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Commissioning of a new ING DIMM at ORM

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Overview

- Introduction to Seeing + DIMMs.
- The new DIMM (R2D2).
- Initial R2D2 tests (internal and with old DIMM),
- Problems with R2D2 commissioning + solutions.
- R2D2 at present.
- Comparison of new DIMM with old ING DIMM.
- Comparison of seeing measurements with two ING DIMMs, TNG DIMM and WHT.

Seeing

- Seeing is the apparent “twinkling” of stars.
- Turbulent layers of air refract light and disrupt the wavefront.
- This “blurs” the star during an exposure.
- The size (or FWHM) of the resulting seeing disk is measured in arcseconds.
- Seeing limits resolution of astronomical observations and causes scintillation.

What's a DIMM?

- Need to monitor the seeing for quality control and the planning of observations.
- Differential Image Motion Monitors (DIMMs) are used.
- DIMMs have two entrance apertures which produces two images of the same star seperated by the distance between apertures.
- Differential motion of the two images is used to produce a seeing measurement.
- Effects of windshake or tracking errors are essentially negligible.

DIMMs at ORM

- ING's RoboDIMM (RD), next to the William Herschel Telescope.
- IAC DIMM and TNG DIMM.
- Generally comparable seeing measurements, but TNG DIMM seems to measure better seeing - due to location on mountain?

R2D2

- RoboDIMM2 (“R2D2”) is a new DIMM located in the same tower as RoboDIMM.
- Advantages over RoboDIMM:
  - Faster CCD readout - seeing measurements every 40s instead of 4 minutes.
  - More robust and accurate mount.
  - Can recover pointing after power loss.
- Based on the TNG DIMM.
- First light September 2018.

Comparison with RD

- Early work focused on comparing R2D2 to RoboDIMM as a check.
- Certain nights showed different seeing measurements between DIMMs (despite being in same tower).
- Also having many problems with R2D2 not finding (or losing) stars. More on this later.

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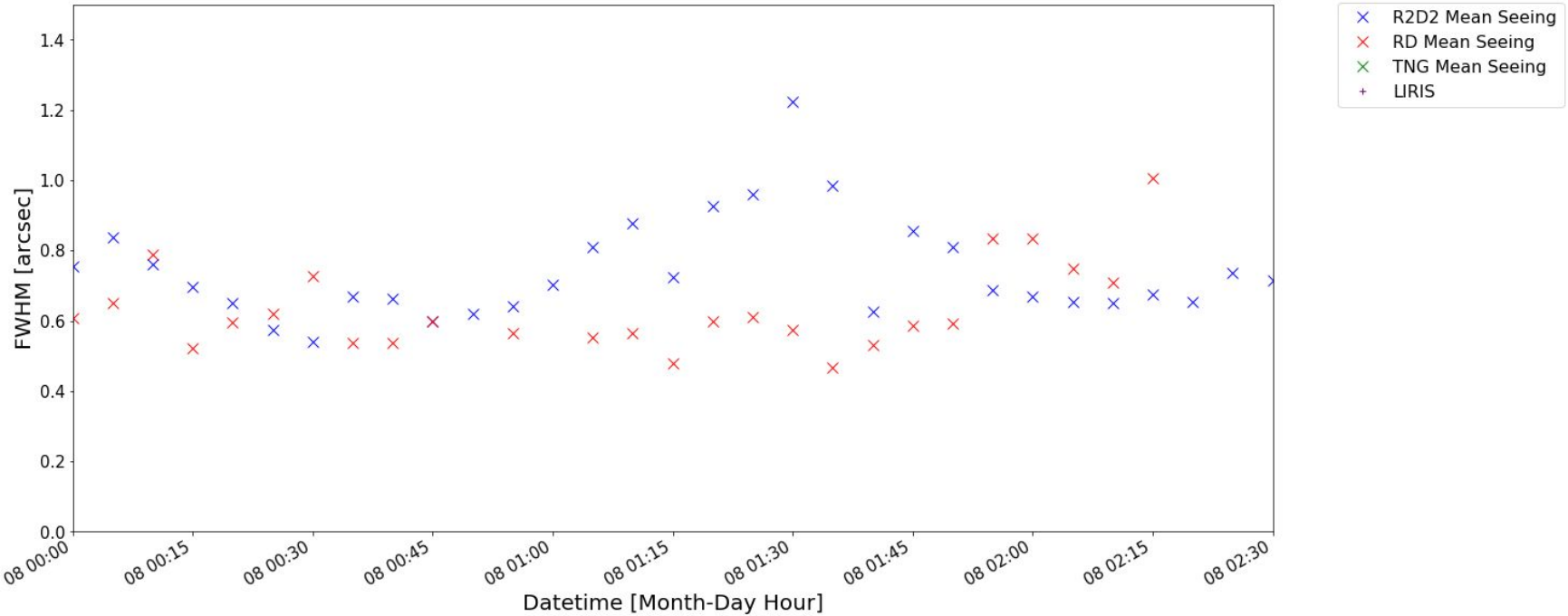
2018/11/08

