Status of BOREXINO

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on behalf of the BOREXINO collaboration
The BOREXINO collaboration

- Belgium
  - I:R:M:M: European Joint Research Center – Geel

- Canada
  - Queen’s University – Kingston

- France
  - Collège de France – Paris

- Germany
  - Max-Planck Institute für Kernphysik – Heidelberg
  - Technische Universität – Münchhen

- Hungary
  - KFKI-RMKI Research Institute for Particle & Nuclear Physics – Budapest

- Italy
  - INFN e Dipartimento di Fisica – Genova
  - INFN e Dipartimento di Fisica – Milano
  - INFN e Dipartimento di Fisica – Pavia
  - INFN Laboratori del Gran Sasso
  - INFN e Dipartimento di Chimica – Perugia

- Poland
  - Institute of Physics, Jagiellonian University – Cracow

- Russia
  - JINR - Dubna
  - Kurchatov Institute - Moscow

- USA
  - Bell Laboratories, Lucent Technologies
  - MIT - Boston
  - Princeton University – Princeton
  - Virginia Polytechnic Institute
• BOREXINO: brief review of the main features
• The physics program
• The CTF (prototype of BOREXINO) as a tool for testing the radiopurity of the whole apparatus and tuning the purification methods
• Status of the detector
• Schedule
**BOREXINO: the detector**

- **Goal**: sub-MeV neutrinos detection
- unsegmented liq. scint.
- neutrino-electron elastic scattering
The big challenge to measure sub-MeV neutrinos

- High level of intrinsic radiopurity needed
- Low background from $^{222}\text{Rn}$, $^{210}\text{Pb}$ and $^{210}\text{Po}$
- Low background from $^{85}\text{Kr}$ and $^{39}\text{Ar}$

How do we manage this?

- High level of cleanliness
- Three different methods to purify the scintillator
- Dedicated low count-rate Rn emanation measurements
- Dedicated plants for purification of Rn and Kr in N$_2$
- Stripping of the scintillator
- Radiopurity tests through the CTF (prototype of BOREXINO)
BOREXINO: ancillary systems
# BOREXINO: radiopurity requirements

<table>
<thead>
<tr>
<th></th>
<th>Typical Conc.</th>
<th>Borexino level</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{14}$C</td>
<td>$^{14}$C/$^{12}$C $&lt;$ 10^{-12}</td>
<td>$^{14}$C/$^{12}$C $\sim$ 10^{-18}</td>
<td>old carbon</td>
</tr>
<tr>
<td>$^{238}$U, $^{232}$Th</td>
<td>~ 1ppm in dust</td>
<td>~10^{-16}g/g(PC)</td>
<td>distill., water extraction, column chromatography</td>
</tr>
<tr>
<td></td>
<td>~ 1ppb stainless steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{222}$Rn</td>
<td>~ 10Bq/m$^3$ in air</td>
<td>~ 70 $\mu$Bq/m$^3$ in PC (0.3 ev/day/100tons)</td>
<td>$N_2$ stripping</td>
</tr>
<tr>
<td></td>
<td>~ 1ppm in dust</td>
<td>$&lt; 10^{-13}$g/g(PC)</td>
<td>water extr.</td>
</tr>
<tr>
<td>$K_{\text{nat}}$</td>
<td>~ 1ppm in dust</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{85}$Kr, ($^{39}$Ar)</td>
<td>1.1Bq/m$^3$ (13mBq/m$^3$) in air</td>
<td>0.16$\mu$Bq/m$^3$ (0.5 $\mu$ Bq/m$^3$) in $N_2$</td>
<td>see slide on noble gases in BOREXINO</td>
</tr>
</tbody>
</table>

If secular equilibrium is broken: contaminants such as $^{210}$Pb, $^{210}$Po
Contamination from $^{222}\text{Rn}$, $^{39}\text{Ar}$ and $^{85}\text{Kr}$ could cause a serious background problem for low count-rate experiments.
$^{37}$Ar

$Q_{EC} = 813.5\,\text{keV}$

$^{37}$Cl (stabil)

$^{39}$Ar

$Q_{\beta^-} = 565\,\text{keV}$

$^{39}$Ka (stabil)
Noble gases in BOREXINO

$^{222}\text{Rn}$ problem solved by stripping with high purity $\text{N}_2$ ($\text{Rn} < 1\mu\text{Bq/m}^3_{\text{gas}}$)

For an allowed count rate of 0.01$\text{ev/day/ton}$ in BOREXINO due to $^{39}\text{Ar}^{85}\text{Kr}$:

~0.4ppm ($\text{Ar}/\text{N}_2$) for Ar (~0.2ppt for Kr)

best $\text{N}_2$ available in Europe:

0.4ppm for Ar (6ppt for Kr)

