JPAS

THE FIRST STAGE IV DARK ENERGY EXPERIMENT

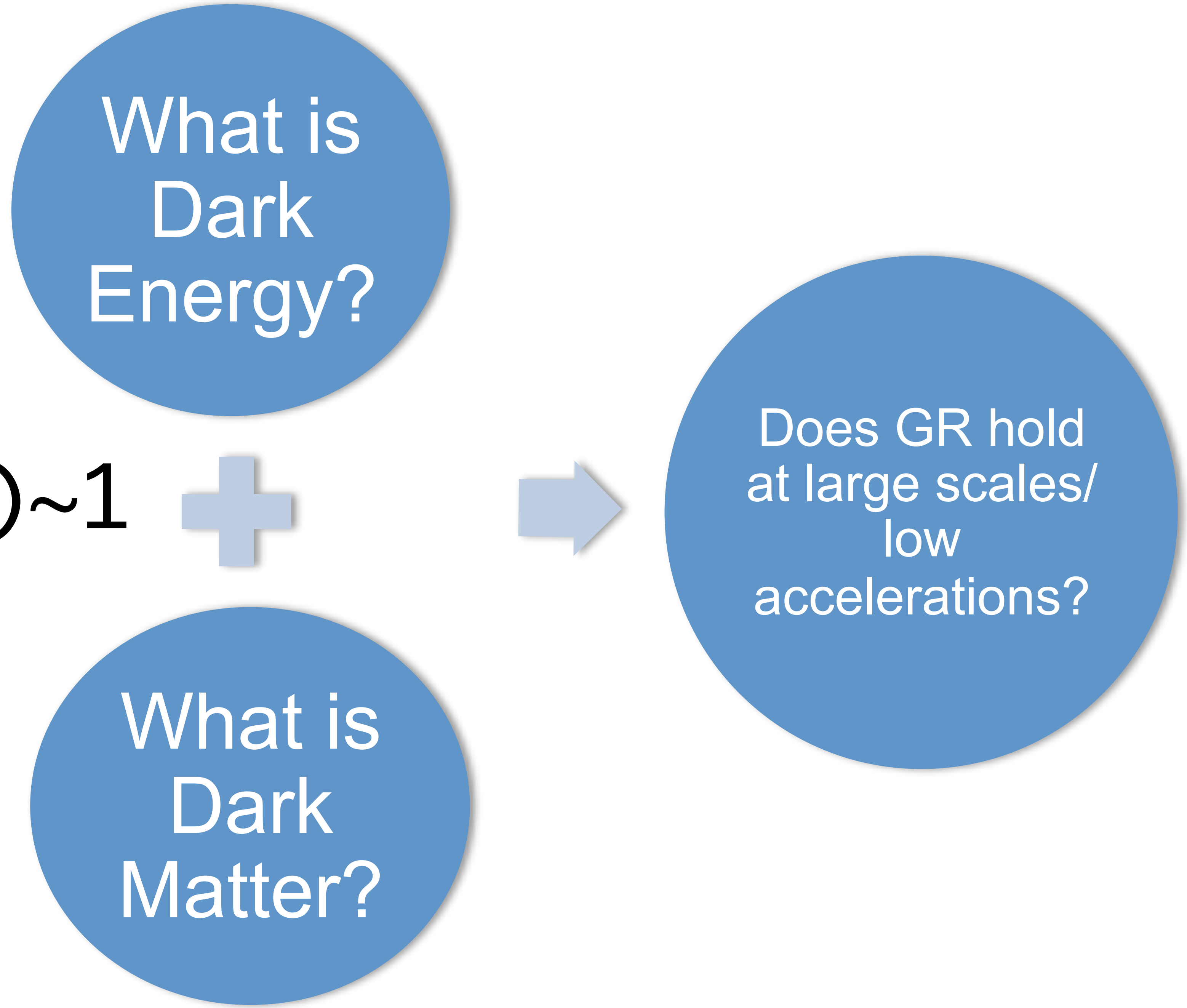
TXITXO BENITEZ (IAA-CSIC)

BIG QUESTIONS IN COSMOLOGY

BAOs
SNIa
Cluster Counting
Cosmic shear

$P(w=-1|CDM)\sim 1$

Cluster lensing
Cosmic shear
LSS studies



JPAS = ALL SKY IFU

Original motivation: you don't need spectroscopic redshift precision to measure the BAO scale; 0.003(1+z) photo-z are enough (Benitez et al 2009, PAU Consolider)

Javalambre-PAU Astrophysical Survey:

***Competitive in all "canonical" Dark Energy probes**

- BAOs+LSS

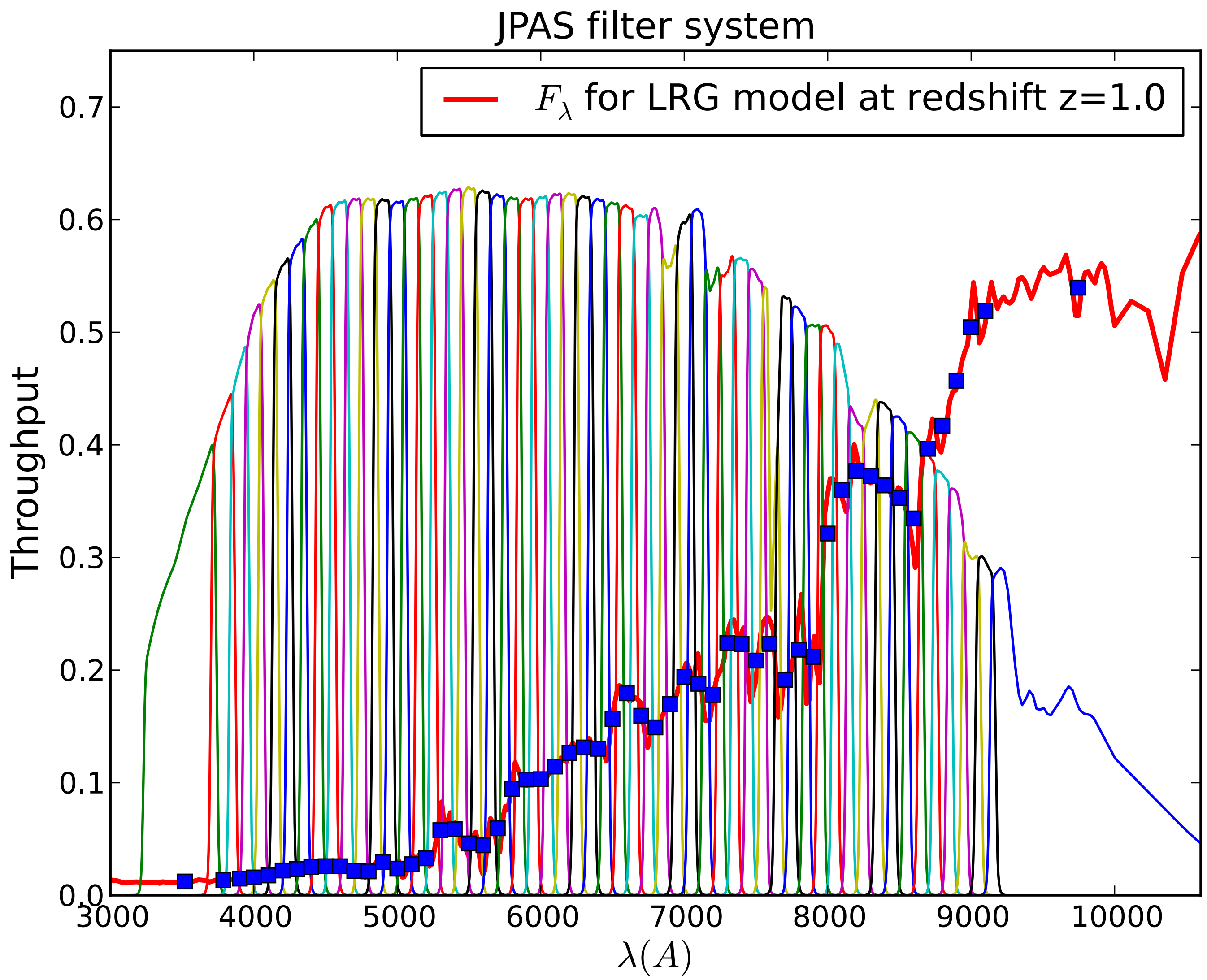
- SNIe

- Cluster Counting

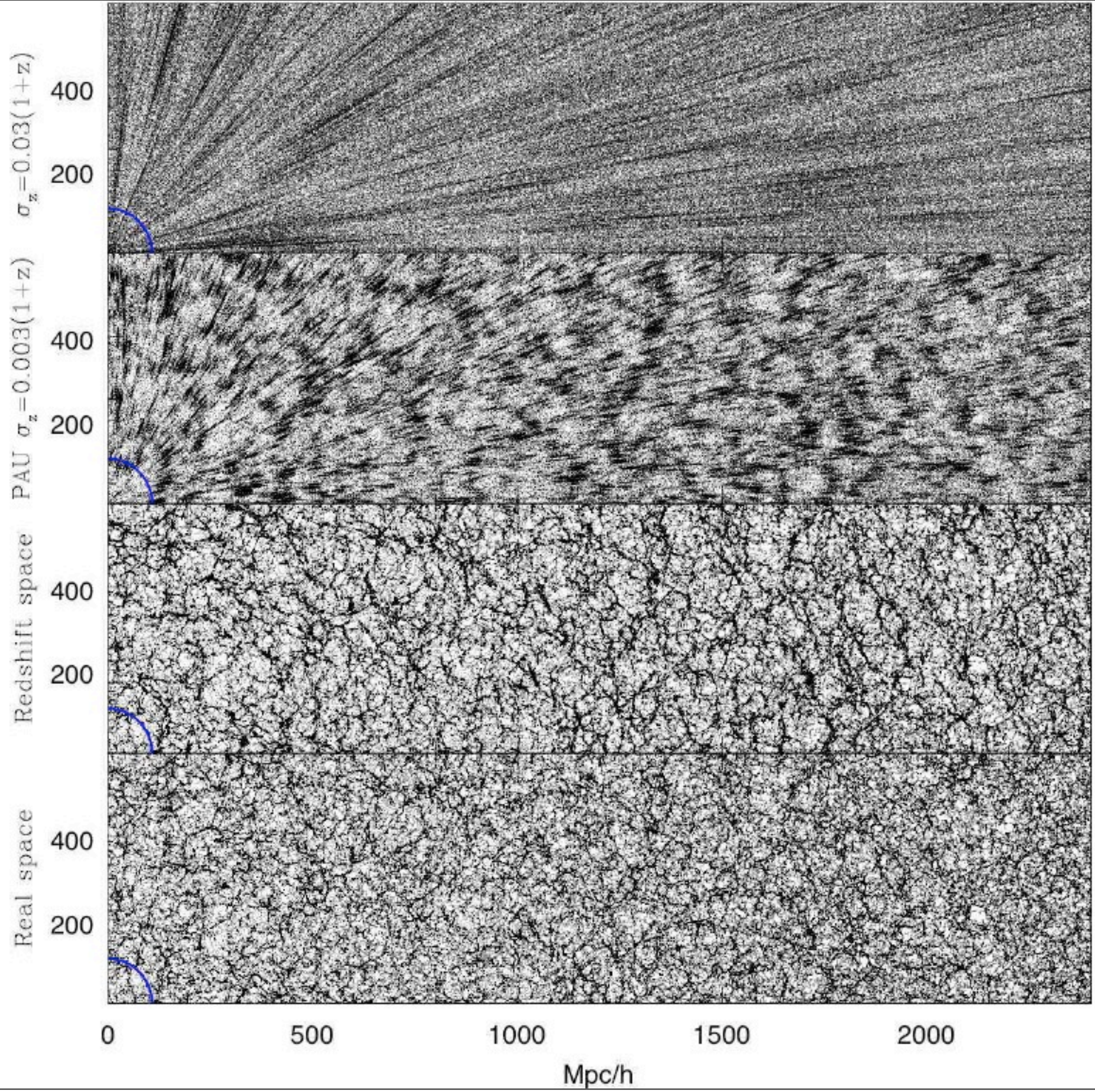
- Weak lensing

***Almost every other major area in Astrophysics, AGN, Galaxy Evolution, the Galaxy, Solar System**

see Benitez et al. 2013

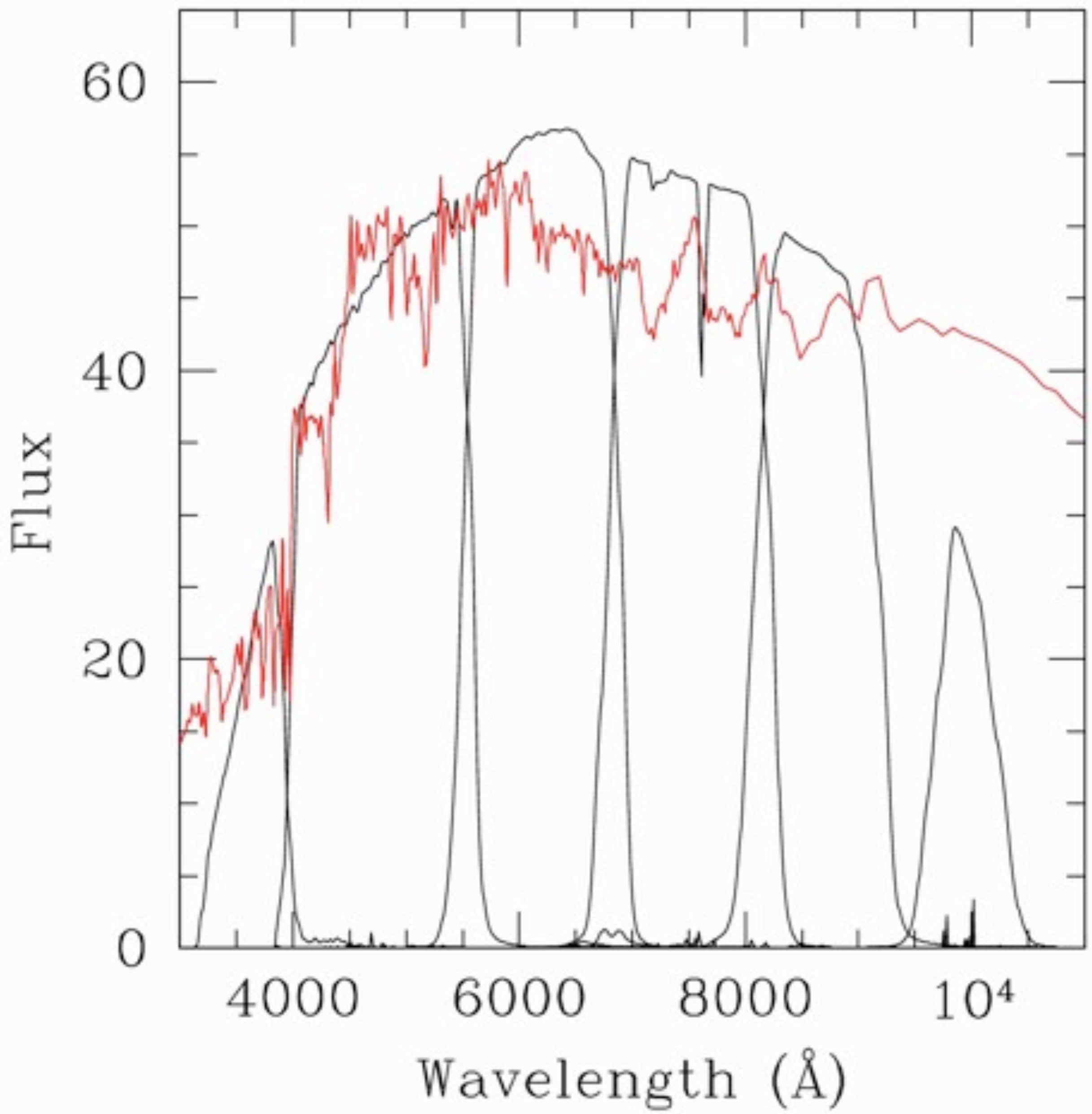


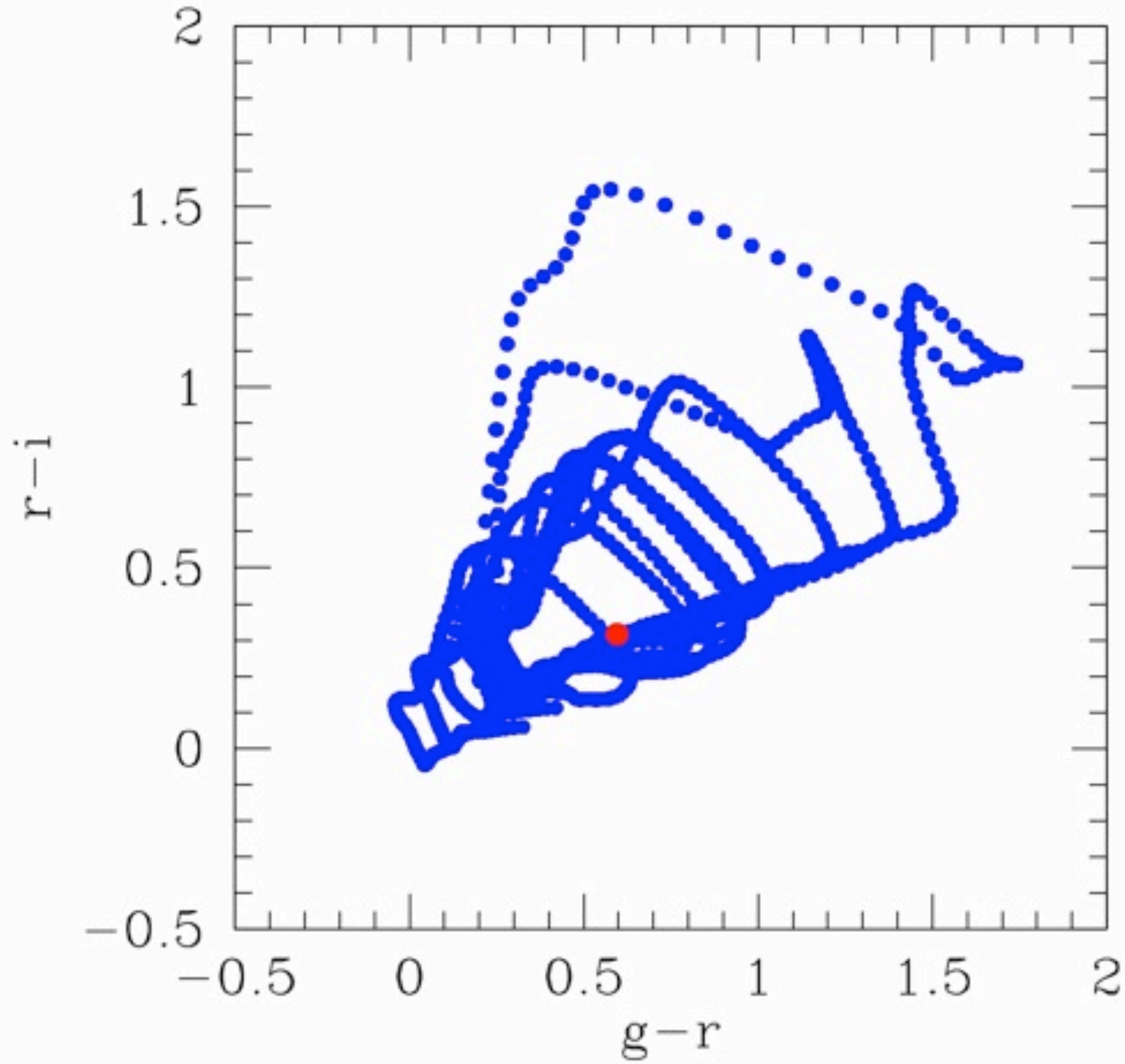
54 NB filters, 5 BB filters
240-480s exposure
8500 sq.deg.



