



5th EDOARDO AMALDI CONFERENCE ON GRAVITATION WAVES
TIRRENIA (PISA) - ITALY
JULY 6-11, 2003

The Brazilian Spherical Detector: Progress & Plans

Odylio D. Aguiar
INPE / BRAZIL

LIGO-G030372-00-Z

Cryogenics

- Prof. Nei F. Oliveira Jr. (USP) (Co-PI)
 - Prof. Giorgio Frossati (UL) (Co-PI)
 - Sergio T. de Souza (USP) (M)
 - Jorge Weber (INPE) (M)

Astrophysical Sources and Gravitation

- Dr. José Carlos N. de Araújo (INPE)
 - Dr. Oswaldo D. Miranda (ITA)
 - Dr. Edgard C. de Rey Neto (INPE)
- Cláudio Souza Castro (INPE) (M concluded)
 - Wayne de Paula (ITA) (U)
- Bruno Woltzenlogel Paleo (INPE) (U)

Vibration Isolation

- Dr. José Luiz Melo (INPE)
- Dr. Walter F. Velloso Jr. (USP)
- Antônio Unias de Lucena (INPE) (U)

Transducers

- Dr. Odylio D. Aguiar (INPE) (PI)
 - Dr. Carlos Frajuca (CEFETSP)
 - Kilder L. Ribeiro (INPE) (Ph.D.)*
- Luiz Alberto de Andrade (IAE) (Ph.D)*
 - Marco Remy (INPE) (Ph.D)
- Sergio Ricardo Furtado (INPE) (Ph.D)
 - Leandro Alves Carneiro (INPE) (U)

Hardware for Cosmic-Ray Veto

- Dr. Anderson C. Fauth (UNICAMP)
- Lúcio Camargo Filho (UNICAMP) (U)

Data Analysis

- Dr. Rubens M. Marinho Jr. (ITA)
 - Dr. Nadja S. Magalhães (ITA)
 - Claudemir Stellati (ITA) (Ph.D)
- César Augusto Costa (INPE) (Ph.D)
 - Emílio S. Matos (INPE) (M)*
 - Katia M.F. Costa (ITA) (M)
- Liana Cavalcante Lima (INPE) (U)

MiniGRAIL
(Netherlands) →

SFERA (Italy)

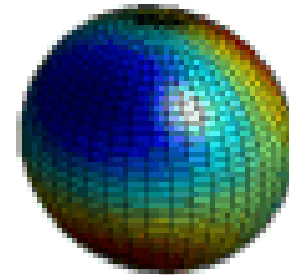
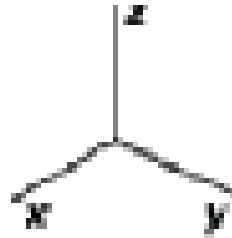
Mario SCHENBERG
(Brazil)



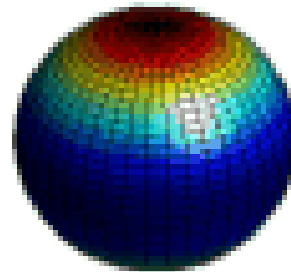
Antenna quadrupole modes



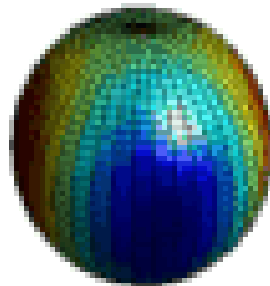
Modo 1



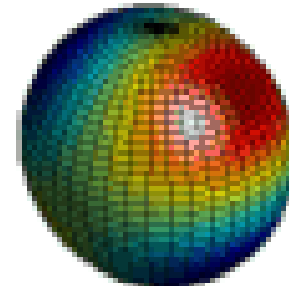
Modo 2



Modo 5



Modo 3



Modo 4

From the output of 6 transducers
tuned to the antenna quadrupole modes

$$\Psi(\theta, \phi, \omega) = \sum_i^5 a_i(\omega) \Psi_i(\theta, \phi)$$



spherical harmonics

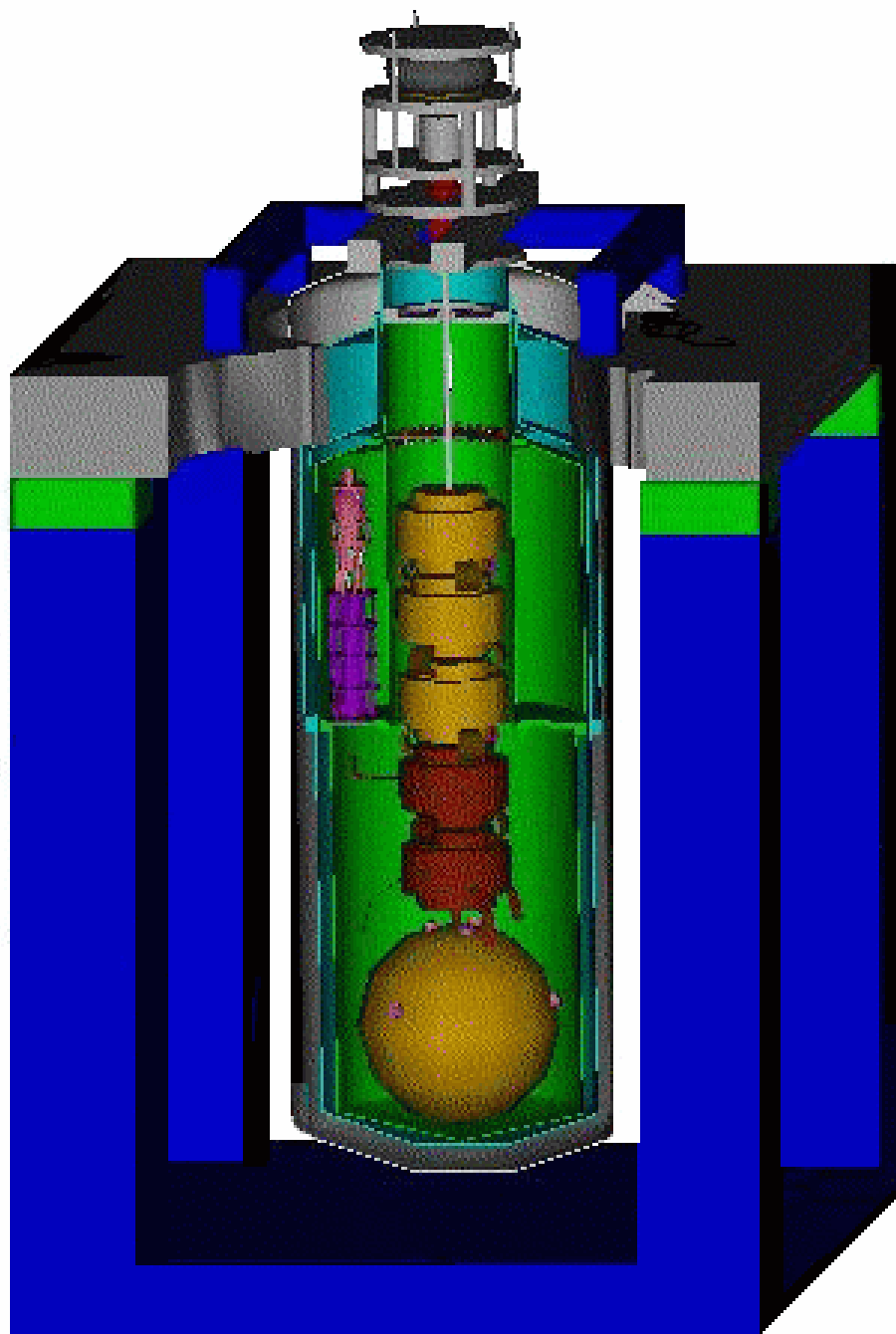
$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}$$

