Re-considering bKAGRA EOM layout

May 2017

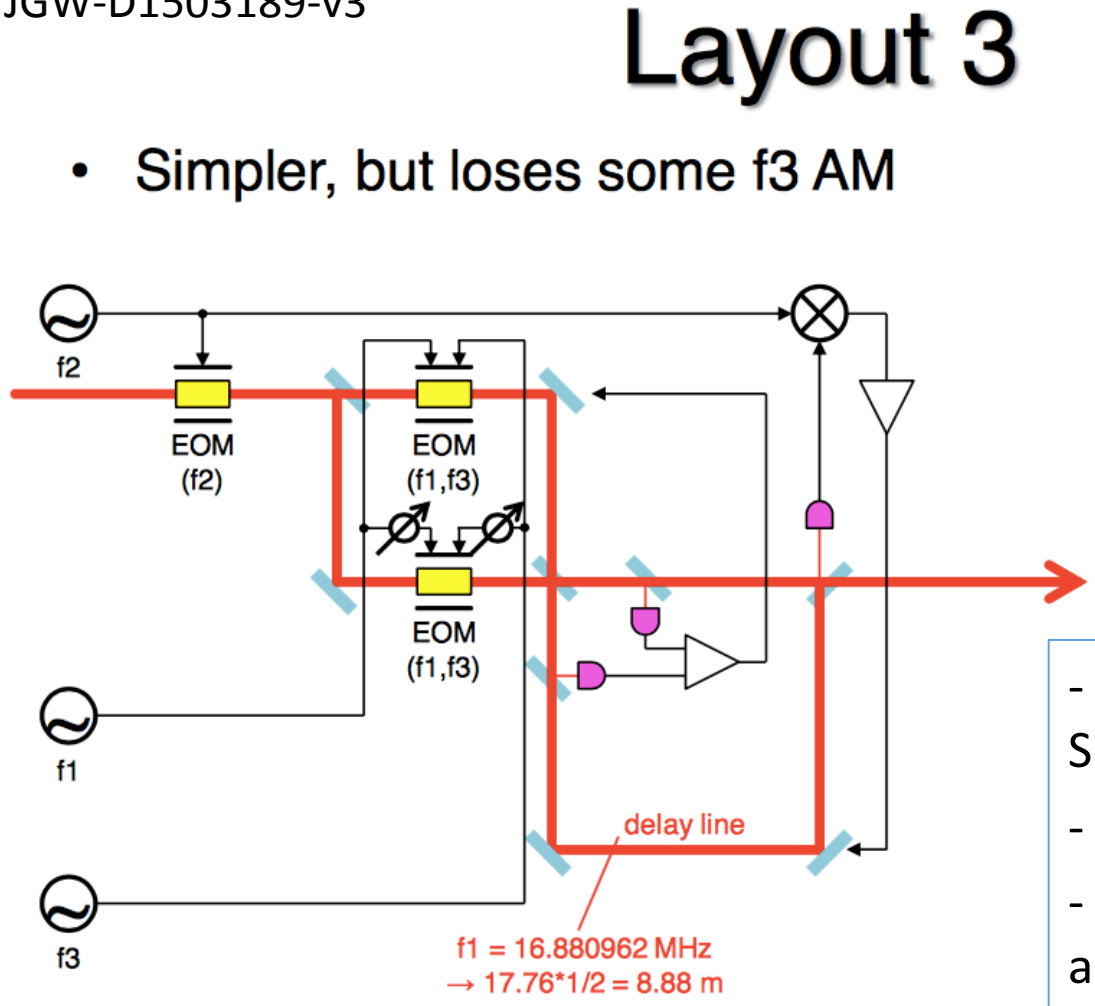
Yutaro Enomoto

default plan

JGW-D1503189-v3

Layout 3

- Simpler, but loses some f3 AM



- f1: PM and AM (depending on SRC detuning)
- f2: PM only
- f3: AM only (used only for lock acquisition phase)

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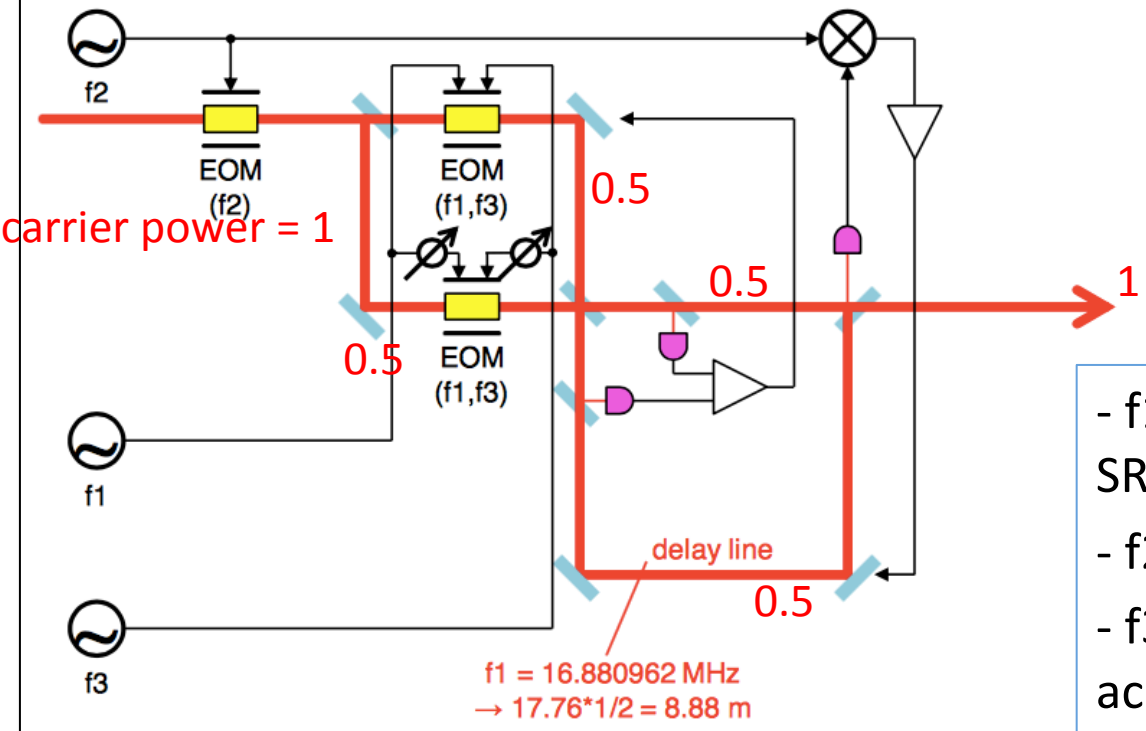

