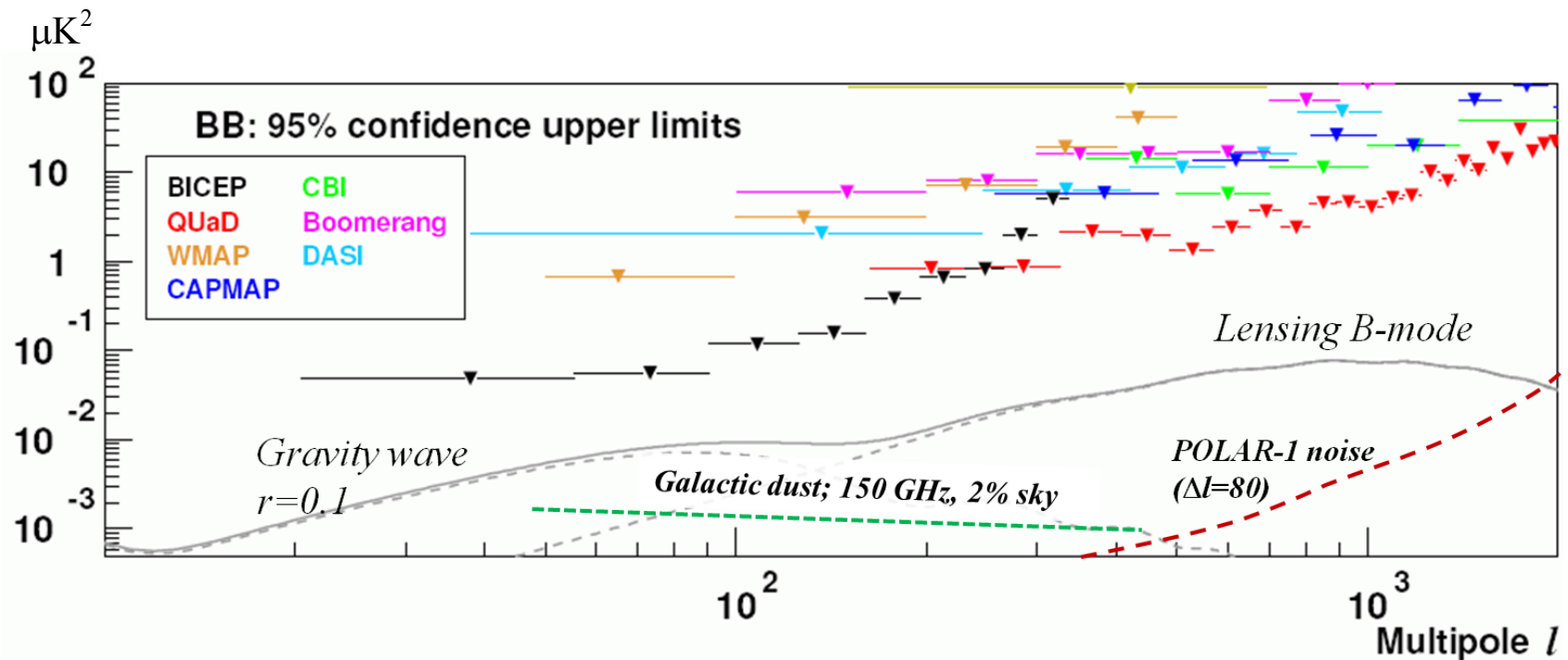


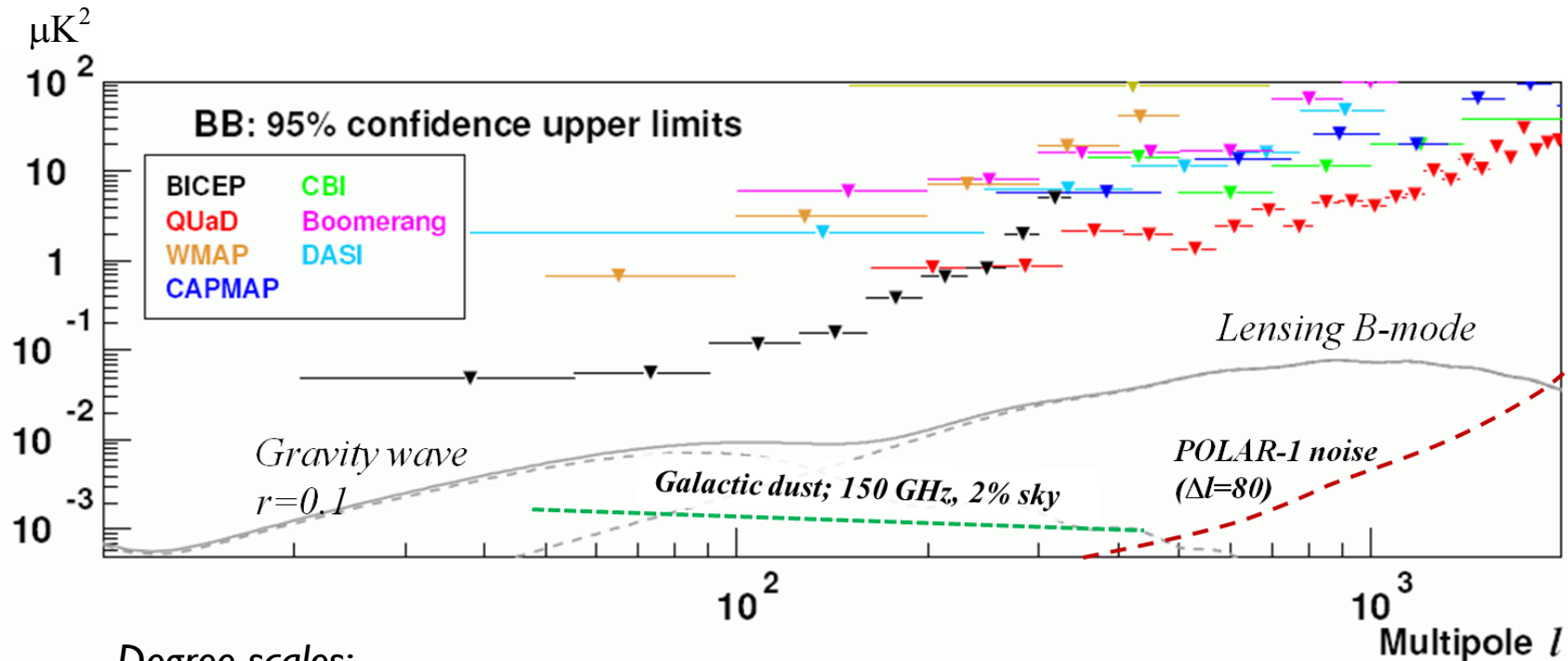
Measuring the B-mode CMB polarization at degree-arcminute scales with the POLAR Array



Or ... “What to build if you want it all.”

Ki Won Yoon
Stanford University

CMB B-mode polarization measurements as of last year...



