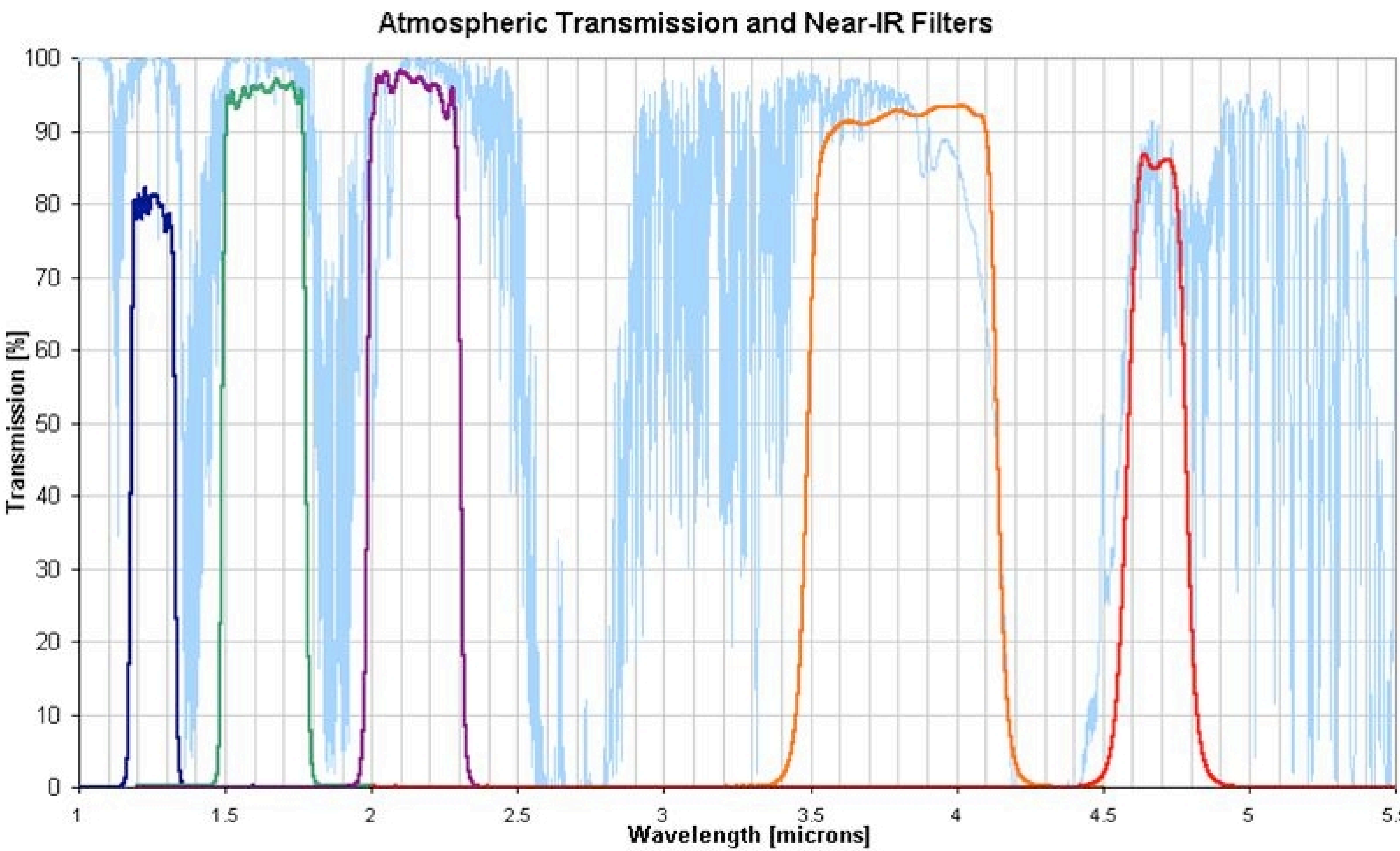
Comments on Near-IR Photometry

Michael Connelley
Jan 2, 2011

Introduction to the Infrared

- Near-IR: 1 to 2.5 microns
  - Silicon cutoff to thermal rise
  - Sky brightness dominated by OH emission
- Mid-IR: 3.0 to 20 microns
  - Thermal rise to atmospheric cutoff
  - Sky brightness dominated by thermal emission of air and telescope
- Far-IR: 20 to 350 microns
  - Atmospheric cutoff to sub-mm window opening
  - Only accessible from space


Atmospheric Transmission and Near-IR Filters
Transmission [%]
100
90
80
70
60
50
40
30
20
10
0
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
Wavelength [microns]

The Problem

- The sky is bright and variable
- It’s never “photometric”
- The air and telescope are glowing
- You’re doing what the pros were doing 30 years ago

The Problem

- The sky is bright and variable
  - H-band sky brightness is dominated by OH airglow
  - OH emission varies with time and water vapor column
  - Sky brightness beyond 2.5 microns is dominated by thermal emission.

