Brazilian projects and brazilian telescope access – complementarity with LSST

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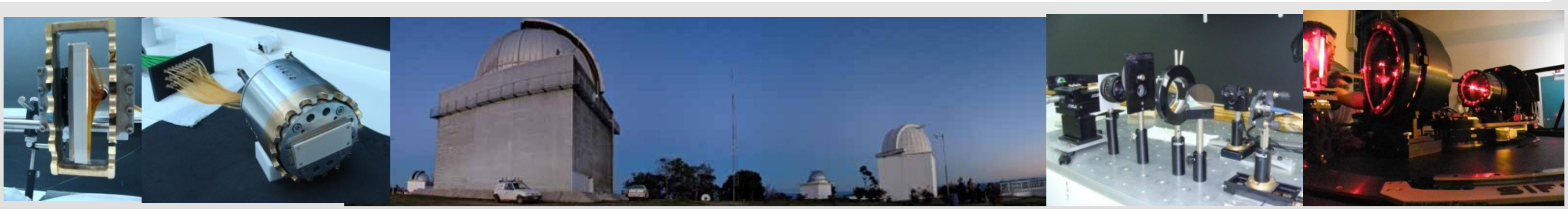
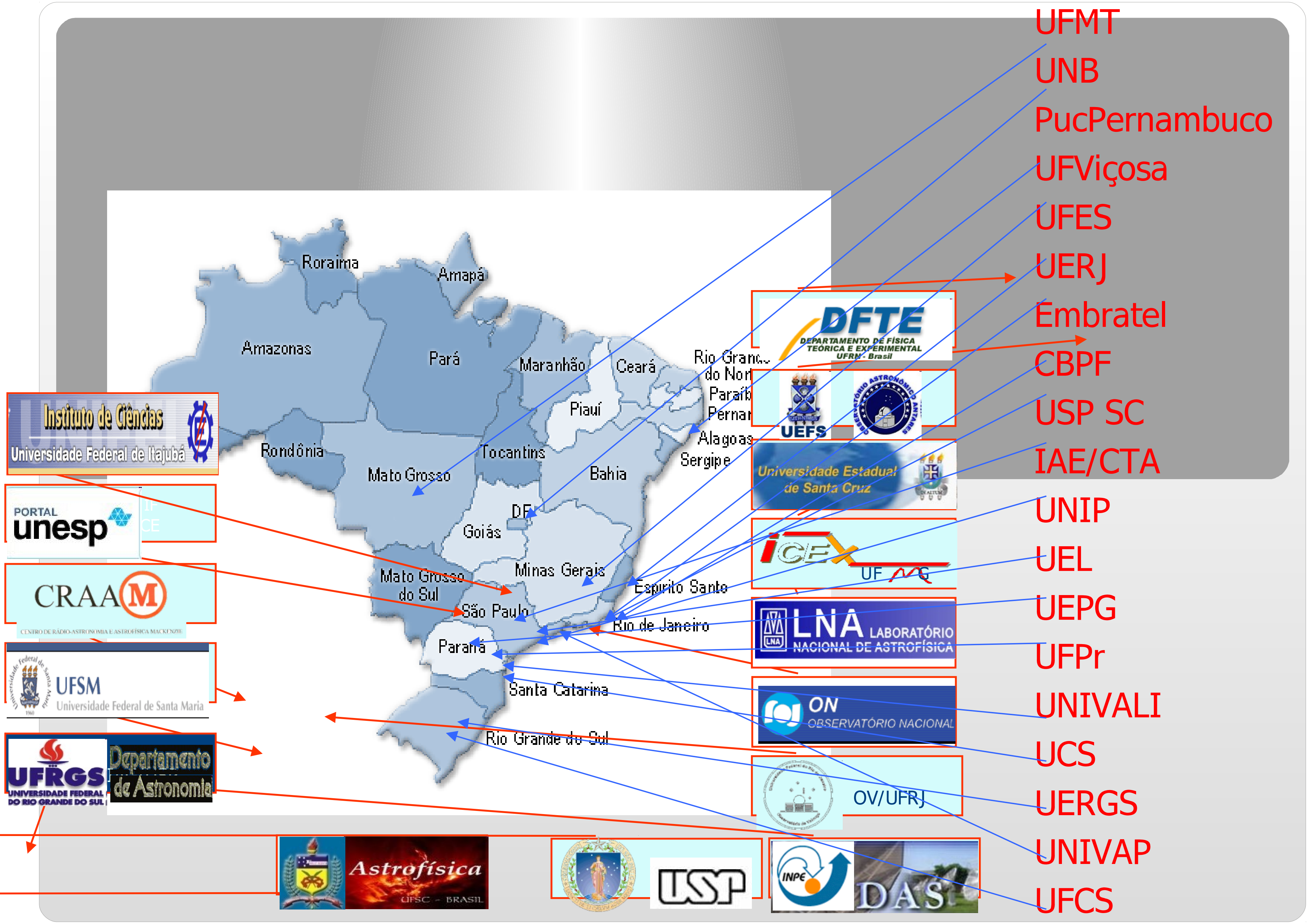
IAG – University of São Paulo



Outline:

- **Brazilian community in one slide**
- **Brazilian telescopes**
- **SOAR instruments - follow-up of LSST targets**
- **Other Brazilian projects:**
  DES, J –PAS/Pau Brasil and S-MAPS



UFMT
UNB
PucPernambuco
UFViçosa
UFES
UERJ
Embratel
CBPF
USP SC
IAE/CTA
UNIP
UEL
UEPG
UFPr
UNIVALI
UCS
UERGS
UNIVAP
UFCS
Roraima
Amapá
Amazonas
Pará
Maranhão
Ceará
Rio Grande do Norte
Paraíba
Pernambuco
Piauí
Alagoas
Sergipe
Rondônia
Tocantins
Mato Grosso
Bahia
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Goiás
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Espírito Santo
Mato Grosso do Sul
São Paulo
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UFRN - Brasil
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ICEx
UF MG
LNA LABORATÓRIO NACIONAL DE ASTROFÍSICA
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Departamento de Astronomia
Astrofísica
UFSC - BRASIL
USP
INPE
DAS

Observatório do Pico dos Dias

SOAR

Gemini

CFHT

Telescopes in which Brazil has participation

Brazilian participation in Gemini Consortium

- **Two 8m telescopes, installed at Cerro Pachón, Chile, and Mauna Kea, Hawaii;**

- **International consortium with seven partners;**

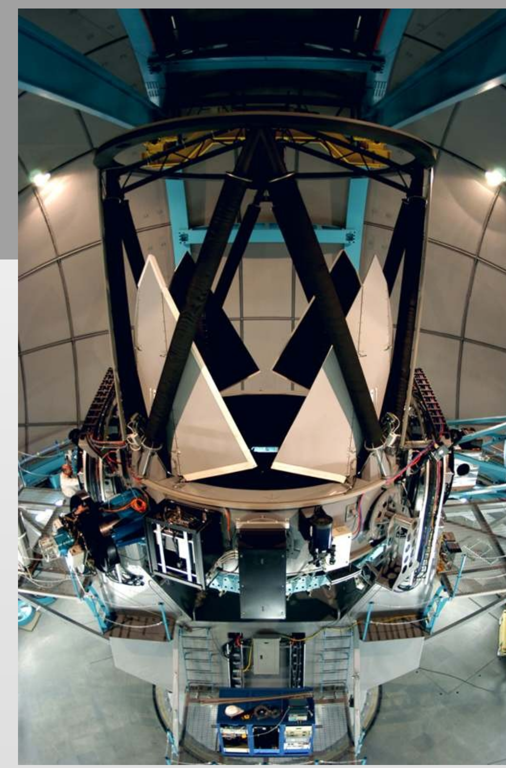
- **Brazil has 5% of the observing time;**

- **LNA is the home of the Brazilian NGO.**

- **Brazilian community is the most productive of the consortium in the relative number of papers…**

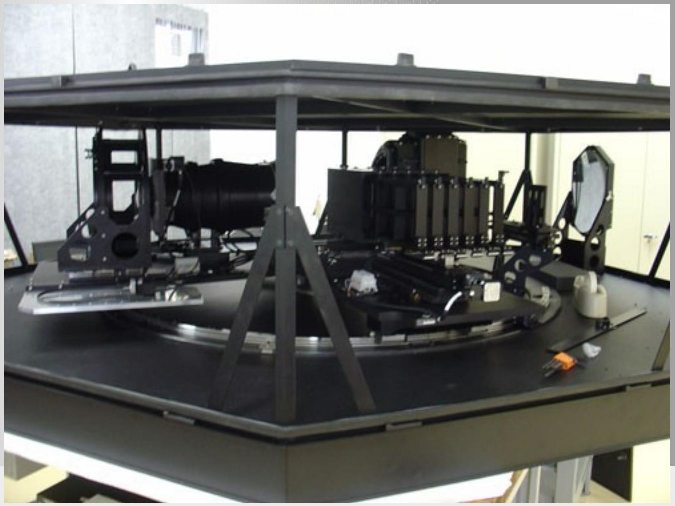
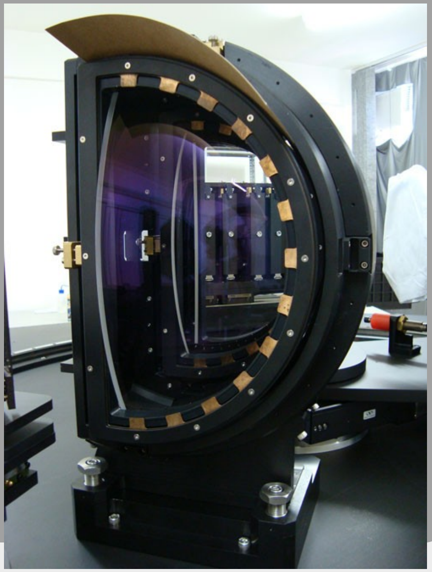
Management of the Brazilian participation at the SOAR telescope is done by LNA

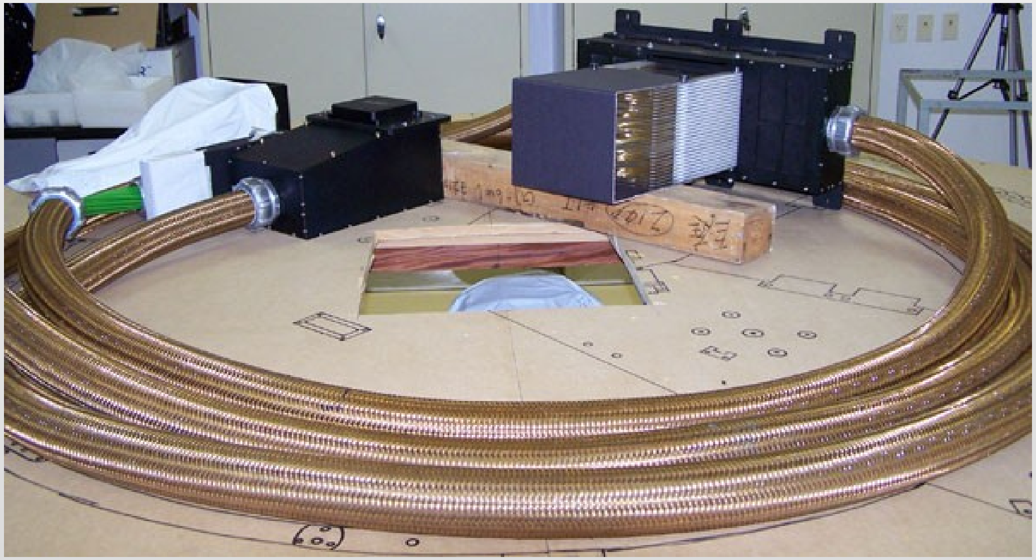
- **SOAR: Southern Astrophysical Research: 4.1 m telescope installed at Cerro Pachón, Chile;**
- **Collaboration USA – BR;**
- **First light in 2005;**
- **Brazil is a major partner (~34% of the observing time);**
- **Designed for excellent optical quality;**
- **All partners have responsibilities in the construction of first and second generation of instruments.**



SIFS -SOAR Integral Field Spectrograph

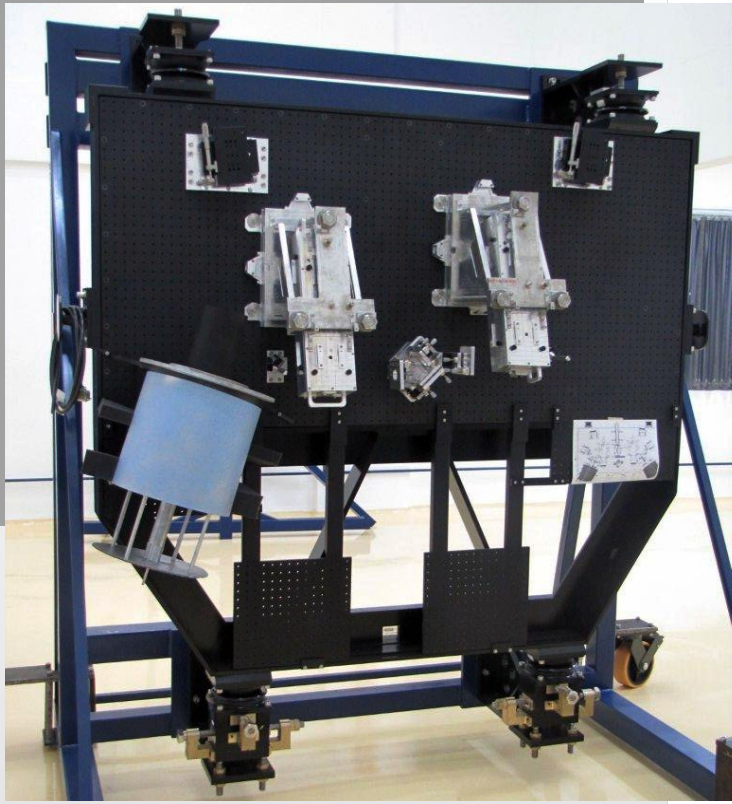
- 1300 fibers;
- 400-1000 nm;
- 10 x 5" field;
- R = 5 – 30k;
- VPH gratings.
- Use with GLAO

