Input and Output Optics for Phase-2 Operation

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Public Advisory Board

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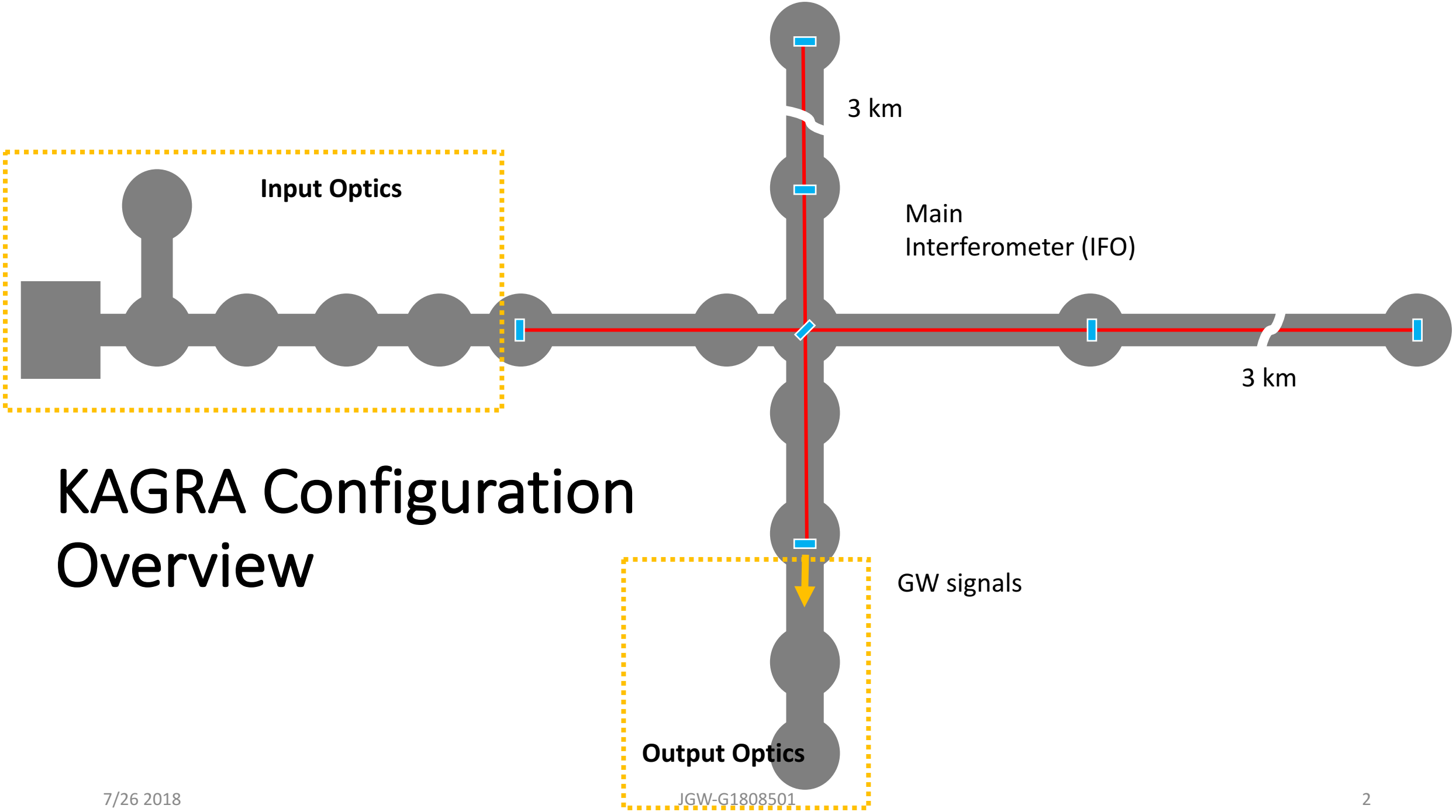
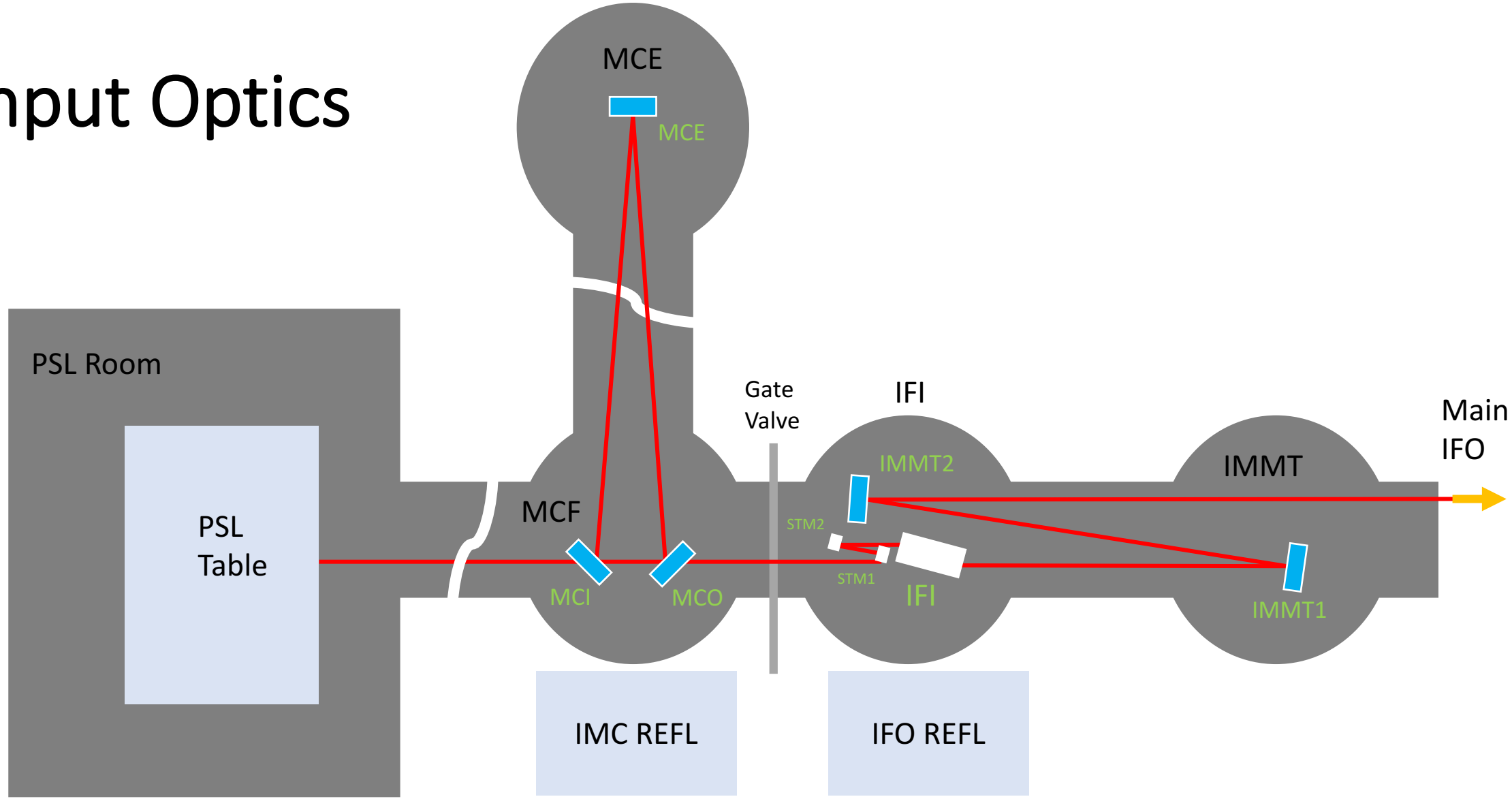
Roles of Input and Output Optics Group

