

A New Seeing Monitor and Profiler for Eureka, on Ellesmere Island

SCAR AAA 6th Workshop, September 2021

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Eureka, 80N, Ellesmere Island, Canada
Polar Environment Atmospheric Research Laboratory (PEARL)
600 m



PEARL photo: CANDAC

Dome C, 75S, Antarctica
Concordia Station
3200 m



Concordia photo: ARENA

http://www.unice.fr/MG/bdr/1991/2/A/ARENA_EXPOSE/PEARL_VISION.pdf



PEARL photo: CANDAC



Clarity

Usable sky ($V < 2$ mag): **86%**

Clear sky ($V < 0.5$ mag): **68%**

Photometric sky: **48%**

[MK: 80%, 70%, 50%]¹

Steinbring et al., 2012, PASP, 124, 185

Opacity

Median tau (225 GHz): **0.14**

Modal tau (225 GHz): **0.09**

[ALMA: 0.08, South Pole: 0.06]²

Matsushita et al., 2013, IAU, 124, 185, 204

Asada et al., 2012, SPIE, 8444, 1

Brightness

Grey (V): **19.7** mag/sq-arcsec

[MK: 19.5, Dome C: 19.8]³

Dark (V): **20.7** mag/sq-arcsec

Infrared (J): **15.8** mag/sq-arcsec

Infrared (Kd): **<200** microJy⁴

Steinbring et al., 2012, PASP, 124, 185

Sivanandam et al., 2012, SPIE, 8446, 43

Steinbring, 2017, PASP, 129, 15003

Seeing

Median total (V): **0.76** arcsec

Median free (V): **0.50** arcsec

[MK: 0.75, 0.33; CTIO: 0.79, 0.50]

