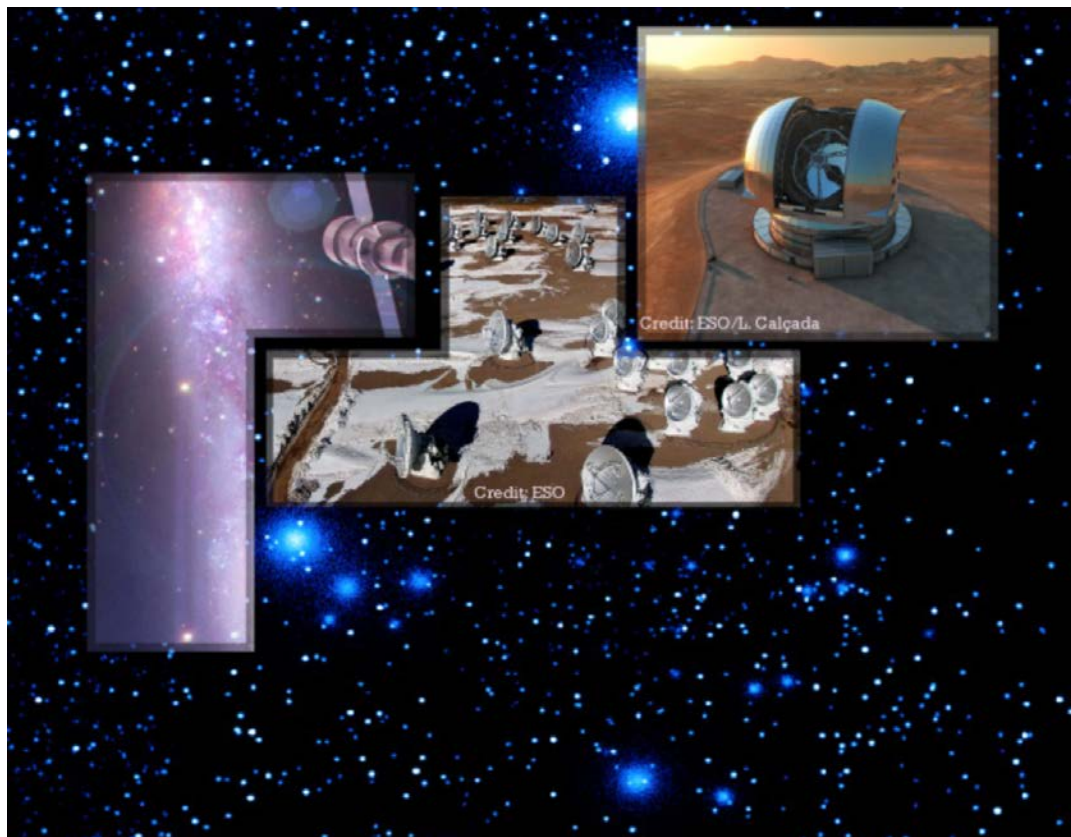




ESO-Athena Synergies*



Paolo Padovani, ESO, Germany
ELT Science Office

* Based on PP, F. Combes, M. Diaz Trigo, S. Etori, E. Hatziminaoglou, P. Jonker, M. Salvato, S. Viti, et al., ESO-Athena Synergy White Paper, arXiv:1705.06064



The ESO-Athena White Paper

■ The ESO-Athena Synergy Team (EAST):



- **PP** (chair) **Françoise Combes** (Observatoire de Paris, France), **Ana Díaz Trigo** (ESO), **Stefano Ettori** (INAF-OABO), **Evanthia Hatziminaoglou** (ESO), **Peter Jonker** (SRON, The Netherlands), **Mara Salvato** (MPE, Germany), and **Serena Viti** (UCL, UK)



- EAST tasked by the Athena Science Study Team and ESO to study synergies between Athena and optical/NIR and sub/mm (ESO) ground based facilities (VLT and ELT, ALMA and APEX)





The ESO-*Athena* White Paper

■ White Paper to identify:

1. needs to access ESO facilities to achieve *Athena* science
2. needs to access *Athena* to achieve ESO science
3. science areas where the synergetic use of *Athena* and ESO facilities in the late 2020s will result in scientific added value



The ESO-Athena White Paper

arXiv.org > astro-ph > arXiv:1705.06064v1

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Astrophysics > High Energy Astrophysical Phenomena

ESO-Athena Synergy White Paper

P. Padovani, F. Combes, M. Diaz Trigo, S. Ettori, E. Hatziminaoglou, P. Jonker, M. Salvato, S. Viti, C. Adami, J. Aird, D. Alexander, P. Casella, C. Ceccarelli, E. Churazov, M. Cirasuolo, E. Daddi, A. Edge, C. Feruglio, V. Mainieri, S. Markoff, A. Merloni, F. Nicastro, P. O'Brien, L. Oskinova, F. Panessa, E. Pointecouteau, A. Rau, J. Robrade, J. Schaye, F. Stoehr, L. Testi, F. Tombesi

(Submitted on 17 May 2017)

