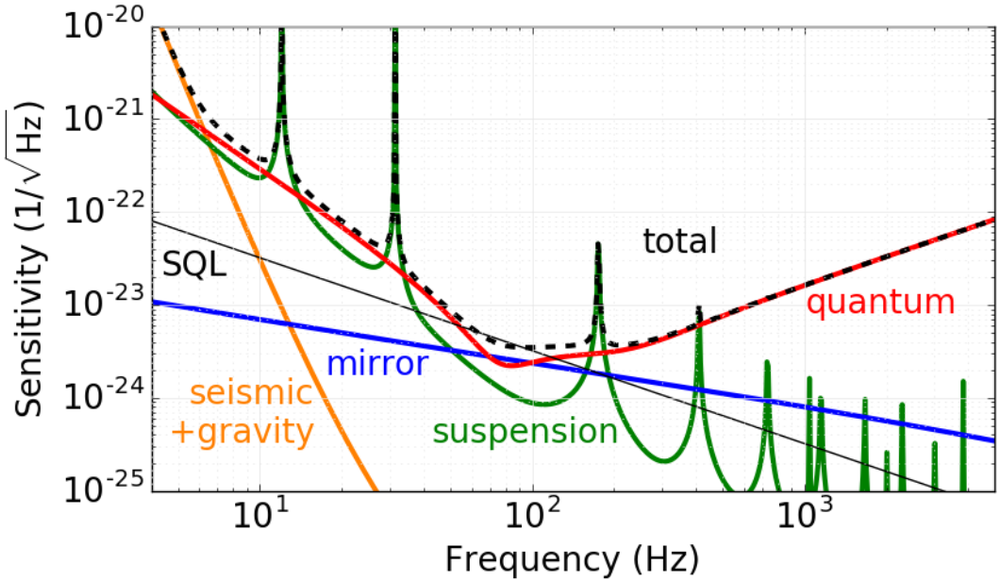
Status of frequency-dependent squeezing experiment at TAMA

YuhangZhao representing filter cavity team

Introduction



- Limitation of quantum noise for GW detector.
- Quantum noise maybe more severe for KAGRA.
- Squeezing is promising for reducing quantum noise.
- Filter cavity makes squeezing beneficial for the whole band.

Our filter cavity experiment is in-construction now in TAMA300.

Content

- Squeezing and filter cavity
- filter cavity experiment overview
- filter cavity experiment new progress
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Squeezing and detector

- Squeezing can be understood as the arrangement of sideband.
- The quantum noise is composed of radiation pressure noise and shot noise. The reduction of these two components can be done by using squeezing with different orientation.

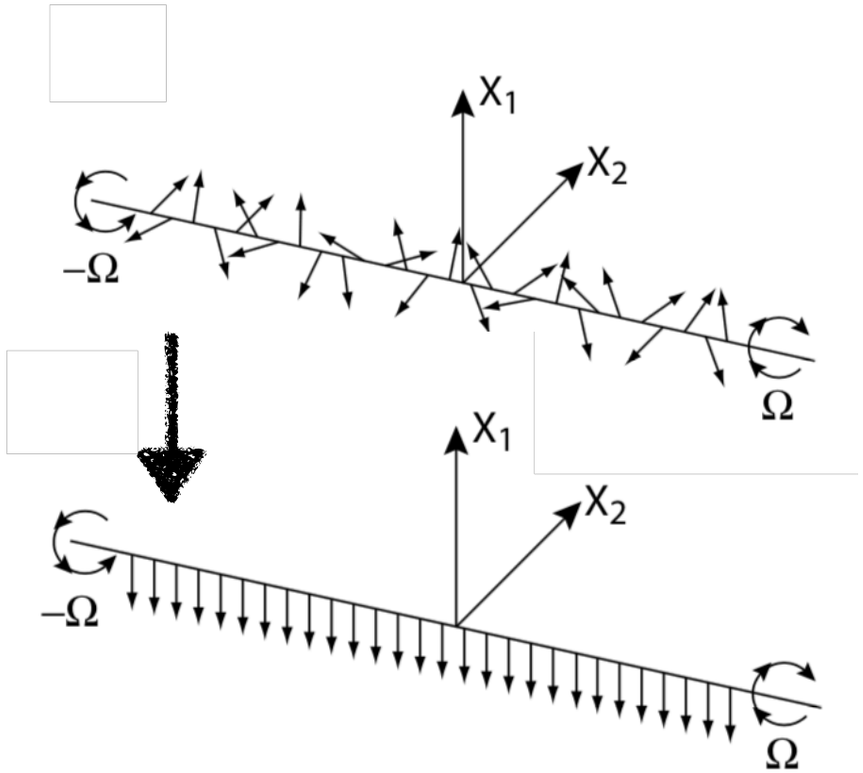
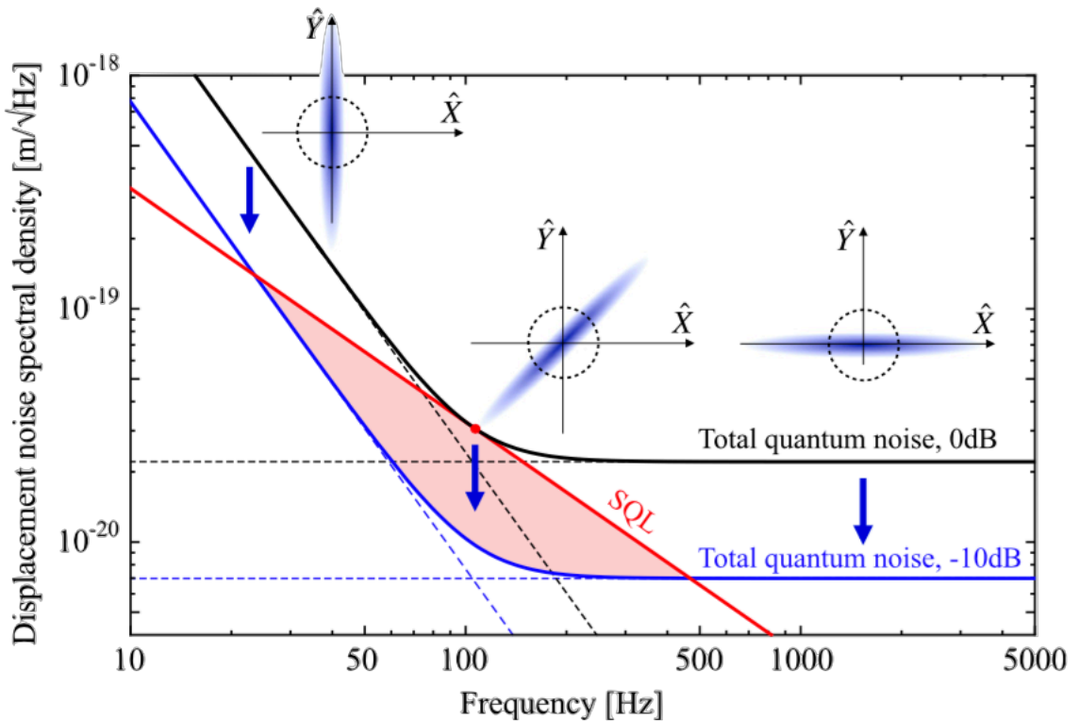


