Commissioning Observations of 7DT and Upcoming 7DS

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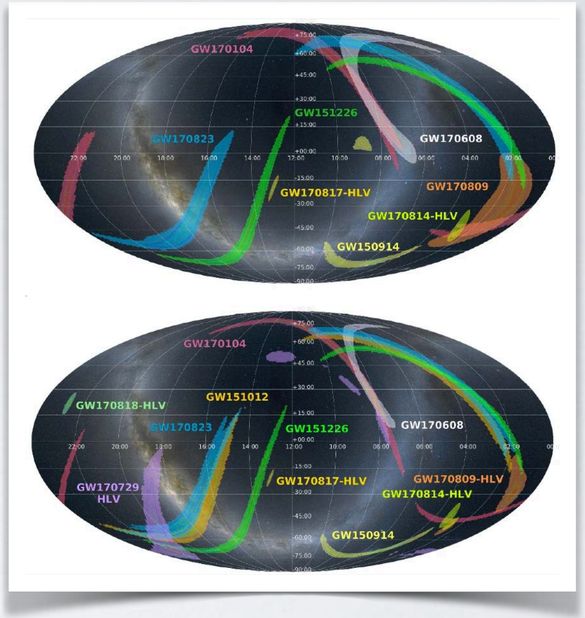
January 29 2024

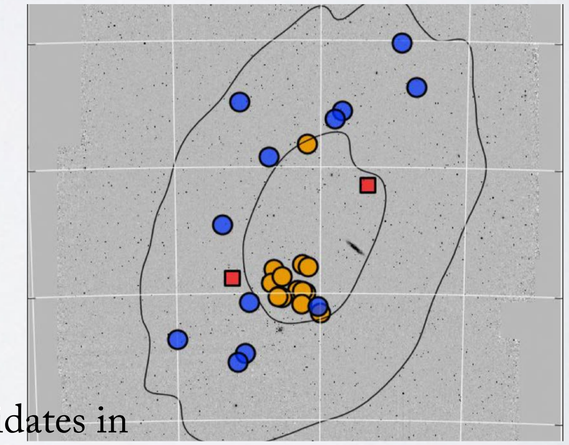
Multi-Messenger Astronomy

- *3 Challenges to EM Counterpart Identification*
  1. *Wide Localization Area*
     - *a few100's square degrees for O3*
     - *a few10's of square degrees for O4?*
  2. *Faint, Fast-declining Transients (kilonova)*
     - *Peak apparent magnitudes are R = 17 ~ 22.5 mag.*
     - *They become a few mag fainter in several days.*
  3. *Numerous Transients and Bogus Signals in large FoVs*
     - *a few100's transients and/or variable objects in 10 square degrees*
     - *a few10^5's artifacts in 10 square degrees*

Sky locations of GW events confidently detected in O1 and O2
(Fig 5 of Abbot et al. 2020)



GW 190814
NSBH (O3)

