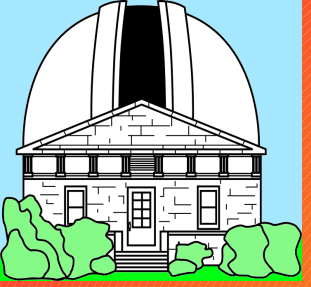
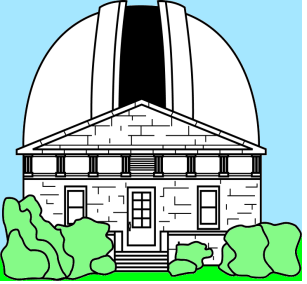


Deep South Telescope
DST

Norbert Zacharias
Charlie Finch
(for the team)

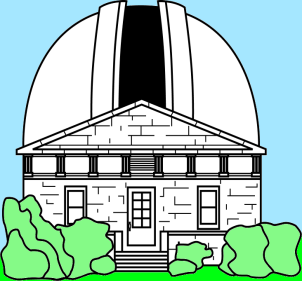
U.S. Naval Observatory
Astrometry Department
Optical Reference Frame Div.

norbert.zacharias@navy.mil
nzIAUc8@gmail.com



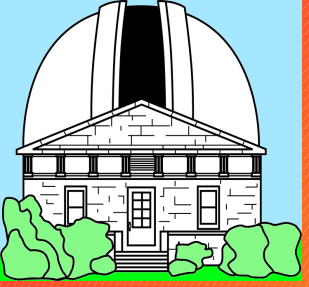
the team ...

- USNO instrument shop:
  - Gary Wieder, Chris Kilian, Phil Eakens
- FRAMEx collaboration:
  - Valeri Makarov, Nathan Secrest, Bryan Dorland, Jean Souchay
- Contractors:
  - Greg Bredthauer, Marion Zacharias
- CTIO: Esteban Parkes ...
- PlaneWave:
  - Ralph Emerson, Kevin Ivarsen, Matt Dietrich …
- Princeton Instruments: Mike Melle ...

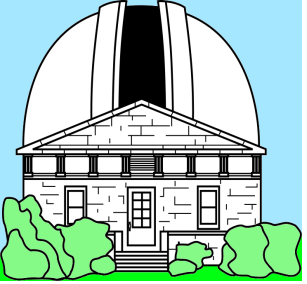


Layout of talk

- History of DST project
- Deployment of instrument
- Science program
- Target selection
- Status of operations
- Conclusion

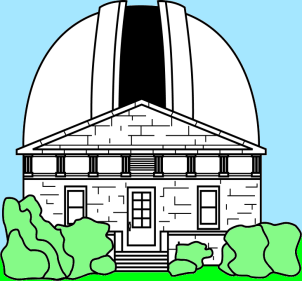


History of DST project



timeline

- 2015 / 2016 begin planning
  - era of astrometric all-sky surveys from ground comes to an end due to Gaia success
  - need large aperture (“going deep”) telescope in the south
- 2017 market research, budget approved, get PW1000
- 2018 :
  - order 4k CCD camera from Princeton Instruments
  - construction of telescope completed
  - December: test observing at PW factory in California near LA



