A Decade of Astronomy at Dome A

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Traverses to Dome A with Astronomy programs/instruments since 2007

CHINARE & Year	Members[a]	New Facilities & Instruments
24th (2007/2008)	2	PLATO, CSTAR, Pre-HEAT, Gattini, Snodar, DASLE
25th (2008/2009)	1	Nigel, Snodar2, SAVER
26th (2009/2010)	2	FTS, HRCAM, SHABAR
27th (2010/2011)	2	KLAWS, DIMM, SEU Platform
28th (2011/2012)	4	AST3-1, PLATO-A, DIMM
29th (2012/2013)	3	HRCAM2
30th (2013/2014)[b]	-	-
31st (2014/2015)	2	AST3-2, KLAWS-2G, NIRSPEC, CSTAR-II
32nd (2015/2016)	2	Webcams, Wind turbine
33rd (2016/2017)	4	KLCAM
34th (2017/2018)[b]	-	-
35th (2018/2019)	4	KL-DIMM, nKLAWS-2G, KLCAM2, KLCAM3 NISBM, MARST, Microthermal
36th (2019/2020)[b]	-	-

4 milestones, 3 stages

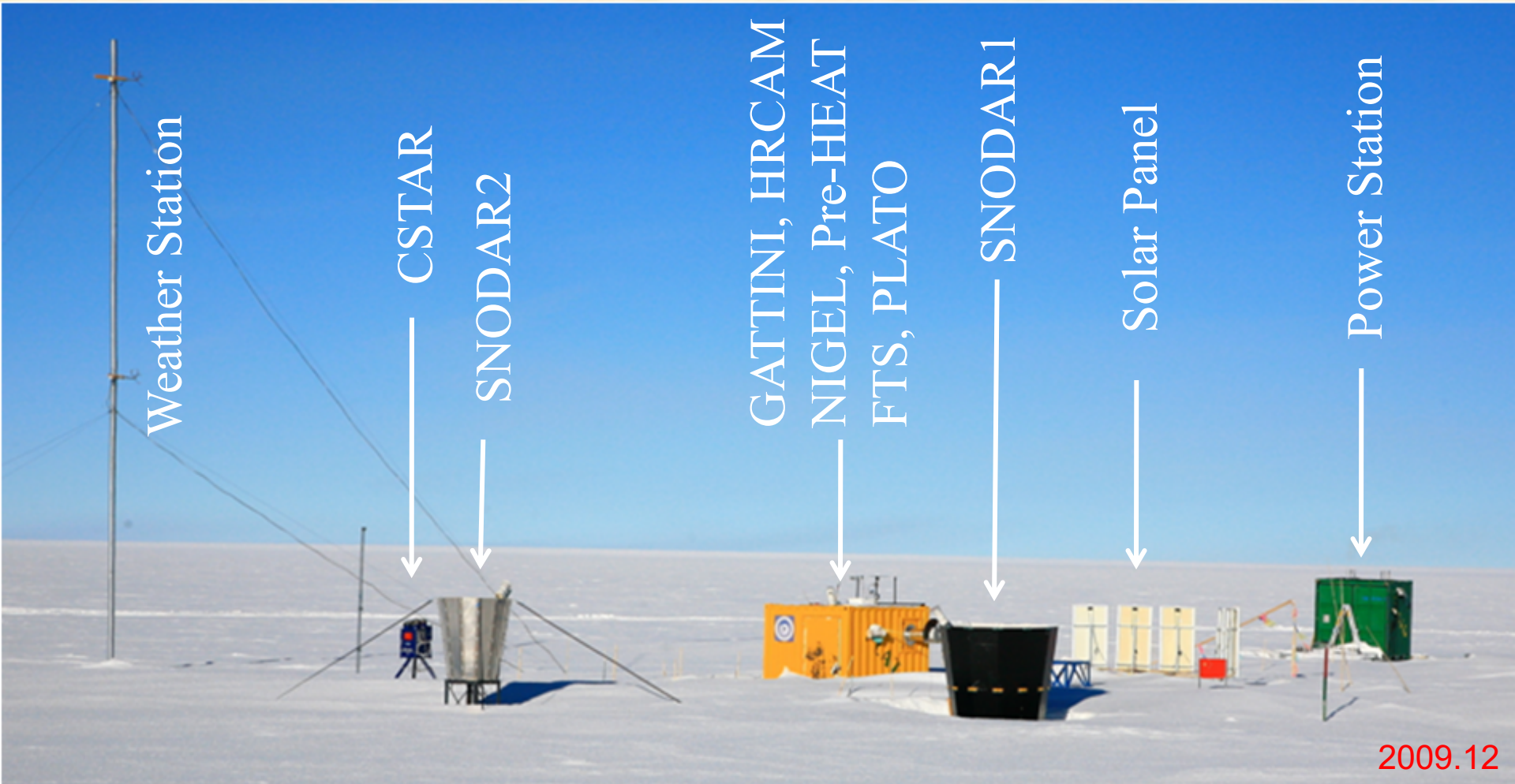
(Shang 2020)

Outline:

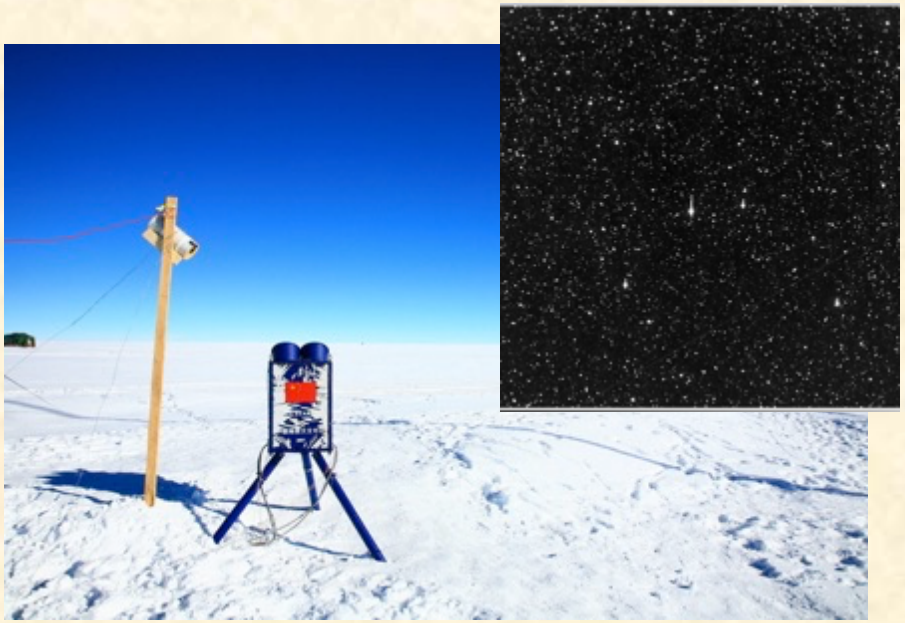
- Milestones and scientific results
- Site testing results
  - THz/sub-mm
  - Optical

