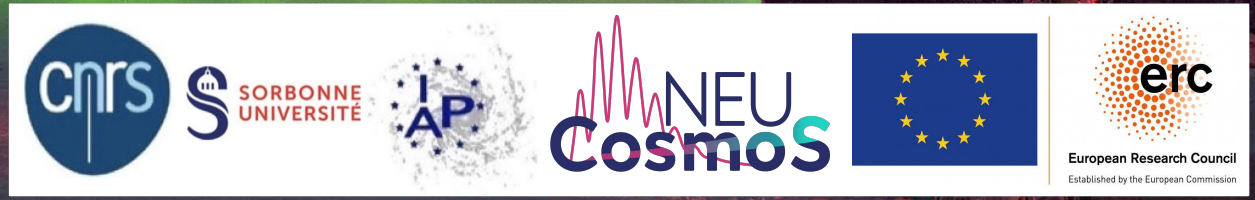
Cosmology from SPT-3G

Federica Guidi on behalf of the SPT-3G collaboration and the NEUCosmoS group

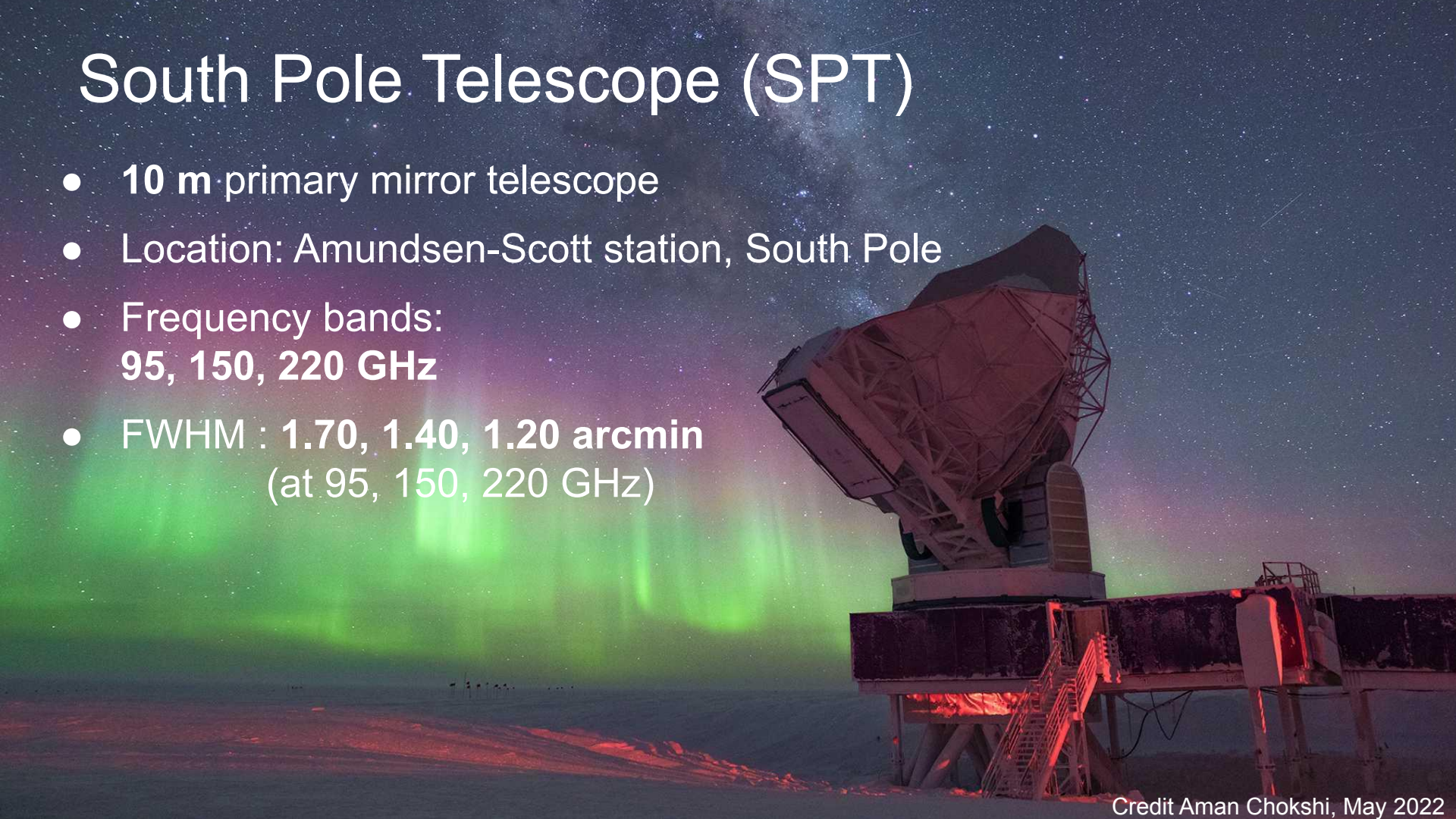
From Planck to the future of CMB
Ferrara, 26 May 2022



Credit Aman Chokshi, May 2022

South Pole Telescope (SPT)

- **10 m** primary mirror telescope
- Location: Amundsen-Scott station, South Pole
- Frequency bands:
  95, 150, 220 GHz
- FWHM : **1.70, 1.40, 1.20 arcmin**
  (at 95, 150, 220 GHz)



Credit Aman Chokshi, May 2022

SPT-3G

Third survey camera installed on SPT, after SPT-SZ and SPT-pol

- deployed in early **2017**
- field of view **2.8 deg2**
- diameter of the focal plane **0.43 m** (**3.5** larger area than before)
- ~**16 000** transition-edge sensor (**TES**) bolometers
  - fabricated on **10** monolithic 150 mm silicon **wafers**
  - operating at **300 mK**.

