Alignment Investigations towards Advanced Virgo

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LSC-VIRGO 05/2007
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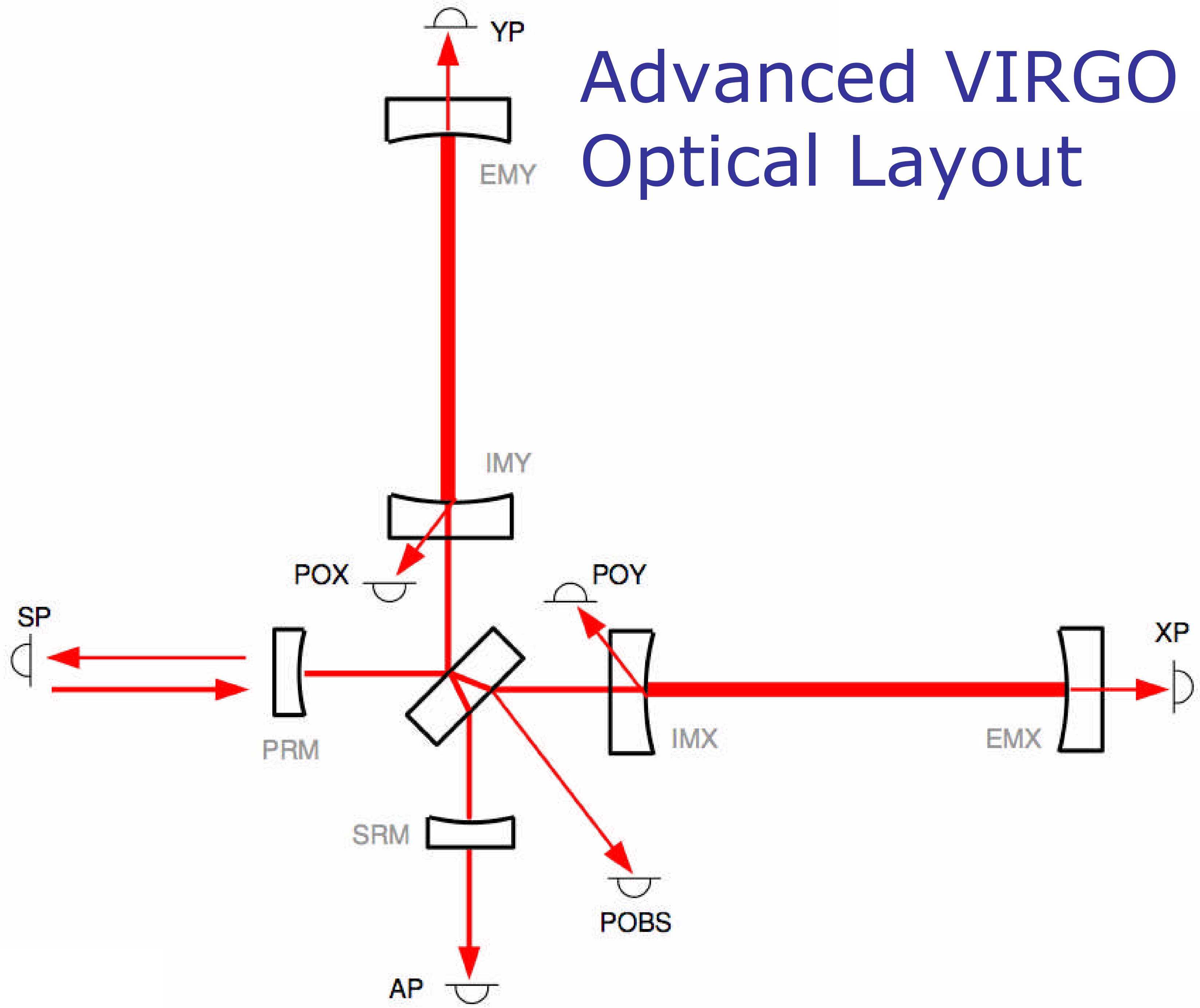
LIGO-G070365-00-Z

