ISDT Report
Time-domain Science

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ISDT time-domain group
(15 members)

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Update of Detailed Science Case

1. Introduction
2. Overview
3. Fundamental physics and cosmology
4. The early Universe
5. Galaxy formation and the intergalactic medium
6. Extragalactic supermassive black holes
7. Exploration of nearby galaxies
8. The formation of stars and planets
9. Exoplanets
10. Our solar system

Thirty Meter Telescope
Detailed Science Case: 2007

TMT Science Advisory Committee

No section for time-domain science

Time-domain science??

Supernovae

Tidal disruption

Pulsar

GRBs

Cataclysmic variable

Stellar pulsation

AGNs

RR Lyrae

Microlensing

Cepheids

...

Planet transit

Asteroids

Eclipsing binary

YSOs

Asteroid occultation

Luminous blue variable

Time-domain science??

DSC 2014

Type Ia SN

Core-collapse SN

SN progenitor

GW sources

GRBs

Tidal disruption

CVs

Pulsars

Cepheids

Time-domain science??

Target of opportunity observations

Type Ia SN　　GW sources　　Tidal disruption

Core-collapse SN　　GRBs　　Classical novae

Rapid response (telescope, operation)

Time-resolved observations

CVs, X-ray binary (accretion disk)　　Pulsars

Rapid sampling (instruments)

Monitoring observations

Cepheids　　RR Lyrae

Binaries　　AGNs

Flexible time allocation

Frontier: Short timescale transients

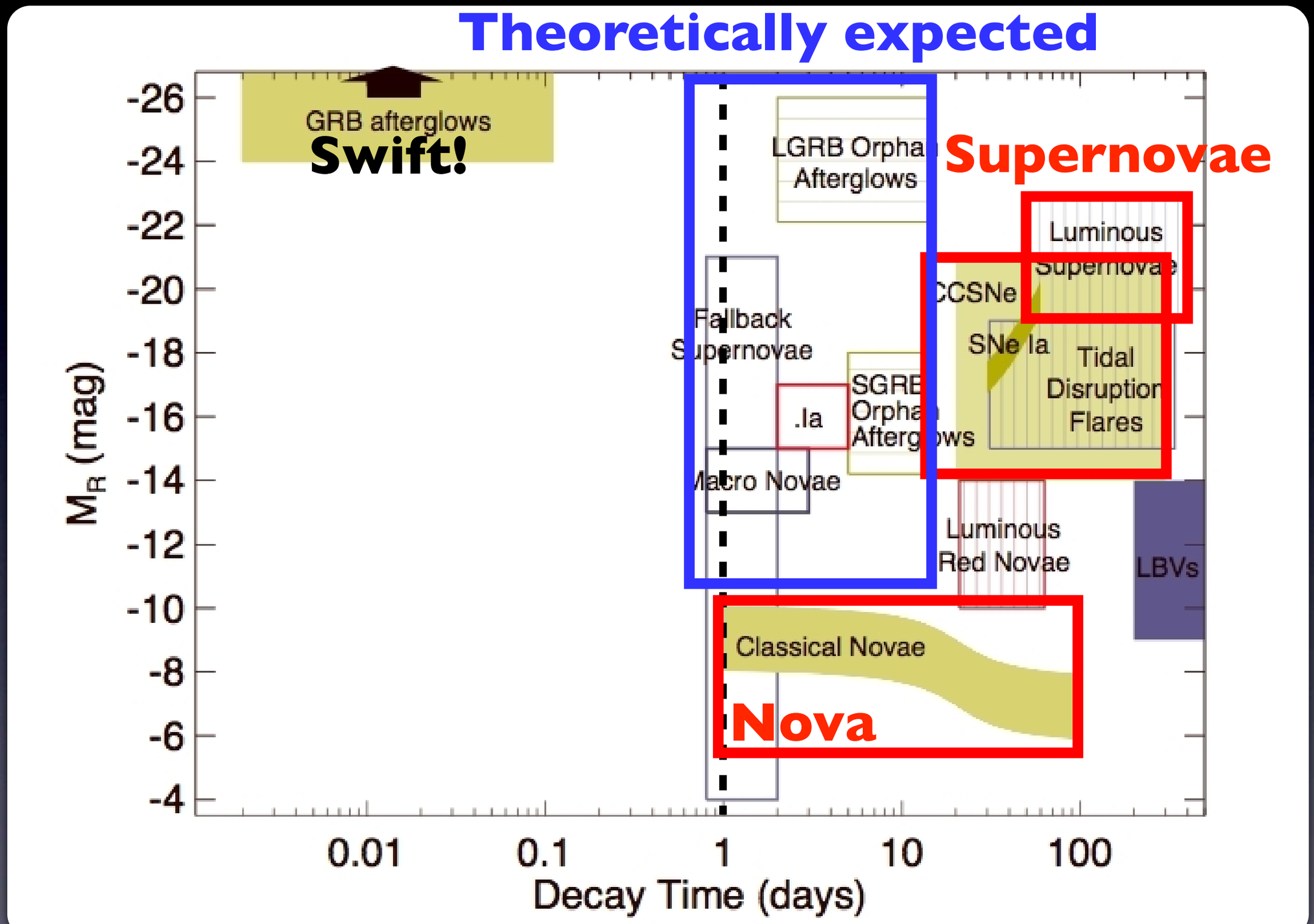
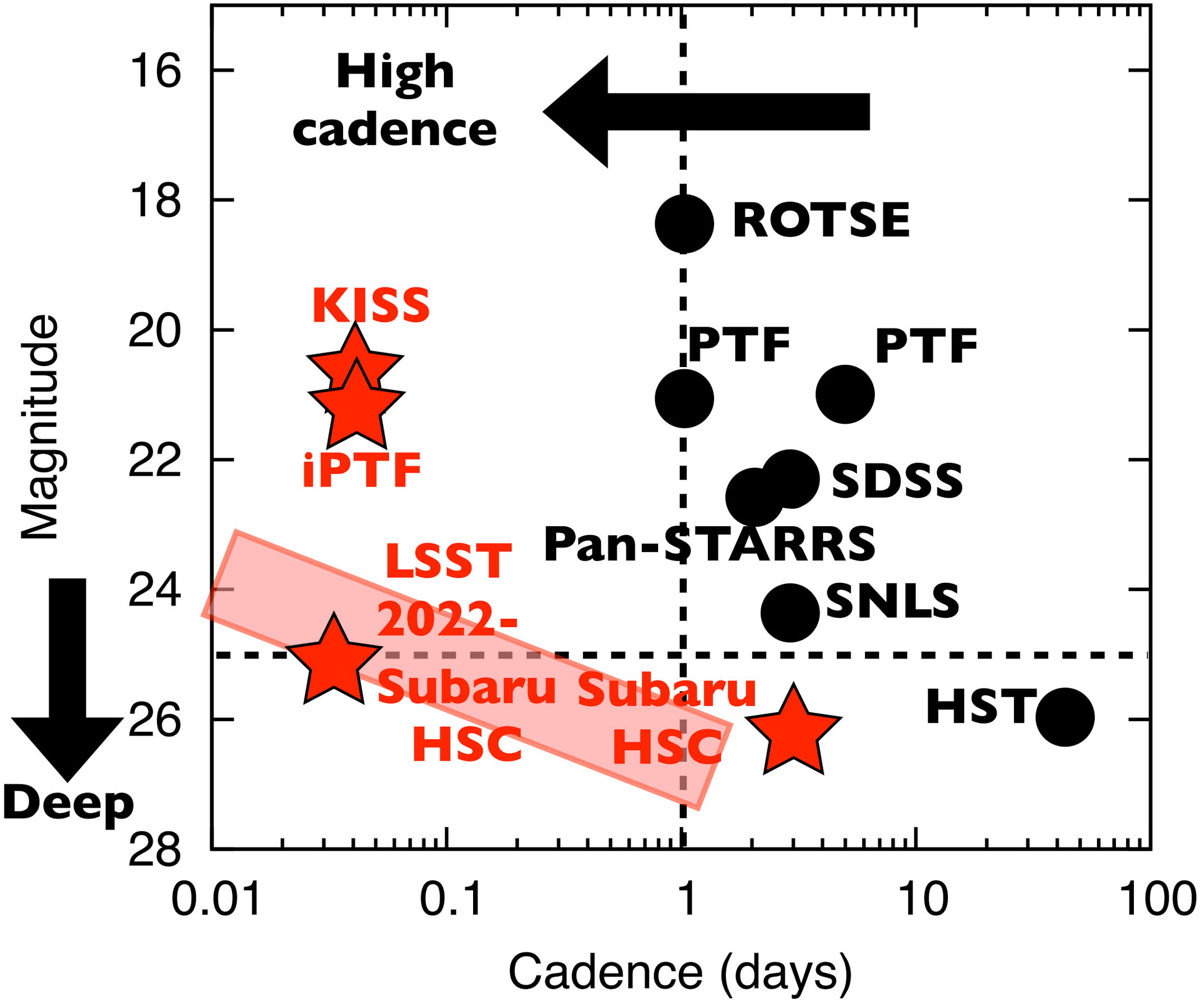


