The WFIRST Interim Design Reference Mission

Capabilities, Constraints, and Open Questions

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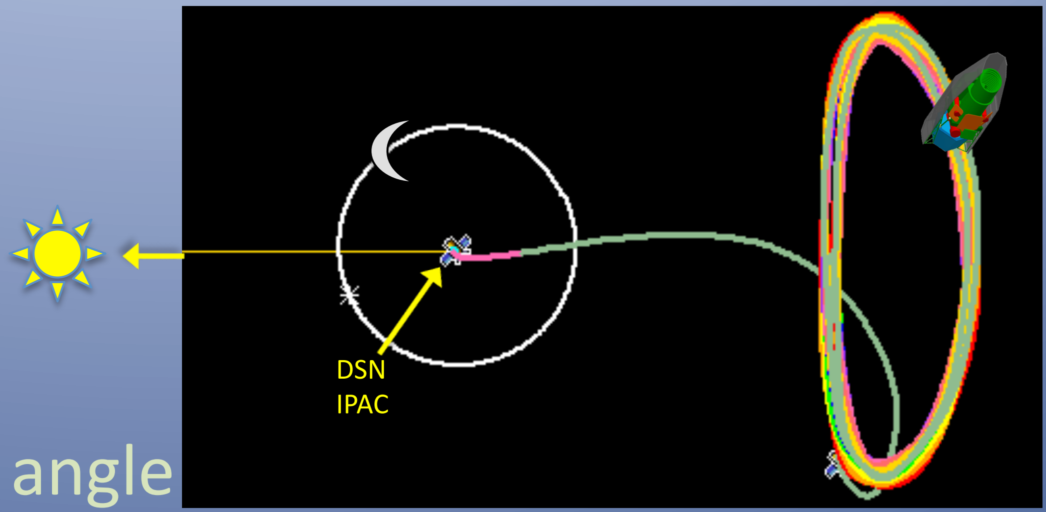
Disclaimer

- The capabilities and constraints described herein are for the Interim Design Reference Mission
  - Which evolved from the JDEM Omega RFI design
  - Which evolved from the SNAP/DESTINY/ADEPT mission concept studies and consultation with the Science Coordination Group
- The mission will continue to evolve in response to pressures of natural selection

Mission Description

- L2 Halo orbit
  - ~8 10^5km radius
  - 25°-35° Earth-Sun angle
- 5 year mission life
  - 10 year consumables
- DSN for communications
- Data Center at IPAC



