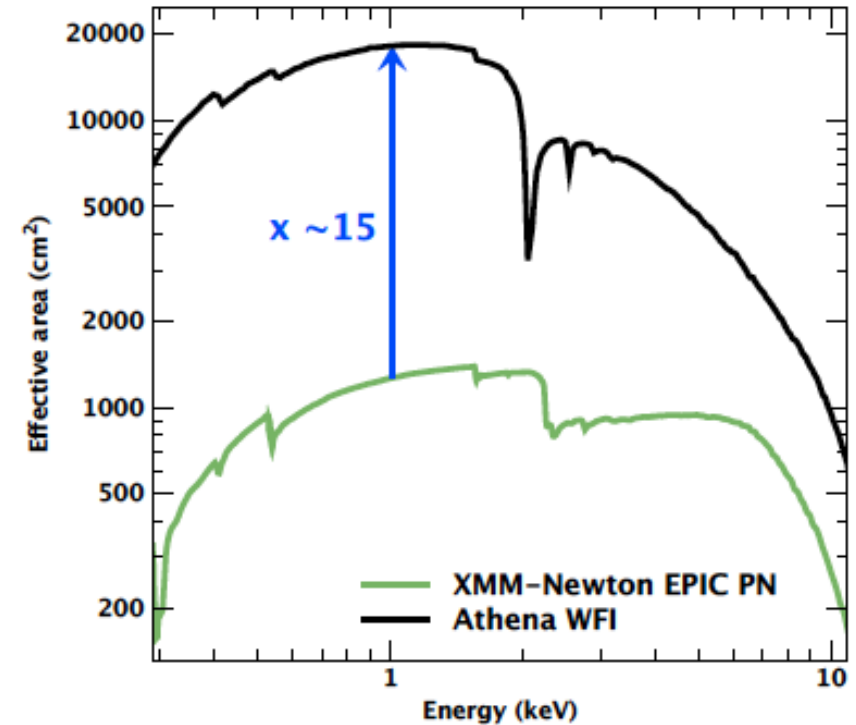
Future

- The Large Synoptic Survey Telescope (LSST) will be a game changer, observing the accessible sky at a cadence of days in up to six bands.
 - First light in 2020.