Figure from LSST Science Book
(after PTF collaboration, Rau+09, Kasliwal+,Kulkarni+)

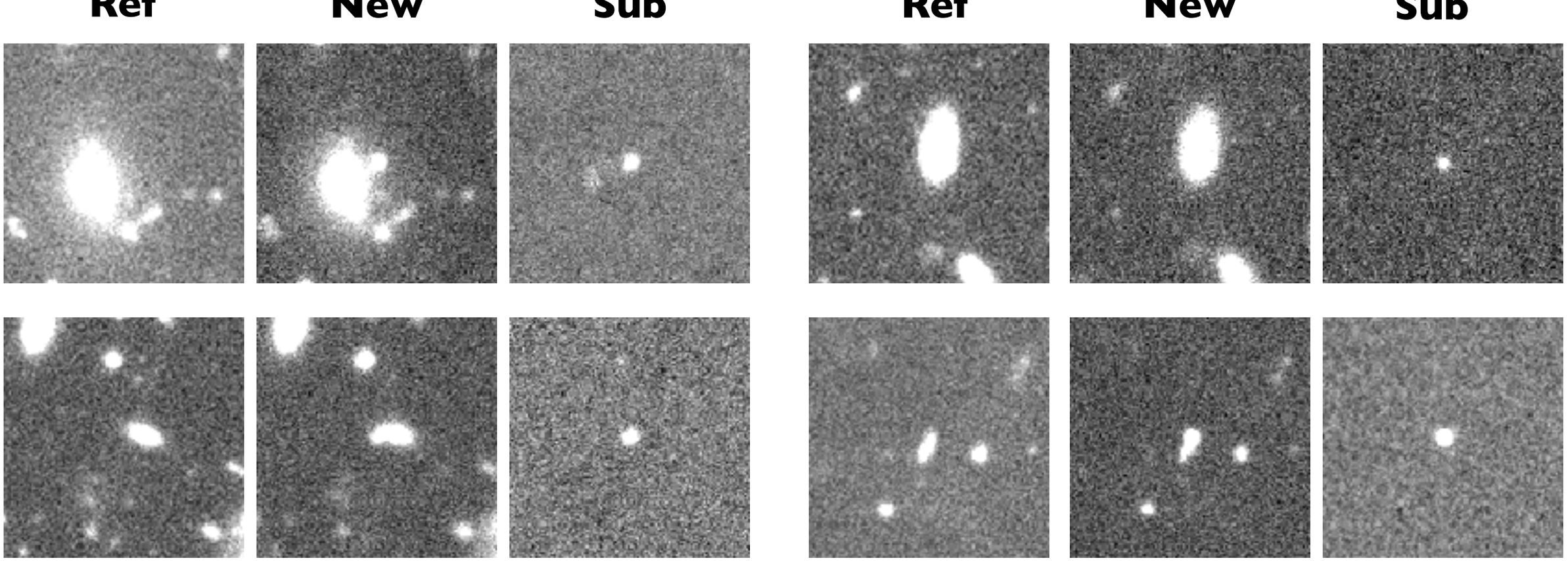

High cadence
ROTSE
KISS
PTF
PTF
iPTF
SDSS
Pan-STARRS
LSST 2022-
SNLS
Subaru HSC
Subaru HSC
HST
Deep
Magnitude
16
18
20
22
24
26
28
0.01
0.1
1
10
100
Cadence (days)

First transient survey with Subaru/HSC (2014 July 2-3 UT)

