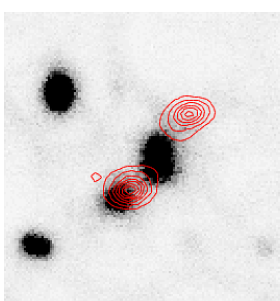
Searching for HI absorption in the brightest southern radio galaxies

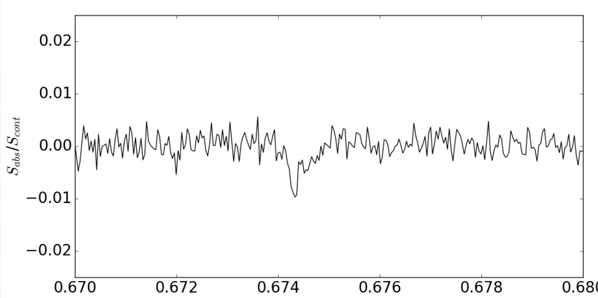
Elizabeth Mahony

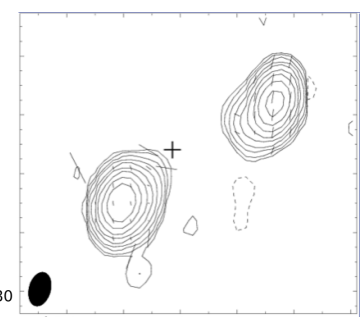
University of Sydney / CAASTRO

+ FLASH team: E. Sadler, J. Allison, V. Moss, M. Glowacki, S. Curran, M. Whiting, R. Morganti.

ASKAP-FLASH



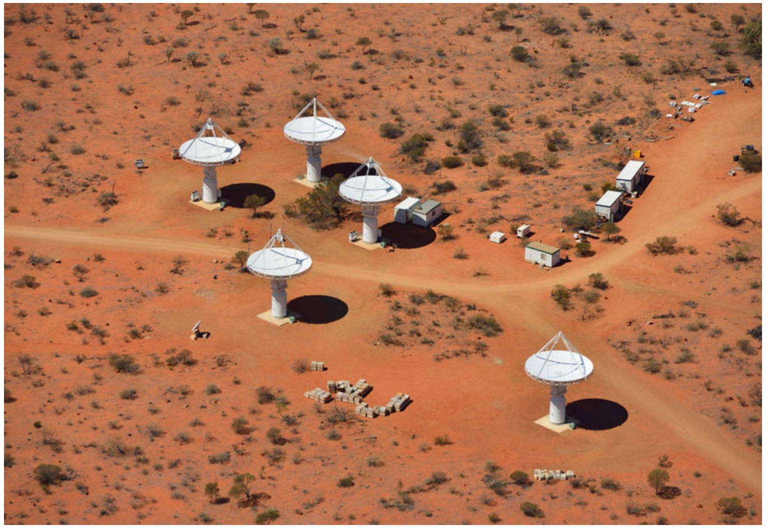




The FLASH survey

The **F**irst **L**arge **A**bsorption **S**urvey in **H**I:

- Search ~150,000 sightlines for HI in absorption
- No pre-selection on background target sources
- HI-selected galaxy sample at $0.4<z<1.0$.



Detections can be split into two categories:

- **Intervening absorbers:** Study the *cosmic evolution of HI*, testing current galaxy evolution and mass assembly models
- **Associated absorbers:** Study *AGN fuelling and feedback* processes in powerful radio galaxies

Image credit: CSIRO

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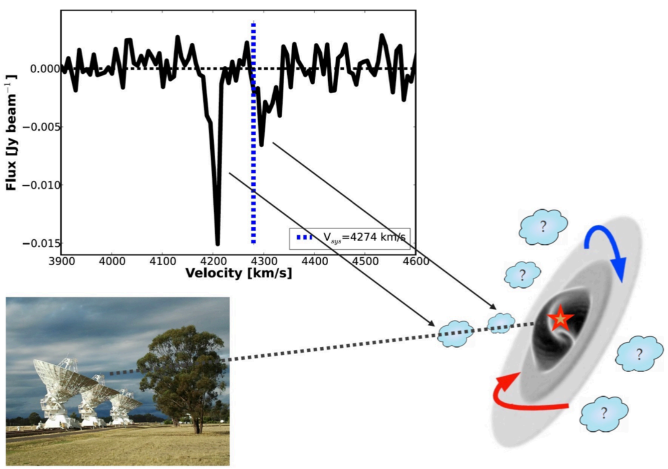
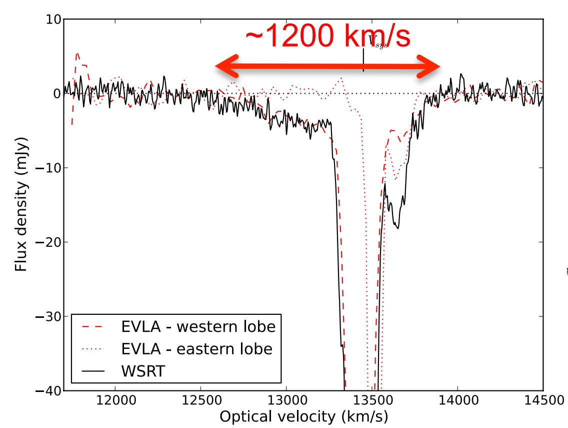
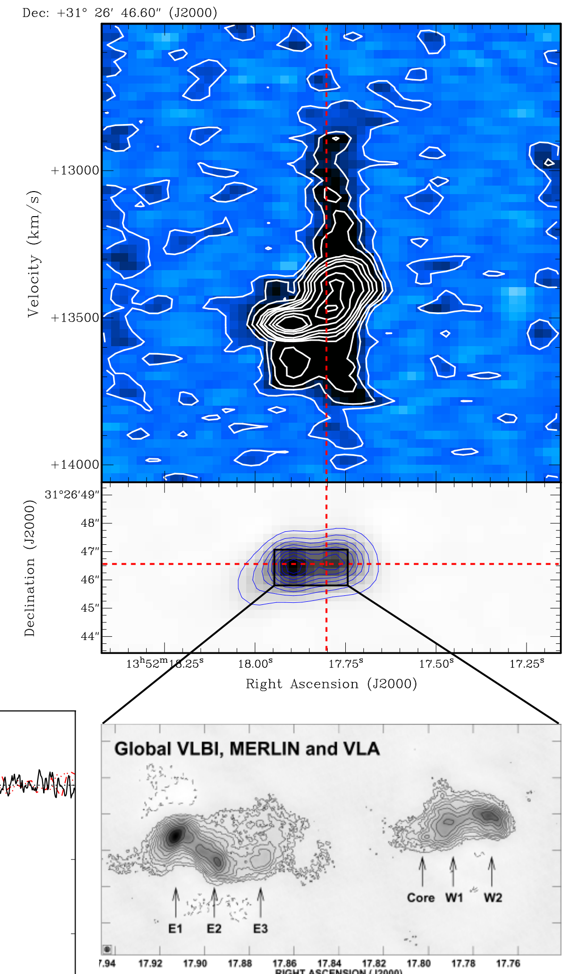
AGN fuelling and feedback

