Les amas dans la toile cosmique:

Optical Surveys

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outline

- The Abell catalogue: the first large scale cluster survey
- Galaxy redshift surveys: what are they for?
- Optical surveys landscape
- JPAS – *Javalambre Physics of the Accelerating Universe Astrophysical Survey (+ JPLUS, SMAPS)*
- PFS/SuMIRe – *Prime Focus Spectrograph for the Subaru Measurement of Images and Redshifts*

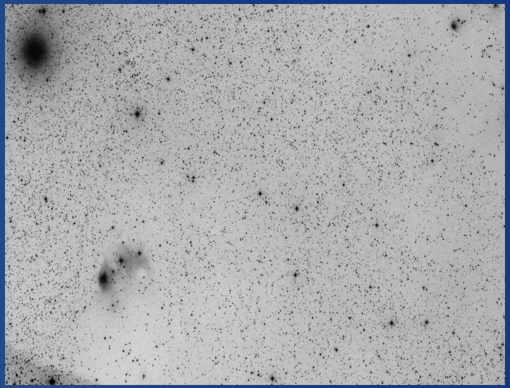
The first large-scale cluster survey: *the Abell catalogue*

- Abell (1958): *The Distribution of Rich Clusters of Galaxies* **PhD work at Caltech supervised by Don Osterbrock**
- **POSS**: Palomar Observatory Sky Survey

  conducted by Caltech with a grant from the National Geographic Society

  936 photographic plate pairs (red and blue) taken between Nov./1949 and Dec./1958 with the 48 inch Schmidt telescope of Palomar Observatory
- **visual** examination of 879 pairs of plates with $\delta > -27^0$
- clusters selected in objective, physically meaningful way
- catalogue of 2712 clusters; 1682 in the statistical sample (complete up to z=0.2)
- Parameters: richness, **(m_{10}, photometric)** redshifts

George Abell (1927-1983)



richness distribution
(mass function)

no detectable evolution at low z

THE DISTRIBUTION OF RICH CLUSTERS OF GALAXIES*

GORGE O. ABELL†
Mount Wilson and Palomar Observatories
Carnegie Institution of Washington, California Institute of Technology
Received September 30, 1957; revised November 13, 1957

ABSTRACT

A catalogue is prepared of 2712 rich clusters of galaxies found on the National Geographic Society–Palomar Observatory Sky Survey. From the catalogue, 1682 clusters are selected which meet specific criteria for inclusion in a homogeneous statistical sample. An investigation of the sample leads to the following conclusions: (1) the distribution function of clusters according to richness, $N(n)$, increases rapidly as n decreases; (2) the data allow no significant decision that the spatial density of cluster centers varies with distance; (3) galactic obscuration of the order of a few tenths of a magnitude (photored) exists at high northern galactic latitudes around galactic longitude 300°; (4) there is a highly significant non-random surface distribution of clusters, both when clusters at all distances and when clusters at various distances are considered. An analysis of the distribution yields evidence that suggests the existence of second-order clusters, that is, clusters of clusters of galaxies. A statistical test reveals no incompatibilities between the observed distribution and one of complete second-order clustering of galaxies.

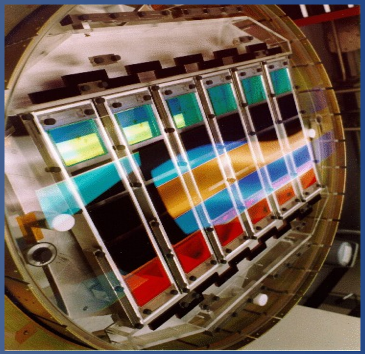
dust distribution

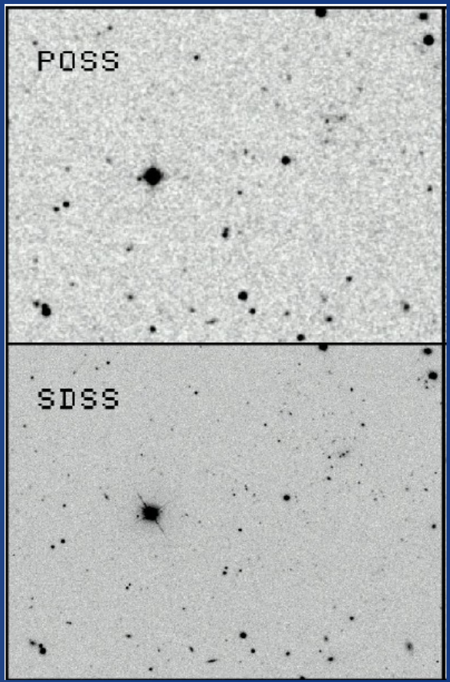
cluster clustering

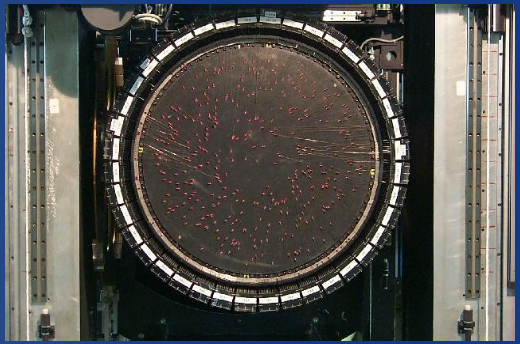
Bahcall (1999, PASP)

post-Abell survey science

- technology:
- CCDs: sensitivity (speed!), linearity
- spectral *multiplexity*: multi-object spectrographs
- Multi-wavelength





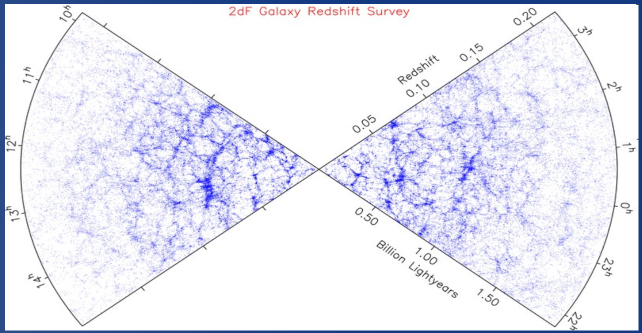


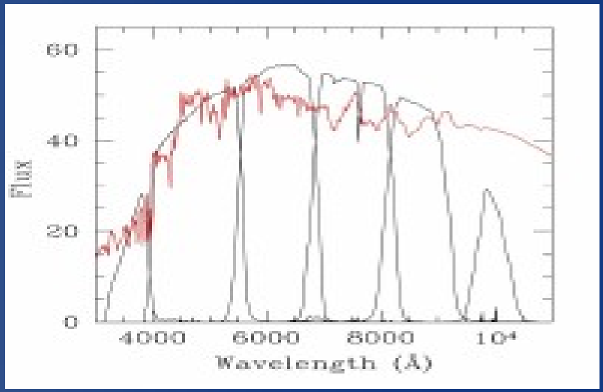
- cluster science:
- cosmology: optical, X-ray, NIR, sub-mm, mm
- structure, galaxy evolution: optical, UV, NIR, radio

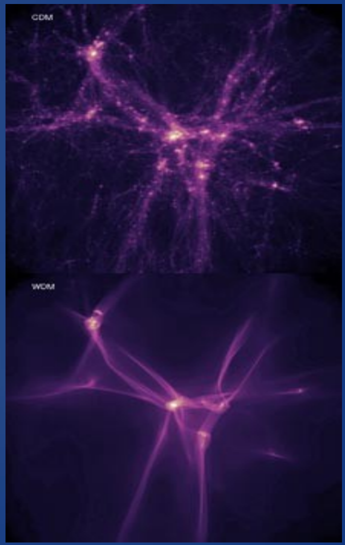
Galaxy Surveys

- Parameters:
  - area, depth (limiting flux): volume
  - accuracy in distances: spectroscopic or photometric redshifts

- Main driver today: cosmology
  - Aim: to obtain 3-D maps of the galaxy distribution: cosmology is imprinted in the galaxy distribution
  - the data obtained for cosmology (spectra or colors) is useful for many other studies



