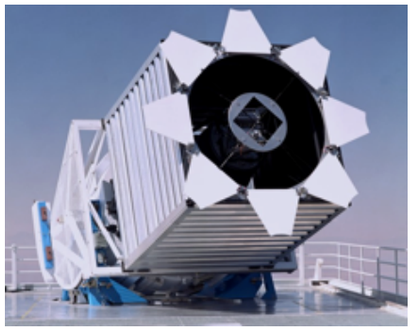
Data Management and Processing for SDSS-III and SDSS-IV

Adam S. Bolton
University of Utah

ING -- 2013-11-05

SDSS-IV: Massive Astronomical Survey Spectroscopy 2014-2020

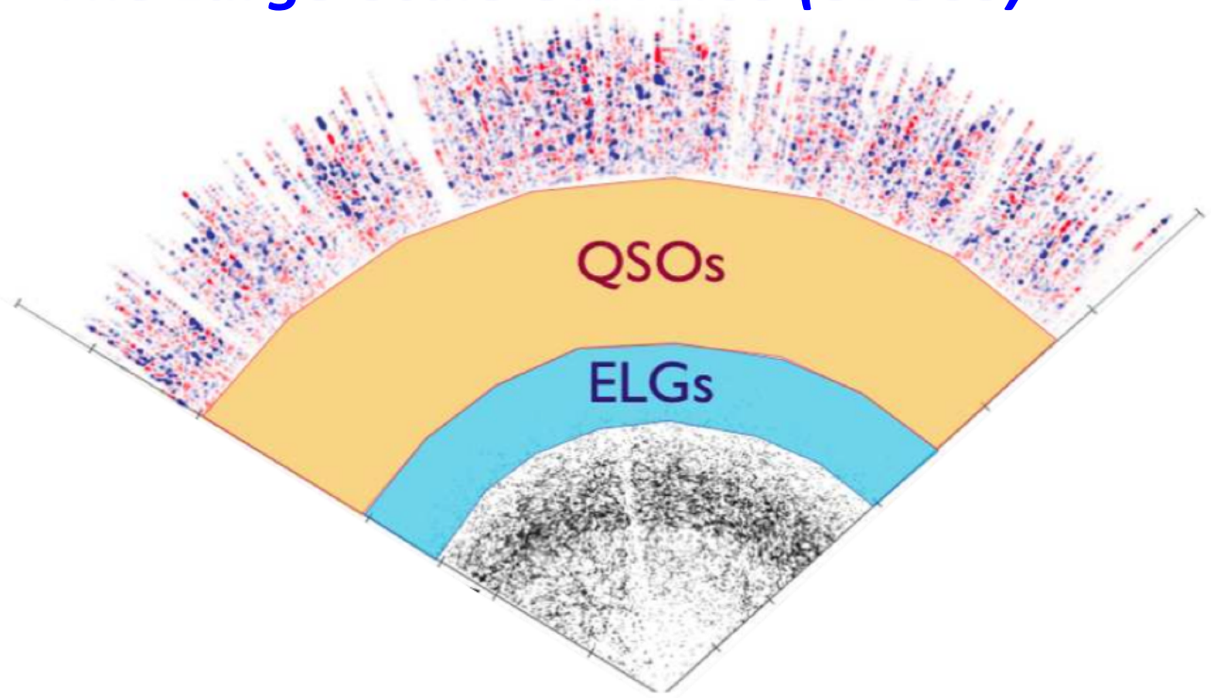
Collaboration forming now!



2.5-meter Sloan Digital Sky Survey Telescope (Apache Point, NM)

2.5-meter duPont Telescope (Las Campanas, Chile)

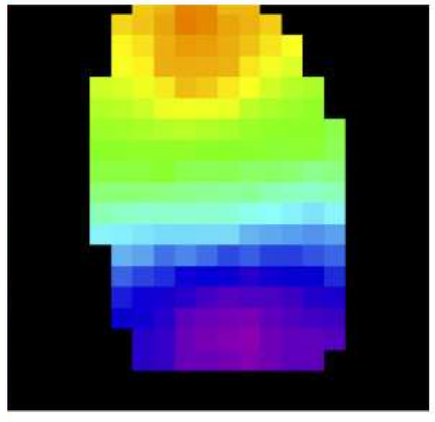
The Large-Scale Universe (eBOSS)

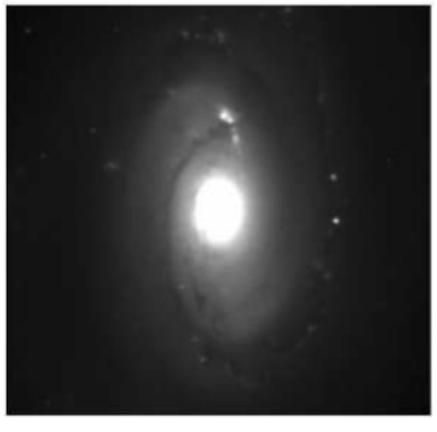


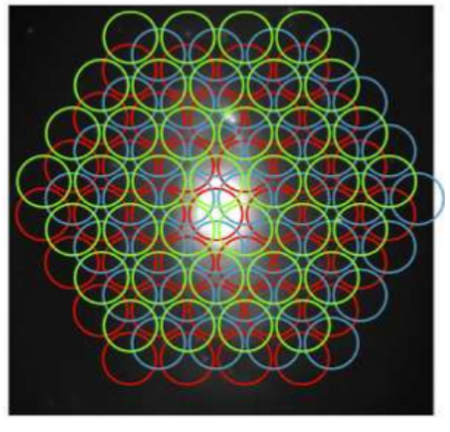
Mapping galaxies & quasars and measuring dark energy

The Local Universe (MaNGA)

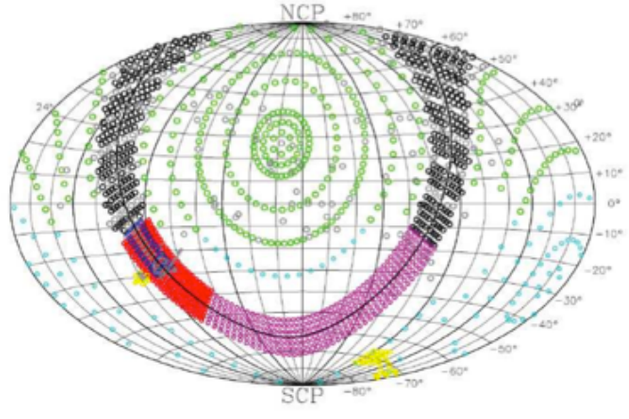
Discovering the architecture of nearby galaxies

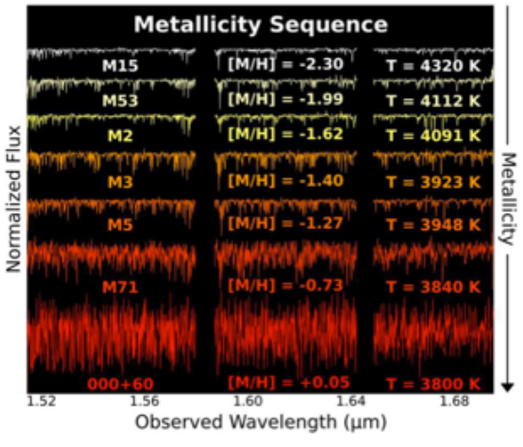






Our Galaxy (APOGEE)





Dynamical structure and chemical archaeology of the Milky Way

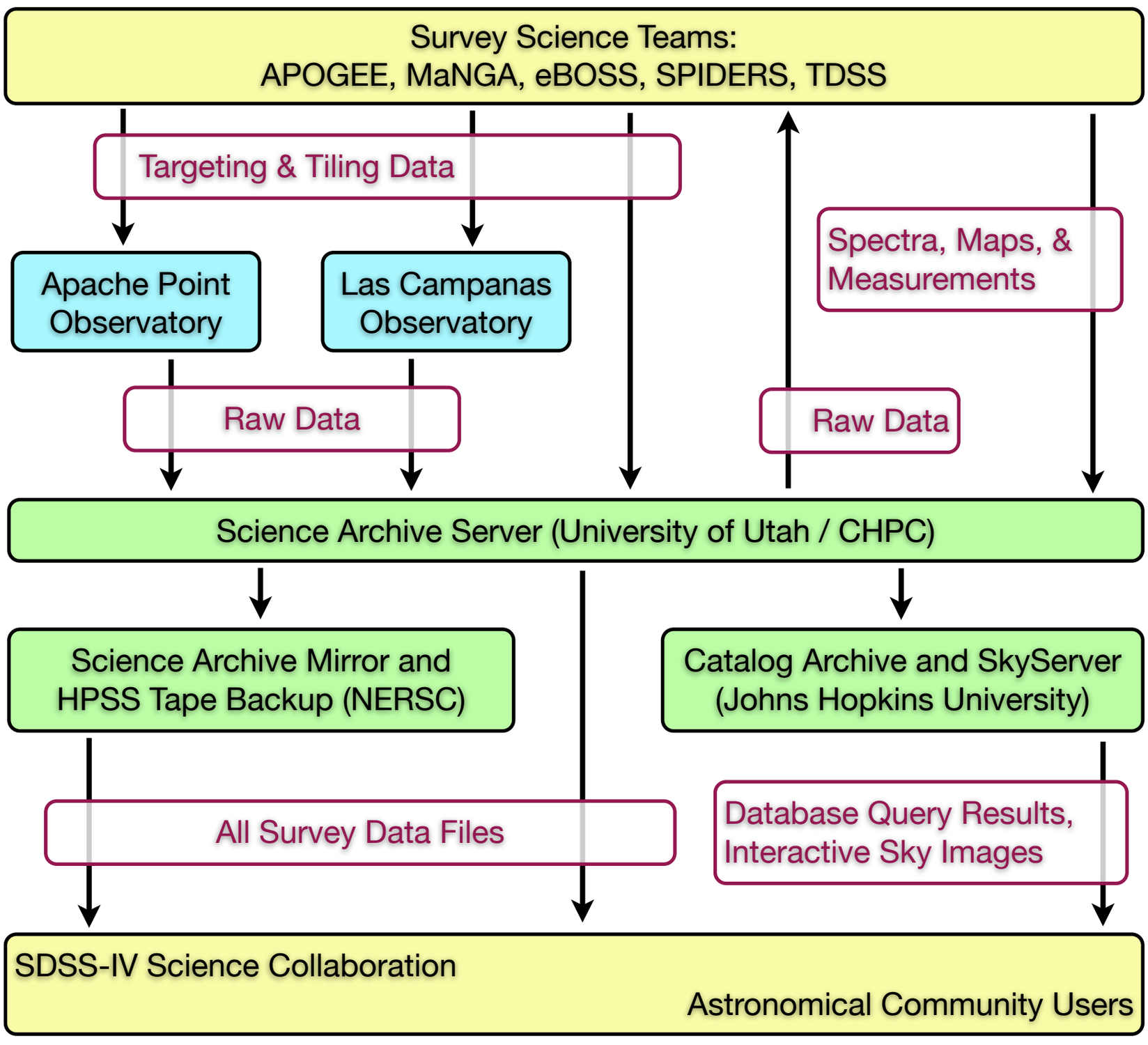
SDSS-IV Data Management Mission

- Ensure correct distribution, documentation, and archiving of all raw and reduced survey data products
- Support development, operations, & version control of software for core survey data reduction & analysis
- Determine and coordinate major project IT needs
- Facilitate electronic collaboration and communication within the project
- Integrate data flows with core survey operations
- Reconcile data-related needs of multiple project stakeholders
- Create & execute plans for public data release and long-term archiving

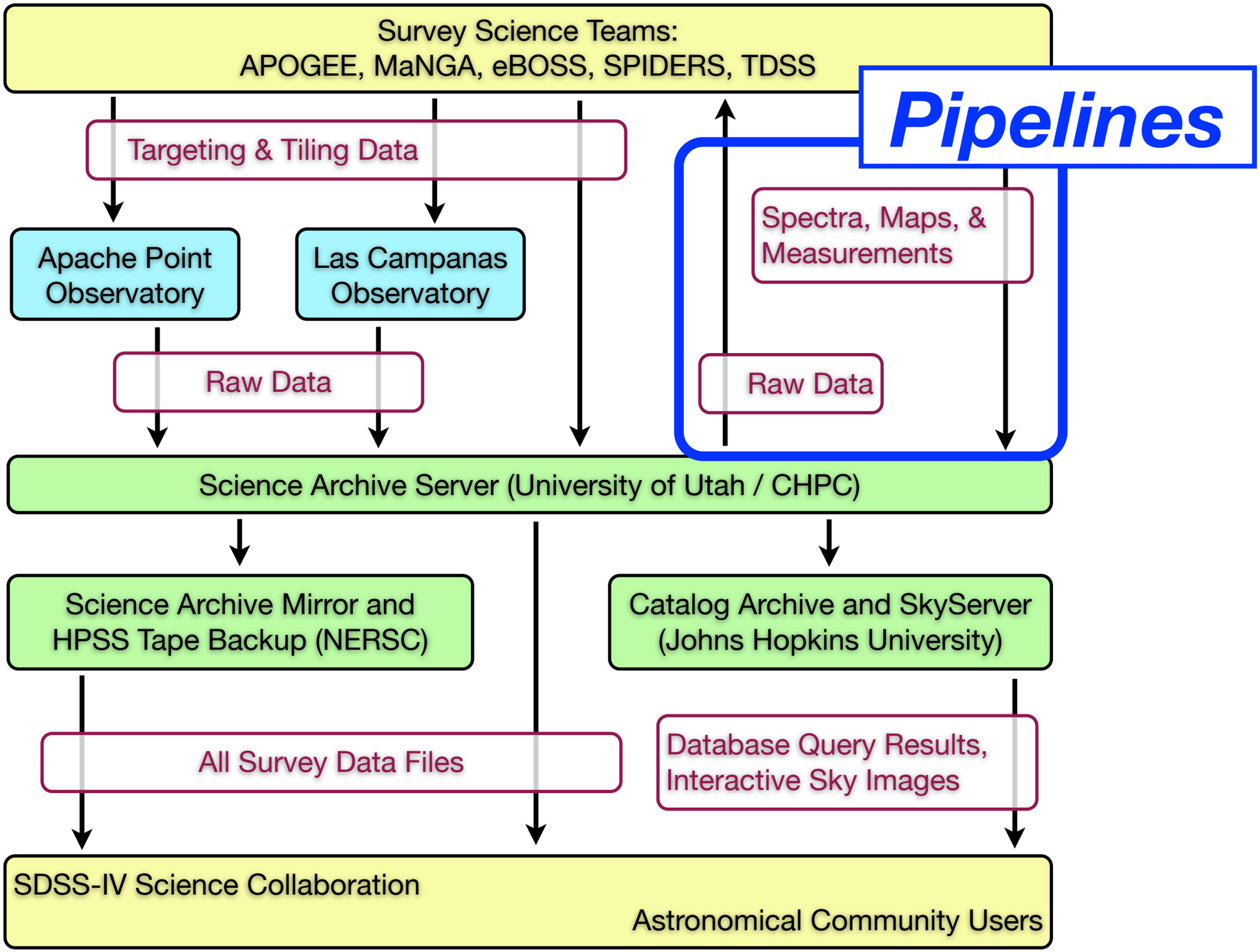
Core SDSS-III data management systems

- Science Archive Server (SAS)
  - Central online repository of raw & reduced SDSS data
  - Support for data transfers by http, rsync, bbcp, Globus
- Science Archive Mirror (SAM)
  - Online mirror of all SAS data and metadata content
- High-Performance Storage System (HPSS) tape backup
  - Off-line long-term backup & disaster recovery
- Documentation & Collaboration Server (DCS)
  - Wiki, software repository, code browser, ticketing system, mailing lists, publication lists, project announcement system
- Catalog Archive Server (CAS) & SkyServer
  - Public-facing DB server with powerful query functionality
  - Interactive browsable sky front-end to SDSS database

