Tomo-e Gozen
突発天体全天サーベイ観測計画

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http://www.ioa.s.u-tokyo.ac.jp/~tmorokuma/research/WS/201702KOOLSTomoe/ProgramKOOLSTomoe201702.html

岡山UM(2017/09/04-05)でも議論を

Contents

- Purpose
- Tomo-e SN Survey Plan
- Follow-Up Observations
- Summary

提案されたサイエンス@研究会(2017/2)

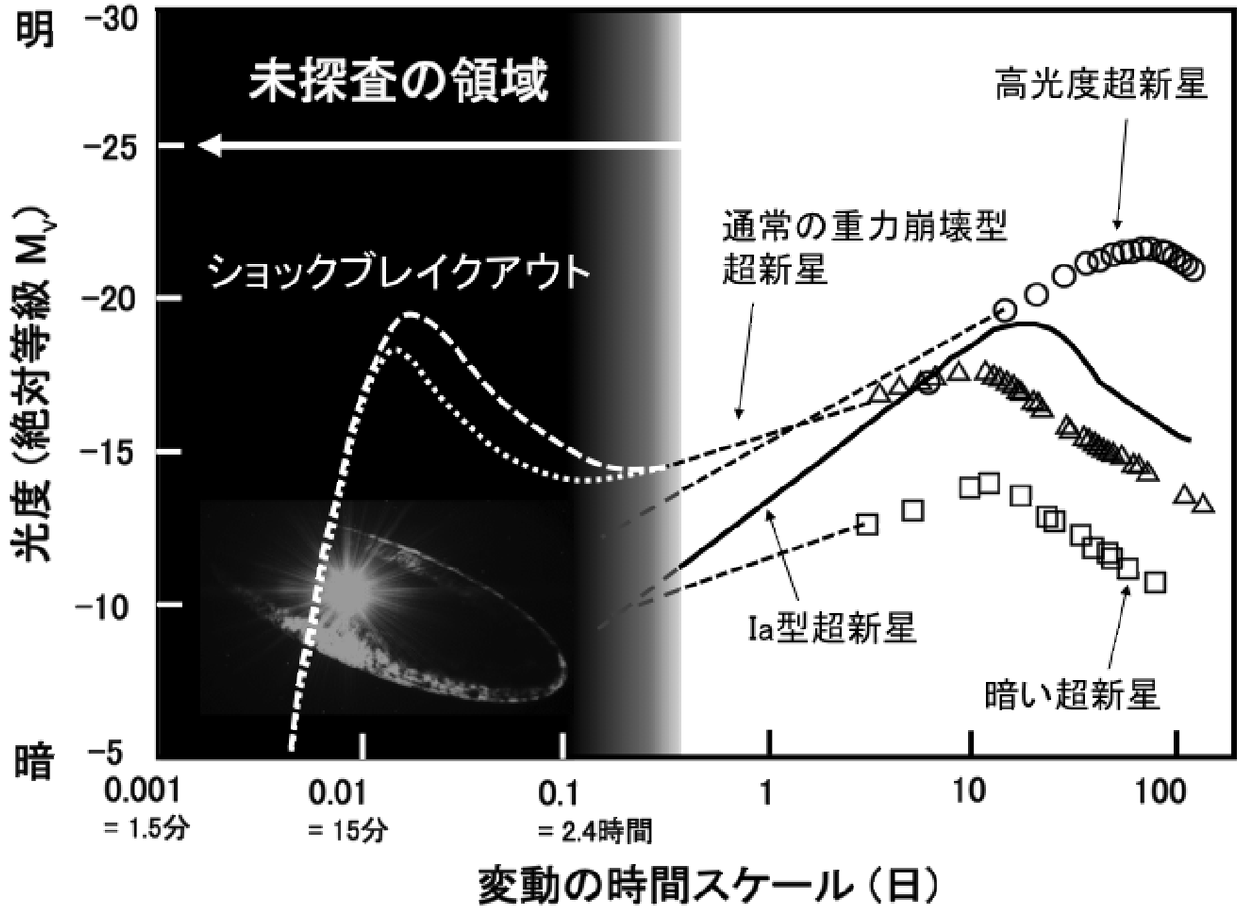
- 超新星
- パルサー
- 重力波
- ニュートリノ
- 偏光サーベイ
- Ultra-Long GRB
- Fast Radio Burst
- AGN
- X-ray transient
- UV transient

- 彗星・小惑星
- 流星
- 近地球天体
- 宇宙デブリ
- 移動天体
- スーパーフレア, M型星フレア, 激変星

Purpose

研　究　目　的（概要）※ 当該研究計画の目的について、簡潔にまとめて記述してください。

本研究では，(1) 84 台の高感度 CMOS センサを用いて 20 平方度を覆う超広視野カメラ *Tomoe Gozen*(以後 *Tomoe*) を開発し，(2) 10,000 平方度を 2時間 間隔でモニターするという過去に無い高頻度の広域観測を，東京大学木曽観測所口径 1m シュミット望遠鏡を用いて 400 夜実施する．これにより，近傍宇宙において，超新星 ショックブレイクアウト(約 10 天体) を含めた約 50 天体の超新星爆発最初期の高精度データを取得し，精密な理論モデルを構築することで，質量放出を含めた重力崩壊型超新星爆発直前の大質量星の最期の姿を明らかにする．加えて，超新星を含む多種多様な短時間変動現象を検出し，動的宇宙の未探査の時間パラメータ領域を開拓する．

