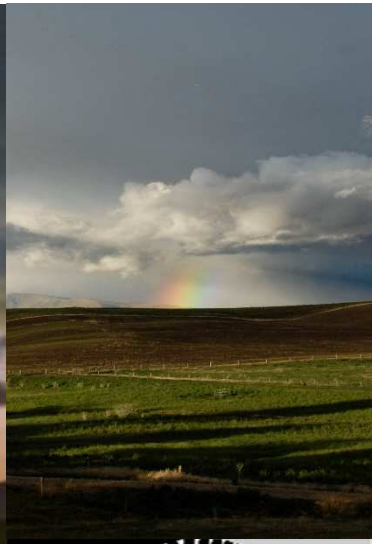
NIWA MIR-FTS program: Lauder & Arrival Heights site reports



The future of the NIWA MIR-FTS program

NIWA is committed to MIR-FTS measurements at both sites (Lauder & Arrival Heights). The MIR-FTS programme is a core atmospheric research activity. NIWA views NDACC network participation as a critical component of the Lauder and Arrival Heights measurement programmes.

Funding:

- NIWA has indicated stable funding for the coming years (supports ~1.2FTE).
- A major investment in AHTS instrumentation in 2014/15 – a new MIR 125HR and NIWA-designed solar tracker.
- The support agreement with Antarctica New Zealand is to be renewed in 2016. We have no indication that there will a change to the status quo. Antarctica New Zealand has indicated it will continue to support NIWA's atmospheric research programme (all measurements) at Arrival Heights.

Staffing:

- John Robinson, Dave Pollard and Dan Smale ensuring instrument operation, spectra acquisition and basic QA/QC.
- Dan, processing of retrievals for NDACC submission, SFIT4 and error analysis.
- Ben Liley working on NDACC compliant O_3 retrievals (Corrine's work, just published…).
- Nicholas Jones contracted for support. We hope to continue contract work.
- TCCON Scientist position has been filled, Dave Pollard. 0.6FTE TCCON 0.3FTE MIR.
  - Familiarization of MIR-FTS program (SFIT2/SFIT4 processing, Bruker operations).

New initiatives:

- None, consolidation of current activities. Much work still to be done.

NDACC Submission to date:

Lauder and Arrival Heights:

- Total column only: CH_4, $ClONO_2$, CO, HCl, HF, HNO_3, N_2O, O_3, HCN, C_2H_6
  GEOMS-V002 HDF format (all data).
- Current till end of 2014.
- Meta data files updated.
- NDACC Rapid Delivery system: pilot test scheme: monthly delivery of Lauder CO profiles (as of April 2015), thanks Bavo!

Current retrieval strategy (both sites):

- SFIT2_v3.82b:
  non NDACC compliant micro windows
  NCEP daily P,T profiles
  Conglomerate A priori species profiles: 'reftoon', local, satellite
  29 layer atmosphere
  Hitran 2000
- Linefit12.
- Monthly routine processing:
  HBr Cell tests, pre-processing spectra QA/QC, retrieval of HF, HCl, $ClONO_2$.

Current submission activity:

- Good Progression towards SFIT4 NDACC compliant retrievals.
- Plan to submit first batch of SFIT4 NDACC IRWG compliant retrievals in Jan 2016.

With our limited resources, spectra quality and instrument performance is of highest importance, even if at the expense of other work.

Instrument operation over the past year:

Lauder:

- 120HR (MIR/NIR):
    - No extended downtime. Going well.
    - MIR measurements taken most clear days.
    - NIR measurements monthly.
    - Issue with poor input aperture index control.
    - ILS consistent and stable.
- 125HR (NIR):
    - No extended downtime. Going well.
    - NIR measurements most clear days.
    - Timing issues.
    - Laser failure Jan 2015.
    - ILS consistent and stable.

Arrival Heights: 120M (MIR):

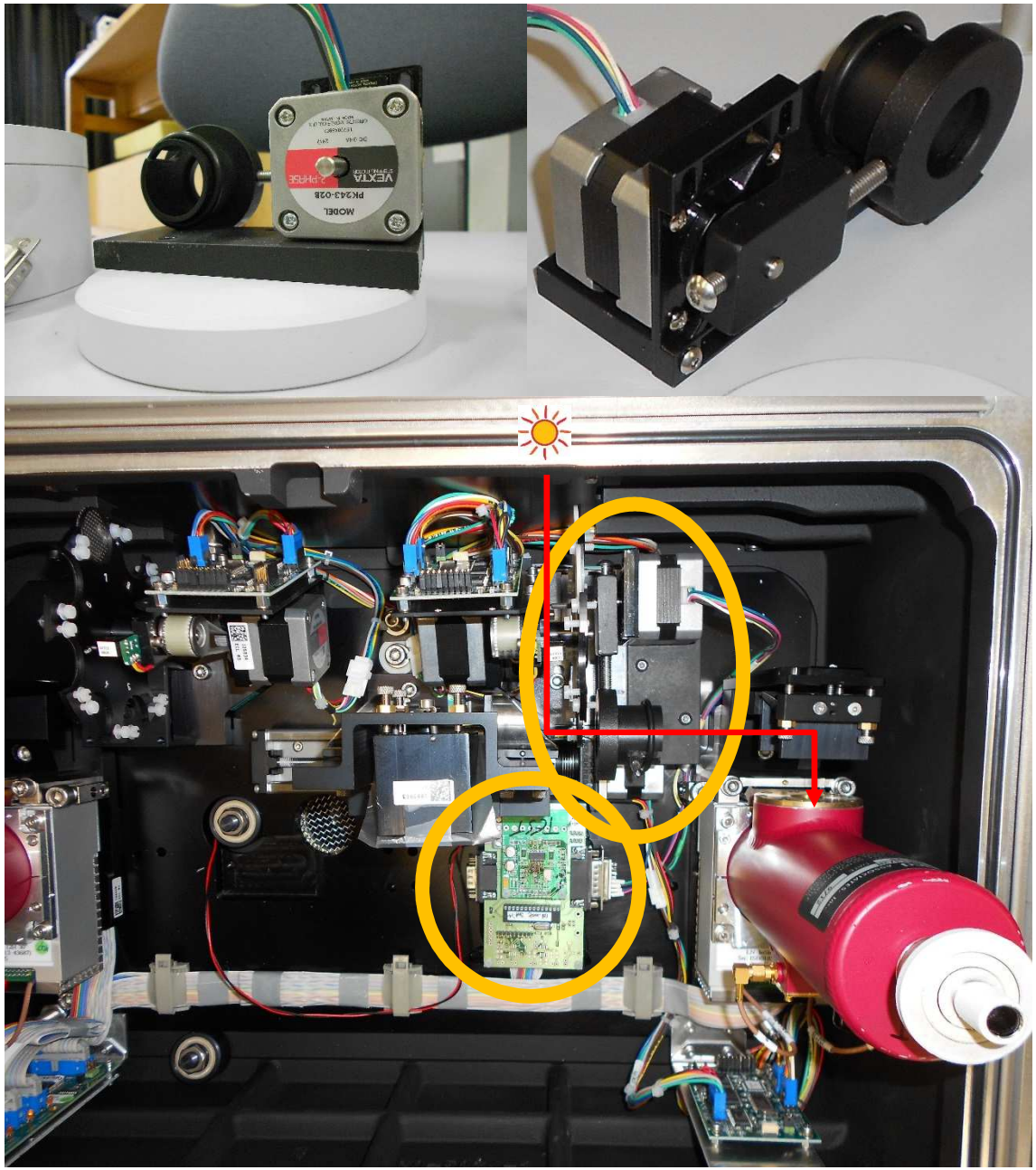
- Extended down time: Jan 2015-April 2015
    - 3 days of obs in first 4 months of 2015.
    - First serious downtime in 10 years due to Antarctica NZ staffing issues and instrument behaviour.
- Increasing erratic behaviour: random acquisition errors. Lucky to get replacement 125HR down there whilst 120M still working.
- ILS consistent and stable, no ILS issues.

Instrument developments :

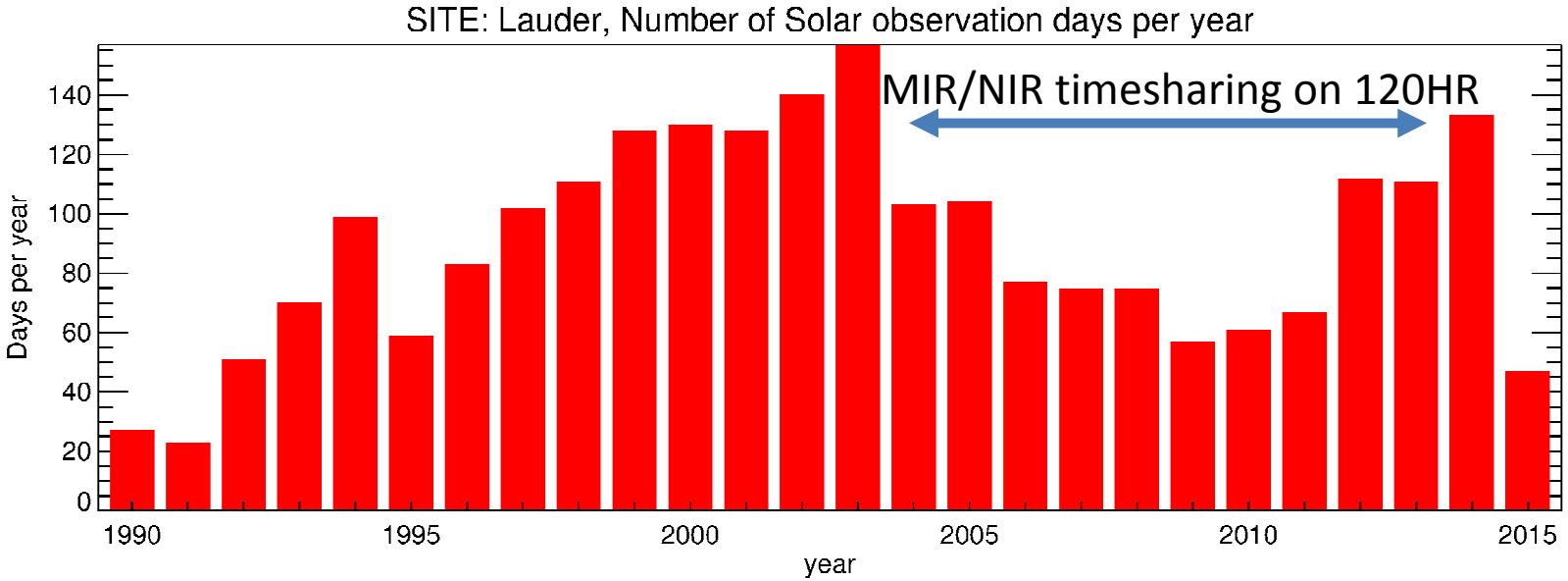
- Purchase of three N_2O 2cm cells.
- Trialling new solar tracker s/w. Move from VB6 to Python.
- 125HR running OPUS 7.2, Win7. 120HR AQP limited to WinXP (eventual obsolescence).