PlaneWave CDK1000

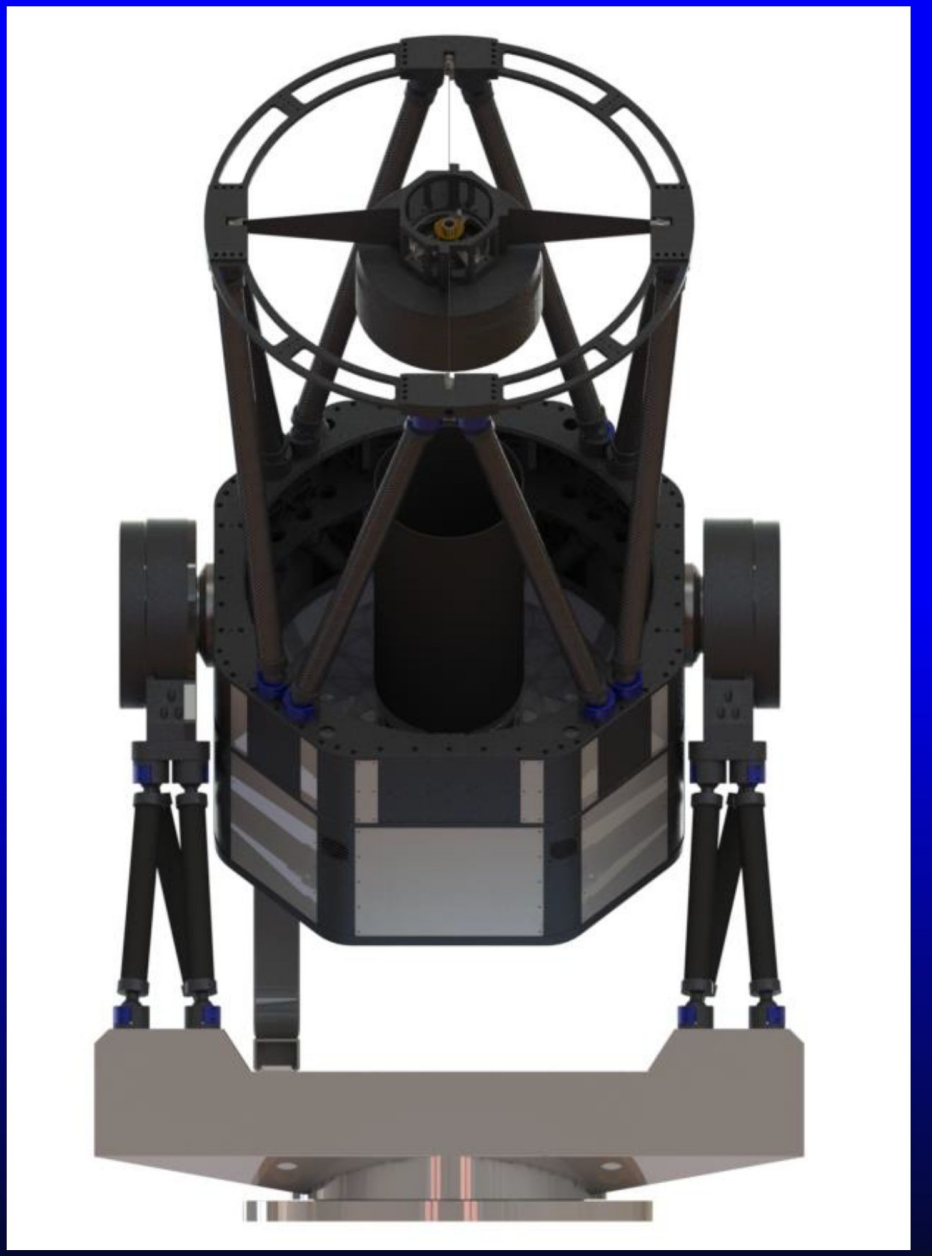
Fits in 16’ dome

Focal plane is at eye height

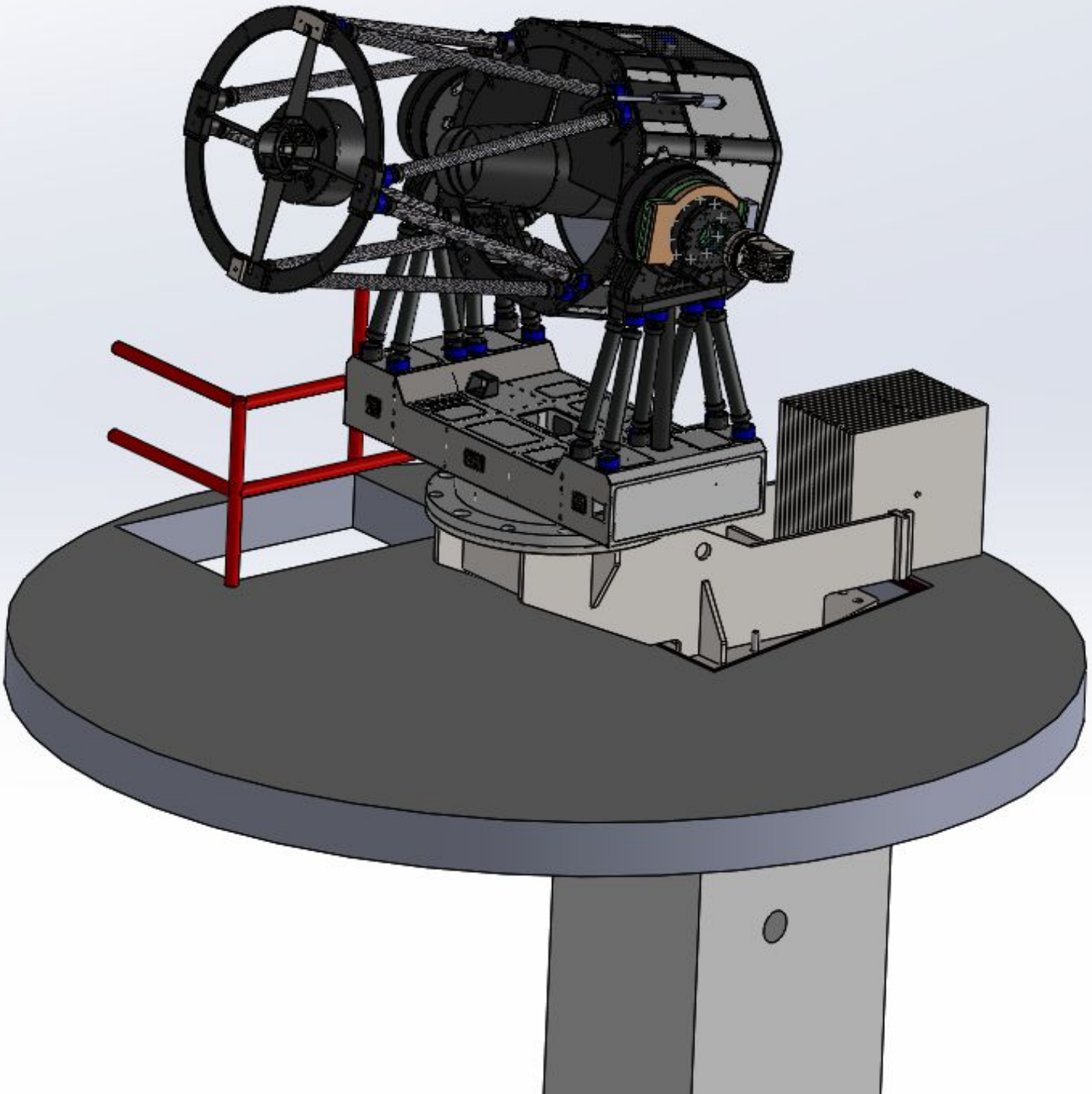
Optical benches on the sides are de-rotated

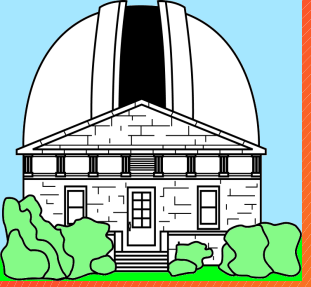
All cables and electronics are inside truss poles, forks, base and cable tray

