# Top Ten Questions

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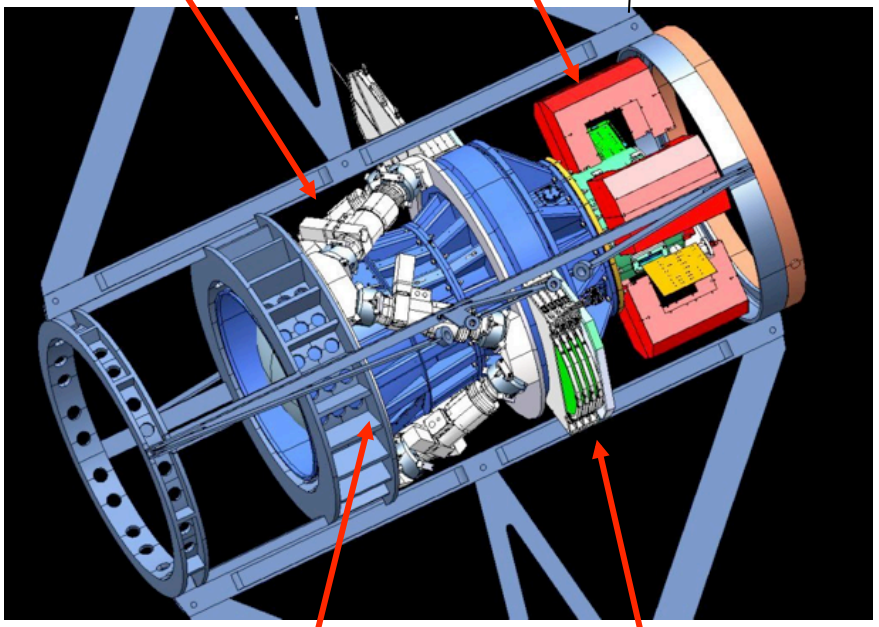
NAA

# Top Ten Questions

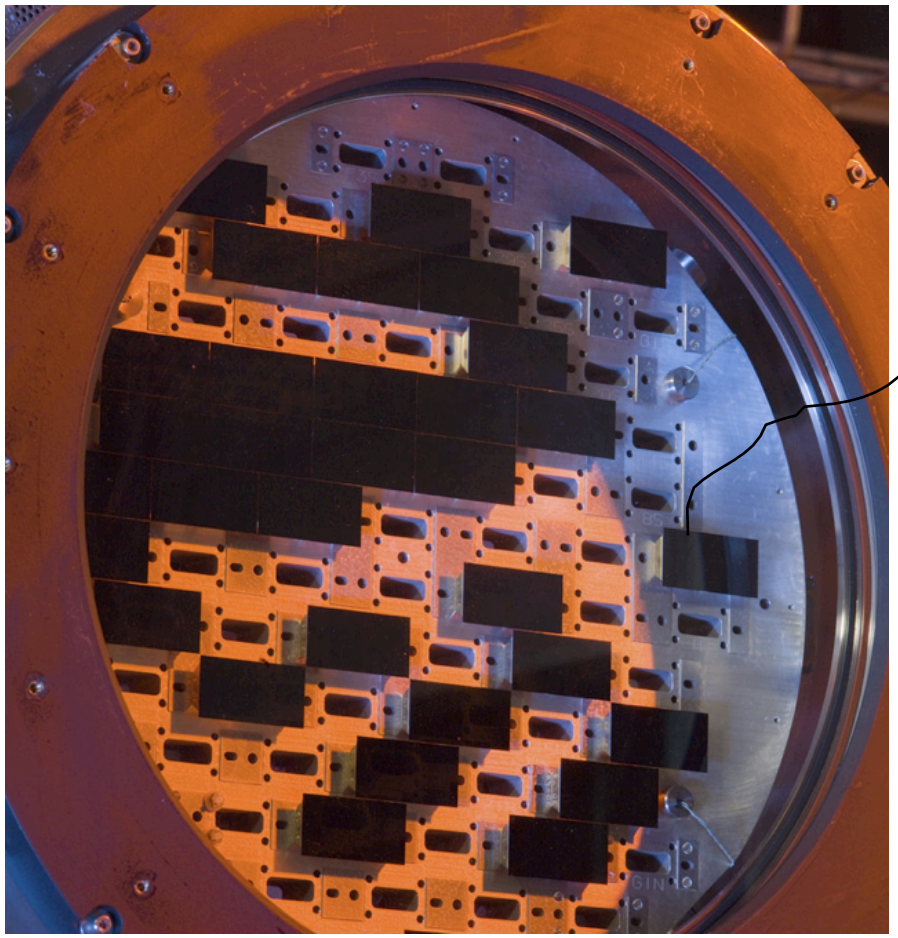
## About the Dark Energy Survey (DES) and the Dark Energy Camera (DECam)

