40m arm locking plan

Koji Arai / Pi-day, 2014
LIGO-G1400221-v1

Achievements and status:

- ALS for both arms ~ running for about two years
  difference from aLIGO: 40m ALS uses delay-line freq. discrim. & phase tracker due to the different fluctuation level and requirement

- PRMI/DRMI ~ locked
  the lock has been unstable since last vent for adjusting the PRC length

- 3f PRMI+one arm ALS: done

- Working on PRFPMI lock with ALS

1/SQRT(TR) signals:

- available from the beggining of the new LSC (since 2011)

Recent development:

- investigating if "**CESAR**" is useful for CARM and DARM locking

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What's CESAR? ~ "Composite Error Signal for Arms"

The numbers are for the single arm of the 40m

- ALS — linear range: almost infinitely linear
  noisier (0.3pm/rtHz@100-1kHz, 50pm_rms)

- 1/SQRT(TR) — linear range ~15nm_pp
  less noisy (0.1pm/rtHz@100-1kHz)

- PDH — linear range ~ 1nm_pp, ~5nm_pp after linearization
  further less noisy (0.03pm/rtHz@100-1kHz)

Why don't we combine all of these to produce a composite error signal that is linear everywhere and less-noisy at the resonance?

YES: CESAR can do it!

Link to Related: 40m ELOGs

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Error signal composition in CESAR?

TR is normalized to have maximum of 1

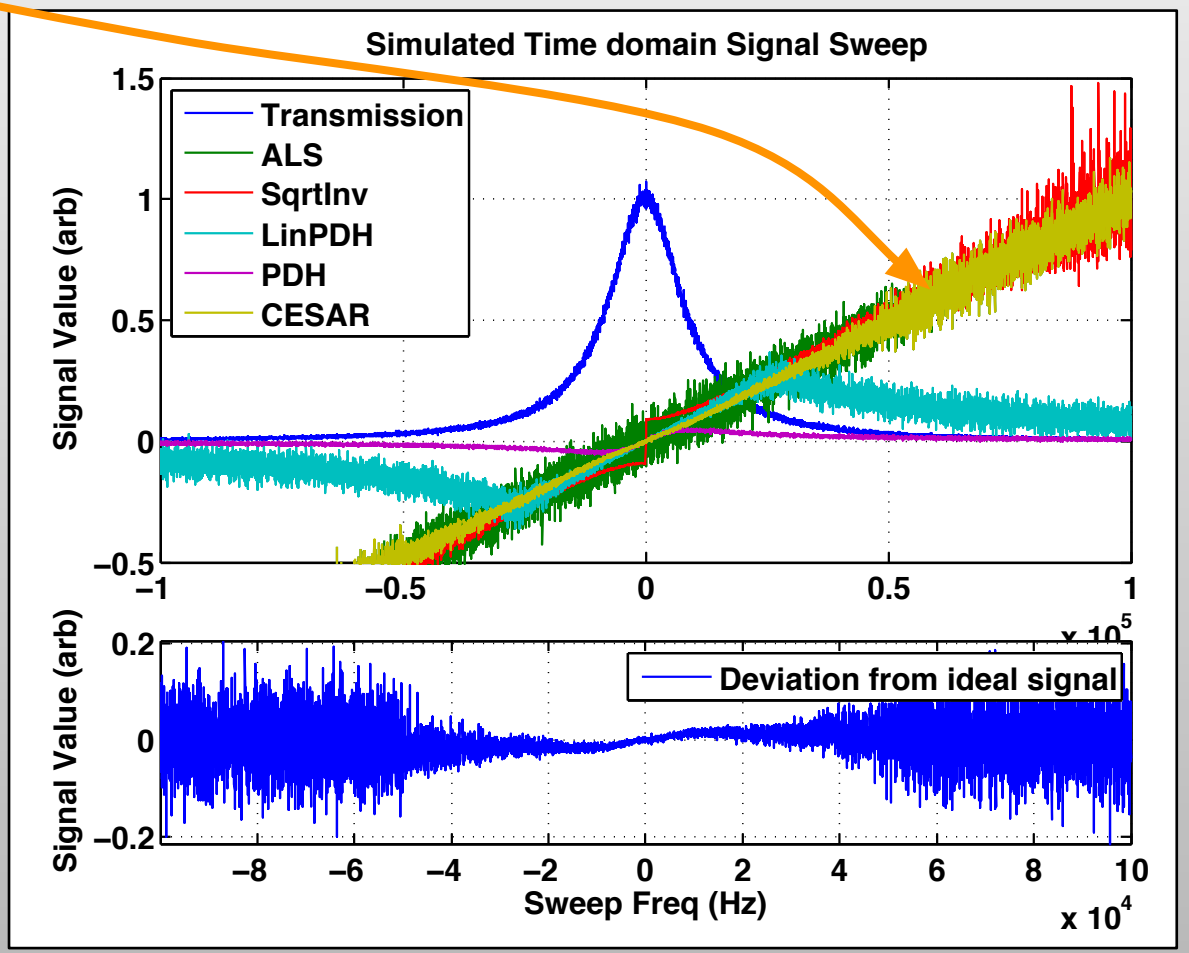
TR < Pthresh: CESAR = ALS

TR >= Pthresh: CESAR = [sign(PDH)/SQRT(TR)]*(1-TR) + [PDH/TR]*TR

Note:

