

# Progress on Optical/infrared observations for gravitational wave/neutrino sources

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on behalf of the A03 team

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Yoichi Yatsu (Titech), Kotaro Niinuma (Yamaguchi U.), Tomoki Morokuma (CIT)

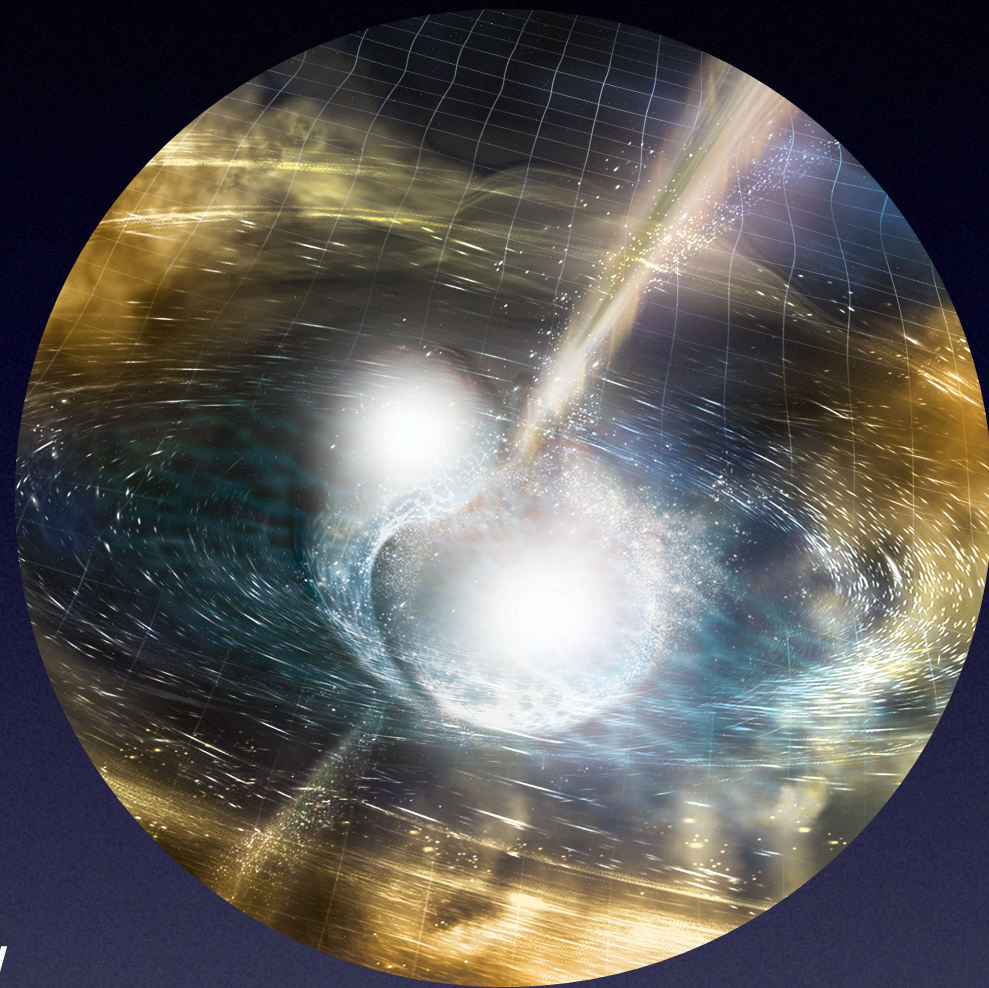


- **Roles of optical/infrared observations**
- **Gravitational wave sources**
- **High-energy neutrino sources**



# Multi-messenger astrophysics: roles of optical/IR observations

## Gravitational wave



(C) NSF/LIGO/  
Sonoma State University/A Simonnet

## High-energy neutrino



(C) IceCube/NASA

### Accurate position

(high angular resolution,  $\sim$  arcsec)

### Accurate redshift

(high spectral resolution,  $\lambda/\Delta\lambda > 1,000$ )

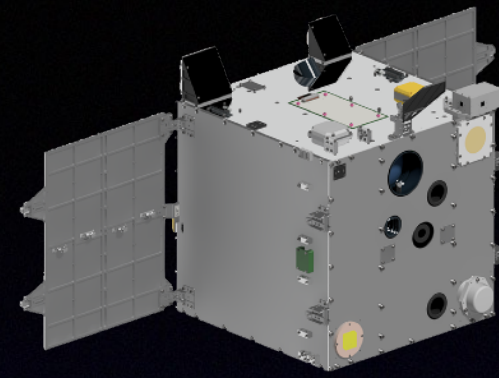
**Nucleosynthesis in  
neutron star mergers**

**Identification of  
high-E neutrino sources**



# A03: Optical/IR/Radio follow-up with multiple facilities

Wide field (HSC)  
Spectroscopy (PFS)

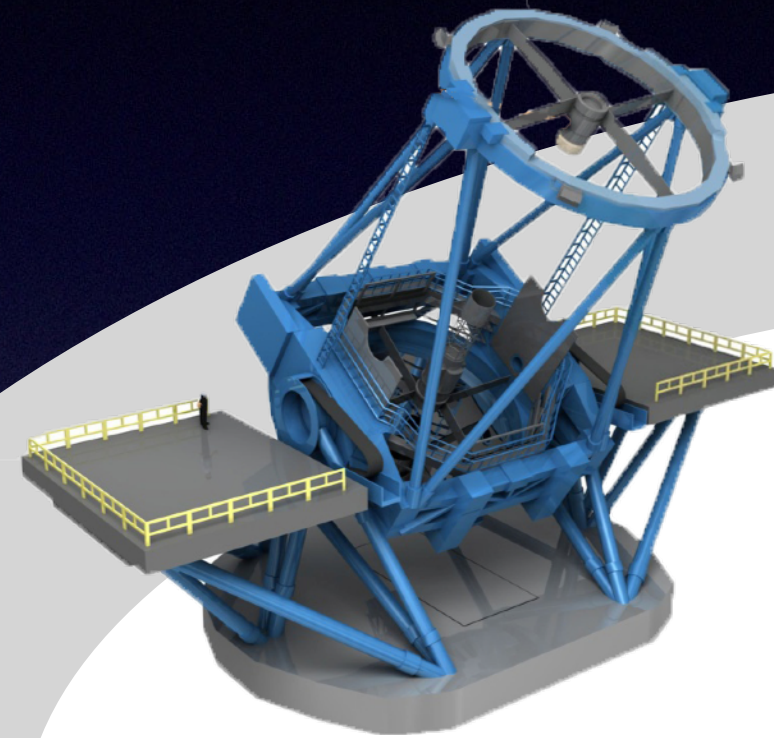
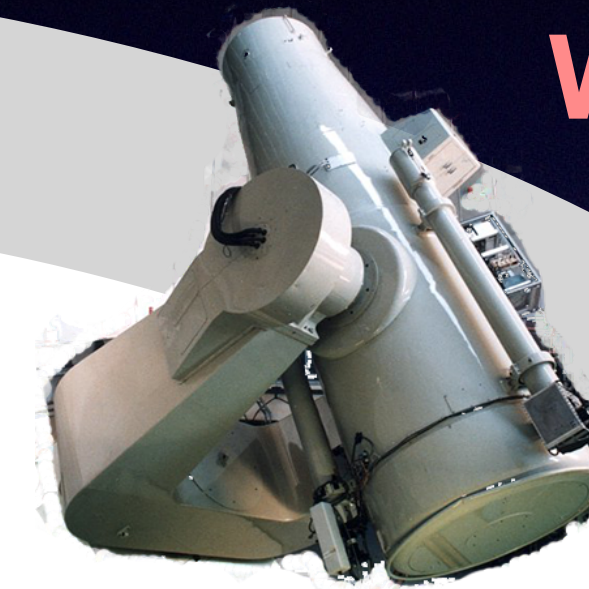