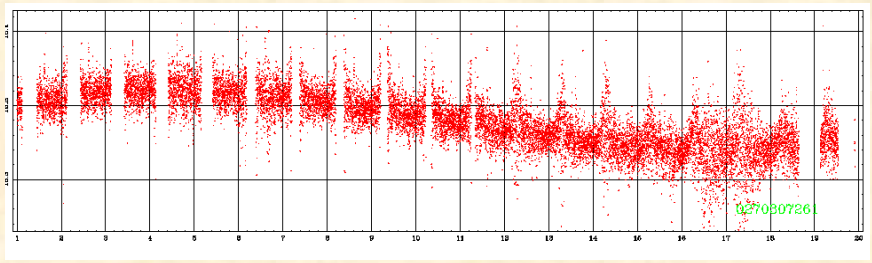
Astronomical Observatory at Dome A: 1st Stage

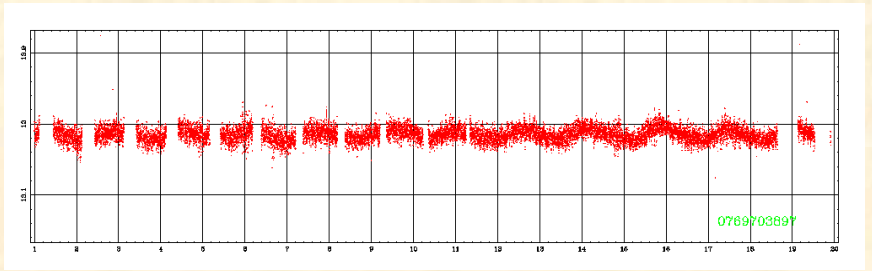
- Since 24th CHINARE (2007/2008)
- Collaborations: China, Australia and US
- Power and communication by PLATO

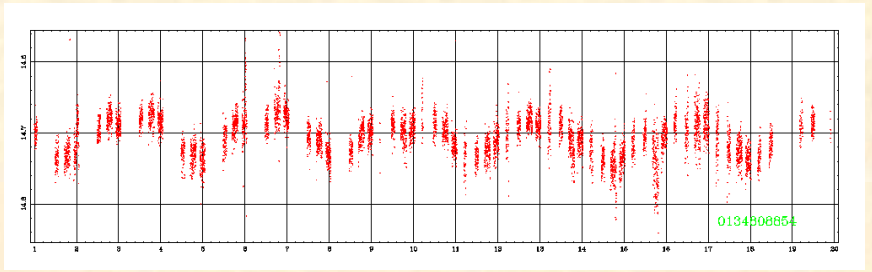


CSTAR (1st generation)









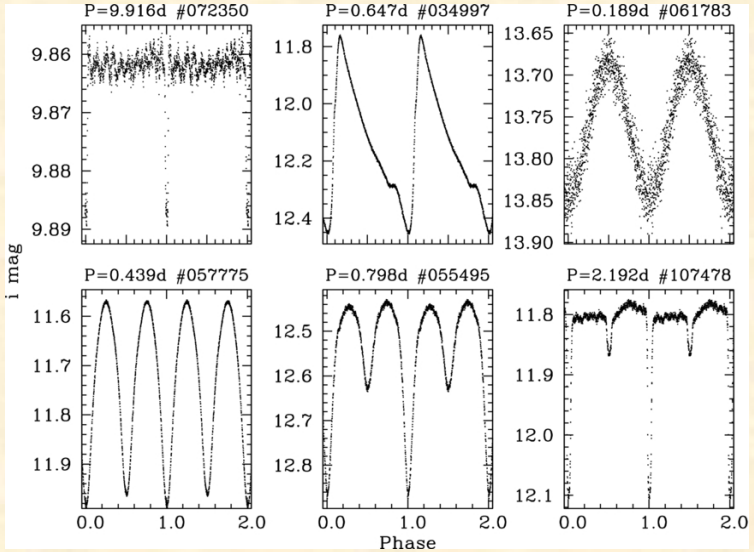
Light Curves (variable stars)

CSTAR:

- Small telescope array
  （14.5cm x 4）
- Field of view: 20 deg^2 (area of 80 full moons)
- Staring at the south celestial pole for months
- Taking an exposure every 20-30 sec

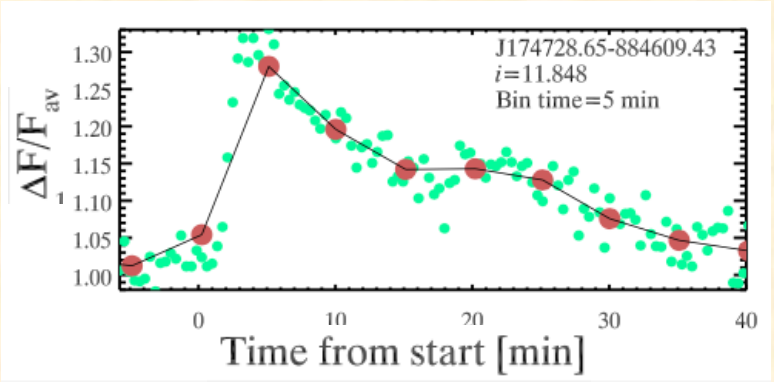
CSTAR (1st generation)

