Star Formation at Redshift 1:
Multi-object near-infrared spectroscopy
with CIRPASS

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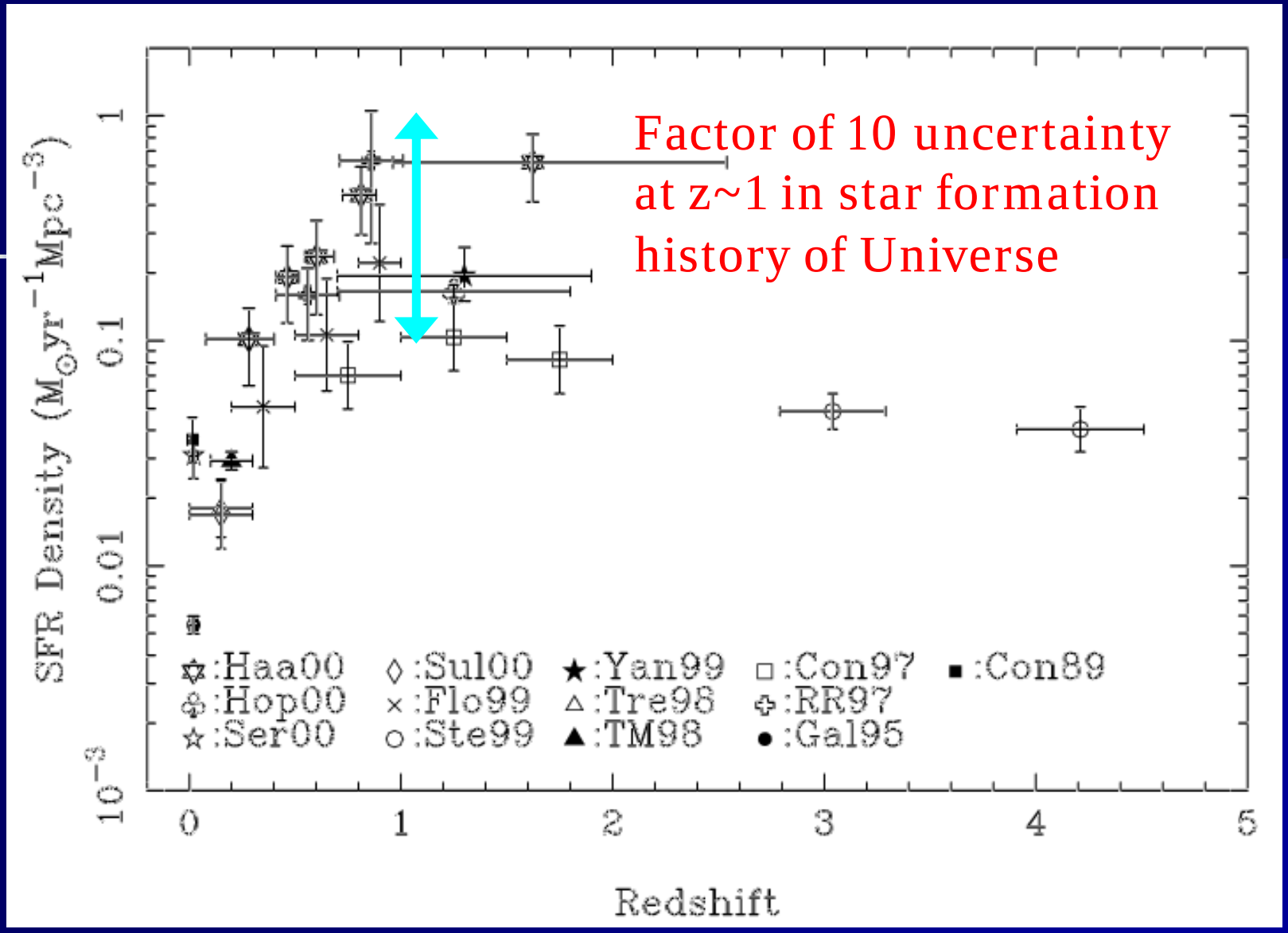
Background

- Key problem in observational cosmology
  => At what epoch did majority of stars form?

