The PAU
(Physics of the Accelerating Universe)
Survey
at the William Herschel Telescope

Cosmology with Photometric Redshifts

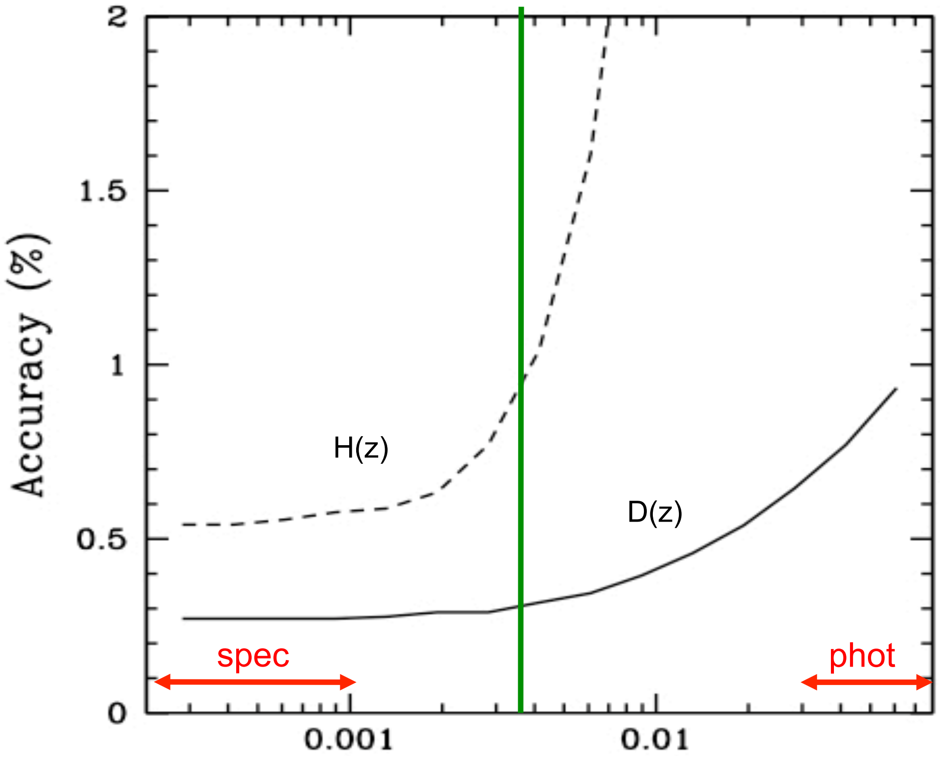
Francisco Javier Castander (ICE, IEEC-CSIC, Barcelona)
on behalf of the Pau Survey collaboration

PAU motivation

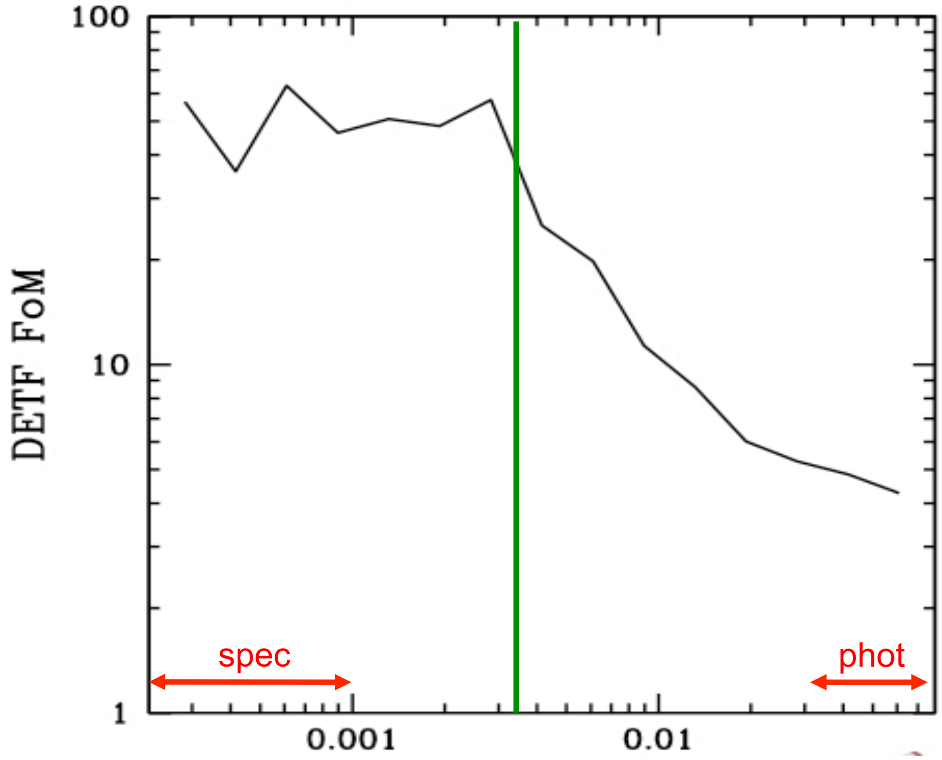
- For some cosmological applications redshifts do not need to be very precise

PAU motivation

BAO



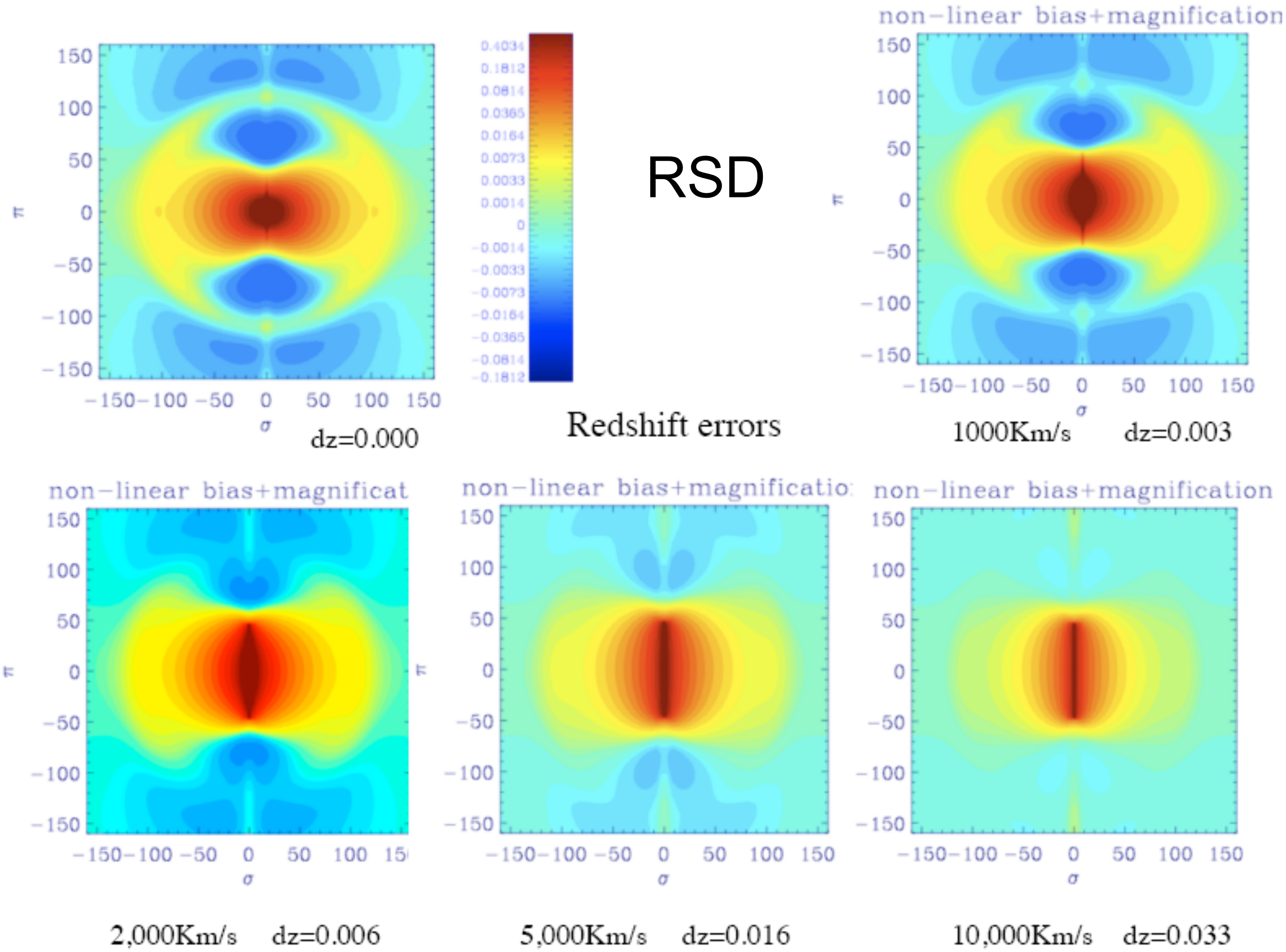
Δz / (1+z)



