FIREBall-2:

The Faint Intergalactic-medium Redshifted Emission Balloon

A UV multi-object spectrograph for detecting the low-z circumgalactic medium

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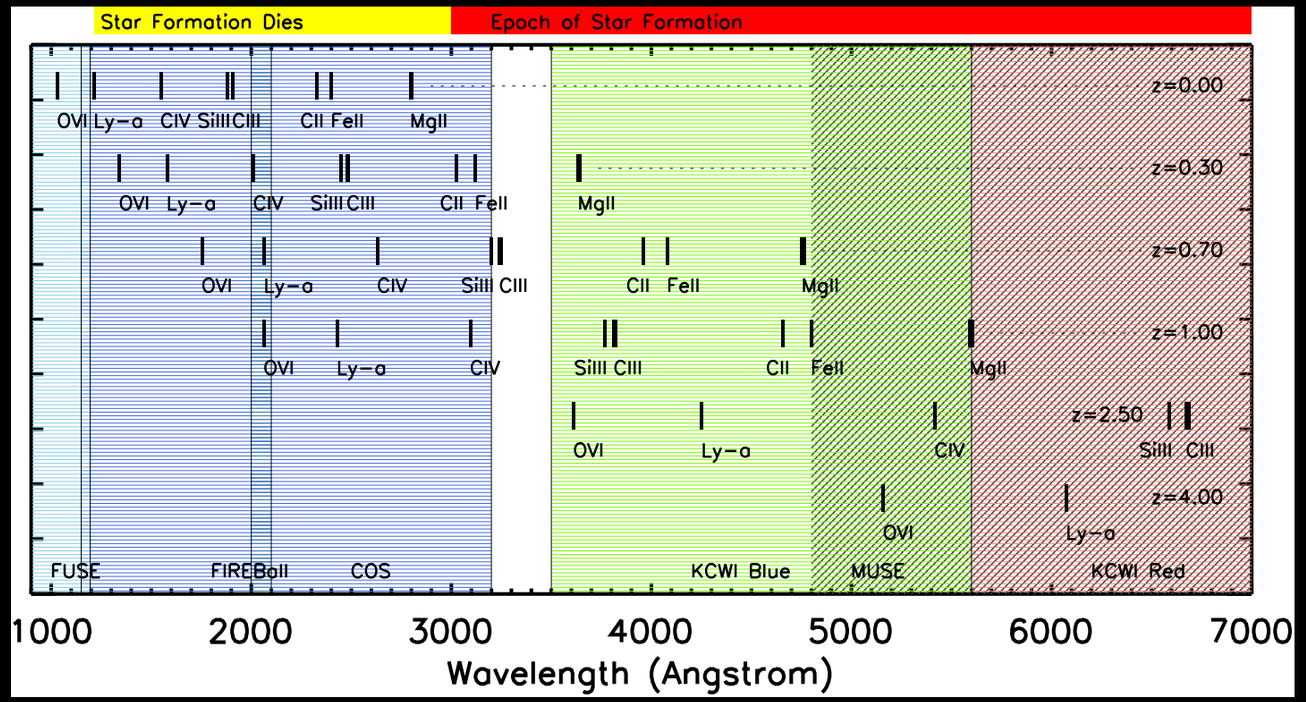
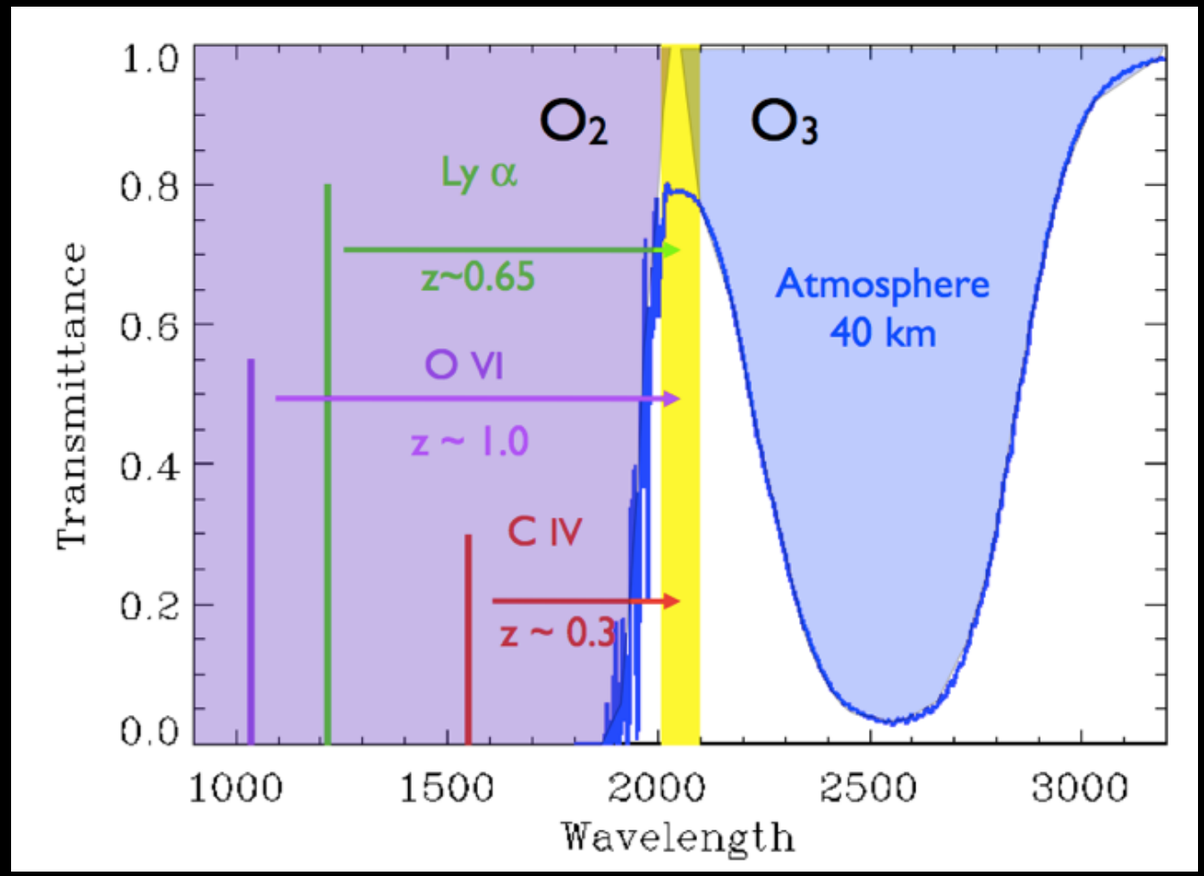
cnes

BALLOON UV WINDOW





FIREBall-2 Target Emission lines

FIREBALL-1: RECAP

Goals

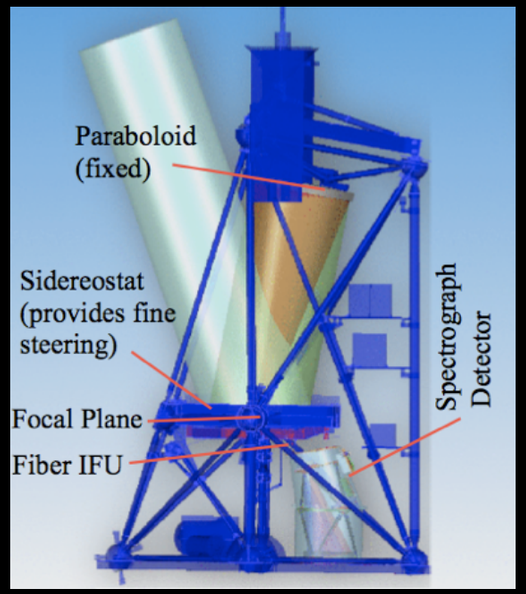
(1) Discover & map Circum-galactic medium to explore IGM-galaxy co-evolution

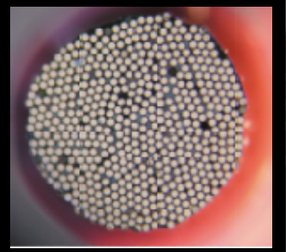
(2) Pathfind UV integral field spectroscopy