Advanced VIRGO Optical Layout

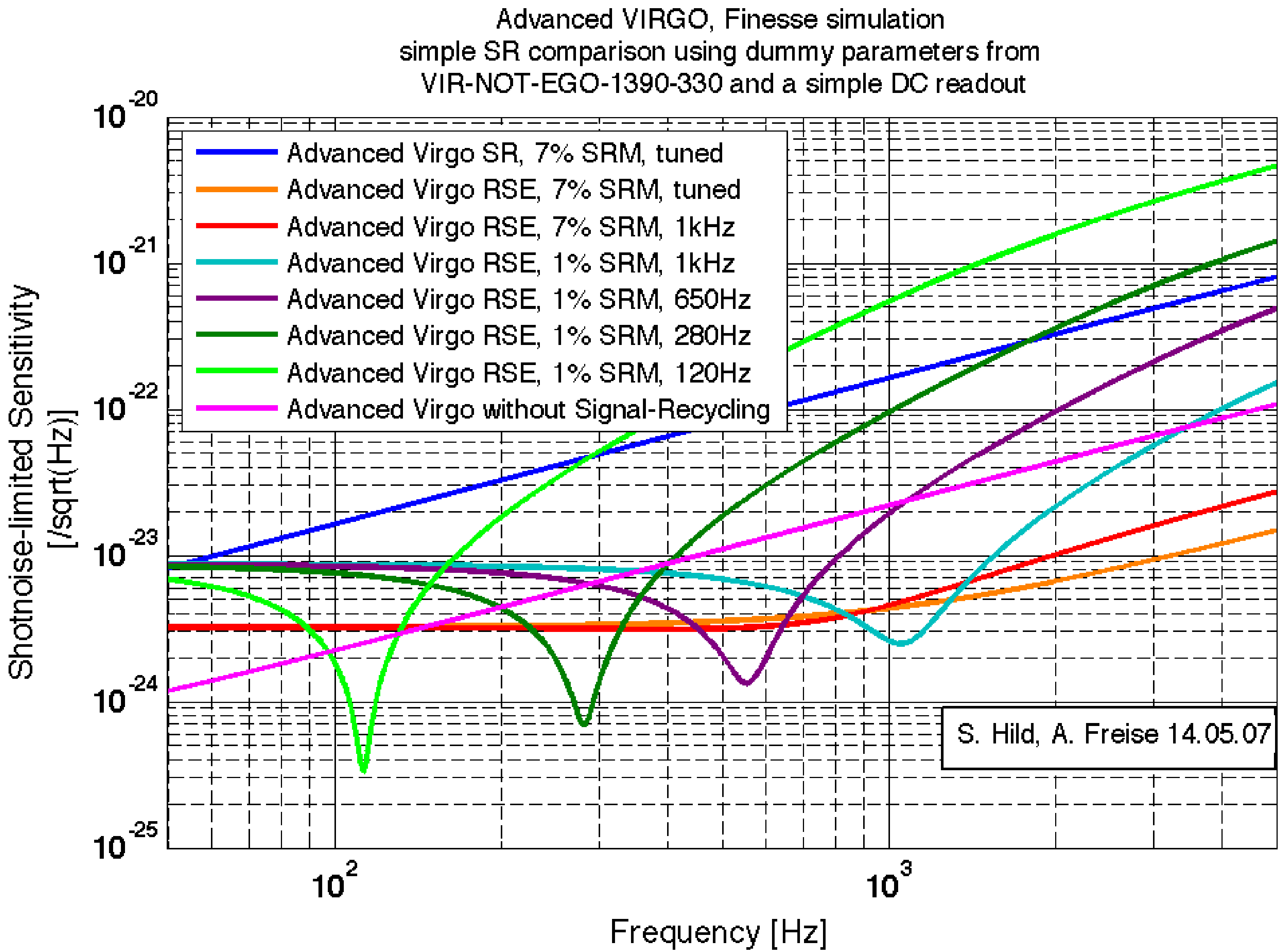
- Take 'dummy' optical layout as available from the Advanced VIRGO working groups (in the EGO/VIRGO working area)
- Try to perform preliminary analysis of alignment schemes and noise estimates
- Use computer scripts and simulation methods developed for VIRGO (wide search of parameter space)

