Overview and prospects of Suspension-point interferometer

WP3 meeting @ Paris

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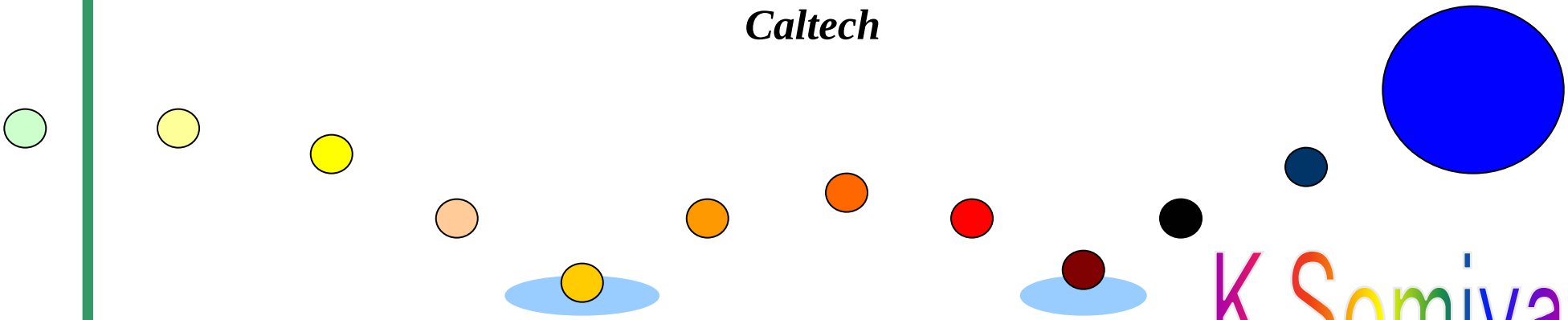
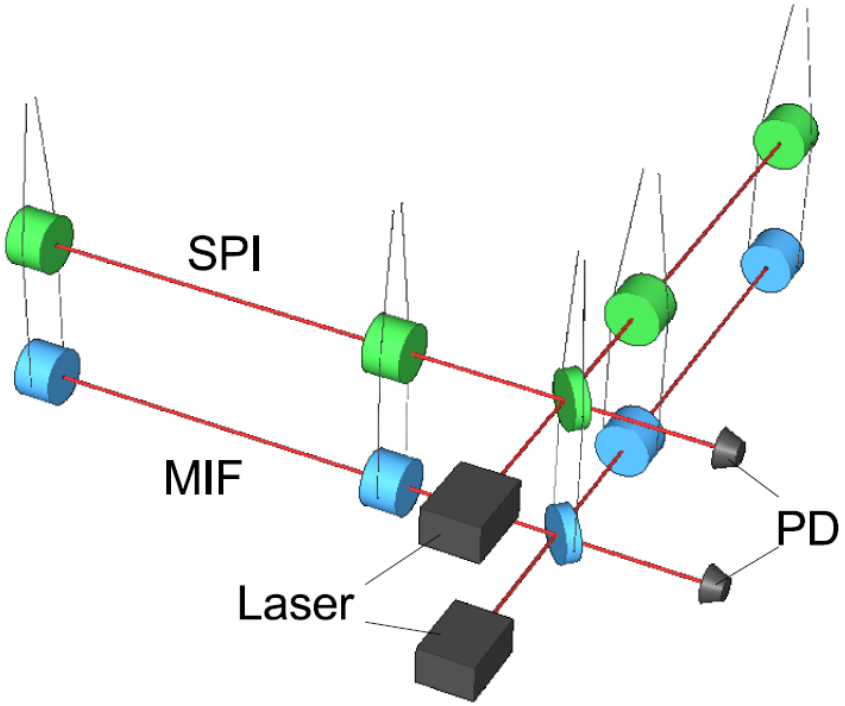
Caltech



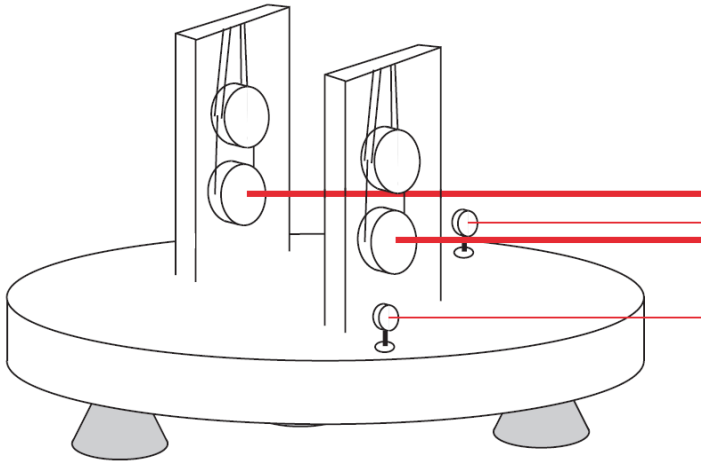
SPI
~ Suspension-Point Interferometer ~



- **Original idea is by R.Drever [shown in a book, 1991]**
- **Experiment by Y.Aso [PLA 2004]**
- **Extended interpretation as "*Suspension Platform Interferometer*" [Caltech 40m, Hannover 10m , etc.]**

Number of benefits:

