An expendable polarisation backscatter sonde

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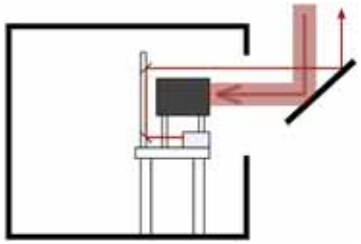
Topics for this talk

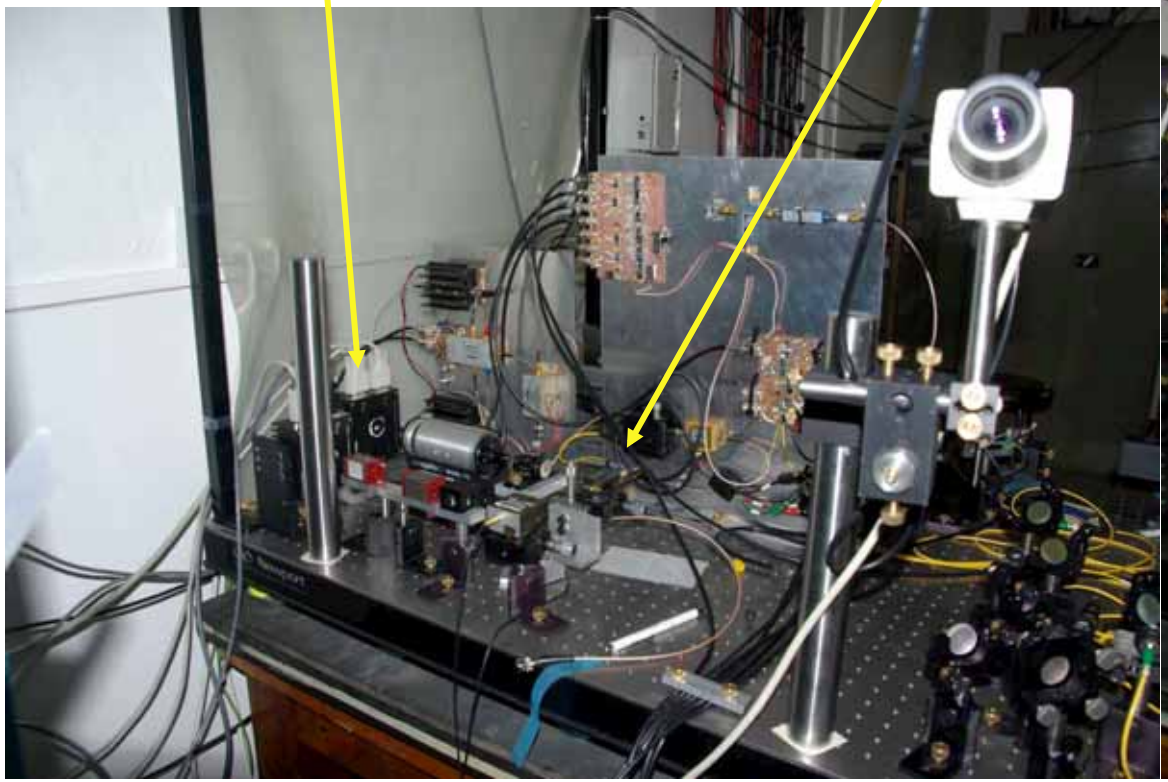
- A bit of shameless advertising for U of A lidar/radar
  - (Mostly DIAL)
- The backscatter sonde idea

- U of A Physics includes
  - Optics
    - high power lasers for LIGO, lidar, guide stars
  - Atmospheric Physics
    - radar (AAD/UA collaboration)
  - Institute for Photonics and Advanced Sensing
    - Overarching structure with which Opt & Atmos groups associated

