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CAST STATUS REPORT

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<u>A Solar Axion Search Using a Decommissioned LHC Test Magnet</u>

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One year after the approval of CAST (13. 4. 2000), the preparation status of the different items of the axion telescope can be summarized as follows :

1) MAGNET

The conceptual design of the infrastructure for the moving magnet is ready.

The magnet will be mounted on a supporting girder together with the Magnet Feed Box (MFB). These elements are recovered from the previous installation existing in SM18 for the test of the LHC prototype magnets. The installation is expected to take place in summer 2001.
The magnet cold mass has to be inserted in a horizontal cryostat, requiring a new thermal screen working at around 70 K. The LHC-CRI group will take care of this assembly in the new SMA18 facility for the LHC series magnets.

The second phase of CAST requires a low pressure helium gas enclosure at low temperature in the cold bores of the magnet. EST-ME will start the mechanical design of the flanges and tubing to include in the magnet and MFB, in order to avoid delicate modifications once the assembly is in place. A re-design of the inner magnet structure will also allow to install later small X-ray focusing mirrors inside the magnet cryostat. This modification might also allow the shortening of the magnet end-caps by ~10 to 20 cm.

A power supply has been ordered by CERN. The SL-PO group takes care of the manufacturing of the 14 kA power converter according to the design of the converters used for the cold tests of the LHC magnets.

The 15 mbar, 2 g/s pumping station, needed to subcool the magnet at 1.9 K, is to be delivered either by Darmstadt, or, by the US collaborators, which have found one available from BNL.

Magnet assembly will start in July 2001.

Magnet commissioning including cryo-infrastructure, will be done by the LHC division.

2) CRYOGENICS

The conceptual design is ready.

The Cold Box was dismantled and transferred to SUH8, where normal full maintenance of equipment is taking place.

New gas bag housing and helium buffers from LEP2 are in preparation.

Dismantling of LEP1 helium buffers and removal of LN2 reservoir behind SUH8 is planned for May 2001.

The MFB has been moved to bld. 110 for revision.

First meetings with ST & IT were organised for the necessary external utilities (water, compressed air, electricity, network).

First studies of principal cryo process are finished. A detailed P&I diagram and implementation drawings are in preparation.

3) MOVING PLATFORM

The conceptual design has been prepared at CERN. Its stability has been checked by a computer Structural Analysis Program (SAP2000) by the construction firm PYLON, using the steel design codes : U.S. ASD and LRFD, EUROCODE 3-1993, and British (BSI 1990). The conclusion was that an additional load of at least $\sim 30\%$ should be allowed.
The construction has been started in Greece and will be completed middle of June 2001. The official order went out from CERN 4. 5. 2001.

4) X-RAY DETECTORS

Preparation and tests of 3 different options go parallel at CERN and in CAST home institutes. The already achieved background level is $\sim 10\times$ worse than the one assumed in the CAST proposal ($\sim 2 \cdot 10^{-6}/s \cdot cm^2 \cdot keV$). However, we expect to reach this level with shielding, a more efficient cosmic-veto and a new two-dimensional readout design. All detectors will be mounted on security valves, which are closing the magnet vacuum at each exit hole. Valves and adapter pieces have been ordered.

a) TPC : the mechanical design and construction of the drift region, i.e. window-drift plane, race-track electrodes and external container, is ready. The 12 drift electrodes, in the region of the HV degrader, have been made of aluminised plexiglas.
For the 3 planes which form the proportional chambers, we have performed a FE calculation of the mechanical strength of frames made of Plexiglas or Delrin under the load of the wires. The results show that the 2 materials are mechanically very similar. The Cu-Be wire has arrived, and the 3 wire planes could be ready end of July 2001.
The readout electronics : The front-end electronics will be identical to that used for the HARP TPC. Work still to be done is the design of the printed circuit boards which couple the front-end electronics to the wire planes (the sense wires need to be coupled to the electronics using 3 kV capacitors).

