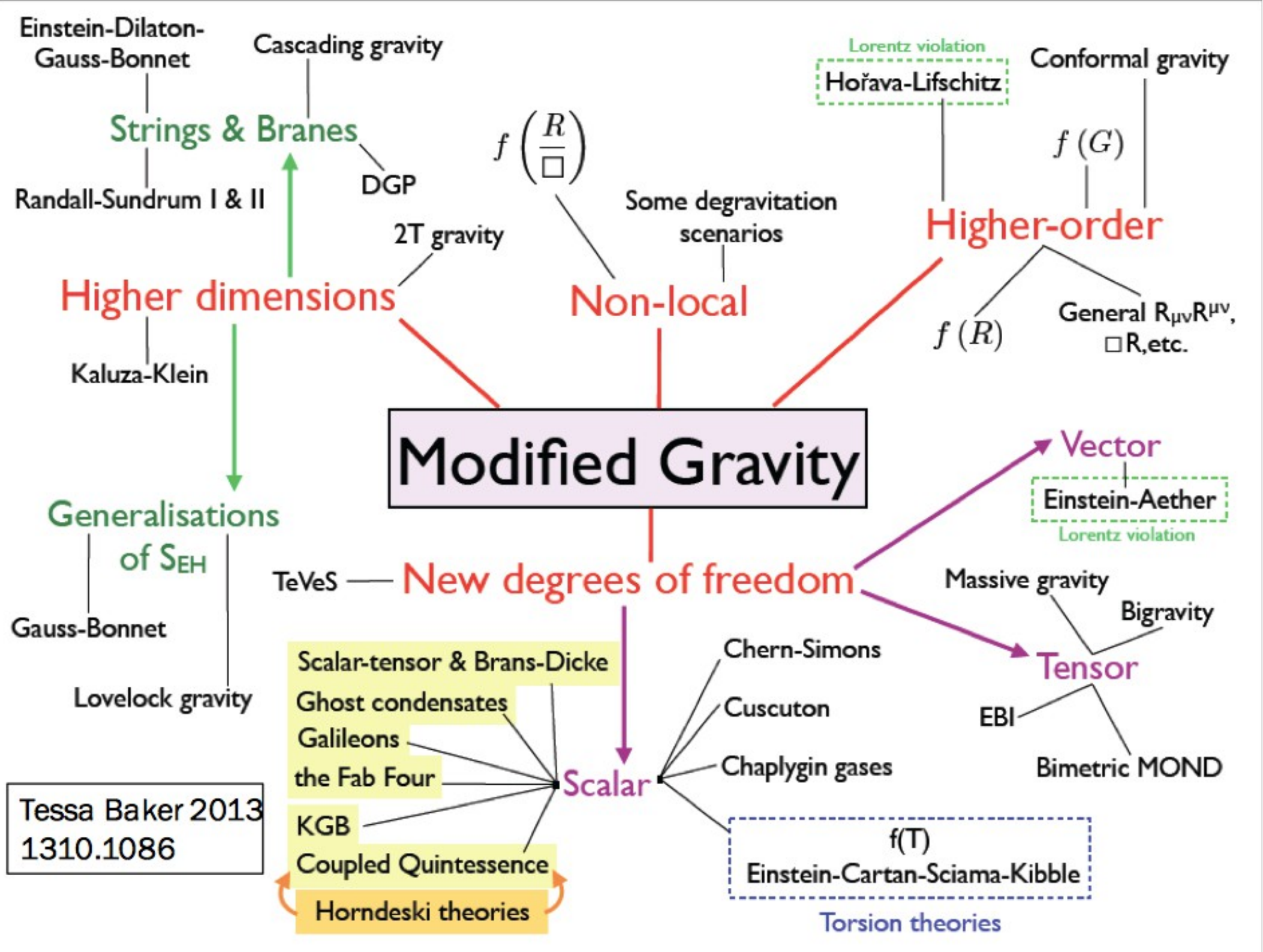
Cosmologie et Gravitation

Possible explanations for ä>0

1. It is a cosmological constant, and there is no problem ('anthropic principle', 'string landscape') – unsatisfactory but agrees with data
2. The (supernova) data is wrong – unlikely
3. We are making a mistake with GR (aka 'backreaction') or the Copernican principle is violated ('LTB') – unlikely
4. It is something evolving, e.g. a scalar field ('dark energy')
5. GR is wrong and needs to be modified ('modified gravity')

how to characterize?

