Concept and Current Status of Japan 4m RSE

March 2003 @Livingston
Kentaro Somiya

LIGO-G030110-00-Z

K.Somiya

Two Types of RSE Control Scheme

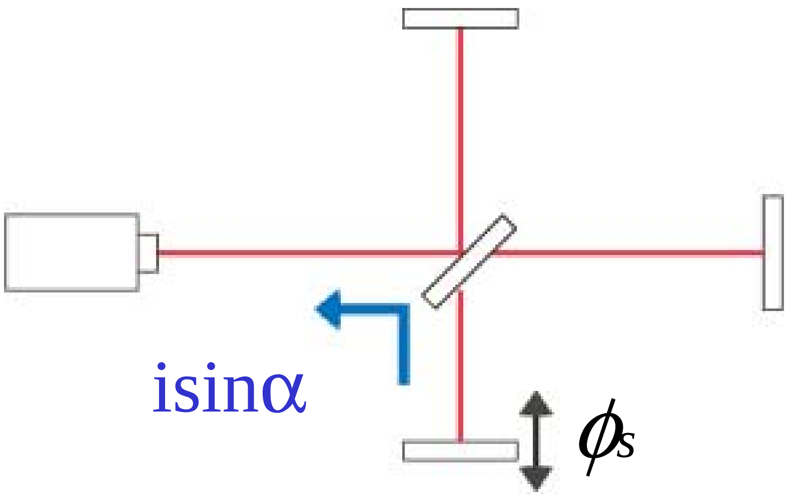
A couple of sidebands are used.

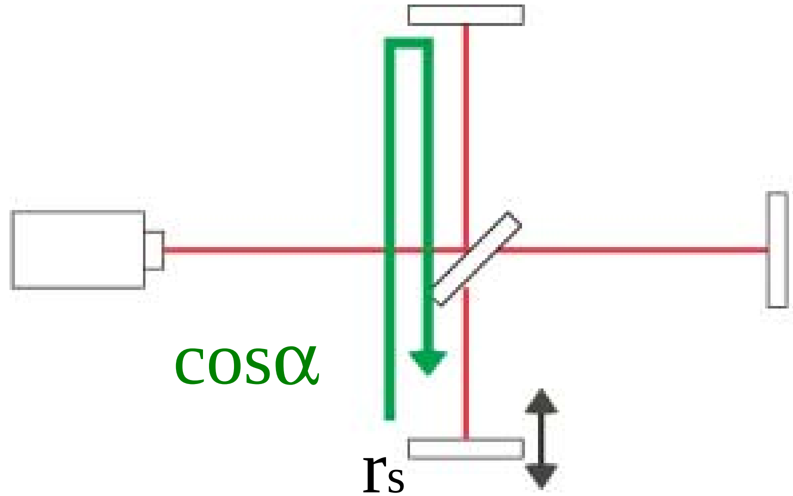
1) **Low/High Scheme : 9MHz and 180MHz**

2) **Low/Low Scheme : 9MHz and 18MHz**

For both method, asymmetry is optimized for ls signal.

Asymmetry Optimization for ls (obtained by SB)





$$l_s \approx \phi_s \times \text{transmittance of SRMI}$$

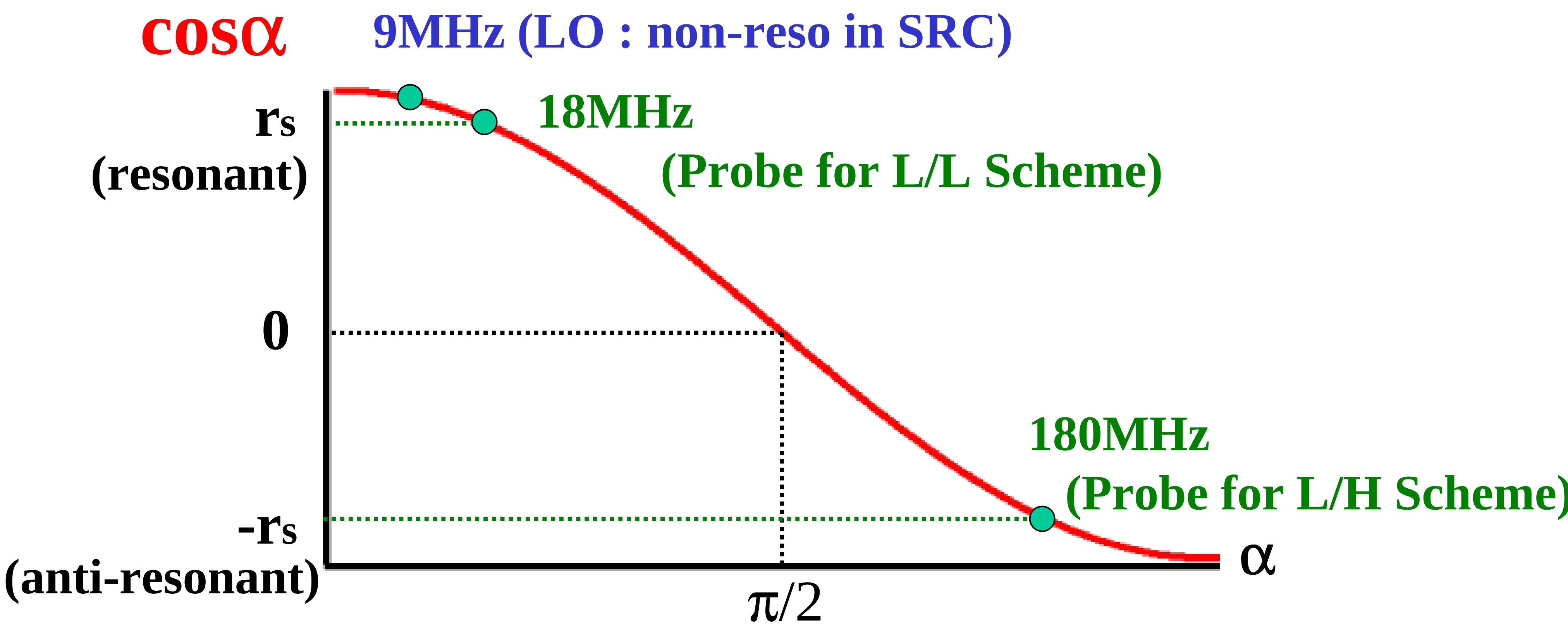
$$= \phi_s \times \left[i \sin\alpha + i \sin\alpha \times r_s \cos\alpha + i \sin\alpha \times (r_s \cos\alpha)^2 + \ldots \right]$$