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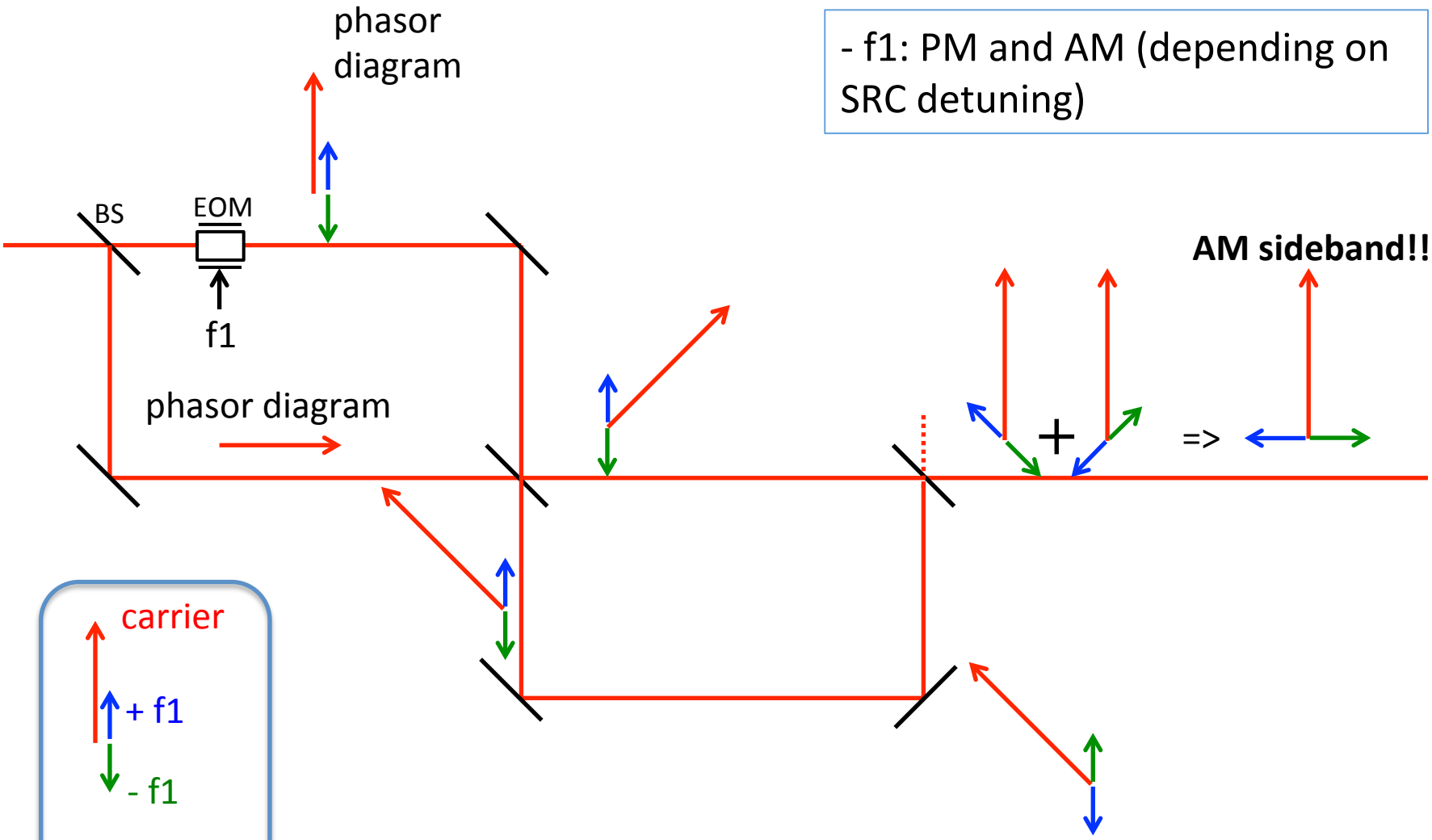