Slide M. Kuntz 2017


Einstein-Dilaton-Gauss-Bonnet
Cascading gravity
Strings & Branes
Randall-Sundrum I & II
DGP
2T gravity
Higher dimensions
Kaluza-Klein
$f\left(\frac{R}{\Box}\right)$
Non-local
Some degravitation scenarios
Lorentz violation
Hořava-Lifschitz
Conformal gravity
$f(G)$
Higher-order
$f(R)$
General $R_{\mu\nu}R^{\mu\nu}$, $\Box R$,etc.
Modified Gravity
Generalisations of S_{EH}
Gauss-Bonnet
Lovelock gravity
TeVeS
New degrees of freedom
Vector
Einstein-Aether
Lorentz violation
Massive gravity
Bigravity
Tensor
EBI
Bimetric MOND
Scalar-tensor & Brans-Dicke
Ghost condensates
Galileons
the Fab Four
KGB
Coupled Quintessence
Horndeski theories
Scalar
Chern-Simons
Cuscuton
Chaplygin gases
f(T)
Einstein-Cartan-Sciama-Kibble
Torsion theories
Tessa Baker 2013
1310.1086

Dark Energy and Modified Gravity change the growth of structure

General Relativity

Modified Gravity

Growth ⟷ Density Velocities ⟷ Geometry (gravitational potentials)

(conservation/Euler equation)

$$f\delta = -\frac{\nabla \cdot v}{aH}$$

(Poisson equation)

$$-k^2\Psi \equiv 4\pi G a^2 \rho\Delta$$

Slide V. Pettorino 2017

via modifications of the gravitational potentials

Sondes de l'Univers

Sonde	Bakground Cosmology : w_0, w_a	Perturbations : $f\sigma_8$, γ, many others !
Supernova	SN proches et lointaines (diagramme de Hubble)	SN proches (champ de vitesses)
BAO	Pic BAO (150 Mpc / H_0)	Reshift Space Distorsions (vitesses autour des surensités)
Amas	Comptage (peu précis)	Fonction de masse (calibration difficile : X, SZ, lentille)
Clustering	3x2 pt	P(k) densité visible
Lensing	3x2 pt	P(k) potentiels

