Waveplate Tests

Oliver Ford
IPP Greifswald

The AUG IMSE system has 3 auxiliary waveplates, specified as:
- λ/2 at 653.5nm
- λ/4 at 653.5nm
- λ/4 Ferro-electric Liquid Crystal at 653nm -
  (Always λ/4 and should switch principle axis orientation by 45°)

Are these exact? Can the inaccuracies or non-ideal effects cause the non-zero ellipticity seen by the IMSE?

1) Laser align polarisers, camera, and spectrometer.
2) Full scan first polariser with no waveplate to find 0° and 45° positions (±~0.05°)
3) Insert and laser align waveplate. Non-normal incidence makes a significant difference!
4) Set polarisers crossed and scan waveplate rotation
   - complete extinction for all wavelengths at 0°.
5) Set waveplate at 0°, measure spectrum normalisation.
5) Set waveplate at 45° (now ±~0.2°), measure spectrum.

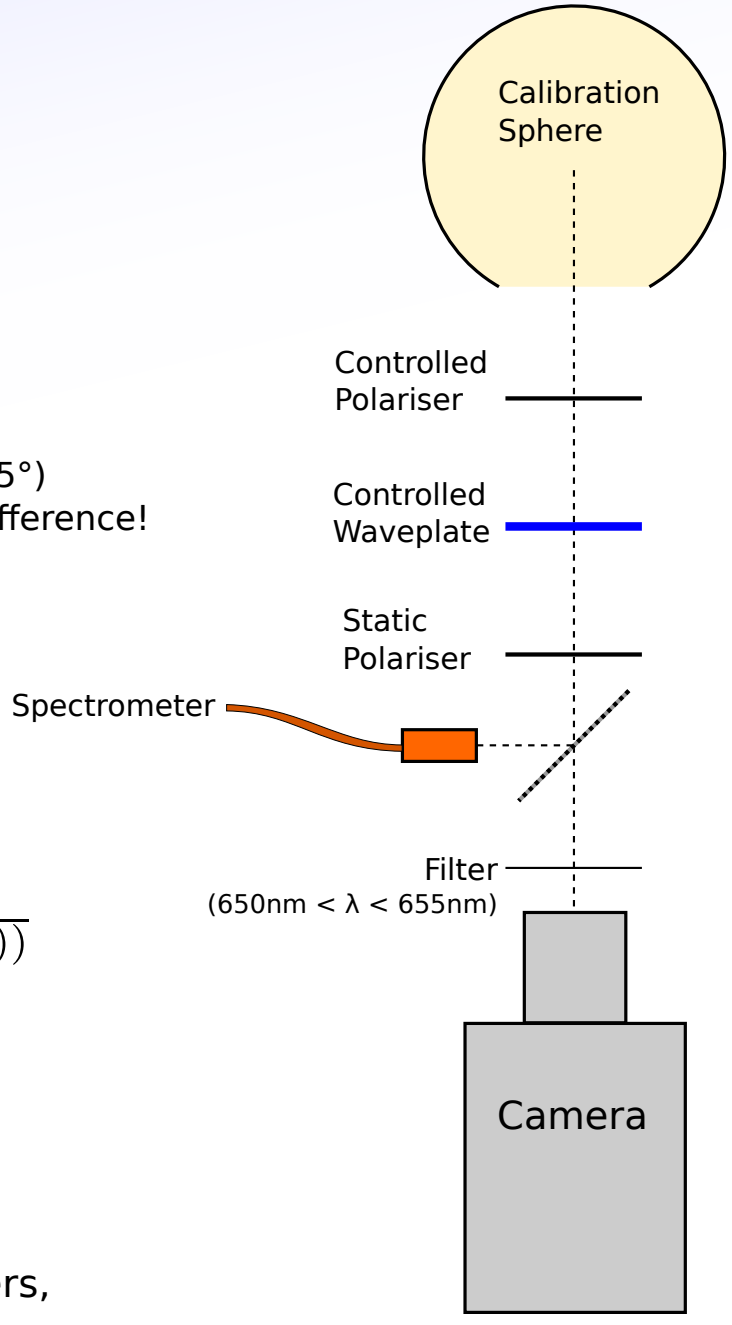
Phase diff: $\phi(\lambda) = \frac{2\pi L}{\lambda}\left(n_o(\lambda) - n_e(\lambda)\right)$