Δz / (1+z)

Padmanabhan

PAU motivation

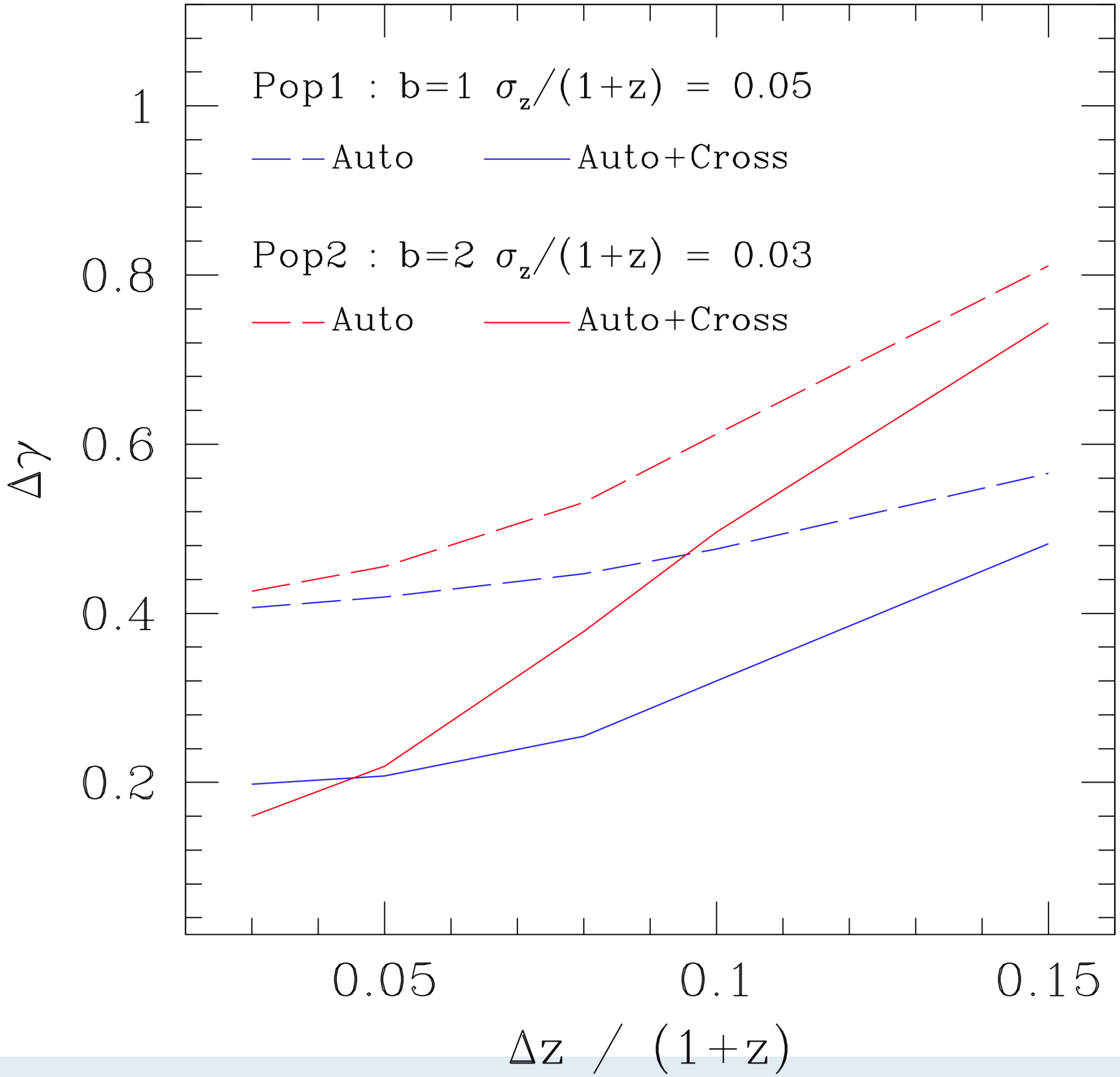


PAU motivation

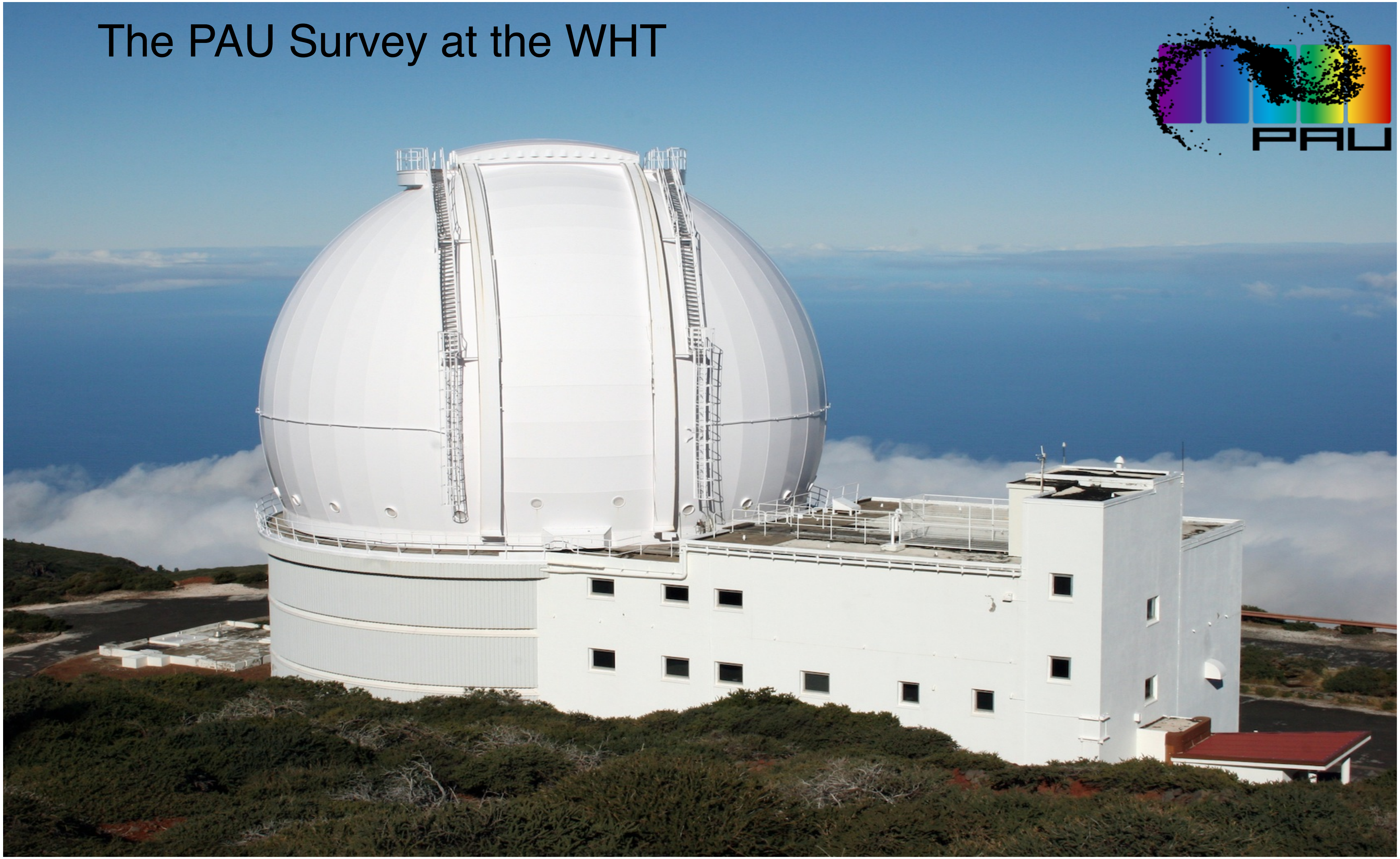
- For some cosmological applications redshift do not need to be very precise

- Good sampling allows to select several samples in same volume helping to beat cosmic variance

PAU motivation



The PAU Survey at the WHT



PAU at the WHT

PI : E. Fernández (UAB/IFAE)
Co-Is: E. Sánchez (CIEMAT), E. Gaztañaga(IEEC/CSIC), R. Miquel (IFAE), J. García-Bellido (IFT/UAM), M. Delfino (PIC)

PAUCam PI: F. J. Castander
Project Manager: C. Padilla; **System Engineer**: L. Cardiel, **DAQ:** J. de Vicente; **Mechanics**: F. Grañena; **Control**: O. Ballester; **Optics and integration**: R. Casas, J. Jiménez.

