Spectro-polarimetry with NLST

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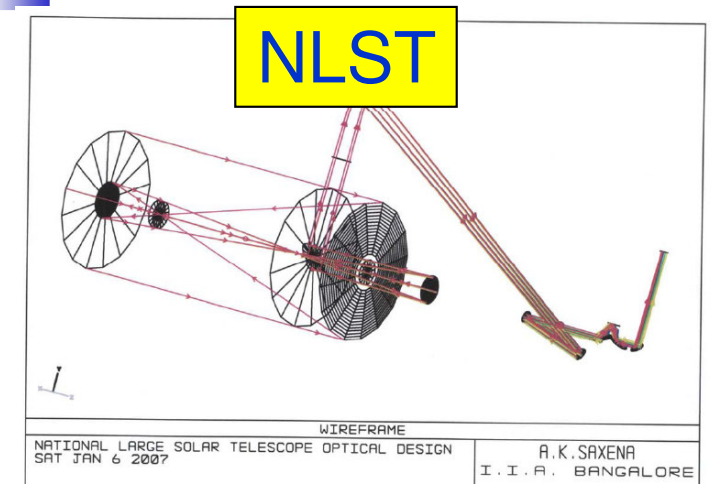
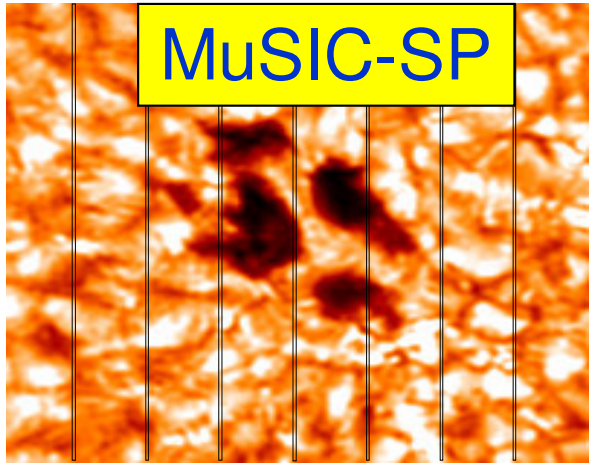
Plan of the Talk