SDSS-IV high-level data flow schematic



SDSS-IV high-level data flow schematic



Current SDSS-III Pipeline Model

APO

APOGEE pipeline team

APOGEE compute nodes

BOSS pipeline team

BOSS compute nodes

MARVELS pipeline team

MARVELS compute nodes

SEGUE-II pipeline team

SEGUE-II compute nodes

All Raw SDSS-III Data

Raw APOGEE data

Reduced APOGEE data

Raw BOSS data

Reduced BOSS data

Raw MARVELS data

Reduced MARVELS data

Raw SEGUE-II data

Reduced SEGUE-II data

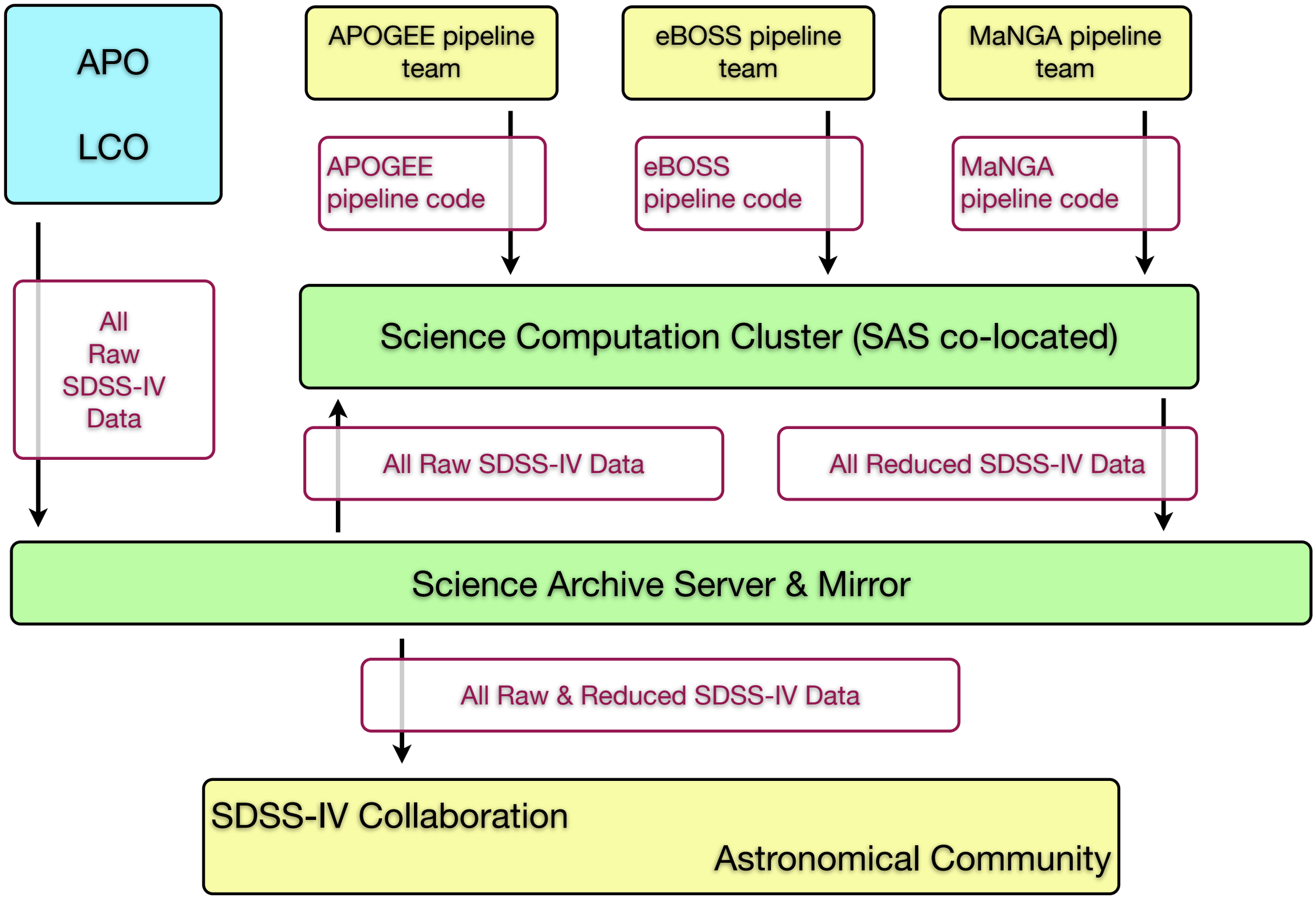
Science Archive Server & Mirror

All Raw & Reduced SDSS-III Data

SDSS-III Collaboration

Astronomical Community

Future SDSS-IV Pipeline Model

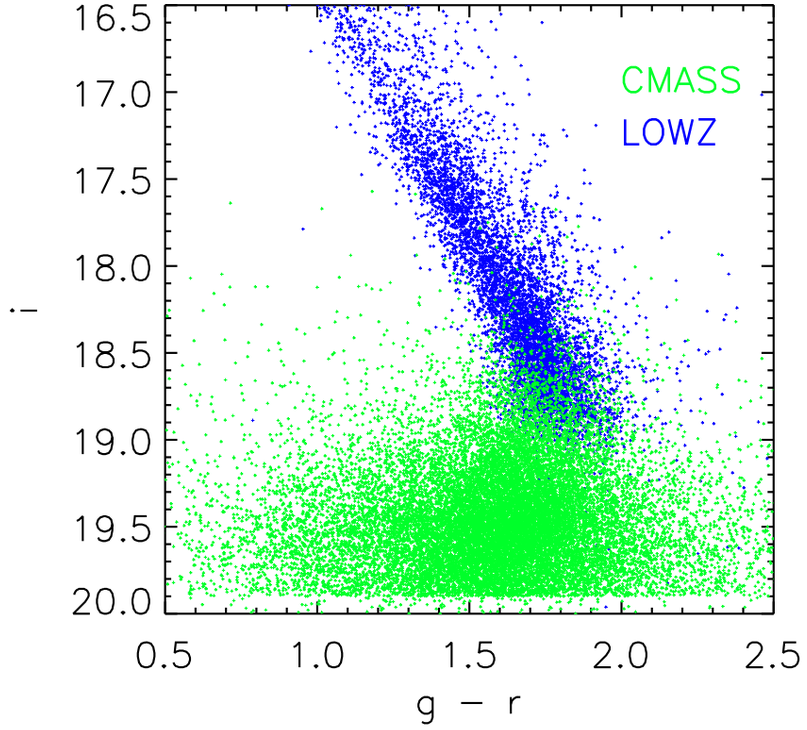


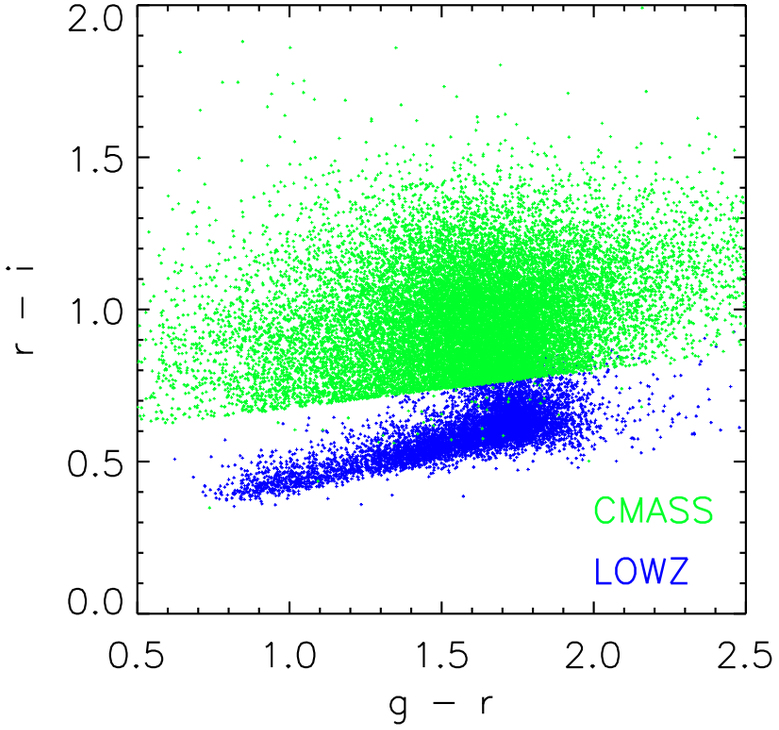
BOSS redshift survey in a nutshell

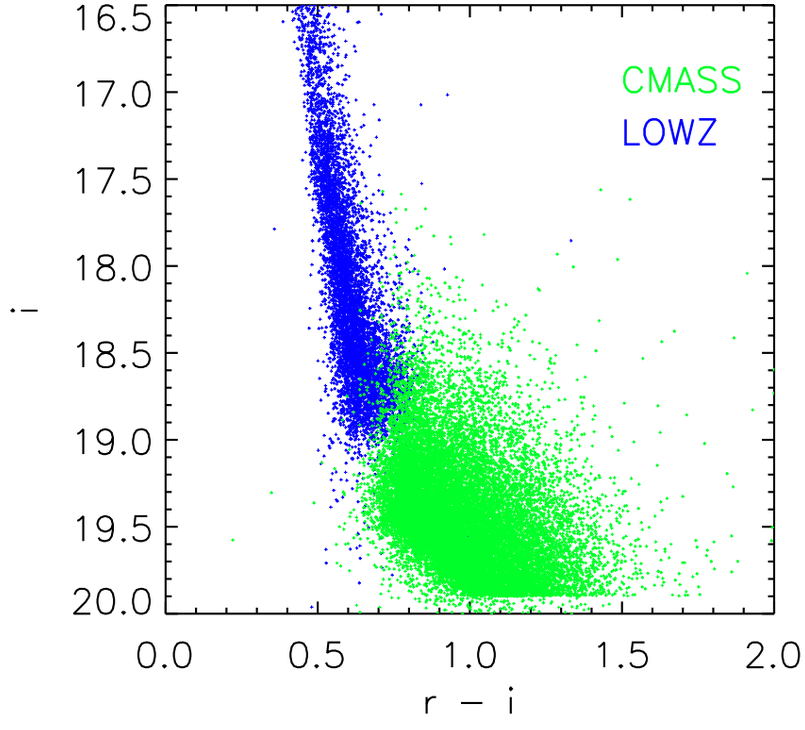
Select targets photometrically

CMASS = BOSS higher-redshift galaxy targets

LOWZ = BOSS lower-redshift galaxy targets



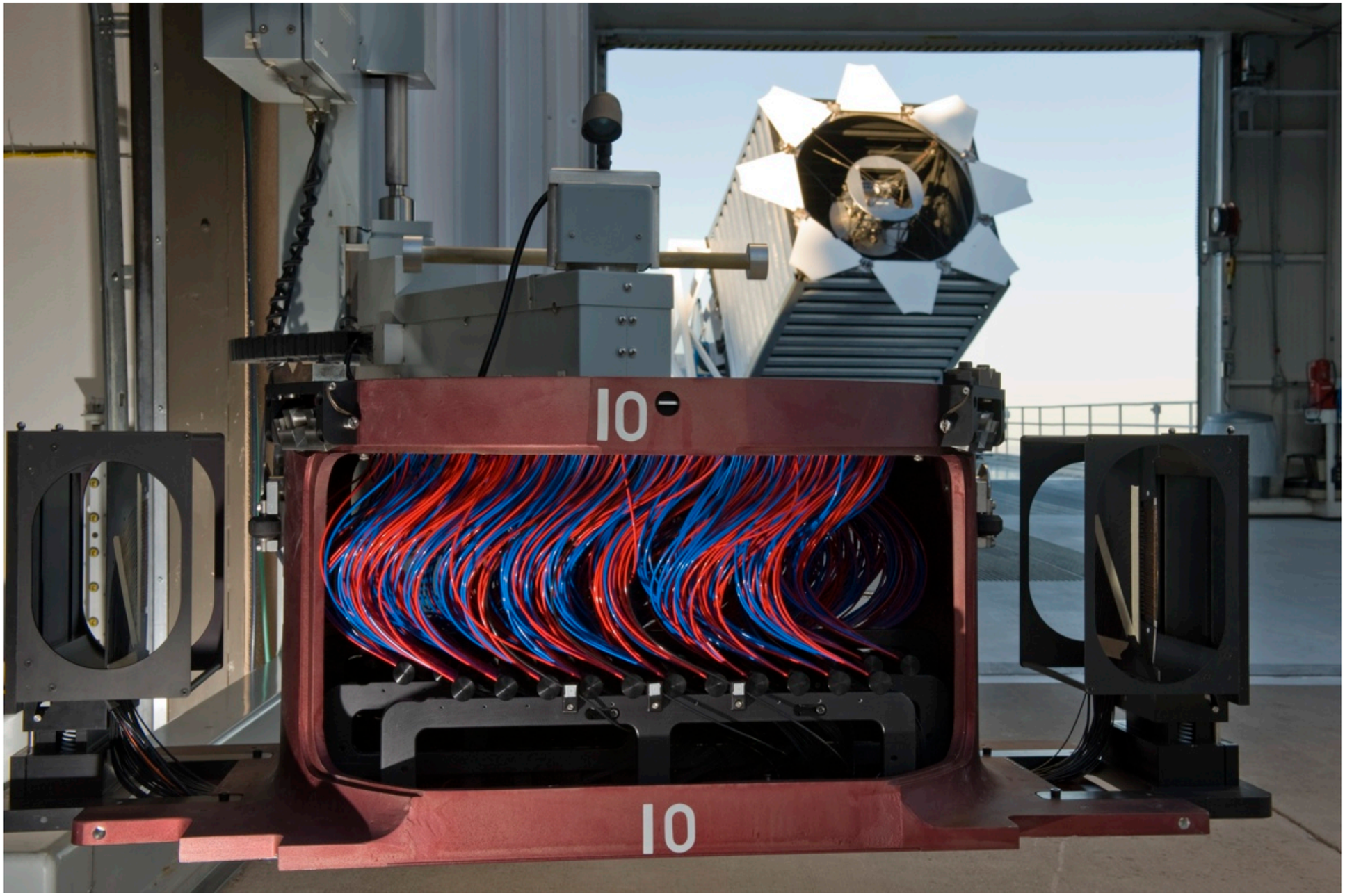




(N.B.: don't forget quasars!)