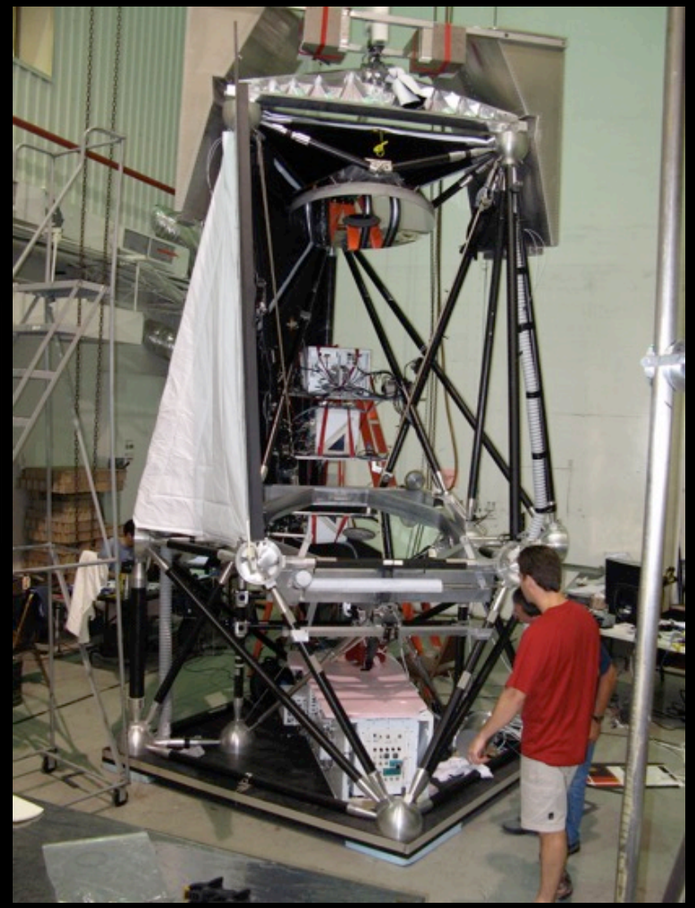
(3) Pathfind next generation high performance UV detectors

Design

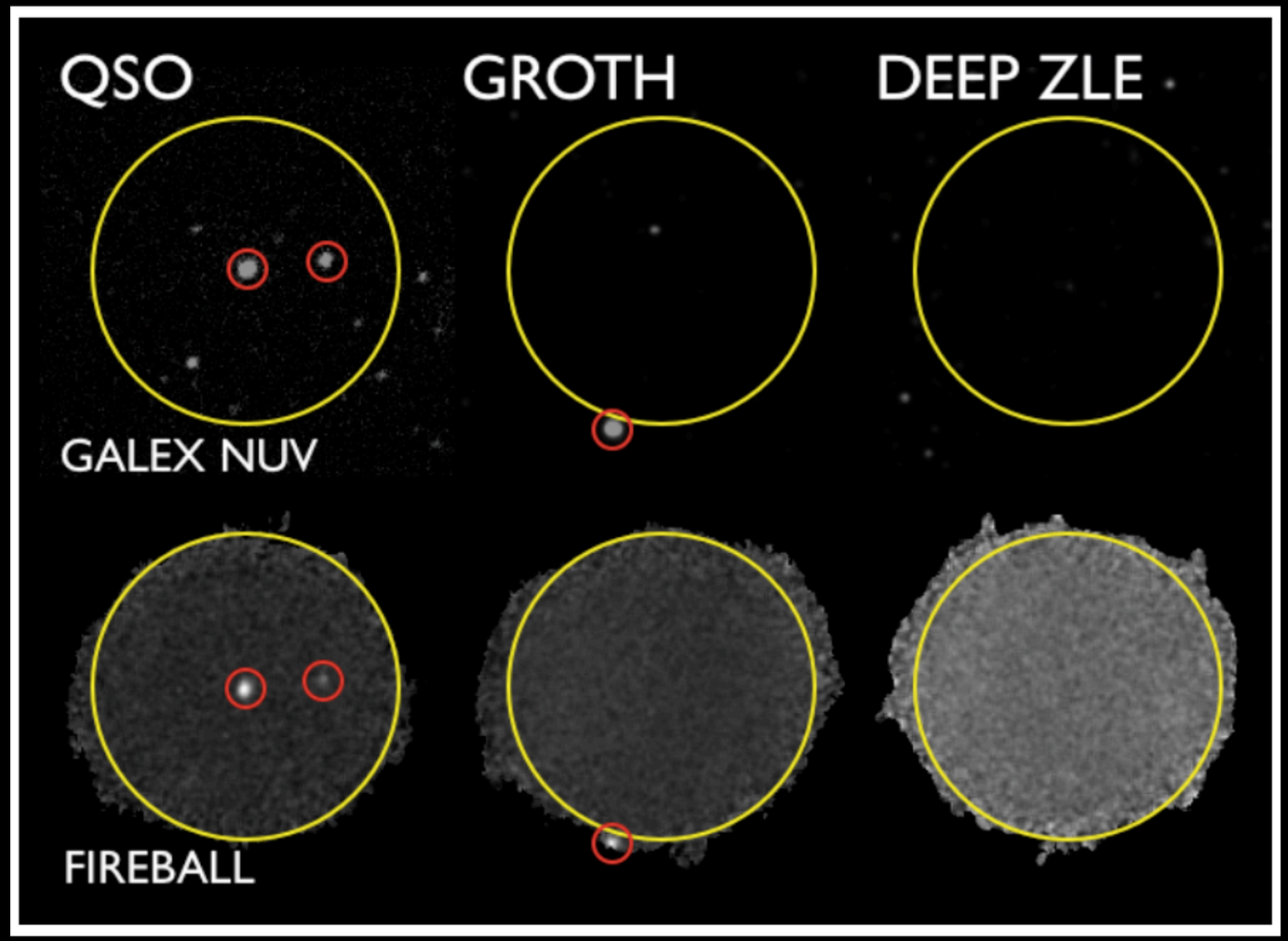
- ✓ 1 meter f/2.5 paraboloid+sidereostat
- ✓ CNES gondola & pointing system
- ✓ Fine guidance with ~3 arcsec pointing
- ✓ Fiber IFU (300 8” fibers, 3 arcmin field of view)
- ✓ High resolution R~5000 Offner spectrometer
- ✓ Bandpass balloon UV window: 2000-2200Å
- ✓ Gen-1 detector: GALEX NUV spare
- ✓ 1st flight 7/07, 2nd flight 5/09 (1st science flight)
- ✓ FIREBALL-2: UV photon counting CCD