PAUDM & Science PI: E. Gaztañaga
Simulations: F.J. Castander; **Operation**: N. Tonello; **Data Reduction**: S. Serrano; **QA&Validation**: N. Sevilla.

The Survey Team:

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[1] CIEMAT, Madrid

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[3] IFAE/UAB, Barcelona

[4] IFT/UAM, Madrid

[5] PIC, Barcelona

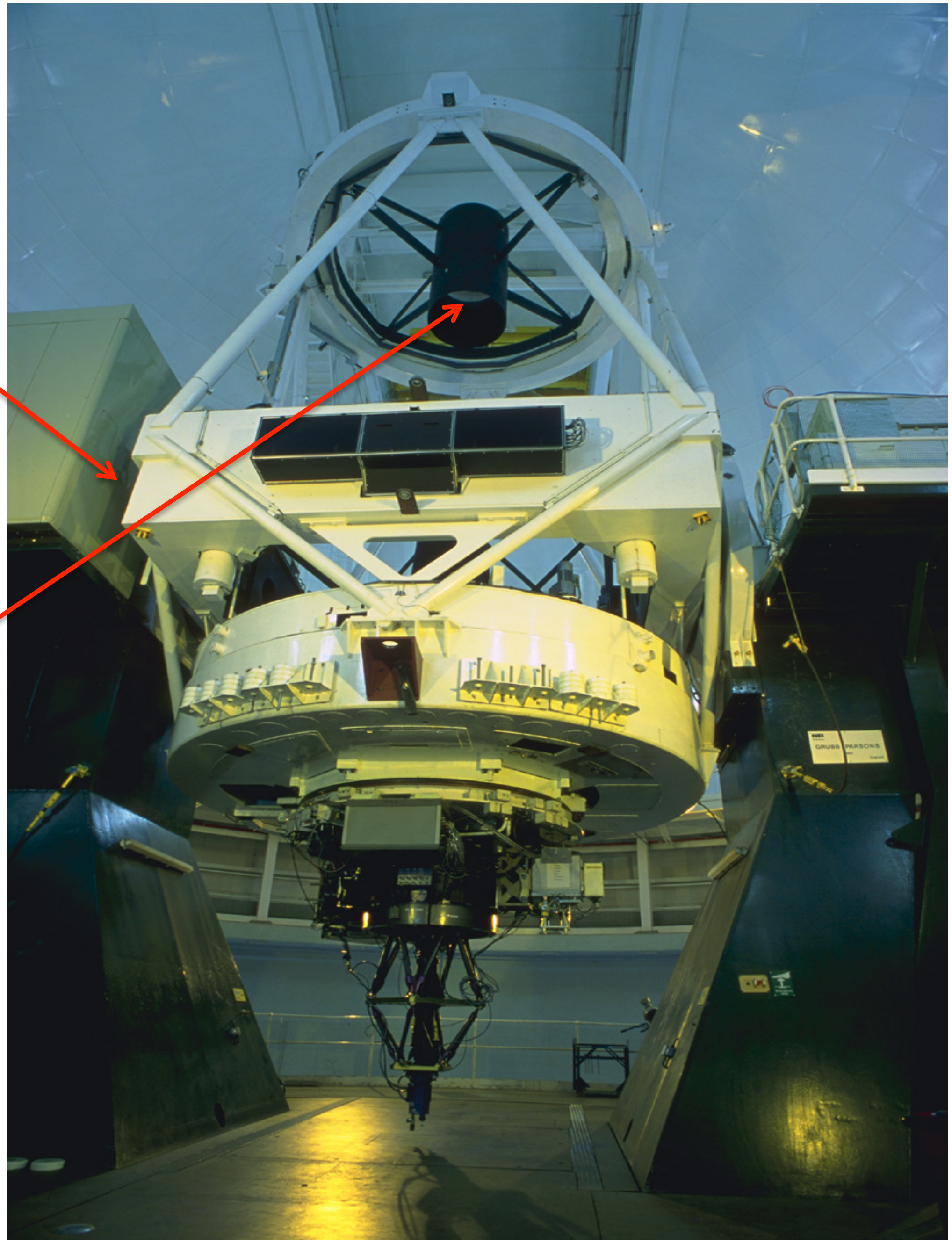
PAUCam at WHT

WHT Telescope

- Diameter: 4.2 m
- Prime focus: 11.73 m
- Focal ratio: f/2.8
- FoV: 1 deg ∅, 40' unvignetted
- Scale: 17.58''/mm ⇔ 0.26"/pixel

PAUCam will be mounted at the prime focus:

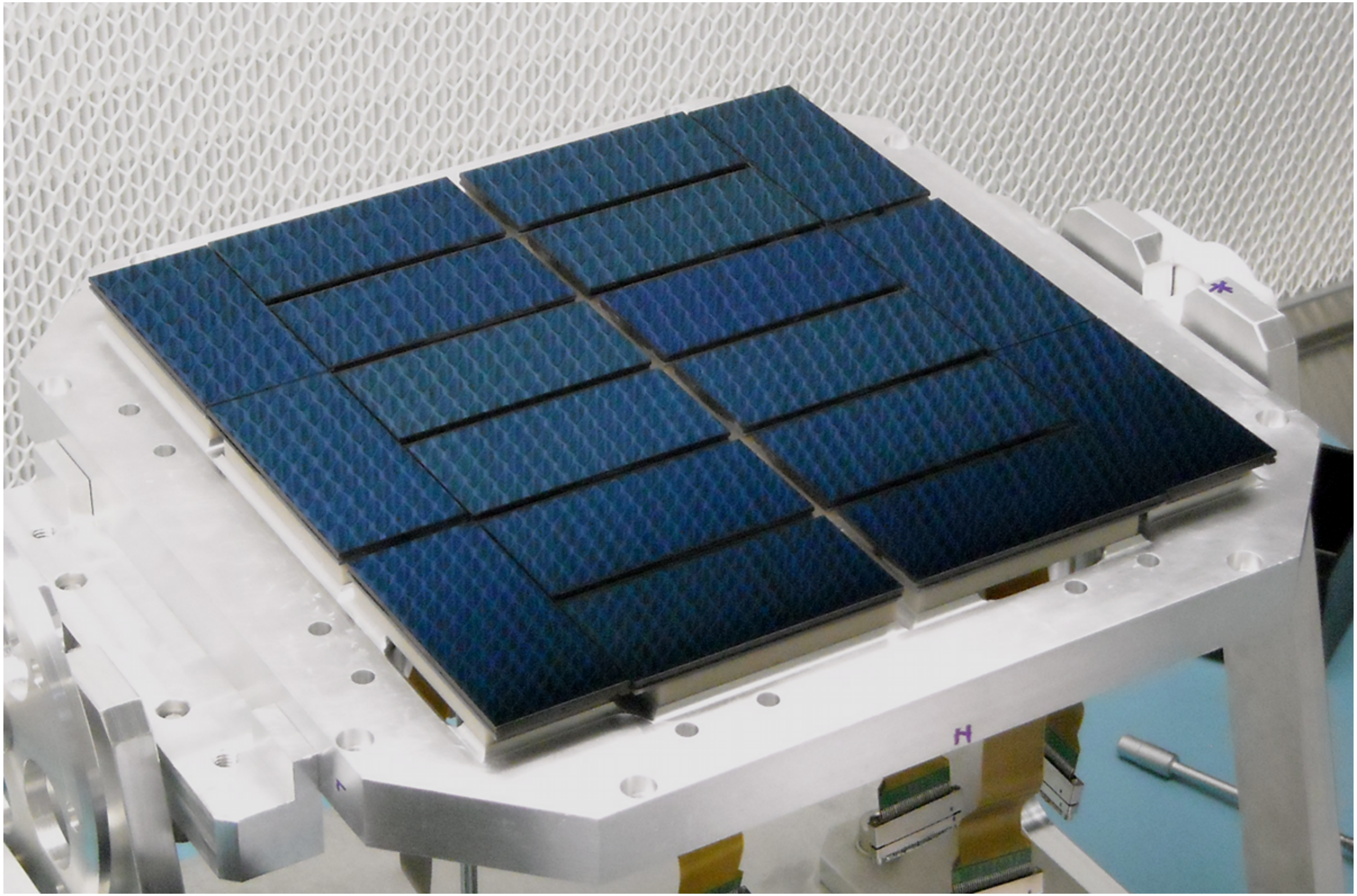
Strong limitation in the weight: **max. 235 kg**.



