Ali CMB *P*olarization *T*elescope

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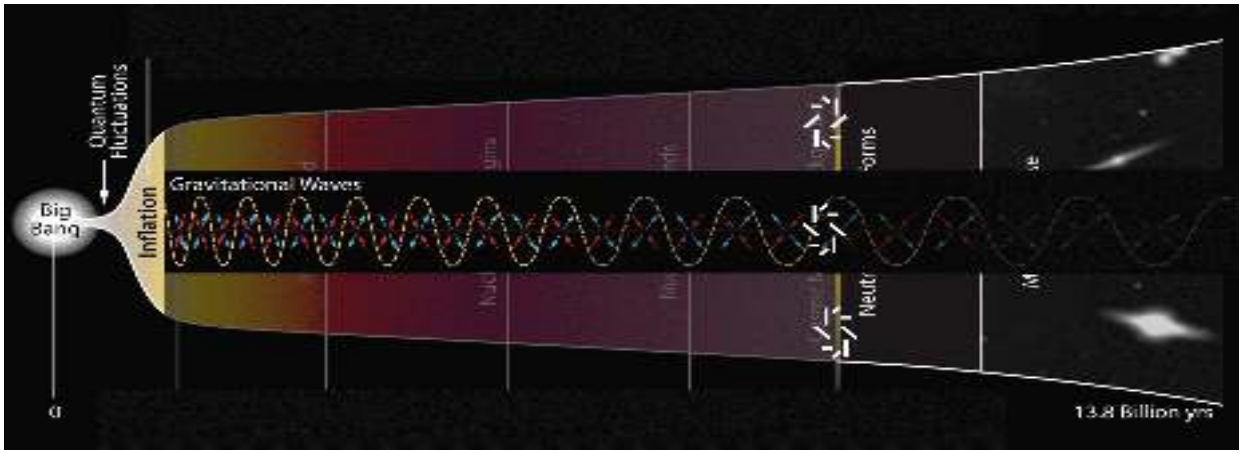
Sep.7 2019@BNU

Outline

- **Brief introduction for AliCPT**
- **Site**
- **instrument**
- **AliCPT-1 science and data analysis**
- **summary**

*Ali C*MB *P*olarization *T*elescope

- A ground based CMB polarization telescope
- B mode science: BB,TB, EB measurements -> r, α …



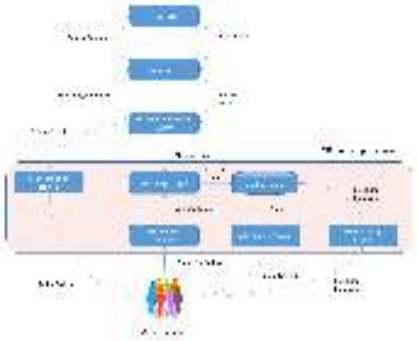
Credit: JPL/BICEP team

- AliCPT-1: on going project
  - Proposed in 2014, and launched in 2016.
  - 2016 ～ 2021
  - A small aperture Telescope@5250m, 95&150 GHz, 4 modules: ~ 7000 dets
- AliCPT-2: planning in progress
  - 2021 ～
  - 19 modules in AliCPT-1
  - +/? large aperture Telescopes@more frequencies…
  - r, non-r science, e.g. neutrinos, Dark energy …

AliCPT-1 collaboration

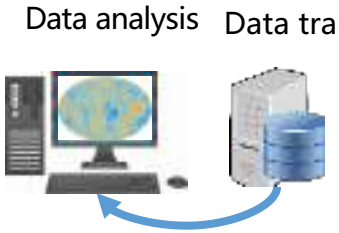
- Led by the IHEP, the international cooperation includes: about 100 scientists from China, US, Europe.
- Funded already by the CAS, NSF of China.
- Executive board: Xinmin Zhang, Chao-Lin Kuo, Fang-jun Lu

AliCPT-1 Work Breakdown and schedule



AliCPT-1 schedule :

- Mar. 2017, Start site construction
- Nov. 2018, Review and accept the building
- ➢ Dec. 2019, Finish Mount development, ship to B1 site and start commissioning
- Dec. 2020, B1 deployment and first light
- 2021-2022, Accumulate data and achieve CMB polarization map



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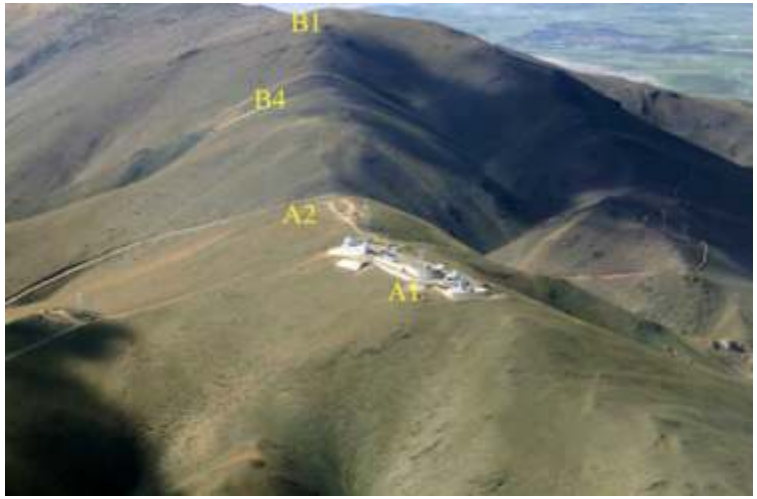
AliCPT-1 site

Located on a hilltop B1 (32°18′38″ N, 80°01′50″ E),
in the Ngari(Ali) Prefecture of Tibet,
at an altitude of 5250 meters.

