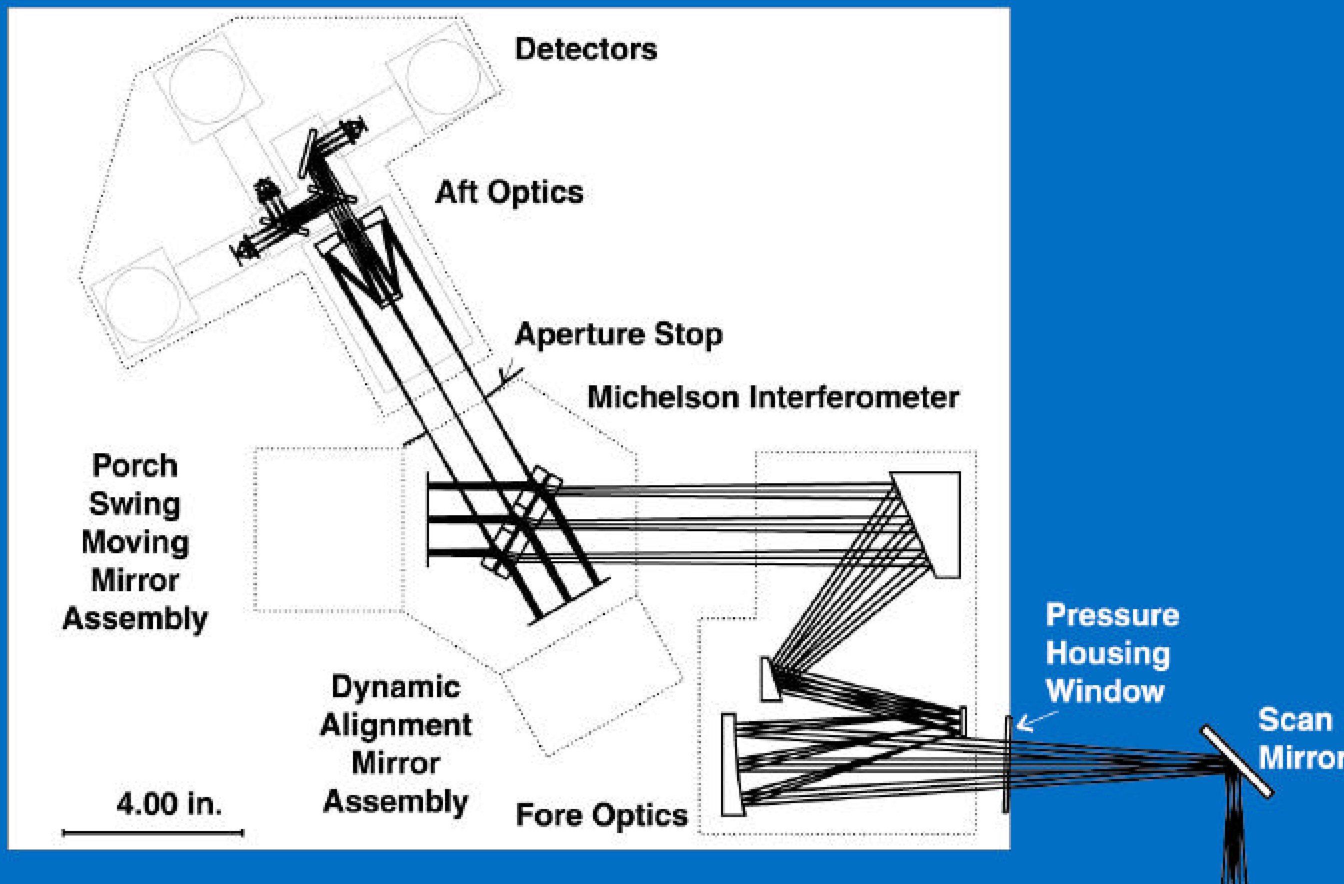
NAST-II Detectors

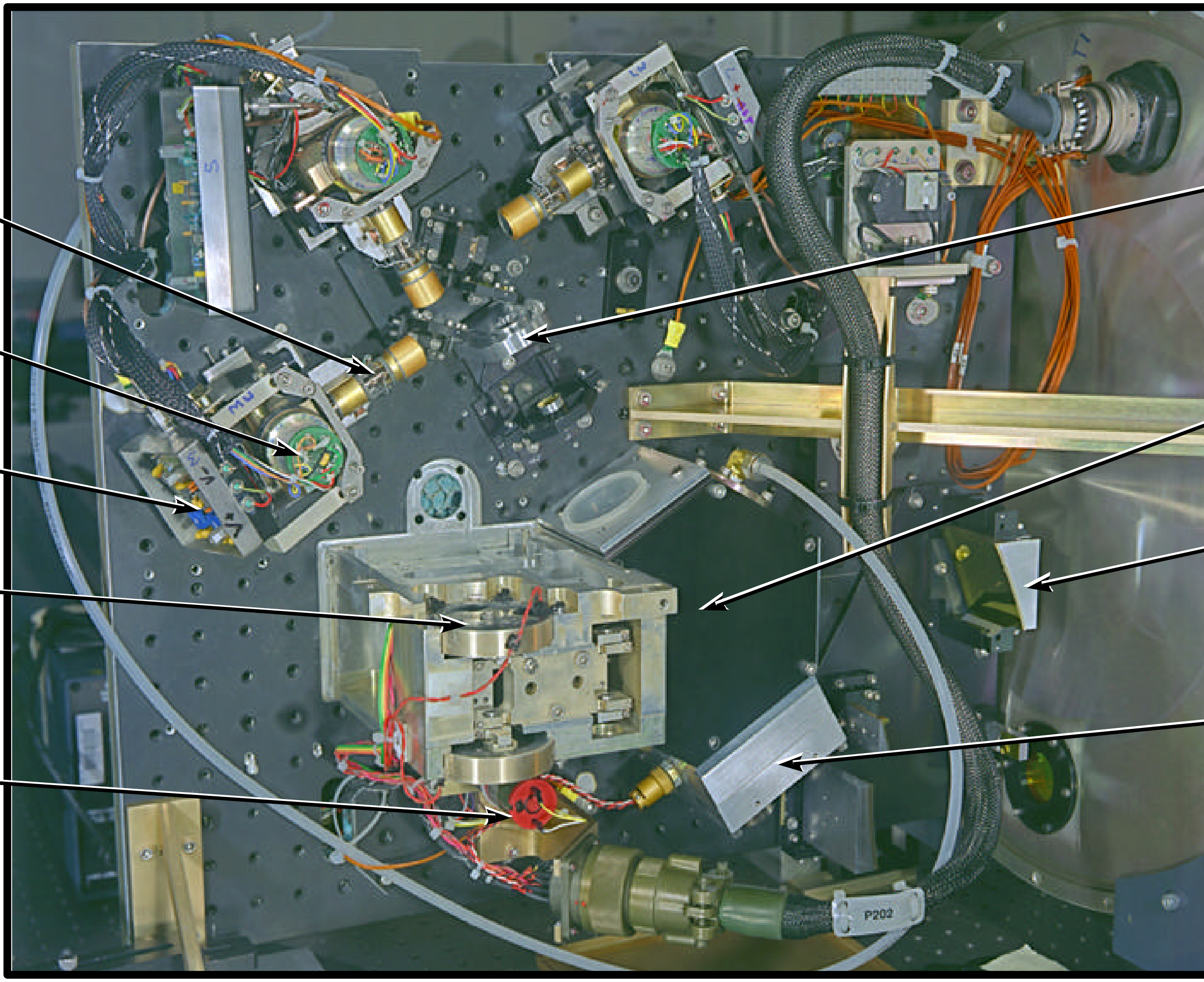
- NAST design constraints
- Scaling from NAST-I
- Reduced NEDN
- Detector array yields
- Pointing issues
- Detector vendors

