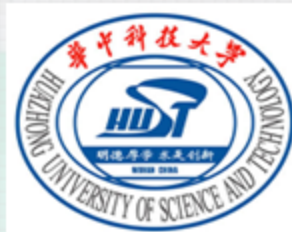


A large-scale passive laser gyroscope operated at 532 nm

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Jinpei Yao, Yawen Liu, Kui Liu, Zehuang lu, and Jie Zhang**



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of Physics, Huazhong University of Science &
Technology, P. R. China





HUST

HUST



CGE (Center for Gravitational Experiments)

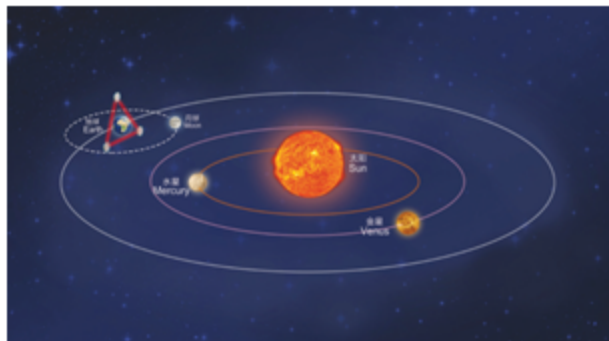


- **Background**
- **Design and realization**
- **Preliminary results**
- **Summary**

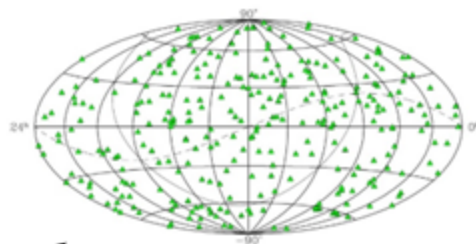
Background



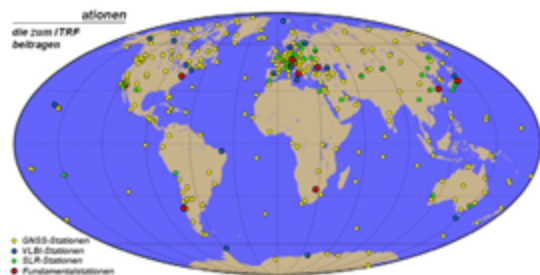
TianQin mission



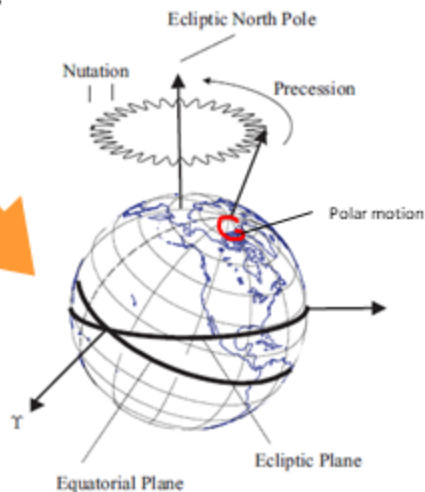
Celestial reference frame



Earth reference frame



EOP parameter



Sagnac effect



Sagnac frequency

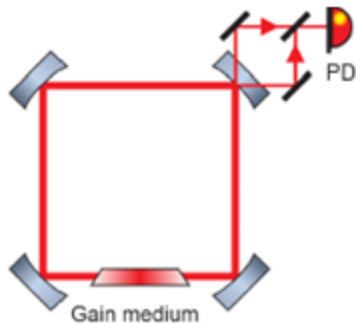
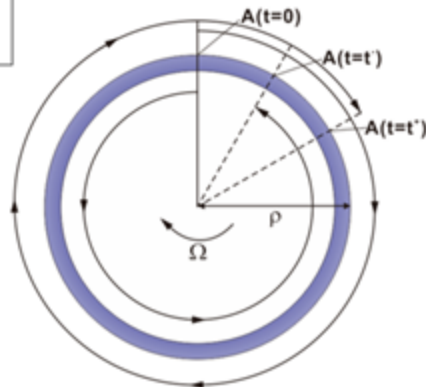
Area enclosed

Angle between rotation and gyro axes

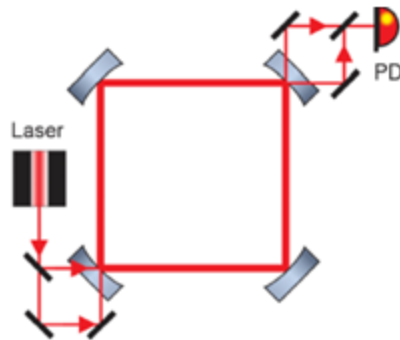
$$f_s = \frac{4A}{\lambda P} \Omega \cos \theta$$

Perimeter

(Earth) rotation rate



Ring Laser Gyroscope (RLG)