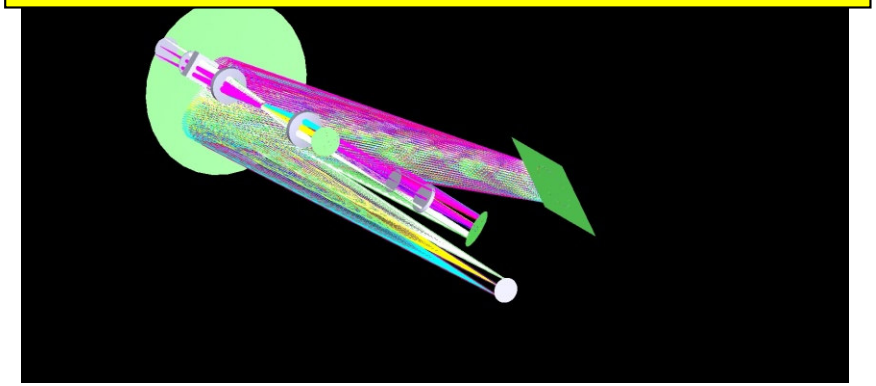
NLST



MuSIC-SP

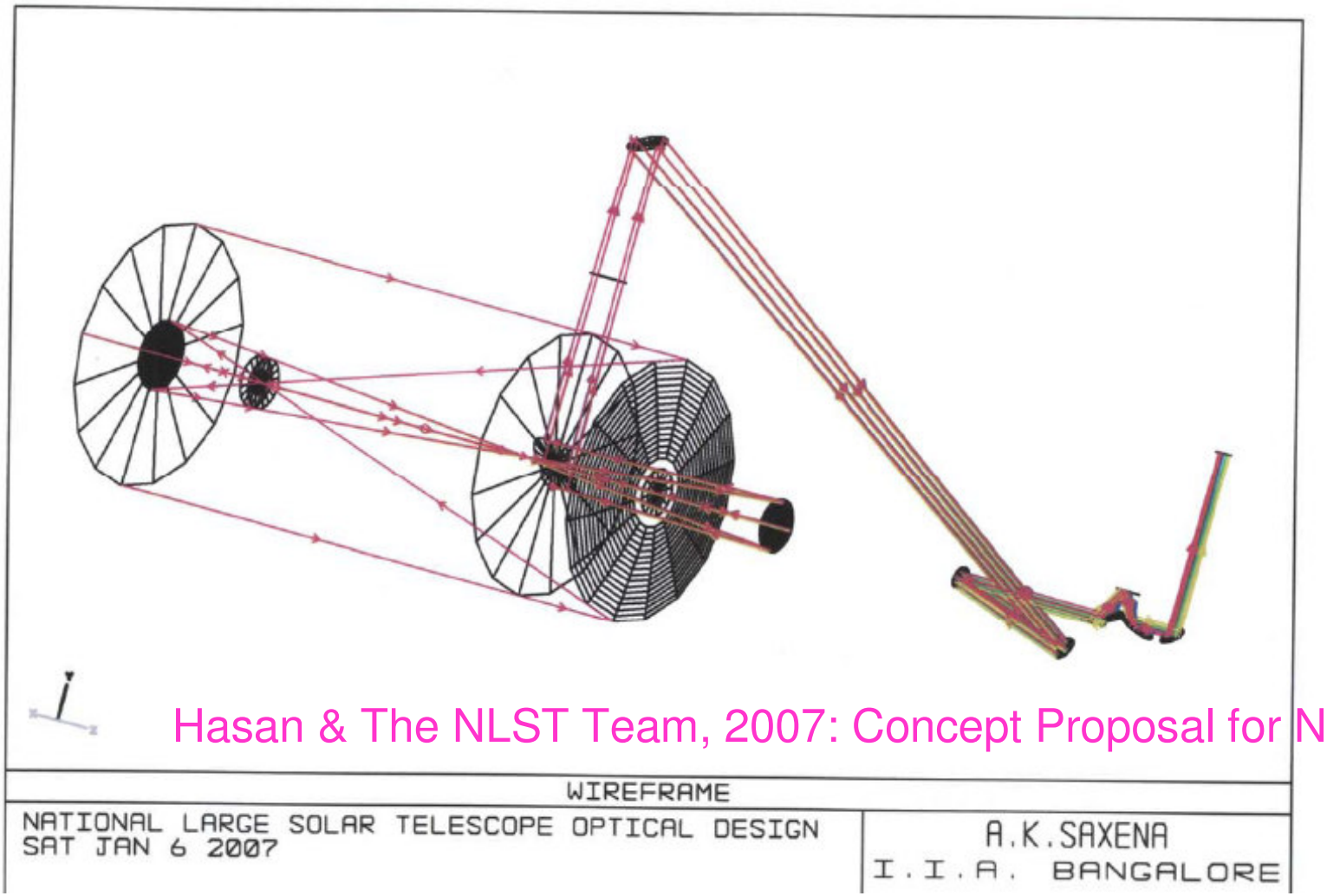


CONCEPT REALIZATION



SUMMARY & STATUS

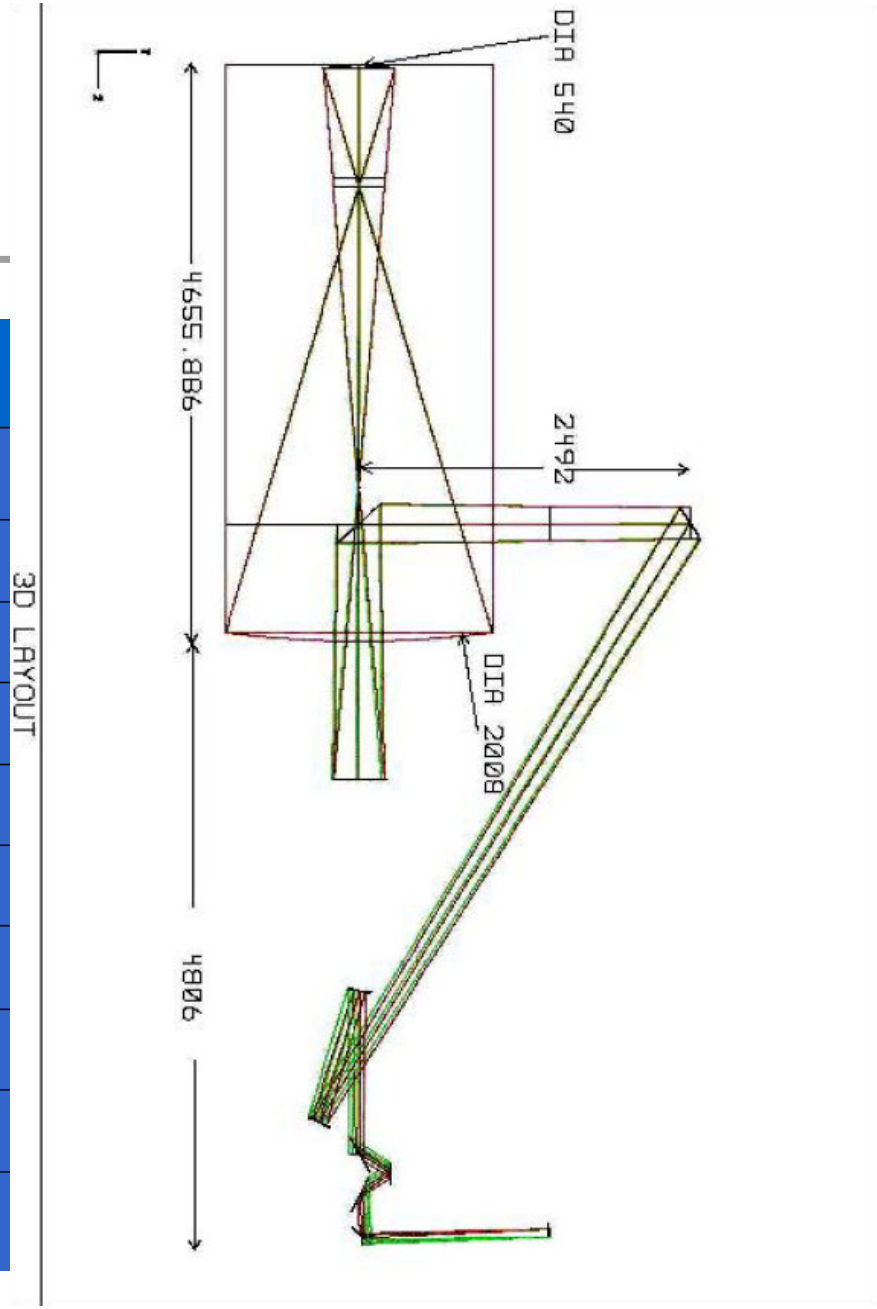
NLST



Hasan & The NLST Team, 2007: Concept Proposal for NLST

NLST

Summary of NLST Telescope features	
Aperture (Primary Mirror M1)	: 2 Metre
Focal Length	: 4 Metre
Optical Configuration	: 3 Mirror, Gregorian on -axis
Field of view	: 300 arc sec
Final focal ratio of the system	: f / 40
Image Scale	: 2.58 arc sec mm-1
Optical quality	: < 0.1 arc sec over the field of view
Wavelength of operation	: 3800 A to 2.5 microns
Polarization accuracy	: 1 part in 10,000
Active and Adaptive optics	: to realize near diffraction limited performance



3D LAYOUT

NLST Science Requirements

- Small-scale Magnetic Structuring of quiet and active regions
  - Requirements: 0.1″ ; NC ; ~30mA ; 30″X30″ ; 0.1%
- Waves in the flux tubes and active regions
  - Requirements: 0.1″ ; ~1min ; <60mA ; 100″X100″ ; 0.1%
- Time evolution of small-scale fields in quiet as well as active regions
  - Requirements: 0.1″ ; ~1min ; ~30mA ; 30″X30″ ; 0.1%
- Hanle polarization measurements
  - Requirements: NC ; NC ; <30mA ; NC ; 0.01%

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NLST Science Requirements

- Magnetic coupling between the photosphere and chromosphere
  - Requirements: ≤ 1″ ; < 3min ; <60mA ; 100″X100″ ; 0.1%
- Emerging Flux Region
  - Requirements: ≤ 1″ ; < 3min ; <60mA ; 180″X180″ ; 0.1%
- Molecular Line SP
  - Requirements: ≤ 1″ ; NC ; <20mA ; NC ; 0.1%
- Magnetic Helicity
  - Requirements: ≤ 1″ ; < 3min ; <60mA ; 180″X180″ ; 0.1%
- Off-limb Observations
  - Requirements: ≤ 1″ ; < 3min ; <60mA ; NC ; 0.01% ; Scattered Light < 1%