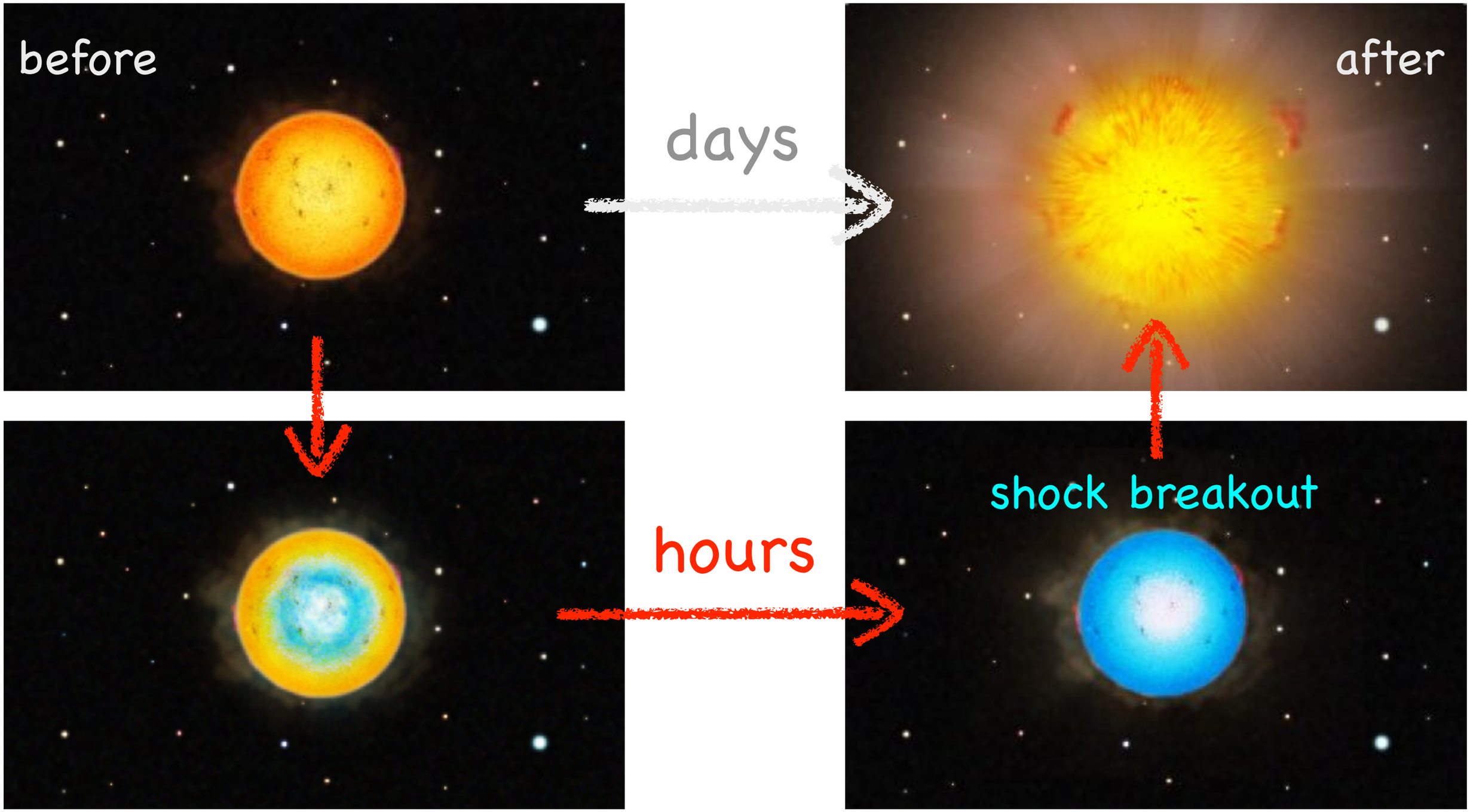


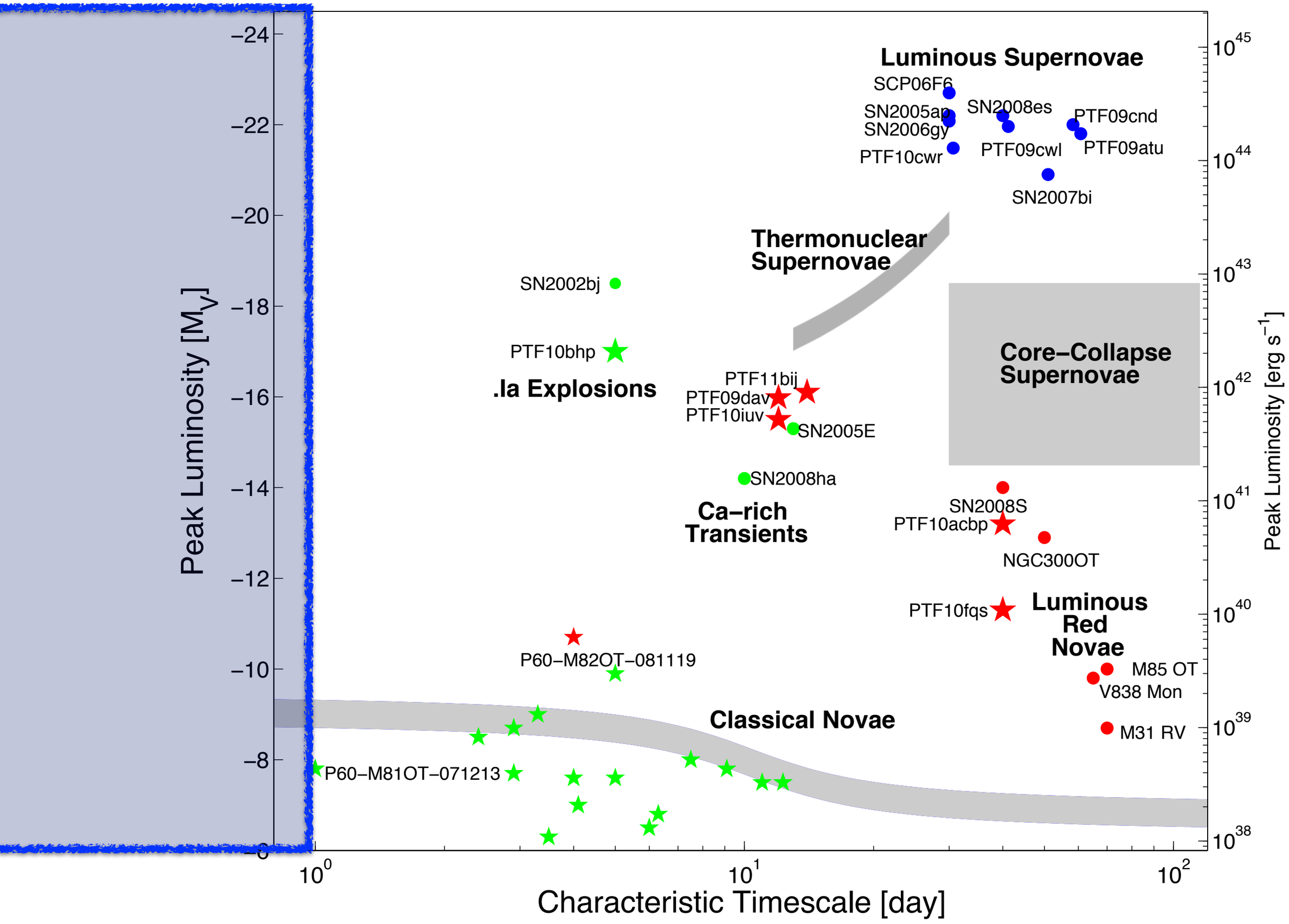
expected #(SN) / yr

- ~1,000 SNe
- ~a few tens young SNe
- a few shock breakouts

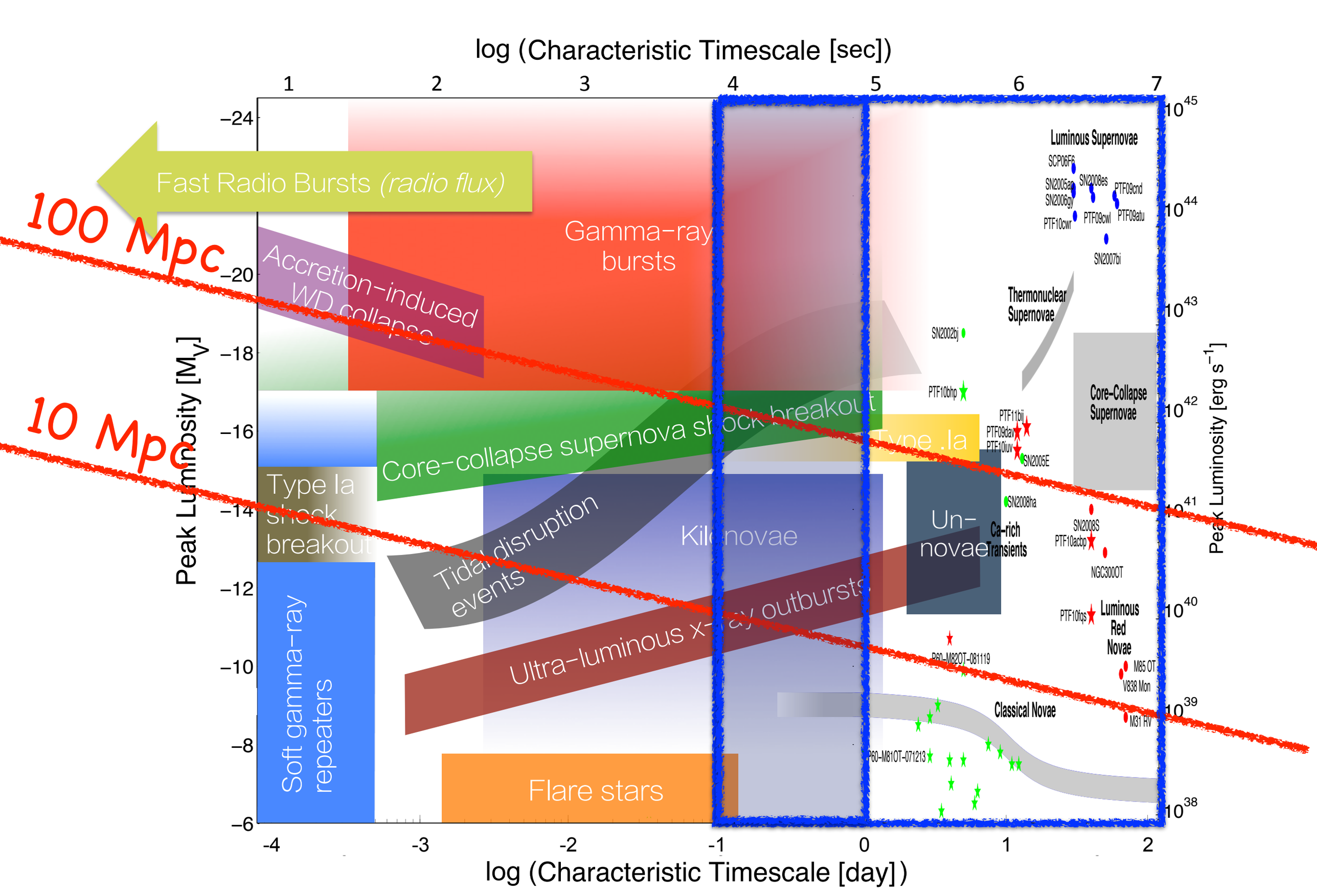
"Moment" of Supernova Explosion

Supernova Shock Breakout





Kasliwal 2011, Cooke (http://www.astro.caltech.edu/~ycao/B&ETalks/B&E_FRBs_Cooke.pdf)



