Mopra
Ideas for Future Operations

Turning challenge into opportunity

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In times of turmoil, great opportunity looms

- Snapshot of my private brain
  - This is **not** a CSIRO proposed/endorsed perspective!
- Opportunities for improvements in
  - Management (operations/facility)
  - Software
  - Hardware

Management aspects

- Operations
  - Observation planning
  - Maintenance planning (might fit in with CSIRO's resource planning?)
  - Execution of observations

Software

- Improving operations software
  - Queue mode
  - Web frontend
  - Data quality monitoring
- Some already available, others easily made available

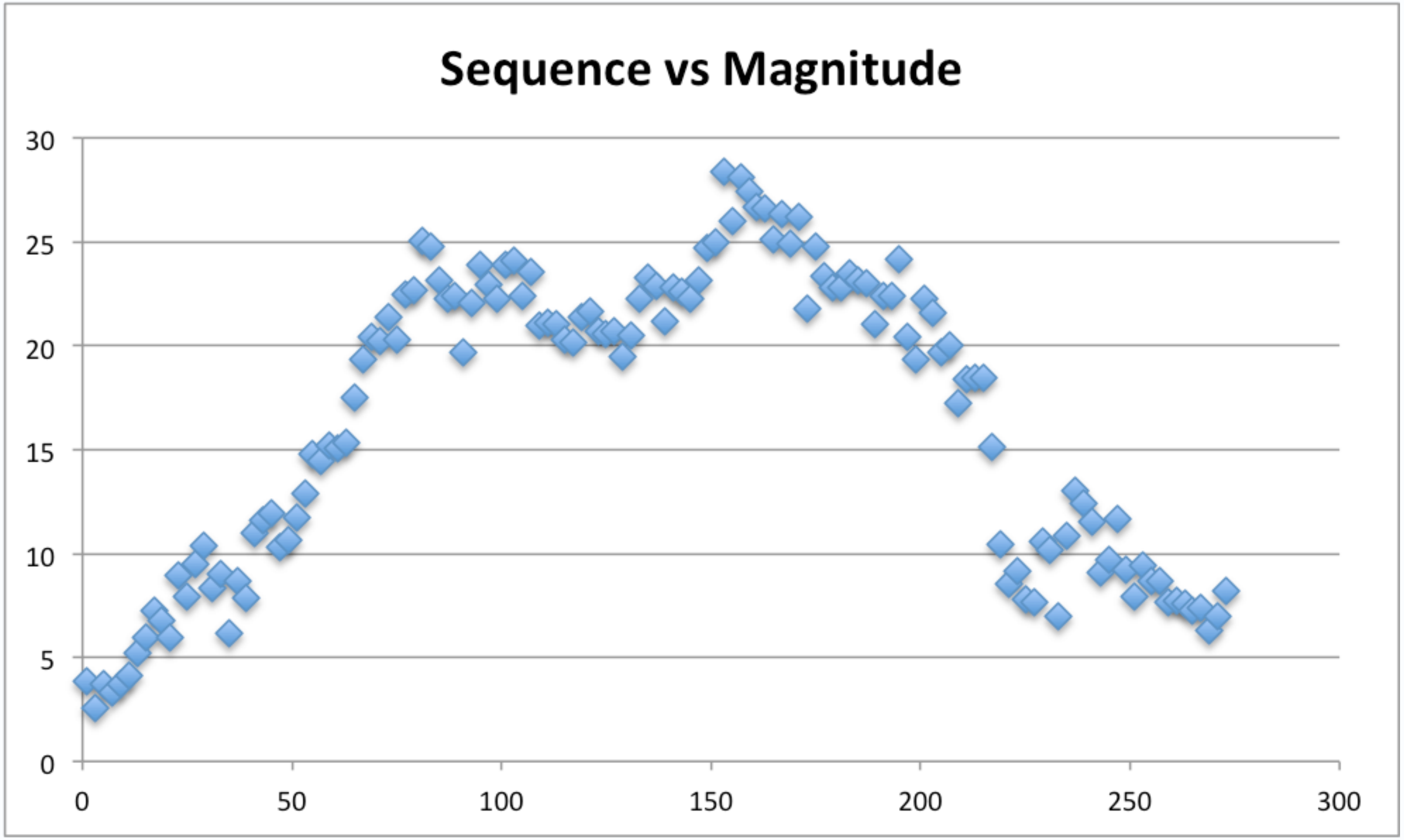
Software: Expanding Queue Mode 1

- Already able to do much more than you know:
  - Autopoint (c.f. pointing)
    - `M999, VY_CMa, J2000, 07:22:58.33, -25:46:03.00, pointing.sch,PNT 6`
    - Executes pointing until residuals better 6 arcsec
  - Stowing the antenna
    - `M999, , , , ,NULL,STOW`
  - Waiting for a number of seconds (or until a UT)
    - `M999, , , , ,NULL,WAIT 2015-12-12 22:33:44`
    - `M999, , , , ,NULL,WAIT 60`
  - Setting the focus
    - `M999, , , , ,NULL,FOCUS 16.8`

