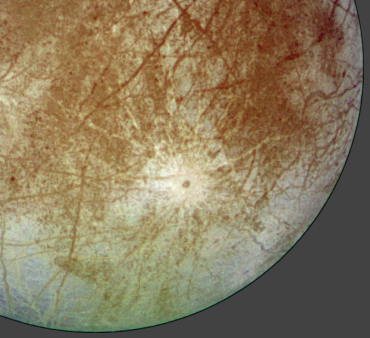
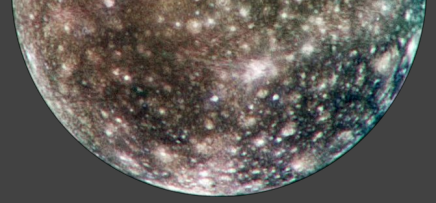
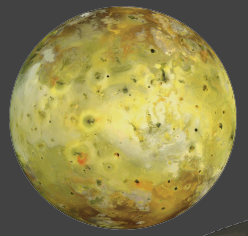
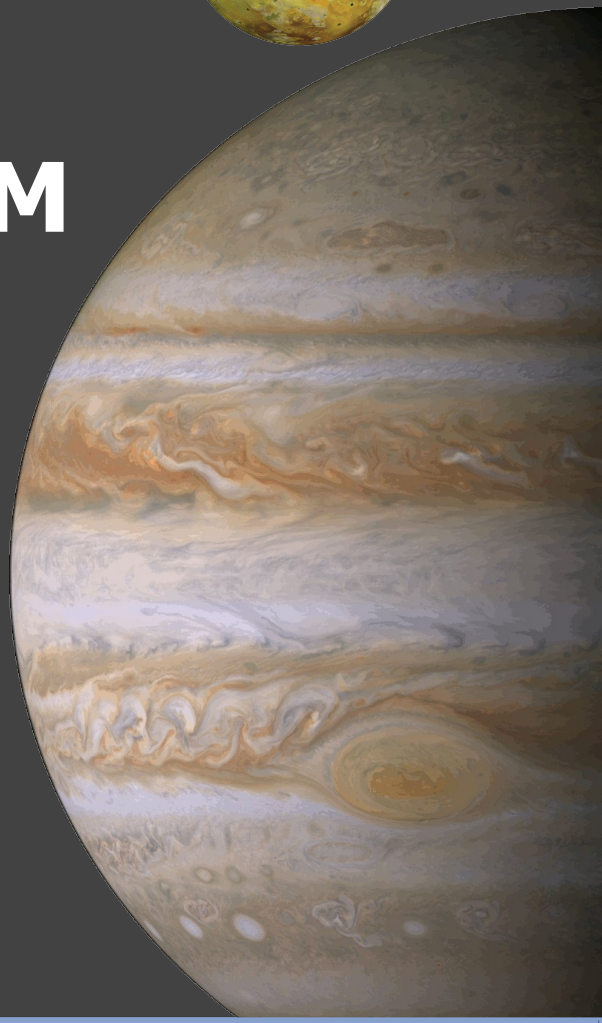
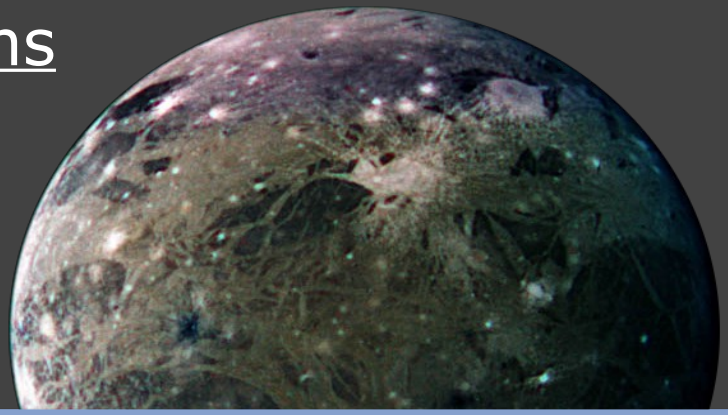

Spectropolarimetry for EJSM

the SPEX instrument

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SRON
Netherlands Institute for Space Research

