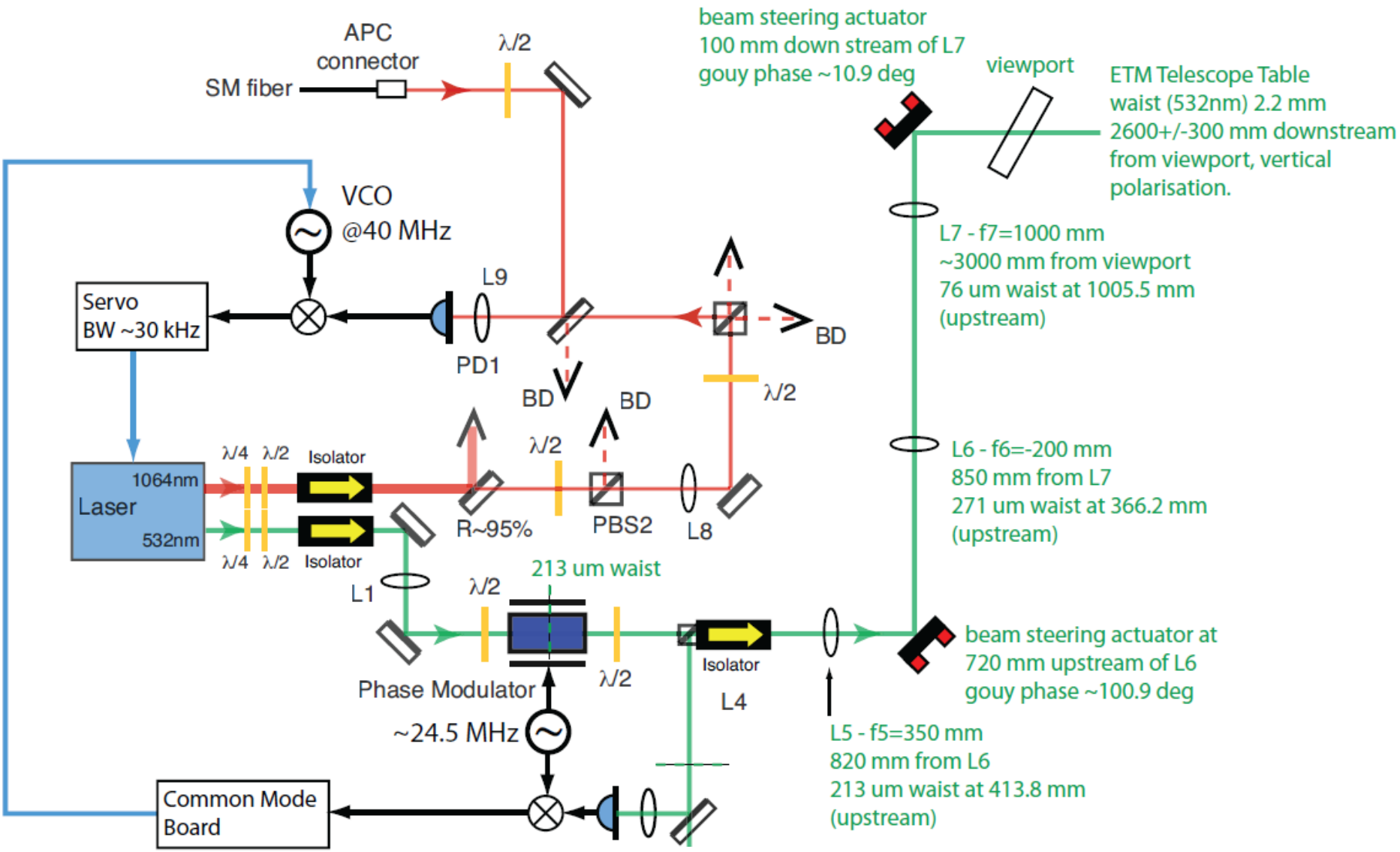
Arm Length Stabilization at LHO

March 19, 2013

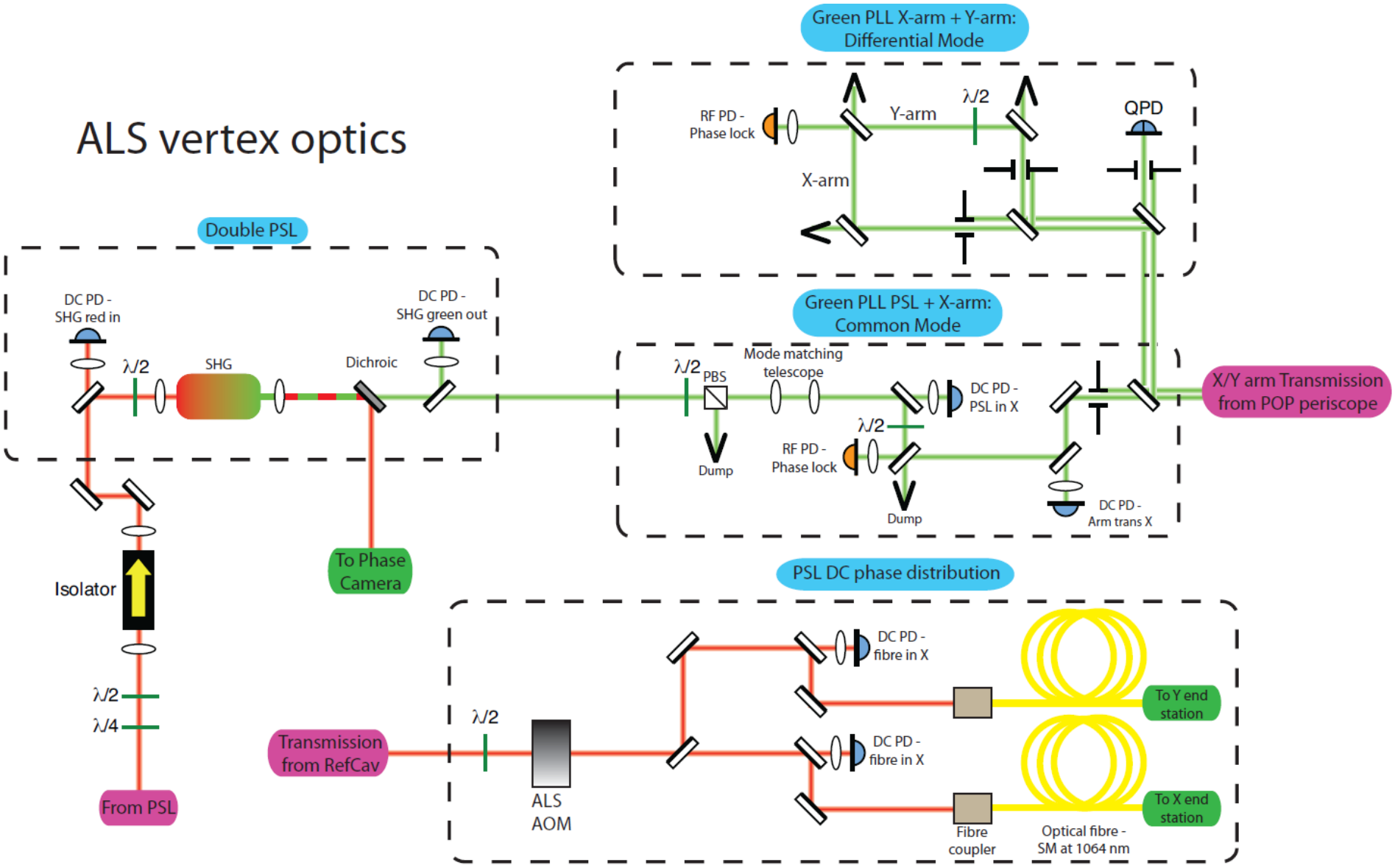
Daniel Sigg
LIGO Hanford Observatory

Setting it up

- Linear operating region of detector very small
  - Each coupled degree-of-freedom makes it harder
  - Slow response due to long arm cavity storage time
- Initial LIGO: Wait and catch
  - But: no or misleading information away from resonance
  - Critically depending on mirror velocity
- Advanced LIGO: Arm length stabilization
  - Decouple arm cavities by locking from the end
  - Use a separate wavelength: doubled Nd:YAG at 532 nm
  - Recombined green light in the corner not depending on the recycling cavities


