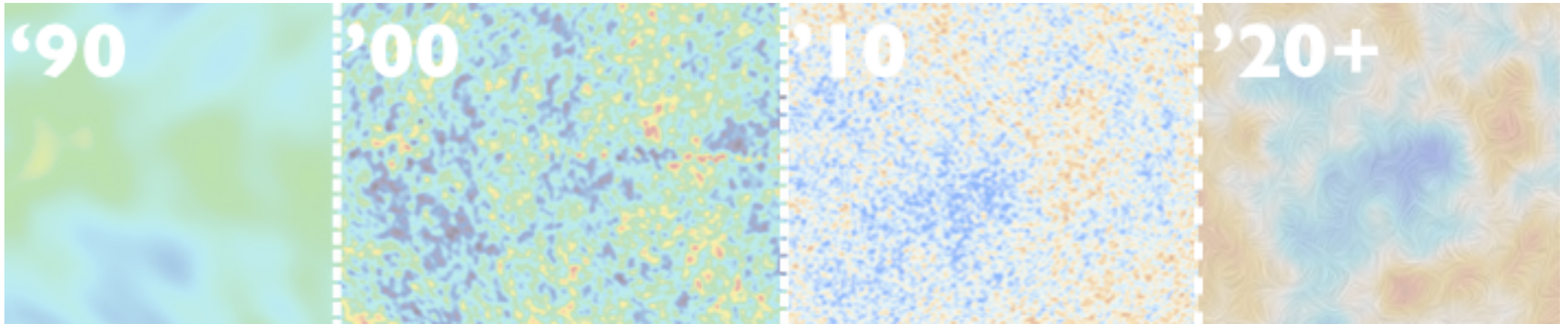


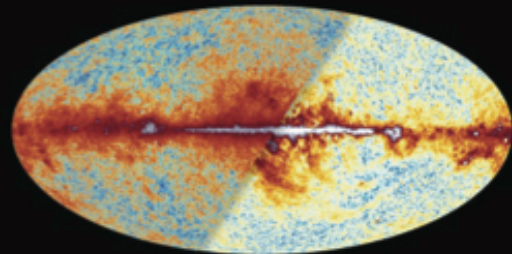
Feuille de route «Mesures du CMB»