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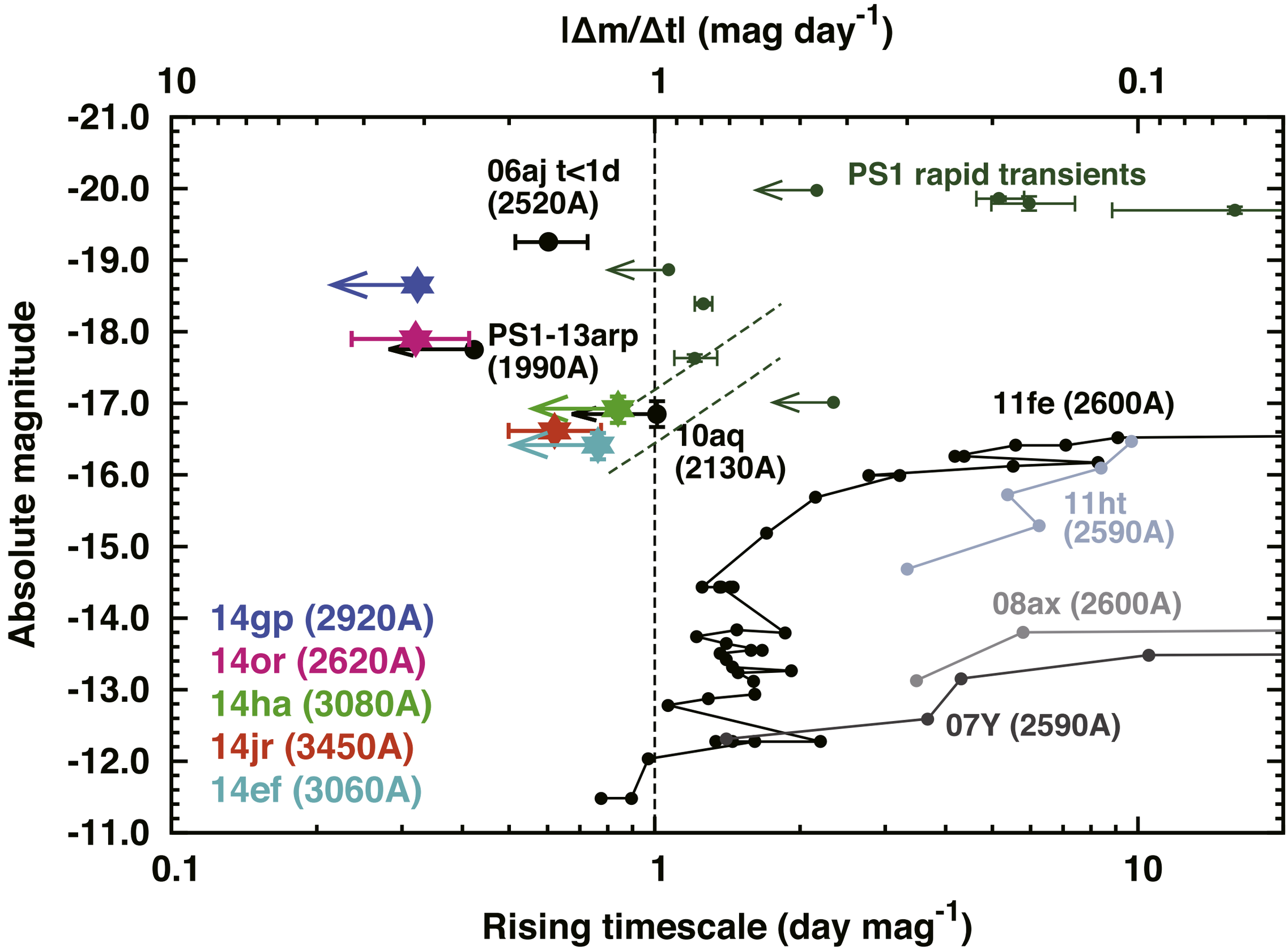
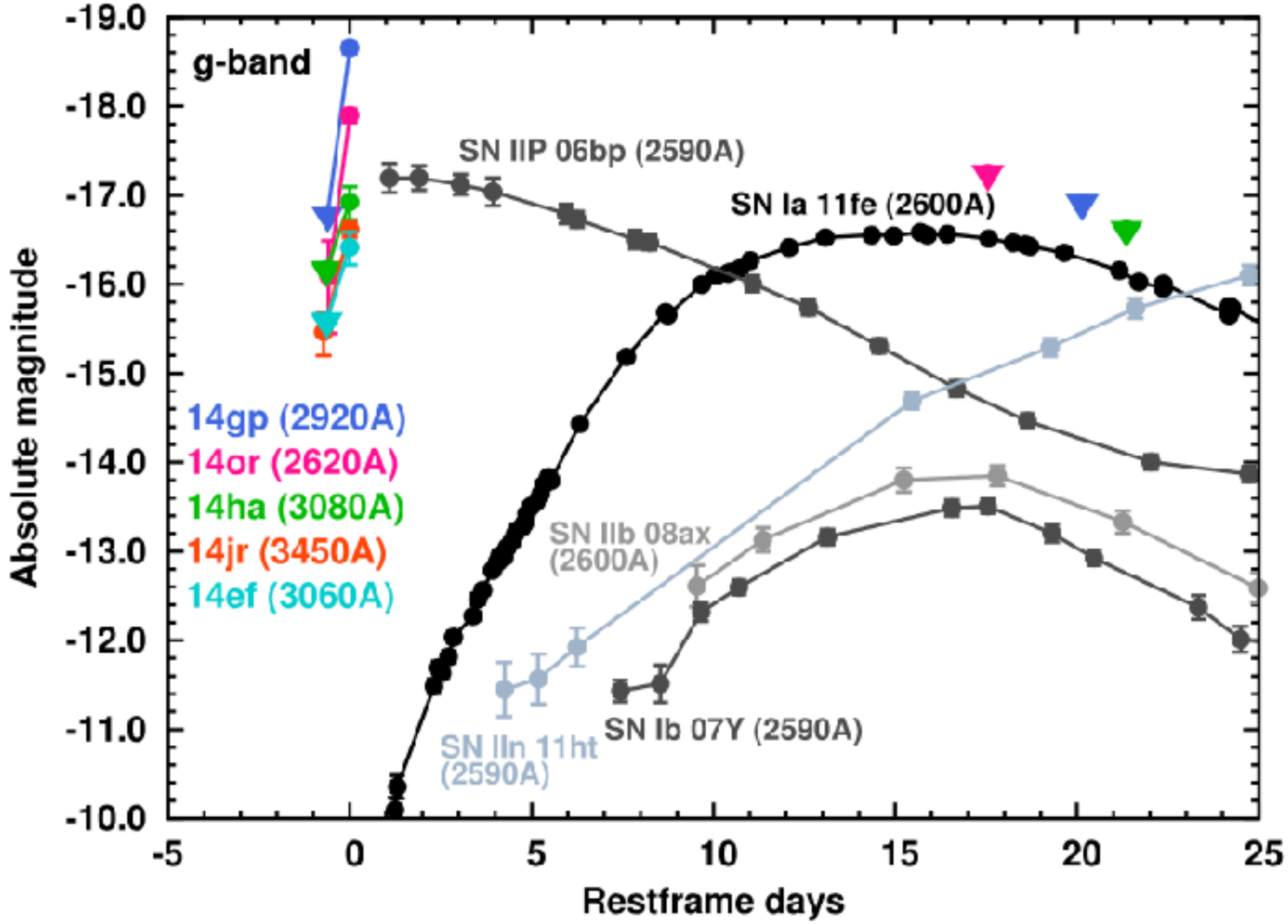


Tanaka, Tominaga, TM+2016, Subaru/HSC (e.g, Drout+2014, PS1)



Lower-z, Brighter ==> Higher S/N

Denser Sampling

Quicker Follow-up

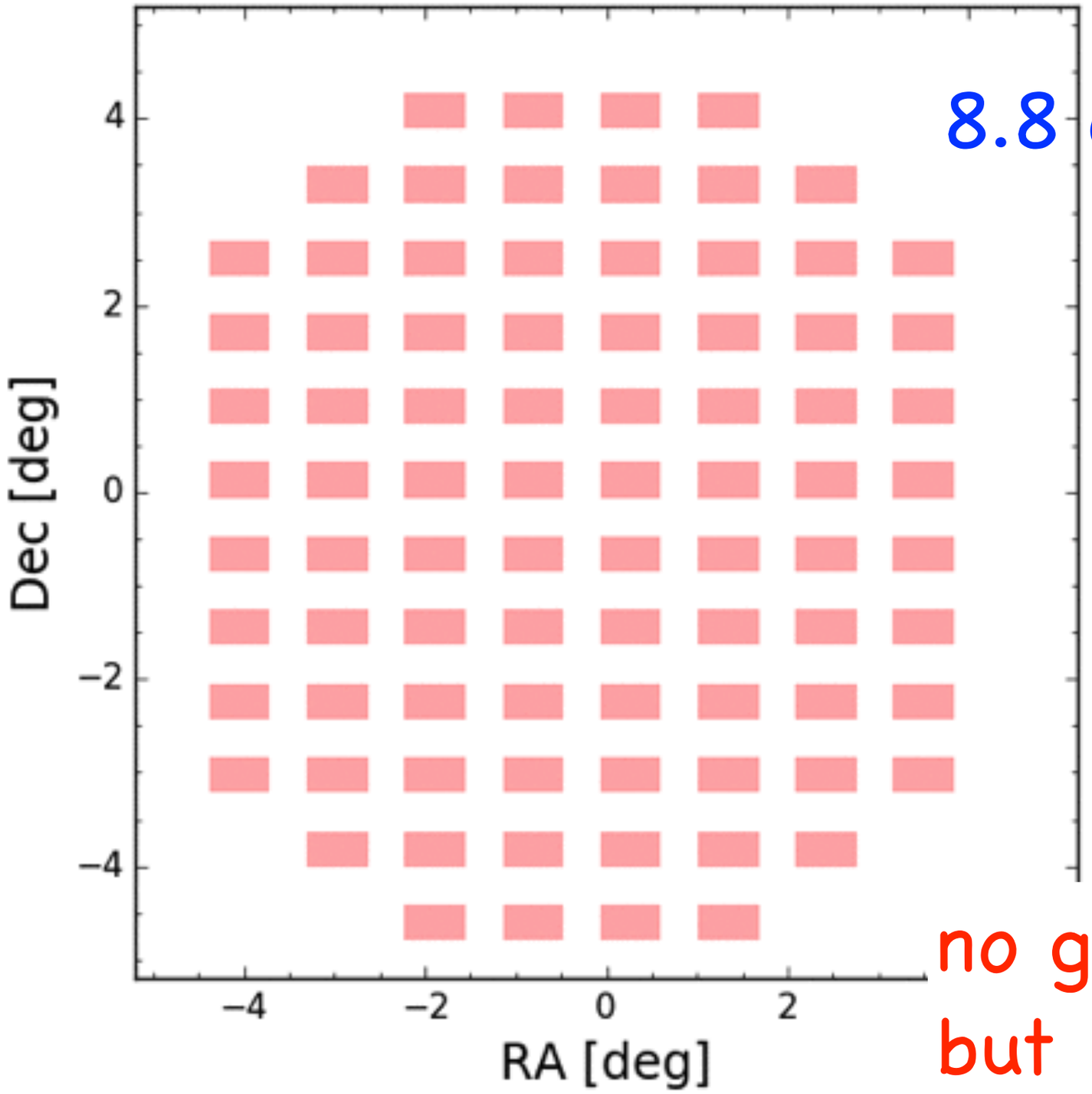
Tanaka, Tominaga, TM+2016, Subaru/HSC (e.g, Drout+2014, PS1)