APC
connector
SM fiber
λ/2
beam steering actuator
100 mm down stream of L7
gouy phase ~10.9 deg
viewport
ETM Telescope Table
waist (532nm) 2.2 mm
2600+/-300 mm downstream
from viewport, vertical
polarisation.
VCO
@40 MHz
Servo
BW ~30 kHz
L9
PD1
BD
BD
BD
λ/2
L7 - f7=1000 mm
~3000 mm from viewport
76 um waist at 1005.5 mm
(upstream)
λ/4
λ/2
Isolator
1064nm
Laser
532nm
λ/4
λ/2
Isolator
R~95%
λ/2
PBS2
L8
L6 - f6=-200 mm
850 mm from L7
271 um waist at 366.2 mm
(upstream)
213 um waist
L1
λ/2
Phase Modulator
λ/2
Isolator
L4
beam steering actuator at
720 mm upstream of L6
gouy phase ~100.9 deg
~24.5 MHz
L5 - f5=350 mm
820 mm from L6
213 um waist at 413.8 mm
(upstream)
Common Mode
Board

ALS vertex optics



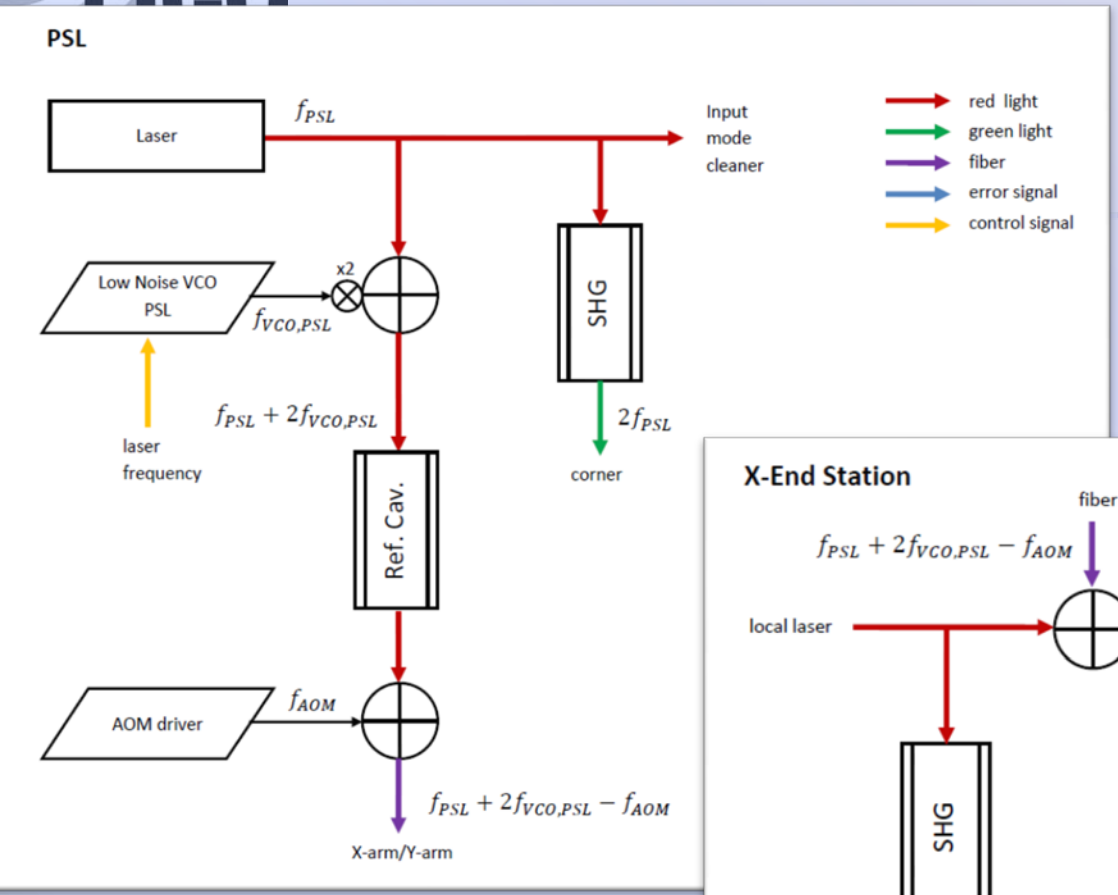
ALS Integration Plans at LHO

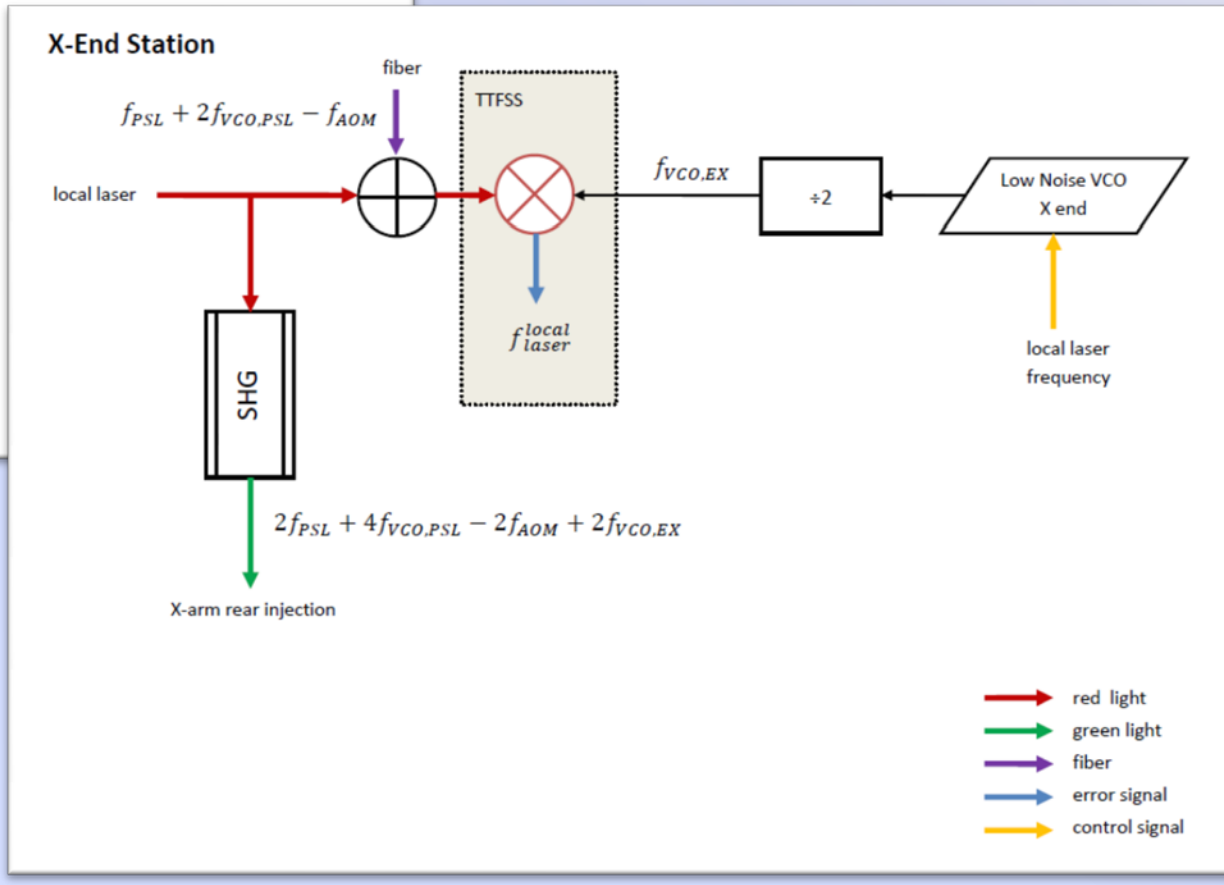
- OAT (One arm test)
  - Subsystem readiness, in particular BSC SEI and SUS
  - Early experience with a long cavity
    - Basic functionality validated
    - No information on noise (not surprisingly)
  - Successfully completed in Fall 2012
- HIFO-Y (Half Interferometer Y-arm)
  - Learn about stability between red and green locking
  - Starts now
- HIFO-X(Y) (Both arm cavities)
  - Learn about relative stability of arm cavities
  - Starts this summer

