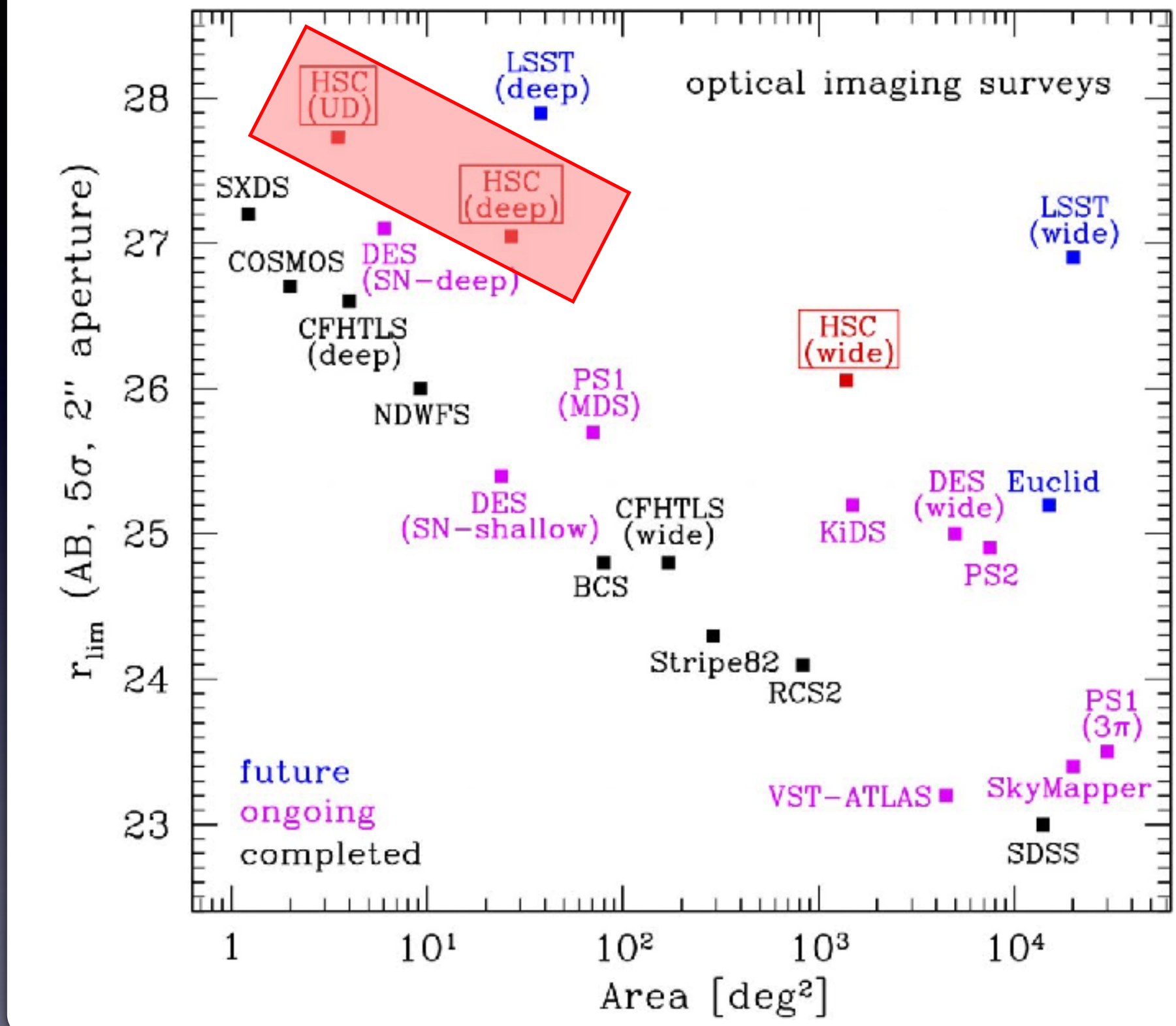
Time-Domain Science with Subaru/HSC

Masaomi Tanaka (NAOJ)

Time-Domain Science with Subaru/HSC

- **Transient survey with Subaru/HSC**
- **Multi-messenger astronomy**
- **Future**



http://hsc.mtk.nao.ac.jp/ssp/science/weak-lensing-cosmology/

Masahiro's talk

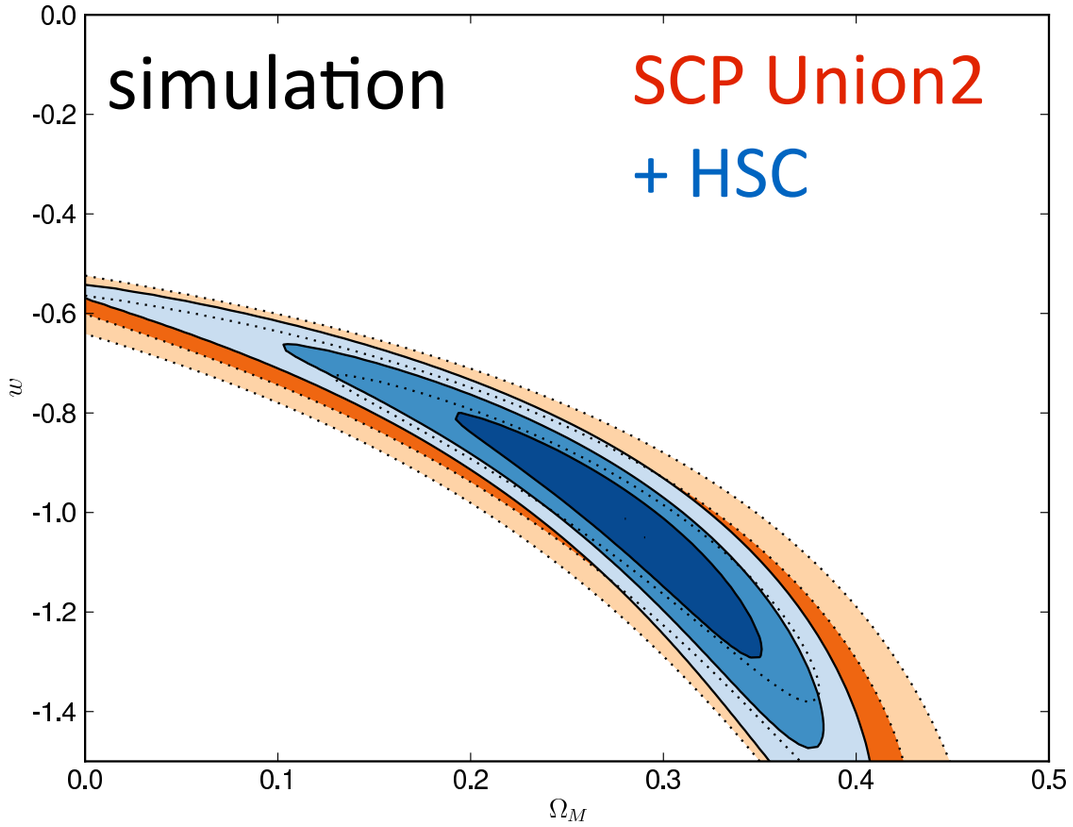
SSP Transient survey (2016 Nov-, COSMOS)

HSC transient working group:
Naoki Yasuda, Nozomu Tominaga, Tomoki Morokuma, Nao Suzuki,
Ichiro Takahashi, Takashi Moriya, Keiichi Maeda, Masaki Yamaguchi, et al.