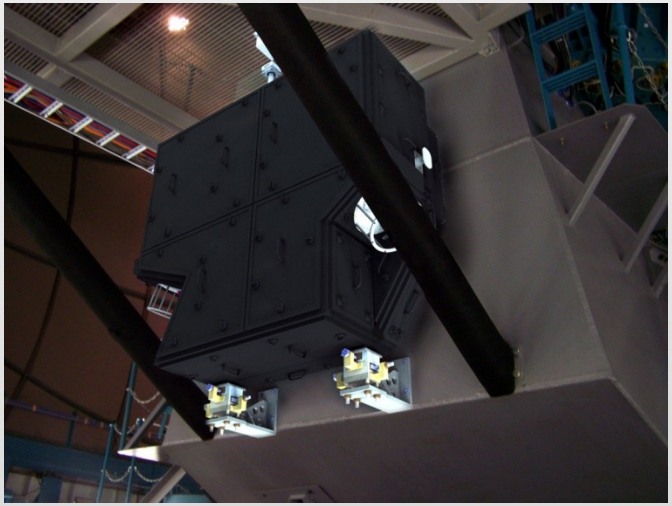
STELES - SOAR Telescope Echelle Spectrograph

- **R = 50k (80k max);**
- **300 – 900nm in one shot – UV;**
- **Nasmith fed – flux calibration;**
- **Fixed configuration – stability;**
- **No moving optical parts;**
- **1.8 x 1.5m;**
- **800kg.**



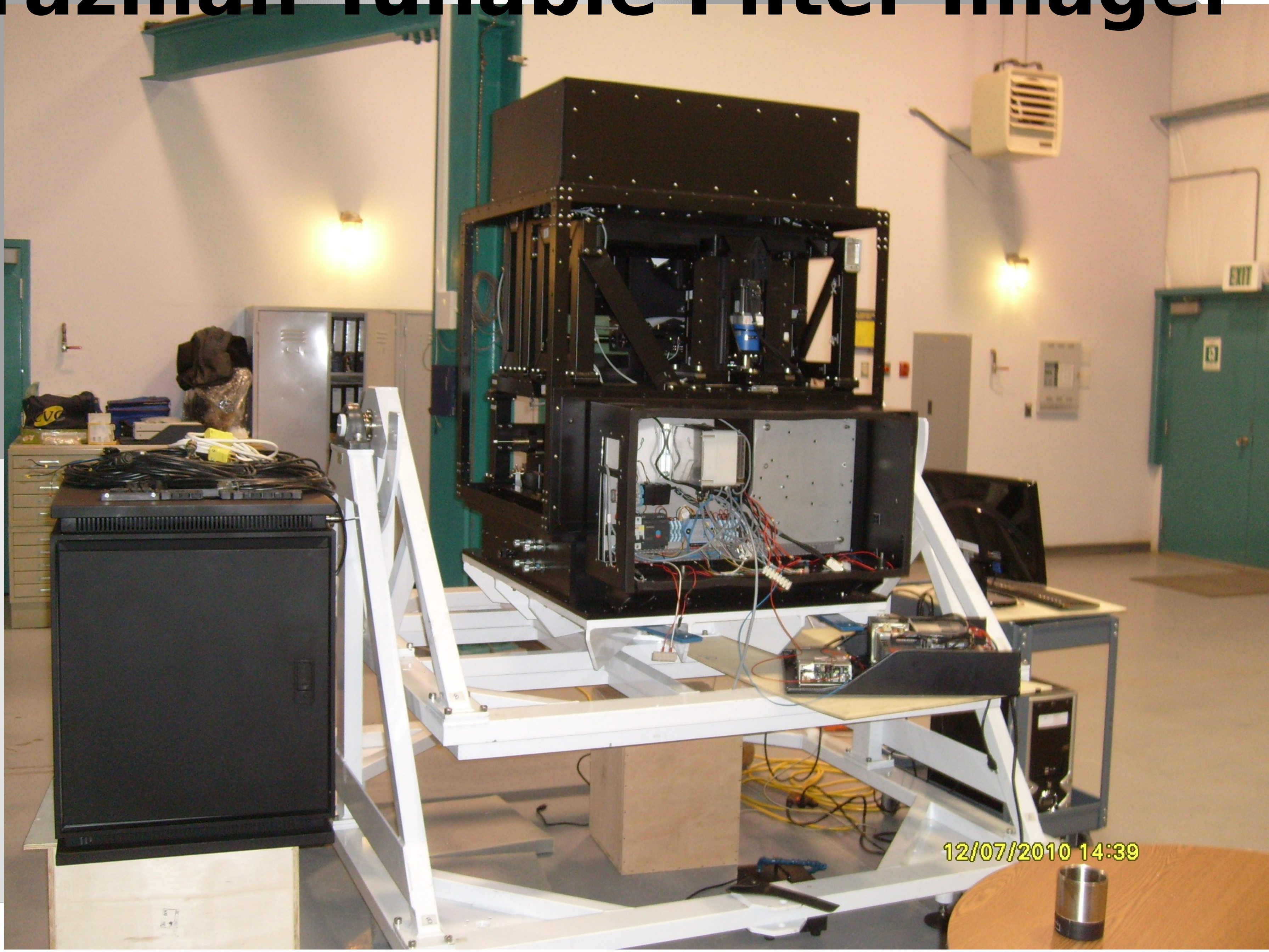
STELES in integration Lab at LNA

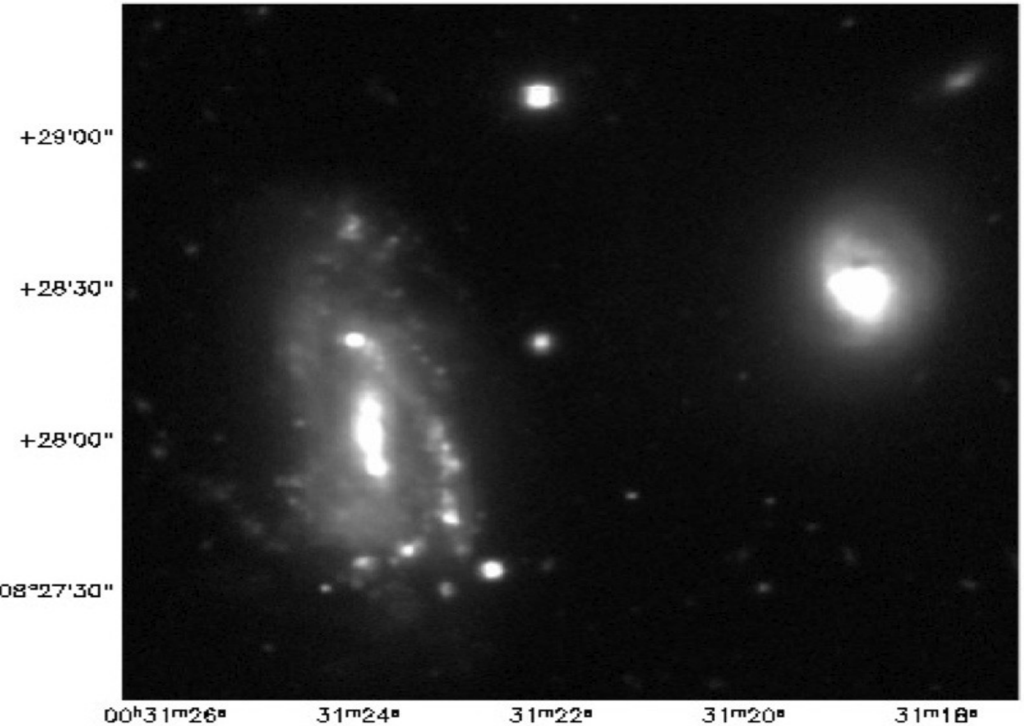
It will be installed at SOAR end of 2012.



Artistic impression of STELES installed at SOAR.

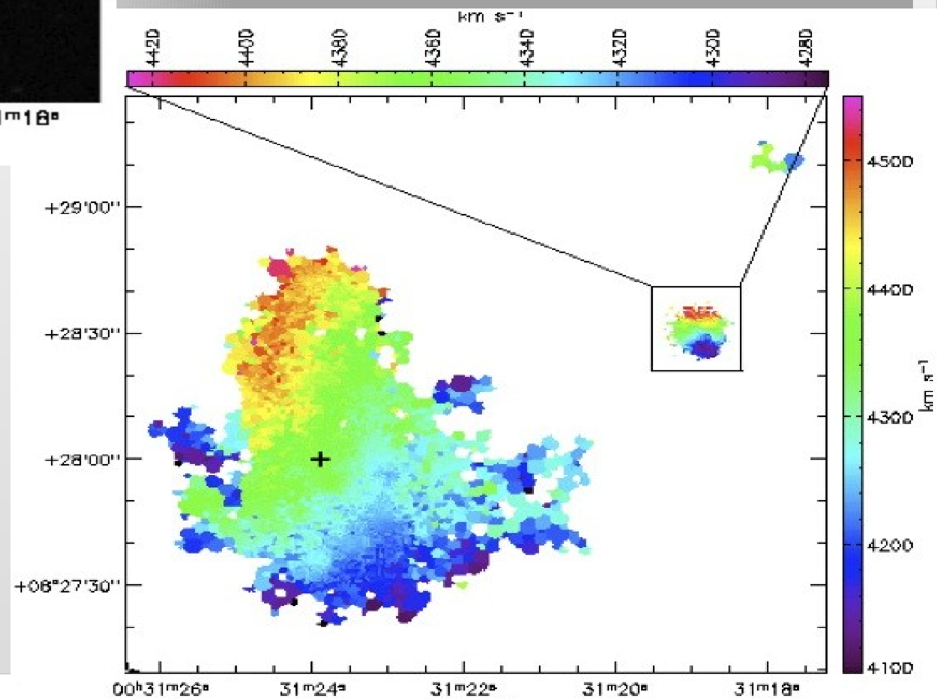
Brazilian Tunable Filter Imager





High resolution arm of

BTFI – Brazilian Tunable Filter Imager

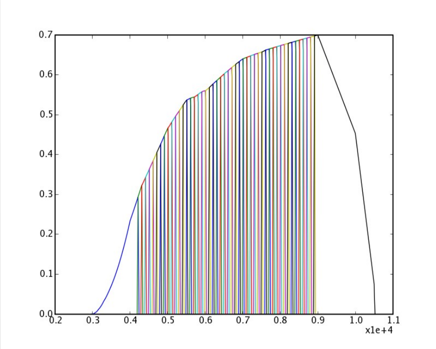


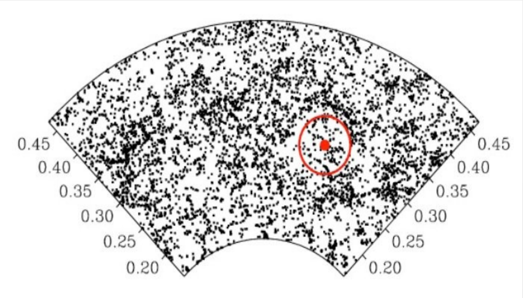
BTFI

Tunable Filter in the optical domain – R = 25-35000
Field of view: 3 arcmin
Pixel size 0.12 arcsec

To be used with GLAO

Brazilian survey projects for cosmology and other studies
DES/J-PAS/Pau-Brasil/S-MAPS/PFS-SuMIRe





LSST – DES Synerg

DES & LSST are very similar surveys:

- Ground based imaging
- Large area
- Multi-Band
- Southern sky

Most of the know-how DES will develop will certainly be very useful for LSST

Cadence and depth are obvious differences

As “cosmological machines” both are steps towards the same goal and will use similar probes:

- Weak-Lensing
- Cluster counts
- BAO (mostly photometric redshift based)

What is JPAS?

- **J-PAS**: Javalambre Physics of the Accelerating Universe Survey

(Pau-Brasil - the Brazilian contribution to JPAS)

- **Spain-Brazil collaboration (50% each partner): 2 telescopes (2.5m and 0.8m) in Teruel, Spain with wide field cameras. Survey of the sky in 56 filters.**

- **Main institutions in Spain: *Centro de Estudios de Física del Cosmos de Aragon*(CEFCA, Teruel) and IAA (Granada). In Brazil: ON, UFRJ, CBPF, IAG, IFUSP, INPE, UFSC, etc**

FULLY FUNDED!

Observational strategy for J-PAS:

(2.5m dedicated telescope)

- **Measurements of positions and photometric redshifts for more than 14 M red galaxies more luminous than L* with i < 22.5 in 8000 square degrees of sky**
- **Comparison: SDSS/DR7 ~1 million galaxies (of all types) brighter than r=17.8 in ~9000 square degrees**
- **What is new: filter system is optimized for BAOs!**
- **Main goal: measure transverse and radial BAOs**

(this was the driver for the area of the survey and filter design)

Radial BAO requirements

- **Redshifts** and positions for enough objects, n~0.001 (h/Mpc)^3
- Peak width of the BAO feature ~ 10Mpc
- Redshift precision $dz/(1+z) < 0.003$ to avoid signal degradation
- Traditional photo-z have $dz/(1+z) \sim 0.03$
- Usual approach: spectroscopy