M. Douspis
(and some slides from F.R. Bouchet)
on behalf of the working group

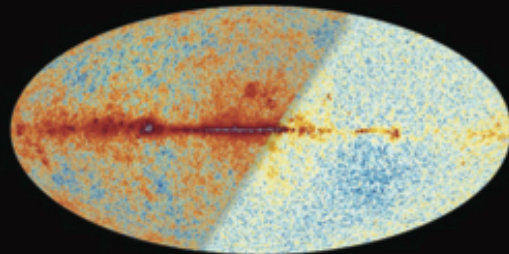


Status

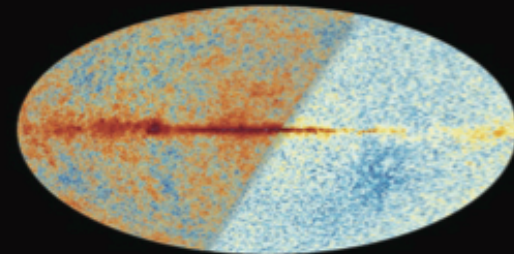
Now available in a store near you



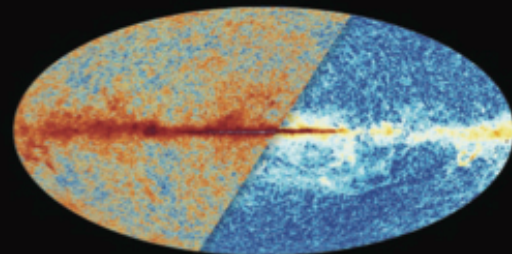
30 GHz



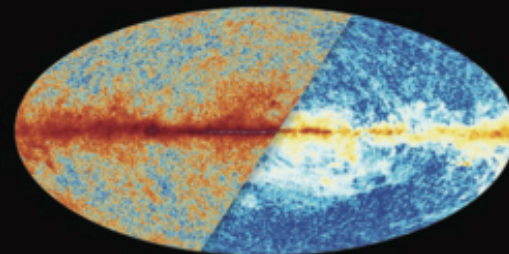
44 GHz



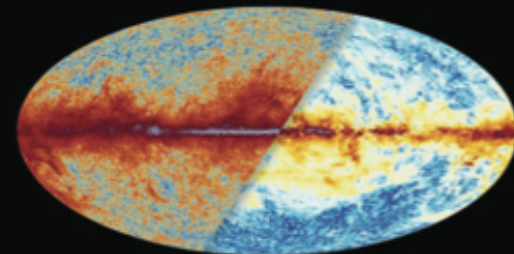
$3.5\mu\text{K.deg, } 13'$ 70 GHz



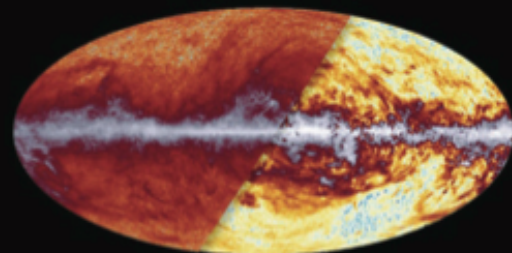
$1.3\mu\text{K.deg, } 9.7'$ 100 GHz



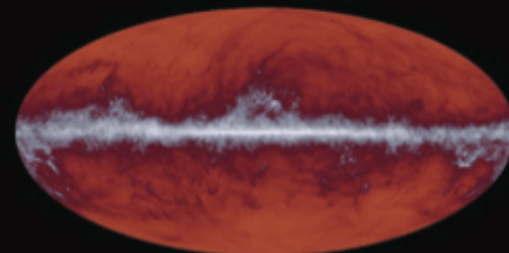
$0.5\mu\text{K.deg, } 7.3'$ 143 GHz



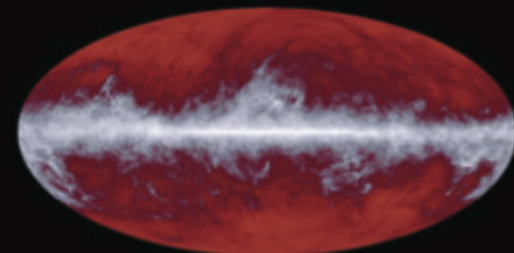
$0.8\mu\text{K.deg, } 5.0'$ 217 GHz



353 GHz



545 GHz



857 GHz

to be updated in 2016

Status

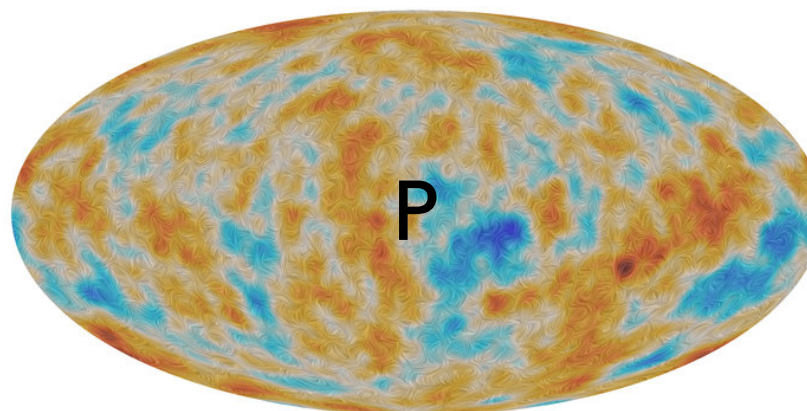
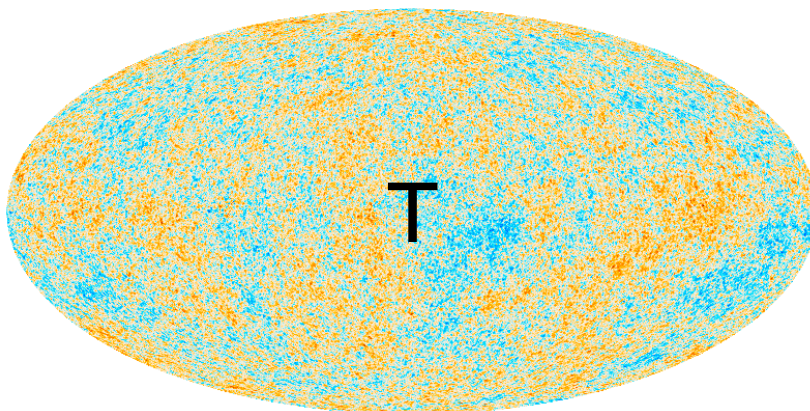


Table 9. Parameter 68 % confidence levels for the base Λ CDM cosmology computed from the *Planck* CMB power spectra, in combination with the CMB lensing likelihood (“lensing”).

Parameter	<i>Planck</i> TT+lowP+lensing
$\Omega_b h^2$	0.02226 ± 0.00023
$\Omega_c h^2$	0.1186 ± 0.0020
$100\theta_{\text{MC}}$	1.04103 ± 0.00046
τ	0.066 ± 0.016
$\ln(10^{10} A_s)$	3.062 ± 0.029
n_s	0.9677 ± 0.0060
H_0	67.8 ± 0.9
Ω_m	0.308 ± 0.012
$\Omega_m h^2$	0.1415 ± 0.0019
$\Omega_m h^3$	0.09591 ± 0.00045
σ_8	0.815 ± 0.009
$\sigma_8 \Omega_m^{0.5}$	0.4521 ± 0.0088
Age/Gyr	13.799 ± 0.038
r_{drag}	147.60 ± 0.43
k_{eq}	0.01027 ± 0.00014

