



# VISTA eXtreme Multiplex Spectrograph - VXMS

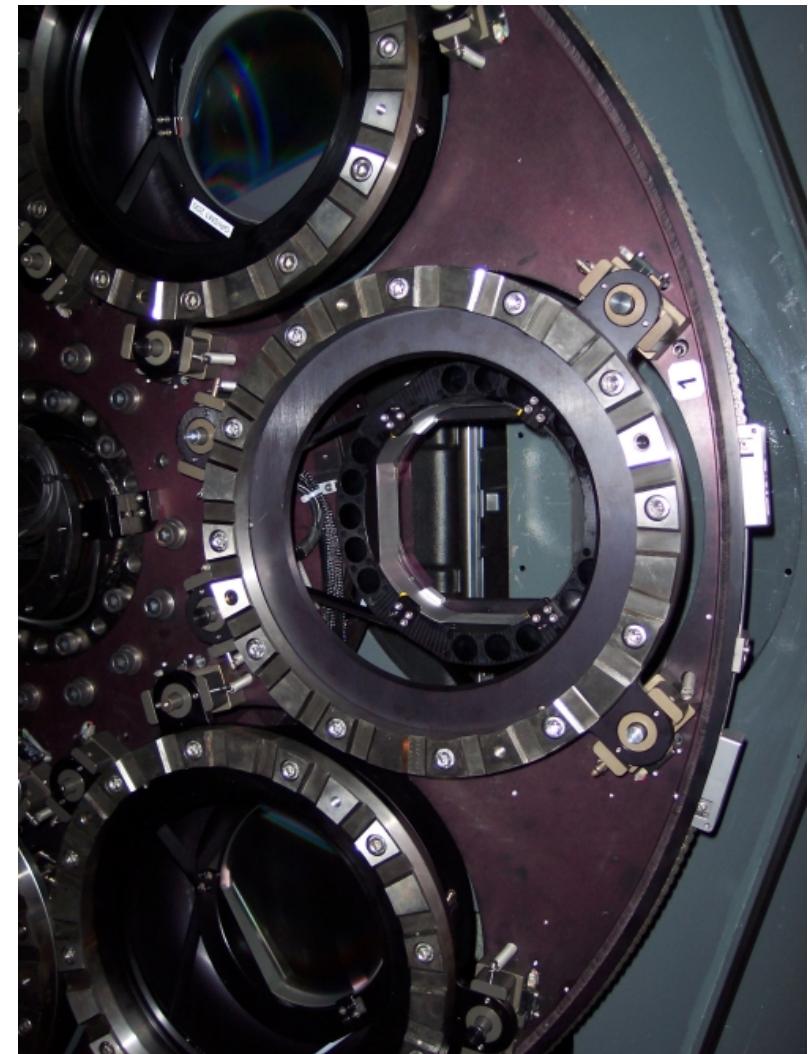
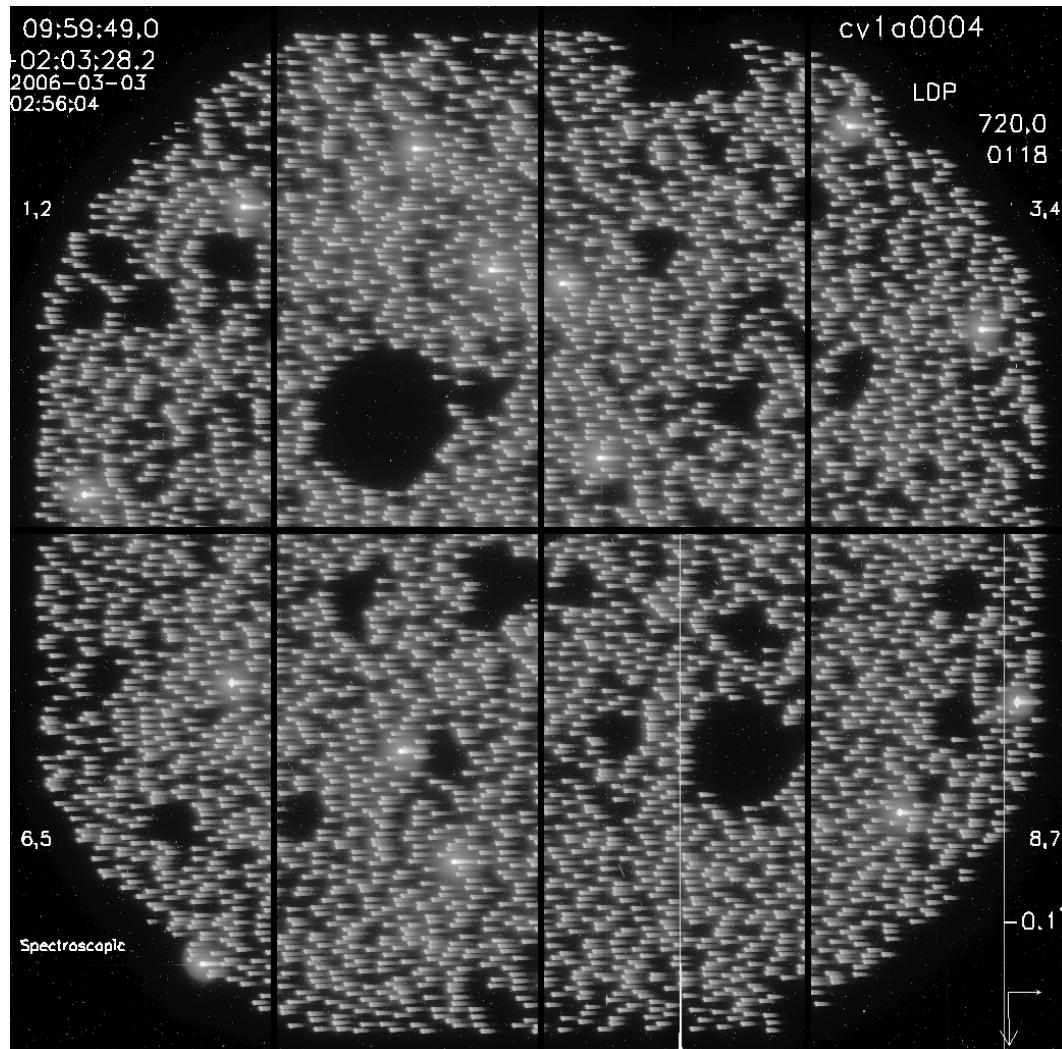
T. Shanks et al (Durham University)

