Issues for Future Progress: Practical Survey Design

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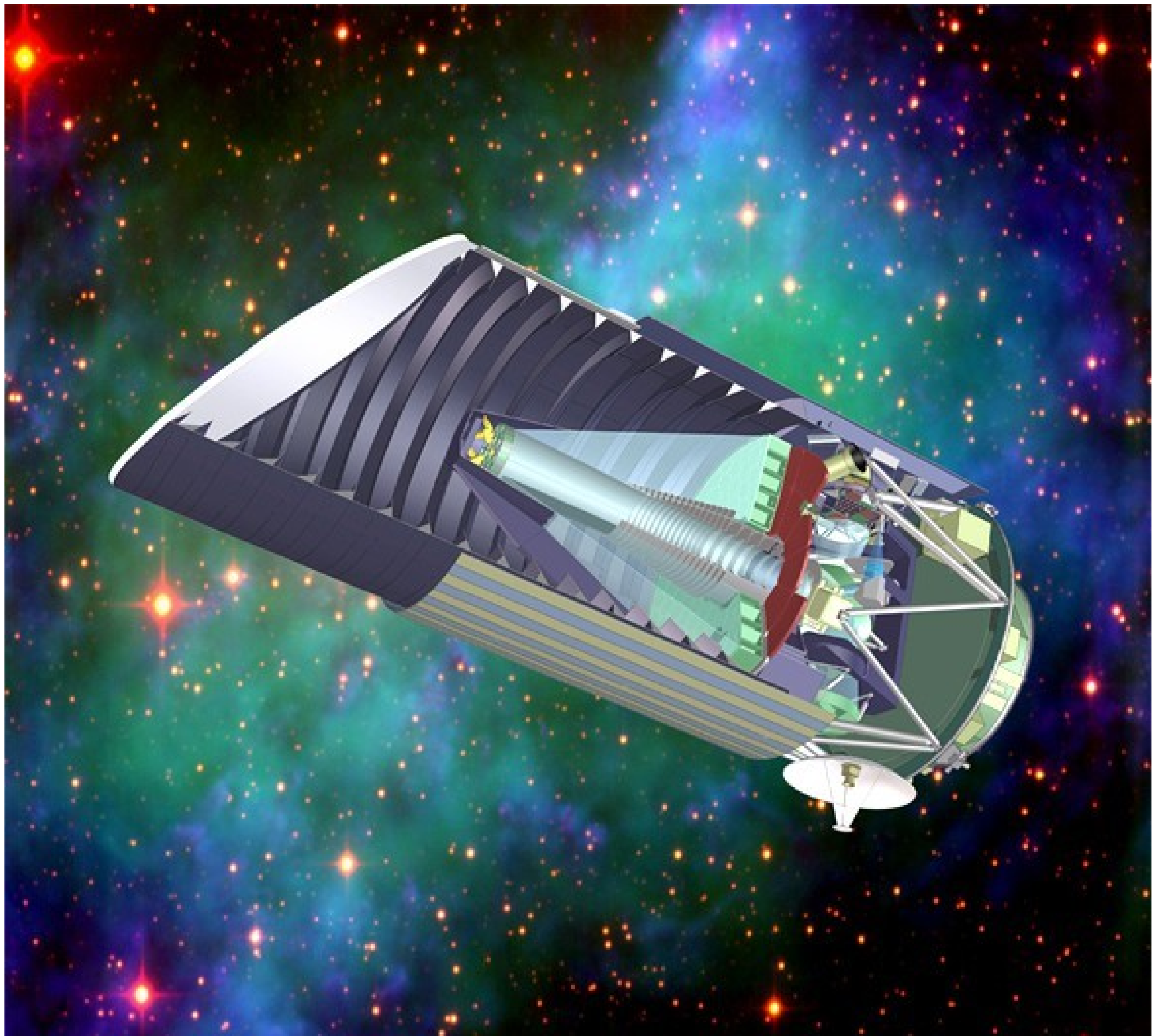
SNAP



SNAP: An Integrated Experiment

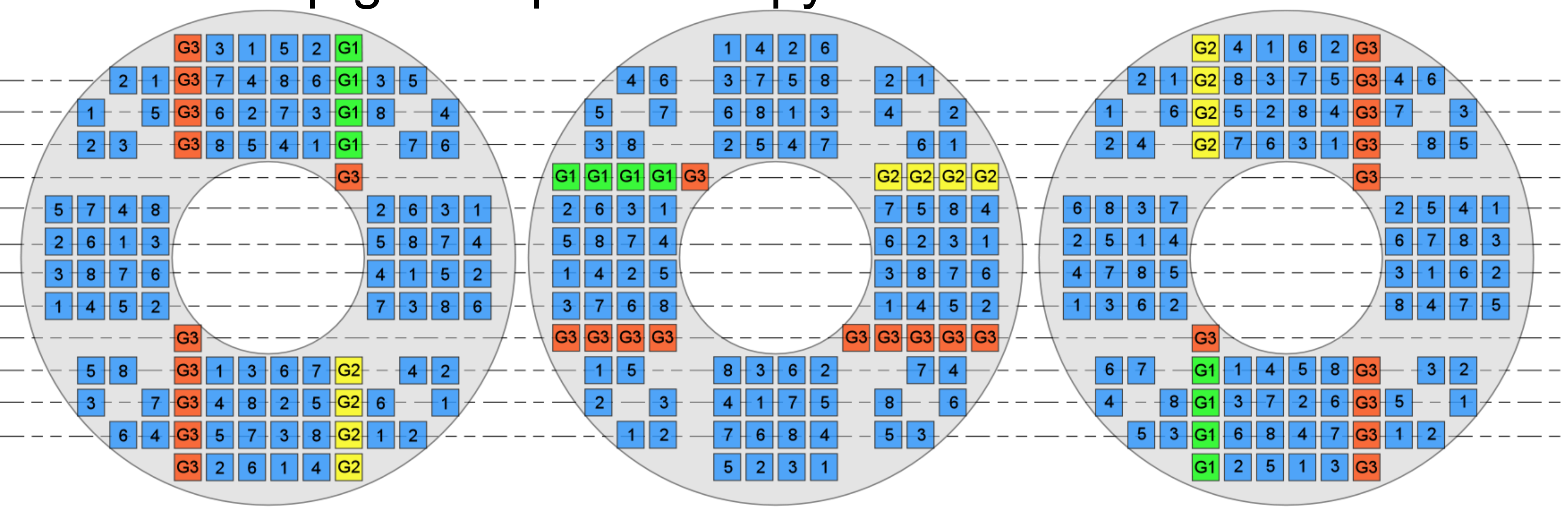
- Integrated science – statistical and systematic control with the union of SNe, WL, and BAO
- Integrated instruments
  - Imager used for SNe, WL
  - IFU used for SNe, WL
  - Grisms used for WL, BAO
- Integrated surveys
  - Deep survey contributes to SNe, WL PSF calibration, photo-z calibration
  - Wide survey for WL and BAO