LL NAST Optical Layout

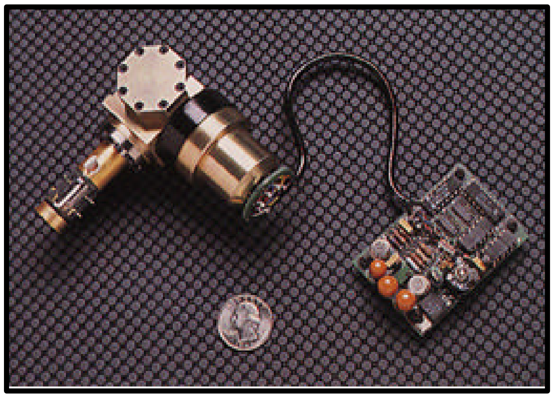


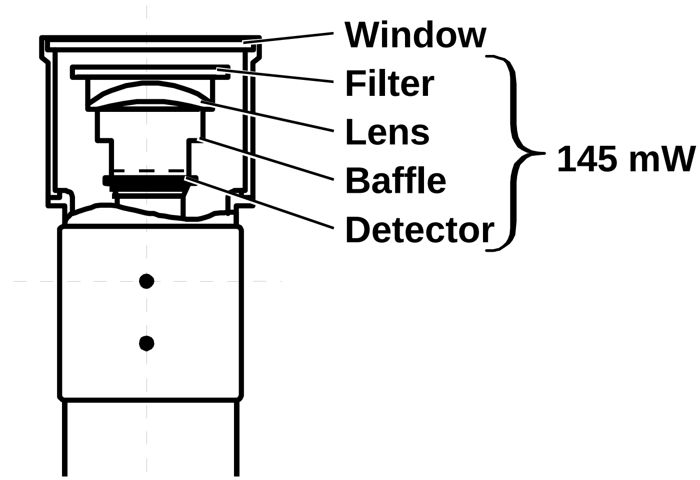
- High optical throughput requires large 1 mm detectors
- Optical system images entrance pupil onto detector
- Maximum use of reflective optics