➔ Sobrin et al. 2022 (arXiv:2106.11202, design and performance)

Science cases:

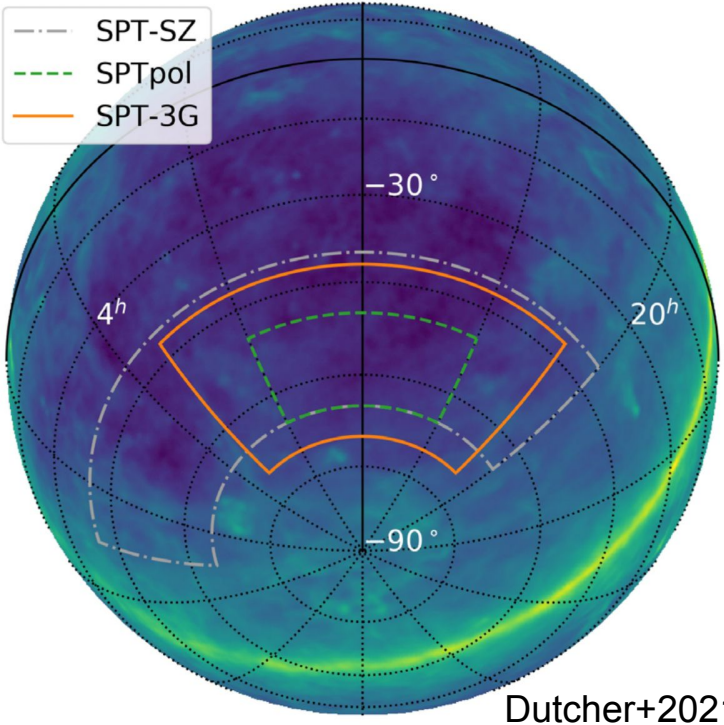
- **Cosmological constraints**
- Delensing in the BICEP/Keck field
- High ell TT
- Low ell BB
- DES x SPT
- tSZ kSZ
- Spatially varying cosmic birefringence
- Axions
- Pont sources, transients, asteroids, planet 9
- Clusters (see talk by Laura Salvati)
- …

Credit Aman Chokshi, May 2022

SPT-3G 2018

First survey with ~ half of the focal plane during 2018

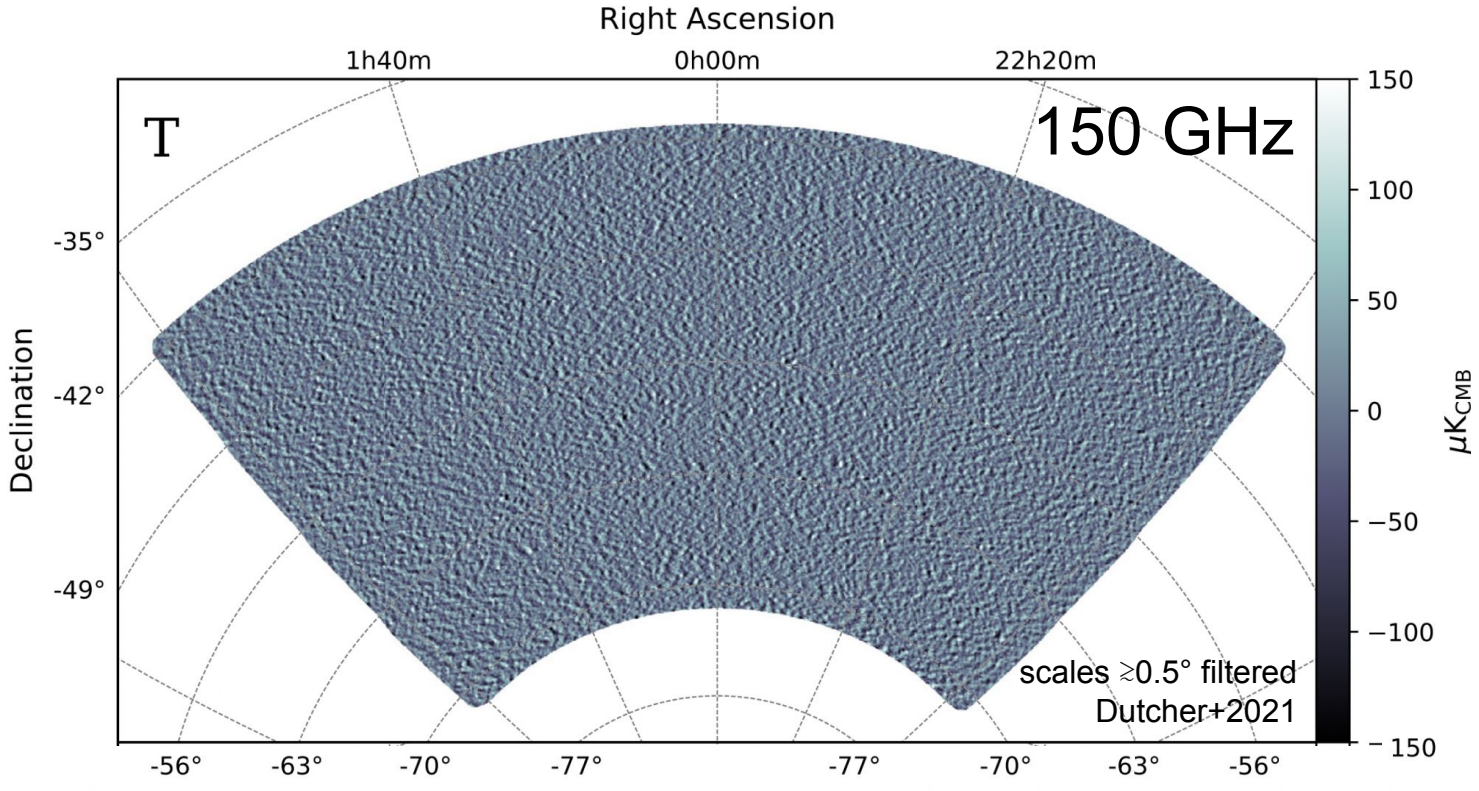
- **four months**
- **6600** active detectors in average
- baseline (winter) field: **1500 deg2** covered with stepping constant elevation rasters (1 deg/s, ~100 s per scan)
  - −42° to −70° declination and from
  - 20h 40m to 3h 20m right ascension
  - overlap with the BICEP/Keck field