Parameter	TT, TE, EE+lensing+ext
Ω_K	$0.0008^{+0.0040}_{-0.0039}$
Σm_ν [eV]	< 0.194
N_{eff}	$3.04^{+0.33}_{-0.33}$
Y_p	$0.249^{+0.025}_{-0.026}$
$dn_s/d \ln k$	$-0.002^{+0.013}_{-0.013}$
$r_{0.002}$	< 0.113
w	$-1.019^{+0.075}_{-0.080}$

→ Λ CDM OK

Status

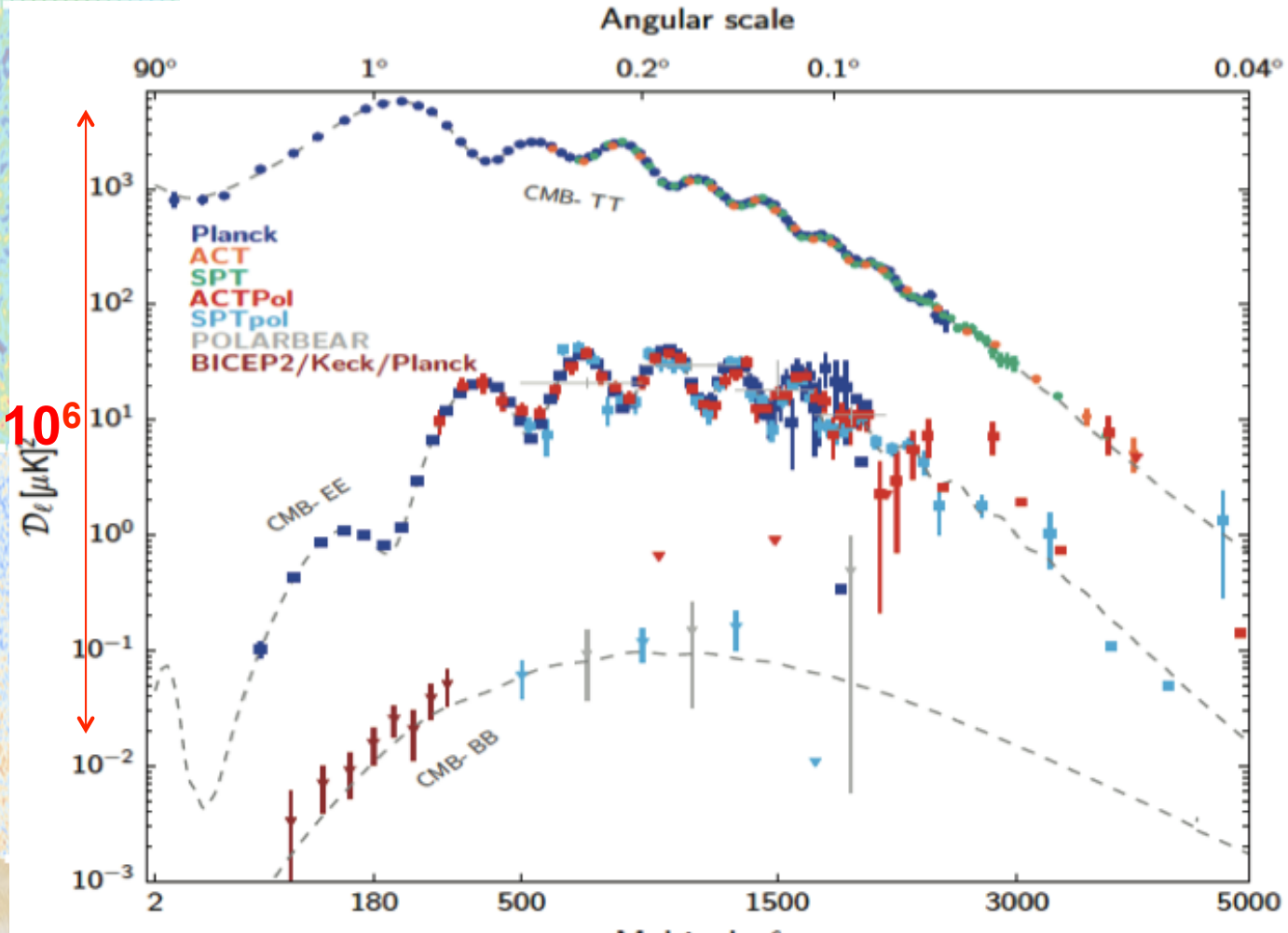
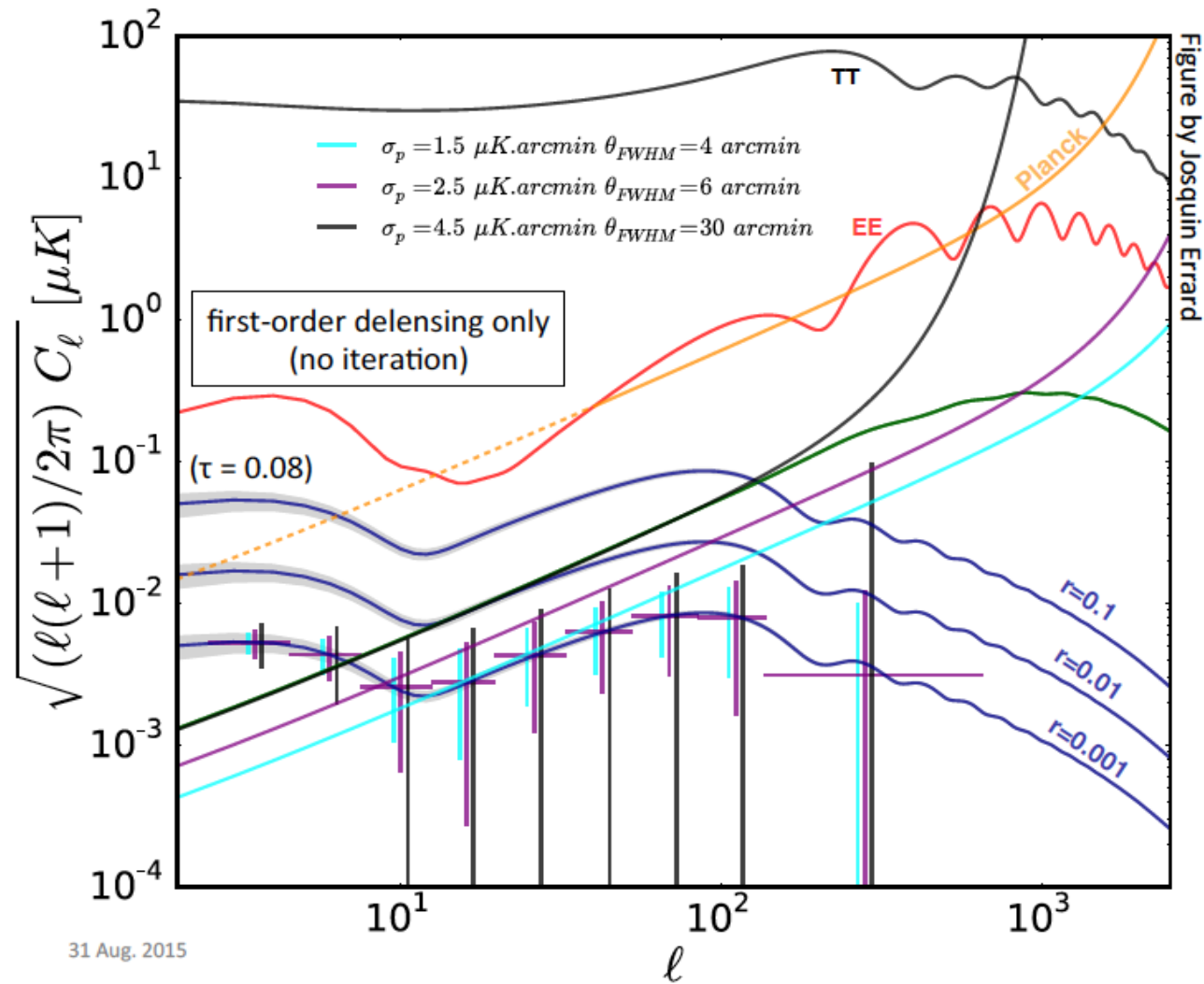


