Optical follow-up observations of nuclear transients detected by eROSITA: Testing the state of changing-look AGN

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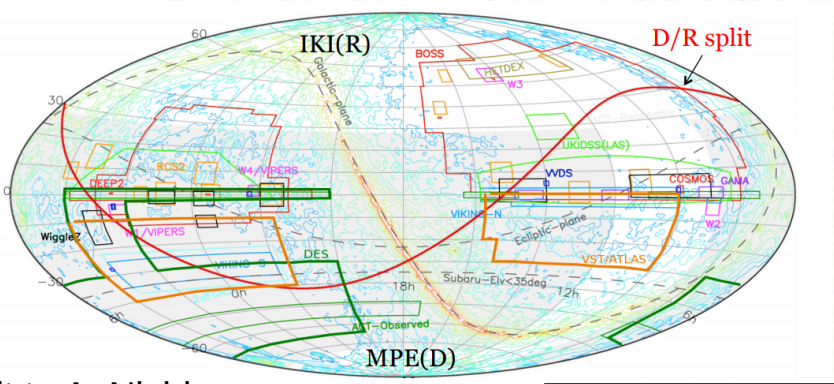
Special thanks: Shenli Tang (UT), Miho Kawabata (Kyoto U.)

SUBARU UM 13.1.2022

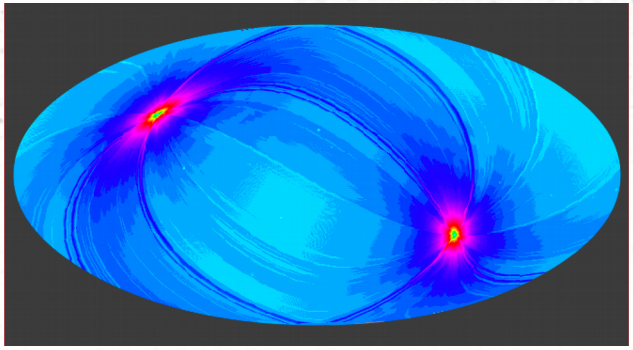
eROSITA: extended ROentgen Survey with an Imaging Telescope Array