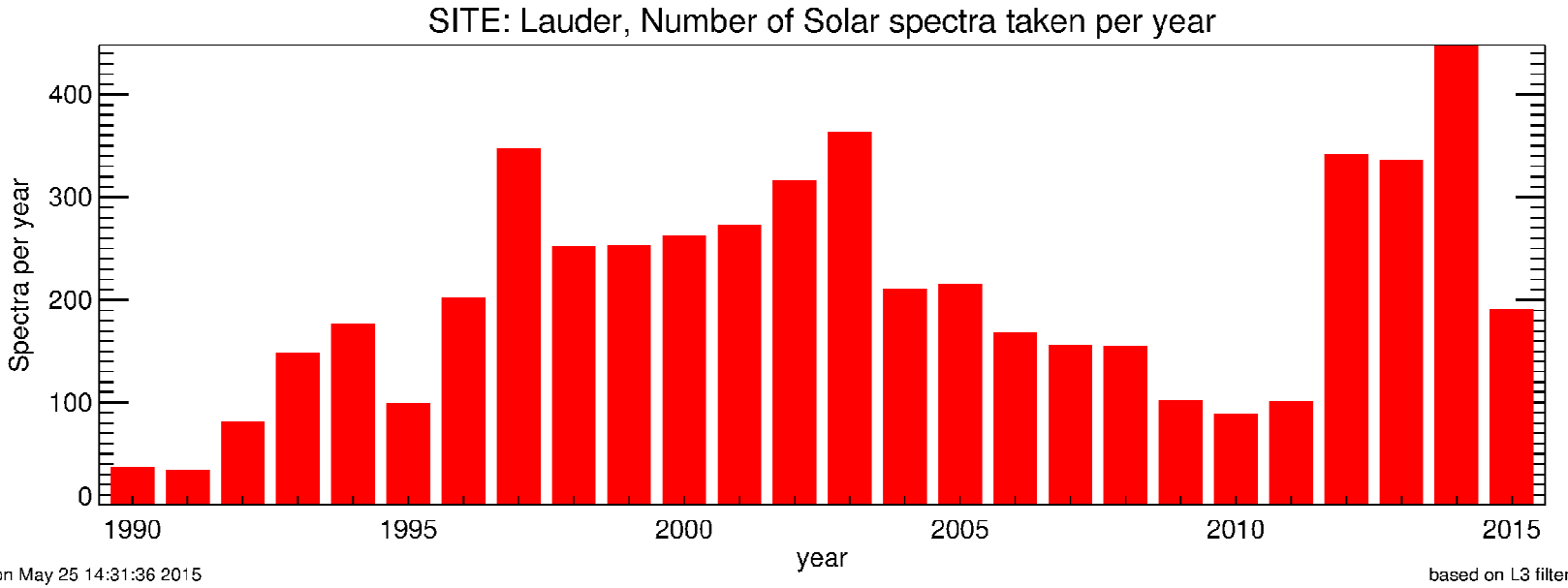
Automated Cell Holder for HBr/N_2O 2cm cell :

- When lamp is on, and source mirror are configured for non-solar, the cell is automatically raised into optical beam path (else it lowers under gravity).
- Stepper motor controlled by PIC-chip.
- No need to breach instrument vacuum and re-evacuation for cell placement.
- Designed and constructed by John Robinson.