Table 7. Planck peak positions and amplitudes.

PEAK		
Number	Position [ℓ]	Amplitude [μK^2]
<i>TT</i> power spectrum		
First	220.0 ± 0.5	5717 ± 35
Second	537.5 ± 0.7	2582 ± 11
Third	810.8 ± 0.7	2523 ± 10
Fourth	1120.9 ± 1.0	1237 ± 4
Fifth	1444.2 ± 1.1	797.1 ± 3.1
Sixth	1776 ± 5	377.4 ± 2.9
Seventh	2081 ± 25	214 ± 4
Eighth	2395 ± 24	105 ± 4
<i>TE</i> power spectrum		
First	308.5 ± 0.4	115.9 ± 1.1
Second	595.3 ± 0.7	28.6 ± 1.1
Third	916.9 ± 0.5	58.4 ± 1.0
Fourth	1224 ± 1.0	0.7 ± 0.5
Fifth	1536 ± 2.8	5.6 ± 1.3
Sixth	1861 ± 4	1.2 ± 1.0
<i>EE</i> power spectrum		
First	137 ± 6	1.15 ± 0.07
Second	397.2 ± 0.5	22.04 ± 0.14
Third	690.8 ± 0.6	37.35 ± 0.25
Fourth	992.1 ± 1.3	41.8 ± 0.5
Fifth	1296 ± 4	31.6 ± 1.0