- Different stars being tracked - cause of discrepancy?



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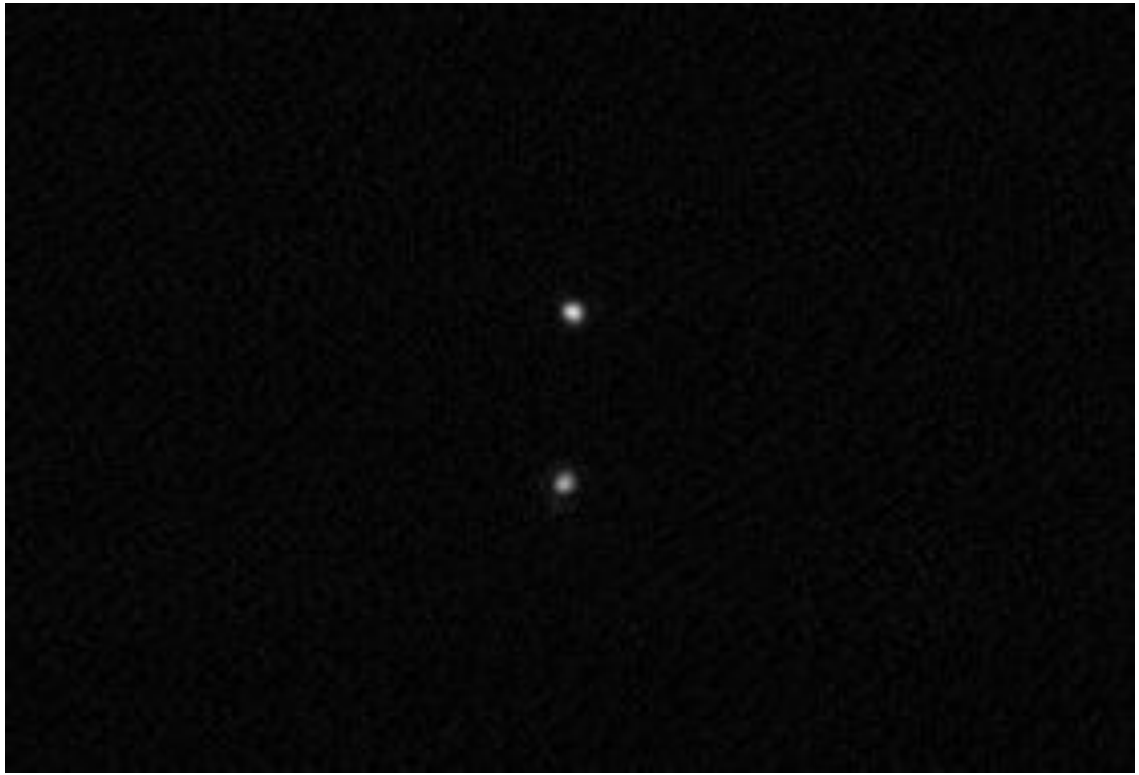
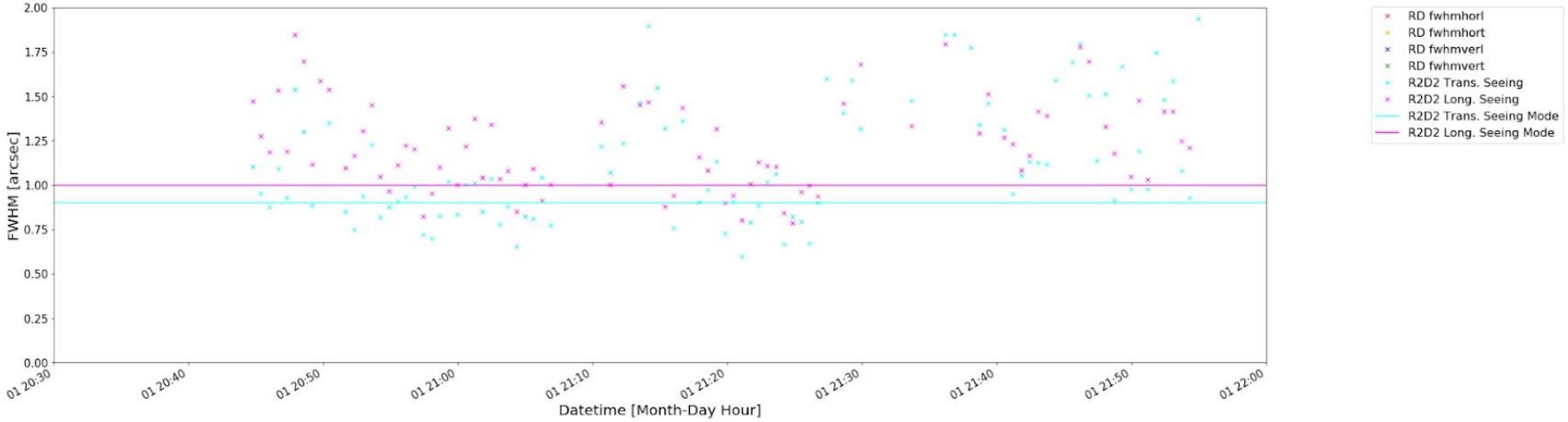
DIMM Images



