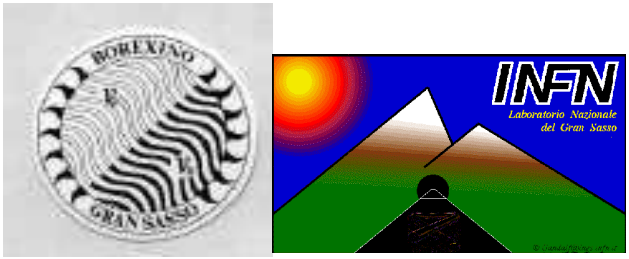
Neutrinos & implications for
Physics beyond the Standard Model
11-13 Oct 2002

Status of BOREXINO

Aldo Ianni

on behalf of the BOREXINO collaboration



Aldo Ianni
INFN – Gran Sasso Laboratory

The BOREXINO collaboration

•**Belgium**

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

•**Canada**

Queen's University – Kingston

•**France**

College de France – Paris

•**Germany**

Max-Planck Institute fuer Kernphysik – Heidelberg
Technische Universitaet – Muenchen

•**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, Jaegollian University – Cracow

•**Russia**

JINR - Dubna
Kurchatov Institute - Moscow

•**USA**

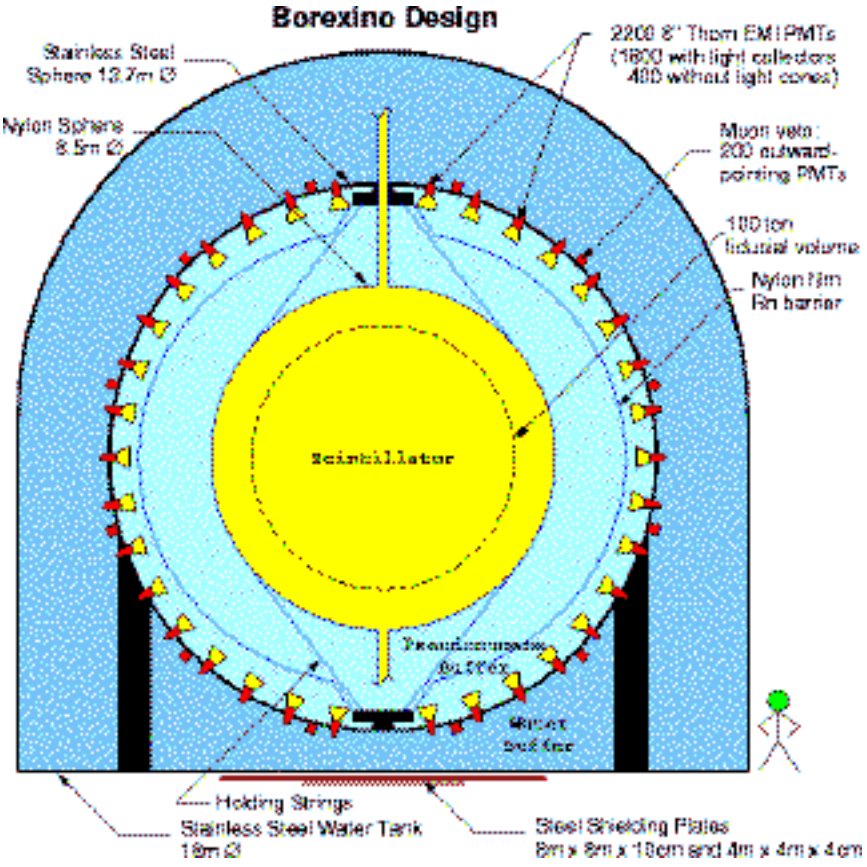
Bell Laboratories, Lucent Technologies
MIT - Boston
Princeton Univeristy – Princeton
Virginia Polytechnic Insitute

Outline

- **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

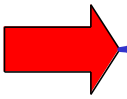
•**Goal: sub-MeV neutrinos detection**
•**unsegmented liq. scint.**
•**neutrino-electron elastic scattering**