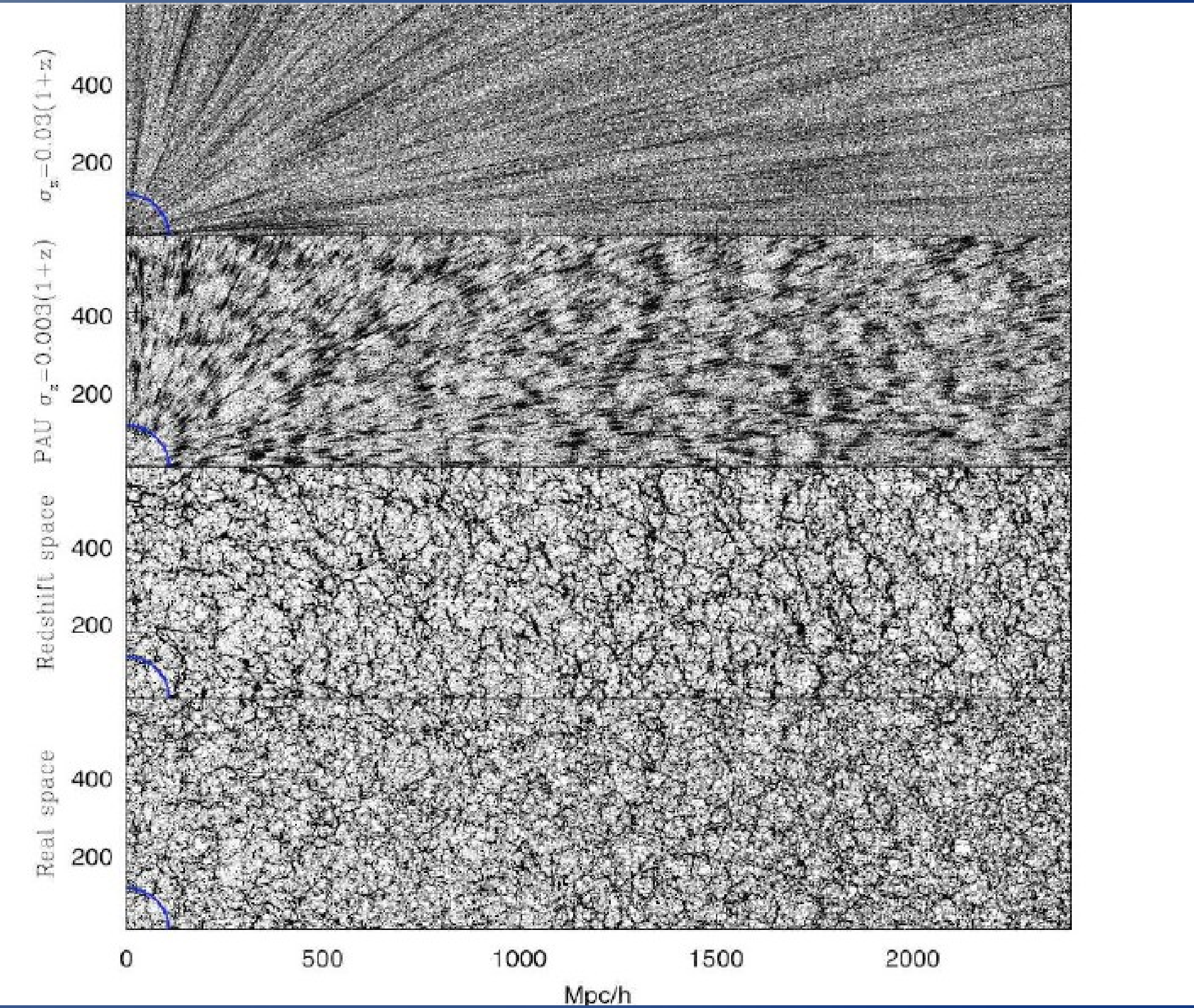




- accuracy:
  - normal spectra: ~100km/s
  - photo-z:
    - SDSS: ~10,000km/s
    - JPAS: ~1000km/s

- physical effects:
  - redshift space distortions due to peculiar velocities
  - bias: mass x light

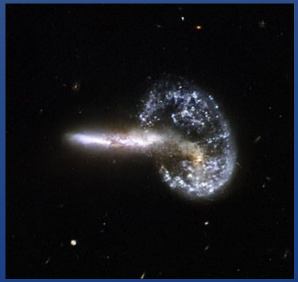
- data analysis:
  - challenging!
  - Bayesian methods

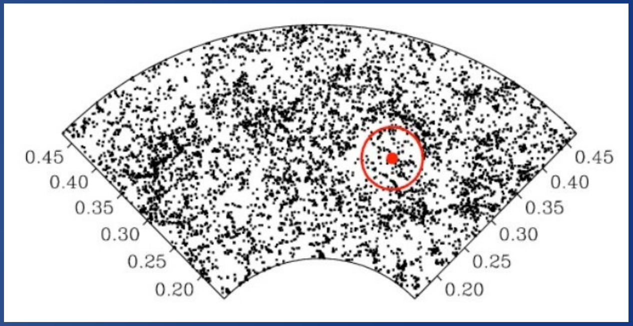


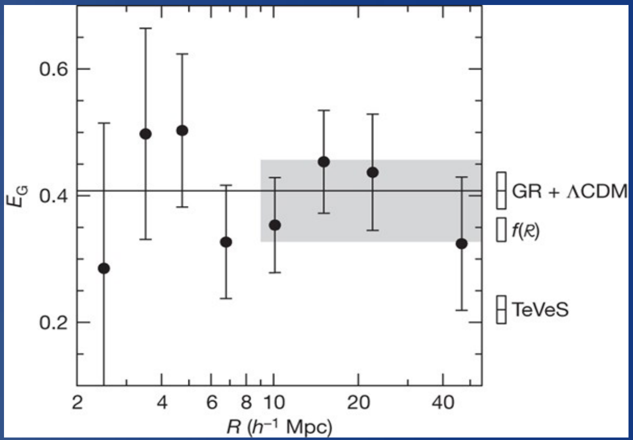
Benitez et al. (2009)

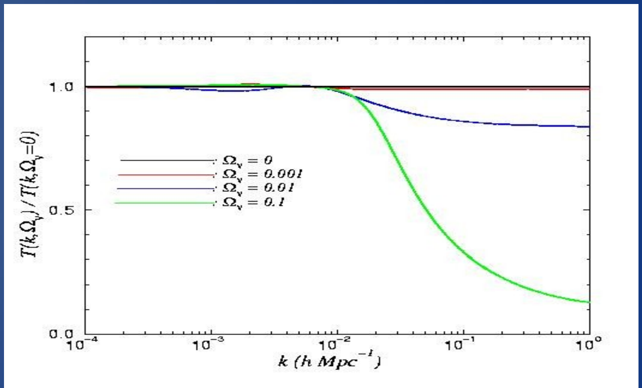
Galaxy surveys: applications

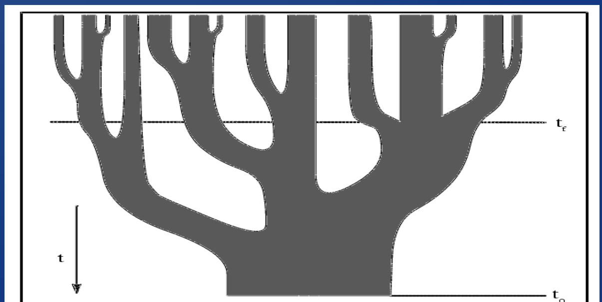
- Cosmology: BAOs (transversal & radial), weak-lensing, cluster counts, dark matter, …
- Tests of gravitation theory: joint analysis of expansion and structure growth
- Large scale structure: from galaxies and groups to superclusters
- neutrino mass
- Galaxy evolution: SFR, M*, morphology, environment, mergers
- Galaxy archeology
- ...











Advantages and Challenges for cluster science

- Advantages:
- Large number of objects
- Samples well defined
- Cosmology in a variety of ways
- Very rich astrophysics: ICM, galaxy evolution, feedback(s),...

- Challenges
- Cluster identification and selection:

  galaxy overdensity

  red sequence

  X-ray emission

  Sunyaev-Ze'ldovich effect

- Mass calibration: relationship between cluster mass and observables (e.g., richness)

  importance of weak-lensing

  calibration for the full redshift interval of the samples

  (equilibrium?)

Survey landscape

CURRENT SURVEYS

Survey	Telescope	Métodos	Timeline
SDSS BOSS	Spectroscopy 2.5m (SDSS)	BAO z<0.7	2009-2014
DES	Broad band imaging 4m	BAO(transversal),SN, WL, CL,	2012-2016
Pan-STARRS1(2)	Broad band imaging 1.8m	SN, WL(?), CL	2009 (2014?)