- Unprecedented data down to i =16 mag (20-30sec exp. time)
- Data realease
  - https://nadc.china-vo.org/data/data/cstar/f
- Over 30 papers on
  - Variable stars
  - Asteroseismology
  - Stellar flares
  - …
  - Site testing



Phased Light Curves (variable stars)

(Wang+ 2011)
(Zhou+ 2010)

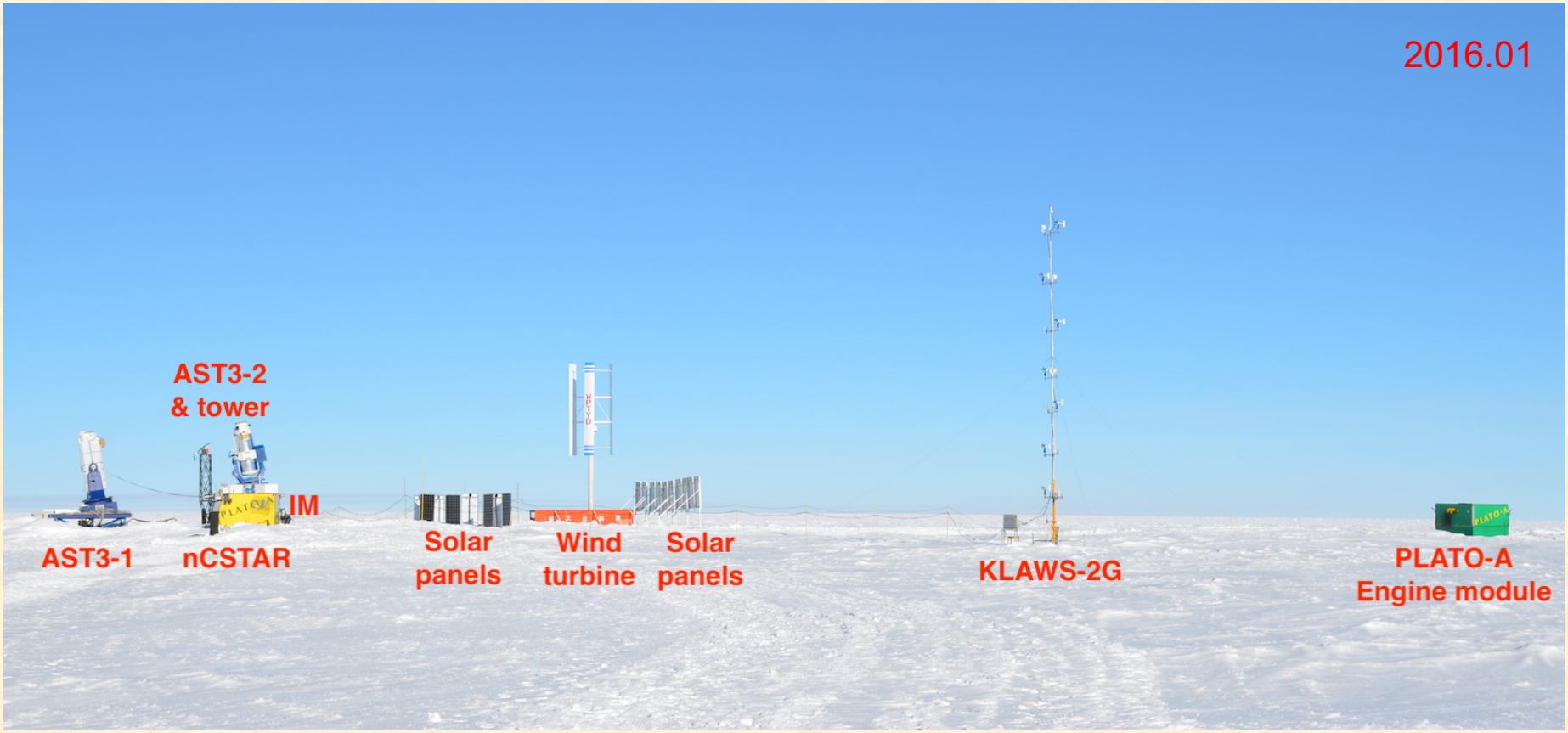


Stellar Flare

(Liang+ 2016)
(Oelkers+2016)

Astronomical Observatory at Dome A: 2nd Stage

- 2nd site since 28th CHINARE (2011/2012)
- Collaborations: China and Australia
- Power and communication by PLATO-A



AST3 (2nd generation)

Antarctica Survey Telescope

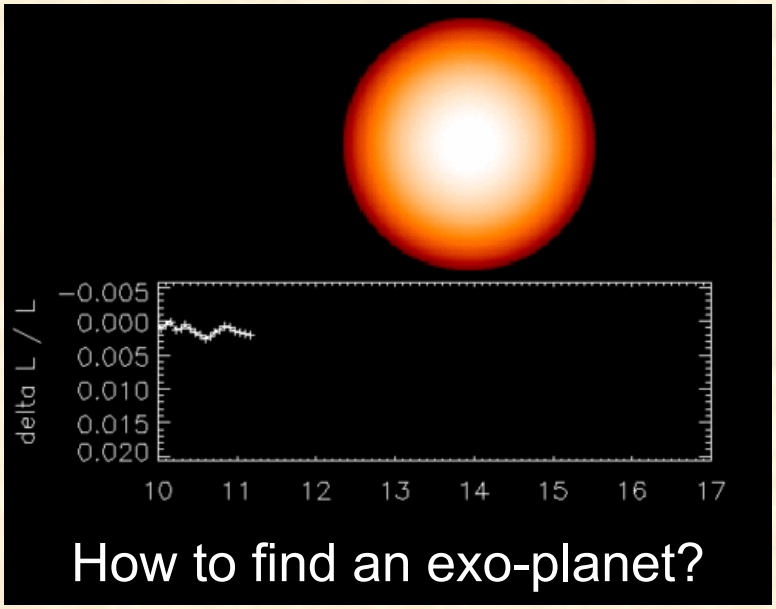
Time-domain astronomy

- Supernovae
- Exo-planets
- GRB
- Gravitational wave objects
- …

AST3:

- Survey telescope（50cm x 3）
- Field of view: 4.3 deg^2

  (area of 16 full moons)
- Pointing and tracking



How to find an exo-planet?

