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Report on E2 Lock Losses

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Background Information

- **Coarse tidal actuation disabled during E2**
  - » **Expect periodic lock losses as dynamic range exceeded**
  - » **Rate of lock loss determined by linear combination of common-mode and differential-mode tidal slopes**

    (steep slope -> short locked stretches)
- **Pitch compensation reduces effective range**

  (must push harder with upper coils)
- **Residual mirror imbalances require DC offsets in coil currents**
  - » **Asymmetry leads to saturation sooner in one direction**

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Background Information

- **Data taken in recombination configuration (no recycling) and with individual arms**

- **Actuation configuration:**
  - **L+ -- Equal push on ETMX and ETMY**
  - **L- -- Opposite push on ETMX and ETMY**
  - **l- -- Opposite push on ITMX and ITMY (and ETMX/ETMY)**

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Observations

- **Lock durations:**
  - » **Recombination locks lasted typically an hour**
  - » **Qualitative correlation of lock length with slope confirmed**
  - » **But lock lengths shorter when CM tidal slope falling, suggesting asymmetric sensitivity (see figure)**

- **Y arm behavior:**
  - » **Transmitted light thru Y arm drifted linearly with time, suggesting misalignment steadily worsening**
  - » **Optical levers for both pitch and yaw confirmed drift**
  - » **Interpreted as mistuning of pitch compensation and yaw balance**
  - » **ETMY output matrix retuned on 4th day, giving smaller drifts**

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Observations

- **X arm behavior:**
  - » **Transmitted light thru X arm fairly flat during locks (well-tuned output matrix)**
  - » **But rapid, non-linear degradation seen just before lock loss**
  - » **Yaw of ETMX showed modest, linear drift**
  - » **Pitch flatter, but same rapid, pre-loss degradation**
  - » **Two coils on ETMX with large DC offsets**
  - » **Symptoms suggest “premature” saturation in one or more ETMX coils, causing mirror twist, light degradation and loss of servo gain**

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Observations

- **Coil currents**
  - » **Examined trends of ETMX and ETMY and found anomalous behavior in upper left (UL) coil of ETMX:**
    - – **“Software rails” seen in data acquisition ADC at expected +/-2 Volts for all ETMX, ETMY coils**
    - – **But just before lock-loss, evidence of “hardware rail” seen in ETMX UL (Odd, symmetric, exponential decay of min/max envelope, suggesting internal electronic saturation in UL circuit (see figure)**
    - – **During one such “decay” checked monitor points on ETMX controller (mid station) with portable oscilloscope. Observed severe, asymmetric railing at +2 V on UL, moderate railing on UR, almost none on LL and LR.**
    - – **Railing much reduced once lock lost and reacquired**
    - – **Power spectrum of ETMX UL coil current anomalous**

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Conclusions on Saturation

- **Necessity of tidal actuation confirmed!**
- **Premature saturation in UL coil very likely (some coil has to go first, but this behavior seems pathological - faulty circuit?)**
- **Some observations hampered by AC coupling of DAQ to coils (but not relevant to scope readings)**
- **New improved controller design installed on one mirror at LHO and in pipeline for others**

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Other Work

- **Complete list of lock stretches (>1 minute) can be found on team web site**

  (from Dave Chin's DMT lock transition monitor)

- **Masahiro Ito's glitch monitor identified four distant earthquakes (Montana, Tonga, Peru, Japan) correlated with lock losses during E2**