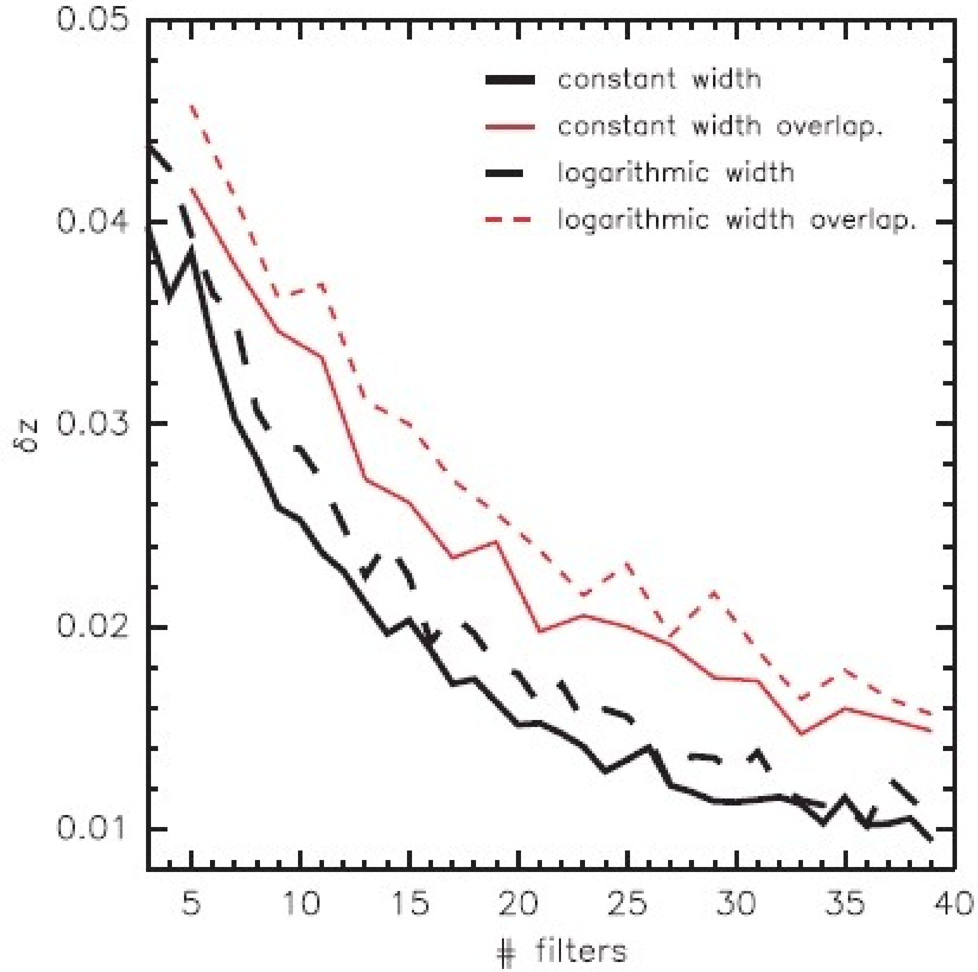
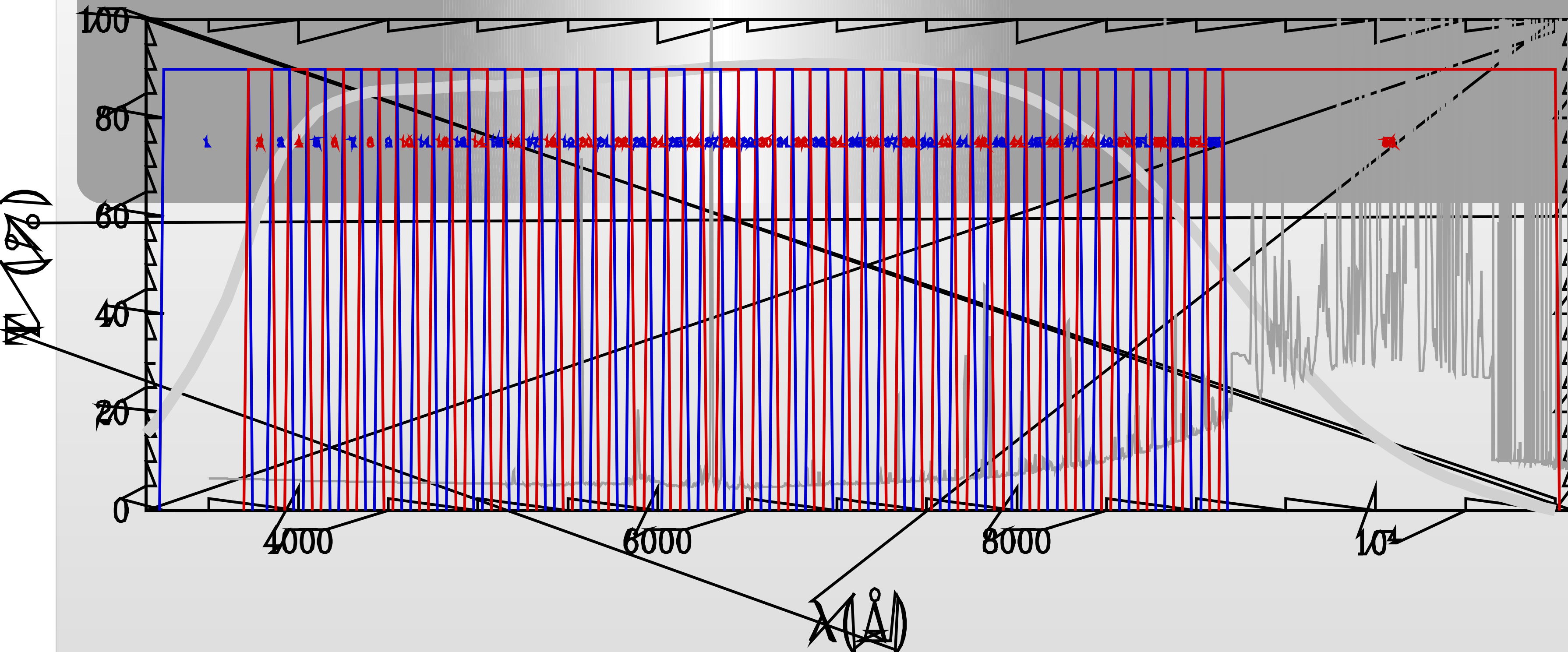


Figure 4. Dependence of the rms of quantity $(z - z_b)/(1 + z)$ for those galaxies with odds > 0.99 as a function of the number of filters for the four types of filter systems considered in the Letter and including near-IR observations (see

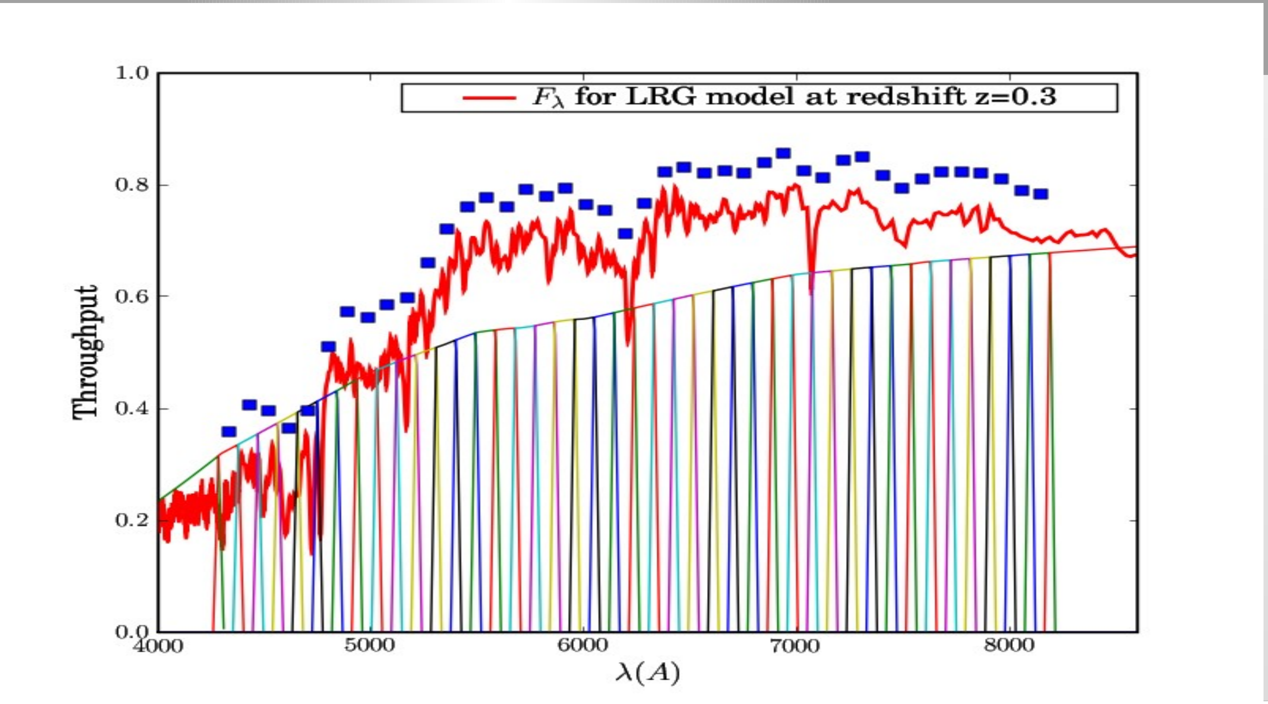
JPAS



- **Low resolution spectroscopy of the whole northern sky**

☛ ”IFU with R~40-80” over > 8000 deg2

- **Allows other science to be done!**



Extragalactic objects

☛ ~ 13 million LRGs to z<1.1 - $\sigma z \sim 0.003(1+z)$

☛ ~ 100 million ELGs to z<1.3 - $\sigma z \sim 0.0025(1+z)$

☛ ~ 200 million galaxies to z<1.5 - $\sigma z \sim 0.01(1+z)$

☛ ~ 2-3 million type-1 quasars to z<6 - $\sigma z \sim 0.0015(1+z)$

☛ Thousands of SNe (w/o need of spectr. follow-up)

☛ Serendipitous discoveries

Applications

☛ BAOs, P(k), bispectrum, non-gaussianities

☛ > 105 clusters & groups

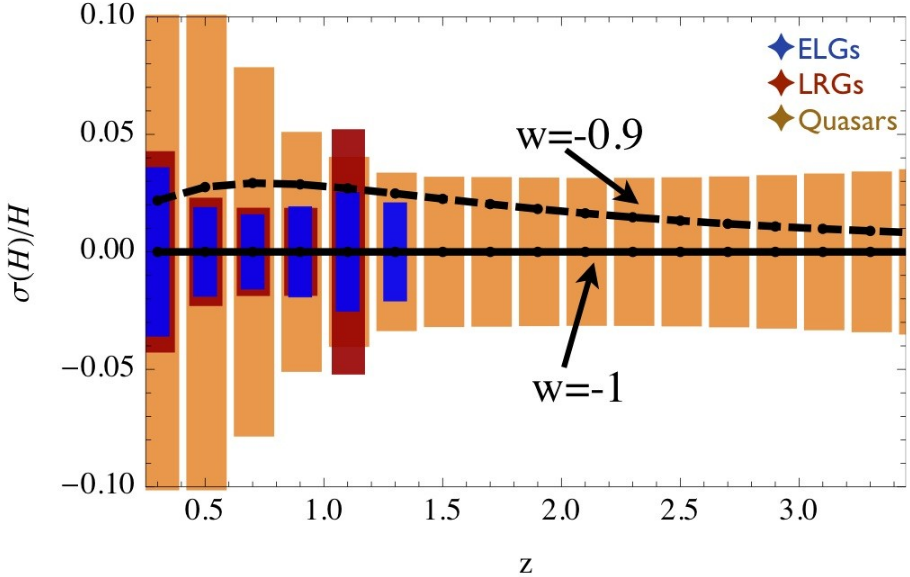
☛ Weak lensing complementarity

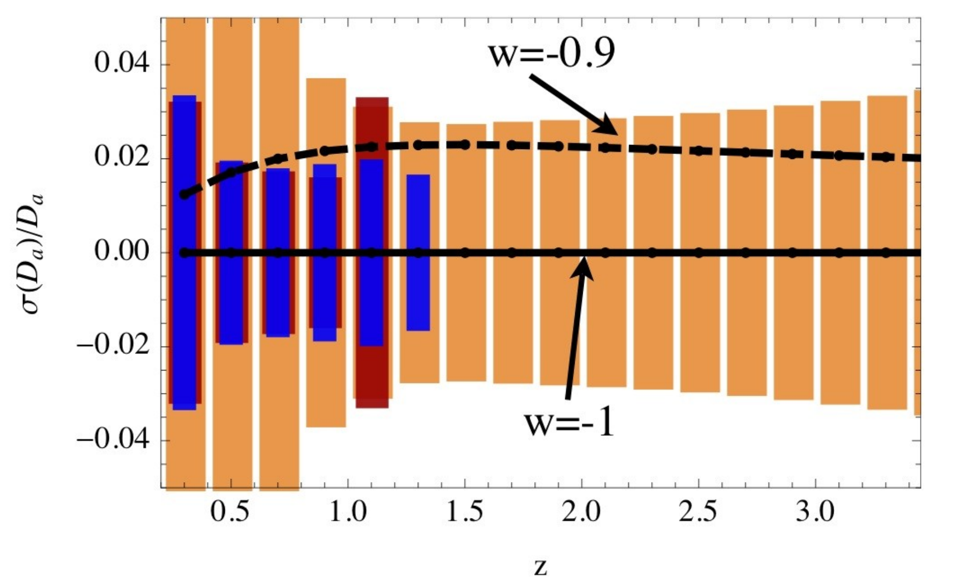
☛ Massive catalog for galaxy evolution

☛ Resolved stellar populations of nearby galaxies

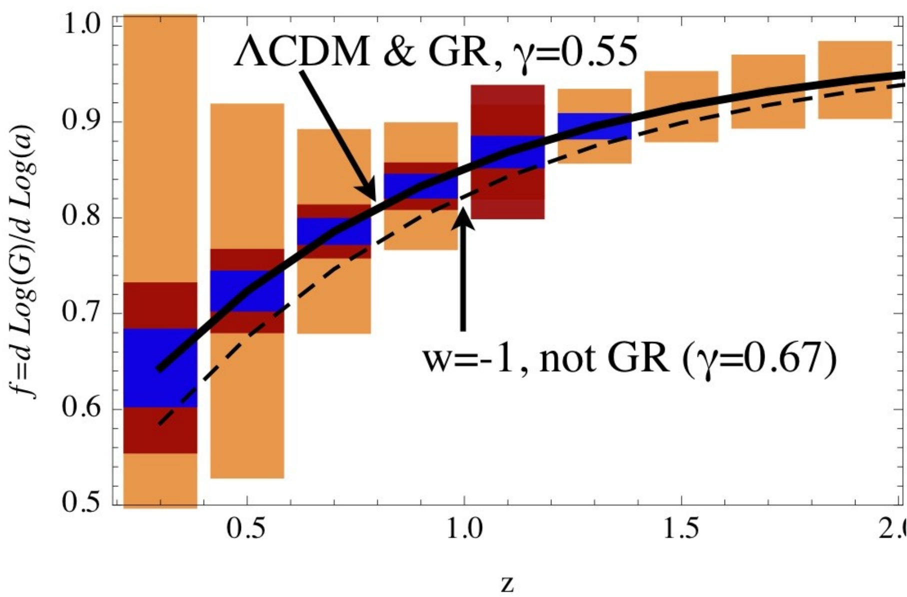
☛ ...

