Goals and Plans for Camera I&T Calibration

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This Session

- Review Camera I&T calibration goals, specifications, and tasks.
- Identify I&T calibration technical issues.
- Identify I&T calibration data management issues.
- Identify work to be done for PDR/CD-1.

Camera I&T Calibration Goals

Purpose: Establish camera photometric performance before integration with telescope.

- Determine fixed operating parameters.
- Determine system response times.
- Determine spatial uniformity and camera “flats”.
- Measure chromatic bandpasses.
- Validate ghosting (scattered light) model.

Flow-Down of Error Budgets

SRD Photometric Design Specs	Repeatability of measured magnitudes of bright sources.	Uniformity across the sky of the internal zero-point for bright and faint sources.	Relative accuracy of color zero-points for main-sequence stars.
Overall Specification	5 millimag	10 millimag	5 millimag
Instrumental Calibration (A)	3 millimag	5 millimag	3 millimag
Atmospheric Characterization	4 millimag	5 millimag	3 millimag
Images, Grids, and Algorithms (incl Verification)	2 millimag	7 millimag	3 millimag

(A) Combined telescope and camera.

NOTE: 1 millimag ≅ 0.1%

Flowdown to Camera

- Stability – budget is 0.2% for uncontrolled variations in throughput.
  - (QE • CTE • Gain) stable to < 0.2% over times shorter than calibration cadences:
    - Dome screen beginning and end of each night
    - Sky standards every epoch (3-4 days)

- Uniformity – budget is 0.35% for uncontrolled variations in throughput.
  - Relative (QE(x,y) • CTE • Gain(x,y)) controlled to < 0.25%.
  - Relative optics/filter transmission T(x,y) controlled to < 0.25%.

  → The product of these two is what really matters.

- Color zero-points – budget is 0.2%
  - Measure relative (T(λ) • QE(λ)) (over passbands) with error < 0.2%.

Camera Calibration Matrix

Large Synoptic Survey Telescope

LSST Camera Calibration Matrix

	Parameter	Summary Specification		Production Tests	Raft Tests	Camera Calibration	Dome/Sky Calibration
Sensors and Elex							
	QE(λ,x,y)			x			
	CTE(x,y)			x			
	Gain(e-,x,y)	Non-linear < 3% Full Well		x			
	Full Well	90000 e-		x			
	Cross Talk	residual < 3σ(sky)		xx		??	??
	Fringe(λ)	< 5% (p2p)		x		xx	xx
	Dark Current	< 1 e-/s/pix		x	?	xx	xx
	Electronic Noise	< 5 e- rms		x		xx	xx
	Persistent Charge	< 0.02% Full Well (20 e-)		x			
	Bad Pix Map	<1% bad pix		x		xx	xx
Throughput and Scattered Light							
	Optics/Filters T(λ,x,y)	0.25% rel meas error		x		??	
	QE(λ,x,y)·CTE·G(e-,x,y)	0.25% rel meas error				??	??
	Throughput (λ,e-,x,y)	0.35% rel meas error				xx	
	Scattered Light (λ,x,y)	< 3% model error	(TPC)			xx	
Key:	x	Acceptance value					
	xx	Calibration value					

Complete this for PDR.

Integrated Camera Calibration

When …

Camera is completed and sitting in SLAC assembly room.

Electronics and DAQ working.

Peripherals (shutter, filters, etc) in place and working.

Goal

Verify we are ready to ship the Camera to the mountain.

Method

Run the camera as if it were taking data on the telescope!

Images to Record and Analyze

Bias frames.

Darks (long and short).

Calibration Images

Integrated Camera Calibrations

- Flat Screen – "Plane Wave Surrogate"
  - Not particularly useful without optical beam from the telescope.

- Preliminary Studies of Optical Calibration Configurations
  - Andy Scacco and Allesandro Sonnenfeld
  - Keith Bechtol (presentation later)

- Camera Calibration Optical Bench
      - » Aurelien Barrau and Alexia Gorecki

Need concept and preliminary design for PDR.