Sky split between RU and DE consortium

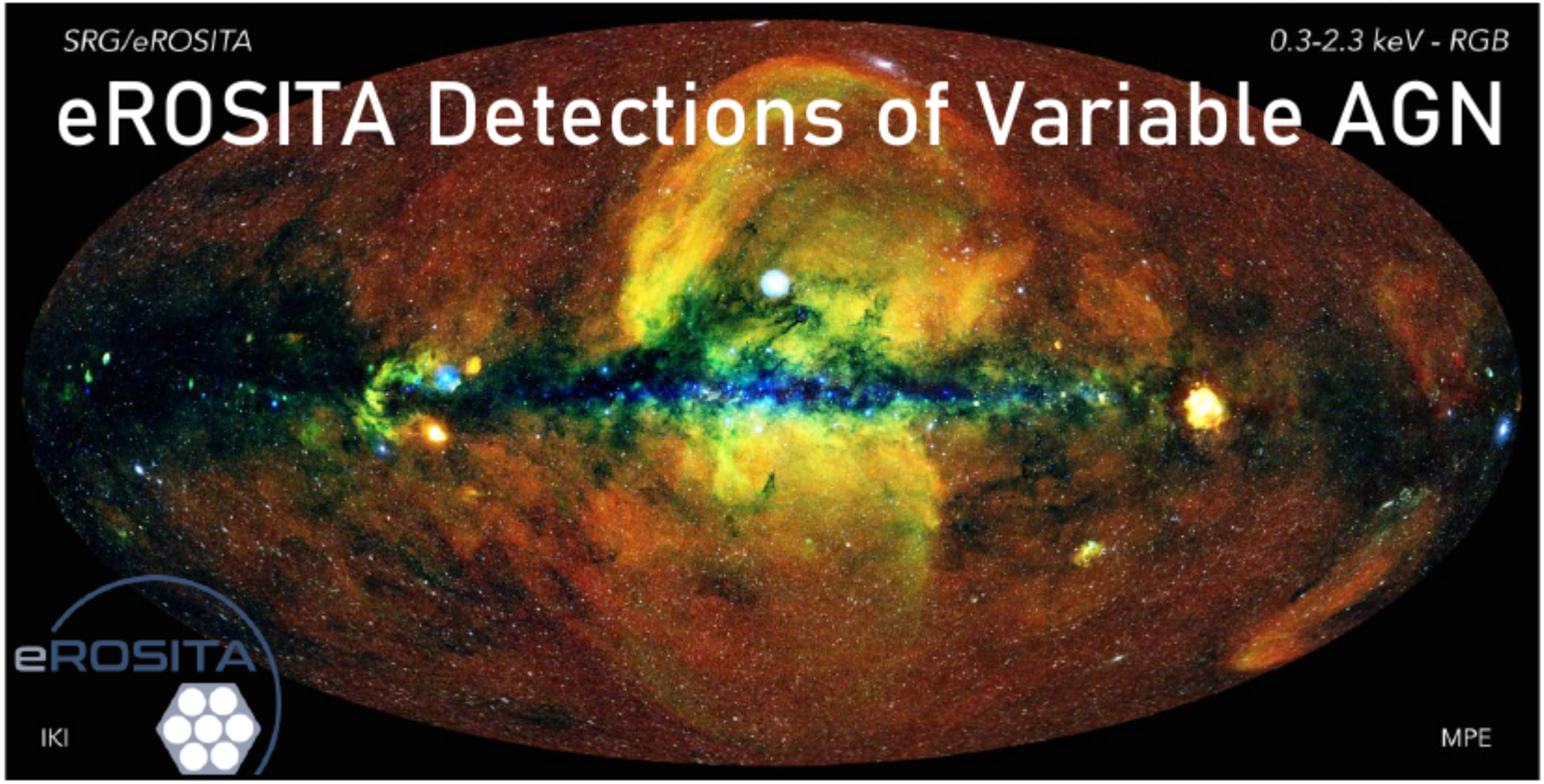


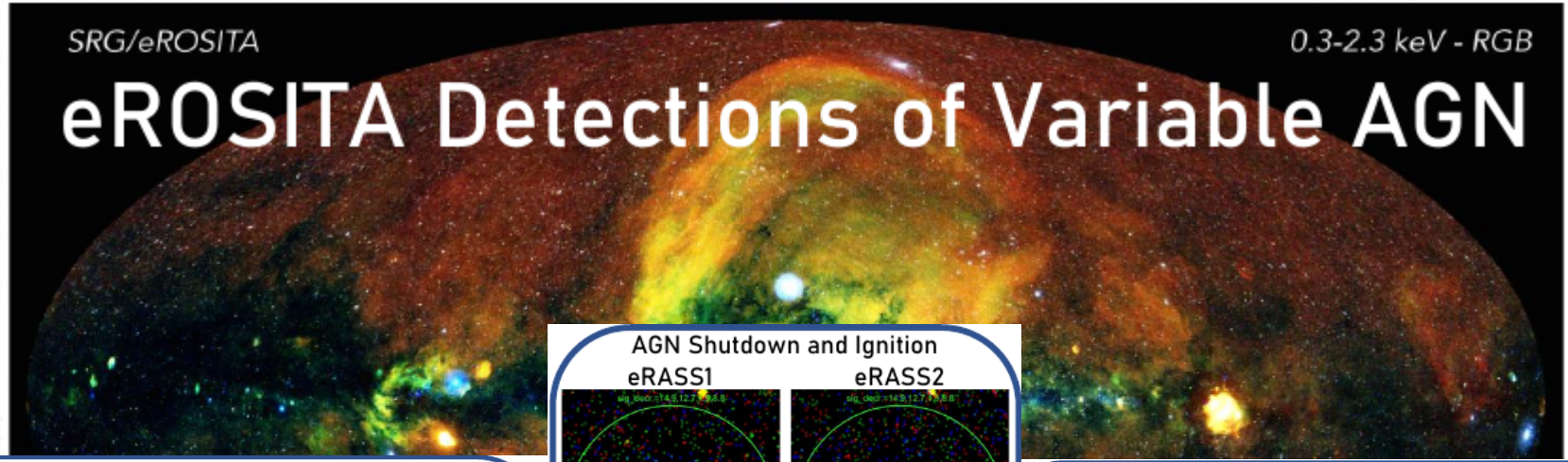
credit to A. Nishizawa

Exposure map
eRASS4

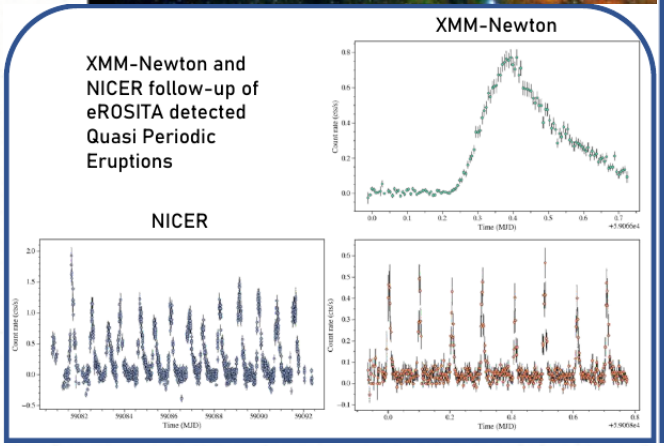


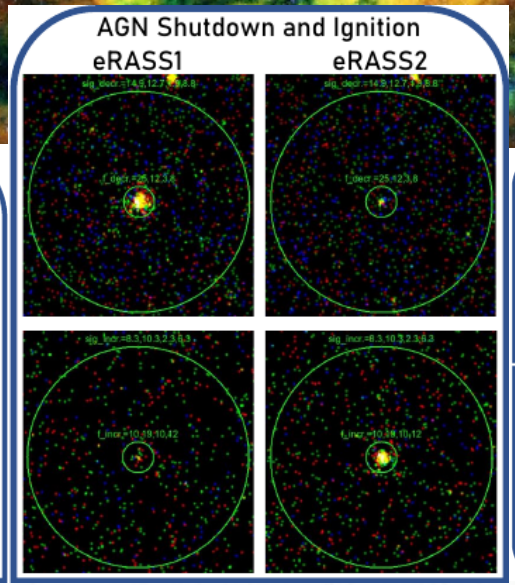
Launch Dec 2019
Every 6 months
All sky scan eRASS1-8
(now eRASS4-5)
0.2-10 keV


SRG/eROSITA
0.3-2.3 keV - RGB
eROSITA Detections of Variable AGN
eROSITA
IKI
MPE

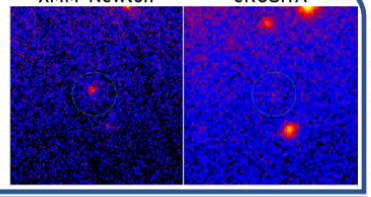


XMM-Newton and NICER follow-up of eROSITA detected Quasi Periodic Eruptions

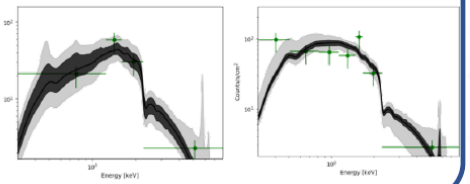




Comparison with archival data: The disappearance of an XMM detected AGN



Spectral variability: change from obscured to unobscured spectrum in 6 months



plus TDEs, X-ray binaries etc...

Optical Follow-up Observations

- Many telescopes join the effort to follow-up as many sources as possible. Major facilities are:
- Southern Sky: SALT,VLT,NTT,**Gemini-S**,SOAR + many small <1m telescopes for photometry
- Northern Sky: LBT,**Gemini-N**,Asiago,**NOT,Seimei,Nayuta**

Identify and follow-up of ignition & shut-down Events

- Main Interest: Search for Changing-Look AGN

  * confirm the event in the optical and build a statistical sample (set benchmark data for evolutionary studies)

  * Questions to be answered: How fast can the accretion flow be re-started/shut-down

    What kind of spectral changes do we see and on what time scales etc...

- Secondary: TDEs, QPEs, X-ray binaries, active stars etc…

Observationally very extensive & expensive Project

A little Statistics on our follow-up Program

- Currently eRASS4/5

  * basic catalog eRASS4 about 1900 X-ray transient candidates

  * Currently about 260 with spectroscopic follow-up

  * ~55 spectra taken from Japan (not all successful)

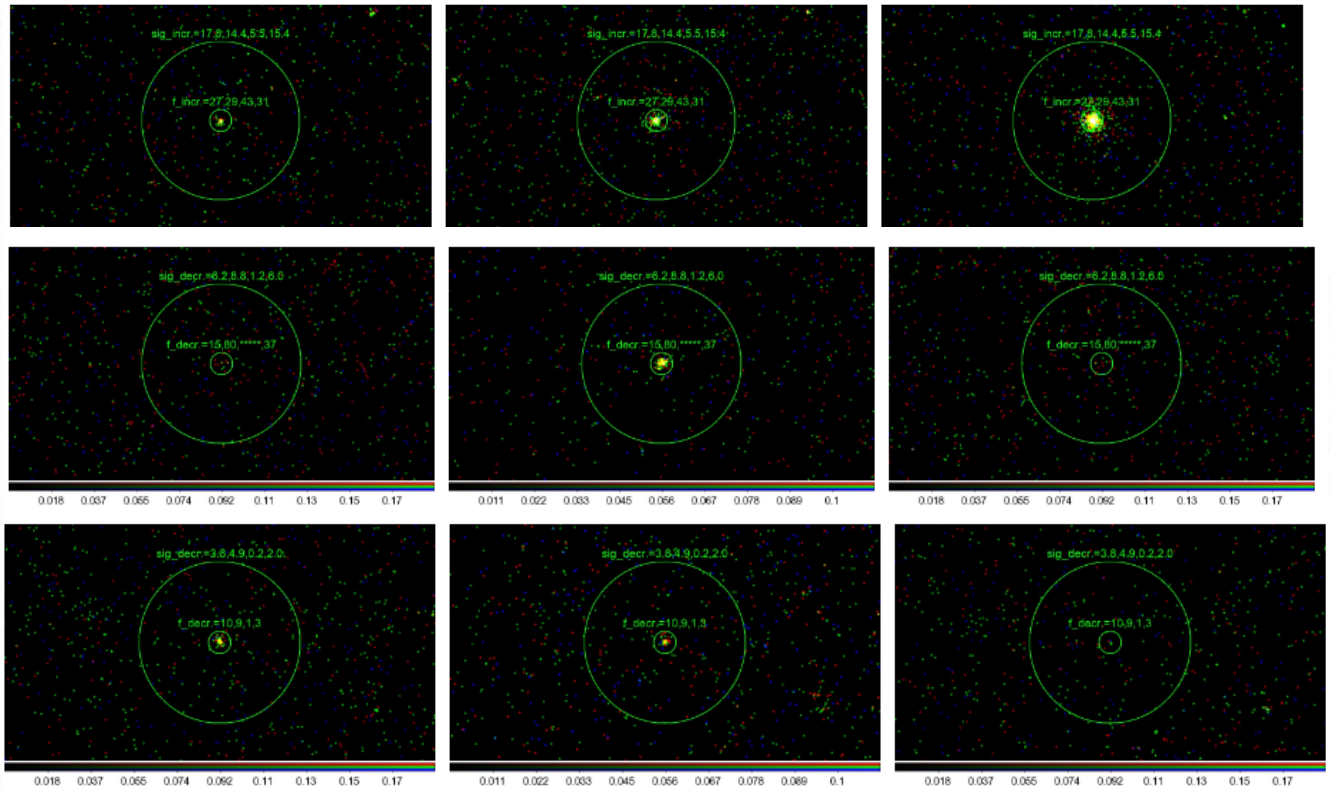
  * bright targets → Seimei/Kools+Nayuta/Malls