Interlude: On the topic of pointing…

- Followed AH Sco at 3mm and UU For at 7mm across the sky
- Results for 3mm:
  - El < 40 deg: Pointing once an hour OK
  - El >= 40 deg: Pointing optional for up to ~3.5h
- Results for 7mm:
  - Pointing may be entirely optional.
- **Must** start with uncorrected pointing mode,
  e.g. "newcain pparam"!

Interlude: On the topic of pointing…



Software: Expanding Queue Mode 2

Automated scheduling modes

- Long Term Predictive scheduling
- Short Term Predictive scheduling
- Reactive scheduling

Software: Expanding Queue Mode 2

Automated scheduling modes

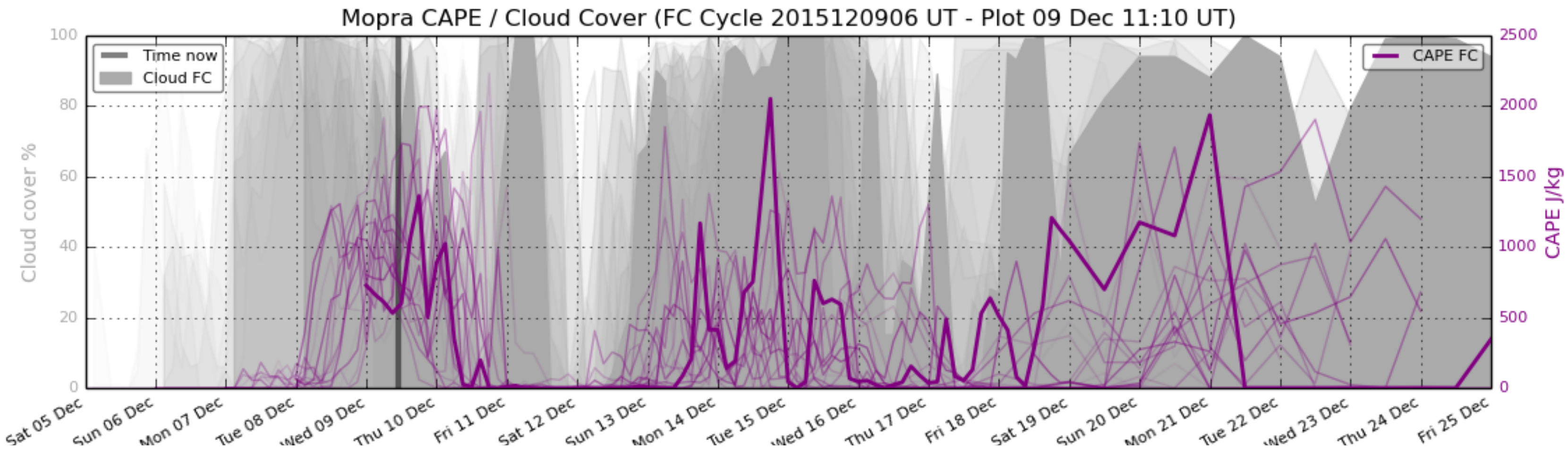
- Predictive scheduling:
  - Climate considerations
    - Past years Tsys
  - Atmospheric conditions
    - No CO scheduled with more than 20mm PWV forecast/calculated
    - (We already have GFS forecast data, and the presently calculated data)
  - Source elevation / transit times
    - Optimise maps for ideal start times resulting in as much high elevation observing time as possible
- Reactive scheduling:
  - System monitors actual conditions and aborts e.g. >1000K CO observations and substitutes a 7mm or 15mm project

