Control of a Dual Recycled Michelson IFO with independent bandwidth and peak sensitivity tuning

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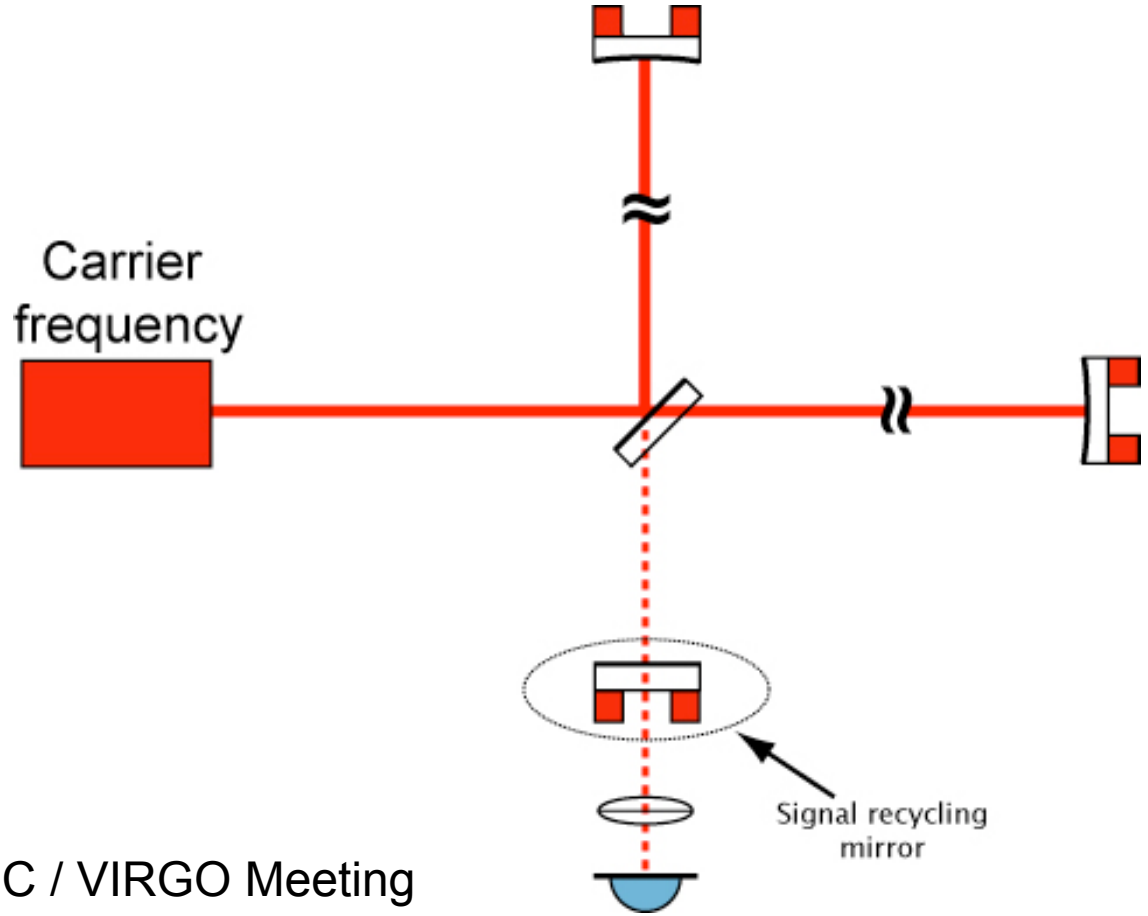
Overview

- Detector configurations
  - Signal recycling and Variable Reflectivity Signal Mirrors
- Controlling the detector bandwidth and peak sensitivity
- Results
  - Signal Recycling
  - VRSM - Signal recycling
  - VRSM - Dual Recycling
- Summary

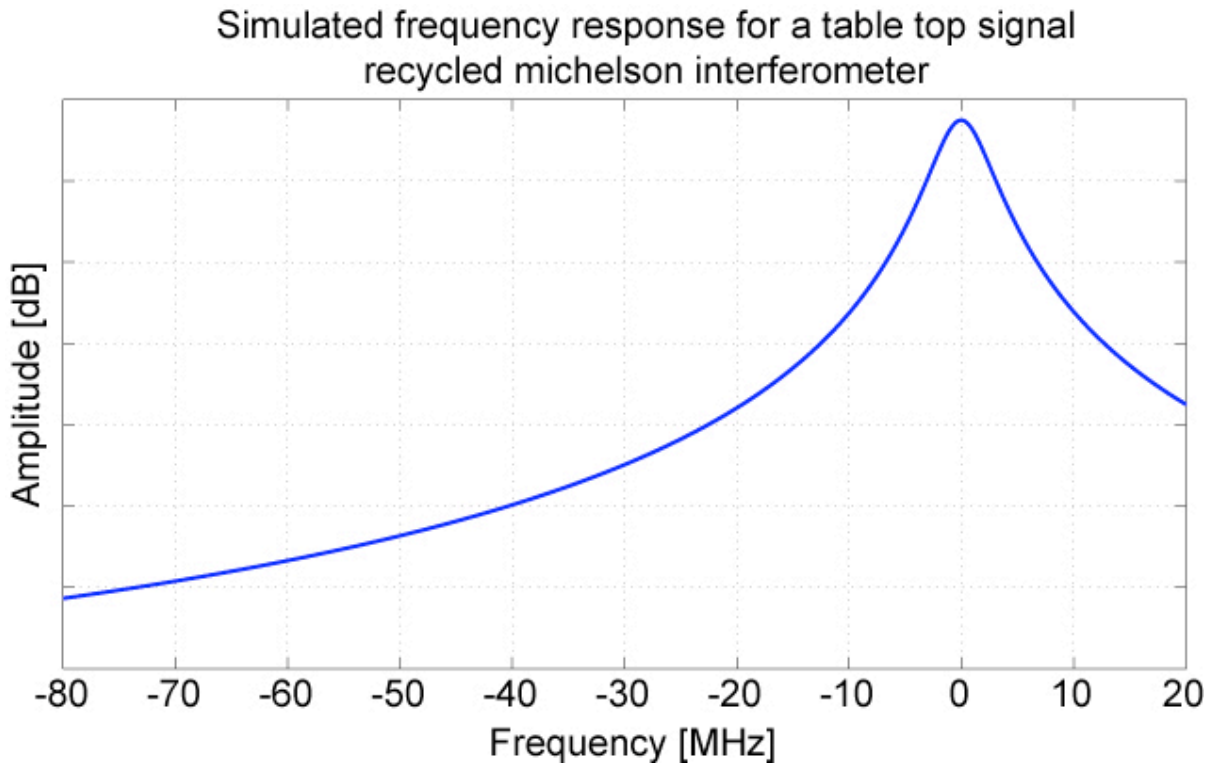
Signal recycling

- Tuned Signal Recycling → Signal cavity is resonant for the carrier frequency (fund. mode)