突発天体全天サーベイ観測計画

10,000 deg2 - 2 hr cadence - 18 mag depth
10,000 deg2 - 1 day cadence - 19 mag depth

- no filter: effectively g+r bands
- 1 visit
  - 3 sec exposure: [0.5 sec exposure] x 6
    - ~18 mag
  - 2x3 or 2x2 dithering to fill the gaps
  - ~60 deg2 (partially vignetted by ~30%)
- cadence: 2 hours
- survey area (per 2 hours): ~10,000 deg2 (EL>30 deg)
- 3-5 times visits per night
  - ~19 mag for daily stacked data
- weather factor: usable (half), photometric (30%)

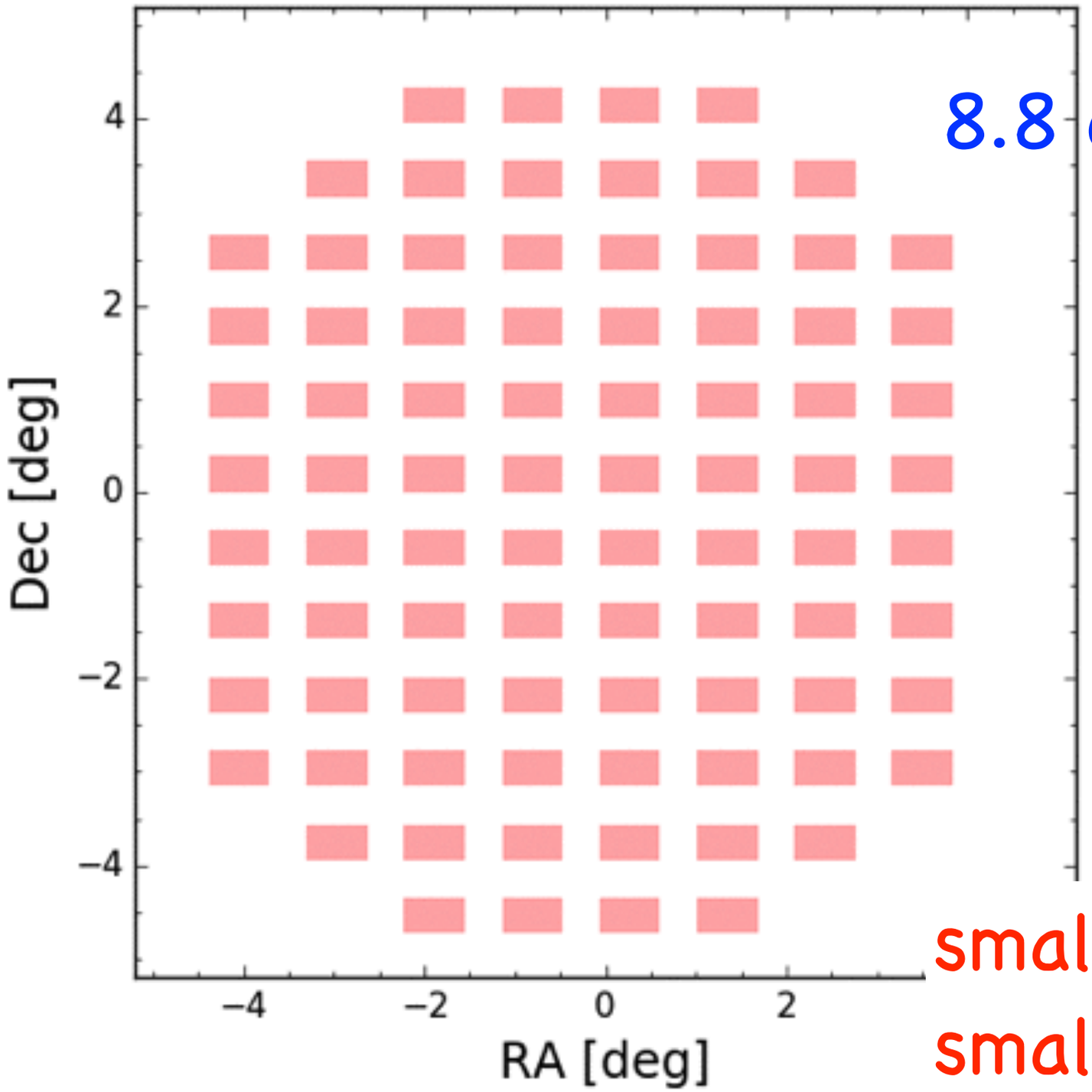
2x3 dithering



8.8 deg (diameter)

