La cosmologie à l'IN2P3

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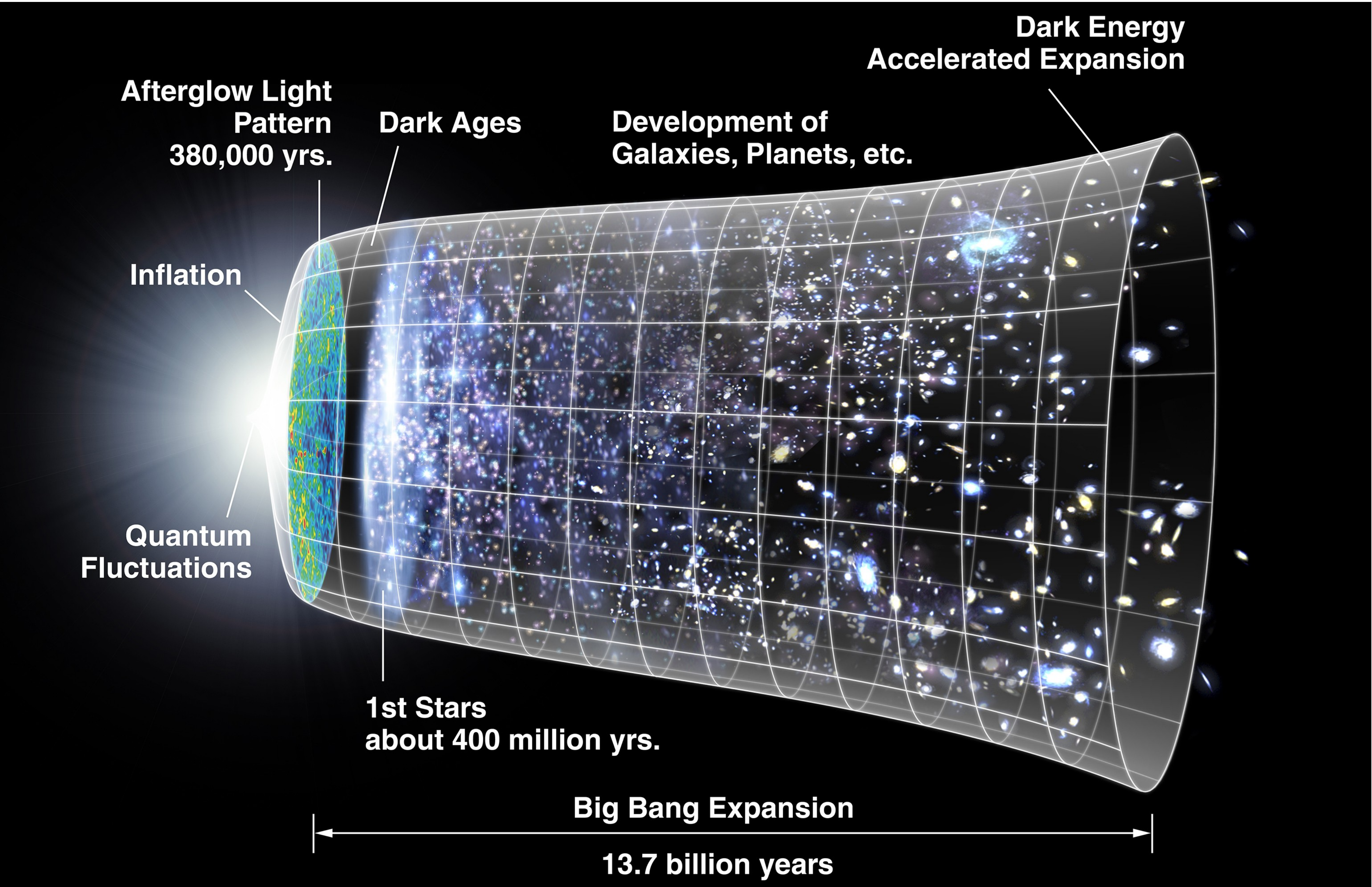
(LPNHE)

Le modèle standard



Paramètres cosmologiques

- Densités et équations d'état des fluides peuplant l'Univers (en unités de $\rho_{critique}$).
- Densité → Ω_{stuff}
  - Ω_m : matière non relativiste (CDM)
  - Ω_b : baryons.
  - Ω_r : matière relativiste ou radiation (négligeable)
  - Ω_k : courbure
  - Ω_Λ / Ω_X constante cosmologique / "énergie noire"

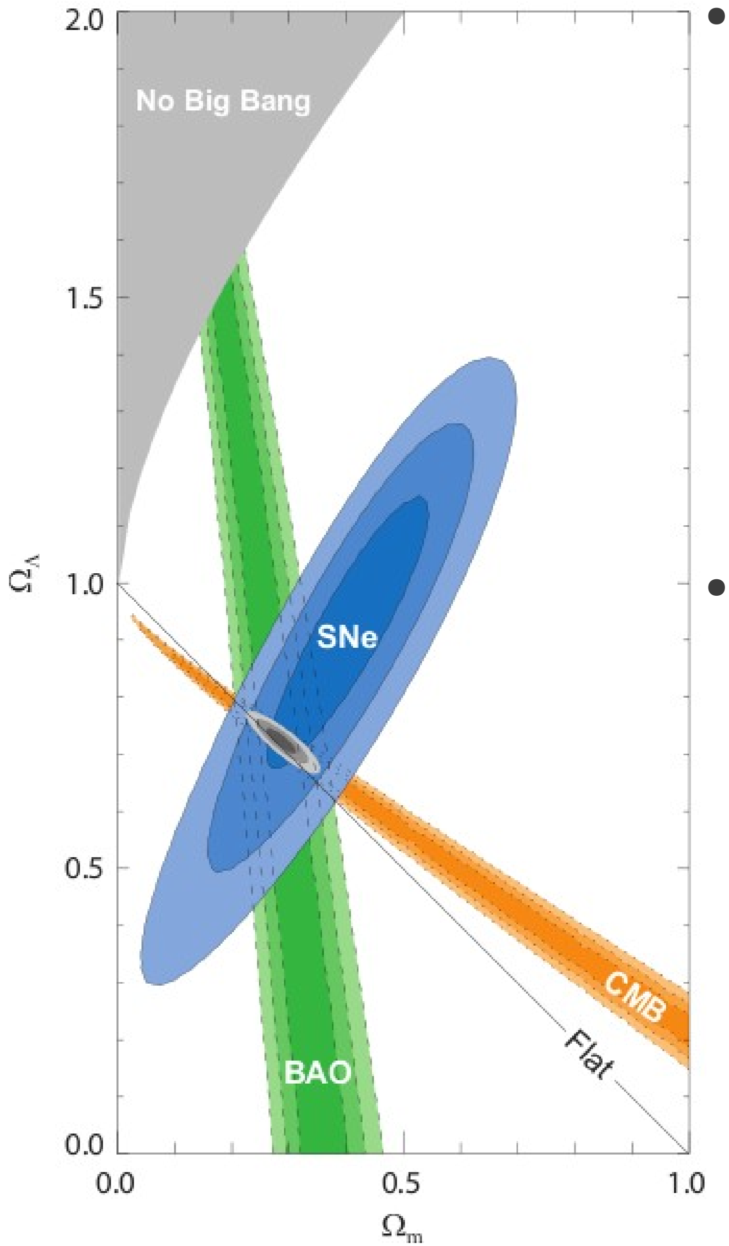
    → Équation d'état de l'énergie noire: $p_X = w \rho_X$

…/…

Paramètres cosmologiques

- Fluctuations primordiales
  - Scalaires $P_s(k) \sim A_s\, k^{ns-1}$
  - Tensorielles $P_t(k) \sim r\, A_s\, k^{nt-1}$
- Réionisation
  - τ
  - $z_{reionisation}$

ΛCDM



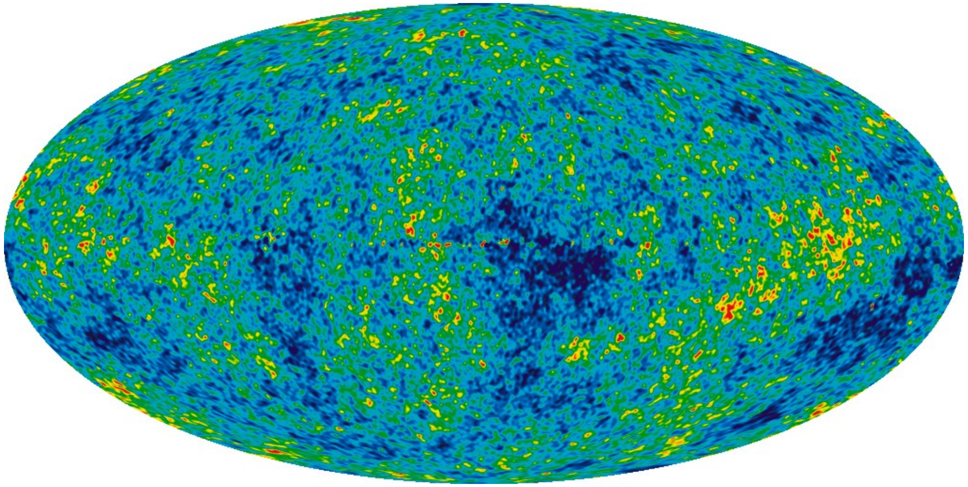
- L'Univers est ~ plat (CMB+H0), avec une faible densité de matière noire non baryonique (CMB+clusters+BAO), et sa densité d'énergie totale est dominée par une énergie noire répulsive de nature inconnue (supernovae)
- Equation d'état de l'énergie noire

$$p = w\rho \quad w < -1/3$$

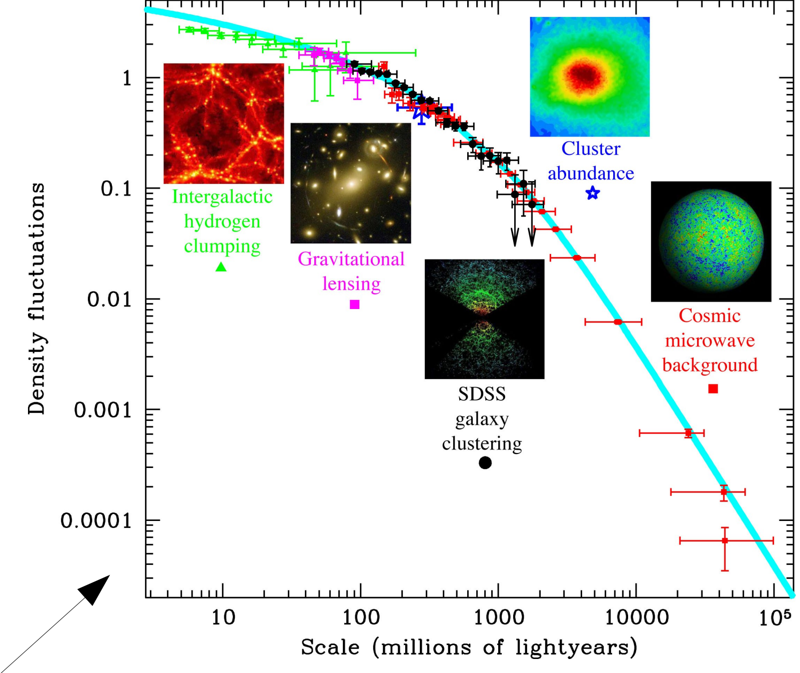
w = -1 → constante cosmologique

w > -1 → “quintessence”

w < -1 → trucs exotiques



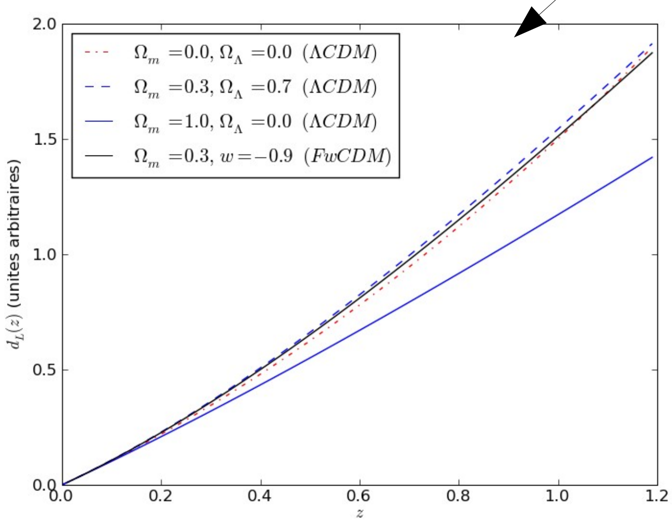
CMB anisotropies



Density fluctuations

ΛCDM

Geometric tests



Sondes cosmologiques

→ CMB

→ croissance des structures

→ Tests géométriques

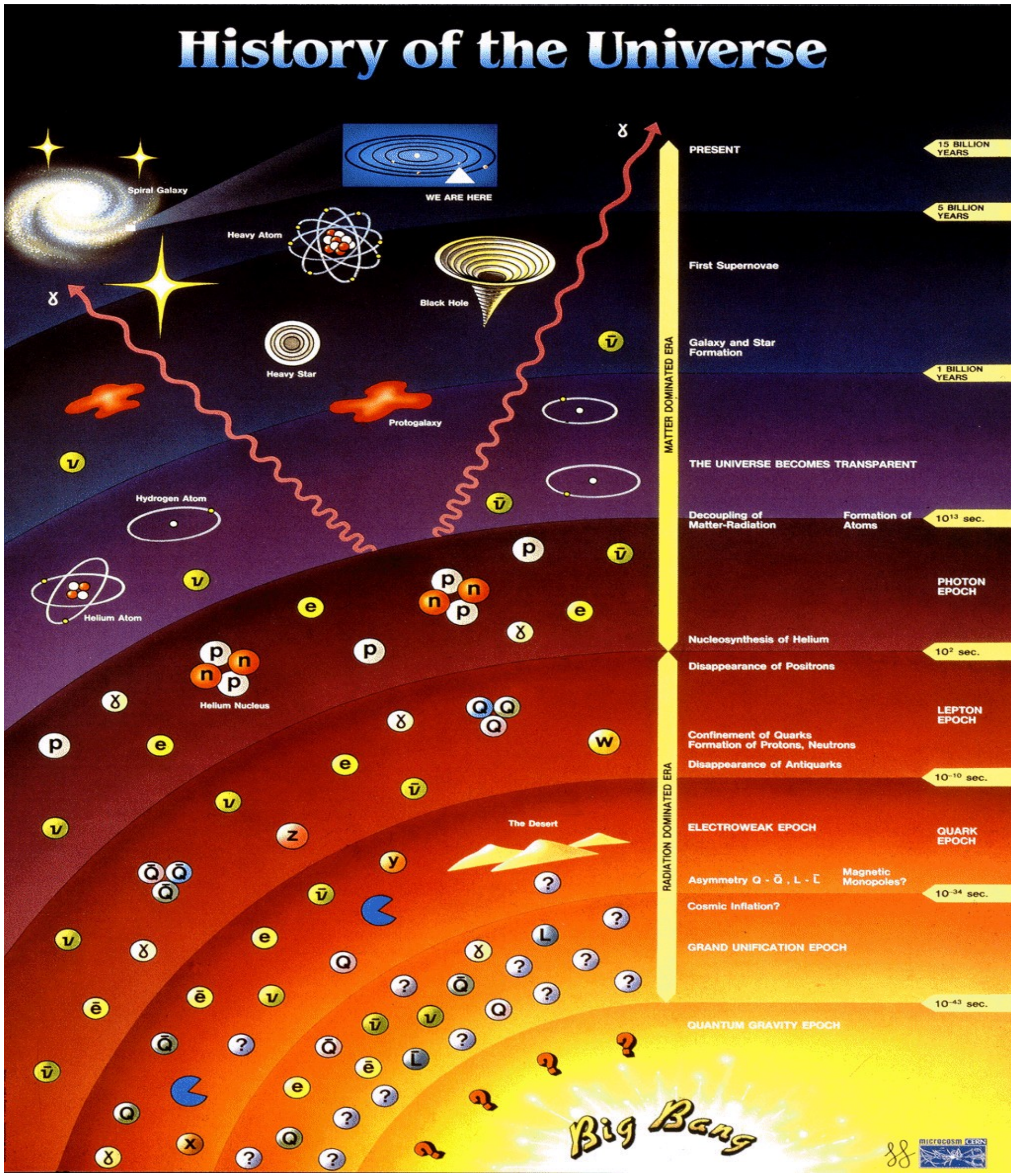
⚠ Dégénerescences

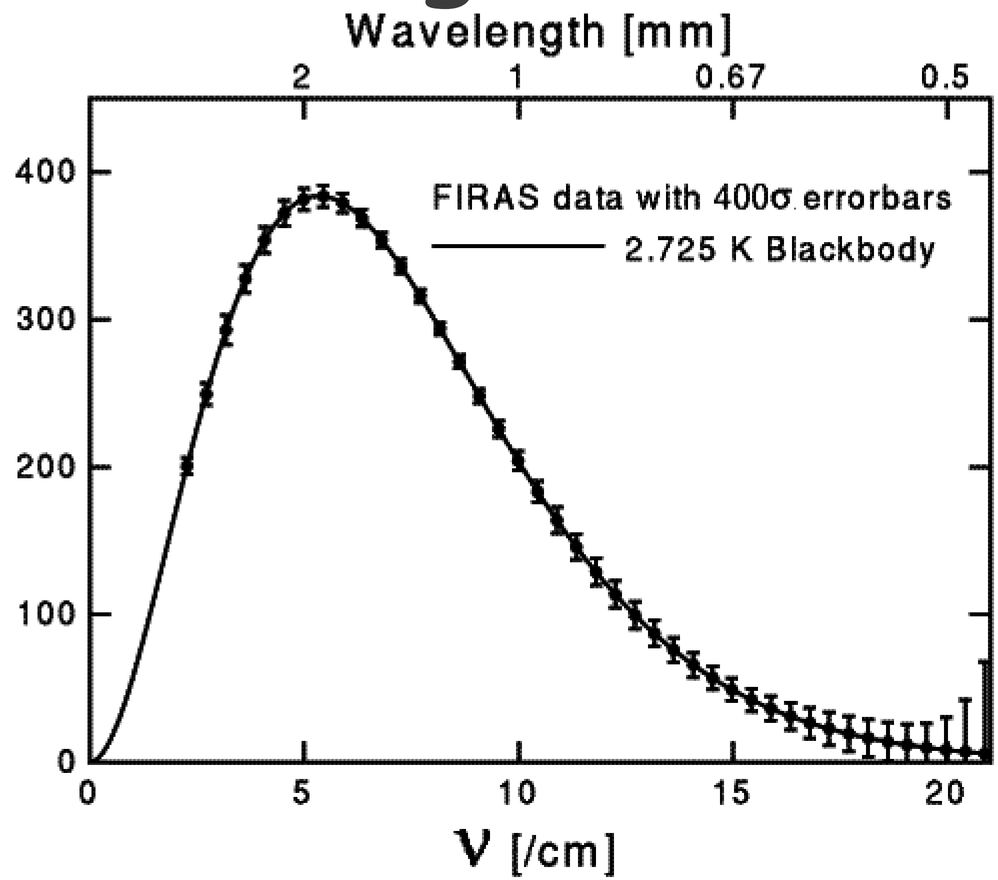
Cosmologie à l´IN2P3

- 3 sondes principales
  - CMB
  - Supernovae de type Ia
  - Pic Acoustique des Baryons
- Futur : 2 axes de recherches principaux
  - Nature de l'énergie noire (w)
  - Détection des modes B / fluctuations tensorielles

Cosmic Microwave Background

Cosmic Microwave Background

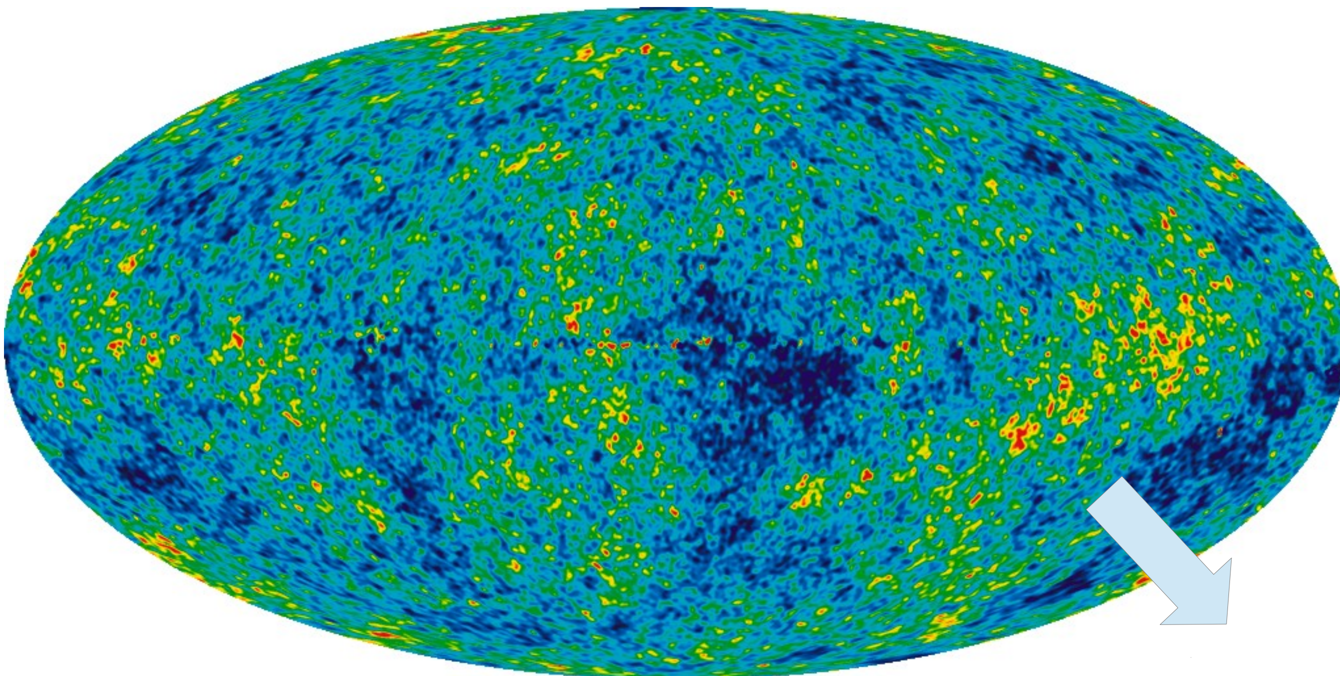




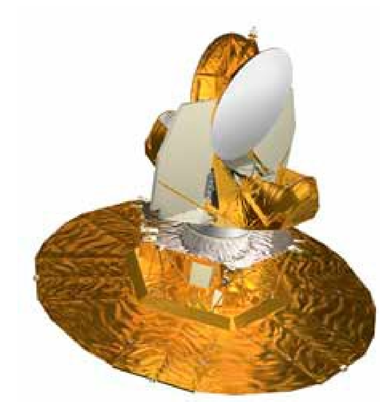
$T = 2.725 \pm 0.002$ K

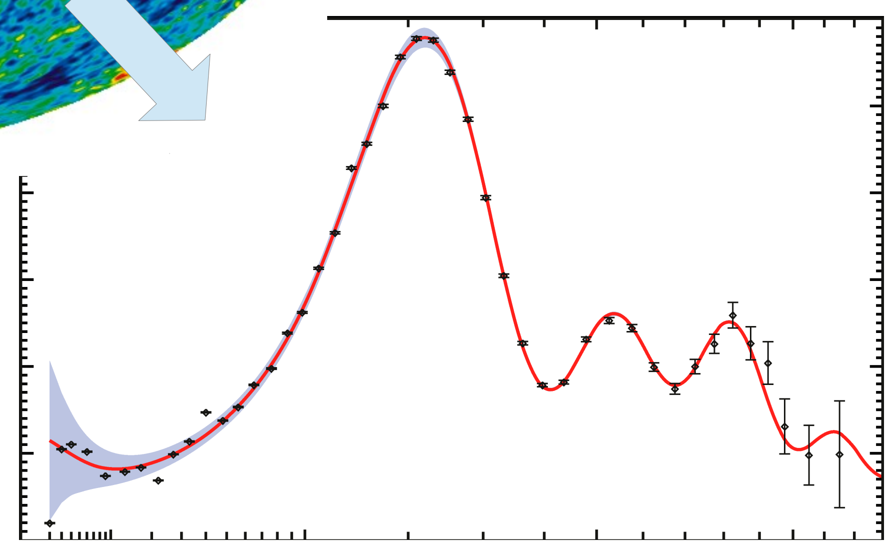
$\delta T / T \sim 10^{-5}$

Anisotropies de temperature



WMAP 7-years
(± 200 μK)





Jarosik et al, 2011
Larson et al, 2011
Komatsu et al, 2011

$$C_\ell = \frac{1}{4\pi(2\ell+1)} \int \delta T(\vec{n_1})\ \delta T(\vec{n_2})\ P_\ell(\cos(\vec{n_1}.\vec{n_2}))$$

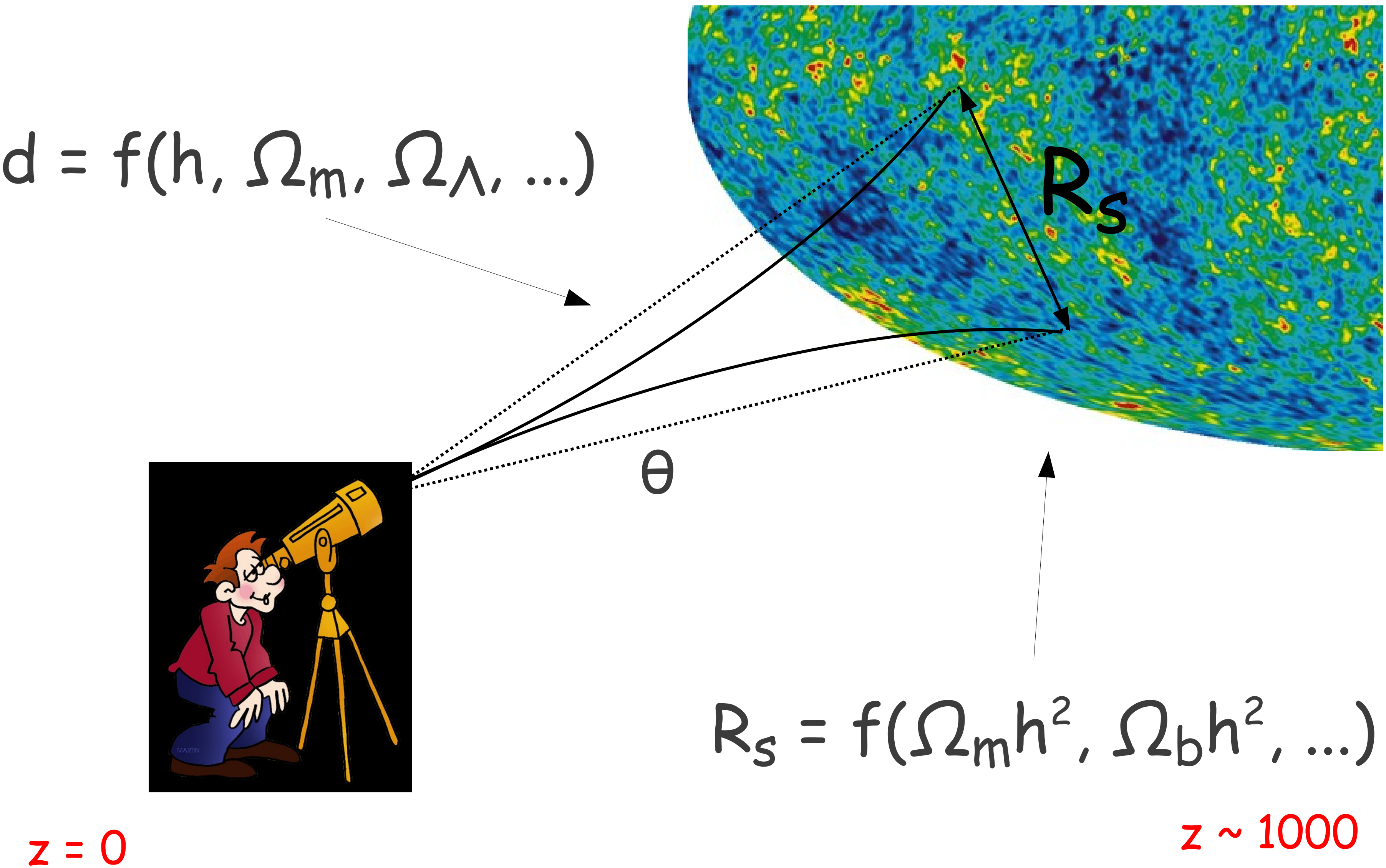
Avant la recombinaison...