Easy access to cables and electronics

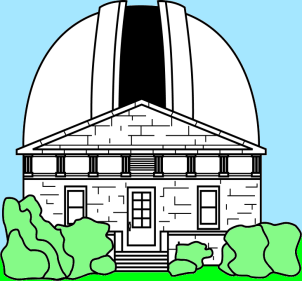


- 1.0 m apert.
- f = 6.0 m
- 2 foci
  - optical
  - near-IR
- robotic





Deployment of Instrument at CTIO



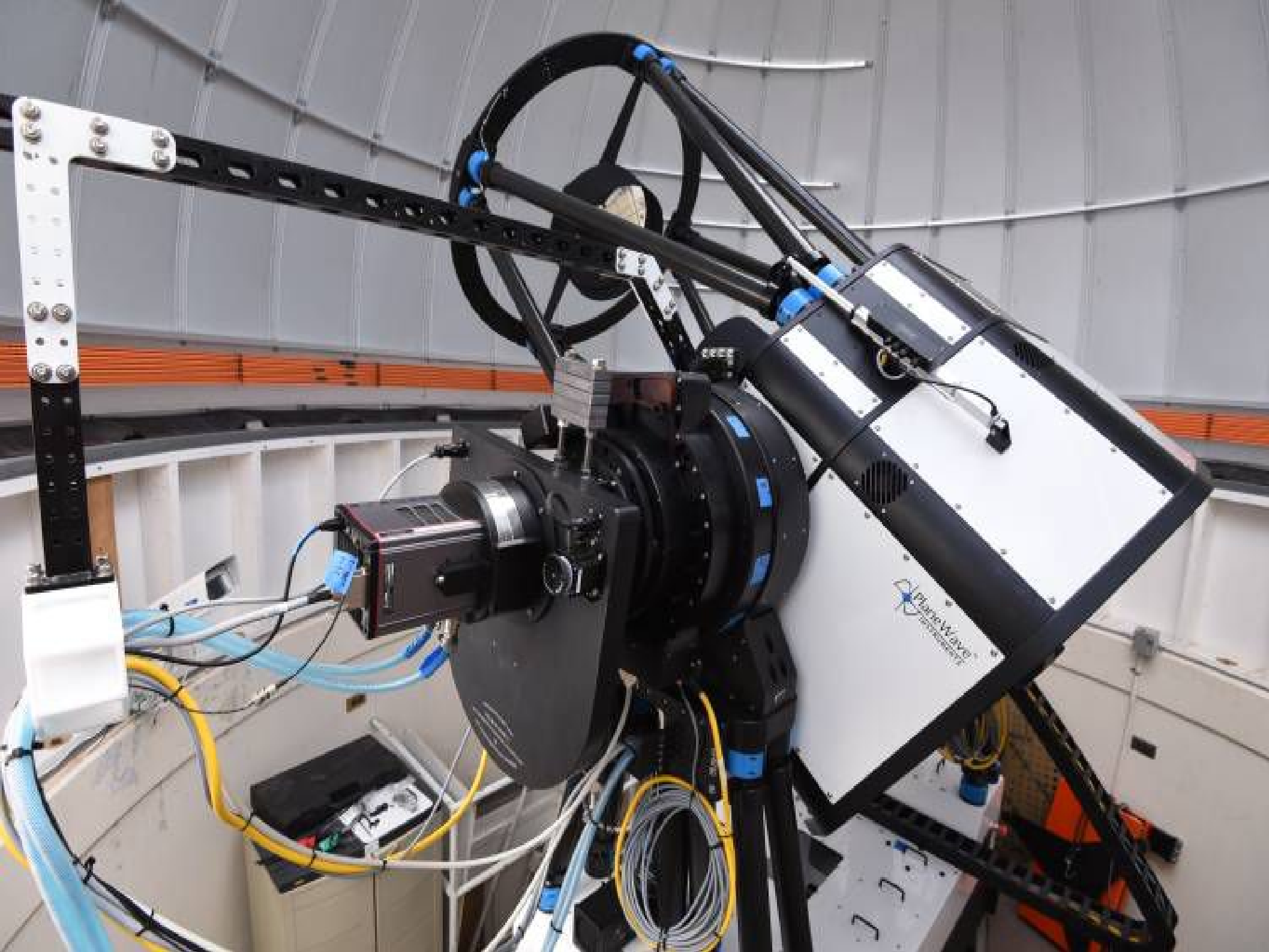
2019

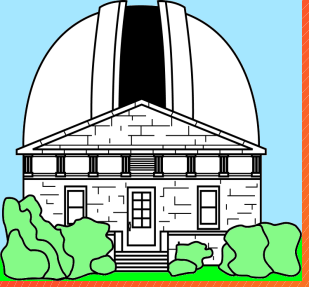
- 4k camera delayed: accident during shipment
- March: deploy telescope at CTIO w. small test camera
- June, July: 2nd trip to CTIO:
  - finish system integration (except 4k camera), all devices
  - implement and test operations software
- August: 3rd trip to CTIO:
  - install 4k camera, finish up deployment
  - Aug 13: first light
  - Aug 24: operational

March 2019 CTIO

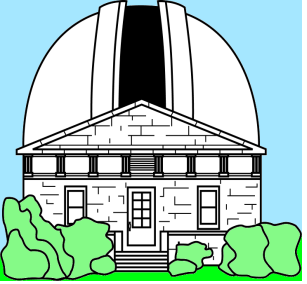
Princeton Instruments camera

- 4k by 4k E2V CCD
- 4 port low-noise read
- lifetime vacuum
- therm.electic cooling to -90 C
- no more liquid N2



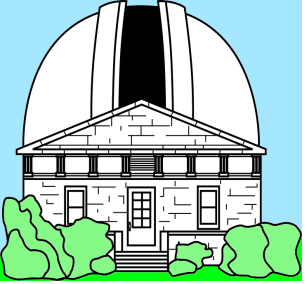


Science Program



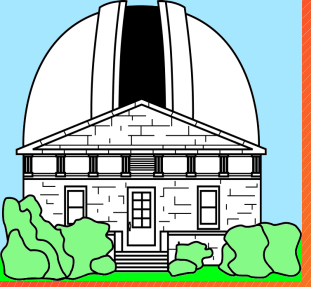
DST is used for FRAMEx

- follow-up on Gaia – VLBI “odd sources”
  - target extragalactic sources with radio-optical position offsets
  - high cadence observing with various filters (B,V,R,I)
  - is there a connection between astrometric offset and other parameters (brightness, color, structure ...)?
  - do optical observations from the ground (arcsec resolution) “see” a different center of light than Gaia does?