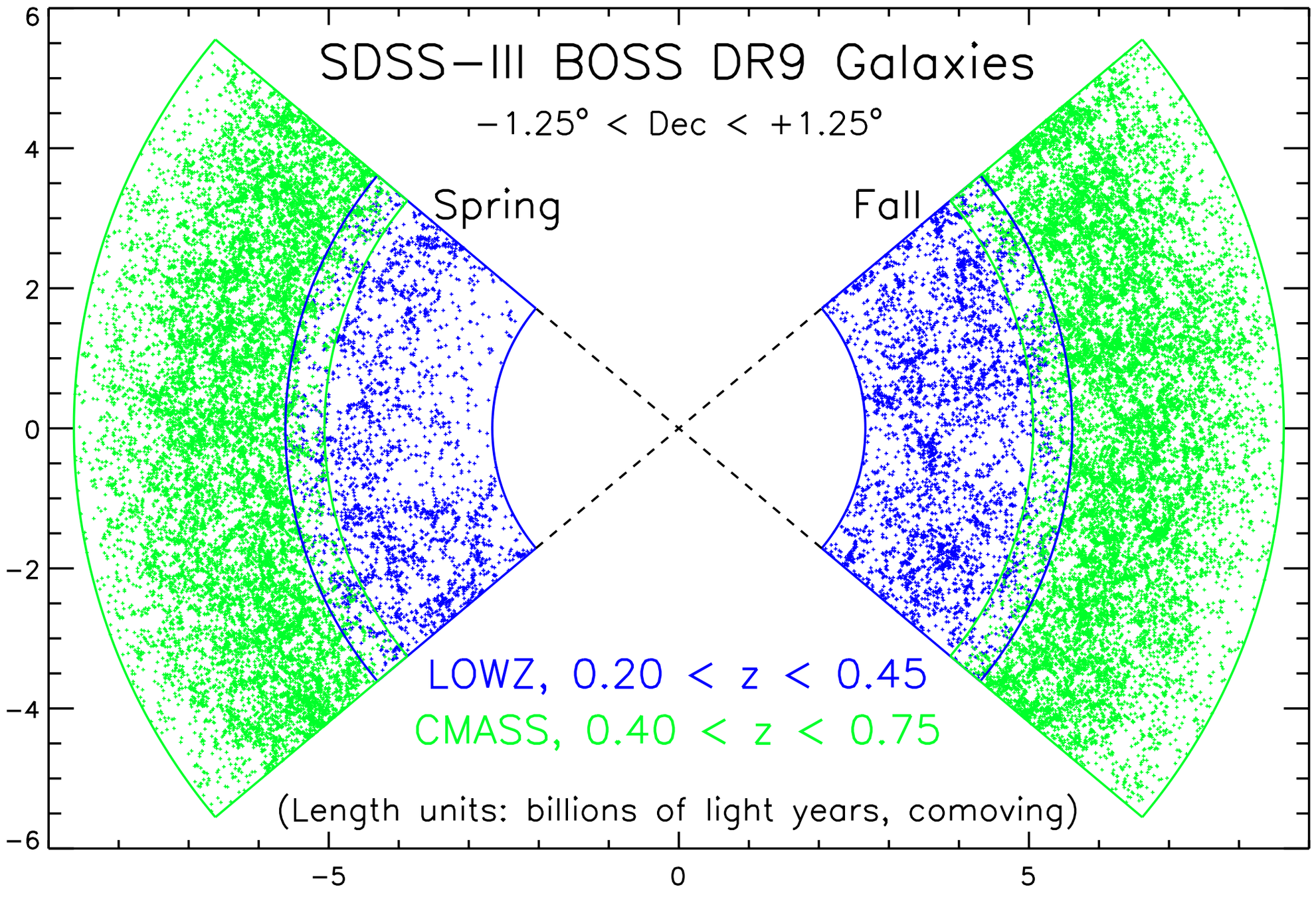
BOSS redshift survey in a nutshell

Observe them spectroscopically



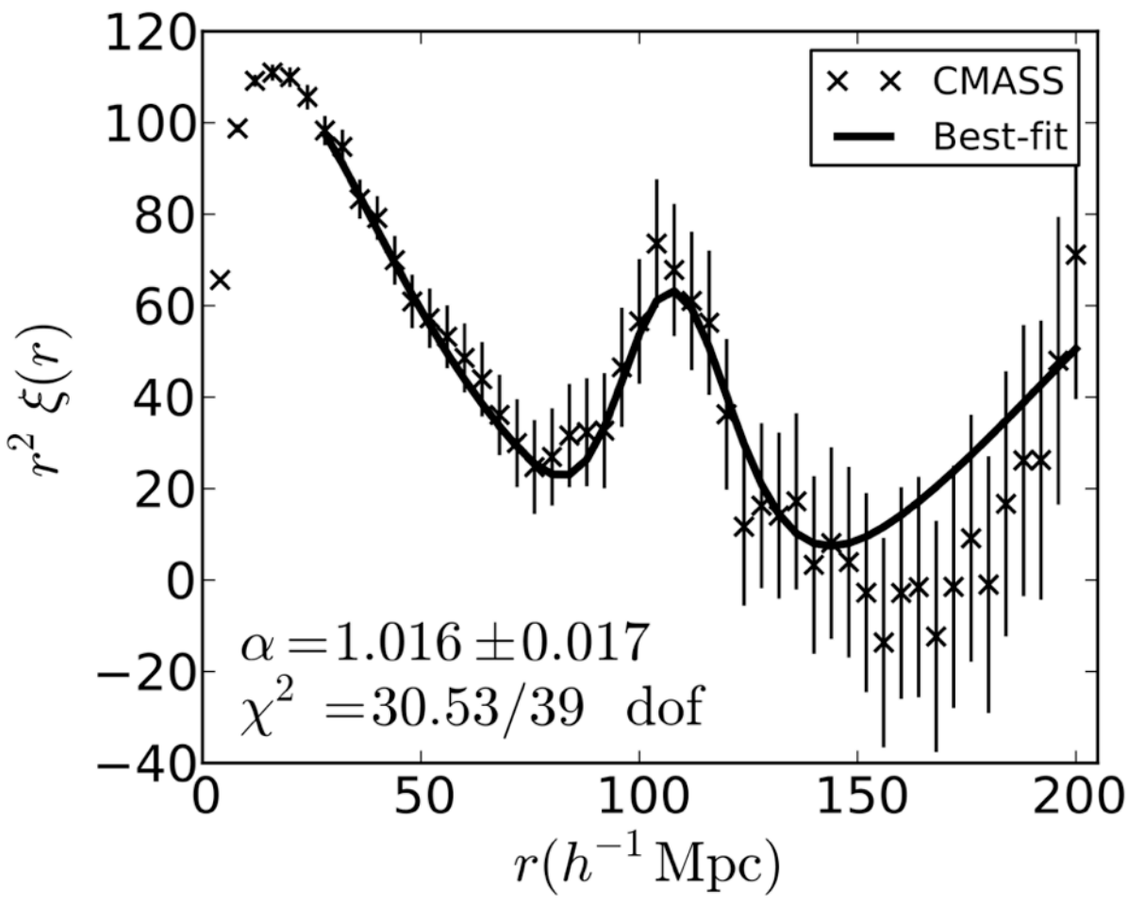
BOSS redshift survey in a nutshell

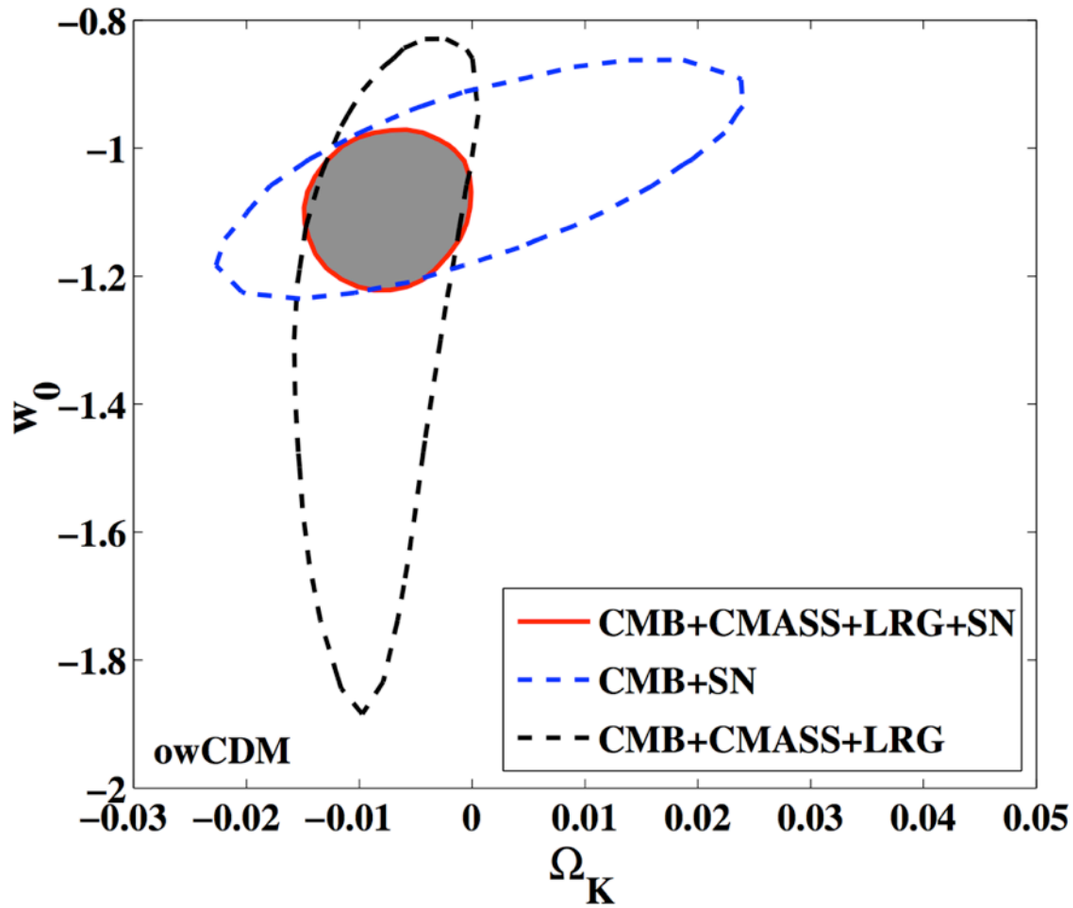
Measure their redshifts to make a 3D map



BOSS redshift survey in a nutshell

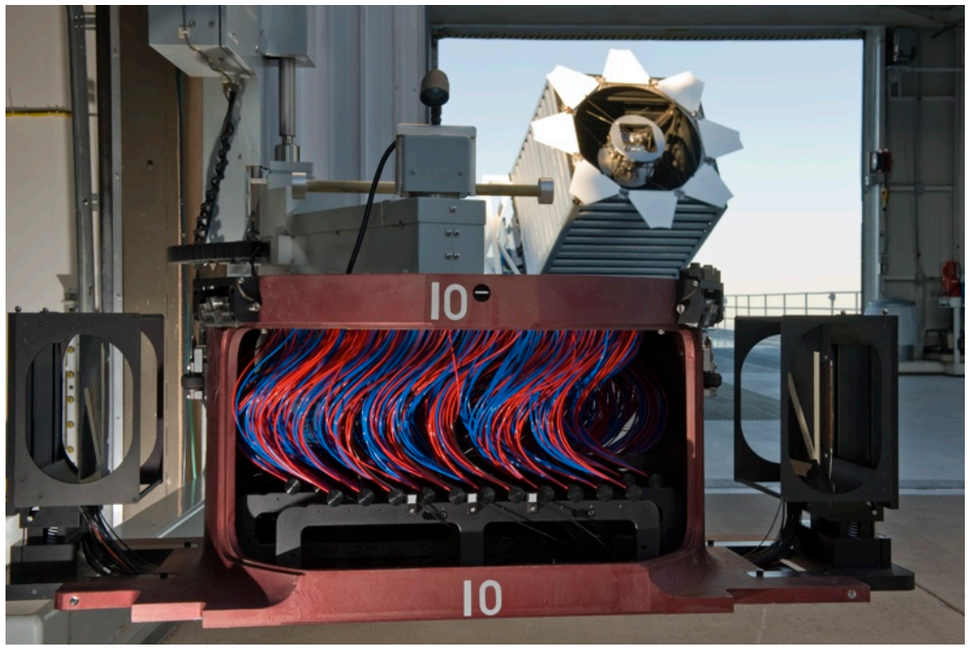
Measure 2-point correlation function and constrain dark energy parameters

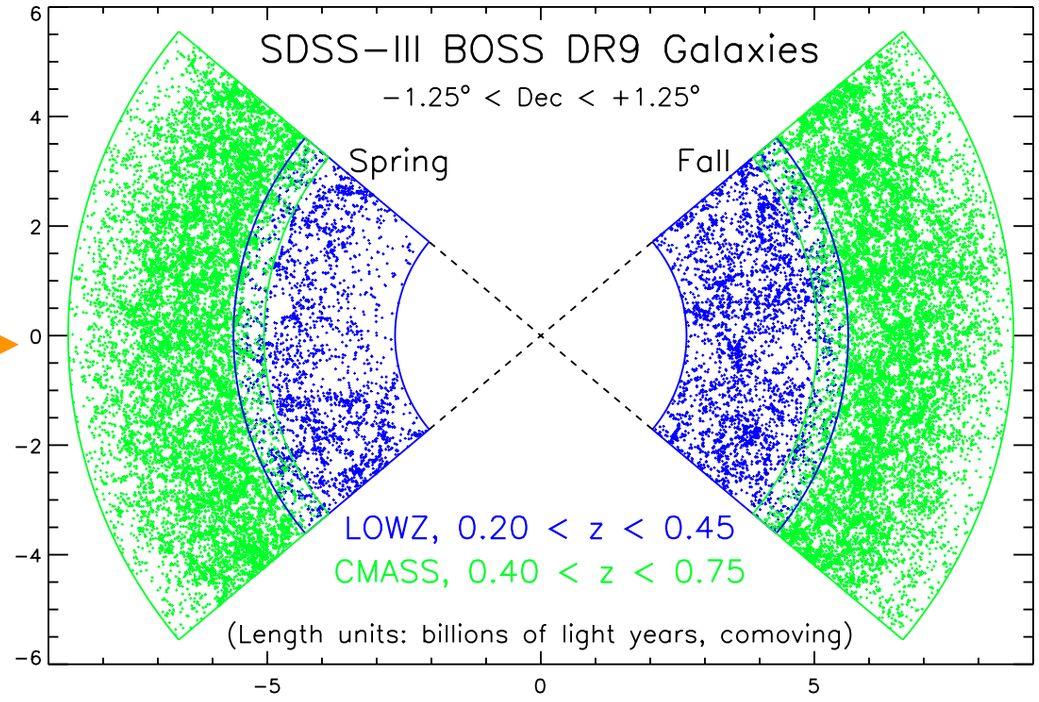




Anderson et al. 2012

What really goes on in this step?





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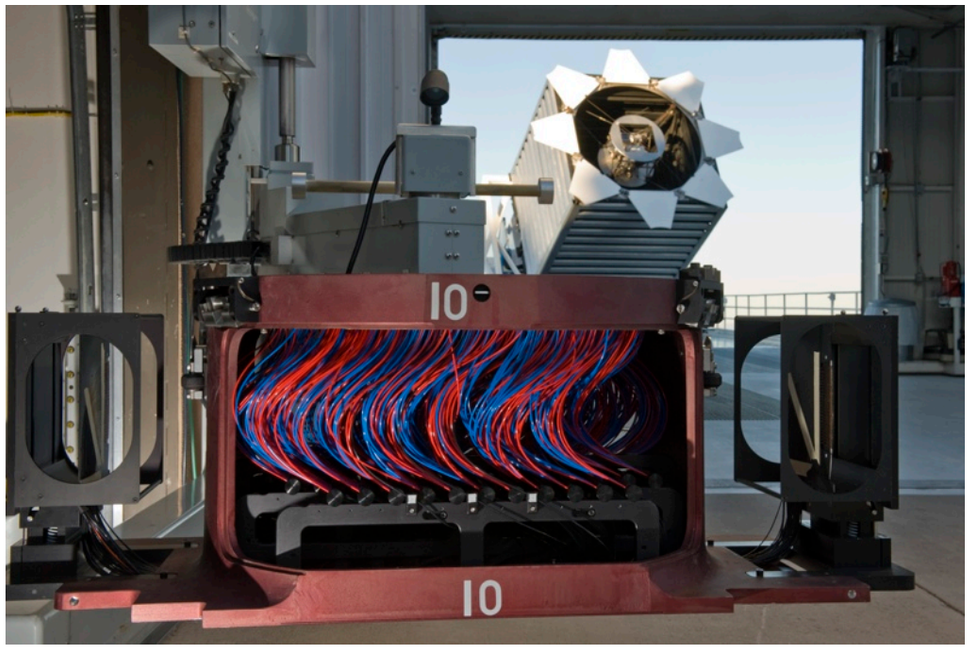
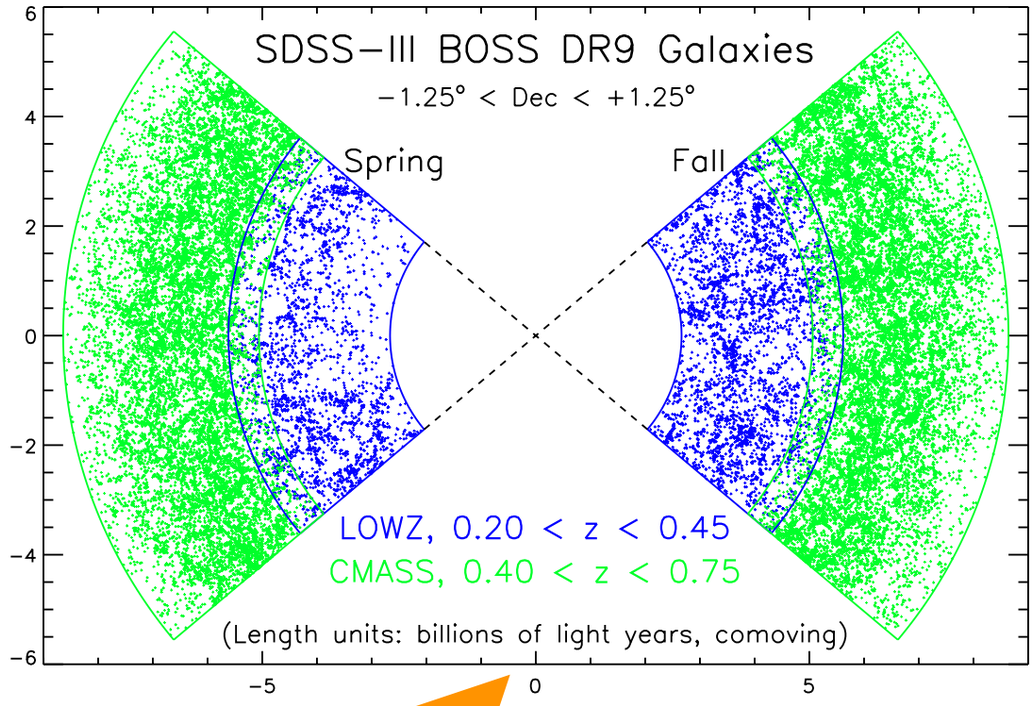