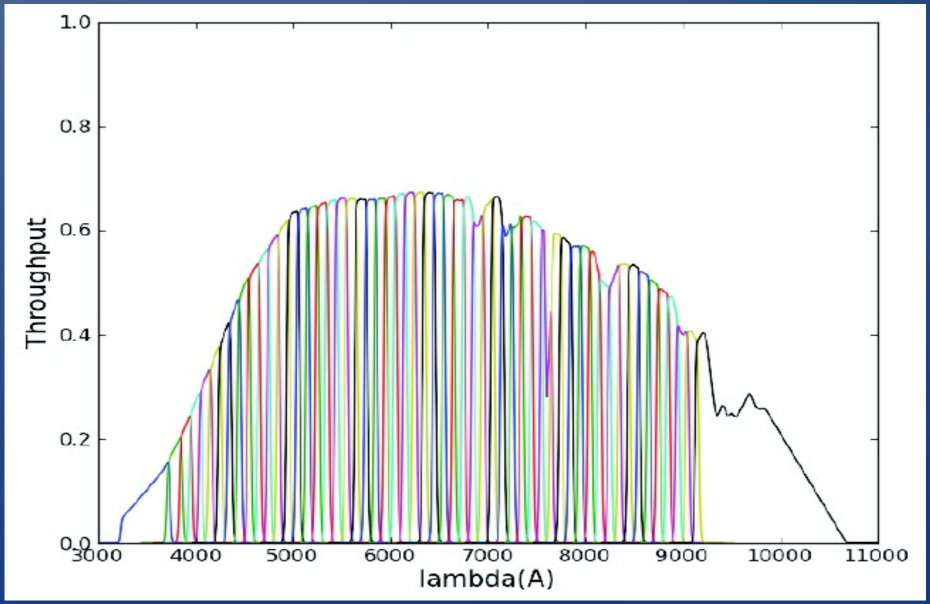
FUTURE SURVEYS

Survey	Telescope	Métodos	Timeline
BigBOSS	Spectroscopy	BAOs (10000 sq.deg)	2018(?)-2024
LSST	Broad band imaging, 8.4m	BAO(transversal), SN, WL	2018?
Euclid	Satellite, broad band imaging, grism	SN, WL, CL ?	2019?

JPAS 2013-2019?
PFS/SuMIRe 2017-2023?

JPAS
Javalambre Physics of the Accelerating Universe Astrophysical Survey

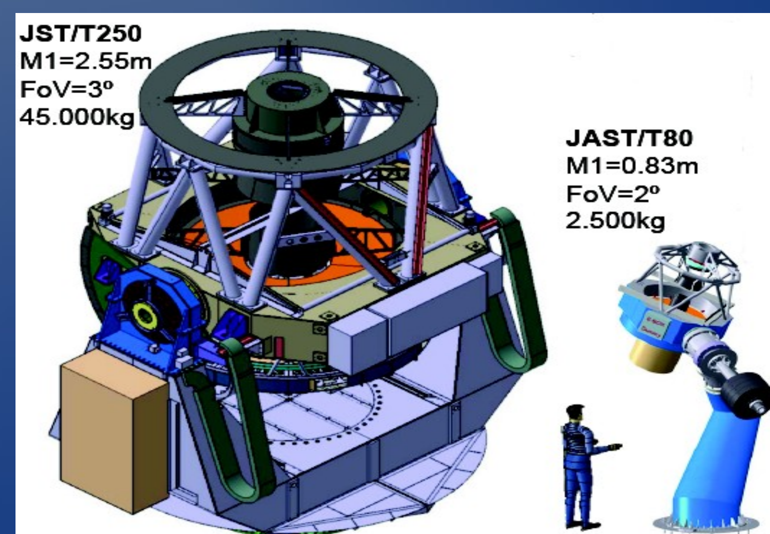
- A new concept of survey: we plan observing ~8000 sq. deg. with 56 filters (54 narrow band and 2 broad band filters) up to I < 22.5
- System designed to achieve photo-z for more than 100 million LRGs up to z~1 with accuracy ~0.003(1+z)
- Dark energy: it will measure radial and transversal BAO, SNe, weak-lensing, cluster counts, high redshift QSOs
- Clusters, quasars, galaxy evolution, galaxy archeology, small bodies in the Solar system...



jpas-paubrasil.org

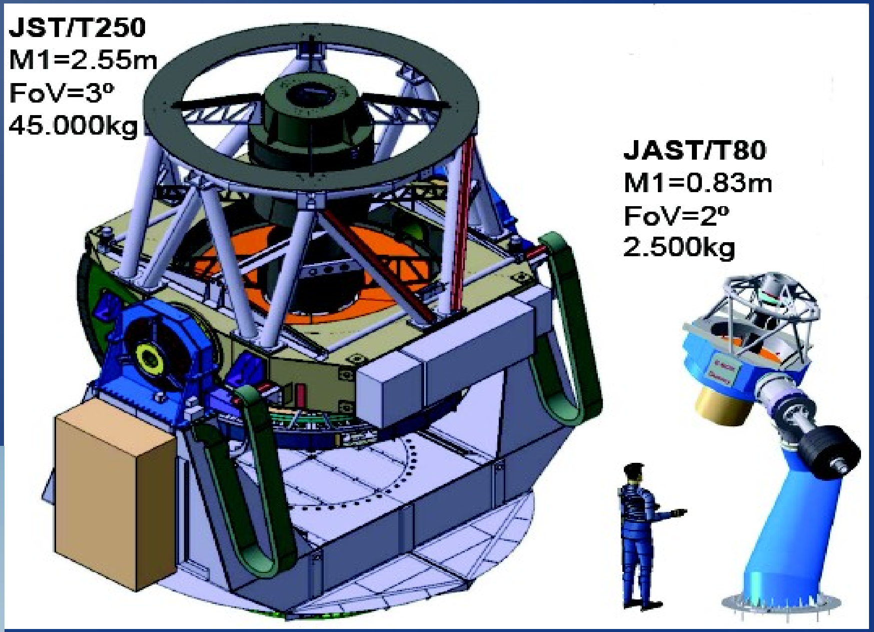
JPAS
Javalambre Physics of the Accelerating Universe Astrophysical Survey

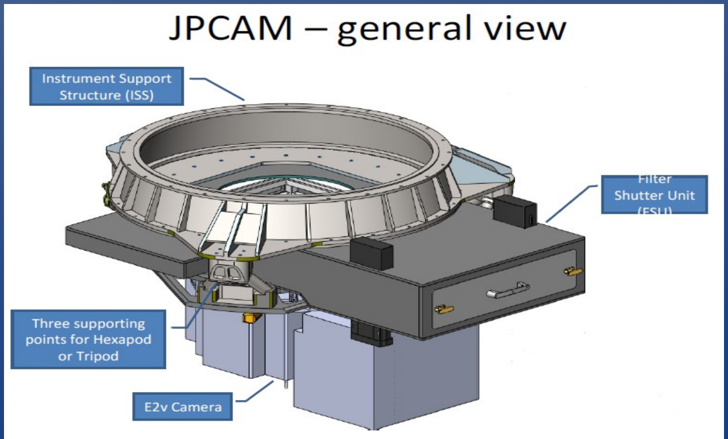
- Colaboration between Brazil and Spain:
  - Brazil: ON, CBPF, UFRJ, IAG, IF, INPE, UFRGS, UFSC,...
  - Spain: IAA, CEFCA, IAC, UCM,...
- JAO: Javalambre Astrophysical Observatory, Teruel, Aragón
- Spain (CEFCA) is responsible for the JAO and Brazil for the cameras

