

Optical/Electrical Components Needed for iKAGRA IMC Servo

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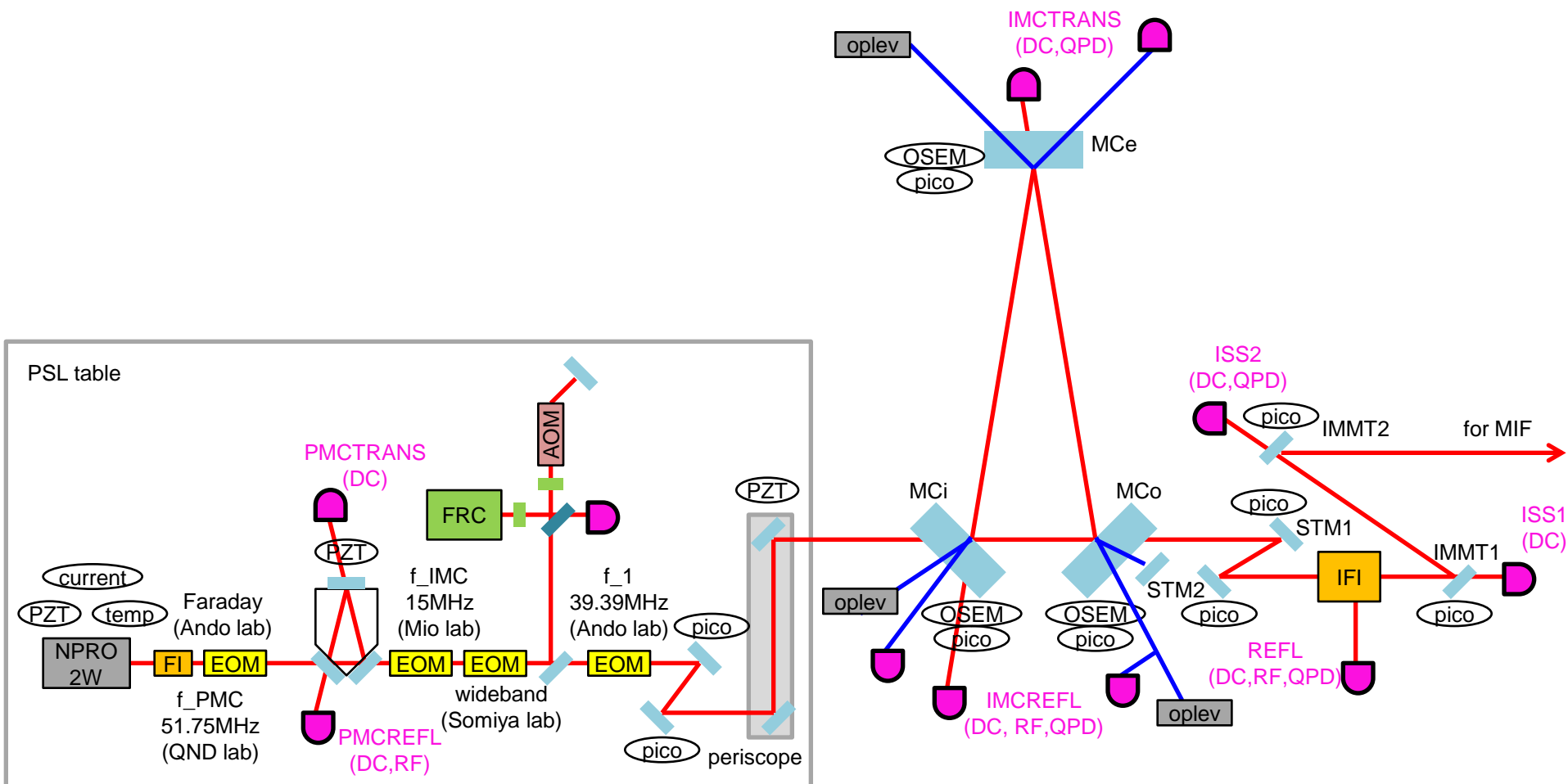
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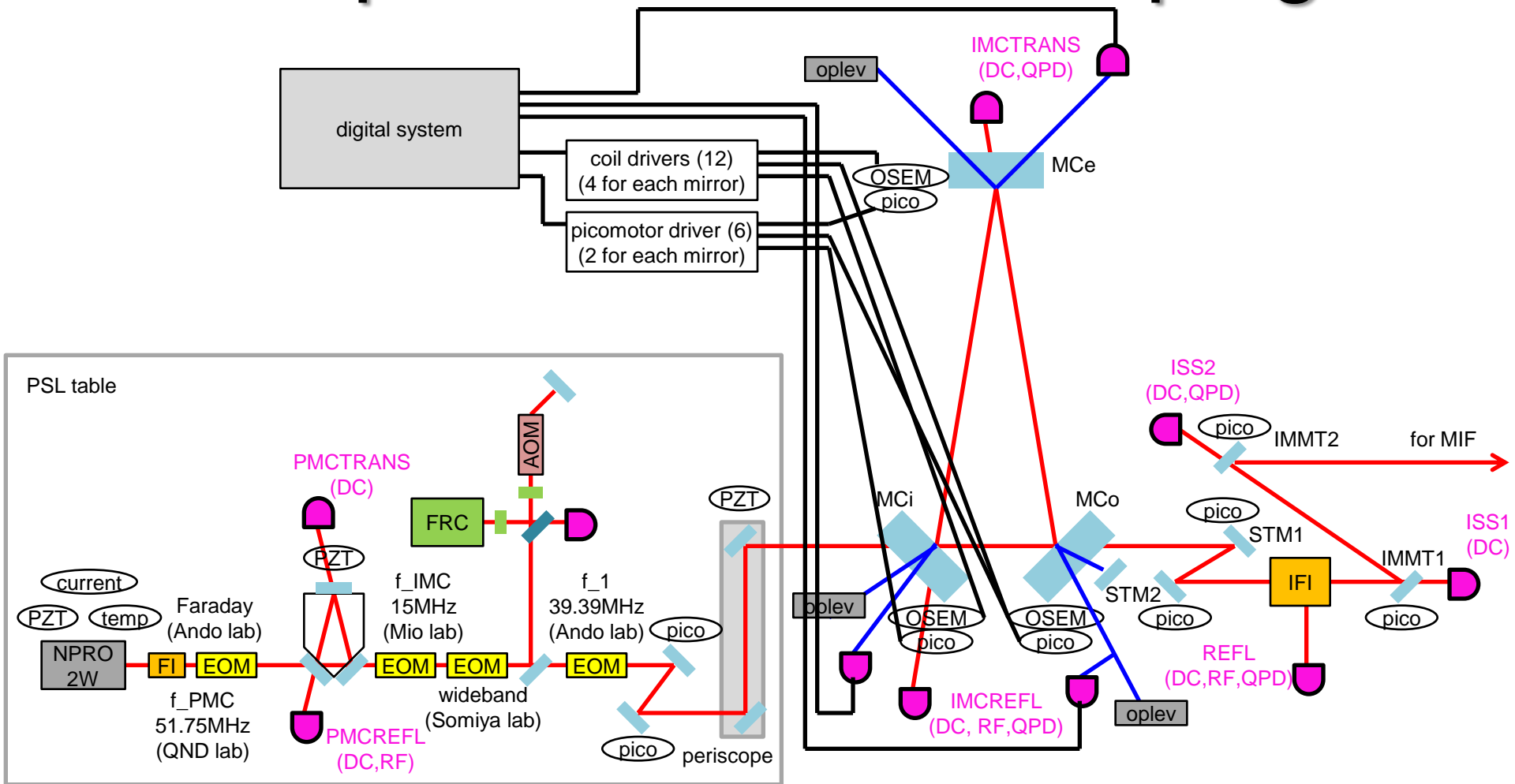
Scope