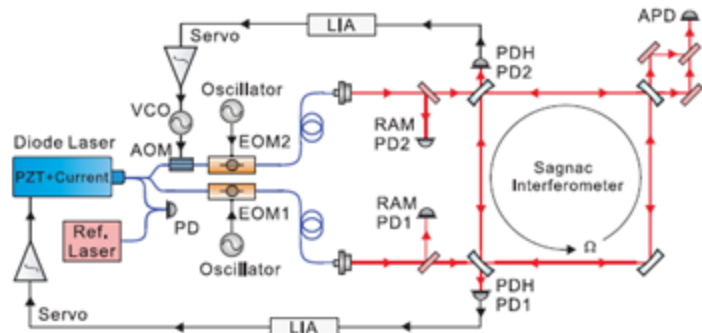
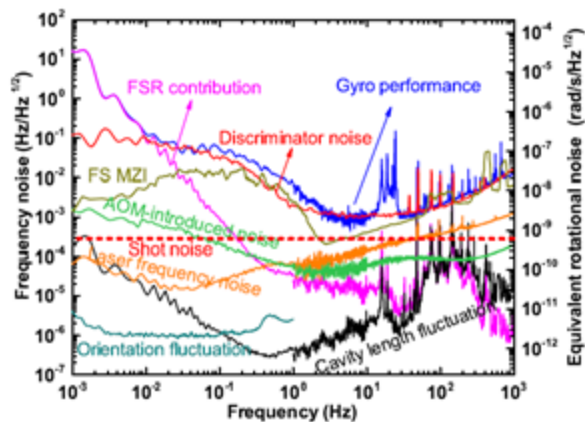


Passive Ring Gyroscope (PRG)

PRGs in our group (HUST-0)



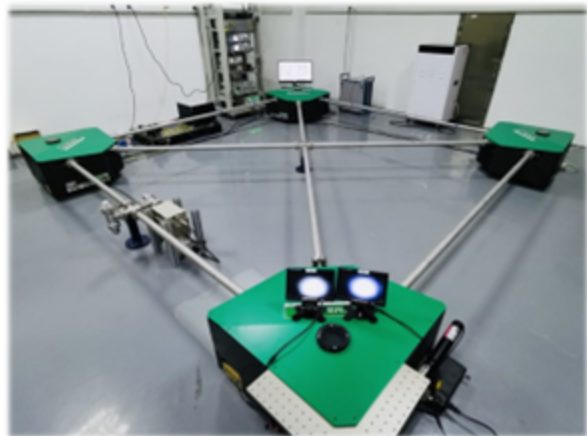
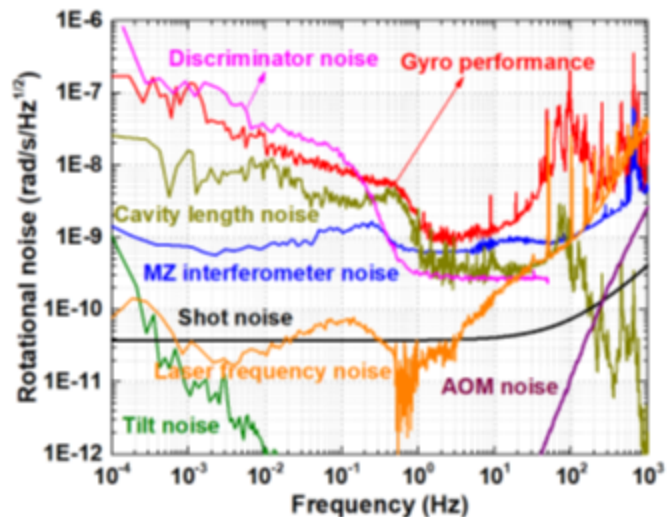
- Size: 1 m×1 m
- Wavelength: 1064 nm
- Sagnac frequency: 34.4 Hz
- Q-factor: 5.3×10^{11}
- Resolution: 2×10^{-9} rad/s@1000 s



PRGs in our group (HUST-1)



- Size: 3 m × 3 m
- Wavelength: 1064 nm
- Sagnac frequency: 104 Hz
- Q-factor: 1.2×10^{12}
- Resolution: 4×10^{-10} rad/s @ 10000 s