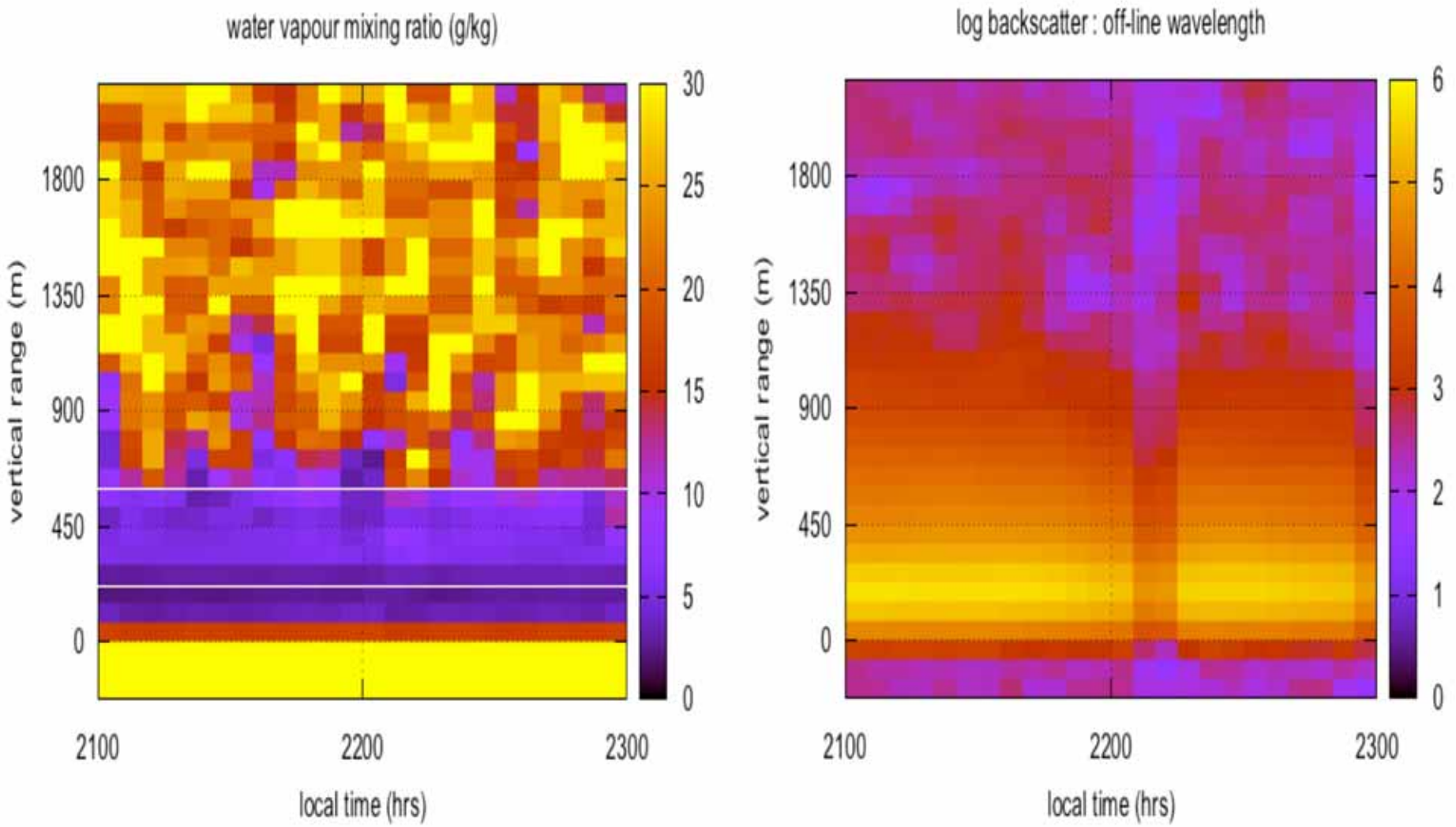


Water vapour differential absorption lidar

- Receiver and optical amp.
- Master lasers
  - 823 nm, ca 20 mW, CW
    - 1 µs pulses @ 1.5 kHz from AOMs



- DIAL results, Adelaide 22 03 2010



Water vapour DIAL

- Lab demo working (ARC and BoM funding)
- Mobile version under construction (DSTO funding)
- Limited at present by unsuitable choice of water resonance
  - For specific humidity typical of Adelaide we want resonance about 3 x weaker
  - But would work for location with 3 x less specific humidity!