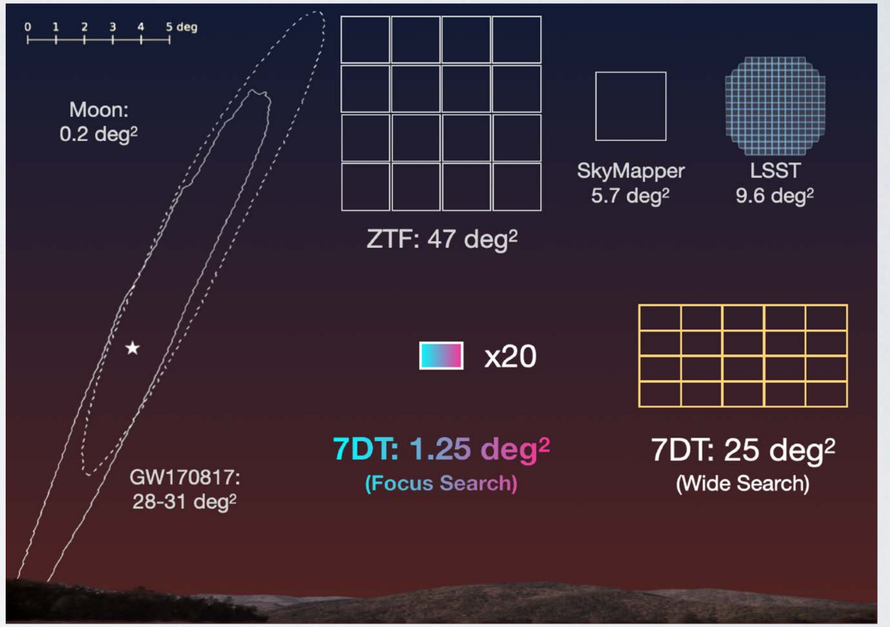


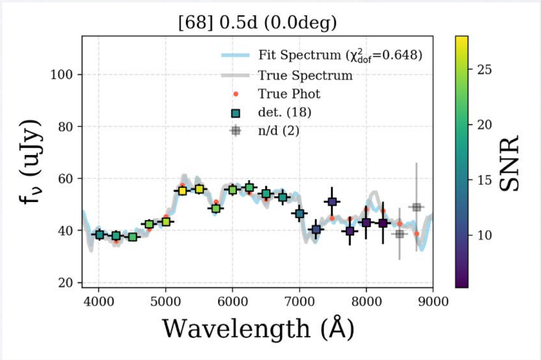
20 to 30 transient candidates in
~18.5 deg^2

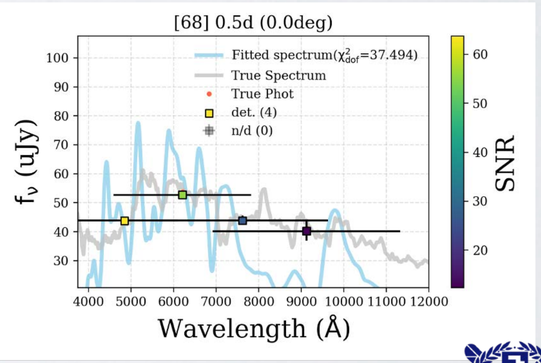
Thakur et al. 2019

What do we need?

1. *Wide Field of View*
   - *Need to cover as much area as possible.*
2. *Flexible Operation*
   - *Need to start follow-up as soon as possible.*
3. *Real Time Analysis*
   - *Need to distinguish real and bogus objects.*
   - *Need to keep covering localization areas while analyzing obtained data.*
4. *Low Resolution Spectroscopy*
   - *Need to classify among transients.*