Thickness L set from design wavelength λ0: $L = \frac{\phi(\lambda_0)\lambda_0}{2\pi(n_o(\lambda_0) - n_e(\lambda_0))}$

For other wavelengths: $\phi(\lambda) = \frac{\lambda_0}{\lambda}\frac{(n_o(\lambda) - n_e(\lambda))}{(n_o(\lambda_0) - n_e(\lambda_0))}\phi(\lambda_0)$

For crossed polarisers, expect intensity: $I \propto \frac{1}{2} \pm \frac{1}{2}cos(\phi)$

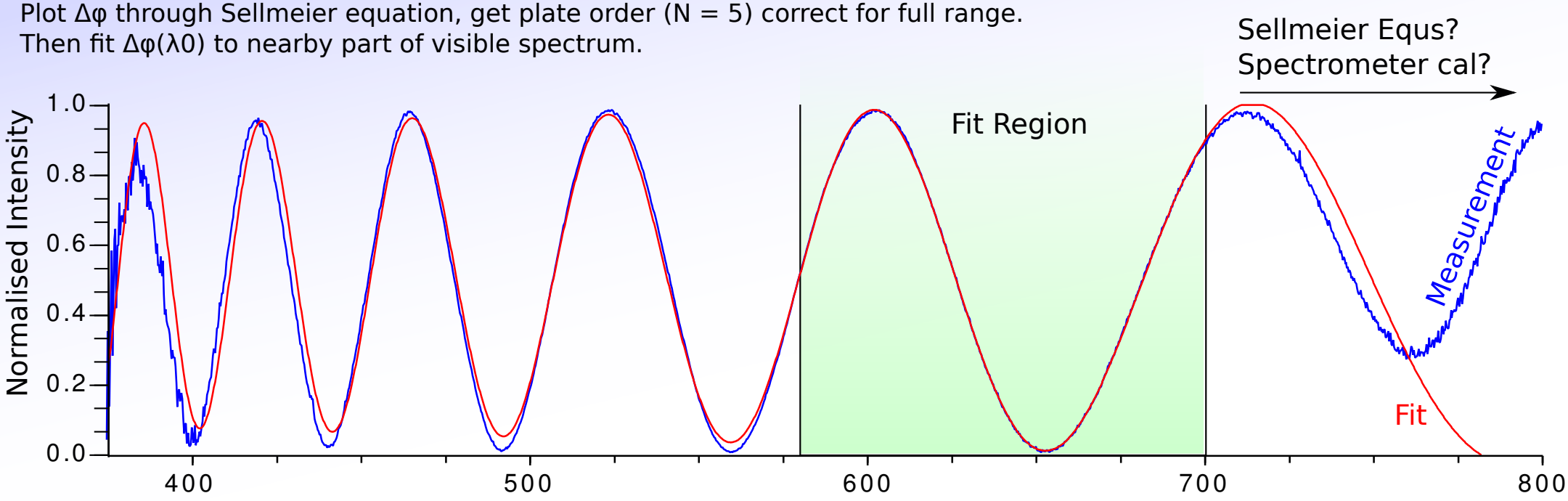