The future of lidar at Adelaide –

- Buckland Park field station
- New Multi-use LIDAR facility
- Complements existing radars:
  - MF Radar
  - VHF wind profiling radar
  - RASS

Ice fraction in mixed phase cloud

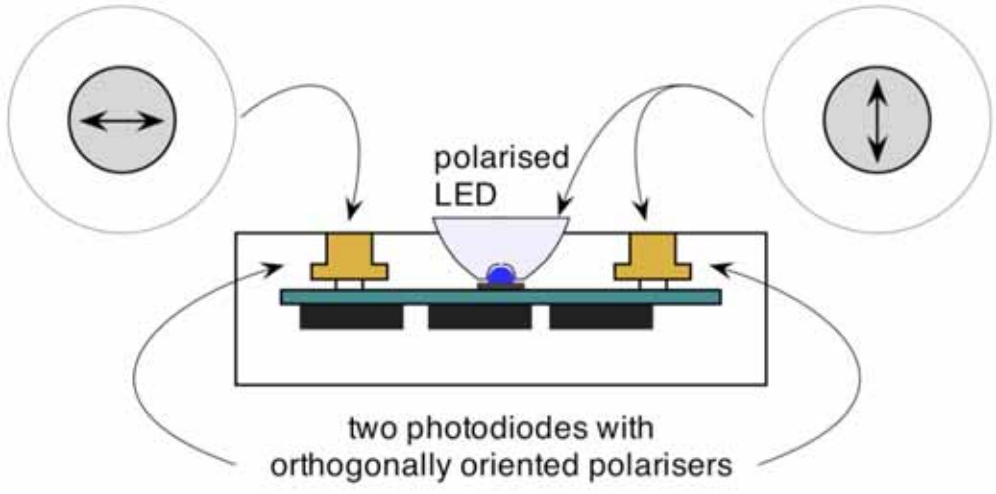
- Mixed phase cloud with super-cooled liquid is quite common
  - Aircraft icing hazard
  - Of importance to overhead surveillance and satellite communication
  - Much of microphysics still not understood
  - Ice fraction is important for understanding radiative properties of clouds

- mm-wave radar
  - Only remote sensing method that can *profile* the ice-fraction
- Lidar sees only near edge of cloud - unless optically thin
  - Lidar + radar is a good combination though!
- Radiometric methods can sense mixed phase
  - Overhead platforms have difficulty distinguishing cloud over snow or ice
  - But radiometer + radar is also good

Wanted: a low-cost polarisation backscatter sonde

- Measure depolarisation of backscatter from LED inside a cloud
- Modern LED's (light emitting diodes) have high power and are cheap
- E.g. blue (470 nm) at 400 mW costs ca $10.

- Plan: make LED based sondes
  - piggy-back on ordinary sondes (e.g. RS92)
  - Vaisala sells suitable interfaces to the RS92



Cobald

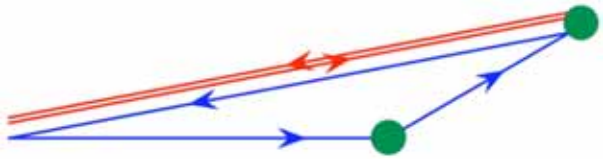
- An existing LED based backscatter sonde
  - Dual wavelength
  - Does not have depolarisation capability
- Thomas Peter group @ ETH, Zurich; see

