SNAP-L

PROBING THE NATURE OF DARK ENERGY..

A.EALET

CPPM/IN2P3

SNAP collaboration

Berkeley / Berkeley Lab

Caltech

CPPM Marseille,CNRS/IN2P3

CRAL Lyon, CNRS/INSU

Fermi National Laboratory

GSFC

Indiana U.

IPNL Lyon, CNRS/IN2P3

JPL

LAM Marseille, CNRS/INSU

LPNHE Paris, CNRS/IN2P3

RIT

Sonoma State

Univ. of BC/Victoria

Univ. of Michigan

Univ. of Pennsylvania

Univ. of Stockholm

SLAC

STScI

Yale U.

University
of Victoria

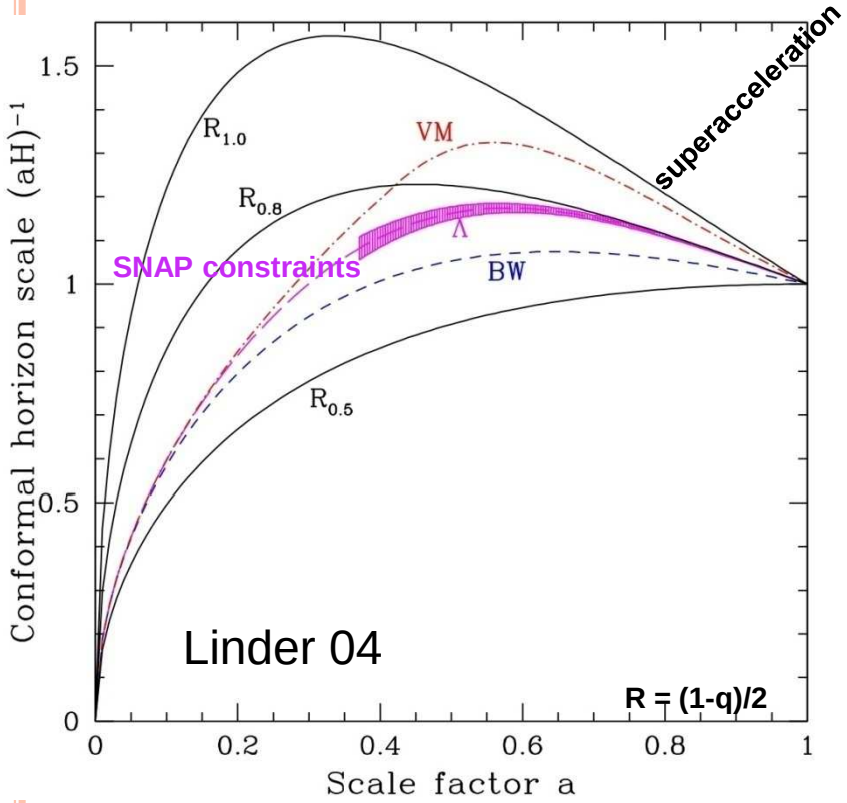
PROBING THE NATURE OF DARK ENERGY..

Require very precise measurements and interpretation:

- **Compare effect of dark energy on the expansion rate (geometry)**
- **with the effect of dark energy on growth of cosmological structures**
- **Need more than one probe to do consistency tests between gravity effect and expansion history**
- **Most promising approaches : SNe, WL, BAO, clusters…**
- **All probes will be systematic errors limited**

SNAP-L = clean, well controlled measurements for both SNIa (geometrical) and WL (dynamical) using space advantages

SNAP OBJECTIVES



Map the expansion history precisely and see the transition from acceleration to deceleration.

Test the cosmology framework – alternative gravitation, higher dimensions, etc.

Modifications of the expansion history = w(z).
an underlying theory beyond Einstein gravity?
=>Growth history and expansion history work together.

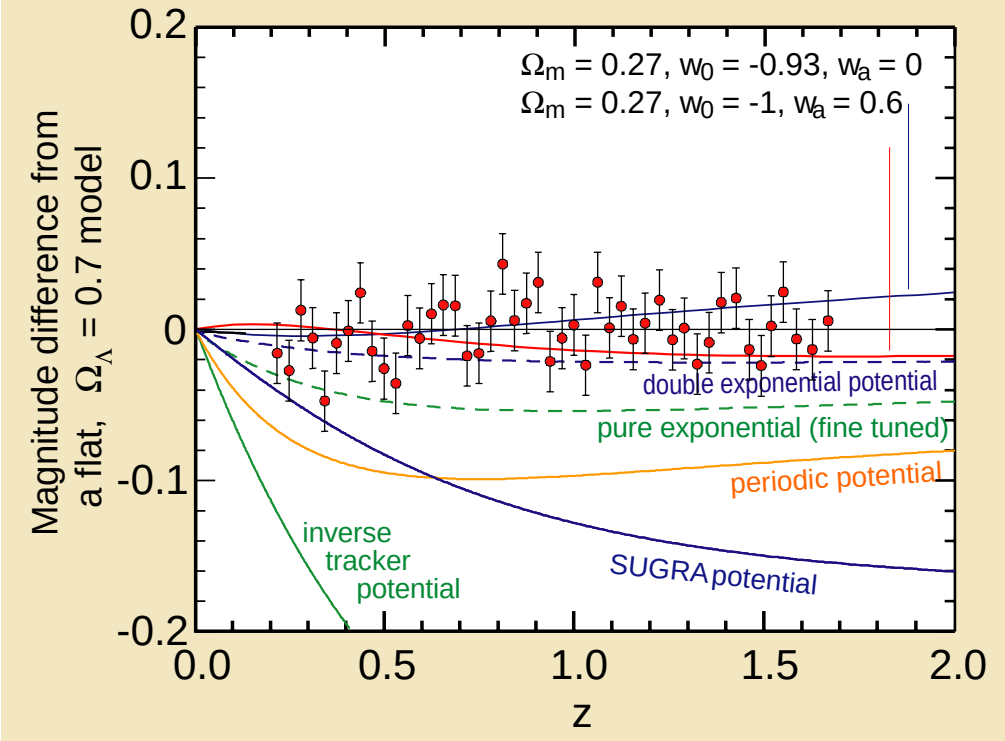
Mission objectives

Systematic effects are dominant ..
=>need simulation + instrument optimisation to identify and control all effects **..**

Supernova	Lensing
standardisation	Theoretical uncertainties on power spectrum
Contamination	Shear calibration
Selection bias	photoZ biases
Evolution/dust	Psf stability
Photometric calibration…	Shape correlation ….