- Probe the fuelling and feedback mechanisms in AGN
  - Study the distribution of cold gas in the central regions of radio AGN
    - Is the gas infalling or in outflow?
    - How do the radio-jets interact with the ISM? Does it play a role in regulating SF? Or in driving outflows?



Maccagni et al., 2014





Mahony et al., 2013

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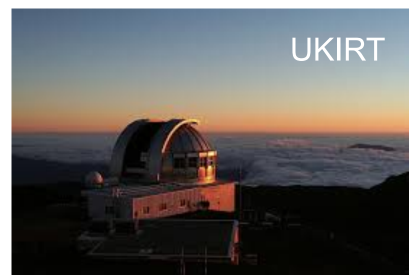
The 2-Jy sample

- Observed 16 sources selected from the 2-Jy sample with ASKAP-BETA
  - Sample of the brightest southern radio sources selected to be brighter than 2 Jy at 2.7 GHz (Wall+ Peacock 1985)
  - Redshift range $0.2<z<0.7$
- Pilot for FLASH survey – sources selected based on flux density only
- Comprehensive multi-wavelength follow-up (Morganti+93, Tadhunter+93, Morganti+99)

Multi-frequency radio imaging

Deep optical imaging and spectroscopy



Near, mid and far-IR data

X-ray imaging

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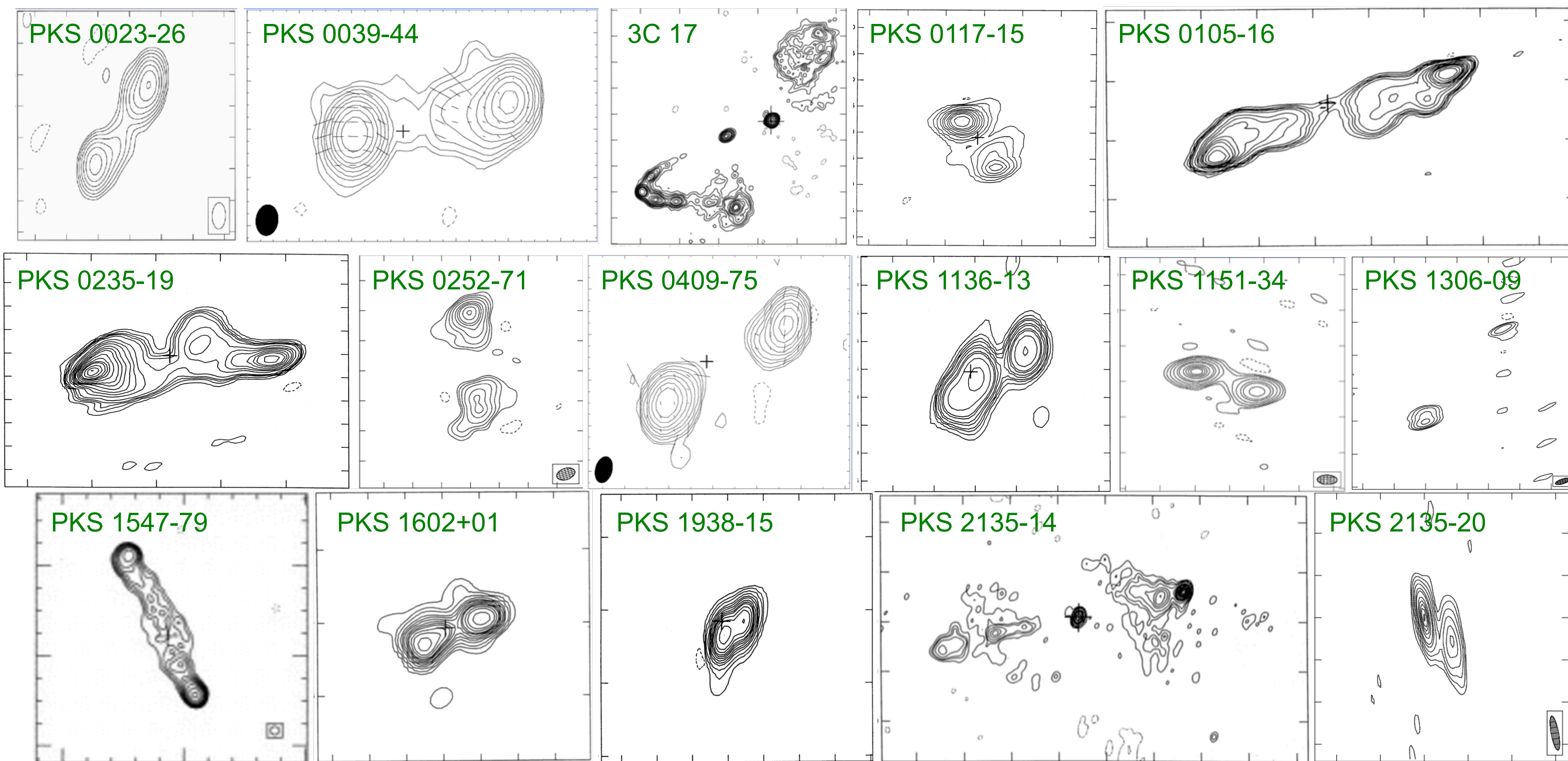
The 2-Jy sample

- Observed each source for 3-7 hrs per source, aim to reach optical depths of ~few per cent.
- Wide range in source size covered!