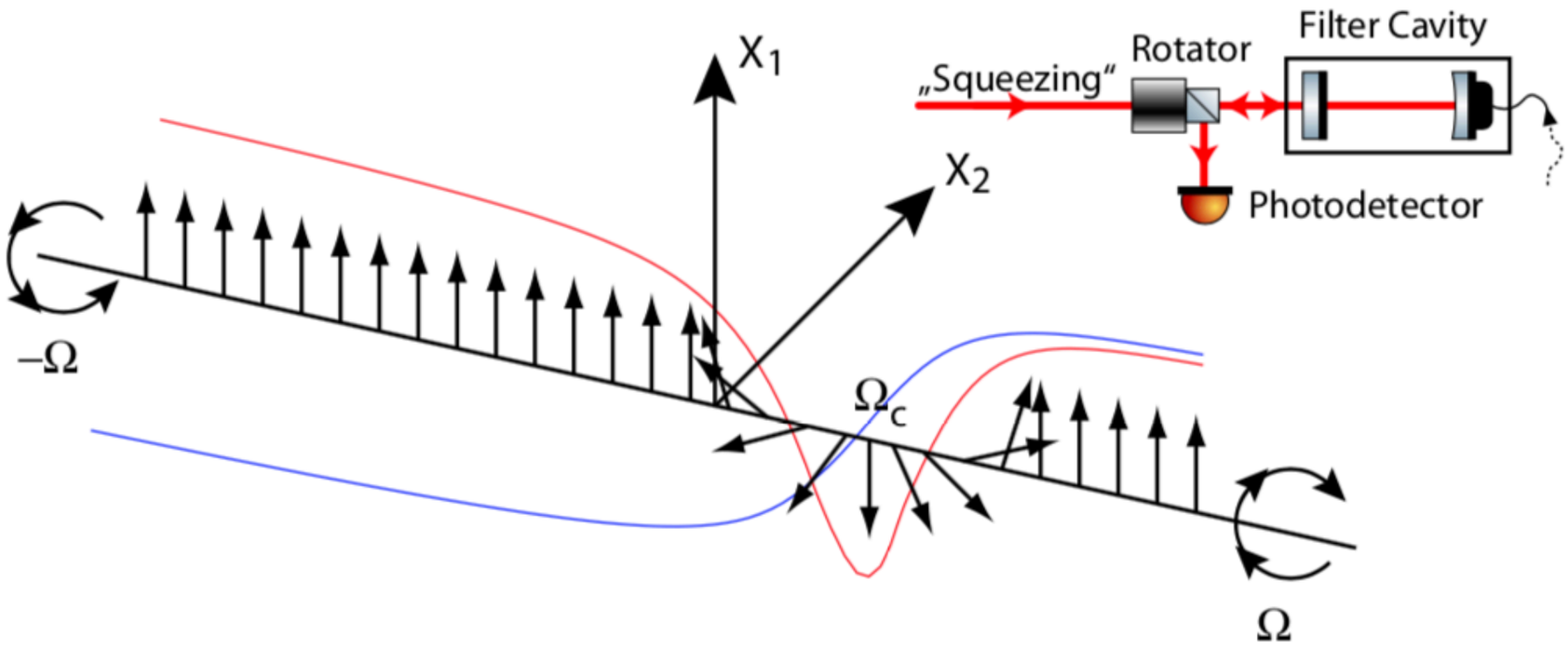
Illustration of squeezing from sideband picture



Reduction of quantum noise

Filter cavity

- Regulate the sideband amplitude and phase.
- The filter cavity performance is determined by the loss per unit length.



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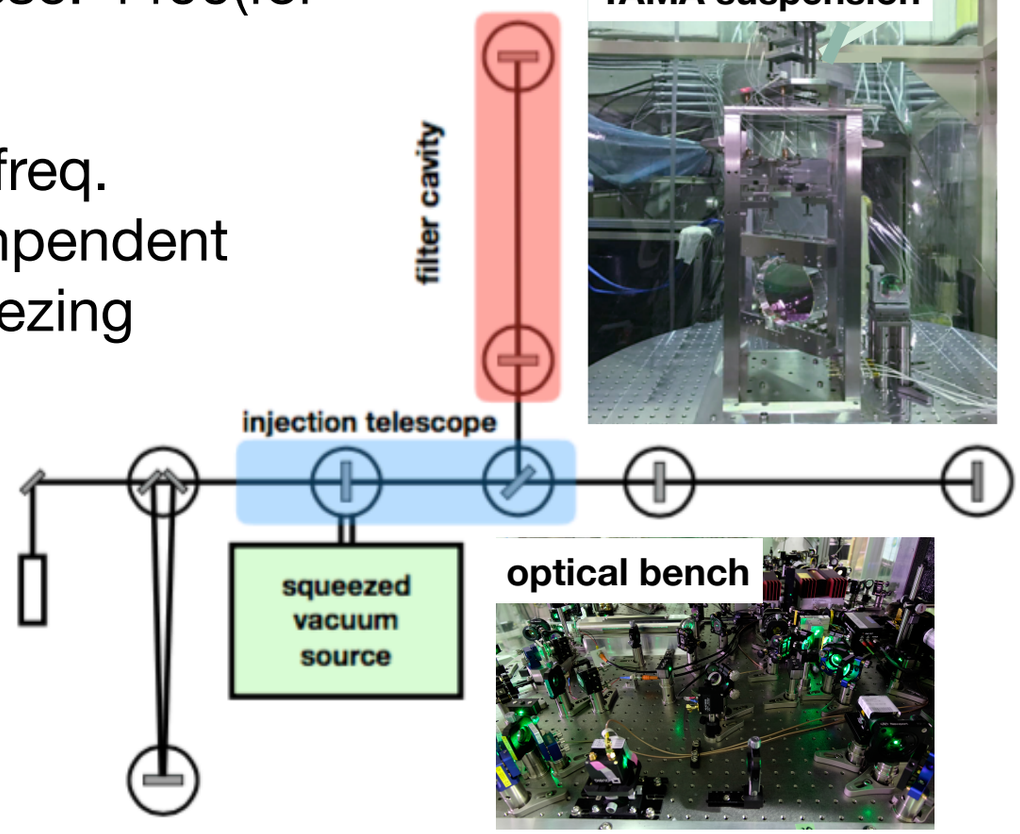
Overview

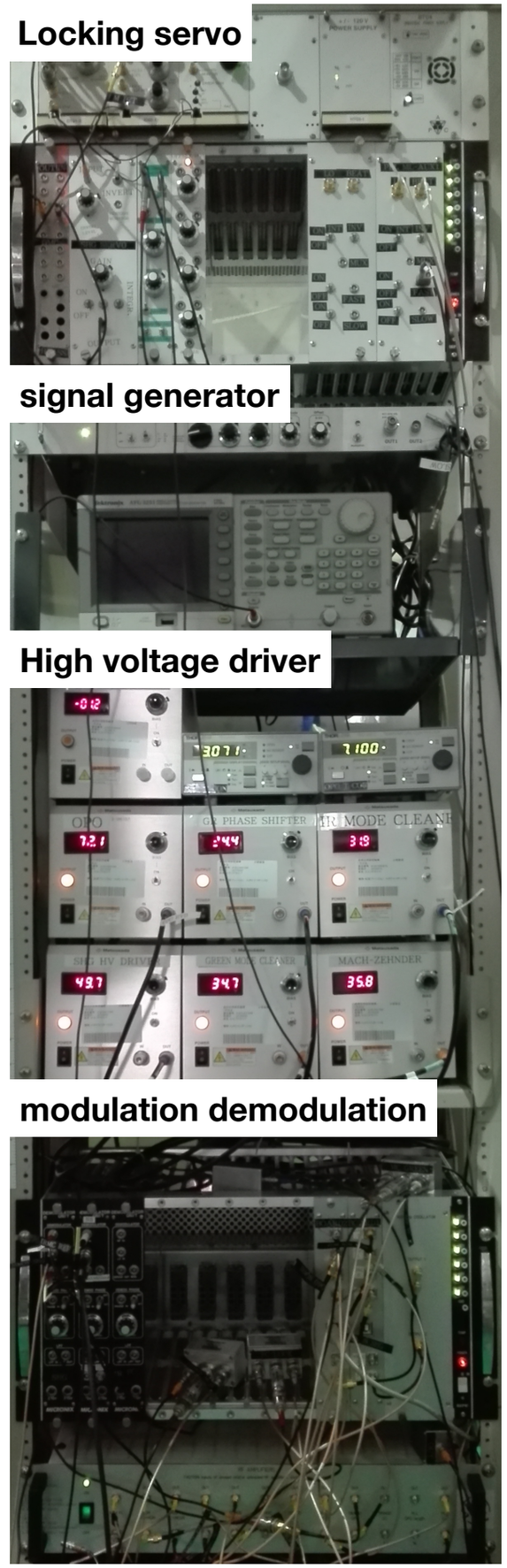
Goal: Full scale filter cavity prototype to demonstrate frequency dependent squeezing with rotation at 70Hz