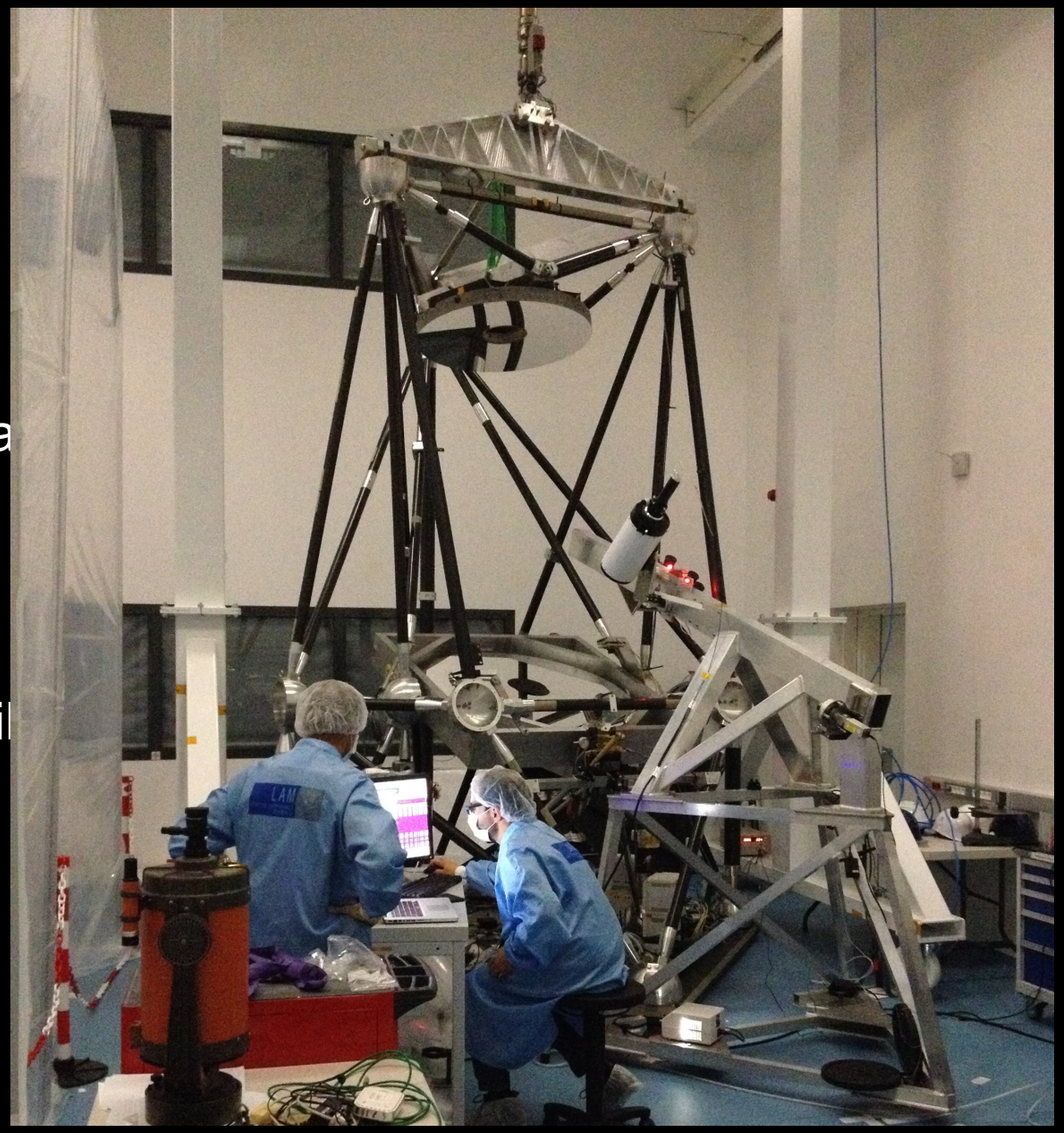


FIREBALL-1 RESULTS



FIREBALL-2 OBJECTIVES

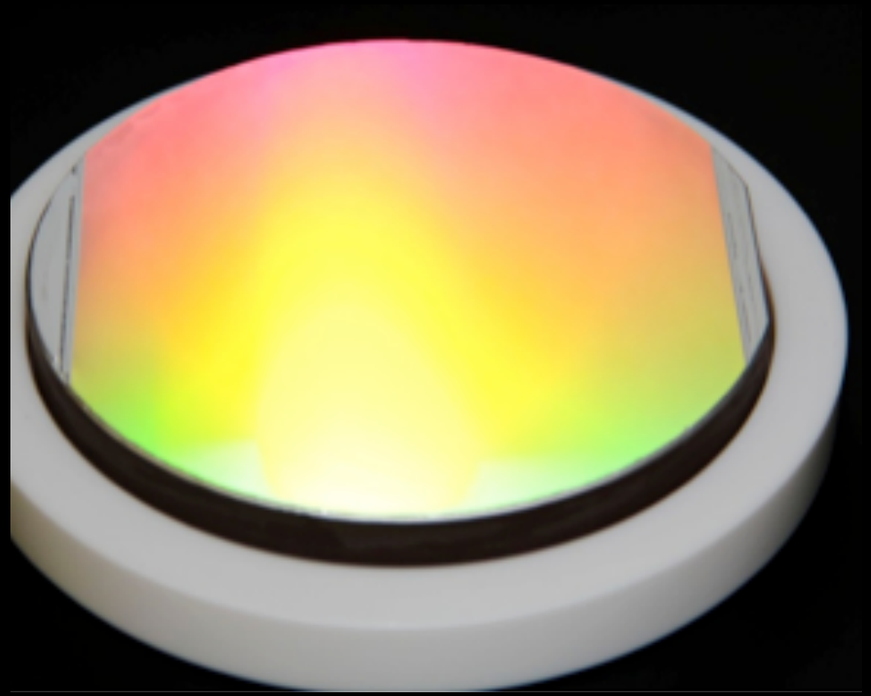
- *AMBITIOUS SCIENCE*
  - Mapping emission lines from the faint IGM/CGM
  - Targeted, higher efficiency, better angular resolution tha FB-1
- *ULTRAVIOLET TECHNOLOGY TEST-BED*
  - High QE, Low noise, UV detector technology
  - Efficient grating, reflective UV multilayer coatings and fi
  - Multi-Object Spectroscopy
- *FUTURE INSTRUMENT BUILDERS*
  - Three U.S. Ph.D.'s on FIREBall-1
  - Six U.S. graduate students on FIREBall-2



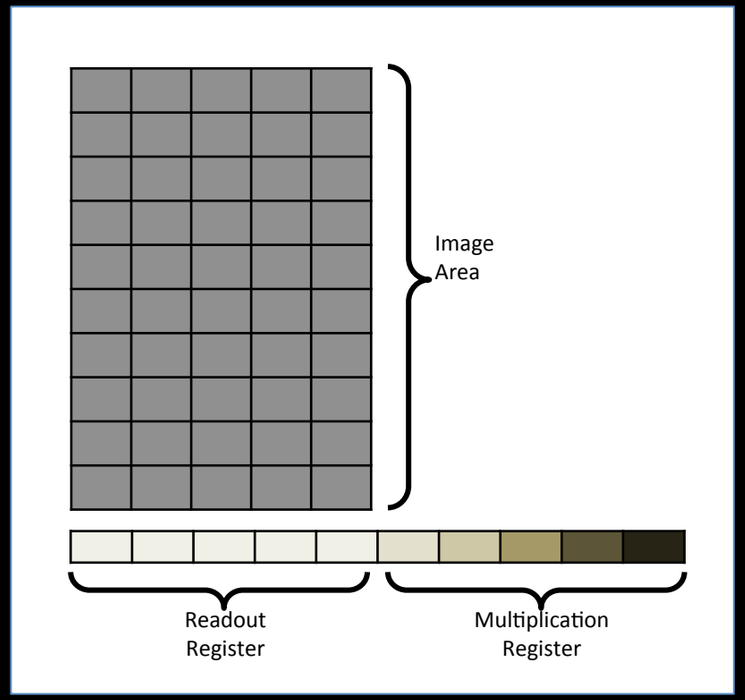
FIREBALL-1 VS. FIREBALL-2

	FB-1	FB-2	GAIN
DETECTOR QE	0.05	0.70	14
NET EFFICIENCY	0.001	0.03	30
SLIT WIDTH	8″	4″	(2)
FIELD OF REGARD	8 SQ. ARCMIN	900 SQ. ARCMIN	110
BANDPASS	150A [0.12]	75A [0.06]	0.5
FIGURE OF MERIT	1	1500	1500
CGM REGIONS	1	50/FIELD	50
SELECTION	BLIND	PRESELECTED	
SENSITIVITY	74000 LU	1400 LU	(53)
SENSITIVITY	8200 LU	200 LU	(40)