Sondes de l'Univers

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DESI

LSST

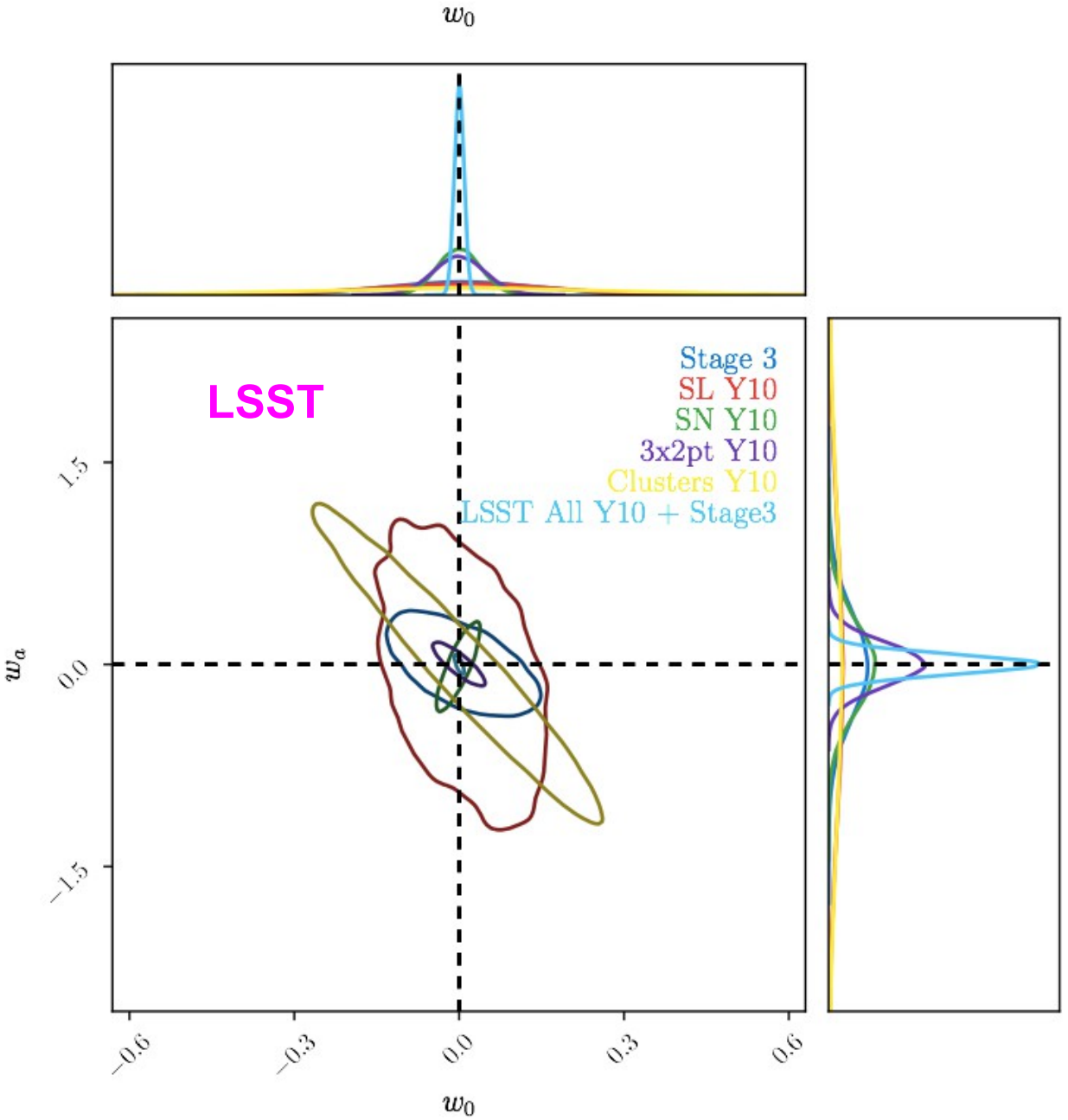
EUCLID

WFIRST

SKA ?