Lauder: MIR Observation days per year

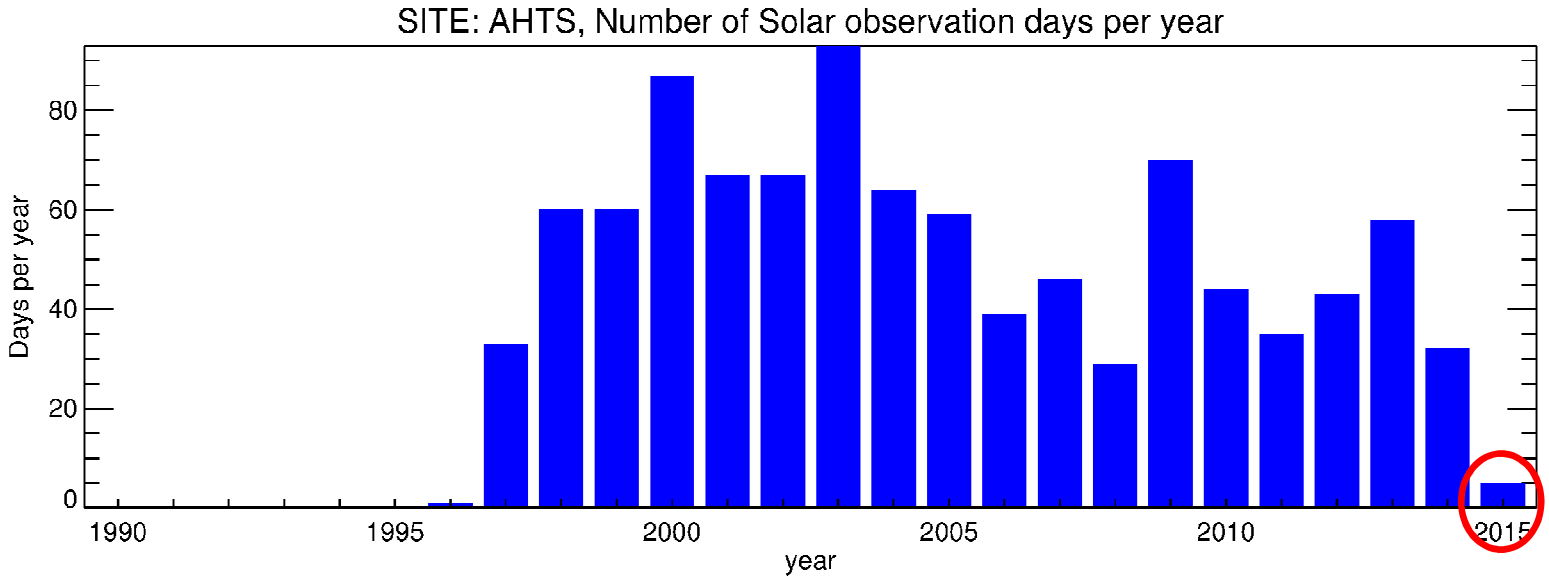




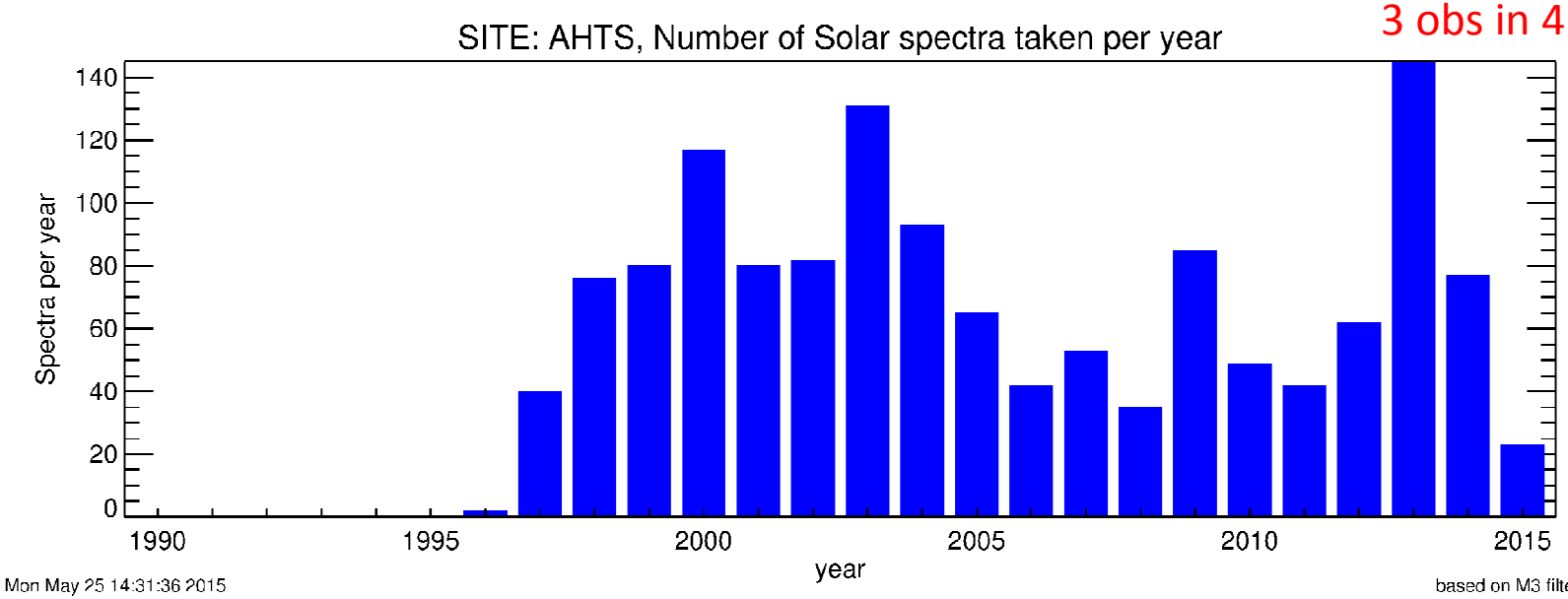
Mon May 25 14:31:36 2015

based on L3 filter

Arrival Heights: MIR Observation days per year



3 obs in 4 months…

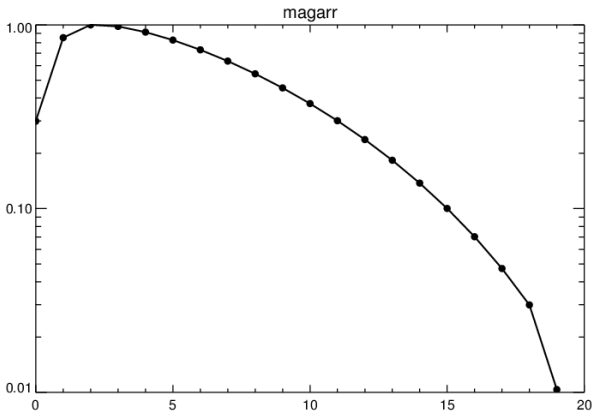


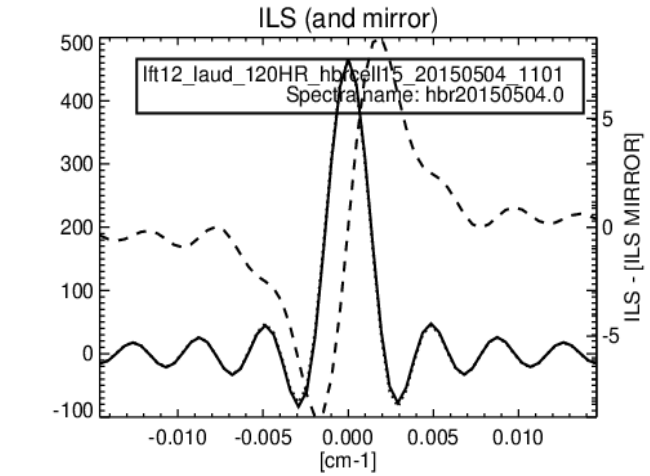
ILS: HBr cell analysis with Linefit12

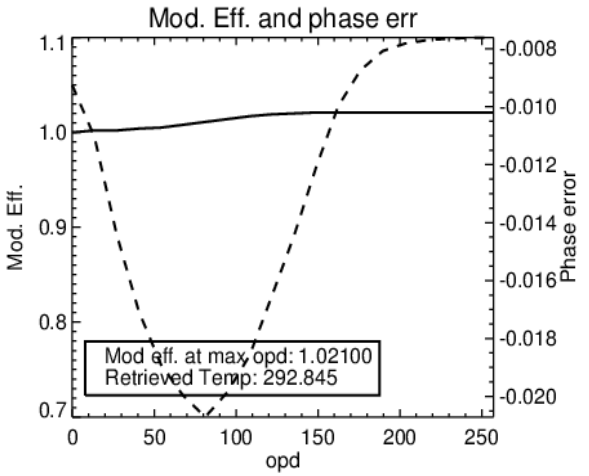
- HBr cell measurements conducted monthly at both sites, all instruments.
- Analysis of all spectra (2002-present) using Linefit12. Batch processed with IDL code.
- Position-dependent regularisation strengths derived for Lauder 120HR, AHTS 125HR and AHTS 120M. Currently only applied to AHTS_125HR Linefit12 retrievals. Many thanks to Frank Hase for his help!

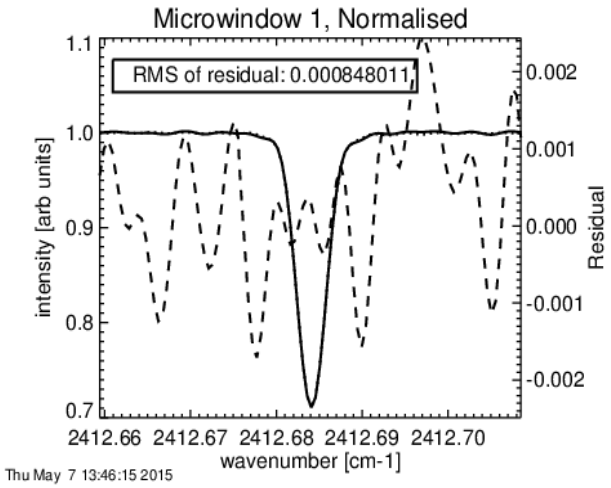
Example:
Right: Lauder 120HR HBr cell spectra
taken on 4th May 2015.

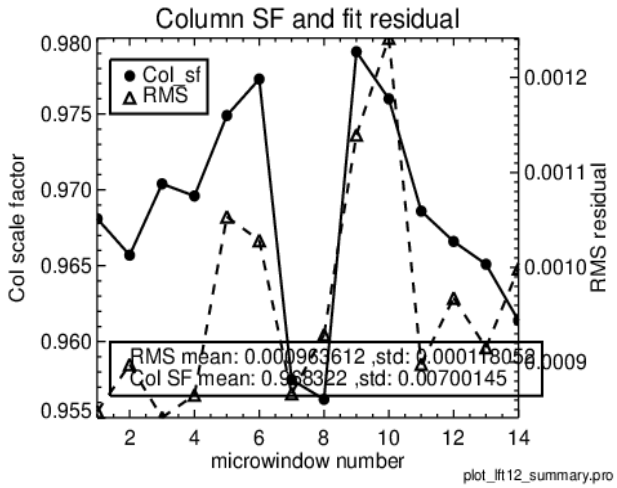
Below:
Derived position-dependent regularisation strengths for Lauder 120HR



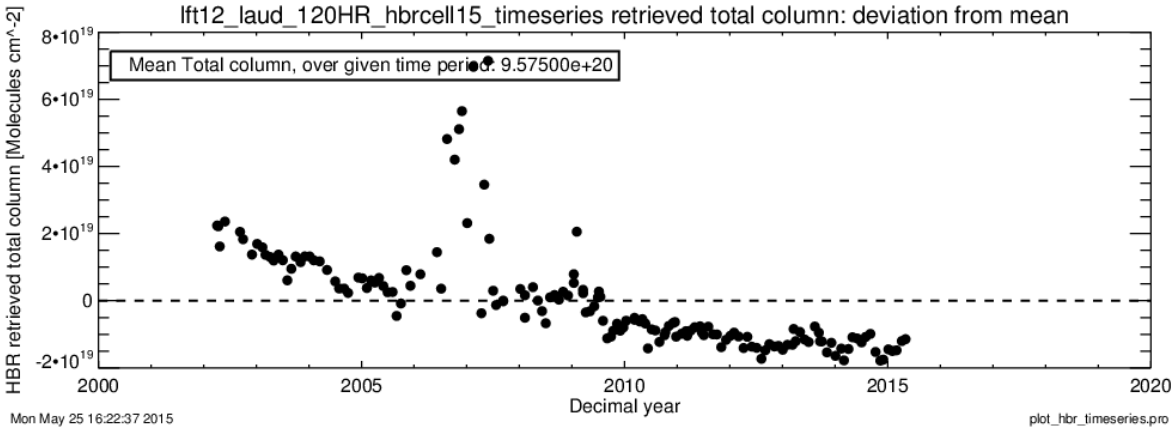


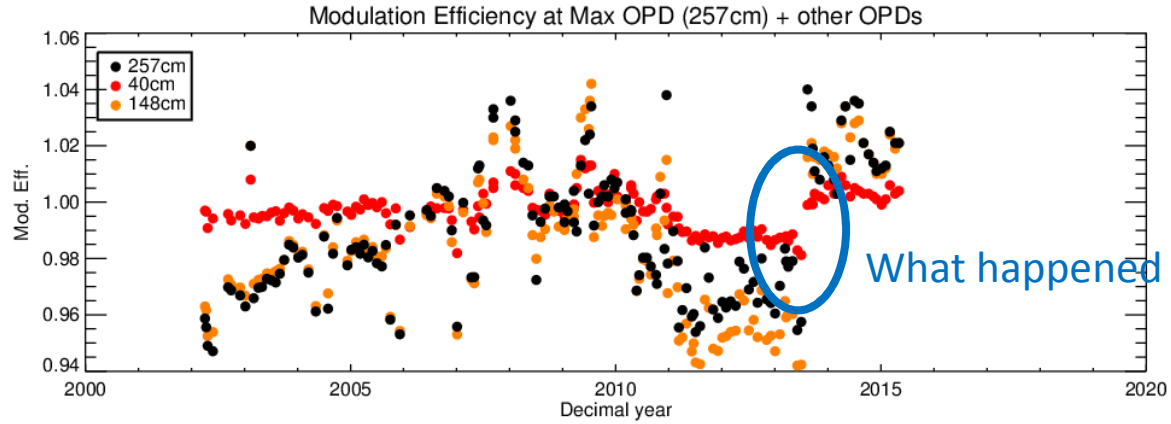




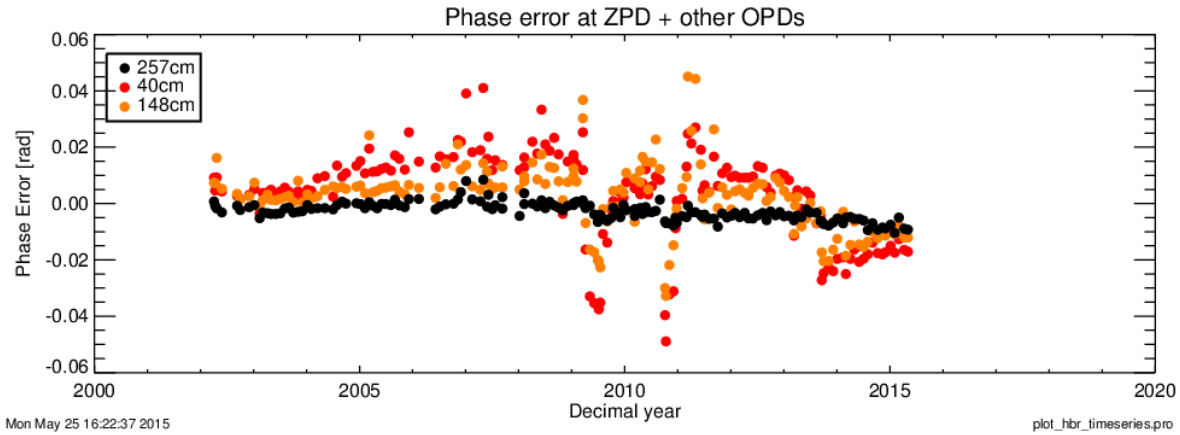


Lauder 120HR HBr cell (#15) time series.