- Plasma (photons + baryons + matière noire)

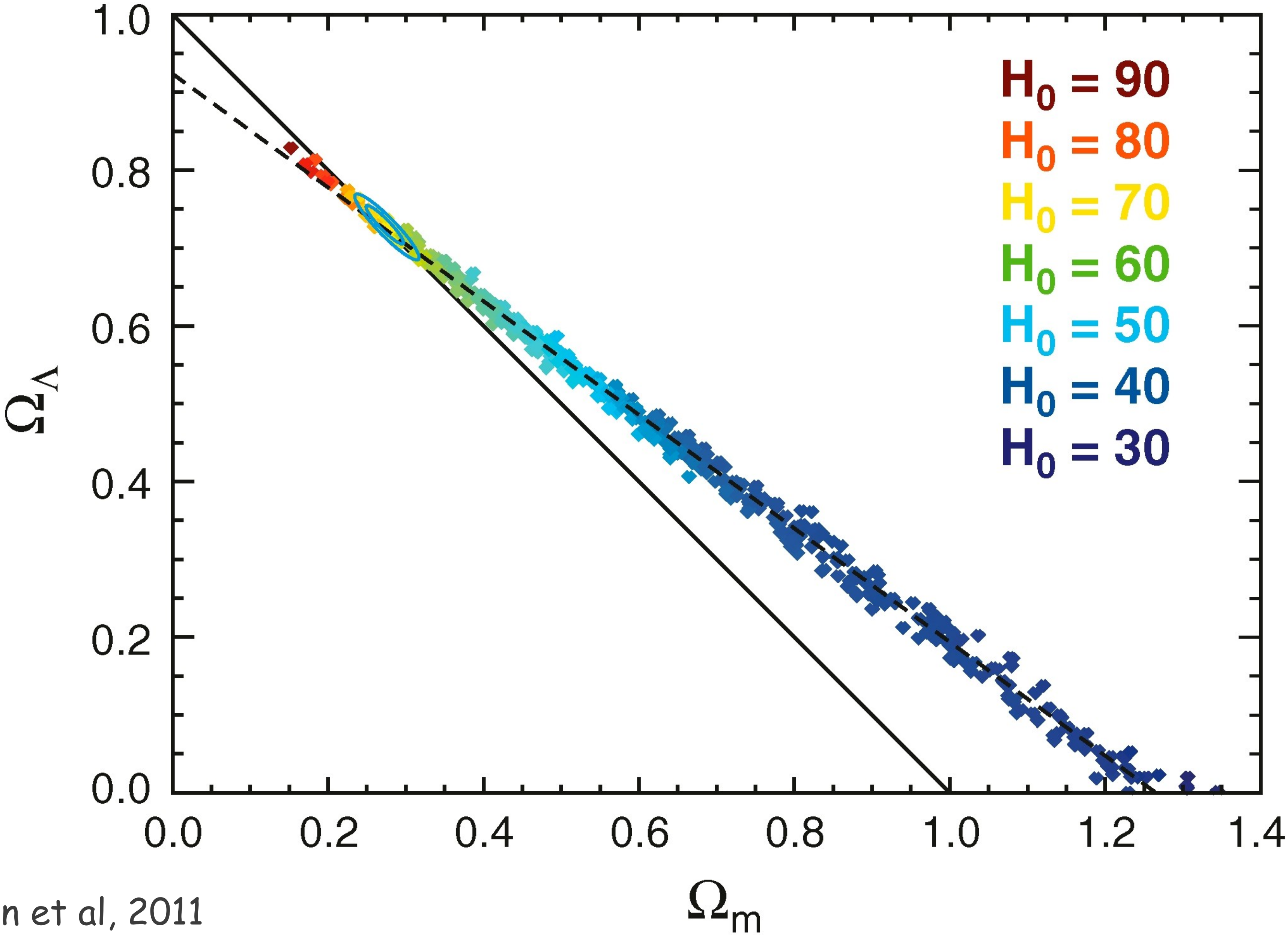
Oscillations + croissance

- Fluctuations primordiales ($P(k) \propto k^{n_s-1}$)
- (ρ_m, ρ_b, ρ_γ, n_s, ...) → anisotropies
  - (CMBFast (Seljak & Zaldarriaga, 1996)
  - CAMB (Lewis, 2008)

Échelle @ z ~ 1000

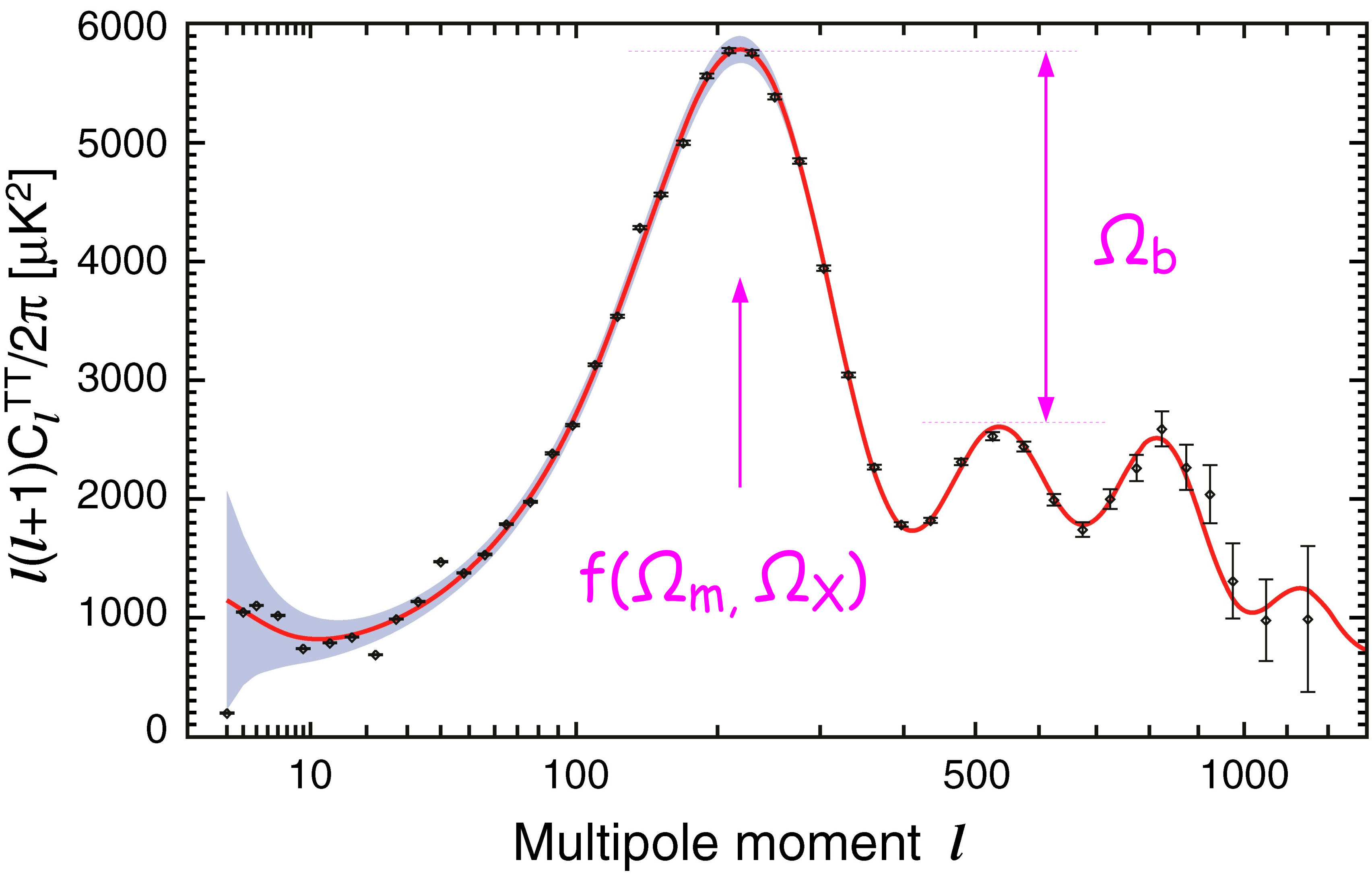


Dégénerescence géométrique



Larson et al, 2011

Spectre de puissance (TT)



Class	Parameter	*WMAP* Seven-year ML[b]
Primary	$100\Omega_b h^2$	2.227
	$\Omega_c h^2$	0.1116
	Ω_Λ	0.729
	n_s	0.966
	τ	0.085
	$\Delta^2_{\mathcal{R}}(k_0)$[d]	2.42×10^{-9}
Derived	σ_8	0.809
	H_0	$70.3\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$
	Ω_b	0.0451
	Ω_c	0.226
	$\Omega_m h^2$	0.1338
	$z_{\rm reion}$[e]	10.4
	t_0[f]	13.79 Gyr

(Komatsu et al, 2011)

Polarisation

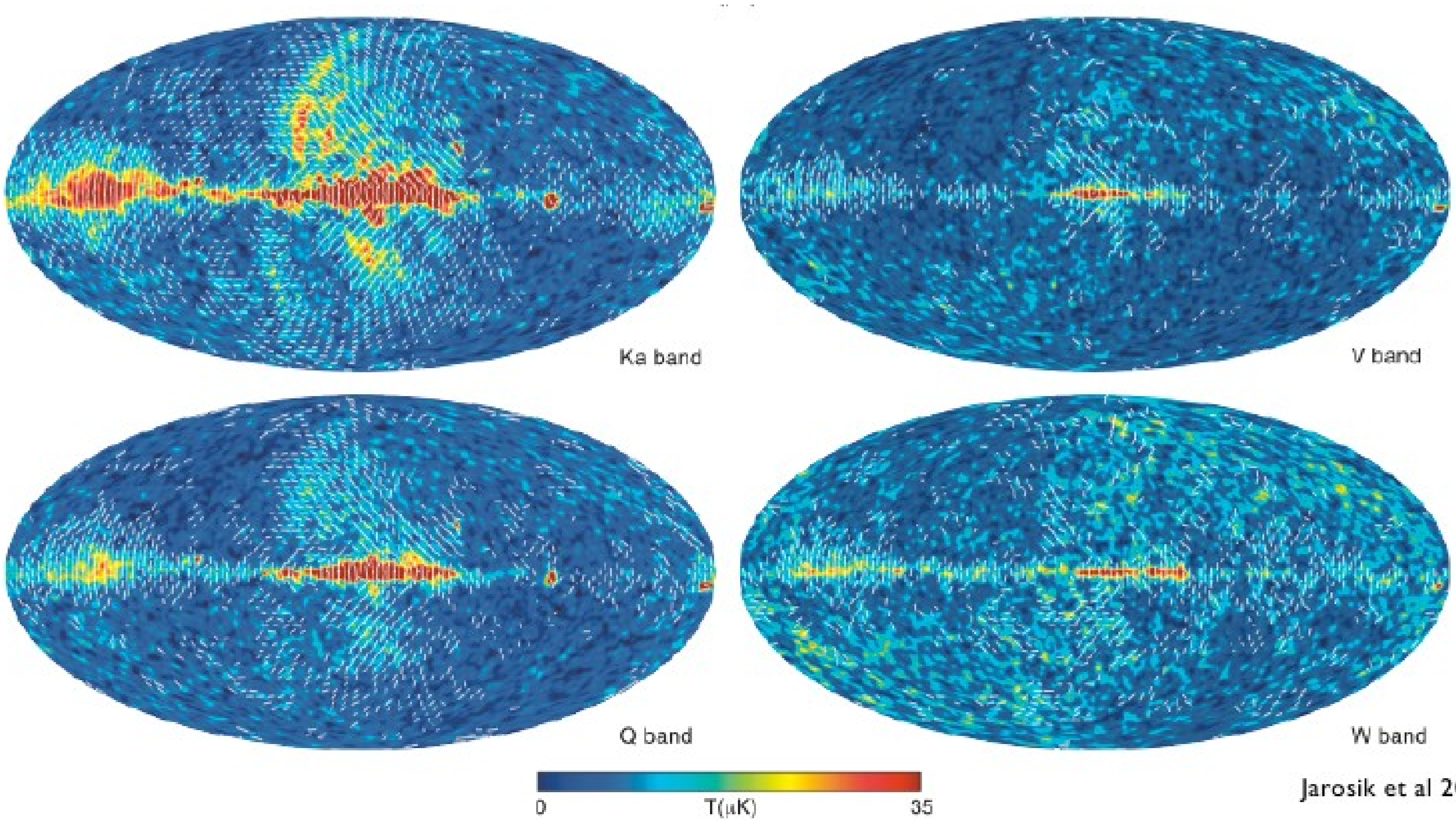
- Photons CMB faiblement polarisés

  (~ 10% du signal)

- Thomson scattering
  - Au moment de la dernière diffusion

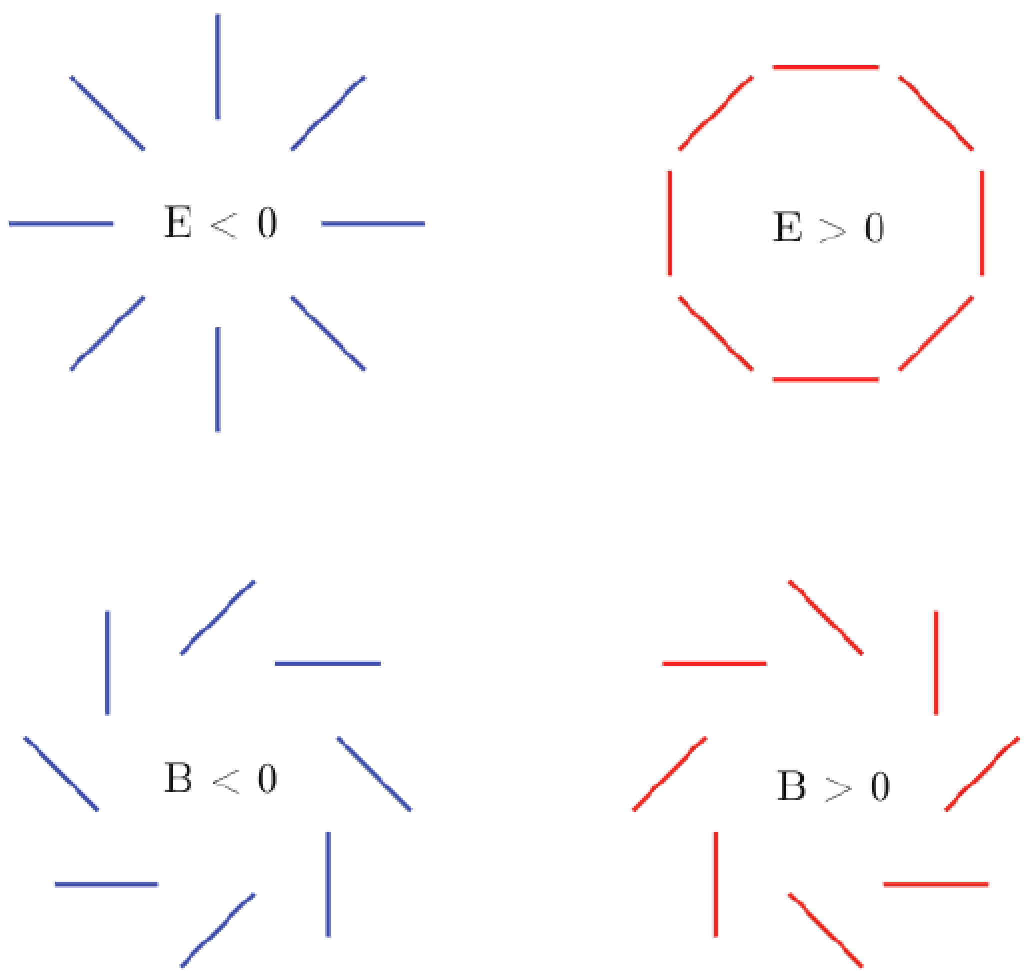
    (si anisotropies quadrupolaires locales)
  - Au moment de la réionisation

Polarisation



Jarosik et al 2011

Modes E / Modes B



Thomson scattering
Reionisation

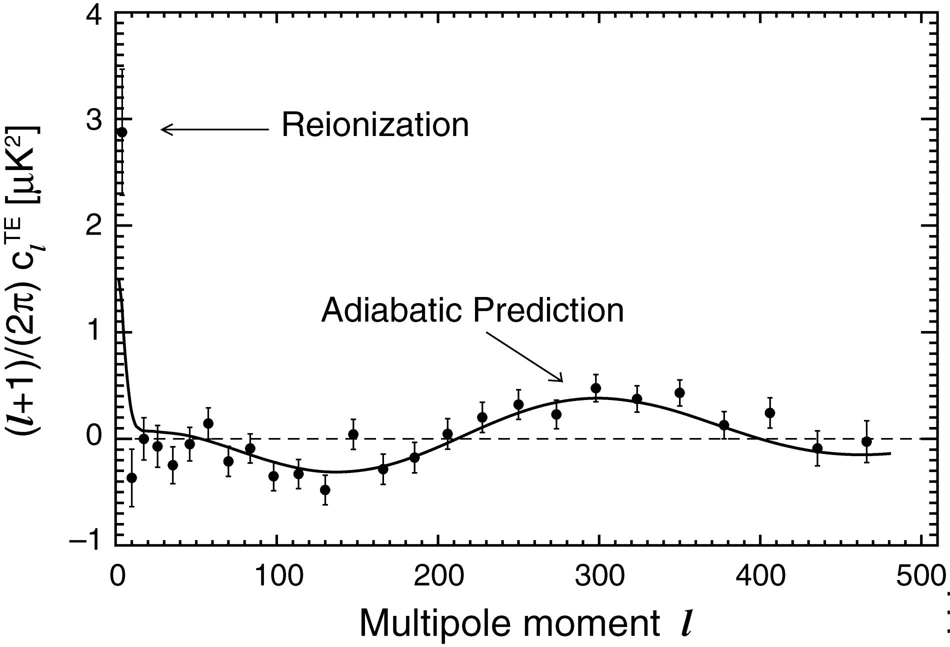
Détectés

Modes tenseurs

ou alors …

Lensing (avant plans)
Effets instrumentaux

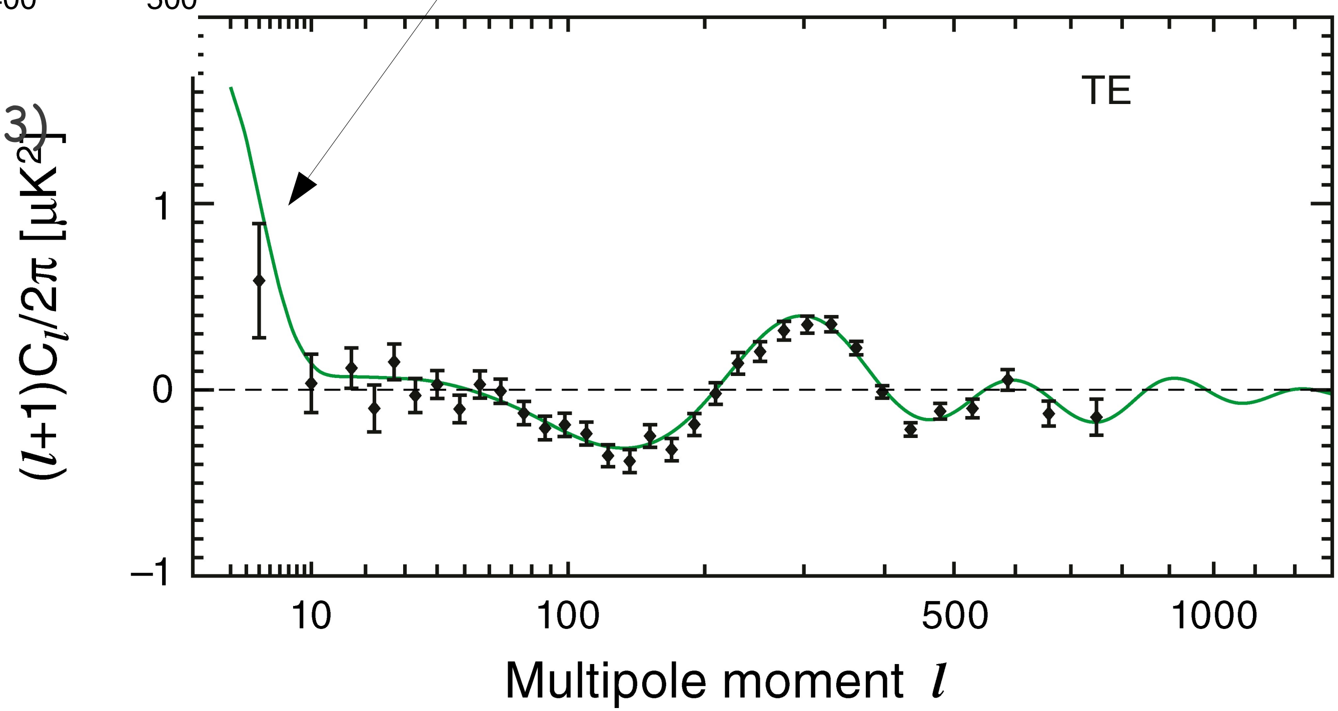
Réionisation



WMAP1: (Spergel et al, 2003)

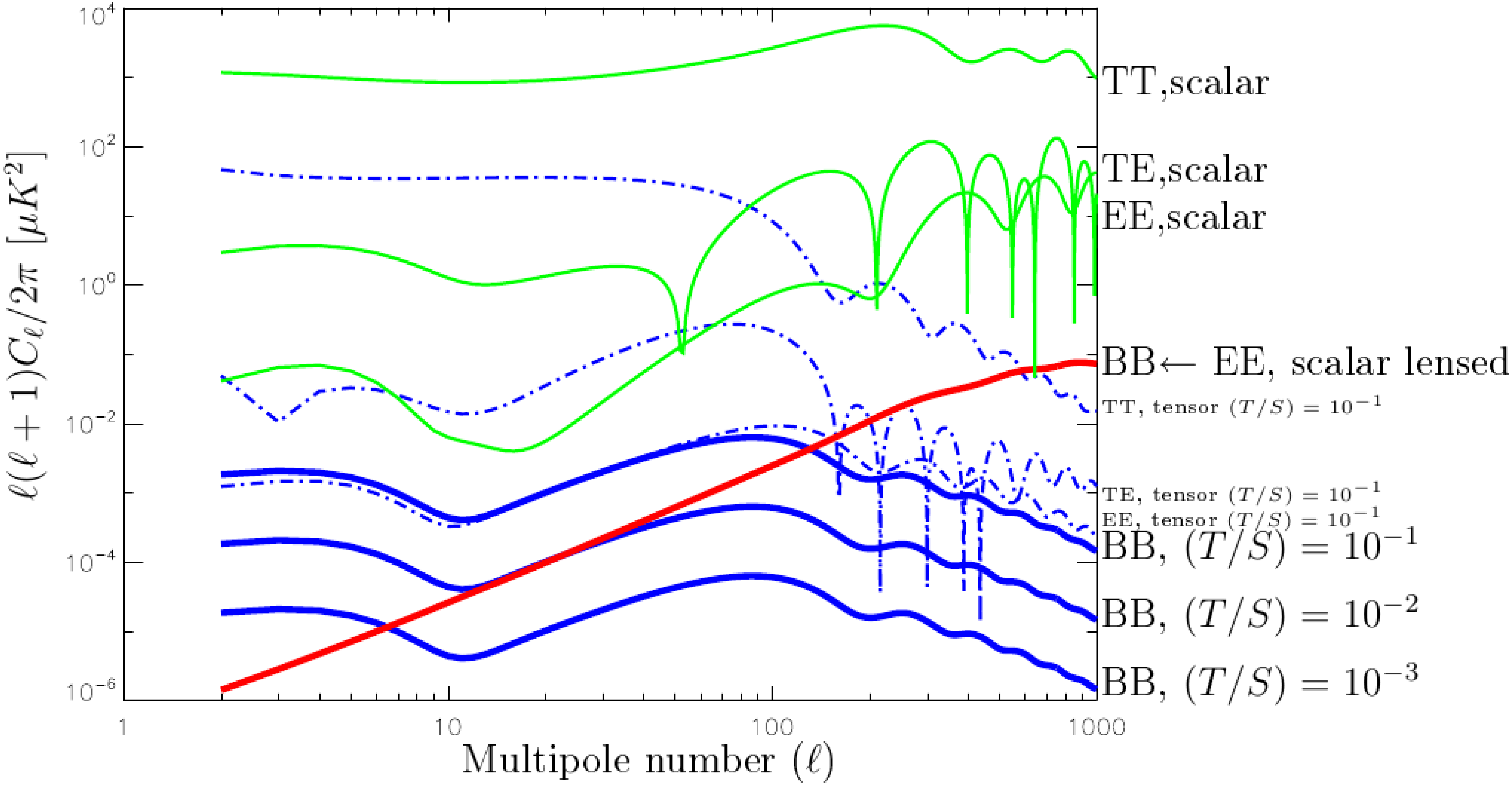
Amplitude ↔ Profondeur optique

Position ↔ $z_{reionisation}$



WMAP7: (Komatsu et al, 2011)