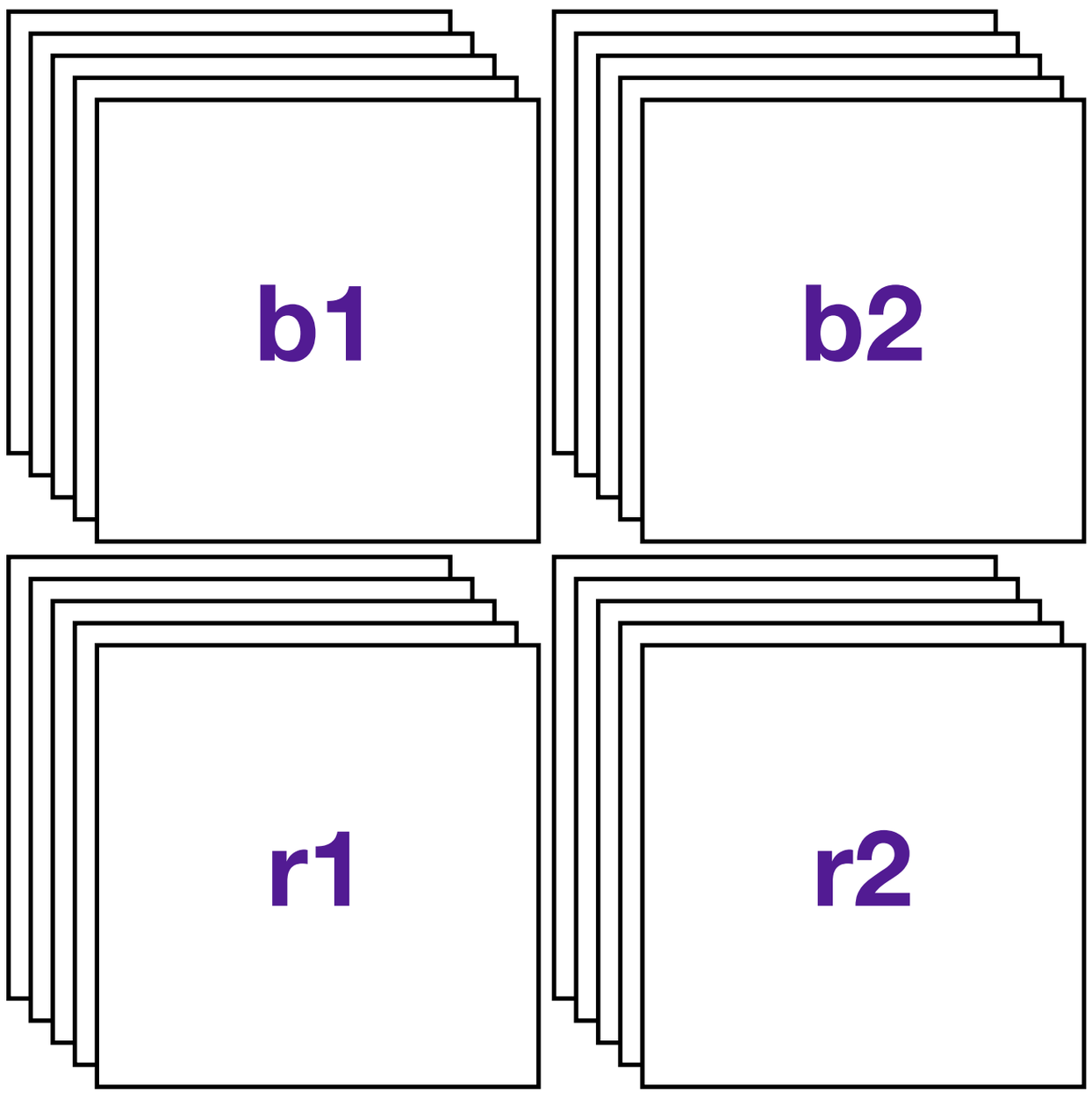
BOSS SPECTROSCOPIC PIPELINE

BOSS Spectroscopic Pipeline Overview

- Fully automated IDL software pipeline
- Inherited & modified from SDSS-I/II
- Cluster-parallelized by plates of 1000 fibers
- Extensive execution logging and QA plot generation
- Raw pixel errors estimated from first principles
- Errors propagated to redshifts and classifications
- Exceeds BOSS redshift science requirements
- Schlegel et al. in prep, Bolton et al. 2012, AJ, 144, 144

Science Frames

~5 exposures X 4 cameras X ~4,000x4,000 pixels



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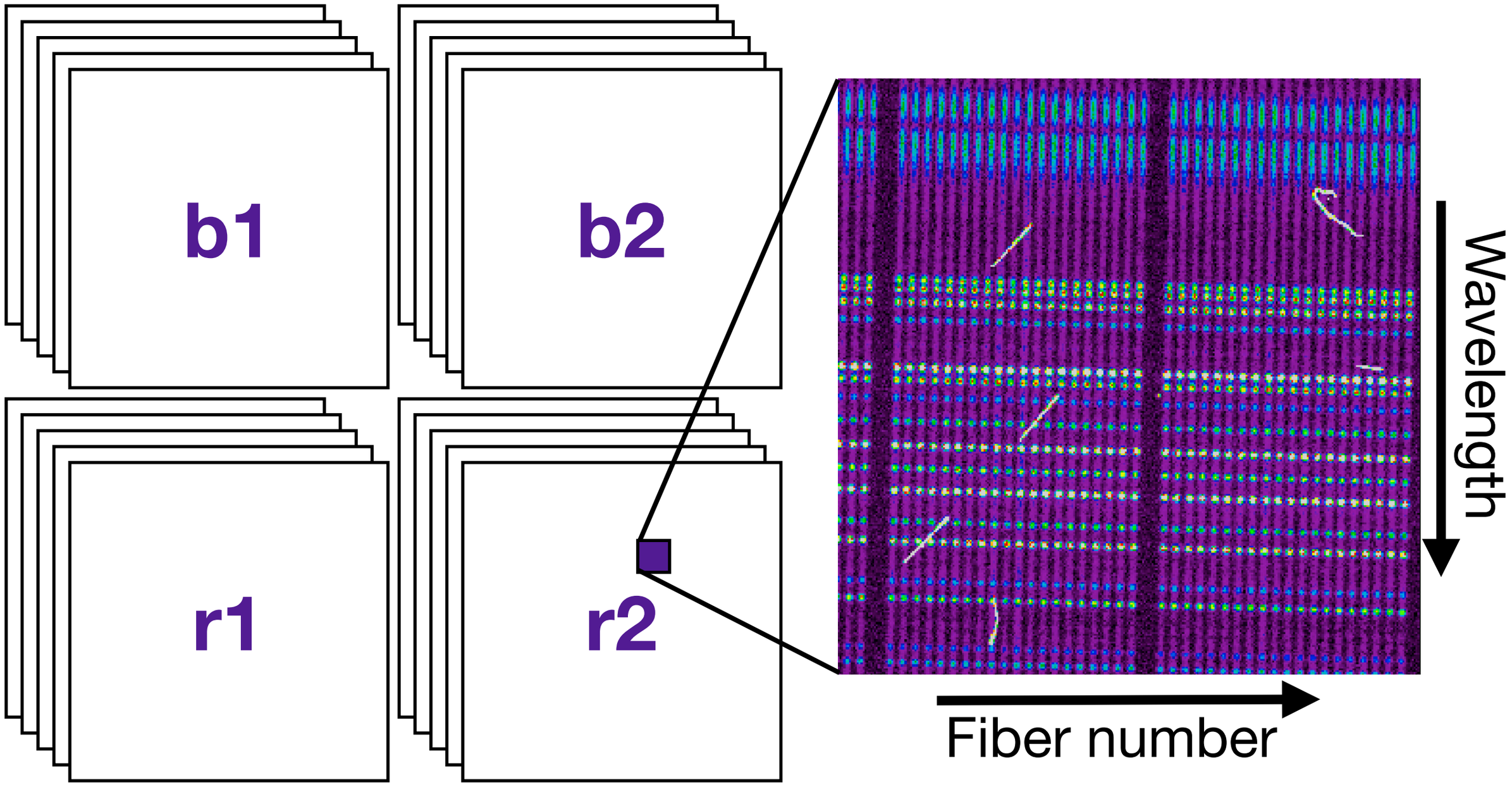

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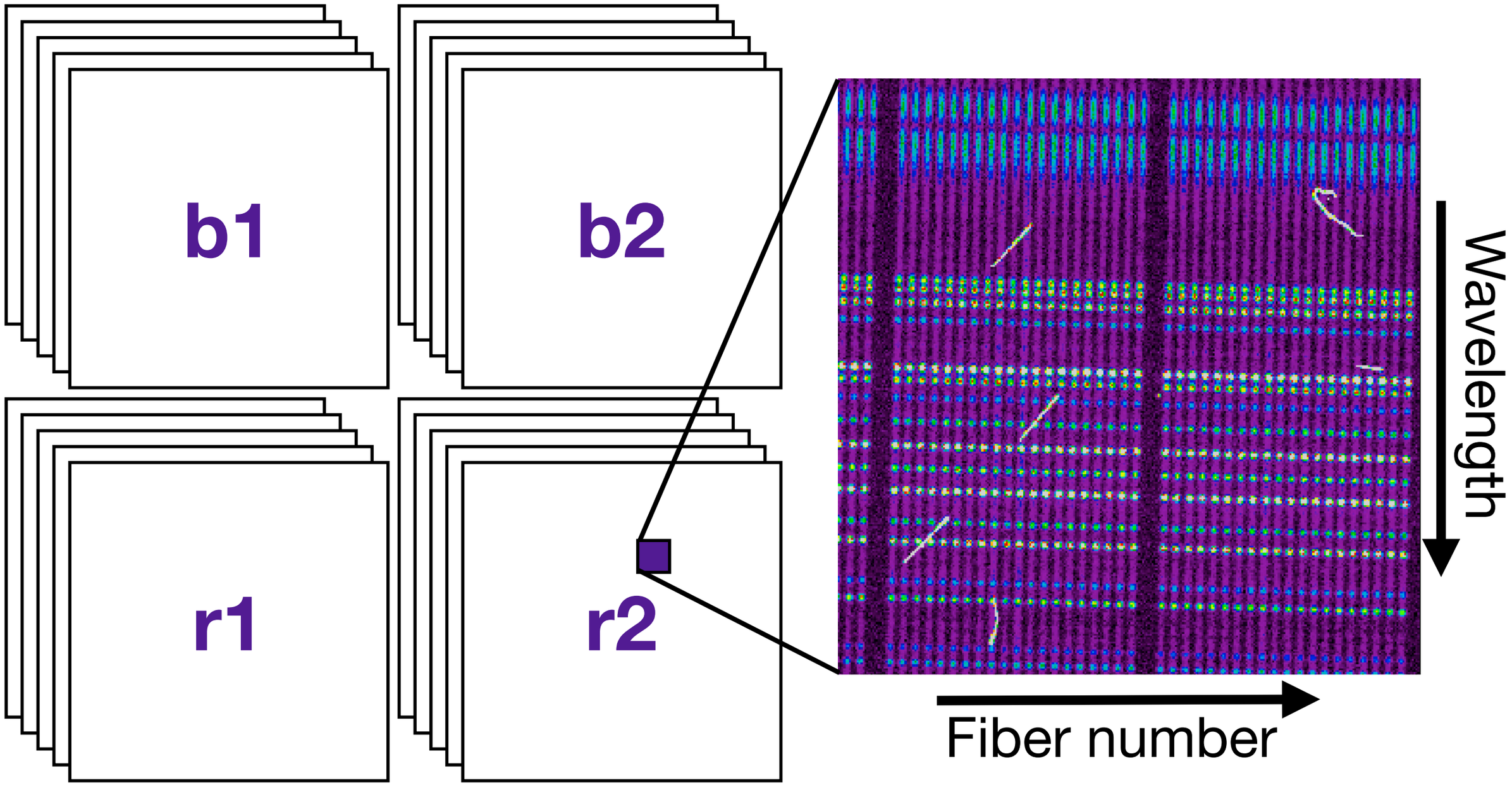
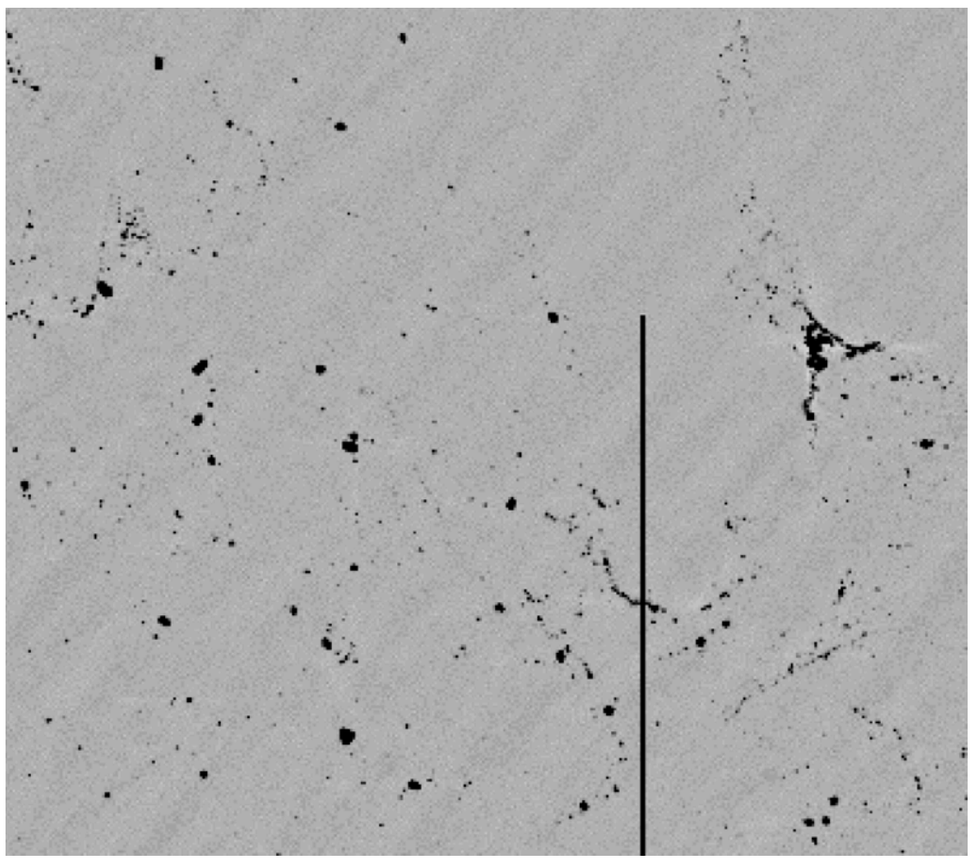
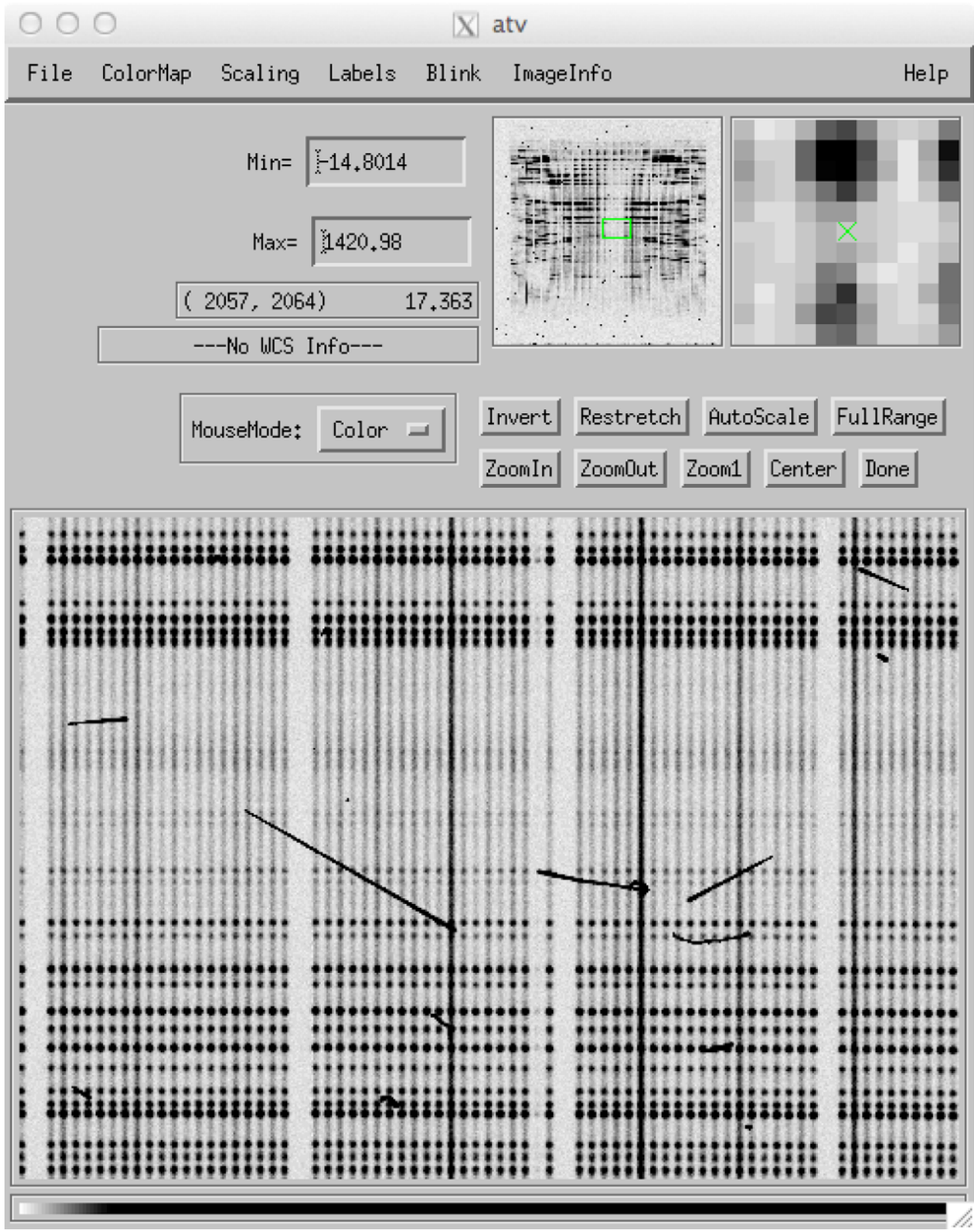


Most counts are night-sky photons!