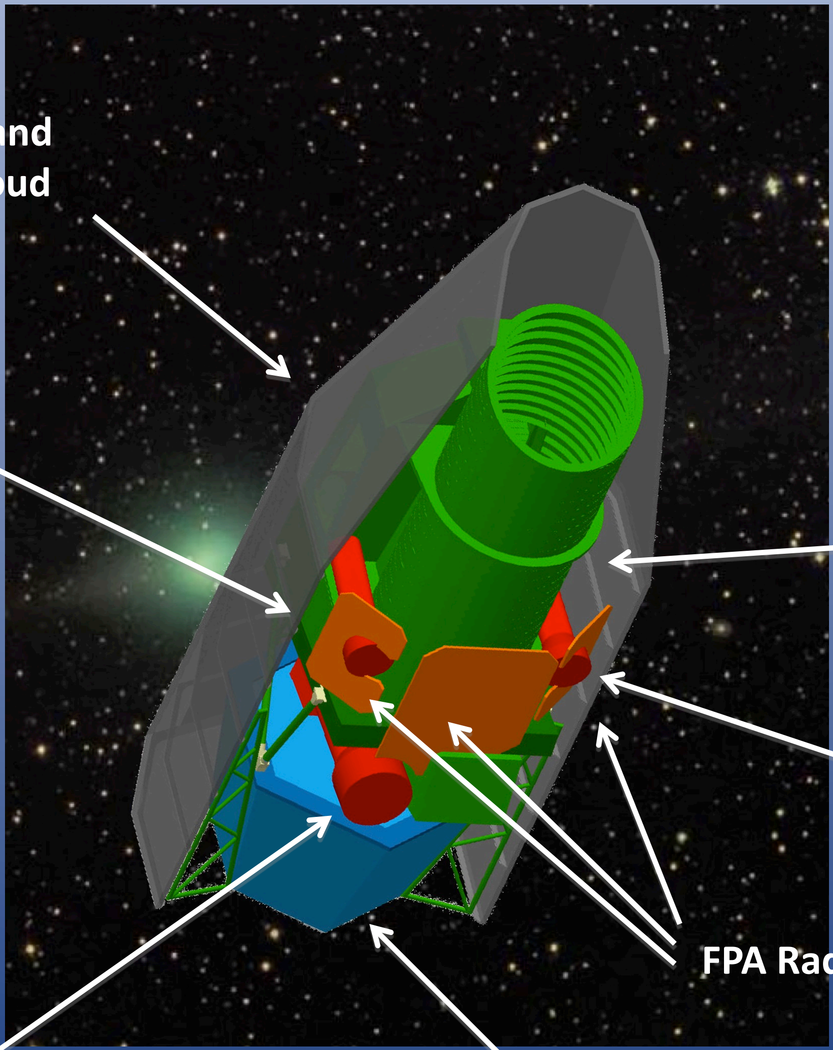
Sample Survey Program

- Wide Survey: 11,000 deg^2 per year
  - Optimized for galaxy redshift survey
- Deep Survey: 2,700 deg^2 per year
  - Optimized for weak lensing
- Deeper synoptic survey(s): 1.44 deg^2, 5.76 deg^2
  - 5-day revisit cadence for SNIa ($z<1.2$, $z<0.8$)
  - *Ranga Ram Chary talk yesterday: 1-10 PISN/deg^2/yr*
- Galactic bulge: 7 fields, 2.04 deg^2
  - 15 minute revisit cadence, nonstop over 72 days, for planetary microlensing
- Galactic plane survey
- Guest Observer program

Some Fine Print

- Deep Survey
  - 5 steps equal to detector gap size, 160 sec per exposure
  - Uniform ImC depth: 5 exposures at all points
  - Repeat for second filter, at 5° roll offset
  - Third filter at shallower depth
- Wide Survey
  - 2 steps to fill gaps, 150 sec per exposure
  - Repeat for second filter, at 5° roll offset
  - Stacking all data from both SpCs gives 6 out of 8 exposures at most points in survey
  - 30 deg^2 per day
- No synoptic repeat visits planned for these surveys