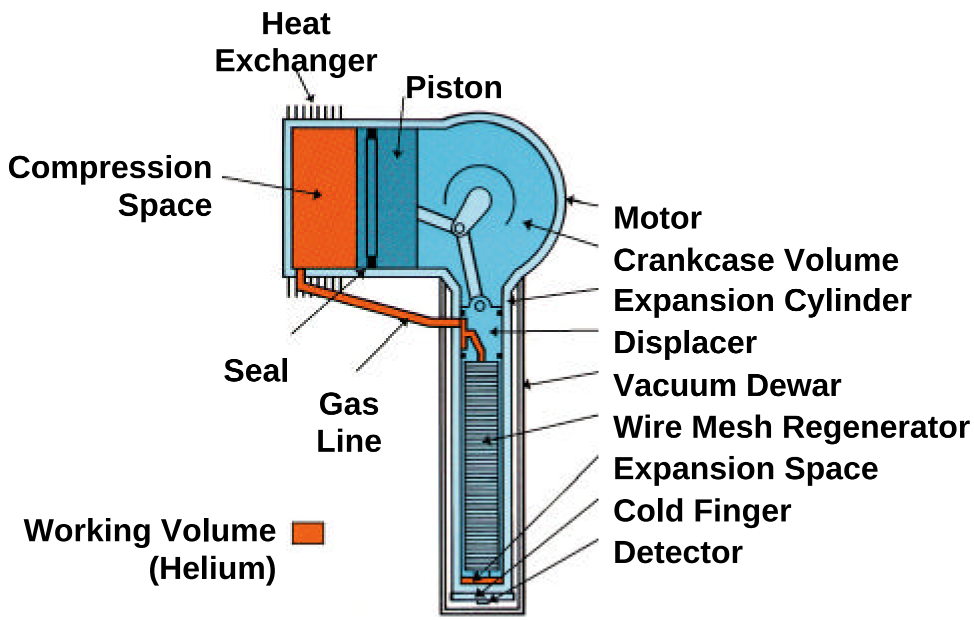
LL Instrument Baseplate — Optics

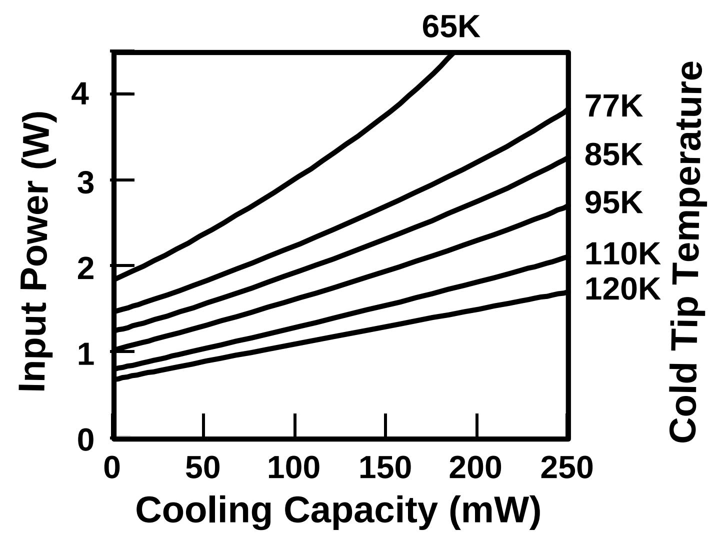


NAST Interferometer Integral Cooler





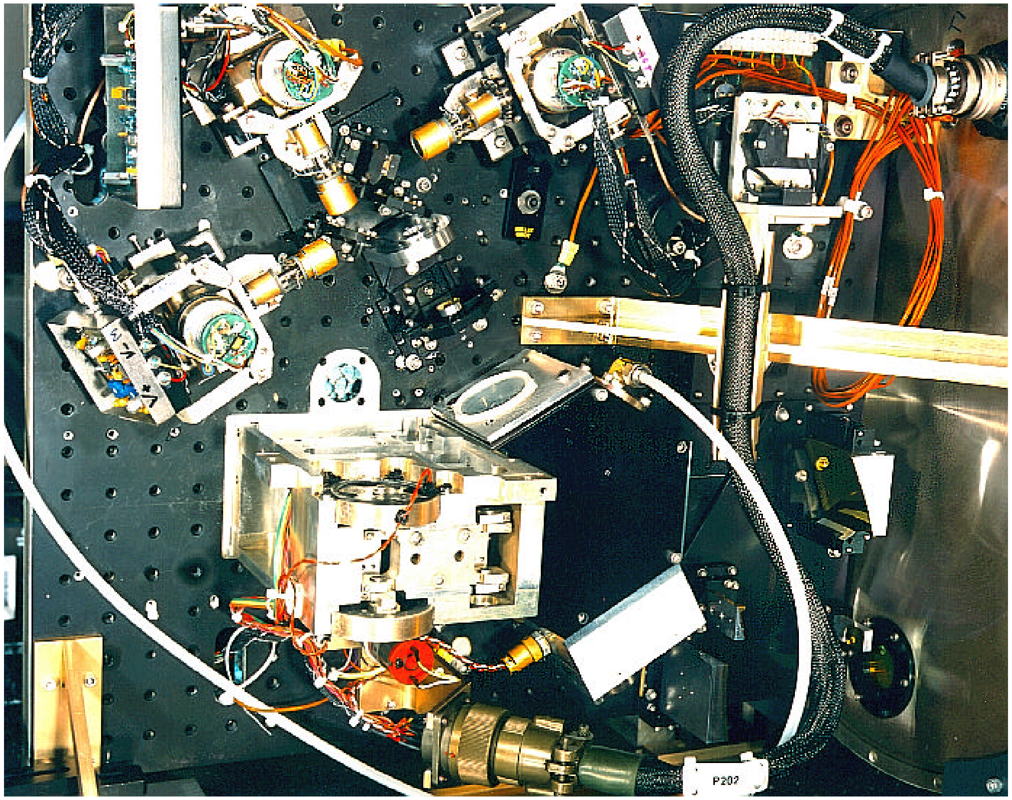




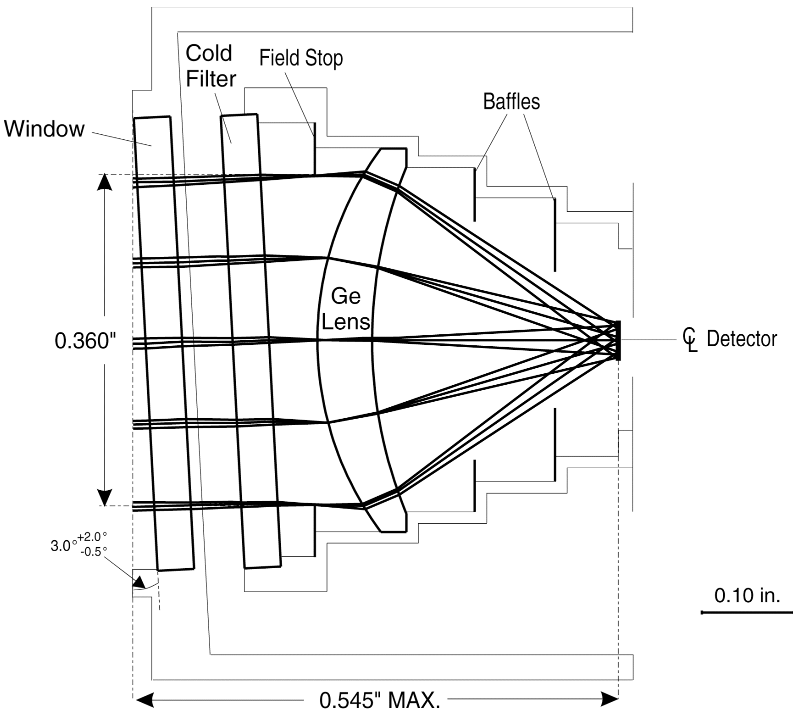
999999-4
XYZ 7/14/03

Background Radiance in NAST-I

- **NAST-I operates at room temperature (ground and flight)**