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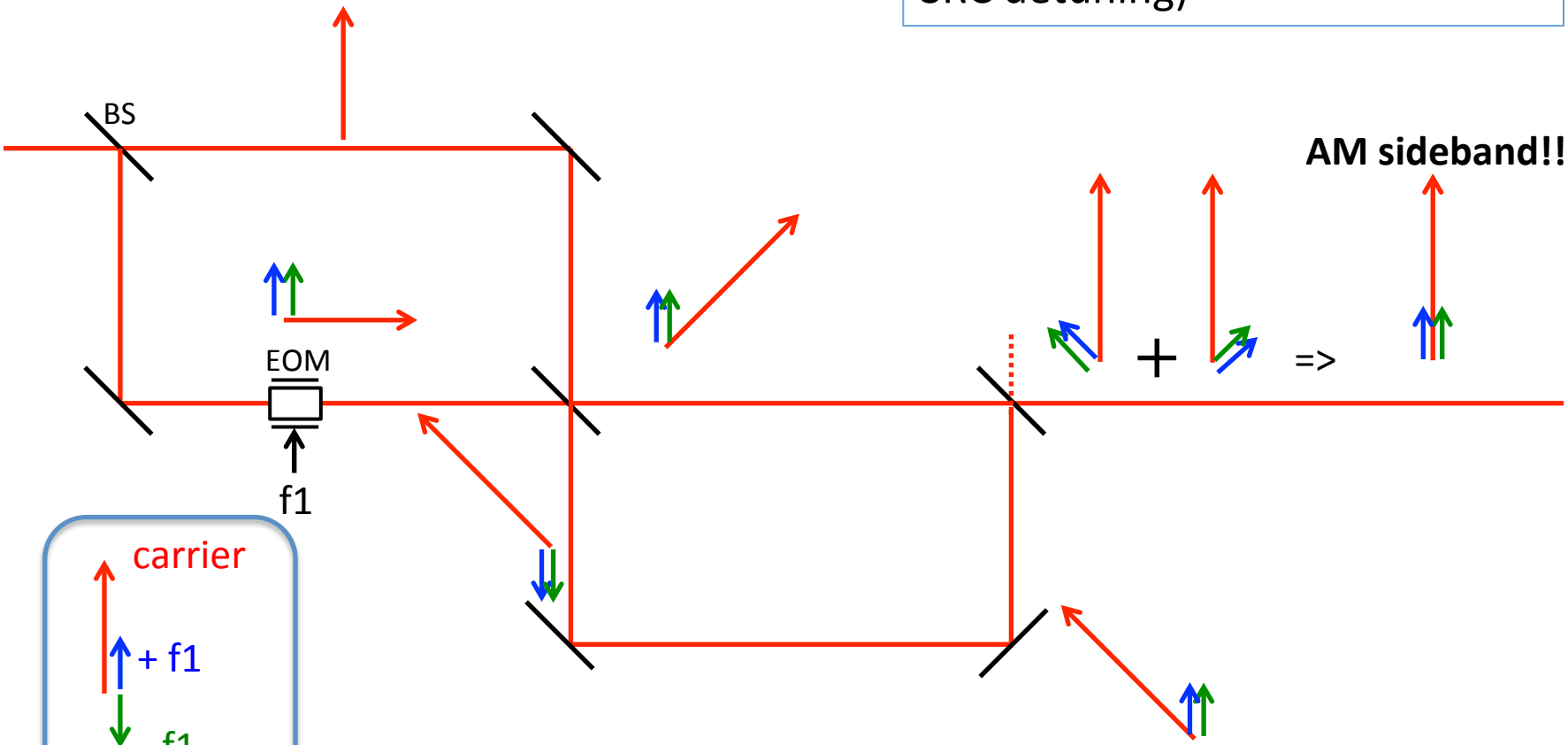

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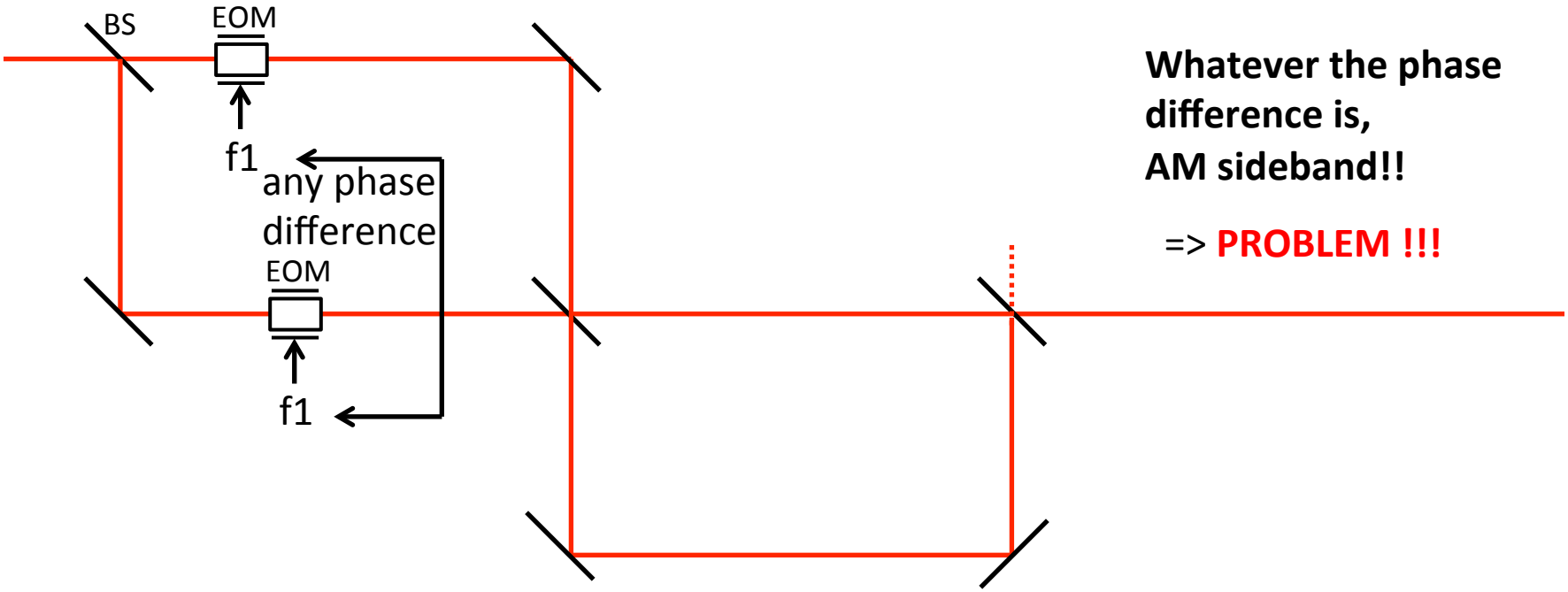

