

21cm Cosmology Workshop 2024 & Tianlai Collaboration Meeting

21cm Cosmology Workshop Summary

Reza Ansari
Univ. Paris-Saclay & Irfu/DAP (CEA)

21cm Cosmology workshop , Hangzhou, China, 24 July 2024

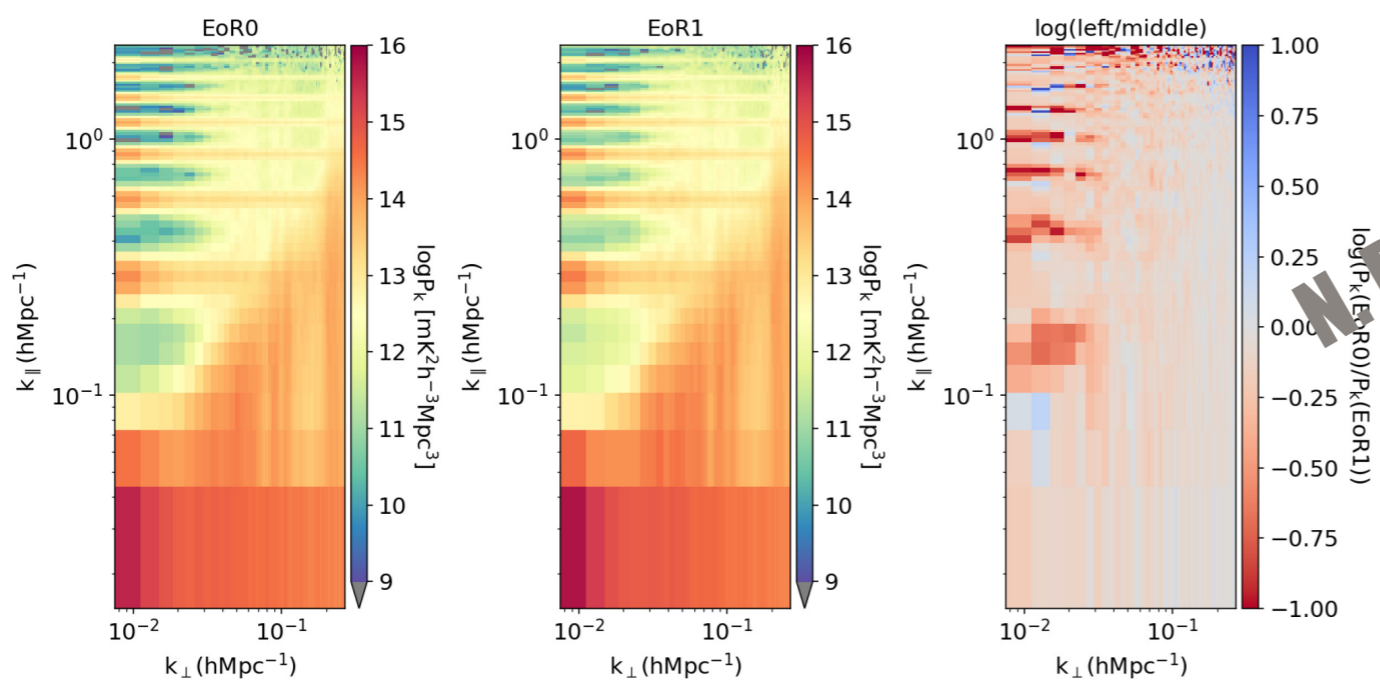
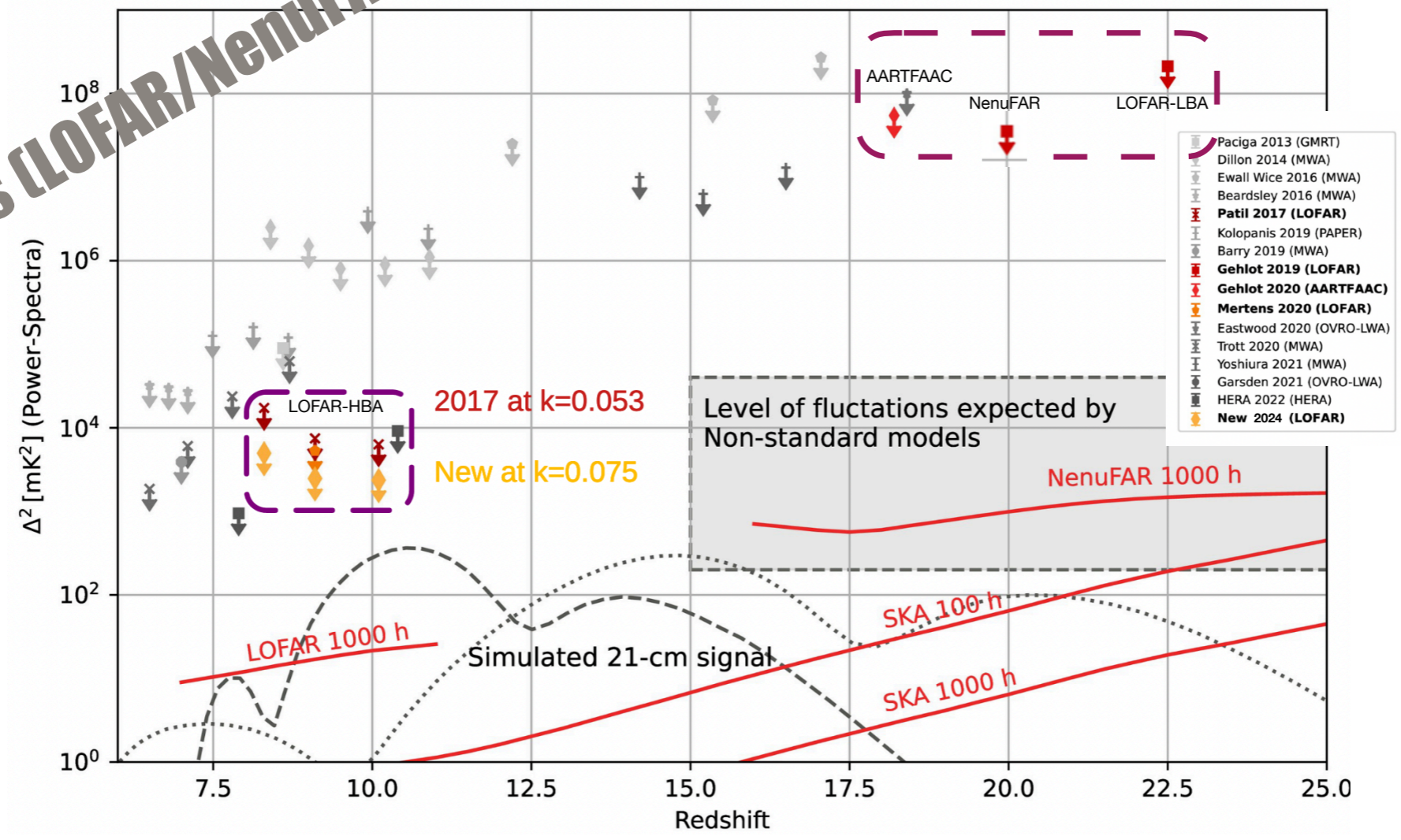
The summary speaker