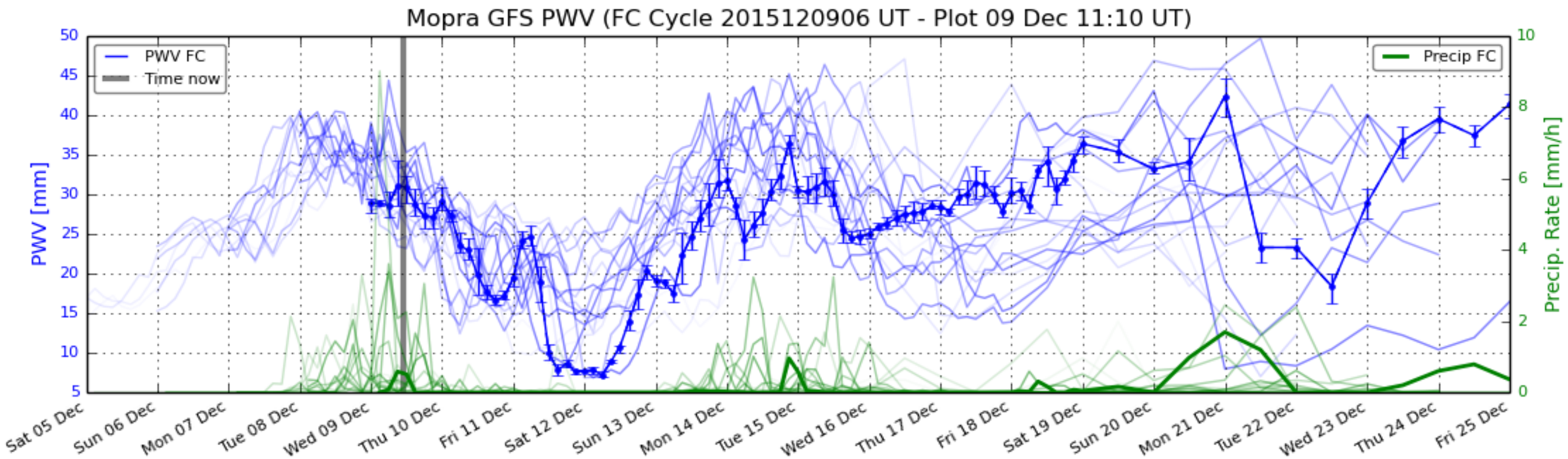
Software: Expanding Queue Mode 2

Automated scheduling modes

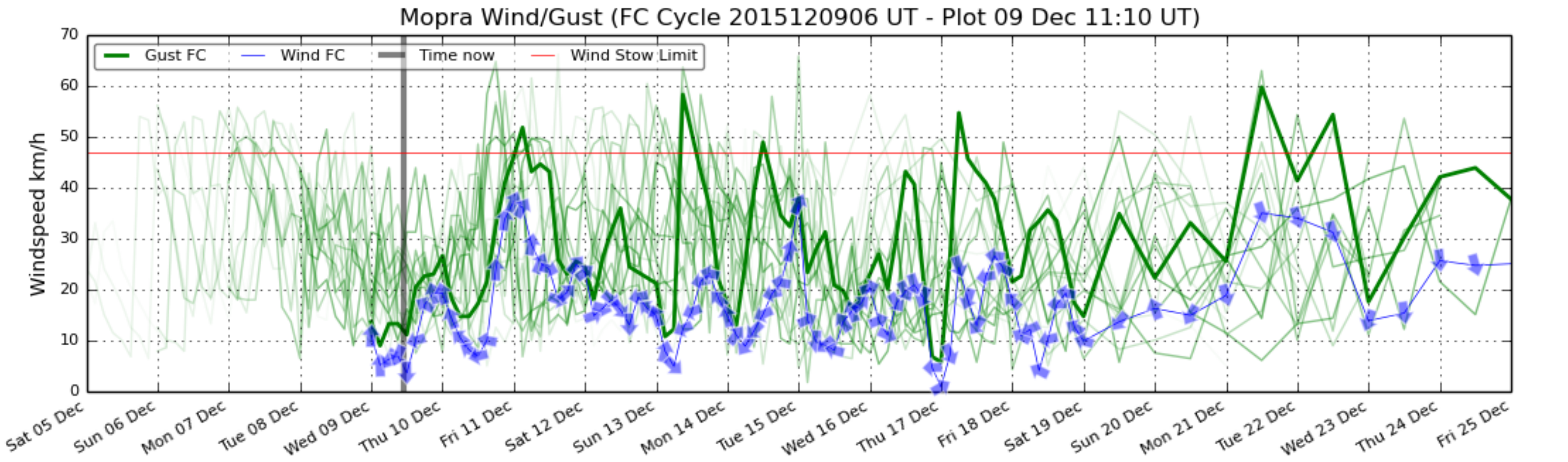
- Long Term Predictive scheduling
  - Manual process, based on statistical analysis
- Combined manual/automatic approach initially, fully automated after first semester
  - Short Term Predictive scheduling
  - Reactive scheduling