Next

I. B-modes (r, nT) all scales



31 Aug. 2015

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Next

1. B-modes (r, nT) all scales
2. E-modes to Cosmic Variance
3. Intensity CMB
 - 3.a) tSZ clusters
 - 3.b) kSZ large scale velocity field
 - 3.c) CIB, ...
4. Measure of EM-spectrum (y , μ , line) $[\text{FIRAS} \times 10^{(3-4)}]$
(probe energy budget until $z < 10^6$)

Next

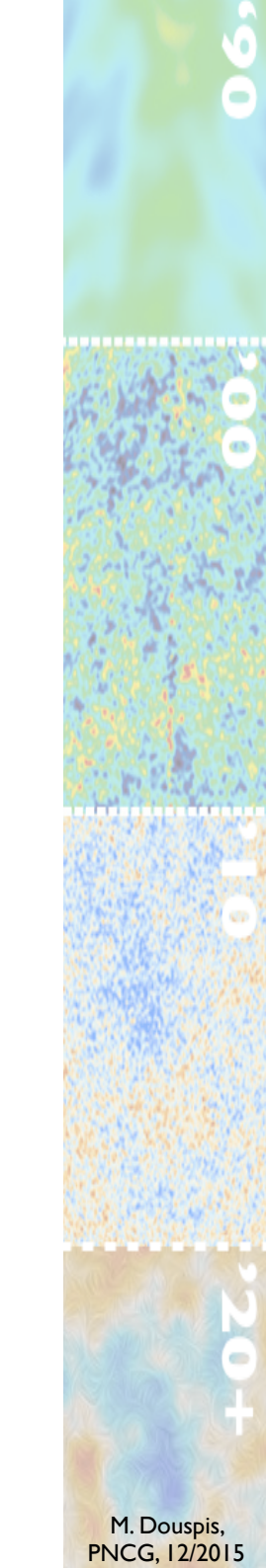
- Physics of inflation [1]
- Physics of neutrinos (Sum m_{ν} , N_{eff} , c_{vis} , etc.) [2,3]
- Any other fundamental constraints (as Planck did)
(curvature, isocurvature fluctuations, variation of constants,
of cross-section, parity violation, primordial magnetic fields,
DM annihilation...) [1,2,3]
- Cartography of dark matter (contribution peaks $z \sim 1.5$?)
[corrélations astro] [1,2,3]
- Cosmology/astrophysics, alone or synergy with other
experiments (SZ/hot baryons, CIB, reionisation,...) + ISM
[2,3]

Next

- France contributed on some of these subjects in Planck.
- European and French community are now in front of the next generation experiments
- What role France will play in ground, balloon, space future experiments ?
(Science, SGS, hardware)
- «CMB roadmap working group» set up !

CMB roadmap WG

- Le 10/09/2015, mandat est donné par le CNES, l'INSU, l'IN2P3 et le CEA au Programme National Cosmologie et Galaxies d'établir les éléments de la stratégie française en ce domaine, en incluant les aspects sol, ballon et spatiaux dans la feuille de route.
- Le 18/09/2015, composition finalisée du groupe:
 - Banday
 - Bernardeau
 - Bouchet (Président)
 - Désert/Ponthieu
 - Douspis
 - Ganga
 - Lagache
 - Rodriguez
 - Tristram
 - Arnaud (PNCG)
 - Binetruy (CNES-GT Phys. fondamentale)
 - Renault (CNES-GT Astrophysique)
- Le 02/10/2015, première réunion (Ballon, pilot, planB, foregrounds)
- NB: Beaucoup d'existant (WG détecteurs, Florence, Core+ meeting, S4 meeting...)
- Les 26-27/11/2015, deuxième réunion (espace, mise en place de groupes de travail)
- Compte rendu public/meetings mensuel



CMB roadmap subWGs

- Groupe « questions scientifiques CMB », responsables Bernardeau et Binetruy, pour analyser ce qu'on peut apprendre sur l'inflation si $r \sim 0.01$, si $r \sim 0.001$, ce qu'on peut tirer de la cartographie du lentillage (en fonction des échelles couvertes), seul et en synergie avec d'autres traceurs (Euclid, galaxies, etc.), et le potentiel des mesures spectrales en fonction de leur sensibilité.
- Groupe « avant-plans polarisés du CMB », responsables Banday et Tristram, pour synthétiser les (mé-)connaissances, et les résidus réalistes, en fonction de divers scénarii et méthodes, et en prenant en compte les effets instrumentaux pertinents (fuite de T dans E et B, connaissance imparfaite des bandes passantes...) que ce soit en imagerie ou pour la mesure du spectre.
- Groupe « mesure instrumentale du CMB », responsables Rodriguez et Ponthieu, pour analyser les différentes possibilités instrumentales, en fonction des questions scientifiques (cf. ci-dessus, $r=0.01$, $r=0.001$, lentillage, spectre, au sol ou dans l'espace), avec une approche système (top-down, alors que le groupe détecteur est plutôt dans une approche bottom-up).