- Xuelei : *Hi Reza, we should find a summary speaker*
- Reza : *OK, I don't know, maybe we can ask XXX*
- Xuelei : *Yes, it would have been nice, but he said that he is too busy*
- Reza : *It's a pity, let's see ... euh ... what do you think of YYY ?*
- Xuelei : *Wonderful ! I had exactly the same idea.*
- Reza : *Good, so let's ask her.*
- Xuelei : *Unfortunately, I already tried. She told me that she is busy tomorrow afternoon - A teleconf with her lab management.*
- Reza : *I have no other suggestion. We can simply skip it, nobody will complain*
- Xuelei : *No, we should have a summary talk. I thought that you could do it ...*
- Reza: *What ? Me ? You are kidding. What do you want me to summarise, I wasn't listening to the talks !*
- Xuelei: *Come on Reza, you can't just come and spend your time eating in the restaurant and then relax. We are here to work - Science count on us !*

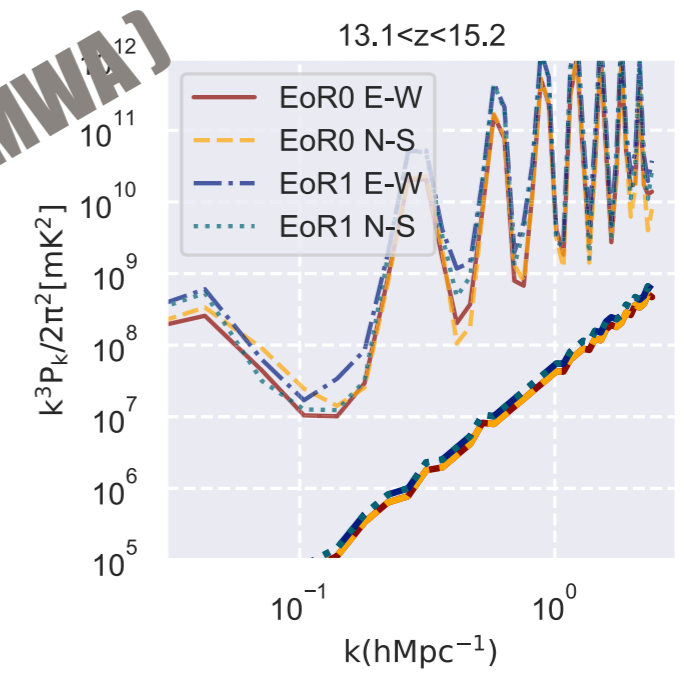
Workshop sessions

1. EoR & Cosmic Dawn
2. Post EoR Intensity Mapping
3. Data analysis challenges
4. Simulation & forecasts
5. Global spectrum experiments
6. Experimental challenges
7. Looking Beyond

F. Mertens (LOFAR/NenuFAR)



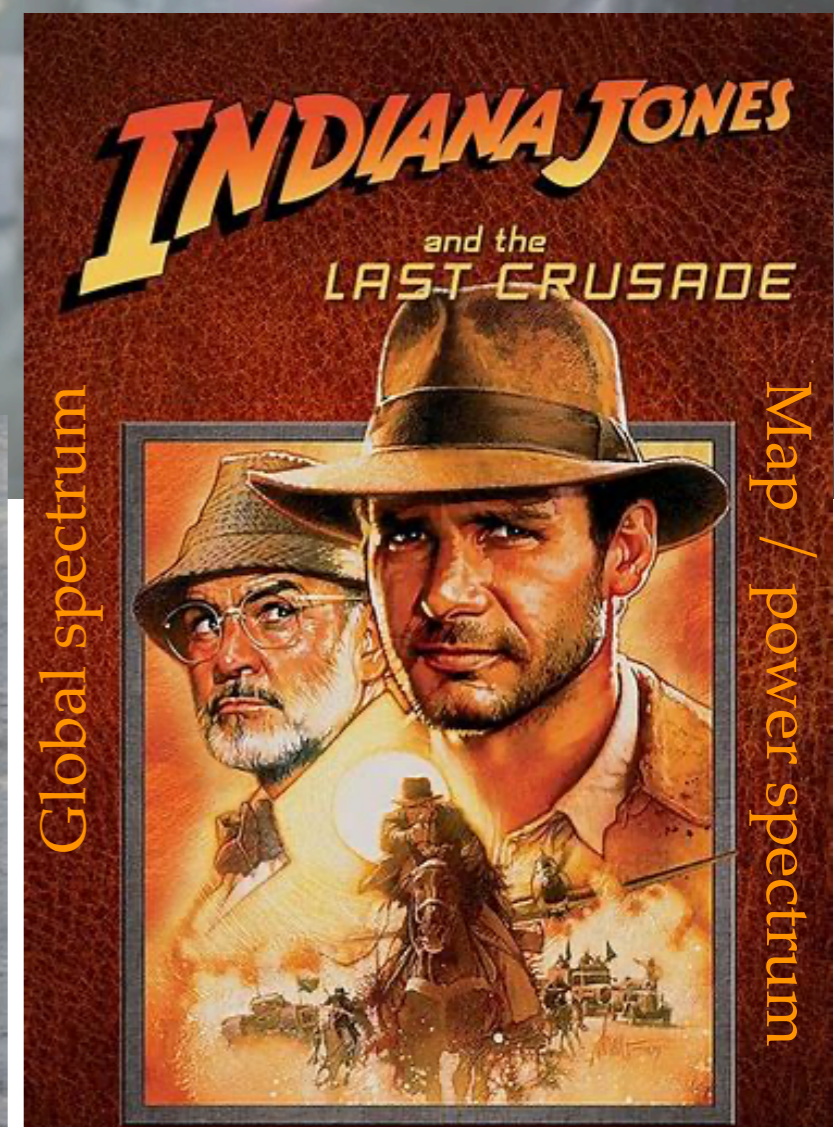
N. Barry (MWA)



The Cosmic Dawn, the holy grail of 21cm Cosmology The endless quest ?