Advanced VIRGO Optical Layout

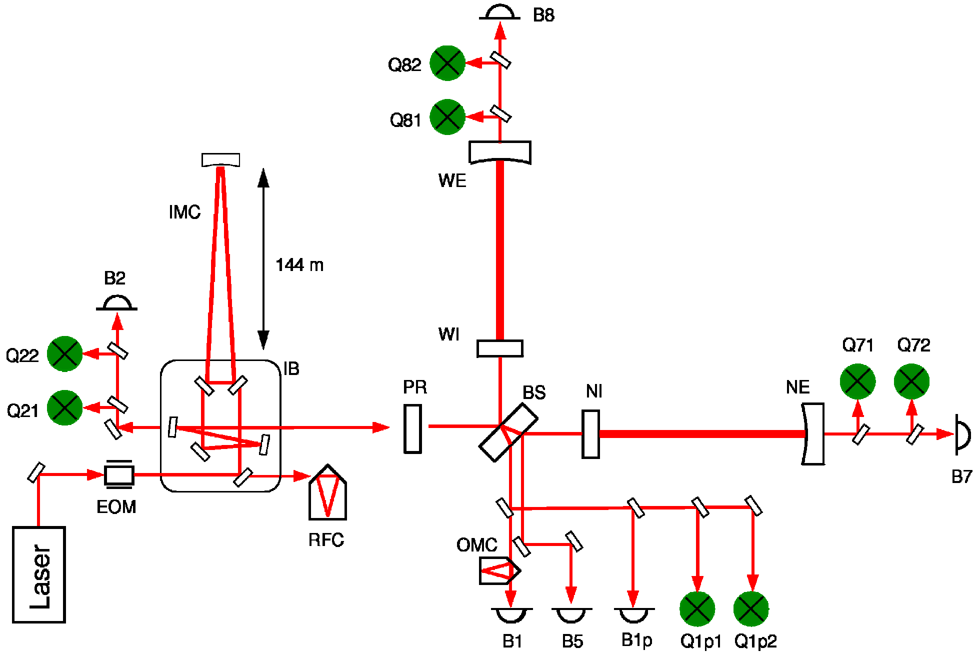


Optical Layout Overview

- Optical path lengths: as VIRGO
- 0.5 MW circulating power in arm cavities
- Tuned RSE configuration (DC read-out, no locking scheme)


Advanced VIRGO, Finesse simulation
simple SR comparison using dummy parameters from
VIR-NOT-EGO-1390-330 and a simple DC readout
Advanced Virgo SR, 7% SRM, tuned
Advanced Virgo RSE, 7% SRM, tuned
Advanced Virgo RSE, 7% SRM, 1kHz
Advanced Virgo RSE, 1% SRM, 1kHz
Advanced Virgo RSE, 1% SRM, 650Hz
Advanced Virgo RSE, 1% SRM, 280Hz
Advanced Virgo RSE, 1% SRM, 120Hz
Advanced Virgo without Signal-Recycling
S. Hild, A. Freise 14.05.07
Shotnoise-limited Sensitivity [/sqrt(Hz)]
Frequency [Hz]
10^-20
10^-21
10^-22
10^-23
10^-24
10^-25
10^2
10^3

Computing the optical matrix



Example: Initial Virgo Configuration

Finesse File Output

Low Frequency Transfer Functions between the mirror angular motions and the Quadrant-diode outputs

(N output files for N d.o.f)

`Matlab` program to construct the optical matrix

Estimate Controllability

Method to evaluate the **quality** of a control or sensing matrix: using the distribution of the matrix‵ row vectors in the system's parameter space.

