The Photon Simulator (PhoSim)

John R. Peterson

PhoSim Lead

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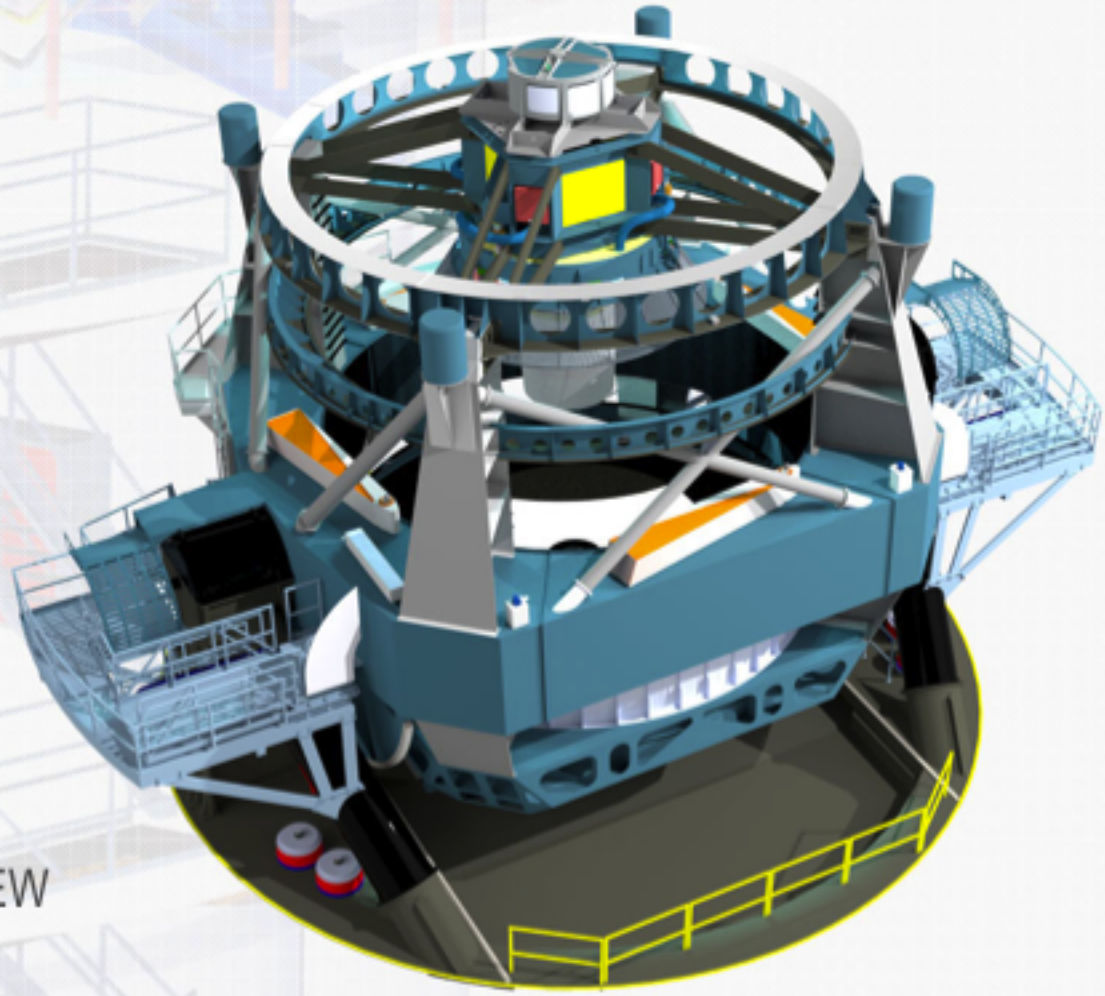
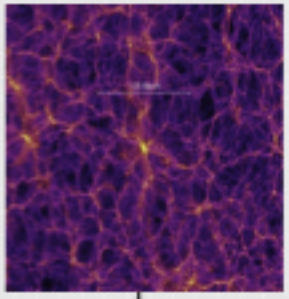
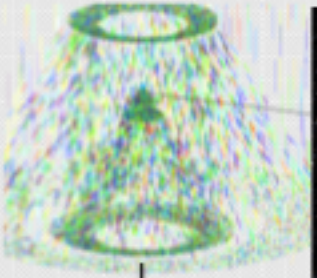
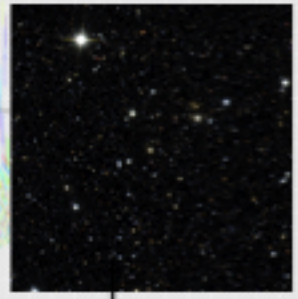


PhoSim Scope



object 0.002 -2.439485 14.5 galaxySED/ Const64e0804z..spec.gz 0 0 0 0 0 0 sersic2D 1.29394 2.4587 1.77 2.980 ccm 2.3 8.2 ccm 2.78 9.45





