HIGH POWER PSL

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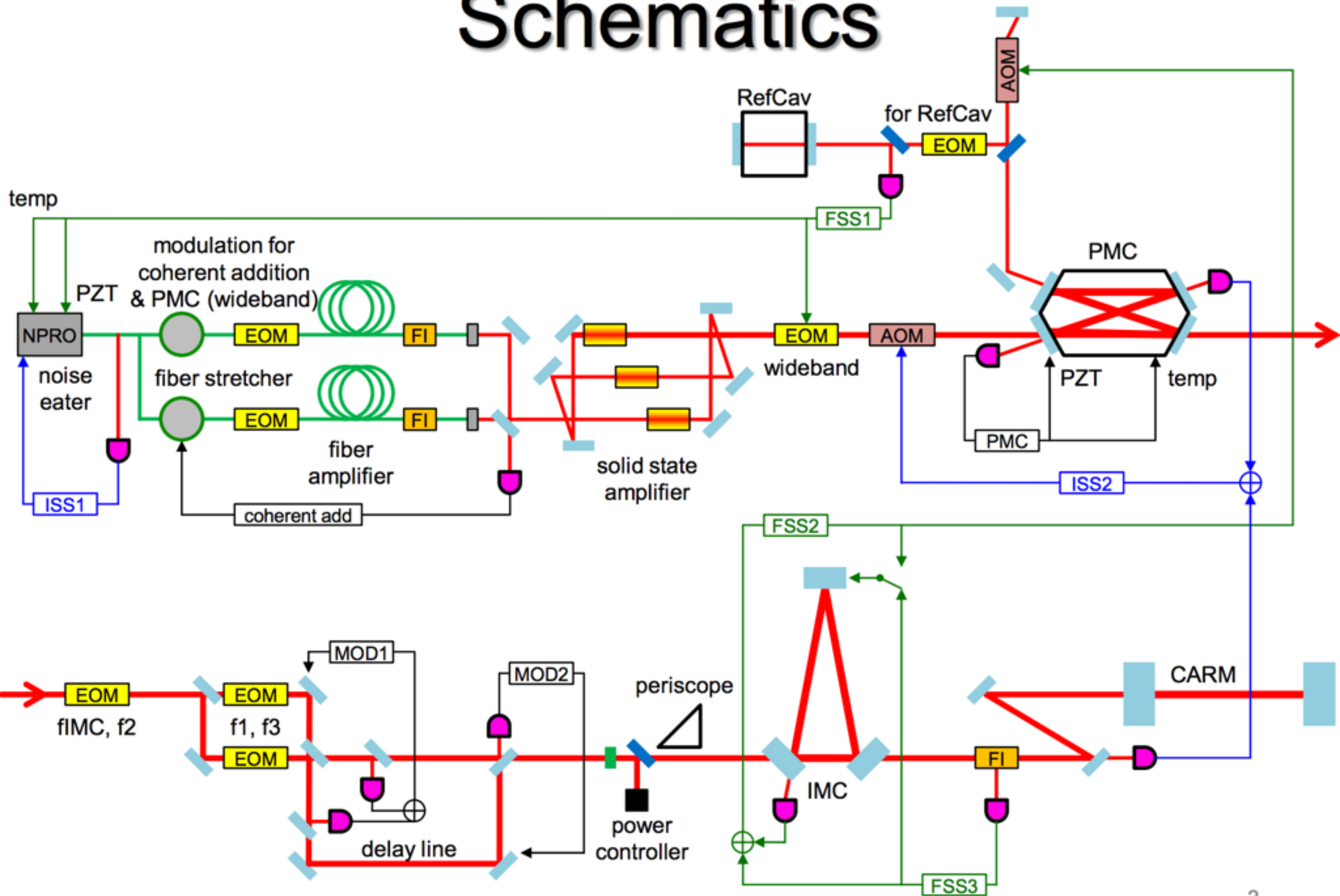
KAGRA

Schematics


RefCav
for RefCav
EOM
AOM
temp
FSS1
modulation for
coherent addition
& PMC (wideband)
PZT
NPRO
EOM
FI
PMC
EOM
AOM
noise
eater
fiber stretcher
EOM
FI
wideband
PZT
temp
PMC
fiber
amplifier
solid state
amplifier
ISS2
ISS1
coherent add
FSS2
MOD1
MOD2
periscope
CARM
EOM
fIMC, f2
EOM
f1, f3
EOM
FI
IMC
delay line
power
controller
FSS3