no gap
but large overlap

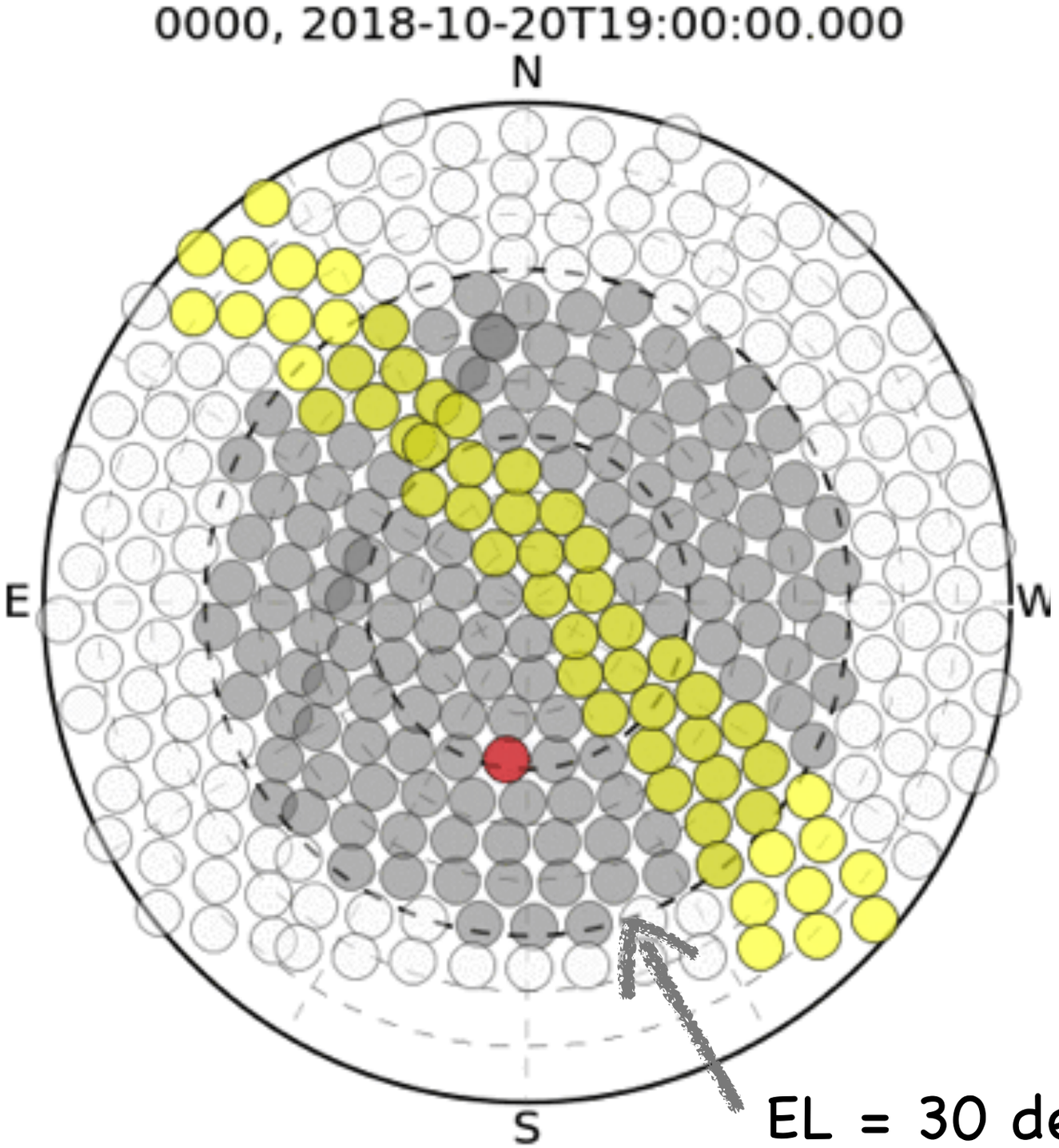
2x2 dithering

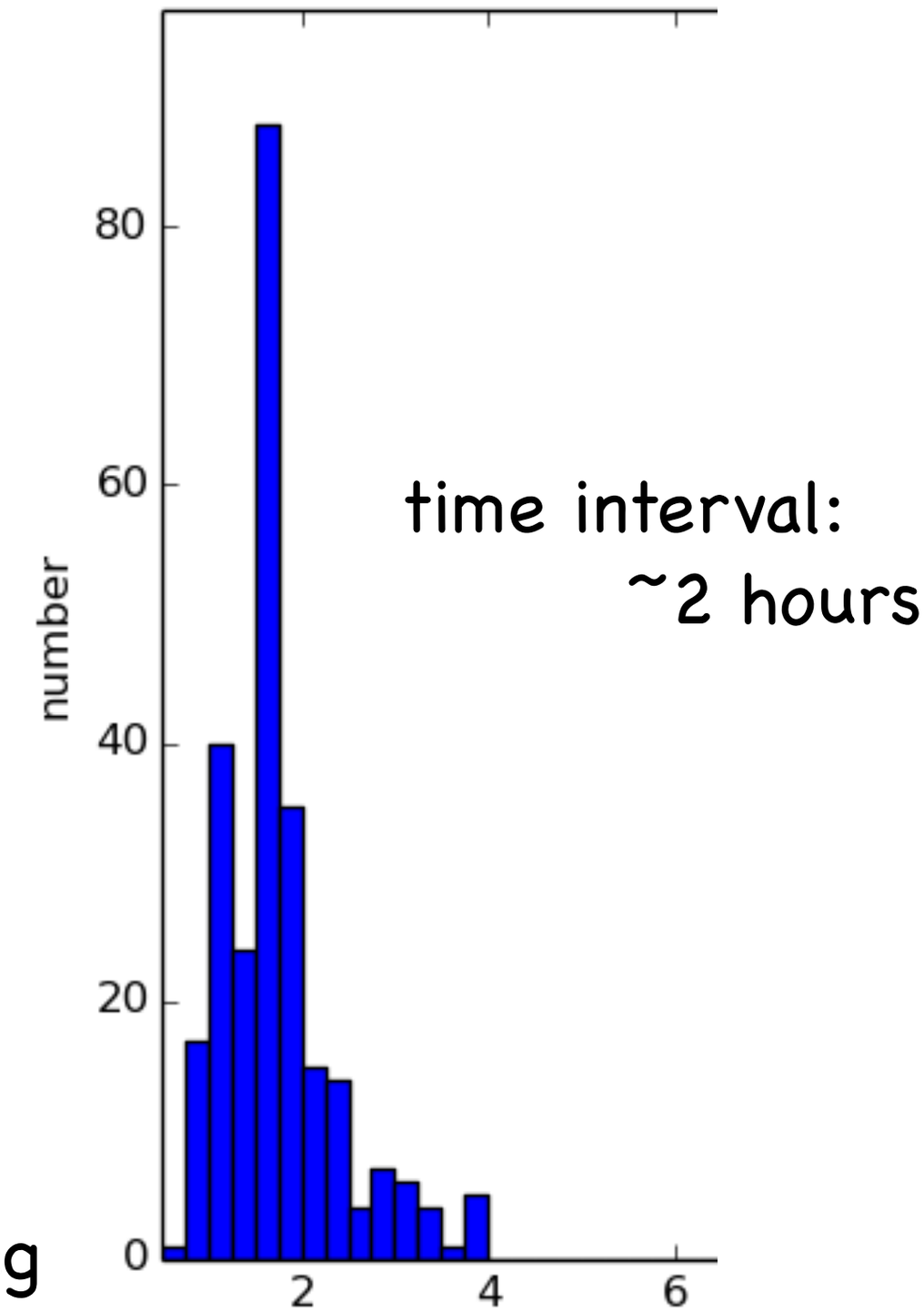


8.8 deg (diameter)

small gap
small overlap
(to be quantified)

Survey Simulation (2017/02, Kyoto)

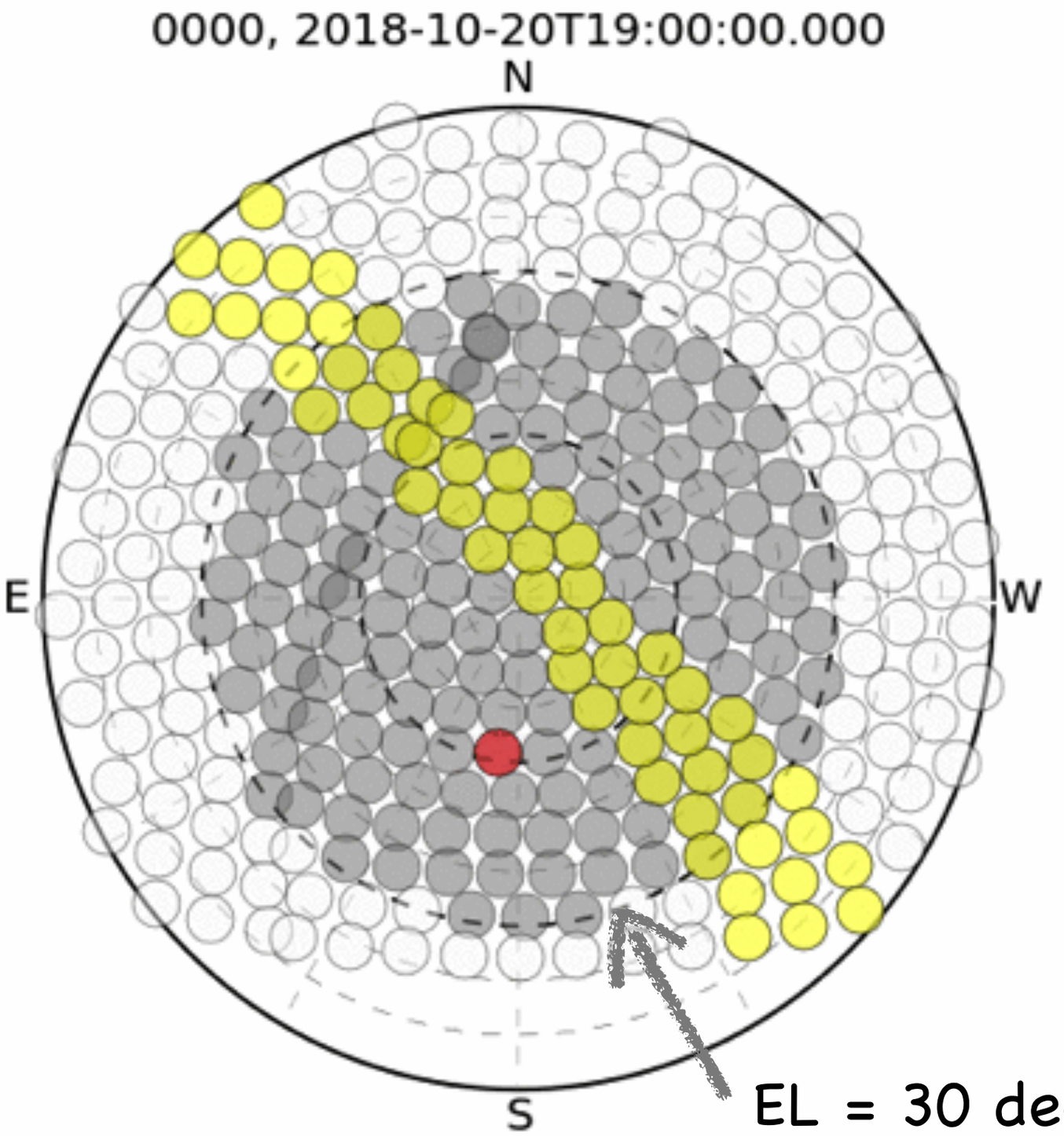




time interval:
~2 hours

Galactic Plane (< +/- 10 deg)

Survey Simulation (2017/07)