J-PAS measurement of H(z) and D_a(z) with BAOs



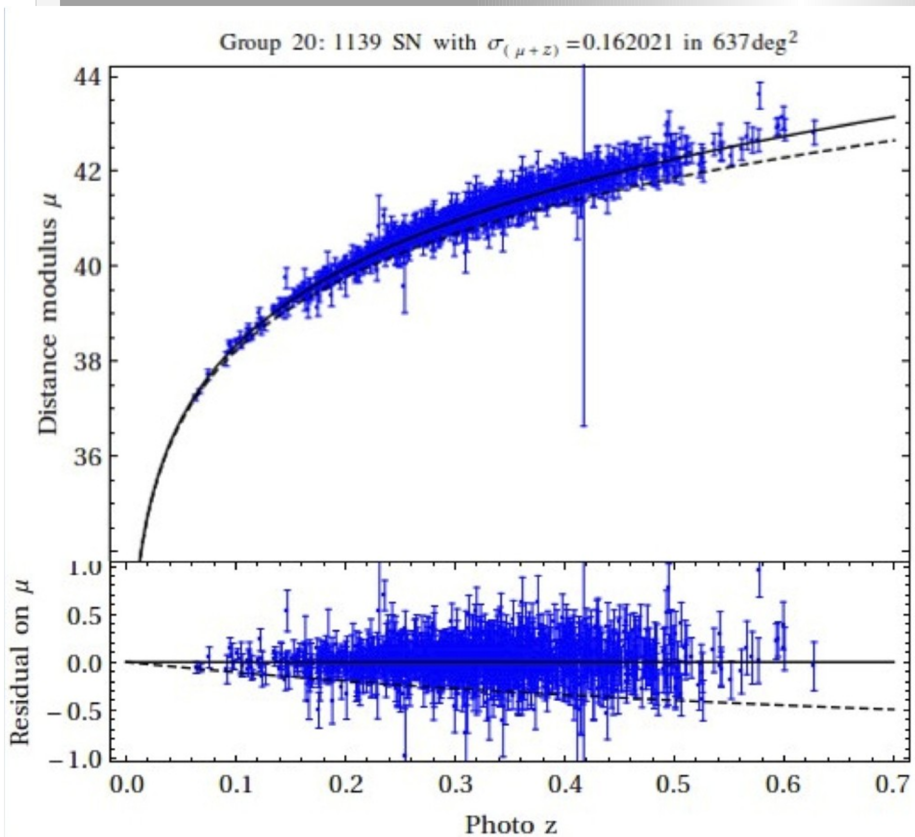


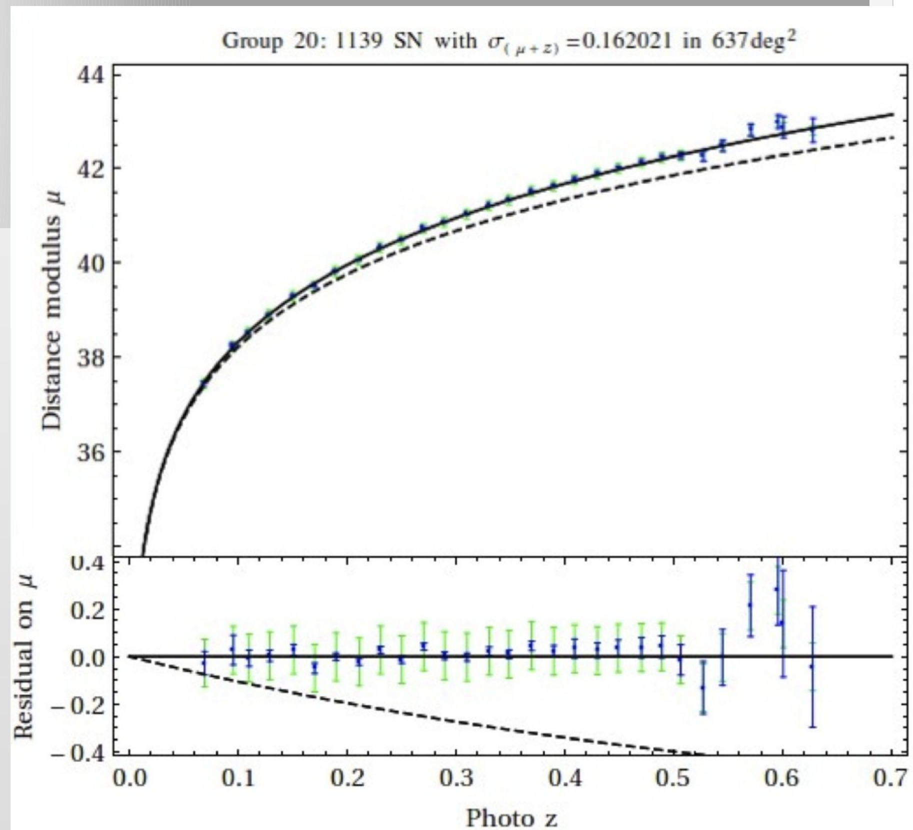
- The excellent photo-z's allow us to measure distances in the angular (D_a) and radial (H) directions to percent accuracy using **BAOs**.
- J-PAS will also be able to measure the matter **growth function**, and to test General Relativity.
- Through BAOs, clusters, SNe and lensing, JPAS will deliver constraints on dark energy equivalent to a DETF Stage III/Stage IV experiment!



Type-Ia supernovae:
Thousands of objects, minimal contamination, no need for spectroscopy

H. Xavier, M. Sako, et al.





Weak lensing

- **Javalambre has excellent seeing conditions, Median ~0.7 arcsec**

- **Good seeing is quite stable in time**

- Broad band "detection image": unique resource for lensing

Cluster counting

- **Automatic census of most L > L* galaxies For z<1**

- **High photo-z resolution: lower mass detection threshold**

- **Best optical cluster catalog available for z < 1**

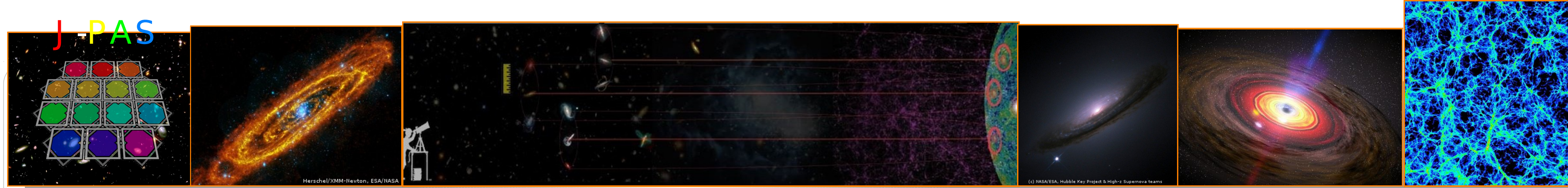
- **SED information available: use stellar mass as calibrator for total mass**

Galaxy Evolution

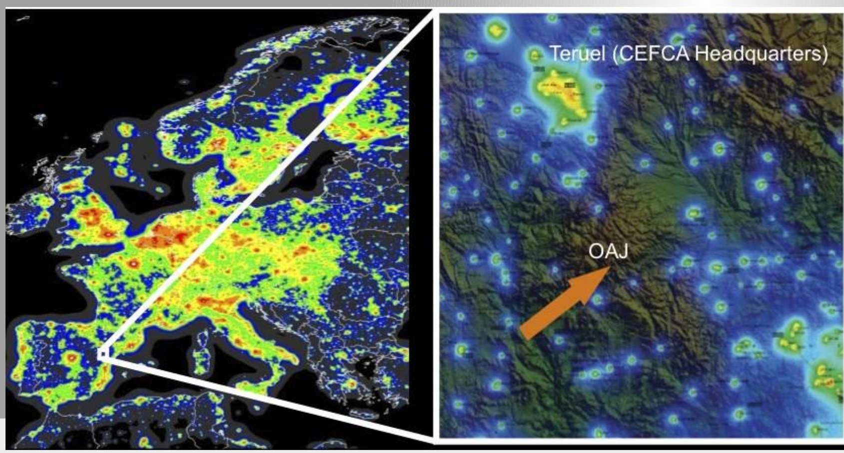
- **Low-res spectroscopy of the whole sky**
- **Redshifts for every L > L* for z < 1**
- **High quality broadband imaging: morphological classification, mergers**

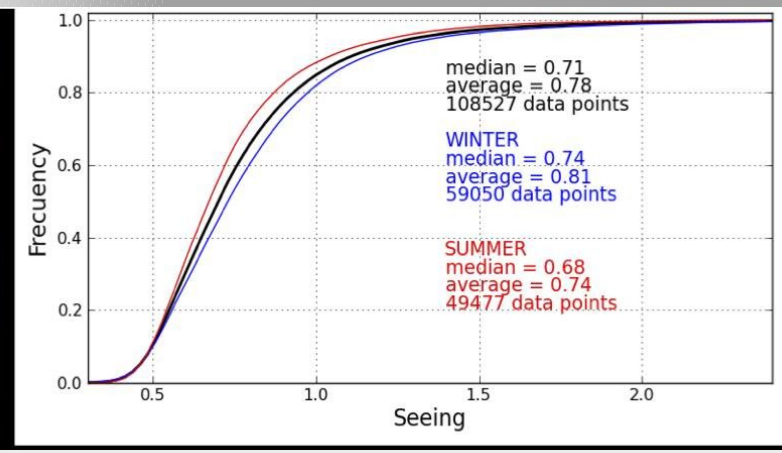
MORE SCIENCE

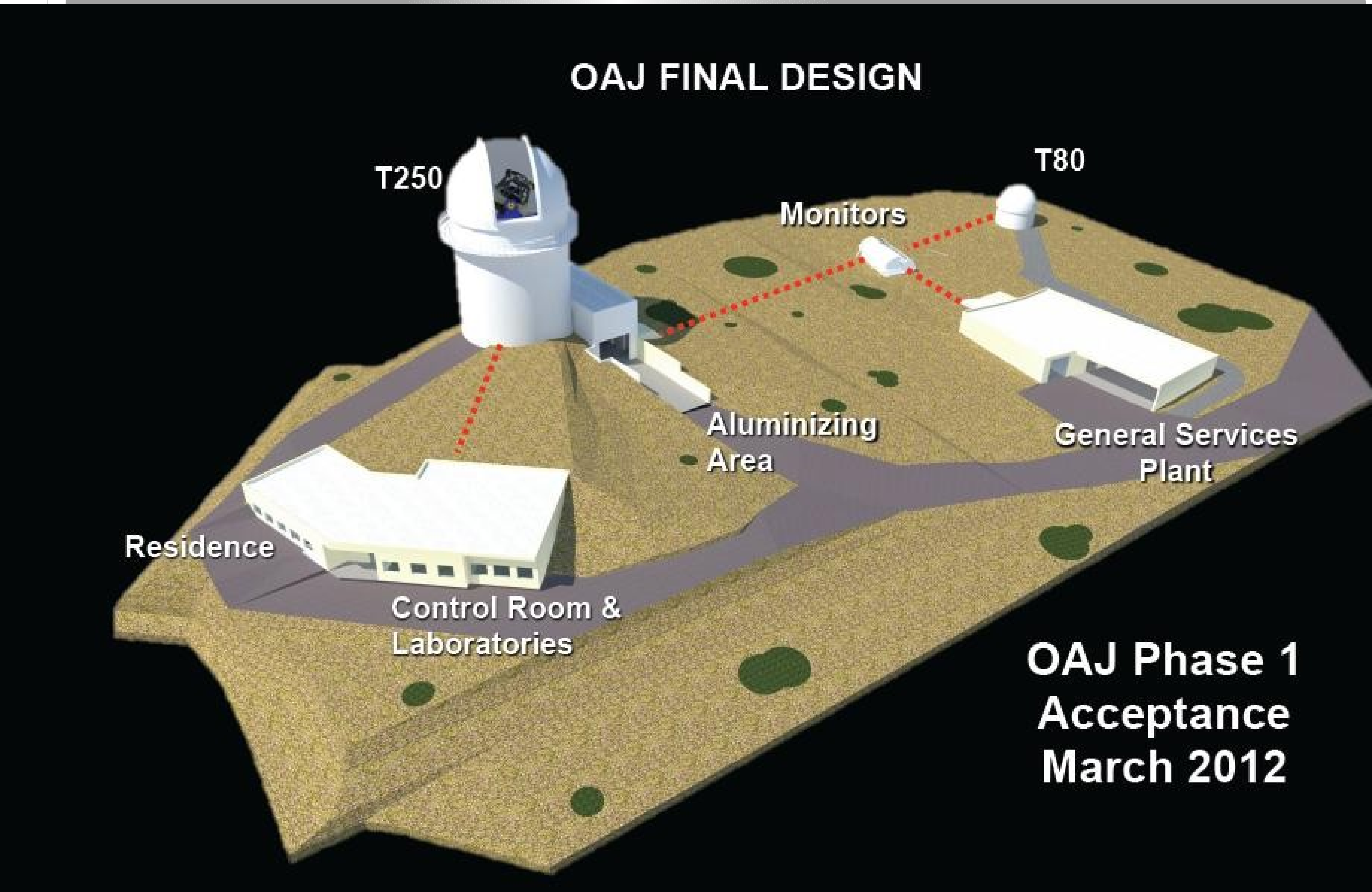
- **QSO's**
- **Stars**
- **Asteroids**
- **GRBs**
- **…**



New observatory & facilities: OAJ - Built & operated by CEFCA






OAJ FINAL DESIGN
T250
T80
Monitors
Aluminizing
Area
General Services
Plant
Residence
Control Room &
Laboratories
OAJ Phase 1
Acceptance
March 2012

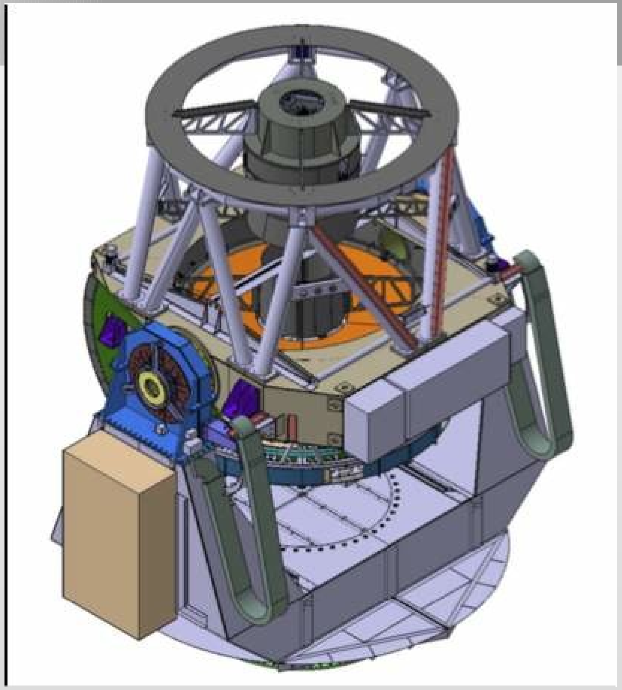
Main telescope: T250

M1 = 2.5m
FoV = 3 deg = 476 mm at FP
Effective coll. area = 3.89 m2
Etendue = 27.5 m2 deg2
Plate scale = 22.67’’/mm = 0.22’’/p
Focal length = 9098 mm (F#3.5)