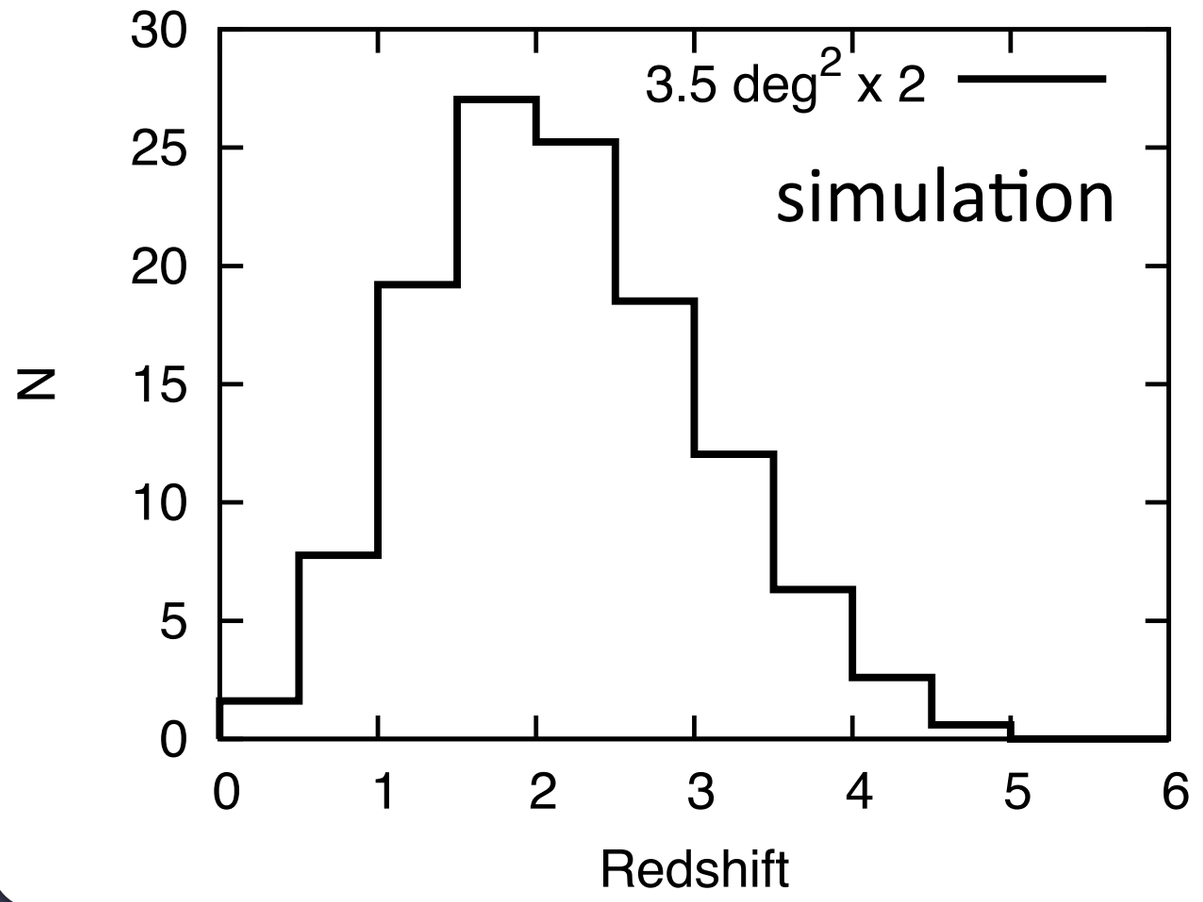
The deepest/widest transient survey as ever

Today

Type Ia SN cosmology



High-z “superluminous” SNe



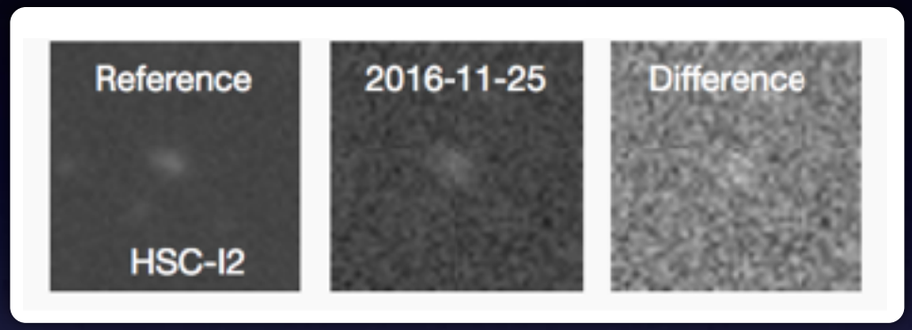
- Tidal disruption => Evolution of SMBH
- SN rate => Success rate of SN/Progenitor system
- New types of transients
- …

Superluminous supernovae

Collaboration with Jeff Cooke (Swinburne)

led by Takashi Moriya et al.

Keck 2 nights
(2017 Feb, Mar)



