
Near-infrared Monitoring
of Gas accretion Event
onto Sgr A*
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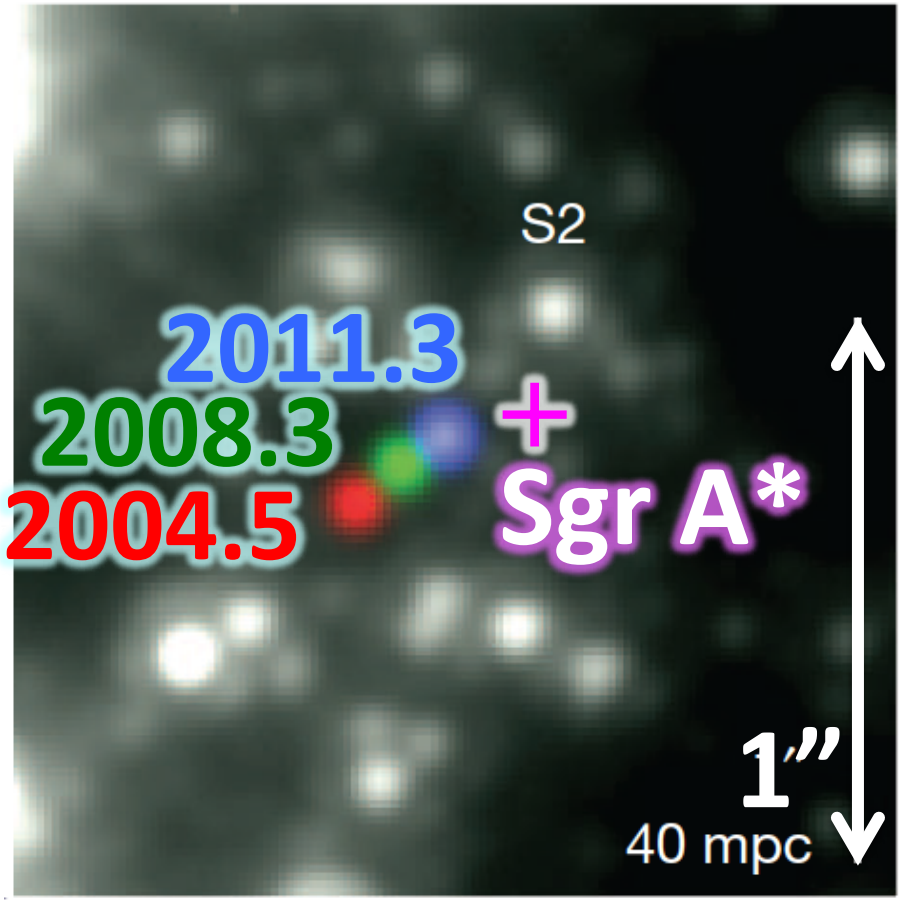
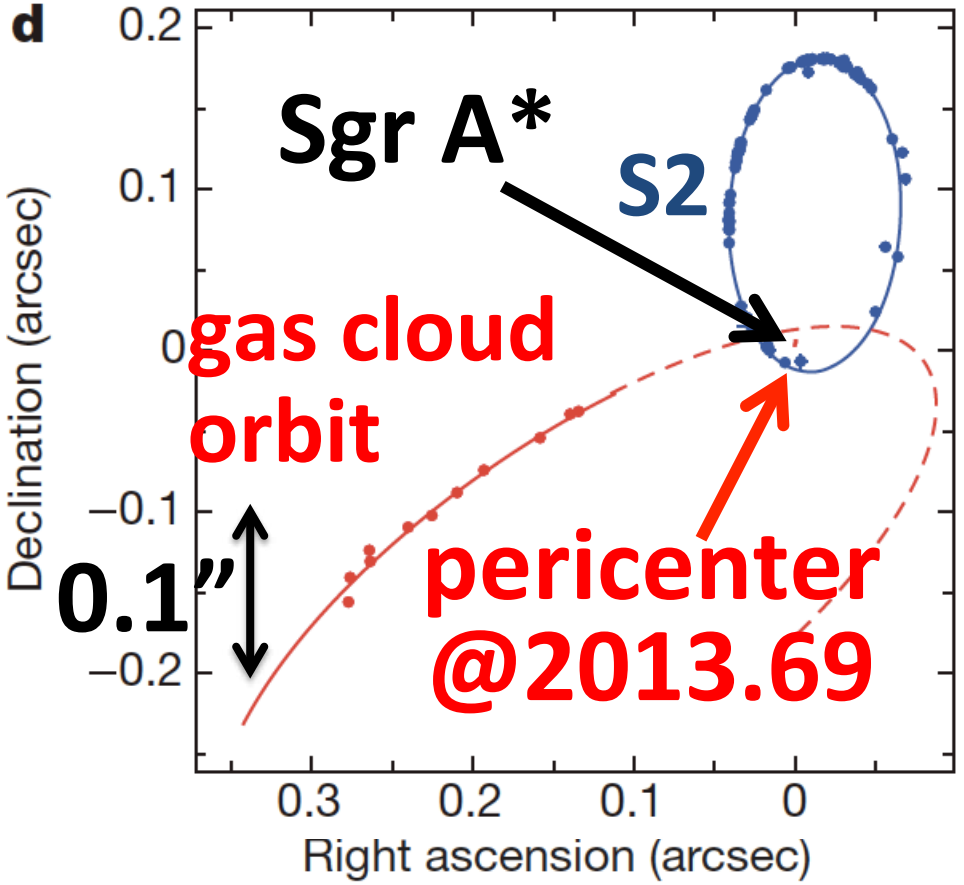
(国立天文台)

Infalling Gas Cloud onto SMBH

Gas cloud approaching to Sgr A* (Gillessen+ 12,13)