Polarimetry Requirements

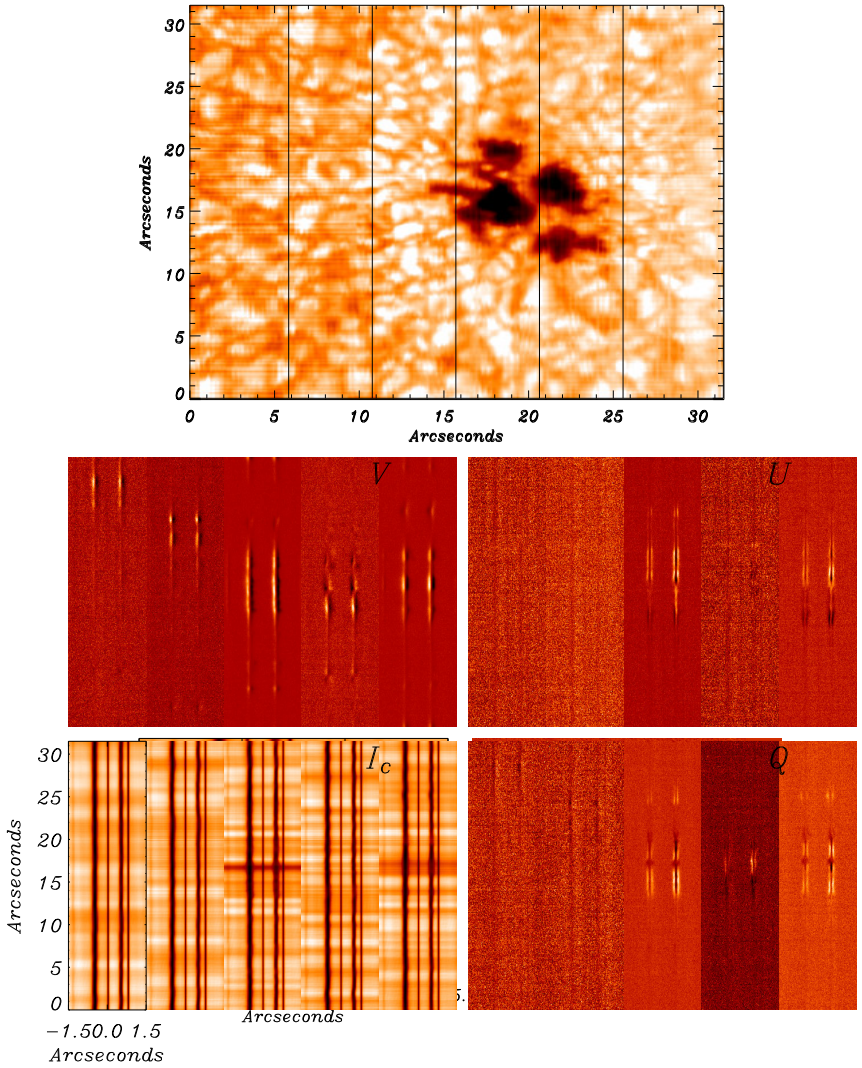
- Sensitivity ~ 1 X 10^{-5}
- Accuracy ~ 5 X 10^{-4}
- Instrumental Polarization Requirements < 1% before modulation and <10% before demodulation
- Position of the Polarimeter and Modulation and Demodulation techniques will be critical
- Wavelength Coverage: 380nm to 2.5μ

Polarimetry with NLST

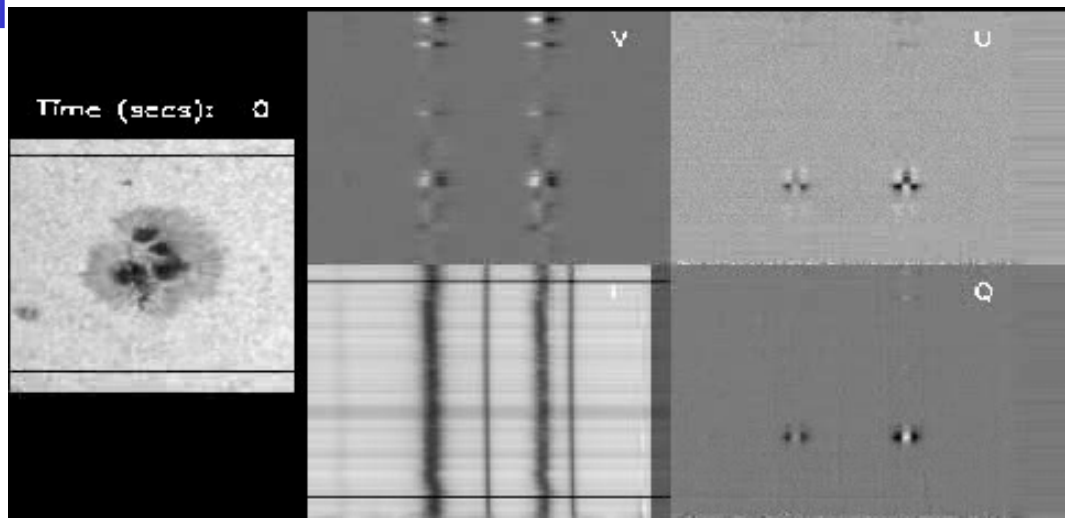
- Visible to NIR Spectro-Polarimetry (SP)
  - Multi-slit Imaging Capable (MuSIC) SP
    - High spatial, spectral and temporal resolution with limited FOV
    - Multi-line option <= 3 spectral lines simultaneously
  - High spectral resolution single slit SP
    - High spatial and spectral resolution with limited FOV and temporal coverage
    - Multi-line option > 3 spectral lines simultaneously
- Visible Light FP-based Spectro-Polarimetry
  - Either 2- or 3-etaon system (IBIS type or TESOS type)
  - Larger FOV and high spatial resolution
  - No simultaneity only near simultaneity even for a single line