see Jeff's talk

Event rate of
"superluminous" supernova
up to z ~ 4
==> star formation and IMF

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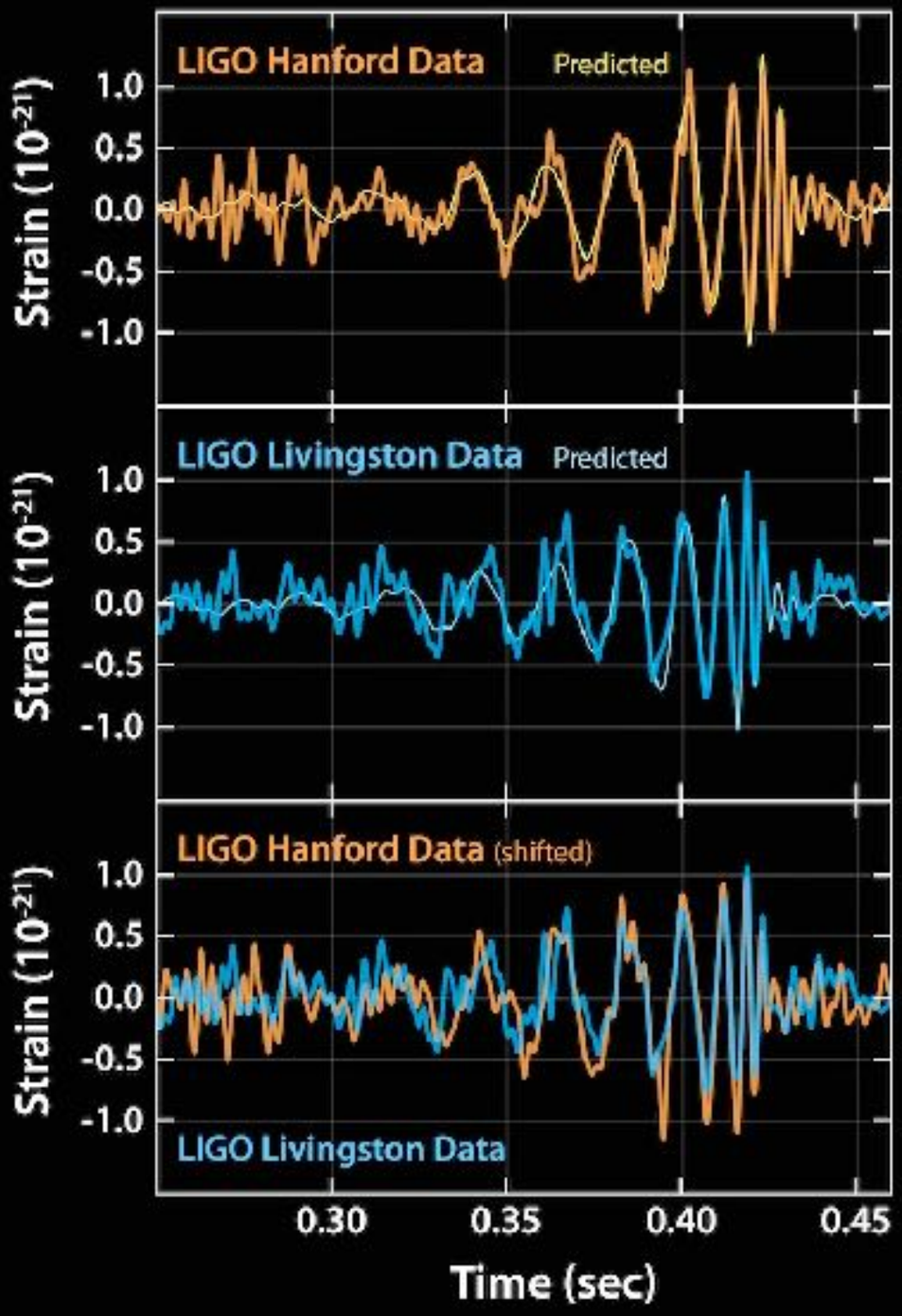
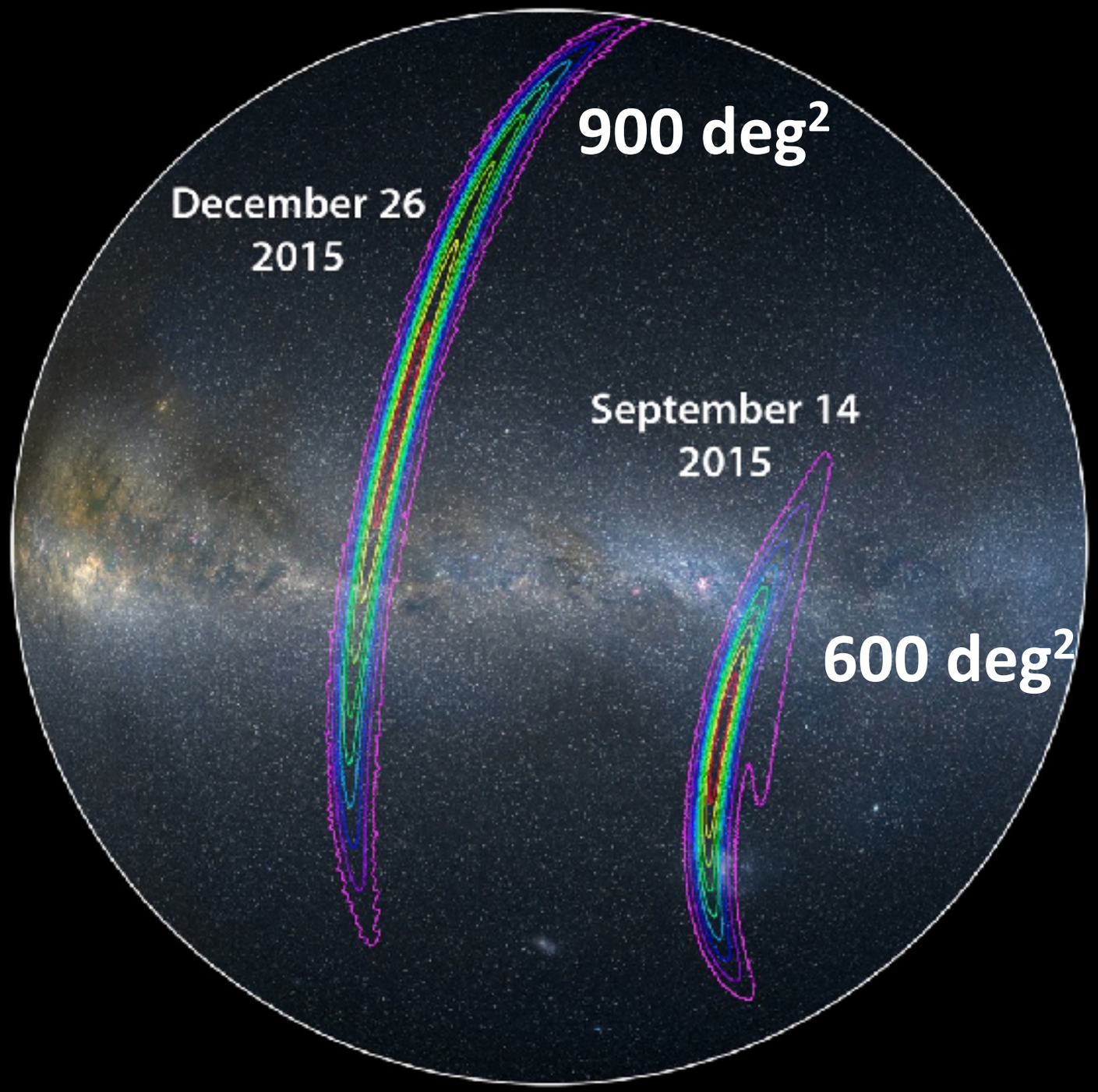
Gravitational wave astronomy

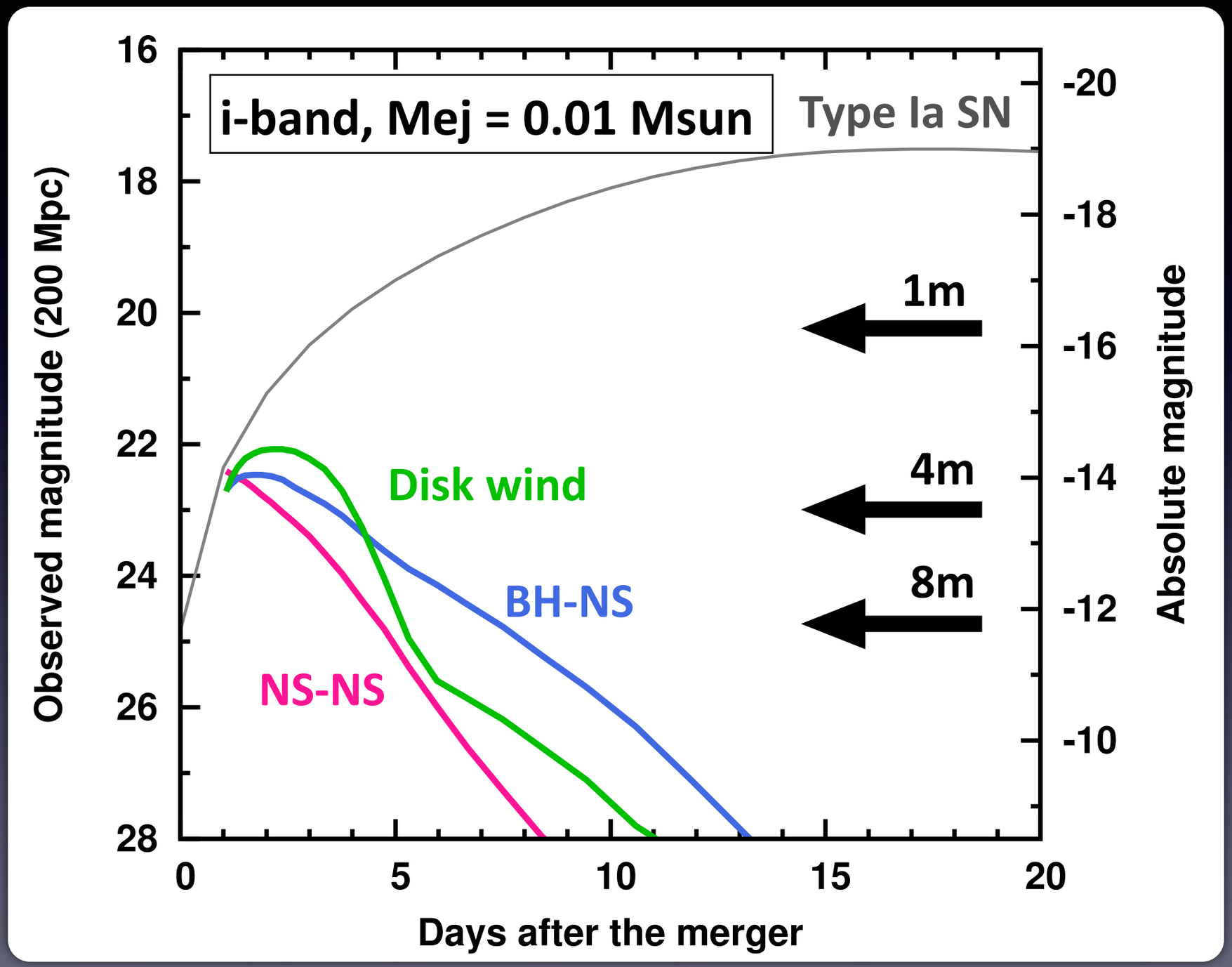
Abbott et al. 2016, PRL, 061102

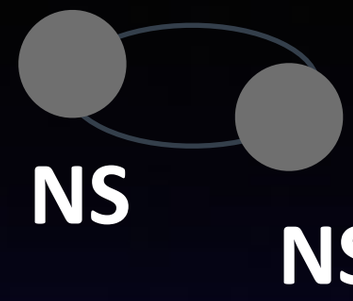




GW150914 = BH-BH merger **=> 10-100 deg2 after Virgo and KAGRA**

Optical emission from GW sources: “kilonova”





r-process nucleosynthesis (Au, Pt)