Whatever the phase difference is,
AM sideband!!

=> **PROBLEM !!!**

after delay line
(f1 sidebands rotates by 180°)

alternative plan

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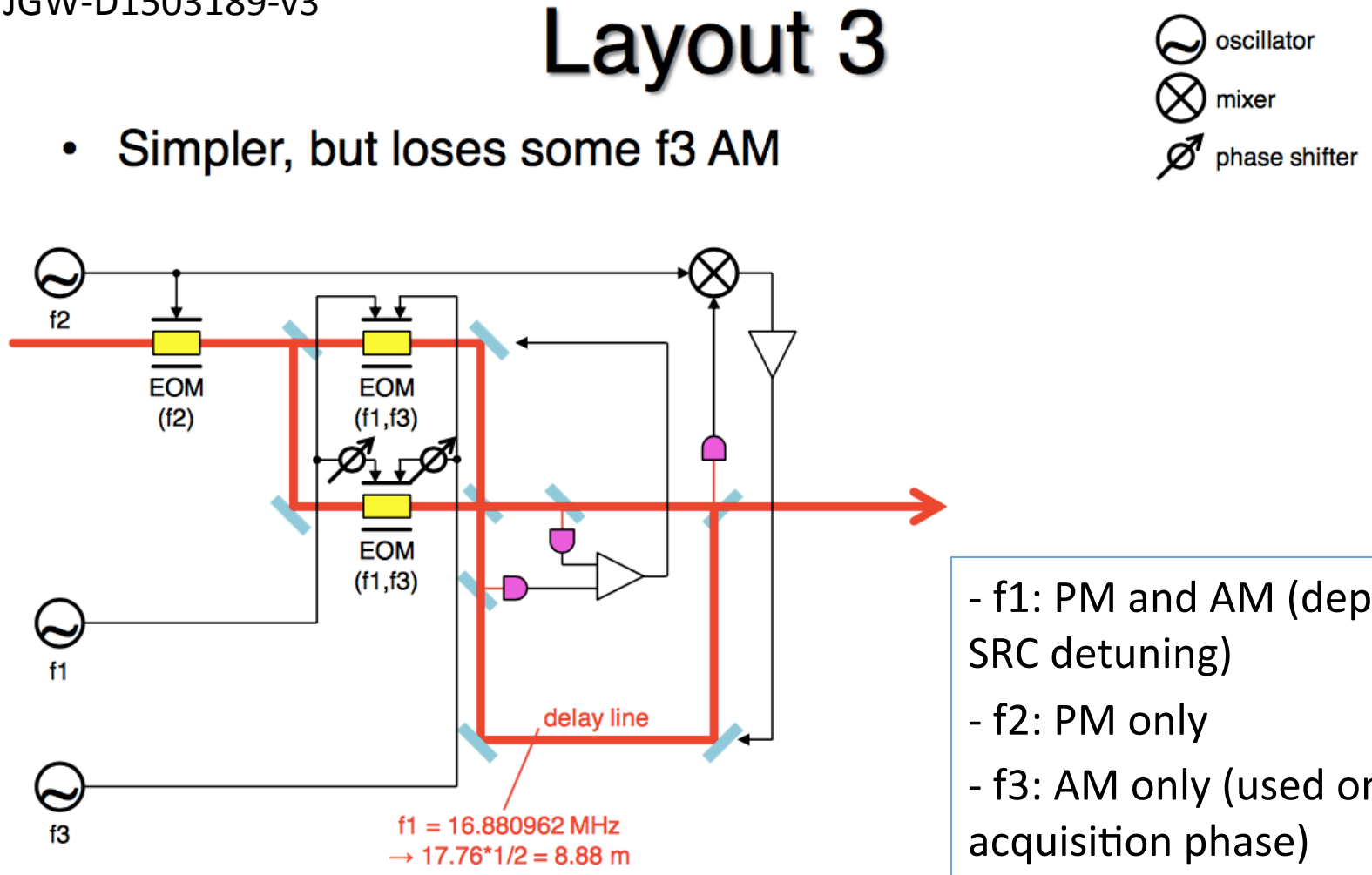