σ_z=0.03(1+z)
PAU σ_z=0.003(1+z)
Redshift space
Real space
400
200
0
500
1000
1500
2000
Mpc/h

Photometric Redshifts: the poor man's spectrograph





SPECTROSCOPY VS NB IMAGING

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Compare imaging with N_F filters to a spectrograph

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v_S for spectroscopy: N_{max} x η

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v_S for spectroscopy: $N_{max} \times \eta$

v_S for imaging: $n_g \times A \times \eta_i / N_F = (n_g A)\times(\eta_I / N_F) = N_{max} \times \eta$

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JPAS N_{max}= 11000x5= 55000 (!!) so $v_S \sim 1250$

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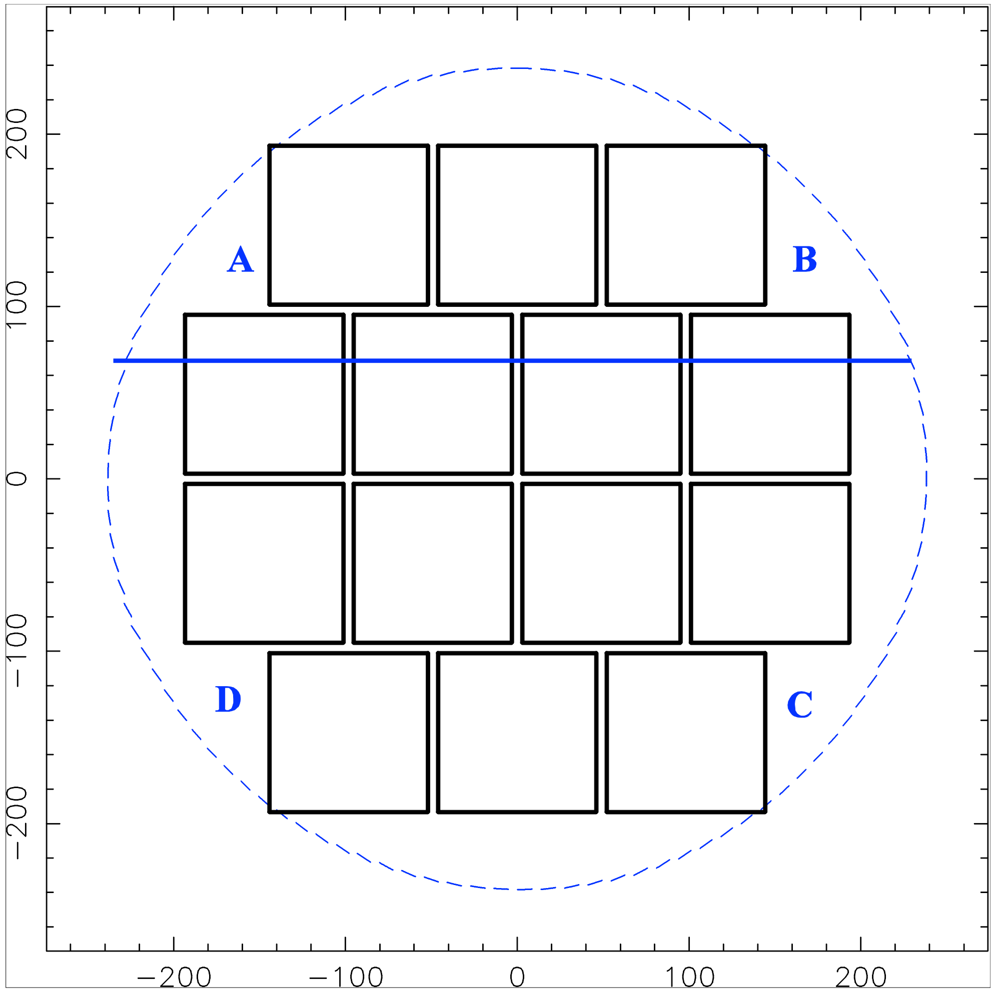
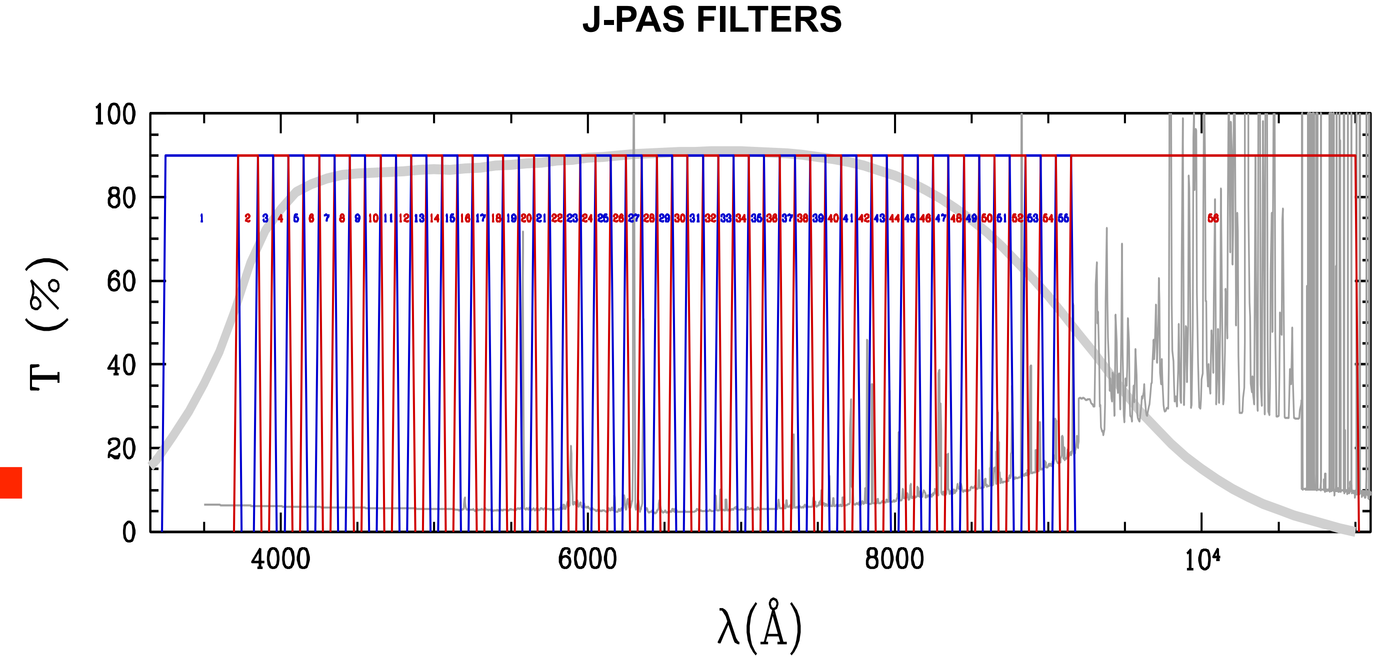
But look at the multiplexing:

Spectroscopy (BOSS): N_{max}=1000 v_S~250

JPAS N_{max}= 11000x5= 55000 (!!) so v_S~1250



+



The all 56 J-PAS filters can be **simultaneously** located at J-PCam.

J-PAS Strategy to driven by moon phase, seeing, weather conditions, etc.

≈ 5000 multiplex spectrograph

But 10 times cheaper, 2 times faster to build

Stage IV experiment starting in 2015

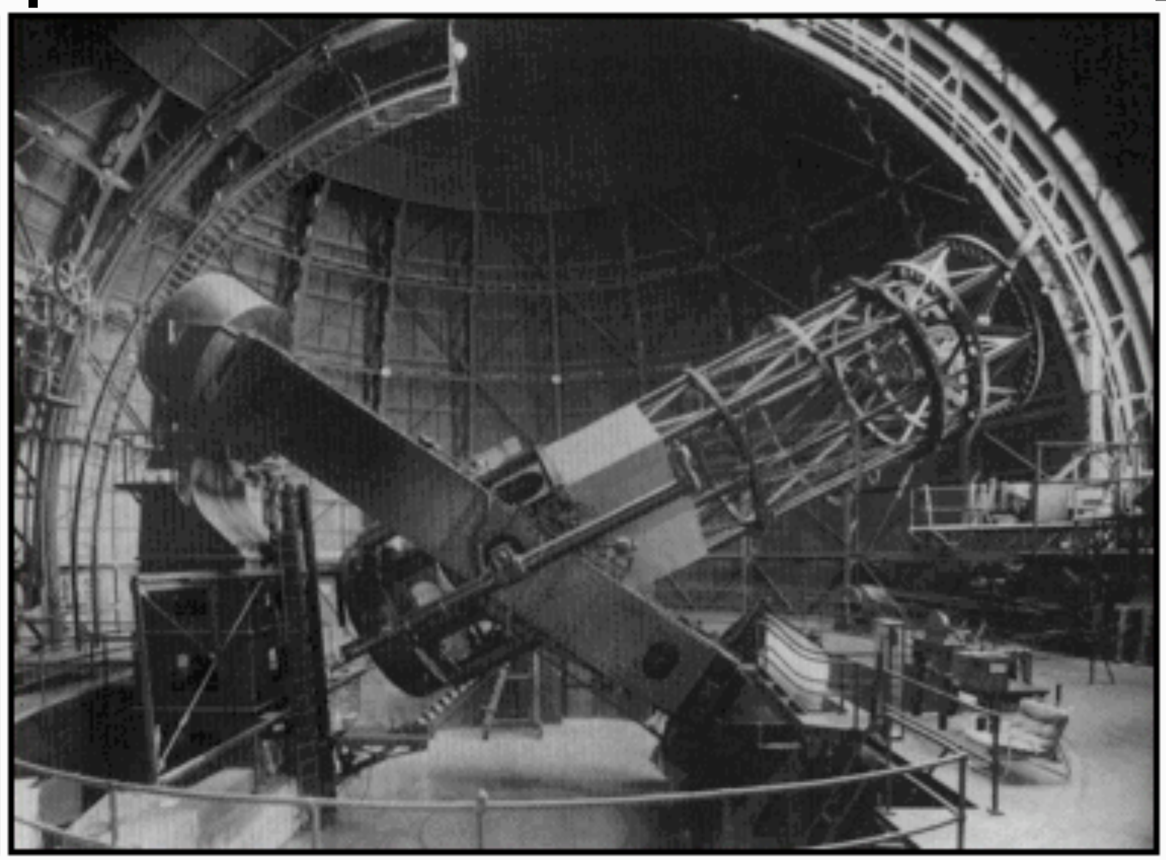
A few % of the cost of other Stage IV projects

~100M redshifts

Cosmological Spectroscopy is more than 100 years old

Reliable, well understood, but hard to improve upon

Edwin Hubble
1889 – 1953



100 inch Mt Wilson Telescope

Milton Humason
1891 – 1972

Photometric Redshifts

- Photo-z still in their teens...
- HST+Empirical templates circa 1997
- Still not consensus about "Best practices"
- Critical technical advances are frequent

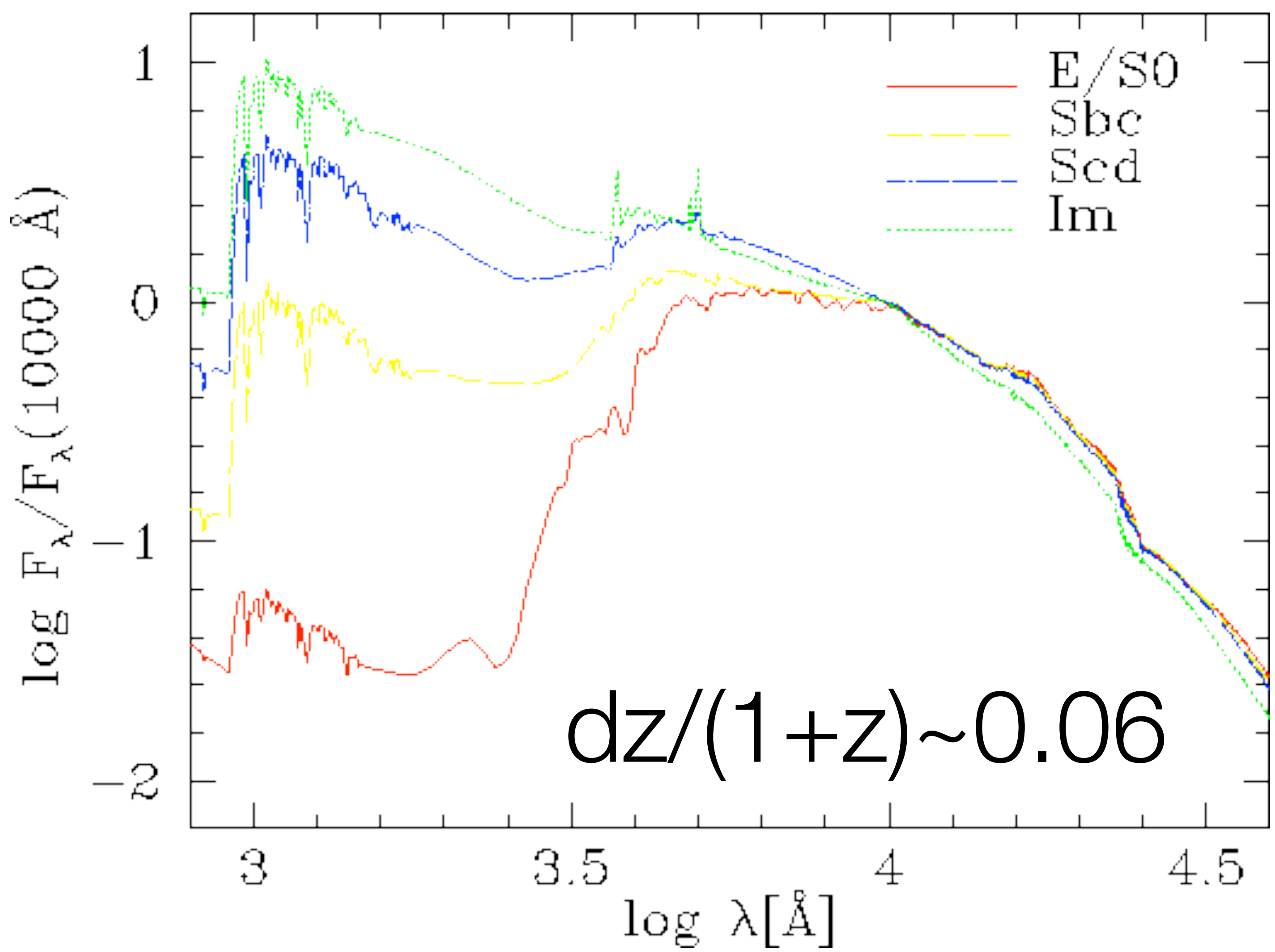
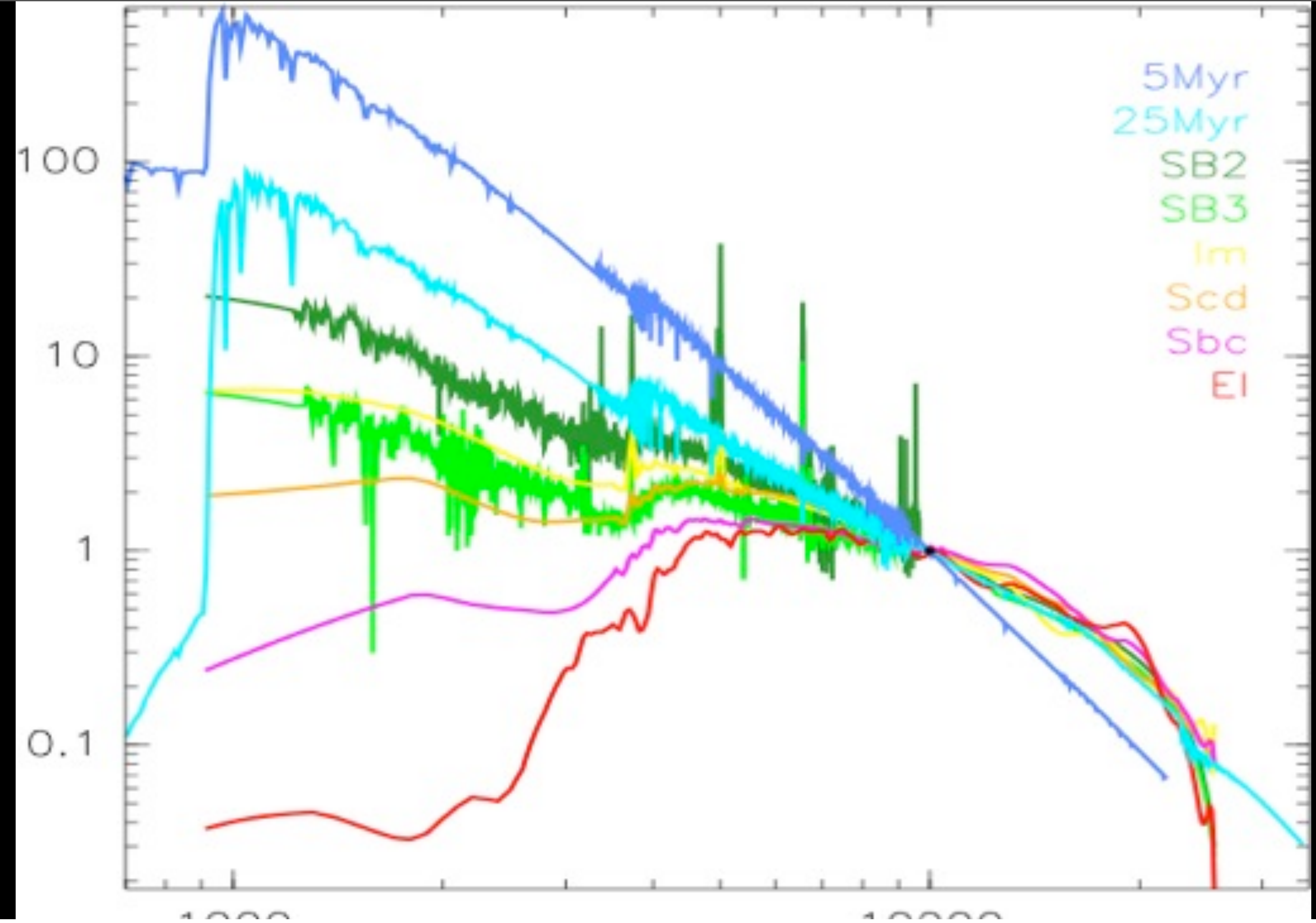


PHOTO-Z



$$p(z\,|\,C, m_0) = \sum_T p(z, T\,|\,C, m_0) \propto \sum_T p(z, T\,|\,m_0)p(C\,|\,z, T)$$