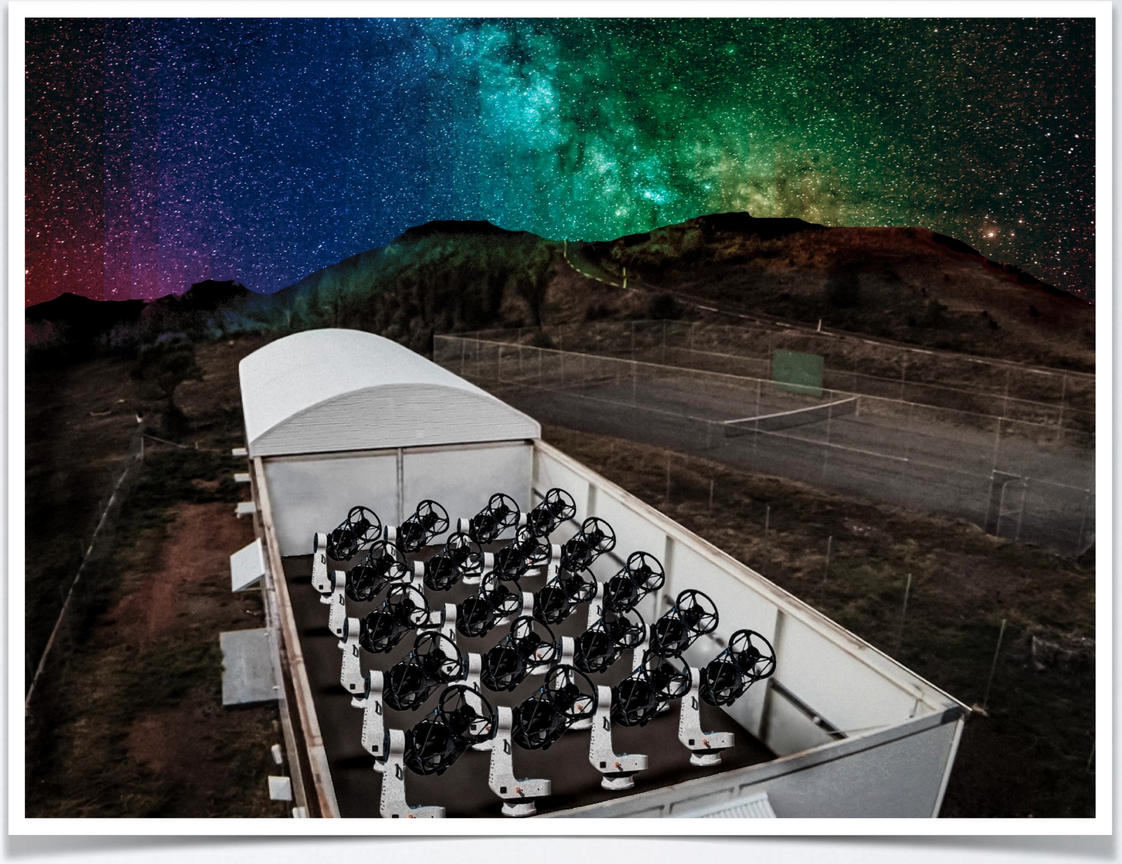




Courtesy of Gregory S. H. Paek

7-Dimensional Telescope in a Nutshell

- *20 × 50-cm commercial off-the-shelf astrograph*
- *40 × 25nm medium band filters + Sloan Broad-band filters*
- *IFU-style Data for a large FoV (~ 1.2 square degrees)*
- *Hotsed by ObsTech at Observatorio El Sauce situated in the Río Hutardo Valley in Chile.*
- *Fully remote observation accommodating automated survey, alert brokers, GW follow-up rankings, etc.*



A conceptual view of 7DT (Image Credit : Mankeun Jeong & Minhee Hyun)

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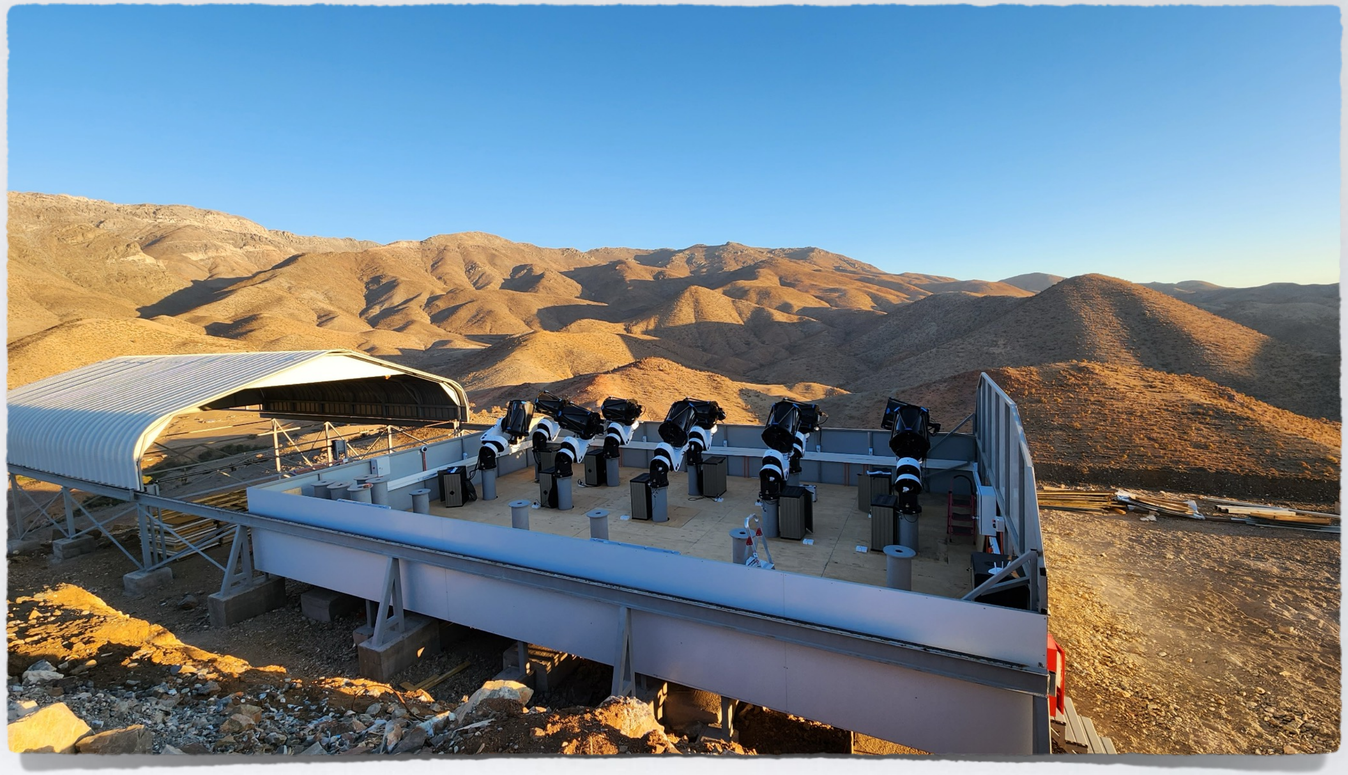