- Cavity length: 300m
- Finesse: 4400(for IR)
- 9dB freq. indenpendent squeezing

TAMA central building



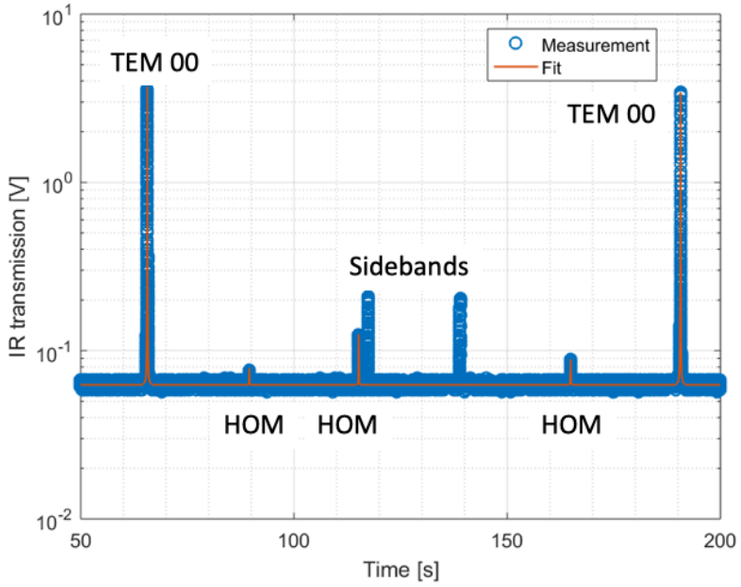
TAMA top view



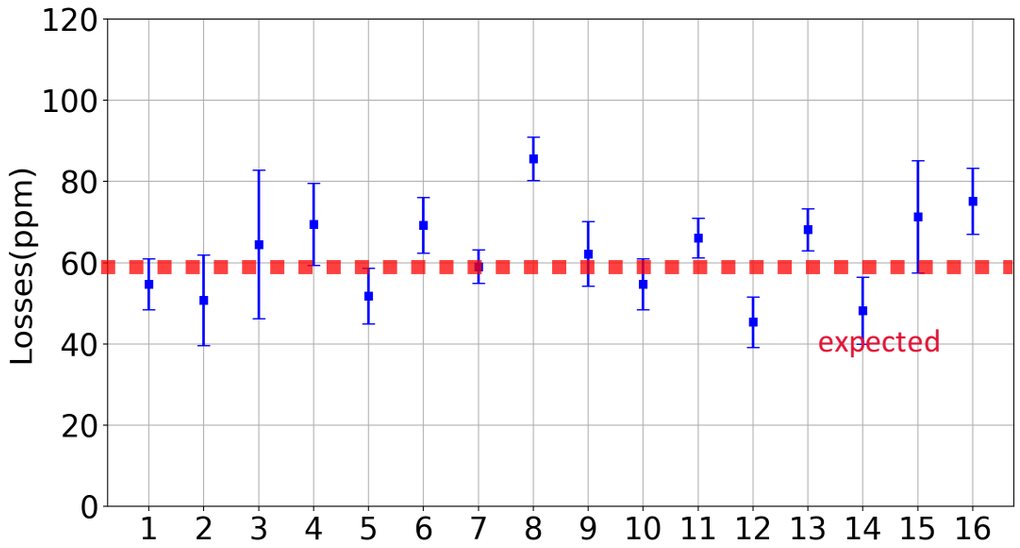
Electronic rack

Filter cavity

- Filter cavity operated with green and IR both locked on resonance.
- The mode matching is around 96%.



- The losses are around 0.2ppm/m.



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Measurement of optical losses in a high-finesse 300 m filter cavity for broadband quantum noise reduction in gravitational-wave detectors

Eleonora Capocasa,[1,2,*] Yuefan Guo,[3] Marc Eisenmann,[4] Yuhang Zhao,[1,5] Akihiro Tomura,[6] Koji Arai,[7] Yoichi Aso,[1] Manuel Marchiò,[1] Laurent Pinard,[8] Pierre Prat,[2] Kentaro Somiya,[9] Roman Schnabel,[10] Matteo Tacca,[11] Ryutaro Takahashi,[1] Daisuke Tatsumi,[1] Matteo Leonardi,[1] Matteo Barsuglia,[2] and Raffaele Flaminio[4,1]

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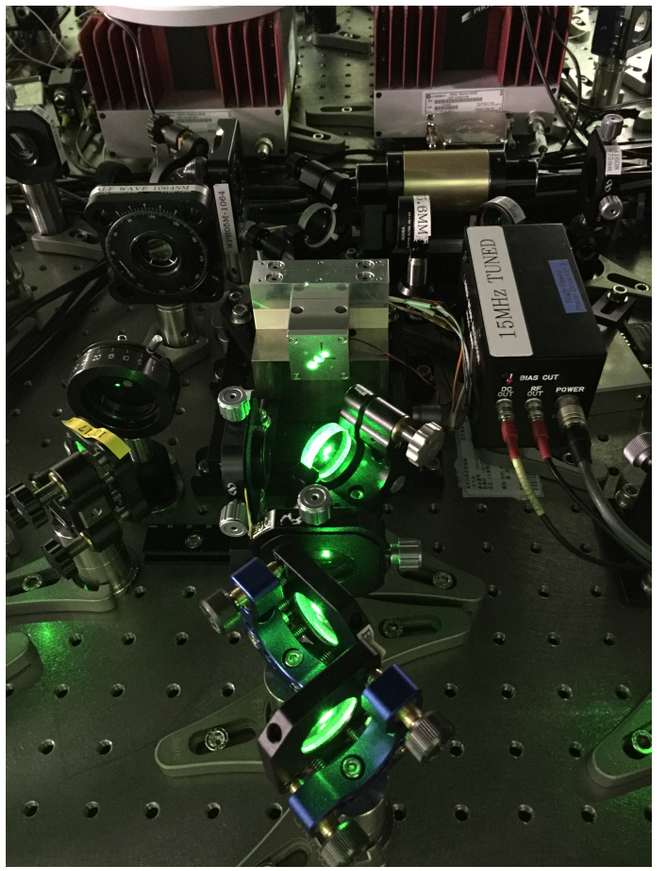
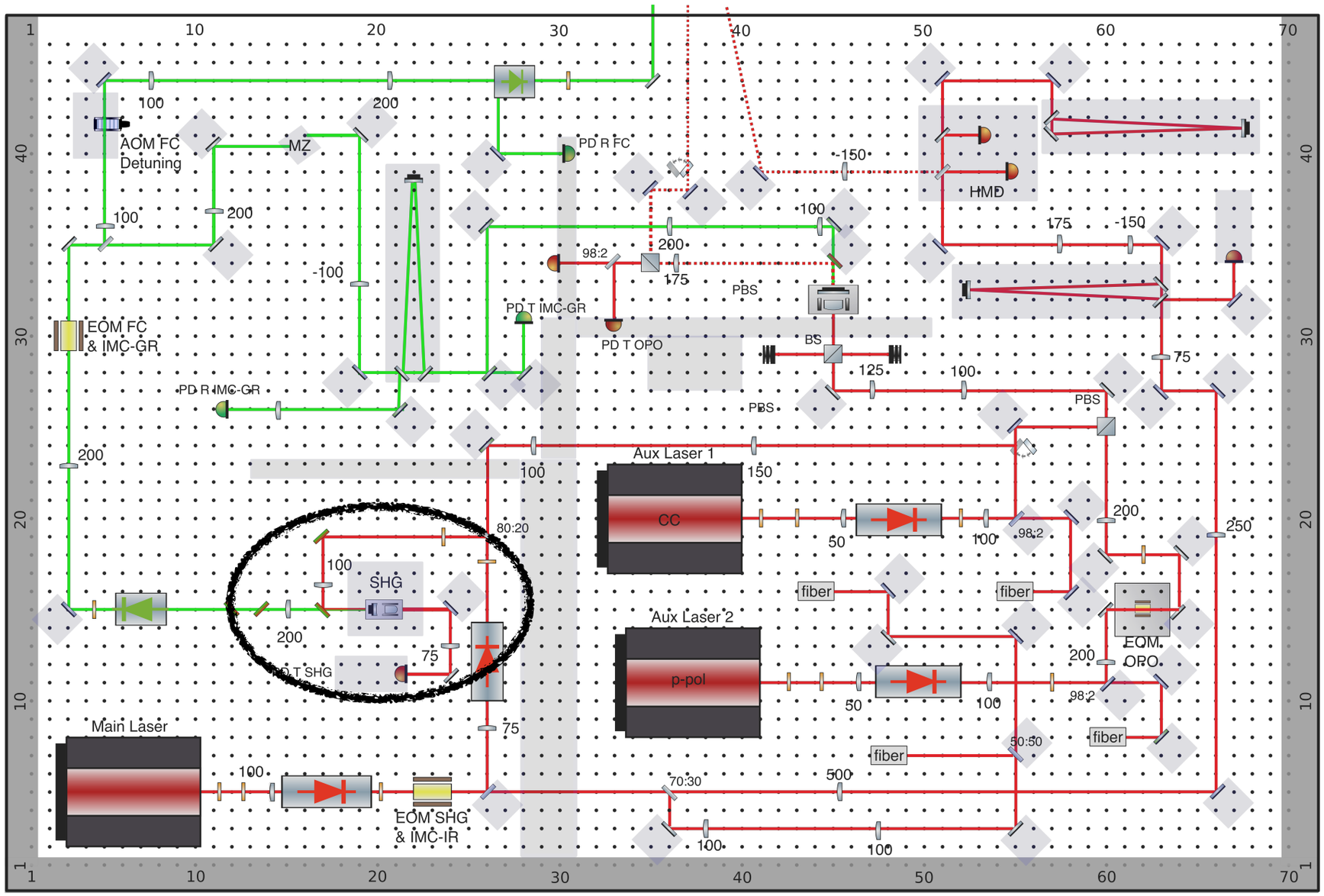
Optical layout