AST3 (2nd generation)

Antarctica Survey Telescope

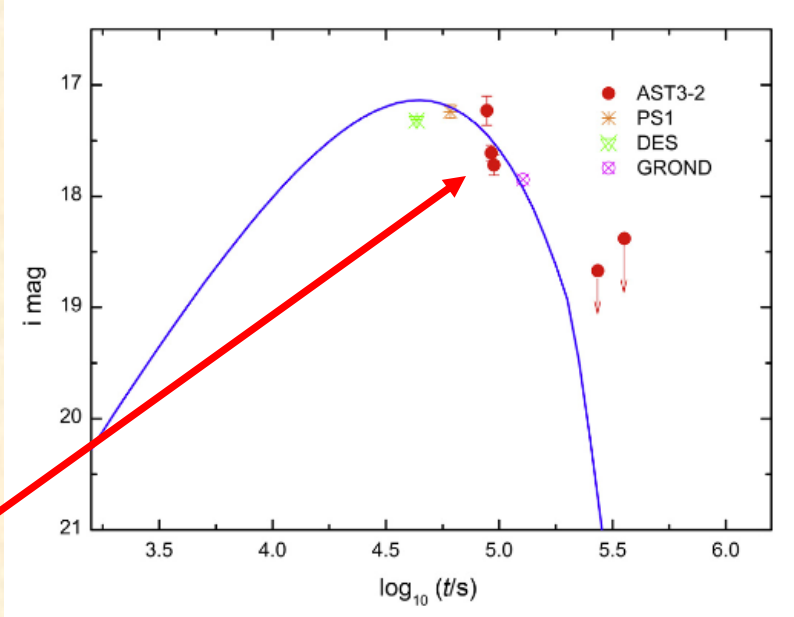
2012 AST3-1 commissioning data

- i ~ 18.7 mag (60 sec)
- Variable stars
- Data released on China-VO

  (Ma+ 2018)

2016-2017 AST3-2 data

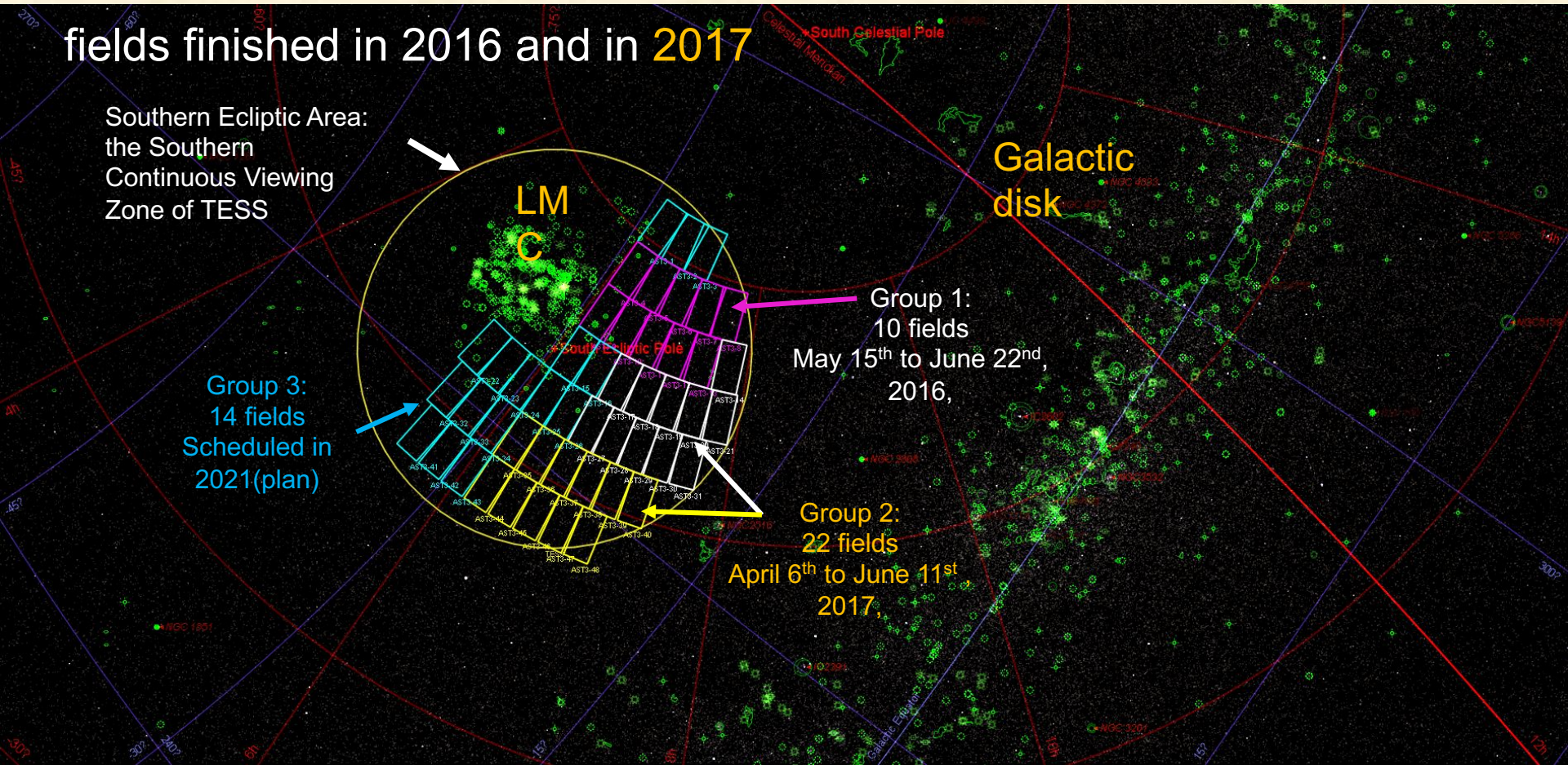
- SN 2017fbq
- GW170817 optical counterpart
- 20 stellar flares (Liang+ 2020)
- Exoplanet search (CHESPA)



(Andreoni+ 2017)
(Hu+ 2017)