Sondes de l'Univers

Sonde
Supernova
BAO
Amas
Clustering
Lensing



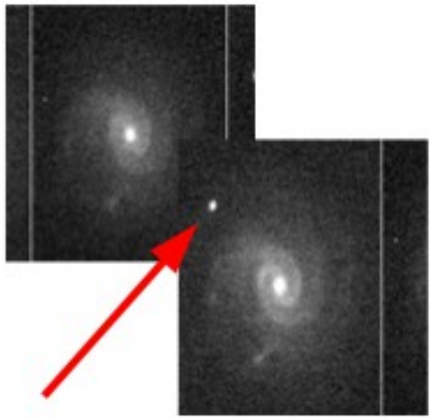
DES

EUCLID

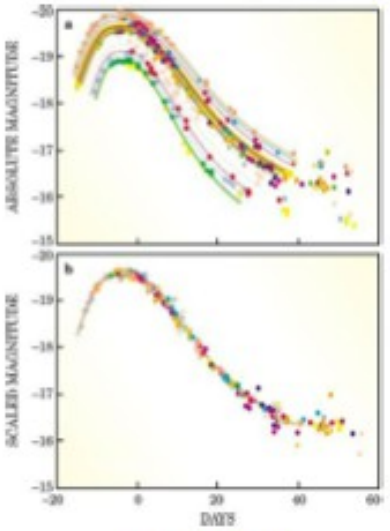
RST

Supernova Cosmology

1. detection

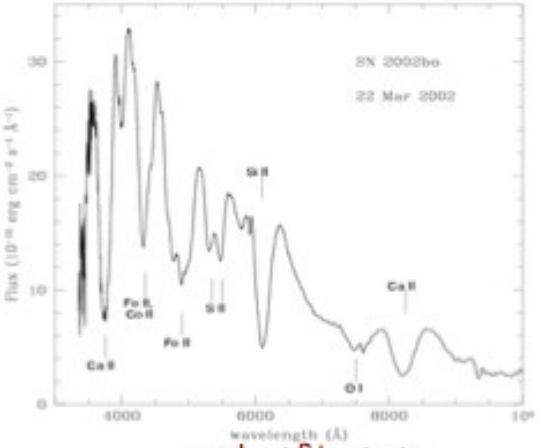


2. photometry



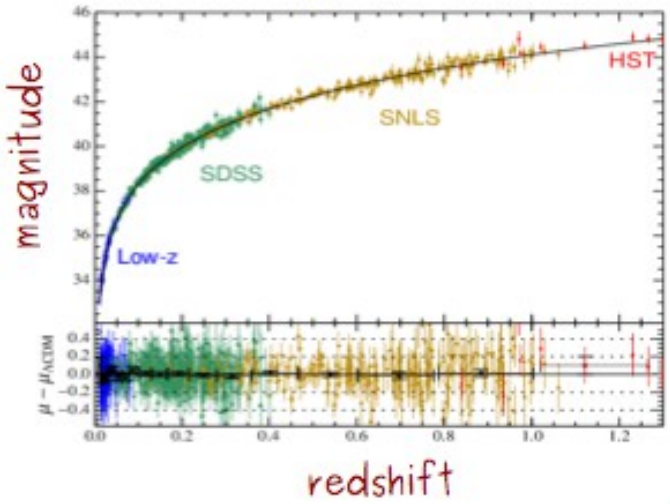
magnitude

3. spectroscopy

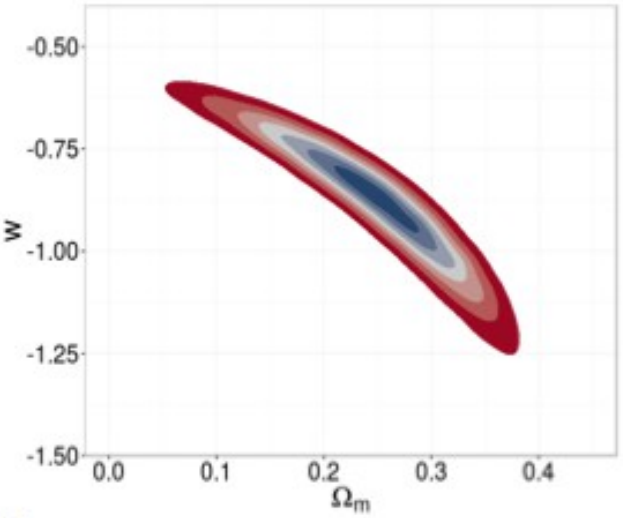


redshift (z)
classification

4. standardization + cosmological fit

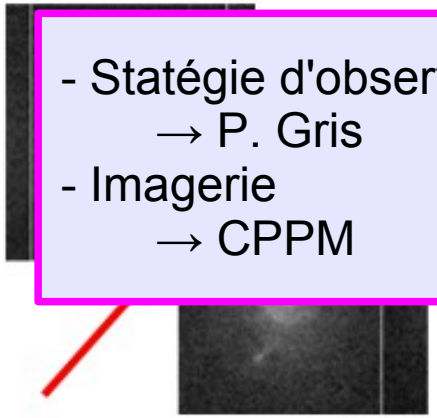


5. Dark Energy constraints



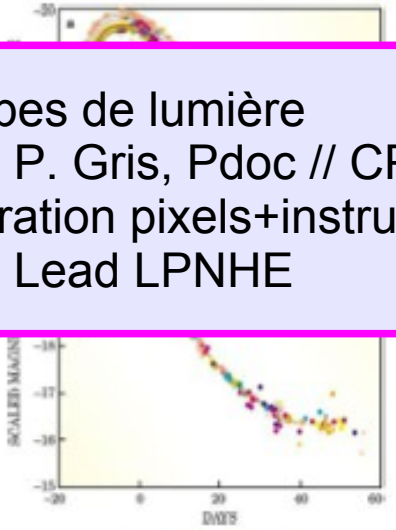
Supernova Cosmology

1. detection



- Statégie d'observation
