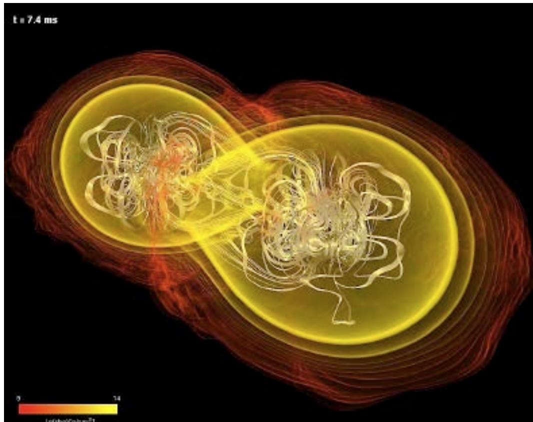
Japanese electromagnetic follow-up network for gravitational wave sources: J-GEM

Michitoshi Yoshida, Hiroshima University
on behalf of the J-GEM collaboration

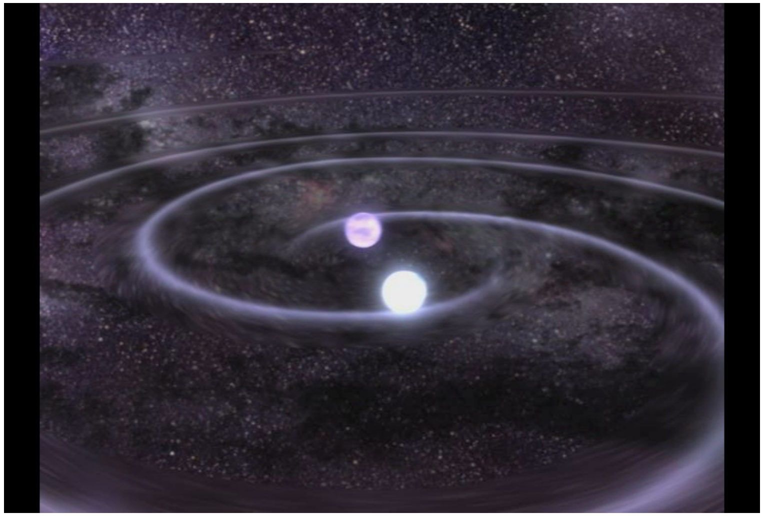
Importance of EM follow-up of GW events

EM identification may provide

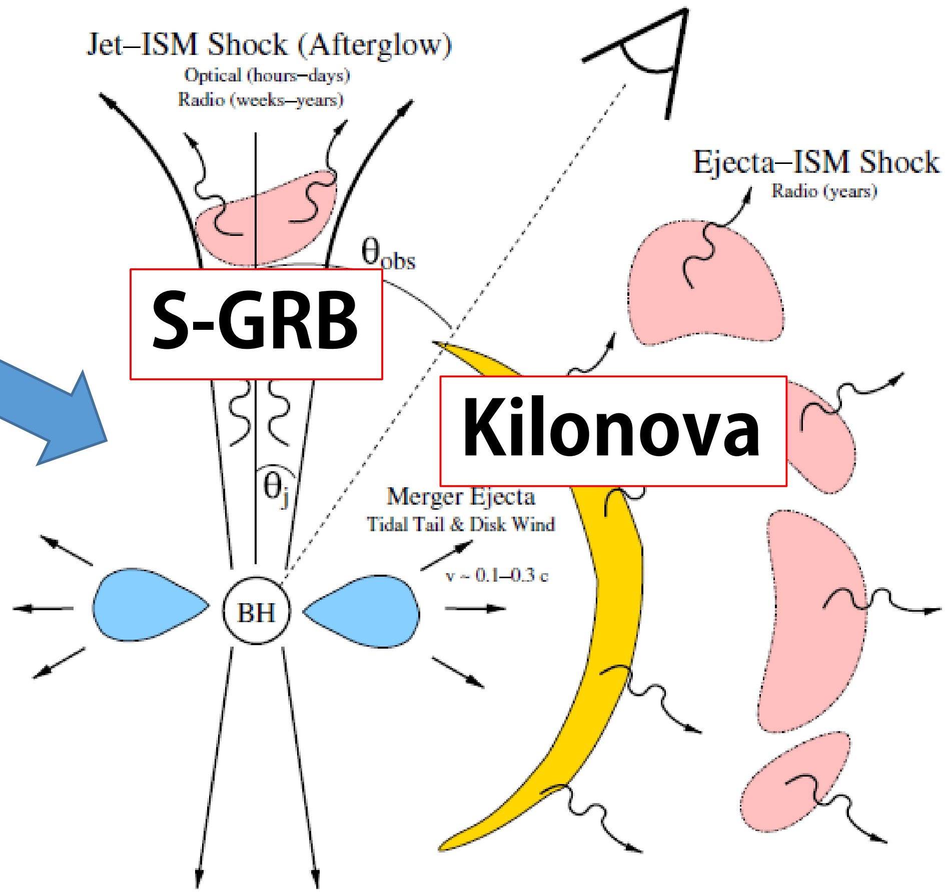
- **Where it is hosted,**
  - **Accurate localization**
  - **Accurate distance**
  - **Their environments (where it is in a galaxy, which type of galaxy, metallicity, density, etc.)**
- **Information of the accompanying physics and progenitors**
  - **Equation of state of neutron star**
  - **Physics of explosion associated with GW**
  - **r-process nucleosynthesis**



Searching for EM counterparts is crucial for understanding the nature of GW sources



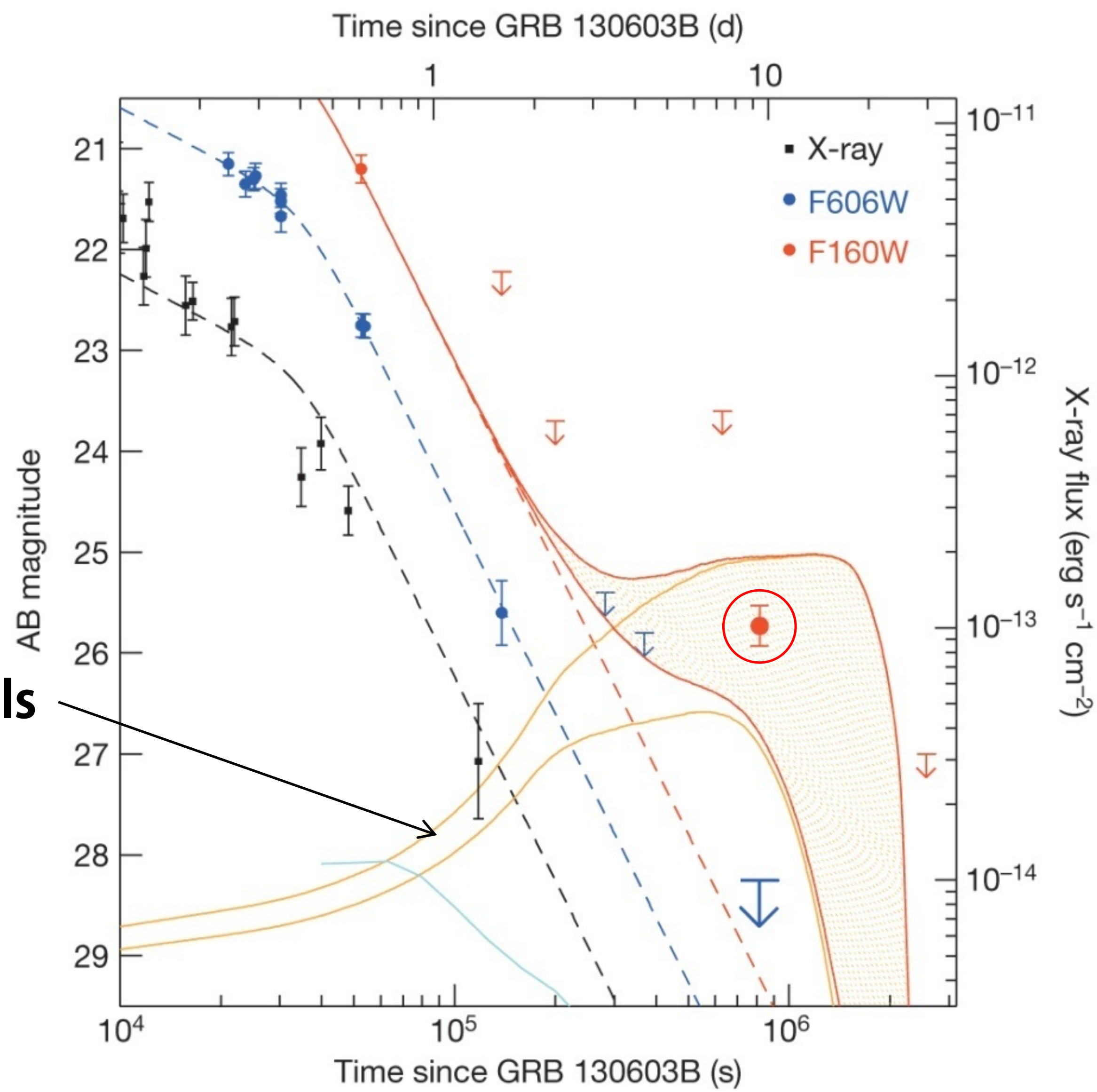
The most promising GW sources ➔ NS-NS merger



Metzger & Berger 2012

Kilonova candidate associated with GRB130603B.

NR Tanvir *et al.* (2013)



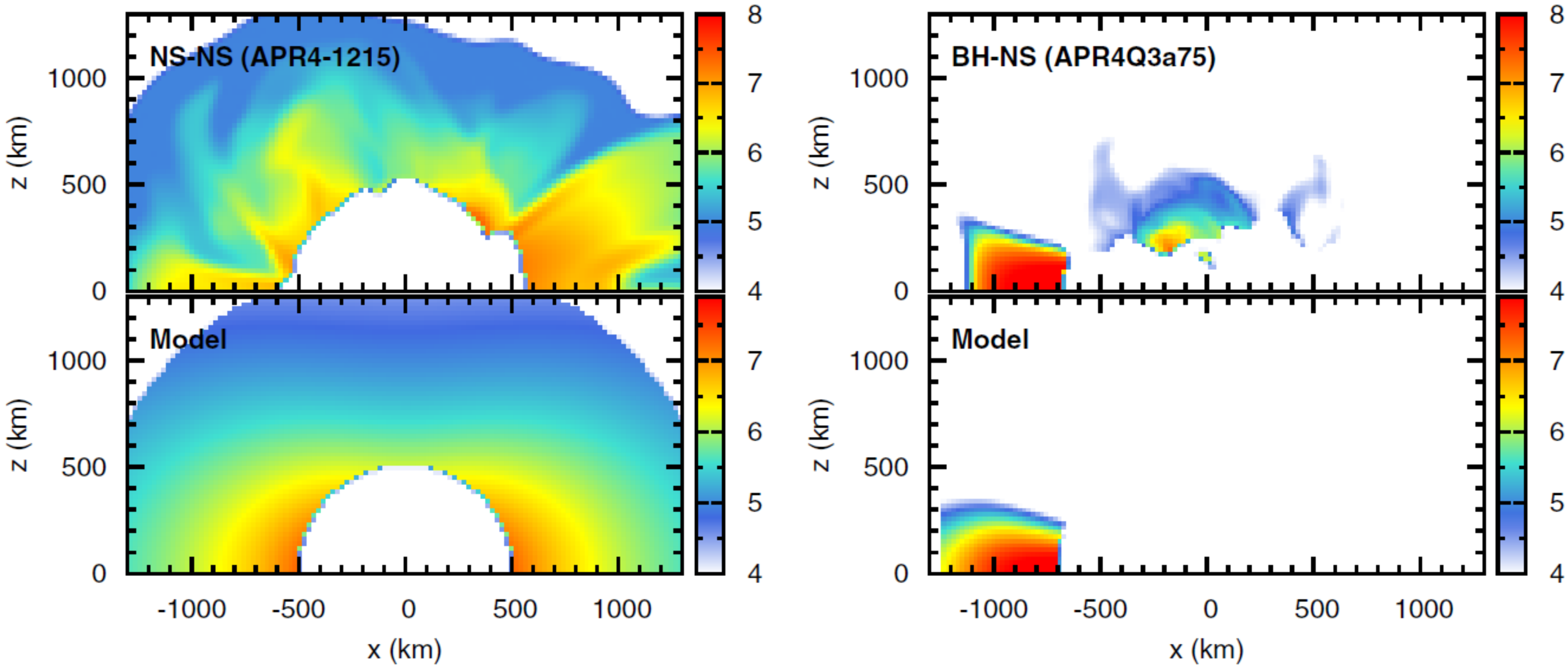
Kilonova models

ejecta mass
10^{-1} $M_\odot$
10^{-2} $M_\odot$

Numerical simulations of kilonova

Tanaka, et al. 2014

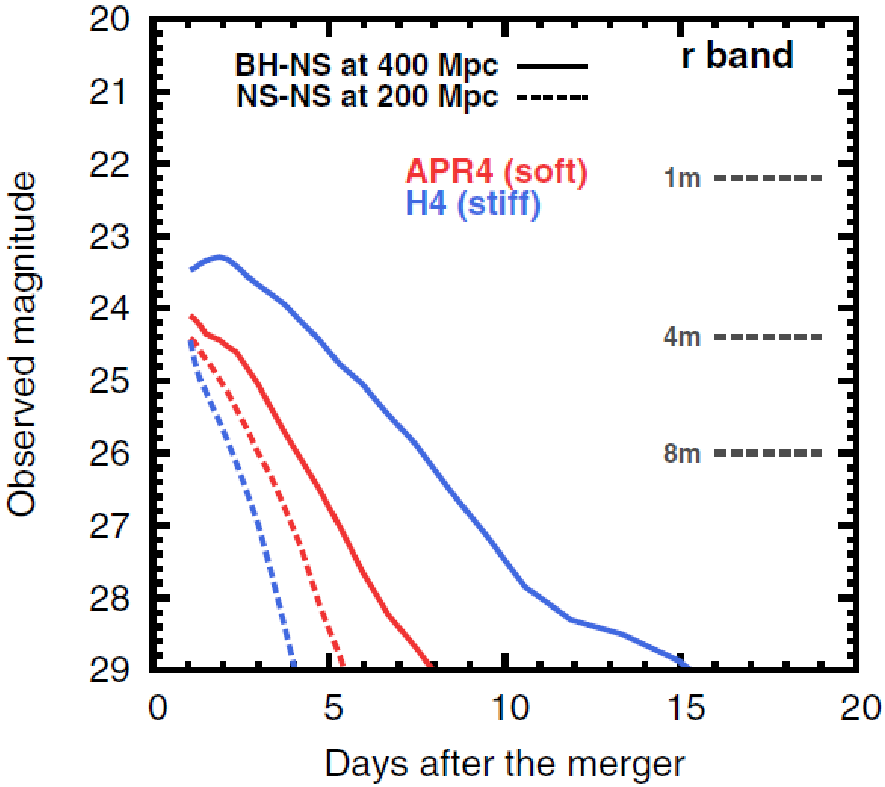
Matter ejection by NS-NS、BH-NS coalescence

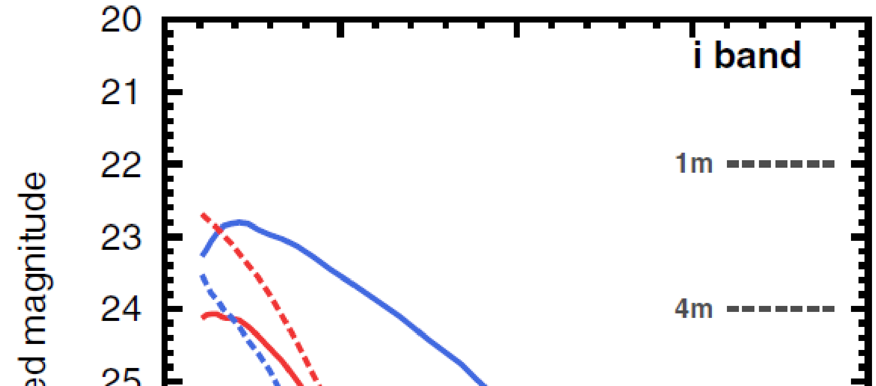


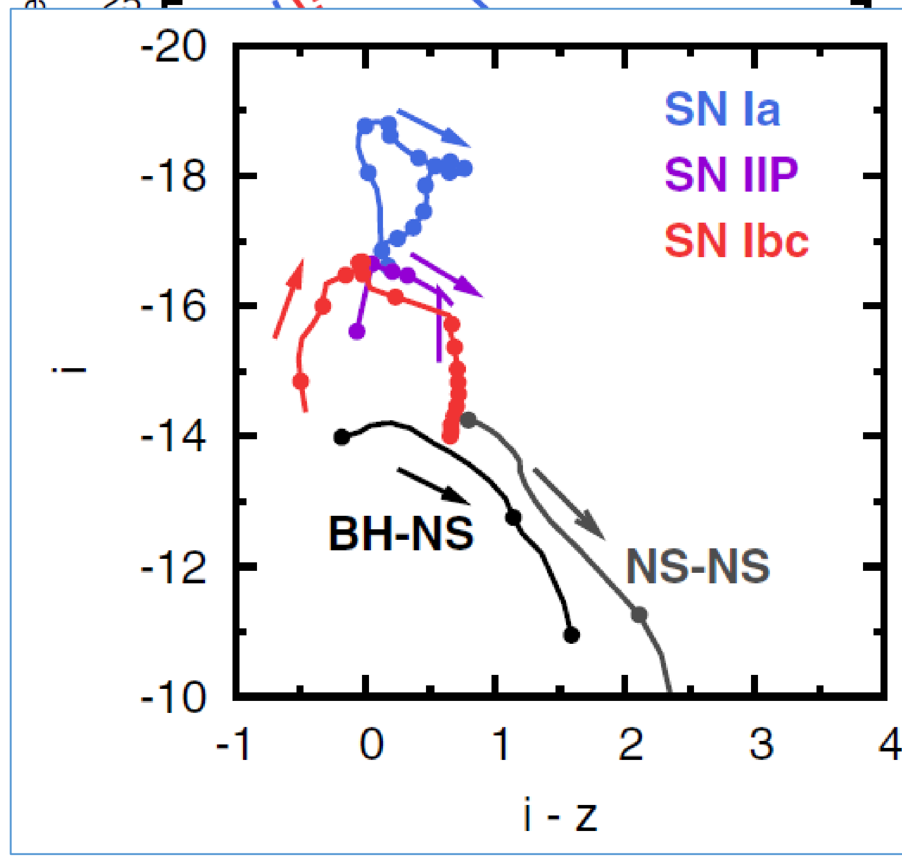
NS-NS merger

BH-NS merger

Light curve models of kilonova (Tanaka+ 2014)







BH-NS merger @ 400Mpc
NS-NS merger @ 200Mpc

can be distinguished from SNe by color variation

The EM follow-up consortium in Japan

- **J-GEM: Japanese collaboration for Gravitational-wave Electro-Magnetic follow-up observation**
- Purpose:
  - Electro-magnetic follow-up of gravitational wave transients detected by advanced GW detectors (LIGO, Virgo and KAGRA)
  - Utilize existing optical, infrared, and radio astronomical facilities of Japanese institutes