The big challenge to measure sub-MeV neutrinos

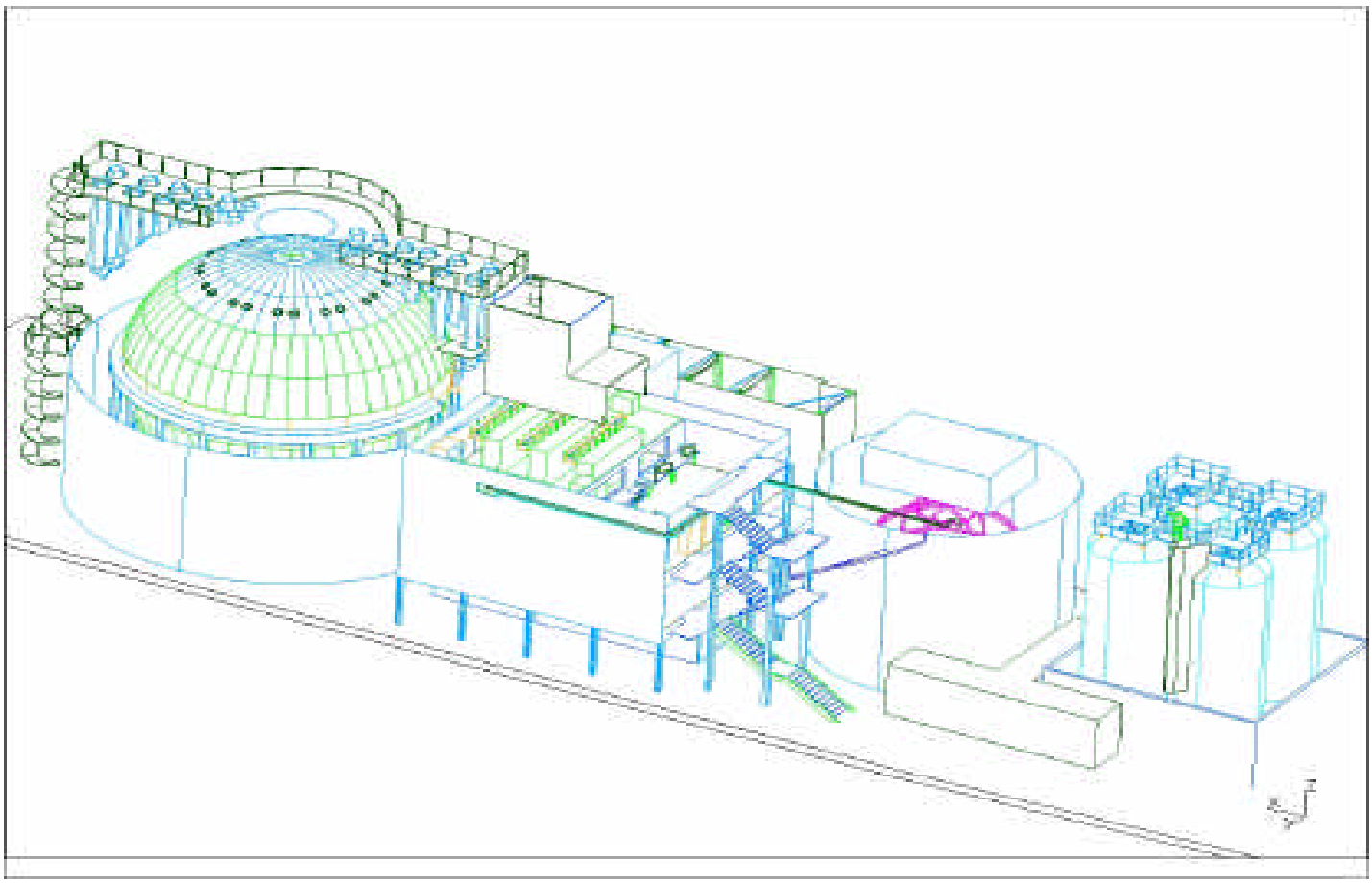
- **High level of intrinsic radiopurity needed**
- **Low background from ^{222}Rn, ^{210}Pb and ^{210}Po**
- **Low background from ^{85}Kr and ^{39}Ar**

