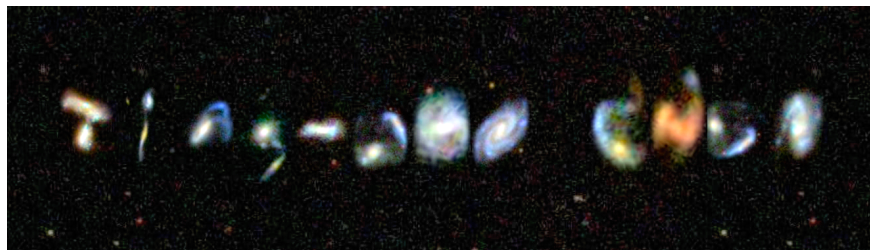


Lulin observatory's rapid response to extreme transients



Janet Ting-Wan Chen 陳婷琬
National Central University



Astronomy community in Taiwan

The Taiwan Astro Community 2025



- Numbers are full-time faculty members eligible to act as NSTC project PIs.
- There also exist faculty members that are not PI-eligible, and also non-university astronomers who are PI-eligible.

credit: Wei-Hao Wang

last update: March 2025

Lulin Observatory

鹿林 = deer forest



120° 52' 25" E

23° 28' 07" N

altitude: 2862m

- average seeing 1.39 arcsec
- in average 193 observational nights (1547.16 hours) per year
- sky darkness $U = 21.78 \pm 0.30$, $B = 22.01 \pm 0.08$, $V = 21.28 \pm 0.06$, $R = 20.91 \pm 0.05$, $I = 19.40 \pm 0.06$ mag arcsec⁻²

Lulin Observatory

鹿林 = deer forest



Lulin Observatory



Lulin Observatory

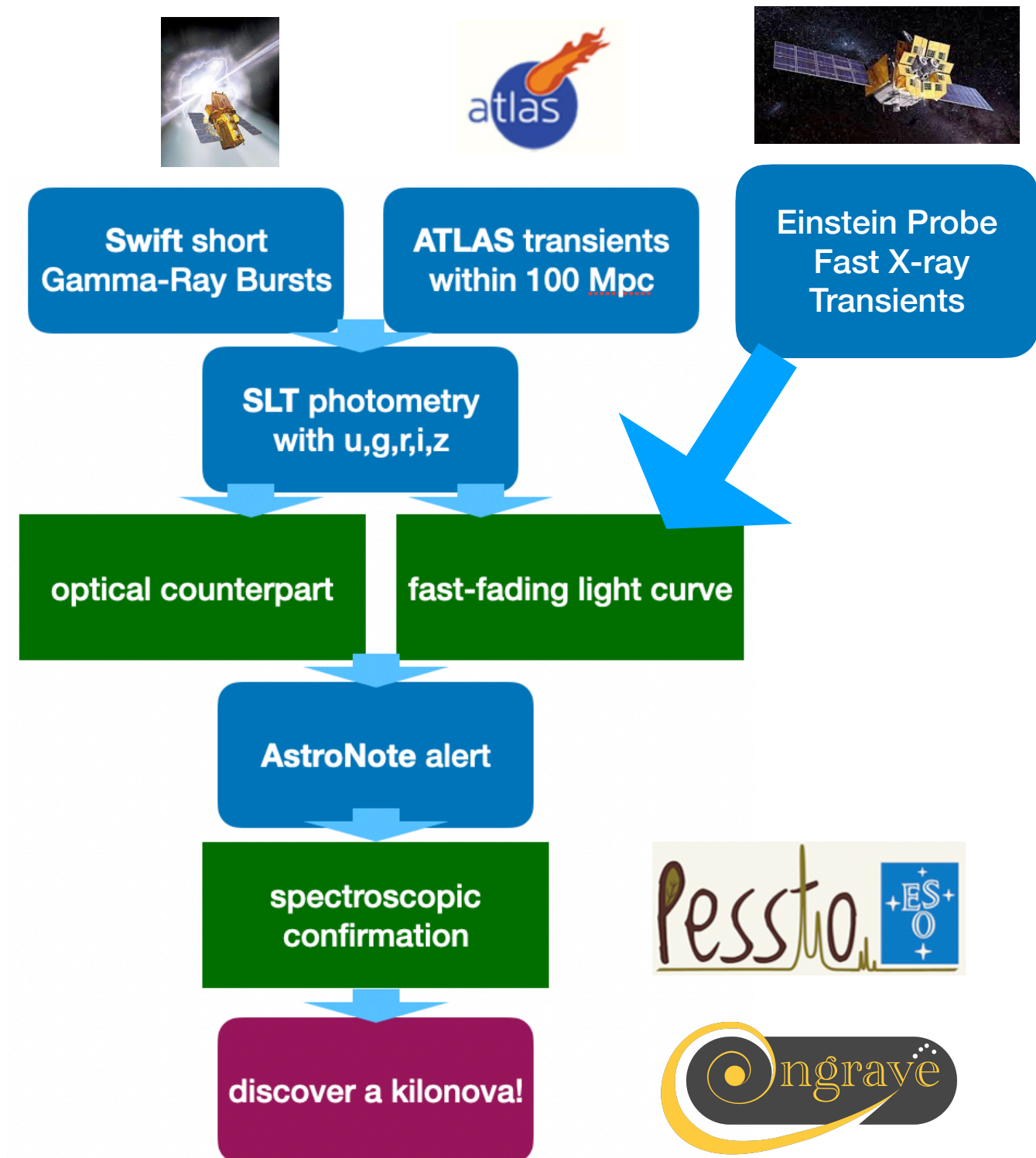


Kinder (kilonova finder) project



0.4-m SLT at Lulin Observatory, Taiwan

- PI: Janet Chen
- Collaboration with Chow-Choong Ngeow, Yen-Chen Pan, Lulin staff (all NCU), Sheng Yang (HNAS), Stephen Smartt & ATLAS, Pan-STARRS (Oxford-QUB) teams, Albert Kong (NTHU)



recursive acronym!

GREAT Lab

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GREAT Lab

Great and Rare Exotic Astronomical Transients
laboratory

Introduction of Our Group

"In observing the changes, we realize that the heavens and earth cannot be contained in a single moment; in observing the constants, we understand that all things, including ourselves, are boundless." ---Su Shi, "Ode to the Red Cliffs."

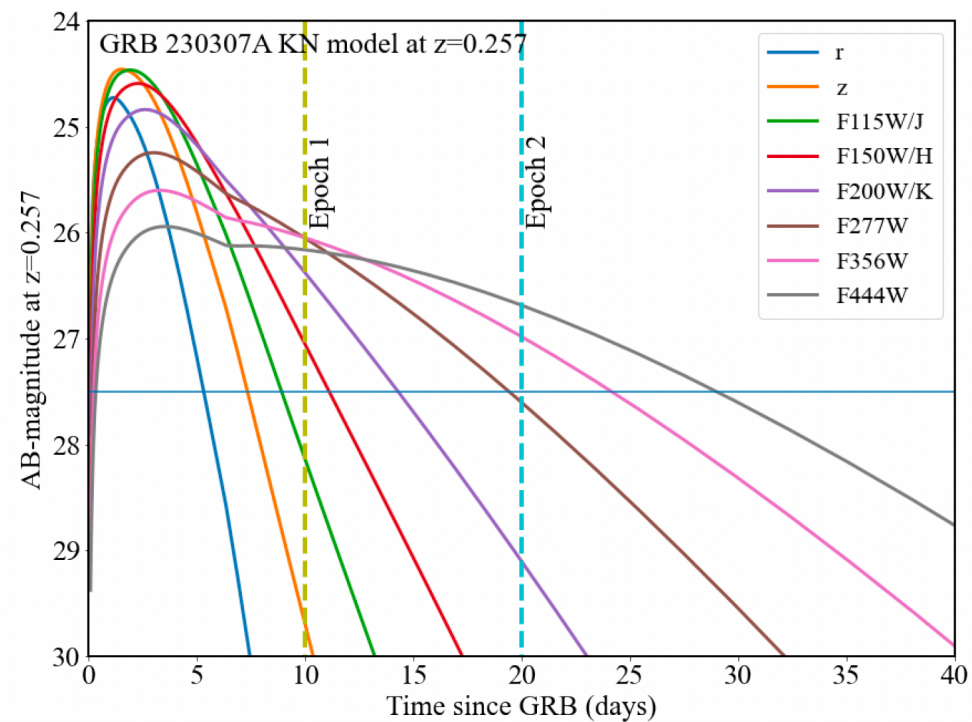
The Universe is filled with dazzling and spectacular celestial explosions. When do they occur? Why do they happen? Where do these eruptions take place? And what unfolds after their occurrence?

<https://sites.google.com/view/great-lab/home>

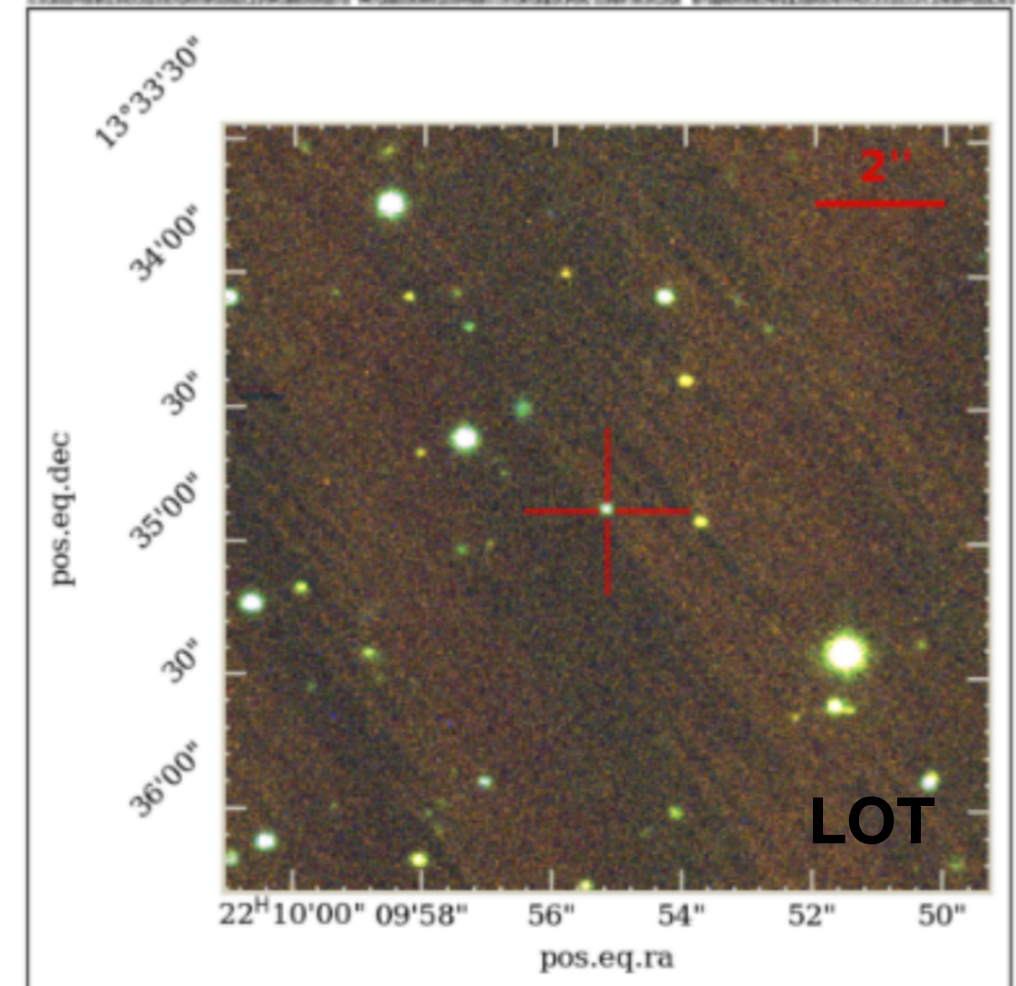
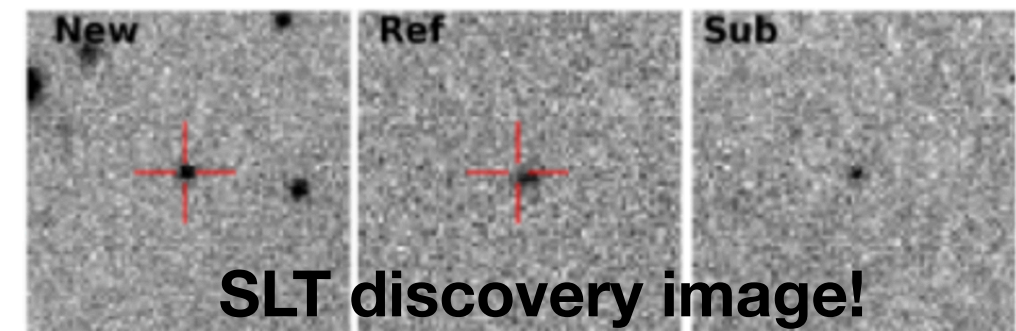
Kinder Data Server <http://kinder.astro.ncu.edu.tw>