Signal recycling



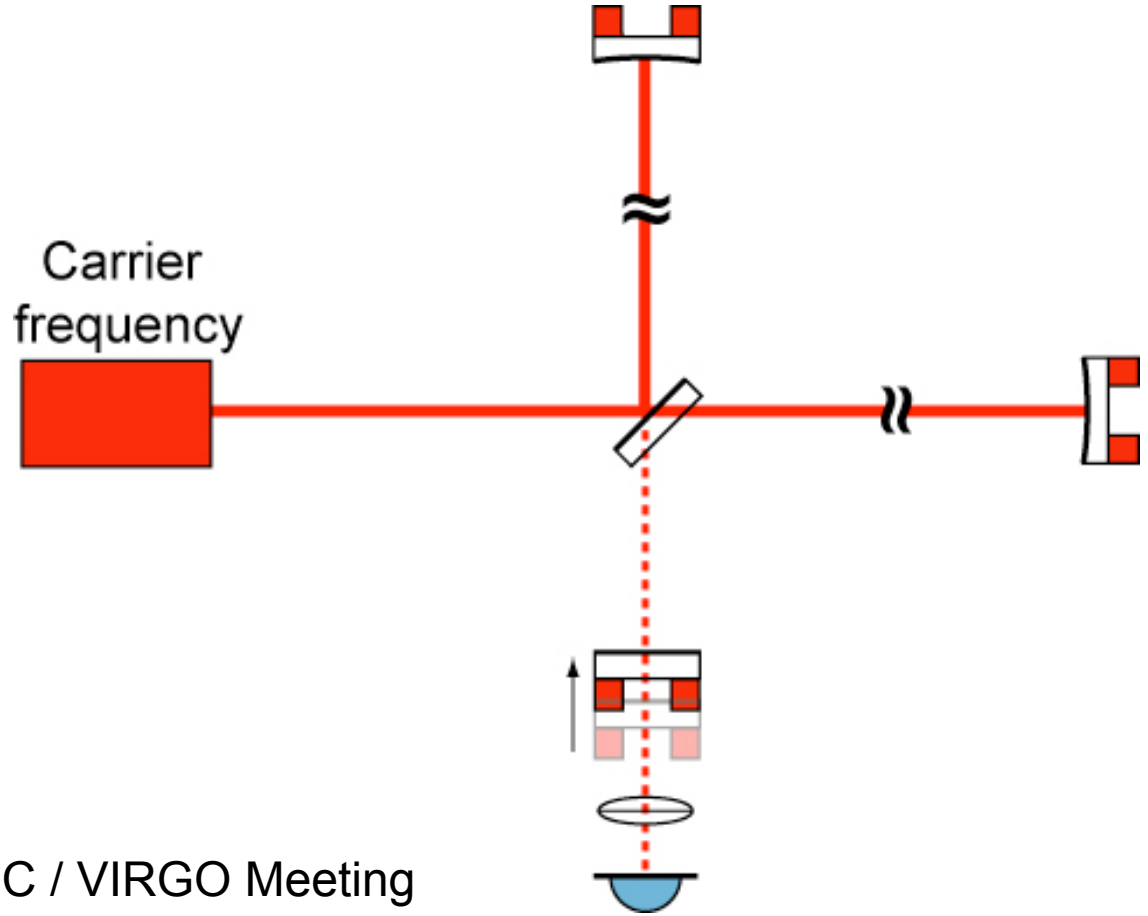
Signal recycling



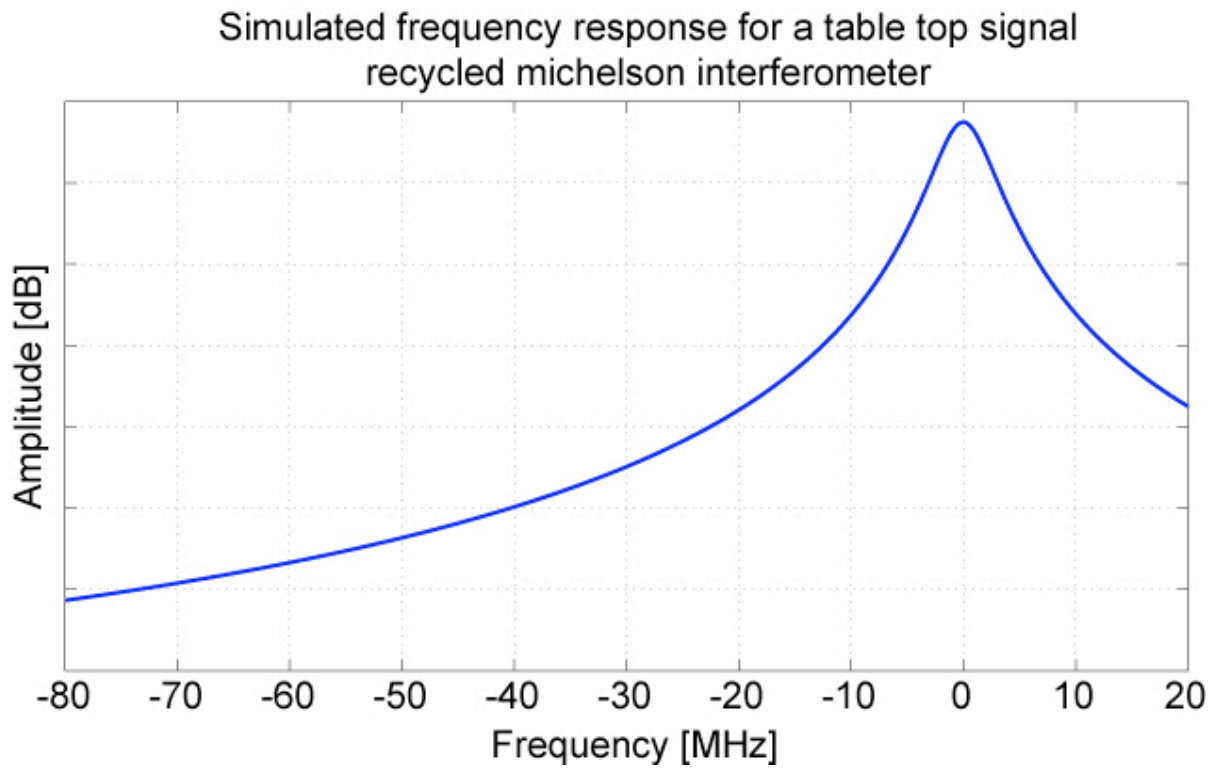
Signal recycling

- Tuned Signal Recycling → Signal cavity is resonant for the carrier frequency (fund. mode)
- Detuned Signal Recycling → Signal cavity is detuned from carrier frequency (fund. mode)