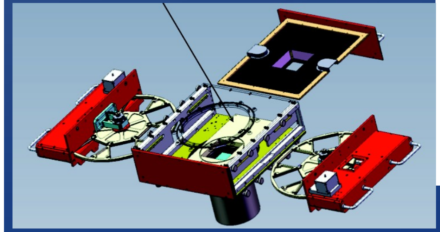


JPAS
Javalambre Physics of the Accelerating Universe Astrophysical Survey

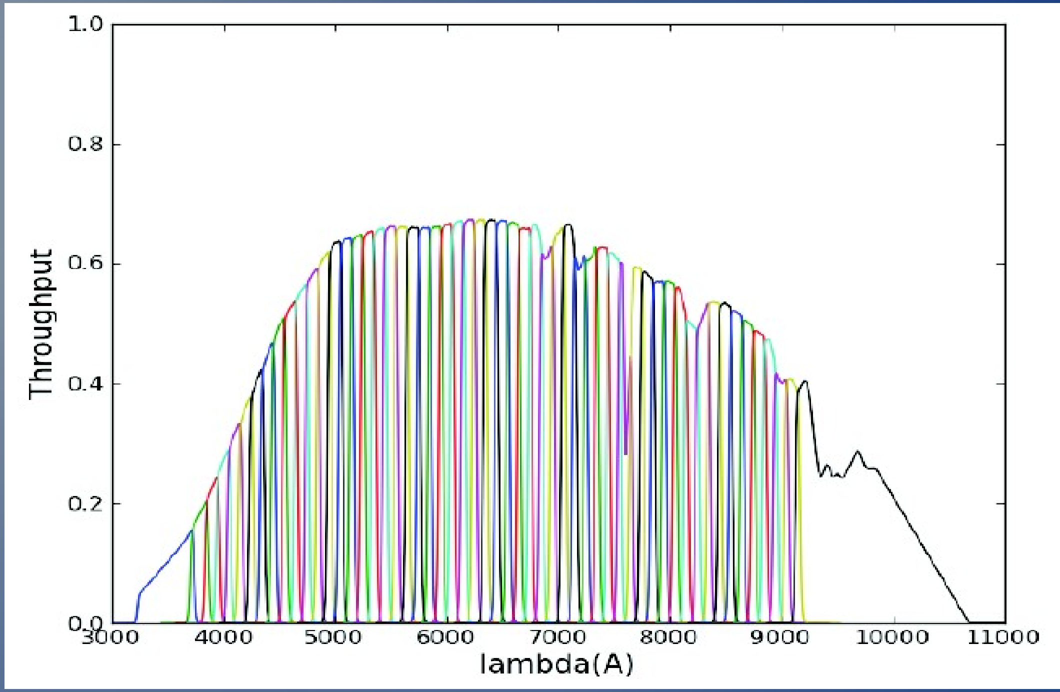
- T250: telescope with diameter of 2.5m+ camera with FOV of 5 sq. deg. with 1.2 Gpixel
- T80: telescope with diameter of 80cm + camera with FOV of 2 sq. deg. for calibration



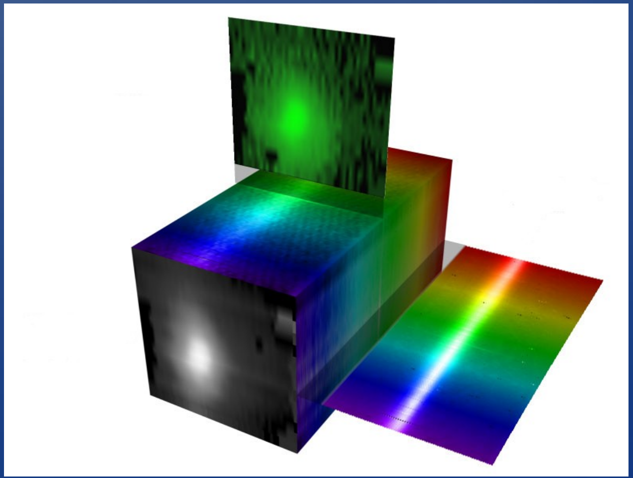




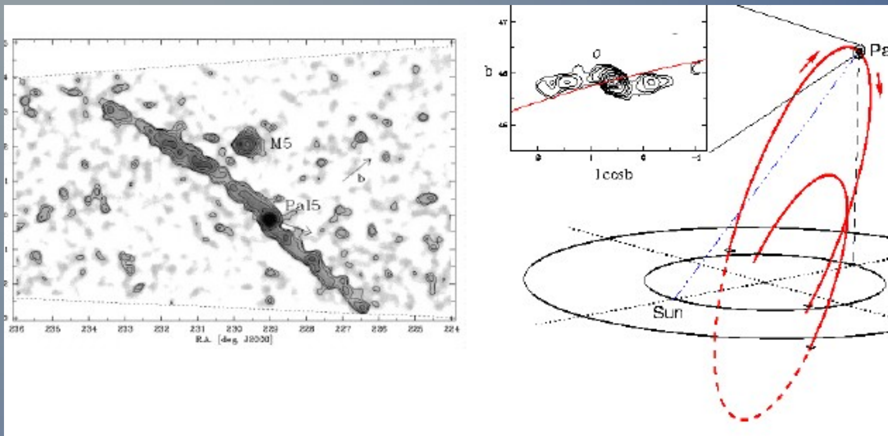
56 filters- accuracy in photo-z: ~0.003(1+z) for LRGs



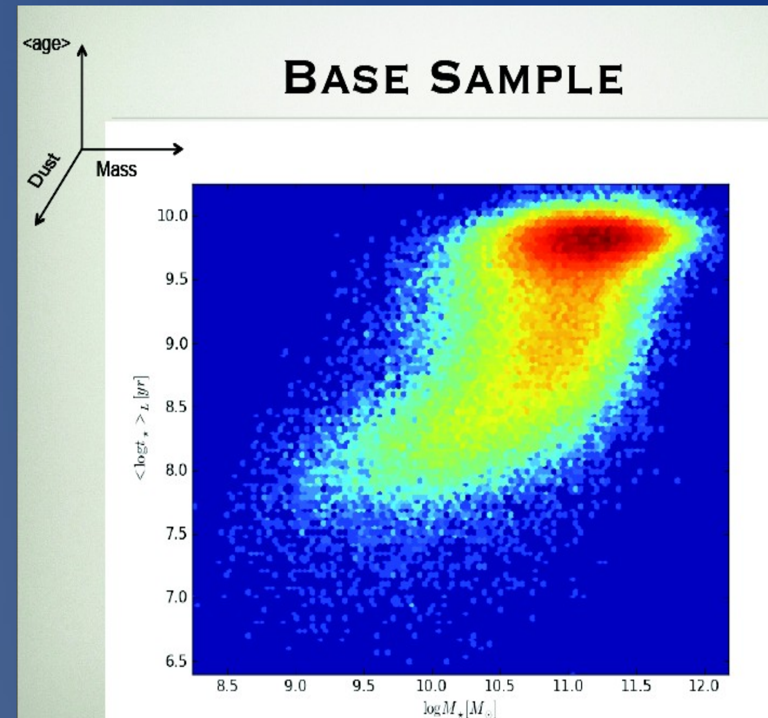
- The photometry corresponds to low-resolution spectra (R~50-60)
- **JPAS: low resolution spectrum for each pixel of a image**
- **"all-sky" *IFU science*!**



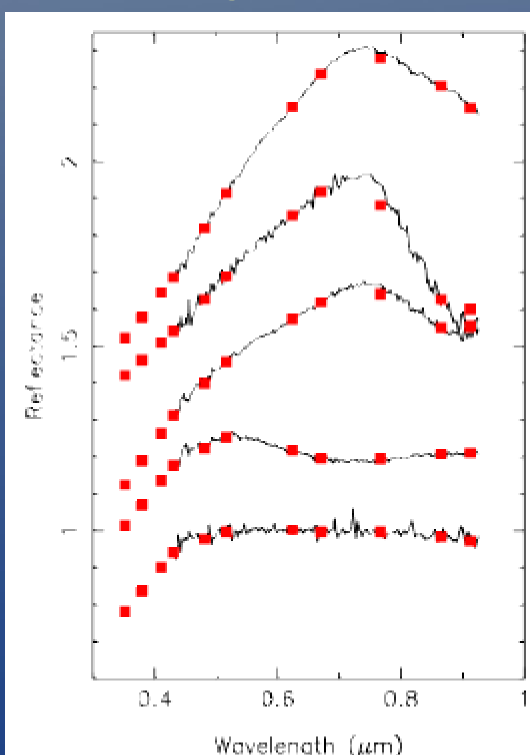
formation of Miky Way through the Observation of halo stars



