The DESTINY of Lensing

Douglas Clowe
Ohio University


DESTINY
Dark Energy Space
Telescope

Destiny Science Team

PI: Tod R. Lauer (*NOAO*)

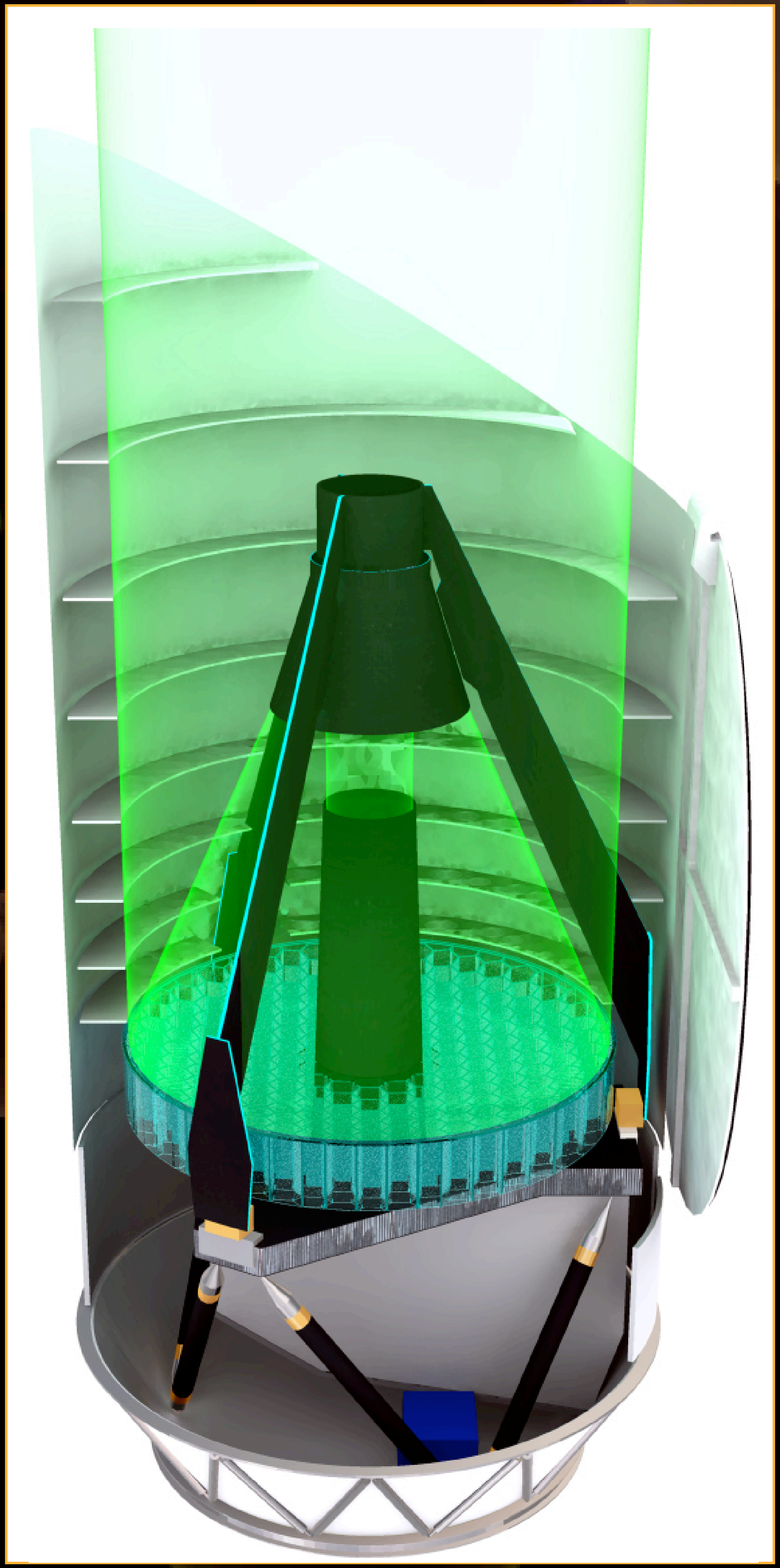
Deputy PI: Dominic Benford (*GSFC)*

Matthew Beasley (*Colorado*)
Chris Burns (*OCIW*)
Kenneth Carpenter (*GSFC*)
Doug Clowe (*Ohio U*)
Ian Dellantonio (*Brown*)
Megan Donahue (*MSU*)
Chris Fassnacht (*UC Davis*)
Wendy Freedman (*OCIW*)
Chris Fryer (*LANL*)
Jay Holberg (*Arizona*)
Aimee Hungerford (*LANL*)
Robert Kirshner (*Harvard*)
Lloyd Knox (*UC Davis*)
Lori Lubin (*UC Davis*)
Sangeeta Malhotra (*ASU*)

Tom Matheson (*NOAO*)
Phillip Pinto (*Arizona*)
Marc Postman (*STScI*)
Yong-Seon Song (*Chicago*)
George Sonneborn (*GSFC*)
Sumner Starrfield (*ASU*)
James Rhoads (*ASU*)
Nicholas Suntzeff (*TAMU*)
Thomas Vestrand (*LANL*)
Robert Woodruff (*LMCO*)
Frank Timmes (*LANL*)
Mike Warren (*LANL*)
Rogier Windhorst (*ASU*)
Ann Zabludoff (*Arizona*)

Optical Design

- 1.65m primary, ULE glass
- Three-mirror anastigmat
- 0.15″ @ 1μm
- Only movable parts are secondary mirror and filter wheel