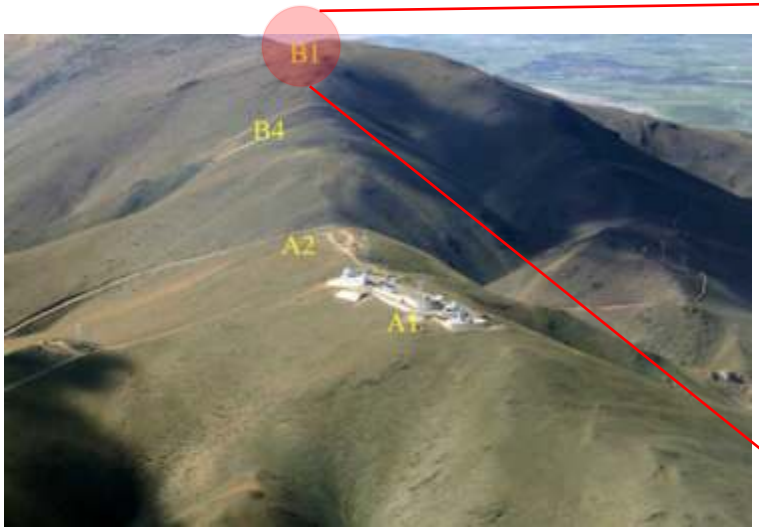
- The Himalayas is to its southwest and runs from northwest to southeast, separating the Ngari(Ali) prefecture from the Indian Ocean.
- AliCPT-1 (B1, 5250m) is only about 1.5 km to the current well-developed A1 station (5100m) of the Ali observatory.

It is only 30 km far from the AliCPT site.