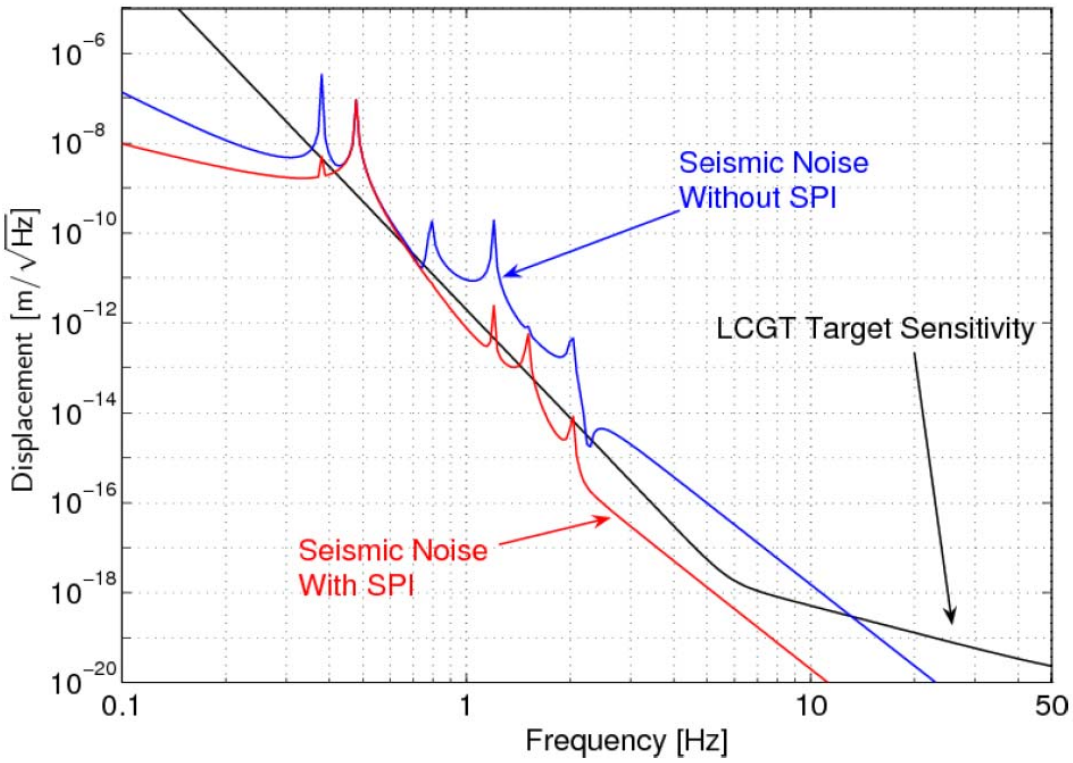
- **ease the lock acquisition**
- **isolate heat-link vibration**
- **reduce the rms motion**
- **reduce seismic noise**

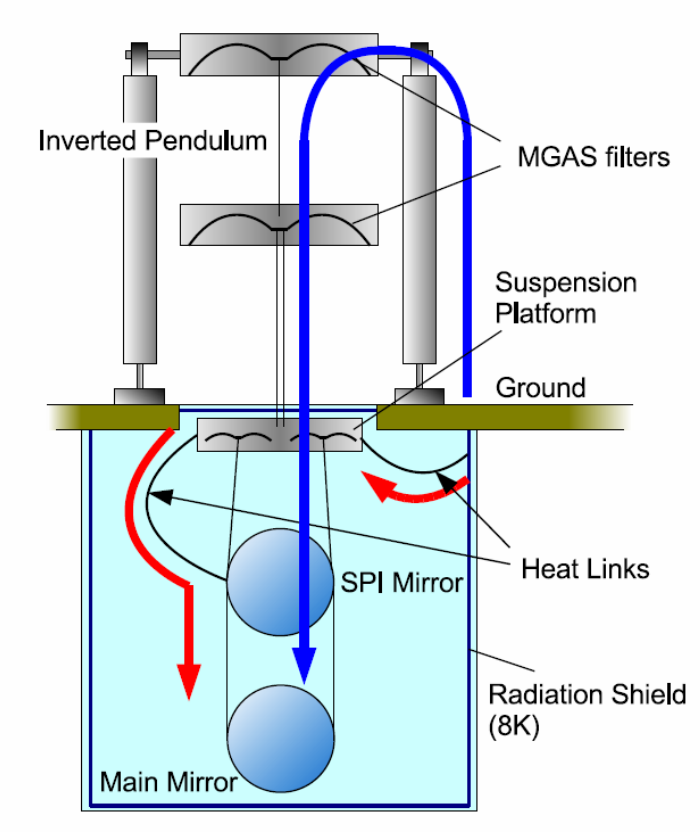


Isolation of the heat-link vibration

[Aso 06]