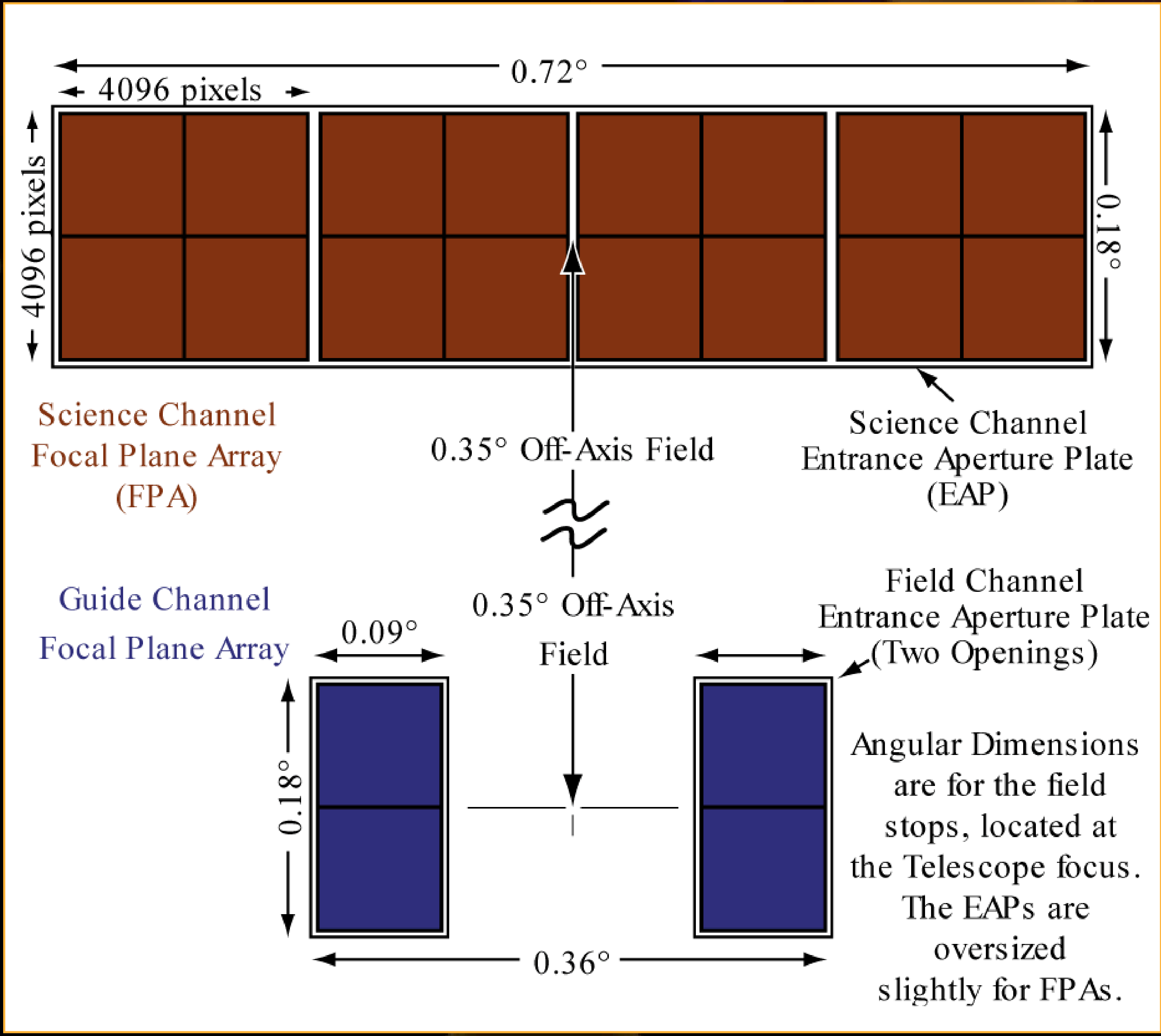
Instrument Parameters

- Science FOV: 0.18° x 0.72°
- Survey areas: SN: 3.2 deg^2; WL: 600 deg^2
- Survey time: SN: 2 yrs; WL: 1 yr

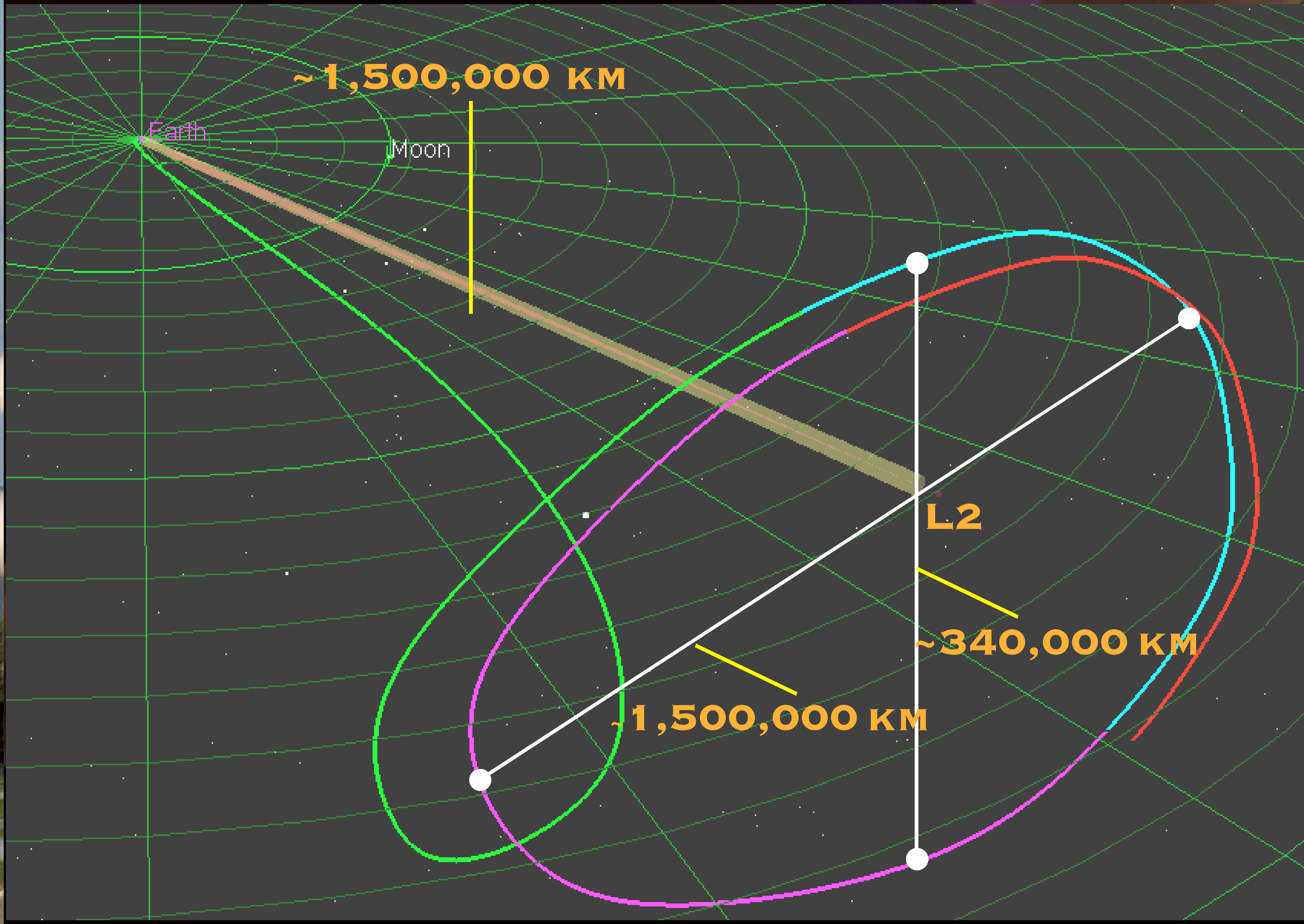
- λ: 0.85-1.7μm $\therefore$ $0.4 \leq z \leq 1.7$
- $\lambda/\Delta\lambda = 75$
- Pointing: 0.010″
- Thermal control: passive; FPA 150K
- 0.15″ Pixels - will require subpixel dithering in surveys for best resolution