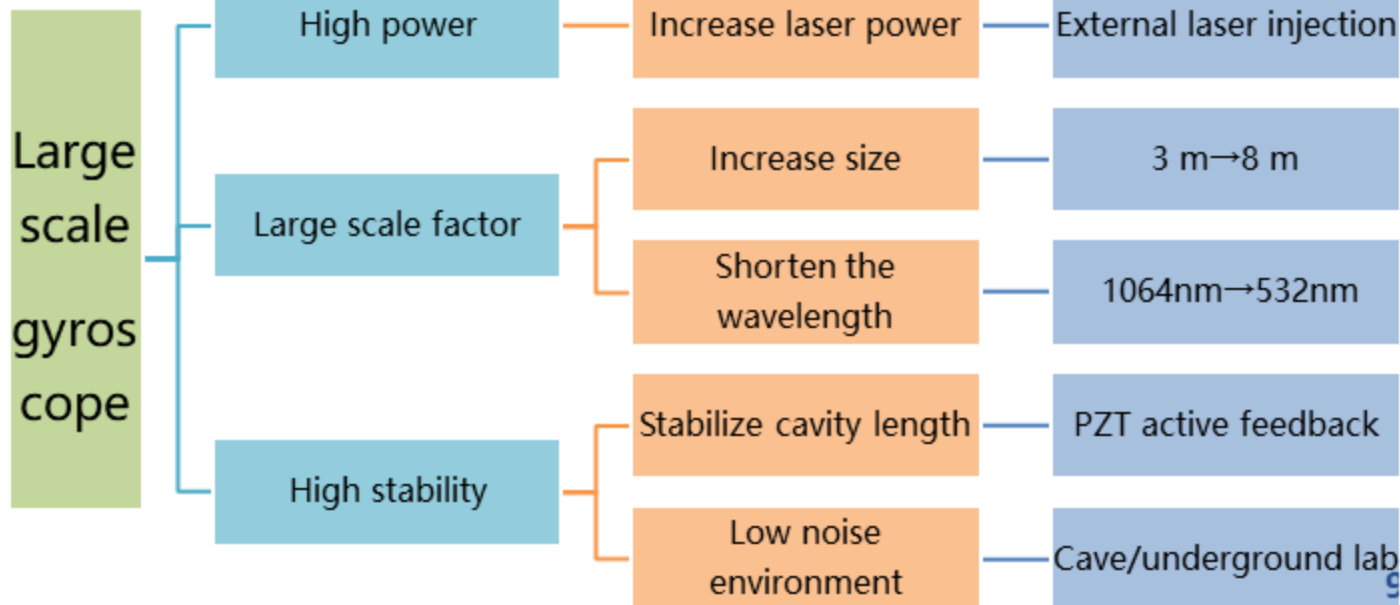
Idea of improvement for PRG



Shot-noise limit:

$$\delta\Omega = \frac{c\lambda}{4A\mathcal{F}} \sqrt{\frac{h\nu}{P_t}}$$

λ	532 nm
A	64 m ²
Sagnac	557 Hz
\mathcal{F}	7.8×10^4
P_t	5 μ w
$\delta\Omega$	2×10^{-12} rad/s/Hz ^{1/2}



- Background
- **Design and realization**
- Preliminary results
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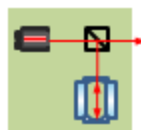
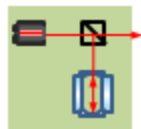
Cave lab