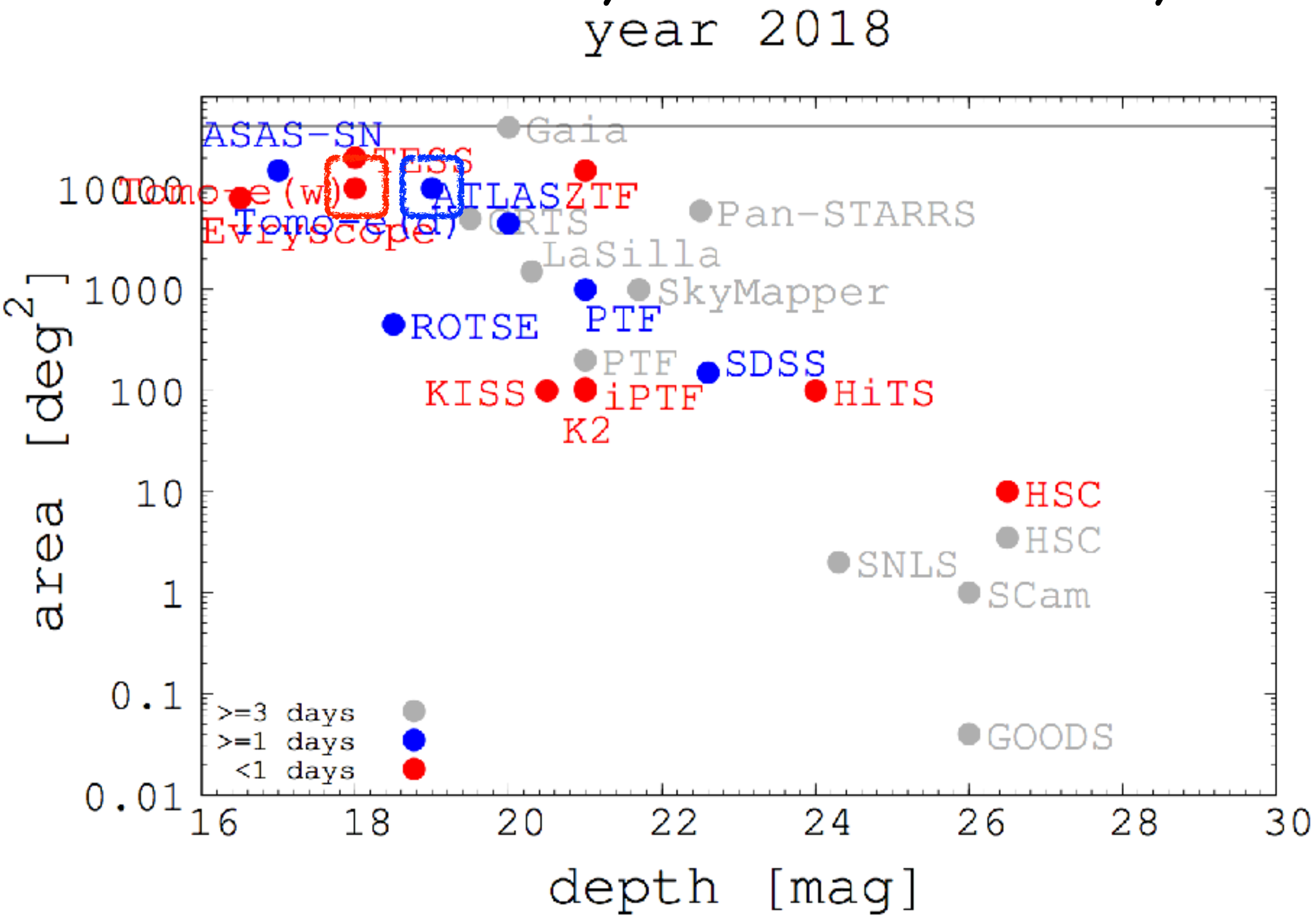
Tomo-e Q1
- 5 deg2
- 1 visit / night

Galactic Plane (< +/- 10 deg)

Tomo-e Gozen SN Survey vs Kiso Supernova Survey (KISS) w/ KWFC

	Tomo-e SN Survey	KISS
instrument	Tomo-e Gozen	KWFC
sensor	CMOS	CCD
readout time	~0 sec	120 sec
period	2017/12-	2012/4-2015/9 (3.5 yrs)
survey area [deg2]	10,000	50-100
cadence	2 hours / 1 day	1 hour
exposure time / visit	3 sec	180 sec
depth	18 mag / 19 mag	20-21 mag
filter	no (~g+r)	g
#(SBOs), #(SNe) / yr	5, 1000	O(0.1)-O(1), 100
data storage	daily-stacked image SN cutout images	all data saved
reference	-	TM, Tominaga, Tanaka+2014

Tomo-e Gozen SN Survey vs other SN surveys



TM, Tominaga, Tanaka+2014

Kiso/~~KWFC~~ observations

Tomo-e Gozen

data transfer

raw images

Ohsawa's pipeline

automatic standard data reduction with KWFC data reduction pipeline

reduced images

catalogs@DB

cosmic ray rejection with *L.A.cosmic*, image warping to the SDSS with *wcsremap*, image subtraction with *hotpants*

subtracted images

SN pipeline

object detection with *SExtractor*

transient candidate catalogs

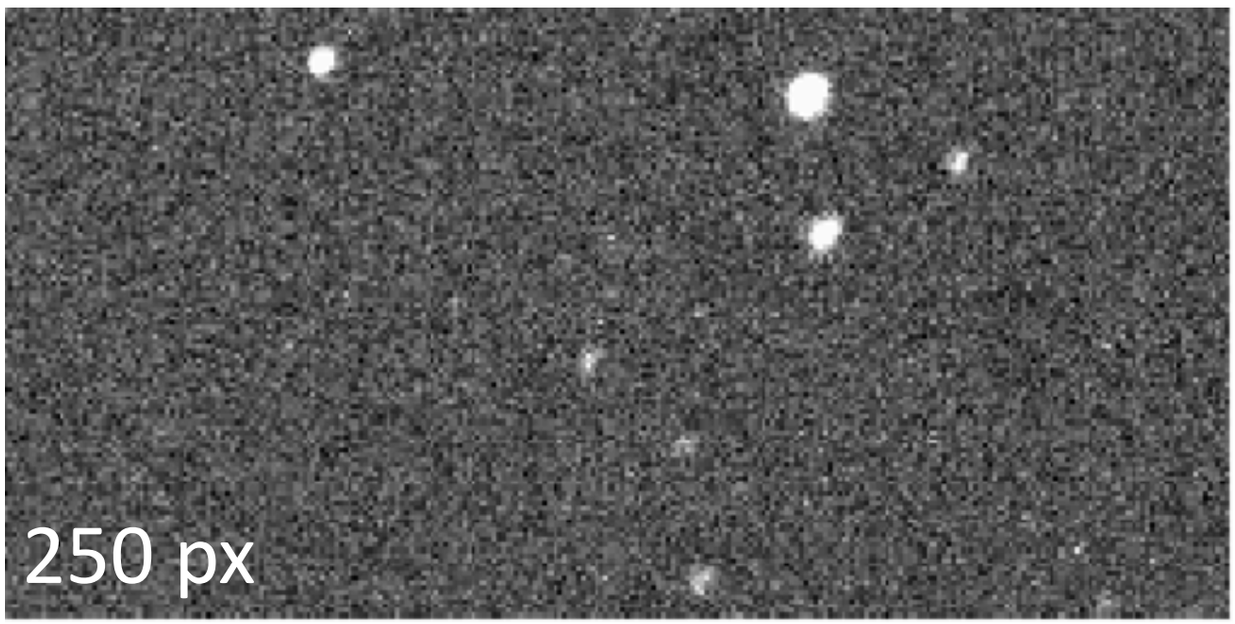
candidate registration with mysql, multi-wavelength data matching, and visual target screening on web browser

follow-up observations

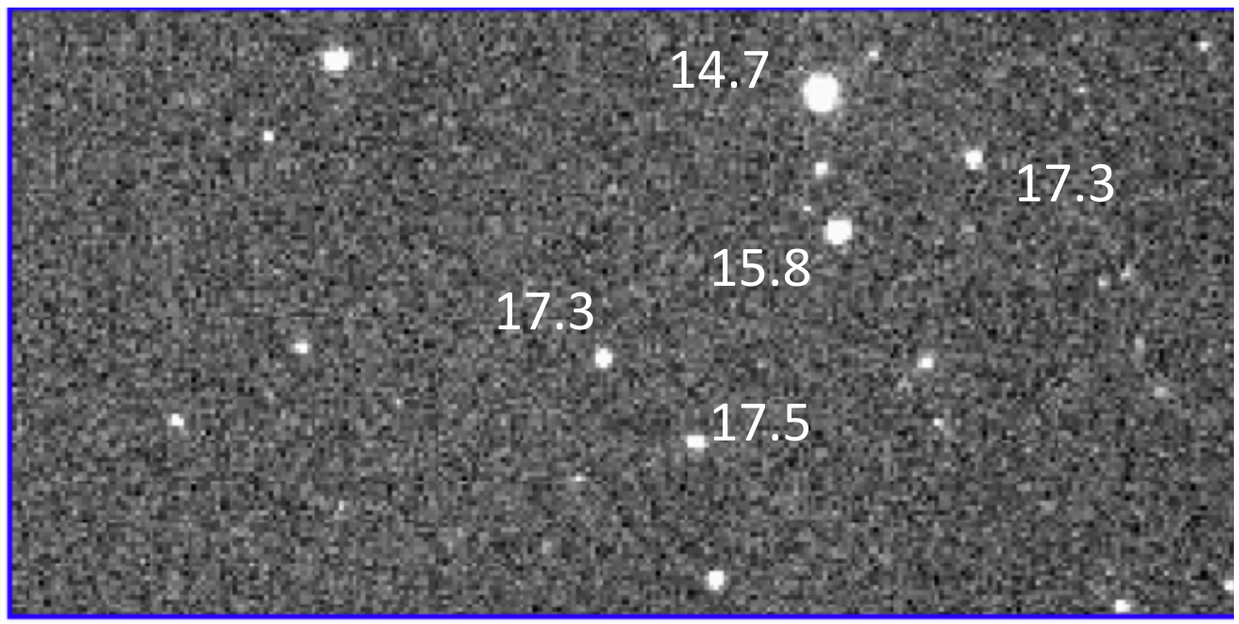
Which objects will be followed up, studies?