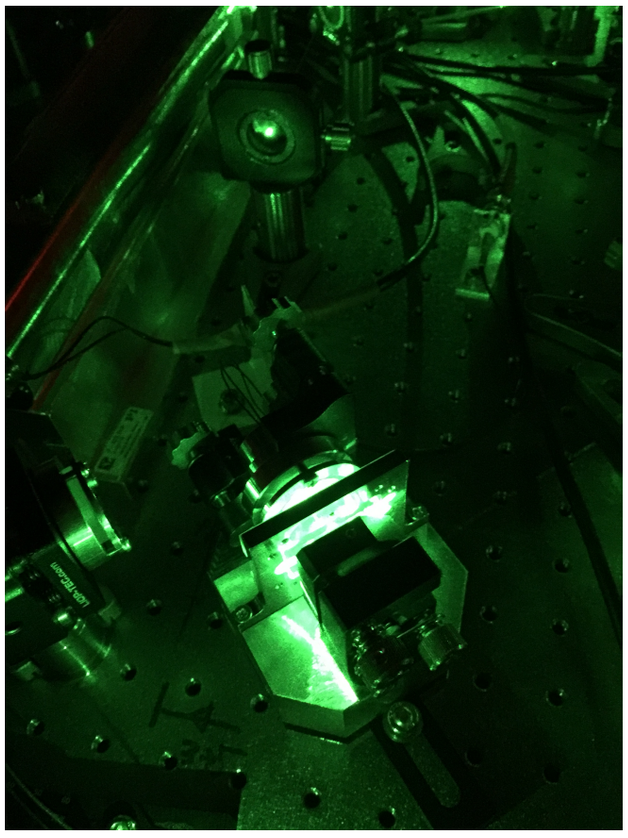


SHG improvement: green power of 267mW at maximum

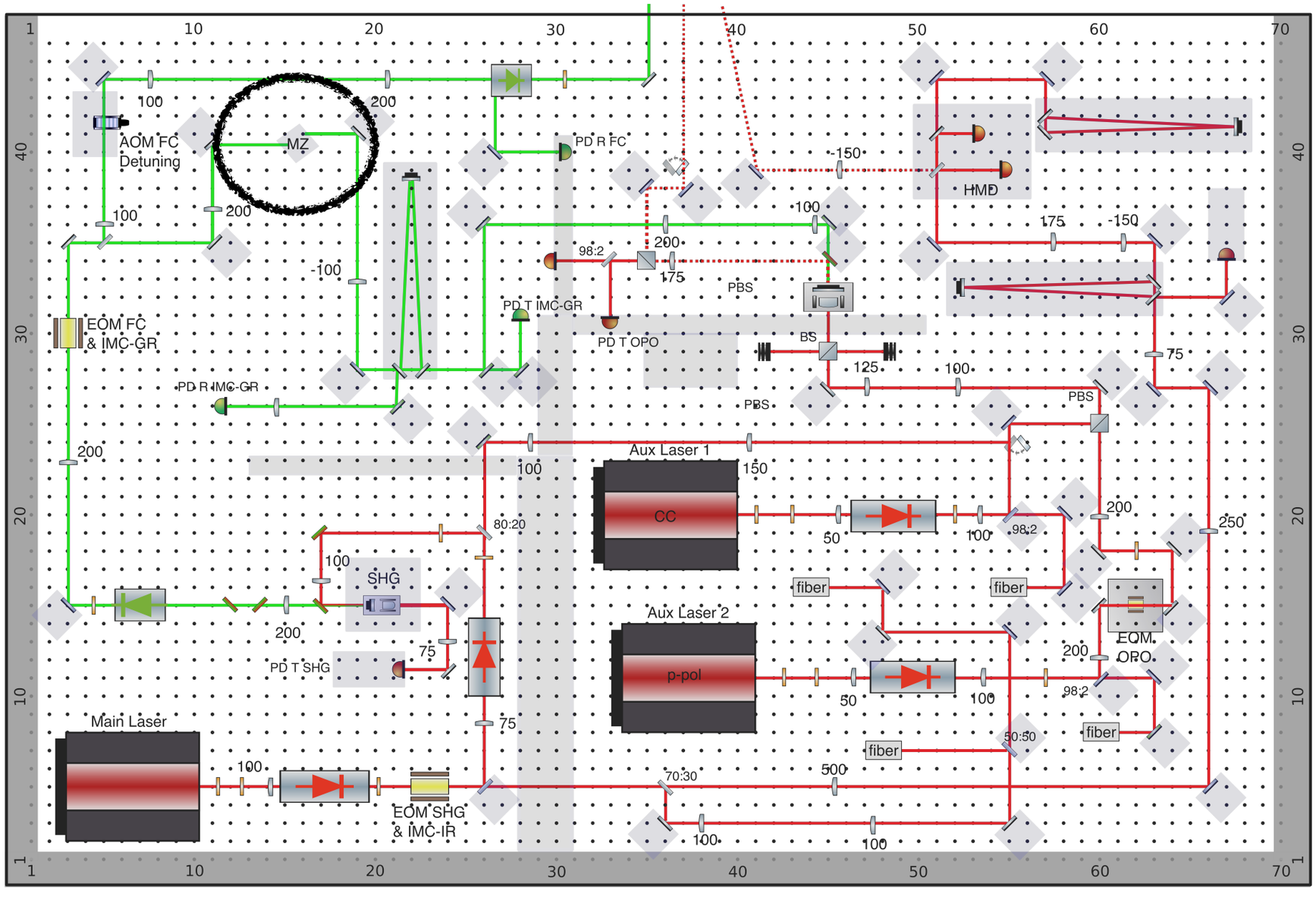


Details in Chienming's talk

Optical layout



Mach-Zehnder operating stably and has power fluctuation of 0.03%



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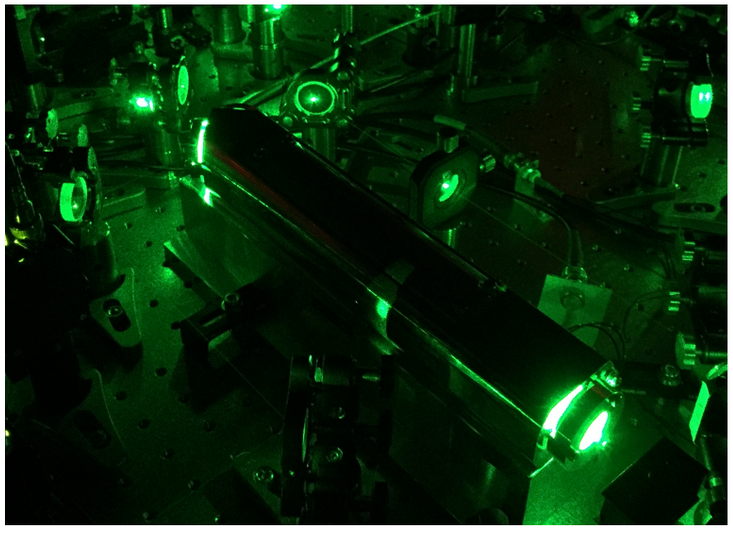
