WiFEESNeD

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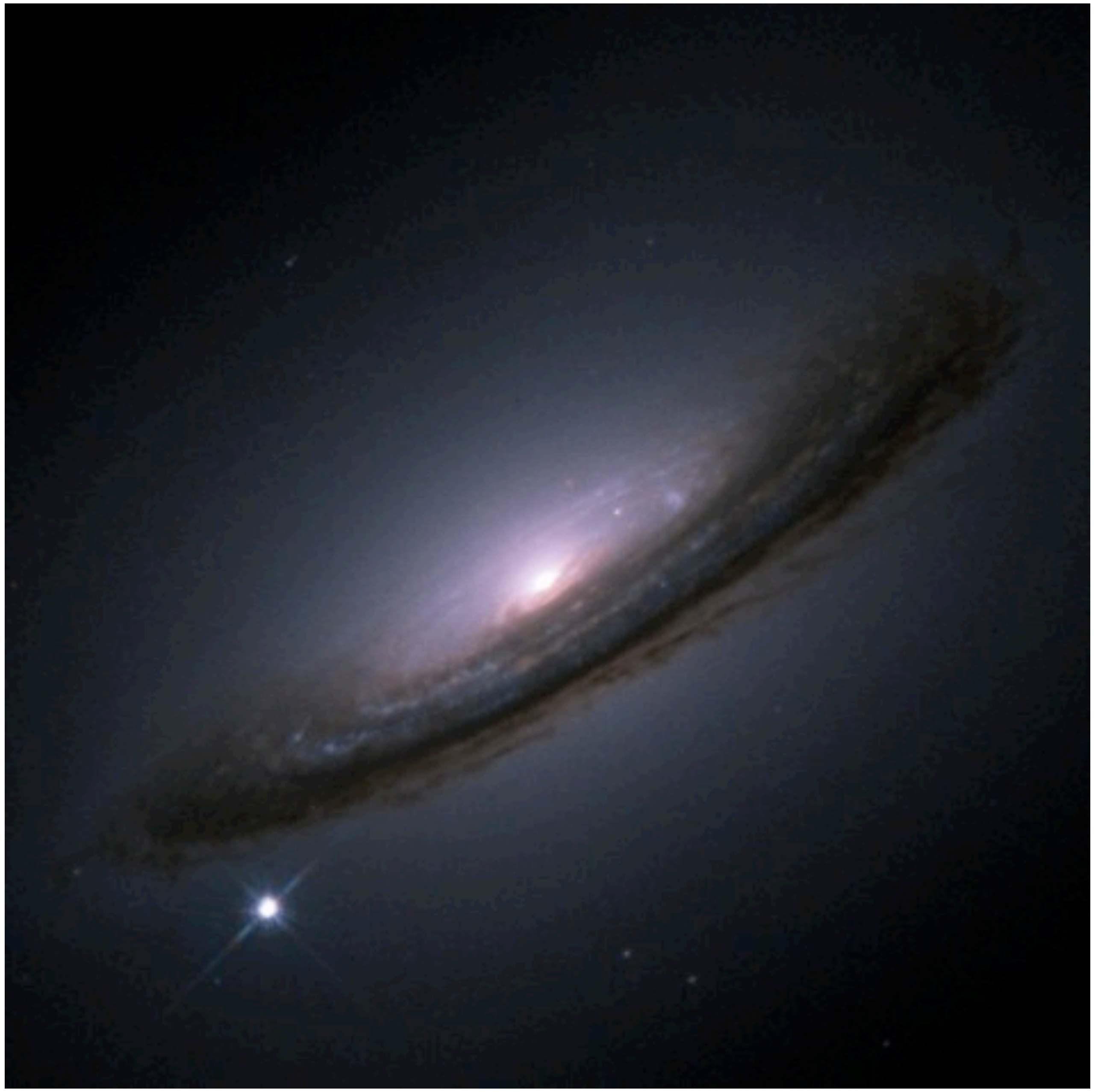
Science