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

w=-1.00000 +/- 0.00001

$(R,\vartheta)=(R_\varepsilon,\vartheta_\varepsilon)$

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

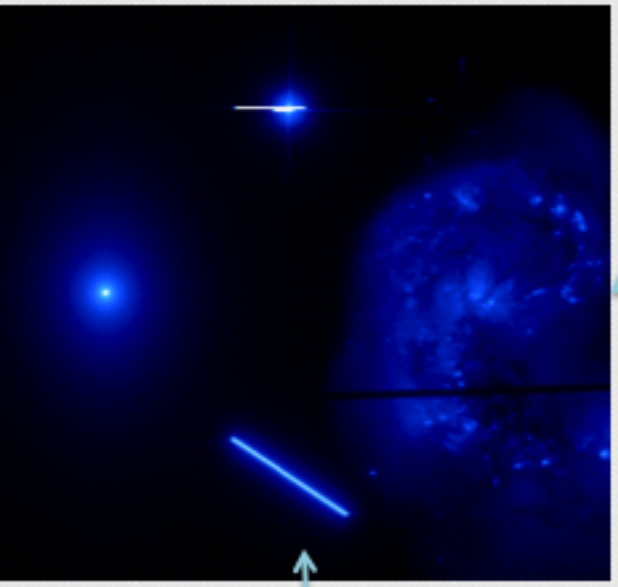
Every piece is stand-alone code that can be run separately, combined with alternative codes, or run as a complete chain

Photon Simulator (PhoSim)

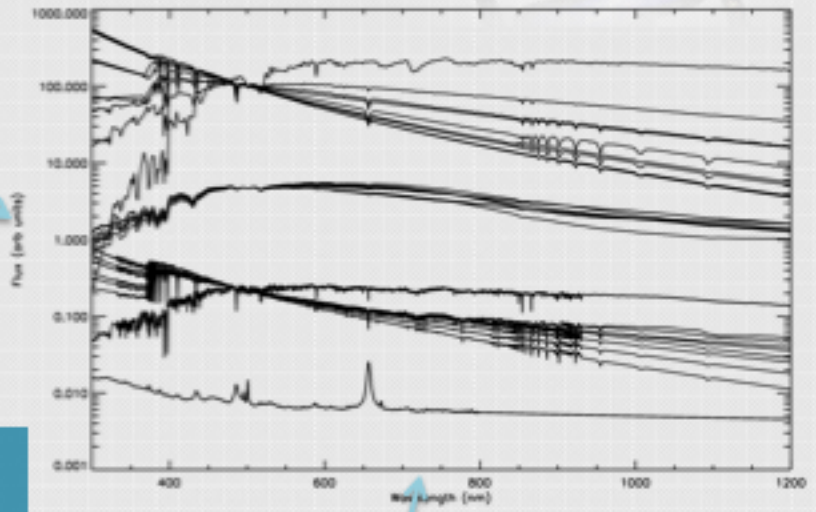
- Main purpose: Generate high fidelity images given an input astrophysical catalog
  - Uses a literal photon Monte Carlo approach
  - Detailed physics of light propagation appropriate for telescope, camera, & atmosphere
  - Open Source / Written in C++ / Designed for Grid Computing
  - Many builders (16) & many ideas/data from throughout entire the project over 8 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