The Advanced Telescope for High ENERGY Astrophysics (Athena) is the X-ray observatory mission selected by ESA within its Cosmic Vision 2015–2025 programme to address the Hot and Energetic Universe scientific theme. The ESO-Athena Synergy Team (EAST) has been tasked to single out the potential scientific synergies between Athena and optical/near-infrared (NIR) and sub/mm ground based facilities, in particular those of ESO (i.e., the VLT and ELT, ALMA and APEX), by producing a White Paper to identify and develop the: 1. needs to access ESO ground-based facilities to achieve the formulated Athena science objectives; 2. needs to access Athena to achieve the formulated science objectives of ESO facilities contemporary to Athena; 3. science areas where the synergetic use of Athena and ESO facilities in the late 2020s will result in scientific added value. Community input to the process happened primarily via a dedicated ESO – Athena Synergy Workshop that took place on Sept. 14 – 16, 2016 at ESO, Garching. This White Paper presents the results of the EAST's work, sorted by synergy area, and deals with the following topics: 1. the Hot Universe: Early groups and clusters and their evolution, Physics of the Intracluster medium, Missing baryons in cosmic filaments; 2. the Energetic Universe: Supermassive black hole (SMBH) history, SMBH accretion disks, Active Galactic Nuclei feedback – Molecular outflows, Ultra-fast outflows, Accretion Physics, Transient Science; 3. Observatory Science: Star Formation, Stars. It then discusses the optical-NIR-sub-mm perspective by providing details on VLT/MOONS, the E-ELT instruments, in particular the MOS, VISTA/4MOST, the ESO and ALMA archives, future ALMA and ESO developments, and finally the (likely) ESO – Athena astronomical scene in the 2020s. (abridged)

Comments: 70 pages, 16 figures

Subjects: **High Energy Astrophysical Phenomena (astro-ph.HE)**; Cosmology and Nongalactic Astrophysics (astro-ph.CO); Astrophysics of Galaxies (astro-ph.GA); Instrumentation and Methods for Astrophysics (astro-ph.IM); Solar and Stellar Astrophysics (astro-ph.SR)

Cite as: [arXiv:1705.06064](https://arxiv.org/abs/1705.06064) [astro-ph.HE]

(or [arXiv:1705.06064v1](https://arxiv.org/abs/1705.06064v1) [astro-ph.HE] for this version)

arXiv:1705.06064v1



The ESO-Athena Synergy Workshop



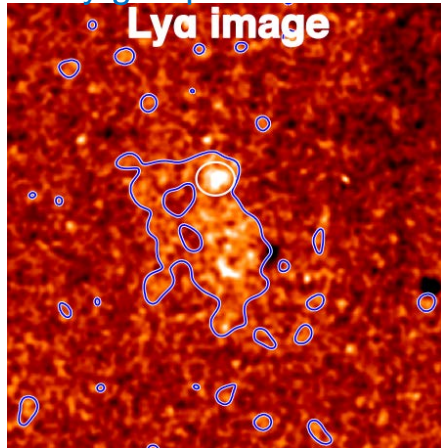
ESO, Sept. 14 – 16, 2016



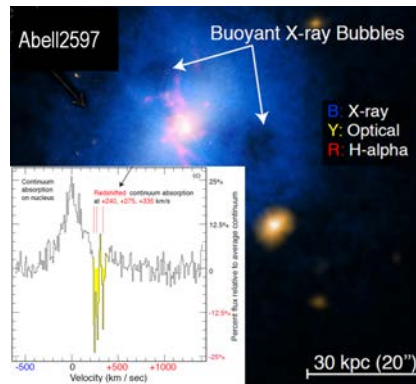


ESO-Athena Synergy Topics (compiled around Athena science)