Gyro Lab design

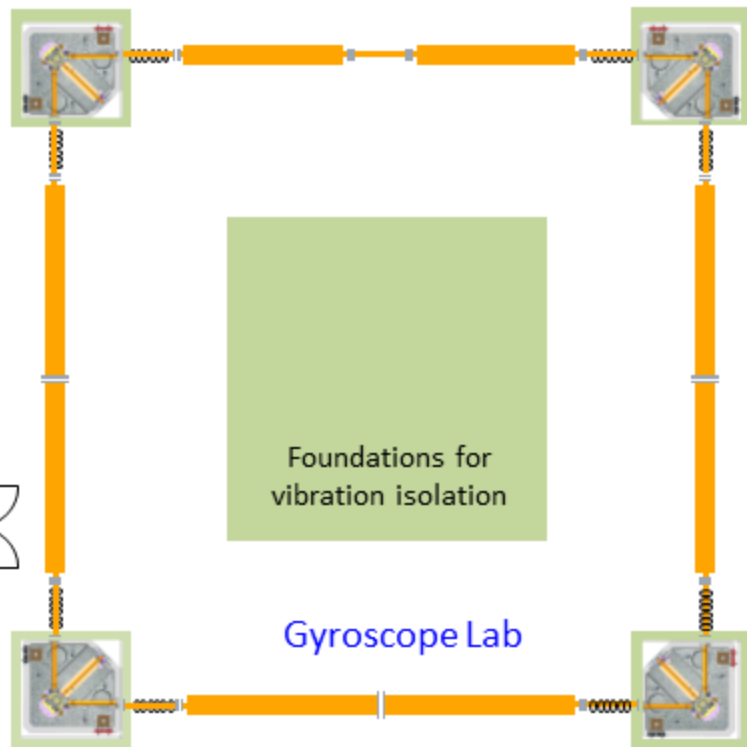


Ultra-stable lasers
+
H-maser signal
distribution



Preparation
room

Isolation
room

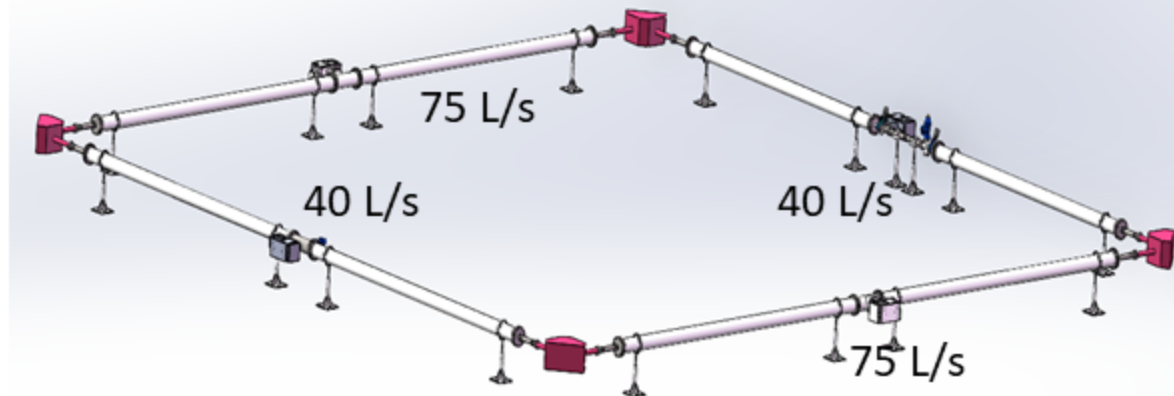


Gyroscope design



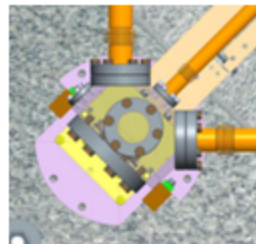
Vacuum

CF100 vacuum tube for better flow conduction



Vacuum level: 6×10^{-6} Pa

PZT



Piezo stage

Stroke: $80 \mu\text{m}$



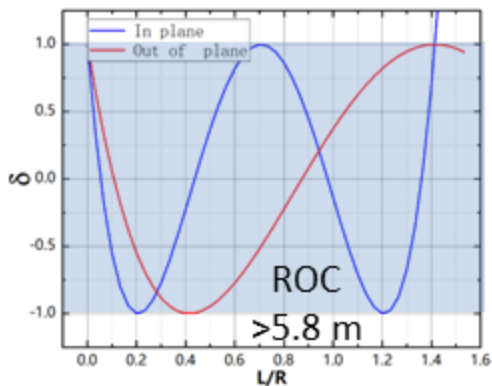
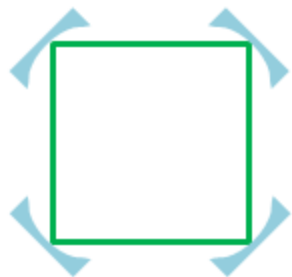
Stroke: $10 \mu\text{m}$

In-vacuum piezo

Mirror selection



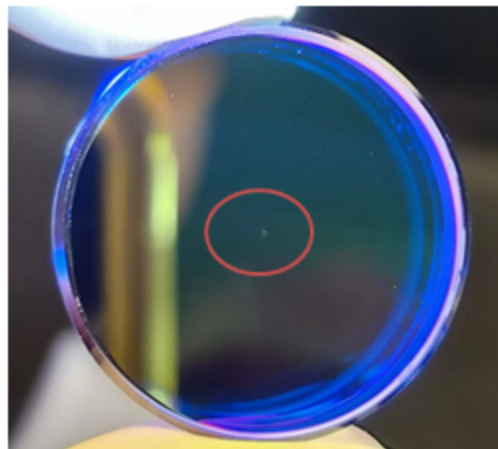
Radius of curvature selection



Diameter	25.4 mm
ROC	10.2 m
Coating	IBS
RMS	< 1 Å
Rs	> 0.99998 @45°@532 nm
Ts	~2 ppm
Beam size	4.5 mm ²