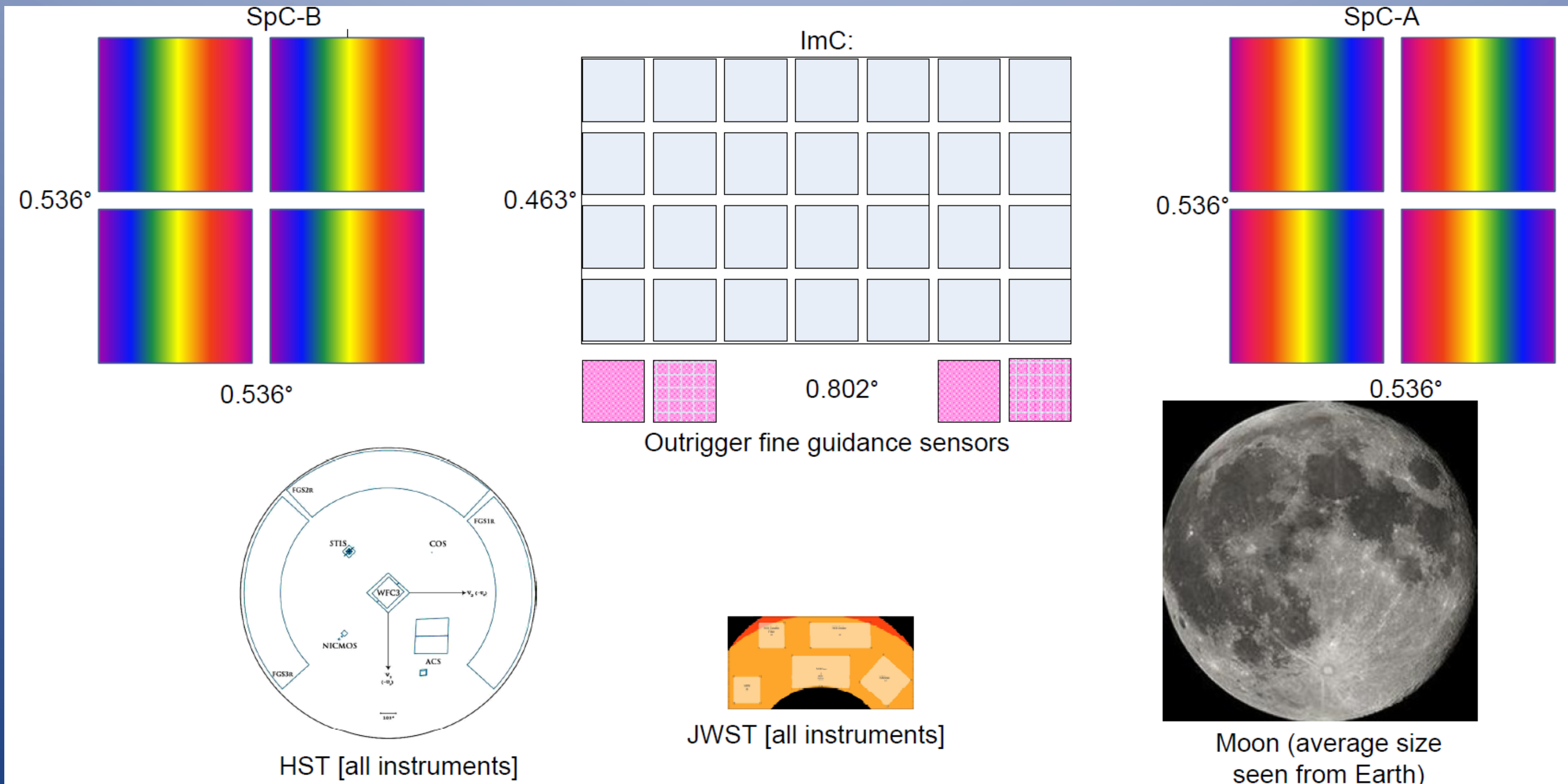
Observatory



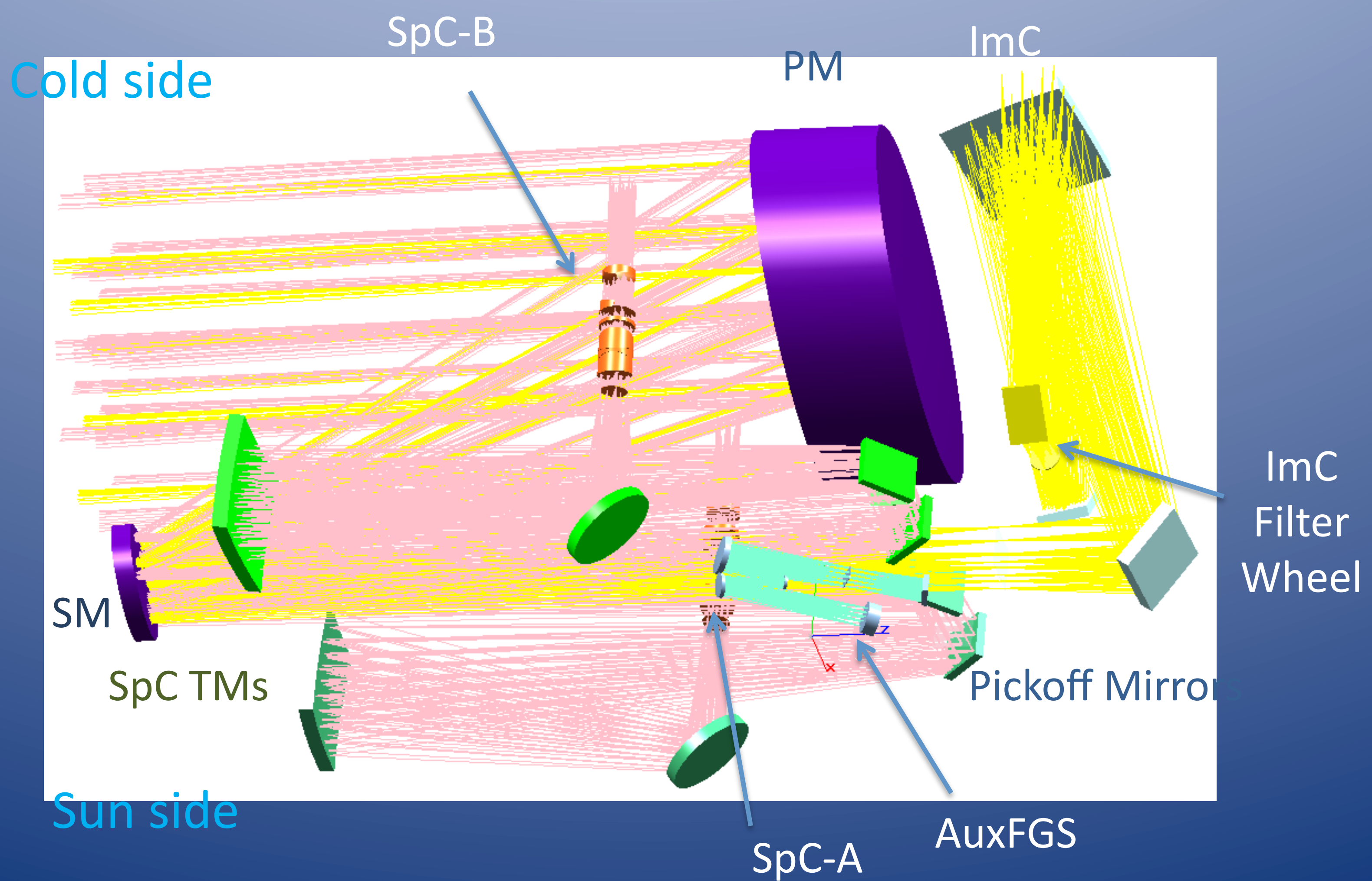
Payload

- Telescope: 1.3m un-obscured TMA
- Three instrument channels
  - Imager:
    - 7x4 H2RG HgCdTe, 0.18” arcsec/pixel
    - 5 filters plus R~75 prism for slitless spectroscopy
    - 0.76µm – 2.0µm
  - 2 Counter-dispersed slitless spectrometers:
    - 2x2 H2RG HgCdTe, 0.45”/pixel
    - R~230 (pt src, 2 pix resel), or 1250-1500 km/s/arcsec
    - 1.1µm – 2.0µm