Current status of site @ 5250 m

Review and Accepted in 2018.11



See Yong-Jie's talk

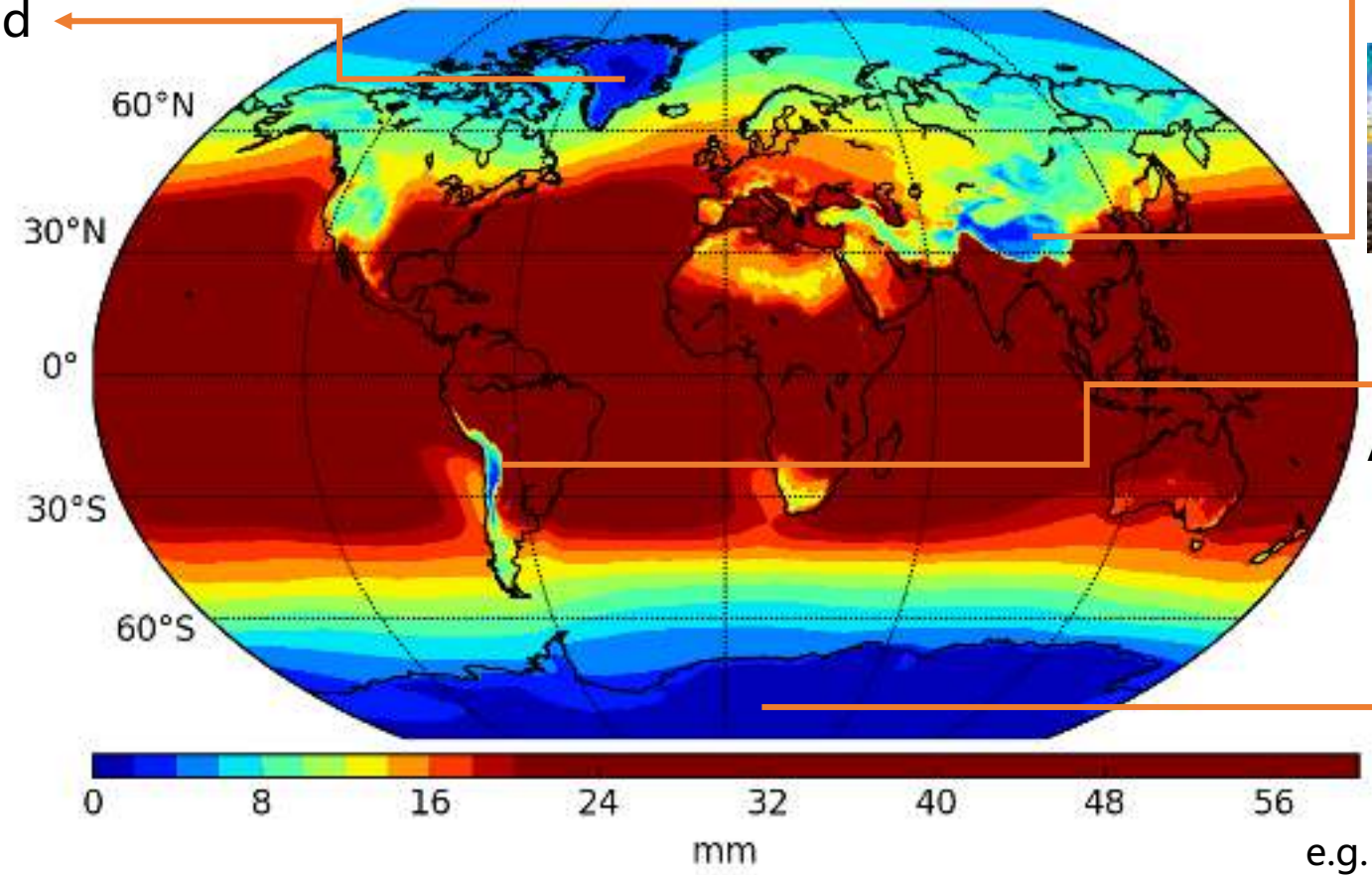
CMB observations on earth

Greenland

Ali, Tibet

POLARBEAR

ACTpol



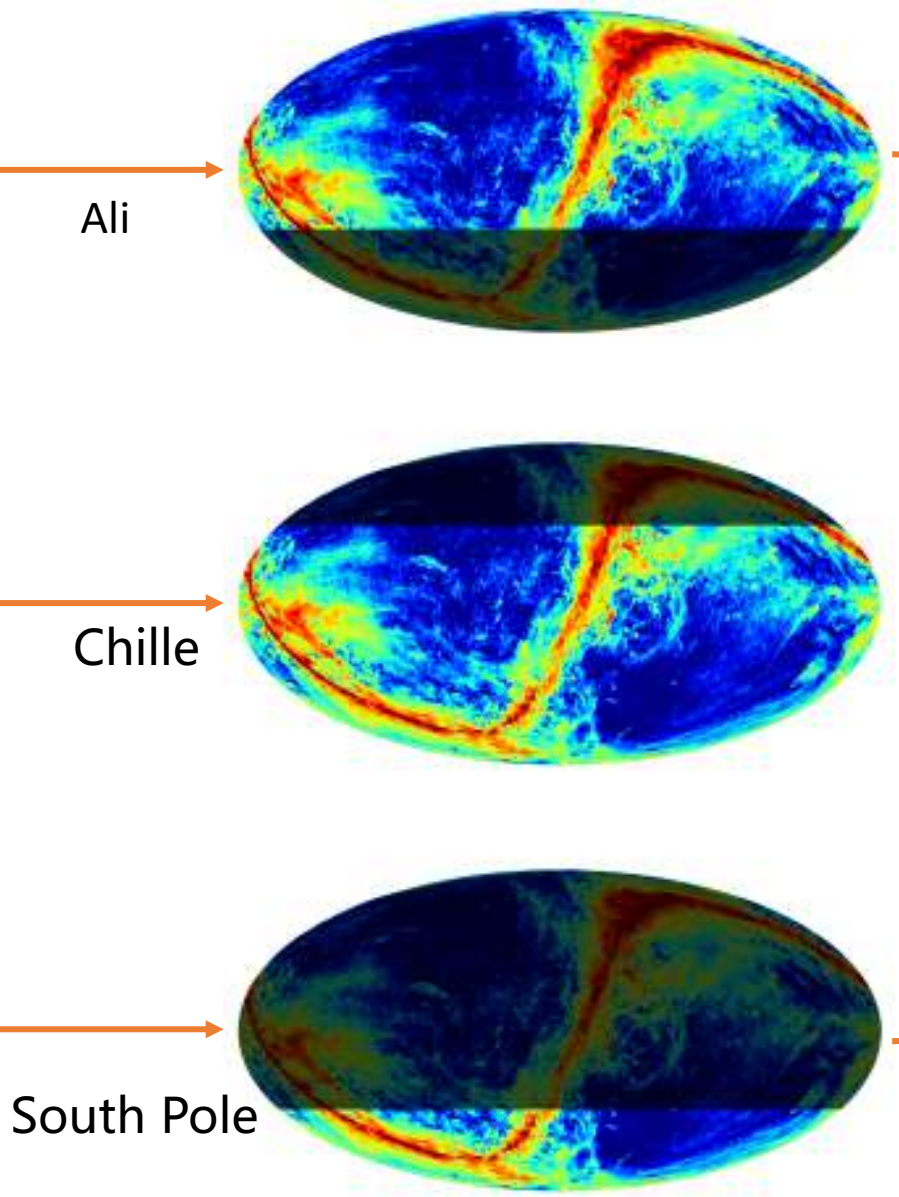
Atacama

South Pole

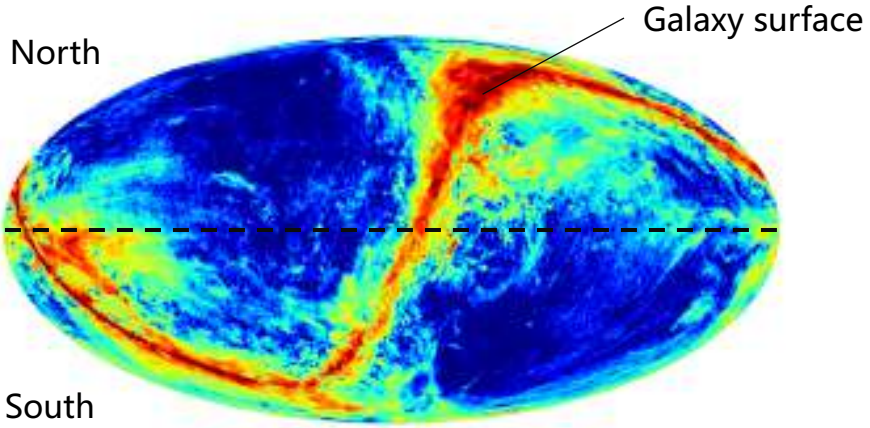
e.g. SPT and BICEP

H. Li *et al* arXiv:1710.03047

Ali: one of the most excellent sites for CMB observation on earth



- **AliCPT-1 :**
  - Can cover the whole northern sky;
  - Will observe deeply on the low emission areas of the Milky Way in North



➢ **Ali Observatory:**
- Unique geographical advantages: large sky coverage.
- To realize the whole sky coverage from earth, together with the Atacama and South Pole telescopes.

