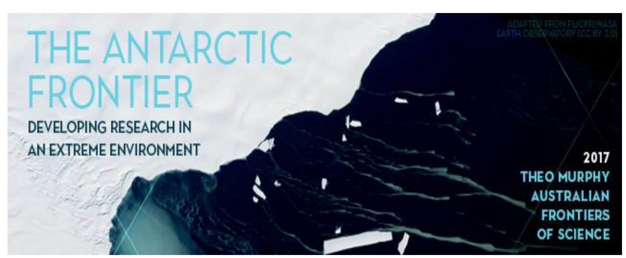
The Kunlun Infrared Sky Survey (KISS) with AST3-NIR Camera

Jessica Zheng



KISS

First comprehensive exploration of **time varying Universe in the Infrared**

- **2MASS**, **time sensitive**
- **SkyMapper, infrared**

Science

- **Star formation**
- **Brown Dwarf & Hot Jupiters**
- **Supernovae**
- **Exoplanets around M Dwarfs**
- **Fast Transients, Fast Radio Bursts, and Gravitational Wave Sources**
- **Reverberation Mapping of Active Galactic Nuclei(AGN)**
- **Gamma Ray Bursts**
- **The cosmic Infrared Background**

*** Burton, M. G., Zheng, J., Mould, J., Cooke, J., Ireland, M., Uddin, S. A., Zhang H., Yuan, X., Lawrence, J.,Ashley, M. C. B., "Scientific goals of the Kunlun Infrared Sky Survey (KISS)," Publ. Astron. Soc. Aust. 33, DOI: 10.1017/pasa.2016.38**

AST3-NIR Camera and KISS

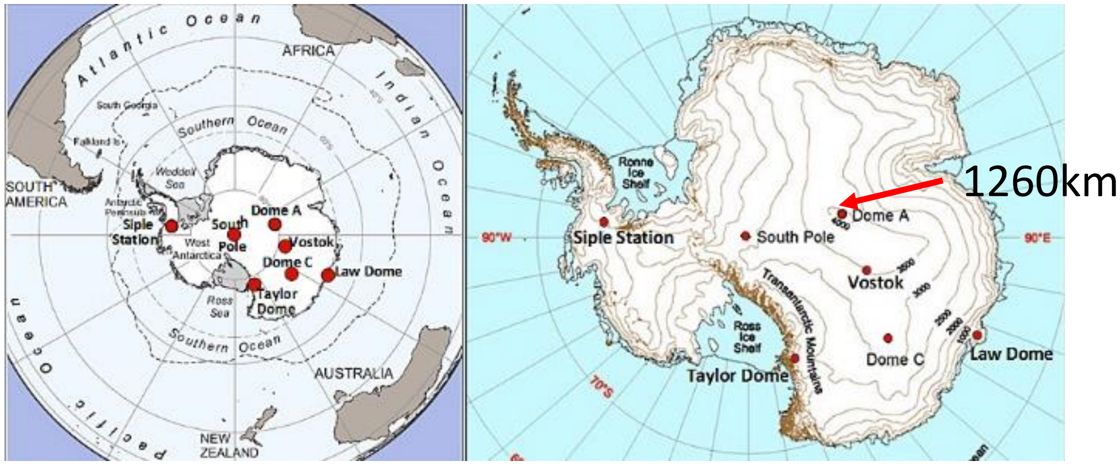
- One of AST3 dedicated to conduct **the Kunlun infrared sky survey at K_{dark}(KISS).**
- Technical concept developed during early 2014.
- China responsible for **telescope hardware and control, logistics, deployment.**
- Australia responsible **for instrument hardware and control, and power generation system.**
- **Project Kick-off meeting** happened during 2015 International Collaboration Meeting on Antarctic Survey Telescopes (AST3), **March, Hong Kong 2015.**
- The telescope is already **built and** is now **being tested at NIAOT.**

Why in Antarctic?

