Measurements of Polarized Light Scattering by Atmospheric Particles with the Passive Aerosol and Cloud Suite (PACS)

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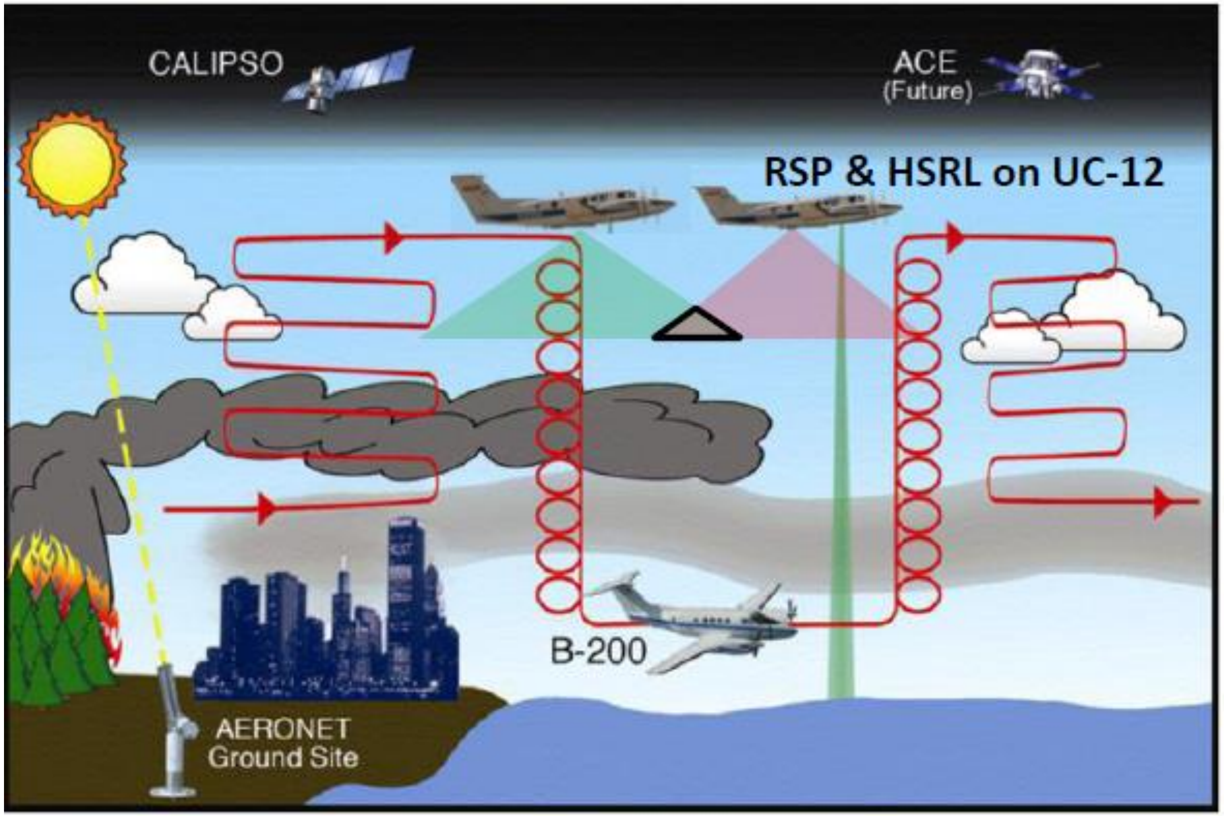
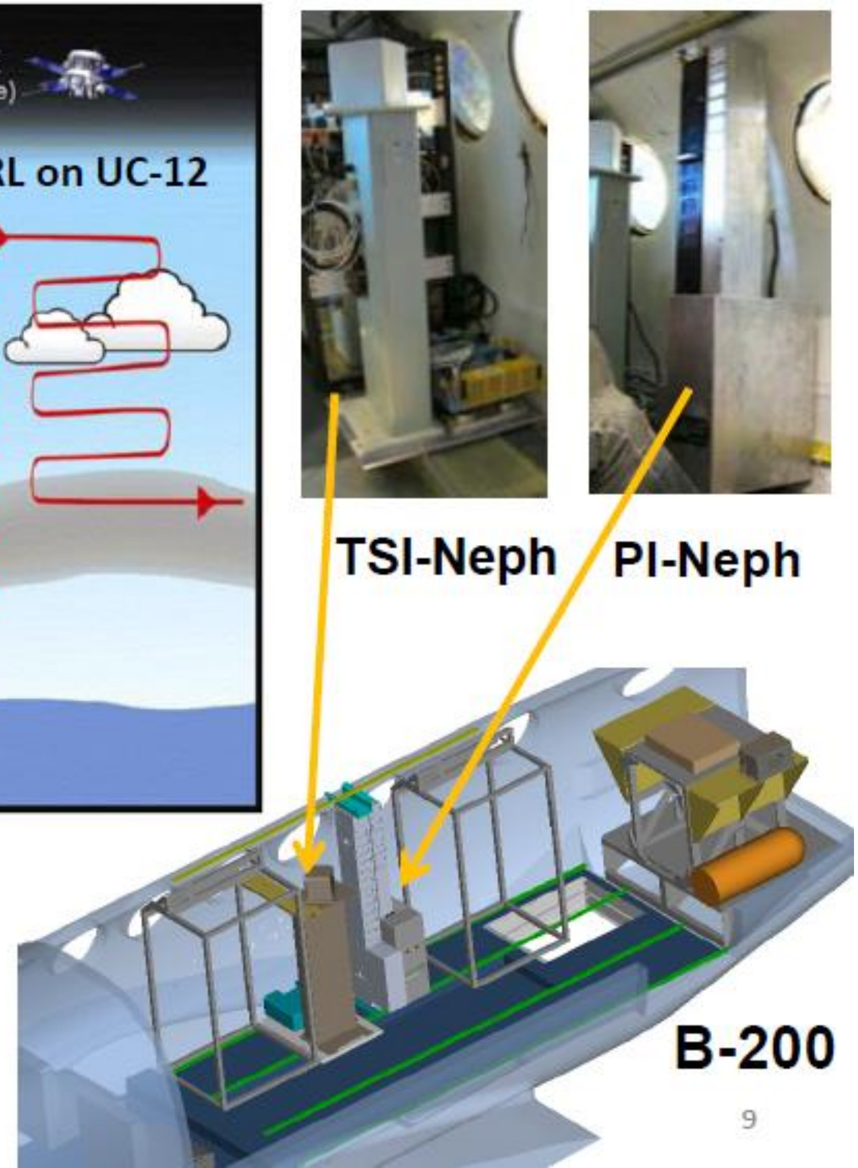
PACS – Passive Aerosol and Cloud Suite:

In preparation for NASA ACE Mission

- Multi-Angle Imaging Polarimeters for Aircraft and Space
    - UV, Hyperangular VIS, SWIR
- High resolution cameras
    - TIR
    - VIS-SWIR
- Aircraft in situ validation
    - PI-Neph (Polarized Imaging Nephelometer)
    - Open-Ineph (Open Path System)

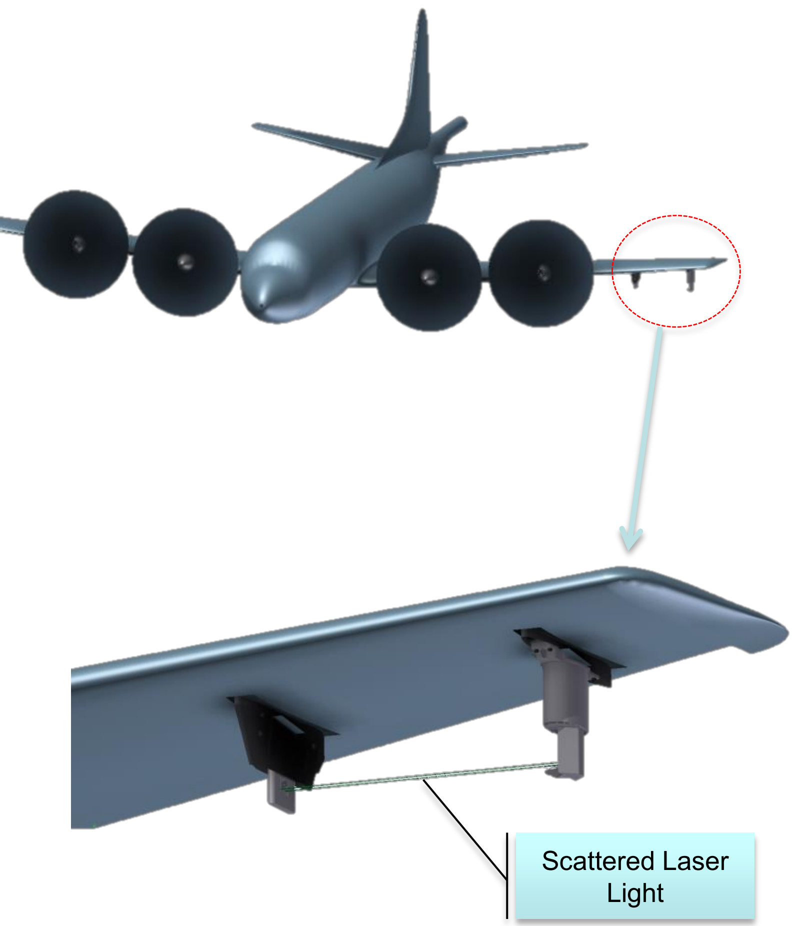
PI-Neph: Measuring In situ Aerosols P11 and P12 from Aircraft