Wide field (UV)

PETREL

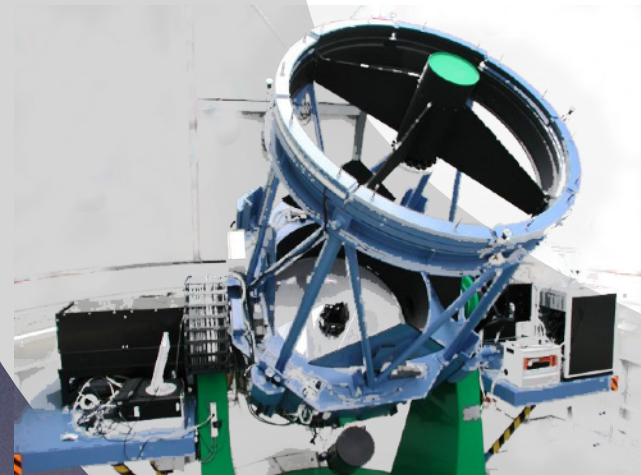
Kiso (1 m)

Wide field

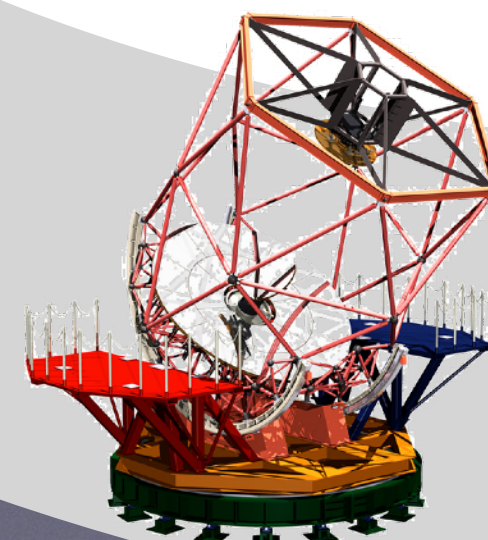


Talk by H. Zhang =>  
Subaru (8.2 m)

Spectroscopy  
/monitoring



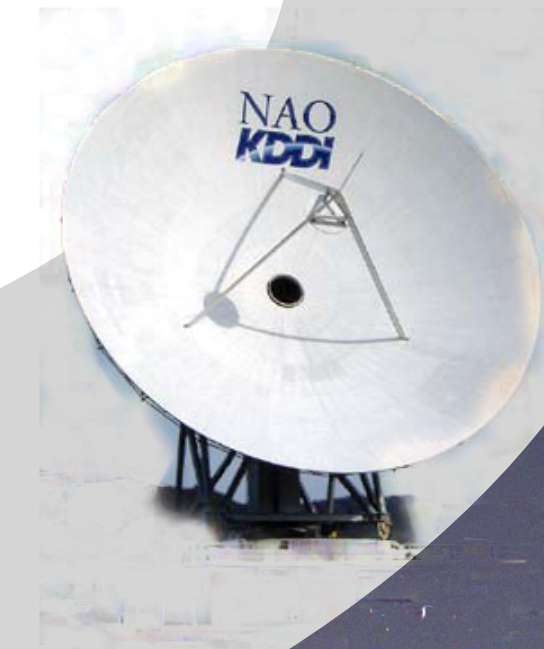
Poster by  
K. Kawabata =>  
Kanata (1.5 m)



Poster by K. Taguchi =>  
Seimei (3.8 m)



TAO (6 m)



EA VLBI

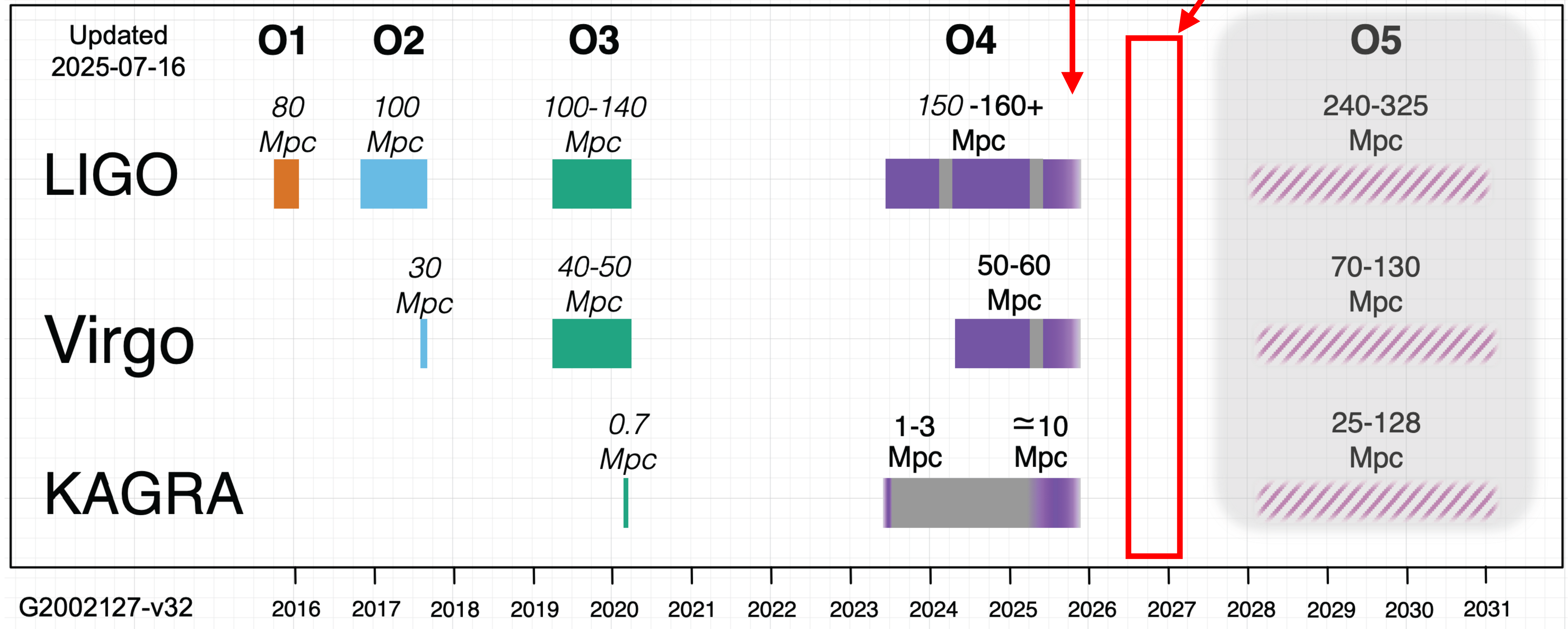
<= Poster by  
K. Matsubayashi  
(new optical instrument,  
2026 Fall)