Benitez et al. 2009

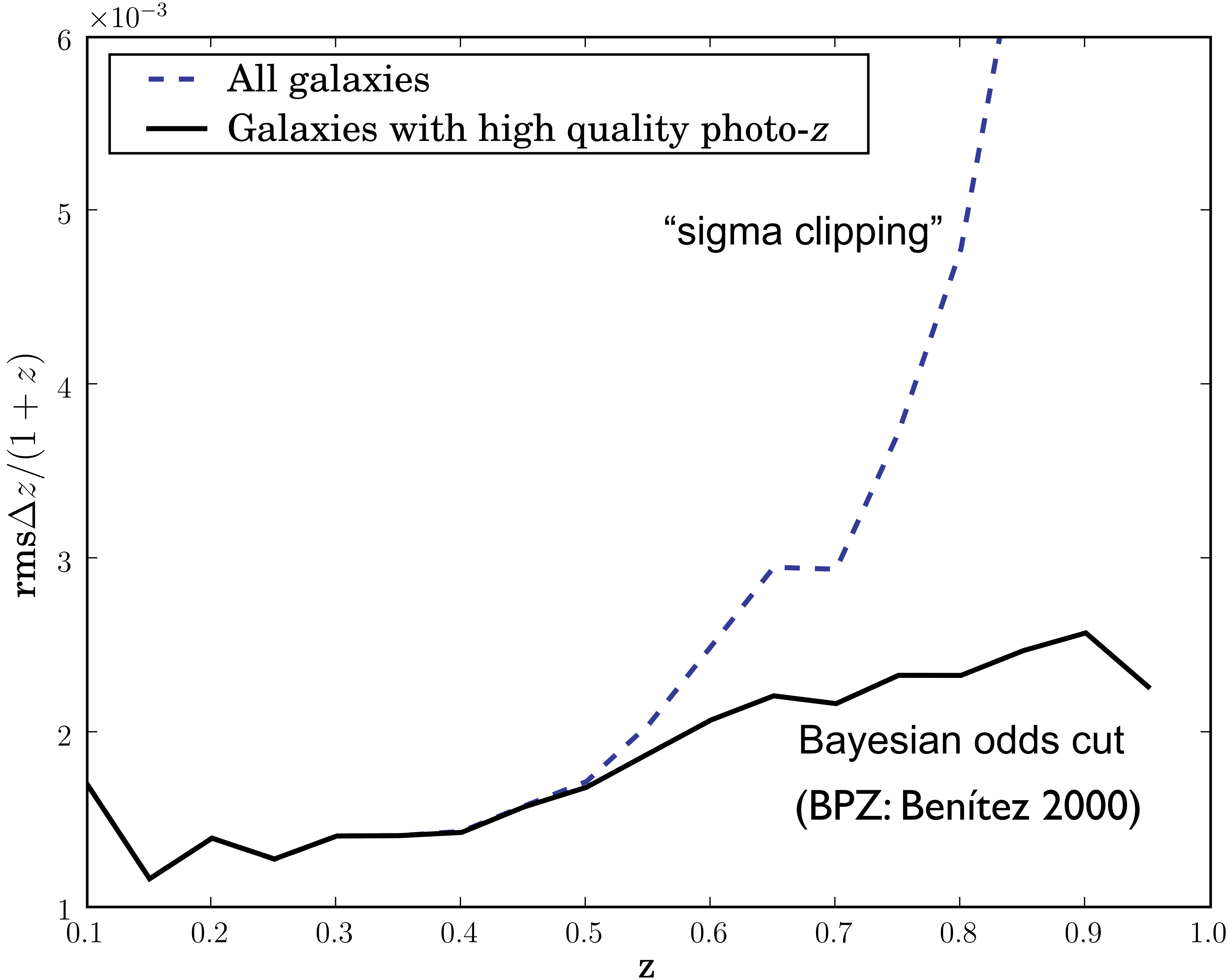
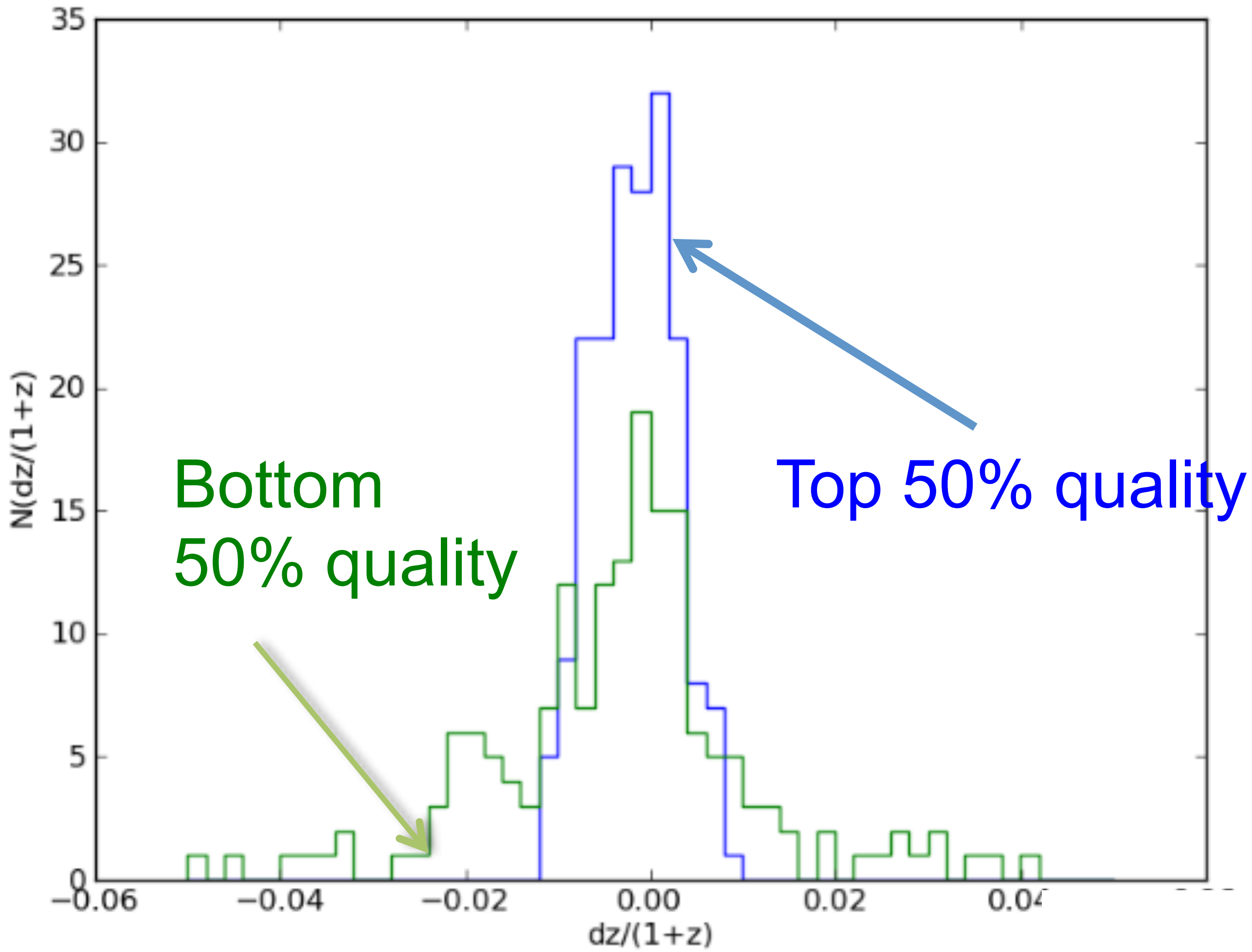


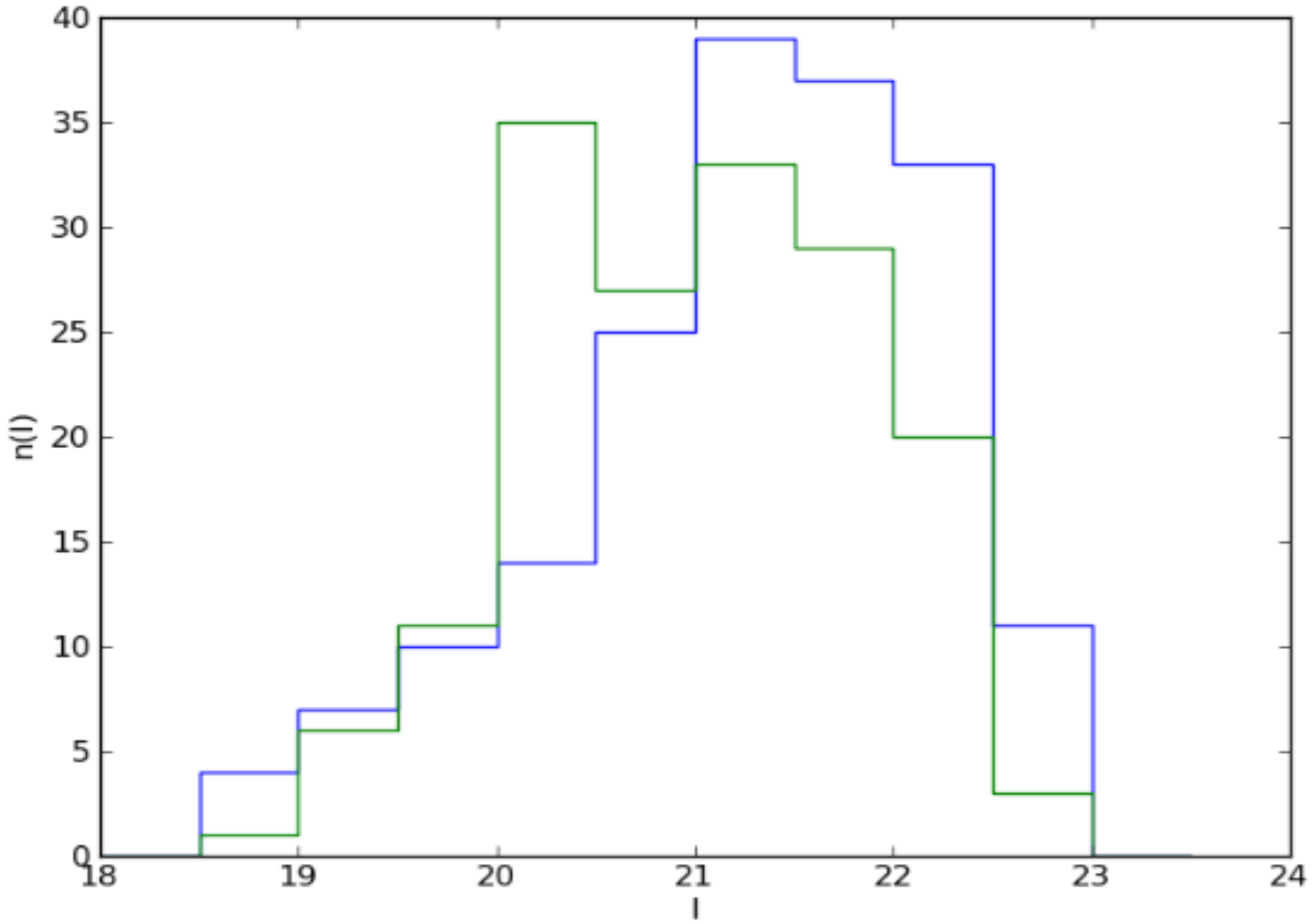
Figure 13. Photometric redshift error as a function of redshift, for all $L > L_\star$, $I < 23$ red galaxies, and for the subset with high-quality photo-z.



-COSMOS (Ilbert et al. 2009) catalog
~300A filters
-Photo-z with high odds 0.0045(1+z)

Bayesian Odds provide a reliable precision predictor!

- Magnitude or S/N cuts are not Efficient
- Need to use Bayesian approach with a quality indicator
- “Battle tested”



The ALHAMBRA Survey: Bayesian Photometric Redshifts with 23 bands for 3 squared degrees.

A. Molino[1], N. Benítez[1], M. Moles[2], A. Fernández-Soto[3], D. Cristóbal-Hornillos[2], B. Ascaso[1], Y. Jiménez-Teja[1], W. Schoenell[1], P. Arnalte-Mur[4], M. Pović[1], D. Coe[5], C. López-Sanjuan[2], Díaz-García L. A.[2], I. Matute[1], J. Masegosa[1], I. Márquez[1], J. Perea[1], A. Del Olmo[1], C. Husillos[1], E. Alfaro[1], T. Aparicio Villegas[9], M. Cerviño[1], V. J. Martínez[3], J. Cabrera-Caño[6], R. M. González Delgado[1], J. A. L. Aguerri[7], J. Cepa[7,8], T. Broadhurst[10], F. Prada[1], L. Infante[11], J. M. Quintana[1]

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[7] *Instituto de Astrofísica de Canarias, Vía Láctea s/n, La Laguna, Tenerife 38200, Spain*
[8] *Departamento de Astrofísica, Facultad de Física, Universidad de la Laguna, Spain*
[9] *Observatrio Nacional-MCT, Rua Jos Cristino, 77. CEP 20921-400, Rio de Janeiro-RJ, Brazil*
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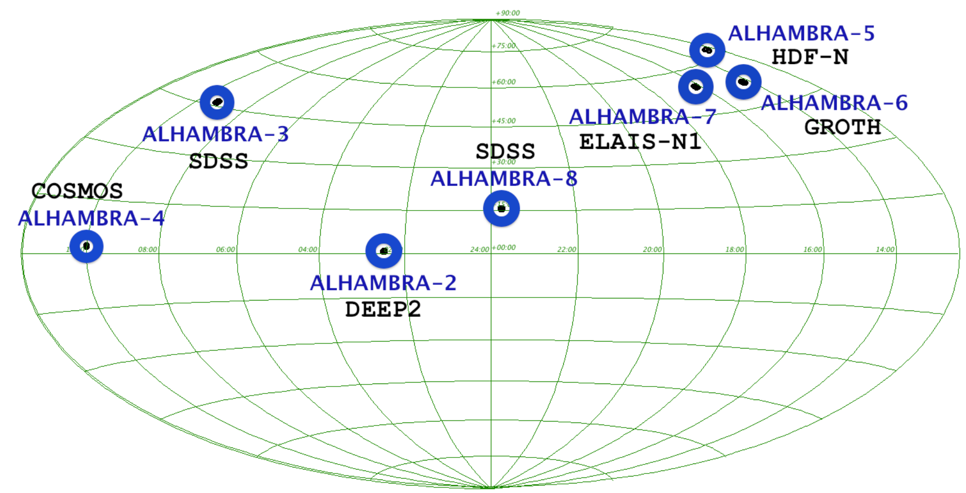


Figure 1. The figure shows the different fields observed by the ALHAMBRA survey along with their correspondence with other existing surveys. The mean galactic coordinates are specified in Table 1.

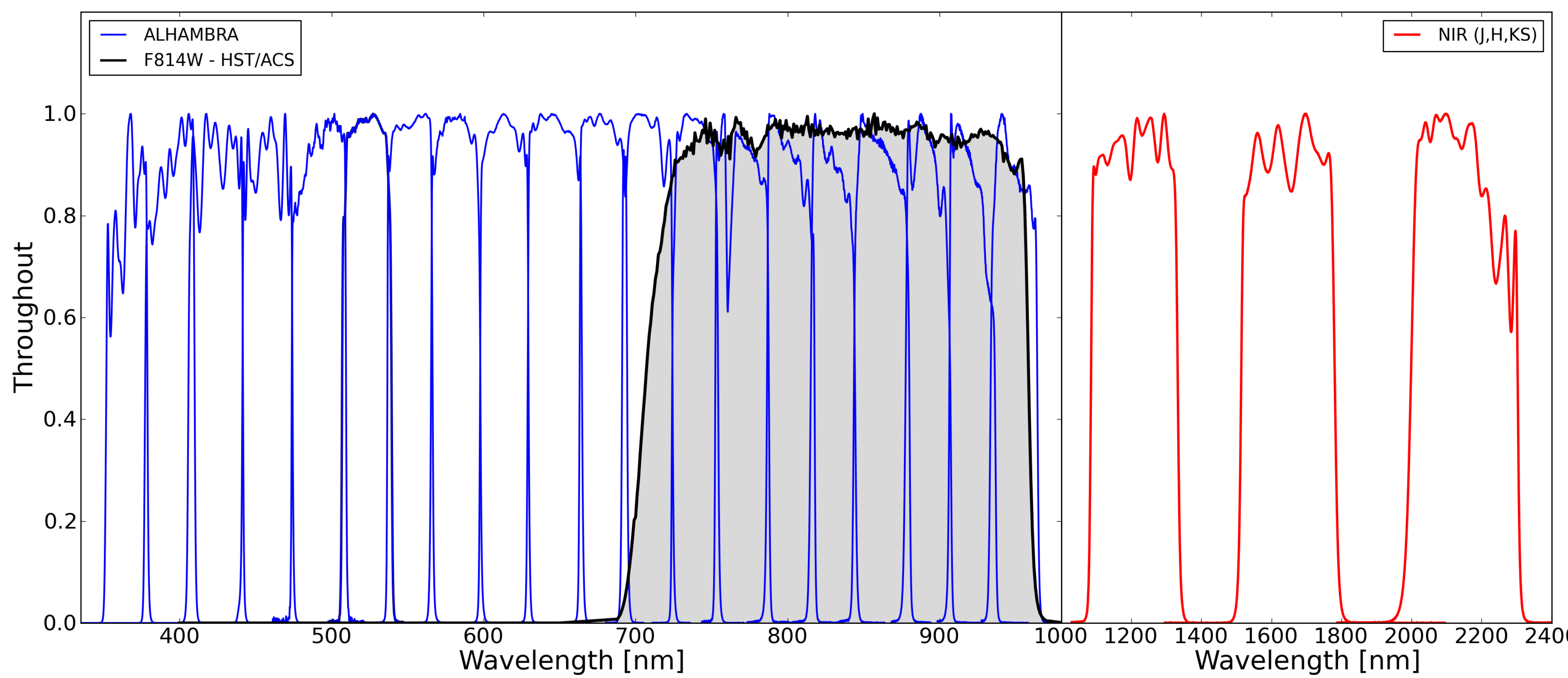
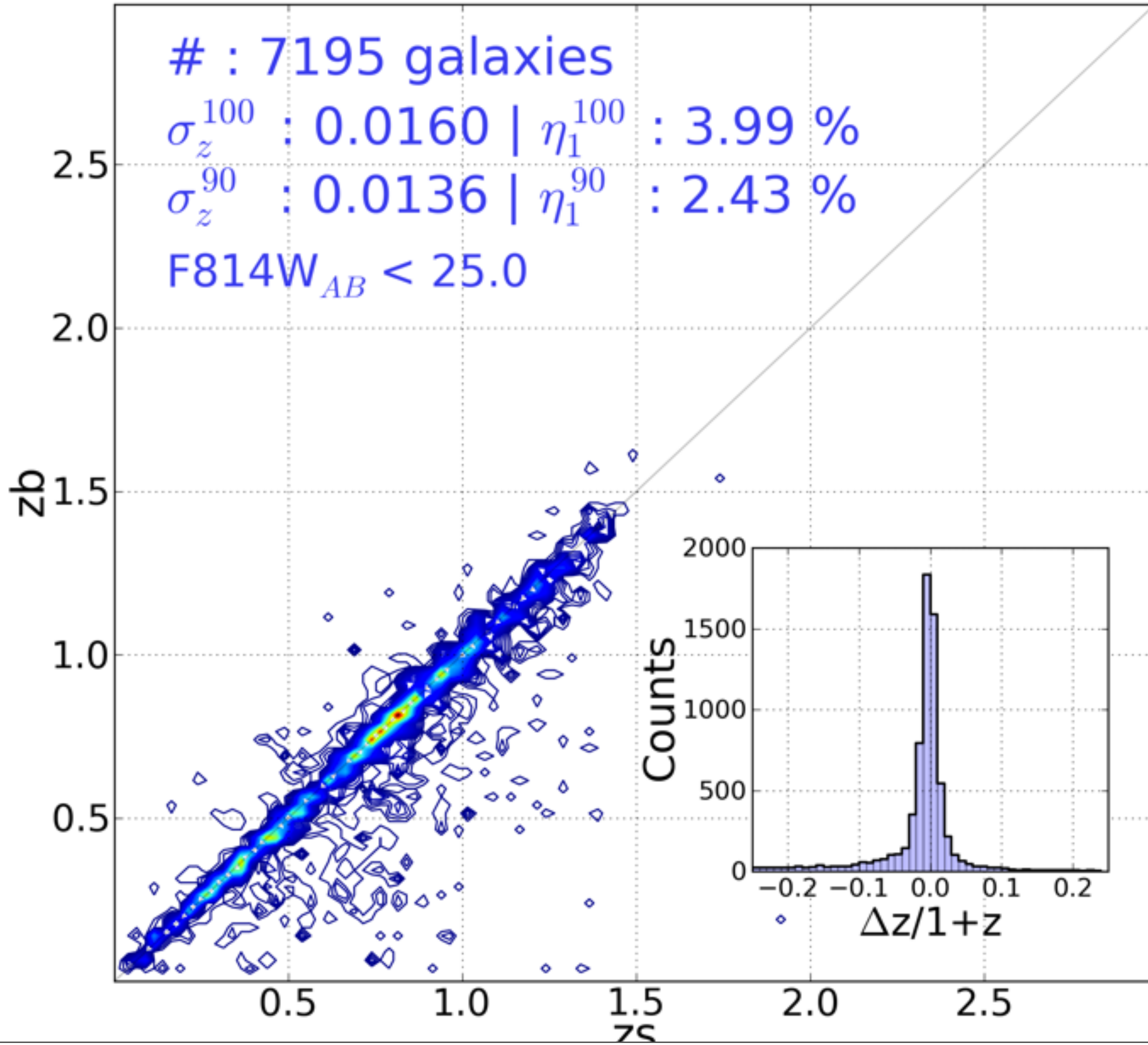


Figure 2. The ALHAMBRA survey filter set. On the left-hand side, solid blue lines represent the Optical filter system composed by 20 contiguous, equal-width, non overlapping, medium-band (∼300$\AA$) filters. The solid black line corresponds to the synthetic F814W filter used to define a constant observational window across fields. On the right-hand side, solid red lines represent the standard JHKs near-infrared broad bands.



