The Photon Simulator (PhoSim)

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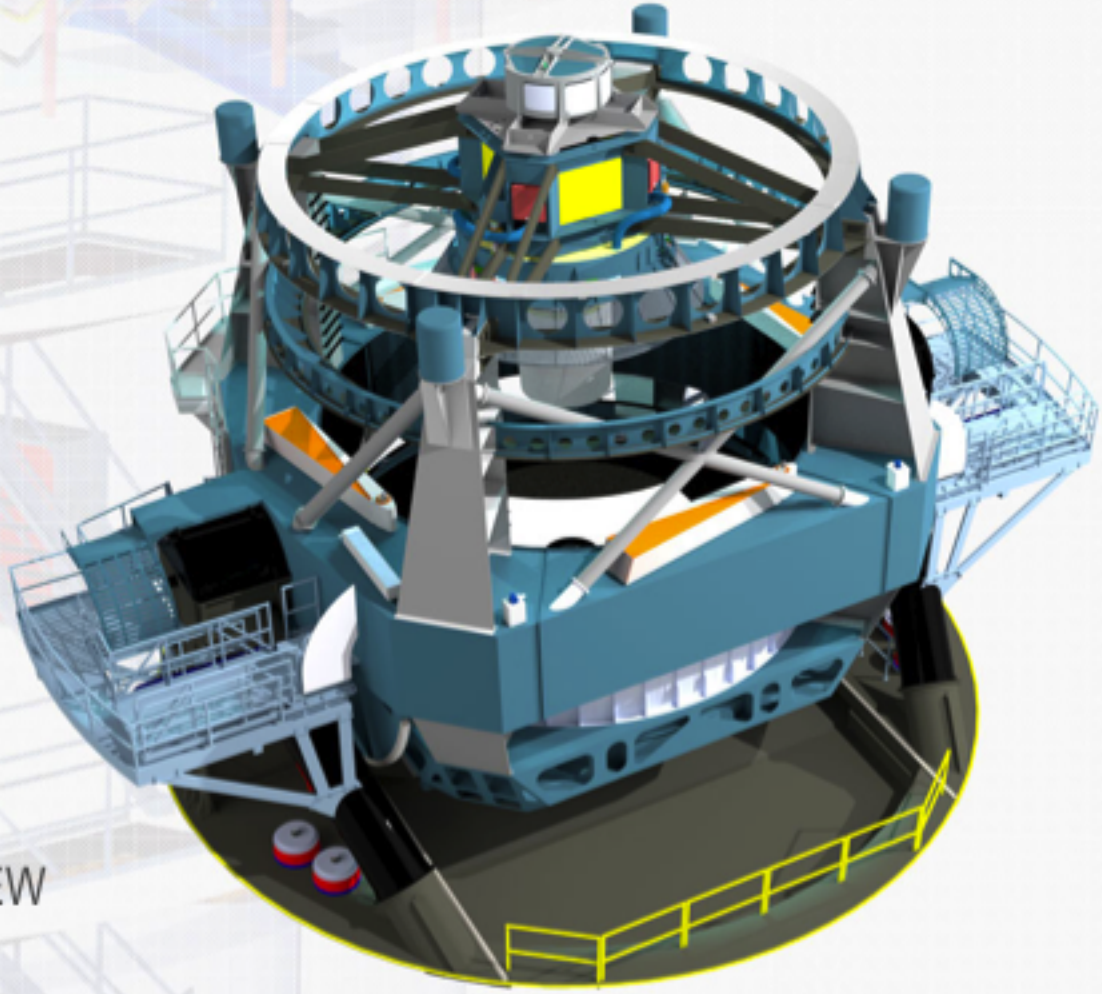
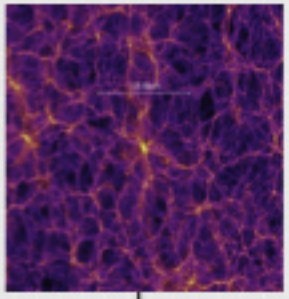


PhoSim Scope



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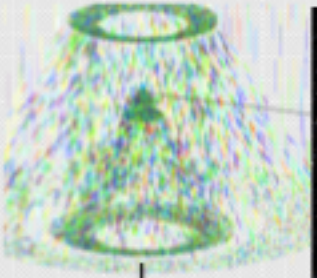
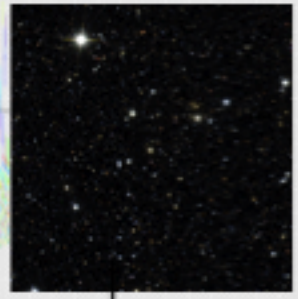




r=23.2
e1=0.021
e2=0.032
α=40.3245
δ=-30.237
σ=0.63"

w=-1.00000 +/- 0.00001

$(R,\vartheta)=(R_E,\vartheta_E)$

Universe → Catalogs → Photons → Images → Catalogs → Measurements

COSMO-LOGICAL, MW, & SOLAR SYSTEM SIMULATOR:
Synthetic Universe is constructed

CATALOG CONSTRUCTOR (CATSIM):
Universe is parameterized in instance catalogs; augment w/ some information

