Progress on AST3-3 IR Camera Design

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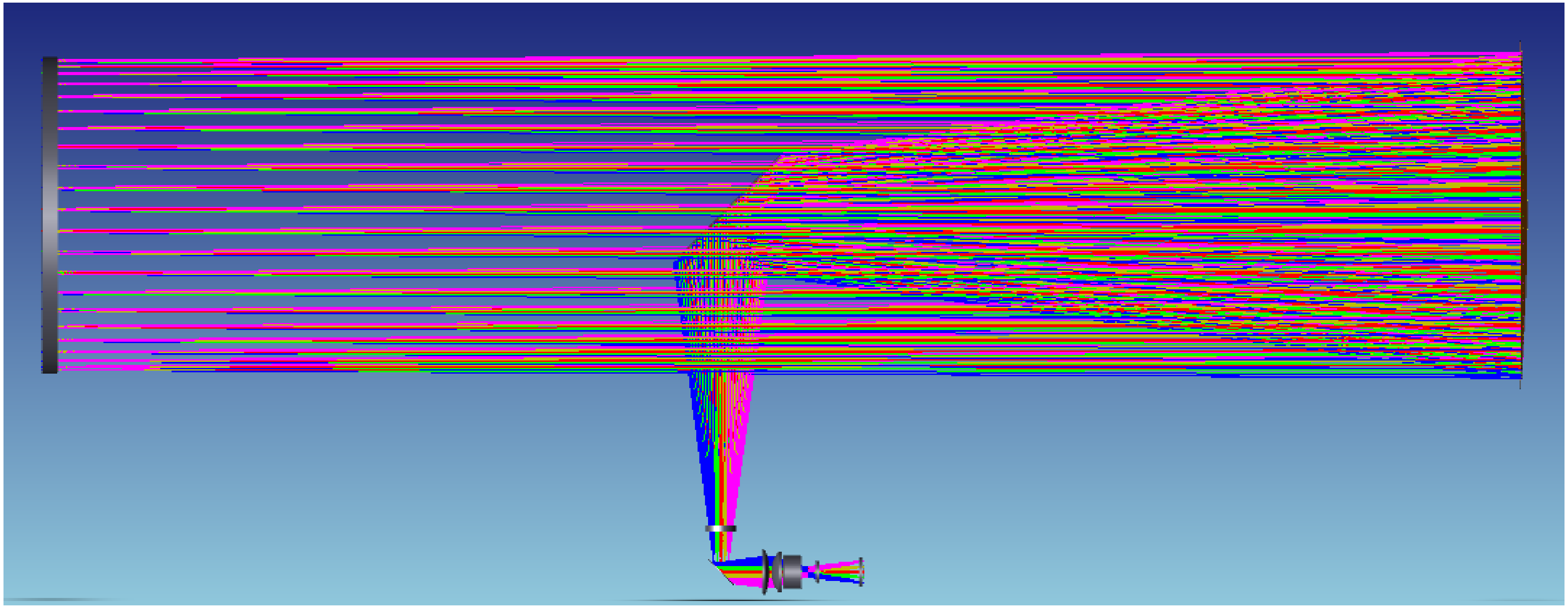
AST3-3 IR Camera and KISS

- AST3-NIR is version of AST3 dedicated to conduct the KISS infrared sky survey at Kdark.
- 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.
- AST3-3 telescope already funded and currently is at manufacturing. IR camera funded by Australian government LIEF grant 2014(PI:Jeremy Mould) .
- Project Kick-off meeting happened during 2015 International Collaboration Meeting on Antarctic Survey Telescopes (AST3), March, Hong Kong 2015.

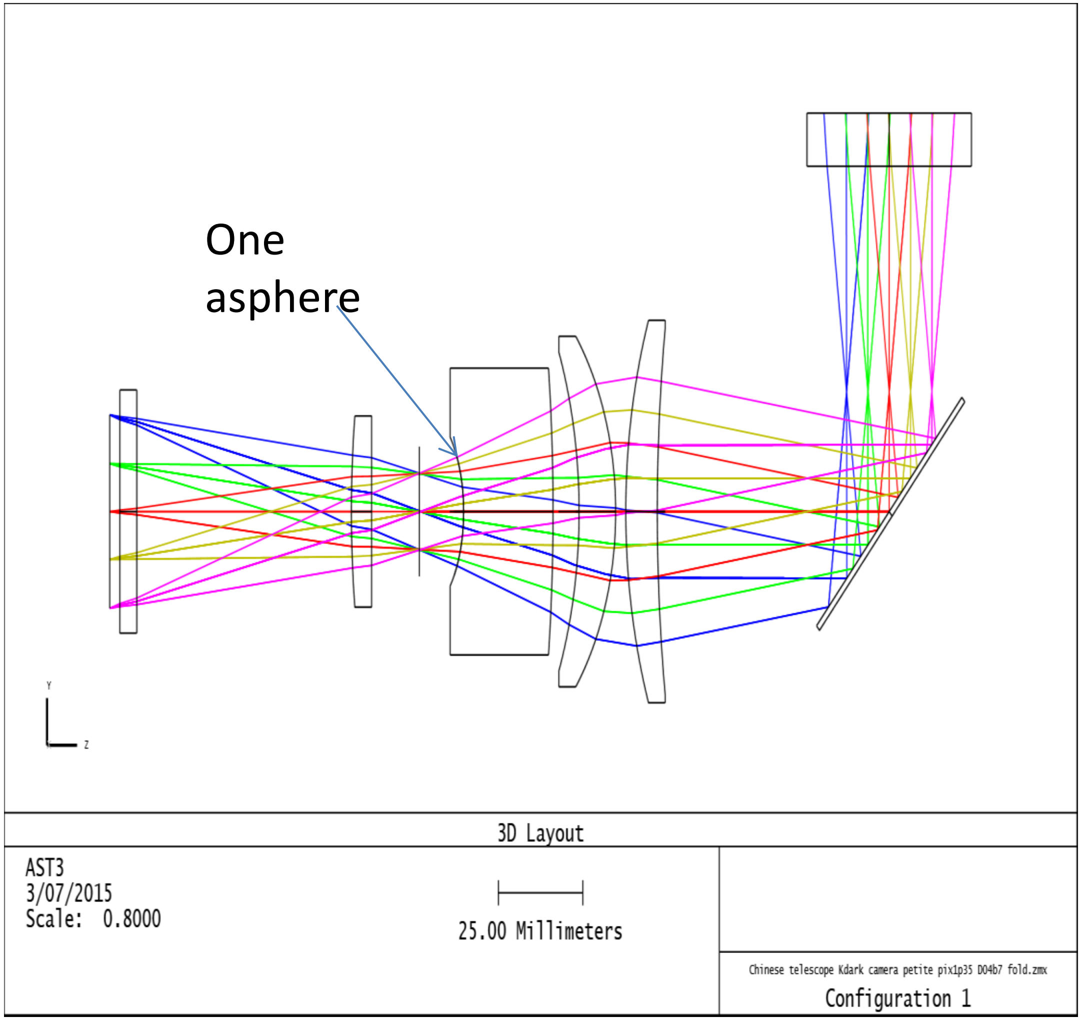
Key parameters (thanks to Jeremy, Jon and Xiangyan)

Parameter	Value
λ ($\Delta\lambda$)	2.36 (0.18) μm (K_{dark})
Diameter	68cm
Image Quality	1.9″(1.1 x diffraction limit)
Array	2048 x 2048, 18μm pixels H2RG Teledyne preferred
Sampling	1″
Field of View	30´ x 30´
Achieving:	
Background limited integration time	25 secs
1σ 25 seconds	18.0 mags.
10σ 1 hour	18.5 mags.
Saturation limit (in 25 sec)	K_{dark} = 11.1 mags.
With Background Sky [South Pole]	K_{dark} = 17.0 mags/arc²=100μJy/arc²