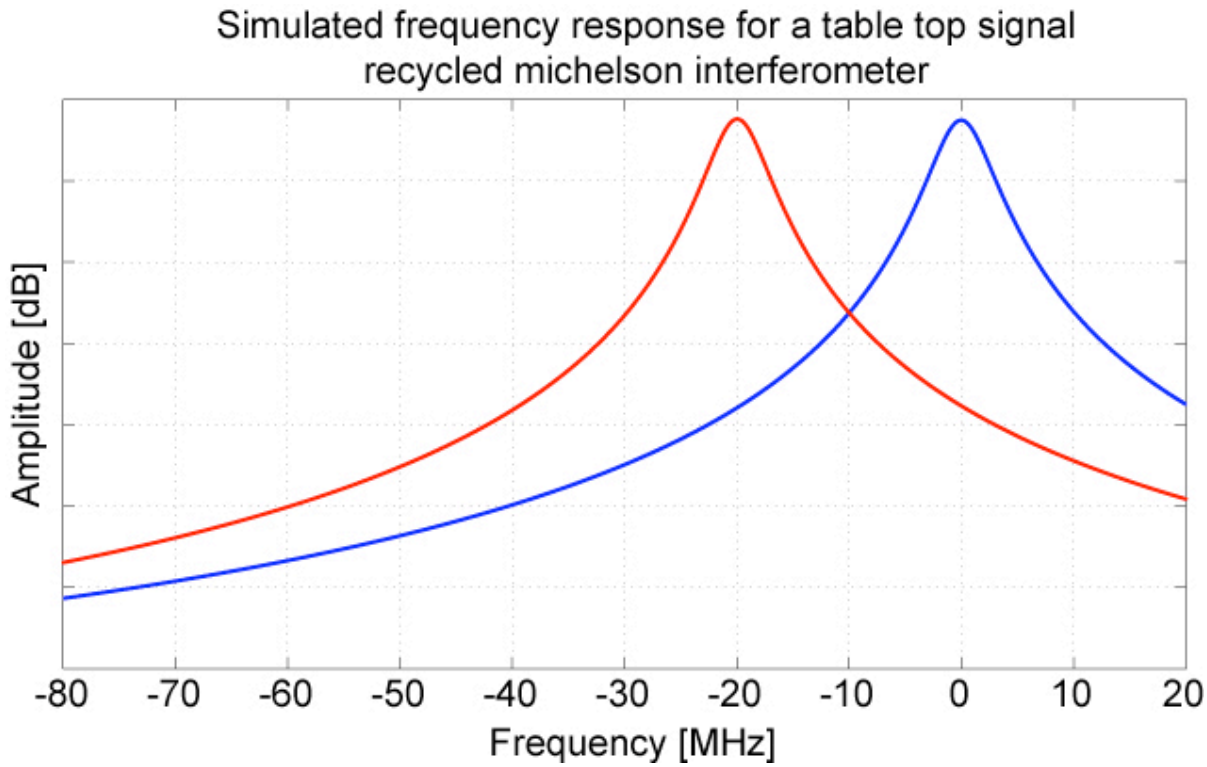
Signal recycling



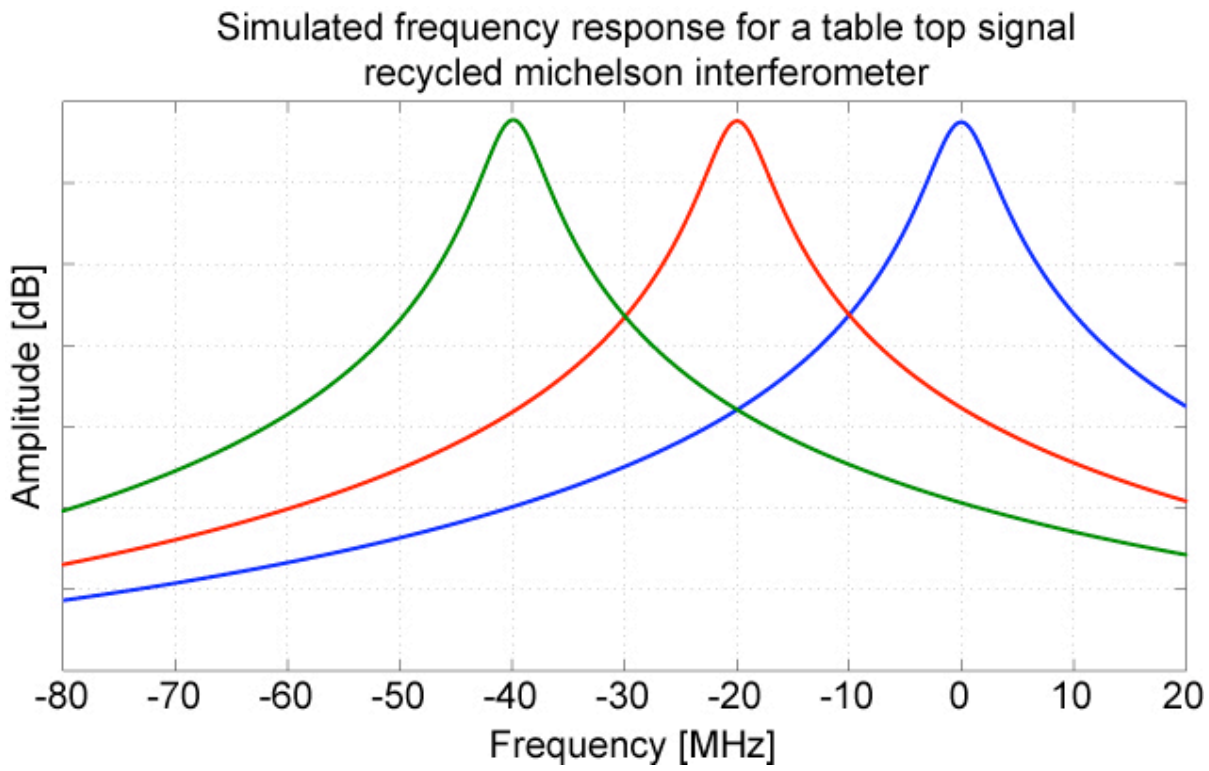
Signal recycling



Signal recycling



Signal recycling



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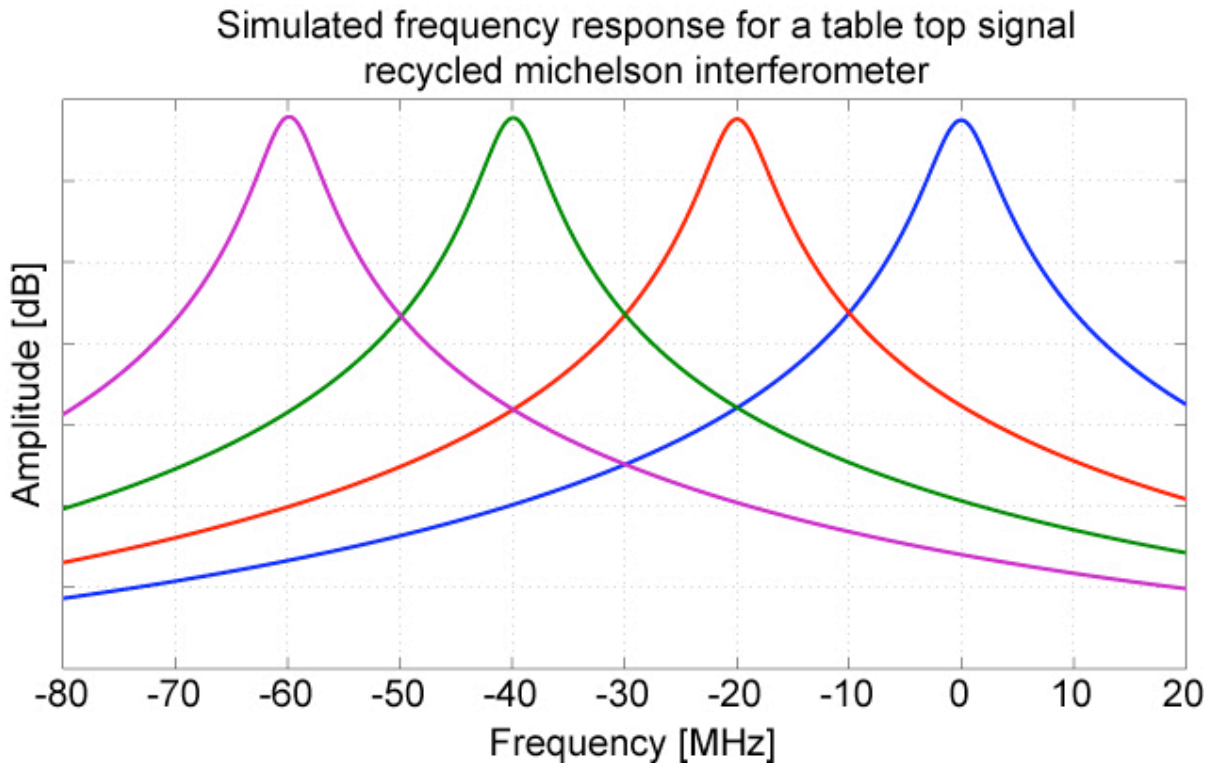
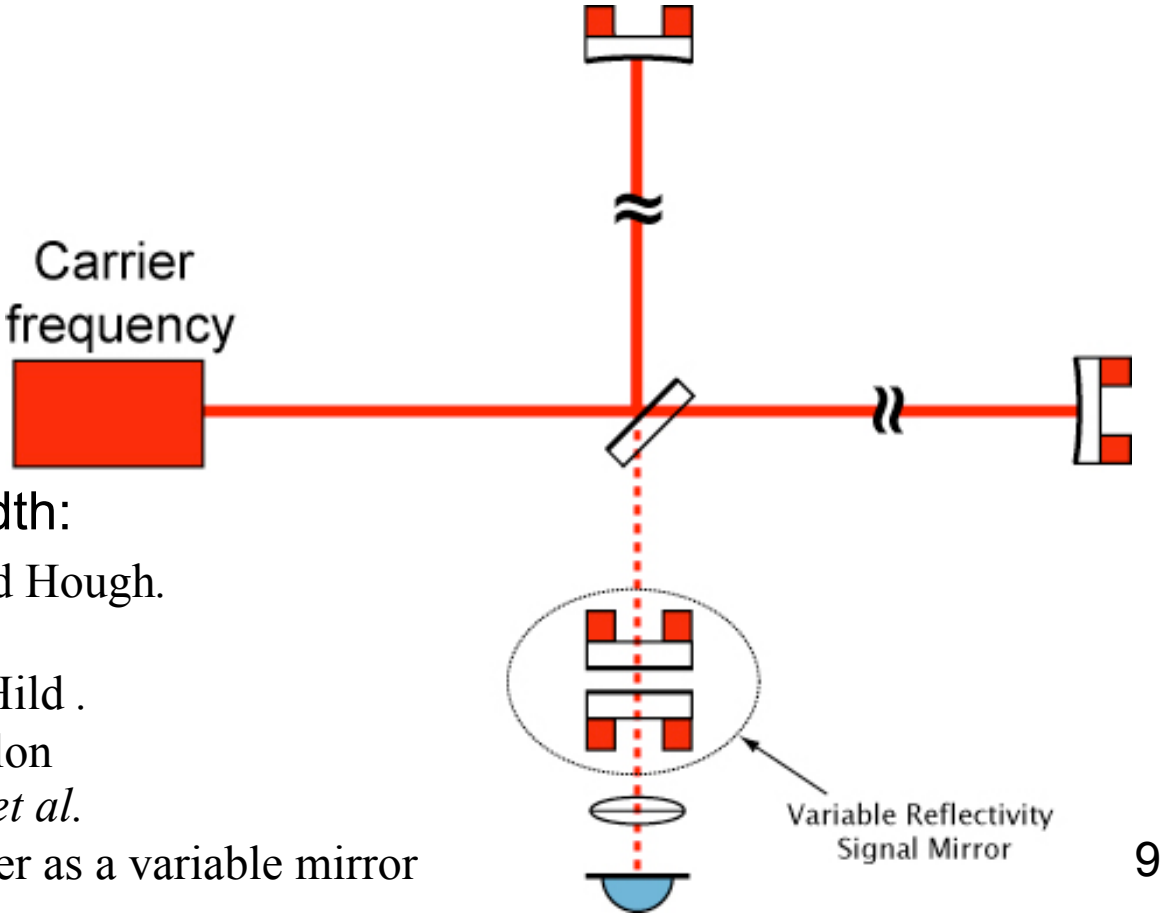


