CERN-SPSC-2007-021 and SPSC-M-757
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Running CAST 2008-2010

We need to run CAST for 3 more years, in order to fully exploit its discovery potential [see Figure 1 &2]. We feel it is important that the time line of the full ^{3}He phase of the experiment is already present on the financial and manpower plans for both CERN and the Collaborating Institutes. In addition, for all concerned, it is not efficient to ask first for an extension of 2 years with all the administrative work associated with an MoU, proposals to SPSC, funding agencies, etc., and then repeat this process relatively soon afterwards.

We consider that it is well worth covering the maximum axion rest mass range that CAST is able to reach, which also happens to coincide with the cosmologically motivated limit, entering also into a theoretically-astrophysically motivated parameter phase space. This will be achieved with an existing well-understood apparatus, which most probably until 2010 will not face major interventions/upgrades as we have had in the past. In particular, to complete the presently ongoing ^{3}He upgrade we will need 2 or more months of 2007 than foreseen, being thus already a little beyond schedule[1] This is a delicate work and it touches also diverse safety aspects, which we must deal appropriately, in order to exclude an accident during operation, which could be, for example, the contamination or even the loss of the expensive ^{3}He. In short, there is no room to rush, in order to advance faster.

The reduced running period of 2007 itself already compresses the data taking periods for the years 2008-2010. Furthermore, we do optimise CAST performance all the time. For example, with the ongoing efforts to implement also a 2nd X-ray optics with Micromegas detector at the focal point, CAST's discovery potential can be increased, making some reiterations unnecessary, following a predefined scanning protocol. This is one of the best improvements we consider, the need for this became obvious during the 2006 run. There is now a proposal to replace the TPC with a pair of well-shielded and potentially very-low background Micromegas detectors. This will be reviewed for acceptance by the CAST Steering Committee to be held on the 25/26 June 2007. After a setback when the 2nd X-ray optics failed to meet the specifications, the LLNL team now has new funding to make a second optics and the collaboration are now following two alternative and more promising coating techniques for the optics - aided by consultants from NASA and CERN. The ^{3}He gas (1.17 m^3) has now been delivered to CERN.

Considering the availability of CERN resources to meet the CAST request to run in 2008 to 2010. Firstly the costs of running the CAST magnet (Table 2 of the CAST request); consultations with the financial and operations planners of TS have led to estimates of annual power costs of 170-200 kCHF. This amount was considered to be well within the error margins of the total CERN annual consumption[2] and did not present any undue problems in terms of present energy provision planning.

Consultations with the AT-ECR group concerning the 180 kCHF annual contribution for Magnet Cryogenics M&O indicated that about 100 kCHF of the annual cost is allocated to CAST for 1FTE from a piquet team that covers 7 installations around CERN. The non-running of CAST would not reduce the number in the team and would save CERN just the remaining 80 kCHF costs for

[1] CAST now expects to start ^{3}He data taking at the end of September. The delay is due to an accumulation of many small delays. CAST work has been slowed down considerably inside CERN by the general density of work in this crucial year for LHC installation and the low priority assigned to CAST with respect to LHC by design teams, technicians from support groups, main workshops, welding services. The LHC installation has reduced the availability of personnel and slowed down the response time of the cryogenic, vacuum and electrical support groups. Within CAST, delays in ordering materials have occurred due to the high load placed on the doctoral student responsible for the project. Late deliveries of key components and errors in fabrication have also contributed. Finally, significant mechanical and personnel safety systems for the magnet and movement system have been imposed on CAST which have required study and design before orders and fabrication could be started. The implementation of these systems on the magnet has and will cause some additional delays to the re-commissioning of CAST.

[2] The CAST peak power consumption of 0.7 MW is estimated to be approximately 3 ‰ of the peak power consumption of LHC.

maintenance and consumables/fluids. An important unforeseen future expenditure was identified, namely the near-obsolescence of the cryogenics PLC-based control system and the eventual need to replace it[3]. The estimated cost of the upgrade is estimated at 150 kCHF and would normally be requested from PH. In the event of PH being unable to fund this upgrade, CAST will find the resources to cover the costs. The upgrade would also add 0.55 FTE to AT-ECR manpower request for the years 2008 & 2009 (see footnote 3).

In response to the request for trimming the request to PH, CAST had already trimmed the staff request to an absolute minimum. In terms of Fellows and Associates, CAST hopes to receive from PH at least the continued support of one Applied Fellow. From 2008 onwards the Applied Fellow will be responsible for the operation and development of the ^{3}He system given that the CAST Collaboration has agreed to assume the present CERN responsibility for the Slow Control system in order to make way for this new task (which it considers essential for the successful operation of the ^{3}He system).