Calibration, Part 1

bias subtraction,
gain correction,
pixel-response correction,
bad-column masking,
cosmic-ray rejection,
pixel error estimation





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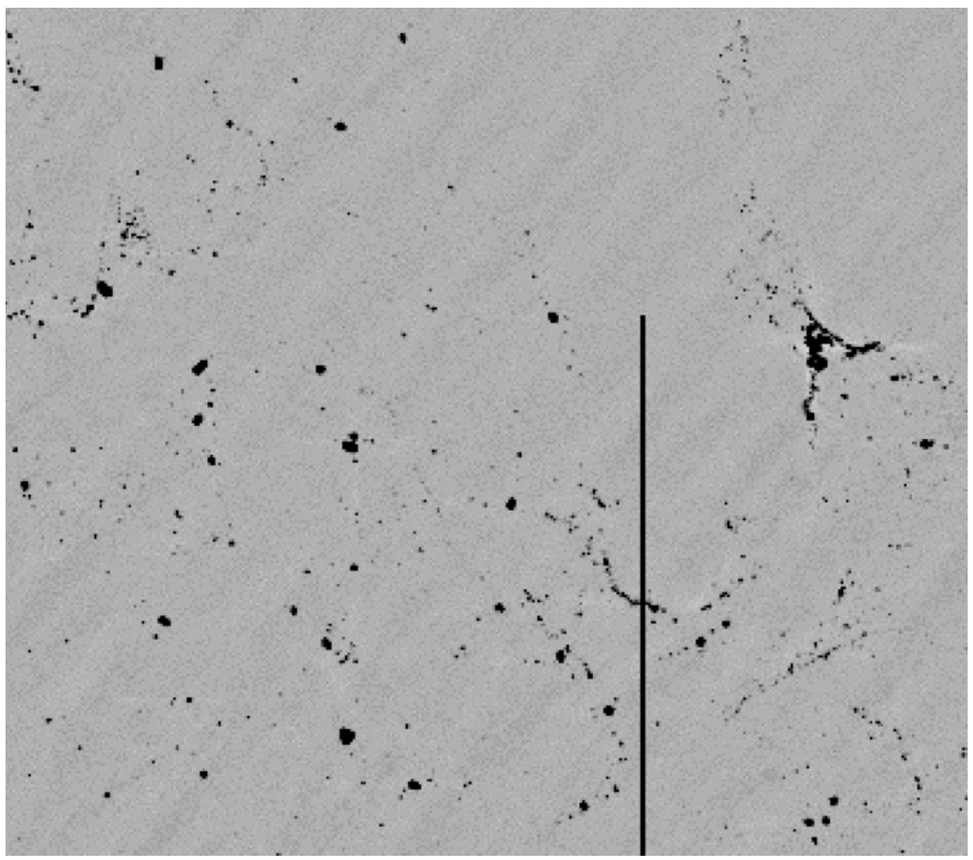
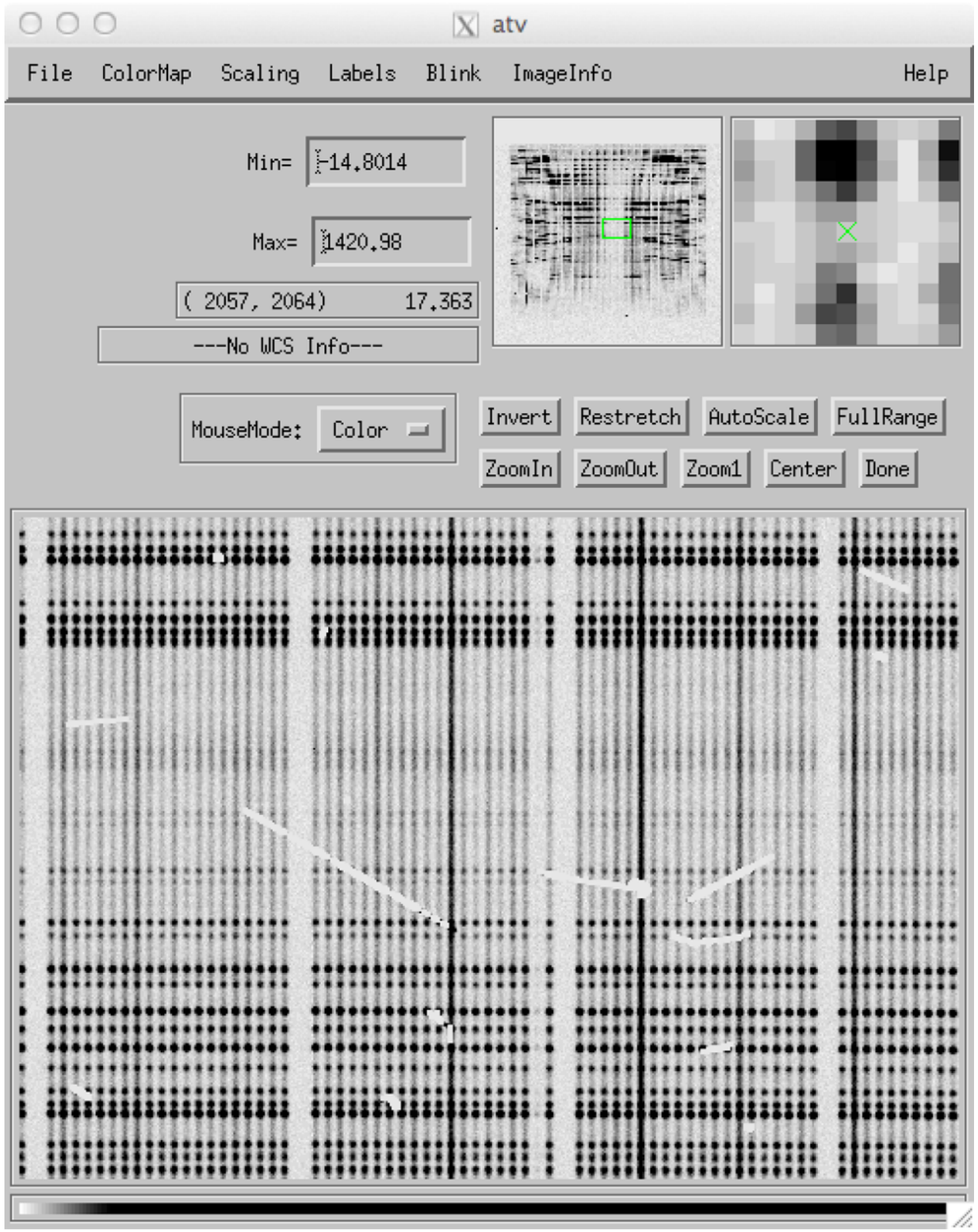
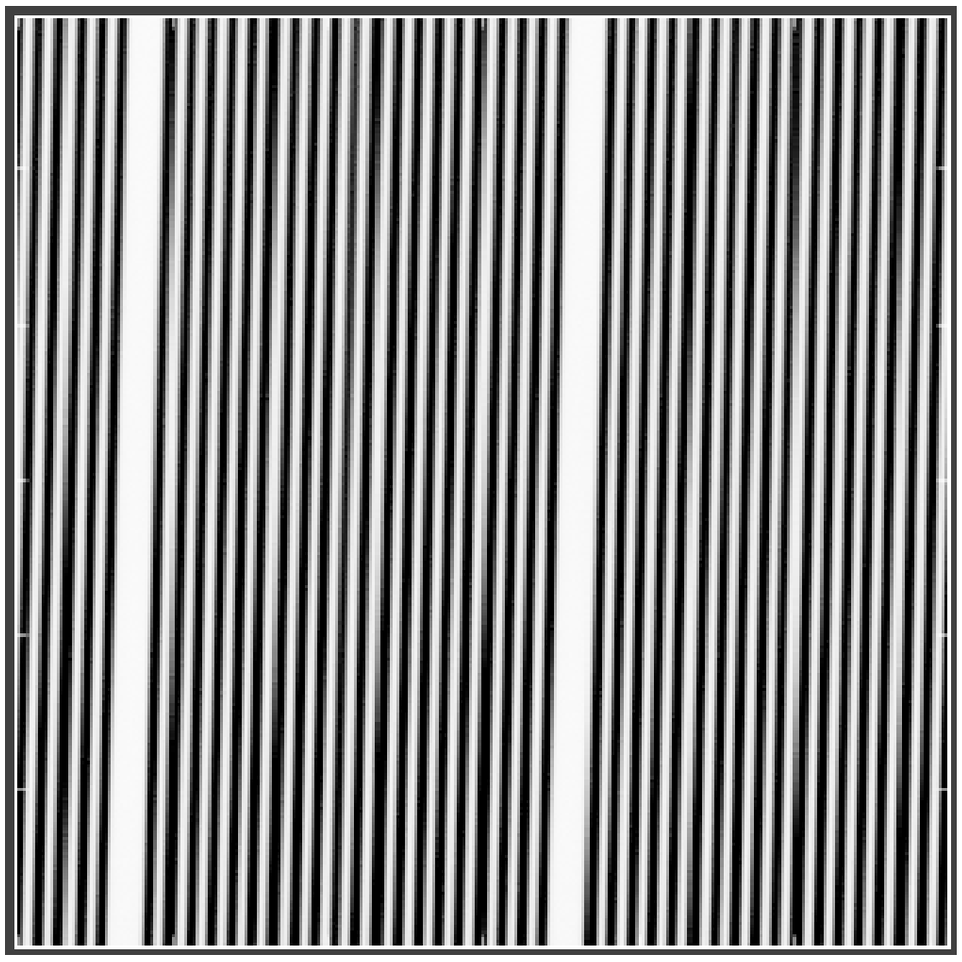