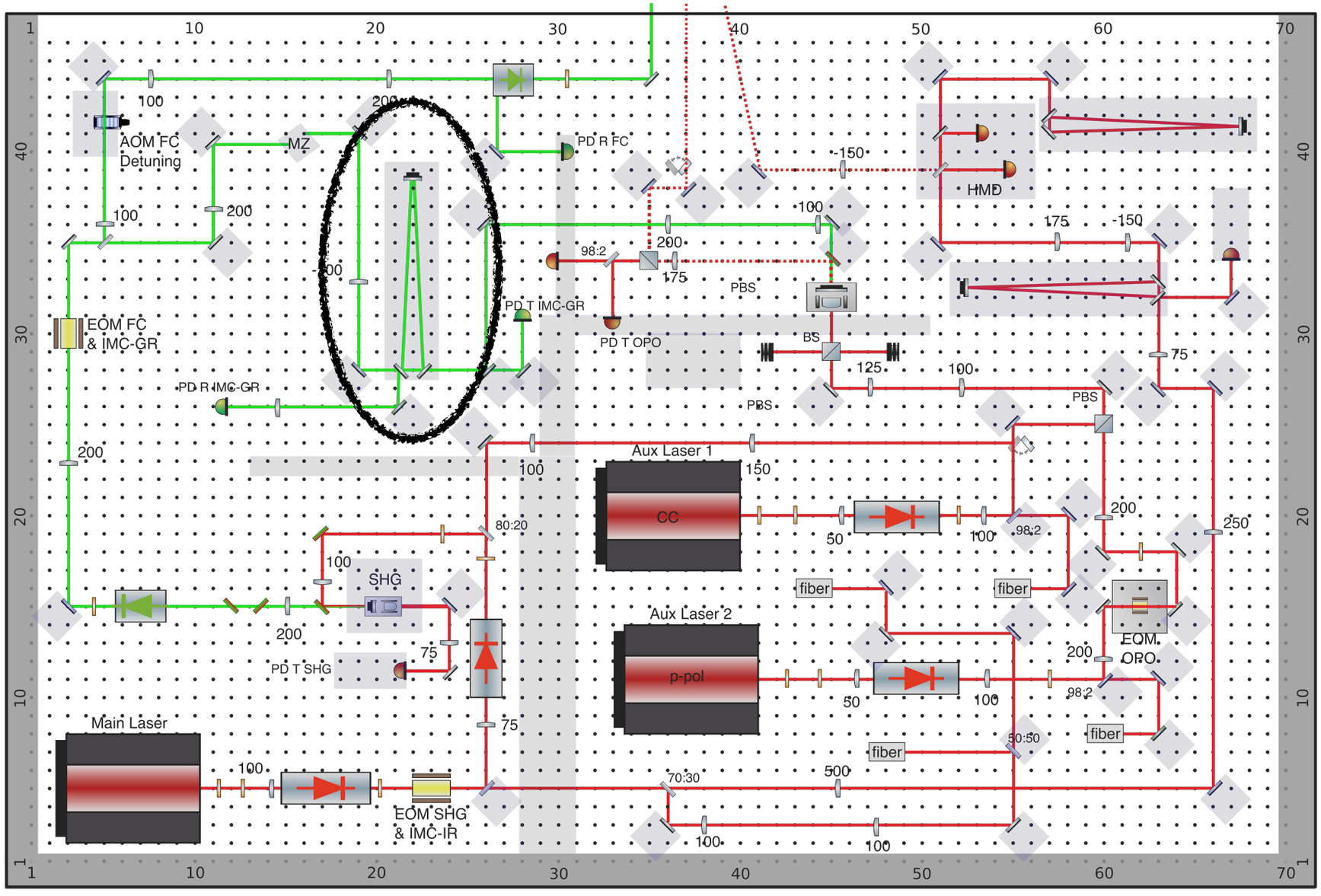


Green mode cleaner
operating with a transmission of 79%



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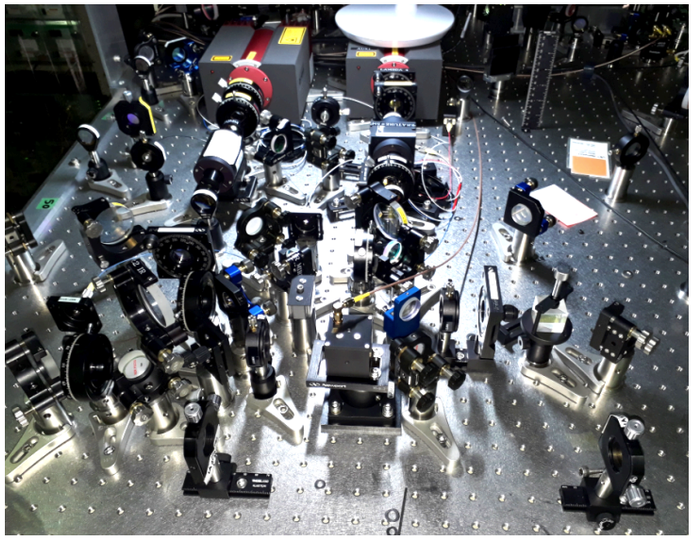
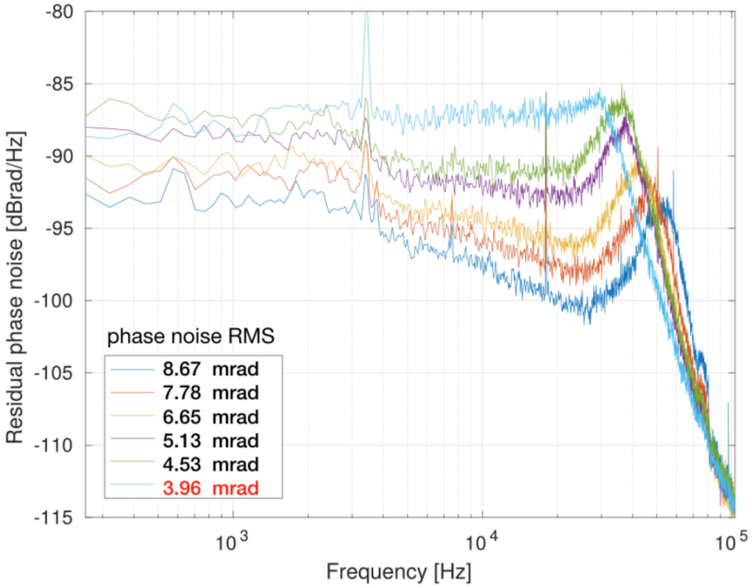
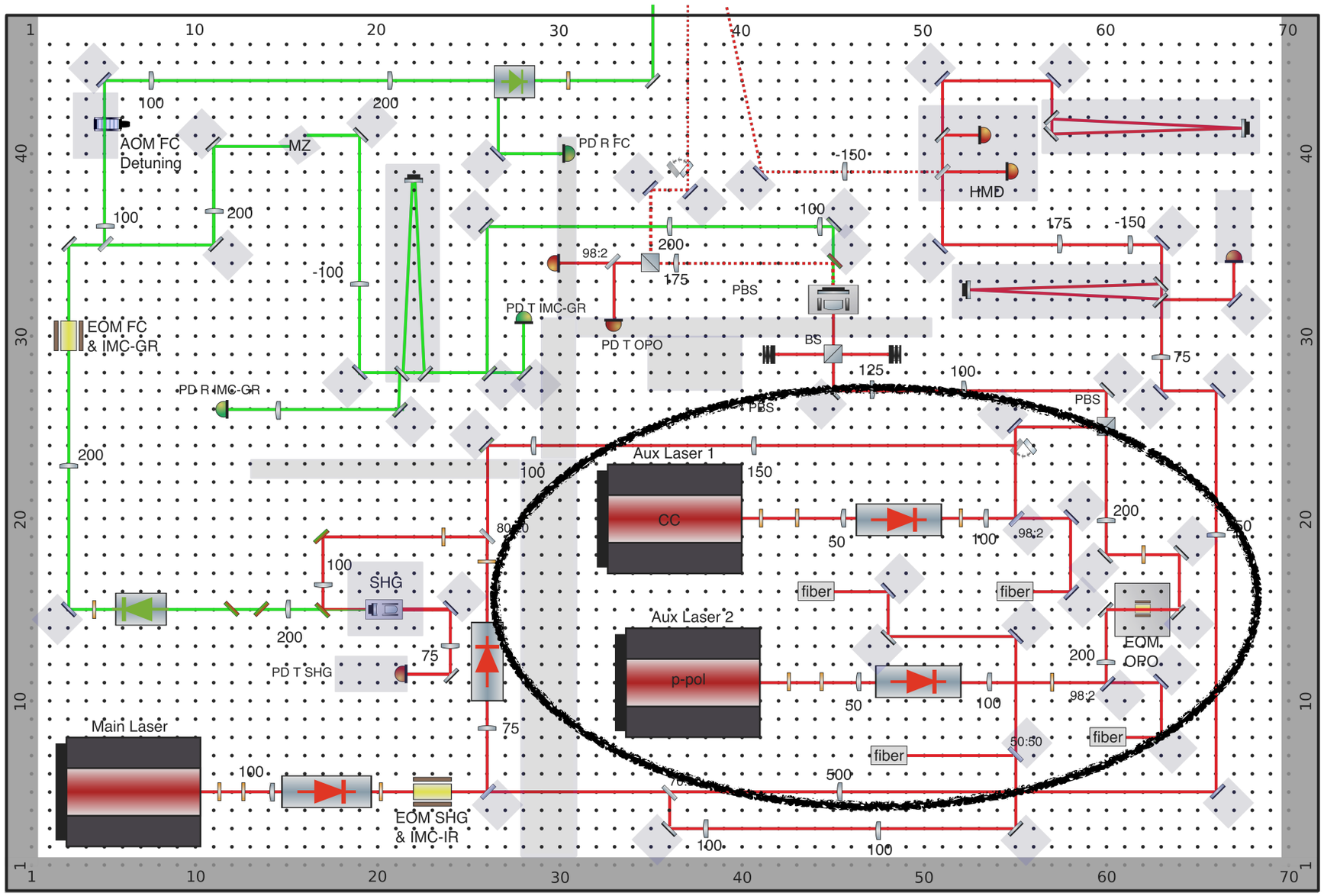