Seismic noise introduced via heat link

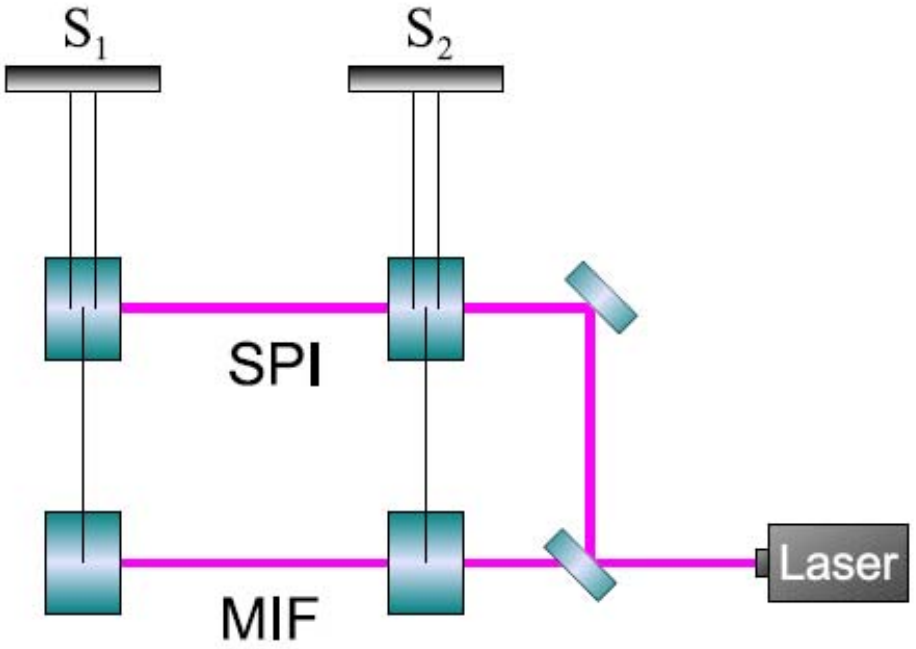


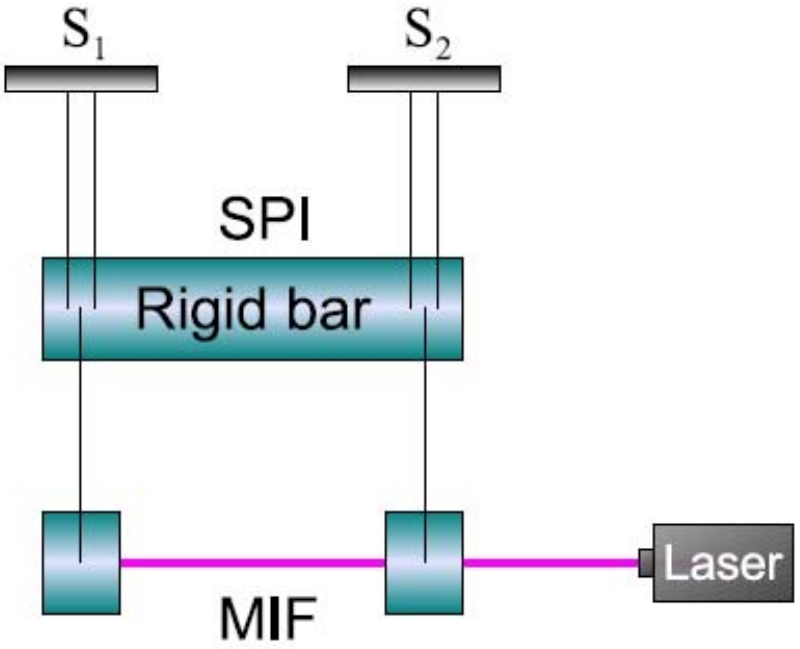


Main reason to accommodate SPI in LCGT

(there are alternative plans, though)