- Roles of optical/infrared observations
- **Gravitational wave sources**
- High-energy neutrino sources



# Status of GW observations





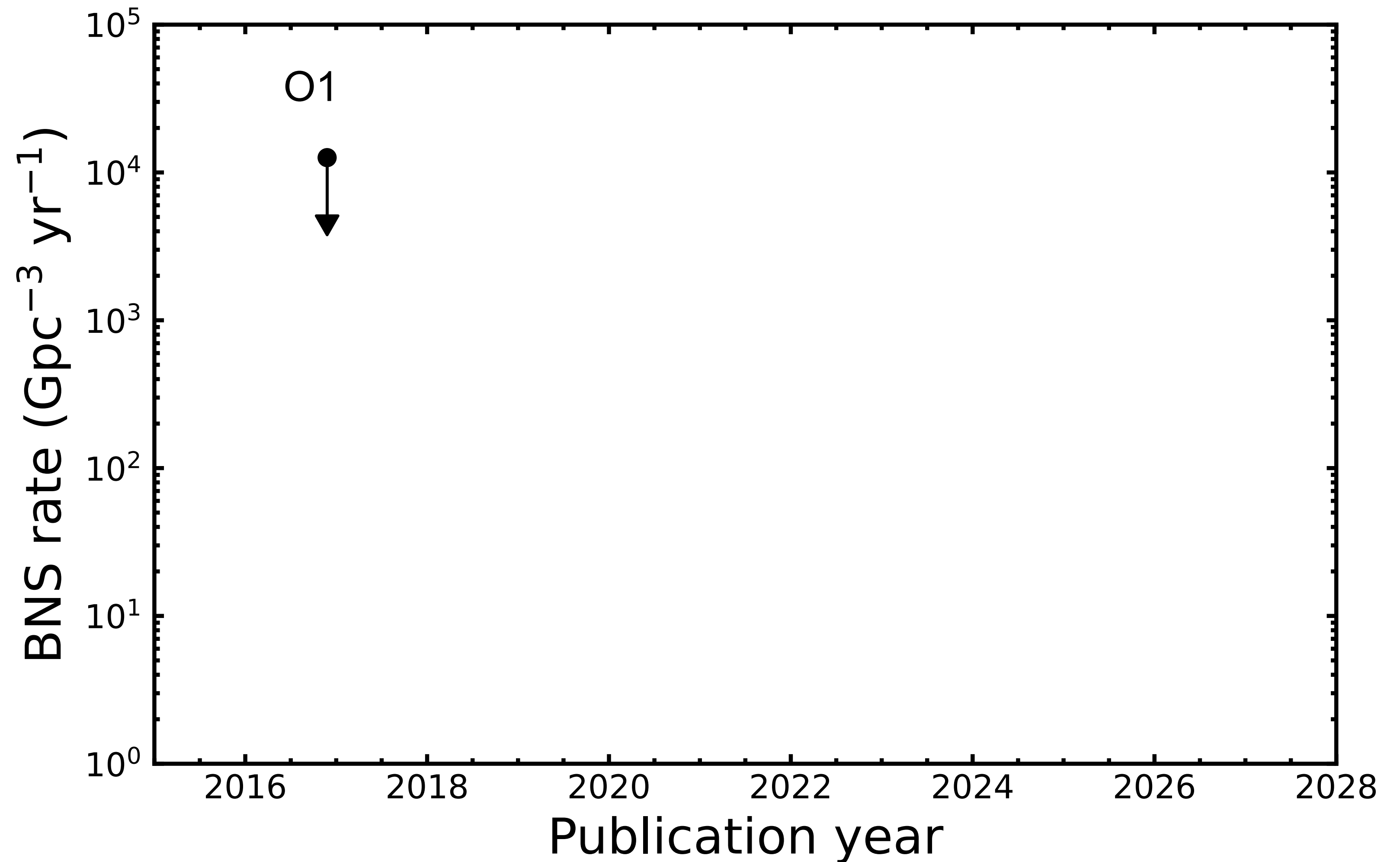
# Event rate of neutron star merger

Number of event  
within 100 Mpc  
(all sky)

~4 events/yr



~0.4 events/yr  
(2-3 events in 10 yr)