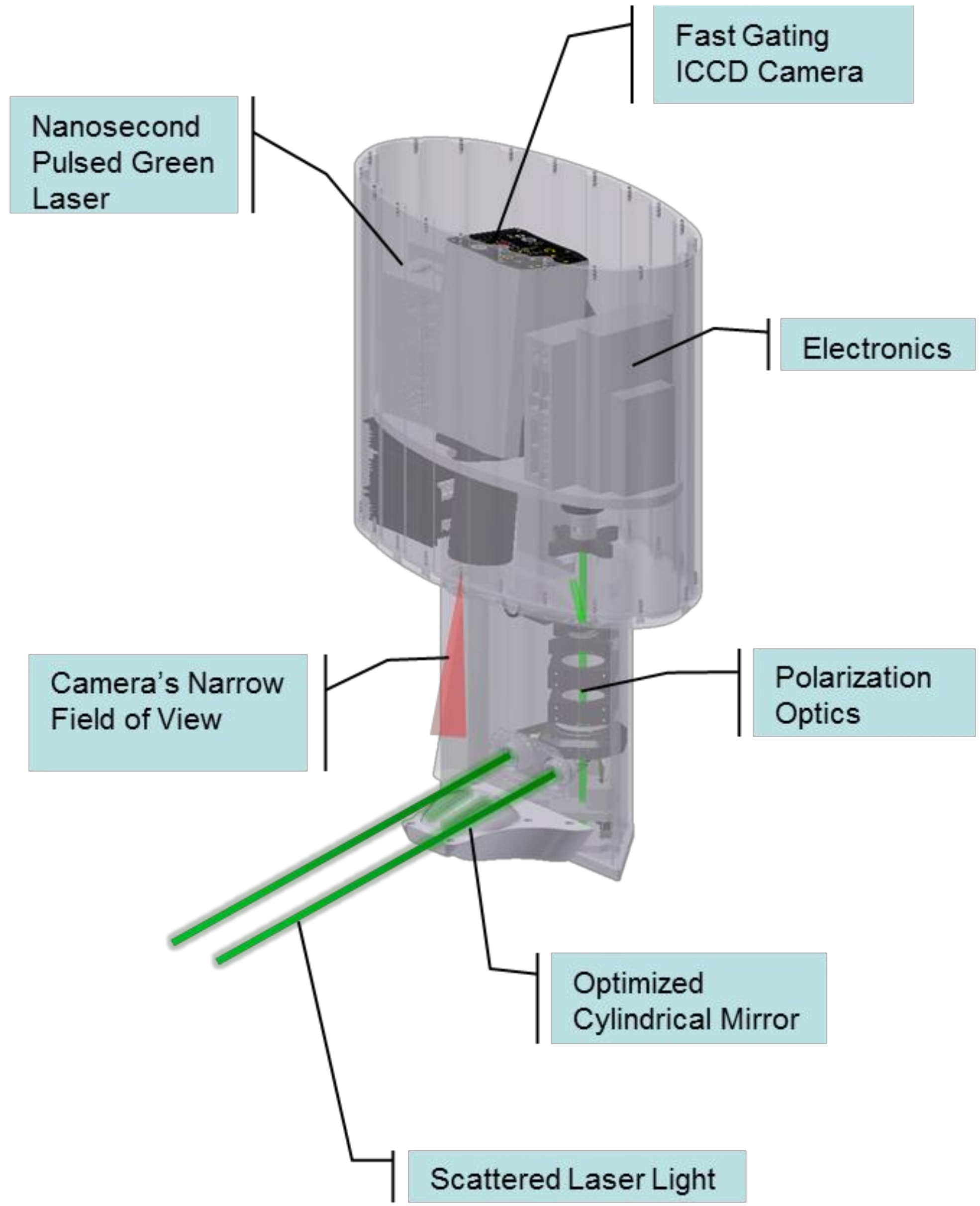




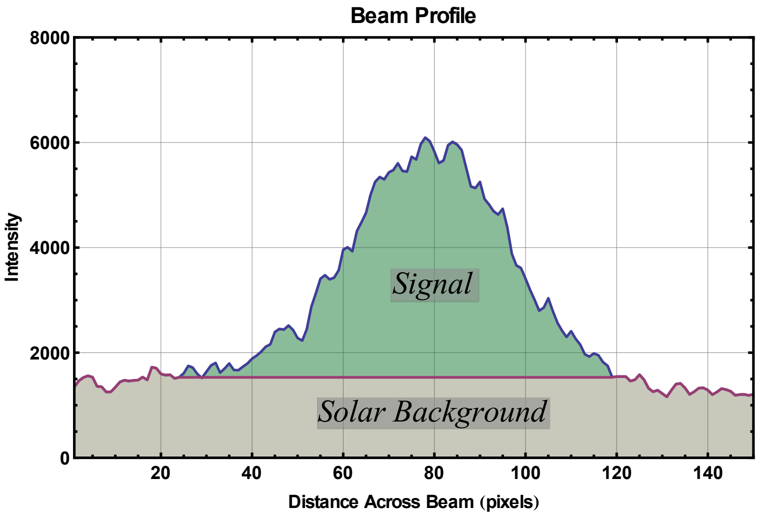
See Dolgos et al. presentation coming soon…

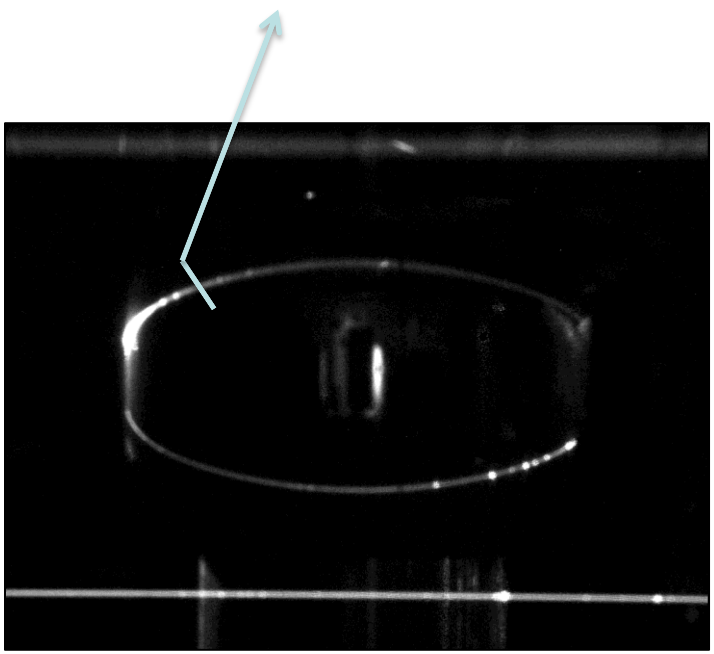
Open Imaging Nephelometer in the NASA P3 Aircraft