Recommendations from OAT

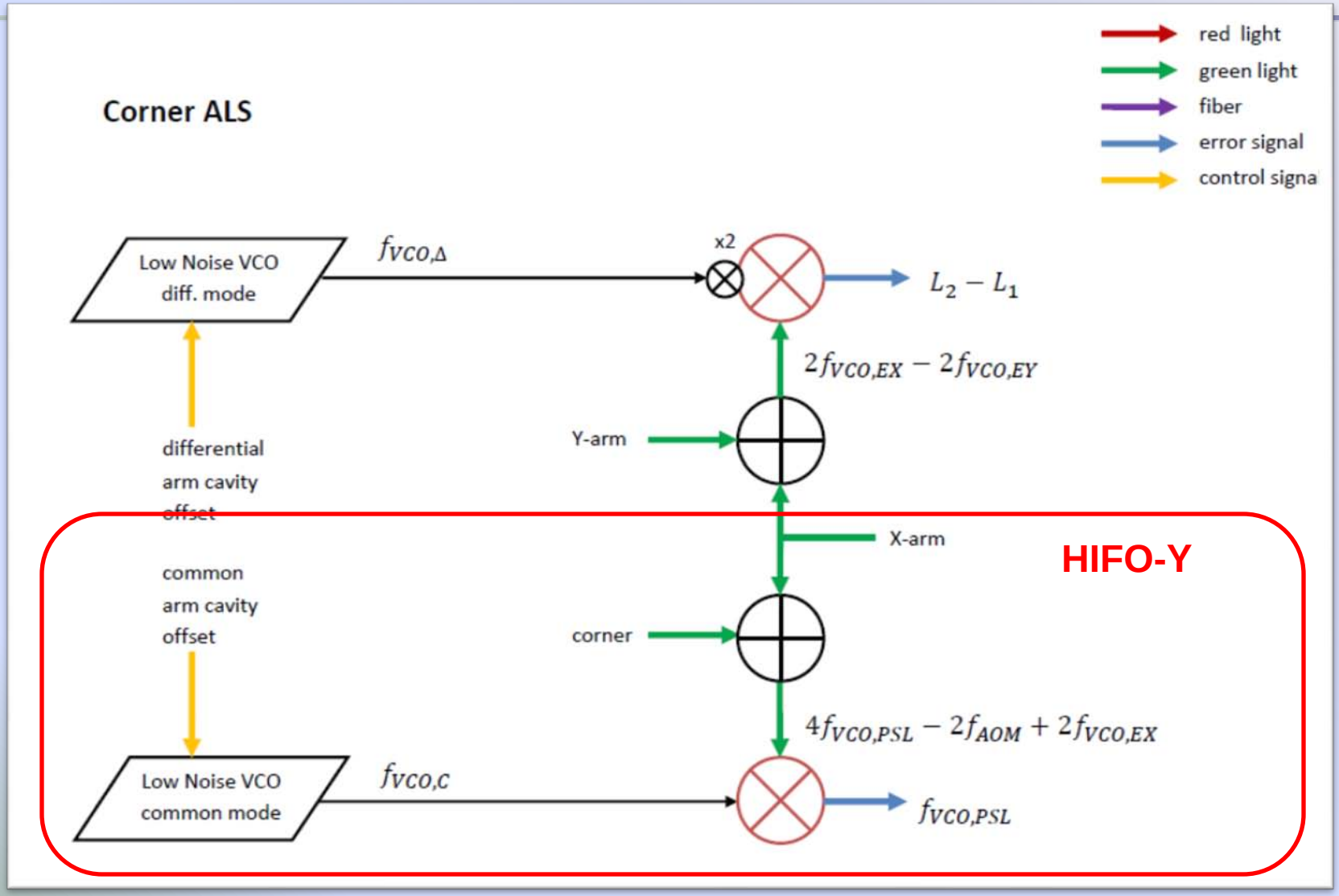
- Wavefront sensing not required for green beams
- But, need automatic input steering for green beam
- Additional hardware was required to support automation
  - Fiber polarization correction
  - Some additional photodiodes
  - Measure the PLL beat note
- Automation requires more attention

HIFO-Y Locking





Corner ALS


Corner ALS
red light
green light
fiber
error signal
control signa
Low Noise VCO
diff. mode
$f_{VCO,\Delta}$
x2
$L_2 - L_1$
$2f_{VCO,EX} - 2f_{VCO,EY}$
Y-arm
differential
arm cavity
offset
X-arm
HIFO-Y
common
arm cavity
offset
corner
$4f_{VCO,PSL} - 2f_{AOM} + 2f_{VCO,EX}$
Low Noise VCO
common mode
$f_{VCO,C}$
$f_{VCO,PSL}$

Summary

One arm test has been successfully completed

HIFO-Y is underway

Establishing the basic functionality between different subsystems was straight forward with only small problems—a significant and refreshing improvement compared to the first steps of initial LIGO commissioning.

Documents

- Design: T0900144
- Part of Full Interferometer Integration
  - Plan: T1200437
- OAT (One arm test)
  - Plan: T1100080
  - Result: L1200261
- HIFO-Y (Half Interferometer Y-arm)
  - Plan: T1300174
  - Starts now
- HIFO-X(Y) (Both arm cavities)
  - Starts this summer

LIGO