http://www.iac.ethz.ch/groups/peter/research/Balloon_soundings/COBALD_sensor

COBALD and Wyoming sonde

Single & multiple scattering

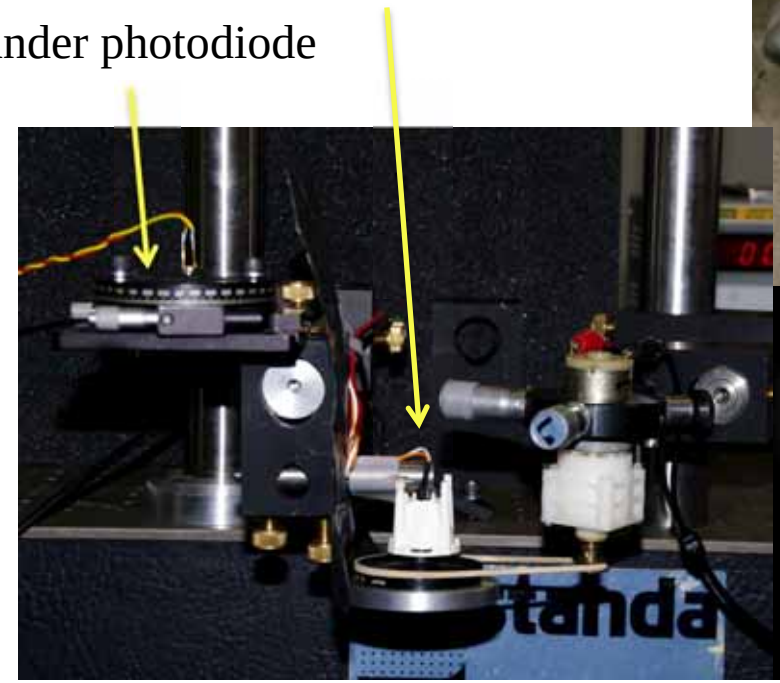
- Single **backscattering from spherical droplet gives little depolarisation**
  - Small for finite detector aperture
  - Vanishes as detector aperture tends to tiny
- But there is depolarisation from multiple scattering
  - How much is not obvious
  - Modelling is needed

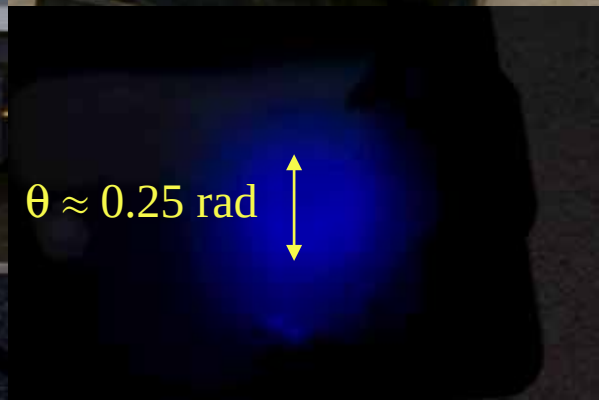


- **Ice crystals give significant depolarisation**
  - How much info on growth habit can be gleaned from depol'n is unknown