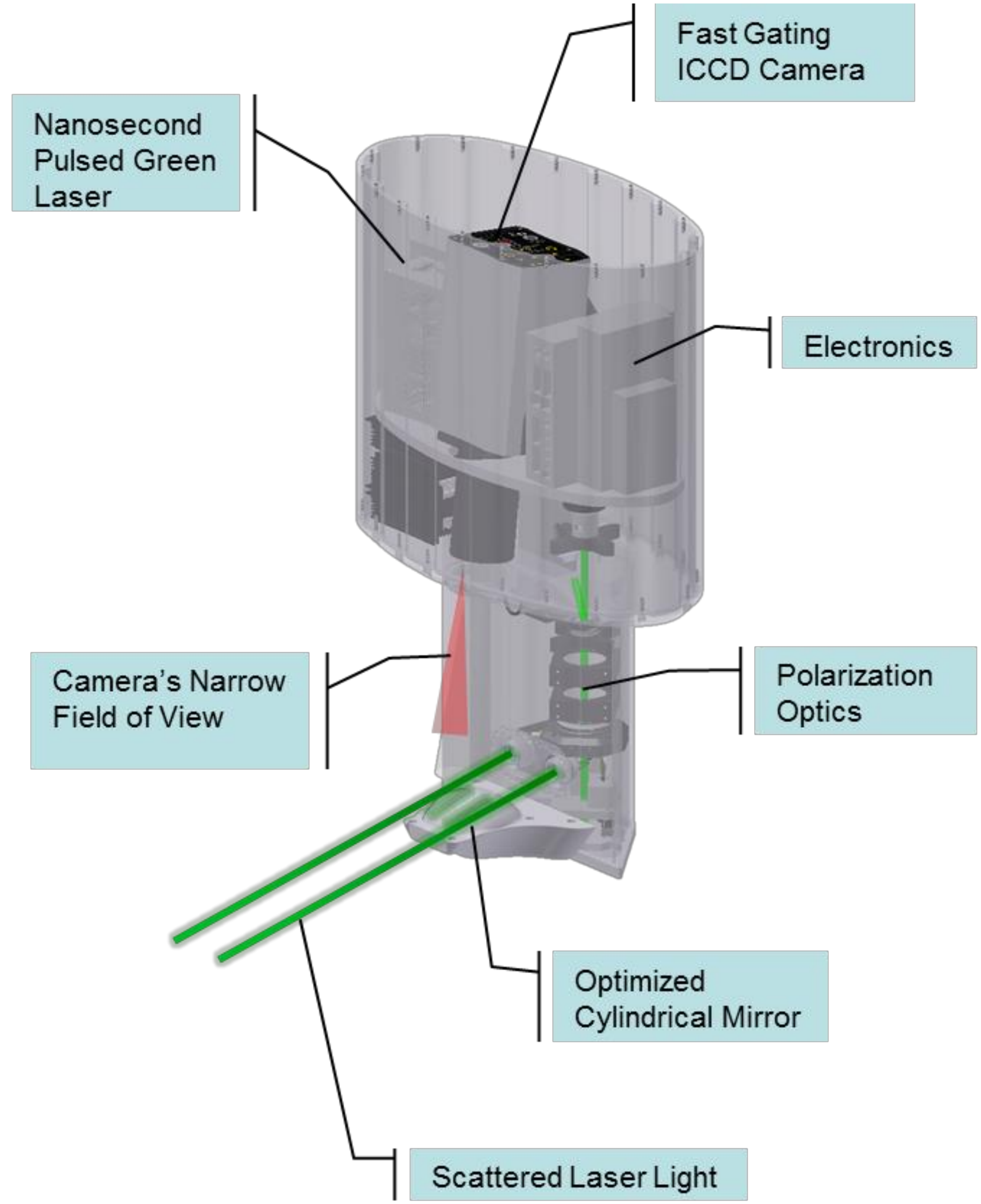




Open Imaging Nephelometer in the NASA P3 Aircraft





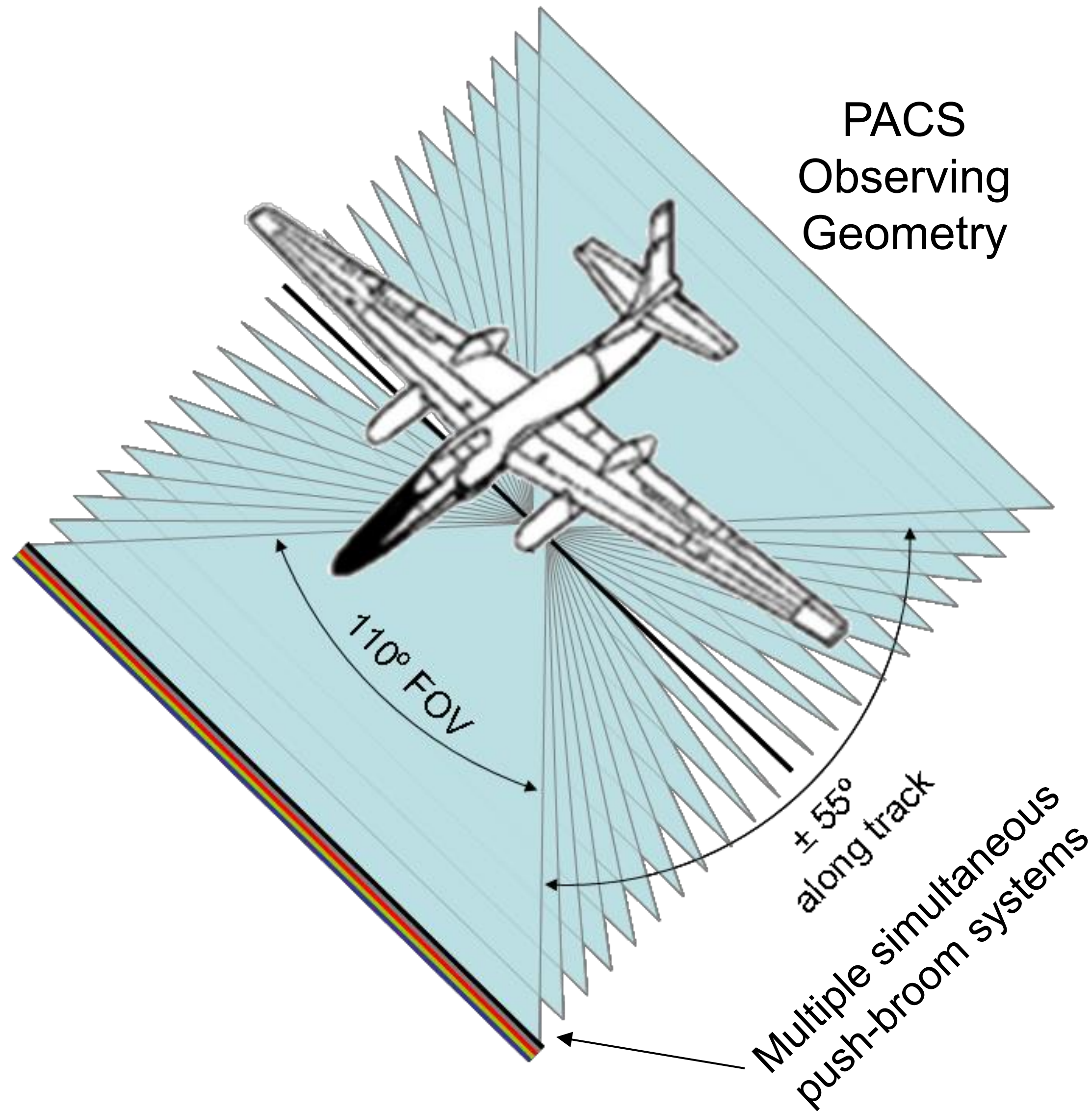


PACS Airborne ER2 Polarimeter

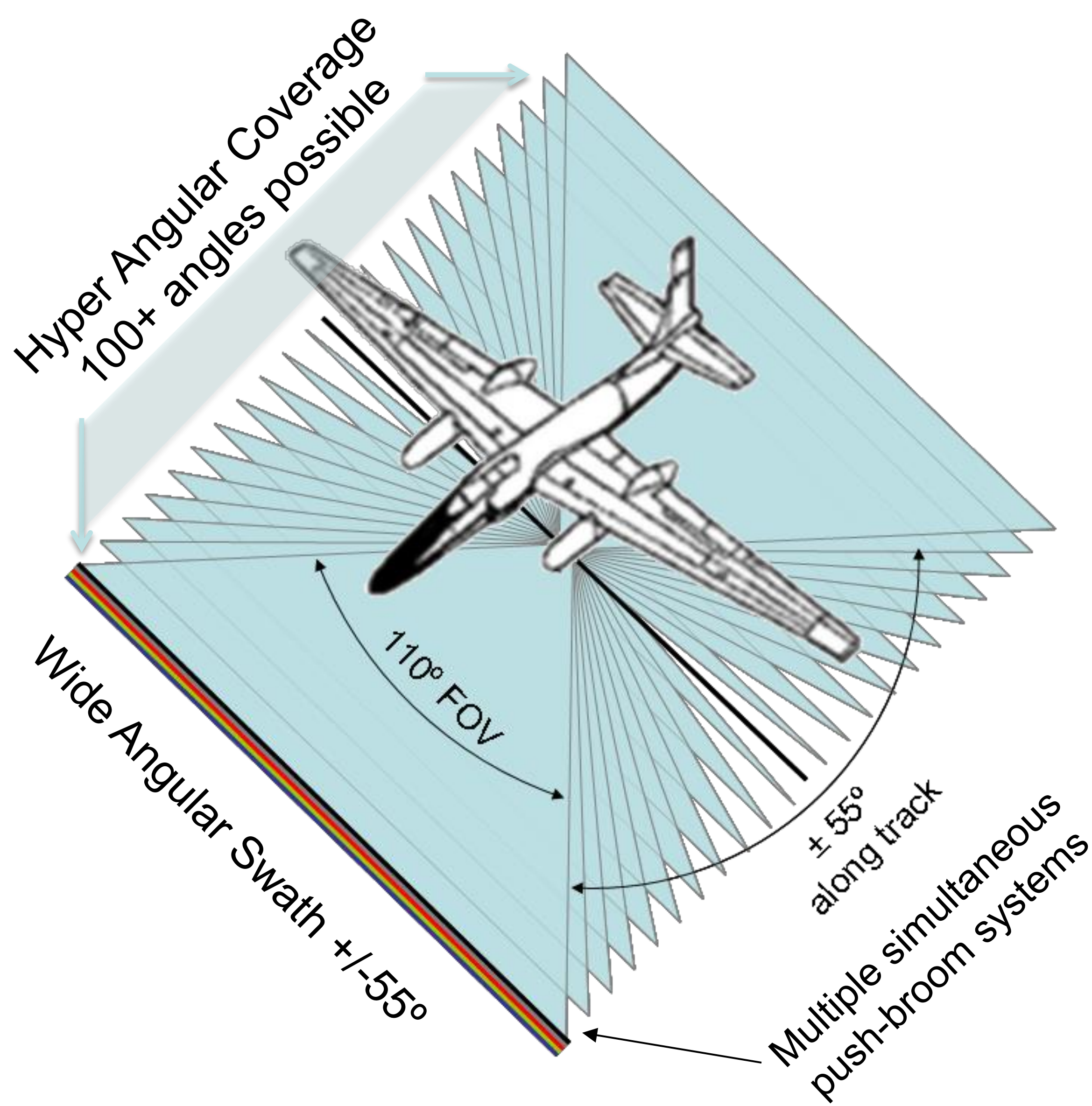
PACS ER-2 Facts

Current VNIR system
- Ground Resolution = 37m
- Swath = 37km
- 470, 550, 670, 766, 870nm
- 1 K pixel X-track
- 65+ angles for all wavelengths