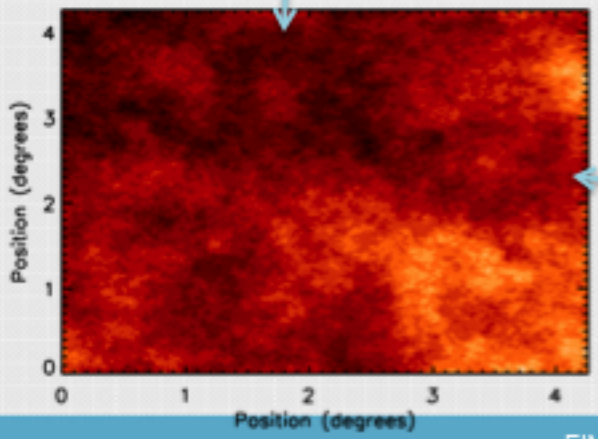
Astronomical Objects



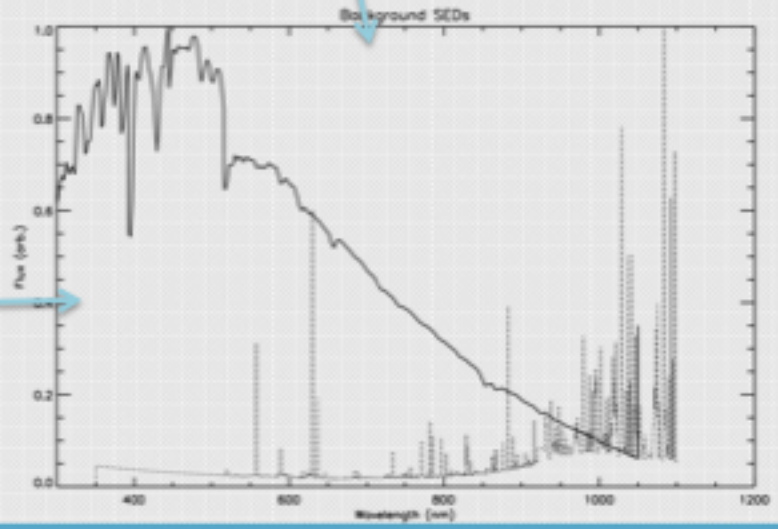
Monte Carlo photon wavelength and direction from catalog information