Rigidity of SPI

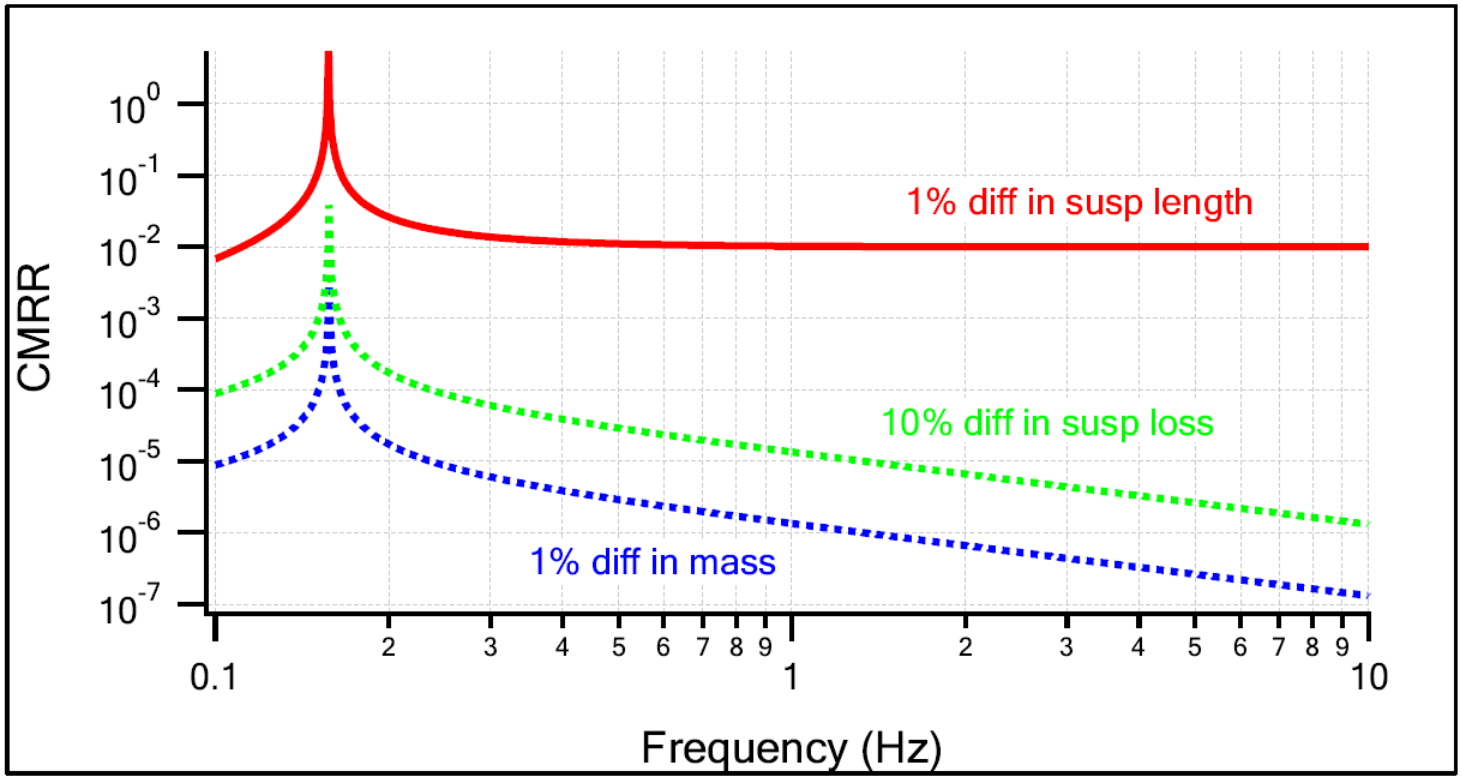




- In principle, no seismic noise in MIF
- In practice, 1-10% common mode will remain
- Sensing noise may limit the rigidity of SPI