AST3-3 IR Camera Preliminary Design

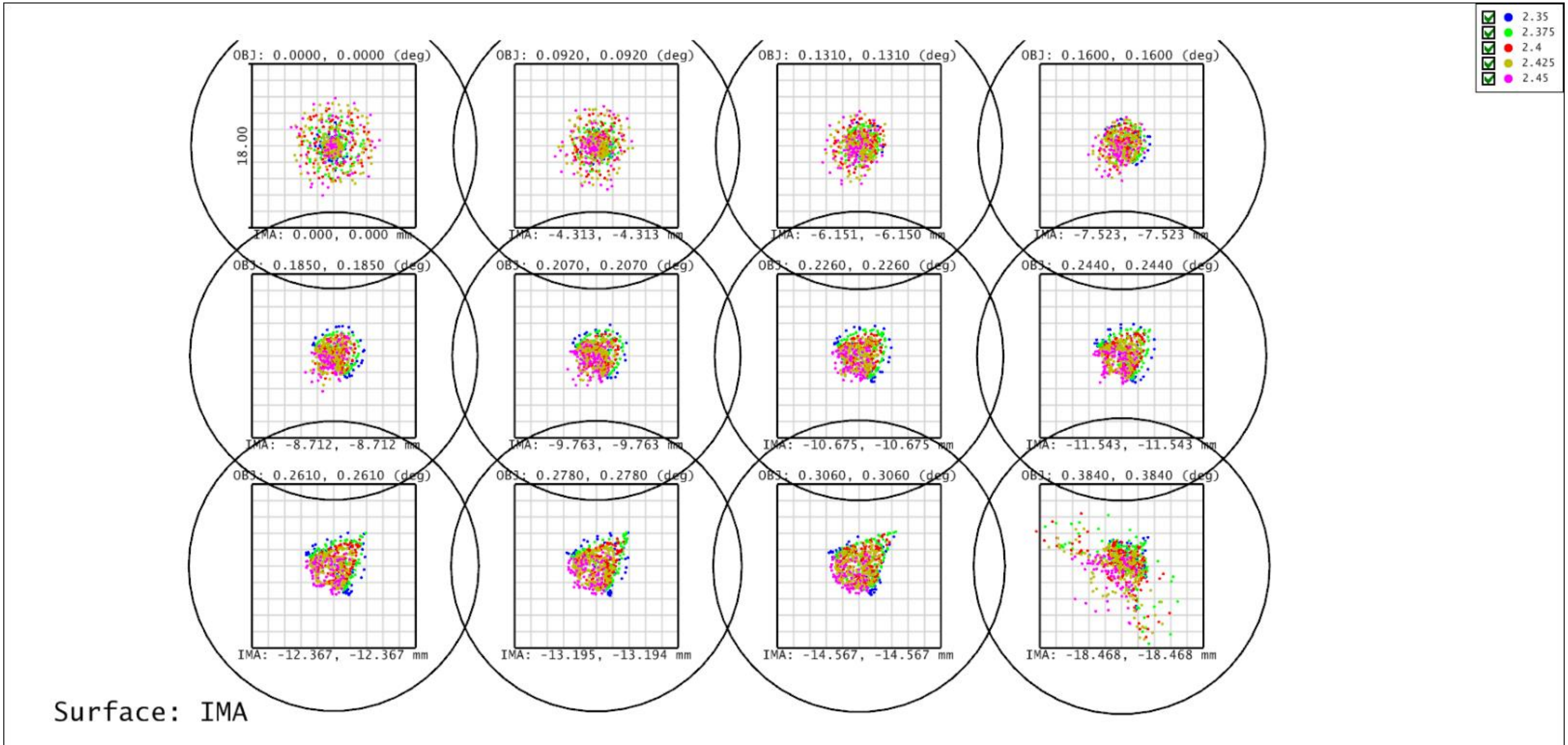


Optical design of IR camera



- Design has one asphere.
- Pixel size:
  - ✓ 18 µm.
  - ✓ 1.35” based on approximate calculations of size of total PSF including diffraction, as-designed aberrations, tolerances and seeing.
- Field:
  - ✓ 2048 x 2048 pixels.
  - ✓ 2765” x 2765”.

PSF



Spot Diagram

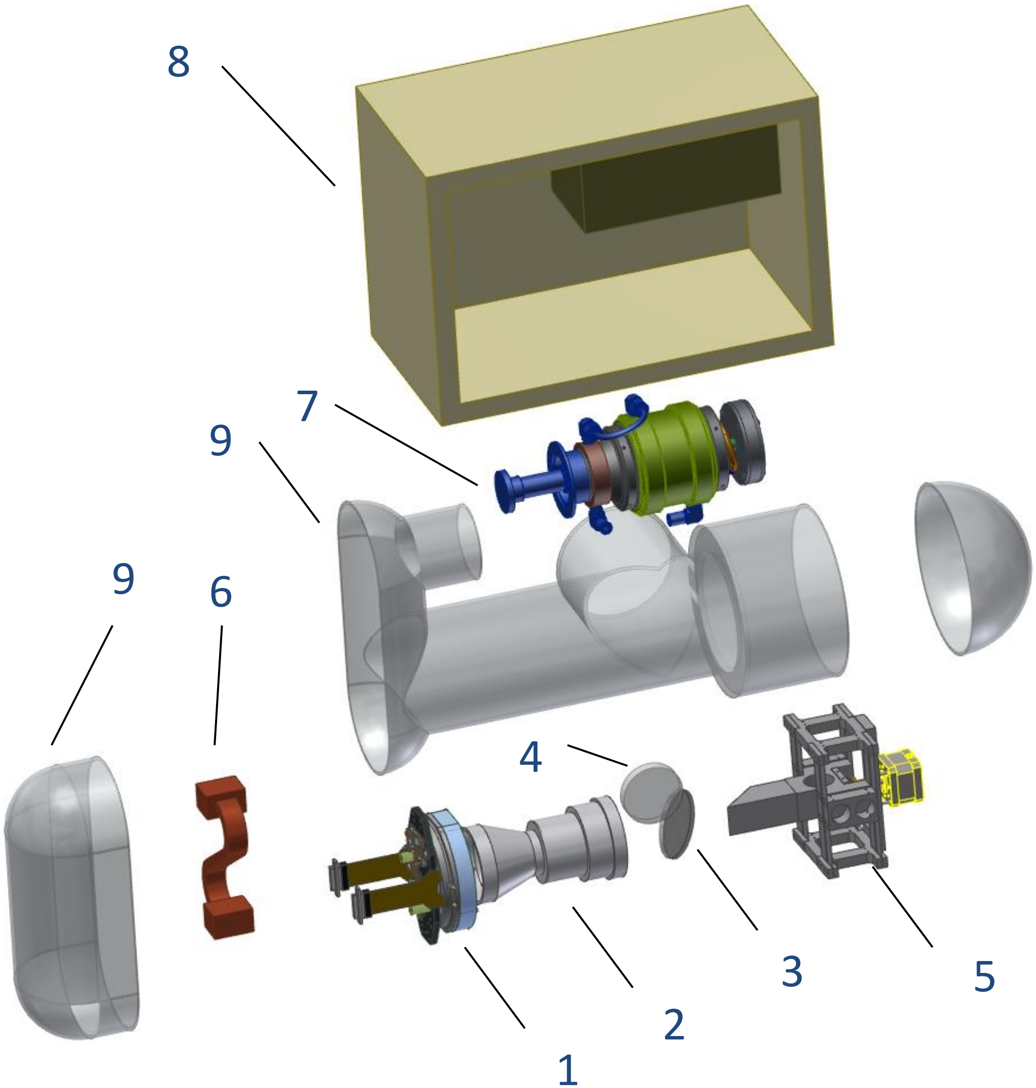
AST3
3/07/2015
Units are µm. Airy Radius: 15.7 µm

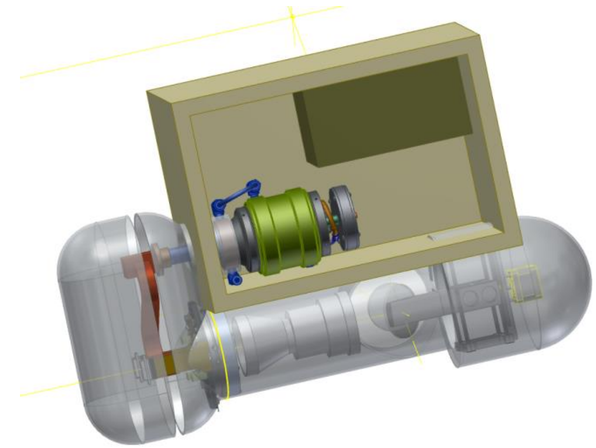
Field	1	2	3	4	5	6	7	8	9	10	11	12
RMS radius :	2.256	1.876	1.691	1.608	1.666	1.772	1.900	1.993	2.114	2.186	2.228	3.098
GEO radius :	5.575	4.937	4.632	4.044	4.060	3.915	4.098	4.199	5.052	5.051	5.549	10.097