- Start discussion on listing up what we need for iKAGRA IMC (and PSL) servo
- Focus mainly on optical and electrical components
- References:
 - [JGW-T1402349](#) (iKAGRA PMC study)
 - [JGW-G1402302](#) (FSS modeling)
 - [JGW-G1402520](#) (GWADW2014 IOO poster by Nakano)
 - [JGW-D1402507](#) (IOO 3D drawing)
 - [JGW-T1302068](#) (layout around IMMT)
 - [JGW-D1402492](#) (IMC suspension cabling)
 - [JGW-D1402516](#) (anchor, floor mortar, floor cutting lines)
 - [Wiki/SmallOptics](#) (list of small optics)
 - [Wiki/OutputTables](#) (list of output optical tables)

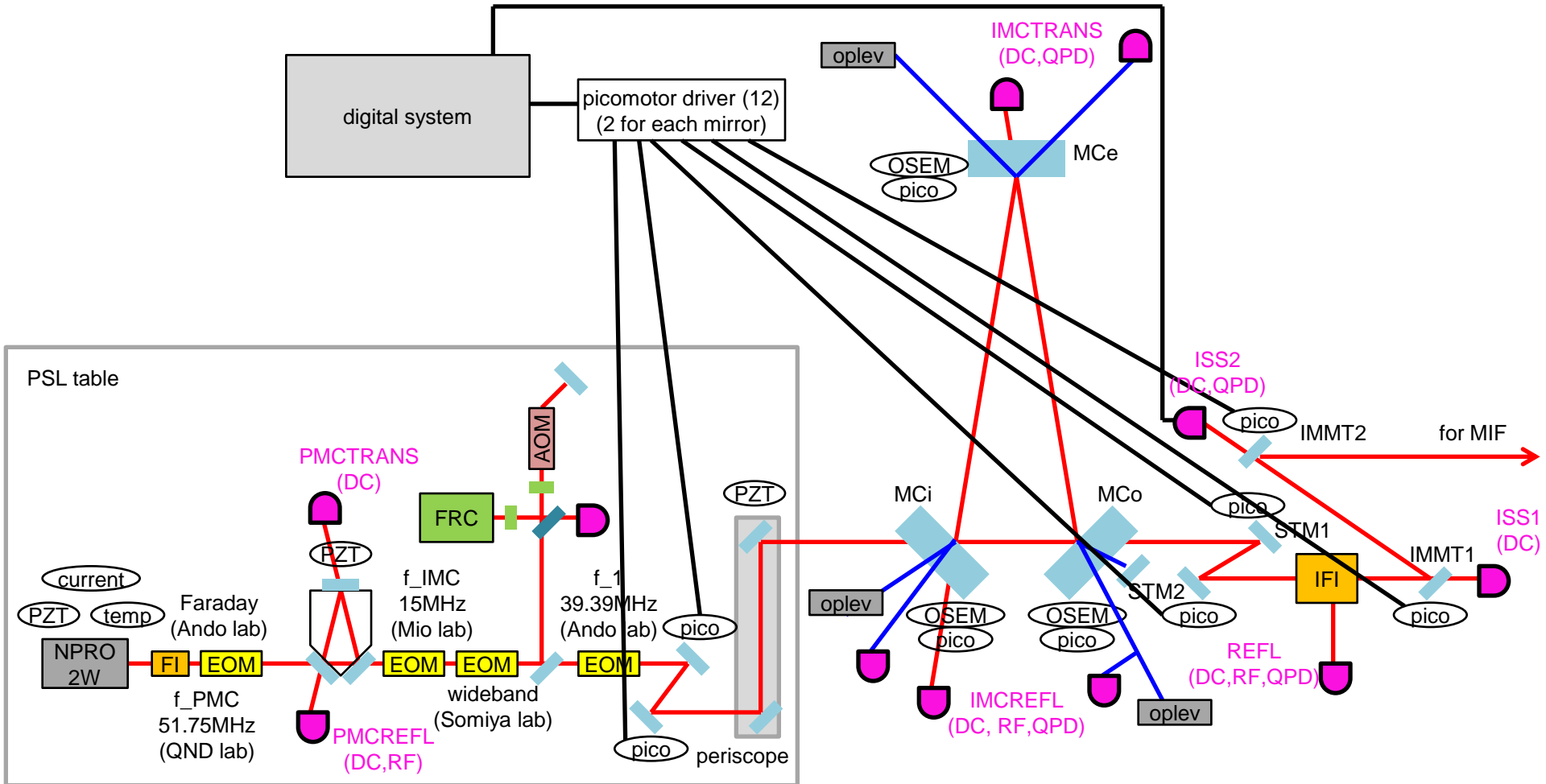
Optical Configuration



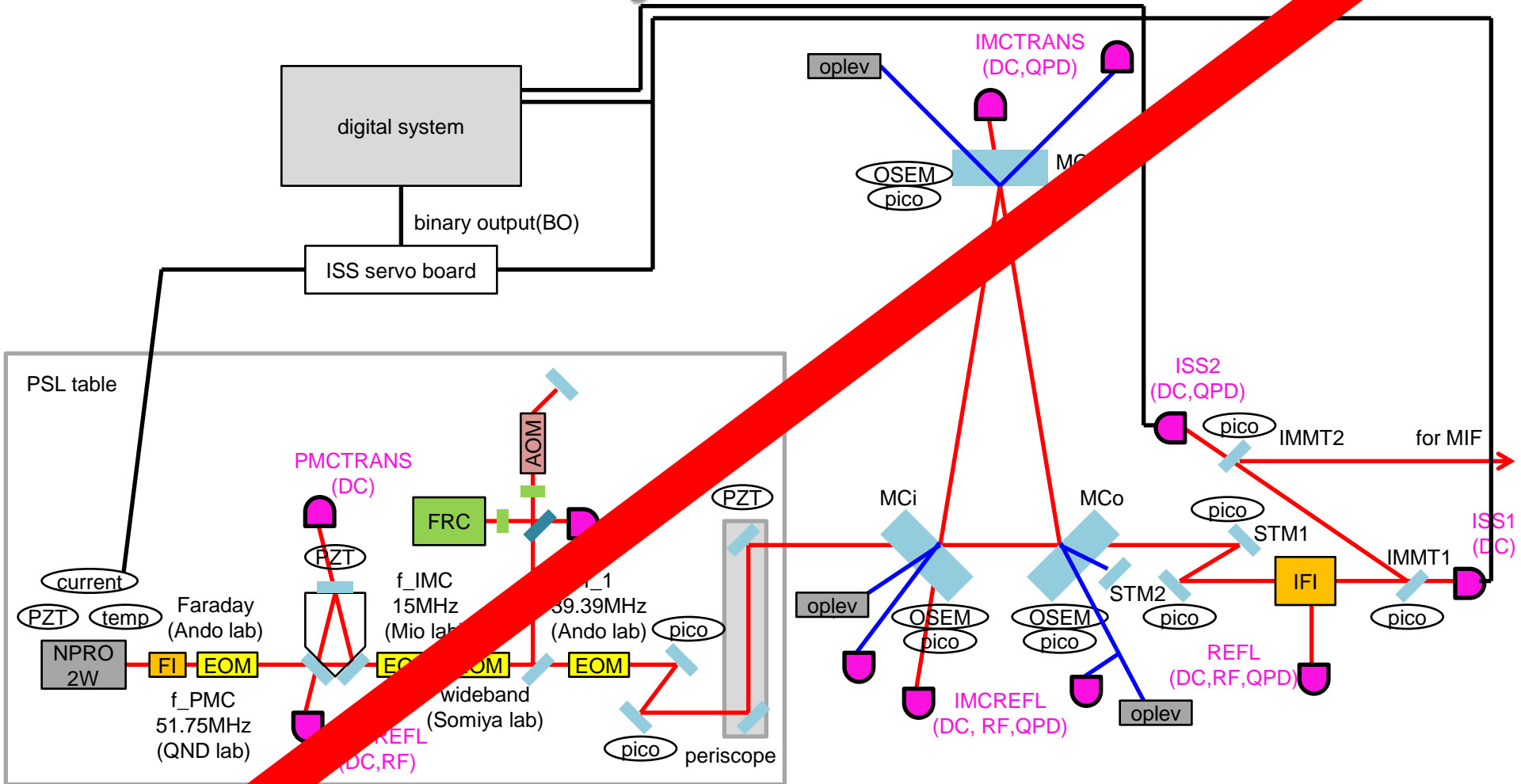
Suspension Local Damping



Initial Alignment