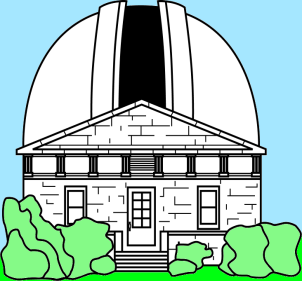


other DST projects

- 10% of time to Chile (likely begin next semester)
- 2nd port (focus) of DST for near-IR camera
- mount can move non-sidereal, arbitrary tracks:
  - capable of observing asteroids incl. NEOs, PHAs
- other programs TBD in future

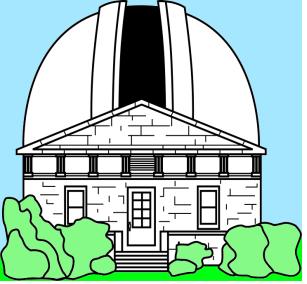


Target selection for FRAMEx program



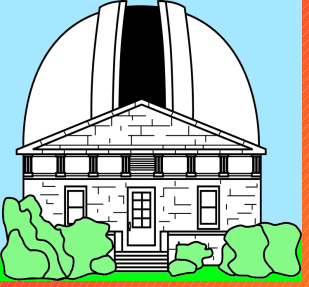
DST extragalactic targets

- most sources are in Gaia DR2 and have VLBI observ.
- 4 groups:
  - nearby AGN targets (Nathan Secrest), some need VLBI obs.
  - "odd" sources from ICRF3 (Valeri Makarov)
  - other sources with significant radio-optical pos.difference (RFC)
  - "control sample" = no significant radio-optical pos.difference
- selected sources as bright as possible (R <= 18.5)
- about even distribution along RA, Dec <= +25 deg

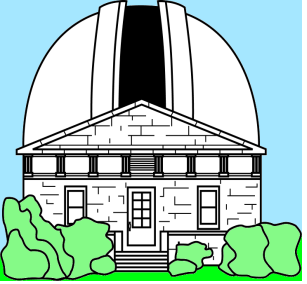


numb. of sources by radio-optical pos.dif	
no info	23
up to 2.9 mas	50
2.9+ to 5.0 mas	14
5.0+ to 10.0 mas	32
10.0+ to 30.0 mas	38
30.0+ to 100.0 mas	15
100.0+ to 300.0 mas	8
over	12
total	192