- 130 view angles for 670nm
- 110° FOV cross track
- +/- 55° FOV along track

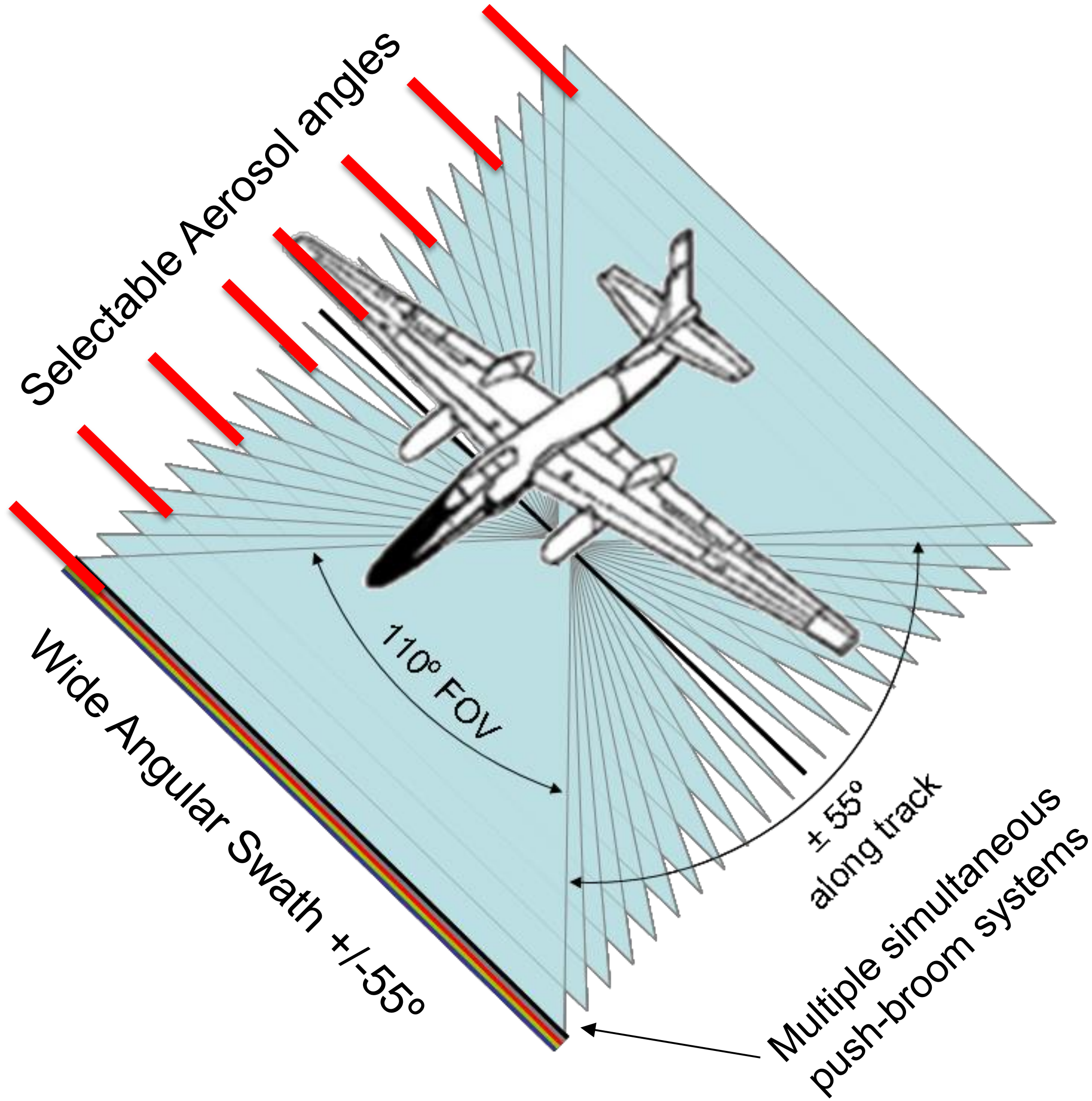
SWIR Under construction:
- 1650, 1880, 2130, 2250nm
- 320x256 pixels
- Adjustable FOV
- Mounted together with PACS VNIR



PACS Observing Geometry:

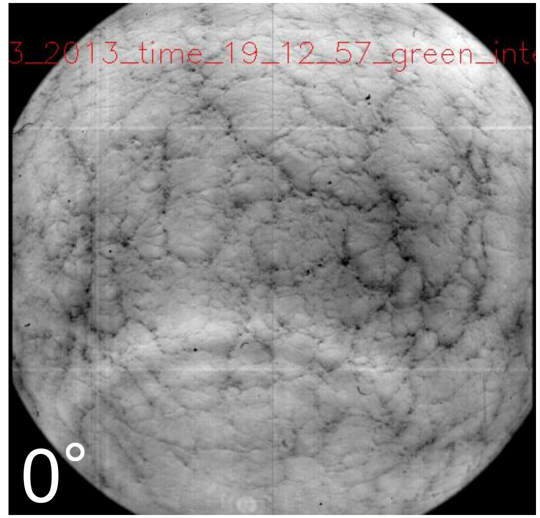


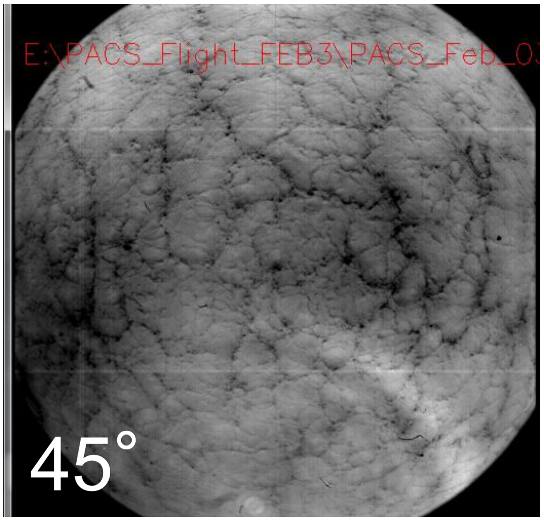
PACS Observing Geometry:

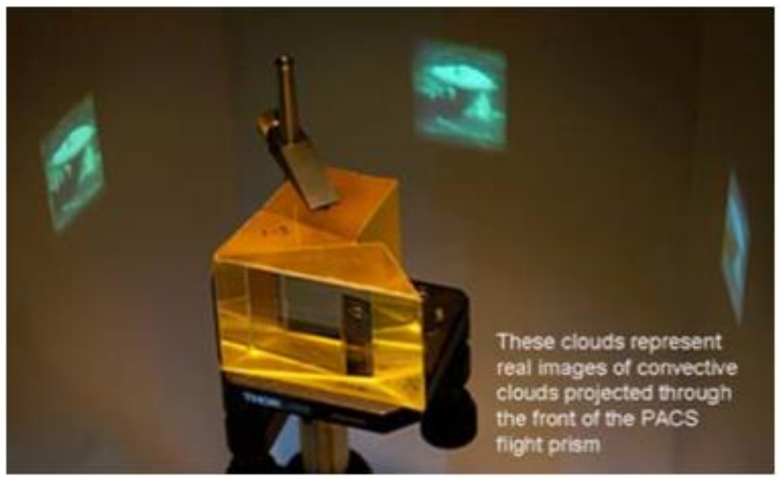


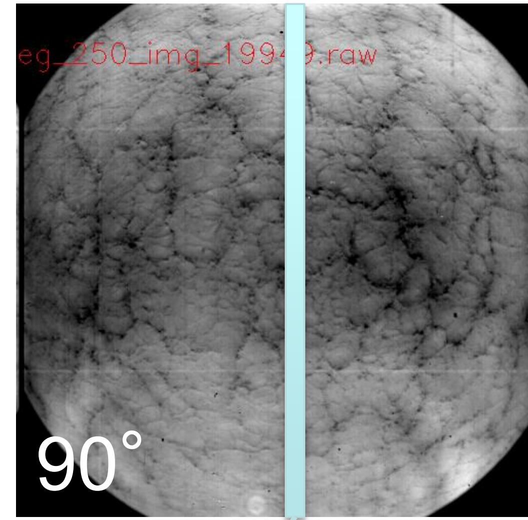
PACS

Three Polarized Images

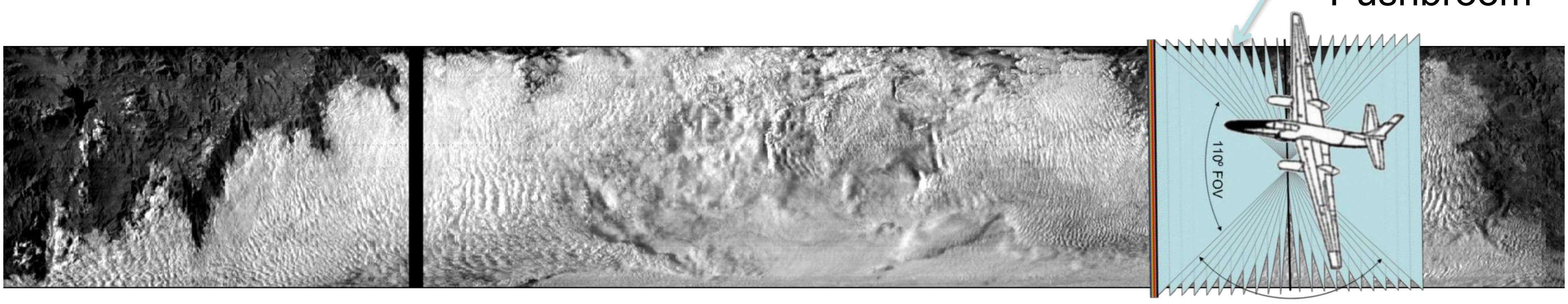


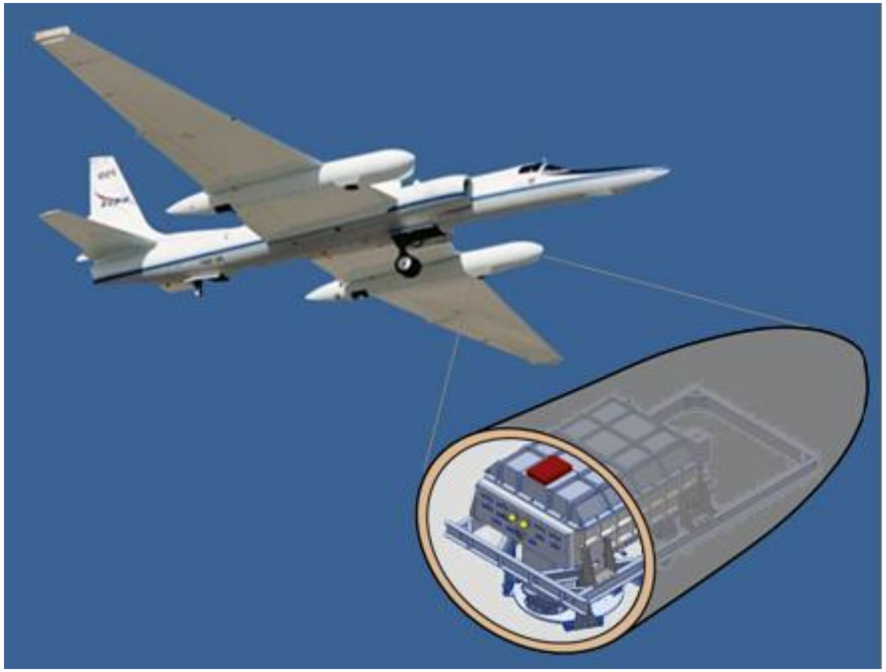




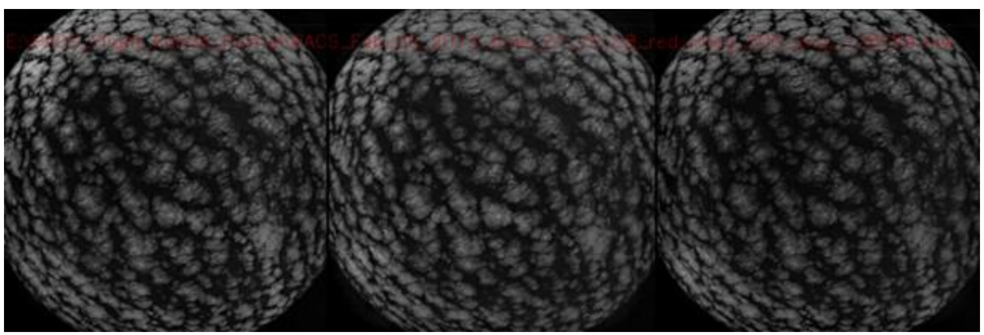


Single View
Pushbroom

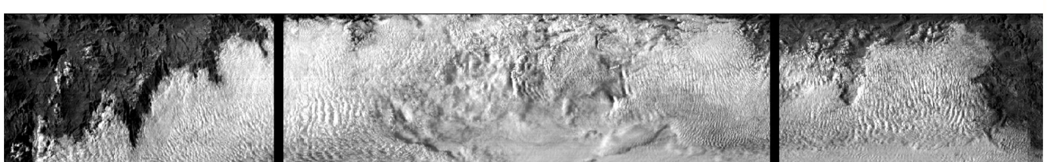




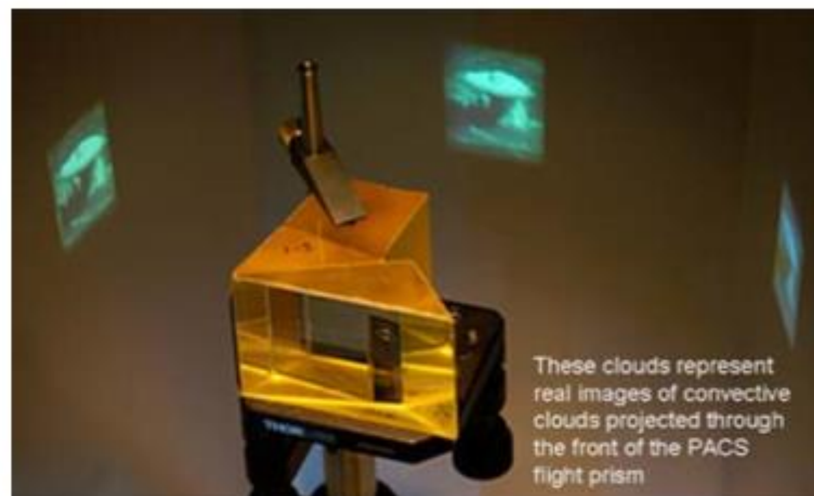
3 Simultaneous Polarized Images at 0, 45 and 90°