Modes B



10^4
10^2
10^0
10^{-2}
10^{-4}
10^{-6}
1
10
100
1000
Multipole number (ℓ)
$\ell(\ell+1)C_\ell/2\pi\ [\mu K^2]$
TT,scalar
TE,scalar
EE,scalar
BB← EE, scalar lensed
TT, tensor $(T/S) = 10^{-1}$
TE, tensor $(T/S) = 10^{-1}$
EE, tensor $(T/S) = 10^{-1}$
BB, $(T/S) = 10^{-1}$
BB, $(T/S) = 10^{-2}$
BB, $(T/S) = 10^{-3}$

Détection des modes B

- $l \sim 10$ (domine sur lensing) → $l > 1000$ (lensing)
  - Test inflation
  - Levée dégénerescence géométrique
- Signal très ténu - dépend de r = (T/S)
  - bcp de photons, résolution ~ 1 arcmin

    → grand miroir
  - ~ all sky (grandes échelles)

    → grand plan focal (matrices de bolomètres)
- Contrôle des systématiques instrumentales

  → modulation du signal (lame $\frac{1}{2}$ onde en rotation)

Telescopes au sol

- Atacama Cosmology Telescope (ACT)
  - 6-m, res ~ 1 arcmin
  - http://www.princeton.edu/act/
- South Pole Telescope (SPT)
  - 10-m, res ~ 1 arcmin
  - http://pole.uchicago.edu/
- Polarbear
  - http://bolo.berkeley.edu/polarbear
- EBEX (ballons) → E and B Experiment (EBEX)
  - http://calvin.phys.columbia.edu/group_web/ebex/index.php?a=intro
-

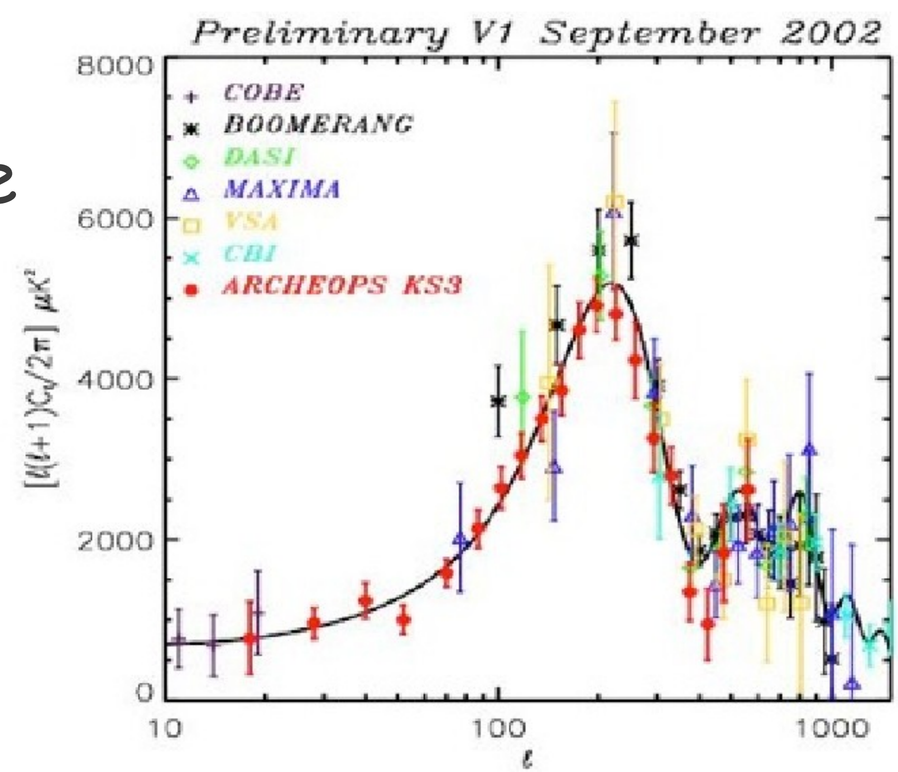
Missions Spatiales

- CMBPol
  - http://cmbpol.uchicago.edu/index.php
- B-Pol
  - http://www.b-pol.org/index.php

→ pour le moment, projets sol/ballons prioritaires ("technology not ready", "risk of NULL signal").

Activités IN2P3

- Historique
  - Archeops (ballon CNES, PCC/SPP, CRTBT Grenoble)
  - Vol scientifique: 2002
  - Mesure 1er pic acoustique
  - Test technos Planck
    - (froid + bolos)



Planck

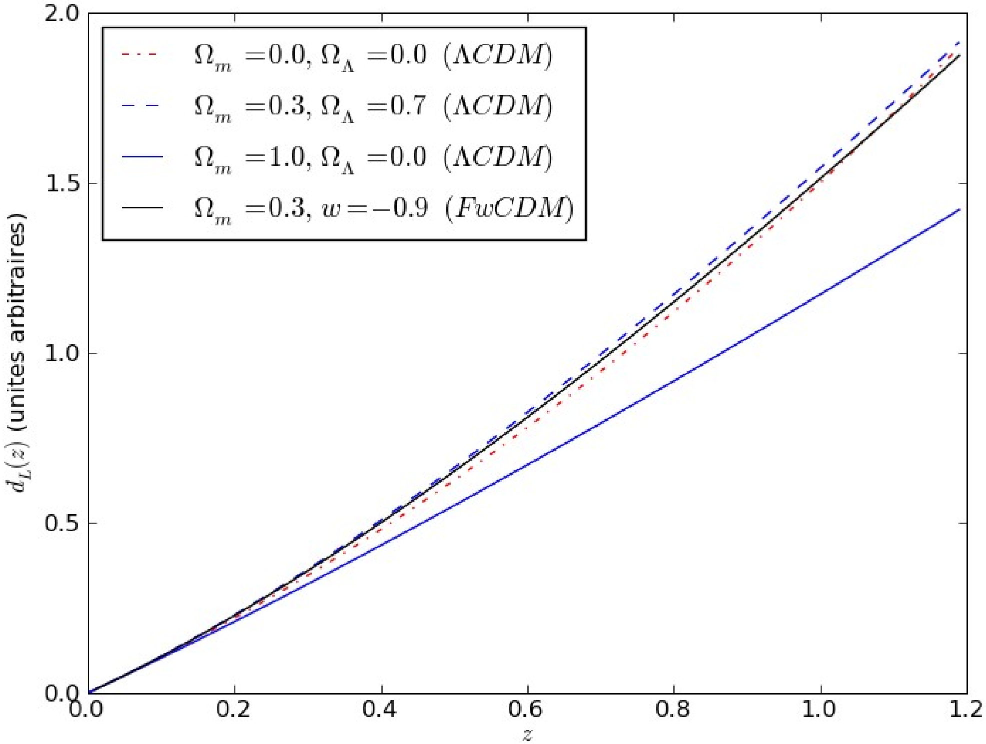
- Implication IN2P3 dans HFI
  - (IN2P3 + INSU + CEA)
  - PI: J.-L. Puget (IAS)
- 6 bandes (HFI)
  - (soustraction avant-plans)
- Resolution ~ 5 arcmin
- Spectres en T → l ~ 2000
- Polarisation E jusqu'à l ~ 1000
- Polarisation B ??? Ca dépend de r...
- Résultats ~ début 2013

R&D : QUBIC

- Q & U Interferometer for cosmology
  - 40-cm
  - lame ½ onde dans plan pupille
  - interférométrie
- Mesures au sol (Dôme C - Concordia)
- France + Italie + Irlande + UK + USA
- APC + CSNSM : R&D bolomètres (DCMB)

Supernovae

Chandelles standard distances de luminosité

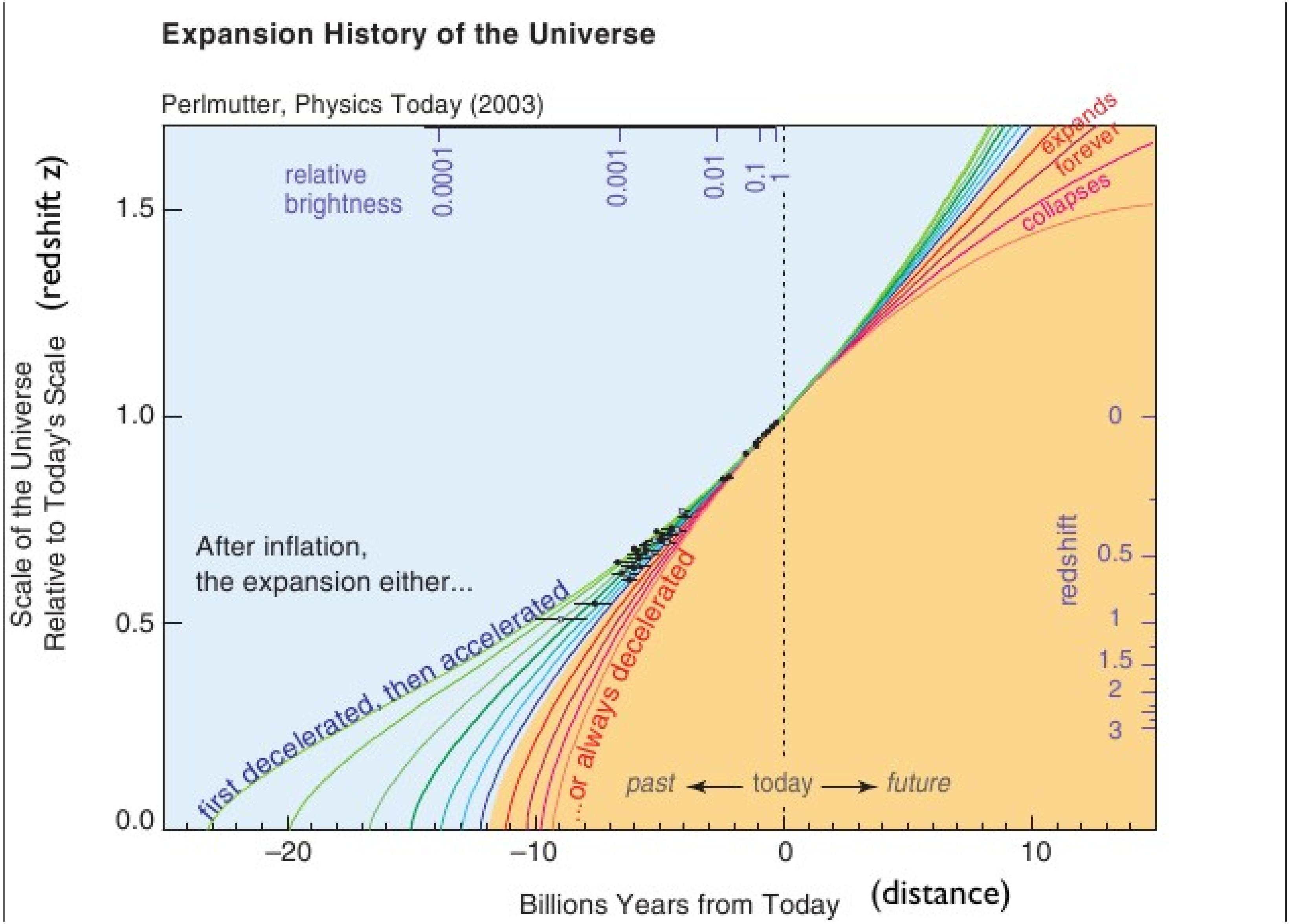


- Observables:
  - Redshift $z = \delta\lambda/\lambda$
  - Flux apparent
  - Angle apparent
- Chandelles standard

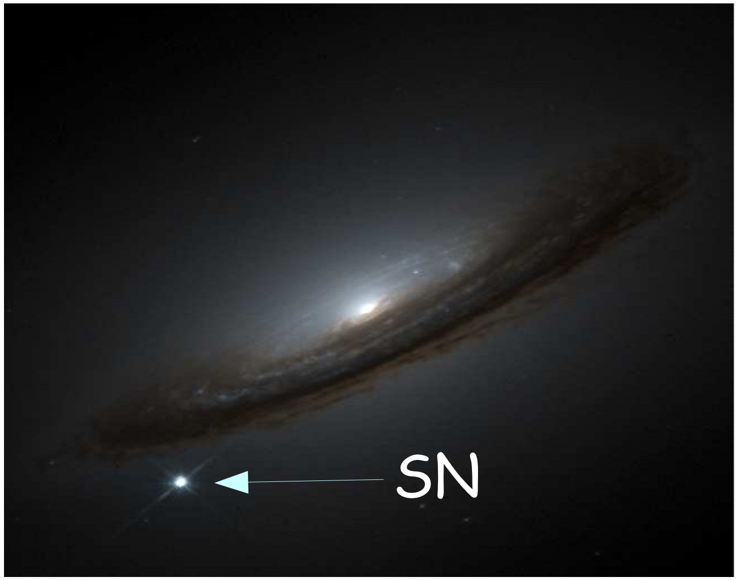
$$\Phi_{obs} = \frac{L(\lambda_{obs}/(1+z))}{4\pi(1+z){d_L}^2}$$

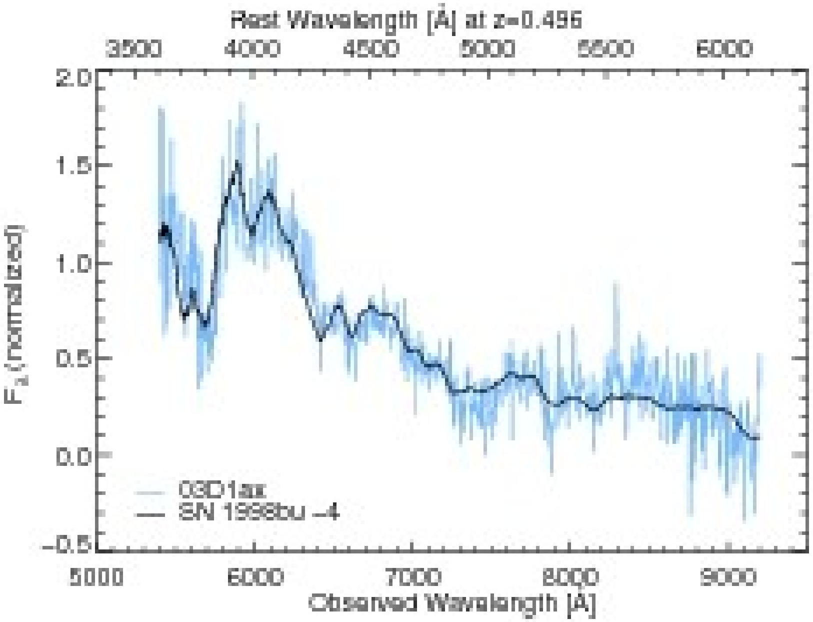
- Quasi-dégénerescences → 1 paramètre bien mesuré.
- d_L(z) → histoire (intégrée) de l'expansion

Histoire de l'expansion



Supernovae de type Ia





- Explosions thermonucléaires (WD)
  - Événements rares (~1 / Gal / 1000 yr)
  - Lumineux (~10^{10} luminosités solaires)
  - Brefs (~ 1 month)
  - $\sigma(L_{max})$ ~ 40%

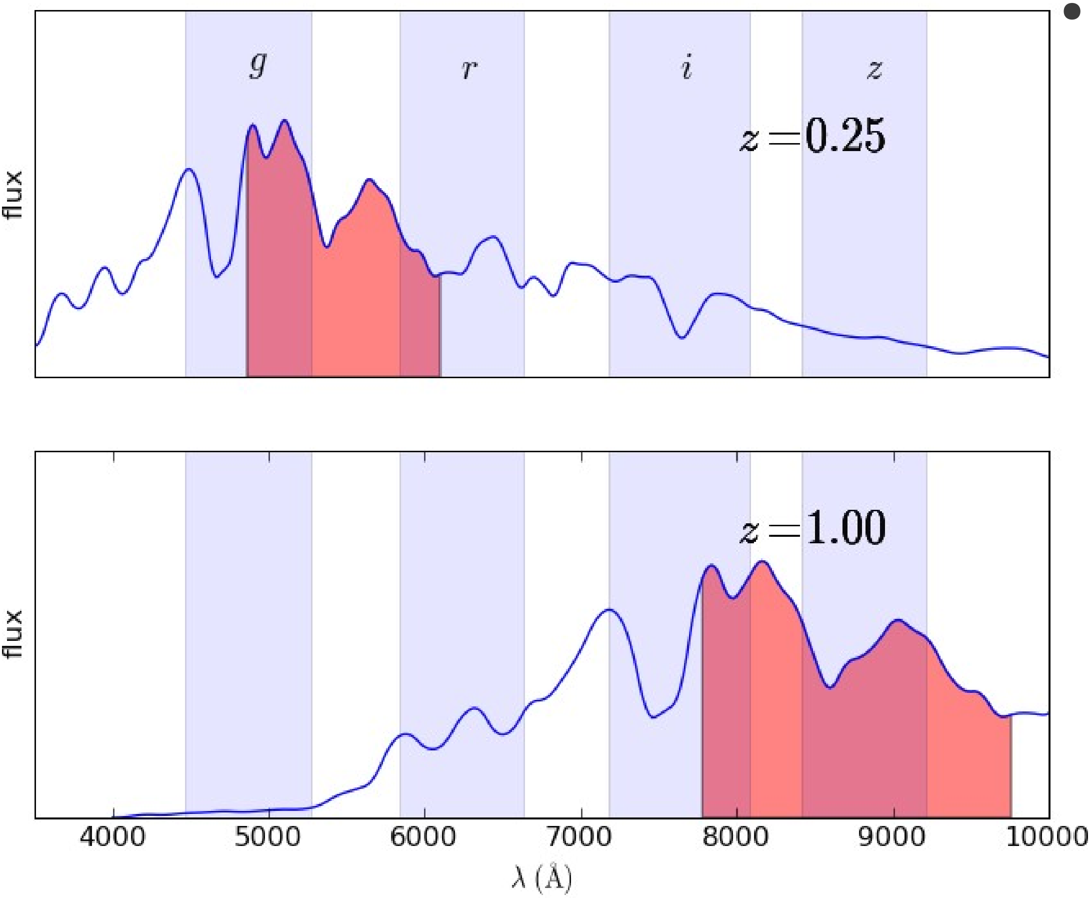
Standardisables → σ(Lmax) ~ 15%

Spectroscopie

→ Identification (raies larges)

→ Composition chimique + vitesses

Distances de luminosité



- Flux ds référentiel au repos

  @ differents redshifts

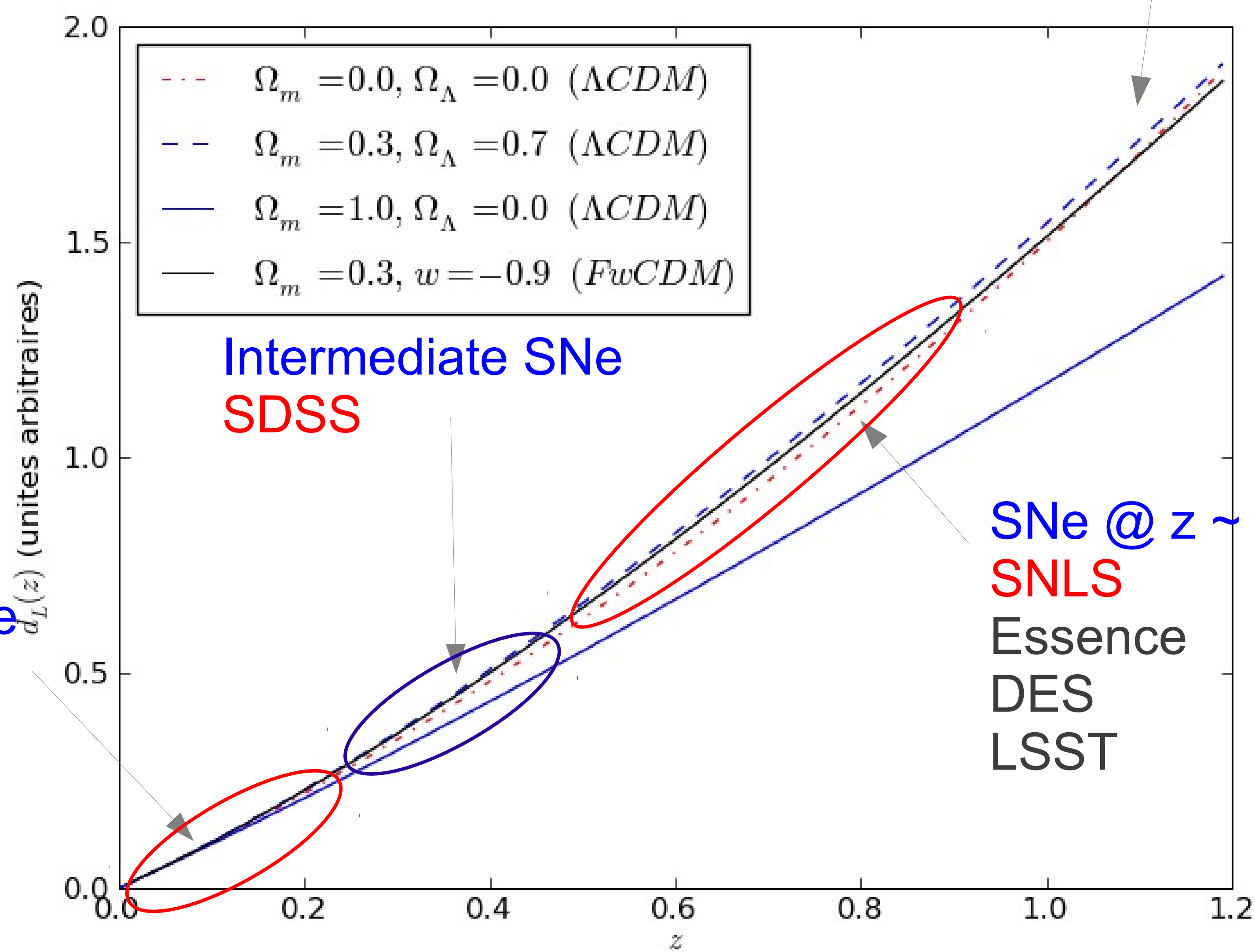
  → modèle empirique → interpolation entre mesures.

  → Entrainés sur supernovae proches et distantes.

SALT2 (Guy et al, 2007), SIfTO (Conley et al, 2007), MLCS2k2 (Jha et al, 2007), CMAGIC (Wang et al, 2003)...

Roadmap

SNe @ z>1
HST
SNAP/JDEM
Euclid...



Intermediate SNe
SDSS

SNe @ z ~ 0.8
SNLS
Essence
DES
LSST

Nearby SNe
SNfactory
Cfa, KAIT,
SkyMapper
...


