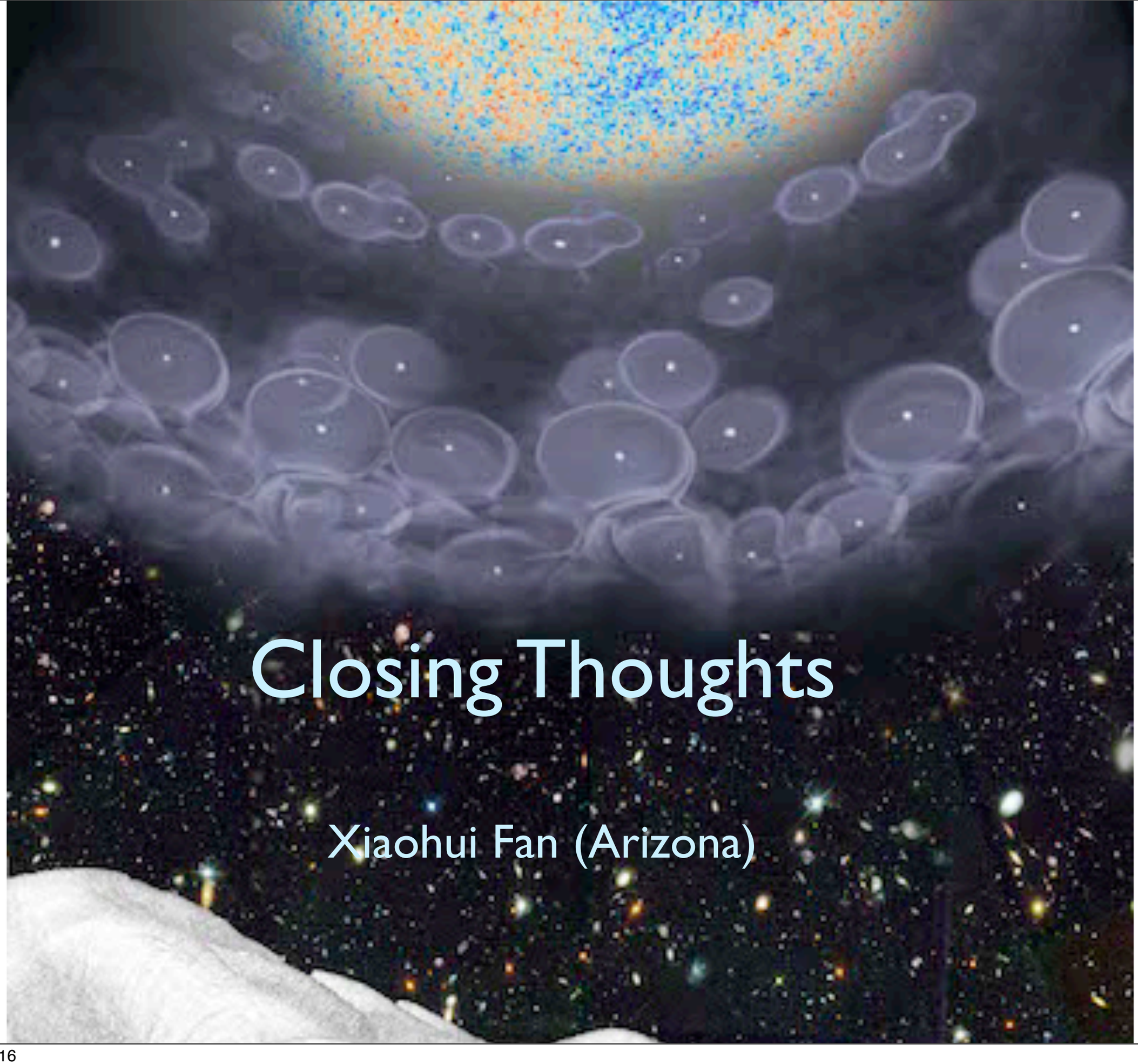


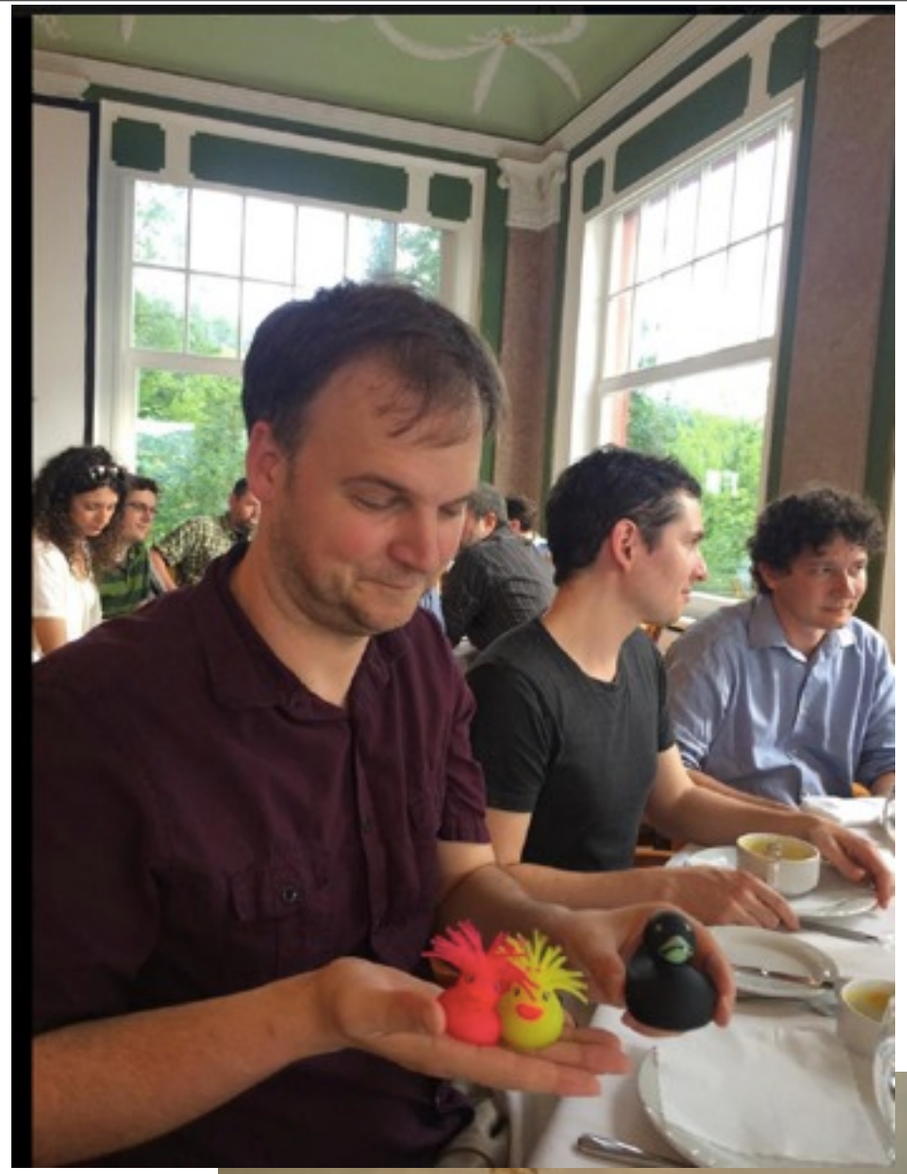
Closing Thoughts

Xiaohui Fan (Arizona)