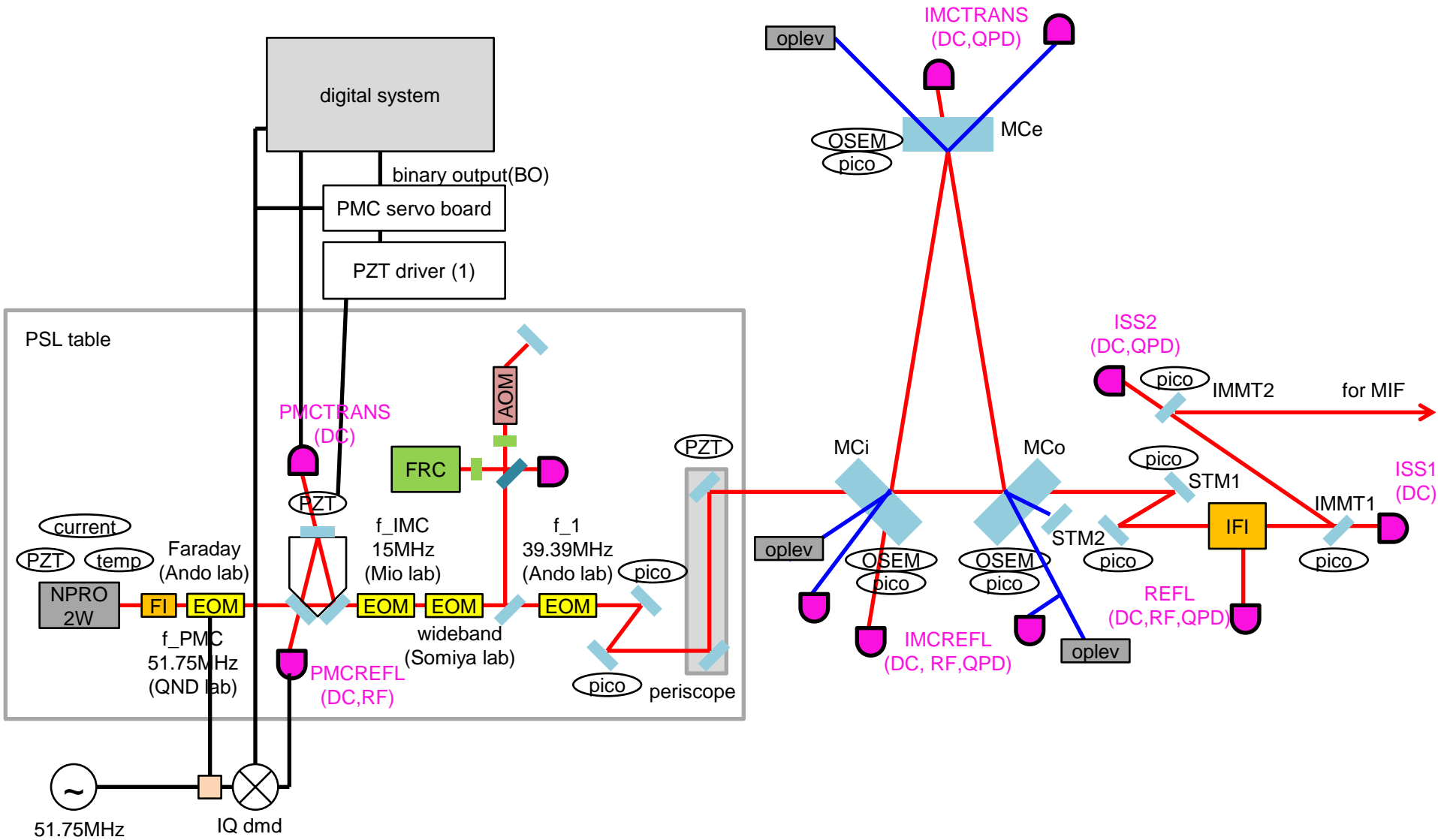


Intensity Stabilization

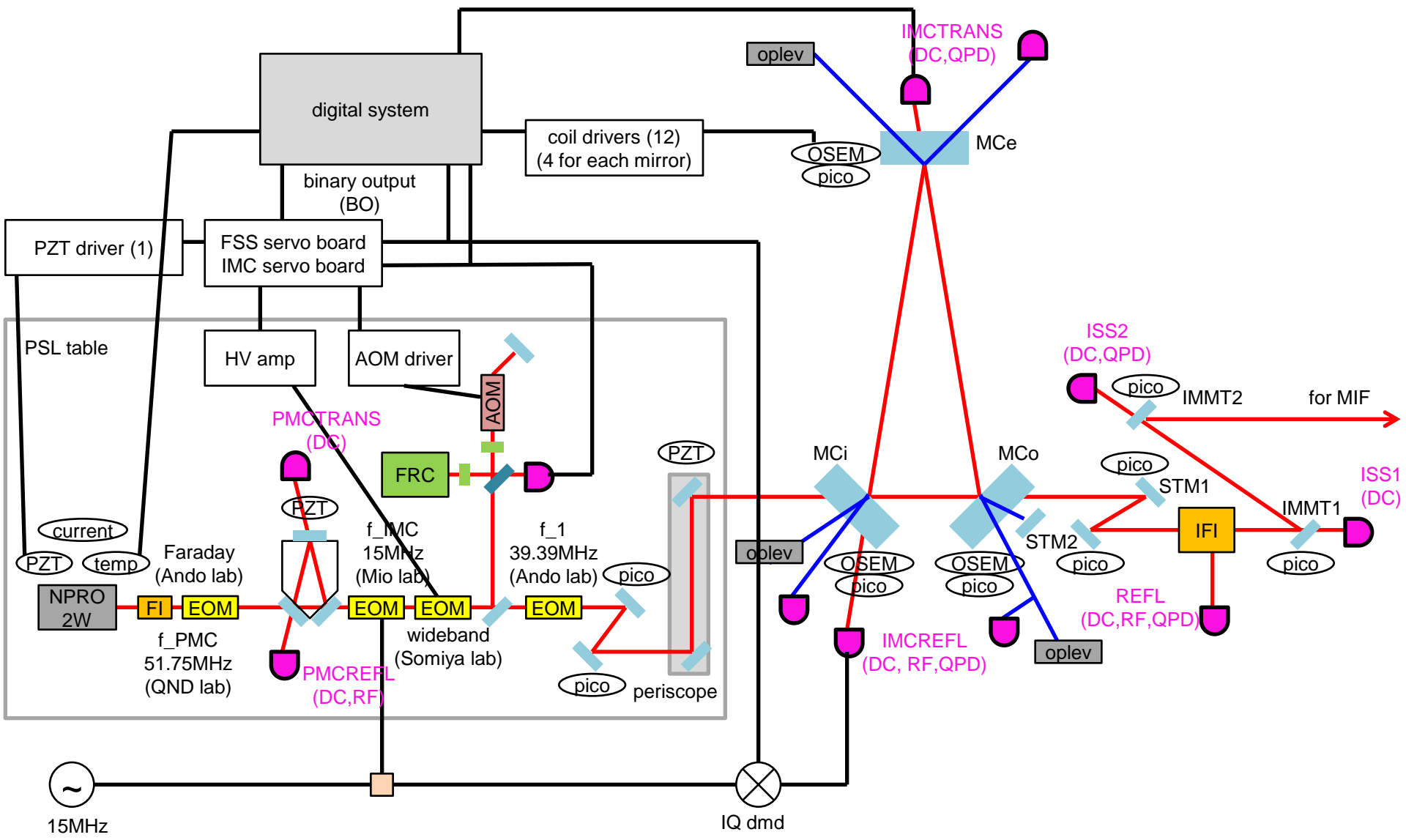


ISS is not a default plan in iKAGRA

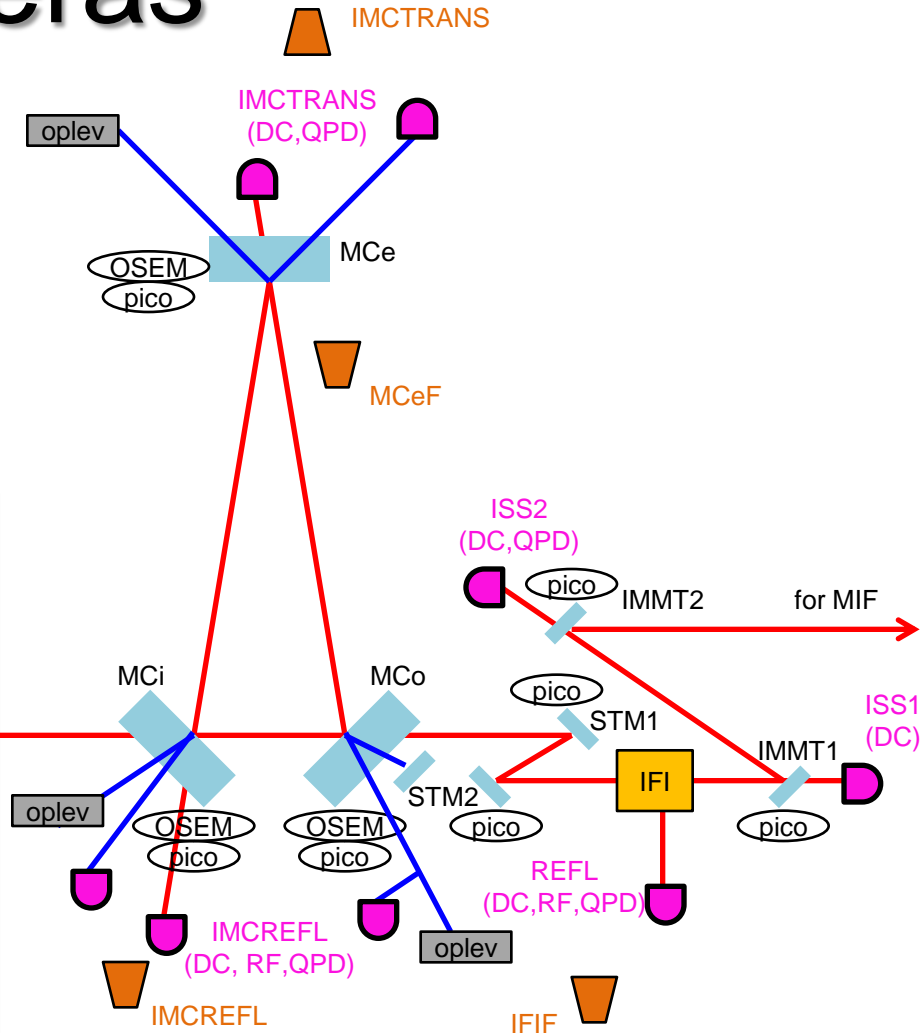
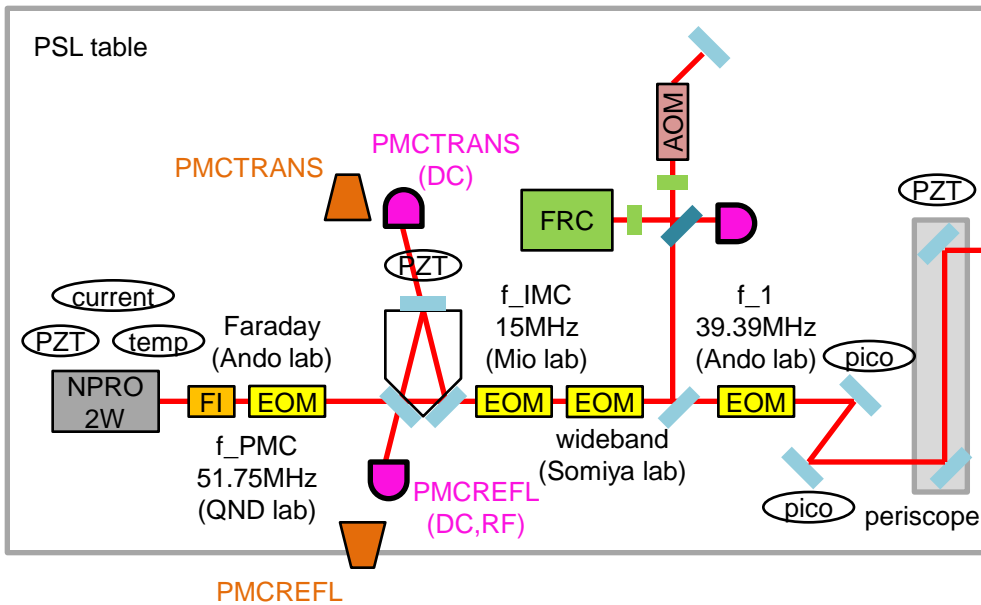
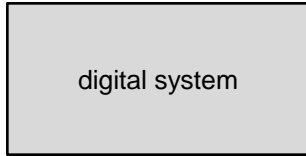
PMC Servo



Frequency Stabilization



Cameras



6 cameras?

How do we put their signals in the digital system?