Utrecht University, TNO, ASTRON, Dutch Space, MECON, Cosine

Netherlands Organisation for Scientific Research

Outline

Spectropolarimetry

SPEX Instrument

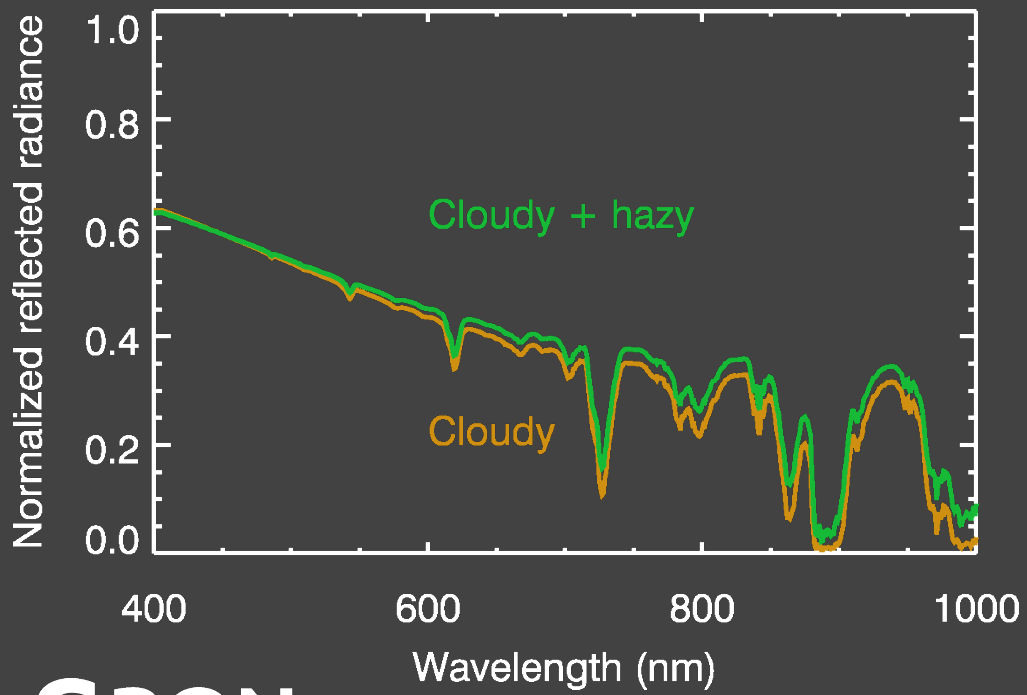
SPEX Simulator

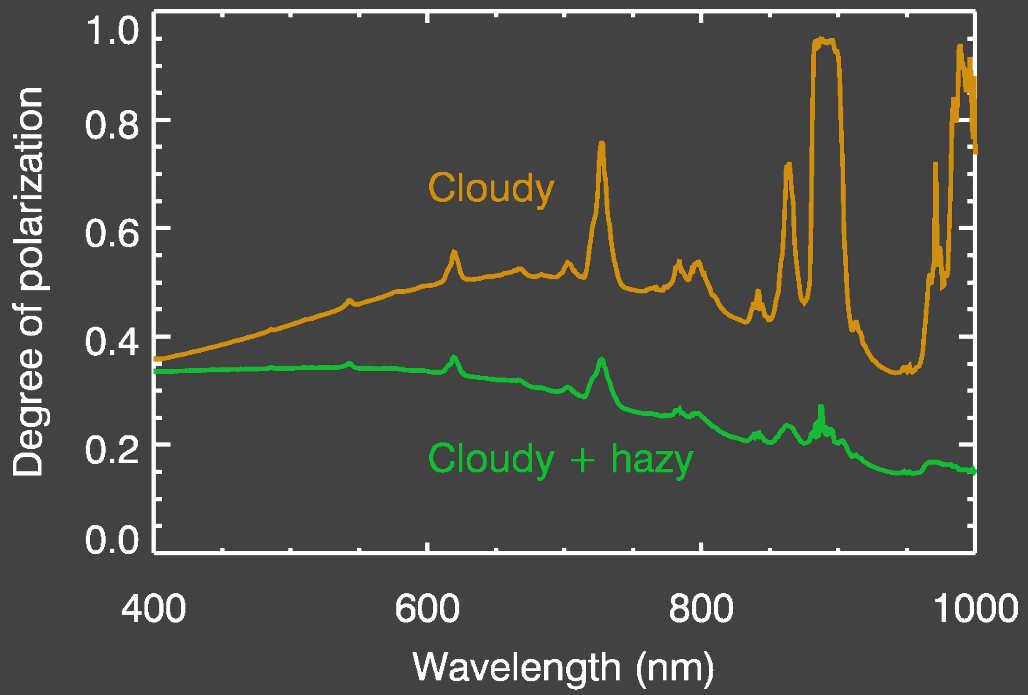
Radiation hardness

Summary

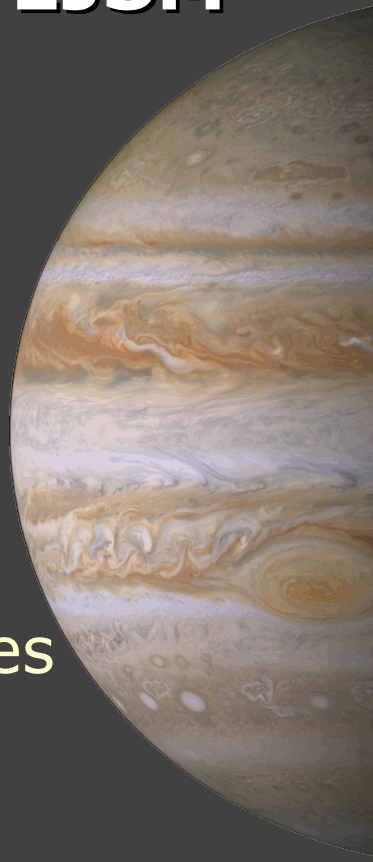
Spectropolarimetry

- Polarization state of light: direction of oscillation of E-M-field
- Degree of polarization of scattered and reflected light is ***very*** sensitive to size, shape & composition of the scatterers
- Strong wavelength and scattering (phase) angle dependence





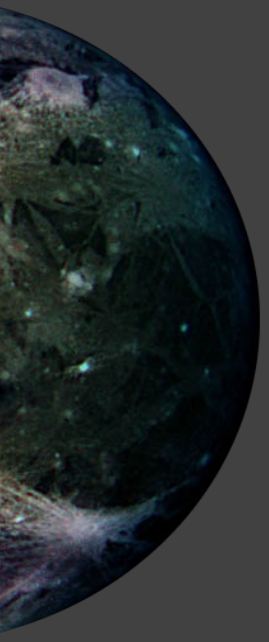
Science case for spectropolarimetry on EJSM



EJSM science objectives:

Characterizing the composition and structure of

Jupiter's atmosphere : aerosol & cloud particles
Jupiter's rings : ring particles
Surface Jovian moons : roughness, regolith particles

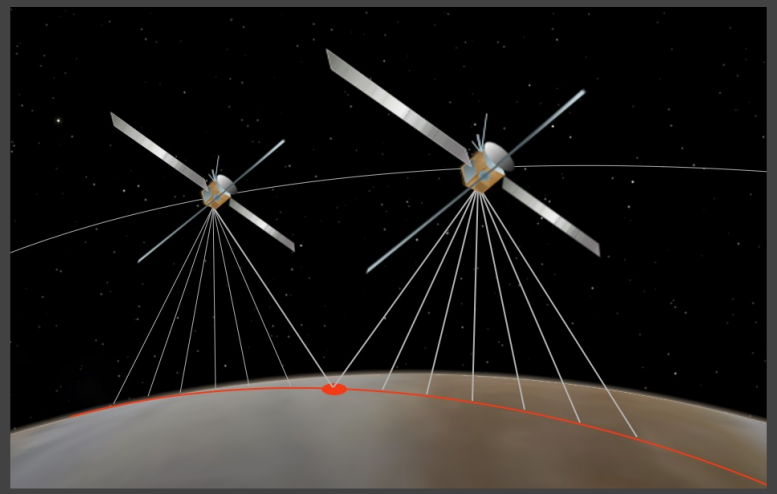


Spectropolarimetry can reveal the microphysical properties and spatial/temporal distribution of scattering particles