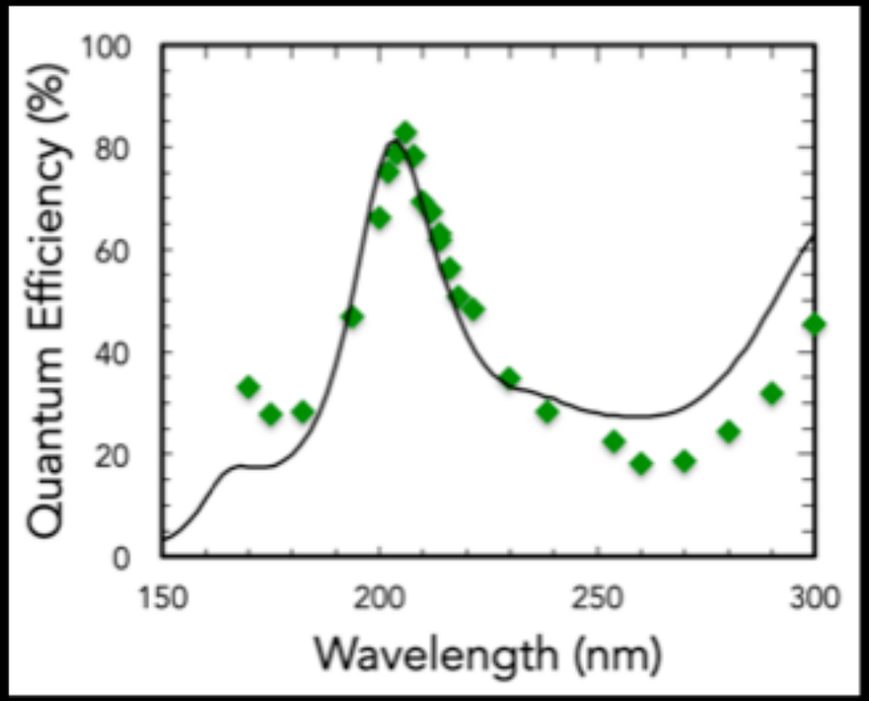
FIREBALL-2 TECHNOLOGY INNOVATIONS



Curved grating acts
as Schmidt Corrector

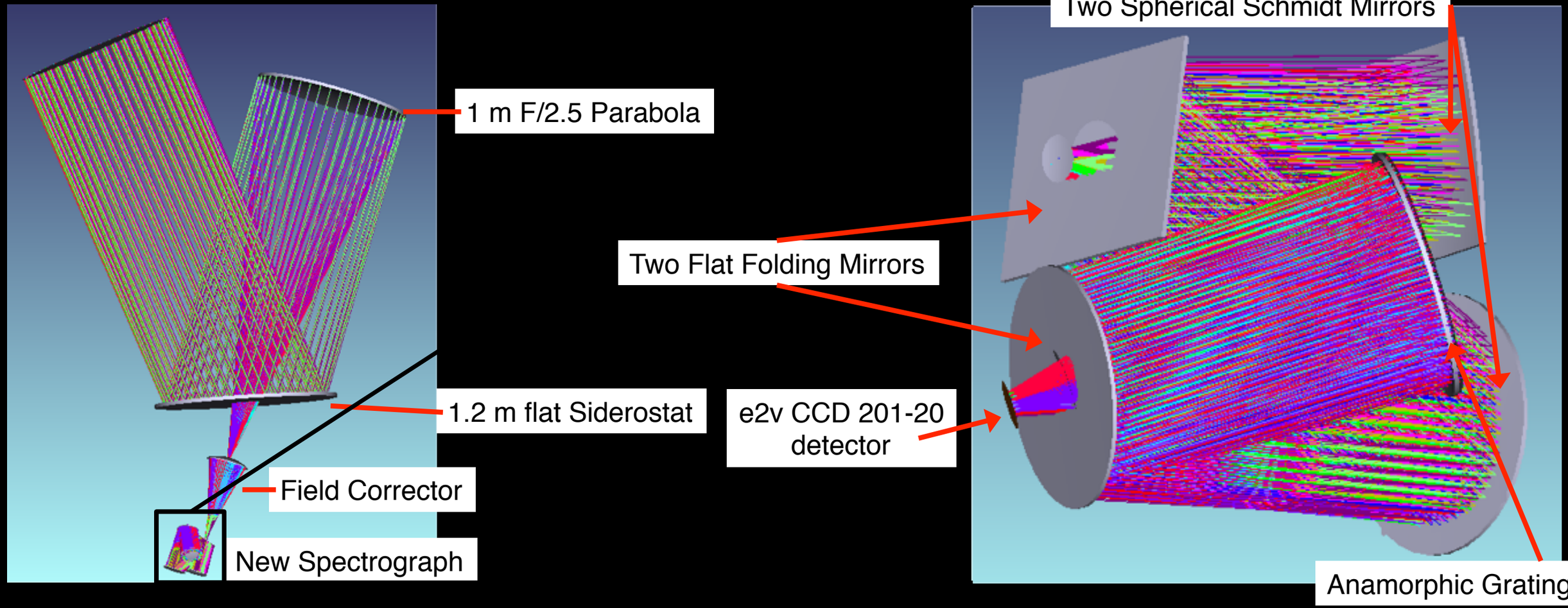


Electron Multiplying CCD
(EMCCD) for low noise



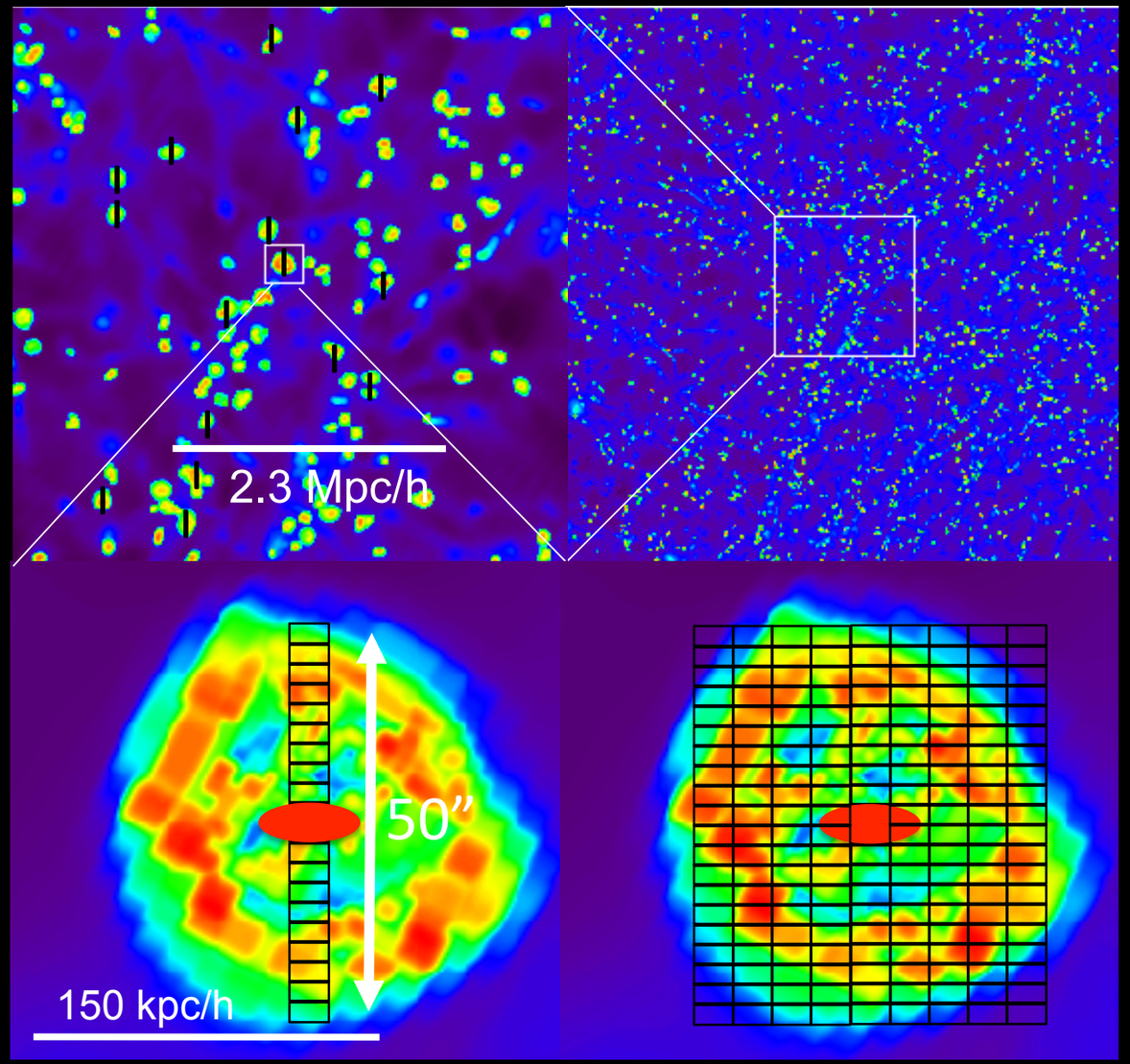
High UV quantum efficiency CCD
detector

