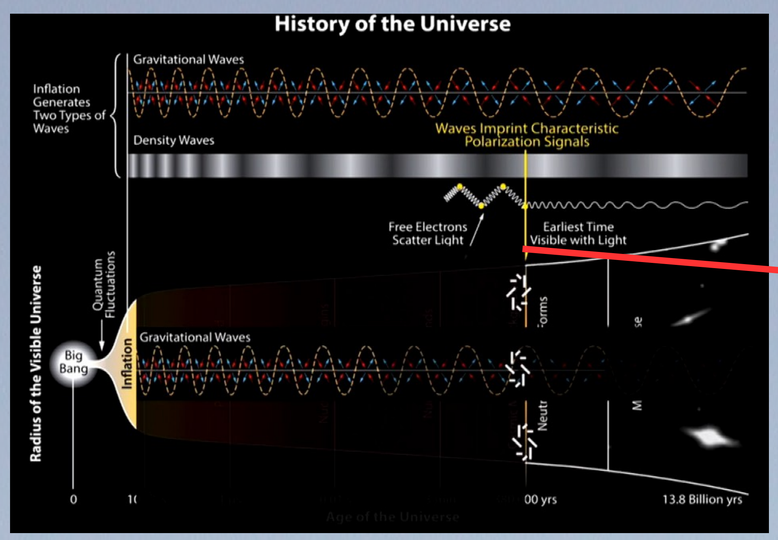
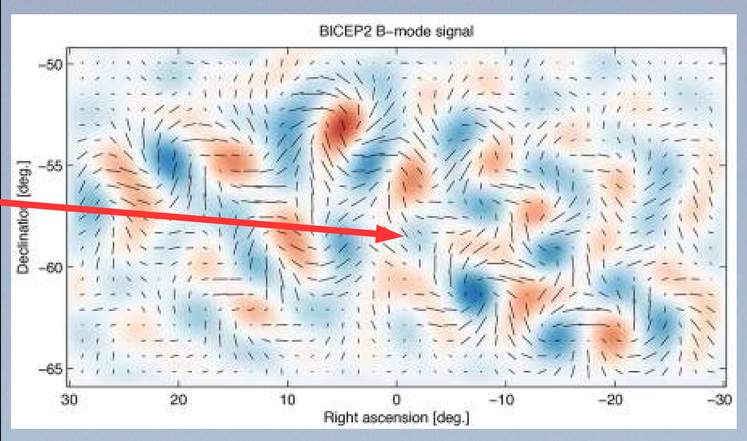
QUBIC experiment

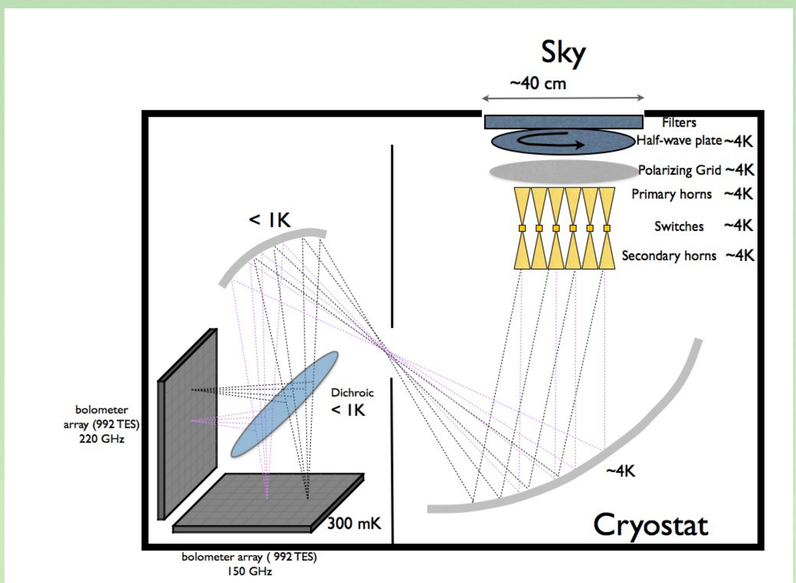
The “QUBIC” acronym stands for “the Q&U Bolometric Interferometer for Cosmology. It is a future experiment dedicated to the measurement of the B-MODES POLARISATION of the COSMIC MICROWAVE BACKGROUND (CMB) anisotropies. It will be situated at the Dome C antarctic site, and it will be the first BOLOMETRIC INTERFEROMETER.





Inflation is a model of the Universe at age 10^{-34}s after the Big Bang (BB) that can explain some difficulties of the BB model:
- it naturally solves the horizon problem: why the Universe is so homogeneous, though the causal connected region earlier in the Universe history was very small?
- it explains why the space is flat (to get a flat space without inflation the fine tuning of initial conditions is needed).
- it also generates the primordial perturbations and produces SM particles.