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The 2-Jy sample

Source	z	Radio class	Optical class	Cont. flux (Jy)	Hrs obs.	Sabs/Scont (5σ)
PKS 0023-26	0.322	CSS	NLRG	11.7	3	4%
3C17	0.220	FRII	BLRG	10.4	4	8%
PKS 0039-44	0.346	FRII	NLRG	5.9	3	10%
PKS 0105-16	0.400	FRII	NLRG	8.6	2.5	2%
PKS 0117-15	0.565	FRII	NLRG	9.1	2.5	2%
PKS 0235-19	0.620	FRII	BLRG	6.5	3	3%
PKS 0252-71	0.563	CSS	NLRG	8.5	4	1%
PKS 0409-75	0.693	FRII	NLRG	21.1	4	0.5%
PKS 1136-13	0.554	FRII	QSO	8.0	4	4%
PKS 1151-34	0.258	CSS	QSO	7.5	3	6%
PKS 1306-09	0.464	CSS	NLRG	7.0	7	1.5%
PKS 1547-79	0.483	FRII	BLRG	6.0	3	2%
PKS 1602+01	0.462	FRII	BLRG	7.7	7.5	1.5%
PKS 1938-15	0.452	FRII	BLRG	12.3	3	2%
PKS 2135-14	0.200	FRII	QSO	7.2	3	10%
PKS 2135-20	0.635	CSS	BLRG	3.8	4	5%