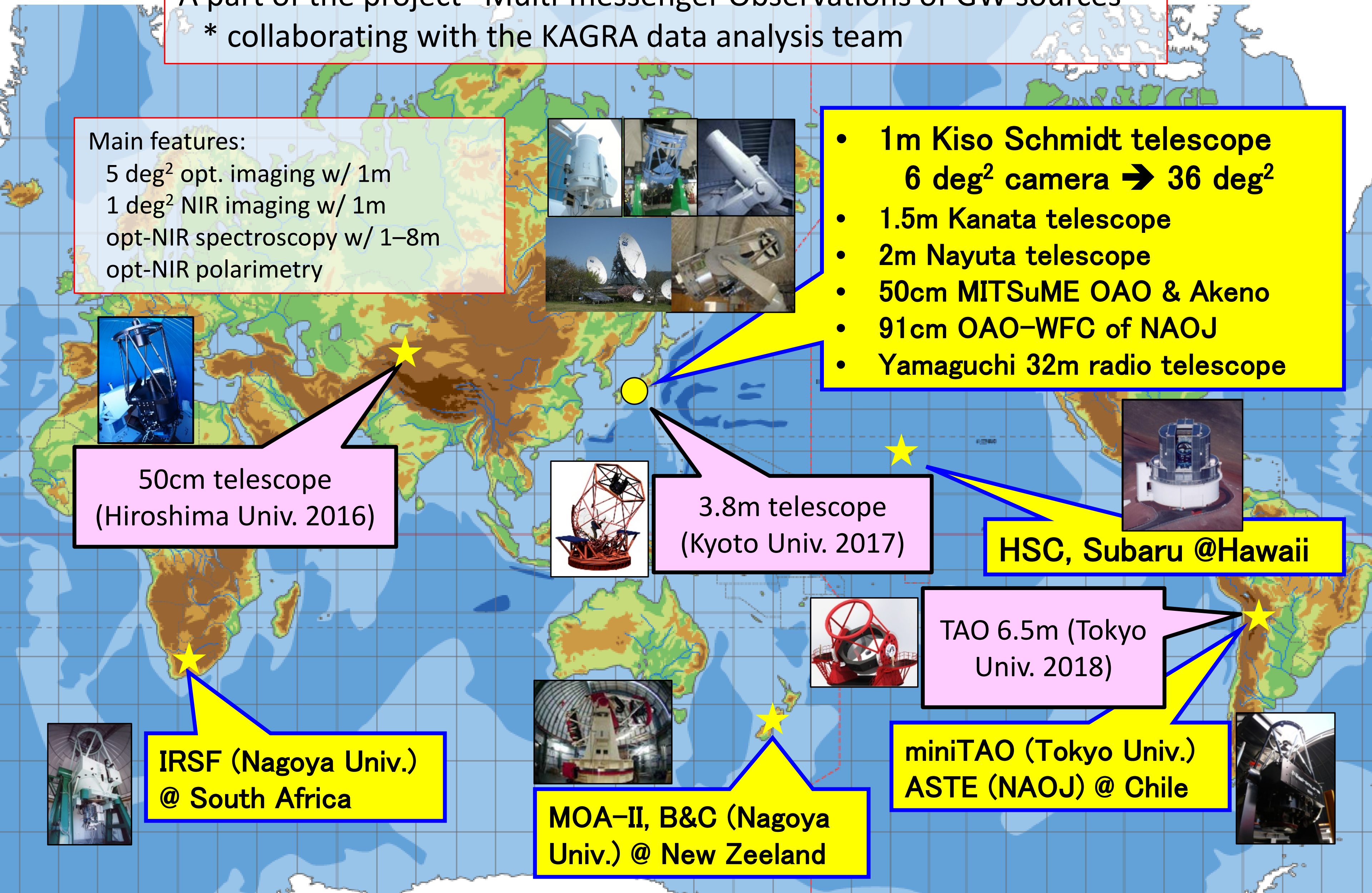
Members

- M. Yoshida (PI), K. S. Kawabata, M. Uemura, H. Nagashima (Hiroshima Univ.)
- N. Yasuda (IPMU, Univ. of Tokyo)
- K. Motohara, M. Doi, T. Morokuma, Y. Tamura, R. Osawa, S. Sako (Univ. of Tokyo)
- N. Kawai, Y. Saito, Y. Yatsu, R. Itoh (Tokyo Inst. of Tech.)
- M. Tanaka, H. Nagai (NAOJ)
- F. Abe, Y. Asakura (Nagoya Univ.)
- K. Ohta, T. Tanaka, N. Seto, T. Nakamura (Kyoto Univ.)
- N. Kanda, H. Tagoshi (Osaka City Univ.)
- N. Tominaga (Konan Univ.)
- Y. Itoh (Hyogo Pref. Univ.)
- K. Yanagisawa, D. Kuroda, K. Matsubayashi (OAO, NAOJ)
- K. Fujisawa (Yamaguchi Univ.)
- T. Nagayama (Kagoshima Univ.)

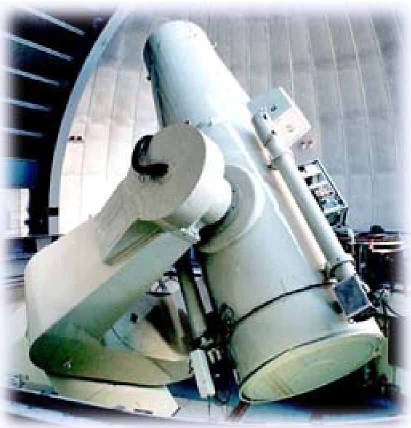
J-GEM (Japanese collaboration for Gravitational-wave Electro-Magnetic follow-up)

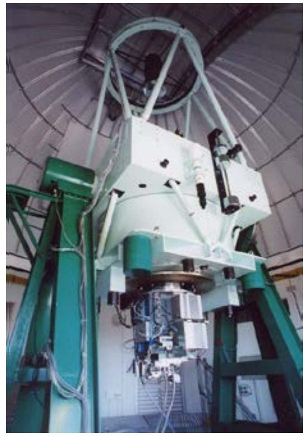
A part of the project “Multi-messenger Observations of GW sources”
* collaborating with the KAGRA data analysis team

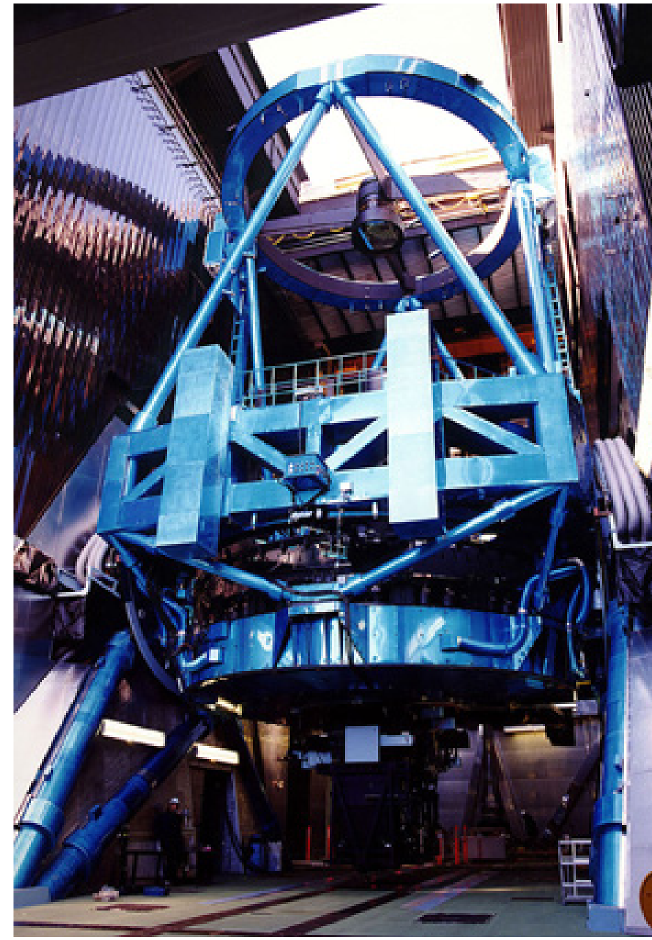
Main features:
- 5 deg^2 opt. imaging w/ 1m
- 1 deg^2 NIR imaging w/ 1m
- opt-NIR spectroscopy w/ 1–8m
- opt-NIR polarimetry

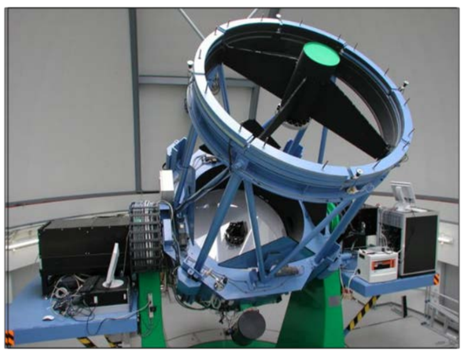


Telescopes currently joining J-GEM



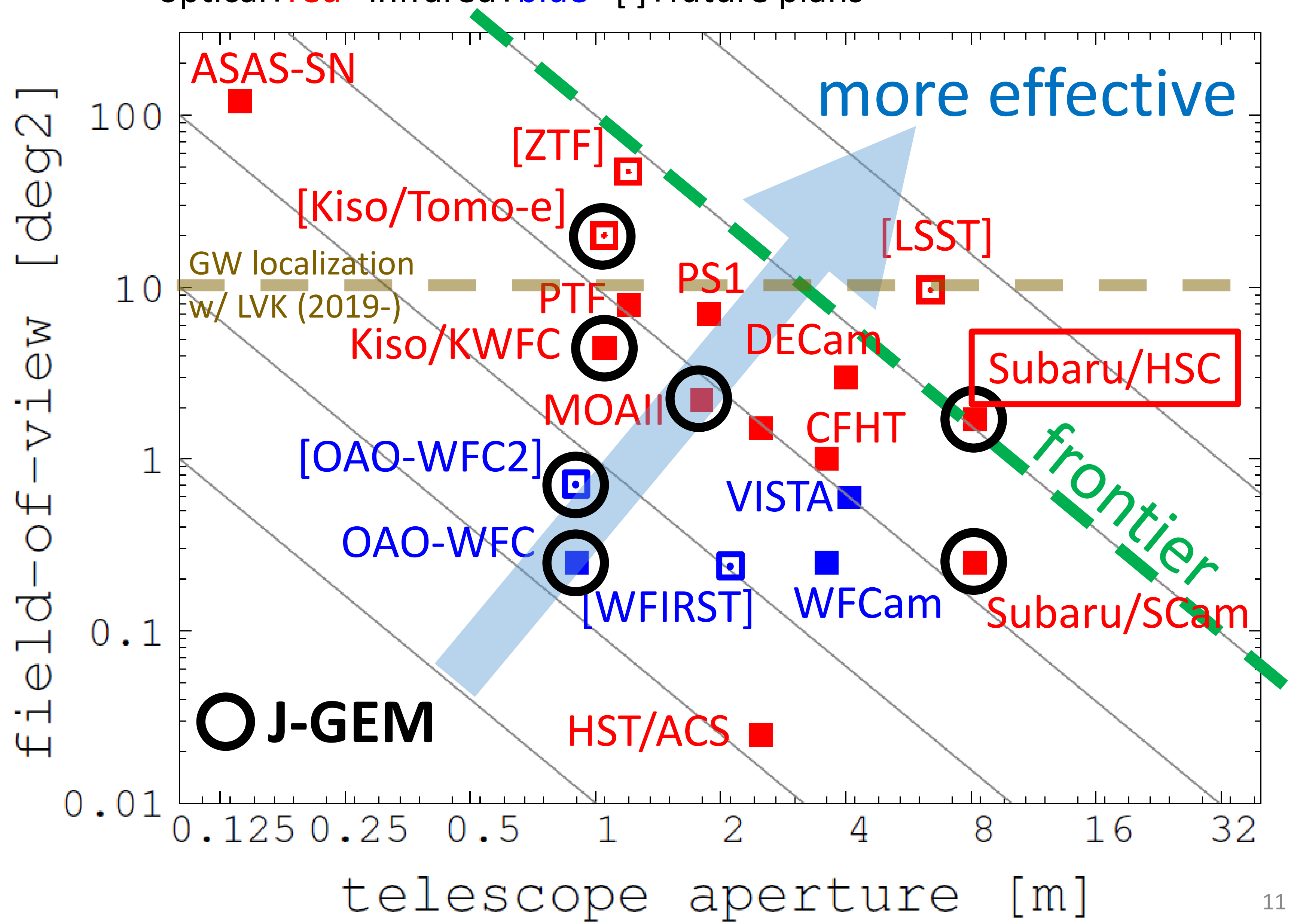




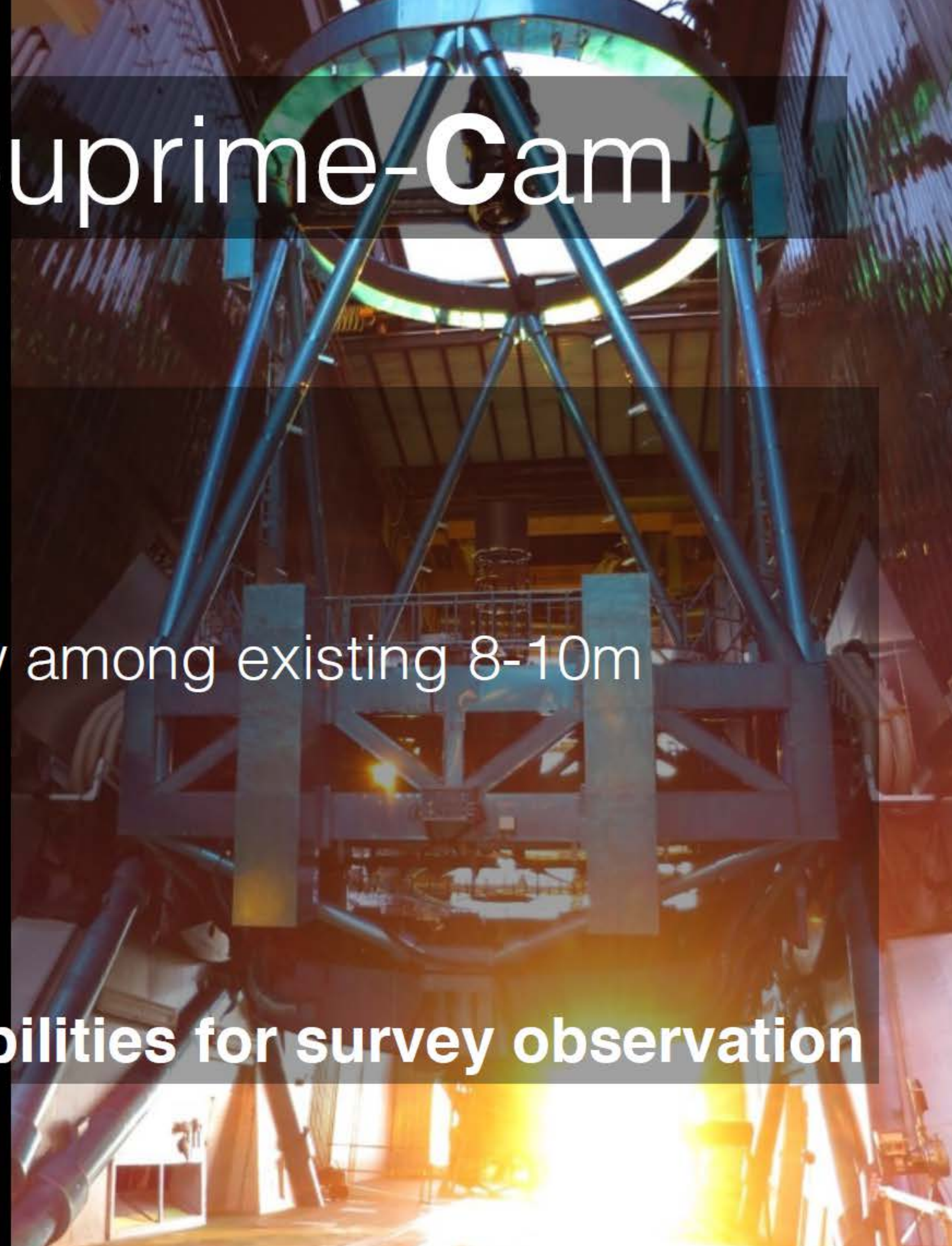


Optical infrared wide field facilities in the world

optical : red infrared : blue [ ] : future plans



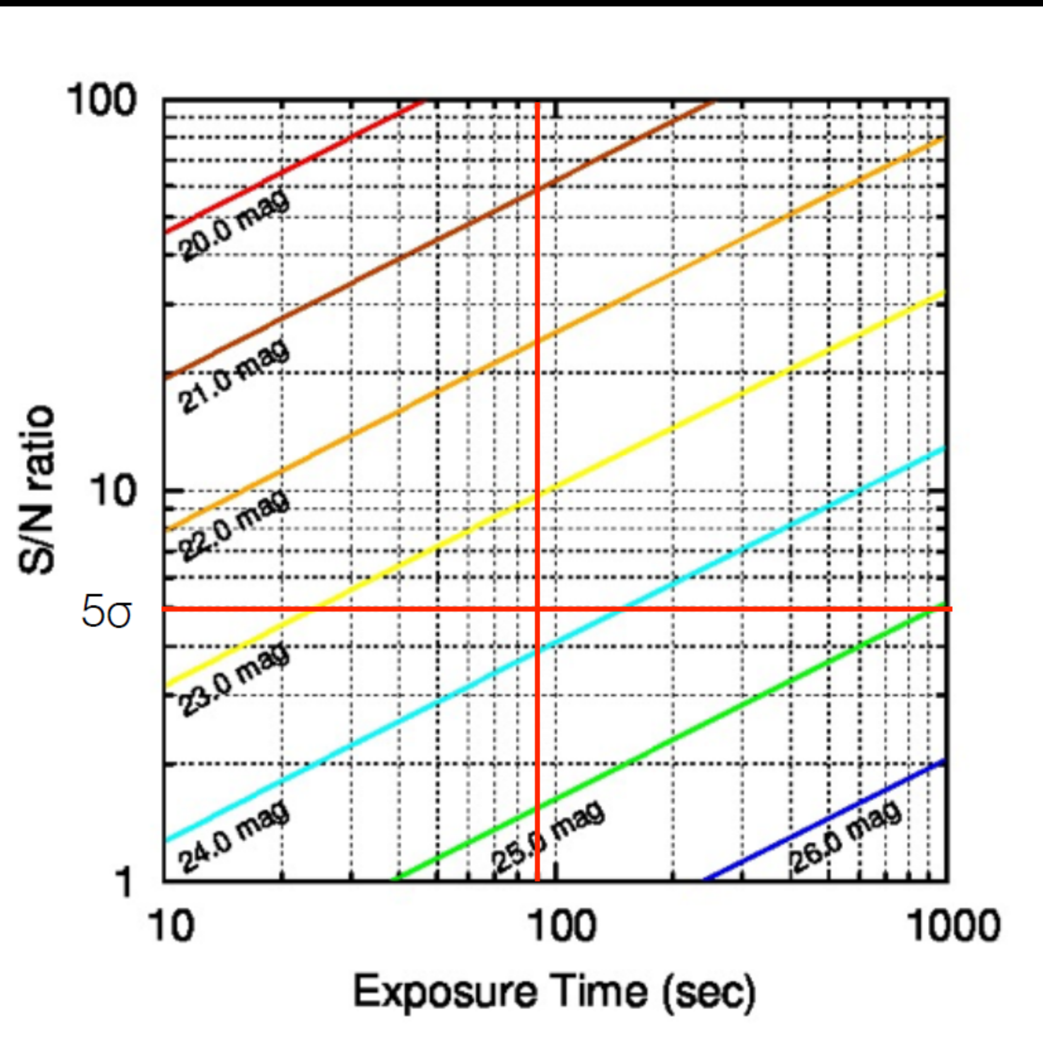
Hyper **S**uprime-**C**am



- **8.2m**
  - Large aperture
- **1.5degφ**
  - Widest field of view among existing 8-10m facilities
- **less than 0.5arcsec**
  - Fine image quality

