



Jet Propulsion Laboratory
California Institute of Technology

Performance Error Budget: Stability

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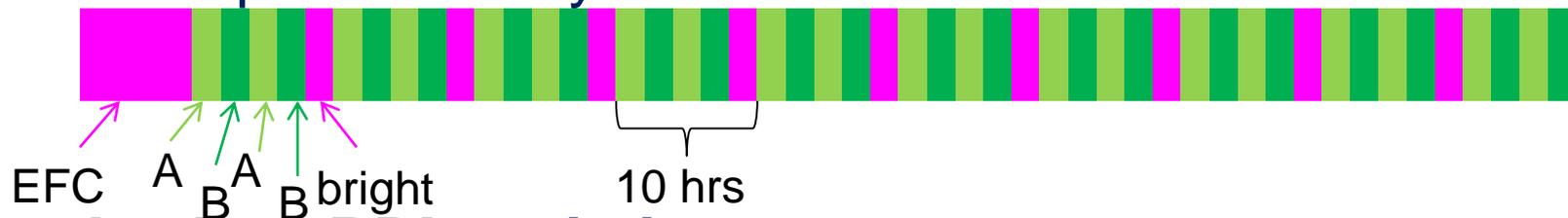
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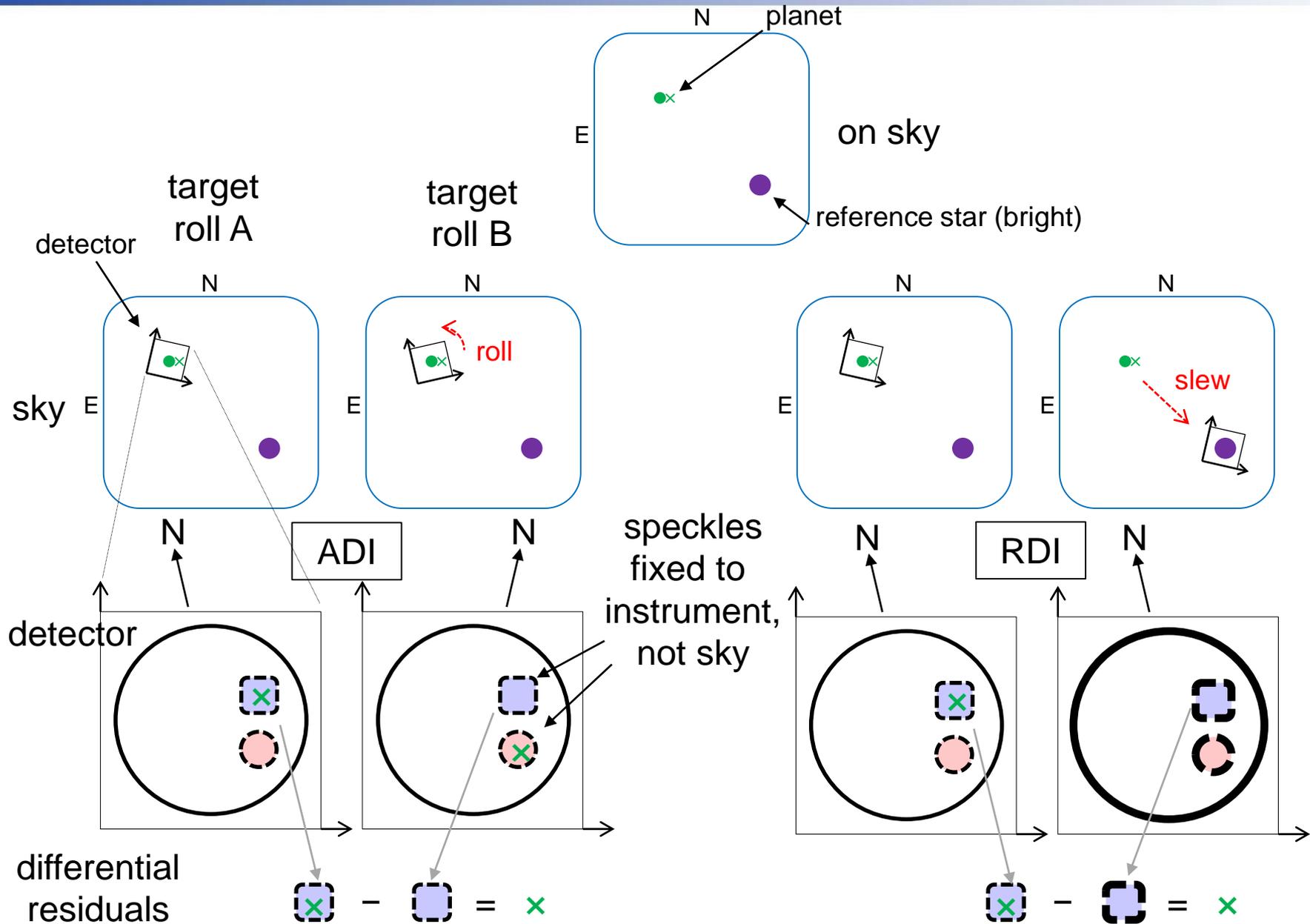
- **Observing scenario**
 - EFC, freeze high-order
 - Imaging / spectroscopy RDI
- **Error budget structure**
 - Performance requirement
 - Measurement noise
 - Optical stability
 - Allocations / CBE std MUF / CBE unity MUF
- **Insight into terms**
 - RWA jitter
 - Observatory thermal
 - CGI internal