Dutcher+2021

➔ Dutcher et al. 2021 (arXiv:2101.01684, maps, bandpowers, ΛCDM)
➔ Balkenhol et al. 2021 (arXiv:2103.13618, ΛCDM Extensions)

SPT-3G 2018 Maps



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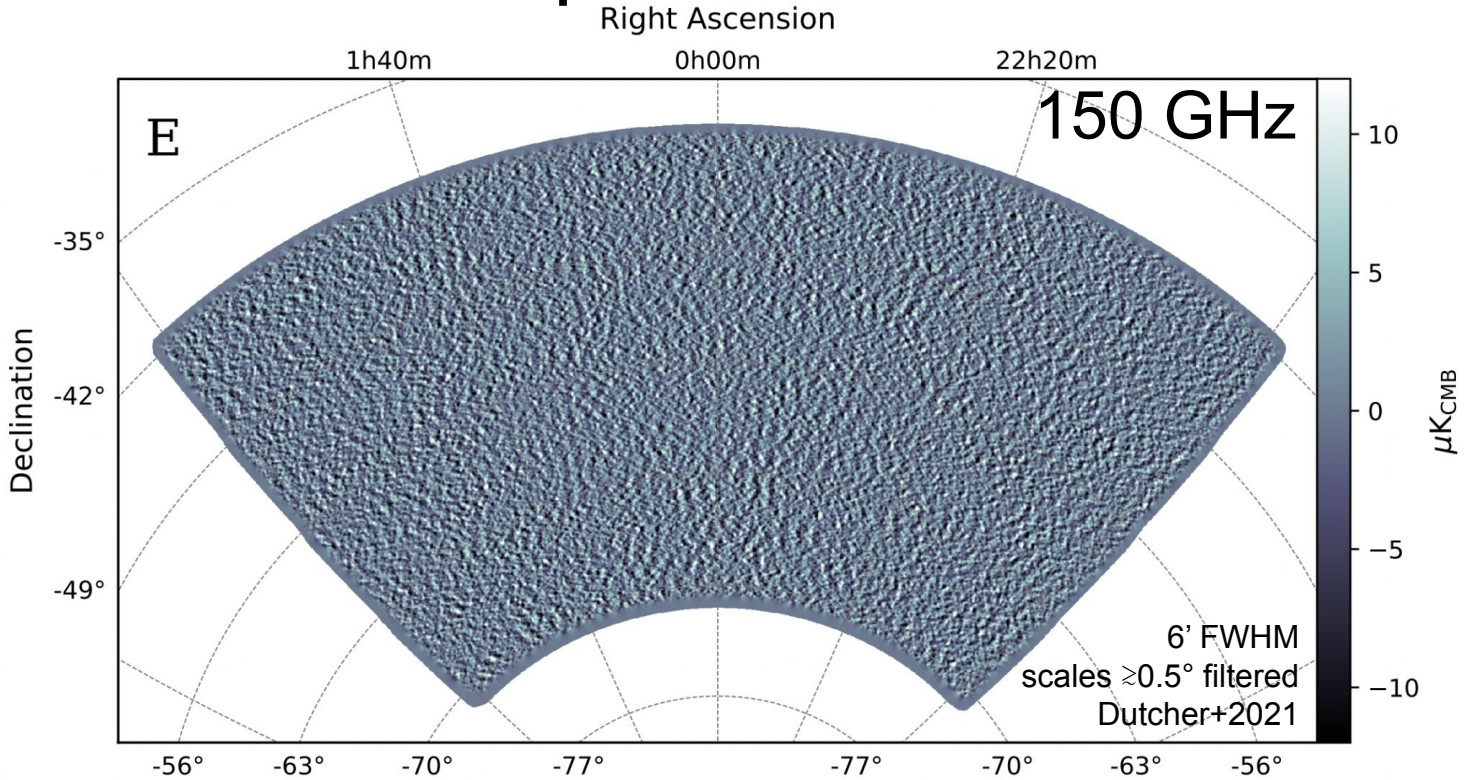
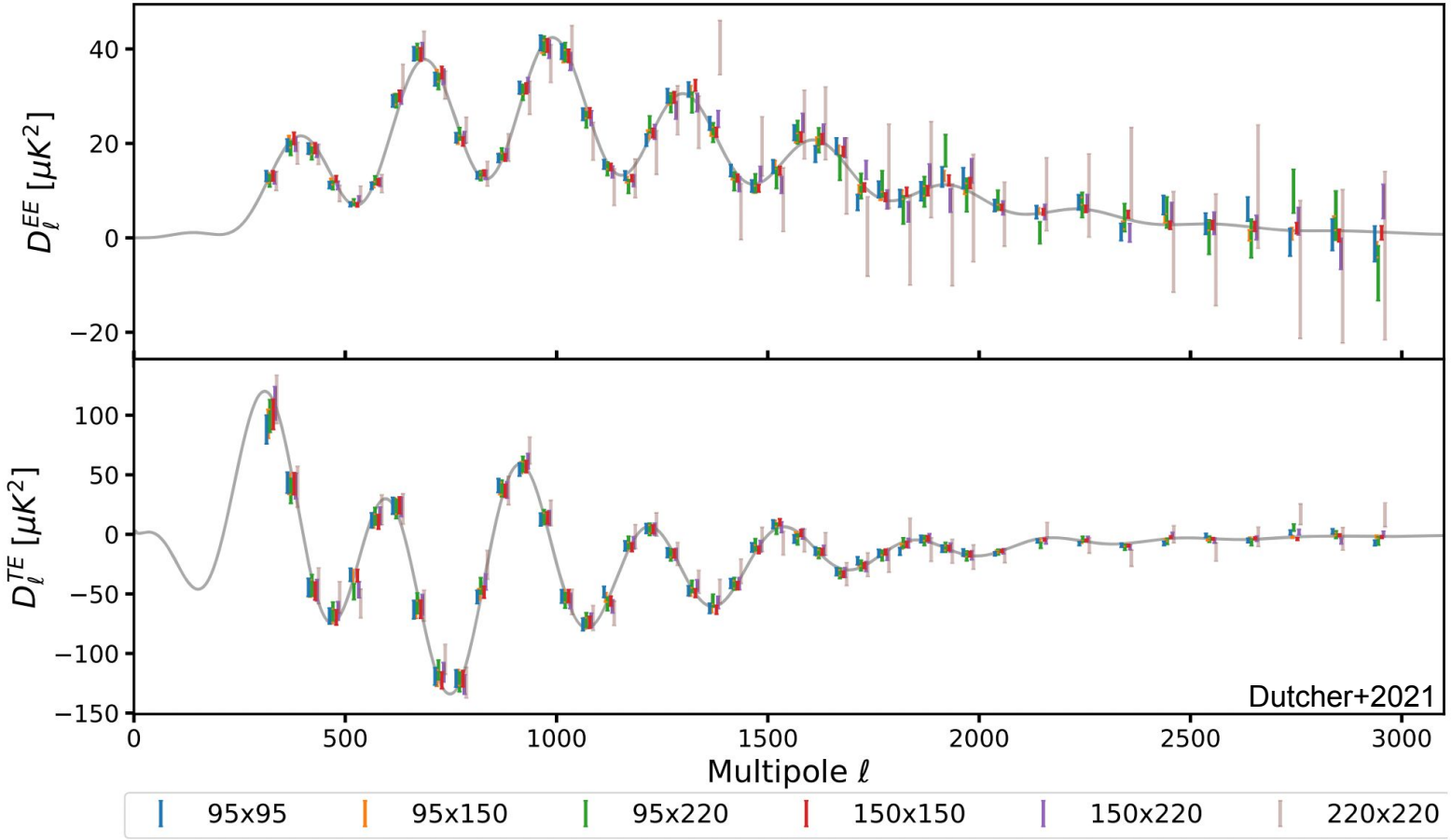