PLL can be locked up to 400MHz

contribution from visitor Marco Vardaro





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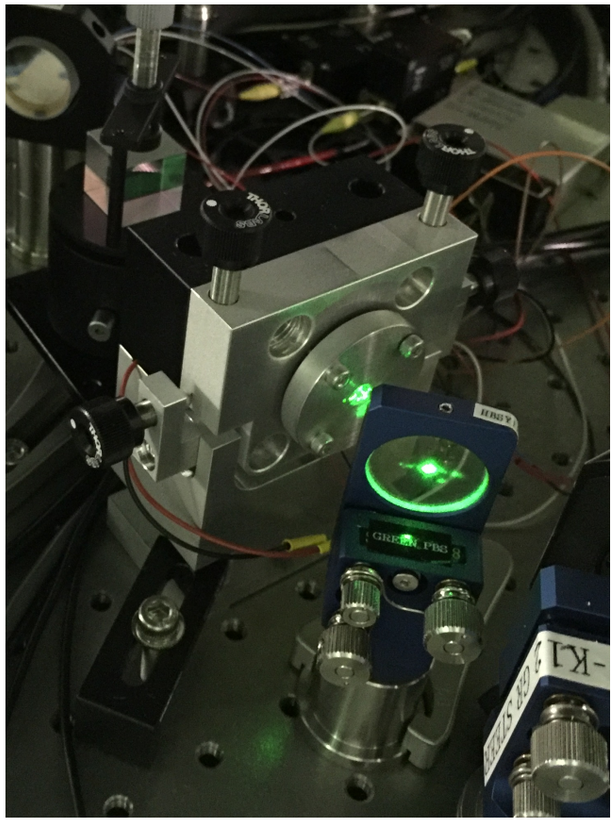
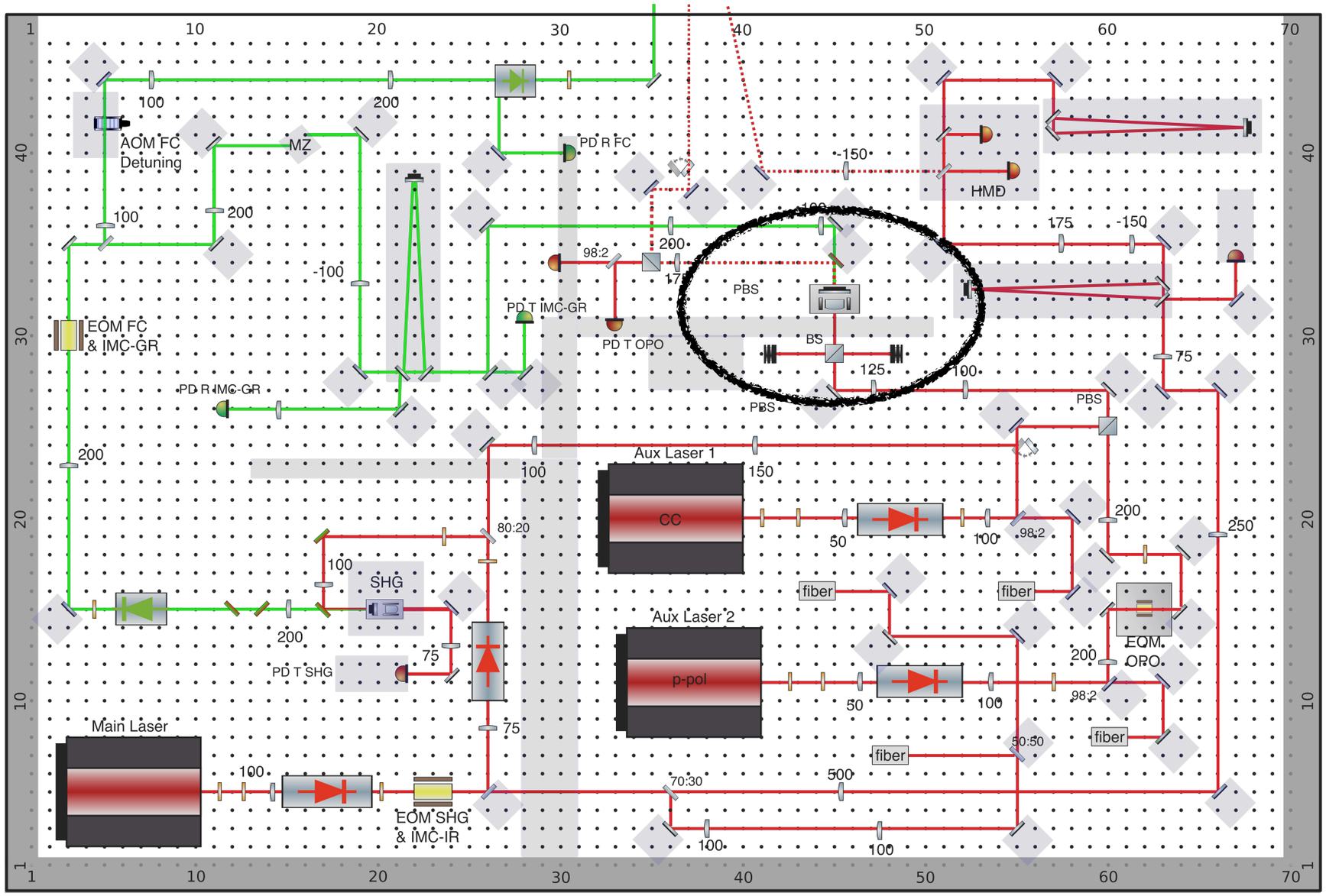


OPO installed, its pump threshold of 80mW.