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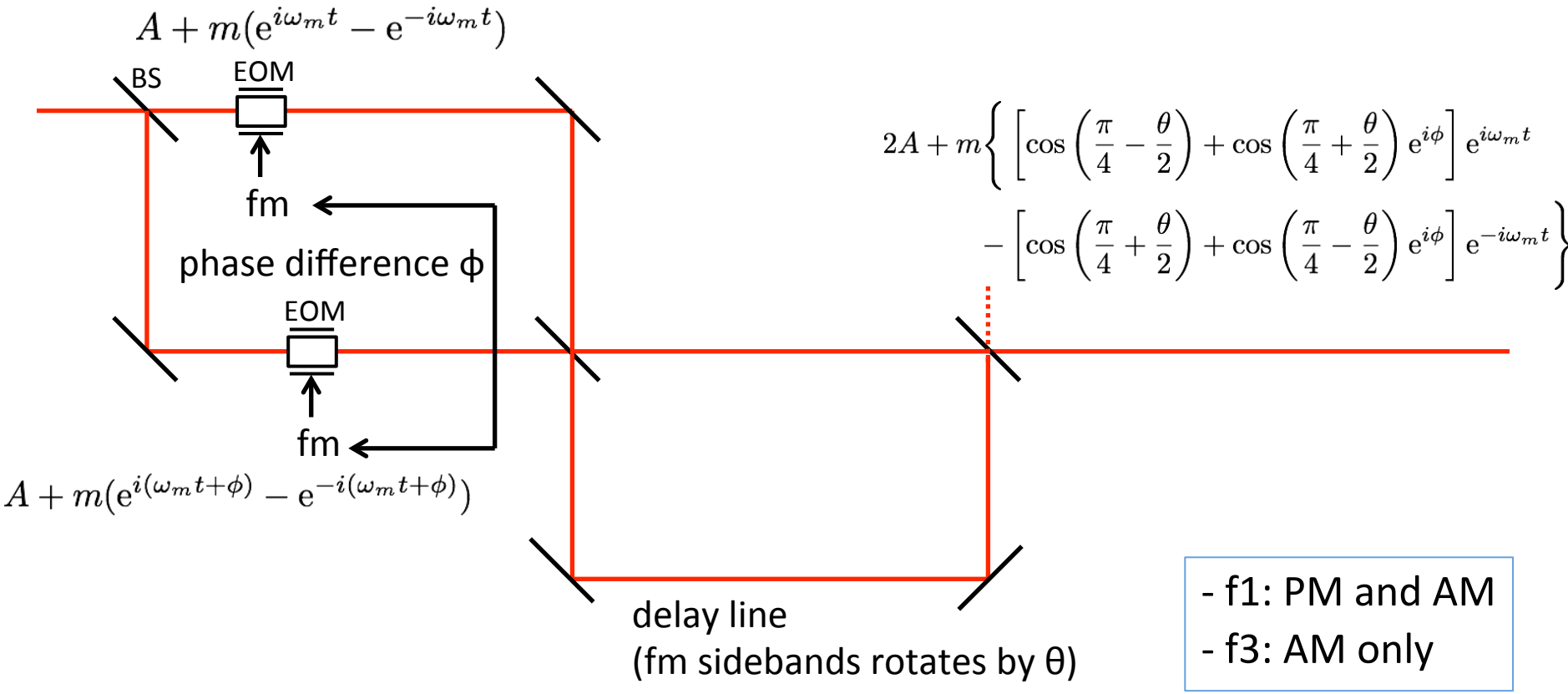

- f1: PM and AM
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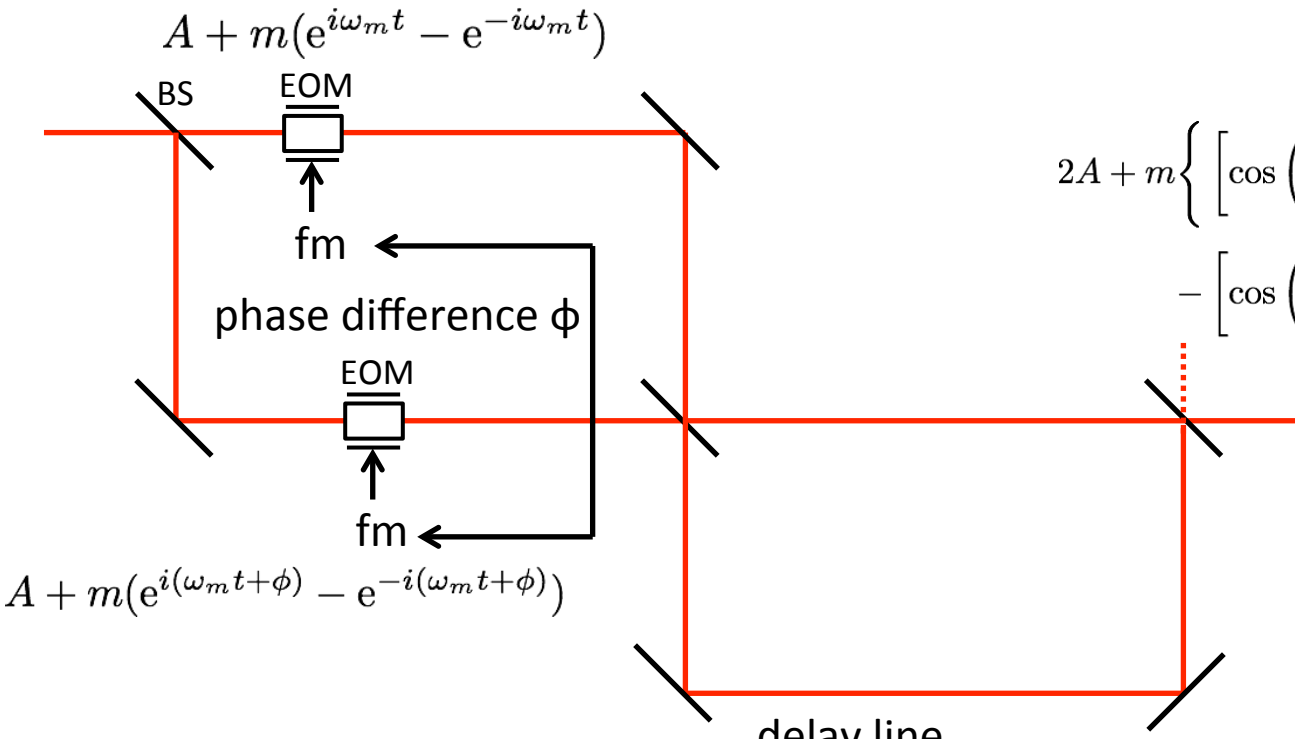
alternative plan