R2D2 Internal Tests

- Two seeing measurements - transverse and longitudinal.
- Found large discrepancies between the two some nights.
- Image scale? CCD rotation? Need to test on sky.



R2D2 Manual Tests

- Spent several nights at the WHT controlling and monitoring the DIMMs to check different aspects of R2D2.
- These tests included:
  - CCD image scale test (measure distance between binary star pair on the CCD).
  - Focus test .
  - CCD orientation.
- Noticed while performing these tests that the DIMM pointing was very bad.

R2D2 Pointing Fixed

- Still having problems with R2D2 not finding stars, or losing them mid-measurement.
- On a DIMM test night in late February, this was solved:
  - Manually created a 16 star pointing model by slewing to known stars and centering them in the CCD FOV by hand.
  - Success! R2D2 is now consistently finding stars and all are fairly well centred.
- Further problems (memory leaks + server crashes), but all were eventually solved.

R2D2 Now

- Consistently finding stars and continuing to track them properly.
- Memory leak and server problems fixed.
- Overall R2D2 operating as planned.
- Measuring differences against TNG DIMM - likely due to position on the mountain.
- Need to check with old DIMM (RoboDIMM) to ensure there's no discrepancy.

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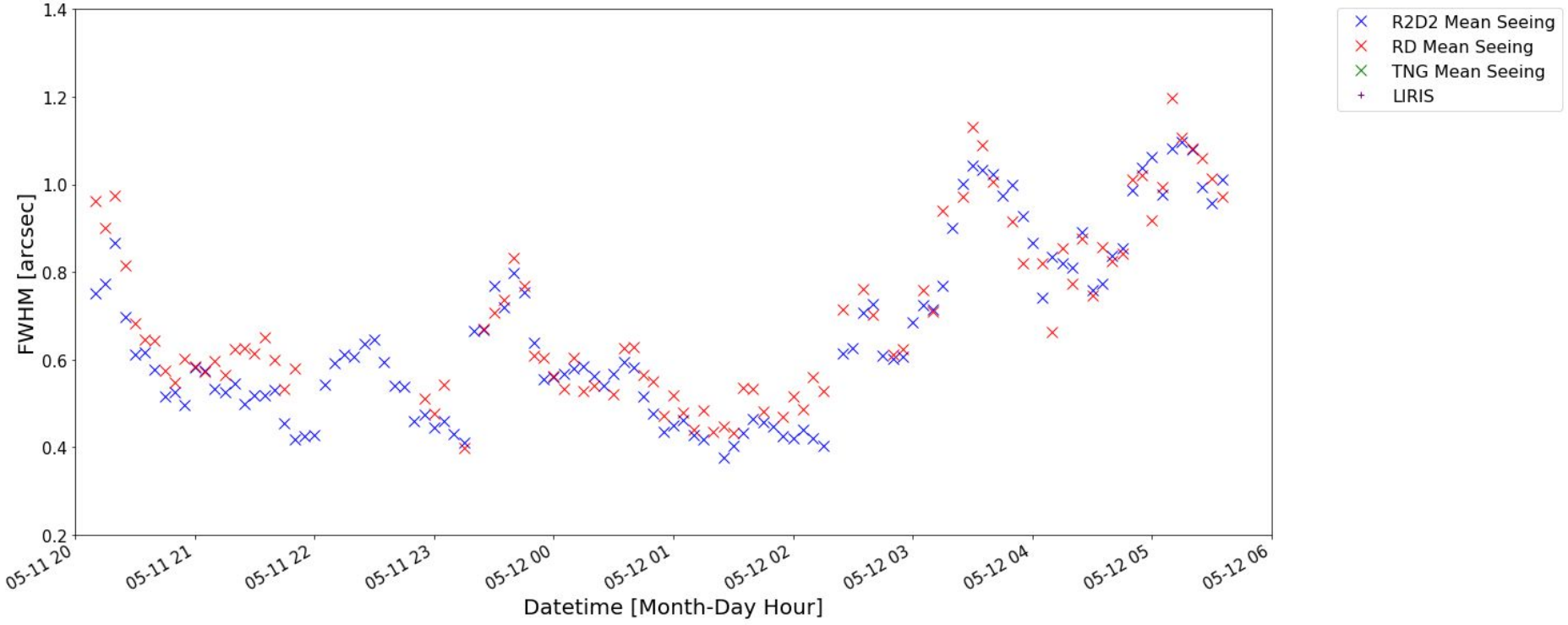
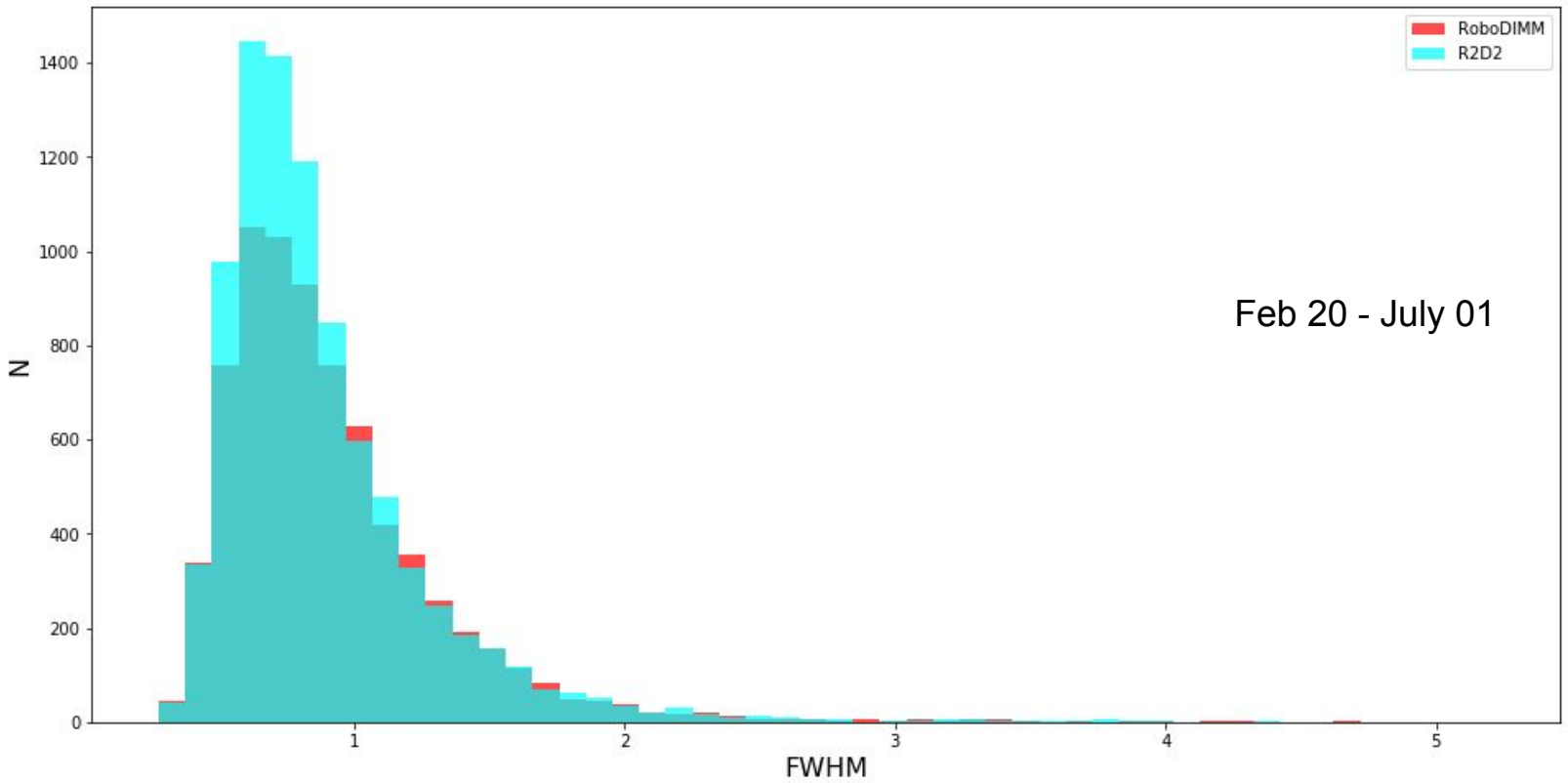
2019-05-11