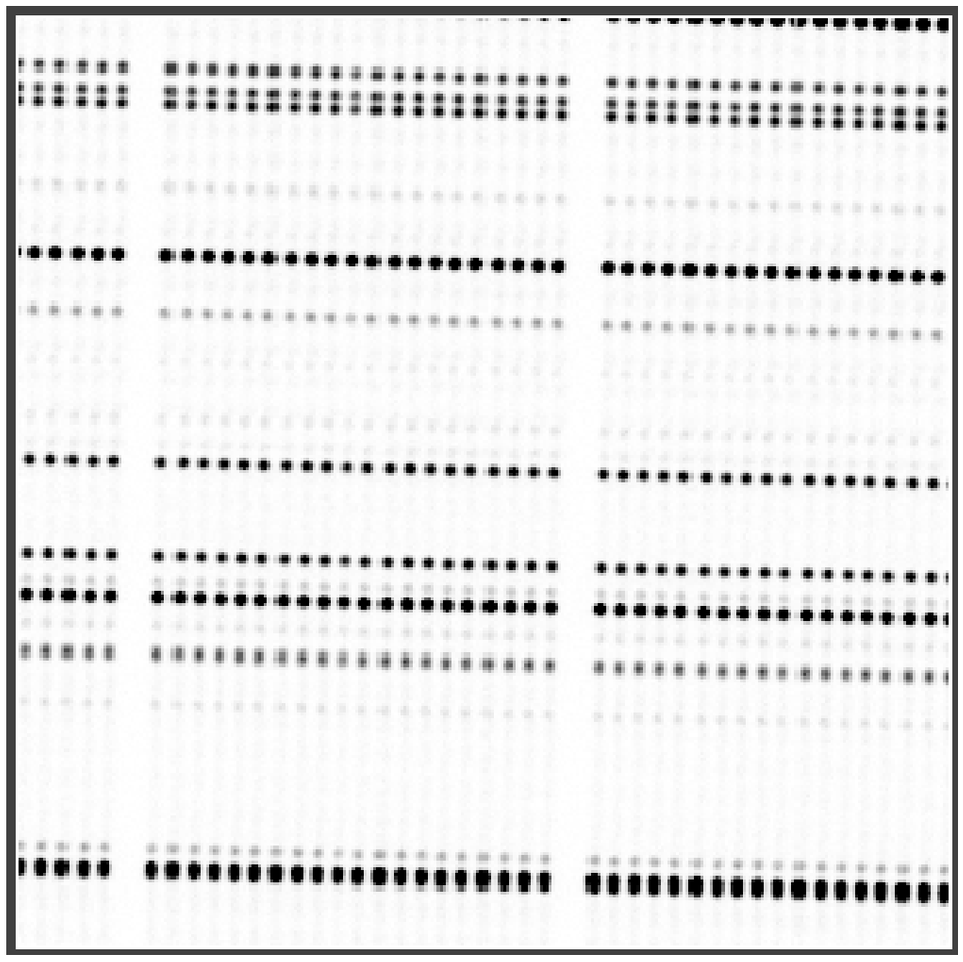
Calibration, Part 2

Flat Frames



trace positions
fiber-to-fiber throughput
cross-sectional profile

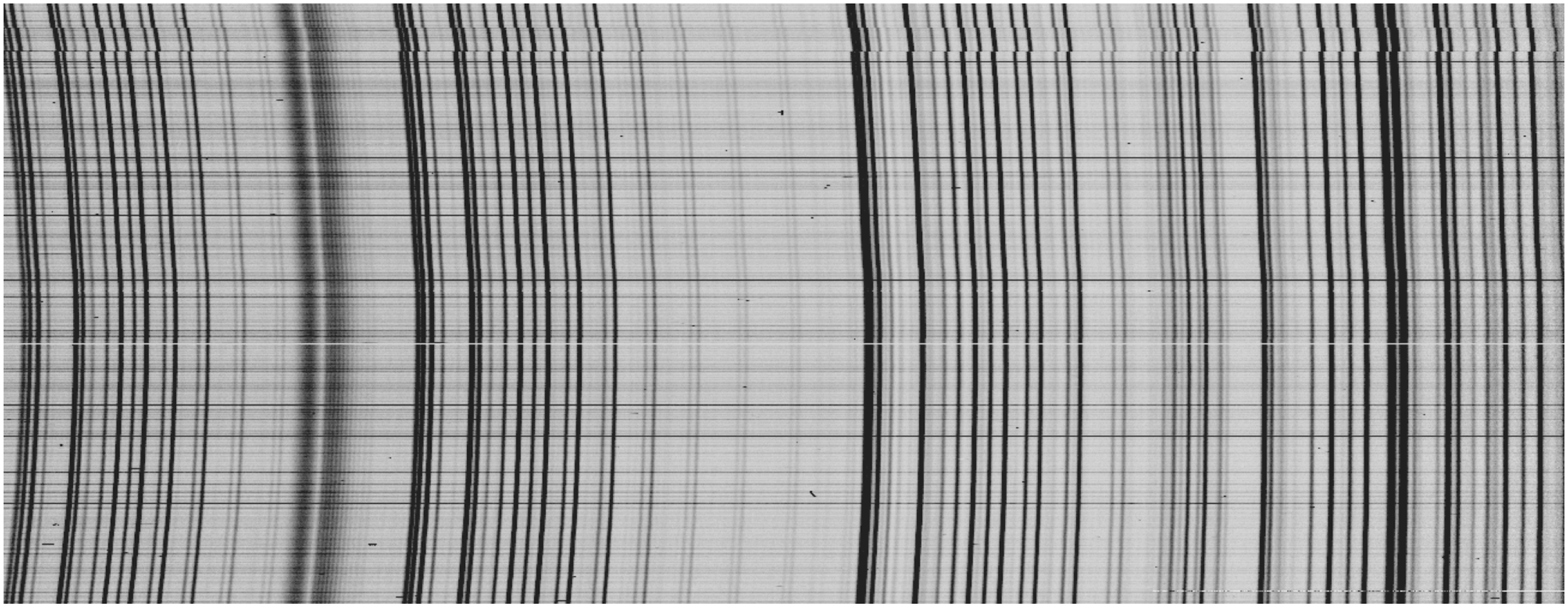
Arc Frames



wavelength solution
spectral resolution

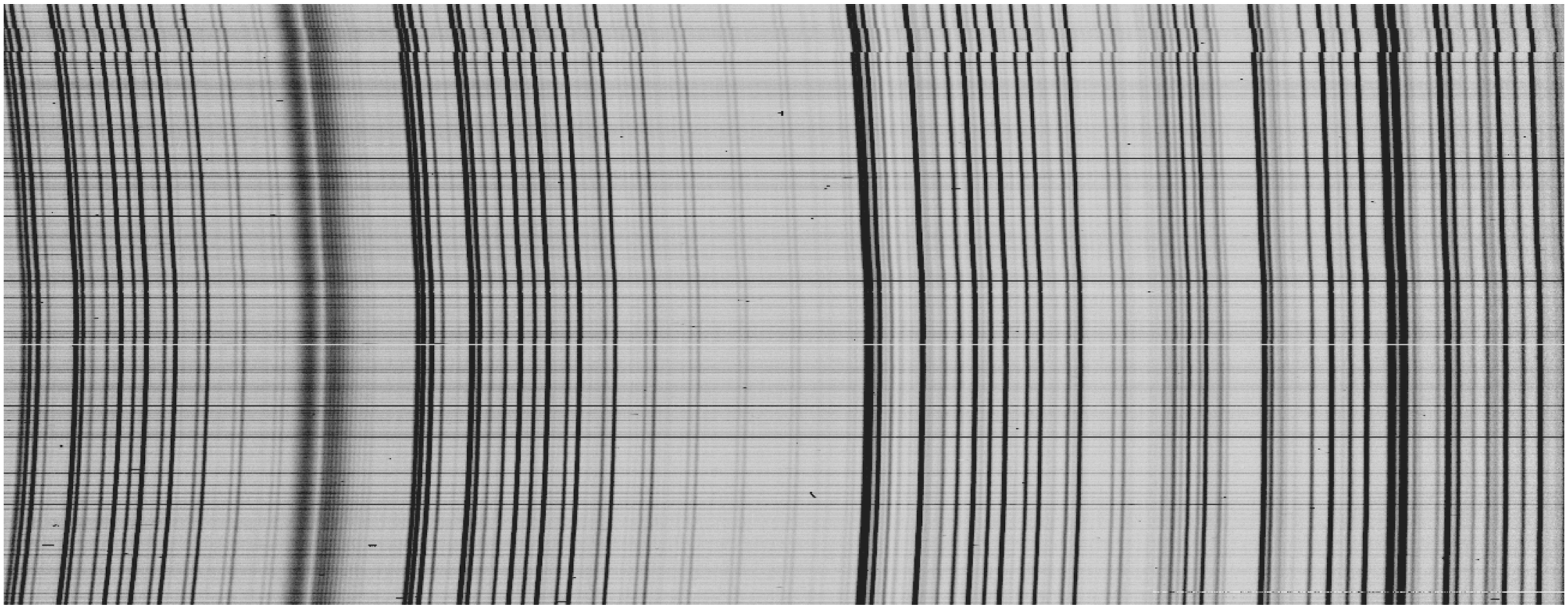
Extraction

Profile fitting “optimal extraction”, a la Horne 1986



Sky Subtraction

B-spline sky model in un-rebinned pixel space



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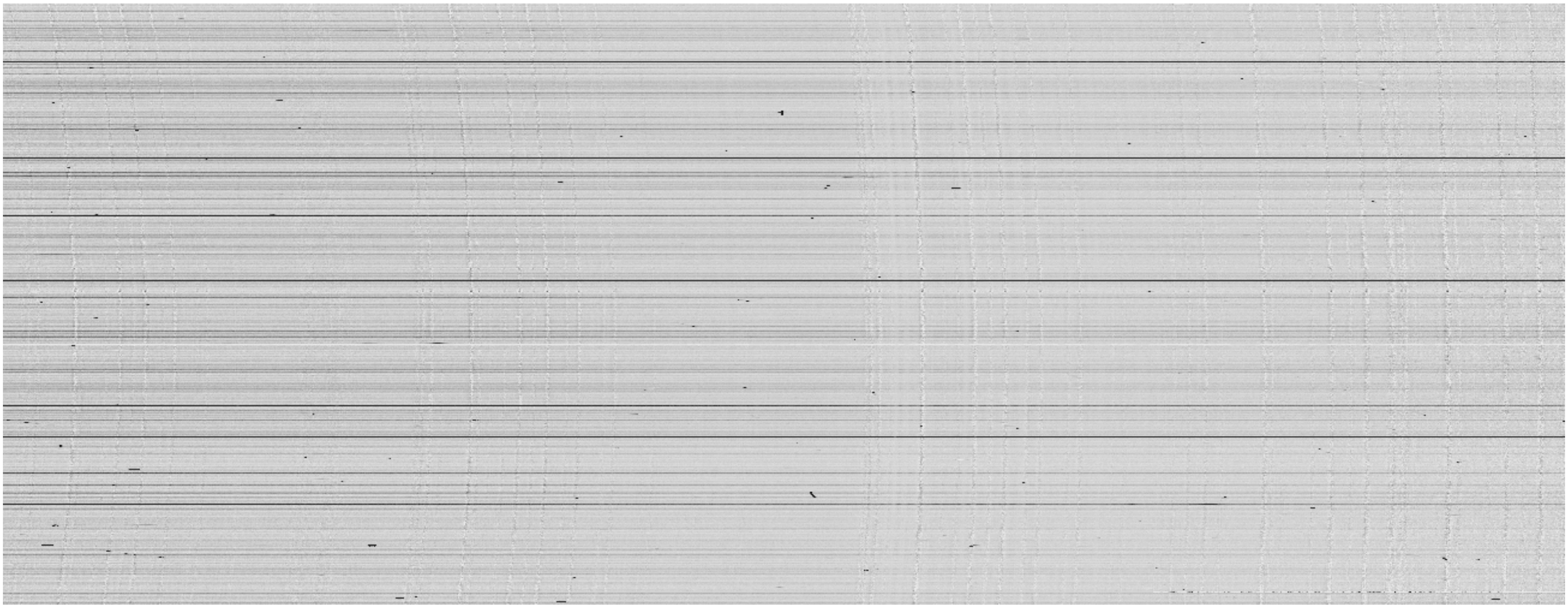
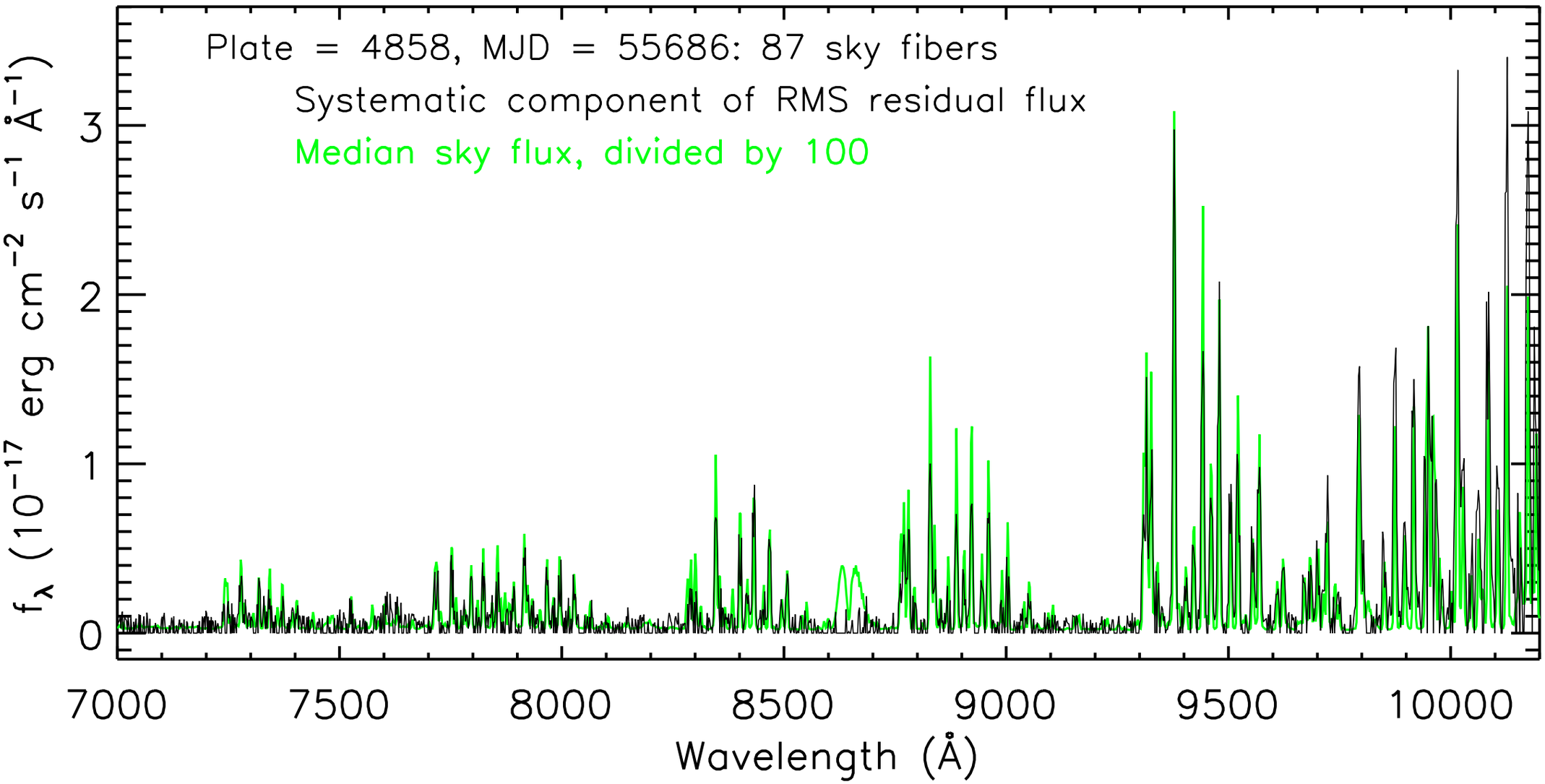