- **“OS6” observing scenario**
 - 8 hrs EFC on bright reference, freeze EFC
 - Four 2 hr observations on target with alternating roll
 - Slew to reference, 2 hrs on reference
 - Repeat 10 hr cycle

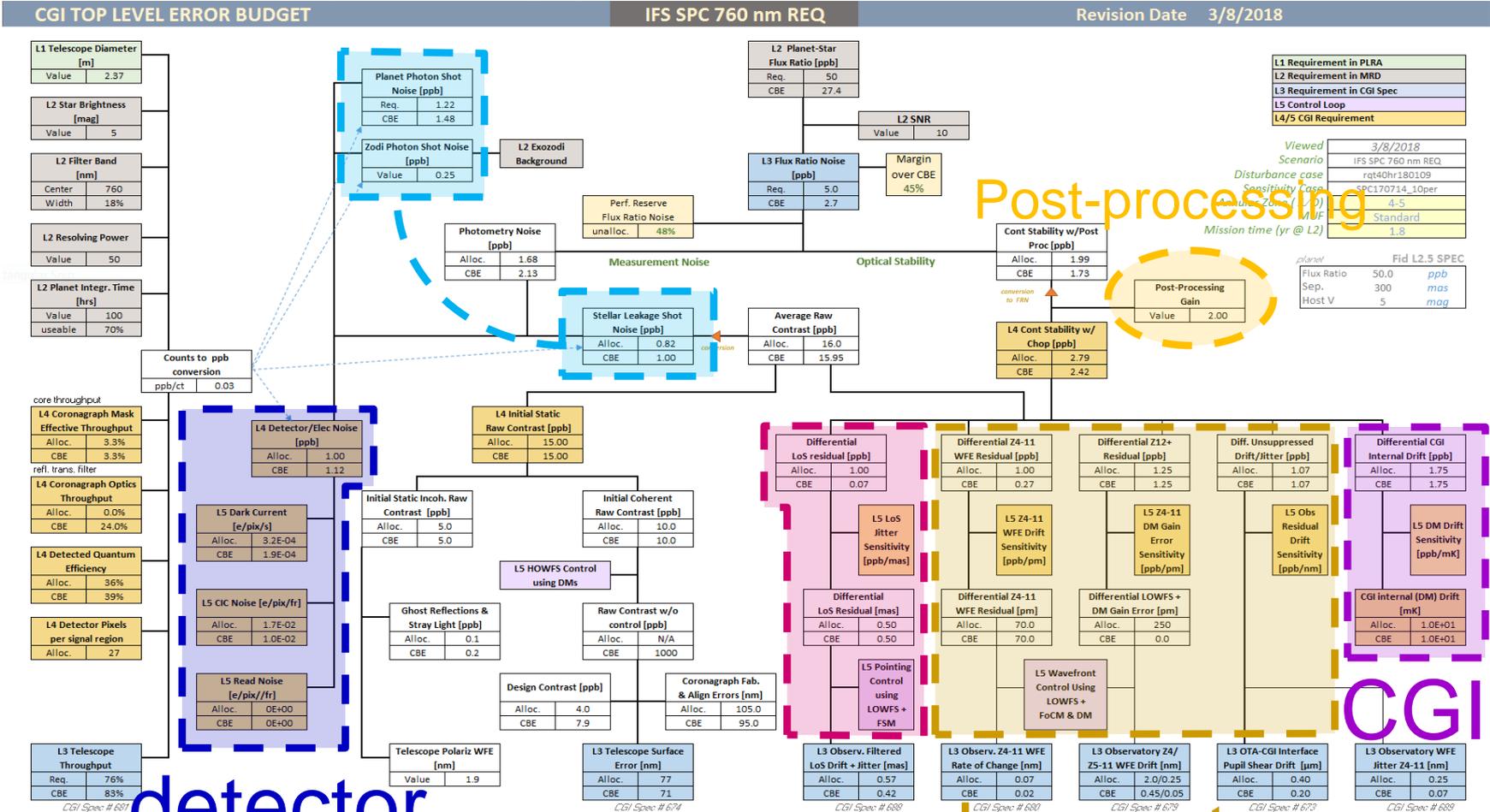


- **Analyze RDI statistics**
 - Simple pixel-by-pixel subtraction, target minus reference