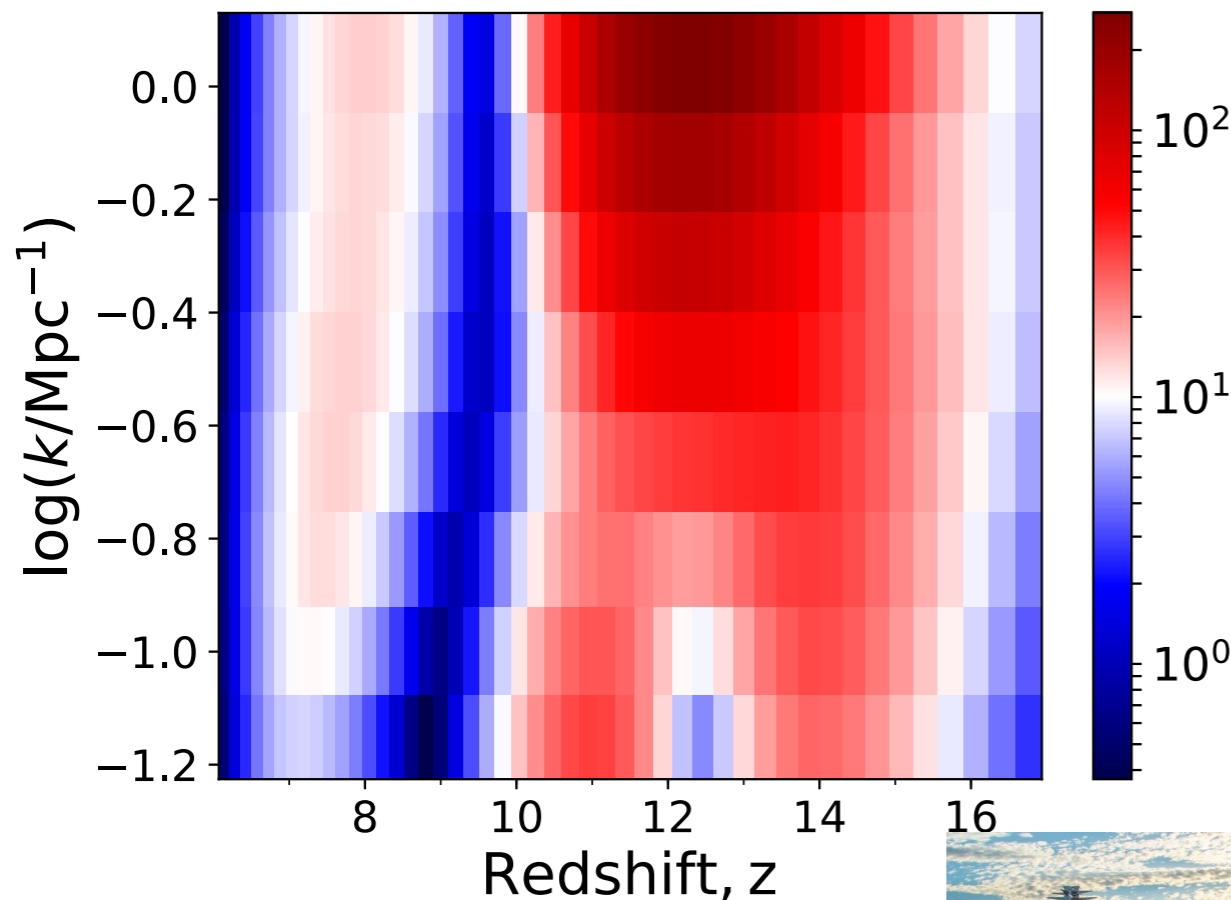


Holy Grail, Enc. Britannica

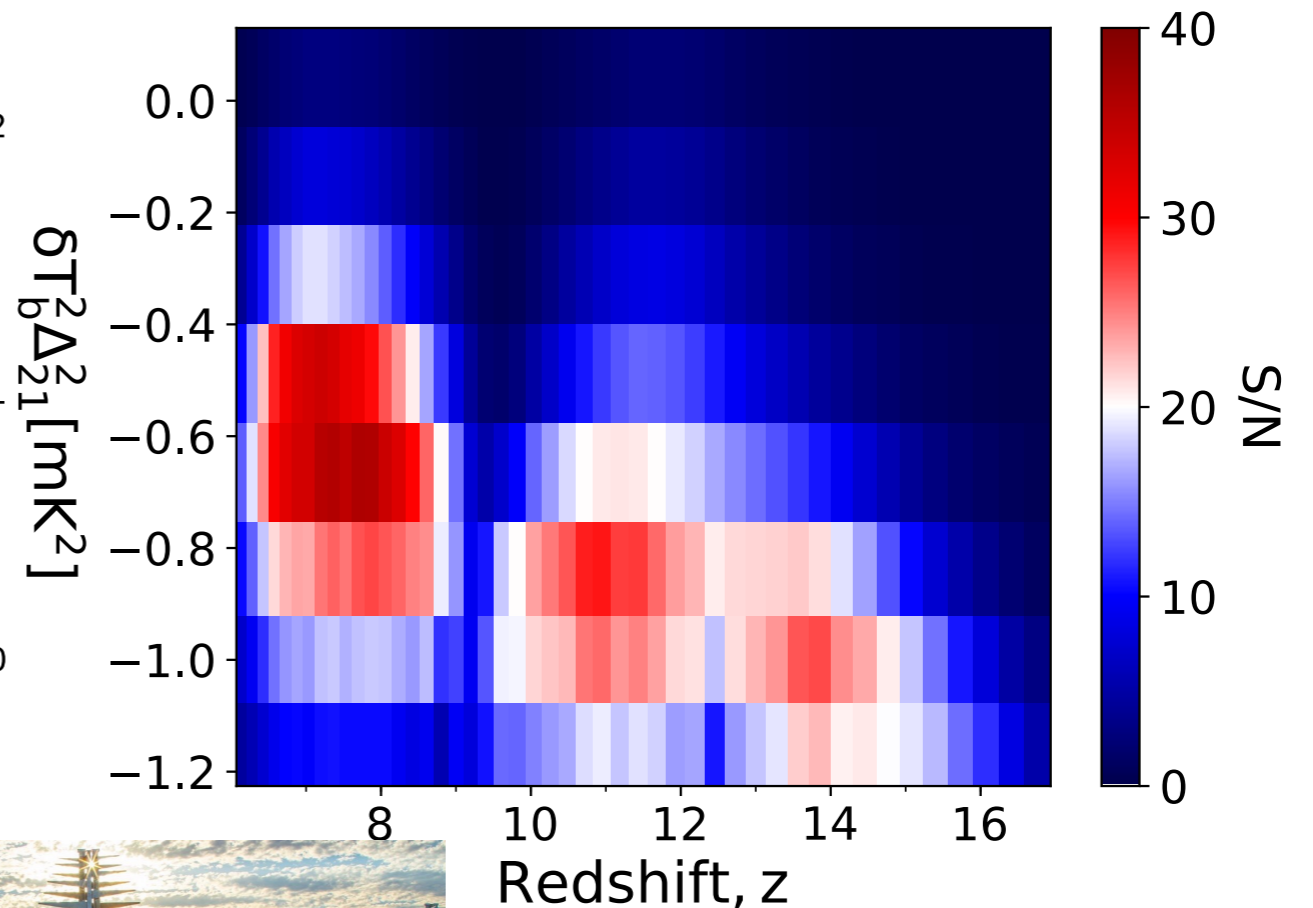


The SKA will detect the power spectrum of these fluctuations with very high signal to noise

1D power spectrum from “fiducial model”



S/N from a 1000h SKA-low observation



Andrei Meisinger



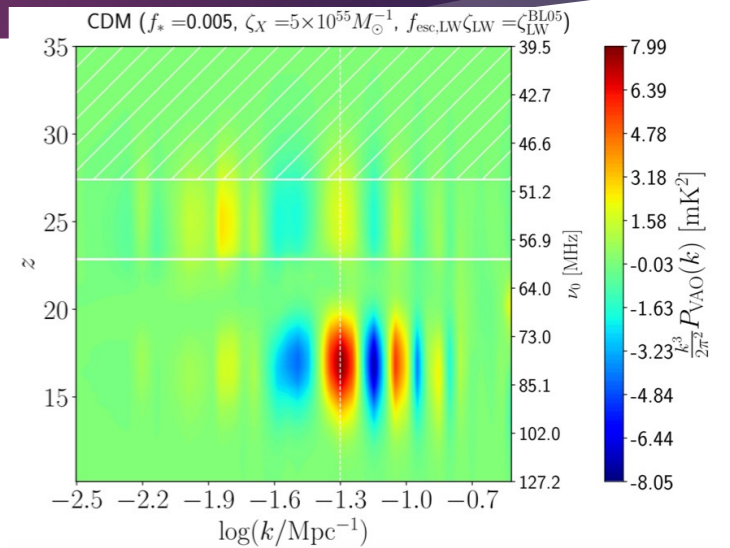
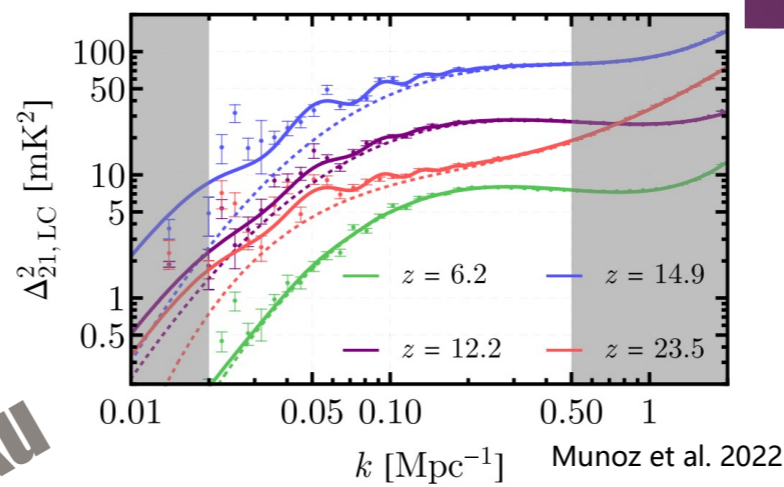
Kaur, Gillet, AM (2020)

The bright future of LIM

E. Kovetz / S. Libanore

Promises only bind those who believe them !

VAO features on 21 cm power spectrum -- a standard ruler at Cosmic Dawn



See also: Dalal+10, Visbal+12, Fialkov+12, McQuinn+12
Munoz 19, Park+19, Cain+20, Sarkar+22

Yidong Xu

- ❖ IM cross correlation signal with single dish instrument (Parkes, GBT, FAST ...) - *L. Wolz*
- ❖ Progress on purpose designed , built or under construction instruments for IM : Tianlai, HIRAX, BINGO
 - ❖ Analysis challenges
 - ❖ Calibration - *R. Byrne* (Sky based / Redundant / Unified scheme)
 - ❖ Component separation / foreground subtraction - *I. Carucci* - Several blind separation methods, PCA still efficient compared to other methods - Promises of ML / NN ?
 - ❖ *S. Cunnington* : Follow the **Cross-correlations**. They will guide you out of the maze
 - ▶ Intensity Mapping is a low-cost alternative to conventional galaxy surveys, with independent systematic errors, and is well worth pursuing
 - ▶ The lack of direct link between redshift and radial distance is both a curse and a blessing. There is more to explore than simply the BAO scale. In principle, there are a number of cross-checks and redundancies in the data.
 - ▶ It will be exciting to see to what extent the full dream of learning about the dark energy through intensity mapping will be realized.

Calibration Calibration Calibration

R. Byrne

Summary

- Contaminants removal in HI IM: need to characterise the instrument, model systematics, and optimise BSS methods
- By detecting (again) the cross-signal with the WiggleZ galaxies, we tested BSS steps

- PCA is still our best friend
- We are seeing that separating scales for the cleaning (multiscale cleaning) is more efficient
- Will this –together with many other improvements– allow us to go after an independent detection?

I. Carucci

Getting ready for the SKAO HI IM science

Challenges:

- “mode-mixing” breaks the smoothing and prevents foreground removal
- PSF deconvolution — an ill-posed inverse problem; achieving the desired precision of 1 in 10,000 is not feasible

Solution: other way around?