Multi-slit Spectro-polarimetry

- Single-slit vs Multi-slit:
  - Single-line/line pair in single-camera observations
  - Availability of large format CCDs
  - Time reduction by the number of slits.



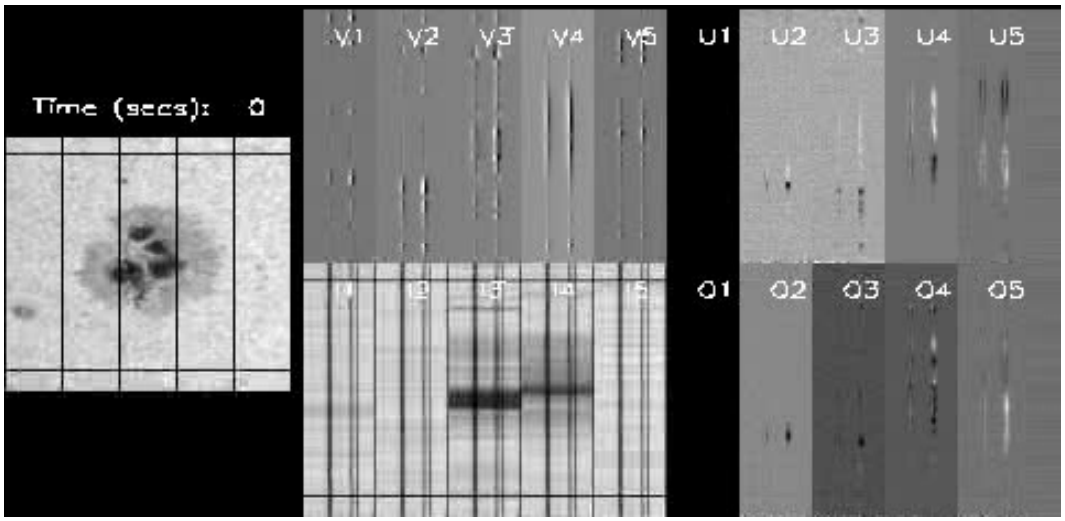
Scanning the 2D FOV



Inst.: ASP
Tel. : DST

- 60” X 60” FOV
- Slit width of 0.3”
- Stokes [I, Q, U, V] are processed data not the raw data.
- Time taken to complete the scan is 17-minutes.
- Time taken for each slit position is 5seconds.

