Instrumentation for Cosmological Surveys

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eXtreme Multiplex Spectrograph

Outline of Talk

- Science Drivers for Cosmological Surveys
- Competitiveness of 4m Telescopes
- Extreme Multiplex Spectrographs
- Conclusions

Thanks to Tom Shanks, Robert Content, Santiago Becceril and the NG1DF/XMS teams

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Cosmology Survey Science

- BAO z~0.7 (LRGs+ELGs)
- Z-space distortions (z<0.7)
- Group M/L vs L (GAMA)
- Photo-z calibration for imaging surveys
- Follow-up of space-based surveys (Planck Herschel, eROSITA)
- Legacy Spectroscopic Archive of Northern Sky

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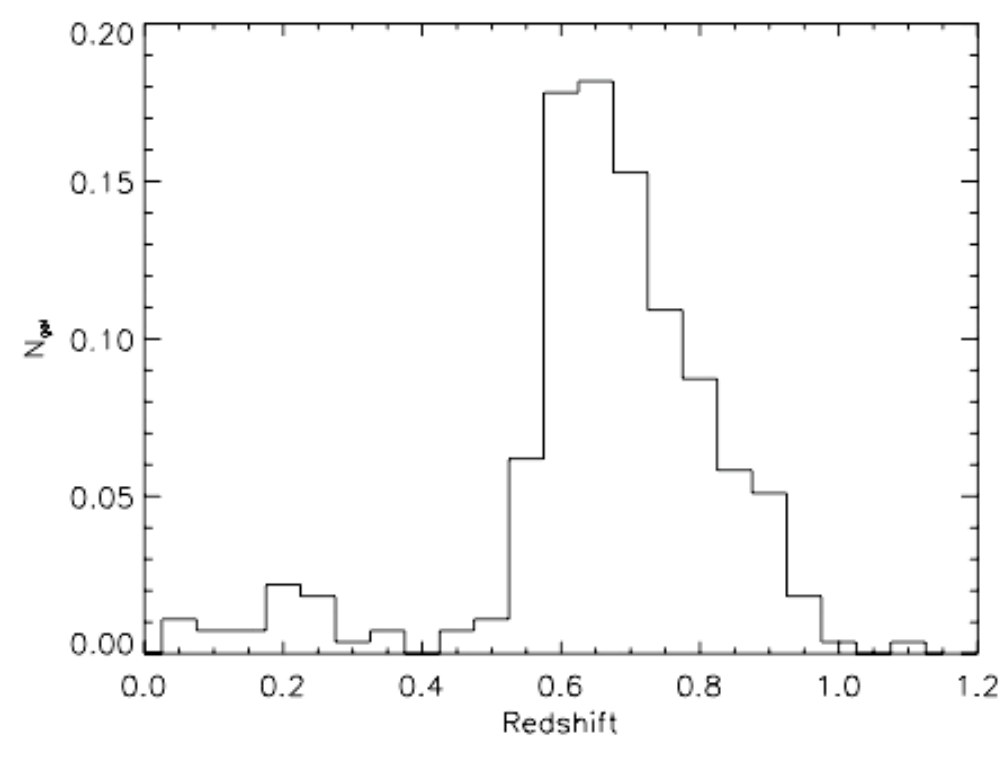
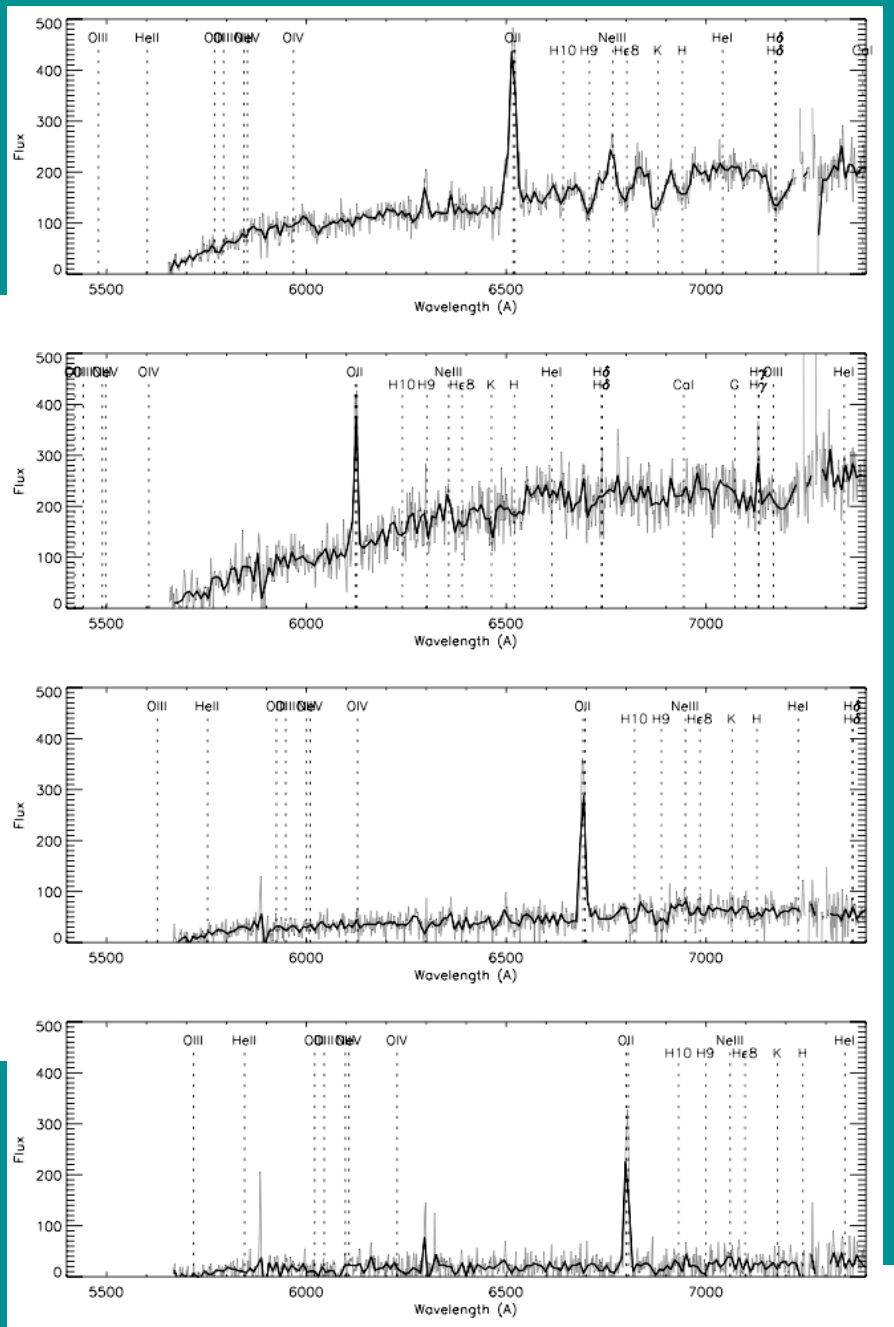
AAΩ Emission Line Galaxies