+for aligned polarisers,
- for crossed



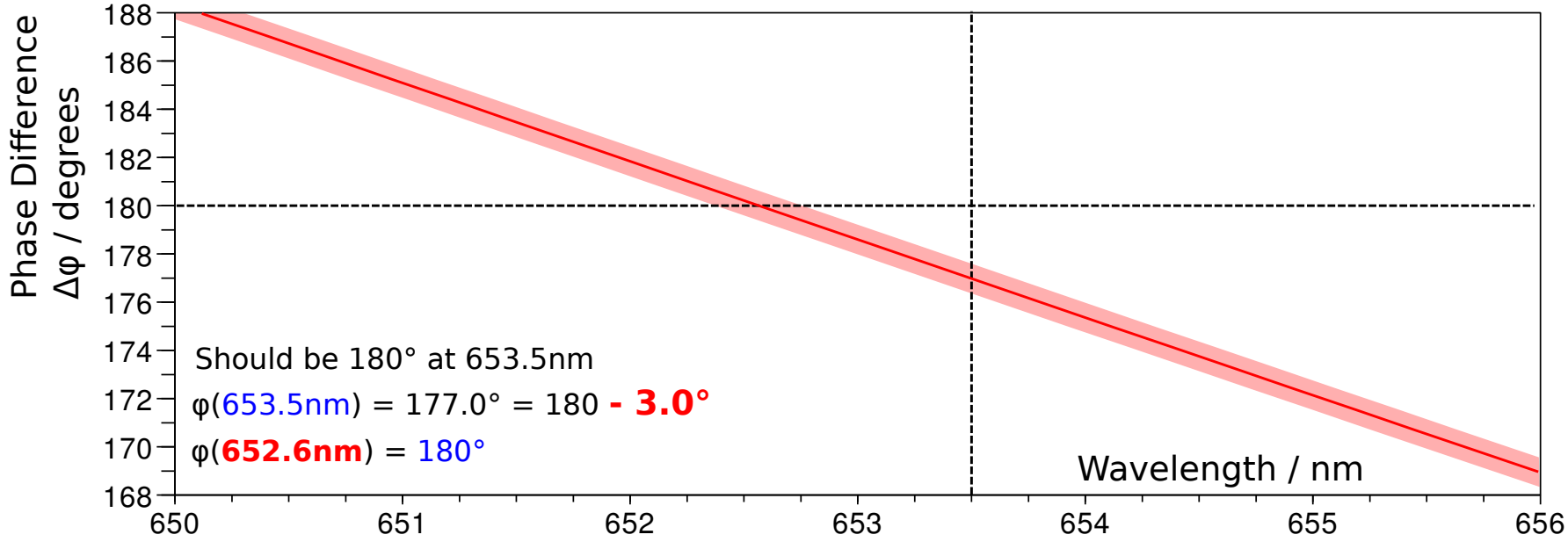
Waveplate Tests - Half Wave

Oliver Ford
IPP Greifswald
gmds/SPECLAB/397

Plot Δφ through Sellmeier equation, get plate order (N = 5) correct for full range.
Then fit Δφ(λ0) to nearby part of visible spectrum.



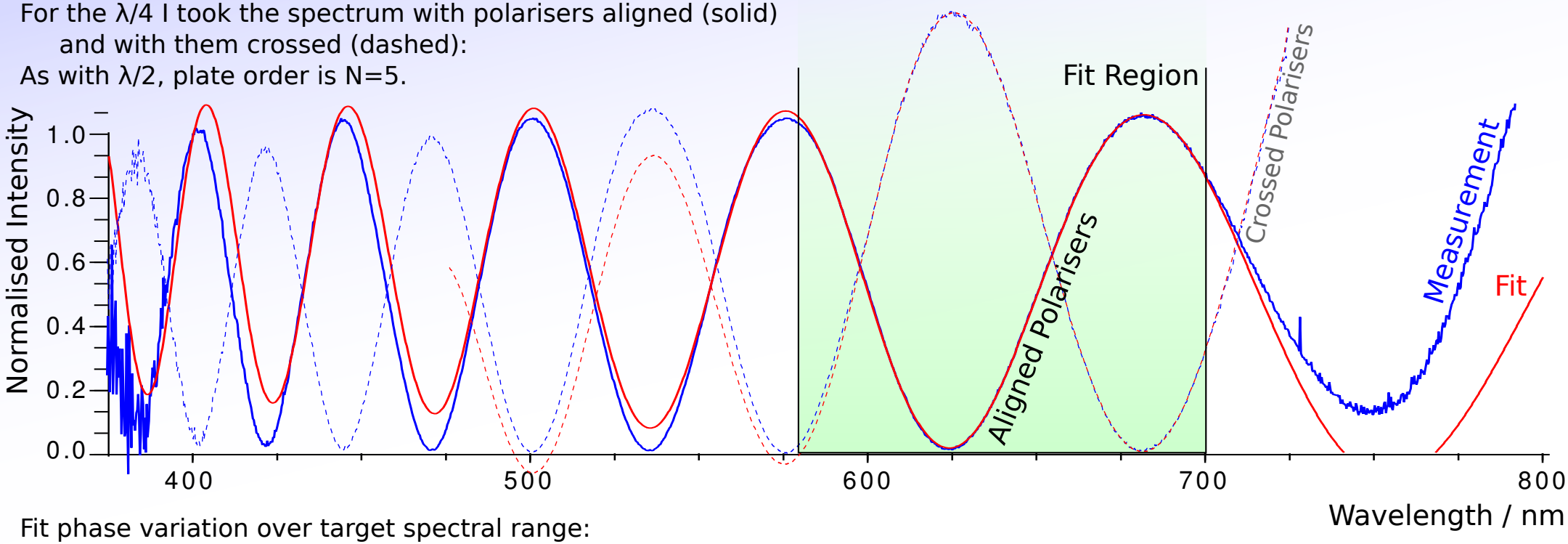
Phase variation over target spectral range is:



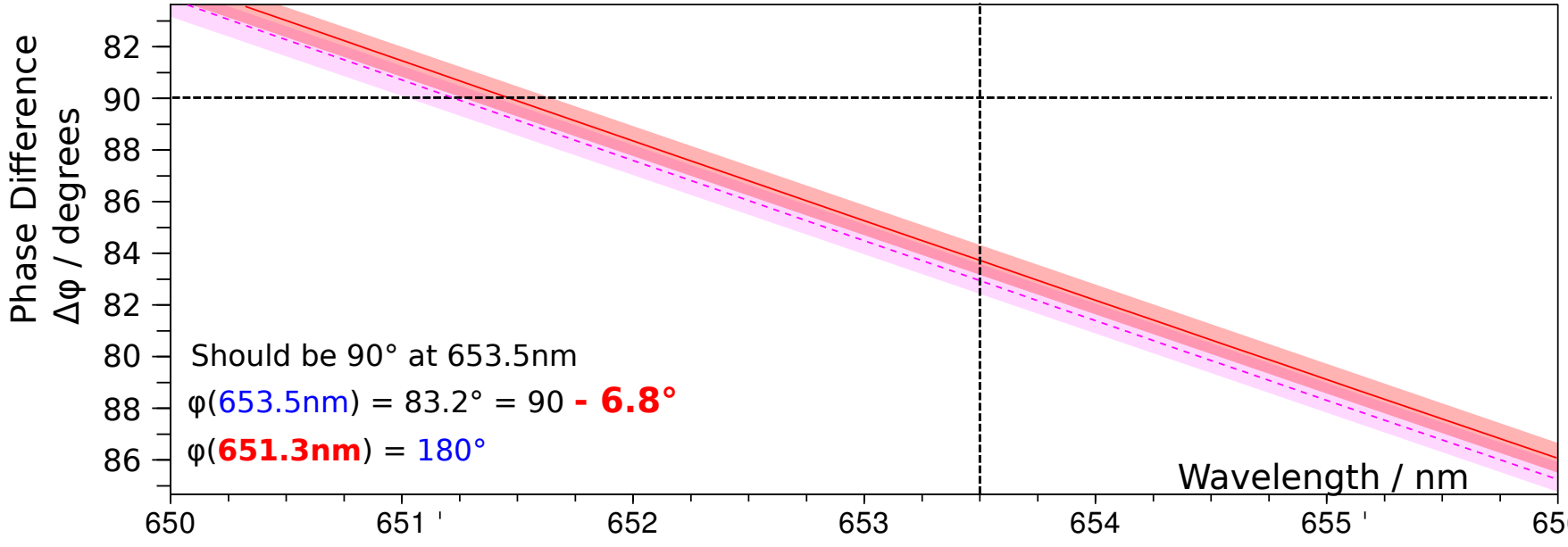
Waveplate Tests - Quarter Wave

Oliver Ford
IPP Greifswald
gmds/SPECLAB/400

For the λ/4 I took the spectrum with polarisers aligned (solid)
and with them crossed (dashed):
As with λ/2, plate order is N=5.