What happened here…?



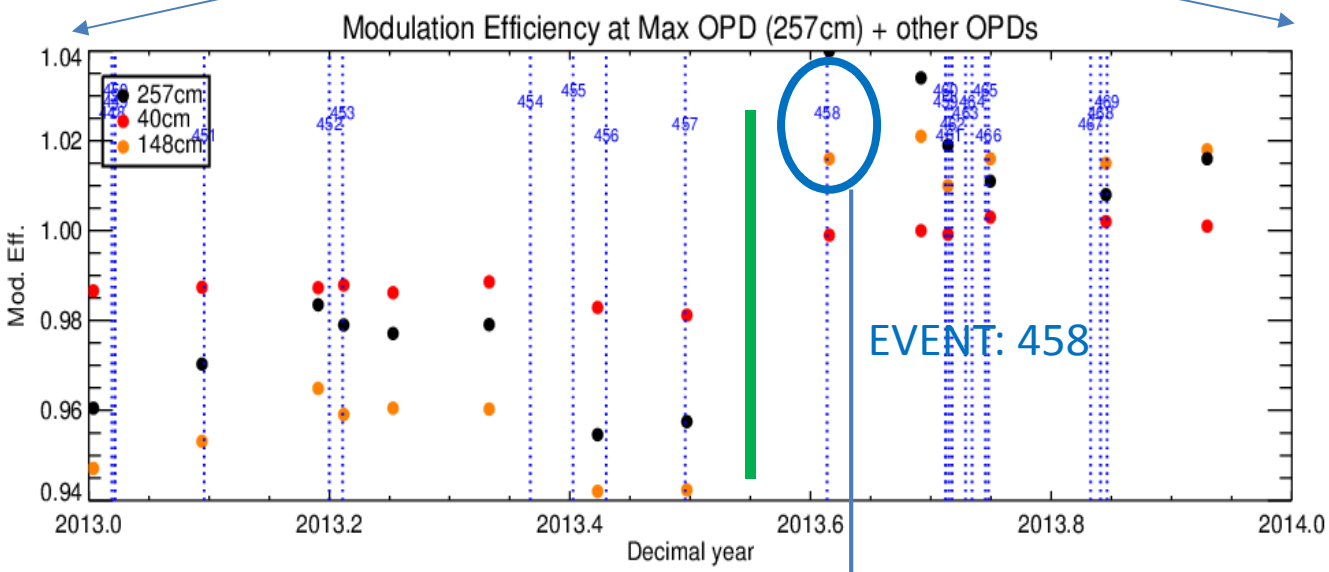
Interlude…: introducing the event summary file

A simple visual cross referencing system:

- Instrument log book entries are summarized in a softcopy (ascii textfile).
- An event log is generated from the log book summaries and filtered
- The event log can be over plotted on data or diagnostic time-series.
- Fast and simple cross referencing.

- Example: An MIR-FTIR event log over plotted on Linefit12 output (NIR events taken out) from previous slide.

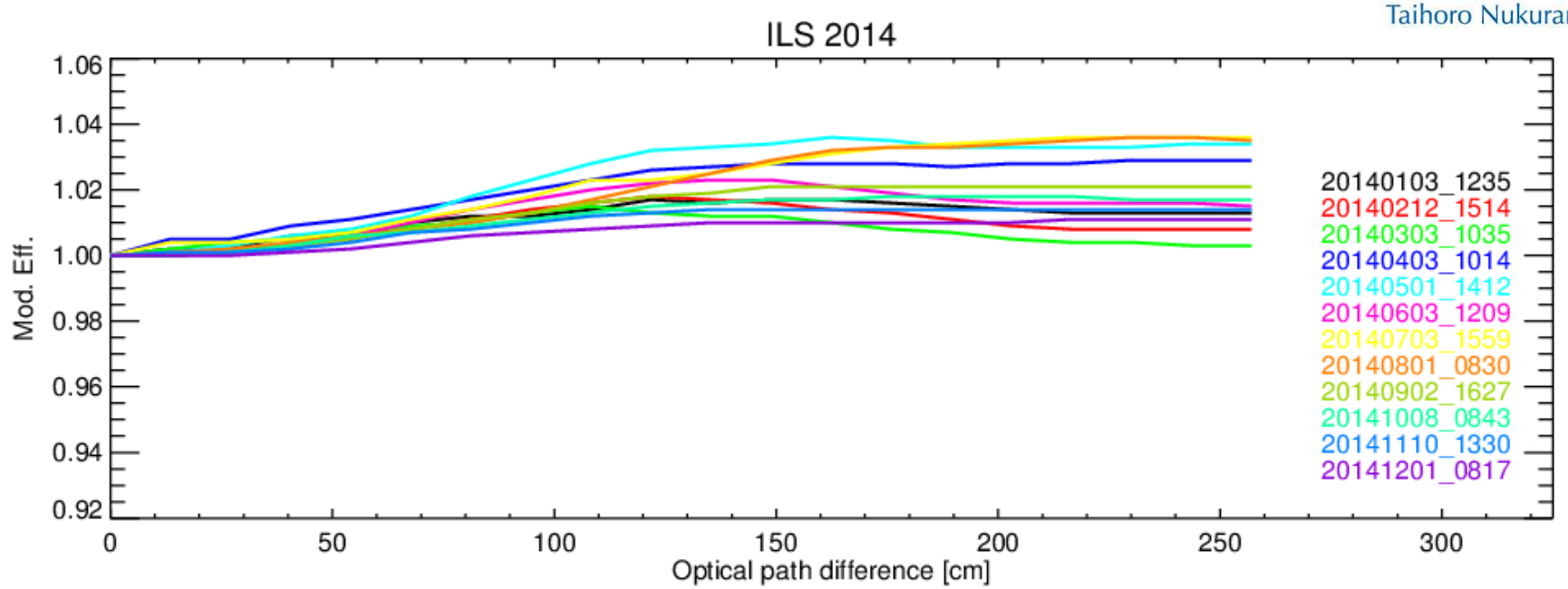
What happened here…?
[from previous slide]

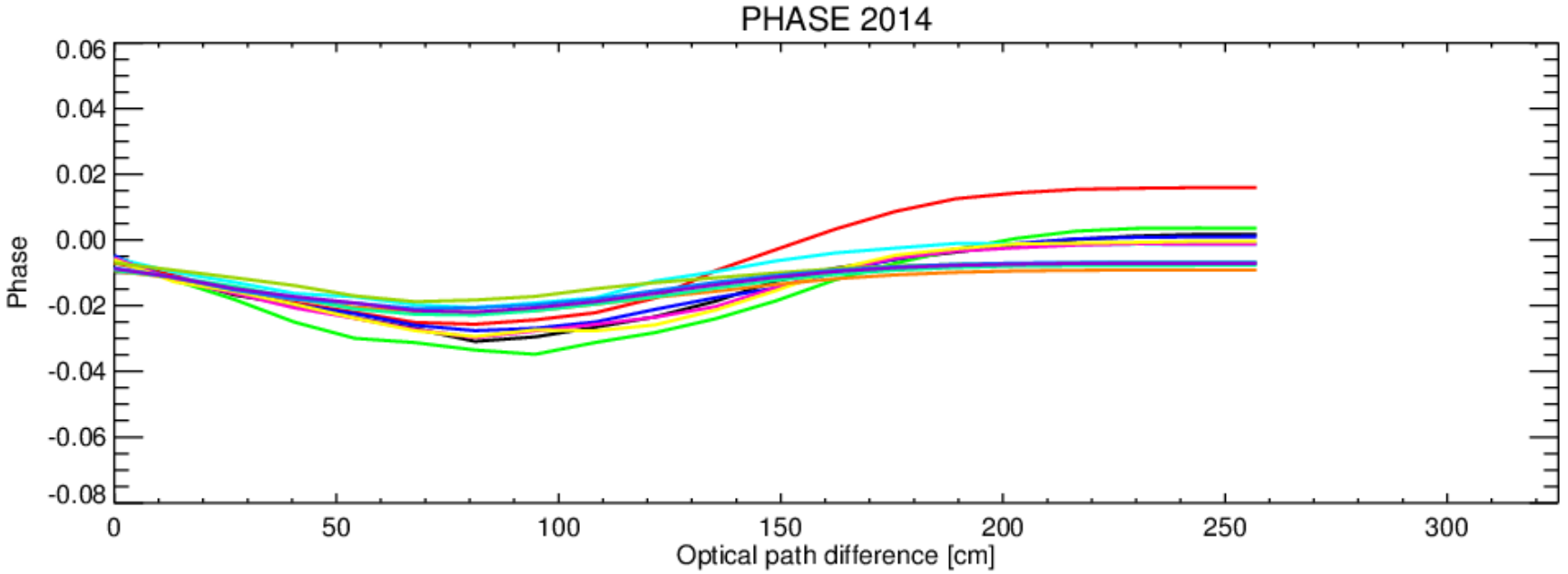


Event file entry:

```
2013.43013699 ; 456 2013/06/07 - MCT det pumpdown LF
2013.49589041 ; 457 2013/07/01 - new SIOS laser LF
2013.61369863 ; 458 2013/08/13 - alignment due to suspected scanner pad wear. LF
2013.71232877 ; 459 2013/09/18 - investigating reasons for general lower cell levels.
```