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



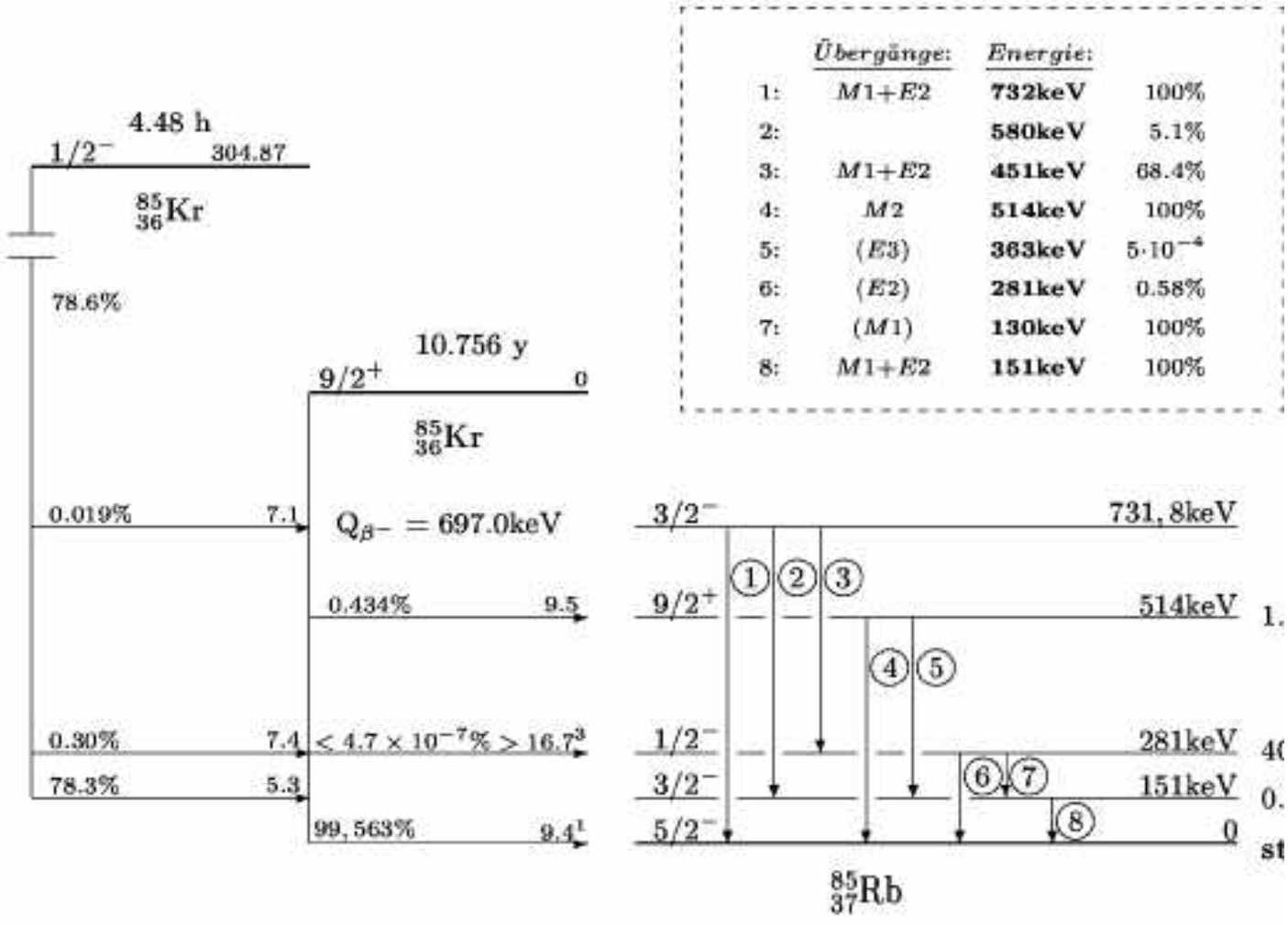
BOREXINO: radiopurity requirements

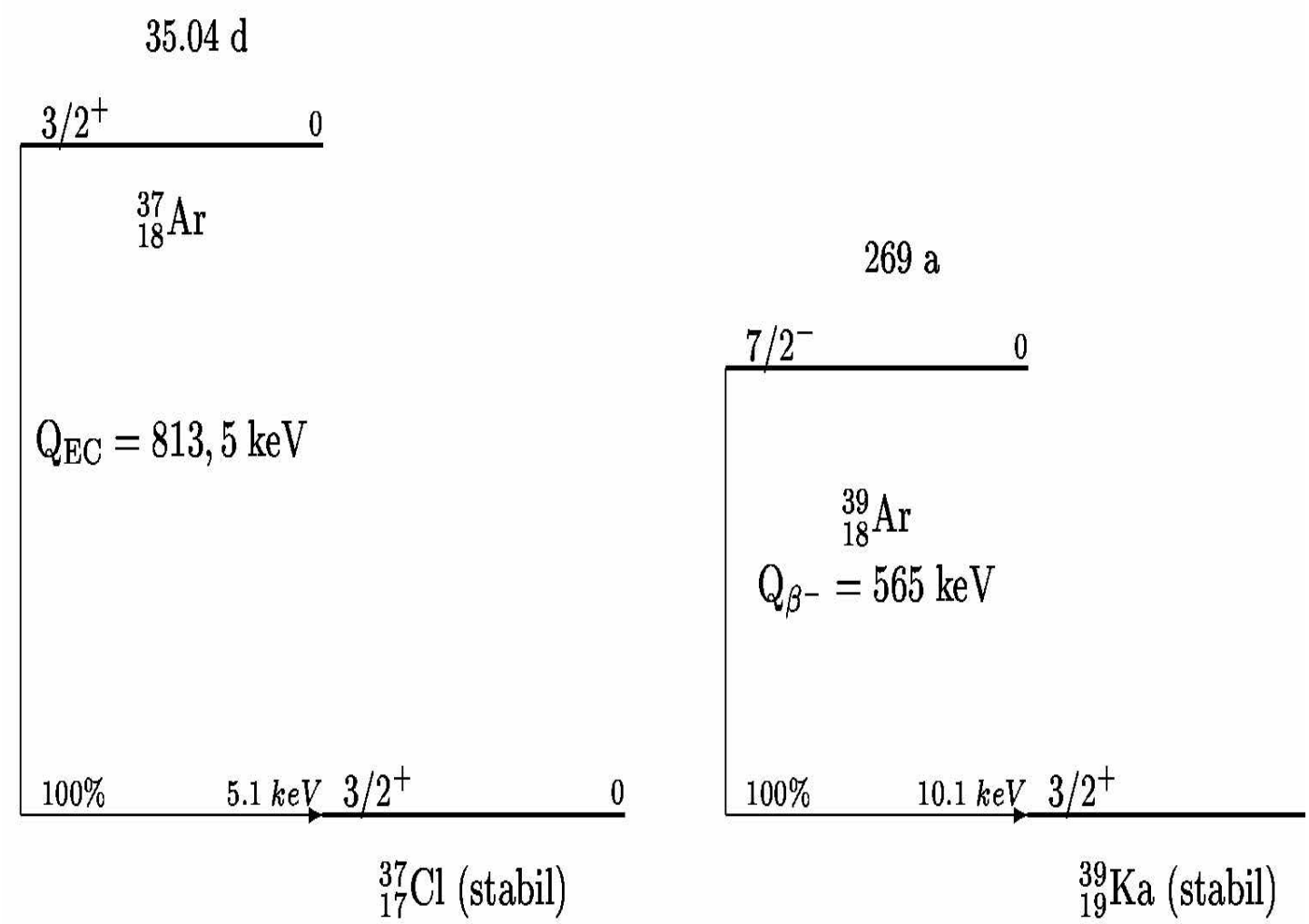
	Typical Conc.	Borexino level	Strategy
^{14}C	$^{14}C/\ ^{12}C<10^{-12}$	$^{14}C/\ ^{12}C\sim10^{-18}$	old carbon
^{238}U, ^{232}Th	~ 1ppm in dust ~ 1ppb stainless steel ~ 1ppt IV nylon	$\sim10^{-16}$g/g(PC)	distill.,water extraction, column chromatography
K_{nat}	~ 1ppm in dust	$<10^{-13}$g/g(PC)	water extr.
^{222}Rn	~ 10Bq / m^3 in air	~ 70 μBq / m^3 in PC (0.3ev/day/100tons)	N_2 stripping
^{85}Kr, (^{39}Ar)	1.1Bq/m^3 (13mBq/m^3) in air	0.16μBq/m^3 (0.5 μ Bq/m^3) in N_2	see slide on noble gases in BOREXINO

If secular equilibrium is broken: contaminants such as ^{210}Pb, ^{210}Po

Noble gases in BOREXINO