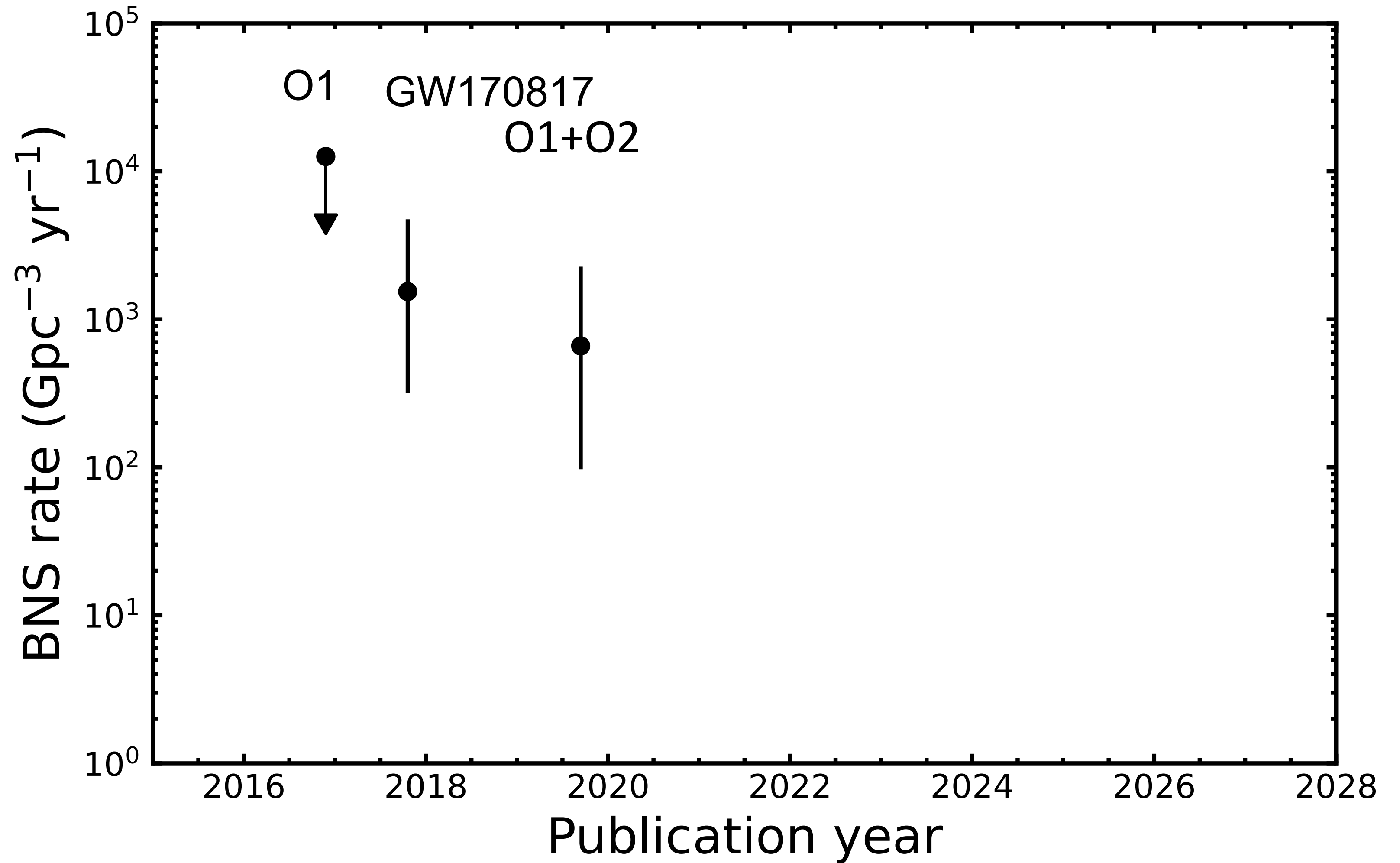
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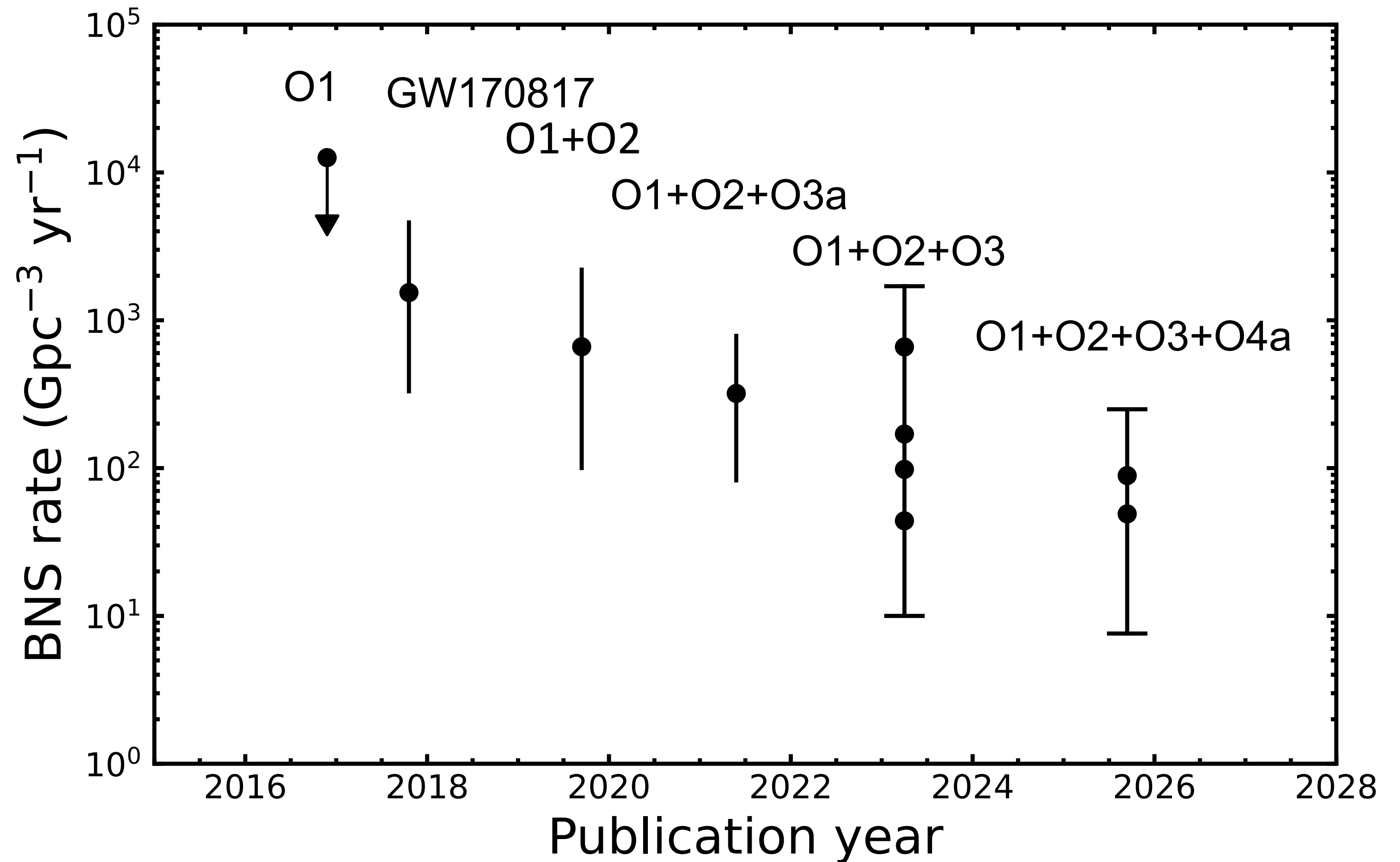
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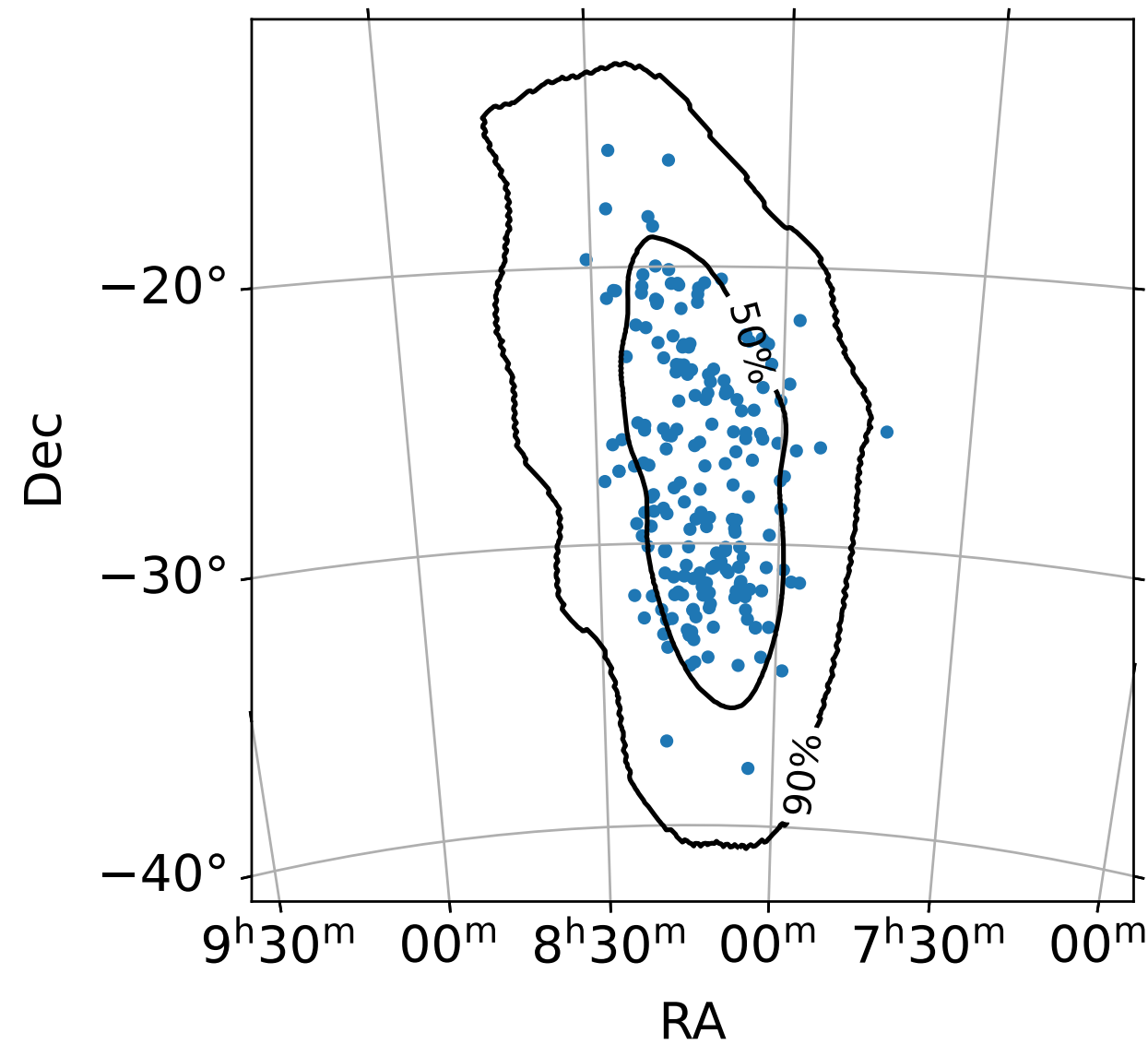