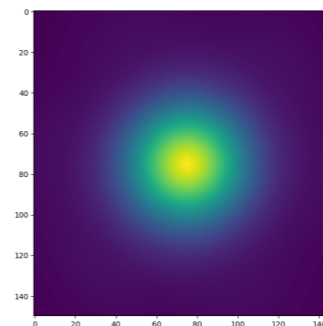
Counterintuitive approach:

✓ **reconvolution rather than deconvolution**

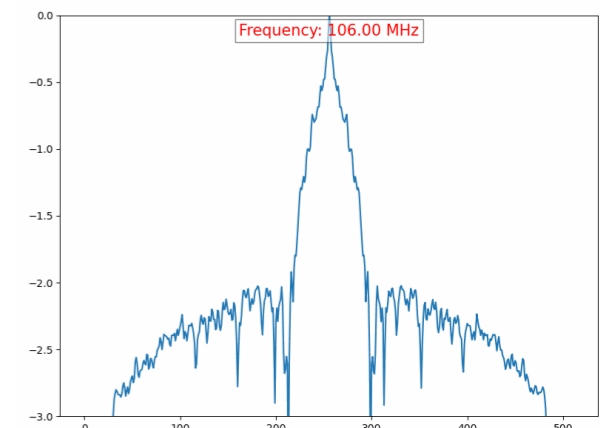
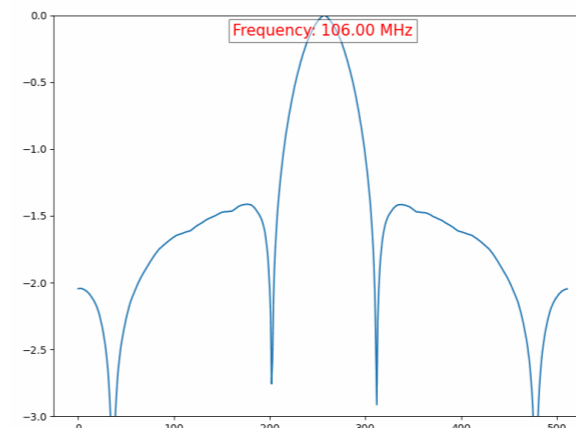
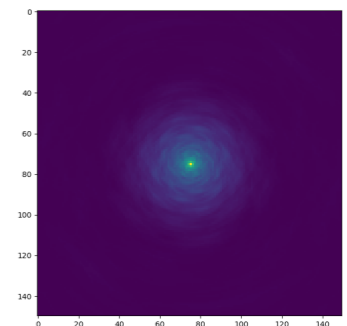
Reduction of mode mixing: suppressing high- k_{\perp} modes that vary significantly with frequency, which dominate the effect of mode mixing.

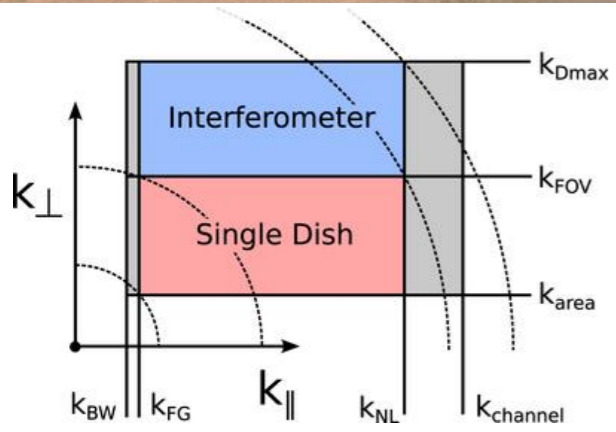
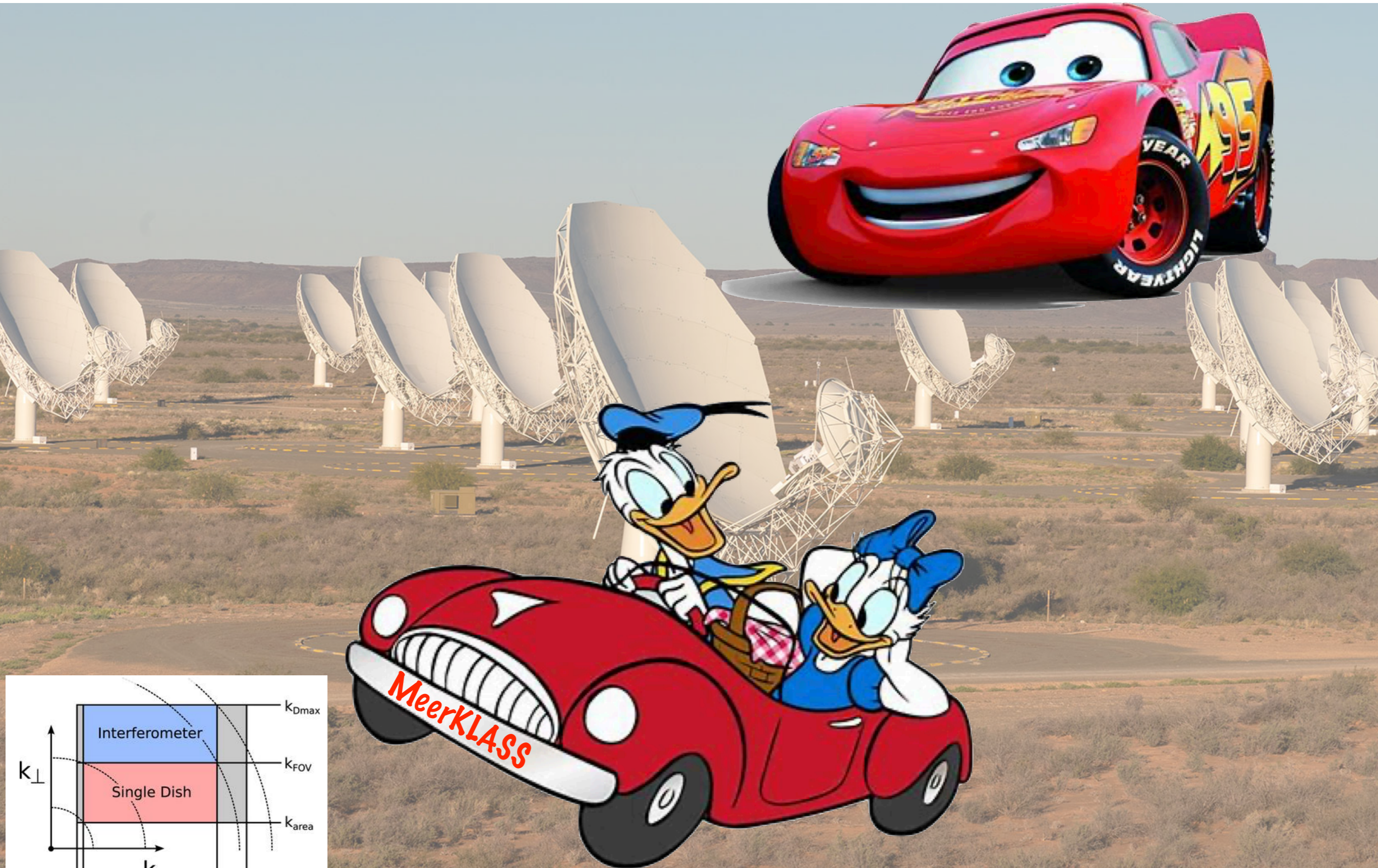
Le Zhang