  * faint objects → Gemini N+S

  * Make use of OISTER time Open Use at Nayuta + Gemini FT

eROSITA - Events

eRASS1 eRASS2 eRASS3



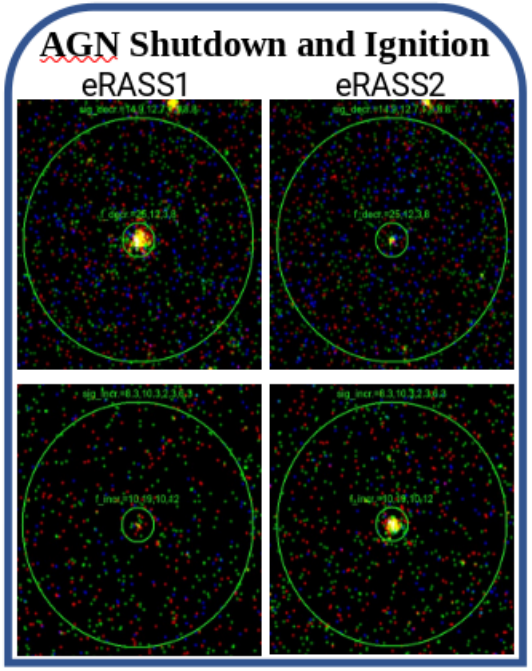
X-rays getting brighter

Single flare

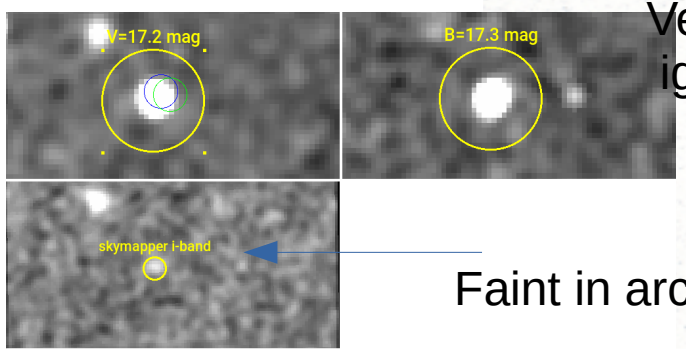
Shut-down

eROSITA Target Selection

Changing Look AGN



Ignition event

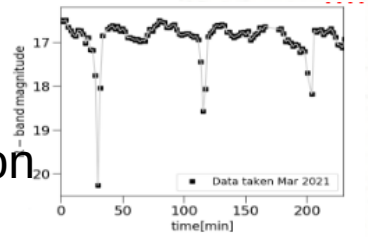


Very bright after ignition

Faint in archival data

Shutdown event

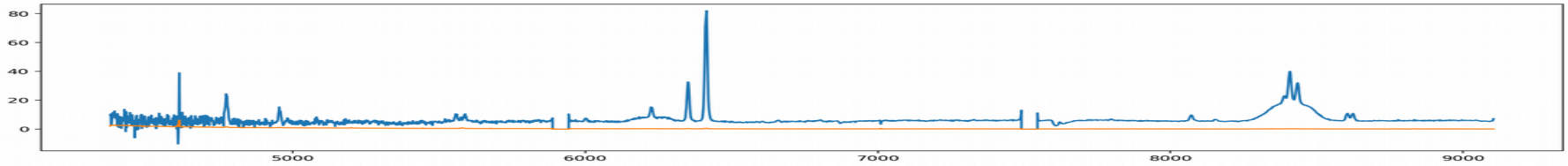
Need to confirm the current magnitude:
Some cases mag drop ~1mag
→ faint targets move to GMOS



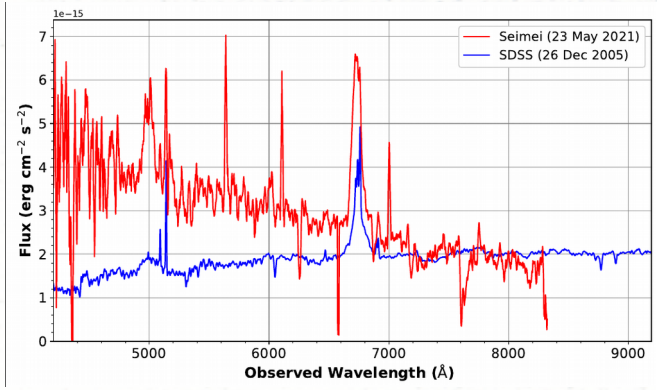
In some cases no archival information so we identify e.g. galactic sources

Optical Spectroscopy

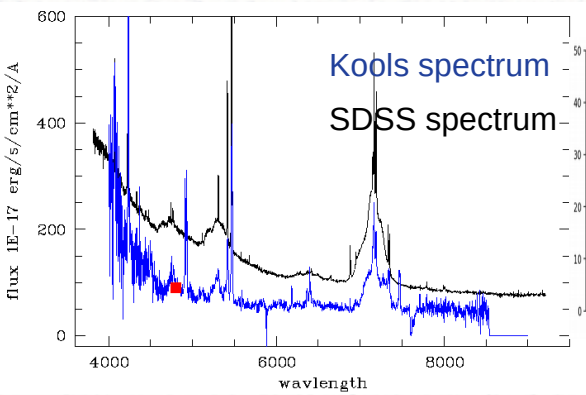
- Essentially 4 cases: (1) std quasar spectrum (little change)



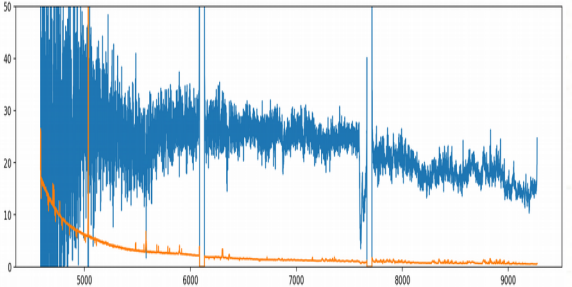
(2) std quasar spectrum (clear brightening response to ignition event)



(3) std quasar spectrum(clear fading response to shut-down event)

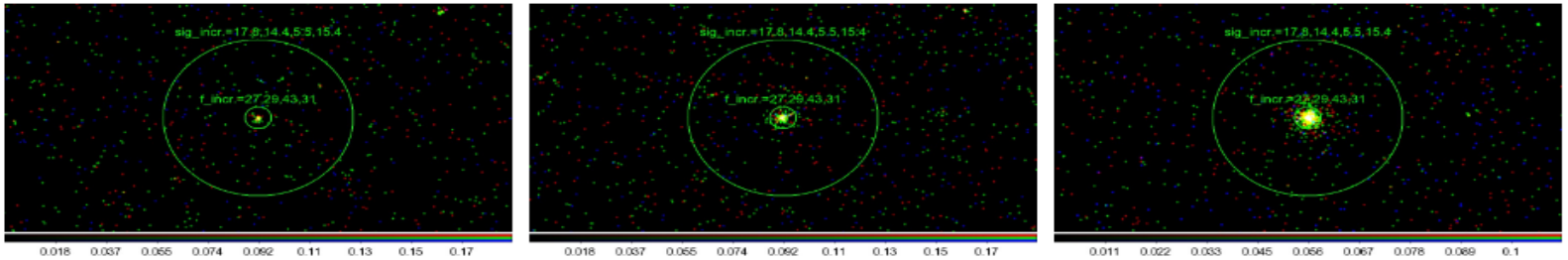


(4) galaxy spectrum(no obvious response in optical)