The Astronomer's Telegram

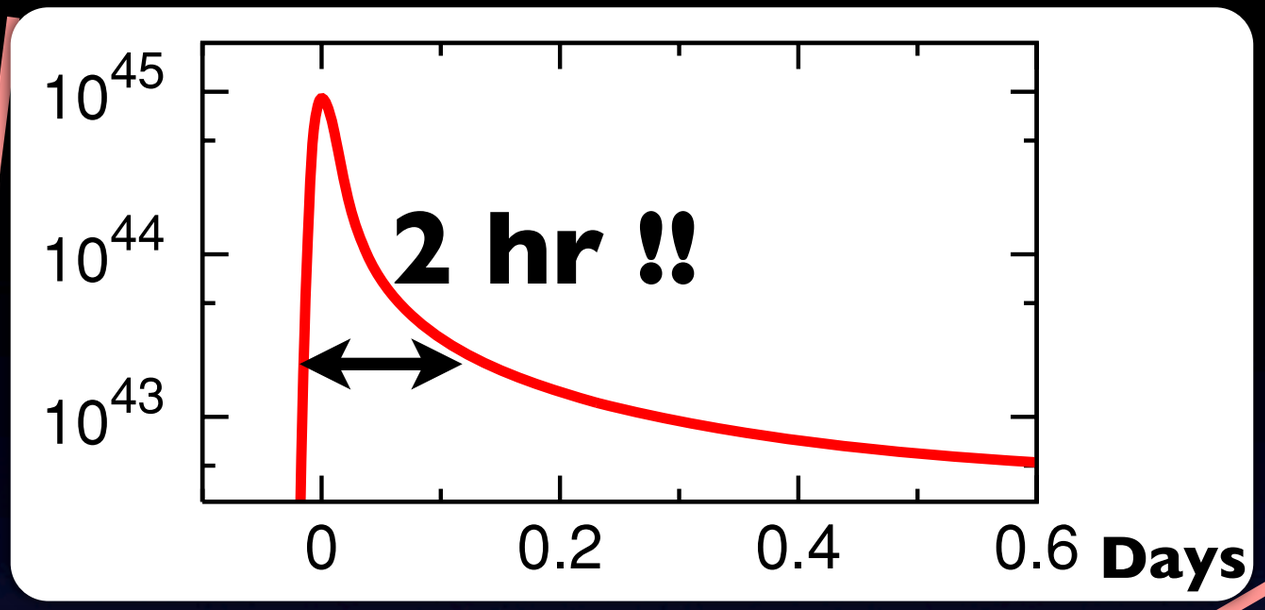
First supernova candidates discovered with Subaru/Hyper Suprime-Cam

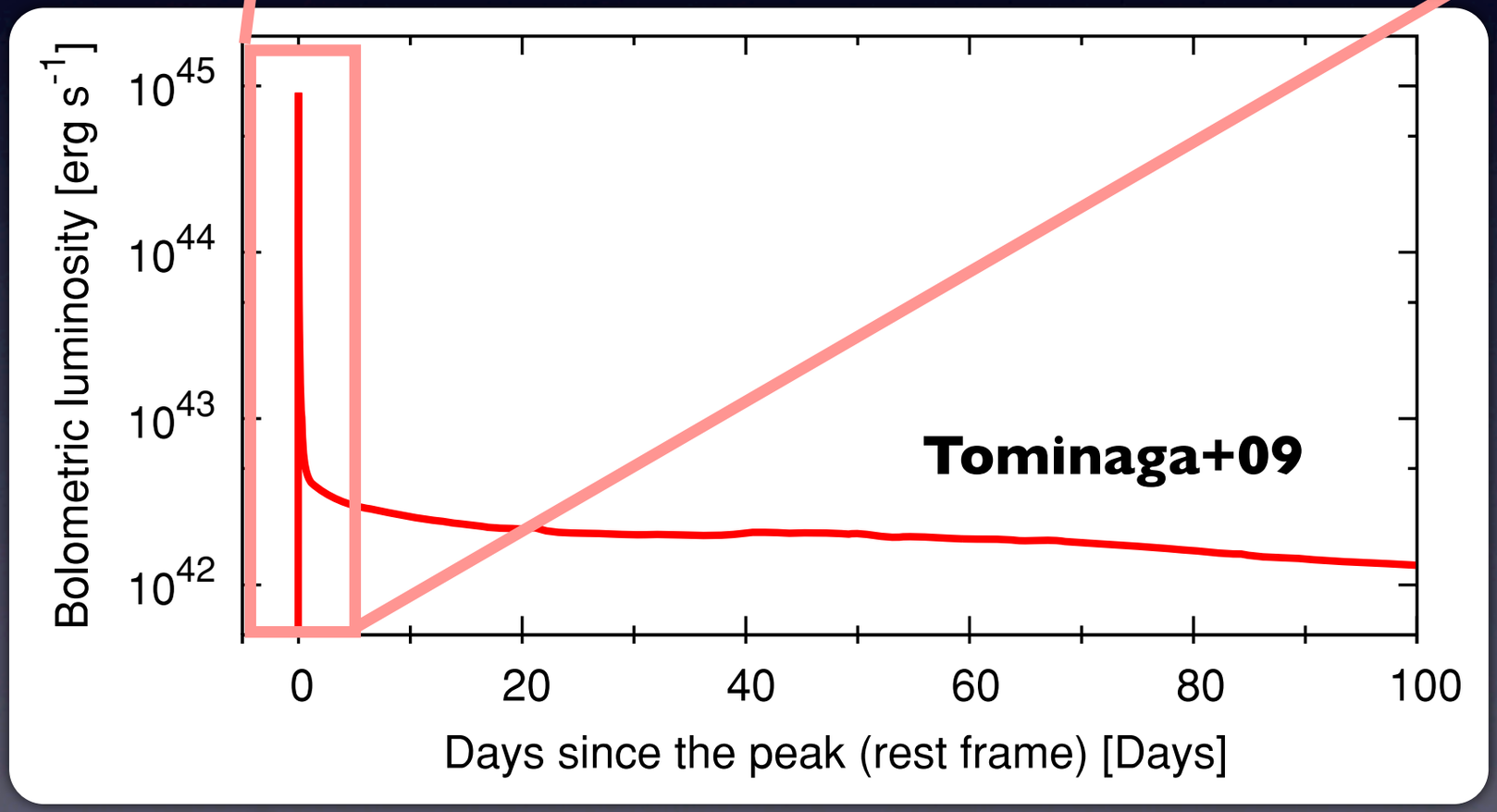
ATel #6291; *Nozomu Tominaga (Konan U./Kavli IPMU, U. Tokyo), Tomoki Morokuma (U. Tokyo), Masaomi Tanaka (NAOJ), Naoki Yasuda (Kavli IPMU, U. Tokyo), Hisanori Furusawa (NAOJ), Jian Jiang (U. Tokyo), Satoshi Miyazaki (NAOJ), Takashi J. Moriya (U. Bonn), Junichi Noumaru (NAOJ), Kiaina Schubert (NAOJ), and Tadafumi Takata (NAOJ)*
on 4 Jul 2014; 15:51 UT