  → P. Gris
- Imagerie
  → CPPM

2. photometry



magnitude

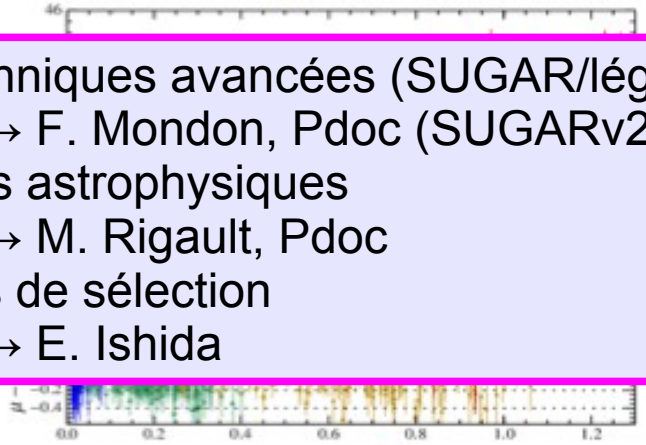
- Courbes de lumière
  → P. Gris, Pdoc // CPPM
- Calibration pixels+instrument+ciel
  → Lead LPNHE

3. spectroscopy

redshift (z)
classification

- Stratégie de suivi spectro
  → E. Ishida
- Système d'alerte
  → Pdoc

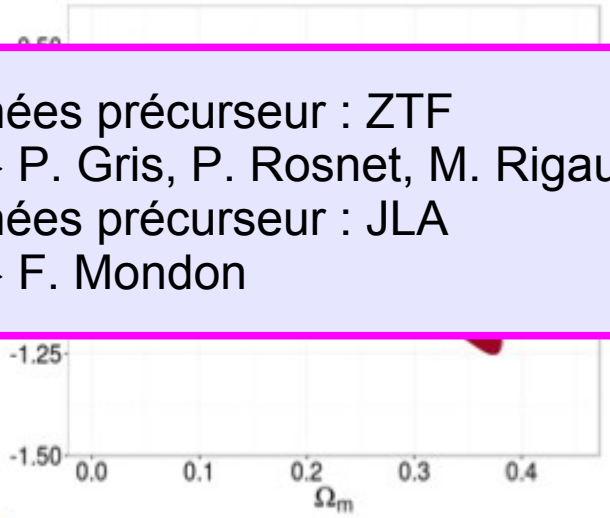
4. standardization + cosmological fit



redshift

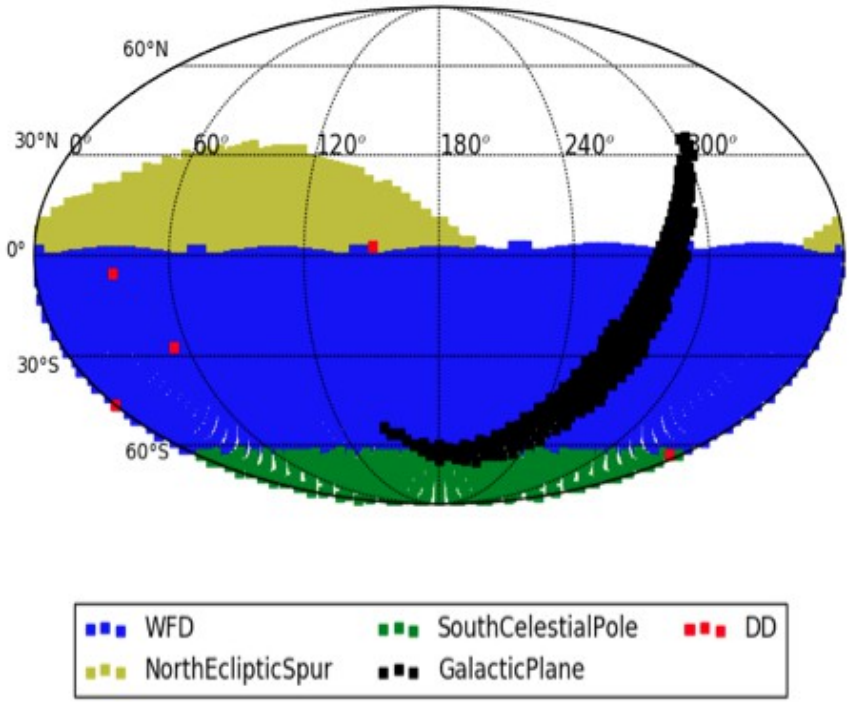
- Techniques avancées (SUGAR/léget):
  → F. Mondon, Pdoc (SUGARv2)
- Biais astrophysiques
  → M. Rigault, Pdoc
- Bais de sélection
  → E. Ishida