PSF ⊗ PSF



PSF

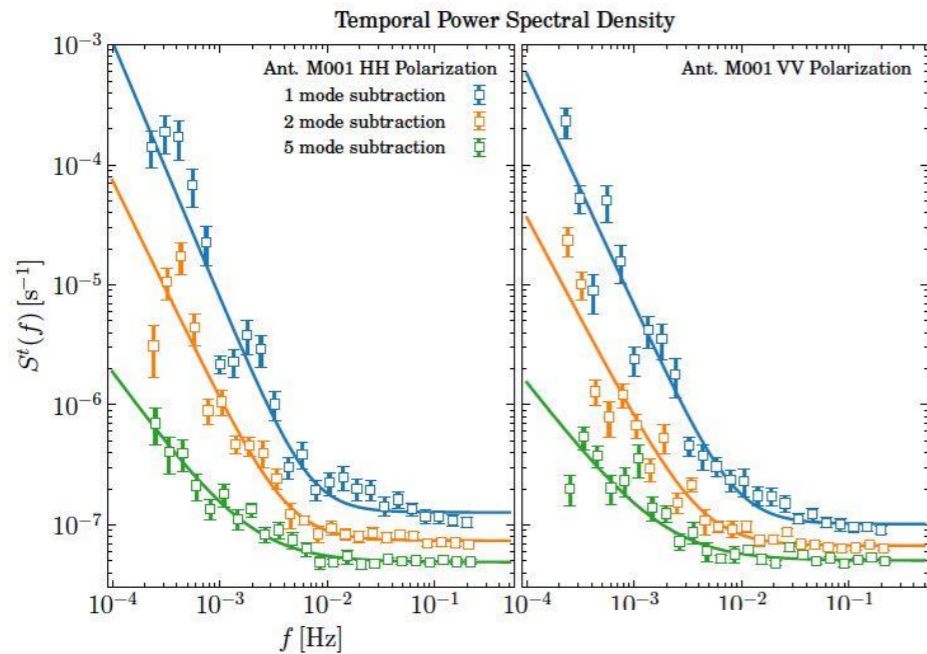




Bull et al. (2015)

Challenges

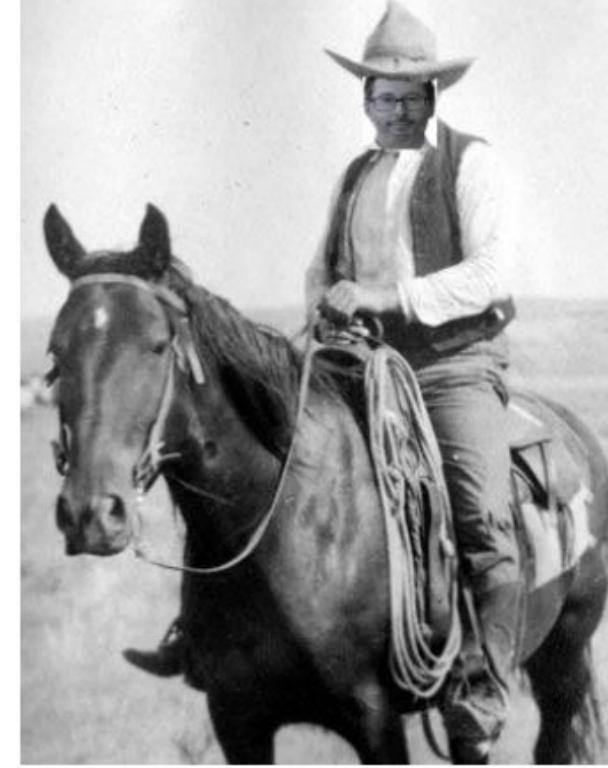
MeerKAT 1/f noise analysis - gain fluctuations



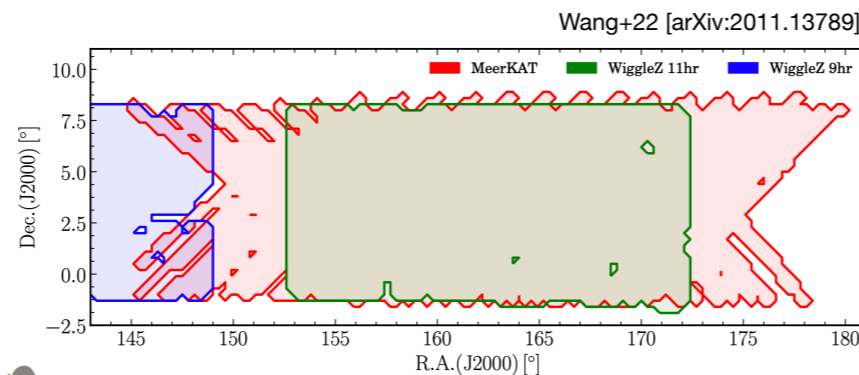
- Noise is correlated in time
- Important to have fast scanning mode
- We can clean it as a foreground
-> time scale of 100s of seconds

