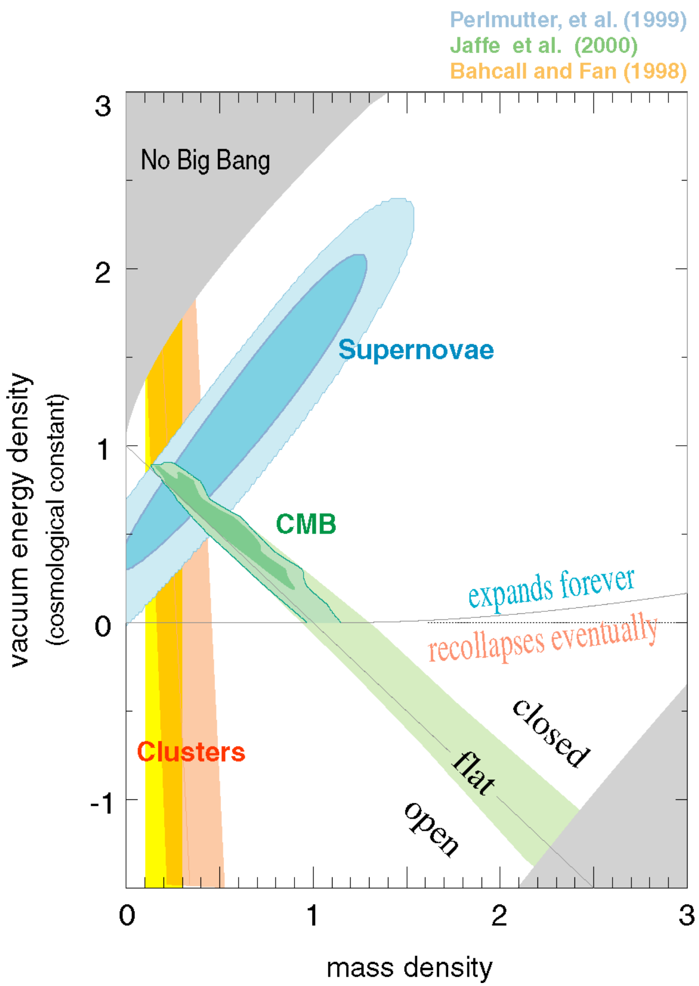
Imageurs grand champs dans l'Espace: DUNE & SNAP

Jean-Paul KNEIB
LAM

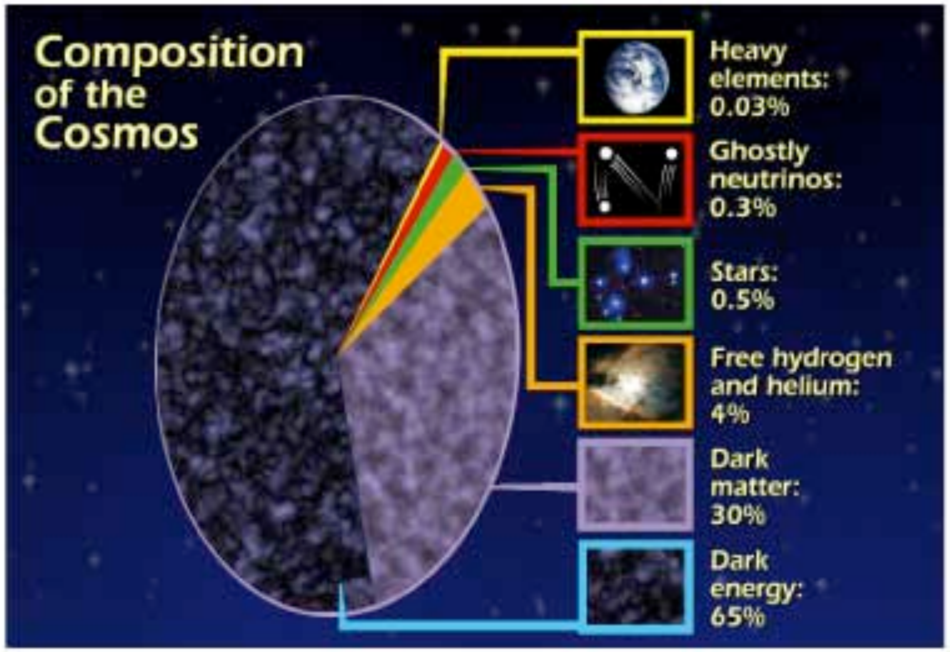
Cosmology: Concordance ΛCDM Model



Outstanding questions:

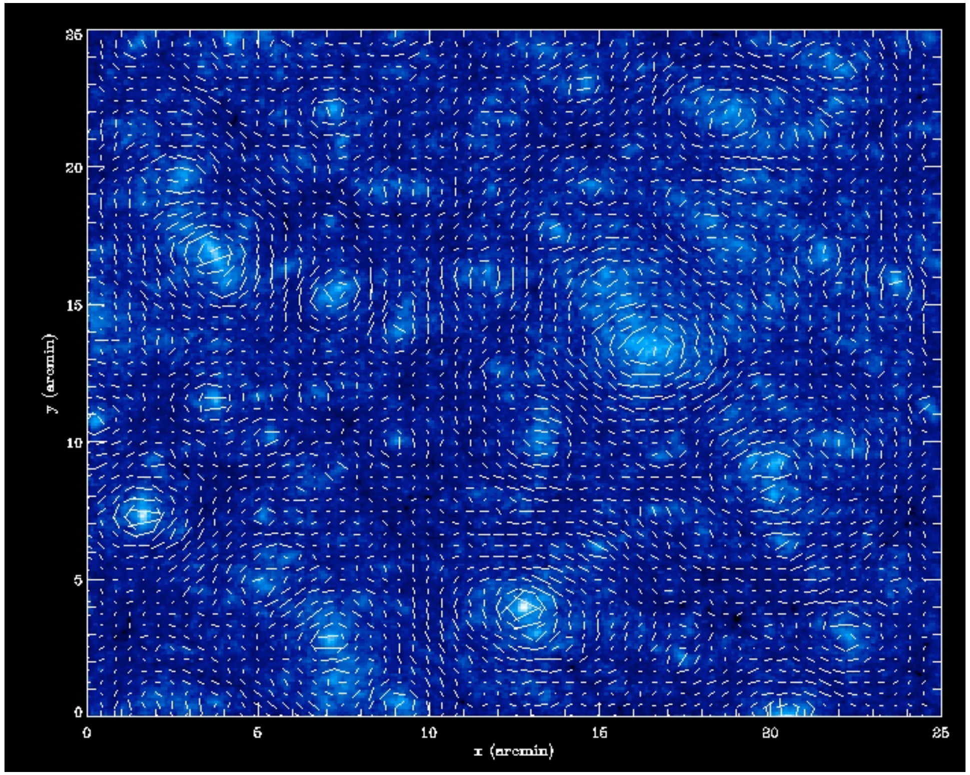
- initial conditions (inflation?)
- nature of the dark matter
- nature of the dark energy