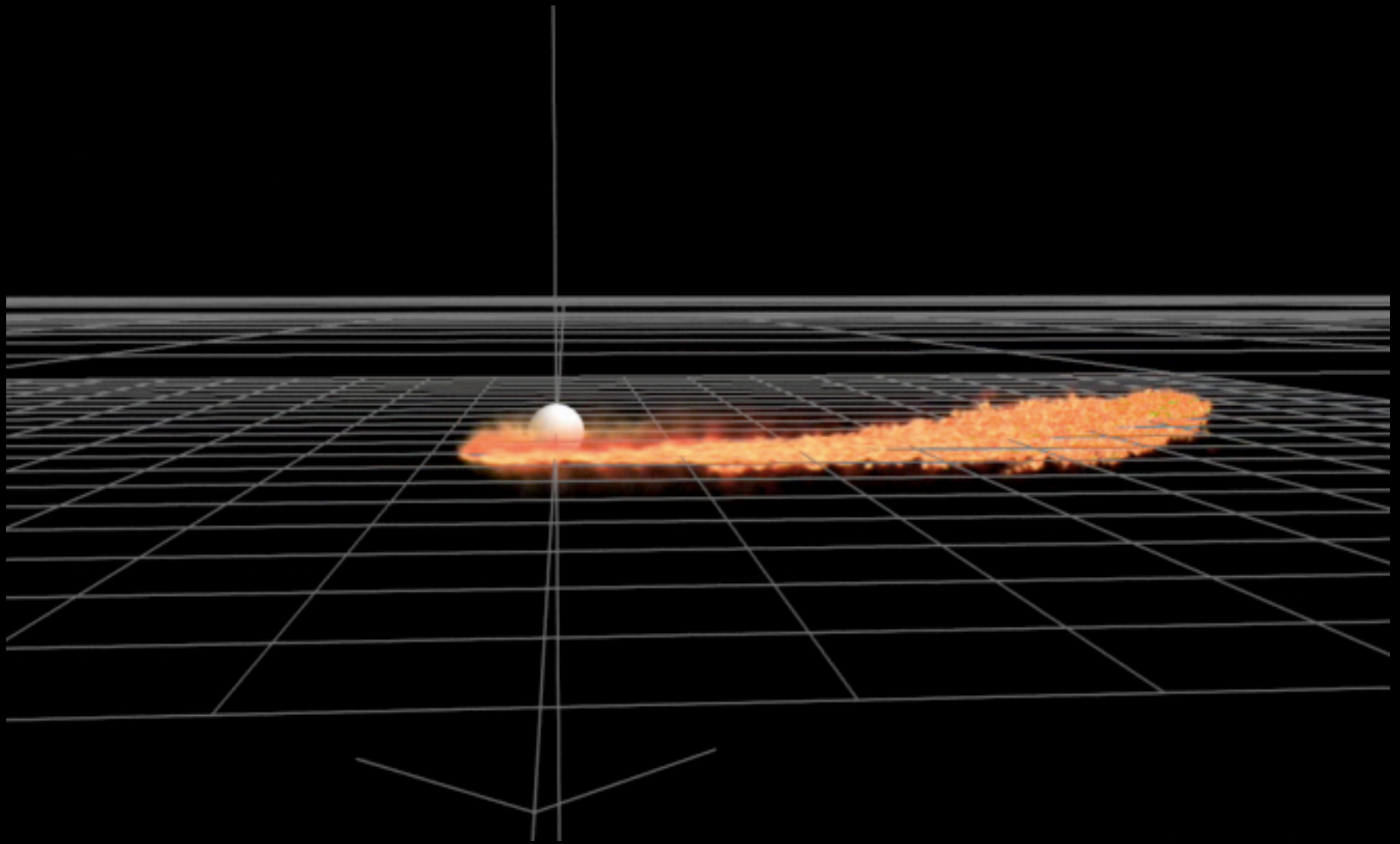




Pericenter: ~ 2200 *Rs* (180 AU) from Sgr A*

Infalling Gas Cloud onto SMBH

Saitoh+ 13 (arXiv1212.0349)



Infalling Gas Cloud onto SMBH

PI	Band	Instrument	Title	Allocated Time	Strategy	UT observing dates
Ott	cm	VLA	Molecular Absorption Survey against the G2 Cloud Sgr A* Accretion Event	10h	Spectrum across multiple bands	triggered at a flux >6Jy, rms tau ~10^-3
Reid	cm	VLBA	Astrometry of Sgr A*: Preparing for the Infall of a Gas Cloud	2 x 2 x 6h	Pre-encounter 22 and 43 GHz astrometry	February 2013
public NRAO	radio	VLBA	Angular size measurements and astrometry of SgrA*	1 full track @ 2 bands	single, pre-encounter, baseline measurement	beginning of semester 2013A, eNews letter
public NRAO	radio	VLA	Continuum monitoring	13 x 2hrs x 8 bands	initially bimonthly, then monthly monitoring	eNews letter
Yusef-Zadeh	mm	VLBA	Joint VLBA/Chandra/EVLA Monitoring of the Gas Cloud G2 as it Encounters Sgr A*	6 x 7h	3mm monitoring with Chandra/VLA	May 2013
Marrone	millimeter	SMA	Polarizatic monitoring	5 x 7hrs	monthly monitoring of polarization and RM, Jan-May 2013 (to be reproposed for next semester)	
Haggard	radi	EVLA	[illegible] Gas Cloud G2 as it Encounters Sgr A*	6 x 7hrs	Roughly monthly sampling near pericenter, simultaneous w/ Chandra obs	
Bower	millimeter	ALMA	The G2 Gas Cloud Encounter with Sagittarius A*: Accretion Structure on Scales of 3000 to 1 Schwarzschild Radii	10 x 1hrs x 2 bands	monthly monitoring beginning in 2013	
Ott	(sub)millimeter	ALMA	Molecular Absorption Survey against the G2 Cloud Sgr A* Accretion Event	3.4h	Spectrum across multiple bands	triggered at a flux >6Jy, rms tau ~10^-3
Martin	(sub)millimeter	ALMA	Fuelling the Galactic center super massive black hole			
Ho	(sub)millimeter	ALMA	Proper Motions of Gas in the Immediate Vicinity of the Galactic Supermassive Black Hole			
Eckart	submm	APEX	Differential L'-band spectroscopy of the Dusty S-cluster Object (DSO/G2) approaching SgrA*	56h		
Gillessen	NIR	SINFONI/VLT	Watching a gas cloud disrupt [...]	70h	Two epochs of deep integral field spectroscopy to follow evolution of line shape	
Gillessen	NIR	NACO/VLT	Watching a gas cloud disrupt [...]	20h	ToO: If SgrA* changes in 2013, get multi-band lightcurves	
Ghez	NIR	Keck/OSIRIS & [illegible]	A LGS-AO Study of our Galaxy's Central Black Hole and its Environs	18 x half-nights (~80 hours)	Deep Imaging & Spectroscopy of the central arcsec	
Eckart	NIR	[illegible] VLT	[illegible] oscopy of the Dusty S-cluster Object (DSO/G2) [illegible] SgrA*	10h		
Eckart	NIR	NACO/VLT	Nature of variable SgrA* X-ray and polarized NIR flares: Probing the accretion stream and source variability during the passage of DSO/G2	20h		
Nishiyama	NIR/MIR	IRCS, HiCIAO, COMICS/Subaru	Gas Cloud Accretion onto the SMBH SgrA*	15h	ToO: NIR spectroscopy, NIR polarimetry, or MIR imaging	
Baganoff	X-ray	Chandra	Monitoring the Tidal Disruption of a Gas Cloud Approaching Sgr A*	6 x 20ksec	Roughly monthly sampling around pericenter time	Chandra schedule
Ponti	X-ray	Chandra / HETG	X-ray monitoring of Sgr A* during outburst	280ksec	ToO: If SgrA* gets brighter than Lx = 10^36 erg/s	
Haggard	X-ray	Chandra	Joint Chandra/XMM/EVLA Monitoring of the Gas Cloud G2 as it Encounters Sgr A*	6 x 50ksec	Roughly monthly sampling around pericenter time	Chandra schedule
Haggard	X-ray	XMM	Joint Chandra/XMM/EVLA Monitoring of the Gas Cloud G2 as it Encounters Sgr A*	1 x 30ksec	Single obs. near pericenter	
Ponti	X-ray	XMM	Capturing a major accretion event of Sgr A*	230ks	ToO: If Sgr A* becomes brighter than 10^35 erg/s	
Ponti	X-ray	XMM	Monitoring Sgr A*	100ks	Monitoring the cloud-SgrA* interaction	2x50ks
Grosso	ray	X		150ks		3x50ks
Degenaar	X-ray	Swift	Swift/XRT monitoring observations of the Galactic Center region	82ks	Bi-weekly monitoring (1ks/obs)	April 1, 2012 - March 31, 2013
Degenaar	X-ray	Swift	Continuing a Swift legacy: the monitoring campaign of the Galactic Center	248ks	Daily monitoring (1ks/obs)	April 1, 2013 - March 31, 2014
Haggard	X-ray	Swift	Swift Monitoring of the Encounter Between Sgr A* and the Gas Cloud G2	68ks	Monitoring weekly, then twice weekly, then daily near pericenter (1ks/obs)	April 1, 2013 - March 31, 2014
Morris	X-ray	Suzaku	Capturing a major accretion event of Sgr A*	200ks	ToO: if Swift > 5 x 10^35 erg/s	
Sunyaev	Gamma	INTEGRAL	Forthcoming major outburst of Sgr A*? Once in a life-time chance for INTEGRAL	2000 ksec	ToO	
Wilms	Gam	[illegible]	Observing the Galactic Center Region with INTEGRAL	1000 ksec		
Kuulkers	Gamm	[illegible]	Regular and frequent INTEGRAL monitoring of the Galactic Bulge region	479 ksec		
Yusef-Zadeh	Gamma	Fermi	The Gamma-ray Variability of Sgr A* Induced by an Infalling Cloud	duration of flare	ToO: LAT flux >5x10^{-6} ph/cm^2/s or enhanced Lx	