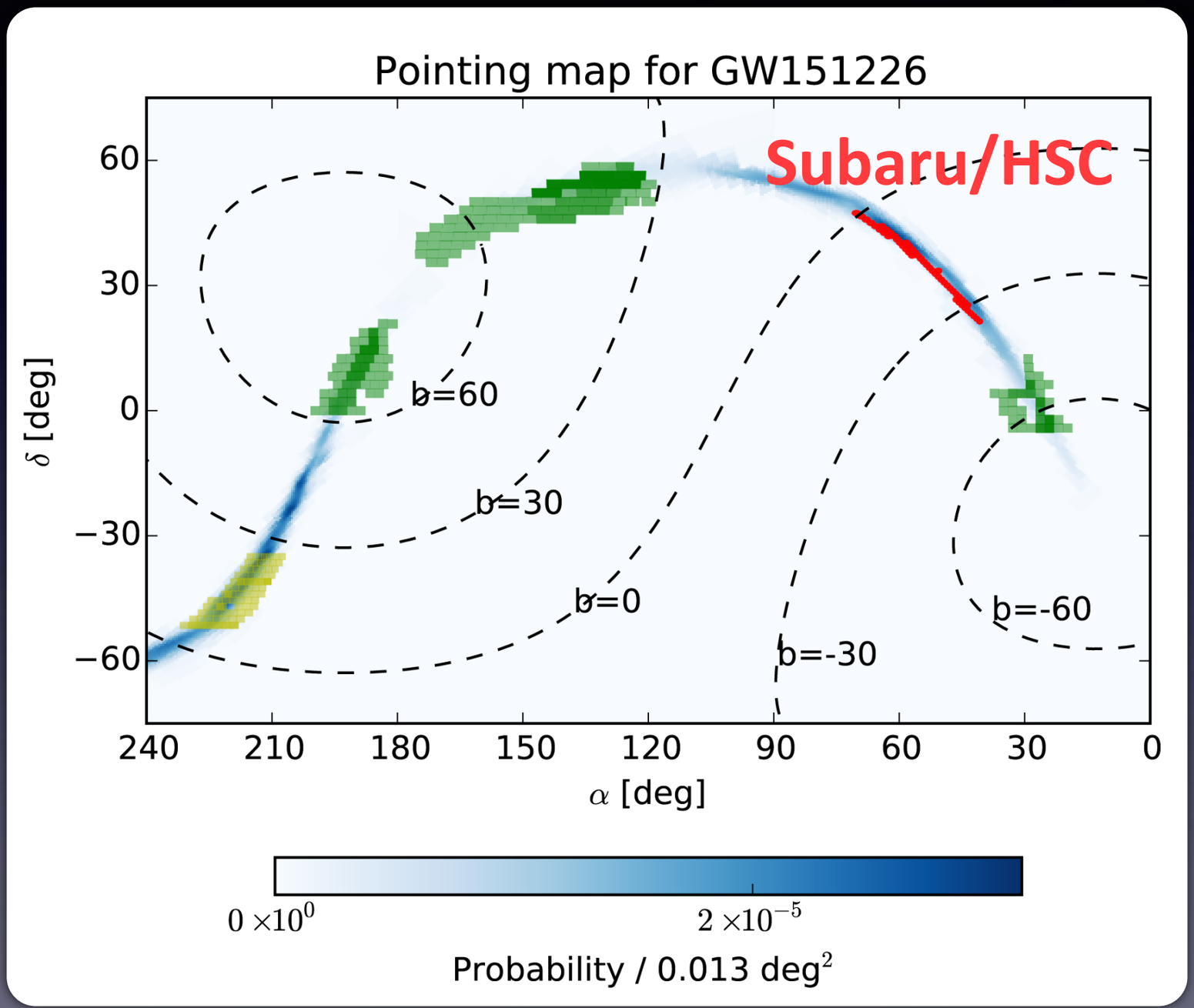
MT 2016

Detection of the counterpart => Ejection of r-process elements

Subaru/HSC is the unique instrument for GW follow-up

ToO transient search for GW151226 (BH-BH)

J-GEM (Japanese collaboration for GW-EM follow-up: Yoshida et al.)



64 deg² (7%) in 0.5 night!

Yoshida, Utsumi, Tominaga et al. 2017, PASJ, 69, 9

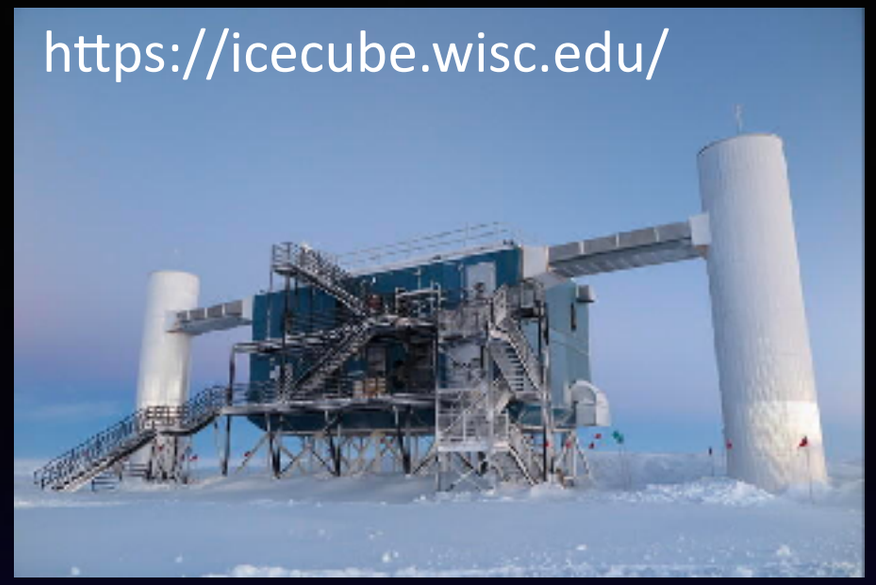
HSC: 1256 candidates and ~60 likely extragalactic transients