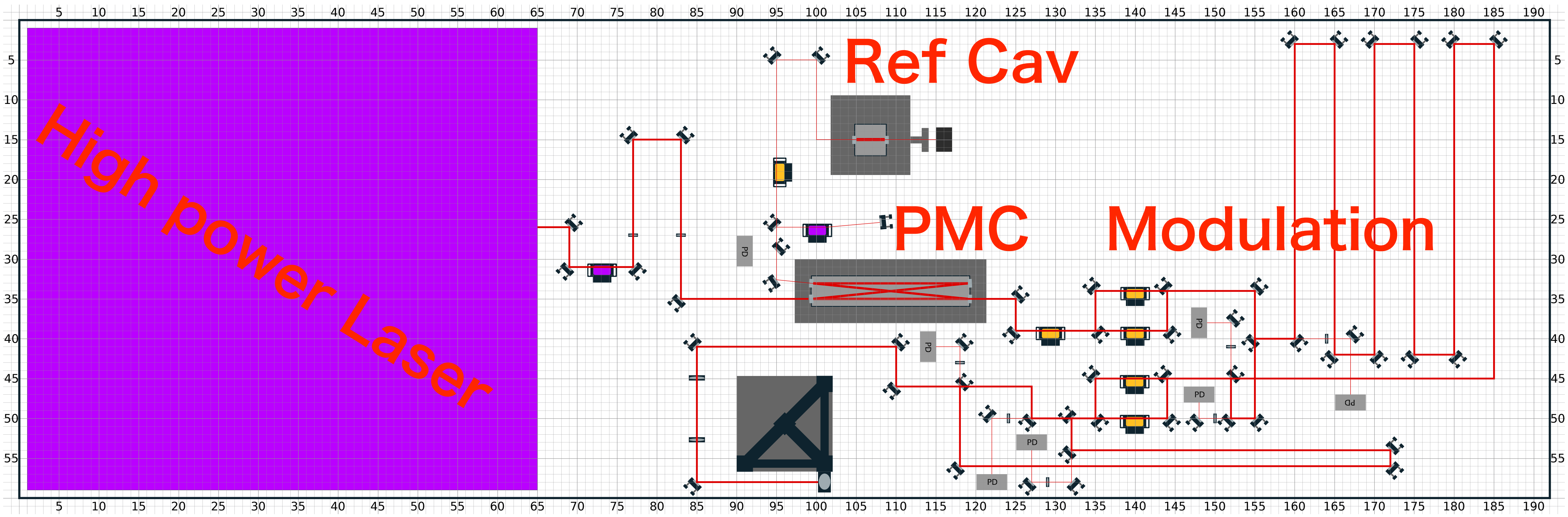
Concept

- RefCav after PMC to reduce beam jitter
- Use PMC auxiliary transmissions for RefCav and ISS to save power
- Simple, but loss less f1(PM-AM), f2(PM), f3(AM) modulation
  - ✓ PM-AM switchable for f1
  - ✓ loses some f3 AM, but doesn't matter much since f3 AM is used only for the lock acquisition
- Use less EOMs as possible
  - ✓ use same EOM for coherent addition and PMC servo
  - ✓ use same EOM (doubly-resonant) for f2 and IMC
  - ✓ use same EOM (doubly-resonant) for f1 and f2