Contamination from ^{222}Rn, ^{39}Ar and ^{85}Kr could cause a serious background problem for low count-rate experiments


4.48 h
1/2⁻
304.87
85 36 Kr
78.6%
10.756 y
9/2⁺
0
85 36 Kr
0.019%
7.1
Q_β− = 697.0keV
0.434%
9.5
0.30%
7.4
< 4.7 × 10⁻⁷% > 16.73
78.3%
5.3
99, 563%
9.41
Übergänge: Energie:
1: M1+E2 732keV 100%
2: 580keV 5.1%
3: M1+E2 451keV 68.4%
4: M2 514keV 100%
5: (E3) 363keV 5·10⁻⁴
6: (E2) 281keV 0.58%
7: (M1) 130keV 100%
8: M1+E2 151keV 100%
3/2⁻
731, 8keV
9/2⁺
514keV
1/2⁻
281keV
3/2⁻
151keV
5/2⁻
0
85 37 Rb


35.04 d
3/2+
0
37 18Ar
QEC = 813, 5 keV
100%
5.1 keV
3/2+
0
37 17Cl (stabil)
269 a
7/2−
0
39 18Ar
Qβ− = 565 keV
100%
10.1 keV
3/2+
39 19Ka (stabil)

Noble gases in BOREXINO

^{222}Rn problem solved by stripping with high purity N_2 (Rn < 1μBq/m$^3_{gas}$)