http://tpweb2.phys.konan-u.ac.jp/~tominaga/HSC-SN/

The moment of supernova explosion





Deep, high-cadence survey (g = 27 mag)

supernovae at z~2

TMT/MOBIE spectroscopy within 30 min

New window to study supernovae
(SFRs, SN progenitor, SN kinetic energy)

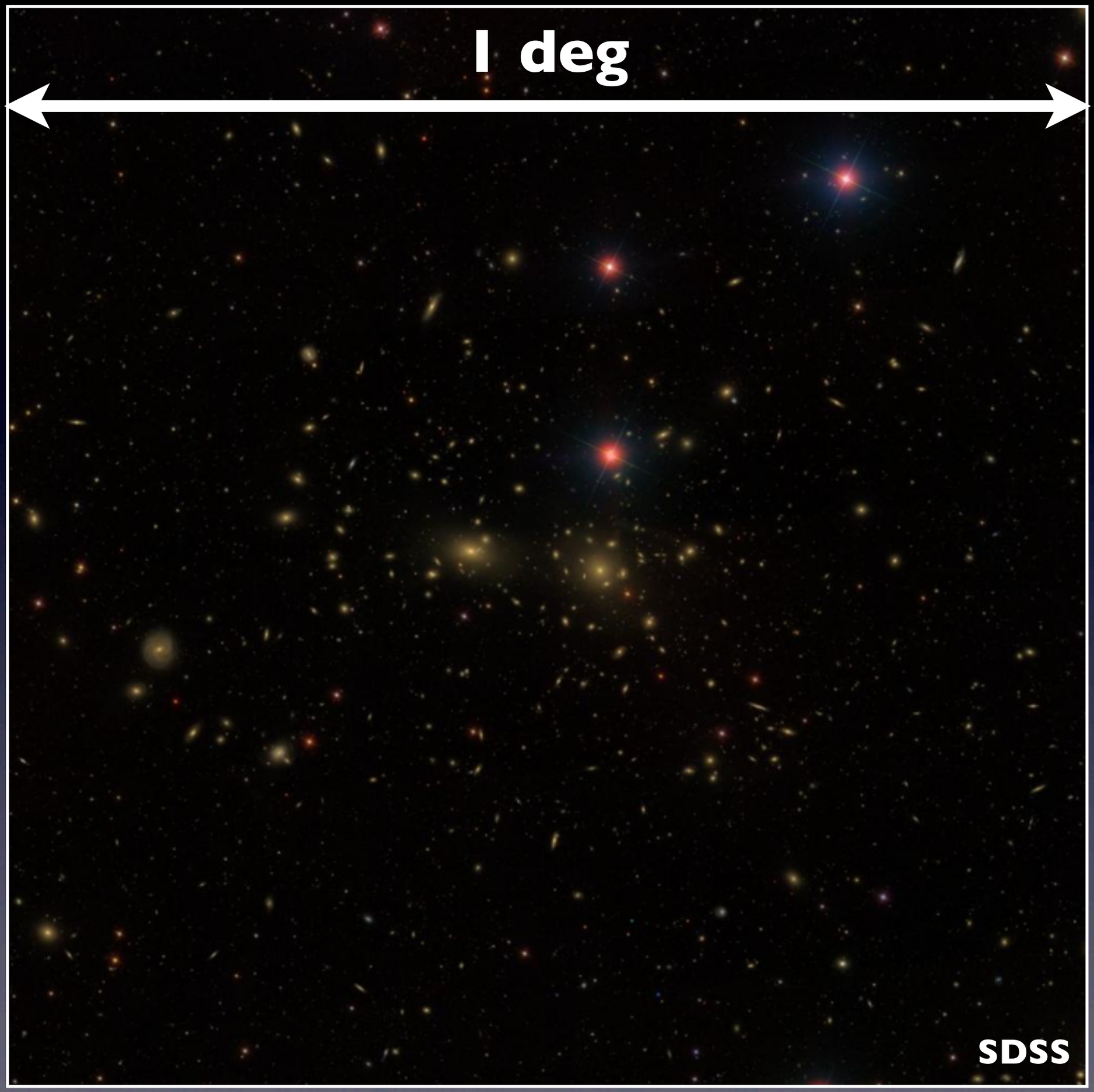
Paradigm shift in 2020s: Gravitational waves

2017 -
- Advanced LIGO (US)
- Advanced Virgo (Europe)
- KAGRA (Japan)

→ NS-NS merger with 200 Mpc

"Multi-messenger" astronomy

- Compact binaries
- Properties of dense matter
- r-process nucleosynthesis
- ...