ELGs (OII 3727Å) from SDSS +AAOmega in range 19.1<I<20.1 (Bielby et al 2009)

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Galaxy sky densities

- i<20 all galaxies ~2500deg^{-2}
- i<21 z~0.5 em+absn galaxies ~5000deg^{-2}
- 21<i<22 all galaxies ~9000deg^{-2}
- 21<i<22 z~0.7 OII em galaxies ~5000deg^{-2}
- r<25 z~3 LBGs ~3600deg^{-2}

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Competitiveness of 4m tel

- Exploit AΩ advantage at prime focus
- Maximise the multiplex to increase survey rate (reduce shot noise)
- Dedicated survey facilities to increase sky coverage/volume (reduce cosmic variance)

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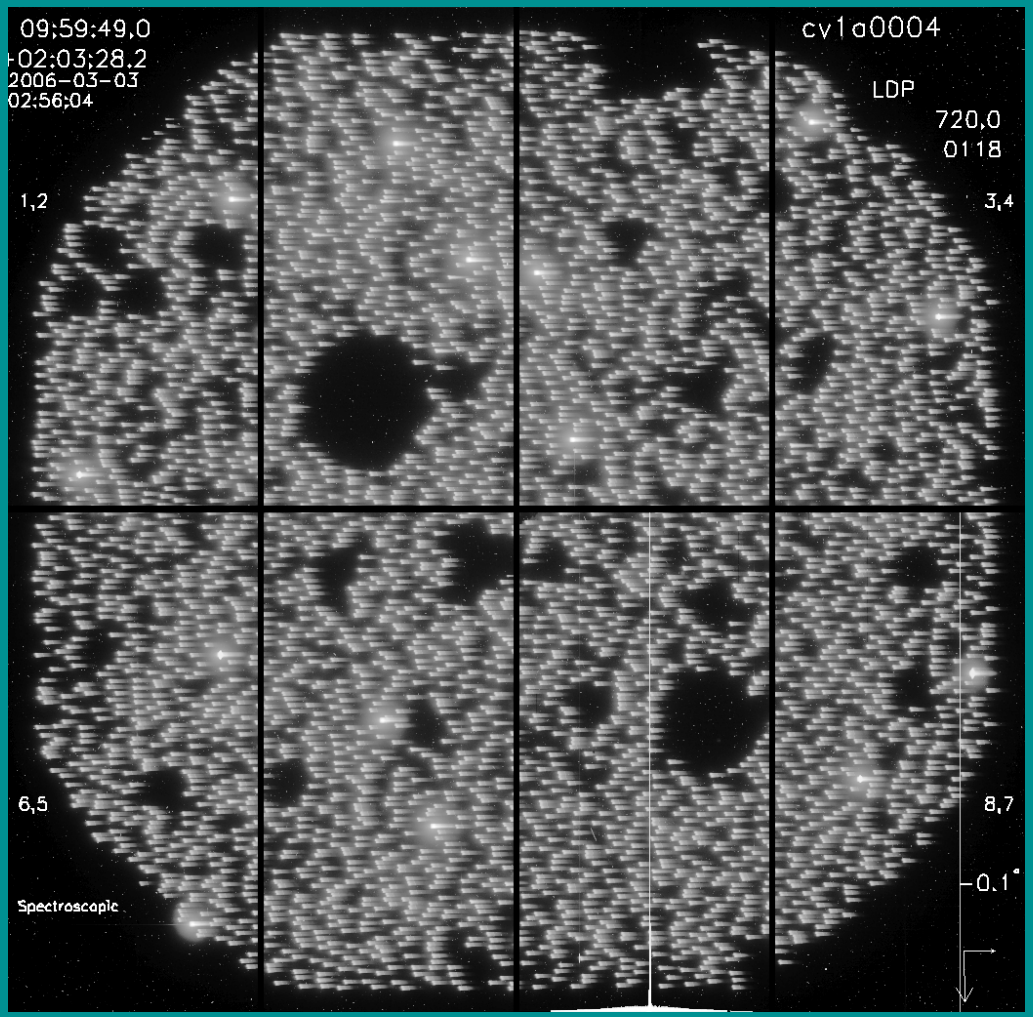
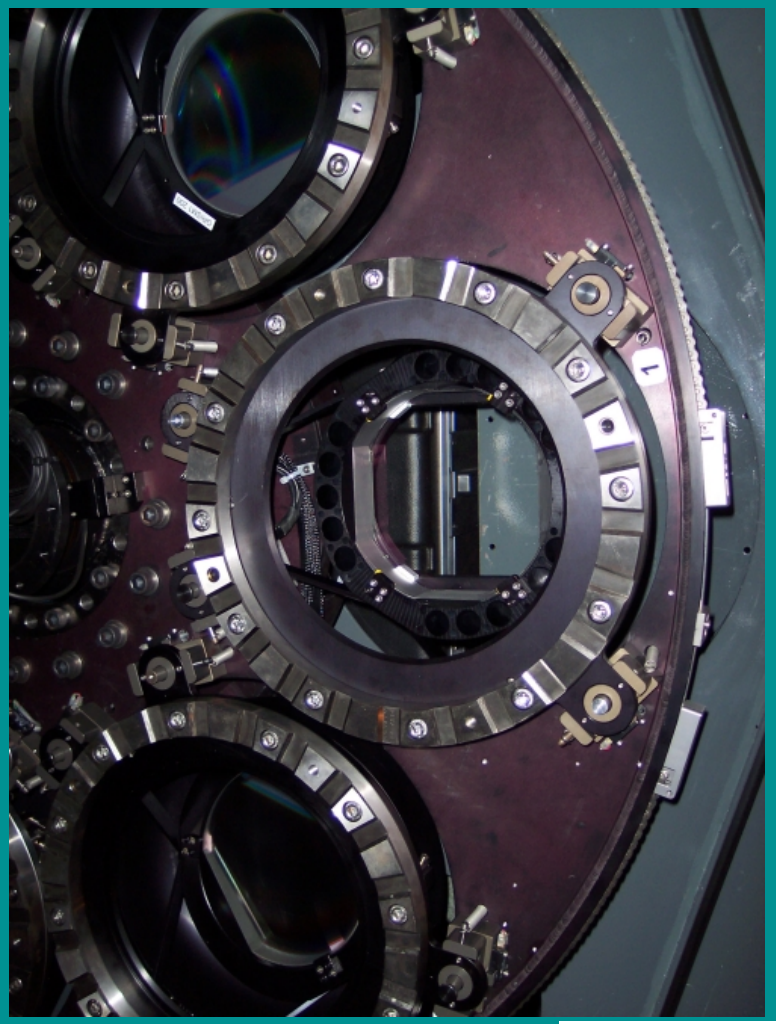
Extreme Multiplex Spectroscopy (PRIMUS)