→MAIN Science goals for a SPACE Wide-Field Imager

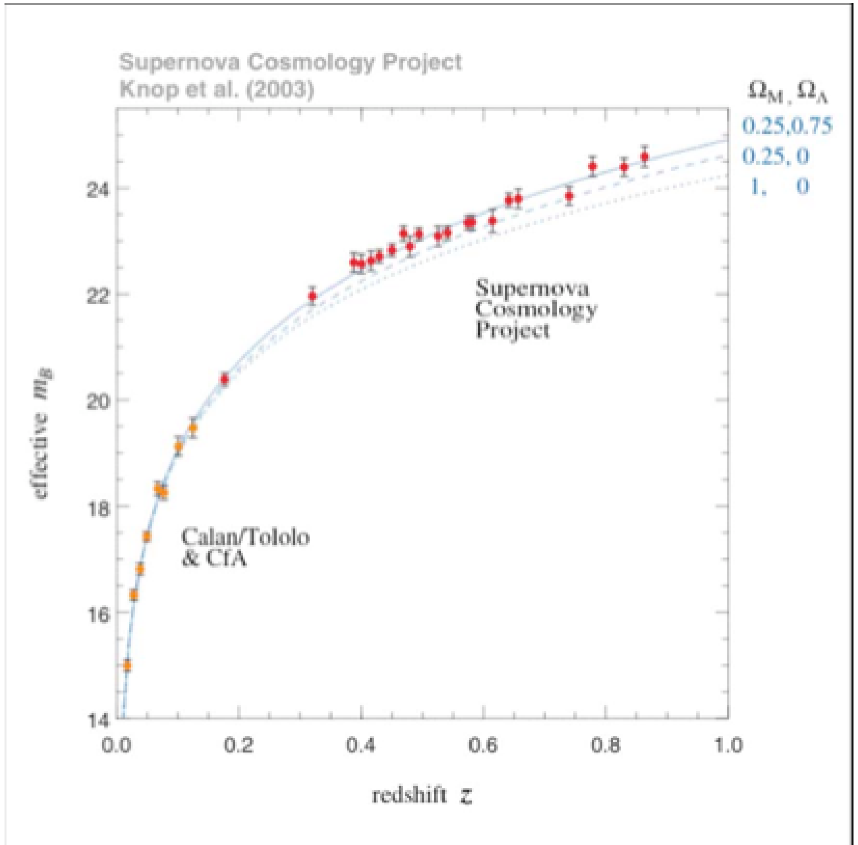


Primary Science Drivers: Weak Lensing and Supernovae

Mapping the Dark Matter
with weak lensing



Hubble diagramme with SNe



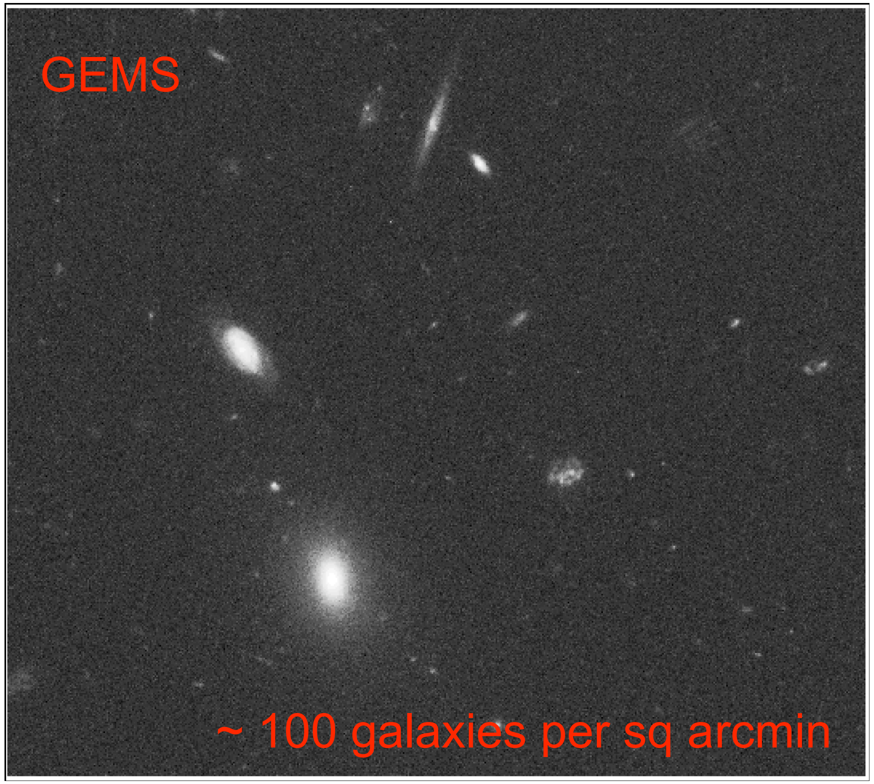
Why Go Into Space?