GRB 231117A

- short-GRB, $t_{90} = 0.67 \pm 0.07$ sec
- Kinder discovers the GRB afterglow!
- $z = 0.257$ from the host
- one of the closest sGRBs observed to date
- ENGRAVE with JWST/HST
- G. Anderson is leading the draft



7.39 hours after the Swift trigger

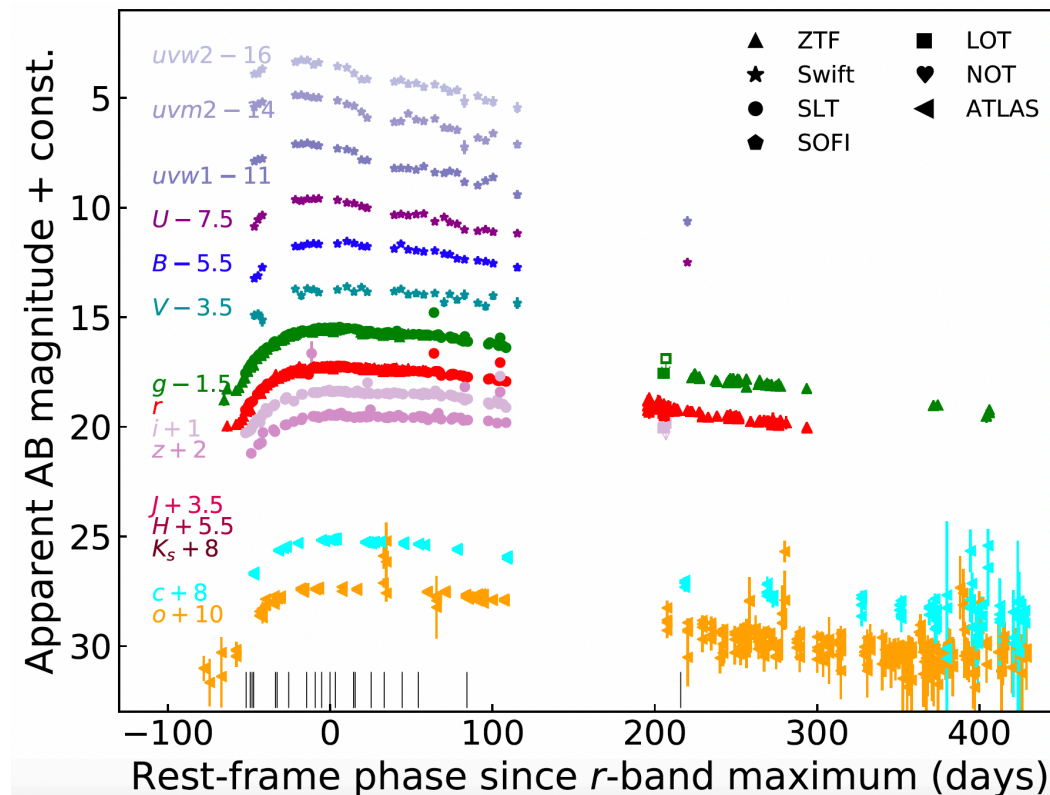
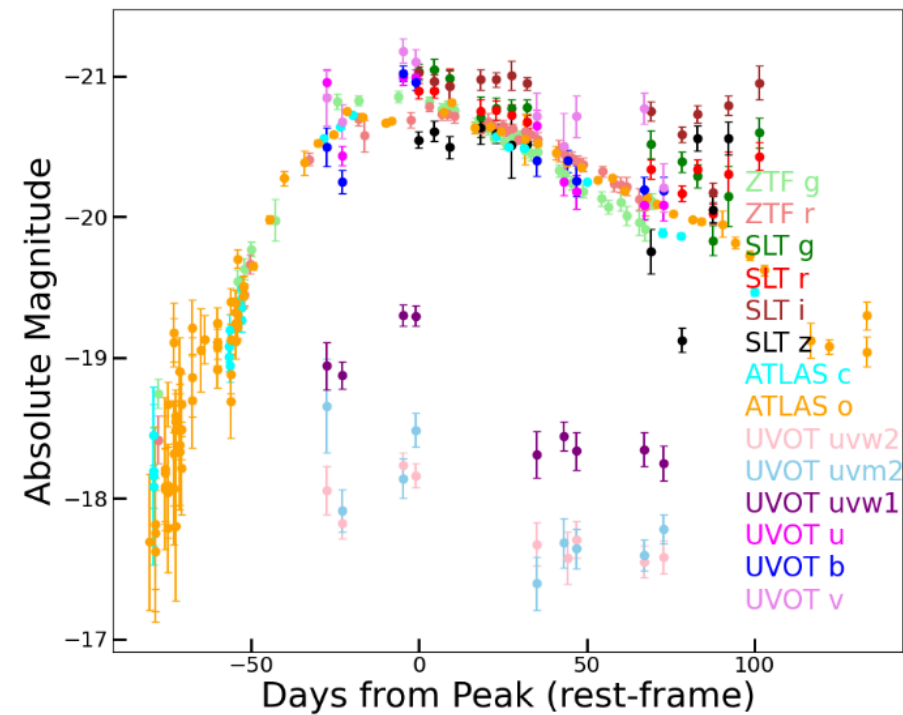


Kinder follow-up observations

Superluminous supernovae
(Sankar.K et al., in prep.)
(Chen & Yang et al., in prep.)

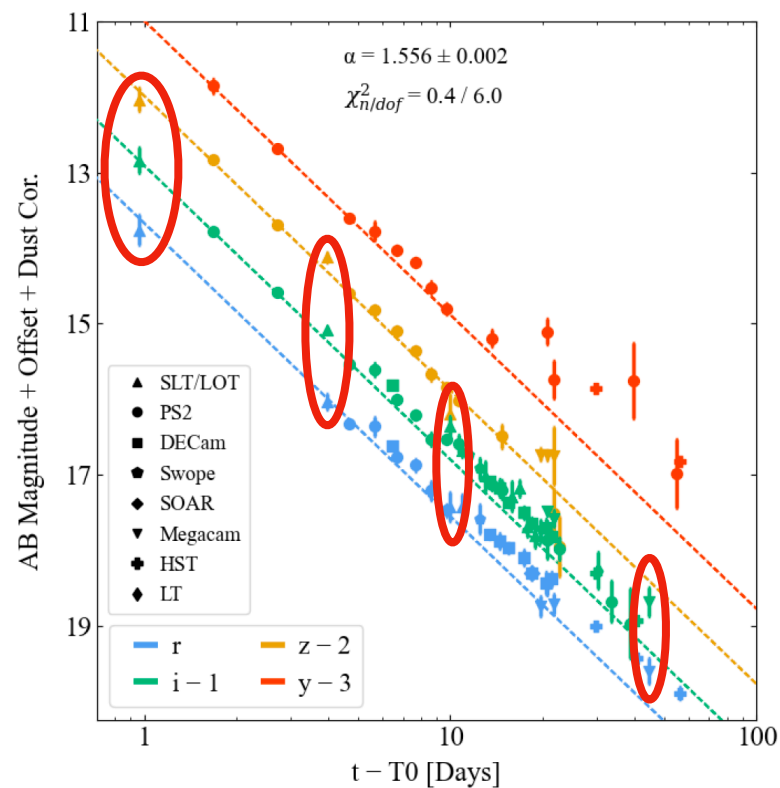


Aiswarya Sankar.K



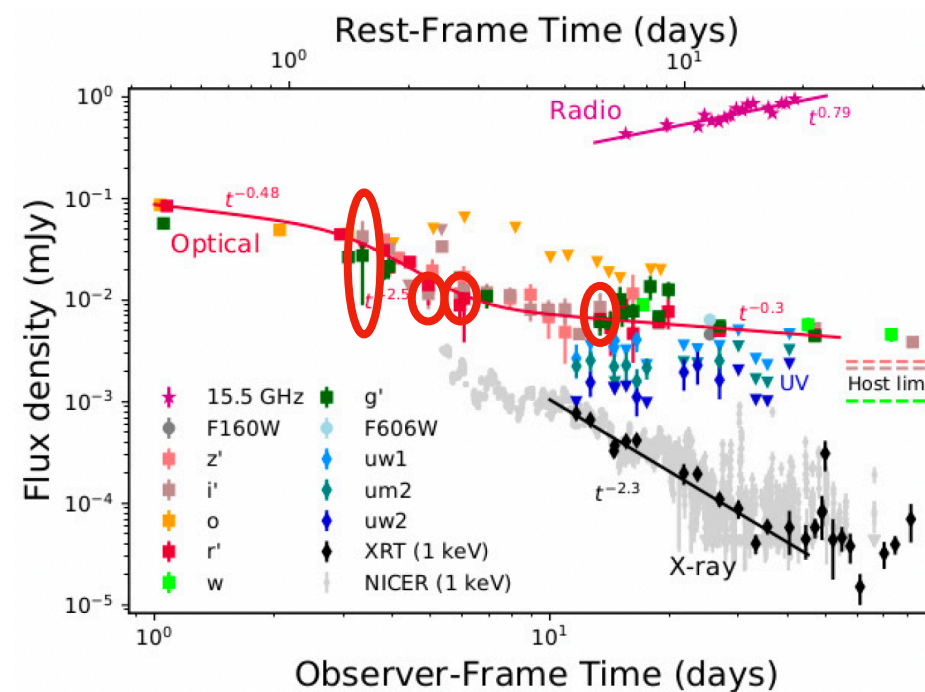
more Kinder follow-up observations

Gamma-ray burst
(Fulton et al. 2023,
ApJL)



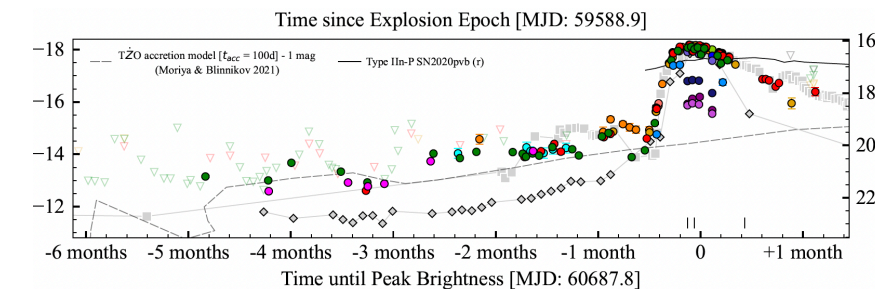
GRB 221009A

Tidal Disruption Event
(Pasham et al. 2023,
Nature Astronomy)