Box width : 18 Reference : Centroid

Chinese telescope Kdark camera petite pix1p35 D04b7 PSF.zmx
Configuration 1 of 1

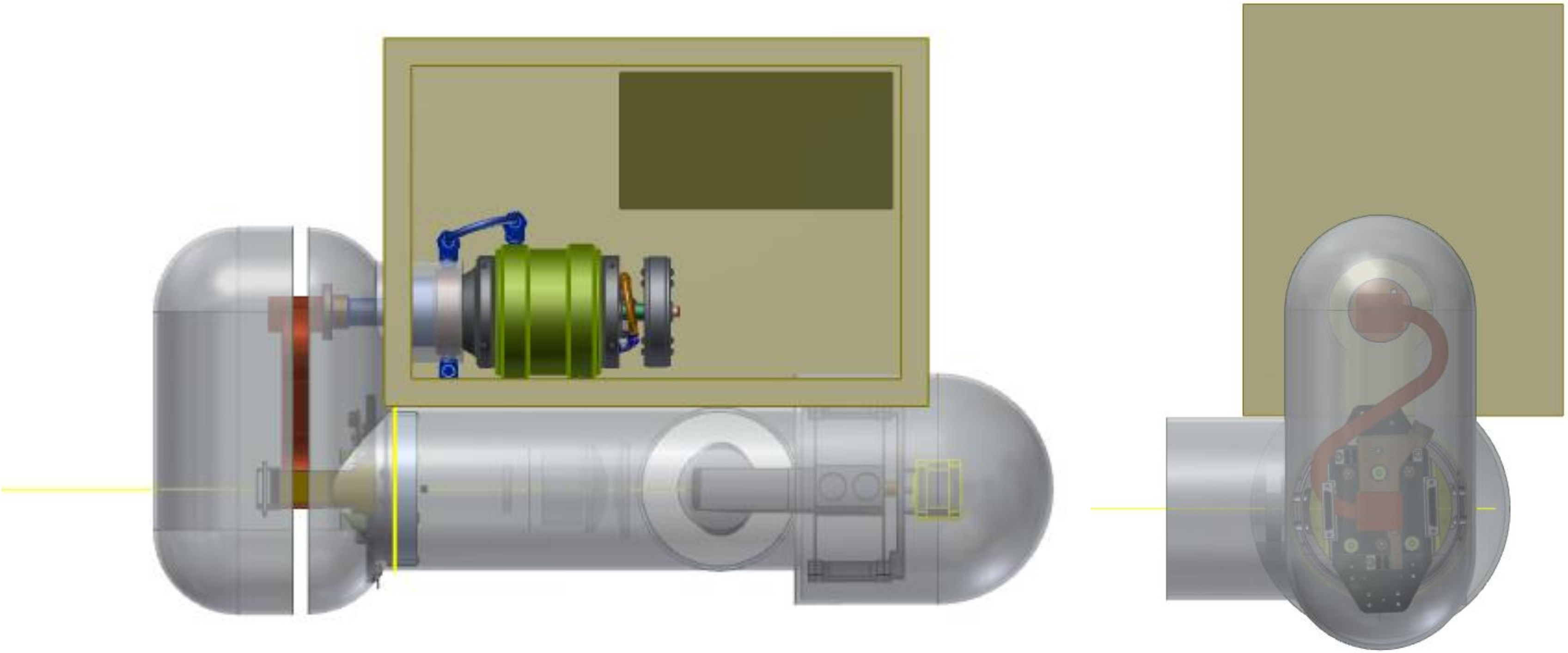
IR camera Concept





1 – Detector assembly
2 – Optical Camera
3 – mirror
4 - Vacuum window
5 – Focusing Mechanism
6 – Cold Strap
7 – Cryocooler (Sunpower Stirling)
8 – Electronics Thermal Cabinet
9 – Vacuum vessel

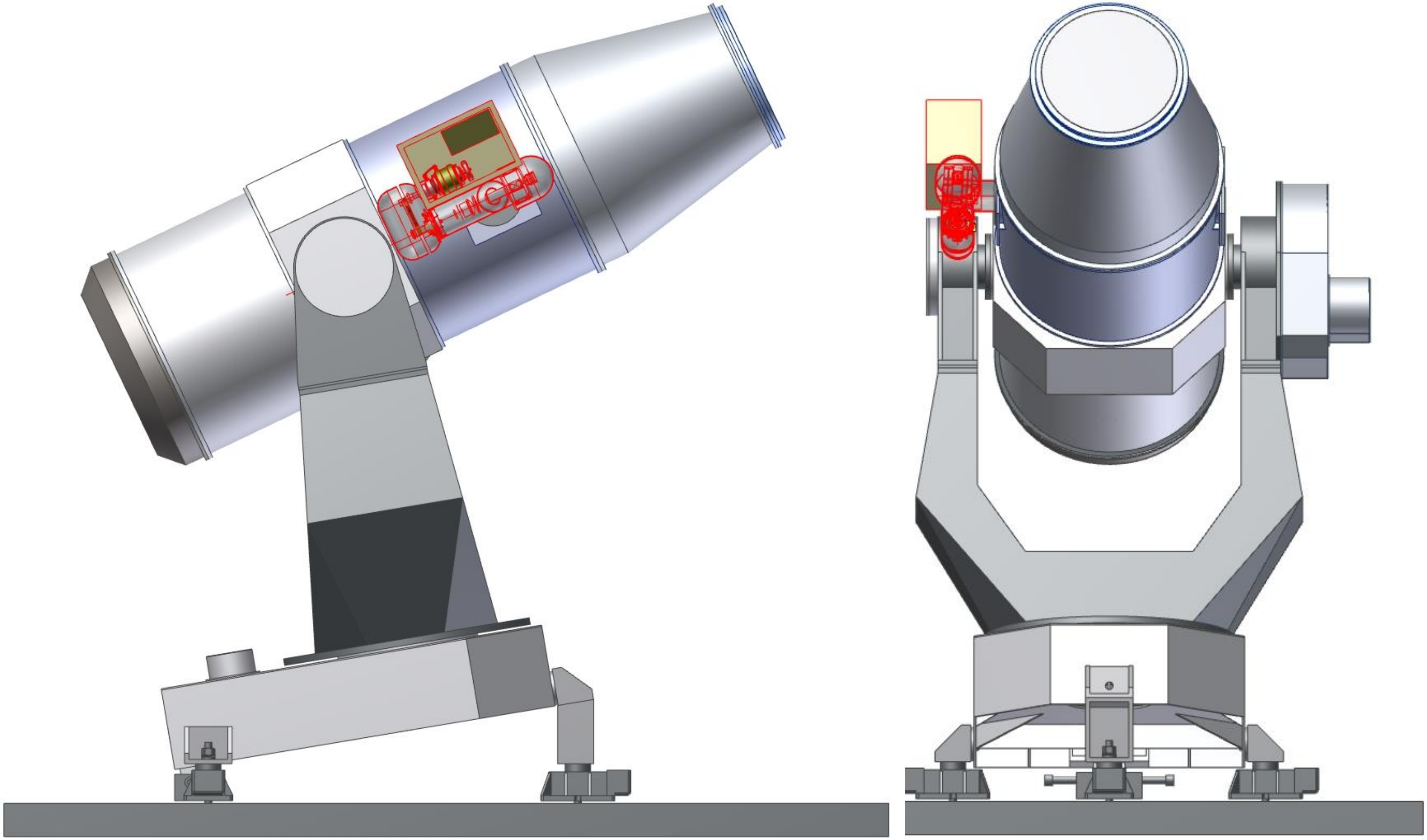
AST3-3 IR Camera Layout



Overall Dimensions, approx: 700 x 500 x 300

Mass approx 30 kg

IR Camera on AST-3 telescope



Stray light and thermal analysis

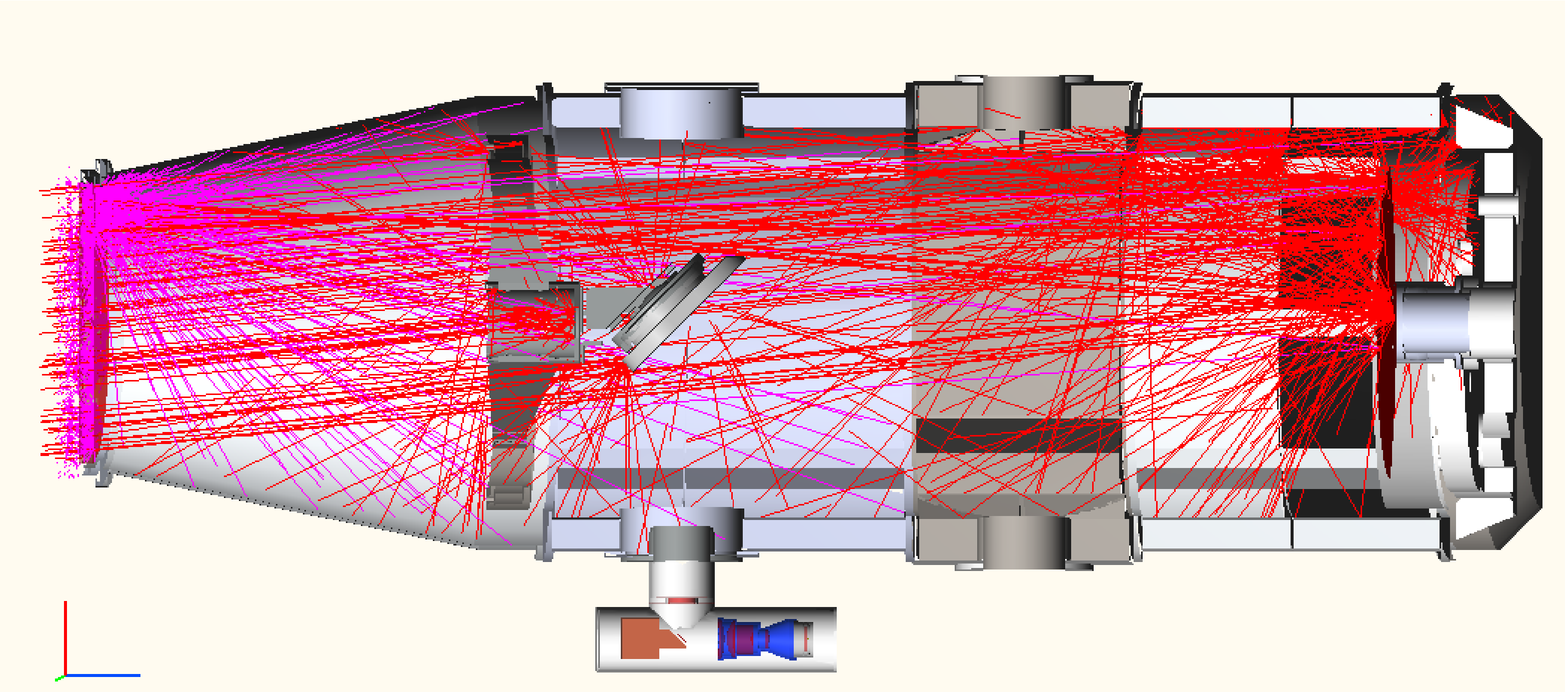
- Scattering light analysis
- Thermal self emission