- **Very powerful capabilities for survey observation**

Depth



Subaru web site

HSC survey imaging

i~24.2

z~23.6

for 90sec exposure

cf) **DECam 4m 3deg²**

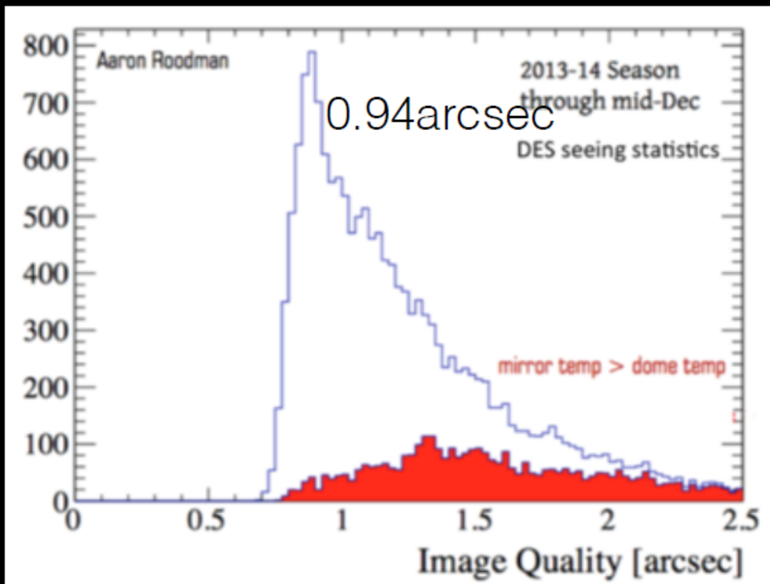
i~22.5

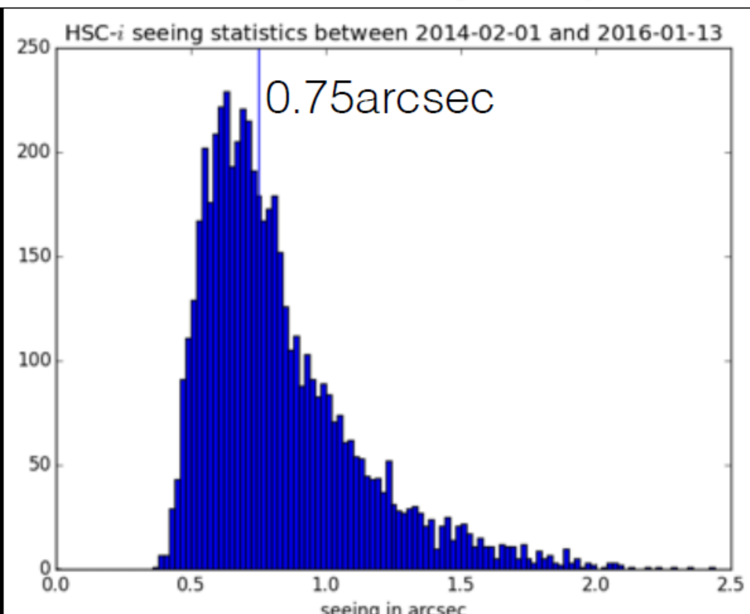
z~21.5

for 90sec (Abbott+2016)

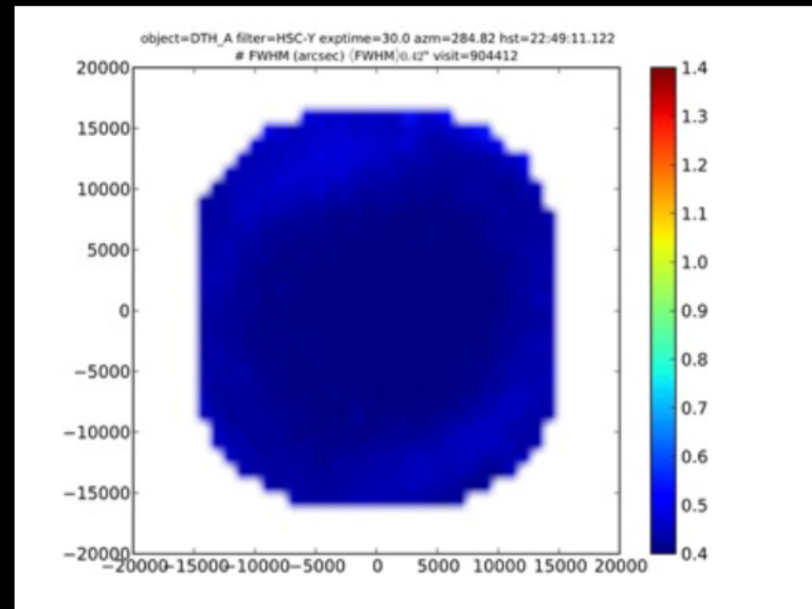
PSF statistics

Shanks (2015, arxiv:1507.07694)





One of the best records



0.4” on the whole region

A combination of HSC optics & Subaru driving system makes good imaging quality.
→2nd reason why HSC is Great

Filter Exchanging sequence

25~30mins in total

- **Go** to the zenith (~mins)
- **Closing** mirror covers (~5mins)
- **Extend** the filter stacker (~1min)
- **Pull** out installed filter (~4mins)
- **Retract** / **extend** the stacker if necessary (~3mins)
- **Put** in the desired filter (~4mins)
- **Retract** the filter stacker (~1min)
- **Open** the mirror cover (~5mins)
- **Go** to target (~mins)
- **Focus** (~5min)

Not always available

Schedule for September 2016

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				Sep 01 ●	Sep 02	Sep 03
				SSP HSC Keck Prochaska HSC	SSP(Queue) HSC Keck Furlanetto HSC	SSP(Queue) HSC Keck Furlanetto HSC
Sep 04	Sep 05	Sep 06	Sep 07	Sep 08 ◐	Sep 09	Sep 10
SSP HSC Keck Cohen HSC	SSP HSC Keck Cohen HSC	SSP HSC	S16B-071I Matsuoka FOCAS	S16B-029 Shibuya FOCAS	S16B-071I Matsuoka FOCAS	S16B-034 Goto FOCAS
Sep 11	Sep 12	Sep 13	Sep 14	Sep 15 ○	Sep 16	Sep 17
S16B-074 Furusawa FOCAS	TBD S16B-116 Morokuma FOCAS	Service FOCAS S16B-116 Morokuma FOCAS	Taiken FOCAS TBD	UH Nienke SCExAO	Eng IRD/CHARIS/SCExAO	
Sep 18	Sep 19	Sep 20	Sep 21	Sep 22	Sep 23 ◑	Sep 24
Eng RD/CHARIS/SCExAO	TBD S16B-081 Kodama MOIRCS	Obs MOIRCS	S16B-050 Sorahana MOIRCS	TBD S16B-088 Minowa IRCS+AO188(LGS)	TBD S16B-088 Minowa IRCS+AO188(LGS)	TBD S16B-006 Tanaka IRCS+AO188(LGS)
Sep 25	Sep 26	Sep 27	Sep 28	Sep 29	Sep 30 ●	
S16B-094 Helminiak IRCS+AO188 S16B-006 Tanaka RCS+AO188(LGS)	Queue HSC S16B-049 Yoshida HSC	Queue HSC S16B-049 Yoshida HSC	Queue HSC S16B-049 Yoshida HSC	Queue HSC S16B-049 Yoshida HSC	UH-23B Tholen HSC	

Schedule for December 2016

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				Dec 01	Dec 02	Dec 03
				UH-33A Magnier HSC SSP HSC	UH-33A Magnier HSC SSP HSC	UH-33A Magnier HSC SSP HSC
Dec 04	Dec 05	Dec 06 ◐	Dec 07	Dec 08	Dec 09	Dec 10
UH-33A Magnier HSC SSP HSC	SSP HSC	S16B-071I Matsuoka FOCAS	S16B-071I Matsuoka FOCAS S16B-080 Yasuda FOCAS	S16B-071I Matsuoka FOCAS S16B-080 Yasuda FOCAS	S16B-081 Kodama MOIRCS	
Dec 11	Dec 12	Dec 13 ○	Dec 14	Dec 15	Dec 16	Dec 17
S16B-081 Kodama MOIRCS	TBD UH-27A McPartland MOIRCS	Eng IRD/CHARIS/SCExAO UH-27A McPartland MOIRCS	Eng IRD/CHARIS/SCExAO UH-27A McPartland MOIRCS	UH-37A Gaidos SCExAO+AO188 UH-27A McPartland MOIRCS	UH-37A Gaidos SCExAO+AO188 UH-19A Ebeling MOIRCS	UH-16A Hodapp SCExAO+AO18
Dec 18	Dec 19	Dec 20 ◑	Dec 21	Dec 22	Dec 23	Dec 24
UH-16A Hodapp SCExAO+AO188	S16B-097 Kotani SCExAO+AO188	S16B-104 Currie SCExAO+AO188		SSP HSC	S16B-031 Koda HSC	SSP(Queue) HSC SSP HSC
Dec 25	Dec 26	Dec 27	Dec 28 ●	Dec 29	Dec 30	Dec 31
SSP HSC	SSP HSC GTO HSC	SSP HSC	Gemini von der Linden HSC	Gemini Shappard HSC SSP HSC	Gemini Shappard HSC SSP HSC	SSP(Queue) HSC Queue HSC

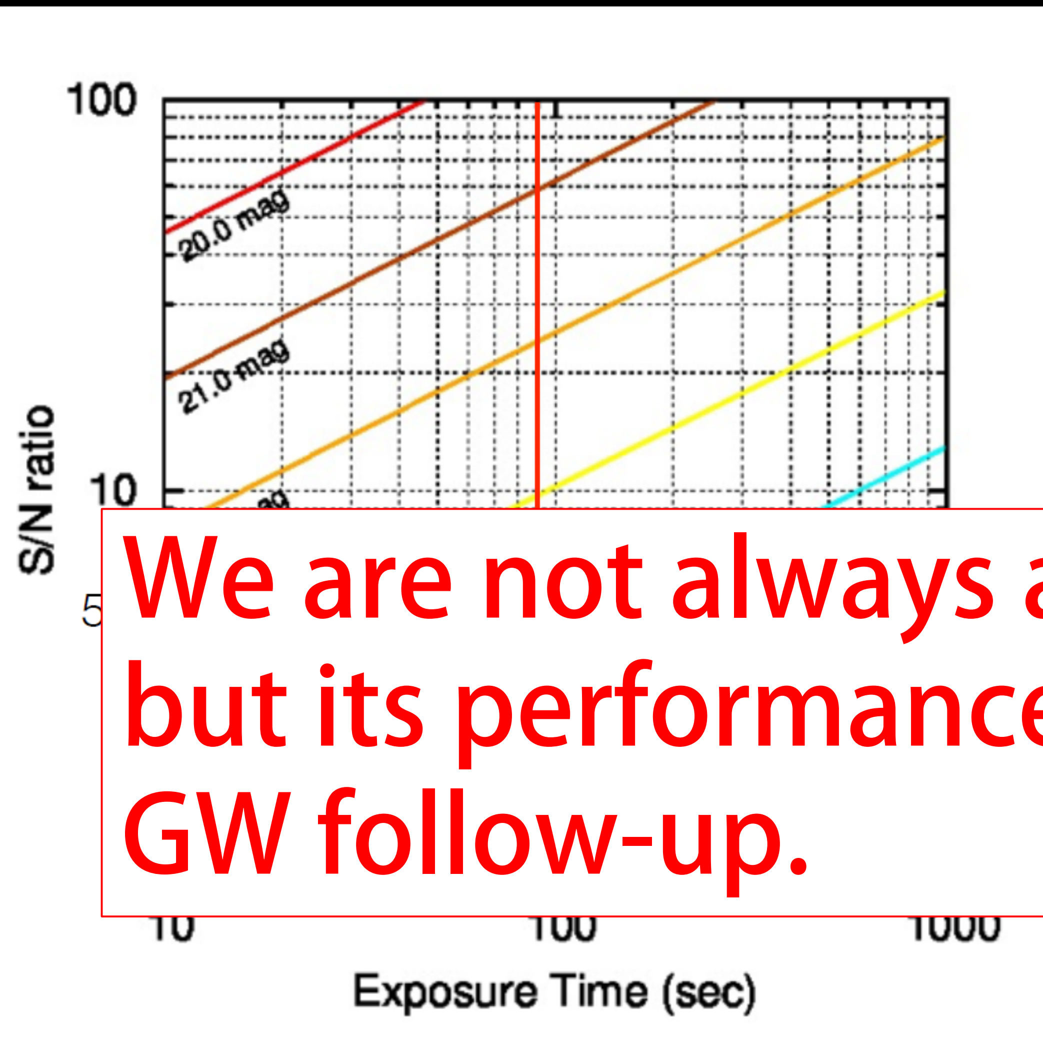
- ~ 1/2 month at maximum will be allocated
- but **only** Subaru time can be used
- Filter exchange is not available on the beginning and end of run

Not easy to initiate ToO just after the GW trigger

Initiating ToO

- **There is no automatic mechanism to initiate ToO**
- **Make a plan considering many limitations**
- **<u>For rapid ToO</u>**
  - Phone call to Director of Subaru (24hrs OK)
- **<u>For non-rapid ToO</u>**
  - submit request by 9:00 am HST one day before observing night.
- We ARE STILL REQUIRED to explain importance even if proposal was accepted

Depth



Subaru web site

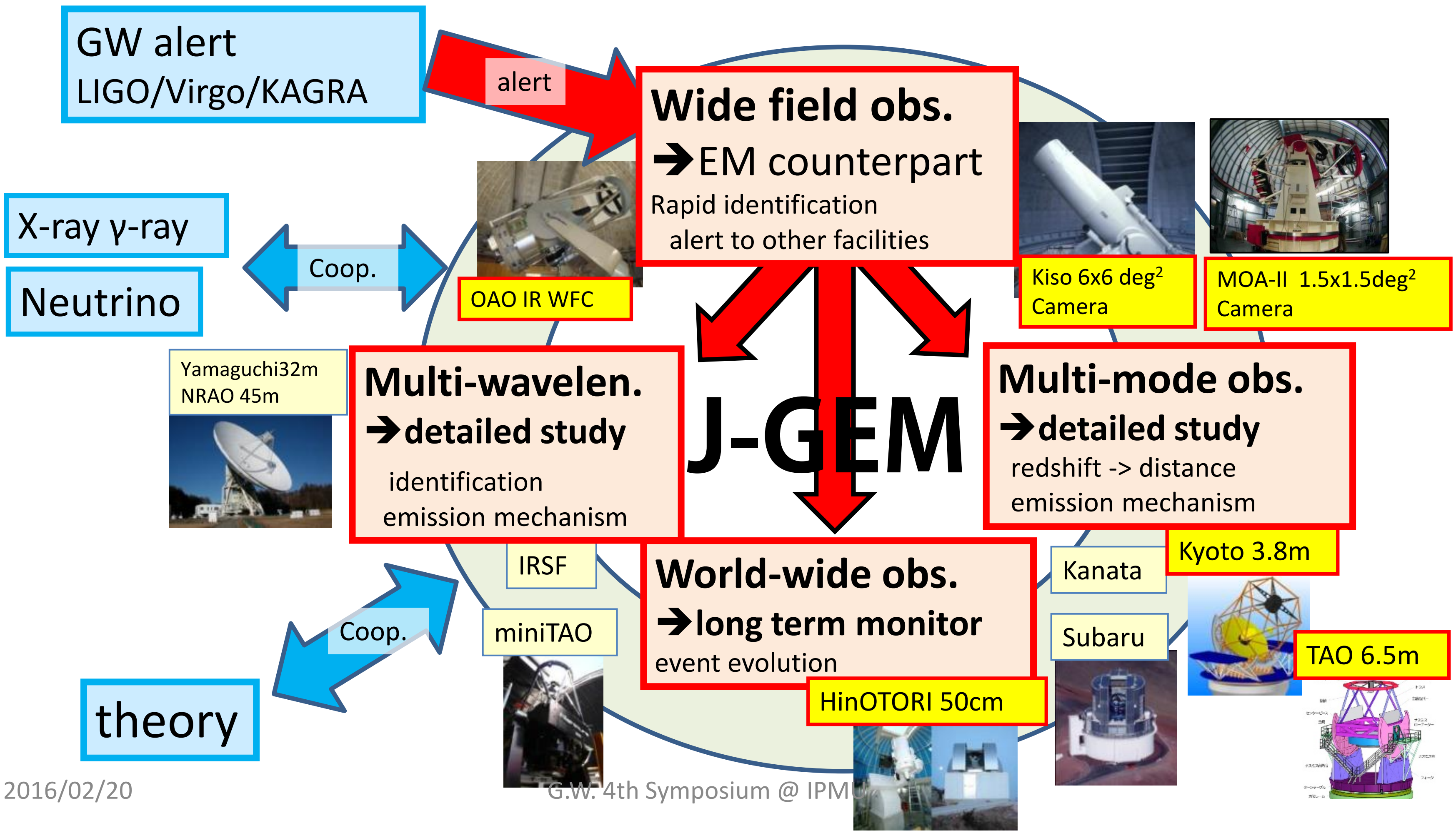
HSC survey imaging
i~24.2
z~23.6
for 90sec exposure

We are not always able to use HSC, but its performance is the key for GW follow-up.