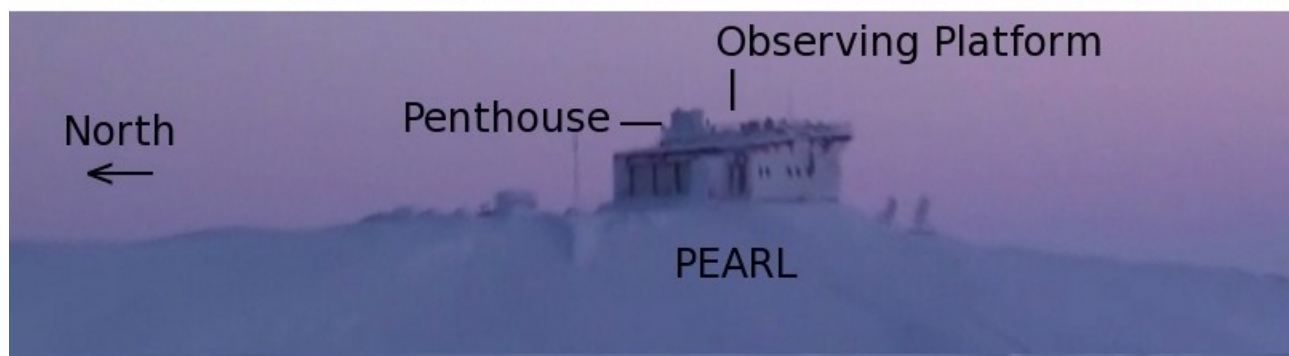
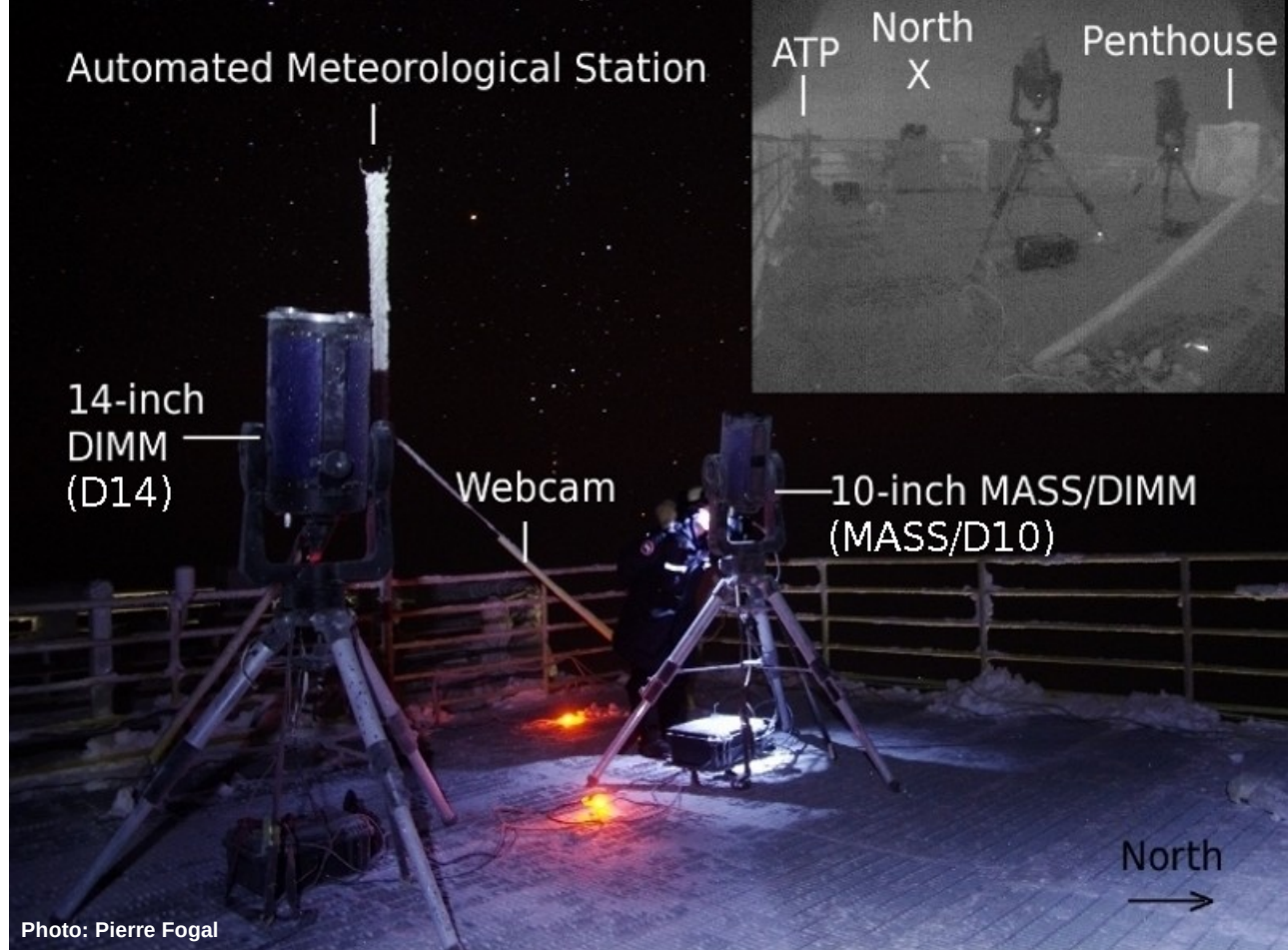
Modal free (V): **0.23** arcsec

Steinbring et al., 2013, PASP, 125, 866

Hickson et al., 2013, MNRAS, 433, 307

Hickson et al., 2010, SPIE, 7733, 53

Maire et al., 2014, SPIE, 91453



1: Gemini usable, clear, and photometric fractions, 2: Yearly means, 3: Median of 12 degree twilight, 4: Inferred from 3 to 20 micron spectra, and ~60 years of balloon temperature profiles

