LSC Changes in Preparation of High Power Operations

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High power operation

- First step: making it available
  - H1: ~5 W laser, low optical efficiency
    - new PMC installed, 80% transmission
    - Main EO modulator damaged, loses 15%, to be replaced soon
    - Currently 3 W into MC, maybe 60% of this at RM
    - 10 W Laser head will need some service
  - L1: ~3 W laser
    - PMC efficiency good
    - EO modulators lose ~30%
    - Need to service laser head, diagnose modulators

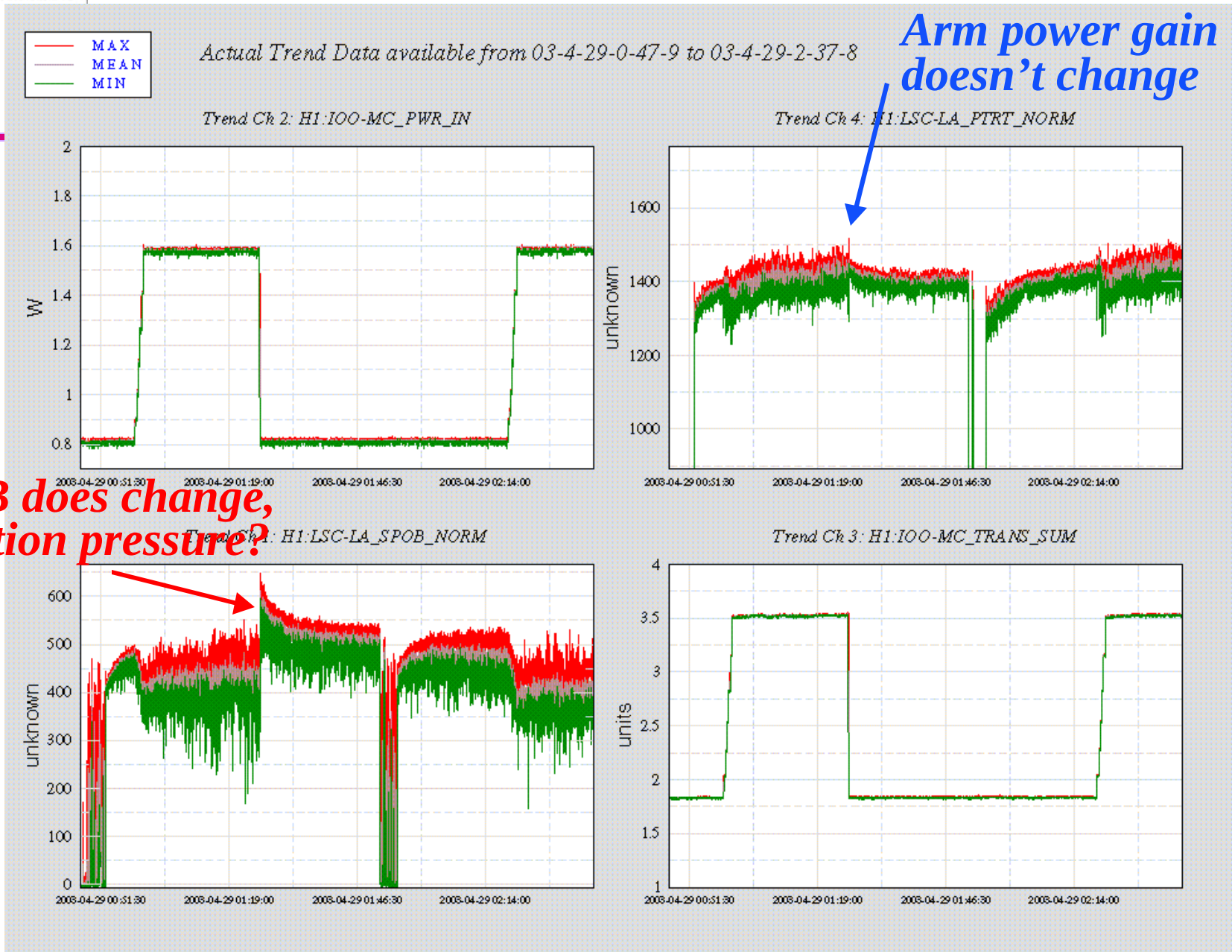
High power operation

- Second step, using it
  - Plan: lock at ~1/10 full power, then turn up the power
    - Radiation pressure misalignments a real problem at full power
  - Remote power control
    - DC motor rotation stage for ½-wave plate
    - Installed & working on H1 (Rick & Christina)
    - Epics sequencer, serial port communication to motor controller