Gouy Phase Telescopes

- We need two QPDs for each port we want to monitor the beam alignment
- It would be nice to have standardized Gouy phase telescopes for each port

- Below is an example aLIGO one (~ 15 cm x 55 cm)
[LIGO-T1000247](#)

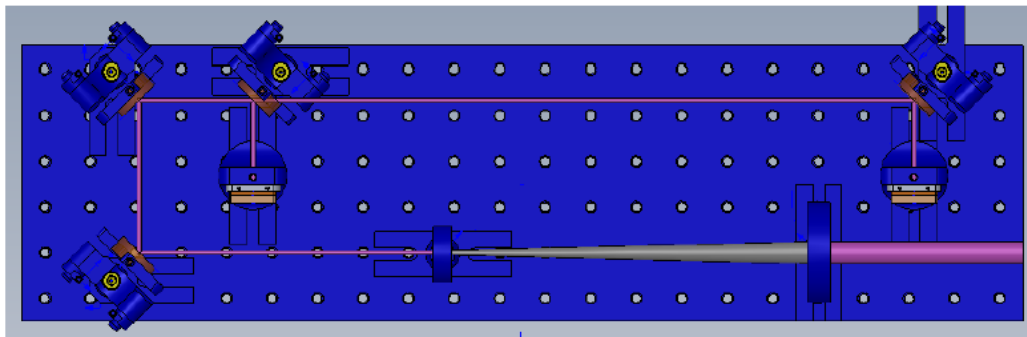
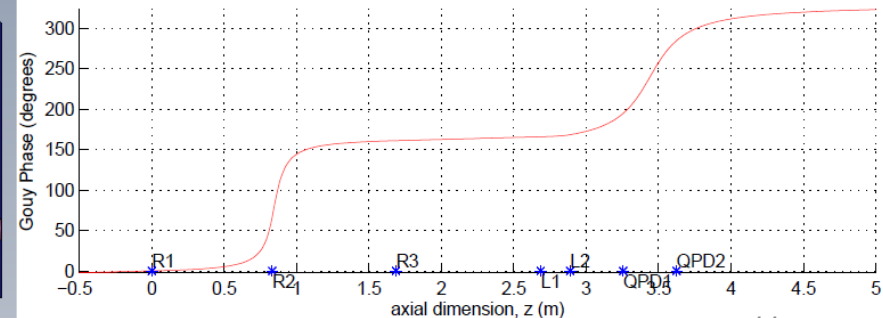
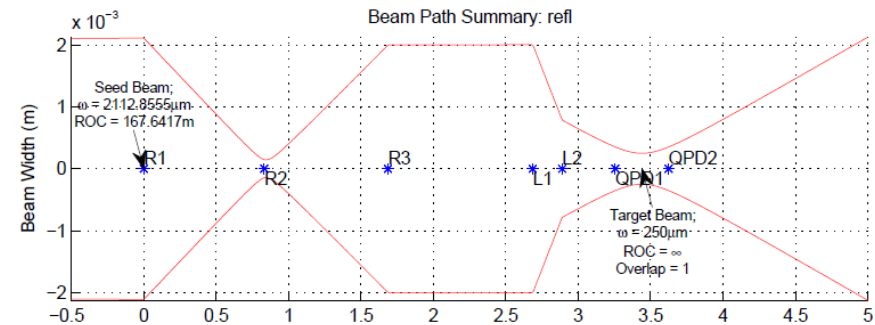


Figure 2: The REFL port QPD layout.

Figure 1: The REFL port telescope beampath.

Optical Components Missing

- PSL periscope
 - we have dumped rods available in Ando Lab
 - [Newport 45](#)
 - [Newport M-340-RC](#) **already delivered to Ohshima-san**
- Gouy phase telescopes and other optical components for each port
 - we can buy flat mirrors and mounts with a rough estimate of numbers, but what do we do for lenses?
- High voltage amplifier for broadband EOM
 - [Newport 3211](#) (0.5 MHz bandwidth)
 - already included in TTFSS servo board**
- AOM for FRC?
 - was already there at ICRR (including a driver)**
- I suppose there are much more.....

FSS Topology (rough idea)

- IMC servo (2 MHz/rtHz @ 0.1 Hz, 0.1 Hz/rtHz @ 10 Hz)
 - AOM (common mode board; DC – 100 kHz) AOM: 3110-197
driver: 1110AF-AEFO-1.5
(Crystal Technology)
efficiency: 5.3 MHz/V, range: 90-130 MHz
 - MCE (digital system; DC – 1 Hz; optional)

Actuation efficiency and range?

- FRC servo (with rough estimate, 170 Hz/rtHz @ 1kHz)
 - laser temp (digital system; DC – 0.1 Hz)
efficiency: 3 GHz/V, range: 30 GHz
 - laser PZT (FSS board; DC – 1 kHz)
efficiency: 1 MHz/V, range: 100 MHz
 - EOM (FSS board; 1 kHz – 1 MHz)
efficiency: $0.01 * (f/1 \text{ Hz}) \text{ Hz/V}$, range: 0.6 MHz

Numbers to remember:

- Kamioka seismic noise 2e-7 m/rtHz @ 0.1 Hz, 1e-11 m/rtHz @ 10 Hz, 1e-13 m/rtHz @ 100 Hz
- IMC suspension vibration isolation ratio: 0 dB @ 0.1 Hz, -60 dB @ 10 Hz, -140 dB @ 100 Hz
- IMC round-trip length: 2*26.65 m
- laser frequency: 2.8e14 Hz
- NPRO free-run frequency noise: 10 kHz/f Hz/rtHz

DGS Related

- standalone digital system is needed by Nov 2014
- it is not considered as a baseline DGS schedule
 - full digital system with networks will be available only from Jan 2015
- VIS will also need a standalone for IMC suspensions
 - maybe one standalone will do for VIS & IOO

AEL Related

- PMC(1) / FSS(1) / IMC(1) servo circuits

TTFSS servo board is already there at ICRR
[JGW-D1301823](#) TTFSS board is for EOM path and PZT path (copy of [LIGO-D040105](#))

IMC servo board is not there yet
[\(LIGO-D040180](#) aLIGO common mode servo board)
- RF PD(4) / RF QPD(4) / DC PD(7) / DC QPD(4) (at least!)

PMCREFL	IMCREFL A/B	PMCREFL	IMCTRANS A/B
IMCREFL	REFL A/B	PMCTRANS	ISS1 A/B
REFL		IMCREFL	(it would be nice to have
FRCREFL		IMCTRANS	2 more at PSL table for
		REFL	incident beam monitor)
		ISS1	
		ISS2	
- IQ demodulators(17ch)

1 for each RF PD, 4 for each RF QPD
 (for RF PDs, we use phase shifters because we do fast servo in IOO)
- RF distributors

f_PMC: split into 2 (EOM, PMCREFL)
 f_IMC: split into 11 (EOM, IMCREFL, 4xIMCREFLA/B, FRCREFL)
 f_1: split into 21? (EOM, REFL, 4xREFLA/B, AS, 4xASA/B, POX?, POY?)
- RF source(3)
- picomotor drivers(18ch, at least!)