SEDs

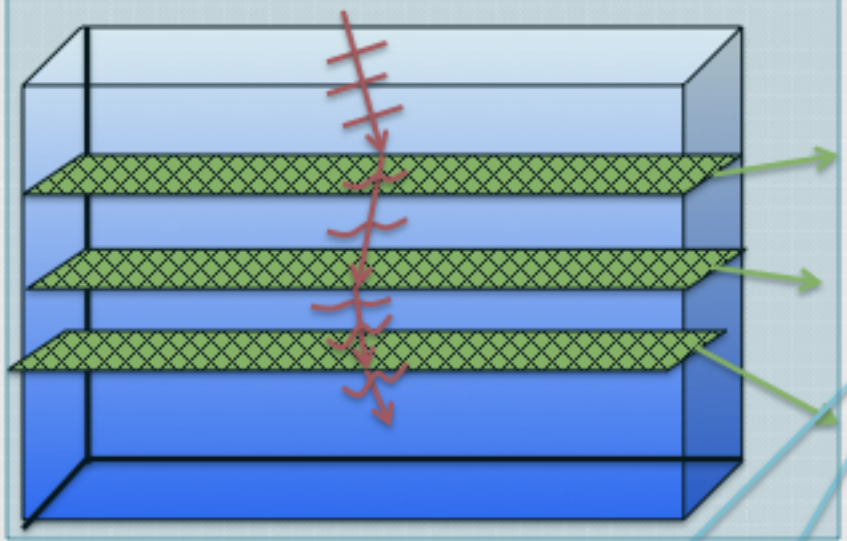
Spatial Models



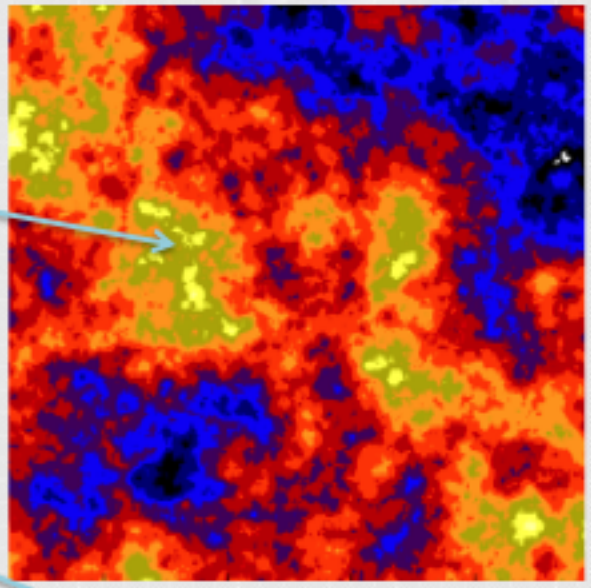
Background Emission

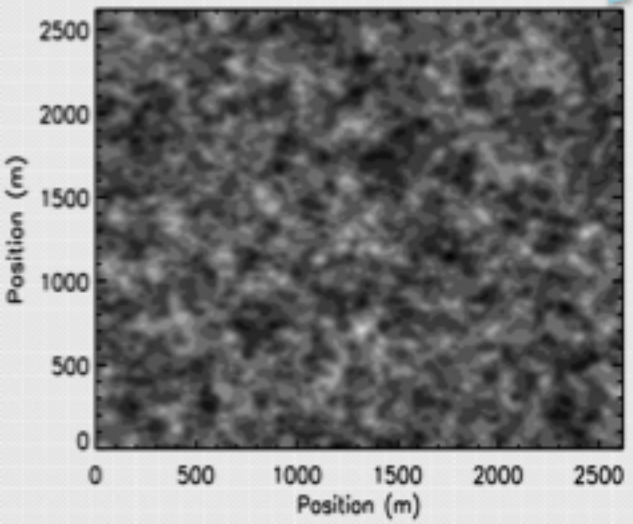


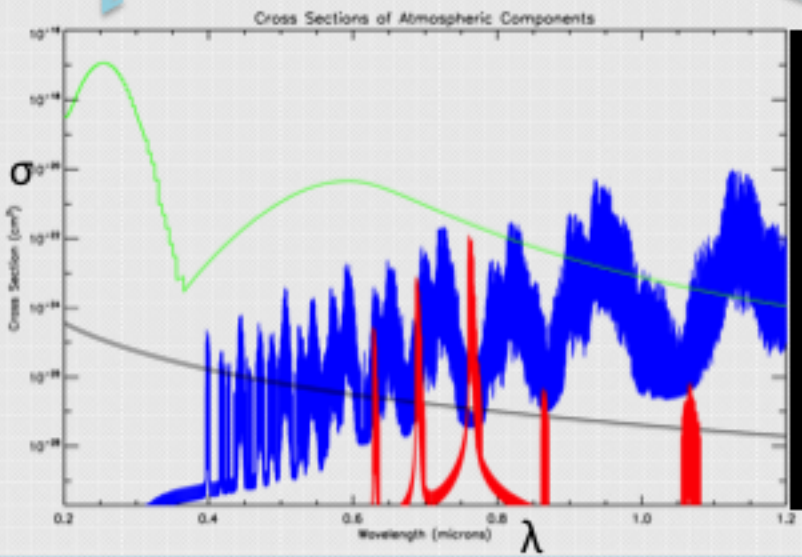
Atmosphere Physics

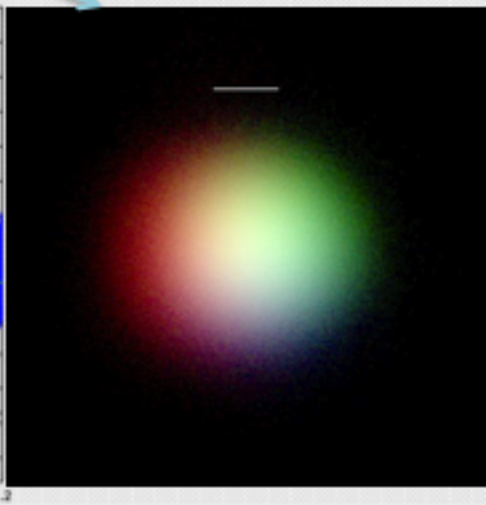


Photons propagated using Turbulence screens, Cloud & Atmosphere opacity, Atmospheric dispersion