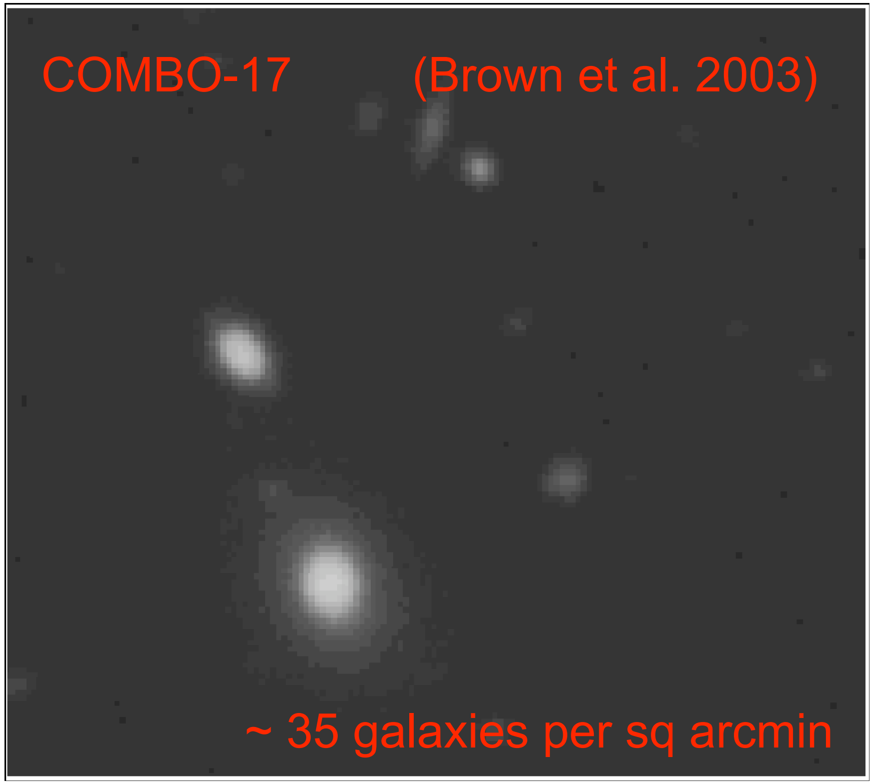
- **0.1" to 0.2" angular resolution over wide field** (excellent point source sensitivity).
- **Near-infrared** unaffected by atmospheric emission/absorption
- Continuous, year-round observation of selected fields
- **Stability!** …essential for moving from 10% to 1% measurements

Need/Interest of Wide Field

- **large number of objects** => Better statistics
- **Rare objects**, only found in wide field surveys