Focal Plane Layout

- Science FPAs:
  2k x 2k arrays, 2 x 8 mosaic
- Guide FPAs:
  2k x 2k arrays, 2 x 2 sparse mosaic



Launch Around 2013



DESTINY Surveys

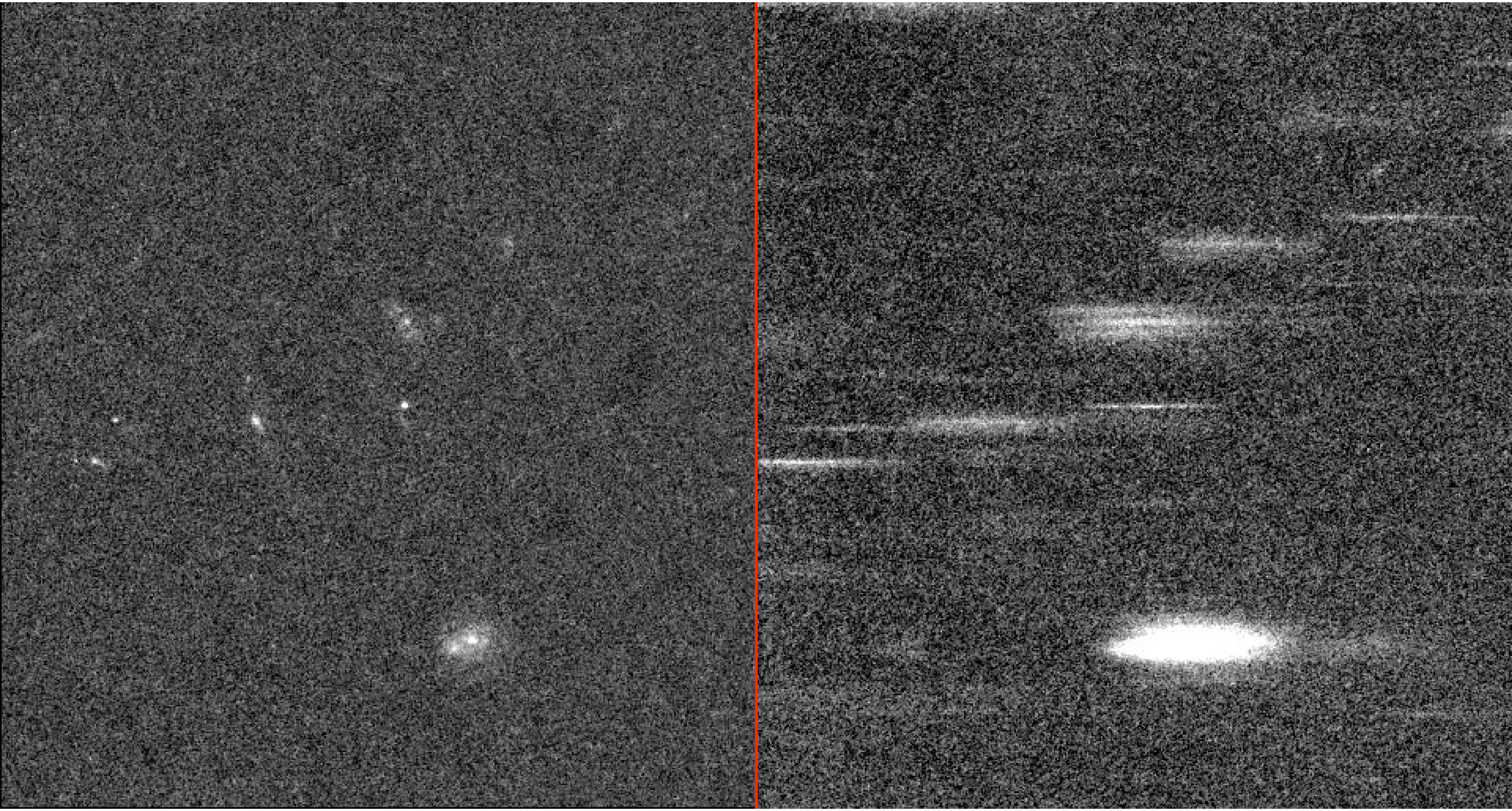
- SN1a survey over 3°^{2} - first two years
- WL survey 600°^{2} - third year—leverages imaging and spectroscopy.
- Medium-deep lensing survey with ~50 resolved galaxies/arcmin^2, emission line redshifts for 5-10.
- Goal of w_0 to 0.05 and w_a to 0.20
- *Complete heritage - use the minimal instrument required*
- *Do only in space what must be done in space - leverage ground based observations.*
- *All spectra all the time. Complete spectro-photometric time series on all SN events, spectral coverage of all lensing targets.*
- *Highly automated survey - no time critical operations.*

Weak lensing method

The Destiny survey is positioned to take advantage of the two primary weak lensing techniques– shear power spectrum cross-correlation, and weak lensing tomography.