Details in Chienming's talk

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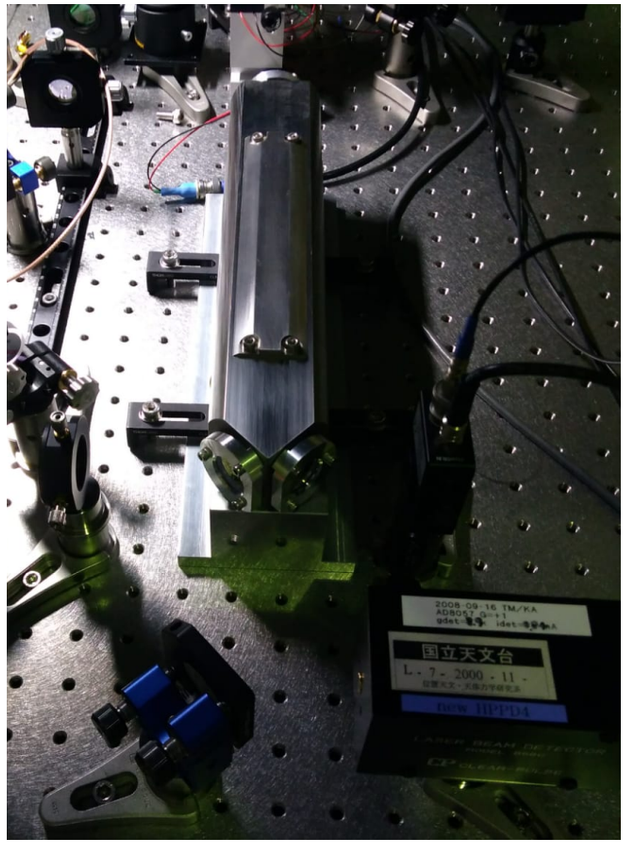
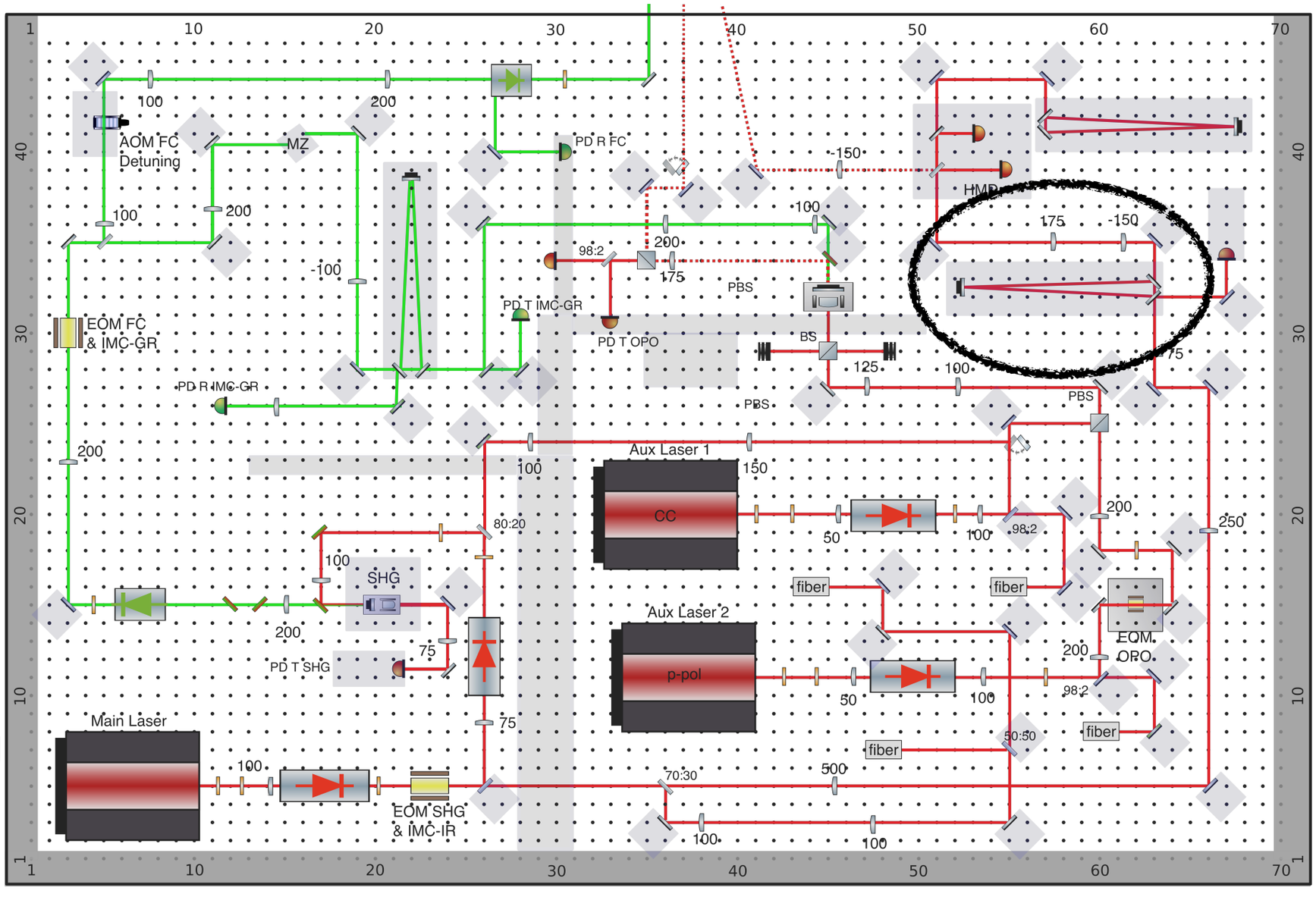
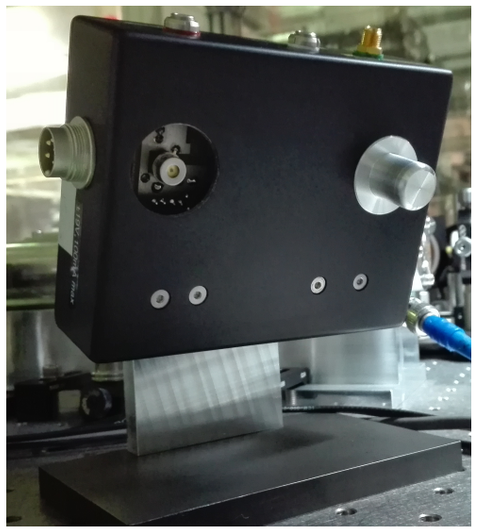