5. Dark Energy constraints



- Données précurseur : ZTF
  → P. Gris, P. Rosnet, M. Rigault, Pdoc
- Données précurseur : JLA
  → F. Mondon

LSST Observing Strategy



Current baseline (minion_1016)

Total number of visits : 2,448,282
(1 visit = 2 exposures of 15s)

3 types of surveys:

- **universal (WFD) ~ 90% -> Supernovae**
- **mini-surveys : ~5%**
- **Deep (DDF) : ~5% -> Supernovae**

DDF

4 DDF -> ~ 10000 Sne Ia (10 years)
-> completeness : z ~ 0.6

Work in progress:

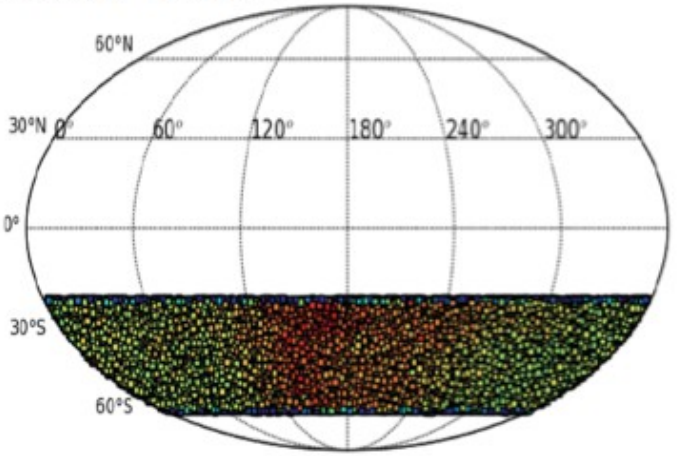
- **number of DDFs (probably 8 to 10)**
- **synergy with other surveys (Euclid, WFIRST)**
- **spectroscopy measurements (4MOST, ESO-NTT, …)**

WFD

Current strategy : not suitable for Sne Ia science

Work in progress:

- **Rolling cadence**



- **Number of Sne Ia ?**
- **Completeness ?**

PLAsTiCC

Photometric LSST Astronomical Time-series Classification Challenge

A data challenge aimed to prepare a larger community for the LSST data paradigm

- PI: Renee Hlozek, simulations: Rick Kessler
- SNANA simulations → Light curves in observer-frame (no images!)
- 3 years worth of LSST data, ~ 100 MB
- ~ 10^7 objects
- Around 20 transient models (galactic and extra-galactic, periodic and non-periodic)

Expected release date:

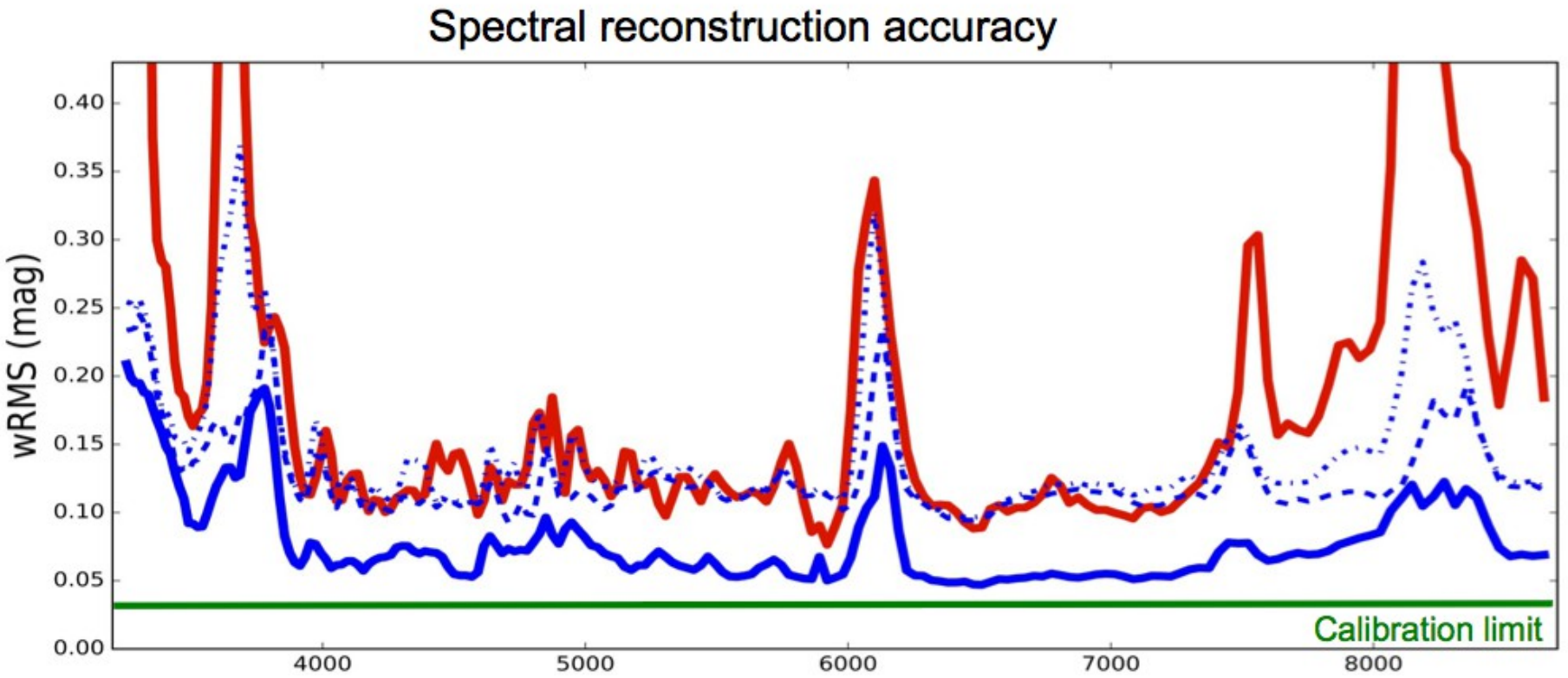
Summer/Fall 2018

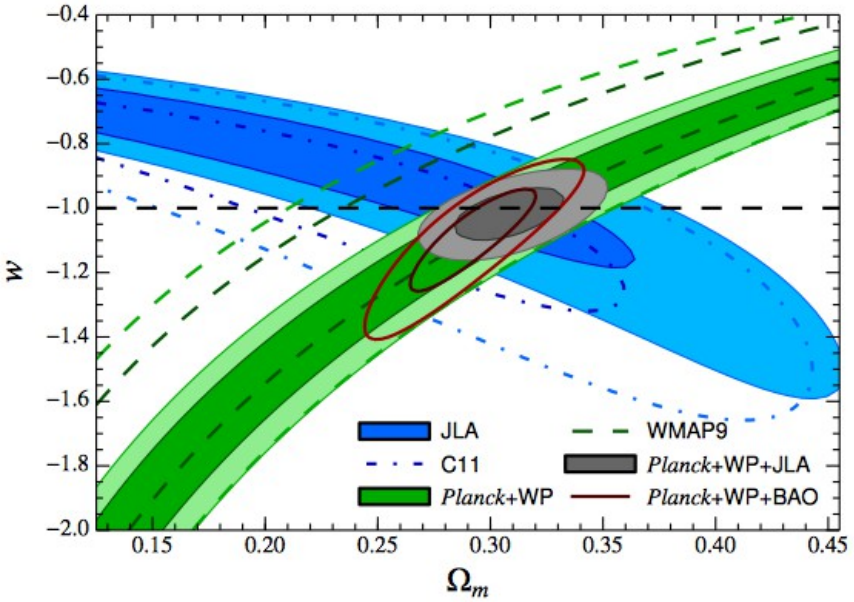
- Please respect model-information policy: ``don't ask, don't tell"

- Not all models will be present in the training sample
- Supervised classification + novelty detection
- Deployment: kaggle + RAMP