1. How much does DECam cost?
2. How much does a CCD cost?
3. How much does DECam weigh?
4. Will DECam use binning?
5. How long will DECam spend on a single field of view?
6. Why isn't there any adaptive optics used? How will DECam deal with bad seeing or distortion frpm the atmosphere?
7. How will the data get from the telescope on the mountain in Chile to the data archive and processing center at NCSA at UIUC?
8. How does the corrector avoid chromatic aberration?
9. How far is z=1?
10. In an expanding universe, what doesn't expand?

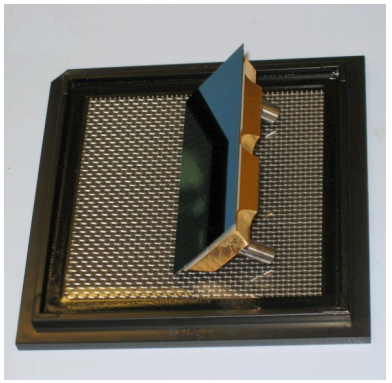
# 1. How much does DECam cost?



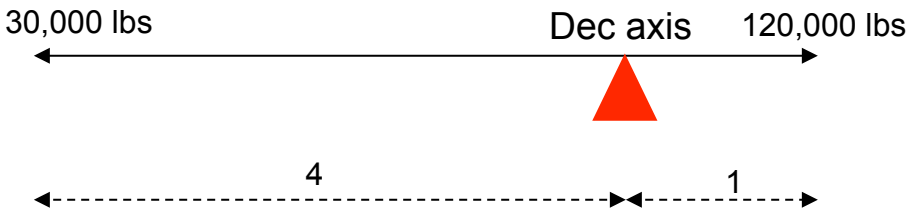
## 2. How much does a CCD cost?



~$50,000
ea.

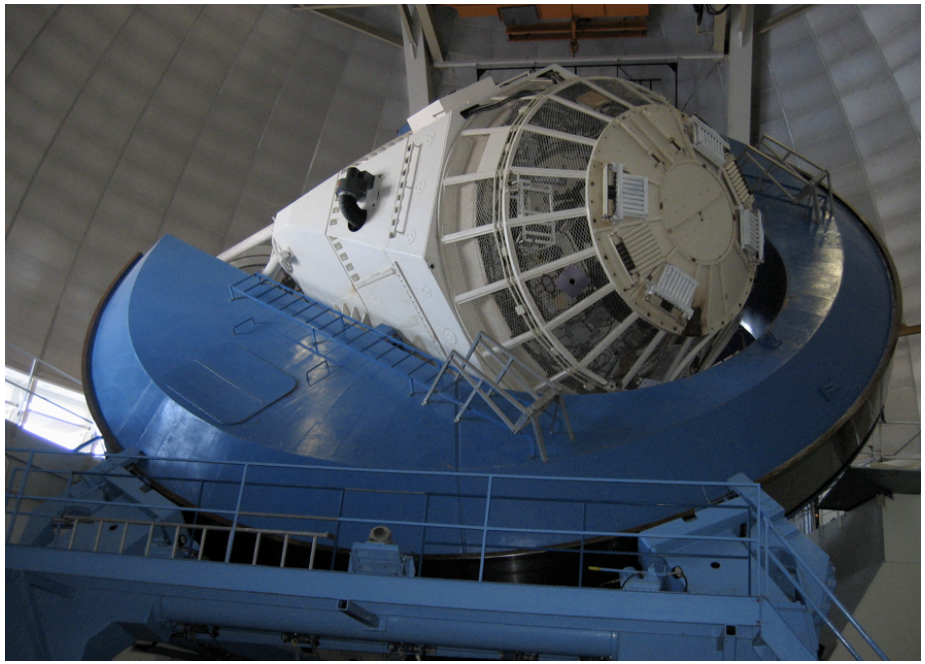


# 3. How much does DECam weigh?

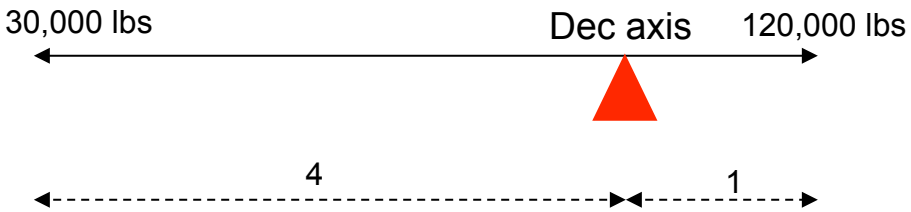



- The total weight of the upper structure is about 30,000 pounds.
- DECam weighs about 7,500 pounds.
  - DECam = corrector + imager + filter changer + shutter.
- The rest of the upper structure weighs about 22,500 pounds.
  - This includes the upper Surrier truss, outer ring, flip ring, fins, and prime focus cage