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Current status of mount

- ✓ Being tested in factory now
- **Will be shipped to site by end of 2019**

See Cong-zhan's talk

Azimuth:

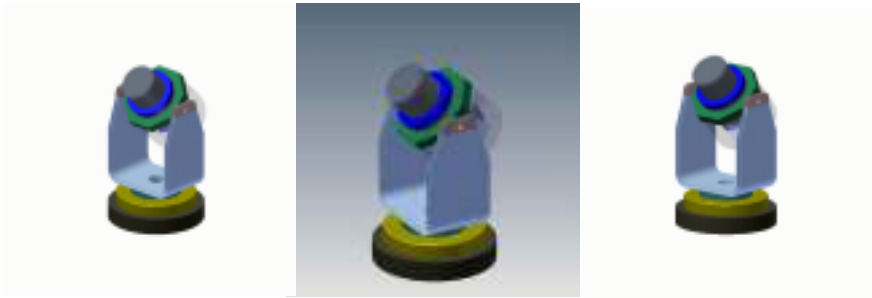
• Range	±270 deg
• Angular speed	5 deg/s
• Angular acceleration	5 deg/s^2

Elevation:

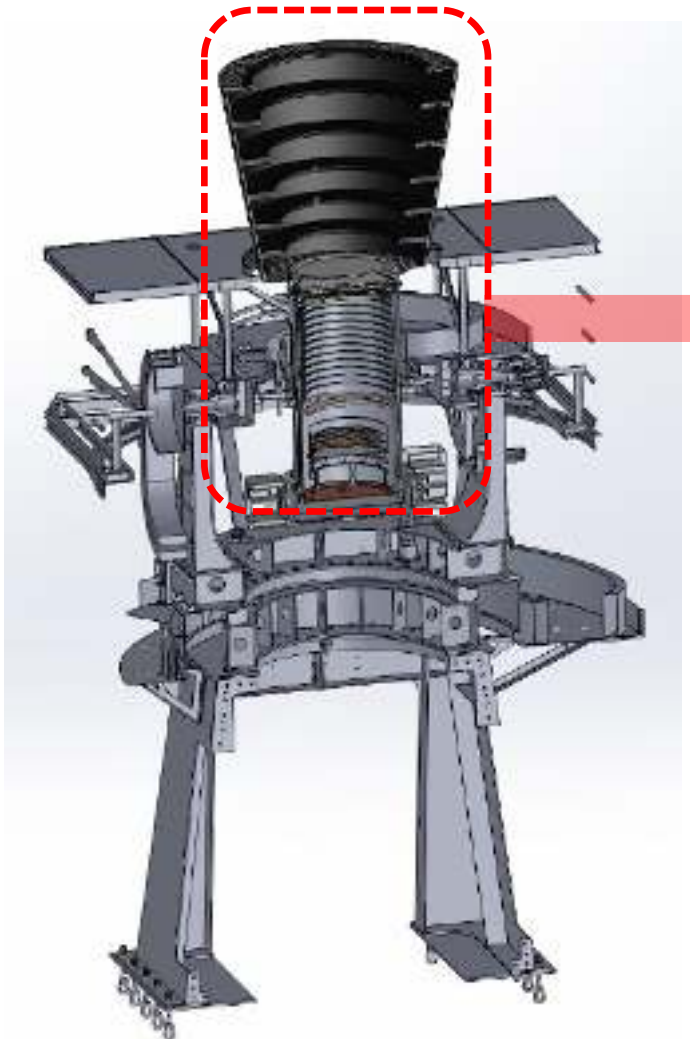
• Range	45–135 deg
• Angular speed	>1 deg/s
• Angular acceleration	1 deg/s^2

Boresight (Theta):

• Range	0–181 deg
• Precision	15″
• Angular speed	>2 deg/s
• Angular acceleration	1 deg/s^2



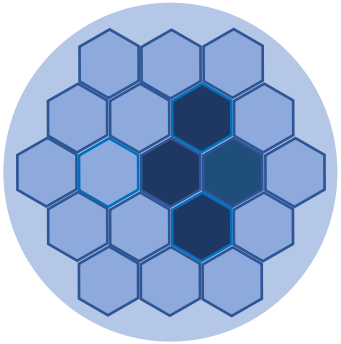
Current status of receiver



(IHEP /Stanford)

- ✓ Optical system: finished design and under fab.
- ✓ TES detectors: finished the detailed design.
- ✓ Multiplexing readout system: finished the detailed design.
- ✓ Cryostat: under fab soon

See Maria's talk



	AliCPT-1
Frequency	95/150GHz
Aperture	72cm
F factor	f/1.4
Number of detectors	~ 6816