AT 2022cmc

SN Precursors
(Brennan et al., submitted
arXiv:2503.08768)



SN 2022mop

Einstein Probe (EP) instrument

Wide-field X-ray Telescope

WXT (12 modules)

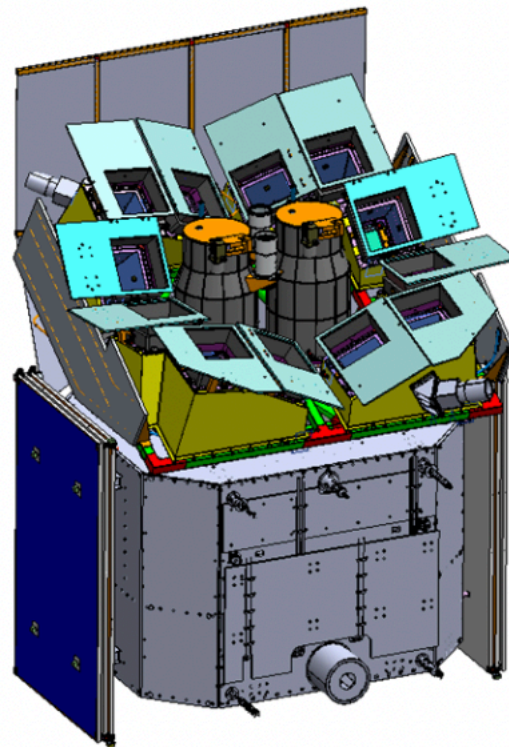
Lobster-eye MPO + CMOS

FoV: ~ 3600 sq deg (1.1 sr)

Band: 0.5 - 4 keV

Resolution: $\sim 5'$ (FWHM)

Sensitivity: ~ 1 mCrab @1ks



Follow-up X-ray Telescope

FXT (2 units)

Wolter-1 + pn-CCD (eROSITA)

FoV: ~ 1 deg

Band: 0.3 - 10 keV

Resolution: $\sim 24''$ (HPD, on-axis)

Effe. area: ~ 300 cm² @1keV (x 2 units)

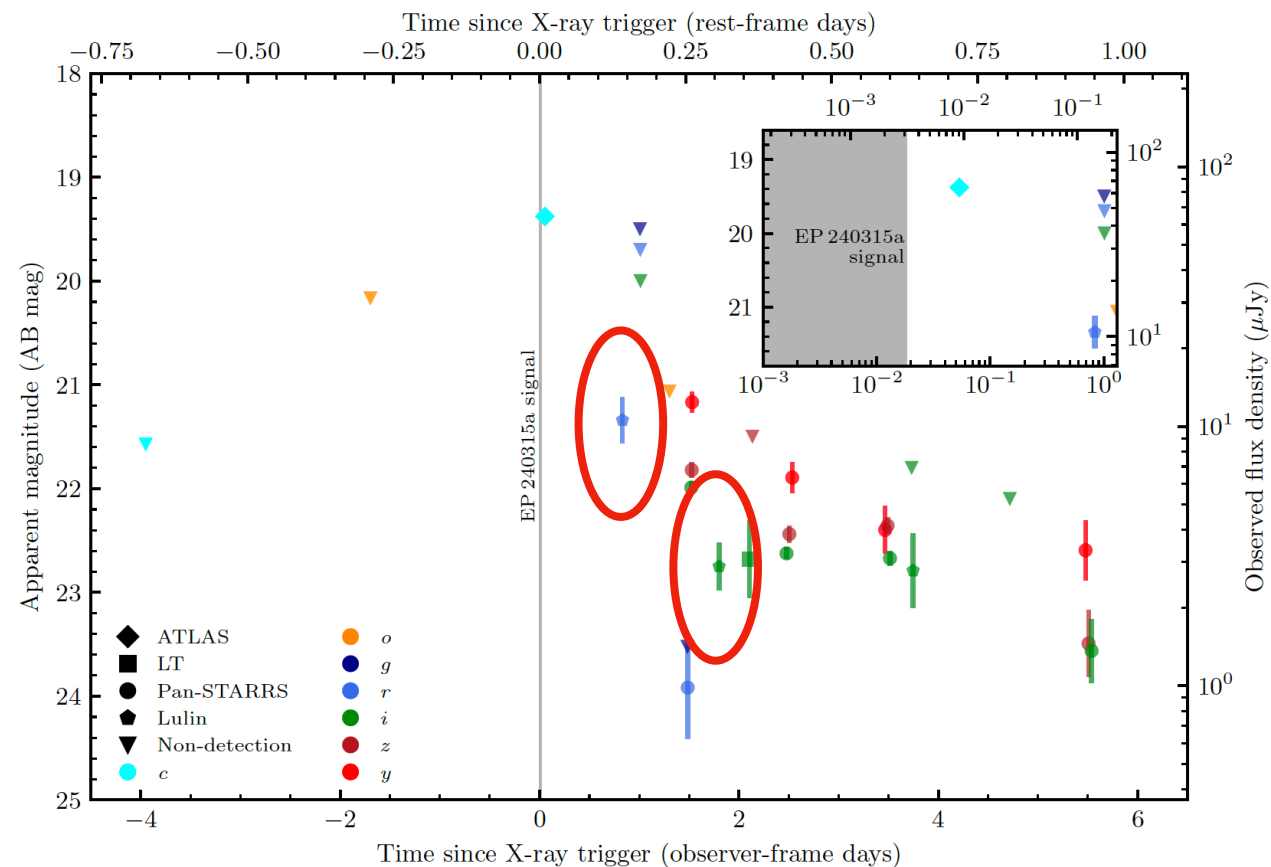
twelve WXT modules surrounding two FXT telescopes

Yuan et al. 2022

Kinder optical counterpart search for Einstein Probe X-ray transients

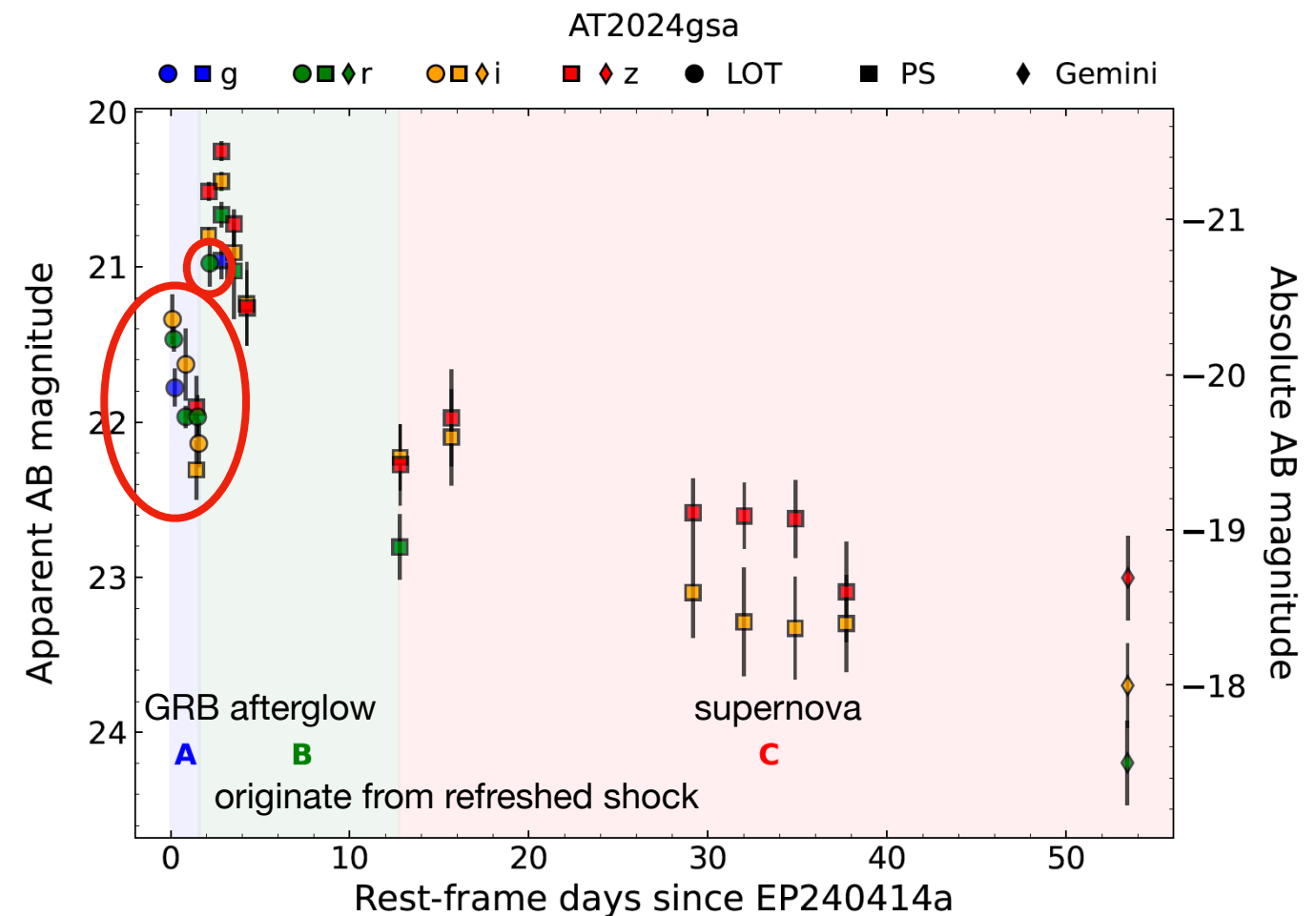
EP240315a

(Gillanders et al., 2024, ApJL)



EP240414a

(Srivastav & Chen & Gillanders et al.
ApJL, 2025.)



Kinder optical counterpart search for Einstein Probe X-ray transients

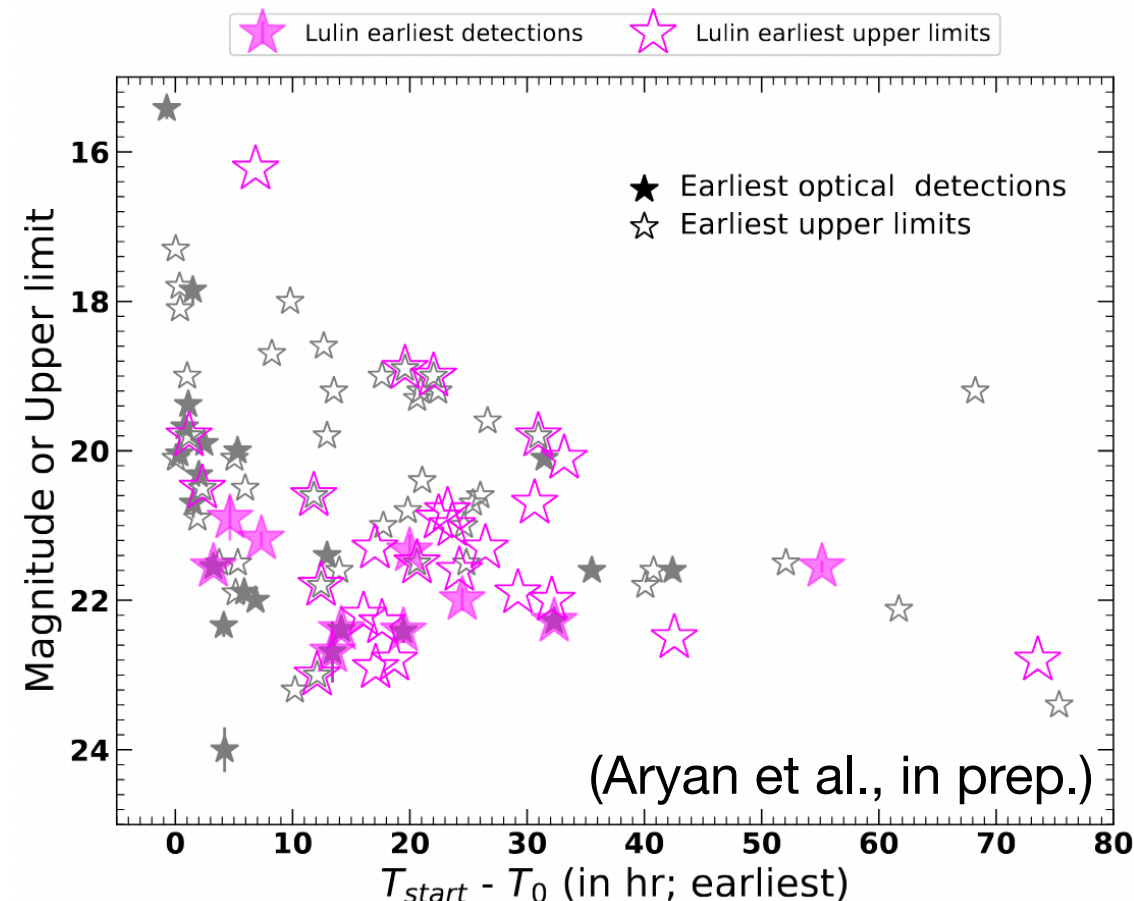
EP - Lulin sample
(Aryan et al., in prep.)