SPEX is complementary to model payload and essential for meeting overall science objectives

SPEX: Spectropolarimeter for Planetary EXploration

Remote sensing instrument for measuring and characterizing aerosols, clouds, dust, hazes, surfaces and rings

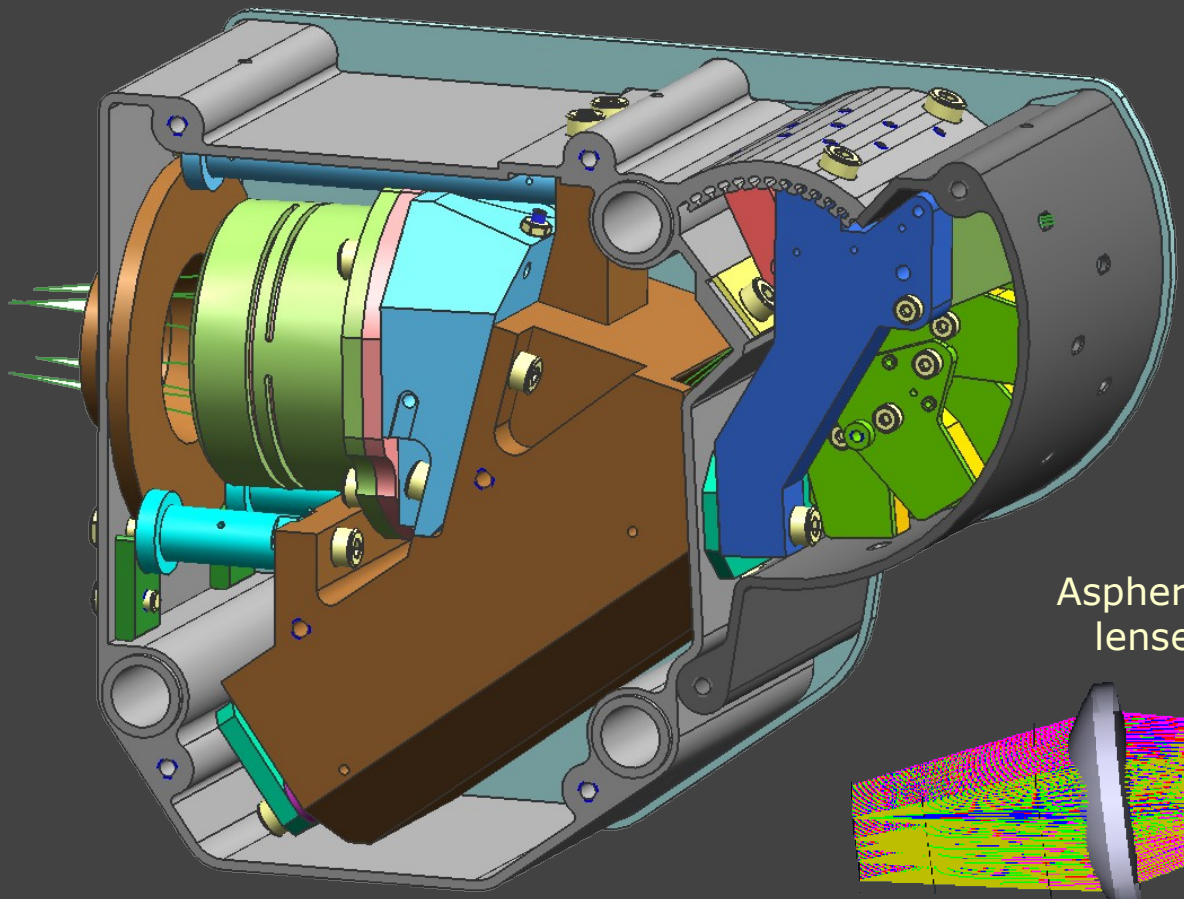


Innovative instrument concept:

- Simultaneous measurement of polarization state and flux
- Wavelength range 400 - 800 nm
- No moving parts – fixed viewing angles
- Compact and low mass

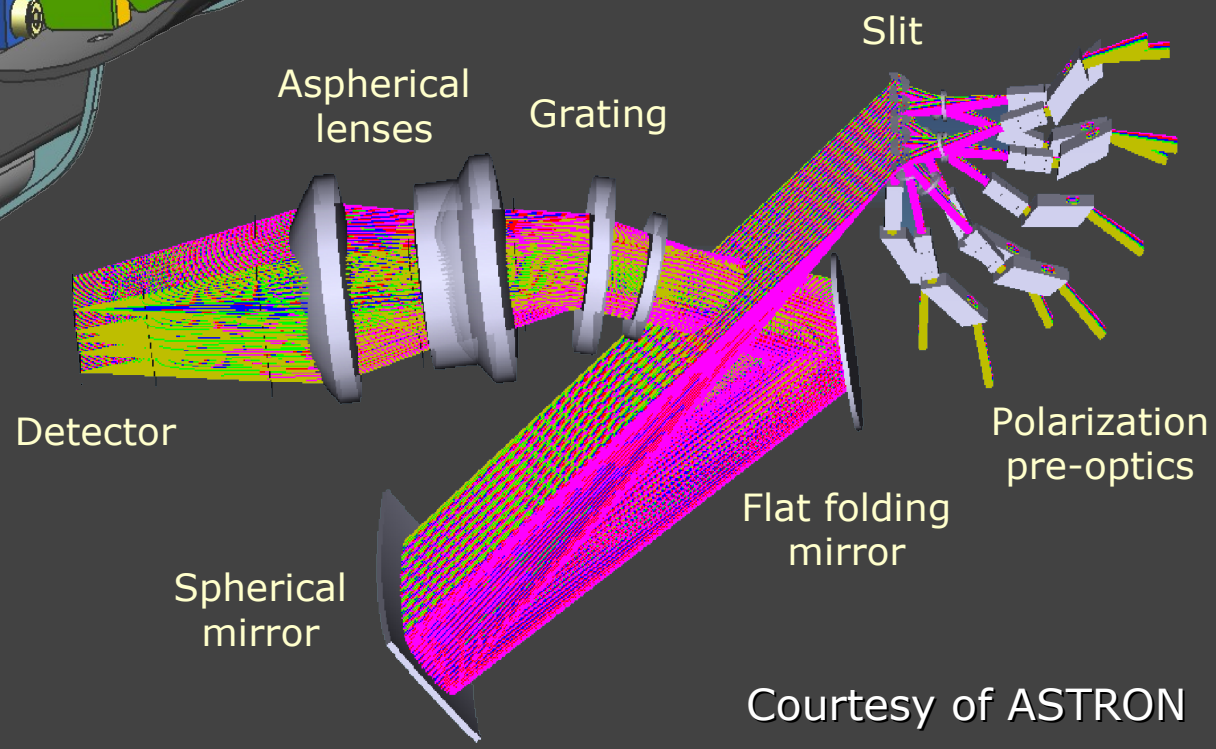
Multi-wavelength
Multi-polarization
Multi-viewing angle
Imaging spectropolarimeter