2 for each mirror
 PSLSTM1/2
 STM1/2
 IMMT1/2
 MCi/e/o (top stage)
 (it would be nice to have 2 for each PD/QPD for aligning the beam into them)
- PZT drivers(3ch)

2 for periscope mirror
 1 for PMC
 (1 for laser is included in TTFSS)
- coil drivers(12ch)

4 for each MC mirror

By Schedule (DGS, AEL)

Month	To Do	VIS/AOS	IOO
2014/10	install PSL table		
2014/11	PMC FRC		SR560 RF PD x 2, DC PD x 2 TTFSS servo board RF source x 2 & splitter / mixer PZT driver x 1ch
2014/12	align beam to IMC install IMC sus	oplev QPD x 3	picomotor driver x 4 ch
2015/1	digital system installed IMC LSC	coil drivers x 12ch picomotor driver x 6 ch	SR560 RF PD, DC PD x 2 RF source x 1 & splitter / mixer
2015/2	IMC ASC		RF QPD x 2, DC QPD x 2 IQ demod x 8ch (in fabrication) RF distributors PZT driver x 1ch
2015/3	improve IMC install REFL/AS table		PMC servo board IMC servo board DC PD x 2, DC QPD x 2

•Blue things are already there (might need modification or soldering)

•Red things are temporary

Oplev QPD: [JGW-D1402411](#) (S5981)

Picomotor Driver

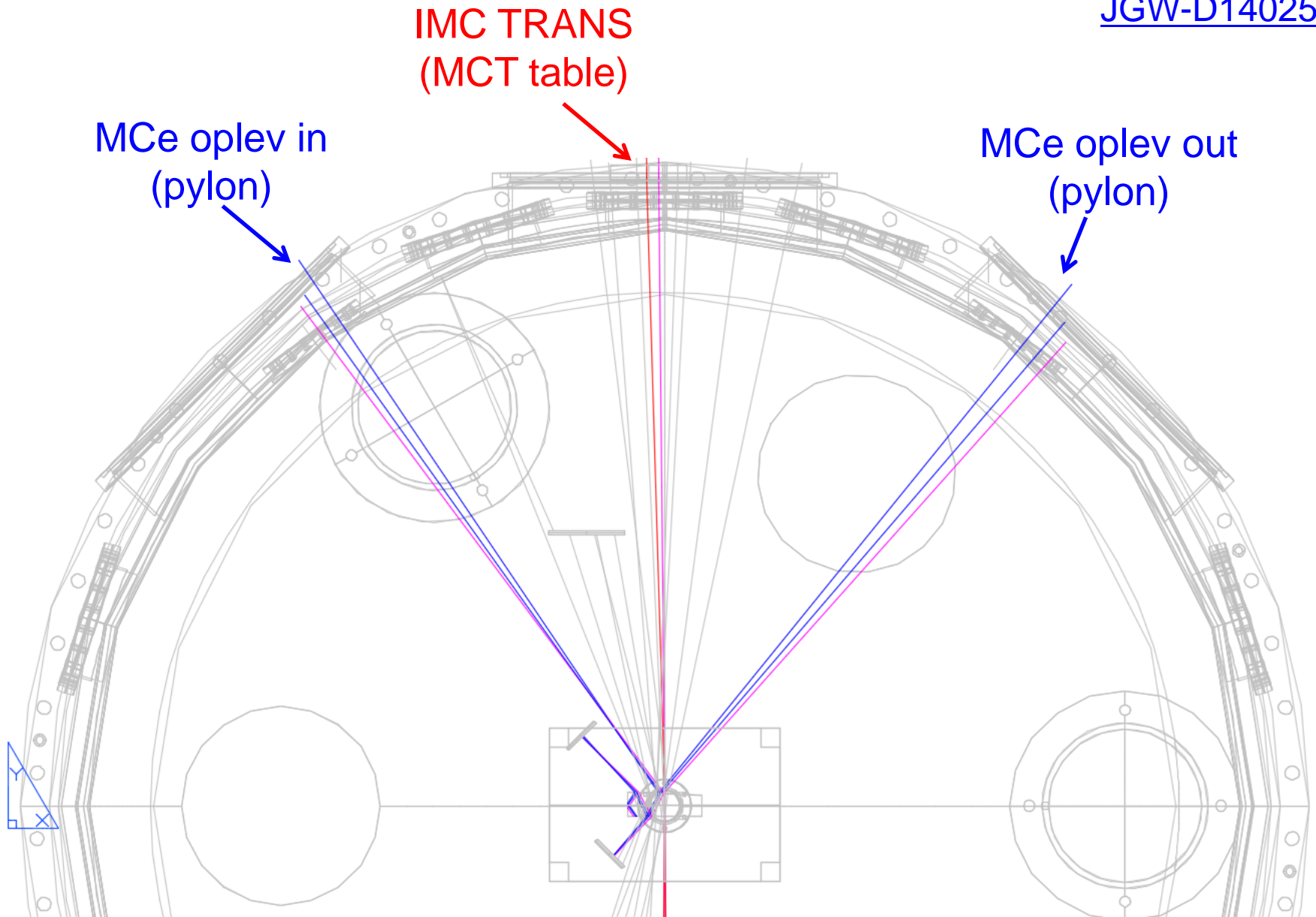
- For CLIO, NewFocus drivers below were used
PICOMOTOR EHTERNET CONTROLLER 8752
INTELLIGENT PICOMOTOR DRIVER 8753
Now, they are discontinued and replaced with
[Four-Axis Picomotor Controller/Driver Kit 8742-4-KIT](#)
- Picomotor control with EPICS and Python
<http://gwwiki.icrr.u-tokyo.ac.jp/JGW/wiki/CLIO/Technicals/PMEPICS>
<http://gwclio.icrr.u-tokyo.ac.jp/lcgtsubgroup/digitalsystem/2012/03/new-focus-picomotor-controlled-at-stda.html>
- No special interface circuit is needed for controlling picomotor from digital system

Cables

- TBD
- [JGW-D1402492](#) (IMC suspension cabling)