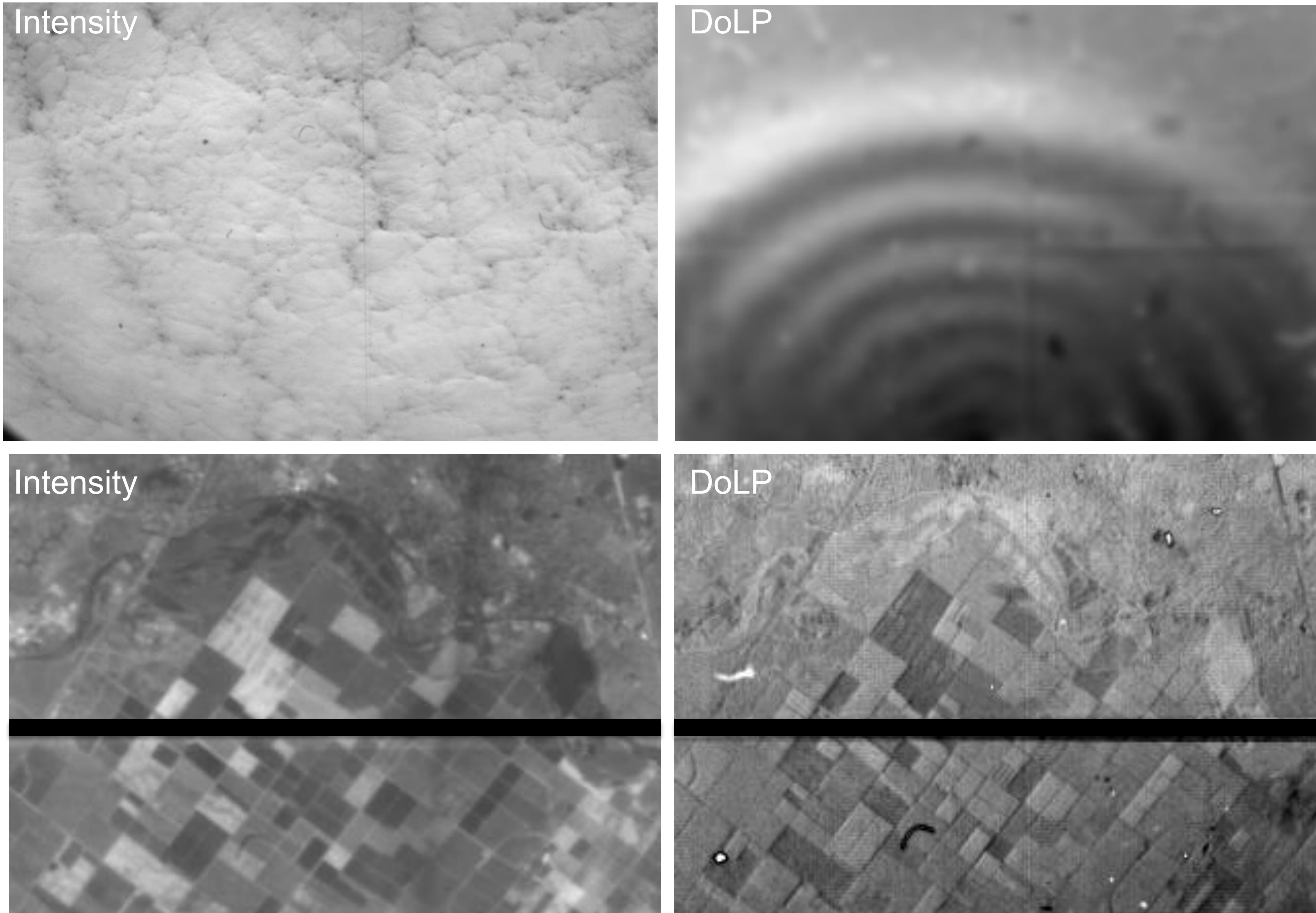
Example of Cross track nadir image of a cloud field over land

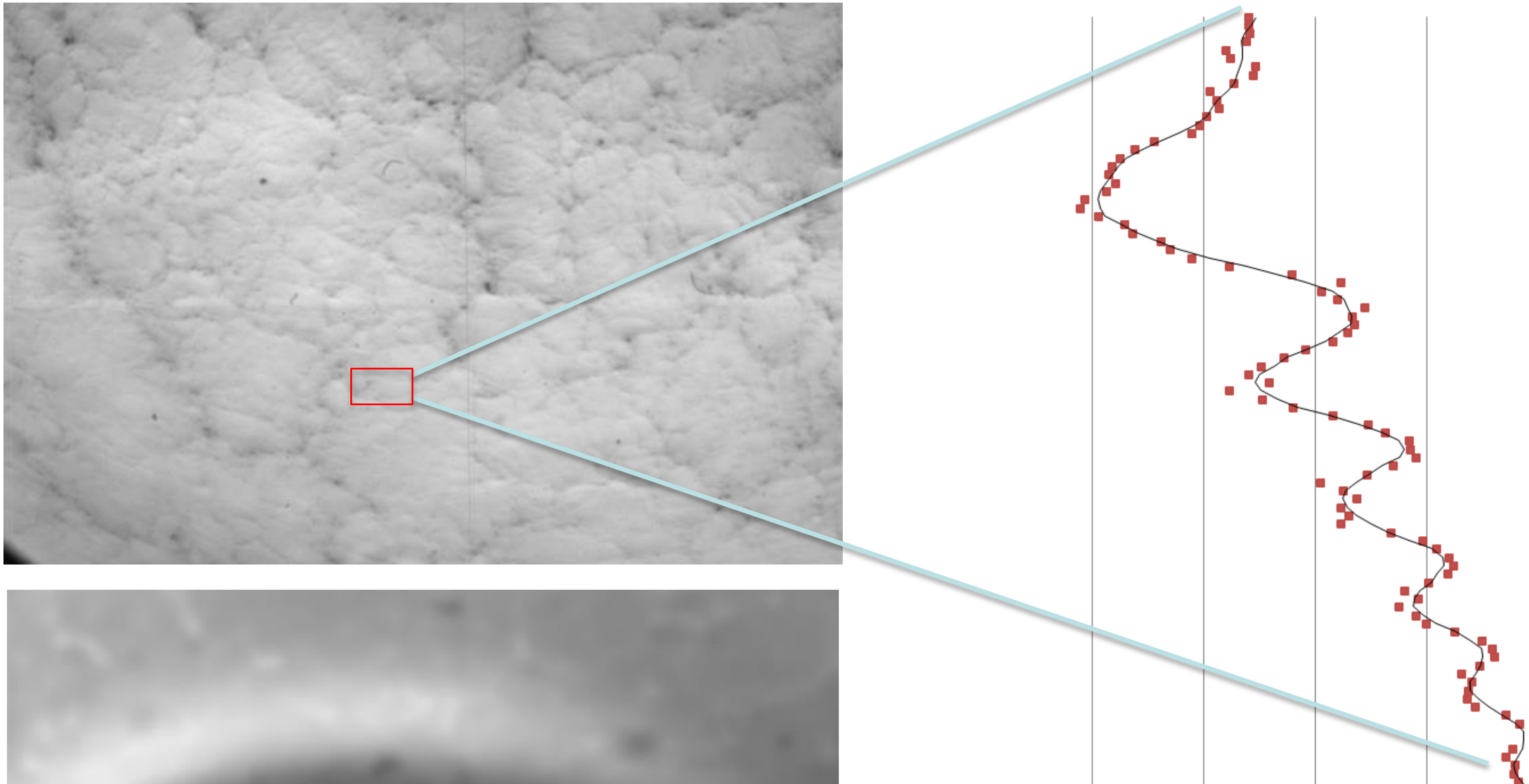


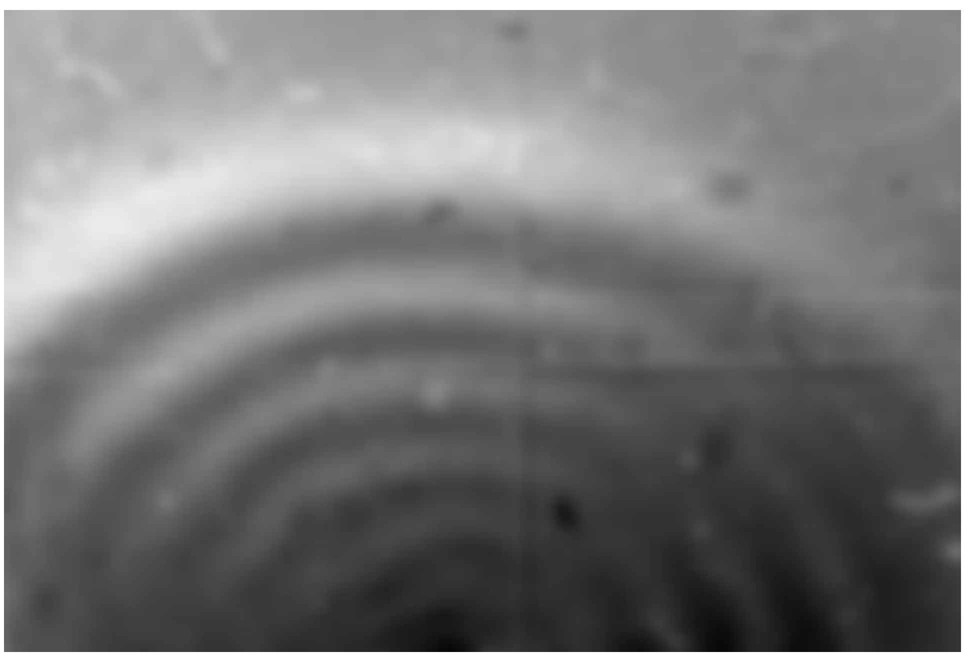
Demonstration of the PACS Prism:



Examples of PACS Data from PODEX

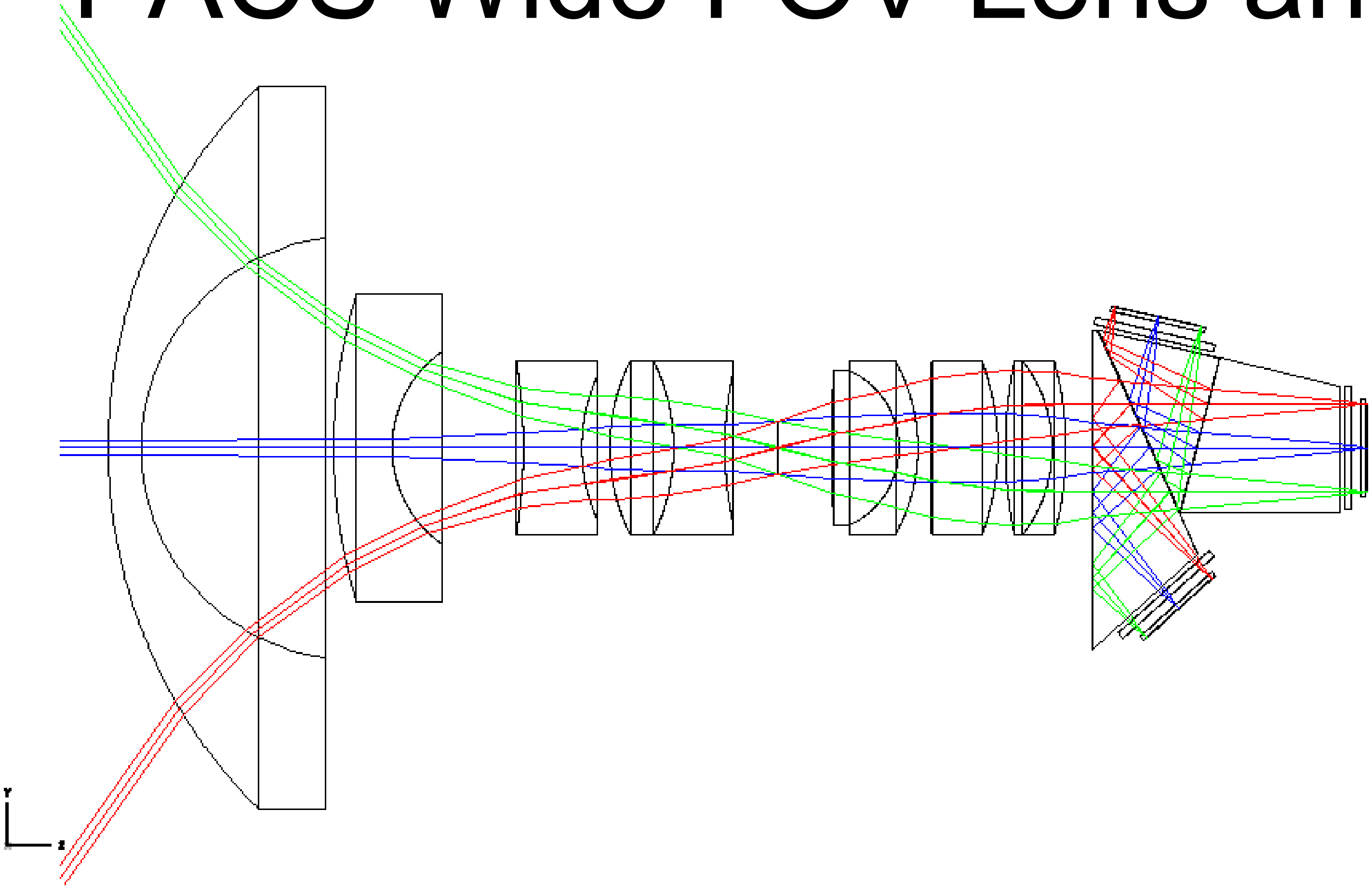






Hyperangular Capability Provides Cloudbow from small area (~2x2km from space)

PACS Wide FOV Lens and Prism

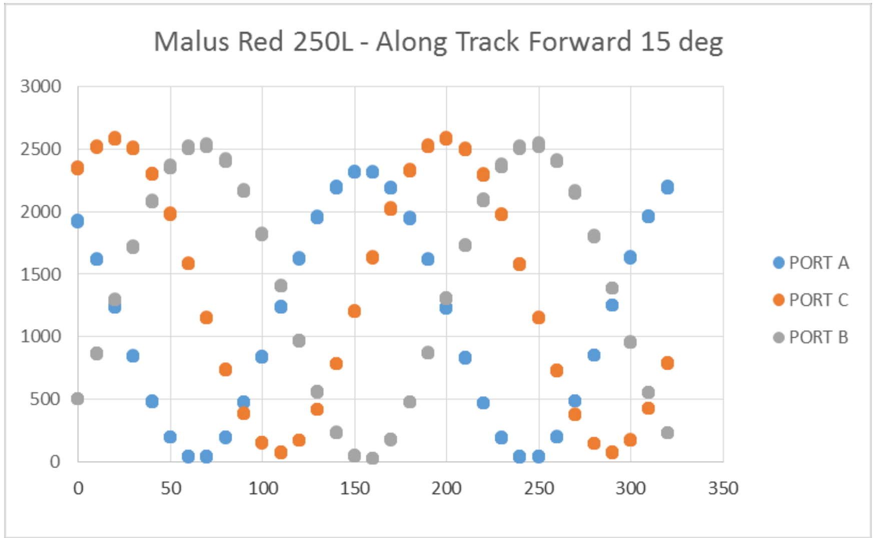


Calibration Challenges???

PACS Calibration Strategy

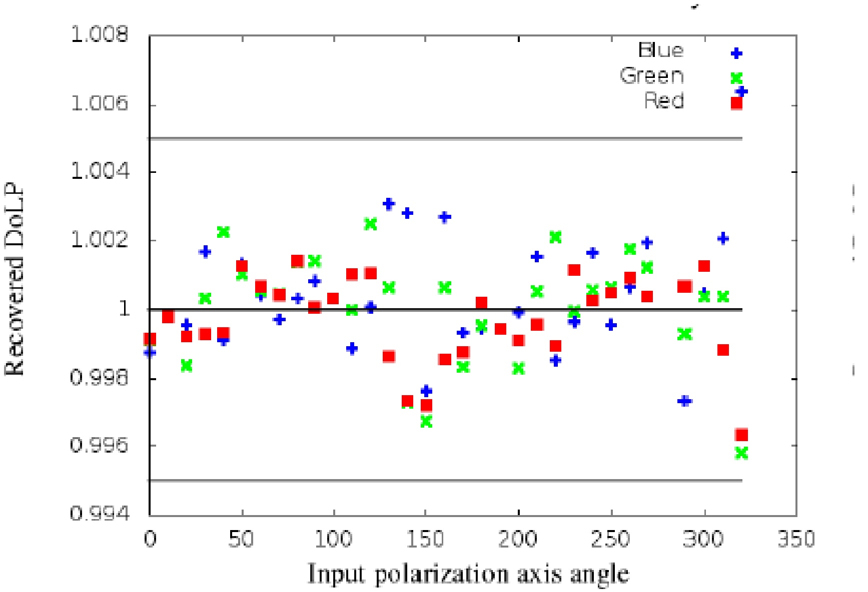
Intensities are measured in each port from known Stokes vector inputs

$$\begin{bmatrix} I_{Port\ A} \\ I_{Port\ B} \\ I_{Port\ C} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ B_{11} & B_{12} & B_{13} \\ C_{11} & C_{12} & C_{13} \end{bmatrix} \cdot \begin{bmatrix} S_{0\ input} \\ S_{1\ input} \\ S_{2\ input} \end{bmatrix}$$