Payload field of view



Optical layout



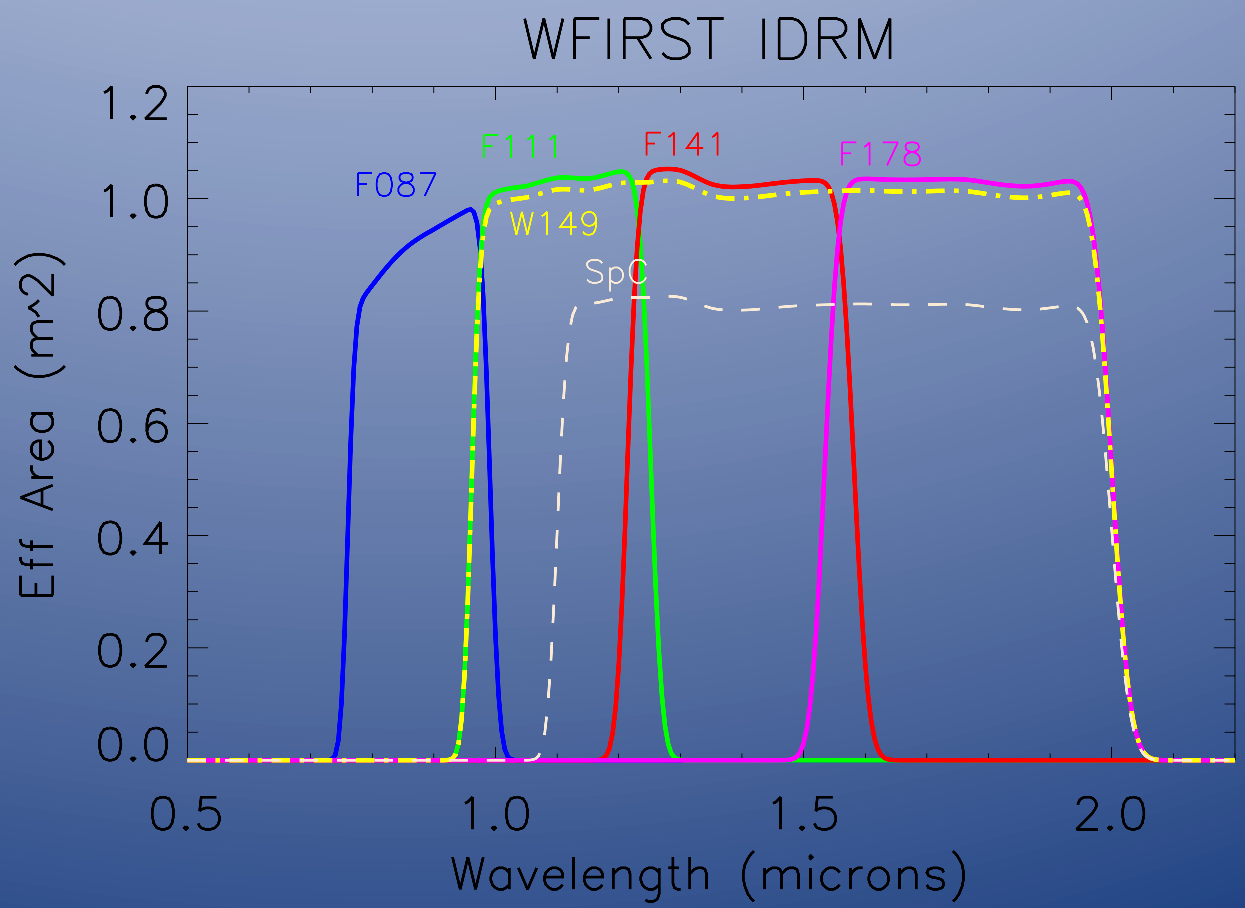
IDRM Effective Area

Plot shows Effective area for each filter and each SpC.

SN prism throughput is ~5% lower than the filters.

BAO prism thruput is higher in single-channel design.

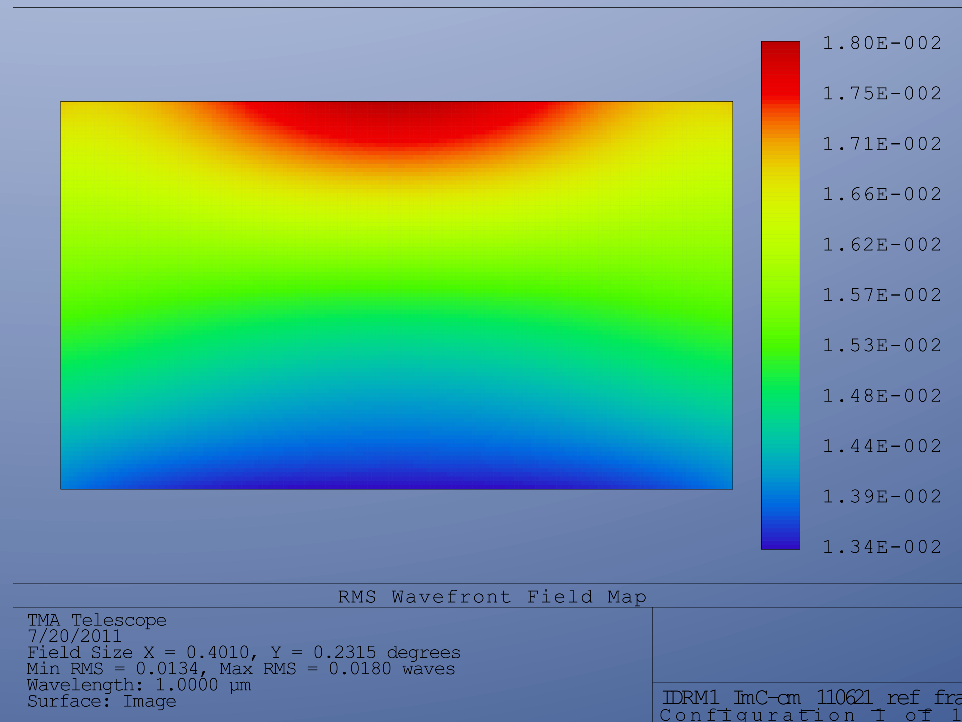
Det QE used here may be optimistic below ~1.3µm