AOB
CANADA-FRANCE-HAWAII TELESCOPE
www.cfht.hawaii.edu
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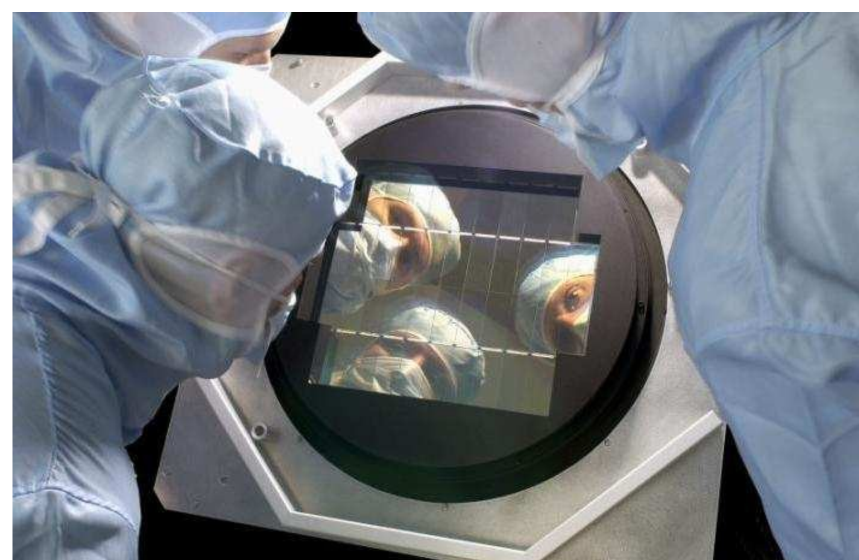
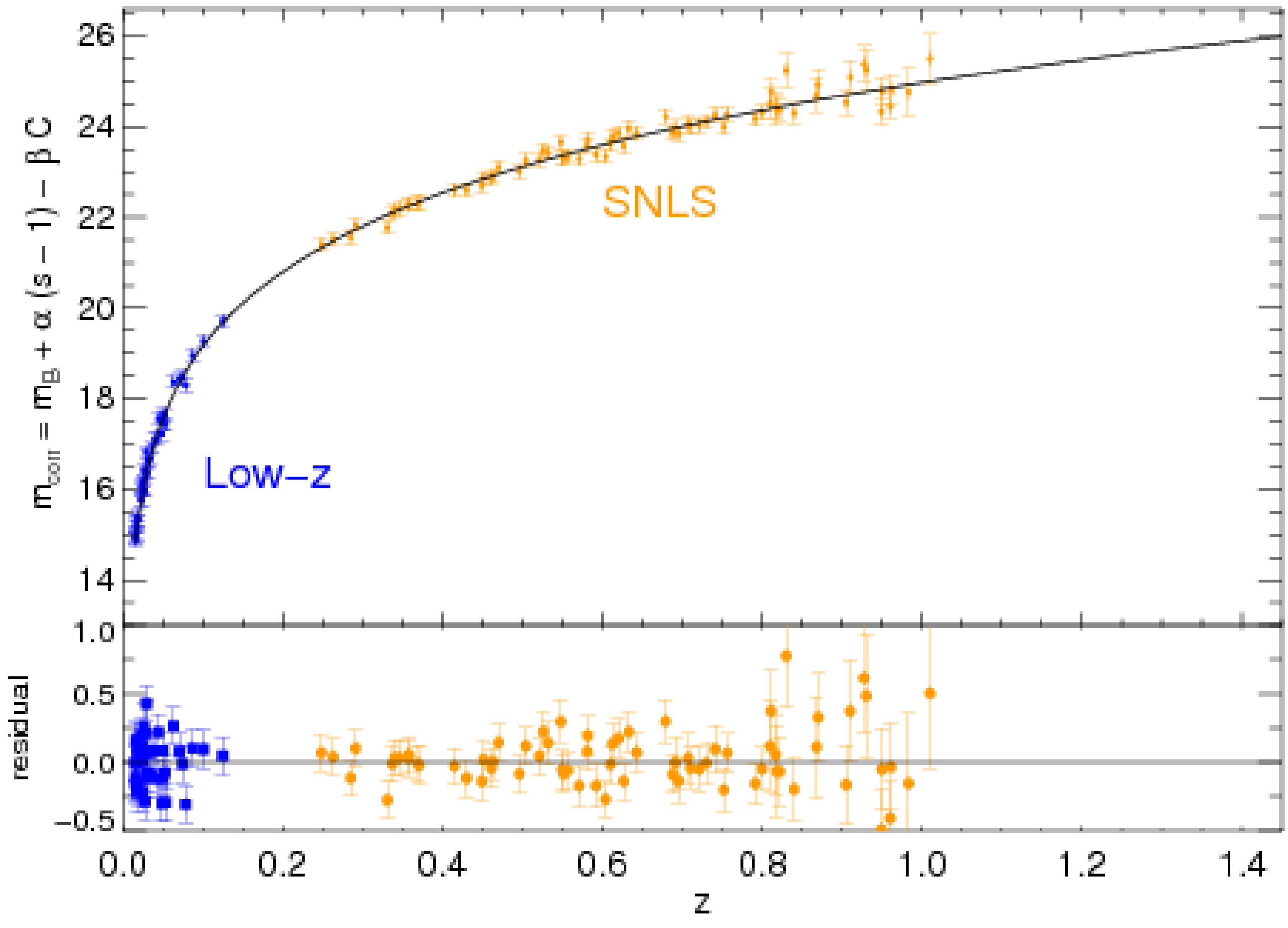
The MegaCam imager

- CEA / DAPNIA
- 1 deg2, 36 2k x 4k CCDs
- Good PSF sampling (0.18'')
- Excellent image quality (0.7'')
- ugriz bands (350 → 950 nm)

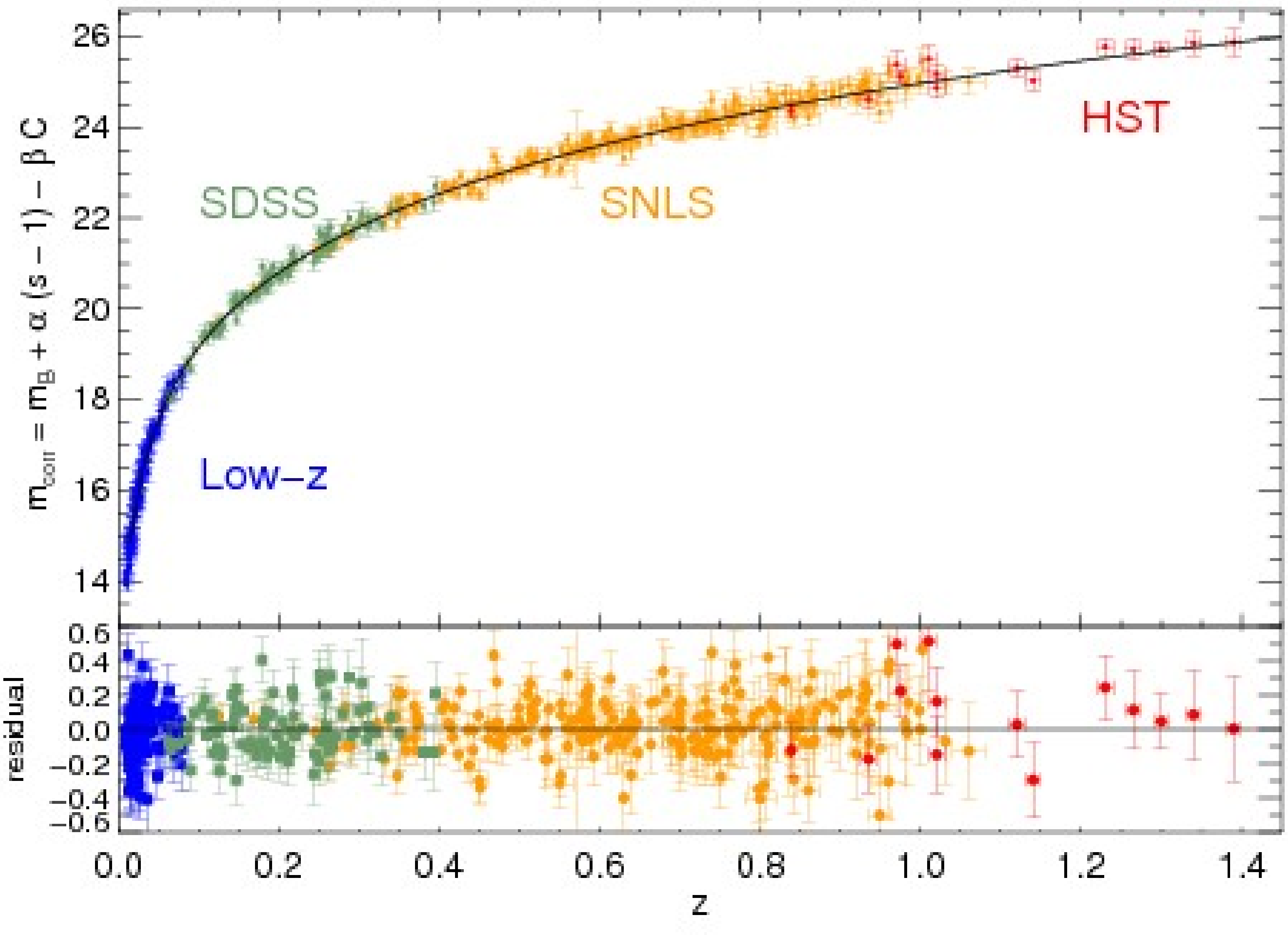


SNLS1

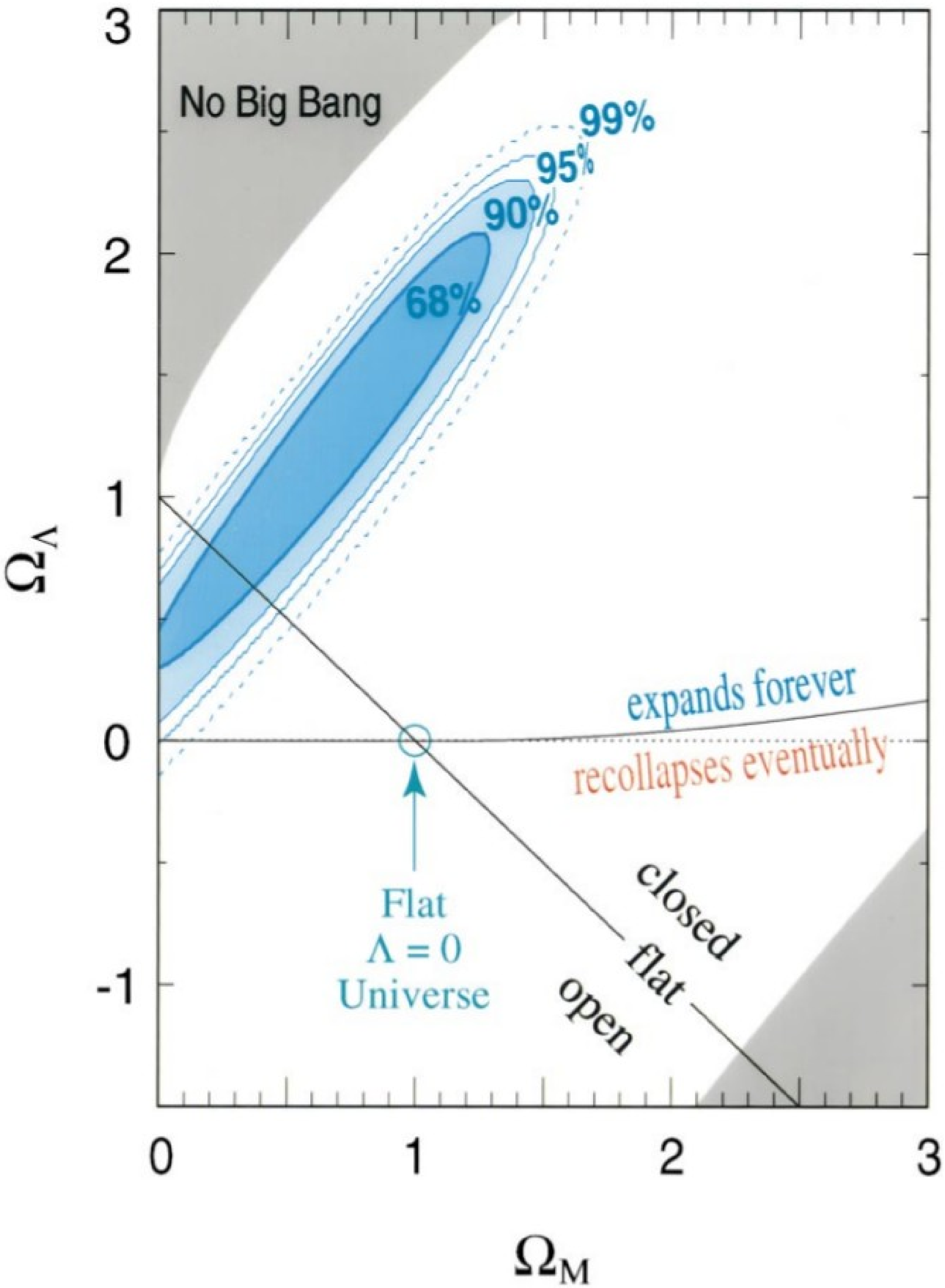


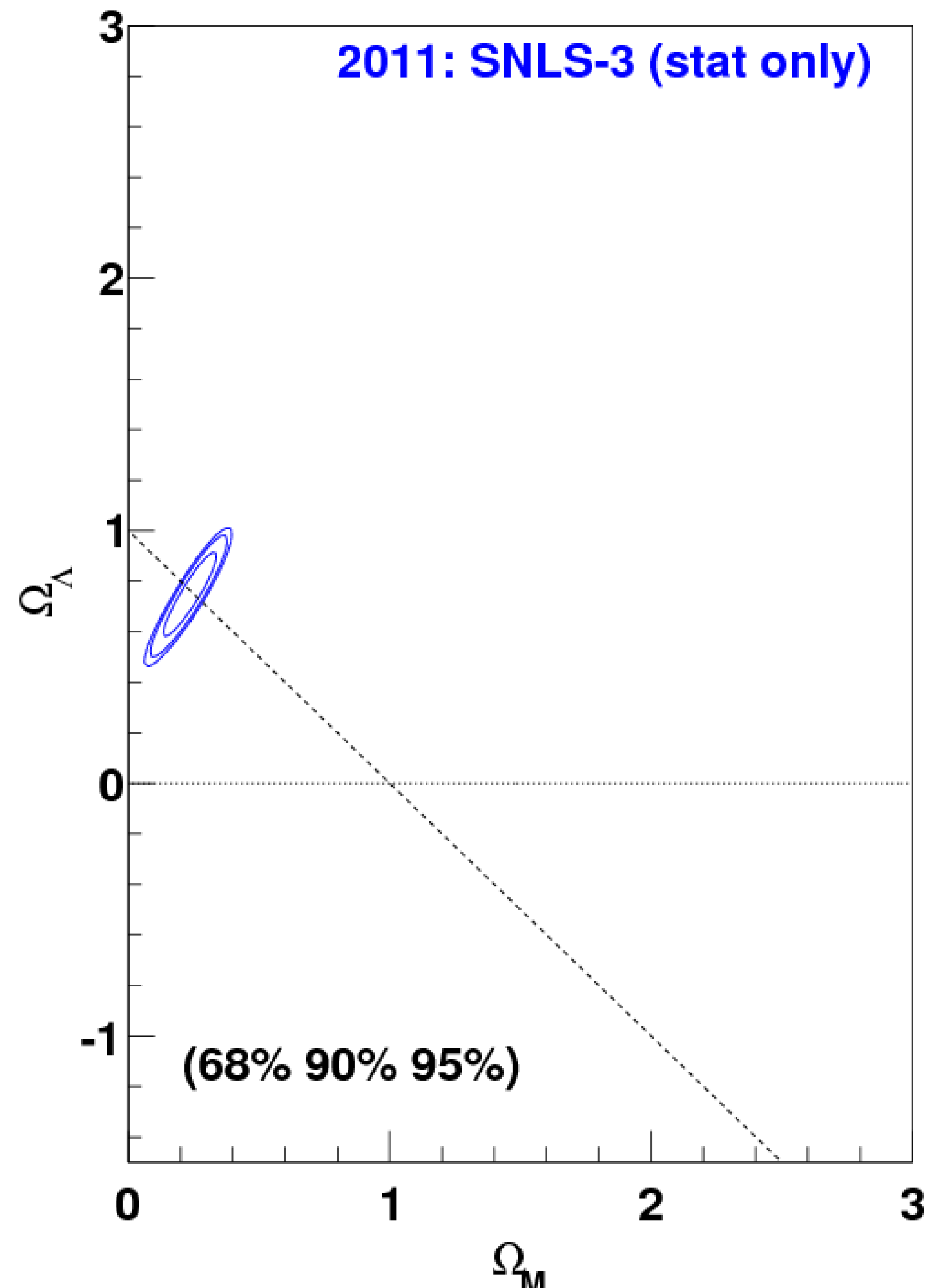
(Astier et al, 2006)

SNLS3



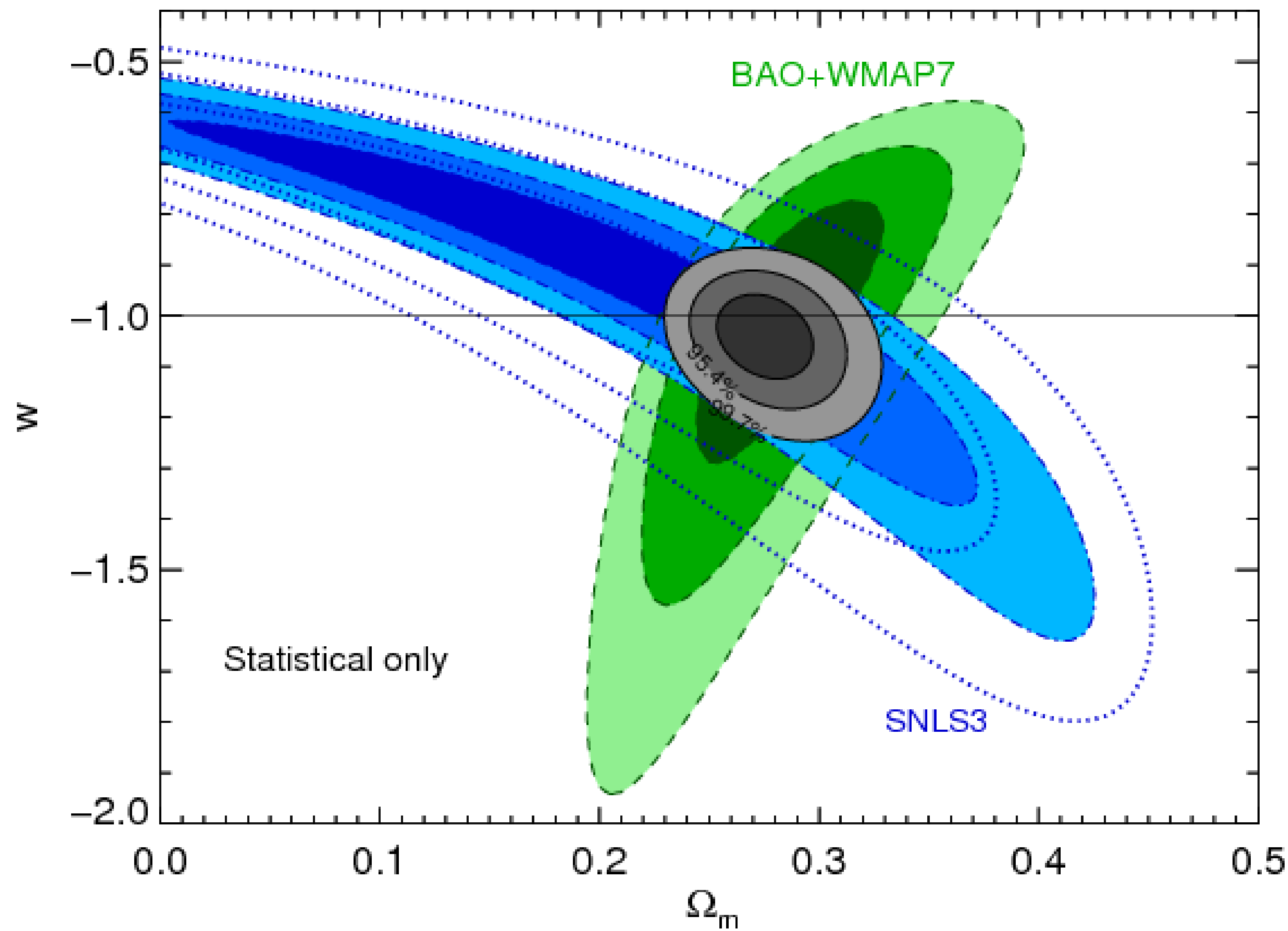
(Guy et al, 2010, Conley et al, 2010)


No Big Bang
99%
95%
90%
68%
expands forever
recollapses eventually
Flat
Λ = 0
Universe
closed
flat
open
Ω_Λ
Ω_M
3
2
1
0
-1
0
1
2
3


2011: SNLS-3 (stat only)
(68% 90% 95%)
Ω_Λ
Ω_M
3
2
1
0
-1
0
1
2
3

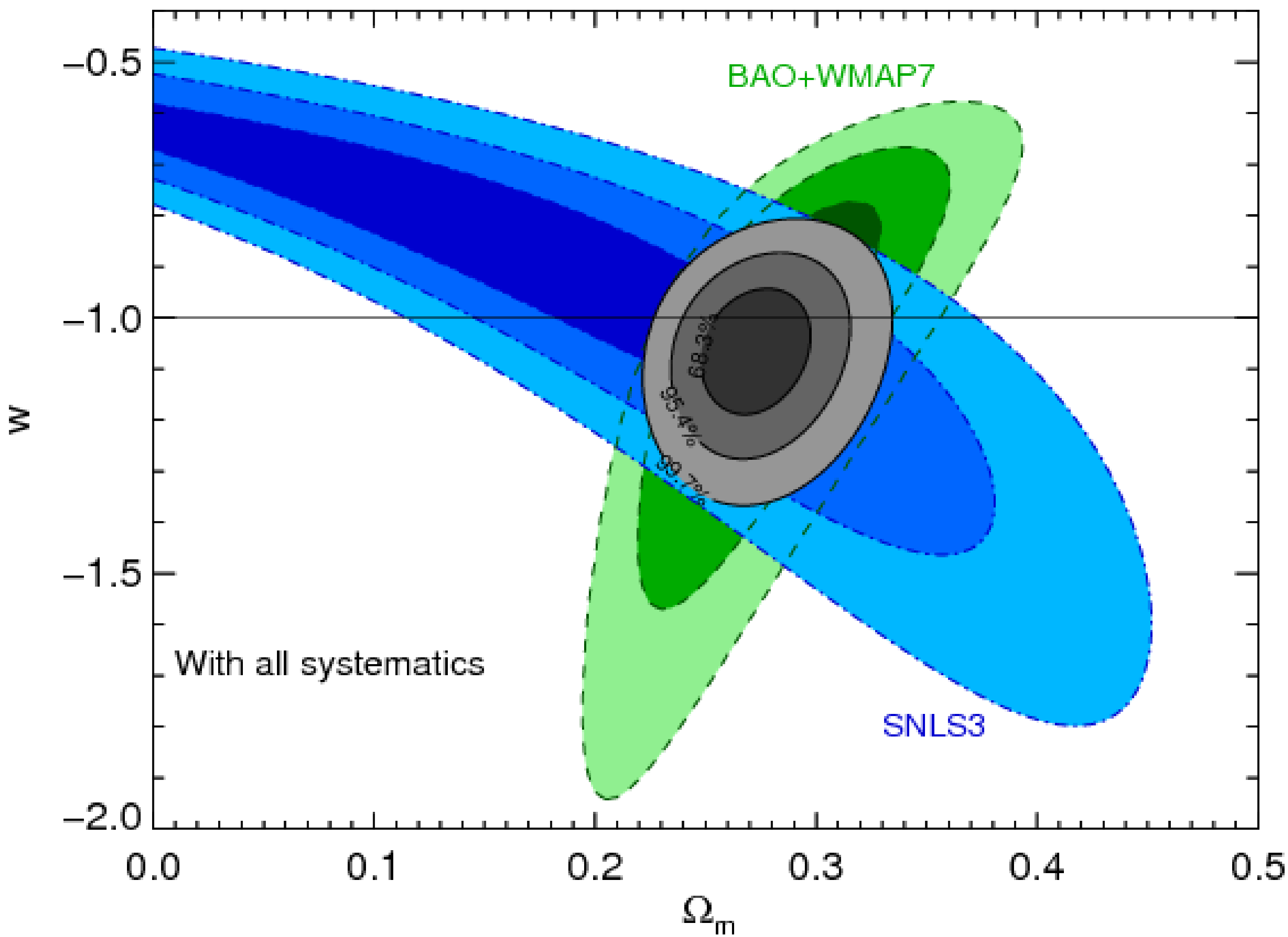
w = -1

Contraintes sur w



(Sullivan et al, 2011)

Contraintes sur w



(Sullivan et al, 2011)

Systematics

Table 7: Identified systematic uncertainties

Description	Ω_m	w	Rel. Area [a]	w for Ω_m=0.27
Stat only	$0.19^{+0.08}_{-0.10}$	$-0.90^{+0.16}_{-0.20}$	1	-1.031 ± 0.058
All systematics	0.18 ± 0.10	$-0.91^{+0.17}_{-0.24}$	1.85	$-1.08^{+0.10}_{-0.11}$
Calibration	$0.191^{+0.095}_{-0.104}$	$-0.92^{+0.17}_{-0.23}$	1.79	-1.06 ± 0.10
SN model	$0.195^{+0.086}_{-0.101}$	$-0.90^{+0.16}_{-0.20}$	1.02	-1.027 ± 0.059
Peculiar velocities	$0.197^{+0.084}_{-0.100}$	$-0.91^{+0.16}_{-0.20}$	1.03	-1.034 ± 0.059
Malmquist bias	$0.198^{+0.084}_{-0.100}$	$-0.91^{+0.16}_{-0.20}$	1.07	-1.037 ± 0.060
non-Ia contamination	$0.19^{+0.08}_{-0.10}$	$-0.90^{+0.16}_{-0.20}$	1	-1.031 ± 0.058
MW extinction correction	$0.196^{+0.084}_{-0.100}$	$-0.90^{+0.16}_{-0.20}$	1.05	-1.032 ± 0.060
SN evolution	$0.185^{+0.088}_{-0.099}$	$-0.88^{+0.15}_{-0.20}$	1.02	-1.028 ± 0.059
Host relation	$0.198^{+0.085}_{-0.102}$	$-0.91^{+0.16}_{-0.21}$	1.08	-1.034 ± 0.061

(Conley et al, 2011)

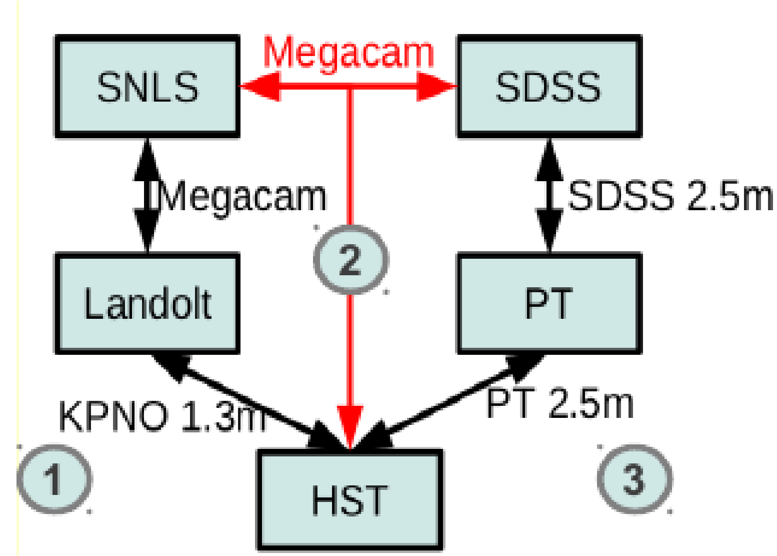
Chaine métrologique

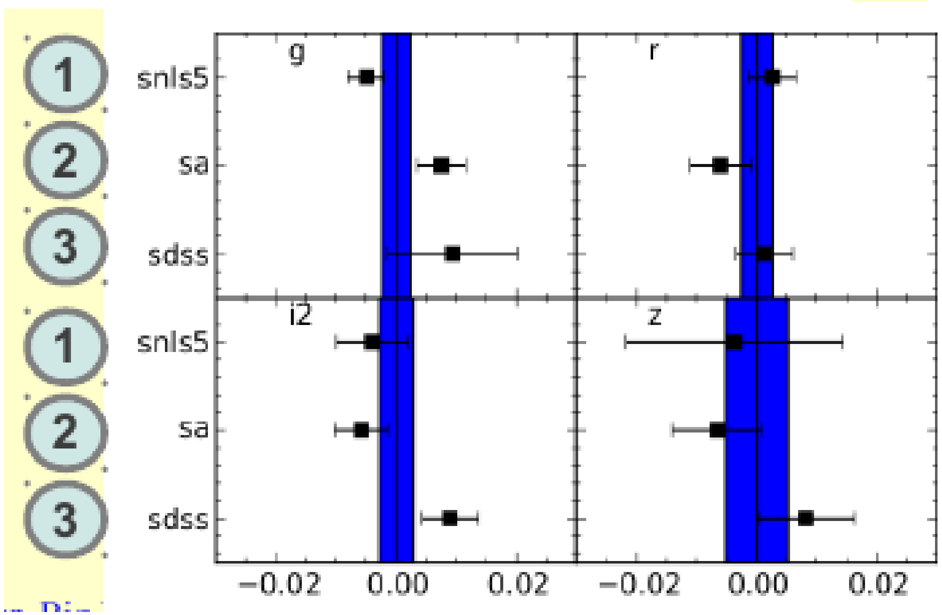
- Calibration relative en flux
  - → standard fondamental
  - → modèles naines blanches pure H
- Problème