R2D2 Now


RoboDIMM
R2D2
Feb 20 - July 01
N
FWHM
0
200
400
600
800
1000
1200
1400
1
2
3
4
5

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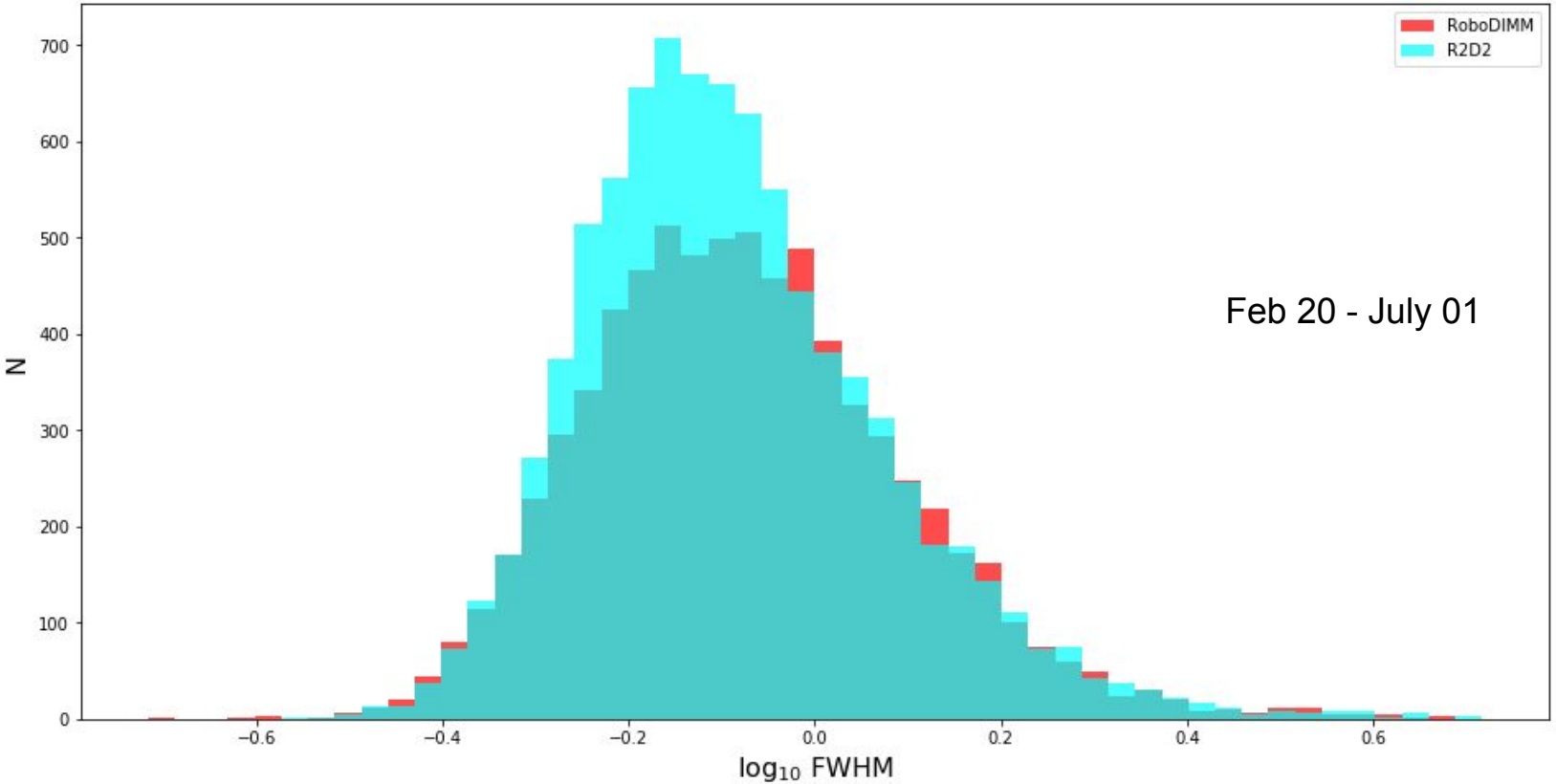
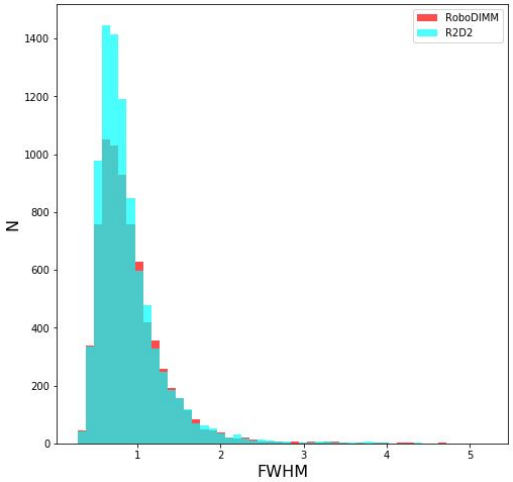
R2D2 Now