FIREBALL-2 UPGRADES: SPECTROGRAPH

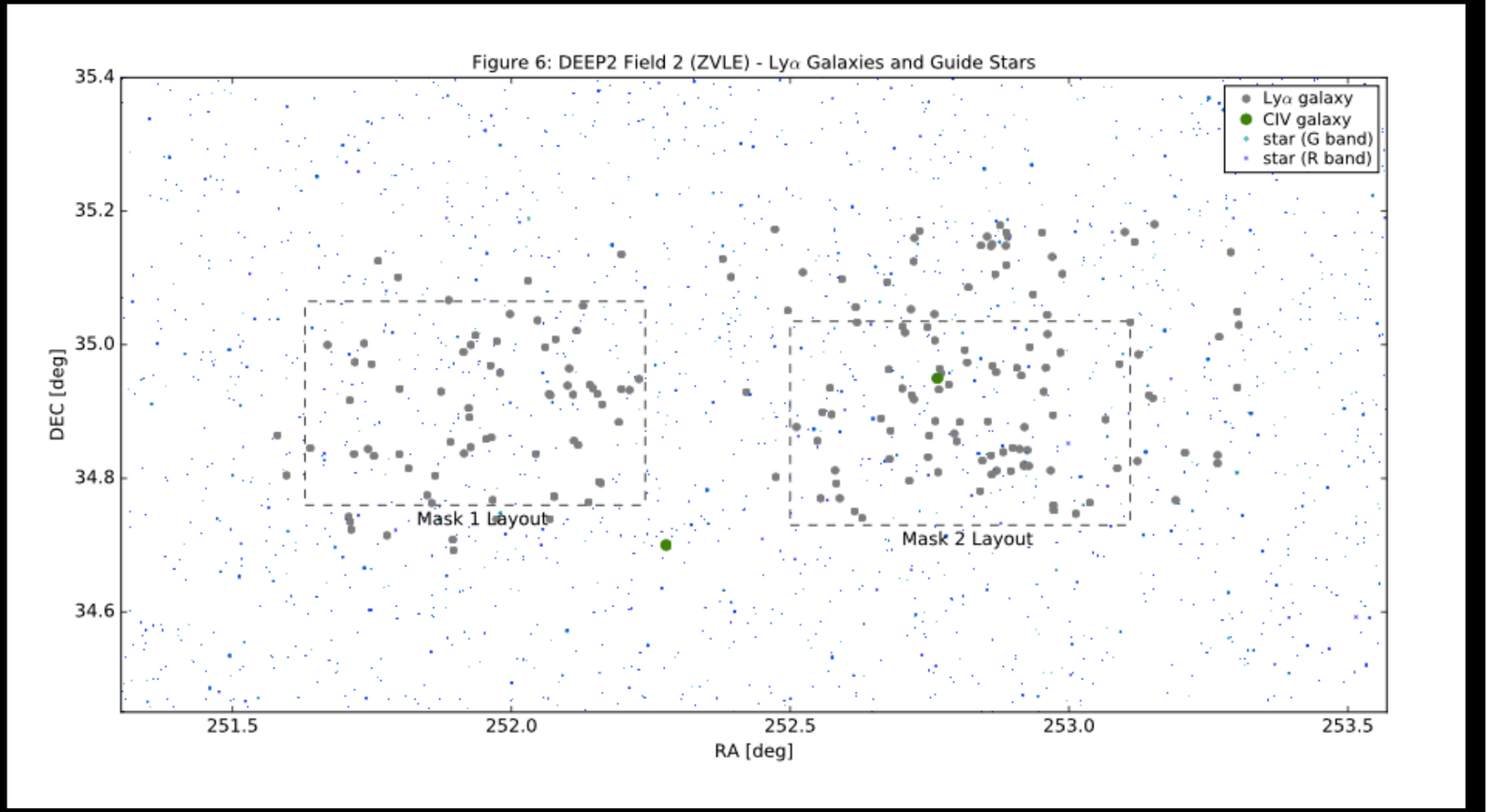


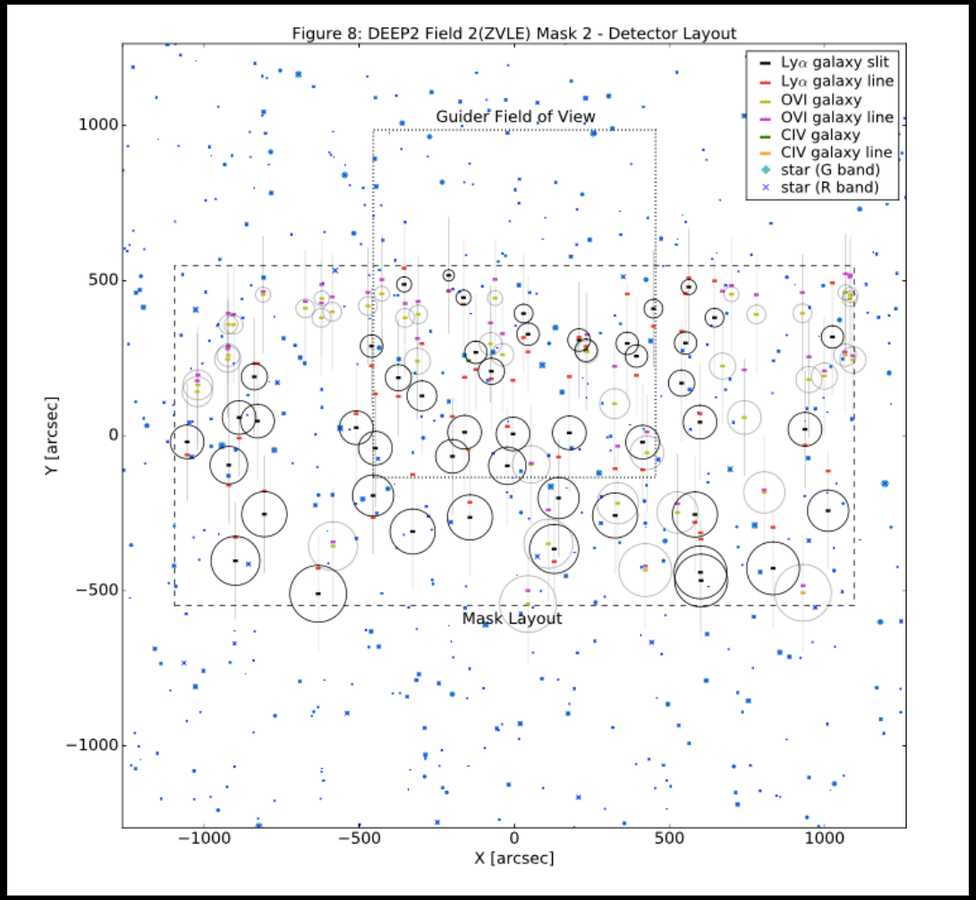
Observing Strategies

-Focus on dense fields to take full advantage of large FOV and multiplexing capabilities
-Single slit or scanning mode
-Will observe at least one QSO field