  Standard fondamental

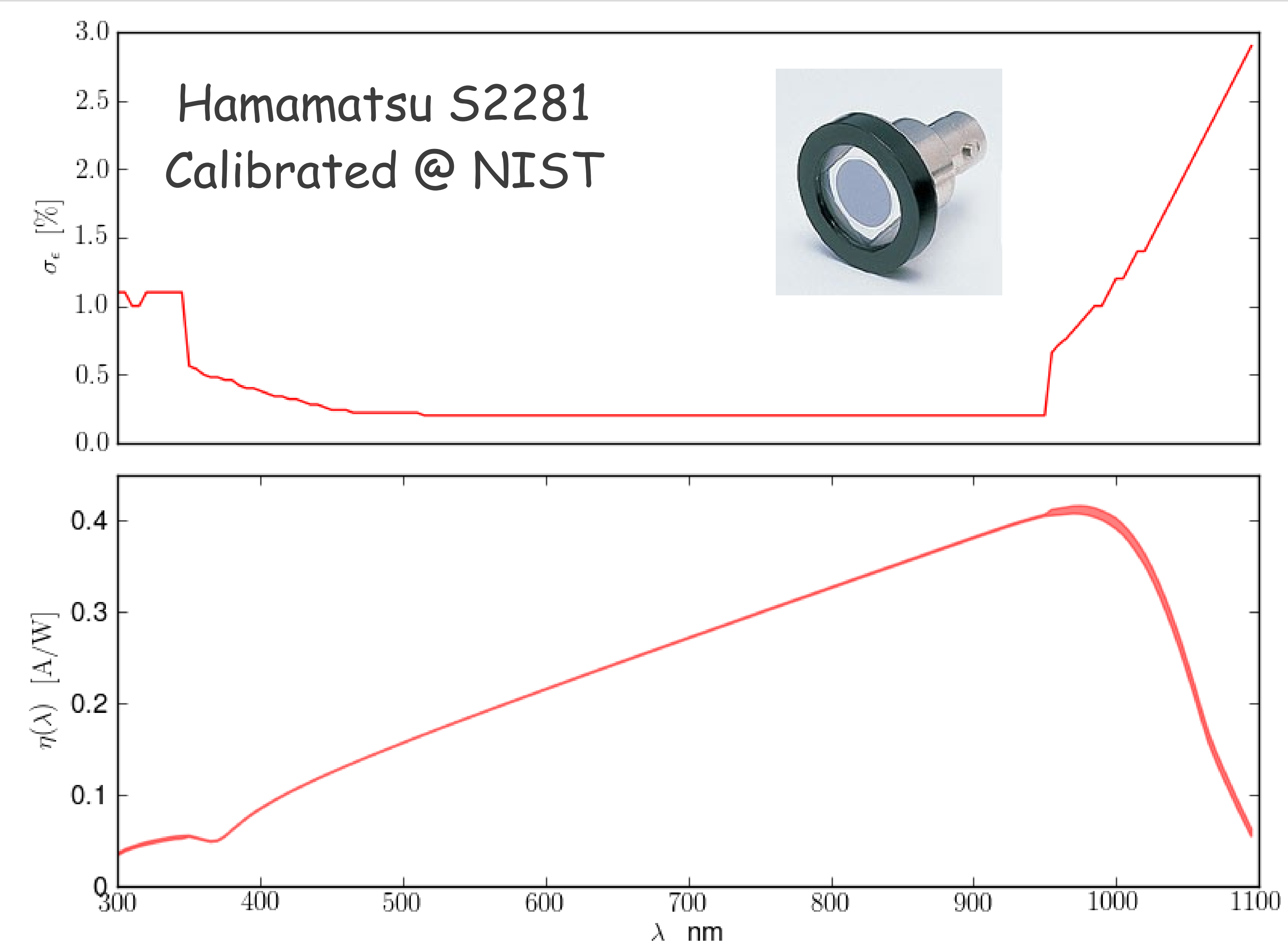
  =

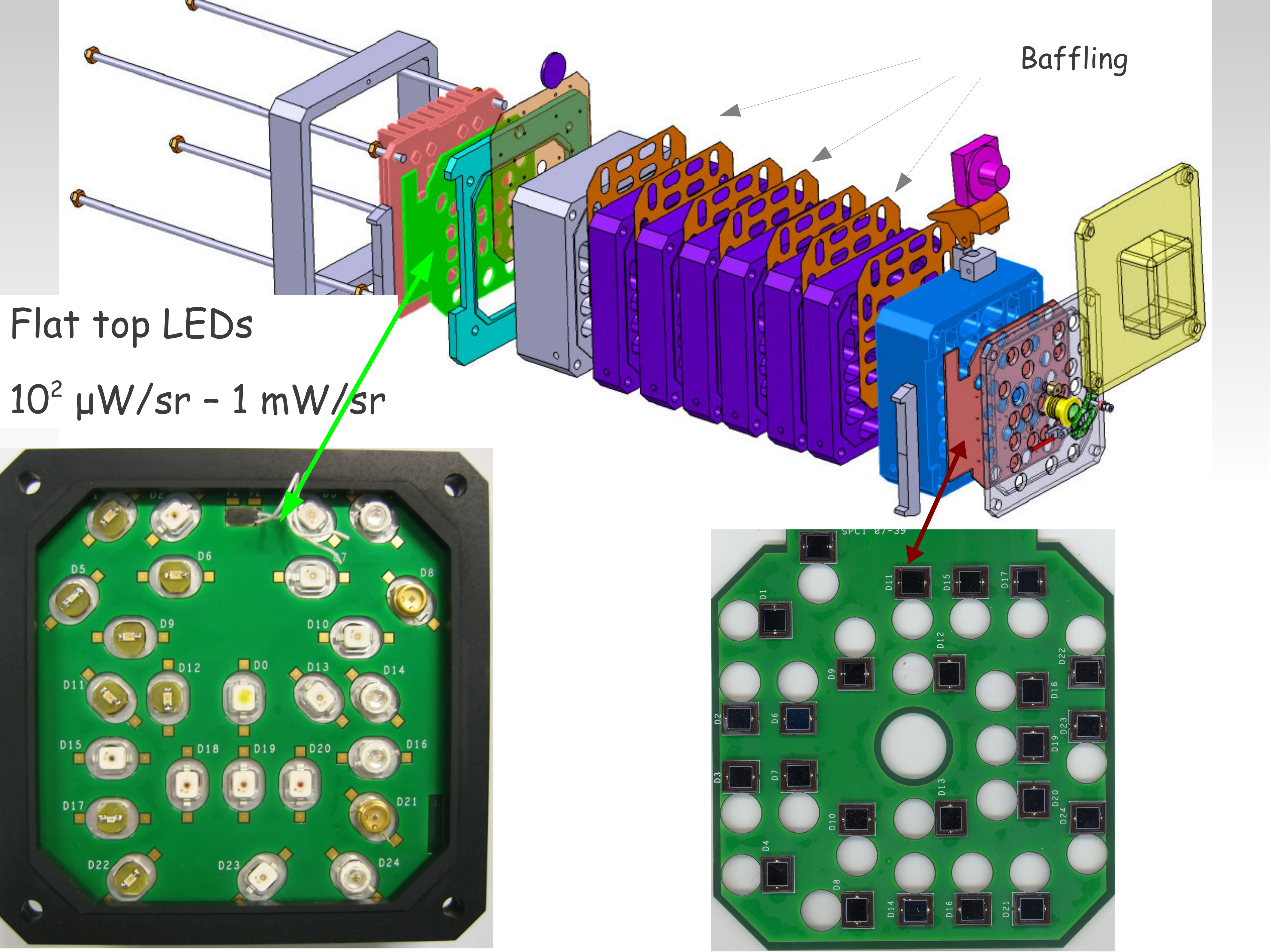
  objet astrophysique...
- Redondances chaine de calibration
  - → incertitudes ~ 0.5%
  - → target ~ 0.1%

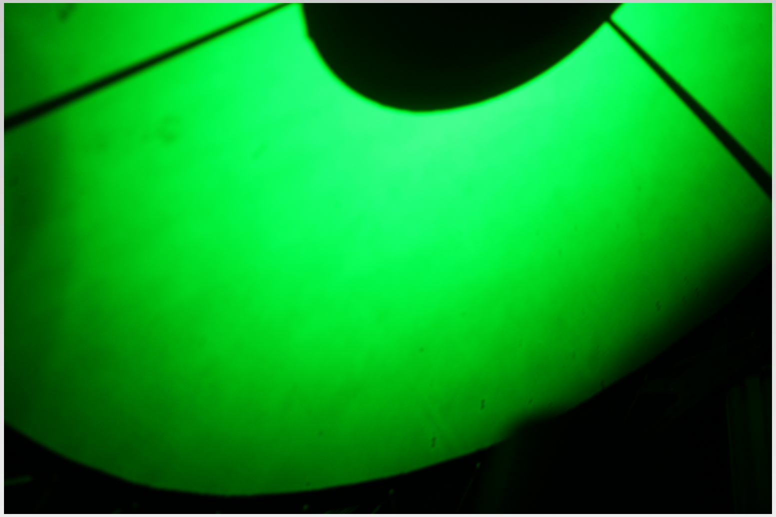
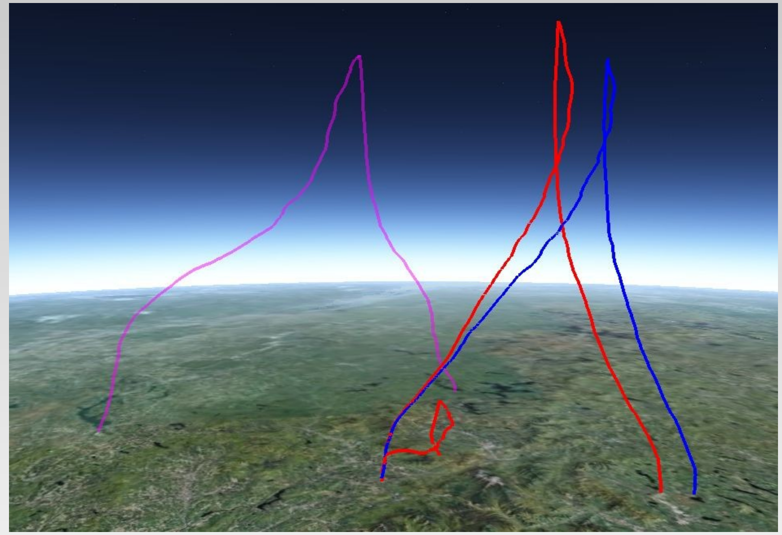
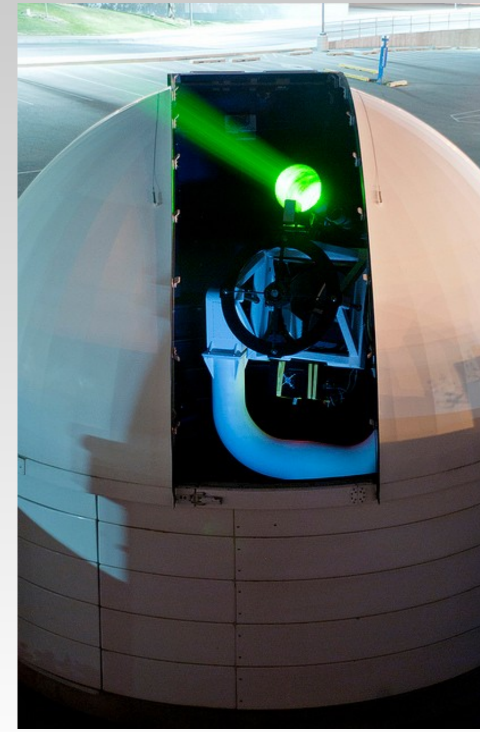


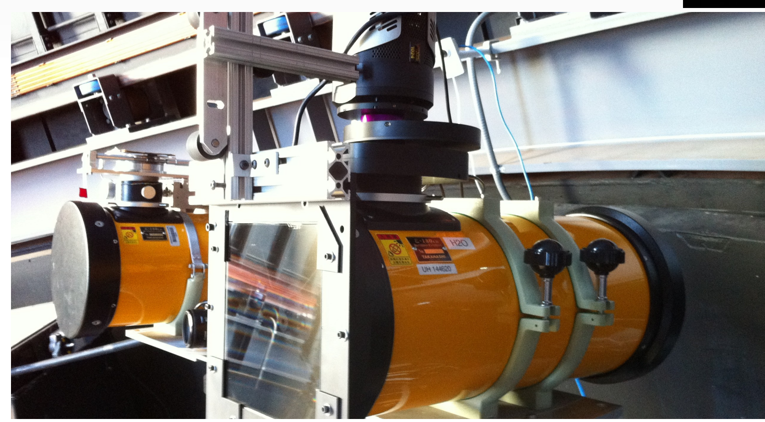


Standard de laboratoire

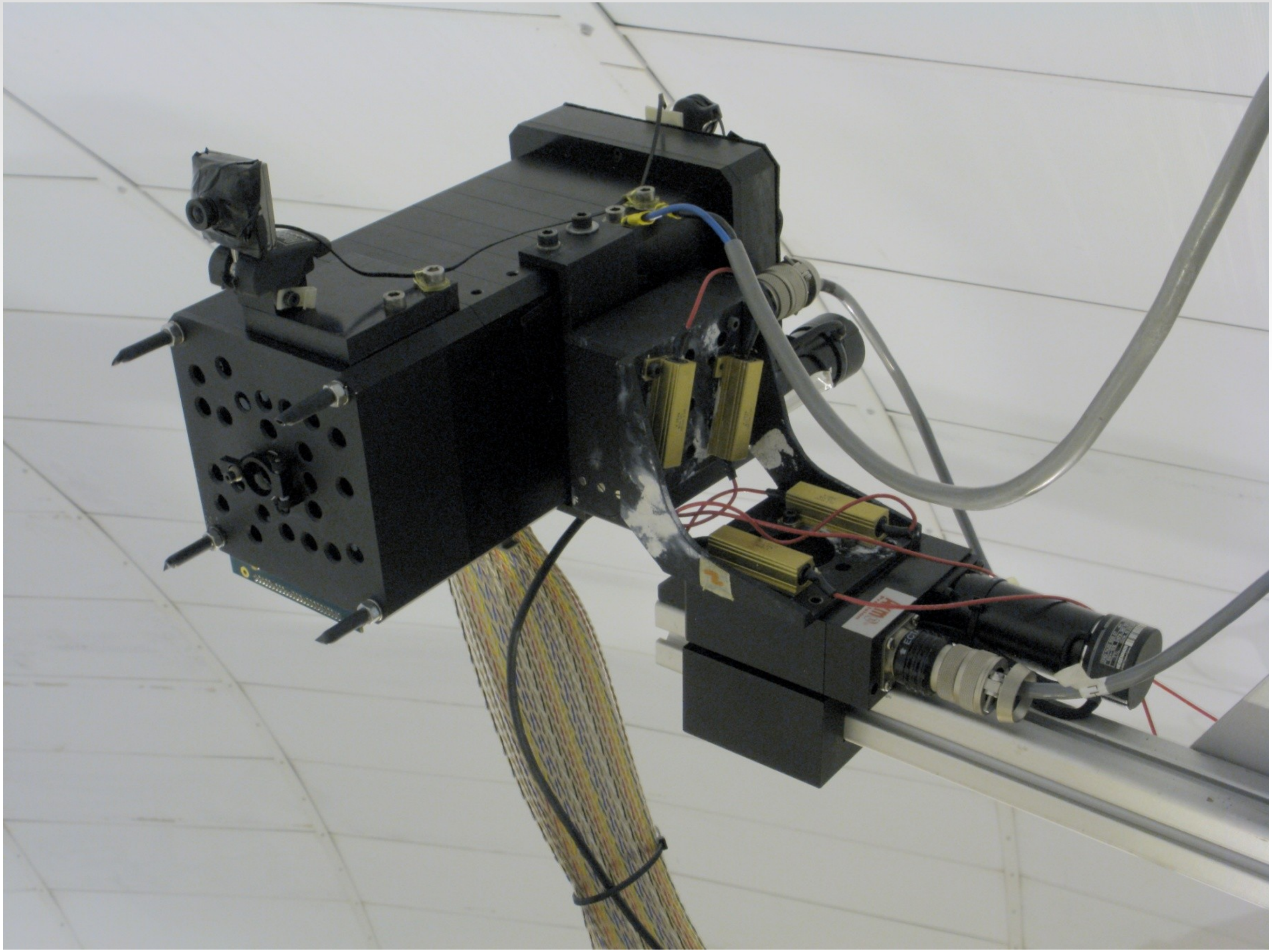



Baffling
Flat top LEDs
10^2 μW/sr – 1 mW/sr



Installation @ Hawaii



Systematics

- Systématique dominante

  → calibration photométrique

  → calibration stellaire : gros progrès (0.5%)

  → calibration instrumentale : intense activité R&D

- Systématiques astrophysiques

  → sous dominantes

  → solubles dans la statistique (?)

  (plus de SN → meilleur entrainement modèles empiriques)

- Début détection corrélation propriétés SN ↔ environnement

(Sullivan et al, 2010)

Futur: grands surveys photométriques

	FOV	aperture	first light	status	who/where
SDSS-III	7 deg2	2.5m	2008	observing	Apache Point
VST @ ESO	1 deg2	2.6 m	2011	observing	ESO/Paranal
HyperSuprimeCam	2.3 deg2	8 m	2012	~first light	Japan/Subaru
Dark Energy Survey	3 deg2	CTIO-4m	2012	commissioning	Fermilab/CTIO
Pan StarsS	7 deg2	1.8 m	2007	observing	Univ. Hawaii
Pan StarsS 2	7 deg2	1.8 m x 2	2013 ?	funded	Univ. Hawaii
PFS on Subaru	2.3 deg2	8.2m	2017	~funded	Japan/Subaru
BigBoss (spectro)	7 deg2	4m	?	not funded	DOE/NOAO
LSST	10 deg2	8 m	2019	approved	DOE/NSF
WFIRST	0.7 deg2	1.3 m	2020(+ ?)	??	NASA
Euclid	0.5 deg2	1.2 m	2019	« adopted »	ESA

Le futur

- Imagerie grand-champ

Visible ($z<1$) & infrarouge ($z>1$)

- Dark Energy Survey (DES)
  - (4-m, 3 deg^2, visible)
- Large Synoptic Survey Telescope (LSST)
  - (8-m, 9 deg^2, visible, première lumière ~ 2019)
- Euclid
  - (1.2-m, 0.5 deg^2, visible & infrarouge, 2019 ?)

Surveys SNe

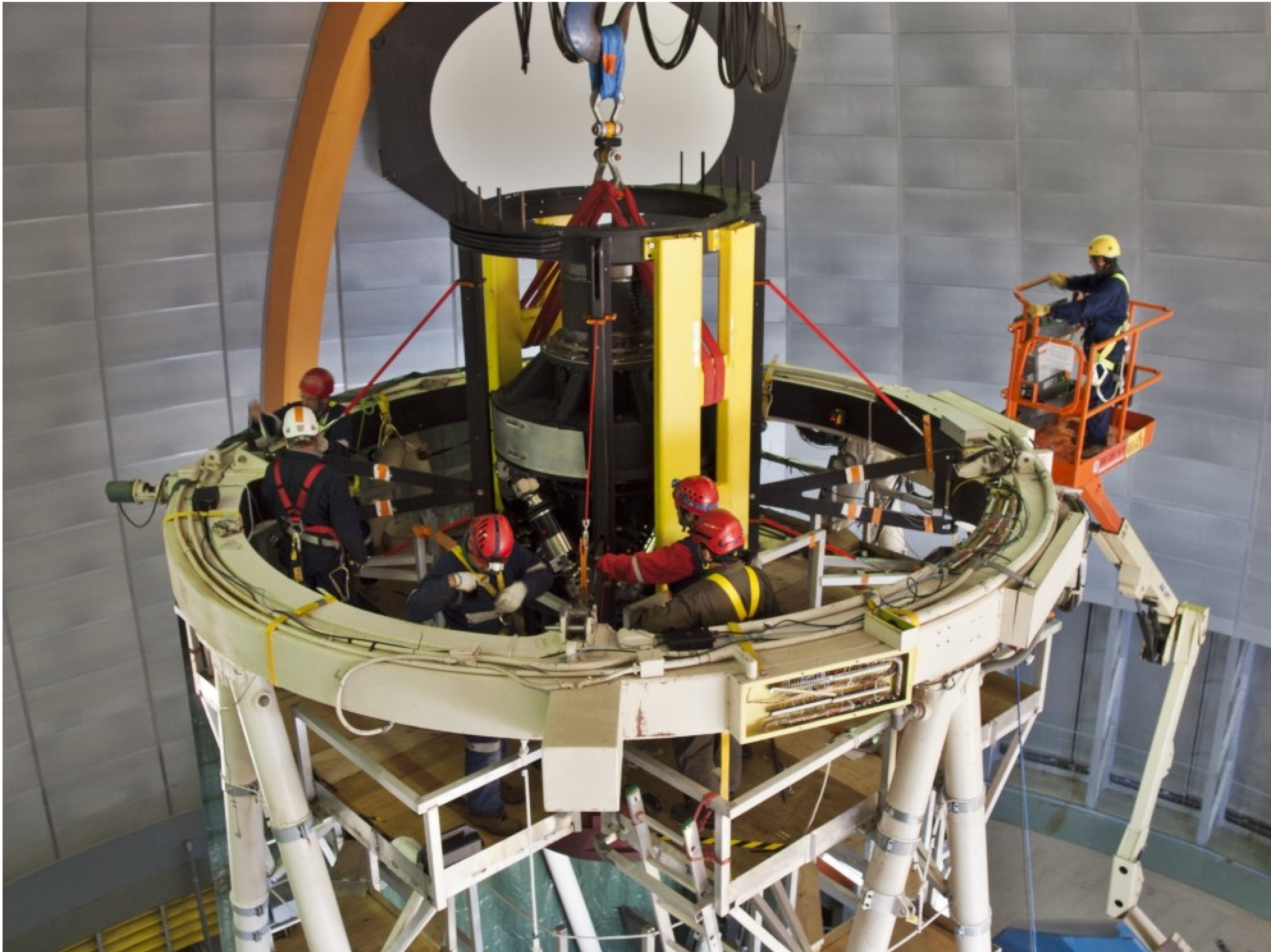
- Statistiques importantes ~ O(10000)
- Gamme de décalage spectral (z)
  - @ z ~ 0.05 (PTF, SkyMapper)
  - @ 0.3 < z < 1 (Visible + NIR : DES, LSST)
  - @ z > 1 → infrarouge → mission spatiale, Euclid.
- Excellente calibration (0.1%)
- Excellent échantillonage courbes de lumière
  - 3 bandes , -10 < t < +30 → mesure amplitude ~ 3%
  - Pas de spectro !