Observations

OPERATIONS SIMULATOR (OPSIM):
Operation parameters

PHOTON SIMULATOR (PHOSIM):
Atmosphere, Telescope, & Camera physics formulated in terms of photon manipulations

DATA MANAGEMENT (DM) STACK
Image processing to produce catalogs

CATALOG (LEVEL-3) ANALYSIS:
Produce astrophysical measurements at catalog level

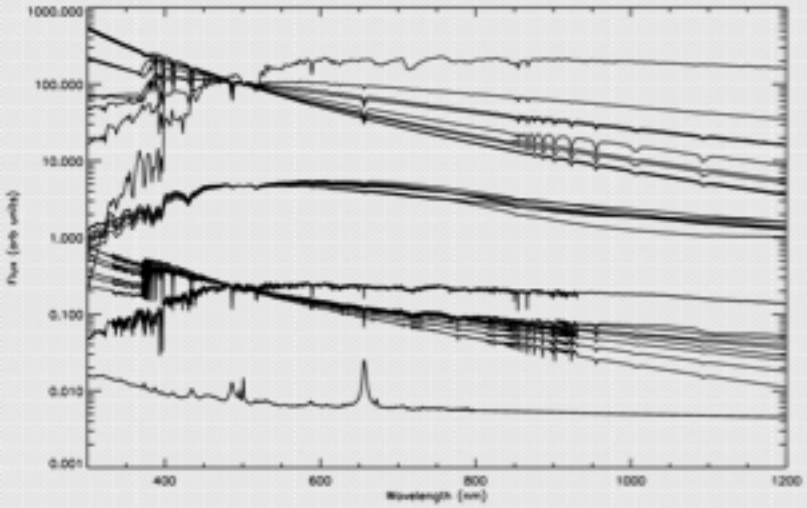
Every piece is stand-alone code that can be run separately, combined with alternative codes, or run as a complete chain

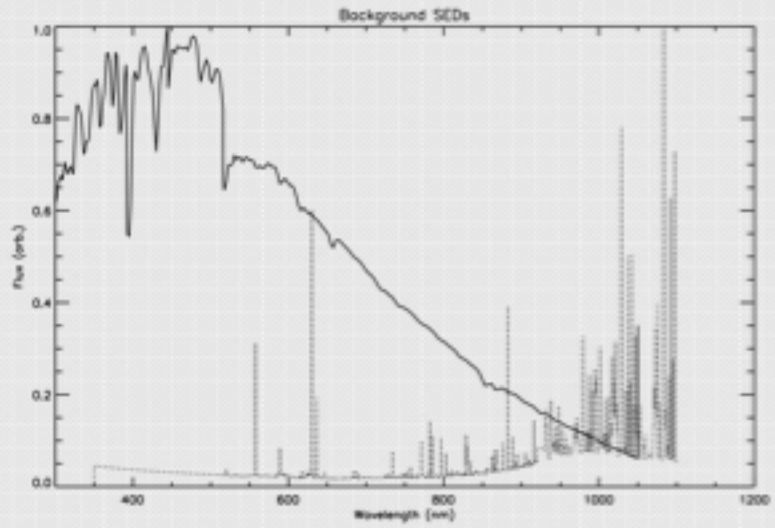
Photon Simulator (PhoSim)

- Main purpose: Generate high fidelity images given an input astrophysical catalog
  - Uses a literal photon Monte Carlo approach
  - Detailed physics of light propagation appropriate for telescope, camera, & atmosphere
  - Open Source / Written in C++ / Designed for Grid Computing
  - Many contributors (~16 pd/students/sr. scientists) & many ideas/data from throughout entire the project over several years; Dozens of users
  - Currently refining complications of physics details & adding more detail to the input LSST design
- Uses:
  - Test data management software
  - Early LSST design verification
  - Trade studies during design/construction/commissioning
  - Early Exploration of LSST Potential Science