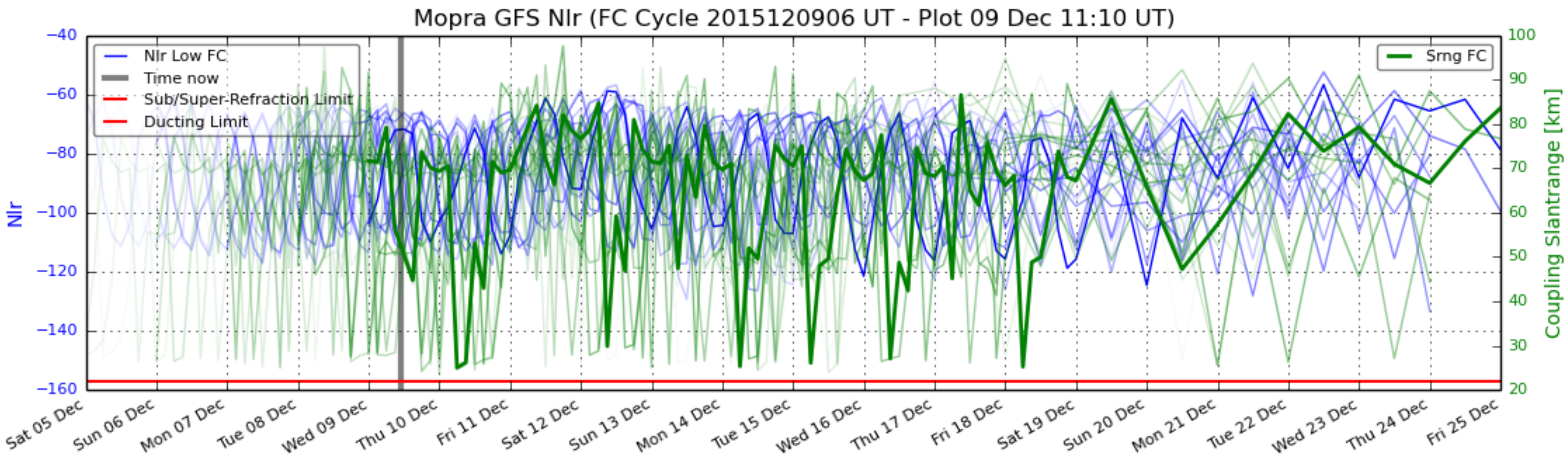
Predictive scheduling: Short term GFS





Expanding Queue Mode 2





http://wxserver.inside.net

Expanding Queue Mode 2

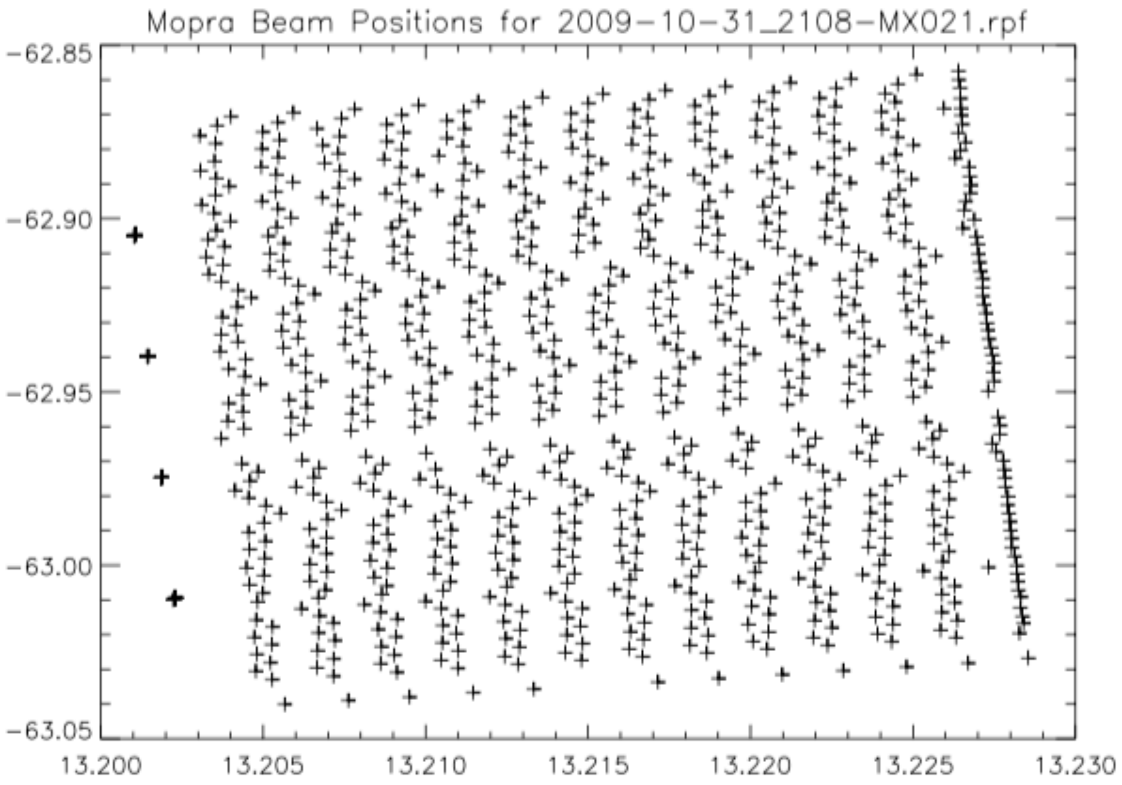
- Web interface
  - Queue files were never meant to be manually generated
  - But perhaps that's preferable and more flexible as all users really are "power users"?
- Leverage schedule file generators built by existing Mopra teams
- Queue generator considers predictive criteria when scheduling
- Queue manager considers reactive criteria while observing
  - Can abort/reschedule/switch campaign
- This mechanism largely implemented many years ago for ThRUMMS adaptive undersampling technique