- **Laser and Optics**
  - To satisfy the frequency, beam jitter, and spatial mode requirements for the laser provided by LAS
- **Input Mode Matching Telescopes (IMMTs)**
  - To install the telescopes and match the spatial mode to the main interferometer mode
  - (suspensions and mirrors are provided by VIS and MIR respectively)
- **Output Mode Cleaners (OMC)**
  - Designing, manufacturing, installing the OMC
- **Output Faraday Isolator (OFI)**
  - Designing, manufacturing, installing of OFI
- **Output Mode Match Telescopes (OMMTs)**
  - Same for IMMTs

KAGRA Configuration Overview

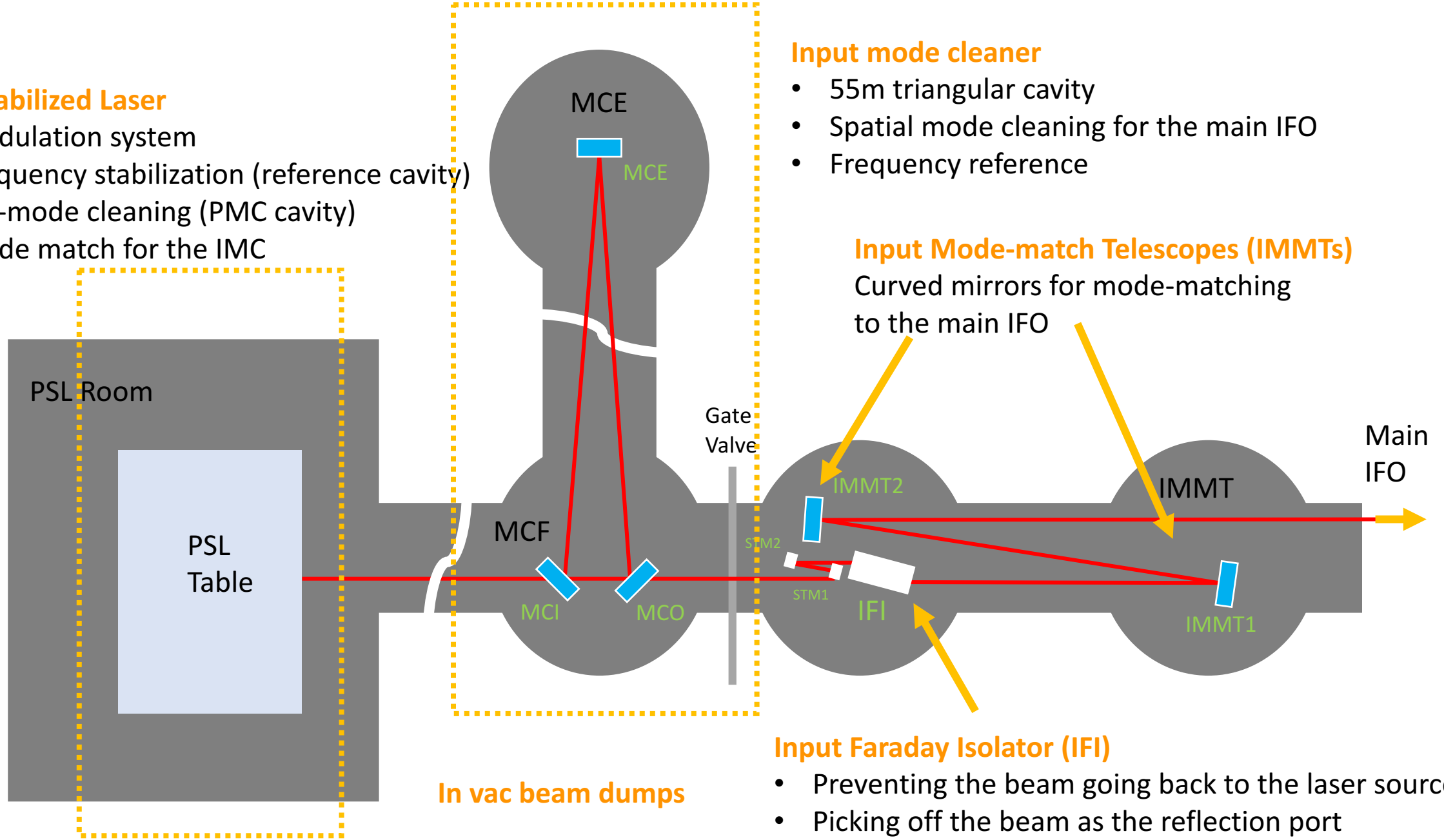


Input Optics



Pre-Stabilized Laser

- Modulation system
- Frequency stabilization (reference cavity)
- Pre-mode cleaning (PMC cavity)