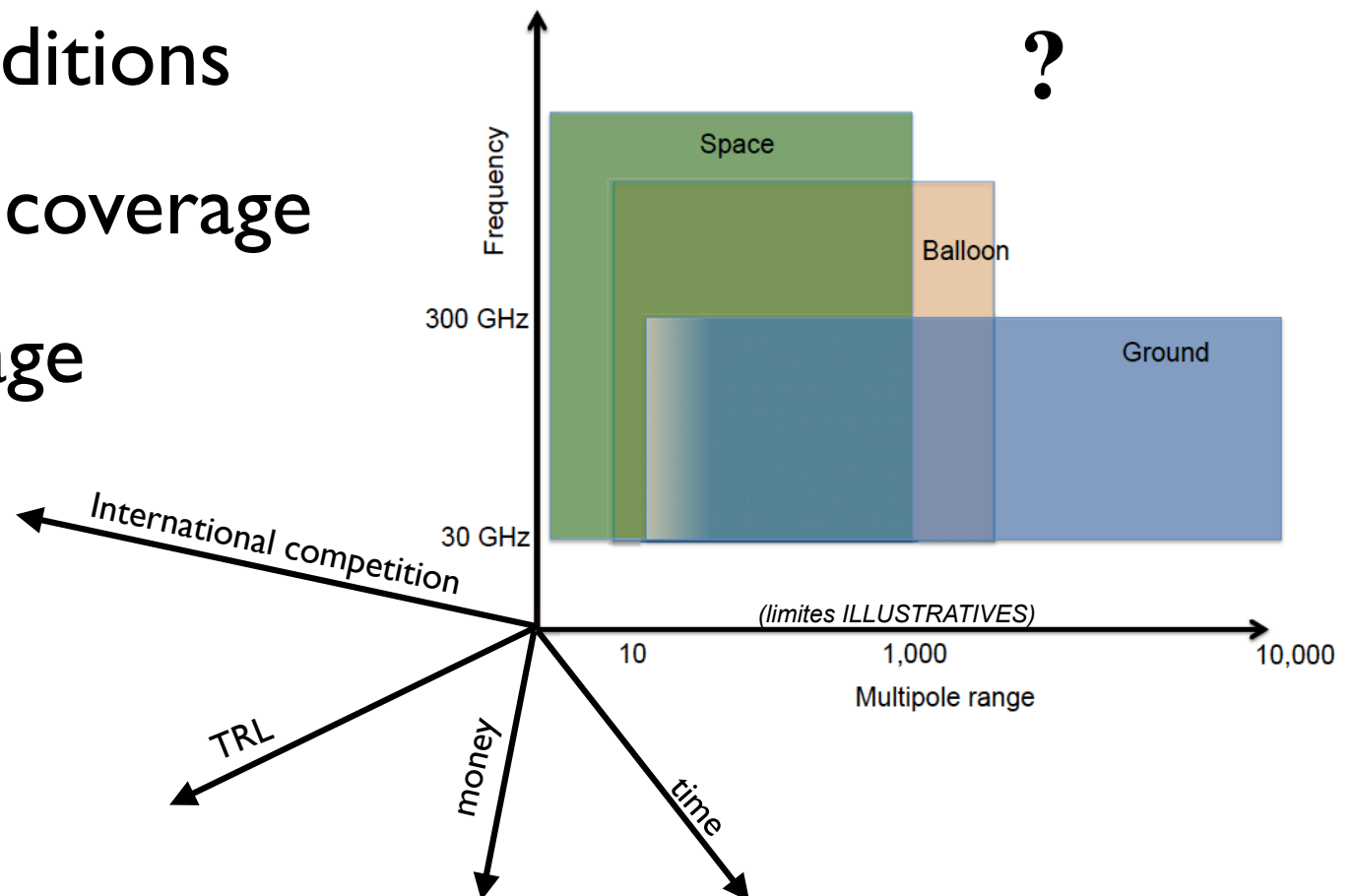
Why is it not clear ?