PAUCam mechanics

• Body of camera made of carbon fiber, shaped to minimize wall thickness and reduce weight

PAUCam focal plane

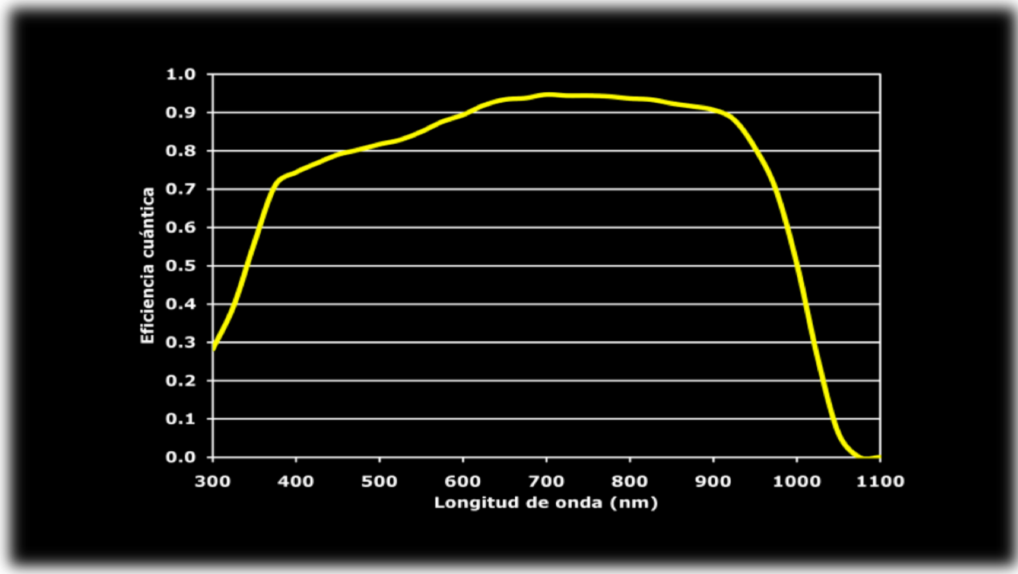


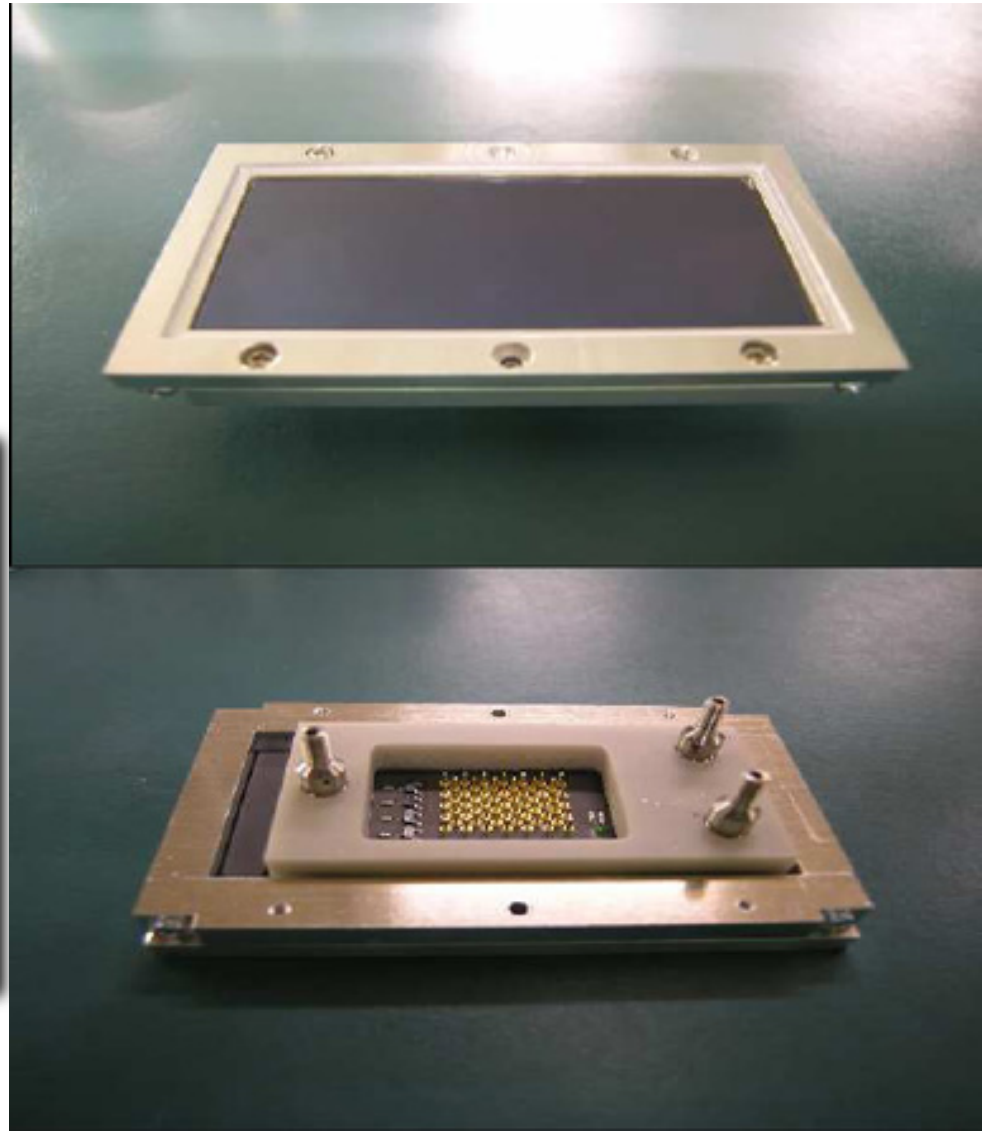
PAUS CCDs

Detectors

- **Hamamatsu photonics (2k X 4k) 200µm thick fully depleted: 15µm pixels**

- **Telescope f/2.8 ➔ 0.26" /pixel.**





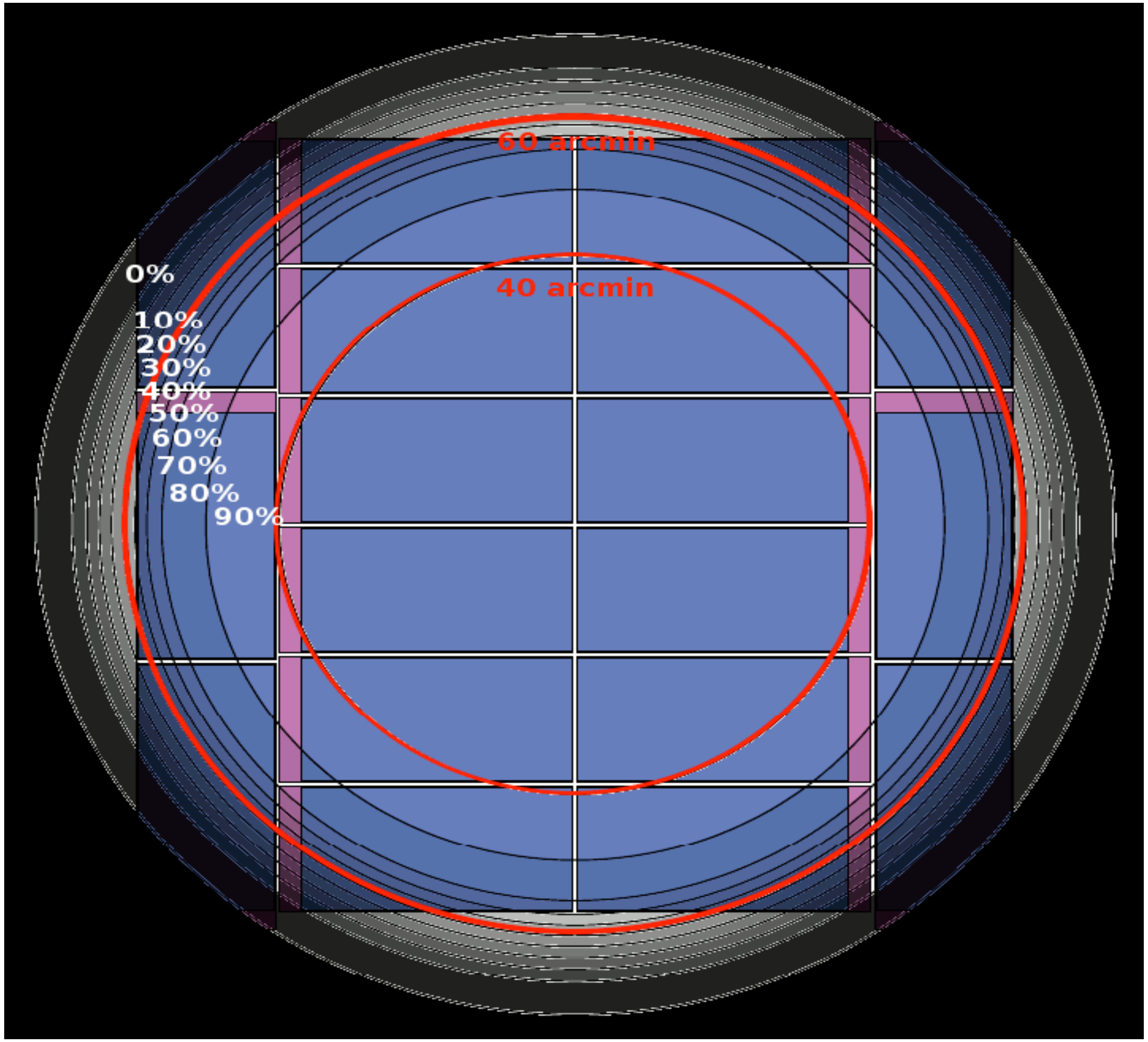
PAUCam focal plane

8 central CCDs with almost 100% exposure for imaging.