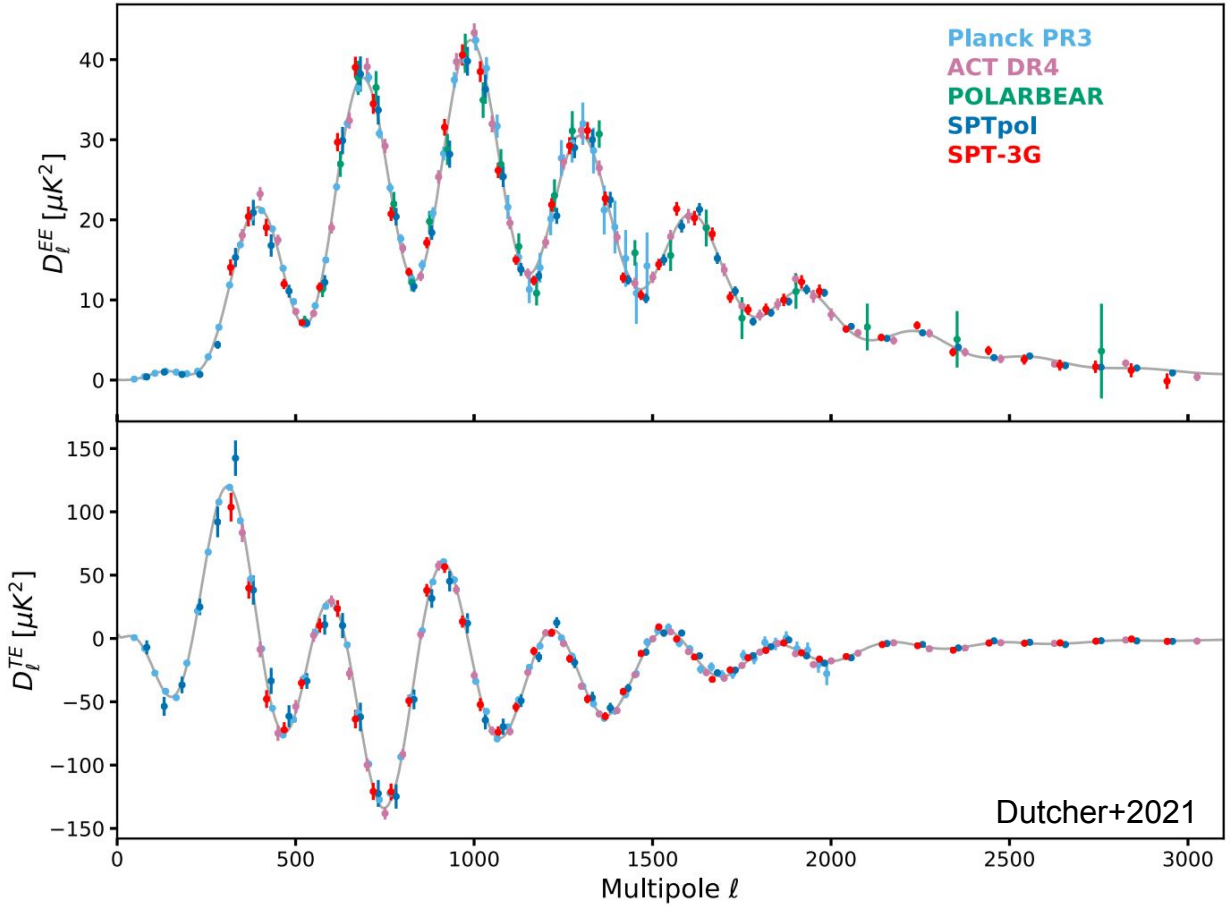
Polarized map depths: **29.6, 21.2, and 75 μK−arcmin** at 1000 < l < 2000
(at 95, 150, 220 GHz)