$$O_{ij} \cdot \beta_j = s_i$$

Optical Matrix

Mirror angular movement

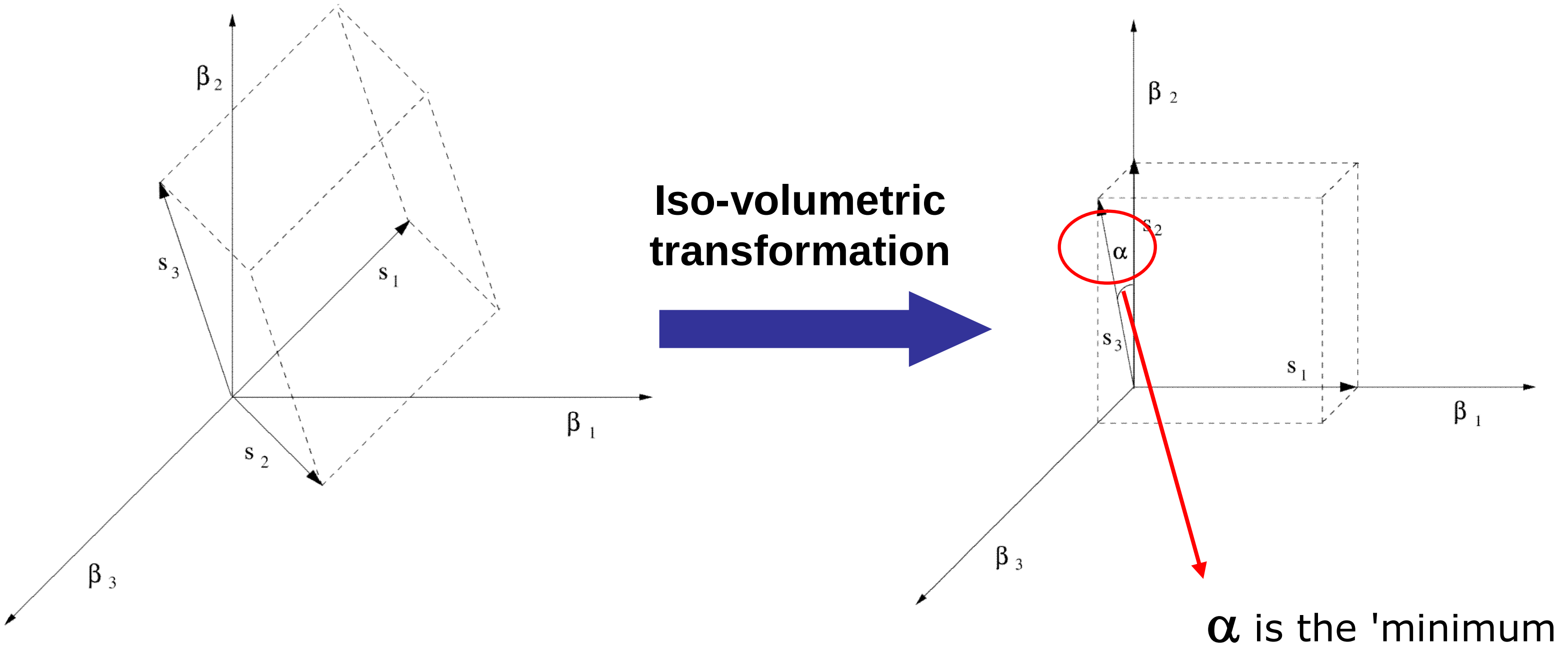
Signal

$O =$

	β_1	…	β_n
s_1	O_{11}	…	O_{1n}
…	…	…	…
s_m	O_{m1}	…	O_{mn}

Estimate Controllability

In an over-determined system (e.g. VIRGO) we select the subset of diode signals which provides maximally separated vectors (`Matlab` script) and we use the "minimum equivalent angle" between them as the figure of merit when comparing control topologies (quality parameter).