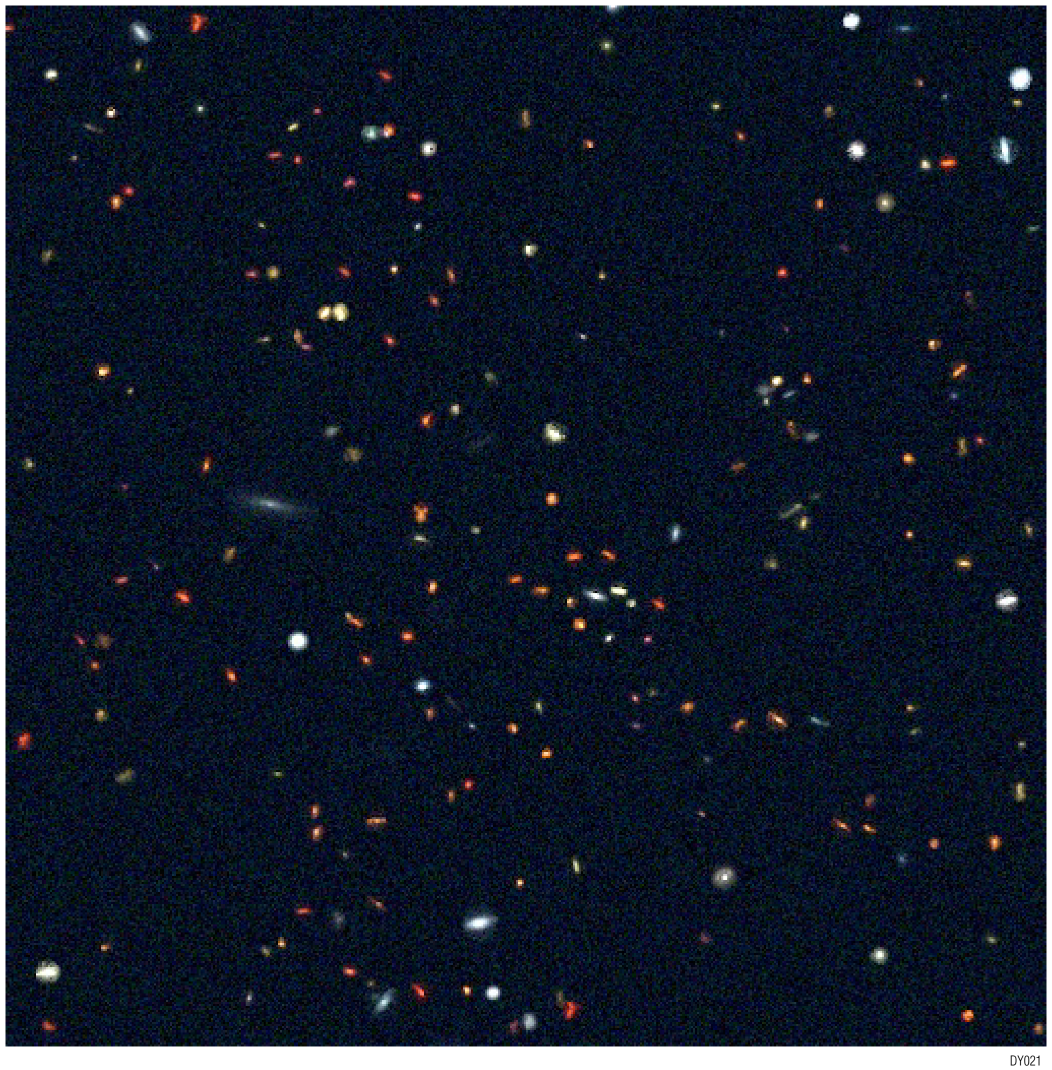
This is possible because of the spectral coverage of the slitless spectroscopy.