Survey Challenges

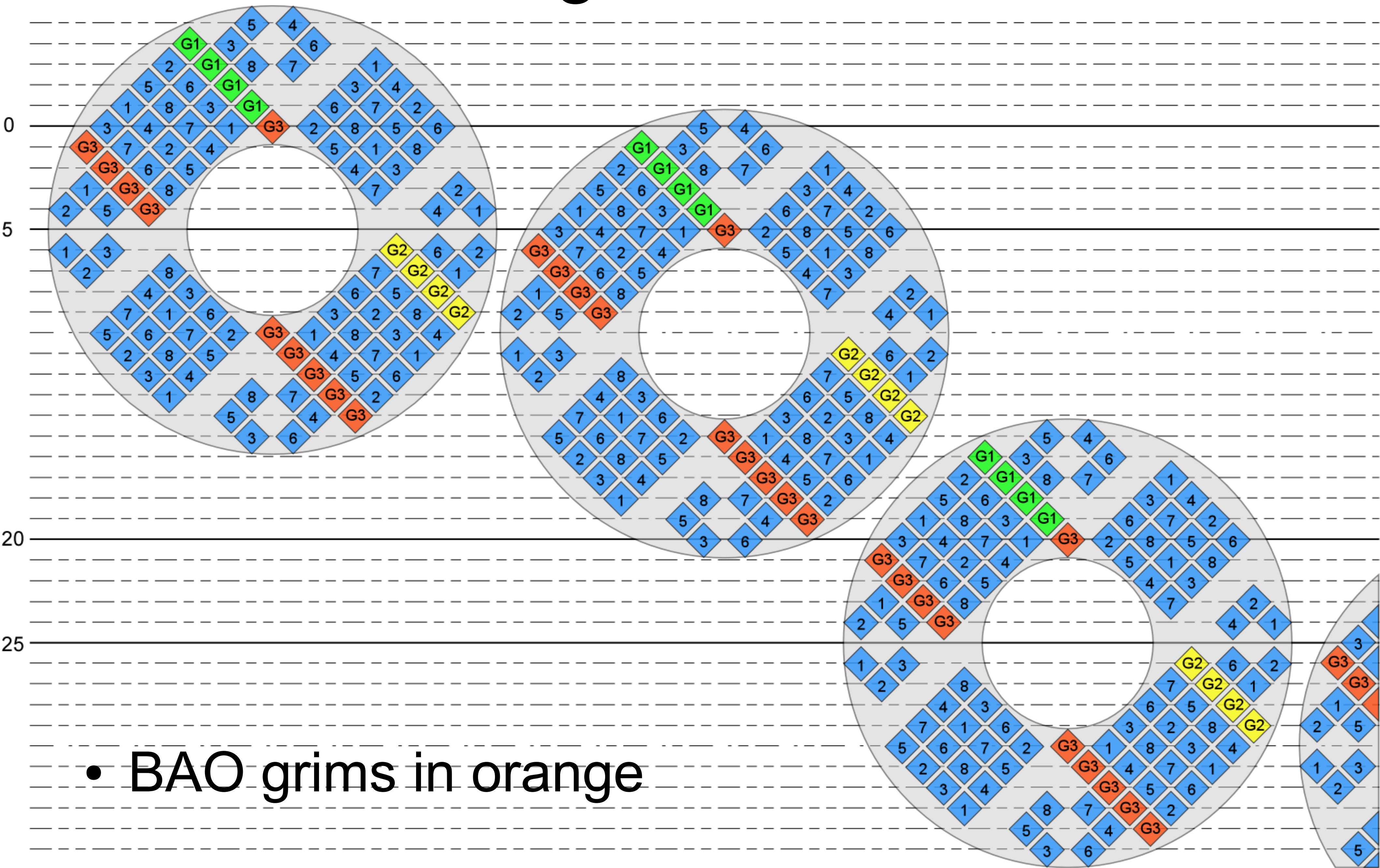
- Wide fields of view are optically challenging: compact detector layout fills precious focal plane
- Observing 8 bands with fixed filters
- Spacecraft orientation changes 4 times over the course of a year
- Filled survey area: no residual gaps from gaps between detectors
- SNAP solutions can be useful for other surveys

Horizontal Scan

- Shift by one detector pitch
- Works with 90 degree rotations
- Deep Survey
  - 8 independent bands (in blue) imaged in 10 rows
  - Deep grism spectroscopy in 2 rows



Diagonal Scan



- BAO grims in orange

Diagonal Scan

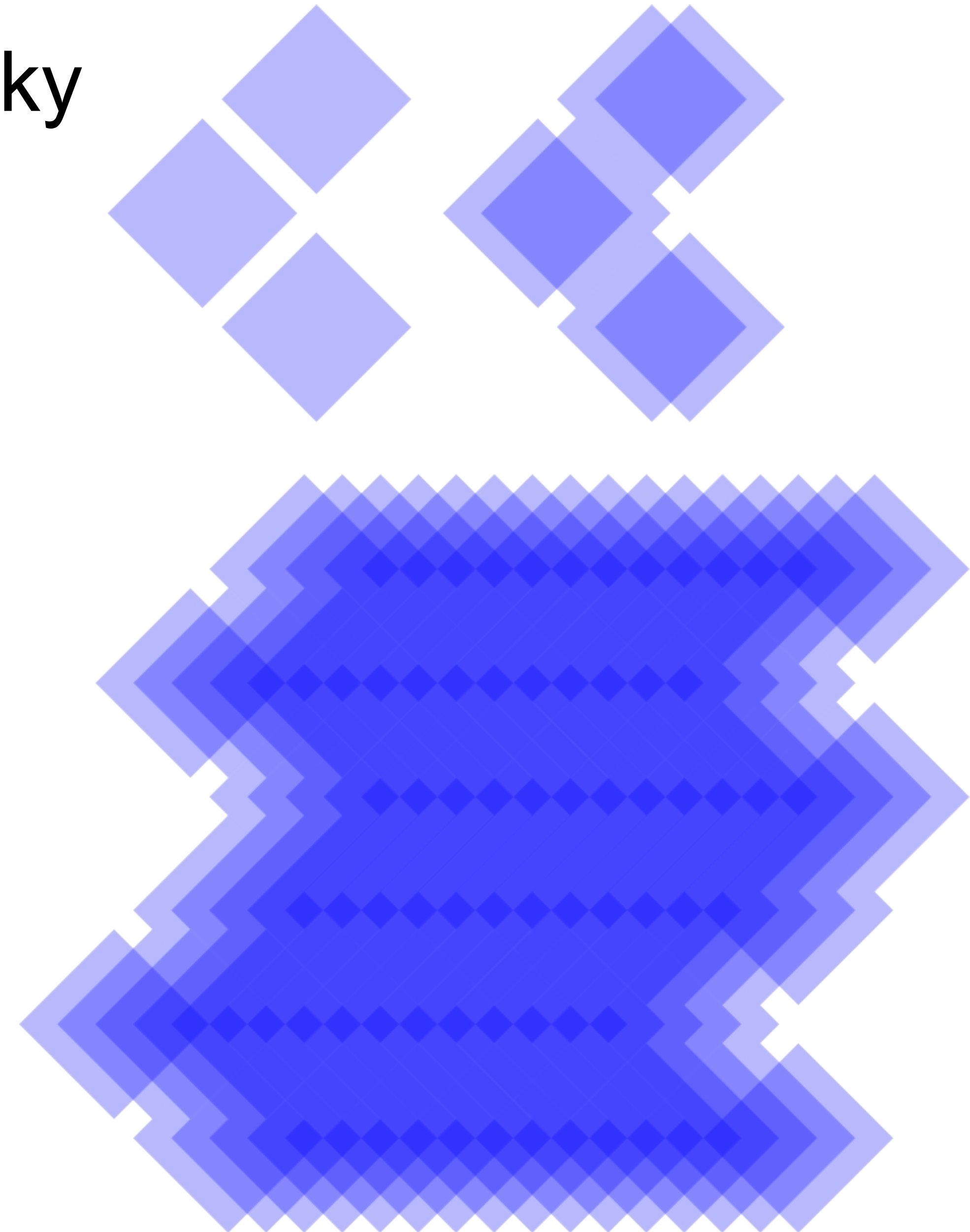
- Good focal plane defined by annulus: additional grism row in horizontal scan optically difficult
- Shift left by sqrt(2) detector pitch
- Shift down by alternating [5,10] sqrt(2) detector pitch
- Wide Survey
  - 8 independent bands + BAO grism imaged in 10 rows
- Large edge effect not good for deep survey