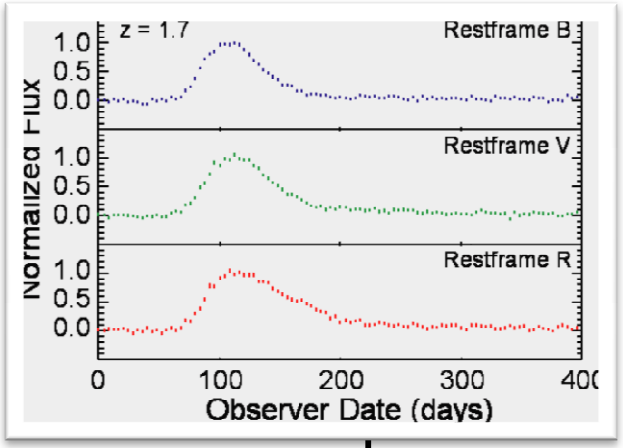
SN IN SNAP-L

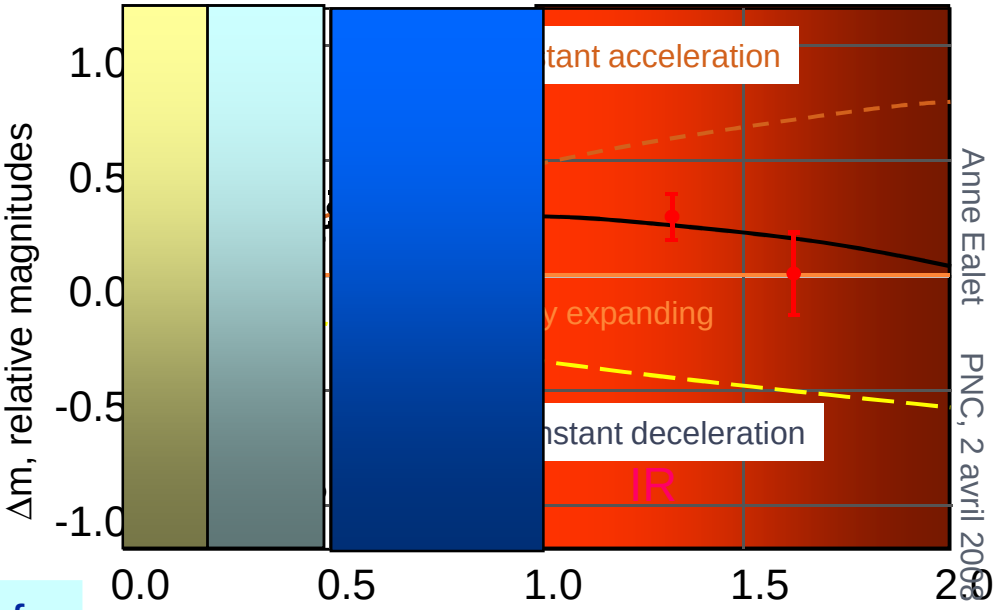
- SNs see the time evolution of the universe



•Ground surveys well advanced and already systematic limited (SNLS)
•Local sample needed for reference (SNfactory)

SN IN SNAP-L



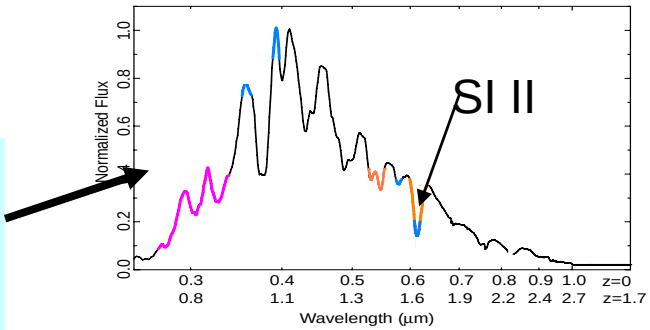


➢Fitted lightcurve S/N~50 in 3 colors of the SNe restframe => 9 filters + NIR

~2000 well measured SNe
redshift range up to 1.7
= > NIR

➢Identify SNe type +Subclassification => R~100 spectrum into NIR

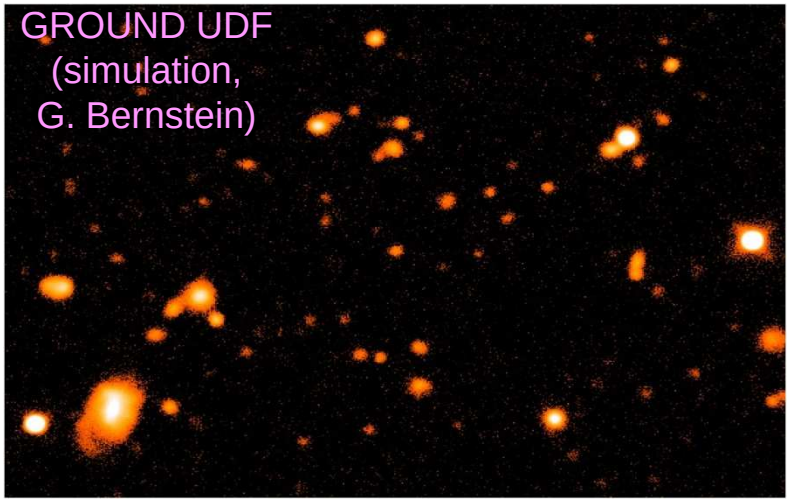
➢Precise redshift = > spectroscopy + NIR