Surface property parameters(thanks to NIOAT)

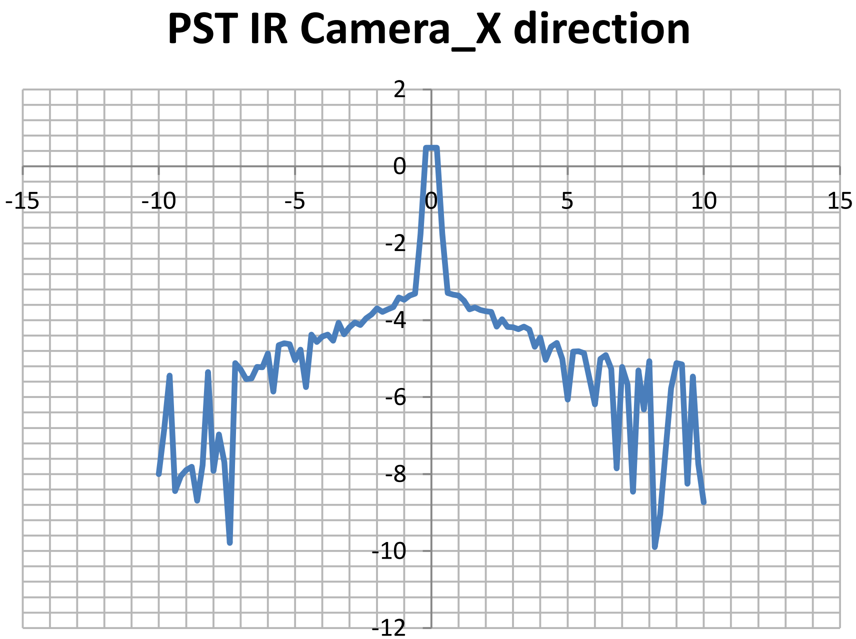
material	absorptance	Specular Reflectance	Transmittance	BRDF A	BRDF B	BRDF g	Emissivity
mirror	0.03	0.956	0	0.00096	0.01	2	0.03
lens	0.001	0.015	0.984	0.00001	0.015	2	0.001
Tube/baffle	0.95	0.00001	0	0.0318	1	0	0.95
ITO	0.13	0.00187	0.85	0.0001	0.015	2	0.13

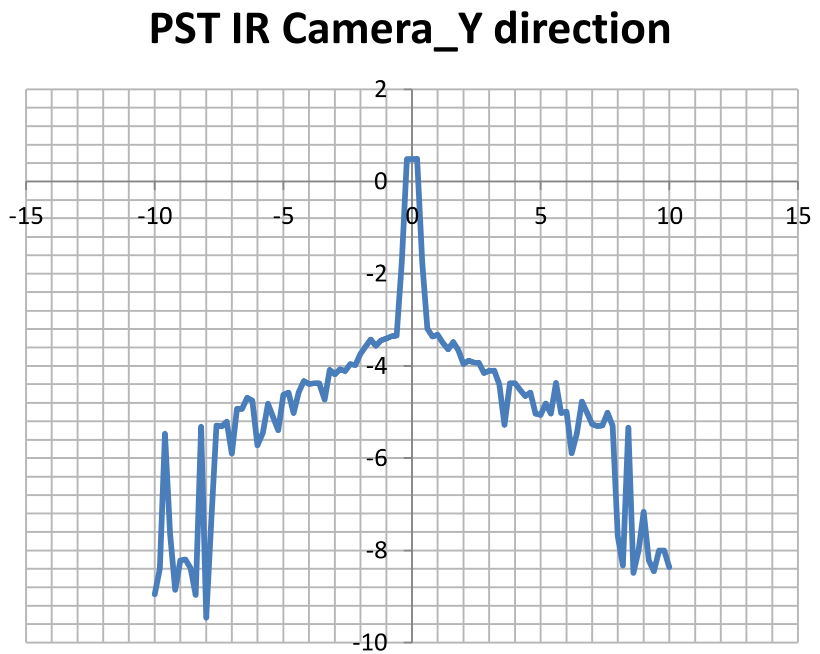
Point Source Transmittance

PST: Standard for stray light rejection evaluation.
PST(θ) = focal plane irradiance/entrance aperture irradiance(θ)