Li et al., 2021, MNRAS;
Ifan et al., 2024, MNRAS

J. Wang. / M. Spinelli

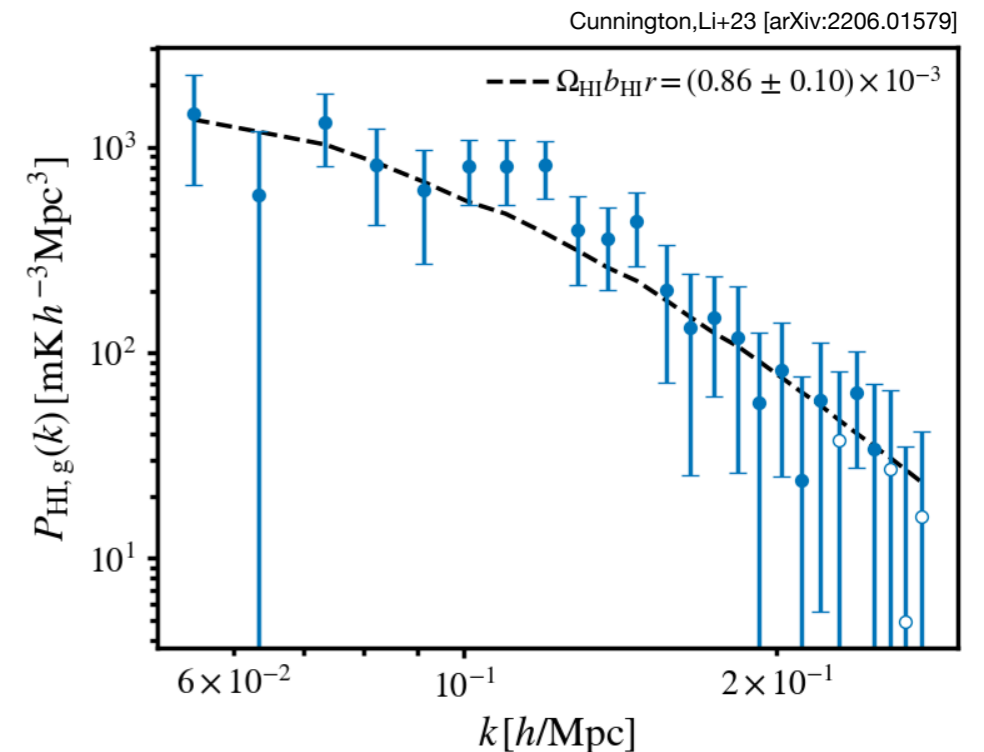


Can instead make a detection with
cross-correlations



S. Cunningham

- Positive correlation (7.7σ) between galaxy survey and array of dishes in single-dish mode
- The first detection of its kind
- Important milestone for doing LSS cosmology with SKA intensity mapping





STAR THE EMPIRE STRIKES BACK

HI intensity mapping with the MIGHTEE survey: power spectrum estimates

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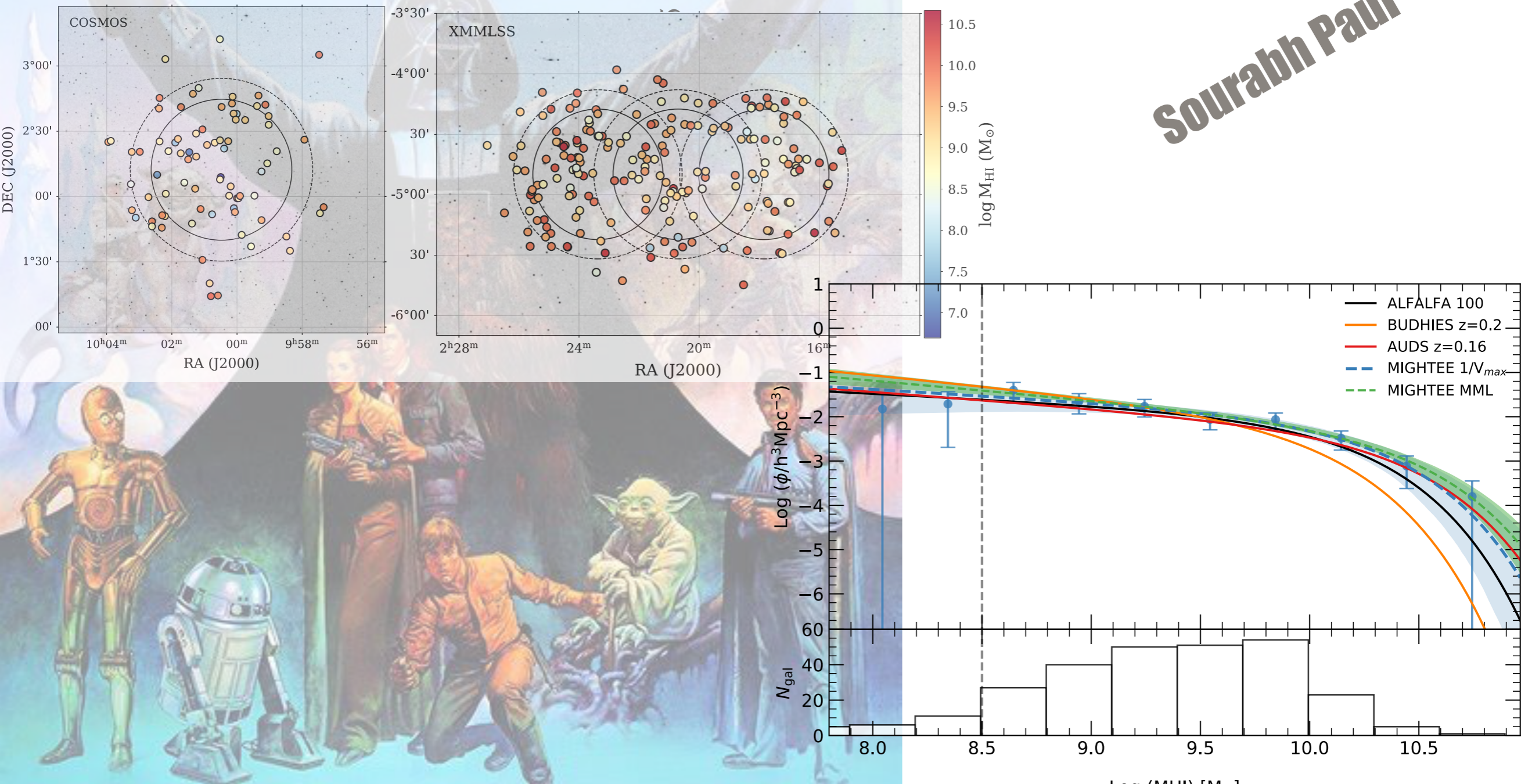
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Apr 2021



Space: The final frontier
These are the voyages of the
Starship, Enterprise
Its 5 year mission
To explore strange new
worlds
To seek out new life and new
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To boldly go where no man
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STAR TREK V THE FINAL FRONTIER