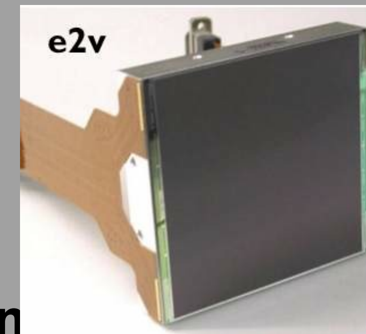
Type = Ritchey Chrétien-like
Mount = Alt-azimuthal
Focus = Cassegrain
Field corrector = 3 lenses
Mass = 45.000 Kg

Manufacturer: AMOS
FDR accepted; on site by Q3 2012

M1 blank : SCHOTT → AMOS



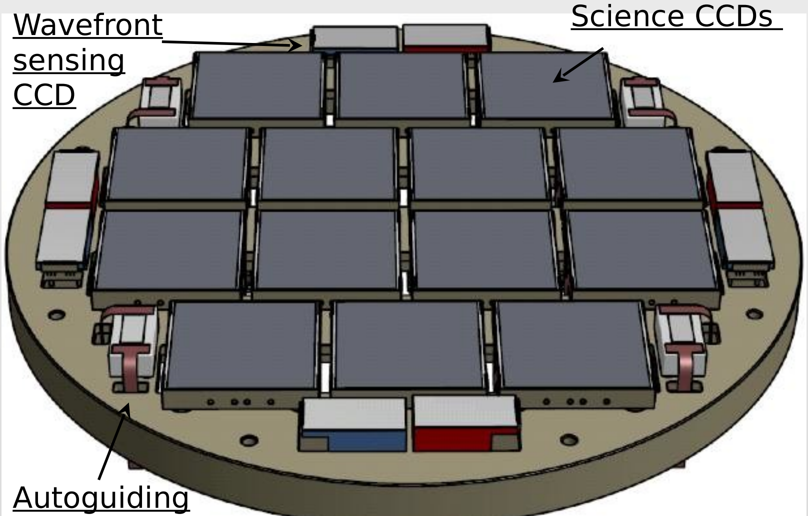
Camera: JPCam

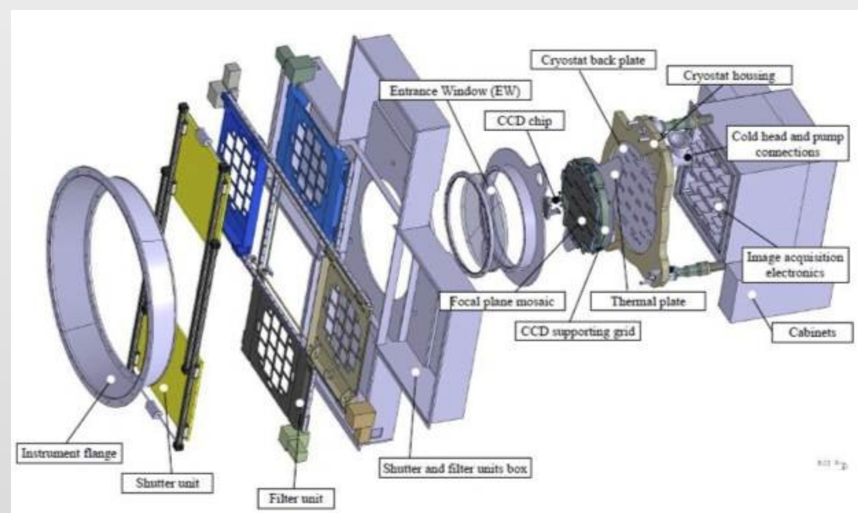


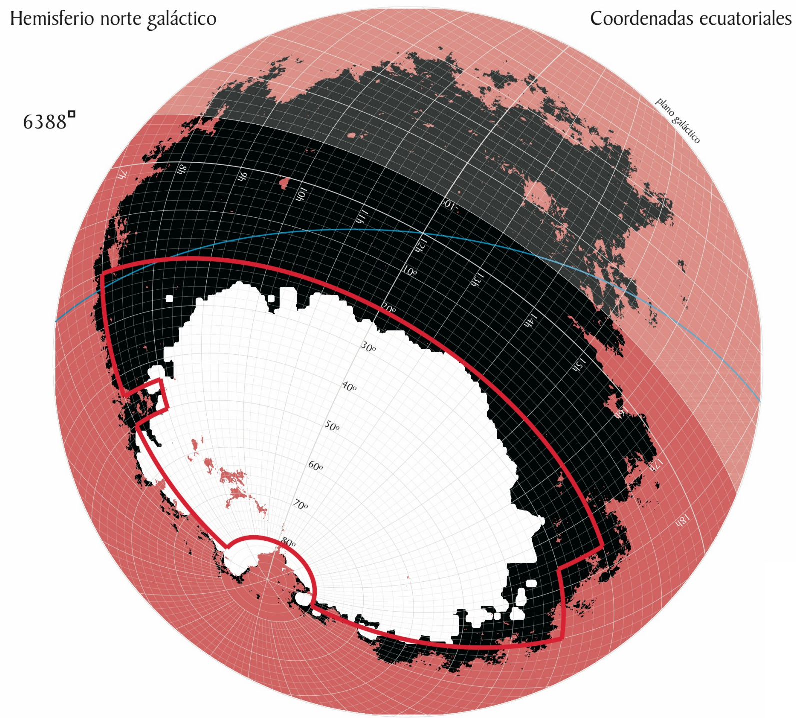
CCDs: 9,216k x 9,216k by e2V
QE > 80% (400-880nm)
RoN @ 1MHz=5.0 e-/pix
These CCDs are only available sin
13 mm gap between CCDs
Detector controller – 16 channels per detector

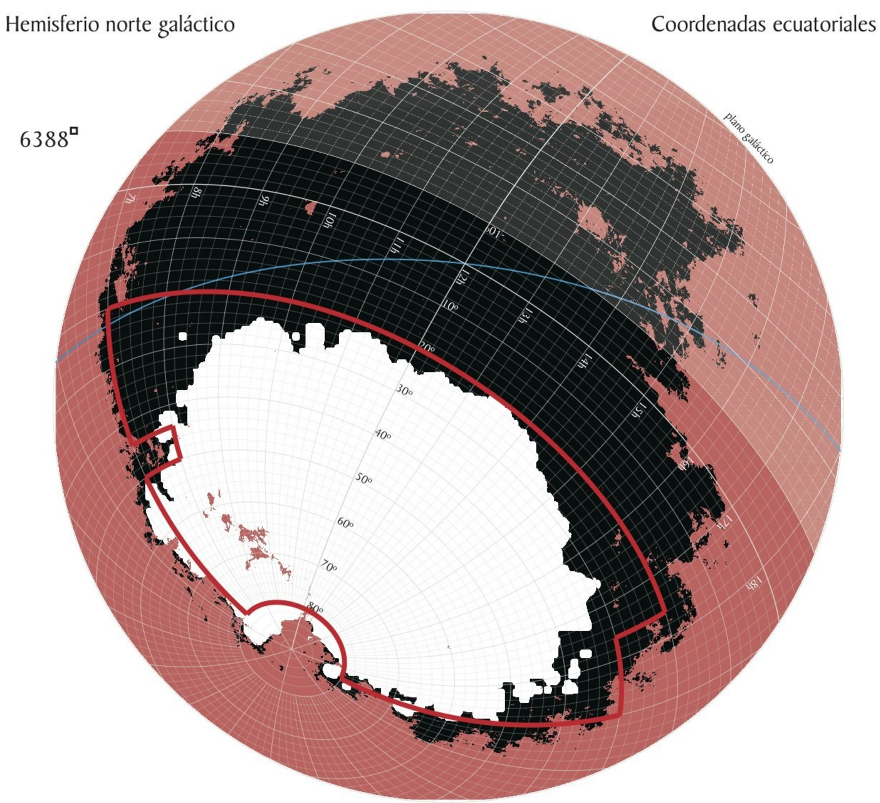
Mosaic of 14 CCDs, 1.2 Gygapix

Exploded view of camera









Courtesy from A. Fernandez-Soto

Cadence of JPAS – 3 epochs

JPCam (for the T250-N)

Design, Planning and Status

Keith Taylor (IAG/ON)
Toni Marin-Franch (CEFCA)
Jordi Cepa (IAC)

Personnel

Filter/Shutter Unit (INPE)

- Rene Laporte – optical engineer
- Mario Celso – systems/controls engineer
- *Contractors:*
  - Fernando Santoro (MRO) – lead mechanical engineer
  - Lucas Marrara (TopCooler) – mechanical engineer

Cryostat and detector focal plane (e2v)

- Ian Palmer (Project Manager)
- Paul Jorden (Project over-sight)
- Graham Fenemore-Jones (mechanical engineer)
- …

Interface management (AMOS)

- Gregory Lausberg – interface control
- Olivier Pirnay – project manager

4th JPAS meeting (Madrid)
February, 2012

~8000 squared degrees - 70% N and 30% S (overlap with LSST)

Brazil is responsible for JPCam

CEFCA pays for maintenance, operations, data management

Brazil & Europe have 9 months grace period extra before data is public

Brazil has the right for telescope usage for 7 years at least (other surveys?)

Brazil has full partnership in ALL aspects – not just science

Participants from more than 25 institutions in Brazil, Spain, US, China, Venezuela, Argentina, India, Italy,

Immense Legacy value due to the nature of the survey. Clusters and groups of galaxies, galaxy evolution, quasar studies, star formation (giant IFU), stellar astrophysics, halo stars, asteroids, weak lensing, etc…

S-MAPS:

(Southern Massive Astrophysical Panchromatic survey)

Copy of the system to the southern hemisphere

0.8m telescope at Cerro Tololo

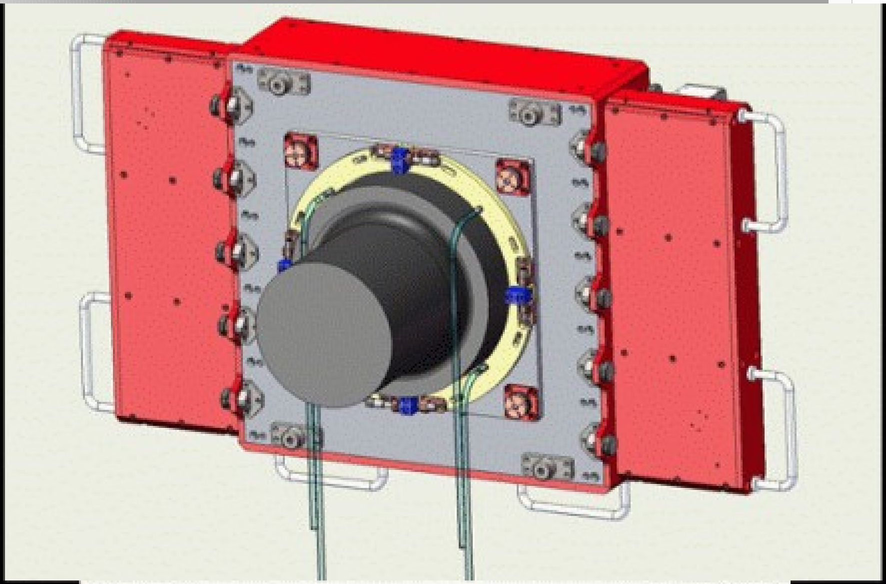
(fully funded)

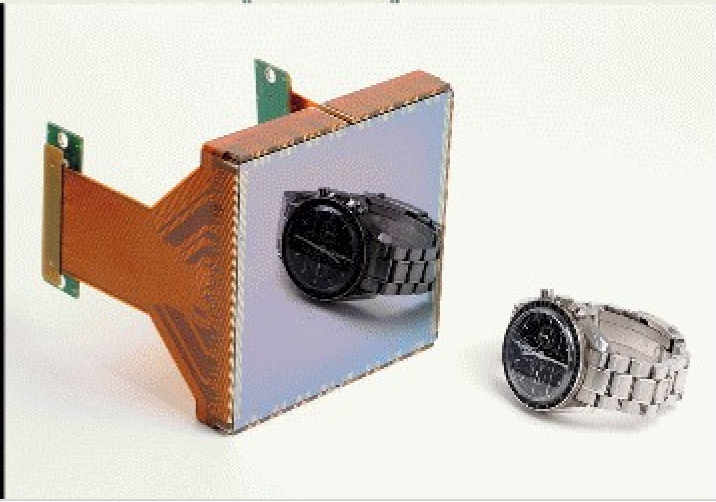
2.5m telescope at Cerro Pachon

(looking for funding and for more partners)

- RJ: ON, UFRJ, CBPF
- SP: IAG, IF/USP, INPE, UNICSUL, UFABC
- MG: LNA
- SC: UFSC
- RG: UFRGS, UNIPAMPA
- BA: UESC
- **80cm telescope+camera (S-PLUS survey)**

T80-south Located in Cerro Pachon





S-PLUS IN NUMBERS

- 83 cm M1 diameter
- Effective FoV @ T80Cam: 2.1deg2
- Plate scale: 0.5”/pix

- Sky area: ~8000deg2 covered by S-MAPS
- 12 filters (SDSS g,r,i,z + 8 intermediate/narrow widths). 3 in common with S-MAPS (uJ, OII, Hα)
- Limiting magnitudes (S/N >5):
    - AB>22 in ALL filters
    - AB>23 in uJ. gSDSS, rSDSS & iSDSS
- Texp in each filter: ~40s – 300s (dark time)
- Integration time “on target” per pointing ~ 30min
- Total time per pointing (including overheads) ~ 45min
- 1800h/year useful time at the OAJ □ > 5000 deg2/year
- Total execution time □ ~ 2-2.5 years (including gray time)
- Starting in ~ March 2013 (at least 1-1.5 years ahead of S-MAPS)