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BETA spectra

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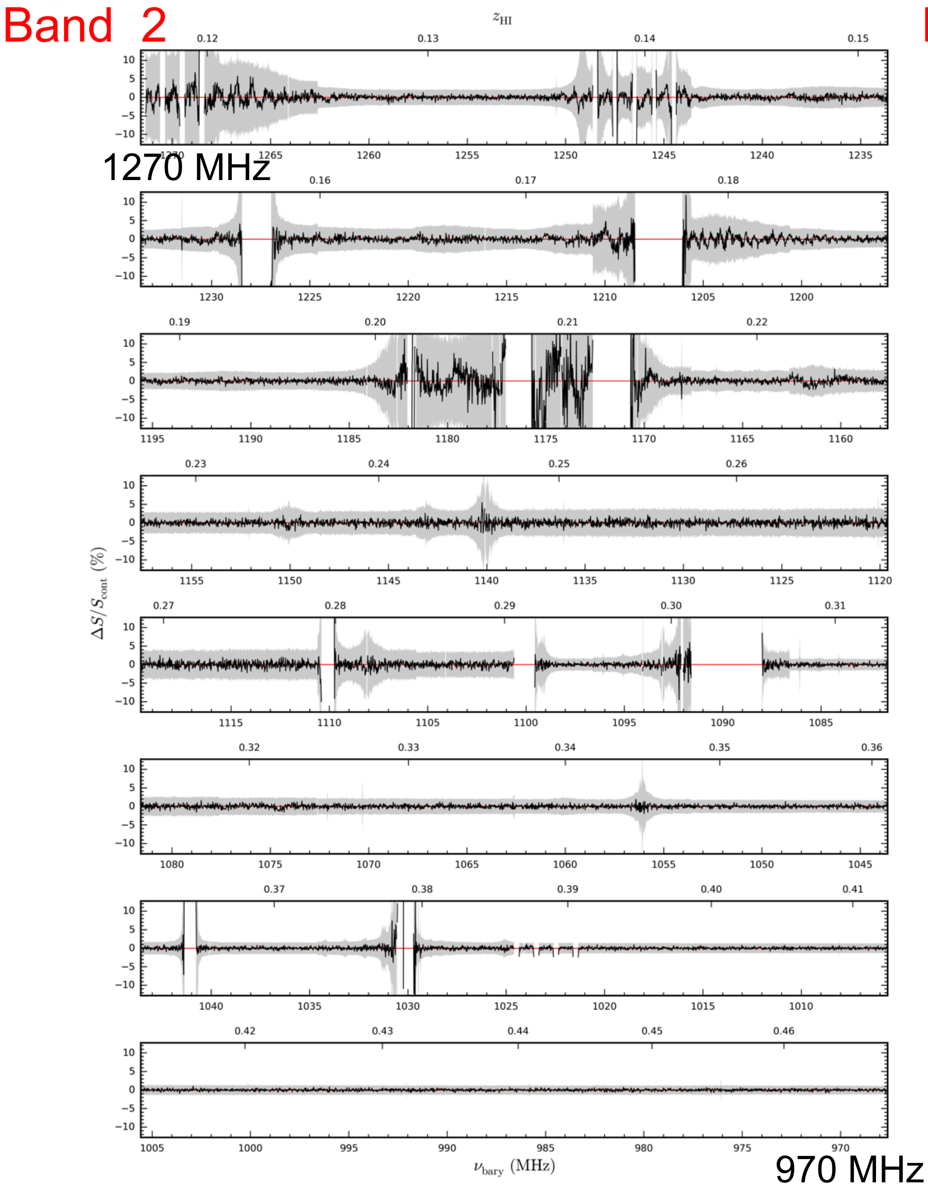
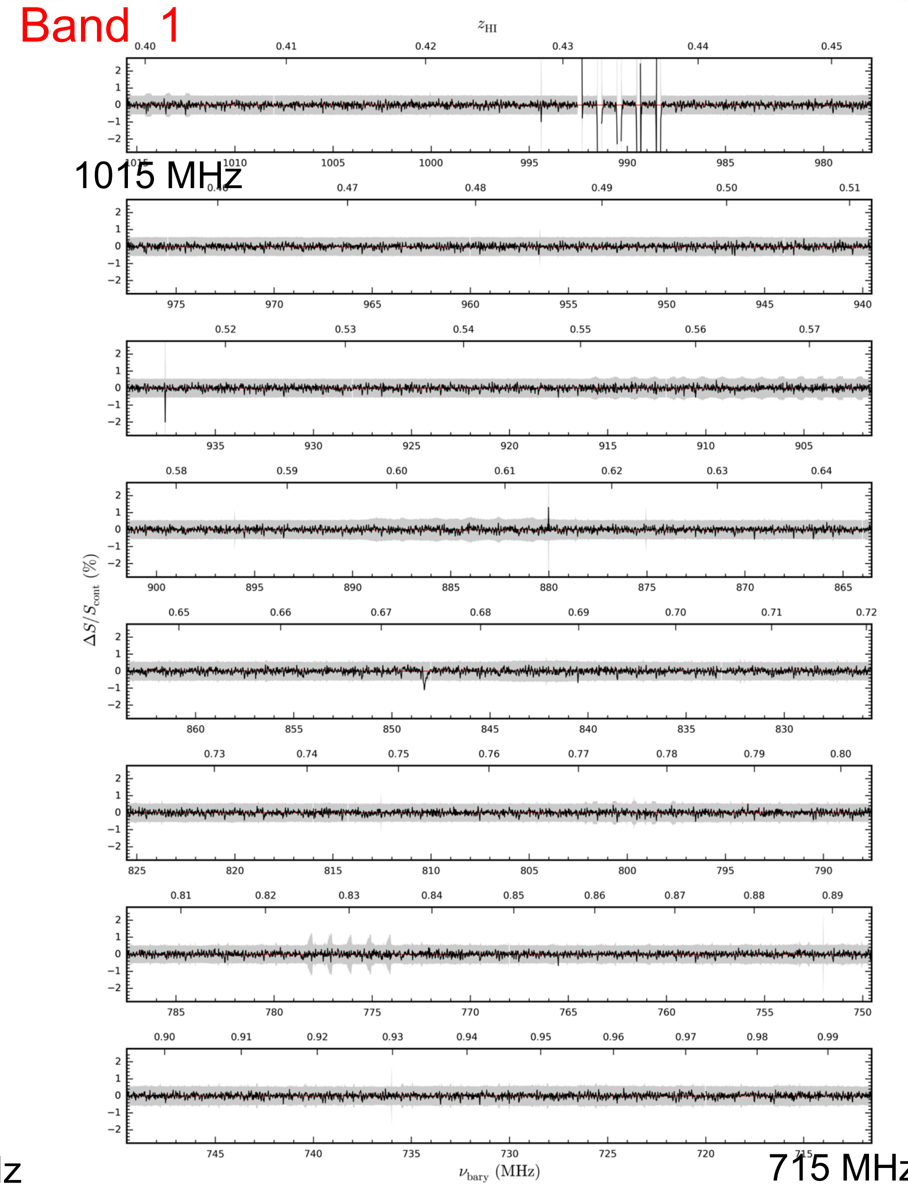
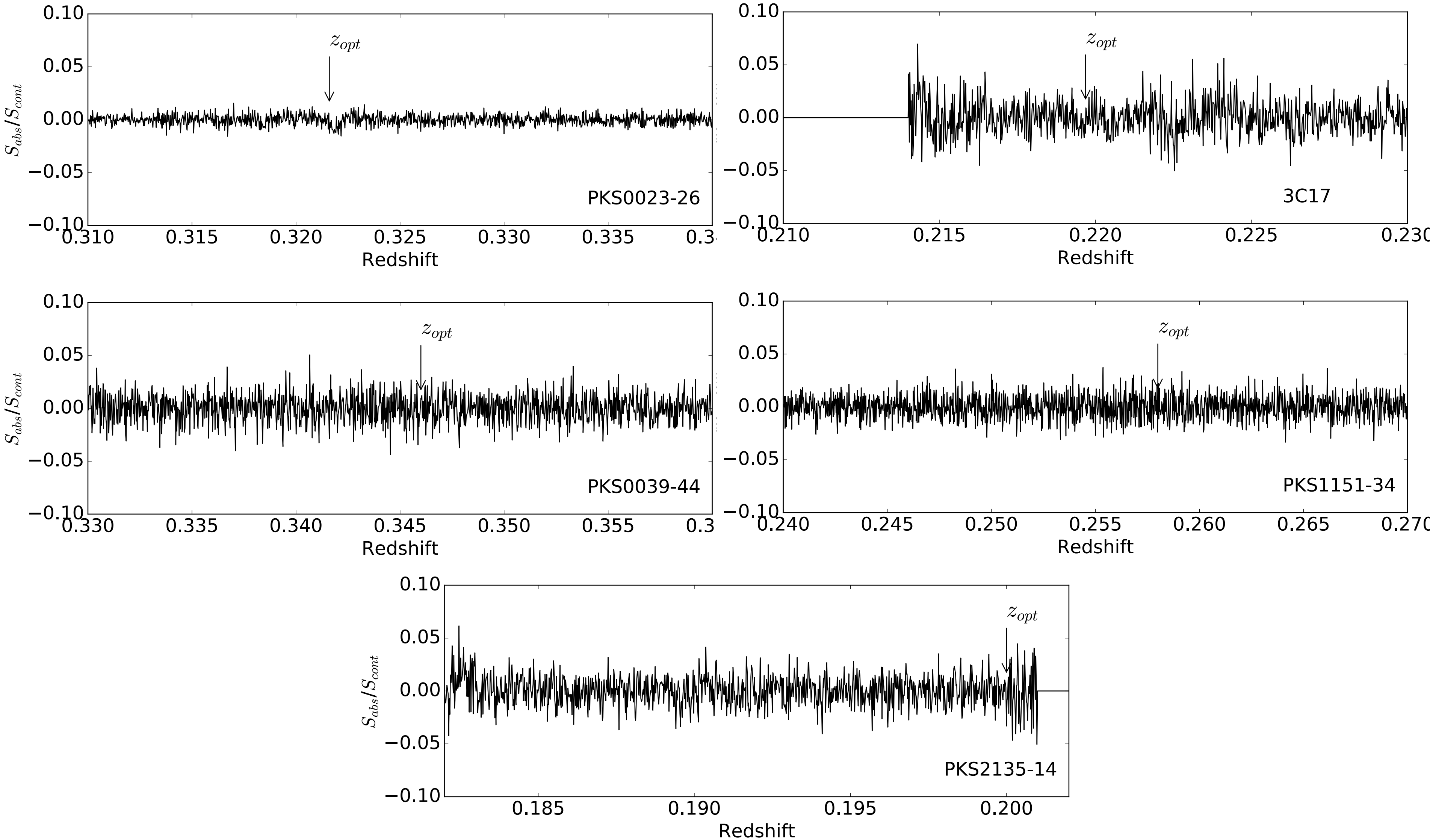




Band 2 spectra (0.2<z<0.4)