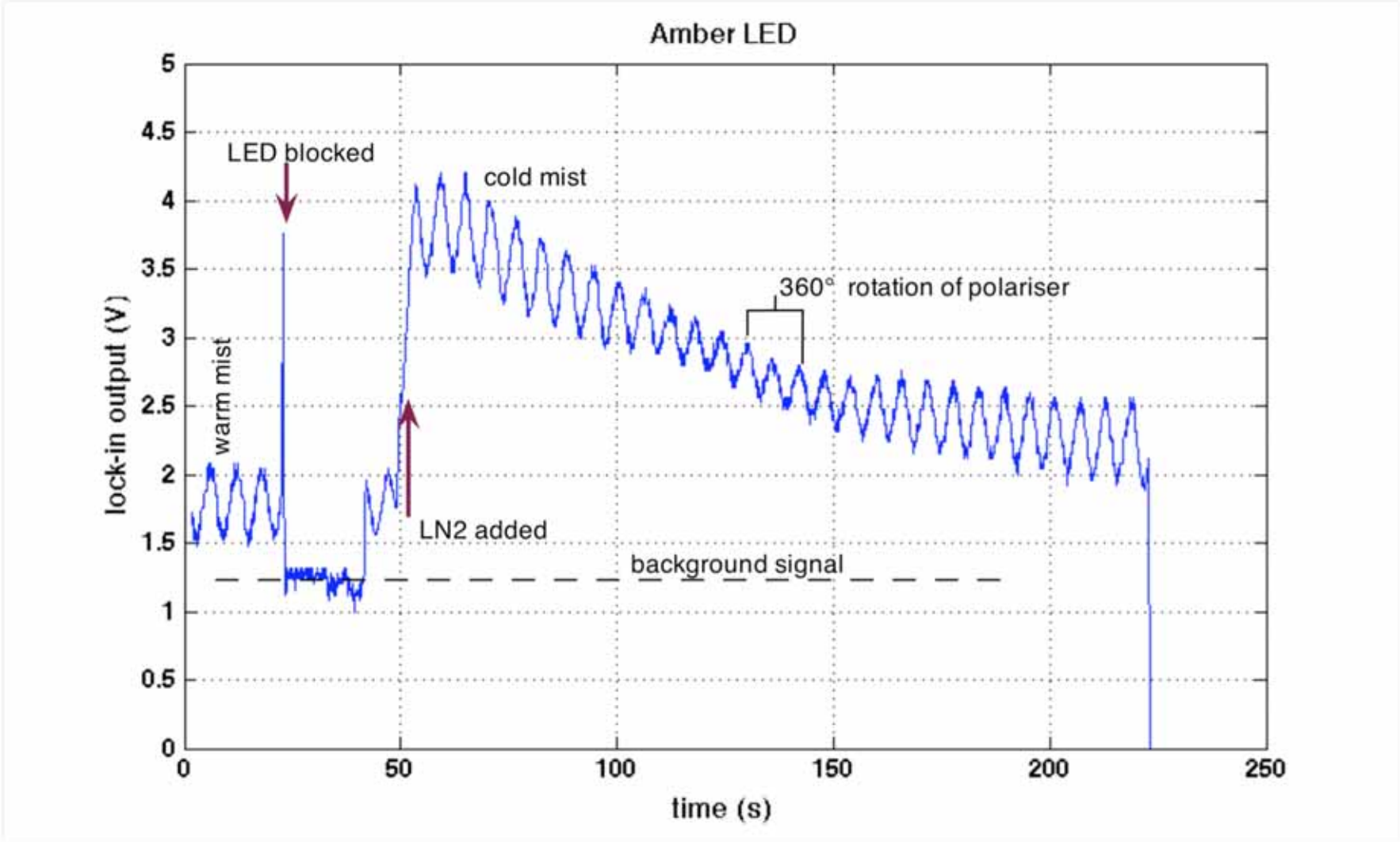
A feasibility experiment

- Warm mist from ultrasonic mister (top photo)
- Cold mist by adding liquid N_2 to water (middle photo)
- Blue or amber LEDs used
  - with lenses to minimise beam spread
- *Rotating* polariser under LED
- *Fixed* polariser under photodiode