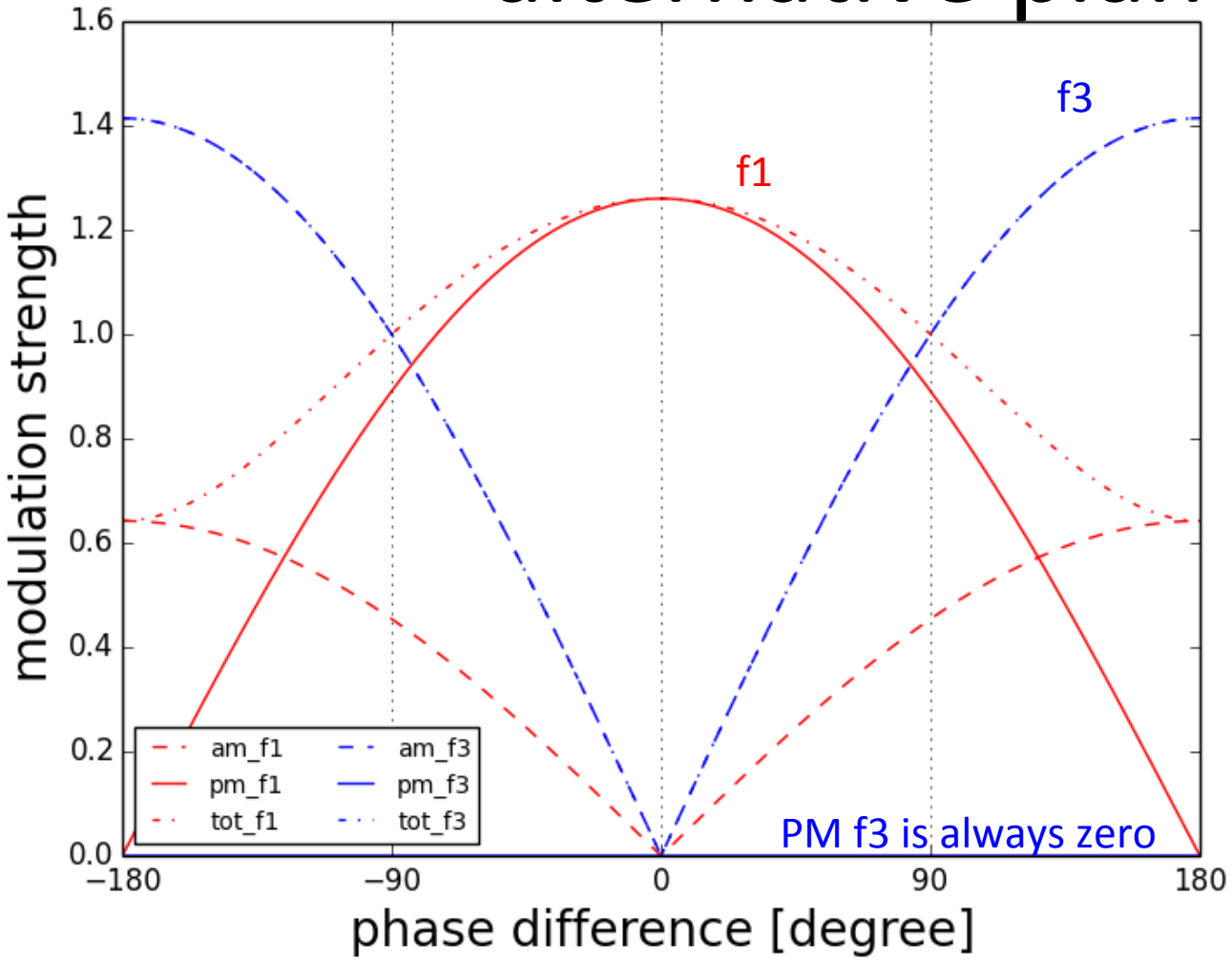
$$2A + m\left\{ \left[\cos\left(\frac{\pi}{4} - \frac{\theta}{2}\right) + \cos\left(\frac{\pi}{4} + \frac{\theta}{2}\right) e^{i\phi}\right] e^{i\omega_m t} - \left[\cos\left(\frac{\pi}{4} + \frac{\theta}{2}\right) + \cos\left(\frac{\pi}{4} - \frac{\theta}{2}\right) e^{i\phi}\right] e^{-i\omega_m t} \right\}$$

- f1: PM and AM
- f3: AM only

delay line 2.66 m --> $\theta(f_1) = 54°$ --> combination of PM and AM (next page)