25′ FoV ~5000 slits at R~40

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Extreme Multiplex Spectroscopy (NG1dF, XMS)

- 4 cloned spectrographs to cover 1deg^2 field at prime focus
- Gives ~4000 slits at default resolution R~400 (10Å) over 2000Å range (slits 1.″5x10″)
- 10x PRIMUS resolution → absorption+emission line z rather than PRIMUS photo-z
- Using eg 5200-7200Å range could survey 250000 galaxy redshifts at z~0.7 in 10 nights
- → 2dFGRS in 5% of the observing time at 6x larger z and ~4mag fainter

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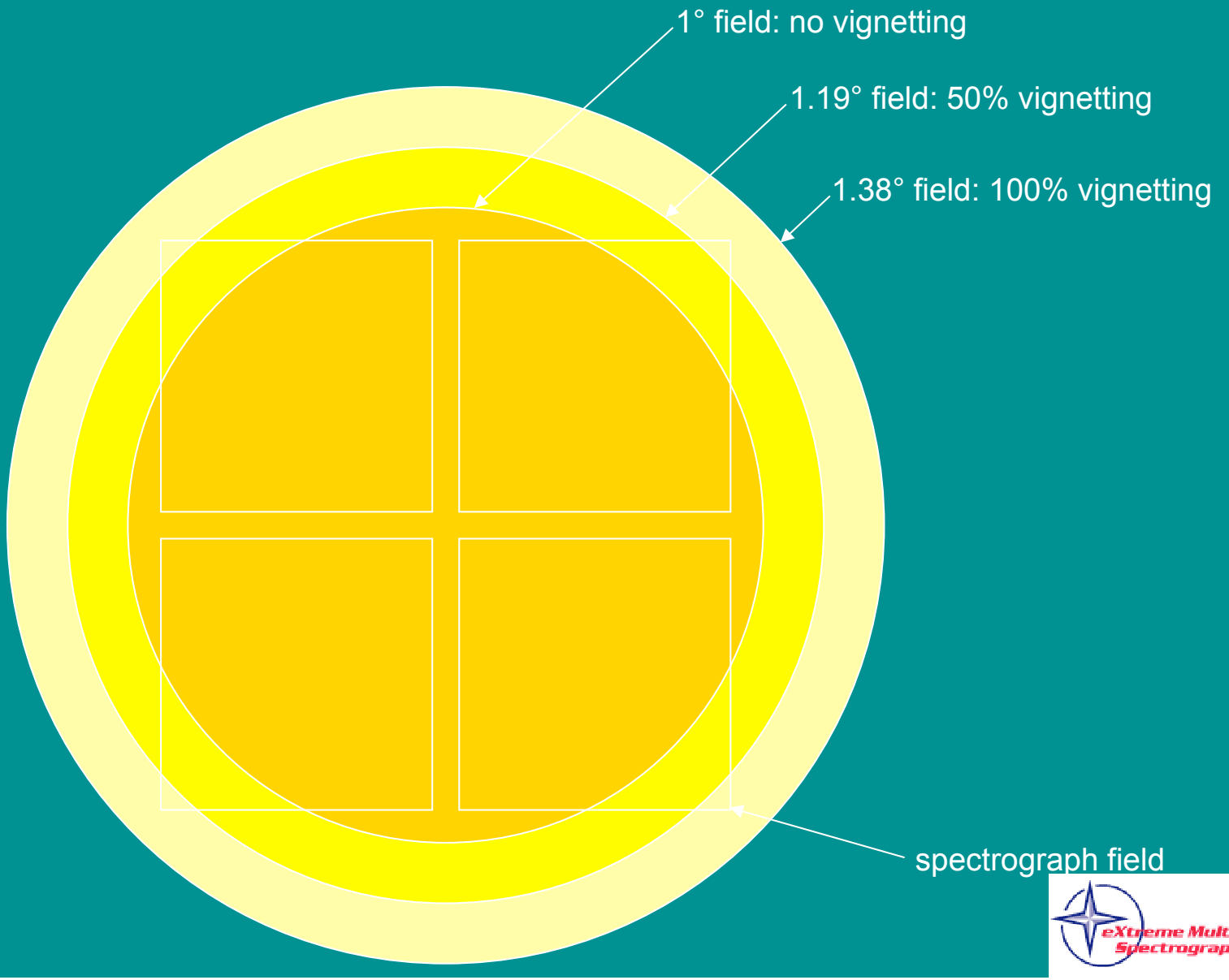
Extreme Multiplex Spectroscopy (NG1dF, XMS)