Common-mode rejection

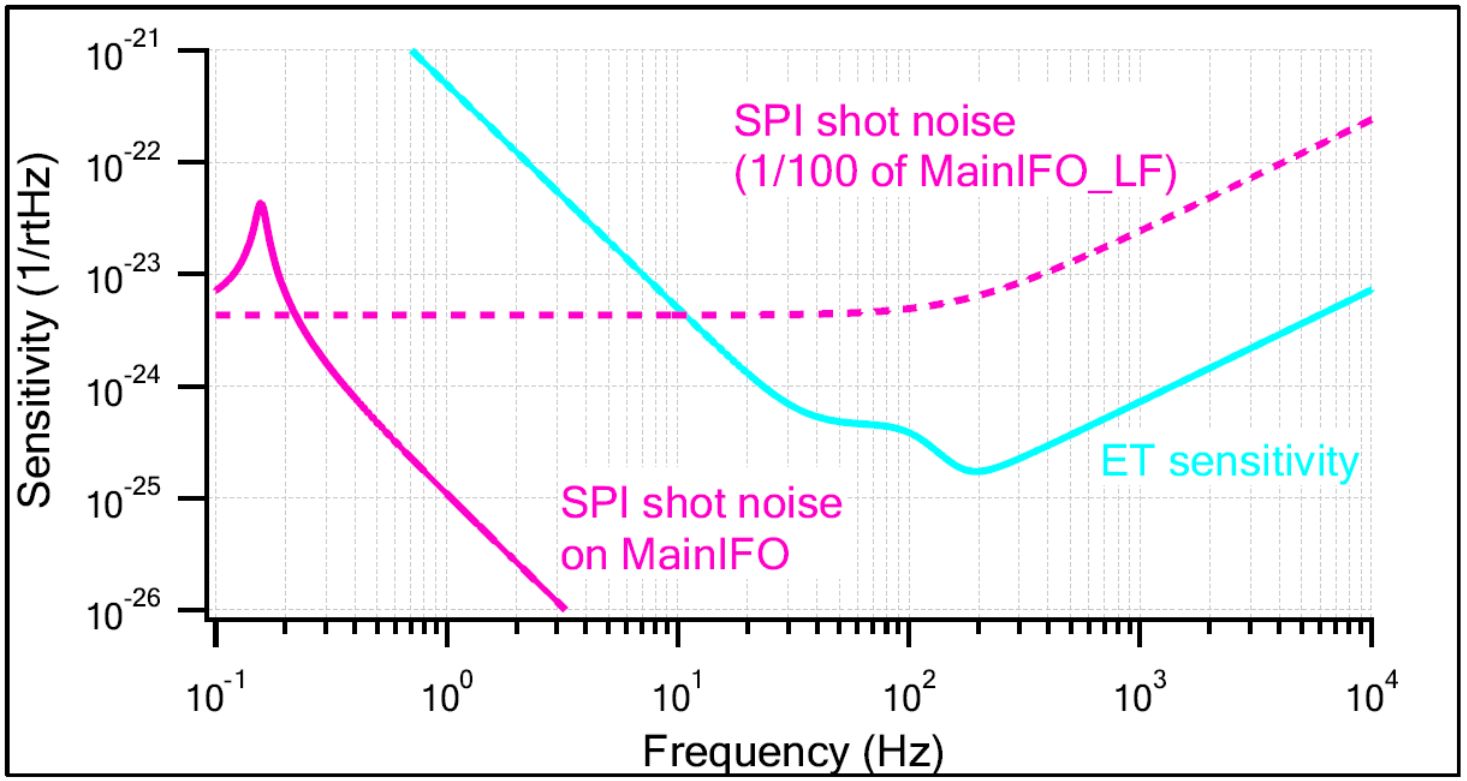
with ET's 10m suspensions



Mostly due to the length difference

Shot noise of SPI

with ET's 10m suspensions

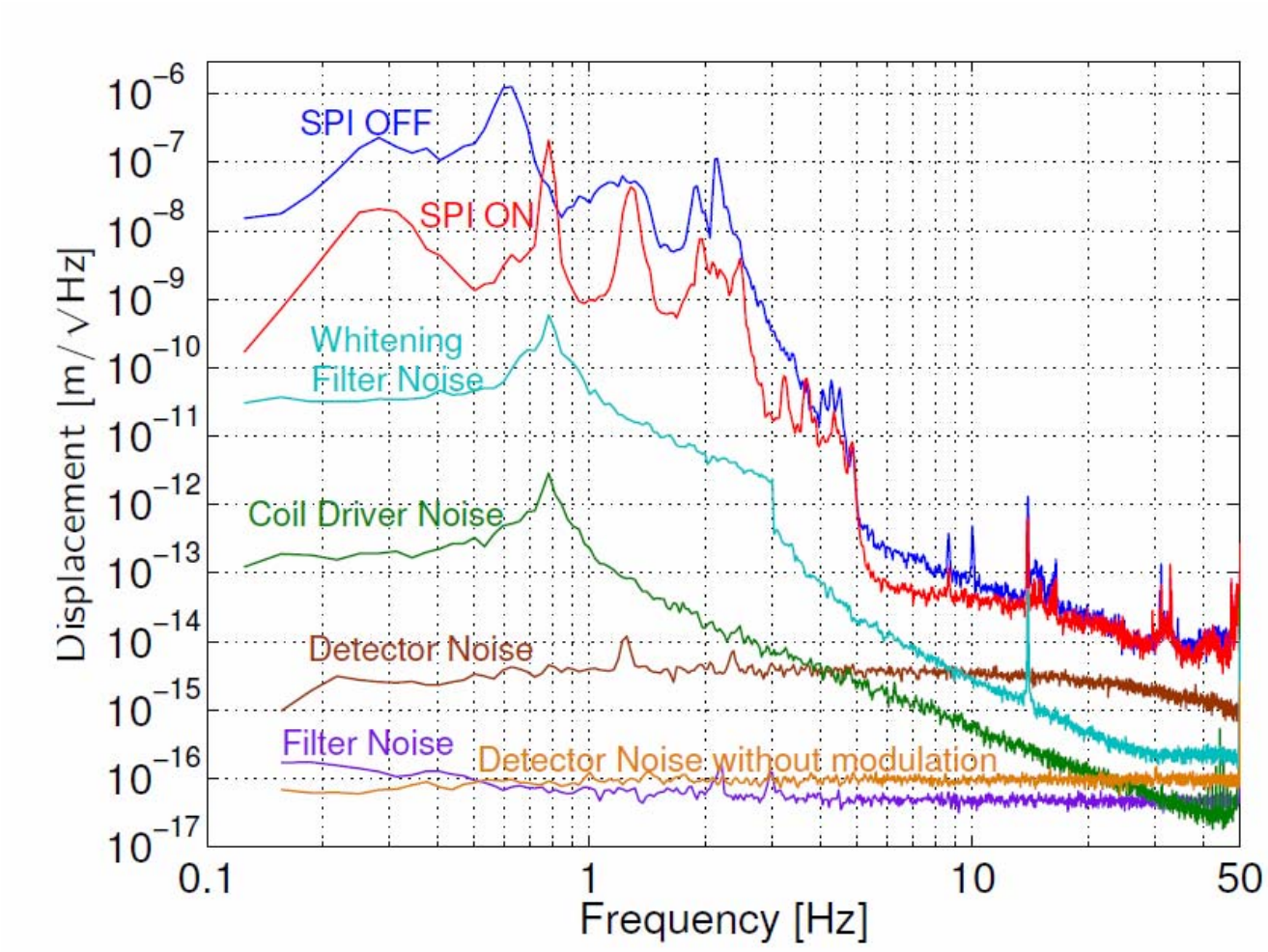


SPI shot noise won't limit the sensitivity

(even with 1/100 of the MIF power)