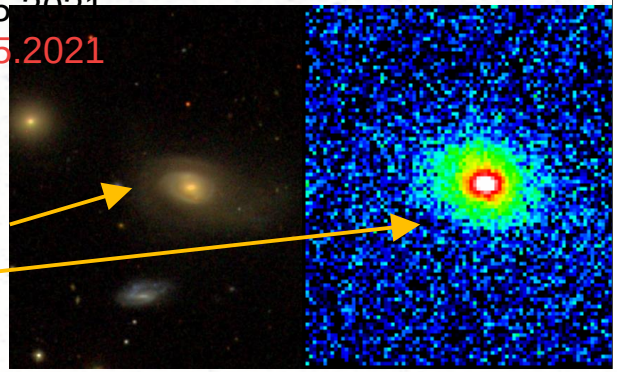
Ignition Event

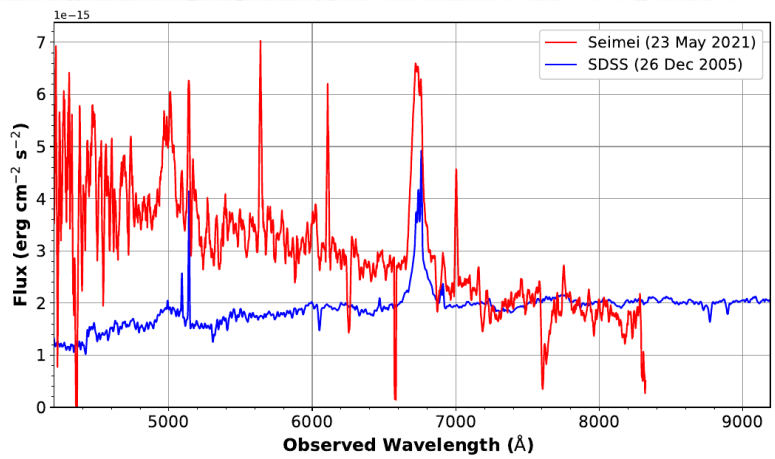
eRASS 1 | eRASS2 | eRASS3



Follow-up request 21.5.2021
Photometry check 22.5.2021
Seimei Spectroscopy 23.5.2021

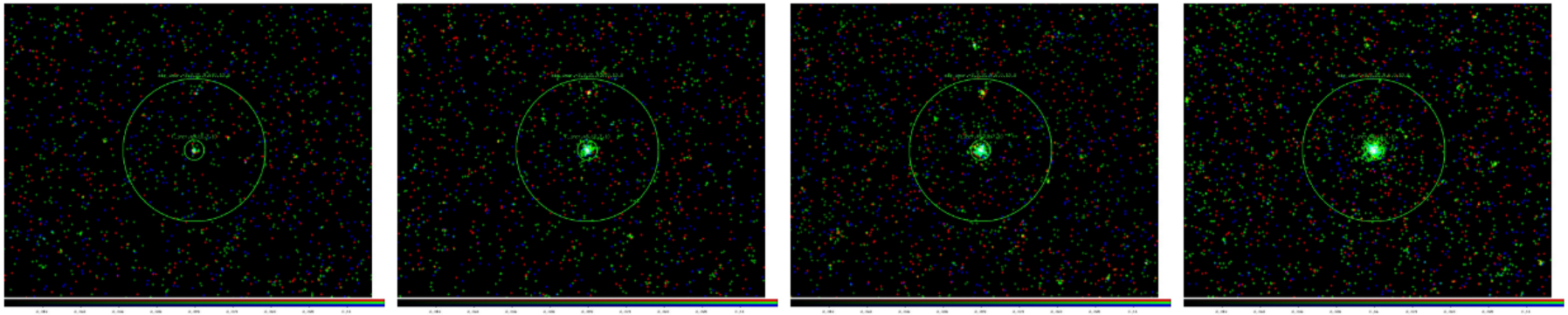
SDSS PSF mag = 16.9
PSF mag 22.5. = 16.0
total: g=14.2 mag