Schematic overview of EM follow-up

- Detect GW EM counterpart with wide-field observations
- Study the physics of EM counterpart with multi-mode observations

→ The nature of GW transient

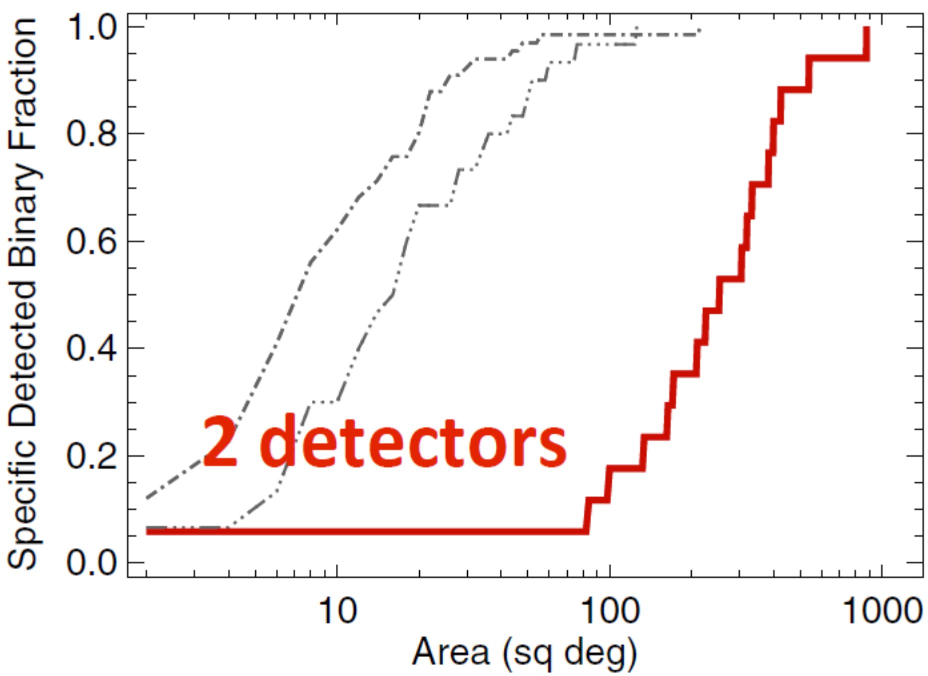


Localization of the GW telescopes

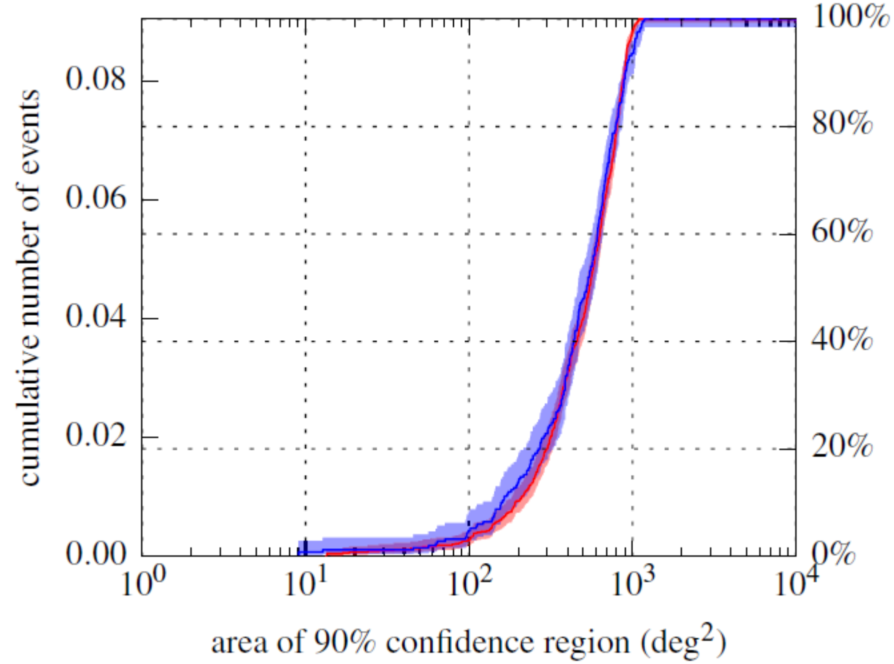
Area

~ 500 deg2 (median)

100 - 1000 deg2 (S/N <== position, inclination)



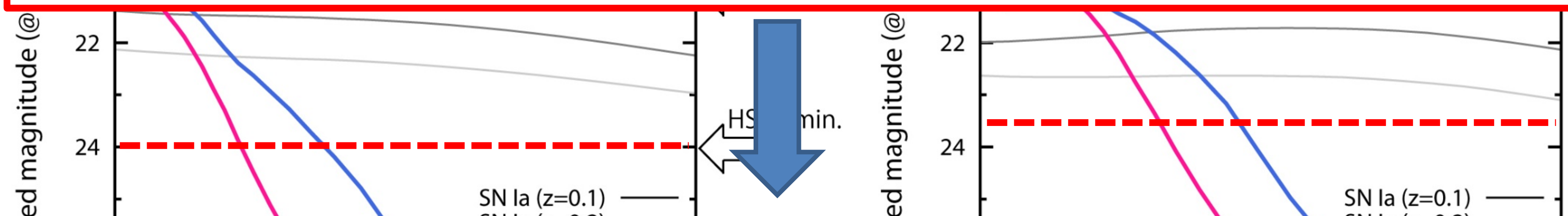
Kasliwal & Nissanke 2014



Singer et al. 2014

Expected light curve of kilonova @ 100Mpc (Tanaka+ 2014)

Detectable with 1-m class telescopes within 1 – 2 days after merger
HSC can follow the light curve for 1 – 2 weeks



Quick follow-up with small telescopes
+ Deep observations with Subaru HSC

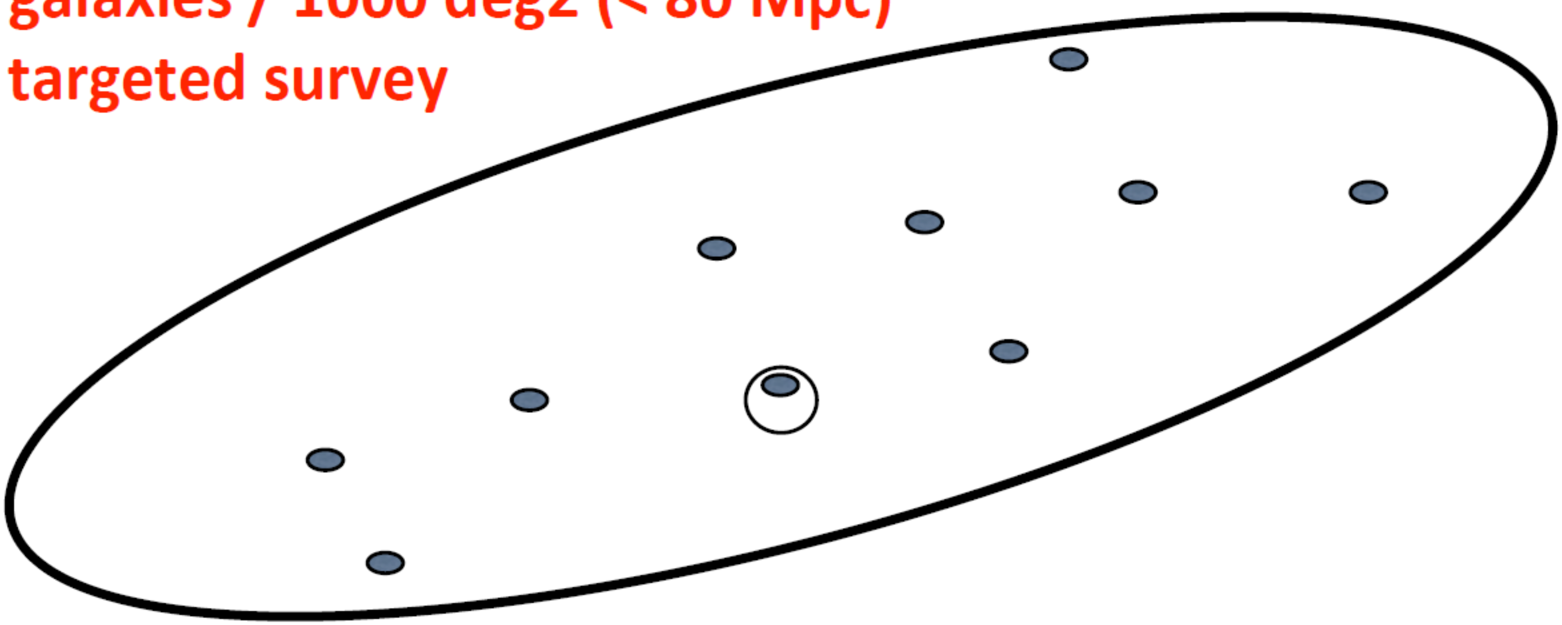
Nissanke et al. 2013, ApJ, 767, 124
Kopparapu et al. 2008, ApJ, 675, 1459
White et al. 2011, CQG, 28, 085016

Number density of galaxy

~ 100 galaxies / 10 deg2 (< 200 Mpc, L>0.1 L*)
~10,000 galaxies / 1000 deg2 (< 200 Mpc, L>0.1 L*)

~700 galaxies / 1000 deg2 (< 80 Mpc, L>0.1 L*)
==> ~1 galaxy for HSC field of view

If we select brightest sample (~50% in B band luminosity),
~50 galaxies / 1000 deg2 (< 80 Mpc)
==> targeted survey

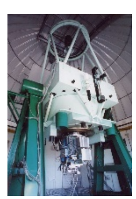


Follow-up observation strategy of J-GEM

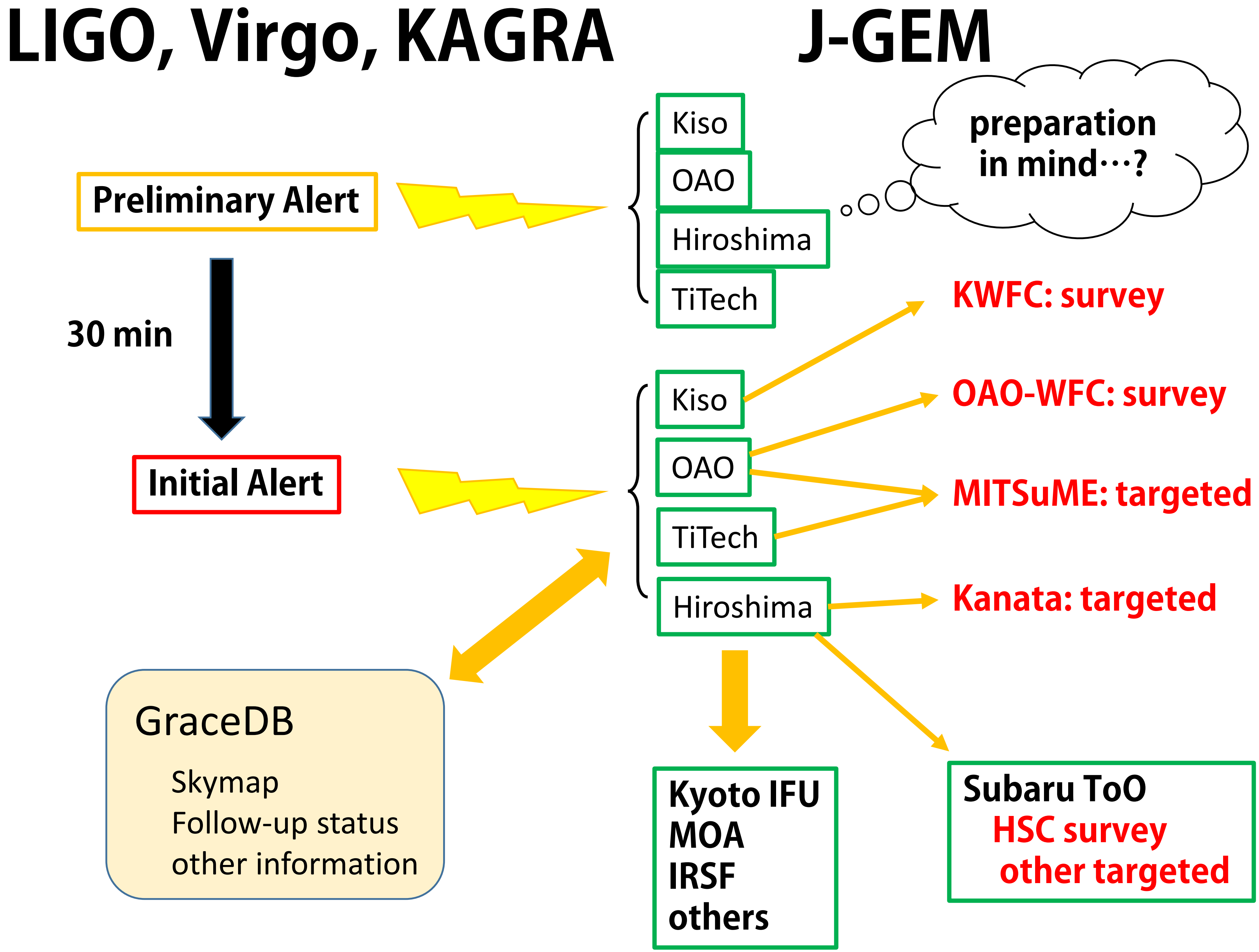
- Blind survey
  - 10 deg^2 – 100 deg^2 blind survey within GW error area
  - KWFC, MOA-II and Subaru HSC
  - 1 color or 2 colors with short exp-time (1 – 3 min) survey



- Targeted observation
  - Select target galaxies using nearby galaxy catalogs
  - Kanata, Nayuta, MOA-II, IRSF, OAO-WFC and MITSuME
  - 1 color with ~10 min exp-time per one galaxy





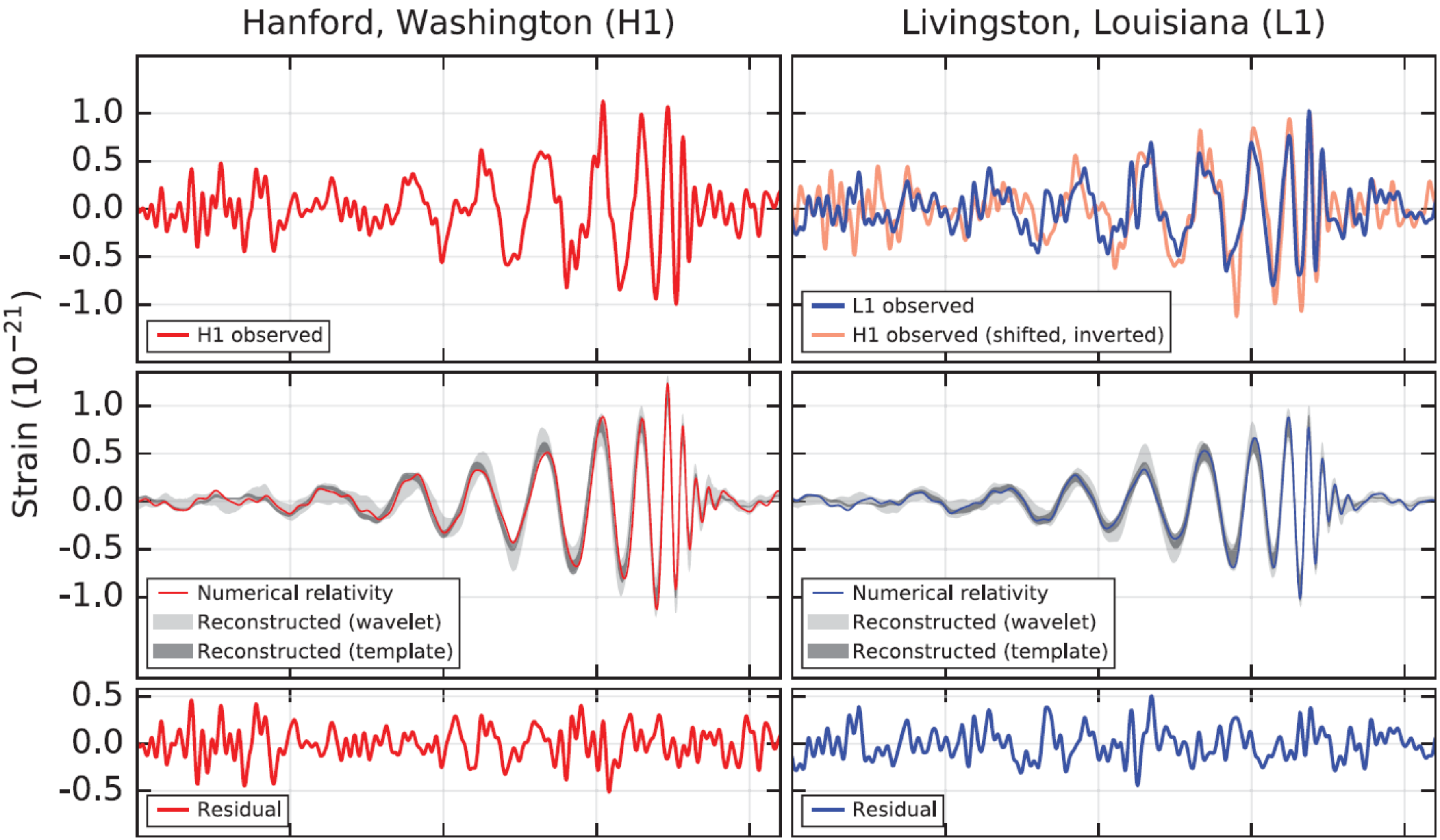

LIGO, Virgo, KAGRA
J-GEM
Preliminary Alert
30 min
Initial Alert
Kiso
OAO
Hiroshima
TiTech
preparation in mind…?
KWFC: survey
OAO-WFC: survey
MITSuME: targeted
Kanata: targeted
Kiso
OAO
TiTech
Hiroshima
GraceDB
Skymap
Follow-up status
other information
Kyoto IFU
MOA
IRSF
others
Subaru ToO
HSC survey
other targeted

HSC follow-up strategy

1. Prompt wide field observations
   - within 5 days after the GW event, if possible
   - 1 min exposure in 2 bands (i and z)
     ➔ 5σ limiting magnitudes: ~24mag for i, ~23.5mag for z
   - 2 times visits for one field (effective FOV is ~1.1 deg^2)
   - ~60 deg^2 can be surveyed with 2 colors within a half night
2. Second observations for checking the color-magnitude evolution of the transients
   - within a few days after the prompt observations
3. Third observations for getting the reference images
   - 1 – 2 months after the second observations

- Data reduction procedure
  - prompt obs. data – 2nd obs. data ➔ candidate selection
  - prompt – 3rd, 2nd – 3rd, then study color-mag evolution of the candidates ➔ characterization

GW150914



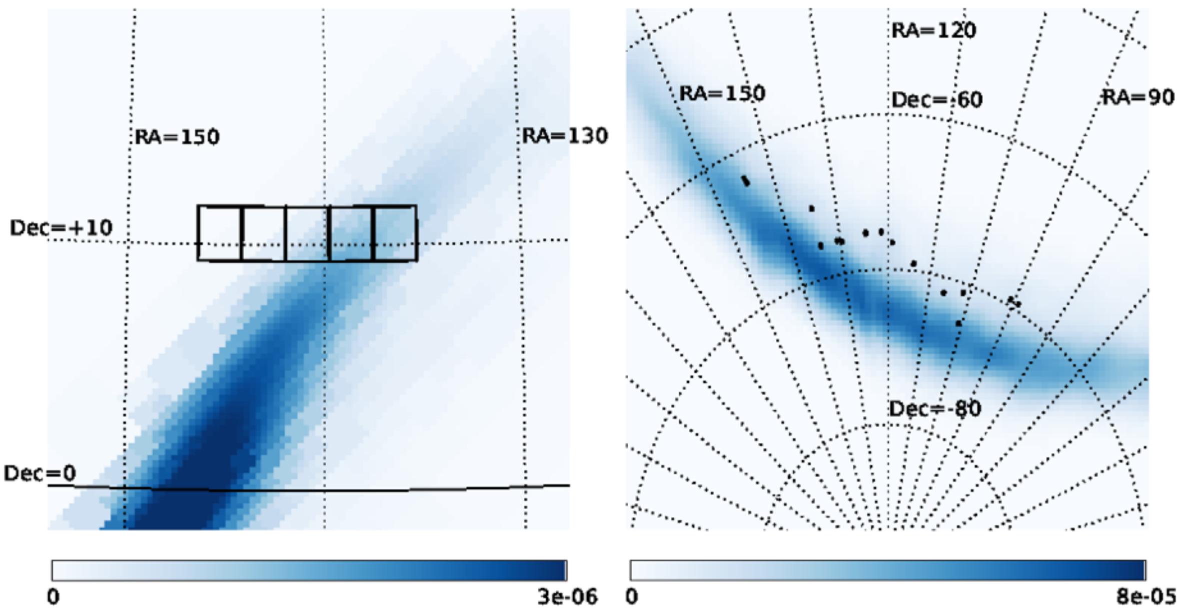
$36M_\odot$ BH + $29M_\odot$ BH → $64M_\odot$ BH at 410Mpc