Possible Targets

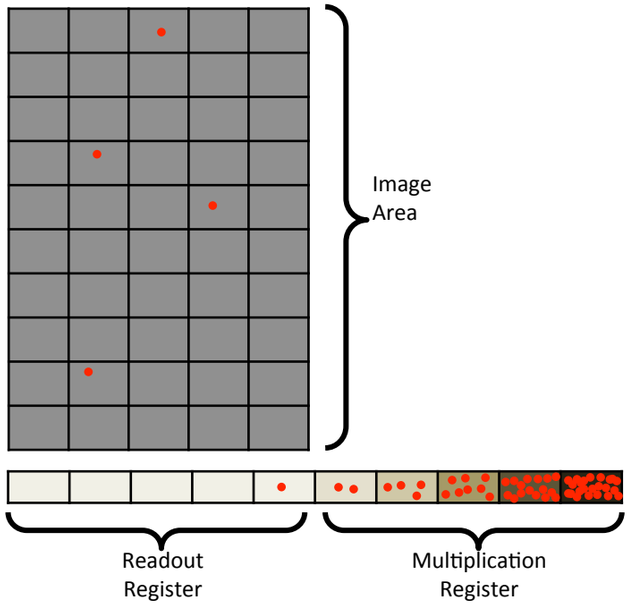


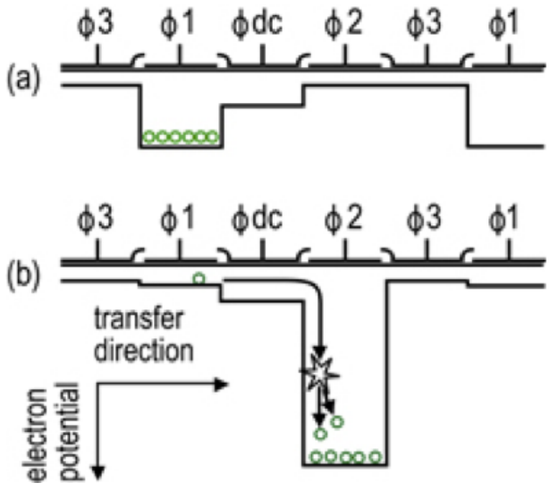


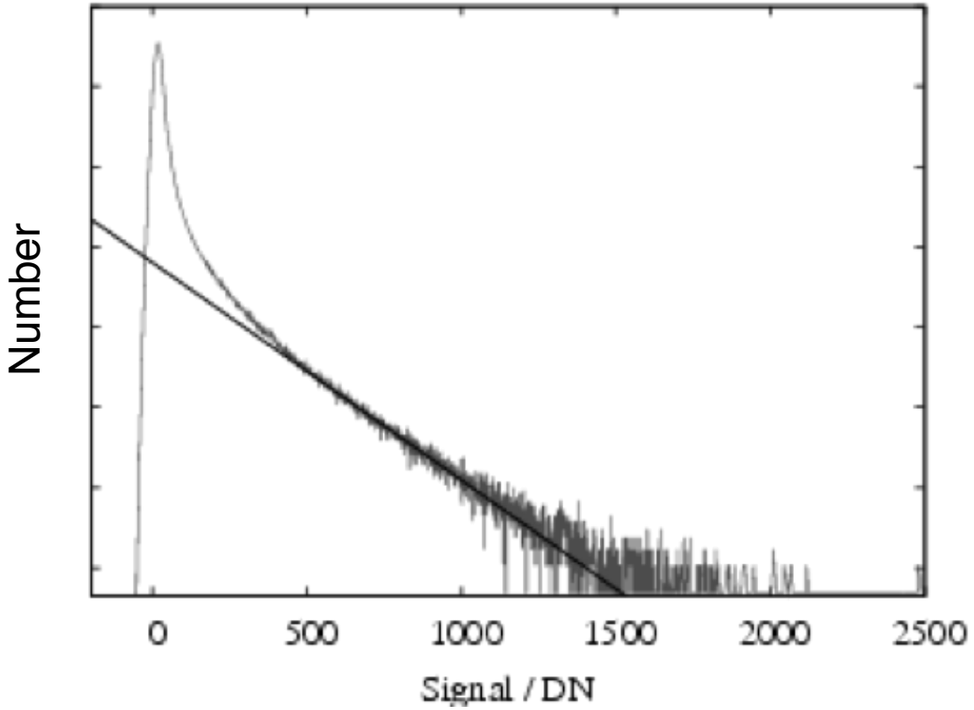
FIREBALL-2 UPGRADES: DETECTOR

	CHANGE FROM FB-1
DETECTOR	DELTA-DOPED, AR-COATED E2V CCD201-20 REPLACES MCP
CONTROLLER	NUVU CONTROLLER REPLACES GALEX SPARE FRONT END ELECTRONICS
CRYOCOOLER	SUNPOWER COOLER
SHUTTER	TWO SHUTTERS TO ENSURE LOW LIGHT EXPOSURE ON DETECTOR