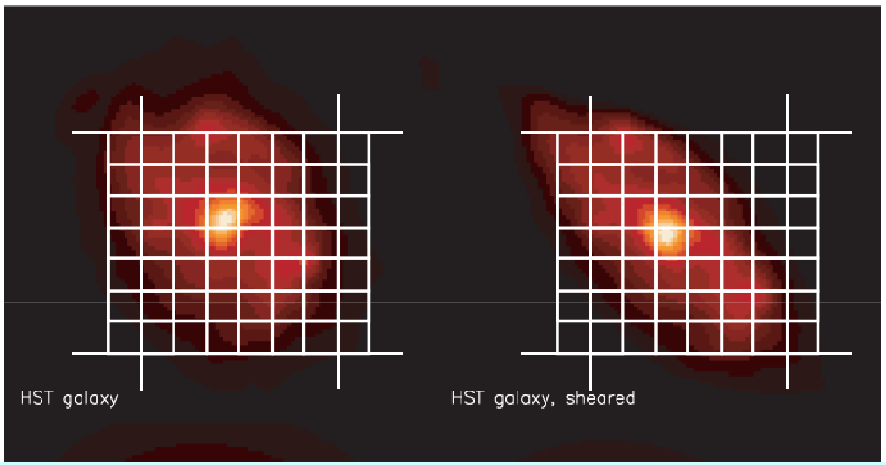
WL MEASUREMENT

access to the growth measurement

Quantities



Qualities

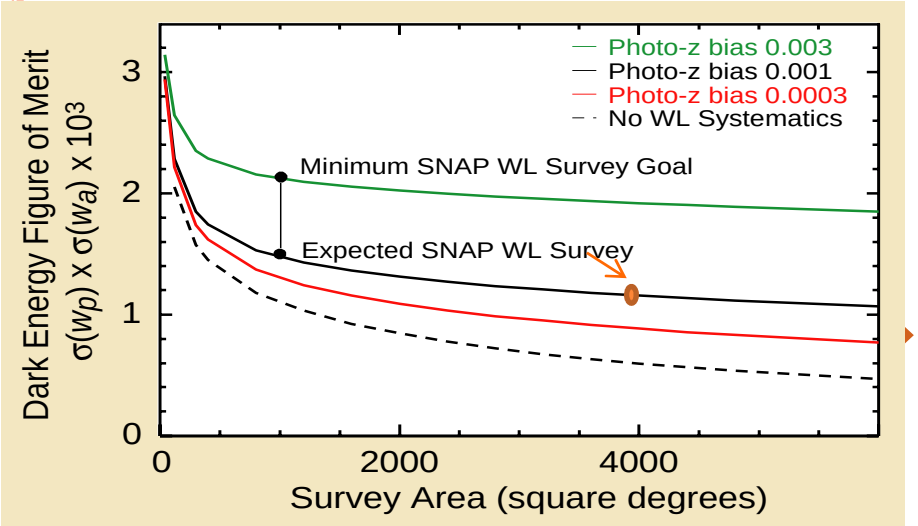


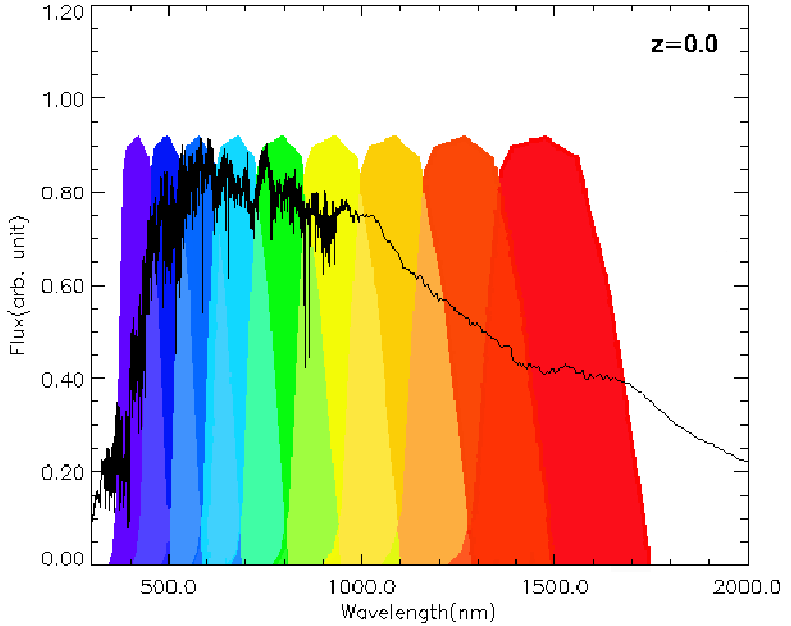
To ensure a well controlled WL measurement

- Increase the number of resolved galaxies
- Precise measurement of the galaxy ellipticities (shear) ~0.1%

Spatial resolution + PSF stability (=> stable telescope)

WL NEEDS = REDSHIFTS





Needs excellent photometry, for photometric redshifts

<u>Requires NIR + UV</u>

Need calibration

=> Need spectroscopic redshifts

<u>Requires NIR spectroscopy</u>

the DETF considers this to be <u>the option that guarantees results</u>

SNAP surveys

Survey	Area(sq.deg)	Depth(AB mag)	n_{gal}(arcmin^{-2})	N_{gal}
Deep/SNe	15	30.3	250	10^7
Wide	4000	27.8	100	$10^{8.5}$
Extended	7000-10000	26.7	40-50	10^9

*** and SNAP is in 9 colors!**

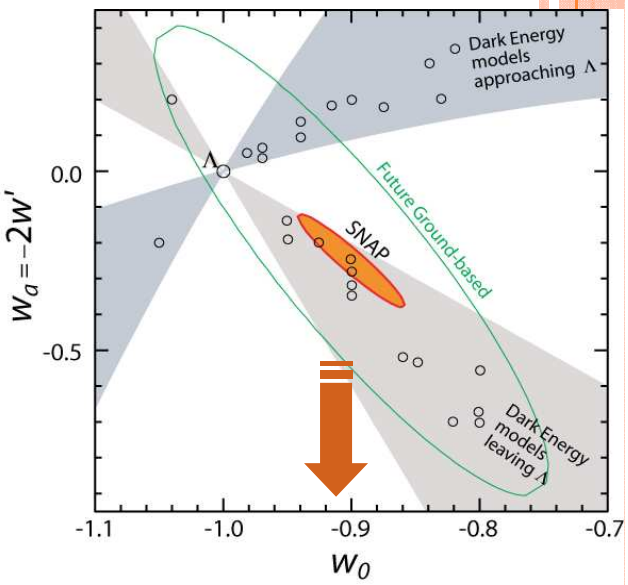
In numbers…

- One billion of photometric z (9 filters)
- Half a million of spectroscopic z 0<z<3
  (current ground ~15000)
- 80 000 clusters (today ~5000)
- BAO on 24 Gpc^3
- Correlation with ISW, SZ