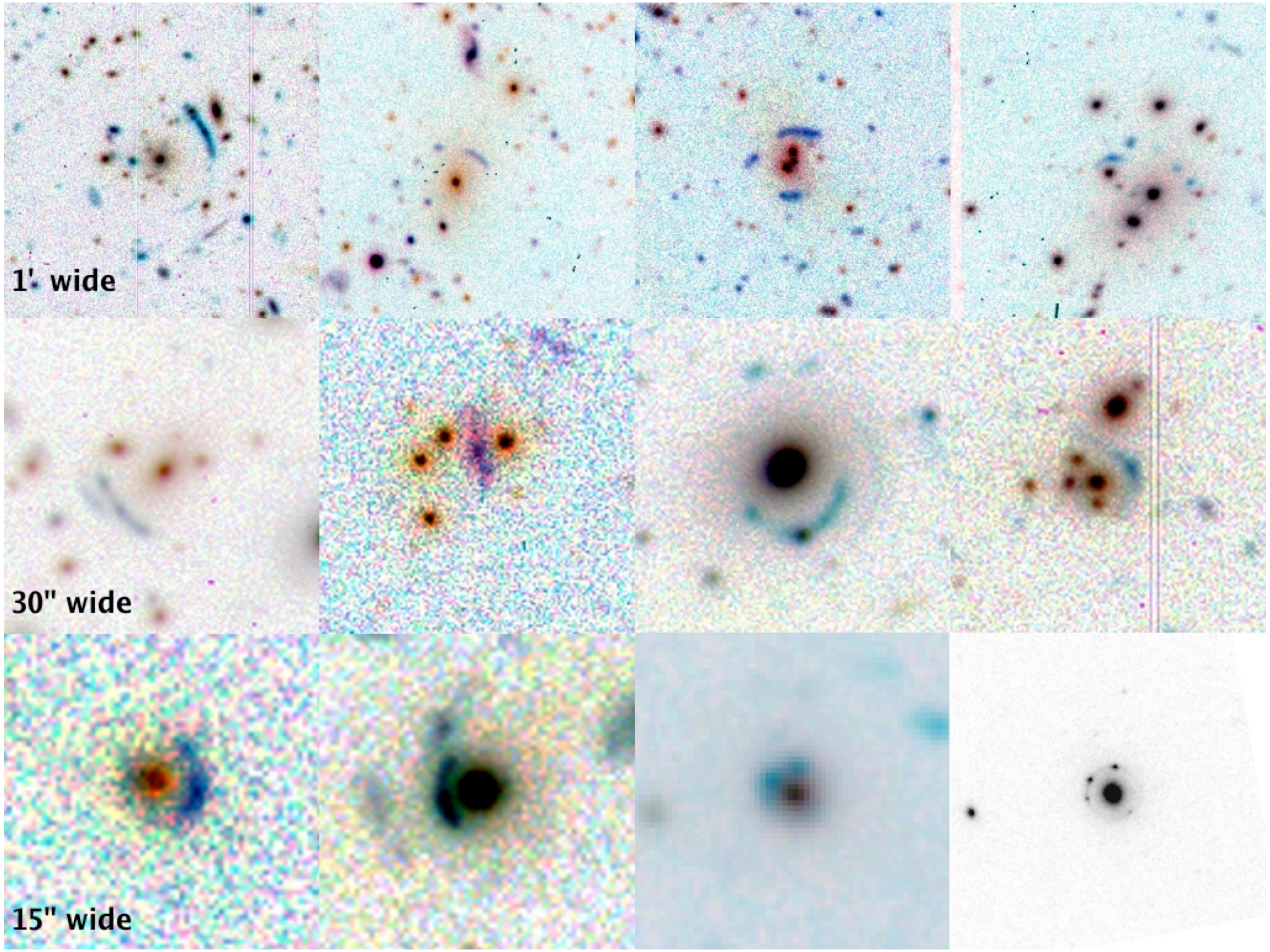
Space-based imaging vs ground





- Space-based imaging has a significantly higher surface density of resolved sources, which can probe the matter density power spectrum at higher redshifts than will ever be feasible from the ground.

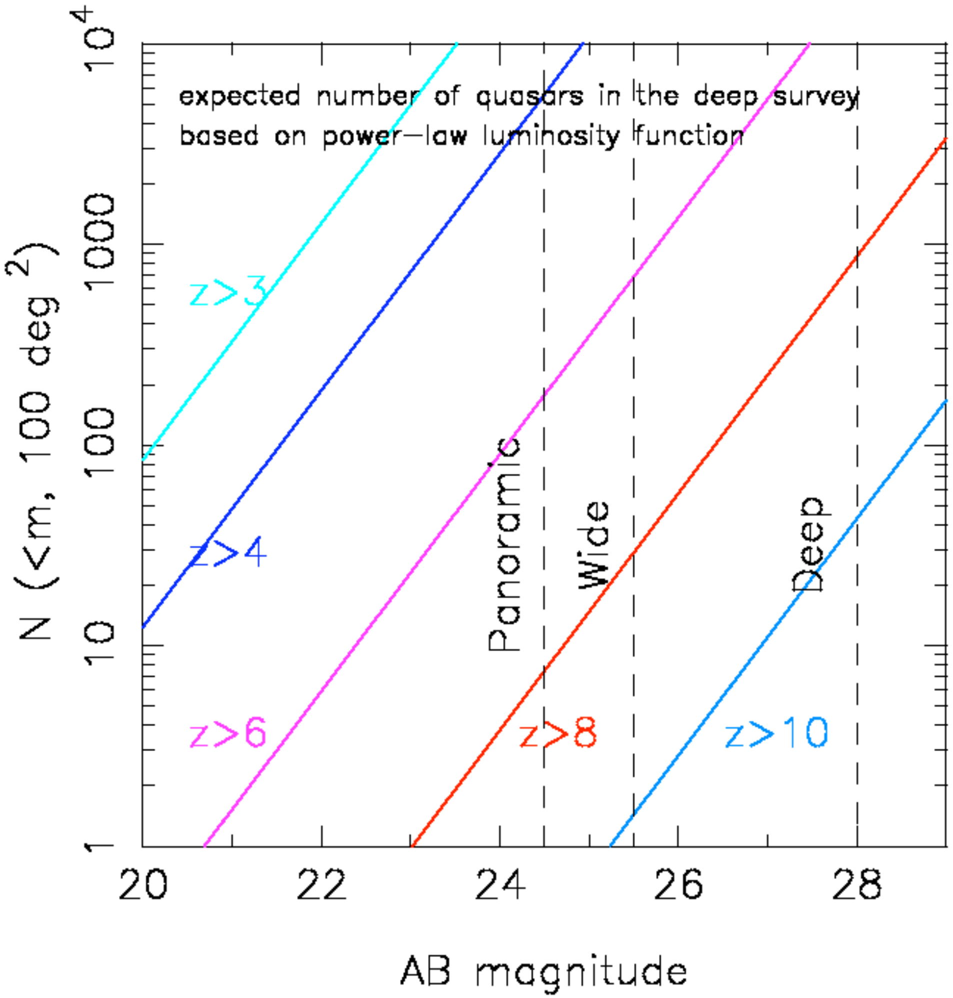
Strong Lensing surveys in **CFHT-LS**: probing galaxies and group halos



Probing the end of dark ages

- **Hi-z quasars search:**
  - Very wide survey: 7000 sq.deg, effective selection down to 24.5
  - z~3 quasars: 200 – 400 per sq. deg
  - Hundreds of z~6 quasars
  - Maybe 10 luminous quasars at z = 9 – 10?
- **Similar Hi-z galaxies search in the Deep Fileds**