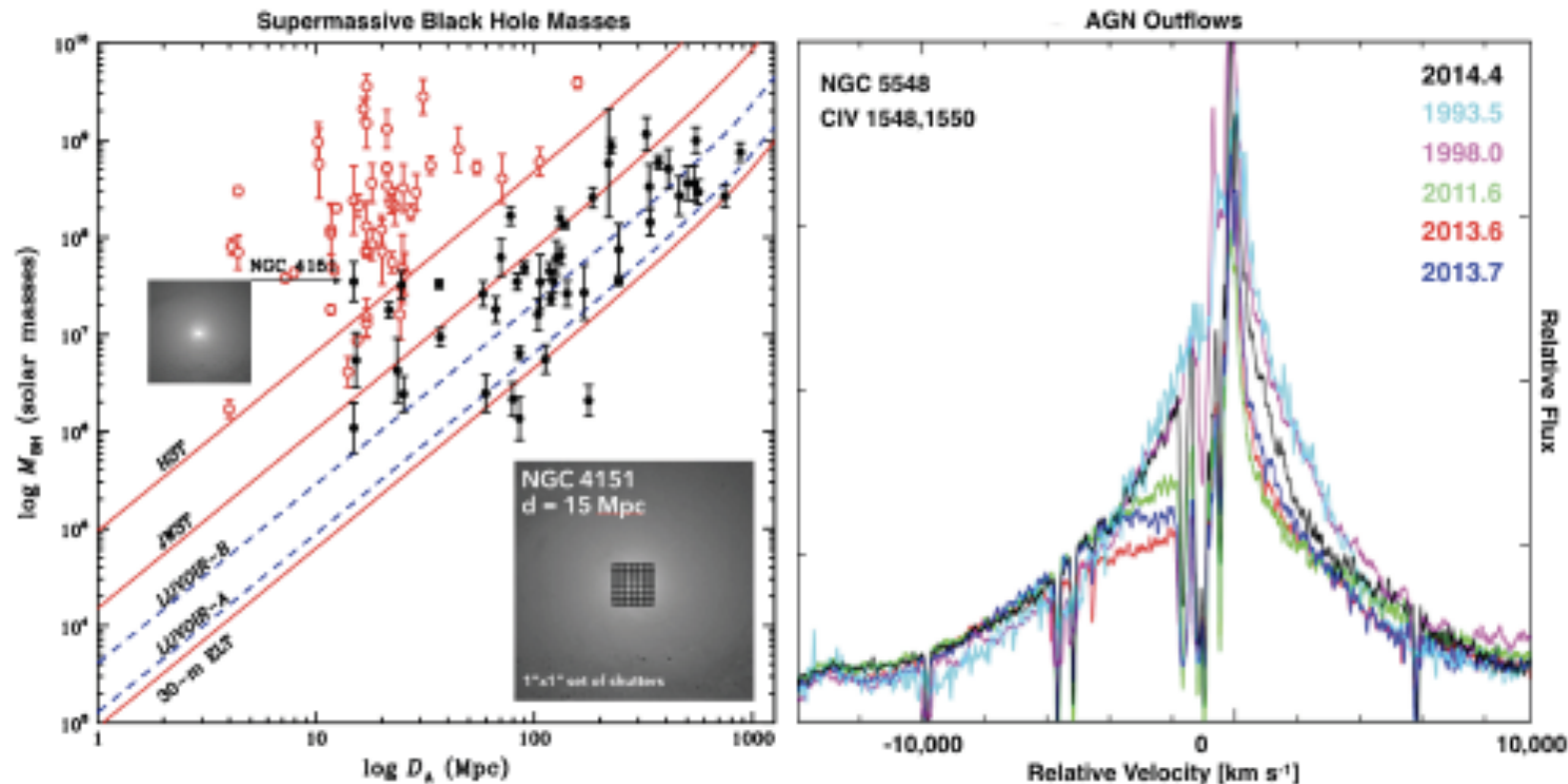
Future

- ESA's Advanced Telescope for High-Energy Astrophysics (ATHENA) will have capabilities for X-ray RM similar to what we have at longer wavelengths.
 - Basic problem now is that the time scales involved are minutes, but it takes ~ 5 ks to get a good spectrum.
 - Current launch date is 2031.



Future

- NASA's Large Ultraviolet Optical Infrared Surveyor (LUVOIR) will enable stellar dynamical measurement of AGN black hole masses and high S/N spectra for study of outflows in multiple resonance lines.
 - Launch NET 2039

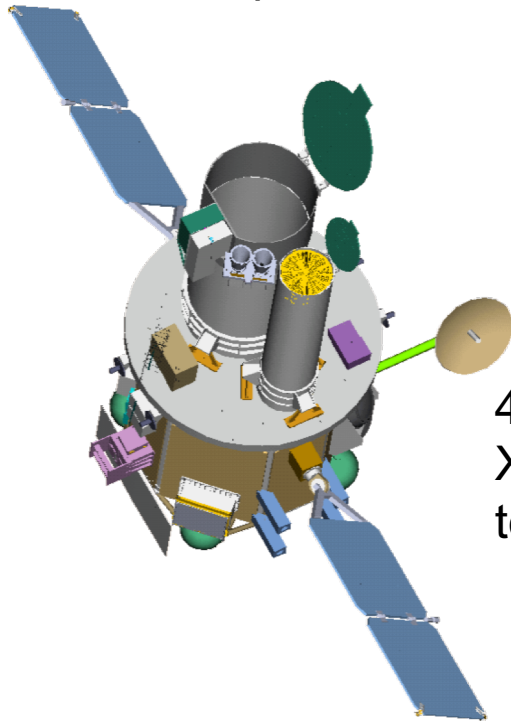


Current state of affairs

- Area of most concern: we need to carry out RM programs on more AGNs in the rest-frame UV.
 - Strong resonance line absorption used to scare me – Jerry Kriss’s talk shows that it’s another probe.
 - AGN STORM showed that we need to move beyond geometry – to understand RM results, modeling of physics needs to be included.
 - AGN STORM and other programs have also shown that simultaneous X-ray monitoring is essential for a complete picture.
- However, all UV and X-ray observatories are highly oversubscribed public facilities.

Kronos

70-cm ultraviolet/
optical telescope



40-cm
X-ray
telescope

- Lessons from *Kronos* that turned out to be true:
- Simulations are of limited utility.
 - “No battle plan survives first contact with the enemy*.” (Usually attributed to Helmuth Karl Bernard Graf von Moltke, though I’d not be surprised if Sun Tzu 孫子 said it first...)
- Neither NASA (nor anyone else) is going to give you a \$200M mission if you can’t get 200 *Hubble Space Telescope* orbits as a demonstration.
- The *Hubble Space Telescope* Time Allocation Committee (TAC) is not going to award you 200 orbits until they see a velocity-delay map from ground-based data.