Experimental demonstration

[Aso 06]

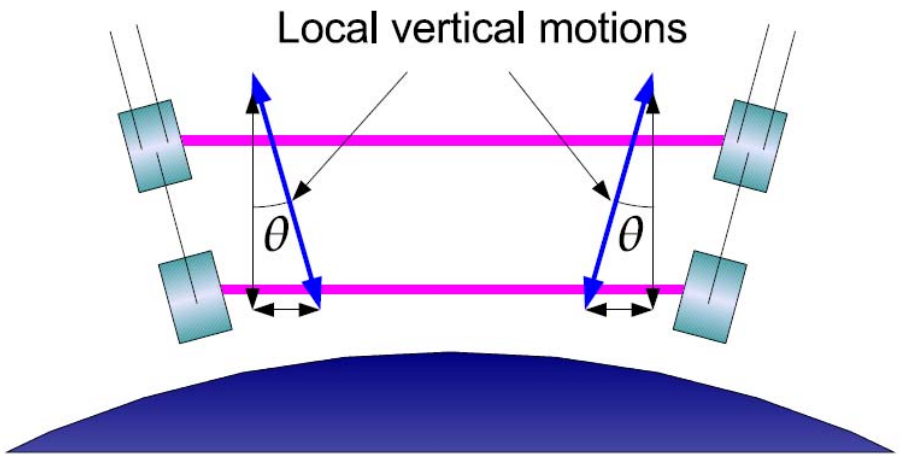


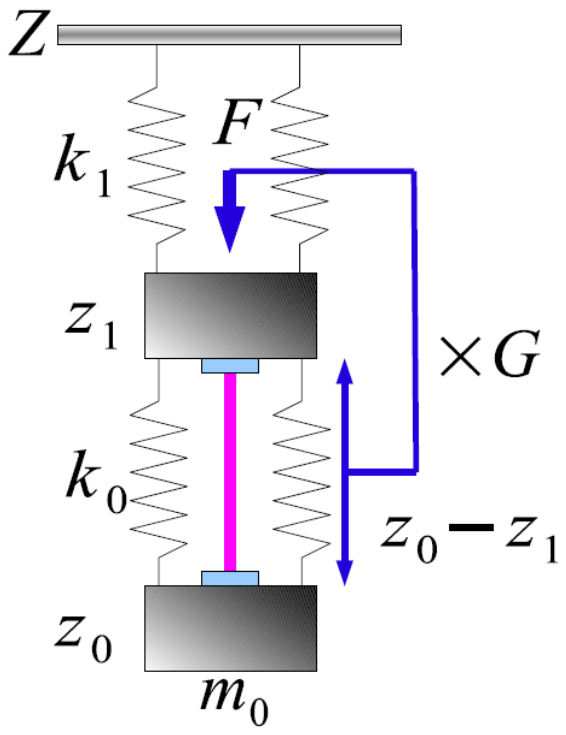
Improvement of the sensitivity with SPI

Issues on SPI

- Vertical coupling and VSPI
- Alignment of SPI and MIF
- Improvement of CMRR
- Xylophone with SPI