Follow-up observations of GW150914

- KWFC on 105 cm Schmidt telescope at Kiso observatory ➔ 24 deg^2
- tripole5 on the B&C 61cm telescope in New Zealand ➔ 18 nearby galaxies

Observation dates: September 18 - 26, 2015

observed area Left: KWFC, Right: tripole5



Limiting magnitudes:
KWFC 18.9 – 19.2 mag. for I-band
tripole5 g-band: 18.9 mag. r-band: 18.7mag. i-band: 18.3 mag

No EM counterpart was detected

➔ Morokuma, T., et al., 2016, PASJ, 68, L9

Morokuma, T., et al., 2016, PASJ, 68, L9

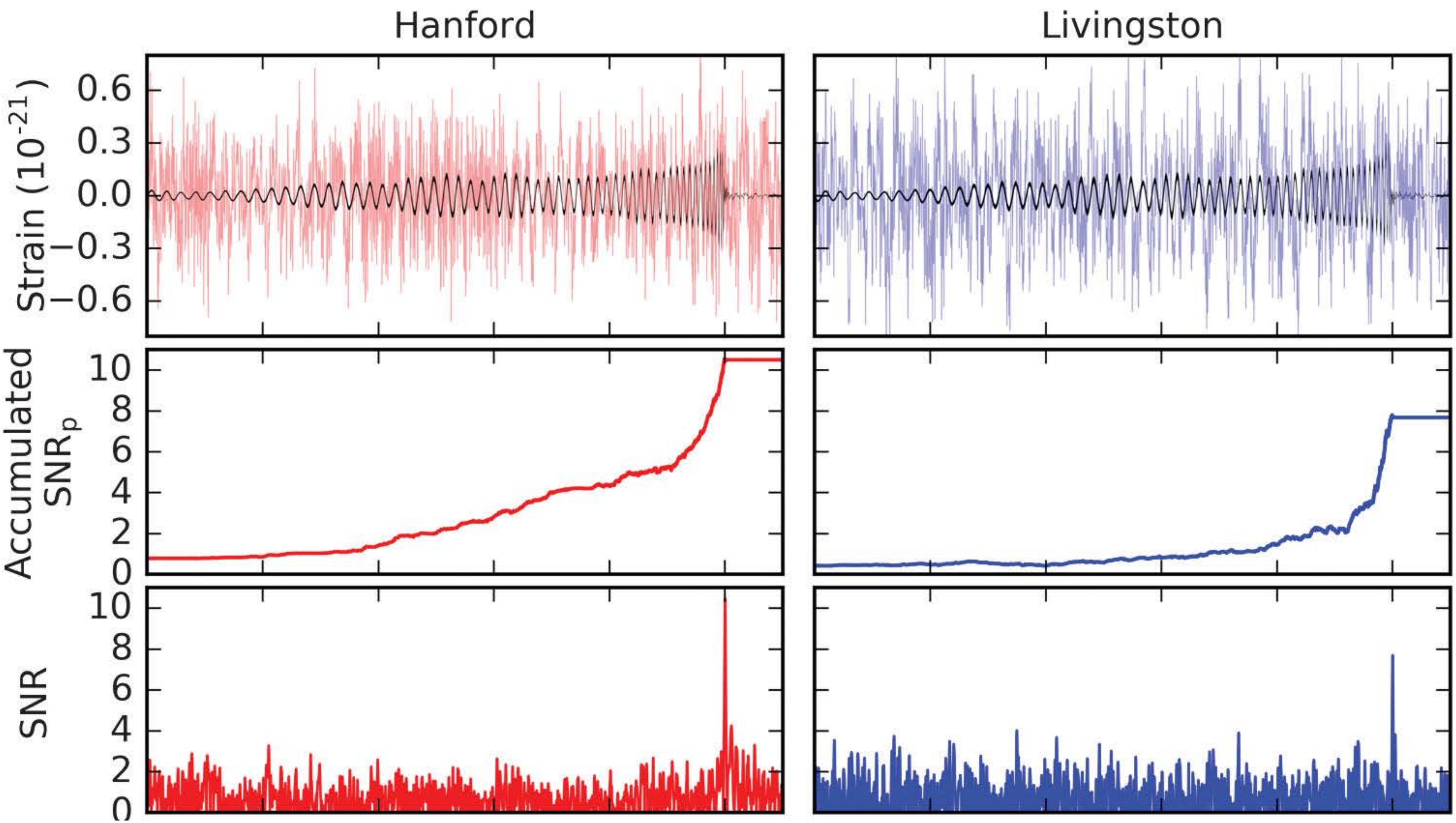
Publ. Astron. Soc. Japan (2016) 68 (4), L9 (1–6)
doi: 10.1093/pasj/psw061
Advance Access Publication Date: 2016 June 26
Letter

Letter

J-GEM follow-up observations to search for an optical counterpart of the first gravitational wave source GW150914

Tomoki MOROKUMA,[1,*] Masaomi TANAKA,[2] Yuichiro ASAKURA,[3] Fumio ABE,[3] Paul J. TRISTRAM,[4] Yousuke UTSUMI,[5] Mamoru DOI,[1] Kenta FUJISAWA,[6] Ryosuke ITOH,[7] Yoichi ITOH,[8] Koji S. KAWABATA,[5] Nobuyuki KAWAI,[9] Daisuke KURODA,[10] Kazuya MATSUBAYASHI,[11] Kentaro MOTOHARA,[1] Katsuhiro L. MURATA,[12] Takahiro NAGAYAMA,[13] Kouji OHTA,[11] Yoshihiko SAITO,[9] Yoichi TAMURA,[1] Nozomu TOMINAGA,[14,15] Makoto UEMURA,[5] Kenshi YANAGISAWA,[10] Yoichi YATSU,[9] and Michitoshi YOSHIDA[5]

GW151226



14.2M$_\odot$ BH + 7.5M$_\odot$ BH → 20.8M$_\odot$ BH at 440Mpc

2015-12-28 01:28:13 (JST) GCN/LVC_INITIAL_SKYMAP

TITLE: GCN/LVC NOTICE

NOTICE_DATE: Sun 27 Dec 15 16:28:13 UT

NOTICE_TYPE: LVC Initial Skymap

TRIGGER_NUM: G211117

TRIGGER_DATE: 17382 TJD; 360 DOY; 2015/12/26 (yy/mm/dd)

TRIGGER_TIME: 13133.647758 SOD {03:38:53.647758} UT

GROUP_TYPE: 1 = CBC (= compact binary coalescence)

SEARCH_TYPE: 3 = HighMass (including BH)

PIPELINE_TYPE: 4 = GSTLAL

FAR: 6.340e-09 [Hz] (one per 1825.5 days)

CHIRP_MASS: -1.0000 [M_solar]

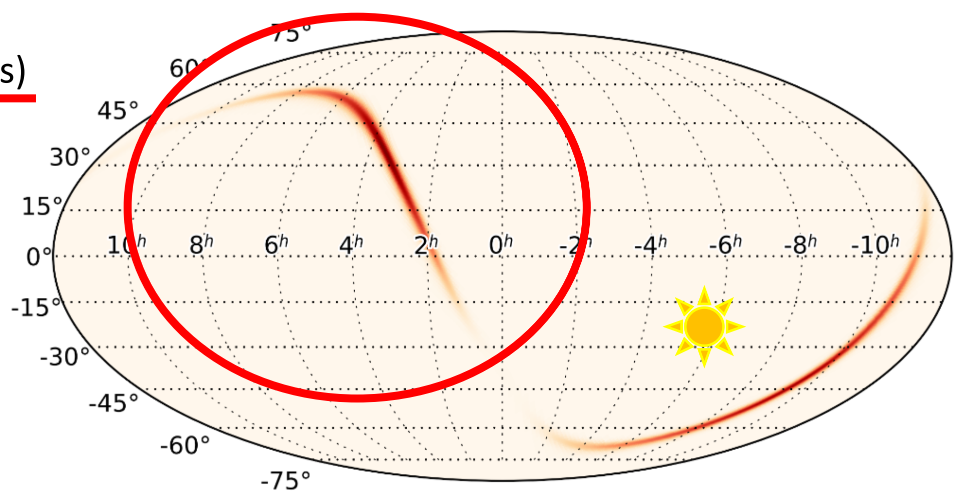
ETA: -1.000

MAX_DIST: -1.00 [Mpc]

TRIGGER_ID: 0x0

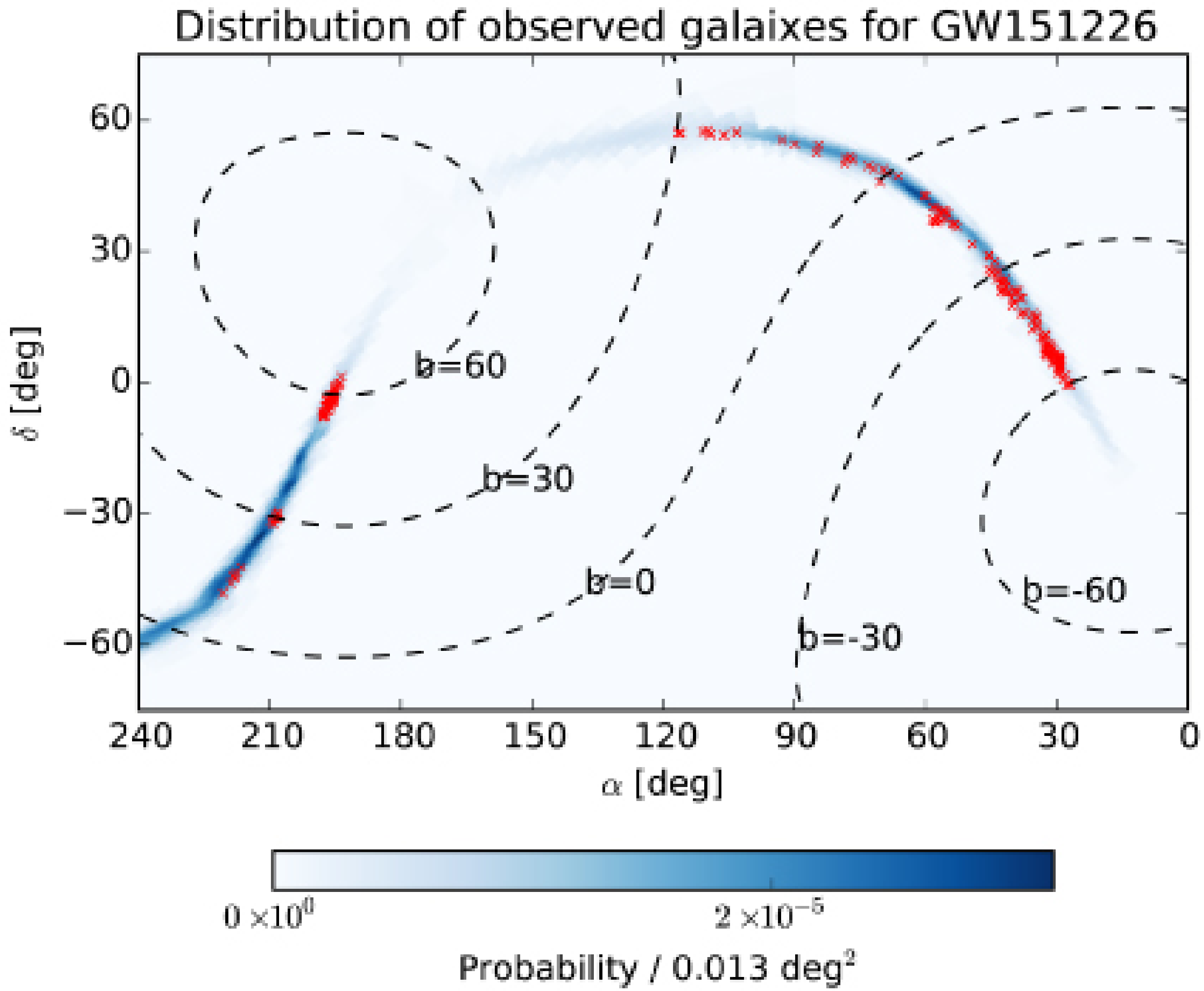
MISC: 0x2100003

error region: ~1300deg^2 (90%)

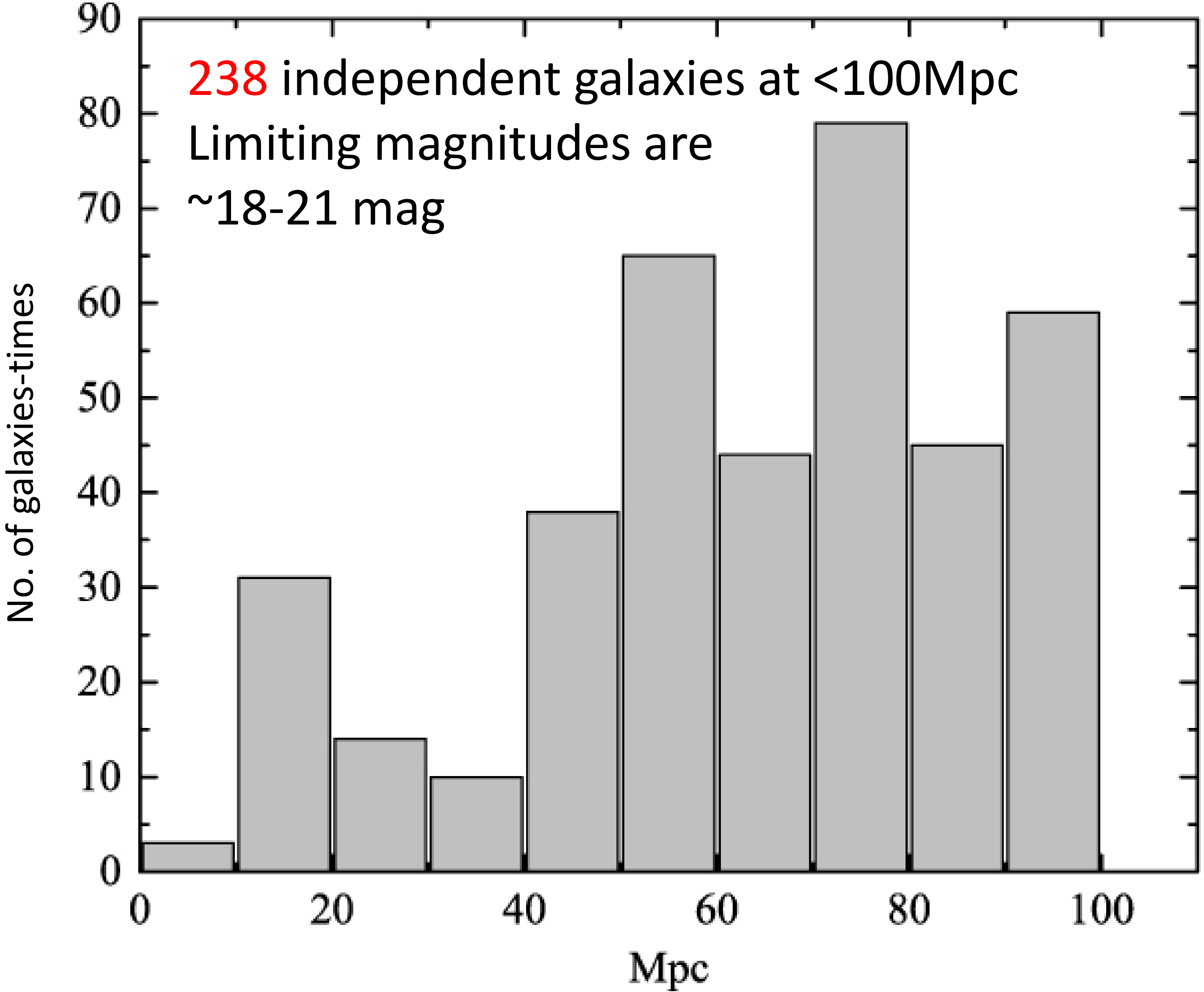


Targeted survey

Nayuta/MINT, Kanata/HONIR, TIT-OAO50cm/MITSuME (opt), OAO91cm/OAO-WFC, IRSFF/SIRIUS (NIR)



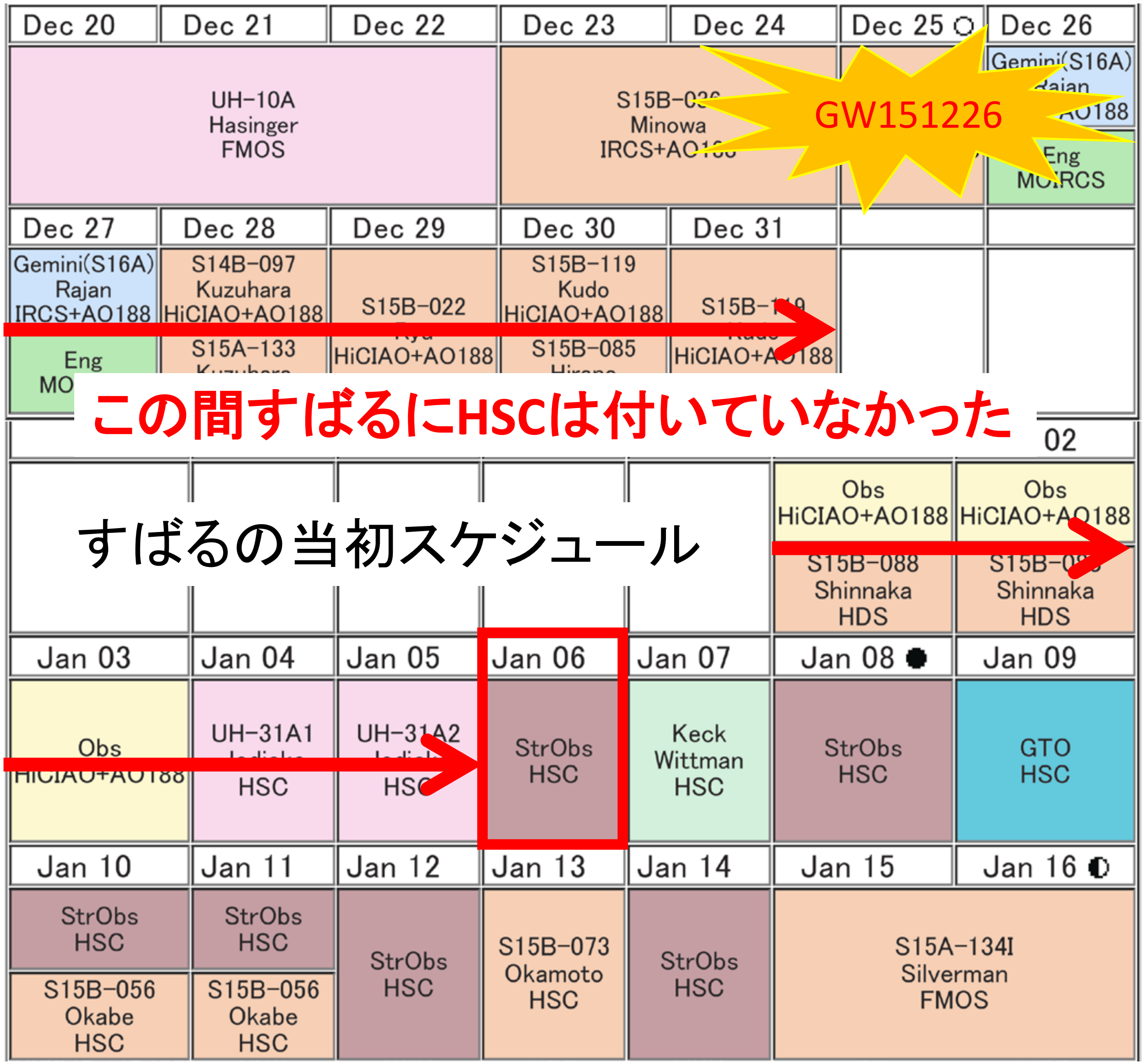
Observed galaxies



Let’s use Subaru！

- How about the observation schecule?