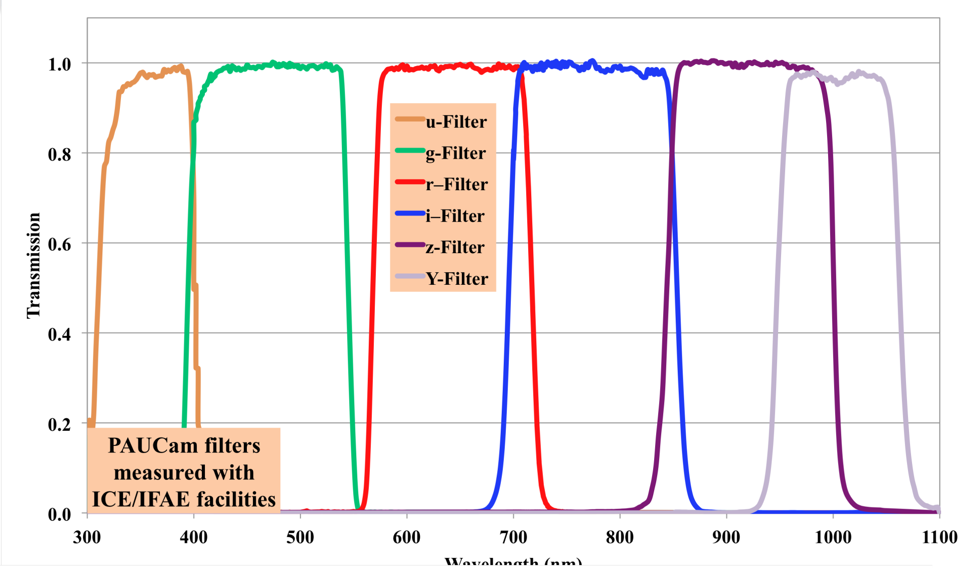
Rest of the CCDs:
2 for guiding
8 for additional photons

40 narrow band (10nm) filters covering the range ≈ 450-850 nm
6 BB filters u g r i z Y.

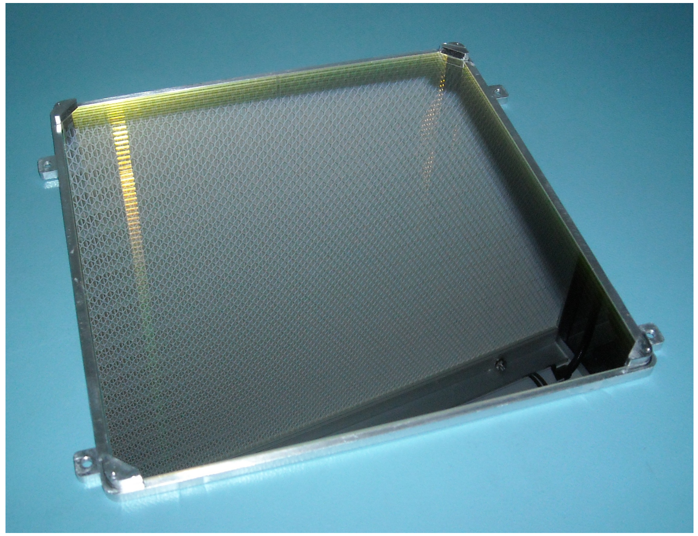
Optimization: central CCDs will have 8 NB, others BB

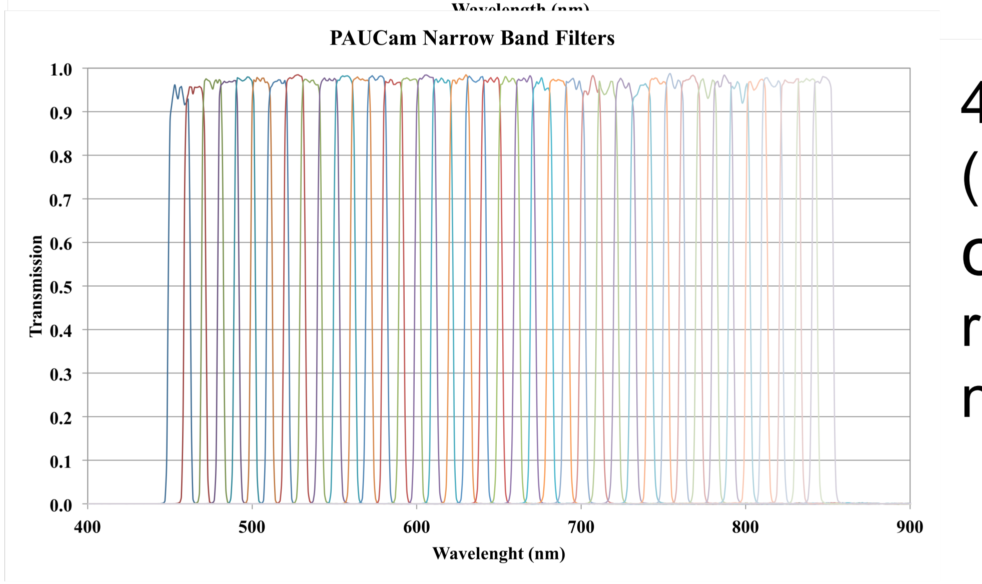


PAUCam filters

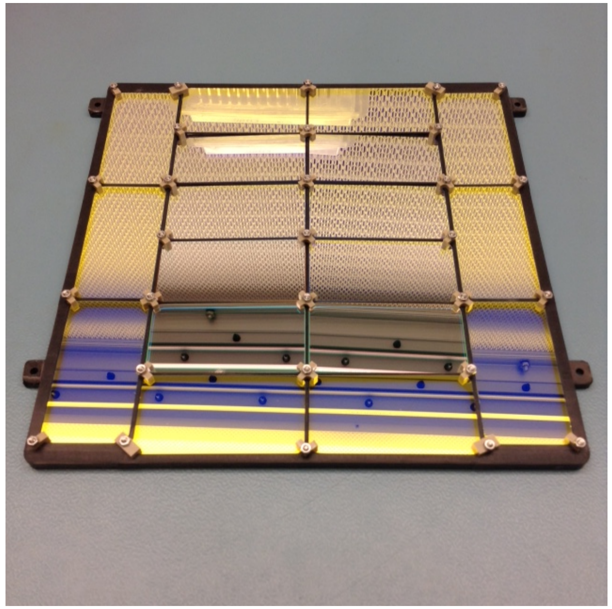


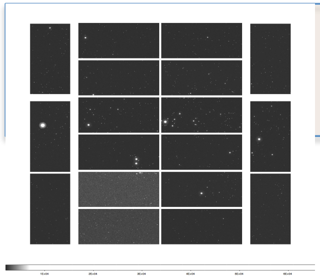
6 BB filters:
u g r i z Y.