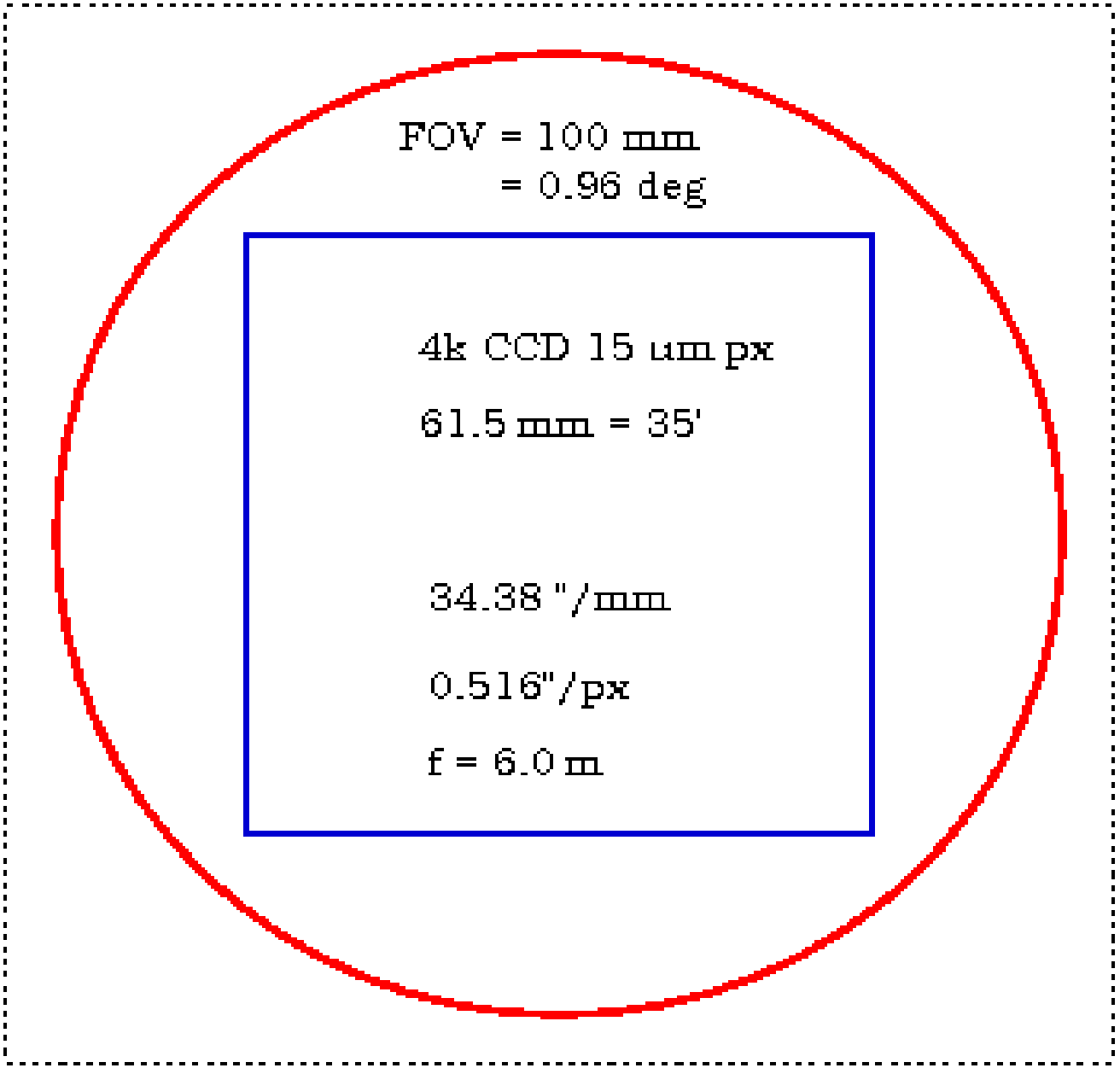
= 4 per 0.5 h RA

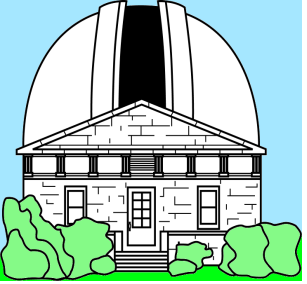


Status of operations