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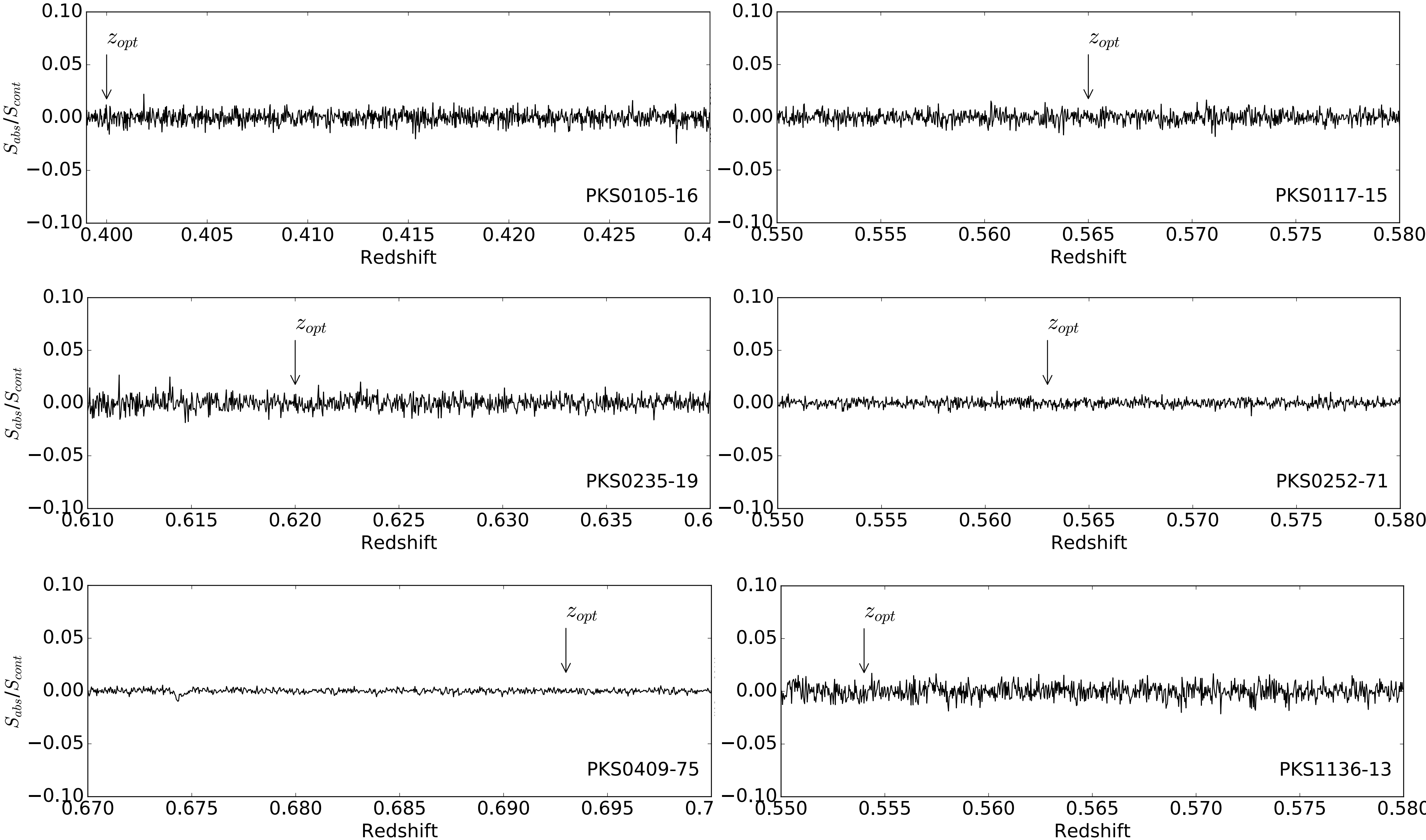

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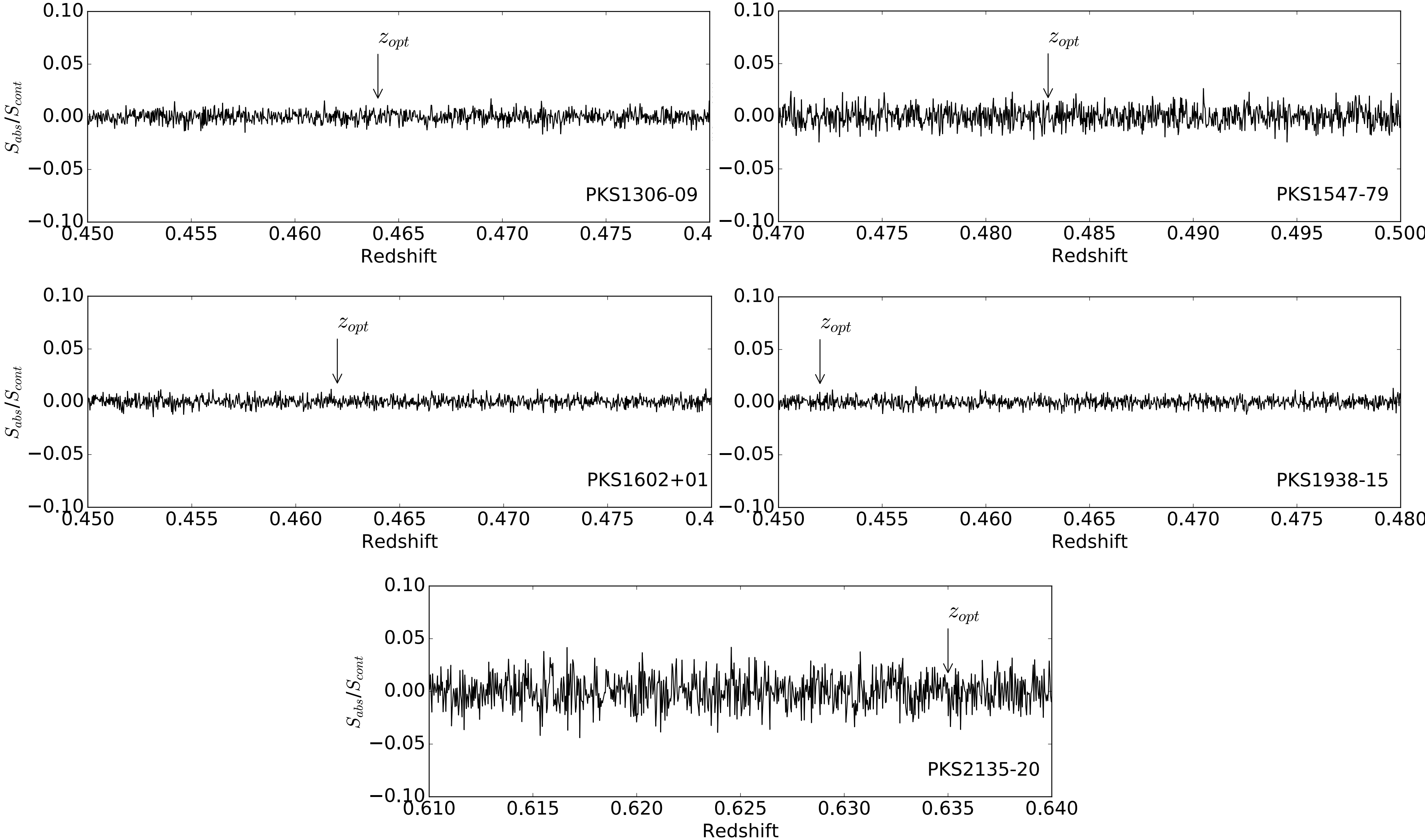