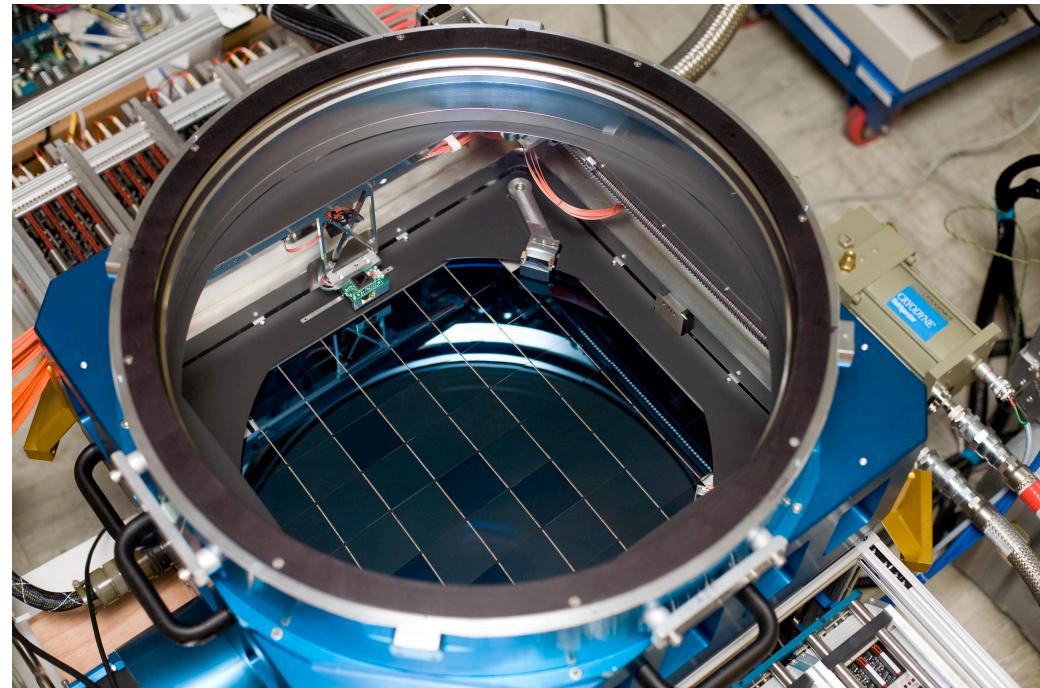
# VXMS Concept Development

- Started in 2004 with NG2dF - Next Generation 2dF
  - ~10000 slits at  $\sim 3500 \text{deg}^{-2}$  for AAT 2dF - Content +Shanks (2008, arXiv:0808.2367)
- Two feasibility studies completed to use existing 1 degree field at AAT 3.9-m and Calar Alto 3.5-m
- New interest prompted by
  - Magellan IMACS PRIMUS 5000 slits in 25' fov
  - BigBOSS  $3500 \text{deg}^{-2}$  ELG sky density for BAO
- VISTA eXtreme Multiplex Spectrograph
  - ESO MOS Call deadline 1/3/11