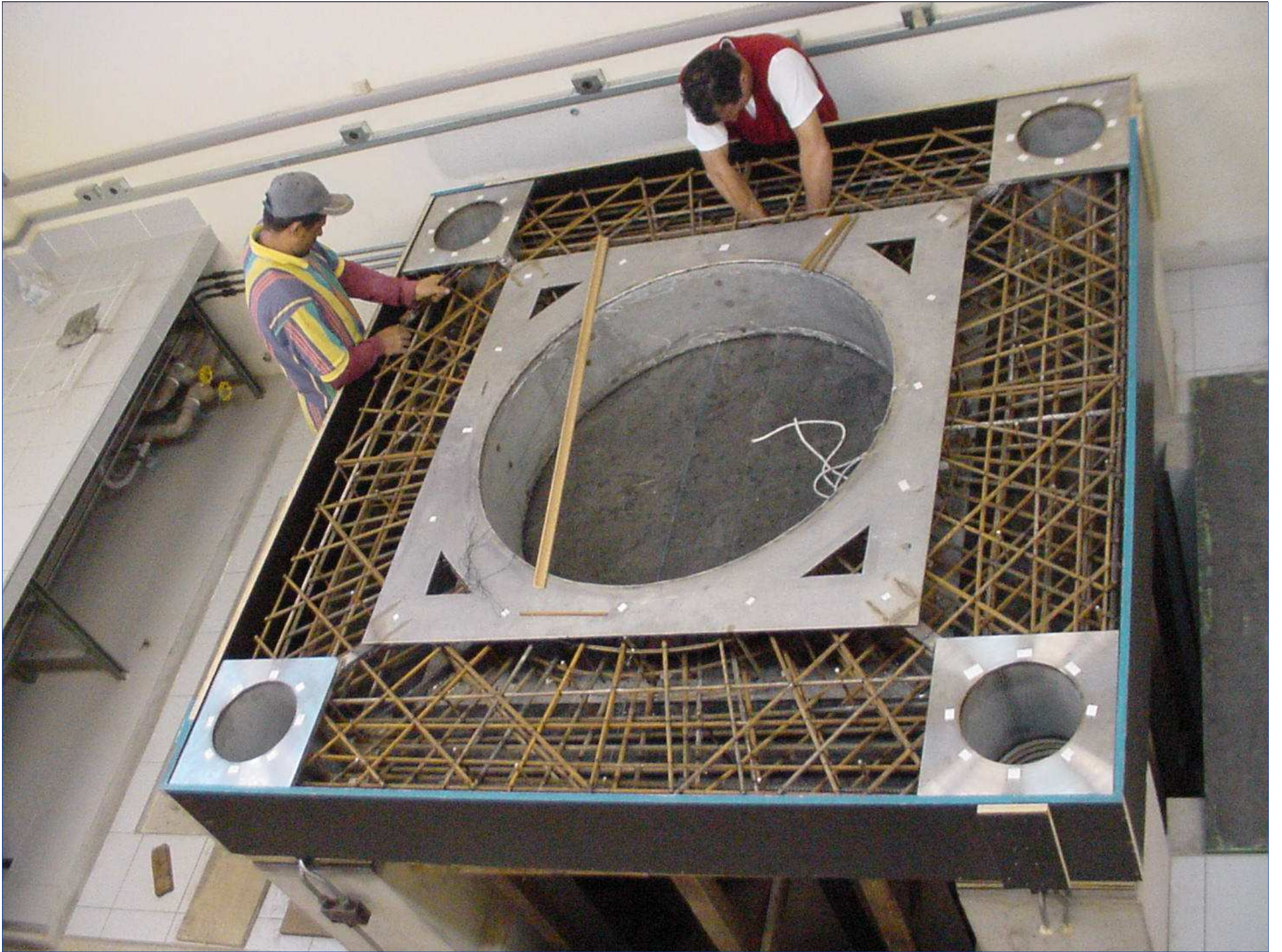
$$h_{xx} + h_{yy} + h_{zz} = 0$$

$$h = \begin{bmatrix} h_{xx} & h_{xy} & h_{xz} \\ h_{yx} & h_{yy} & h_{yz} \\ h_{zx} & h_{zy} & h_{zz} \end{bmatrix}$$