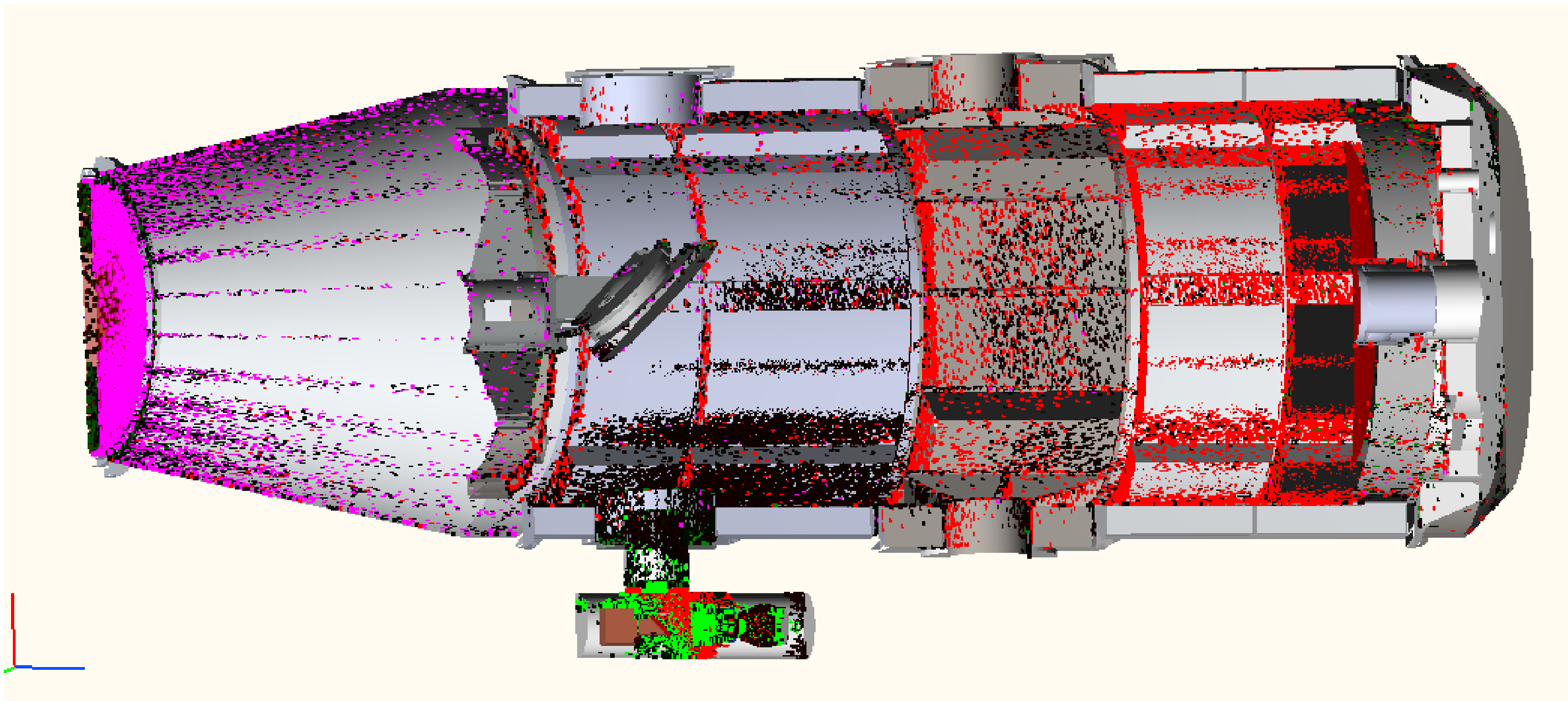
PST for IR camera





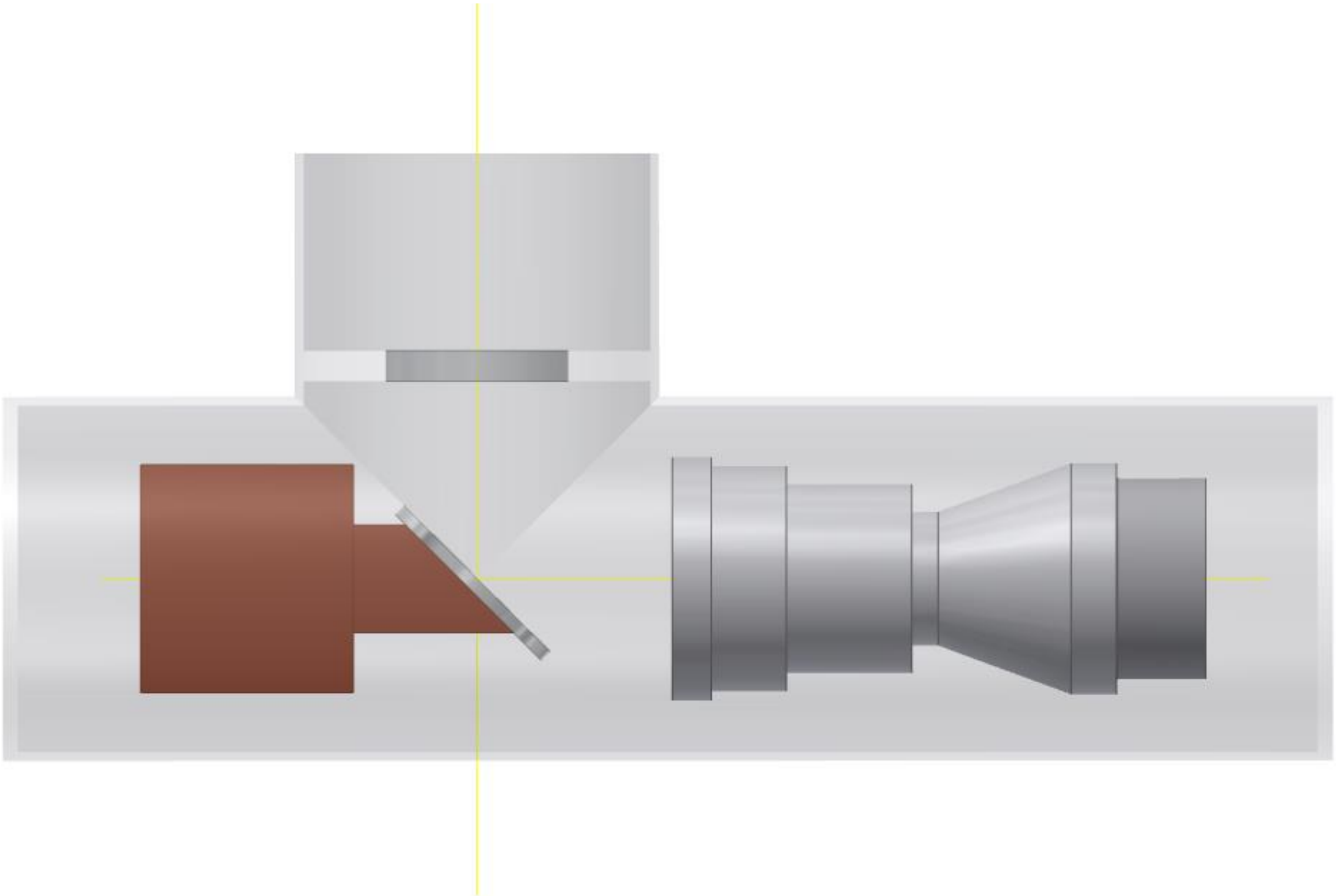
Thermal self emission

Flooded Light from Detector Surface(Solid angle)



Three Temperature Zones:
- ✓ Zone1: Ambient temperature.
- ✓ Zone2: IR camera relay lens body.
- ✓ Zone3: Filter and FPA.