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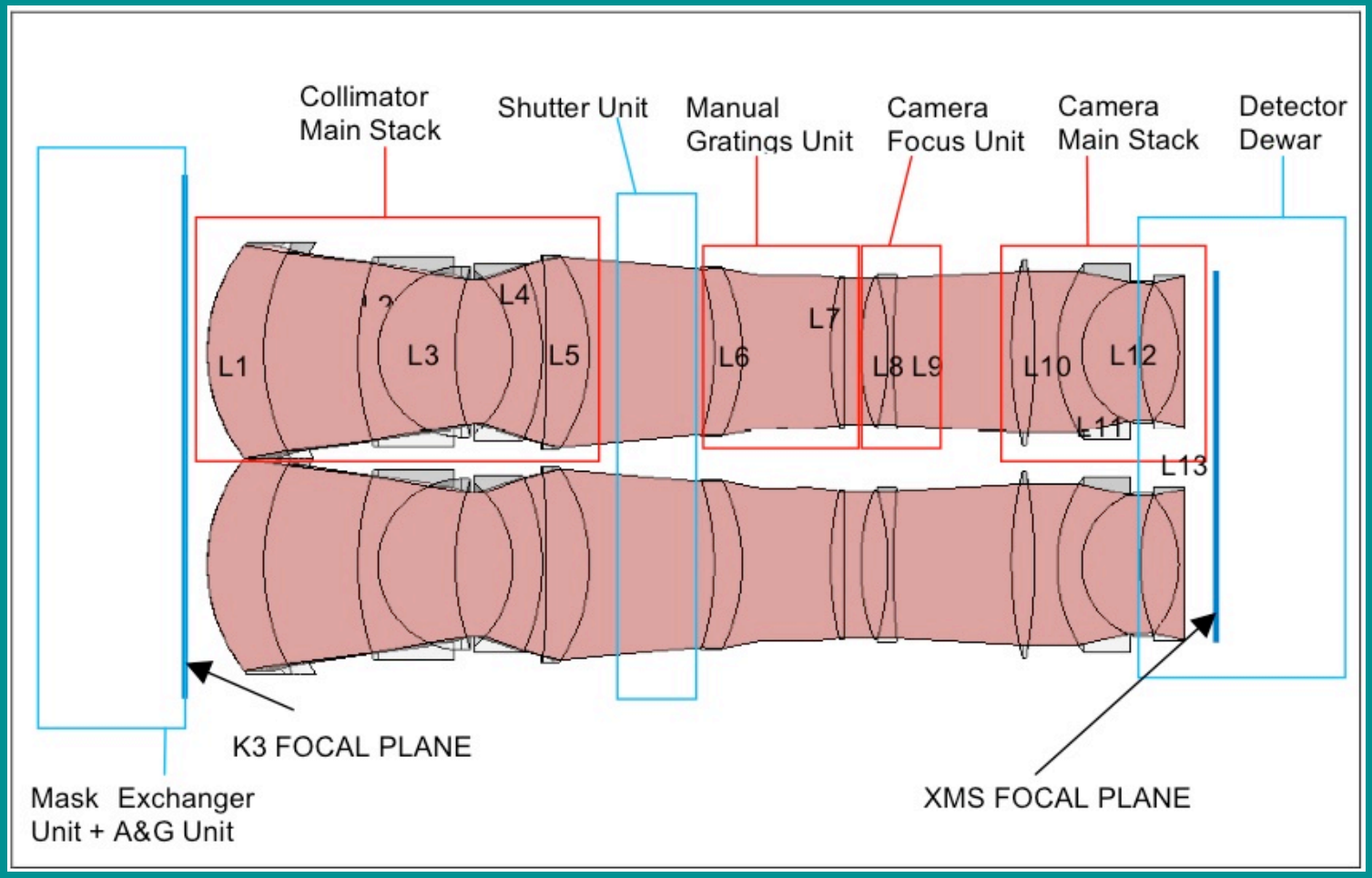