Check the coating

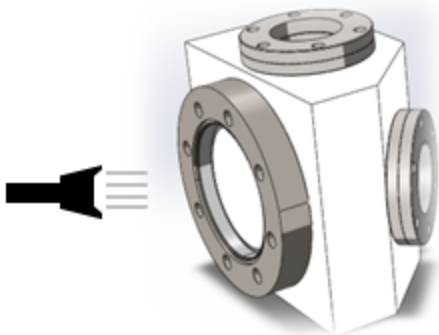
Flashlight



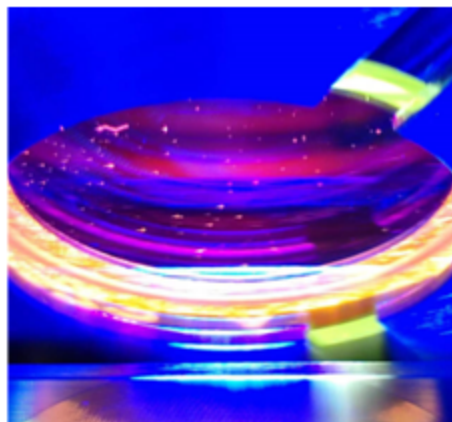
Mirror selection



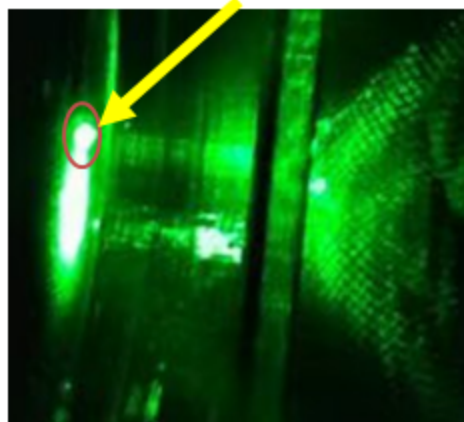
Check the mirror



Dusts on the mirror



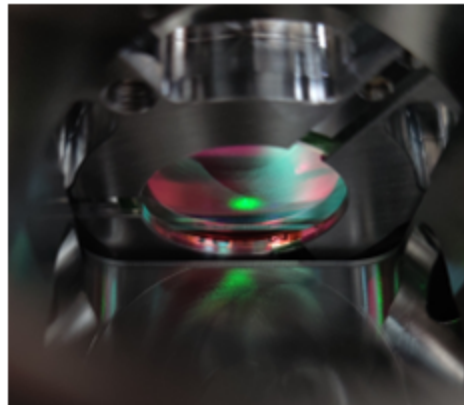
Scattering spot



Supermirror and its mount



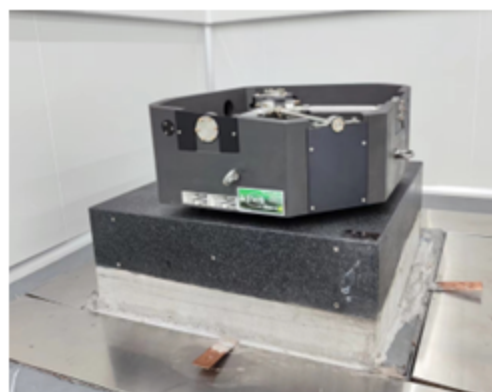
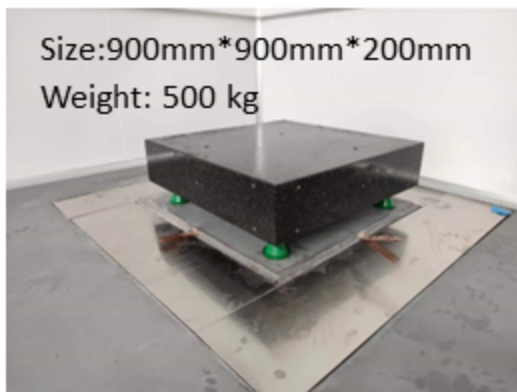
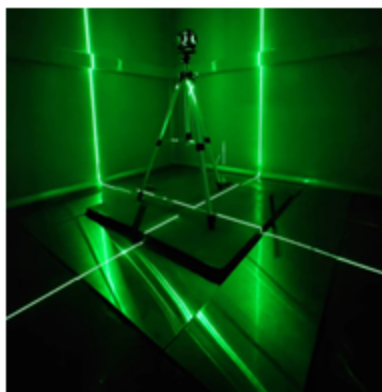
Resonant laser spot