: 7195 galaxies
σ_z^{100} : 0.0160 | η_1^{100} : 3.99 %
σ_z^{90} : 0.0136 | η_1^{90} : 2.43 %
$F814W_{AB}$ < 25.0
zb
zs
Counts
Δz/1+z

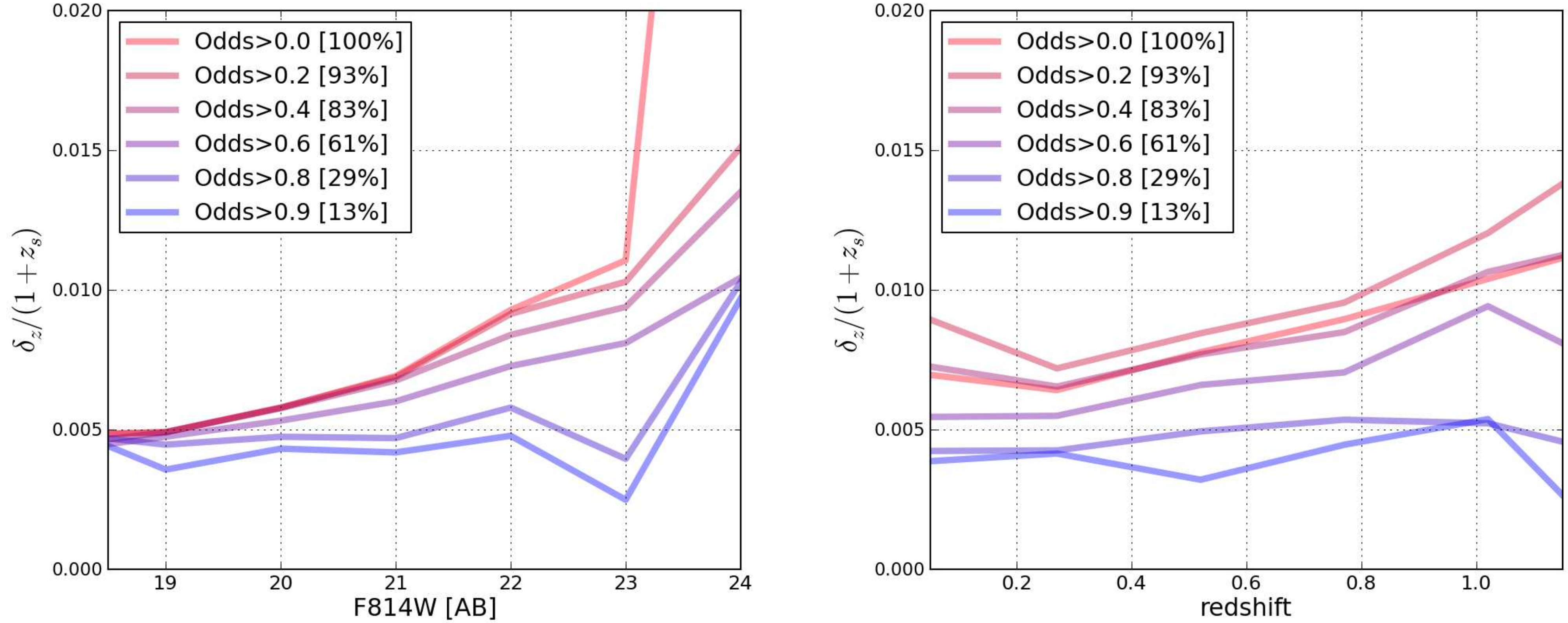
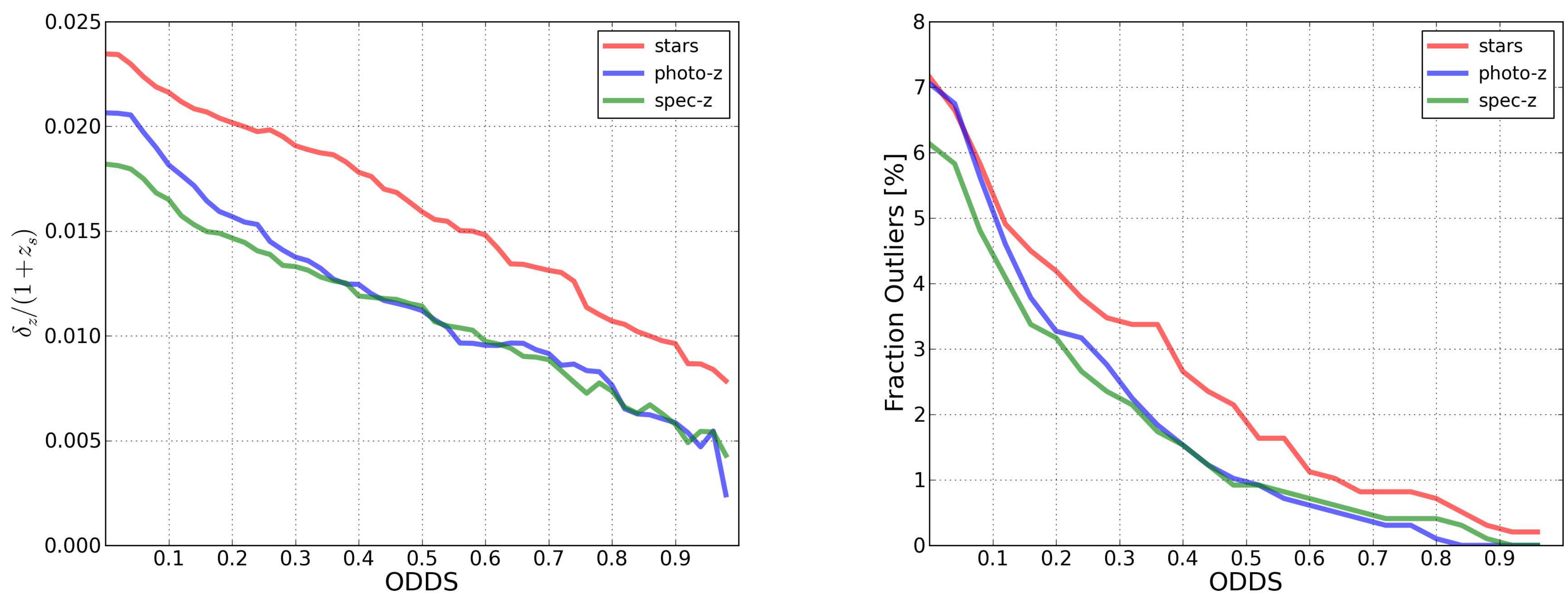
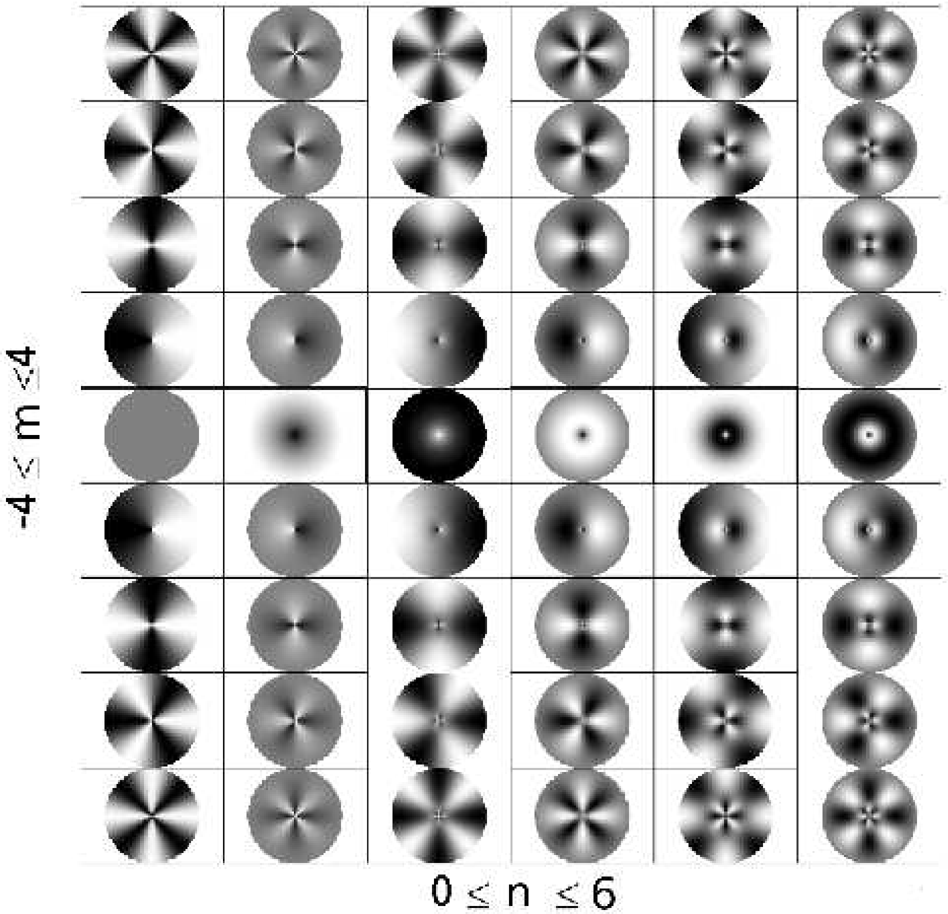
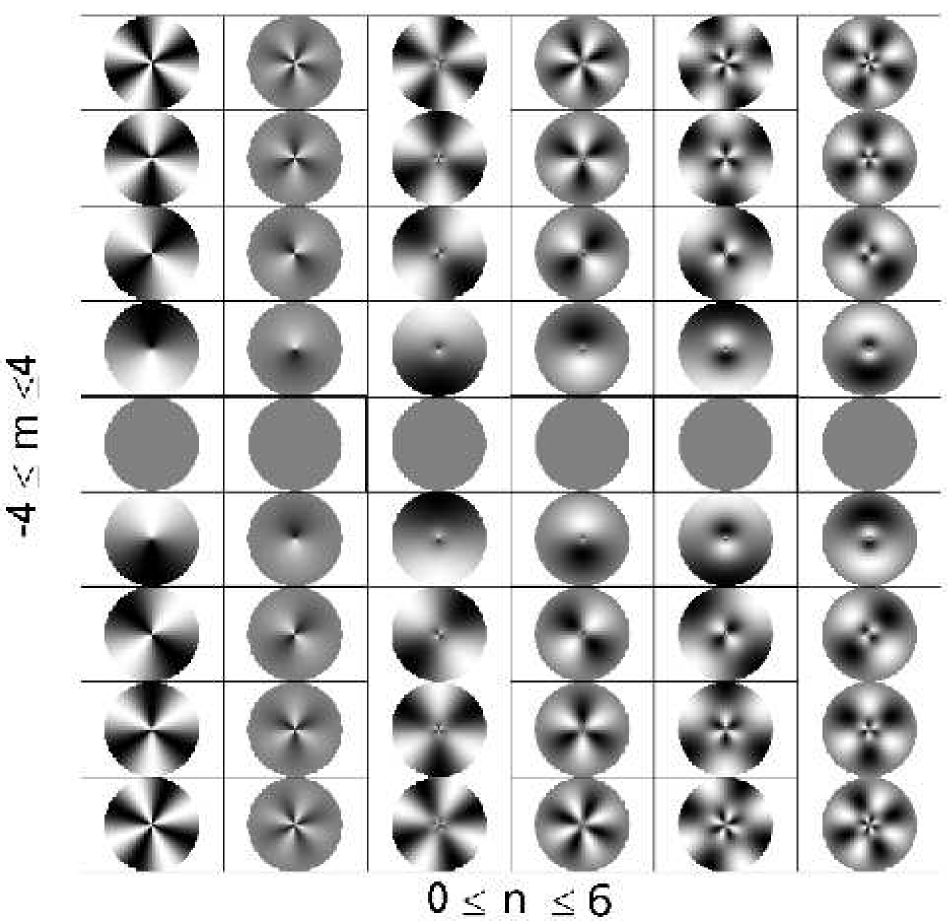


Figure 25. Photometric redshift accuracy as a function of apparent magnitude F814W (left panel) and spectroscopic redshift (right panel). We explored the expected accuracy for our photometric redshifts in terms of a specific magnitude range and redshift range applying different $Odds$ intervals.




-4 ≤ m ≤4
0 ≤ n ≤ 6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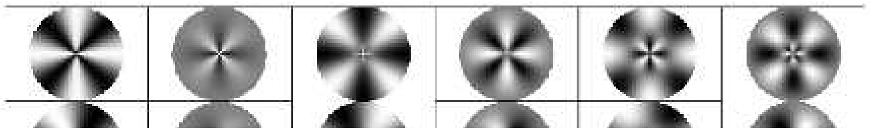
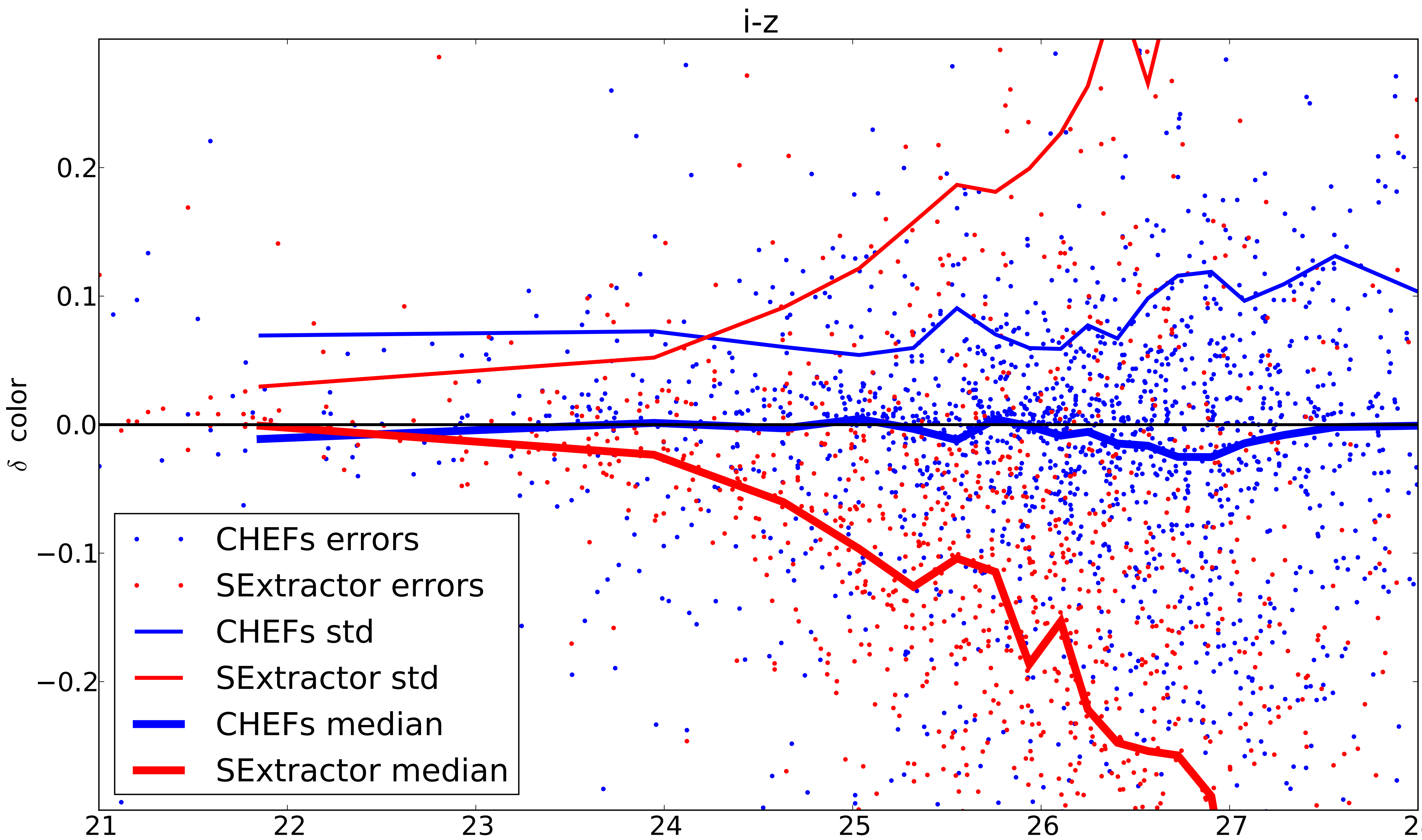
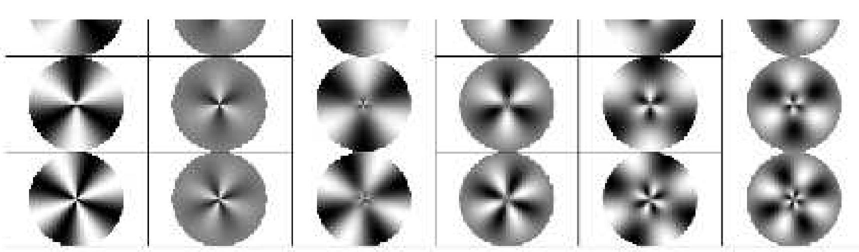