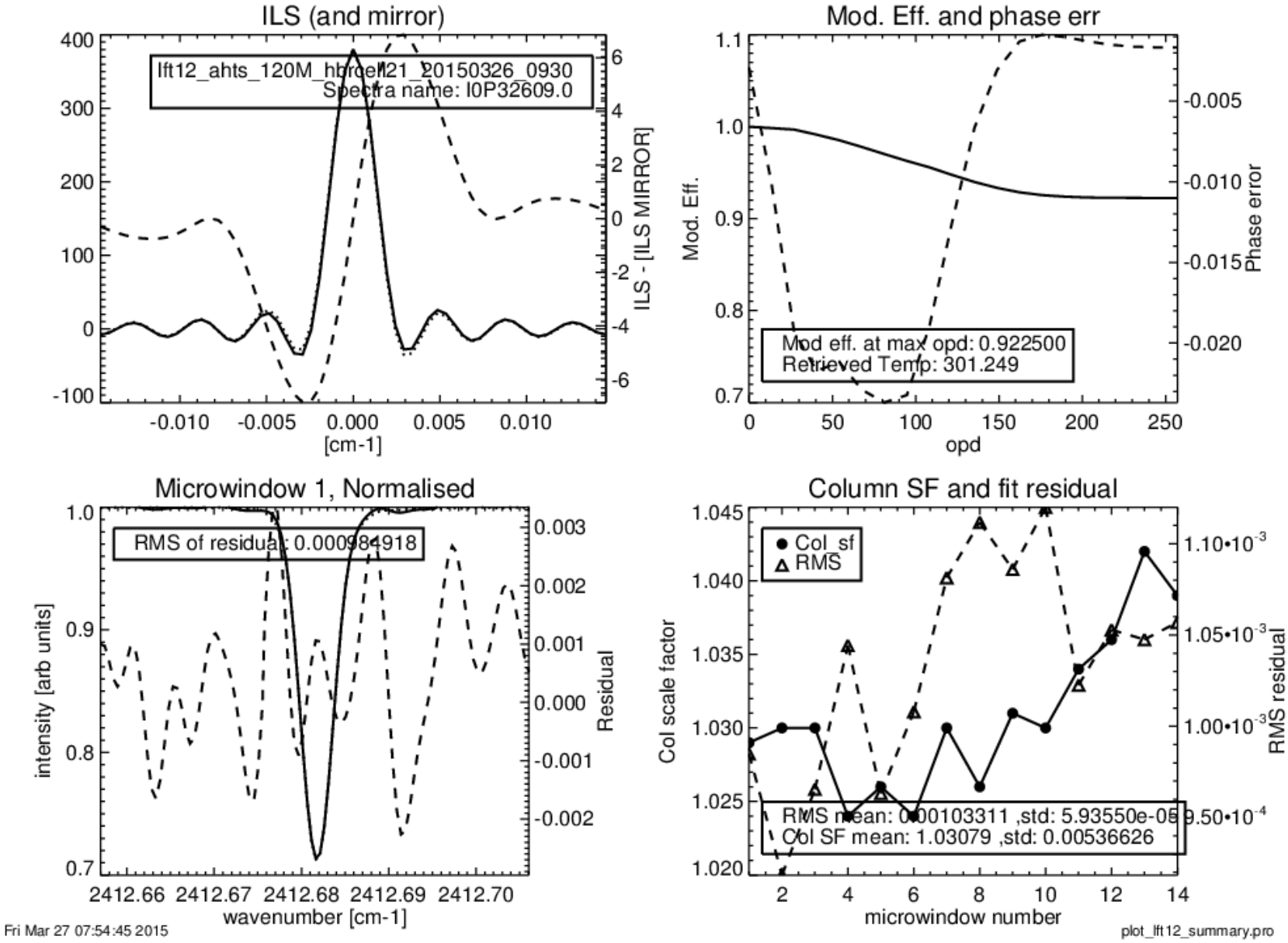
Lauder 120HR HBr cell (#15) cont.



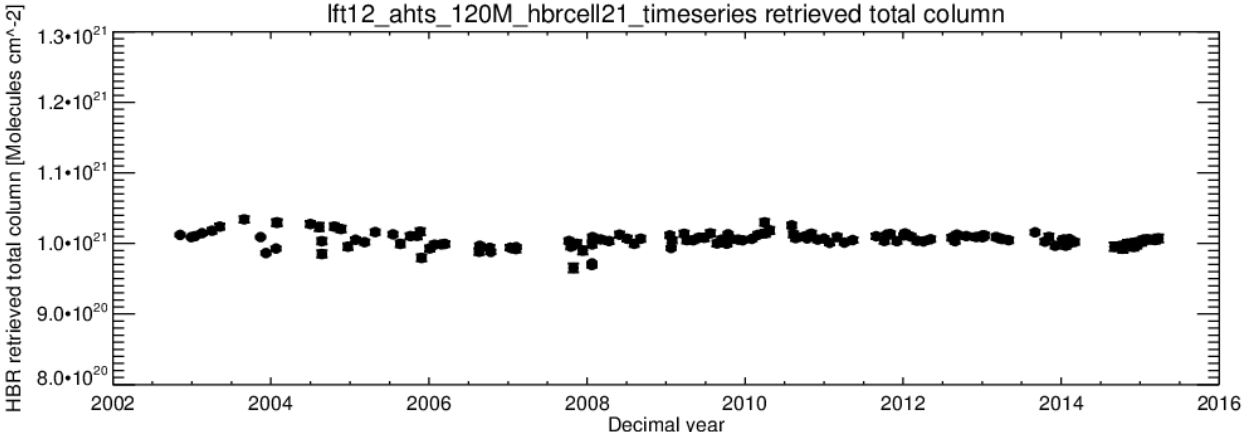


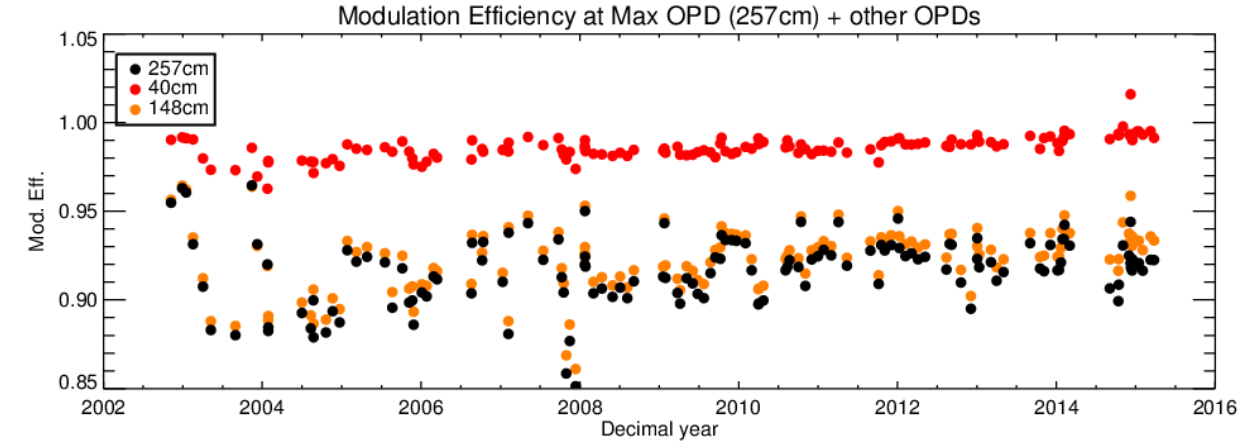
Arrival Heights 120M HBr cell (#21)