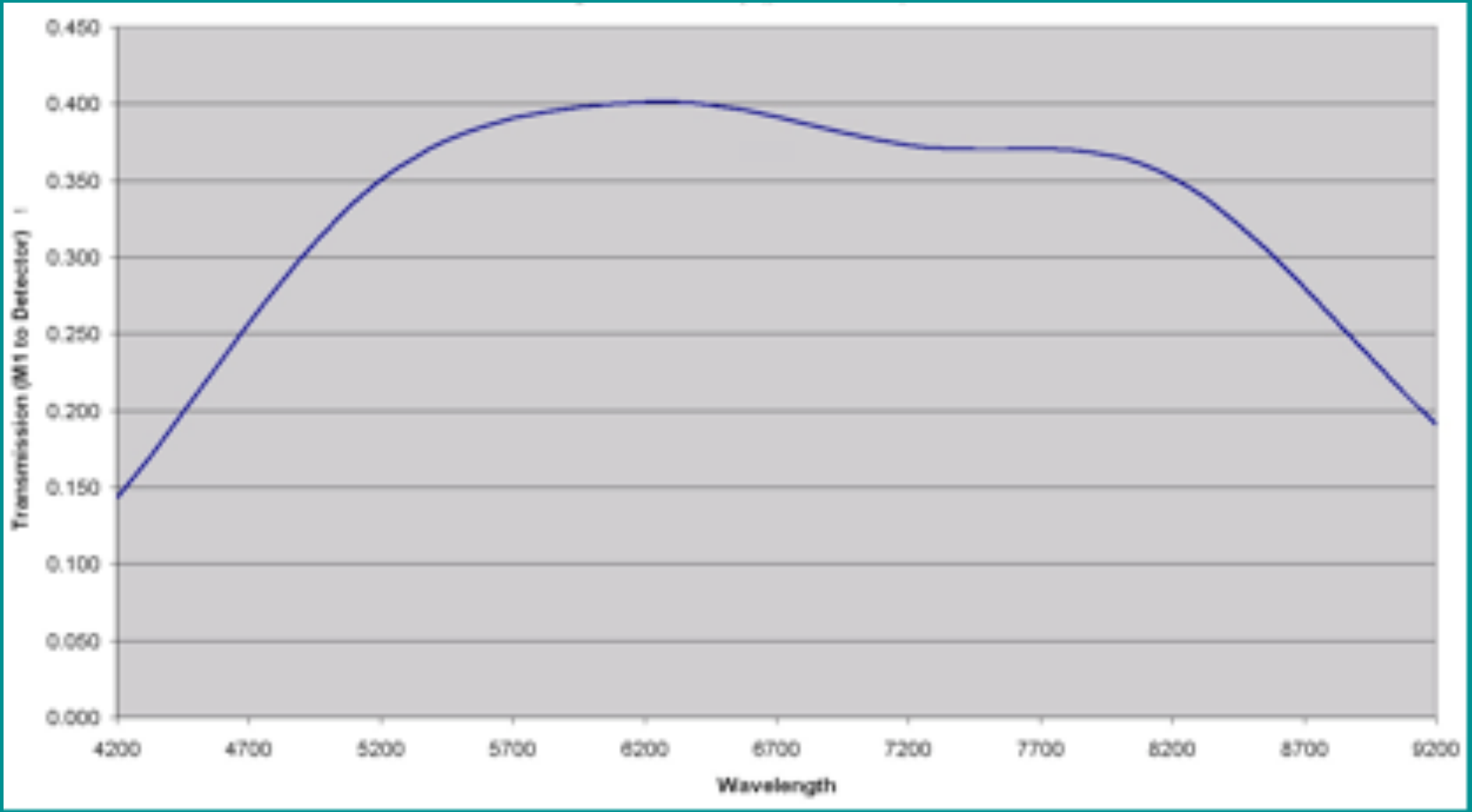
XMS Optical Layout