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

→ **~0.4ppm(Ar/N_2) for Ar (~0.2ppt for Kr)**

best N_2 available in Europe:

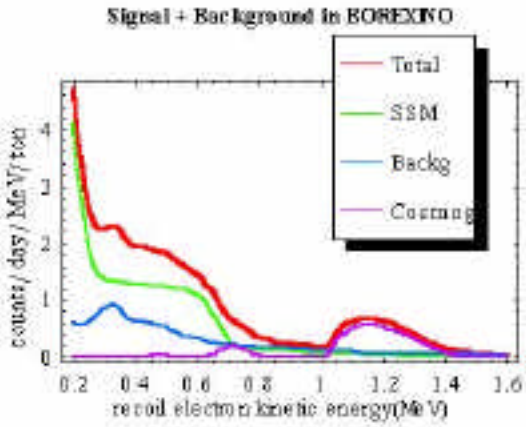
→ **0.4ppm for Ar (6ppt for Kr)**

Ar	Kr
Problem solved with found gas supply	Problem solved by: •cryogenic adsorption in N_2 •Adsorption on a molecular sieve (0.5nm pore size) •Low pressure steam stripping

Solar neutrinos signal and internal background

- Neutrino window [0.25,0.8] MeV
- $C14/C12 = 3 \cdot 10^{-18}$
- U, Th at 10^{-16} g/g
- K at 10^{-14} g/g
- effic.for PSD=95%
- effic. for CE=90%
- Ar and Kr according to requirements

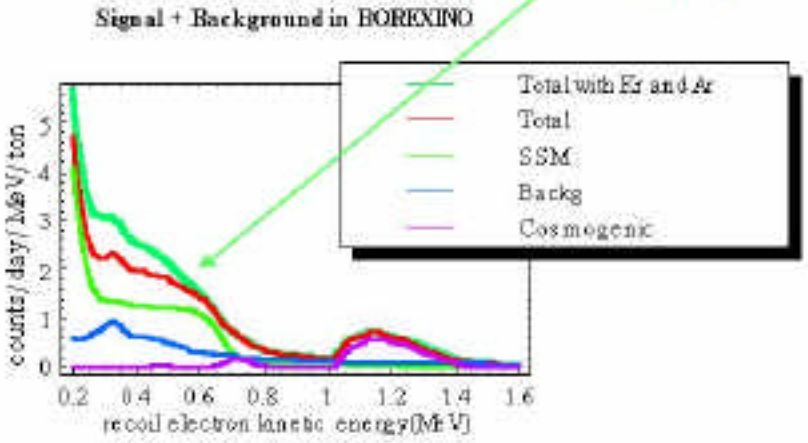
→ S/N = 1.89 for SSM



Muon-induced background according to T. Hagner et al. Astrop. Phys. 14(2000)33-47

Solar neutrinos signal and internal background

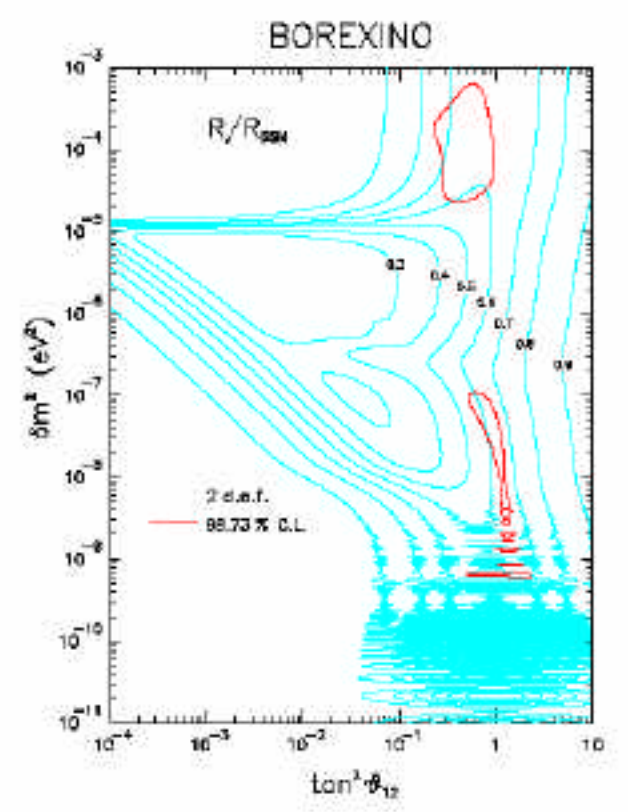
with Kr 40 times the requirement and Ar within it