 - Retain “post-processing” as an unspecified set of activities that act on the RDI subtraction residuals
 - Post-processing factor does not double-count what RDI subtracted

ADI and RDI cartoons



shot noise



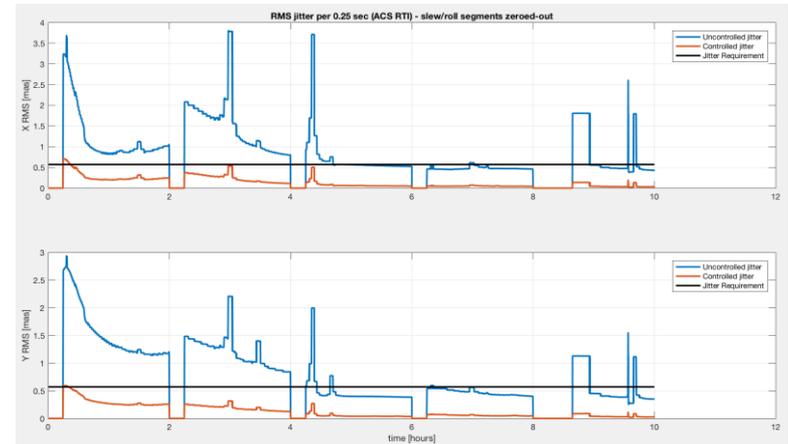
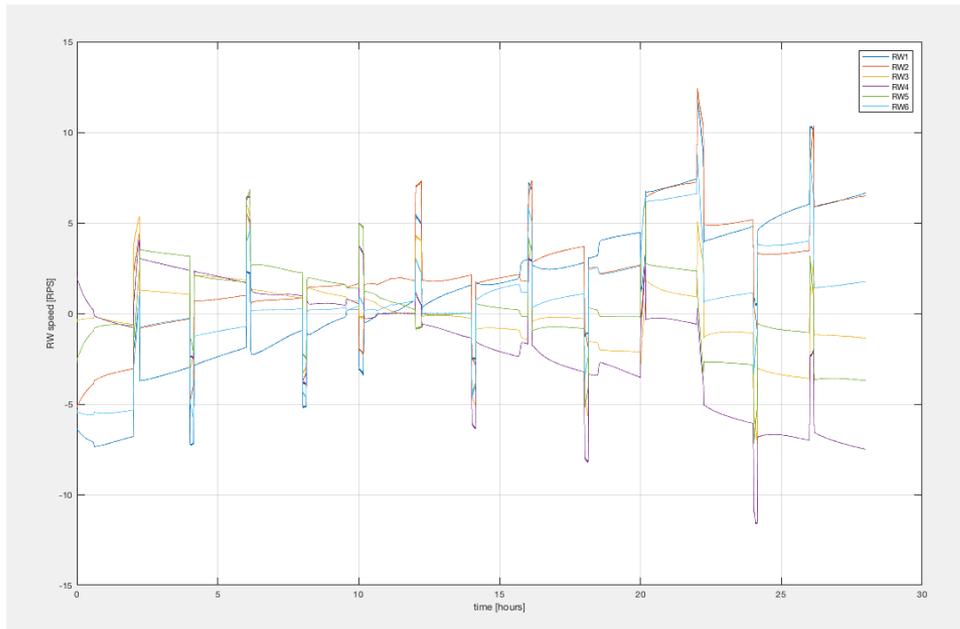
detector