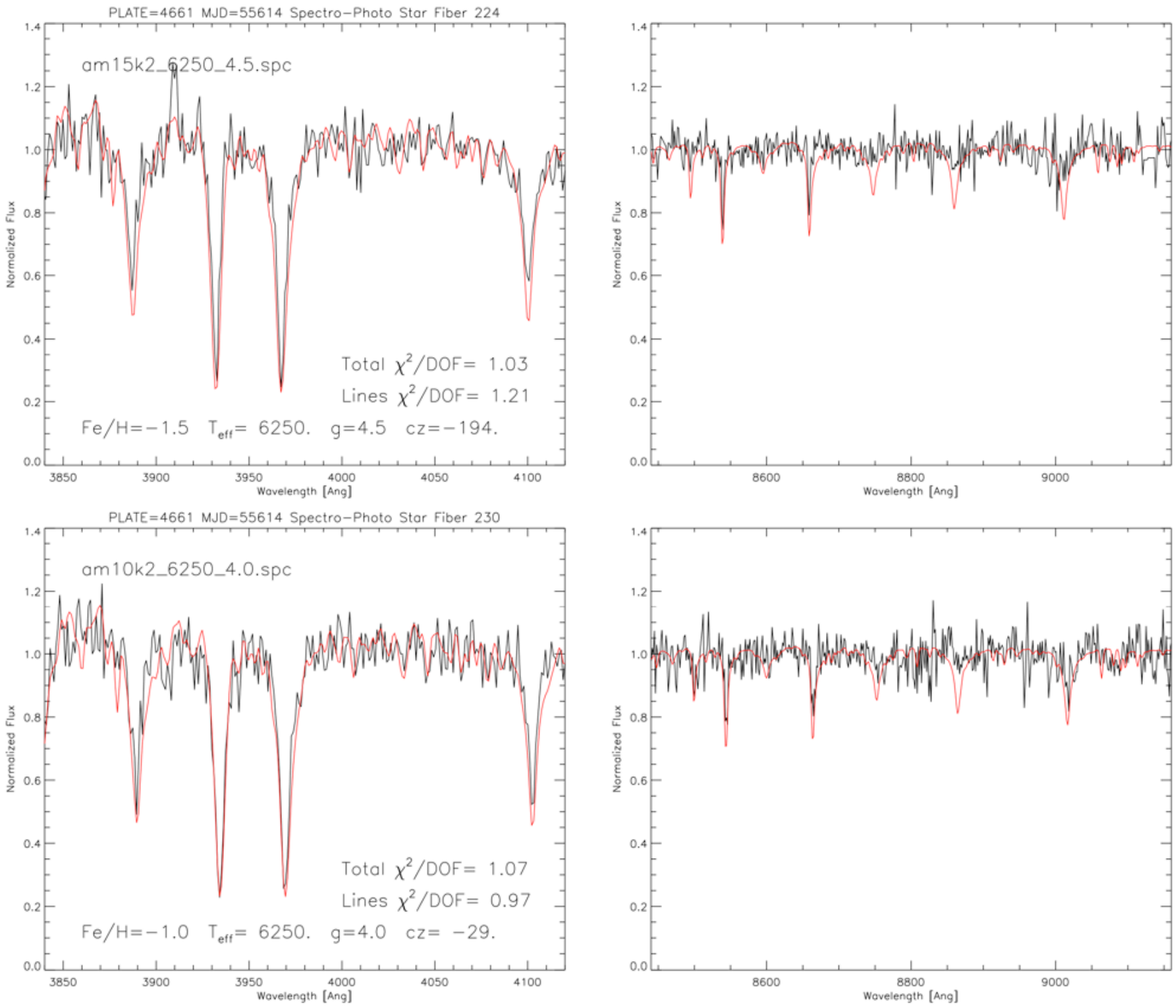
Sky Subtraction Quality

Systematic residuals < ~ 1% even on sky lines



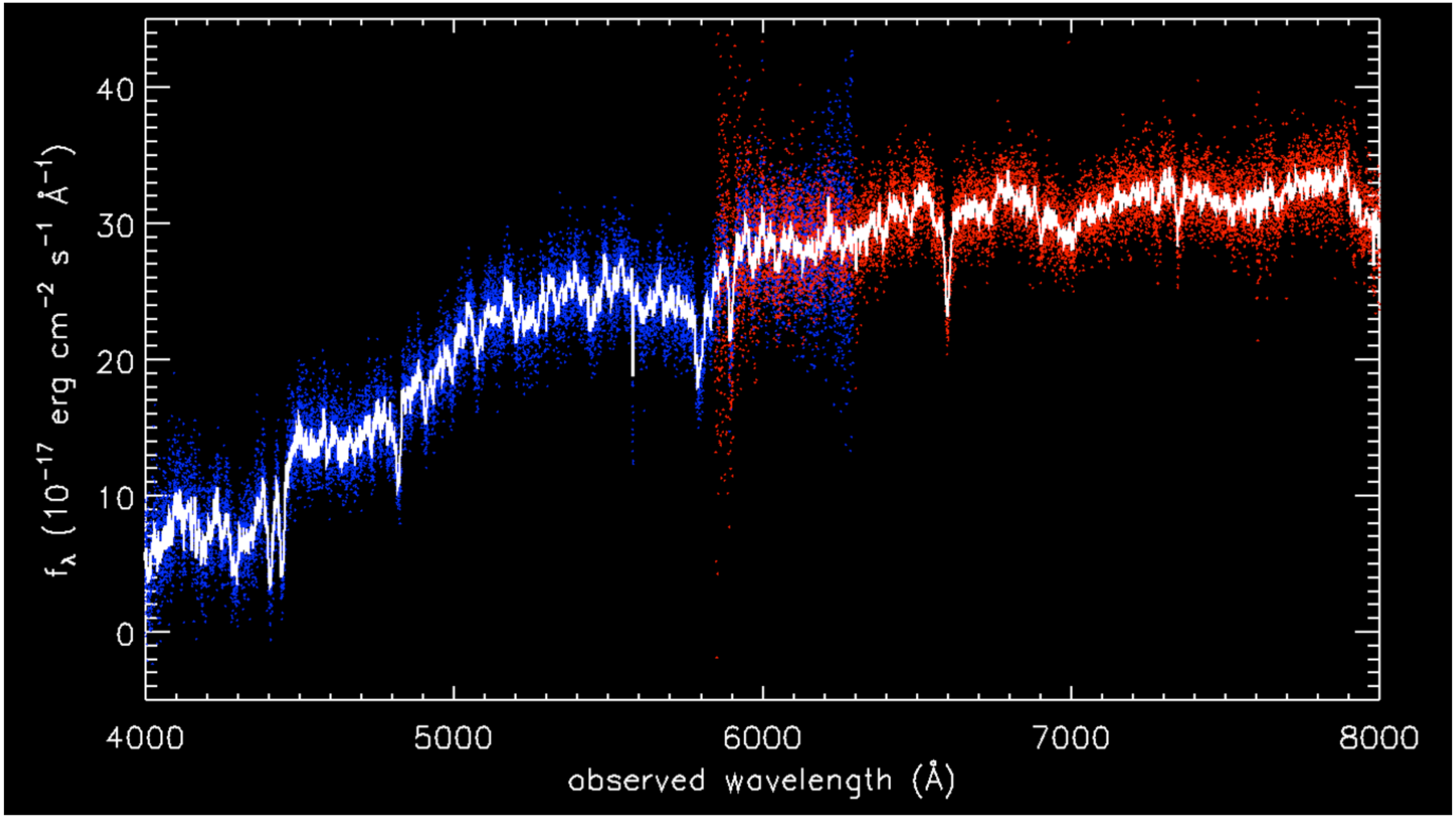
Calibration Part 3: Spectrophotometry

F-star model atmospheres selected by line fitting



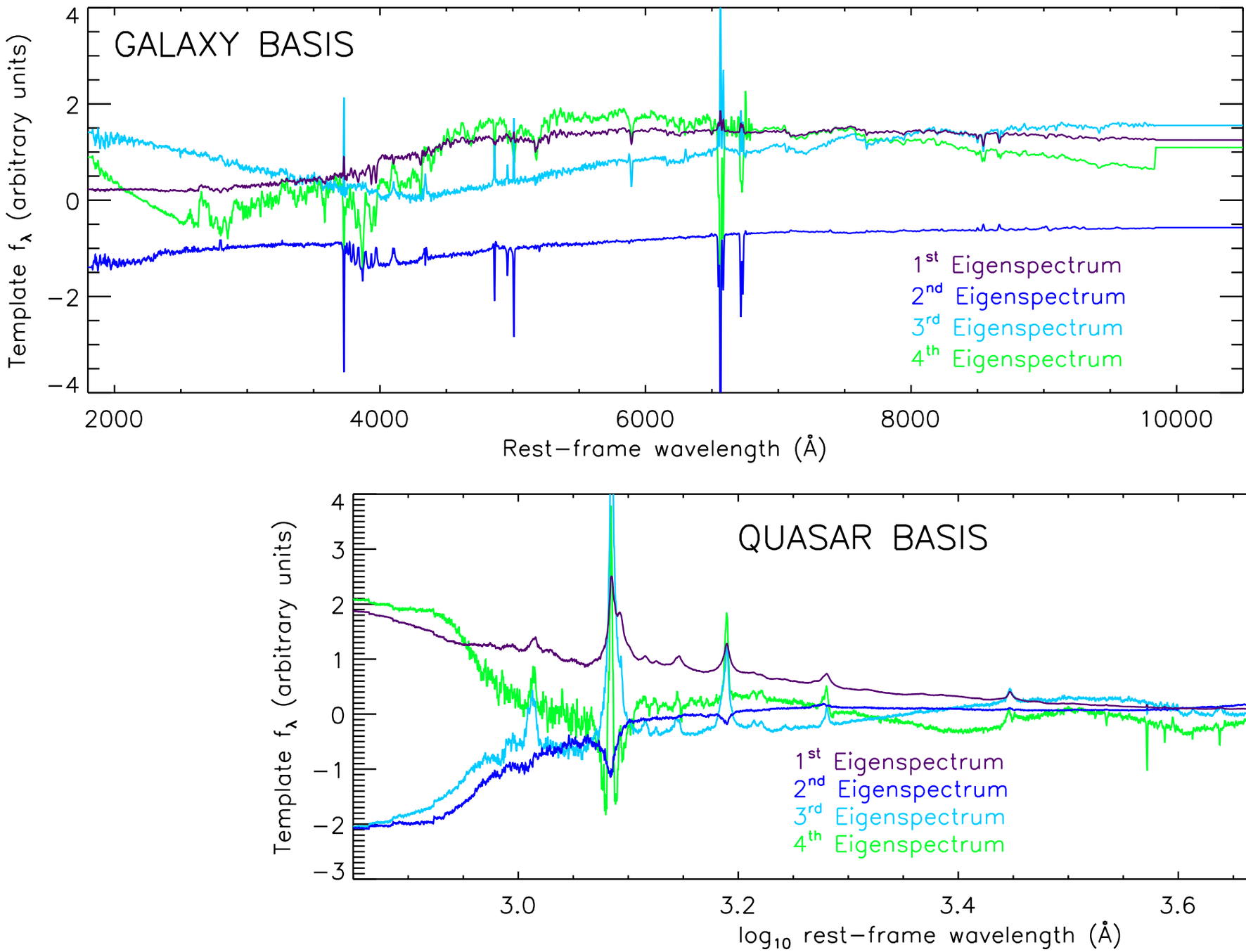
Coaddition

B-spline model for output coadd:
fitted to all fluxed frames,
evaluated at dlogλ = 10^{-4}



Redshift Measurement and Classification

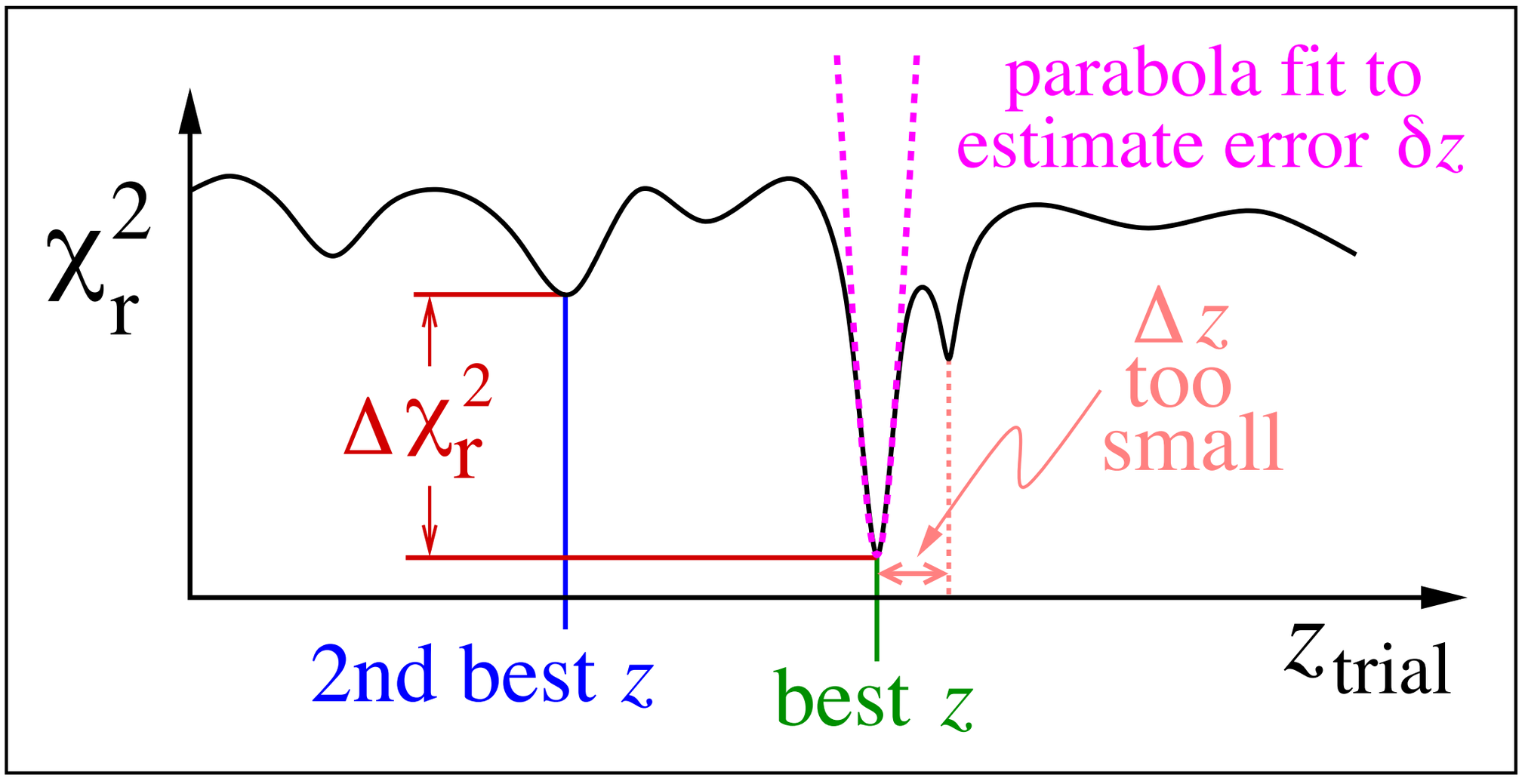
Fitting done using bases of PCA Eigenspectra