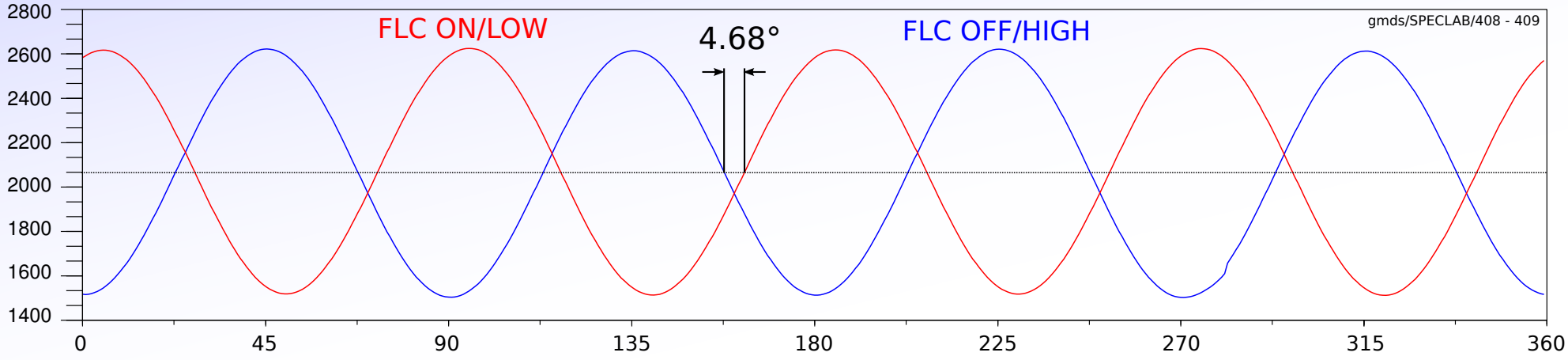
Fit phase variation over target spectral range:



Waveplate Tests - FLC

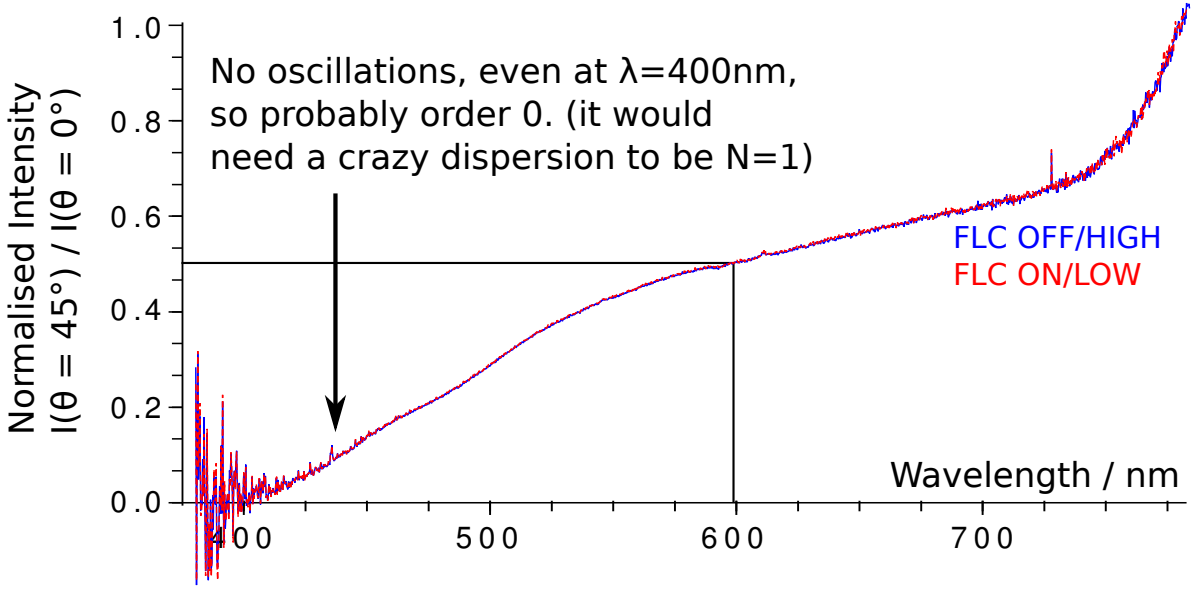
Oliver Ford
IPP Greifswald
gmds/SPECLAB/408,409