-4 ≤ m ≤4


i-z
δ color
0.2
0.1
0.0
−0.1
−0.2
21
22
23
24
25
26
27
28
CHEFs errors
SExtractor errors
CHEFs std
SExtractor std
CHEFs median
SExtractor median

-4 ≤ m ≤4



0 ≤ n ≤ 6

- IAA-CSIC (MICINN)
- CEFCA
- Observatorio Nacional, Río de Janeiro
- Departamento de Astronomia, Universidade de São Paulo
- Centro Brasileiro de Pesquisas Físicas

Centro de Estudios de Física del Cosmos de Aragón

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- Centro Brasileiro de Pesquisas Físicas

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SANCTI PAVLI CÆLVM AGER MEVS

JPAS-SPAIN

CEFCA: Mariano Moles, **Javier Cenarro**, **David Cristóbal**, **Antonio Marín-Franch**, **Carlos Hernández-Monteagudo**, Alessandro Ederoclite, Jesús Varela López, José Luis Lamadrid, Kerttu Vironen, Luis Alberto Díaz, Luisa Valdivieso, Natalio Maicas, Sergio Chueca, Susana Gracia, Axel Yanes Díaz, Carlos López-Sanjuan, Nicolás Gruel

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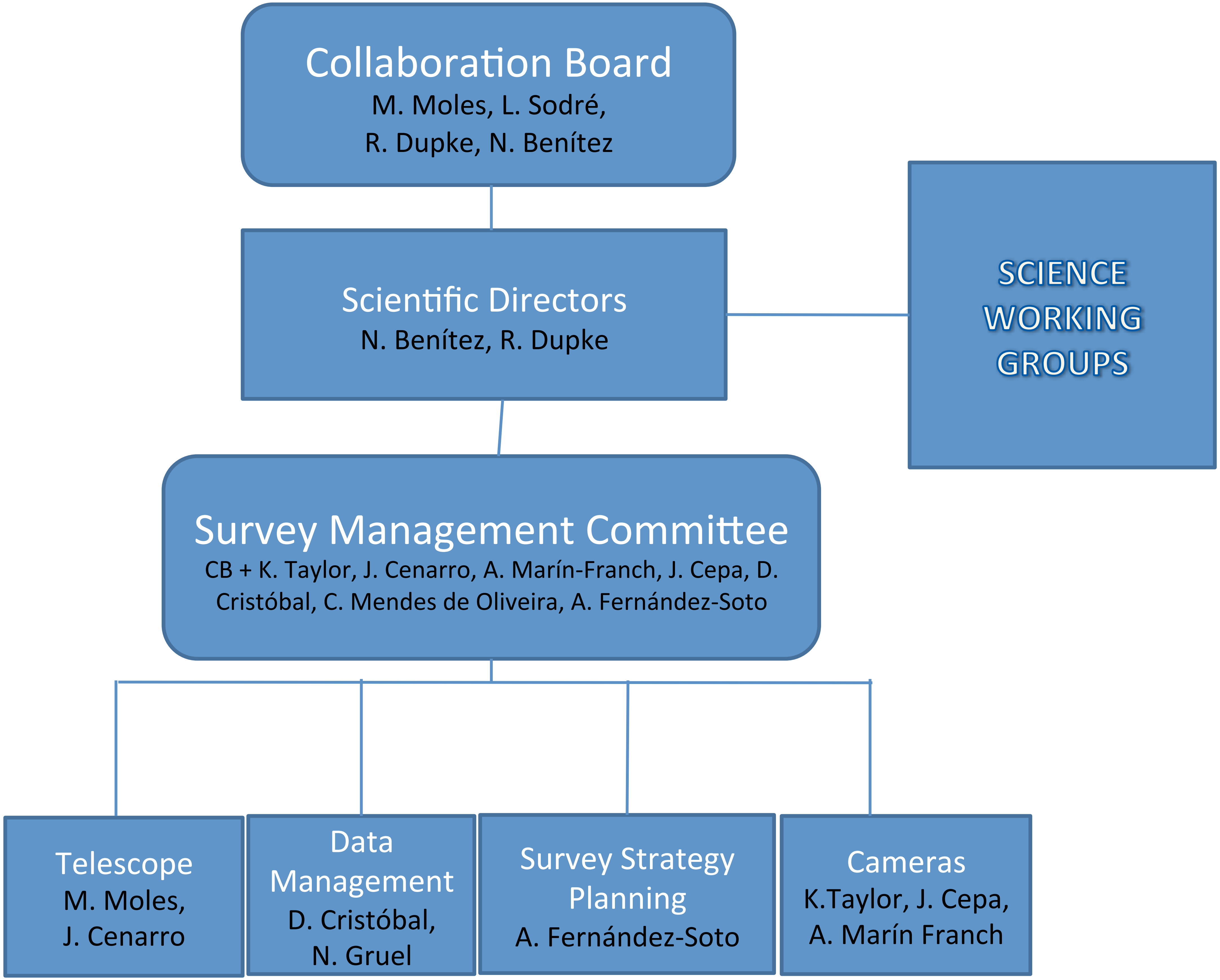
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R. Dupke, N. Benítez
Scientific Directors
N. Benítez, R. Dupke
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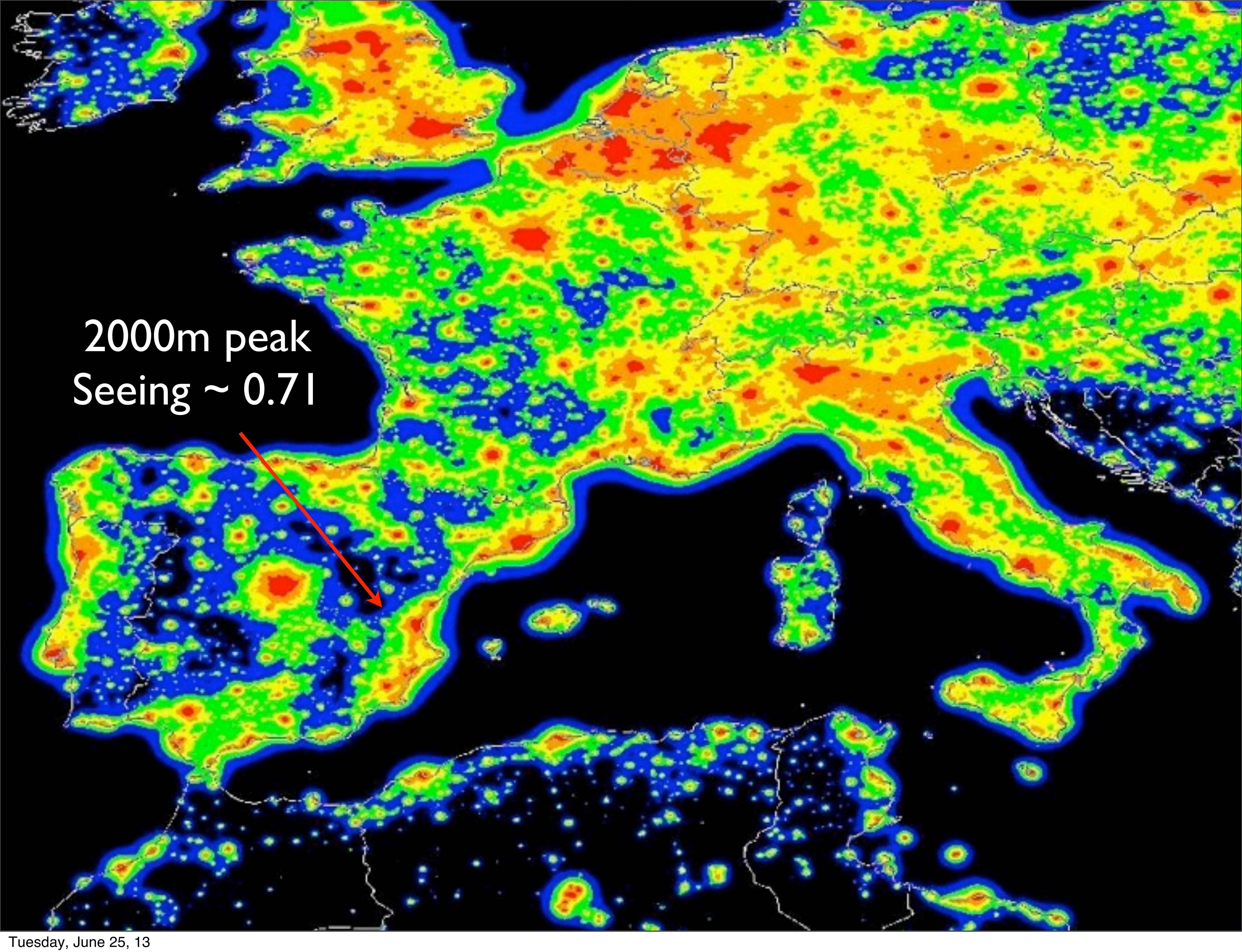
2000m peak
Seeing ~ 0.71

PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, 122:363–372, 2010 March

Site Testing of the Sierra de Javalambre: First Results

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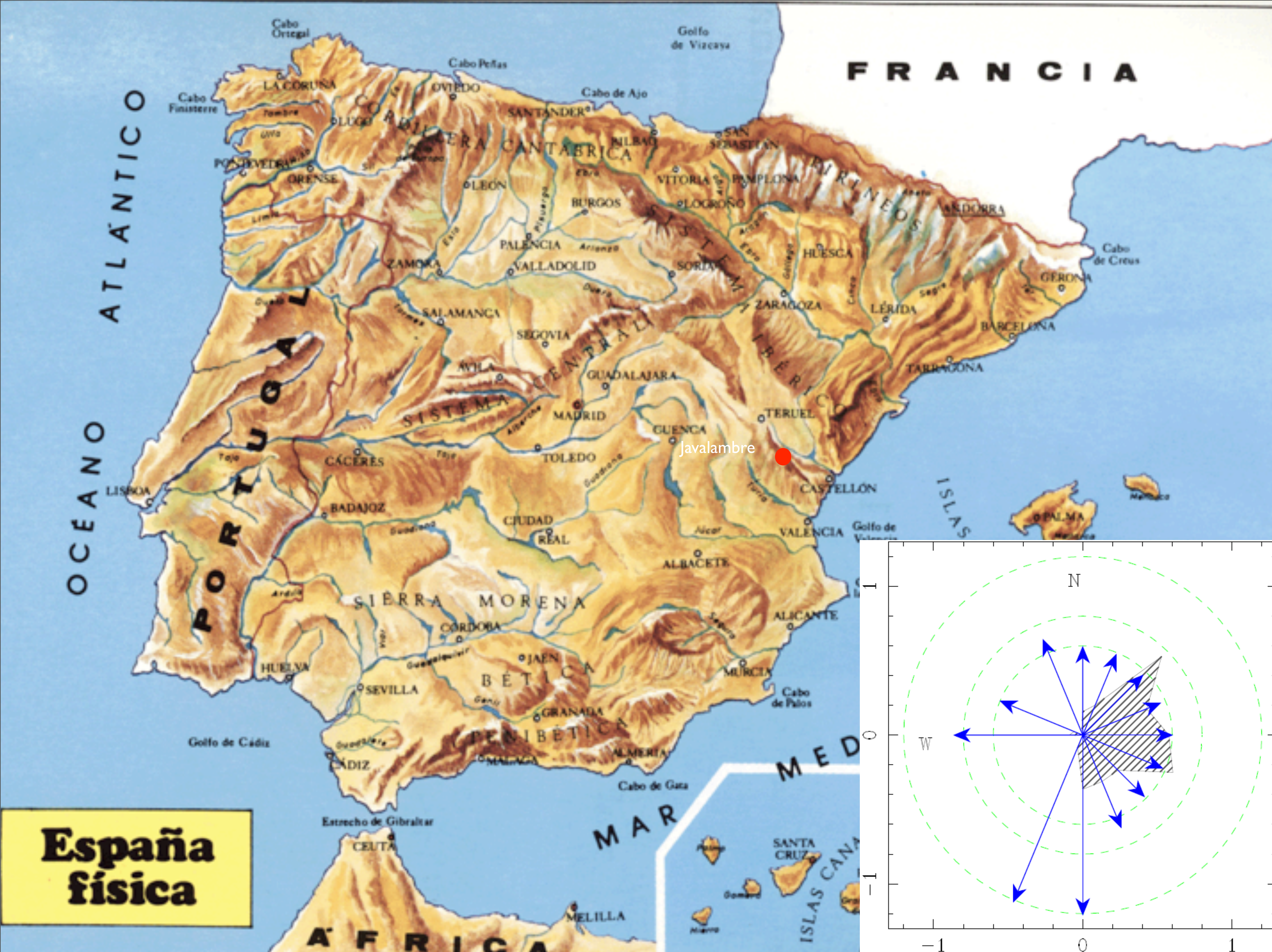
-- Dark Site - ~ no pollution
-- SB(sk): B= 22.8,V= 22.1, R = 21.5,I = 20.4
-- k_V = 0.22 (0.18) - Summer (few values)
-- Seeing: Med = 0.71”, Mode = 0.58”, for 5h when < 0.8”
-- Clear Nights: 53% / 62% / 74%

Mauna Kea (1987)	0.50″	Racine (1989)
Javalambre	~0.71” (2009)	
La Palma (1997)	0.76″	Muñoz-Tuñon et al. (1997)
La Silla (1999)	0.79″	ESO webpage*
Paranal (2005)	0.80″	ESO webpage**
MtGraham (1999-2002)	~0.97″	Taylor et al. (2004)
Paranal (2006)	~1.00″	ESO webpage***
KPNO (1999)	~1.00″	Massey et al. (2000)
Lick (1990-1998)	~1.90″	MtHamilton webpage****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OCÉANO ATLÁNTICO
PORTUGAL
ÁFRICA
MAR MED
Golfo de Vizcaya
Cabo Ortegal
Cabo Peñas
Cabo de Ajo
Cabo Finisterre
Cabo de Creus
Cabo de Palos
Cabo de Gata
Golfo de Cádiz
Estrecho de Gibraltar
CORDILLERA CANTÁBRICA
PIRINEOS
SISTEMA IBÉRICO
SISTEMA CENTRAL
SIERRA MORENA
BÉTICA
PENIBÉTICA
LA CORUÑA
OVIEDO
SANTANDER
BILBAO
SAN SEBASTIÁN
LUGO
PONTEVEDRA
ORENSE
LEÓN
BURGOS
VITORIA
PAMPLONA
LOGROÑO
ANDORRA
HUESCA
GERONA
PALENCIA
VALLADOLID
ZAMORA
SORIA
ZARAGOZA
LÉRIDA
BARCELONA
SALAMANCA
SEGOVIA
ÁVILA
GUADALAJARA
TARRAGONA
MADRID
TERUEL
CUENCA
Javalambre
TOLEDO
CÁCERES
LISBOA
CASTELLÓN
BADAJOZ
CIUDAD REAL
VALENCIA
Golfo de Valencia
ALBACETE
ALICANTE
CÓRDOBA
JAÉN
MURCIA
HUELVA
SEVILLA
GRANADA
ALMERÍA
MÁLAGA
CÁDIZ
CEUTA
MELILLA
PALMA
SANTA CRUZ
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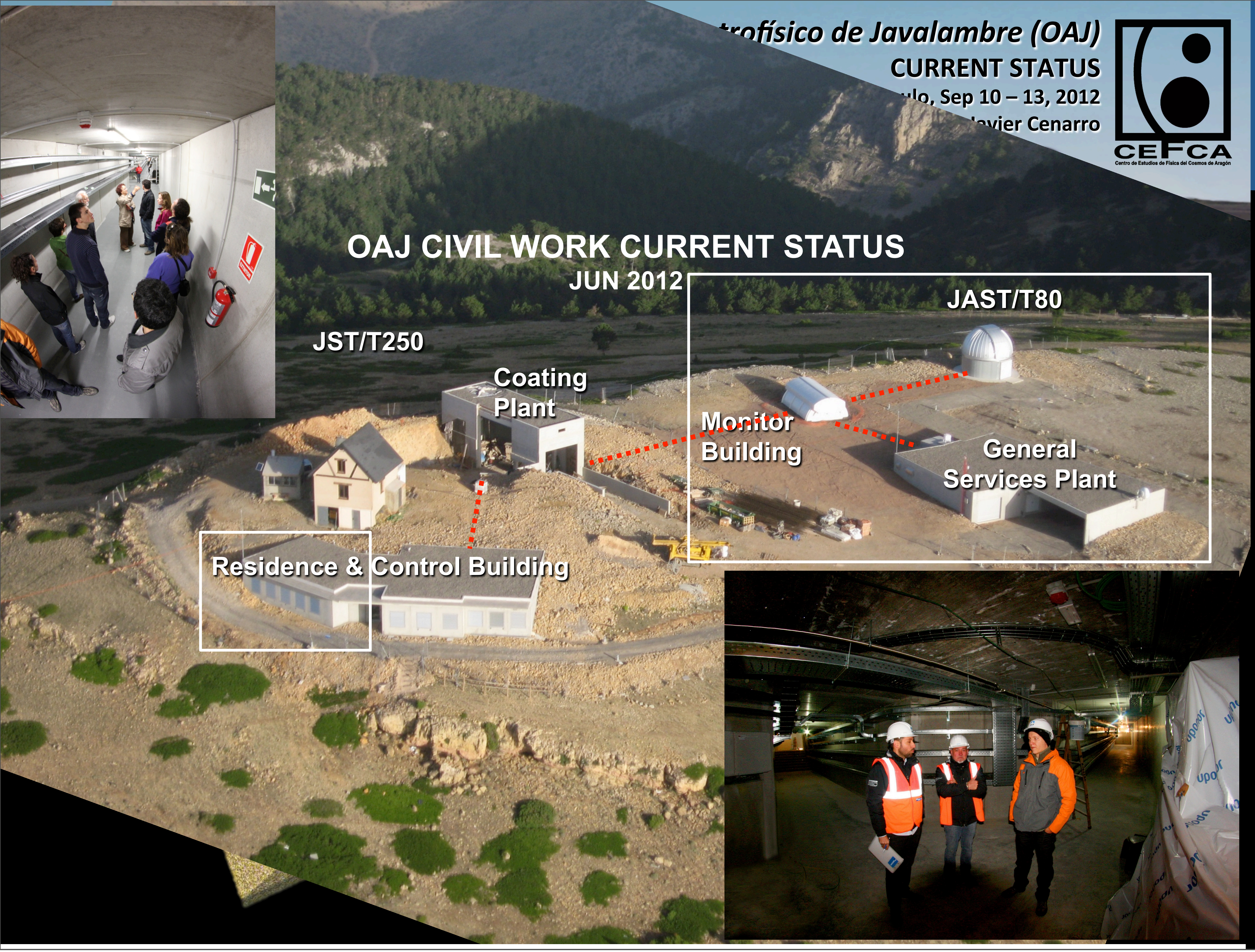
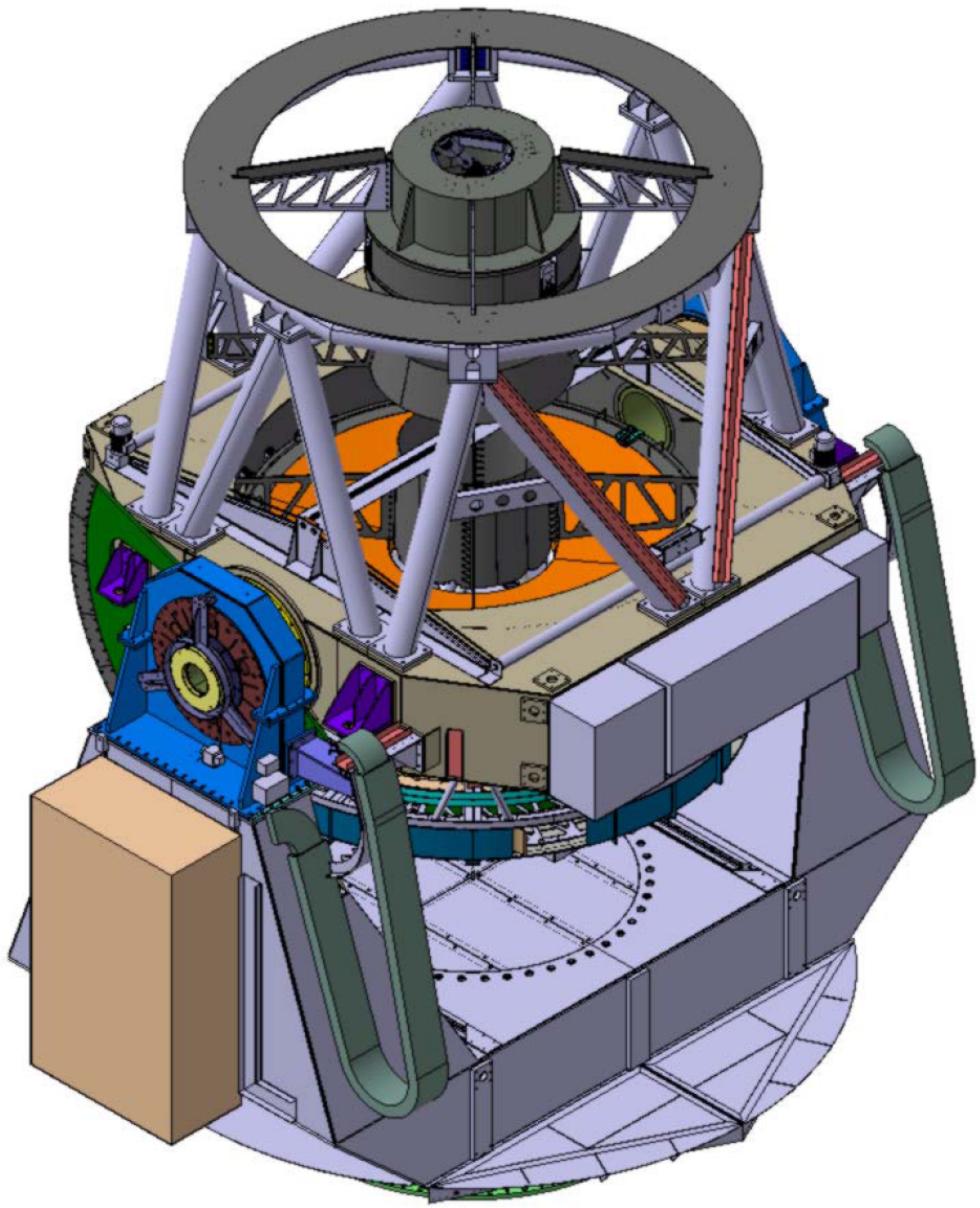
Tuesday, June 25, 13