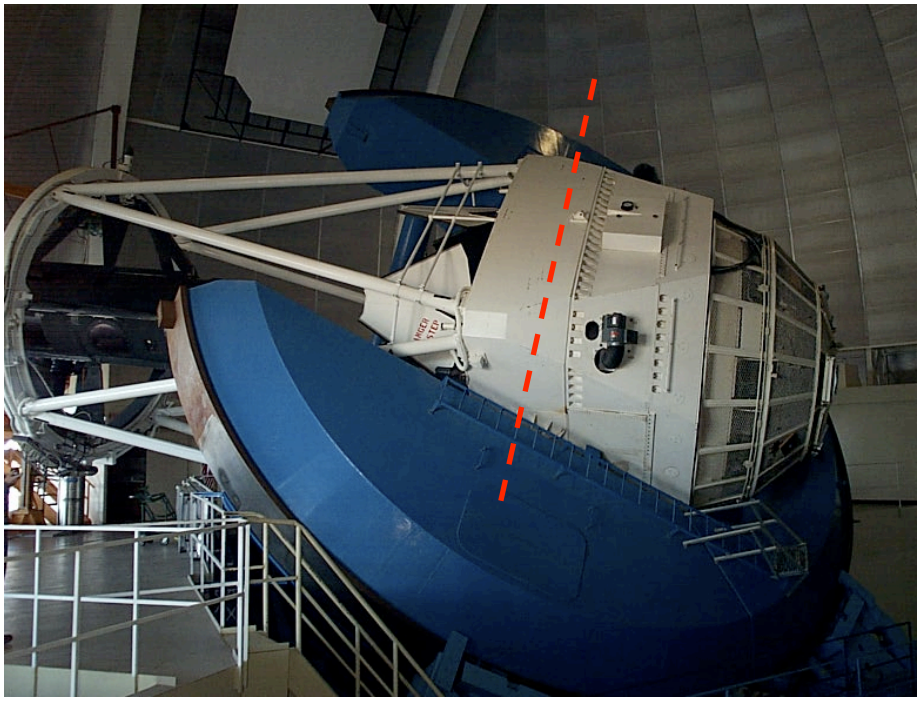
# 3. How much does DECam weigh? (Continued)

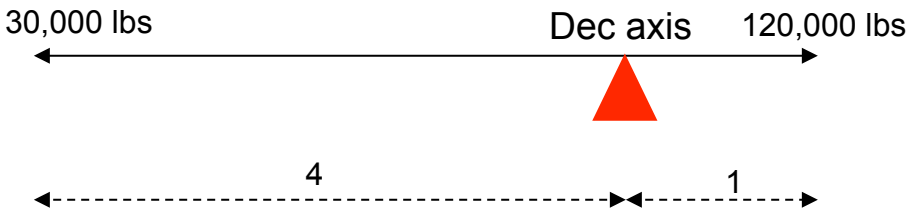


- The lower structure is comprised of the primary mirror, mirror cell, ring girder, and Cassegrain cage.
- The total weight of the lower structure is about 120,000 pounds.



# 3. How much does DECam weigh? (Continued)






- The weight above the declination axis must be balanced by the weight at the opposite end of the 4:1 lever arm system.

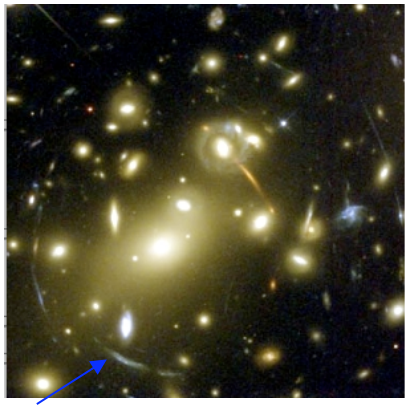
$$(m_{upper}g) \times r_{upper} = (m_{lower}g) \times r_{lower}$$