b) A Micromegas detector prototype has been extensively tested at CERN and in Saclay (detector effective surface = 200 cm^2, conversion gap = 6 cm). The frame is made out of plexiglas (being a low radioactive material) and the anode plate is a 100 μm epoxy. Anode copper strips, 317 μm pitch, were printed by conventional PCB technique at CERN. Gassiplex chip is used for the readout.
For most of the tests a mixture of Argon with 10% isobutane was used. The veto scintillators were 30 cm$\times$30 cm in size. For the energy calibration we used ^{55}Fe and ^{109}Cd sources. The raw counting rate was $\sim$3 Hz. The main background rejection (by a factor of ~ 100) comes from the different spatial event topologies. The remaining background counting was $\sim 10^{-5}/s \cdot cm^2 \cdot keV$ in the energy range 0.8 to 10 keV, which is the CAST relevant range. During this test, the detector was not shielded against environmental background.
By implementing a two-dimensional strip detector board, the rejection factor is expected to improve. Such a detector prototype has been built and will be tested soon.
The final detector version will consist of two types, both having two-dimensional readout (strip pitch of 350 μm) : a) 60 cm$\times$60 cm, and b) 1.5 cm$\times$1.5 cm, which will be used at the focal plane of the X-ray mirrors (see below) and can be built with pad readout to further

improve the background rejection.
Time schedule : a) the mechanical design using low-radioactive materials such as plexiglas or delrin, is ready. We have started with the frame construction and the design of the two-dimensional PCB board. b) The production of final frames and PCB boards is expected at the beginning of June 2001. c) The first detector should be ready at the end of June. d) Beginning of July, test of the first detector at CERN, and e) In september 2001, the construction of the detectors should be completed.

c) CCDs : An X-ray CCD camera will serve as detector for the "sun's axion image" obtained with the help of the Wolter type mirror telescope (see below). A camera including the required readout electronics is available at the MPI semiconductor laboratory in Munich. With the exception of the smaller size (3×1 cm^2 instead of 6×6 cm^2) its function is identical to that of the pn-CCD camera on the XMM/Newton X-ray observatory, which was launched into orbit December 1999 and is functioning perfectly ever since.
The characteristics of this device as relevant for CAST are:
1/ Geometry: 1×3 cm^2 active area; pixel size 150×150 μm^2; 300 μm thick silicon.
2/ Close to 100 % quantum efficiency of the detector over the full relevant energy range (0.3 to 10 keV).
3/ Windowless operation even in vacuum without efficicency loss is possible.
4/ Very good energy resolution allows to set a very low energy threshold (below 0.5 keV).
5/ Rejection of background (e.g. m.i.p's and radioactive sources) from event topology and spectral analysis is possible.

Very low background rates have been obtained already in a first quick measurement. In constructing the camera no particular care has been taken to use only low radioactive materials or to implement shieldings. Thus, it seems to be possible to reduce this background further by rebuilding the camera using CCD chips already available at the MPI semiconductor laboratory.

5) TELESCOPE - SUN ALIGNMENT

A strategy for Solar tracking has been developed in collaboration with the EST division: they will provide very accurate measurements (0.001^o precision) of magnet orientation in geocentric coordinates, for a large sample of possible magnet positions. This information will be used in combination with astronomical codes able to predict the position of the Sun in the same reference frame. Two such codes have been tested by comparing their predictions with the astronomical ephemeris for CERN's geographical position: the accuracy found is better than 0.005^o any time of the year. The cumulative error expected in the prediction of the solar centroid is smaller than 5% of the solid angle subtended by the magnet bore. In paralell, an engineering design for platform motor control has been completed. A LABVIEW-based code encompassing the astronomical calculations and driving of the motors is under development and tests using model motors are to begin immediately.

6) X-RAY FOCUSING

X-ray mirrors have been widely used for decades in X-ray astronomy; they can focus X-rays from the Sun to a $\sim$ mm spot, improving the signal-to-noise ratio. This method was not