Amar Aryan

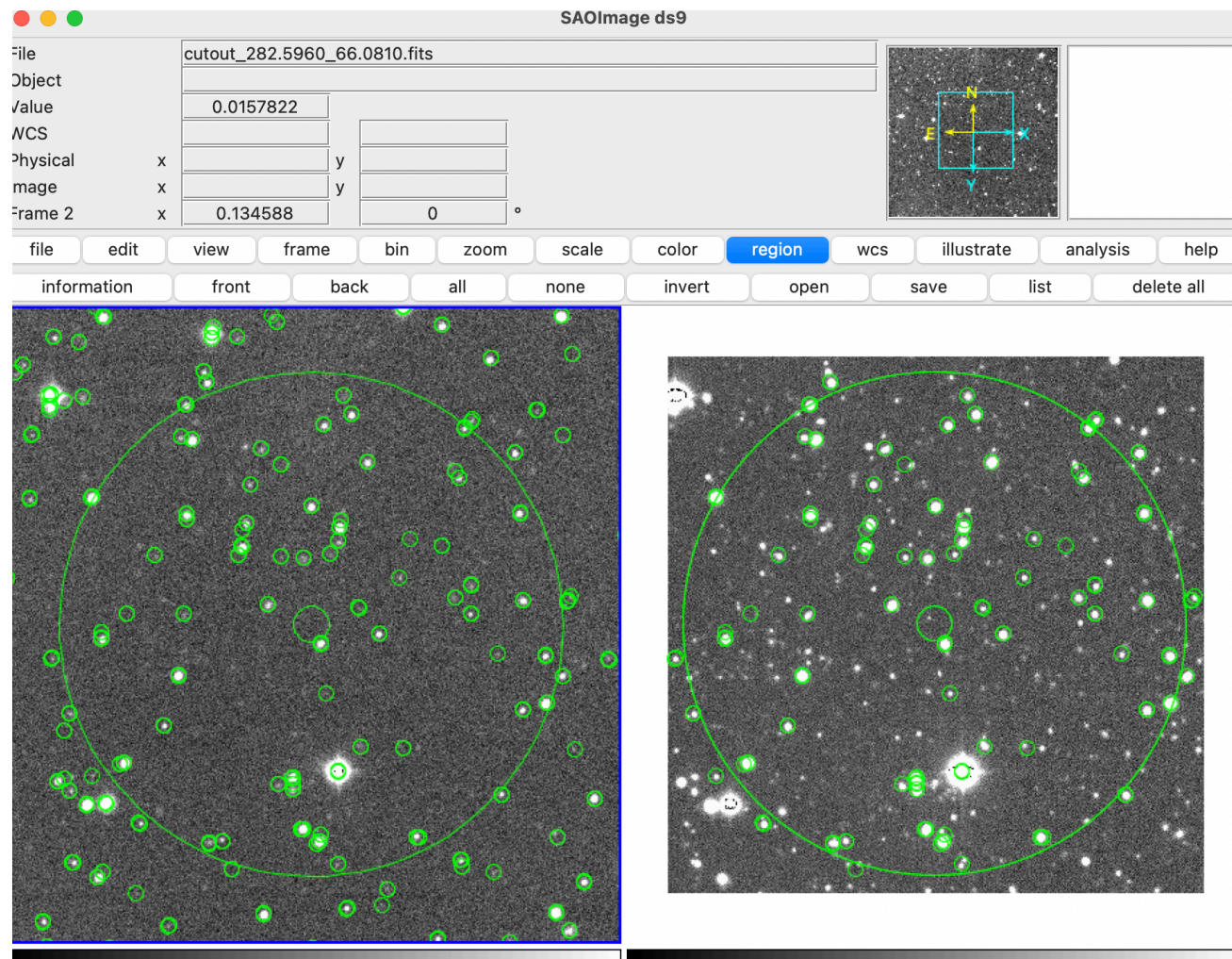
Lulin follow-up:

- 42 in total
 - 12 optical detections, among them we discovered 5 optical counterparts!
 - 30 upper limits
- Optical counterparts are generally faint, typically below 20 mag and fade rapidly.
- Most EP FXTs may be linked to GRBs or jetted TDEs.



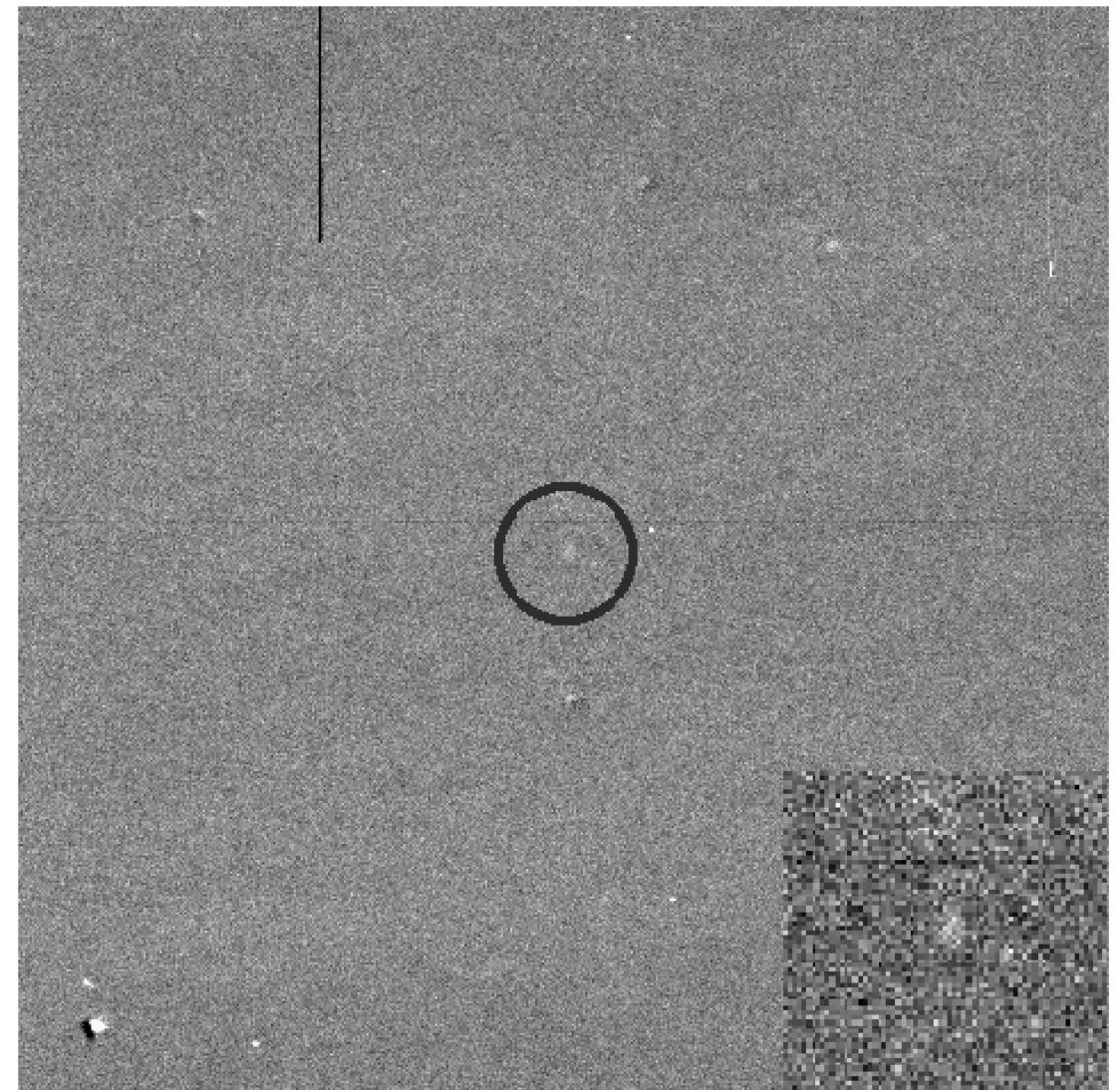
Kinder optical counterpart search for Einstein Probe X-ray transients