$$30{,}000lbs \times 4 = 120{,}000lbs \times 1$$

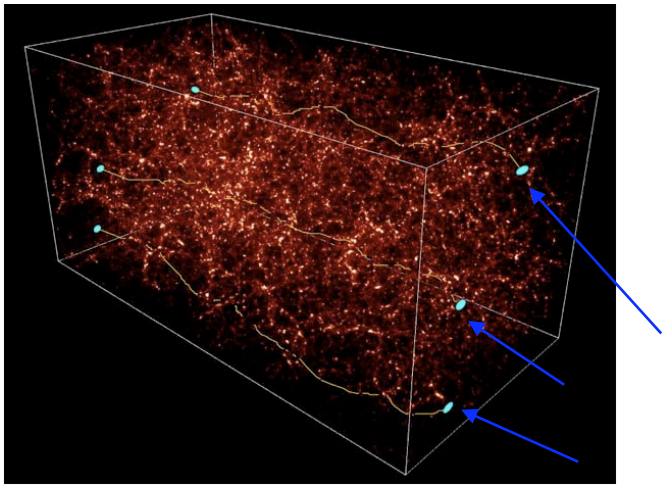
# 4. Will DECam use binning?

- The Dark Energy Survey will not use binning, because high resolution is desired, especially for weak lensing, where accurate measurements of galaxy shapes is difficult, yet critical.

- Binning may be provided as an option for community users.



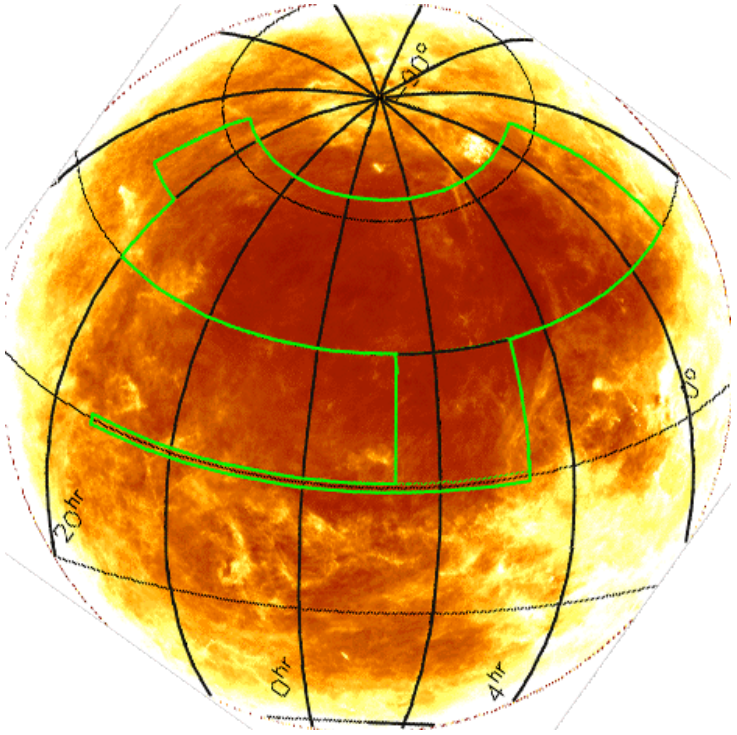
Arcs produced by strong lensing



Weak lensing produces more subtle distortion of galaxy shapes

# 5. How long will DECam spend on a single field of view?

- 100 seconds + 17 second readout time
- This is driven by the desire for 8 tilings/ observing season: to observe the survey area 8 times/season.




DES survey area is outlined in green

# 6. Why isn't adaptive optics used?

- The large field of view (3 square degrees) of DES makes adaptive optics especially challenging and costly.
- Good location minimizes bad seeing:
  - Elevation: 2123 meters
  - The median seeing of 0.9 arc sec is sufficient for the proposed science
- Maintain focus & alignment using the hexapod.
- The telescope's thermal environment was improved by installation of large ventilation doors & ventilation subsystems