1 deg
SDSS

GW alert error
e.g. 6 deg x 6 deg
(not box shape in reality)

No electromagnetic counterpart
No gravitational wave astronomy

GW detection

Subaru HSC
1.5 deg

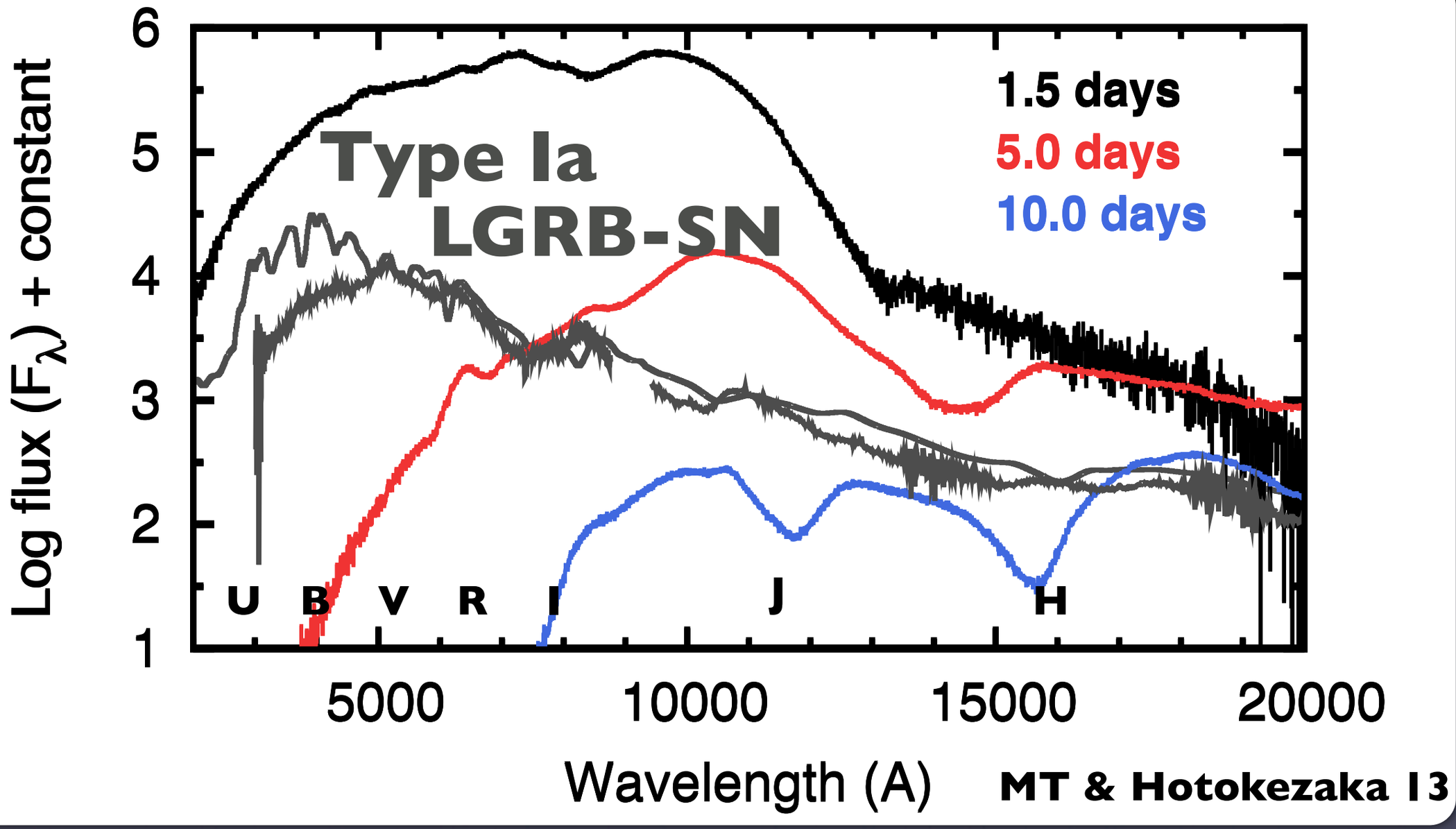
LSST
3.5 deg

EM transient search w/ wide-field telescope (e.g., LSST, HSC)

1 deg

Source identification (TMT)

Smoking gun: spectroscopic identification



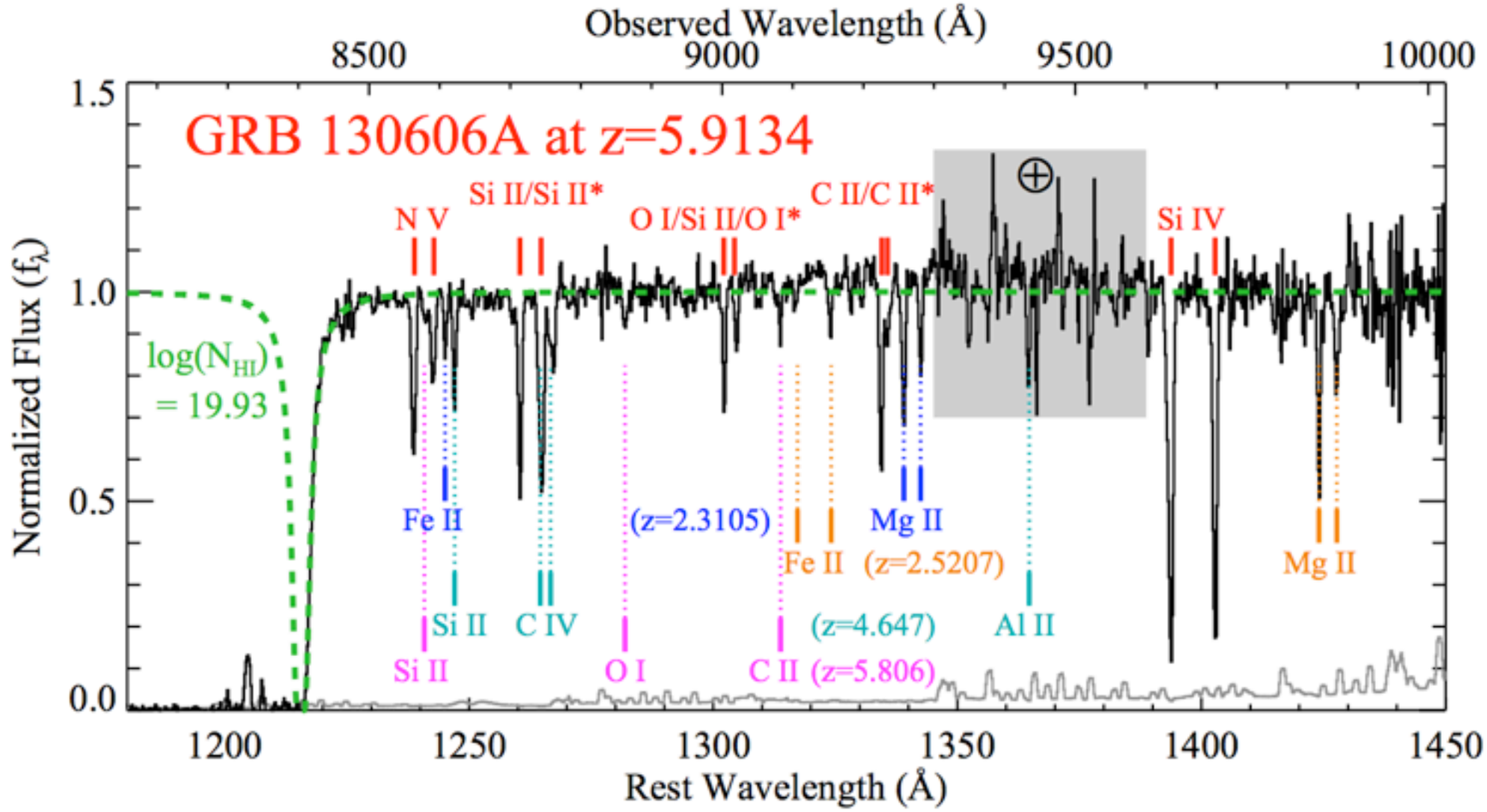
Optical/NIR spectroscopy with MOBIE+IRIS