Motivation for a Multi-Slit Spectrograph

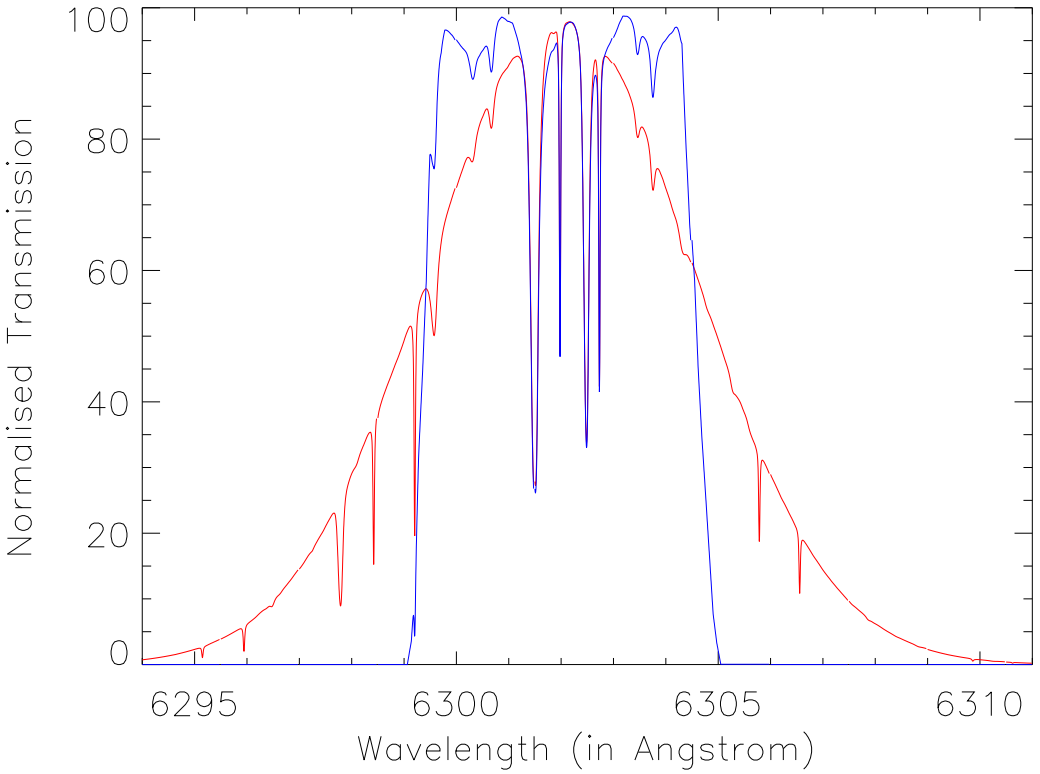


SIMULATED
Inst.: ASP
Tel. : DST

- Time limitation can be reduced by the number of slit.
- Availability of large format CCDs allow for a multi-slit configuration.
- Improvements on the narrow-band filters, particularly, the filters with square profile.

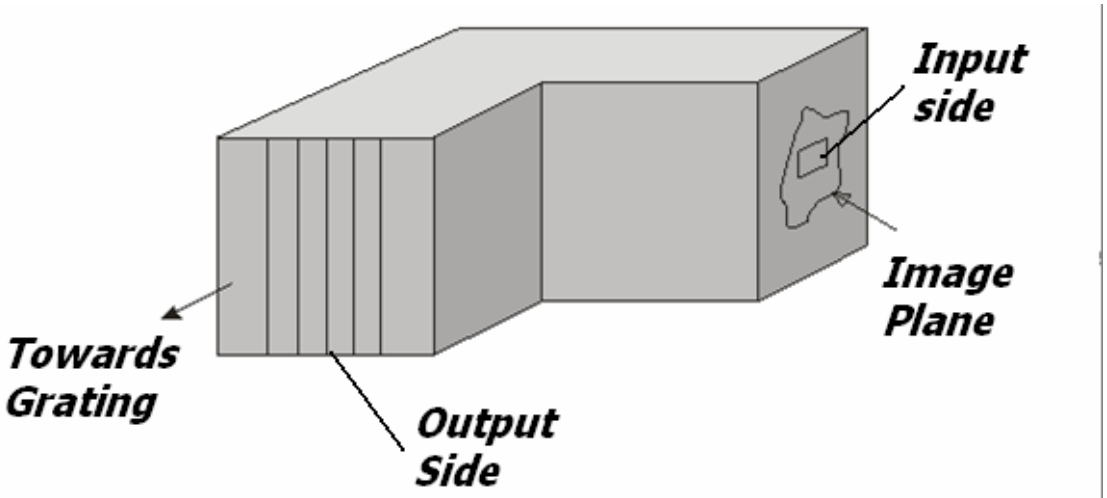
Critical Components – Special Filter

- Requires special/custom made filter with square filter profile
- Narrower the bandwidth it is better
- Better transmission for better signal level



Critical Components – Fiber Bundle

- Requires special/custom-made fiber bundle
- Smaller the fiber size is better
- Good Transmission over large wavelength region (Visible to NIR)