Current Status

- *12 × 50-cm commercial off-the-shelf astrographs are installed and are being commissioned.*
- *20 × 25nm medium band filters + Sloan Broad-band filters*
- *A data storage server of 1 PB, **Lyman**, is ready.*
- *A GPU-based data process server with 2 NVIDIA A100 cards, **Proton**, is ready.*
- *Network synchronization with KREONET is being carried out.*







Commissioning Procedures

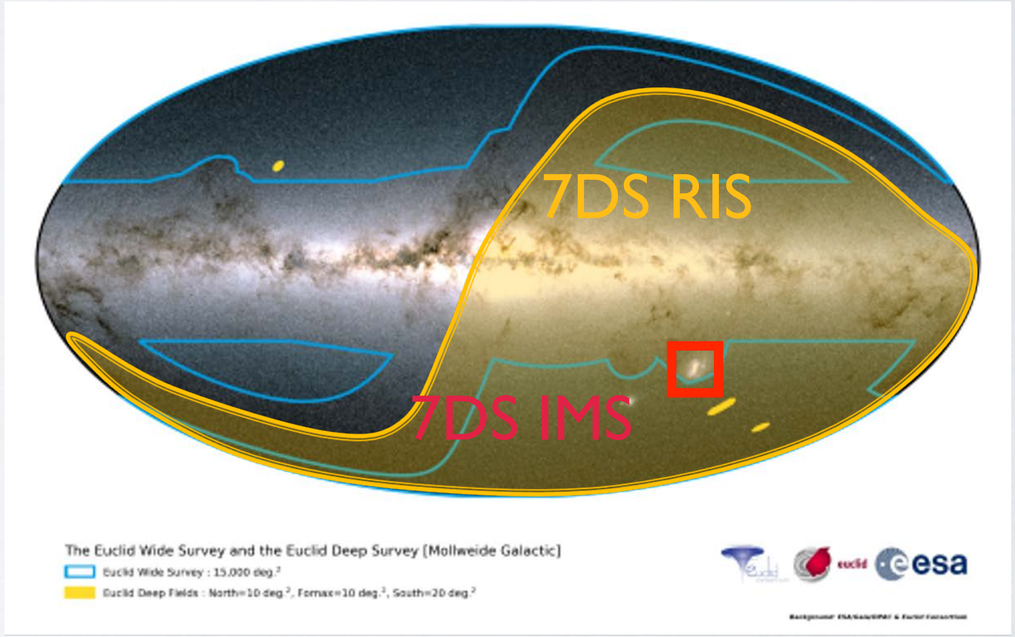
- *Instrument Functionality Testing*
  - *Opto-mechanical Test*
  - *Mount-modeling: Polar alignment*
  - *Focus measurement*
  - *Optical quality assessment*
- *Science Verification*
  - *Evaluating bias, dark, and flat*
  - *Producing master calibration frames*
  - *Spectrophotometric calibration*
  - *Evaluating astrometry*
  - *Evaluating image depths*

Science beyond Gravitational-wave Astronomy

Subject	Now	7DS	Scientific Value
Time-series Spectra of Quasars	~1000	>30,000	Complete Census of SMBH AGN Variability
RM Measurement of SMBH Mass	~100	10,000	Growth History of SMBHs
Velocity Maps of Galaxies	~10,000	50,000,000	Galaxy Evolution
Galaxy Clusters	100,000	100,000	Cosmology, Galaxy Evolution
Early Spectra of SNe	~10	>1,000	Physical Mechanism of SNe
Time-series Spectra of Stellar Objects	1,000,000	10^9	Stellar Evolution
Time-series Spectra of Small Bodies of the Solar System	100	>10,000	Origin of the Solar System, Census of Asteroids/Comets