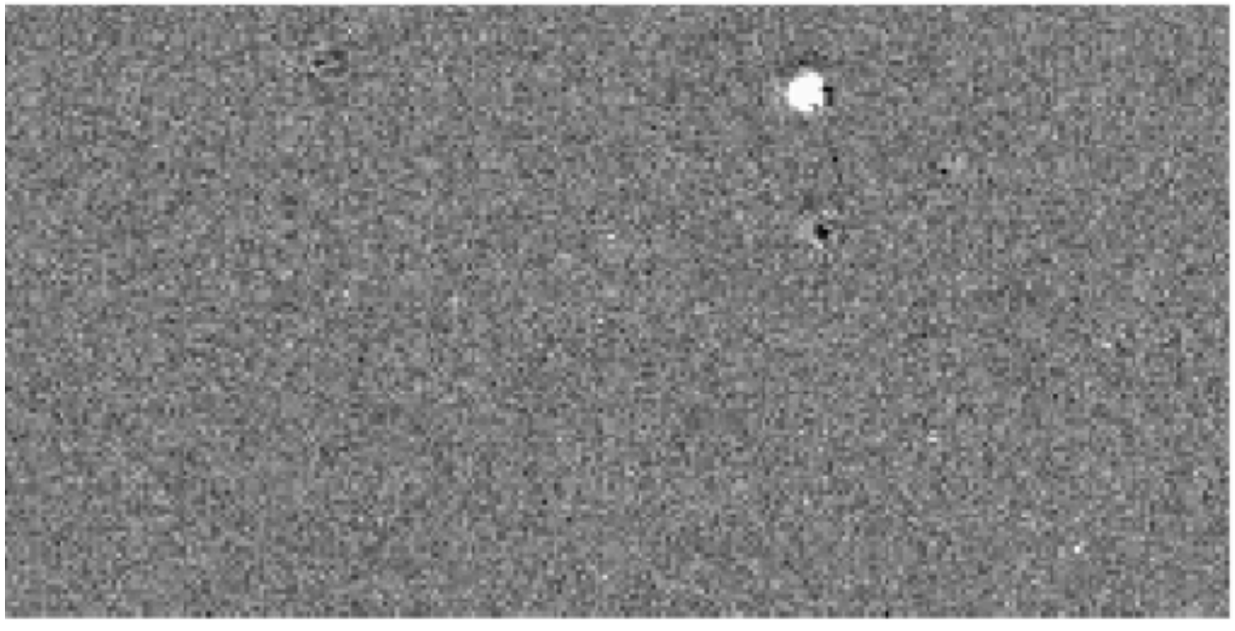
Image Subtraction

Tomo-e



SDSS r





(Tomo-e) - (SDSS r)

- Pan-STARRS1 (3pi)と
- > 12-14 mag (PS1 saturation)
  - それより明るい天体は
    - 測光ベース
    - Tomo-e同士引き算
- 1 core for 1 chip ==> 専用計算機

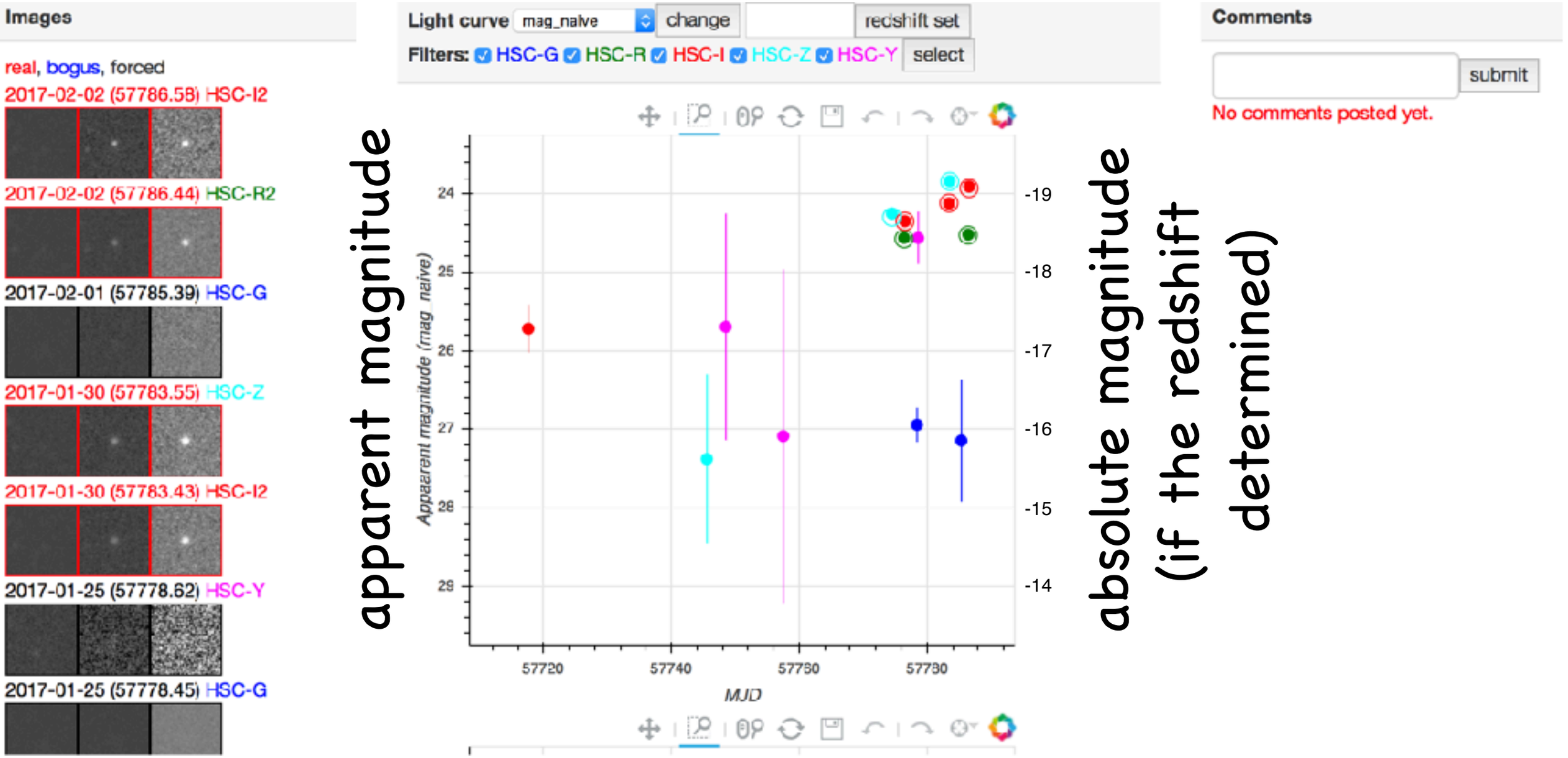
Target Handling System (Subaru/HSC)

developed by M. Tanaka et al.