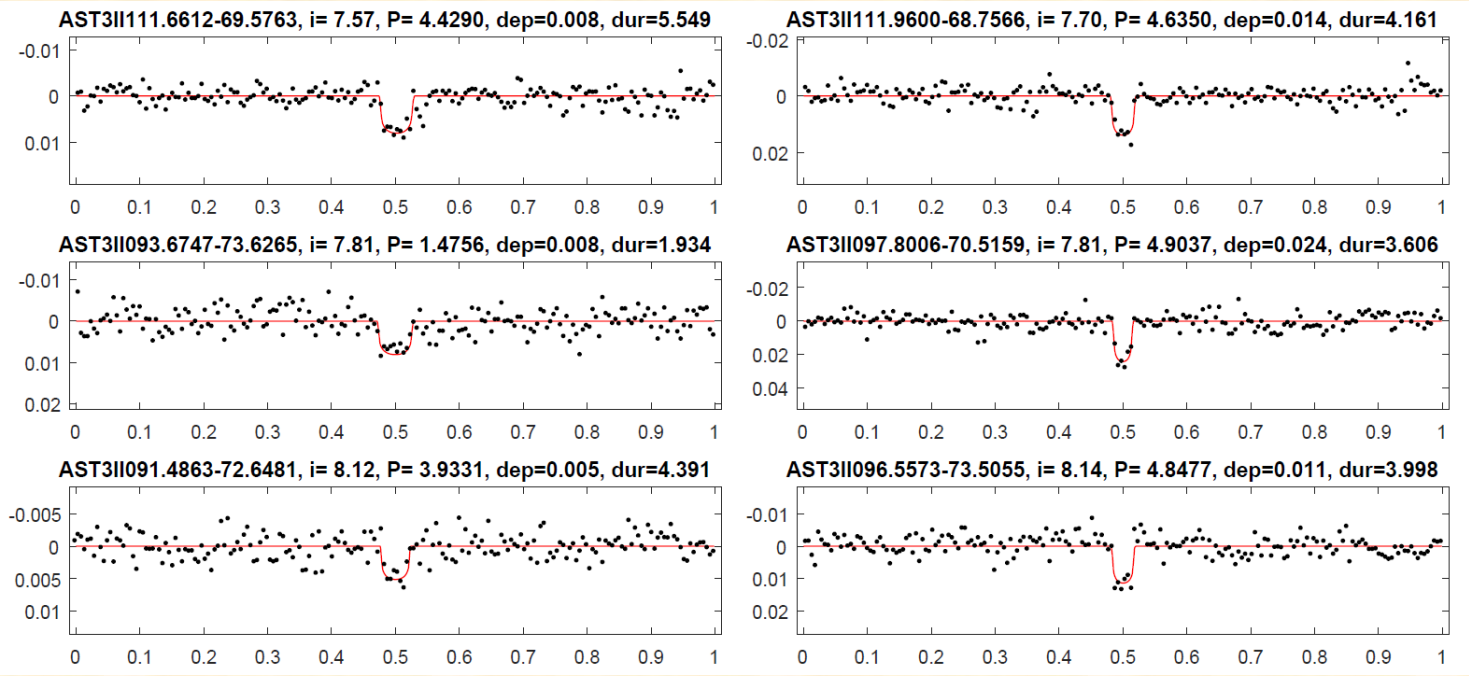
CHESPA (CHinese Exoplanet Searching Program from Antarctica) by NJU

- Selected fields in planned TESS area
- Non-stop (>1 month) monitoring, before TESS launch
- Cadence: 12 minutes for short period transits
- Sources brighter than i =15mag



CHESPA (CHinese Exoplanet Searching Program from Antarctica) by NJU

- 116 transiting exoplanet candidates
- DR2 (http://casdc.china-vo.org)
  - Over 85000 high precision light-curves (7.0 ≤ i ≤15.5)
  - Over 1000 new variables
  - Over 10 exoplanet candidates that were missed by DR1 and TESS



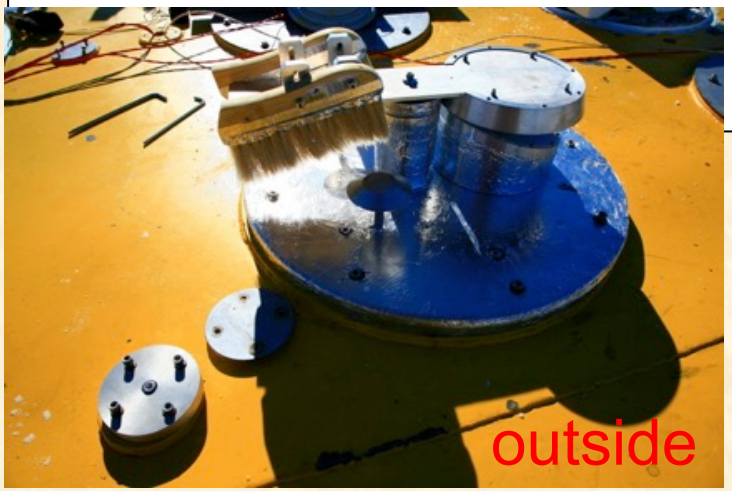
(Zhang+ 2019)

Site Testing

Astronomical site testing in THz (sub-mm)

THz FTS (Fourier transform spectrometer)

- Install in 2010
- Measure transmission in 0.75-15THz (400 to 20μm)



Pre-HEAT @450 μm

- Installed in 2008

Astronomical site testing in THz (sub-mm)

Pre-HEAT (Yang+ 2010)