# Several follow-up efforts

**S240422ed**

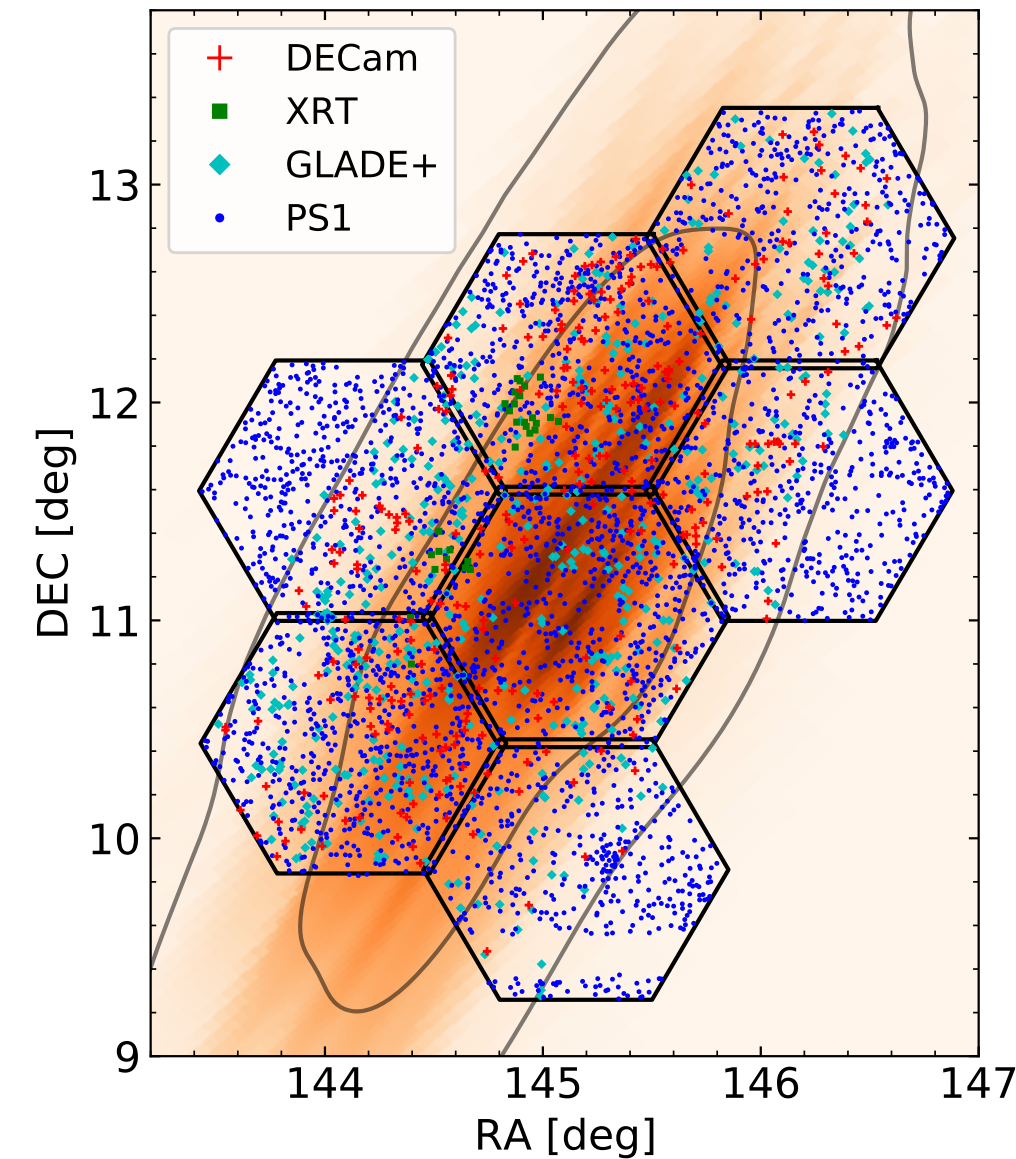
(BH-NS merger => terrestrial)



IR follow-up with  
Subaru/MOIRCS  
(Takahashi+25, PASJ)

**S250328ae**

(well localized BH-BH merger)



First follow-up with  
Subaru/PFS  
(Zhang+25, submitted to ApJ)

**see H. Zhang's talk**

**S251112cm**

(Sub-solar mass event?)