  - Compensating for power increase
    - MC: EO shutter is throttled down
    - IFO: Leave in acquire mode, ramp up LA Pin parameter
    - QPDs:
      - dynamic range already used up by acquisition power swings
      - Need to reduce analog whitening gain, while compensating digitally
      - Mods: lowered transimpedance to 1 kohm, whitening gain at max, fixed analog gain at end increased from 2 to 3

LA code compensation

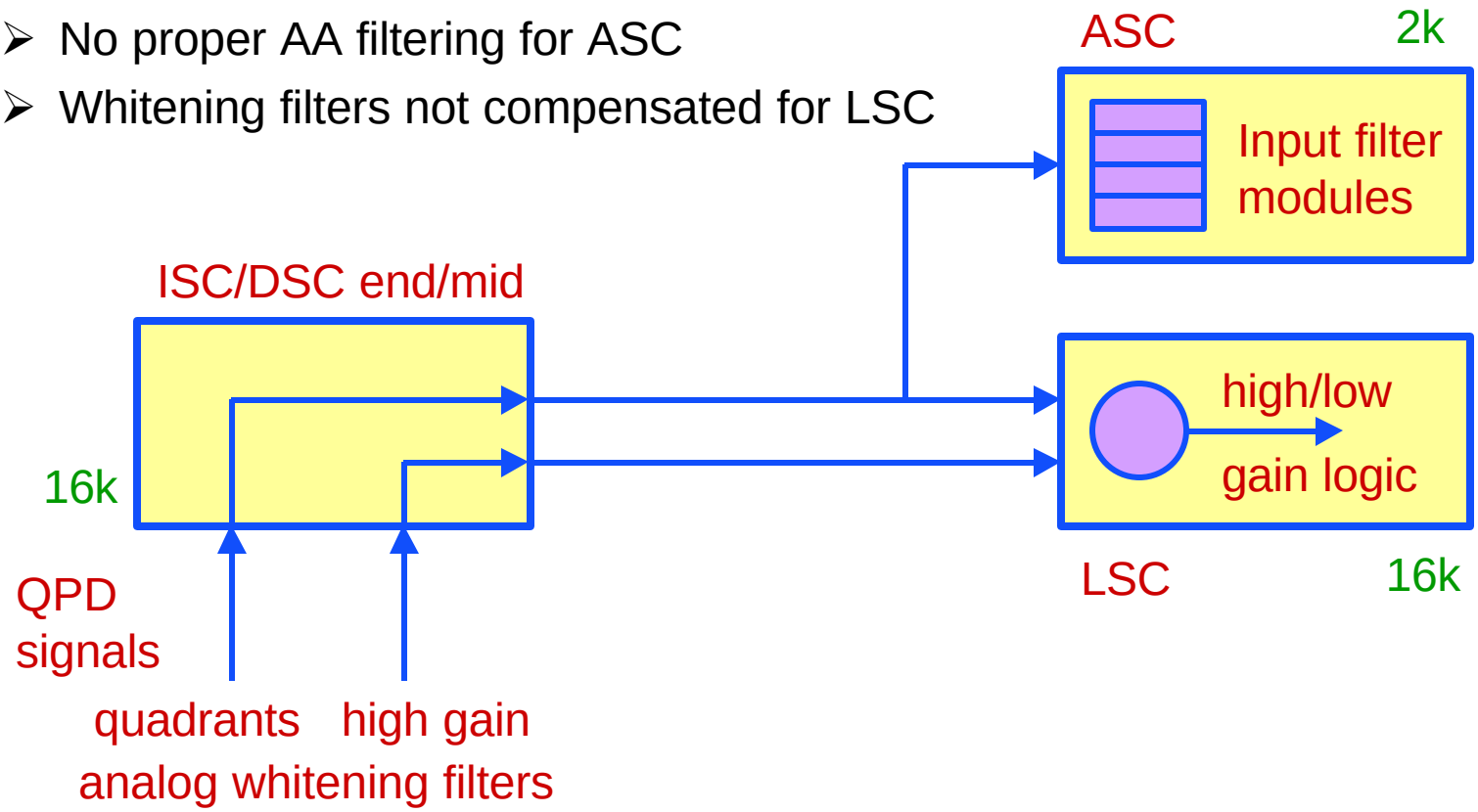
- Pin parameter
  - Power measurements (SPOB, PTRR, PTRT) are all divided by Pin
    - Their meaning remains the same as the power is increased: Grec/Trm
  - Sensing matrix elements are all multiplied by Pin
    - Input matrix elements (inverse of sensing matrix) are reduced proportionally to the power increase … more later
  - Works on H1 for a 2x power increase: 0.8 W to 1.6 W
  - QPD gain reallocation performed on LSC-LA_PTRR/T_SLOPE channels