- Star formation rate (SFR) higher in recent past
  => peaks around z=1-2?

- Large discrepancies between SFR estimates obtained from different methods

  => different indicators have uncertain relative calibration and are differently affected by dust extinction



Madau-Lilly diagram (from Hopkins et al. 2001)

Hα as an SFR indicator

- Hα (6563Å) emission line
- Hα luminosity proportional to ionising flux from massive stars

  => instantaneous SFR
- Relatively immune to metallicity effects
- Less susceptible to extinction than the rest-UV
- tracing Hα to early epochs forces a move to NIR at z>0.6

Hα in the Infrared

- Previous Hα surveys in NIR restricted to small samples

  => long-slit spectroscopy (inefficient for surveys in terms of telescope time)

  => e.g. Glazebrook et al. (1999), Tresse et al. (2002) @z~1 , Erb et al. (2003) @z~2

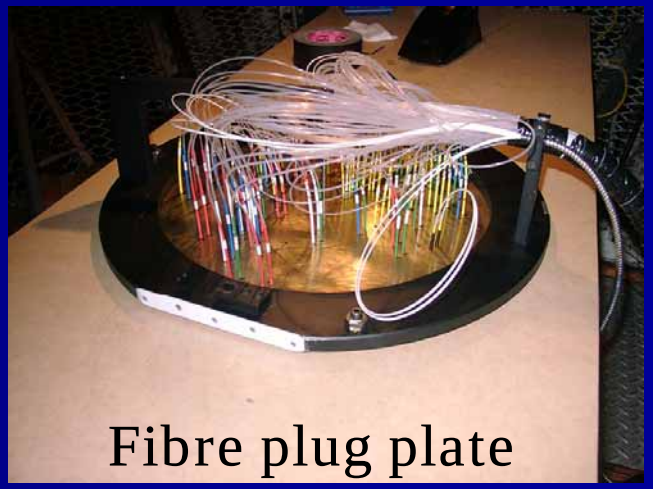
- Need a large sample (several hundred!) to address the issue properly