>100 galaxies with Seimei,  
Kanata, MiTSuME, and SaCRA  
(~90 Mpc, 370 deg<sup>2</sup>)

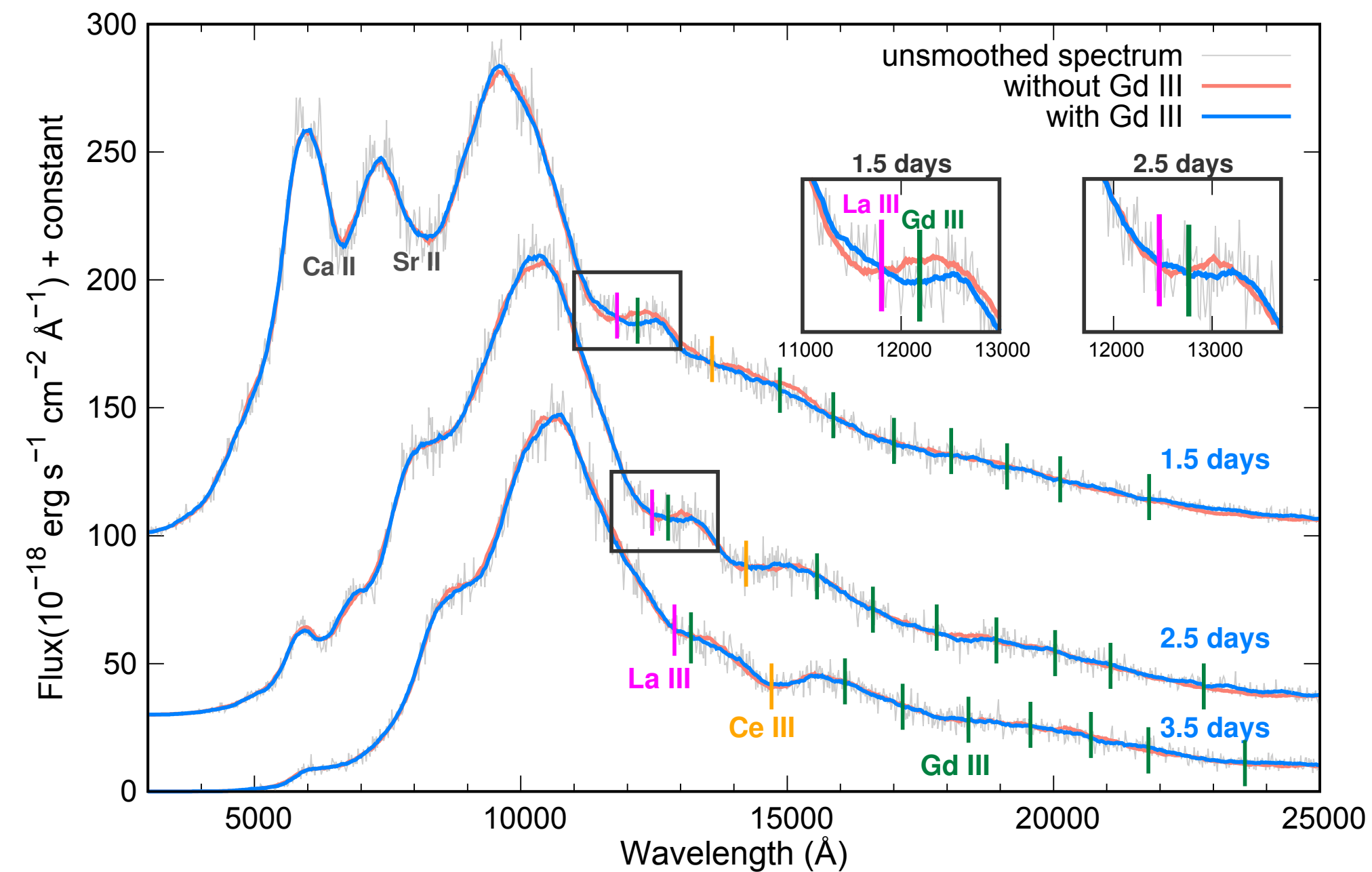
**Taguchi+25, GCN 42725  
(yesterday)**



# Heavy element nucleosynthesis: element identifications => abundance estimate

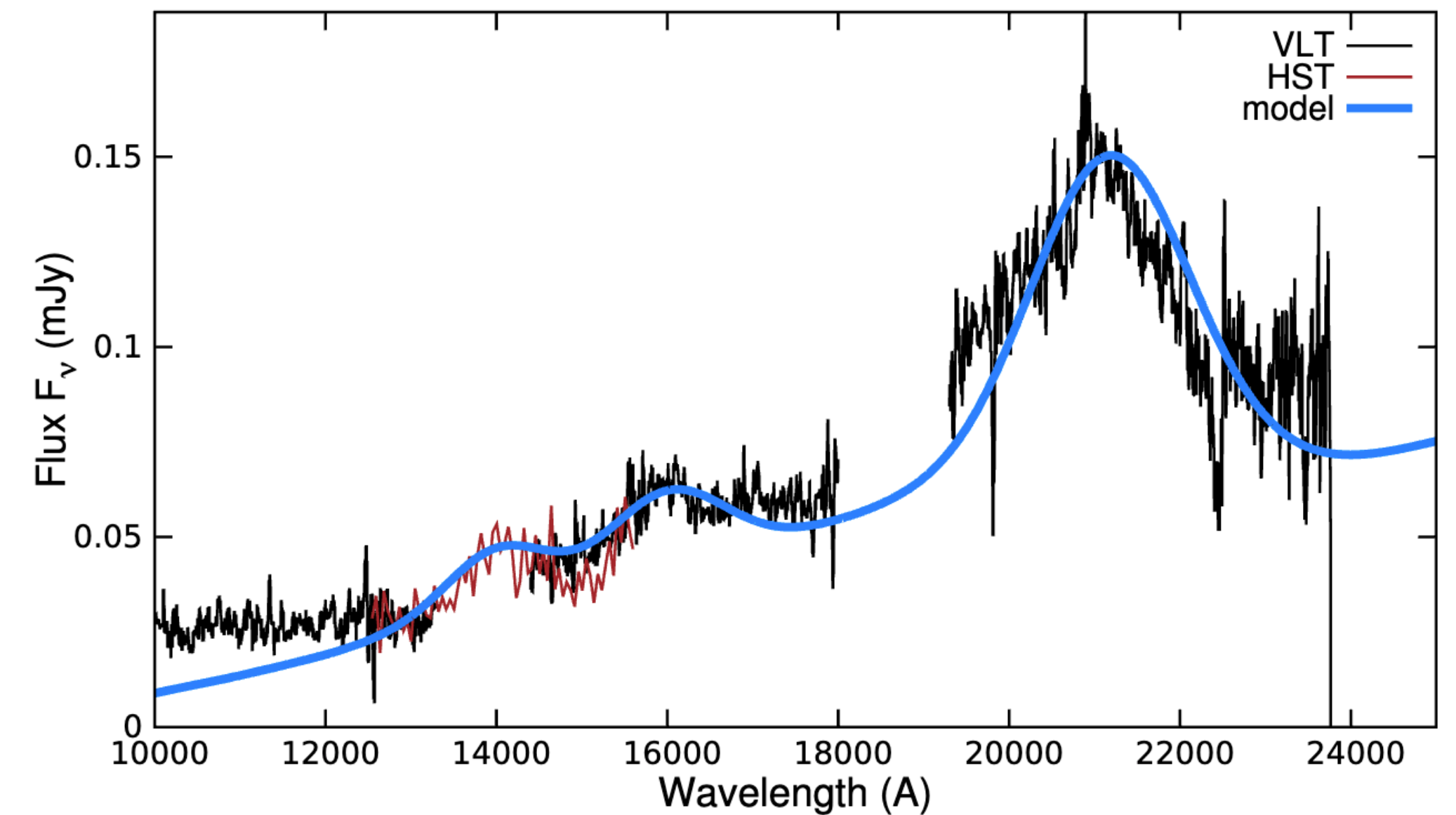
Collaboration with C02 (Kenta Hotokezaka)