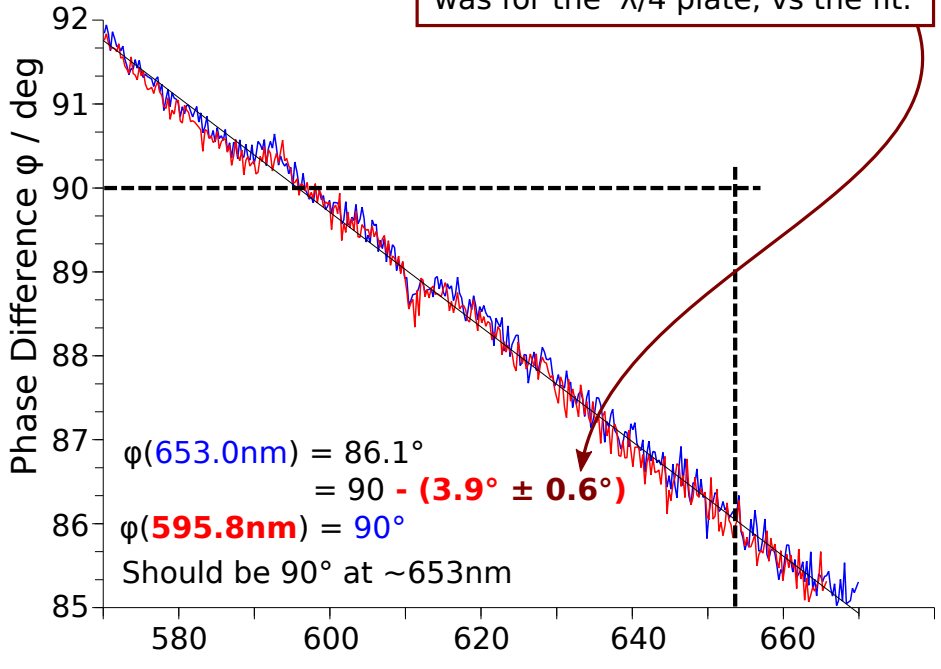
First, scan FLC between aligned polarisers to find axis in both ON/LOW and OFF/HIGH modes.



ON axis should be 45° from OFF, but is ***4.68°*** less (±0.05° from *sin θ* fits of avg image centre).
This is apparently fairly temperature sensitive.
Next, use fitted sine to average spectrum at all max/min (θ = 0° and θ = 45° respectively).
Plot spectrum, but can't fit it as I don't have the dispersion (don't know the material),
so have to trust the normalised reading = $\frac{1}{2} + \frac{1}{2}cos(\phi)$

Because I don't really trust the I(45°)/I(0°) method. This is how far out the same method was for the λ/4 plate, vs the fit.