CEFCA
Centro de Estudios de Física del Cosmos de Aragón



JST/T250 BUILDING

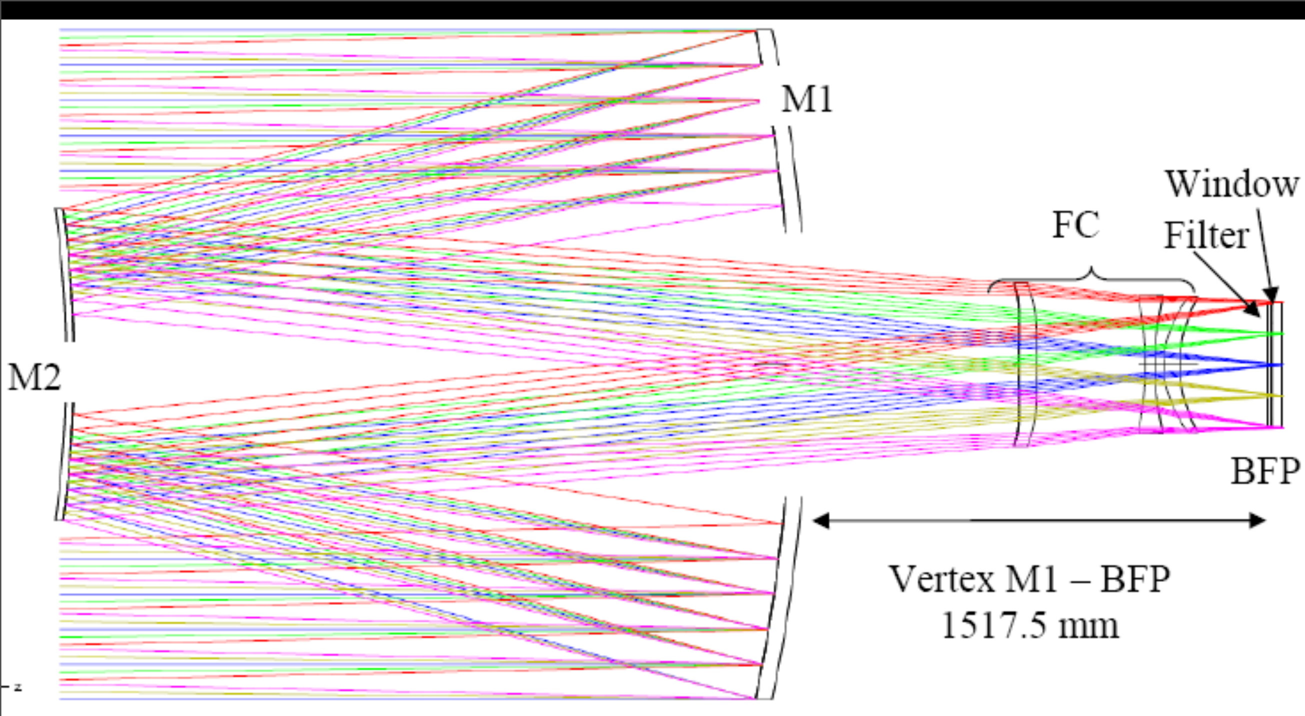


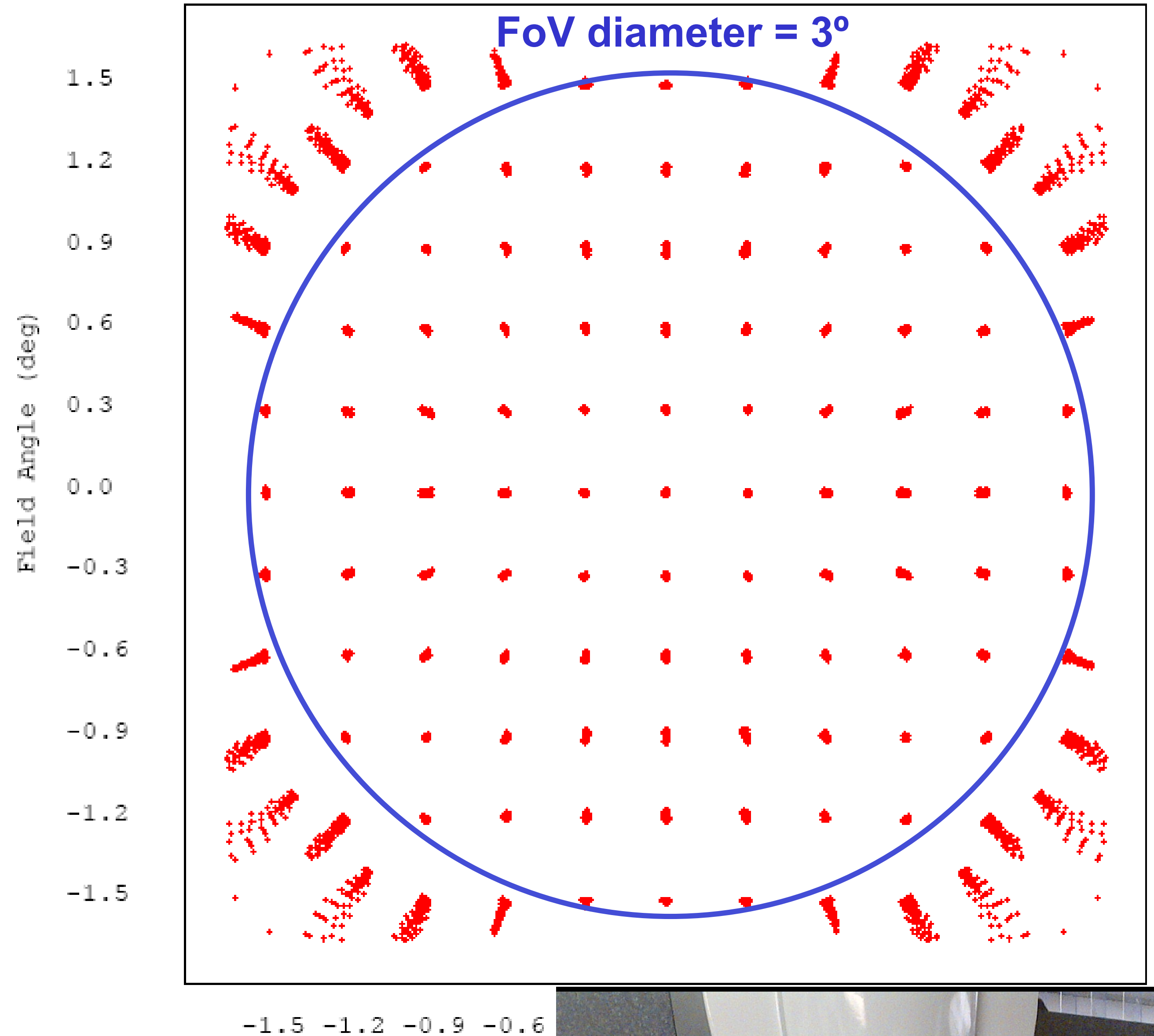
JST/T250

- M1 (∅) = 2.55 m
- FoV (∅) = 3 deg = 476 mm at FP
- Effective collecting area = 3.89 m^2
- Etendue = 27.5 $m^2 deg^2$
- Plate scale = 22.67 arcsec/mm
  = 0.22 arcsec/pix
- Focal length = 9098mm → F#3.5
- IQ EE50 (∅) < 12μm = 0.27 arcsec
- IQ EE80 (∅) < 20μm = 0.45 arcsec

- Mount = Alt-azimuthal
- Config. = Ritchey Chrétien-like
- Focus = Cassegrain
- Field corrector of 3 lenses
- Mass ~45.000 kg
- 1st Eigenfrequencies > 10 Hz

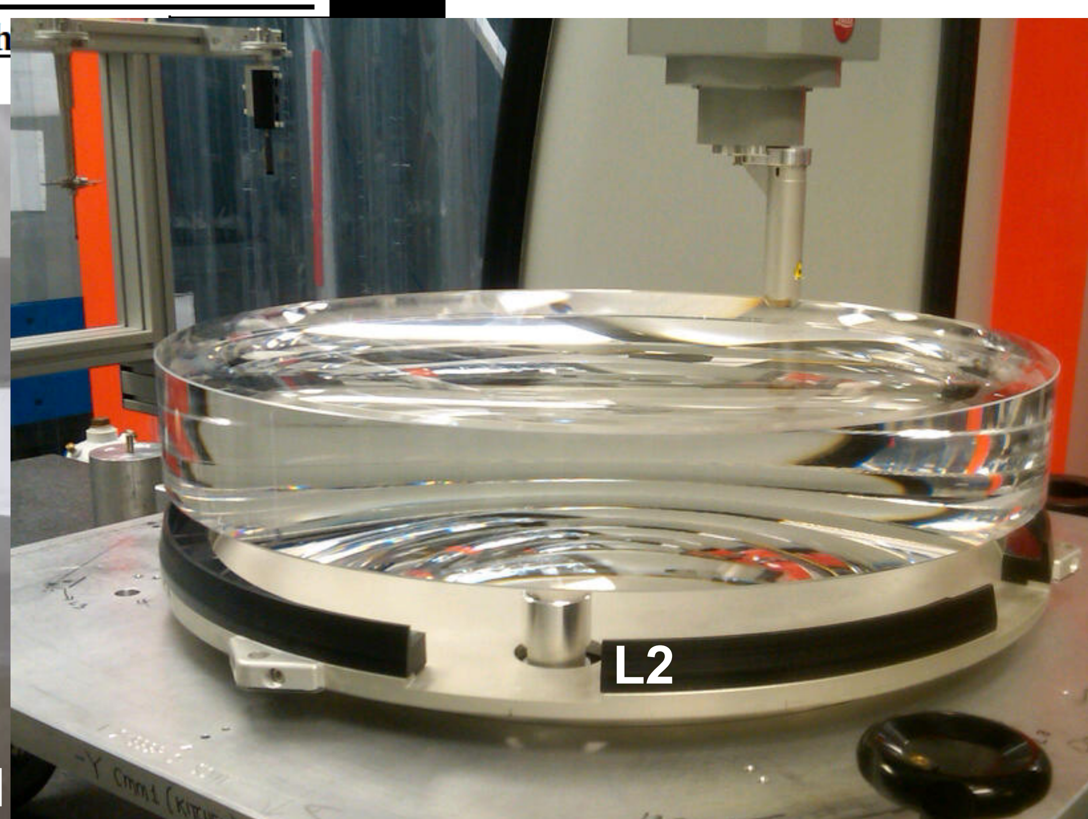
- Manufacturer: AMOS (Belgium)
- Current Status: AIV – Integration
- On site: when dome & building finished

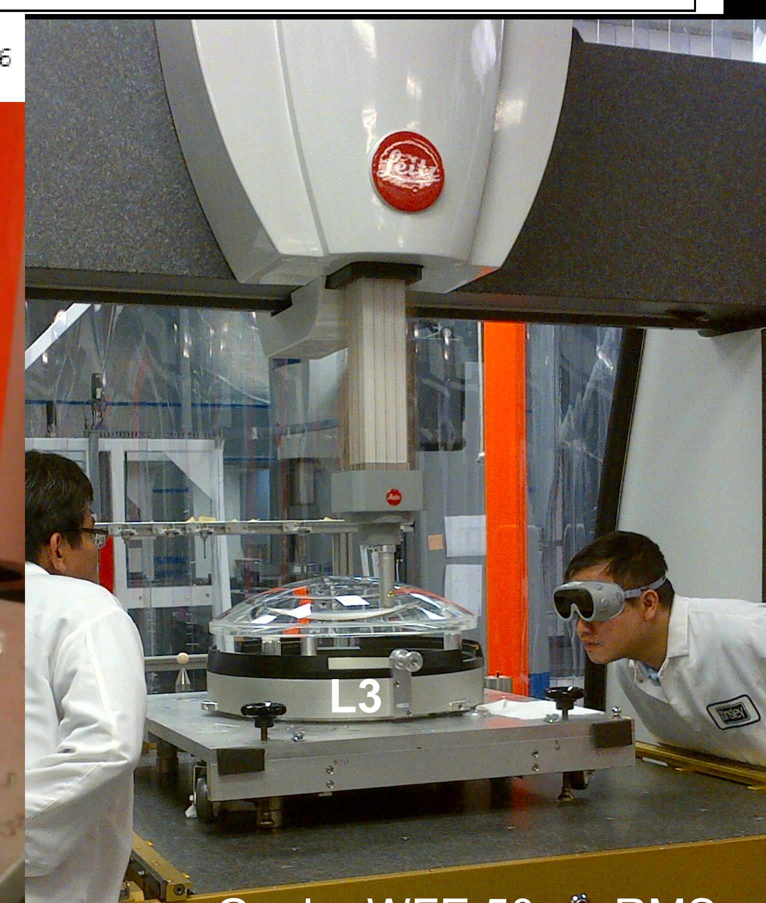




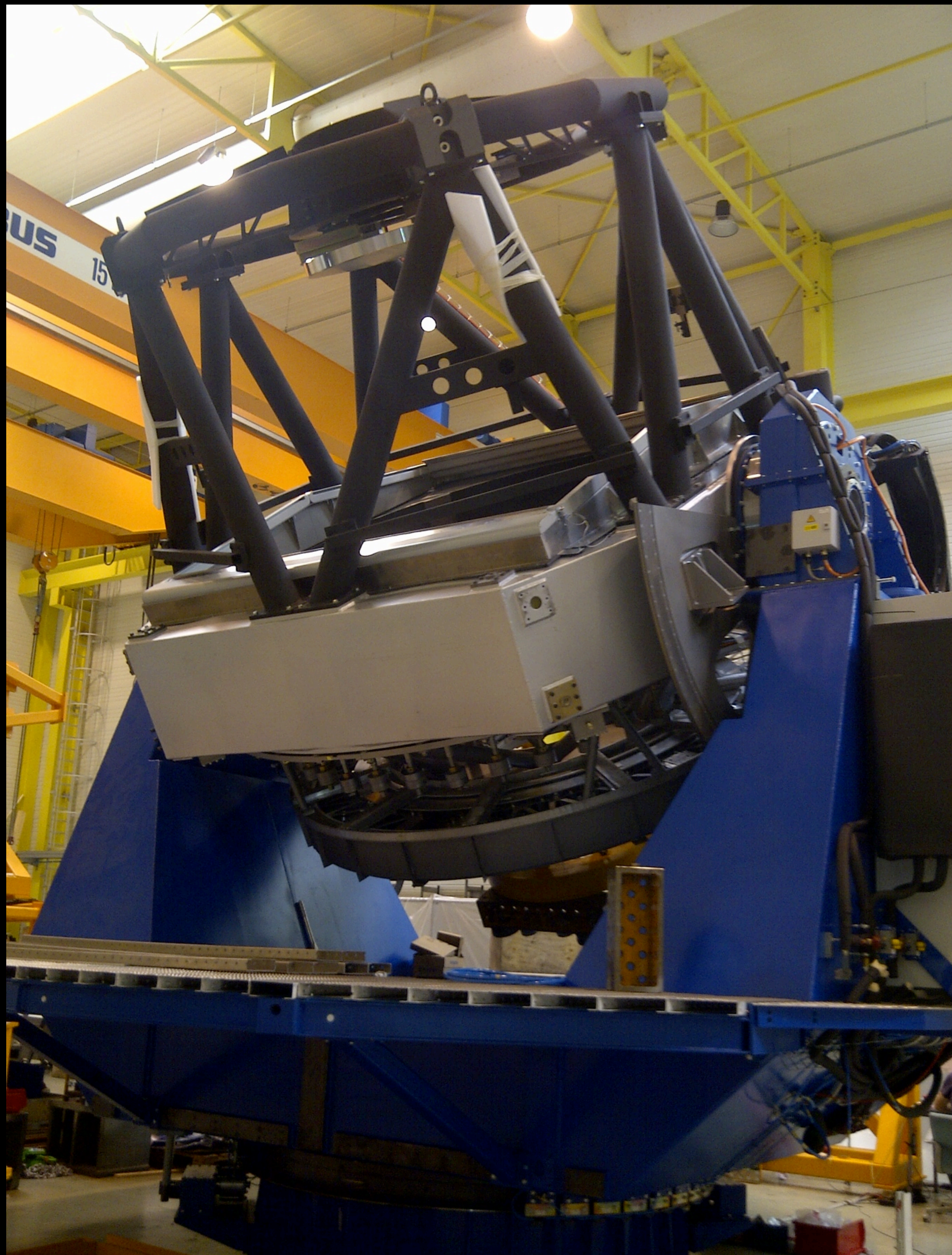
	Distance (mm)
M1 – M2	2207.7
M2 – L1	2909.654
L1 – L2	335.0225
L2 – L3	27.35545
L3 – Filter	273.2982
Filter – Dewar window	4
Dewar Window – CCD plane	8