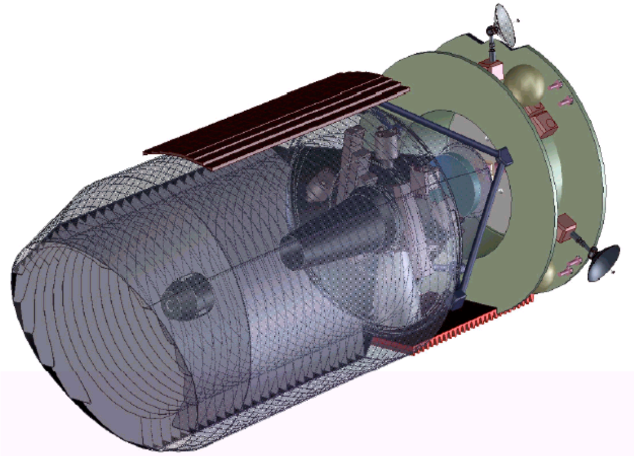
⇒ but requires IR

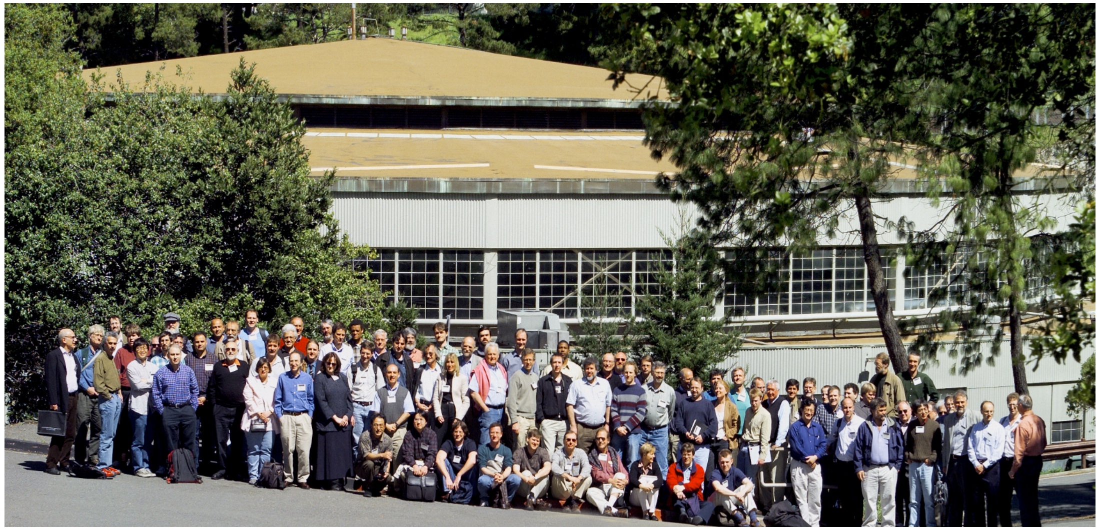


Science Goals with a WF Space Imager

- Primary goal: Cosmology with WL and SNe
  - Measurement of the evolution of the dark energy equation of state (w,w') from z=0 to ~1
  - Statistics of the dark matter distribution (power spectrum, high order correlation func)
  - Reconstruction of the primordial power spectrum (constraints on inflation)
- Cross-correlation with CMB
  - Search for correlations of Galaxy shear with ISW effect, SZ effect, CMB lensing
  - Search for DE spatial fluctuations on large scales
- Study of Dark Matter Haloes:
  - Mass-selected halo catalogues (about 80,000 haloes) with multi-λ follow-up (X-ray, SZ, optical) $\rightarrow$ halo mass calibration
  - Strong lensing: probe the inner profiles of haloes
- Galaxy formation and evolution (SN field will be very deep!):
  - Galaxy bias with galaxy-galaxy and shear-galaxy correlation functions
  - Galaxy clustering with high resolution morphology
- Core Collapse supernovae:
  - constraints on the history of star formation up to z~1
- Fundamental tests:
  - Test of gravitational instability paradigm
  - Dark Energy clustering
  - Distinguish dark energy from modification of gravity

The SNAP Telescope (DOE lead)

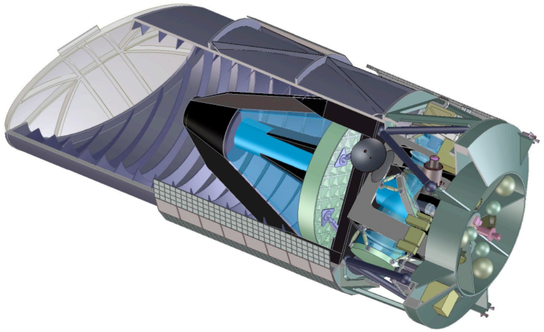


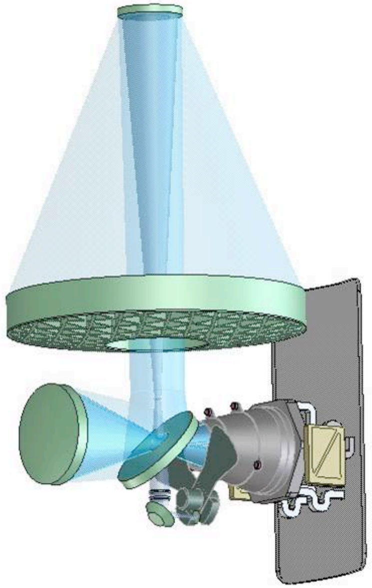


- **~2m aperture**, 3 mirror anastigmat
- Diffraction limited in I across the **1 square degree** fixed focal plane
- Optimized to repeatedly scan sky in **9 filters**

•Dedicated survey system
•**3 year planned life**: passive cooling, few moving parts or expendables
•May operate much longer

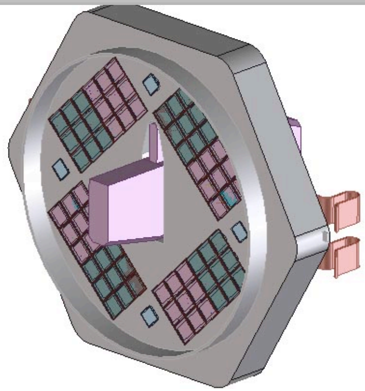
SNAP

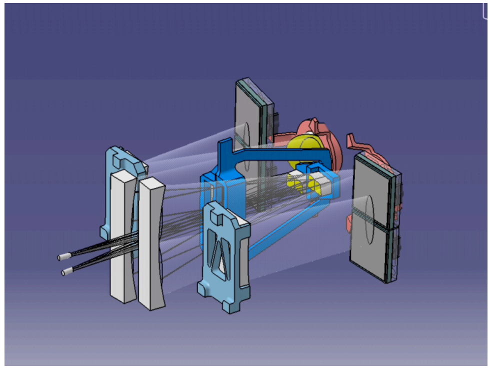




BUT Primaire:
-Mesurer quelques milliers de SN avec des systématiques à 1-2 %
-un suivi de ~1000°^{2} pour des mesures de cisaillement gravitationnel
=>complémentarité scientifique sur l'énergie noire…