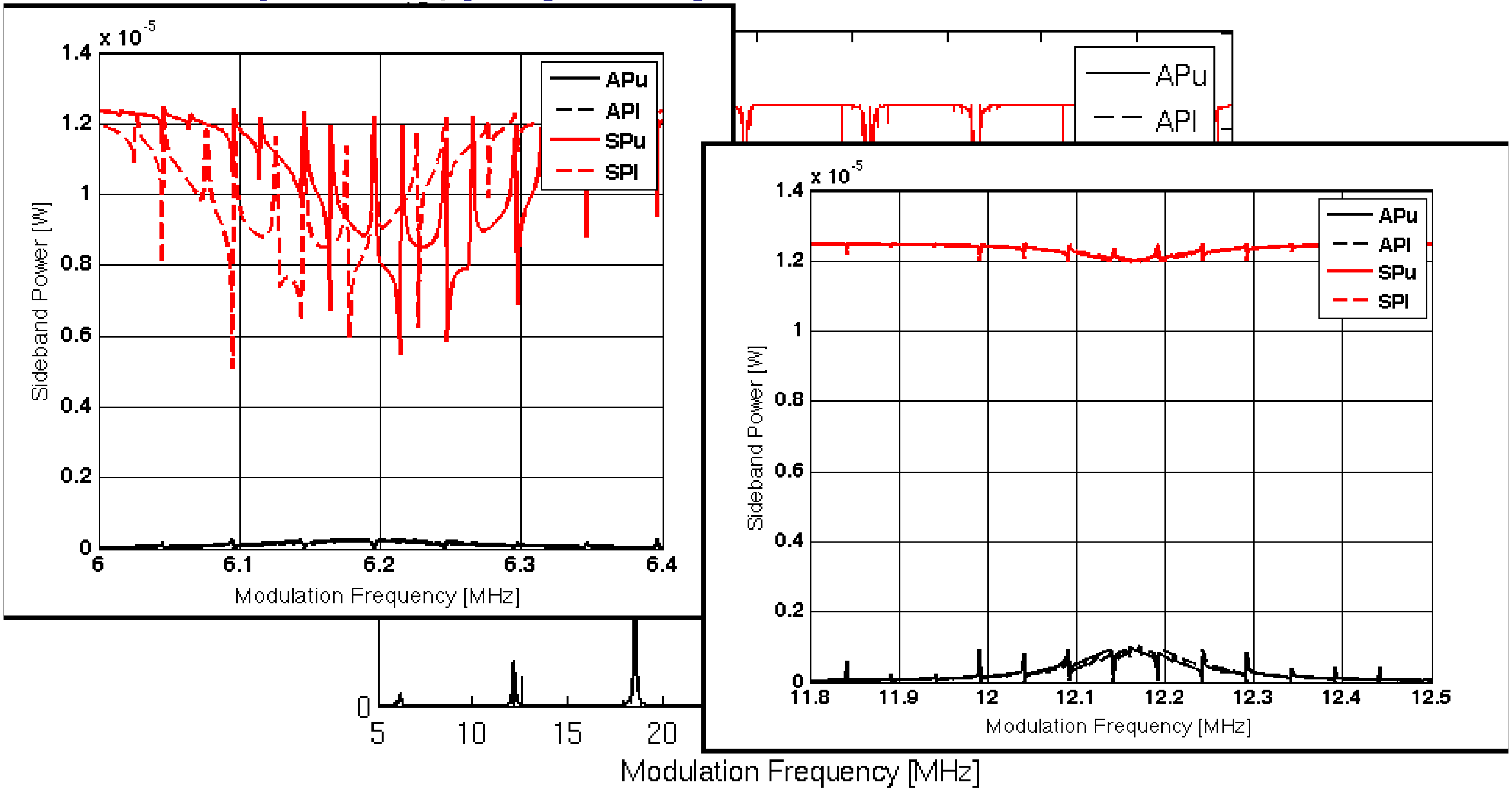


α is the 'minimum equivalent angle'