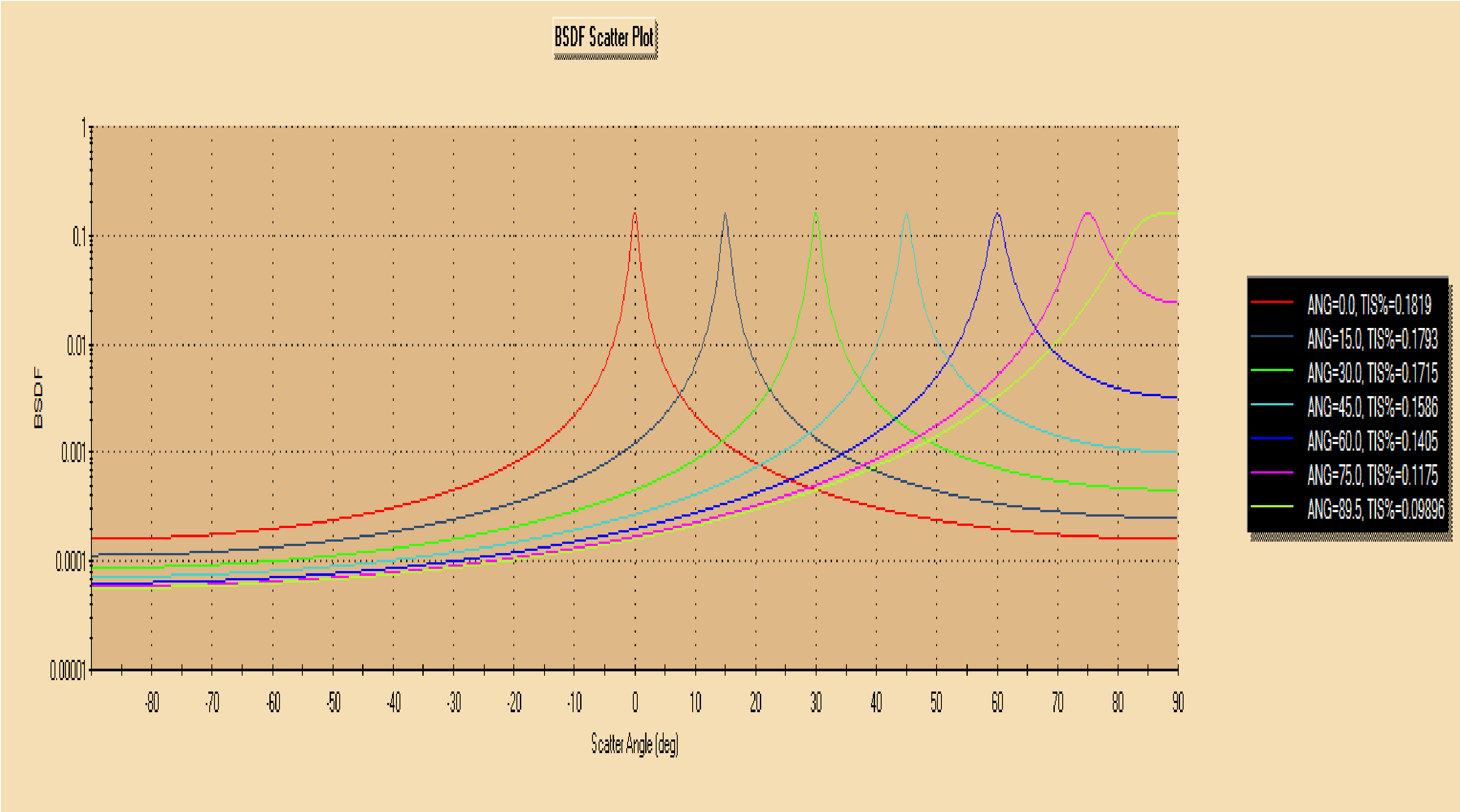
Model for stay light analysis



Thermal emission with Black paint

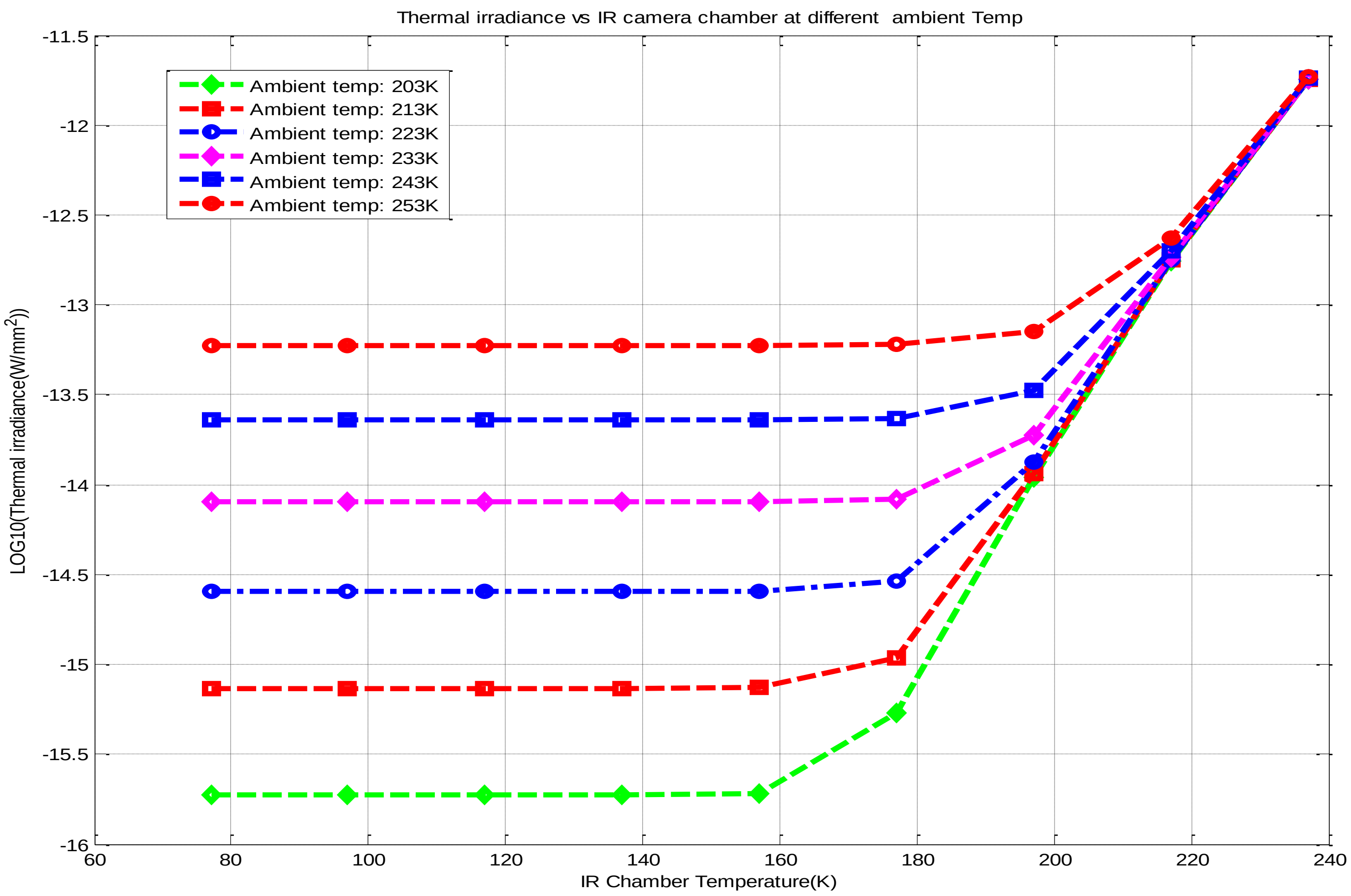
- Thermal irradiance with IR camera chamber temperature.

Black paint

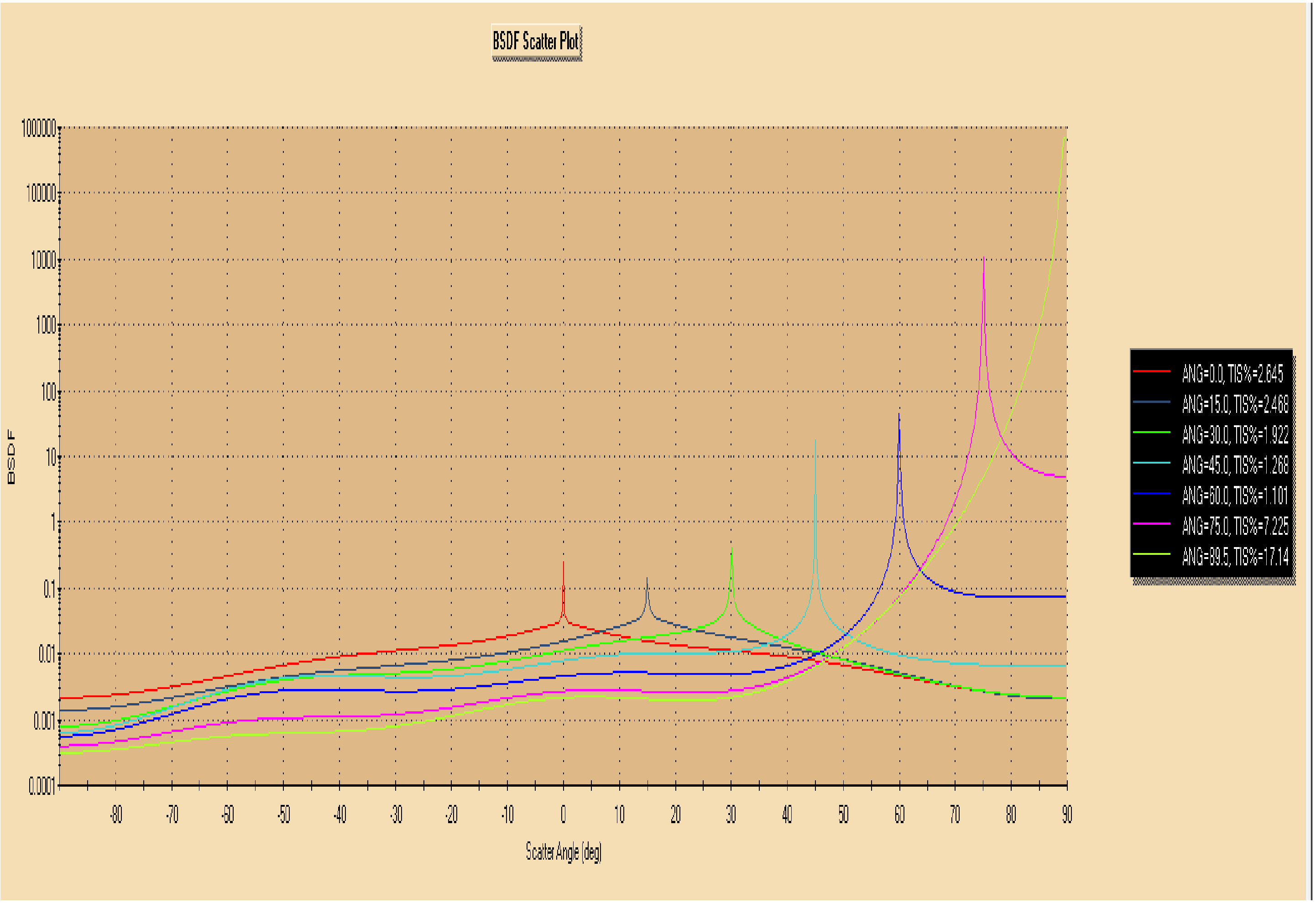


BSDF Scatter Plot
BSDF
1
0.1
0.01
0.001
0.0001
0.00001
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
Scatter Angle (deg)
ANG=0.0, TIS%=0.1819
ANG=15.0, TIS%=0.1793
ANG=30.0, TIS%=0.1715
ANG=45.0, TIS%=0.1586
ANG=60.0, TIS%=0.1405
ANG=75.0, TIS%=0.1175
ANG=89.5, TIS%=0.09896

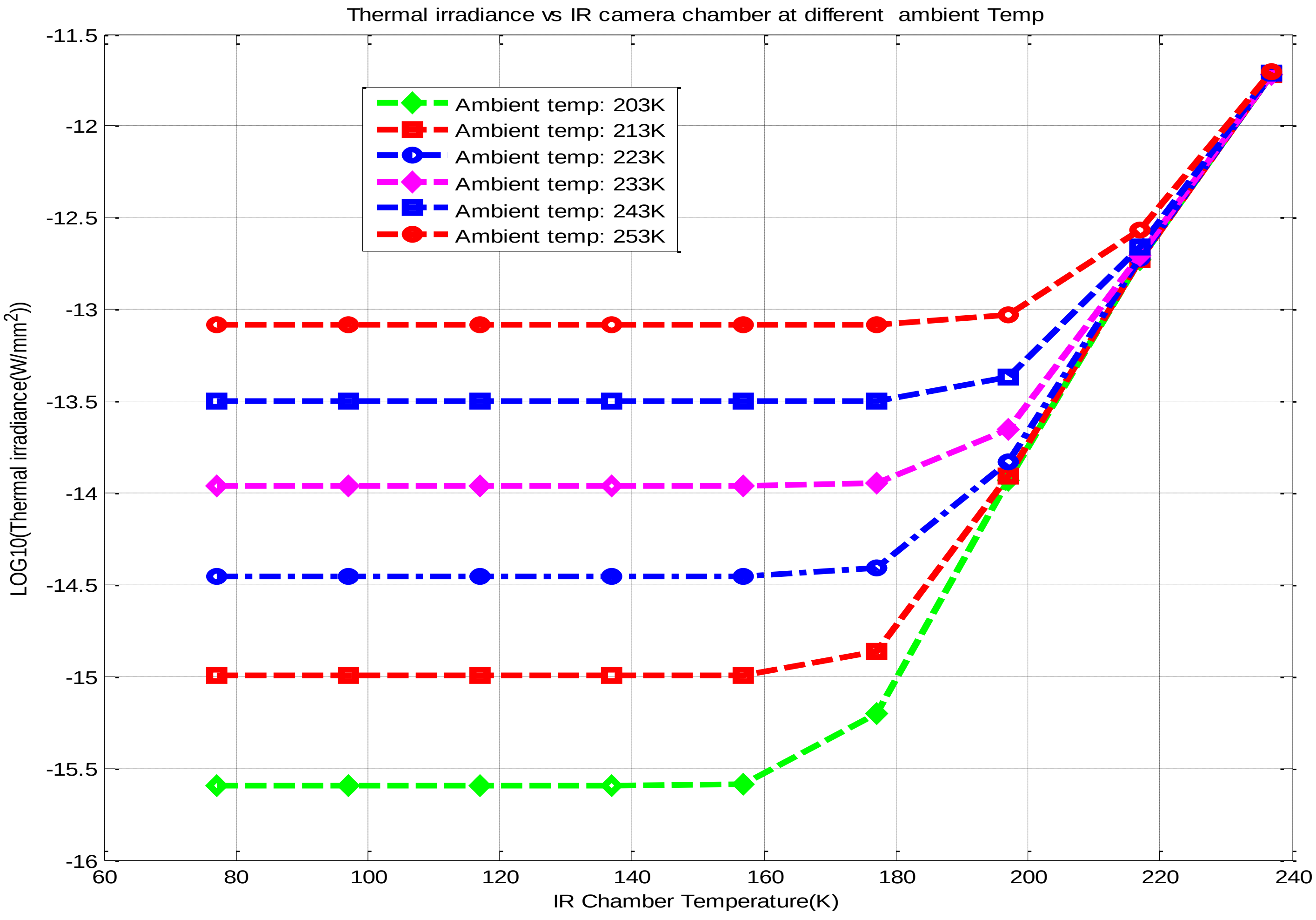
TSE vs IR Camera chamber temperature with black paint