SPT-3G 2018 Power spectra



SPT-3G 2018 Power spectra

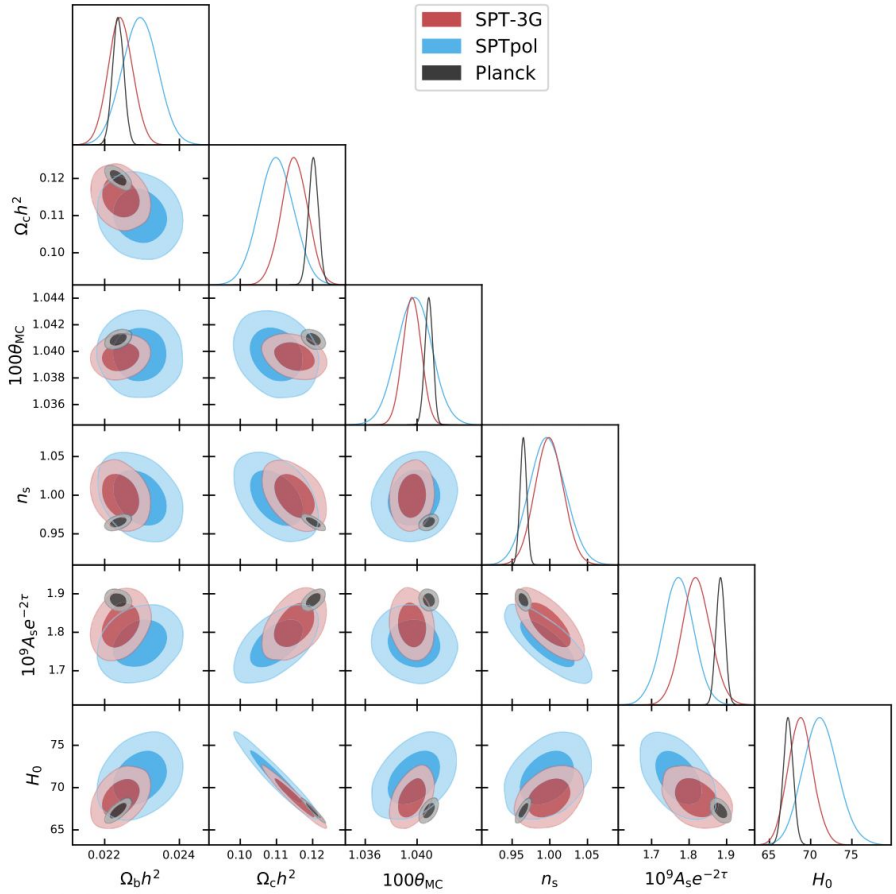
- Already very constraining despite coming from only 4 months of observations and half of the focal plane
- SPT best measurements of the polarised CMB at intermediate angular scales (EE: 300 ≤ l ≤ 1400, TE: 300 ≤ l ≤ 1700)
- Lead to SPT's tightest cosmological constraints from EE/TE data



Dutcher+2021

SPT-3G 2018 ΛCDM constraints

- More constraining than SPTpol, and consistent with it
- Consistent with Planck although they are largely independent
  - SPT-3G 2018 sensitive to intermediate and small angular scales of EE/TE, while Planck uses mostly larger scales TT/TE/EE, with large constraining power coming from TT
  - A small area is shared by the two surveys
  - Only a global re-calibration of SPT-3G relies on Planck