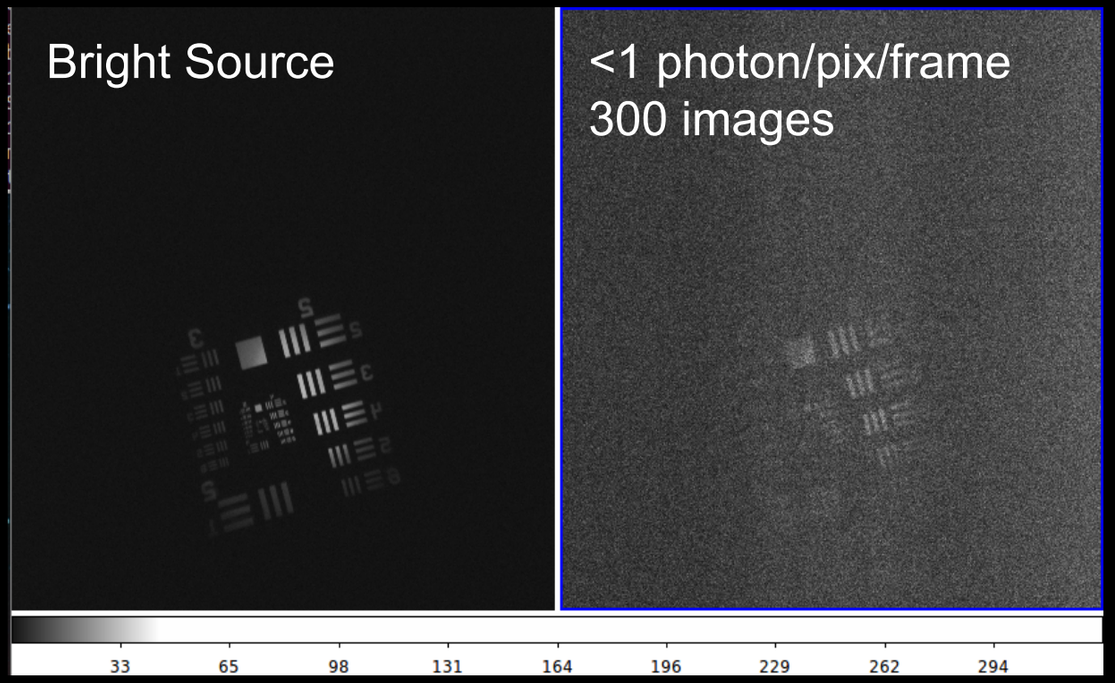
FIREBALL-2 UPGRADES: EMCCD DETECTOR



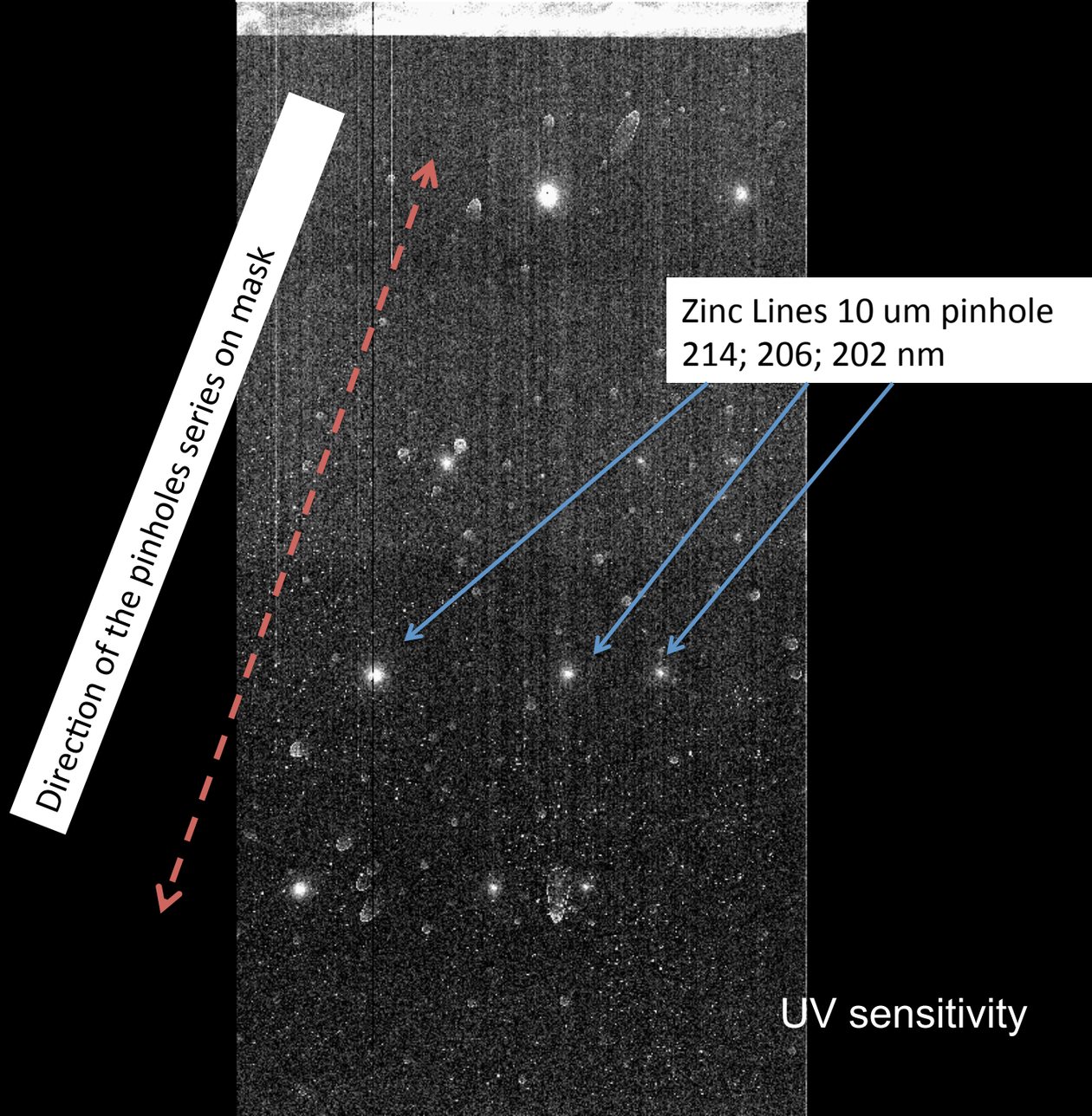




FIREBALL-2 UPGRADES: DETECTOR

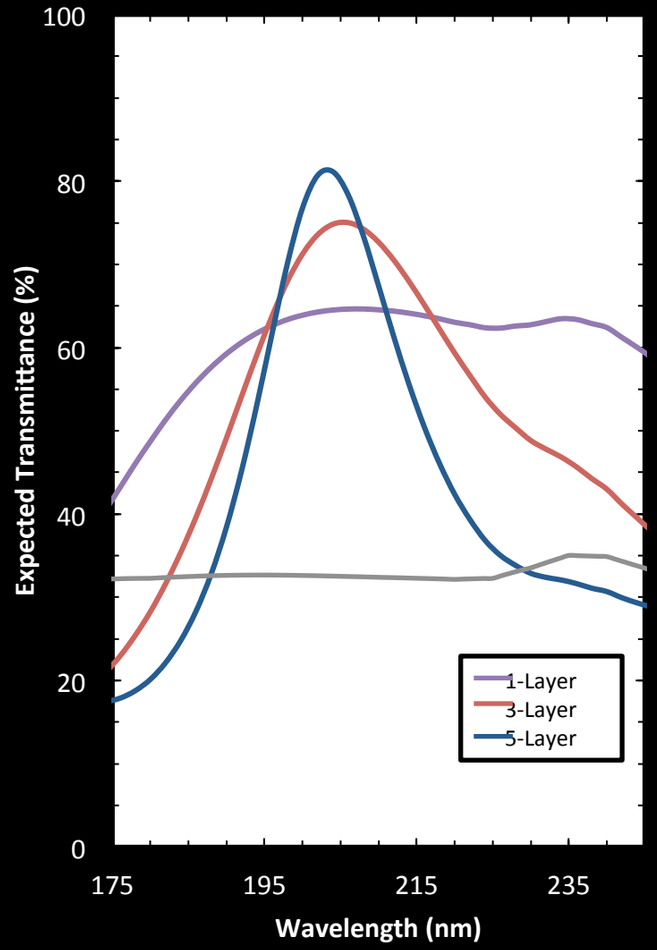


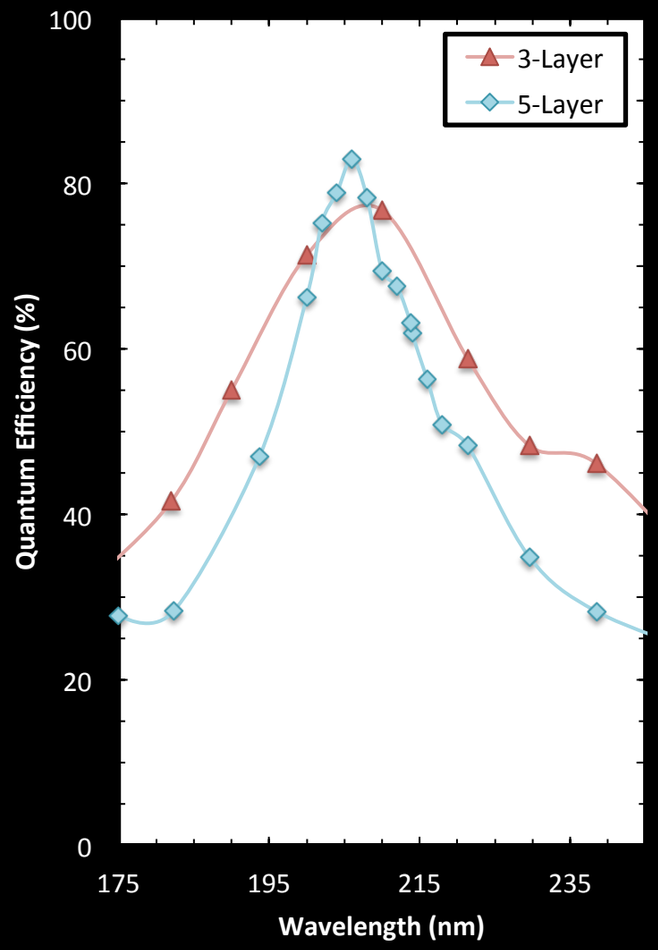
Photon Counting

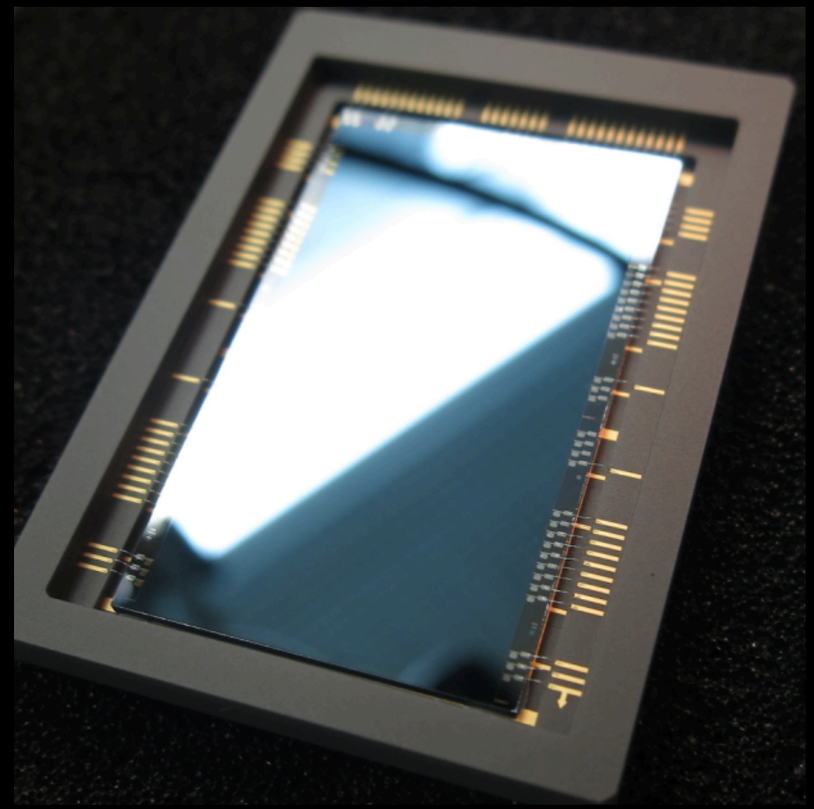


UV sensitivity

FIREBALL-2 UPGRADES: DETECTOR







Measured QE for a device that has been thinned, delta-doped, and has a custom AR coating for the FIREBall-2 bandpass.