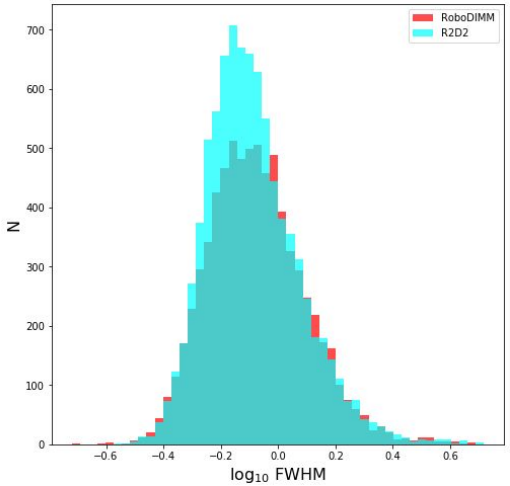


R2D2 Now

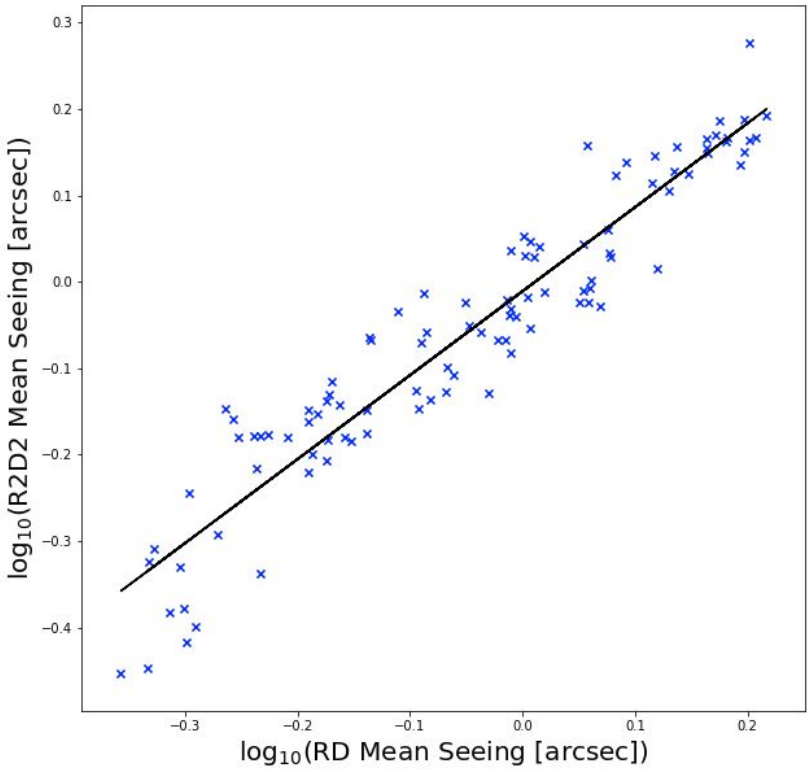
- Distributions are very close:
  - R2D2 Mean = 0.89
  - RoboDIMM Mean = 0.91
  - R2D2 Median = 0.78
  - RoboDIMM Median = 0.82

- RoboDIMM seems to systematically report slightly higher seeing measurements.