Reionization

When?

Source?



Looking forward to a good weekend

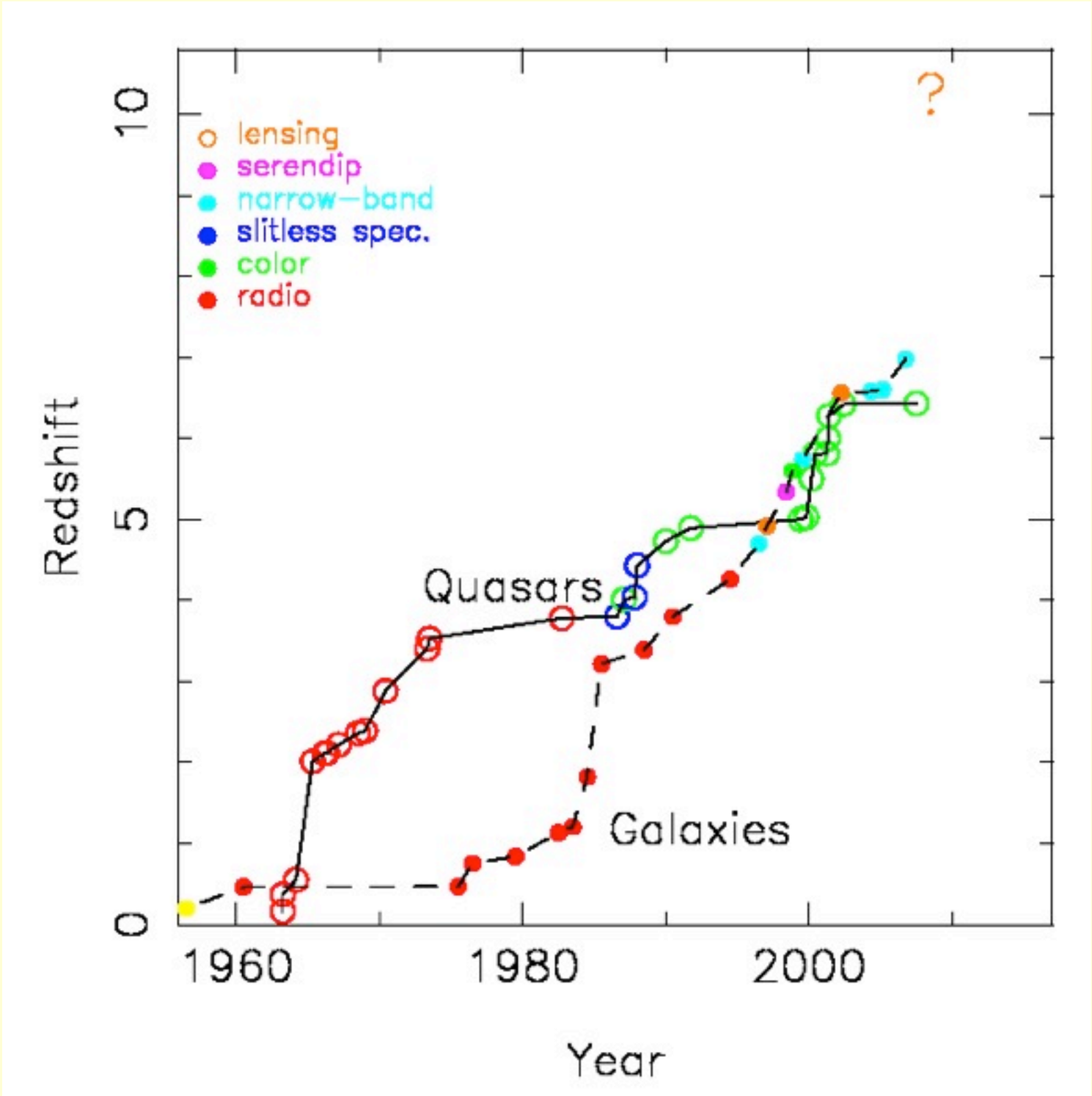
Thank you!