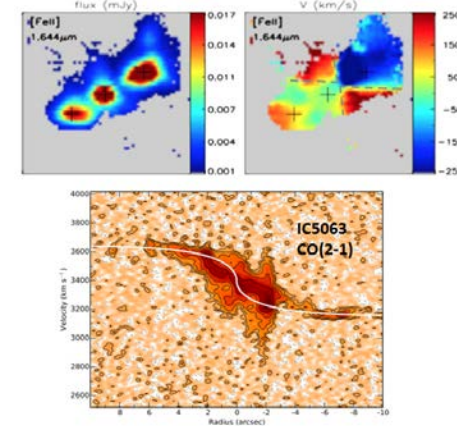
Early groups and clusters



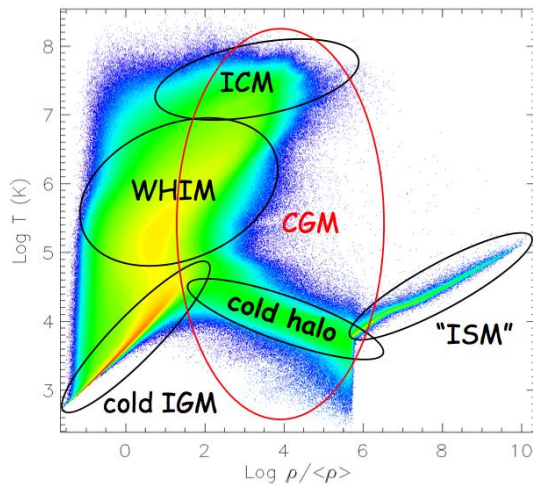
Physics of the ICM



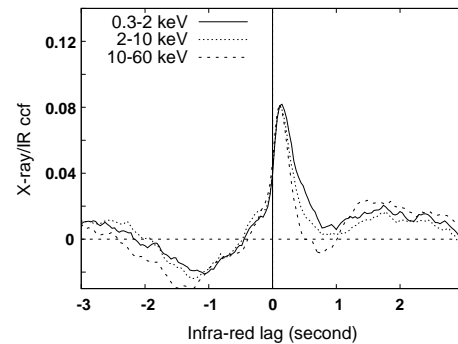
AGN outflows



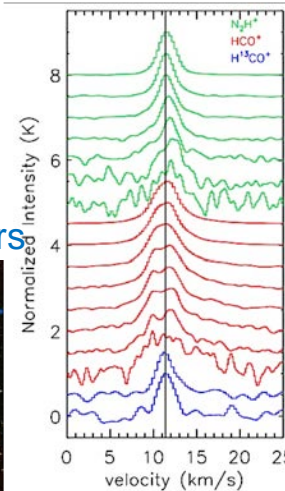
Missing baryons in cosmic filaments



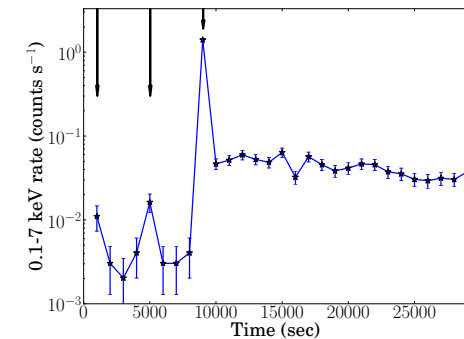
Accretion physics



Star formation



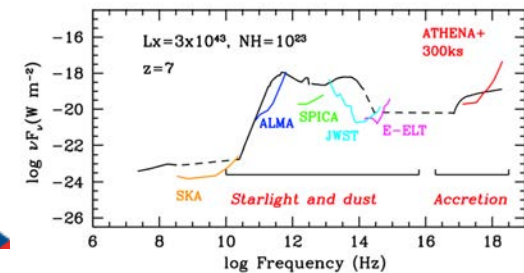
Transients



High-energy emiss. from stars



SMBH history





The ESO-*Athena* astronomical scene in the 2020s: the Extremely Large Telescope



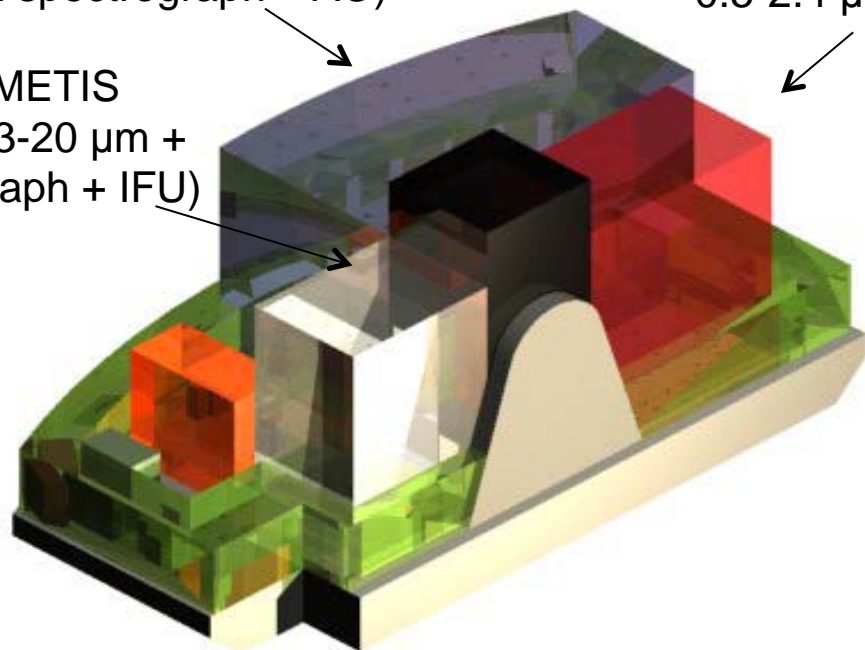


The ESO-Athena astronomical scene in the 2020s

ELT/MICADO + MAORY
(imager 0.8-2.4 μm + low-R spectrograph + AO)