- Mode match for the IMC



Input mode cleaner

- 55m triangular cavity
- Spatial mode cleaning for the main IFO
- Frequency reference

Input Mode-match Telescopes (IMMTs)

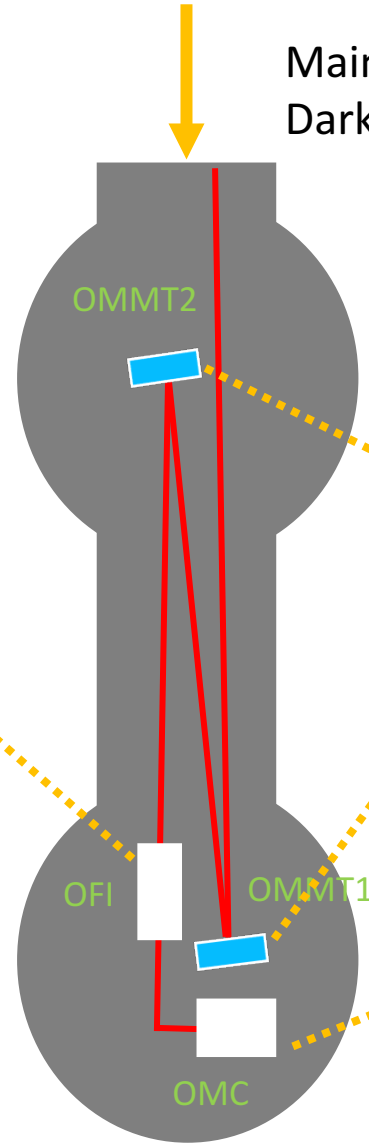
Curved mirrors for mode-matching to the main IFO

In vac beam dumps

Input Faraday Isolator (IFI)

- Preventing the beam going back to the laser source
- Picking off the beam as the reflection port

Output Optics

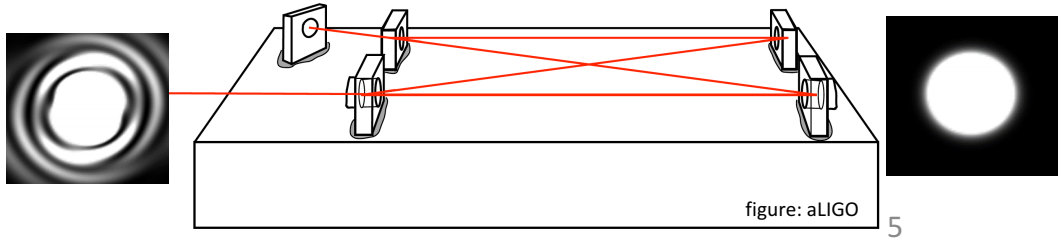


Output Faraday Isolator
To prevent the laser beam from going back to the main interferometer

Output Mode-match Telescopes (OMMTs)
Curved mirrors to reduce the beam radius and to match the OMC cavity

Output Mode Cleaner (OMC)
To remove the higher order spatial modes and modulation sidebands for the low noise GW detection