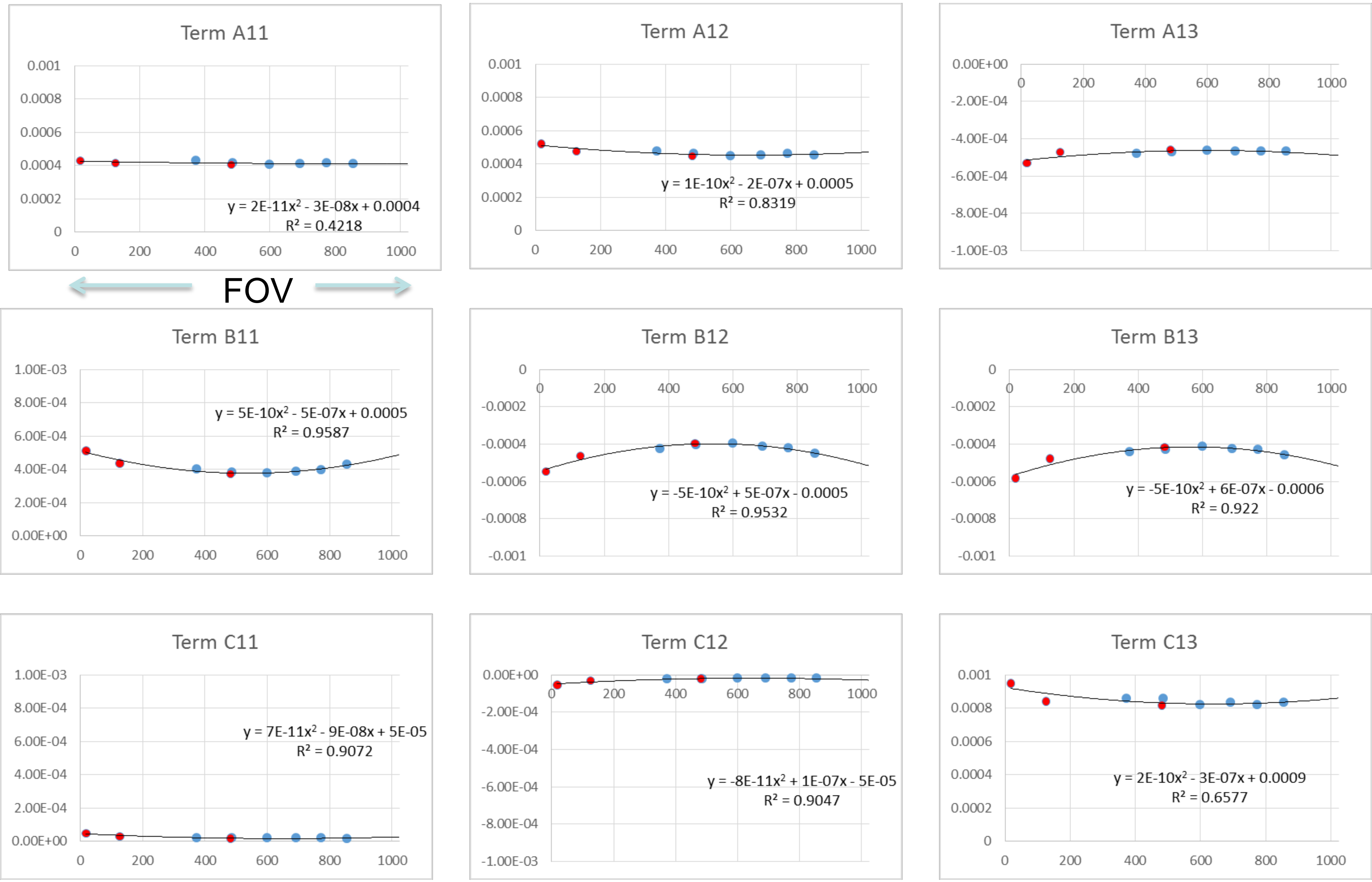


A characteristic Matrix is determined to represent the PACS Optics at different FOVs

$$\begin{bmatrix} S_{0\,input} \\ S_{1\,input} \\ S_{2\,input} \end{bmatrix} = \left[Inv\ C \right] . \begin{bmatrix} I_0 \\ I_{45} \\ I_{90} \end{bmatrix}$$

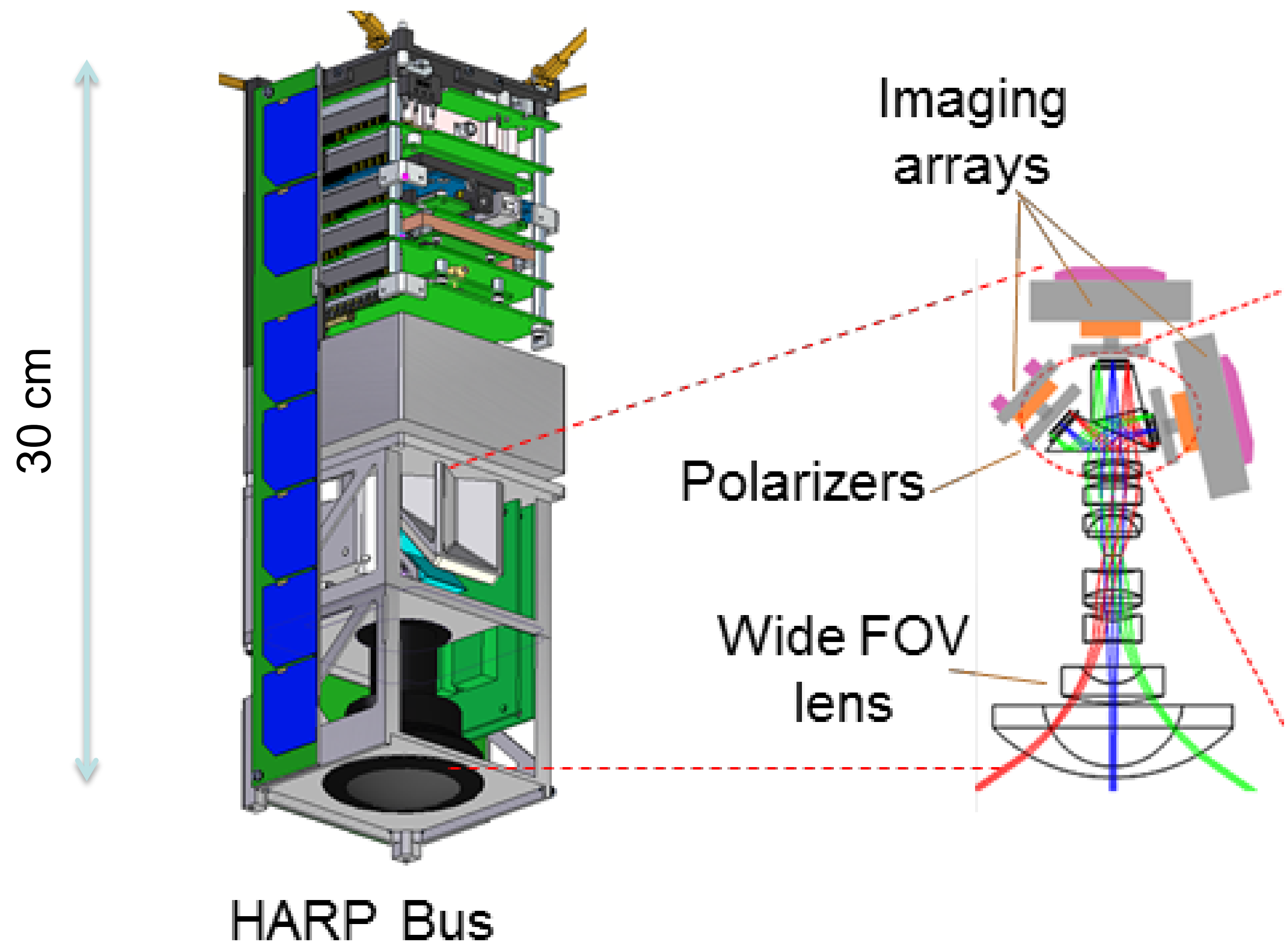


Elements of the PACS Characteristic Matrix as a function of FOV



HARP CubeSat Mission

HyperAngular Rainbow Polarimeter – Funded by NASA InVEST Program
Planned for 2015

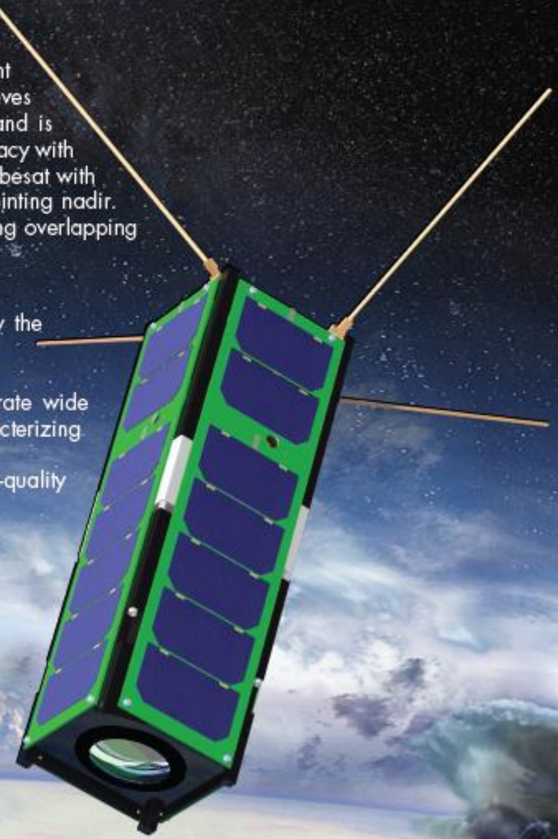


HARP

Hyper-Angular Rainbow Polarimeter

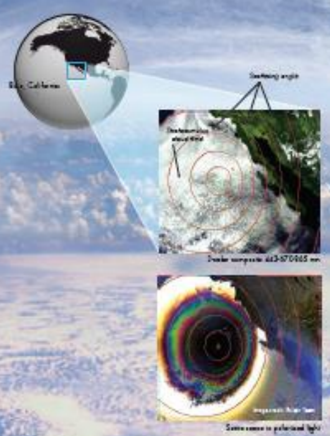
In-Space Validation of Earth Science Technologies (InVEST)

The HARP payload is a wide FOV imager that splits three spatially identical images into three independent polarizers and detector arrays. This technique achieves simultaneous imagery of three polarization states and is the key innovation to achieve high polarimetric accuracy with no moving parts. The spacecraft consists of a 3U Cubesat with 3-axis stabilization designed to keep the imager pointing nadir. The hyper-angular capability is achieved by acquiring overlapping images at very fast speeds.



OBJECTIVES:

- Space validation of new technology required by the NASA Decadal Survey Aerosol-Cloud-Ecosystem (ACE) mission
- Prove the on-flight capabilities of a highly accurate wide FOV hyper-angle imaging polarimeter for characterizing aerosol and cloud properties
- Prove that cubesat technology can provide science-quality Earth Sciences data



UMBC

NASA

Joint Center for Earth Systems Technology (JCET)

NOAA

Space Dynamics Laboratory

Utah State University Research Foundation

Thank you.