$$= \phi_s \times \frac{i \sin\alpha}{1 - r_s \cos\alpha}$$

ls is maximized when

$$r_s = \cos\alpha$$

Two Solutions for Optimized Asymmetry



LOW/LOW Freq. Mod. → Ctrl. Scheme of Japan RSE

LOW/High Freq. Mod. → Ctrl. Scheme of Glasgow RSE

In the case with Power Recycling

Signal is maximized when

$$\cos\alpha = \frac{r_s + r_p}{1 + r_s r_p}$$

Japan 4m ⟶ α=0.2367 for r_s=0.89, r_p=0.89

Glasgow 10m ⟶ $\alpha=\pi/2$ and $r_s=-r_p$

Both scheme meets the optimized condition.

Good and Bad of Japan RSE Scheme

- 9-18MHz is realized by 1 modulation and its harmonics.

Simple!

- Not too high freq. is used for L- detection.

alternative to DC readout

- ls signal is smaller if the 2nd harmonics are used.

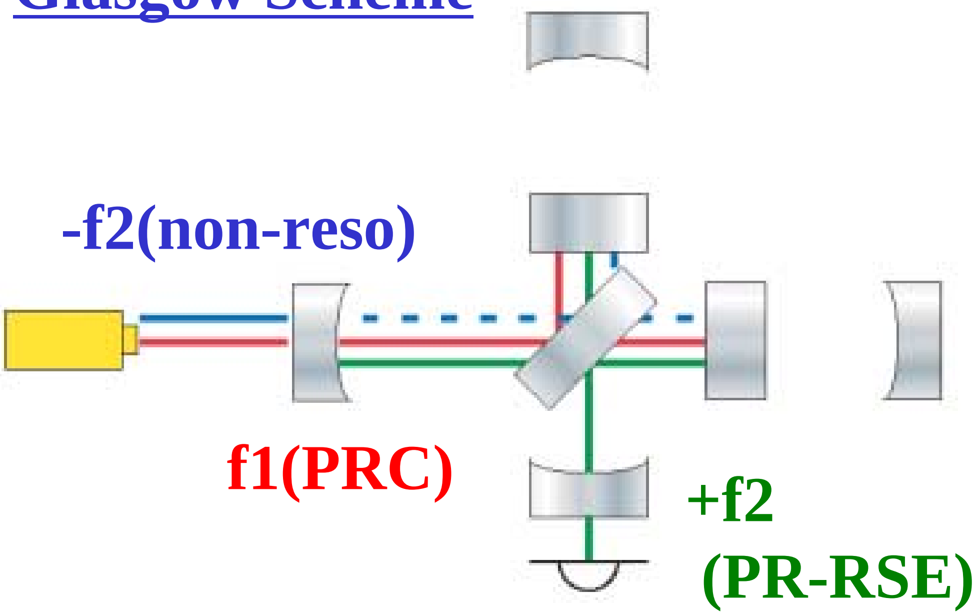
for about m/2

- l- signal is smaller.