5 independent
components













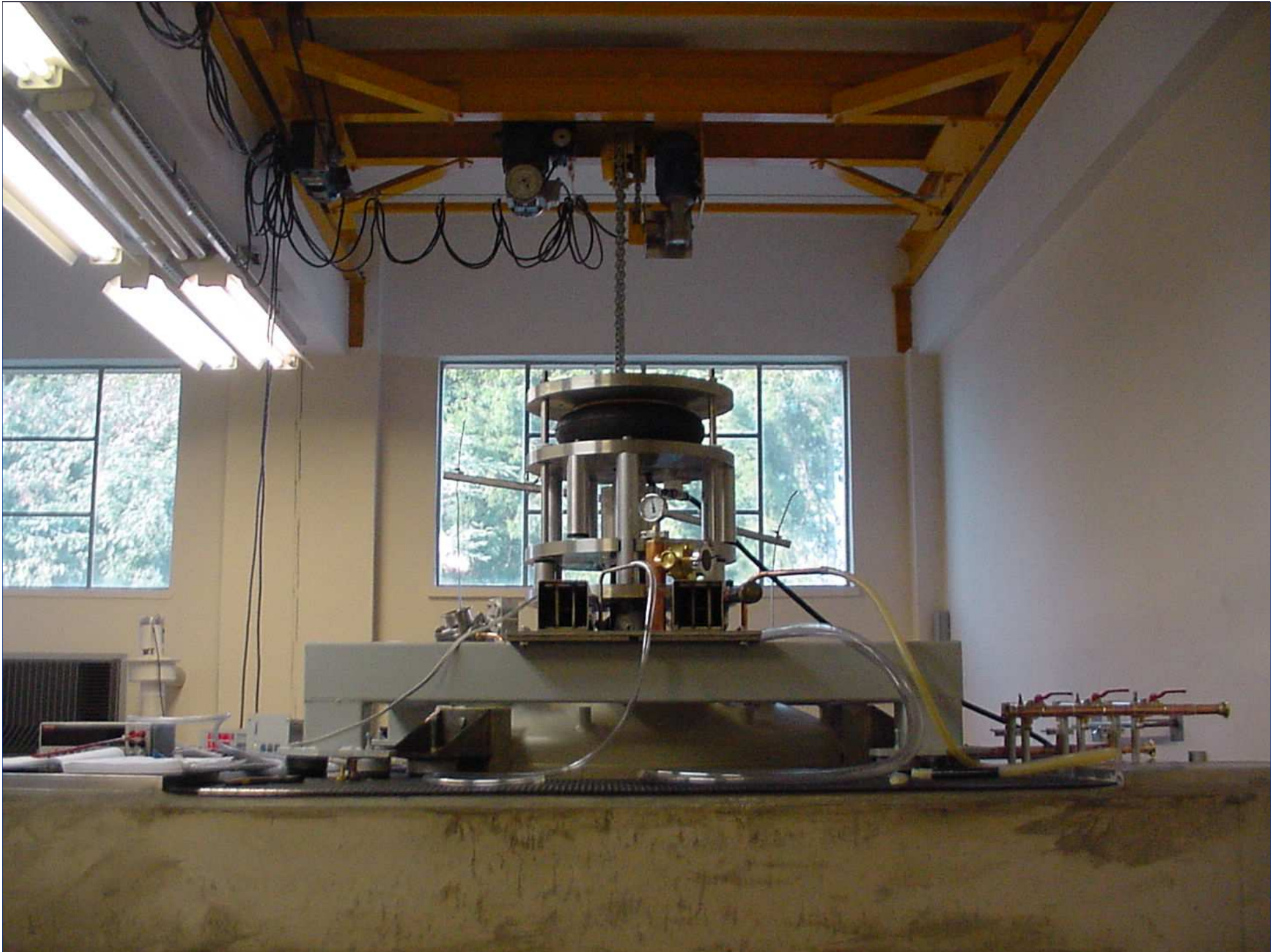














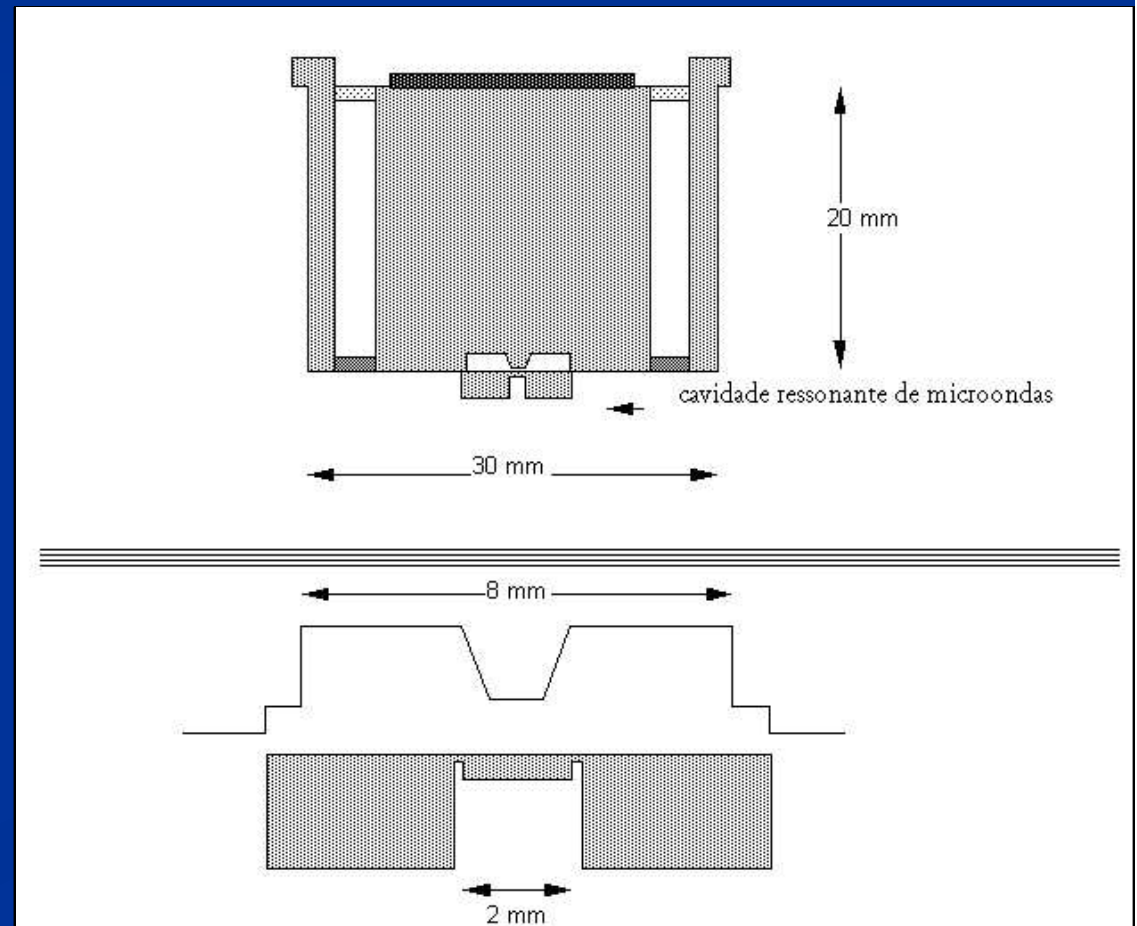
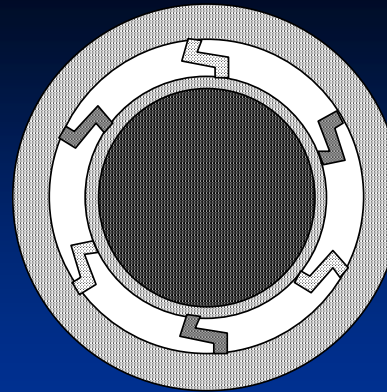