Difference from aLIGO

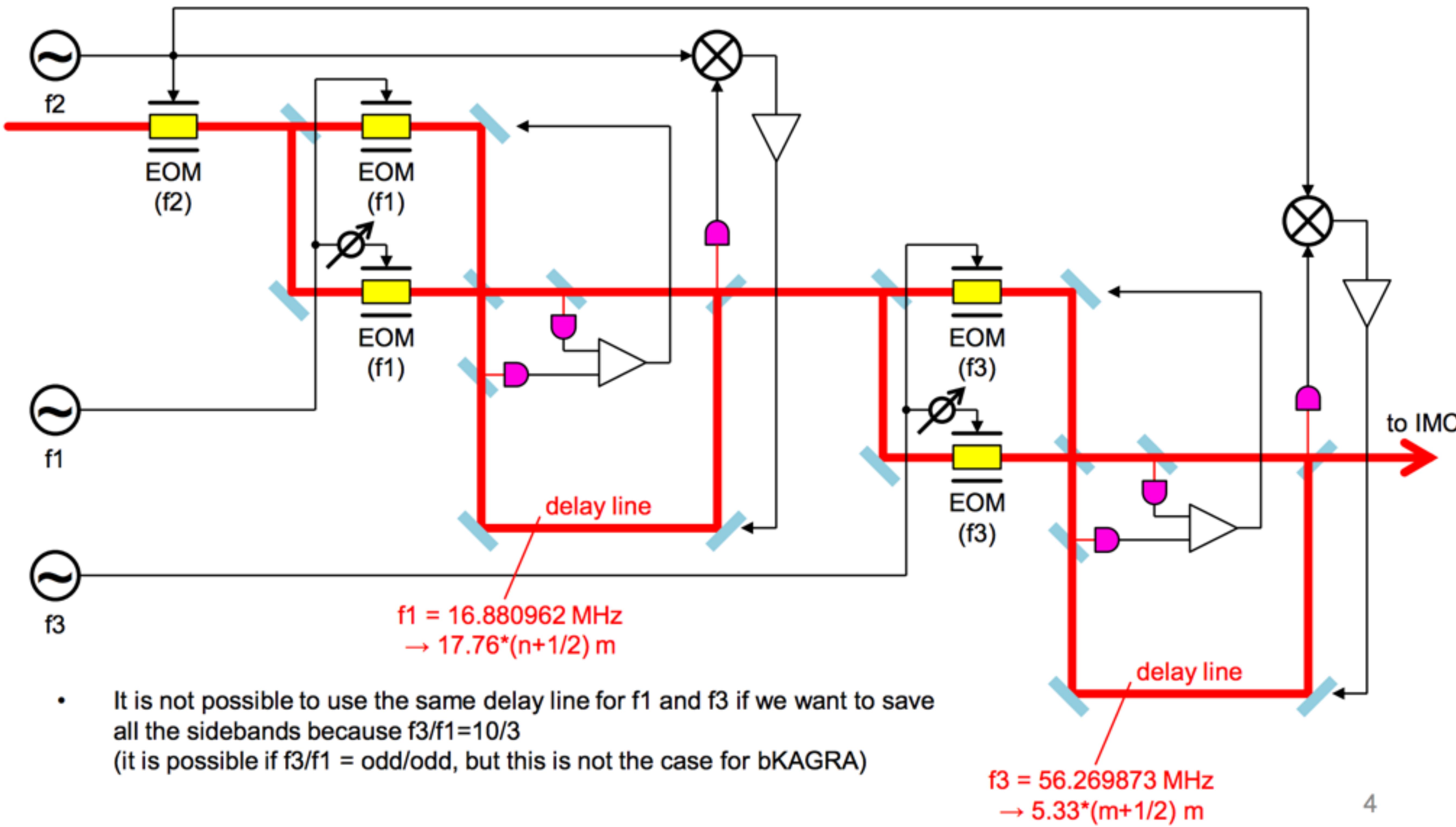
- The position of wide band EOM
  - ✓ after fiber amplifier (high power) to avoid phase delay
    - ➡ We need high power compatible wide band EOM.
- The EOMs for modulation
  - ✓ We use not only PM but also AM to extract control signal of main interferometer

PSL design (Plan)