Dark Energy Survey

- Blanco 4-m telescope (CTIO, Chile)
- DECam (Fermilab)
  - 570 Mpixels, 74 red sensitive CCDs, ~ 3 deg^2
- 570 nuits (5 ans)
- Survey principal:
  - 5000 deg^2 (BAO + Lensing)
- SNe Ia (6 - 30 deg^2)

  → 3000 Sne Ia @ $z<1$

https://www.darkenergysurvey.org/

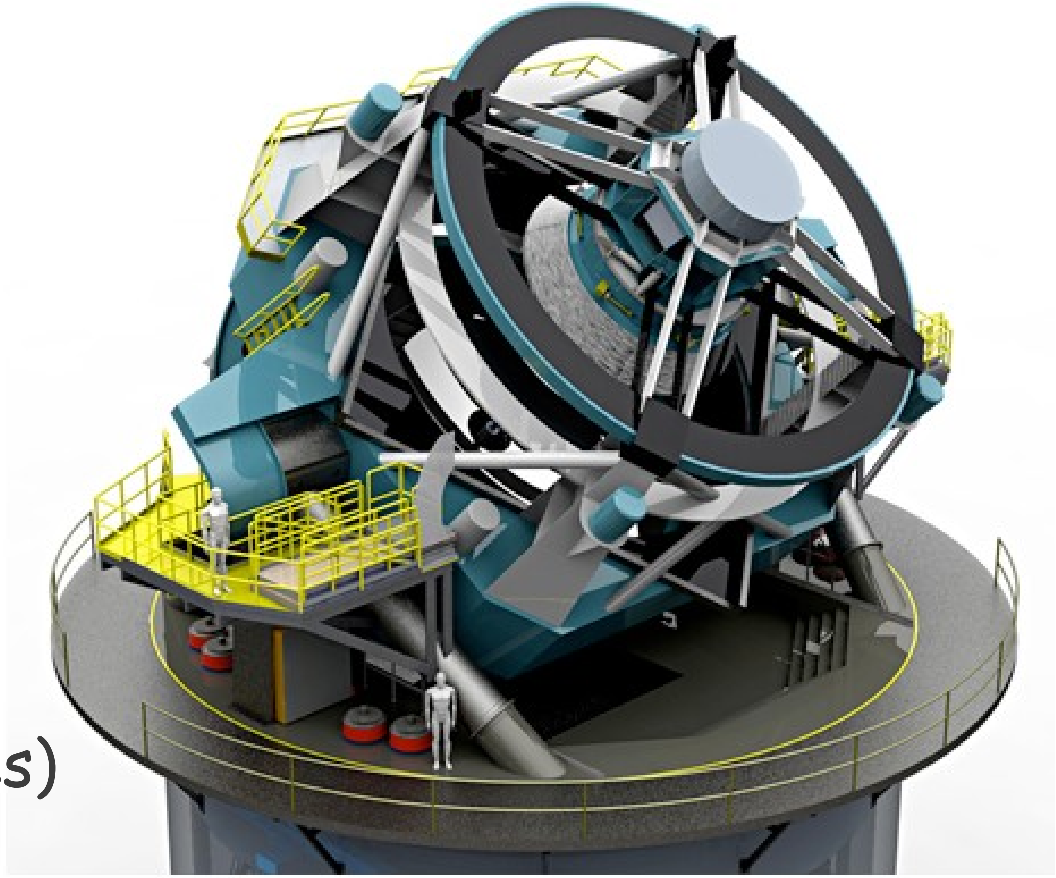


LSST

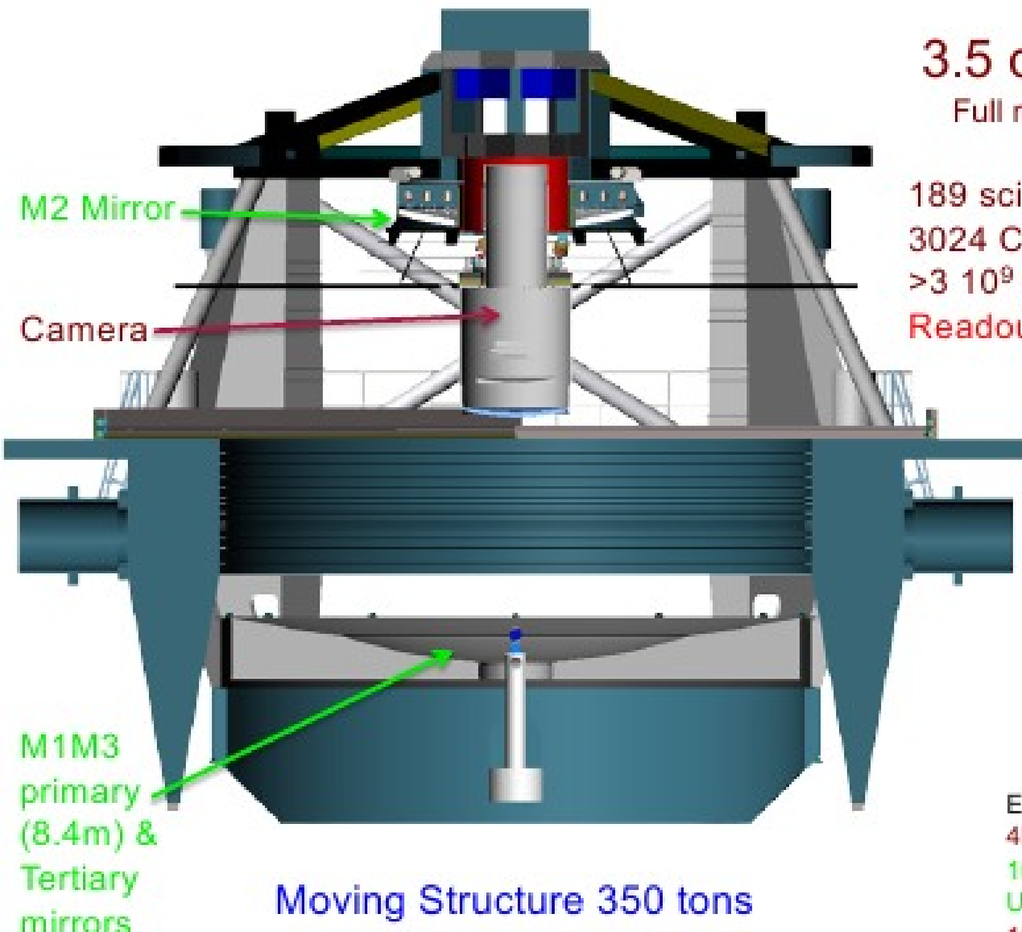
- 8.4 m (6-m equivalent)
- 9.6 deg² (ugrizY)
- 3 Gigapixels
- Lecture rapide ~ 2s

- All sky survey (20,000 deg²)

- Science
  - BAO (redshifts photométriques)
  - Lensing
  - Supernovae @ low & high z
  - Galactic structure
  - transients
  - …



LSST : Wide , Deep and Fast



Moving Structure 350 tons
60 tons optical systems

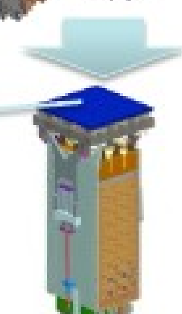
Field of view :

3.5 deg (9.6 deg^2 =.023% sky sphere)

Full moon = 0.5 deg = 4.8 10^{-6} of sky sphere

Focal plane diameter : 64 cm

189 science CCD (21 rafts)
3024 Channels
>3 10^9 pixels
Readout: 2s



E2v CCD 250 ,
4kx4k , 10 µm pixels
100 µm deep depleted
UV to IR sensitive
16 channels output
Designed by Dedicated
R&D for LSST

1 raft = 3x3 CCD
150 M pixels
(1/2 Megacam)

LSST : Project & Collaboration
& mise en place du projet

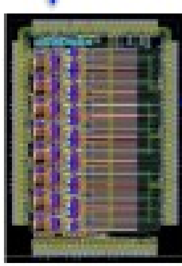
- 2003, LSST = internationnal collaboration , multi-agences :
  - NSF main agency : in charge of telescope , site & data management
  - DOE in charge of the camera (Leading lab : SLAC)
- August 2010, LSST selected by « Astro2010 » as The ground project for next decade :
  - NSF & DOE in the US and IN2P3 in France moved on to include LSST in their programs
  - LSST passed with succes major review in 2011 (PDR in August et CD-1 en November)
  - → LSST has a callendar : start construction 2014 + first light 2019 + start science 2020
- France / IN2P3 , for its contribution to the camera, & Chile, for the site, are the only non-US among the 36 LSSTc members . Data acccess is foresseen to a larger non-US community in 2021 , it will help to cover running cost (67 letter of intent received for ~ 450 scientists at 25 k$/year/scientist)
- In 2012 , a HEP like collaboration (detector & computing & science) has been put together under DOE request , LSST DESC (Dark Energy Science Collaboration) , IN2P3 is part of it.

LSST collaboration and French contributions (1 / 2)

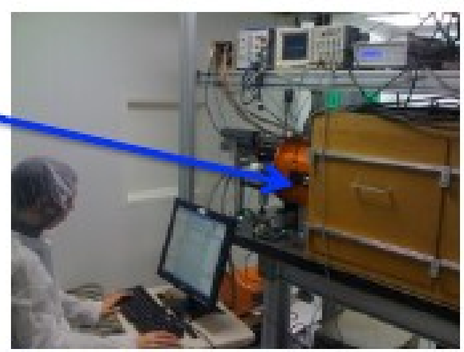
- France & LSST :
  - France (IN2P3 & INSU laboratoires) submitted a letter of intent to LSST in 2006
  - Today 8 IN2P3 laboratories (APC, CCIN2P3, CPPM , LAL , LMA , LPNHE , LPCC, LPSC) are involved in the LSST , some since 2007 .
  - LSST-France count today :

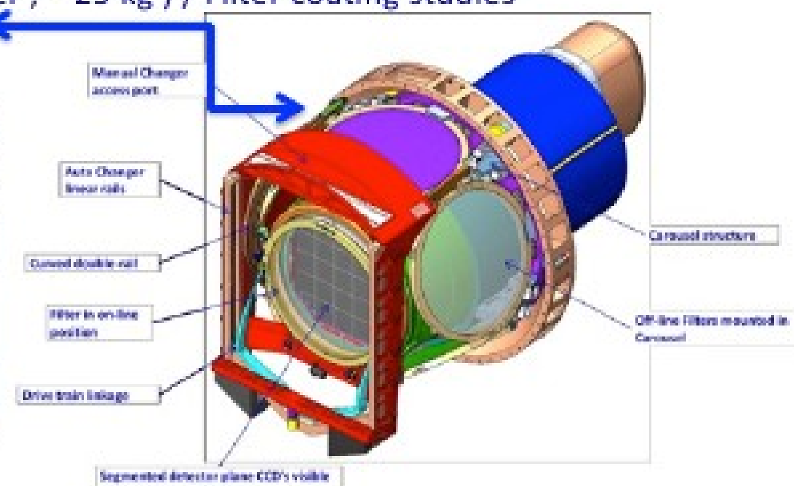
    ~ 40 physicists & 40 ITA , 25 FTE are working today at IN2P3 on the camera

    ~10-15 INSU physicists will also join the project/Dark Energy science at some point.
  - Contribution to the camera :
    - CCD qualification/test and CCD electronic readout & control (201 CCD /3216 readout channels)
    - Filter changer (each filter is 70 cm diameter , ~ 25 kg) / Filter coating studies
    - calibration and characterization system



8 channels CCD readout ASICS

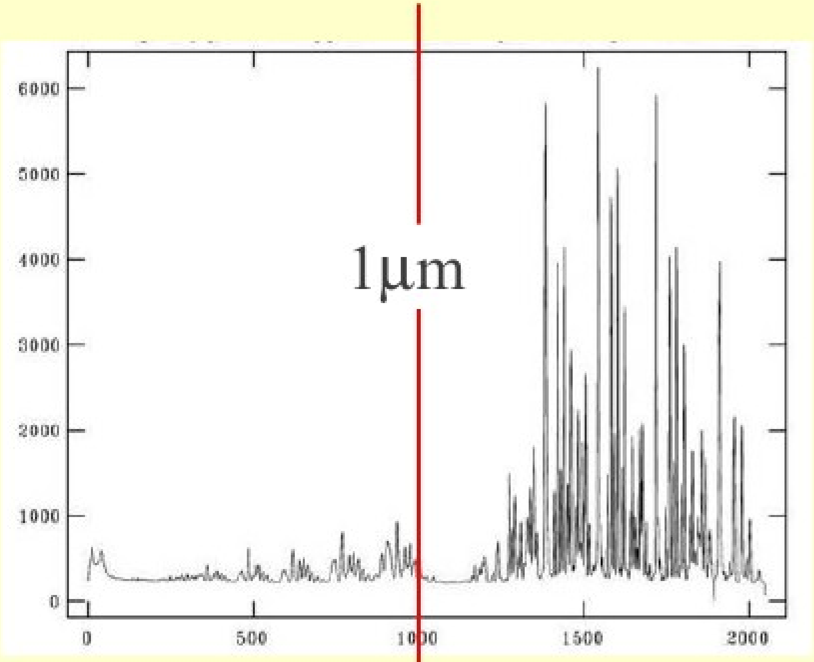




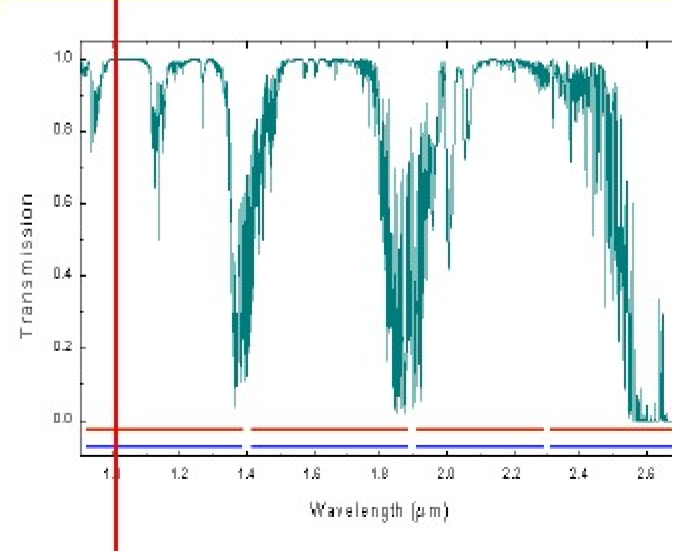
z > 1 ? Go to space !

There
Is
No
Alternative

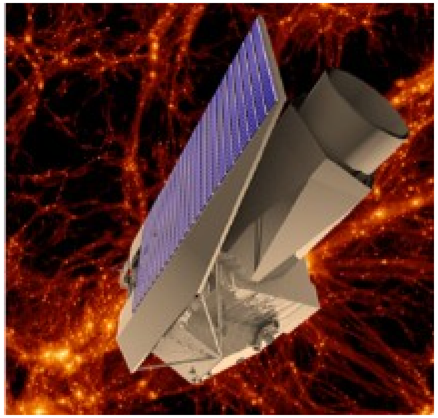
Atmospheric emission



Atmospheric Absorption



Euclid



- ESA "M" mission (109 labs, 13 countries)
- 1.2-m
- 0.5 deg^2 Visible (1 band)
- 0.5 deg^2 infrarouge (3 bands)
- 15,000 deg^2
- Lensing + BAO + (si possible) supernovae (IR)

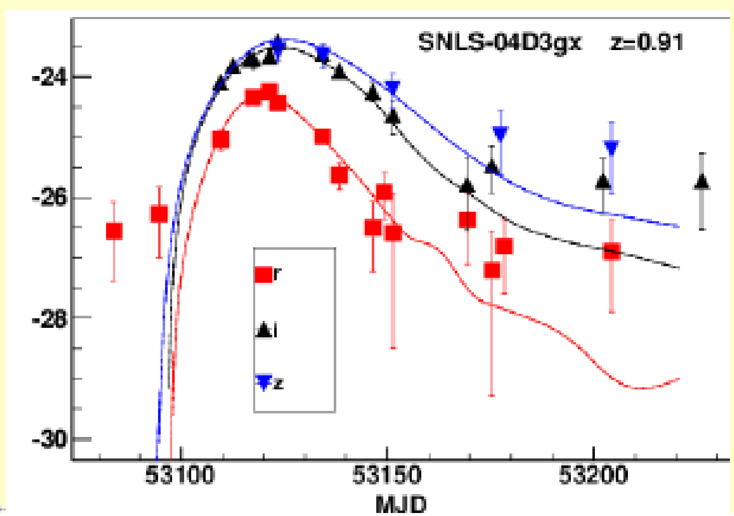
IN2P3, IRFU, INSU

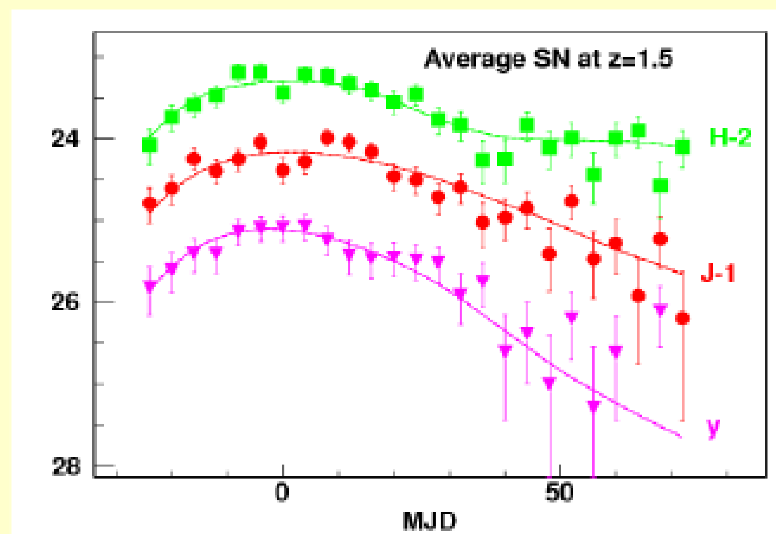
Euclid + LSST

LSST wide Survey → 0.05<z<0.35 (~8000)

LSST Deep fields → 0.15<z<0.95 (8800)

LSST Deep fields + Euclid IR Photometry → 0.75<z<1.55 (1750)





Euclid + LSST

Summary :

	z min	z max	area	duration	statistics
Hi-z	0.75	1.55	20	6	1740
Mid-z	0.15	1.05	50	18	8800
Low-z	0.05	0.35	3000	6	8000

All surveys are redshift limited !

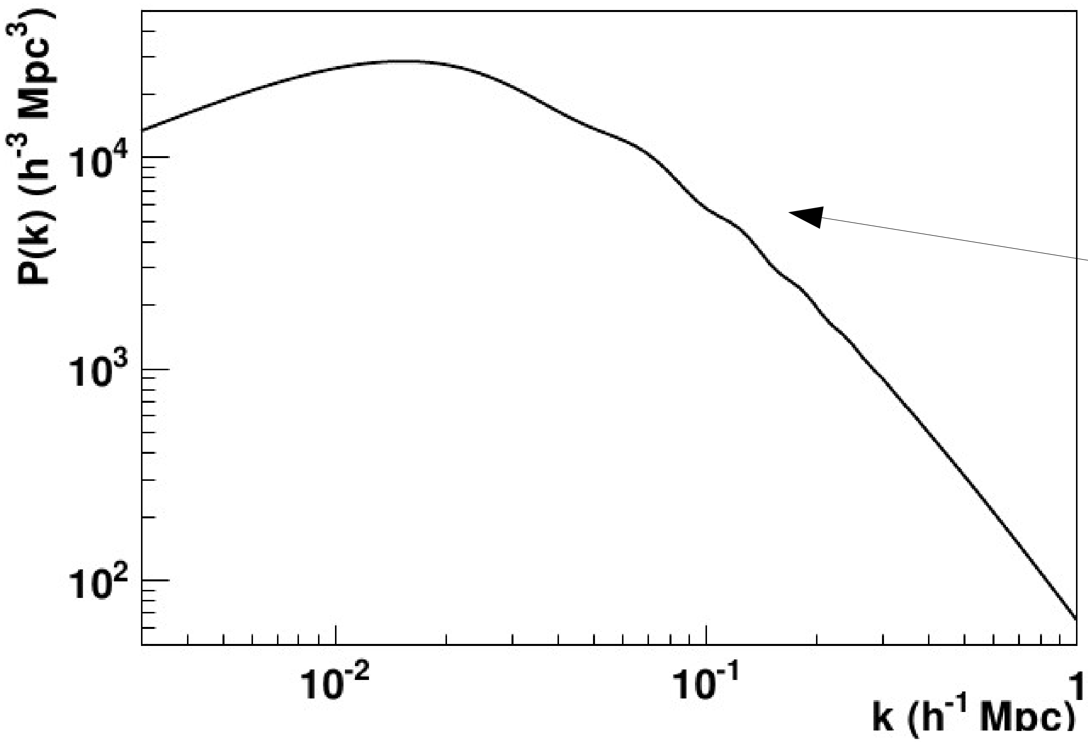
Cosmological constraints with "geometrical" Planck priors + flatness.

	sig(w_0)	sig(w_a)	FOM
3 surveys	0.022	0.25	204
low+mid	0.026	0.22	137
mid+high	0.030	0.40	82

$\sigma(w_0) = 0.022$

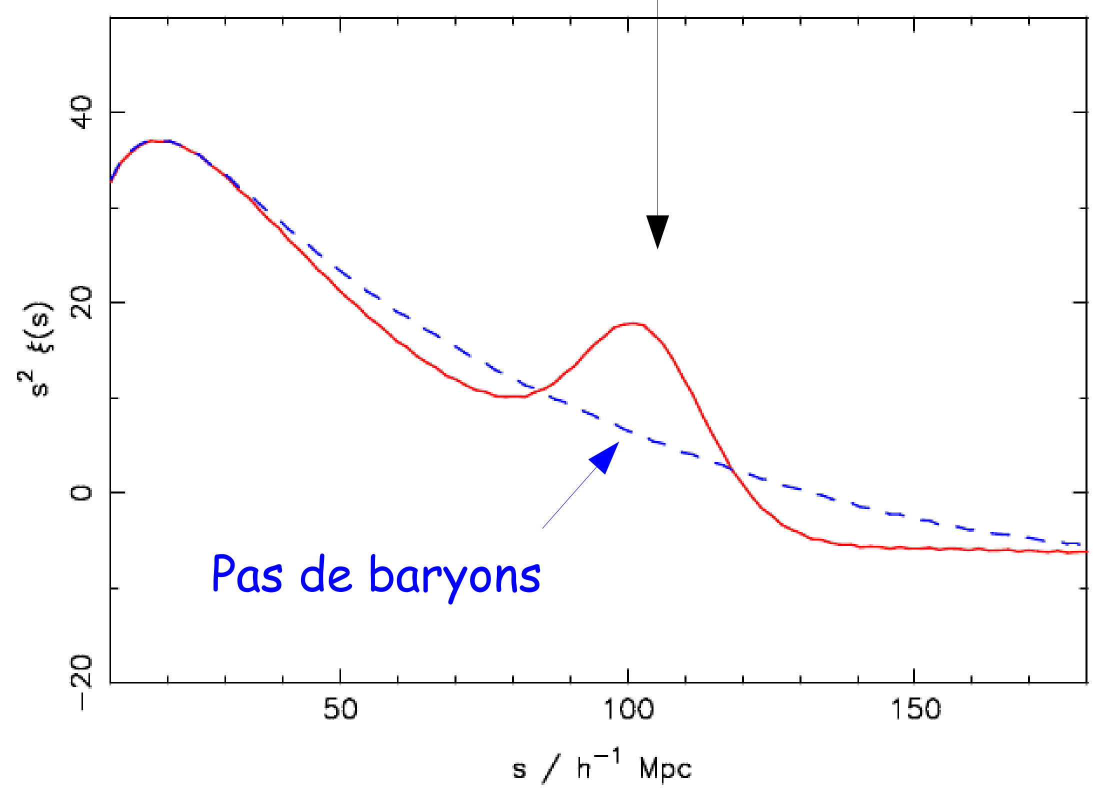
- Euclid's contribution is sizable although not dominant.
  Can be made larger with more observing time …
- Final Euclid stack reaches ~28th mag (point-source, 5 sigma)