Performances

Synergy of Supernovae + Weak Lensing

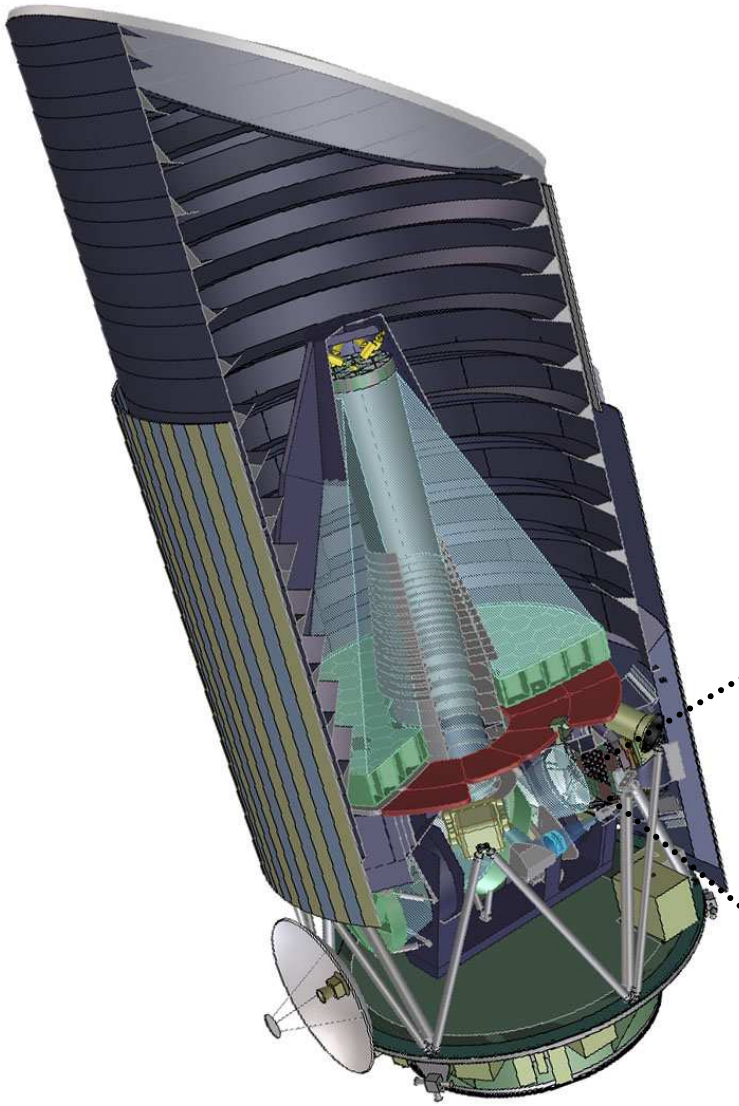
- Comprehensive: no external priors required!
- Huge improvement over future ground surveys
- Stand alone (no ground follow up)



	Uncertainties for scenario with…	$\sigma(w_p)$	$\sigma(w') \equiv -\sigma(w_a)/2$	Merit
SNAP alone	SN+WL	0.021	0.12	203
SNAP + Planck	SN+WL (no systematics)	0.010	0.05	1001
	SN+WL	0.016	0.09	371
	SN+WL + flat+gnd(WL+BAO)	**0.014**	**0.07**	**555**
SNAPExtended	**SN+WL(extended+Plank +gnd(WL+BAO)**	**0.012**	**0.05**	**911**
Comparison	space(WL+BAO)+gnd(WL)+Planck	0.019	0.12	231

SNAP INTRUMENT

Three Mirror Anastigmat Telescope	
Field of View	1.37 square deg
Resolution	< 0.06 arcsec FWHM blur
Bandpass	0.4-1.7 μm