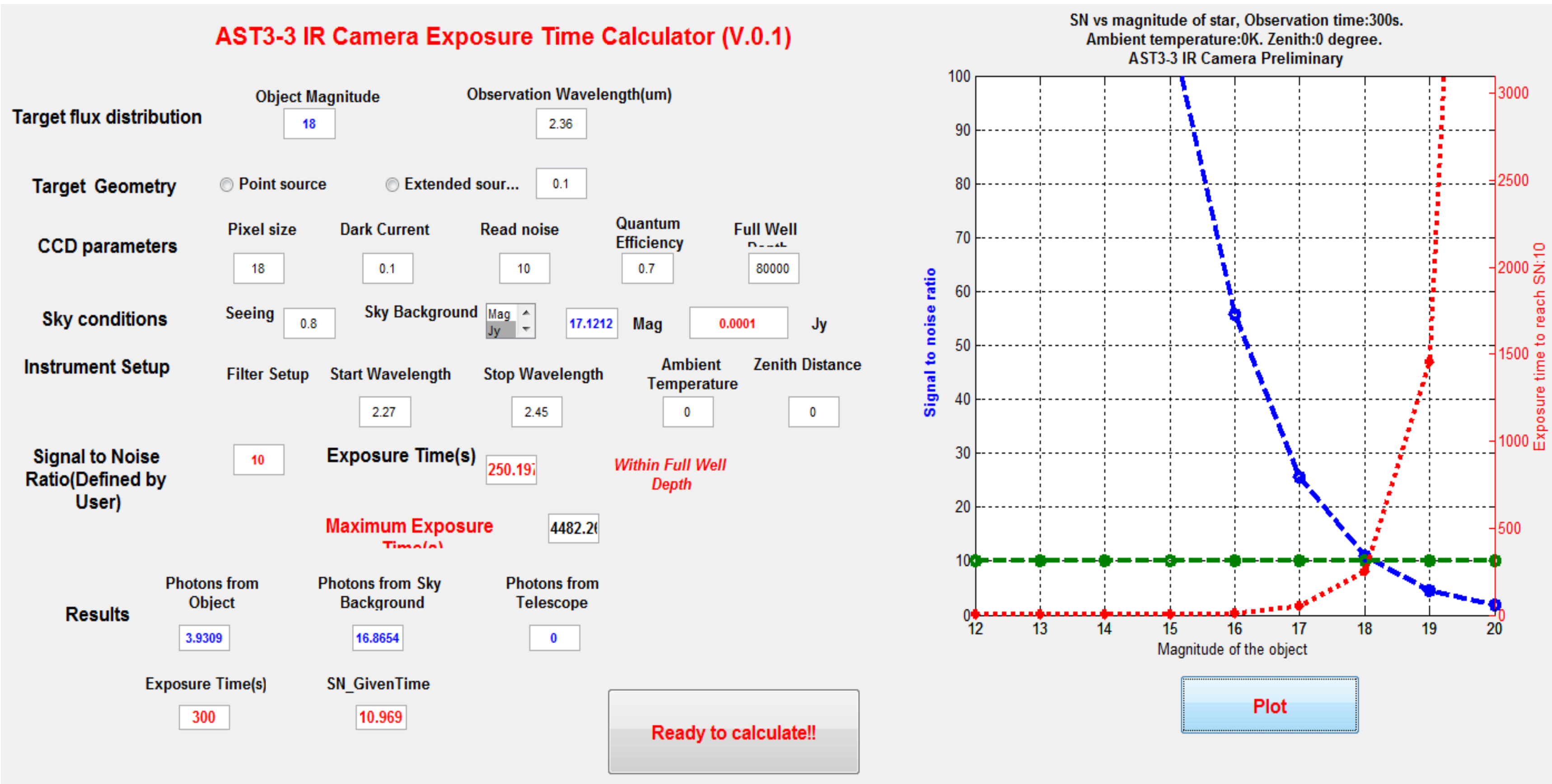
Acktar Vacuum black



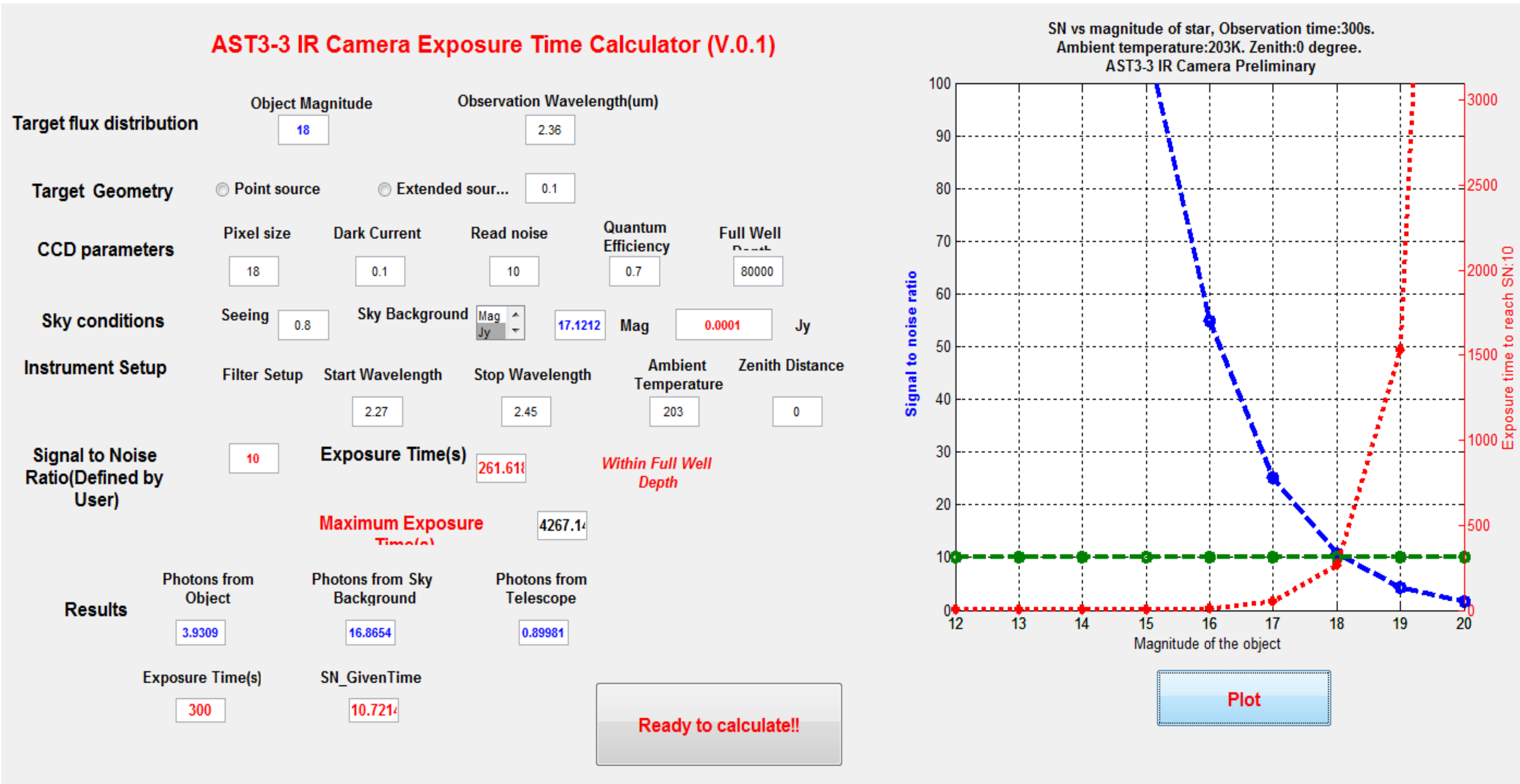
Thermal irradiance when the IR camera chamber painted with Acktar vacuum black paint