- Determine SN rate
- Cosmology, stellar evolution, chemical enrichment
- M_{SN} ~ -19
- ~1 SN $century^{-1}$ $galaxy^{-1}$
- Length of SN: ~ month



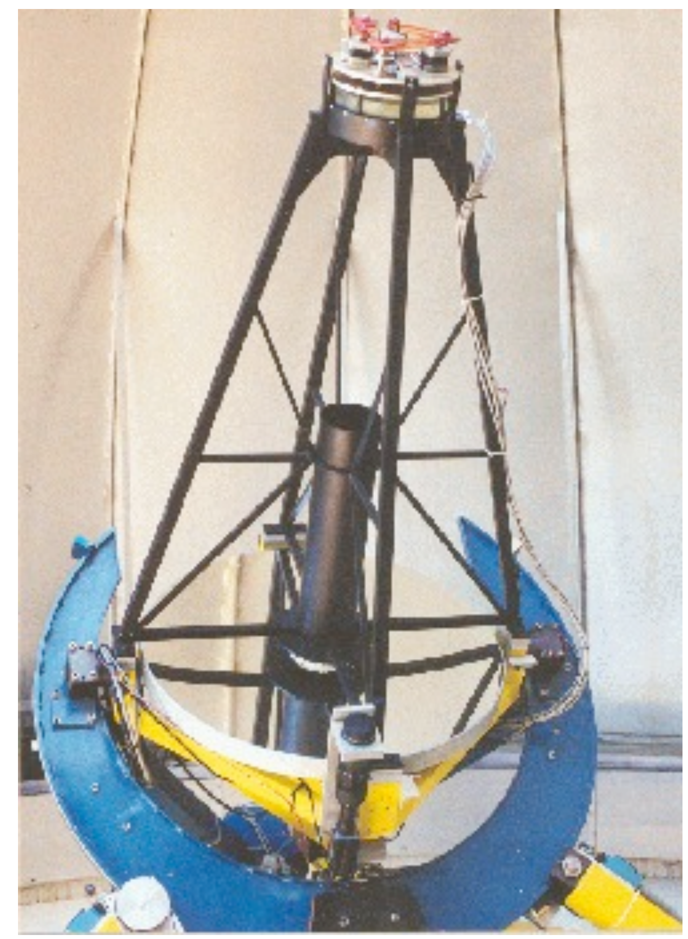
Other Projects

- KAIT: “The most successful SN search engine in the world”
- finds ~ tens of SNe per year

Telescope

The telescope is a 30 inch Ritchey Chretien on an equatorial mount.