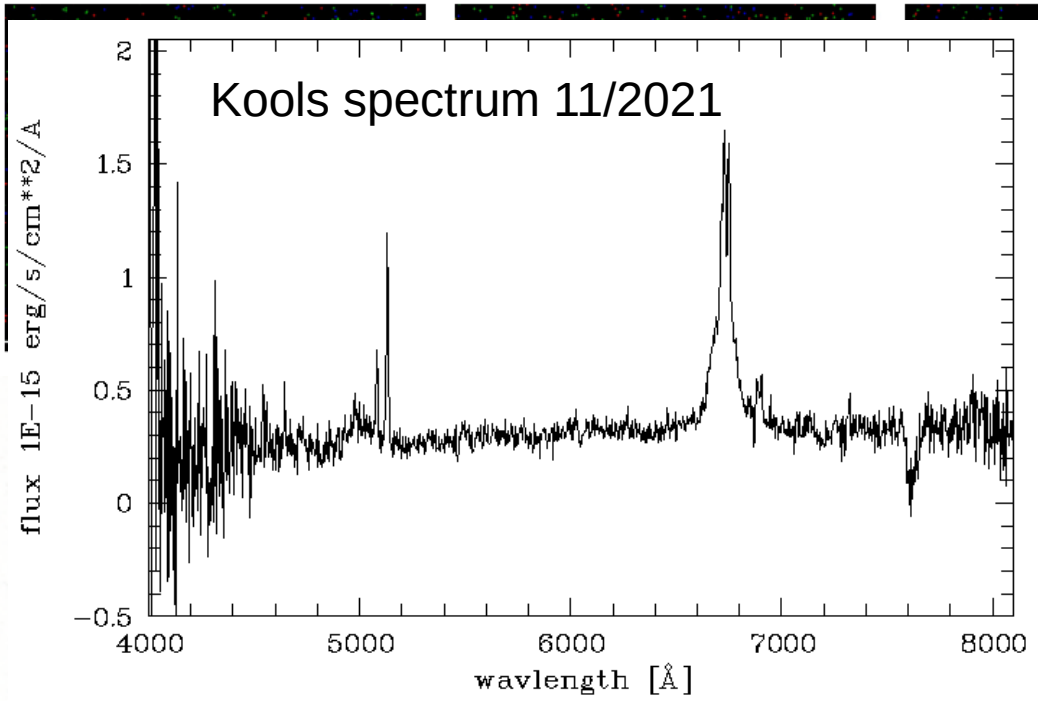
Ignition Event: Example II

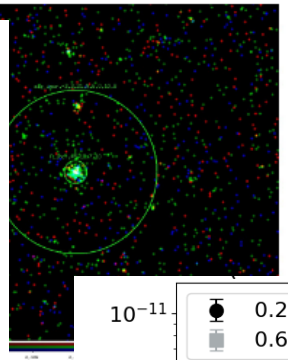
eRASS 1 eRASS2 eRASS3 eRASS4

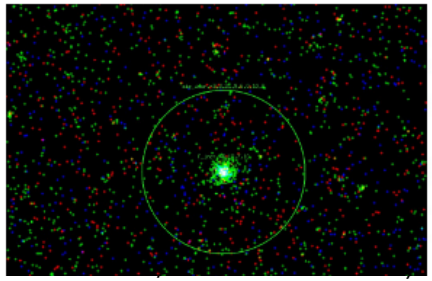


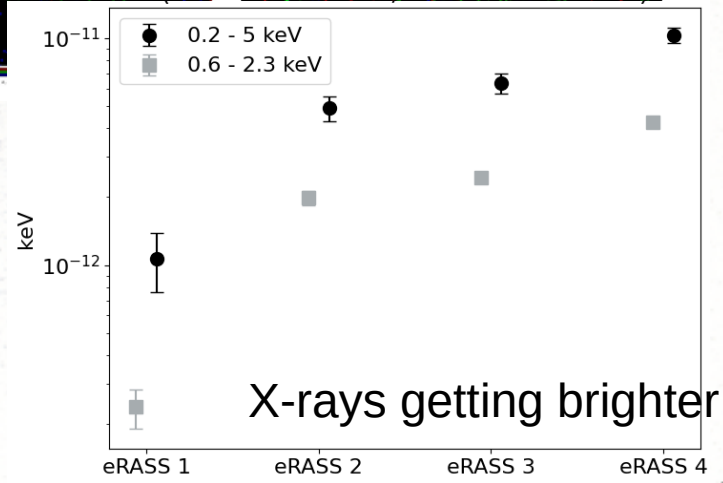
Ignition Event: Example II

eRASS 1 eRASS2 eRASS3 eRASS4

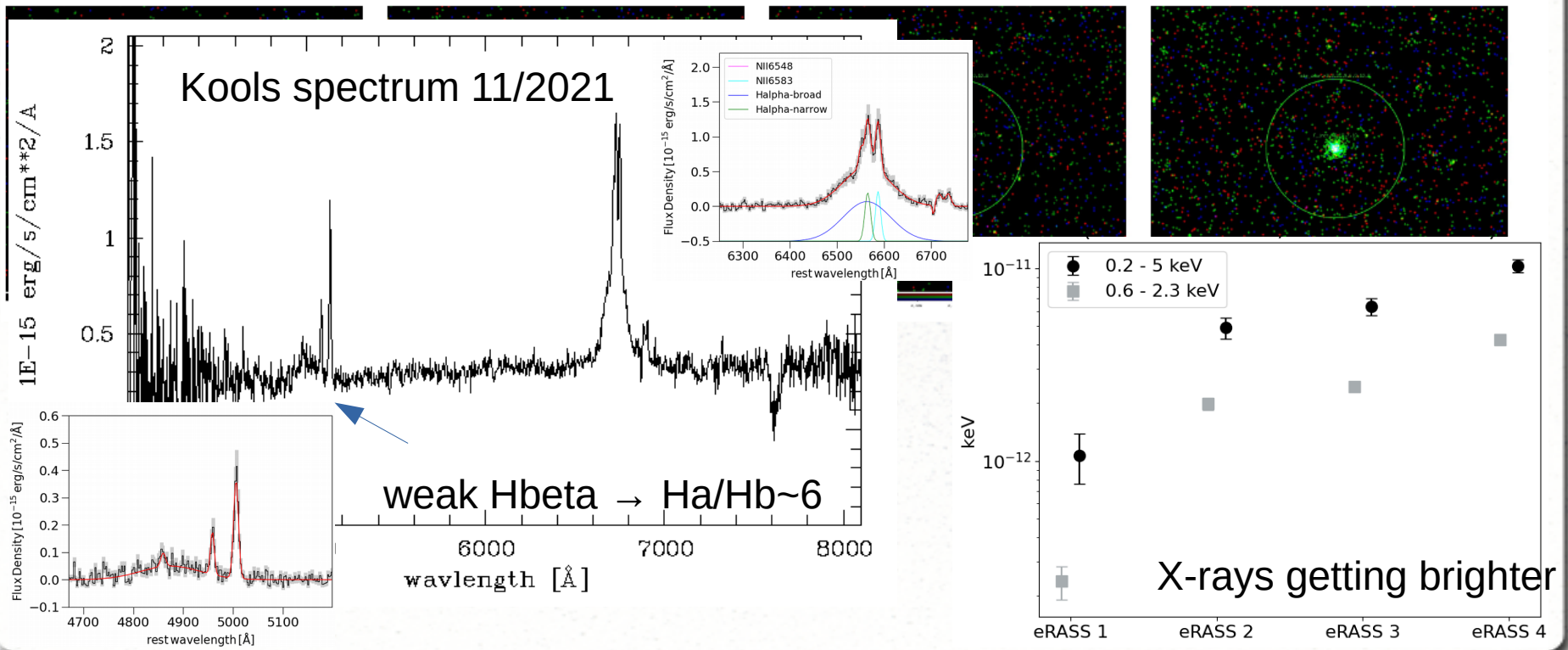






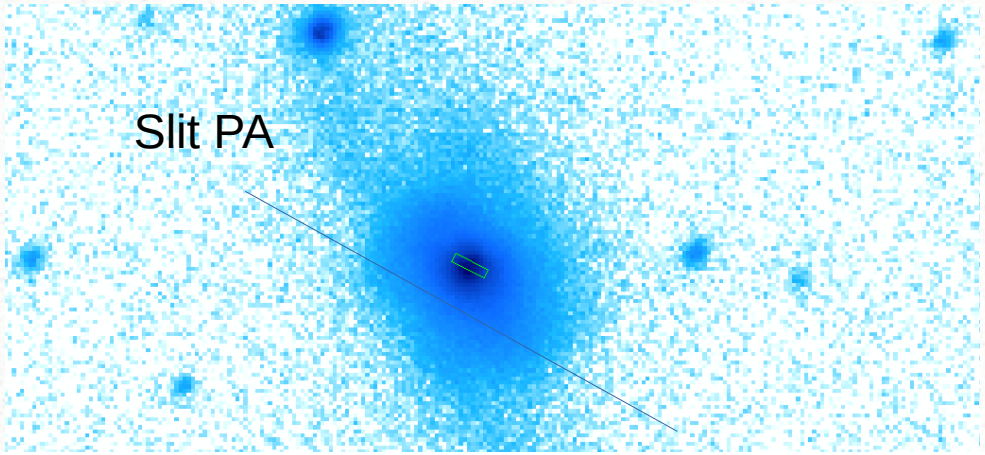