method I: catalogue match



Left:- LOT image Right:- DESI LS template

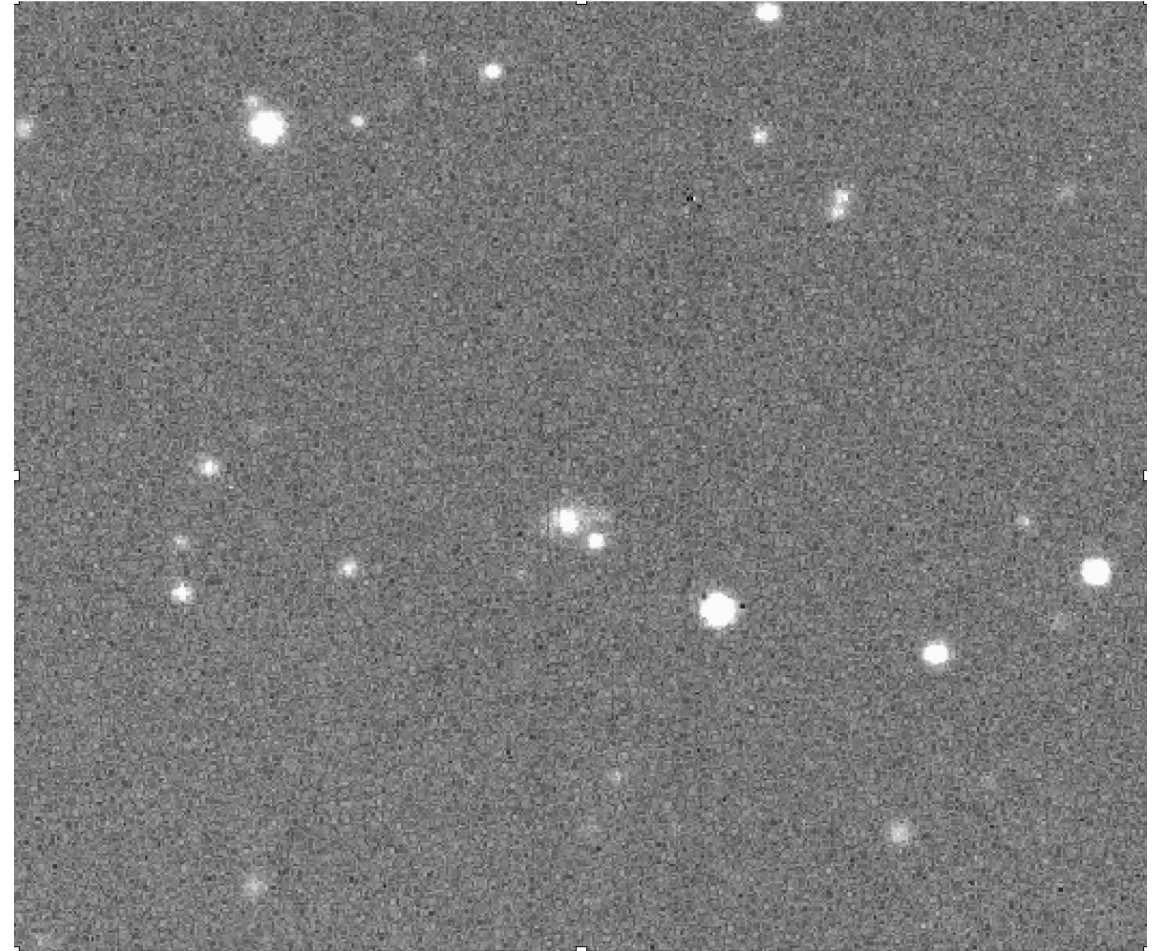
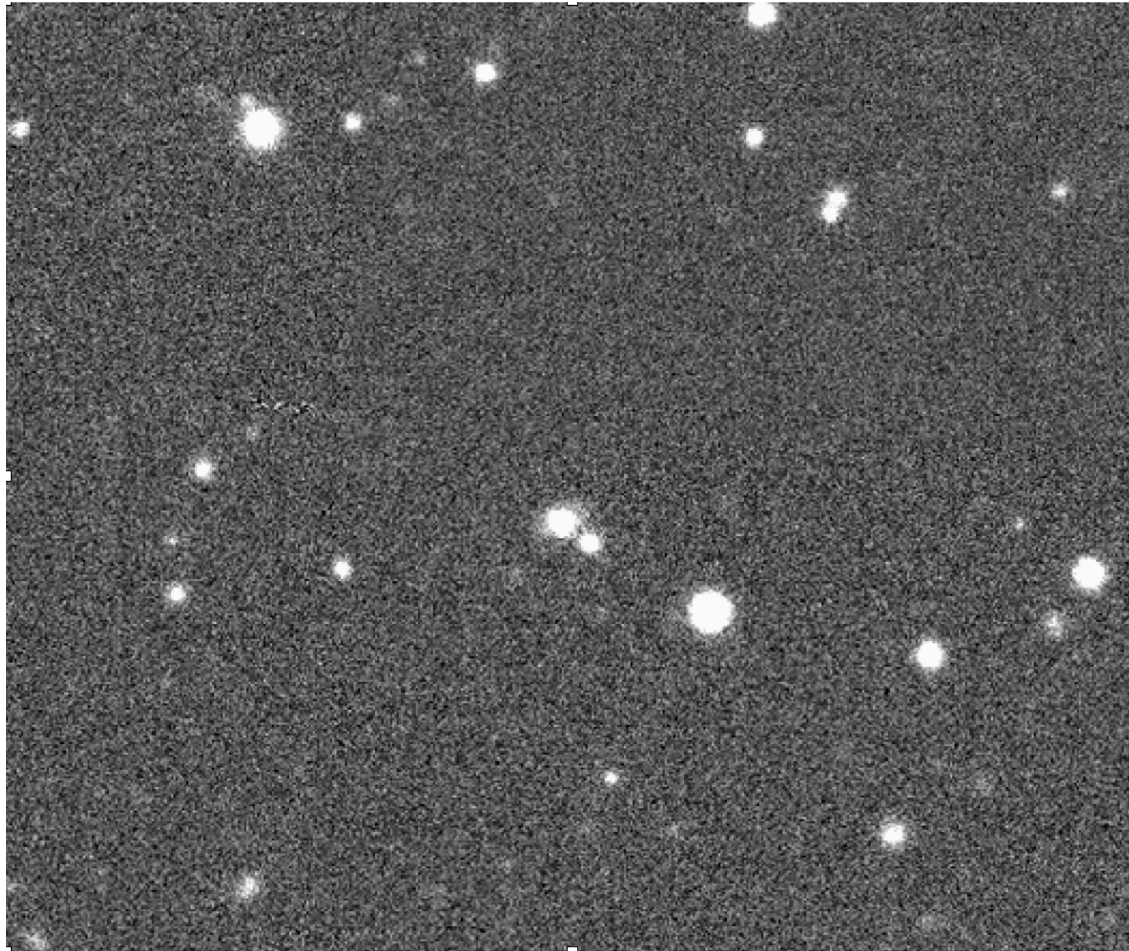
method II: template subtraction



Kinder pipeline

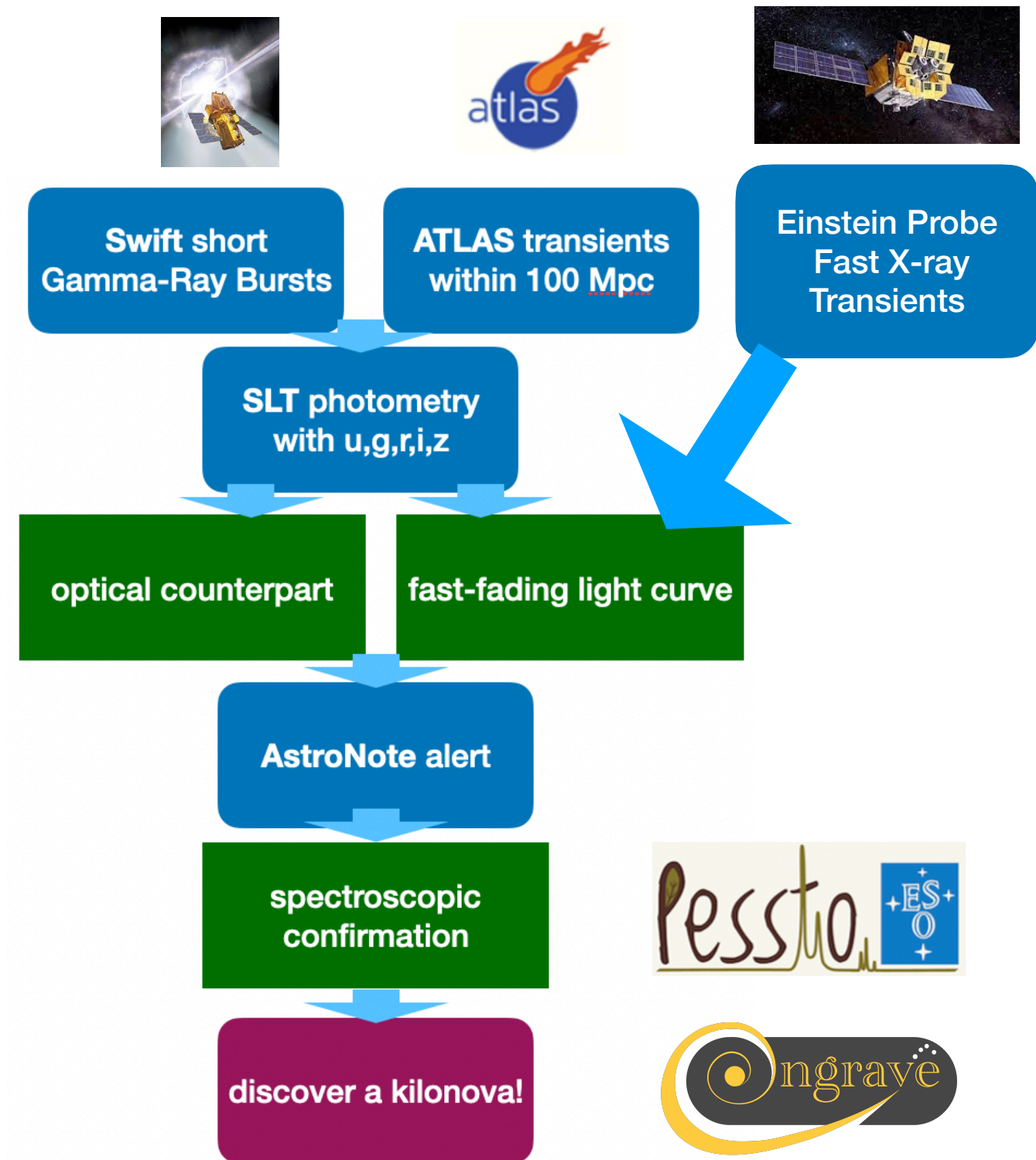
Kinder optical counterpart search for Einstein Probe X-ray transients

method III:
by eye!



Kinder (kilonova finder) project

The story of SN 2024ggi



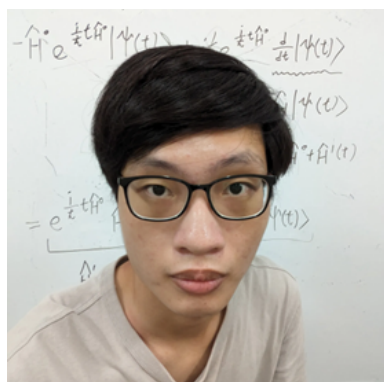
SN 2024ggi

Discovery and Extensive Follow-Up of SN 2024ggi, a nearby type IIP supernova in NGC 3621

TING-WAN CHEN (陳婷琬) ¹ SHENG YANG (杨圣) ² SHUBHAM SRIVASTAV ³ TAKASHI J. MORIYA ^{4, 5, 6}
STEPHEN J. SMARTT ^{3, 7} SOFIA REST ⁸ ARMIN REST,^{9, 10} Hsing Wen Lin (林省文) ¹¹ HAO-YU MIAO (繆皓宇) ¹
YU-CHI CHENG (鄭宇棋) ^{12, 13} AMAR ARYAN ¹ CHIA-YU CHENG (鄭家羽),¹ MORGAN FRASER ¹⁴
LI-CHING HUANG (黃立晴) ^{12, 13} MENG-HAN LEE (李孟翰),¹ CHENG-HAN LAI (賴政翰),¹ YU-HSUAN LIU (劉宇軒) ^{1, 15}
AISWARYA SANKAR.K,¹ KEN W. SMITH ⁷ HELOISE F. STEVANCE ^{3, 7} ZE-NING WANG (王澤寧),^{2, 16}
JOSEPH P. ANDERSON ^{17, 18} CHARLOTTE R. ANGUS ¹⁹ THOMAS DE BOER,²⁰ KENNETH CHAMBERS,²⁰
HAO-YUAN DUAN (段皓元) ²¹ NICOLAS ERASMUS ²² MICHAEL FULTON ¹⁹ HUA GAO ²⁰ JOANNA HERMAN,²⁰
WEI-JIE HOU (侯偉傑),¹ HSIANG-YAO HSIAO (蕭翔耀),¹ MARK E. HUBER ²⁰ CHIEN-CHENG LIN (林建爭) ²⁰
HUNG-CHIN LIN (林宏欽),¹ EUGENE A. MAGNIER,²⁰ KA KIT MAN (文家傑) ²³ THOMAS MOORE ^{19, 24}
CHOW-CHOONG NGEOW (饒兆聰) ¹ MATT NICHOLL ¹⁹ PO-SHENG OU (歐柏昇) ^{25, 15} GIULIANO PIGNATA,^{26, 18}
YU-CHIEN SHIAU (蕭聿謙),²⁷ JULIAN SILVESTER SOMMER ²⁸ JOHN L. TONRY ²⁰ XIAO-FENG WANG (王晓峰) ^{29, 30}
RICHARD WAINSCOT,²⁰ DAVID R. YOUNG ¹⁹ YOU-TING YEH (葉祐廷),³¹ AND JUJIA ZHANG (张居甲) ^{32, 33}