- **Cold field stop and baffles within detector package significantly reduce background radiation from surrounding structures**
- **Some flux is modulated by the interferometer and detected**



Optical Bench



NAST Detector Assembly

NAST-II Detectors

- NAST design constraints
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- Reduced NEDN
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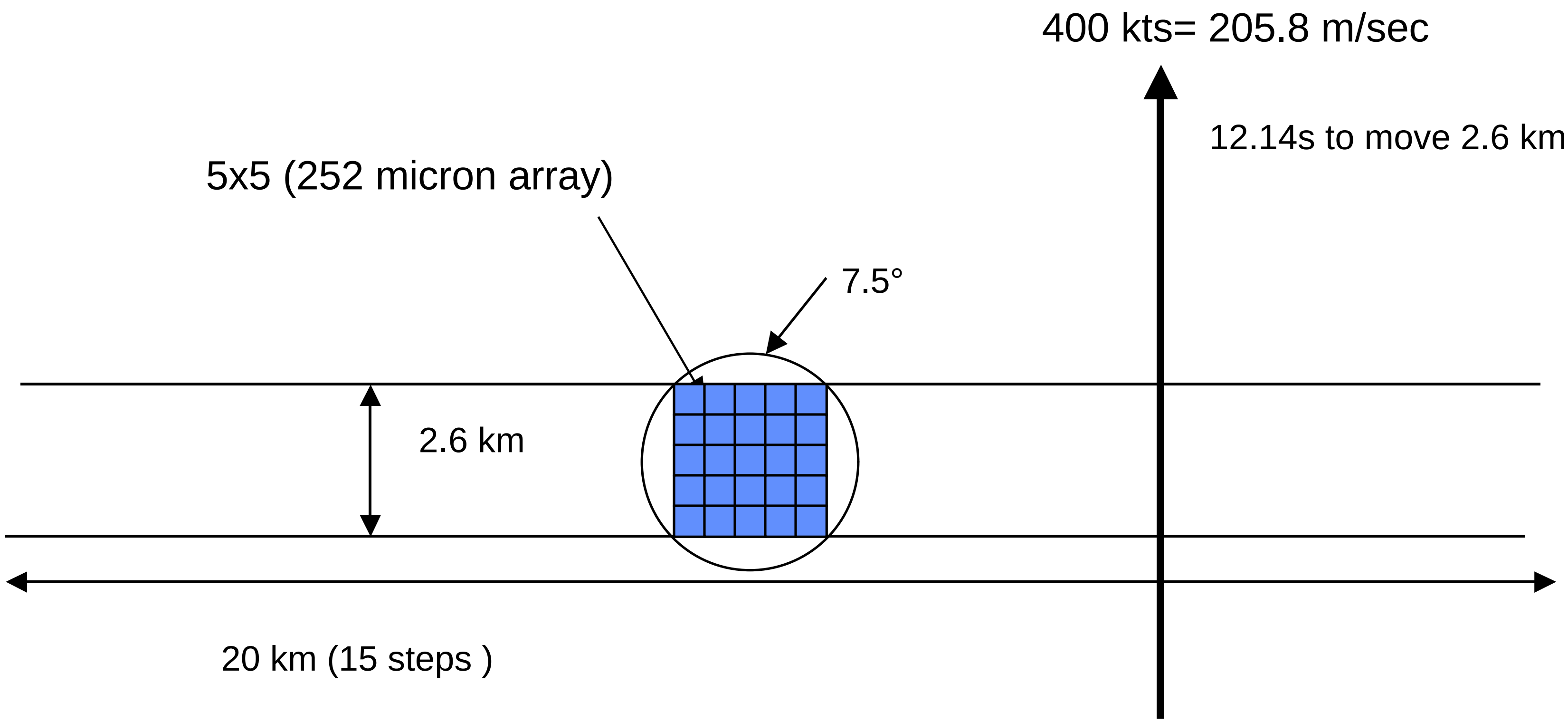
Scaling from NAST-I