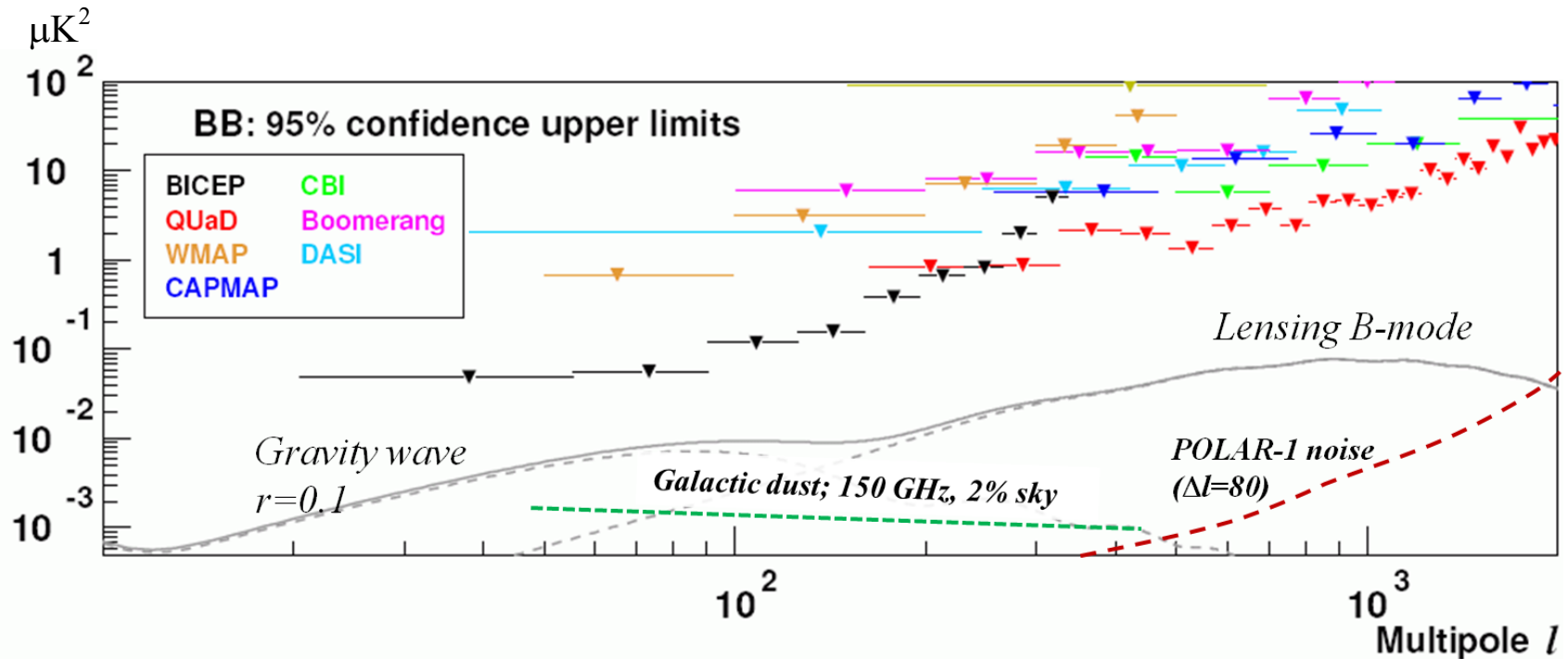
Degree scales:

- generated by primordial gravitational waves
- direct measurement of inflation energy scale

Arcminute scales:

- theory verification; breaks parameter degeneracy
- dark energy, expansion history, LSS between recombination and moderate z
- constrain neutrino masses

CMB B-mode polarization measurements as of last year...