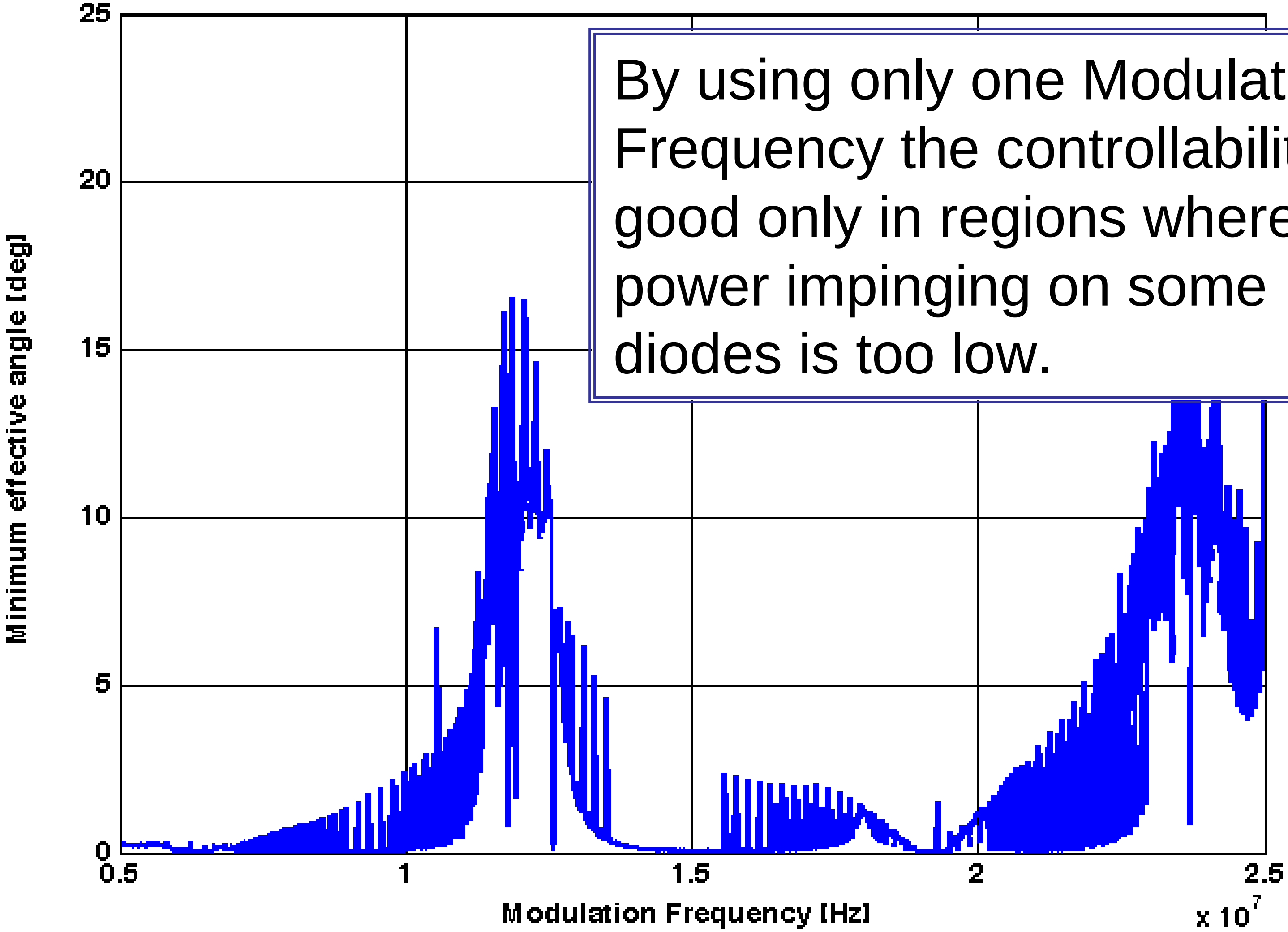
Step by Step

- Look at sideband resonances
- Select 'useful' ranges for modulation frequencies
- Evaluate the controllability

Choosing a modulation Frequency (1/3)