Survey Strategy

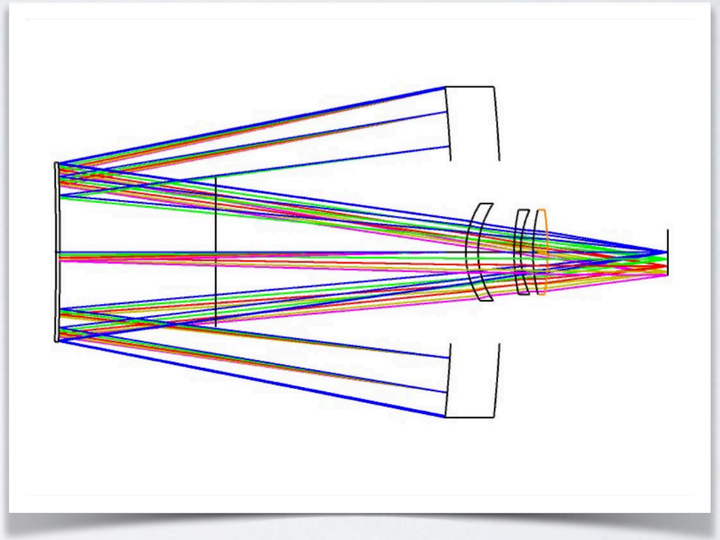
Surveys	Survey Area (deg^2)	Cadence	Depth (5yr)	Exposure Time per epoch per filter
Reference Imaging Survey	20,000	-	20 mag	3 min
Wide-field Survey (WFS)	1,620	14 days	23.3 mag	3 min
Intensive Monitoring Survey (IMS)	12.6	1 day	25.1 mag	3 min

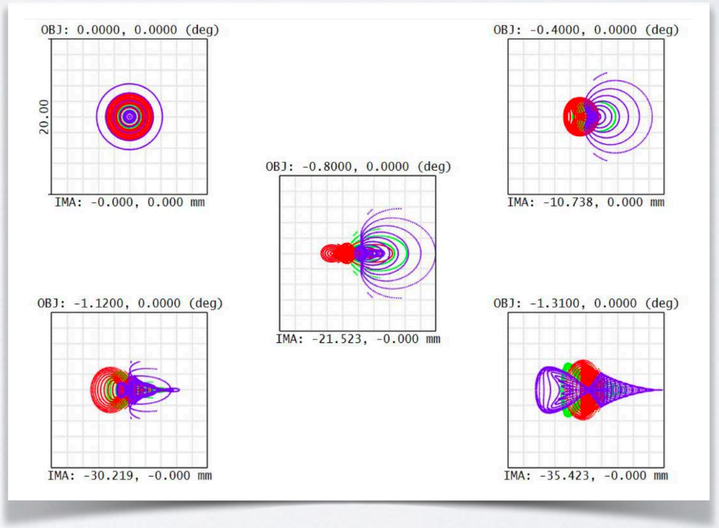


The survey depths are estimated assuming 1.5″ seeing and 70% survey efficiency.

Commissioning Procedures: Functionality Test

- *Opto-mechanical Test*
  1. *Collimation*
  2. *Field-tilt adjustment*
- *Mount-modeling: Polar alignment*
- *Focus dependency measurement*
- *Optical quality assessment*