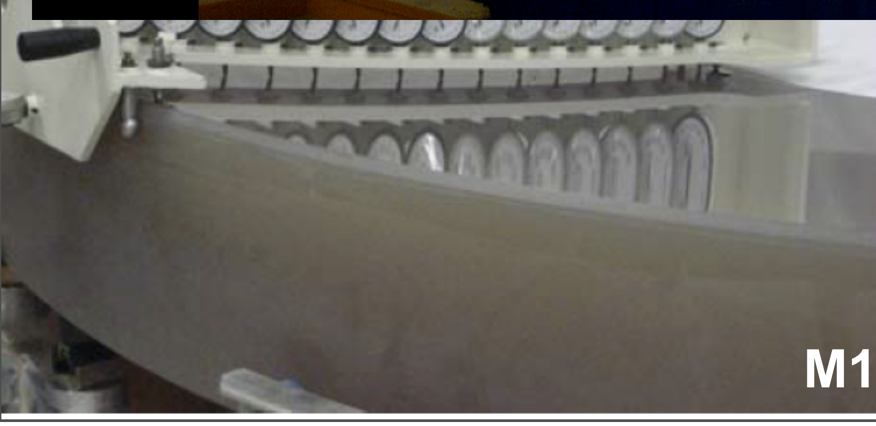
ed profilometer designed for T250 M1 OAJ set on th

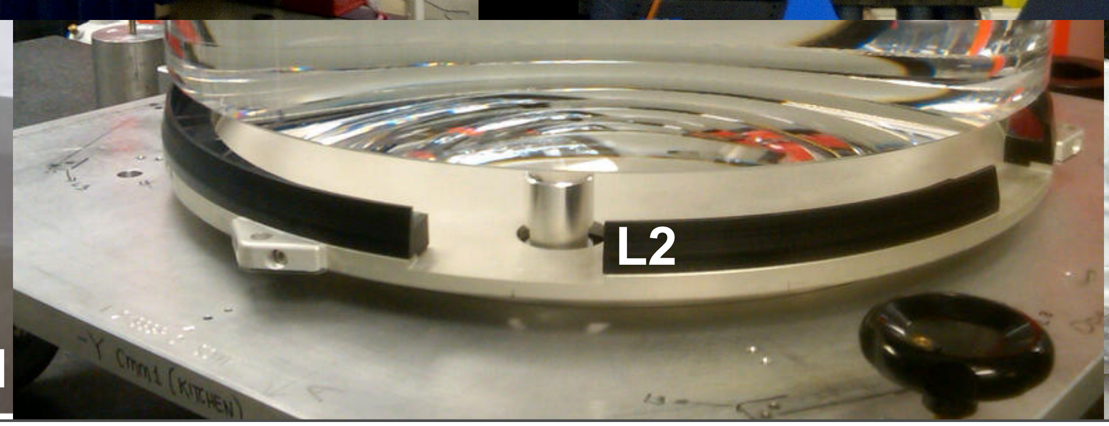


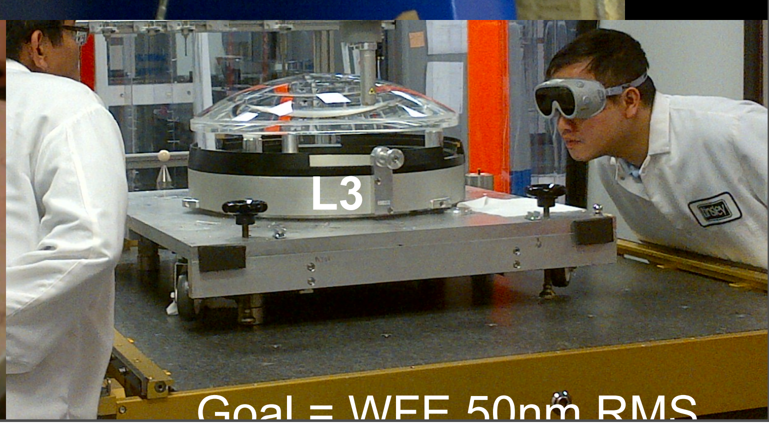


JST/T250



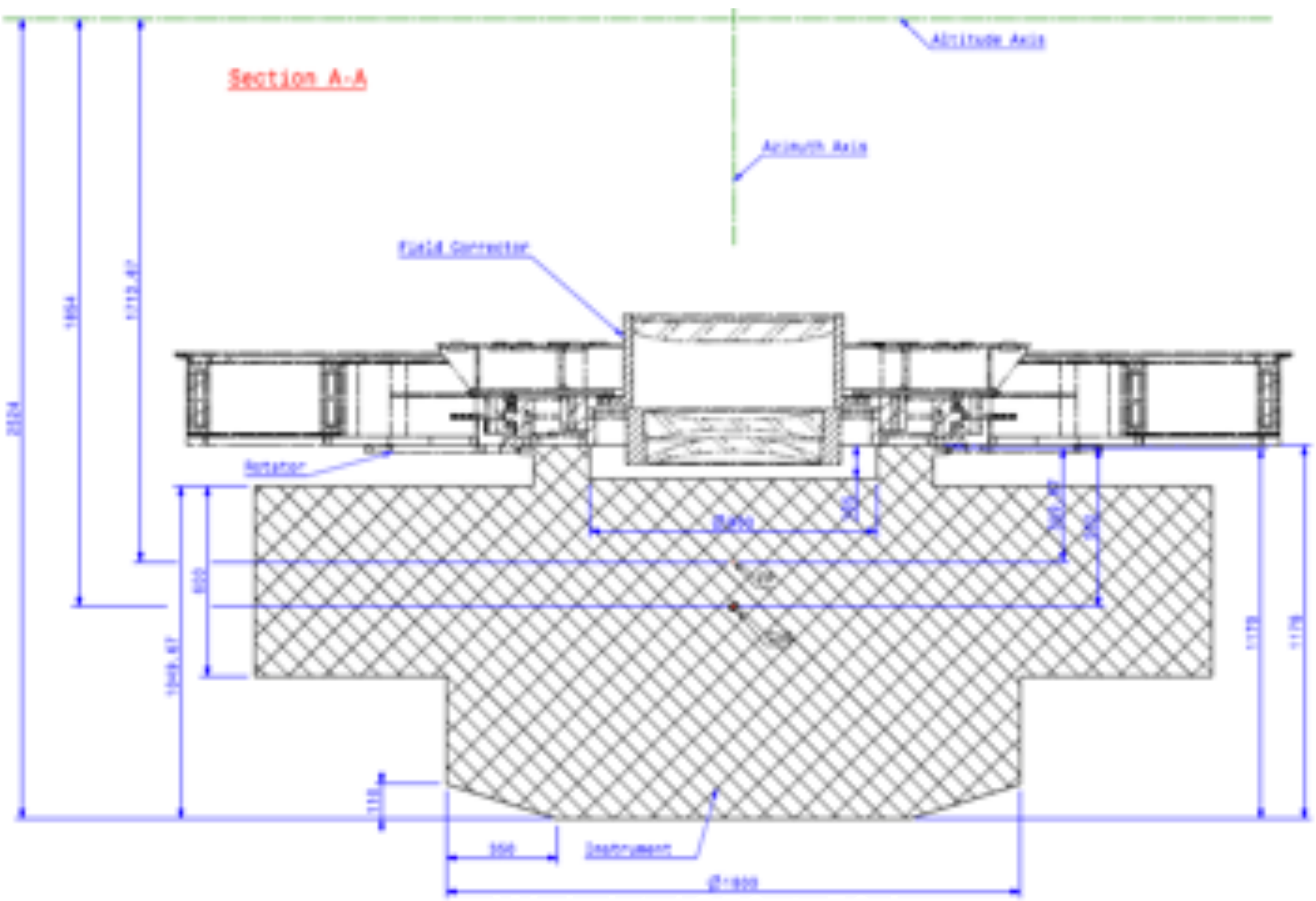


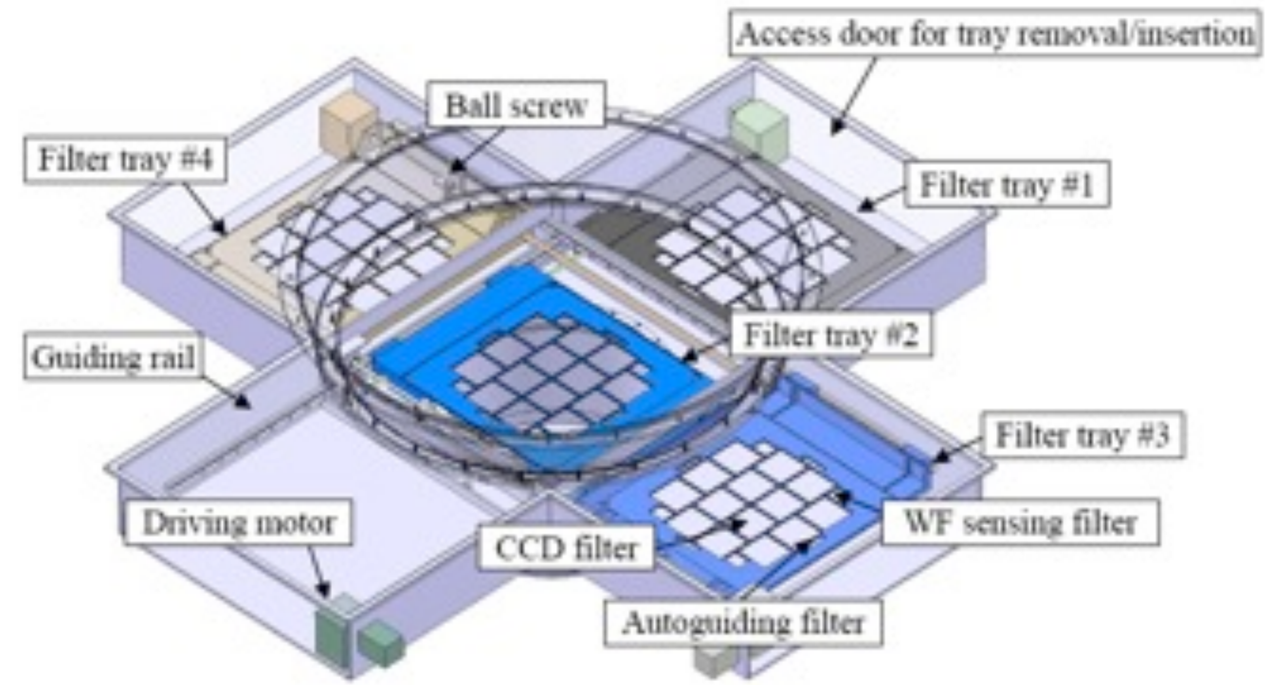


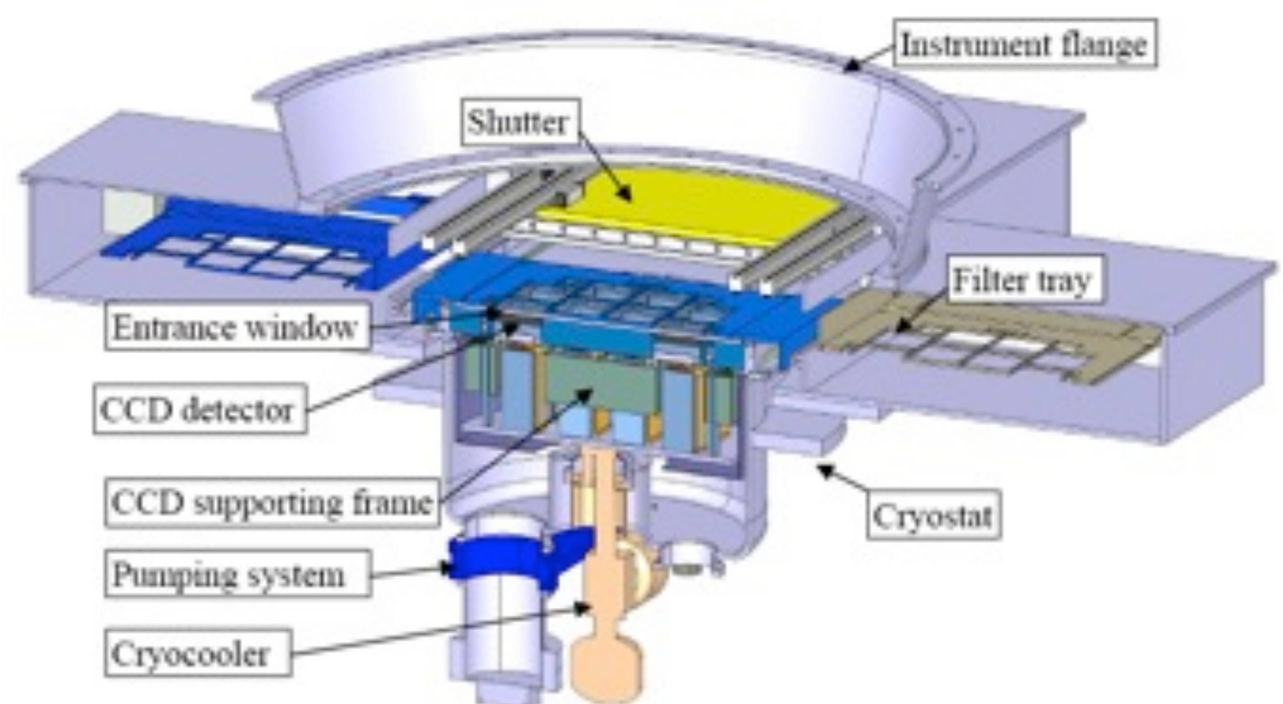


http://arxiv.org/abs/1301.4175 Taylor et al. 2013

J-PCAM: A PANORAMIC CAMERA @ T250 FOR J-PAS







The the 56 J-PAS filters can be **simultaneously** located at J-Pcam.

Conceptual Design by AMOS

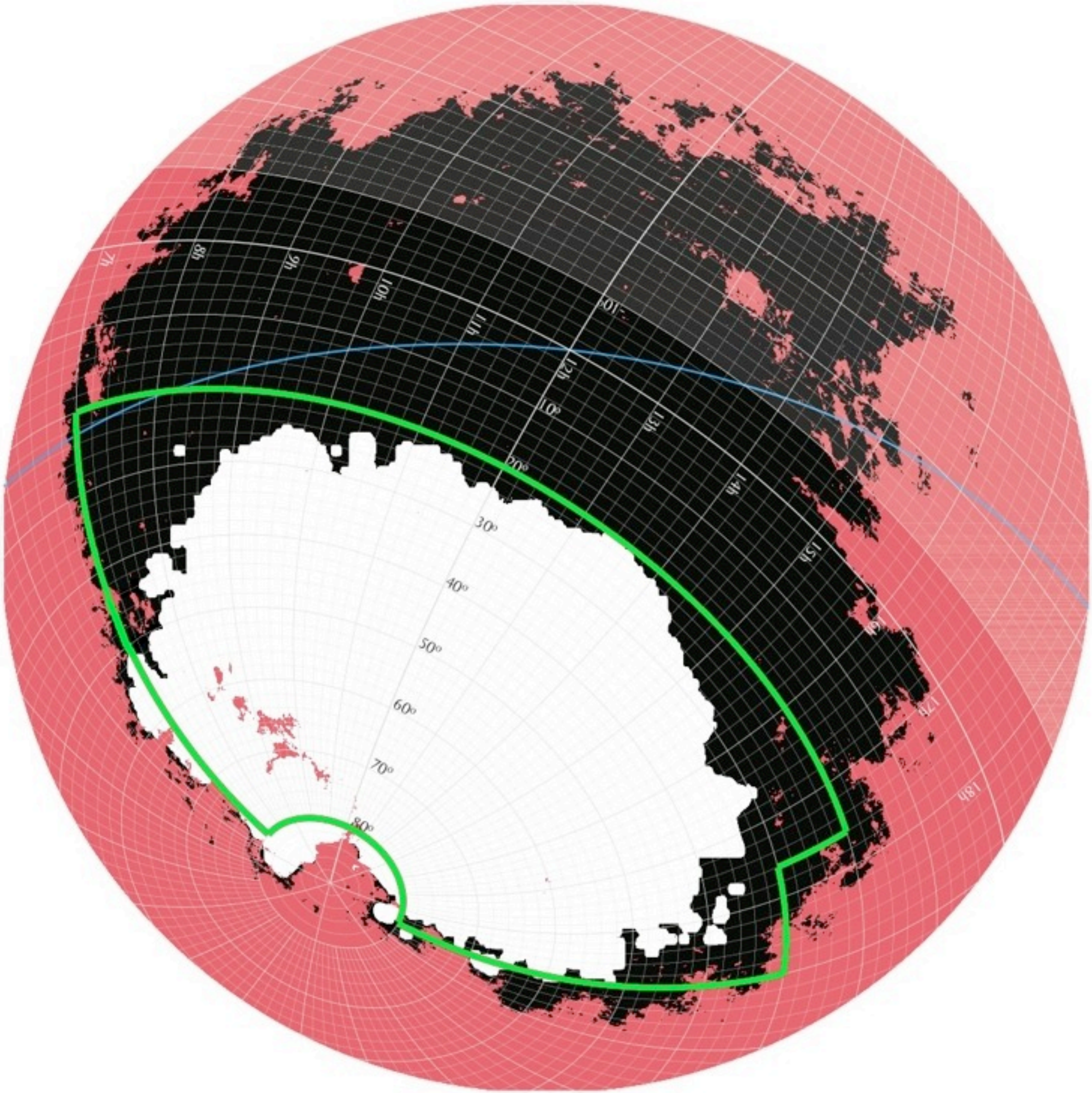
DATA MANAGEMENT

UPAD: Teruel Data Center, 2.5PB, 300 cores

- JPAS raw data ~1PB of data
- Real storage needs ~2PB
- Pipelines: scaled ALHAMBRA pipelines +SWARP

Gradually increasing data flow, time to fine tune: JPLUS(2013), JPAS-Pathfinder (2014), JPAS(2015)

"J-PAS data management pipeline and archiving", Cristóbal Hornillos et al. 2012, SPIE 8451


7h
8h
9h
10h
11h
12h
13h
14h
15h
16h
17h
18h
-10°
10°
20°
30°
40°
50°
60°
70°
80°