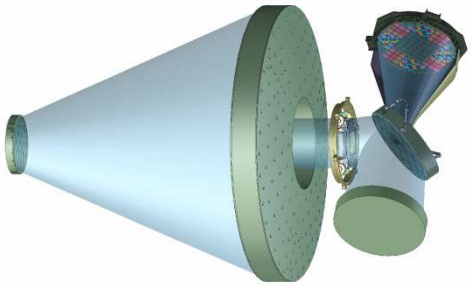
Simple= Telescope 2 m class

One cold focal plane at 140 K

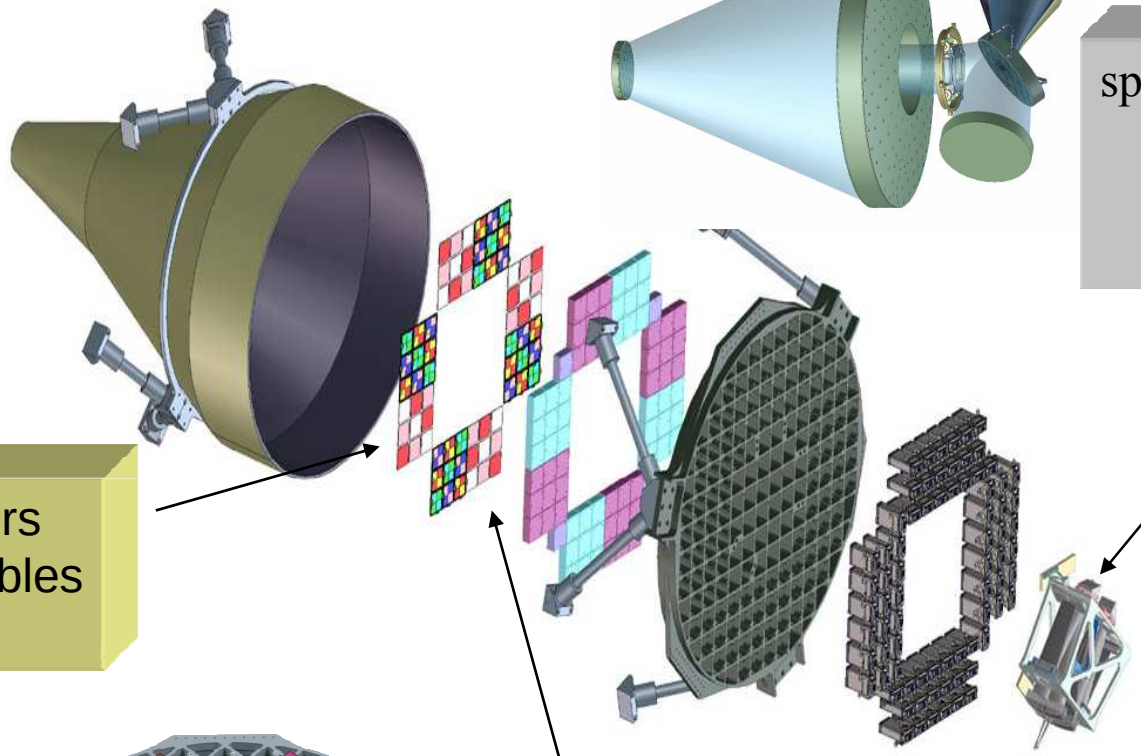
L2 lagrange point

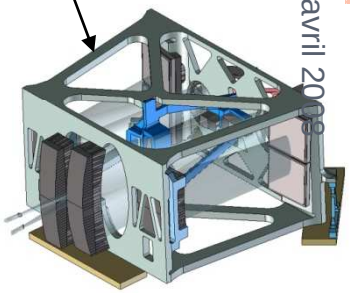
Instrument

Telescope 2m

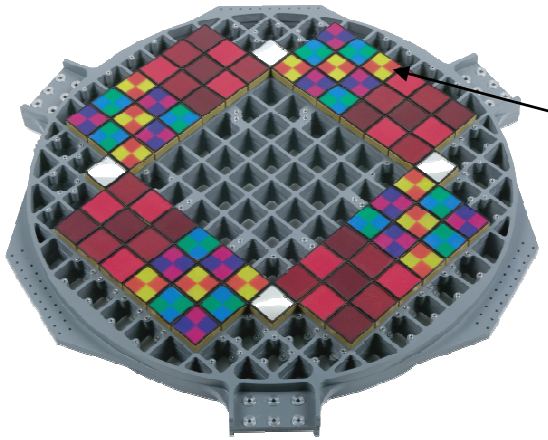


spectrographe 3D IFU slicer
visible+IR
R=100
3''x3'' , [0.35-1.7]µm





9 filters
6 visibles
3 IR



Imager visible + IR
pixel scale = 0.10 arcsec/pixel (visible),
0.17 arcsec/pixel (NIR)
4kX4k CCDs [0.35-1]µm 0.5 Gigapixels,
36 2kX2k HgCdTe [1-1.7] µm

R&D 2003-2006

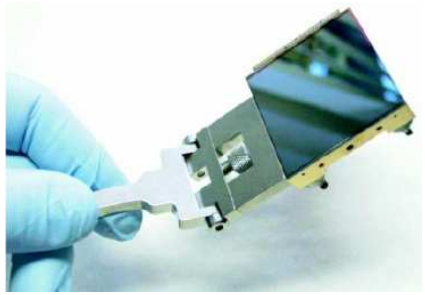
well advanced on (DOE funding)

telescope

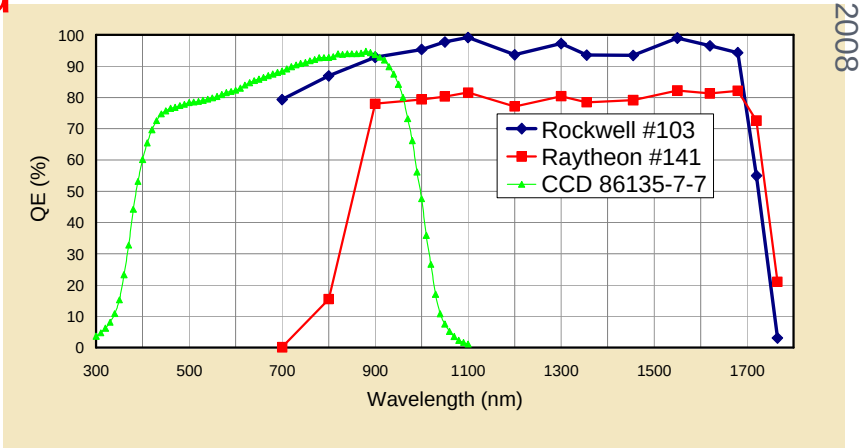
detectors and electronics visible and NIR

spectrograph demonstrator (french CNES/CNRS/DOE)

= > all requirements are achieved



T operation = 140 K



IR detectors ..
new and impressive performances

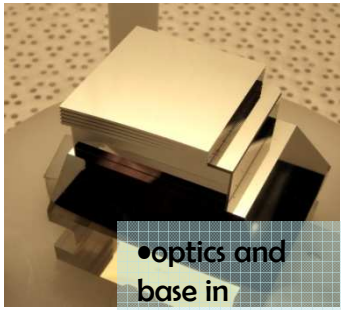
LA PARTICIPATION FRANÇAISE

Un leadership sur le spectrographe (LAM/CPPM/IPNL)

- Responsabilité française
- Intégration forte dans le projet
- démonstrateur (instrument complet)
- pour la validation des performances (LAM/CPPM/IPNL)
- simulation/traitement des données