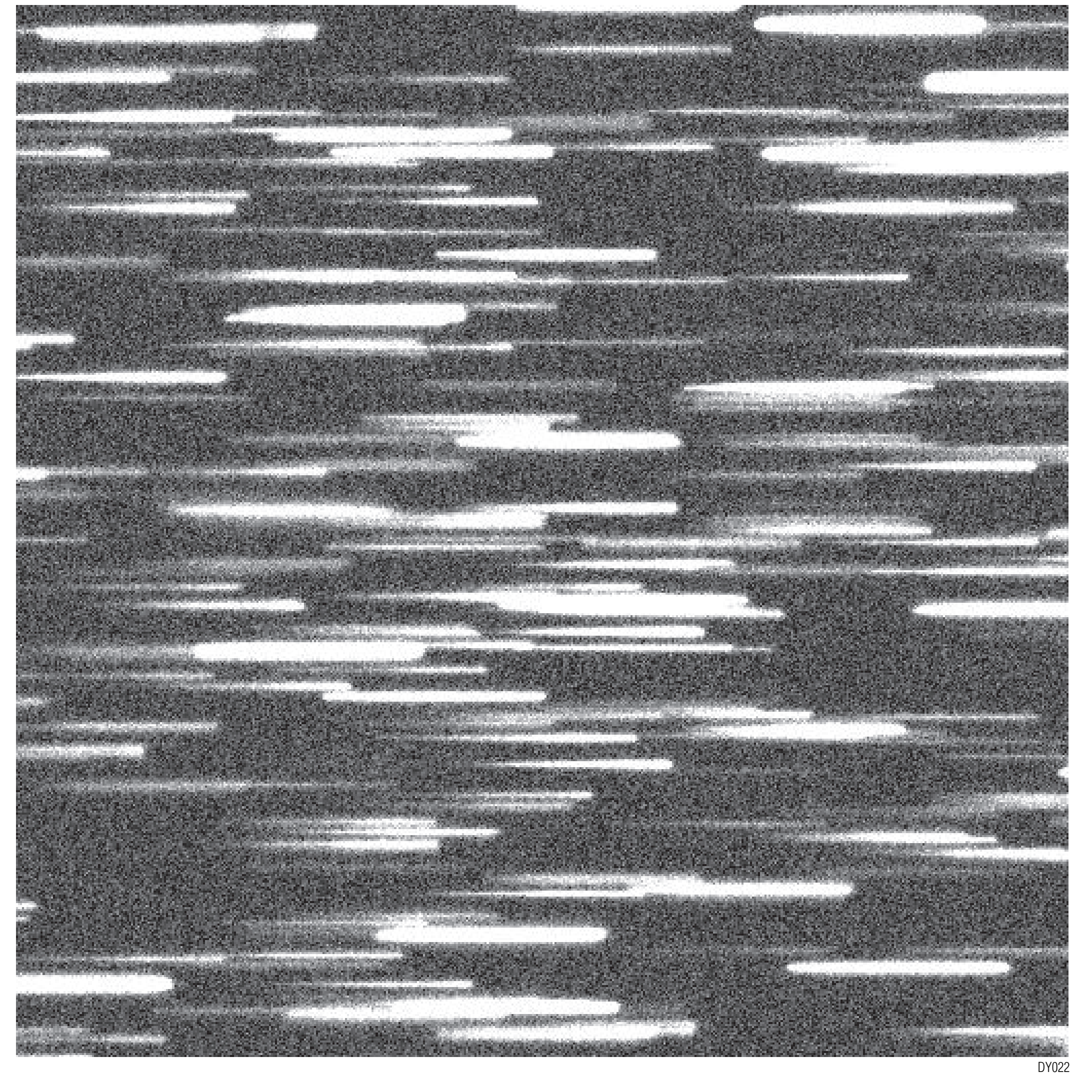
ACS Grism Images of SN2002FW (z = 1.30)



Riess et al. (2004)