EOM layout1

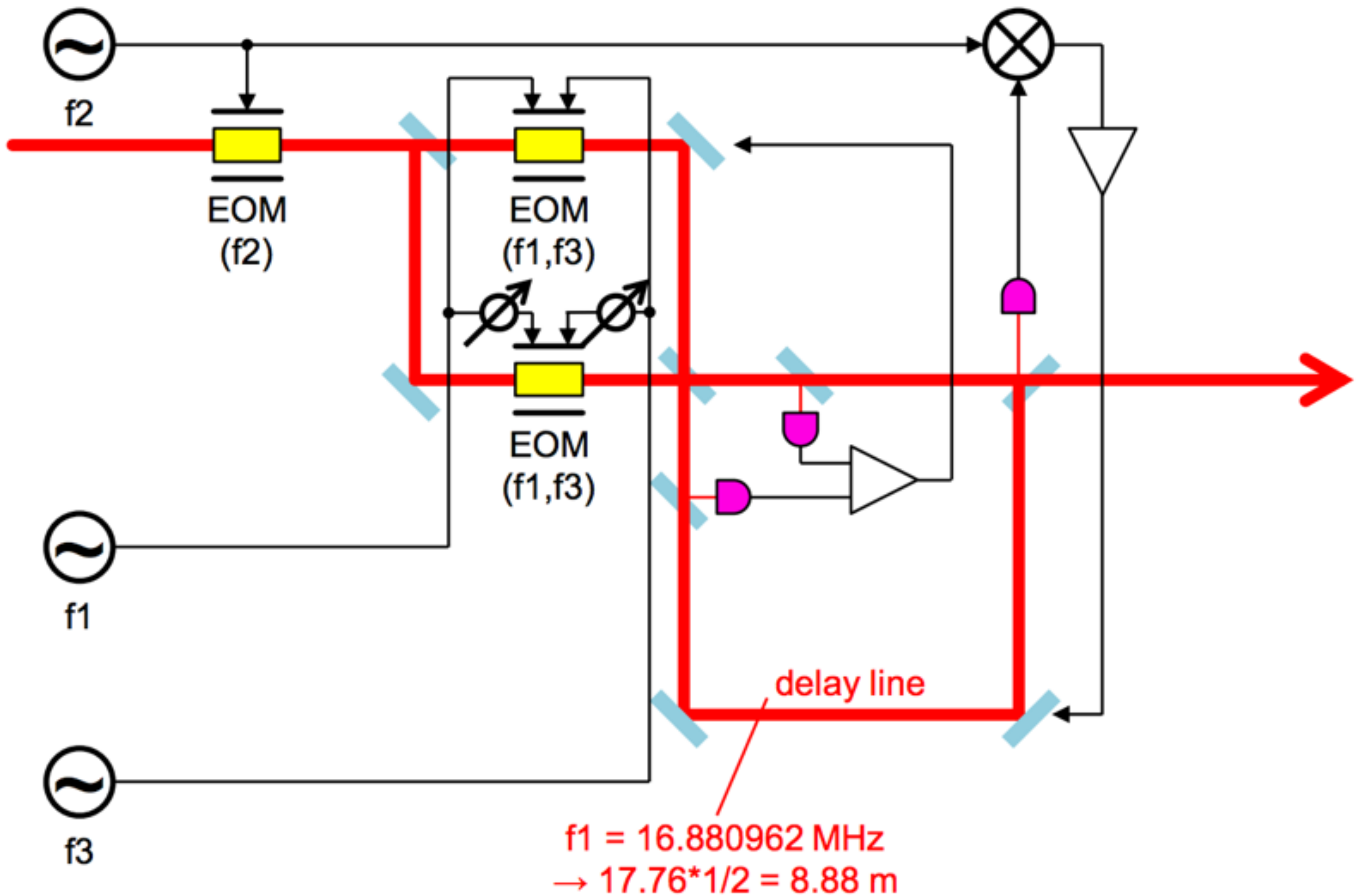
- Saves the whole power



- It is not possible to use the same delay line for f1 and f3 if we want to save all the sidebands because f3/f1=10/3
(it is possible if f3/f1 = odd/odd, but this is not the case for bKAGRA)