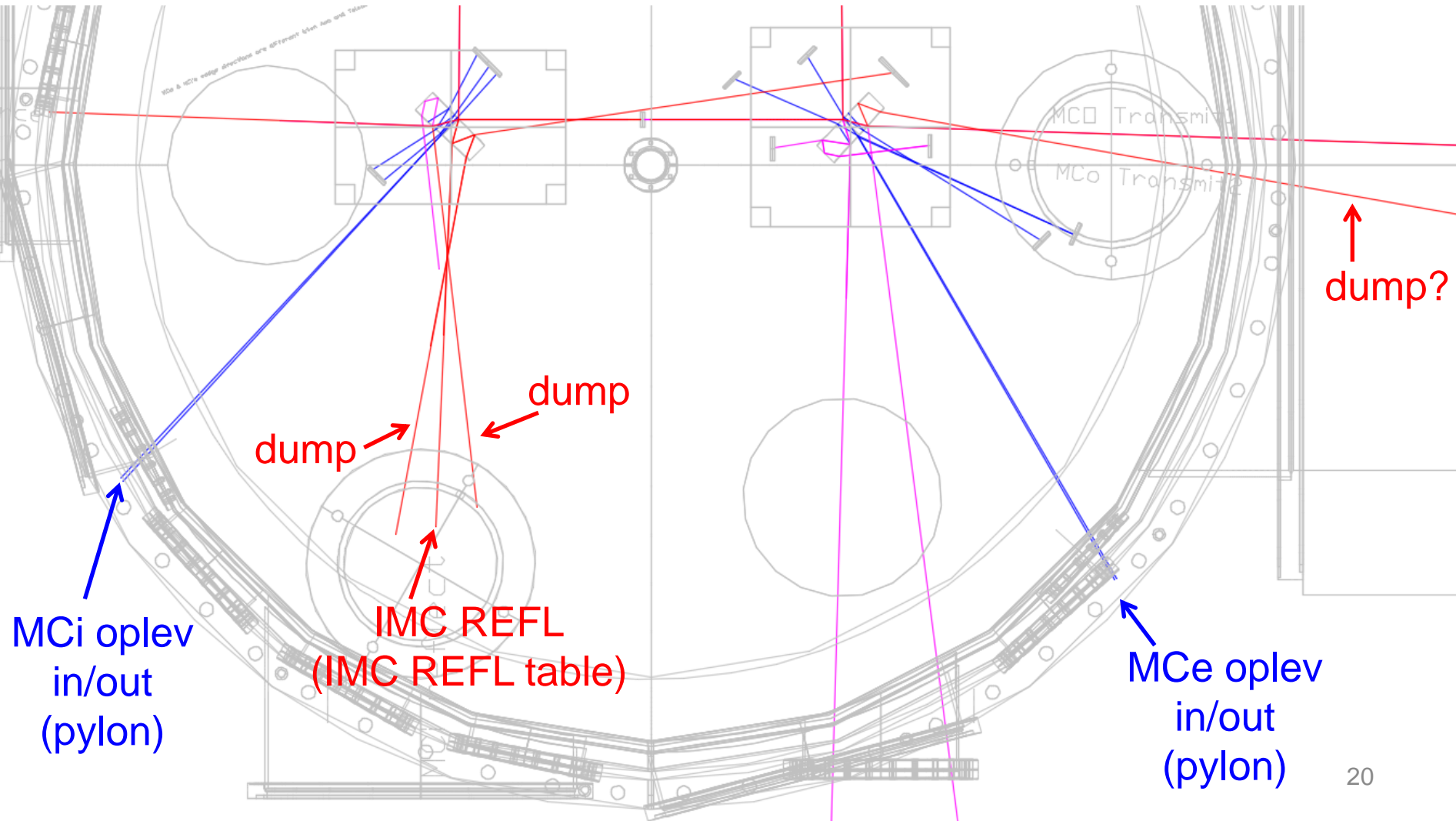
Beams around MCE

[JGW-D1402507](#)



Beams around MCI and MCo

[JGW-D1402507](#)



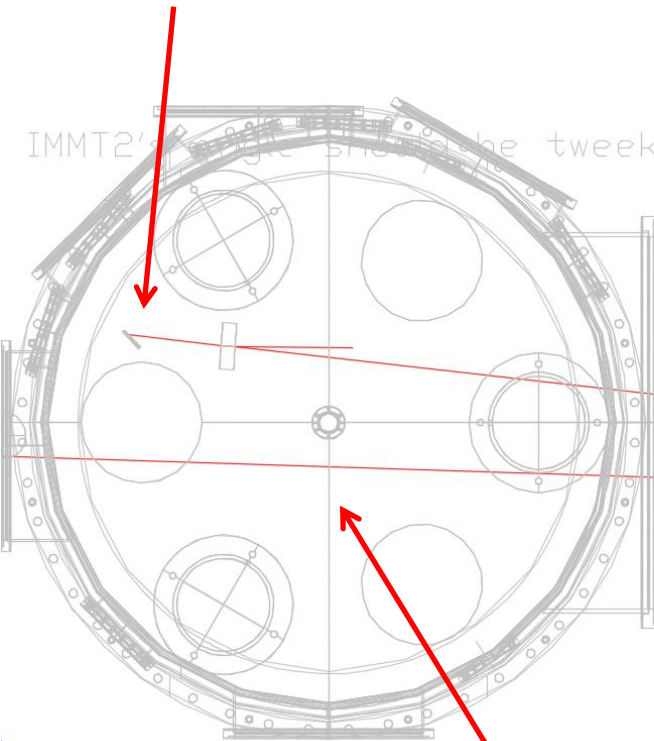
Beams around IMMT1/2

[JGW-D1402507](#)

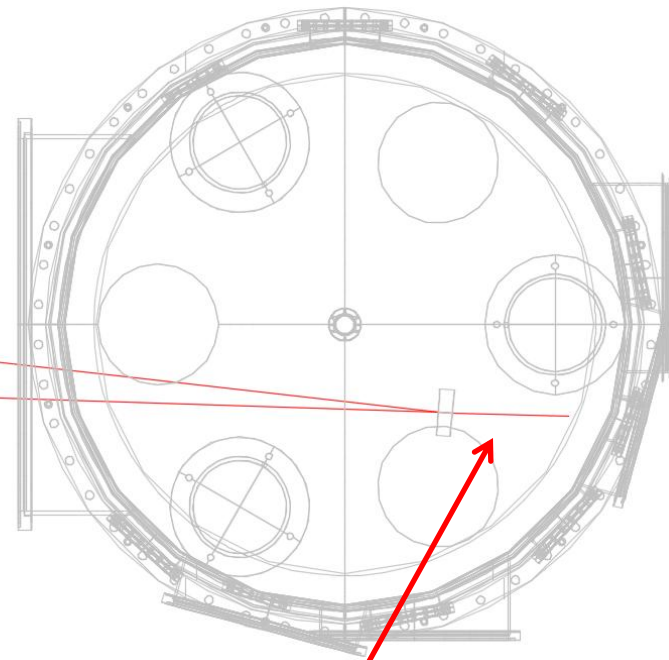
ISS2
(pylon->IMMT2 table)

IFI not included in the drawing yet

IMMT2's angle should be tweaked upward, later.



REFL
(REFL table)