*Actual data

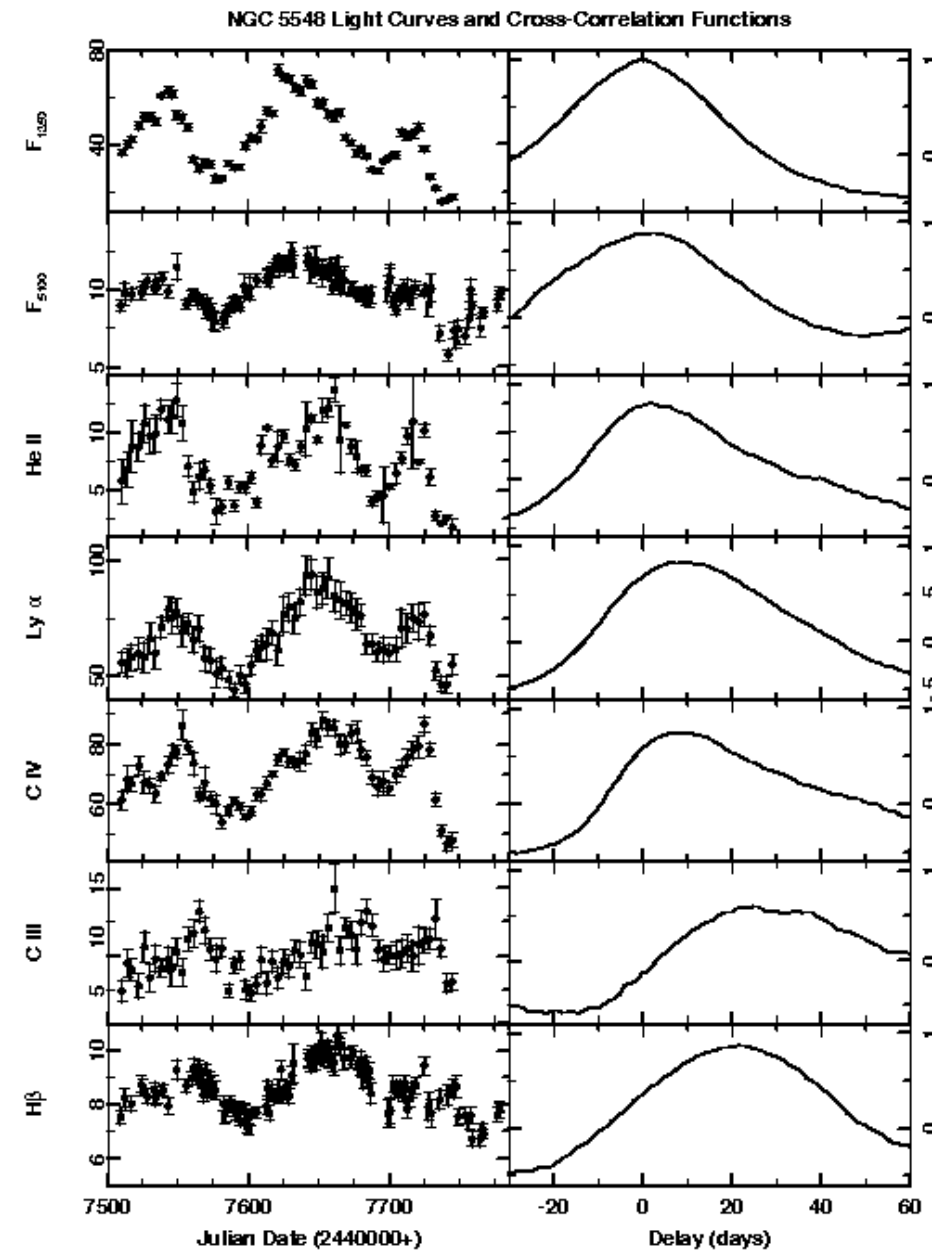
AGN STORM *HST* Proposal History

| Cycle | Year | Proposal | Outcome |
|-------|------|----------------|--|
| 12 | 2003 | 200 orbit STIS | First quartile, first under cutoff for LARGE |
| 13 | 2004 | 200 orbit STIS | Second quartile, S/C and STIS technical concerns (lifetime. STIS failed 2004 August) |
| 17 | 2008 | 200 orbit COS | Second quartile (first post STS-125 cycle) |
| 18 | 2010 | 200 orbit COS | First quartile, first under cutoff for LARGE |
| 19 | 2011 | 200 orbit COS | First quartile, first under cutoff for LARGE |
| 20 | 2012 | 180 orbit COS | Fourth quartile |
| 21 | 2013 | 179 orbit COS | First quintile, ACCEPTED |

Getting approval to do RM with *HST* is very difficult.

Breakthrough!

- The fundamental difficulty with RM is that it is resource-intensive.
- Success was achieved when the RM community proposed *as a community* (The International AGN Watch) for a campaign with *IUE* and assorted ground-based telescopes in 1988-89.



Data from Clavel et al. 1991
and Peterson et al. 1991

My recommendation

- Emulate the International AGN Watch and propose high-cadence RM projects as a community.
- There is some urgency to this since *Hubble* has not been serviced since 2009. Optimistic projections for its operational future extend to ~2025.