RWA (reaction wheels) observatory thermal

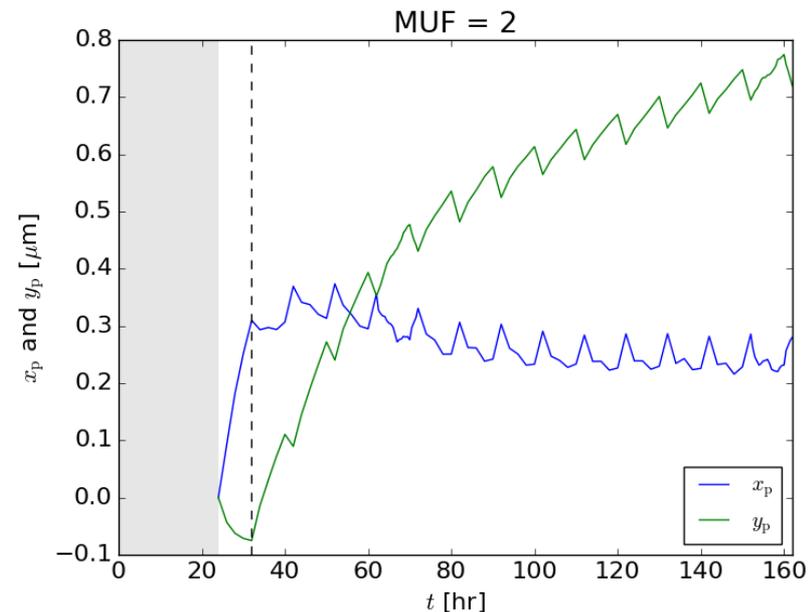
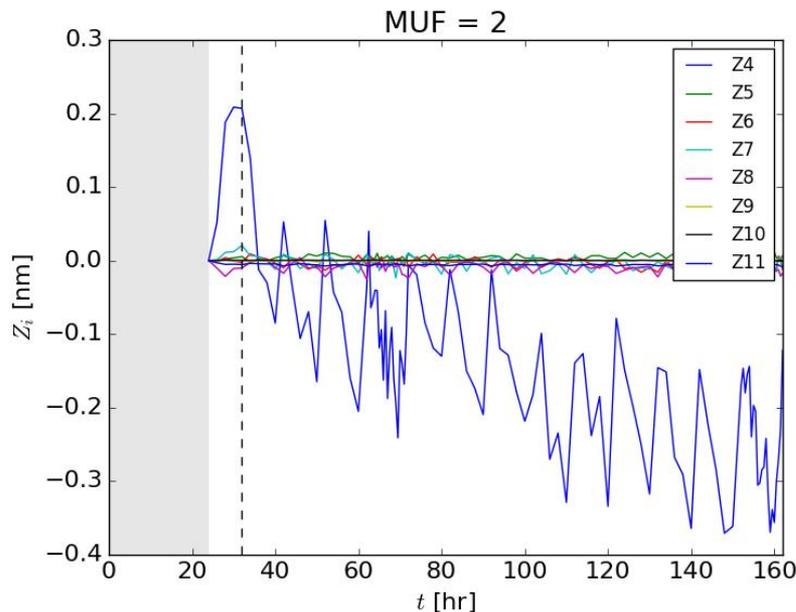
CGI

- **3 dominant input categories**
 - RWA
 - 6 Reaction wheels
 - Speeds change to counteract solar pressure
 - Line-of-Sight jitter, WFE jitter, beamwalk
 - Observatory thermal
 - STOP modeling of OS6
 - WFE from optics motion, bending, pupil shear
 - CGI internal
 - DM settling
 - DM thermal

- Jitter effect calculated for each wheel at each speed
- Wheel speed profile involves many choices
- Dominant impact is changes in jitter amplitude between target and reference
- Require 0.5 mas rms change target-reference
 - Expect 0.21 mas rms change (std MUF)



- **STOP modeling gives WFE from optic motions and bending, pupil shear**
- **LOWFS reduces WFE Z4-Z11, but introduces high-order WFE from DM gain errors**
- **Require 250 pm Z5+ 40 hrs, 0.4 mm pupil shear 10 hrs**
 - Expect 0.2 pm Z5+ 40 hrs, 0.04 mm pupil shear 10 hrs (unity MUF)