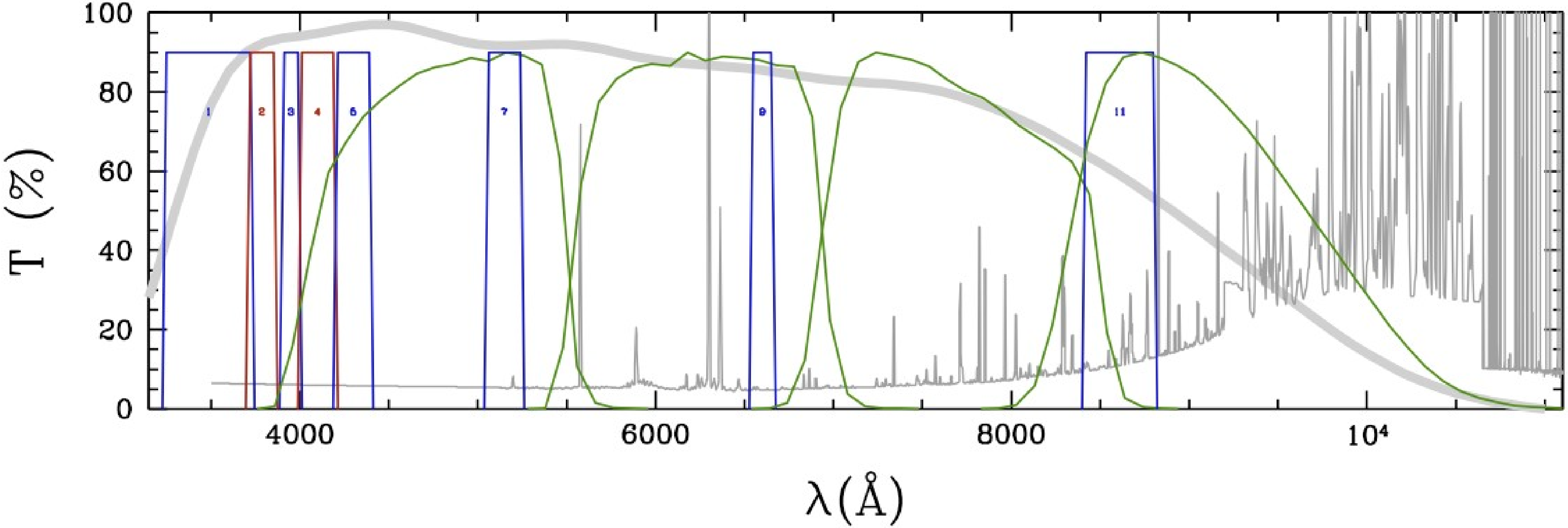
S-PLUS MOTIVATION
Survey of 8000 sq degrees in 12 filters in the southern hemisphere

To provide the Photometric Calibration of S-MAPS

+

A wide variety of scientific applications for most kind of Astrophysical topics: Galaxy Evolution, 2D Stellar Populations, SF rates, Cosmology, SNe, GRBs, Extragalactic Tidal Streams, Milky Way science, Stellar Classification, Extrasolar planets, etc… FOR FREE!!

THE 12 J-PLUS and S-PLUS FILTERS



Based on lessons learned from Bailer-Jones (2000, 2004), Bessell (2005), Jordi et al. (2006)

"Stellar physical parameters can be recovered with a combination of 10-15 medium and broad band filters with S/Ns ~50"

SDSS (*g*, *r*, *i*, *z*) + u*J* + J378_[OII] + J395_[H+K] + J410_[Hδ] + J430_[G-band] + J515_[Mgb-Fe] + J655_[Hα]+ J861_[CaT]

A few J-PLUS and S-PLUS SCIENCE CASES

STELLAR POPULATIONS WITH J-PLUS and S-PLUS

- **Systematic analysis of *__stellar populations of massive spheroids__* with J-PLUS and S-PLUS up to z~0.2-0.3**
- ***__2D stellar population gradients__* in nearby galaxies up to z~0.03. Azimuthal binning in nearby galaxies improves depth by ~3mag (5s) in all the J-PLUS and S-PLUS filters (galactocentric distances of 80"–250" for Virgo ellipticals).**
- **Sampling the bright end of the *__Lyman Break Galaxy (LBG) Luminosity Function__* at z~2.5. Thousands of LBGs all over the J-PLUS and S-PLUS 8000deg2 with AB~22 bluewards the Lyman forest at z~2.5.**

EMISSION LINE GALAXIES WITH J-PLUS and S-PLUS ([OII] + Hα)

- **A catalogue of ELGs in the Local Universe: recalibrate *__the SFR of the Local Universe__* from a much larger volume. Ha and [OII] filters in J-PLUS and S-PLUS allow to study the ionized gas emission to z~0.017 down to Ha fluxes ~5x10-15 ergs−1cm−2.**

Plans for a polarimetric survey of the southern sky with accuracy of 0.1% at V=15-16

Summary 1

JPAS survey (70%in the south, 30% in the north)

- Time scale: ~ Q1 2014 + 4-5 yrs
- Uses 54 narrow band and 2 broad band filters
- Depths ~ 21 - 22.5 (AB) [5σ, 3 arcsec2 aperture]
- Dedicated 2.5 m telescope w/ 3 deg FoV ☛ 27.5 m2 deg2 Étendue

J-PLUS and S-PLUS surveys (8000 degrees N and S)

- Dedicated 0.8m telescopes with 2.1 deg^2 FOV
- Time scale: Q1 2013 + 2 yrs
- Uses 12 filters (8 narrow band and 4 sloan filters)
- Will do photometric calibration for large telescope survey

- 56 narrow-band filters are great, but cannot trump spectroscopy!

⇒ **Full fruition of the survey requires excellent calibration sets to higher *z*!**

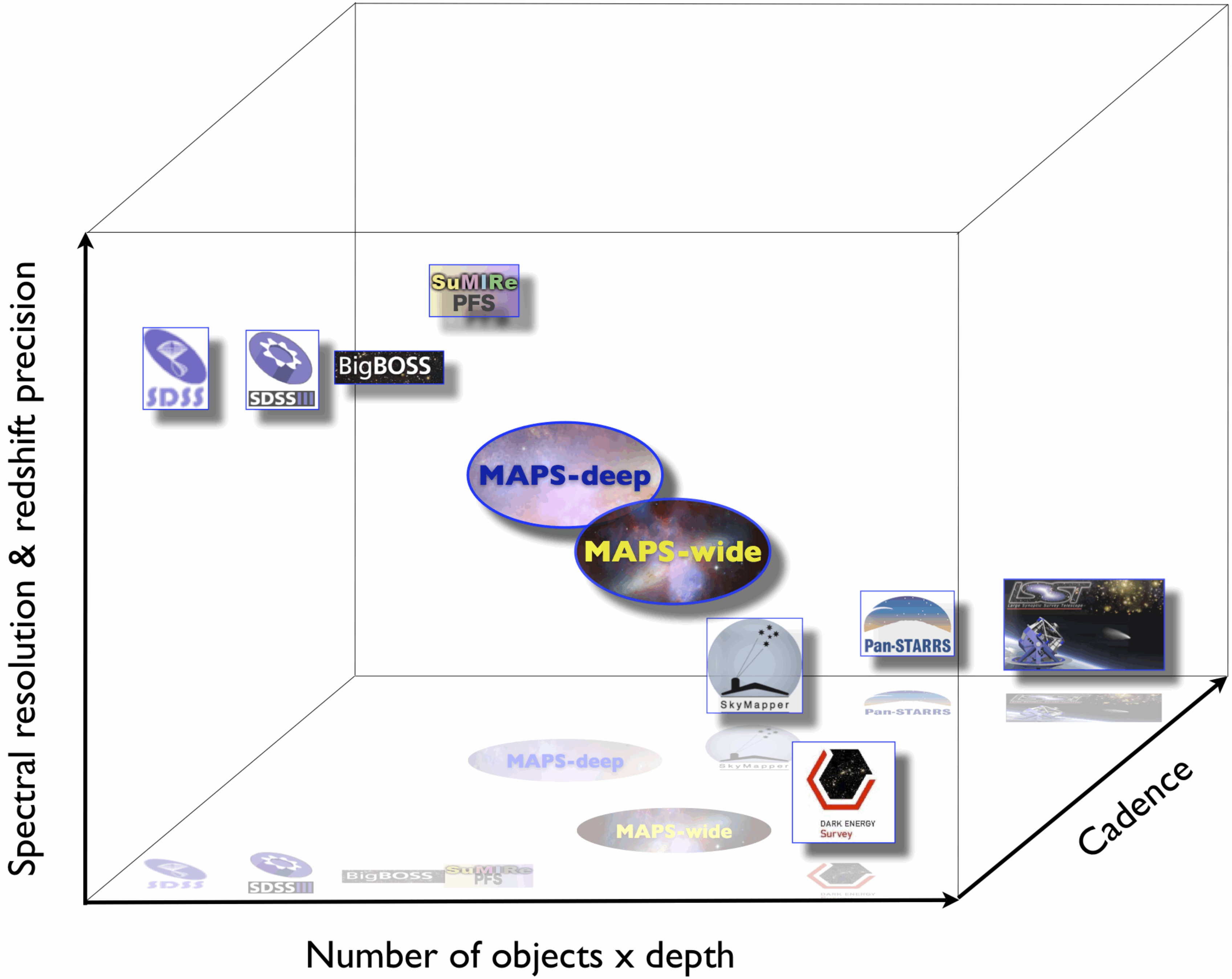
⇒ **PFS, BOSS, …**

⇒ **Cross-calibration, selection functions**

⇒ **Complementarity between:**

MOS surveys ; narrow-band imaging surveys ; ugriz imaging surveys

eg: (SuMIRe/PFS) (JPAS - SMAPS) (DES-LSST)



Spectral resolution & redshift precision
Number of objects x depth
Cadence
SDSS
SDSS III
BigBOSS
SuMIRe
PFS
MAPS-deep
MAPS-wide
SkyMapper
Pan-STARRS
LSST
DARK ENERGY
Survey

Final Summary

- **SOAR and Gemini ideal to do follow up of LSST sources. In particular, SOAR instruments such as SIFS, STELES and BTFI, now going on line, can be used for follow up of LSST sources.**

- **DES has some important complementarity with LSST regarding expertises in data management and software production.**

- **J-PAS will have an overlap of 2000 sq degrees or more with LSST and can be used to obtain low resolution spectroscopy of important LSST fields (for example for the study of clusters, weak lensing, etc)**

- **J-PLUS and S-PLUS will image the whole sky in 12 bands and in polarized light, can complement LSST work specially in stellar astronomy**

- **S-MAPS, when funded, will do MAPS-wide and MAPS-deep.**
- **MAPS-deep may be complementary to LSST, e.g. for photo-z's.**

Thanks to Abramo,Cypriano,Cenarro and Castilho for providing several slides

PFS – Prime focus Spectrograph

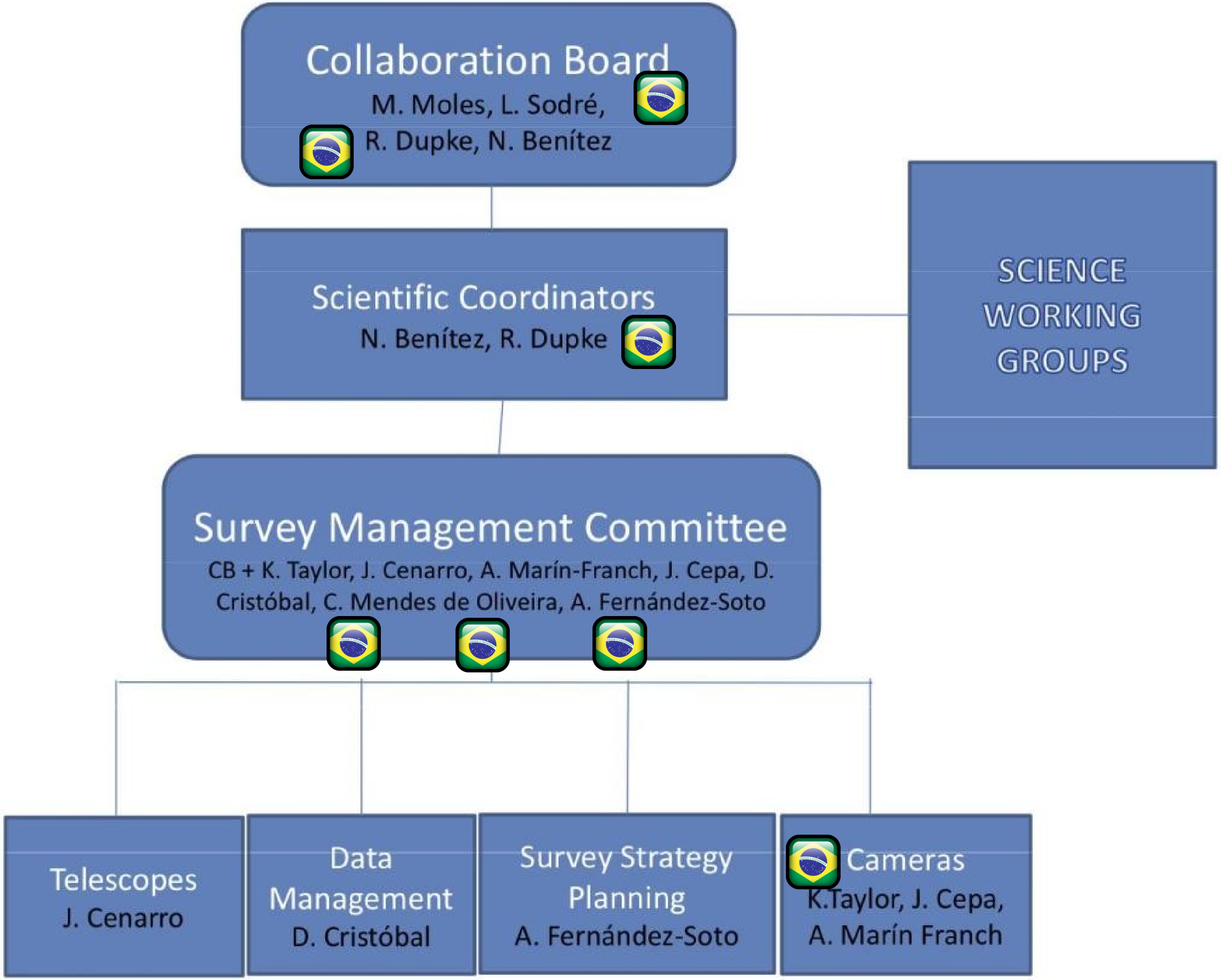
Fiber instrument to be used with Hiper suprime Cam with 1.5 degree field and 2500 fibers (SUMIRE)