$\theta(f_3) = 180°$ --> AM only (ϕ=180° is preferable)

alternative plan



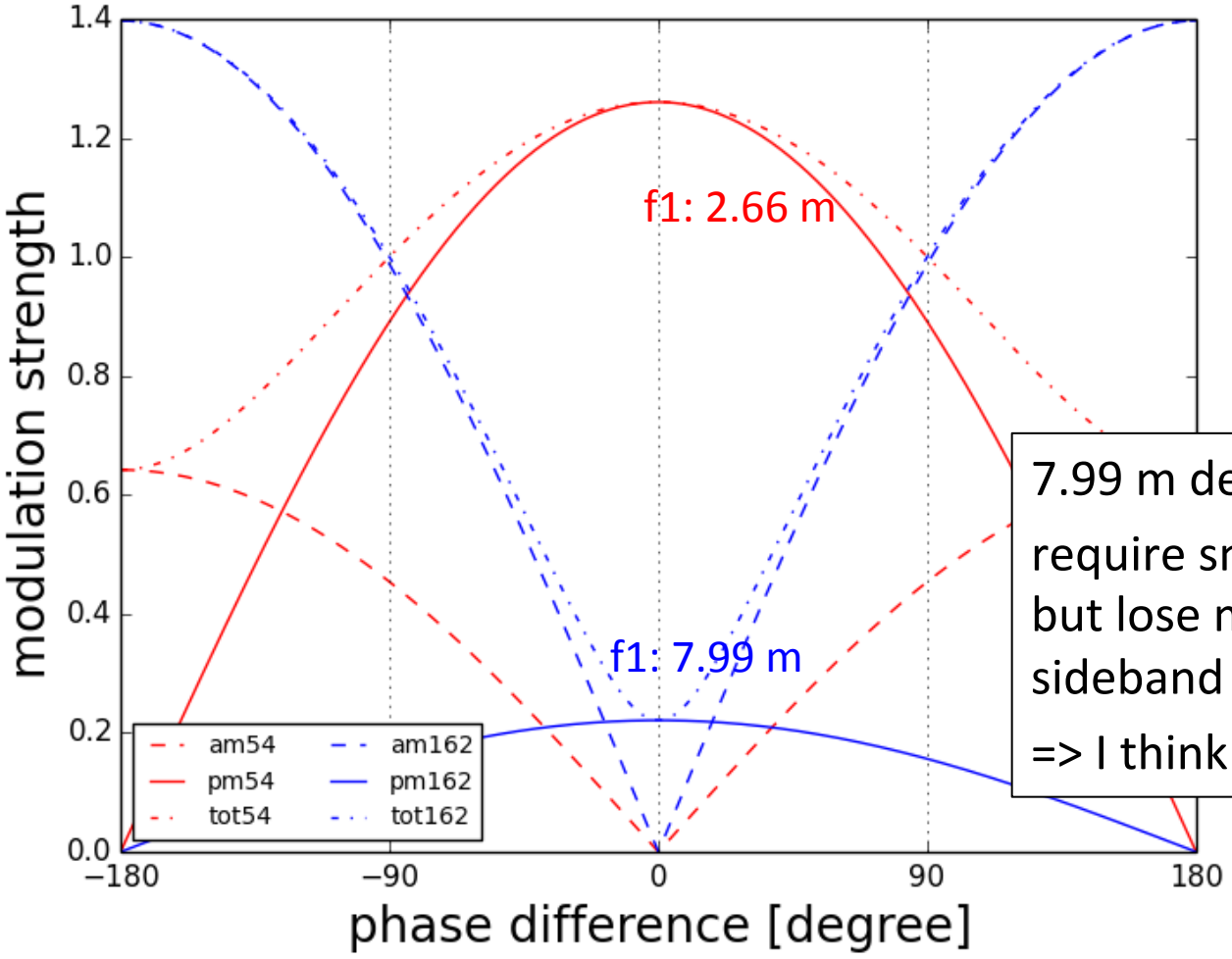
- f1: PM and AM
- f3: AM only

delay line 2.66 m --> $\theta(f_1) = 54°$

$\theta(f_3) = 180°$

$$2A + m\left\{\left[\cos\left(\frac{\pi}{4} - \frac{\theta}{2}\right) + \cos\left(\frac{\pi}{4} + \frac{\theta}{2}\right)\mathrm{e}^{i\phi}\right]\mathrm{e}^{i\omega_m t} - \left[\cos\left(\frac{\pi}{4} + \frac{\theta}{2}\right) + \cos\left(\frac{\pi}{4} - \frac{\theta}{2}\right)\mathrm{e}^{i\phi}\right]\mathrm{e}^{-i\omega_m t}\right\}$$

2.66 m vs. 7.99 m



7.99 m delay line is also OK.

require smaller changes of design, but lose much more power of f1 sideband to create AM at f1

=> I think 2.66 m is better.

- f1: PM and AM
- f3: AM only

delay line 2.66 m --> $\theta(f_1) = 54°$

delay line 7.99 m --> $\theta(f_1) = 162°$

$$2A + m\left\{\left[\cos\left(\frac{\pi}{4} - \frac{\theta}{2}\right) + \cos\left(\frac{\pi}{4} + \frac{\theta}{2}\right)\mathrm{e}^{i\phi}\right]\mathrm{e}^{i\omega_m t} - \left[\cos\left(\frac{\pi}{4} + \frac{\theta}{2}\right) + \cos\left(\frac{\pi}{4} - \frac{\theta}{2}\right)\mathrm{e}^{i\phi}\right]\mathrm{e}^{-i\omega_m t}\right\}$$