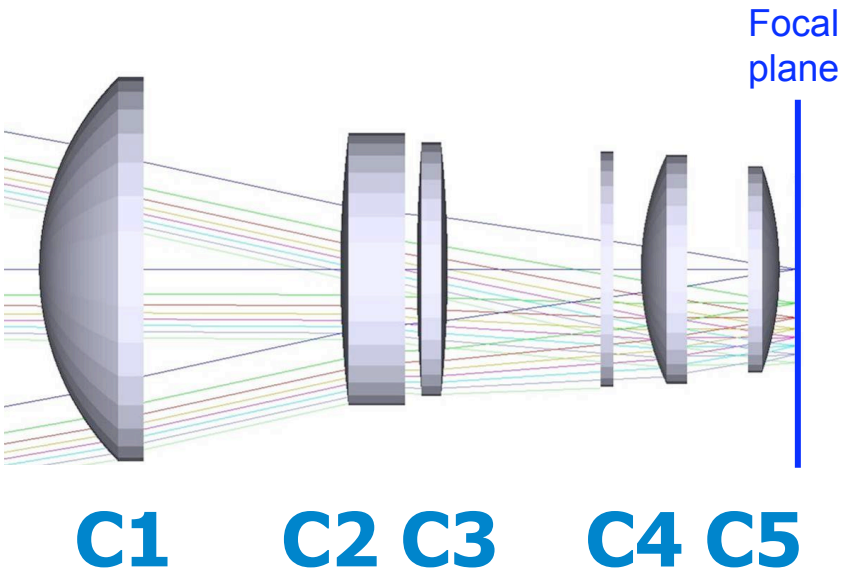
Elevation: 2123 meters

# 7. How will the data get from the telescope on the mountain in Chile to the data archive and processing center at NCSA at UIUC?

- It's network the whole way.
- Wireless from the mountain to La Serena and cable thereafter.
- The entryway to the US is through Miami.
- Need to average ~36 Mbps over 18 hour period to return a typical DES night.
- There are hopes to have something more like 100 Mbps.

## 8. How do the optics avoid chromatic aberration?

- The corrector was designed to minimize chromatic aberration.
- To first order, the corrector does not magnify the image.
- In such a situation, there is very little intrinsic chromatic aberration in the first place, thus, one does not need to worry about it very much.
- In practice there is a modest amount near the edge of the field of view.

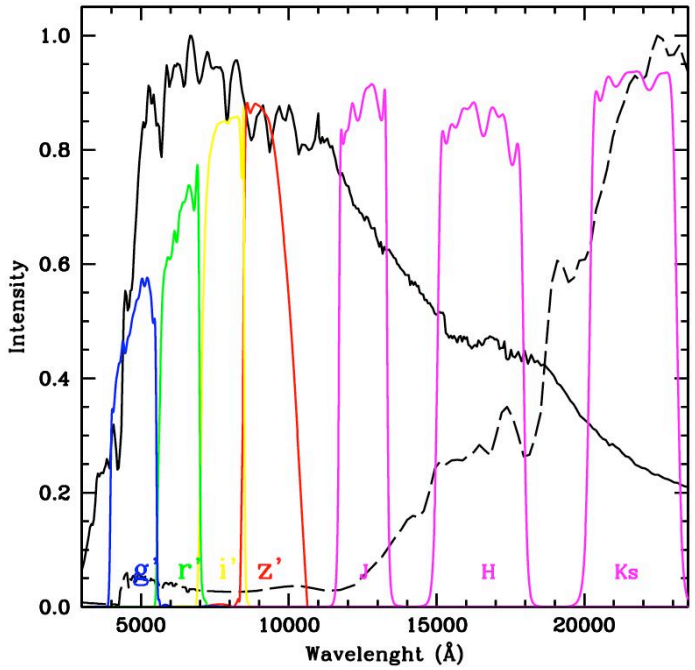



Blanco corrector

# 8. How do the optics avoid chromatic aberration? (Continued)

- Because the corrector is always used in conjunction with filters, correction for chromatic aberration would only need to be done within the bandpass of each filter, not over the entire optical wavelength range as one normally does for telescopes used for visual observation.

- Additionally, the telescope can be refocused for each filter.