- **Australia** has a **long history** in **Antarctic Astrophysics**
- **Existing China-Australia collaboration in Astronomy**
- **The ARC LIEF grant 2014(PI: Jeremy Mould)**

- **Continuous observing time > 3 months during winter**
- **Low temperature and sky background in infrared**
- **2.4µm: longest wavelength from the Earth, deep imaging**
- **Less cloud, Low turbulence boundary layers, and large Isoplanatic angle**
- **Dry air, high transmission in infrared**

The Major Challenges



Geographically

- **High altitude: 4094m**
- **Low pressure: 570hPa**
- **Extreme low temperature & large temp difference**
- **Harsh weather conditions: snow, ice, radiation**

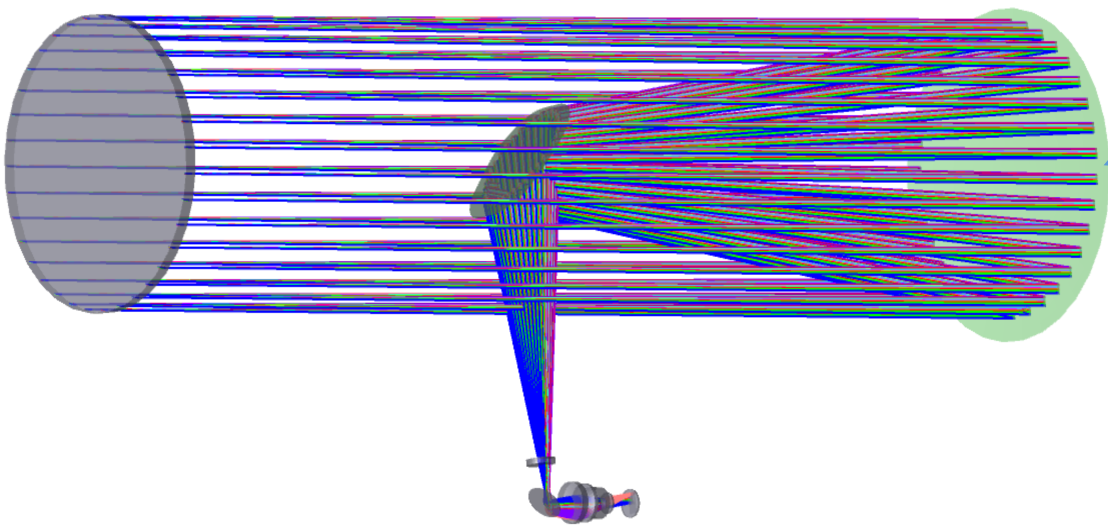
Administration:

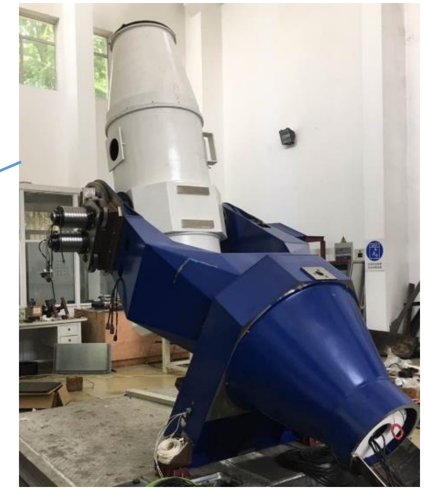
- **Transportation: complicated & limited support**
- **Installation/testing: limited working time/facilities**
- **Operation: low-bandwidth communication link**
- **Logistics: limited summer support, no winter-over**
- **Multiple parties**

Key Parameters

Parameter	Value
λ ($\Delta\lambda$)	2.375(0.23) µm (K_{dark})
Pupil	50cm
Image Quality	1.9″(1.1 x diffraction limit + tolerance and seeing)
Array	1280 x 1032, 15µm pixels Leonardo detector, mosaic.
Sampling	1.35″ pixels
Field of View(FOV)	~28.7´ x 46.1´
Assuming: Background Sky [South Pole]	K_{dark} = 17.0 mags/arc²=100µJy/arc²
Achieving:	
Background limited integration time	228 secs(200K)
1σ 30 × 2 seconds	18.2 mags. [Vega magnitudes].
10σ 1 hour	21.4 mags.
Saturation limit (in 60 sec)	K_{dark} = 10.7 mags.