- 1/SQRT(TR) is unsigned and is only linear at the foothill of the resonance

- PDH/TR is a linearized PDH



Simulink time-domain simulation by Eric Quintero

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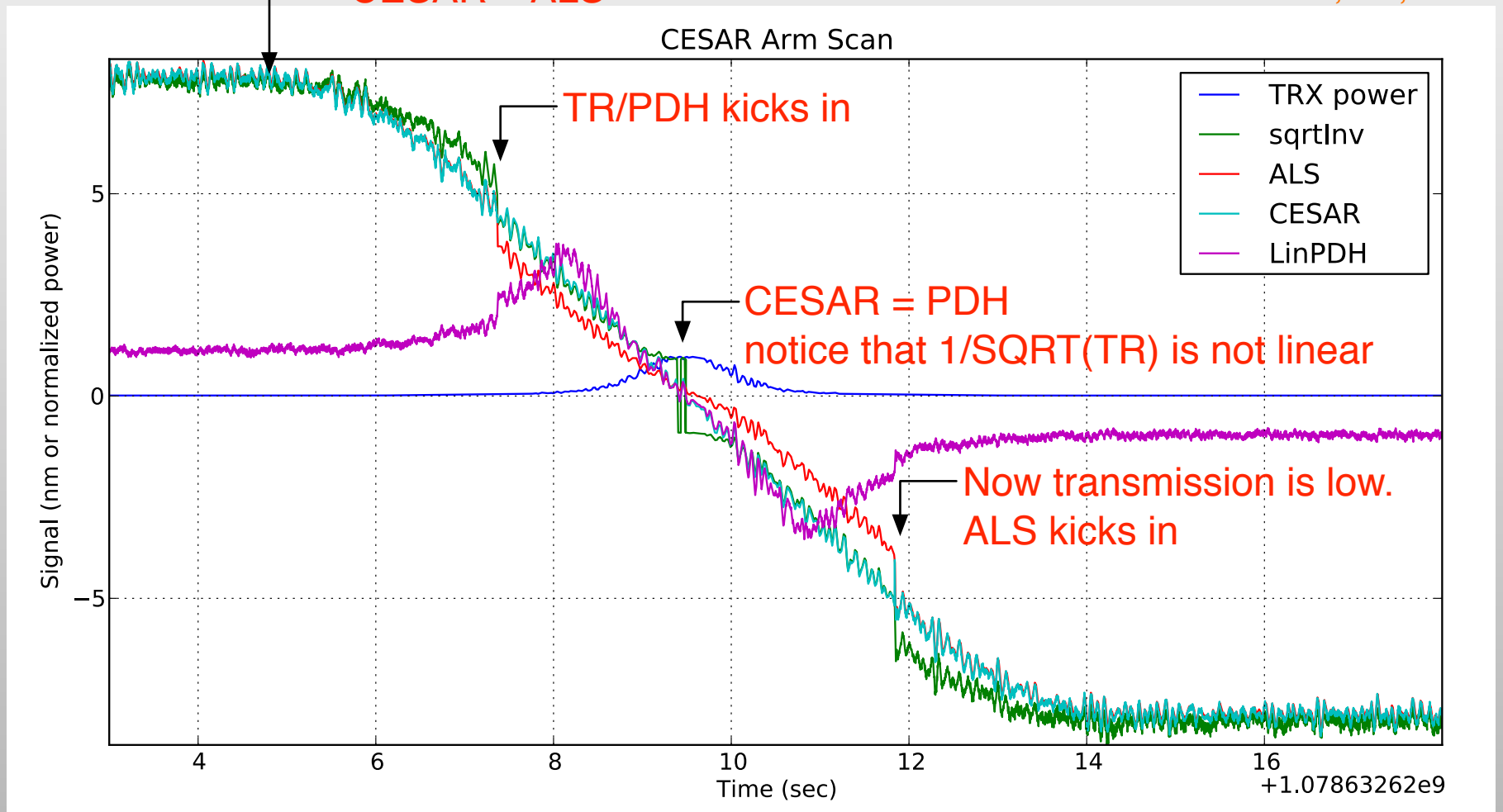
Demonstration of CESAR on an arm of the 40m

The arm was stabilized with the composite error signal.
The offset on the error signal was scanned from -8nm to +8nm.