cm - submm

NIR - MIR

X-ray

γ-ray

Infalling Gas Cloud onto SMBH

Science: Jet Formation

accretion disk～10^5 *Rs* ＞ pericenter 2,200 *Rs*

disk & gas collision → accretion rate↗

1. Observations of Gas Cloud

NIR spec → H recomb. lines → spatial dist.
+simulation → accretion timing, mass

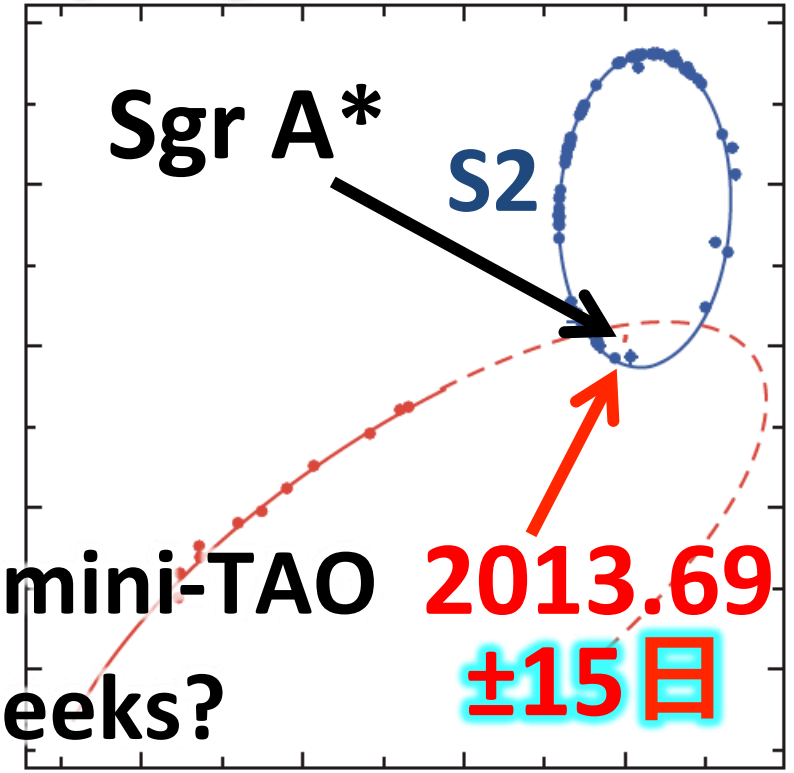
2. Observations of Jet

NIR spec, polarimetry ← synchrotron
→ time variation of jet/internal mag. field

NIR polarimetric monitoring

→ long-term variation

NIR Monitoring of Sgr A*



<Observation plan>

- everyday : IRSF
- everyday in 2-4 months : mini-TAO
  2/yr(Spring, Autumn) 8 weeks?
- ToO: Subaru
- ToO: mini-TAO
- ToO: Daigaku renkei

NIR Monitoring of Sgr A*

<Status>

- **IRSF → OK (2013/1-6)**
- **Subaru (ToO)**

  → 13A(13/2-7): approved

  → 13B(13/10?-14/1): submitted

  (Subaru + Gemini time-exchange)
- **Daigaku renkei (ToO) → OK**
- **mini-TAO/ANIR → ??**

NIR Monitoring of Sgr A*

IRSF/SIRIUS/SIRPOL

unique facility where NIR frequent monitoring is possible

IRSF

- 1.4 m
- dedicated for SIRIUS
- South Africa (32.3° S)

  ↔ Sgr A* Dec. = −29.0°

SIRIUS/SIRPOL

NIR simult. (Polari) Imaging

(J : 1.25, H : 1.63, Ks : 2.14 μm)

- Resolution 0”.45/pix

  (cf. 8m: ～0”.02)
- FoV 7’.7 × 7’.7

NIR Monitoring of Sgr A*

mini-TAO/ANIR

mini-TAO

- 1.0 m
- Spring/Autumn、～2 months
- Atacama (23.0° S)