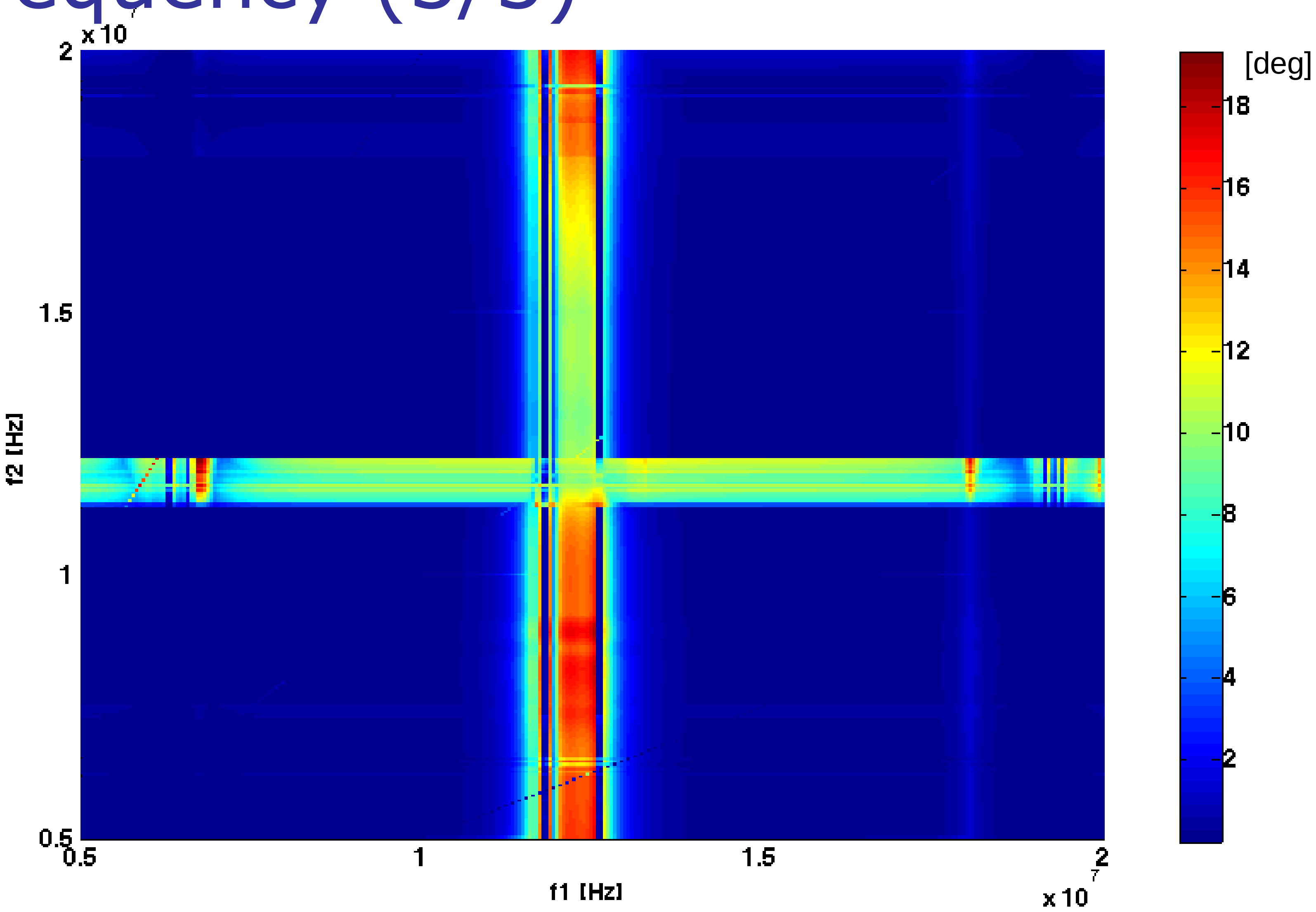


Choosing a modulation Frequency (2/3)



By using only one Modulation Frequency the controllability is good only in regions where the power impinging on some diodes is too low.

Choosing a modulation Frequency (3/3)



Next steps

- Investigate additional output signals
- Work on length sensing in parallel
- Fix frequencies
- Optimise setup further
- Do noise projections