Dutcher+2021

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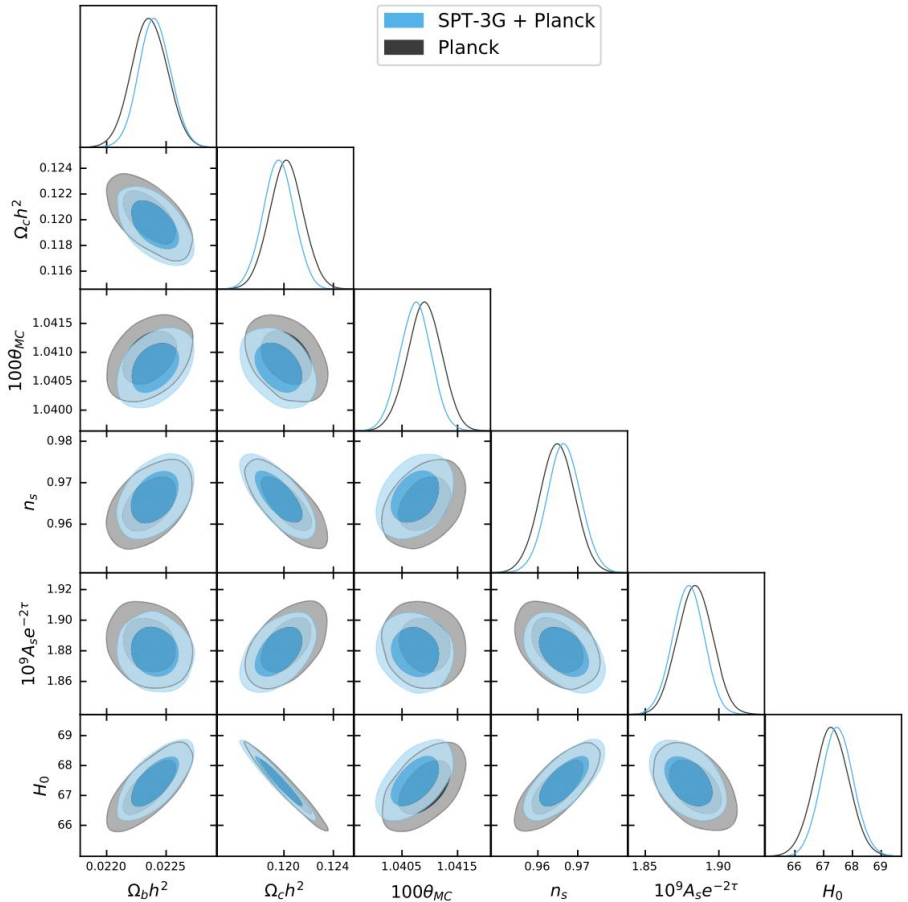
  - Only a global re-calibration of SPT-3G relies on Planck
- Even with this little amount of data, SPT-3G 2018+Planck slightly improves the Planck-only constraints



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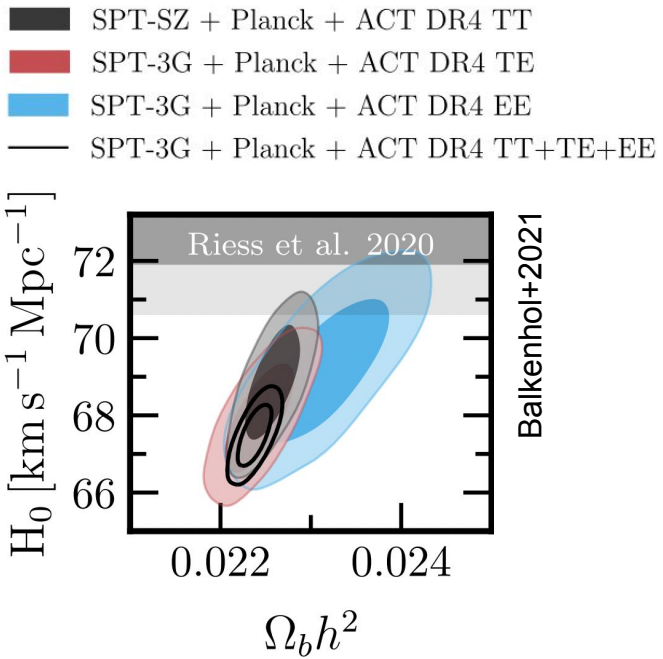


- Very good **consistency with ΛCDM**
  (χ^2 = 513.0 for 528 band powers, PTE = 0.61)
- Balkenhol et al. (2021) and Dutcher er al. (2021) constrained a bunch of **ΛCDM extensions**, with **no significant improvement over ΛCDM**