DECam filter bands

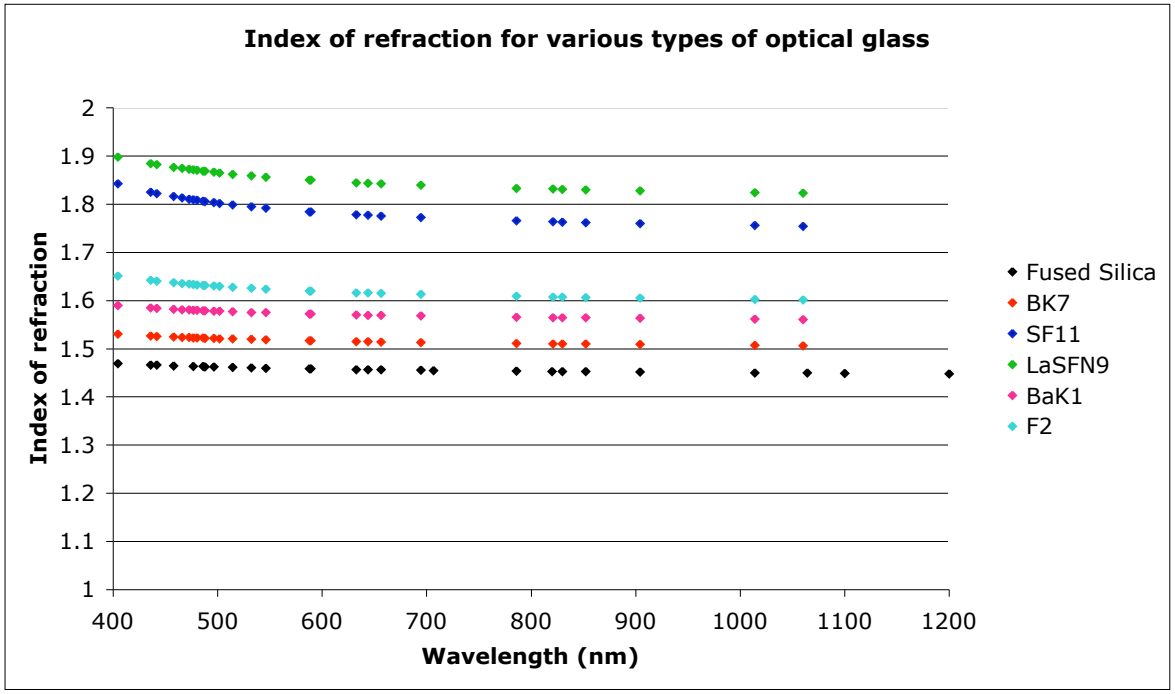
# 8. How do the optics avoid chromatic aberration? (Continued)

- So it is not necessary to use multiple materials as one normally does for a refractor telescope.
- And, it would be difficult to do so, because large pieces of glass in any material other than fused silica are difficult to make and would take a long time to procure.

Fused silica blank for DECam corrector

# 8. How do the optics avoid chromatic aberration? (Continued)

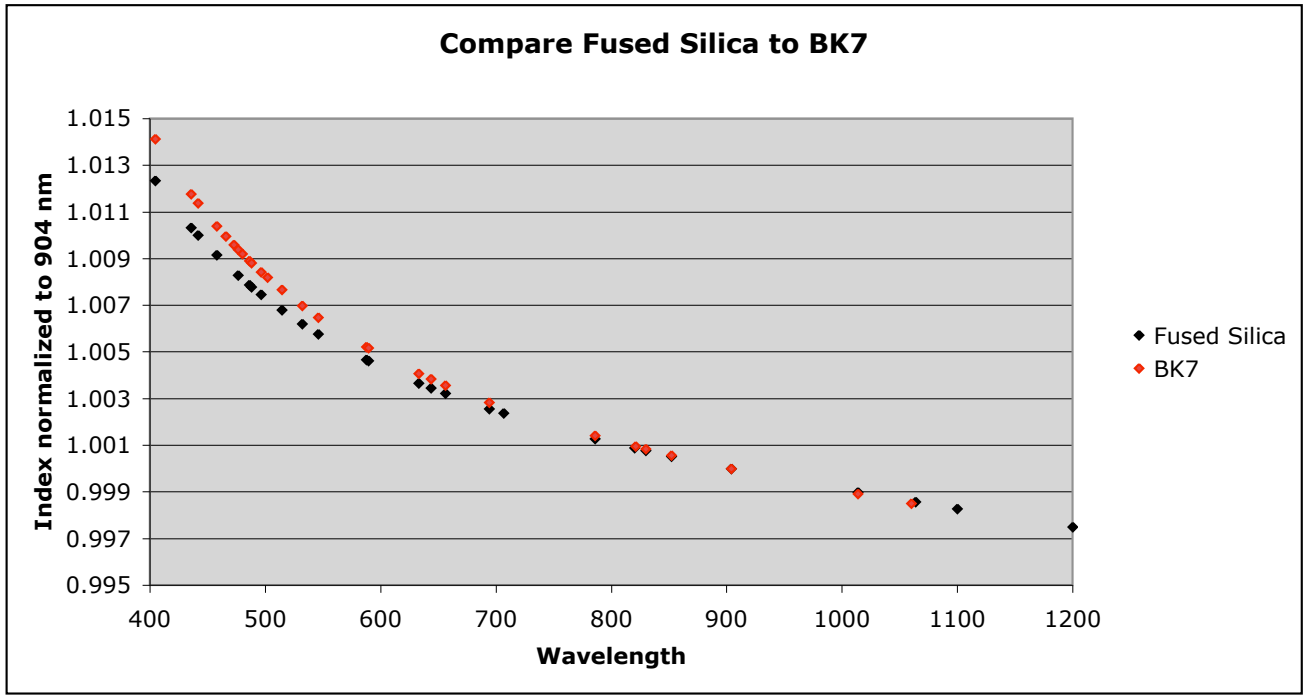
- The index of refraction of fused silica changes less over the optical band compared to other optical materials.