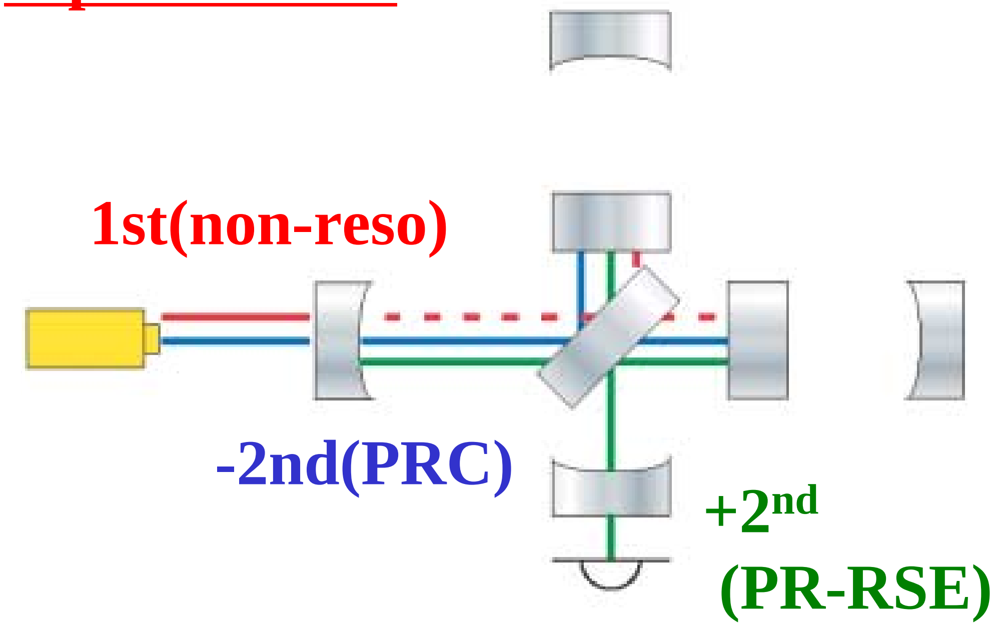
because of the resonant conditions

SB Resonant Condition

Glasgow Scheme



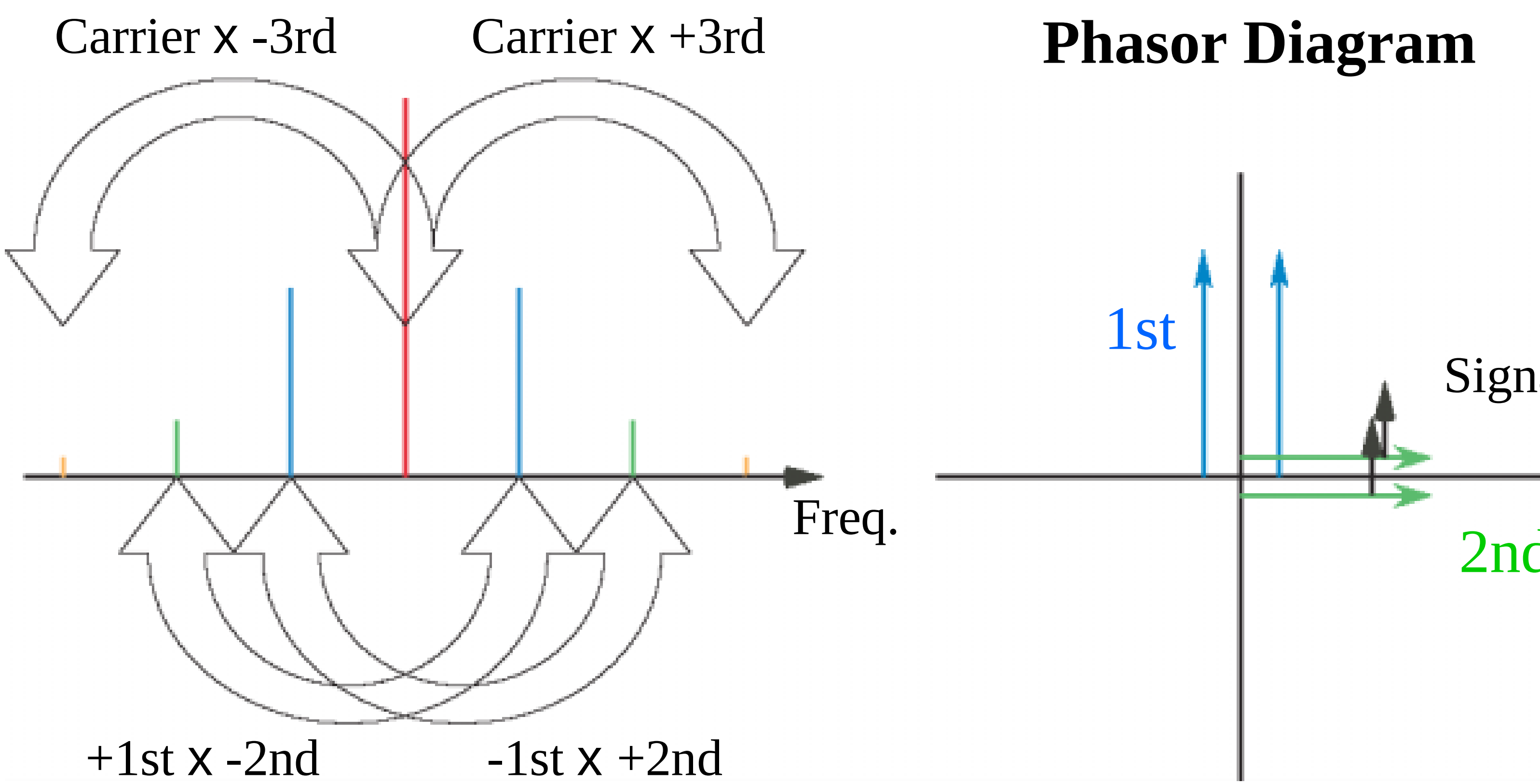
Japan Scheme



L- : DP f2
L+ : BP f1
l- : BP DDM
l+ : BP f2-f1
ls : PO f2-f1

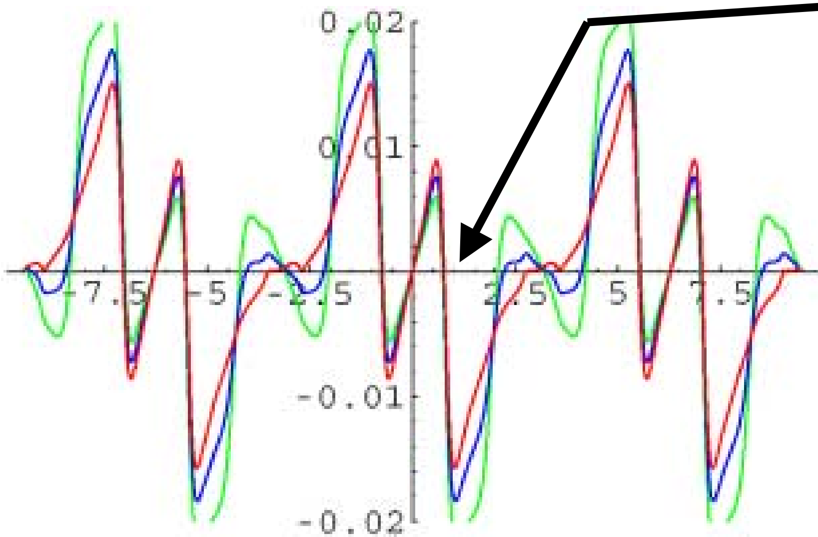
L- : DP 2nd
L+ : BP 2nd
l- : BP DDM
l+ : BP <u>3rd</u>
ls : PO <u>3rd</u>