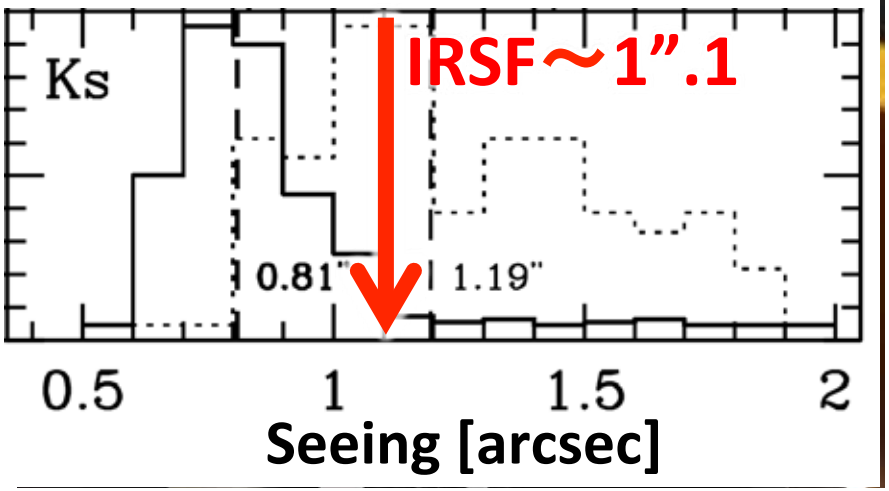
  ↔ Sgr A* Dec. = −29.0°

ANIR

OptNIR Imaging

(BVRI, YJHKs, Narrow-band)

- Res. 0”.30/pix ↔ 0”.45(IR
- FoV 5’.0 × 5’.0
- Seeing ～ 0”.8@Ks



NIR Monitoring of Sgr A*

Subaru/IR cameras

Subaru

- 8.2 m
- Hawaii (19.8° N)

  ↔ Sgr A* Dec. = −29.0°

  low elevation, obs < 5h/night

IRCS+AO188+LGS

NIR Imaging Spectroscopy

HiCIAO+AO188+LGS

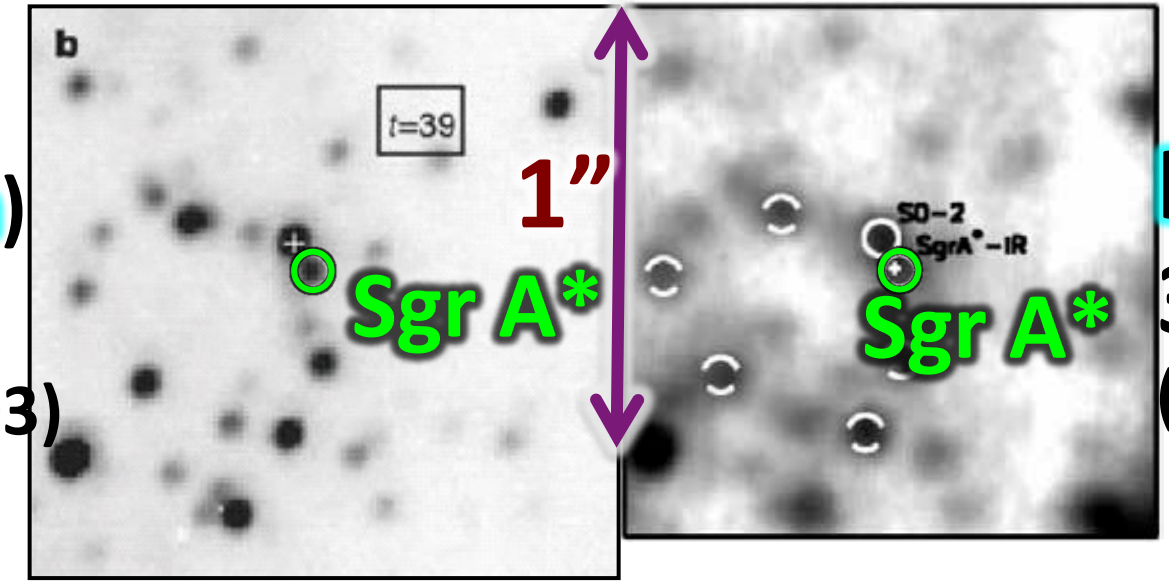
NIR Imaging Polarimetry

COMICS

MIR Imaging spectroscopy

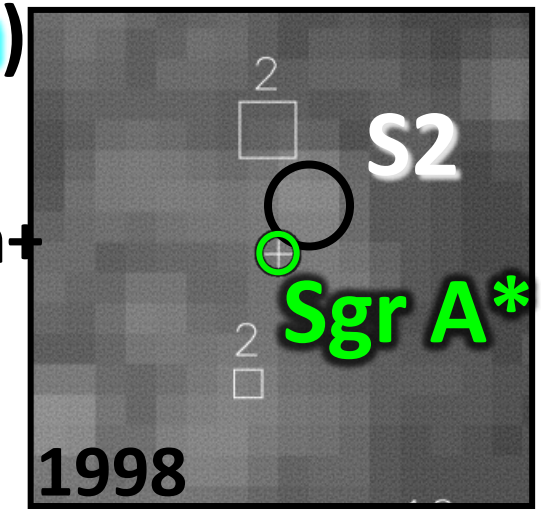
Sgr A*Monitoring with IRSF

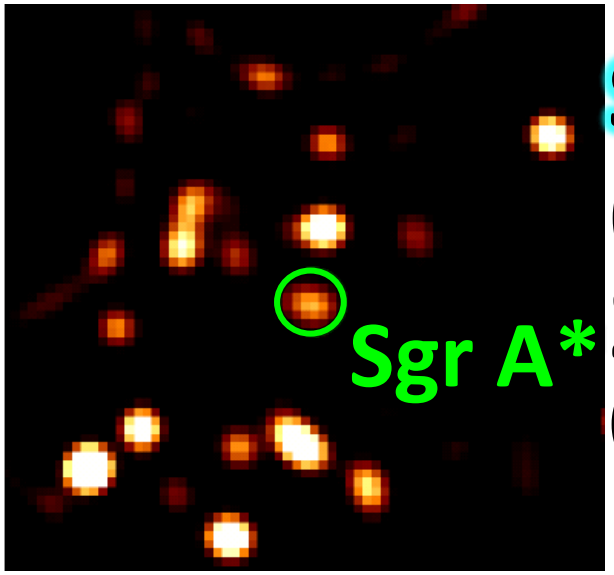
VLT (8m)
1.6 μm
(Genzel+ 03)



Keck (10m
3.8 μm
(Ghez+ 04)

HST (2.4m)
1.9 μm
(Yusef-Zadeh+ 08,
image:Paα,
Scoville+ 03)