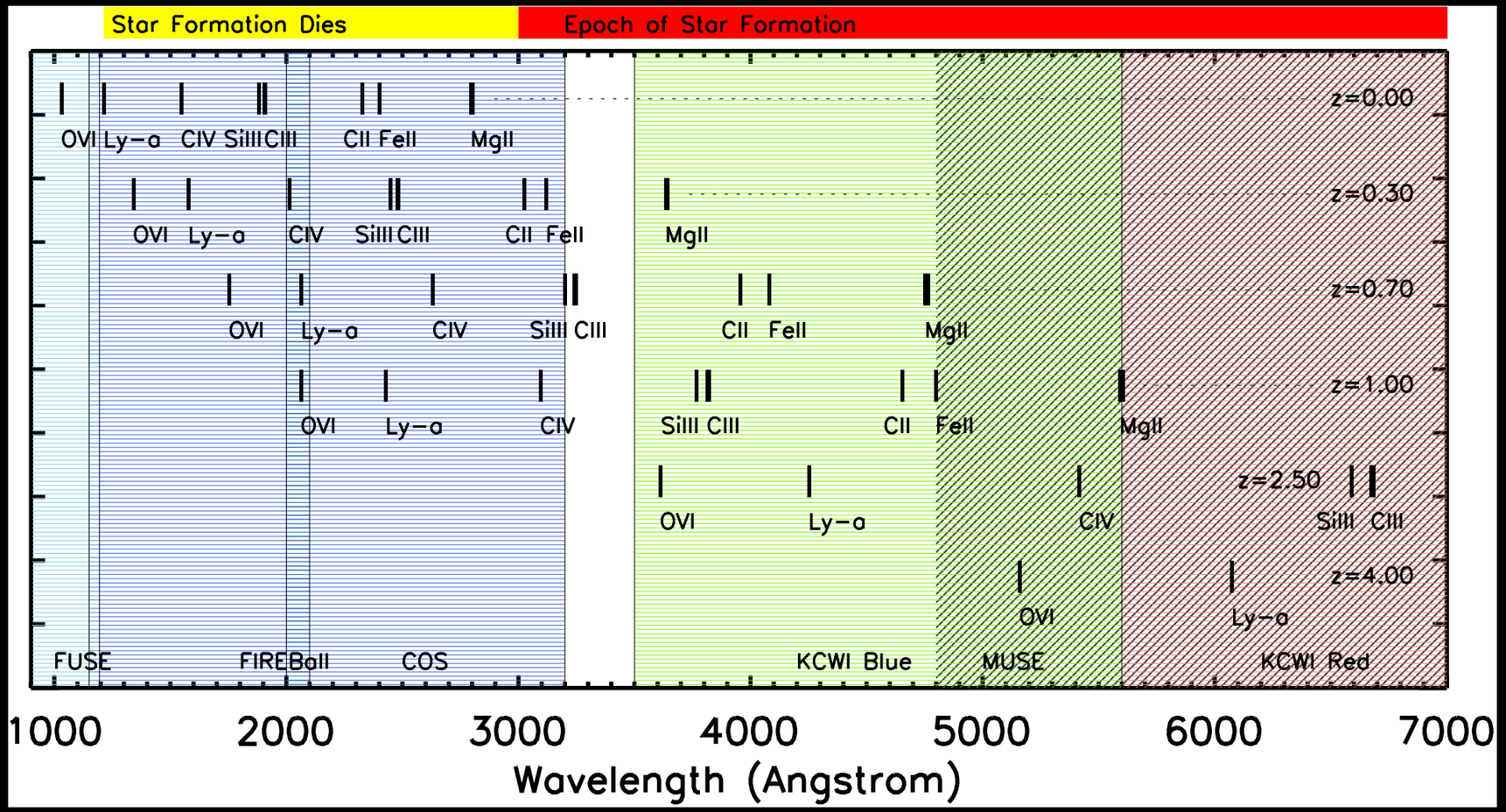
FIREBALL-2 OVERALL PERFORMANCE

Requirement	Expected Performance	Within Requirement?
Detector QE	>50%	✓
Detector Noise (CIC, dark current)	<0.001 event/pix/ frame for each	Contingent on clocking scheme/exposure time
FOV, Angular resolution	11’ x 35’, 4” resolution	✓
Spectral Resolution	R~2150, Δλ~1Å	✓
Pointing Stability	3 arcsec	✓
Spectral Range	2000-2080 Å	✓
Overall Throughput	>5%	Re-coating optics to correct damage

FIREBALL-2 SCHEDULE:

June 2016: 4-axis closed loop guidance, initial functional testing complete
Sept 2016: Full functional testing with guidance. Hanging sky tests
Jan 2017: Install re-coated optics and re-align instrument.
May 2017: Ship integrated gondola to US for field integration/ops
September 2017: Flight from Ft. Sumner!
Fall 2017: Exciting data published!
Future: Satellite!!

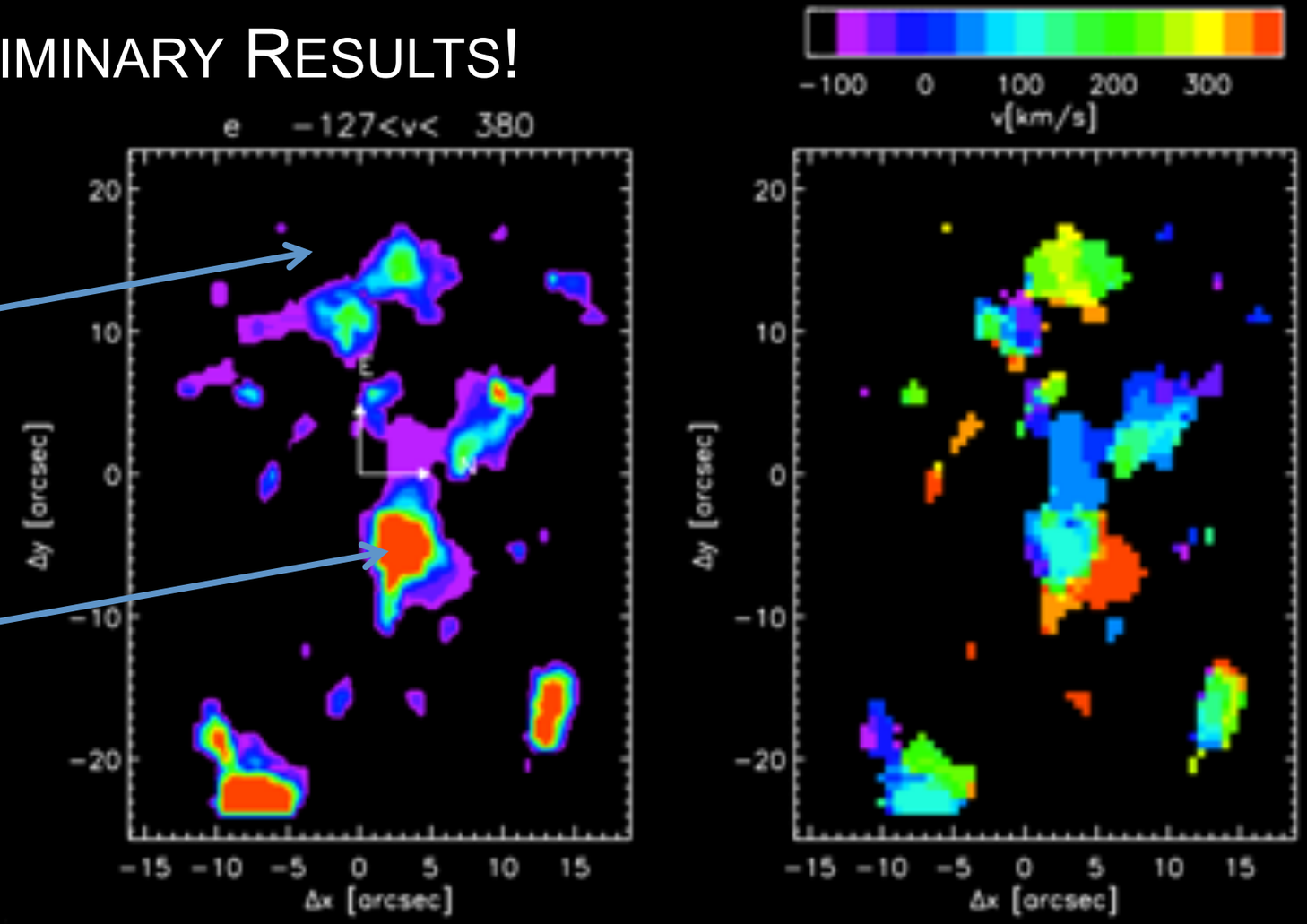
In Instrumentation, as in life, one must have a plan B



VERY PRELIMINARY RESULTS!

Extended
MgII emission

Galaxy



MgII emission from z=0.69 star forming galaxy taken with CWI. Hamden & Martin, in prep

Thanks & Questions?