In vac beam dumps

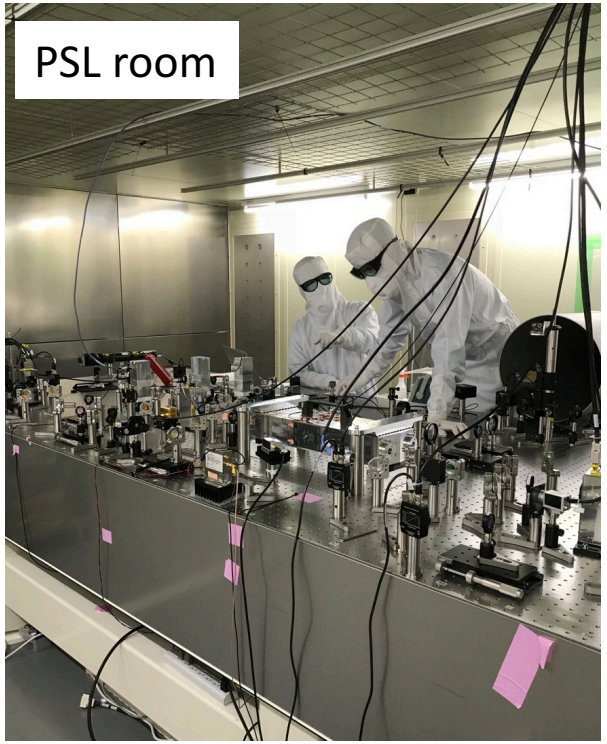


Requirements for Input and Output Optics

- Input Optics
  - Pre-Mode Cleaner HoM less than 5W w/ TEM00 165W (LIGO)
  - Frequency Stability less than 100mHz drifts per sec
  - Beam Jitter (as PSL periscope motion)

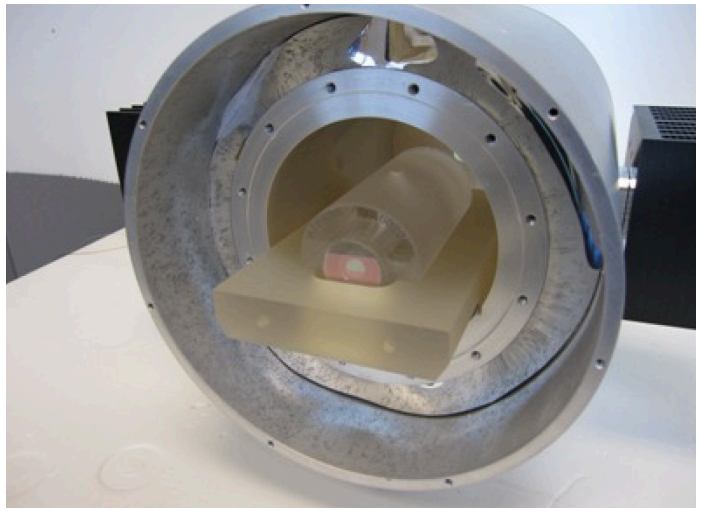
$$\delta x < (5 \times 10^{-10} + 5 \times 10^{-3}\ \mathrm{Hz}/f^4)\,\mathrm{m}/\sqrt{\mathrm{Hz}}$$
$$\delta\theta < (2 \times 10^{-11} + 2 \times 10^{-4}\ \mathrm{Hz}/f^4)\,\mathrm{rad}/\sqrt{\mathrm{Hz}}$$

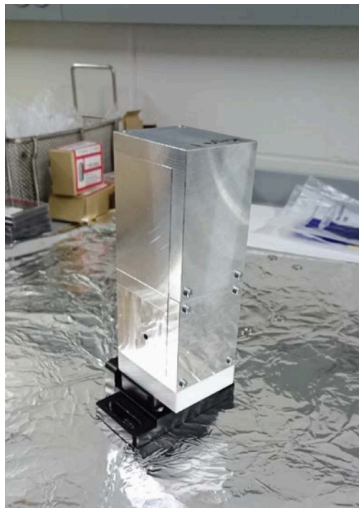
- Output Optics
  1. Shot noise increases by 5% or less
  2. Signal loss at Output Faraday Isolator and PDs for 5% or less
  3. Other excess noise does not exceed 1% of goal sensitivity