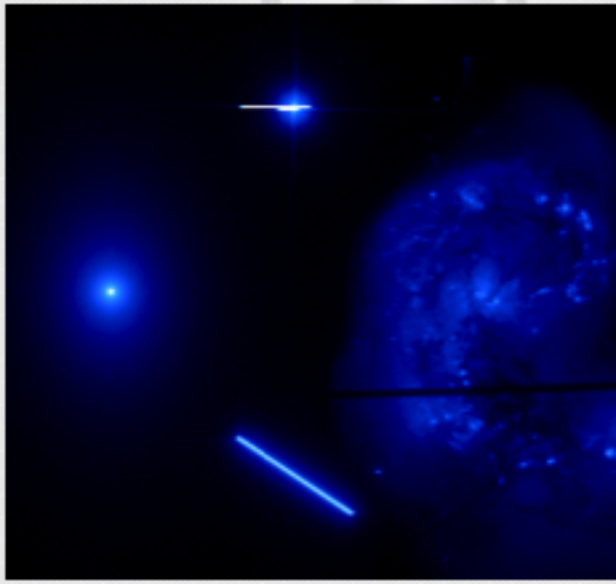
Photon Monte Carlo Approach

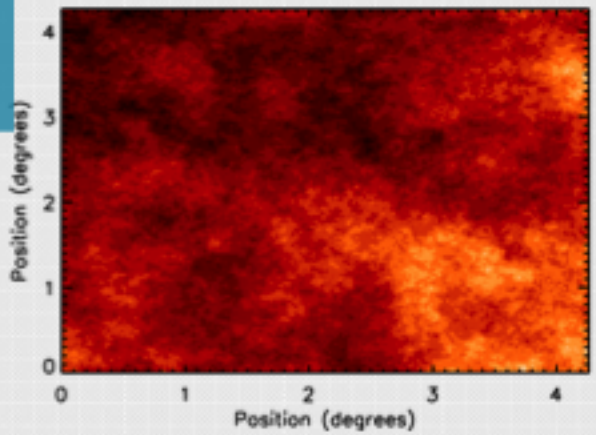
Sky Simulation



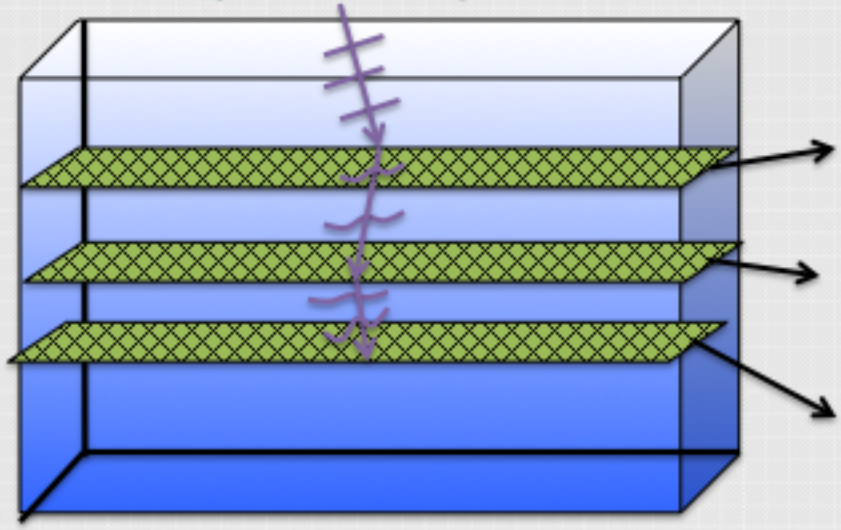


Monte Carlo Photon wavelength and direction from astrophysical parameters in catalog and models of background