IR mode cleaner operating with transmission of 80%



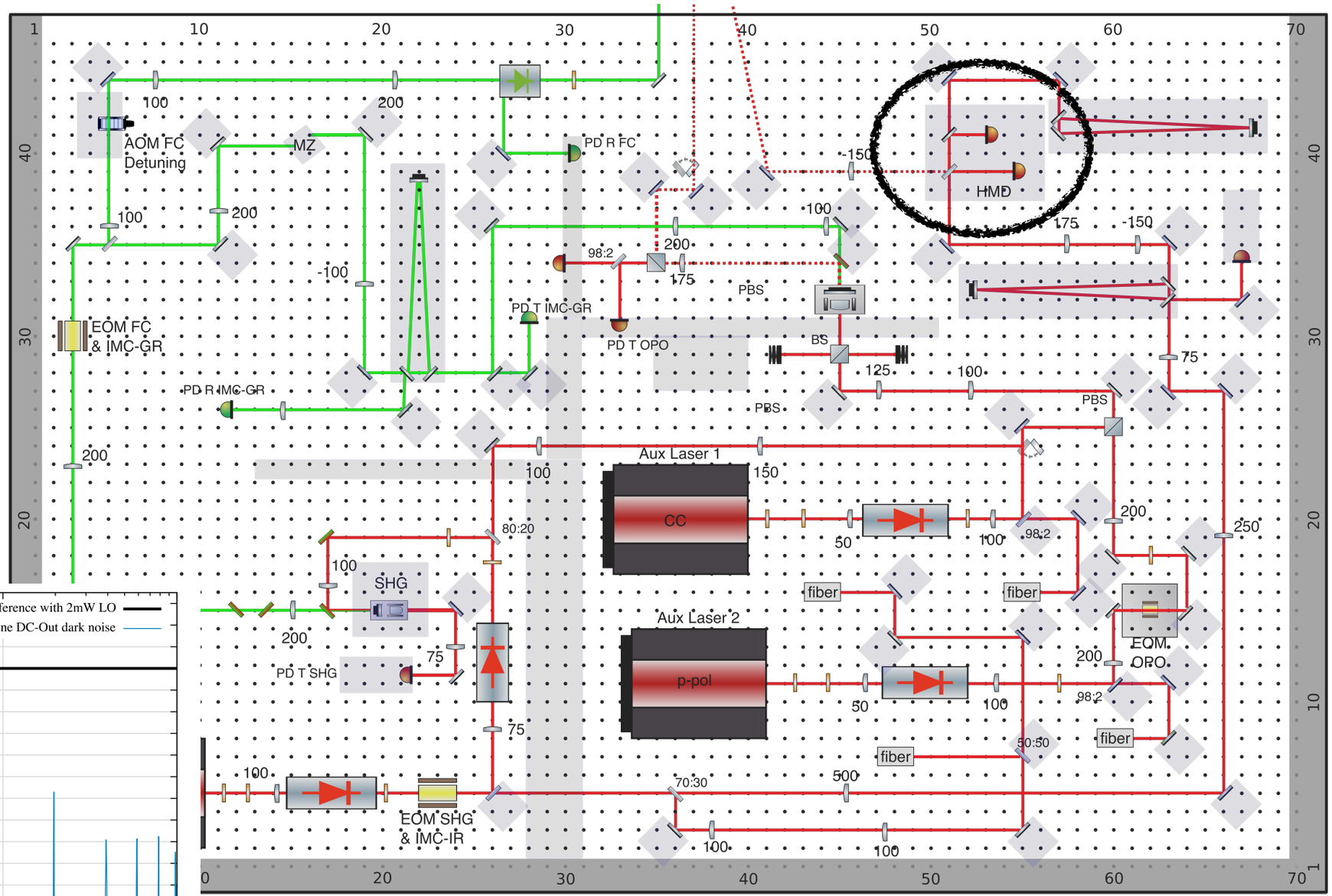
Optical layout

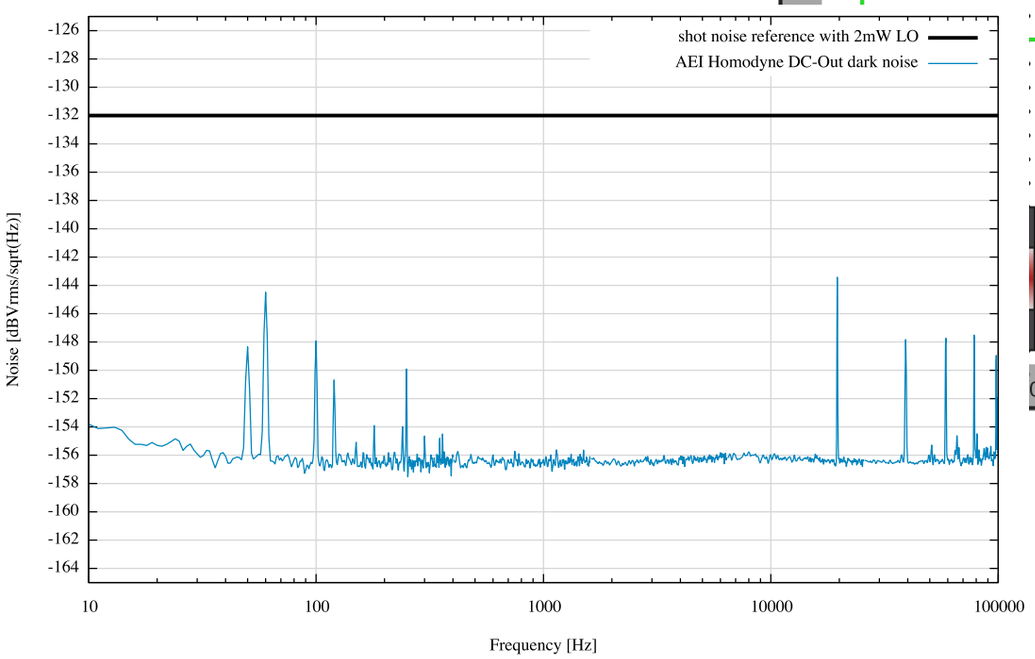


Homodyne detector

installed

provided by AEI





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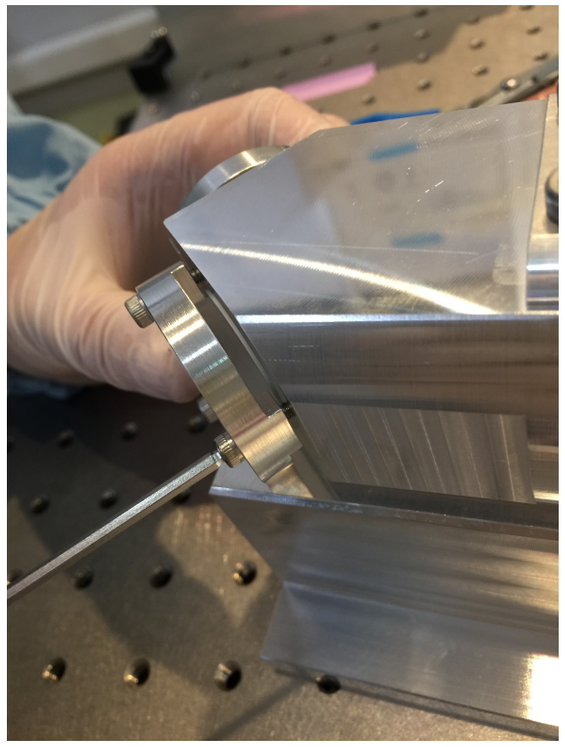
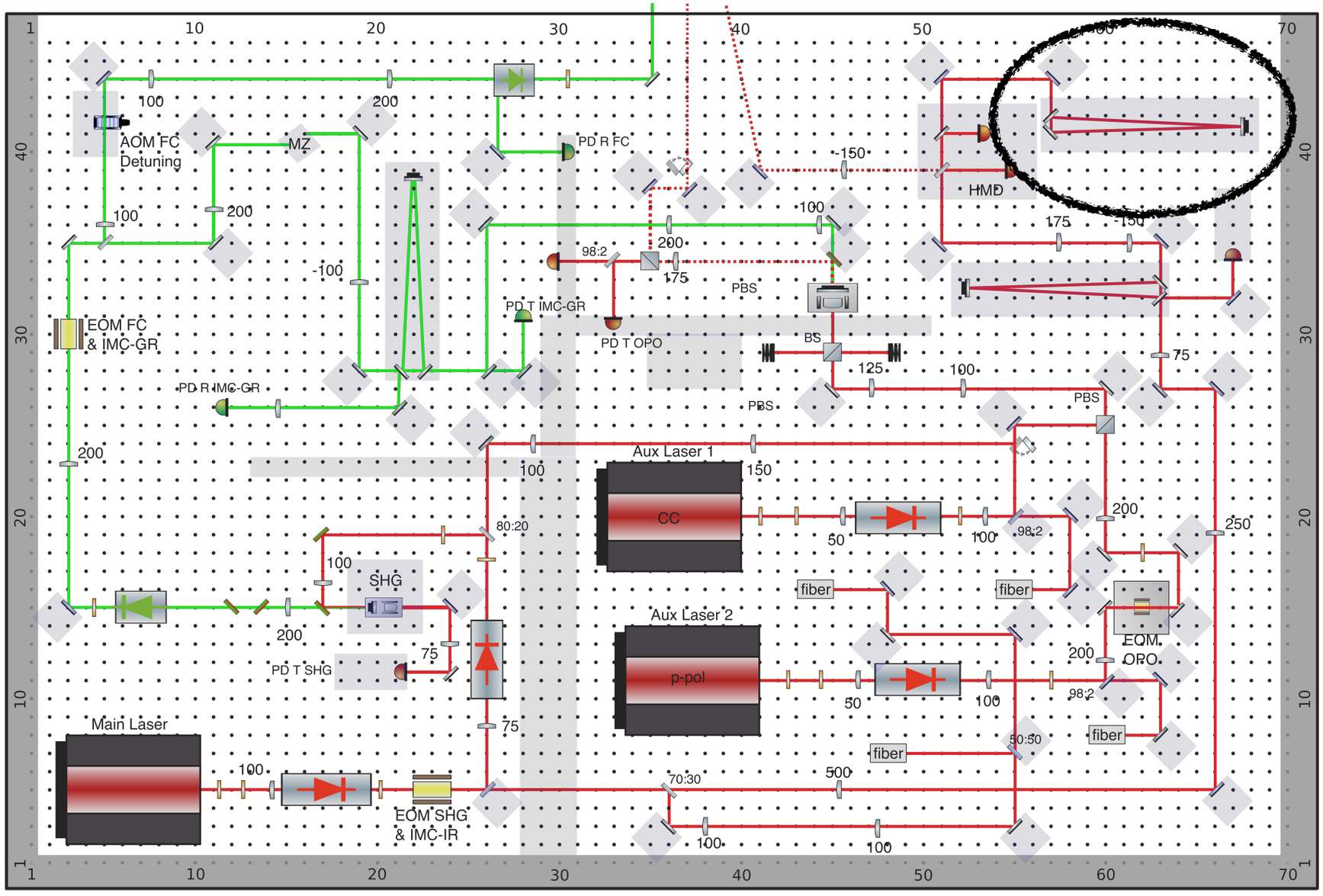


Alignment mode cleaner
assembled and alignment ongoing



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Summary

- Filter cavity is installed and characterized
- We are arriving the point to have frequency independent squeezing

Future

- Measure the frequency independent squeezing soon
- Inject frequency independent squeezing into filter cavity
- Applying auto-alignment system, new digital control system