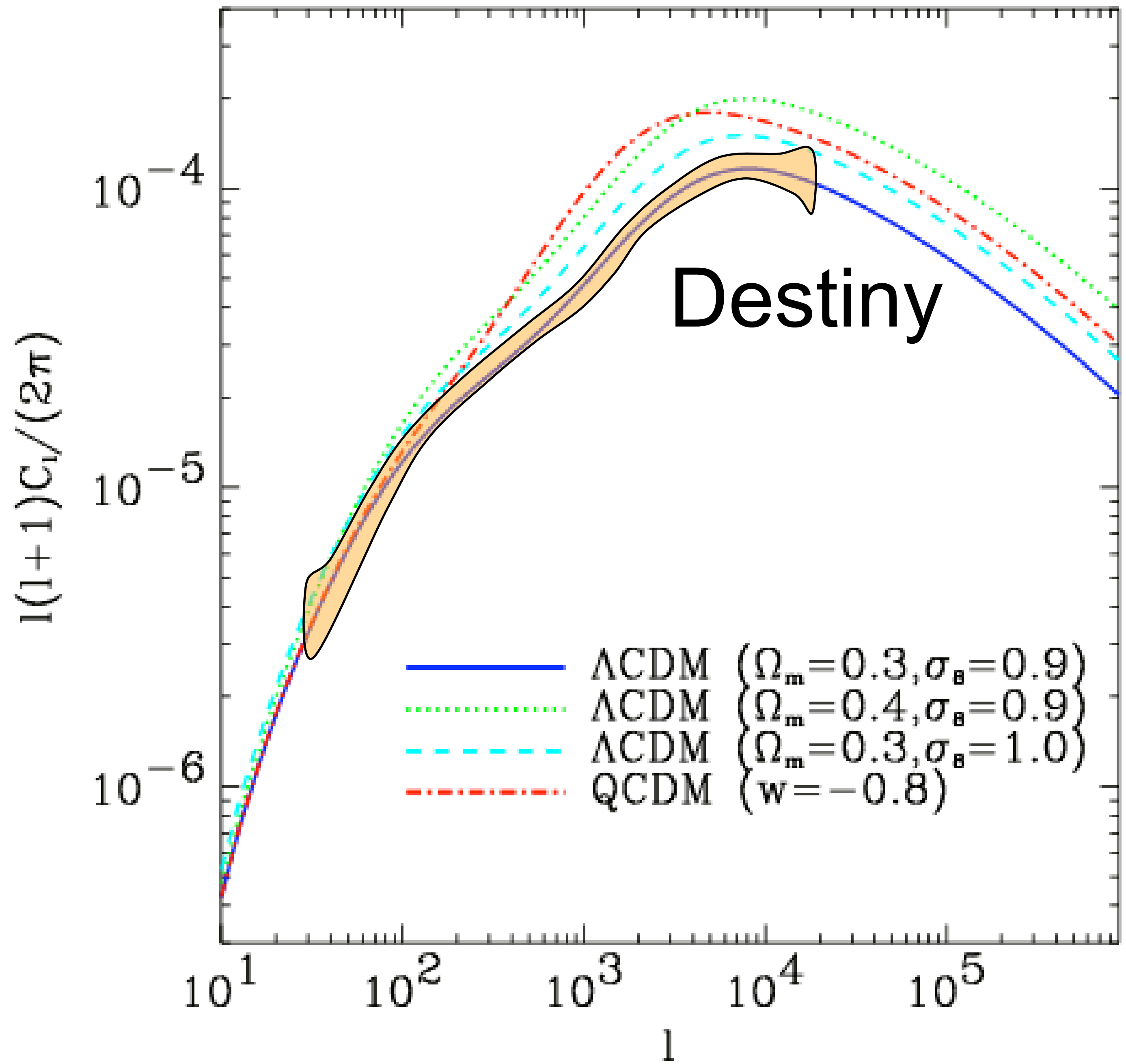
WL Observations





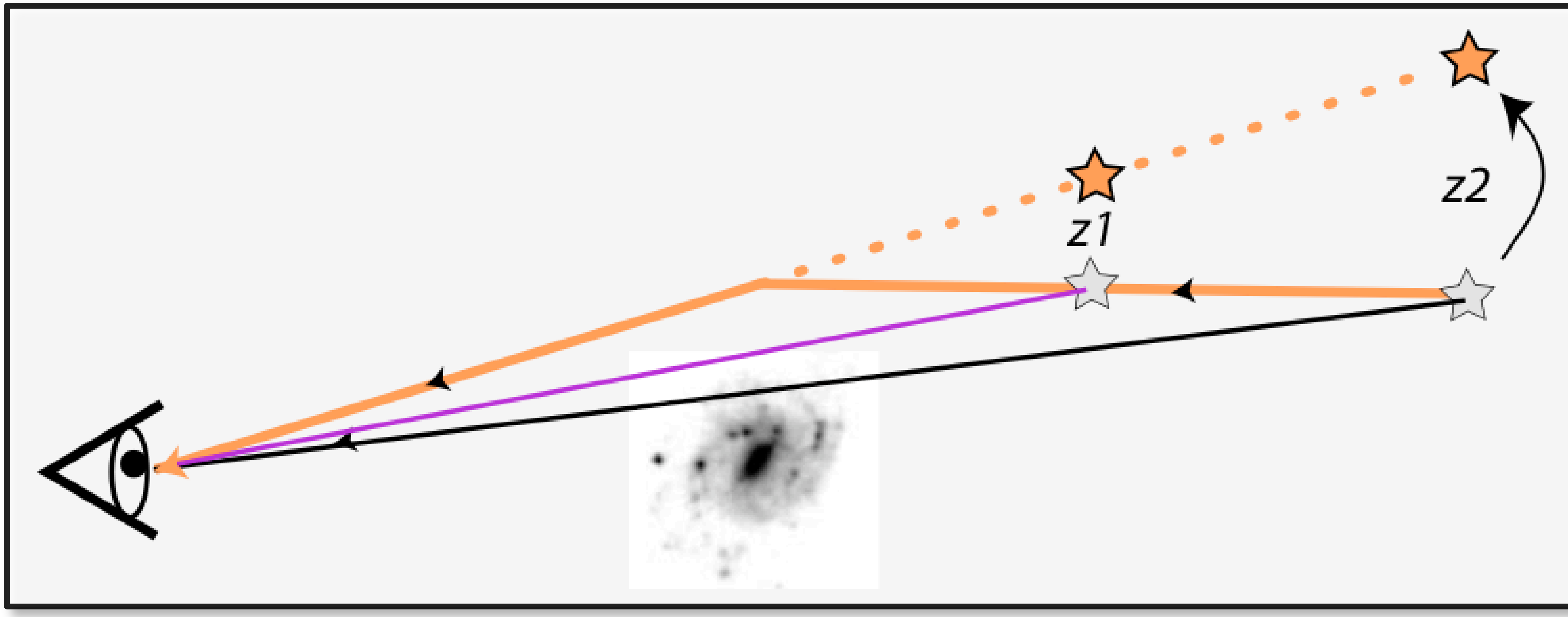
1. Filter: Locate and measure shapes of galaxies
2. Spectroscopy: Obtain low resolution spectra of each galaxy, positions known from imaging at the same location
3. Use natural rotation of field on revisits to disentangle overlapping spectra.

Weak Lensing Measurement



$$C_\ell^{x_a x_b} = \int dz \frac{H(z)}{D_A^2(z)} W_a(z) W_b(z) P^{s_a s_b}(k = \ell / D_A; z)$$

Tomography



Ratio of Deflection Angles:

(Slide borrowed from G. Bernstein, 2005)

$$\frac{\delta\theta_1}{\delta\theta_2} = \frac{\left(\frac{D_{LS}}{D_S}\right)_1}{\left(\frac{D_{LS}}{D_S}\right)_2}$$

Needs very good redshift resolution and extremely sensitive to bias in photo-zs!

No knowledge of foreground mass is required!

Destiny's unique advantages.

- Resolution (at z we will have ~4x the image resolution of LSST). This has several consequences:
  - A higher density of resolved sources; less than half of the $25<R<26$ sources are resolved in ground-based imaging.
  - Higher S/N for a fixed exposure time
  - Better shape measurements of the resolved sources.

Destiny advantages (cont.)

- Accurate photo-z from NIR spectroscopy, supported by SN-survey redshifts and ground-based imaging
  - Choice of bands in NIR can be tailored for redshifts.
  - We can piggy-back off existing (or soon-to-be existing) ground-based optical surveys for optical colors to supplement the NIR spectroscopy.
  - We have the supernova survey to lean on. With a typical exposure around 5×10^5 seconds, the SN survey will produce redshifts of ~10^5 galaxies (about 40 per square arcminute) — this is a huge resource for calibrating redshifts.