Vertical-motion coupling

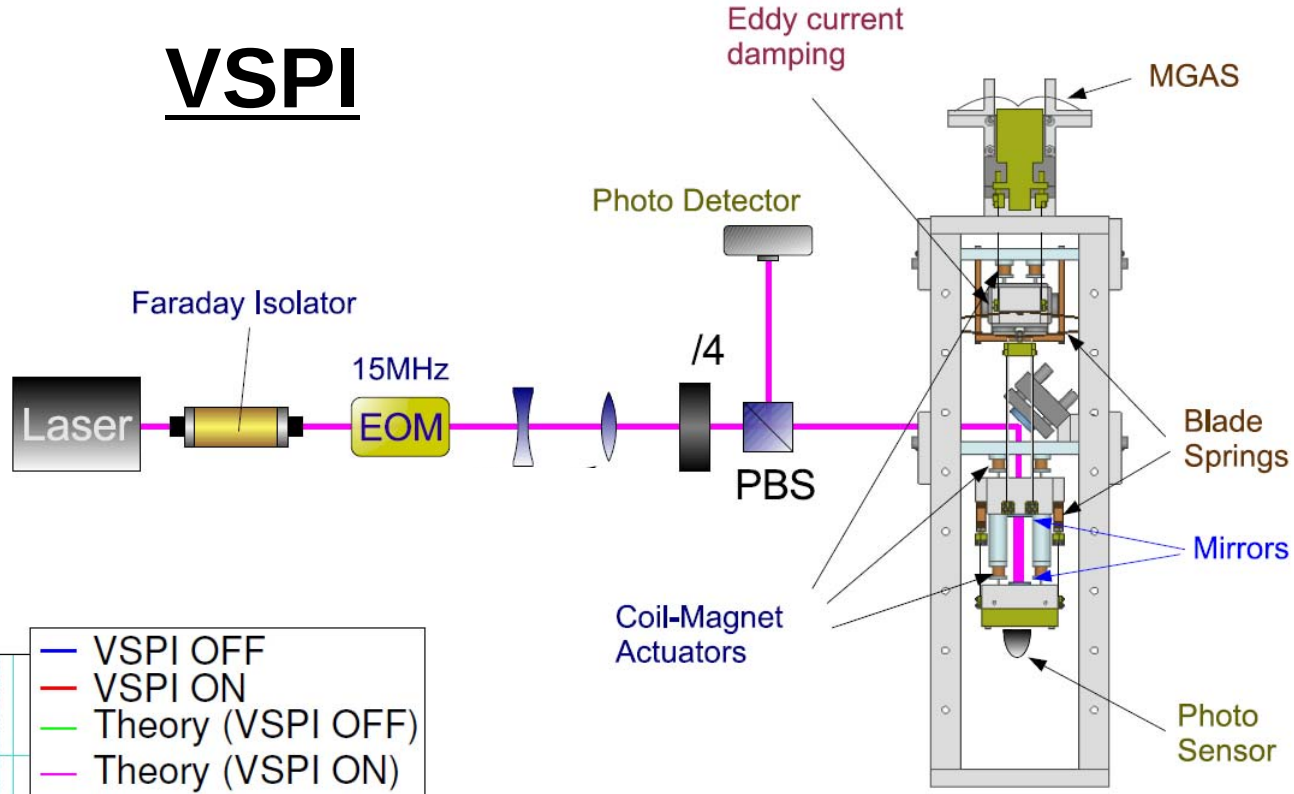


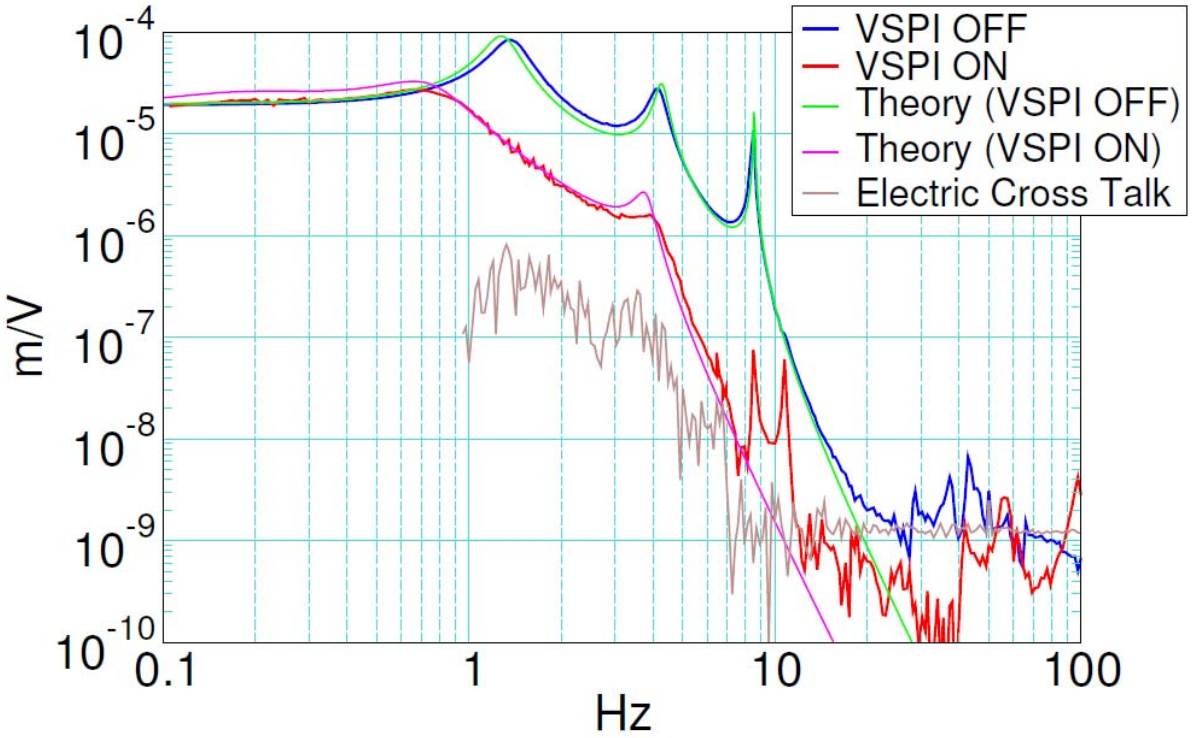


- SPI doesn't help reducing vertical-horizontal couplings
- There is an idea of VSPI (Vertical SPI)

VSPI

[Aso 06]



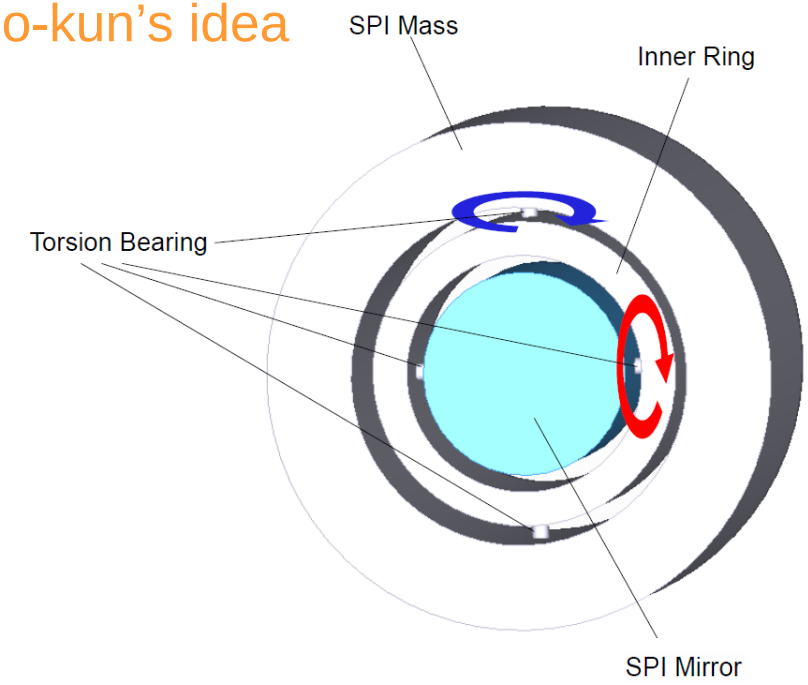


Experimental demo to reduce V-H coupling

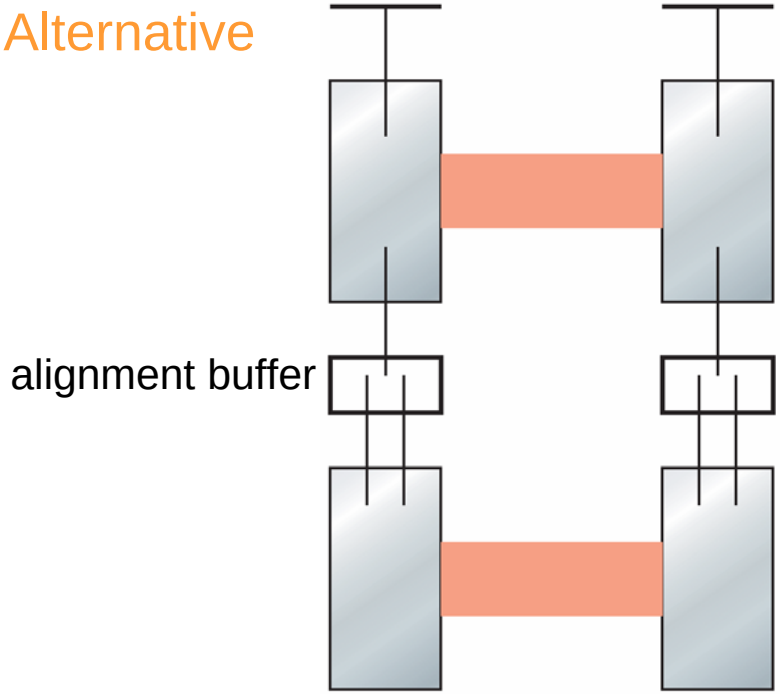
Co-alignment problem

If we do not want to use a strong actuator in MIF,
we cannot align the MIF mirrors independently from SPI.