CIRPASS

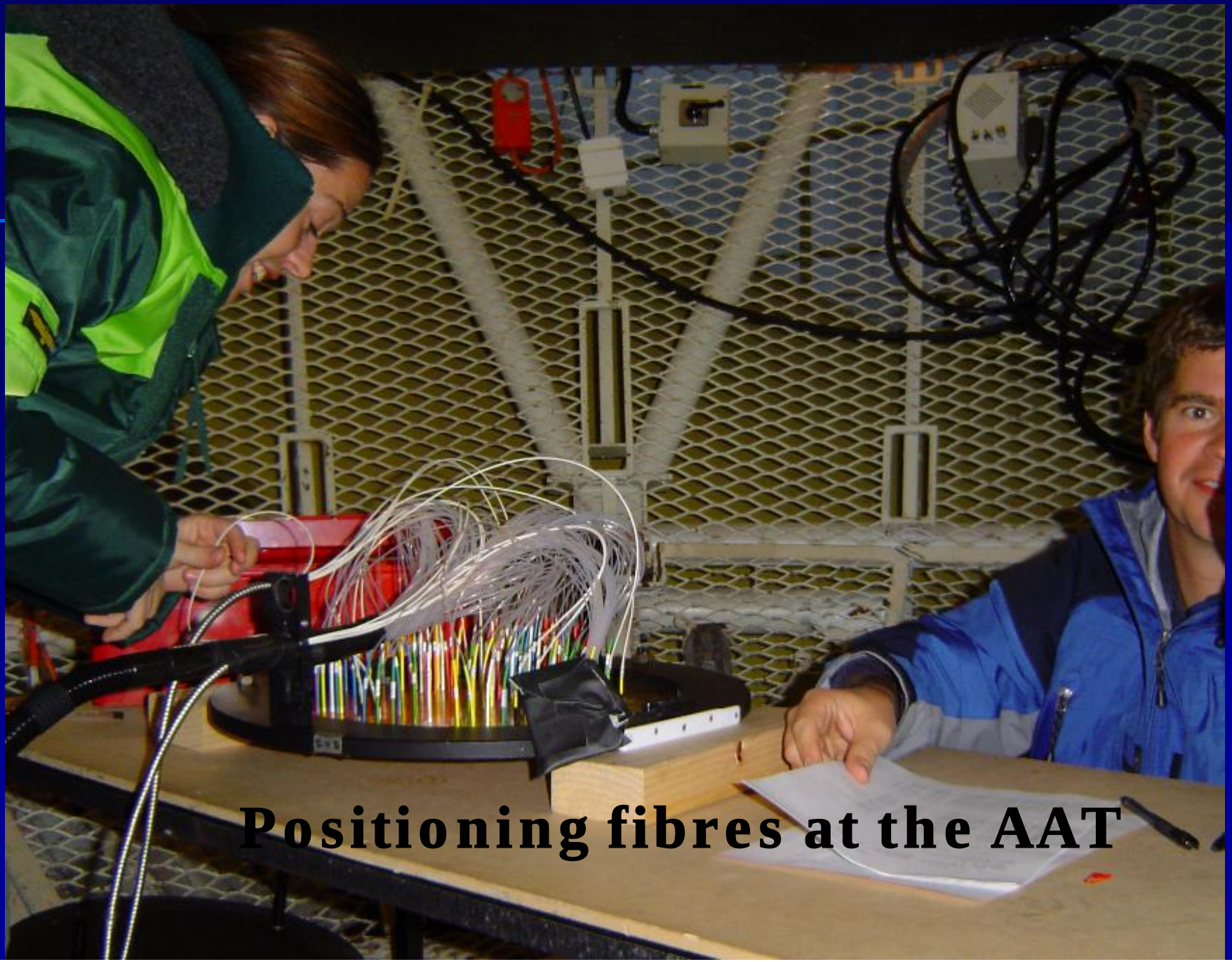
Cambridge InfraRed PAnoramic Survey Spectrograph

- A near infrared fibre-fed spectrograph
- Built at the IoA (Parry et al.) with support of Sackler foundation & PPARC
- Two modes
  => Integral Field Unit with 490 elements
  => Multi-object mode, 150 fibres
- Operates between 0.9-1.67 micron
- resolving power R~5000, great sensitivity between skylines

Instrument cryostat on dome floor



Fibre plug plate



Positioning fibres at the AAT

Hα Survey with CIRPASS

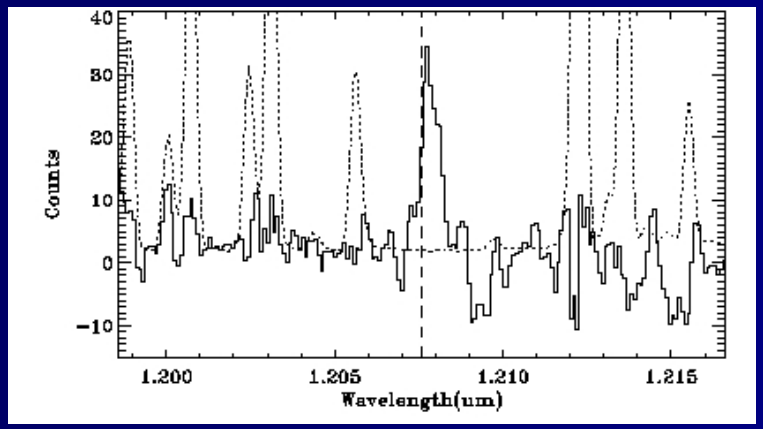
- CIRPASS-MOS - huge multiplex advantage over any other IR spectrograph, making it ideal for surveys
- use the same robust star formation tracers used locally (e.g. Hα) at z>1 to study history of star formation.