System PSF

- ImC Net PSF:
  - (includes jitter, charge diffusion, pixelization, etc)

Filter	R(EE50) arcsec
F087	0.13
F111	0.14
F141	0.15
F178	0.18



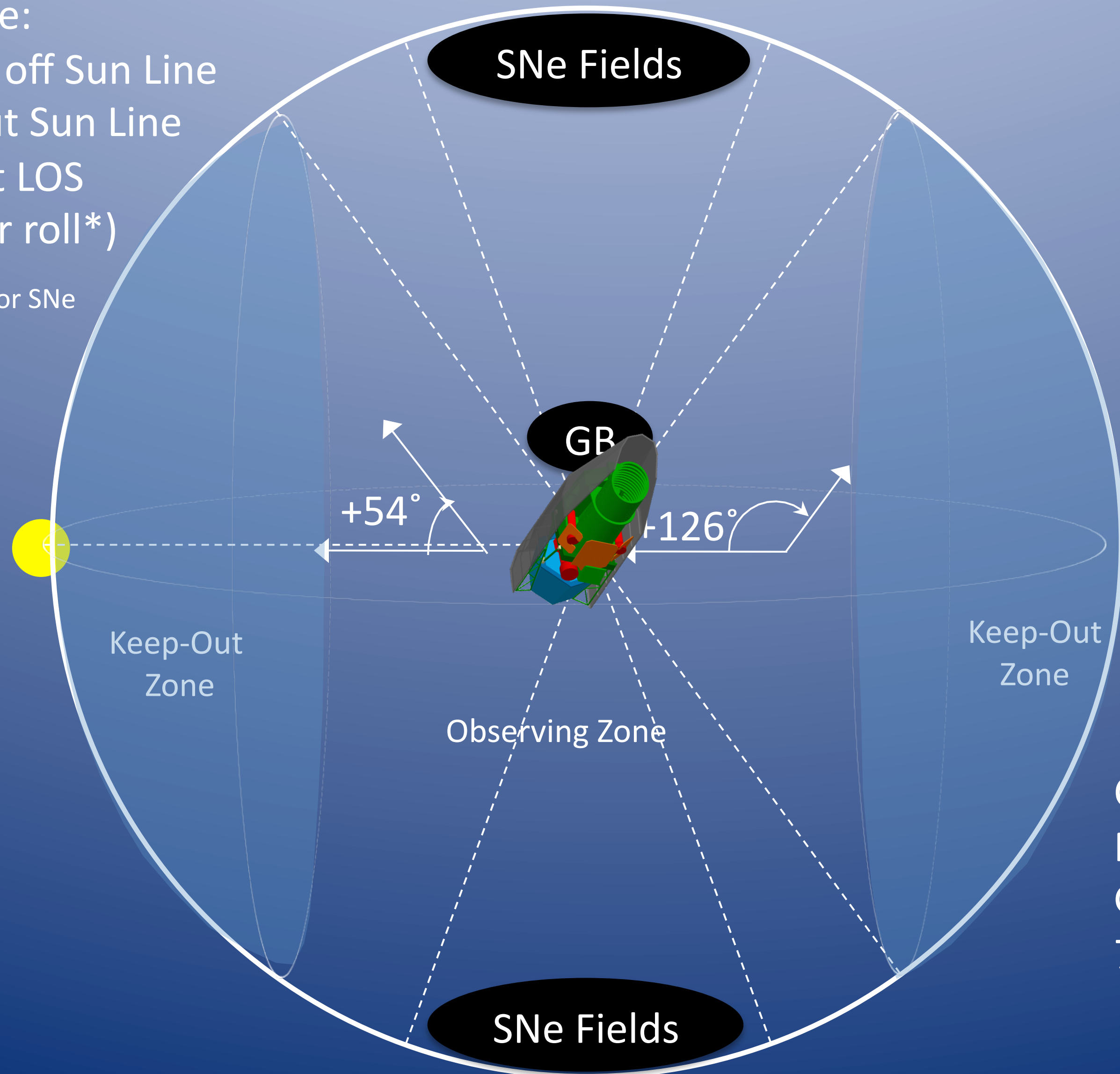
- Design residual wavefront error:
  - ImC: 13-18nm rms (map above)
    - Observatory budget: 83 nm
  - SpC: 35-73nm RMS
    - Observatory budget: 213 nm