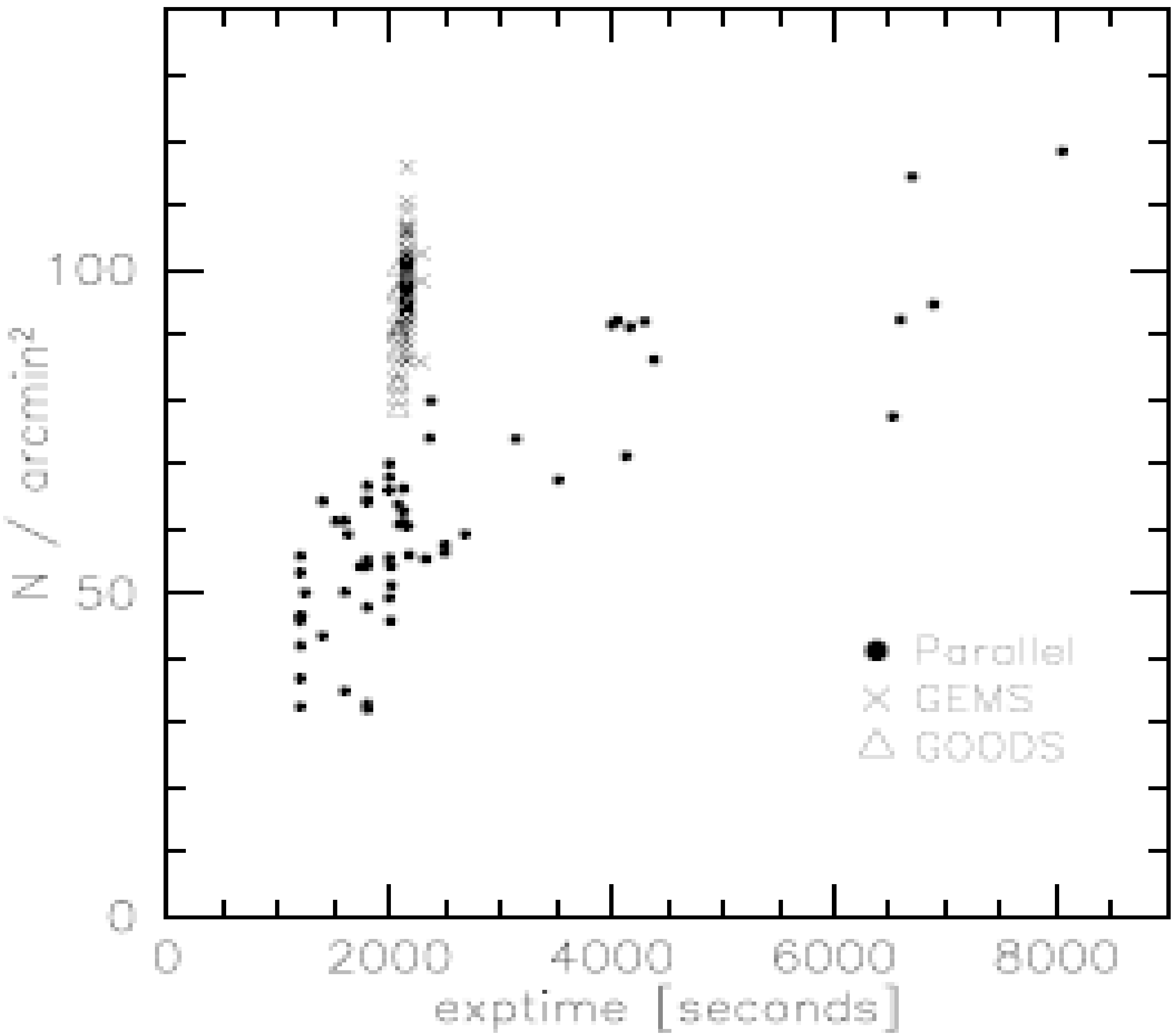
This means redshift estimates that are more reliable and have less bias than broad-band photo-z's!

Number of resolved sources versus exposure time for ACS:

From Schrabback et al., 2007

Sweet spot at 50 resolved objects for ~1 micron imaging in ~2000 seconds of imaging.

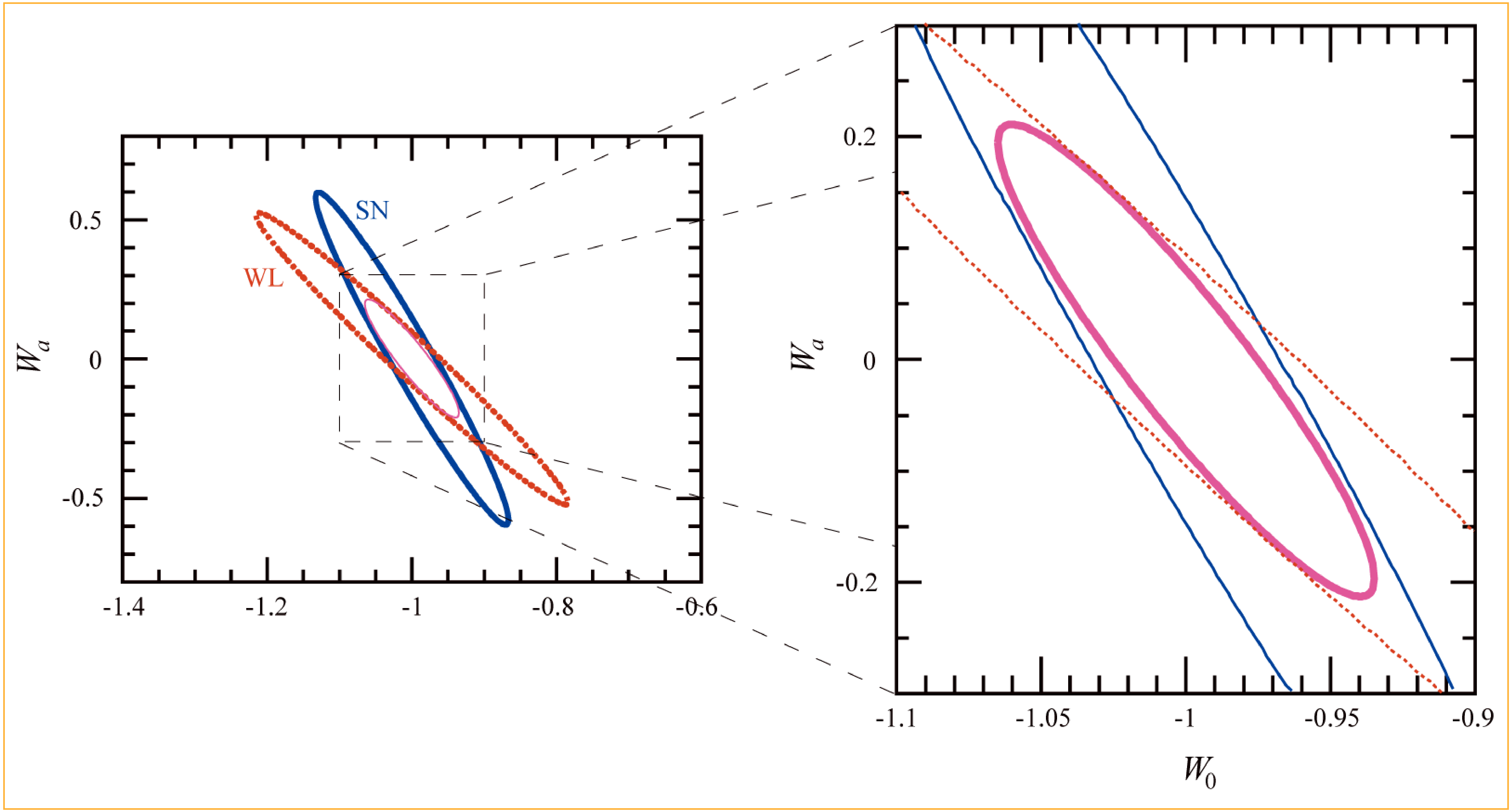
Sub-pixel dithering required to recover diffraction limit in both imaging/ spectroscopy