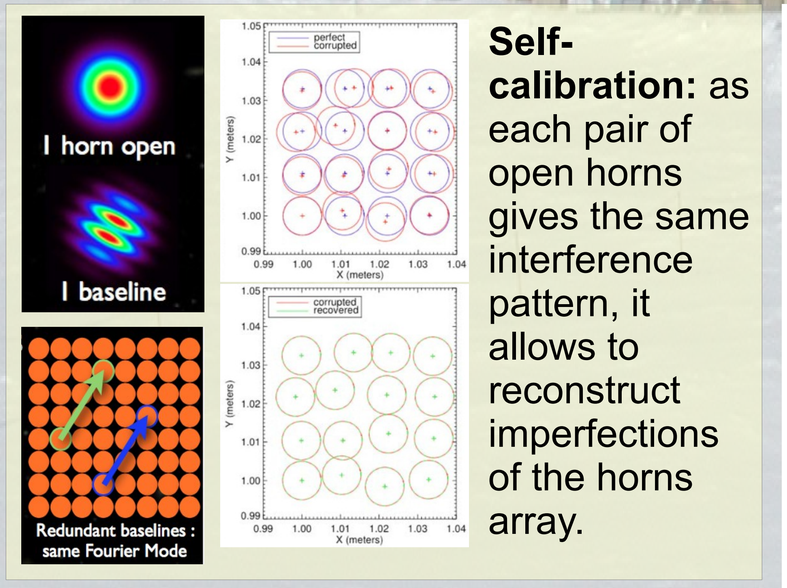
At the period of inflation Universe expands exponentially => huge acceleration of a huge mass gives gravitation wave (GW) => GW modulates the polarization of CMB producing B-modes (as on the picture on the left). B-modes are often called “smoking gun” of inflation as it is the only direct observational signature of the inflationary phase of the early Universe.



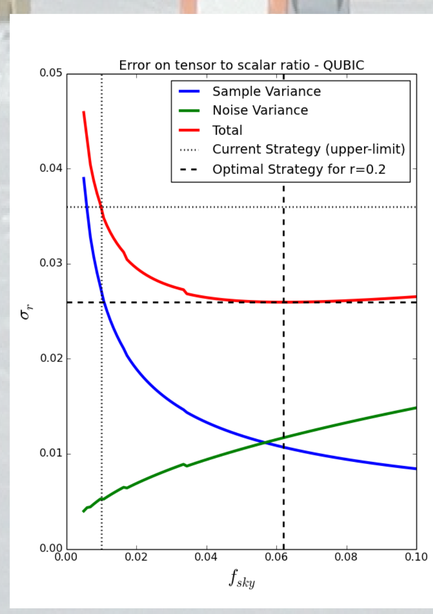
The QUBIC instrument concept
- Millimetric equivalent of the Fizeau interferometer
- Modulation of the incoming polarization using a half-wave plate (HWP)
- Each couple of horns = a diffractive pupil
- The interference patterns are imaged on the bolometric array.

Why bolometric interferometer? Other possible instruments are:
- ✓ Imagers with bolometers, which have very good sensitivity.
- ✓ And interferometers, which has clean systematics due to well known angular resolution.

Bolometric interferometer would have both those pros due to sensitivity of bolometers and systematics control by **self-calibration**

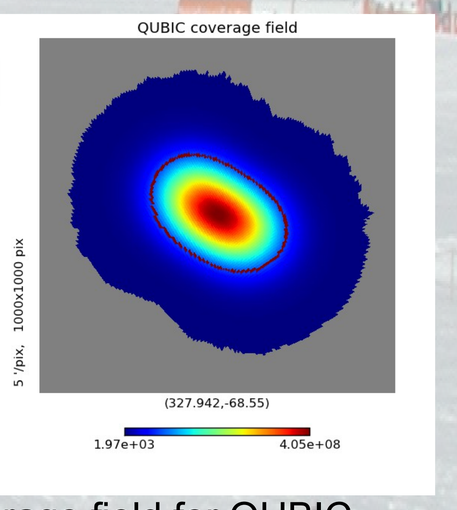


Self-calibration: as each pair of open horns gives the same interference pattern, it allows to reconstruct imperfections of the horns array.



SCANNING STRATEGY is a way to move the instrument and its parts that allows to collect most clean data and reconstruct the power spectrum with highest accuracy possible. It has to be balanced between:
- Sample variance (bigger total coverage => spectra are better defined at low ell)