SPEX: Mechanical and Optical design



Dimensions: 15x12x6 cm^3

Courtesy of Mecon



Courtesy of ASTRON

SPEX: Polarization measurement principle

1. *Temporal modulation*: rotating waveplate or liquid crystal.
   → Risk of failure; large power consumption; timing issues.

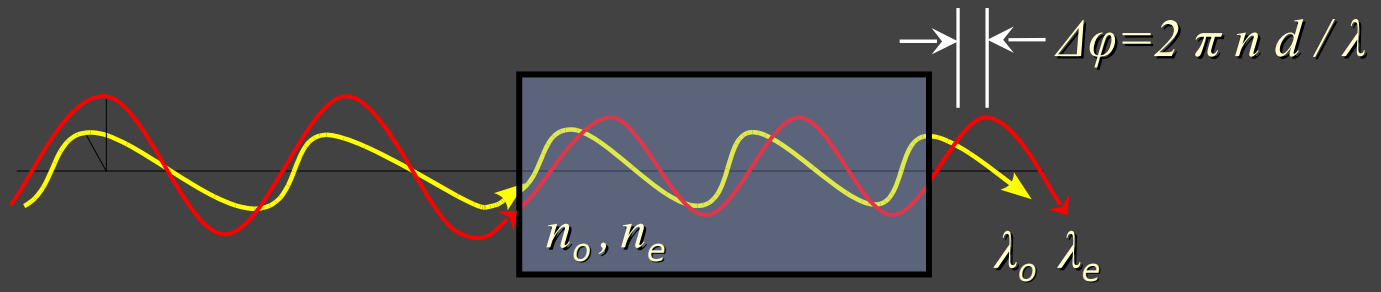
2. *Spatial modulation*: split up beam according to four (three) linear polarization directions.
   → Not precise enough; too large.

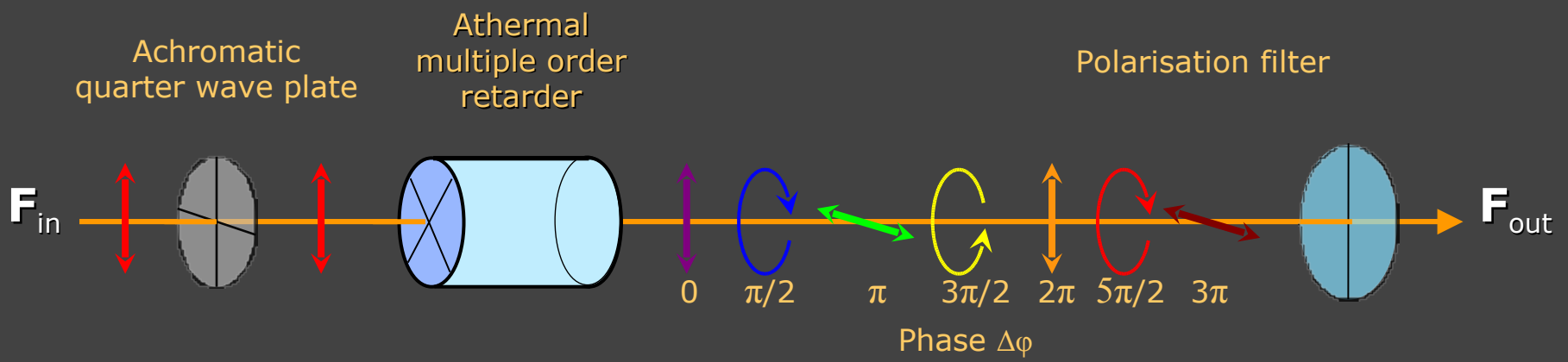
3. *Spectral modulation*: a sinusoidal modulation on the measured intensity spectrum.