camera de 0.5 Gigapixels,
4kX4k CCDs [0.35-1]µm
36 2kX2k HgCdTe [1-1.7] µm



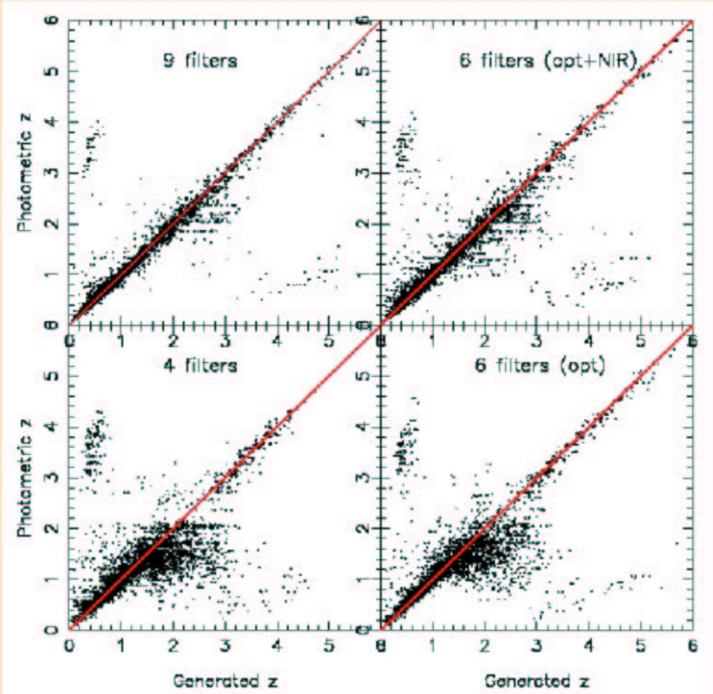


spectrographe IFU visible+IR
3''x3'' , [0.35-1.7]µm

Photometric Redshifts for SNAP

Results

Dz vs **Filter set**



Case 1: 9 filters, optical _ NIR
Dz=0.045 after excluding **2.0**% outliers
at z<1.5:
Dz=0.038 after excluding 1.9% outliers

Case 2: 6 filters, optical _ NIR
Dz=0.065 after excluding **4.1**% outliers
at z<1.5:
Dz=0.054 after excluding 4.0% outliers

Case 3: 4 filters, optical
Dz=0.10 after excluding **10**% outliers
at z<1.5:
Dz=0.076 after excluding 7.6% outliers

Case 4: 6 filters, optical
Dz=0.089 after excluding **7.2**% outliers
at z<1.5:
Dz=0.056 after excluding 5.0% outliers

Simulations can be used to optimize filter selection and band pass shapes

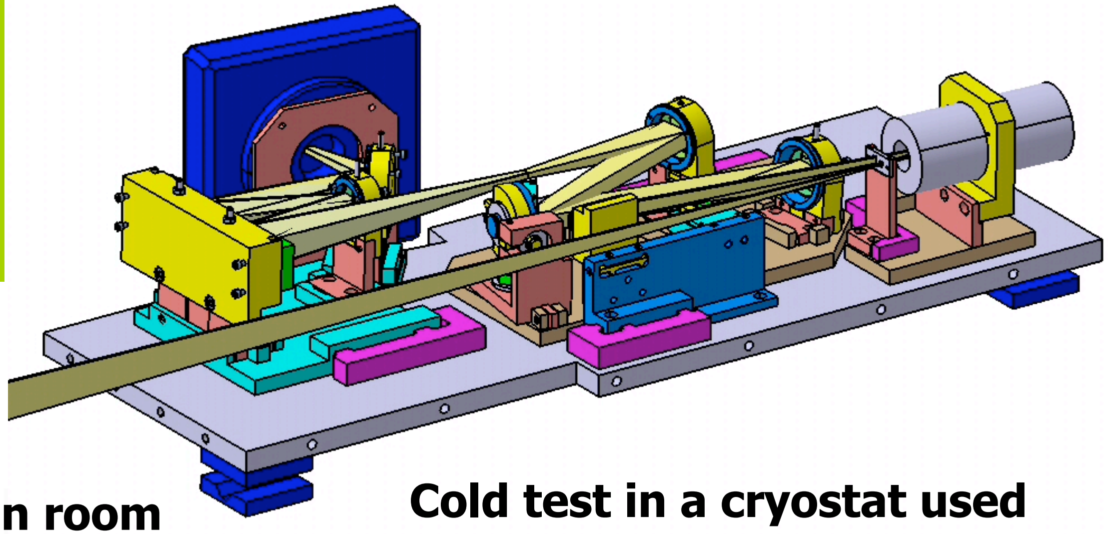
R&D : SNAP Spectrograph demonstrator (LAM)