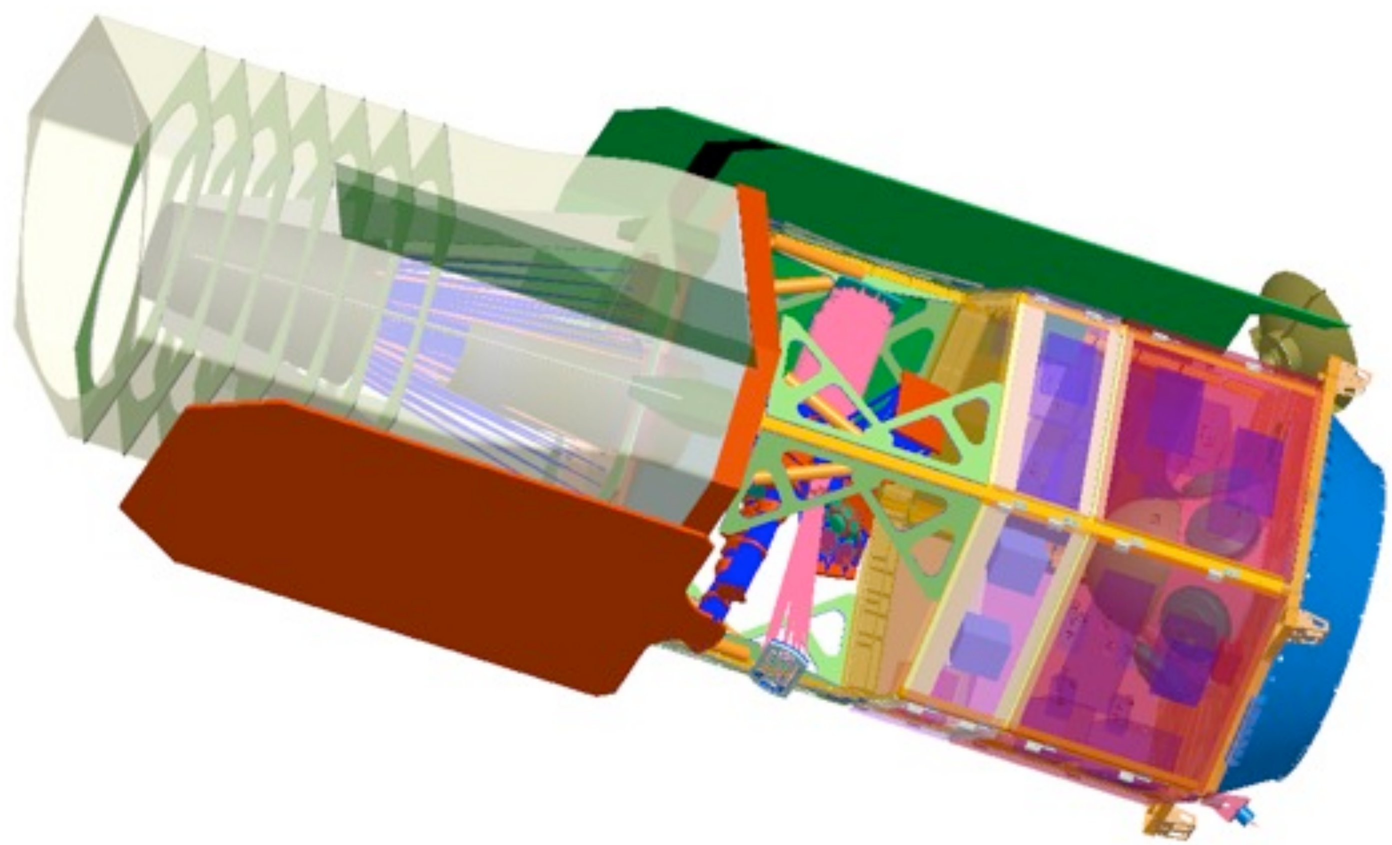
Mirror Diameter	76 cm
Scale	33.2 arc-seconds per mm
Focal Ratio	8.2
North limit	+70 degrees (will increase in future)
Sourth limit	-34 degrees
East limit	-73 degrees
West limit	+73 degrees