Focal Plane

- Inverse Sudoku problem: Non-trivial filter placement to ensure 8 independent filters per row for both horizontal and diagonal scans
- Science detector count: 88 imaging, 10 BAO grisms, 10 photo-z calib grisms
- Effective detectors (neglecting edge effects)
  - SN Imaging: 80
  - WL Imaging: 80
  - BAO: 10
- Have versions going down to ~30 imaging, ~6 grisms (and smaller without diag scan)

Filled Survey

- To get 4 exposures per sky
  - Detector pitch 6p
  - Detector width 5p
  - Step sqrt(2)p
  - Dense focal plane
- 5/6 with 4, 1/6 with 5
  - 96% efficiency to get 4
- (5/6)^2 good focal plane used

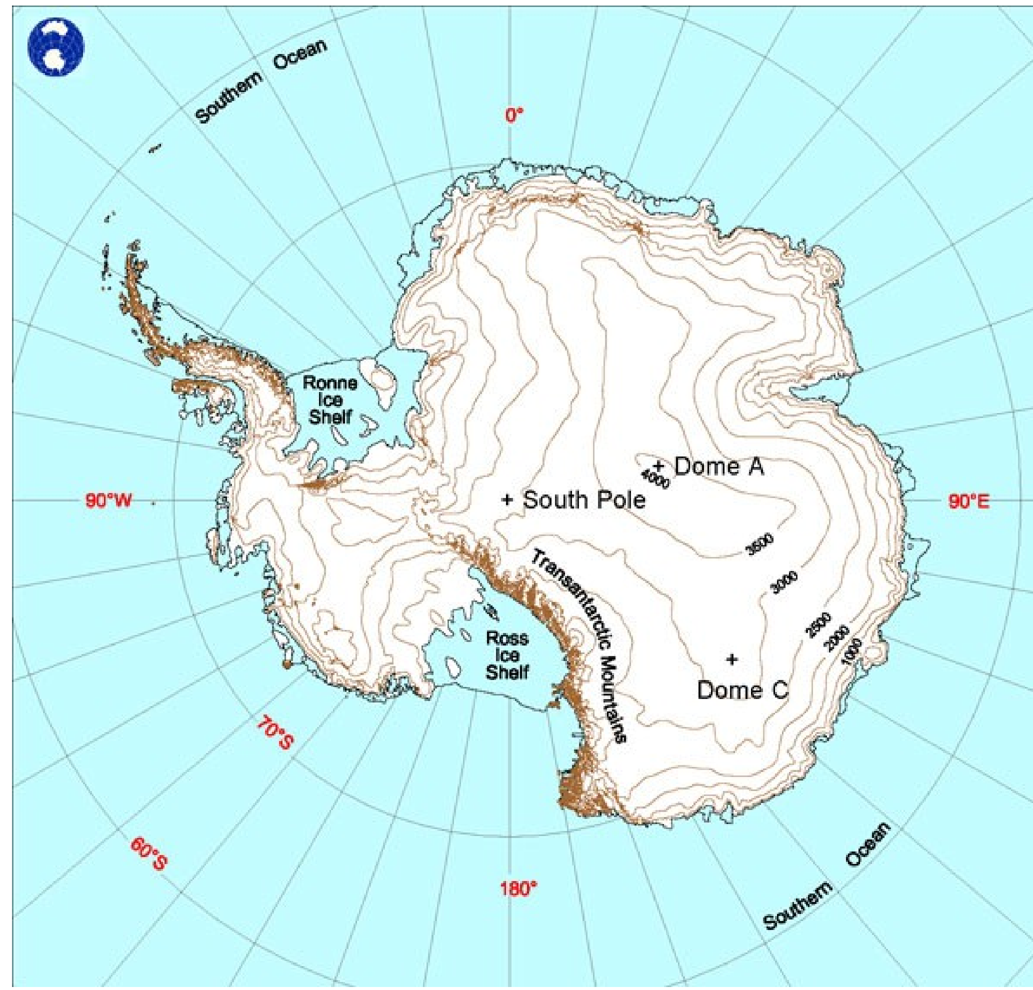


Intertwined Surveys

- SN photometric calibration between low-to high-z surveys e.g. SNFactory, SDSS, SNLS
- Wide-field multi-object spectroscopy
  - SN Ia followup and host-galaxy redshifts, e.g. BOSS, LAMOST, PTF, DES
  - Photo-z calibration, e.g. BigBOSS, DES, LSST
- BAO target selection with imaging surveys e.g. BigBOSS, PTF, DES, LSST
- Optical/NIR SN observation, e.g. DES, VISTA
- Transient searches and followup, e.g. PTF