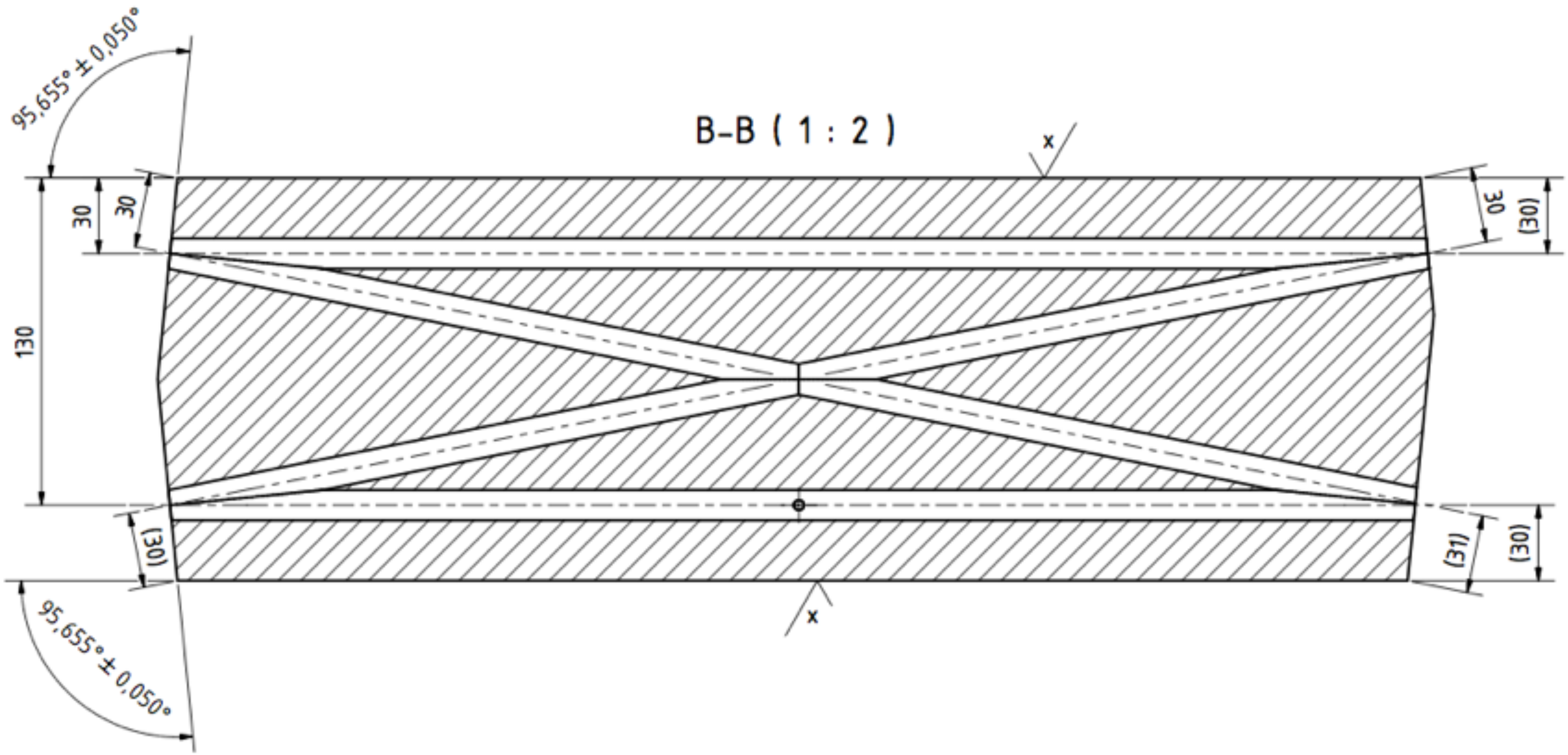
EOM layout2

- Simpler, but loses some f3 AM



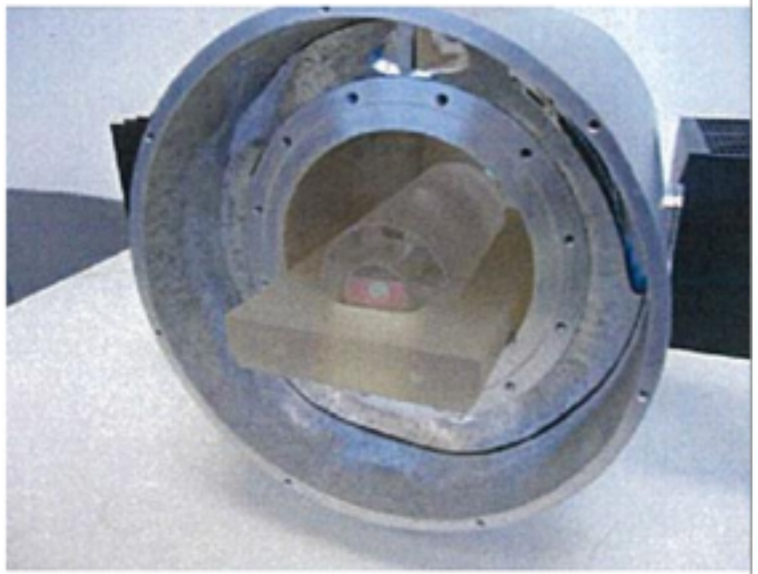
Pre-Mode Cleaner

- We are planning to copy the aLIGO PMC design.