Other Projects: JDEM / WFIRST

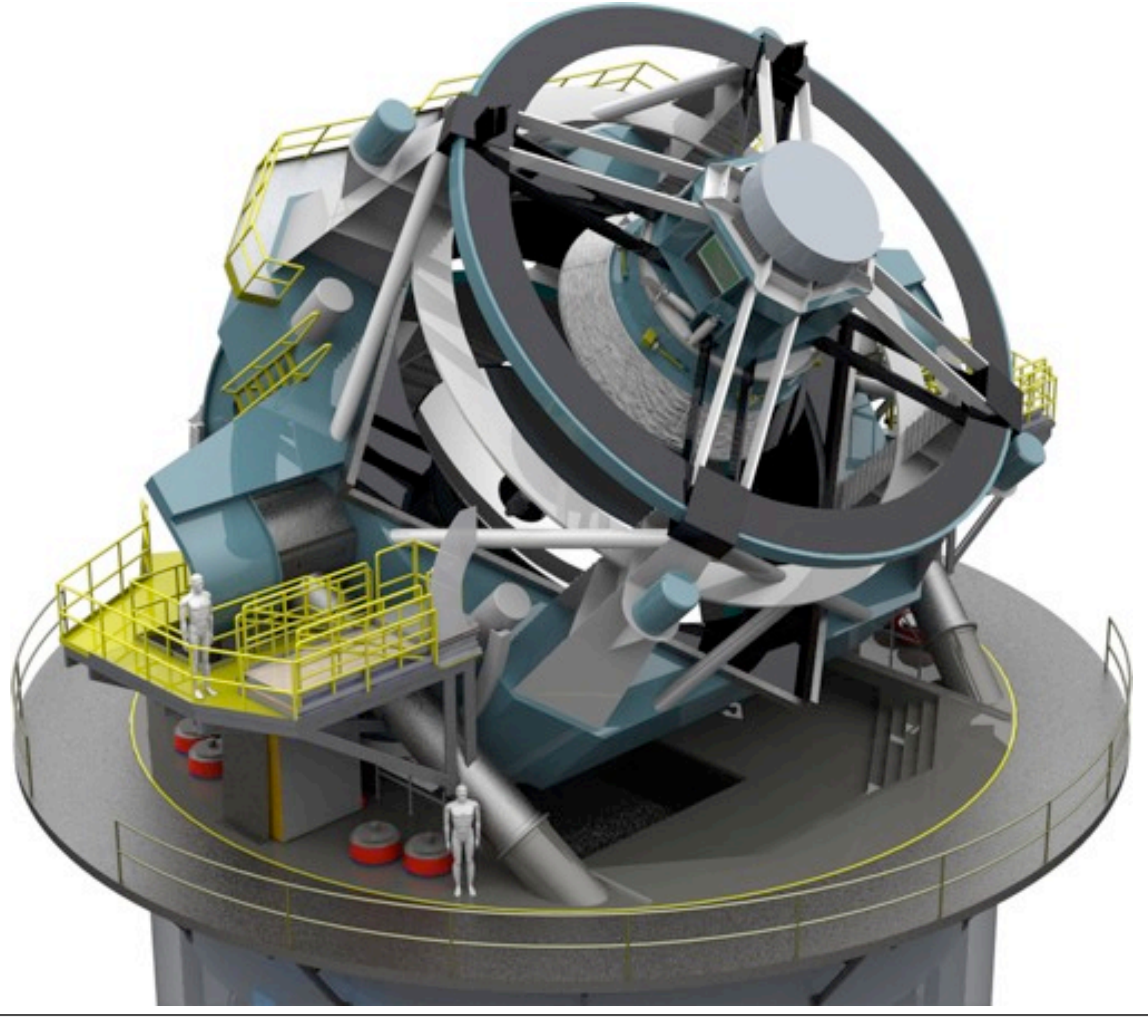
SNe-Ia Field Survey (≥80% Obs. Efficiency; ~8 deg^2-yrs)

- 7 fields (~1.75 deg^2 total, ~95% square) monitored in 5-day cadence assuming 1/5th of each day available for SNe survey
- Total 4800 s of imaging, plus 4800 s for R=75 disperser
- Each filter used once in each 5-day period
- Fields located in low dust regions near ecliptic poles