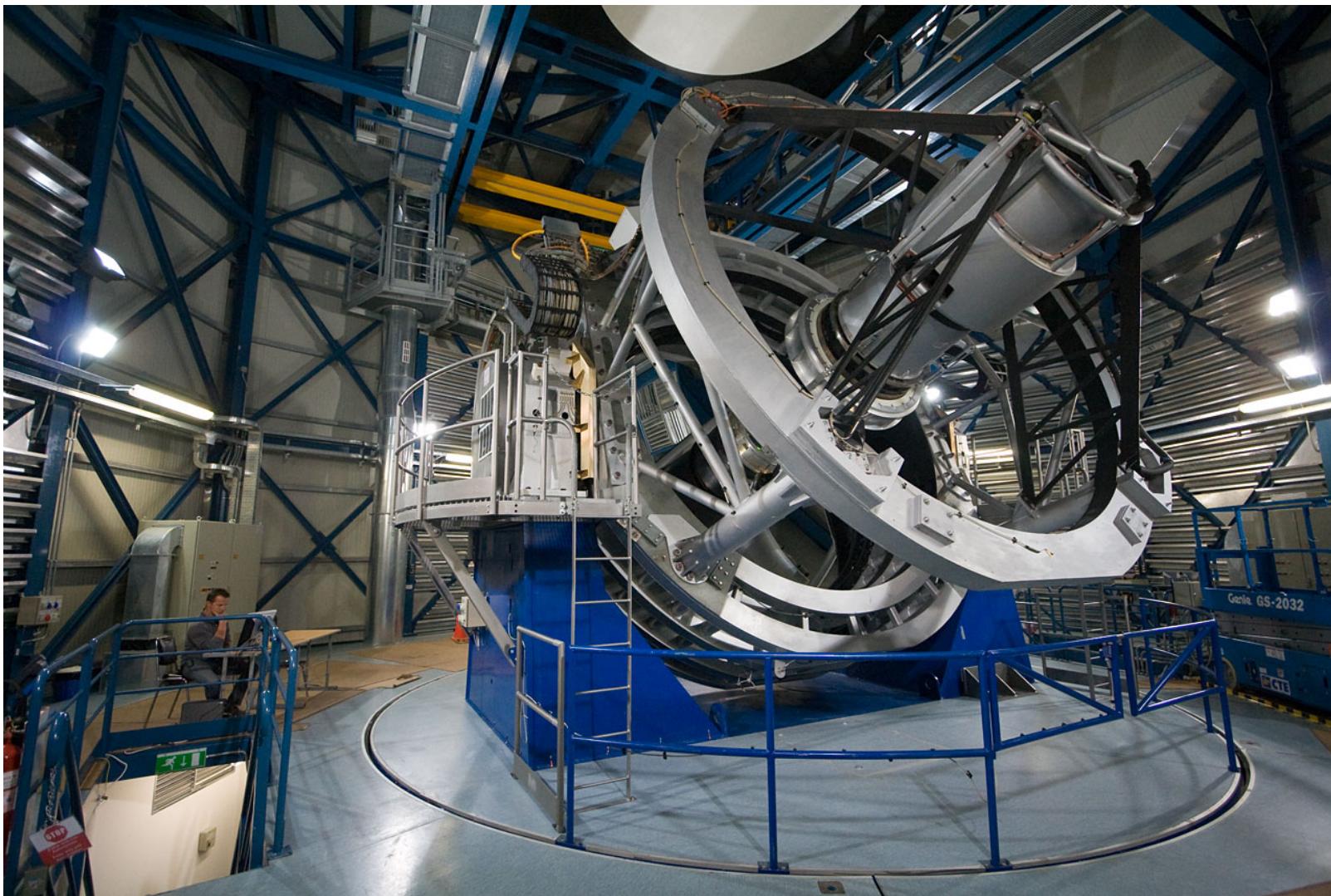
# Magellan PRIMUS

## 25' fov, ~5000 slits at R~40





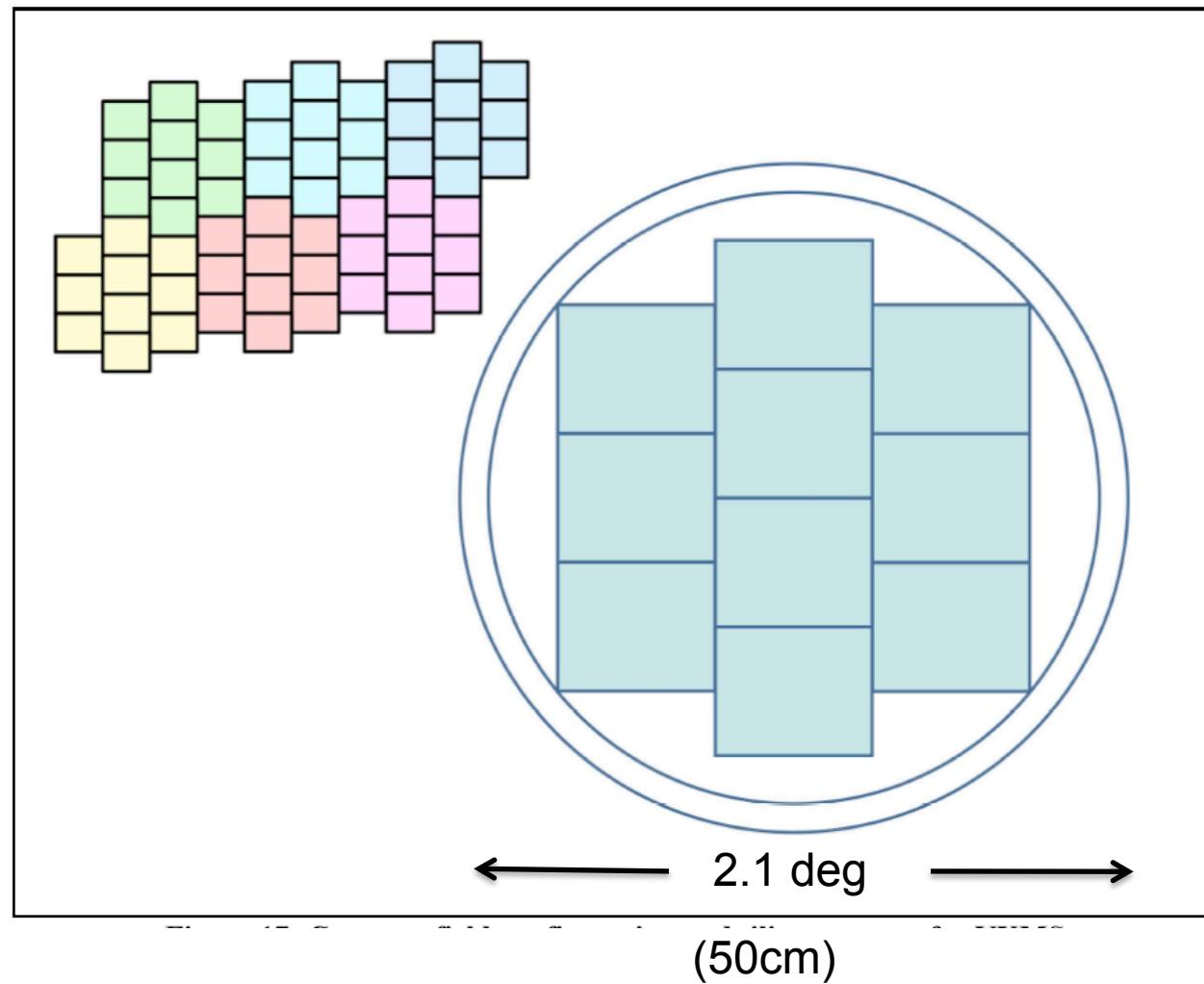
# VISTA 4.1-m telescope



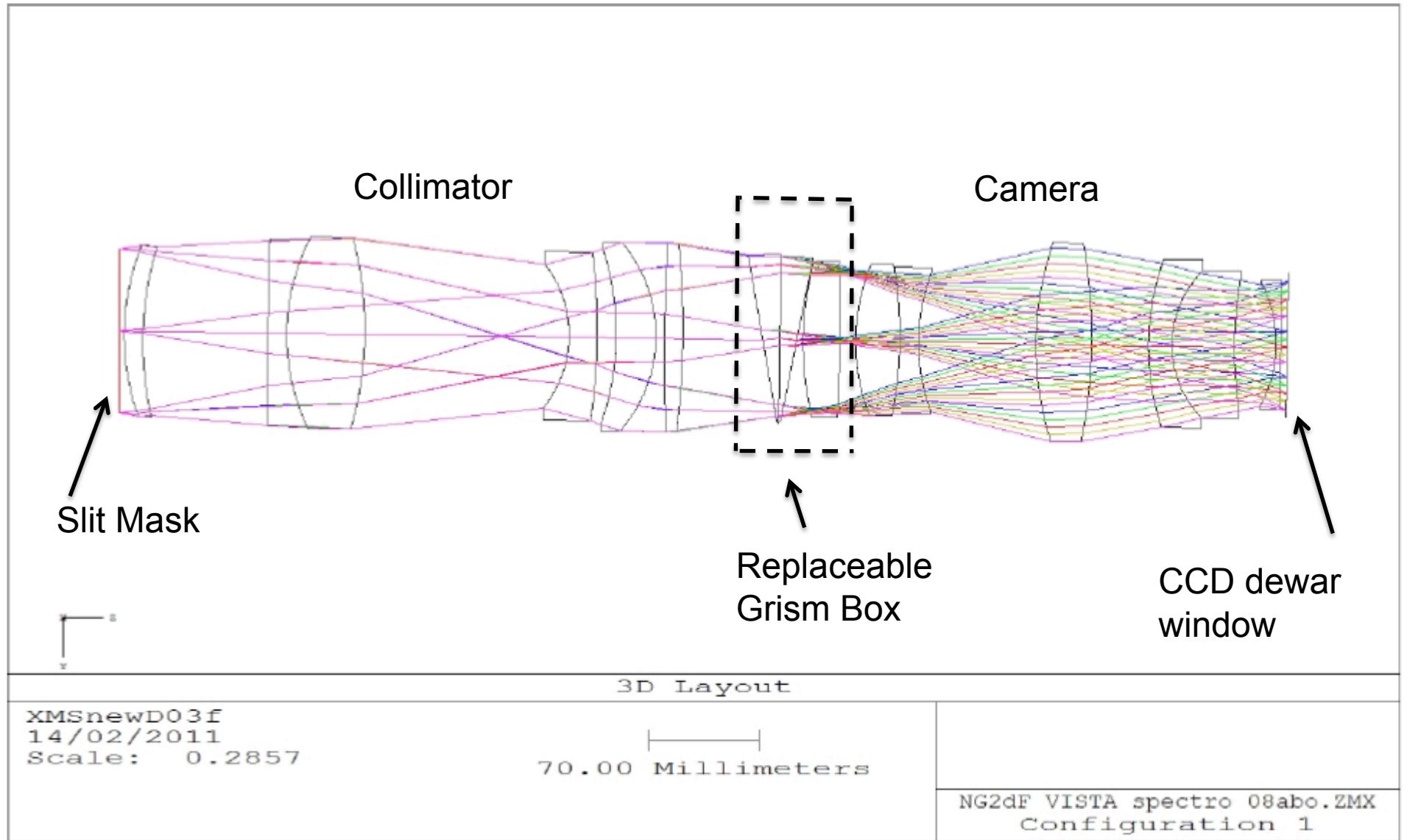
# VXMS outline

- 10 cloned spectrographs to cover ~85% of 2 deg diameter field at VISTA 4.1-m Cassegrain focus
- 10 6kx6k EEV CCDs
- Gives ~10000 slits at resolution  $R \sim 1100/R \sim 3000$  over 550-750/750-900nm ranges
- 25-75x PRIMUS resolution → absorption+emission line z rather than PRIMUS photo-z
- ~90000 galaxy redshifts per night!
- → 2dFGRS in 3 nights at ~10x bigger z and ~4mag fainter!!!
- 4-m 2-degree field ~40x bigger fov and aperture only 4x smaller than 8-m