Remaining issues

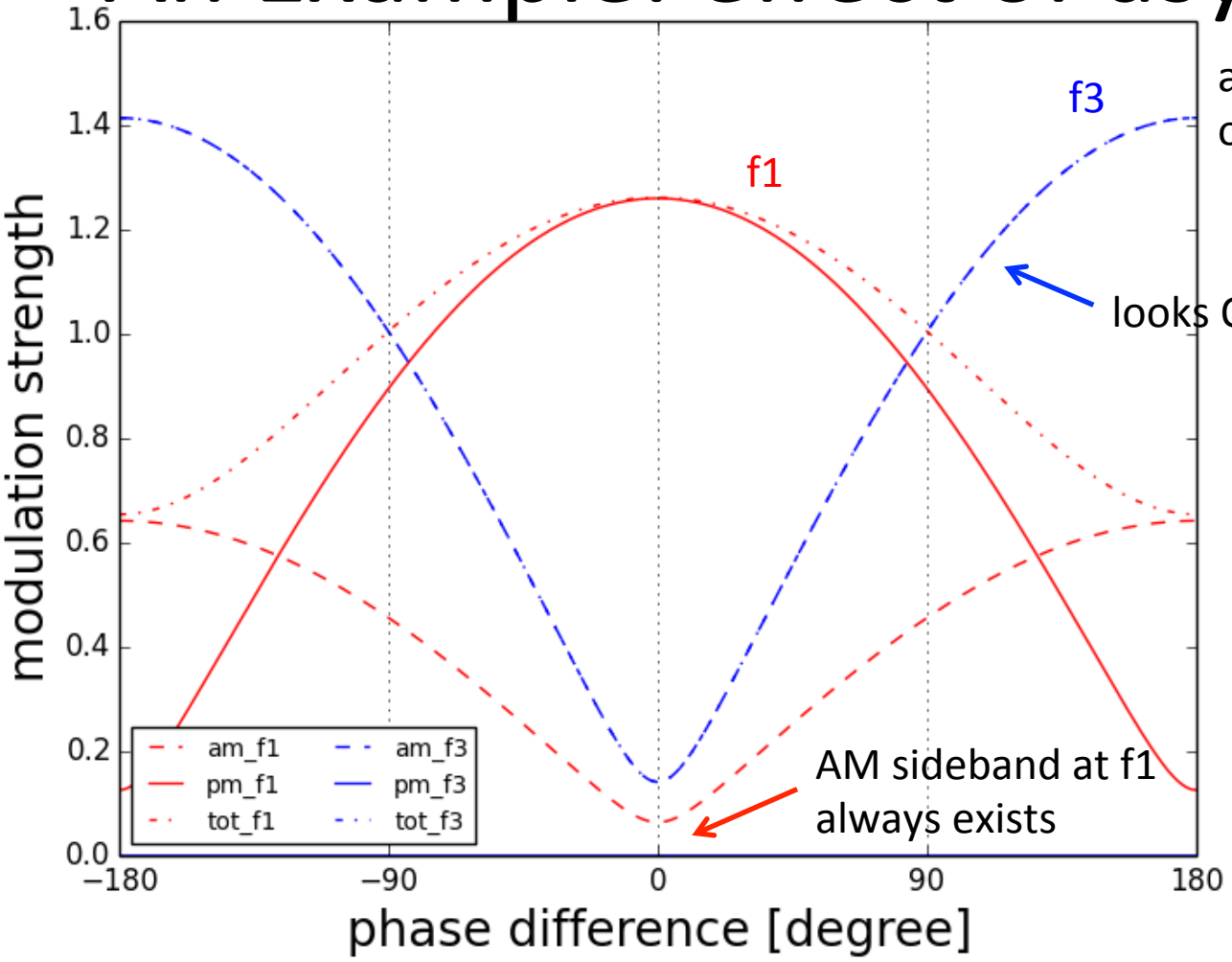
-- Probably we need some control on the phase difference.

- How can we the phase difference? Resonant EOM => phase of transfer function modulation/applied voltage can be different for two EOMs and can even be time dependent.

-- We need to consider the effect of asymmetries with respect to the requirement; modulation depths of two EOMs, non-perfect mid-fringe lock, non-perfect dark-fringe lock, etc..

-- and what else?

An Example: effect of asymmetry



assumed 20 % difference of modulation depths

looks OK for f3

AM sideband at f1 always exists

- f1: PM and AM
- f3: AM only

delay line 2.66 m --> $\theta(f_1) = 54°$

$\theta(f_3) = 180°$

$$2A + m\left\{\left[\cos\left(\frac{\pi}{4} - \frac{\theta}{2}\right) + \cos\left(\frac{\pi}{4} + \frac{\theta}{2}\right)\mathrm{e}^{i\phi}\right]\mathrm{e}^{i\omega_m t} - \left[\cos\left(\frac{\pi}{4} + \frac{\theta}{2}\right) + \cos\left(\frac{\pi}{4} - \frac{\theta}{2}\right)\mathrm{e}^{i\phi}\right]\mathrm{e}^{-i\omega_m t}\right\}$$

transmissivity of f2 and fimc

amplitude transmissivity = $\left|\cos\theta/2\right|$

$$\theta(f_2) = 144^\circ \quad \Rightarrow \quad 0.31$$

$$\theta(f_{\mathrm{imc}}) = 44^\circ \quad \Rightarrow \quad 0.93$$

(assuming delay line length = 2.66 m)

sideband frequencies

Name	Frequency	Type	Mod. index
f1	16.880961MHz	PM	0.2rad (nominal 0.15)
f2	45.0159MHz	PM	0.1rad (nominal 0.05)
f3	56.2699MHz	AM	point of view0.05
2*f3	112.5398MHz	AM	less than ??
f1-AM	16.880961MHz	AM	65% of PM amplitude
fIMC	13.78 MHz	PM	0.025?

http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/MIFIOOInterfaces

(visited on May 22, 2017)