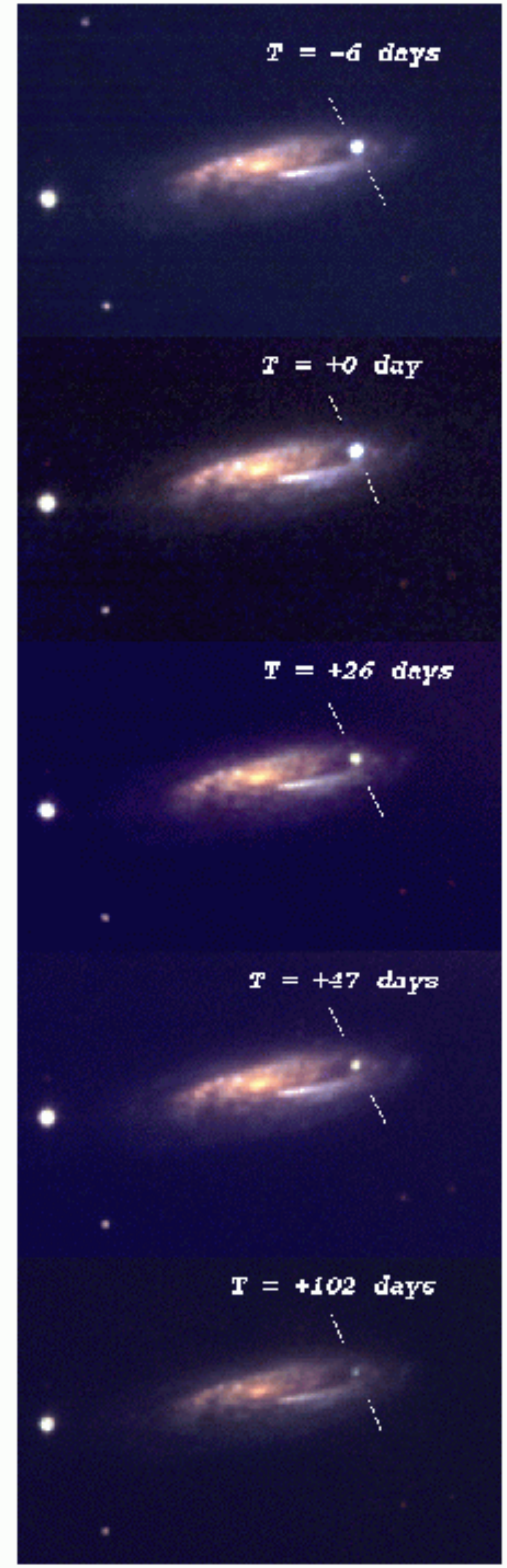
Other Projects: LSST

- 9.6 square degree FOV
- 20,000 square degrees
- z ~ 1.1
- 15 sec exposures every 20 seconds



Technical Requirements

- 1 hr exposure, at 1.5μm
- 5 day return cadence
- 1 square degree FOV
- Survey size: 120 degrees^2
- Should find ~> 60,000 SNe (based on JDEM's estimates)
- Advantages of space-based mission



Calculations

$M_{SN} \sim -19$

$\mu \sim 46$ (at $z=2.0$)

$m_{SN} \sim 27$

$f_{SN} \sim 10^{10}\ 10^{-0.4*27} \sim 0.15$ photons $s^{-1}\ m^{-2}$

$f_{BG} \sim 10^{9}\ 10^{-0.4*23} \sim 0.6$ photons $s^{-1}\ m^{-2}$ $arcsec^{-2}$

Calculations

$$\mathrm{SNR} = \frac{\epsilon f_{\mathrm{SN}} \pi r^2 t}{\sqrt{\epsilon f_{\mathrm{SN}} \pi r^2 t + \epsilon f_{\mathrm{BG}} \pi r^2 t \left(\frac{\lambda}{2r} 206265\right)^2 + \sigma^2}}$$