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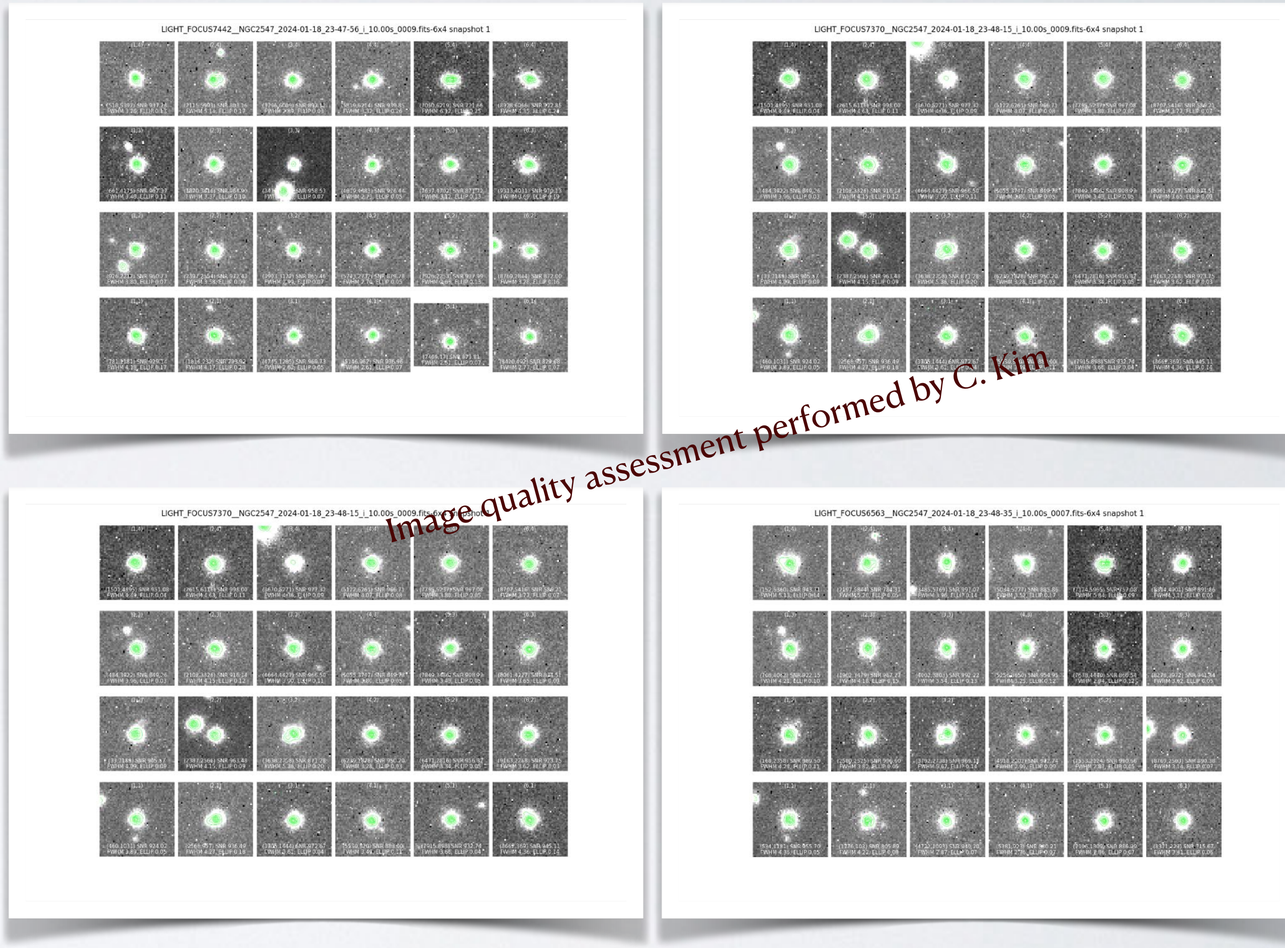
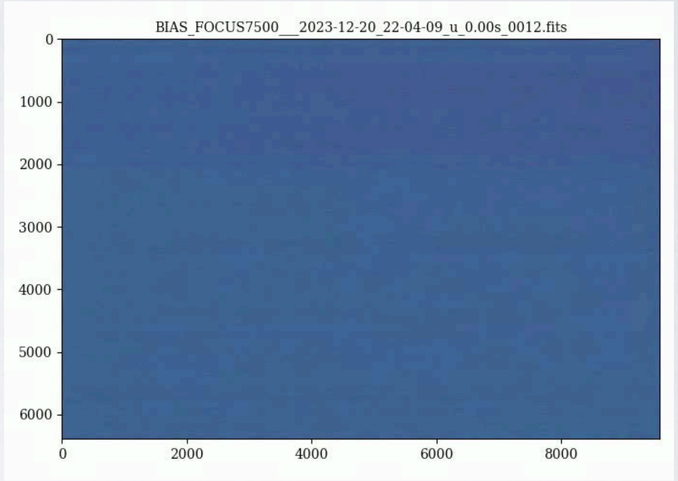
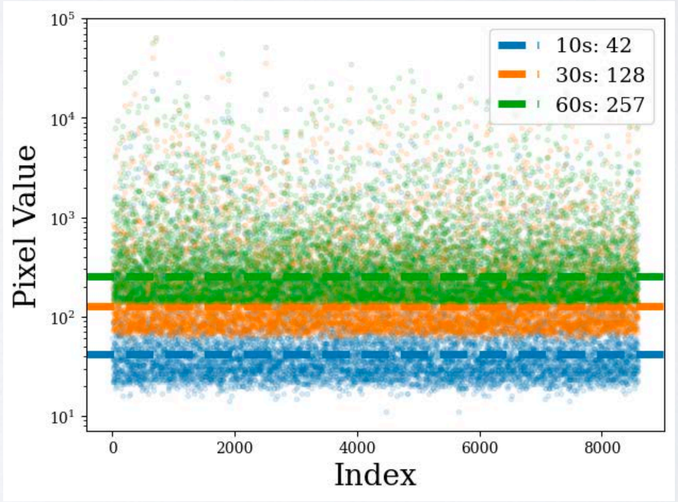