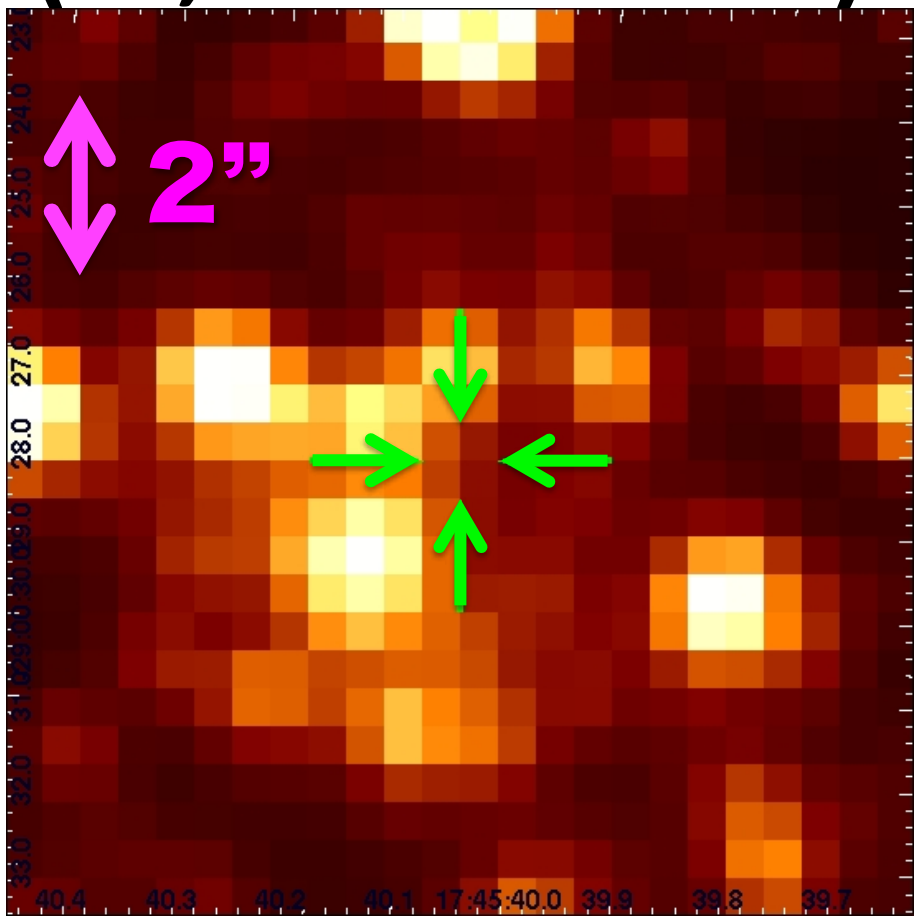




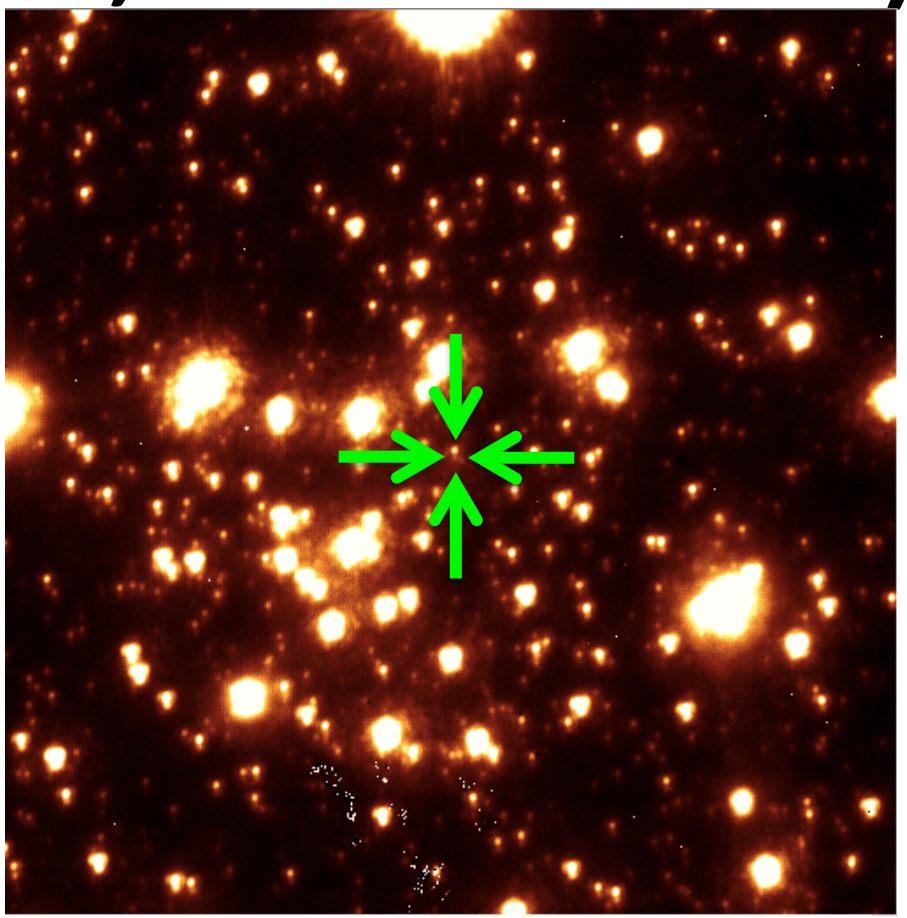
Subaru
(8m)
2.2 μm
(Nishiyama + 08)

Sgr A*Monitoring with IRSF

IRSF/SIRIUS (*Ks*, FWHM=1.0”)



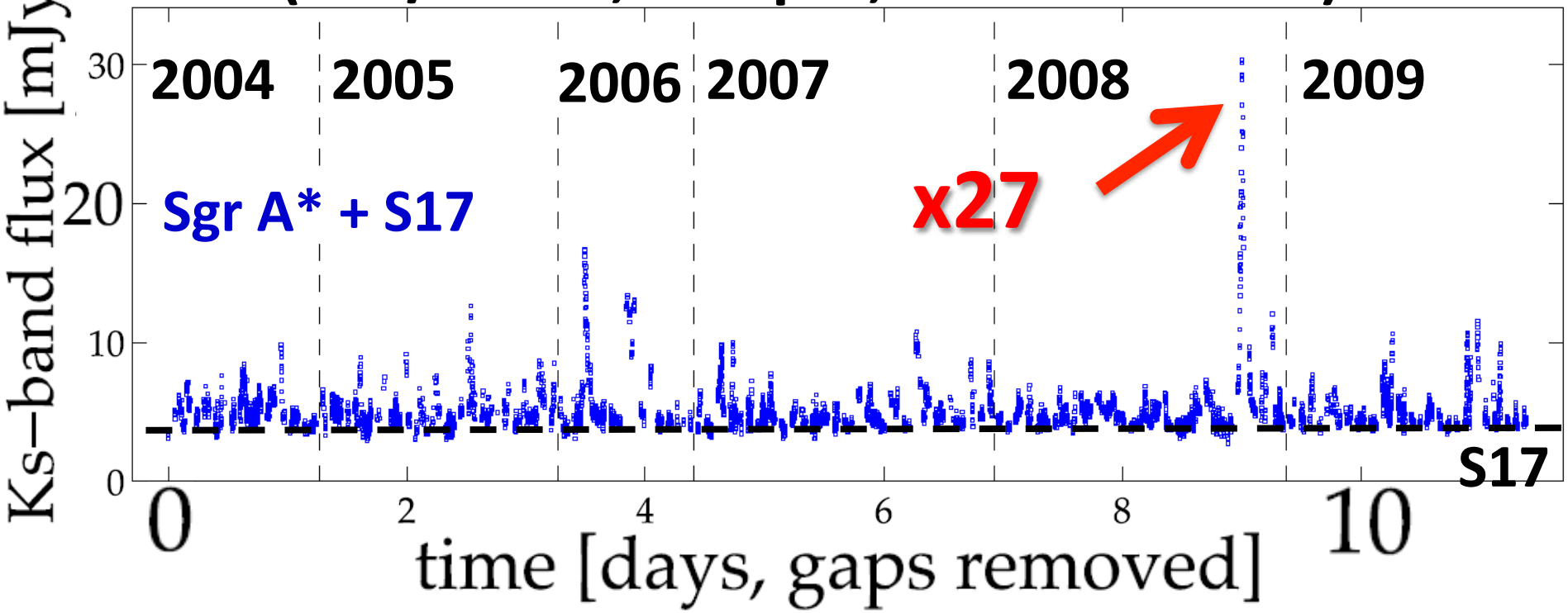
Subaru/IRCS/LGSAO (*Ks*, FWHM～0.08”)