SpC is under-sampled, but pixel scale is adequate for a galaxy redshift survey.

Field of Regard

Observing Zone:
54°-126° Pitch off Sun Line
360° Yaw about Sun Line
±10° roll about LOS
(off max power roll*)

* Larger roll allowed for SNe



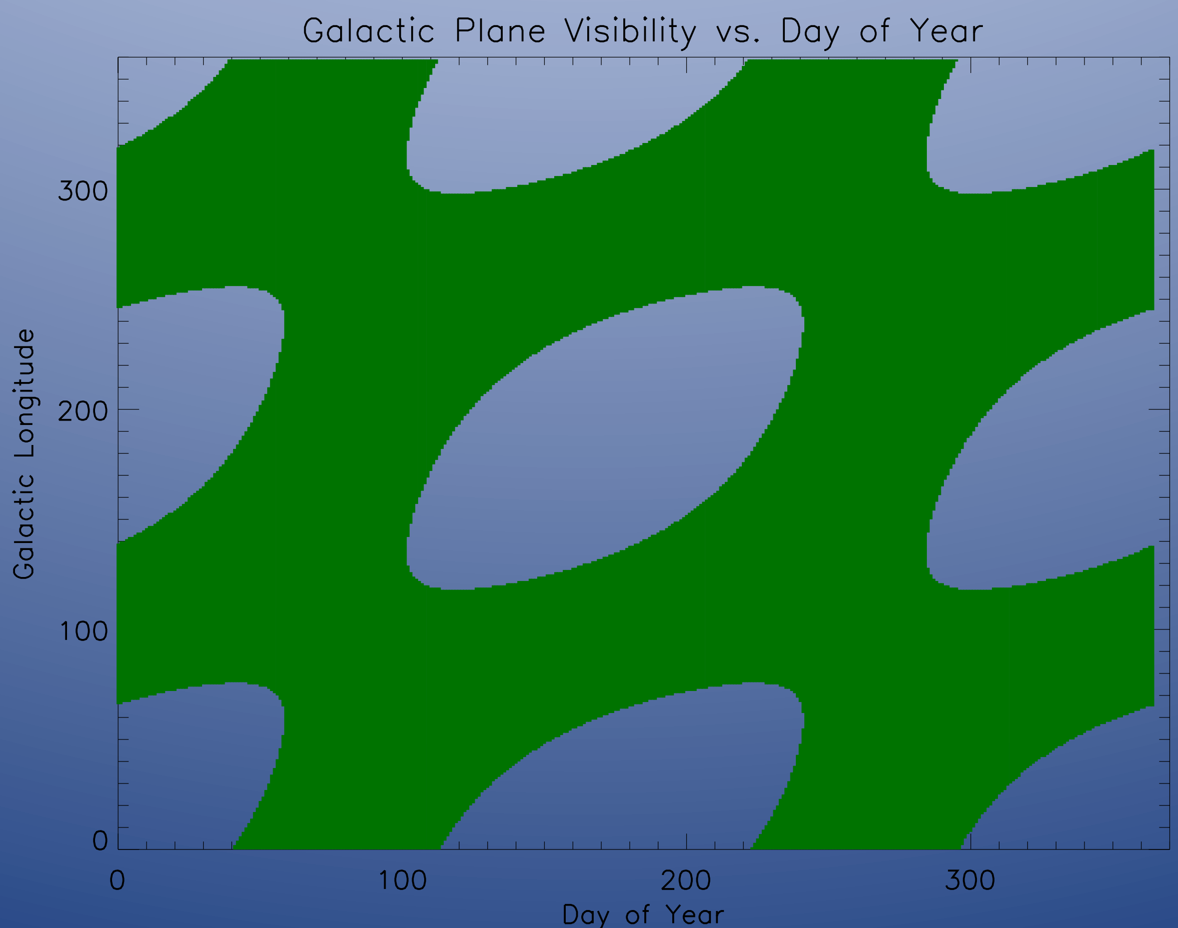
SNe Inertially Fixed Fields must be within 20° of one of the Ecliptic Poles, and can be rotated every ~45 days