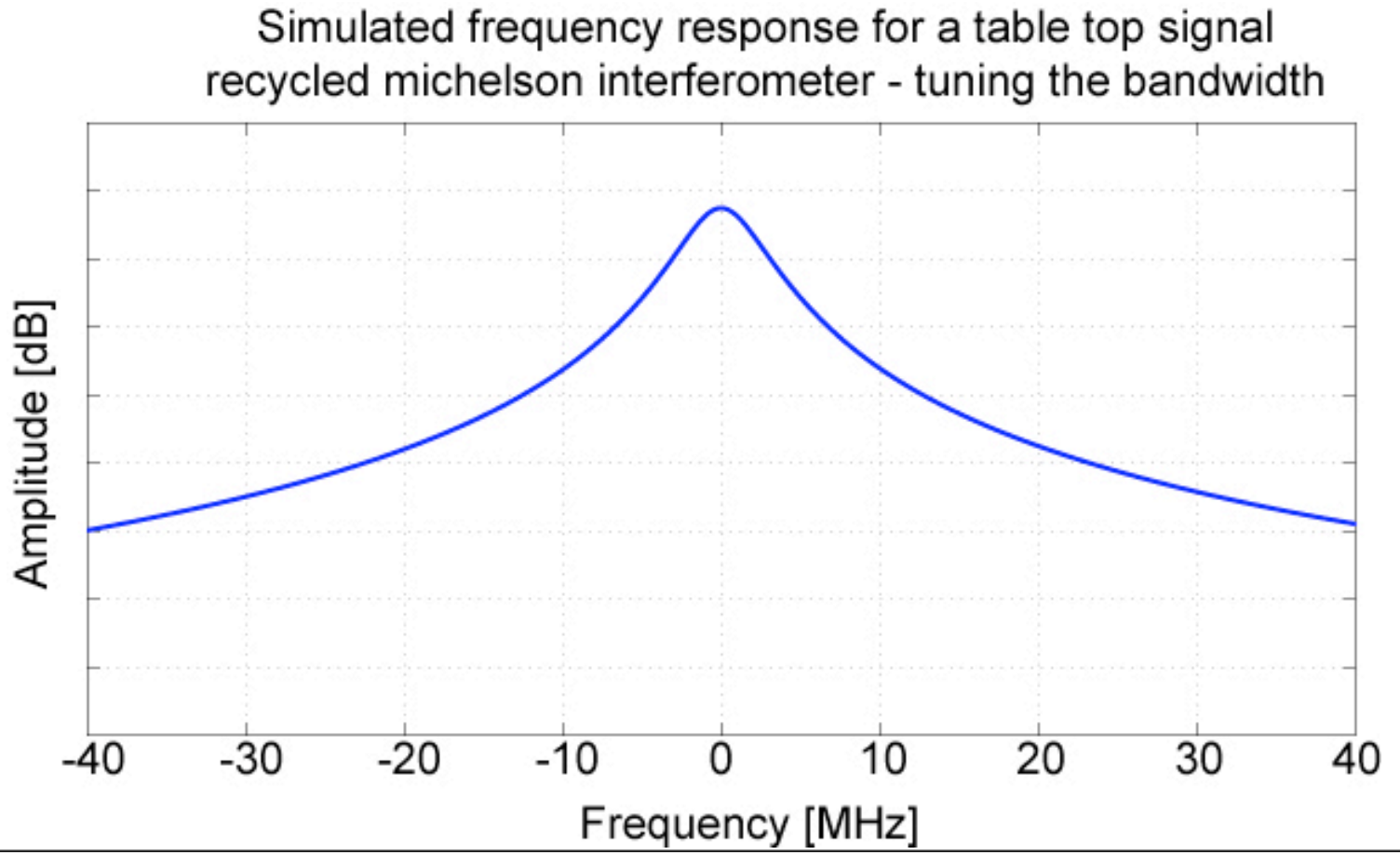
Changing the detector bandwidth



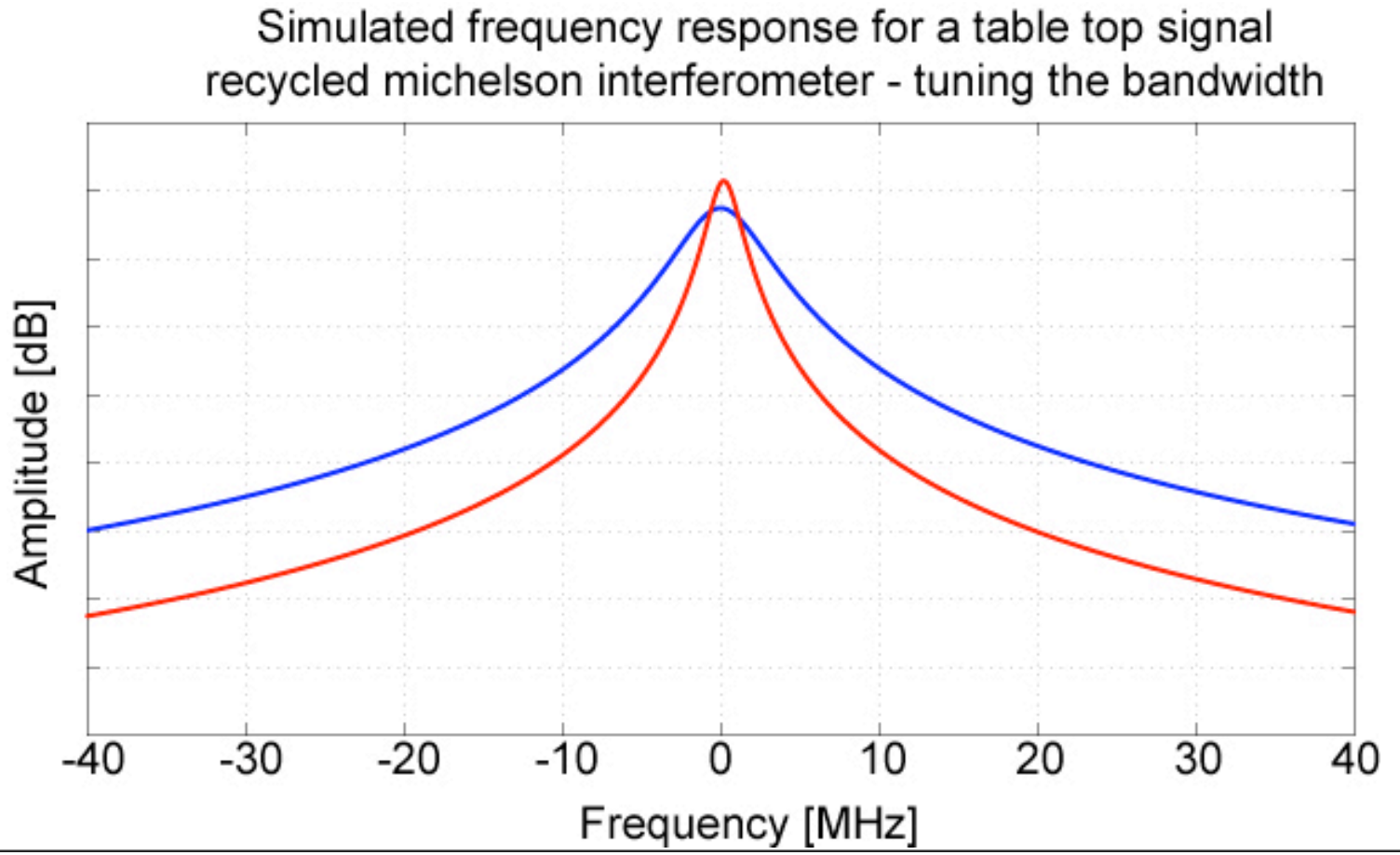
Previous work on controlling the IFO bandwidth:

- First demonstrated by Strain and Hough.
  Three mirror cavity.
- Demonstrated by Kawabe and Hild .
  Using thermal tuning of an ethalon
- Demonstrated later by de Vine *et al.*
  Using a Michelson interferometer as a variable mirror

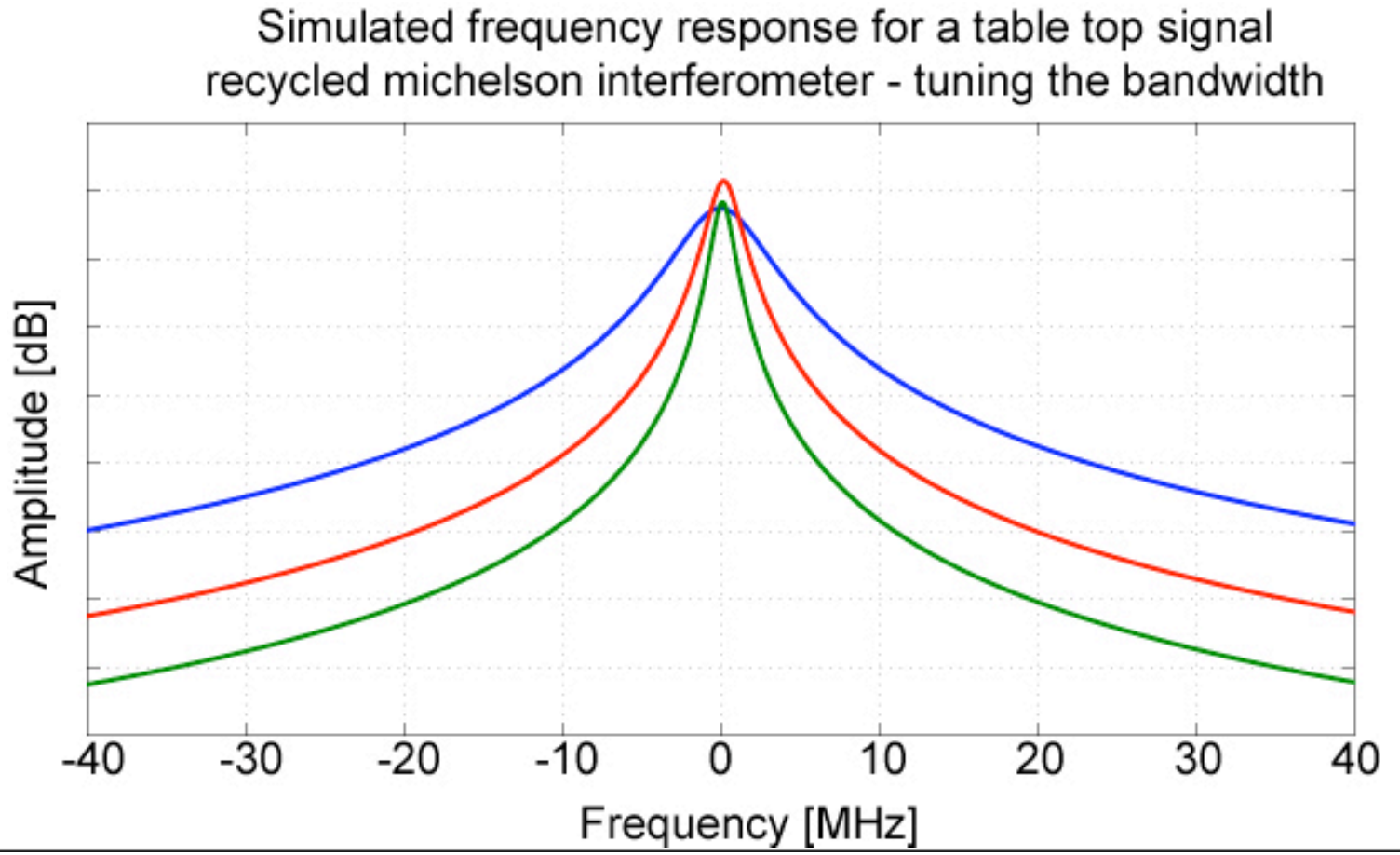
Changing the detector bandwidth



Changing the detector bandwidth



Changing the detector bandwidth

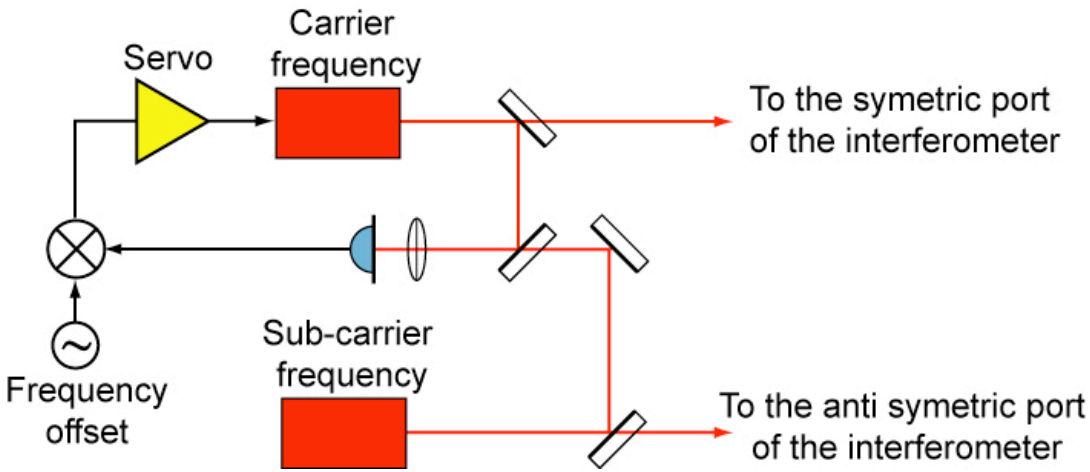


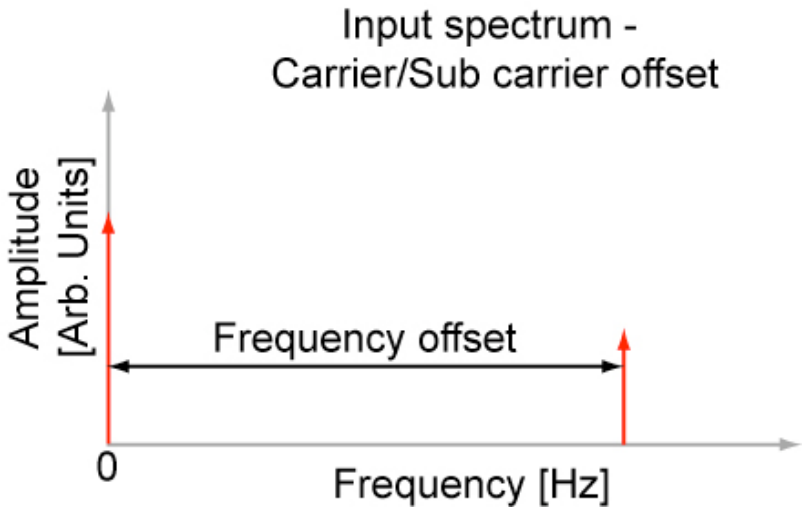
The control system

The control system

- The control system uses a carrier and sub carrier frequency that are frequency offset phase locked.