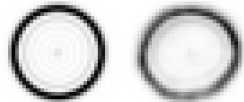


Rapid sampling of a sharpened intrafocal ring-image made with a small aperture



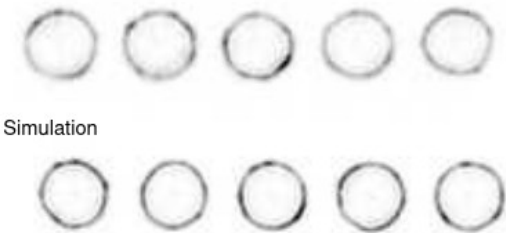
**A ZWO ASI1290MM
1936X1096 pix CMOS USB-
3 (>200 fps full frame, 1
khz for 64X64 sub-raster)
1e- readnoise camera**

RINGSS (Ring-Image Next Generation Scintillation Sensor): a diffraction-limited, intrafocal (-400m conjugate) ideal ring-image (left) of a 13 cm f/5 ~50% centrally-obstructed telescope; (right) real data with a 50-mm achromatic doublet, 20 arcsec across; FoV is 0.5 degree, image summed over 2 seconds

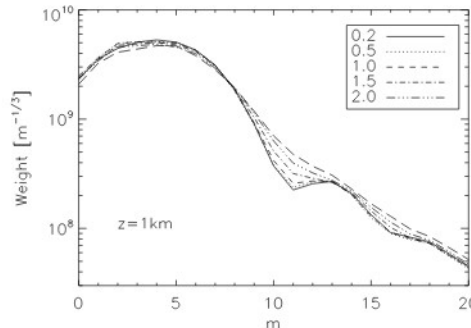
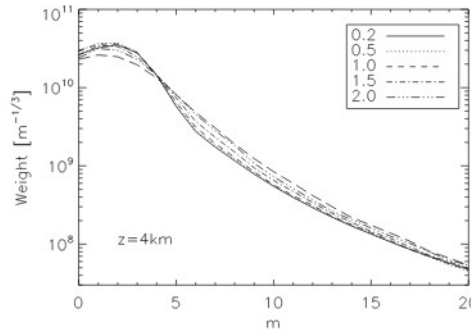
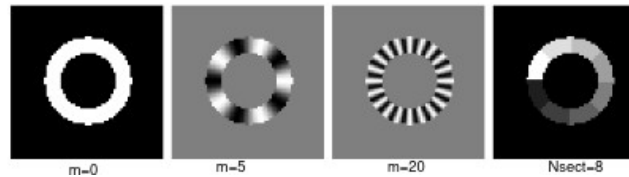


All unobstructed aperture is used; high-framerate readout (~kilohertz) freezes both intensity and image motion in 64 X 64 pixel X 2000 sample cubes

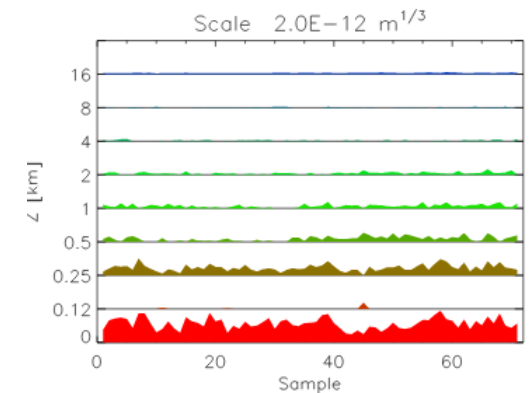
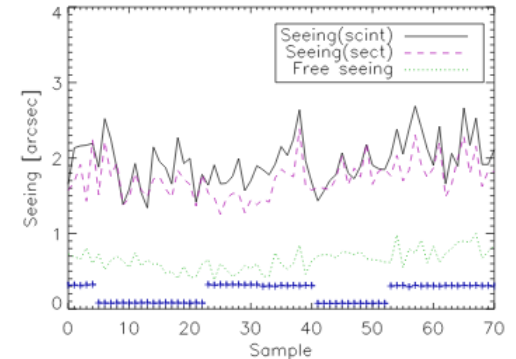
2020-09-13 00:13 Altair



Scintillation modulates the intensity of the image around the whole ring (goes something like the root of height times wavelength) like a Multi-Aperture Scintillation Sensor (MASS) while the relative motion of opposite ring segments is analogous to a Differential Image Motion Monitor (DIMM)



A weighting function correlates those by superposition of layers of turbulence relative to conjugate height, and outputs the integrated seeing and profile.