Uses existing K3 triplet corrector

XMS Transmission



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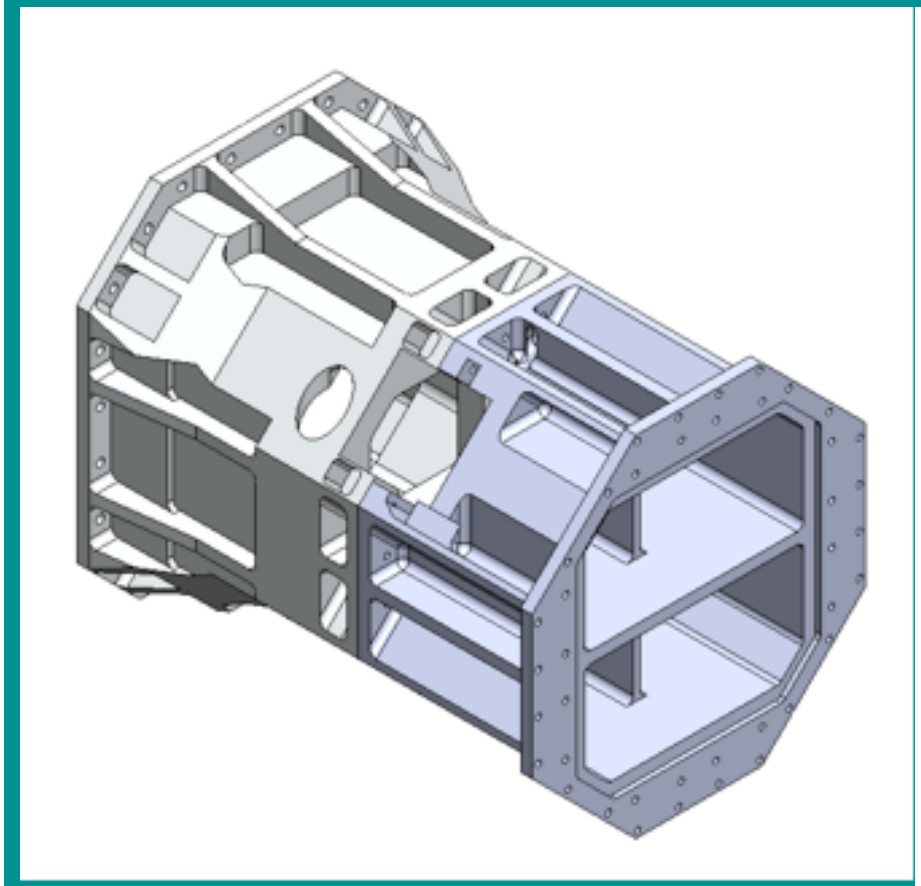
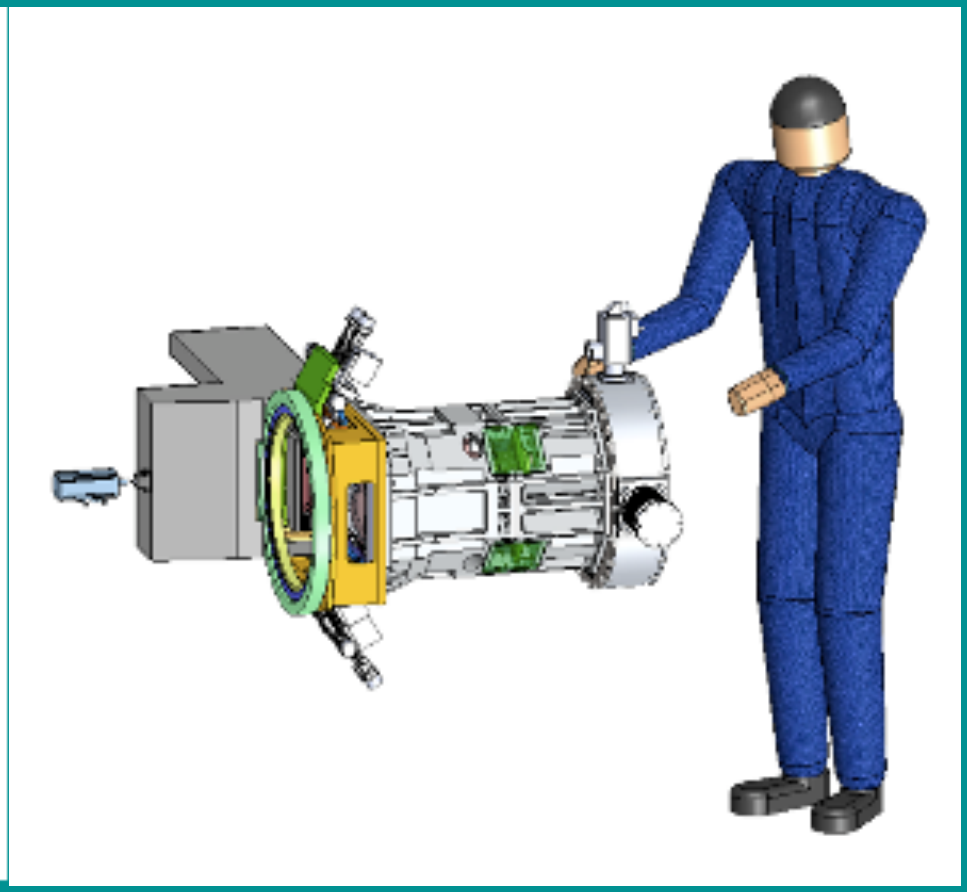
XMS Mechanical Design