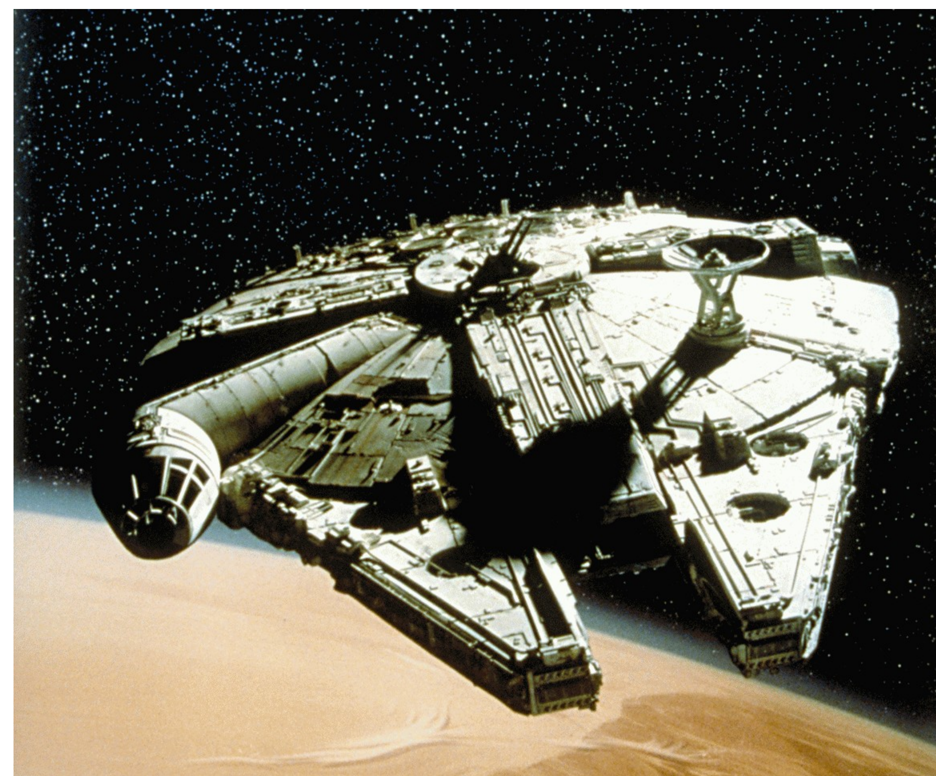
Dome A

- Highest plateau in Antarctica at 4093m
- 1200 km from nearest coastal stations 1100 km from the South Pole
- Summer station exists, winter station planned
- PLATeau Observatory (PLATO) actively taking data



Dome A vs Space

	Dome A	Space
Access	20-day tractor traverse	100 days on spacecraft to L2, one-way trip



Dome A vs Space

	Dome A	Space
Temperature	204K	3K

Dome A vs Space

Dome A

Space

Scary Critters

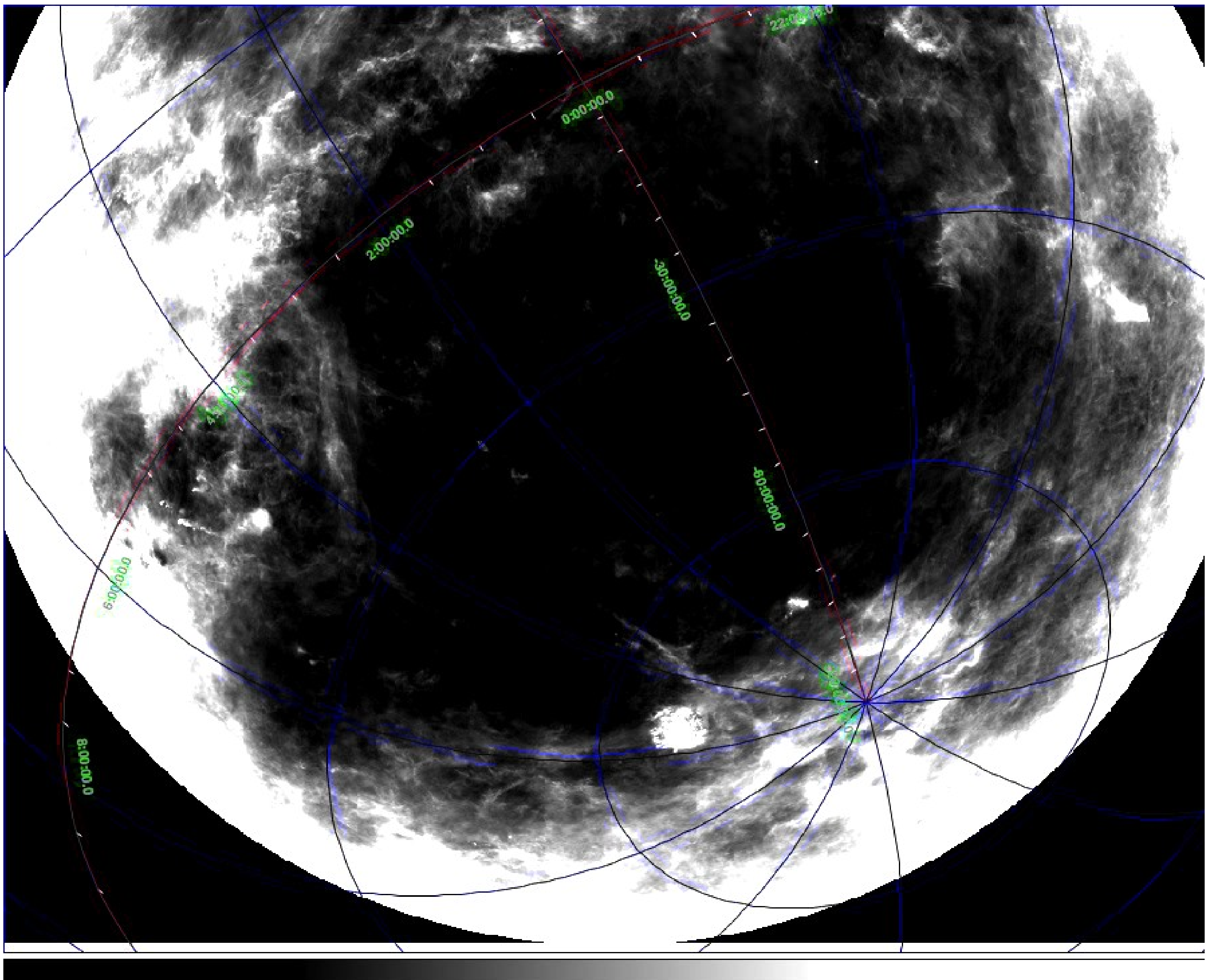
Interesting Dome A Characteristics

- Boundary layer <20-m
- $0.3(\lambda/0.5\mu m)^{-0.2}$” median free seeing expected based on Dome C, first PLATO measurements
- Kdark (2.27-2.45 μm) 0.2” seeing and faint 100μJy/arcsec^2 sky brightness
- Observe every “day”
- Observatory being established by Chinese
  - AST3: 3 0.5-m telescopes, 9 sd imager next summer
  - 1-m telescope pathfinder being developed

Site Characteristics to Cosmology

- BAO – BOSS & BigBOSS doing the job
- Weak Lensing
  - 0.3” (optical), 0.2” (Kdark) seeing
- SNe
  - Nearby SN survey possible with existing and anticipated telescopes
    - No gaps in the time series for template building
  - High-z SN survey: Not efficient
  - High-z SN search: Possible out to z=3

Available Survey Field



Available Survey Field

- At latitude -80° 22' 00”, the available sky restricts SN and WL capabilities
- WL
  - Limited accessible sky: airmass=2 at dec~-30
- SN
  - Desire low Galactic E(B-V) [<0.05,<0.2] and visibility over the season with low airmass <1.7
  - 3000 sq deg with E(B-V)<0.05
  - 800 sq deg with E(B-V)<0.1
  - 2000 sq deg with E(B-V)<0.2