Commissioning Procedures: Science Verification

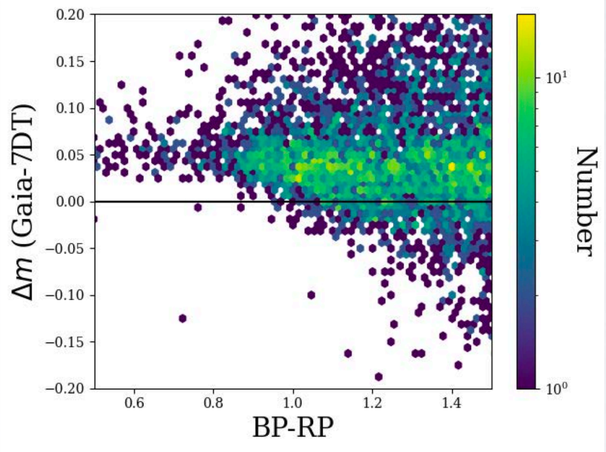
- *Master Bias*
- *Master Dark*
- *Master Flat for Every Filter (5 Sloan Broad-bands + 20 Medium-bands)*
- *Deviation from standard data reduction for CCD data?*

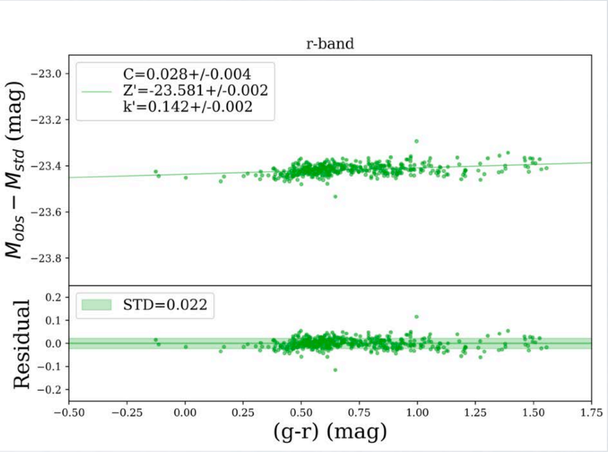


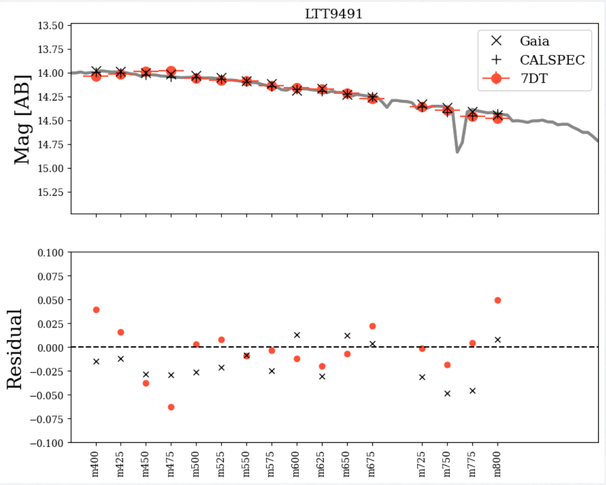


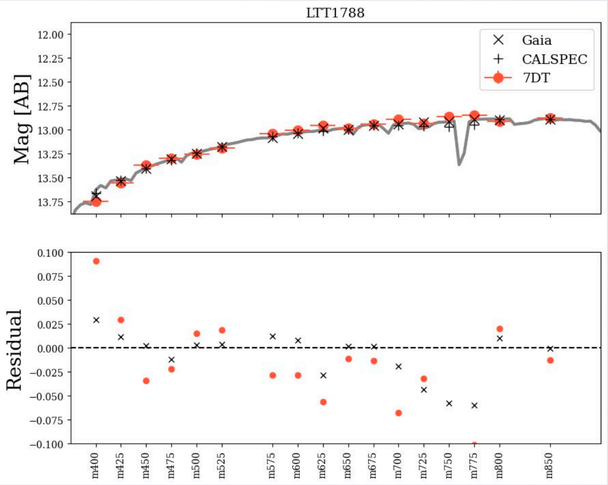
Commissioning Procedures: Science Verification