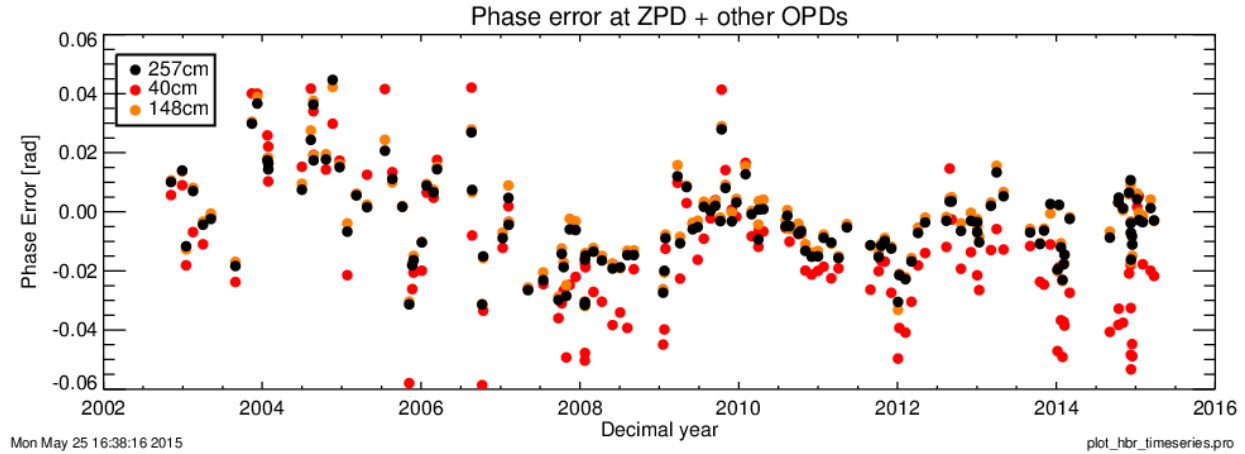
Cell test 26/3/2015



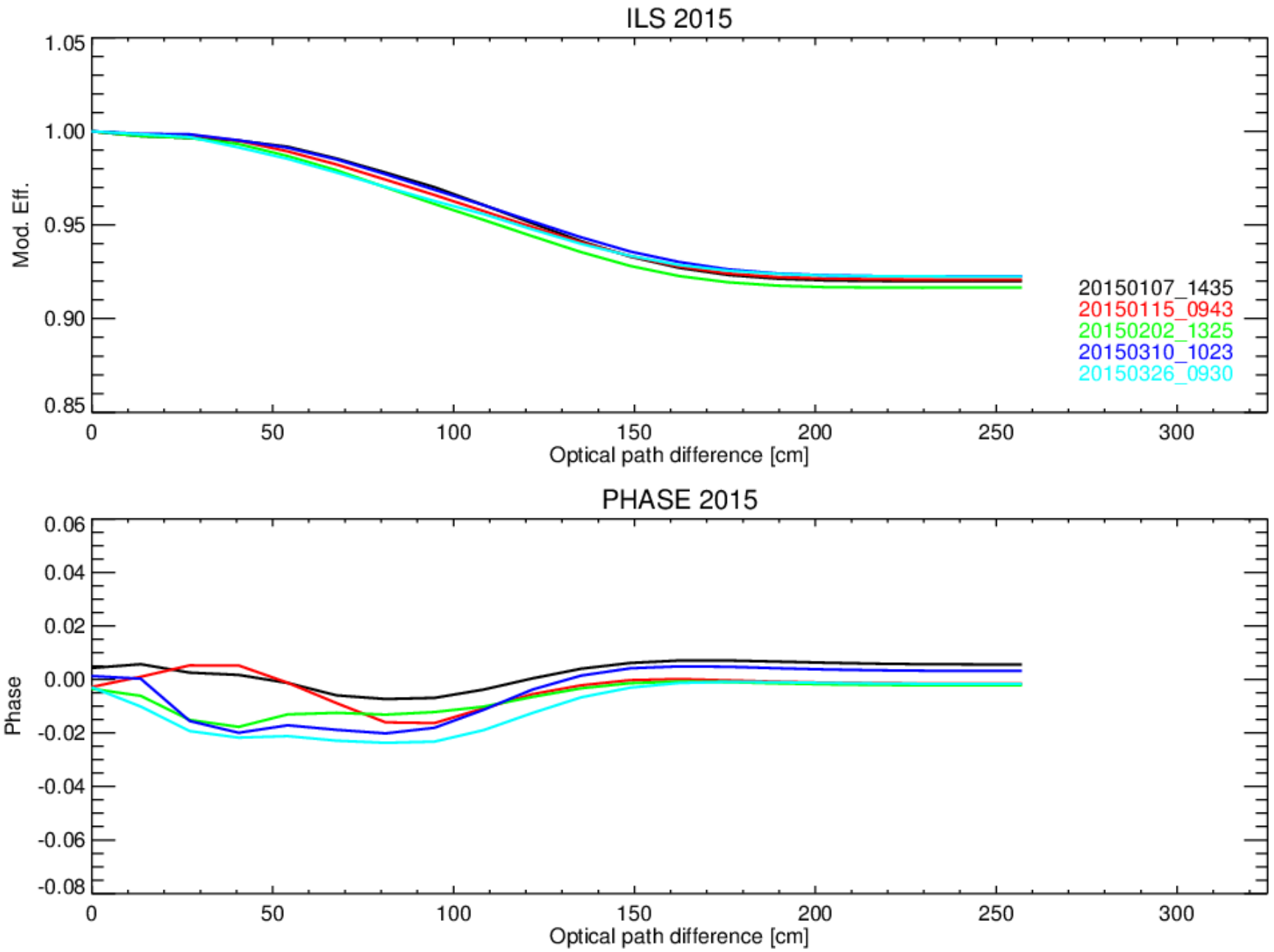
Arrival Heights 120M HBr cell (#21) time series







Arrival Heights 120M HBr cell (#21) time series cont.



Arrival Heights 125HR installation and commissioning

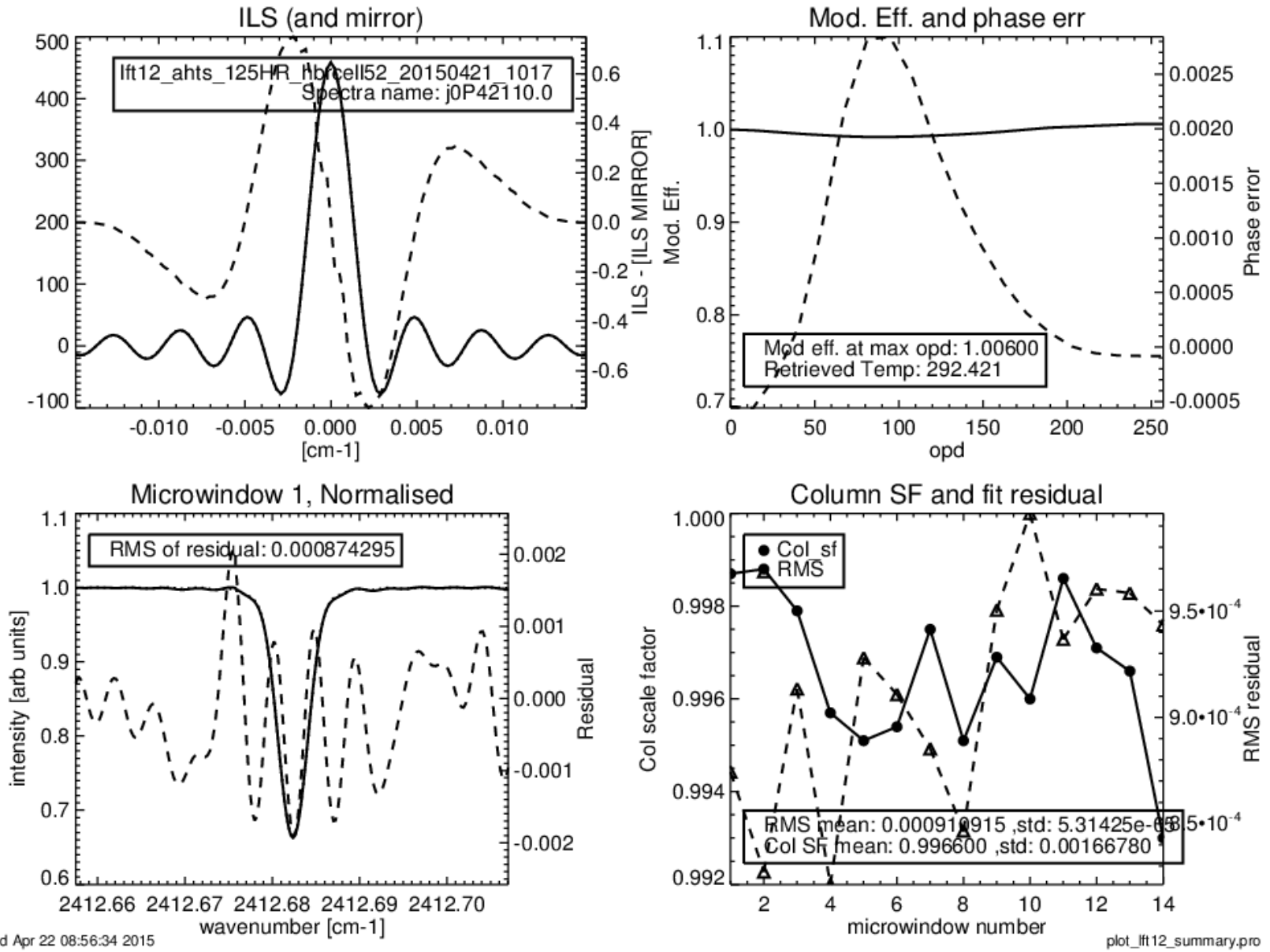
- 125HR arrived at Lauder in late July 2015
- Gregor Surawicz and John Robinson assembled, aligned and tested it at Lauder prior to deployment to Arrival Heights.
- Limited solar measurements made over next two months with an old passive solar tracker.
  - 1 day of Lauder 120HR and AHTS 125HR 9 micron filter intercomparison solar spectra, 22 spectra.
  - HNO_3 TC difference < 1%
- Channelling in 'MCT' spectra. ~5x greater than that of Lauder 120HR and AHTS 120M
  - Tracked issue down to the beam splitter. Inherent channelling, will fit out.
- Nov 2015, 125HR taken apart at Lauder by John Robinson and reassembled at Lauder for practise.

Arrival Heights 125HR installation and commissioning cont:

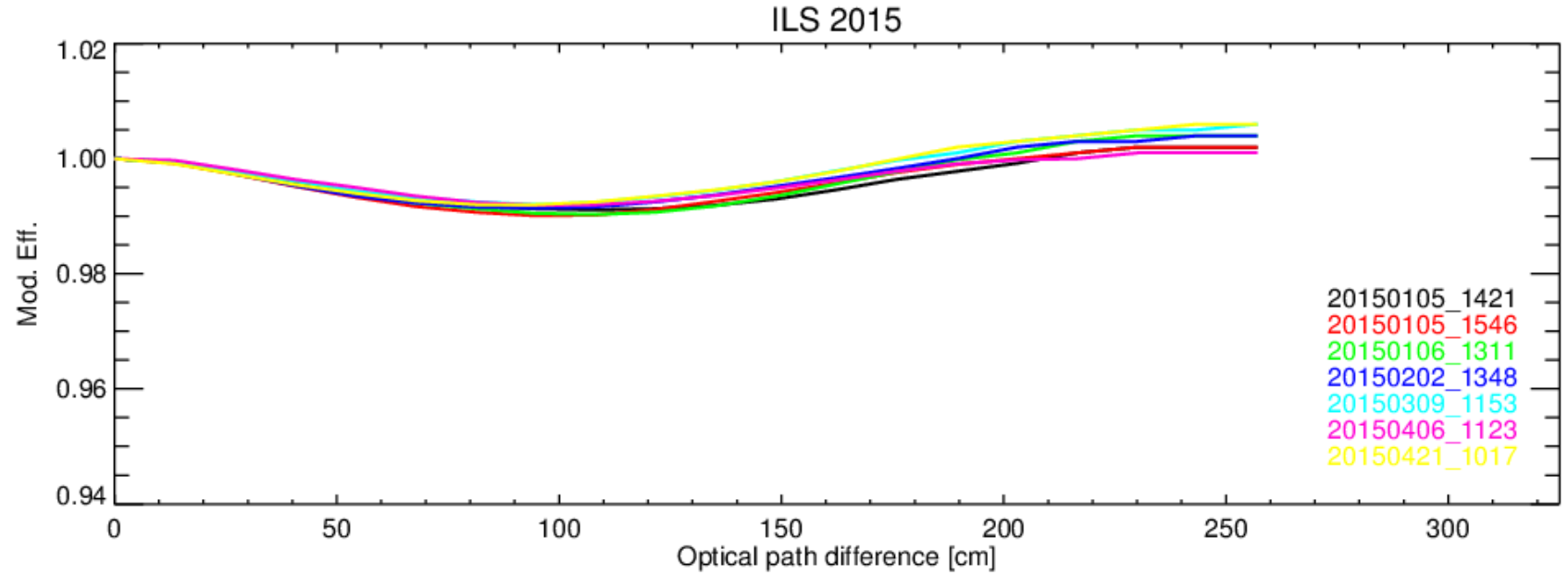
- Dec 2015: installed at Arrival Heights by John Robinson, Dave Pollard and Kate McKenzie
- Single solar tracker, time sharing between 120M and 125HR for inter-comparisons
- Installation and commissioning went without a hitch.