Cheng-Han Lai



Meng-Han Lee



Alex Yu-Hsing Lee

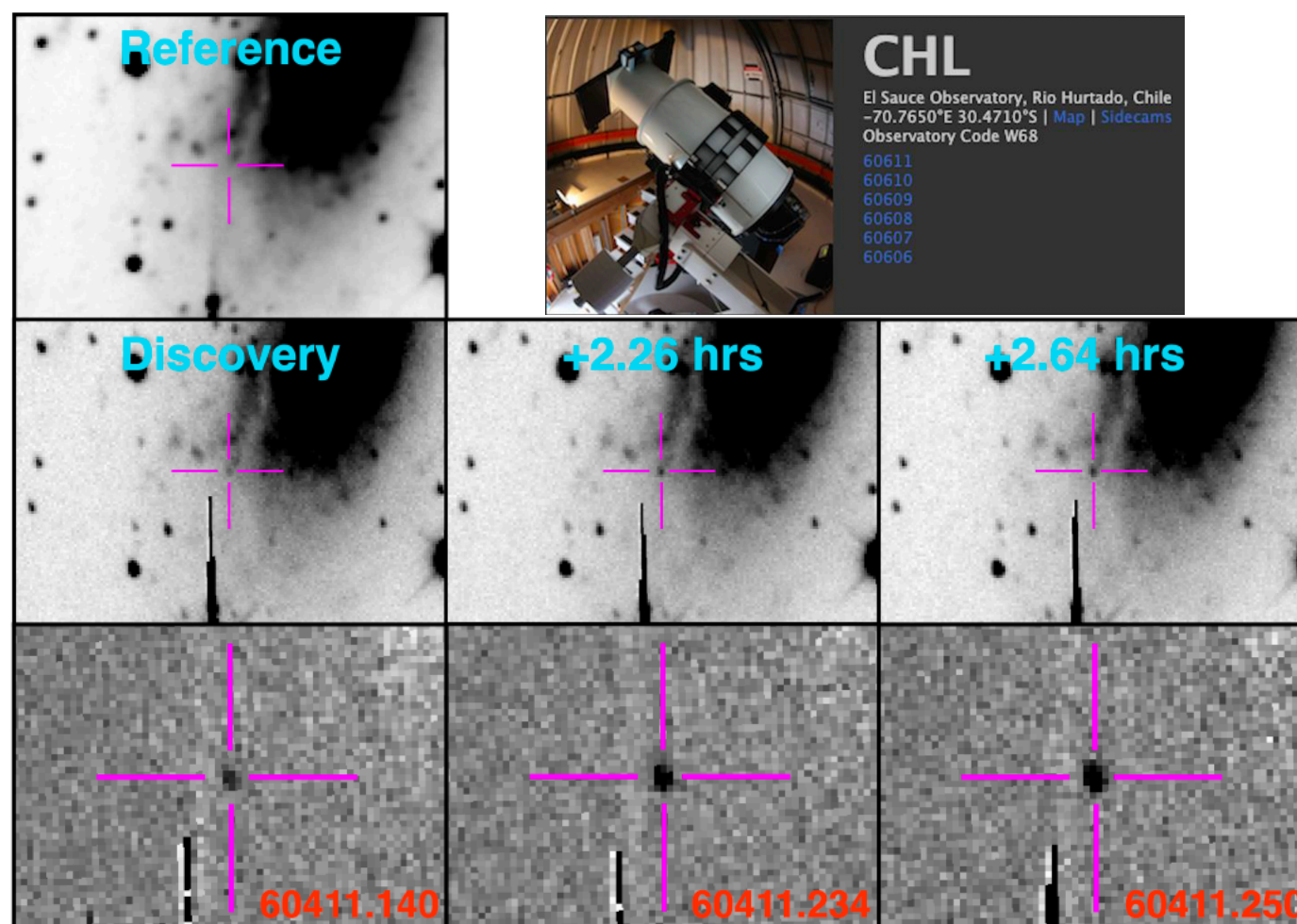
accepted in ApJ; arXiv:2406.09270

SN 2024ggi

Host galaxy NGC 3621
at 6.64 $\pm$ 0.3 Mpc

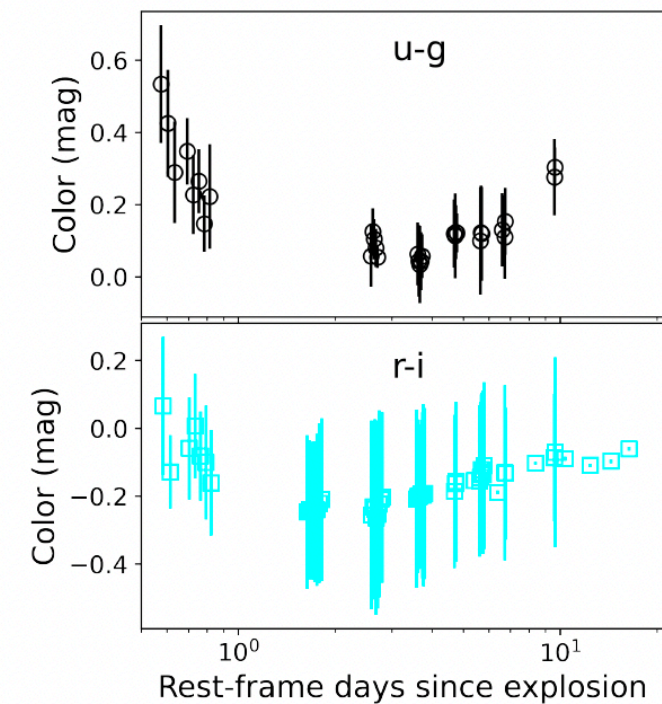
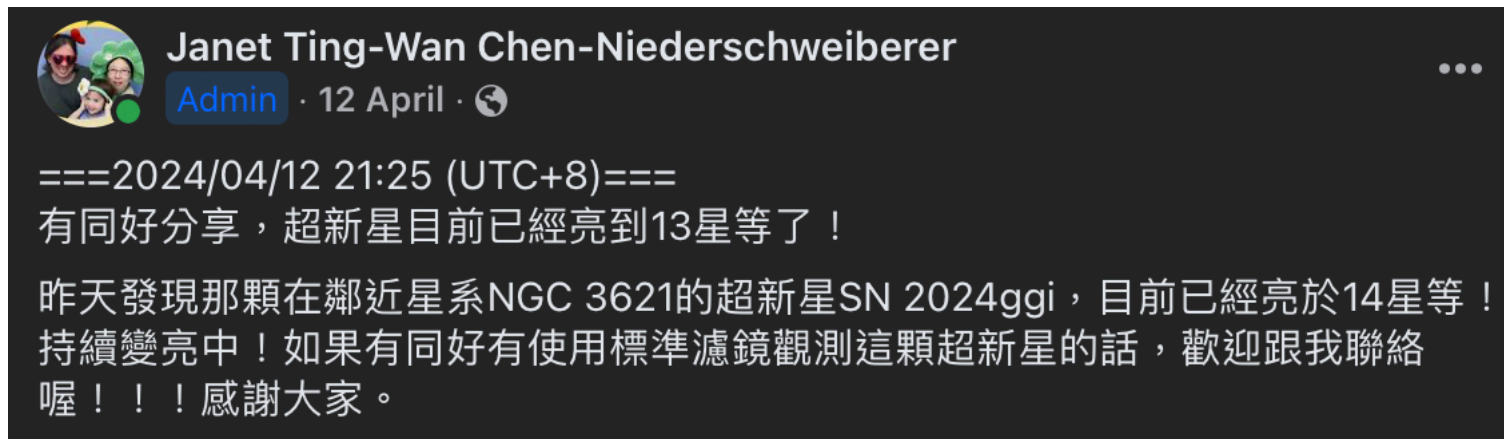


The SN was caught 5.8 (+1.9-2.9) hours
after its explosion by the ATLAS survey!



a rapid intra-night rise of 1.03 mag
over a span of 2.64 hours

Participation of citizen scientists



acknowledgments



- EQMOD ASCOM HEQ5/6: **13cm**
- iTelescope 33: **32cm**
- Taipei Astronomical Museum/
RC12: **30cm**
- Checheng Elementary School/
Planewave CDK17: **43cm**

Citizen scientists are coauthors
in the paper!

Participation of citizen scientists

AstroNote 2023-175

AstroNotes

Stats

2023-06-16 12:02:30 Type: Object/s-Discovery/Classification Bibcode: [2023TNSAN.175....1C](#)

Early-time follow-up observations of SN 2023ixf from Taiwan

Authors: Ting-Wan Chen (TUM/MPA), Sheng Yang (HNAS), Hsing-Wen Lin (UMich), Chia-Ming Chang, Yen-Hsing Lin, Shih-Ping Lai (all NTHU), Hsiang-Yao Hsiao (IANCU), Wen-Li Kuo, Chu-Yuan Lee, Meng-Chen Lin, Shih-Chao Lin (both SHCH), Yu-Chien Shiao, Winson Tsai (Nick-Winson Observatory), Pai-Ling Wang, Yu-Chi Cheng (NTNU), Chow-Choong Ngeow, Yen-Chen Pan, Chi-Sheng Lin, Wei-Jie Hou, Hung-Chin Lin, Jhen-Kuei Guo (all IANCU)

Source Group: [Kinder](#)

Keywords: [Transient](#)

Abstract: We present the early-phase photometry of SN 2023ixf based on images obtained from amateur astronomers and school observatories in Taiwan. Our collected light curve, spanning from 2023-05-20 to 2023-05-21, exhibits a clear rising trend of approximately 2 magnitudes for SN 2023ixf.

We have provided the instrument configuration details and the converted PS1 r magnitude of SN 2023ixf in the table below:

Date	Time (UT)	MJD	Converted r mag	Observer(s)	Filter	Telescope	Instrument	Exp (sec)
2023-05-20	13:35	60084.566	13.4 +/- 0.2	Chia-Ming Chang, Yen-Hsing Lin, Shih-Ping Lai	Luminance	SHOWA 250mm F/12 Refractor	ZWO ASI 6200MM Pro	300s
2023-05-20	14:35	60084.608	-	Pai-Ling Wang	open	escape eQuinox	Galaxy A30s	240s
2023-05-20	14:51	60084.619	13.5 +/- 0.3	Winson Tsai	open	Epsilon-180ED F/2.8	Player One Poseidon-M Pro	120s
2023-05-20	14:58	60084.624	13 +/- 1	Chu-Yuan Lee	open	EQMod Mount	ZWO ASI 533MC Pro	600s
2023-05-20	16:38	60084.693	13 +/- 1	Wen-Li Kuo	STC Astro Multispectra	Zenithstar 81 APO	ZWO ASI 2600MC Pro	300s
2023-05-21	04:10	60085.174	12.8 +/- 0.2	Yu-Chien Shiao	Red	iTelescope T11 Planewave CDK 510mm	FLI ProLine PL11002M	180s
2023-05-21	13:19	60085.555	11.8 +/- 0.3	Hsiang-Yao Hsiao (Kinder; AstroNote #2021-92, Chen et al.)	r	Lulin 40cm SLT	Andor SDK2	60s
2023-05-21	14:01	60085.584	11.5 +/- 0.3	Meng-Chen Lin, Shih-Chao Lin	open	Takahashi Mewlon-250	ZWO ASI533MM Pro	180s
2023-05-21	15:08	60085.631	11.8+/-0.4	Winson Tsai	open	Epsilon-180ED F/2.8	Player One Poseidon-M Pro	180s

the EQMOD system:

Work with citizen scientists for SN 2023ixf

the iTelescope 33 system:

des are not exactly the same, they are mostly consist with 700nm, and the *RGB* filters roughly equally divide the image images were reduced under the standard CCD reduction and flat calibration. After removing the instrument photometry zeropoints against SkyMapper photometry with Gaia star catalogs and SkyMapper source catalogs instruments to SkyMapper photometry system by solving

$$m_{citi} - m_{sm} = C_0 + C_1 (g - r)_{sm},$$

$$m_{citi} - m_{sm} = C_0 + C_1 (g - r)_{sm} + C_2 (g - r)_{sm}^2$$

citizen science images and SkyMapper magnitude, respectively, and C_2 is coefficient of the quadratic term. For the

$$-r_{sm} = -0.20 + 0.63 (g - r)_{sm} - 0.19 (g - r)_{sm}^2, \quad rms = 0.07,$$

$$-r_{sm} = -0.27 + 0.72 (g - r)_{sm}, \quad rms = 0.11$$

$$-g_{sm} = -0.20 + 0.760 (g - r)_{sm}, \quad rms = 0.07$$

$$-i_{sm} = \quad 0.02 - 0.02 (r - i)_{sm}, \quad rms = 0.08,$$

$$L - r_{sm} = -0.13 + 0.38 (g - r)_{sm}, \quad rms = 0.18$$

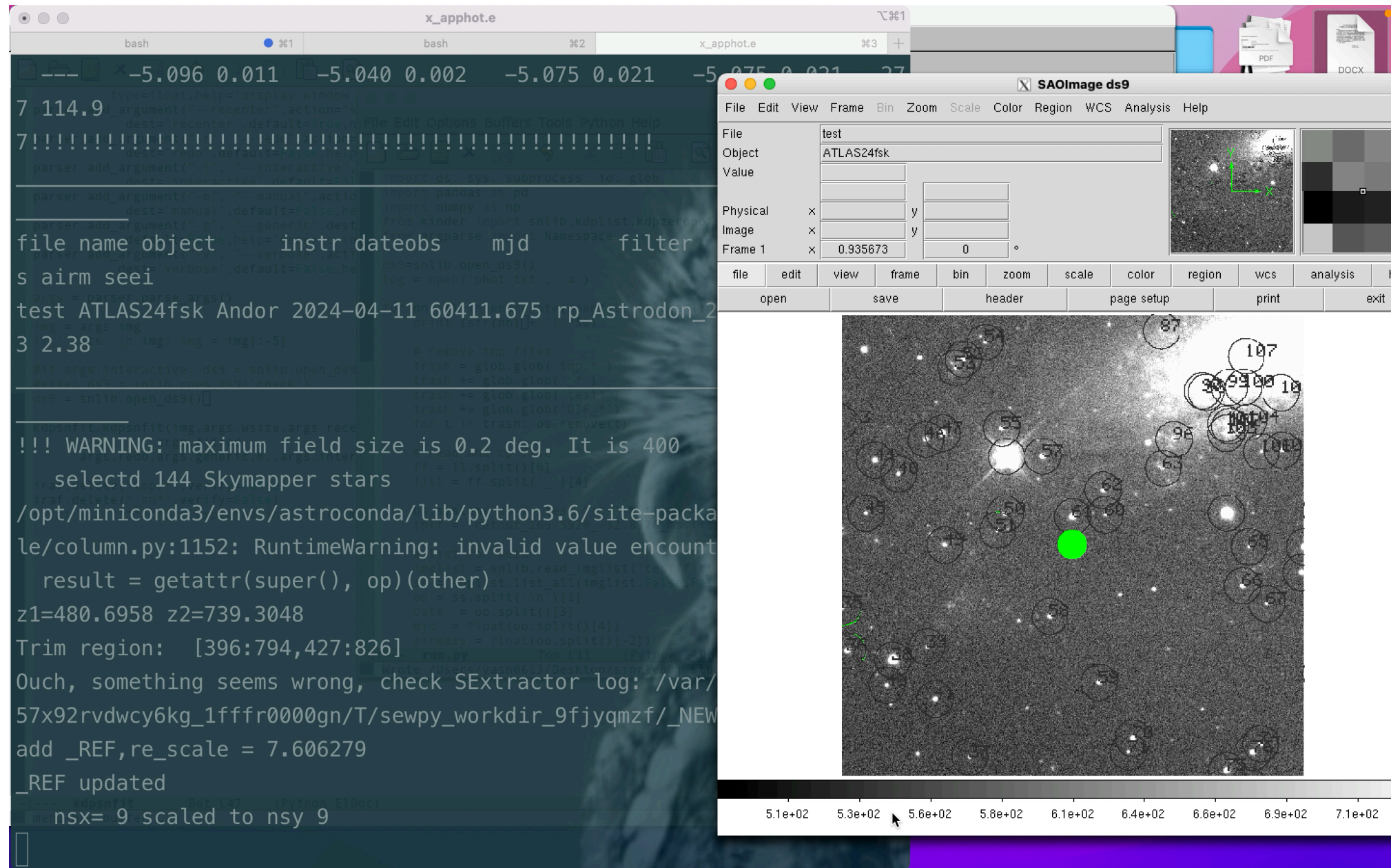
$$R - r_{sm} = \quad 0.07 - 0.17 (g - r)_{sm}, \quad rms = 0.04$$

$$G - r_{sm} = -0.29 + 0.79 (g - r)_{sm}, \quad rms = 0.05$$

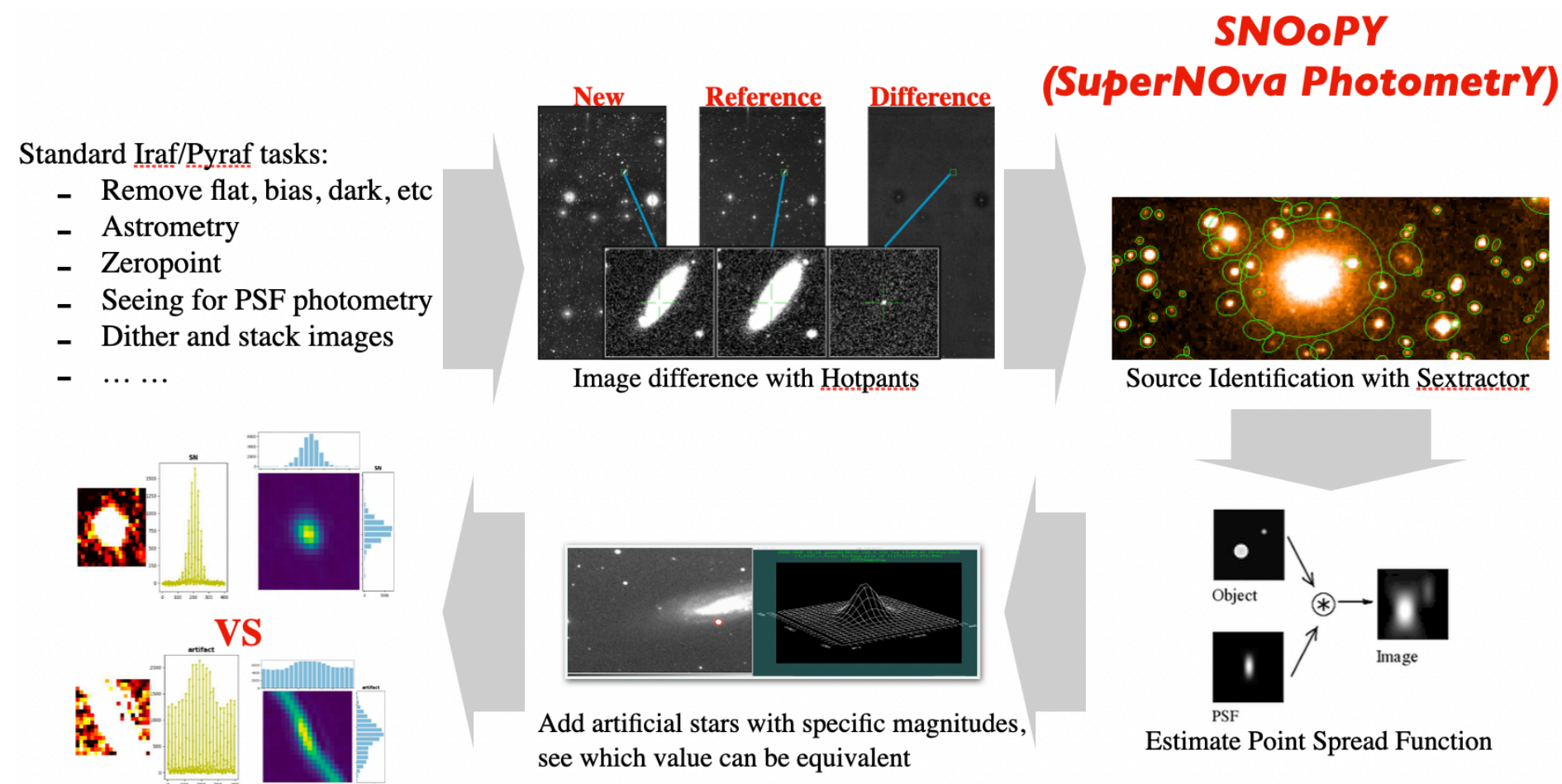
$$B - g_{sm} = -0.25 + 0.72 (g - r)_{sm}, \quad rms = 0.05,$$

Kinder pipeline

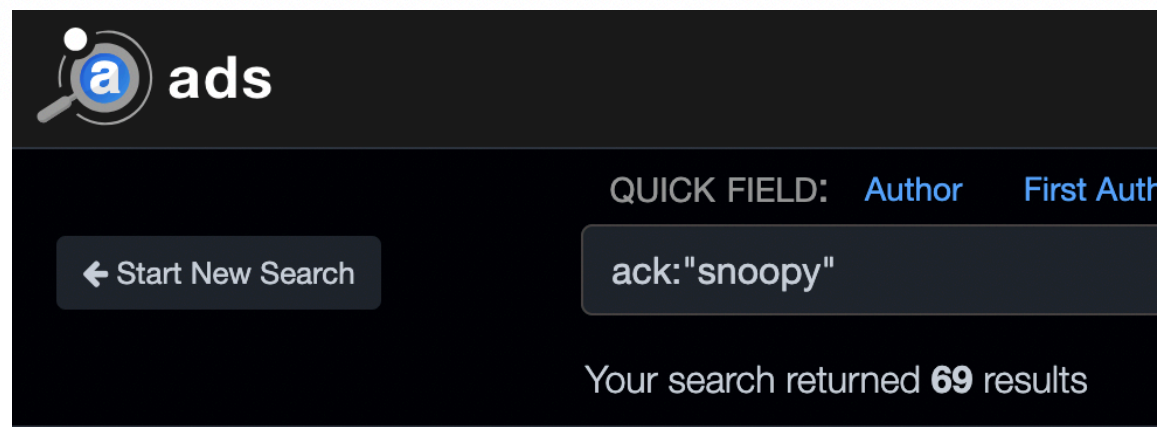
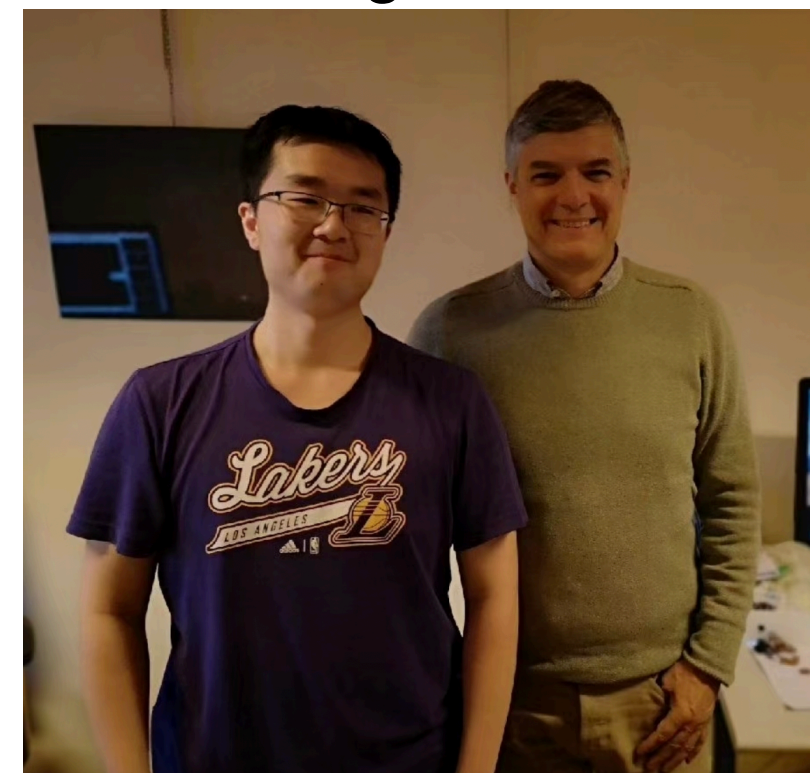
has measuring 1000 data points!