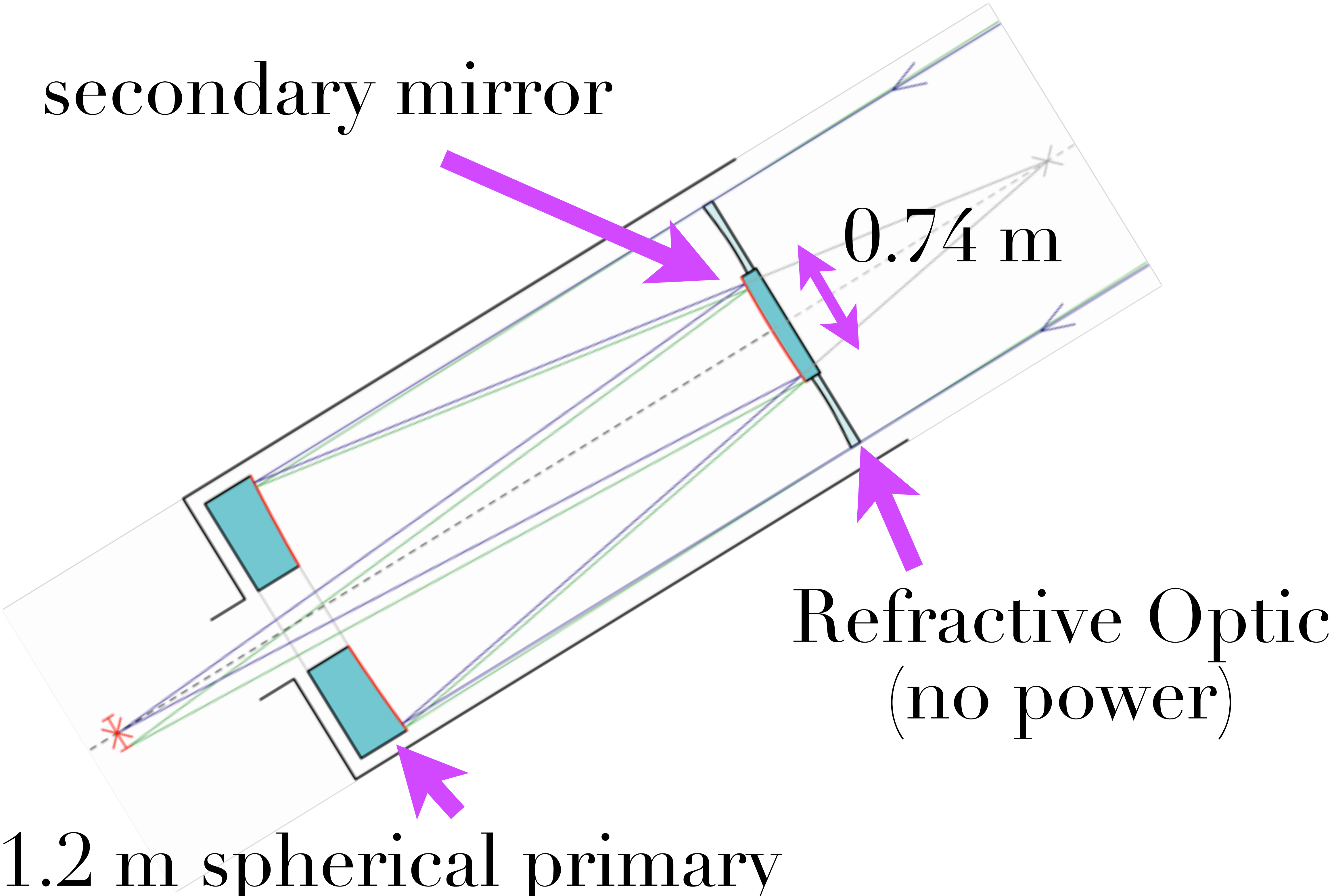
for SNR ~ 10, f_{SN} ~ 0.15, f_{BG} ~ 0.60, t ~ 1 hr,
λ ~ 1.5μm, σ ~ 5, ε ~ 0.5