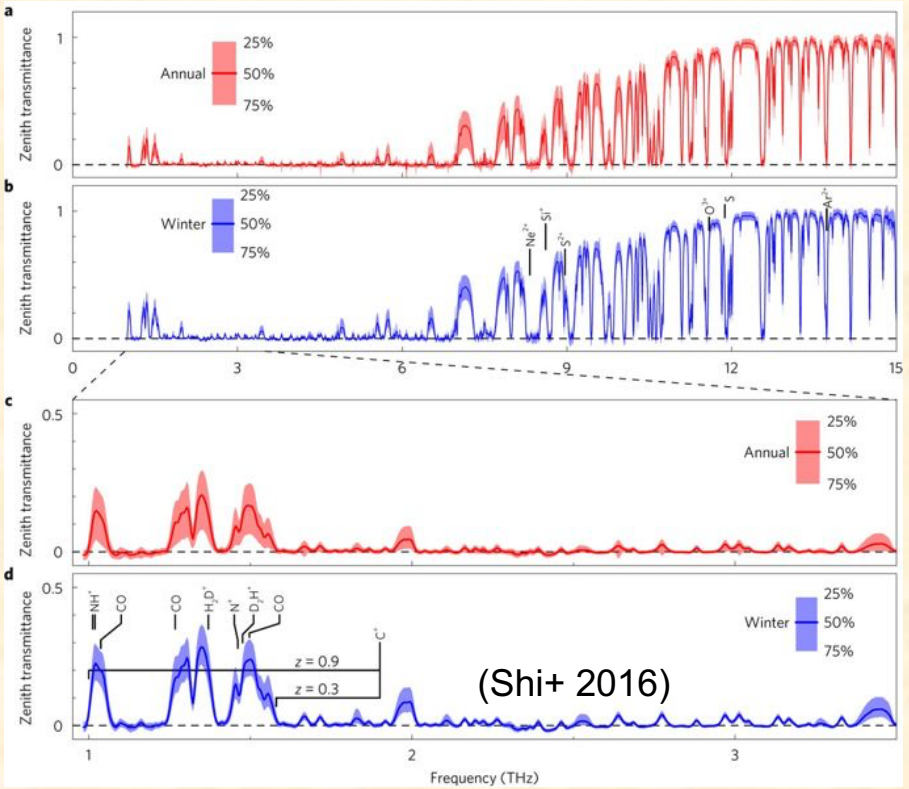
- Top 25% PWV ~ 0.1mm

Nigel spectrograph (Sims+ 2012)

- Top 25% PWV ~ 0.09mm

FTS (Shi+ 2016)

- Median PWV: 0.19mm (0.16mm in winter);
- New THz windows on the ground.



Lowest PWV, best site on earth for THz.

Astronomical site testing in optical

- Low sky brightness (i-band);

  2008 CSTAR data (Zou+ 2010)

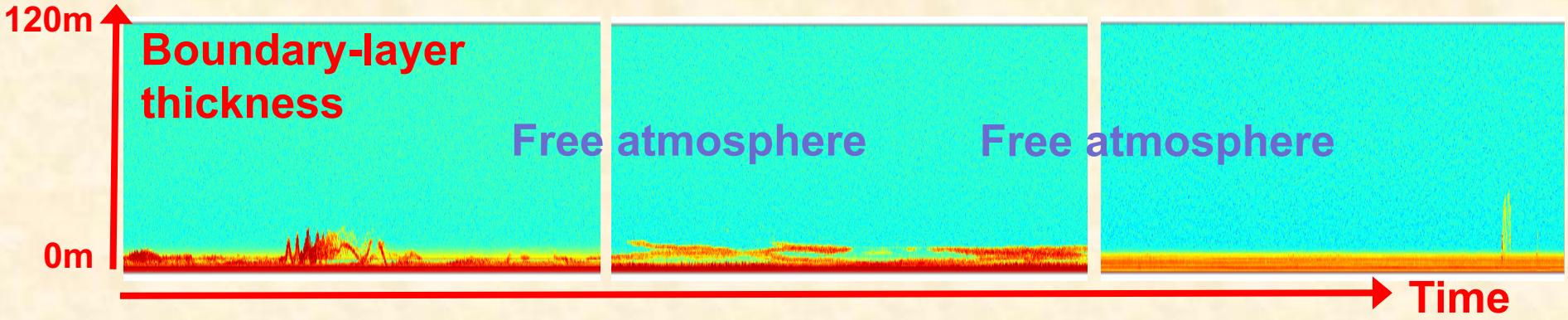
Dome A		20.5 (mag/sq. arcsec)	
La Palma	20.10	Cerro Tololo	20.07
Paranal	19.93	Calar Alto	19.57

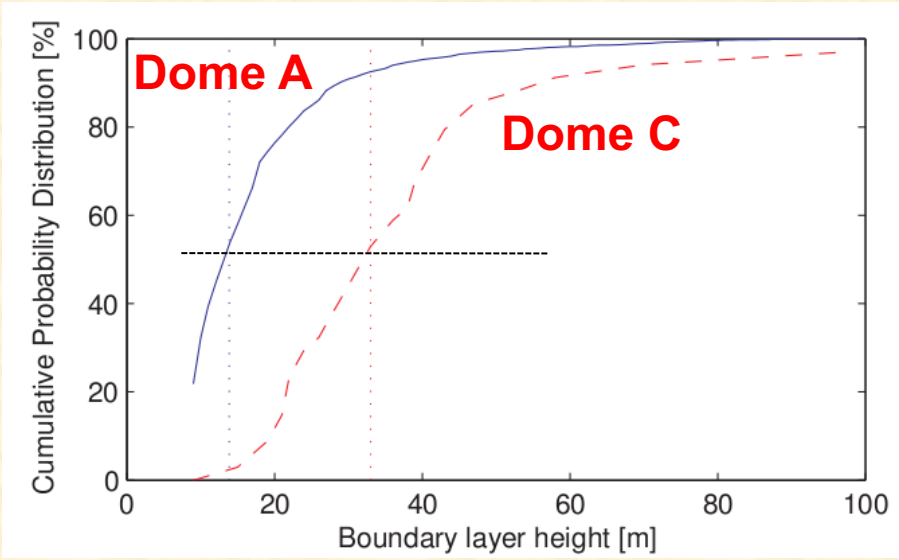
- B,V,R sky background comparable to the best sites in Hawaii or northern Chile.