~25 mag for 5 days @ 200 Mpc

(> 100 SNe within localization area)

NS merger = extremely broad-line, red spectra

GRB as a probe of high-z Universe (by Antonino Cucchiara yesterday)



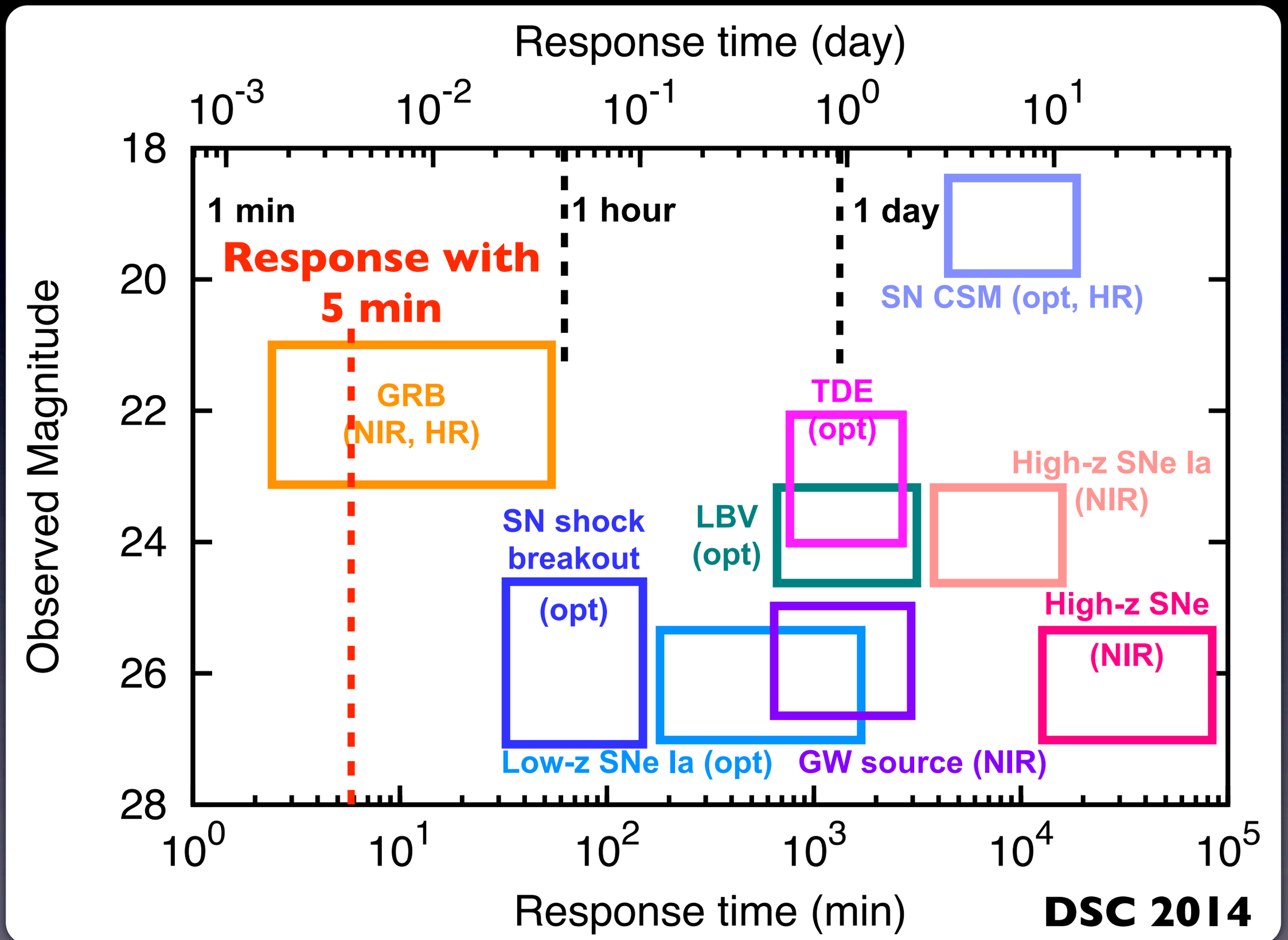
Chornock+13

- Metal abundances
- HI column density
- Ly alpha escape fraction
- Intervening systems

TMT/IRIS can reach z=8-10!