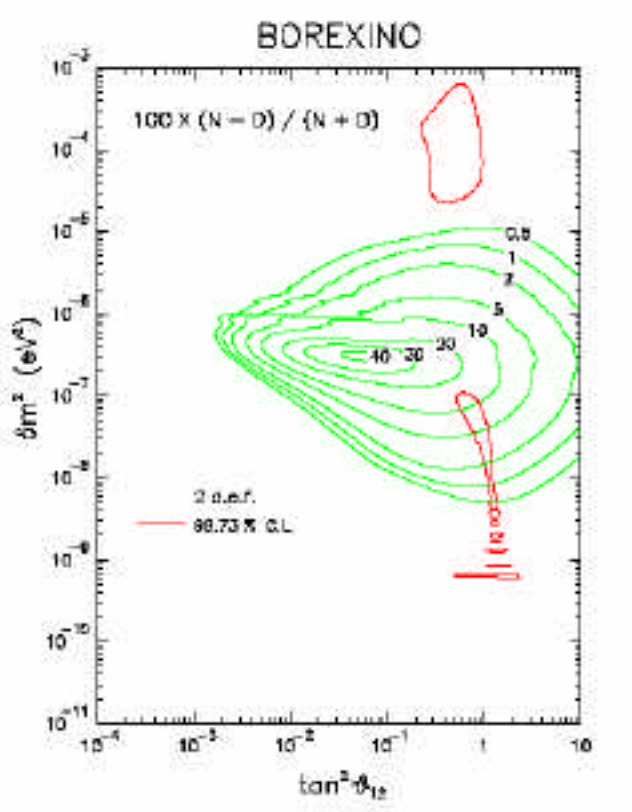


The physics program of BOREXINO

- **Solar neutrinos (strong potentiality for LOW scenario and seasonal variations)**
- **Astrophysics: fluxes from Be and CNO (20% of the signal in the ν-window from CNO)**
- **Neutrino-Electron elastic scattering in the sub-MeV region (to search for a non standard contribution to the cross-section) from solar neutrinos and neutrinos from an artificial source (^{51}Cr)** **[Z. Berezhiani et al, Nucl Phys B638(2002)62; W. Grimus et al, hep-ph/0208132; A.I. et al., Eur. Phys. J. C8(1999)609]**
- **Anti-ν_e detection (10-30 events/yr)[R.S. Raghavan et al, Phys. Rev. Lett. 80(1998)635, C. Rotschild et al. Geo. Res. Lett. 25(1998)]**
- **Neutrinos from supernova (low energy region): in 300tons ~17 ev from $\nu(\nu)^{12}$C NC; ~81 inv-β decay [L. Cadonati et al, Astrop. Phys. 16(2002)361]**