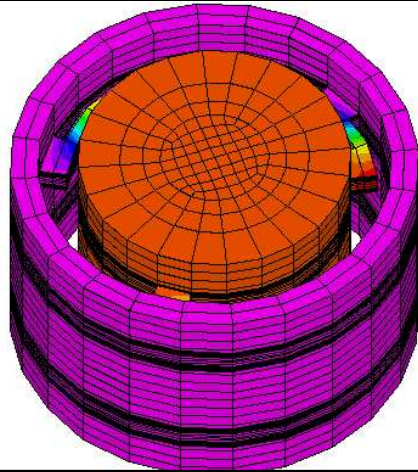
- Non-contactin (microstrips)
2 → 6 parametric transducers

-2-mode CuAl6% resonators
(53 g and 10 mg)

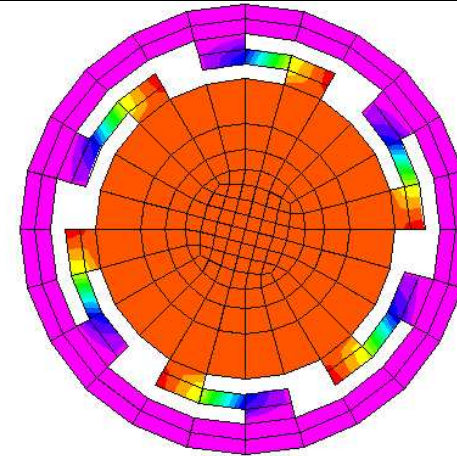
- closed reentrant cavity
pumped at ~10 GHz
($Q_e = 1k \rightarrow 30$ million)

- HEMTs pre-amplifiers
($T_n \sim 10K \sim 14 \text{ K}$)

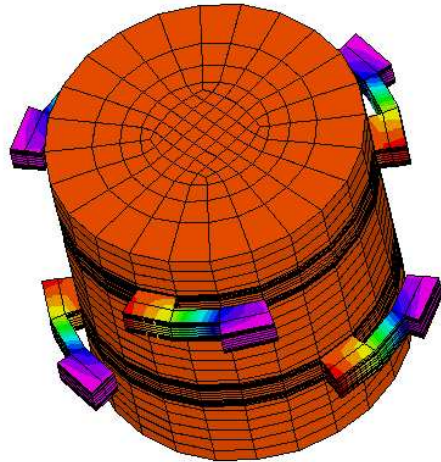




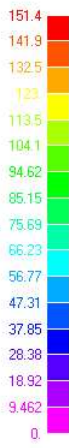
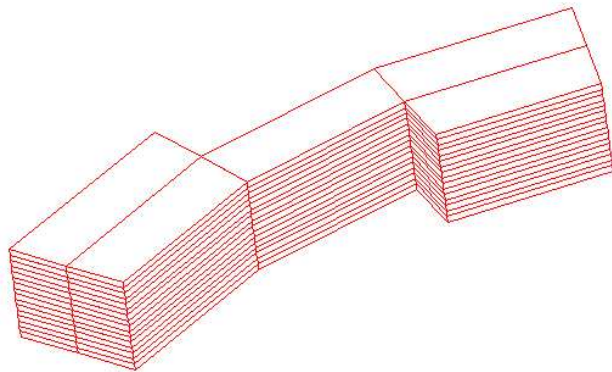
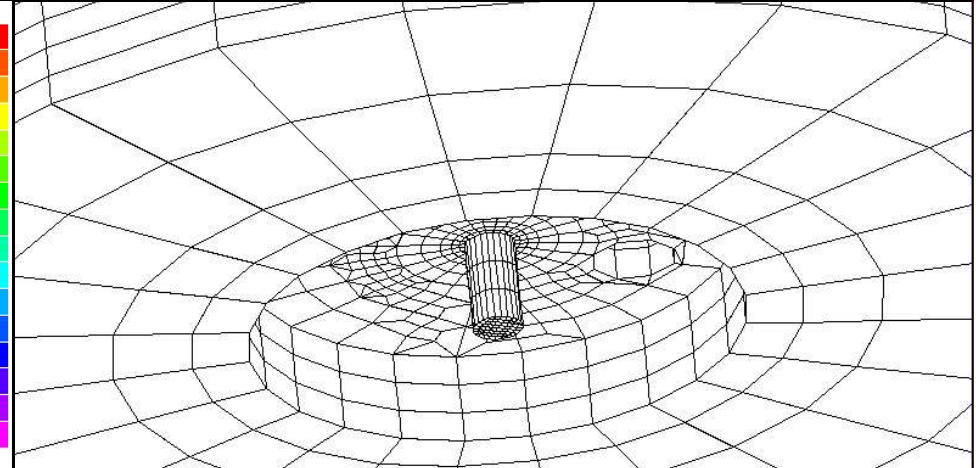
Output Set: Case 1 Mode 3285.604980 H
Deformed(0.151): Total Translation
Contour: Total Translation