Third Harmonic Demodulation



Beat signals of 1st and 2nd SB do not include L+/L- signals.
But beat signals of carrier and 3rd SB are undesirable for THD.

Acquisition of ls signal

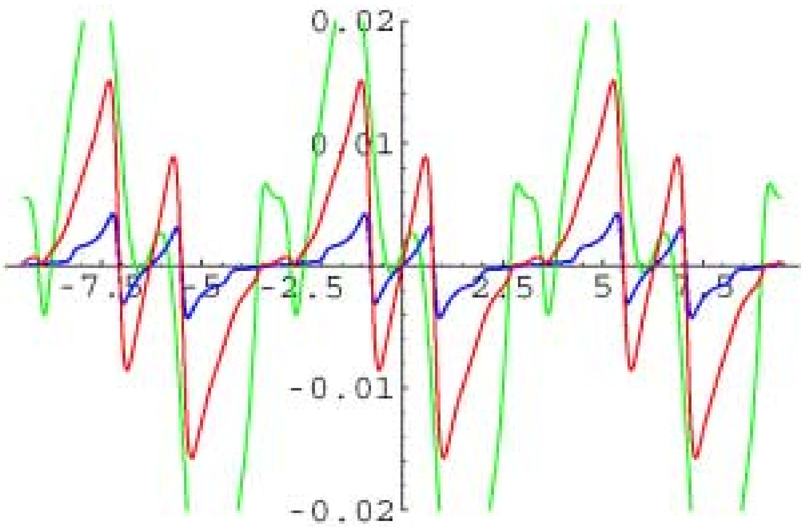


Lock point : -2nd is resonant in SRC

THD I-phase signal at Bright Port

($\psi=\pi/2-0.4$,
w/o PRM and w/o arm cavity)