H1: 2x remote power increase



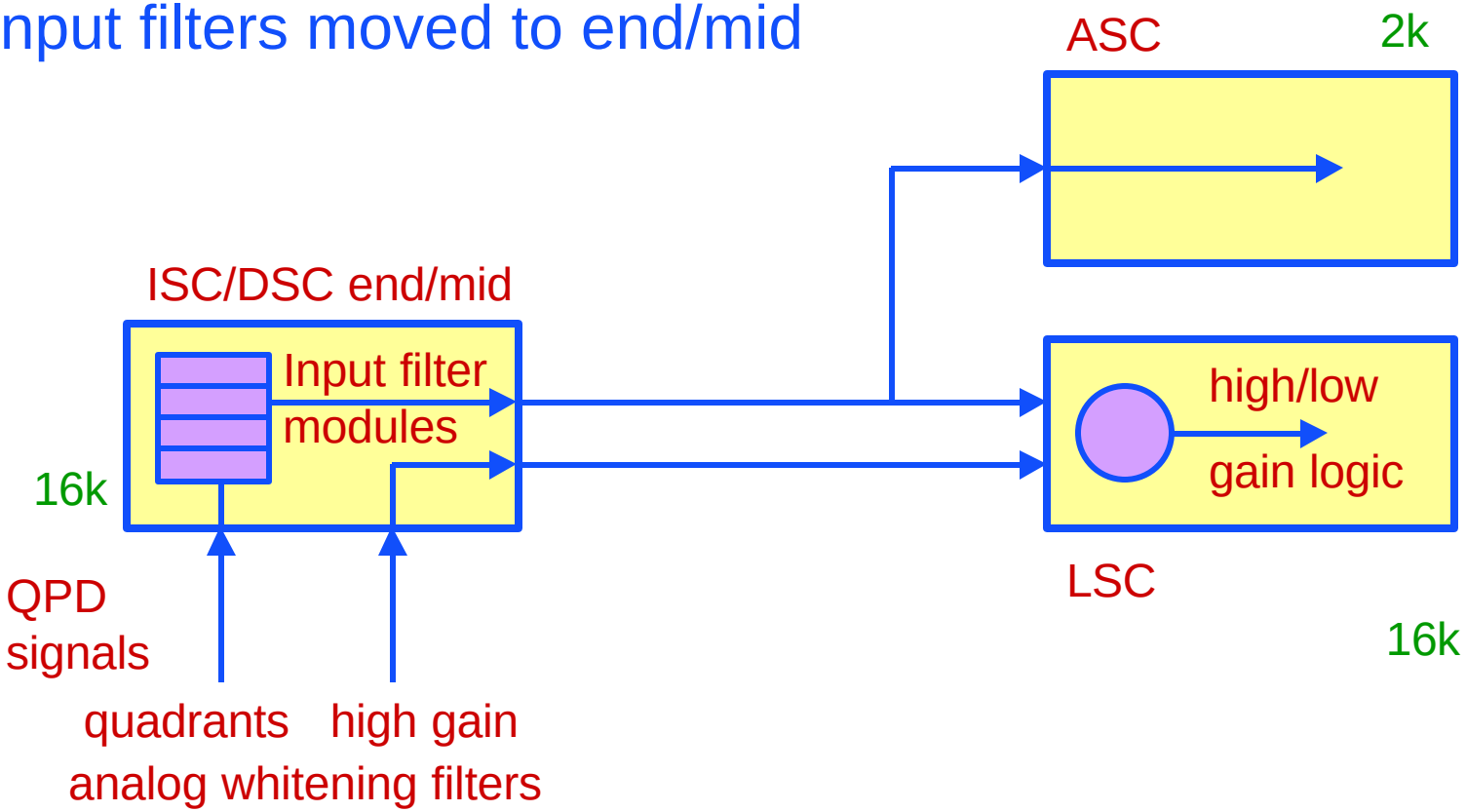
QPD Signals: Present

- Problems:
  - No proper AA filtering for ASC
  - Whitening filters not compensated for LSC