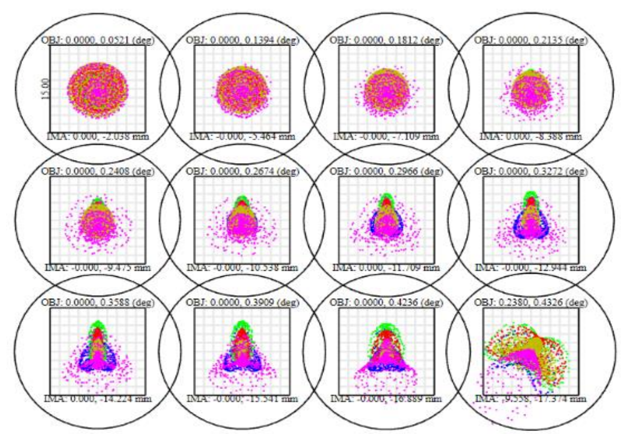
Optical and Mechanical Layout of AST3-3 NIR Camera





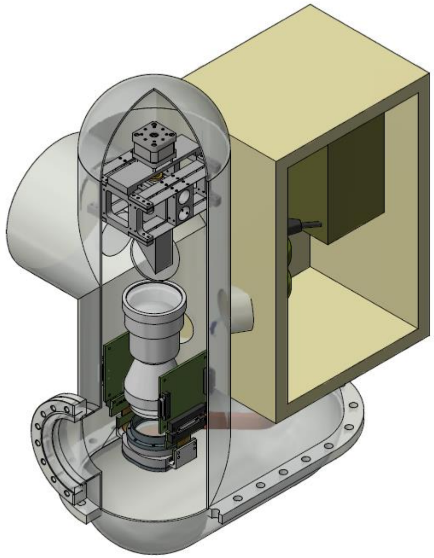
Optical parameters
- EFL:2244
- F/# :4.48

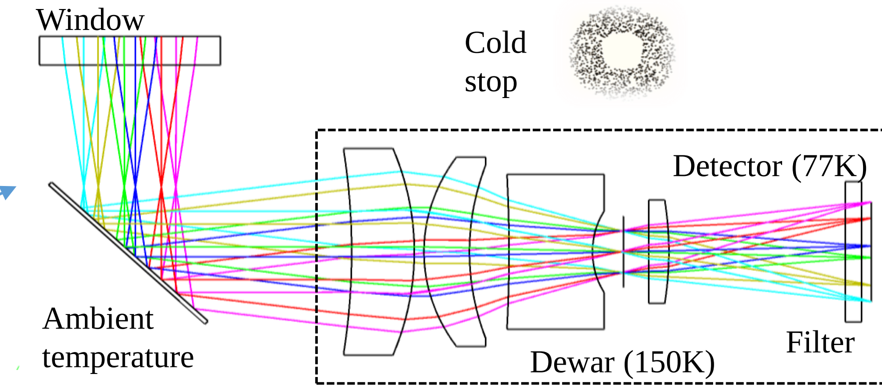
Image quality

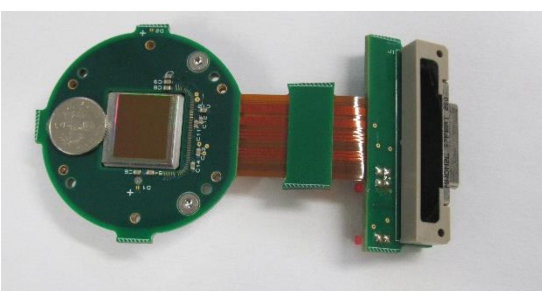


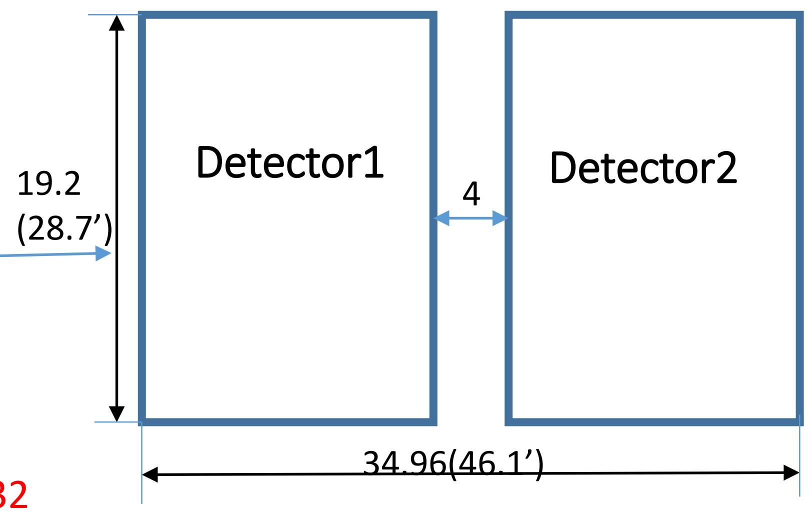
Operation parameters
- Pixel Scale: 1.35”/pixel(Averaged over the FOV)
- Field of view : 28.71’×46.08’
- The gap of the FOV: 6’(4mm mounting gap)