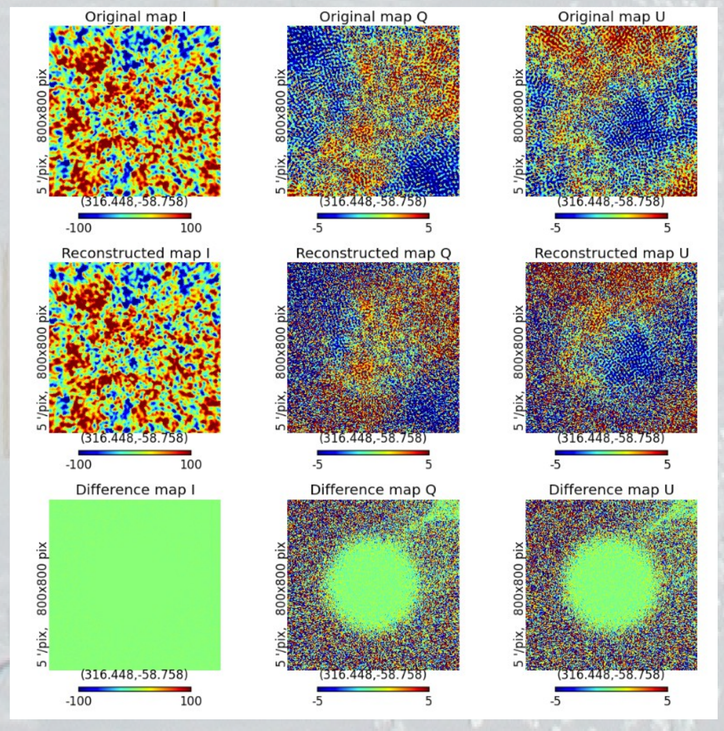
And
- Noise variance (bigger total coverage => more noise in each pixel)

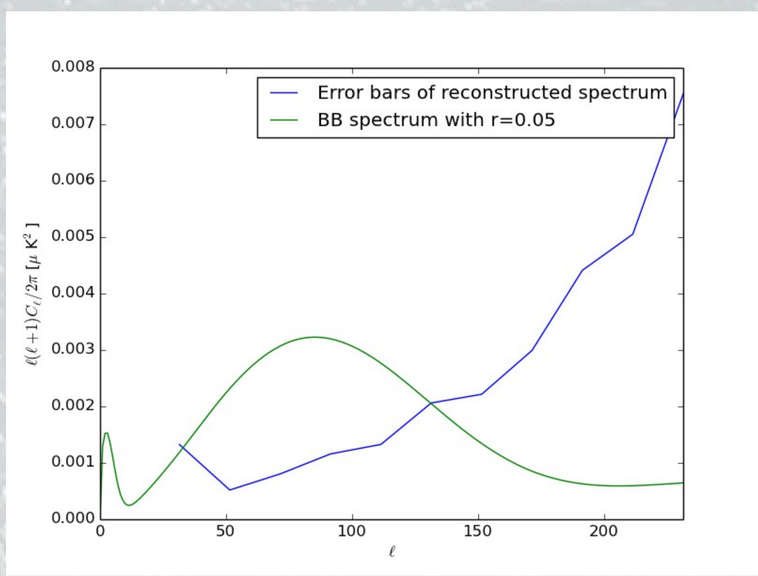


Coverage field for QUBIC instrument due to current Scanning Strategy (limit of coverage better than 20% of maximum is shown with the red line). Coverage threshold level of 20% is chosen to improve apodization and exclude noisy pixels.

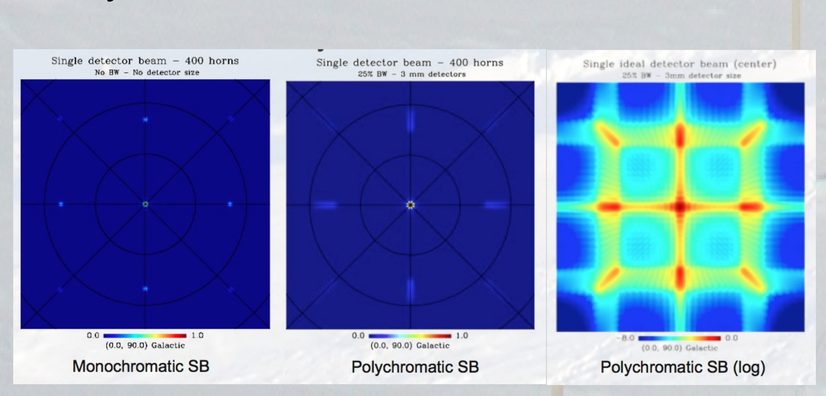
The mapmaking for a bolometric interferometer is not the same as it for the imagers: the synthesized beam (SB) of QUBIC has a multi-peaked feature, which makes the inversion of equation **y = Hx + n** (where **y** is a noisy timeline, **H** – acquisition model, **x** – IQU sky and **n** is a time-correlated gaussian noise) very challenging and CPU costly.

An example of MC simulation of QUBIC ability to reconstruct CMB temperature and polarization. SB is approximated as a sum of gaussian peaks. Input sky is monochromatic. -->





BB-spectrum reconstruction by Xpure package for 100 MC-realizations. The good sensitivity at the region of the peak of primordial B-modes is shown. At the right spectrum is dominated by lensing (not shown), so at this region QUBIC is still sensitive to the total spectrum.



References:
[The QUBIC collaboration, 2010], arXiv: 1010.0645
[Hamilton et al., 2008], A&A 491, 923-927
[arXiv:0903.2350 [astro-ph.CO]