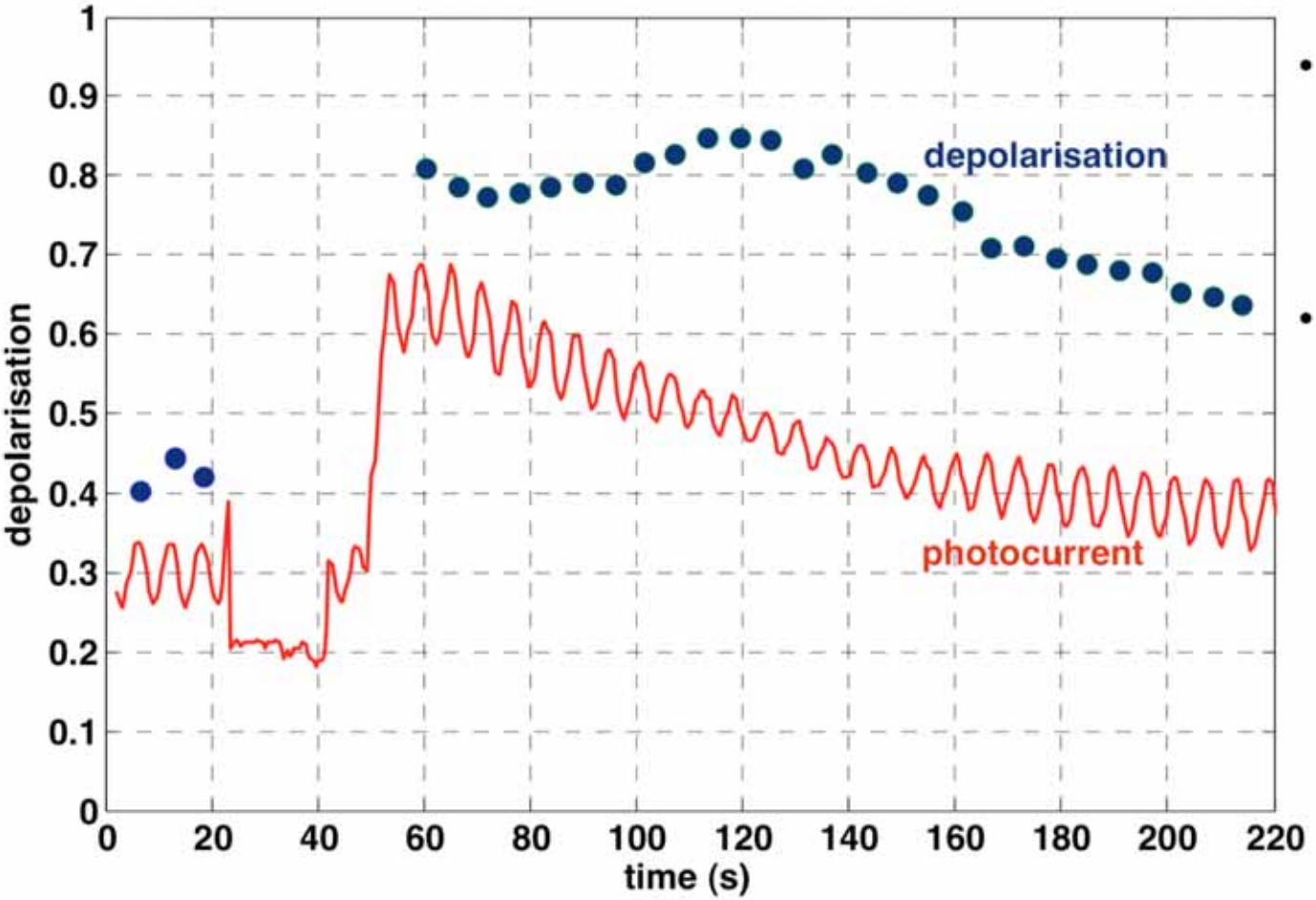




Photodiode signal with rotating polariser



Depolarisation from amber LED

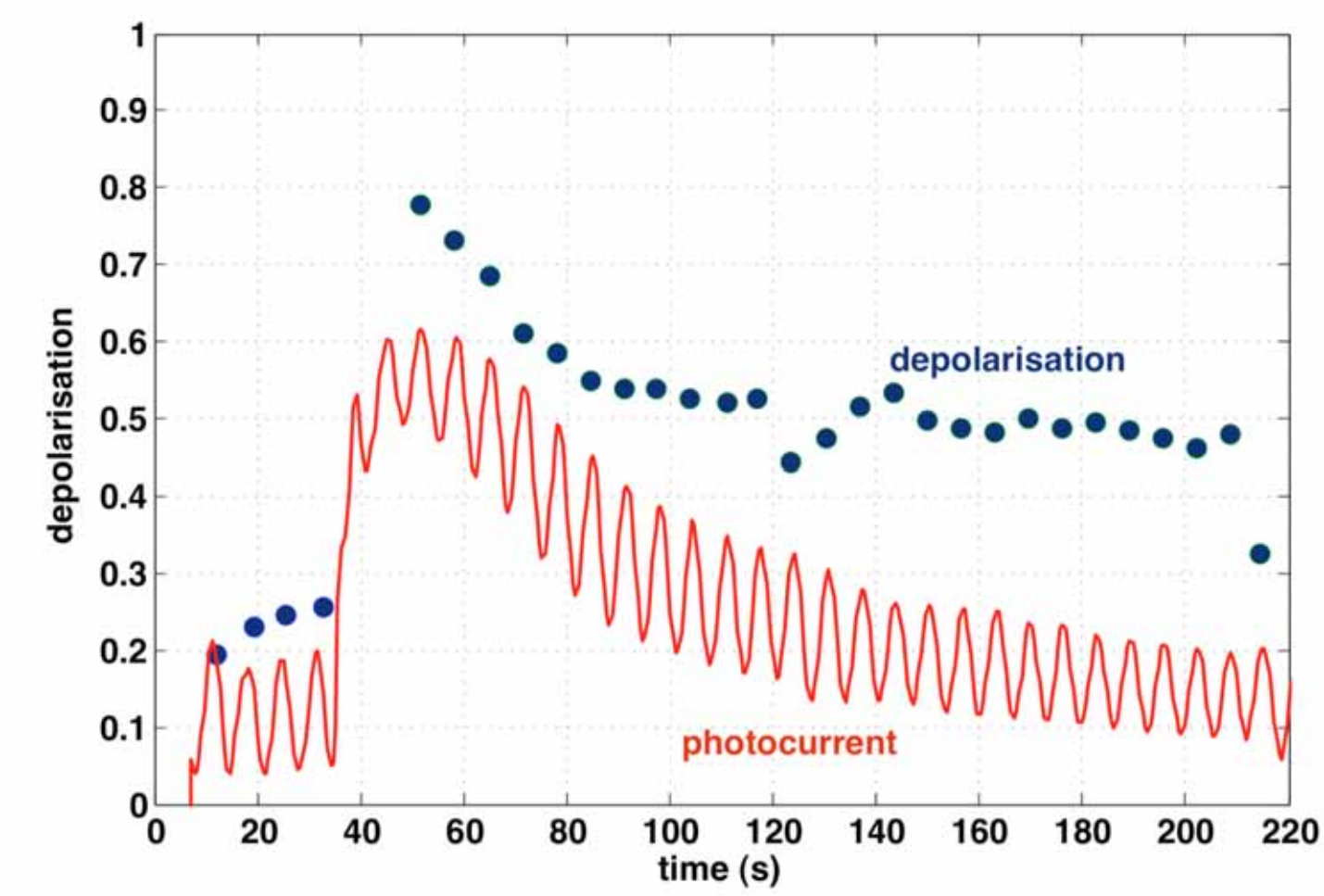


- Depolarisation measure used is

$$\delta = \frac{I_{\perp}}{I_{\parallel}}$$

- Photocurrent
  - low-pass filtered
  - background removed

Depolarisation from blue LED



Needed

- Opportunities for validation
  - Esp. in-situ cloud particle imagers - on planes, towers or tethered balloons
  - mm-wave radar
- Partners
  - with instruments for intercomparison
  - Platforms, balloon facilities etc
- Funding
  - Having the first two in place should make this third problem much easier!