When will HSC be attached to Subaru?



ハワイ観測所長にお願い

- 重力波出ましたから、追跡観測を割り込ませてくださいませ。

割り込ませてもらいました

Dec 20	Dec 21	Dec 22	Dec 23	Dec 24	Dec 25 ○	Dec 26
UH-10A Hasinger FMOS			S15B-0[illegible] Minowa IRCS+AO1[illegible]		[illegible]	Gemini(S16A) [illegible]ajan [illegible]AO188
						Eng MO[illegible]RCS

GW151226

Dec 27	Dec 28	Dec 29	Dec 30	Dec 31		
Gemini(S16A) Rajan IRCS+AO188	S14B-097 Kuzuhara HiCIAO+AO188	S15B-022 Ryu HiCIAO+AO188	S15B-119 Kudo HiCIAO+AO188	S15B-119 Kudo HiCIAO+AO188		
Eng MOIRCS	S15A-133 Kuzuhara HiCIAO+AO188		S15B-085 Hirano HiCIAO+AO188			

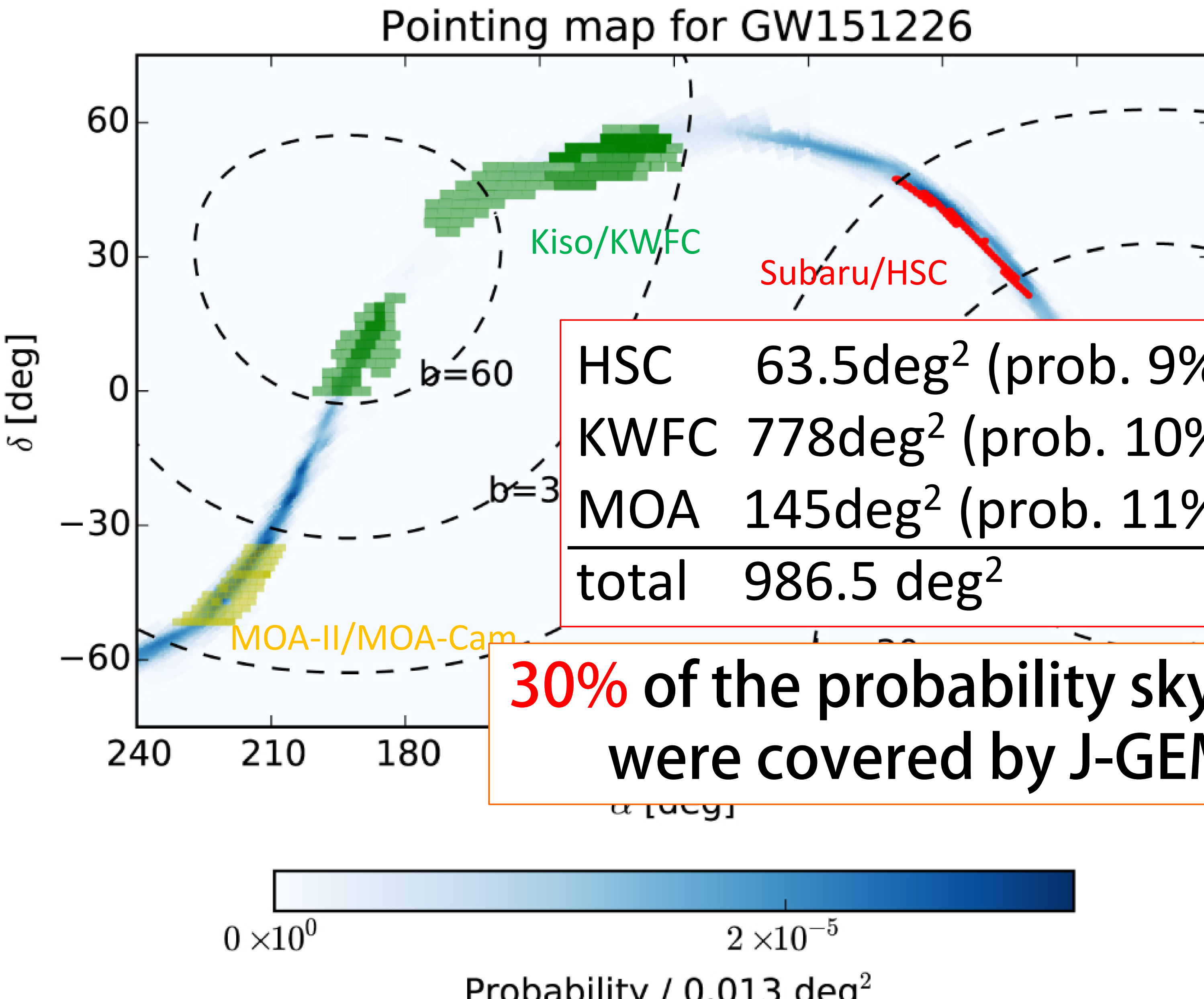
Updated schedule of Subaru

					Jan 01 ◑	Jan 02
					Obs HiCIAO+AO188	Obs HiCIAO+AO188
					S15B-088 Shinnaka HDS	S15B-088 Shinnaka HDS

Jan 03	Jan 04	Jan 05	Jan 06	Jan 07	Jan 08 ●	Jan 09
Obs HiCIAO+AO188	UH-31A1 Jedicke HSC	UH-31A2 Jedicke HSC	S15B-137 Yoshida HSC	Keck Wittman HSC	StrObs HSC	GTO HSC
			S15B-009 Totani HSC			S15B-009 Totani HSC

Jan 10	Jan 11	Jan 12	Jan 13	Jan 14	Jan 15	Jan 16 ◐
StrObs HSC	StrObs HSC	S15B-137 Yoshida HSC	S15B-073 Okamoto HSC	StrObs HSC	S15A-134I Silverman FMOS	
S15B-056 Okabe HSC	S15B-056 Okabe HSC	S15B-009 Totani HSC				

Survey fields

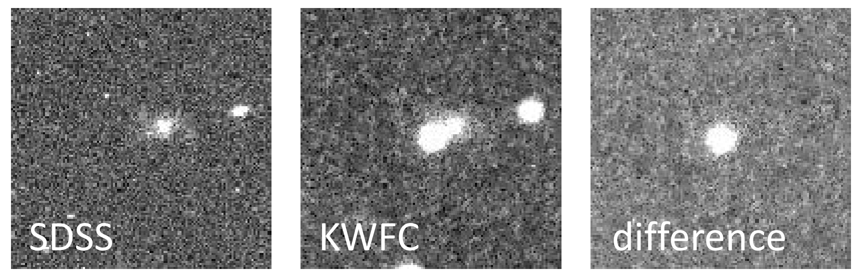


HSC	63.5deg^2 (prob. 9%)
KWFC	778deg^2 (prob. 10%)
MOA	145deg^2 (prob. 11%)
total	986.5 deg^2

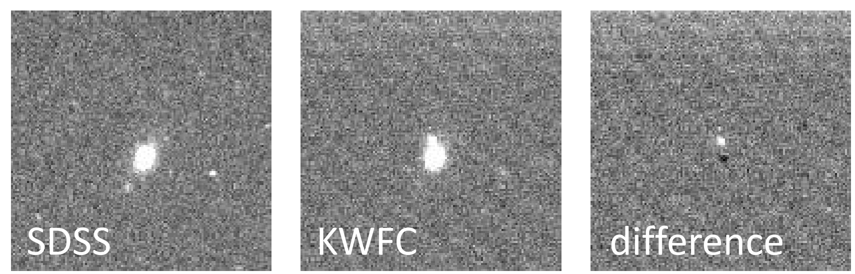
30% of the probability skymap were covered by J-GEM.

Candidates from Kiso/KWFC

- Observed only fields within SDSS footprints for image subtraction
- 13 supernova candidates
  - KISS15ai (30 Dec 2015)
    - r~16.6mag



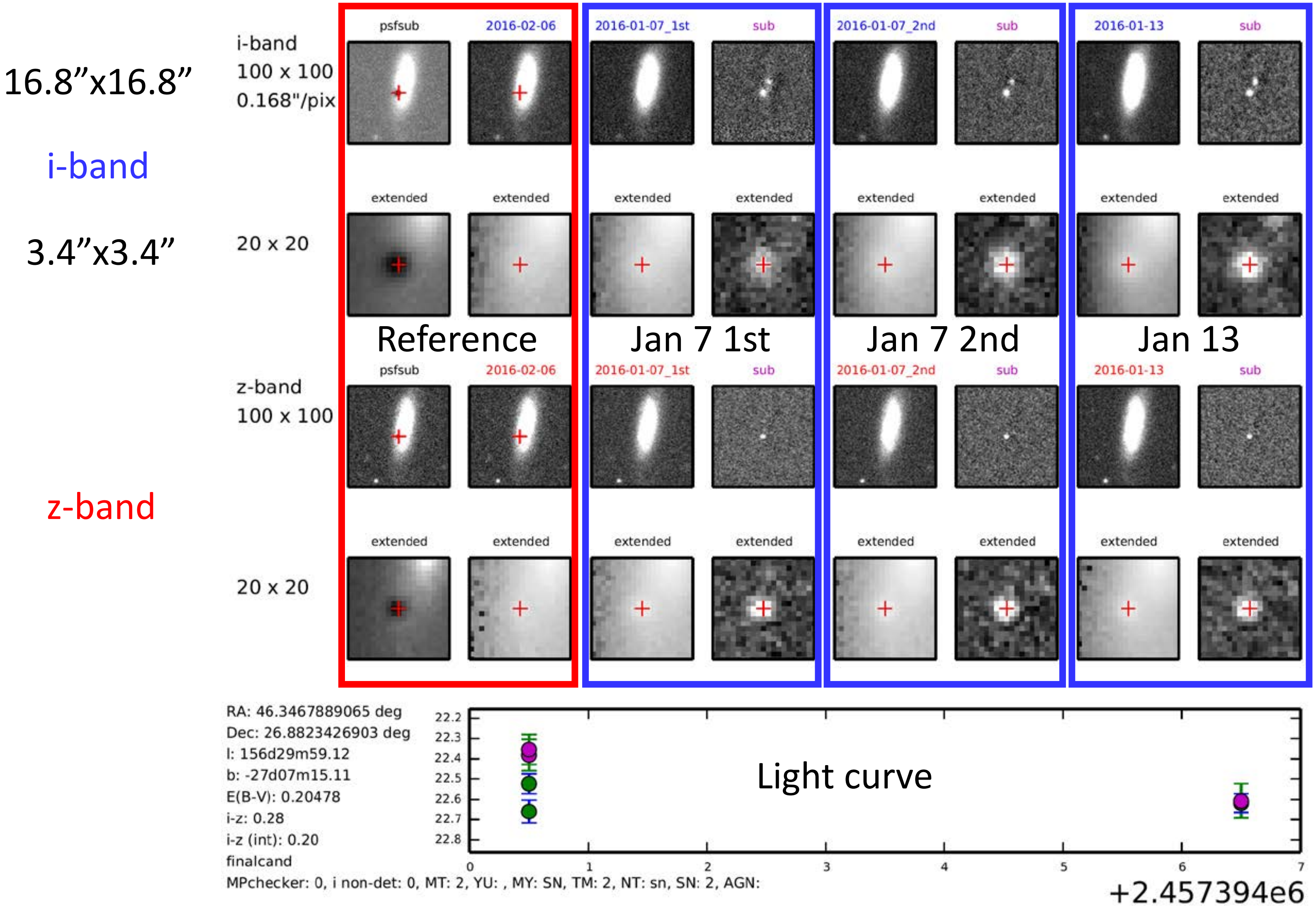
  - KISS16c (3 Jan 2016)
    - r~19.3mag
    - SN2015bl (Type Ia SN)



- 3 of them were already reported as supernovae.
- All of them are too bright for GW151226.

Transient candidates found

- 1256 candidates were found…

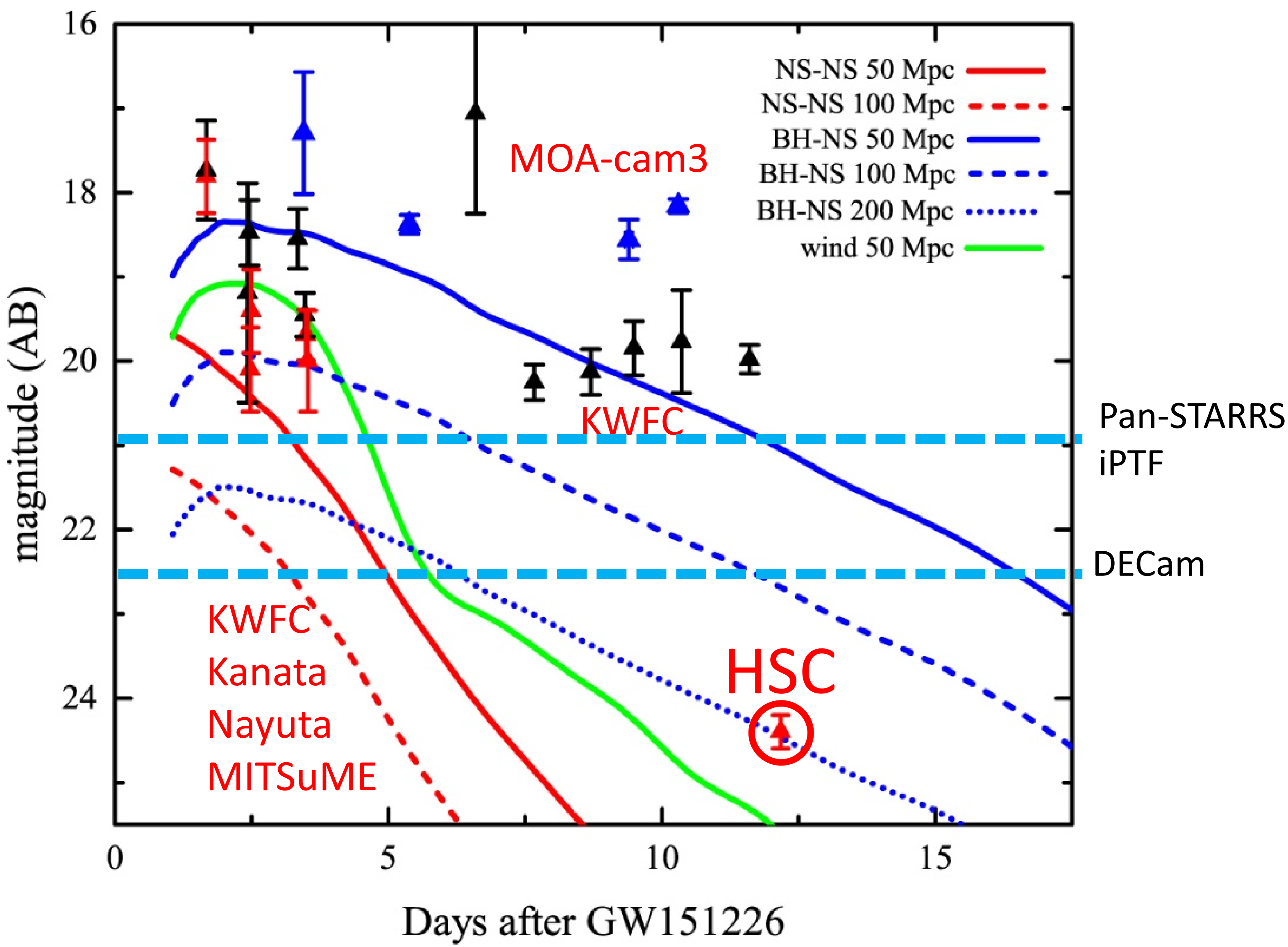


Candidates from Subaru/HSC

- 60 candidates are likely to be astronomical objects.
  - 20 possible AGNs
  - 40 SNe
- No candidate for an optical counterpart of GW151230

This is consistent with the fact that GW151226 was a BH-BH merger at ~440Mpc.

Limiting mag. of the J-GEM follow-ups with kilonova models



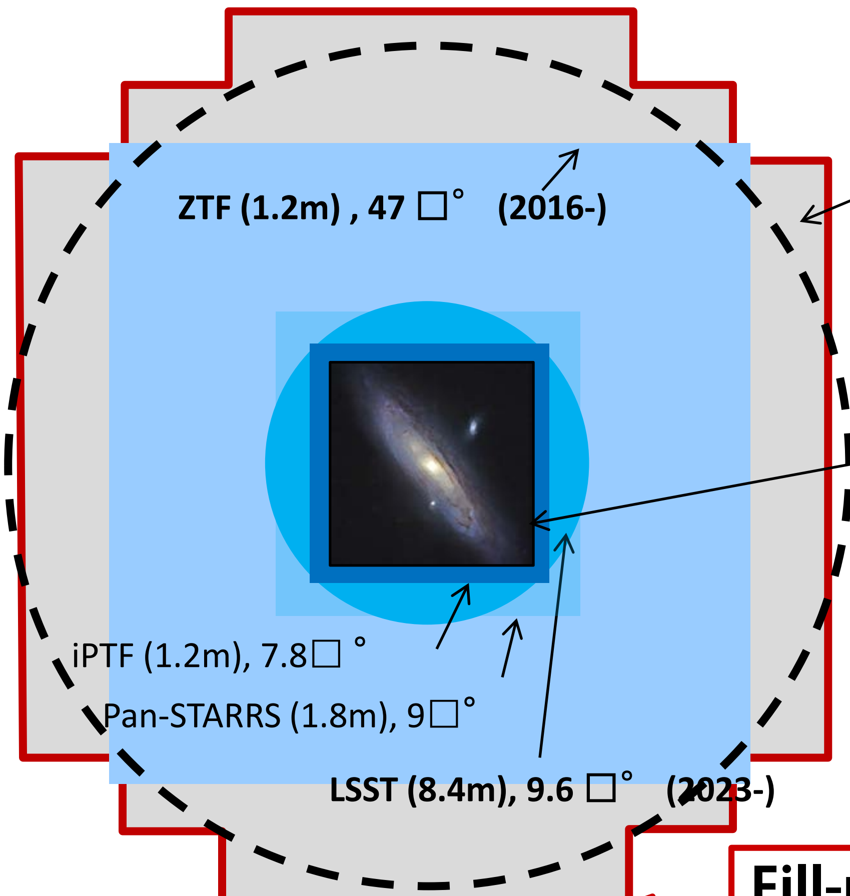
Yoshida, M. et al., 2017, PASJ, 69, 9

J-GEM Follow-Up Observations of The Gravitational Wave Source GW151226[1]