Output Set: Case 1 Mode 3285.604980 H
Contour: Total Translation

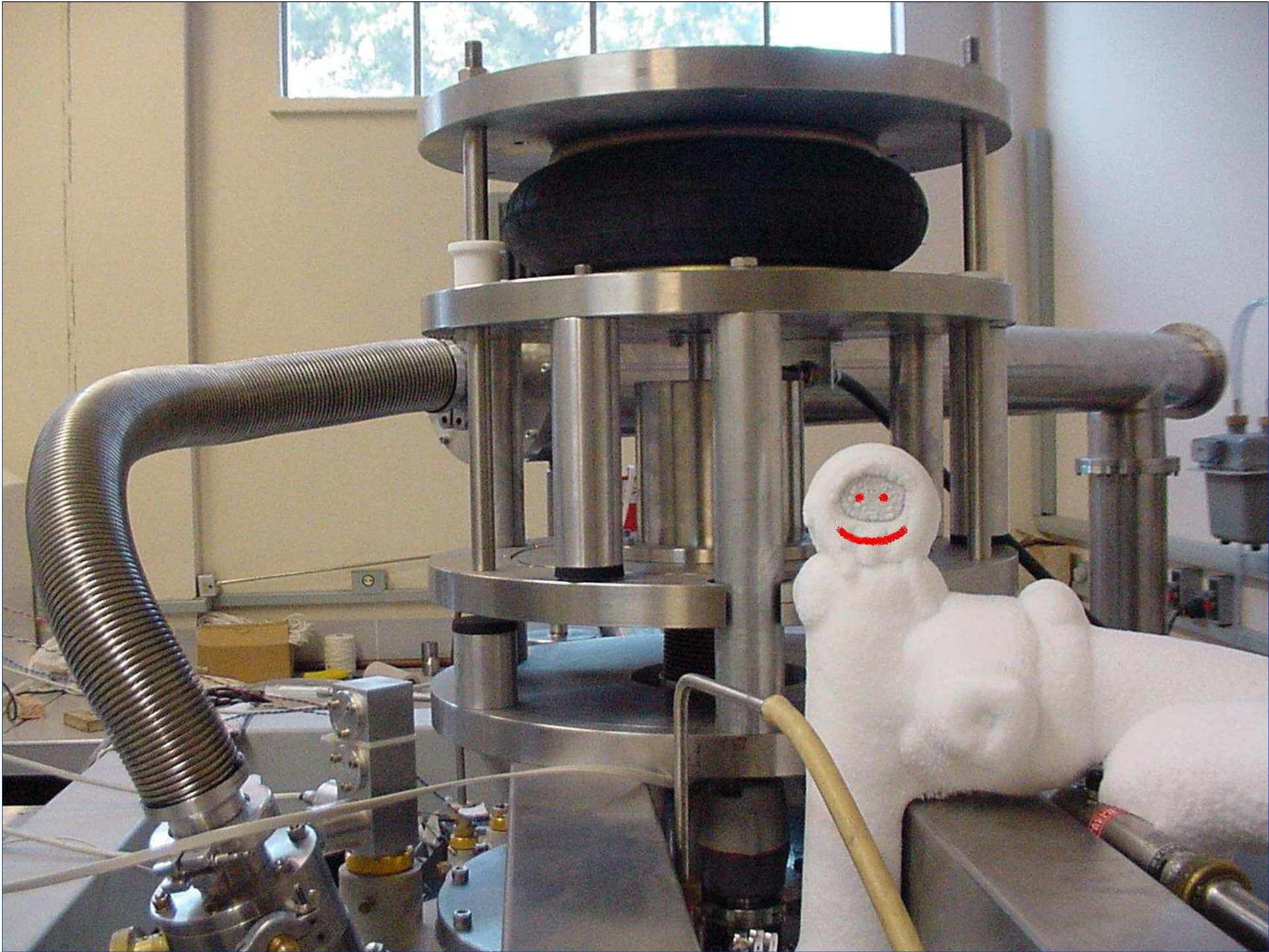


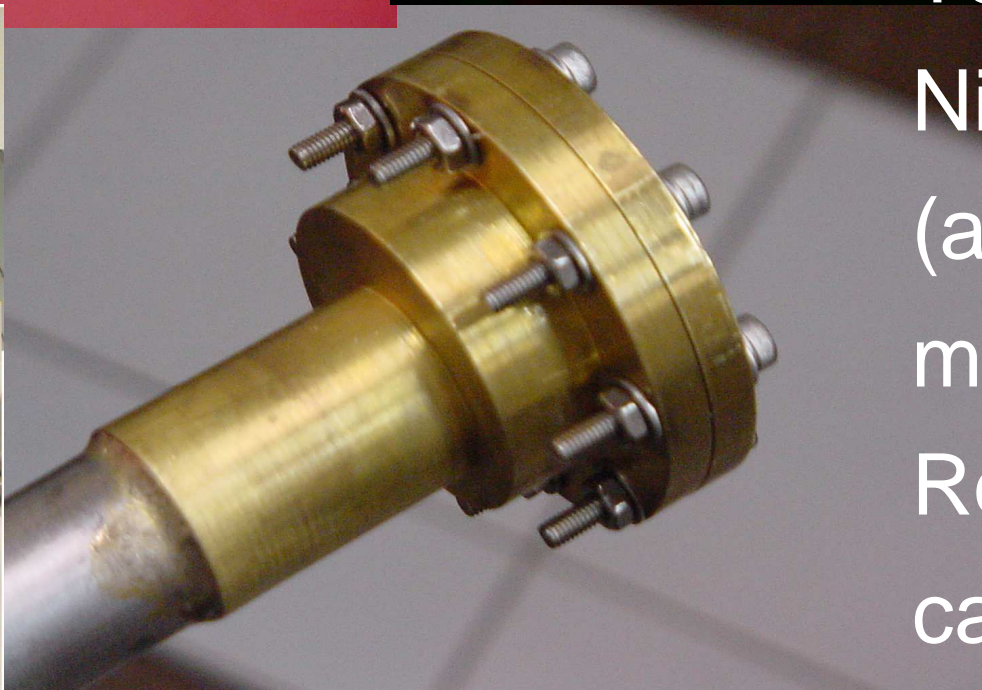
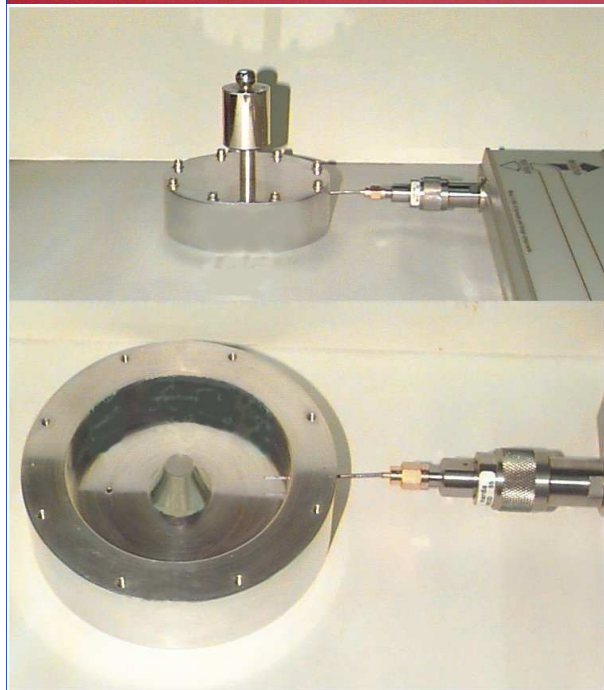