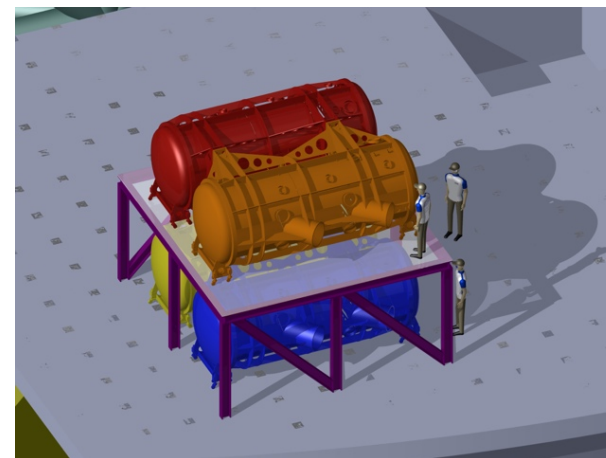
ELT/HARMONI
(IFU spectrograph 0.5-2.4 μm)

ELT/METIS
(imager 3-20 μm + spectrograph + IFU)

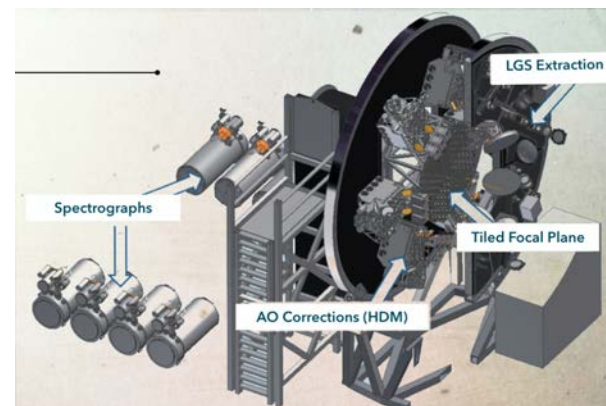


Phase A

ELT/HIRES



ELT/MOSAIC



Running contracts

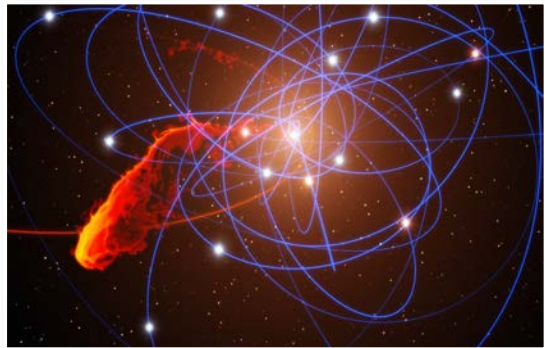
Plus: Science Priorities at ESO document (ESO/STC-551)



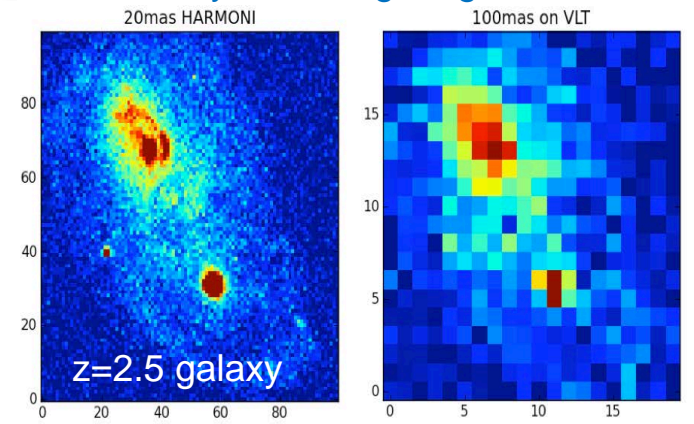


The ESO-Athena astronomical scene in the 2020s: ELT science cases

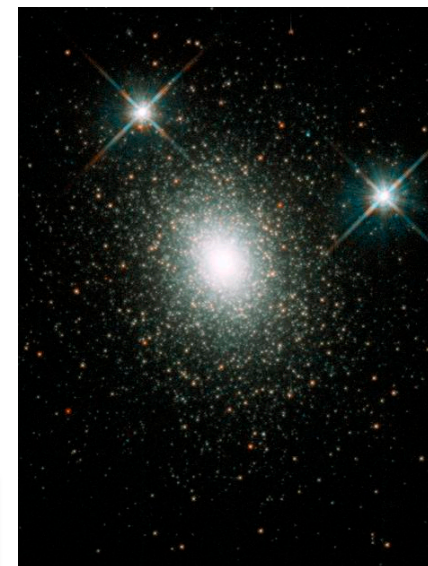
Galactic Centre



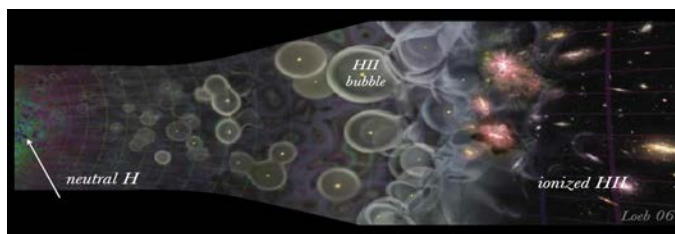
Physics of high-z galaxies



Intermediate-mass BH

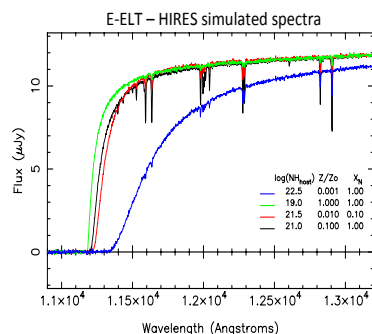
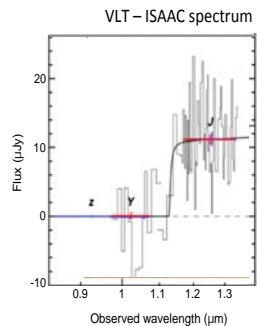