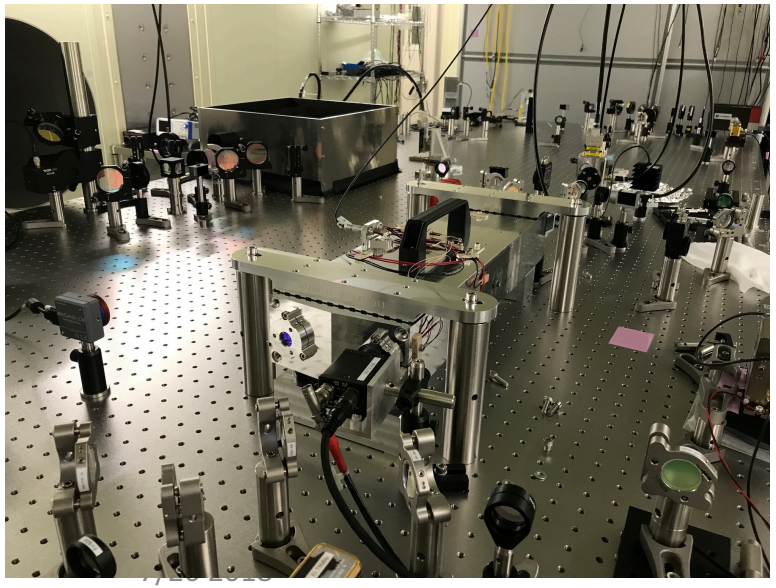
To IMC

Reference Cavity
(Frequency Reference,
commercial cavity)

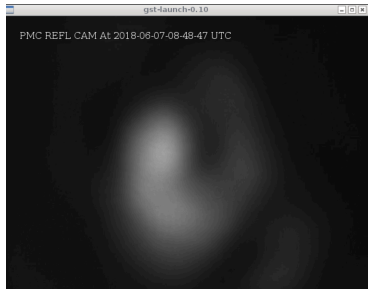




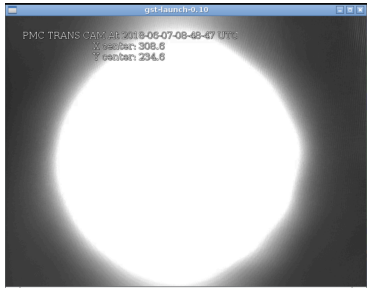
Electro-Optical Modulator
(LIGO type)



Pre-Mode Cleaner
(LIGO type)