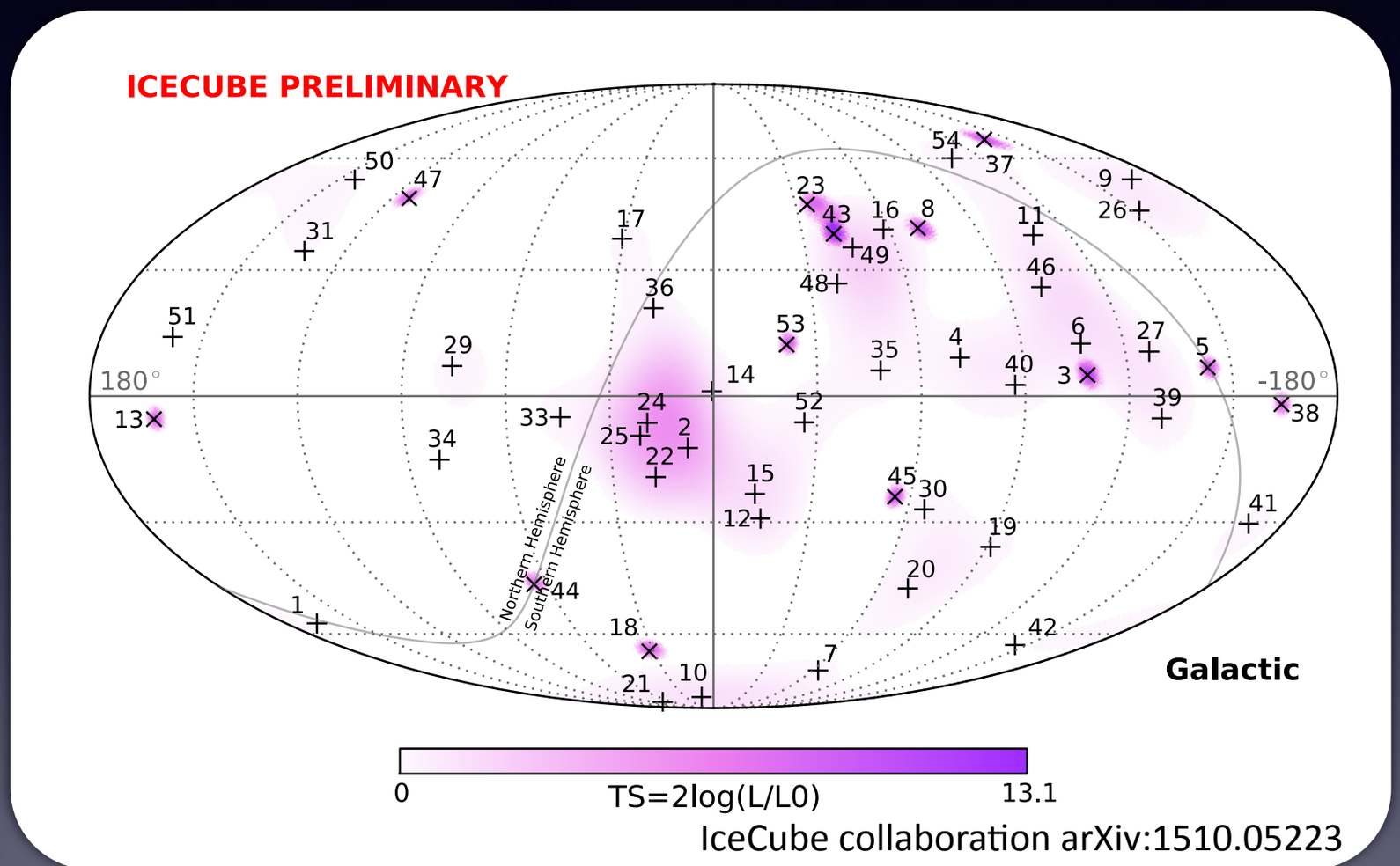
=> Need spectroscopy for the smoking gun

More opportunities for multi-messenger

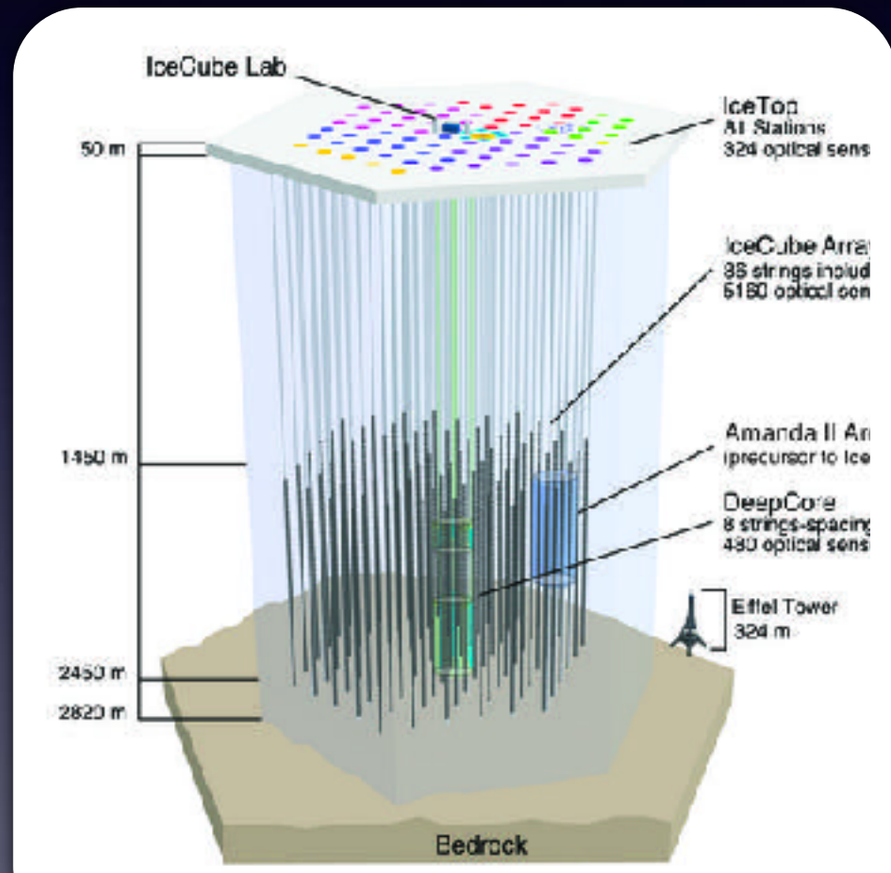
IceCube: high-E (TeV-PeV) neutrino
Real-time alert (2016-)

https://icecube.wisc.edu/





IceCube collaboration arXiv:1510.05223



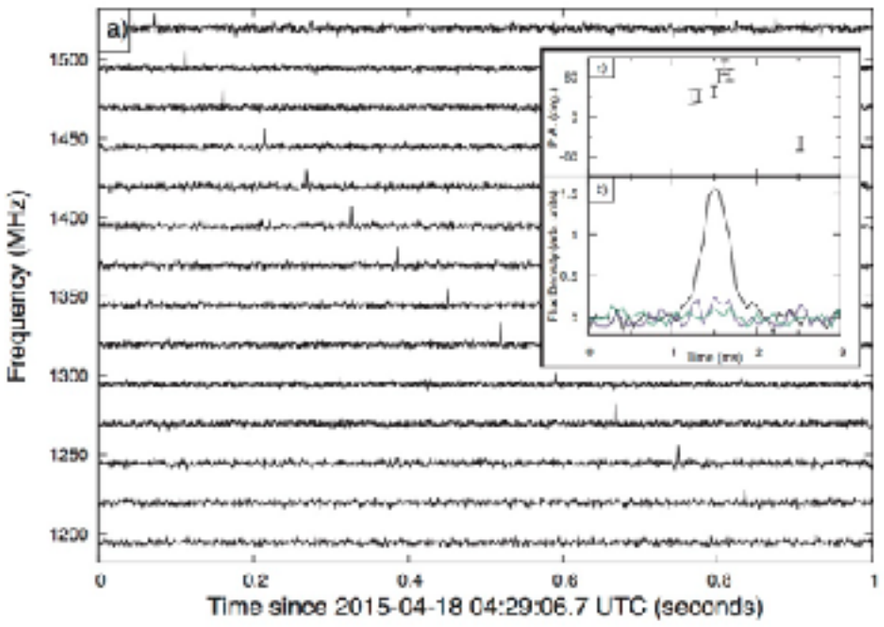
Consistent with homogeneous distribution