Top: Dependence on 3rd harmonics
Elimination ratio of 0%, 50%, 90%

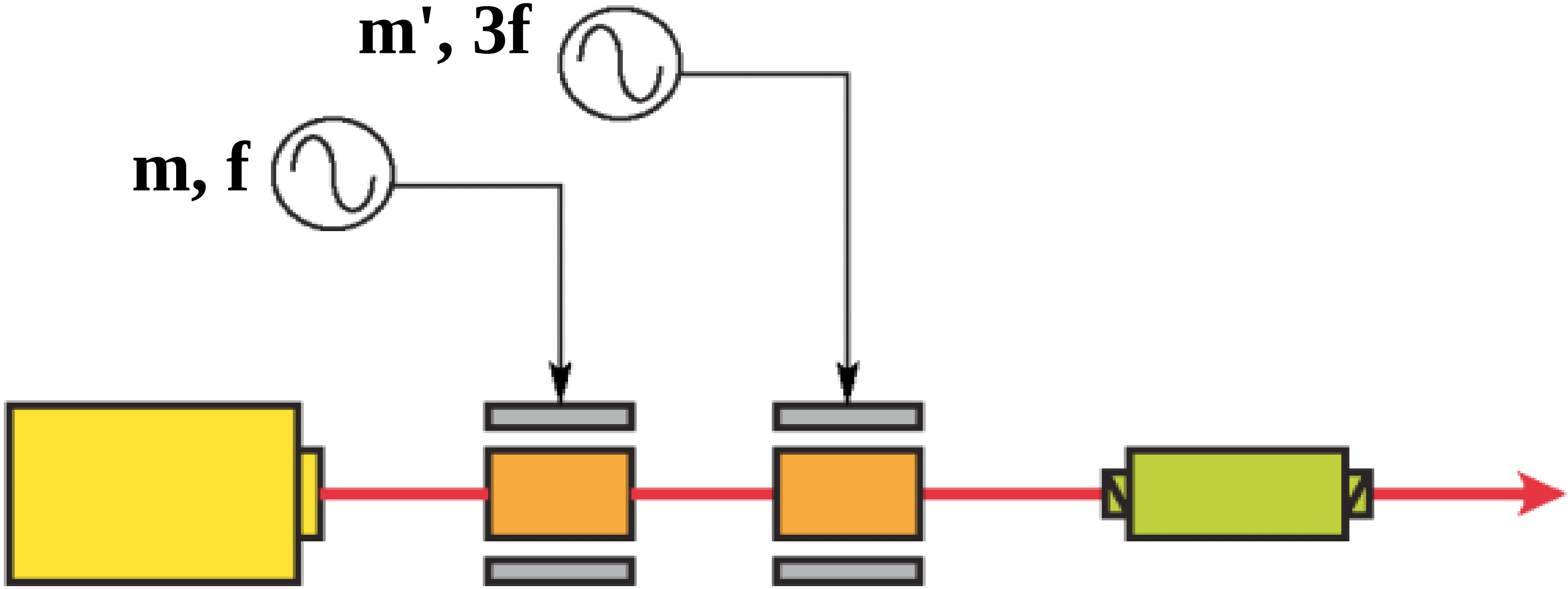


Bottom: Dependence on asymmetry
α=0.5, 0.1, 0.2367 (for 1st SB)

- Residual 3rd harmonics generate another lock point at Broadband SR.
- Too much asymmetry yields an offset to the lock point.

We can acquire ls signal!

Third harmonics elimination by secondary EOM



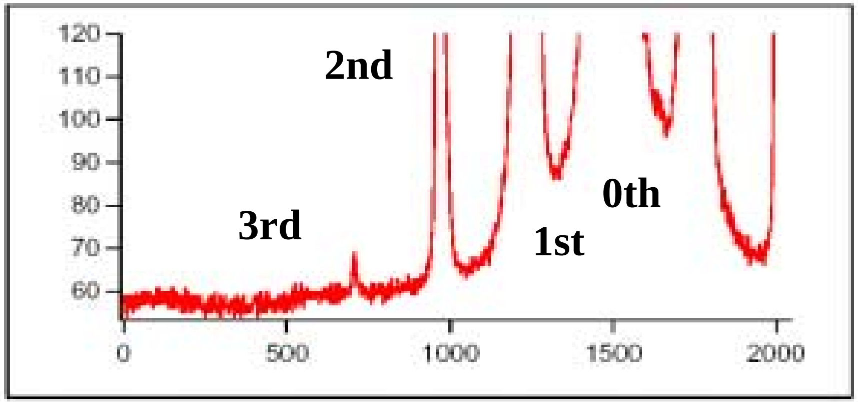
Output $= \left(J_0 + iJ_1 \sin\omega t + J_2 \cos 2\omega t - iJ_3 \sin 3\omega t\right)\left(J_0' + iJ_1' \sin 3\omega t\right)$

→ If $J_0J_1' = J_3J_0'$ then $\sin 3\omega t$ components will be eliminated.

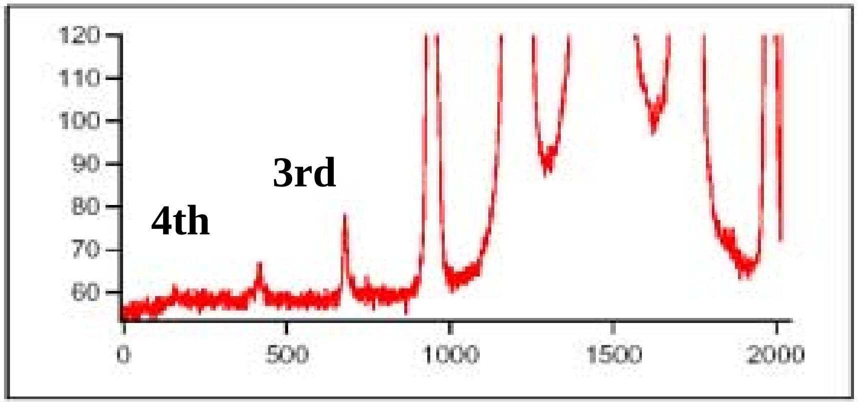
This can be done by single broadband EOM (P. Beyersdorf is developing)