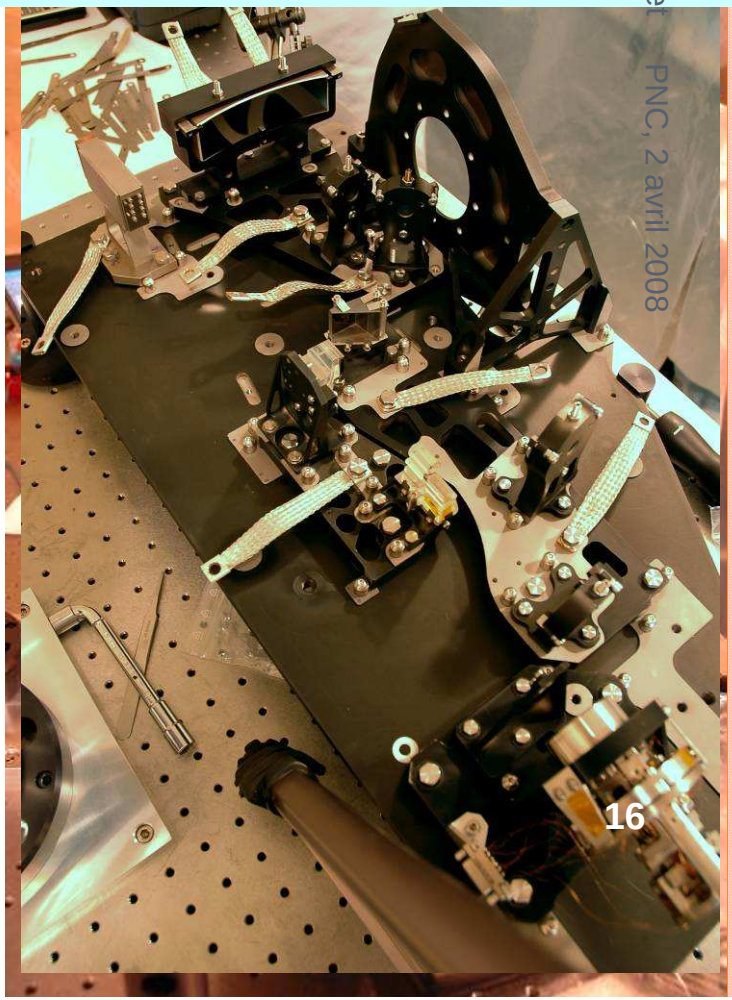
SNAP LE DEMONSTRATEUR

La contribution française

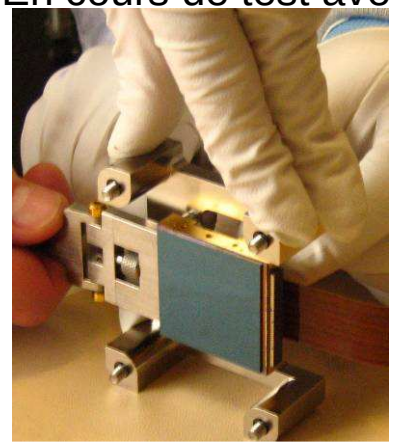


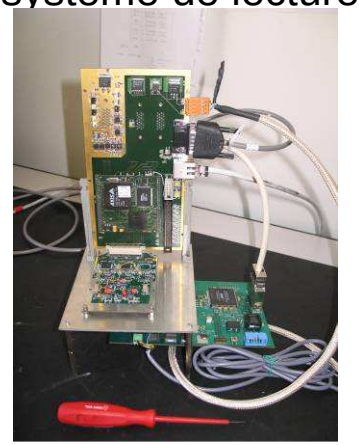
- optics and base in zerodur
- 0.5x10x10 mm by slice
- optics and bench glued by optical contact

Instrument de validation complet
Conception et fabrication 2005/2007 LAM/CPPM
tests visibles réalisés pendant l'été 2007
tests IR réalisés avec détecteur IR HgCdTe

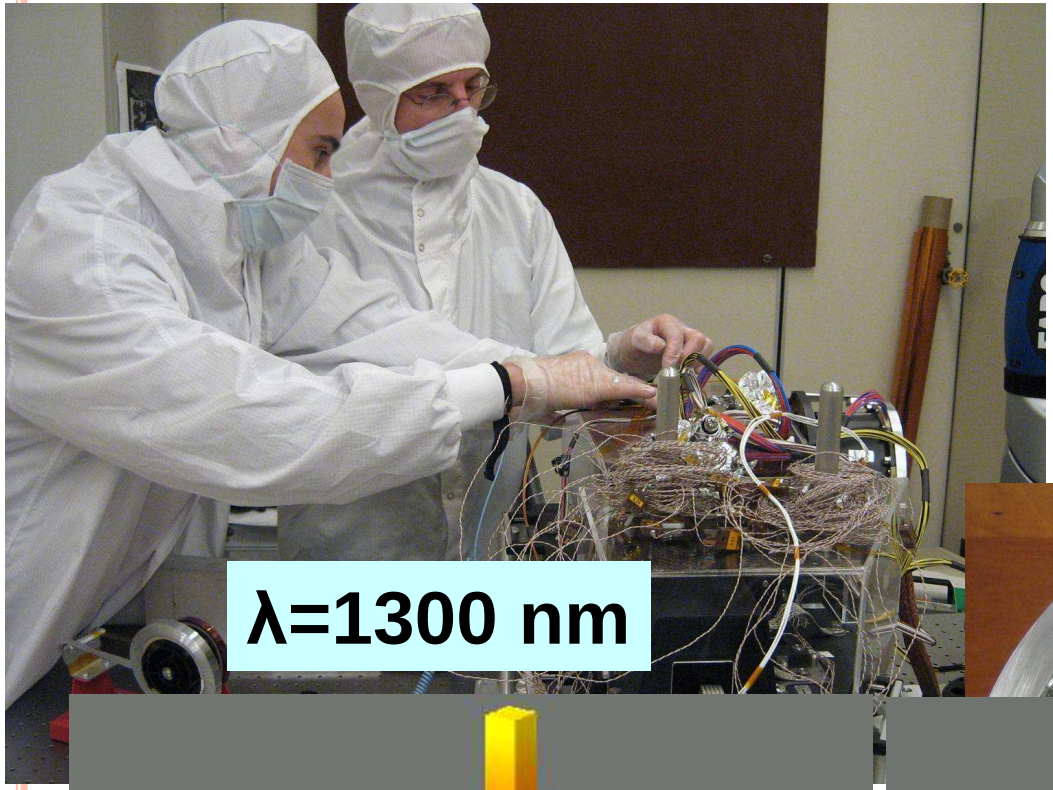


Le détecteur IR H2rG de SNAP reçu a l'IPNL
En cours de test avec système de lecture de l'IPNL