No correlation with TeV gamma-ray sources/GRBs

Localization ~ 1 deg => Subaru/HSC

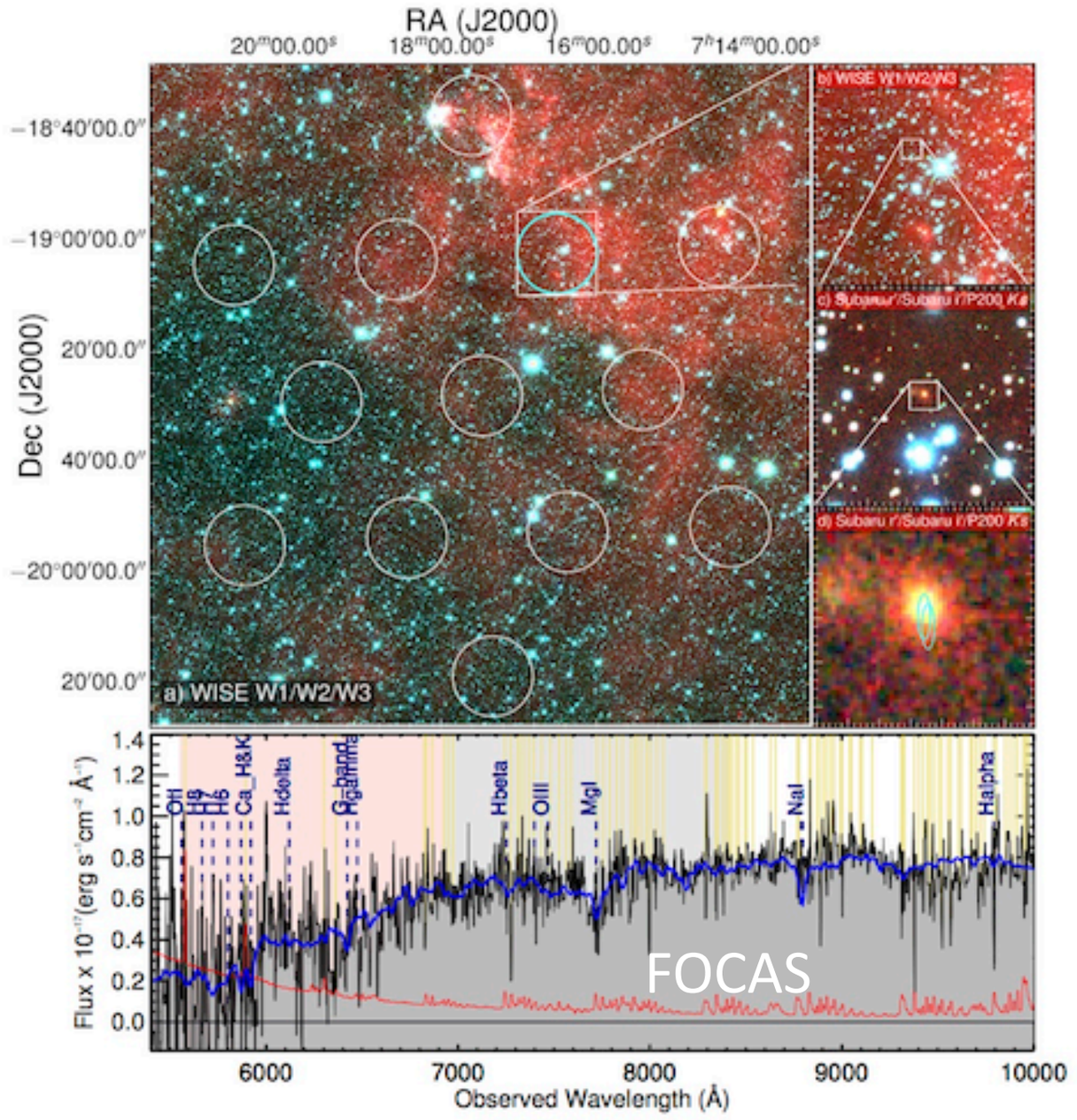
Fast radio bursts: ToO transient search + follow-up

led by Tomonori Totani et al.



Keane+2016

Parkes beam size
~ 15 arcmin (FWHM)



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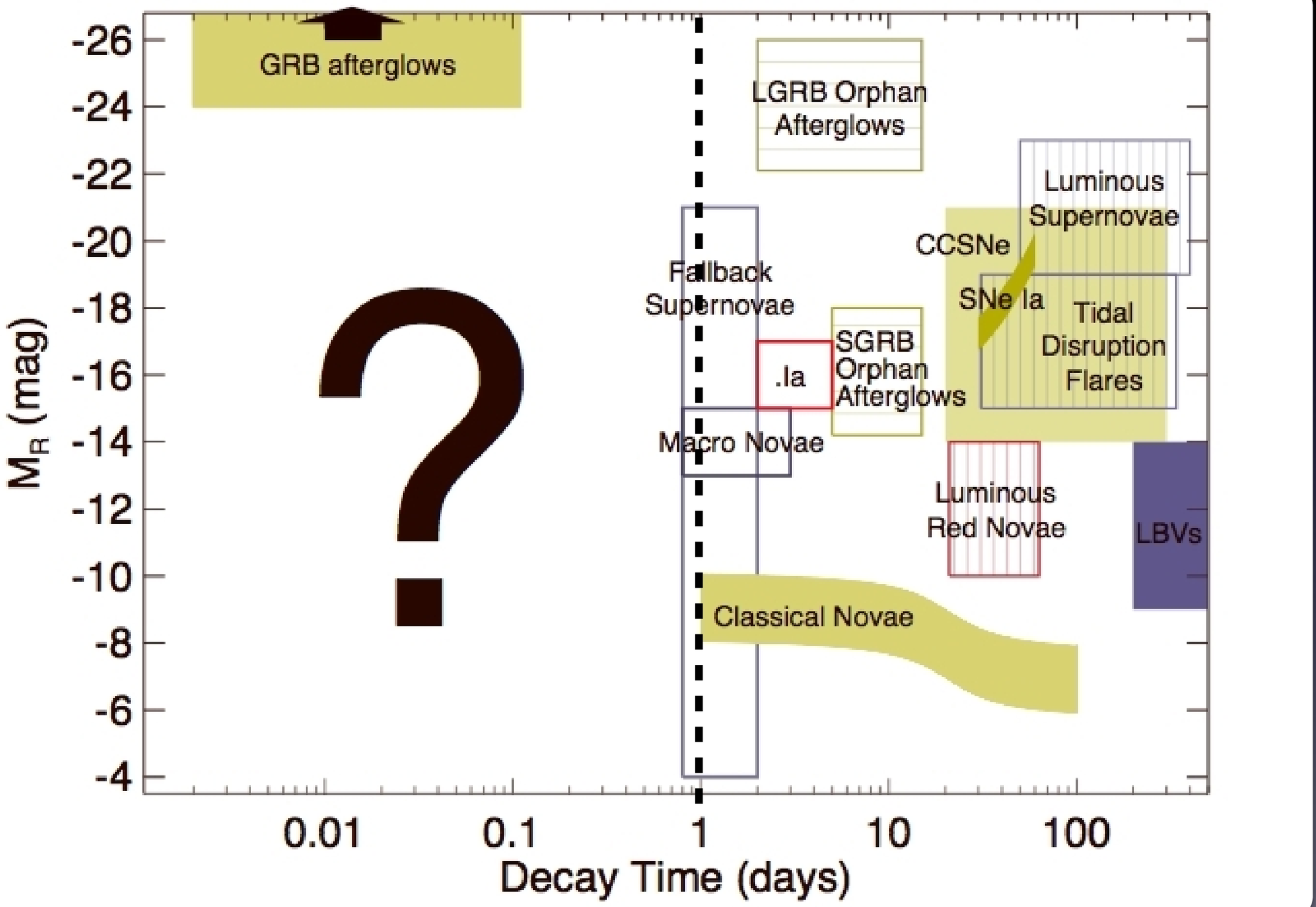
Frontier of transient sky