40 narrow band (10nm) filters covering the range ≈ 450-850 nm

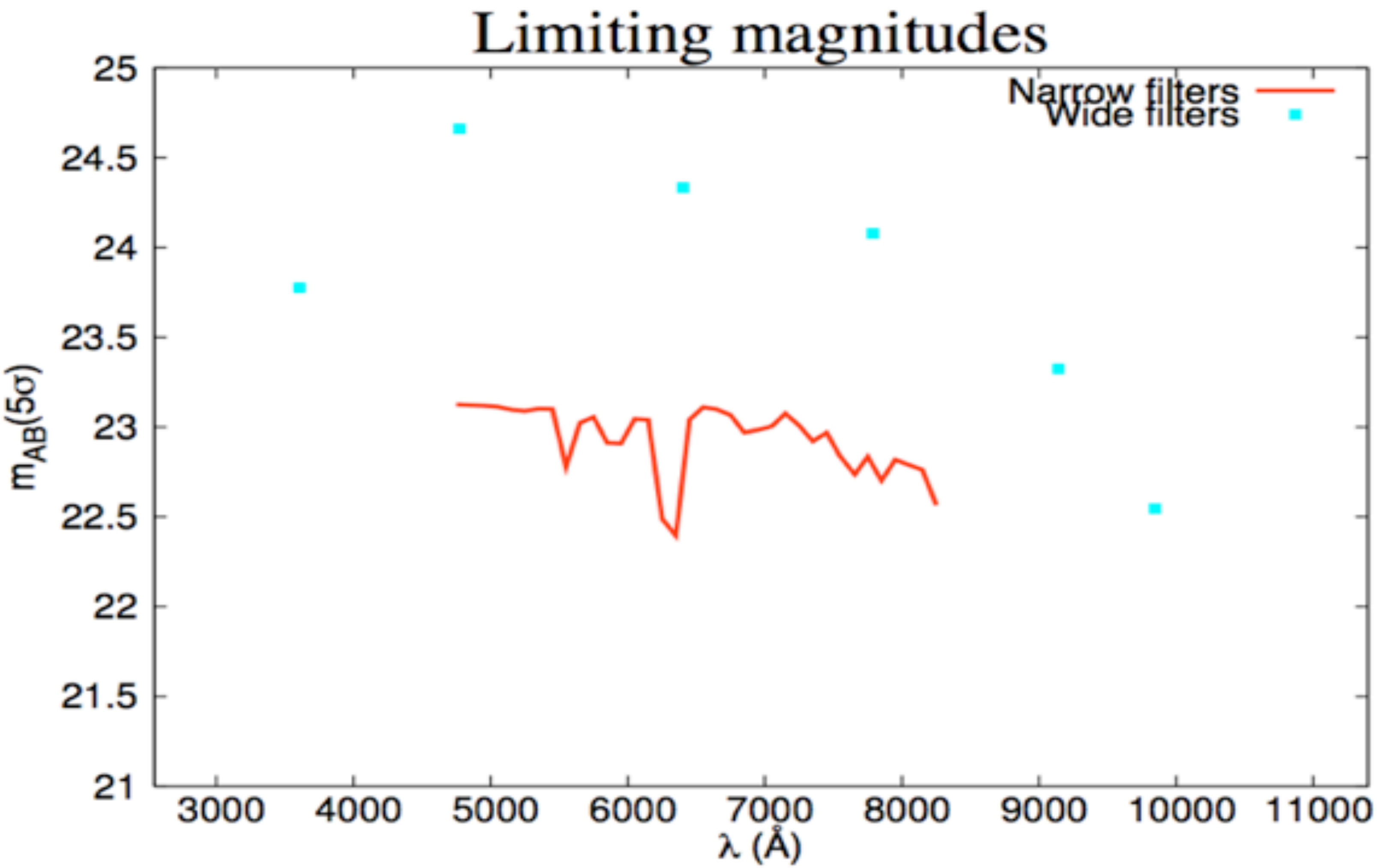




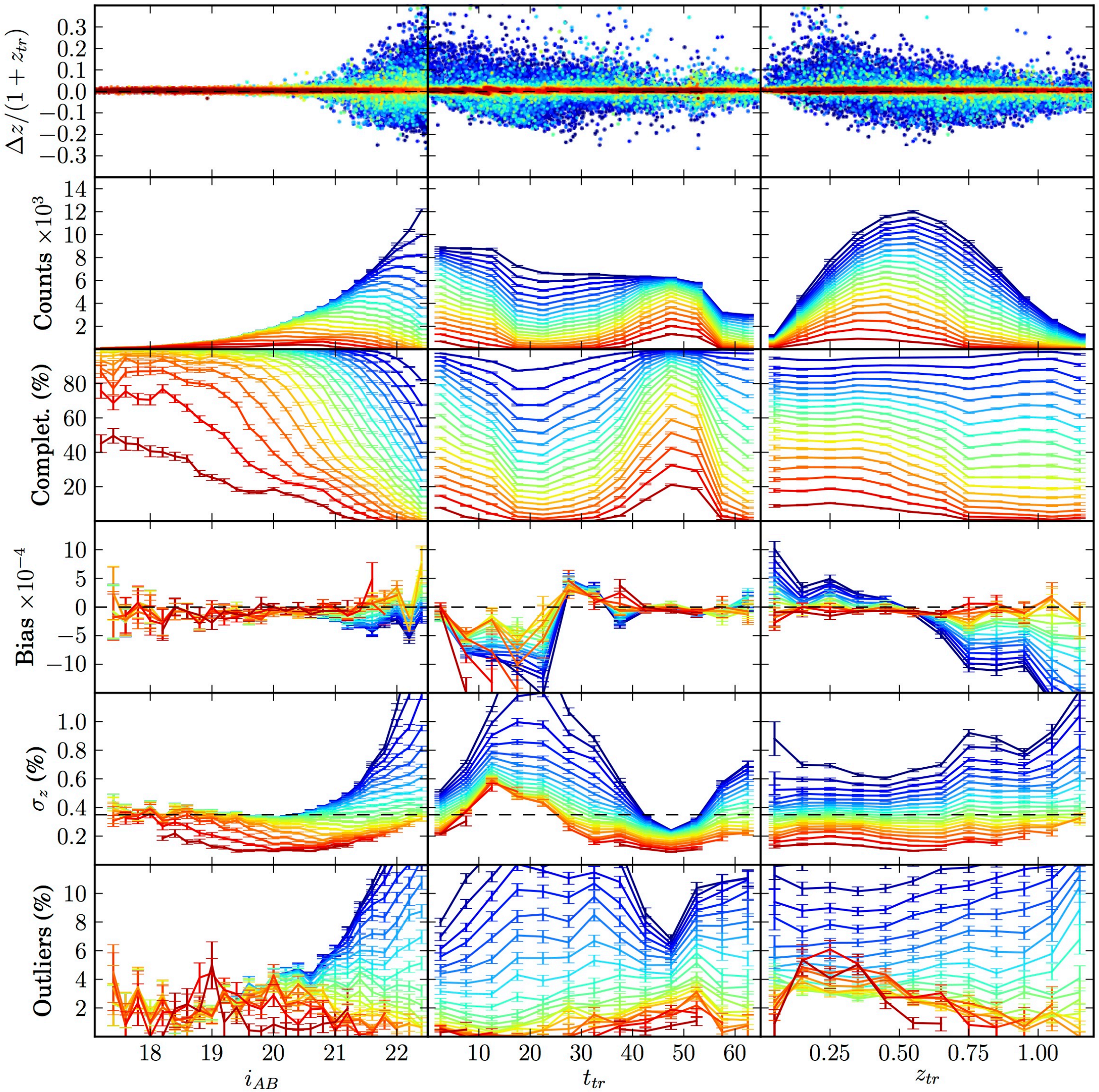
PAU Survey Strategy

- Use 8 central CCDs to define the survey footprint, use the other CCDs to increase S/N.
- Each central CCDs covers the whole survey area twice.
- 5 filters trays with 8 central having NB filters
- Broad bands in the outer CCDs and dedicated trays.
- Detect objects in the broad bands, and then get flux in the narrow bands.
- Push to low signal to noise.
- Surveying capability: sample 2 deg2 / night to iAB < 22.5 mag in NBs $\Delta z/(1+z)$ ~0.0035 and iAB < 24.0 in BBs $\Delta z/(1+z)$~0.05 ➜ >30000 galaxies / night
- Exposure times depend on tray: ~100 s for bluest, ~250 s for reddest.
- No selection effects.