R2D2 Now



- Data taken from periods of stable seeing for both DIMMS, from Feb 20th until the present.
- Gradient is less than 1

  ⇒ RD tends to measure slightly higher seeing

```
RD Gradient  = 0.972 +/- 0.001
RD Intercept = -0.0 +/- 0.0
Correlation Coefficient (R^2) = 0.9004620032082521

L/T Ratio Median =  1.0067327055157127
L/T Ratio Mean =  1.0032407701842825
```

R2D2 Now

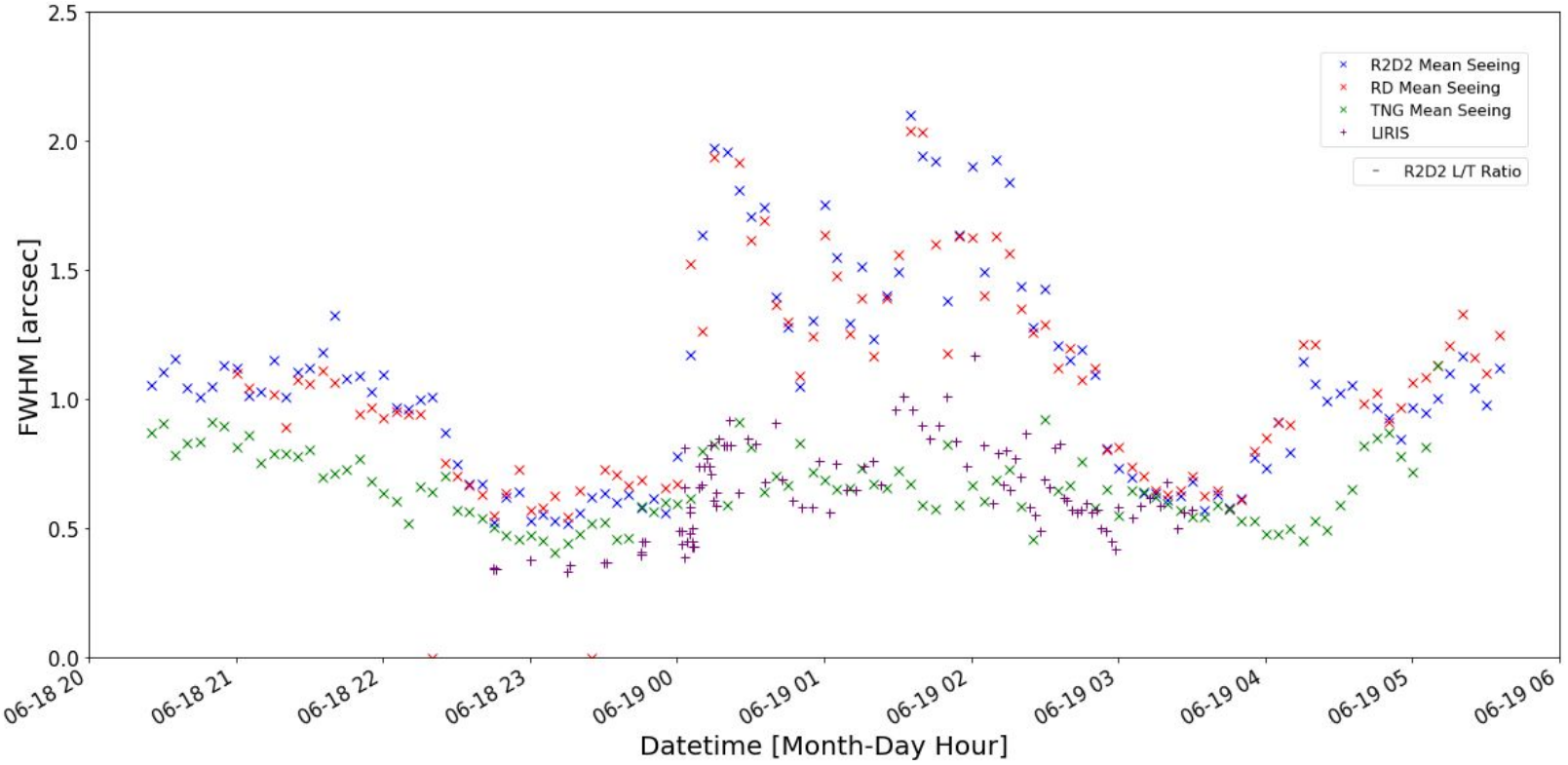
- R2D2 seeing measurements are consistent with RoboDIMM measurements.
- Slight (<0.1”) offset in values reported
  - RoboDIMM more sensitive to higher seeing values.
- Data binned every 5 minutes for both DIMMs:
  - Number of 5 min periods with measurement(s):
    R2D2 = 37499 RoboDIMM = 37516