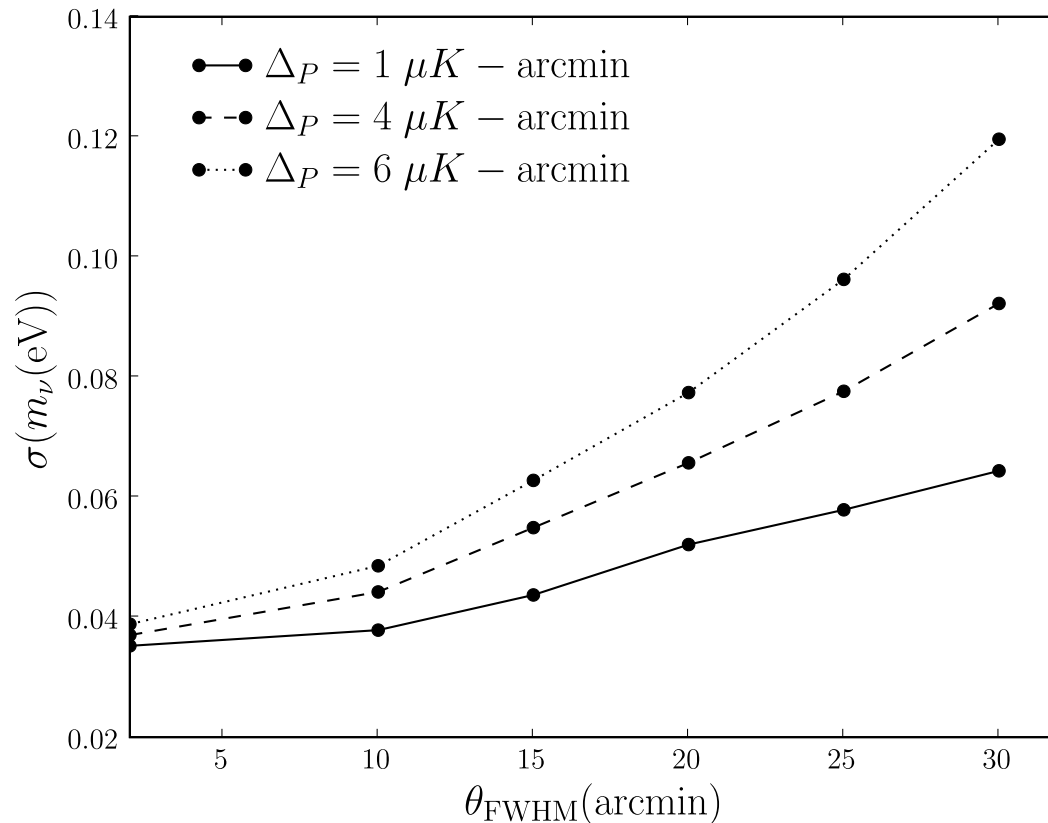


QUaD & BICEP (60-100 detectors) still > 2 orders of magnitude away from lensed B.

Current proposed experiments can attempt statistical detection, but not much more.

Need mapping speed increase by $\sim \text{few} \times 10^2$ to fully explore wealth of information.

Constraints on neutrino mass (Smith et al. 2008)

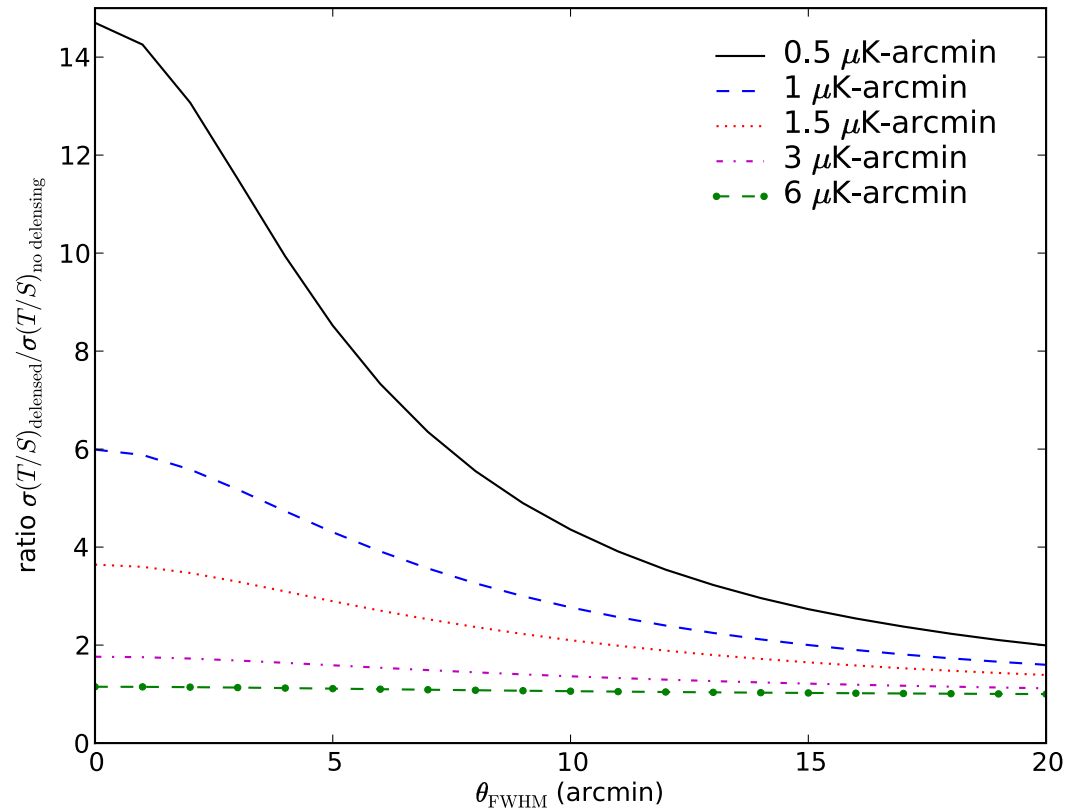


Above predictions for 75% sky survey.