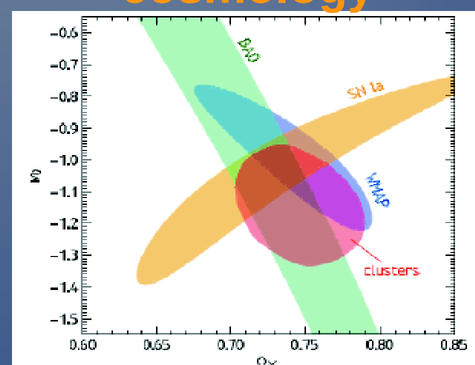
(resolved) galaxy evolution

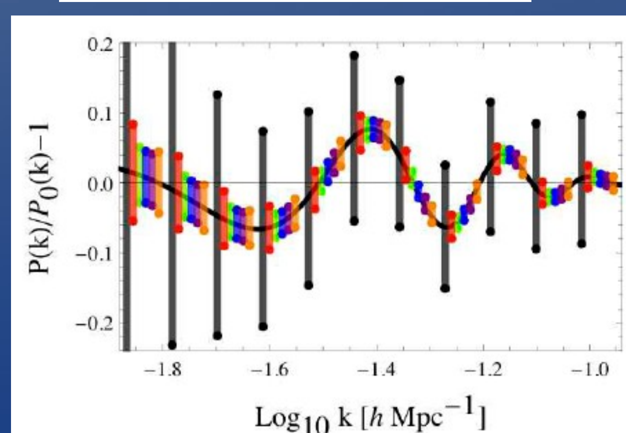


small bodies in the Solar System

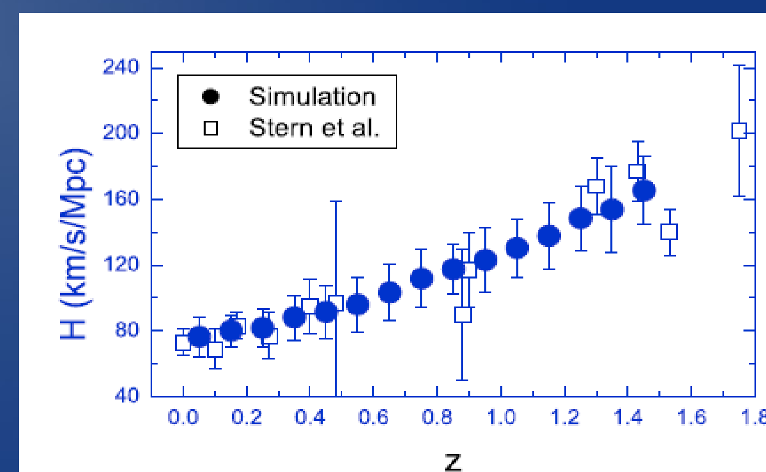


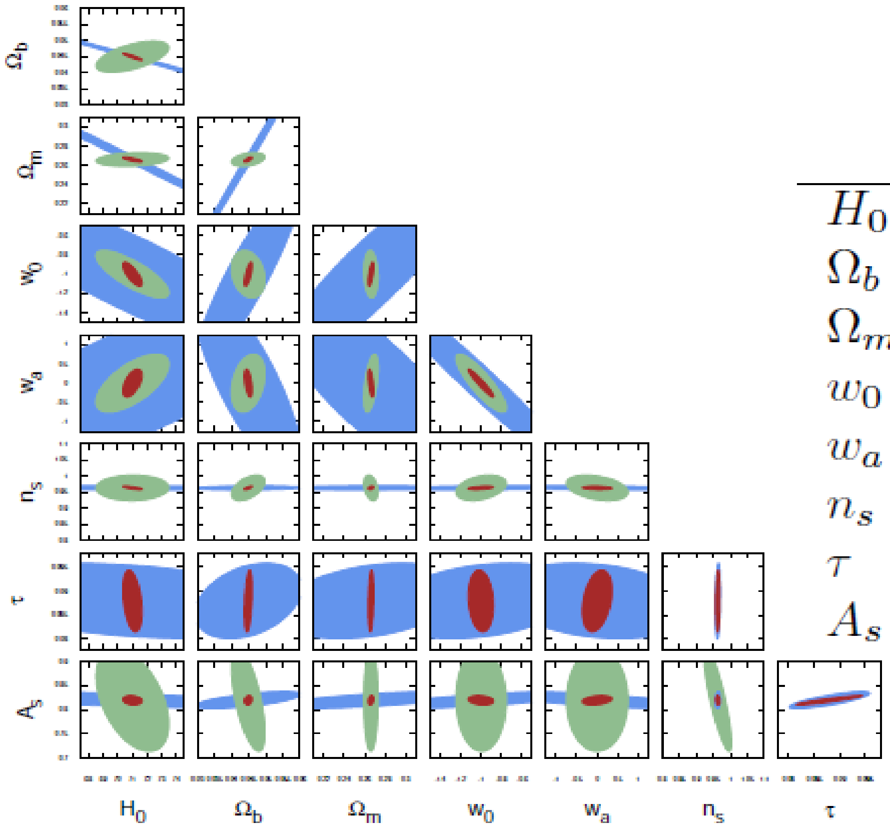
cosmology





Abramo et al. (2012)

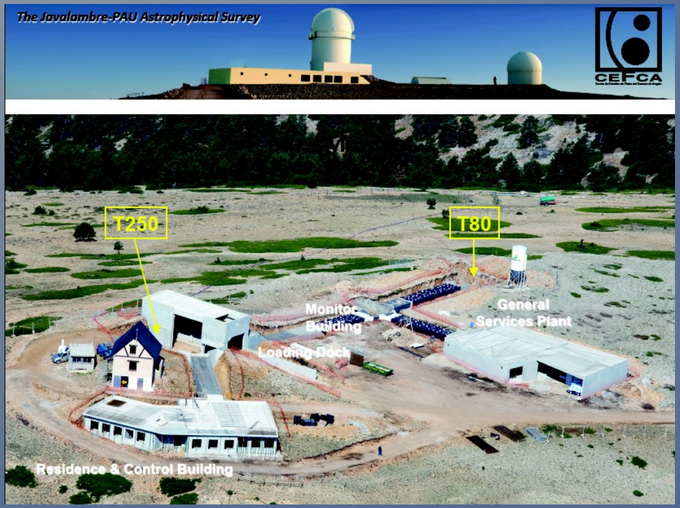




	J-PAS	Planck	J-PAS + Planck
H_0	1.63	8.13	0.42
Ω_b	0.0032	0.010	0.00071
Ω_m	0.0045	0.061	0.0017
w_0	0.16	0.64	0.081
w_a	0.49	1.58	0.24
n_s	0.026	0.0044	0.0037
τ	-	0.0051	0.0042
A_s	0.070	0.012	0.0063

Data	Ω_m	Dark energy parameters	FoM	$\rho_{1,2}$	DIC
BAO (Percival)+SN (Union)	0.315 ± 0.033	$w_0 = -1.033 \pm 0.180$ $w_a = -0.742 \pm 1.520$	14.16	-0.930	10.30
BAO (JPAS LRGs)	0.268 ± 0.032	$w_0 = -1.084 \pm 0.228$ $w_a = 0.380 \pm 1.017$	107.71	-0.941	17.13
BAO (JPAS ELGs)	0.244 ± 0.039	$w_0 = -1.163 \pm 0.242$ $w_a = 0.791 \pm 0.986$	134.59	-0.942	17.31

$$w(z) = w_0 + w_a \frac{z}{1+z}$$



when?

- T80 – september 2012

  J-PLUS: march 2013

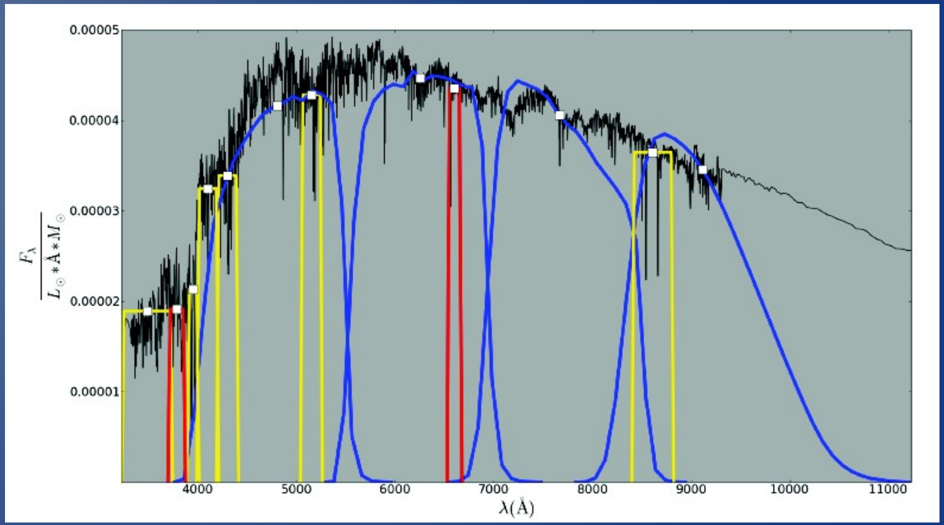
- T250 – june 2013

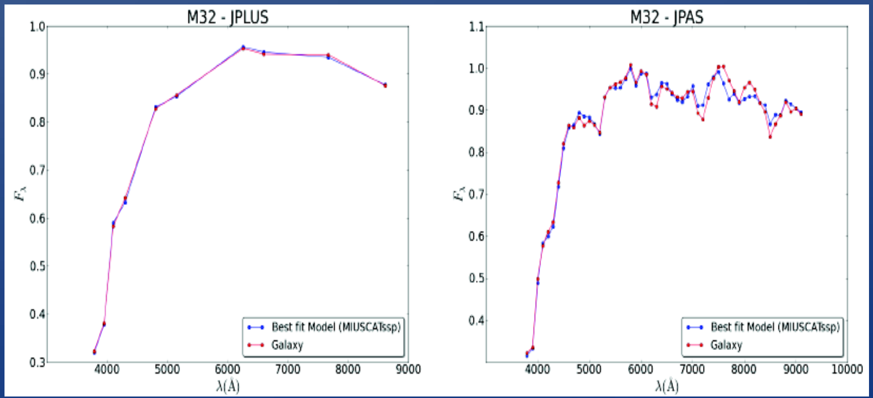
  JCam: february 2014

J-PLUS/T80

The Javalambre Photometric Local Universe Survey

- Motivation:
  - Provide photometric calibration for JPAS
  - Test the scientific, technological and management systems of JPAS
- 12 filters: 4 from SDSS + 8 narrow or intermediate width
- 5000 sq. deg., AB~22-23 (S/N >5)
- start: march 2013
- Duration: 2-2.5 years