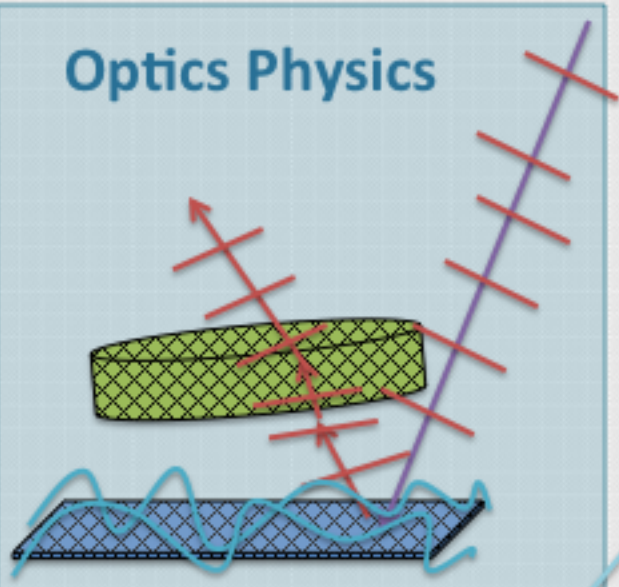




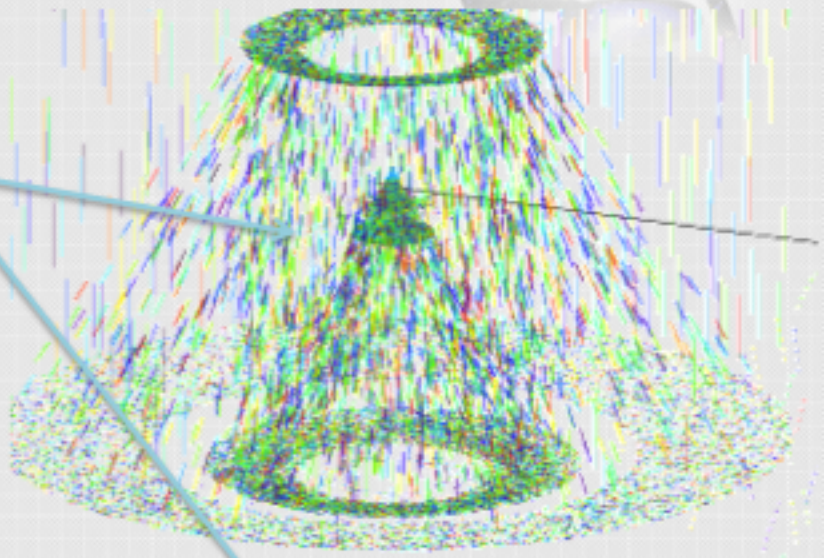


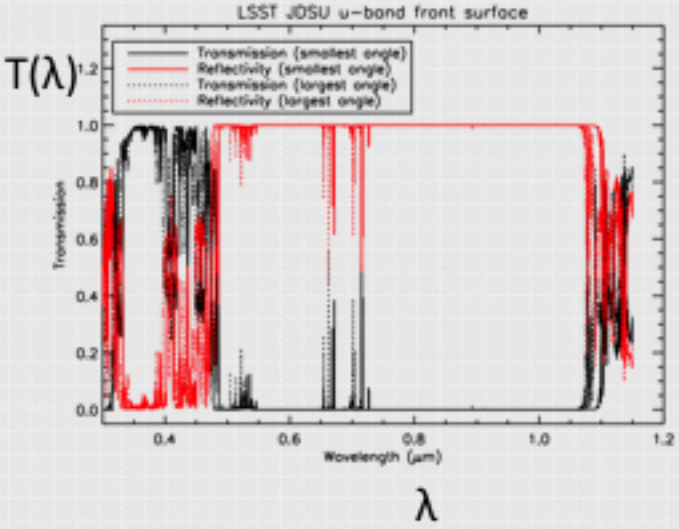


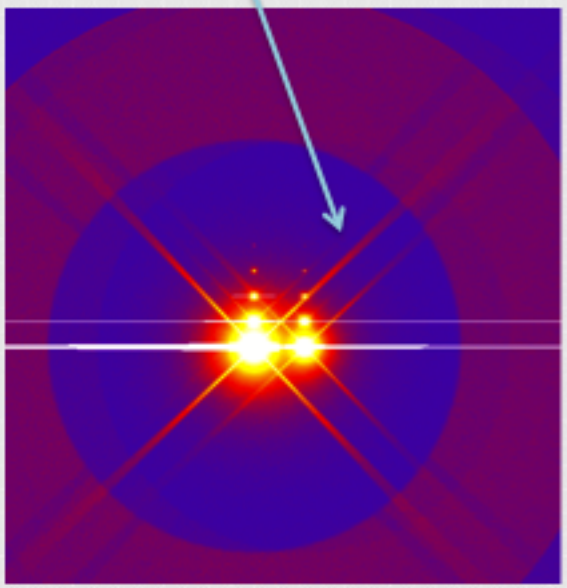
Optics Physics

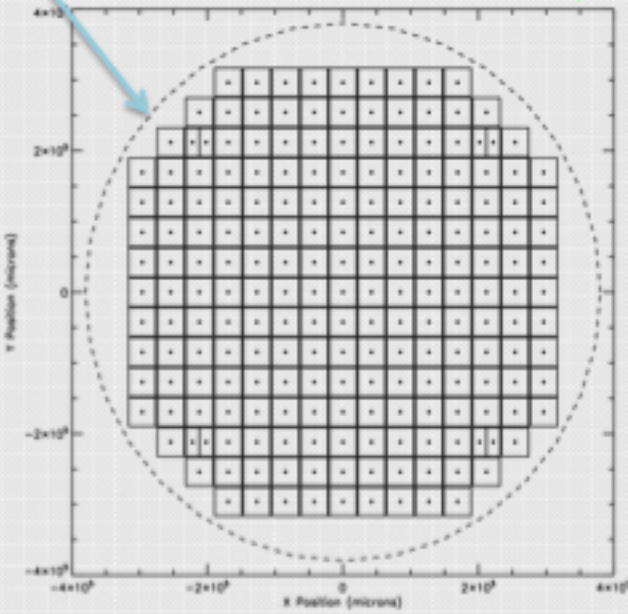


Refract/Reflect photons through optical design including misalignments/ perturbations, coating simulation, diffraction, contamination