Glossary

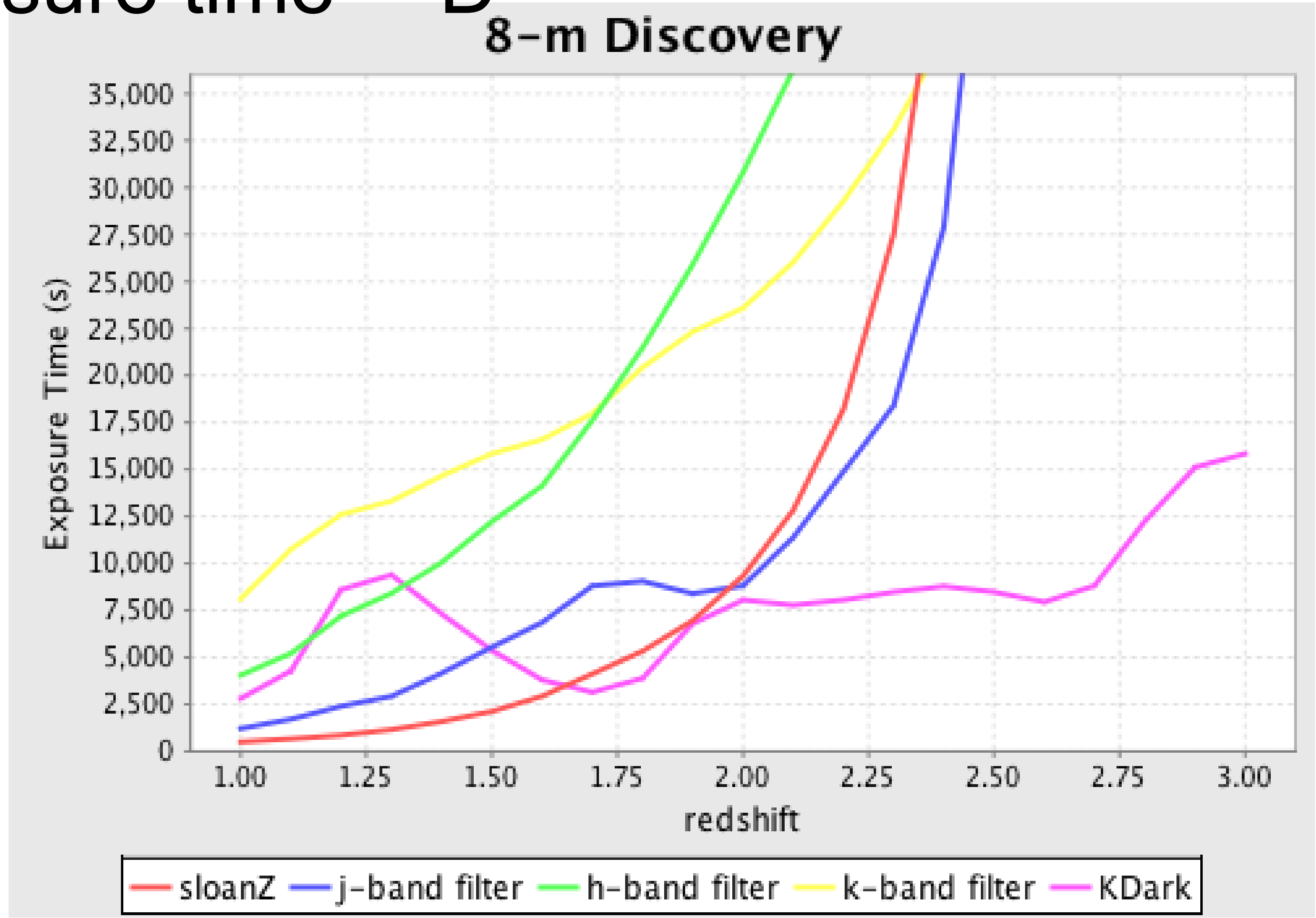
- Discovery – S/N=5 5 days after explosion
- Optical IFU – S/N=25 at peak brightness 0.445, 0.642 μm in 2000 km/s resolution element
- NIR Survey – S/N=25 at peak brightness and 4-day cadence
- Day - 16.5h observing per 24 hours

AST3 Search & 1-m Survey

- AST3
  - Covers the ~6000 sd survey every day in two bands
  - Discovers in one year SNe Ia 145 $z<0.08$
- 1-m
  - Dichroic: Two focal planes, each with a large format imaging detector and an IFU field
  - Optical IFU field lies within the infrared imager field
  - Time to observe 145 supernovae in <<5.5 hours
  - Can afford to have a loose trigger and have at least one spectrum of most transients

High-z Search on an 8-m

- z=1.7, Z-band CCD, 3000s exposure
- 1.7<z<2.75, Kdark 8000s exposure
- Exposure time $\propto D^{-2}$



High-z Search

- 8-m Telescope, 1 sd FOV
- SN survey 10 square degrees, 2-day cadence
- Over 5 months ~ 1200 SNe to be followed elsewhere
- $z<1.7$: Z-band - ¼ SN survey, 3/4 WL survey
- $1.7<z<2.75$: K-dark - ½ SN survey, ½ WL Survey

Risks

- Antarctica
- Technical issues
  - Dew point
  - Power
  - Data transfer
  - Maintenance

Conclusions

- Cosmology probes and surveys are not homomorphic
  - Compactify survey space to minimize $/€/¥
- More of the same or find new observing windows

Numbers of SNe – Low z

- Expect 0.1/yr/sd in the range 0.03<z<0.08
- Assume 3-month window in which new supernova explosions can be followed
  - Night from mid-April to end of August
  - Last observations when SNe are red
- For a survey field 5800 deg^2
  - In 1 years get 145 z<0.08 Sne + discover many more at higher redshifts

IFU and spectroscopy

- Input PSF: Optical IFU seeing dominated, NIR IFU diffraction dominated
- Desire R>300 or λ/dλ>150 per pixel
- Desired >10”x10” FOV – based on SNFactory PSF calibration issues