D ~ 1.2 m

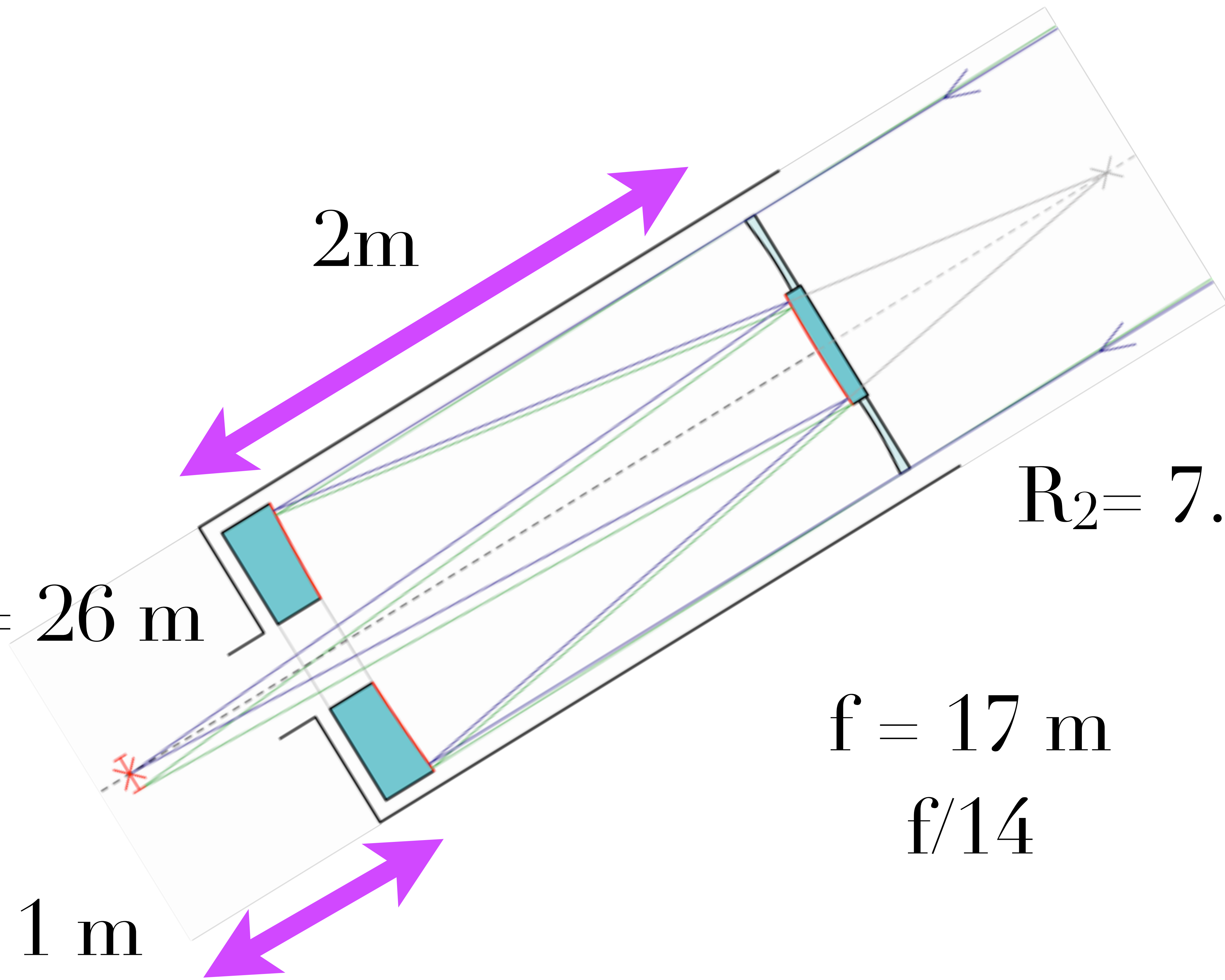
Optical Design

- Primary aperture: 1.2 meter
- FOV: 1 degree x 1 degree
- 20μm pixel size
- 0.2 arcsec pixel^{-1}
- Schmidt-Cassegrain for good wide field performance

Optical Design



Optical Design



Addendum

In[45]:= $\text{Solve}\left[\text{SNR} == \frac{\epsilon R \pi r^2 t}{\sqrt{\epsilon R \pi r^2 t + \epsilon B \pi r^2 t \left(\frac{\lambda}{2 r} 206265\right)^2 + \sigma^2}}, t\right]$ /. $R \to 10^{10}\, 10^{-0.4\, 27}$ /. $B \to 10^{9}\, 10^{-0.4\, 23}$ /. $r \to 0.5$ /.