Nic, Eric, Jenne



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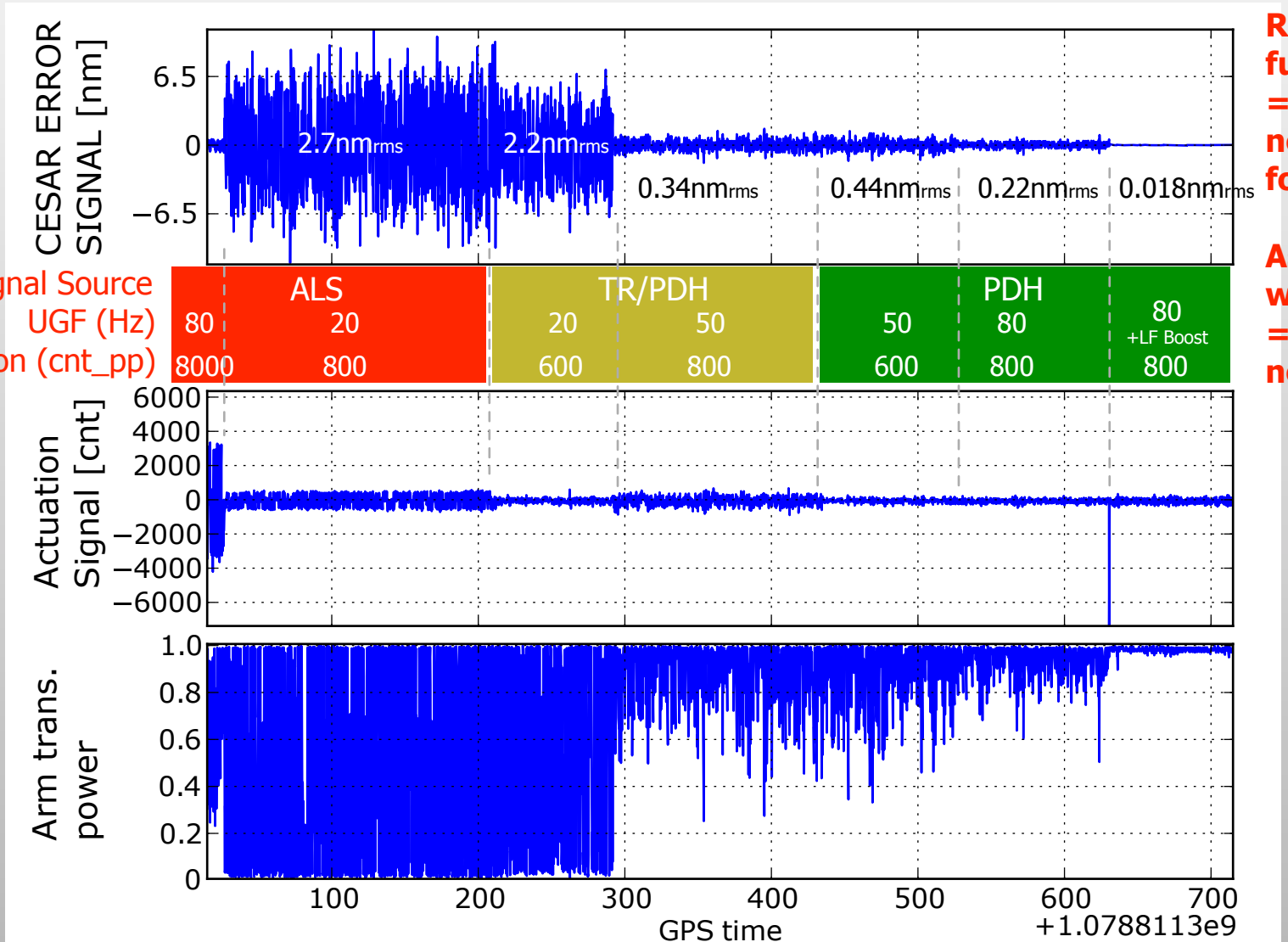
Relieving actuator requirement with CESAR

- Asymptotic cooling of the mirror motion



Raw ALS with full BW (80Hz) => need 8000 cnt for actuation

Asymptotic cooling with CESAR => need only 800 cnt

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Practical things to do

- Smooth transition between ALS and TR/PDH
  rather than hard switching
- Automation of offset / slope matching

Things to be clarified:

- How can we use this CESAR for full locking?
  DARM CESAR and CARM CESAR?

- How can we combine this with the CM servo?

- How can CESAR be compatible with "self CARM locking"?
  CESAR is realized in the CDS.
  The CM servo is analog.

=> What we need is further precise modeling