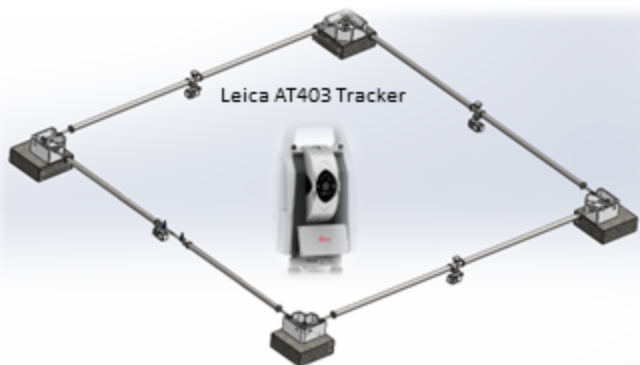
Construction of 8 m gyroscope



Marbled bases for corner boxes



Positioning of corner boxes

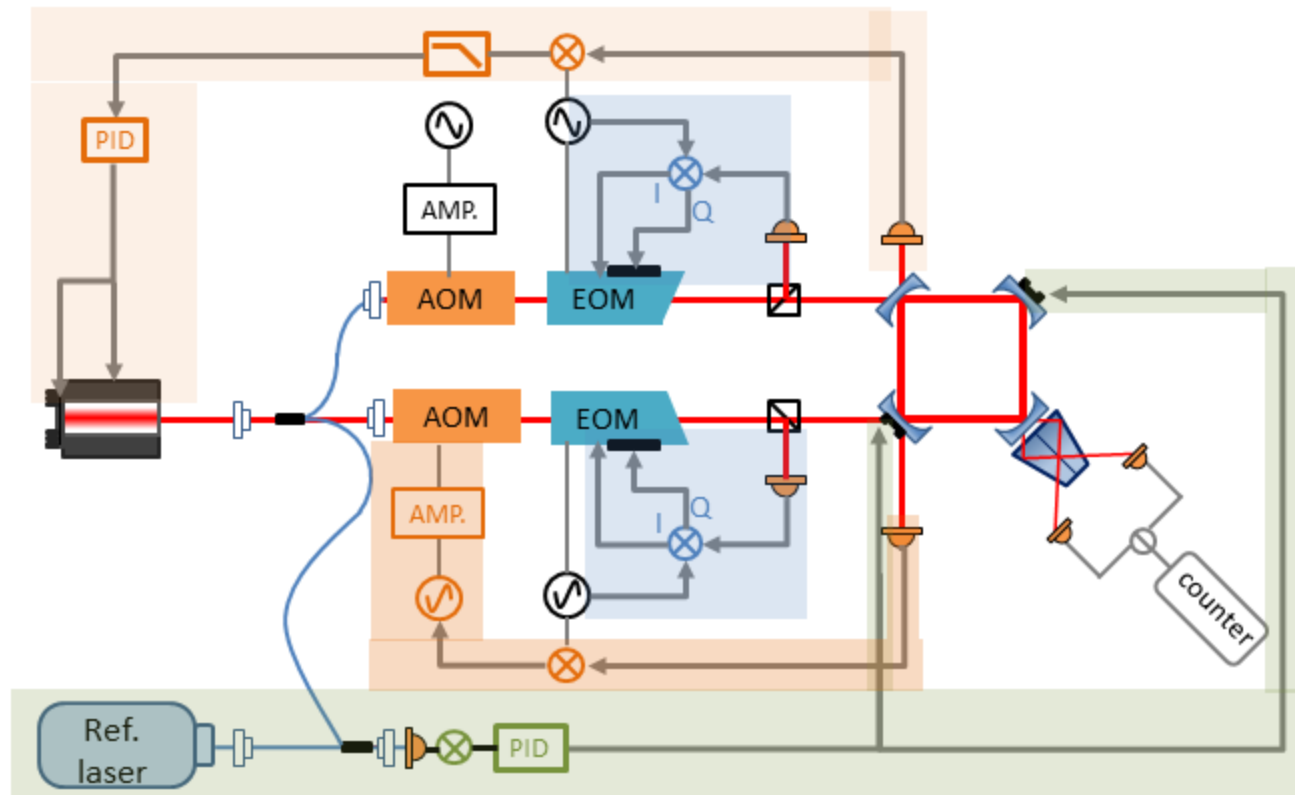


	length(mm)
Side-1	8005.40
Side-2	8005.71
Side-3	8005.31
Side-4	8005.76

Side length difference < 500 μ m