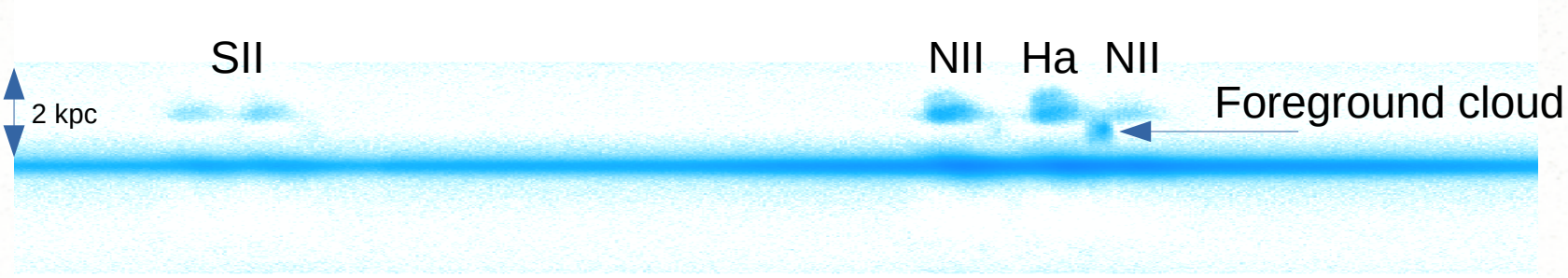
Ignition Event: Example II



Ignition Event: Example II

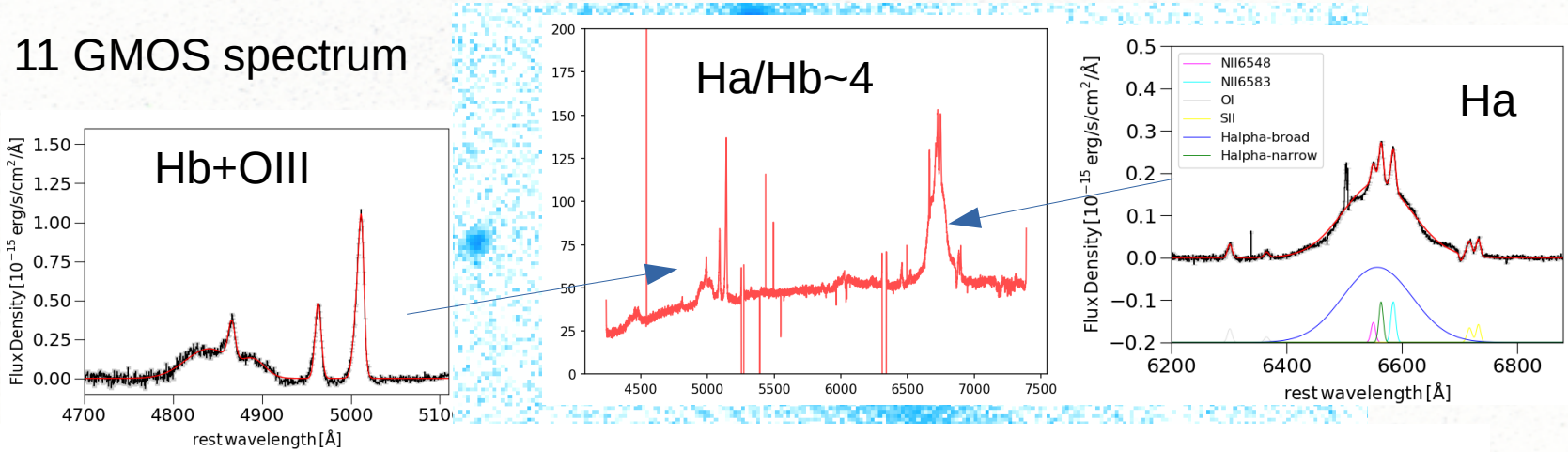
Jan 11 GMOS spectrum

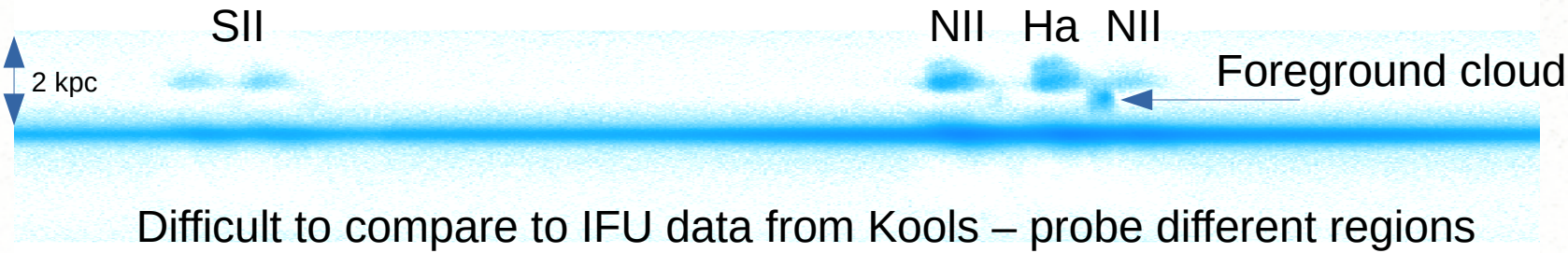




Ignition Event: Example II

Jan 11 GMOS spectrum





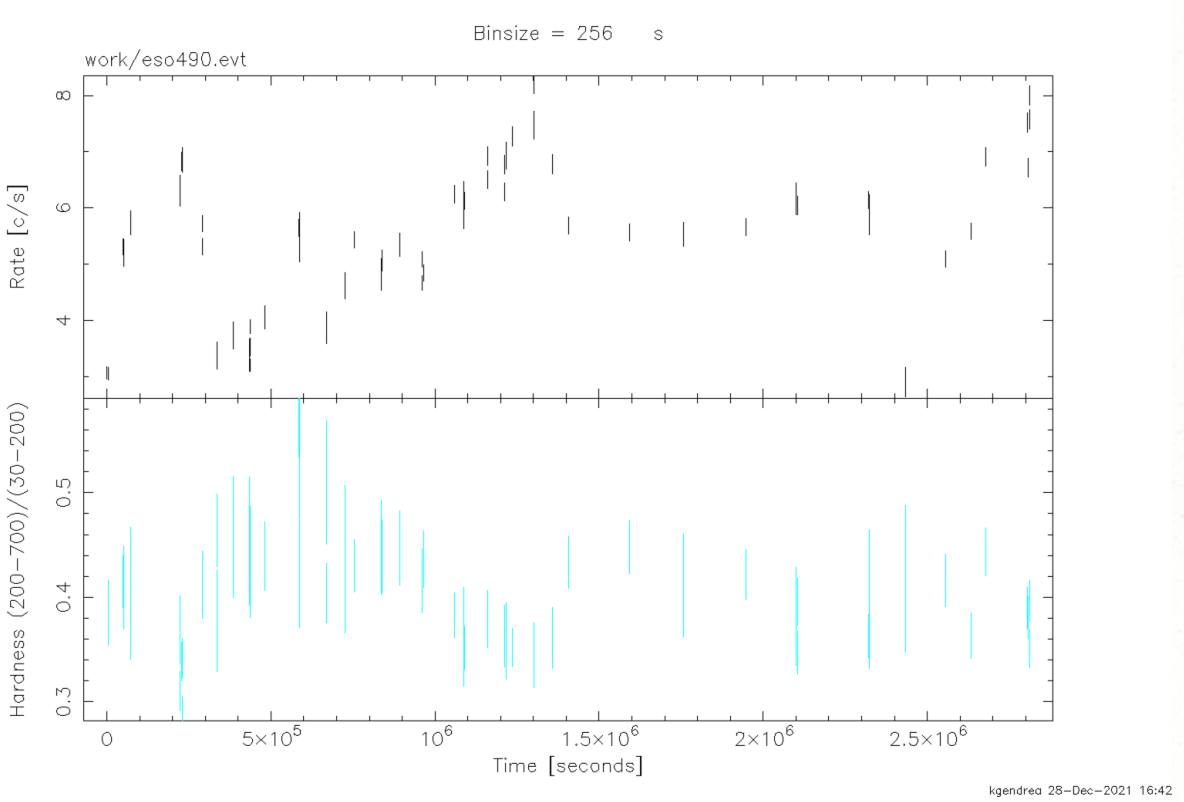
Difficult to compare to IFU data from Kools – probe different regions