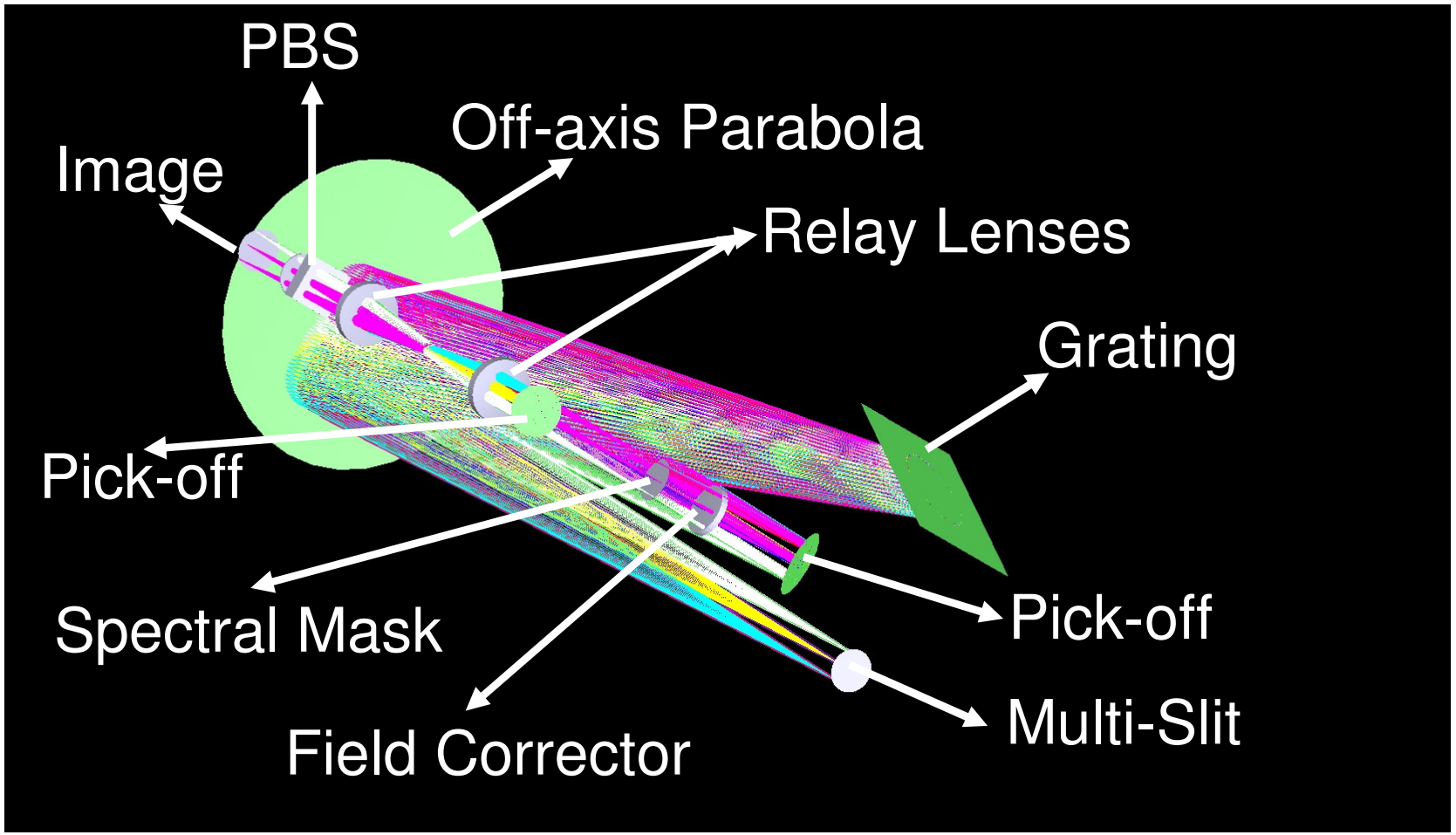


Concept Realization Phase

- An inter-mediate step to realize the concept
- Carried out in two phases – Phase I and Phase II
  - Phase – I
    - Design and development of the multi-slit SP
    - Concept proof for the filter development, usage and its limitations
  - Phase – II
    - Addition of the fiber bundle
    - Concept proof of the fiber bundle development, usage and limitation

Optical Design

Courtesy: Raja Bayanna, USO



Expected Performance – Phase I

- 5-slit of 30mm height (~300”)
- FOV covered ~ 300”X300”
- Required no. of steps ~ 190
- Dispersion = 15.8mA/pixel
- Spectral Resolution ~ 35mA
- Filter: 0.6nm FWHM Square profile
- Spectral Mask Closed width ~ 2.8mm
- Slit separation ~ 5.6mm (~58”)
- Slit width ~ 30micron
- Time taken to scan ~ 25minutes (assuming 7secs per slit position)
- Spectral Mask open width ~ 2.8mm
- Beam separation ~ 2.8mm along the dispersion axis