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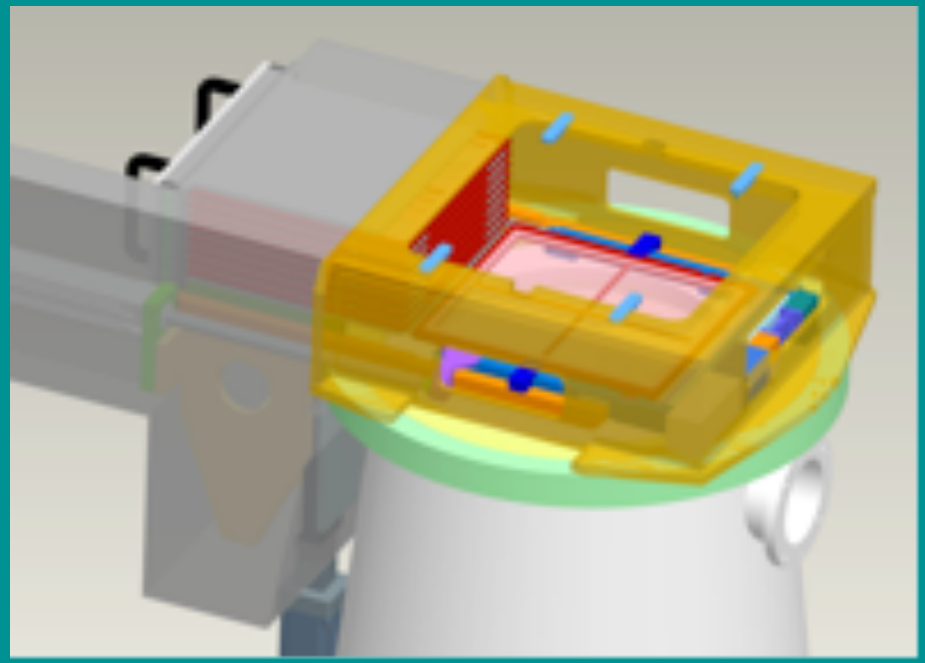
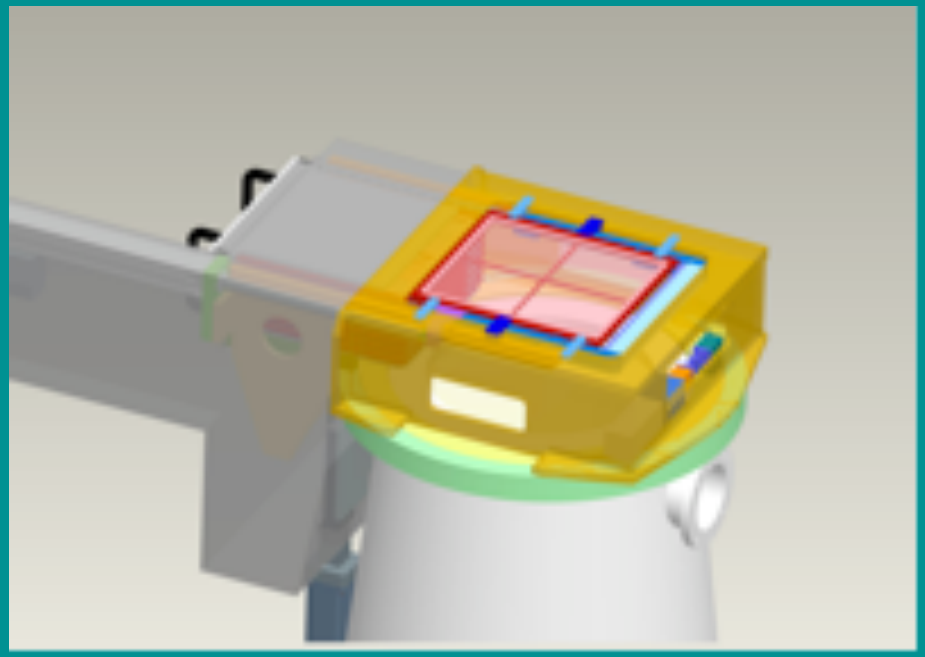
XMS Mask Exchanger





- Ceramic masks
- Laser cut slits
- Integral acquisition & guiding features

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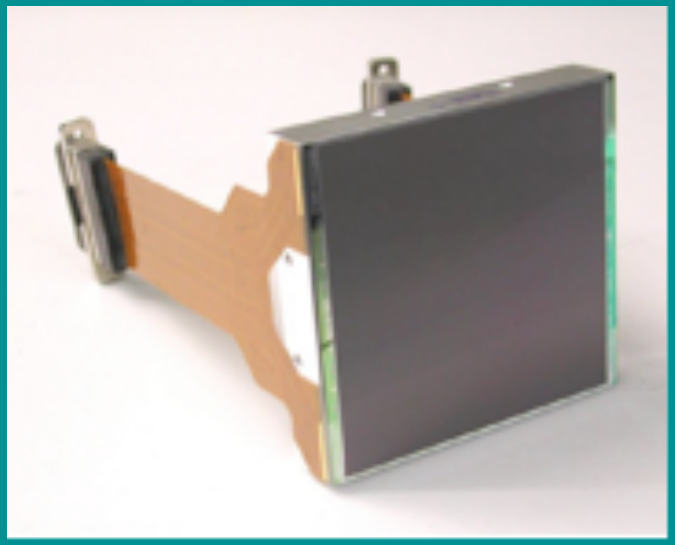
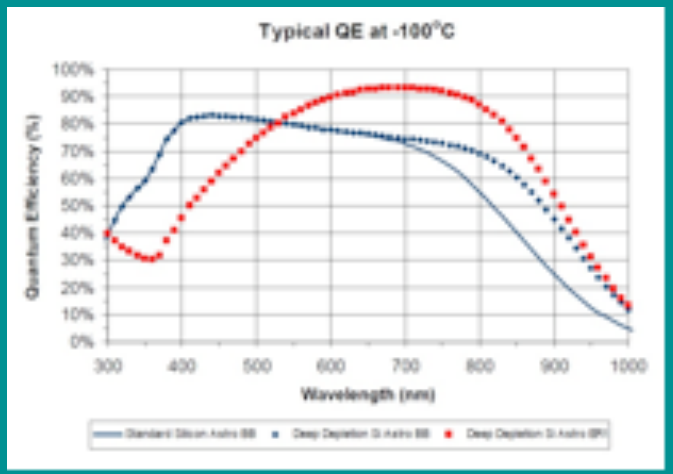
XMS Detectors