# VXMS Field-of-view



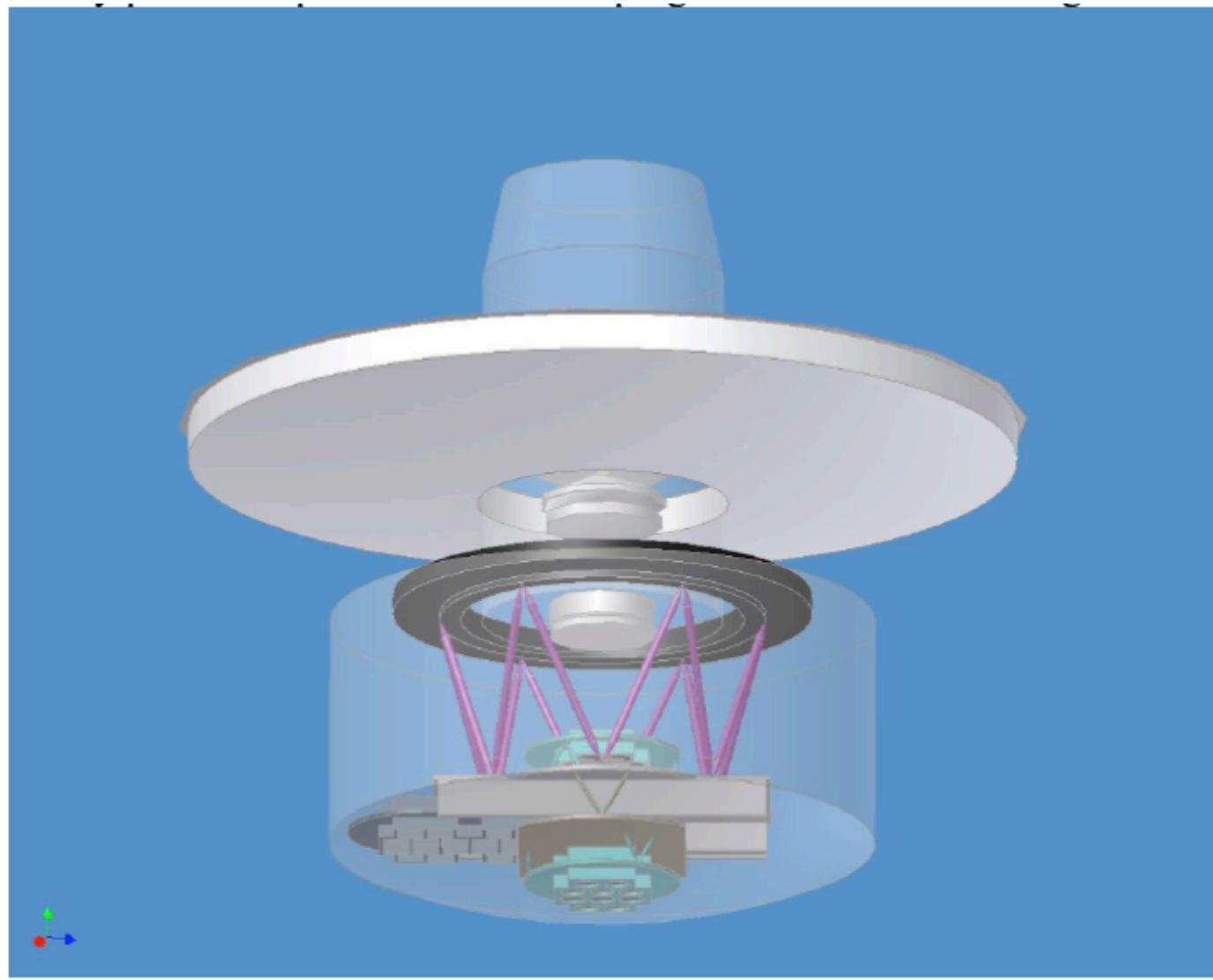
# VXMS Optical Layout – R.Content



# VXMS Specifications

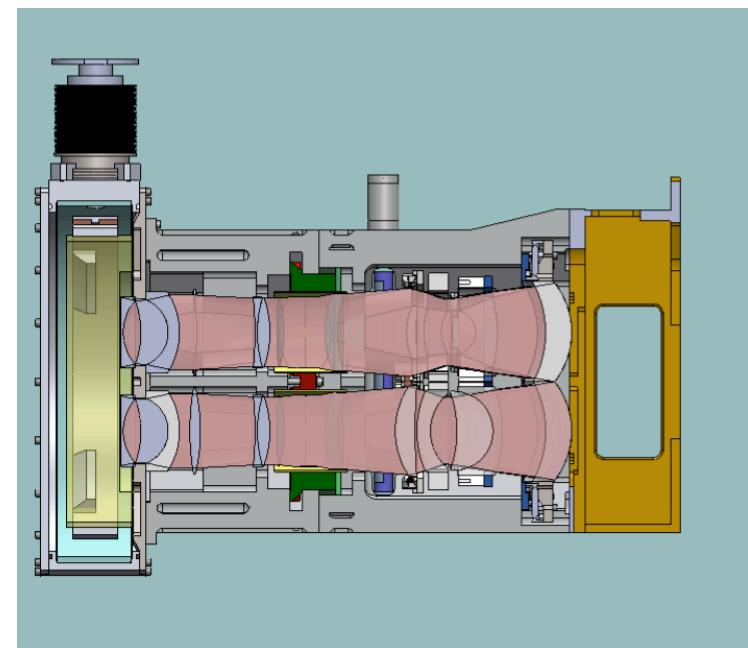
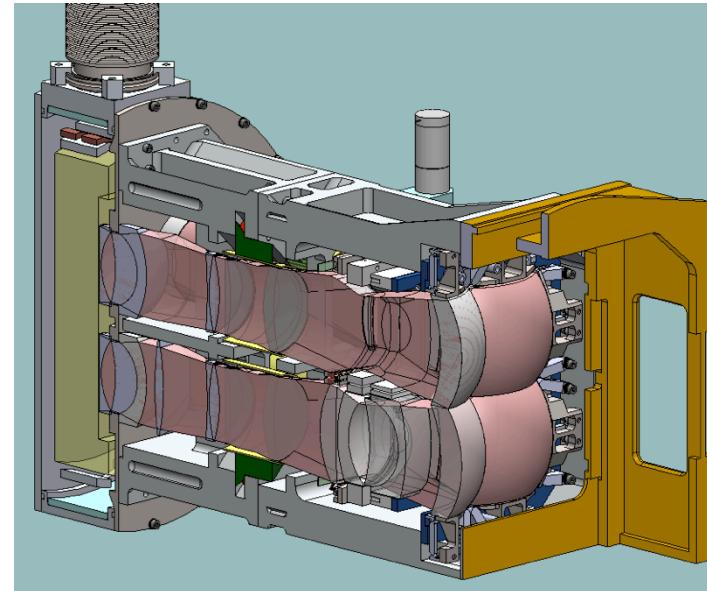
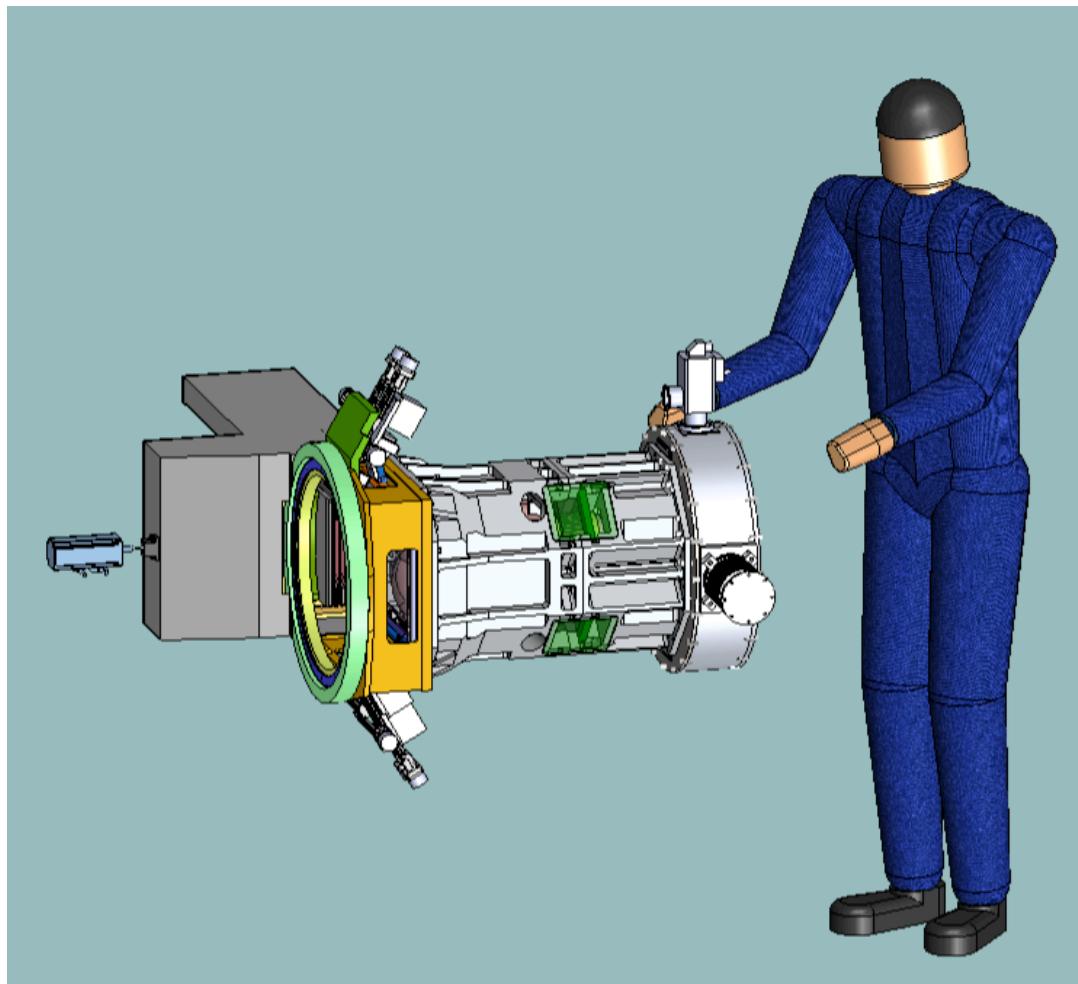
Req. No.	Item	Specification
SC1	Diameter of corrected FoV	2.1 deg
SC2	Image scale at mask focal plane	65 $\mu\text{m}$ / arc sec
SC3	FoV per spectrograph	33 arc min x 27 arc min
SC4	Number of spectrographs	10
SC5	Maximum length of spectrograph optical train	750 mm
SC6	Image quality at mask focal plane (50% EE)	0.4 arc sec (0.3 arc sec goal)
SC7	Image quality at detector focal plane (50% EE)	0.8 arc sec (0.5 arc sec goal)
SC8	Angular (detector) pixel size on sky	15 $\mu\text{m} \Leftrightarrow 0.355$ arc sec
SC9	Spectral range for blue grism	550-750 nm (1430 pixels)
SC10	Spectral resolution for blue grism	R~1100 for 1''.5 slit width
SC11	Spectral range for red grism	750-900 nm (1530 pixels)
SC12	Spectral resolution for red grism	R~3000 for 1''.0 slit width
SC13	Spectral range for CaT grism	840-870 nm (450 pixels)
SC14	Spectral resolution for CaT grism	R~5000 for 1''.0 slit width
SC15	Maximum time to change grisms	5 minutes
SC16	Maximum time to change fields	10 minutes