AST3-NIR Camera



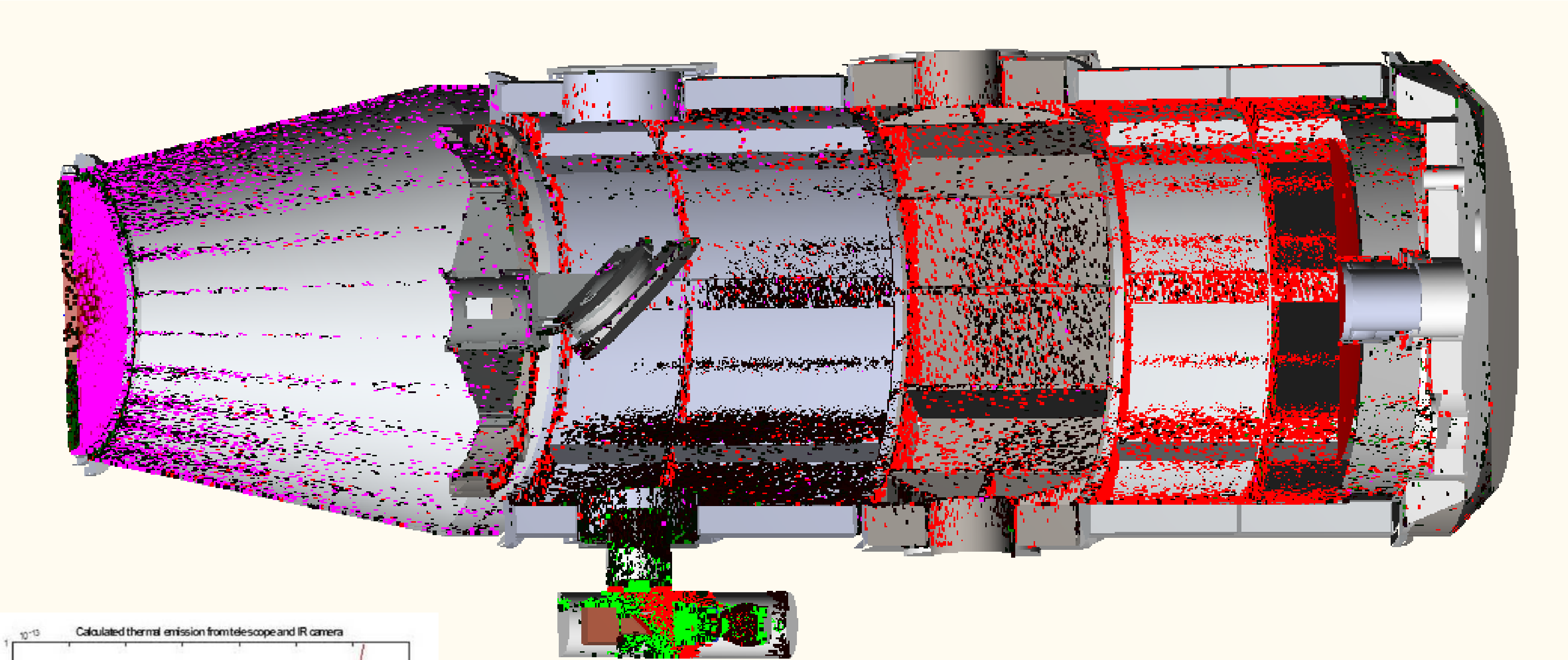


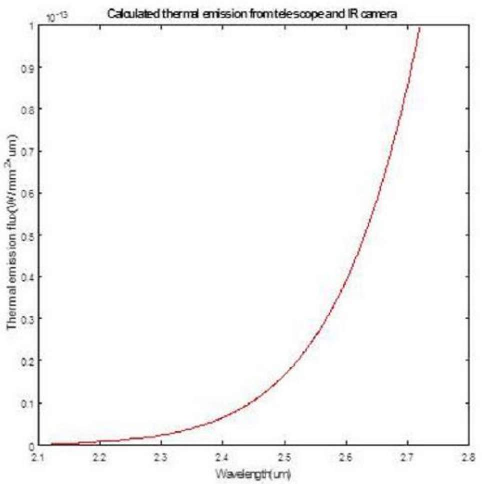




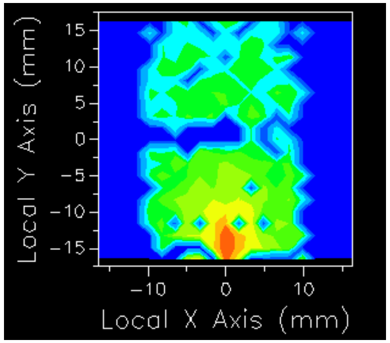
- Chip Specification: 2×1280×1032
- Pixel Size: 15μm
- QE>70%
- Read Noise: 9e- and 30e-
  (Fowler and CDS read out mode)