Concept done

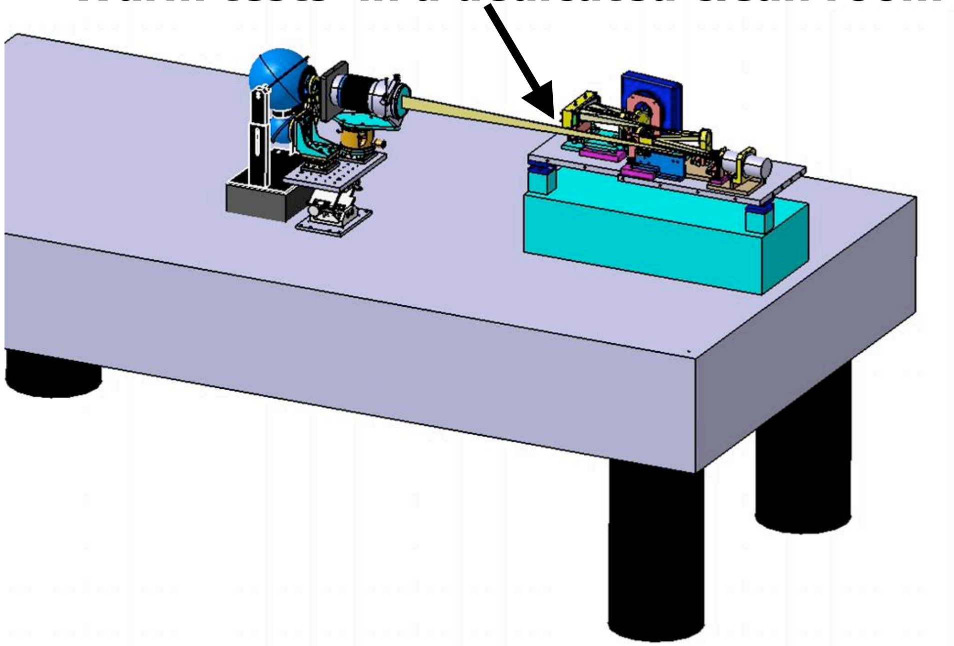
Technical review in Nov 05

Manufacturing started

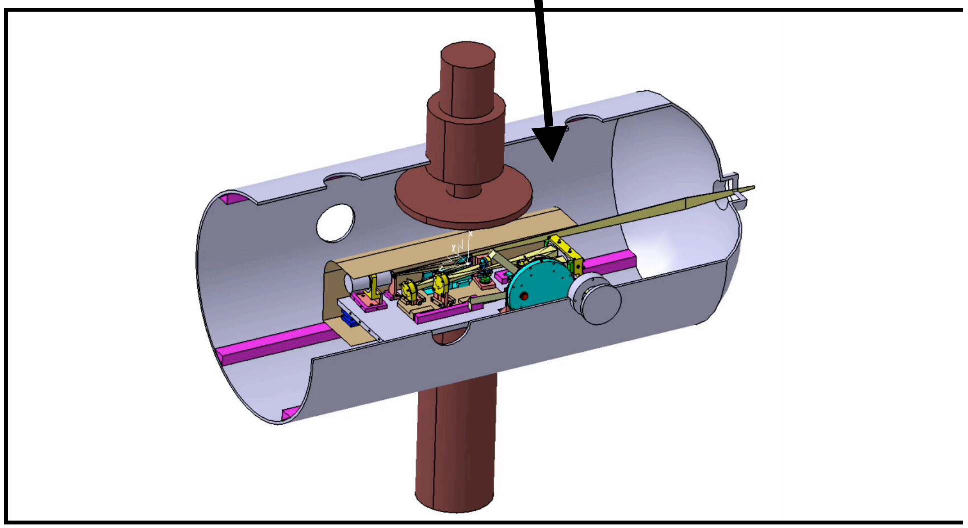
Integration and test for end 2006



Warm tests in a dedicated clean room



Cold test in a cryostat used currently for Herschel in LAM



SNAP Surveys

Survey	Area(sq.deg)	Depth(AB mag)	n_{gal}(arcmin^{-2})	N_{gal}
Deep/SNe	15	30.3	250	10^7
Wide	300-1000	27.7	100	$10^{8.5}$
Panoramic	7000-10000	26.7	40-50	10^9

Synergy of Supernovae + Weak Lensing

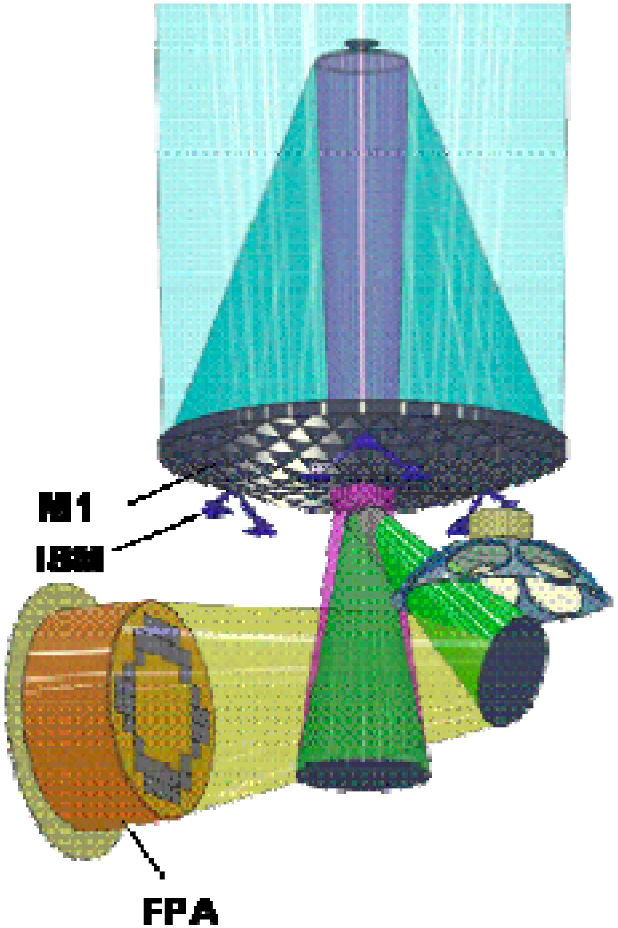
- Comprehensive: no external priors required!
- Independent test of flatness to 1-2%
- Complementary (SNe + WL only):
  - conservative:
    - w_0 to ±0.05, variation w' to ±0.12 (*with systematics*) Λ model
    - w_0 to ±0.03 variation w' to ±0.06 (*with systematics*) SUGRA model
  - Adding panoramic survey and better systematics:
    - w_0 to ±0.03, variation w' to ±0.06 (*with systematics*) Λ model
    - w_0 to ±0.015 variation w' to ±0.03 (*with systematics*) SUGRA model
- Flexible: Panoramic … 5 years mission + BAO