Data pipeline

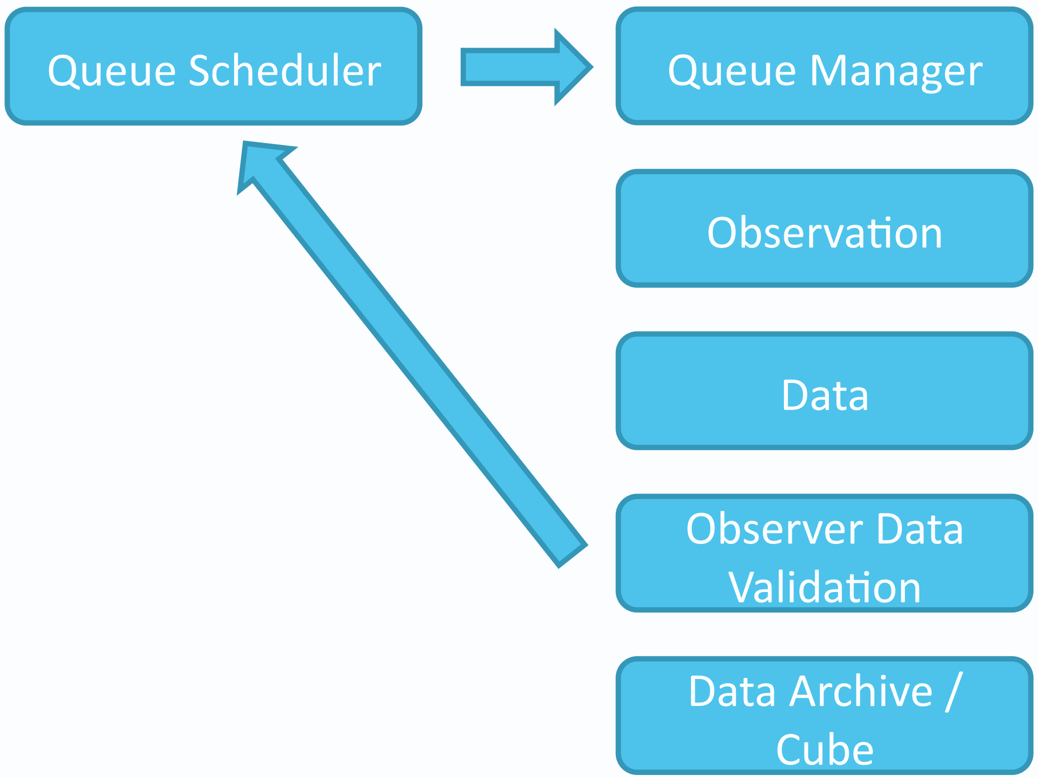
- More automation
- Observer intervention only when something goes wrong
- Data validation
- Requires survey style project
- Well defined outcome metrics
  - Otherwise, waste of time!
- Sensible and cheap approach could be to observe automatically and accept a certain percentage of waste.
- Reobserve what didn't work

Data pipeline

- No point in developing quality tools if nobody looks at them:



Observing Summary



Future perspectives

- Mopra financial impasse might be temporary
- MOPS/MMIC tremendously future proof investments
- But, now is the time to look at what can be done to
  - Retain the forefront position
  - Future proof the facility for when funding returns
- Perhaps optimistic…
- Burton 2009 upgrades paper:
  - Fast mapping (since implemented): Improved mapping speed x 8
  - Multibeam
  - UWB Correlator

Hardware 1: Multibeam

- 7 element Multibeam (Burton 2009)
- Close packed hexagonal arrangement could work
    - CSIRO Concept design study from 2008
- Increase mapping speed x 7
- Requires major improvements:
    - backend (7 x DFB processing)
    - receiver system x 7
- Expensive: On order $ >2-3 m