PAU Survey Strategy



PAU PHZ Performance



PAU Cam Science

PAUCam scientific design

- The PAU Camera has been designed to provide sufficiently adequate photometric redshifts for cosmological surveys and to cover the largest area available by the WHT corrector
- Current science case is based on cosmology with cross-correlations, exploring the intrinsic alignments, obtaining low resolution SEDs
- PAUCam also includes features to allow the widest possible use by the ING general community: broad band filters, additional narrow band filters in the blue (not yet), additional external trays and a community pipeline

PAUS Science: cross-correlations

The cross-correlation scientific case, has been published in (Gaztañaga et al. 2012, MNRAS)

The paper explores several possibilities:

B

F

F + B (different areas)

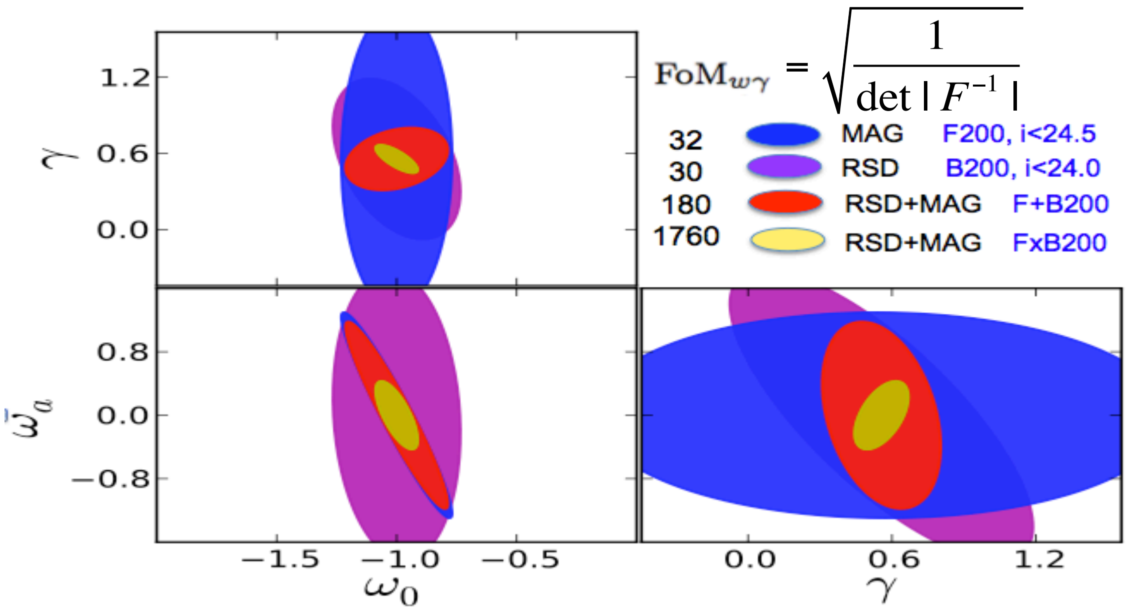
F x B (same area) ← substantial improvement.

B can be seen as a spectroscopic follow-up of a photo-z F sample.

PAU Science: cross-correlations

Effects (WL and RSD) are sensitive to both the equation of state parameter, w = w0 + wa (1-a), and structure growth γ.

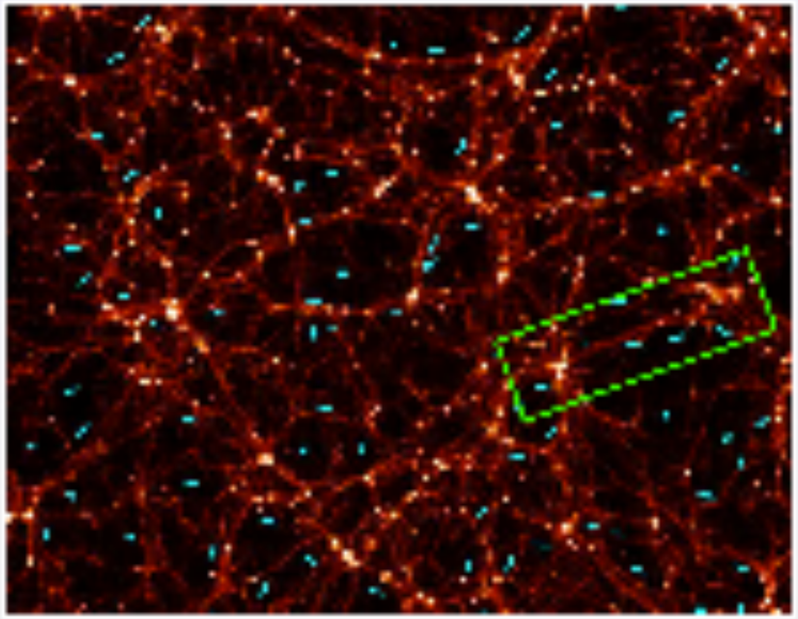
The combination of RSD and WL in the same dataset is very powerful in breaking degeneracies between cosmological parameters
➔A unique advantage of PAU.



Gaztañaga, Eriksen, Crocce, Castander, Fosalba, Martí, Miquel, Cabré, MNRAS, 422,2904G (2012)

PAU Science: intrinsic alignments

2pt correlation: $$\underbrace{\langle \epsilon_i \epsilon_j \rangle}_{\text{observed}} = \underbrace{\langle \gamma_i \gamma_j \rangle}_{\text{GG}} + \underbrace{\langle \epsilon_i^s \epsilon_j^s \rangle}_{\text{II}} + \underbrace{\langle \gamma_i \epsilon_j^s \rangle + \langle \epsilon_i^s \gamma_j \rangle}_{\text{GI}}$$



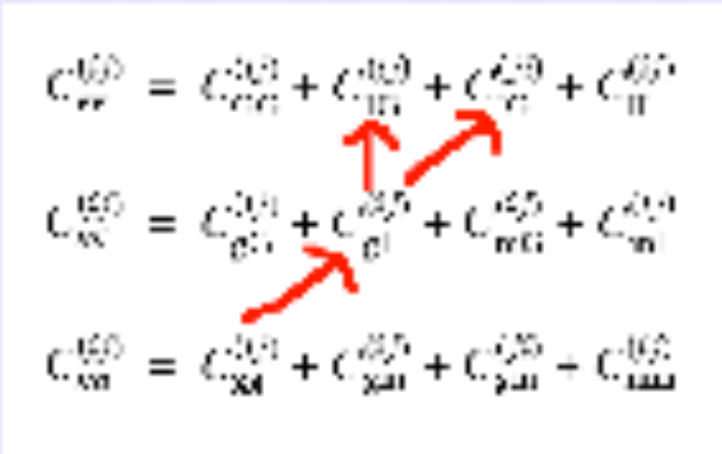
tidal gravitational field generates torques & shear forces

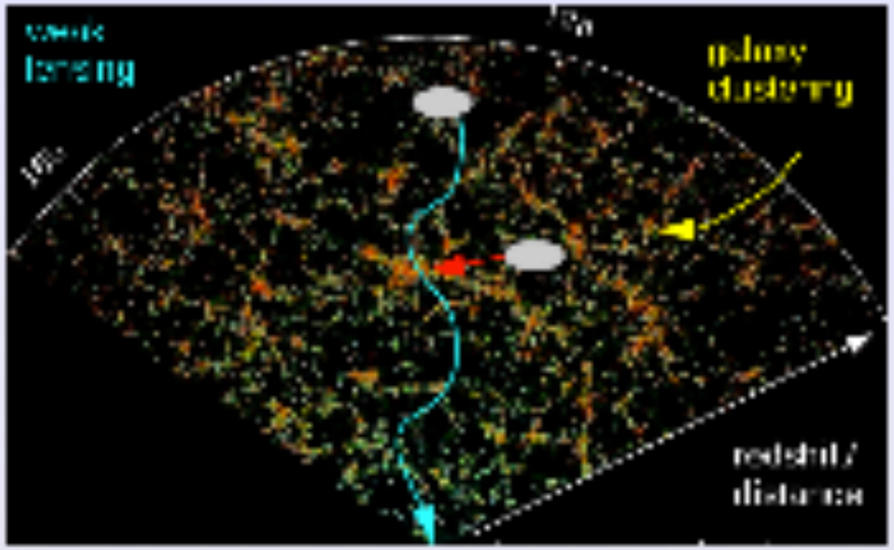
→ angular momenta & shapes of haloes become correlated