Third harmonics elimination experiment

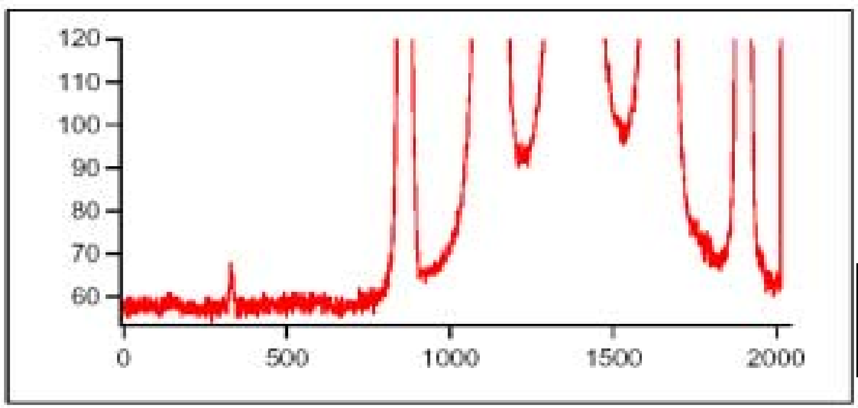
Output of Optical Spectrum Analyzer



Only the primary EOM (0.63rad).



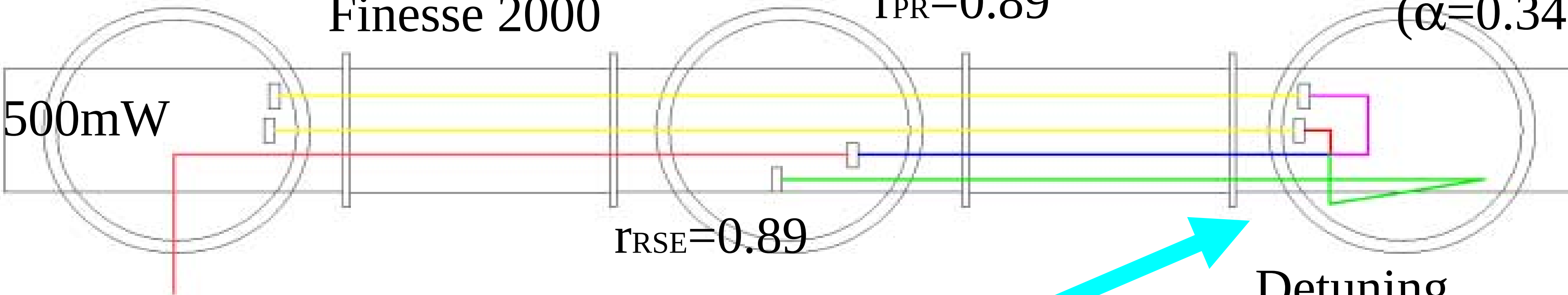
Add the secondary EOM (0.07rad).

