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<b>Parameters of the OPO for squeezed vacuum injection (SQZ) in O3</b>		
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## 1 Overview

This document describes the parameters of the SQZ OPO as implemented during O3.

The main difference with respect to the OPO design described in [T1700104-v2](#) is the reflectivity of the M1 mirror reflectivity @ 532nm (input coupler for green), which was changed from the original  $R = 87.5\%$  to  $R = 98\%$  (see [E1700299](#)).

ECR [E1800193](#) describes the motivation for the change, mainly to increase the green finesse of the OPO so as to require less input green power to pump the OPO, therefore reducing the amount of green light delivered by the fiber system.

## 2 O3 OPO Parameters

Table 2 shows the mirrors coatings of the OPO M1 and M2 mirrors during O3.

M1 1064nm R	87.5%	T	0.125%
M2 1064nm R	99.85%	T	0.15%
M1 532nm R	98.0%	T	2%
M2 532nm R	1.0	T	< 0.10ppm

The O3 OPO 1064nm finesse is 49.6 and the FSR is 851MHz, so the unsqueezed cavity pole is 8.58MHz.

The theoretical escape loss at 1064nm is  $T_{M2}/T_{M1} = 1.2\%$ . This number is consistent with the measured escape efficiency of 98%-99%, indicating that as far as we know, the dominant loss in the OPO is the M2 CLF coupling mirror, not the crystal itself.

The power transmissivity of the on resonance CLF upper-side-band at 3.125MHz is 3.94%. With the OPO at NLG=14.8, generating 14.5db of squeezing, the transmission is enhanced by parametric gain to be 8.6%.

The theoretical 532nm OPO finesse in the ideal lossless case would be  $\sim 315$ . Based on a study on O3 data ([T2000150](#)), the OPO round-trip 532nm loss ( $L_{rt532}$ ) has been increasing from  $\sim 2.1\%$  to  $\sim 3.75\%$ , so the effective finesse of the OPO during O3 has been between 150 and 110.

The corresponding power buildup factor  $G$ , defined as:

$$G = \frac{T_{M1}}{(1 - r_{M1}\sqrt{1 - L_{rt532}})^2} \quad (1)$$

has been therefore between  $G = 50$  and  $G = 25$ .

Given the 1064nm finesse of  $\sim 50$ , the O3 OPO cavity hits threshold at around 900mW of internal circulating pump power. This entails that the threshold in units of input pump power (in the 00 mode) can be between 20 – 35mW. This is consistent with the variations of threshold measurements taken at different times after a crystal position move (for example, here is the latest threshold measurement performed at LLO, [log entry 49428](#), showing a threshold of 35 mW).