The interferometer input

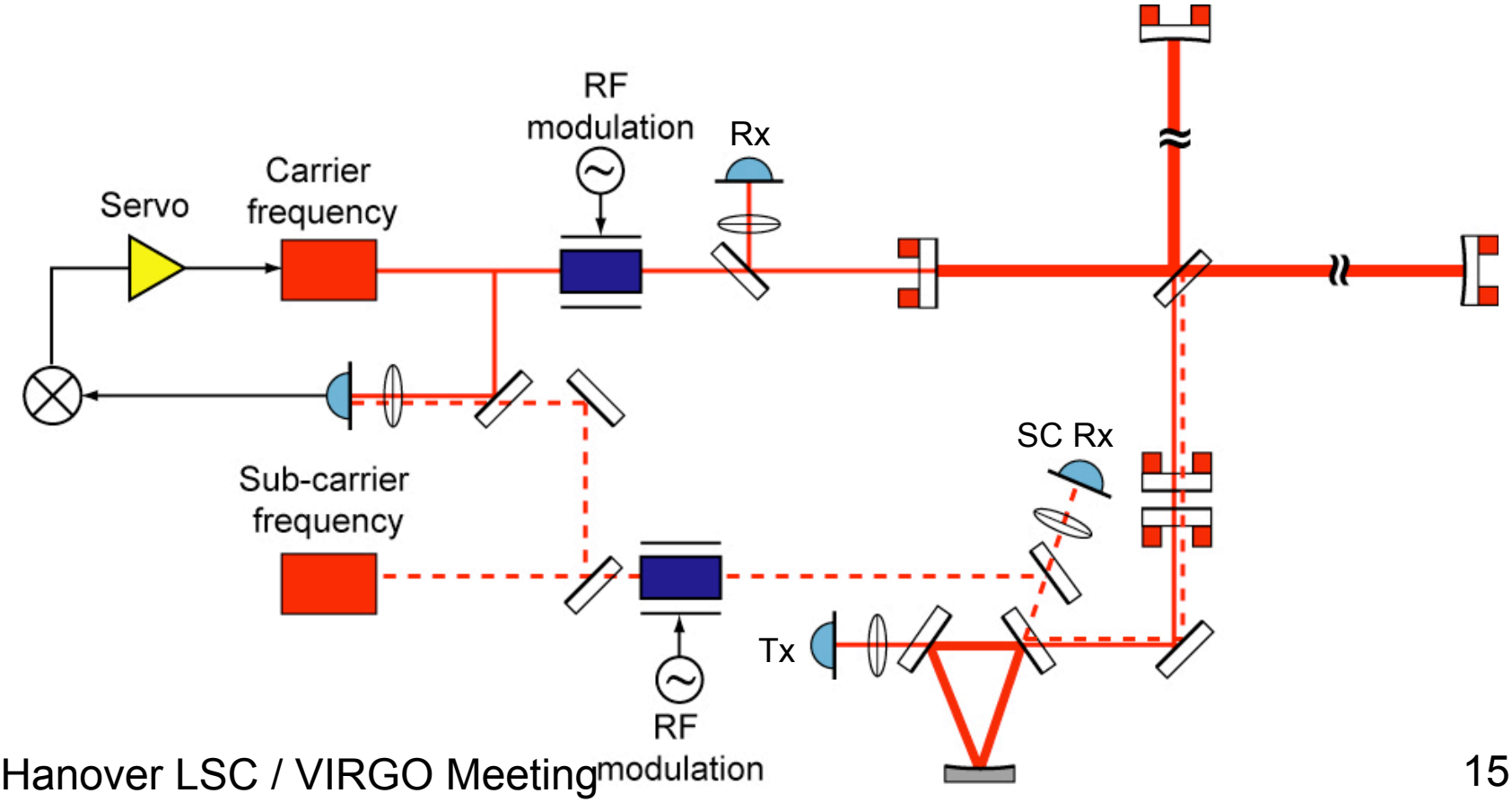




The control system

- The control system uses a carrier and sub carrier frequency that are frequency offset phase locked.
- Both frequencies receive radio frequency phase modulated sidebands. The carrier frequency is injected through the power recycling mirror. The sub carrier is injected into the interferometer by reflecting off the output mode cleaner (which is anti-resonant for this frequency) through the signal recycling mirror.

The control system



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- The signal recycling degree of freedom is controlled by the in-phase quadrature component of the PDH error signal.

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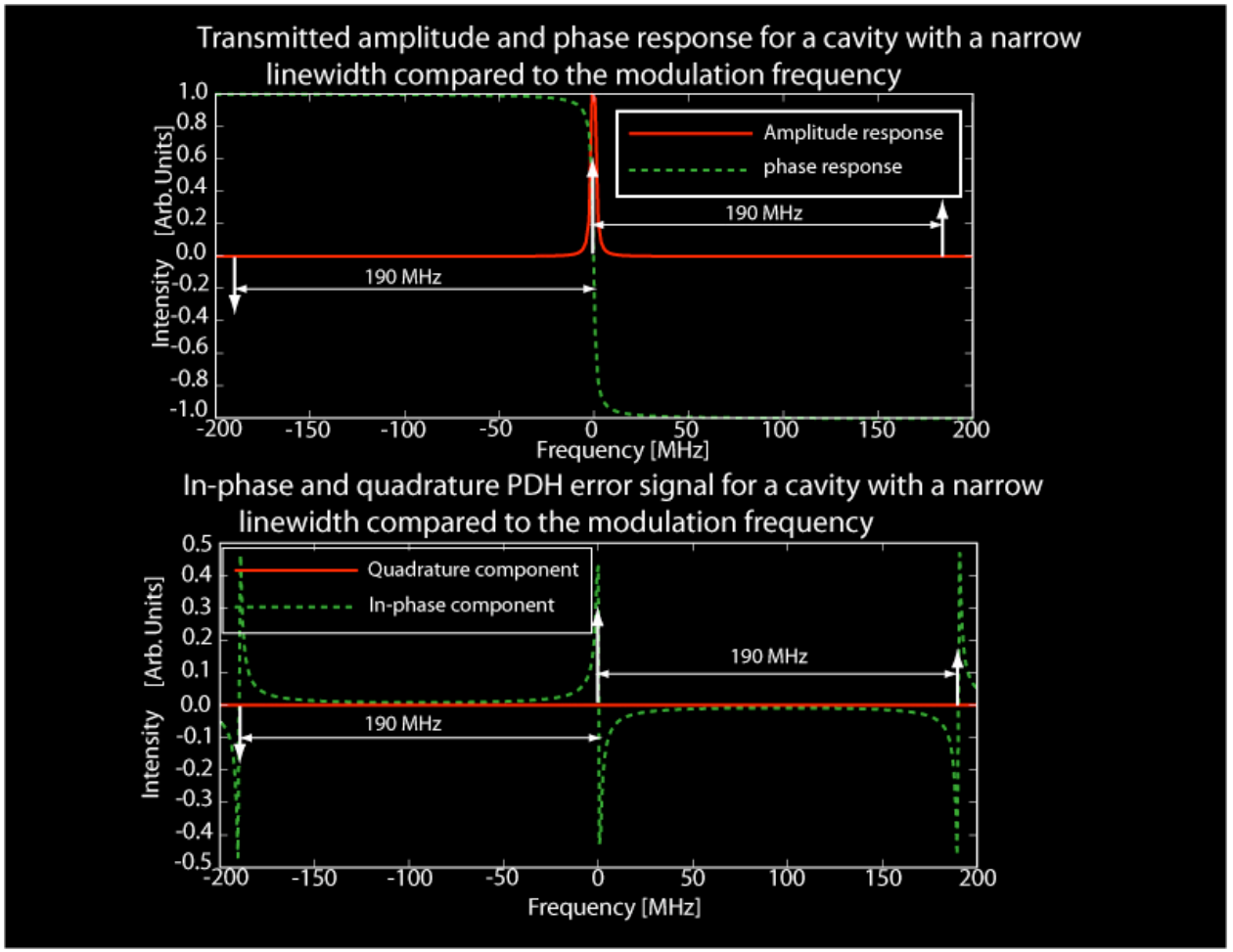
- The signal recycling degree of freedom is controlled by the in-phase component of the sub-carrier PDH error signal.
- The VRSM degree of freedom is controlled by the quadrature component of the sub-carrier PDH error signal.