35%-sky, 6 uk-arcmin survey with 5' FWHM can detect neutrino mass > 0.06 eV.

No significant benefit going from 5' to 1' FWHM beams.

Delensing efficiency (Smith et al. 2008)



Degree-scale B-mode experiments (BICEP2/Keck) will run into lensing foreground limit.

“Delensing” allows for probing below $r=0.01$ (1 $\mu\text{K-arcmin}$ 5' beam \rightarrow 4x delensing).

Modest improvement in delensing efficiency with beams smaller than 5'.

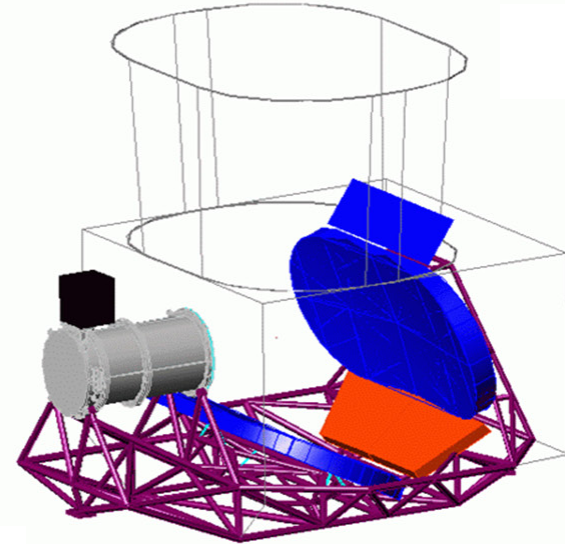
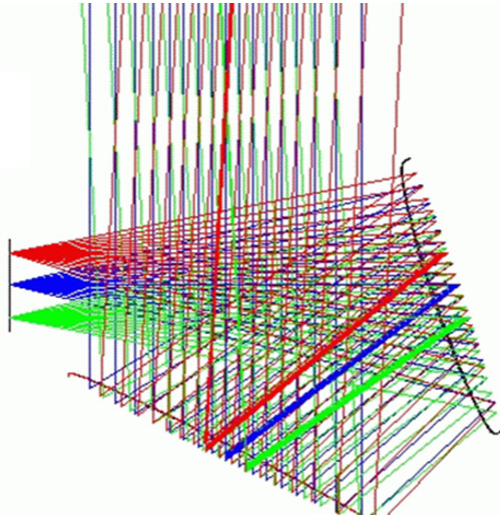
So, what's the bottom line?

Need to go well beyond current proposed instruments, with few $\times 10^4$ detectors across multiple, easily scalable telescopes.

Maximize per-telescope throughput.

Optimize throughput/dollar with medium-size aperture (diminishing ROI for going below 5-arcminute beams).