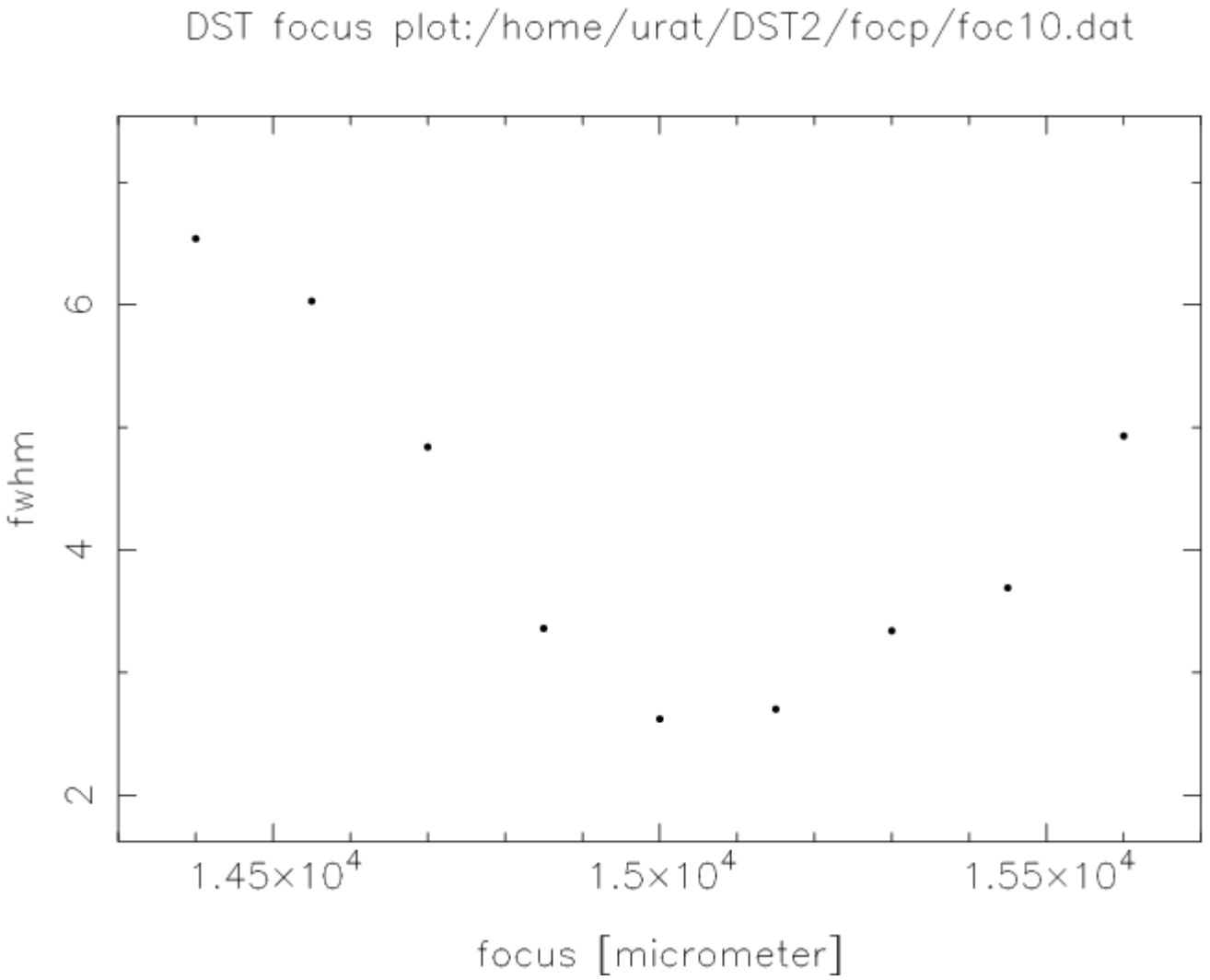
focal plane with single CCD

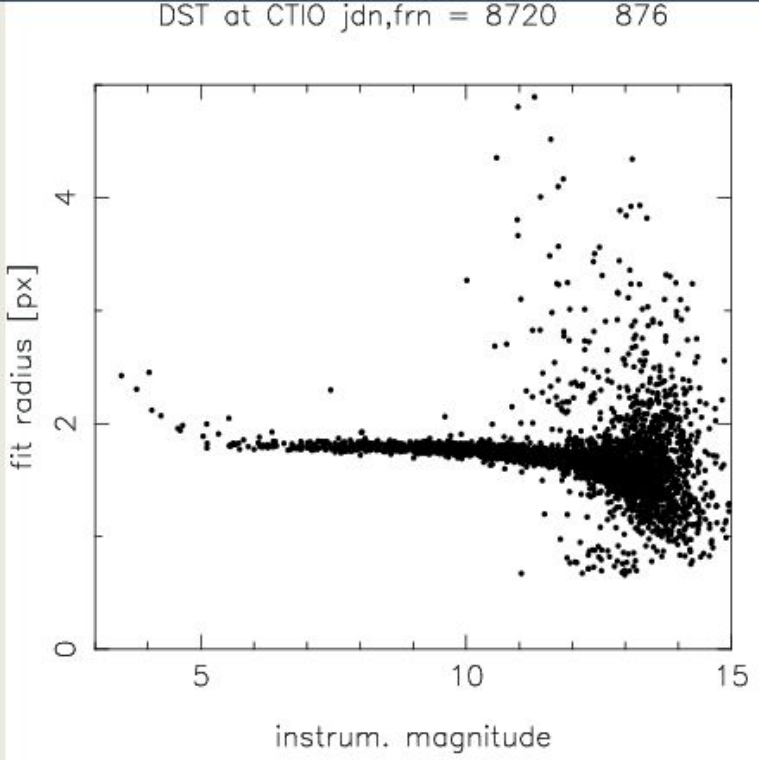


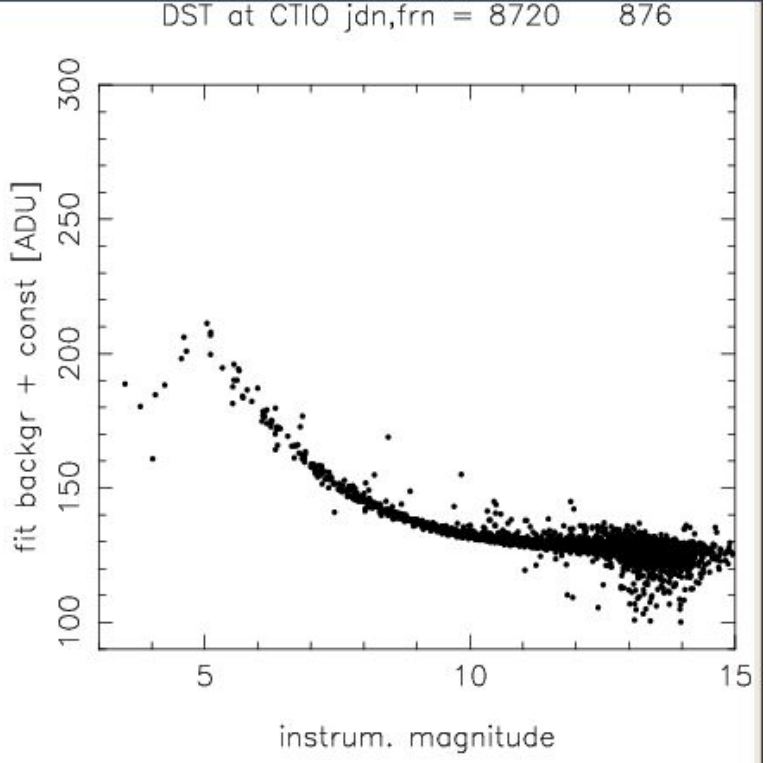


