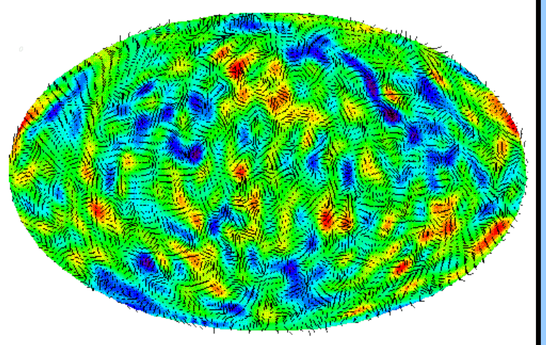

# Scientific Goals and Objectives of PICO - Probe of Inflation and Cosmic Origins


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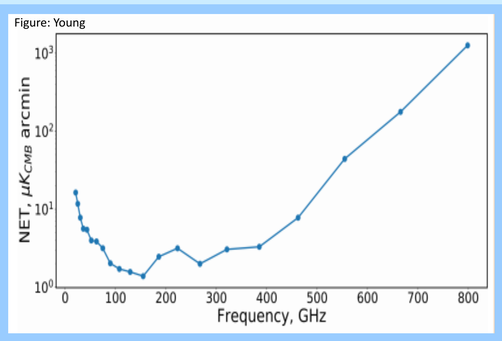
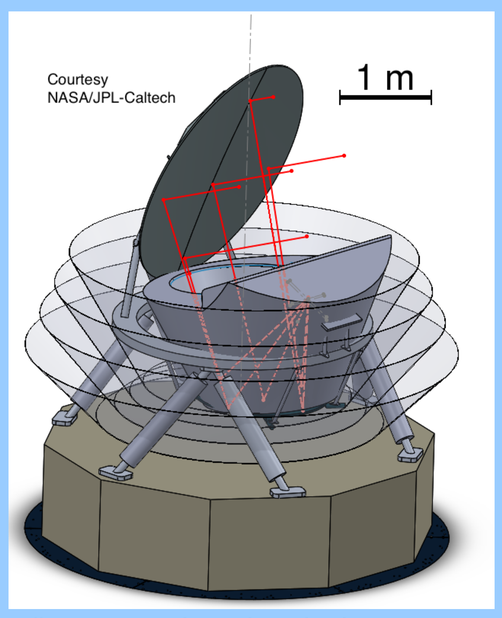
## Mission In Brief

- The Probe of Inflation and Cosmic Origins (PICO) is a space mission concept that is being studied in preparation for the 2020 Astronomy and Astrophysics Decadal Survey
- Millimeter/submillimeter-wave, polarimetric full sky survey from L2
- 1.4 meter aperture 2-mirror telescope
- 21 frequency bands (25% bandwidth) between 21 and 799 GHz
- Diffraction limited resolution: 38' to 1'
- 12,400 polarization sensitive TES bolometers
- 4 year mission
- Noise: 0.63 uK*arcmin in polarization, 70 times the sensitivity of Planck

Figure: Young




Sensitivity of PICO over 21 bands.




Current engineering design of the PICO instrument.

## Fundamental Physics

### *Cosmic Inflation*

- Probe the energy scale at which inflation occurred and exclude certain inflationary models
- Measure or set an upper limit on the tensor-to-scalar ratio r with $\sigma(r) = 5\times10^{-5}$, $r < 10^{-4}$ at 95% CL, 700 times lower than current constraint
- Above prediction includes internal delensing and foreground removal assuming synchrotron and two-component dust model (the correlation between synchrotron and dust is also included); x2.5 margin.

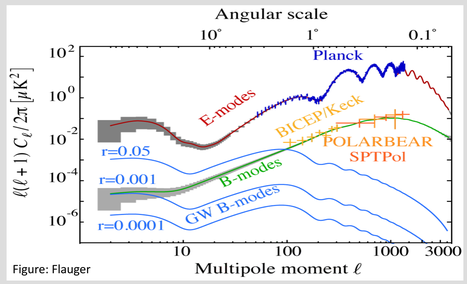



Figure: Flauger

CMB power spectra.

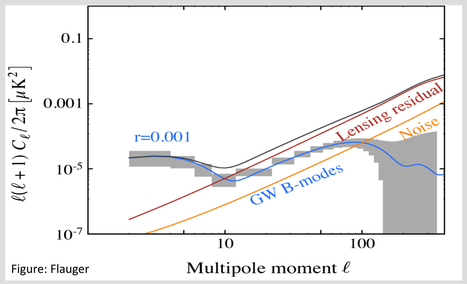



Figure: Flauger

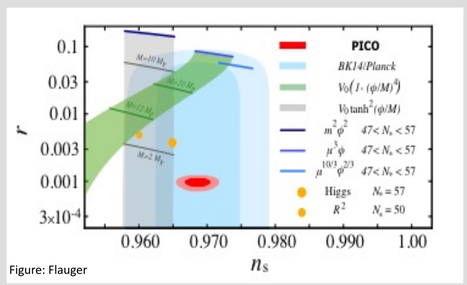
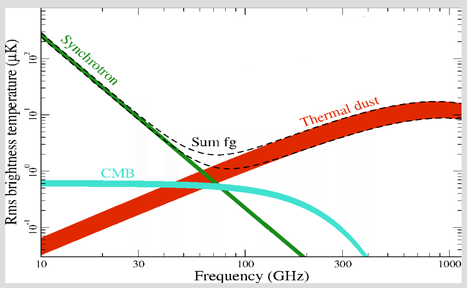



Figure: Flauger

Current and forecast PICO constraints on models of inflationary potentials, if r = 0.001.