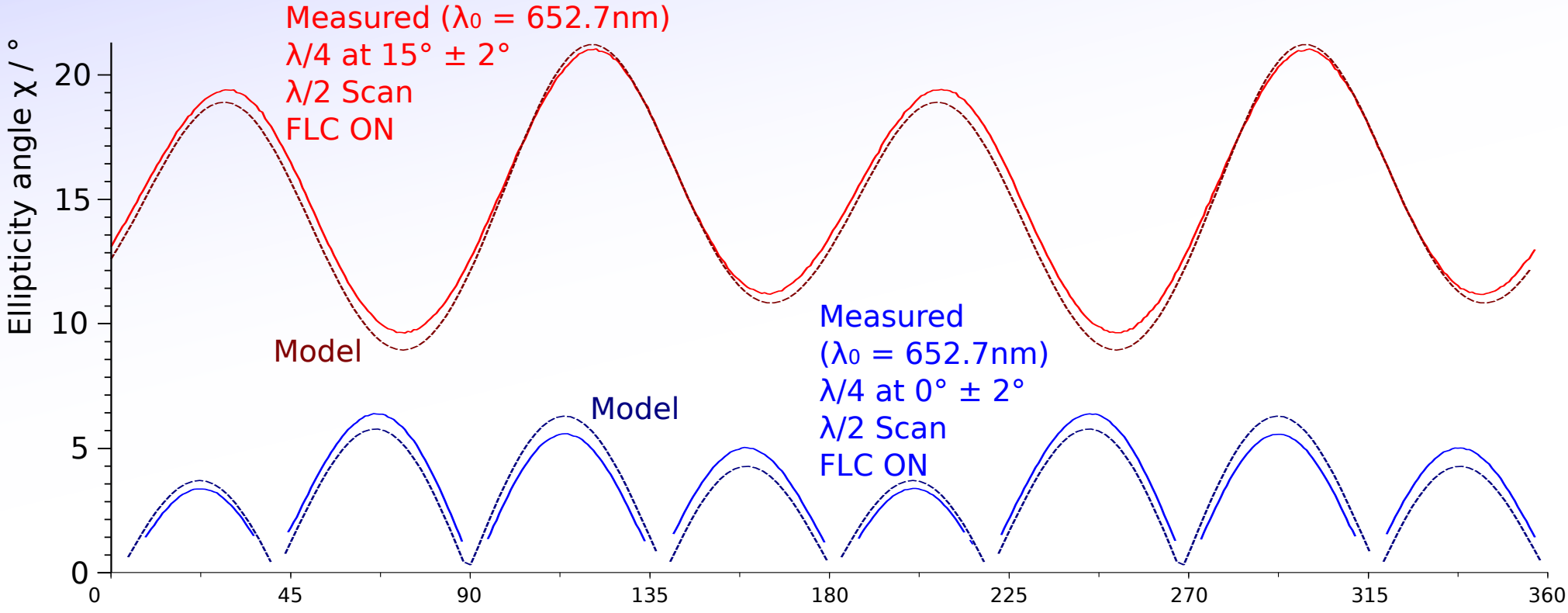




Effect on test setup

Oliver Ford
IPP Greifswald
IMSEProc/PlateGenSource vs gmds/SPECLAB/377,385

The full spectrum test setup had (π-, σ, π+) at (652.3, 652.7, 653.1nm) and the λ/2 plate before the FLC.
Simulating the λ/2, λ/4 and FLC measured phase shifts and offset angles:



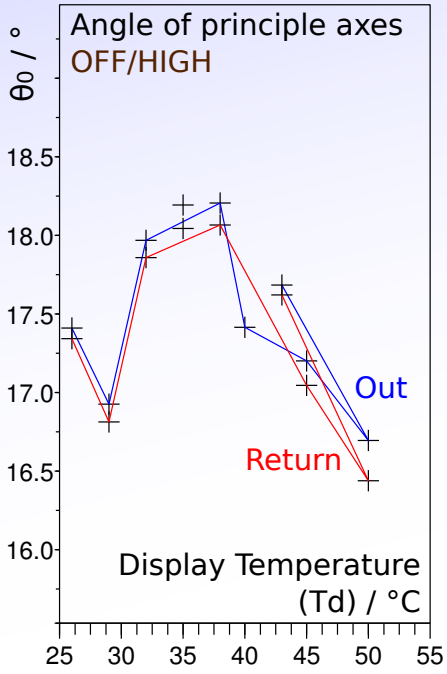
- That seems to get most of it, but there are some small remaining unknown unknowns.
- Phase offsets in all three of λ/2, λ/4 and FLC are a signficant concern.
- λ/2 and λ/4 do not need to be used in plasma measurement:
  - Should adjust the temp cell orientation rather than using the λ/2 - *change mech design!!*
  - Will need some true zero-order precise plates to get performance test down to 0.1° (and a pol. cube, to be sure).
- φ <> 90° effect can be eliminated from switched system, not sure about φ < 90° and Δθ <> 45° together, but that relies on temperature stability of FLC inaccuracy (will test this week).