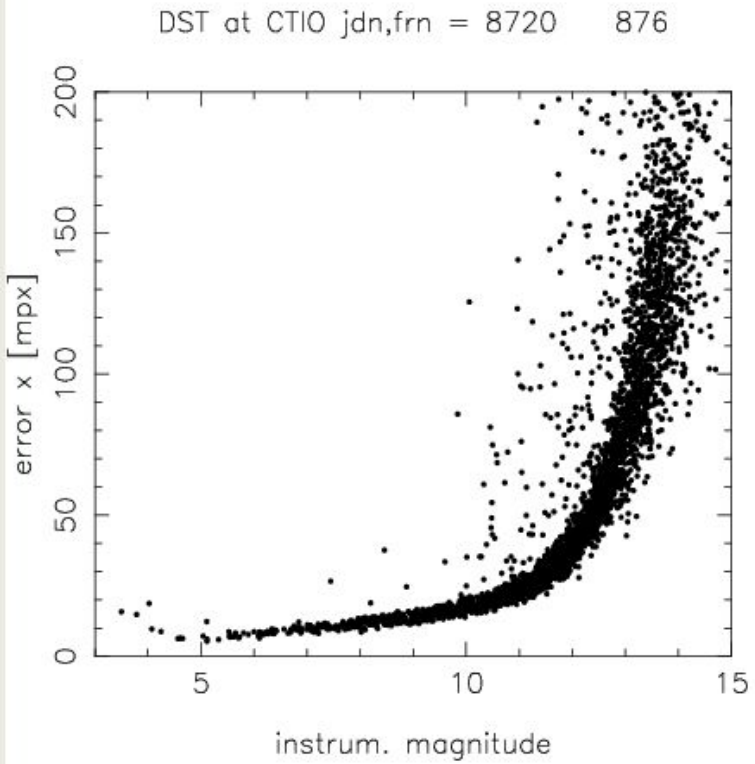
focus curve

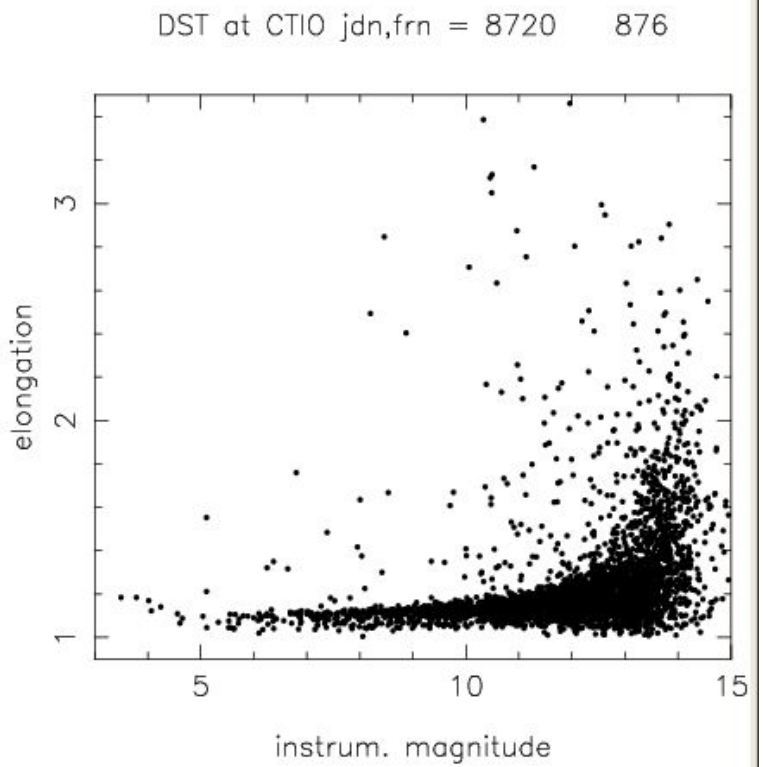
not symmetric
parabola fit
not
appropriate