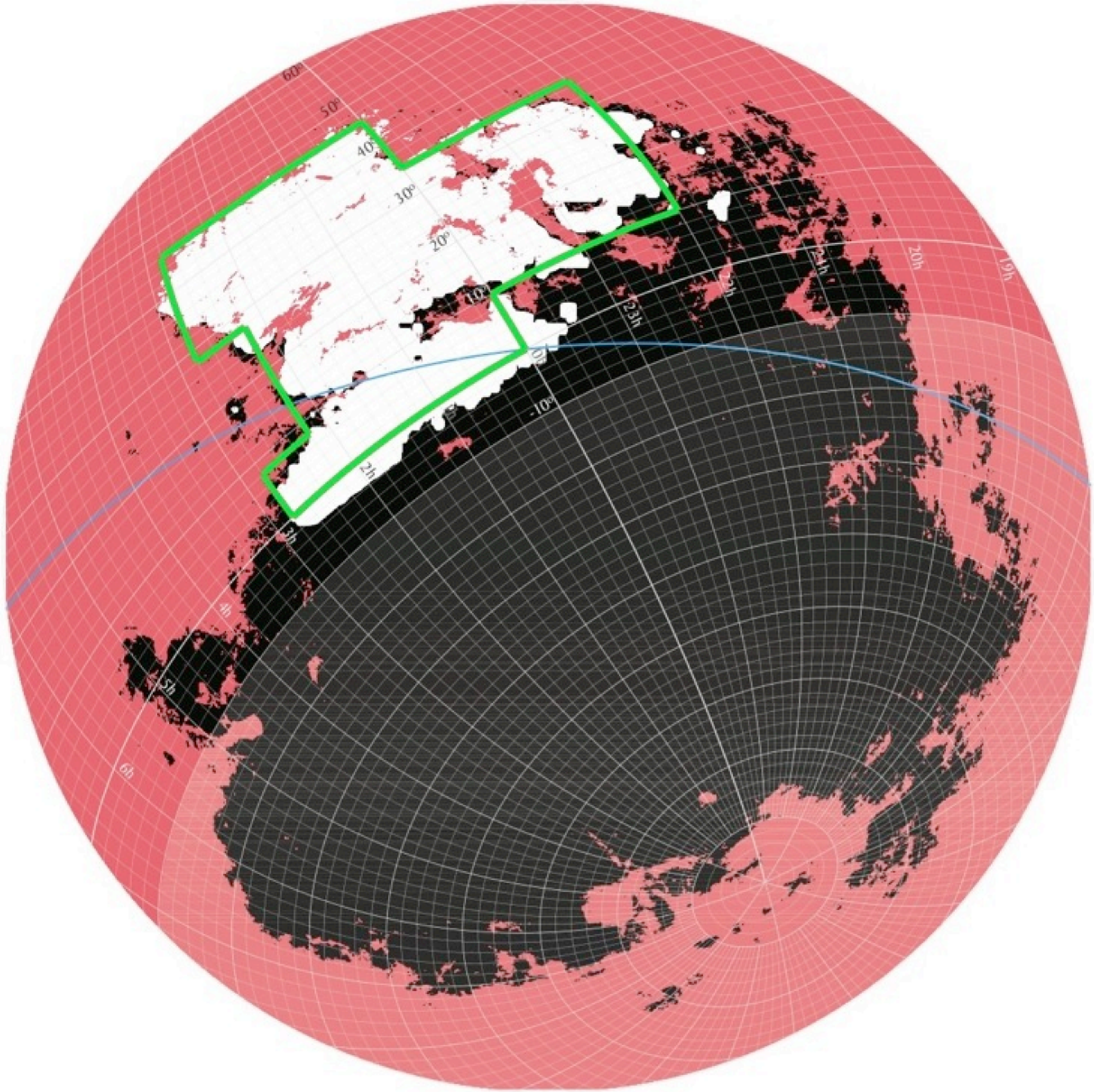
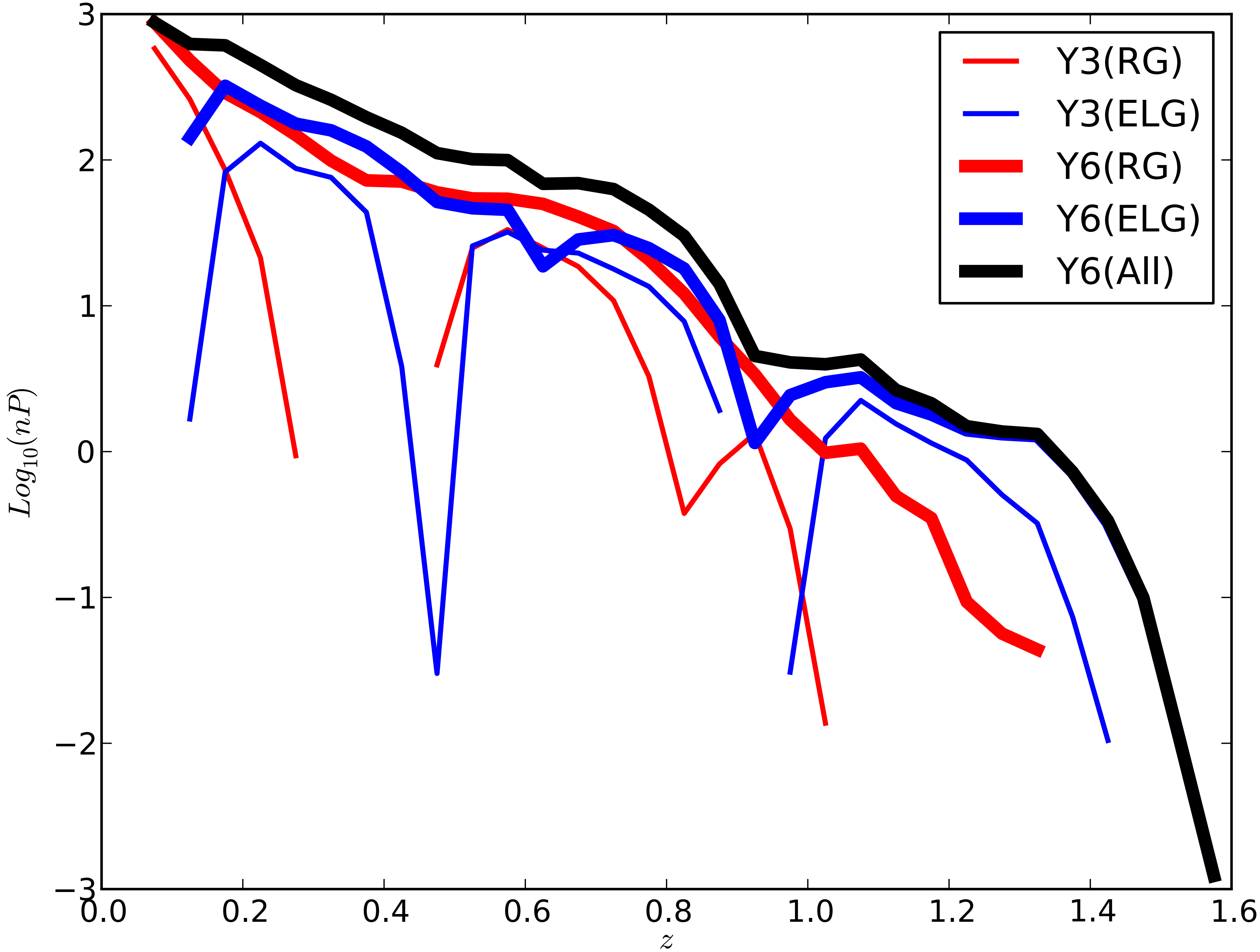

60°
50°
40°
30°
20°
10°
-10°
2h
3h
4h
5h
6h
23h
20h
19h

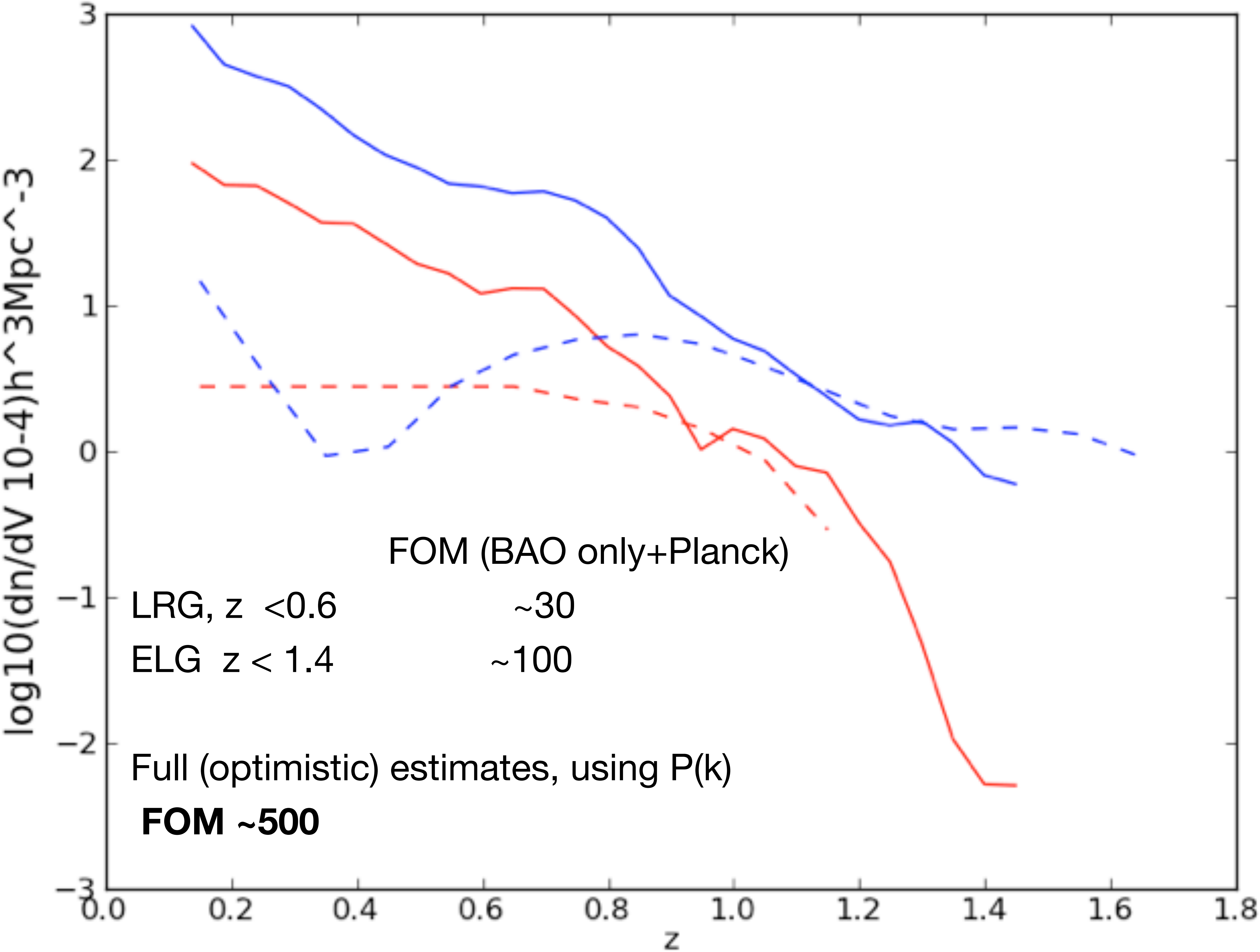
Table 2.2. JPAS Observational schedule

Trays	Date	N_{RG}	N_{ELG}	V_{eff}	$N_{RG}^{z>0.7}$	$N_{ELG}^{z>0.7}$	$V_{eff}^{z>0.7}$
T54	Y2	0.6	10.2	4.0	0.1	5.1	2.4
T543	Y3	4.6	33.9	9.5	0.7	9.4	5.8
T5432	Y4	8.1	57.0	11.9	2.7	14.0	8.0
$T54^232$	Y5	6.0	67.5	12.1	0.2	17.9	8.1
All	Y6	17.6	73.1	13.9	3.7	19.7	9.9

Note. — The first columns indicates how many trays are expected to be completed. The date indicates the number of years after we start. N_{RG} and N_{ELG} correspond to the total number of respectively, Red and Emission Line galaxies. V_{eff} is the effective volume for Power Spectrum measurements



'ig. 7.— Product of the galaxy density for Red Galaxies (RG) and Emission Line galaxies (ELG) by he power spectrum (taking into account the corresponding bias) for different stages of completion f J-PAS


FOM (BAO only+Planck)
LRG, z <0.6 ~30
ELG z < 1.4 ~100
Full (optimistic) estimates, using P(k)
FOM ~500
log10(dn/dV 10-4)h^3Mpc^-3
z
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
3
2
1
0
−1
−2
−3

SN-all types

- Automatic census of ***all*** SN types in regions of the survey with appropriate cadence
- Multiband observations provide automatic classification by type
- ~6000 SNIe survey (PI: Ribamar Reis, Masao Sako)

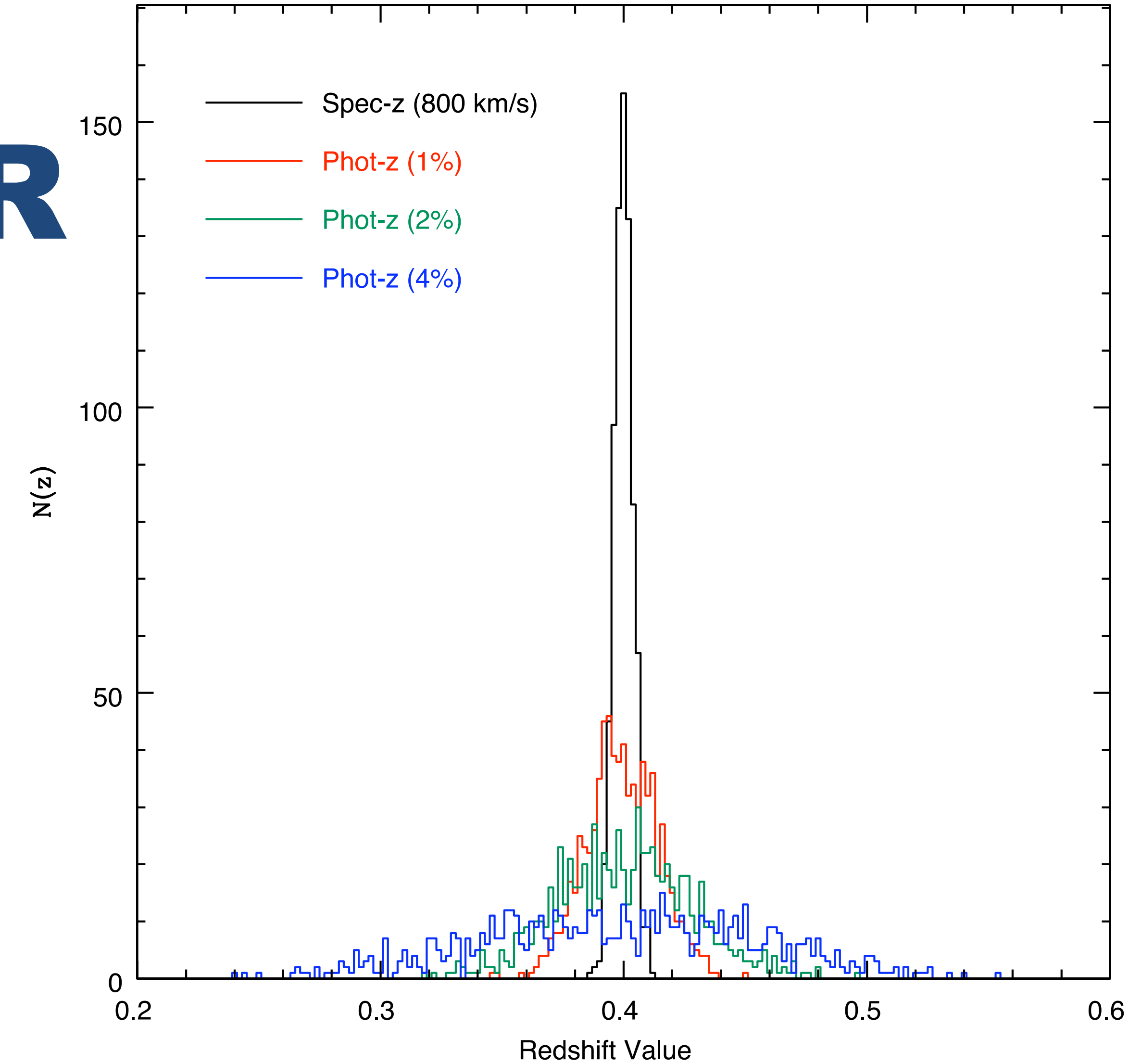
Weak lensing

- Javalambre has excellent seeing conditions (median ~0.7 arcsec)
- Good seeing is quite stable in time
- Broad band “detection image” with r~25 : 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
- Calibration of masses using weak lensing

OPTICAL CLUSTER DETECTION



- $S/N \sim N_{200} / (N_{back})^{0.5}$
- $N_{200} \sim M_{200}^{0.8}$ (Hansen et al. 2010)
- $N_{back} \sim r_{200}^{2} \Delta z \sim N_{200}^{0.84} \Delta z$
- $S/N \sim N_{200}^{0.58} \Delta z^{-0.5} \sim M_{200}^{0.46} \Delta z^{-0.5}$

$$(M_{200})_{S/N} \sim (\Delta z)^{1.09}$$

Broad band surveys Δz~0.04, JPAS Δz~0.003

We can detect groups with masses 1/10th smaller than DES or PanStarrs

FoM ~250

Galaxy Evolution

- Low-res spectroscopy of everything up to $I<22.5$
- Filter set carefully designed to detect emission lines in the local universe
- Redshifts for every $L>L^*$ for $z<1$
- High quality broadband imaging: morphological classification, mergers

More Science

- QSOs: Unique survey, few M QSOs with 0.2-0.3% photo-z to $1<z<3$
- Stars: halo + area in the galaxy
- Asteroids: rotation spectrum
- GRBs
- Low-res spectroscopy of transients!
- Serendipitous discoveries, low frequency objects, etc.

TIMELINE

Summer 2013:

T250 delivery & on-site integration/JPLUS Survey(T80)

Fall 2013:

T250 commissioning starts

Early 2014:

JPAS-Pathfinder Survey, 0.35sq.deg camera

200 sq.deg by year end, verify all pipelines, algorithms

Fall 2014:

JPCAM delivery by E2V

Early 2015: Full JPAS survey starts

~2018: FoM~300 threshold reached

End 2021: Full survey finished

JPAS

FIRST STAGE IV experiment, starting in 2015

Conservative FoM ~ 300 by ~2018, FoM~500 by 2021

~ 100M galaxies with 0.3% photo-z > LSS

~ 300M galaxies with 1% photo-z > Cluster counting, 3D lensing tomography

~ 400M galaxies with 3% photo-z, Cosmic Shear

~ few M QSOs with 0.3% photo-z > Measure w all the way to z=3

~ 0.7 arcsec image of the Northern Sky

- Extremely mass sensitive optical cluster catalog

- Excellent characterization of low-z SN systematics

- 6000 SNIe survey, no spectroscopy required

- Pixel-by-pixel low-res spectrum of the whole northern sky up to m~23/ arcsec^2

Unique, fundamental data for many Astrophysical areas

Done in Spain, 85% funded from Spain (but only 1-2% from regular science funds!)

COMING SOON!