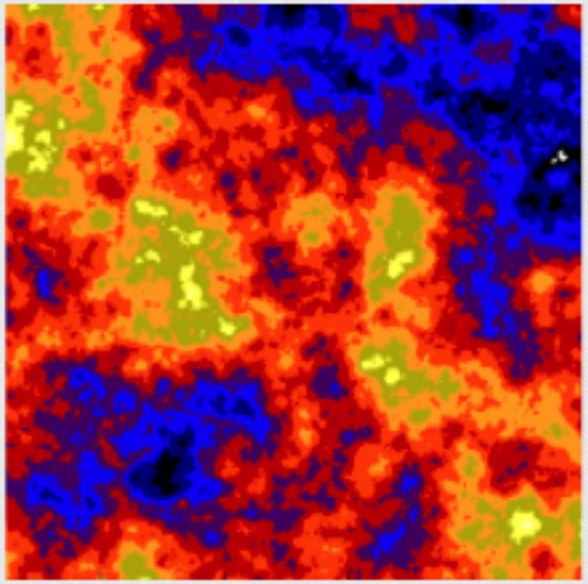


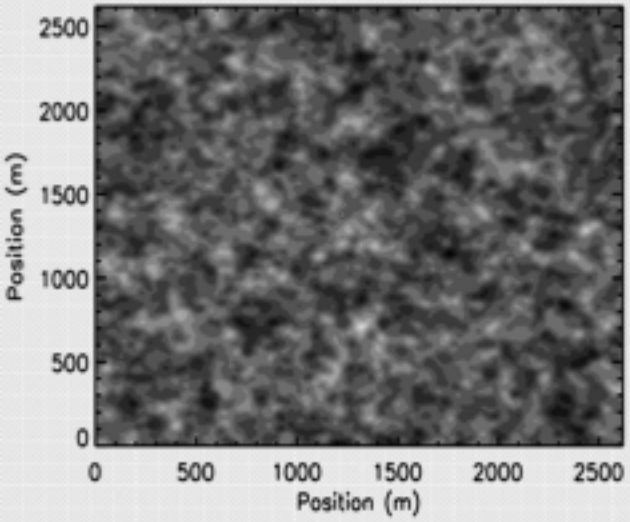


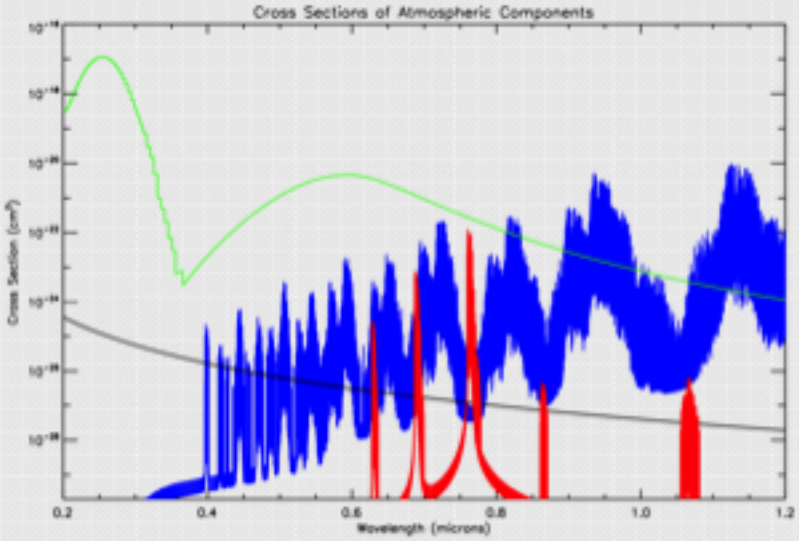
Atmosphere Physics

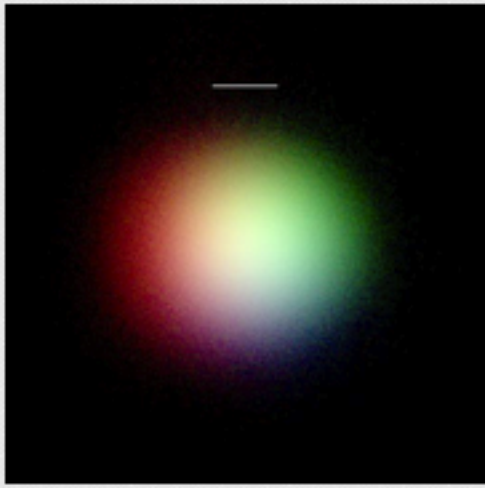


Photons propagated using Turbulence screens, cloud & Atmosphere opacity, atmospheric dispersion