SMAPS
Southern massive astrophysical panchromatic survey

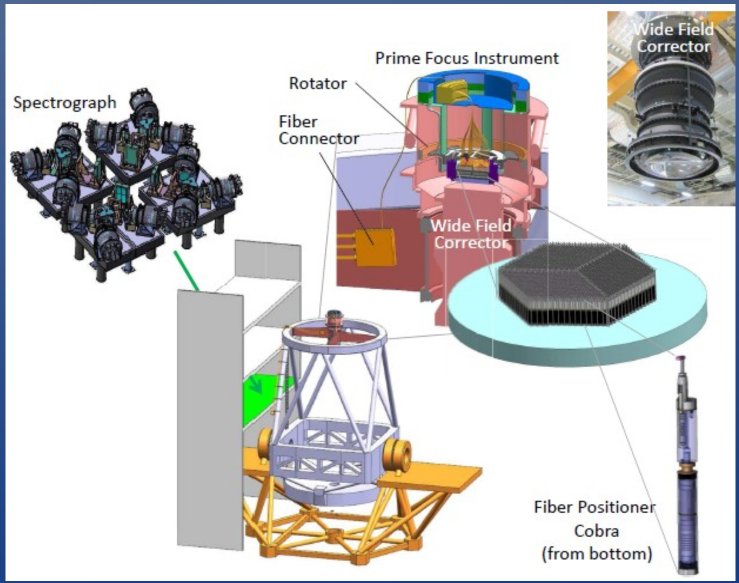
- Souther extension of JPAS, in Cerro Tololo, Chile
- Idea: to clone JPAS telescopes, cameras, etc
- Cost < US$30M
- SMAPS+JPAS: first 'all-sky' optical survey!
- *SMAPS+JPAS: first 'all-sky' IFU-like survey!*
- *www.fma.if.usp.br/smaps*

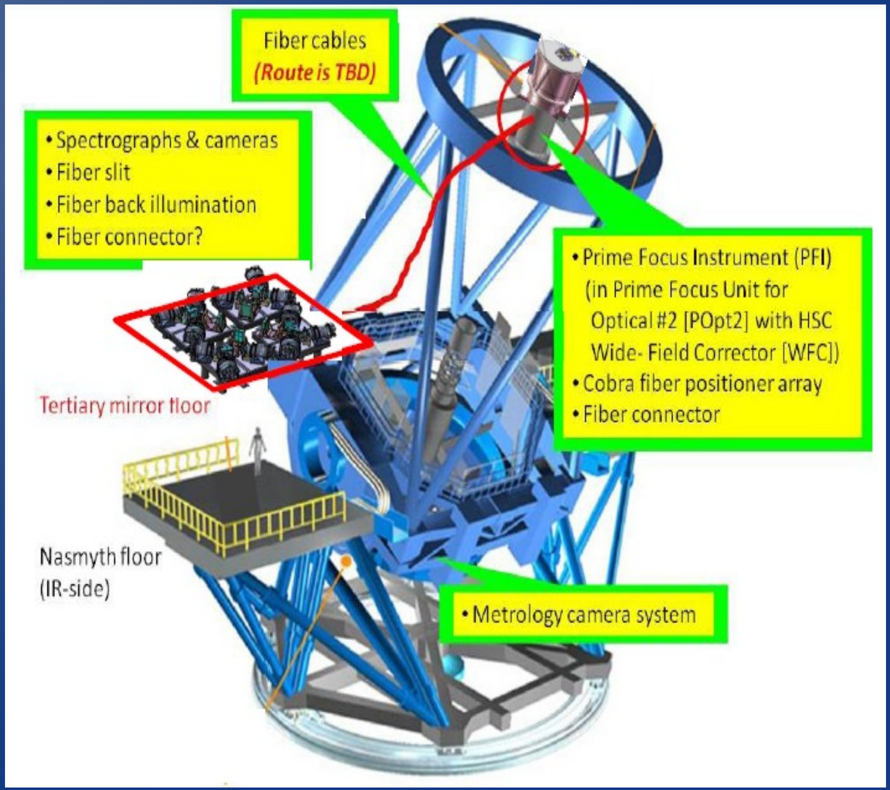
- July 2012 – shipping of T80-South to C. Tololo
- July 2013 – building of T80-South completed at C. Tololo
- 2013 – Camera cold part completed

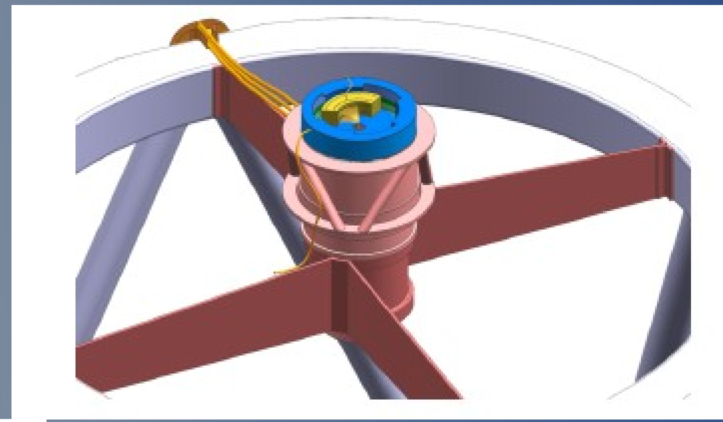
PFS/SuMIRe
Prime Focus Spectrograph for the Subaru Measurement of Images and Redshifts survey

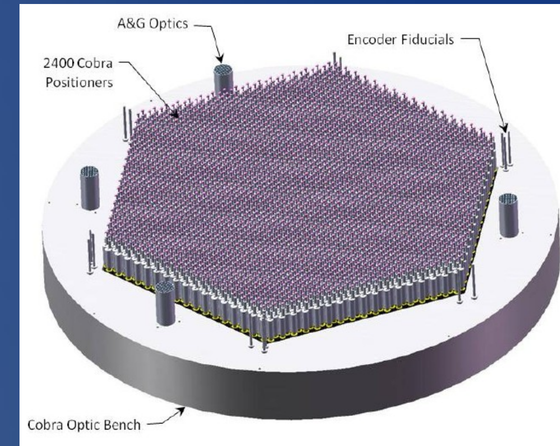
- Sucessor of Gemini WFMOS
- PI: Hitoshi Murayama Kavli IPMU (U. Tokyo)

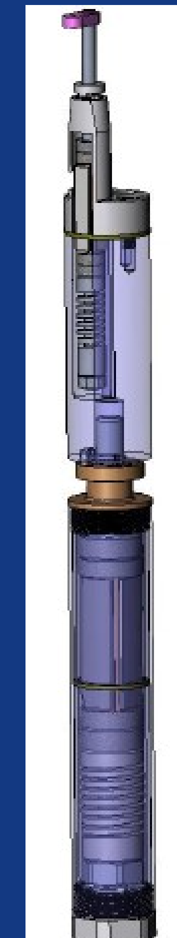
  + Taiwan, Princeton, Caltech, JPL, Johns Hopkyns, LAM/Marseille, Brasil (USP,LNA,...)
- Time span: 2017-2023
- 2400 fibers within a field of 1.3 deg. diameter,
- Spectral range: 0.38 – 1.3 microns, R ~ 3000