Reference cavity

- linear cavity, ULE spacer
- already made (currently at Kashiwa)
  including Zerodur support,
  thermally insulated vacuum can,
  temperature control
- Specsheet available
  from JGW-T1503493



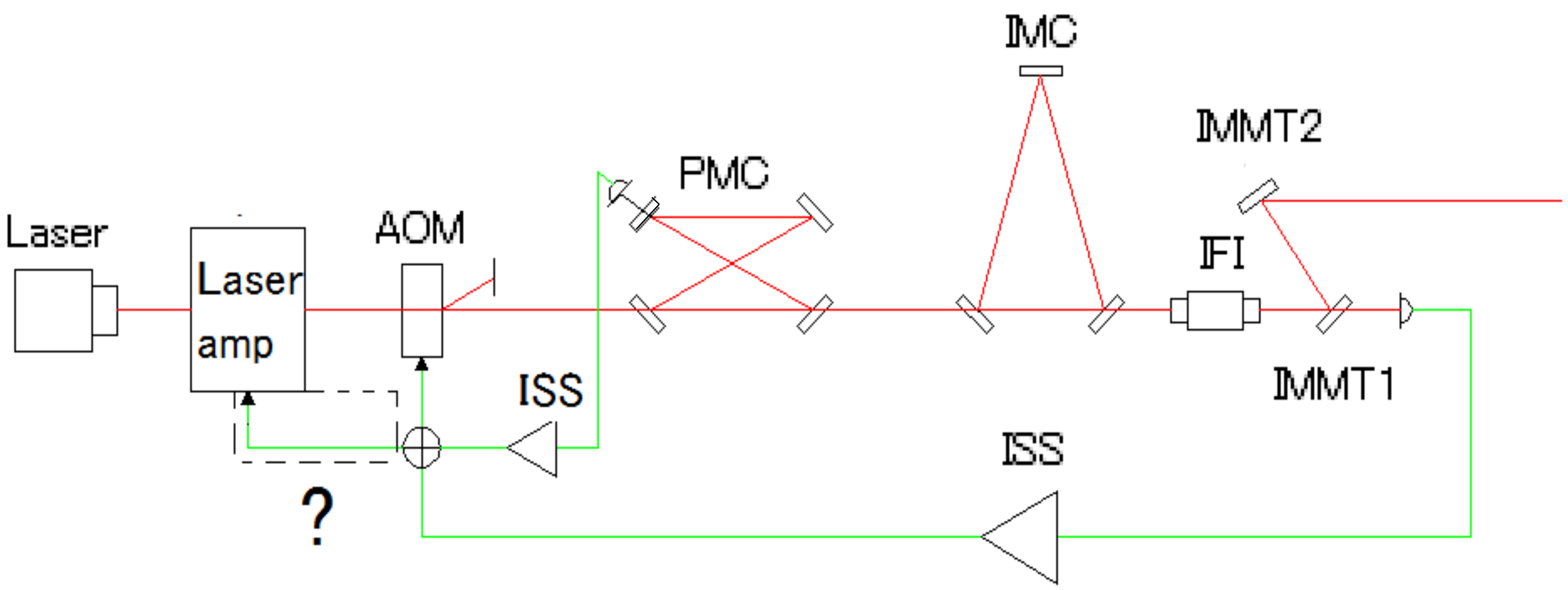
finesse	3e4
round trip length	2*100 mm
FSR	1.5 GHz
cavity pole	22 kHz
TMS	0.11 GHz

- we call it a RefCav or FRC (frequency reference cavity; it stands for fiber ring cavity in iKAGRA!)

Photo from N. Ohmae

Intensity stabilization

- Actuator : AOM (fiber amp? and/or solid state amp?)
- Pick-off light for reference : transmission of PMC and IMMT1



Test Plan for HPIOO

- A high power laser is constructed at Hongo (Mio lab) and there is no enough space for assembling test of PSL.
- Toyama Univ. is working to get manny and space for the lab for testing high power IOO.
- If we get that lab
  - bring the high power laser to Toyama and test the PSL with it.
- If we cannot,
  - test each high power component(PMC, EOM, etc) at Hongo
  - PSL assembling test at Kashiwa with low power laser.