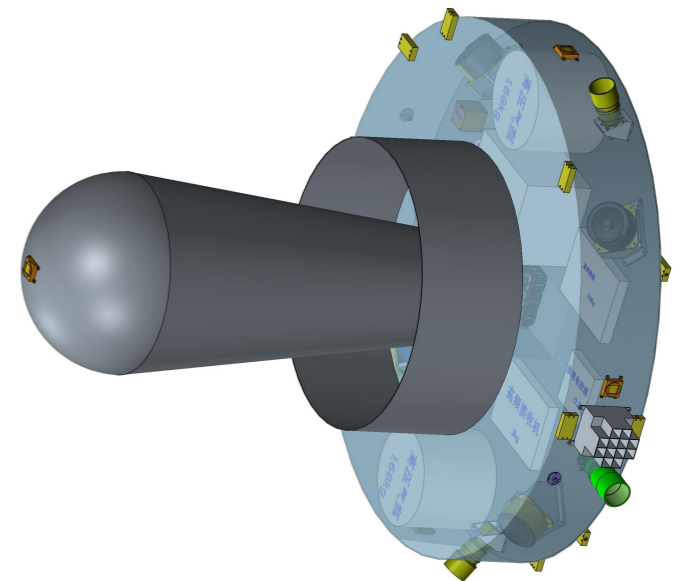
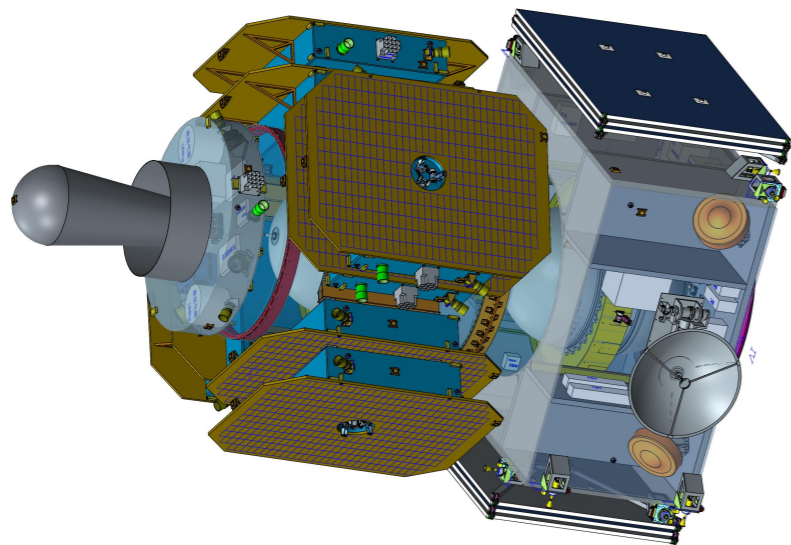
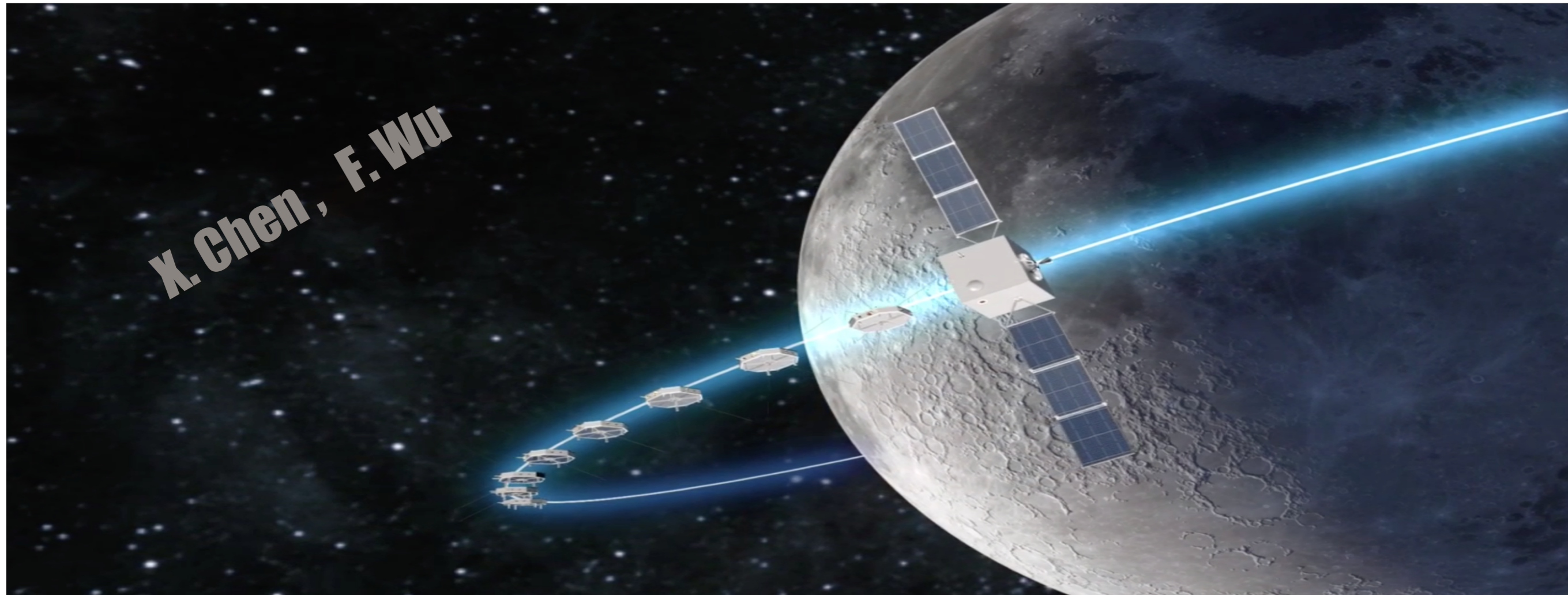
Space: The final frontier
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STAR TREK V THE FINAL FRONTIER

Hongmeng / DSL

X. Chen, F. Wu



Thank You

Special thanks to all the local organisers :
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Yichao LI,

Yixi Tao, Weinan Ma, ...

Thanks to the International Program
committee with **P. Timbie** as the co-chair



Thanks to all the members of the workshop organisation team:

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Wang , Ji-Xia Li , Jing-Yu Zhang , Yi-Xi Tao , Jia-Peng Li

Venue service group

Jia-Peng Li , Yun-Yi Zhang , Cheng-Cheng Xie , Xiang-Ming Yang ,
Zhao Wang

Equipment group

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Photography group

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Manoeuvrable group

Jia-Yuan Huang , Zheng-Hua Yu , Jie Yu , Duo Ji

As well as to shuttle drivers, restaurant and hotel personnel