Local Organising Committee

- Frederick Davies (MPIA)
- Christina Eilers (MPIA)
- Emanuele Farina (MPIA)
- Carola Jordan (MPIA)
- Chiara Mazzucchelli (MPIA)
- Bram Venemans (MPIA)

- for 140-character soundbite of each talk: #DarkAgesHD on twitter
- reflection of what have changed in the last decade in our understanding of reionzation
- results of yesterday's survey
- discussion

Highest Redshift Prediction (XF 2007)



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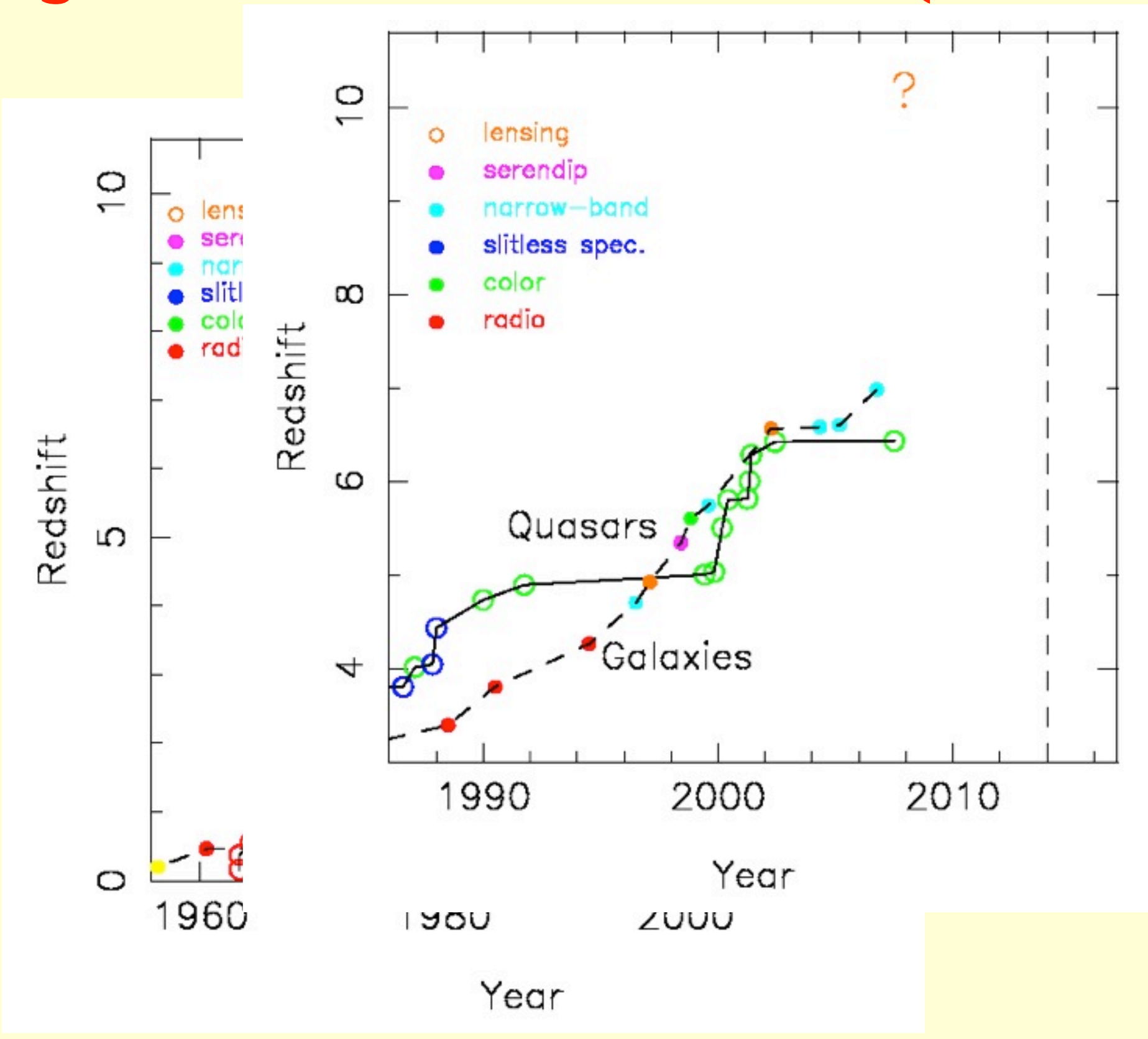