- **DM settling is accommodated by waiting after major DM change**
- **DM thermal needs more work to identify limitations**
 - Piezoelectric coefficient depends on temperature
 - 2.6% per K change in strain
- **Have not yet identified internal thermal disturbances or thermal sensor accuracy**
- **Require 10 mK stability over 10 hours**
 - Expect 3 mK over 10 hours (unity MUF)

- Dominant error budget term depends on coronagraph mode and MUF policy**

	HLC imaging std MUF	SPC IFS std MUF	HLC imaging unity MUF	SPC IFS unity MUF
RWA LoS jitter	X			
RWA WFE jitter				
Thermal WFE drift				
Thermal pupil shear drift				
DM settling				
DM thermal			X	
Dark current		X		X

BACKUP SLIDES

- **Separate individual E -field contributions** $I = |\sum_{i=0}^n E_i|^2$
- **Evaluate four statistics for each E -field component over the observation**
 - $|M|^2, V, |\Delta M|^2, \Delta V$
- **Total raw contrast uses M and V**
- **Stability term is**

$$\sigma_{\text{dyn}} = \left(2|M_{\text{tot}}|^2 \sum_i |\Delta M_i|^2 + \sum_i |\Delta V_i|^2 \right)^{1/2}$$

E_0	Initial coherent
E_1	RWA LoS
E_2	Thermal WFE
E_3	Thermal+DM high-order
E_4	Thermal pupil shear
E_5	RWA WFE
E_6	DM settling
E_7	DM thermal

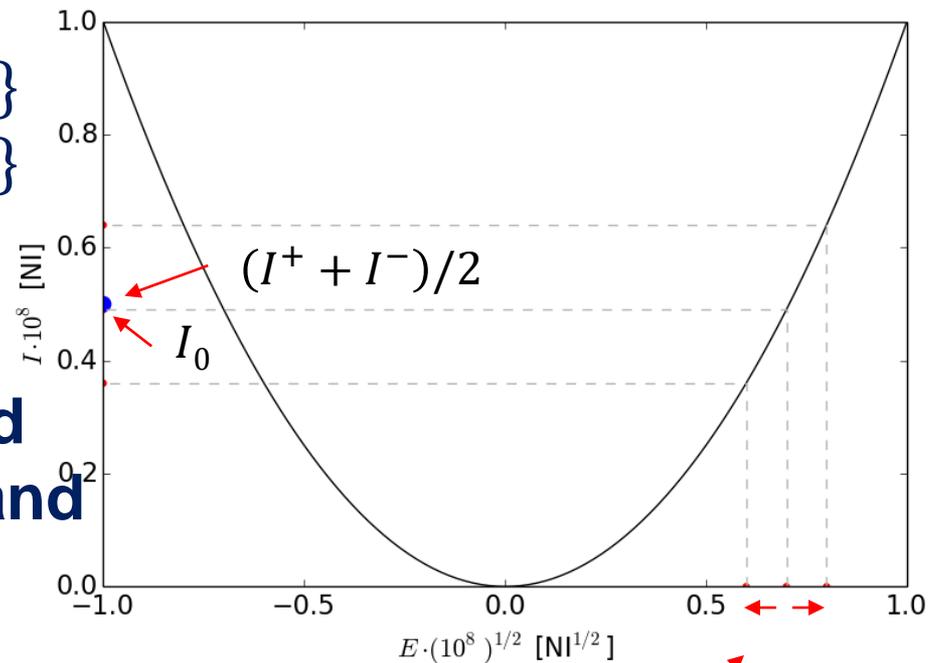
- Average of two intensities with opposite ΔE eliminates cross-term, leaves only quadratic term

$$\Delta I^+ = |\Delta E|^2 + 2\Re\{E_0\Delta E^*\}$$

$$\Delta I^- = |\Delta E|^2 - 2\Re\{E_0\Delta E^*\}$$

$$(\Delta I^+ + \Delta I^-)/2 = |\Delta E|^2$$

- Disturbances that spend equal time with ΔE (+) and (-) have only quadratic term on average
- Jitter impact does not depend explicitly on initial coherent contrast



opposite ΔE