- IPMU - procurement of detectors and spectrograph
- Princeton – IR arm
- Caltech/JPL – fiber positioners
- Marseille – spectrographs
- Brazil – fiber cable

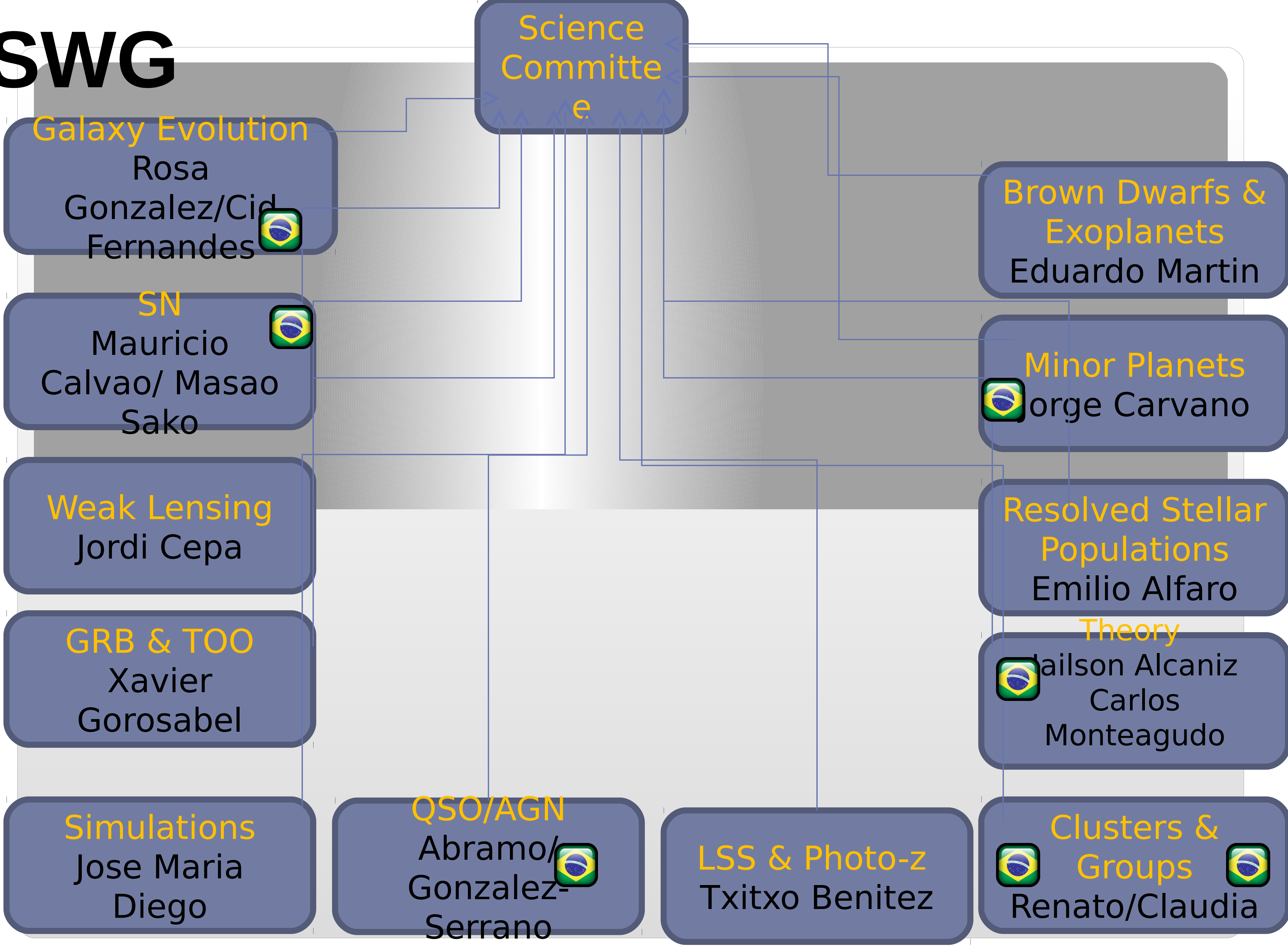
- Two main goals:

Dark energy and Galactic Archeology

Brazilian part of J-PAS = PAU BRASIL



SWG



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Minor Planets
Jorge Carvano
Resolved Stellar Populations
Emilio Alfaro
Theory
ailson Alcaniz
Carlos Monteagudo
Clusters & Groups
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J-PLUS and S-PLUS SCIENCE CASES

COSMOLOGY WITH J-PLUS

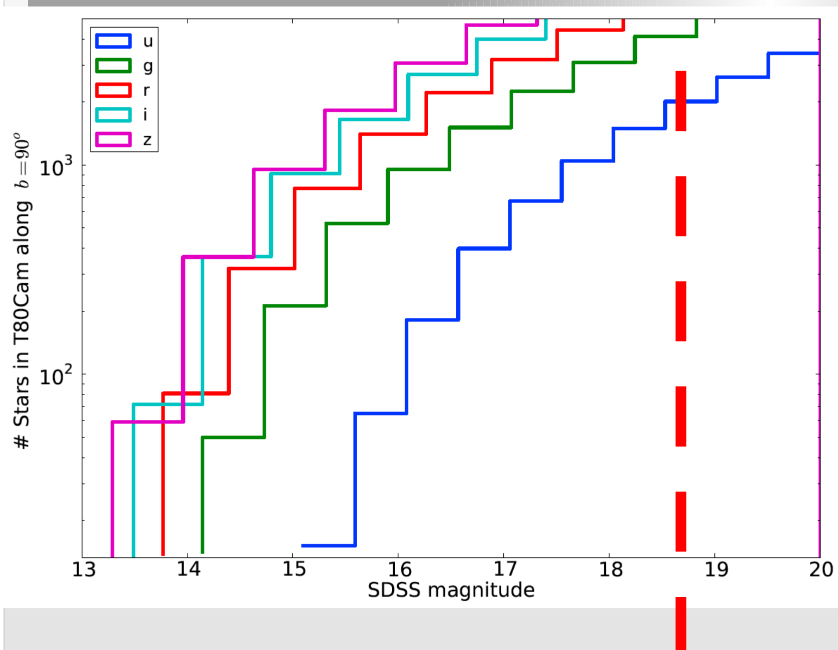
- ***<u>Galaxy Group and Cluster identification</u>***. J-PLUS will provide the most complete catalog of galaxy clusters & groups before the arrival of J-PAS.

- Establish ***<u>Constraints on Cosmological Parameters</u>*** from the cluster/group catalog produced from JPLUS. Given the more complete set of filters and the deeper limit magnitude (as compared to SDSS), J-PLUS data is expected to complement the low mass ends and the high redshift tails.

- ***<u>Angular Power Spectrum Estimation from the LRGs</u>*** in J-PLUS. Computation of the angular power spectrum (in projections along the line of sight within different redshift shells) for the subsample of Luminous Red Galaxies (LRGs) found in J-PLUS.

- ***<u>Study of Recent Thermal History of the Universe: Search for Missing Baryons</u>***. The combination of both PLANCK and J-PLUS data should provide the most stringent test the peculiar motion of the missing baryons.

HOW DEEP WILL S-PLUS GO?



T80Cam STA CCD 10.5k x 10.5k

0.5"/pix ⇒ **FoV = 2.12 deg2**

>1000 calibrating stars per pointing at the Galactic pole!

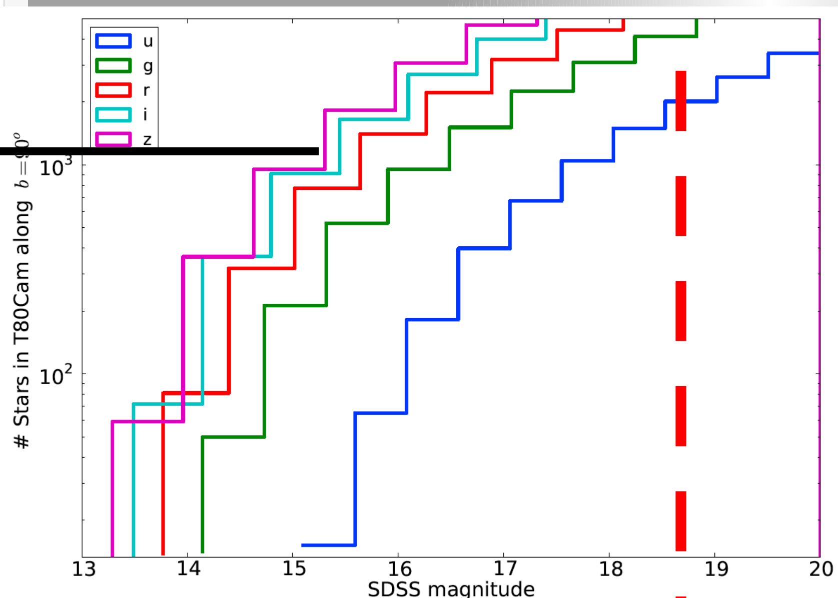
SPECIFICATIONS

AB~18 with S/N ~50 in all filters

Filter	λ_c(Å)	FWHM (Å)	t_{exp} (s)	Comments
u_J	3485	495	53	J-PAS
F378	3782	155	158	$[OII]$, J-PAS
F395	3950	100	243	
F410	4100	200	117	
F430	4300	200	117	
g'	4803	1409	18	SDSS
F515	5150	200	145	
r'	6254	1388	26	SDSS
F655	6550	125	317	Hα, J-PAS
i'	7668	1535	33	SDSS
F861	8610	400	201	
z'	9114	1409	92	SDSS

1520 s integration time "on target"

HOW DEEP WILL J-PLUS GO?



T80Cam STA CCD 10.5k x 10.5k

0.5"/pix □ **FoV = 2.12 deg2**

>1000 calibrating stars per pointing at the Galactic pole!

SPECIFICATIONS

AB~18 with S/N ~50 in all filters

Filter	λ_c(Å)	FWHM (Å)	t_{exp} (s)	S/N > 5
u_J	3485	495	53	AB~22.5 □ 23
F378	3782	155	158	AB~22.4
F395	3950	100	243	AB~22.4
F410	4100	200	117	AB~22.3
F430	4300	200	117	AB~22.3
g'	4803	1409	18	AB~22.2 □ 23
F515	5150	200	145	AB~22.2
r'	6254	1388	26	AB~22.2 □ 23
F655	6550	125	317	AB~22.2
i'	7668	1535	33	AB~22.3 □ 23
F861	8610	400	201	AB~21.8 □ 22
z'	9114	1409	92	AB~21.6 □ 22

1520 s integration time "on target"

1897s integration time "on target"

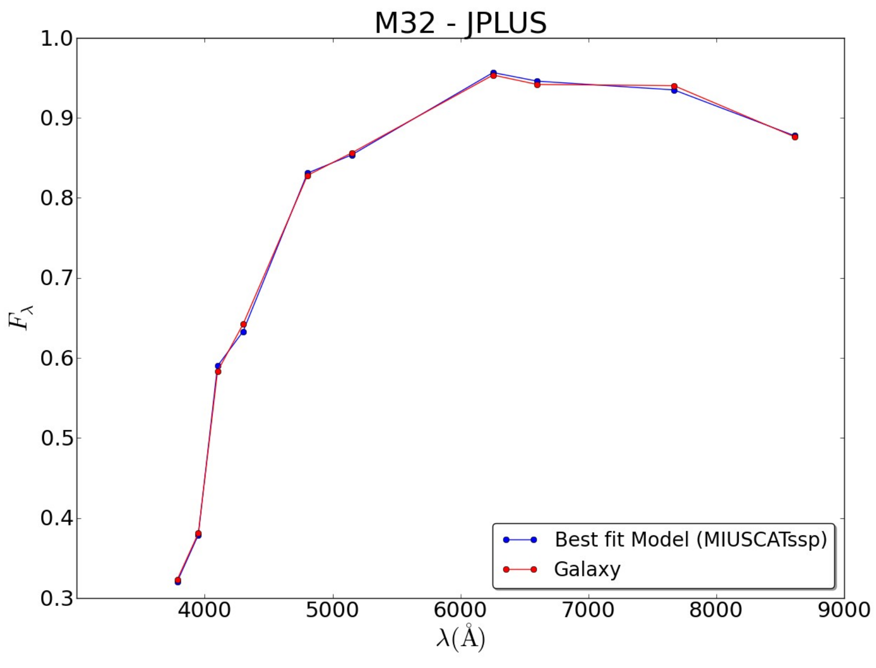
(UJ, g, r, i > 23; rest > 22)

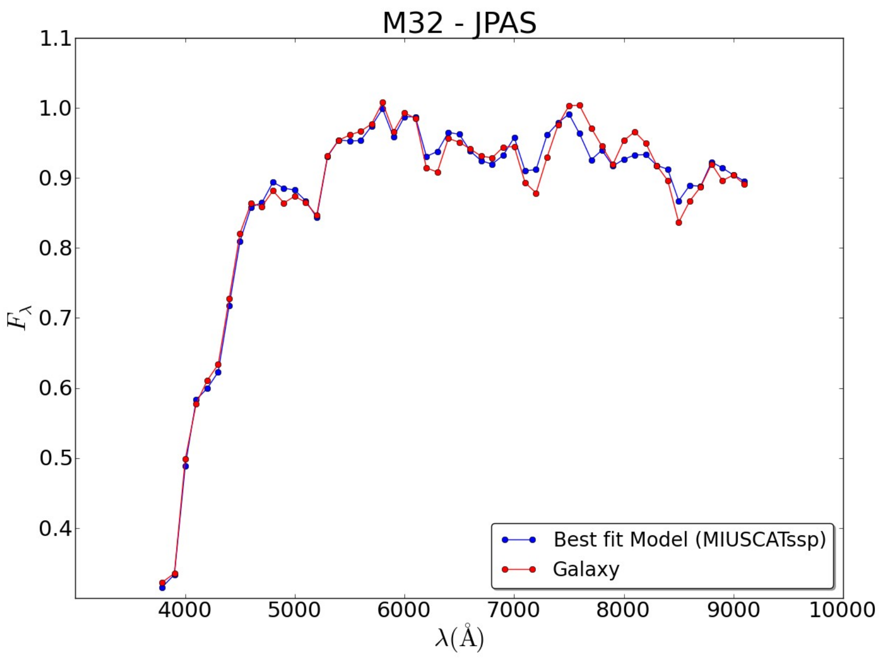
Spectra with J-PAS/S-MAPS and J-PLUS/S-PLUS