→ galaxy ellipticities become correlated

PAU science: intrinsic alignments

Ansatz: Use additional correlations available from weak lensing surveys





G: gravitational shear
I: intrinsic shear
g: intrinsic number densities
m: magnification effects

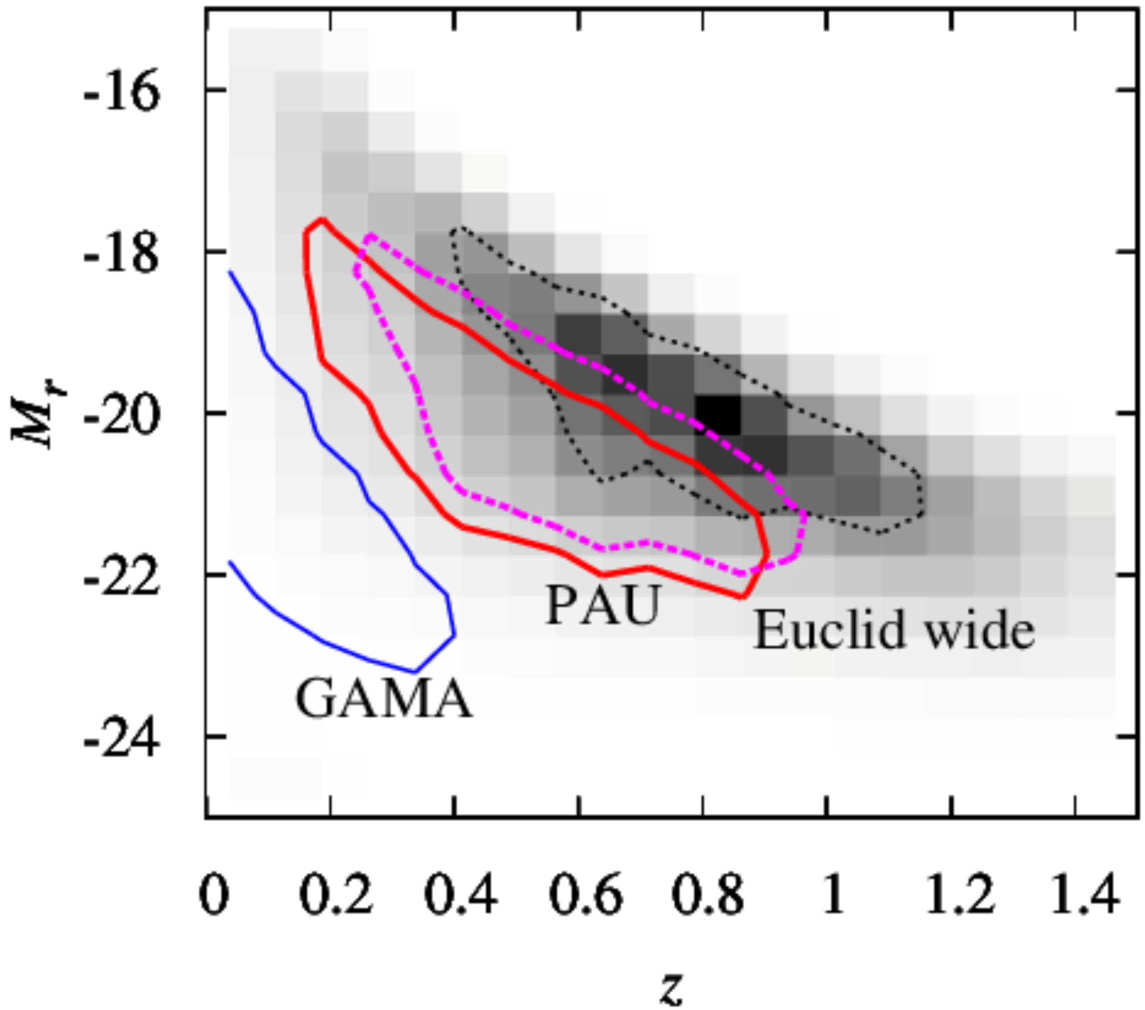
Goal:
Calibrate GI signal via cross-correlation with galaxy clustering

Procedure: *(Bernstein 2009, Joachimi & Bridle 2010)*

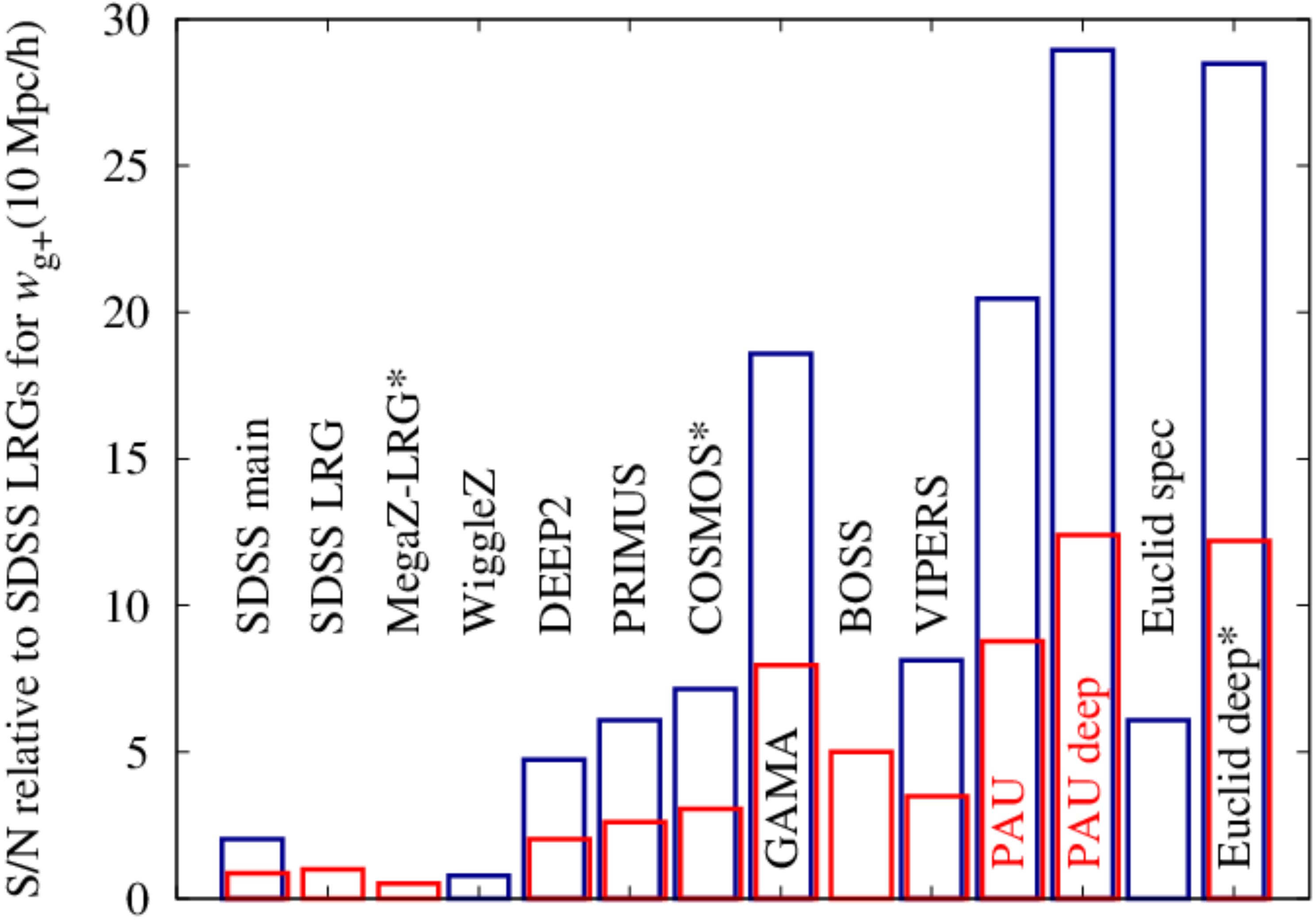
- include galaxy number density correlations
- introduce generic flexible parametrisation for IA and galaxy bias
- marginalise over all IA and galaxy bias parameters

→ **External priors on IA essential to meet Euclid requirements**

PAU science: intrinsic alignments



PAU science: intrinsic alignments



PAUCam

- The PAU Camera is scheduled to be commissioned next June
- It will be offered to the ING general community
- We encourage people to use it