SNOoPY -> Kinder pipeline

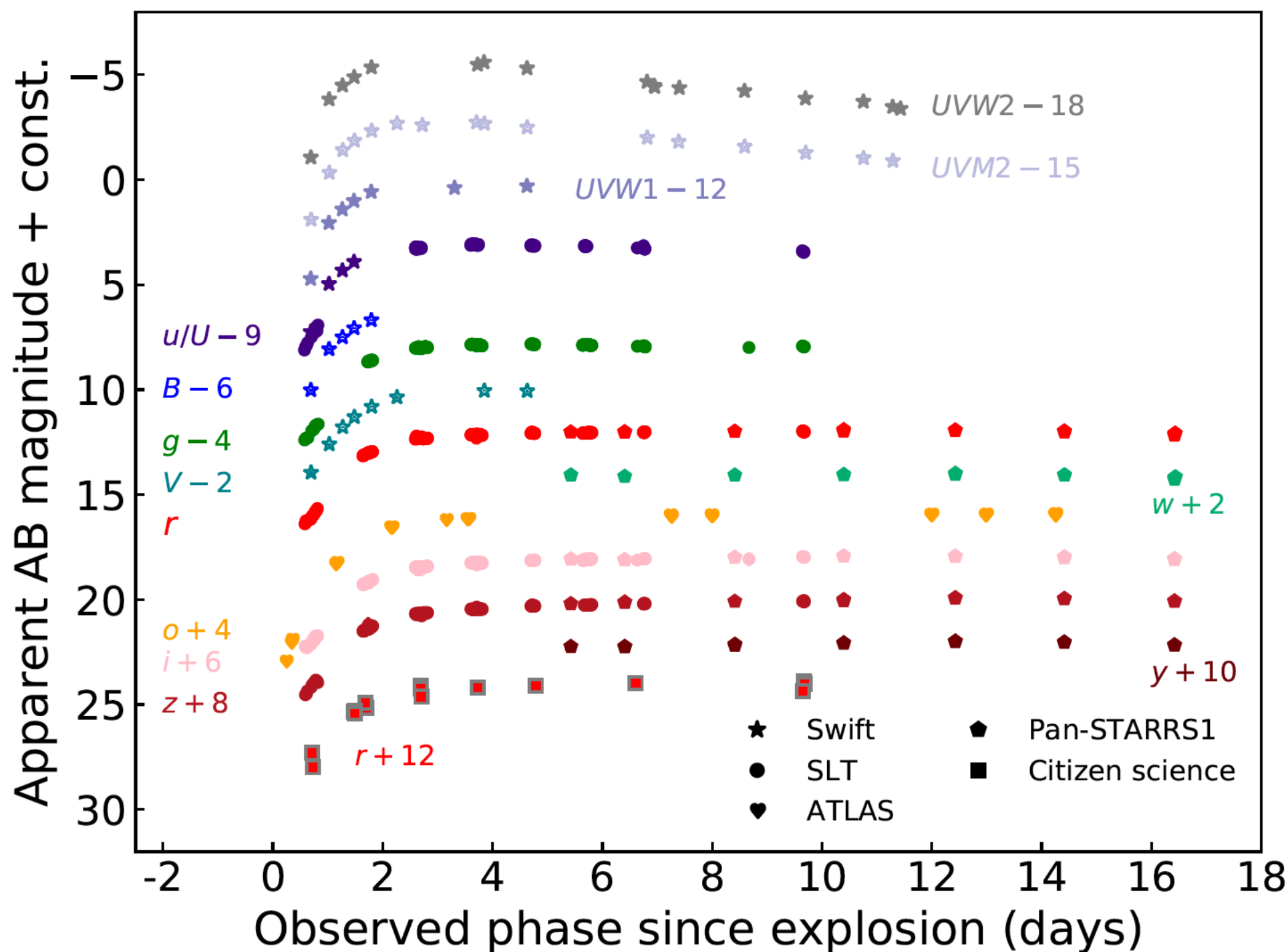


Sheng & Enrico

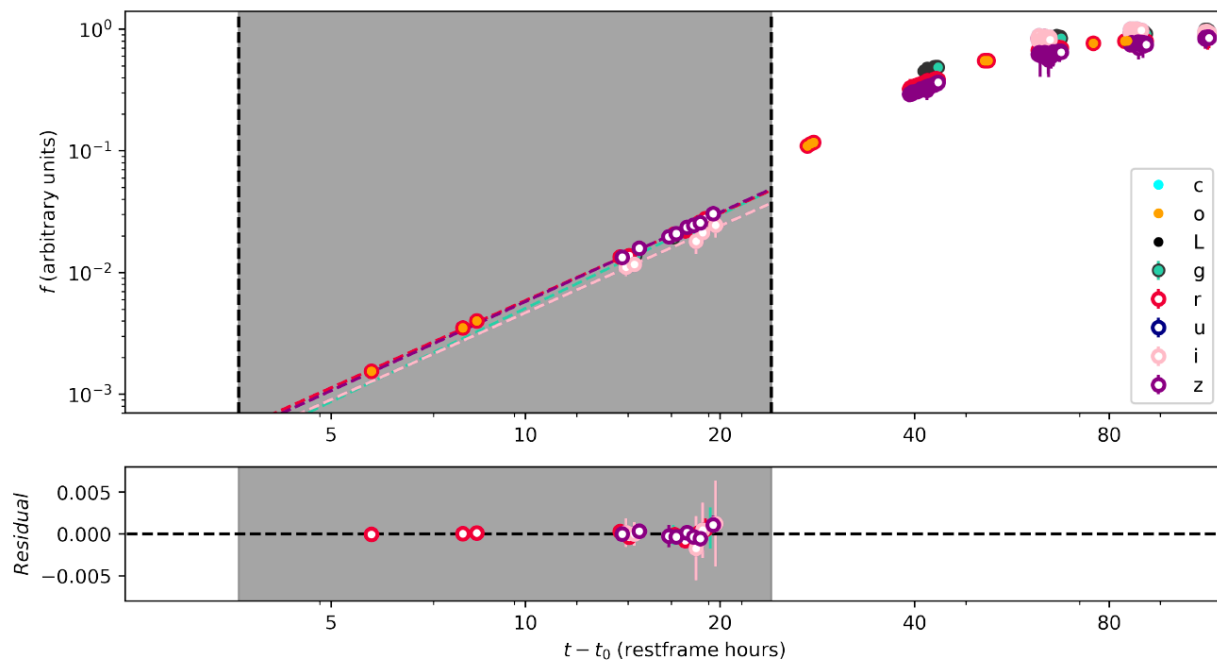


also used in Janet's master thesis (2008)!

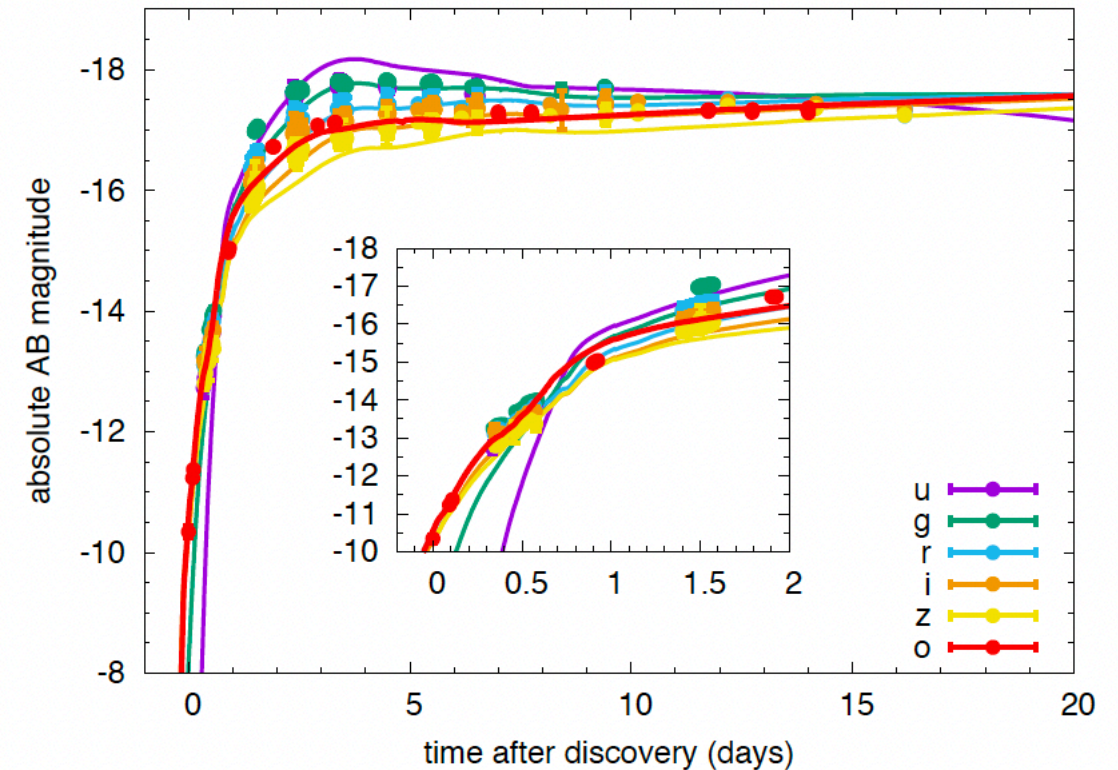
Light curves of SN 2024ggi



Early monitoring is crucial



No significant discrepancies were observed between the data and fits, suggesting an absence of SBO features. While this could result from observational limits, it may also imply the presence of a dense, extended CSM around the RSG based on (u-g) colour.



Based on early-phase light curves, we selected the best matching model from Moriya et al. (2023). This model features an explosion energy of 2×10^{51} erg, a mass-loss rate of $10^{-3} M_{\odot}/\text{yr}$ (assuming a 10 km/s wind), a confined CSM radius of 6×10^{14} cm, $\beta = 4.0$, and a CSM mass of $0.4 M_{\odot}$.

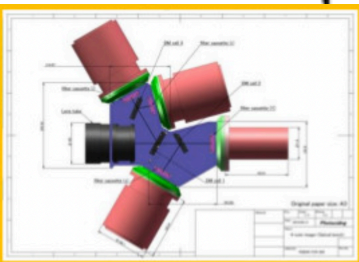
Kinder -> Kindergarten

2-m telescope
@San Pedro Mártir Observatory

UT-6

first light 2024

115° 27' 49" W
31° 02' 39" N



0.4m, 1m telescopes
@Lulin Observatory



UT+8

120° 52' 25" E
23° 28' 07" N

- First instruments:
 - long-slit spectrograph
 - 4-colour imager (r' , i' , z' , y)
- Future instruments:
 - NIR Camera
 - IFU

- Current instruments:
 - imager (UBVRI, $u'g'r'i'z'$, narrow filters)
 - luminous slit-based spectrograph (LISA)
 - TRI-color imaging POLarimeter (TRIPOL)
 - Spectroscope - UVEX

Thank you!

- Thank you, Enrico, Massimo, Laura, and Massimo, for your inspiring contributions to astronomy. Your legacy continues to illuminate our path, and I wish you all a joyful, fulfilling retirement.