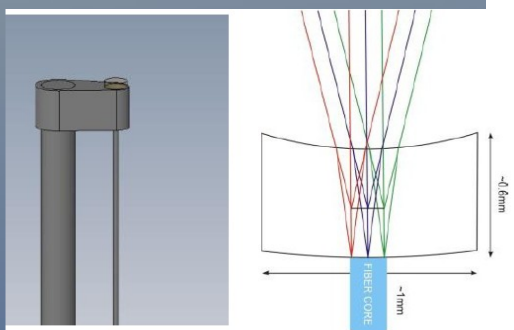


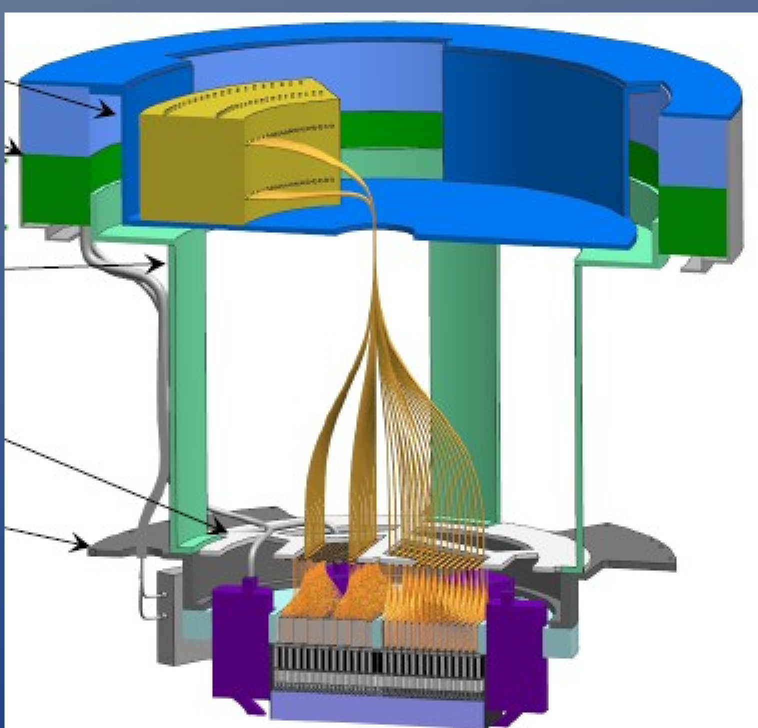


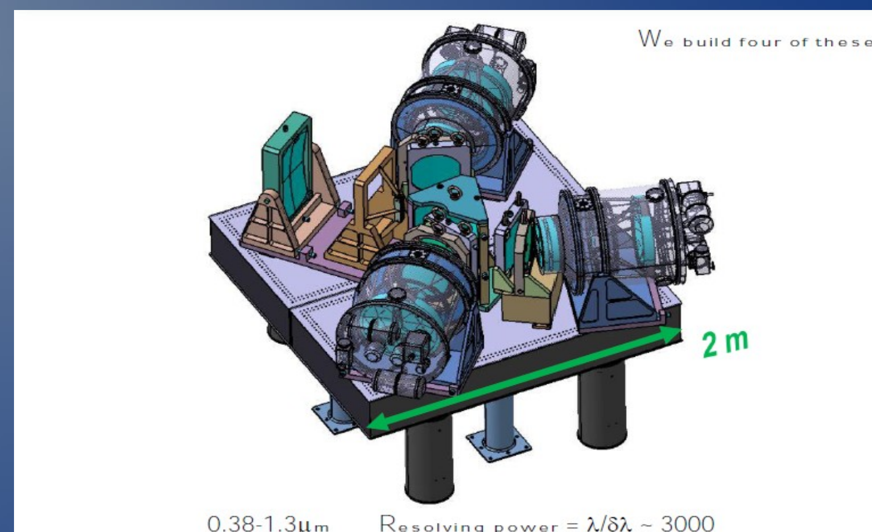


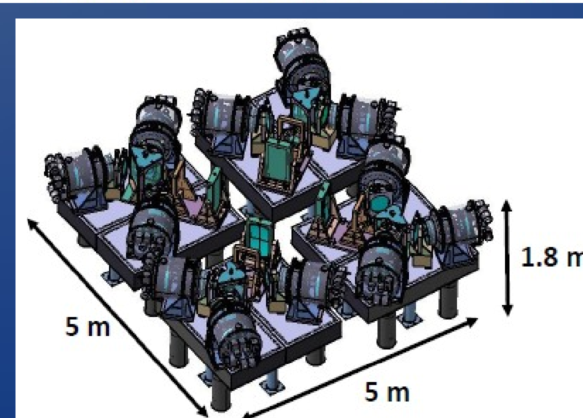

A&G Optics
Encoder Fiducials
2400 Cobra Positioners
Cobra Optic Bench





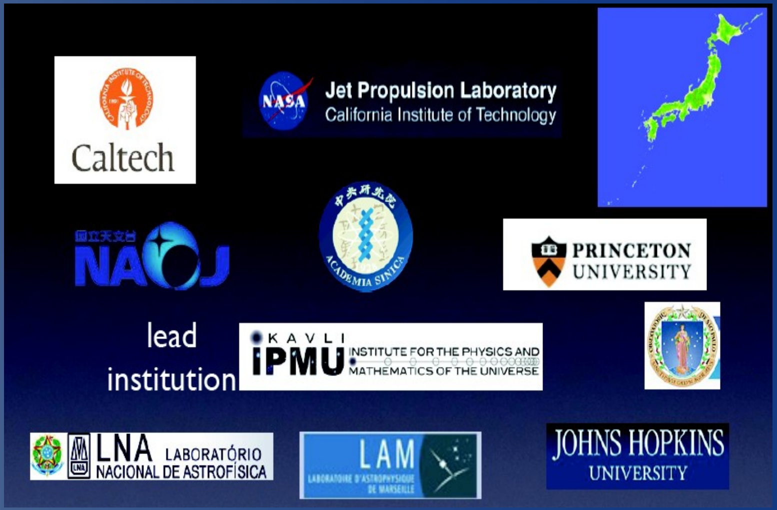


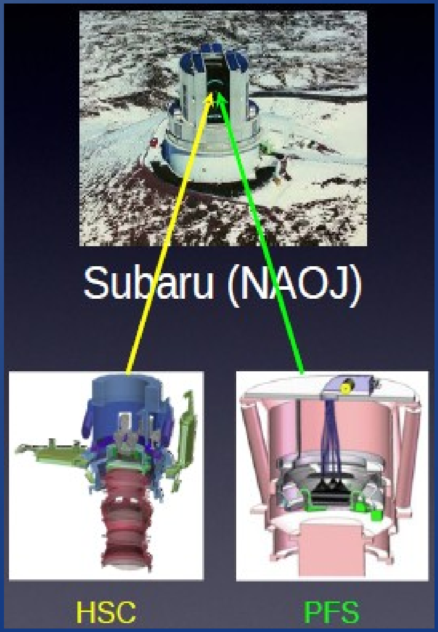

We build four of these.
2 m
0.38-1.3μm Resolving power = λ/δλ ~ 3000


1.8 m
5 m
5 m

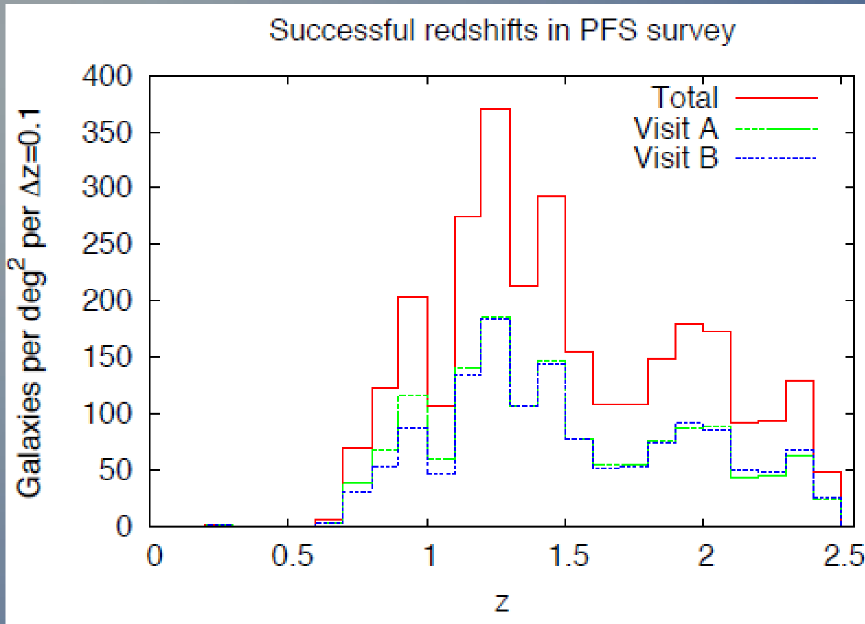
PFS/SuMIRe
Prime Focus Spectrograph for the Subaru Measurement of Images and Redshifts survey