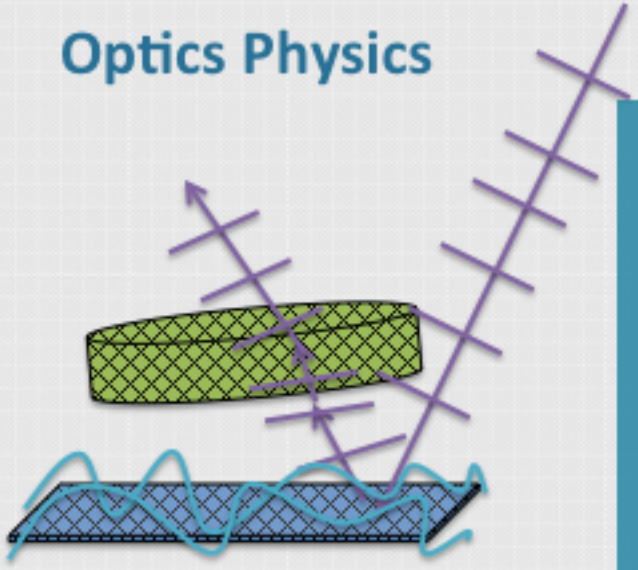




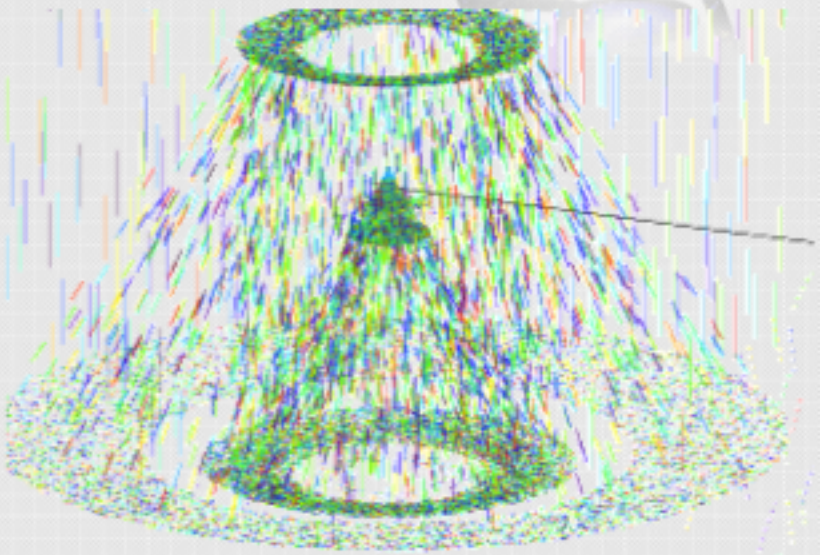


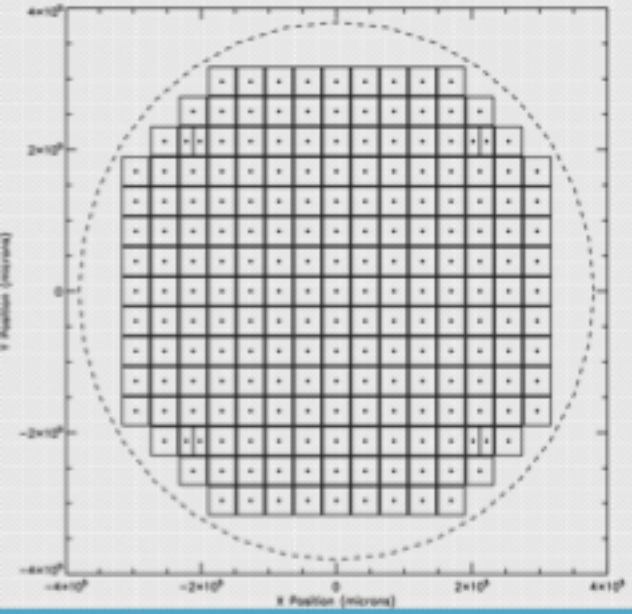


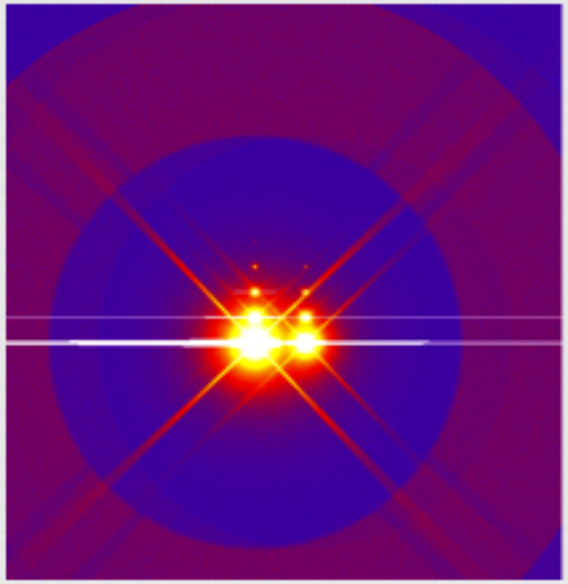
Optics Physics

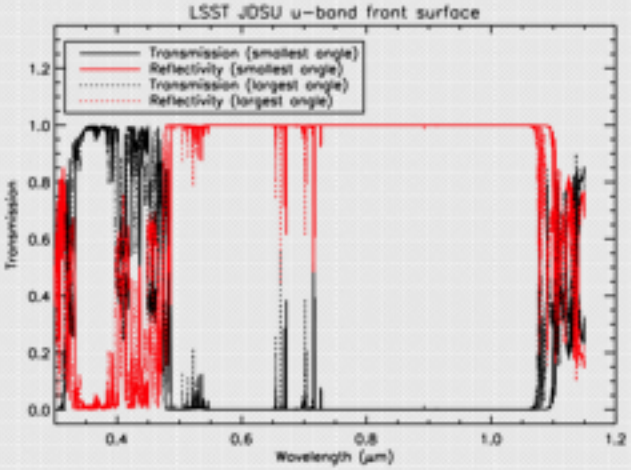


Refract/Reflect photons through optical design including coating simulation, misalignments/ perturbations, diffraction, contamination