Re-ionization of the Universe



Transient Universe

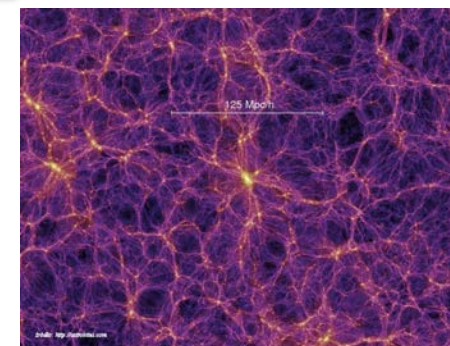
GRB 090423 at $z=8.2$



AGN and SMBH growth



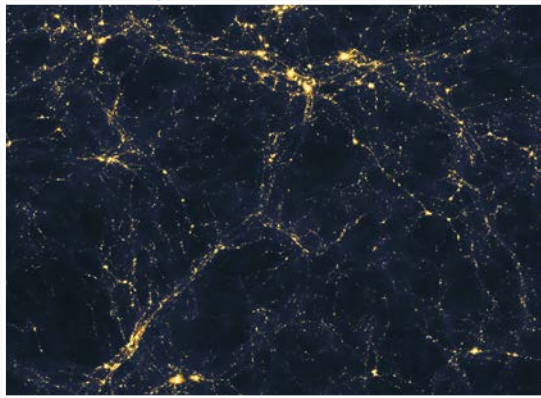
IGM tomography



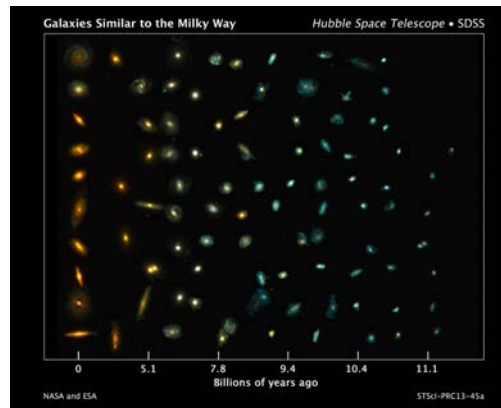


The ESO-Athena astronomical scene in the 2020s: Science Priorities at ESO

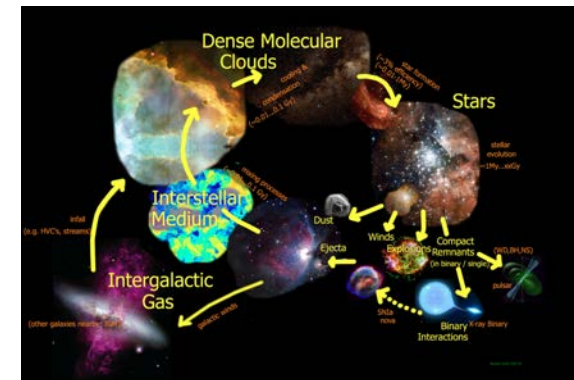
Large-scale structure