AST3-3 AAO IR camera performance(no thermal)



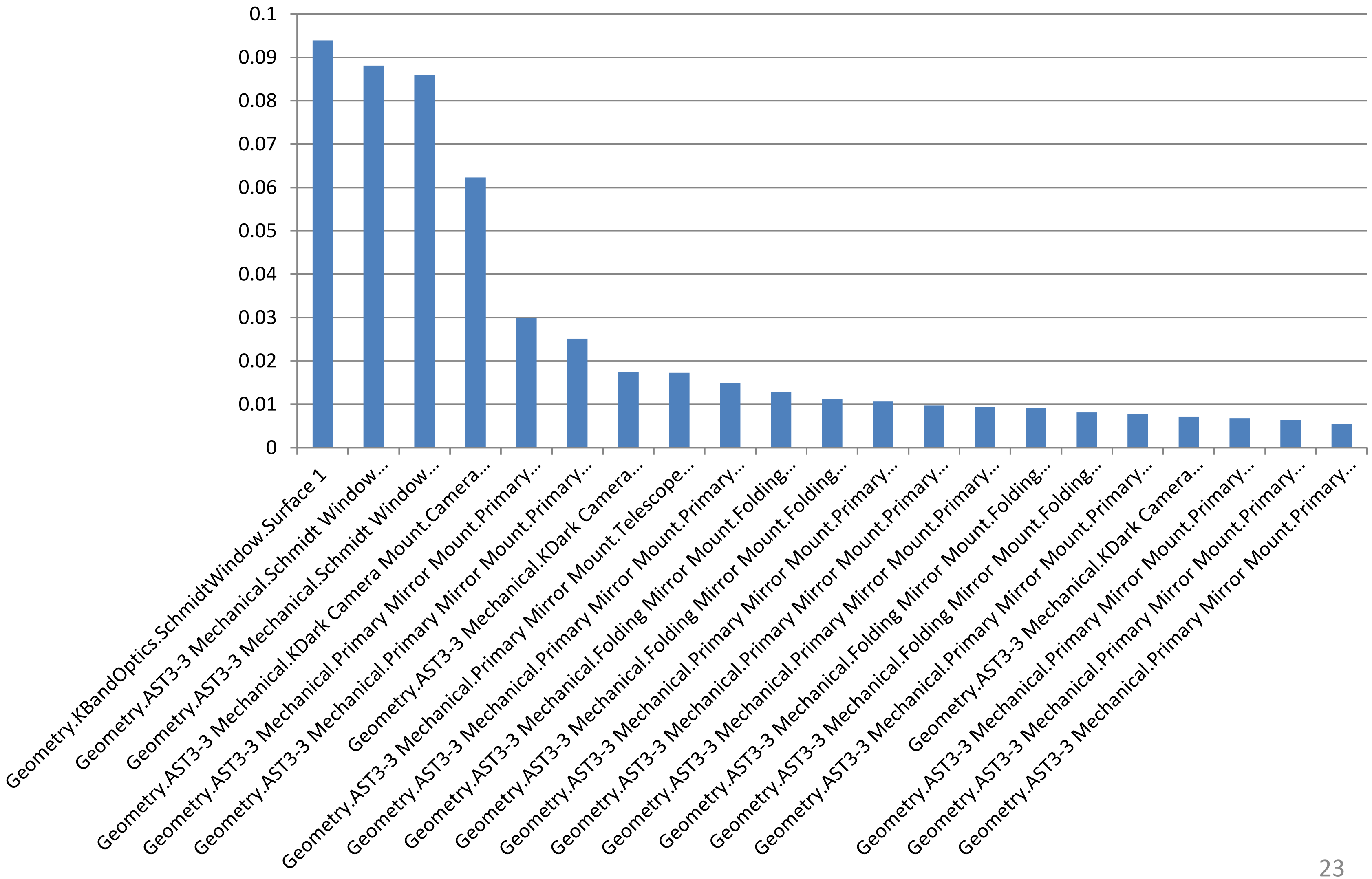
IR camera performance(with thermal: AmientTemp: 203K)



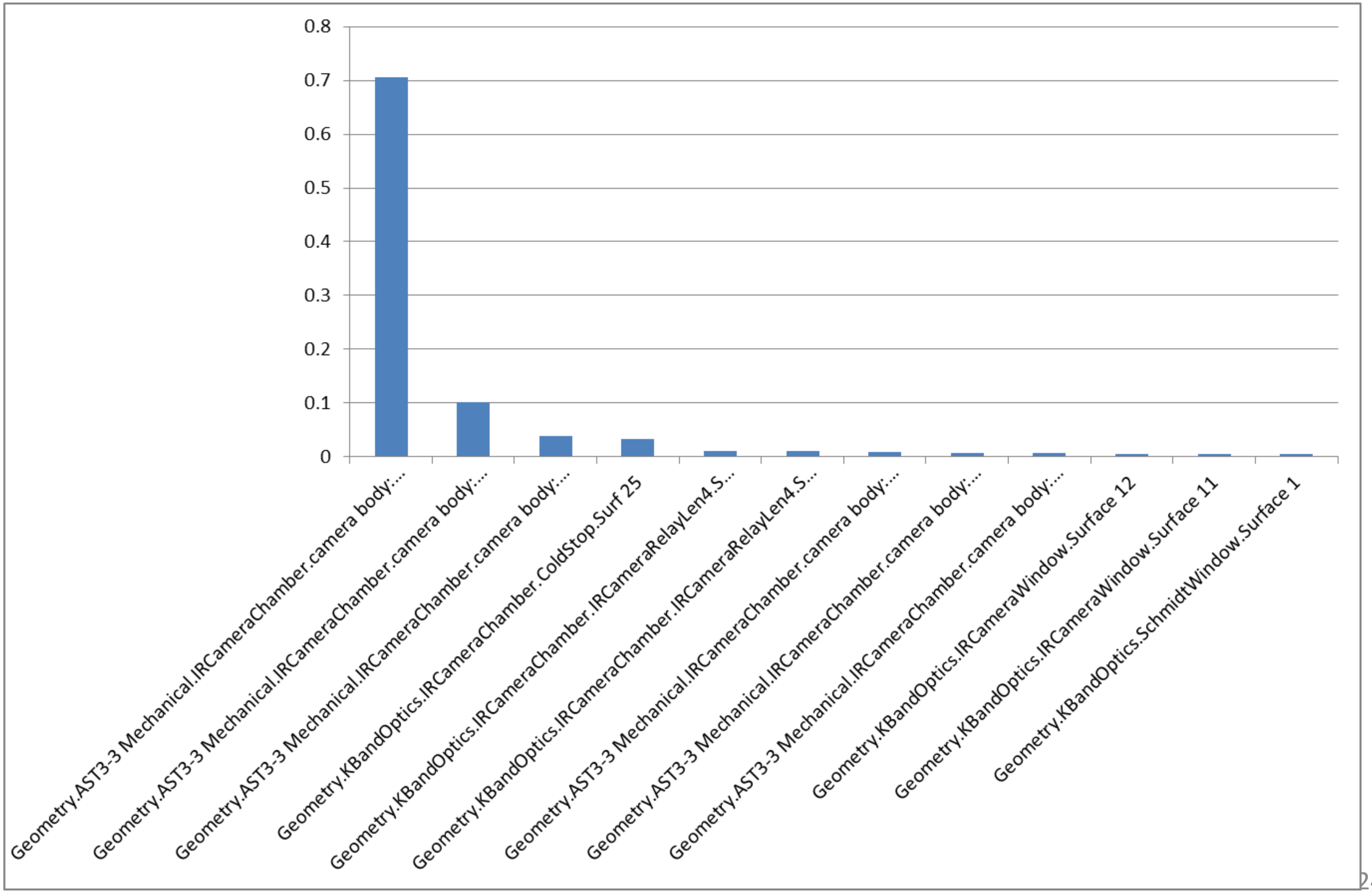
Find major parts contributed to thermal irradiance

- All IR camera chamber cools to <160K,
  - Schmidt window, major contributor
  - IR camera connector flange
- When IR camera chamber doesn't cool
  - IR Camera relay optics and all baffles dominate.

Major thermal contribution from Telescope and IR camera(all optics cool down to 77K(54%))



Major thermal contribution from Telescope and IR camera(Chamber temp to 197K(93.4%))



Plans

- Schmidt window thermal control. When telescope operate in IR, is it possible to defrost using other methods.

Key performance achieved with current design

- FOV: 0.584 degree^2
- 1σ 25 seconds: 18.5 mags at 235K
- 10σ 1 hour: 18.7 mags at 235K
- Kdark sky background: 100μJy/sec^2

More science requirements?

- Can we lock in our current design?


THANK
ALL THE PEOPLE!
memegenerator.net