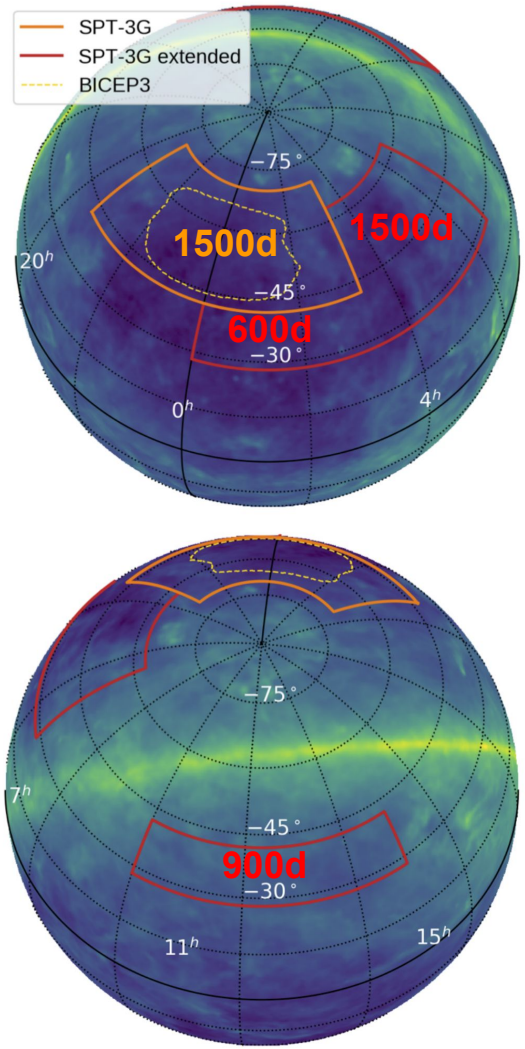
- SPT-3G constraint on **H_0** is as low as Planck's
  - H_0 = 67.49 ± 0.53 km/s/Mpc, obtained combining SPT-3G 2018, Planck, ACT DR4 temperature and polarization spectra (Balkenhol et al., 2021)
  - 4.8σ tension with Riess et al., (2021).
- The central value of **σ_8** aligns more with low-z data, though at current sensitivity the confidence region also overlaps with Planck's
  (σ_8 = 0.8084±0.0069 from SPT-3G+Planck, Dutcher et al., 2021)

Near future prospects

- Include 2018 TT to the EE/TE analysis (Balkenhol et al, in prep.)
  - break degeneracies
- Analysis of 2019+2020 winter maps
  - full focal plane operative
  - factor ~ 3.8 lower noise than in 2018
  - Map depth:
    - ~ 5/4/15 μK-arcmin at 95/150/220 GHz (T)
    - ~ 7/6/21 μK-arcmin at 95/150/220 GHz (pol)
- Observations will continue through at least 2023 (total of 5 years)
  - Goal noise levels: 2.8, 2.6, 6.6 μK-arcmin (T)
  - **ΛCDM constraints comparable with Planck from SPT-3G alone !**
- Extended with observations during the summer season

SPT-3G Summer fields

- In addition to the winter fields:
  3000 deg2 = 1500 (3.1%) + 600 (1.4%) + 900 (2.1%)
- Observing **~4 months** per year
- Noise levels for summer 19/20 + 20/21:
  ~ 11, 10, 38 μK-arcmin (T)
  ~ 16, 14, 54 μK-arcmin (pol)
- Map depth of 2 years of summer observations is
  - ~1.4 times better than the 2018 winter field maps
  - ~2.5 times worse than the 2019+2010 winter fields
- 3 times larger sky fraction than winter
  → reduce sample variance



Forecasts including SPT-3G summer data

SPT-3G–TT/TE/EE baseline = SPT3G TT/TE/EE (winter) + ϕϕ
For a 3500 deg2 summer filed with final sensitivities 13, 12, 43 μK-arcmin (in T), and the goal sensitivity for the winter fields (2.8, 2.6, 6.6 μK-arcmin in T).

ΛCDM

- With **Planck+SPT-3G baseline+summer** the constraints improve by a factor **~1.2** those from **Planck+SPT-3G baseline**

ΛCDM+Neff

- Constraints from **SPT-3G baseline+summer** are a factor
  - **~ 1.2–1.5** tighter than **SPT-3G baseline**
  - **~ 1.5–2** tighter than **Planck alone**
- Constraints from **Planck+SPT-3G baseline+summer** are a factor **~ 1.2–1.3** better than **Planck+SPT-3G baseline**.

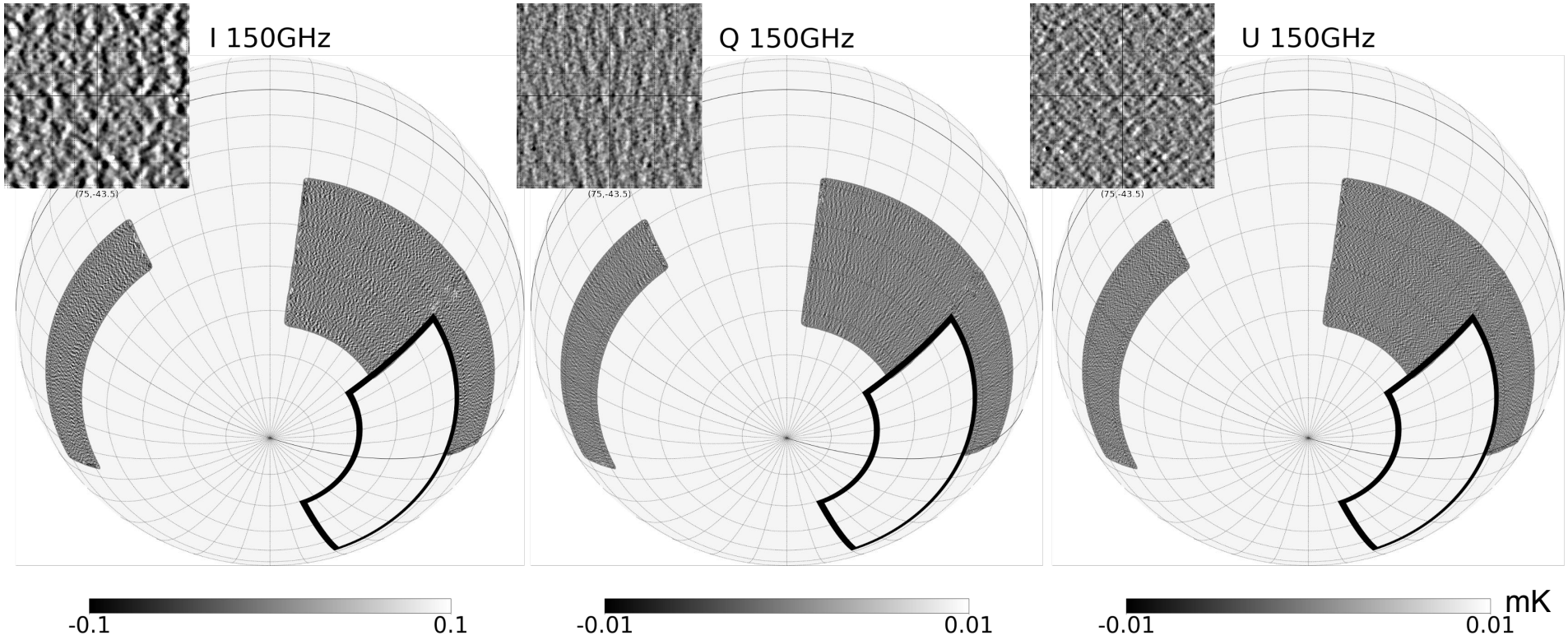
Preliminary! (credit Silvia Galli)