DUNE:
Dark UNiverse Explorer

Baseline: CNES Phase 0 concept (Refregier et al completed in 2005)

- 1.2m telescope
- FOV 0.5 deg^2
- PSF FWHM 0.23'' (I-band)
- NO infrared detectors
- **WL survey: 20000 deg^2** in 1 red broad band, 35 galaxies/$amin^2$ with median z~1, ***ground based complement*** for photo-z's (Cf. Darkcam)
- **SNe survey: 2×60 deg^2**, observed for 9 months each every 4 days in 6 bands, <u>*10000 SNe*</u> out to z~1, ***ground based spectroscopy of host galaxies***
- Tight control of systematic → progress in phase 0
- launch target: 2012

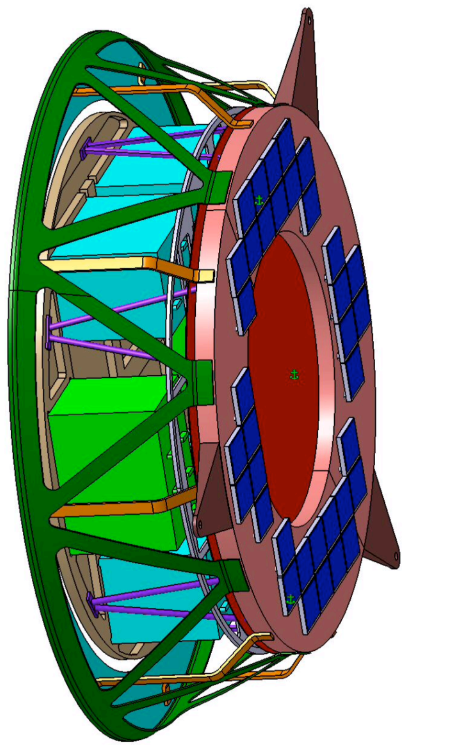
Instrument Concept (Phase 0)



Optics

By Astrium and LAM

Focal Plane



By Z. Sun et al.

DUNE: Résultats techniques de la Phase 0

- Etude des scénarios pour l'orbite, le concept instrumental, la plateforme (CNES, Astrium)
- Proposition du Drift Scanning par Astrium (gain significatif en efficacité d'observation)
- Synérgie avec GAIA
- Concept optique NODI avec distorsions faibles par le LAM, repris par Astrium
- Etude du plan focal par le CEA
- Construction d'une chaîne de simulations d'images
- Etude des besoins de stabilité de PSF: 0.1% précision sur le shear atteint par AOCS et calibration au sol

Conclusions de l'étude DUNE

- DUNE: concept novateur: mission rapide, à coût modéré, centrée sur le WL avec relevé SNe, synergie sol-espace
- Phase 0 fructueuse: solutions techniques innovantes pour contrôler les effets systématiques → pas limité par les mesures de formes
- DUNE obtiendra des contraintes très compétitives sur l'énergie noire et la distribution de la matière noire
- *Relevé supernovae **multi-λ** peut être inclus a un coût modeste*
- Optimisation de la mission: baseline: 2 relevés extrêmes → relevés intermédiaires + reconsidération de l'IR en cours d'évaluation en collaboration avec les US (proposition MIDEX)
- La communauté Française est en avance et a des atouts considérables: expérience CFHTLS/Megacam, weak lensing, supernovae, plan focal, optique, data processing

⇒*Besoin de mobiliser la communauté derrière un tel projet.*

Funding Opportunities

- **CNES-led mission [Unlikely] DUNE Phase 0 estimated cost 250 M€**
  - mini-satellite budget: CNES: 75M€, foreign partners: 75M€ (including launch, not including academic manpower, data processing and science)
  - **Phase A review end of March 2006**
- **DOE-led mission [Possible?] CNES contribution?**
  - DOE is looking for partners. ~100 M$ contribution needed for an early start
- **ESA [Likely?]: *ESA only or ESA+DOE(implication JDEM?)***
  - SSAC recommendation: AO for a mission "*not exceeding a yearly budget, for a launch before 2020*". AO end 2006, beginning of 2007.
  - Interest expressed by Germany, Switzerland, Italy, UK, Spain
- **NASA [Possible]: *Midex or SNAP/JDEM***
  - Midex: $300M class missions (consolidated), fast track, tight management (eg. WMAP)
  - Expect Midex AO at end of 2006 or spring 2007
  - Ongoing discussions with JPL (executives and scientists)
  - Collaboration: French participation to Midex proposal (~20% of total cost, or ~M$30+30)

Agenda

- Mars 2006: **Recommandation du PNG par rapport aux imageurs grands champ spatiaux (type de sondage, IR?, # de filtres, priorité?)**
- Fin Mars 2006: *Revue et décision de passage en phase A du CNES (3 missions dont DUNE)* ***but:*** *avoir une place importante dans une future mission en collaboration avec d'autres partenaires.*
- 2006 -2007: phase A CNES si DUNE est sélectionné (durée ~un an) ***implication plus forte de la communauté PNG (cas scientifique)?***
- Fin 2006-début 2007: AO Midex (?) - AO ESA
- Mi 2006: Proposition Collaboration SNAP DOE-CNES ?
- Mi 2007-fin 2007: Propositions Midex (JPL/CNES) - ESA
- 2012: Cible lancement Midex
- 2013: Cible lancement SNAP si collaboration DOE+XXX (hors NASA)
- >2015: Cible de lancement pour la version ESA (fast track?)
- >2015: Cible lancement SNAP si collaboration DOE/NASA programme JDEM