<table>
<thead>
<tr>
<th>Ar</th>
<th>Kr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem solved with found gas supply</td>
<td>Problem solved by:</td>
</tr>
<tr>
<td></td>
<td>• cryogenic adsorption in $\text{N}_2$</td>
</tr>
<tr>
<td></td>
<td>• Adsorption on a molecular sieve (0.5nm pore size)</td>
</tr>
<tr>
<td></td>
<td>• Low pressure steam stripping</td>
</tr>
</tbody>
</table>
Solar neutrinos signal and internal background

- Neutrino window [0.25, 0.8] MeV
- $^{14}C/^{12}C = 3 \times 10^{-18}$
- U, Th at $10^{-16} \text{g/g}$
- K at $10^{-14} \text{g/g}$
- effic. for PSD = 95%
- effic. for CE = 90%
- Ar and Kr according to requirements

$\text{S/N} = 1.89$ for SSM

Solar neutrinos signal and internal background

with Kr 40 times the requirement and Ar within it

Signal + Background in BOREXINO

<table>
<thead>
<tr>
<th>Category</th>
<th>Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total with $^{87}$Kr and Ar</td>
<td>Green</td>
</tr>
<tr>
<td>Total</td>
<td>Red</td>
</tr>
<tr>
<td>SSM</td>
<td>Light Green</td>
</tr>
<tr>
<td>Backg</td>
<td>Blue</td>
</tr>
<tr>
<td>Cosmogenic</td>
<td>Pink</td>
</tr>
</tbody>
</table>

counts/day/1eV/ton

recal electron kinetic energy [MeV]

0.2  0.4  0.6  0.8  1.0  1.2  1.4  1.6
The physics program of BOREXINO

- Solar neutrinos (strong potentiality for LOW scenario and seasonal variations)
- Astrophysics: fluxes from Be and CNO (20% of the signal in the $\nu$-window from CNO)
- Neutrinos from supernova (low energy region): in 300tons ~17 ev from $\nu(\nu)^{12}$C NC; ~81 inv-$\beta$ decay [L. Cadonati et al, Astrop. Phys. 16(2002)361]
Solar Neutrinos oscillations in Borexino

G. Fogli et al. for rates + G. Fogli et al. in hep-ph/0206162 for global analysis
Neutrino magnetic moment from CTFII: an example to study non-standard contributions to the neutrino-electron elastic scattering in Borexino

\[ \mu_\nu \leq 5.5 \times 10^{-10} \mu_B \text{ (90\% C.L.)} \]

1. Spectrum due to \( \mu_\nu = 5.5 \times 10^{-10} \mu_B \)
2. \(^{14}\text{C}\) spectrum
3. Linear background
Status of Borexino

- Fluid handling tested
- 300 tons of PC procured and stored
- Purifications methods operational
- Electronics tested with 1900 PMTs in three “air runs”
- Rn emanations measurements of all installed vessels, filters and heat exchangers performed
- Optical calibration systems tested during air runs
- CCD cameras for locating items within the detector tested
- IV installation in progress
- CTFIII operational
Inner Vessels installation
The CTF as a tool for tuning the detector before filling

• **CTF main goal**: assessment of the performances of the different BOREXINO sub-systems

• The CTF to test the C14 contents in the PC

• The CTF to test the efficiency of the three purification methods

• The CTF to test the cleanliness of the apparatus
Preliminary results from the CTF tests

- C14/C12 ~ $4 \times 10^{-18}$
- Light yield = 380 p.e./MeV
- $^{238}\text{U}$:
  - before purif.: $(14 \pm 3) \times 10^{-16}$ g/g
  - after purif.: $(6 \pm 2) \times 10^{-16}$ g/g
- $^{232}\text{Th}$:
  - before purif.: $(62 \pm 8) \times 10^{-16}$ g/g
  - after purif.: $(26 \pm 5) \times 10^{-16}$ g/g
- Kr:
  - before strip.: $250 \pm 1$ ev/d
  - after strip.: $46 \pm 20$ ev/d
- SilicaGel reduction factor ~ 3
- Water-Ext. reduction factor ~ 6
- Events position distribution shows not well understood $^{210}\text{Po}$ contamination
- A likely Inner Vessel surface contamination affects the Th and Kr analysis
Next step with the CTF before filling BOREXINO

• Test the vacuum distillation
• Test the efficiency of the surface treatment performed in the CTF fluid handling system to remove $^{210}$Po
# Schedule

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion of installation (Inner Vessel and Filling Stations)</td>
<td>Jan./03</td>
</tr>
<tr>
<td>Definition of a purification strategy through the CTF</td>
<td>May/03</td>
</tr>
<tr>
<td>Solution of the Ar and Kr problem</td>
<td>Mar./03</td>
</tr>
<tr>
<td>Massive purification and filling</td>
<td>Jun./03</td>
</tr>
<tr>
<td>Scintillator filling</td>
<td>Aug./03 →</td>
</tr>
<tr>
<td>Start Borexino background data taking</td>
<td>Sept./03</td>
</tr>
<tr>
<td><strong>Start Borexino data taking</strong></td>
<td>Feb./04</td>
</tr>
</tbody>
</table>