Need more interaction with other ISDTs

Required response time

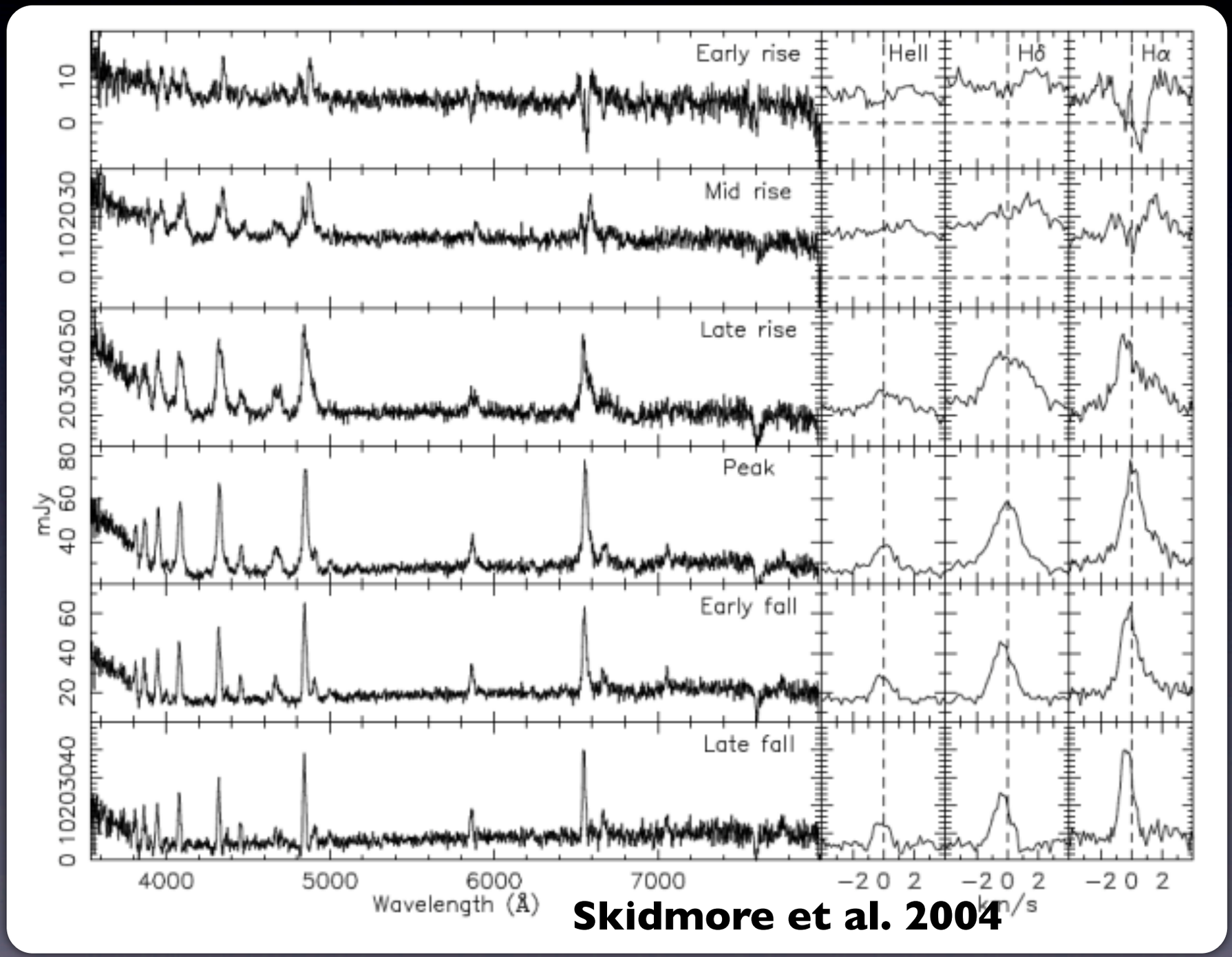


Discussion (yesterday)

- System for ToO?
  - Telescope/instruments become ready in 5 min
    Unique capability of TMT
  - Human judge can easily take more time
    - To maximize the scientific outcome of TMT:
      - Ideally need automated system
      - Prepare templates for observing modes
        (so that observers can quickly select)
- Inter-partner ToO observations?
  - => Key program

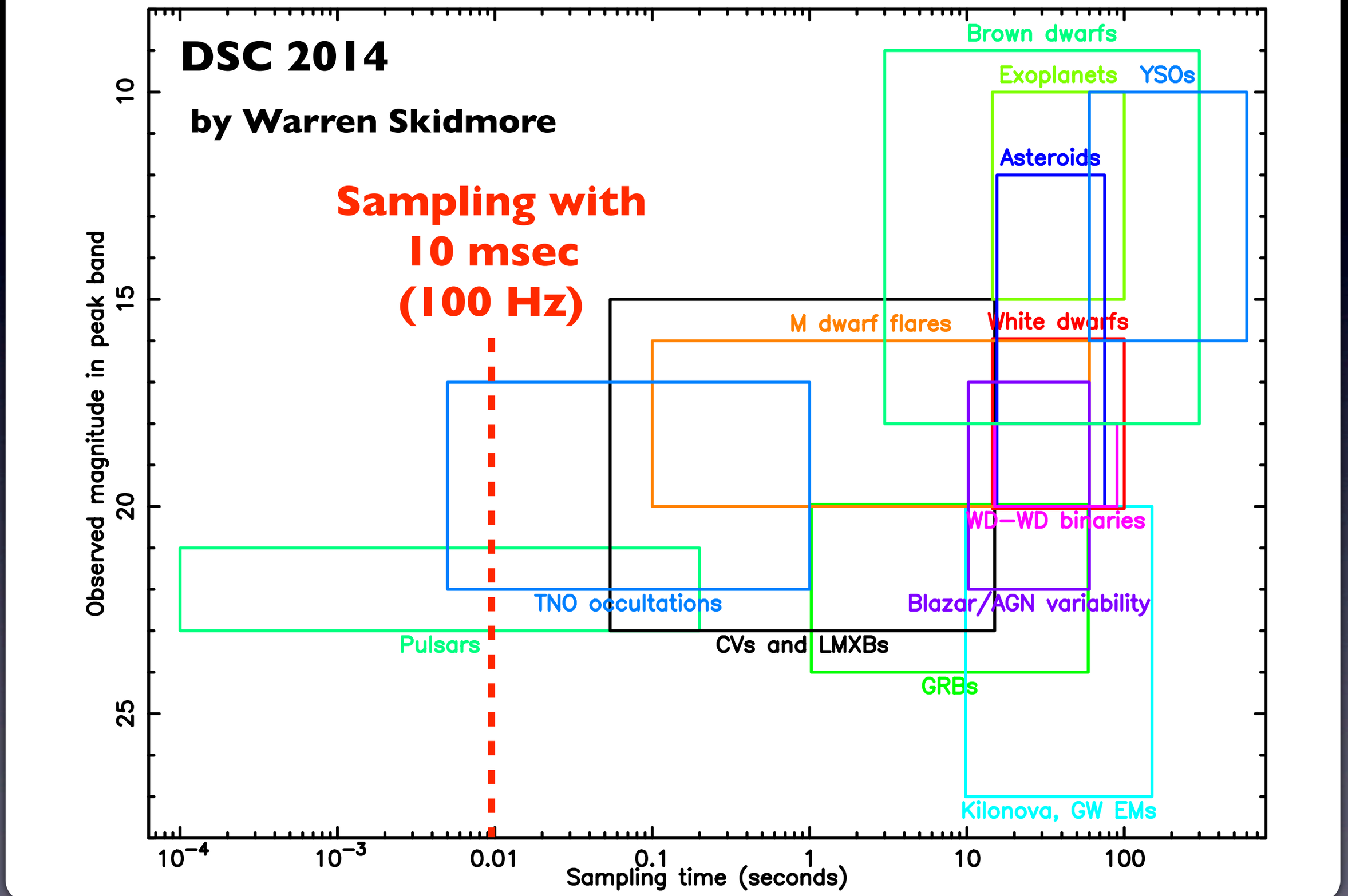
Another frontier: Time-resolved observations