Output Set: Case 1 Mode 3285.604980 H
Contour: Total Translation



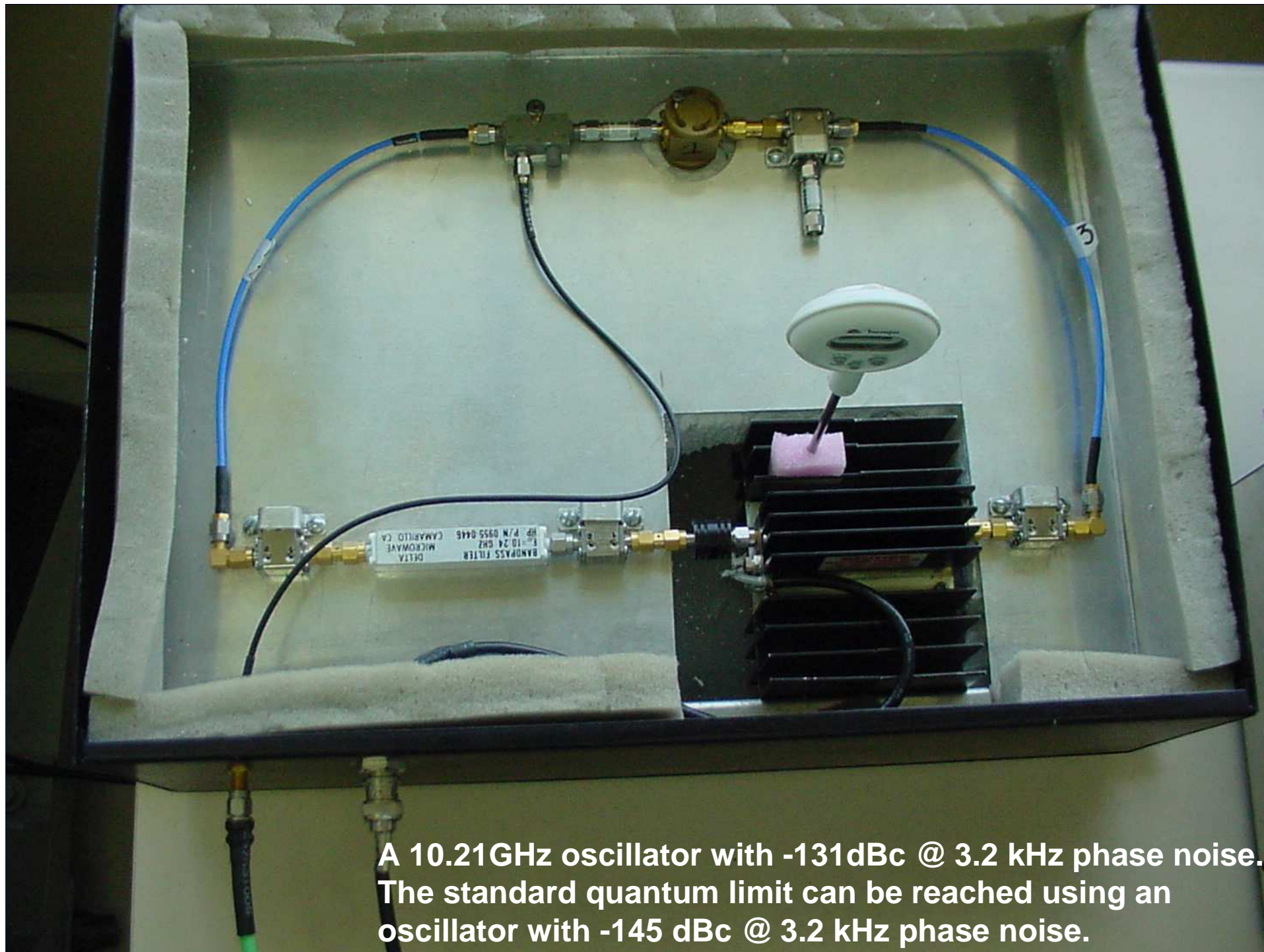
Output Set: Case 1 Mode 3162.027344 H
Deformed(151.4): Total Translation
Contour: Total Translation