## Early phase spectra



Rahmouni+2025, ApJ

## Late phase spectra



Rahmouni+ in prep

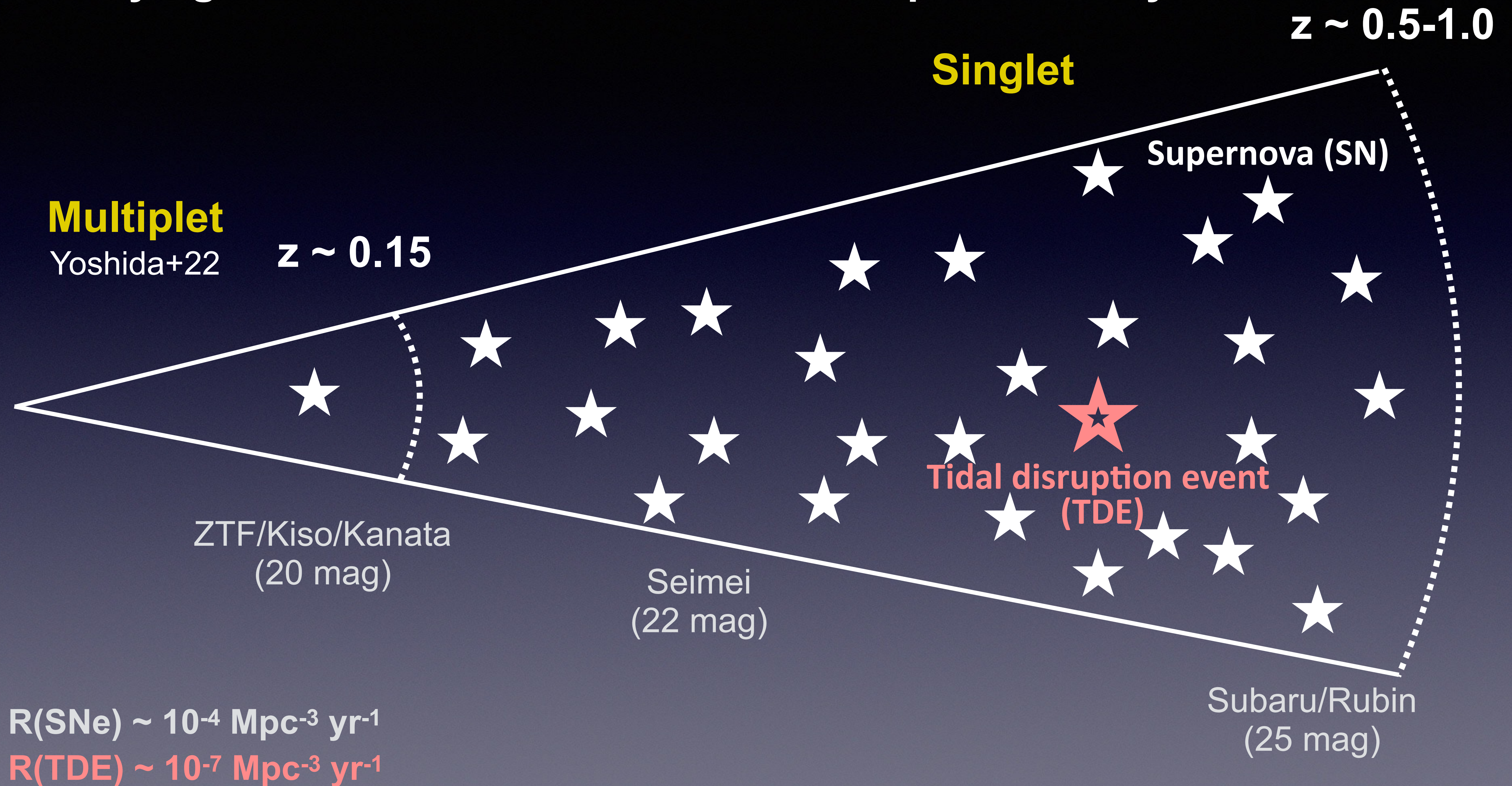
See S. Rahmouni's talk  
and K. Chiba's and Y. Matsubayashi's posters



- Roles of optical/infrared observations
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- High-energy neutrino sources