M32 spectrum (Bica, Alloin, Schmidt 1990) – MIUSCAT SSP models (Ricciardelli et al. 2012; Vazdekis et al. 2012)

Assuming S/N = 50 per filter in all cases

10 J-PLUS filters – 54 J-PAS filters

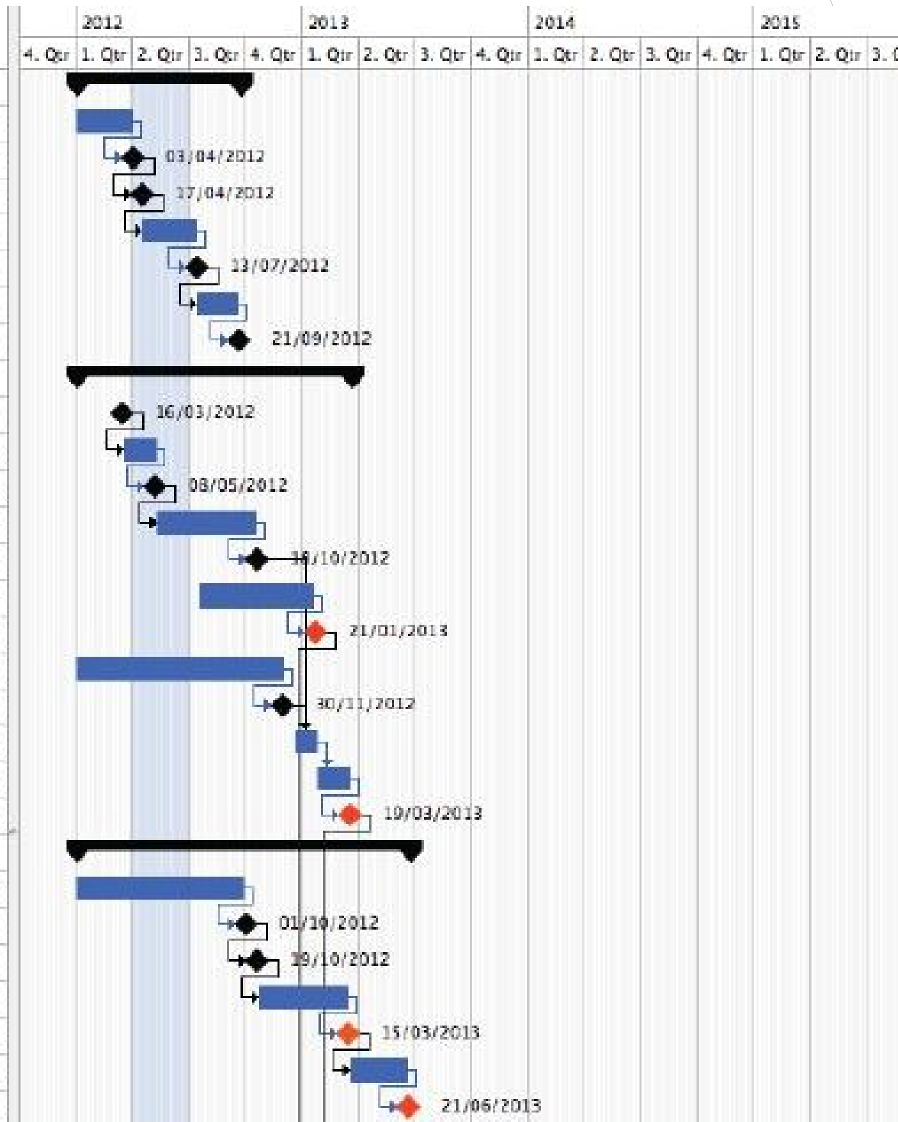




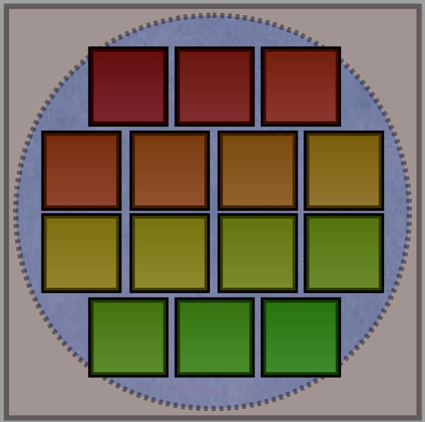
Other science:

- **BAO:cluster counts, SNIa, cosmic shear (requires more observations than originally planned for the survey)**
- **Large scale structure**
- **Transient phenomena: SNs, GRBs, variable stars and asteroids**
- **Stellar populations in the Milky Way halo, halo substracture, satellites**
- **Galaxy evolution: low resolution spectra of ALL galaxies more luminous than L* and z<1 in the area of the survey**
- **Galaxy evolution: spatially resolved spectrum of the closest galaxies to us, as a giant IFU**

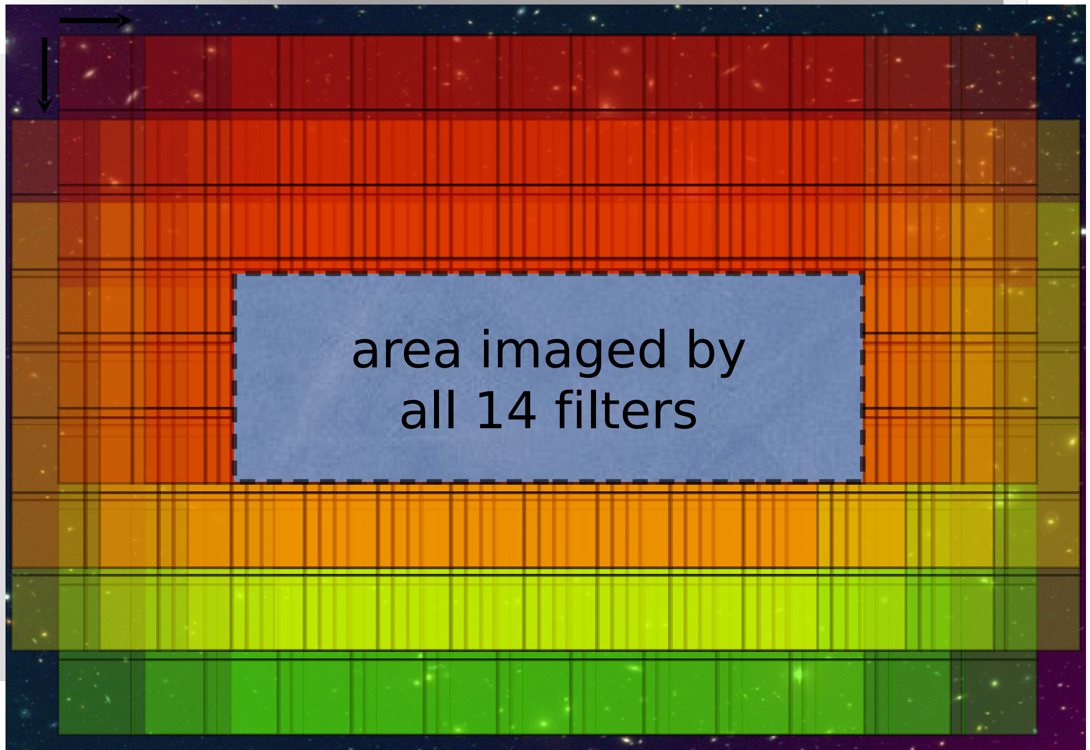
	Task Name	Start	Finish
1	**T80**	**02/01/2012**	**21/09/2012**
2	AIV at factory (ASTELCO, Germany)	02/01/2012	02/04/2012
3	Acceptance at Factory	03/04/2012	03/04/2012
4	Reception at the OAJ	17/04/2012	17/04/2012
5	Engineering Commissioning	18/04/2012	12/07/2012
6	Engineering First Light with OAJ verification camera	13/07/2012	13/07/2012
7	Scientific Commissioning	15/07/2012	19/09/2012
8	Scientific First Light with OAJ verification camera	21/09/2012	21/09/2012
9	**T80Cam**	**02/01/2012**	**19/03/2013**
10	Warm part PDR	16/03/2012	16/03/2012
11	Warm part Final Design	19/03/2012	08/05/2012
12	Warm part FDR	08/05/2012	08/05/2012
13	Warm part AIV	09/05/2012	17/10/2012
14	Warm part acceptance	18/10/2012	18/10/2012
15	J-PLUS Filter Manufacturing	16/07/2012	18/01/2013
16	J-PLUS Filter Acceptance	21/01/2013	21/01/2013
17	Cold Part AIV (Spectral Instruments)	02/01/2012	30/11/2012
18	Cold Part Acceptance	30/11/2012	30/11/2012
19	T80Cam AIV	21/12/2012	24/01/2013
20	T80Cam Commissioning at T80	25/01/2013	18/03/2013
21	T80Cam First Light: J-PLUS readiness	19/03/2013	19/03/2013
22	**T250**	**02/01/2012**	**21/06/2013**
23	AIV at factory (AMOS, Belgium)	02/01/2012	28/09/2012
24	Acceptance at factory	01/10/2012	01/10/2012
25	Reception at the OAJ	19/10/2012	19/10/2012
26	Engineering Commissioning	22/10/2012	14/03/2013
27	Engineering First Light with OAJ verification camera	15/03/2013	15/03/2013
28	Scientific Commissioning	17/03/2013	19/06/2013
29	Scientific First Light with OAJ verificaton camera	21/06/2013	21/06/2013



Each CCD = 1 filter/tray
Filter tray = 14 filters



Strategy: step-and-stare

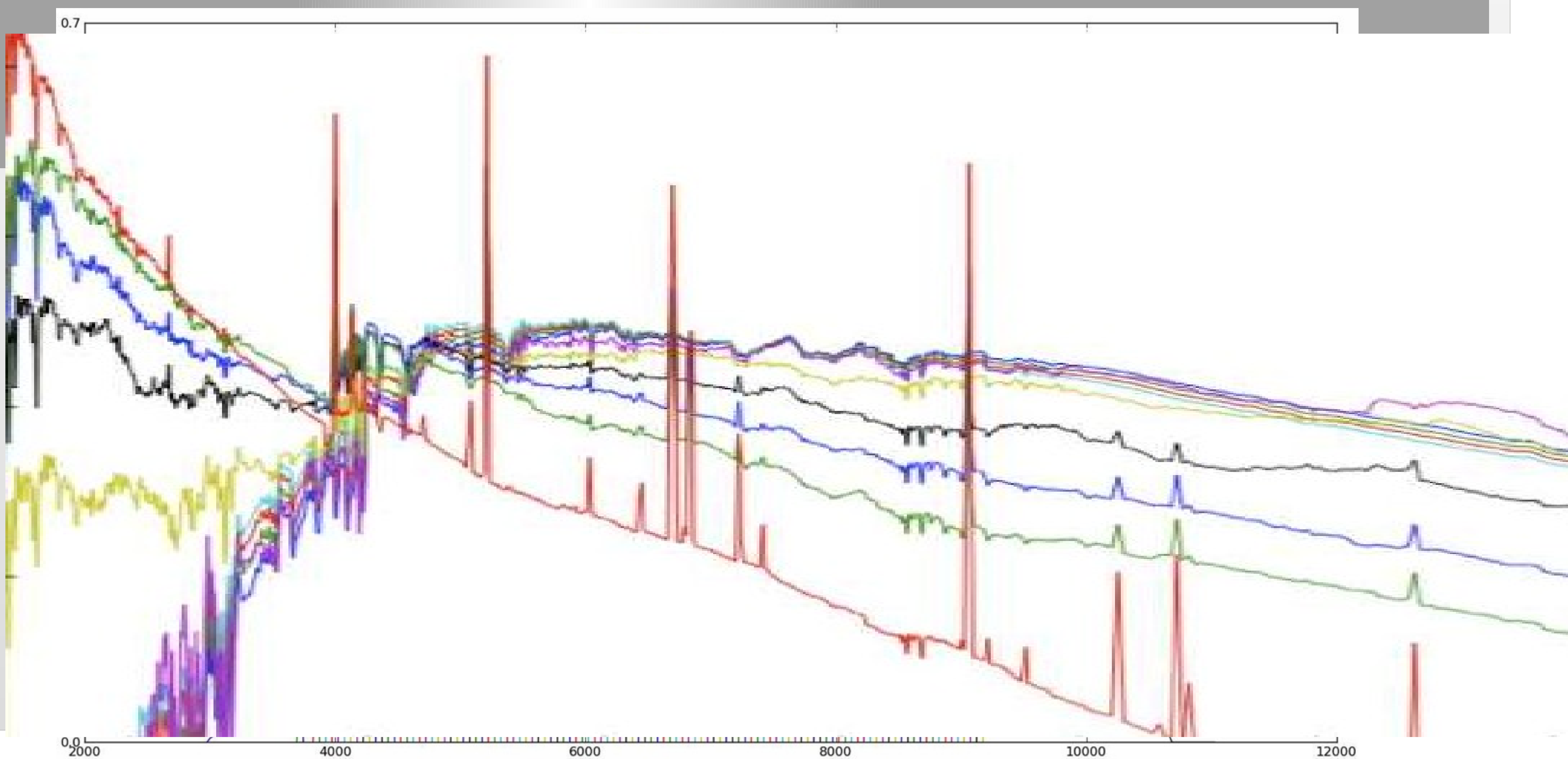


Filter system

Simulations of photo-z quality, efficiency & depth

Inputs from WGs: BAOs, galaxy evolution, AGN, ...

- ☛ Optimal filter system = 56 filters (14x4); 54 narrow (FWHM ~100 A)



<u>WHY:</u>

- **Photo-z's with just enough accuracy**

☛ **for P(k) & BAOs w/ LRG's, $\sigma z \sim 0.003(1+z)$**

- **Many goals achievable with narrow filters that resolve broad SED features & EWs**

☛ **including, but not limited to, the 4000A-break of LRGs**

- **Gain in cost/complexity: camera for imaging vastly cheaper/simpler than MoS**

☛ **no need to identify targets with another survey**

☛ **survey speed: filter out ~98% of photons, but don't throw away any galaxies due to limitations on the number of fibers or fiber collisions**

- **Get everything else "for free"**

☛ **ELGs & whole zoo of galaxies, quasars & AGNs, galaxy evolution, supernovae, minor planets of Solar System, ...**

☛ **"IFU with R~40-80" over > 8000 deg2**