POLAR-I and the POLAR Array

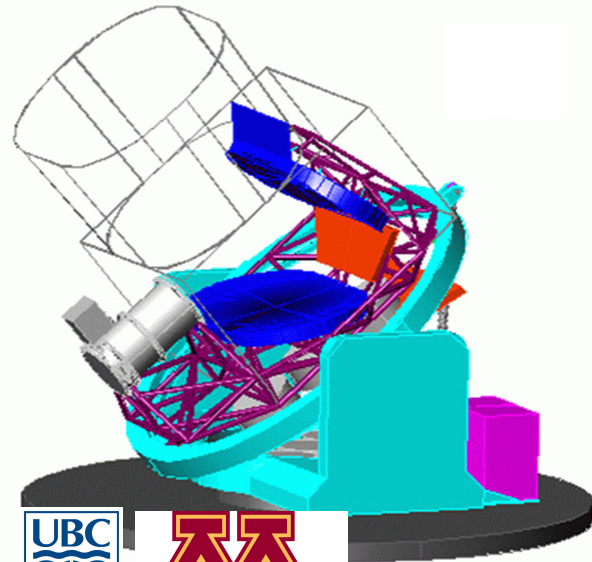


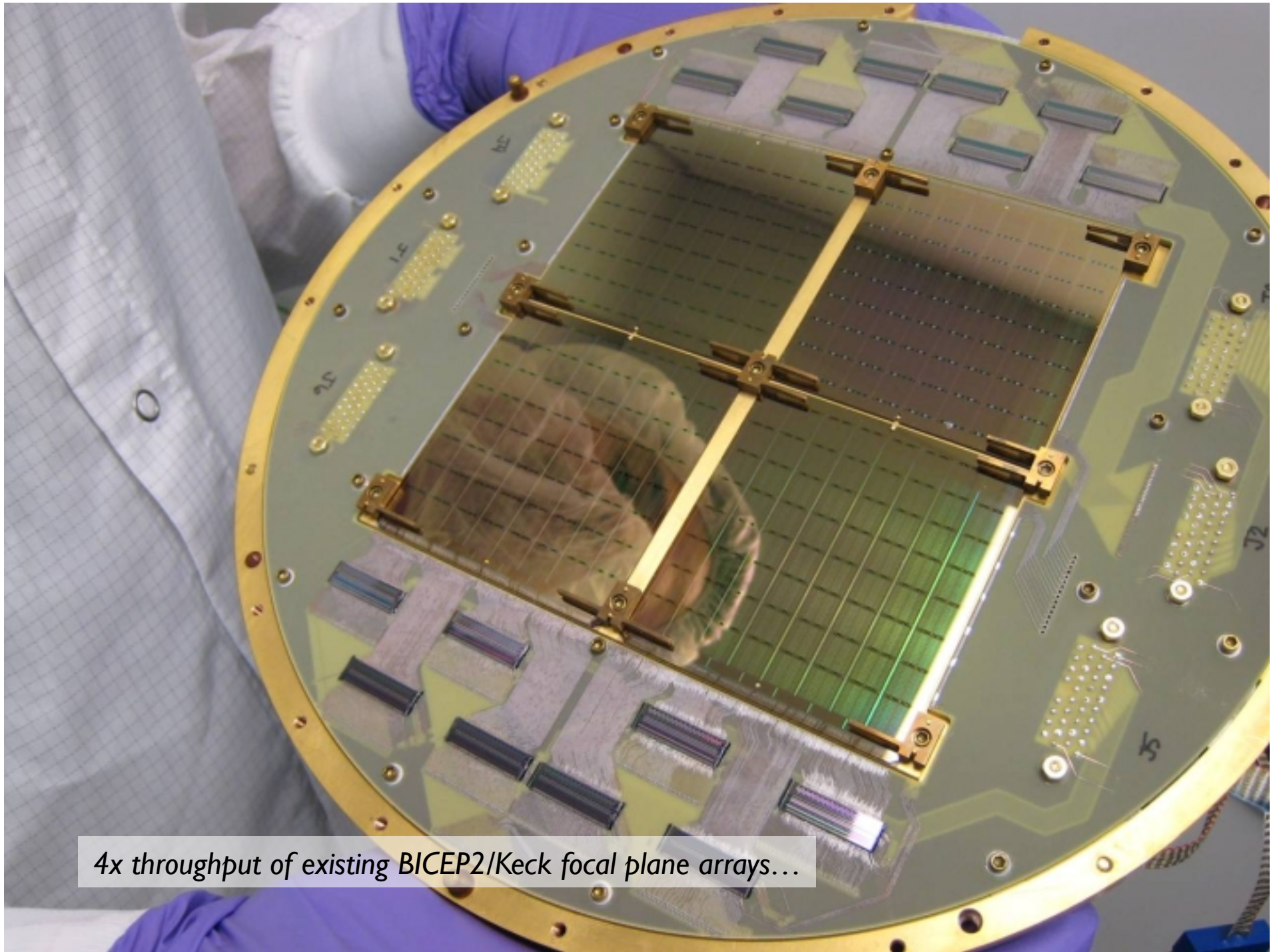
POLAR-I:

- 1.5 m (6'), up to 4608 detectors @ 150 GHz
- ~300 deg² survey
- Funded; target deployment in late 2012

POLAR Array:

- 10 x 2-m telescopes (4'); ~4608 detectors each
- 90, 150, 220 GHz
- 400/15000 deg² dual deep/wide coverages
- TBD