The control system



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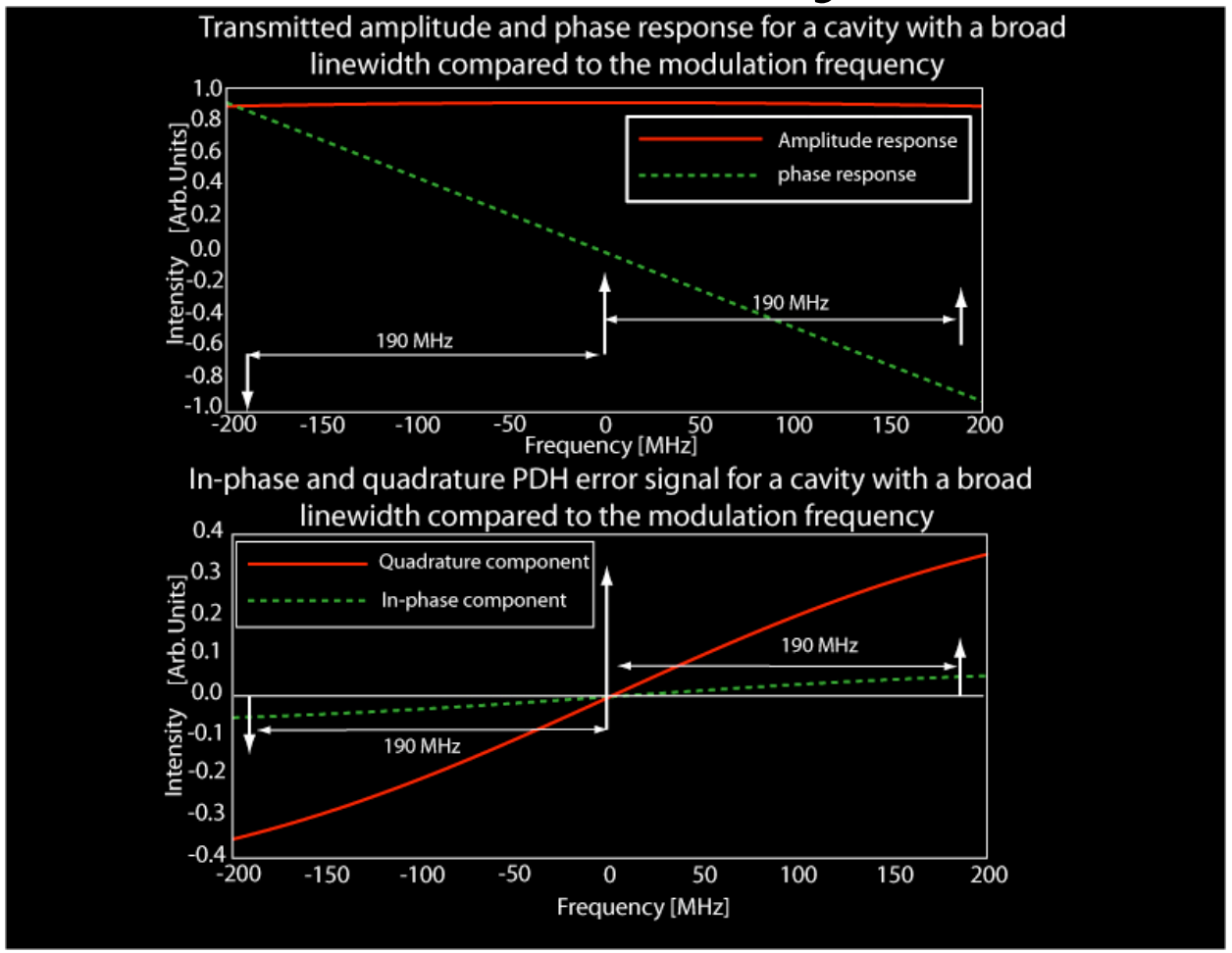

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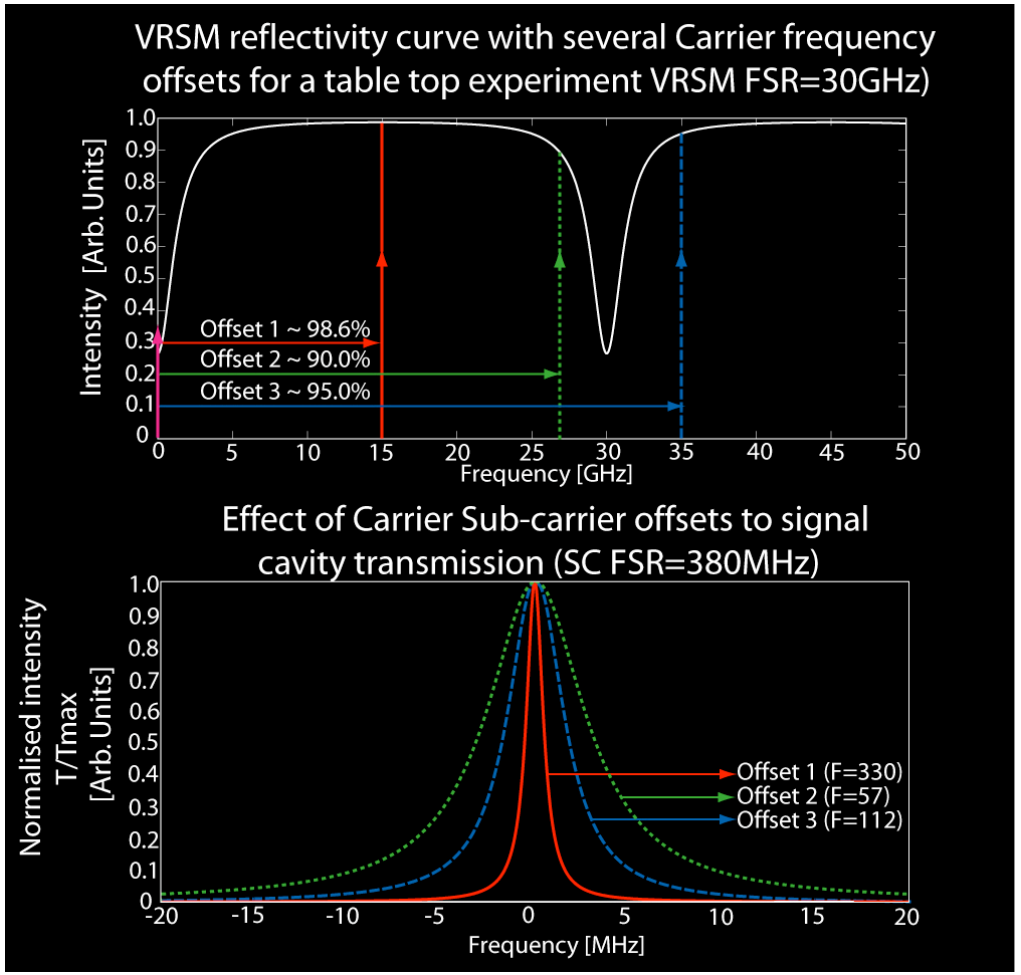
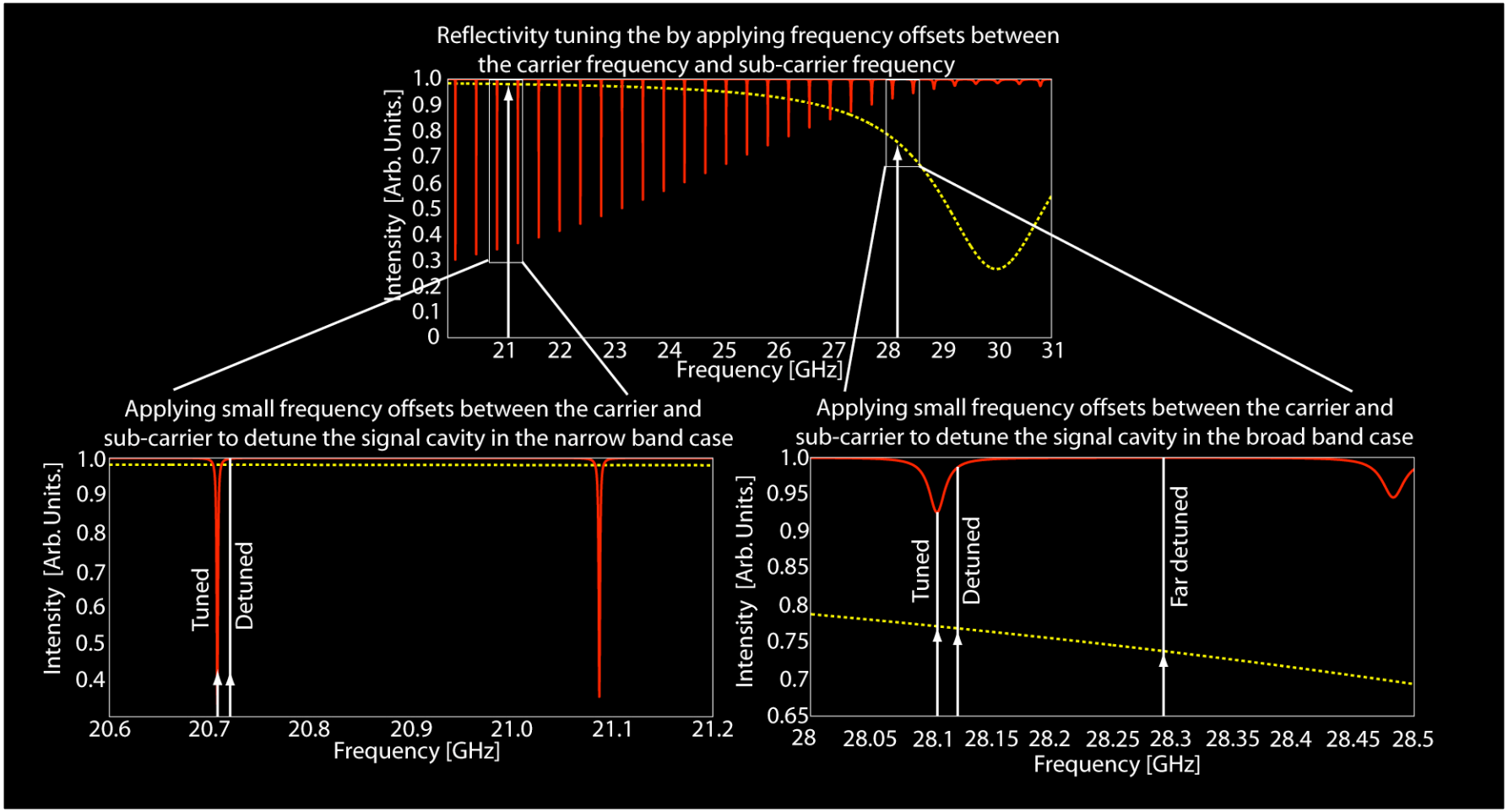
- Both frequencies receive radio frequency phase modulated sidebands. The carrier frequency is injected through the power recycling mirror. The sub carrier is injected into the interferometer by reflecting off the output mode cleaner (which is anti-resonant for this frequency) through the signal recycling mirror.
- The signal recycling degree of freedom is controlled by the in-phase component of the sub-carrier PDH error signal.
- The VRSM degree of freedom is controlled by the quadrature component of the sub-carrier PDH error signal.
- Finally, we control the detector bandwidth and detuning by adjusting the offset frequency between the carrier and the sub-carrier.