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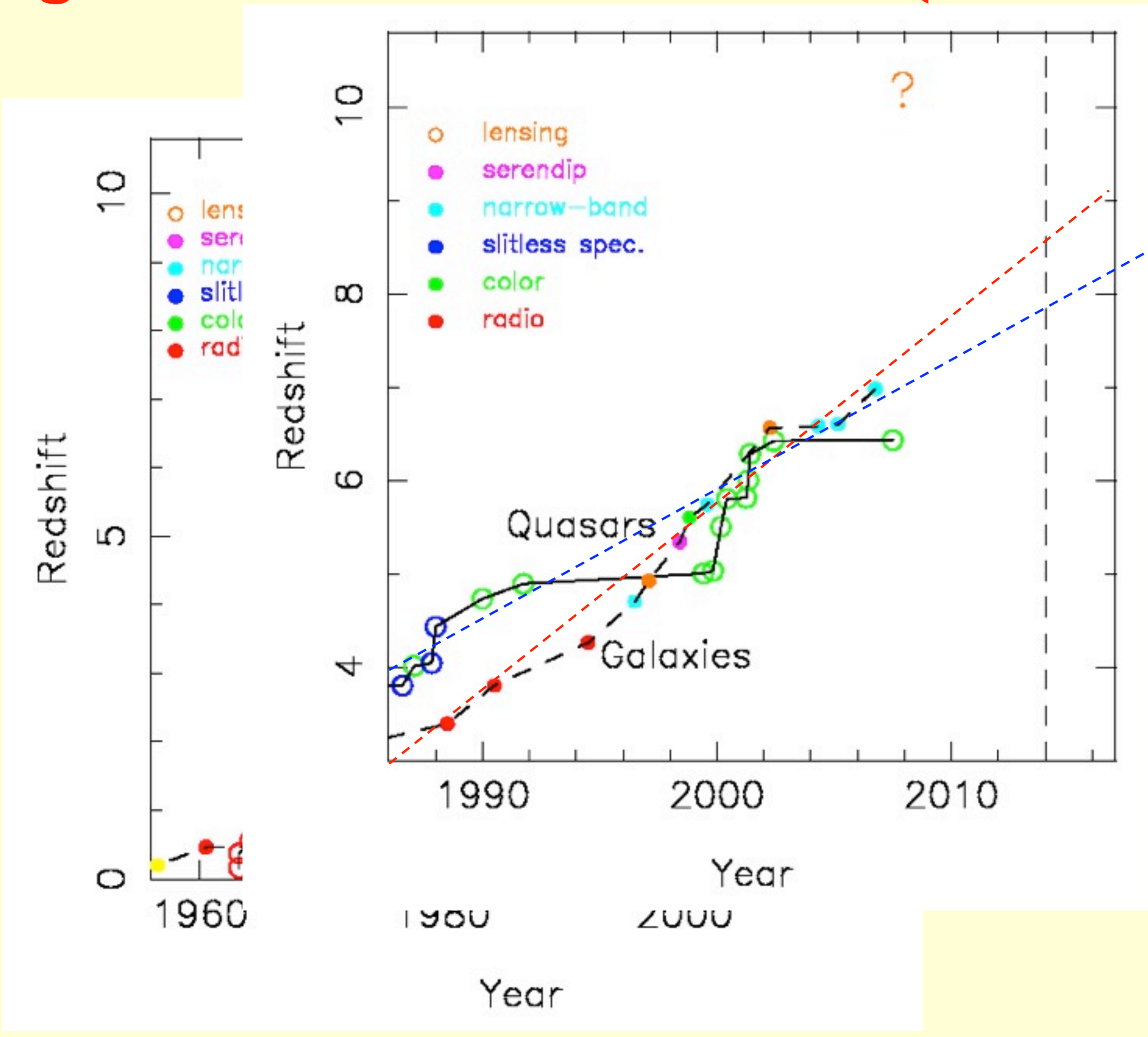

From Fan, Carilli and Keating (2006) ARAA:

- Observations have set the first constraints on the epoch of reionization (EoR), corresponding to the formation epoch of the first luminous objects.
  - Studies of Gunn-Peterson (GP) absorption indicate a rapid increase in the neutral fraction of the intergalactic medium (IGM) from $x_{HI} < 10^{-4}$ at $z \leq 5.5$, to $x_{HI} > 10^{-3}$, perhaps up to 0.1, at $z \sim 6$,
  - while the large scale polarization of the cosmic microwave background (CMB) implies a significant ionization fraction extending to higher redshifts, $z \sim 11 \pm 3$.
  - These results, as well as observations of galaxy populations, suggest that reionization is a process that begins as early as $z \sim 14$, and ends with the "percolation" phase at $z \sim 6$ to 8.
  - Low luminosity star-forming galaxies are likely the dominant sources of reionizing photons.
  - Future low-frequency radio telescopes will make direct measurements of HI 21-cm emission from the neutral IGM during the EoR, and measurements of secondary CMB temperature anisotropy will provide details of the dynamics of the reionized IGM.