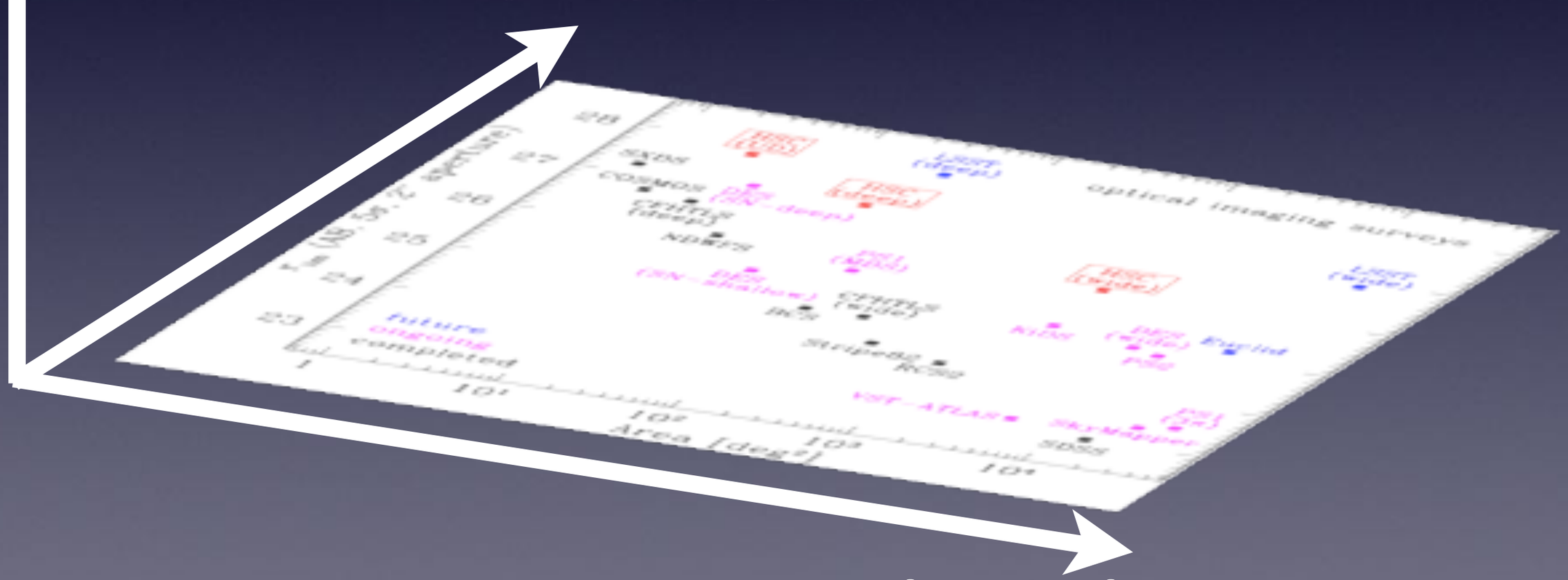


LSST Science Book (after Rau+09, Kasliwal+,Kulkarni+)

3 key parameters of time-domain survey

Cadence (Faster)

Depth (Deeper)

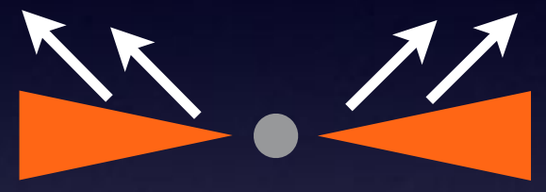


Area (Wider)

Fast transients

- **First signals from supernovae**
  - Shock breakout t ~ a few hours
  - Cooling phase t ~ a few days
- **BH-forming SN**
  - Disk outflow Mej ~0.01 Msun t ~ a few days

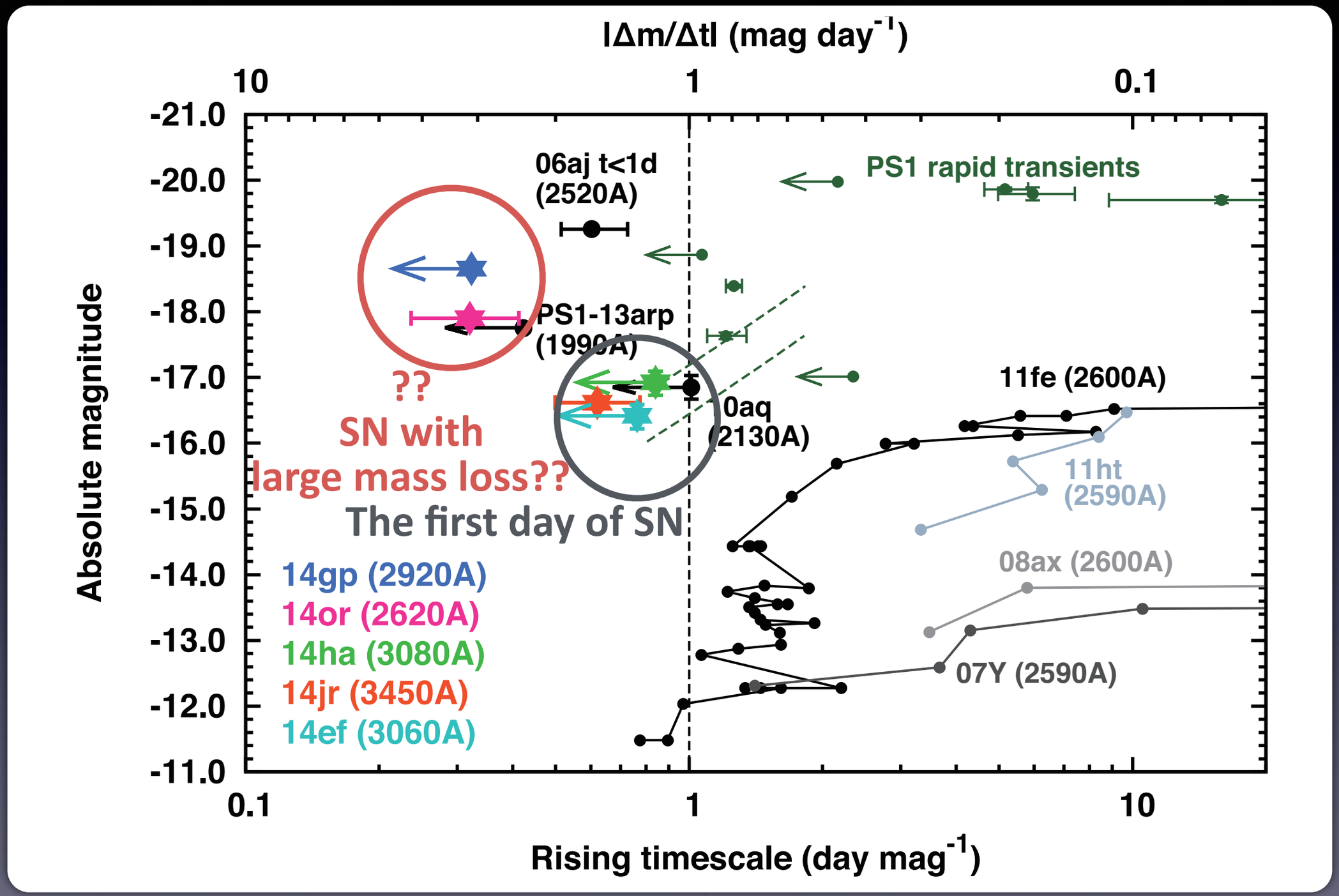
Mej ~ 0.01 Msun



BH or NS

- **Accretion induced collapse of WDs**
  - Disk outflow Mej ~ 0.01 Msun t ~ 1 day
- **Neutron star merger**
  - Disk outflow t ~ a few days
  - Free neutron t ~ 1 day
- **Unknown unknown...**