Carrier/Sub-carrier offset

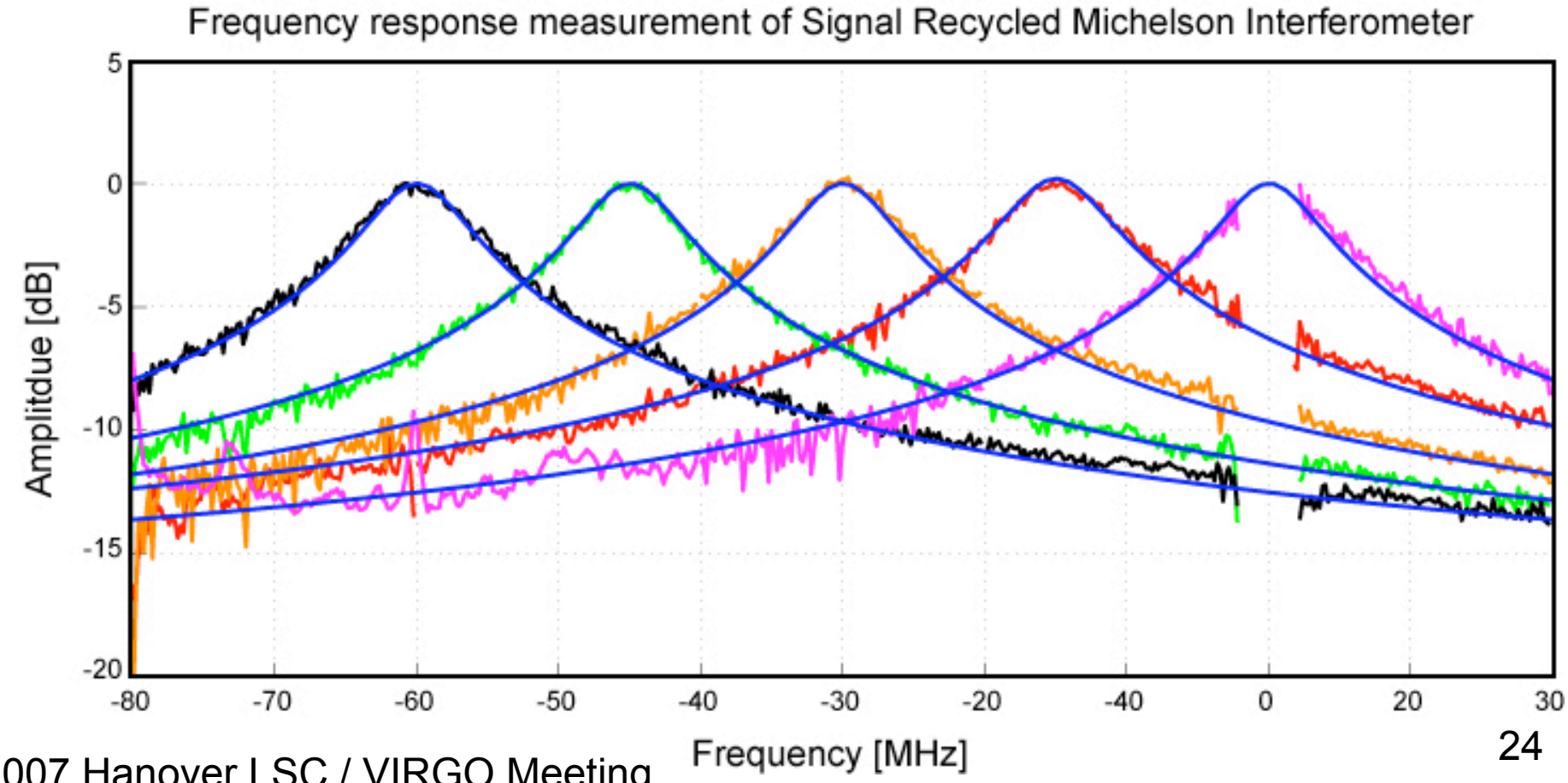


Carrier/Sub-carrier offset

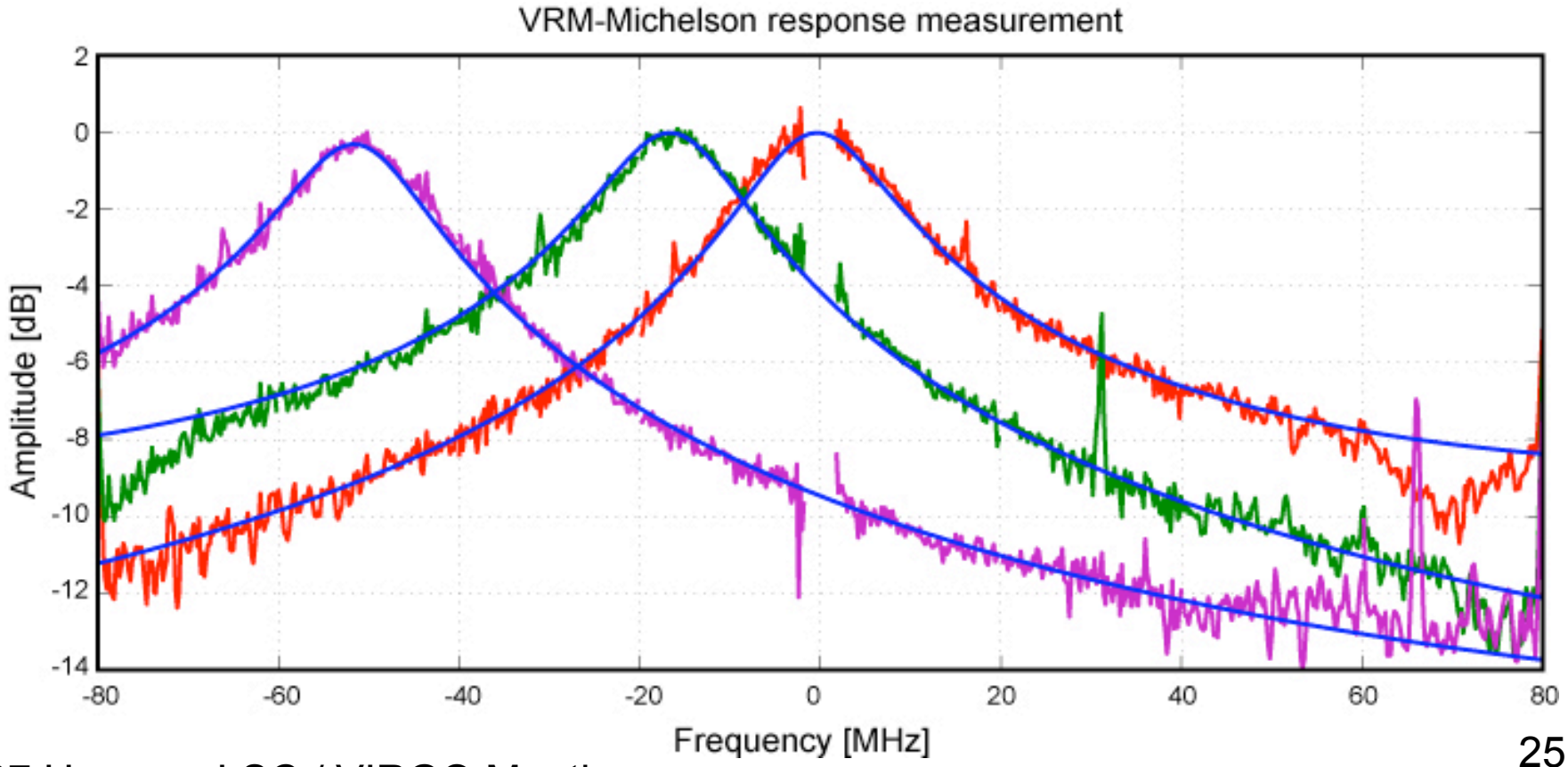


The results

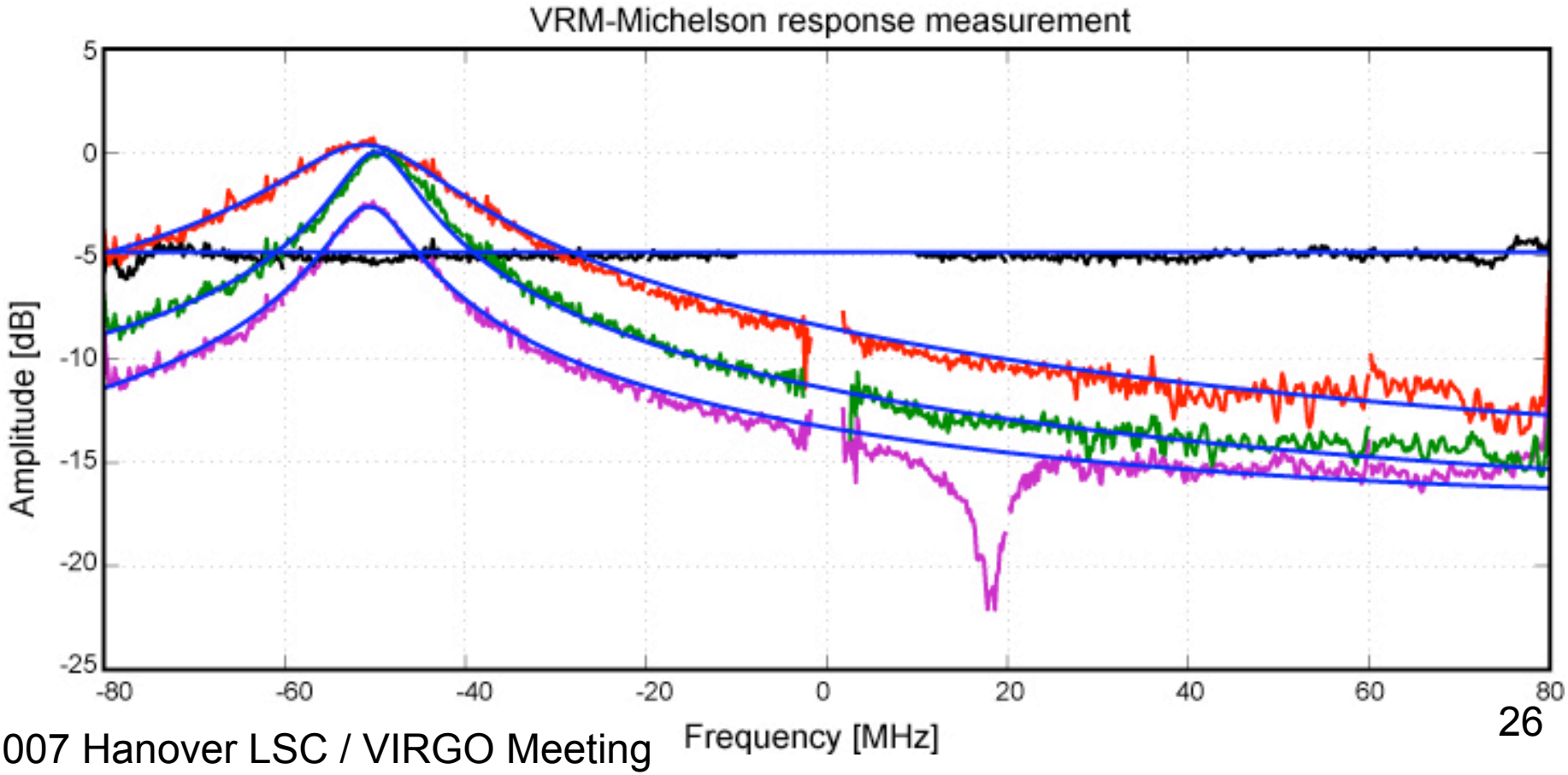
SR results - Detuning



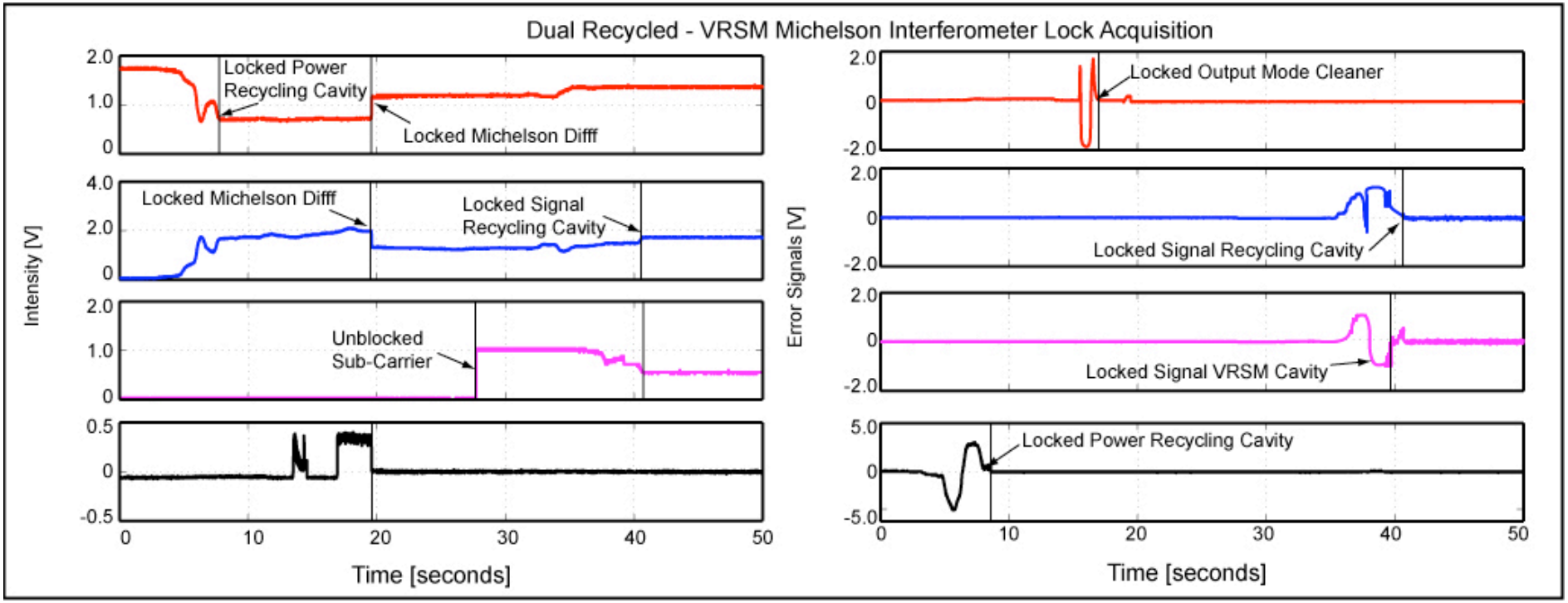
VRSM results - Detuning



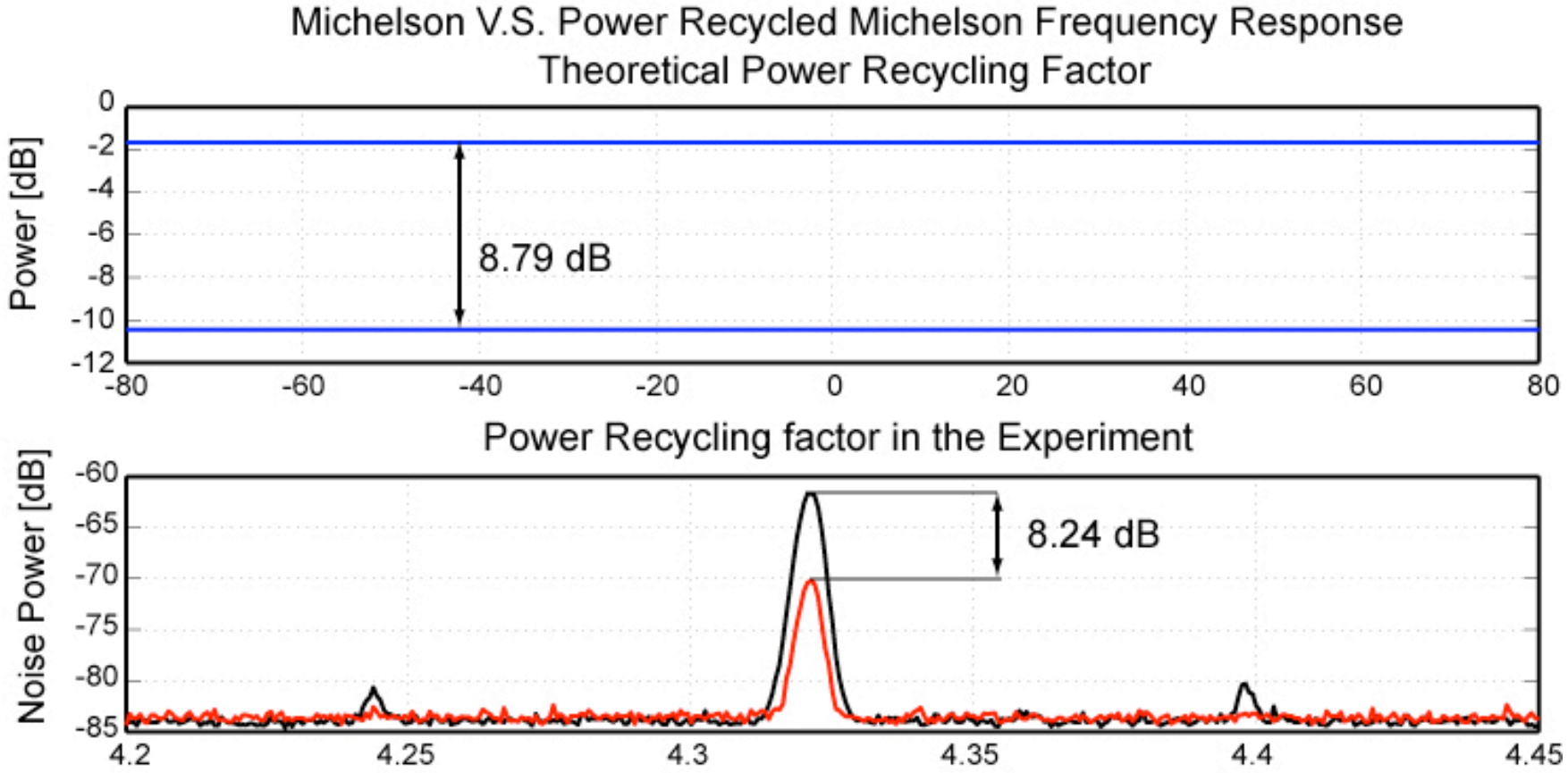
VRSM results - Changing the BW



DR-VRSM results - Lock acq.



Results - Power Recycling factor



Summary

- We have successfully locked a table top DR Michelson interferometer with a variable reflectivity signal recycling mirror and output mode cleaner.
- The control system shows relatively easy tuning of the interferometer bandwidth and/or peak sensitivity.
- Future experiments will try to incorporate this control strategy in a RSE configuration

Thank you for your attention.