Currently OIII flux matching

Ignition Event: Example II

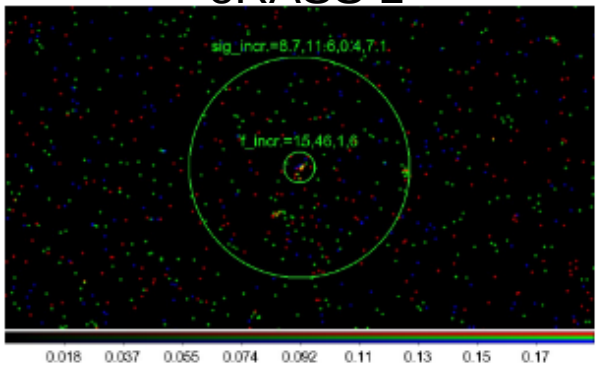
On-going NICER campaign from Nov

Clear changes over past month
also in HR

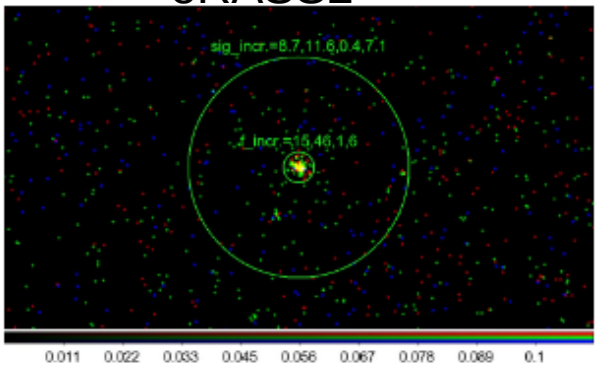


Ignition Event – NLSy1

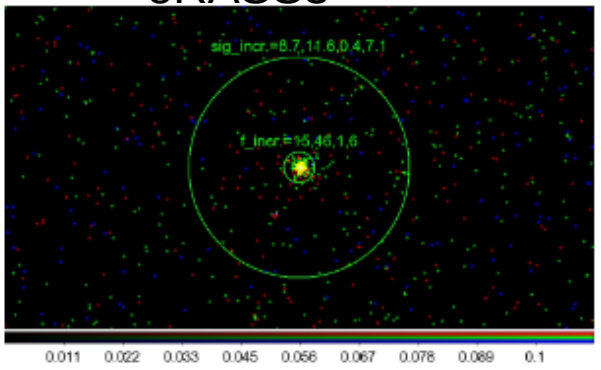
eRASS 1



eRASS2

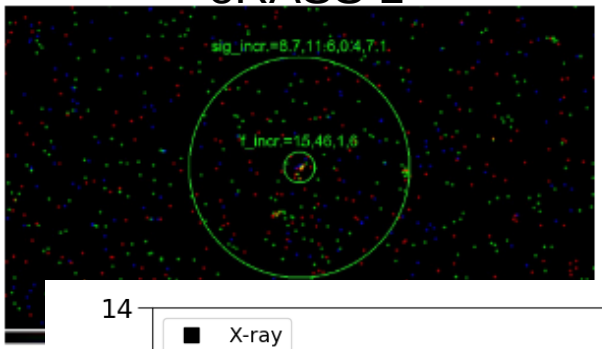


eRASS3

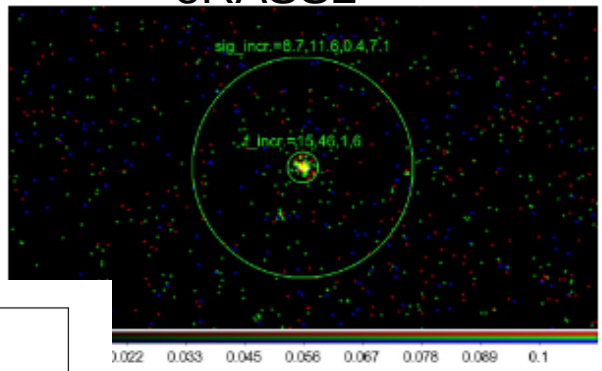


Ignition Event – NLSy1

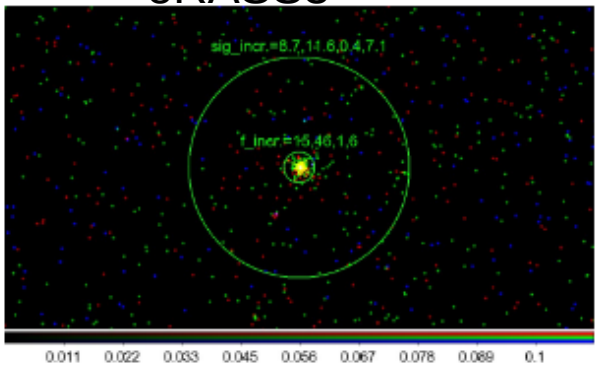
eRASS 1

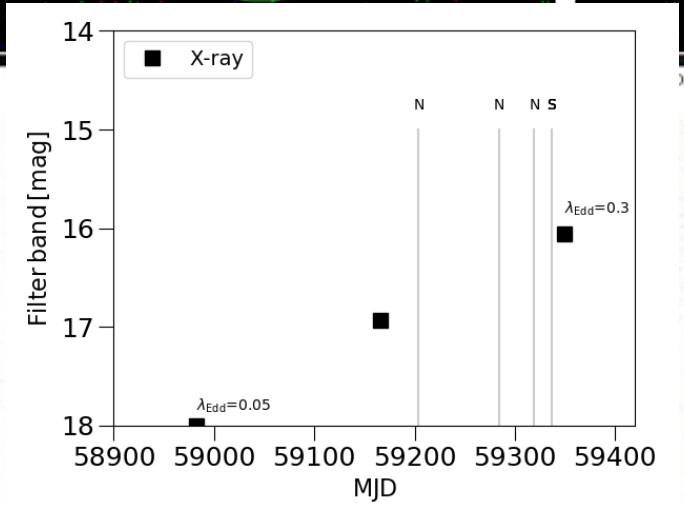


eRASS2



eRASS3





Continuous increase in X-ray flux over 1 year → 5% Edd to 30% Edd (beware uncertainties)

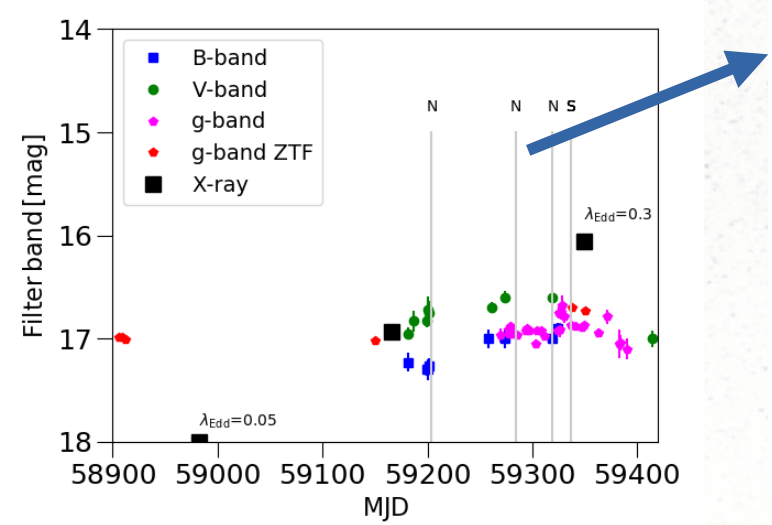
If X-rays continue to rise → candidate for Edd or super Edd accretion

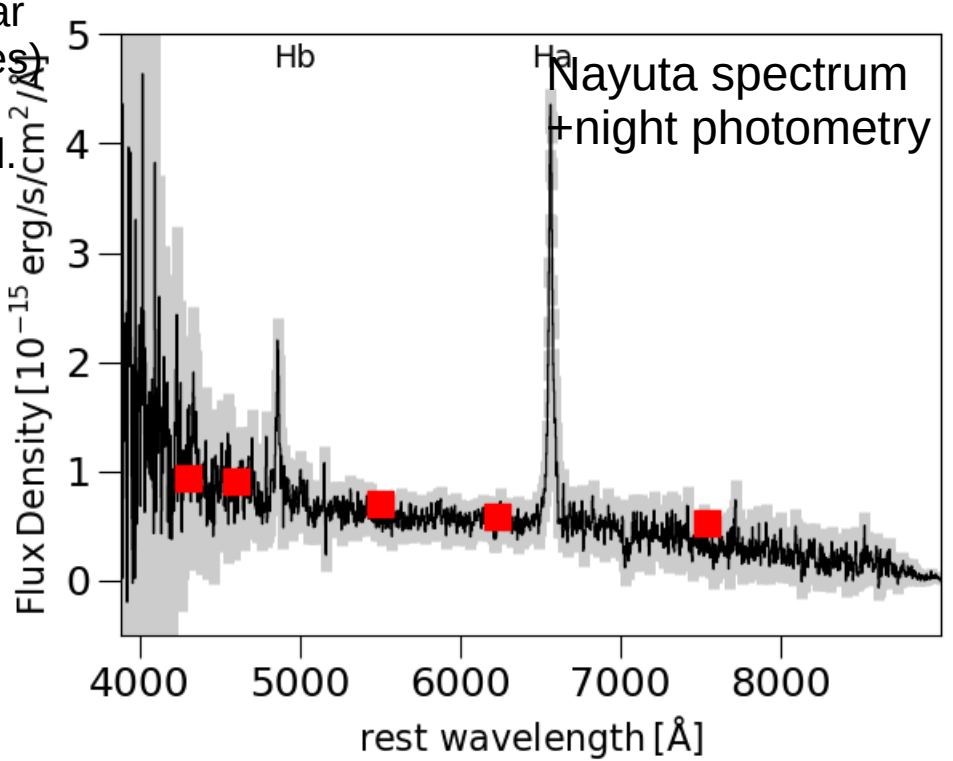
Waiting for eRASS4 data point!!!!