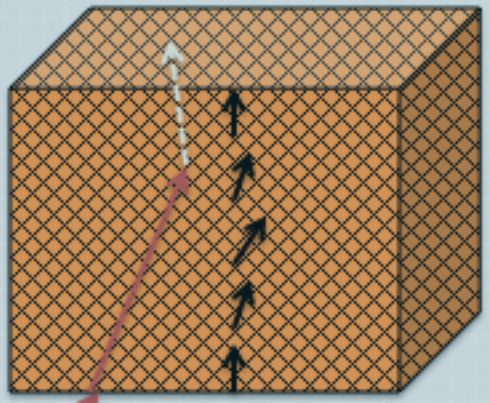


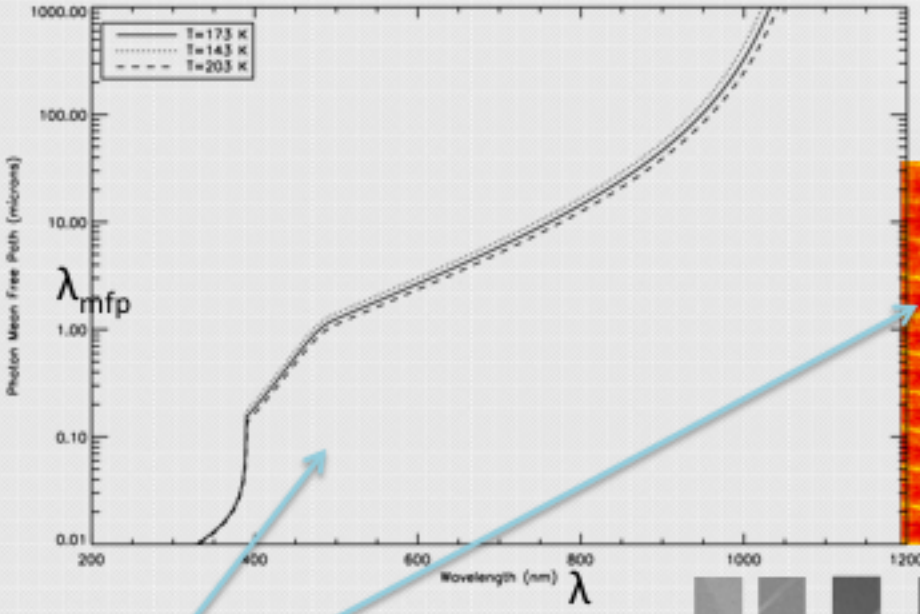


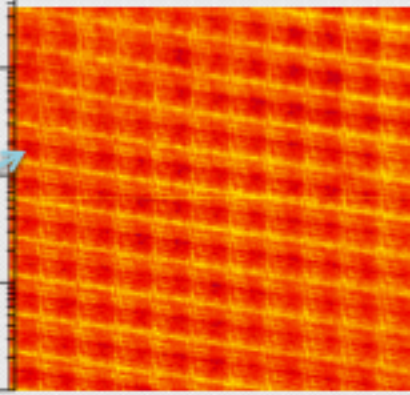




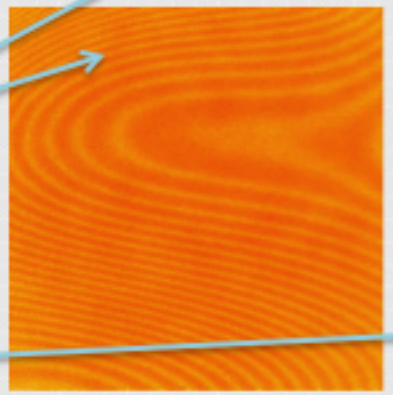
Detector Physics

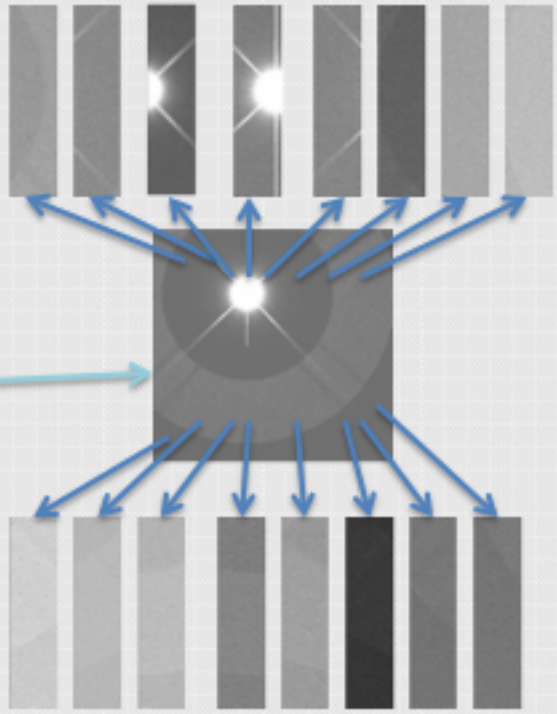