SPT-3G Summer Maps

Only 2 summer seasons, 2 more to come

Preliminary!

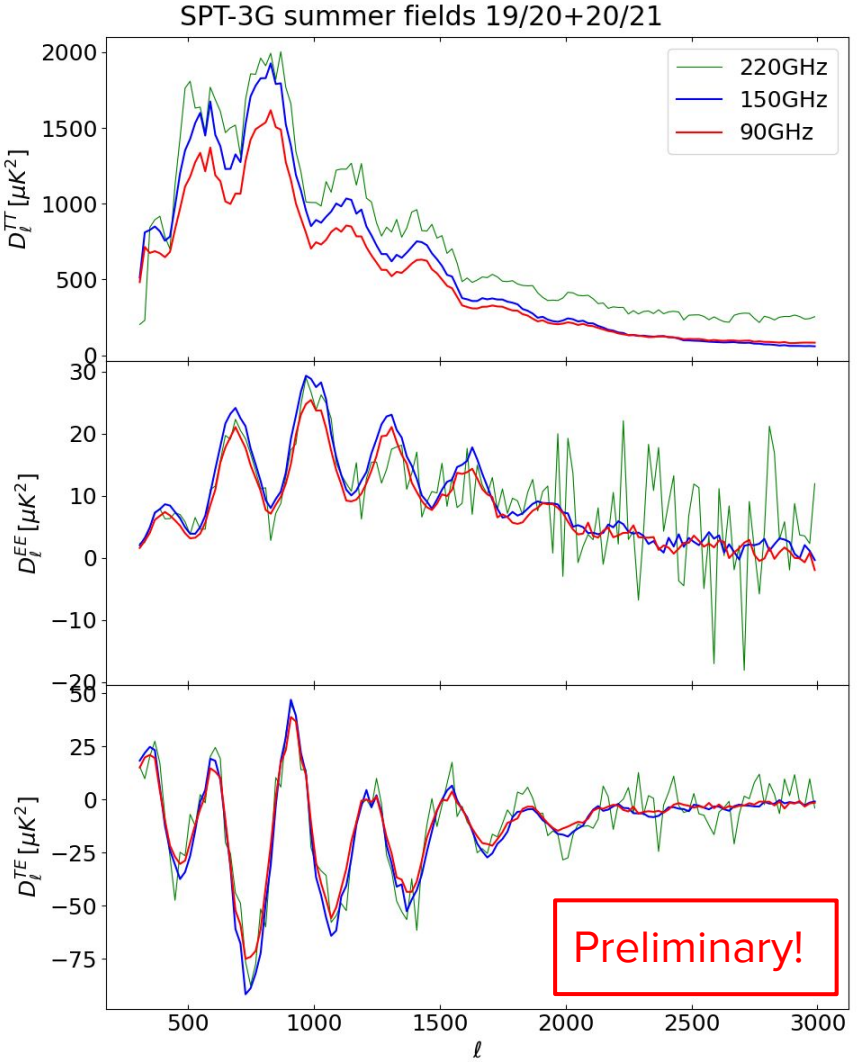
Gaussian smoothed
6 arcmin



SPT-3G Summer angular power spectra

- High signal to noise
  at 90 and 150 GHz
  and $300 \lesssim \ell \lesssim 1500$ (EE)

- This is from only 2 summer seasons (19/20+20/21)
  - 2 more to come, of which:
    - one already on disk (21/22)
    - and the last one planned for 22/23



Conclusions

- **SPT-3G** is obtaining very **high quality data** at **intermediate and small angular scales**
- A **first survey** (2018 — with just 4 months of observation and half of the focal plane operative) observed the baseline field (1500 deg2) providing the **best cosmological constraints from SPT to date**, which are competitive with those from other ground based CMB experiments.
- Data from the **2019+2020** survey are being analysed.
- The survey will **continue** up to a test **2023**, expecting constraints on cosmological parameters with a **precision comparable to Planck** from SPT-3G alone, but in a mostly **independent** way.
- Extra data from the **summer fields** (additional 3000 deg2) will further **improve** the constraints of **ΛCDM** and its **extensions** (up to a factor ~2 better from SPT-3G alone as compared to Planck).

Credit Aman Chokshi, May 2022