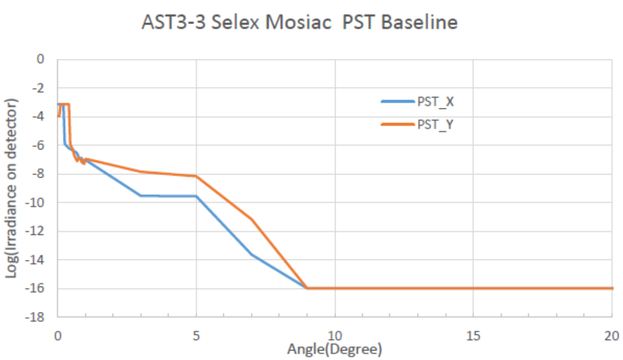
Thermal Emission





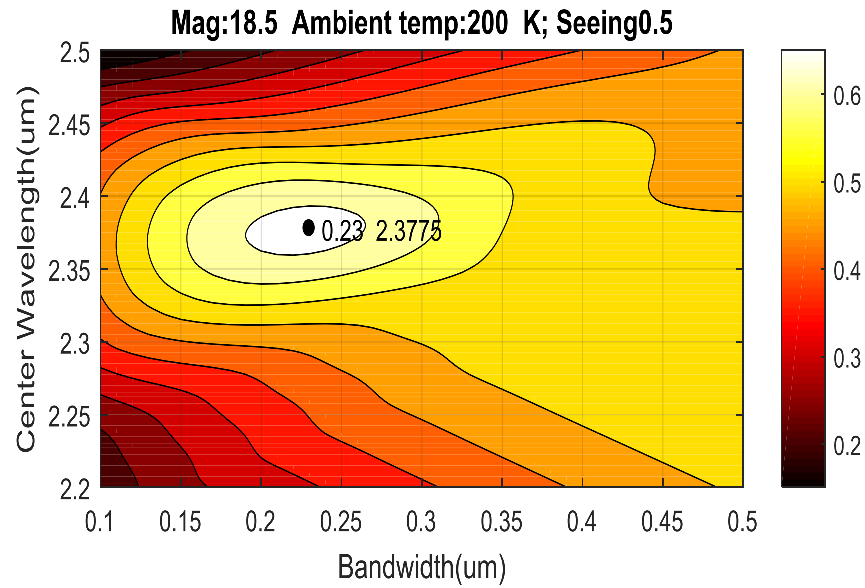
Scattering light

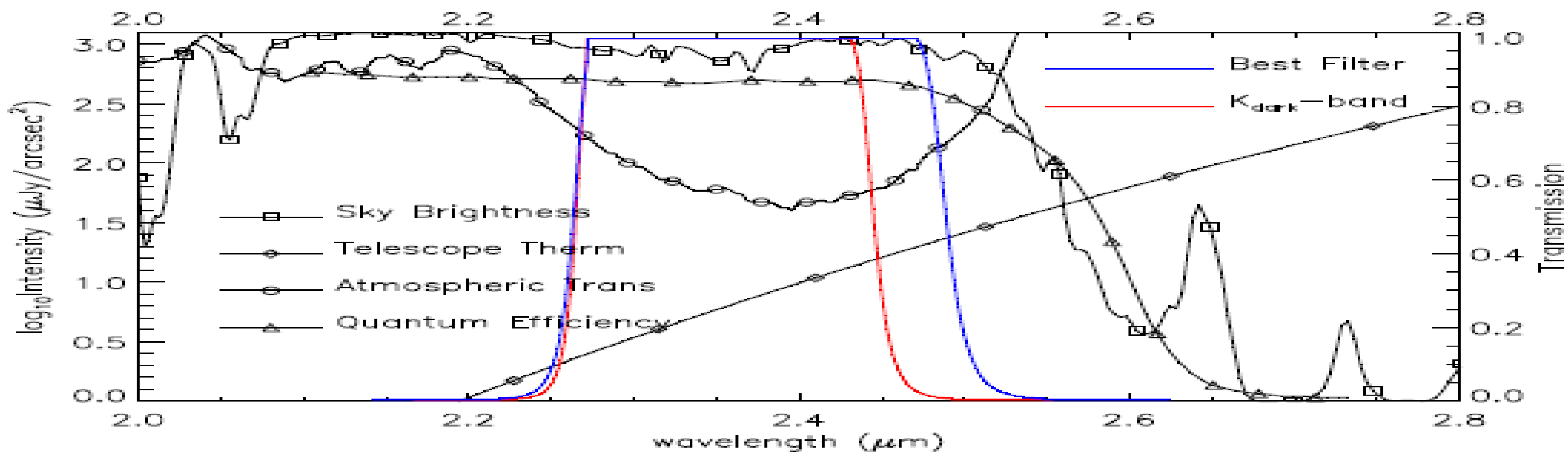




Filter Optimization

- **Center Wavelength:2.375um**
- **Bandwidth : 0.25um**





*Li, Y., Zheng, J., Tuthill, P., et al. "Optimising the K dark filter for the Kunlun Infrared Sky Survey" . 2016, PASA, 33, e008

AST3-NIR Camera Exposure Time Calculator

KISS Camera Exposure Time Calculator

Target flux distribution:

Object magnitude:	18.5