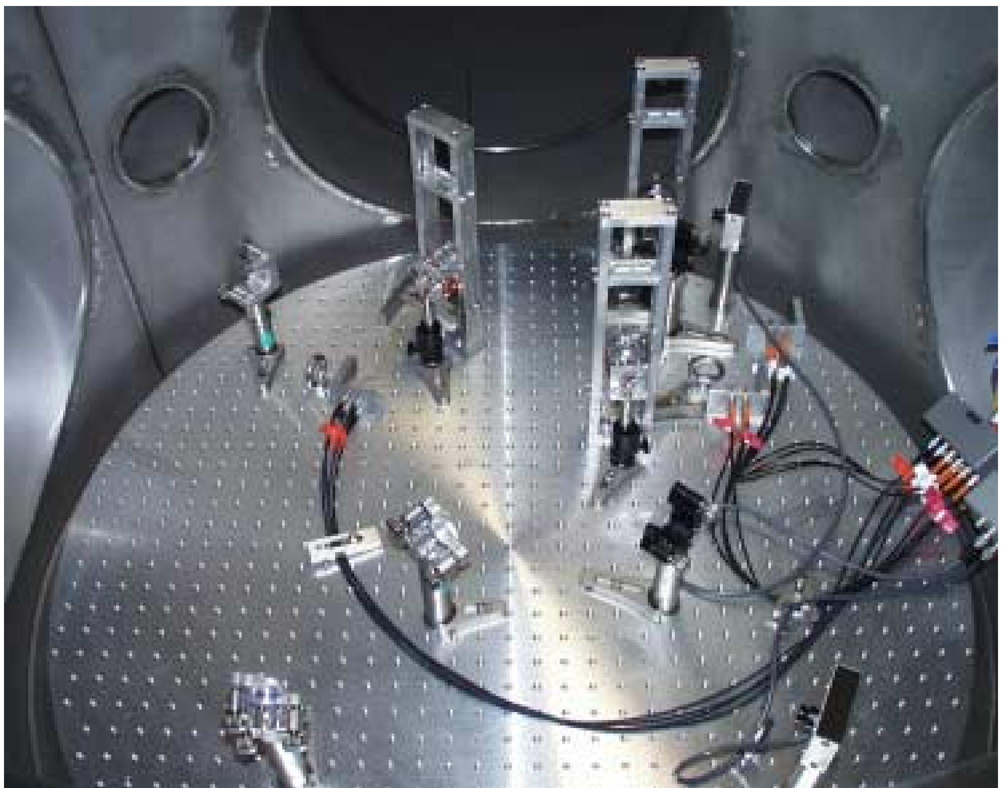


After the adjustment (p:0.87, s:0.07rad).
3rd is eliminated while 4th can be seen.

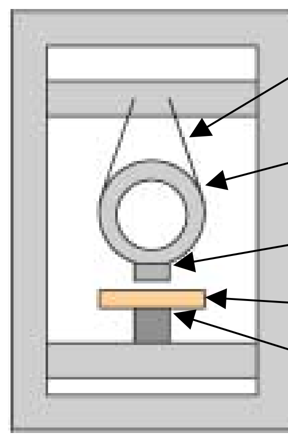
There will be no L+/L- mixture on THD.

4m RSE in Japan : Setup

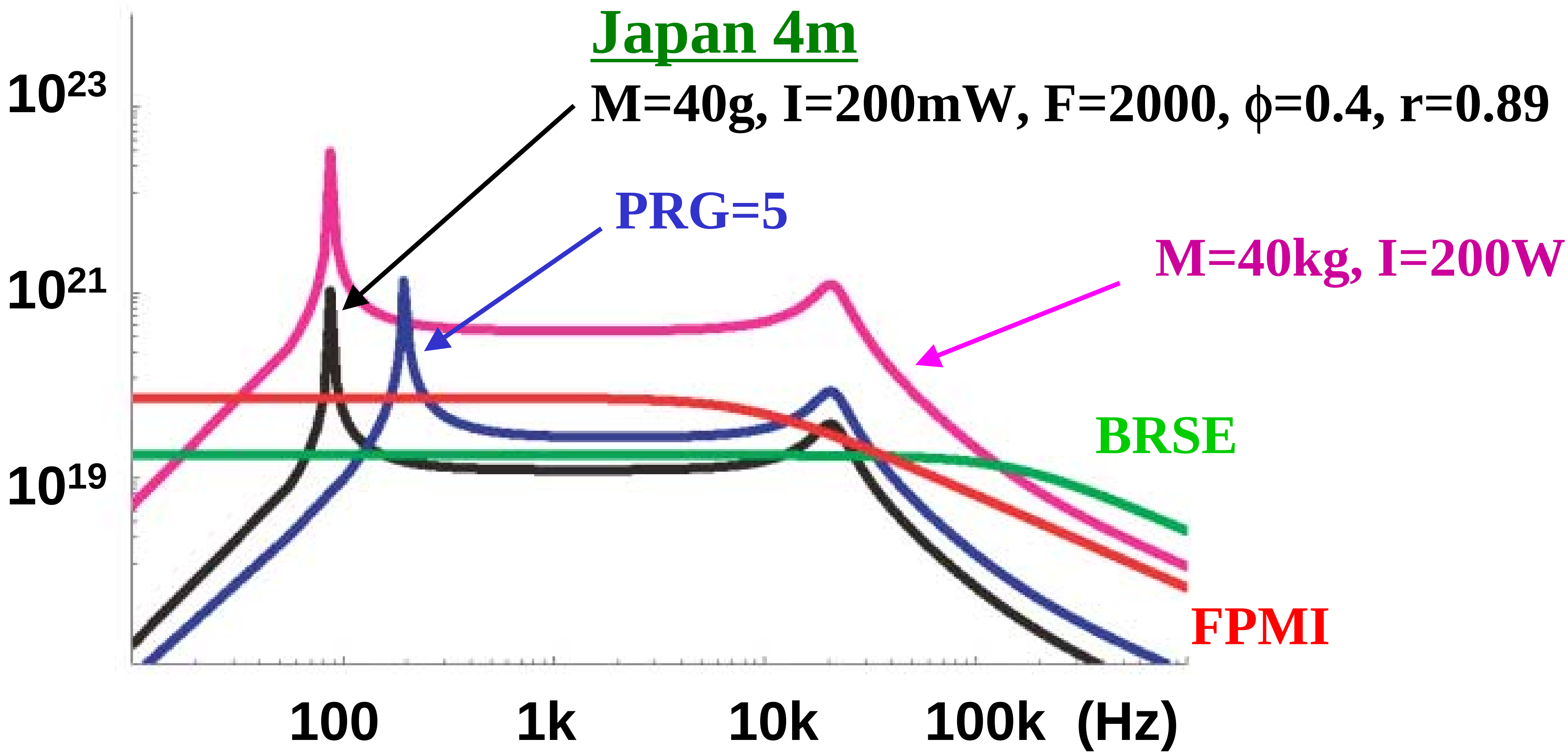




inside



Transfer Function including RP Effect



Using small mirrors is a big advantage to observe the optical spring.