Pilot high-cadence survey with Subaru/HSC



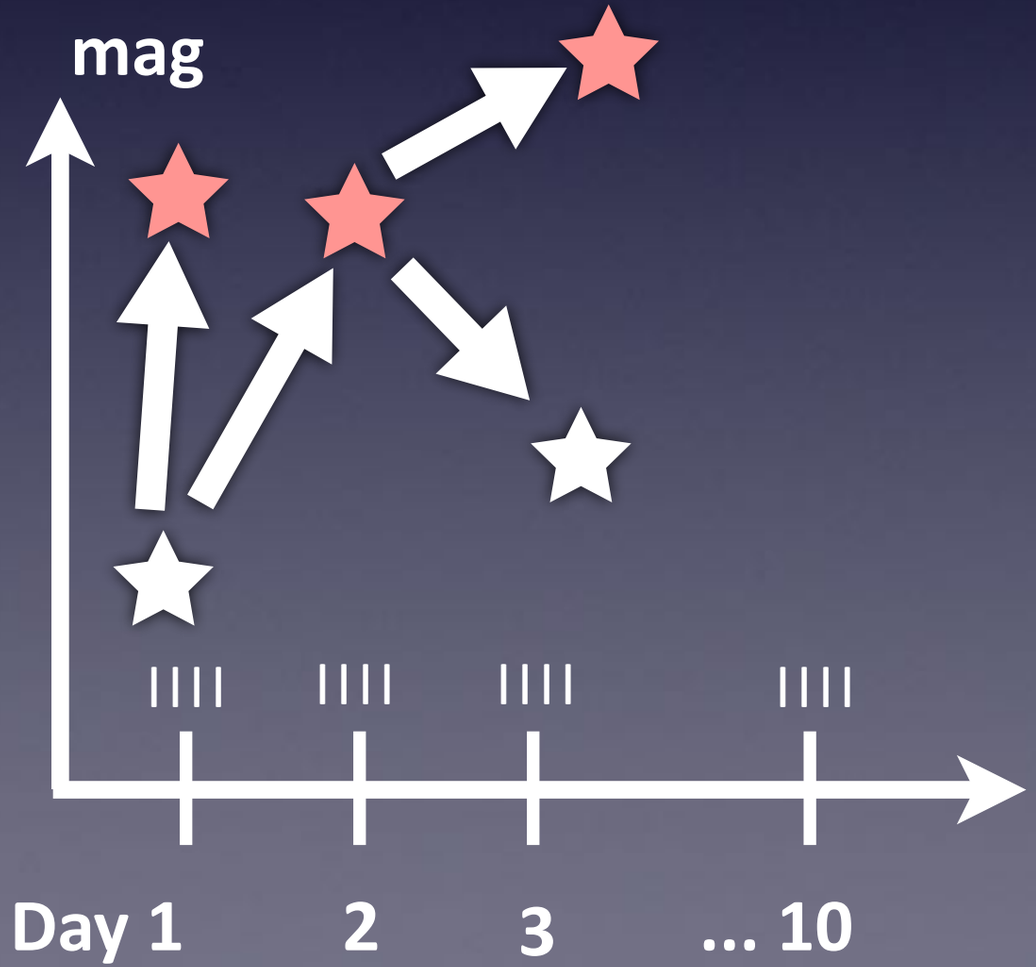
MT, Tominaga, Morokuma, Yasuda+2016 see also Ofek et al.; Gezari et al.

=> Coordinated survey & rapid follow-up are critical

High-cadence transient survey with Subaru/HSC

- Depth: 25 mag (1 min exposure)
- **Cadence: 1 hr + 1 day**
- **10 consecutive 0.5 nights (open-use)**

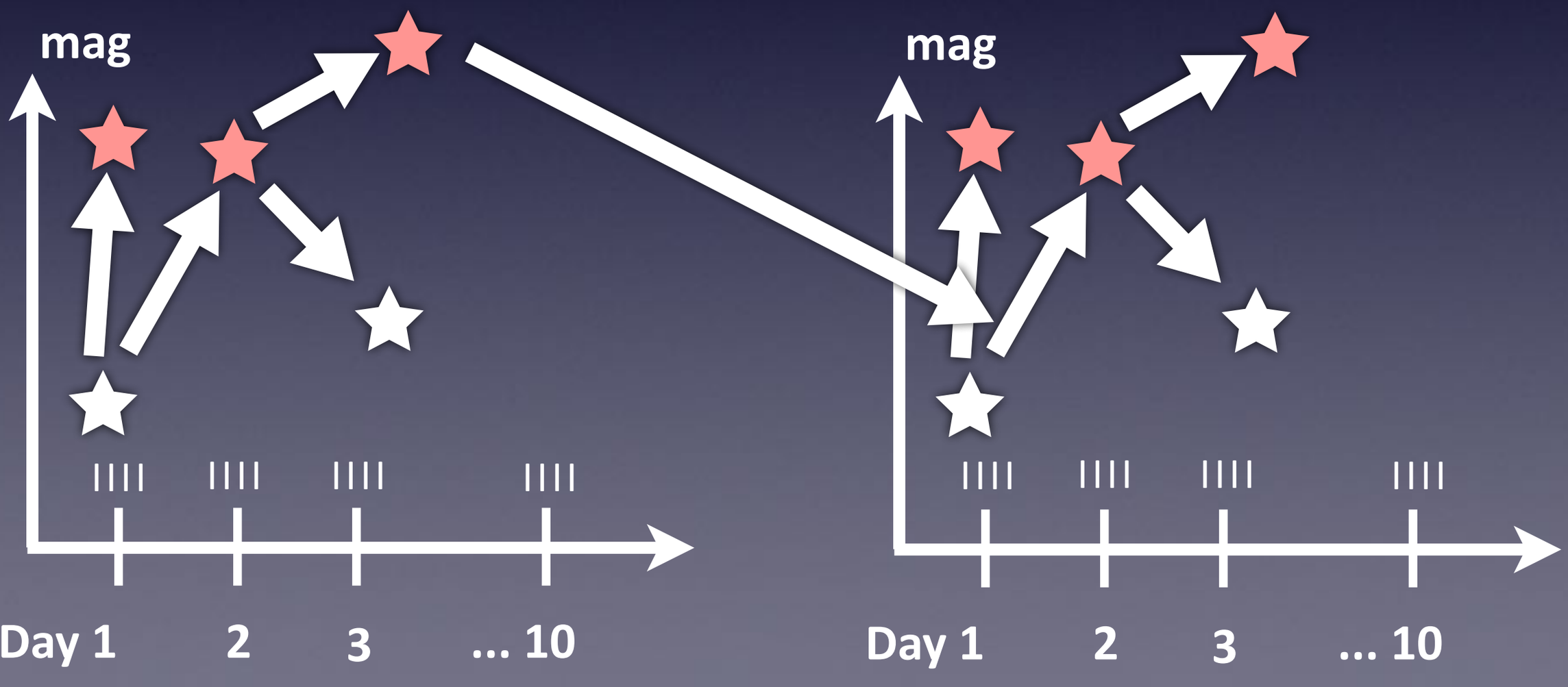
+ Follow-up spectroscopy
+ Coordinated survey (multi-wavelength)



High-cadence transient survey with Subaru/HSC

- Depth: 25 mag (1 min exposure)
- **Cadence: 1 hr + 1 day + 1 month**
- **10 consecutive 0.5 nights x 2 (intensive)**

+ Follow-up spectroscopy
+ Coordinated survey (multi-wavelength)



- **(1. Myself)**
  Time-domain, transient, and multi-messenger (GW, ν)
- **(2. On-going collaboration)**
  SSP transient survey + Keck follow-up (J. Cooke)
- **(3. Short/Long term collaboration)**
  Short: SSP + follow-up (current scheme)
  Long: Dedicated high-cadence transient survey
- **(4. Size)**
  ~5 HSC nights (normal) to ~10-20 HSC nights (intensive)
  + spectroscopic follow-up + multi-λ coordination
- **(5. Instrument)**
  HSC, no big demand for new instruments
- **(6. Operation)**
  Flexible scheduling = cadence observations in queue mode
  Inter-partner ToO