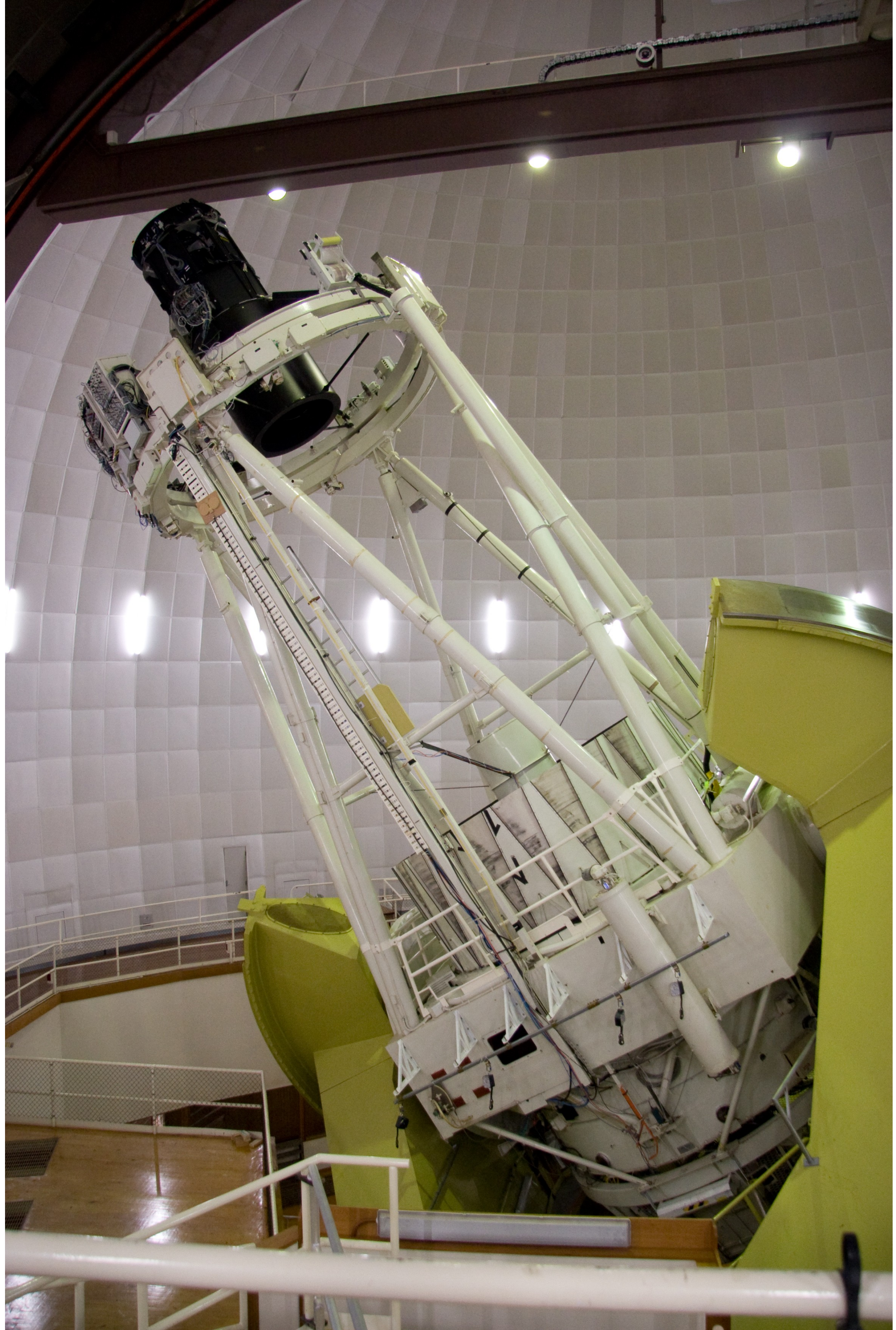
Baryon Accoustic Oscillations



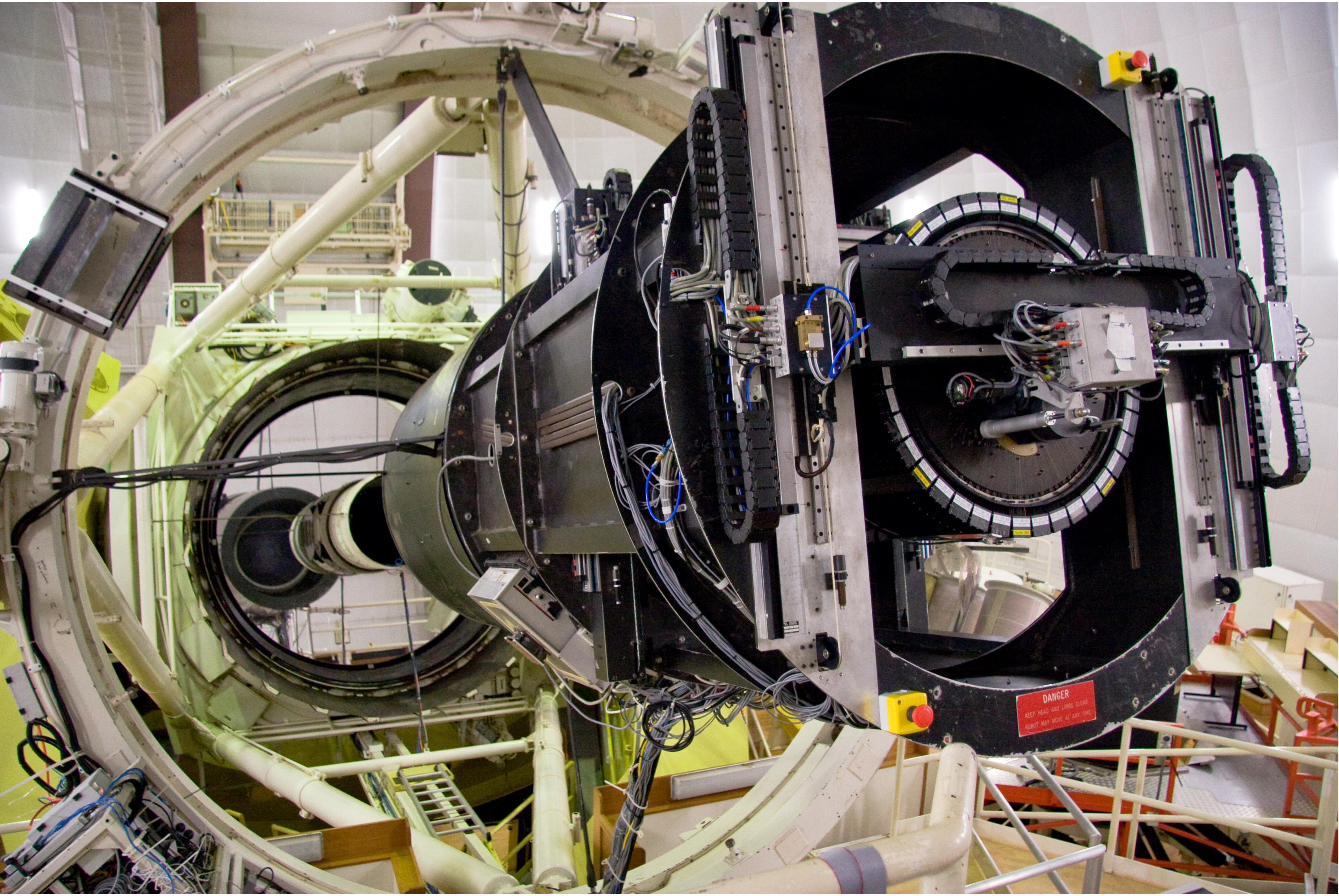
Horizon sonore
@ recombinaison

Spectre de puissance
@ z ~ 0

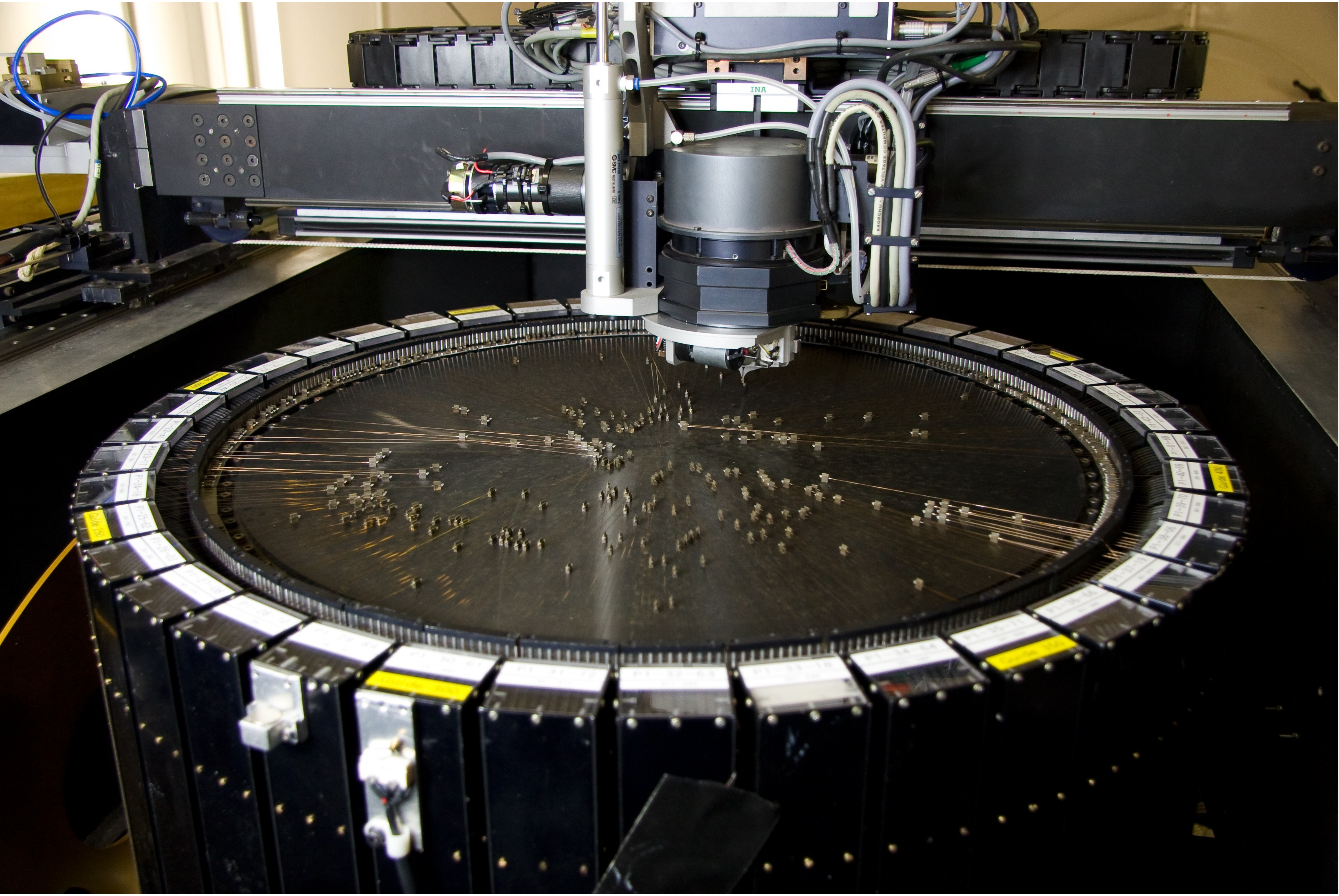




(AAOmega)

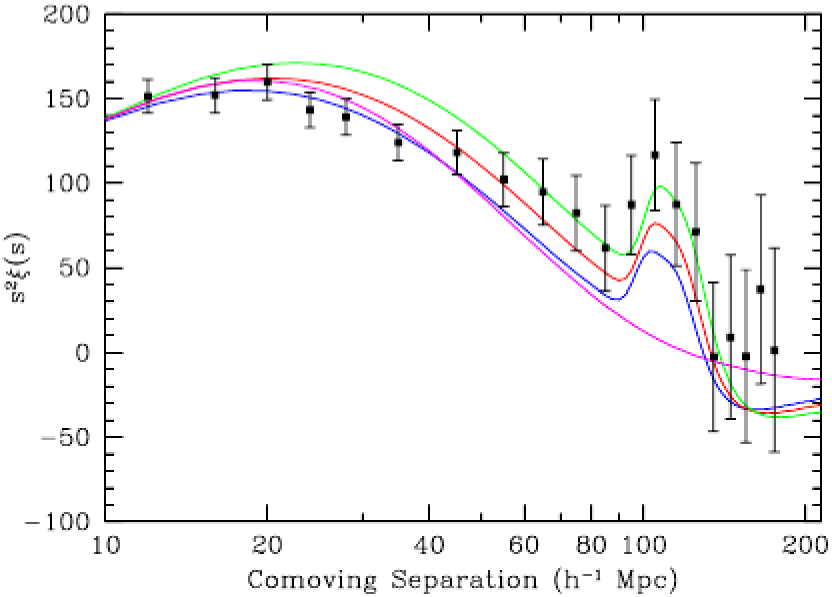


AAOmega



(AAOmega)

BAO



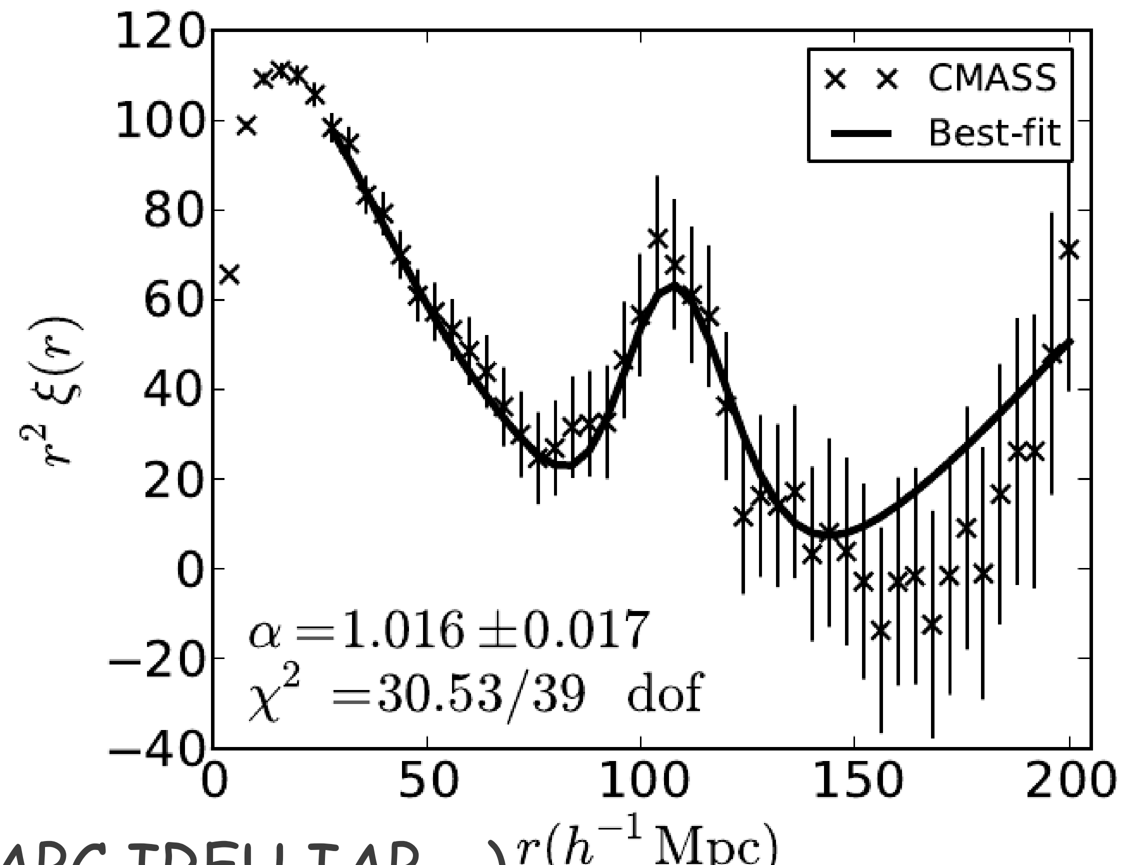
SDSS

(Eisenstein et al, 2005)

BOSS

(Anderson et al, 2012)

Arxiv:1203.6594

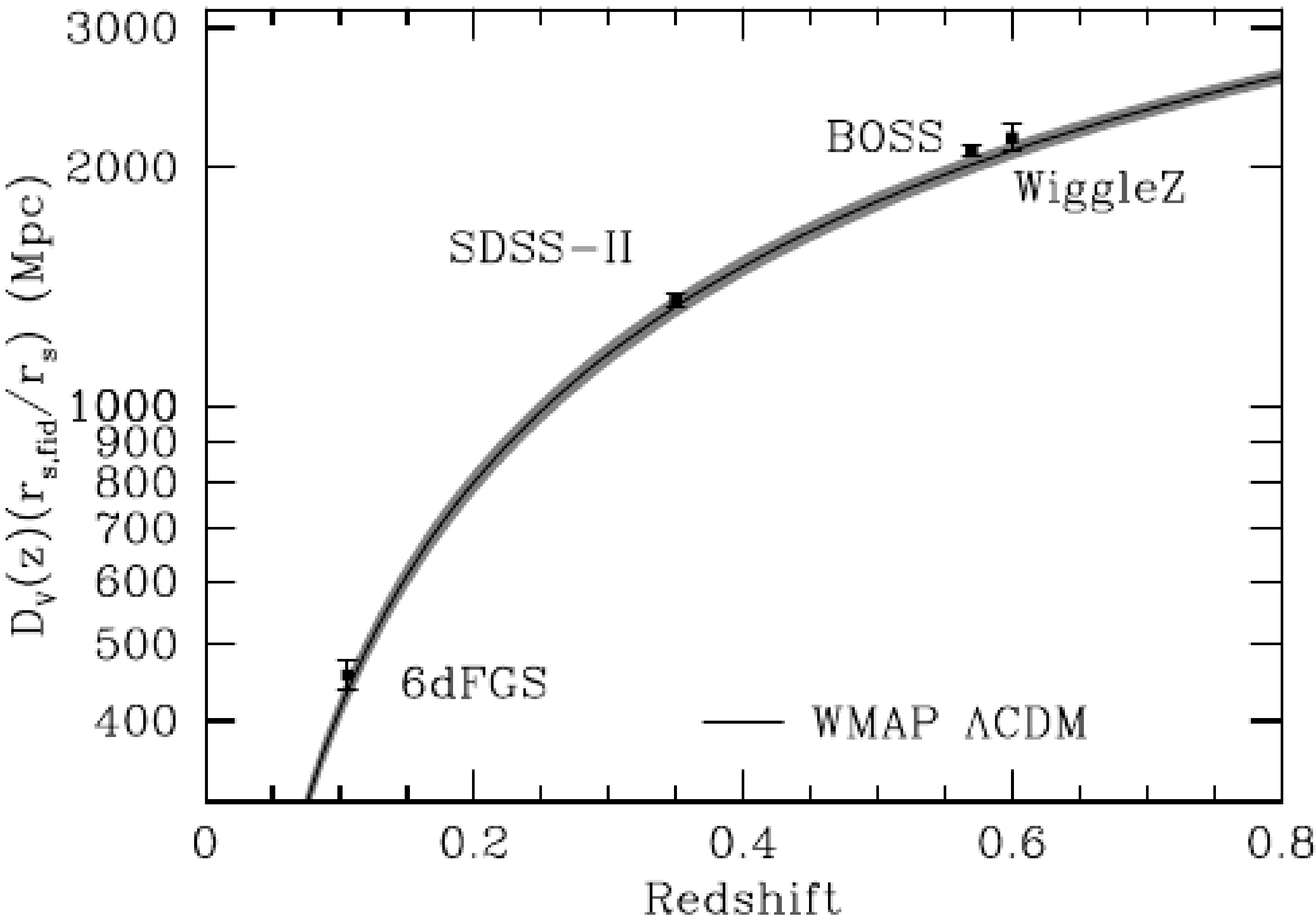


(APC IRFU IAP....)

BOSS (2009-2014)

- Upgrade of SDSS original spectrographs
  - R ~ 2000
  - 1000 fibers (3 degrees on the sky)
  - 1.5 millions luminous red galaxies
  - 160000 high-redshift quasars (Lyman-α forest)
- 10,000 square degrees
  - LRG → $z \sim 0.3$ (σ_d/d @ 1%)
  - CMASS → $z \sim 0.55$
  - Ly-α forest → $z \sim 2.5$ (σ_d/d @ 1.5%)

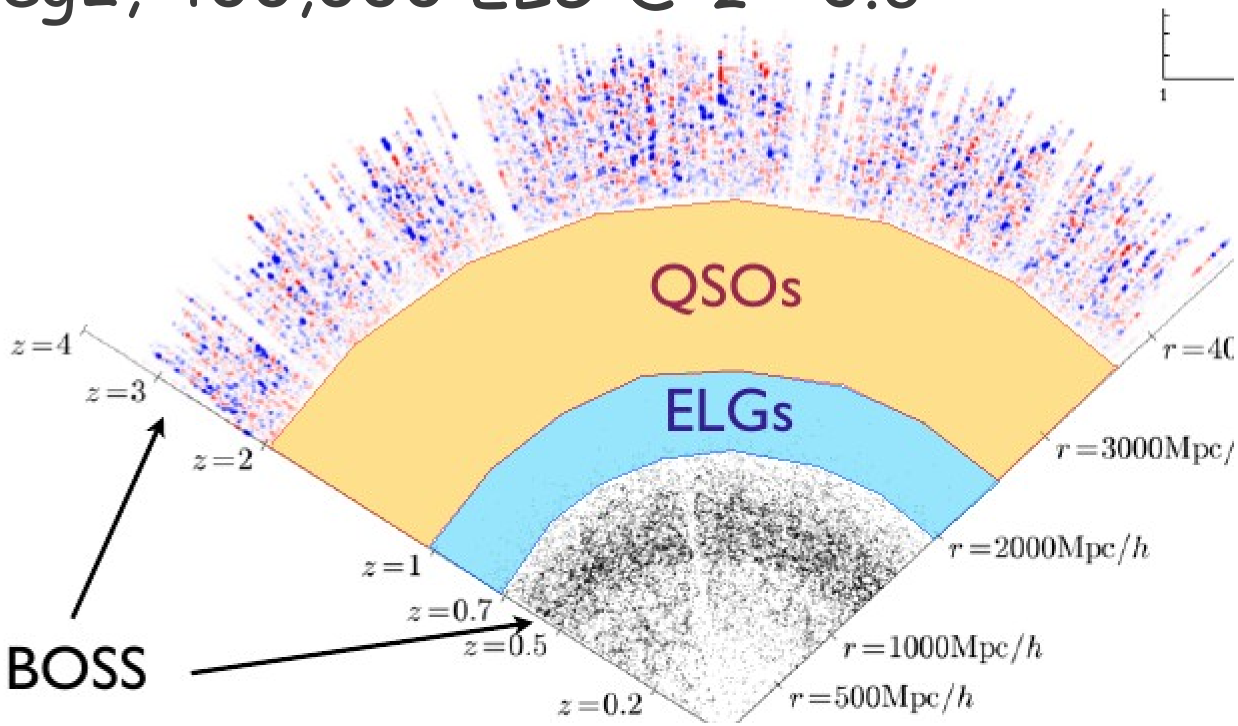
BOSS



3000
2000
1000
900
800
700
600
500
400
$D_V(z)(r_{s,fid}/r_s)$ (Mpc)
BOSS
WiggleZ
SDSS-II
6dFGS
WMAP ΛCDM
0
0.2
0.4
0.6
0.8
Redshift

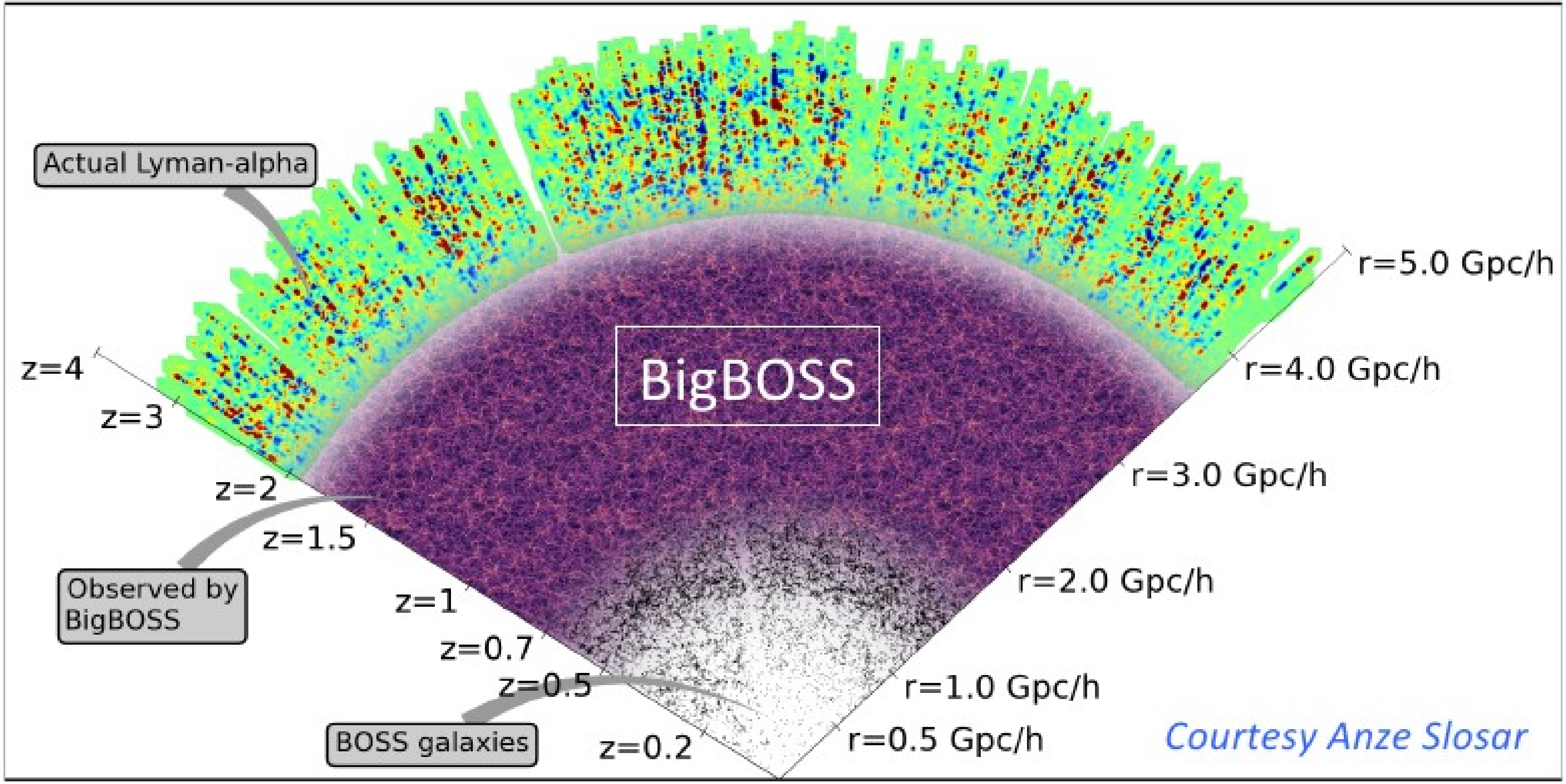
e-BOSS

- BAO @ z > 0.7
- BOSS extension (same spectrograph ?)
- Higher redshift Emission Line Galaxies (ELG)
- 2,500 deg2, 400,000 ELG @ z > 0.6



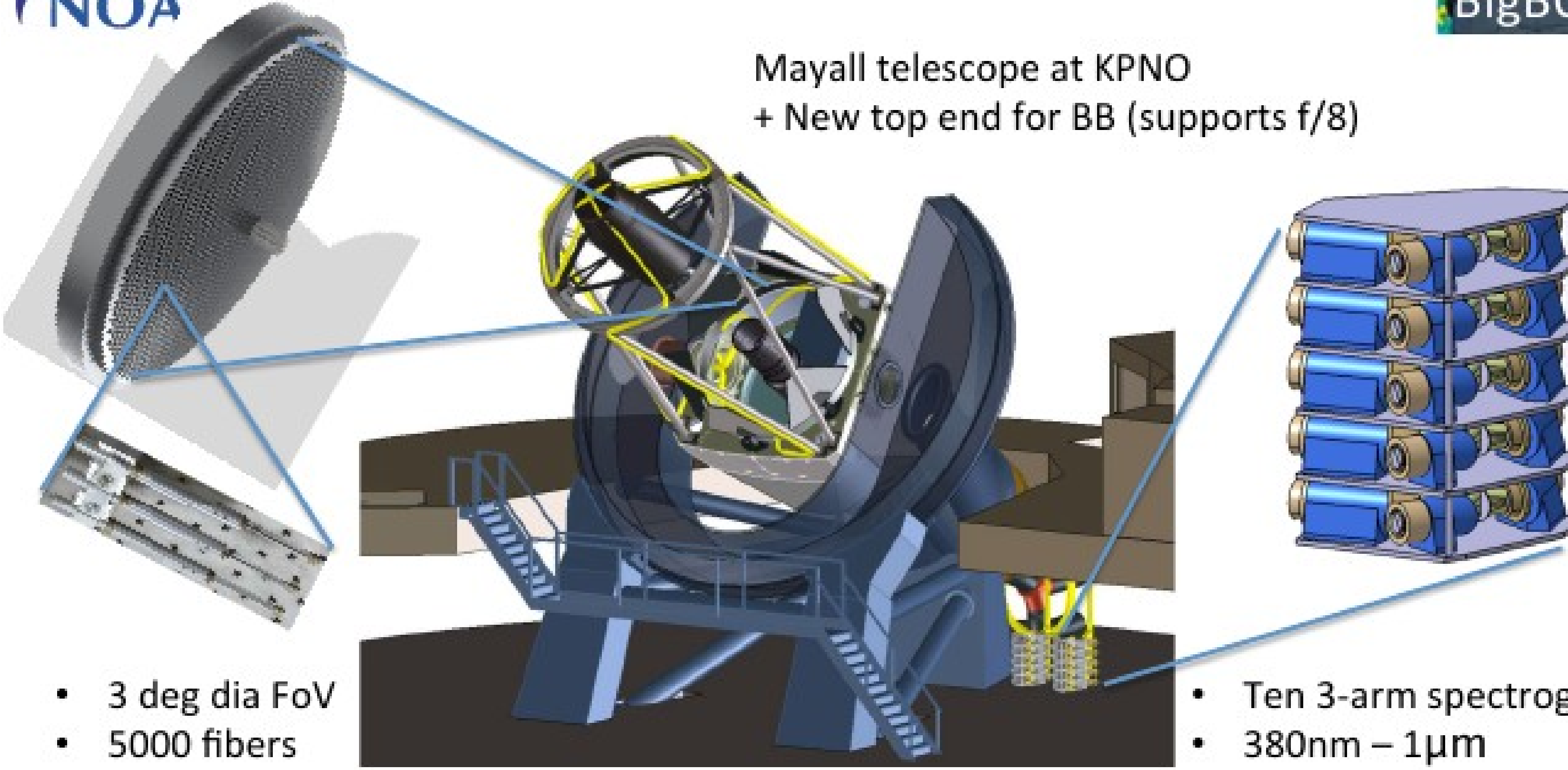
BigBOSS

- 14,000 deg^2, 5000 fibres,
- 20 10^6 redshifts – 2 10^6 quasars



The BigBOSS Capability

Mayall telescope at KPNO
+ New top end for BB (supports f/8)