The Problem

- It’s never “photometric”
  - Water vapor is a major source of opacity
  - “Clouds” of water vapor drift through telescope beam

The Problem

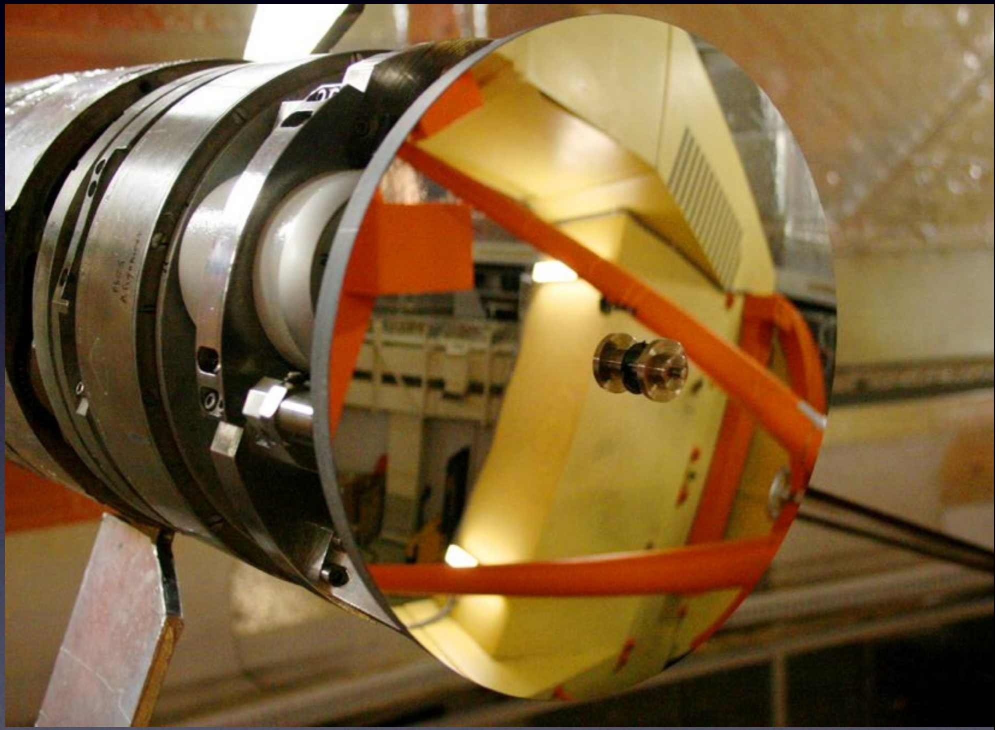
- The air and telescope are glowing
  - The air, telescope, and surroundings are at 273 K
  - 273 K blackbody peaks around 10 microns

Doing What the Pros Were Doing 30 Years Ago

- Pros
  - Better detectors and computers
  - Thermoelectric cooling
  - It’s a previously solved problem
- Cons
  - Small budget
  - Lack of access to facilities and engineering
  - Non-optimal site