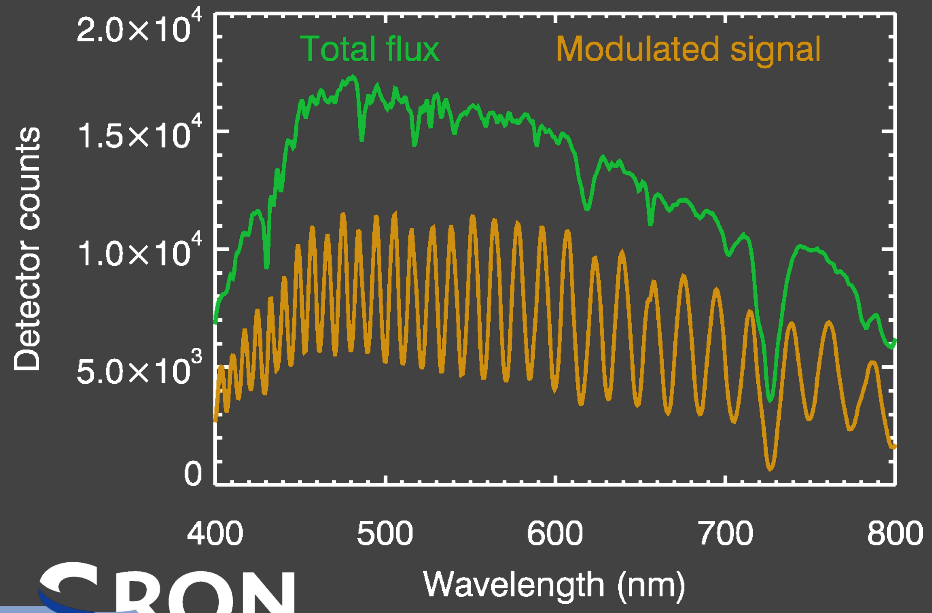
Key technology:

Birefringent crystals Patented (Keller, Snik, SIU)