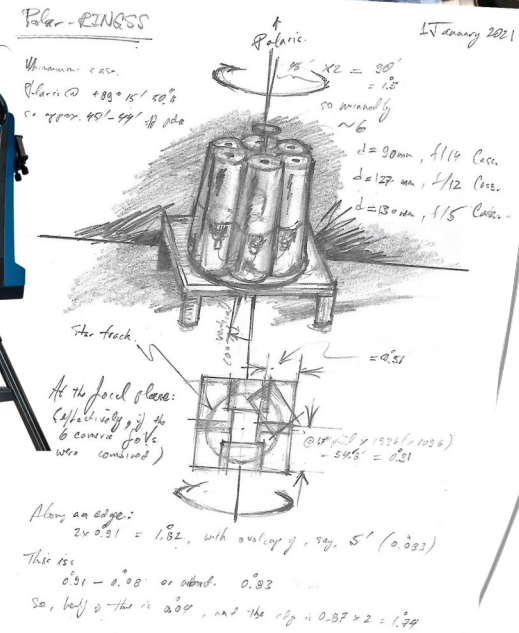


RINGSS is a more compact and robust replacement for MASS/DIMM and SLODAR

Old: Three fairly large telescopes: two 10-inch and one 12-inch Schmidt-Cassegrain OTAs, for four instruments; either a Slope Detection and Ranging (SLODAR) requiring a bright binary star, or two telescopes working together, with one slicing the aperture into sections, each with an APD requiring high voltage to get a turbulence profile (MASS: Multi-Aperture Scintillation Sensor) the other, with two small sub-apertures, reading a CCD at slow 5 fps to get integrated seeing (DIMM: Differential Image Motion Monitor) for which all apertures must always be kept clear of frost – probably by wiping it – as heating will ruin the local conditions, and produce undesirable tube seeing.

New: One small 5 to 8-inch OTA, and mostly software; a low-power CMOS camera imaging through a small aperture at kilohertz rate gives both the profile and seeing/timescale of turbulence. Radiator and blower clears the aperture. Small, single-axis rotation mount could allow fully automated operation.

The MASS/DIMM at PEARL (below) at first sunrise, February 2012.



Roughly to scale: single monitor and a redundant unit (right) on a constant-rotation stage; Polaris guaranteed to be within the FoV of a camera, even if mount stops – bulletproof/overkill!