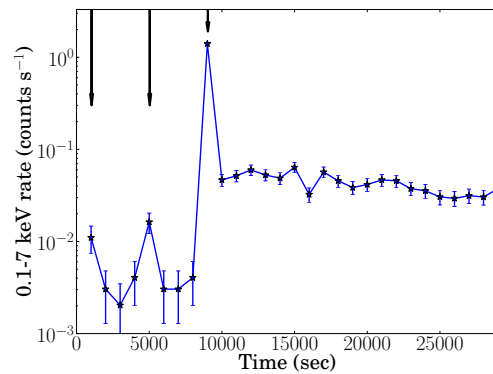
Structure and evolution of galaxies



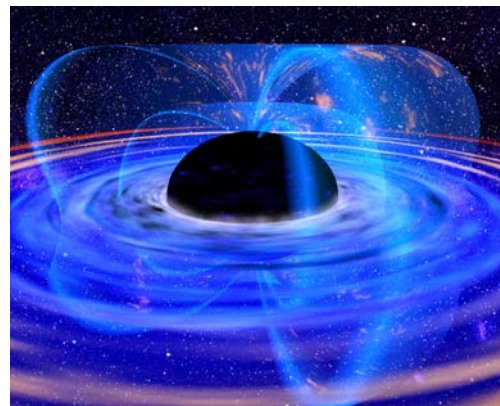
Life cycle of interstellar matter



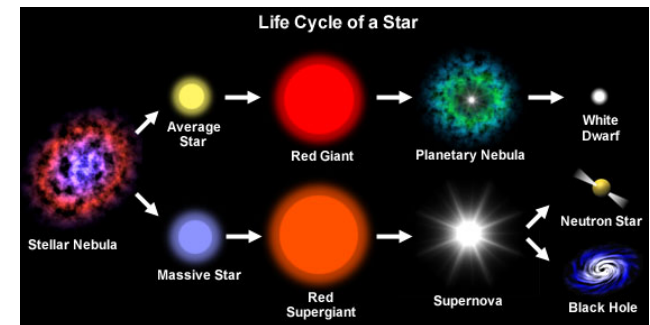
Time-domain astronomy



Extreme states of matter



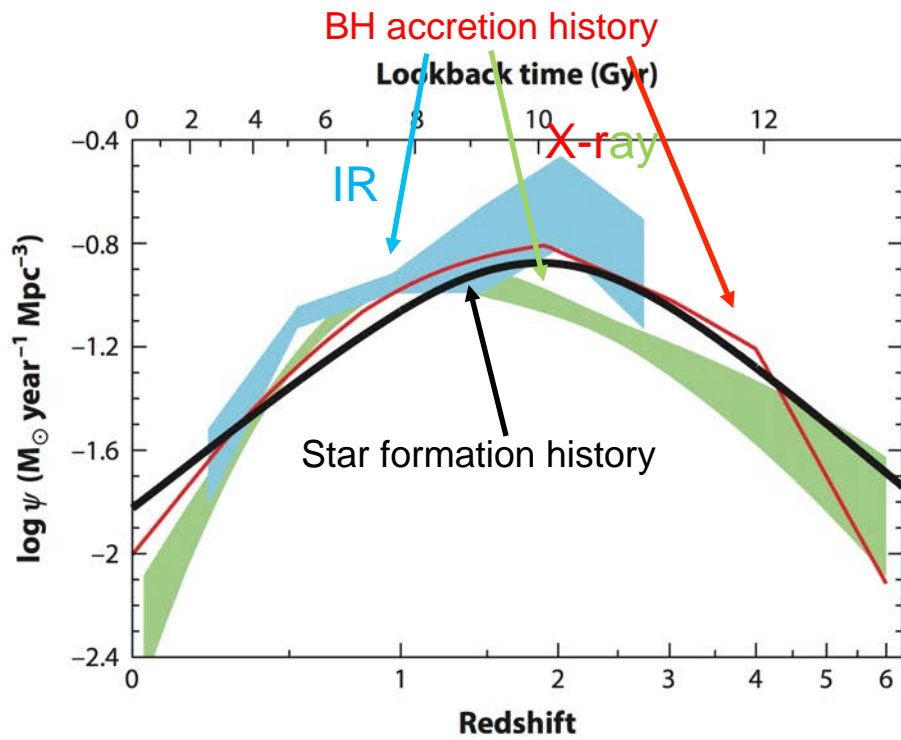
Life cycle of stars



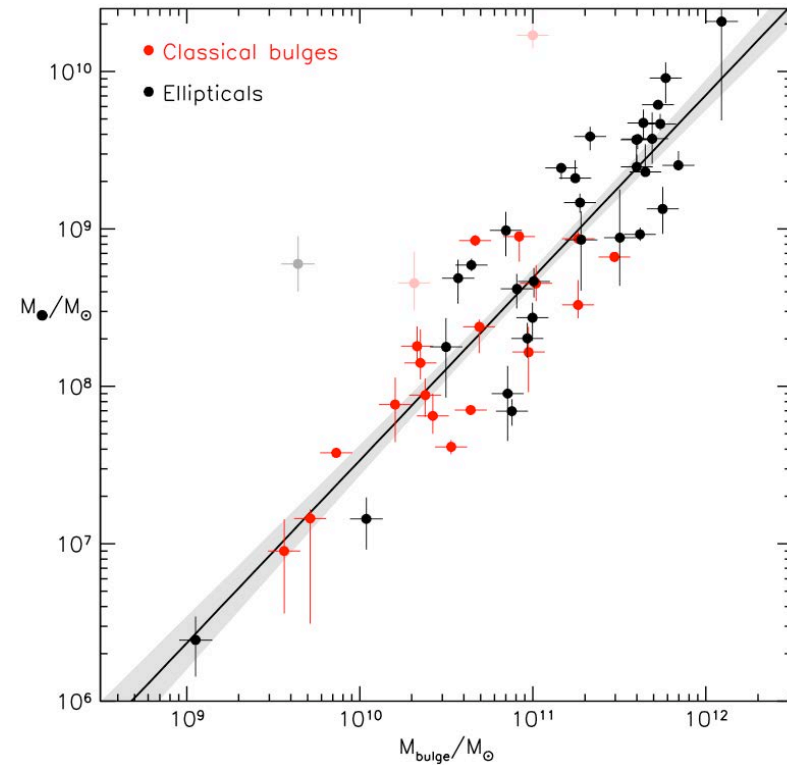
Science Priorities at ESO document (ESO/STC-551)