SPEX: Polarization measurement principle

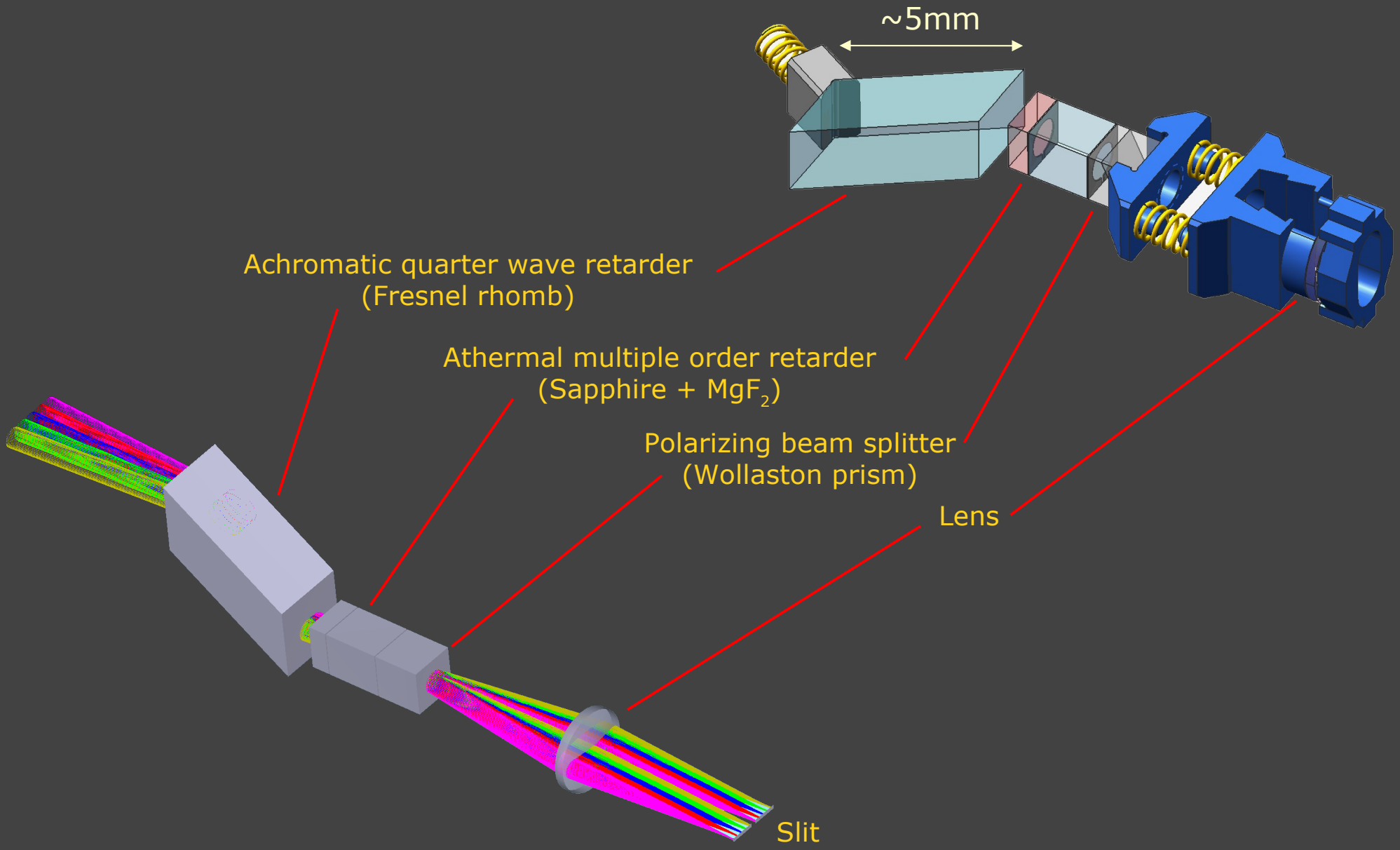






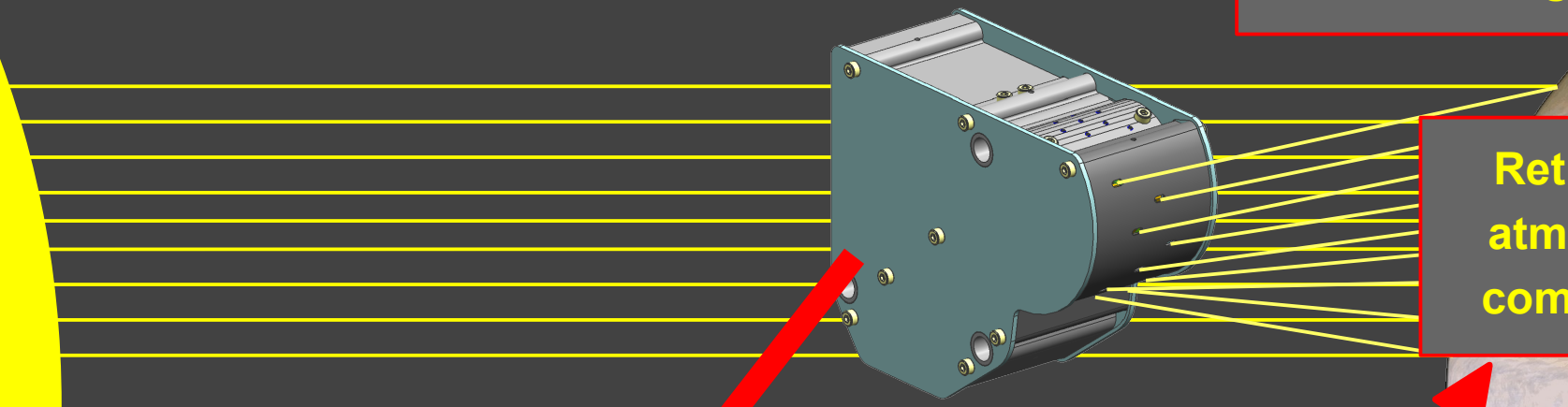
- **Polarization encoded in flux spectrum: spectral modulation**
- **Amplitude ~ degree of linear pol. (DoLP)**
- **Phase ~ angle of linear pol. (AoLP)**