Aso-kun's idea

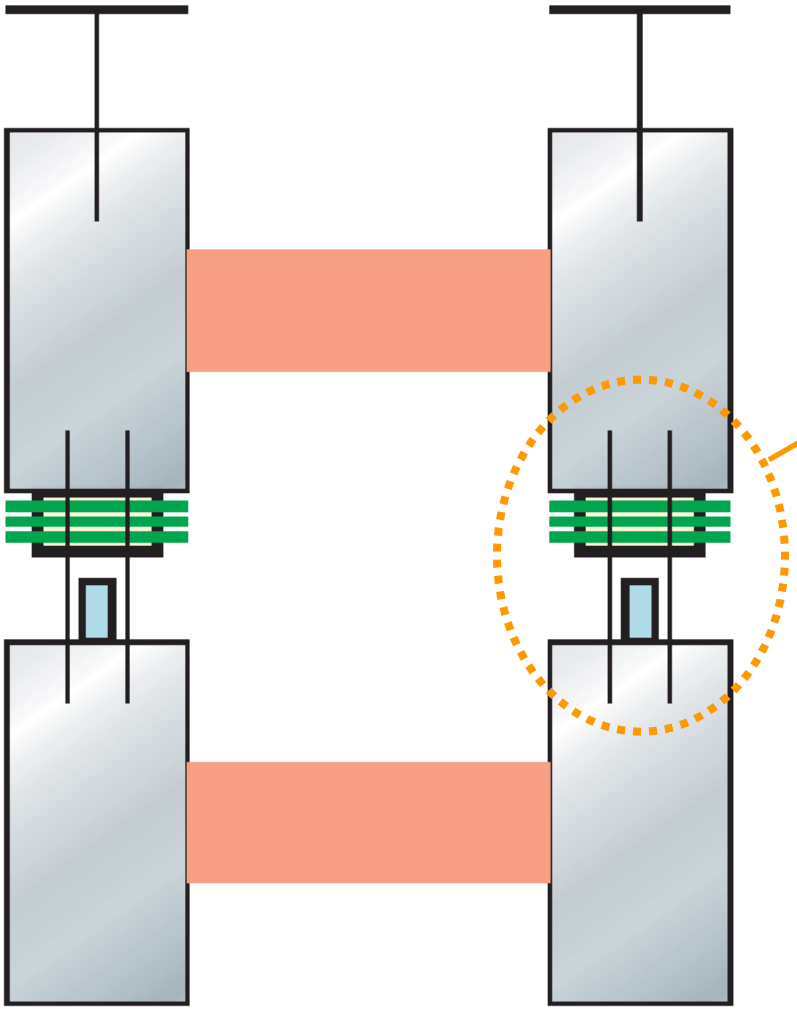


Alternative



These options may degrade the CMRR

Improvement of CMRR

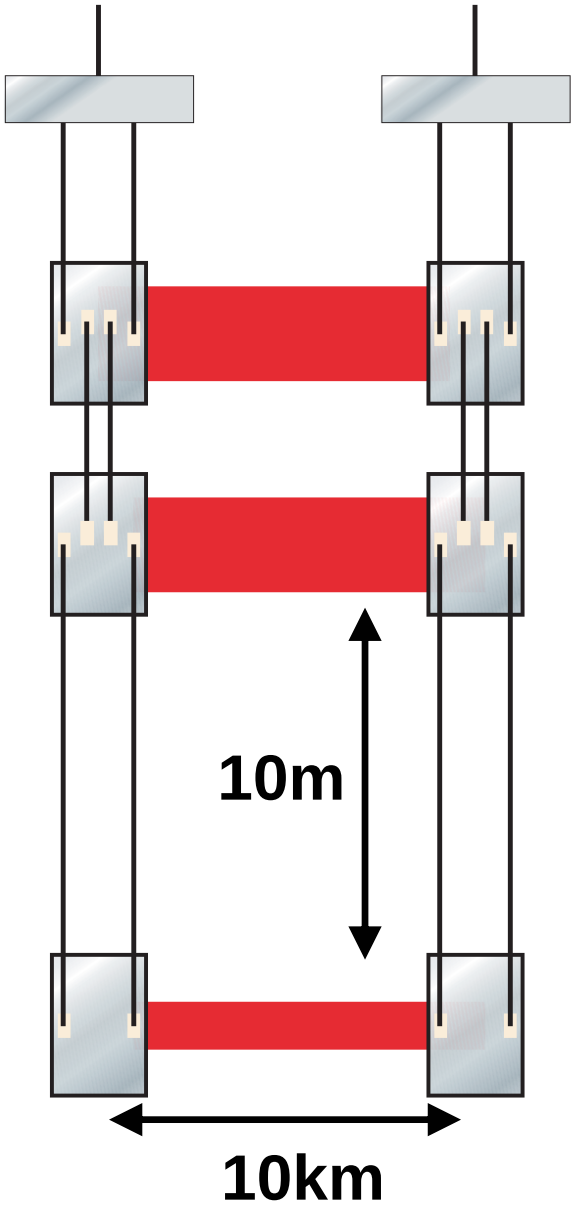


Fiber + Magnetic
(Hybrid suspension system)

Imbalance Δl is cancelled by adding acceleration Δg

Residual common-mode motion may be suppressed to 1e-3~1e-5

Xylophone with SPI



- **Top stage: MF 10-100Hz**

  Low mirror thermal noise
  High power

- **Mid stage: HF 100-10kHz**

  Extremely high power
  Low optical loss + squeezing

- **Bottom stage: LF 1-10Hz**

  Low power + very low temperature
  Low suspension thermal noise

Discussions about SPI in LCGT

- **Comparing with alternative plans**
  - thinner heat links (heat-link noise)
  - green laser (lock acquisition)
  - better isolation (seismic noise)
- **Co-alignment problem**
- **Limited budget**
- **Still undecided to use SPI or not**