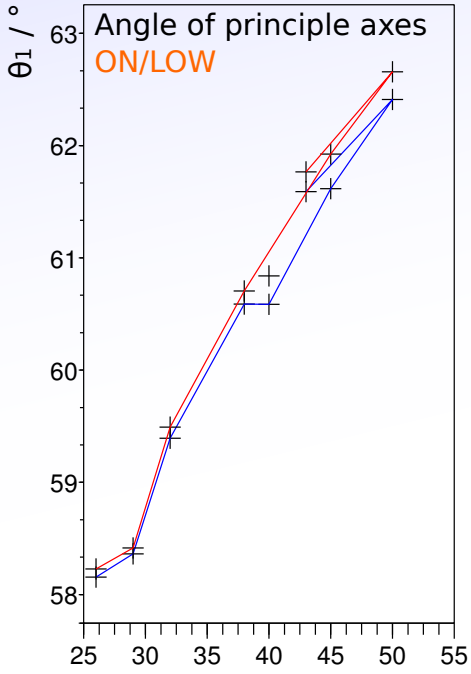
- With small ellipticity (χ < 5°) and set at a strategic operating angle, the ADSH system works to 0.1°, but none of the PDSHs, even with interlace calibration work better than 1° so cross checks, single fringe measurements, and most importantly ellipticity measurements can not be performed.

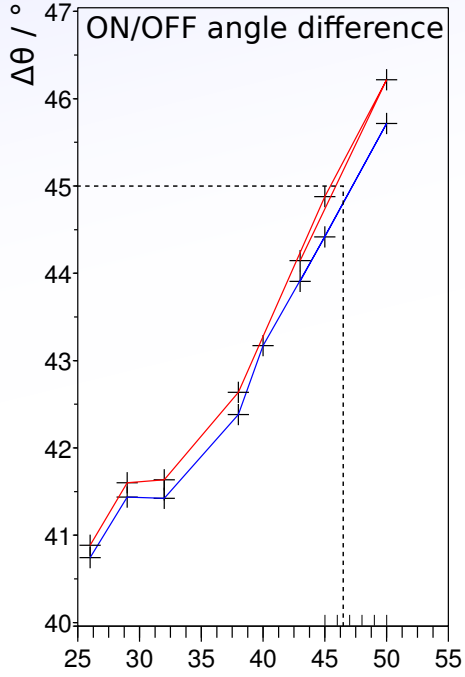
Waveplate Tests - Temperature Effect on FLC

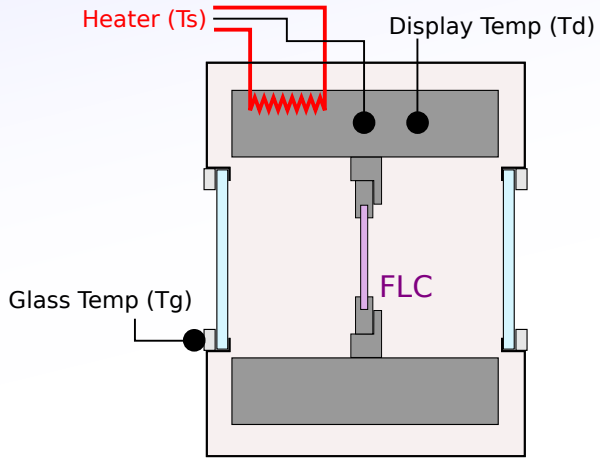
Oliver Ford
IPP Greifswald
gmds/SPECLAB/408,409

Loaded FLC into centre of temperature cell with windows.
Set a temperature, measured in block and on glass retrainer rings.









Tg ~ Td-3 and air
temp inside ~(Tg+Td)/2

Temperature seems to effect only θ when on, and only φ when off. Running at 47°C gives 45°±0.5° switch and Δφ = 84°