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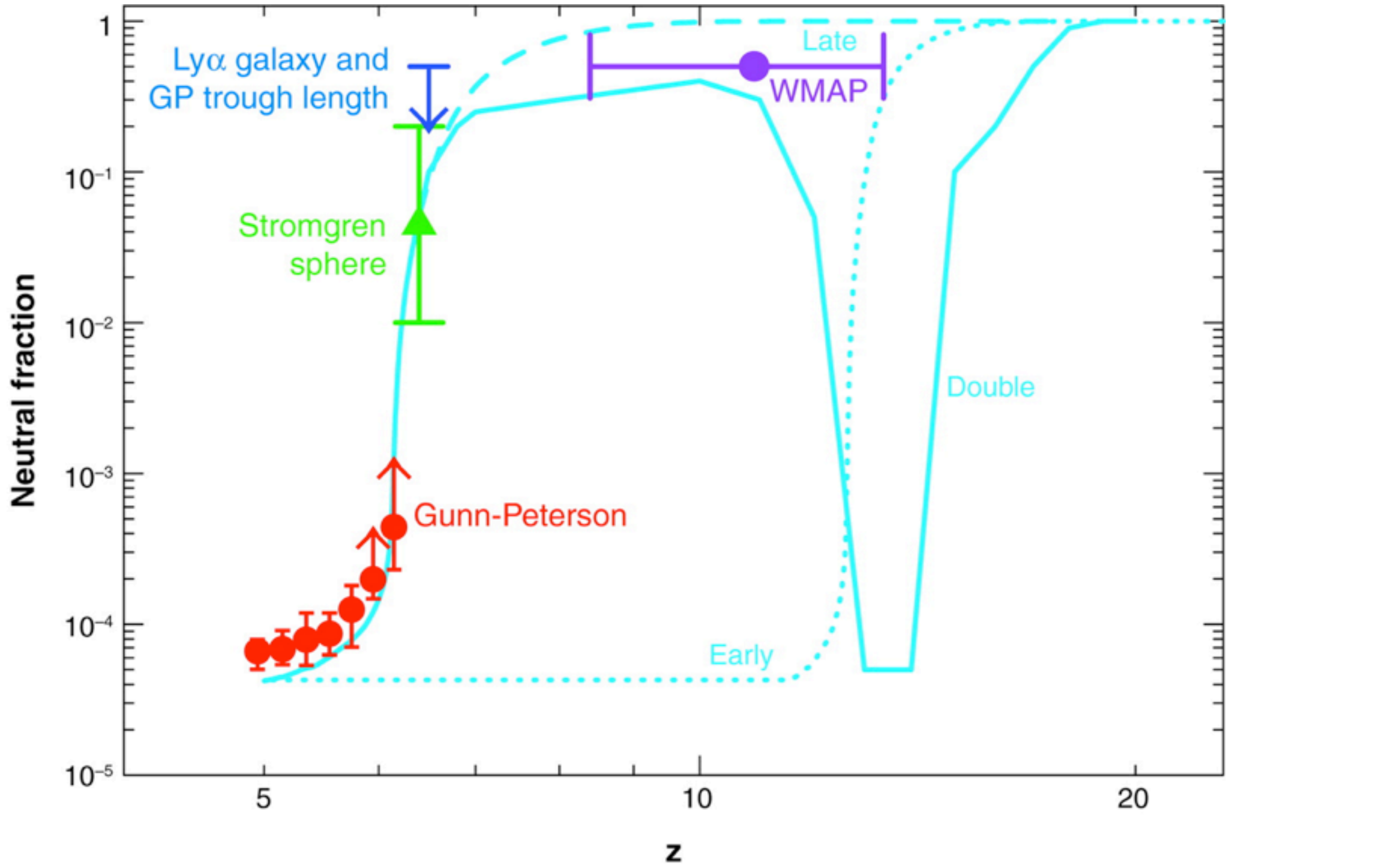
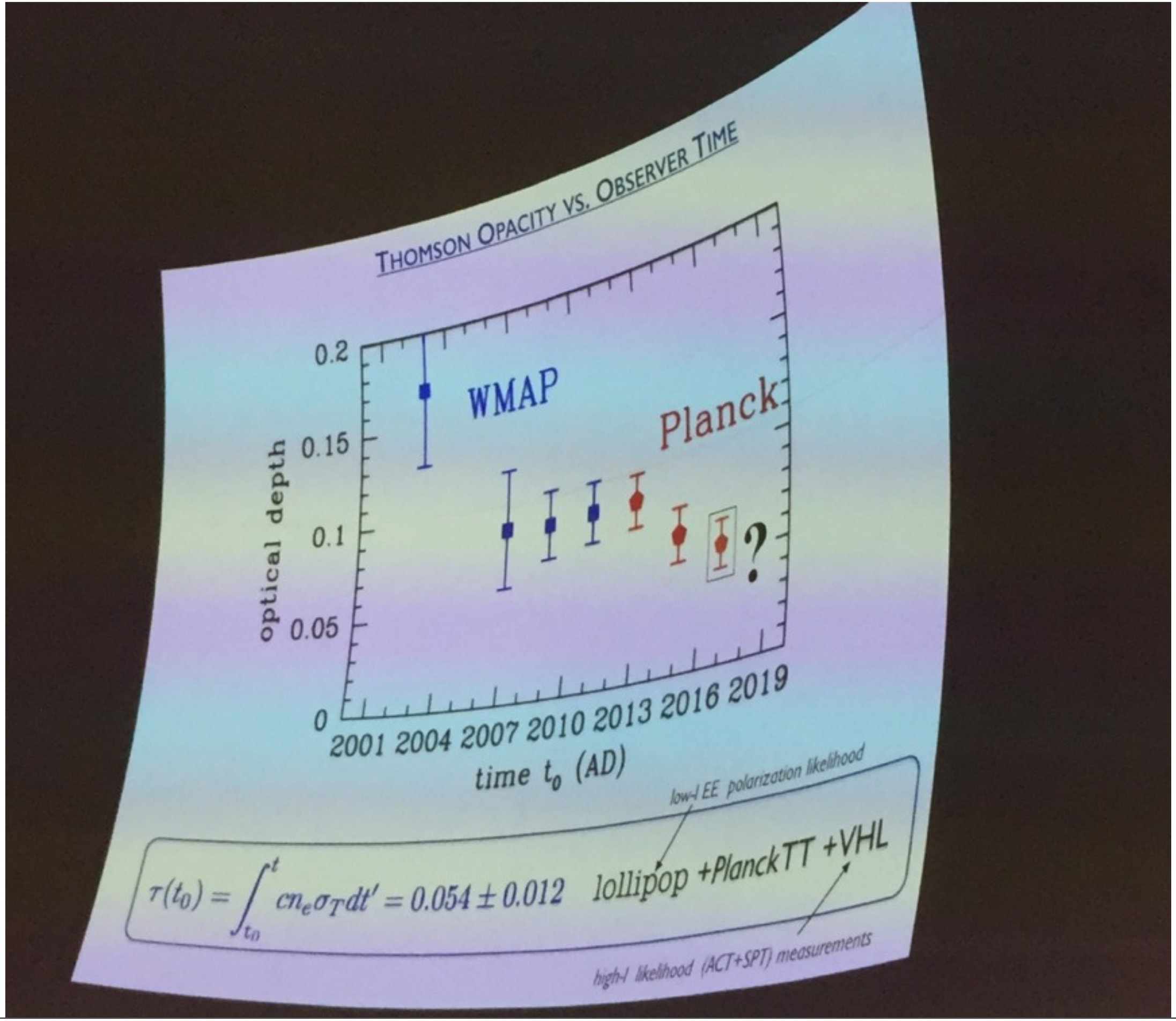
  - These results, as well as observations of galaxy populations, suggest that reionization is a process that begins as early as $z \sim 14$, and ends with the "percolation" phase at $z \sim 6$ to 8. **simpler than we thought?**
  - Low luminosity star-forming galaxies are likely the dominant sources of reionizing photons. **AGN are back!**
  - Future low-frequency radio telescopes will make direct measurements of HI 21-cm emission from the neutral IGM during the EoR, and measurements of secondary CMB temperature anisotropy will provide details of the dynamics of the reionized IGM. **still waiting...**