Ref. gr-qc 0208048

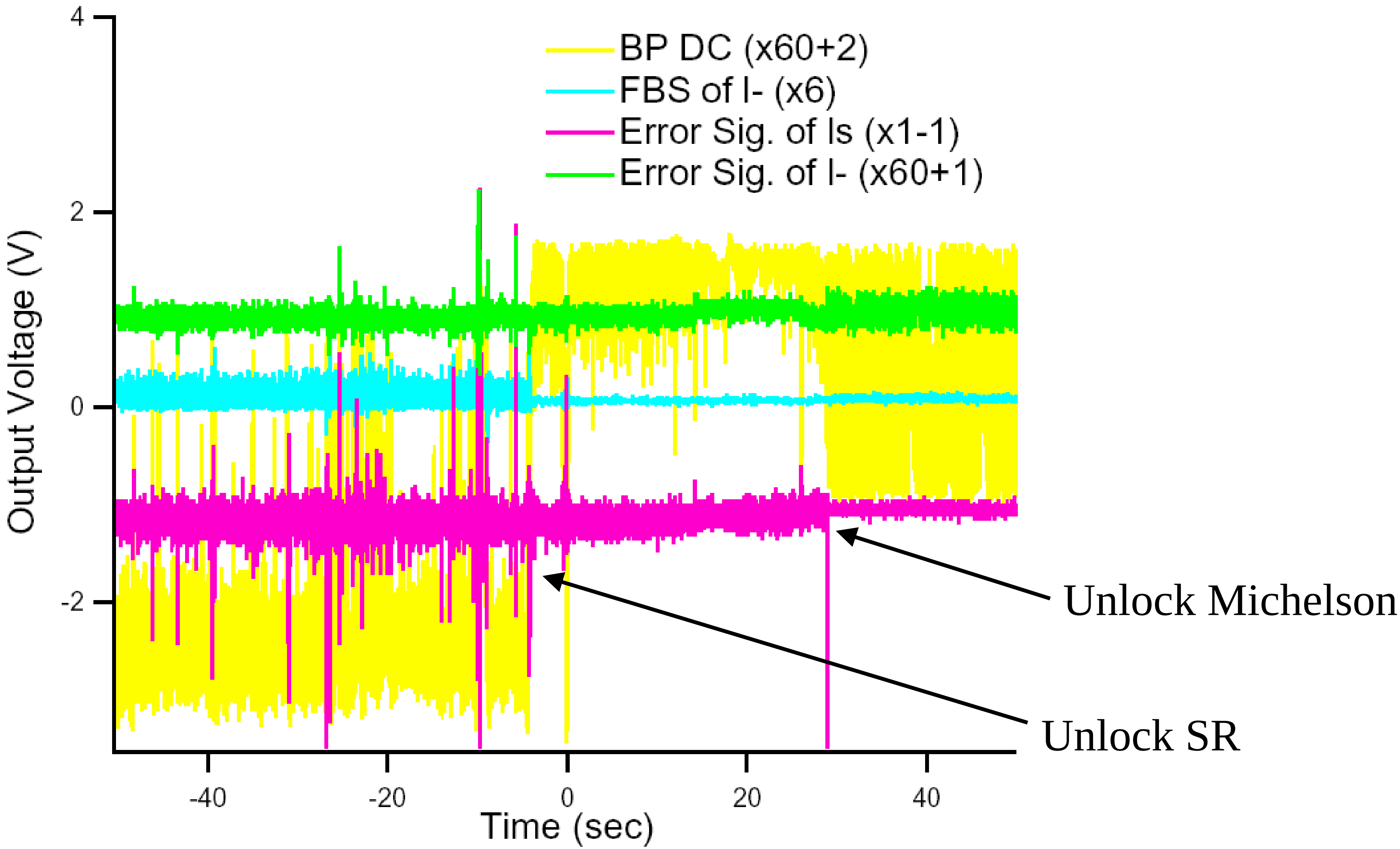
Current Status

- **Initial optical setup with suspensions**
- **Third harmonics elimination**
- **l- lock with 1^{st} demodulation**
- **l- lock with 3^{rd} demodulation**
- **ls lock with 3^{rd} demodulation**
- **Optical Analysis of SB unbalance**
- **l- lock with double demodulation**
- **Arm lock with 1^{st} demodulation**
- **L+/L- lock with 2^{nd} demodulation**
- **TF measurement**
- **Power Recycling (optional)**

DONE!

TO BE DONE

I think it's locking (w/o arm cavities)



Double Demodulation