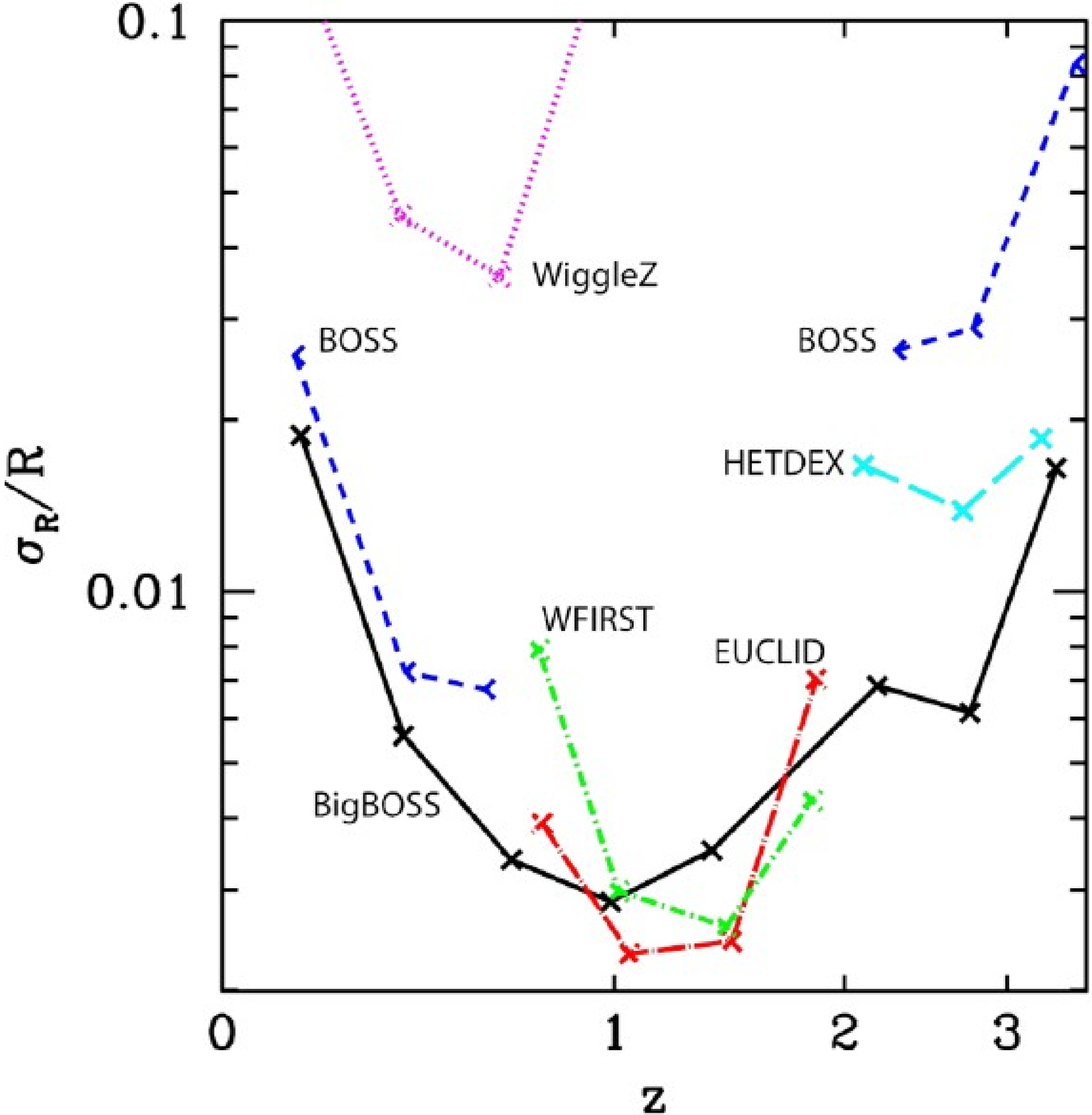


- 3 deg dia FoV
- 5000 fibers

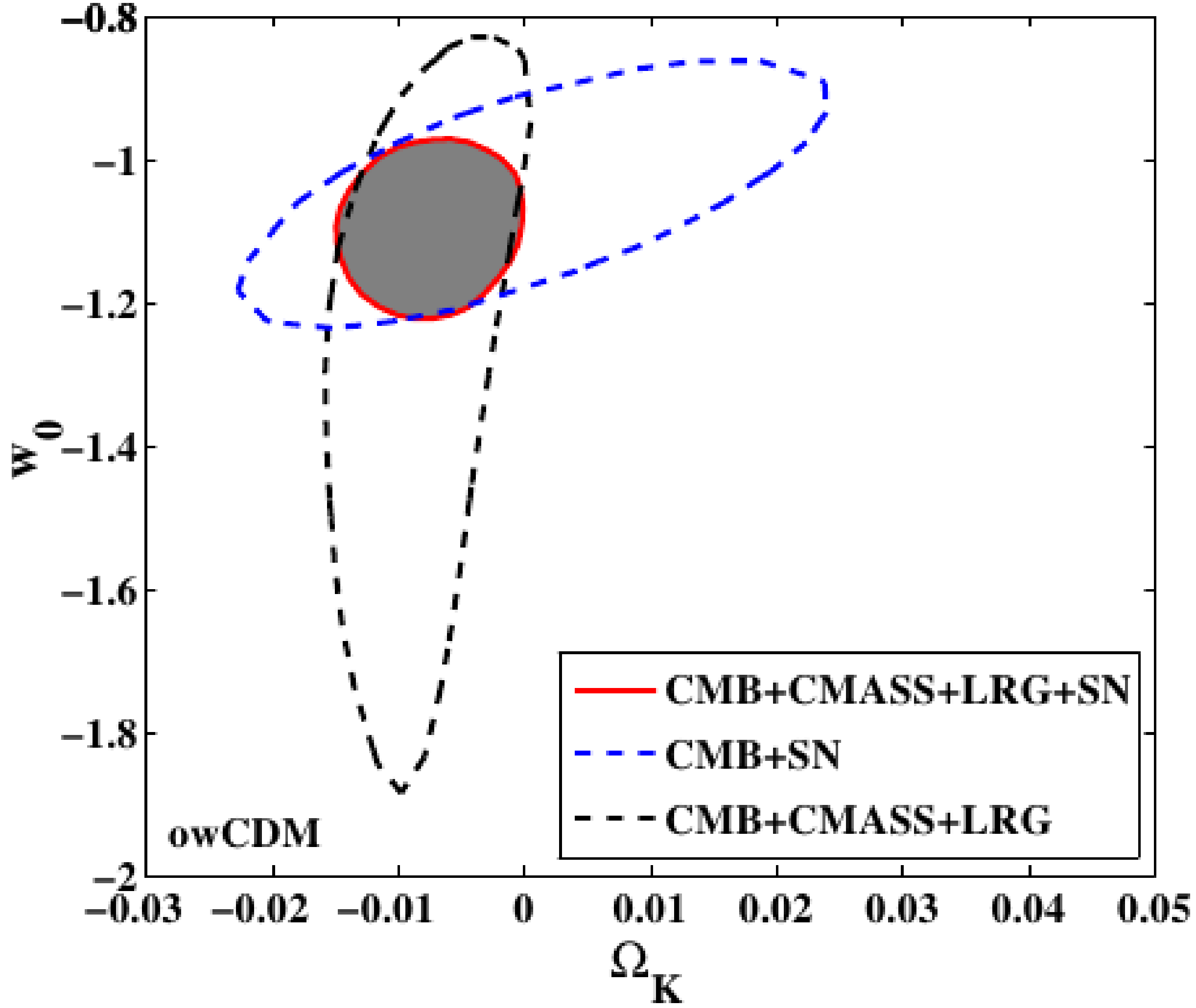
- Ten 3-arm spectrographs
- 380nm – 1μm

Nearly 40,000 spectra per night!!

See Natalie Roe's talk!


0.1
0.01
WiggleZ
BOSS
BOSS
HETDEX
WFIRST
EUCLID
BigBOSS
σ_R/R
0
1
2
3
z

Conclusion

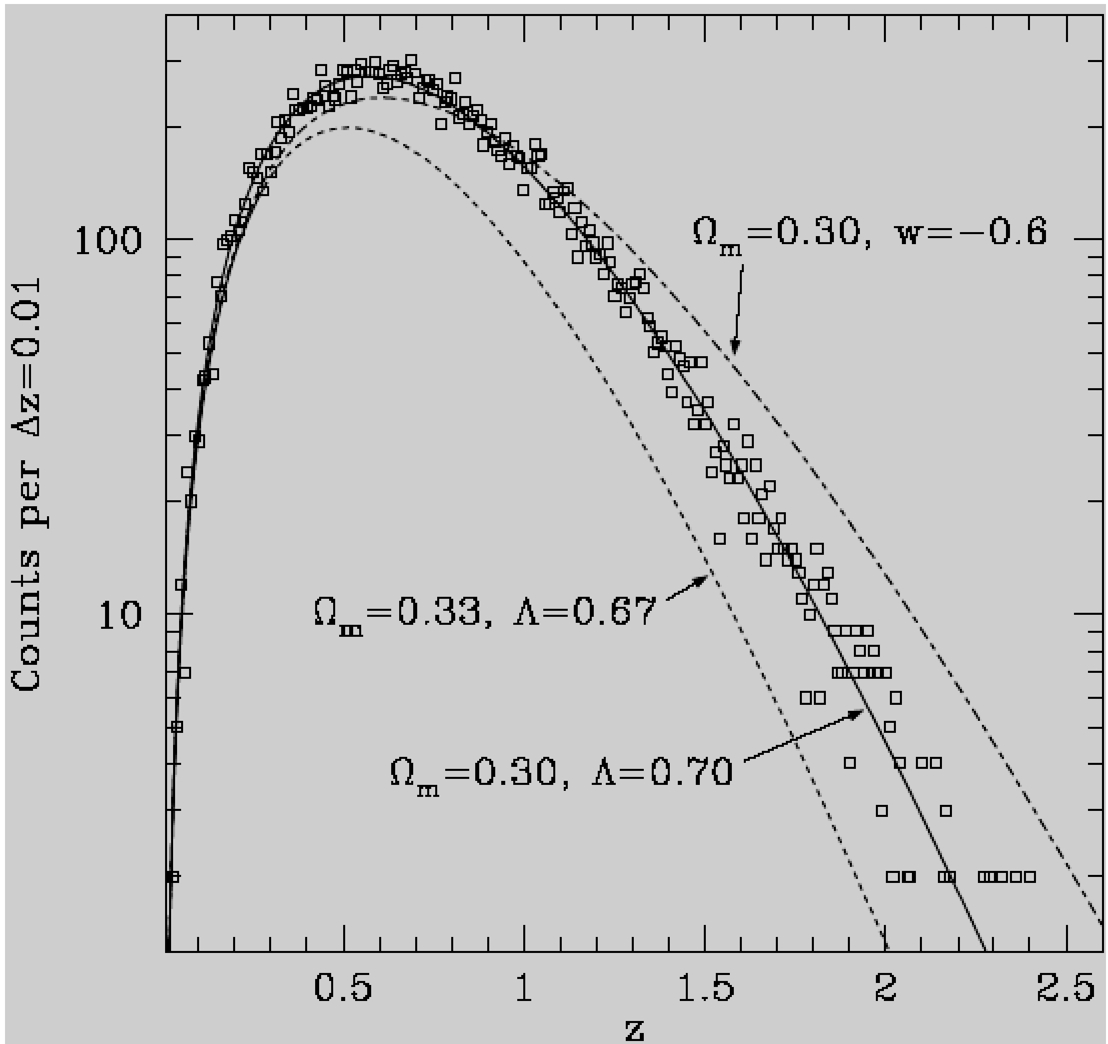


−0.8
−1
−1.2
−1.4
−1.6
−1.8
−2
w_0
−0.03
−0.02
−0.01
0
0.01
0.02
0.03
0.04
0.05
Ω_K
CMB+CMASS+LRG+SN
CMB+SN
CMB+CMASS+LRG
owCDM

Conclusion

- CMB
  - Planck absorbe l'essentiel de l'effort
  - Mesure modes B ?
- Supernovae de type Ia
  - Indispensables pour contraindre w
  - Expertise reconnue en imagerie grand champ
- BAO
  - Sonde très robuste. Systématiques ?
  - Expertise spectro grand-champ
  - Big-BOSS ? DECSpec ? HET ? ...
  -

backup



Counts per Δz=0.01
100
10
0.5
1
1.5
2
2.5
z
Ω_m=0.30, w=−0.6
Ω_m=0.33, Λ=0.67
Ω_m=0.30, Λ=0.70

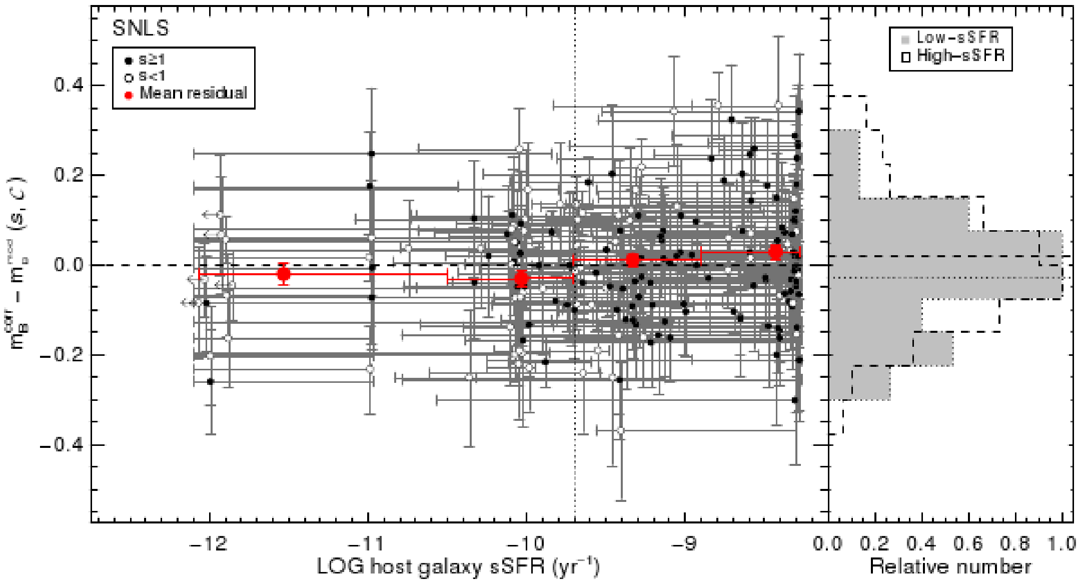
Calibration Accuracy

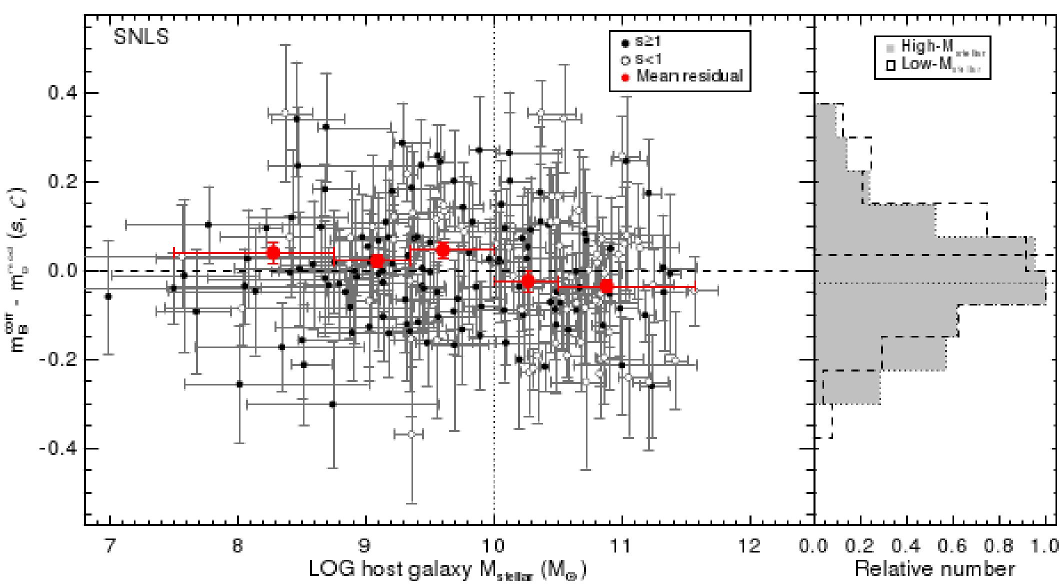
	g_M	r_M	i_M	z_M
Aperture corrections	< 0.001	< 0.001	< 0.001	< 0.001
Background subtraction	< 0.001	< 0.001	±0.005	< 0.001
Shutter precision	±0.0015	±0.0015	±0.0015	±0.0015
Linearity	< 0.001	< 0.001	< 0.001	< 0.001
Second order airmass corrections	< 0.001	< 0.001	< 0.001	< 0.001
Grid Reference Colors	< 0.001	< 0.001	< 0.001	< 0.001
Grid Color Corrections	< 0.001	< 0.001	±0.002	< 0.001
Landolt catalog	±0.001	±0.001	±0.001	±0.002
Magnitudes of BD +17 4708	±0.002	±0.004	±0.003	±0.018
Total	±0.003	±0.004	±0.006	±0.018
SED of BD +17 4708	±0.001	±0.002	±0.004	±0.007
Total	±0.003	±0.005	±0.007	±0.019

< 1%

(Regnault et al, 2009)

SN Ia Host Galaxies





- SNLS-3: dependence of standardized SN luminosity distances with:

i. host galaxy stellar mass (~ 4 σ significance)

ii. specific star formation rate (~ 2.5 σ significance).

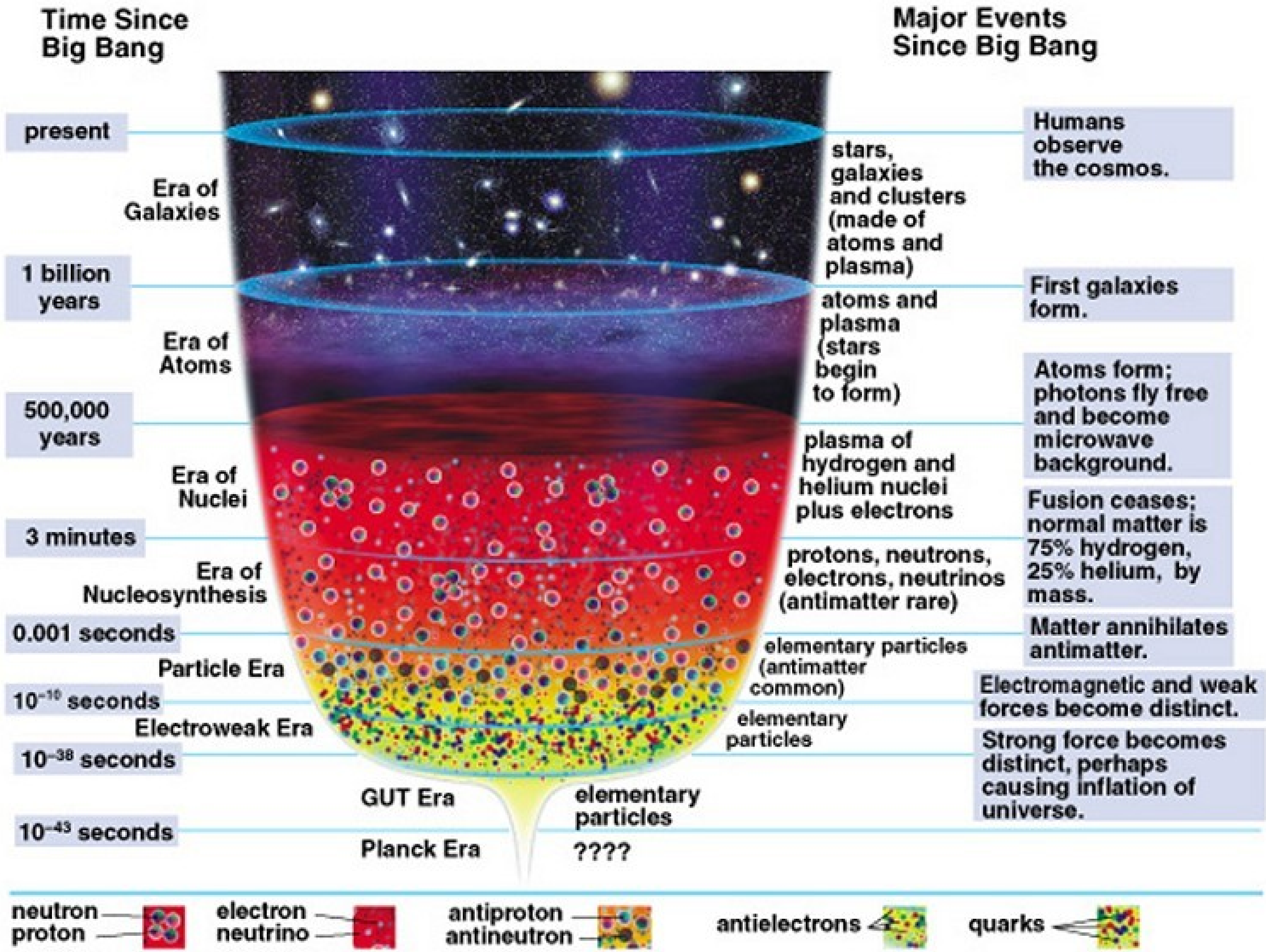
→ *Accounted for by adding a host specific term in the cosmological fit.*

SNLS3 (Sullivan et al, 2010)

Systematics

Experimental Systematics (Calibration, Malmquist bias...)	Non Ia Contamination (Spectral Id)	"K-corrections" (spectral models, lightcurve fitters...)	Non SNe Effects ("Hubble Bubble", peculiar velocities)
• Perret et al, 2008 • Regnault et al, 2009	• Howell et al, 2005	• Hsiao et al, 2007 • Ellis et al, 2008 • Guy et al, 2008 • Conley et al, 2008	• Neill et al, 2007 • Conley et al, 2007
Extinction corrections	**Population demographics**	**Evolution of SNe properties**	**Unusual SNe**
• Conley et al, 2007	• Sullivan et al, 2006	• Conley et al, 2006	• Howell et al, 2006

Le modèle standard



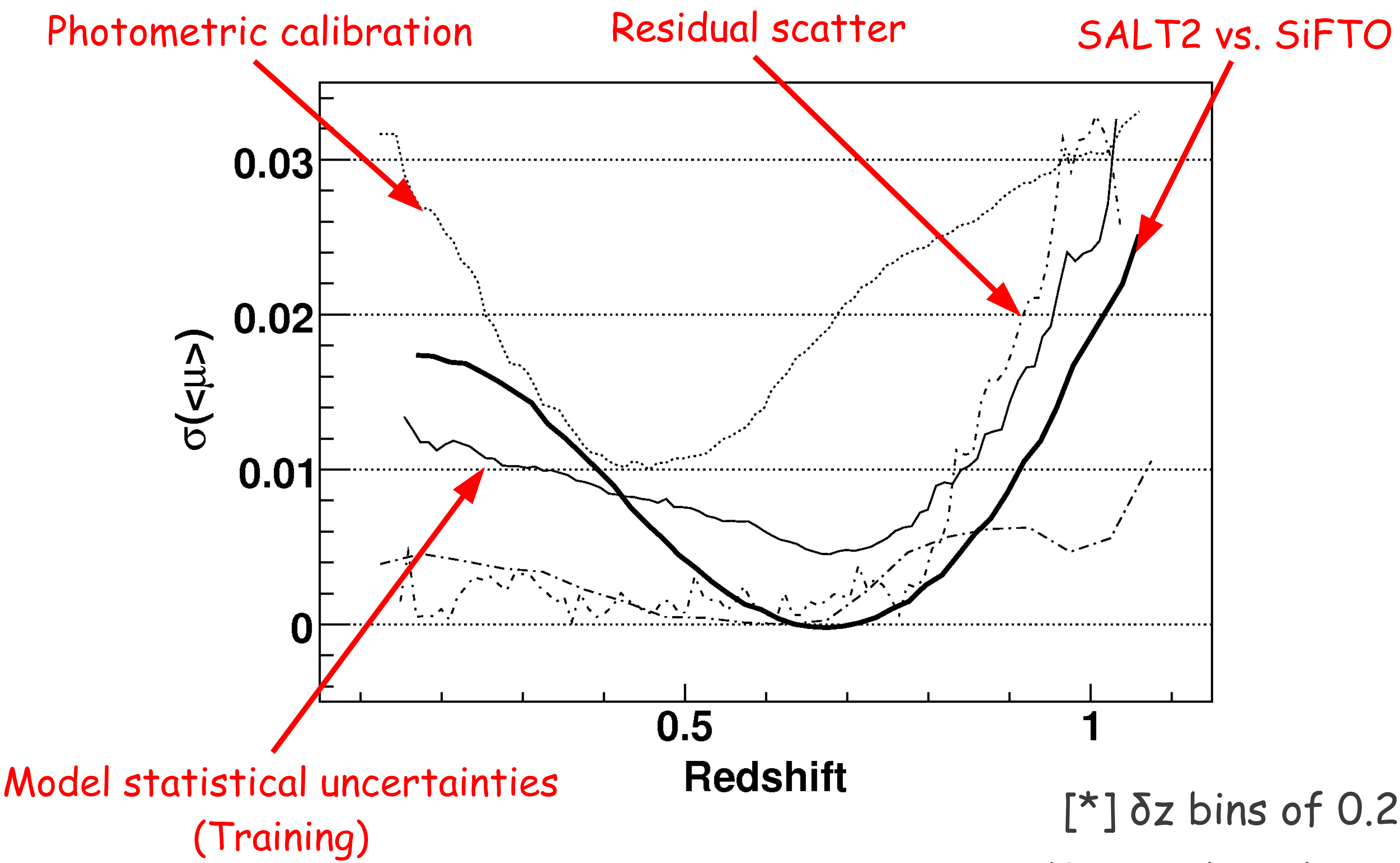
Calibration systematics

Description	w for Ω_m=0.27	Rel area
Stat only	-1.031 ± 0.058	1
All calibration	-1.06 ± 0.10	1.79
Colors of BD 17° 4708	-1.075 ± 0.075	1.31
SED of BD 17° 4708	-1.026 ± 0.073	1.23
SNLS Zero Points	-1.030 ± 0.069	1.21
low-z Zero Points	-1.044 ± 0.065	1.13
SDSS Zero Points	-1.028 ± 0.060	1.02
MegaCam Bandpasses	-1.017 ± 0.066	1.20
low-z Bandpasses	-1.027 ± 0.059	1.04
SDSS Bandpasses	-1.026 ± 0.059	1.02
HST Zero Points	-1.027 ± 0.058	1.03
NICMOS Nonlinearity	-1.029 ± 0.059	1.05

Systematics

Term	Effect on w
Calibration	0.08
SN Model	0.06
Malmquist bias	small
Non-Ia contamination	small
MW extinction	0.01
Peculiar velocities	small
SN color evolution	0.02

Syst. uncertainties on <μ> [*]



[*] δz bins of 0.2

See SNLS3 papers (Guy et al, Conley et al)

Plan

- Le modèle standard du Big-Bang (ΛCDM)
- Sondes cosmologiques
  - CMB
  - Formation des structures
  - Distances de luminosité vs. z (SNe Ia)
  - Distances angulaires vs. z (BAO)
- Projets futurs