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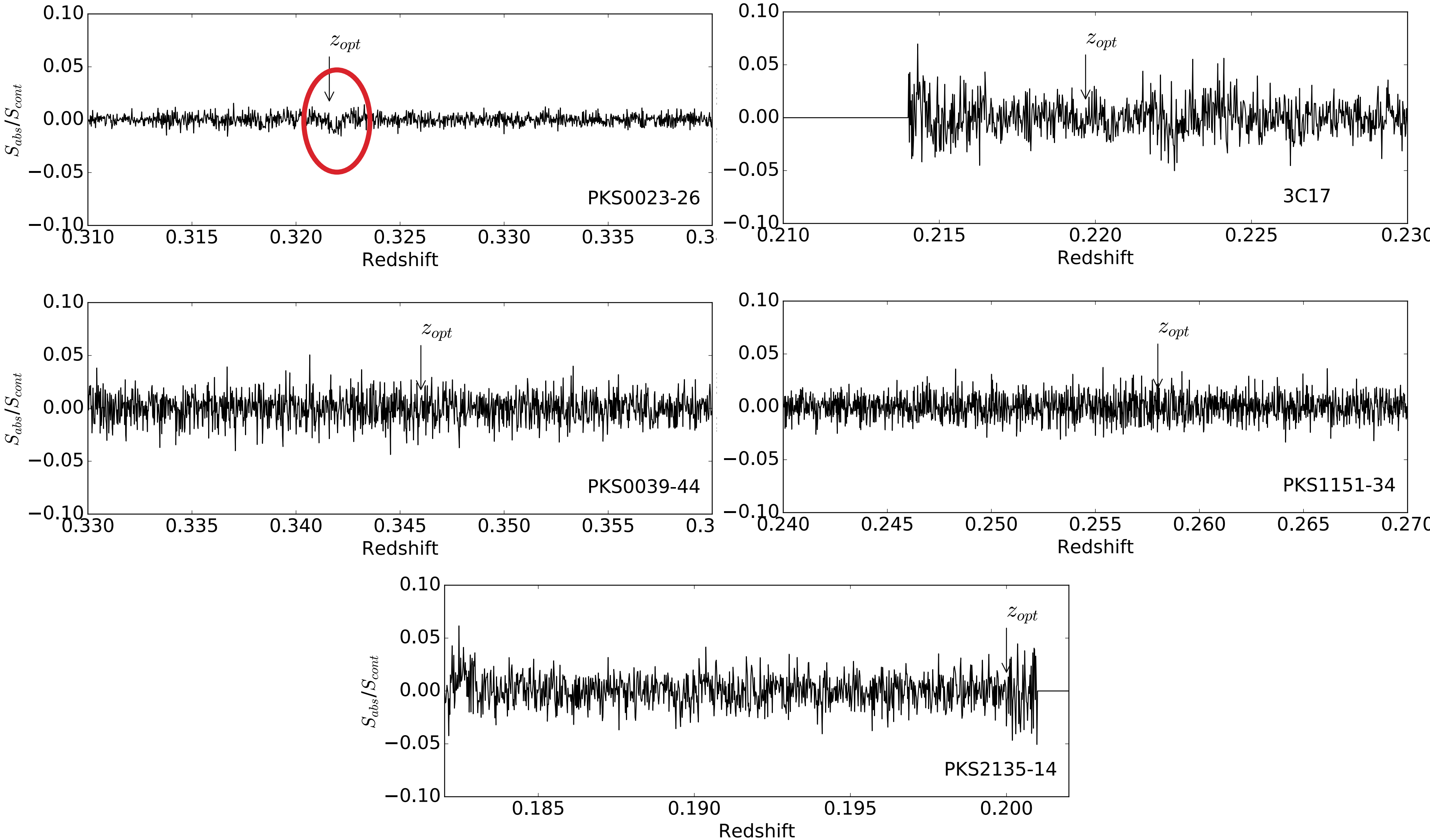