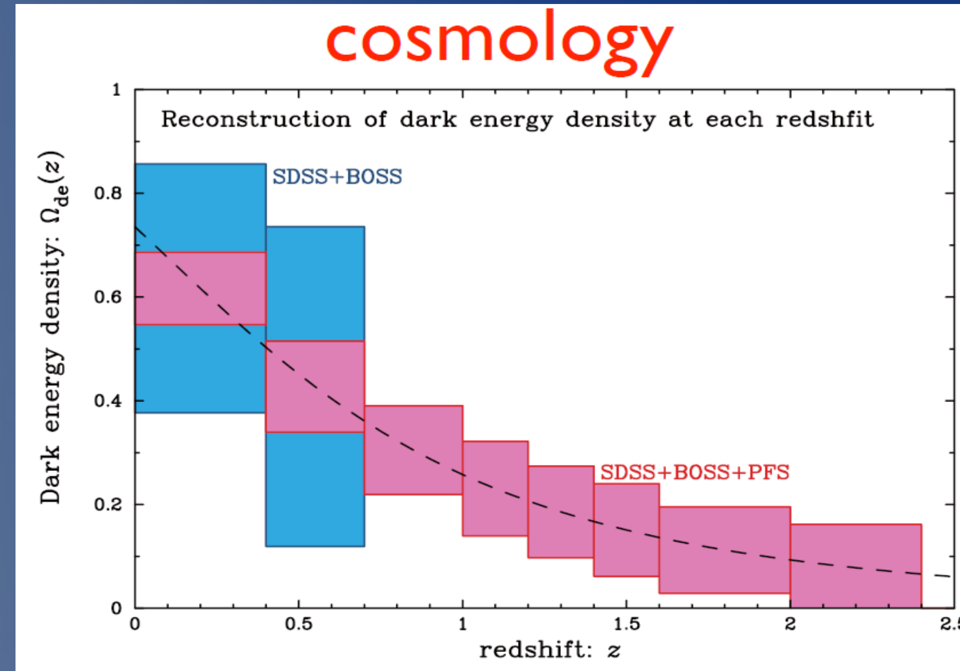
- BAO with ELGs in $0.8 < z < 2.4$ ($9.3\ h^{-3}\ Gpc^3$)
- 6 independent redshift bins: cosmological distances with 3% precision; structure growth (through redshift-distortion measures) to 6%
- Near-field cosmology: assembly history of MW and M31 through the observation of $\sim10^6$ stars with $17<V<20$ ($V\sim21$ in areas containing tidal streams)
- Galaxy population and clustering in $1<z<2$
- Lyman break galaxies and Lyman alpha emitters in $3<z<7$ to quantify the properties of early systems close to the reionization epoch

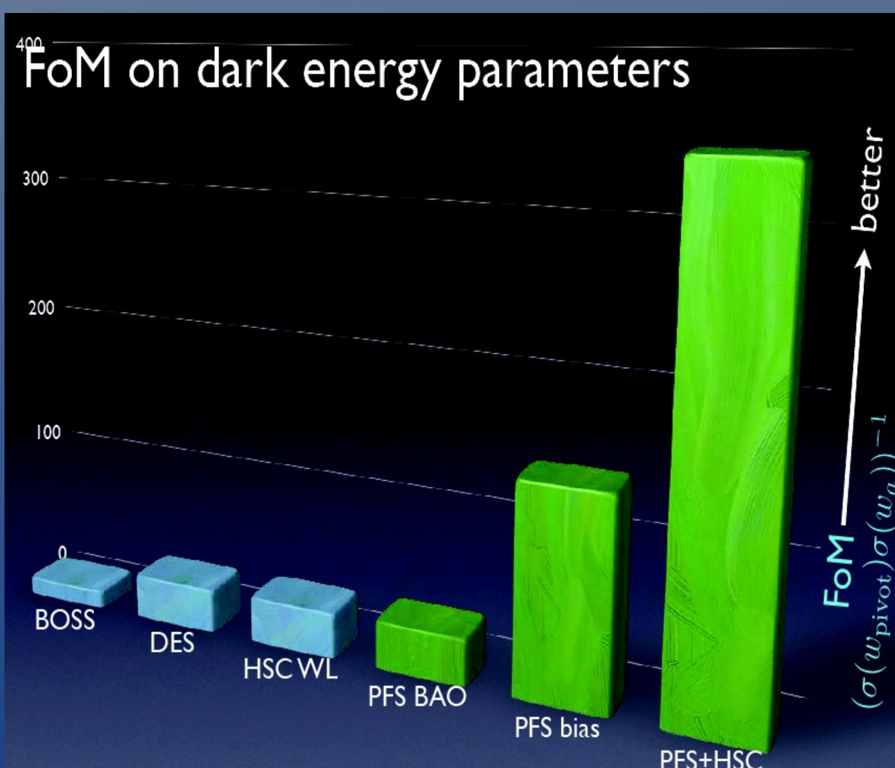


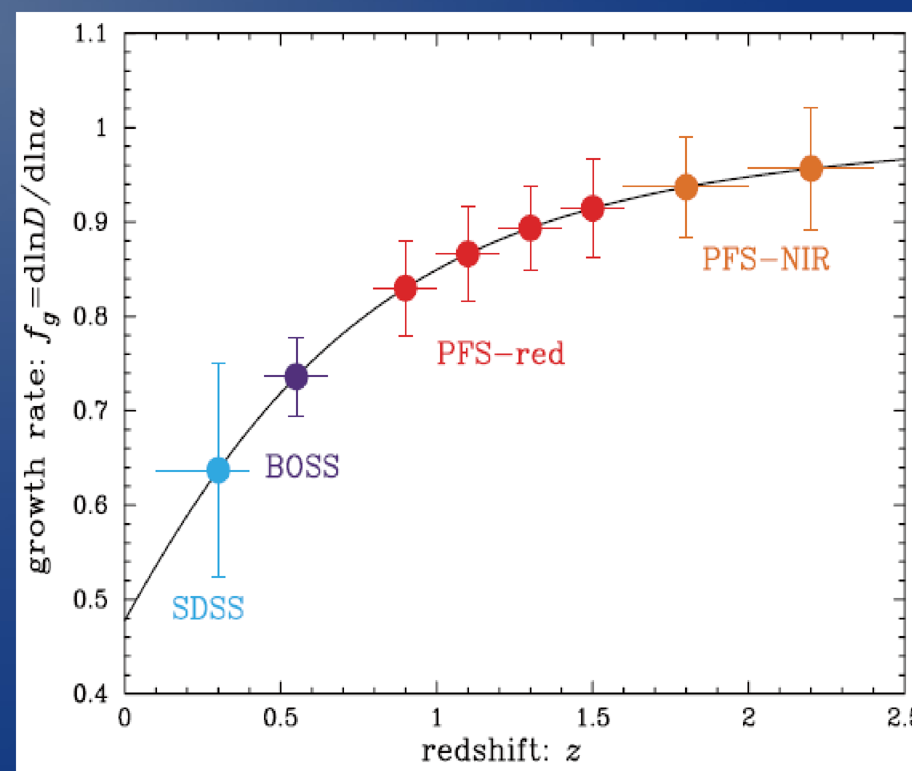


arXiv:1206.0737


Successful redshifts in PFS survey
Galaxies per deg² per Δz=0.1
Total
Visit A
Visit B
z
0 50 100 150 200 250 300 350 400
0 0.5 1 1.5 2 2.5


cosmology
Reconstruction of dark energy density at each redshfit
Dark energy density: $\Omega_{de}(z)$
SDSS+BOSS
SDSS+BOSS+PFS
redshift: z
0 0.2 0.4 0.6 0.8 1
0 0.5 1 1.5 2 2.5


FoM on dark energy parameters
400
300
200
100
0
better
FoM
$(\sigma(w_{pivot})\sigma(w_a))^{-1}$
BOSS
DES
HSC WL
PFS BAO
PFS bias
PFS+HSC


growth rate: f_g=dlnD/dlna
redshift: z
SDSS
BOSS
PFS−red
PFS−NIR
0.4 0.5 0.6 0.7 0.8 0.9 1 1.1
0 0.5 1 1.5 2 2.5

Summary:

- Galaxy surveys are essential tools of contemporary astrophysics
- They allow a large scope of astrophysical applications: solar system objects, Milky Way formation, galaxy evolution, cosmology,…
- New, potentially very interesting surveys: JPAS (+ JPLUS & SMAPS), PFS/SuMIRe
- Potential for new discoveries!