NAST Has Large Field of Regard (FOR)

		NAST-I	GIFTS	CrIS	NAST-II easy	NAST-II hard
SYSTEM						
Alt	**km**	21.1	36000	833	20	20
FOR	**km**	2.6	512	48.0	2.5	2.5
N det		1	128	9	5	5
FOV	**km**	2.6	4	14	0.5	0.5
FRONT TELESCOPE						
FOR input angle	**rad**	0.123	0.014	0.058	0.125	0.125
FOR input angle	**deg**	7.06	0.81	3.30	7.16	7.16
input pupil	**in**	0.276	9.45	3.15	0.276	1.38
output pupil	**in**	1.5	1.38	3.15	1.5	7
magnification		5.43	6.86	1	5.43	5.07
elements		4	5	0	4	4
REAR TELESCOPE						
FOR input angle	**rad**	22.7	2.1	57.6	23.0	24.6
FOR input angle	**deg**	1.30	0.12	3.30	1.32	1.41
Detector size	**μm**	1000	60	800	240	240
f/#		1.00	2.25		0.92	0.92
elements		2	2	5	2	2

NAST-II (Easy)

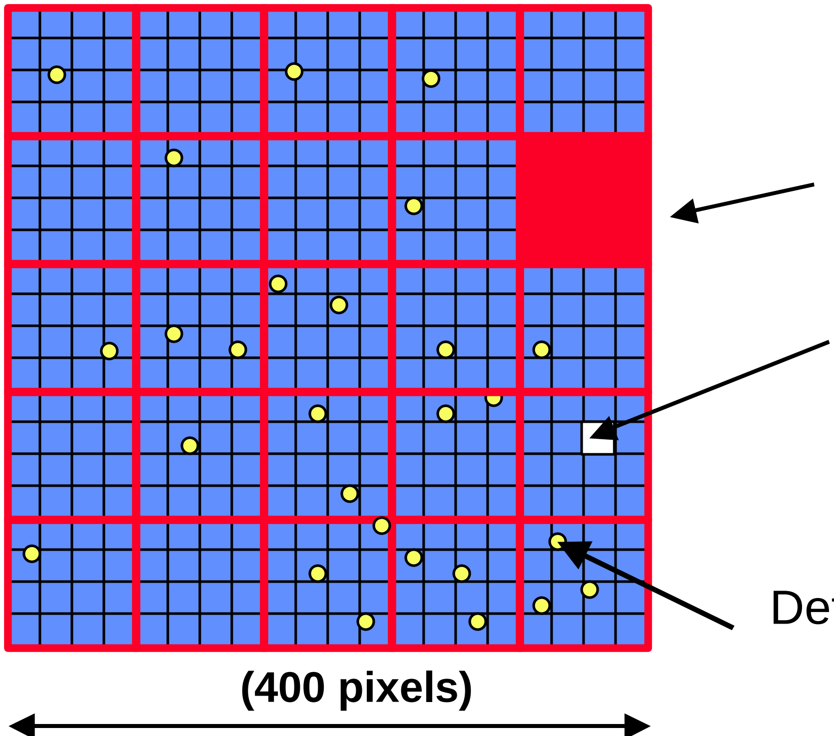


Same scan & step as NAST-I

BLIP NEDN is >5 times poorer

5x5 Arrays Made of sub arrays

Entrance pupil= 0.789 in
7.50° Field on ground



1260 µrad

252 x252 micron pixel matched to optical spot at fast f/0.92 detector optic

~ 16   60 x 60 micron

Defect

$N_{mean}=A/A_0=142$ for GIFTS like array

$N_{mean}=A/A_0=2$ for CrIS like array

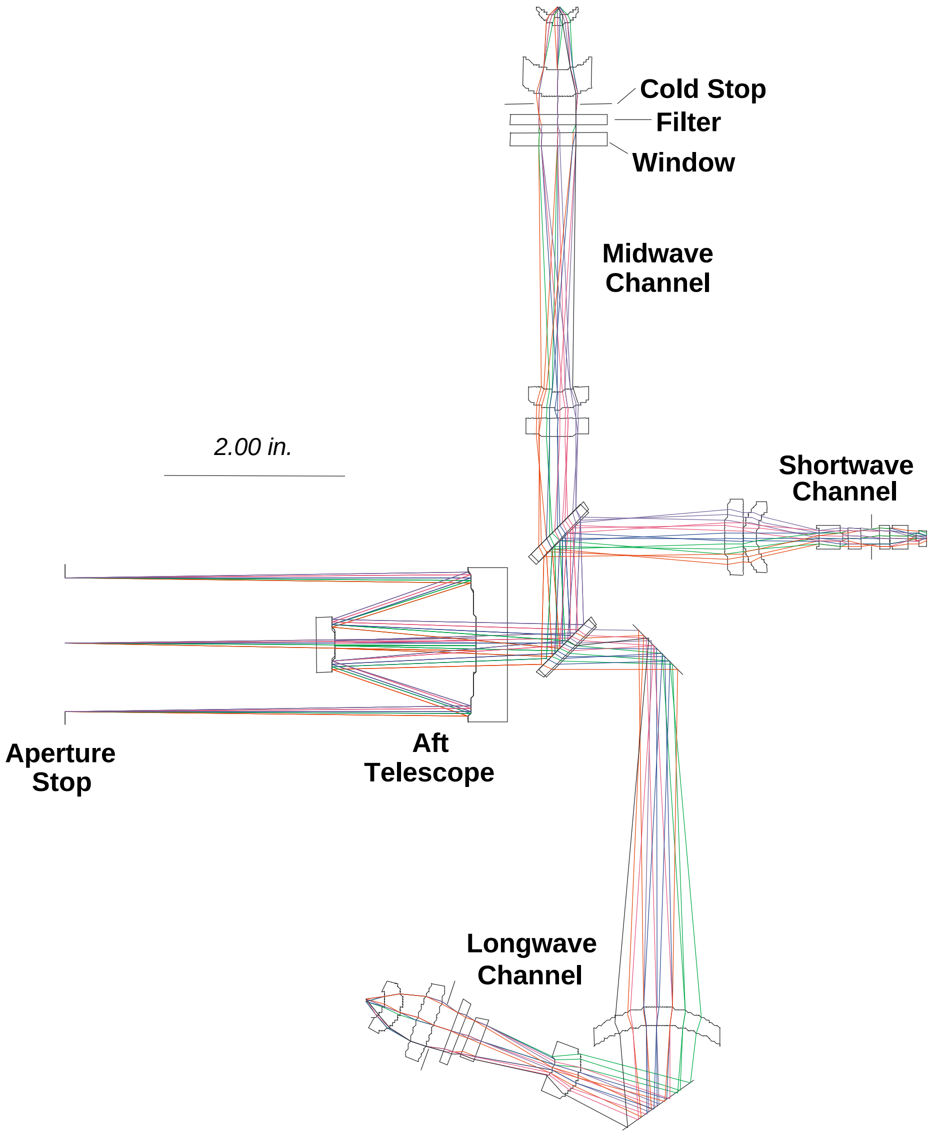
LW Array Defects and Yield

- Poisson statistic for defects
- Probability of N defects in area A is

$$P(N;A) = \frac{1}{N!}\left[\frac{A}{A_0}\right]^N \exp\left(-\frac{A}{A_0}\right)$$

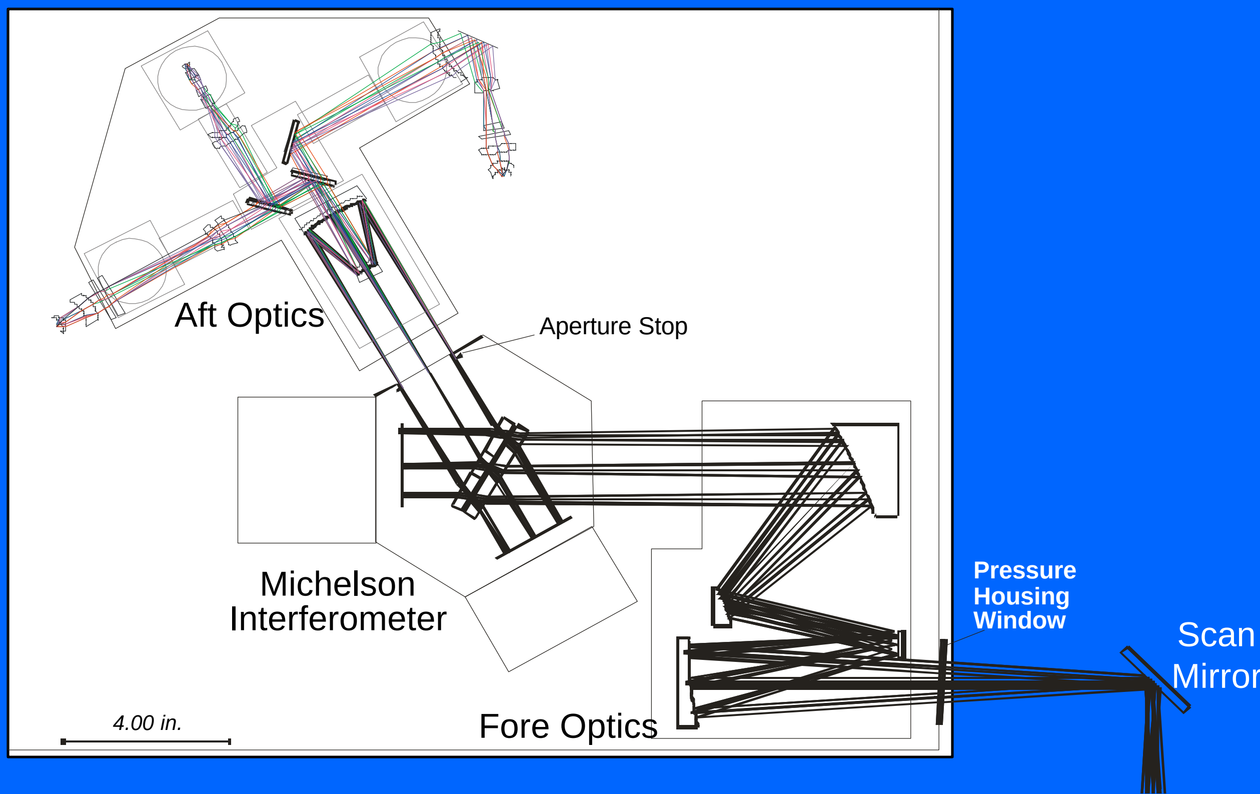
- A_0 is the mean area per defect and A/A_0 is the mean number of defects in A
- LW (14 micron cutoff detectors) examples
  – CrIS: For probability no defects in a 0.8 mil square detector is 0.1, A_0 is 2.8e5 microns^2
  – GIFTS: For probability of good 30 micron square pixels is 0.82, A_0=4.5e3 microns^2
- Improvements can be made by excluding bad sub-pixels

Revised Optical Design



- Strawman leaves scan mirror, input telescope, interferometer, telescope, and dichroics unchanged
- Nominal 16x16 array
- Point response smaller than 60 micron detector size
- +/- 3.795° FOR
- 2.8 km square at 21.1 km
- Entrance pupil 0.273”
- Magnified to 1.5 “

