Current Status of the Borexino experiment

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Talk Outline

- Borexino at a glance
- Detector Status and Commissioning
- Borexino physics: an update
- Background issues & goals, projected sensitivity
- Borexino @ Gran Sasso: what is the future?
Borexino at a glance

- Electron scattering in organic scintillator
- Scintillator 300 tons, fiducial 100 tons
- Two buffers 900 tons; water 2200 tons
- 2200 PMTs, optical coverage 30%
- Muon flux 1/m²/hr;
- 250 KeV threshold (¹⁴C)
Spectrum

Note: Arbitrary Units
$U, Th \ 10^{-16} \ g/g$
Detector Status

- Borexino operating in a restricted mode since incident on August 16, 2002
- Structures finished
- Purification plants completed
- Inner PMTs installed and tested
- Electronics commissioned and calibrated
Air Run with Rn source
Dec 2003

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$^{222}$Rn

$^{218}$Po

$^{214}$Po
Air Run with Rn Source
Dec 2003

Radon Source Run
Decay curve for $^{214}$Bi-Po coincidences
Detector Status

- Stainless Steel Sphere closed on June 9
- Last section of muon veto will soon be installed
Detector Commissioning

July 30 2004
Borexino Physics Goals

- Real time observation of low energy neutrinos: only 1/2000 of solar flux measured in real time so far...
  - New stuff at low energy?

- \(^7\)Be measurement fundamental for comparison of photon luminosity to neutrino luminosity of sun. Check for non-standard energy mechanism in the sun

- Probe the transition matter-vacuum oscillation transition expected (2-3 MeV) in favoured MSW-LMA

- New results on background 1-2 MeV: opportunity for pep+CNO observation

- Super Novae neutrinos

- Geo anti-neutrinos (20 events/yr expected)
Expected $^7$Be Signal

- Theoretical uncertainty of SSM on $^7$Be is 12% (BP04)
- Large experimental uncertainty of $^7$Be flux:
  - $0.91+0.24-0.61$ of BP04 (Bahcall-Peña “Roadmap”)
- Scattering cross section ($\nu-e$) 5 times larger for electron $\nu$ @ $^7$Be energy
- Reduced interaction rate ($\nu-e$) expected at 66% of SSM prediction
MSW-LMA Scenario Signal & projected sensitivity

- 30 ev/day above threshold
- Well positioned from statistical point of view:
  - 11000 ev in 1 yr (1%)
  - 22000 ev in 2 yrs (0.7%)
  - 44000 ev in 4 yrs (0.5%)
- Accuracy of Borexino measurement most likely determined by background and systematics
Background Classes

In increasing order of difficulty...

Background from long-lived isotopes (U, Th, K)

Noble Gases ($^{85}$Kr, $^{39}$Ar)

Radon Daughters ($^{210}$Bi-Po-Pb)

Cosmogenic Background

Goal: keep each source below 1 ev/day in fiducial mass
U-Th Background

- Feasibility of $10^{-16}$ g/g U, Th contamination first demonstrated in CTF (@limits of apparatus sensitivity)

- Highly desirable reduction of background at level of $10^{-17}$ g/g U, Th
  - precision $^7$Be measurement
  - open pep observation

- Collaboration focus on cleanliness & development of purification methods
85\(^{\text{Kr}}\) & 39\(^{\text{Ar}}\)

- Present in air, traces in LN\(_2\) (ubiquitous in purification processes)

- Possible systematic problem: diffusive, penetrates thin plastics over time; need to address overall contamination in detector & leaks over time

- Goal: < 1eV/day ~ 100 nBq/m\(^3\) ~ 0.3 ppm Ar, 0.1 ppt Kr -> \(10^4\) higher than standard LN\(_2\)

- Strategy:
  - Search commercial LN\(_2\) compliant with specs: Achieved!
  - Implement global purge of all detector
Radon Daughters

$^{210}\text{Bi-Po-Pb}$

- Air-borne contamination
- Deposits on exposed surfaces; Possible washoff over time; Cross-contamination?
- Goal of < 1 ev/day... very ambitious!
- Helps vessel built in clean conditions
- Further testing needed in CTF for purification and cross-contamination
- CTF sensitivity far from Borexino ultimate needs
Cosmogenic Background

- Cosmogenic nuclides production related in fundamental way to neutron production rate
- Fast decaying cosmogenic background almost completely removed by tagging with muon
- Cosmogenic nuclides removed include problematic $^{11}$C
  - 30 min, positron, 1-2 MeV spectrum:
  - 14 ev/day fiducial mass
  - tagged in three-fold coincidence with parent muon and neutron capture
pep+CNO neutrinos

- Recent results: $^{11}$C reduced to $< 0.5$ ev/day by coincidence tagging
- pep+CNO neutrinos: 2 ev/day [0.8–1.3 MeV]
- Internal Bgd 0.6 ev/day @ $10^{-17}$ g/g U, Th
- External Background:
  - 1 ev/day in 100 tons
  - 0.1 ev/day in 70 tons
- Opportunity for real-time observation of one of two basic reactions of (4p→He) cycle
Filling Strategy

- How to check ultimate background before committing to fill detector?
- Collaboration decided to fill with water first
- Water displaced top down and replaced with PC
- Allows “early screening” of PC with $4\pi$ shielding
- Cost in time, benefit in background checks & vessel wash
Gran Sasso Situation

- Preventive sequestration of entire Hall C on May 29, 2003, upon discovery of mixing between waste and aqueduct water on Lab site and lacking authorizations
- Government declared state of emergency; strong commitment to repair lab facilities
- Contracts for Lab repairs assigned early May
- Fixing of Hall C to start middle of June, 3mos expected
- Back at work with PC by year’s end
- Collaboration strongly engaged & optimistic
- Agencies strongly committed
Spare Stuff