  2009 Gattini data (Yang+ 2010)

Seeing: Very low atmospheric boundary layer

- Simpler atmosphere layers: boundary layer + free atmosphere layer
- Median atmosphere boundary layer (ABL) thickness of 13.9米 (Snodar)；
- Strong turbulence within ABL，ABL at temperate sites around 10^2-10^3 m





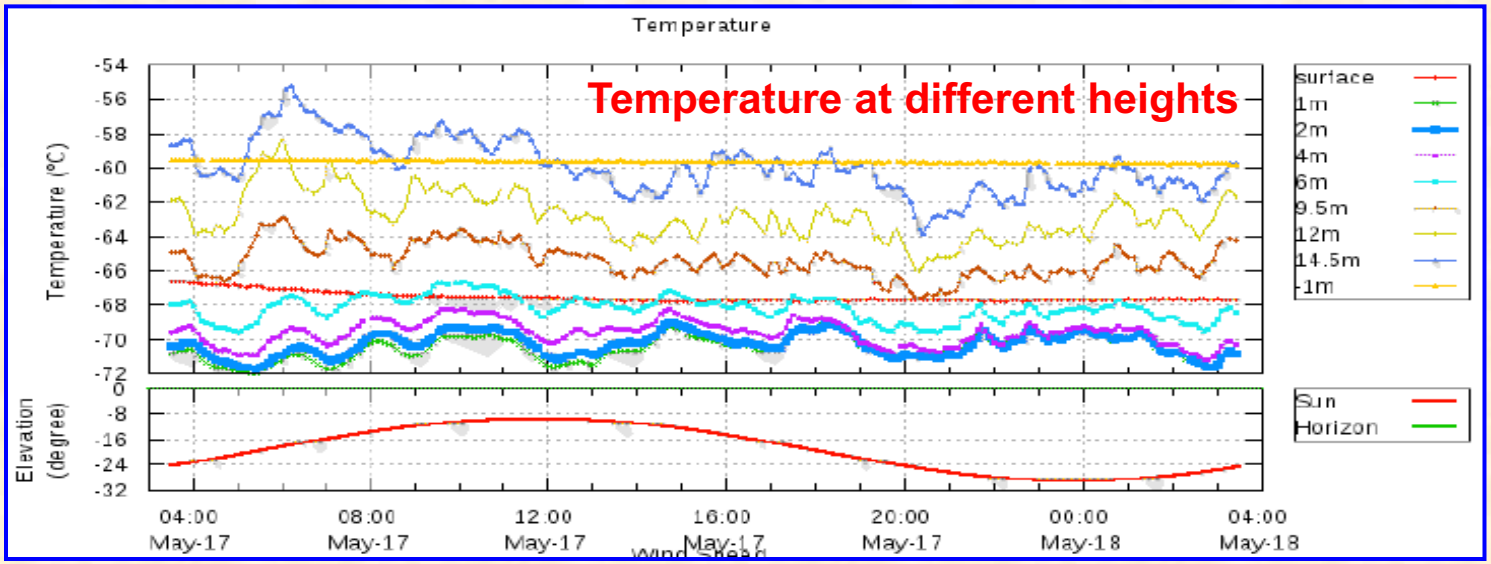
Lower than Dome C (30m)：

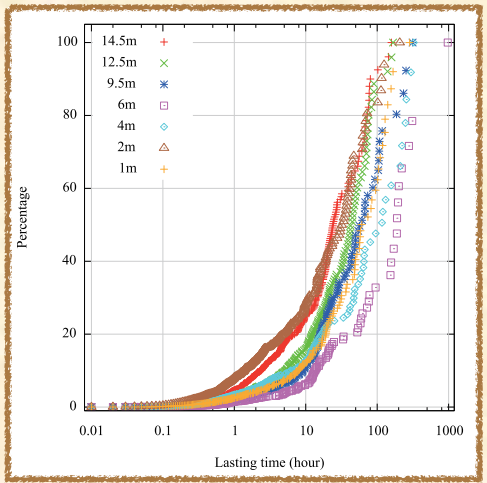
- Easier for construction;
- Good free-atmospheric seeing above ABL.

Snodar data (Bonner+ 2010)

Seeing: Stable atmosphere

- Strong temperature inversion in the atmosphere exists for 70% of the time (2011 data), implying extremely stable atmosphere;





- Temperature inversion (stable atmosphere) lasts long, often more than a week;
- Low wind speed of 1.5m/s – 4m/s.
- KLAWS-2G data (Hu+ 2014, 2019)

Astronomical Observatory at Dome A: 3rd Stage

New Efforts on Site testing

(1) Multi-layer AWS (KLAWS-2G)

Measure temperature inversion and its relationship with seeing

(2) Cloud and Aurora monitor (KLCAM)

Statistics on cloud cover and aurora contamination

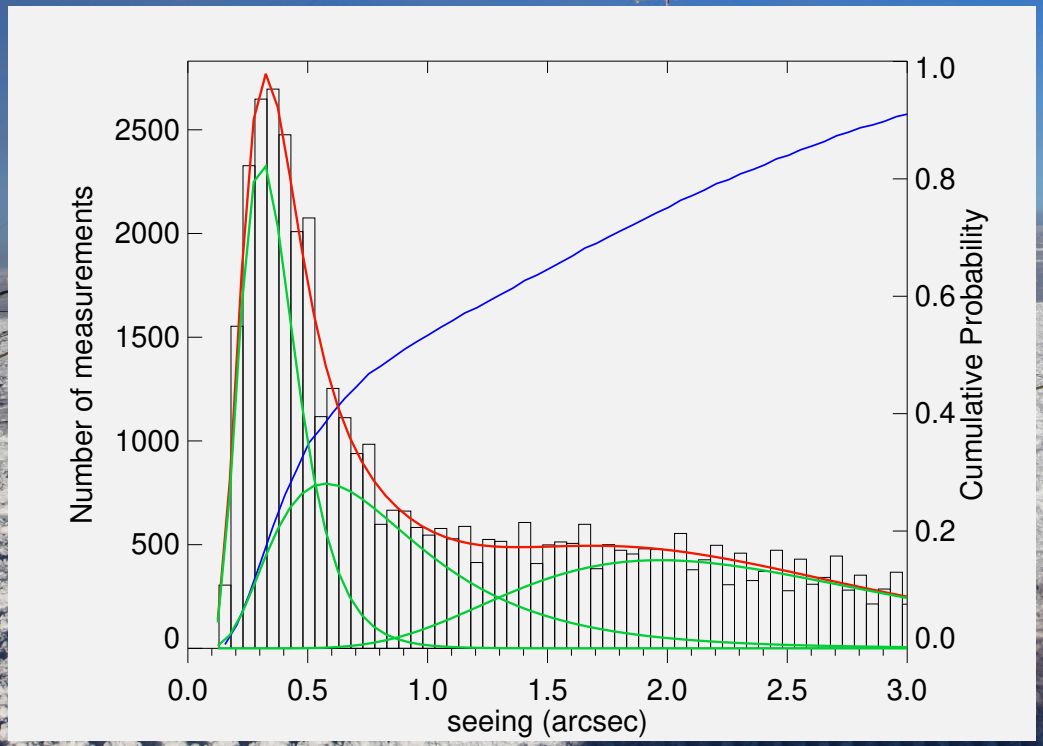
(3) KL-DIMM and tower

Direct seeing measurement

To obtain data and quantify the merits of Dome A being an astronomical observatory.