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Simulation and Data analysis pipeline

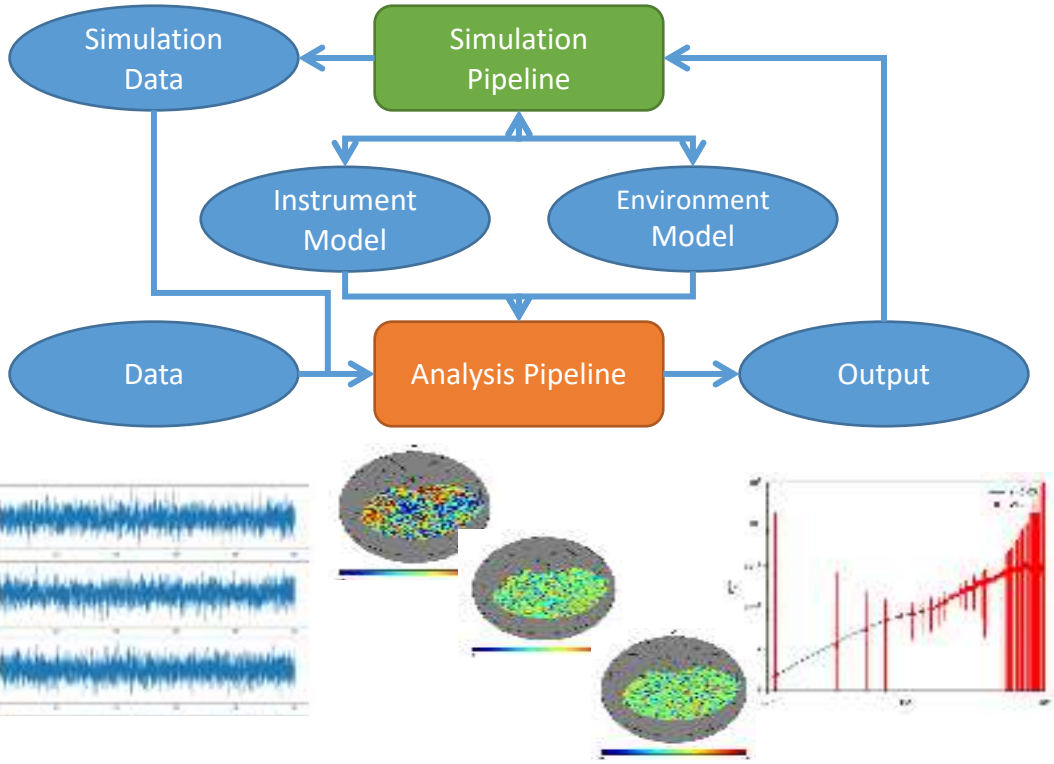
- IHEP, together with APC, SJTU, USTC, BNU and NTU, have established AliCPT-1 Science and Data Analysis team.

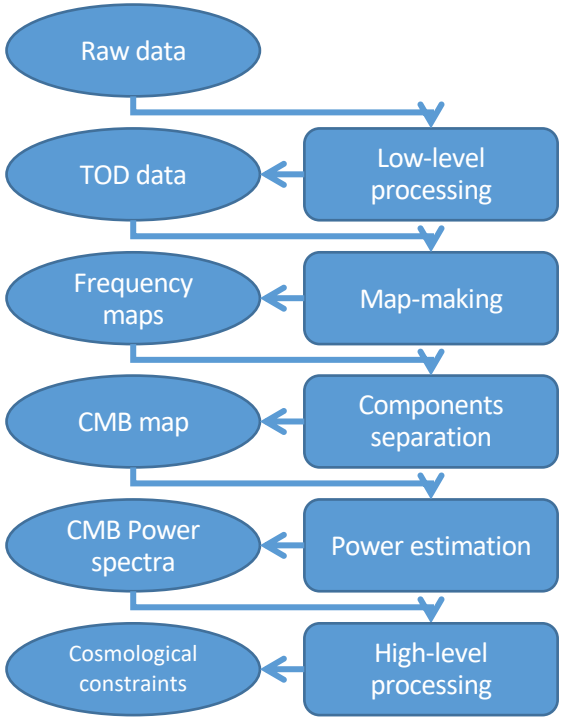
- Hong Li
  - Leader of science team
- Jacques Delabrouille (APC)
  - Senior advisor
- IHEP (Si-yu Li, Yang Liu, Hua Zhai, Zirui Zhang)
  - Architecture
  - Integration
  - I/O Management
  - General algorithm investigation
  - Map-making
  - Bandpass mismatch simulation
  - Beam systematic simulation
  - De-projection
- NTU (Yu-han Tseng)
  - Scan strategy
  - Jack-knife solution
- SJTU (Le Zhang, Jian Yao, Zeyang Sun, Larissa Salatino, Ji Yao, Peng-Jie Zhang)
  - Components separation algorithm investigation
  - Components separation on B-mode
  - CMB x LSS cross correlation
- USTC (Wen Zhao, Shamik Ghosh, Jiming Chen)
  - E/B decomposition
  - Power estimation
- BNU (Bin Hu, Jinyi Liu)
  - CMB lensing reconstruction
- ... Science, early universe, models