Slide by Emille Ishida

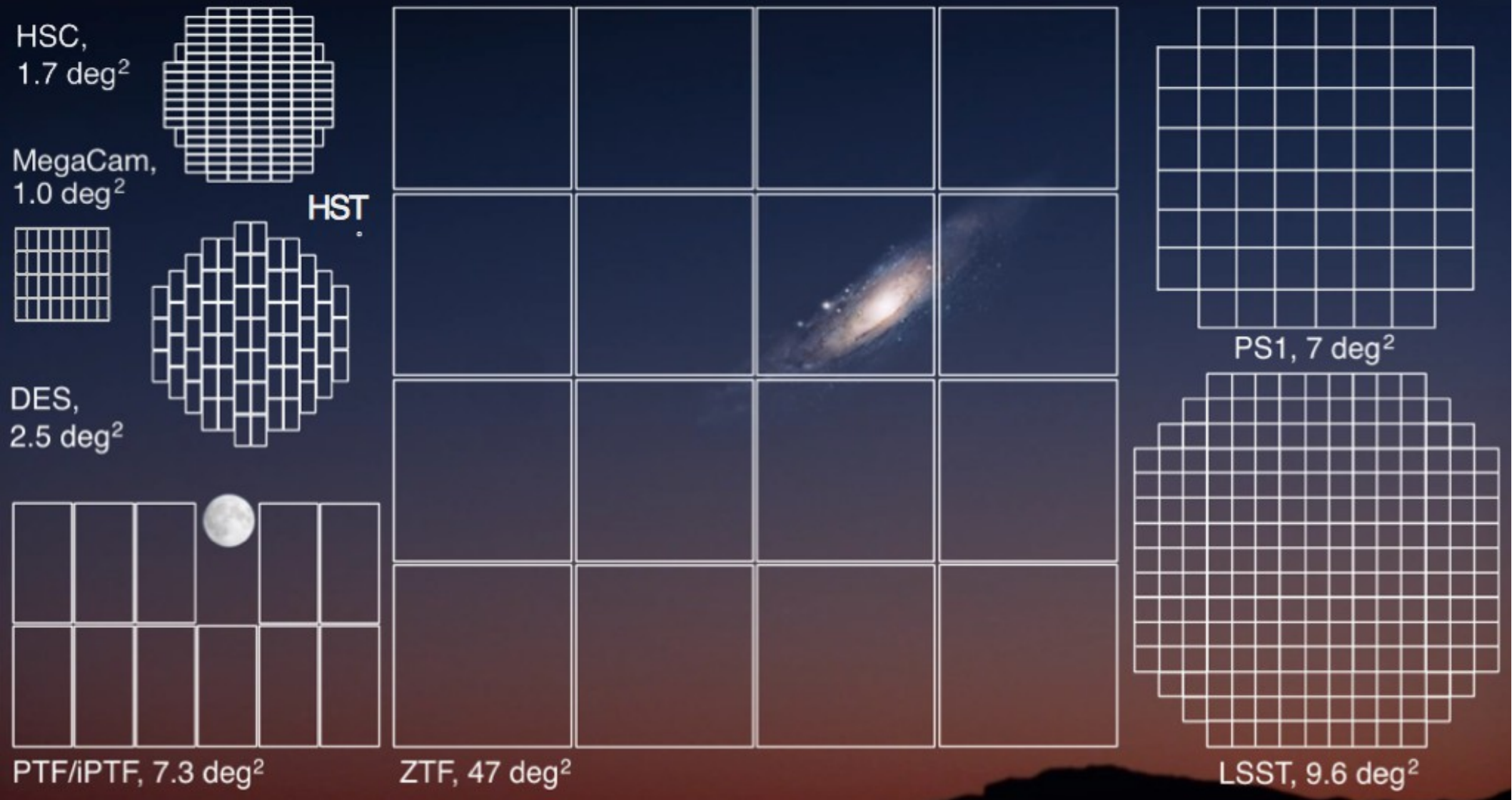
Using SUGAR as a fitter :





?

New Surveys and Time Domain Astronomy



1990 → 2000 ~ 100 SNe Ia | 2000 → 2015 ~ 10^3 SNe Ia | 2017 → 2030 ~ 10^6 SNe Ia

Discovery of Dark Energy | ***Looks like a Cosmological Constant*** | ***Is it really ?***