Sgr A*Monitoring with IRSF

Light curve of Sgr A* 2004 ～ 2009

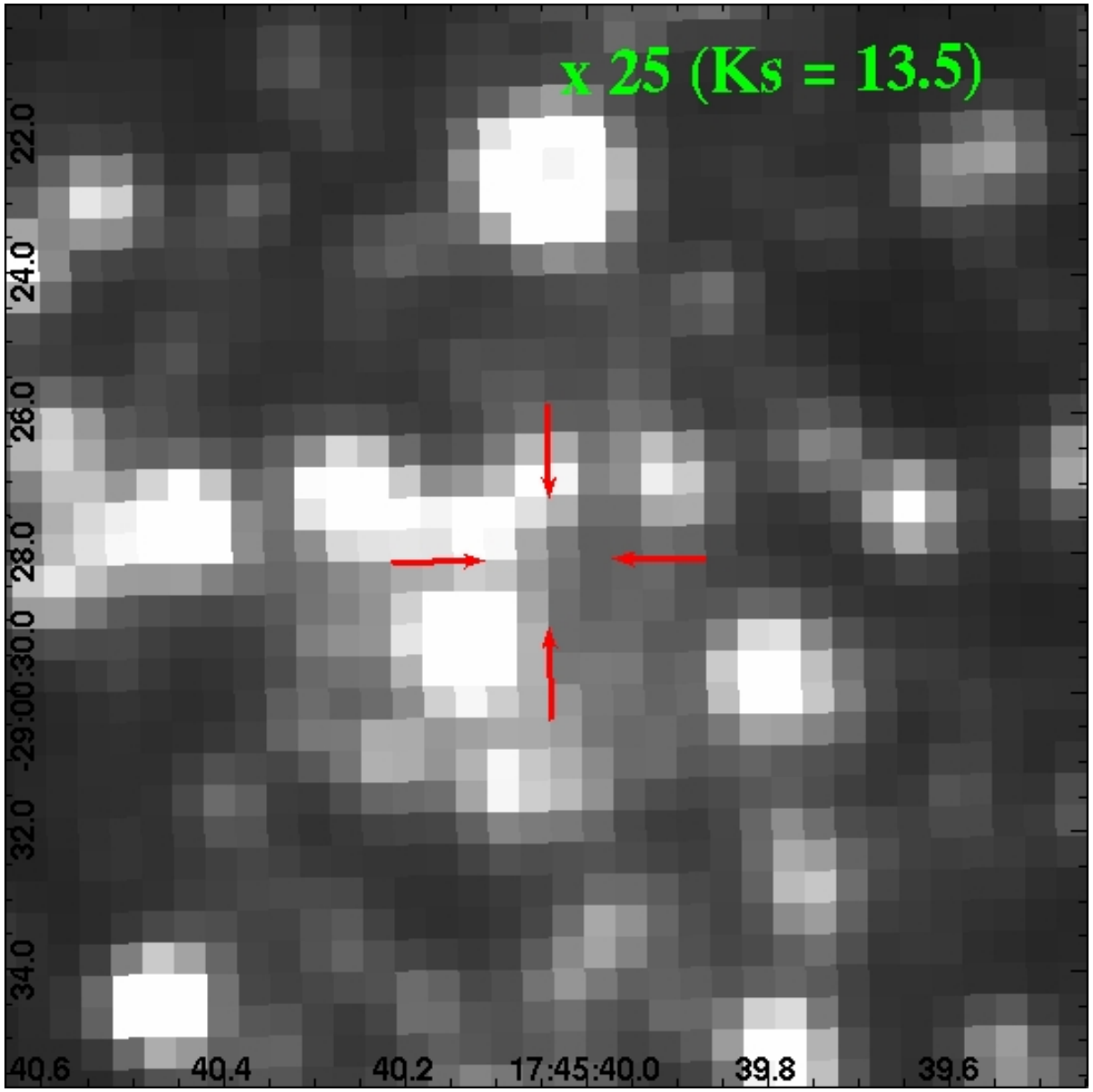
(VLT/NACO, 2.15μm, Dodds-Eden+ 11)



～184 h, total exposure ～72 h

(zero-points are shifted to be the averaged one)