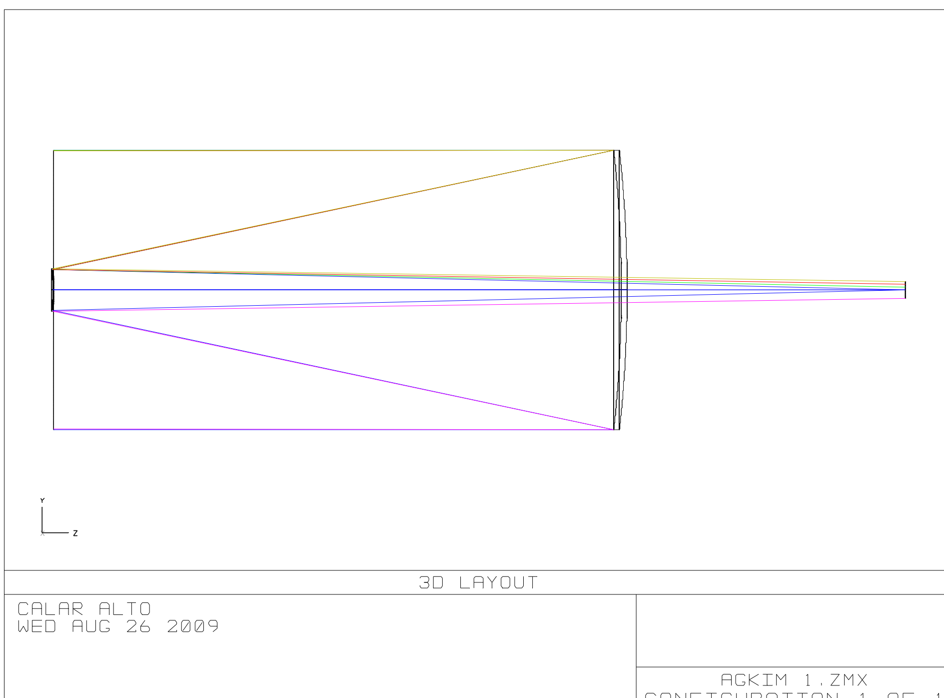
Telescope Specifications

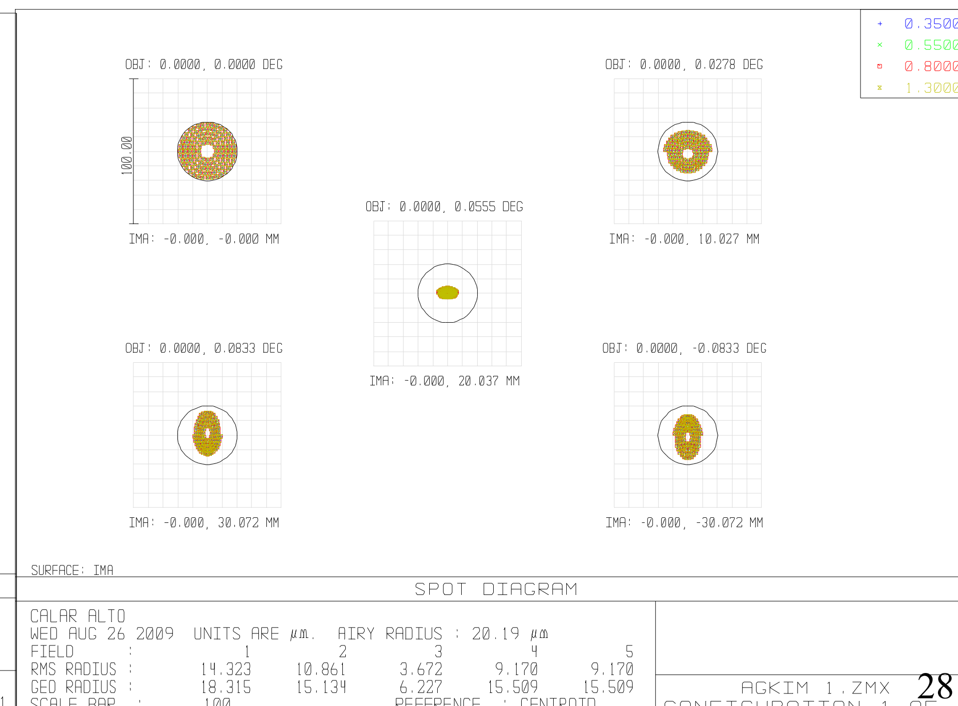
- Diameter: 1m
- Focal length: 21m (0.1as/pix 0.18as/pix)
- RMS blur <0.15” @ 0.5 microns
- Wavelength range: 0.35-2.5 microns
- FOV 10’x10’ no profoundly strong requirement here

2m M1 M2 spacing

- Fast for an RC?

#	Type	Comment	Curvature	Thickness	Semi-Diameter	Conic	Aspheric
0	STANDARD		0.000000E+00	1.000000E+10	0.000000E+00	0.000000E+00	Departure
1	STANDARD	Entrance Aperture	0.000000E+00	2.000000E+03	5.029077E+02	0.000000E+00	(microns)
2	EVENASPH	M1	-2.137403E-04	-2.000000E+03	5.000388E+02	-1.003822E+00	19.20
3	EVENASPH	M2	-1.307051E-03	2.000000E+03	7.556311E+01	-1.612717E+00	3.66
4	COORDBRK		0.000000E+00	1.000000E+03	0.000000E+00	0.000000E+00	
5	STANDARD		0.000000E+00	0.000000E+00	3.009069E+01	0.000000E+00	