- *Spectrophotometric Standardization*
  - *Utilization of Gaia DR3 XP Spectra: Low-R Spectra of 320~1050 nm*
  - *Benchmarks:*
    1. *CALSPEC Spectra for 12 Well-known Spectrophotometric Standard Stars*
    2. *68 Spectrophotometric standard stars collected by ESO*









국가과학난제도전융합연구개발사업
National Science Challenge Initiatives
중력파우주연구단

Commissioning Procedures: Science Verification

- *Benchmarks for our scheduled survey*

1. Reference Imaging Survey:

- *1 visit of 3-minute total exposure*

2. Wide-Field Survey (WFS)

- *1 visit per 10 ~ 14 days*
- *60 ~ 80 minutes per year*
- *Up to 6.5 hours for 5-year operation*

3. Intensive Monitoring Survey (IMS)

- *1 visit per day*
- *600 ~ 800 minutes per year*
- *Up to 65 hours for 5-year operation*



Commissioning Procedures: Science Verification

- *NGC 253, NGC 1097, NGC 6514*
- *PHANGS (Physics at High Angular Resolution in Nearby Galaxies, PI: J. Lee)*
  - *ALMA, HST, and MIRI of JWST*
  - *74 Sample galaxies with ALMA*
  - *32 Sample galaxies were observed with 7DT so far.*
- *The Ultra-Deep Survey (UDS) field*
  - *Photo-z test, cross-check with available spectra*
  - *800 ~ 3000 sec exposures per filter*
- *SPT-CL_J2017-6258 & SPT-CL_J2020-6314*
- *M44, SDSS J0228-0901, GRB231117A, etc.*

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Summary

- *12 of 20 telescopes are installed at El Sauce Observatory located in Rio Hurtado Valley, Chile.*
  - *50-cm, f/3.0*
- *2 sets of 20 medium-band filters of 50 nm width from 400 to 900 nm.*
- *11 cameras of 9576 x 6388 pixels covering 1.2 square degrees*
- *Commissioning procedures are underway for functionality tests and science verification.*
- *We are taking various commissioning data to evaluate the instruments and their capability to satisfy our scientific goals of planned surveys.*



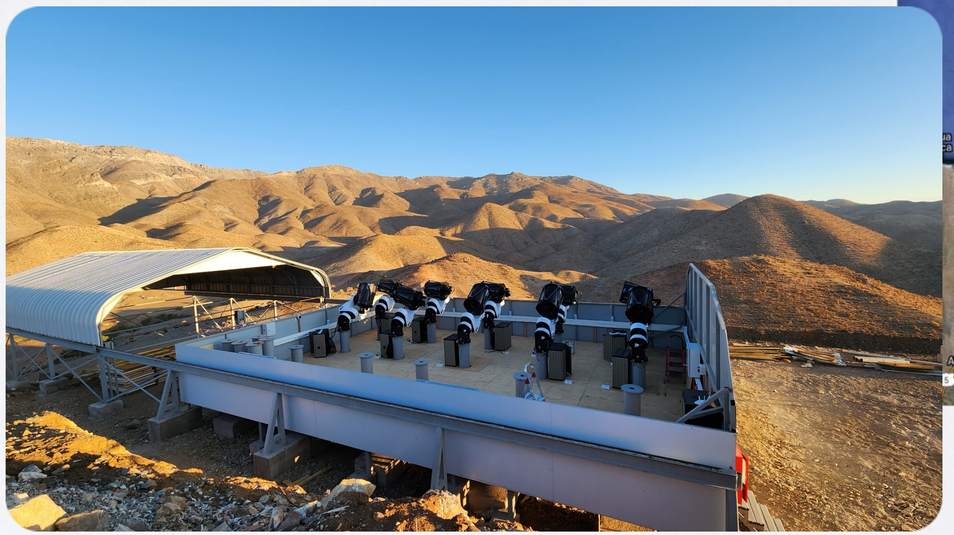


Site : Current Status









- *altitude : 1700 m*
- *more than 300 clear nights (up to 320 nights)*
- *the median seeing : 1.3″*
- *the mean sky brightness : ~22 mag/″*