SPEX: Polarization optics

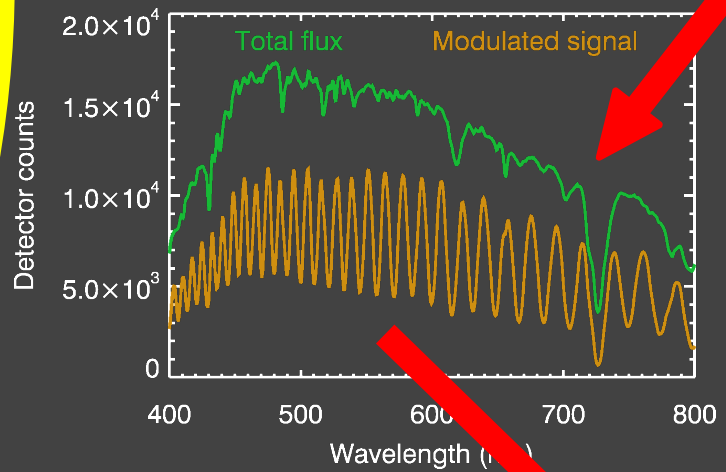


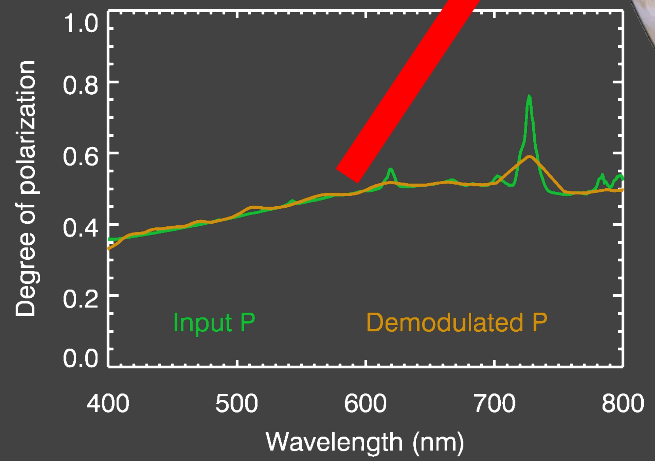
SPEX Measurement & Analysis

Full Stokes radiative transfer modeling



Retrieval of atmosphere composition





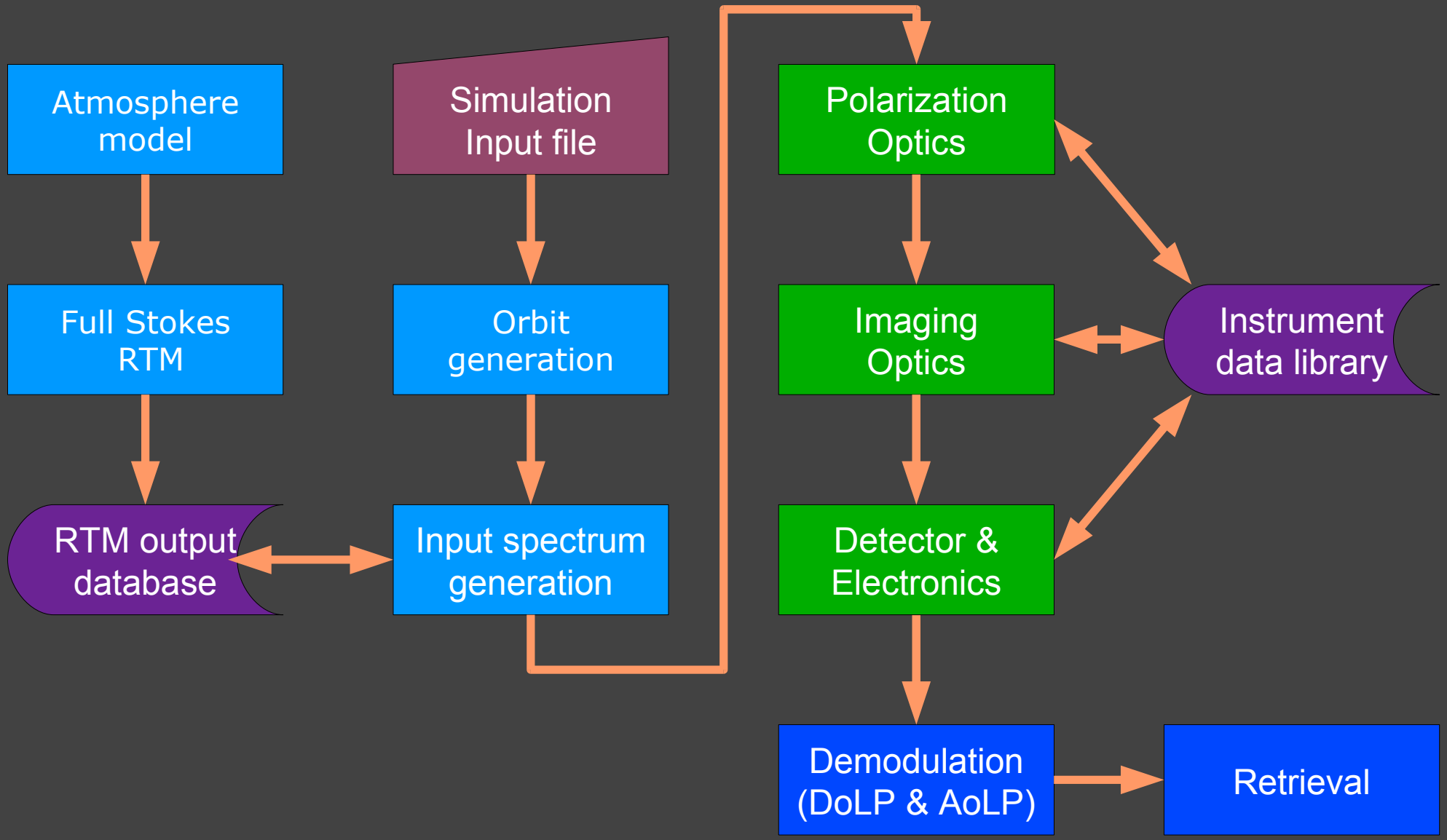
Demodulation → DoLP & AoLP

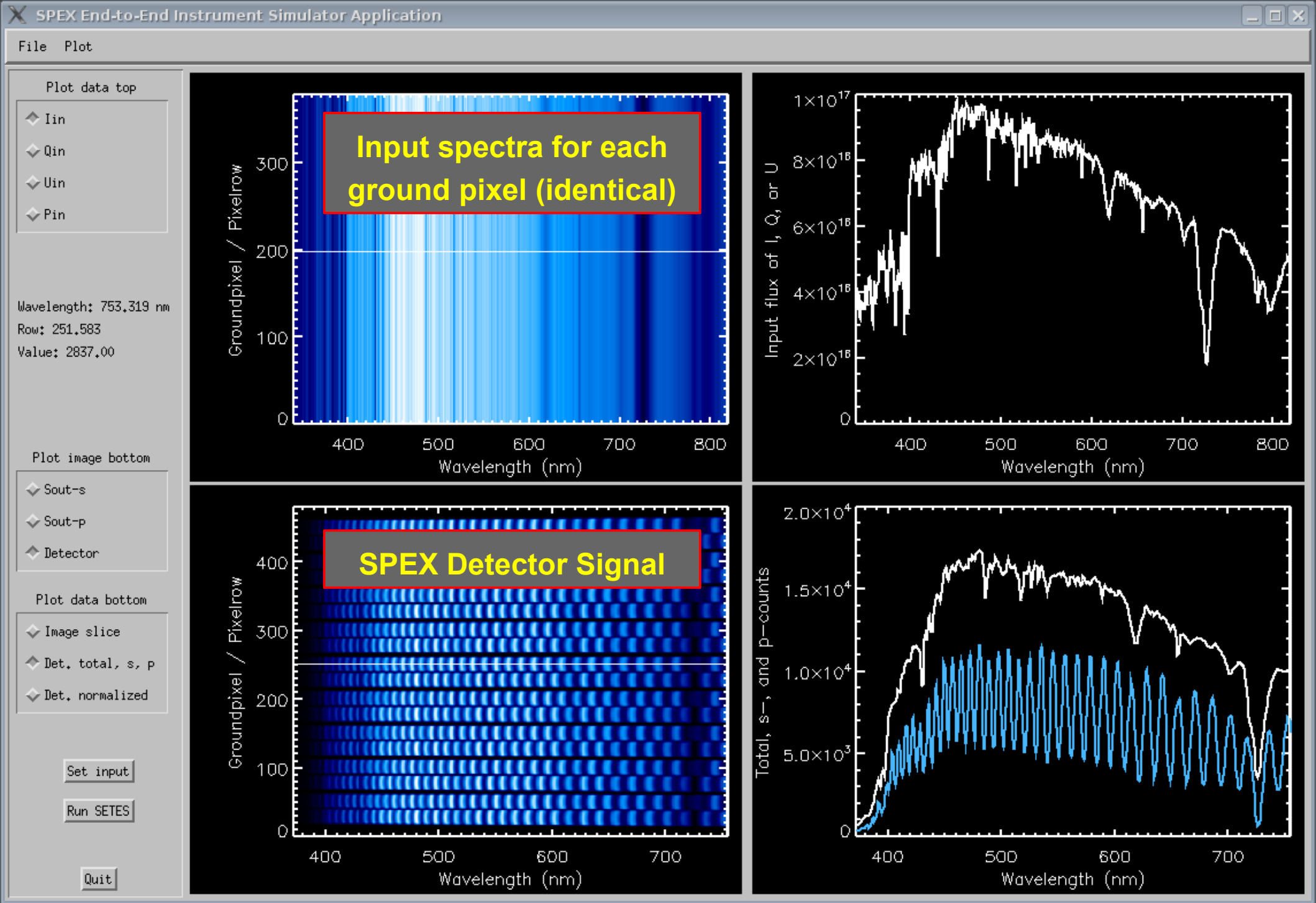
SPEX End-To-End Simulator

Simulator enables:

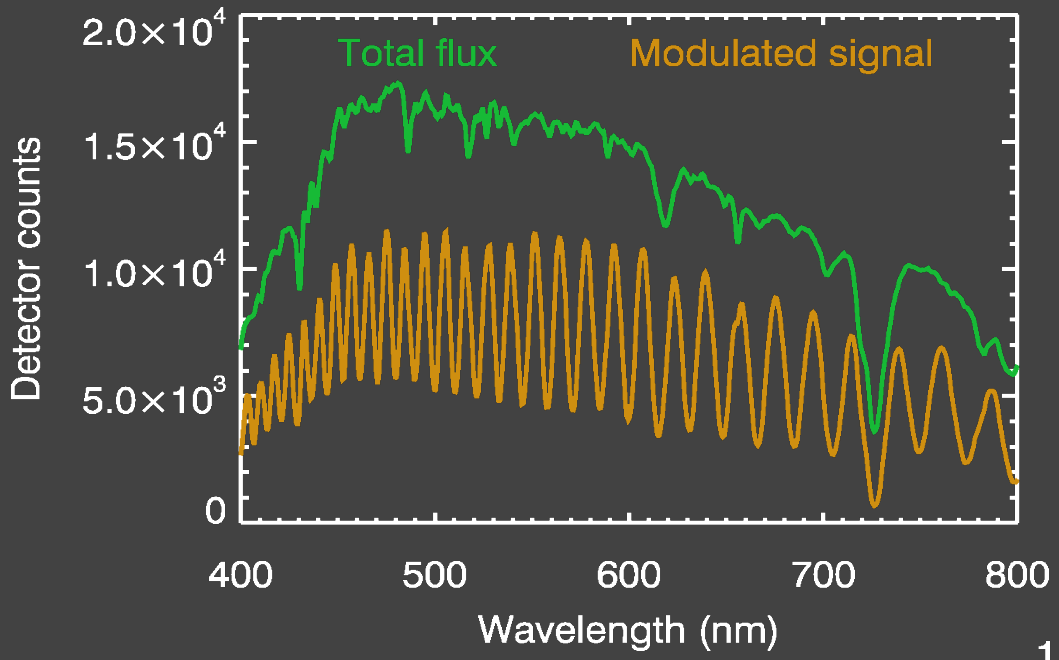
- Support science studies, e.g.
  - Definition of science/instrument requirements
  - Retrieval of particle properties from simulated DoLP and AoLP
- Support design tradeoff studies
- Instrument performance analysis for wide range of mission scenarios
- Evaluation and tracing of possible system degradation
- Testing demodulation algorithms (for obtaining DoLP and AoLP)

SPEX End-To-End Simulator: Model blocks




SPEX End-to-End Instrument Simulator Application
File Plot
Plot data top
Iin
Qin
Uin
Pin
Wavelength: 753.319 nm
Row: 251.583
Value: 2837.00
Plot image bottom
Sout-s
Sout-p
Detector
Plot data bottom
Image slice
Det. total, s, p
Det. normalized
Set input
Run SETES
Quit
Input spectra for each ground pixel (identical)
Groundpixel / Pixelrow
Wavelength (nm)
Input flux of I, Q, or U
SPEX Detector Signal
Total, s-, and p-counts

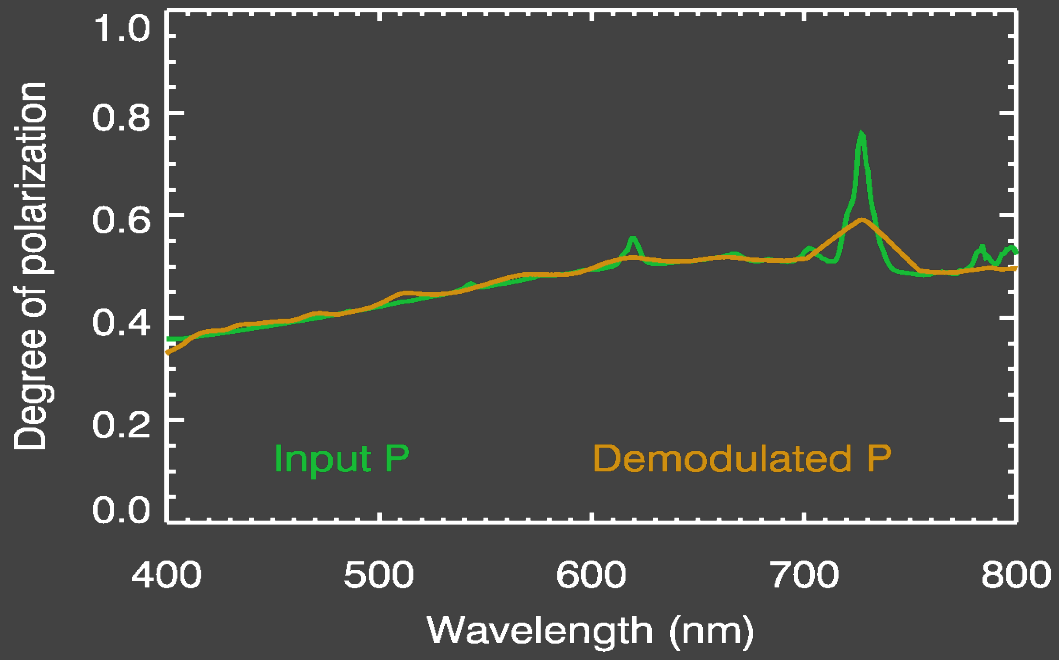
SPEX End-To-End Simulator



Total flux obtained from complementary modulated spectrum (with opposite phase)

Demodulation

- Polarization resolution ~ 20 nm
- Instrument imperfections induce errors
- Algorithm development



SPEX Radiation hardness / TDA

SPEX Critical components:

- Polarization optics : entrance aperture, full exposure
- Fresnel rhomb : BK7G18
  Retarder plates : Al_2O_3 (sapphire) and MgF_2
  Wollaston prism : α-BBO, YVO_4, TiO_2
- Study plan item : Radiation tolerance study of crystals

Common critical components:

- Lenses : Suprasil, F2G12
- Detector and Electronics

Current SPEX development status

- SPEX prototype : procurement of parts has started
- SPEX calibrator unit : lab model successfully finished
- SPEX simulator : operational
  science requirements
  detailed performance analysis
  synergy studies
- TDA : national funding will be requested

Involved parties SPEX instrument

Instrument:

Astronomical Institute, Utrecht Univ.
SRON
TNO / ASTRON
Dutch Space
MECON
Cosine

Science:

Astronomical Institute, Utrecht Univ.
SRON
TU-Delft, DEOS
Instituto de Astrofysica de Andalucia
Astronomy Department, Univ. of California
Oxford University
Cornell University