- Space:
 - Stable conditions
 - frequency coverage
 - sky coverage

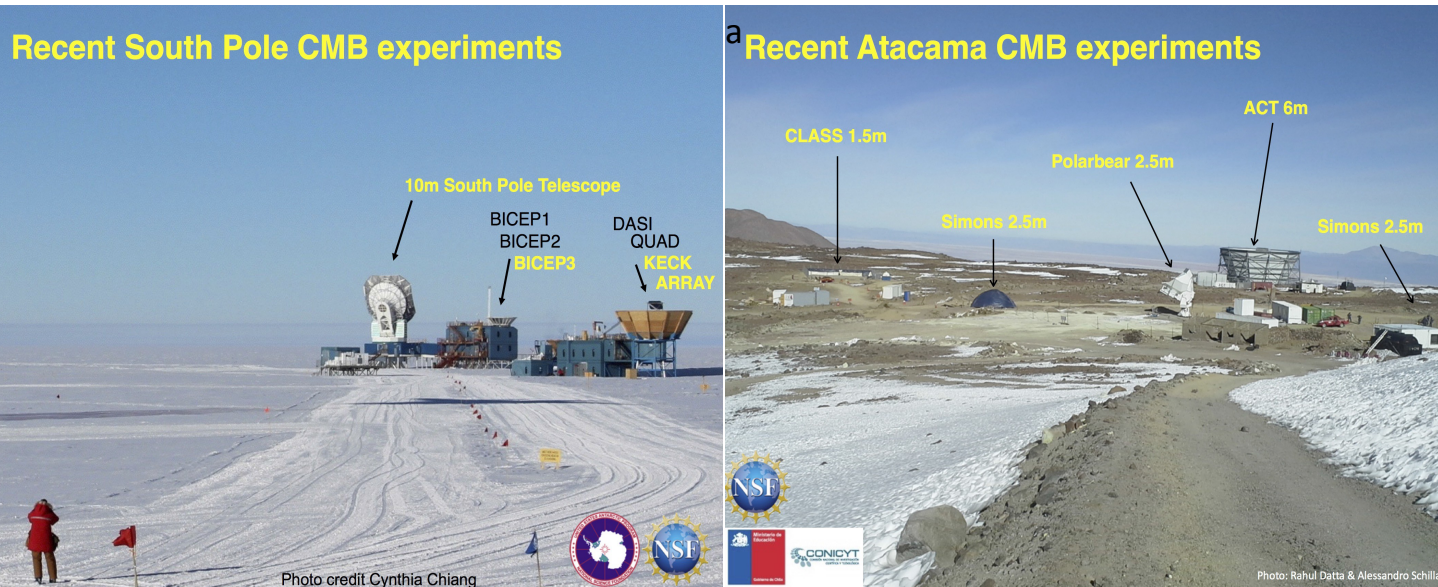
- Ground

- sensitivity
- evolutions

- Not necessarily the same science/legacy



Ground

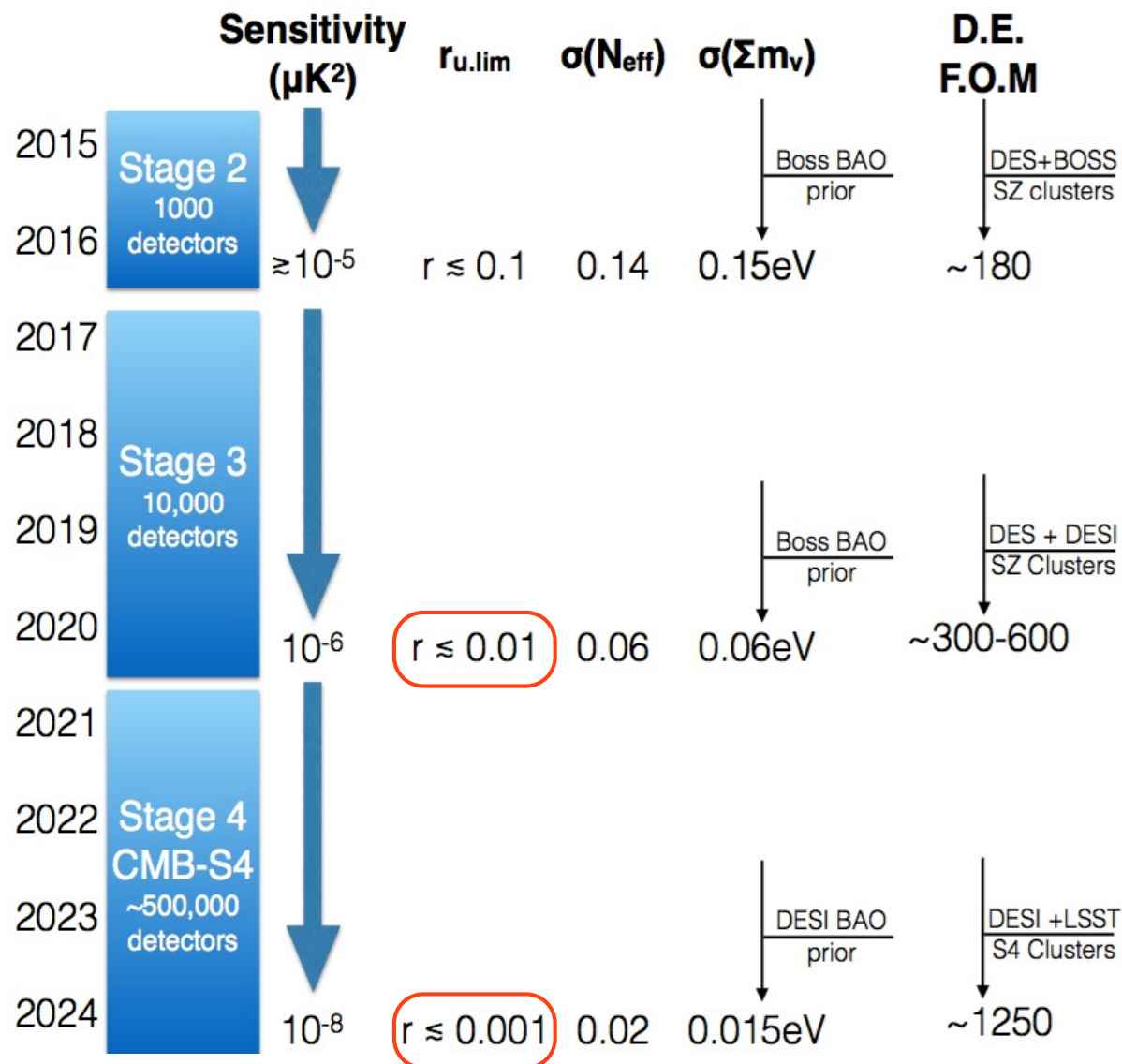


Most of the ground-based “weight” in the CMB is at two sites – either (the Chilean) Atacama Desert, or the South Pole.

And also:
QUBIC, NIKA from France
QUIJOTE, C-BASS from Europe
GroundBird, AMIBA from Asia
Mustang2 in the US

Ground towards CMB S4

- Ground-based is building on S2 & S3
- Complementary, but not dependant on balloons/satellites (so they say)
- US universities DOE, Natl. Labs, HEP community
- International is encouraged (meaning, S4 is not funded yet)



From John Carlstrom@UMich

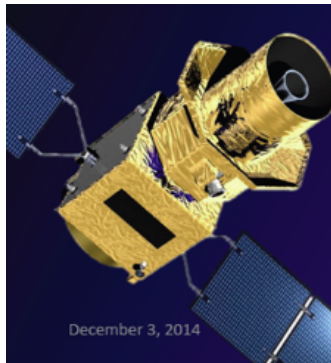
Balloons

- Spider has flown once with 95 & 150 GHz detectors
- The Spider team is preparing for a Jan. 2017 flight with additional 285 GHz detectors
- PIPER is scheduled for launch in a few months
- The present delay is caused by difficulties getting detectors.
- EBEX will be re-proposed next year.
- The US CMB balloon community seems to be scratching its head about how to keep pace with the ground-based community.
- Multiple “rapid-fire” experiments?
