

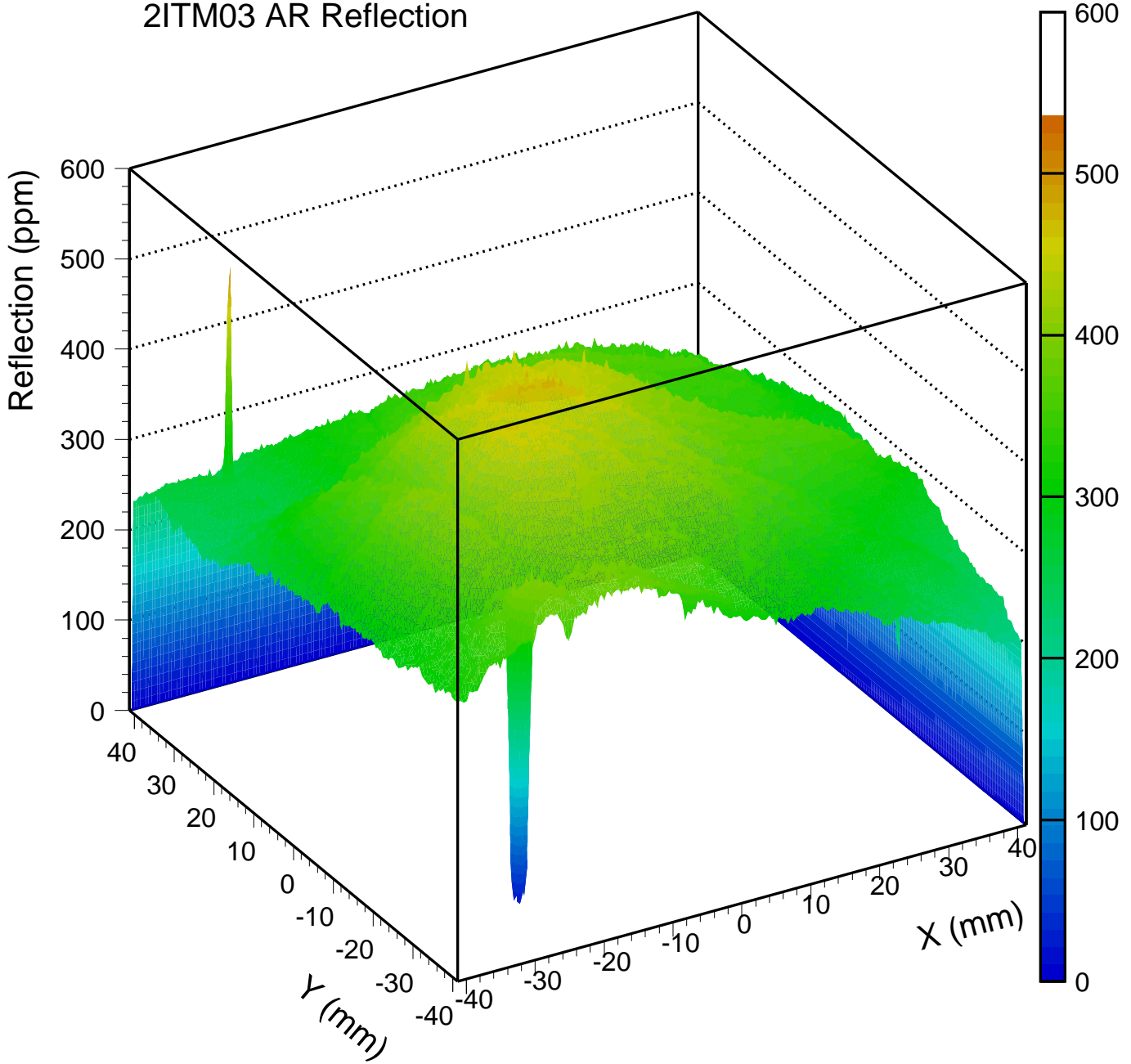
## Etching of AR coating on 2ITM03

Recent developments showed that the AR coating, mainly the SiO<sub>2</sub> layer on LIGO optics, is very sensitive to storage time and current cleaning process.

Known facts:

- a) There are changes in the AR reflection, over time, on stored mirrors. Any contaminant on the AR surface, either hydrocarbons from the air or build-up of an oxide layer, knocks the AR out of spec. This is because the contaminant layer itself can act as an optical thin film layer. When 2ITM03 was shipped from REO, had an initial AR reflection of 800 ppm (about 4 years ago). When recently measured out of the box, it had an AR reflection of 2500 ppm. These changes have been observed also on GEO mirrors. With the AR coating design used to manufacture LIGO's first mirrors, the location of the reflectivity minimum is highly sensitive to the outer SiO<sub>2</sub> layer thickness. According to D. Ness, from REO, who has been modeling the AR changes, a removal of 4nm of SiO<sub>2</sub> is sufficient to knock the AR out of spec. I understand that the AR design was revised later to include more layers to give the coating more bandwidth.
- b) These changes are reversible but, until when? After an initial mirror cleaning with a 2% solution of Liquinox and DI water taken to 70 degrees C and held in the hot solution for 10-15 min. the reflection dropped from 2500 ppm to 2400 ppm. Subsequent "etchings", using different solution concentrations and exposure time to the solution, moved the AR reflection from 2400 to: ~35 ppm, ~30 ppm, ~40 ppm, ~110 ppm, ~200 ppm and, and the current ~350-400 ppm. There seems to be a predictable "etching rate" when parameters are kept constant. See attached graph.
- c) No changes were observed on the HR surface reflectivity of 2ITM03 due to storage time.
- d) What "grows" on the AR surface of the mirror with time? Hydrocarbon contamination or an oxide layer, some residue from the cleaning process?
- e) About Liquinox: it is advertised as no leaving residues on cleaned surfaces. This property has been verified by the manufacturer. **Cleaning Validation Methods** - Test a parameter of rinse water before and after rinsing the cleaned surface. No significant change in the parameter indicates no detectable residue. Parameters measured include: pH, conductivity, resistance, spectrographic methods, sodium concentration, phosphorus concentration, anionic surfactant concentration using inexpensive detergent water testing kits, surface tension, and surface analysis.

2ITM03 AR Reflection



2ITM03 AR Reflection