Survey Plan

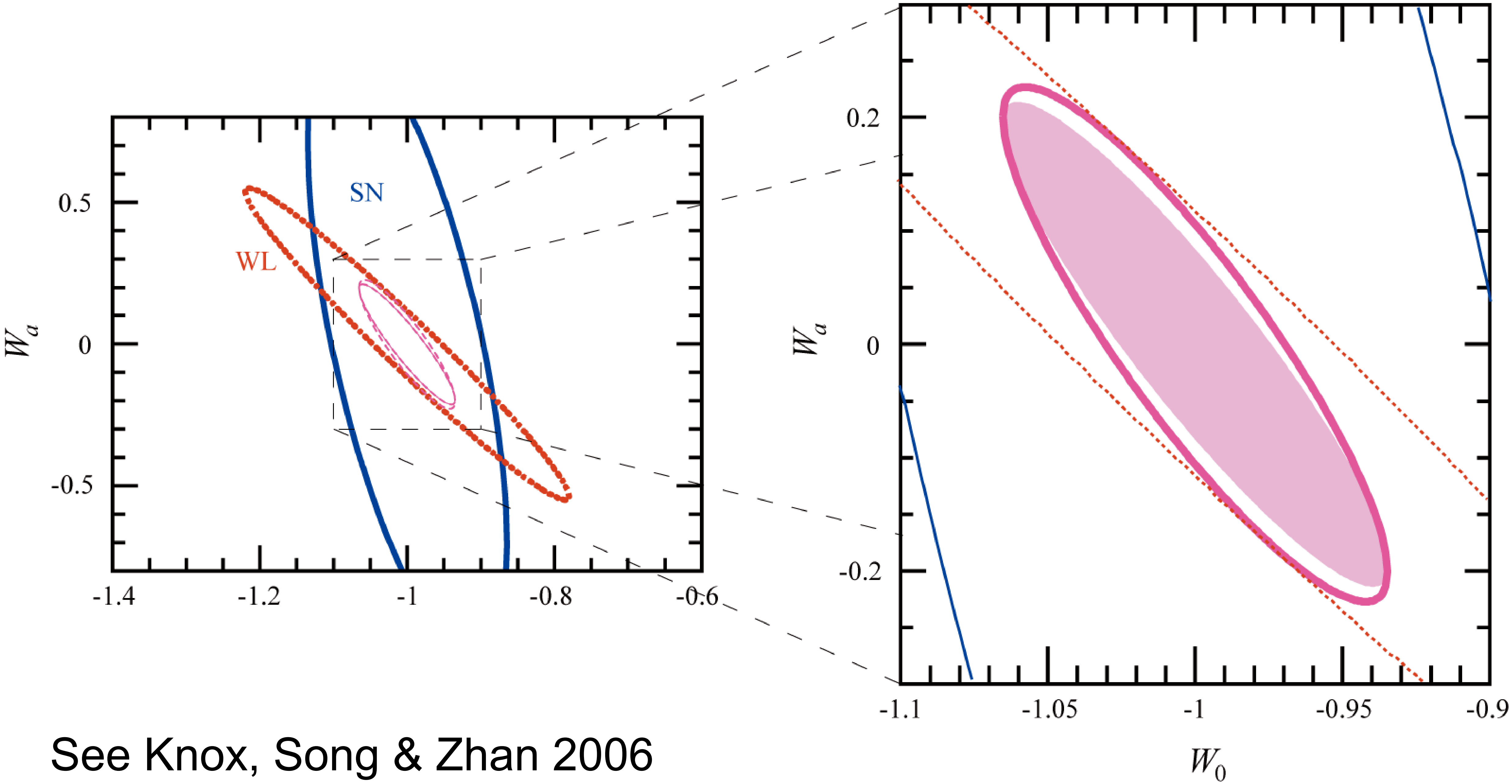
- 600 square degree survey, split evenly over northern and southern ecliptic poles.
- Roughly 70 minutes of spectroscopy, 30 minutes of imaging per field.
- One narrow imaging band at short λ (around 1 micron) to measure shapes. 6-8 sub-pixel dither positions per pointing for PSF reconstruction.
- Spectra covering one full octave of frequency. Revisits every 2 months ensure field rotation for the spectra to disentangle overlaps.

Predicted Survey Results



Assuming a Flat Universe

Predicted Survey Results



See Knox, Song & Zhan 2006

Not Assuming a Flat Universe