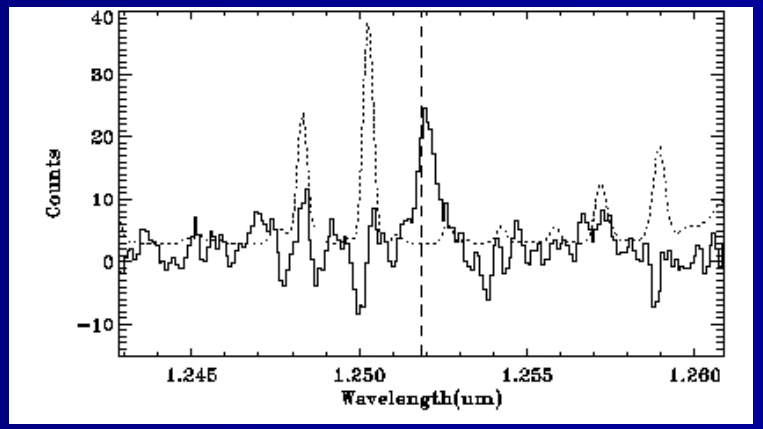
- Aim to survey ~500 galaxies at 0.7<z<1.5

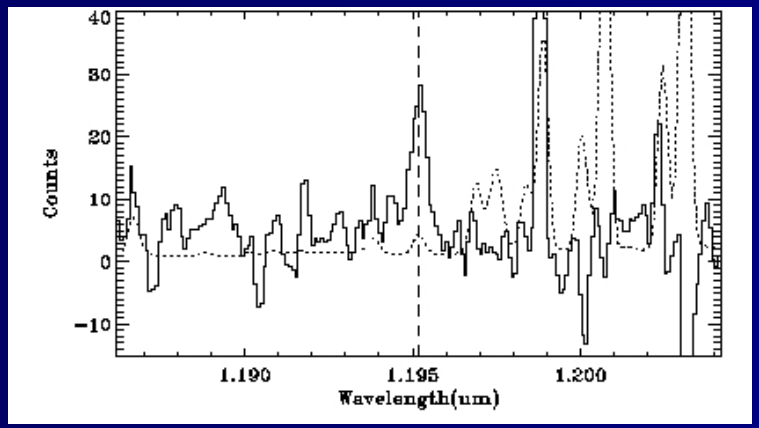
=> observed clouds in Australia
in October, and spent
Christmas/New Year at
WHT on La Palma!

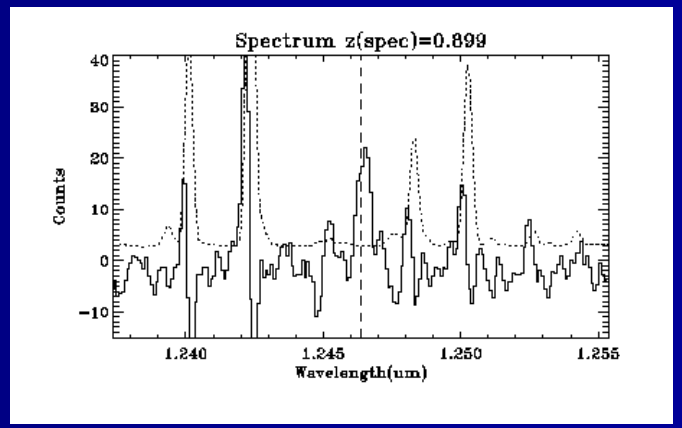
Results!