Observation Wavelength(um):	2.375

Target geometory:

Target geometory	Point source

CCD parameters:

Pixel size(um):	18
Dark current(e^-1/s):	1
Read noise(e^-1/s):	3
Quantum_efficiency:	0.7
Full Well Depth:	80000
SNR(defined by user):	10
Exposure time(s,defined by user):	300

Sky conditions:

Seeing(arcsec):	0.5
Sky background Mag :	16.89

Instrument setup:

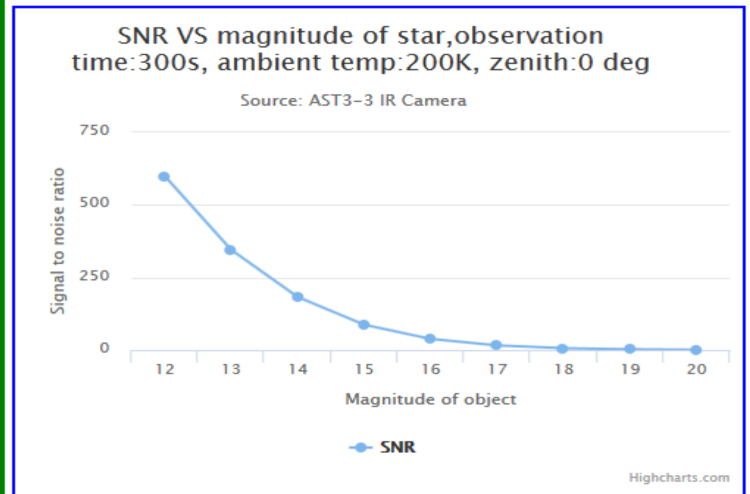
Start wavelength(um):	2.25
Stop wavelength(um):	2.5
Ambient temperature(k):	200
Zenith distance(degree):	0