New Site Testing Results at Dome A

- Median free-atmosphere (FA) seeing: 0.31";
- Chance of FA seeing:
  31% @8m, 49%@14m;
- Seeing and boundary layer thickness are correlated with temperature inversion;



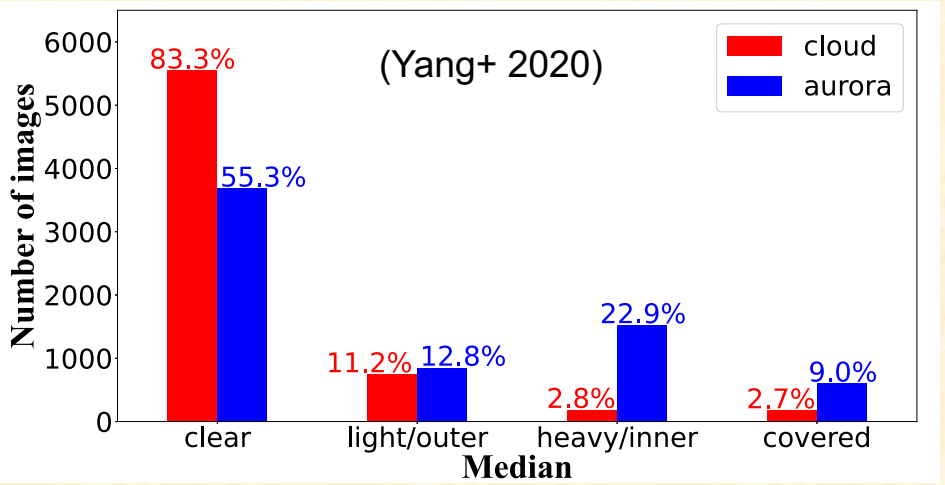
KL-DIMMs
&
8m tower

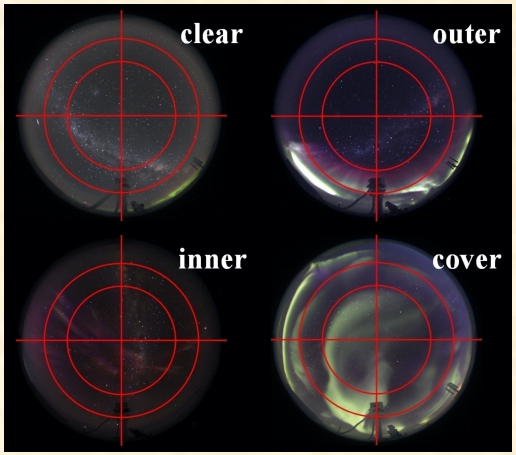
Ma et al. 2020, Nature, 583

2019.01

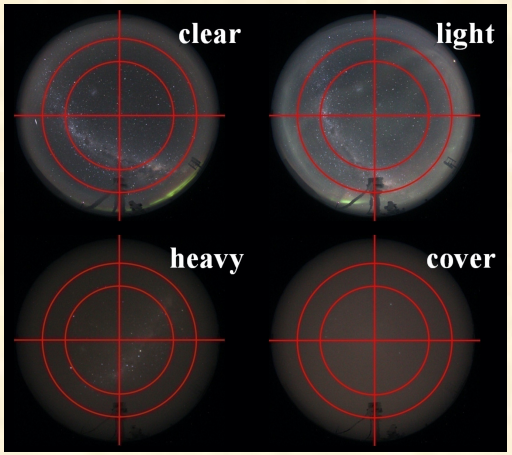
Cloud Cover and Aurora

- Visual inspection of all-sky KLCAM images by 5 people independently;
- Data from 2017 & 2018;
- 83% clear (no cloud);
- 55% free of aurora;

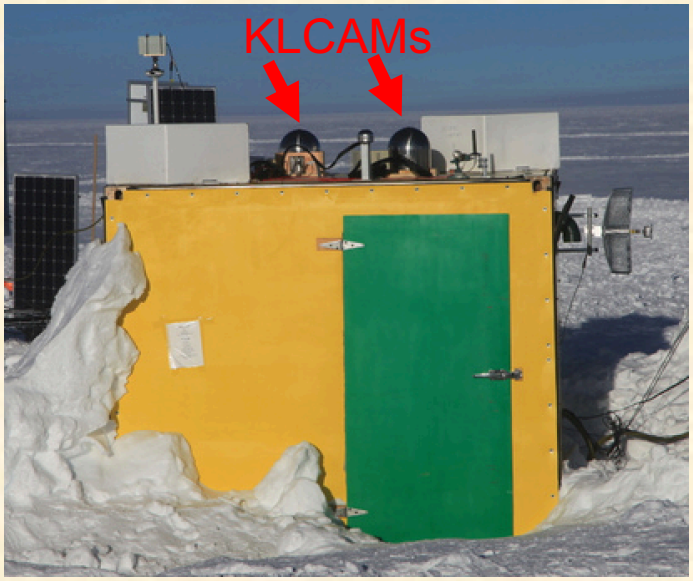




Aurora



Cloud



Summary

- Dome A has been revealed to have the best observing conditions in THz and optical (and IR);
- Dome A is good for time-domain research;
- We learned a lot in instrumentation for Antarctica;

Take advantage of the resources !

- For a complete（up to July 2020） review/reference of the 10+ year work at Dome A, please see Shang 2020, RAA (Research in Astronomy and Astrophysics)

Thanks !