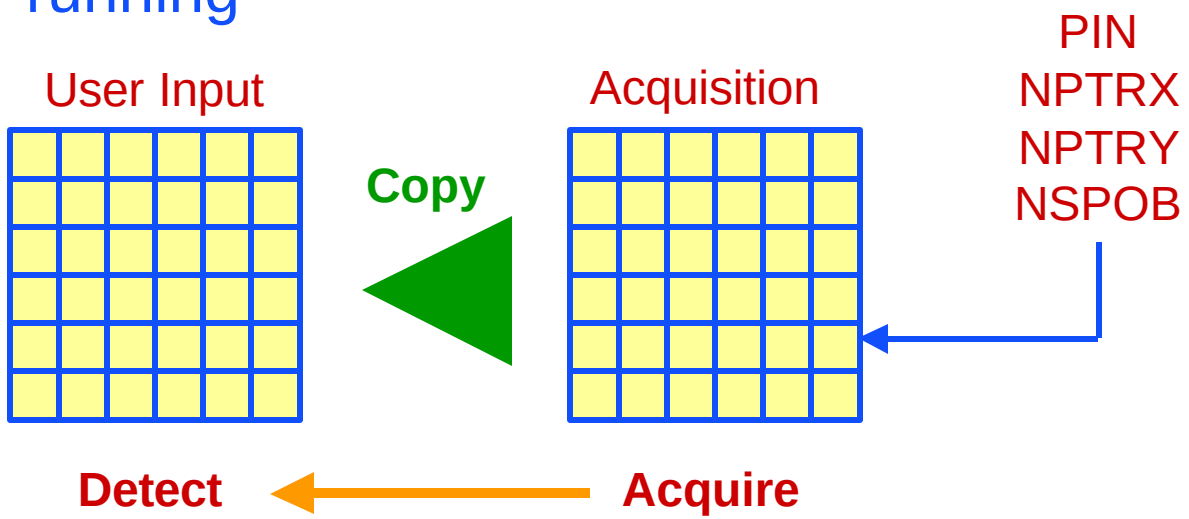
QPD Signals: New

- Input filters moved to end/mid

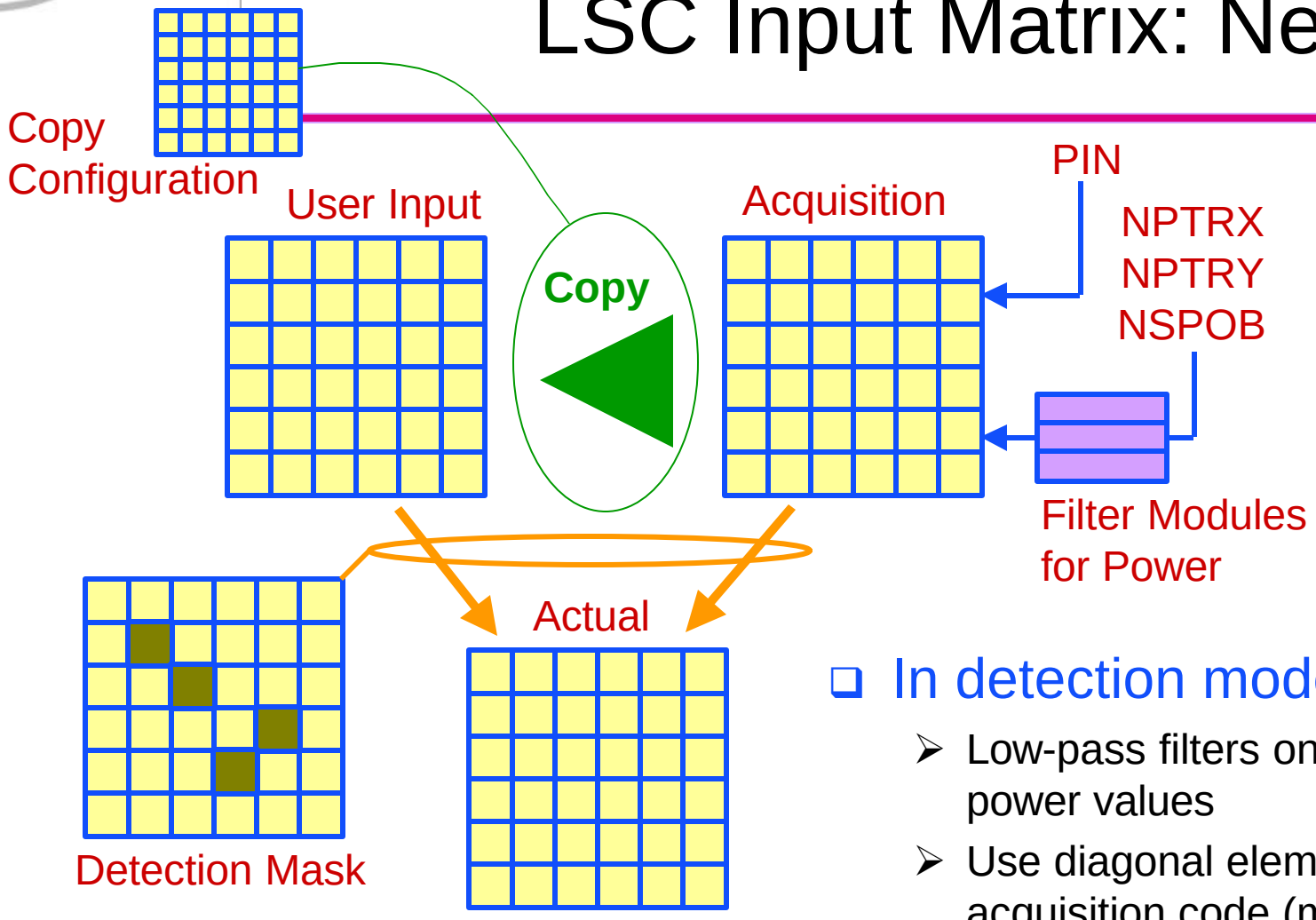


LSC Input Matrix: Present

- Matrix fixed in detection mode
  - No thermal heating adjustment
  - No power increase adjustment
- Noise from power measurements in acquisition mode too high for running



LSC Input Matrix: New



- In detection mode:
  - Low-pass filters on measured power values
  - Use diagonal elements of acquisition code (mask)

Mode Overlap and SPOB in the Sensing Matrix

- **Sensing Matrix Elements**
  - Field amplitude
  - Signal gain
  - Local oscillator

$$A_{Srec} \propto \sqrt{S_{pob}}$$

$$[REFL\_Q] = [a_{SC} A_{Srec}^2][MICH]$$

$$\begin{bmatrix} REFL\_I \\ POB\_I \\ AS\_Q \end{bmatrix} = \begin{bmatrix} a_{SC} A_{Srec}^2 & r_{RM} - t_{RM} a_{SC} A_{Srec} & \\ a_{SC} A_{Srec}^2 & a_{SC} A_{Srec} & \\ & & a_{SC} A_{Srec} \end{bmatrix} \begin{bmatrix} PRC \\ CARM \\ DARM \end{bmatrix}$$

- **Spatial Overlap Coefficient**
  - Changes with thermal lensing, alignment
  - Estimated by input spatial overlap
  - Robust in simulation

$$a_{SC} \approx \frac{1 - r_{RM} r_{MICH}}{t_{RM}} \frac{A_{Srec}}{A_{Sin}} \propto \sqrt{S_{pob}}$$

$$a_{SC} A_{Srec} \propto S_{pob}$$

Erika's FFT results for sideband gain