Source of data http://www.mellesgriot.com/products/optics/mp_3.htm

# 8. How do the optics avoid chromatic aberration? (Continued)

- Fused silica is more “self-achromatic” than BK7.

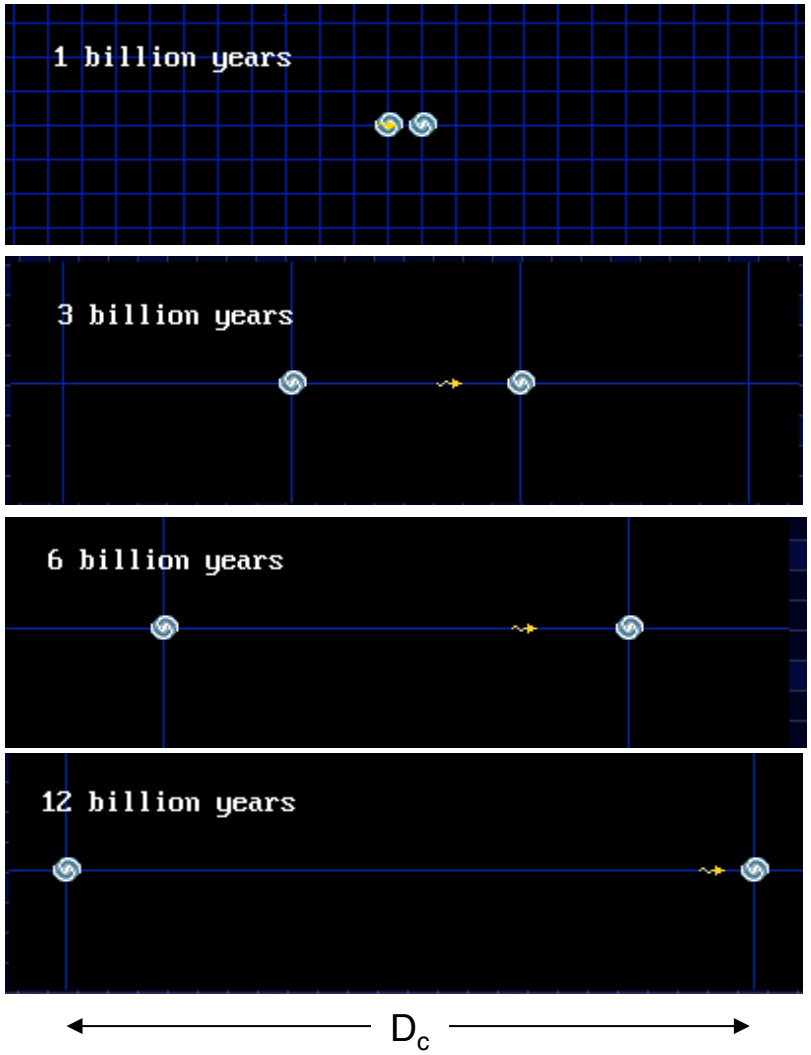



Normalize to 904 nm to better-compare Fused Silica to BK7.

# 9. How far is z=1?

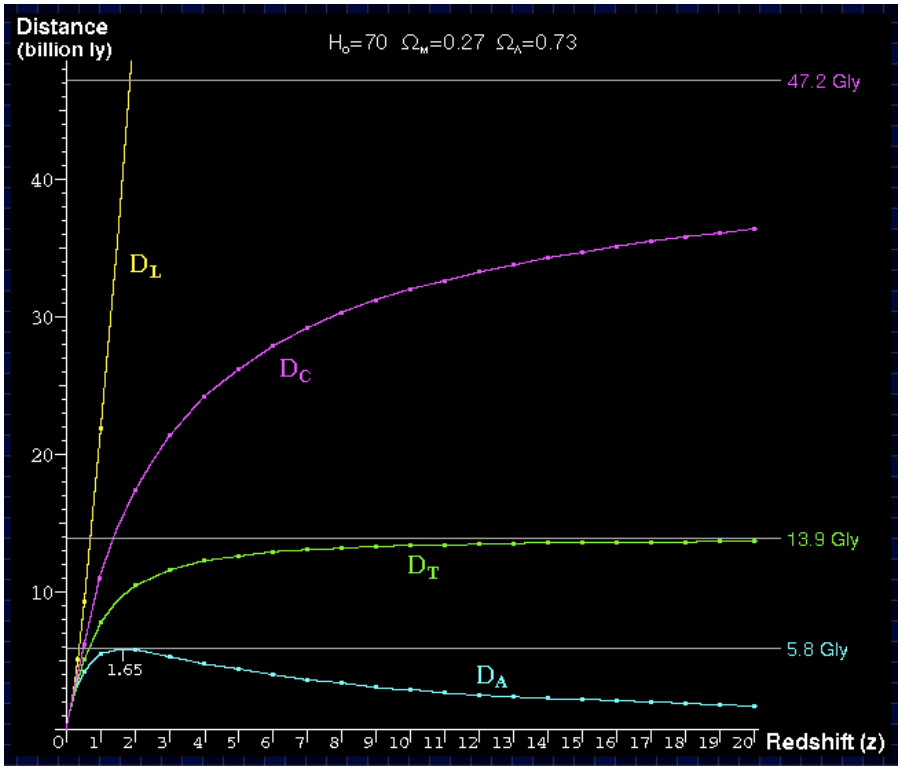
- "DES will count ~100,000 galaxy clusters to z > 1"
- What that really means is:
- "There are 100K clusters between us and a comoving distance, $D_c$, of 3317.3 Mpc. that are bright enough for DES to detect."
- The comoving distance is the distance to the object NOW (or at the time of the observation).