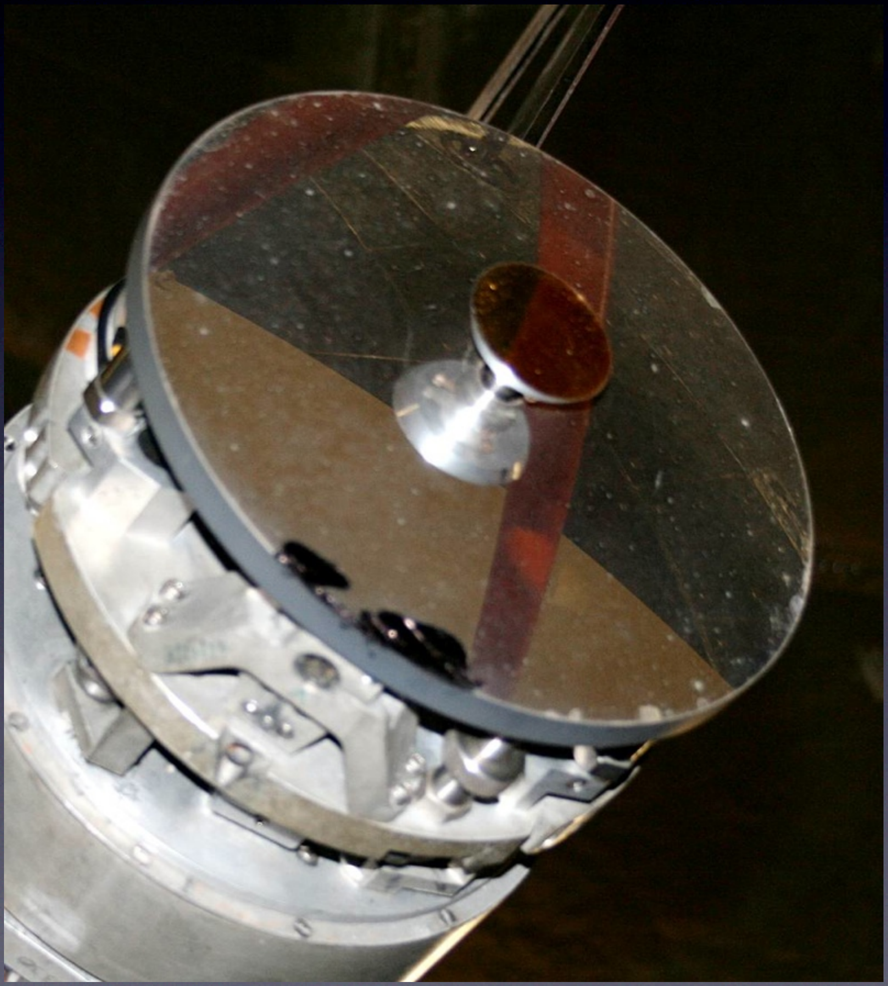
The Solution

- Infrared optimized telescope
- Instrumentation
- Observing technique



IR Optimized Telescope

- Small, undersized secondary
- ‘Button’ in middle of secondary
- Low-emissivity coatings