Hardware 2: Backend

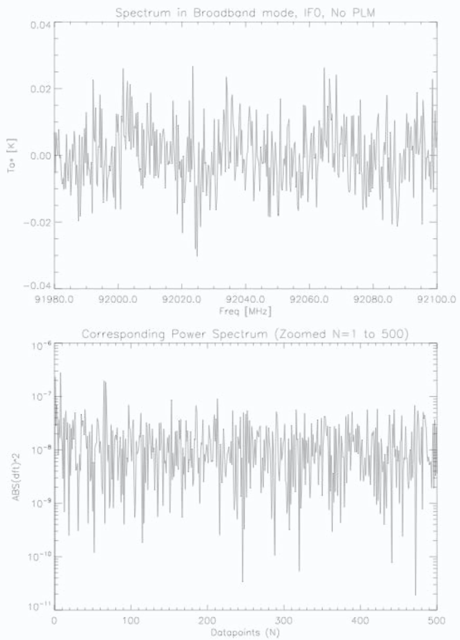
- UNSW MOPS = Mopra Spectrometer
  - DFB = digital filter bank
  - Not a correlator. A correlator correlates wave functions from separate signal sources (e.g. an interferometer). There's only one signal source in Mopra.
  - Runs a sequence of FFTs on a stream of data, ~500ks/s
  - Weighting function is applied to each segment to give the shape of the frequency response
  - Computational problem that has massively parallel solutions
  - UNSW MOPS built in early 2000s, operational since 2007, entering 9th year of operation
  - With 8 GHz BW still the world's widest instantaneous BW (corrections?)

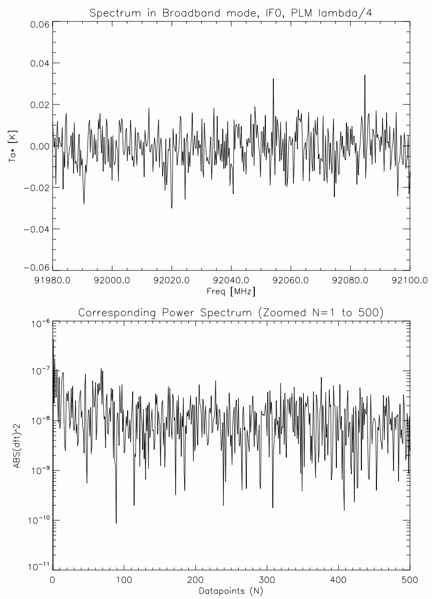
Hardware 2: UWB DFB, MUSE

- Proposal for a 48 GHz DFB:
  - MUSE (Mopra Ultrawideband SpEctrometer) e.g. 69 – 117 GHz
  - Requires upgrading of IF to match BW, currently 4-12 GHZ
  - 2 – 50 GHz, RoF implications, may require multiple separate downconversions at e.g. 2 - 12 GHz
  - Receiver system and LO(s): As long as within the already designed freq ranges OK
  - DFB implementation in software (harnessing e.g. CUDA/GPU computing)
  - Existing channel resolution must remain, 0.1km/s in zoom modes, 1 km/s in broadband mode
  - Data throughput will require parallel processing
  - Fraction of the HW cost of MOPS
  - Data rates high, but manageable: ~ 8 x the data rate of MOPS if spectral resolution is retained.
- ~ $300k project