Low-Mass BHs - NLSy1

Continuous increase in X-ray flux over 1 year
→ 5% Edd to 30% Edd (beware uncertainties)

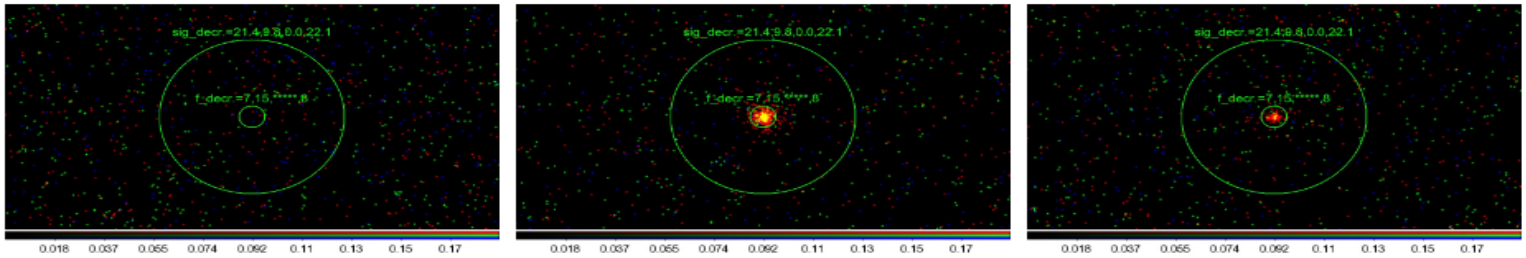
If X-rays continue to rise → Super Edd cand.

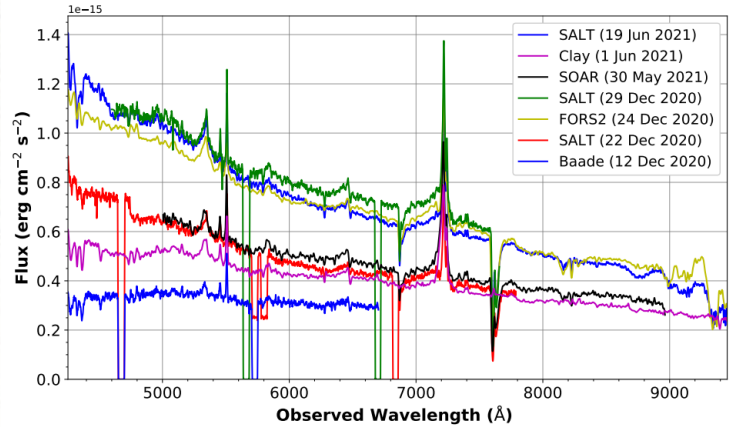




Extreme Burst

eRASS1 eRASS2 eRASS3





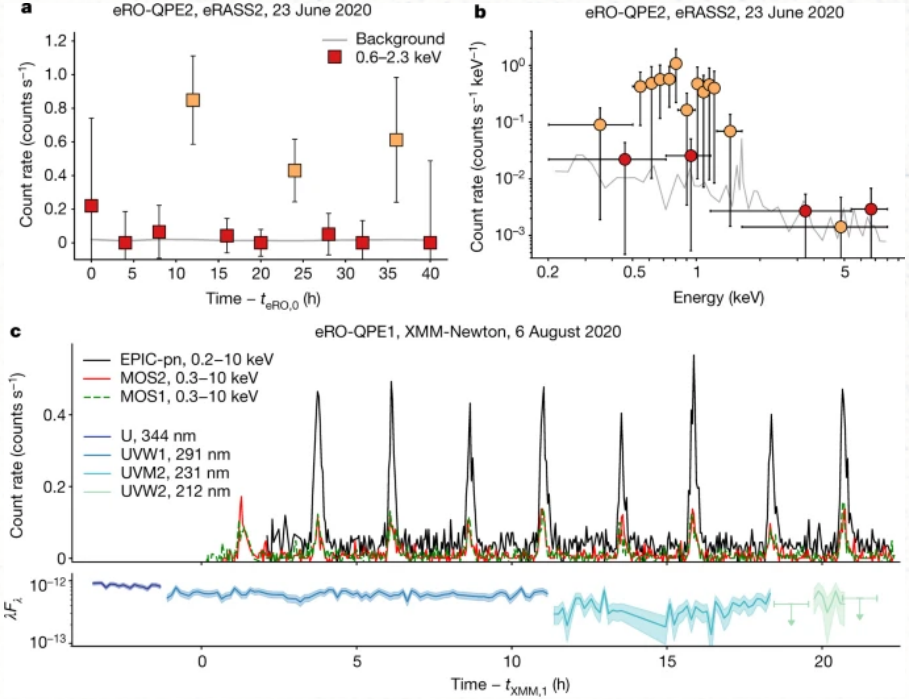
More than factor 100 brightening in X-rays

Optical response through vast spectroscopy and Imaging

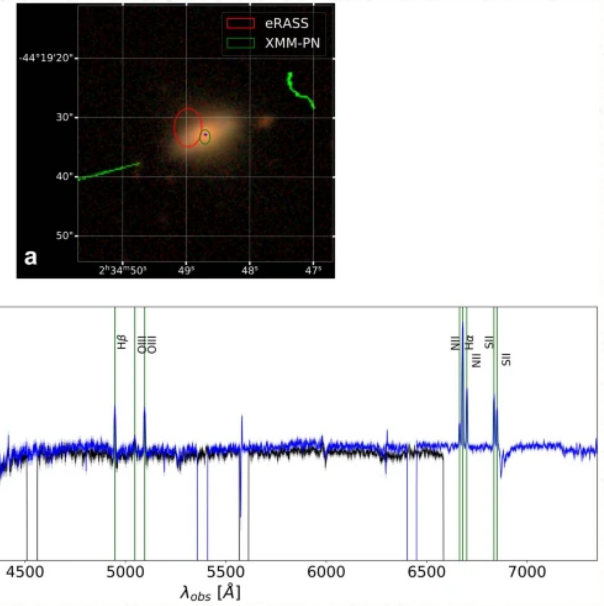
Clear response detected

Quasi Periodic Eruptions

2 QPEs detected by eROSITA presented in Nature as Arcordia et al. 2021



No optical response in both hosts



Summary

- Extensive Follow-up Campaign for eROSITA detected ignition/ shut-down events (targets will multiply each all-sky scan)
- ~268 AGN spectroscopically observed / 20% from Japan
- Most sources do NOT show any significant optical response – or changes compared to archival data (e.g. SDSS)
- Have uncovered many AGN in optical quiescent galaxies
- Now time has started for repeated observations to study time evolution of the events
- We make contributions to other working groups studying X-ray transients