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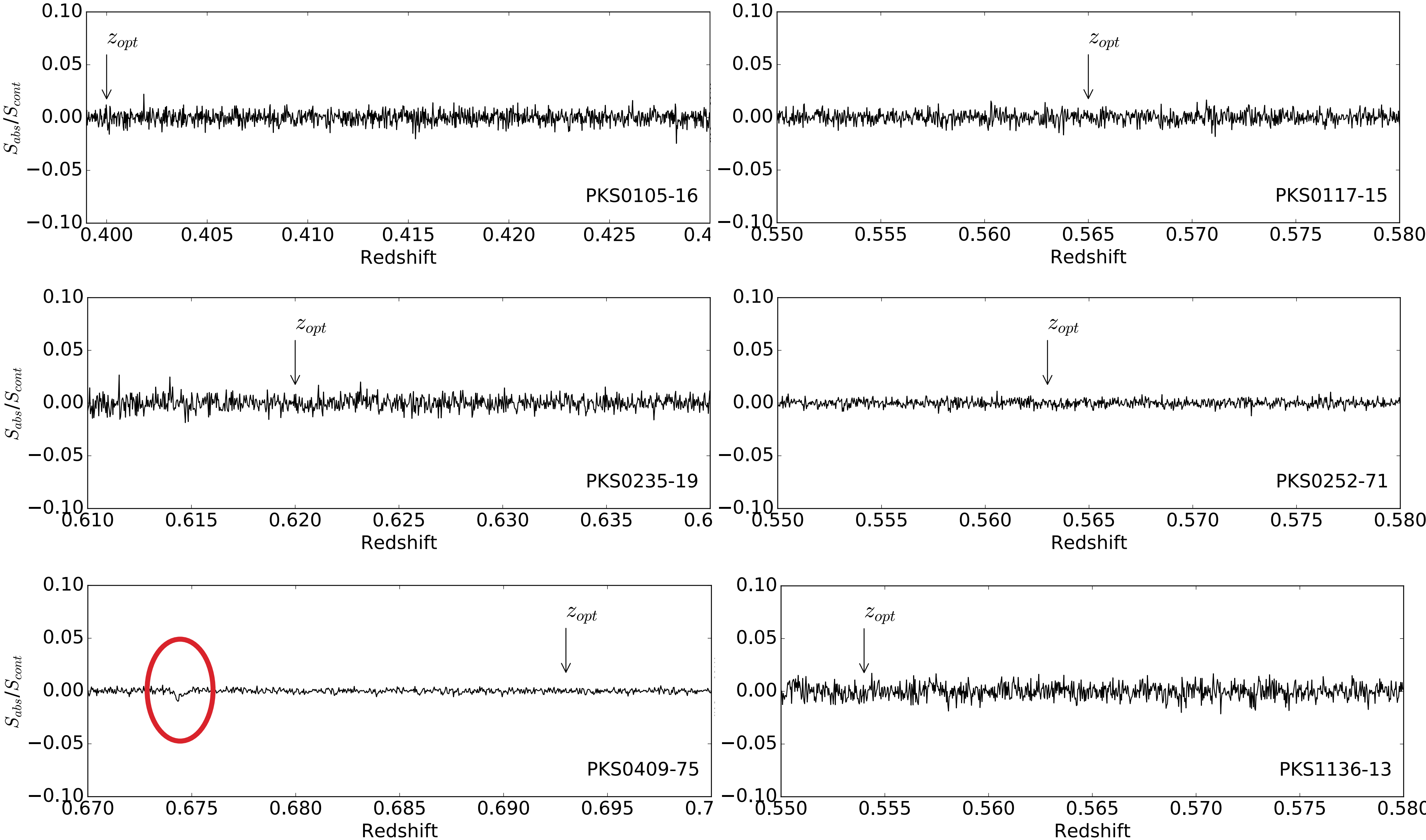
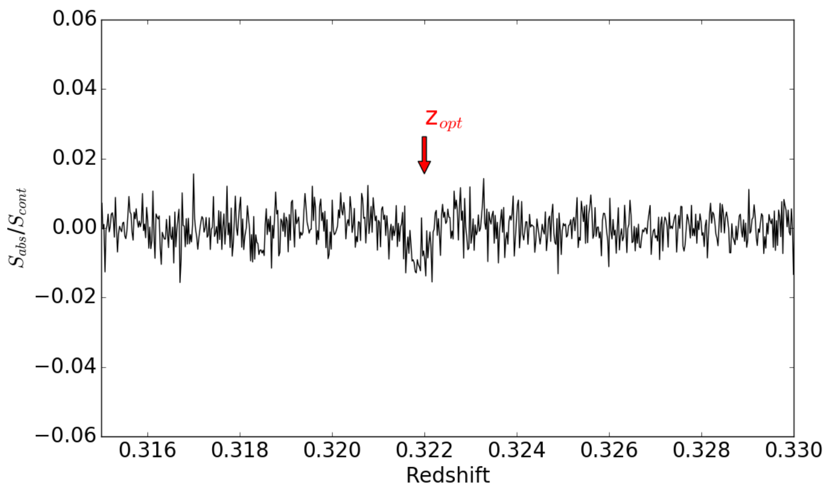
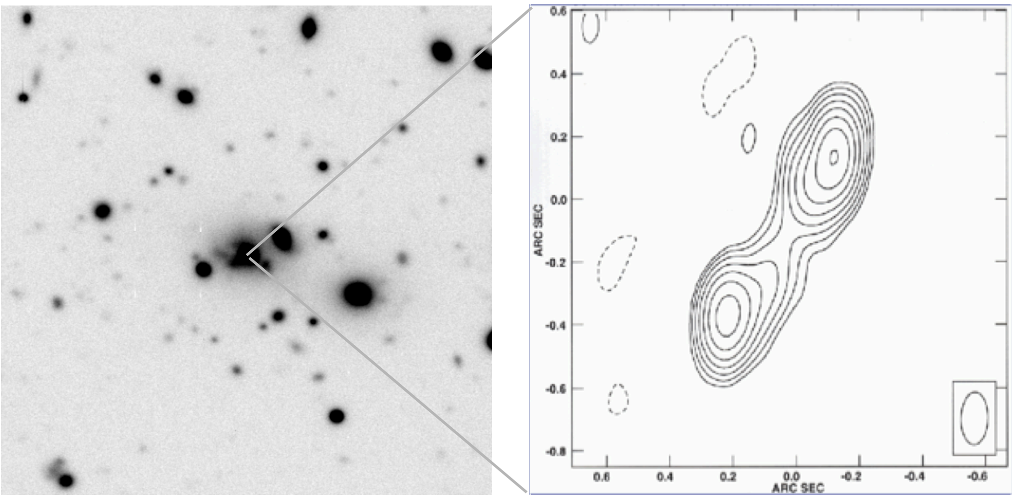