2020.5: integration and testing

Simulation and Data analysis pipeline

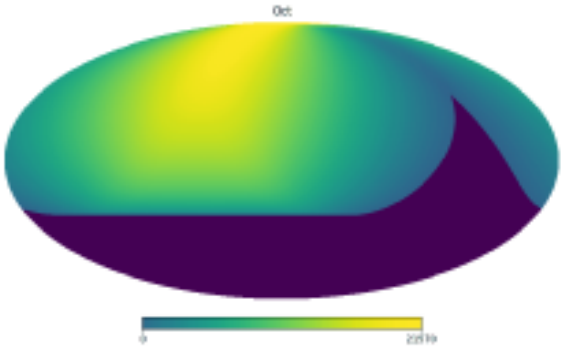
- AliCPT-1 end to end simulation: noise, systematic
- Scan strategy: hit-maps
- Data analysis pipeline: data selection, pointing, deprojection, map making…

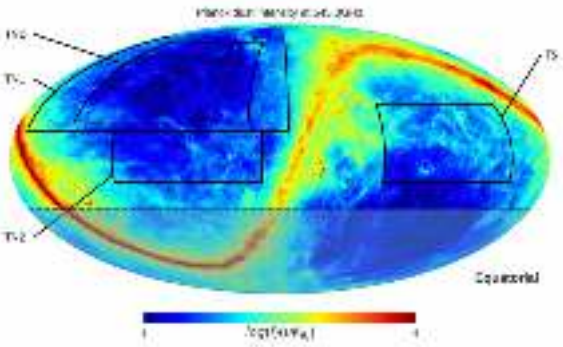


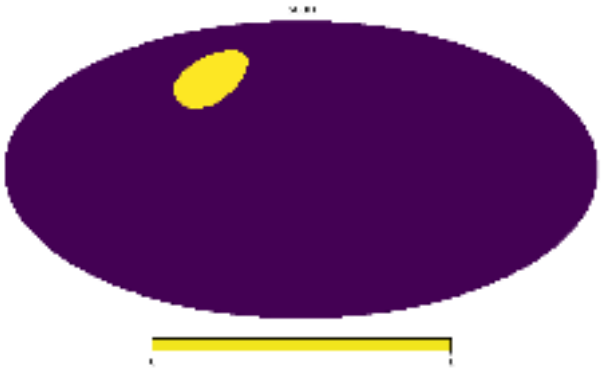


Preliminary concern on Scan strategy

- Characteristics of observation in Ali
  - Sky move fast: helpful for large sky coverage, but not easy to focus within one small patch.
  - “clean” area in north, also in south: helpful for going deep in north, also provide complementary for exiting southern sky observations.



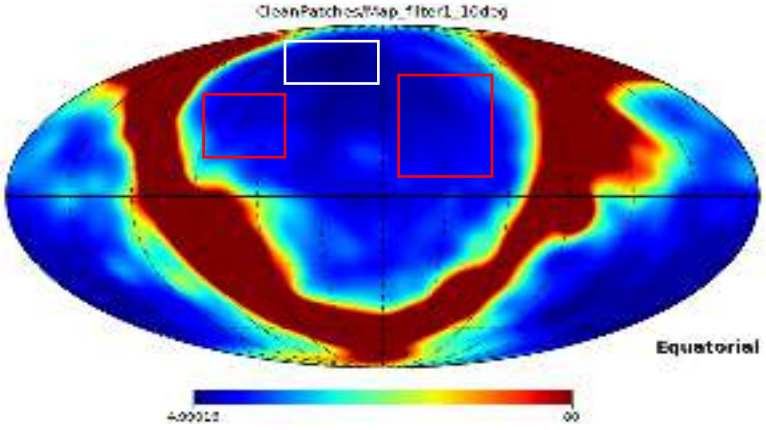




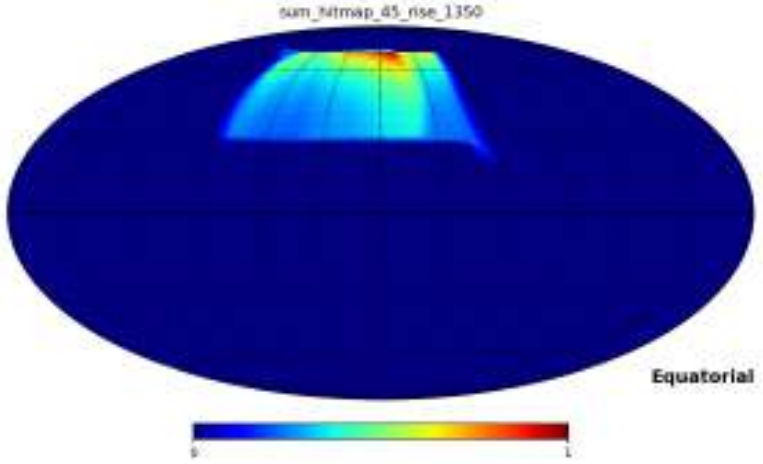
simulation results, Preliminary

Preliminary results of Scan strategy

- Concern on scan strategy
  - Fast scan.
  - Maximize observing efficiency.
  - Large elevation angle and long duration (detector/ground/atmosphere/sky noise).
  - Cross-linking: systematics control and efficiency
  - Uniform coverage / Redundancy.