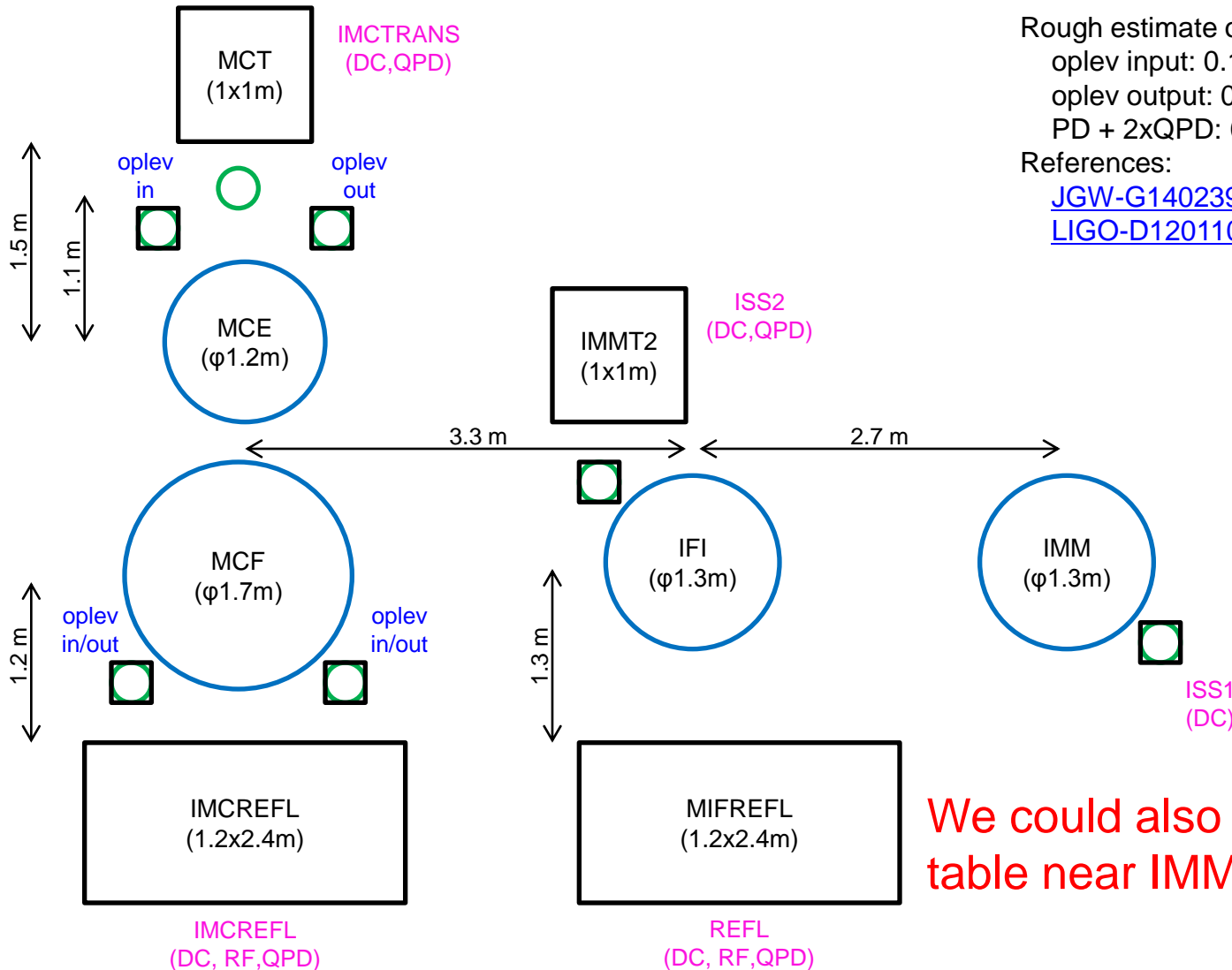


ISS1
(pylon)

Optical Tables / Pylons Layout

- chamber:  pylon:  table: 

[Wiki/OutputTables](#)



Rough estimate of space required

oplev input: 0.1x0.1 m

oplev output: 0.1x0.1 m

PD + 2xQPD: 0.8x0.8 m

References:

[JGW-G1402396](#) (oplev)

[LIGO-D1201103](#) (aLIGO ISCT1 table)

We could also place a 1 m x 1 m table near IMMT1

Small Optics for whole IOO

[Wiki/SmallOptics](#)

- port with DC PD + RF PD + 2 x QPD needs at least periscope, beam shutter, 2 x lens, 3 x mirror, 3 x BS, 4 x beam dump
- optionally HWP, PBS, CCD, +1 x BS
- some ports needs more +3 x mirror, +4 x lens cf. [LIGO-D1201210](#) (aLIGO ISCT6 table)
- there are

[before IMMT]

IMCREFL: DC PD + RF PD + 2 x QPD

IMCTRANS: DC PD + 2 x QPD

REFL: DC PD + RF PD + 2 x QPD

ISS1: DC PD

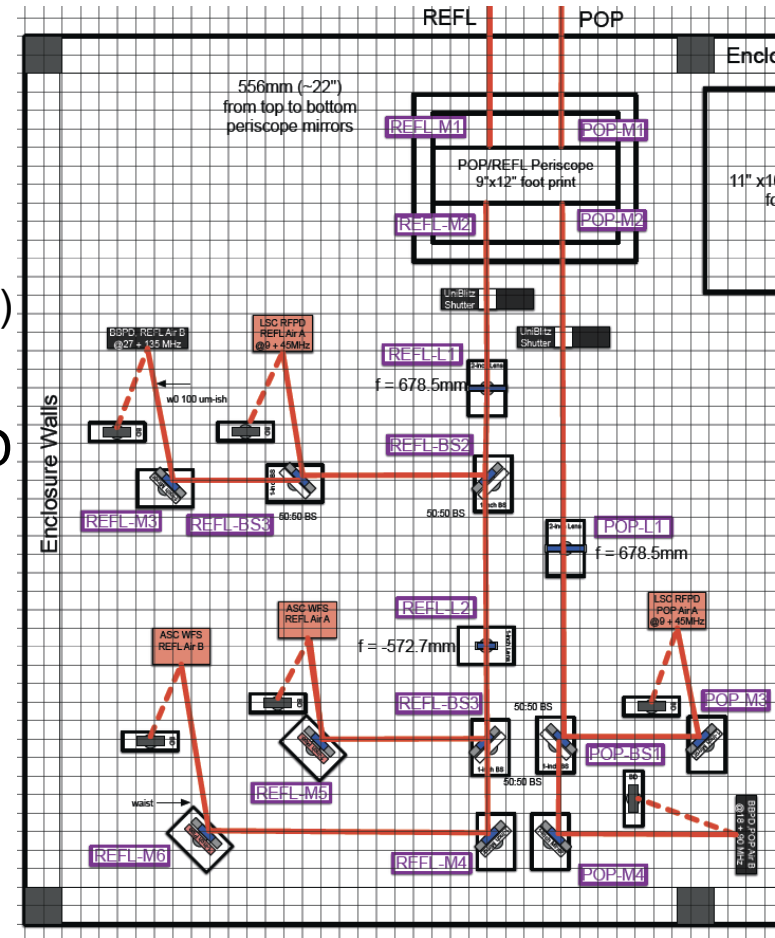
ISS2: DC PD + 2 x QPD

[after IMMT]

AS(SR2): DC PD + RF PD + 2 x QPD

ETMX: DC PD + 2 x QPD

ETMY: DC PD + 2 x QPD



[LIGO-D1201103](#) (aLIGO ISCT1 table)

* one grid is 1 inch x 1 inch

Small Optics for whole IOO

[Wiki/SmallOptics](#)

- My estimation for iKAGRA is;
- 8 periscope: for adjusting the height including 2 mirrors (may have to be 2 inch) and a post mirrors on periscopes are not included in numbers below
- 8 beam shutter: for zeroing the PD offsets and so
- 8 lens (2 inch): for reducing the beam size
- 8-40 lens (1 inch): for Gouy phase telescope, focusing on RF PD
- 16 mirror (2 inch): for steering before reducing the beam size
- 24-48 mirror (1 inch): for steering, folding
- 8 PBS (1inch): for adjusting power
- 24-32 NPBS (1inch): for splitting the beam to PDs, cameras
- 8 HWP (1inch): for adjusting power
- 32 beam dump: for dumping PD reflection
- 8 CCD: for monitoring the beam
- 28 picomotors: for centering the beam on QPDs

Some Important Info (for iKAGRA)

- Suspended optics from laser to PRM chamber are just IMC mirrors
 - we don't suspend IFI nor IMMTs
 - oplevs only for IMC mirrors (no oplevs for IMMTs)
- IMMTs are flat and have picomotors
- we don't need hardware interface between picomotor drivers and digital system

Questions

- Are we going to use IMMTs as actuators for ASC of FPMI?
- Are there PDs/QPDs which should be in vacuum?
 - only MIF REFL? **maybe none for iKAGRA**
- What are we going to do with MCo AR reflected beam?
 - I don't think it is essential for ISC point of view
Miyoki-san says it was in CLIO since IMC TRANS was low power
- How many standalone digital system will be needed by Nov 2014?
- What's the situation about FRC servo circuit? **Nakano has it**
 - Miyakawa-san said he delivered to IOO on Sep 2013
- Are we really going to use FRC? Is it a default plan?
- How many picomotors for a MC mirror? **2**
- What do we need for digital system to picomotor driver interfaces? Do we need some interface circuits? **no**
- What's the camera situation? How do we put them in the digital system?
- Where and how many do we have optical tables and pylons? What are the sizes of them? Do we need periscopes for them?