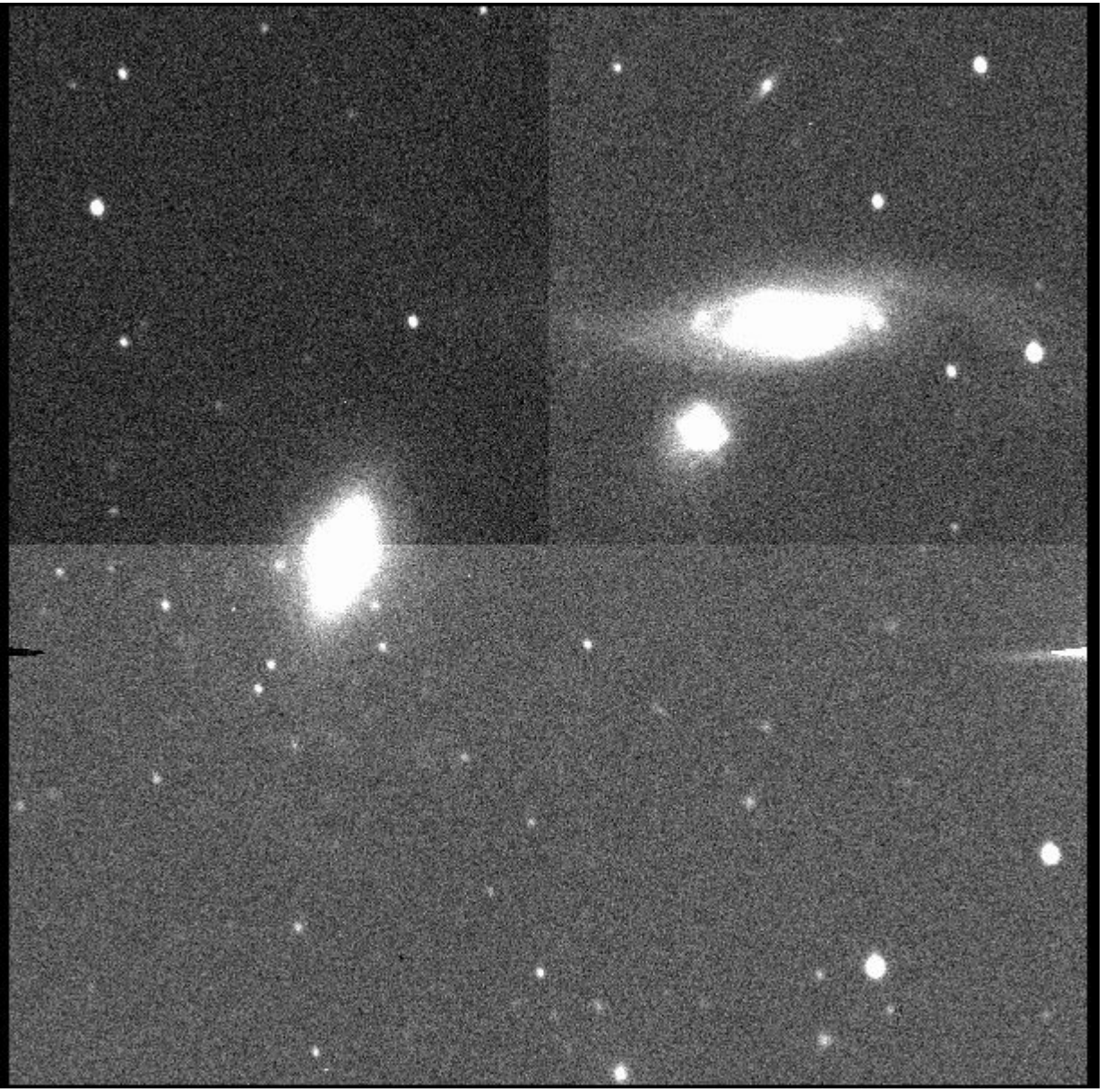


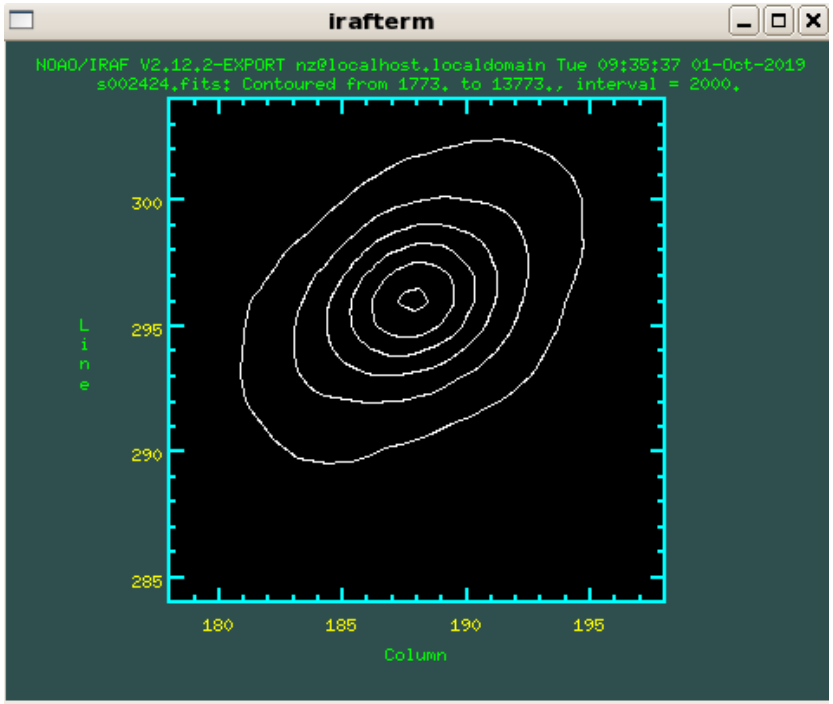


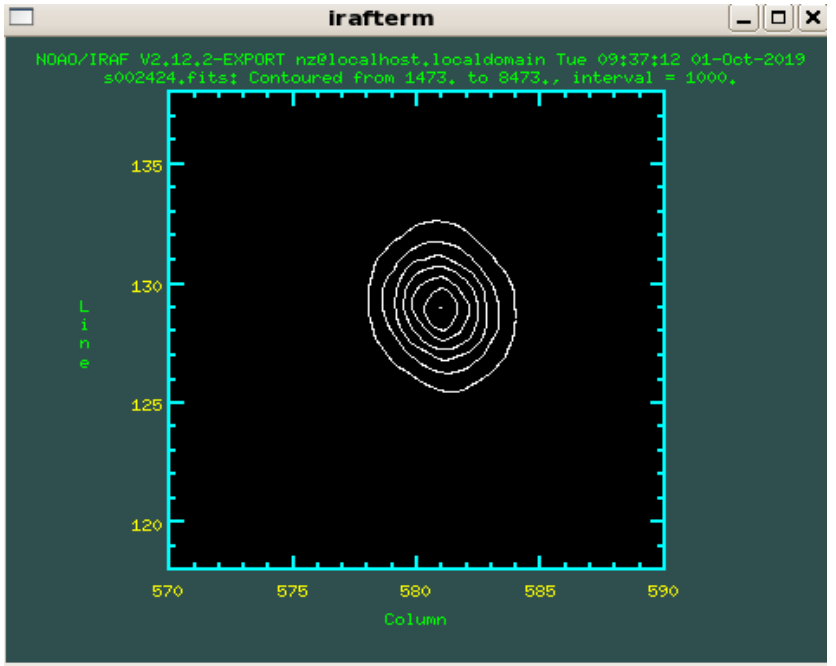


stellar image profile fit results

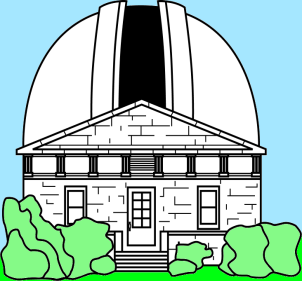
NGC 7465







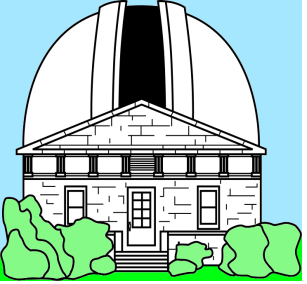
Journees, Paris Observ., 2019 Oct 8



observing statistics

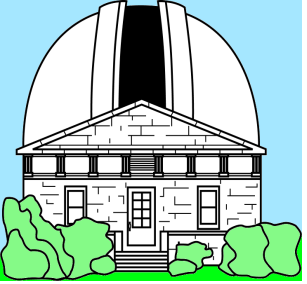
observing from Aug 24 - Sept 30

total number of nights	38
lost due to weather	4
lost due to instrument	4
nights with observations	30
total number of exposures	2797
total number of sources	~ 100



issues

- reading of mount (mirror) temperatures
  - just becomes available now
  - significant improvement in focus prediction expected
- image elongation
  - about 30% of exposures show unacceptable image quality
  - more frequent for longer than shorter integrations, but do see perfect images for some exposures up to 10 min
- “hang-ups”
  - occasional loss of communication to some device
  - typical process for a new telescope to improve robustness
- reduction pipeline: in progress



Conclusions

- DST is operational at Cerro Tololo
  - current program: 199 FRAMEx targets
  - high cadence (every other night) observing (astrometry & photom.)
  - about 100+ exposures per night
  - reduction pipeline in progress
  - still some challenges (not always round images, extended sources)
  - expected single measure precision: 4 - 10 mas (dep.on brightness)
- if your favorite target is not on the list:
  - now is the time to act !