Michitoshi YOSHIDA[2], Yousuke UTSUMI,[2], Nozomu TOMINAGA[3,4], Tomoki MOROKUMA[5,4], Masaomi TANAKA[6,4], Yuichiro ASAKURA[7], Kazuya MATSUBAYASHI[8], Kouji OHTA[8], Fumio ABE[7], Sho CHIMASU[9], Hisanori FURUSAWA[6], Ryosuke ITOH[10,11], Yoichi ITOH[12], Yuka KANDA[10], Koji S. KAWABATA[2], Miho KAWABATA[10], Shintaro KOSHIDA[13], Naoki KOSHIMOTO[14], Daisuke KURODA[15], Yuki MORITANI[4], Kentaro MOTOHARA[5], Katsuhiro L. MURATA[16], Takahiro NAGAYAMA[17], Tatsuya NAKAOKA[10], Fumiaki NAKATA[13], Tsubasa NISHIOKA[18], Yoshihiko SAITO[11], Tsuyoshi TERAI[13], Paul J. TRISTRAM[19], Kenshi YANAGISAWA[15], Naoki YASUDA[4], Mamoru DOI[5,20], Kenta FUJISAWA[21], Akiko KAWACHI[9], Nobuyuki KAWAI[11], Yoichi TAMURA[5], Makoto UEMURA[2] and Yoichi YATSU[11]

Instrumentation activities of J-GEM

1. Tomo-e : Next Generation WFC at Kiso Observatory

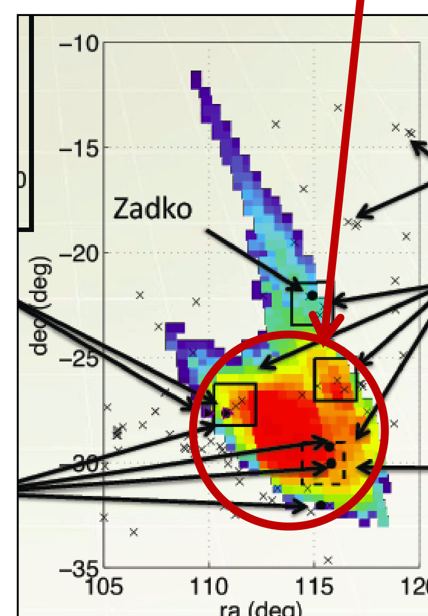


FoV of Kiso 1m Schmidt Telescope φ 9°

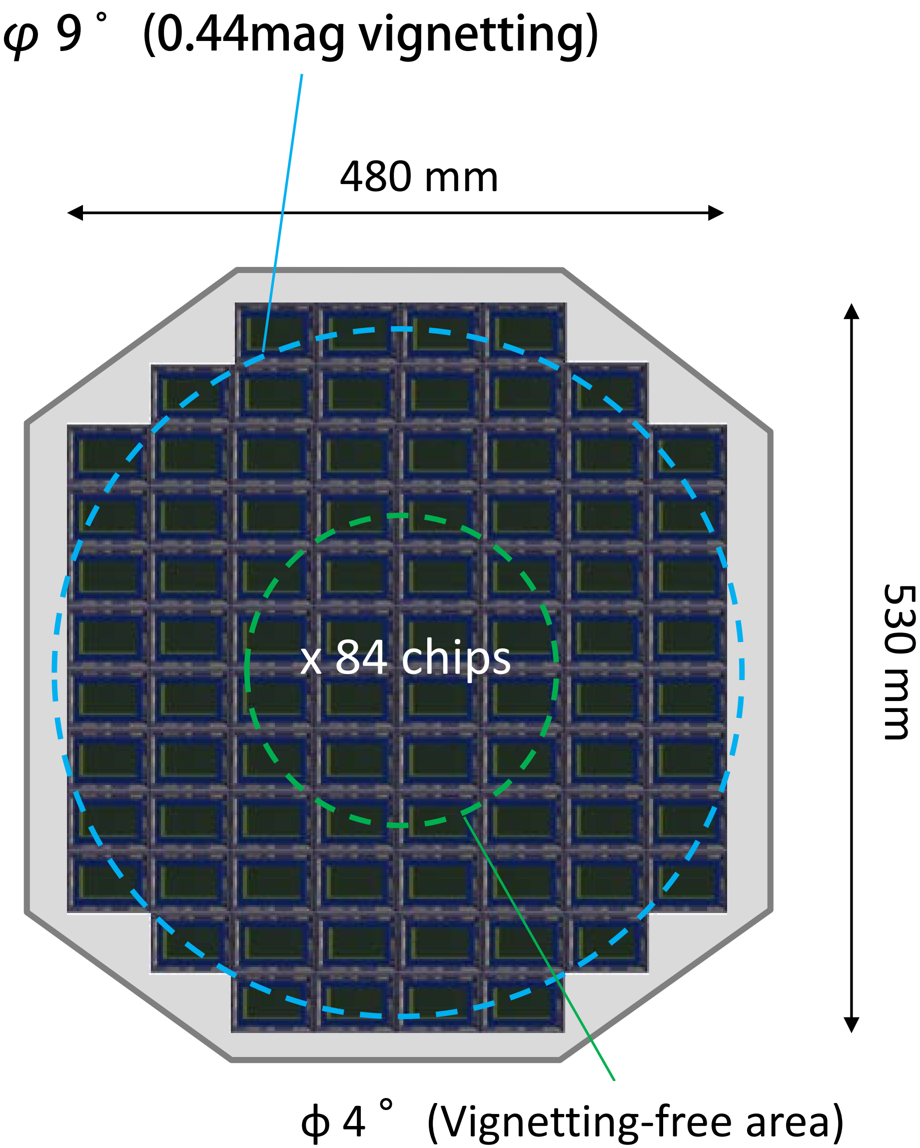
KWFC/Kiso
4.8 □° , CCD

Fill-up 20□° of φ 9°
with CMOS sensors

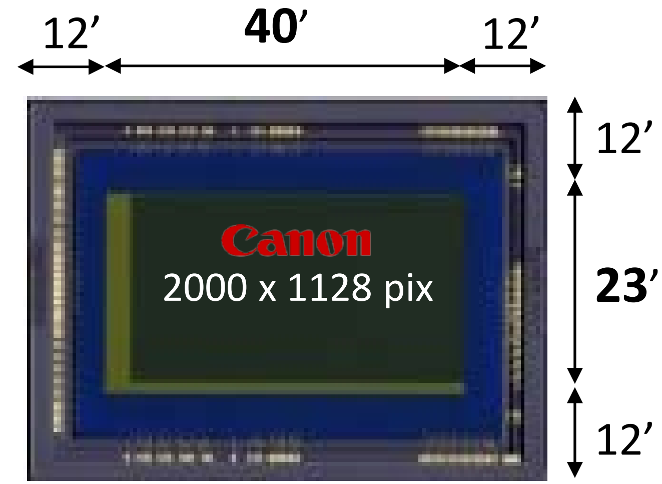
F.O.V
ϕ 9°



Tomo-e: Layout of the Focal Plane



Canon 35mm Full HD CMOS sensor



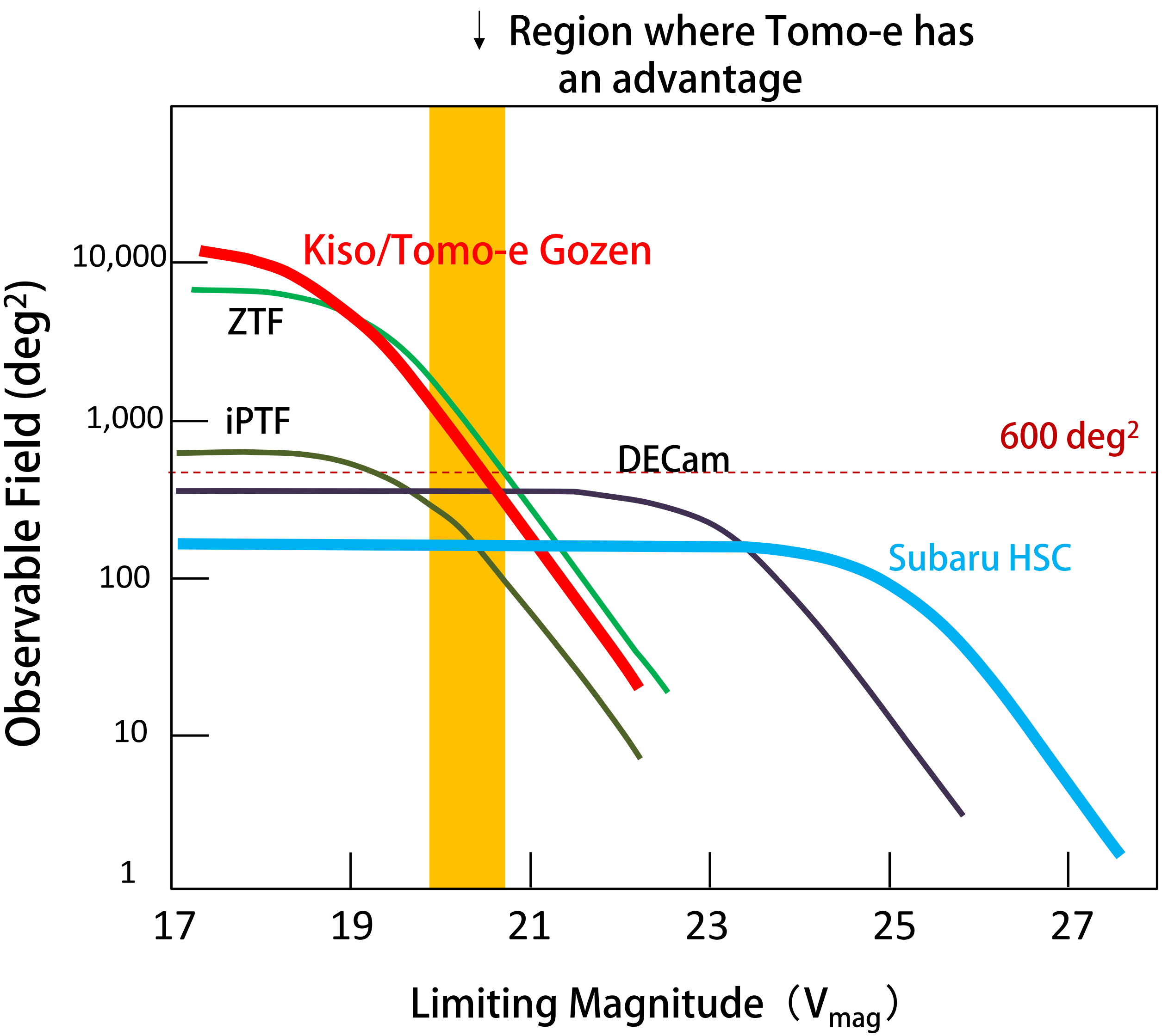
QE~50%@550nm
Low noise : RON < 2e- rms
Large pixel : 18um/pix

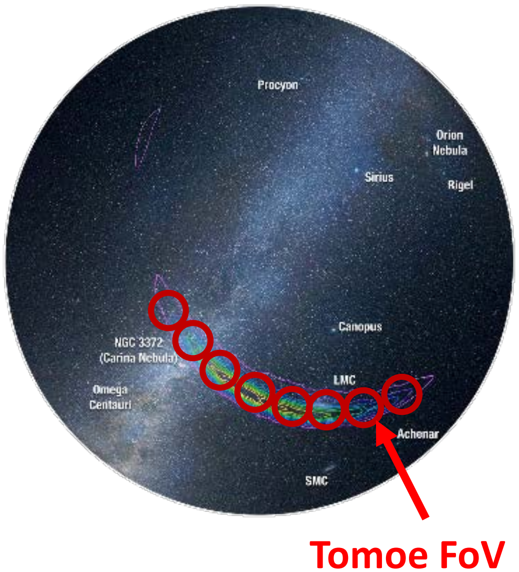
- ✓ Total 190 Mpixels
- ✓ 760 MB/exposure
- ✓ Driven at Room Temperature

Tomo-e: Data Acquisition System

- Data Production Rate : 420MB / one shot
- Requirements :
  - Typical survey observations (3sec exp / 3sec tel. slew)
    ⇒ 70MB/sec
  - 2Hz monitoring observations (2Hz / frame)
    ⇒ 830MB/sec
- Realtime Data Reduction Pipeline
  - Data reduction (calibration, subtraction, source detection) should be completed within ~5sec

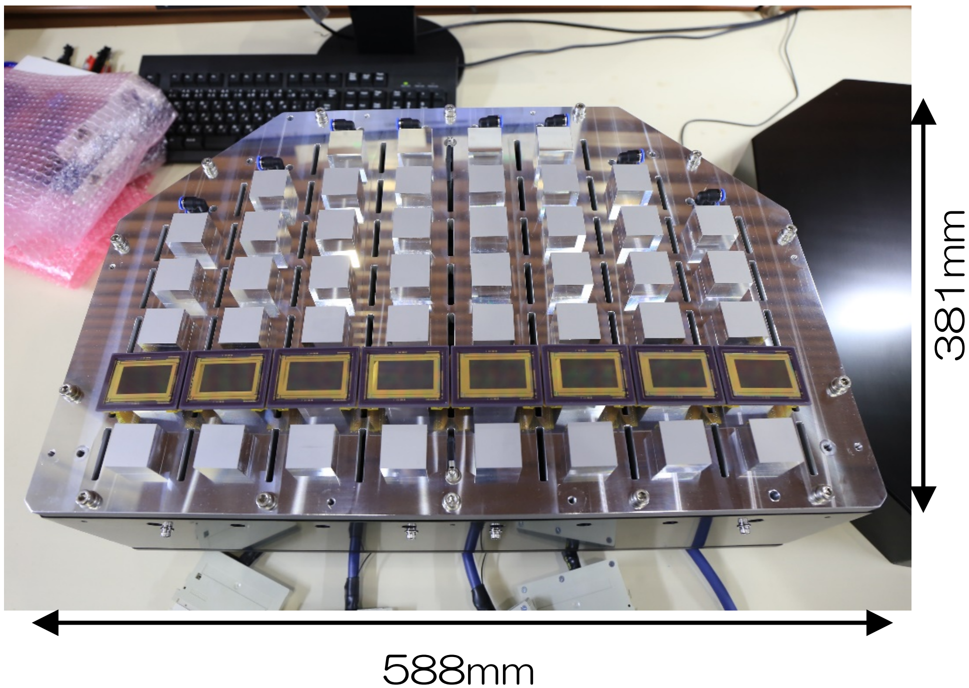
Capability of Tomo-e

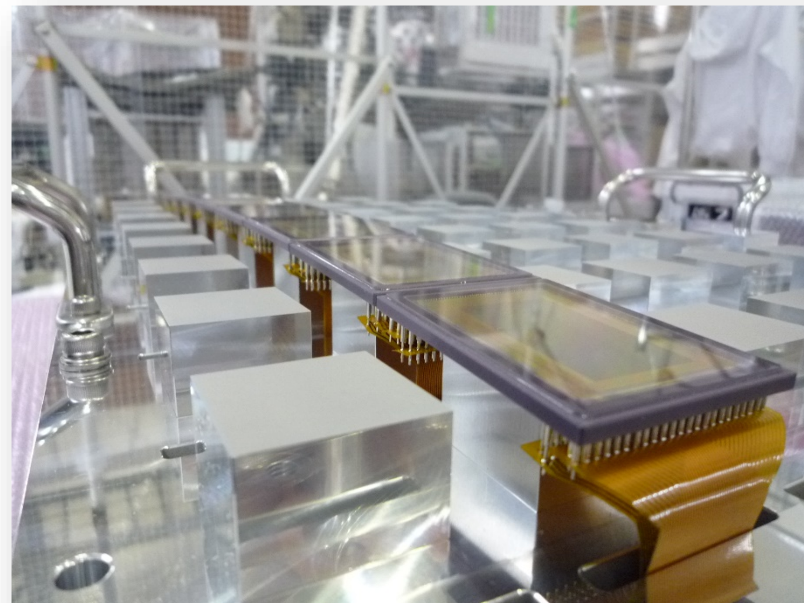




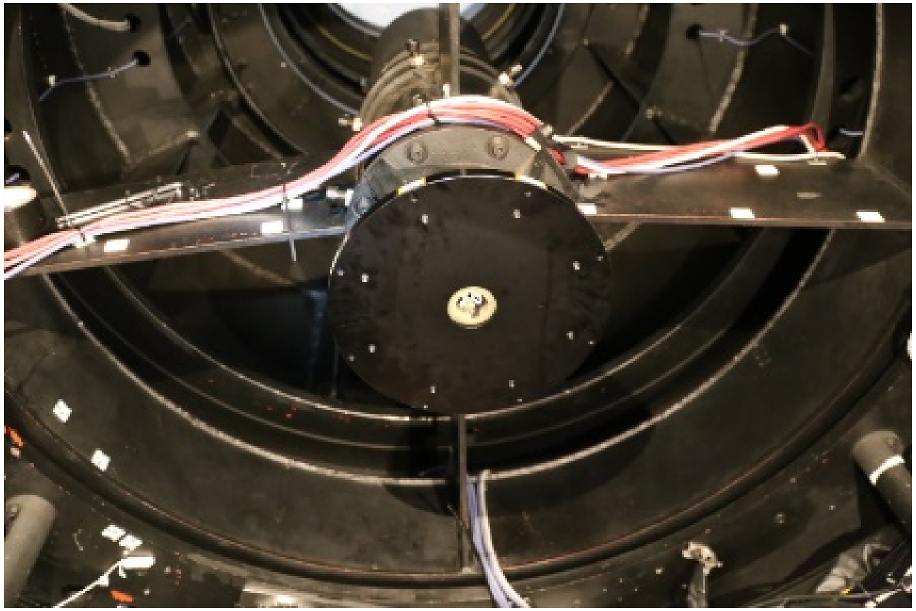
Tomo-e has a big advantage if the position accuracy of GW source is not so good (~100 deg^2)

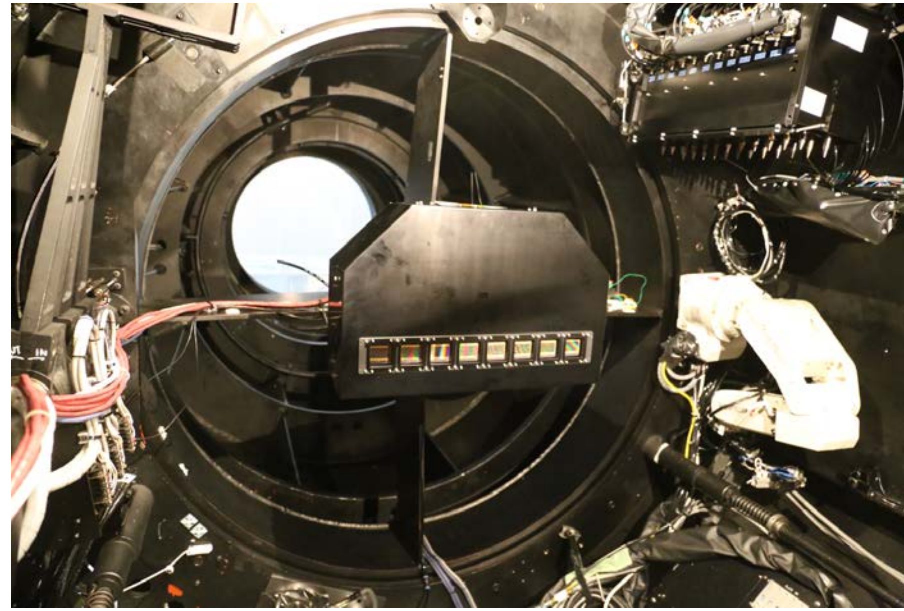
Tomo-e prototype: CMOS Sensors mounted on the Baseplate