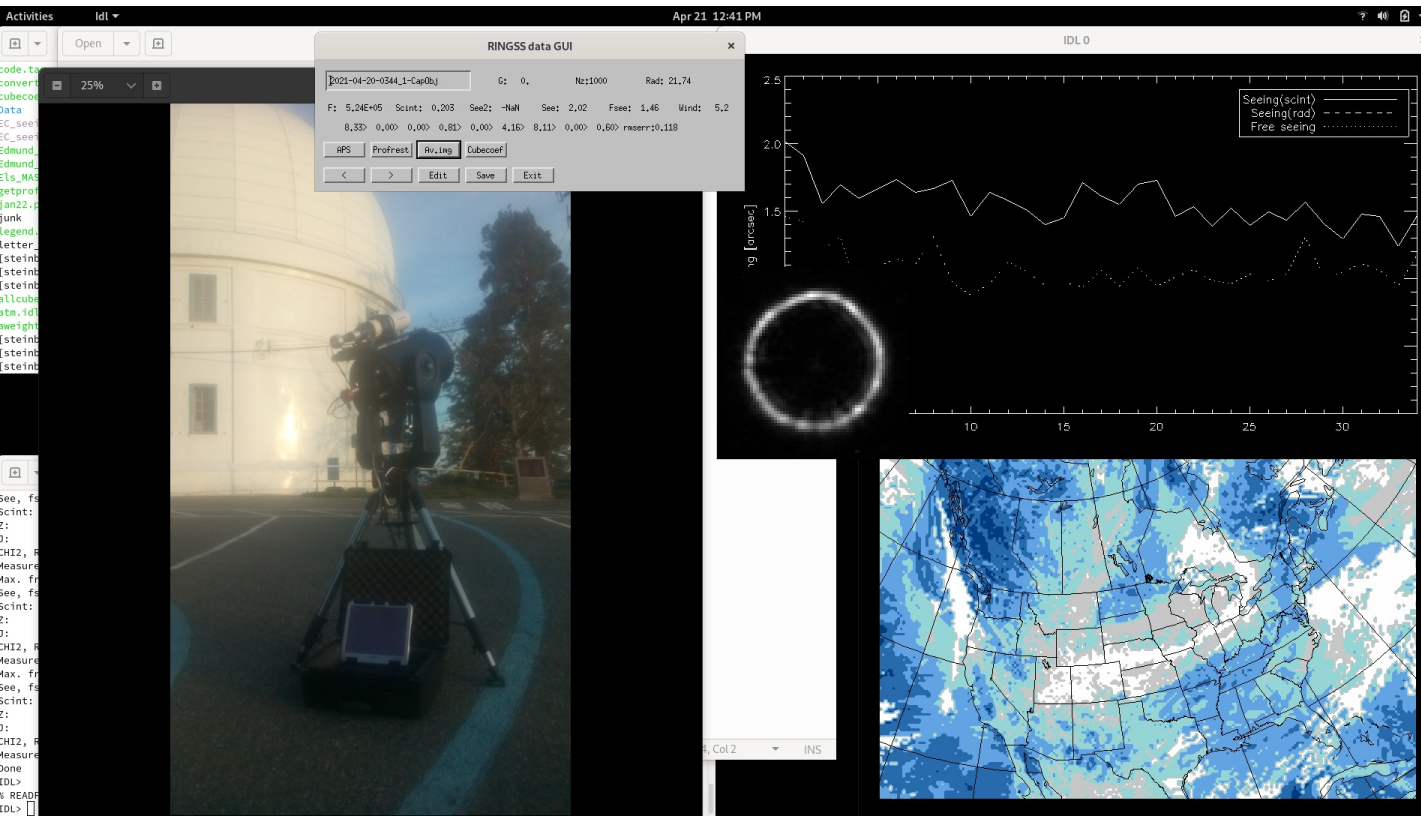
Prototype tested at DAO; now ready to build mobile unit for Eureka/PEARL

Have built and deployed a 6-inch (50% obstruction) prototype at DAO with a stopped-down 10-inch SC OTA, a 50/75-mm achromatic-doublet focal-reducer and a ZWO ASI1290MM identical to the initial CTIO unit, conjugate to ~400 m, operating at V on a cold-modified Meade LX200 mount

Plan is a 5-inch sealed SC OTA on a compact equatorial (single-motor) mount, same camera/focal-reducer (X2 for spares) and a USB-3 port/control-computer focuser and an SDSS r'-filter for better throughput, ready for deployment in "campaign mode" at Eureka/PEARL



Screenshot of first run at DAO (left) RINGSS instrument (top) and whole system packaged for deployment (below)





Still of “Barbeau Observatory” (Barbeau is the highest peak on Ellesmere Island) from *The Midnight Sky*, released on Netflix in December 2020. Just for the record: no, this site has never been considered; it is within QUITINIPAARQ National Park.