Fan X, et al. 2006.
Annu. Rev. Astron. Astrophys. 44:415–62

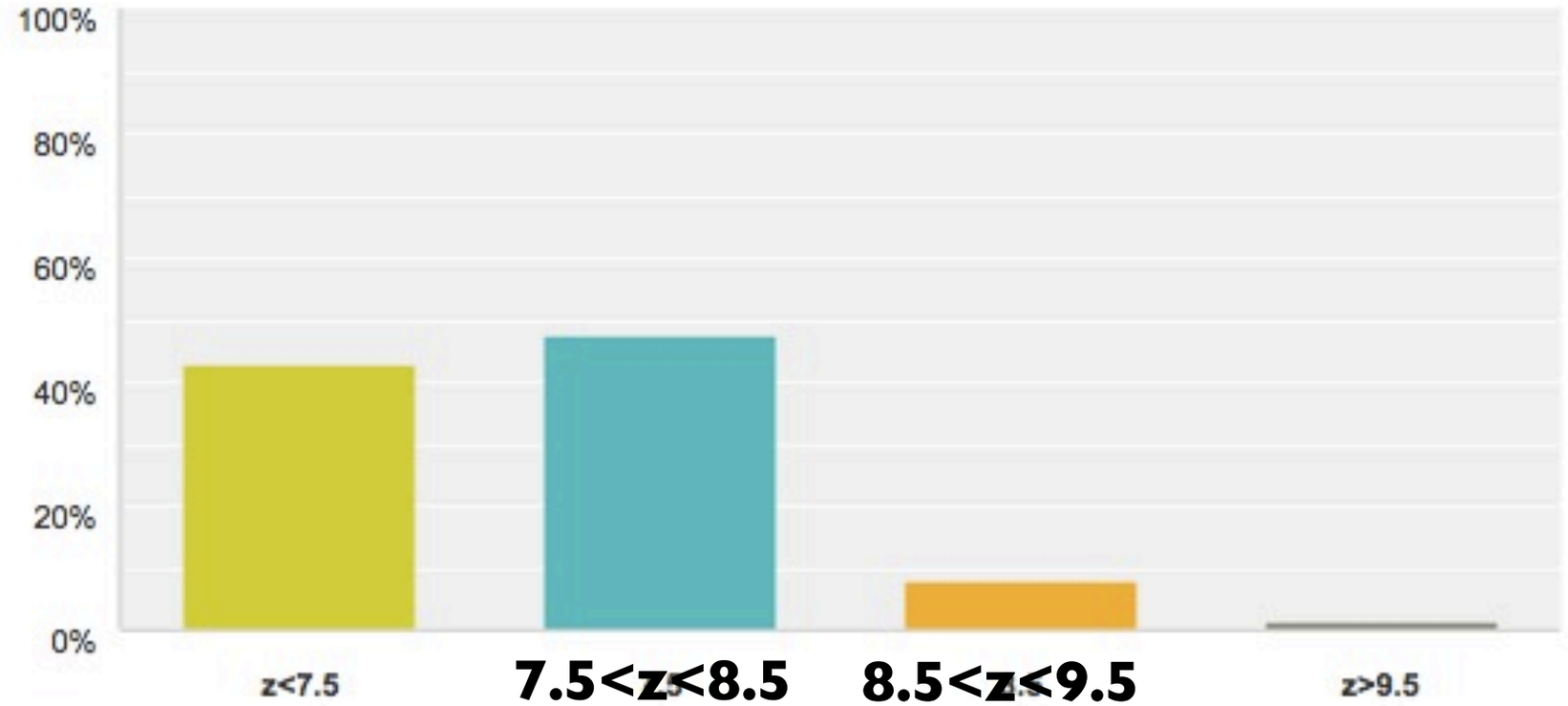

THOMSON OPACITY VS. OBSERVER TIME
optical depth
0.2
0.15
0.1
0.05
0
WMAP
Planck
?
2001 2004 2007 2010 2013 2016 2019
time t_0 (AD)
low-l EE polarization likelihood
$\tau(t_0) = \int_{t_0}^{t} cn_e\sigma_T dt' = 0.054 \pm 0.012$
lollipop +PlanckTT +VHL
high-l likelihood (ACT+SPT) measurements

The reionization vote

- 63/87 participants voted
- 72% voter turnout (same as Brexit)

When did the universe become 50% ionized?