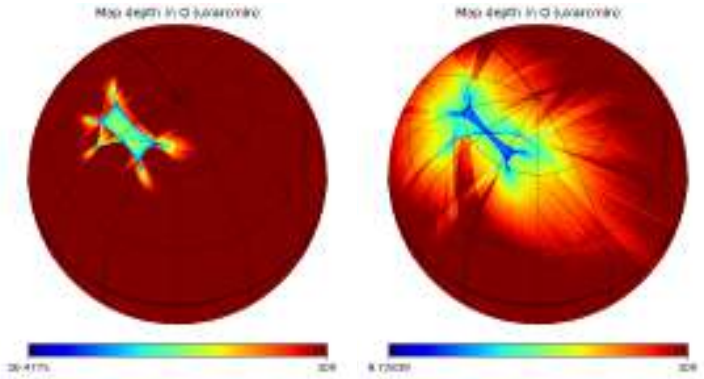
RA~-115deg, DEC~30deg
& RA~150deg, DEC~30deg



simulation results, Preliminary

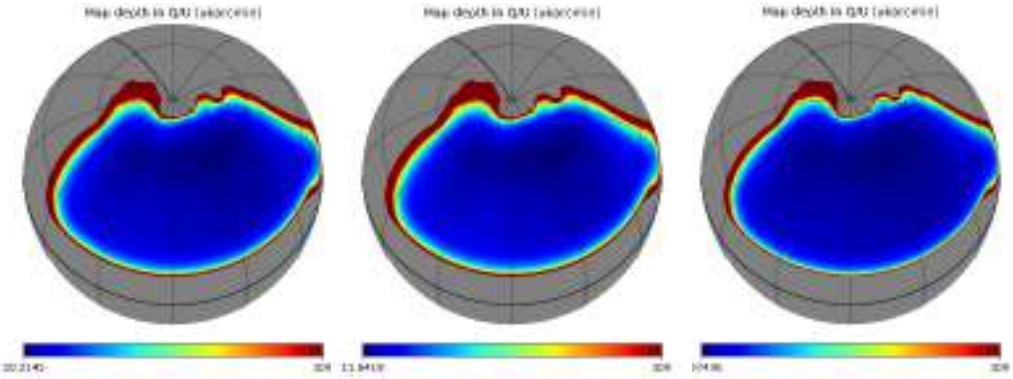
Simulation: sensitivity

AliCPT-1 is designed to have its first light in the winter of 2020



PLANCK 100 GHz & 143 GHz

Pol ~50 uK arcmin in total



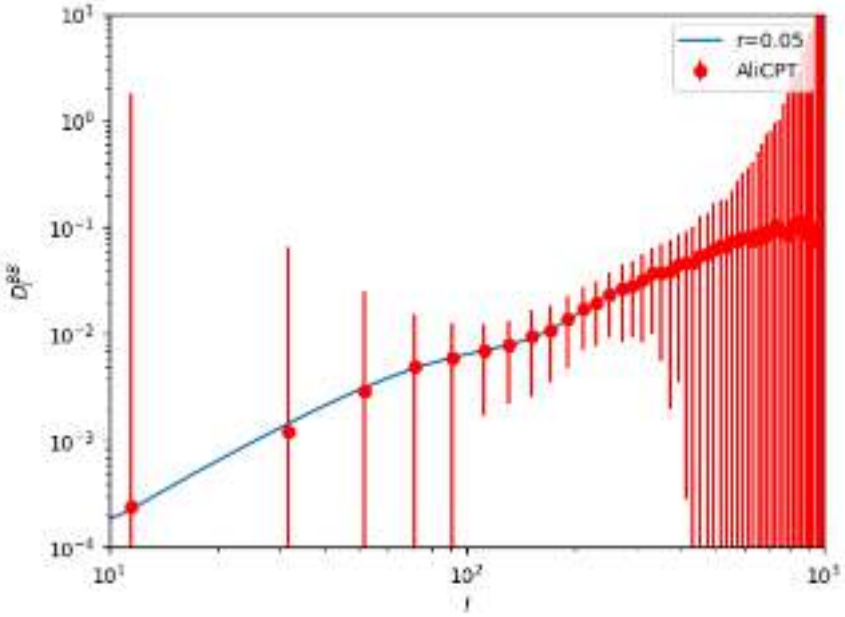
AliCPT 95 GHz & 150 GHz & Total

4 modules 1 season, median map-depth 14 uK arcmin

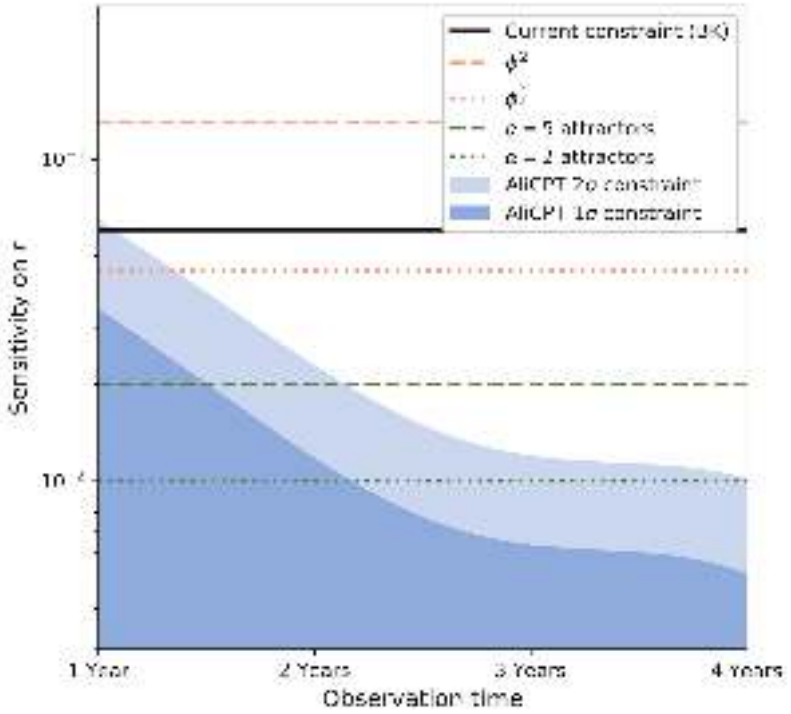
- Probing the primordial gravitational waves (PGWs) with BB spectra.
- Measuring the rotation angle, testing CPT symmetry with TB and EB spectra.
- Investigating the CMB polarization hemispherical asymmetry.
- Studying the cross-correlation between AliCPT and DESI.