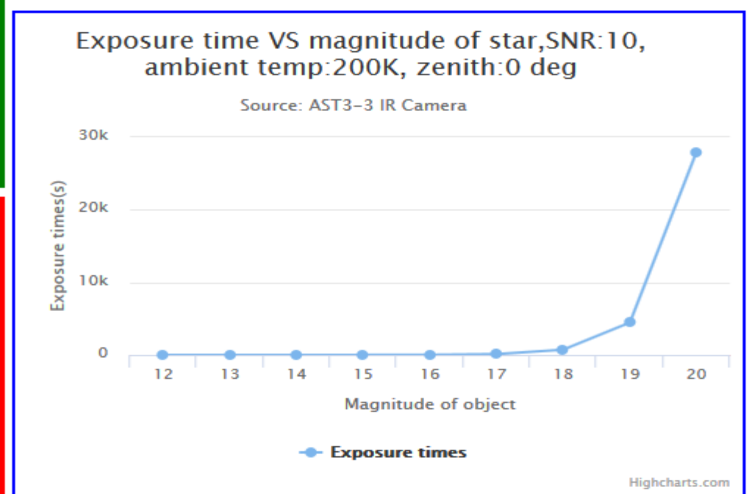
Calculation results

Results:

Calculate

Photons from object(/s):	3.467
Photons from sky(/px/s):	27.838
Photons from thermal(/px/s):	1.030
Exposure time(s, At Given SNR):	1785.913
SNR(At Given Exposure Time):	4.097
Max exposure time(s, Half of Full well depth):	1317.278





http://newt.phys.unsw.edu.au/~mcba/ETC_WebModel/TELESCOPE.html

Special Design Considerations

- **Environmental protection**
  - The telescope tube shall be sealed..
  - Air within the telescope enclosure shall be left to track external ambient temperature.
  - Heaters shall be provided .
  - ITO coated front window is needed to defrost.

- **Be operated fully remotely**

- **Careful engineering**
  - Modular design
  - Hardware redundancies throughout system
  - Data pipeline must include on-site reduction
  - Data security and storage
  - The instrument dewar vacuum >12months
  - Auto-monitoring

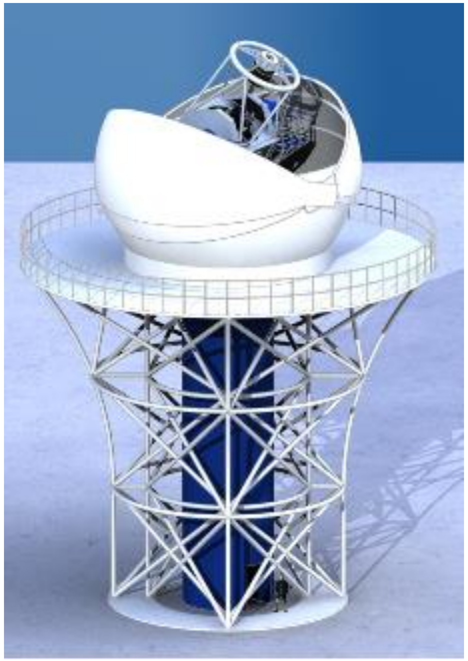
Where Are We Now?

IR detector purchasing difficulty → (row 8)

	Milestone Completion	Due Date
1	Preliminary discussions with DoS re: ITAR	*Jan-15*
2	Project Kick-off (Meeting in Hong Kong)	*Mar-15*
3	Detector & Interface Specification	Jul-15
4	Requirements Review	Aug-15
5	RFQ Teledyne	Aug-15
6	Contract Negotiation (Detector)	Sep-15
7	Purchase Order (Detector)	Oct-15
8	CDR (De-Scope Option)	Dec-15
9	Final Design Review	Apr-16
10	Procurement Lead-time (Detector)	Nov-16
11	Telescope shipped to Australia	Dec-16
12	Float Procurement Lead-time (Detector)	Jan-17
13	AIT @ AAO Facility (location TBD)	Feb. – June
N/A	*Schedule Float*	*~4 months*
14	Camera Pre Delivery Review	Late 2017
15	Shipping to Antarctica	Nov. 2017
16	Commissioning	Jan. 2018
17	Science Survey commences	Feb. 2018

Commissioning: 2019??

The Next: KDUST Instrumentation



Parameter	Value
Aperture	2.5m
FOV	1.5
Bands	Optical: 0.4μm ~1μm Infrared: 1μm ~2.5μm
Resolution	<0.2" in optical
Tower	15m, above the turbulence layer
Power	15kW, Peak 20kW
Mode	Unattended and remote control

- **Australian consortium AAO, UNSW, ANU, the design and construction of the KDUST optical camera.**
- **Building an infrared instrument for KDUST.**


Thank you!