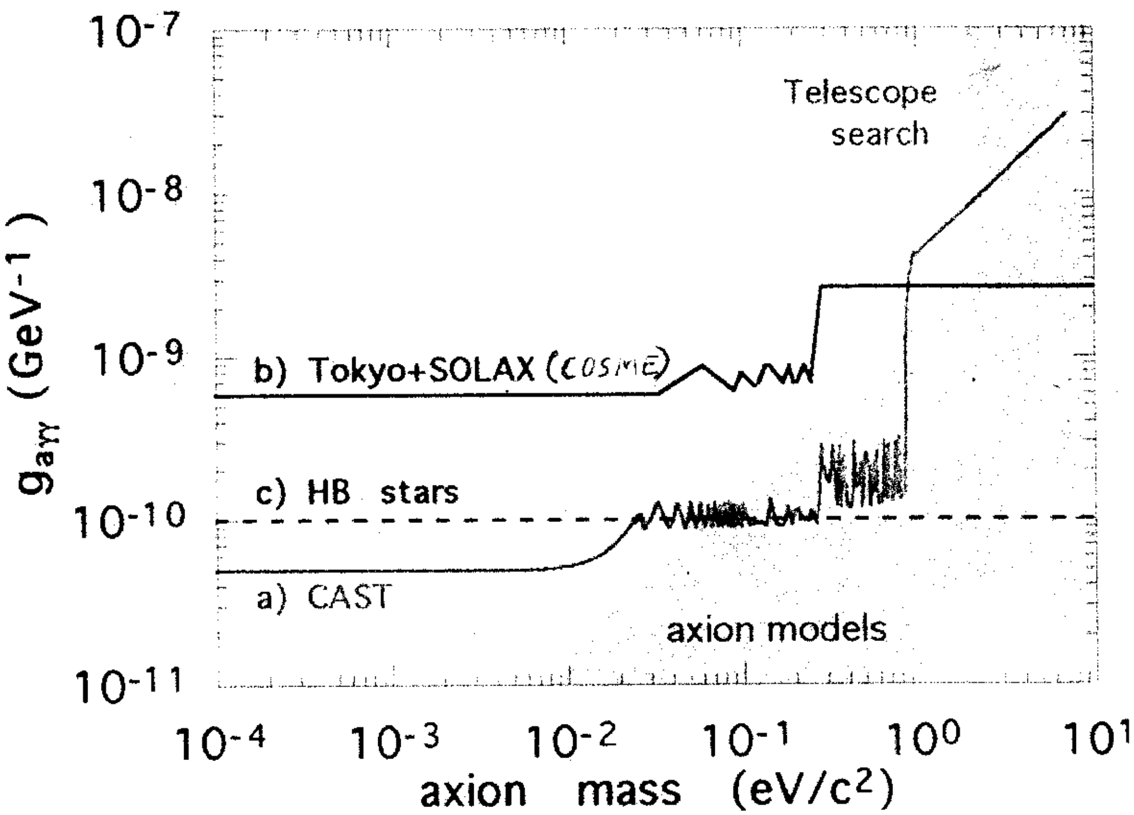
used in any of the two previous axion helioscope experiments. A spare module has been recovered from the German space program ABRIXAS and will be tested from 15. 5. 2001 at the X-ray test facility in Munich/Neuried. The evaluation will be ready before 15. 6. 2001. A first optical test of the module performed recently by the firm ZEISS was very positive, i.e. most probably the mirror system is still in good shape.
The expected improvement of the signal-to-noise ratio due to the much smaller effective detector surface results in a better solar axion detection sensitivity. Pending the final outcome of the tests in Munich, the expected CAST sensitivity for the axion-photon coupling constant is : $g_{a\gamma\gamma} \approx 5 \cdot 10^{-11} GeV^{-1}$ (see also attached exclusion plot). It should be noticed that this additional X-ray focusing is being followed parallel to the initial CAST configuration. We will incorporate similar "lenses" to the other magnet apertures, which the firm ZEISS can build within 1-$1\frac{1}{2}$ years.

7) EXPERIMENTAL HALL

The layout of the exact location of the telescope inside the Hall on the ~2 m lower basement, including the place of the associated equipment such as magnet power supply, pumping station, water demineralizer, etc, is almost final.
The preparation of the experimental hall, including the necessary infrastructure, has started. First of all, LEP cables and supporting structures must be removed, in order to prepare the floor for the telescope turntable.
The use of the recovered X-ray lens requires more space for the turning telescope than foreseen in the CAST proposal. The available space is marginal. There is not enough space for detector shielding. However, more space can be made available by shortening the end-caps, and, by minor scraping of the two walls. Both possibilities are under study by CERN experts.

8) NEW COLLABORATING INSTITUTES

New groups from GSI/TU-Darmstadt, MPE/Munich, Politecnico/Milano and Demokritos/Athens have joined the collaboration. They bring additional equipment and know-how which will improve the performance of the CAST experiment. They also bring additional external financial resources which are necessary to the experiment.



a) Attainable 99.7% c.l. limits on the coupling strength of axions to two photons as a function of axion rest mass in CAST (CERN Axion Solar Telescope).

b) Present experimental limits (Tokyo axion helioscope + SOLAX).

c) Astrophysical constraints (HB stars, theoretical).