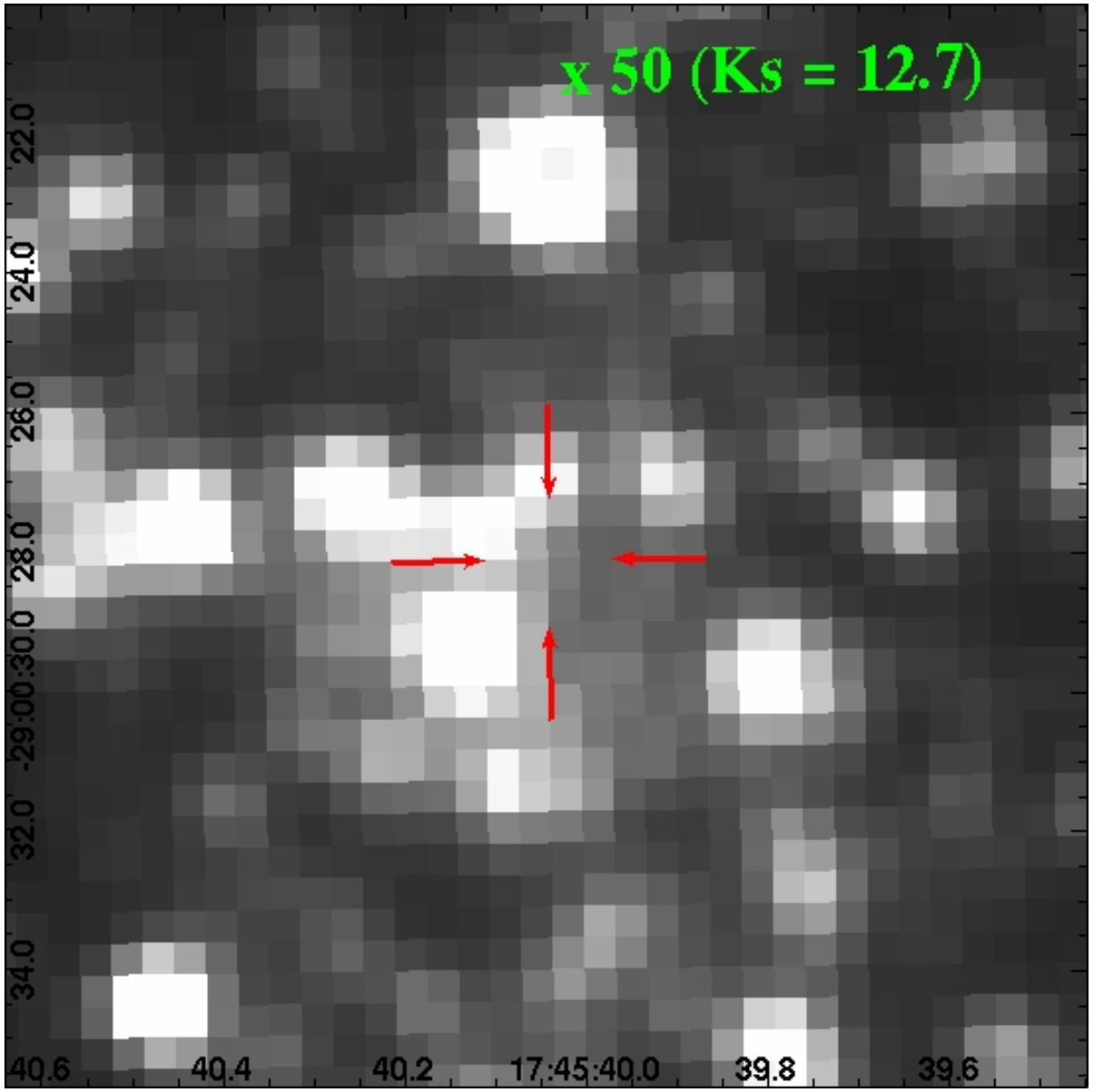
Sgr A*Monitoring with IRSF



x 25

(Ks = 13.5)