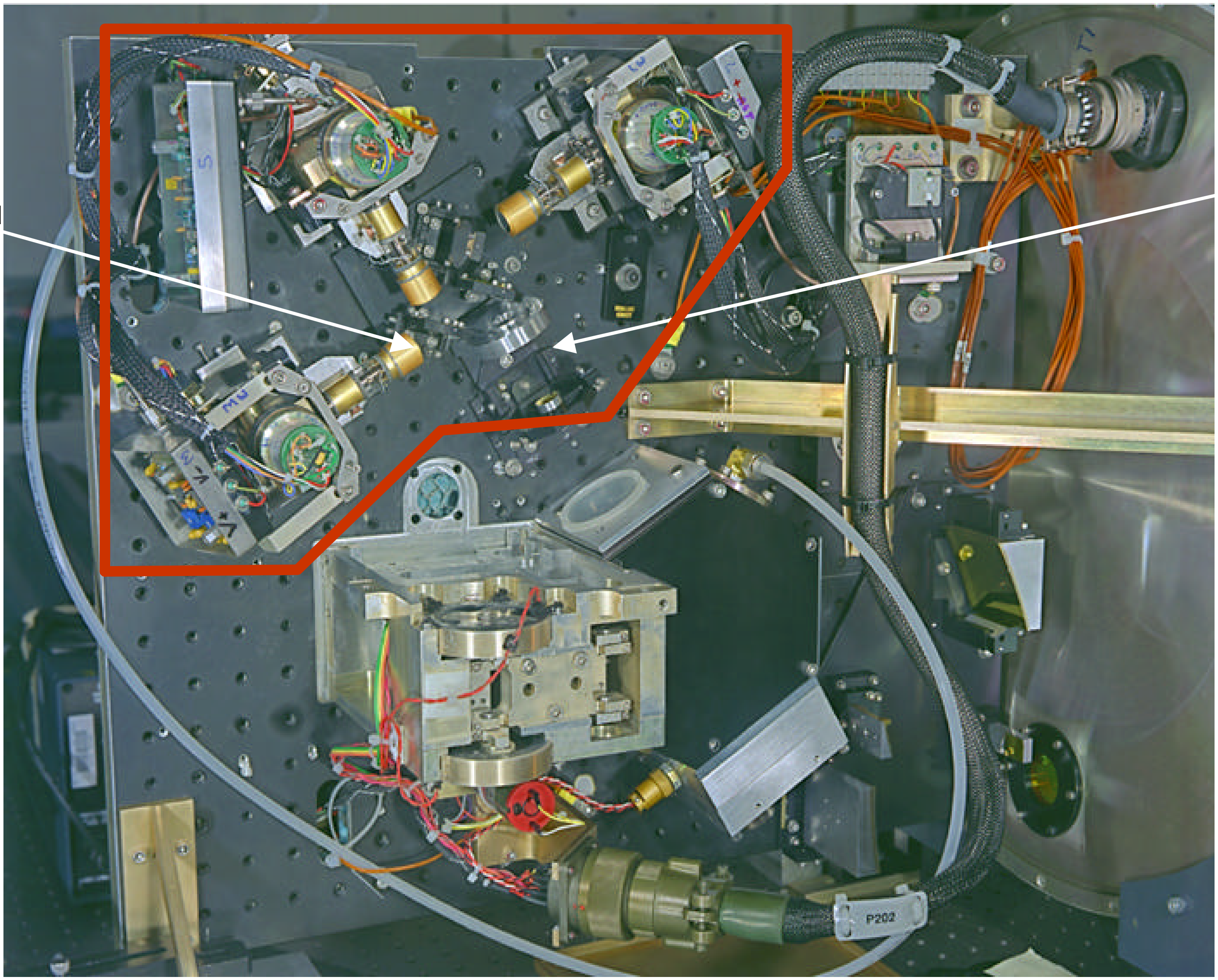
Revised folded NAST II Imager



- Spot size smaller than 60 microns
- New dewar designs

Replace Aft Optics & Detectors

Detector and Dewar



AFT Optics

NAST-II Detectors

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- ➡ Reduced NEDN
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Reduced NEDN

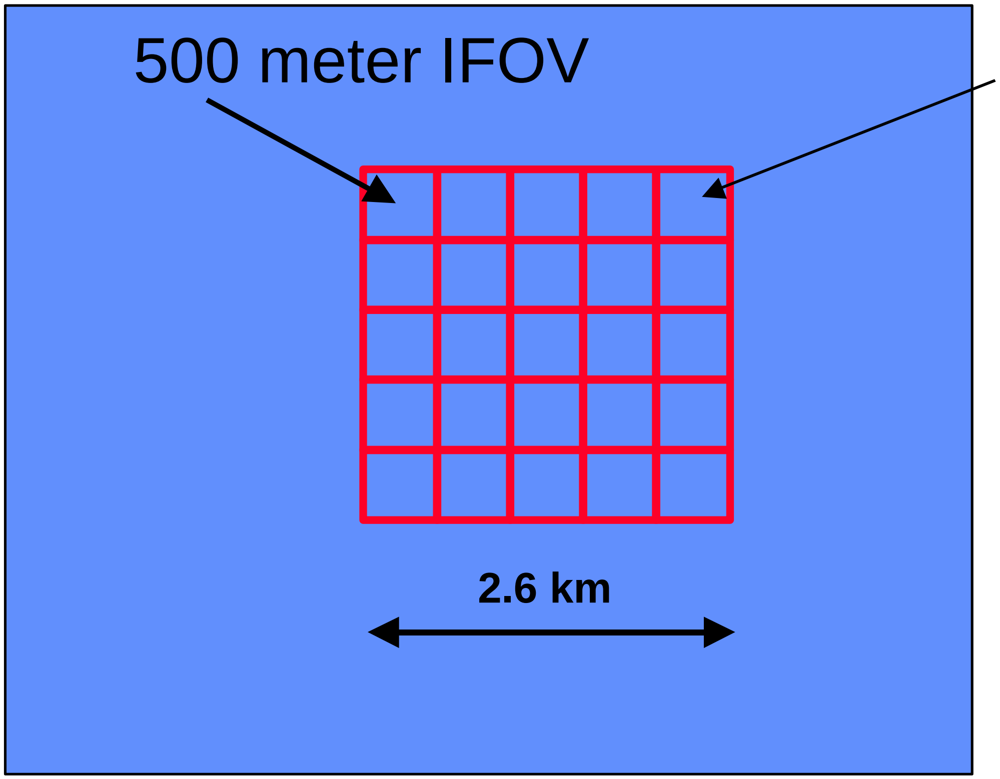
- BLIP NEDN is >5 times poorer
  - 252 micron square detectors due to reduced FOV
- Options for improvement
  - F/# is already very fast so leave f/0.92 alone
  - Increasing aperture will require larger detector and a larger interferometer beam diameter or more self apodization
  - Extend the array along the cross track direction to increase number of detectors, reduce steps, and increase dwell time