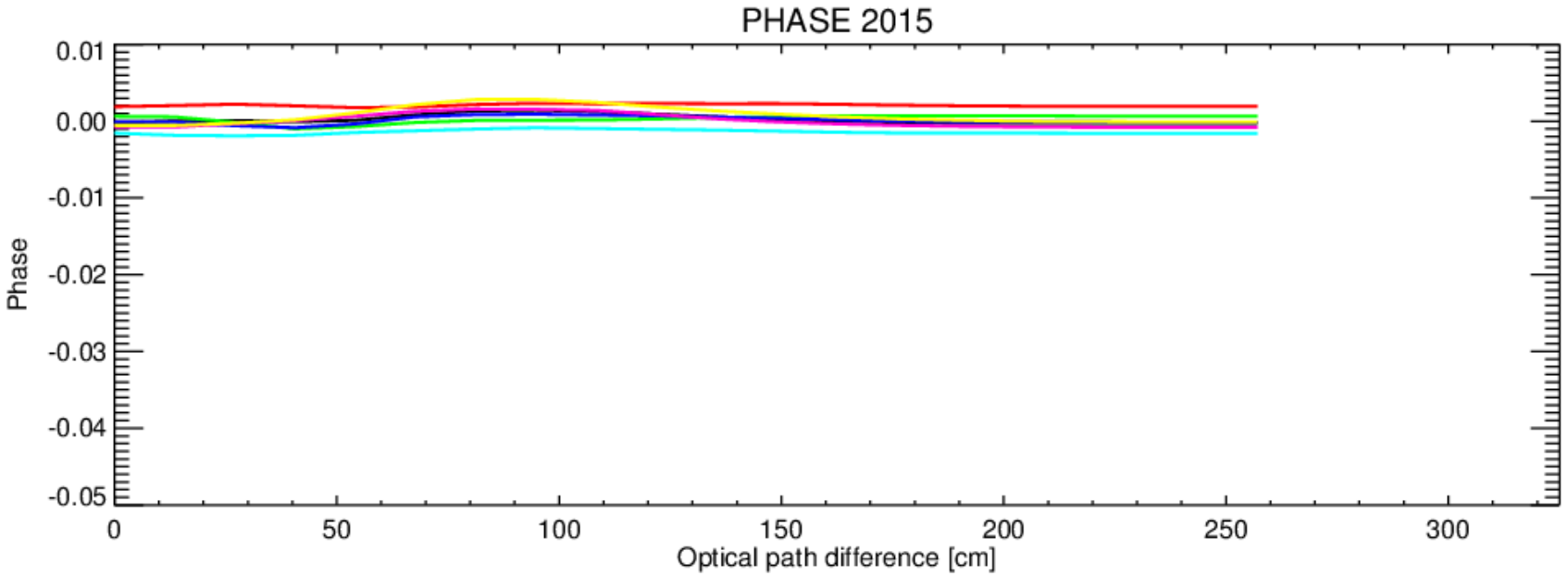
Arrival Heights 125HR installation and commissioning cont:

Cell (#52) 21/4/2015



Arrival Heights 125HR installation and commissioning cont:





Arrival Heights 120M -125HR intercomparison

Intercomparison method:

- Physically limited to 1 solar tracker, so need to time share.
- Design of the intercomparison spectra collection technique based on *Batchelor, JOAT, 2009* (they also had a single solar tracker).
- Split intercomparison up into 3 parts:
  - Collect full sets of filter spectra per instrument, to identify 'macro'-errors
  - Initial intercomparison on a filter-by-filter basis. '2-4-2' approach, again to identify any large inconsistencies in any filter set.
  - Perform full filter inter-comparisons over numerous days, '2-2-2-2-2...' approach.

Results to date:

- No macro errors or large inconsistencies between spectra or retrievals. All filters compared.
- Proceeding with filter by filter approach now. Currently, a lack of data. Need more days.
  - Only 7 days of comparisons. Extend intercomparison in 2015-16 austral summer.
- Initial comparisons of total column retrievals. Retrieval strategy for the 125HR will be optimised and profile comparisons made using Frank's approach in *Hase, JQSRT, 2004*

Species	Difference in total column abundances between coincident Bruker 120M and 125HR MIR-FTS measurements
HCl (Hydrogen Chloride)	-1.3%
O_3 (Ozone)	0.4%
HNO_3 (Nitric acid)	0.05%
HF (Hydrogen fluoride)	1.2%
CH_4 (Methane)	-1.0%
N_2O (Nitrous oxide)	-2%

Difference in total column measurements of 6 species between the Bruker 120M and Bruker 125HR MIR-FTS systems. These are preliminary results based on 3 days of inter-comparison spectra taken in December 2014.

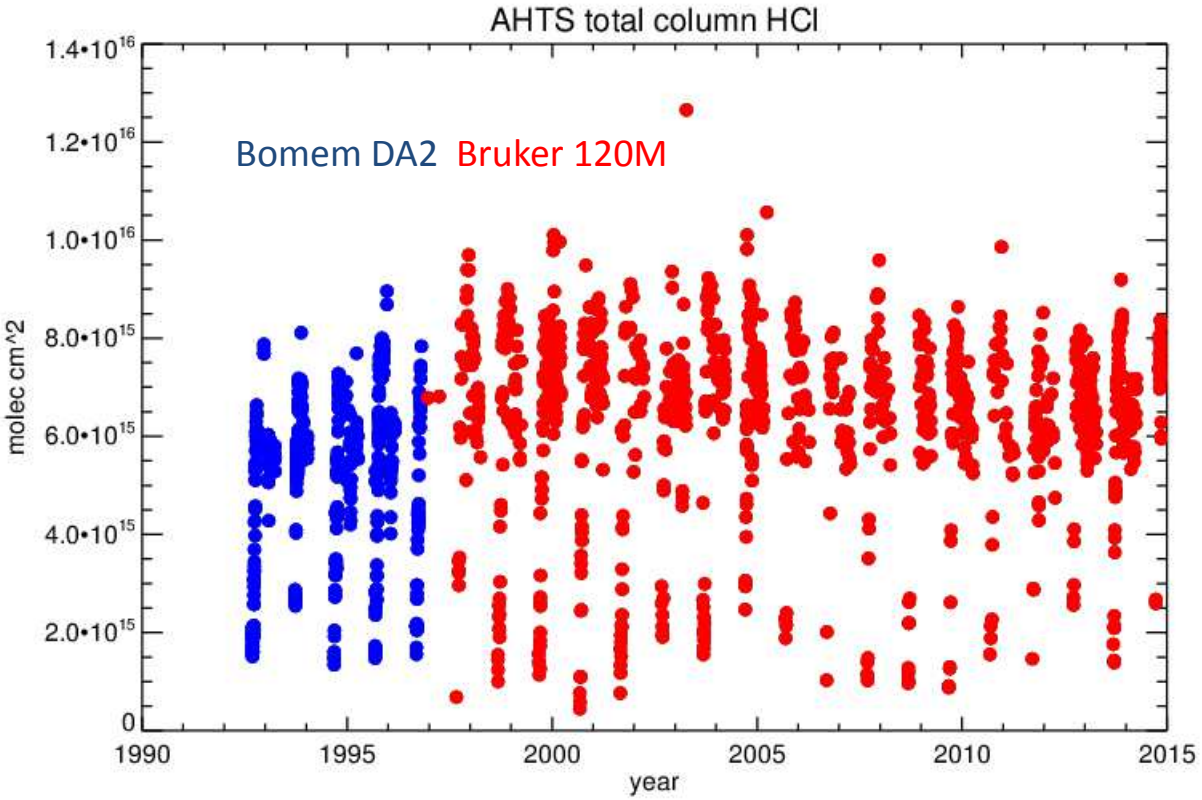
Current and planned activities:

- Moving towards SFIT4 retrievals using the IRWG retrieval strategy guidelines (May2014).
- Continue to partake in IRWG network activities.
- Continue and complete AHTS 120M-125HR intercomparison
  Ideally retire the 120M in Jan 2016
- Replace the aging AHTS FTS solar tracker with a NIWA-360 tracker.
- Dave Pollard to continue MIR-FTS development focusing on SFIT4 retrieval methodology.
- ….and (implicitly) keep taking high quality solar spectra on clear days along with routine checks on instrument performance.

:Save our spectra

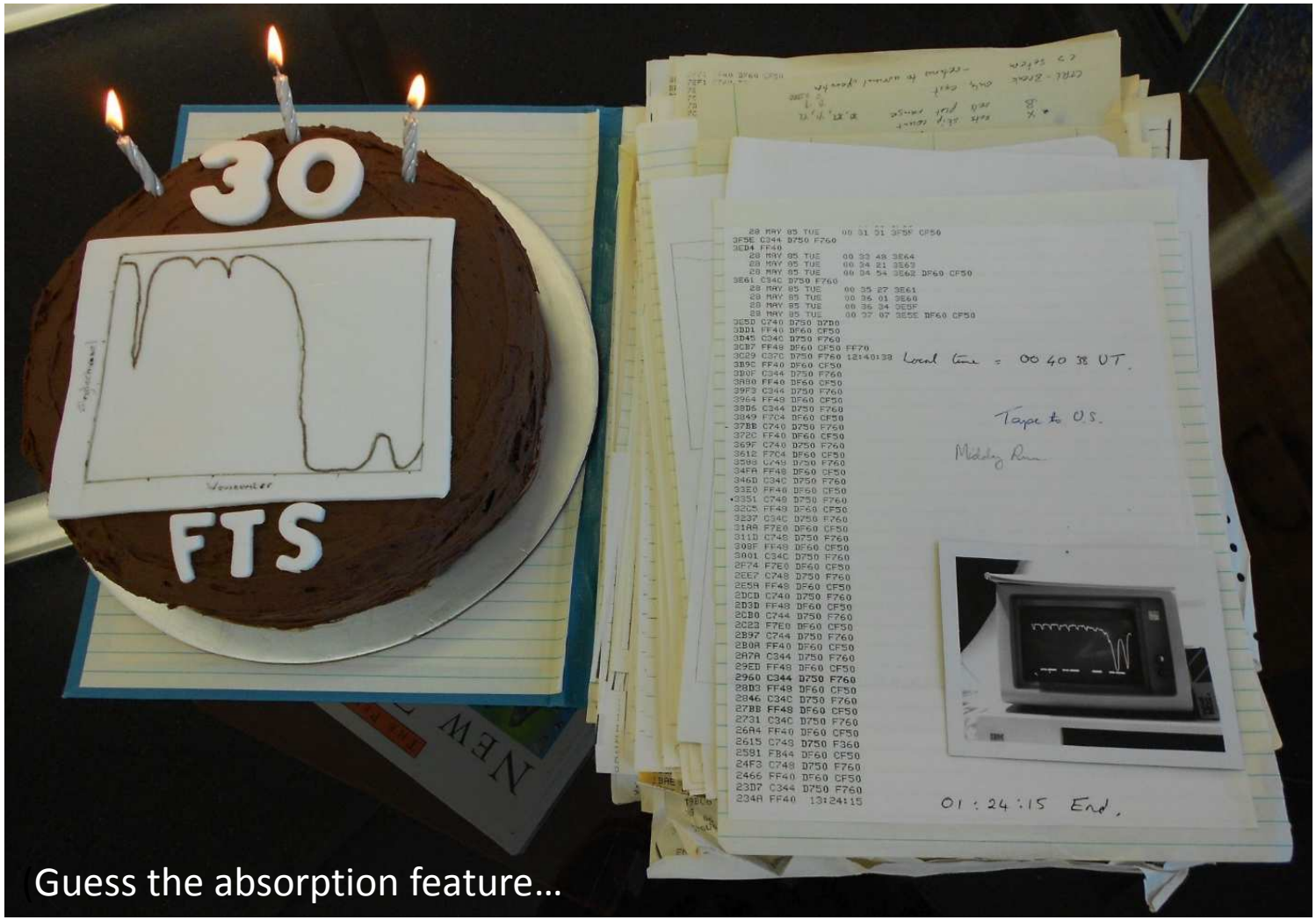
- Completed documenting procedures and site specific meta data before it was lost.
- Spectra converted to current 'BNR' format.
- Data sets saved:

AHTS Bomem DA2 1991-1996
(now in NDACC DHF archive)
AHTS Bomem DA2 1987-1989
Lauder Bomem DA2 1986-1989



Happy birthday Lauder MIR-FTS programme!:

This year marks the 30th anniversary (28th May 1985) of MIR FTS measurements made at Lauder. Measurements made by Frank (or Dave?) Murcray with a Bomem DA2 (Nicholas Jones present).



Guess the absorption feature…

IRWG partners using Lauder & Arrival Heights spectra and/or retrievals:

- Stephanie Kremser (Bodeker Scientific, NZ) and Nicholas Jones and working with Lauder and AHTS spectra on OCS retrievals.
- Mathias Palm and Enrico Dammers performing NH_3 retrievals on Lauder spectra.
- Lauder and AHTS C_2H_6 & CH_4 used by Petra Hausmann + Ralf (IMK) and Whitney Bader + Bruno Franco (Liège).
- Bavo: Lauder and AHTS CH_4, CO profiles for NORS/MACC model comparisons. HNO_3 to Bavo as well.
- Rebecca Buchholz, UCAR Lauder and AHTS CO profiles for MOPPIT intercomparison.

Recent peer reviewed publications:

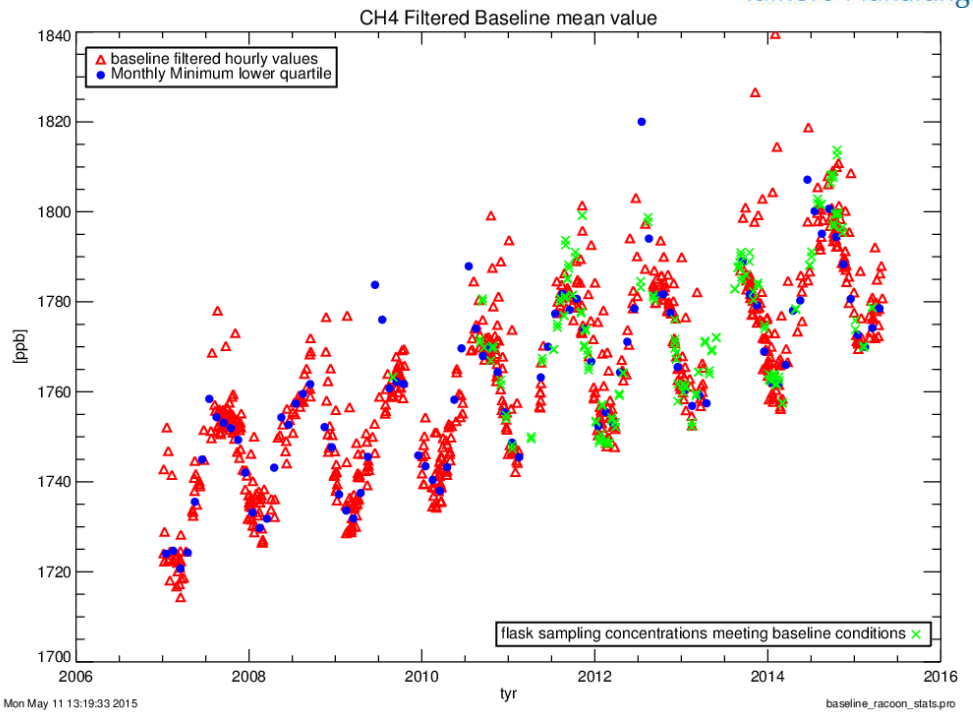
- Barthlott,S, et al,: Using XCO_2 retrievals for assessing the long-term consistency of NDACC/FTIR data sets, Atmos. Meas. Tech. , amt-2014-260, 2015.
- Mahieu E., et al.: Recent Northern Hemisphere stratospheric HCl increase due to atmospheric circulation changes, Nature, 515,104–107 doi:10.1038/nature13857.
- Vigouroux C., et al.,: Trends of ozone total columns and vertical distribution from FTIR observations at eight NDACC stations around the globe, Atmospheric Chemistry and Physics, 2015, 15, pp. 2915-2933.

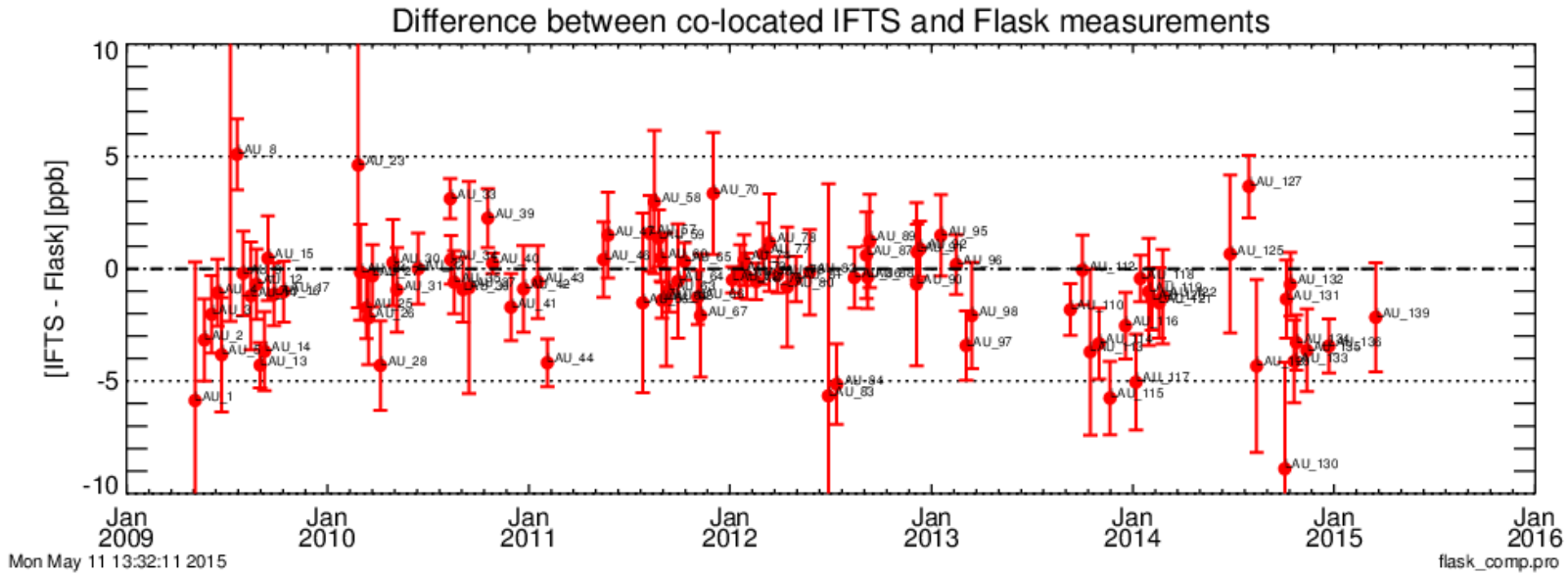
Submitted, and under review:

- Zeng, G., et al.,: Multi-model simulation of CO and HCHO in the Southern Hemisphere: biogenic emissions and model uncertainties, Atmos. Chem. Phys. Discuss., 15, 2615-2678, doi:10.5194/acpd-15-2615-2015, 2015.
- Harris N. R. P. ,et al.,: Past changes in the vertical distribution of ozone - Part 3: Analysis and interpretation of trends, Atmospheric Chemistry and Physics Discussions, 2015, 15, pp. 8565-8608.

In situ MIR-FTS measurements:

- We have been operating an in situ MIR-FTS analyser (*Griffith, AMT, 2012*) since 2007.
- Measurements of CO_2,CH_4,CO and N_2O made continuously.
- CH_4 measurements have been published (*Sepúlveda, AMT 2014*) and also accepted into the WMO-GAW WDGCC database, first such in situ MIR-FTS measurements to do so.
- MIR-FTS –> Flask/GC CH_4 difference: -0.7ppb +/-2.0ppb (within GAW Inter-laboratory comparability limits of 2ppb)





Special thanks:

And lastly a big thank you to the following people who have helped us at Lauder:

- Nicholas Jones
- Ian Boyd, Roger Lin and Jeanette Wild
- Frank Hase
- Bavo Langerock
- Mathias Palm and Jim Hannigan
- Antarctica New Zealand
- Gregor Surawicz

Thank you from Dan, John and Dave