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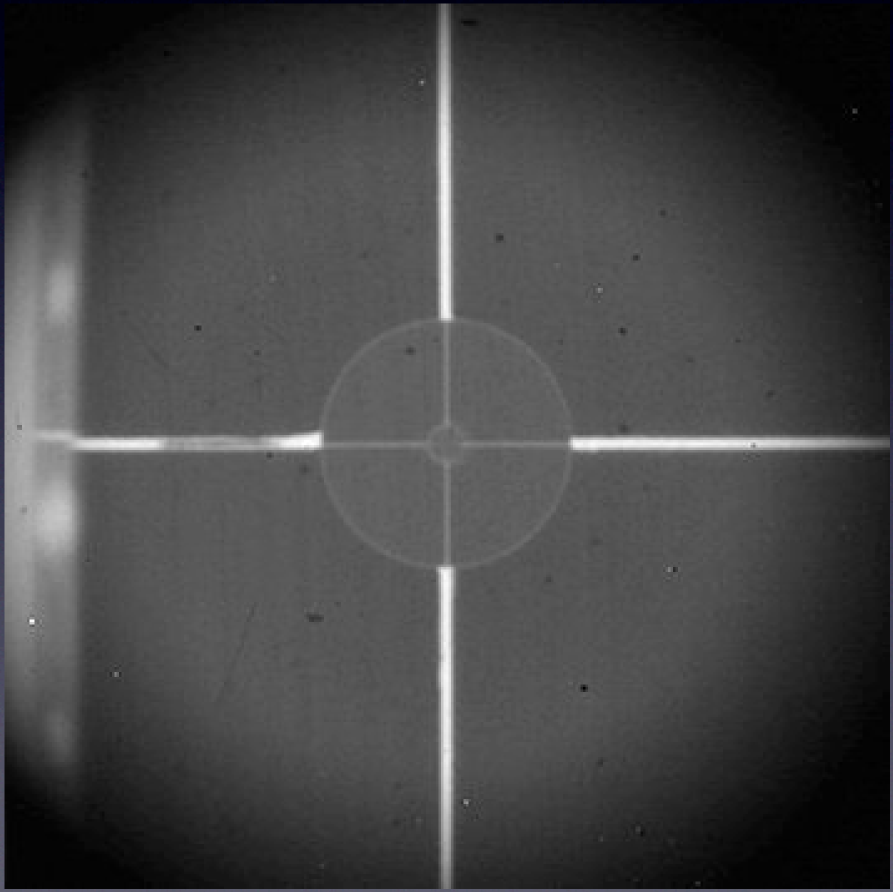
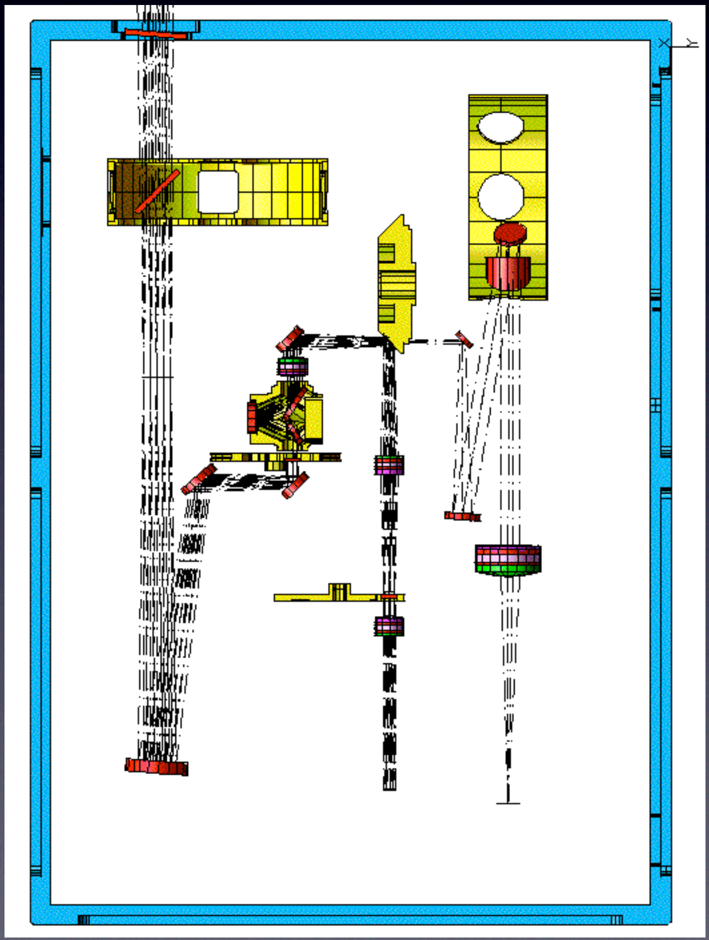


IR Instrumentation

- IR-sensitive detector (PbS, GaAs, InAt, HgCdTe)
- Cold stop
- Special glass types (typically salts)



Observing Technique

- Chop/Nod
  - Chopping: Fast-offsets to sky (2-4 Hz)
  - Nodding is about once per minute
- Dithering: Taking images at different pointings
  - Make good flats
  - Compensates for poor cosmetics
  - Follow changes in sky brightness

Recommendations (1)

- Stick with the near-IR first
  - It gets harder really fast
  - Sky and telescope get brighter
  - Water vapor is more of a problem
  - Targets tend to be fainter
  - Need to cool instrument and detector more
  - Need better site at longer wavelengths

Recommendations (2)

- Dichroic-fed optical guide camera
  - You can usually see your target in the optical easier
  - You can easily see if you’re on target when you’re getting no IR signal
  - Dichroic may need to be cold
- Dither the telescope

Recommendations (3)

- Cool the detector
  - See what can be done with TEC
  - Getting LN2 to a remote site is a pain
  - Dealing with LHe is a big pain
  - LHe is very expensive
- Avoid a chopping mirror
  - Dynamic optical systems are hard to get working

Recommendations (4)

- Cold Stop
  - Image entrance pupil onto a cold stop
  - Prevent detector from seeing thermal glow of telescope, ground, surroundings
- Filters beyond H-band need to be cold
  - They’re opaque over most of detector’s bandwidth, thus high emissivity