Can observe Inertially Fixed Fields in the Galactic Bulge (GB) for 72 days twice a year

Scientific Pointing Constraints (scheduling)

- Microlensing campaigns can't be interrupted
  - 72-day campaigns twice a year; 7 campaigns total
- SNIa campaign can run at low duty-cycle (say one day out of five), but last two years.
- We could almost, but not quite, get both of these to fit in a five year plan.
- SNIa requires constant roll for 45 day intervals
  - interleaving with WL may be problematic due to abrupt changes in thermal environment
- Galactic plane survey conflicts w/microlensing

Galactic Plane Visibility



Pointing Performance

- Pointing jitter: < 40 mas rms, per axis
- Revisit accuracy: ~18 mas
  – Limited by settle time
- Short slews (survey steps): <60s, 30s goal
- Long slews: 180° in < 10 minutes
- The antenna is on a gimbal, so no observing time is lost to downlink
- Unload momentum by hydrazine thrusters

Dynamic Range

- Detectors will be read non-destructively, with frame-time of 1.3 seconds.
  - If 3 samples desired prior to saturation, can observe AB ~13 stars (AB~14 in W149)
  - Cosmic-ray rejection on-the-fly
    - List of CR corrections will be downlinked

Limiting sensitivity

WFIRST			
Imaging: 5σ point-source limiting magnitude (AB)			
WIDE	DEEP	SNIa-1	SNIa-2
24.8	25.75	28.0	28.75
Spectroscopy: 7σ limiting line flux (10^{-16} $ergs^{-1}$ cm^{-2} s^{-1})			
WIDE	DEEP	SNIa-1	SNIa-2
2.3	1.7	0.2	<0.1

Galactic Bulge nominal 5σ limiting magnitude = 30.2, but real limit is crowding
Spectroscopic limit is for galaxies with R(EE50)=0.2"

Euclid limiting sensitivity (from Red Book):
- Imaging 5σ point source in YJH: 24 (AB)
- Spectroscopy 3.5σ point source: 3.0 10^{-16} $ergs^{-1}$ cm^{-2} s^{-1}

Open Questions

- Bandpass: looking at extending to ~2.4μm
- Single channel optical design
  - Add prism wheel, move SpC detectors to ImC
  - Imaging faster, redshift survey slower; total time similar
    - Faster imaging relieves scheduling conflicts
  - More flexible for tailoring observing program
- 4kx4k detectors with 10μm pixels
  - Relieves conflict between fine sampling and large FoV
  - Readout slower -> fewer samples -> higher readnoise and fainter bright limit.
- IFU for SNIa spectroscopy
  - Cost benefit trades are complex

Single Channel Design