Solar Neutrinos oscillations in Borexino

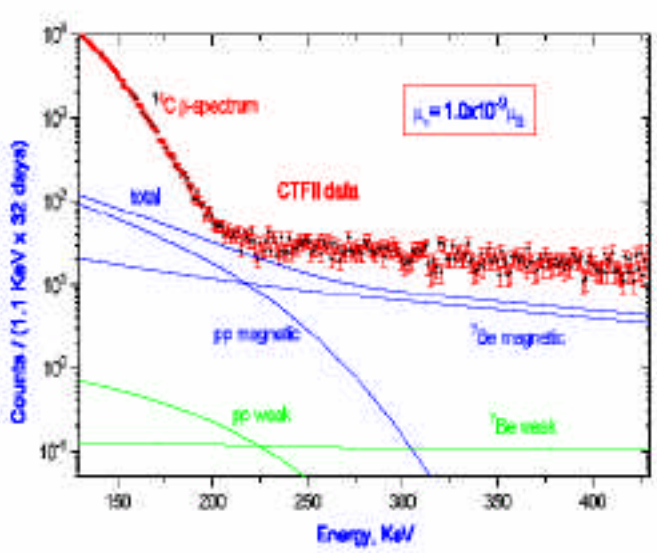


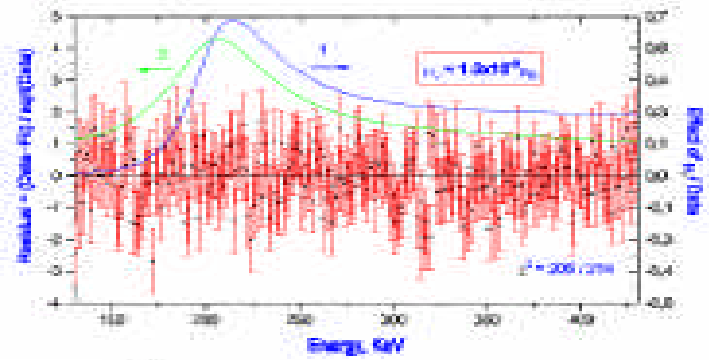


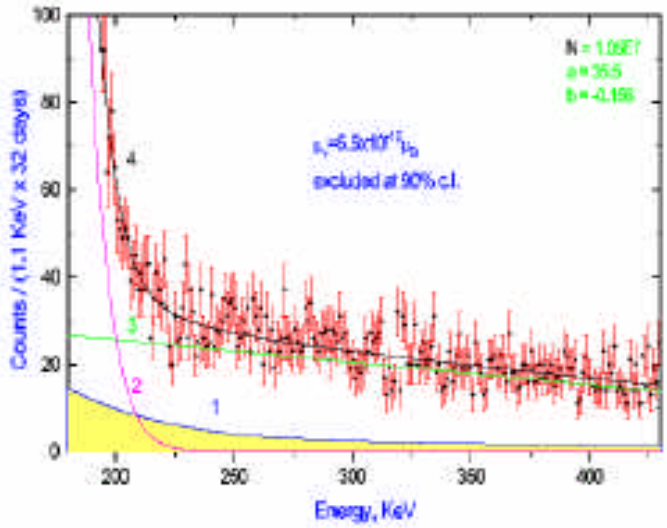
G. Fogli et al. for rates + G. Fogli et al. in hep-ph/0206162 for global analysis

Neutrino magnetic moment from CTFII:

an example to study non-standard contributions to the neutrino-electron elastic scattering in Borexino







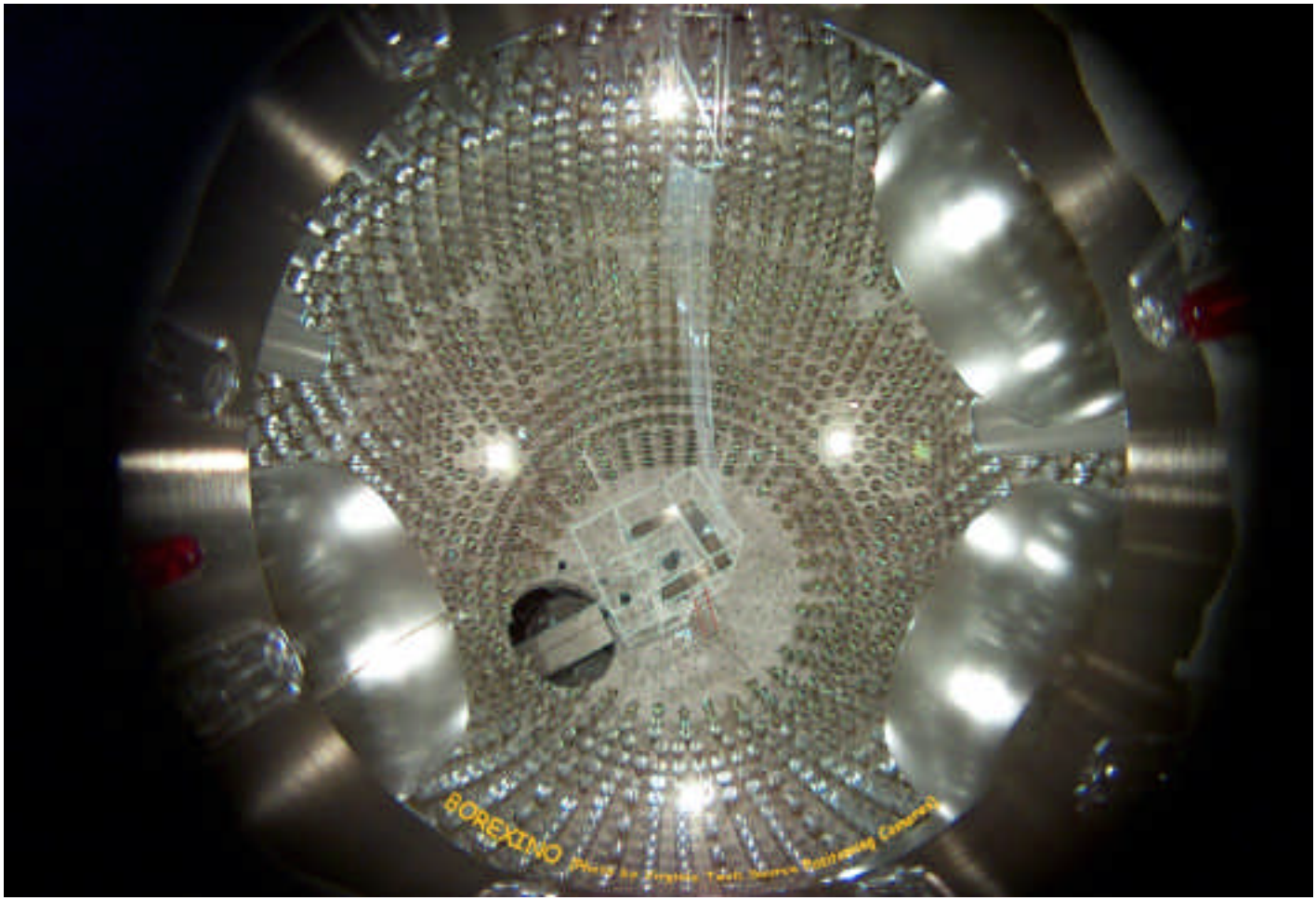
$\mu_\nu \leq 5.5 \cdot 10^{-10}\ \mu_B$ (90% C.L.)