# VXMS VISTA Envelope





*Extreme Multiplex  
Spectrograph*



Acknowledgment: S. Becerril (IAA)

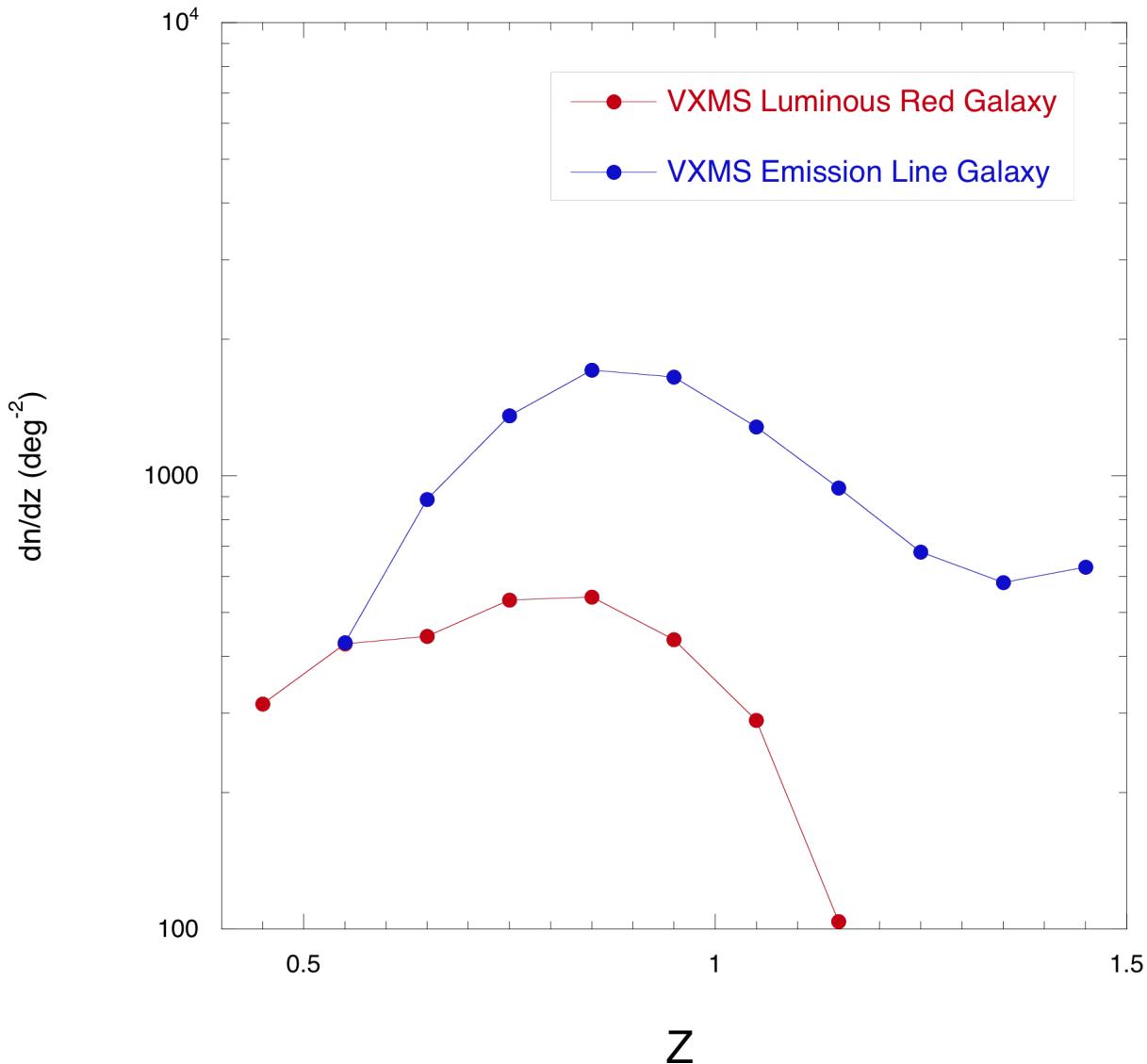
# VXMS Science Aims

- BAO to determine DE equation of state to  $z \sim 1.5$
- Gravitational growth rate via  $z$ -distortion to  $z \sim 1.5$
- Evolution of halo masses and galaxies at  $z \sim 0.7$
- Galactic Archaeology
- Rich galaxy cluster survey
- Photo-z calibration for gravitational lensing
- ....