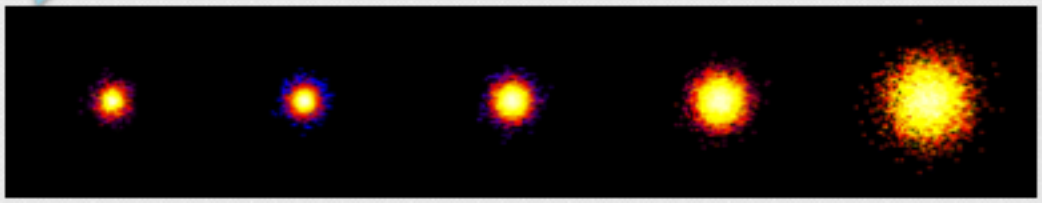


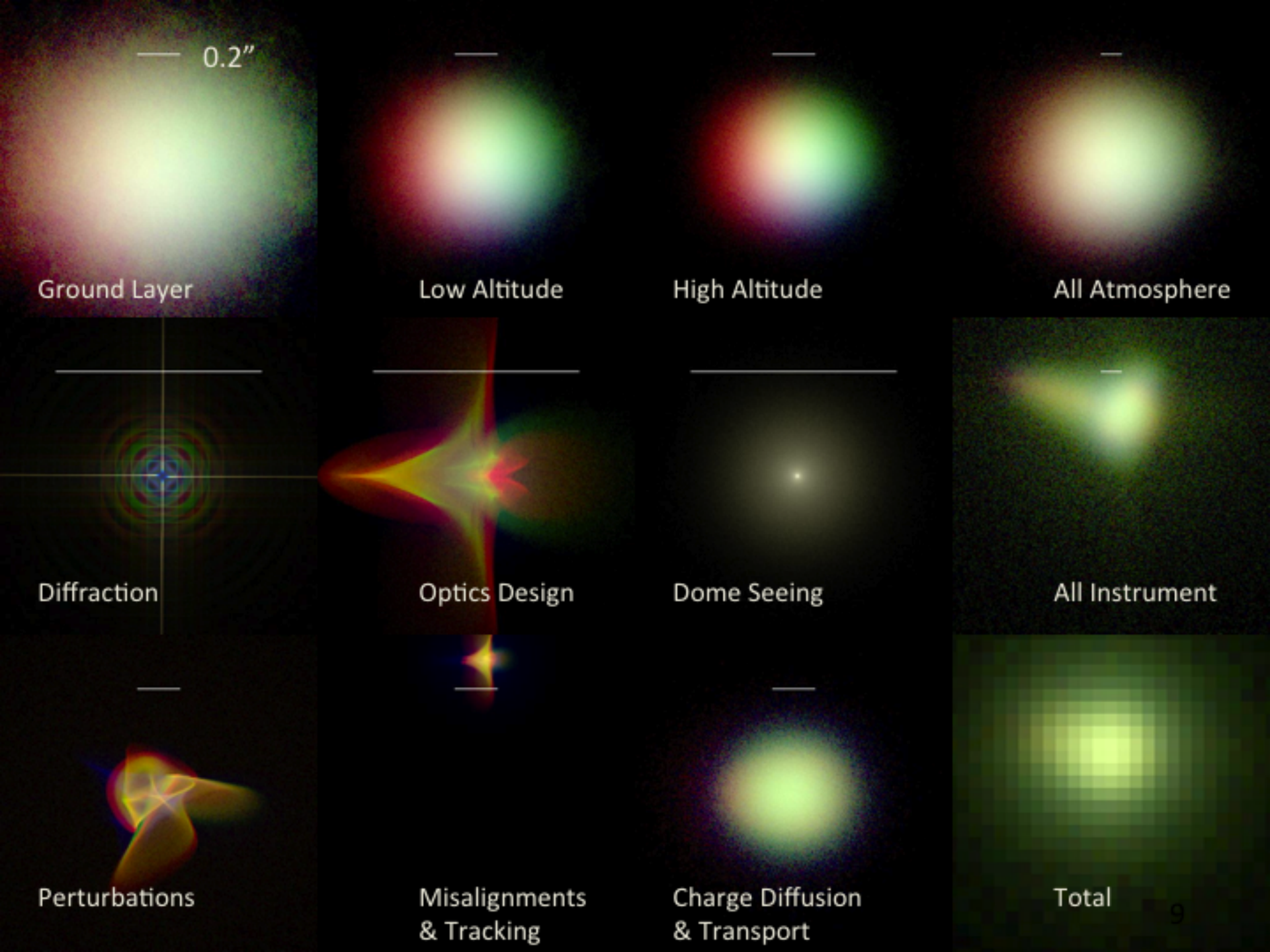


Photons propagated through conversion in Silicon;
Electron charge diffusion simulated;
Digitization & readout simulation to produce final image