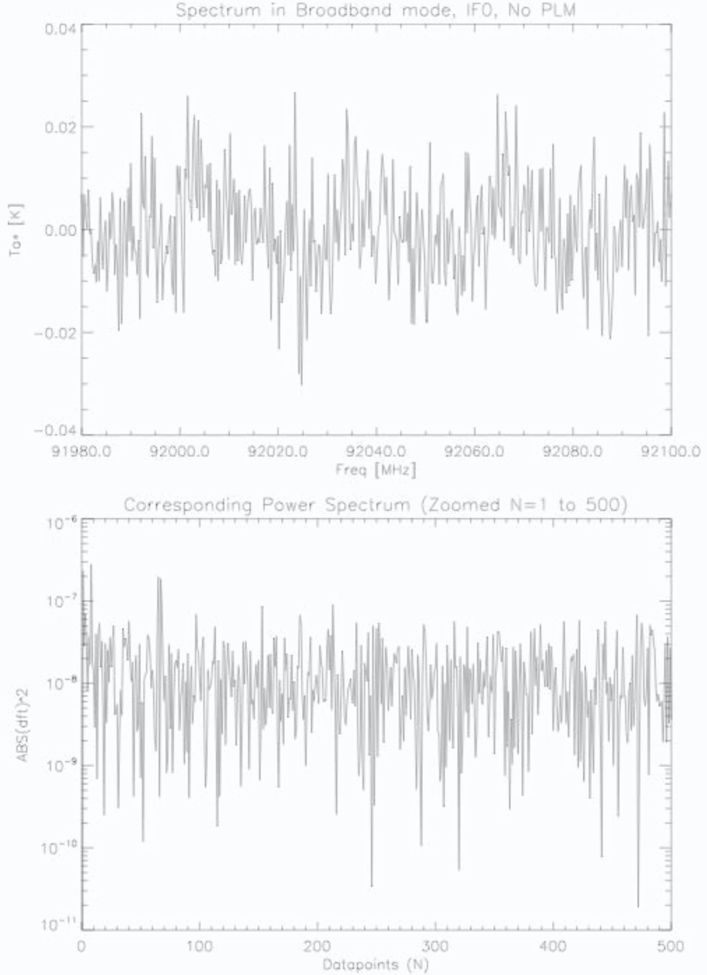
Hardware 3: Standing Wave Mitigation

- Currently no deep observations are possible. Extragalactic science not really feasible.
- "Defocusing" experiments using the subreflector (Indermühle 2010)





Hardware 3: Long integration



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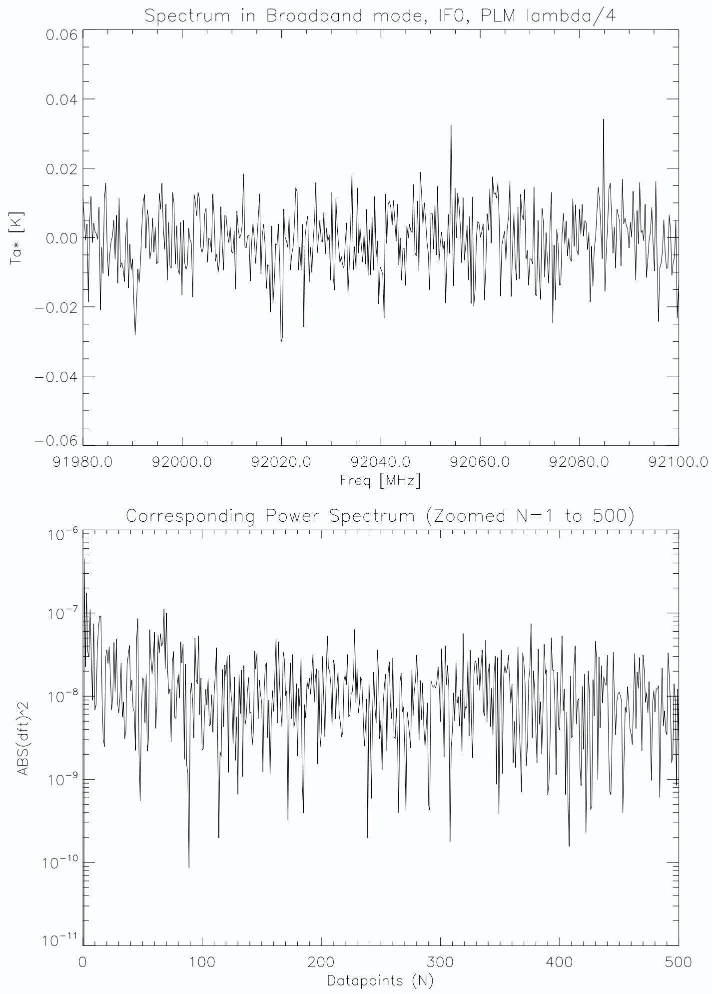
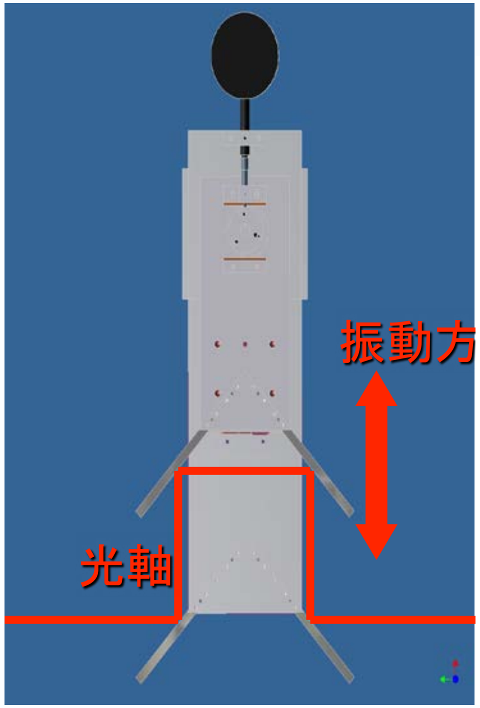
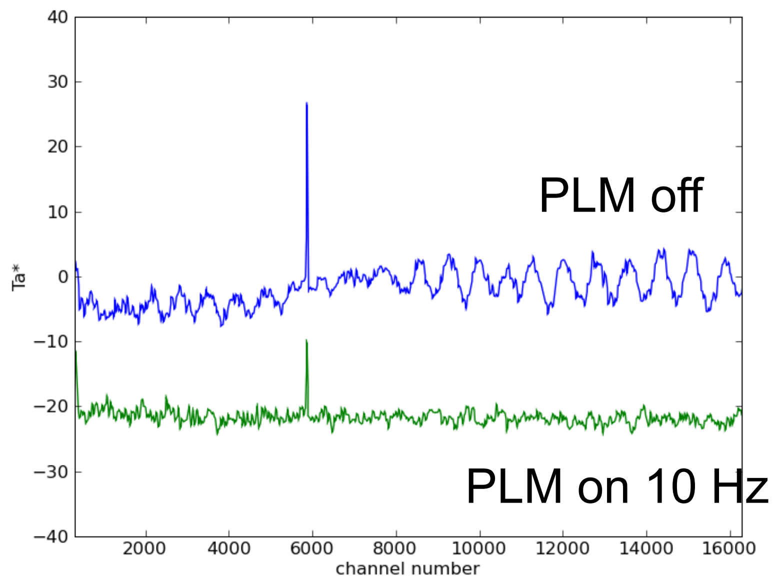