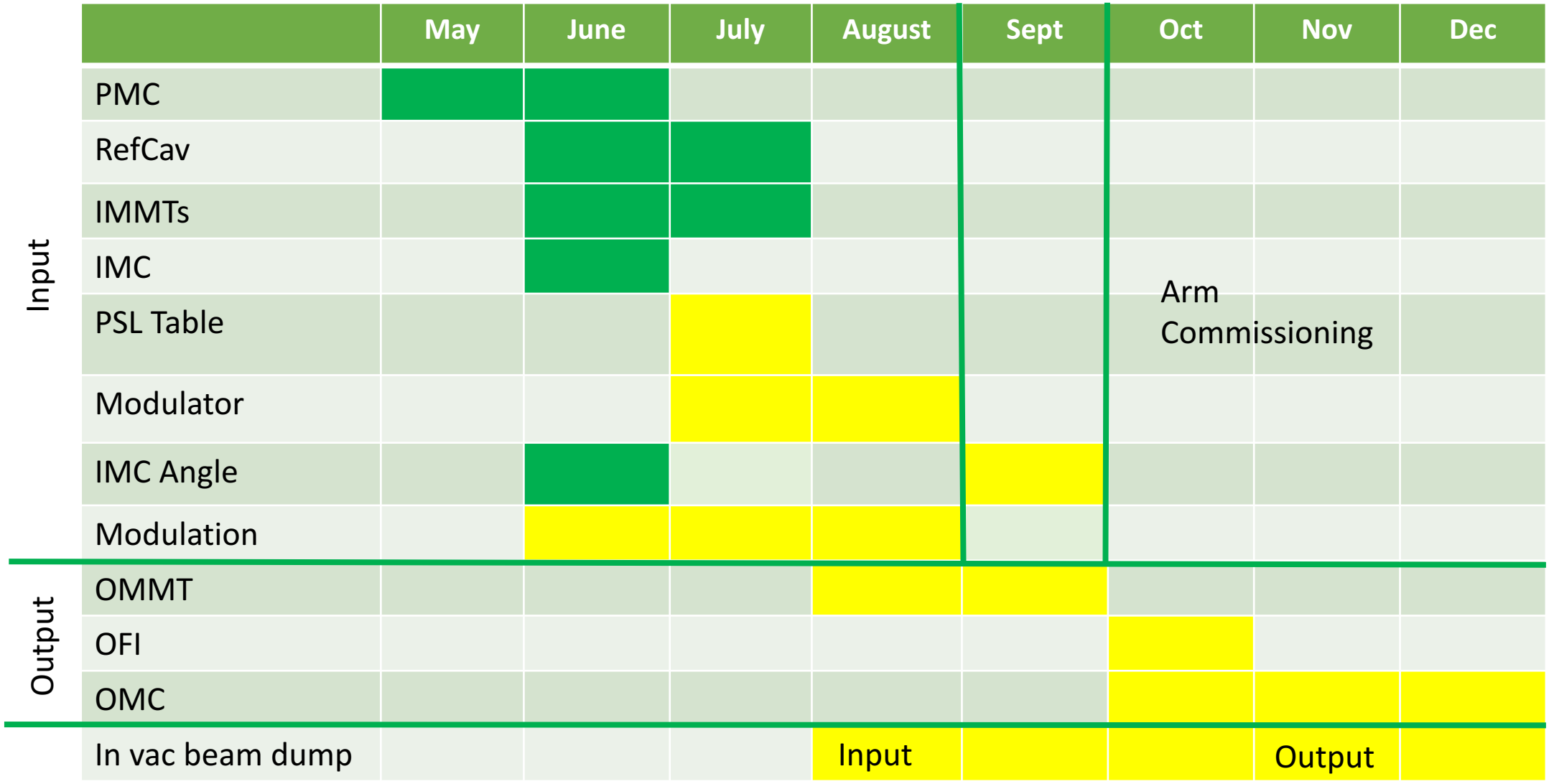
Rejected bean



Transmitting beam

Progress Chart (Installation)

Characterization will follow



Human Resources

	Efforts in Kamioka	Misc.
Kokeyama (Chief)	100% Kamioka	
PhD student 1	90% Kamioka	
Master student 1	100% Kamioka	only for 3 months
Master student 2	50% Kamioka in 2018	leaving in a year
Master student 3	10% Kamioka	for high power laser
Master student 4	10% Kamioka	
Staff1	100% Kamioka,	only for 1.5 month, LIGO expert
Staff2	2% Kamioka	OMC development in Tokyo
Staff3	5% Kamioka	
Many others	less	

- ~4 FTE in total?
- No full time stuff except chief
- Only one full time PhD student
- Managing with remote visitors, but for long term maintenance and noise hunting will be more difficult

Budget Execution Status (Input part)

2017	Budget	Spent
IOO Total	48 M yen	70 %

2018	Budget	Spent (as of July 2018)
PSL Phase-2 (upgrade)	5M yen	100%
High Power	1M yen	100%
Beam dump (high power, in vac)	3M yen	40%
OMC	2M yen	0%
SEO contingency	4M yen	25 %

- Budget 2018 spent mostly for optics
- Some more auxiliary optics for monitoring and analyzing will be required
- No additional parts expected after August
- High power beam dumps in vacuum should be prepared soon