Hyper Suprime-Cam (on 8.2m Subaru telescope)

Target Handling System (Subaru/HSC)

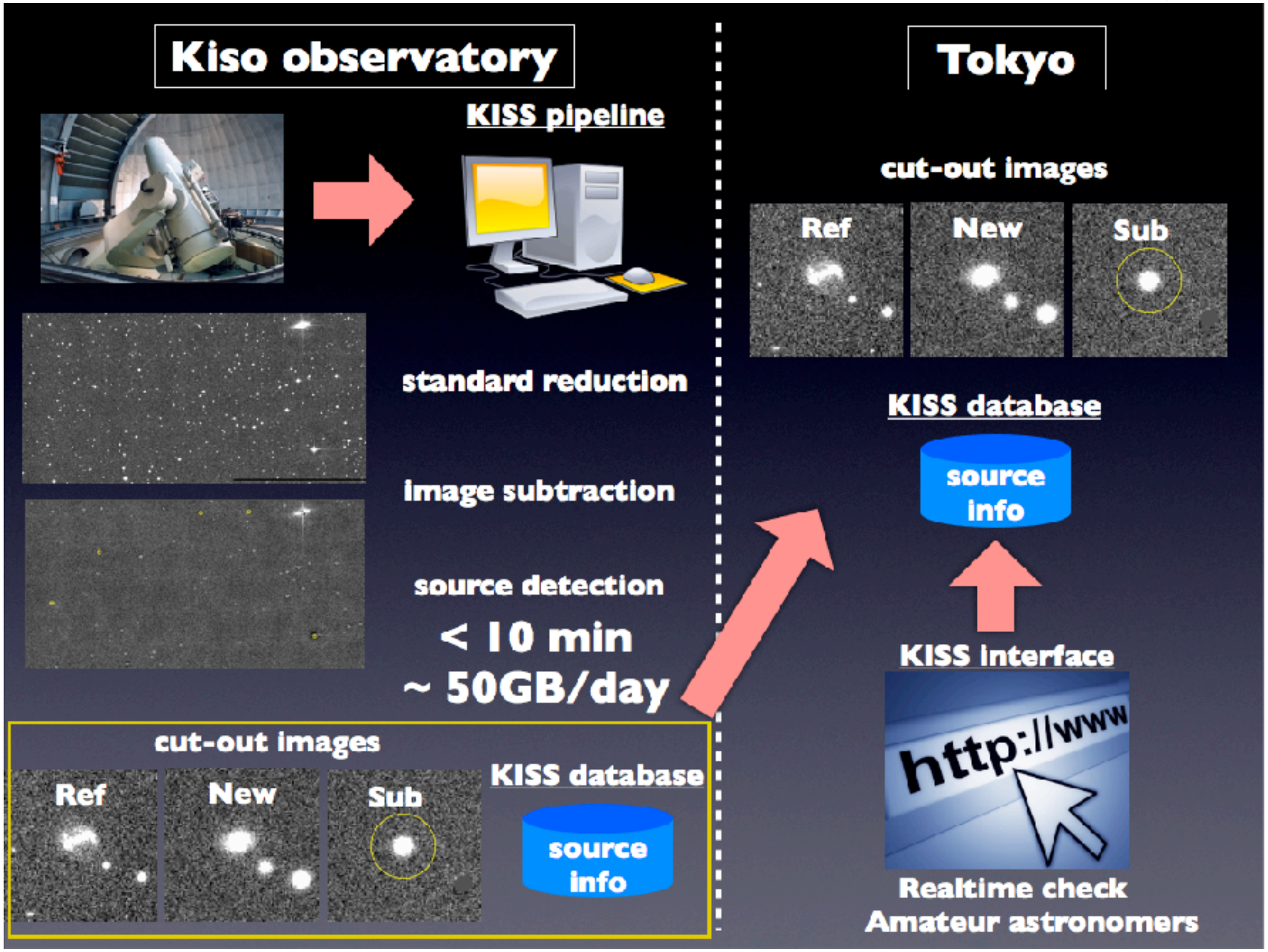
developed by M. Tanaka et al.



Hyper Suprime-Cam (on 8.2m Subaru telescope)

"no-human" alerts for bright candidates

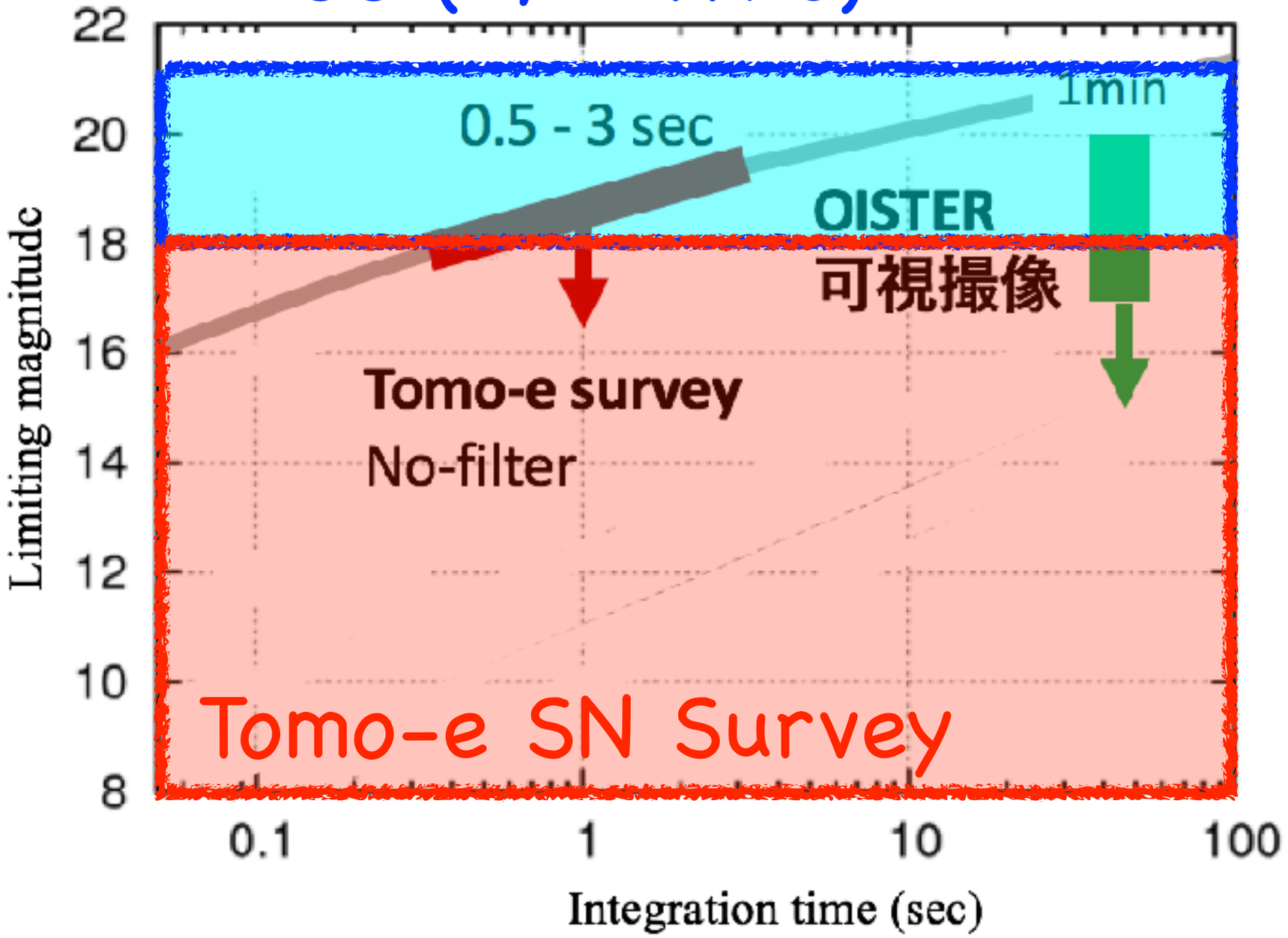
Collaboration w/ Amateur Astronomers Again?



!!! Follow-Up Observations !!!

- After discovering SN candidates...
  - spectroscopic identification
  - multi-band light curves
- most successful recent SN projects
  - PTF, iPTF (Palomar 1.2m)
    - "550 nights of spectroscopy in 4.5 years" (M. Kasliwal)
  - ASAS-SN (0.14m x 8 x 2)
    - bright, <17 mag. Easily observed w/ 1m tel.
- KISS + KISS collaboration + OISTER
  - # of spectroscopic observations (29 spec-ID+) limited.
    - TM+2014, Tanaka+2014, Gabanyi+2017, TM+2017
  - because of faintness (g>19)...
    - brightest spec-ID: g=16.8, SN 2012cm
    - faintest spec-ID: g=20.6, SN 2015aa

KISS (w/ KWFC)



5σ検出限界

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“flash” imaging + spectroscopy

- 国内(+日本よりやや西)での観測が理想的
  - 撮像: Kanata/HONIR(+HOWPol), MITSuME
  - 分光: Kanata/HONIR(+HOWPol), 3.8m/KOOLS-IFU
- アラート・情報共有
  - webに情報(天体名, 座標)をアップロード
    - 各観測所へ定期的に見に行ってもらう
    - 東工大/MITSuMEで実装
    - 追加情報: priority, visibility, finding chart...?
- 信頼性の高い天体は一部自動に?

Summary

- 3秒積分, 2時間cadence, 18 mag, 10000 deg2
  - 1日足すと19 mag
- サーベイ検討WG (tomoesurvey@ioa.s.u-tokyo.ac.jp)
- スケジュール
  - 2017/8: 望遠鏡"サーベイ"試験
  - 2017/12: 試験サーベイ w/ Q1 ==> Q2 ==> Q3 ==> Q4
- To-Do
  - Tomo-e DB ==> 各種突発天体(候補)の抽出
  - アラート準備
  - Image Subtraction w/ PS1データ
  - KISS/HSC-like データ管理システム