Hardware 3: Standing Wave Mitigation

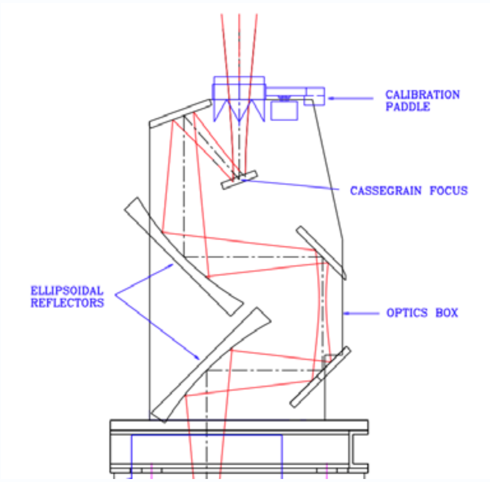
- Nagoya 1.85m telescope experiment (2009)

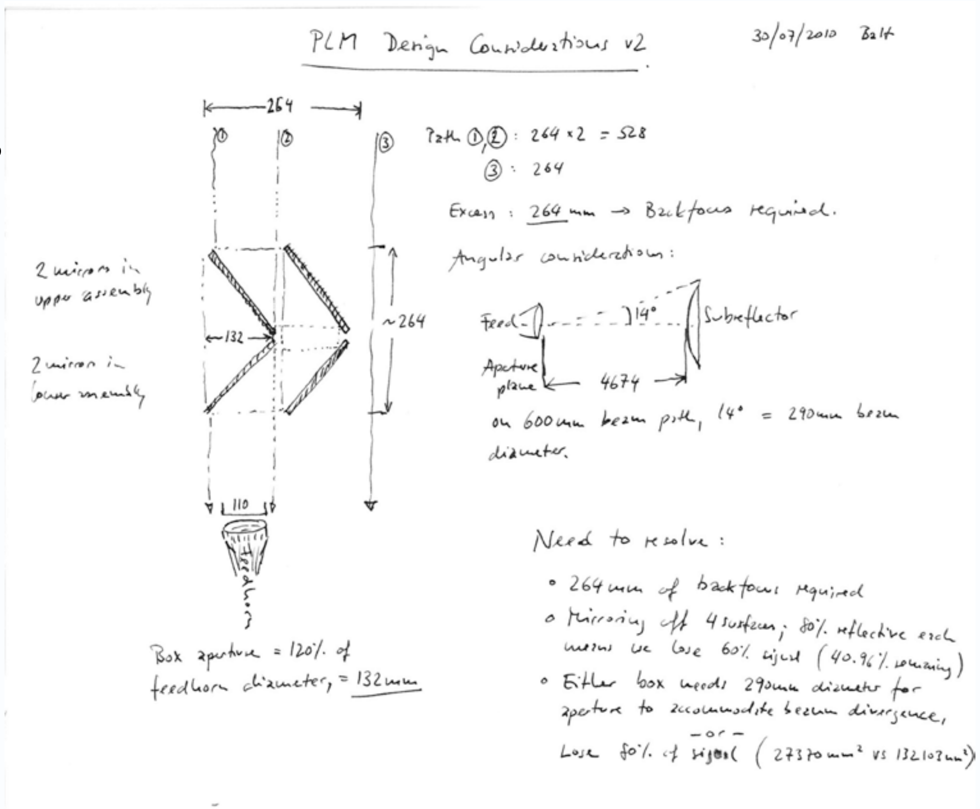




Hardware 3: Standing Wave Mitigation

- For Mopra
  - Optical design considerations





- Good student project, collaboration with engineering?
- <$100k project

Thank you

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