Expected Performance – Phase II

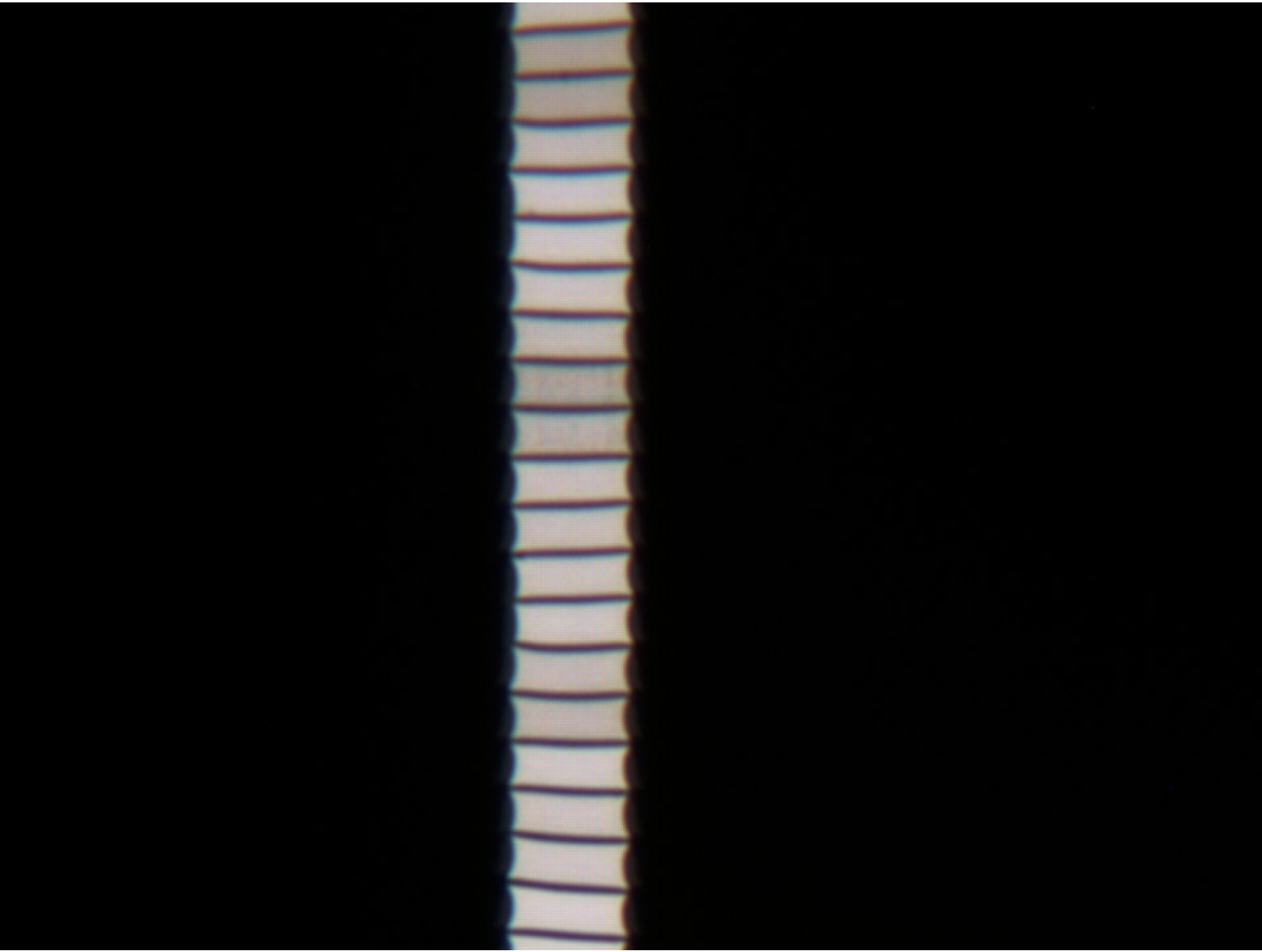
- Front end of fiber:
  - Width X Height ~ 32micron X 8micron
  - 72X288 Fiber Bundle
  - FOV covered 23″X23″ with 0.32″ per 32micron
- Back end of fiber:
  - 5-linear array equivalent to 5-slits
  - Width of the linear array ~ 32micron
  - Height of each linear array ~ 32mm
  - Linear array separation ~ 5.6mm
- Equivalent Slit width ~ 32micron
- Time taken for one 23″X23″ FOV < 15seconds
- Rest of the parameters are the same

Additions for NLST

- Large format CCD (4KX4K)
  - Preferably a ZIMPOL type or DID type
  - Larger pixel size is better (~16micron)
- Multiple beams using dichroic filters
  - To cover different wavelength regions
- Multiple filter developments (atleast 3-wavelengths)
  - Like 6302A, 8542A, & 10830A will cover Photosphere, Chromosphere & Corona

Expected Numbers for NLST

- 4KX4K (16micron square) CCD – Fast Modulation (either by ZIMPOL type or DID type)
- 0.3nm Square profile filter @630.2nm line pair
- 2.15pm spectral sampling
- 140pixels for the spectral coverage
- 29 slits can be accommodated
- Achieved FOV of 30”X30” @diffraction limit



A Sample

Courtesy: Haosheng Lin (IfA, Hawaii)