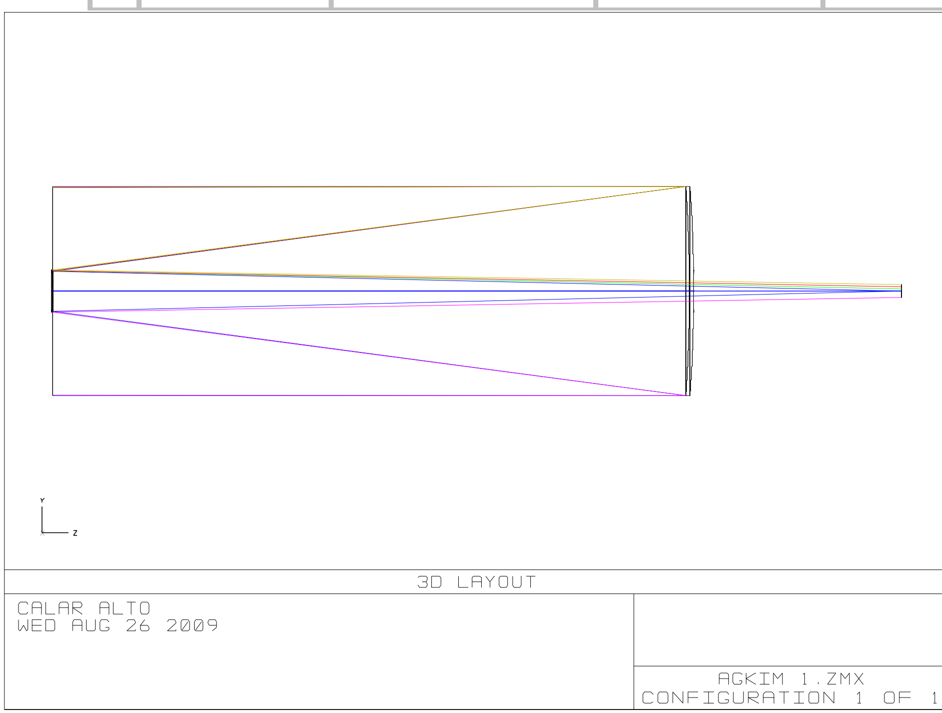


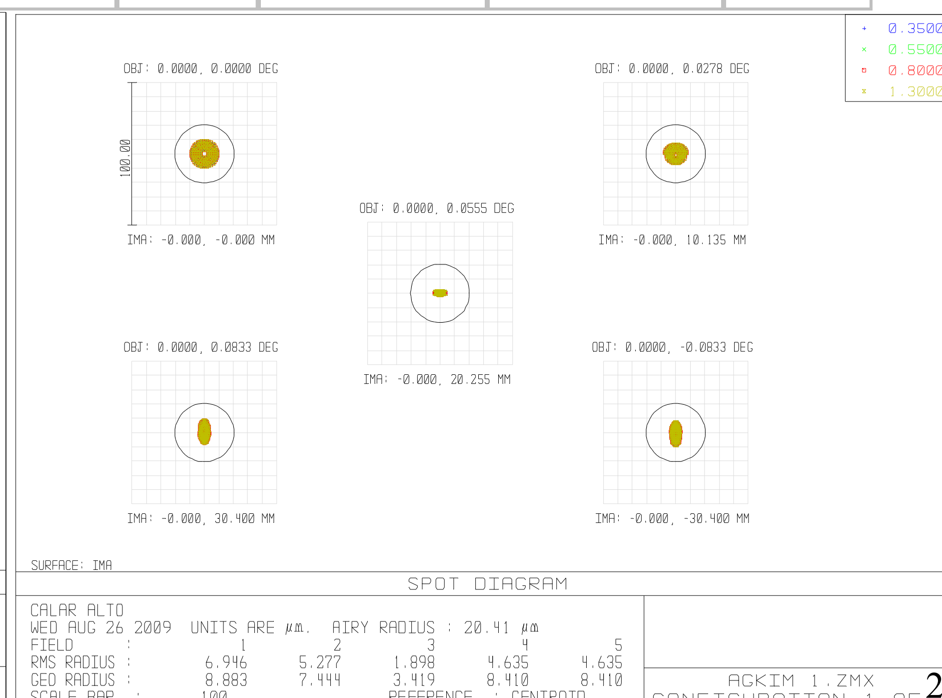


3m M1 M2 spacing

- Better blur performance

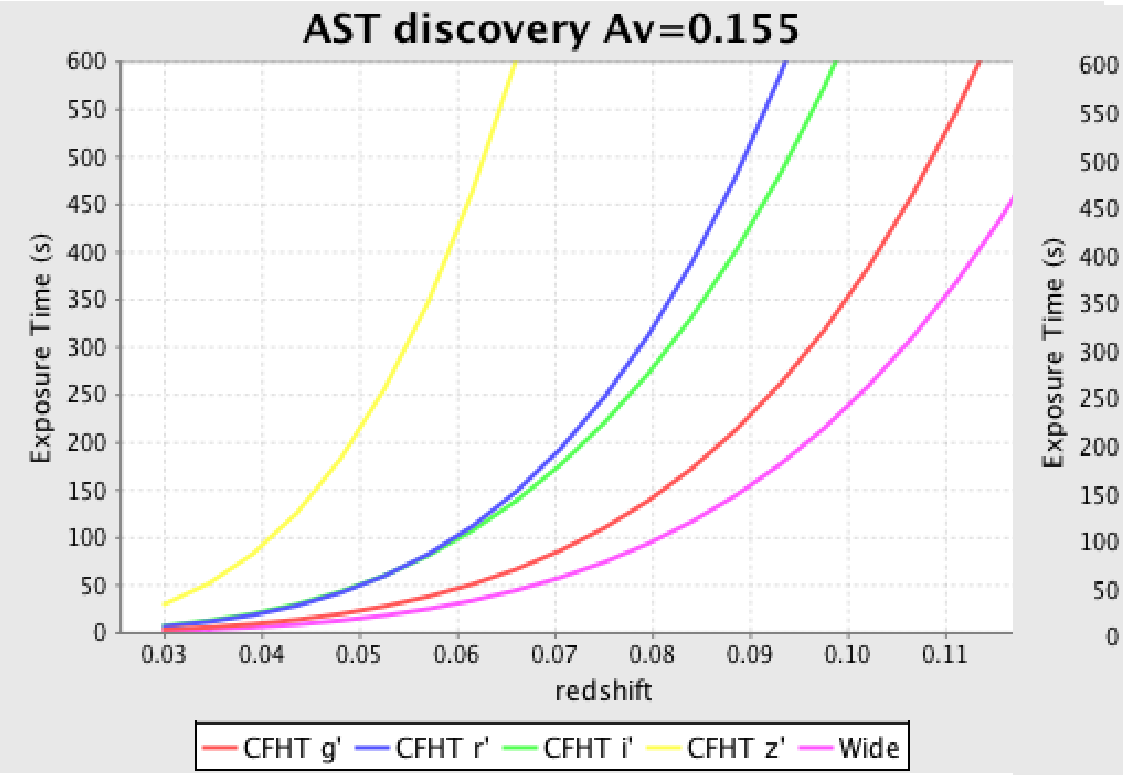
#	Type	Comment	Curvature	Thickness	Glass	Semi-Diameter	Conic	Aspheric
0	STANDARD		0.000000E+00	1.000000E+10		0.000000E+00	0.000000E+00	Departure
1	STANDARD	Entrance Aperture	0.000000E+00	3.000000E+03		5.043616E+02	0.000000E+00	(Microns)
2	EVENASPH	M1	-1.347831E-04	-3.000000E+03	MIRROR	5.000245E+02	-1.013778E+00	4.86
3	EVENASPH	M2	-5.795709E-04	3.000000E+03	MIRROR	1.001221E+02	-2.178078E+00	1.33
4	COORDBRK		0.000000E+00	1.000000E+03		0.000000E+00	0.000000E+00	
5	STANDARD		0.000000E+00	0.000000E+00		3.040968E+01	0.000000E+00	