75 ms spectroscopic sampling for cataclysmic variables (also for X-ray binaries)



Skidmore et al. 2004

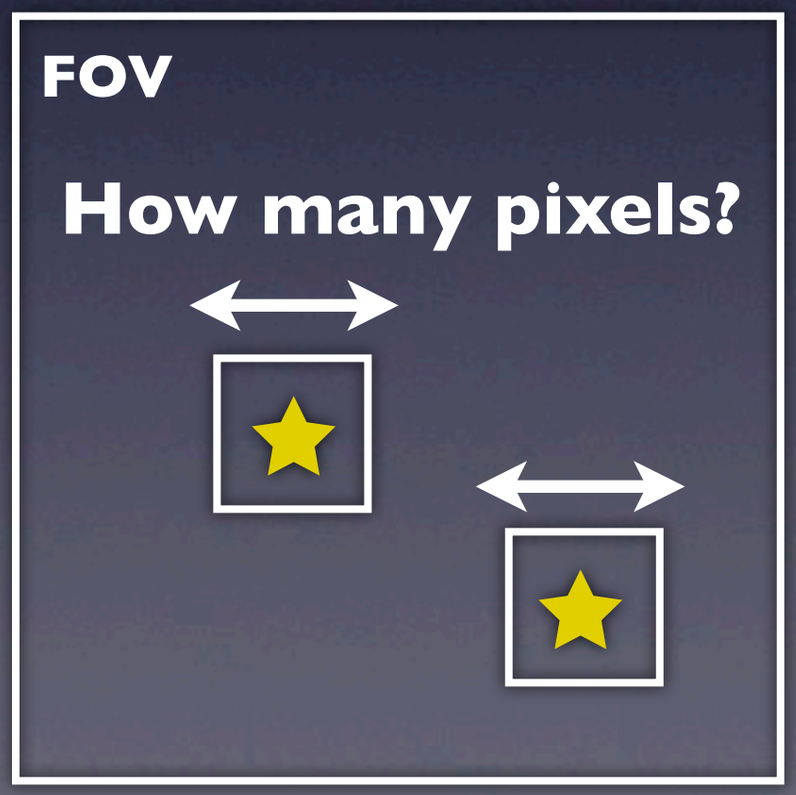
Required sampling time

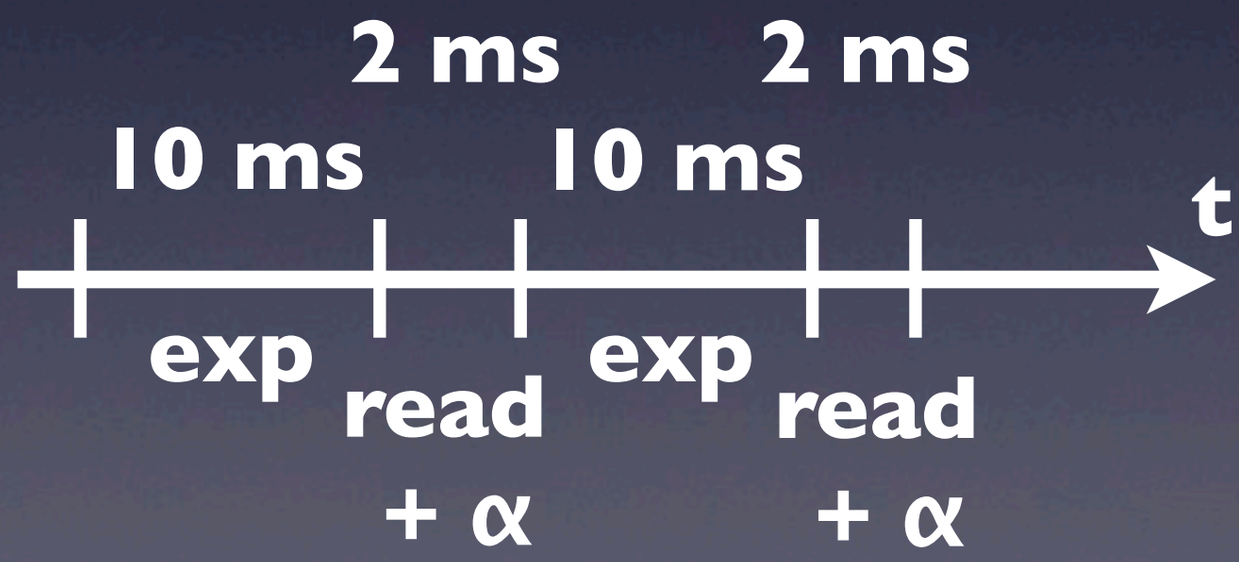


Discussion (yesterday)

- To fully utilize 30m aperture
  - 10 ms sampling
  - 80 % efficiency (= 20% dead time)
  - Accurate, absolute time stamp
    (direct comparison with multi-wavelength data)

- Need only a small part of FOV





Need input from instrument groups

Summary

- **Time-domain science needs TMT**
  - **11 science cases in updated DSC**
- **Time-domain science in 2020s**
  - **Synergy with LSST/HSC transient surveys**
  - **Synergy with gravitational wave telescopes**
  - **Time-resolved observations with 30m aperture**
- **Requirement from time-domain science**
  - **Response within 5 min (=> telescope/operation)**
  - **10 msec sampling with >80% efficiency (=> instruments)**
    Need more communication with instrument groups
- **Key program <=> inter-partner ToO program?**