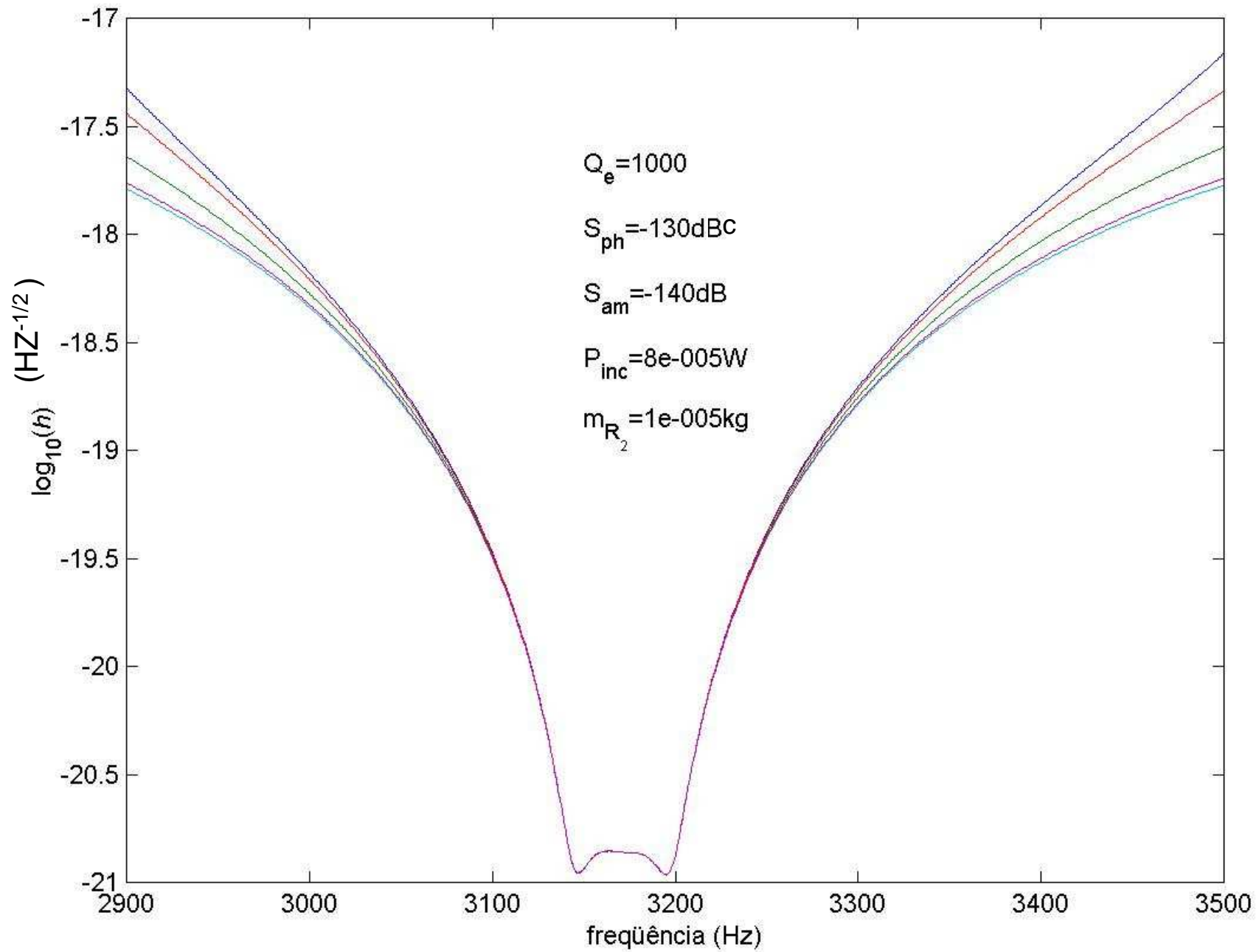


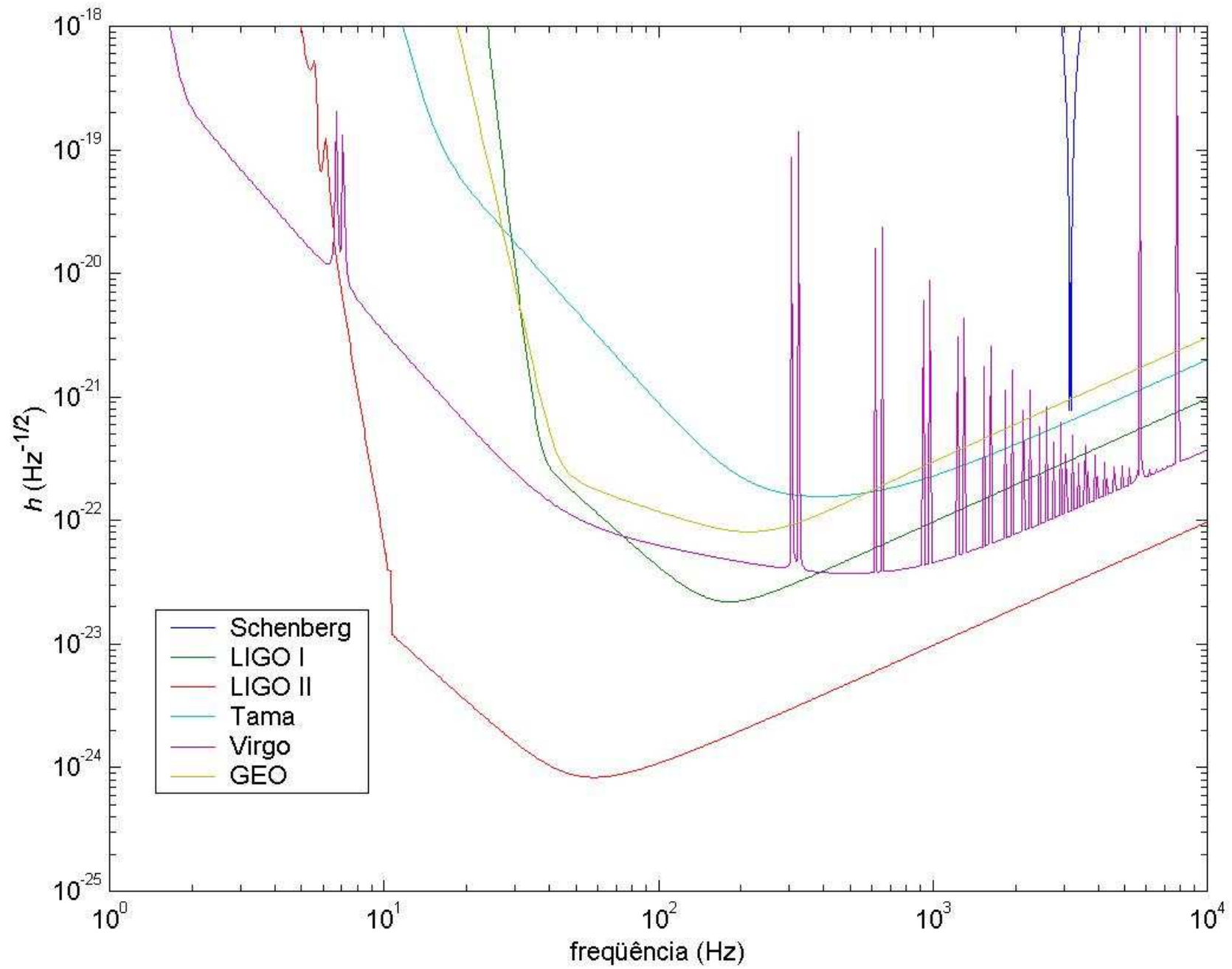


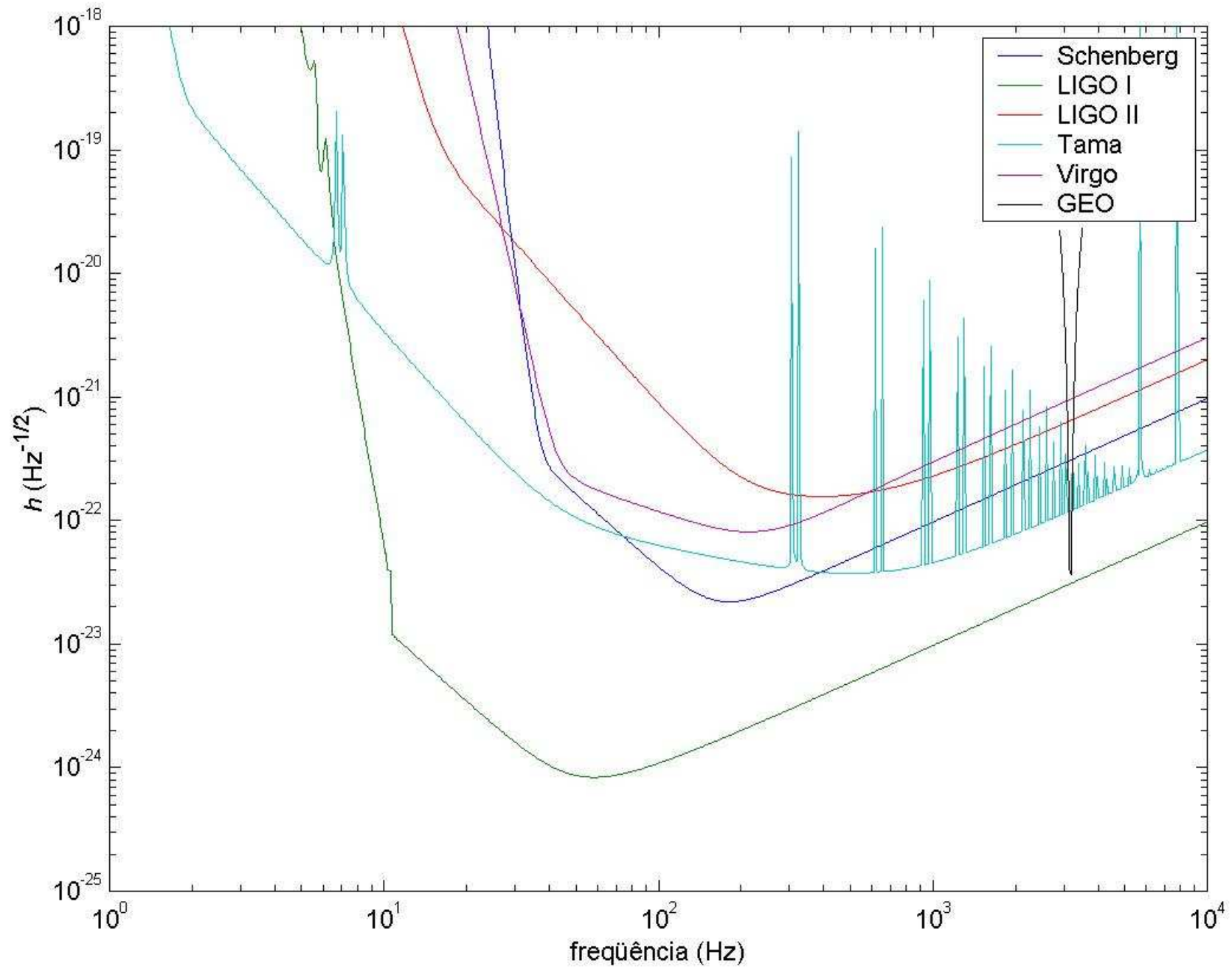
Tests with
Niobium
(and other
metals)
Reentrant
cavities



A 10.21GHz oscillator with -131dBc @ 3.2 kHz phase noise. The standard quantum limit can be reached using an oscillator with -145 dBc @ 3.2 kHz phase noise.







We have been constructing the gravitational wave detector Mario Schenberg at the Physics Institute of the University of São Paulo with the support of FAPESP, the São Paulo Science Foundation. The antenna and its vibration isolation system are already built, and we have cooled it down for a first cryogenic test and mechanical Q (figure of merit) measurement (the Q was ~ 1.5 million at 4.2 K). We also have built a 10.21GHz oscillator with $-131\text{dBc}@3.2\text{kHz}$ phase noise performance to pump an initial CuAl6% two-mode transducer. We plan to prepare this spherical antenna for a first operational run at 4.2K with a single transducer and an initial target sensitivity of $h \sim 10^{-21} \text{ Hz}^{-1/2}$ in a 50Hz bandwidth around 3.2kHz soon.