PKS 0023-26

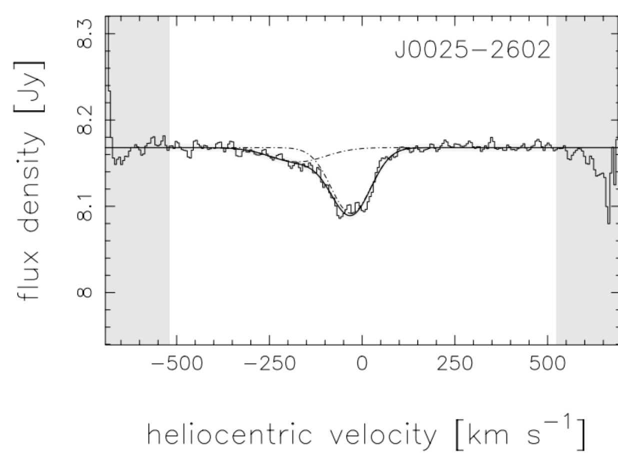
› CSS source at z=0.322





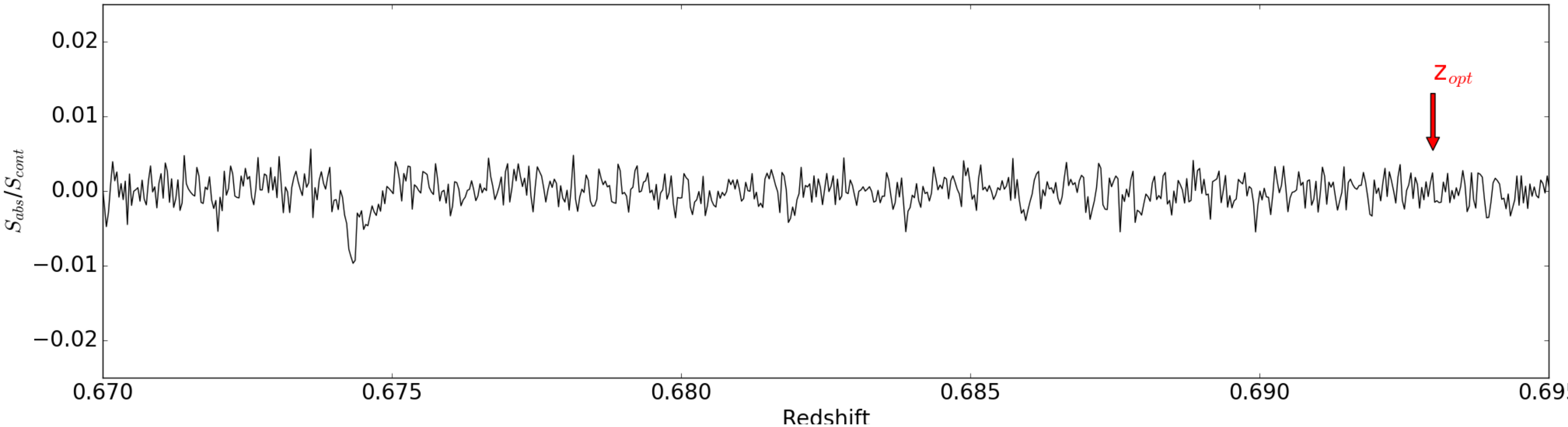
Gemini GMOS-S *Merlin 5 GHz,* Tzioumis+ 2002

› HI previously detected with WSRT:

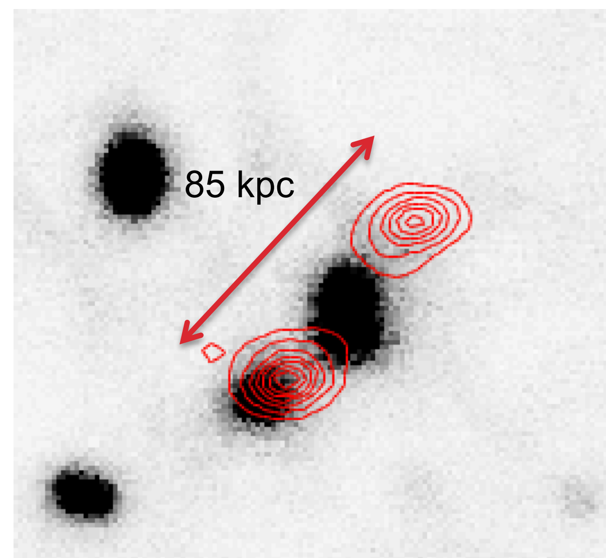


Vermeulen+ 2003

PKS 0409-75



- z_{HI} = 0.674, but z_{opt}=0.693 -> HI blueshifted by 3000 km/s
  - Is this absorption associated with the host galaxy?
  - Or associated with another galaxy in the group?
    - Need follow-up observations for confirmation: optical spectroscopy of nearby source, ALMA
  - A chance alignment?



Background: Gemini i-band
Contours: ATCA 3cm

HI absorption in bright radio sources

- Using BETA observations we detect 2/16 sources; detection rate ~12.5%
  - Is this lower than expected compared with other surveys?
  - **No prior selection on source morphology**

- Lower detection rate than previous studies:
  - Morganti+2001: Searched for HI absorption in 2-Jy sources in the redshift range 0.1<z<0.2 - detected 5/23 sources (22%)
  - Samples of compact sources have higher detection rates of ~30% (i.e. van Gorkom+ 1989, Gereb+ 2014, Maccagni+ 2017)

- Not selecting compact sources or not sensitive enough?
  - Need to be careful about covering factor!

Multiwavelength follow-up is essential!

› FLASH will not *just* be a HI survey – multiwavelength data is essential to understand the processes involved. How do we follow-up detections?

Need in advance

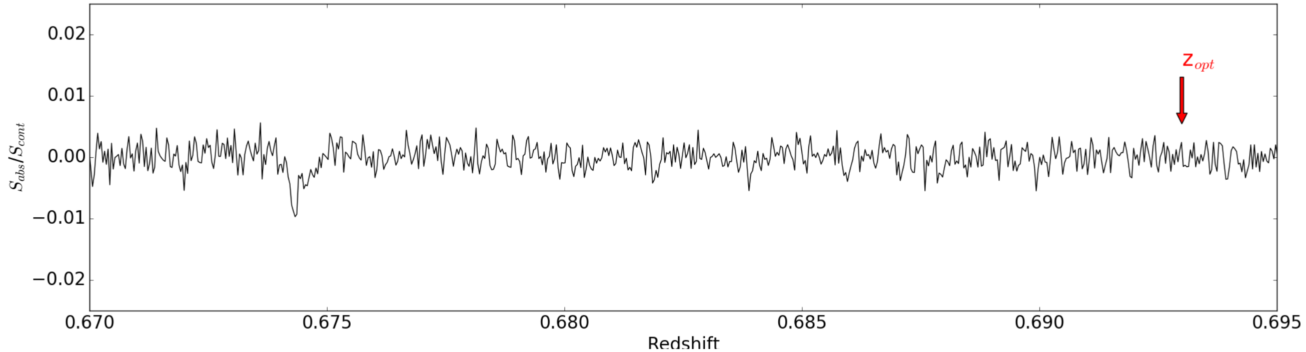
- Redshift of background radio sources -> Taipan, photo-z's?
- High resolution radio data -> VLBI, MWA IPS

Follow-up

- Deep optical/IR imaging of HI absorber -> 8m telescopes?
- Molecular/ionised gas properties -> ALMA, MUSE, SAMI/Manga
- Higher sensitivity absorption -> MeerKAT, uGMRT

Conclusions

- Observed 16 sources selected from the 2-Jy sample with BETA
  - Detected HI absorption in PKS0409-75 at z=0.67, offset from the systemic by 3000 km/s.



  - Detected HI absorption in PKS0023-26 at z=0.322, associated with CSS radio source in merging system.
- This sample highlights the need for complementary multi-wavelength data to maximise the scientific return of future HI surveys
  - Extensive follow-up of detections will be essential
  - Can we use pilot studies like this to model the source population and extrapolate for larger surveys?