Larger aperture considerations

- Larger interferometer beam diameter
  - More vibration problems (quadratic scaling)
- Larger fore and aft telescopes
- Larger detector arrays
  - Sqrt(AΩ)~Dθ product constant through the optics
  - Initial pupil imager 1000 microns & ~f/1 cone
  - At detector 240 microns & f/0.92
  - Aperture Ω fixed by 0.5 km requirement
  - Detector area will scale with aperture
- To buy back a factor of 4 in SNR you need to make the aperture diameter 4 times larger
- Detectors will return to original ~ 1 mm square size!
  - Original SNR for pupil image 920 microns and f/1
  - 5x5 array of 1 mm square detectors needed for same SNR in smaller FOVs

Large Aperture Focal Plane

GIFTS ARRAY



Each array is 20X20 60 micron sub detectors

Aperture 5x

10,000 - 60 micron detectors in red areas

Reduced NEDN

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  - 252 micron square detectors due to reduced FOV
- Options for improvement
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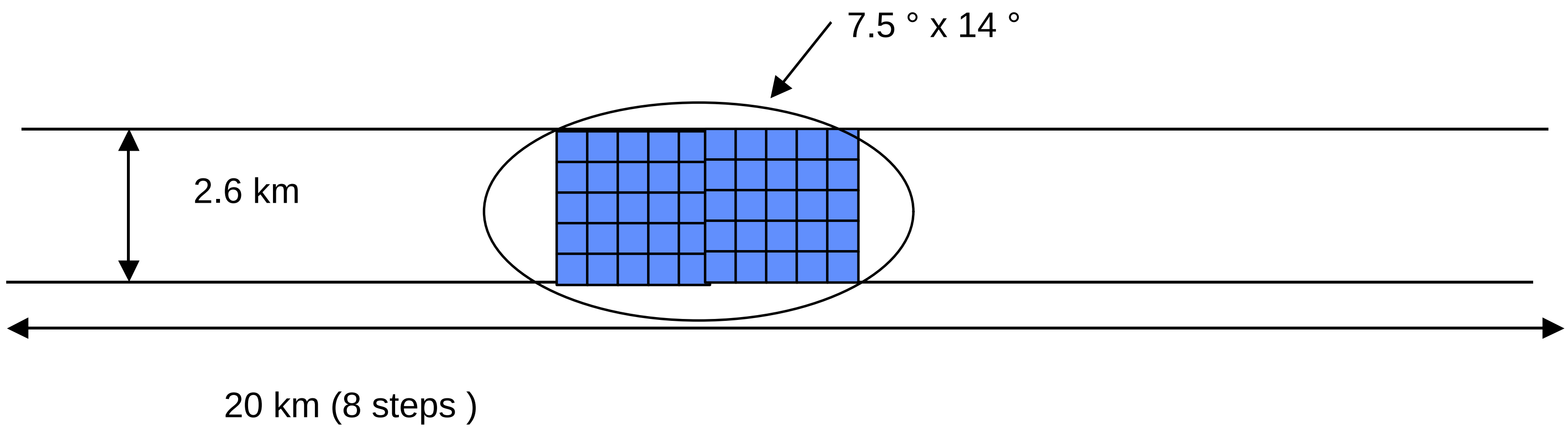
  - Extend the array along the cross track direction to increase number of detectors, reduce steps, and increase dwell time

Larger in-scan array

- Larger array options
  - Only makes sense optical to extend one dimension
  - Effects efery optical design
  - Very difficult optical problem to get improvement in the SNR by sqrt(2)



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Dynamic alignment Does Not Remove Beam Jitter