- Studying the galactic foreground.

…

Preliminary results from simulation



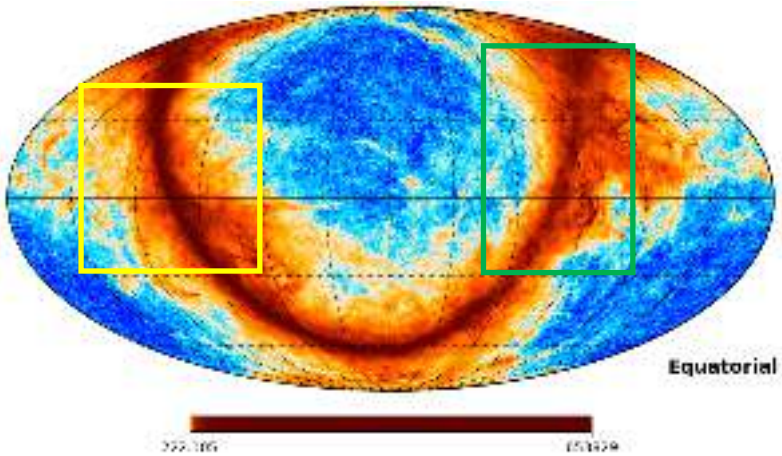
Simulation: BB power spectrum

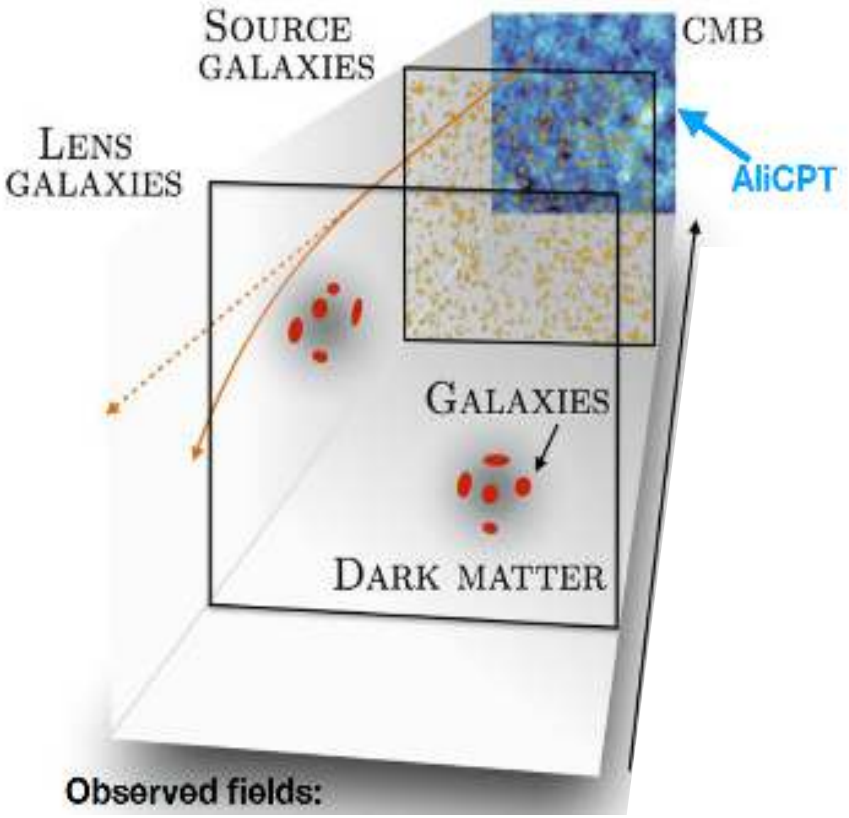


Simulation: r sensitivity

Cosmological study with AliCPT-1

- Cross correlate with DESI
- Scan galaxy: signals for foreground





J. Yao

Summary

- AliCPT-1 target and time schedule:
  - 2014: project proposed
  - 2016: supported from CAS and NSFC
  - 2017 - 2018: site construction
  - 2019:
    - Mount: commissioning before the end of 2019
    - cryostat: delivery Dec. 2019
  - 2020:
    - B1deployment and first light
    - data analysis pipeline: test from 2020.5
  - 2021 ~ 2022: Observation and data analysis
- Future plan: AliCPT-2

Thank you !