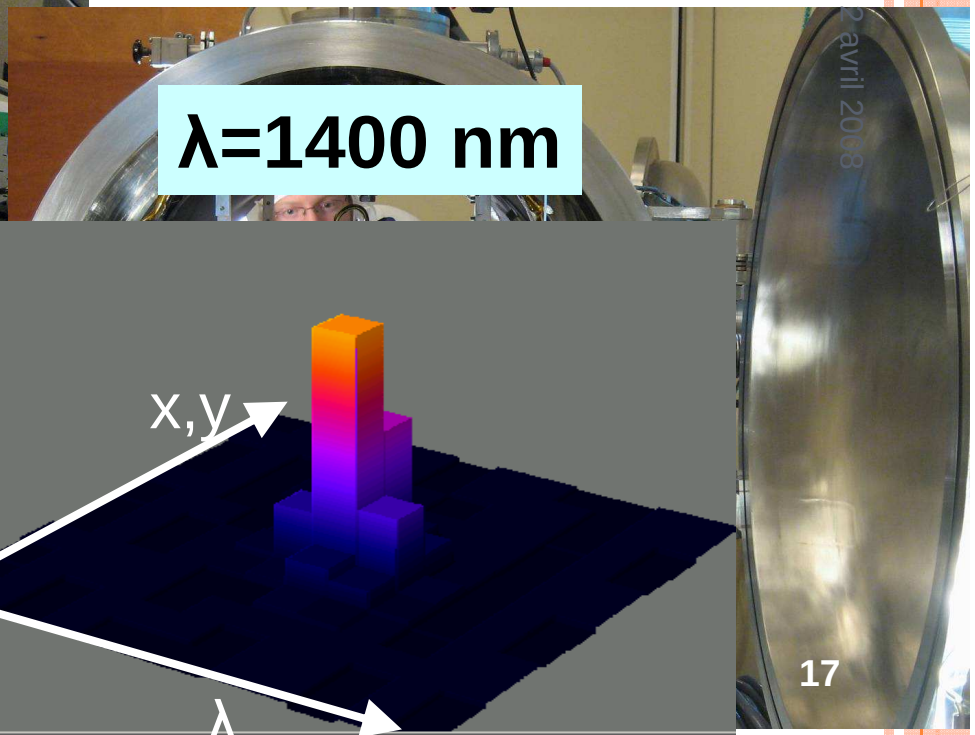


Préparation des tests en cryogénie



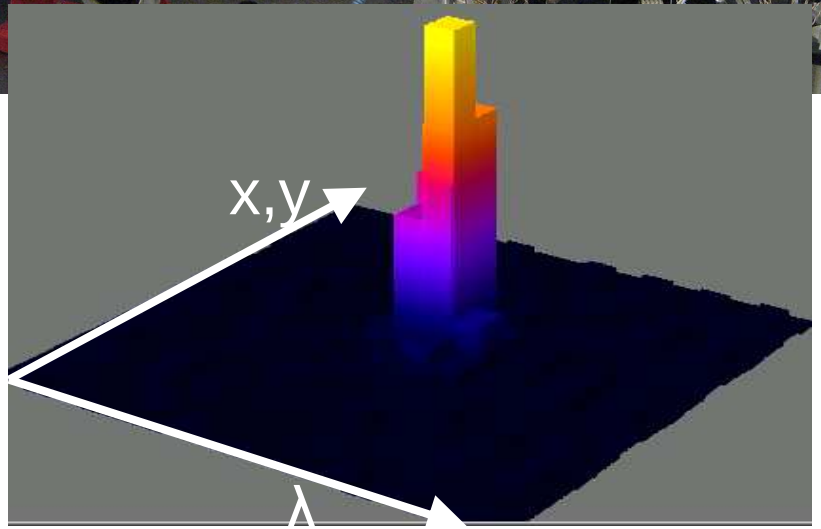
Validation qualité des slicers
Validation spectro photometrie au %
Validation de la simulation

Integration dans le cryostat



λ=1300 nm

λ=1400 nm



retour

Publications en cours

NASA-DOE
Joint Dark Energy Mission

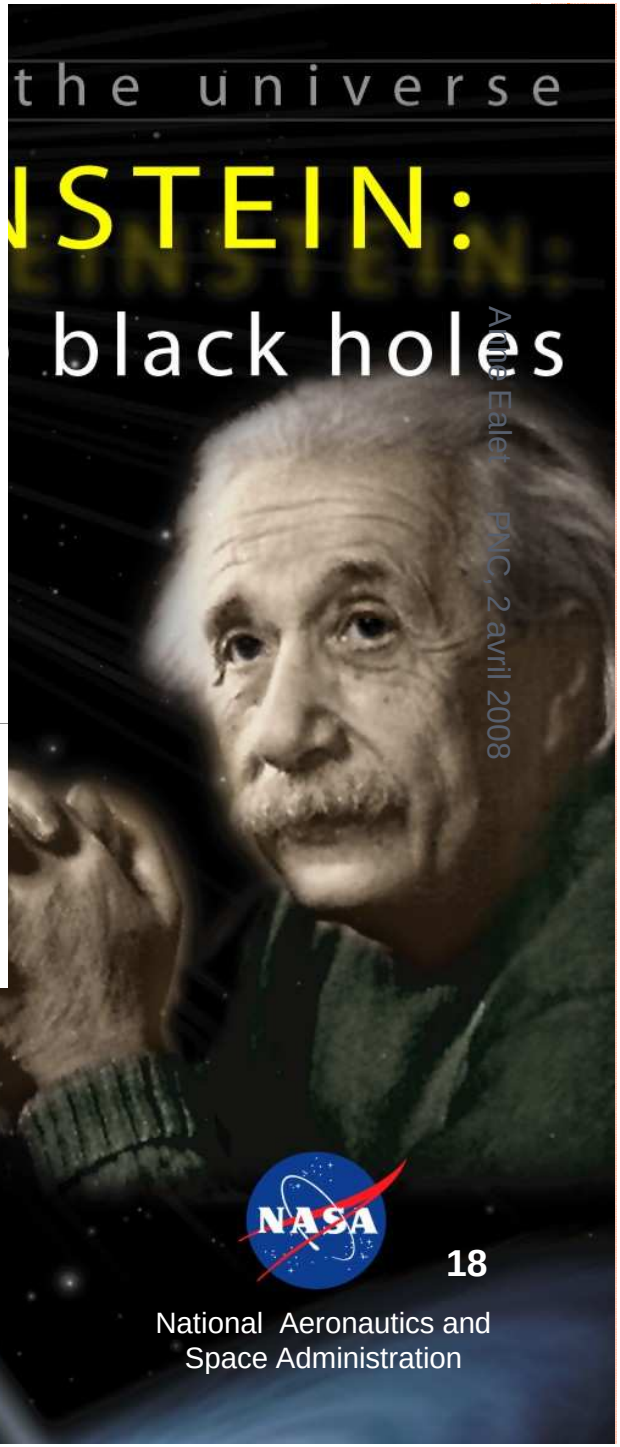
Paul Hertz / NASA

Robin Staffin / DOE

Endorsed by

Raymond L. Orbach
Director of the Office of Science
Department of Energy
September 24, 2003

Edward J. Weiler
Associate Administrator for Space Science
NASA
September 25, 2003



OF A BLACK HOLE?

WHAT IS
DARK ENERGY?

National Aeronautics and
Space Administration

Department of Energy

"Come hell or high water, DOE will fund JDEM."

-- Dr. Raymond Orbach, Director, Office of Science, May 2004

JDEM

- Nov 2003 JDEM Announcement from DOE & NASA
- Feb 2005 Nat'l Academy Sciences: Cmt. on Astro.& Astrophys. reaffirms priorities.
- Aug 2006 NASA selects advanced mission concept studies (ROSES). SNAP, ADEPT, DESTINY
- Sep 2007 Nat'l Academy Sciences: BEPAC chooses JDEM.