SMBH History

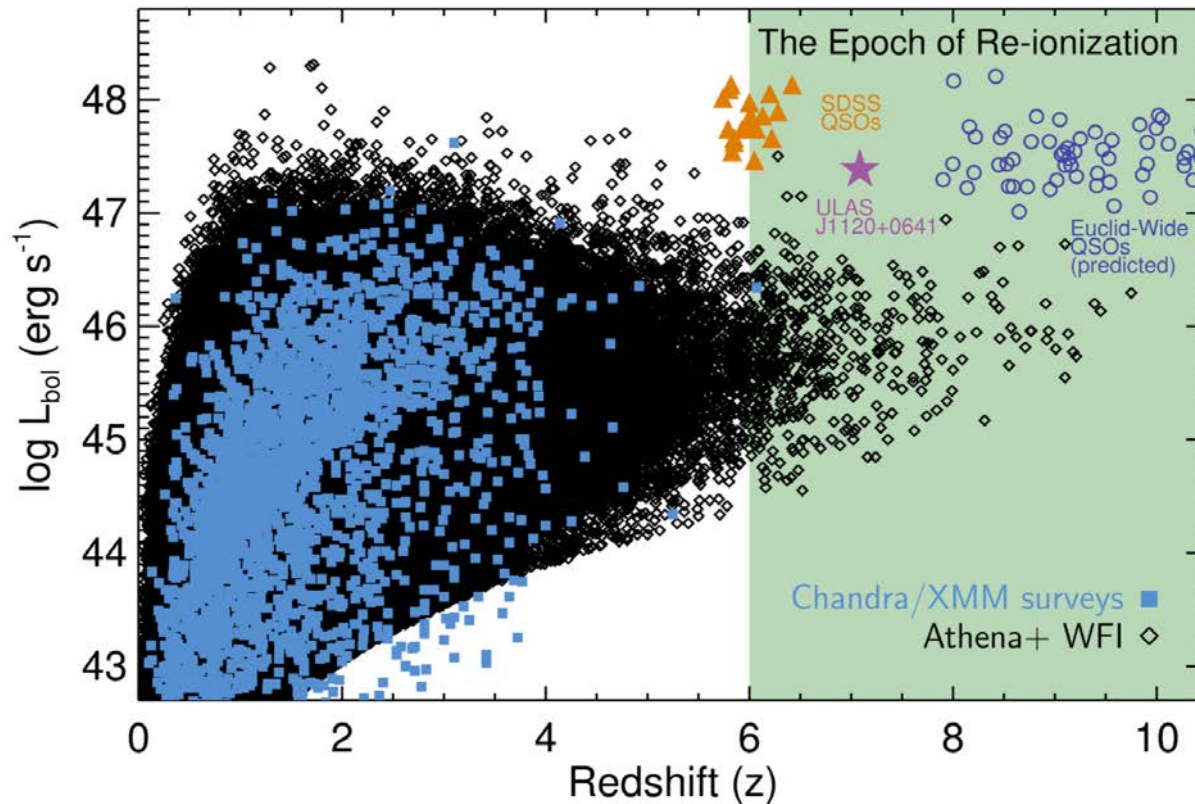


Madau & Dickinson (2014)



Kormendy & Ho (2013)

SMBH History: *Athena's* role



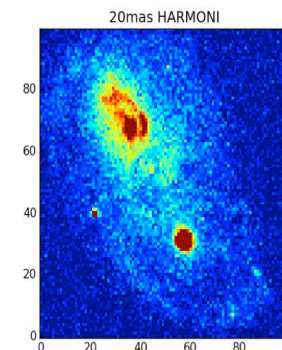
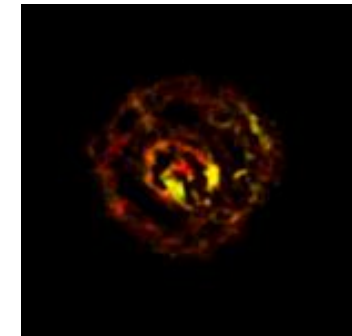
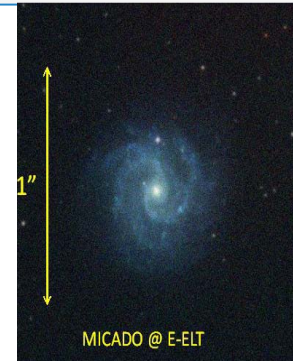
The missing part:
the host galaxy
→ ESO facilities!