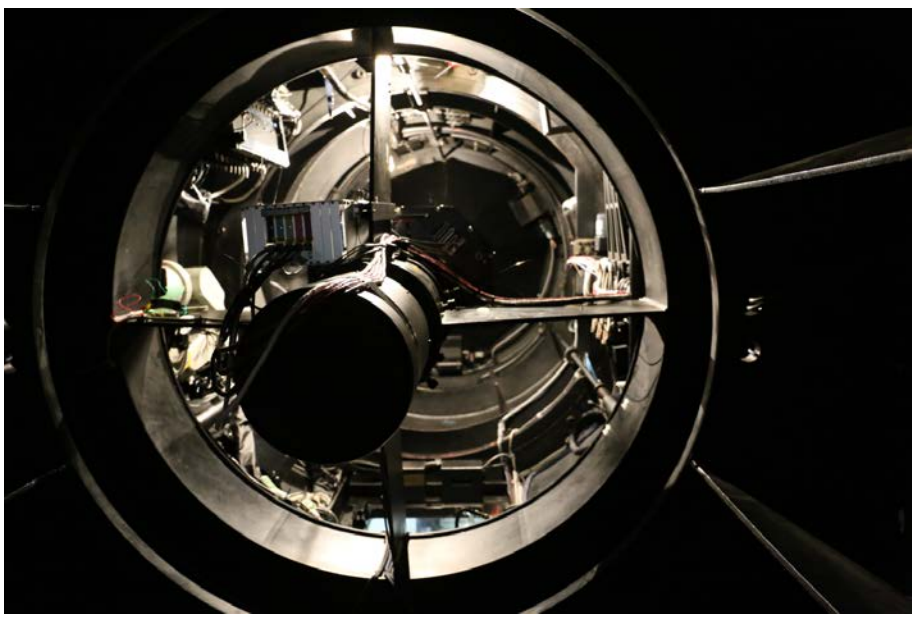


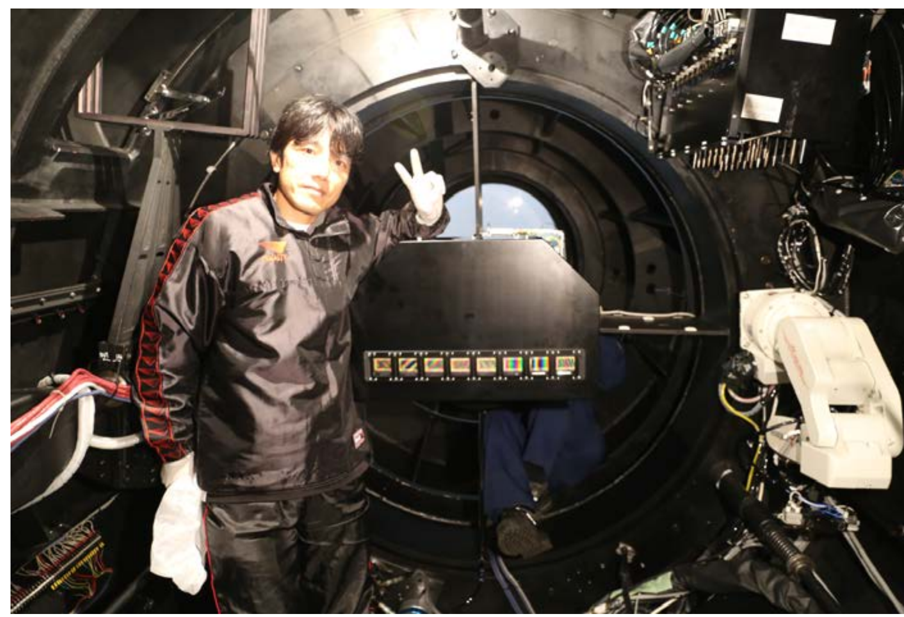


Tomo-e prototype

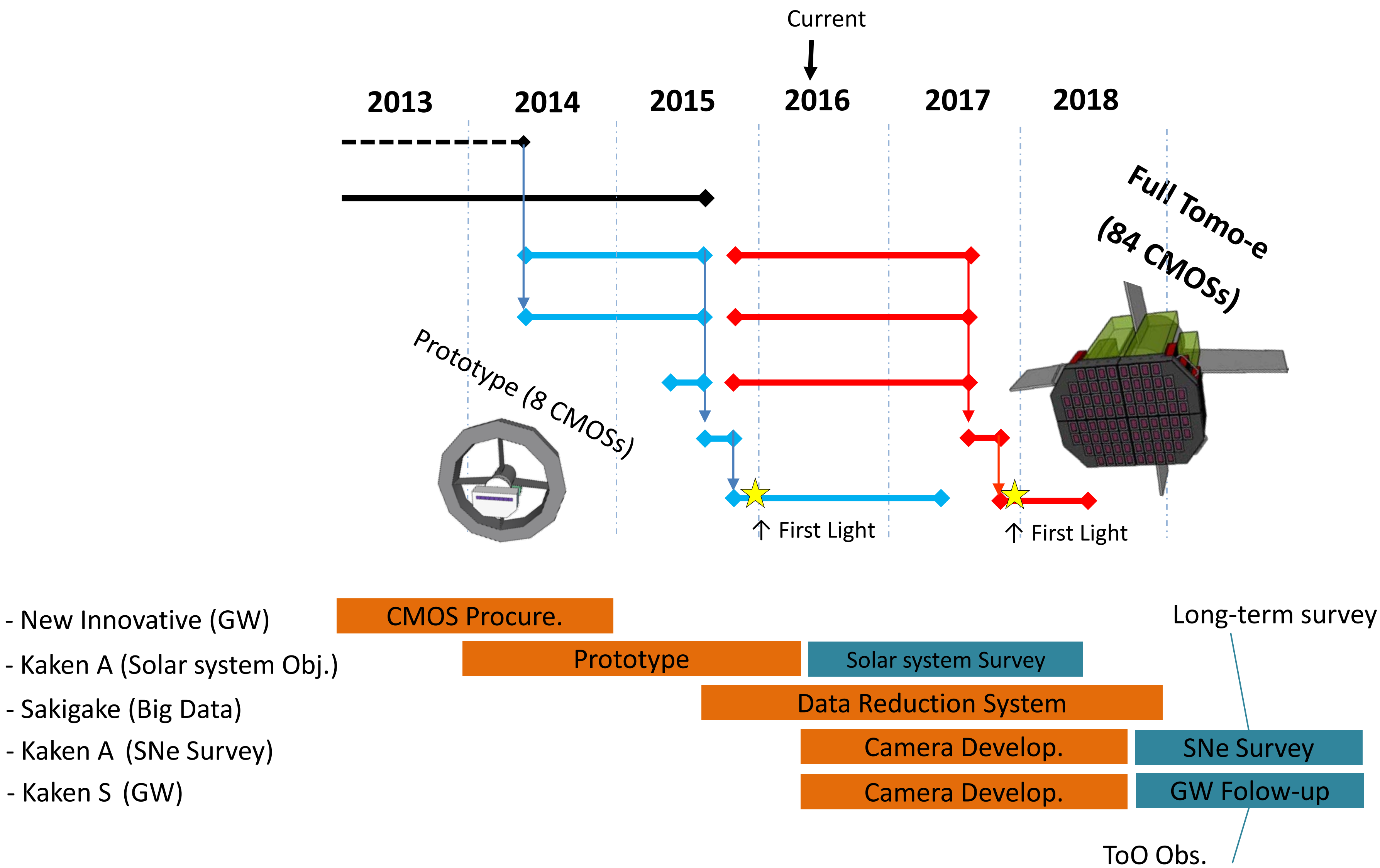






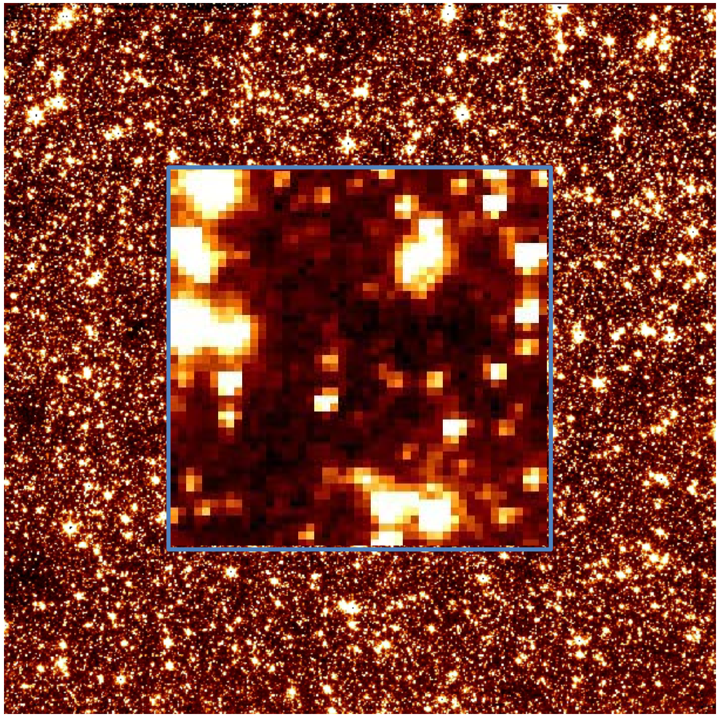


Tomo-e: Development Schedule



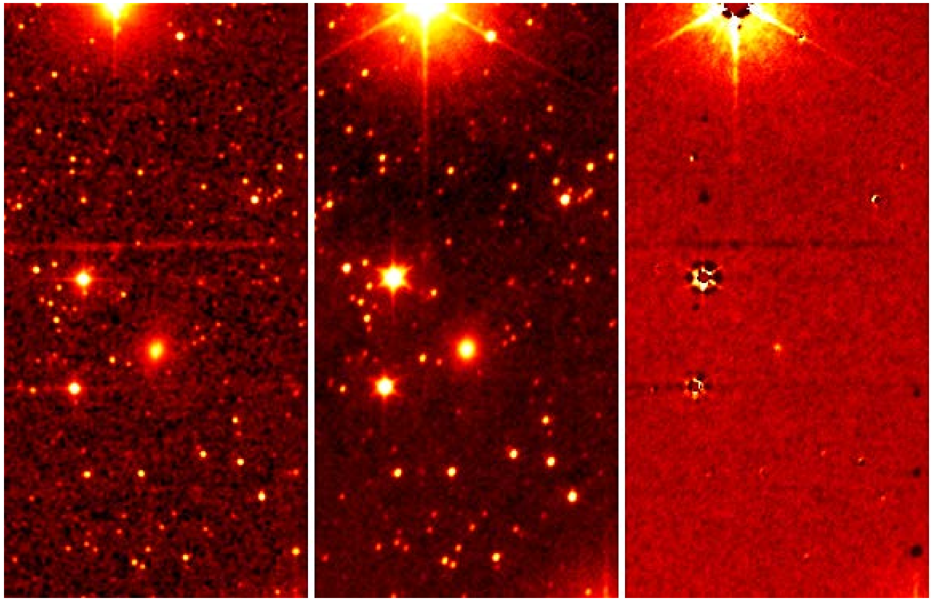
2. OAOWFC: 1 deg^2 NIR camera

- Optical alignment was completed
  - FWHM=2pix entire frame



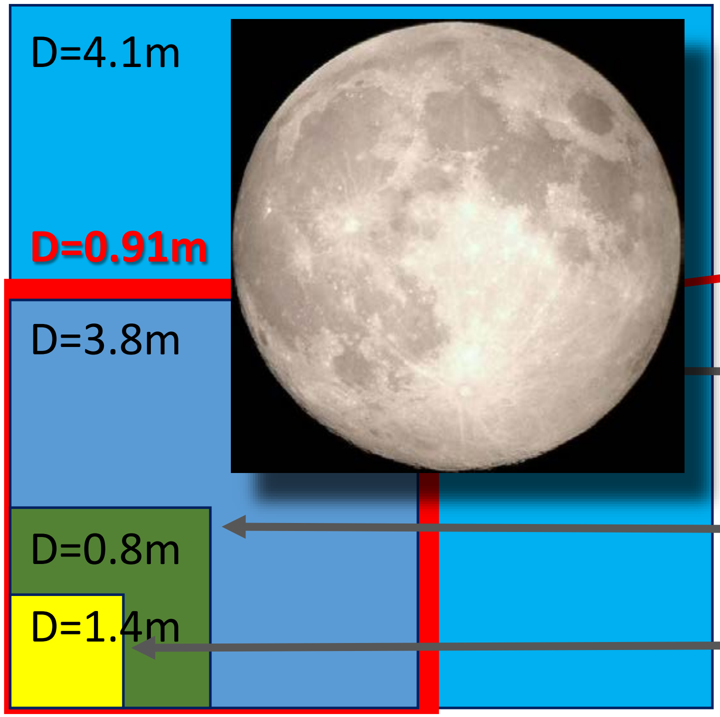
Ks-band image of the Galactic Plane

- LIGO O1 follow-ups were carried out
  - Reached J=17~18 with 15^{min} exposure
  - Almost identical to the 2MASS limit



2MASS　　OAOWFC　　Difference

Comparison FOVs: NIR imagers



ESO VISTA: 0.77 × 0.77 deg^2

OAOWFC: 0.47 × 0.47 deg^2

UKIRT WFCAM: 0.46 × 0.46 deg^2

IRIS: 0.22 × 0.22 deg^2

SIRIUS: 0.13 × 0.13 deg^2

OAOWFC's FOV is one of the largest in the world.

3. IFU for the spectrograph of Kyoto 3.8m telescope

Aim:

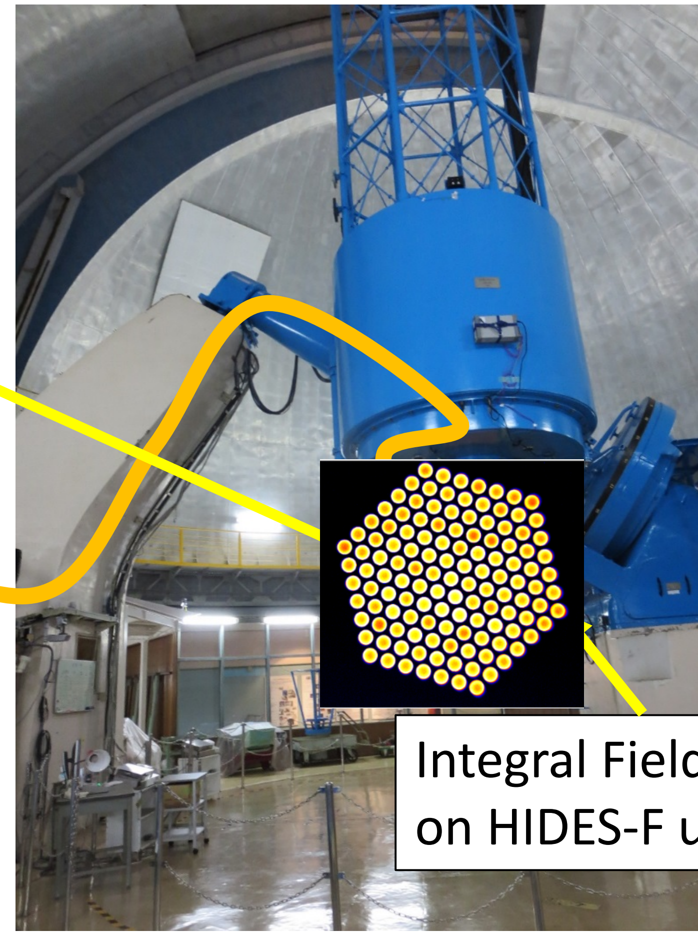
- prompt optical spectroscopy w/ IFU on the Okayama 188 cm and the future 3.8 m telescope
- targets
  - short GRBs of which positional accuracy is less than ~10-20 arcsec
  - optical counterpart candidates of GW sources
- spectroscopy of SNe, galaxies, etc can also be possible

KOOLS-IFU on 188cm telescope

The IFU moves into the optical path by promptly changing units when HIDES-F unit is working, which is used frequently.

Fibre bundle

Optical spectrograph: KOOLS



Integral Field Unit on HIDES-F unit

188cm telescope

KOOLS-IFU on 188cm telescope: Performance

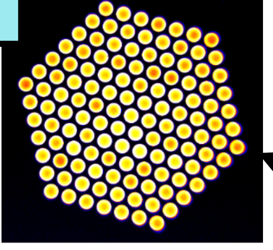
- FoV of IFU: ~ 30″
- FoV of a fibre: ~ 2″ (# of fibres =127)
- Filling factor: ~ 60%
- Wavelength coverage (*): 5020-8830A
- Spectral resolution (*): 600-850
- Limiting mag (30min, 10σ)(*): 18.7 AB

(*) w/ Grism No.2

KOOLS-IFU: Future plan

Equip to the 3.8m telescope (on-going)

Filling factor
~ 100%



CCD grade-up (on-going),
improve throughput

3. HinOTORI: a robotic telescope in Tibet

- Development of a 50cm robotic telescope + 3-color camera system
  ➔ West China (Tibet area)
- FOV: 24 arcmin x 24 arcmin   0.7 arcsec/pix
- Expected limiting mag. (S/N=5 for 10 min exp.)
  – 18.5 mag. u' -band
  – 21.1 mag. R_c-band
  – 20.8 mag. I_c-band

Current status of HinOTORI

The telescope reached at the Ali site and installed in a dome of NAOC on Sep. 7 2016.

➔ We plan to visit Ali in this month

➔ Full commissioning





KOMATSU

大学間連携事業

2011 – 2016　6 universities + NAOJ ➔ GRB

2017 – 2021　8 universities + NAOJ ➔ GW, neutrino, GRB

OISTER WEB Optical and Infrared Synergetic Telescopes for Education and Research @光赤外線天文学大学間連携事業

ホーム | 事業概要 | 活動成果(研究) | 活動成果(教育) | 望遠鏡一覧 | 観測装置 | OISTER Wiki

OISTER Web » 事業概要

事業概要

北海道大学、東京大学、東京工業大学、名古屋大学、京都大学、広島大学、鹿児島大学の7大学と大学共同利用機関である自然科学研究機構・国立天文台が連携し、日本の大学が国内外に持つ中小口径の望遠鏡を有機的に結びつけて、突発天体等の即時および連続観測により、その物理現象の解明をメインテーマとした最先端共同研究の推進と大学における天文学教育を促進するための事業を平成 23年度から6年間共同で実施いたします。平成24年度より埼玉大学、兵庫県立大学を加え観測体制をより強化しました。

本事業は、突発天体のフォローアップ観測および変光天体の連続モニター観測等、天文学の比較的未開拓な次元である「時間軸」に焦点を当てた斬新な研究を行います。“すばる望遠鏡“や”アタカマ大型ミリ波サブミリ波干渉計 (ALMA) “のような大望遠鏡だけでは出来ない種類の最先端研究を行うことにより大学での教育と研究を促進し、広い視野と知識を備えた研究者を育成することを目指しています。また、大学の垣根を越えて広く研究者の人的交流を奨励することが期待されます。

Summary

- We developed a coordinated network of optical-infrared-radio telescopes for follow-up of GW transients, J-GEM.
- The network contains several existing optical-infrared-radio telescopes in Japan, Hawaii, South-Africa, New Zeeland and Chile.
- Subaru HSC is a very powerful optical camera for GW-EM follow-up (m_{lim}~24 mag for 60 deg^2 in a half night)
- Three new telescopes are under construction (50cm in Tibet, 3.8m in Japan and 6.5m in Chile).
- We plan to make EM follow-up for LIGO O2 from this winter.