Relative length error < 1×10^{-5}

Experimental schematics

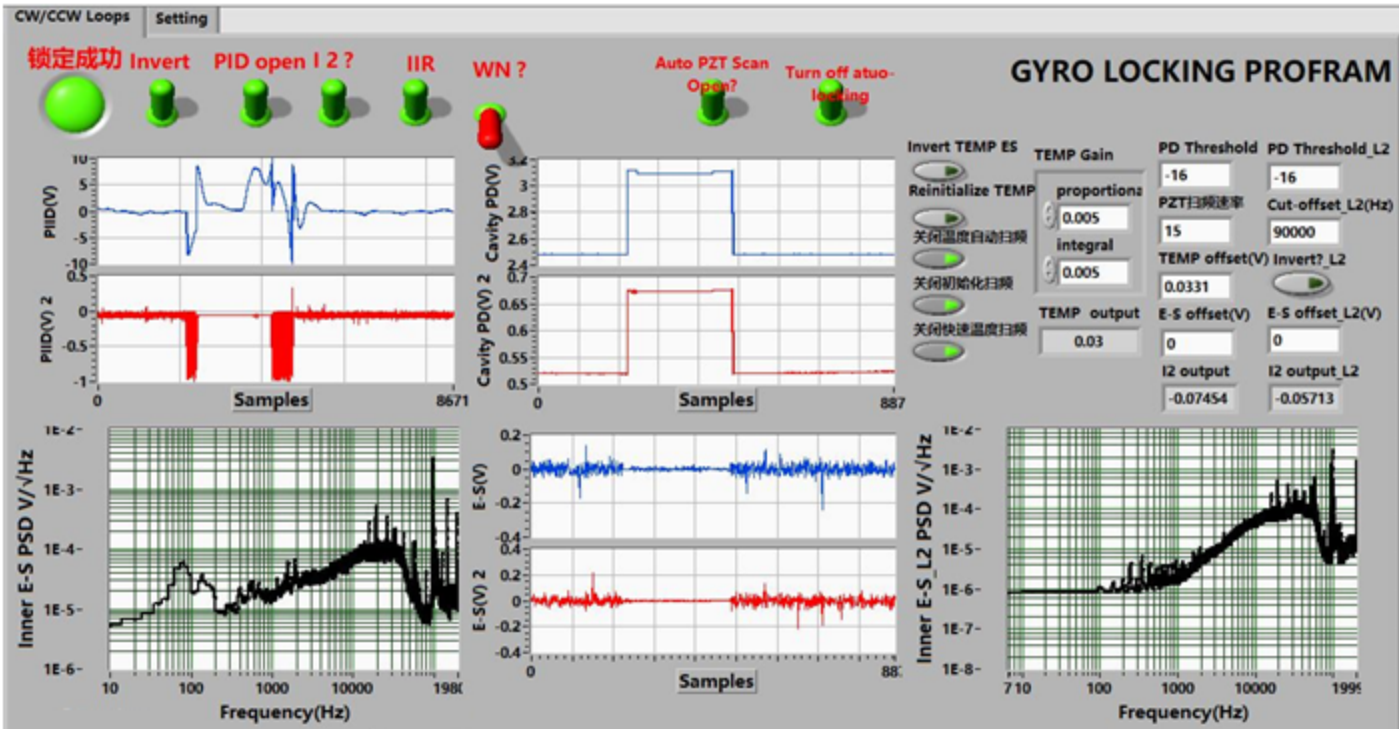


Laser frequency locking

Cavity length locking

RAM effect suppression

Digital locking system

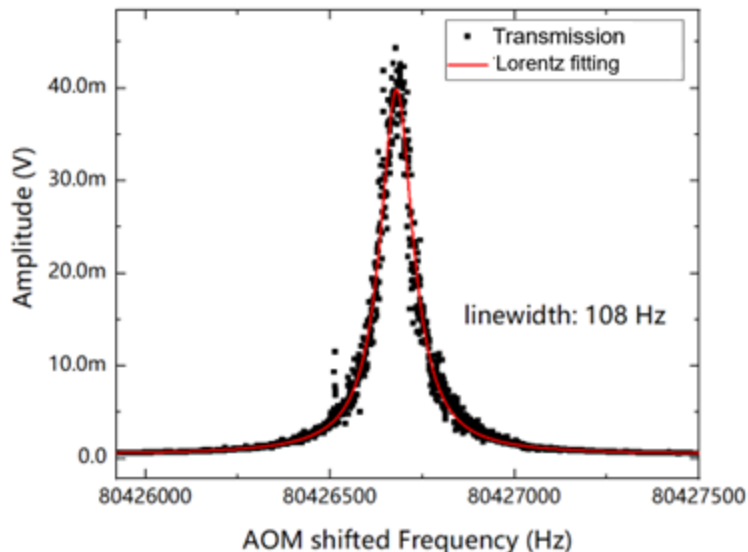
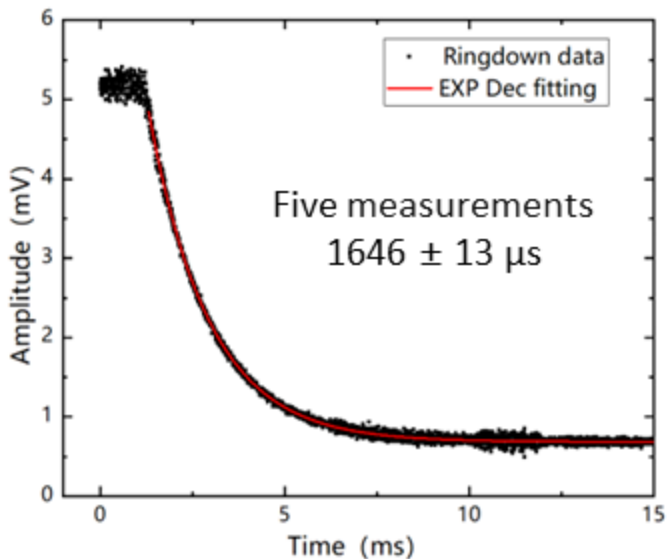