'' The National Research Council's Beyond Einstein Program Assessment Committee has recommended **that the Joint Dark Energy Mission (JDEM), jointly supported by the National Aeronautics and Space Administration and the Department of Energy, be the first of NASA's Beyond Einstein cosmology missions** to be developed and launched with a start of mission in 2009…

Joint Dark Energy Mission : Science Goals

- Beyond Einstein science
  - precisely measure the expansion history of the universe to determine whether the contribution of dark energy to the expansion rate varies with time

- Broader science
  - investigate the formation and evolution of galaxies
  - determine the rate of star formation and how that rate depends on environment

Beyond Einstein

Systematic uncertainties may limit JDEM to modest improvements over ground-based studies.

Broader Science

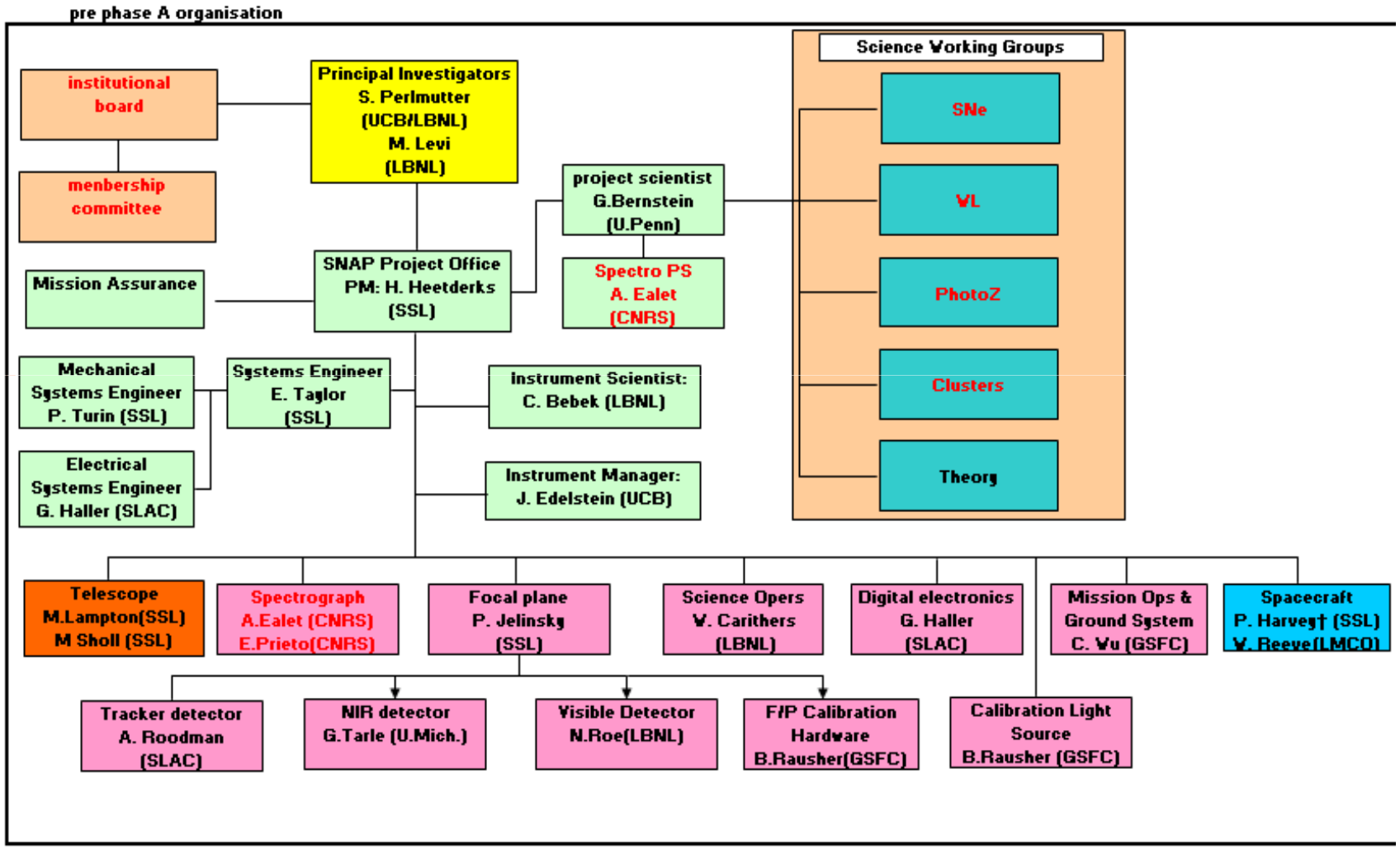
Because of the exquisite datasets that JDEM surveys will produce, there is little risk to the broader science impact.

UN SPECTROGRAPHE POUR JDEM

Le spectrographe francais bien identifié dans le rapport BEPAC

- Principe basse resolution repris par nos concurrents ce qui consolide notre proposition
- Soutien du CNES pour préparer la proposition
- L'avance, l'avantage et le concept innovateur slicer a consolider en 08 avec 2 risques identifiés
  - TRL6 pour le sous-système slicer (LAM)
    - Prototypage en cours
    - Publications des résultats du démonstrateur + tests en vibration
    - Mise en place de la validation par le CNES
  - Management international (NASA/DOE/CNES)
    - endossement CNES en préparation dès la sortie de l'AO

L'organisation actuelle du projet SNAP



PARTICIPATION FRANÇAISE JDEM

mise en place d'une organisation française identifiée pour la proposition JDEM

- un steering committee (CNES, IN2P3, INSU..)
- un élargissement scientifique

  expertise sur SN (IN2P3)
  expertise WL (INSU)
  expertise et leadership sur les clusters et autres science (APC+ INSU)
  expertise photoZ (LAM)

- un 'science advisory group' en élaboration

CONCLUSION

- **SNAP an advanced project ..self contained**
  - **A wide space imager working both in visible and IR**
  - **A low resolution spectrograph onboard in visible and IR**
- **Focus on a precise control of all measurements :**
  spectro for SN
  psf and photoz for WL
- **SNAP adresses first the dark energy problem**

adresses also many other sciences cases with its deep and wide surveys in 9 filters!

- **SNAP a DOE /French project**

JDEM AO expected this year !!
SNAP ready to answer