1. **Spectrum due to $\mu_\nu = 5.5 \cdot 10^{-10}\ \mu_B$**
2. **^{14}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 ~ $4 \cdot 10^{-18}$
- Light yield=380 p.e./MeV
- ^{238}U:

  before purif.: $(14 \pm 3) \cdot 10^{-16}$ g/g

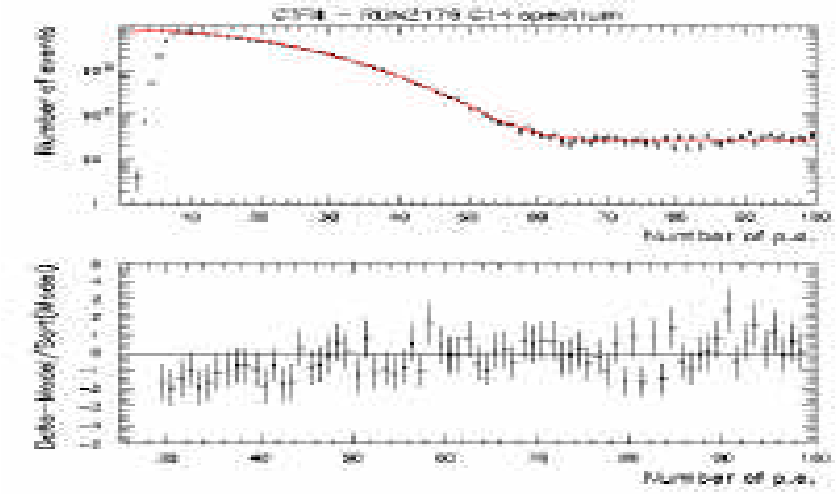
  after purif.: $(6 \pm 2) \cdot 10^{-16}$ g/g
- ^{232}Th:

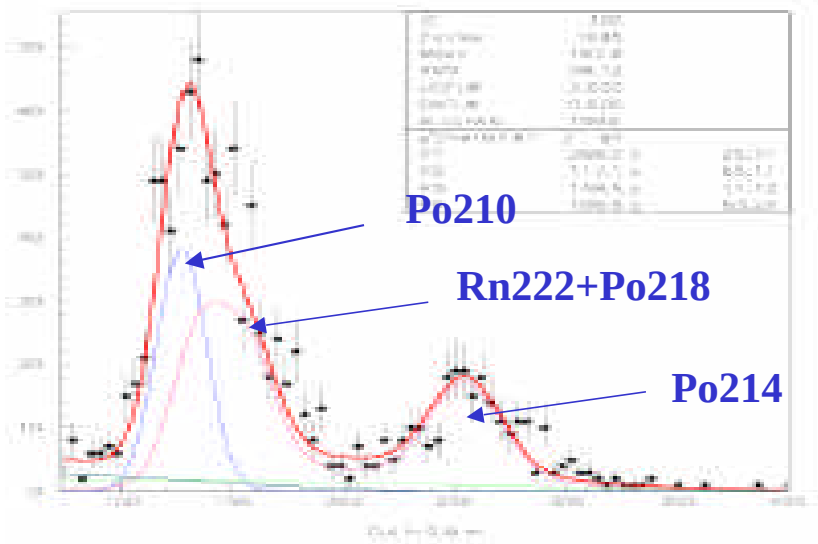
  before purif.: $(62 \pm 8) \cdot 10^{-16}$ g/g

  after purif.: $(26 \pm 5) \cdot 10^{-16}$ g/g
- Kr:

  before strip.: 250 ±1 ev/d

  after strip.: 46±20 ev/d
- SilicaGel reduction factor ~ 3
- Water-Ext. reduction factor ~ 6
- Events position distribution shows not well understood ^{210}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

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