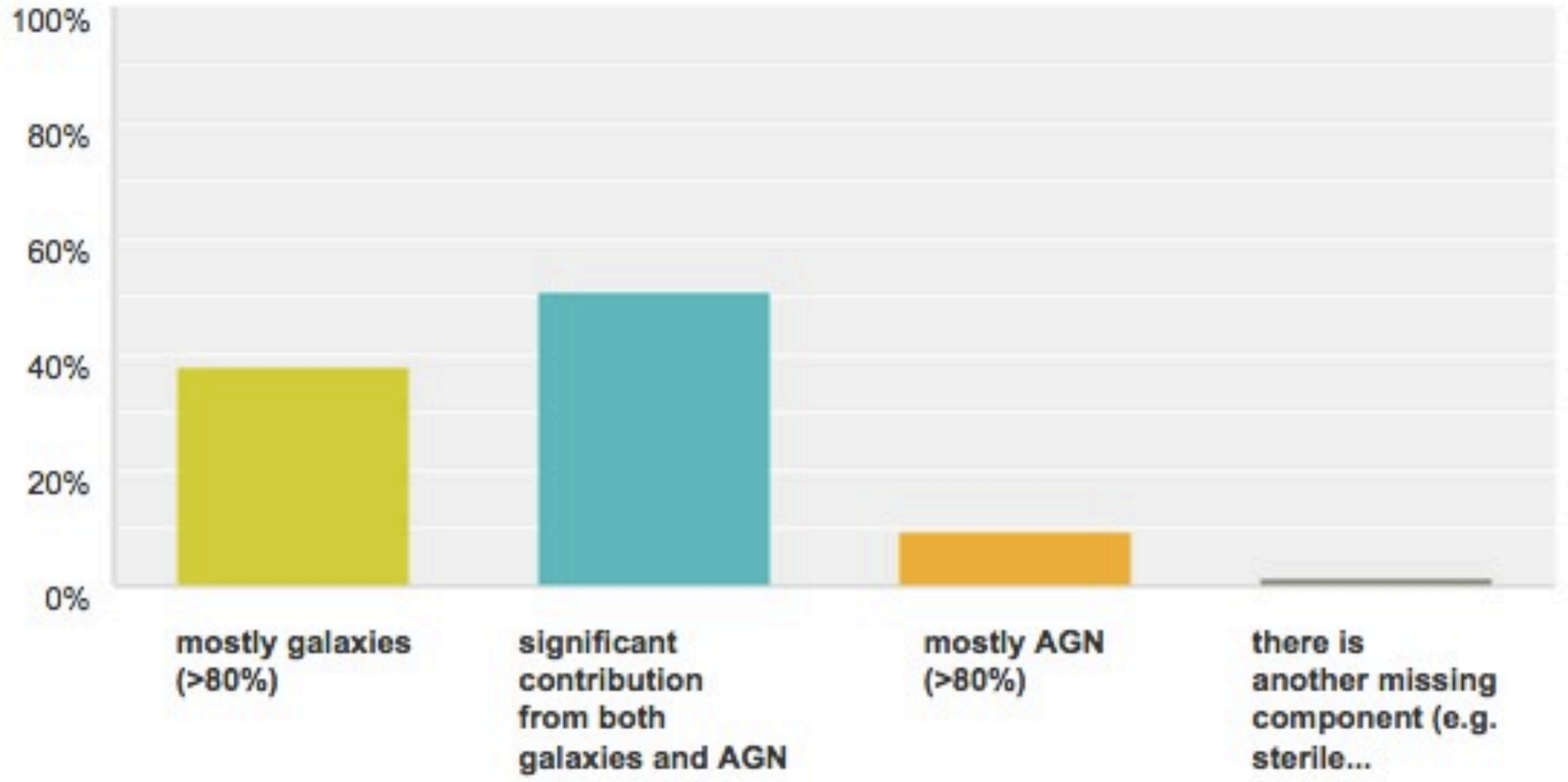
Answered: 63 Skipped: 0



Answer Choices	Responses	
z<7.5	42.86%	27
7.5	47.62%	30
8.5	7.94%	5
z>9.5	1.59%	1
Total		63

What are the main sources of reionization?