Synchrotron, dust and CMB brightness temperature in polarization for 73% to 93% of the sky (Adam et al, Planck 2015 results. X. )

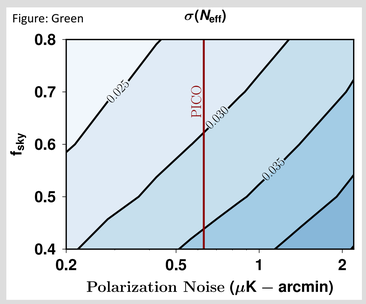
### *Light Relics*

- Probe the effective number of light degrees of freedom $N_{eff}$, which measures the total energy density of radiation excluding photons in the early universe
- CMB temperature and E-modes
- $\sigma(N_{eff}) = 0.03$

### *Sum of Neutrino Mass*

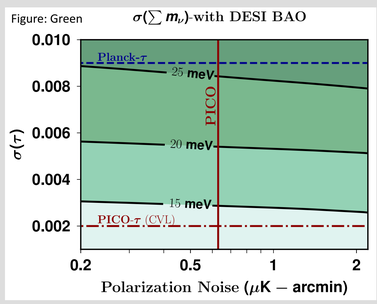
- On small scale, neutrinos free stream out of potential wells and suppress the growth of structure
- Lensing B-modes
- $\sigma(\sum m_\nu) = 14$ meV, with BAO data from DESI

Figure: Green




Left: $\sigma(N_{eff})$ vs noise in polarization and sky fraction. Right: $\sigma(\sum m_\nu)$ vs noise in polarization and $\sigma(\tau)$. Red verticals are the expected performance of PICO.

Figure: Green




## Cosmic Structure Formation

- Star formation history
  - Optical depth to reionization
  - CMB polarization E-mode, sensitive to large angular scales, thus demanding a space mission
  - $\sigma(\tau) = 0.002$
- Determine the role of energy injection due to feedback processes on galaxy formation and evolution
- Obtain all sky CMB Compton Y maps

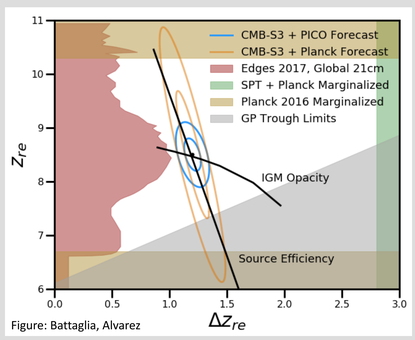


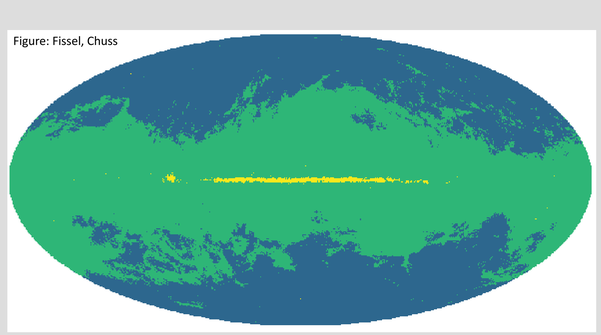

Figure: Battaglia, Alvarez

Fig. Constraints on reionization history from different experiments.

## Galactic Dynamics

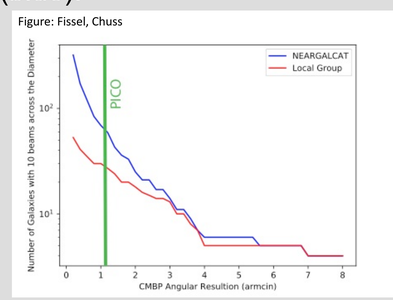
- Star formation
  - Determine if magnetic fields are the dominant cause of low star formation efficiency in our Galaxy
  - Map the magnetic fields of molecular clouds with <1 pc resolution (<0.05 pc for the 10 nearest MCs) at 799 GHz for galactic latitudes -20<b<20
- Interstellar medium of our Galaxy vs nearby galaxies
  - Compare the ratio of energy in magnetic field to turbulence in our Galaxy to that in nearby galaxies
- Determine whether radiative torque is responsible for the alignment of dust grains with magnetic fields
- Determine the influence of the magnetic field on gas dynamics within the Milky Way

Figure: Fissel, Chuss



Area of the sky for which $\sigma(P) \leqq 0.33\%$ for Planck at 5 arcmin resolution (yellow), PICO at 1 arcmin resolution (green), and PICO smoothed to the same resolution as Planck (blue).

Figure: Fissel, Chuss




Number of nearby galaxies for which PICO will have at least 10 resolution elements across the Galaxy

## Legacy Science

- Discover 3000 mm/sub-mm proto-clusters over the entire sky and across redshift
- Discover 3000 highly magnified dusty galaxies across redshift
- Find 1000 mm/sub-mm emitting clusters at 1<z<1.5 and ~20 at z>2
- Detect 4000 radio and dusty galaxies in polarization


## Acknowledgement

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