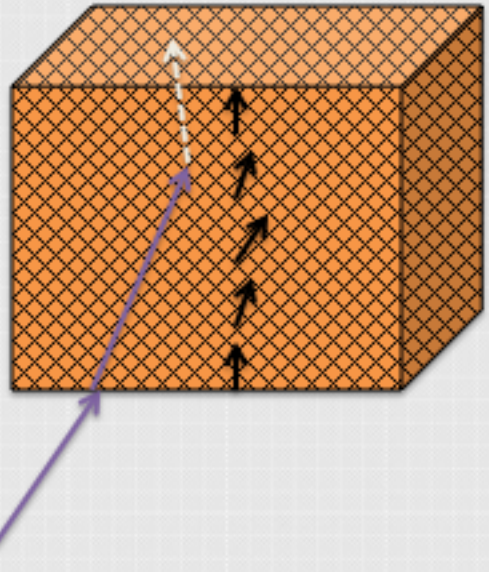


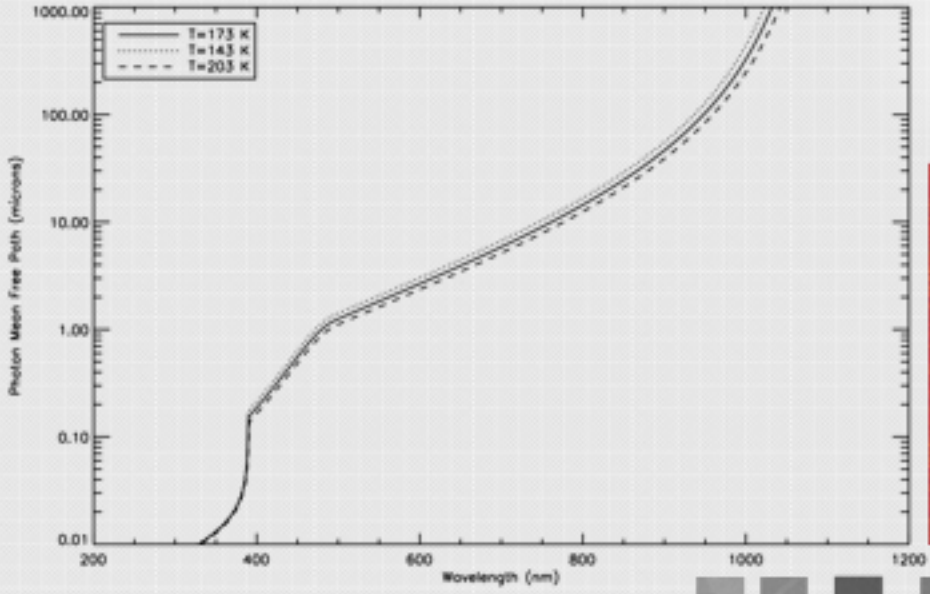


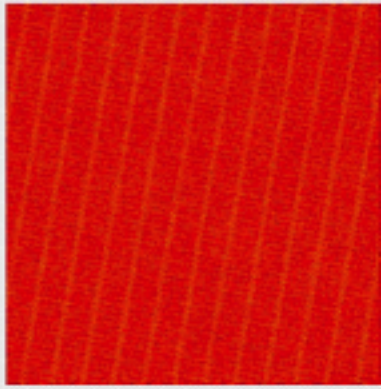




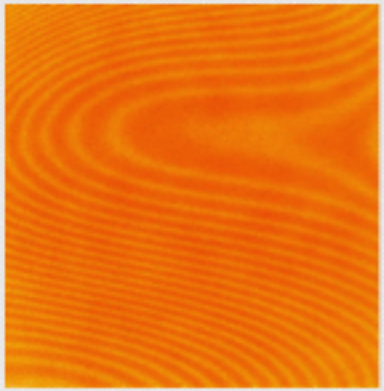
Detector Physics

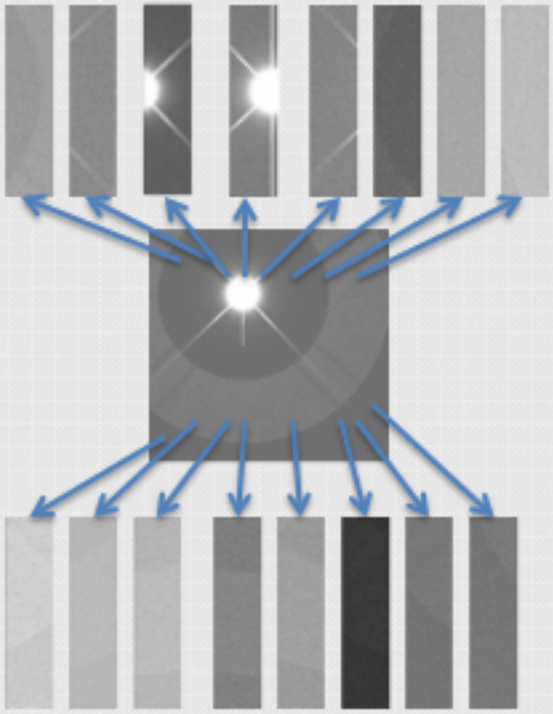


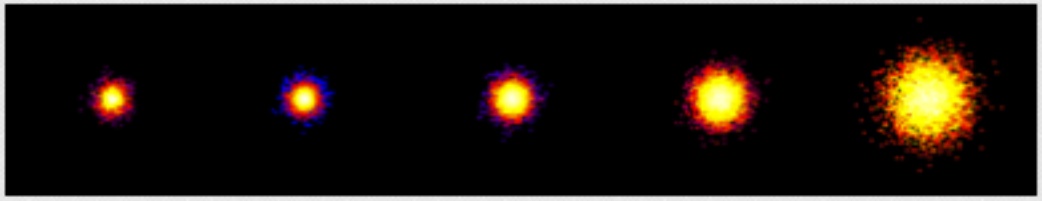




Photons propagated through conversion in Silicon;
Electron charge diffusion simulated;
Digitization & readout simulation to produce final image