- A “fleet” of balloons?
- Ultra-long duration (~3 months) flights?
- French project: PlanB; better mapping of dust foregrounds

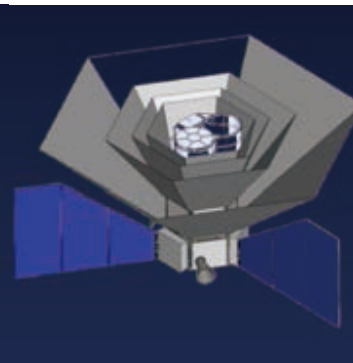
Space

Each with rather different trade-offs/synergies/objectives...

- PIXIE, DARE, EPIC+? (NASA)
- (BPOL, CORE, PRISM, CORE+) CORE++? (ESA)
- LiteBird (JAXA) down selected to a list of 3, early June 2015



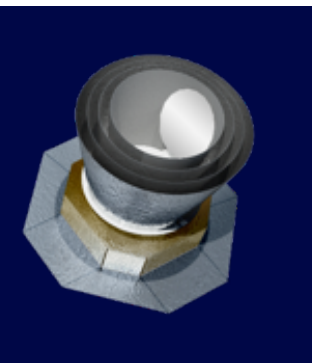
LiteBIRD (JAXA)
30-60' 2 uK/arcmin
+PhyA NASA
Launch 2025



PIXIE (NASA)
Prop dec 2016



DARE (NASA)
Prop dec 2016



Core+ (ESA)
Prop ~fall 2016?
(AC 06/2016)

NB: Jaxa invites
Europe to
collaborate (to
Bmode search, on
litebird, conference
ongoing)

Conclusions

- Complex situation: not much time (selections/involvements within less than 1 year)
- Mastering galactic foregrounds and systematics is crucial at large scales
 - Plan B could help (better proposal needed)
- Knowing LSS may help de-lensing Bmodes at small scales
- Better analyses of our needs for our science (large/small scales, spectrum, high/low frequencies)
 - all that depends also of the value of r
 - analyses of technology (rapidly evolving) needed
- Involvements
 - National? European ? International ? (different timescales)
- WG working and reporting in the next month