- Back Illuminated, NIMO
- Four outputs
- 4096 x 4096 15micron pixels
- 2 e^- Read noise at 50kHz
- 5 e^- Read noise at 1MHz
- 3 e^-/pixel/hour dark at -100−C
- 350,000 e^- Full well
- Requires cryo cooling

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XMS Exposure Times

- i<22 galaxy emission line z from OII 3727Å at S/N>6 in 1hr exposure in ~2´´ seeing
- i<21 galaxy absorption line z at continuum S/N>4 in 1hr exposure in ~2´´ seeing
- r<25 z~3 Lyman break galaxies in 4x3hr exposures in ~1´´ seeing
- Exposure times scaled from VIMOS and AAOmega actual observations and confirmed with MOSCA

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250 night survey concept

- ~4000 galaxy redshifts per hour
- Include ~3000 z~0.7, 21<i<22 OII emission galaxies
- Include ~1000 z~0.5, i<21 absn+em galaxies
- 200 nights → ~4 million z~0.7 galaxies and ~1 million z~0.5 galaxies
- →Total of ~5 million z<1 galaxies over 1600deg^2
- In best seeing (~1″) observe z~3 r<25 LBGs taking 4x3hrs to get ~4000 redshifts
- In 50 nights also get 100,000 z~3 LBGs in 25deg^2

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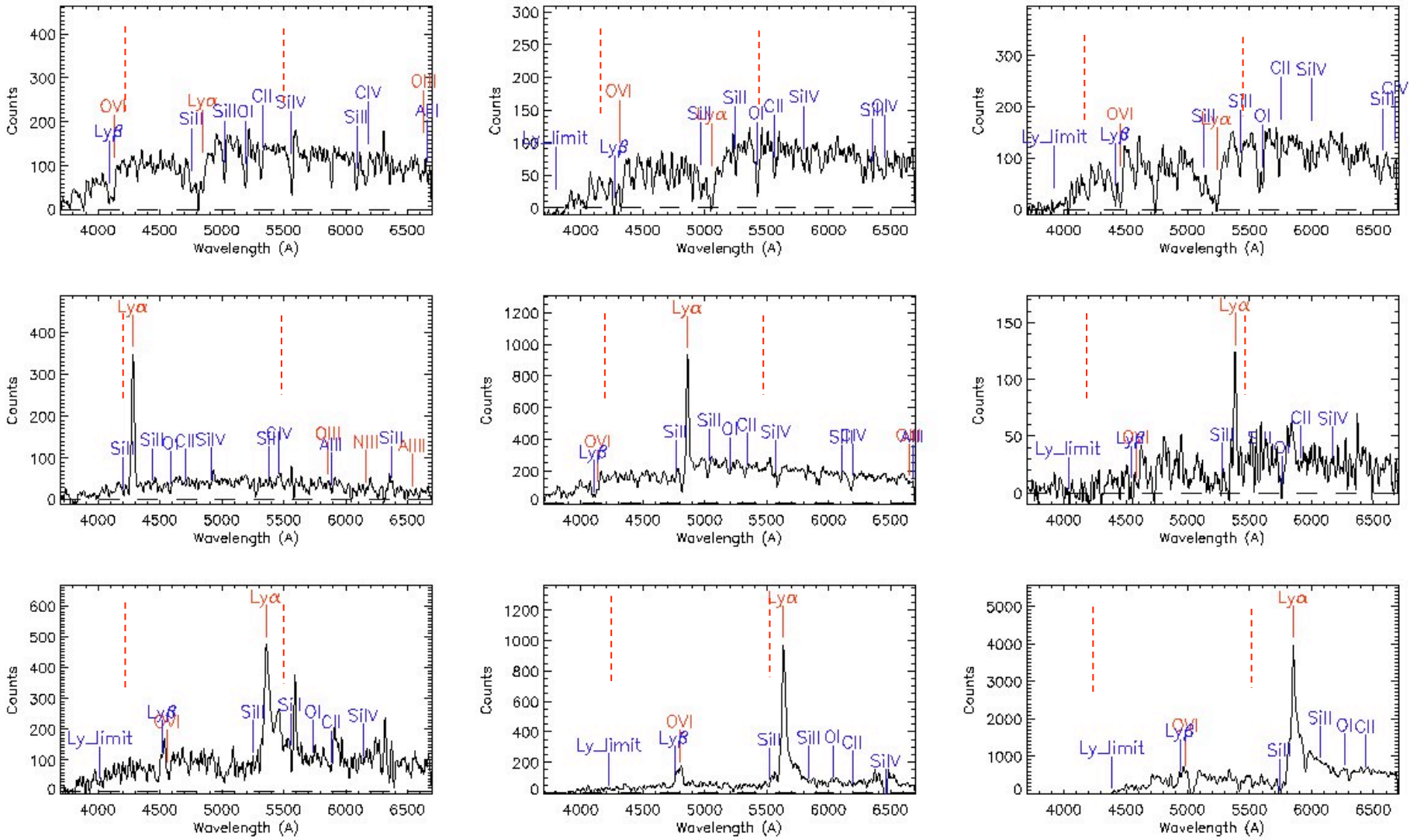
2.5<z<3.5 VLT LBGs



3hr VLT exposure → 4x3hr XMS exposure in ~1´´ seeing

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Conclusions

- XMS offers order of magnitude improvement in MOS multiplex over previous spectrographs (400→4000)
- New generation spectroscopic follow-up to match new generation imaging surveys
- Fully exploits the ~16x bigger field of 4-m class telescopes

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