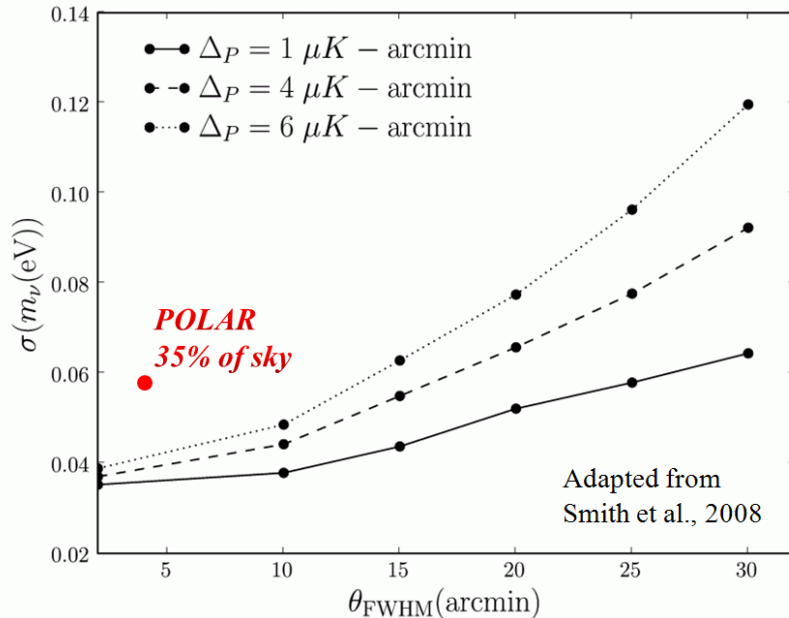




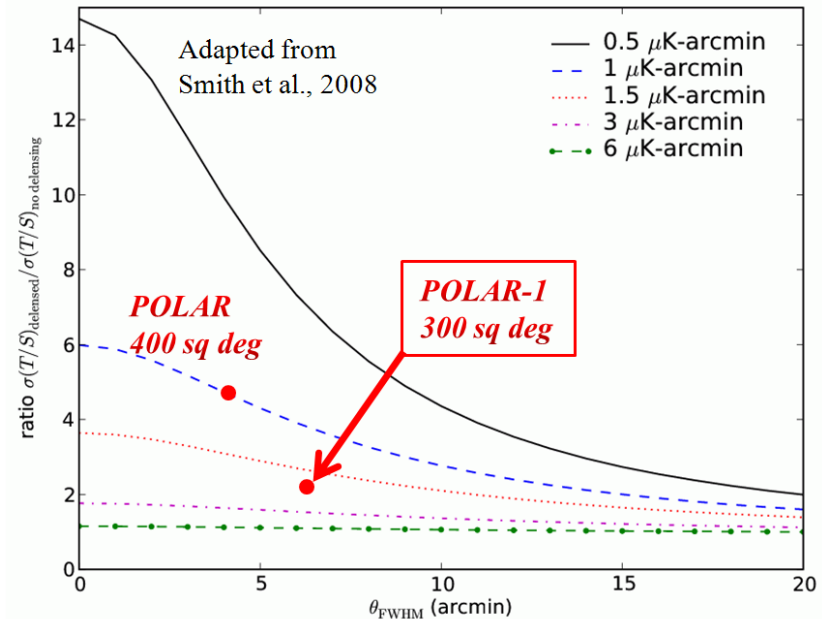
4x throughput of existing BICEP2/Keck focal plane arrays...

What can POLARI and the POLAR Array do?

(a) Constraints on Neutrino Mass



(b) Delensing efficiency



POLAR-1:

- map lensing B-mode with high S/N; reach $r=0.02$
- 2x delensing efficiency

POLAR Array:

- full information extraction on neutrino mass, early dark energy
- 4x delensing efficiency; enable probing below $r=0.01$

Conclusion

Fully exploring the wealth of information in primordial and lensed B-mode CMB polarization requires a huge jump in mapping speed, beyond currently proposed experiments.

Scalable and affordable design needed for ~ 10 high-throughput telescopes.

~ 2 -m primary (4' beams) combined with both deep and wide surveys can address above challenges, and allow for probing $r < 0.01$ by delensing along with exciting precision cosmology from lensed B-mode polarization.

Currently refining optical design and instrument/observing strategies. POLAR-1 deployment in 2 years as a demonstration for eventual POLAR Array.