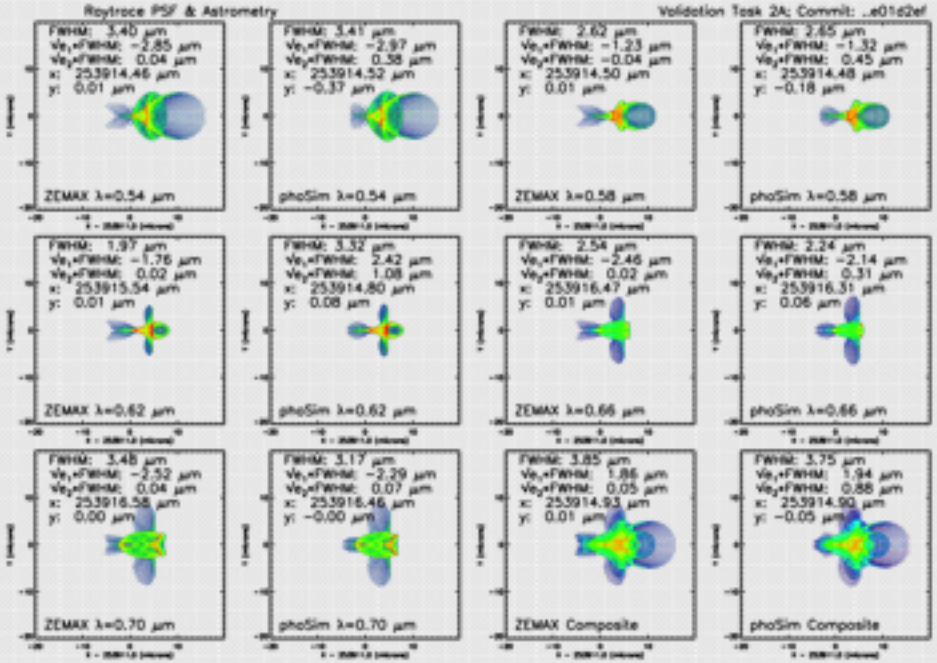


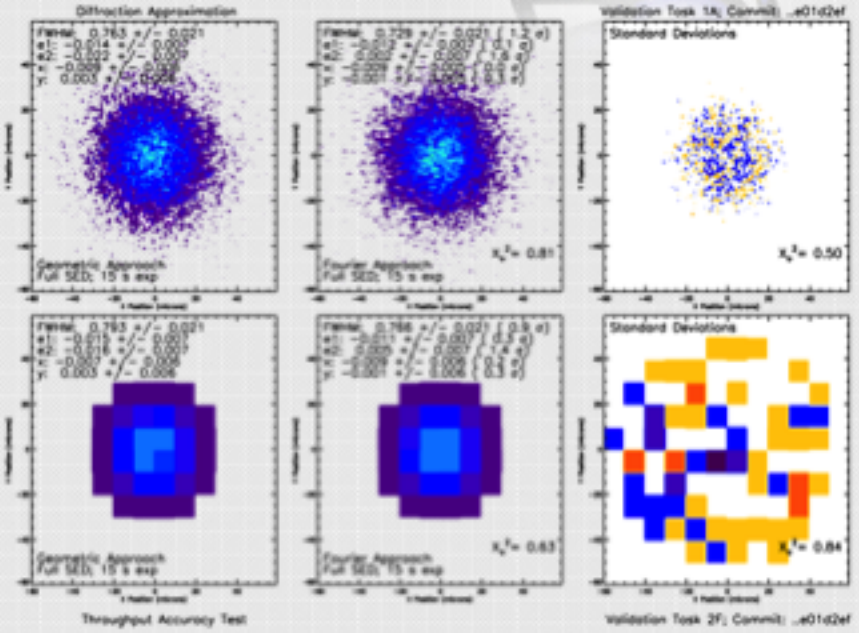

0.2”
Ground Layer
Low Altitude
High Altitude
All Atmosphere
Diffraction
Optics Design
Dome Seeing
All Instrument
Perturbations
Misalignments
& Tracking
Charge Diffusion
& Transport
Total

Detailed Validation Framework

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

Tests approximations & implementation





Future PhoSim Work

- **PhoSim Resources:** Development (both project & off-project) + Production + Many Power Users
- **Work Plan**
  - Image Production
    - Large scale runs w/ DM algorithmic milestones
    - Large scale runs w/ Sys Eng Design/Construction/Commissioning goals
  - Usability
  - Validation
    - Series of validation studies w/ hardware components testing & integrated sys
    - Series of validation studies w/ atm site measurements & site expert team
  - Fidelity
    - Perfecting Many Details: Perturbation update, sensor validation, coating non-unif, ghost validation, tracking update, wind buffeting, defects, microroughness update, dust, degradation, digitization update, glass non-unif, shutter, baffle, glint, cosmic ray data; correlations in atm pars, opacity spatial, galaxy morphology & SED update, background comps, cloud structure detail vs. height, site measurements

Images (several trillion photons/FP)
6 major data challenges & >20 Tb to date