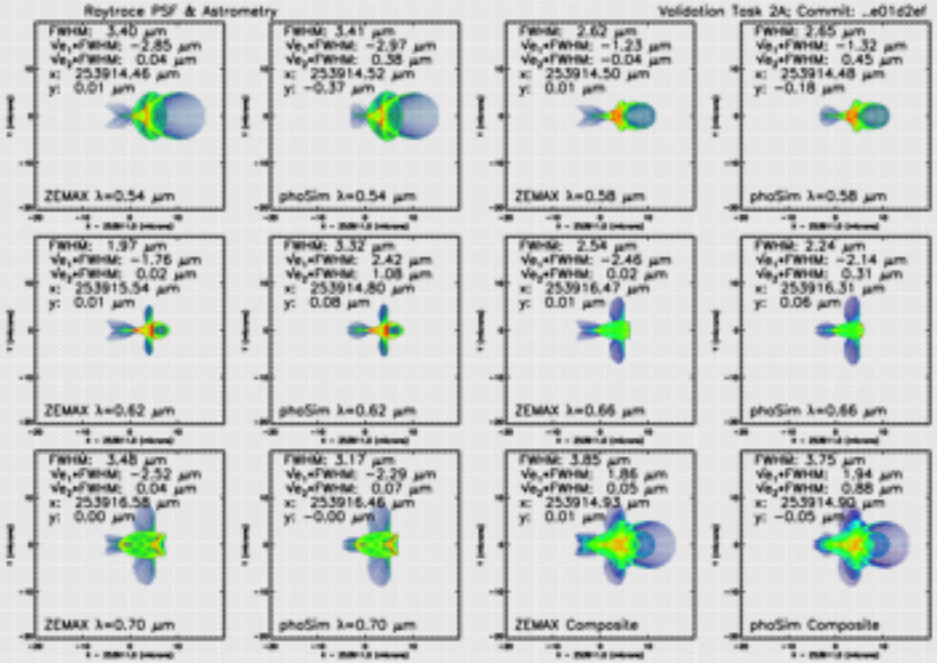


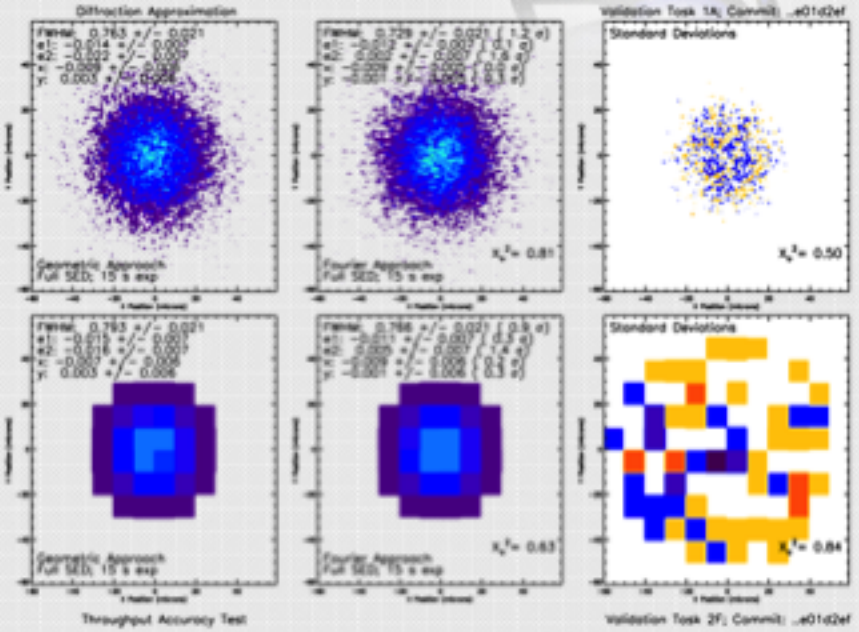


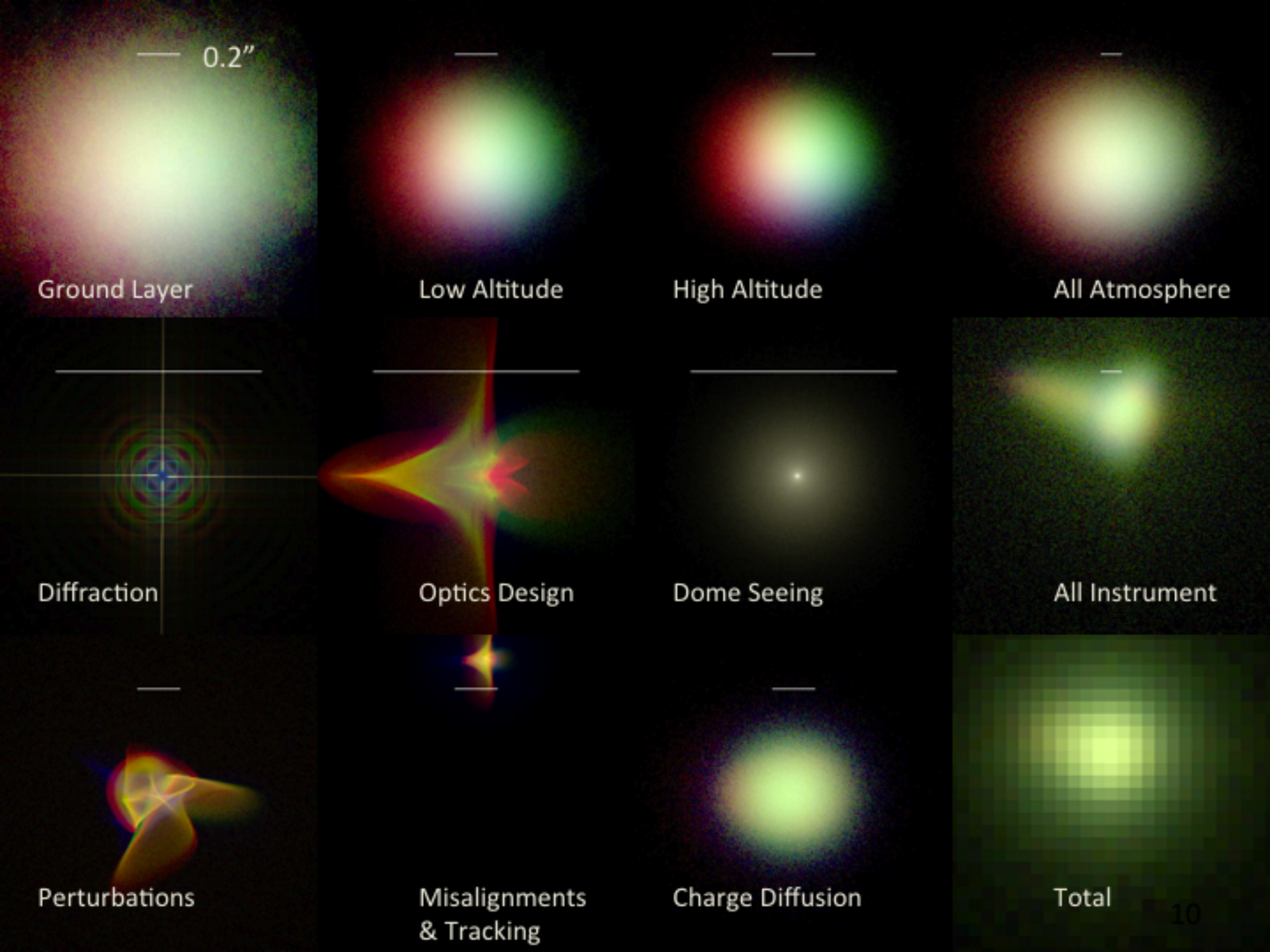
Detailed Validation Framework

Track over 100 metrics & compare w/ Alternative Calculations, Known Analytic Results, or Real Data

Tests approximations & implementation






0.2”
Ground Layer
Low Altitude
High Altitude
All Atmosphere
Diffraction
Optics Design
Dome Seeing
All Instrument
Perturbations
Misalignments
& Tracking
Charge Diffusion
Total

Images (several trillion photons)