# VXMS Cosmology Survey

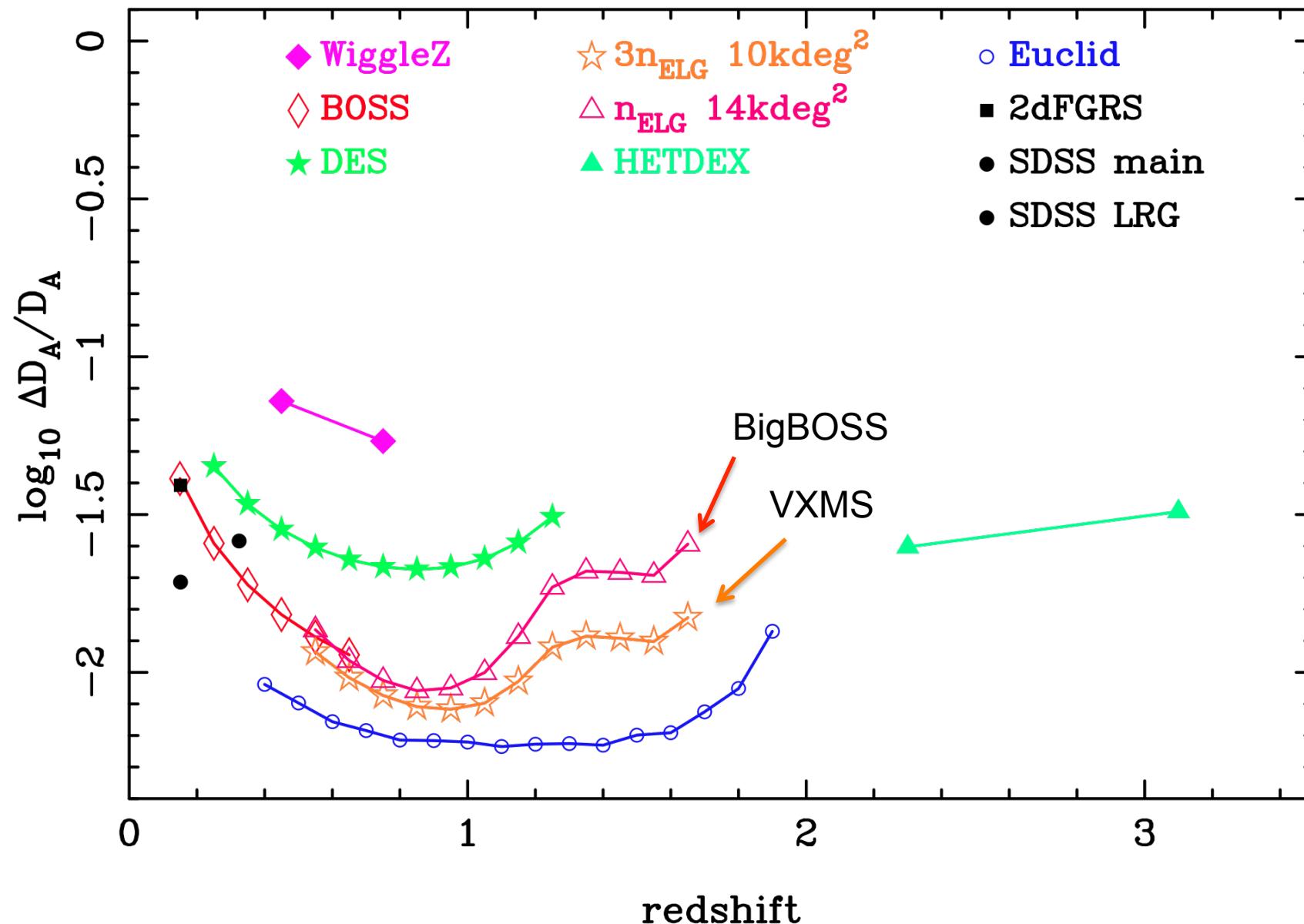
- OII emission line galaxy survey at  $0.5 < z < 1.5$
- $3000 \text{deg}^{-2}$  ELG (+ $300 \text{ deg}^{-2}$  LRG to  $z \sim 1$ )
- $20 \times 10^6$  galaxies over  $10000 \text{deg}^2$  in 440 nights
- BAO + RSD S/N beats BigBOSS at  $1 < z < 1.5$
- Assumes 30min exposures – 2x BigBOSS for ELGs, same as BigBOSS for LRGs
- BigBOSS revisits 5x, VXMS revisits 2x to do 2 spectral bands