# Identifying transient neutrino sources with optical surveys



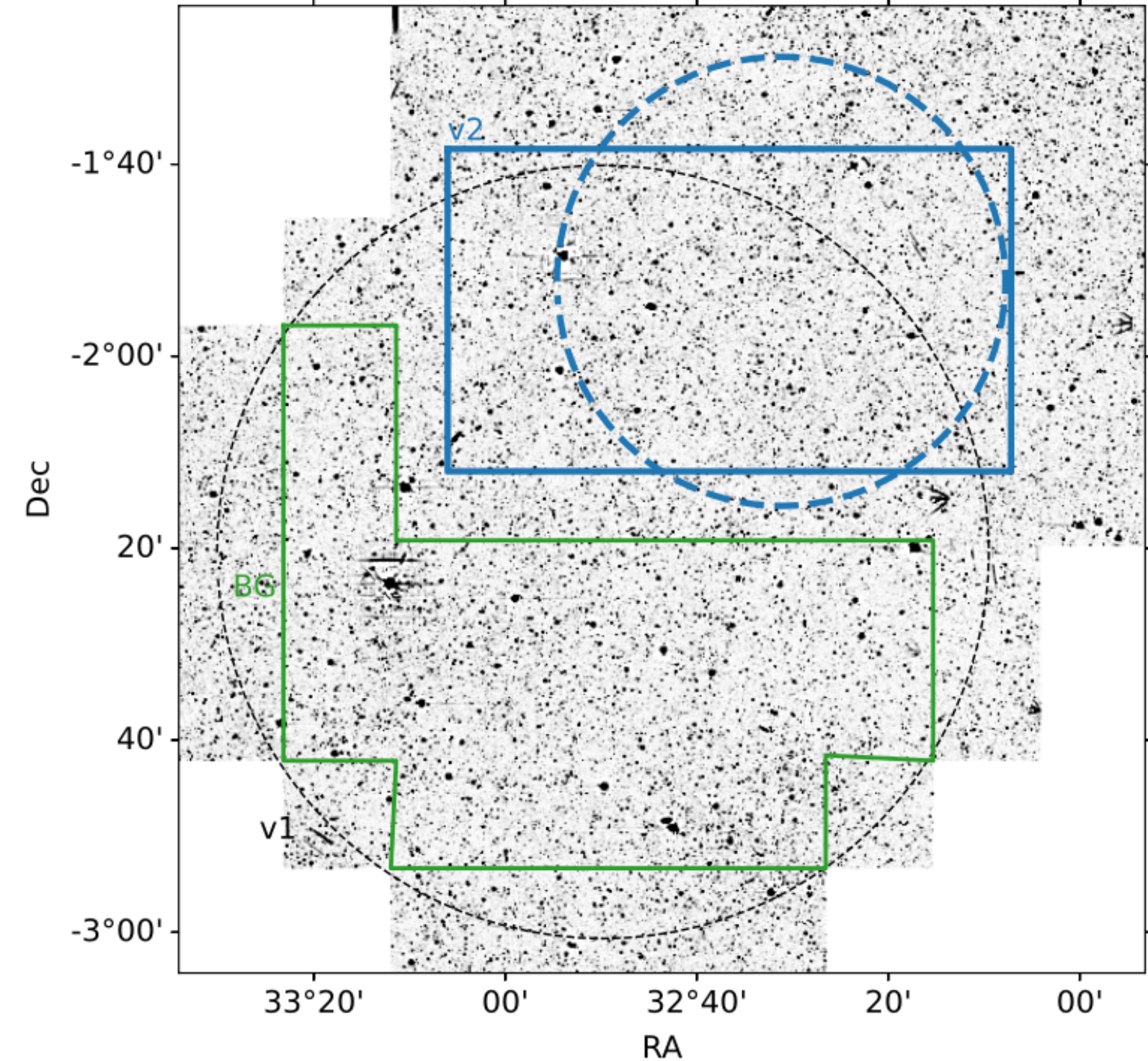


## Multiplet (ZTF)



Toshikage+25, ApJ  
See S. Toshikage's poster

## Singlet (Subaru)

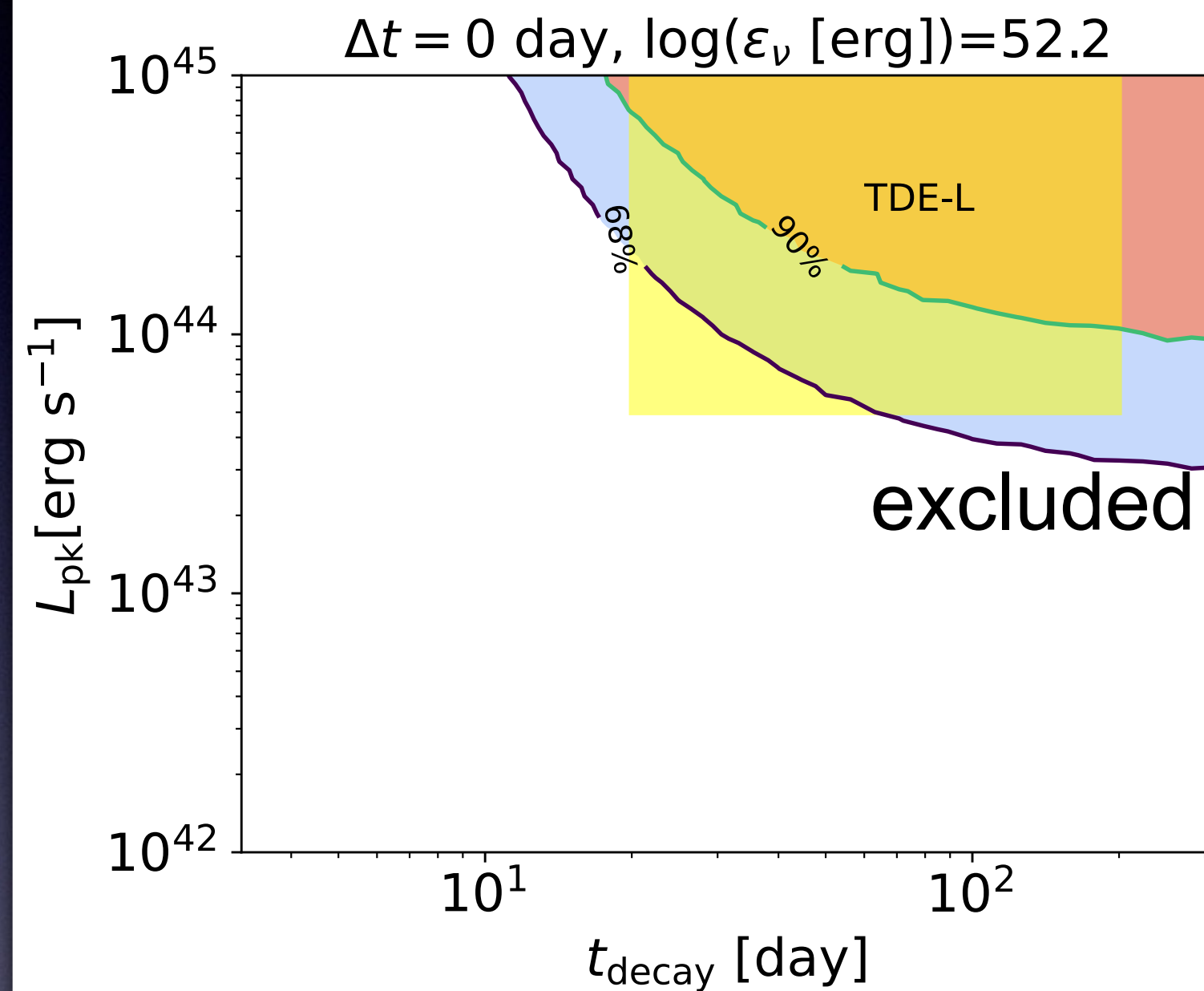


Kimura+ in prep  
See S. Kimura's talk

Blind analysis  
(collaboration with A01 and C01)



## Multiplet (ZTF)



Toshikage+25, ApJ  
See S. Toshikage's poster

=> Real-time follow-up with Kiso

## Singlet (Subaru)

?

Kimura+ in prep  
See S. Kimura's talk

=> Real-time survey data from Rubin



# Summary

- **Optical and infrared observations**
  - Wide-field survey + spectroscopy with the telescope network
  - Optical spectrograph for TAO + Rapid data analysis system for Subaru/PFS and Seimei
- **Gravitational wave**
  - No promising neutron star merger event in O4
  - Several follow-up efforts (Subaru/MOIRCS and PFS) ( $\Rightarrow$  A02)
  - Heavy element identification in kilonova spectra ( $\Rightarrow$  C02)
- **High-energy neutrino sources**
  - Multiplet: ZTF data analysis  $\Rightarrow$  Kiso ( $\Rightarrow$  A01, C01)
  - Singlet: Subaru observations  $\Rightarrow$  Rubin ( $\Rightarrow$  A01, C01)