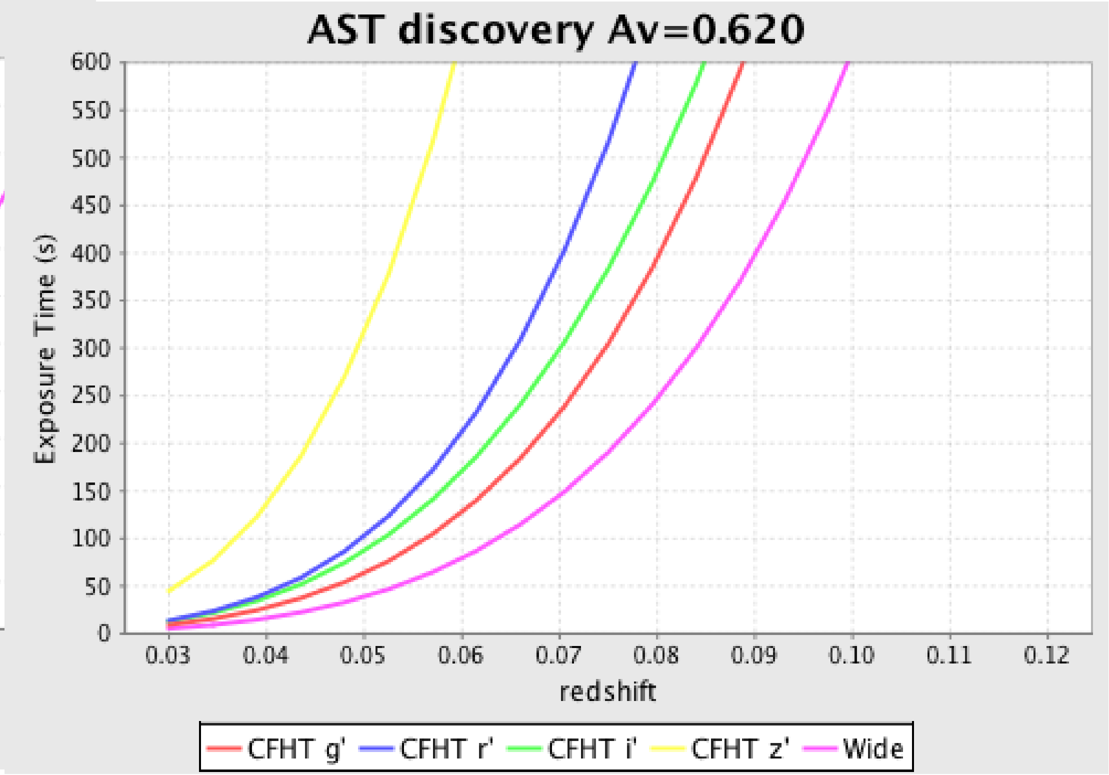




AST3 Search

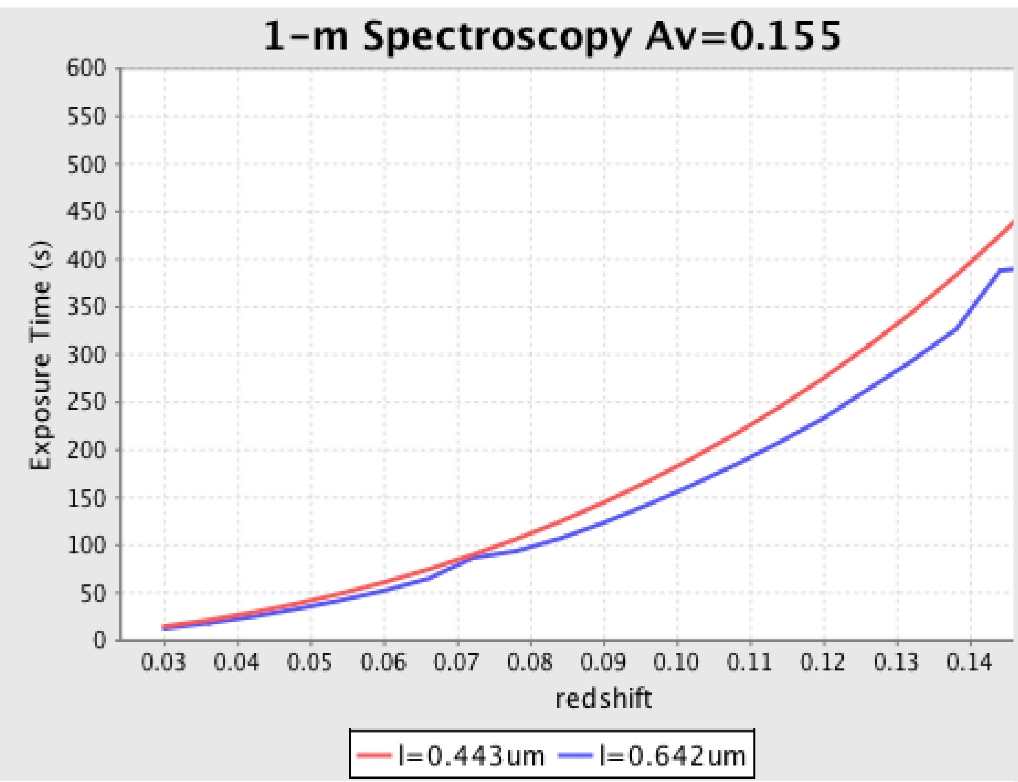
- AST3 can cover the ~6000 sd survey every day in two bands

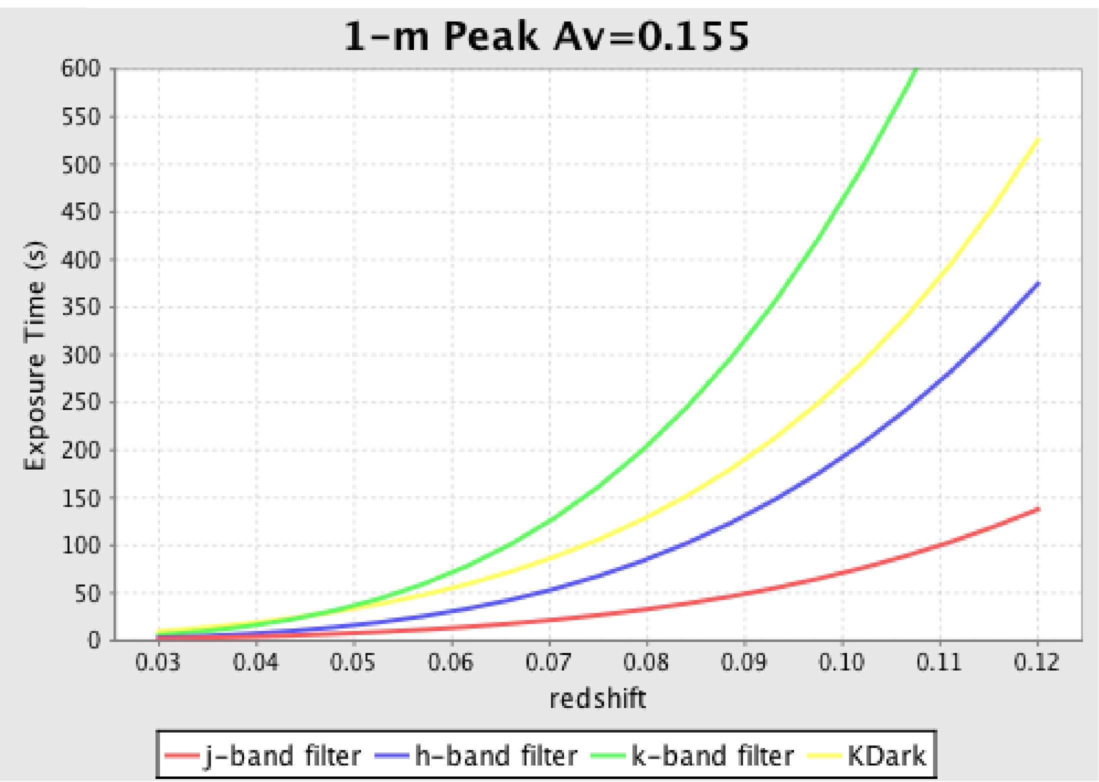




1-m Followup E(B-V)<0.05

- Exposure times for optical spectroscopy and IR imaging





1-m Followup E(B-V)<0.2

- Exposure times for optical spectroscopy and IR imaging