Plus: stellar archetype spectra

Redshift Measurement and Classification

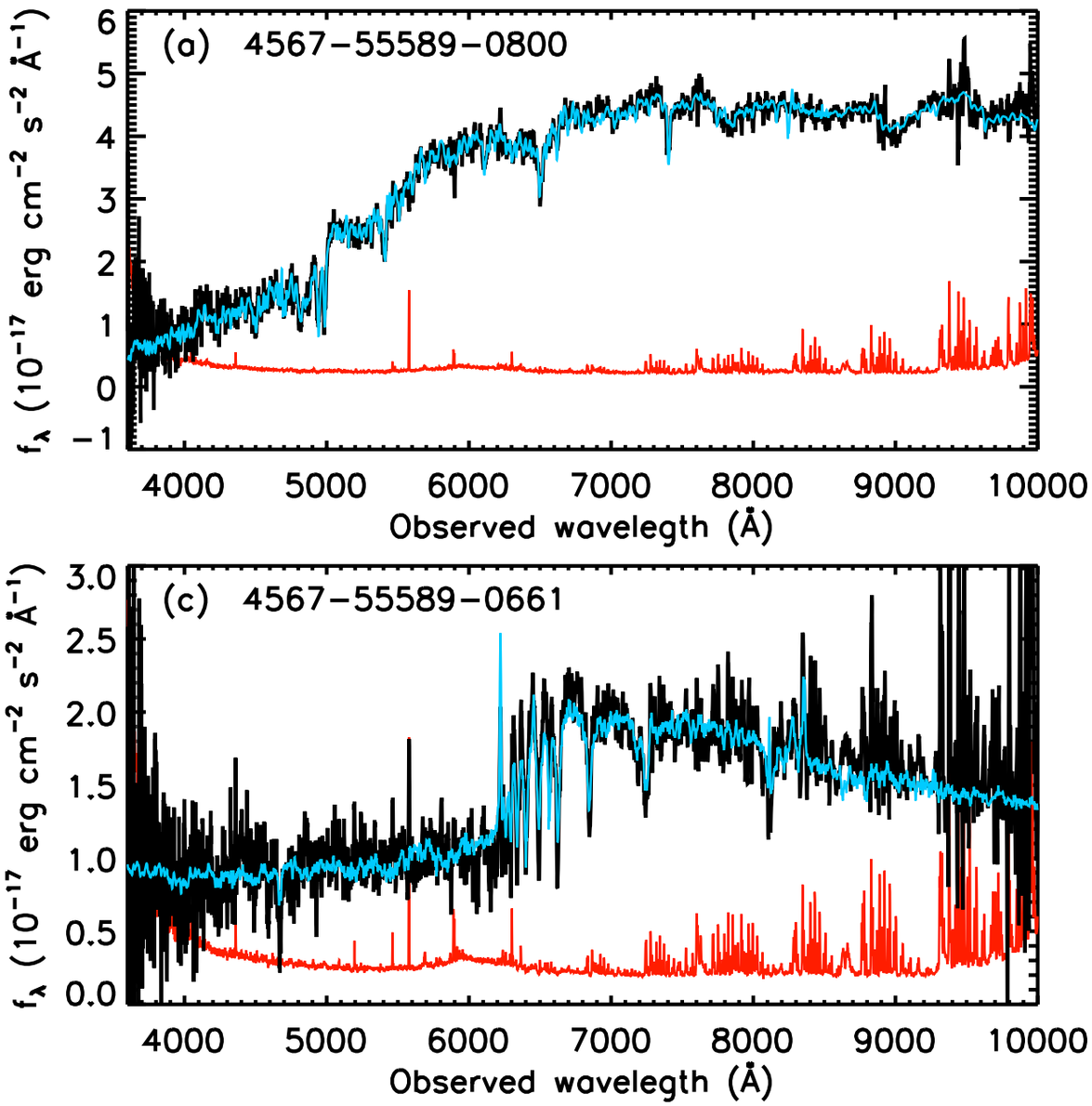
Schematic illustration of the algorithm



Forward modeling allows objective model comparison and error estimation

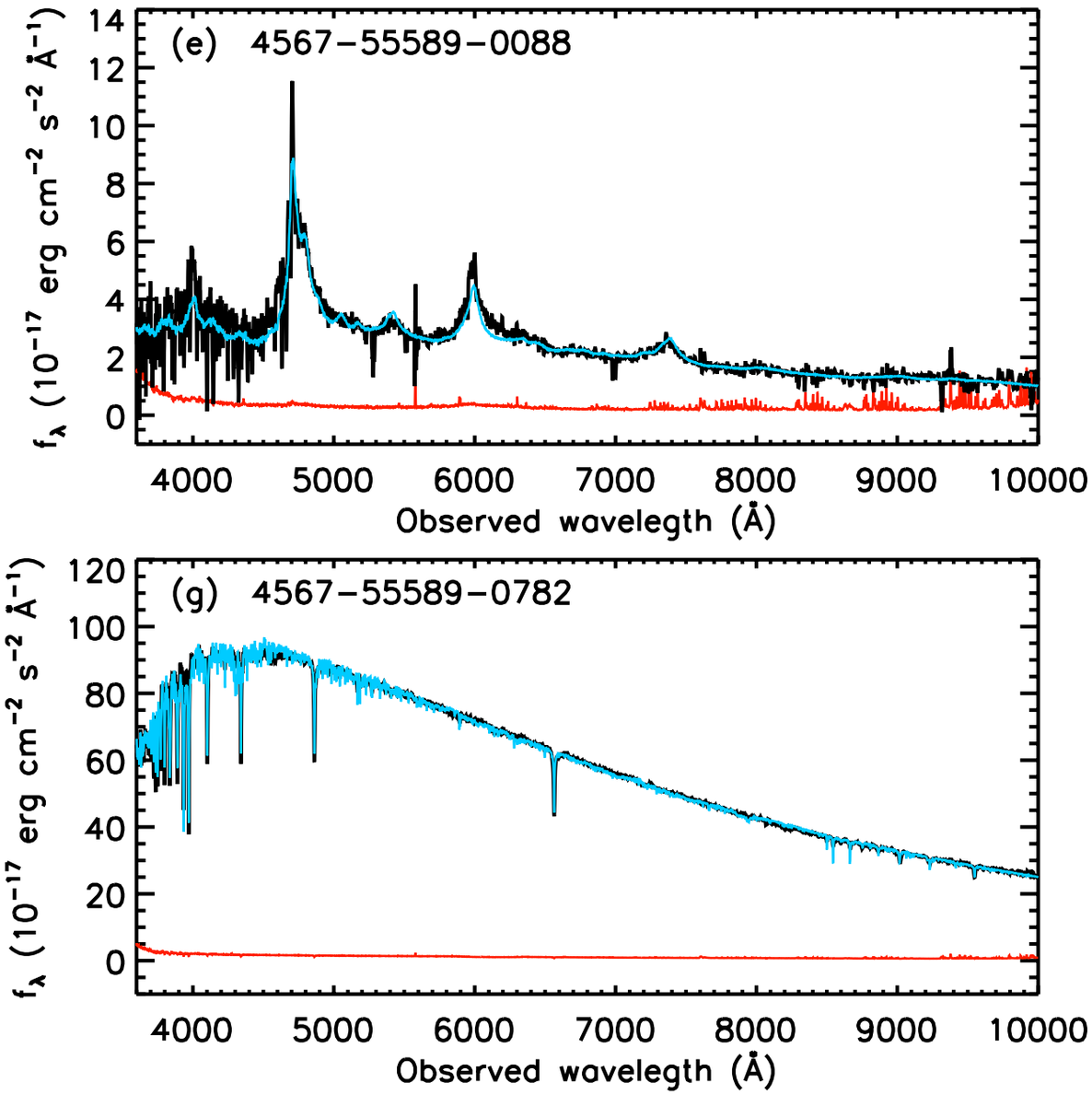
Redshift Measurement and Classification

Example redshift model fits: galaxies



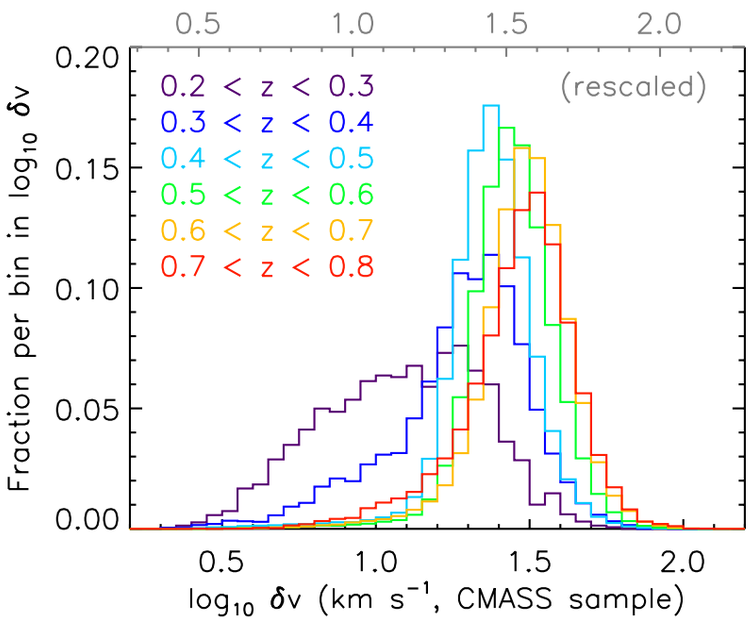
Redshift Measurement and Classification

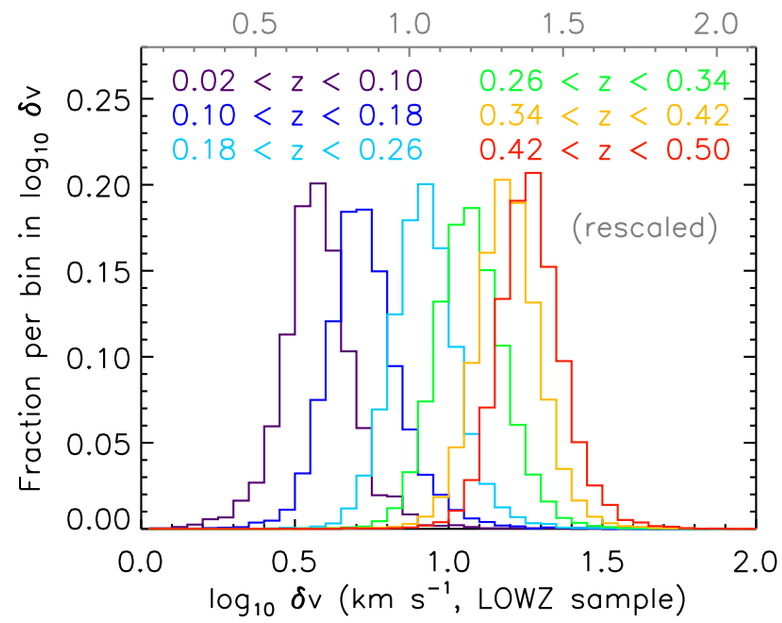
Example redshift model fits: quasars and stars

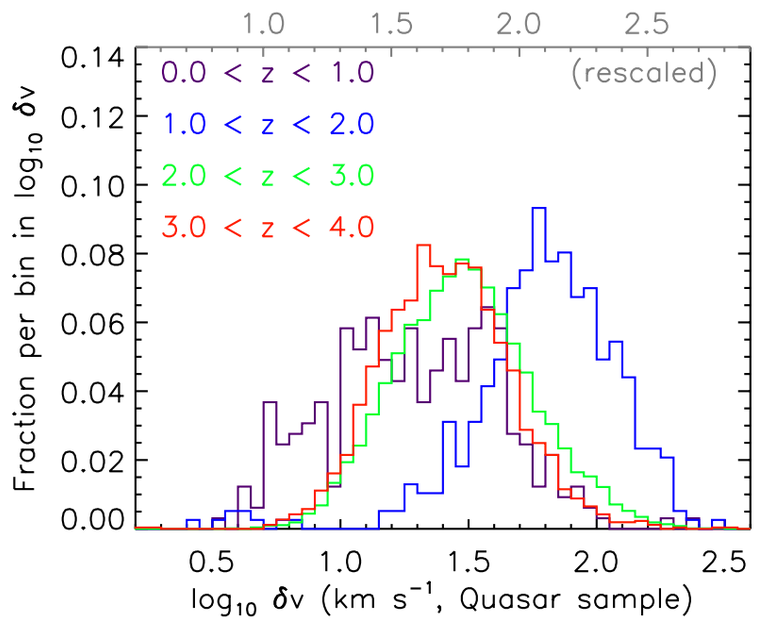


Redshift Measurement Precision

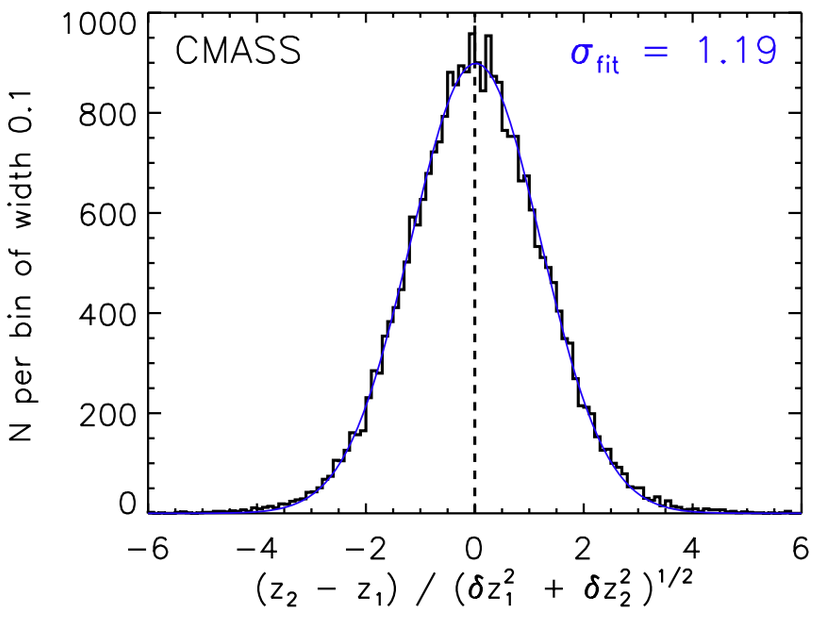
Typical redshift errors: few tens of km/s (statistical):

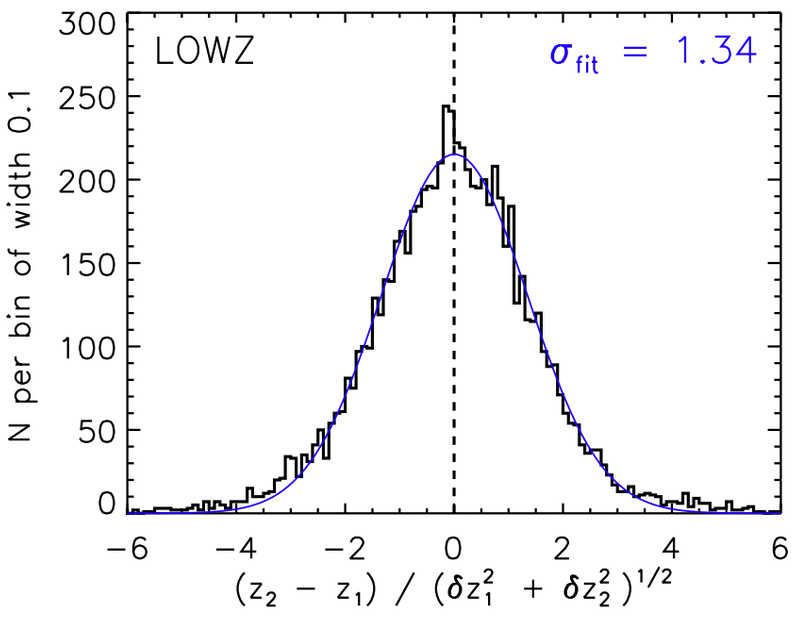


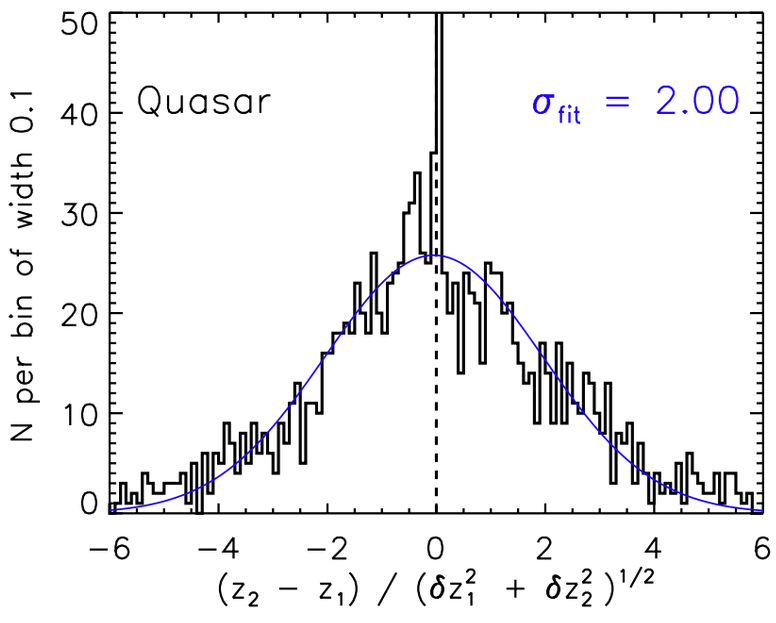




Statistical error estimates substantially accurate:



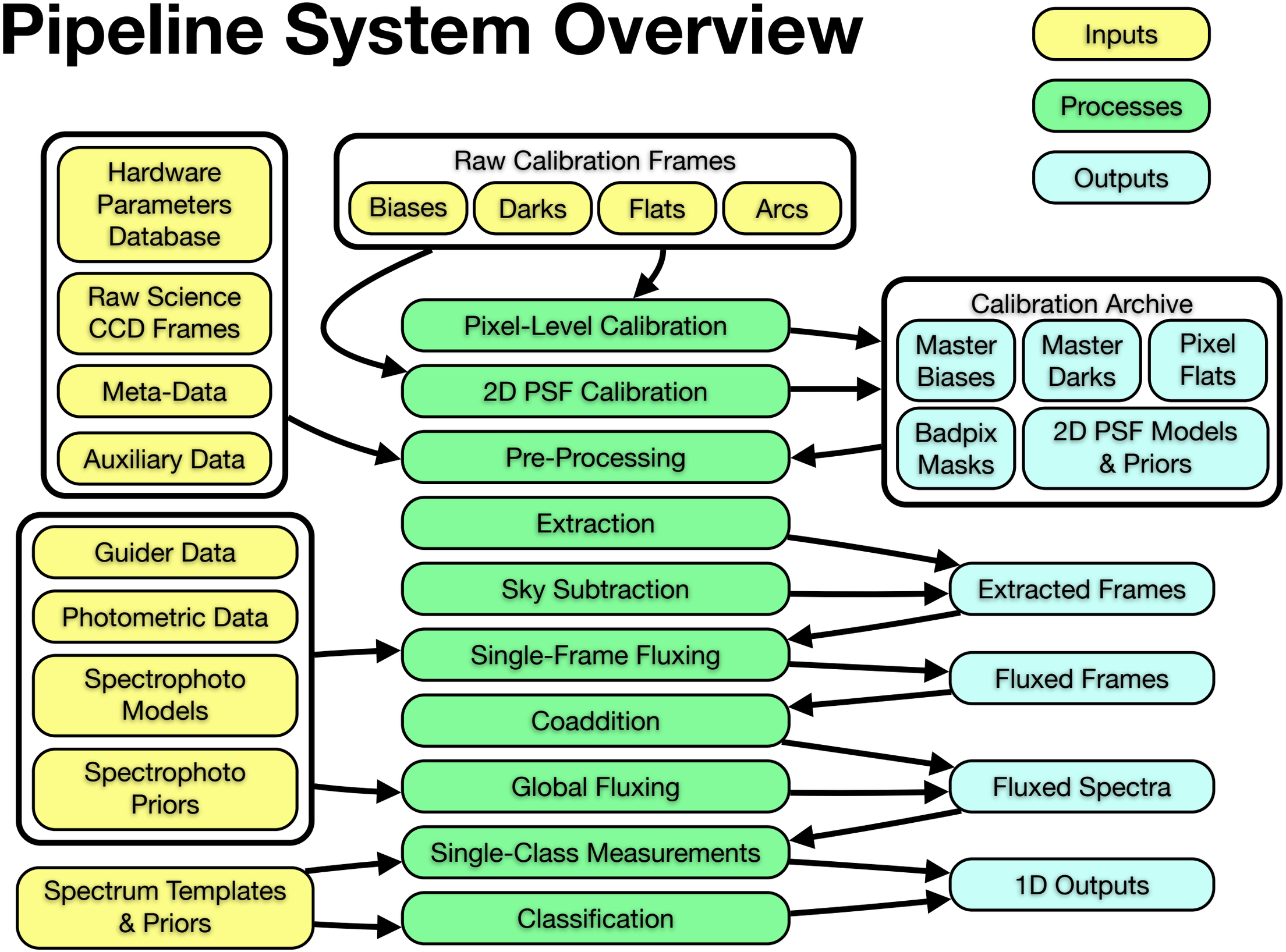




BOSS Pipeline Performance Statistics

Target Sample	CMASS	LOWZ	QSO (2.2 < z < 3.5)
Sample classification success rate	98.7%	99.9%	79%
Target object confirmation rate	95.4%	99.2%	33.6%
Completeness vs. visual inspections	99.6%	100%	98.3%
Purity vs. visual inspections	99.8%	100%	99.4%

Pipeline System Overview



Current and Future Development

- Archetype-based redshift measurement
- More flexible template-class management
- Joint fit to spectroscopic and photometric data
- Unifying redshift and parameter measurement
- Hierarchical Bayesian priors for redshift distribution and physical parameter distributions
- Greater quasar redshift accuracy control
- Performance analysis and optimization for emission-line galaxy (ELG) target class
- Next-generation extraction algorithms