1 Parsec (pc) = 3.26163626 light year



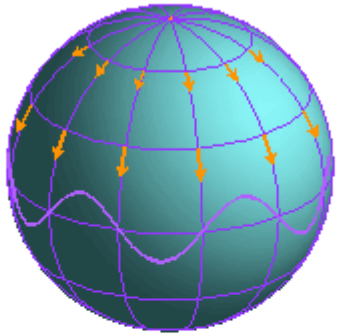
# 9. How far is z=1? (Continued)

- It's fun to note that astronomers use many different distance scales (called distance measures).
  - Comoving distance $D_c$
  - Light travel time distance $D_T$
  - Angular diameter distance $D_A$
  - Luminosity distance $D_L$



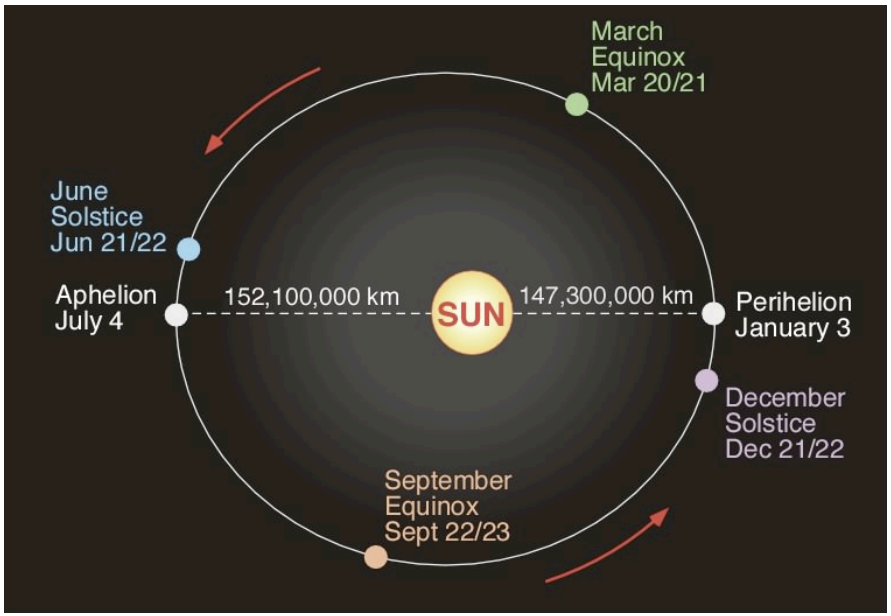
# 10. In an expanding universe, what does/doesn't expand?

- Usually one shows graphics of galaxies moving apart like pennies glued to the surface of an expanding balloon.
- Are galaxies growing larger? Are atoms?
- The usual answer is that bound systems don't take part in the cosmological expansion.
- But how can these systems not be at least slightly affected?



# 10. In an expanding universe, what does/doesn't expand? (Continued)

- What would it mean for a bound system to be "slightly affected"?
- The influence of the expansion on the Earth's orbit around the Sun amounts to a growth by only one part in a septillion ($10^{24}$) over the age of the Solar System.*
- Even on the much larger scale of clusters of galaxies, the effect of the expansion of the Universe is 10 million times smaller than the gravitational binding of the cluster.




Cosmological expansion changed aphelion & perihelion by a factor of only ~$1/10^{24}$

*Cooperstock, et al., http://xxx.lanl.gov/abs/astro-ph/9803097

Price, arXiv:gr-qc/0508052v1