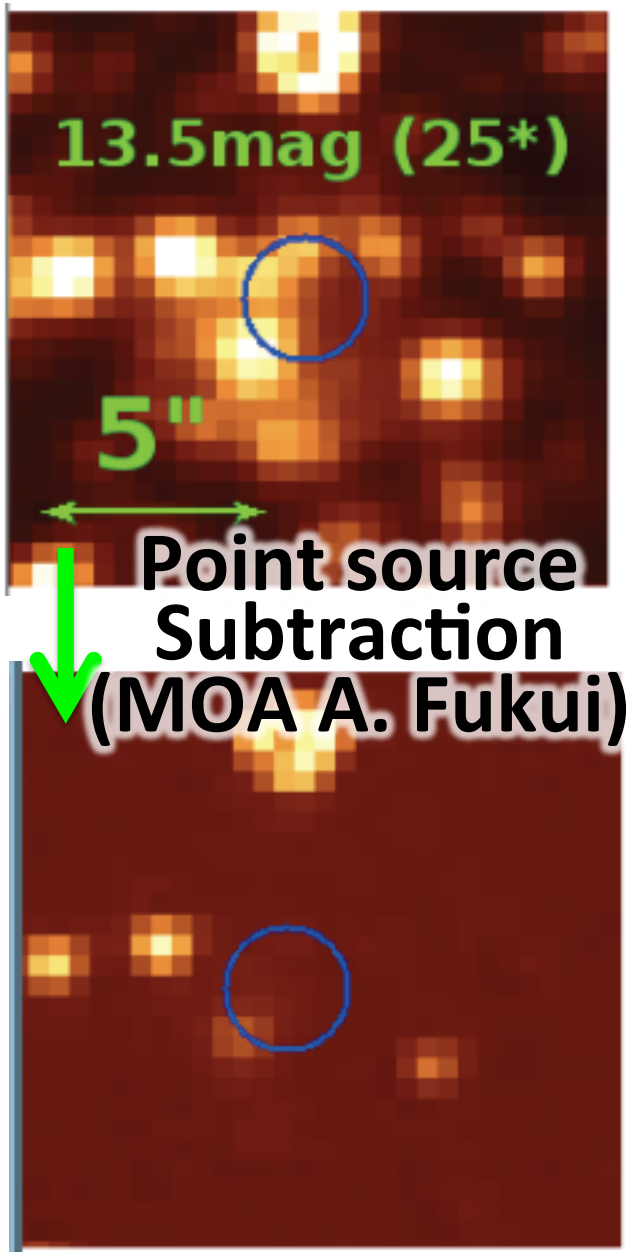
Sgr A*Monitoring with IRSF

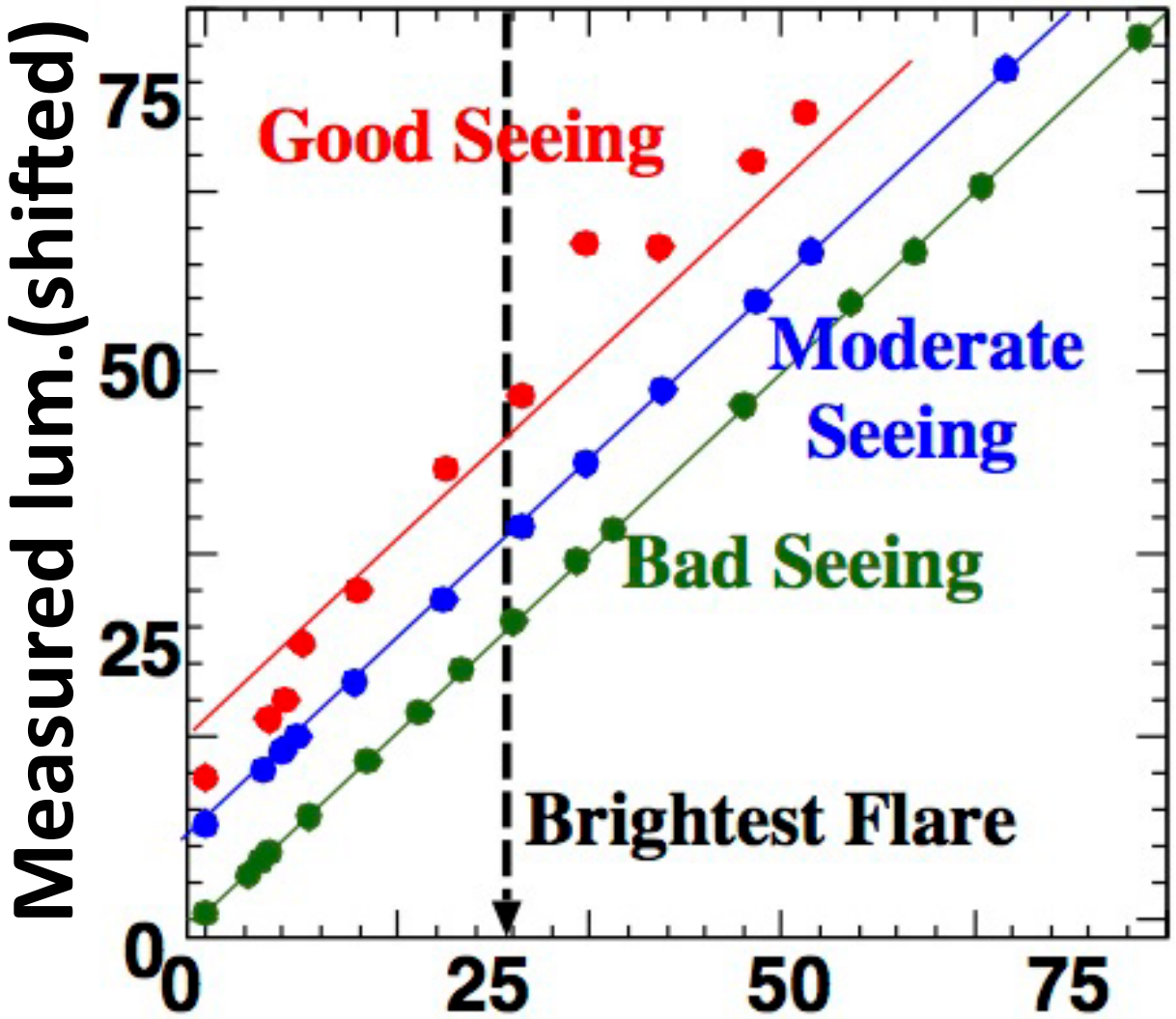


x 50

(Ks = 12.7)

Sgr A*Monitoring with IRSF

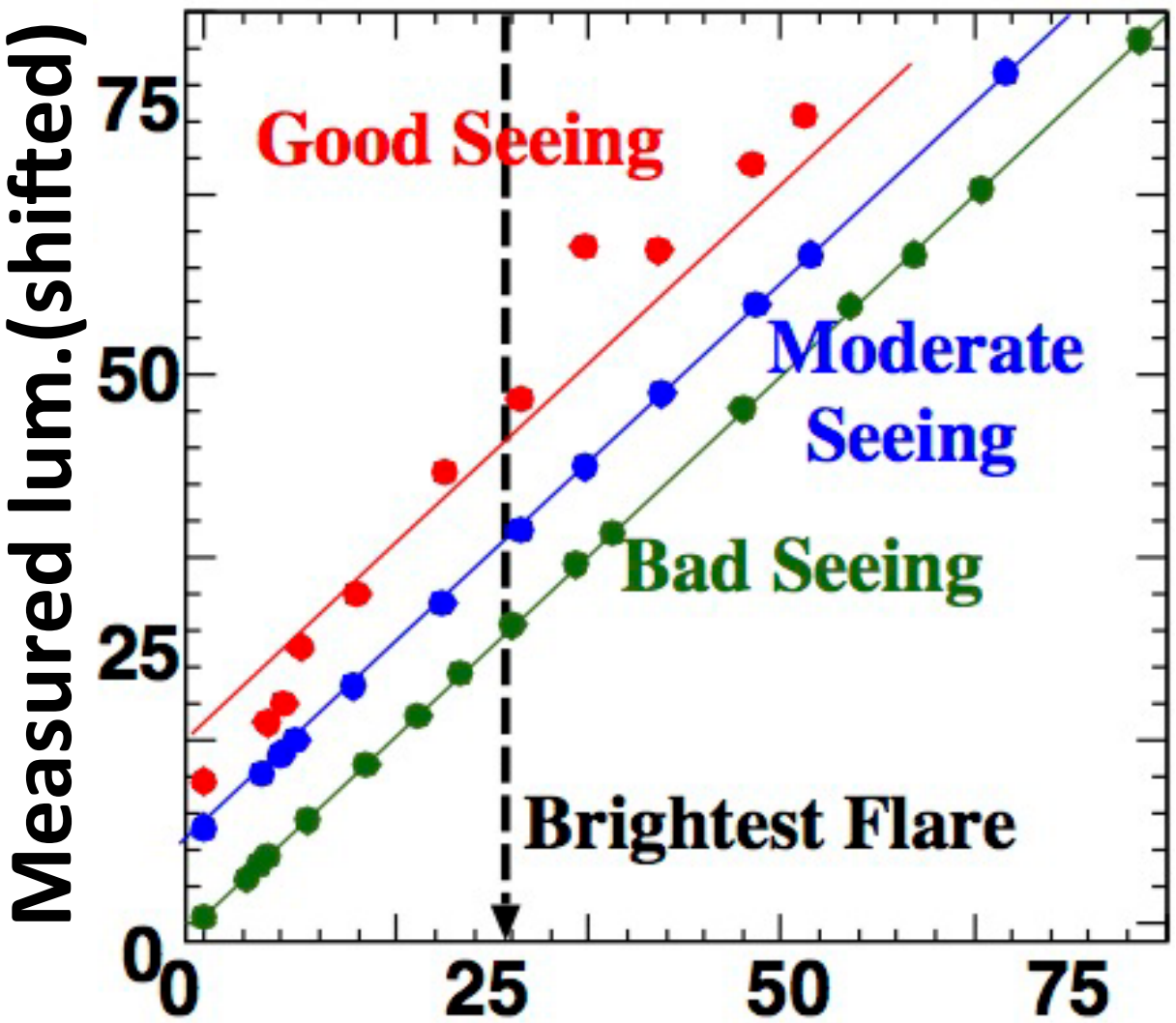




Sgr A*Monitoring with IRSF

Sgr A* monitor with IRSF/SIRIUS + miniTAO/ANIR ↓ 25mJy-flare is detectable

Monitoring
1/day (10-min)



Summary

- Gas accretion on SMBH @～2013/9
- NIR monitoring of Sgr A*
  using IRSF+miniTAO
- Frequently as many as possible (～1/day)
- > 25 mJy-flare detectable
- Flaring → alert for large telescopes
- Follow-up with Subaru, etc.