⇒ R2D2 is reporting seeing values 99.95% of the time that RoboDIMM is.

Comparison with WHT Seeing

- With R2D2 reliably working, we can look into how seeing varies over the observatory site.
- ING DIMM tower is ~75m away from the WHT dome.
- Night of 2019/06/18 is very interesting - DIMMs show spike in seeing over 2hrs while TNG DIMM reports stable seeing.
- Continuous observations with LIRIS performed on this night, so can compare ING DIMMs with TNG DIMM and WHT.

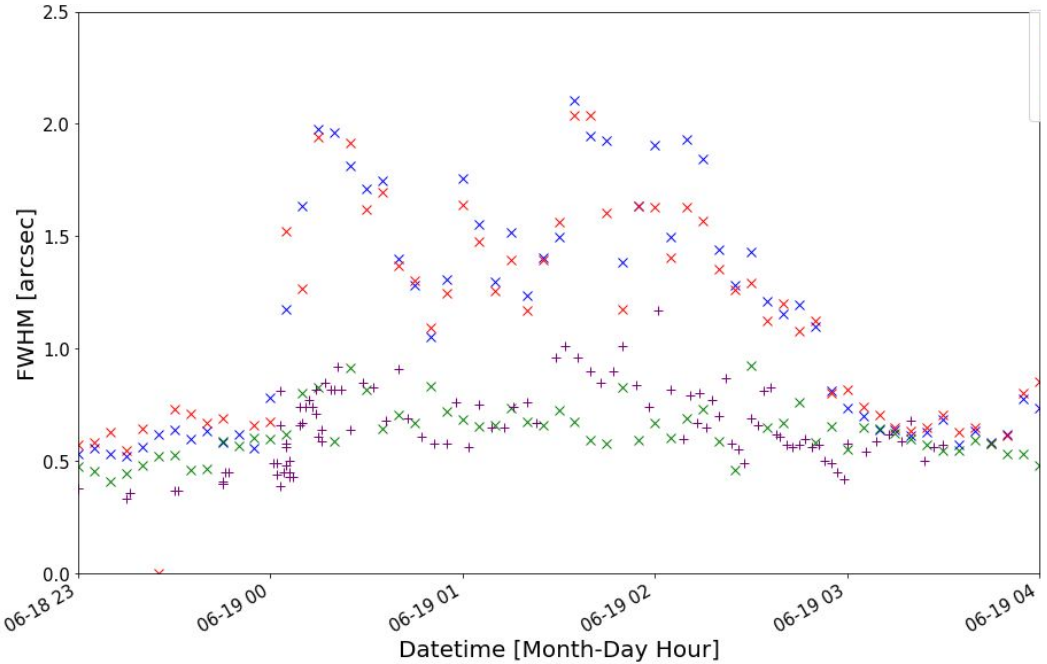
Comparison with WHT Seeing 2019-06-19



Comparison with WHT Seeing 2019-06-19

- Spike in seeing around 00:00UT not seen by WHT!

- Evidence that bad seeing events can be localized.
- Bad DIMM seeing may not mean bad WHT seeing, despite being only ~75m apart.



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Summary

- R2D2 is now working and following RoboDIMM measurements 99.95% of the time.
- Consistency in seeing reported by the two ING DIMMs.
- Differences between ING DIMMs and other DIMMs likely due to local seeing variations.
- Periods of bad seeing can be very localised; reported bad DIMM seeing may not be seen at WHT.