Tilt of beam from each arm (A, B) of the interferometer

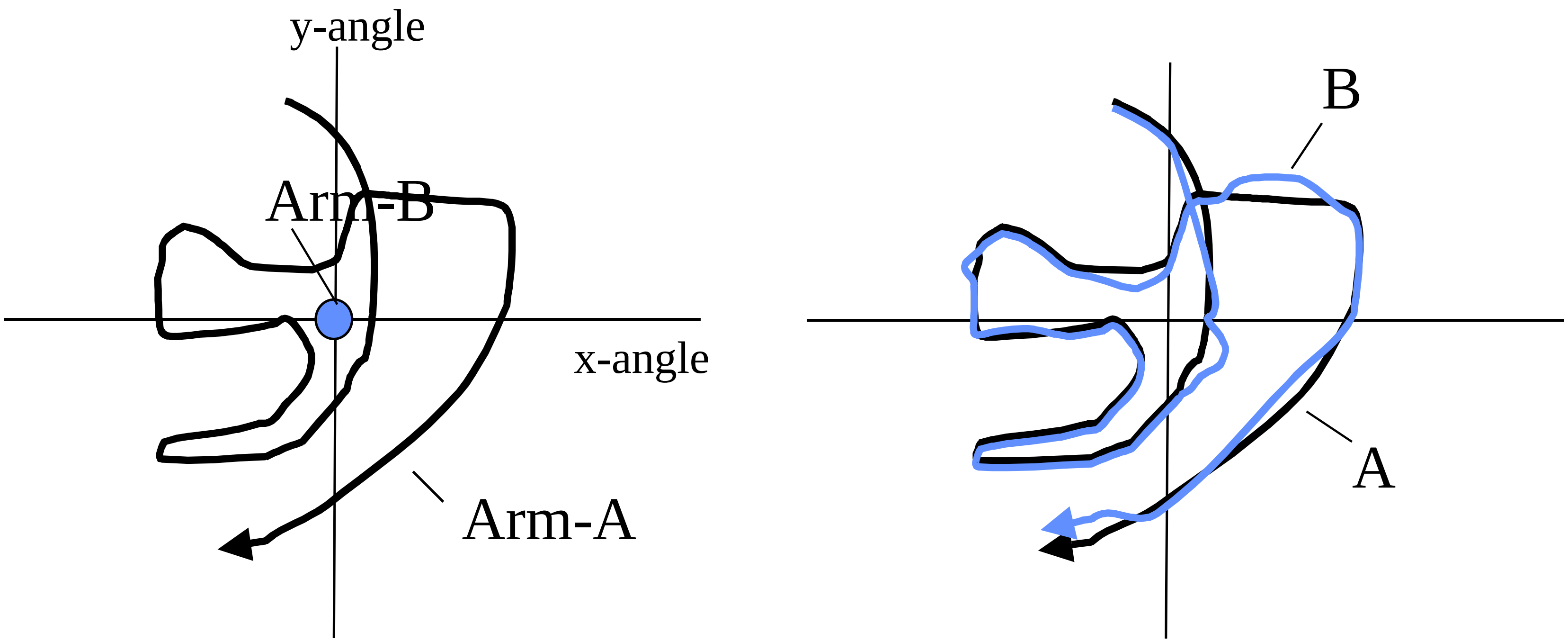
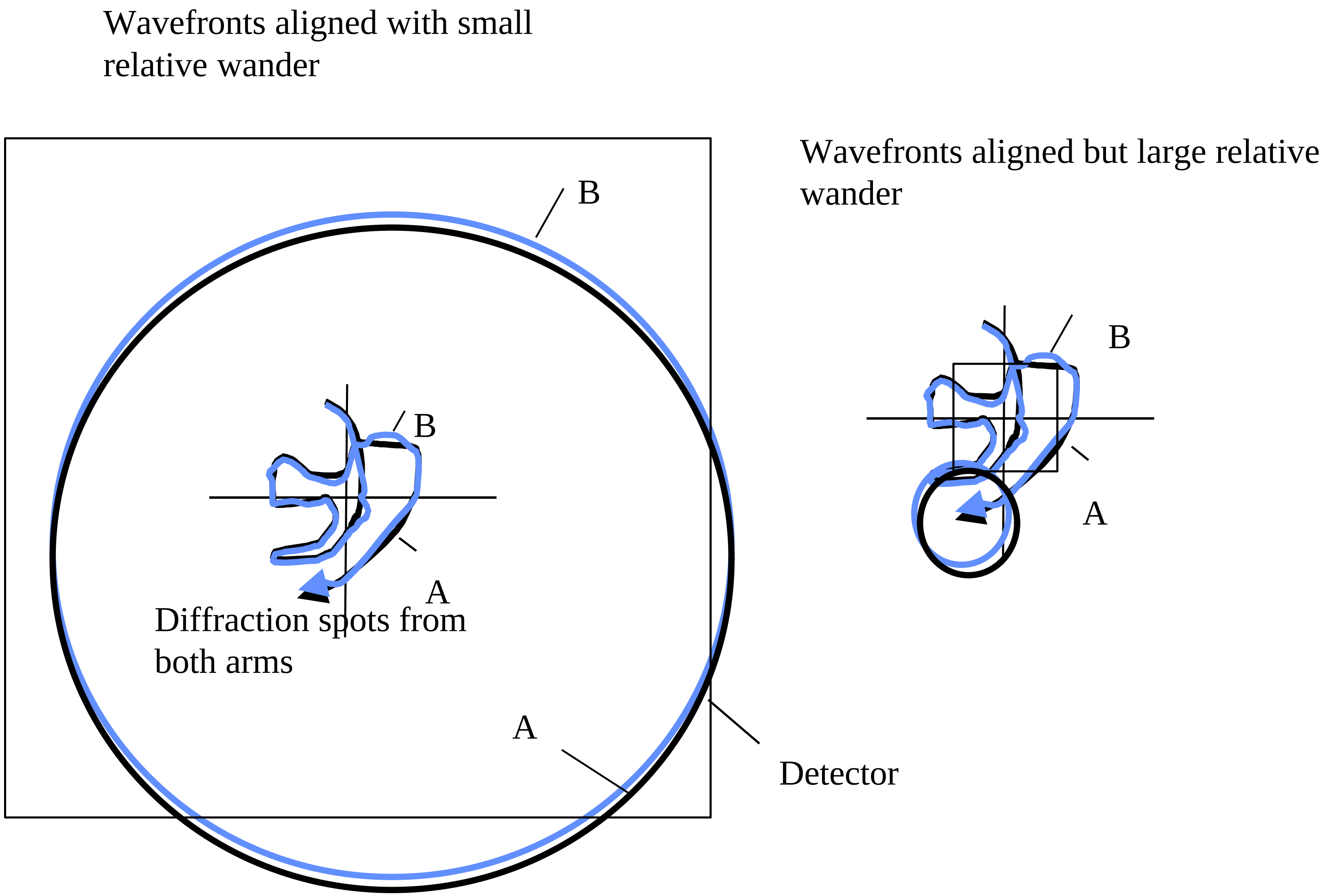


Figure 1a No-dynamic alignment

Figure 1b With dynamic alignment

Smaller fields of view and pointing jitter



NAST-II Detectors

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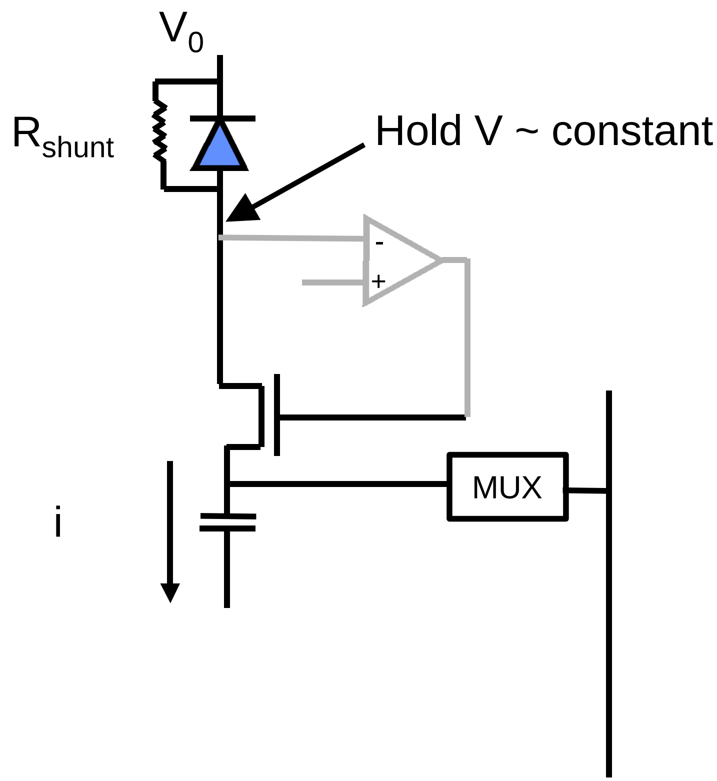
Current IR HgCdTe Array Architecture

- **Nothing very new architecturally in ROIC**
  - **Linear current integration**
  - **Analog multiplexes and output**
  - **Off-chip A-to-D Conversion**

- **Improvements in implementation**
  - **Better manufacturing processes**
  - **Better materials**
  - **Larger arrays**
  - **HgCdTe LW cutoff to 15-17 microns**
  - **Higher Yields**

- **Limited number of suppliers**

Basic circuit circa 1970s



Examples of HgCdTe State of the Art

- Tuning an old architecture
- GIFTS Program
  - BAE 128x128 MW & LW FPA
  - 16 taps @ 8 MHZ
  - 8 KHz frame rate
- Other vendors have similar technology
- More than adequate for NAST-IER

Note: numbers reflect specification not capabilities

Summary

- **Relatively simple replacement with 5x5 array of 252 micron detectors**
- **To achieve high performance (NEDT= 0.25) need larger instrument apertures (5x) & focal planes (10,000 elements) and binning**
- **Find some spare arrays!!!!!!!**