Barret et al. (2013)



SMBH History: ESO-Athena synergies

- Host galaxy starlight and structure, star formation distribution:
 - high spatial resolution optical/MIR imaging (e.g., ELT/MICADO and METIS)
- Dust obscured star formation, cold molecular gas (CO):
 - high spatial resolution sub-mm imaging (ALMA)
- Host galaxy chemical abundance and kinematics:
 - Integral Field Unit spectroscopy (e.g., ELT/HARMONI and MOS) [See V. Mainieri's talk]





Athena's most needed ESO facilities

- Integral Field Units (VLT/MUSE, ELT/HARMONI)
- ALMA
- Multi-object spectrographs (VISTA/4MOST, VLT/MOONS, ELT/MOS)
- NIR imagers (ELT/MICADO)
- High-resolution spectrographs (VLT/UVES, ELT/HIRES)
- ESO archives (LaSilla Paranal, ALMA, ELT)
- Plus (missing and needed by 2-3 cases):
 - single dish sub-mm telescope, wide field of view
 - polarimetric facility @ ELT



Athena's most needed ESO facilities

- Integral Field Units (VLT/MUSE, ELT/HARMONI)
- ALMA
- Multi-object spectrographs (VISTA/4MOST, VLT/MOONS, ELT/MOS)

DISCLAIMER: The views expressed in the ESO-Athena Synergy White Paper are purely those of the individual members of EAST

- Plus (missing and needed by 2-3 cases):
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Summary

- The ESO-*Athena* Synergy White Paper is available
- It deals with a variety of astronomical topics ranging from star formation to clusters of galaxies
- The synergies are **real!**
- Much more can be found here:

arXiv.org > astro-ph > arXiv:1705.06064v1

Astrophysics > High Energy Astrophysical Phenomena

ESO-Athena Synergy White Paper

P. Padovani, F. Combes, M. Diaz Trigo, S. Ettori, E. Hatziminaoglou, P. Jonker, M. Salvato, S. Viti, C. Adami, J. Aird, D. Alexander, P. Casella, C. Ceccarelli, E. Churazov, M. Cirasuolo, E. Daddi, A. Edge, C. Feruglio, V. Mainieri, S. Markoff, A. Merloni, F. Nicastro, P. O'Brien, L. Oskinova, F. Panessa, E. Pointecouteau, A. Rau, J. Robrade, J. Schaye, F. Stoehr, L. Testi, F. Tombesi

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Cite as: **arXiv:1705.06064 [astro-ph.HE]**
(or arXiv:1705.06064v1 [astro-ph.HE] for this version)





Want to know more about the ELT?

Thursday, June 29, Special Session 18

[SS18a] SS18- The European ELT: Project status & plans for early science

close

29.06.2017 From 14:00 to 15:30 Room 346

- | | | |
|-------|-------|---|
| 14:00 | 14:23 | ▶ The Extremely Large Telescope: the future of European ground-based astronomy. (#195)
Michele Cirasuolo - ESO, Garching, Germany |
| 14:25 | 14:40 | ▶ Tracing the phase transition of Al-bearing species from molecules to dust in stellar winds using METIS (#295)
Leen Decin - University Of Leuven, Belgium, Leuven, Belgium |
| 14:40 | 14:55 | ▶ From the inner Milky Way to Local Volume galaxies: resolved stellar populations with EELT-HARMONI (#982)
Oscar Gonzalez - UK Astronomy Technology Centre, Edinburgh, United Kingdom |
| 14:55 | 15:10 | ▶ Searching for variations in the IMF using SimCADO, the instrument data simulator for MICADO@E-ELT (#305)
Kieran Leschinski - University of Vienna, Vienna, Austria |
| 15:10 | 15:25 | ▶ NIR high resolution spectroscopy with WINERED at NTT as a stepping stone for E-ELT (#1127)
Davide Magurno - Università Di Roma Tor Vergata, Roma, Italy |
| 15:25 | 15:40 | ▶ Fibre mounted microlens array manufactured using 3D direct write lithography (#1264)
Robert Harris - Universität Heidelberg, Heidelberg, Germany |

[SS18b] SS18- The European ELT: Project status & plans for early science

close

29.06.2017 From 16:00 to 17:30 Room 346

- | | | |
|-------|-------|--|
| 16:00 | 16:15 | ▶ Massive stars in the Local Universe with E-ELT (#936)
Artemio Herrero - Instituto de Astrofisica de Canarias, La Laguna, Spain |
| 16:15 | 16:30 | ▶ Using Simulated Galaxies to Understand Future HARMONI Observations (#922)
Mark Richardson - University Of Oxford, Oxford, United Kingdom |
| 16:30 | 16:45 | ▶ Simulating mid-infrared images of clumpy tori in AGN with METIS@E-ELT (#506)
Michael Mach - Department of Astrophysics, University Vienna, Vienna, Austria |
| 16:45 | 17:00 | ▶ The METIS Data Reduction System (#534)
Rainer Köhler - University of Innsbruck, Innsbruck, Austria |
| 17:00 | 17:15 | ▶ Simulation of high-z galaxy observations with MOSAIC (#967)
Karen Disseau - Institut für Astrophysik, Goettingen, Germany |
| 17:15 | 17:30 | ▶ The performances of the high resolution spectrograph HIRES (#446)
Nicoletta Sanna - INAF-Astrophysical Observatory Of Arcetri, Florence, Italy |