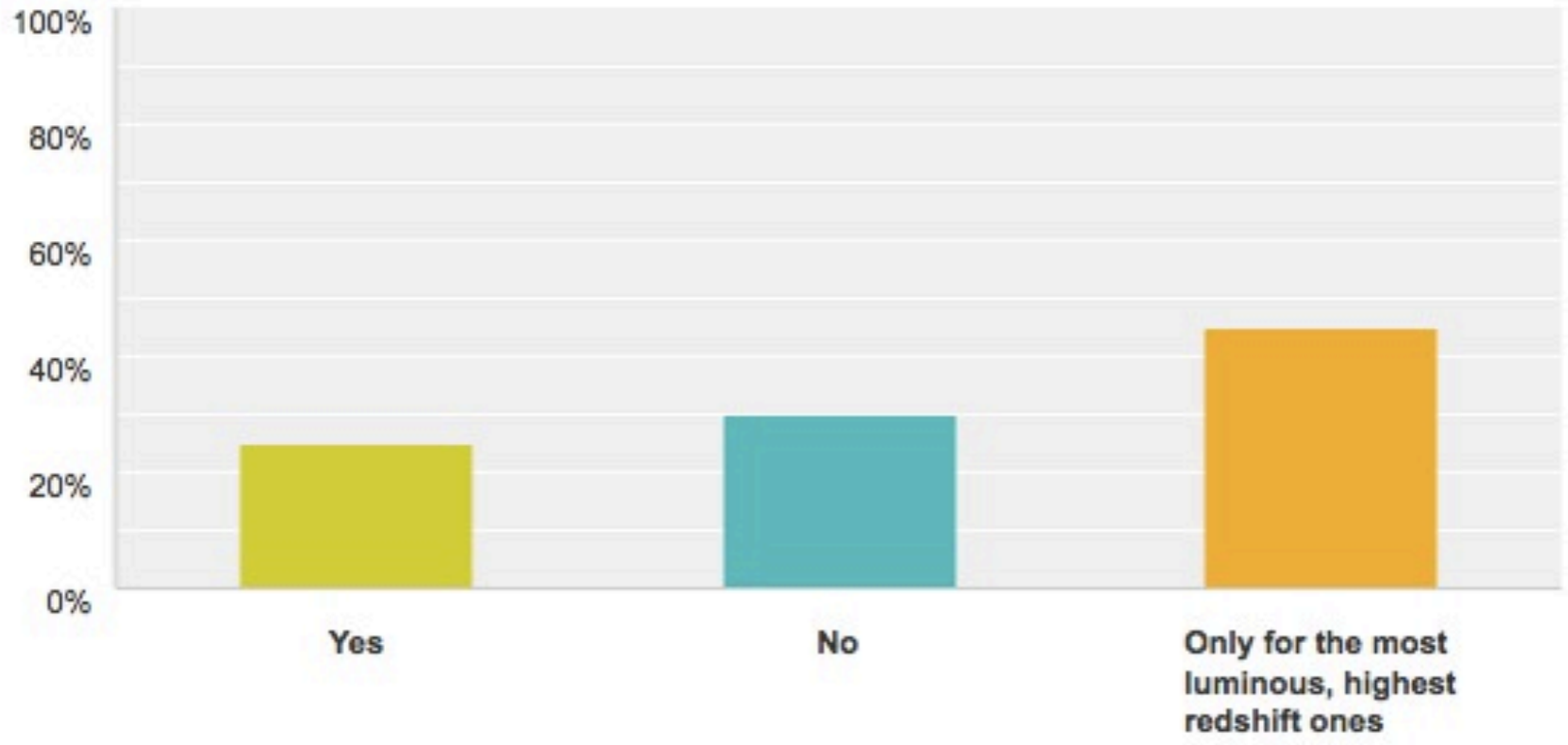
Answered: 63 Skipped: 0



Answer Choices	Responses	
mostly galaxies (>80%)	38.10%	24
significant contribution from both galaxies and AGN	50.79%	32
mostly AGN (>80%)	9.52%	6
there is another missing component (e.g. sterile neutrinos)	1.59%	1
Total		63

Are DCBHs high-z SMBH seeds?

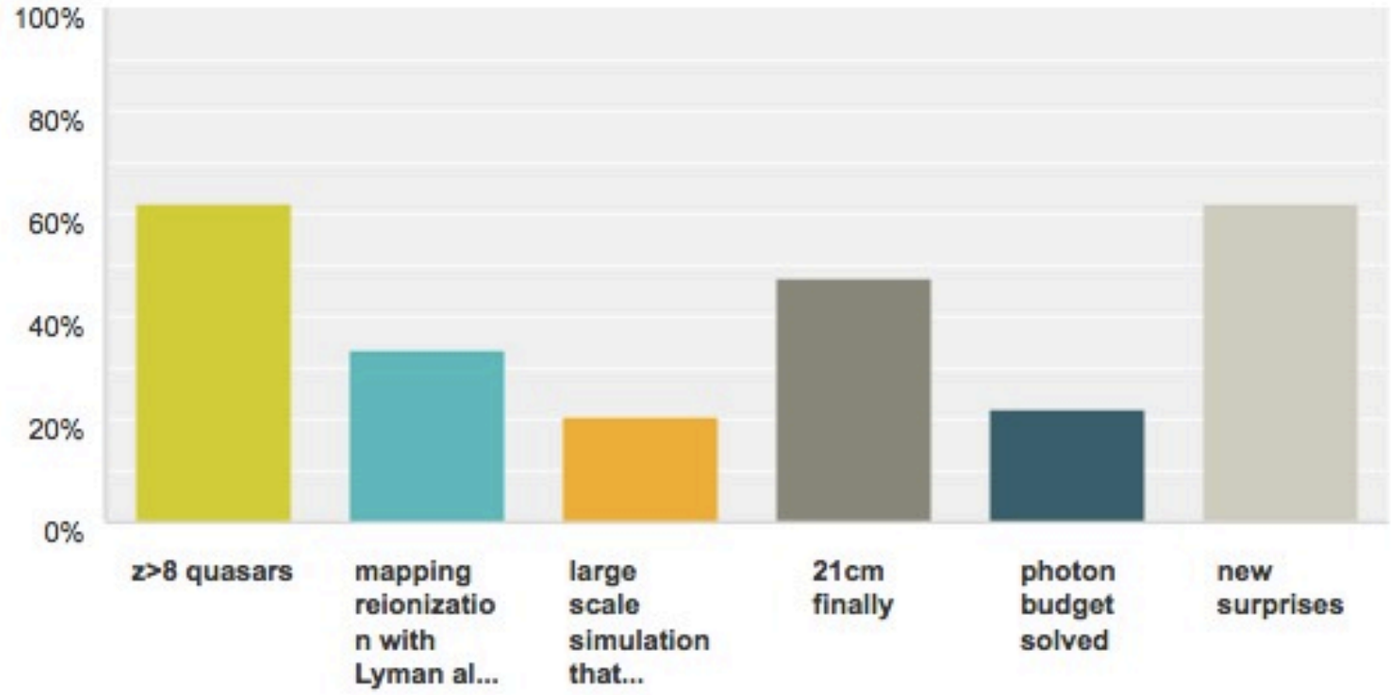
Answered: 60 Skipped: 3



Answer Choices	Responses	
Yes	25.00%	15
No	30.00%	18
Only for the most luminous, highest redshift ones	45.00%	27
Total		60

What area will likely have exciting breakthrough in understanding EoR in the next decade? (multiple choices ok)

Answered: 63 Skipped: 0



Answer Choices	Responses	
z>8 quasars	61.90%	39
mapping reionization with Lyman alpha emitter topology	33.33%	21
large scale simulation that captures all relevant physics	20.63%	13
21cm finally	47.62%	30
photon budget solved	22.22%	14
new surprises	61.90%	39
Total Respondents: 63		

Things that I heard

- **Fabian Walter:** Why haven't we find z~8 quasars?

- **Masami Ouchi:** no serious problem of ionizing photons anymore;now worry about too many ionizing photons

- **Piero Madau:** We have been misled by CMB polarization results on reionization in the last decade

- **Tiziana di Mateo:** the end of dark ages is bright.