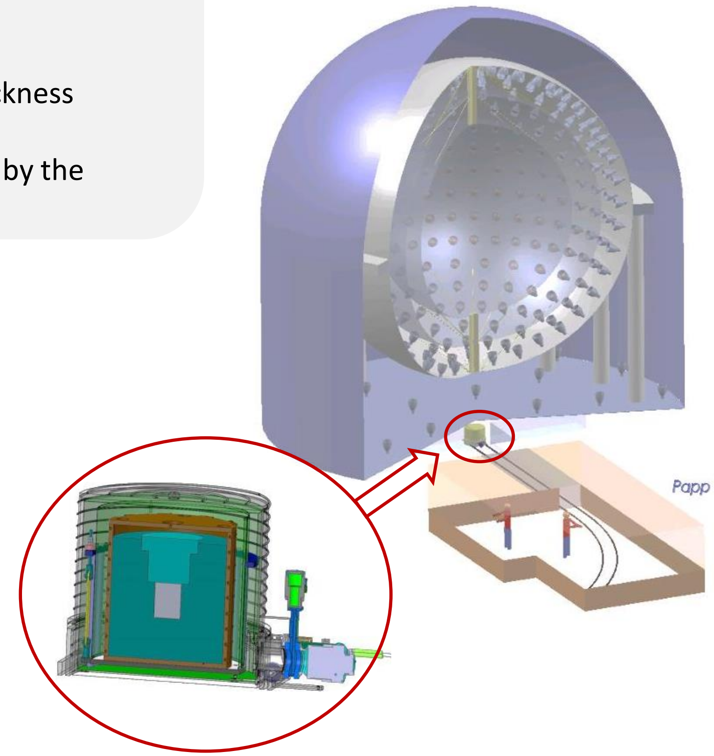
Physik-Department und Excellence Cluster Universe, Technische Universität München, Germany
Dipartimento di Fisica, Università degli Studi e INFN Genova, Italy

A high precision calorimeter for the SOX experiment

Laszlo Papp on behalf of TUM/Genoa SOX calorimeter collaboration

The SOX (Short distance neutrino Oscillations with BoreXino) aims at unambiguously discover or refute eV-scale sterile neutrinos by observing short baseline oscillations of active-to-sterile neutrinos.

- 100 kCi ^{144}Ce-^{144}Pr antineutrino generator (CeSOX), shielded by a 19 cm wall thickness tungstate container, will be placed under the BOREXINO detector.
- To reach the maximal sensitivity, we aim to determine the neutrino flux emitted by the antineutrino generator with a <1% accuracy.



The source-generated heat will be measured by a vacuum calorimeter

- Mass flow with 0.1% stability of high purity water is guarantied by a fixed height water reservoir and high precision flow regulating valve (accuracy 0.05%)
- Ideal $\dot{m}\approx 10$g/s at 1kW power, $\Delta T=25^oC$ and 5mm pipe diameter to keep the relative error low and provide turbulent flow.
- Coriolis flow meters 0.05%, and temperature sensors with 5mK accuracy.
- Systematic error for one heat power measurement

$$\sigma_P{}^2[W] = \sqrt{0.35[W^2] + 0.02[W^2/K^2]\cdot\Delta T^2}$$

  is between 1 and 3 W (~0.4%)
- Calibration will be performed with an electric heater

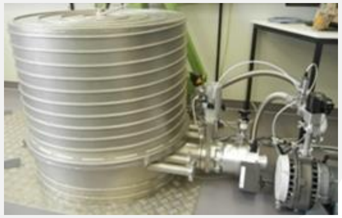
Physik-Department und Excellence Cluster Universe, Technische Universität München, Germany
Dipartimento di Fisica, Università degli Studi e INFN Genova, Italy

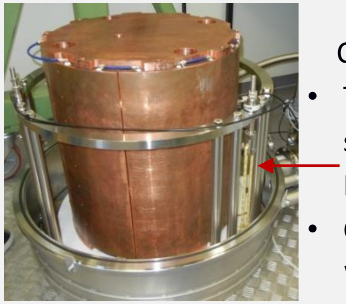
A high precision calorimeter for the SOX experiment

Laszlo Papp on behalf of TUM/Genoa SOX calorimeter collaboration

Convection

- Vacuum tank. 10^{-4} mbar or lower pressure.
- Screws are vented and Silver coated.
- Robust flange with elastic O-ring.
- Powerful, big inlet size (100mm) turbomolecular pump mounted directly on tank.
- Gate valve gives a possibility to isolate the vacuum tank.
- Oil free scroll pump for pre-vacuum





Conduction

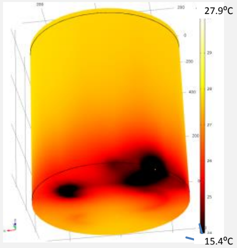
- The heat exchanger located on a stainless steel plate held by three Kevlar ropes (breaking test 7t/each).
- Conduction $\dot{Q} = \lambda \cdot A/d \cdot \Delta T < 0.4\ \mathrm{mW}$ with λ=0.04W/m, A=6·2cm², d=0.3m

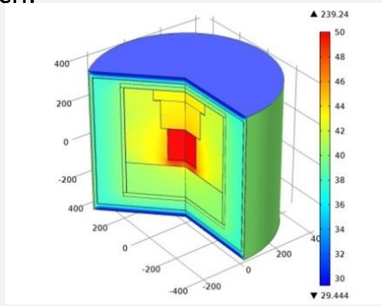
Radiation

- 20mm thick Copper – Guaranties a homogenous heat distribution.
- Stainless steel pipe is brazed into the Copper. Resistant for the coolant high purity water, and brazing gives good heat contact.
- The outer surface of the tank is equipped with a stainless steel spiral pipe for temperature compensation.
- Two stages of heat radiation shields. They are made of 10 layers super insulator each.
- Radiative heat loss is lower than 30 mW:

$$P \approx \frac{\sigma \cdot A_1 (T_1^{\,4} - T_2^{\,4})}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_S} - 1 + (N-1)\cdot(\frac{2}{\varepsilon_S} - 1) + \frac{A_1}{A_2}\cdot(\frac{1}{\varepsilon_S} + \frac{1}{\varepsilon_2} - 1)}$$

A: surface area; ε: emissivity; N: number of shields





Thermal simulations
Copper temperature with water cooling (left)
Cutaway of the tungstate showing the heat distribution (right)