$\lambda \to 1.5 * 10^{-6}$ /. $\text{SNR} \to 10$ /. $\sigma \to 5$ /. $\epsilon \to 0.5$

Out[45]= $\{\{t \to -260.306\}, \{t \to 2479.34\}\}$

In[48]:= $\text{Solve}\left[\text{SNR} == \frac{\epsilon R \pi r^2 t}{\sqrt{\epsilon R \pi r^2 t + \epsilon B \pi r^2 t\, (0.8)^2 + \sigma^2}}, r\right]$ /. $R \to 10^{10}\, 10^{-0.4\, 27}$ /. $B \to 10^{9}\, 10^{-0.4\, 16}$ /. $t \to 1239$ /.

$\lambda \to 1.5 * 10^{-6}$ /. $\text{SNR} \to 10$ /. $\sigma \to 5$ /. $\epsilon \to 0.3$

Out[48]= $\{\{r \to 0. - 0.00916376\, i\}, \{r \to 0. + 0.00916376\, i\}, \{r \to -29.4818\}, \{r \to 29.4818\}\}$

Addendum

In[45]:= $$\text{Solve}\left[SNR == \frac{\epsilon R \pi r^2 t}{\sqrt{\epsilon R \pi r^2 t + \epsilon B \pi r^2 t \left(\frac{\lambda}{2r}\, 206265\right)^2 + \sigma^2}},\ t\right] /.\ R \to 10^{10}\, 10^{-0.4\, 27} /.\ B \to 10^9\, 10^{-0.4\, 23} /.\ r \to 0.5 /.\ \lambda \to 1.5 * 10^{-6} /.\ SNR \to 10 /.\ \sigma \to 5 /.\ \epsilon \to 0.5$$

Out[45]= $\{\{t \to -260.306\}, \{t \to 2479.34\}\}$

In[46]:= $$\text{Solve}\left[SNR == \frac{\epsilon R \pi r^2 t}{\sqrt{\epsilon R \pi r^2 t + \epsilon B \pi r^2 t\, (0.8)^2 + \sigma^2}},\ r\right] /.\ R \to 10^{10}\, 10^{-0.4\, 27} /.\ B \to 10^9\, 10^{-0.4\, 16} /.\ t \to 1239 /.\ \lambda \to 1.5 * 10^{-6} /.\ SNR \to 10 /.\ \sigma \to 5 /.\ \epsilon \to 0.3$$

Out[46]= $\{\{r \to 0. - 0.00916376\, i\}, \{r \to 0. + 0.00916376\, i\}, \{r \to -29.4818\}, \{r \to 29.4818\}\}$

Space background is lower than sky background

Diffraction limited versus seeing-limited

Derived exposure time in space, due to night-day limitations, becomes half as long.

Conclusions: Without AO, a 60m diameter telescope would be required to achieve the same signal to noise for a 27th magnitude source in an amount of time appropriate for our survey size. Note that we changed 1) our sky background area from approximately diffraction limited to about 0.8 arcseconds 2) the magnitude of the sky background from 23 mags per square arcsecond to 16 mags per square arcsecond, and 3) our estimated system efficiency from 0.5 to 0.3 to account for increased sky absorption. AO would help (perfect AO over the entire one degree squared field would require a 4m telescope), but we don't know of any systems that can provide such good AO over such a wide field. Our more realistic (but still extraordinarily generous) guess for wide field AO performance requires a 22m telescope for 0.3 arcsecond seeing over one degree FOV.