First operation



- Background
- Design and realization
- **Preliminary results**
- Summary

Finesse measurement



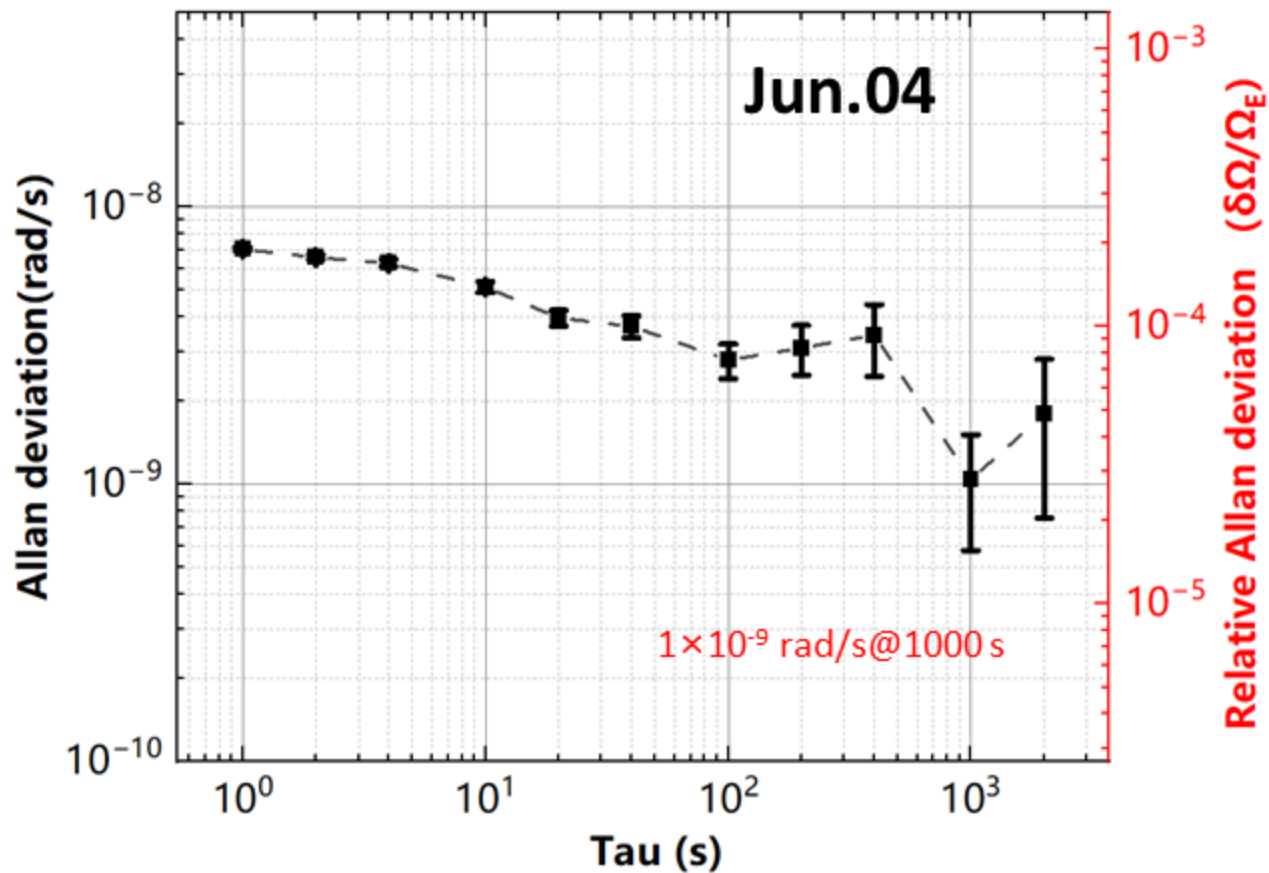
Finesse: $(9.7 \pm 0.7) \times 10^4$

Cavity linewidth: 96.7 ± 0.7 Hz

Q value: $(5.82 \pm 0.04) \times 10^{12}$

Reflectivity: 0.999983

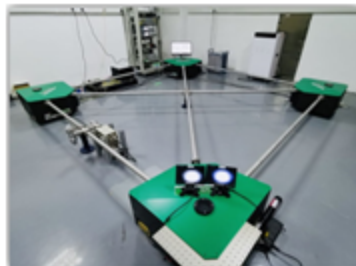
First result



- Optical cavity optimization
- Passive thermal shielding
- Active cavity length control
- RAM suppression
- Beam jitter
- Backscattering

- Background
- Design and realization
- Preliminary results
- **Summary**

HUST-1 Continuous operation a resolution of 4×10^{-10} rad/s

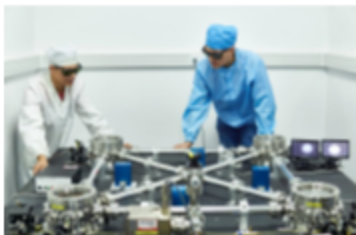


2019

2020~2022

2023

year




Prototype HUST-0
 2×10^{-9} rad/s



HUST-2
successfully closed loop

- Realize a 8 m×8 m passive gyroscope operated at 532nm
- Achieve a Q-factor of 5.8×10^{12} on a 8 m×8 m square cavity
- Achieve a preliminary rotational resolution of 1×10^{-9} rad/s@1000 s on the first run.

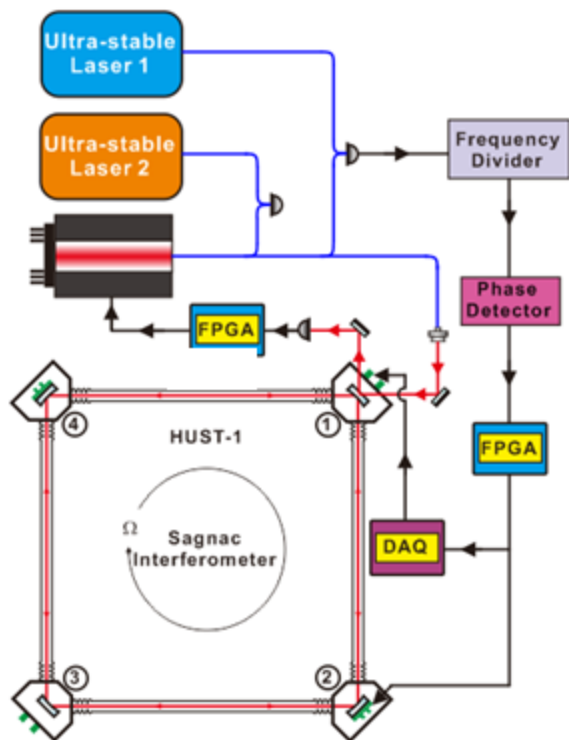
The background of the slide is a photograph of the interior of a space station, likely Skylab. It shows a large, open area with various pieces of equipment, including long, white, cylindrical structures that appear to be part of the station's infrastructure. The lighting is bright and even, typical of an indoor space environment.

Thank you!

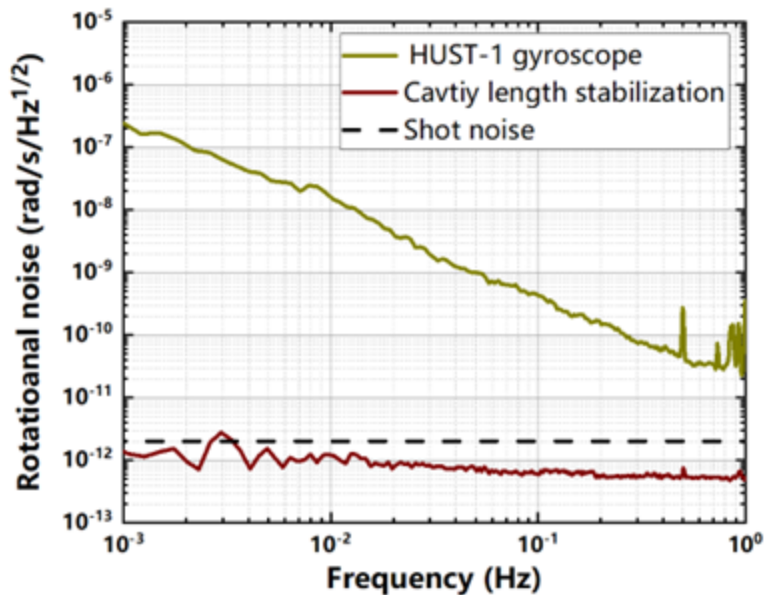
Active cavity length control



Experiment setup



Cavity length control results



Twin gyroscope in Zhuhai



Size	10 m \times 10 m
wavelength	532 nm
Sagnac	521 Hz
FSR	7.5 MHz

Tau	1.6 ms
Q factor	5.7×10^{12}
Trans. power	5 μ W
Shot noise	1.4×10^{12}

Comparison with HUST-1