# VXMS galaxy n(z) relations

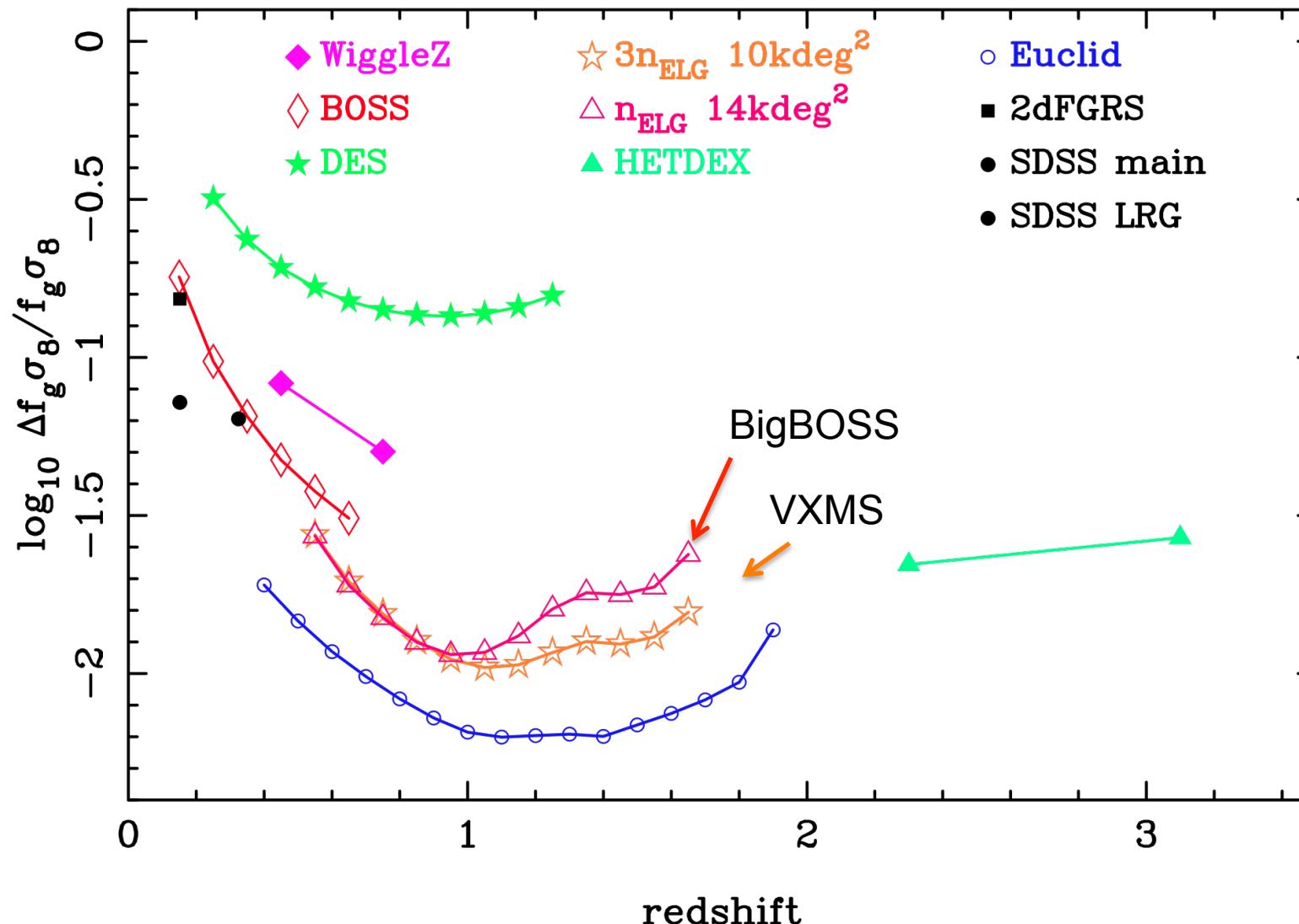


- ELG  $n(z)$  based on DEEP2 to OII<1e-16cgs (~2500deg $^{-2}$ )
- VXMS ELG proposed OII<4e-17cgs (~10000deg $^{-2}$ )
- Use DES gri

# VXMS BAO Comparison



# Gravitational Growth Rate



# VXMS Galaxy Evolution Survey

- $i < 21$  survey of  $\sim 1 \times 10^6$  galaxies photo-z selected at  $z \sim 0.5 < z < 1$  in  $\sim 300 \text{deg}^2$  in  $\sim 200$  nights ( $2 \times 1.5 \text{hrs}$ )
- Study the kpc to Mpc scale, where baryon physics critical
- Trace how stars follow mass
- Determine halo mass function via galaxy groups
- Quantify galaxy formation efficiency via group M/L
- Characterise stellar mass function  $\rightarrow$  dwarfs
- All to a lookback time when Universe was  $< 50\%$  of present age

# VXMS Galactic Assembly Survey

- 3<sup>rd</sup> grism - 847-874nm + R~5000
- Covers Calcium Triplet absorption
- Stellar radial velocity to complement GAIA proper motions to V=20
- 1000deg<sup>2</sup> survey - Galactic Plane+ Centre in ~200 nights
- 10 million stars with radial velocities

# Upcoming Imaging Surveys

- SDSS ( $i < 20$ )  $2500 \text{deg}^{-2}$ + Stripe 82 ( $i < 22$ )  $14000 \text{deg}^{-2}$
- Pan-STARRS  $3\pi$  (grizy) + Medium + Deep
- VST ATLAS (ugriz)+KIDS (griz)
- UKIDSS LAS+VISTA VHS (YJHK)
- ALHAMBRA+PAU Medium-Band surveys
- DES + LSST
- All of these will need spectroscopic follow-up  
    ⇒ Plenty of motivation for VXMS!
- Also ASKAP, SKA and ALMA follow-up for VXMS

# Coherent Survey Programme

- Cosmology Survey
  - ~20 million galaxy redshifts in ~500 nights
- Galaxy Evolution Survey
  - ~1 million galaxy spectra in ~200 nights
- Galactic Assembly Survey
  - ~10 million stellar radial velocities in ~200 nights
- 5 year programme for VISTA – including substantial time for GO programmes

# VXMS Cost

- Estimated cost to build VXMS is **€18m (including ~30% contingency)**
- – cheap cf WFMOS or BigBOSS
- Proposed funding route:-
- ESO contributes **€6m** for hardware
- Durham/Edinburgh/Portsmouth Univ. + LAM + Swinburne
- .....contribute **€2m** direct/in-kind in total
- AAO contributes **€2m?**
- STFC contributes **€2m?**
- More partners needed!

# Summary



- VXMS offers **order of magnitude** improvement in wide-field MOS multiplex ( $400 \rightarrow 10000$ )
- New generation spectroscopic follow-up to match new generation imaging surveys – **DES, KIDS, LSST!**
- VXMS offers uniquely competitive results on:-
  - BAO and Gravitational Growth rate to  $\sim 1.5$
  - Galaxy and Halo Mass Evolution
  - Galactic Archaeology
- **VXMS offers cosmology surveys with 20 million redshifts in advance of EUCLID+SKA.**