HDF-N galaxies, observed in Hα with CIRPASS on WHT









Doherty, Bunker, Sharp et al. *(in prep.)*

Hubble Deep Field North

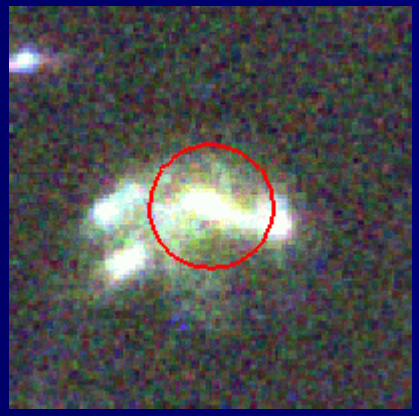
- Limiting flux of 1.0×10^{-16}erg s^{-1} cm^{-2},

  5σ in 3 hours = 5 M_{sun}/yr (for a Ω_m=0.3,Ω_λ=0.7,H_o=70km s^{-1} Mpc^{-1} cosmology)
- 7 detections at >5σ
- Compare Hα to SFR from UV flux

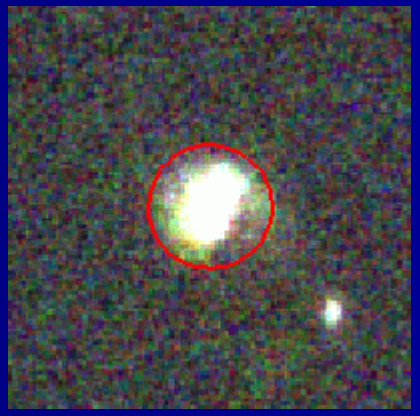
  => photometry from GOODS HST/ACS images,

  B band (4500Å) is rest-frame UV at this redshift
- Find $SFR_{H\alpha}/SFR_{UV}$ ratio of 2-3, consistent with results found by Glazebrook et al., Tresse et al., at similar z

Hubble Deep Field North



extended



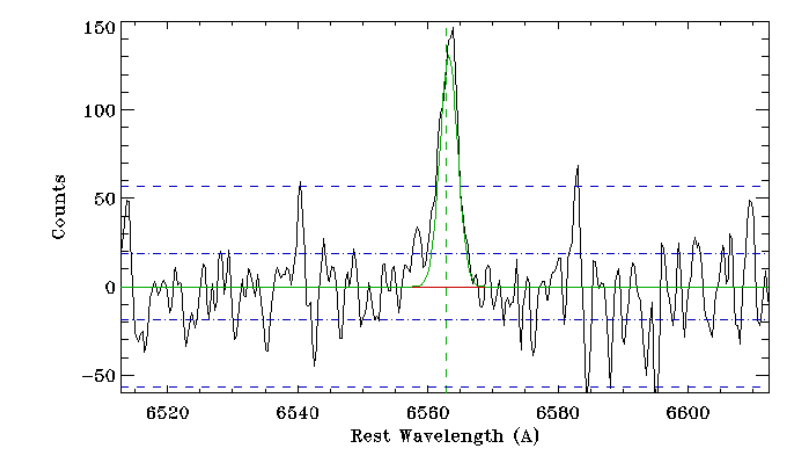
compact

- 1.1” fibres – results heavily seeing dependant
- affects different morphologies differently

Ongoing Work

- We have a spectroscopic sample in HDFN, complete to a mag limit (R~24 mag) - redshifts known from optical (Cohen et al. 2000)

- want true star formation rates: can stack Hα lines



'quick-look' stack of HDFN made by Rob Sharp

- VVDS spec z's – working with VIRMOS consortium, Le Fèvre et al), to expand our sample size

=> Have applied for time on WHT (4m) and VLT (8m)

Conclusions

- Have performed multi-object, near-infrared spectroscopy of z~1 galaxies in HDFN
- Part of an on-going survey to trace SFRs at this crucial epoch
- have presented our brightest detections of Hα in just three hours – proof the technique works!
- can detect star formation to 5 solar masses per year (5σ in 3 hours) on a 4m telescope
- We have ~70 galaxies (with at least upper limits to the SFR) – this already an improvement over previous work
- BUT: Want several hundred to pin down Hα luminosity function at z~1 .
- Complete the survey => applied for WHT and VLT time