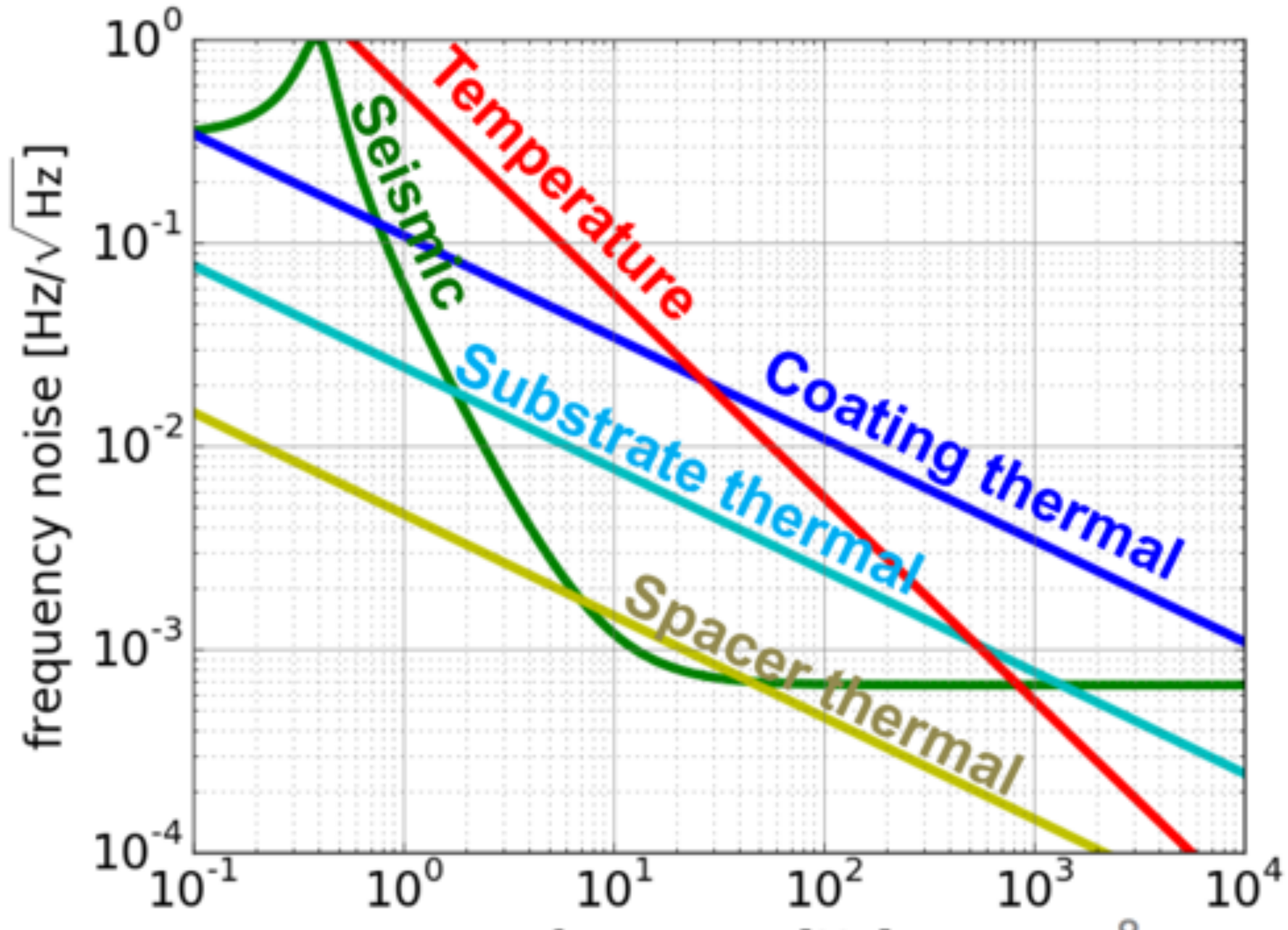
Appendix

RefCav Frequency Stability

- long term drift should be smaller than ~100 mHz/sec
  It corresponds to 8.4 kHz/day and the daily drift will be smaller than the arm cavity FSR (50 kHz). So, we can lock the arm cavity at the same fringe every day.
- this can be achieved by stabilizing the temperature within +/- 1 K at the thermal expansion zero crossing point (this gives < 2e-9 /K of the thermal expansion), and making the temperature drift smaller than 2e-7 K/sec.
- estimated frequency stability is shown right
  seismic: 1e-9 (1Hz/freq)**2 m/rtHz
  vibration sensitivity: 3e-8
  vibration isolation: 1x Minus K

  thermal expansion: 2e-9
  cavity temperature: (1Hz/freq) uK/rtHz

  coating Q: 2500
  substrate Q: 1e6
  spacer Q: 6e4
  coating thickness: 10 um



Calculated by T. Ushiba *et al.*