The CAST Collaboration expenditure for the period 2008-2010, with the assumptions above and including costs borne by institutes for detector maintenance and operation, is presently estimated at 1380 kCHF[4]. The baseline costs of 750 kCHF amount to the equivalent of 5kCHF contribution annually per PhD and above, which is considered quite feasible. Certain key institutes contribute significant sums in addition to this; both for upgrades to existing detectors and for the maintenance and calibration of detectors during the 3 years running (see footnote 4). In addition to data taking shift personnel, institutes also send personnel for extended periods to CERN for the operation of the detectors. At present, for the period 2008-2010, Saclay will undertake to provide a Post Doc at >50% at CERN. Zaragoza and the combined Greek Institutes will each undertake to maintain one PhD student permanently at CERN. The German institutes have PhD student cover for the telescope-CCD until at least mid-2009.

From the CAST viewpoint, the resource situation for the requested extension is tight but feasible both in the Collaborating Institutes and at CERN. Returning to the strategy for running 2008-2010, in view of the lack of contingency and in the worst case scenario of some undesirable development, we think it is scientifically and also practically it is advisable to continue data taking without compromises. For example, to make a fast ramping of a wide pressure band is in principle realistic, and, it could allow CAST to detect an unexpectedly high signal. However, safety aspects should be kept seriously in mind: the higher the pressure of the ^{3}He, the higher the risk to have some undesirable effect, which can lead to an accident. As an example we mention the unpredicted Thermo Acoustic Oscillations, which could have an impact on CAST's performance, but not on its safety. Thus, we have to increase the buffer gas pressure progressively and watch whether some strange behaviour is developing. After all, we only can make a reliable forecast about the performance of CAST, once we have some running experience with the various options of controlling the buffer-gas density, e.g., continuous pressure ramping, or, discrete steps and how many during tracking, etc..

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[3] AT-ECR is planning the phased renewal of a number of these plants following a priority list. The optimal time to renew the CAST system would be in a shutdown between 2008 and 2009. The total cost would be about 150 kCHF shared equally between 2008 & 2009. The AT-ECR manpower requirement in Table 3 would then rise to 0.6 FTE in each of 2008 & 2009 from the 0.05 at present in the technician category.

[4] Estimate of CAST expenditure 2008-2010

CAST expenditure 2008-2010 baseline		
2008-2010 General M&O	450	
Instrumentation, Infrastructure and Safety	150	
Upgrade to cryogenics control system	150	
	750	kCHF
Detector upgrades (largely financed by interested institutes)		
New 2nd Optics	150	~ half available already in 2007
3 New MM (detectors/shielding) 2 sunset, 1 sunrise)	150	Project to be decided June 07 Patras
New CCD with enhanced low energy response	150	
	450	kCHF
Costs to institutes to maintain, calibrate and align X-ray detectors and X-ray optics (minimum estimate based on 2005-2007 costs)		
Detector and Optics M&O 2008-2010	180	kCHF

Thus, we should at the present time consider reaching the ~120 mbar limit in not less than 3 years, which already will be tight. If, for any reason, we have to stop, then CAST will have completed part of the allowed pressure window. In this way CAST will keep its reputation. At a time where other big labs worldwide have only recently started entering axion physics, it is valuable that CAST operates with its best performances.

Finally, it is worth noticing the not so widely known fact that also solar space missions like RHESSI (NASA) and HINODE (Japan) search for solar axions. At the moment it is not clear what their performance compared to CAST's is. Those involved in these projects are solar physicists since 3-4 decades. CAST follows the developments. Three new prospective external collaborators will be presented to the CAST Steering Committee in the forthcoming Collaboration meeting on the 25/26 June 2007. One of these, S. Solanki / MPS, is also a well known solar physicist, whose involvement already provided momentum to the search of low energy solar axions. Along with E. Gazis / Athens and G. Cantatore / Trieste, CAST intends to make first tests in the visible, with minimal interference with the base program of CAST. In this energy range, CAST might be able to perform a "first" run, being, with luck, superior to related celestial investigations. In the upcoming workshop in Patras there are a few talks foreseen, which are apparently in favour of low energy axions, which have not been considered in the past. Therefore, from the meeting next week we hope to update our expectations towards low energy axions, i.e. below ~ 0.5-1 keV.

The new collaborators that CAST will gain for the low energy range should also contribute towards the general CAST financial expenditure.

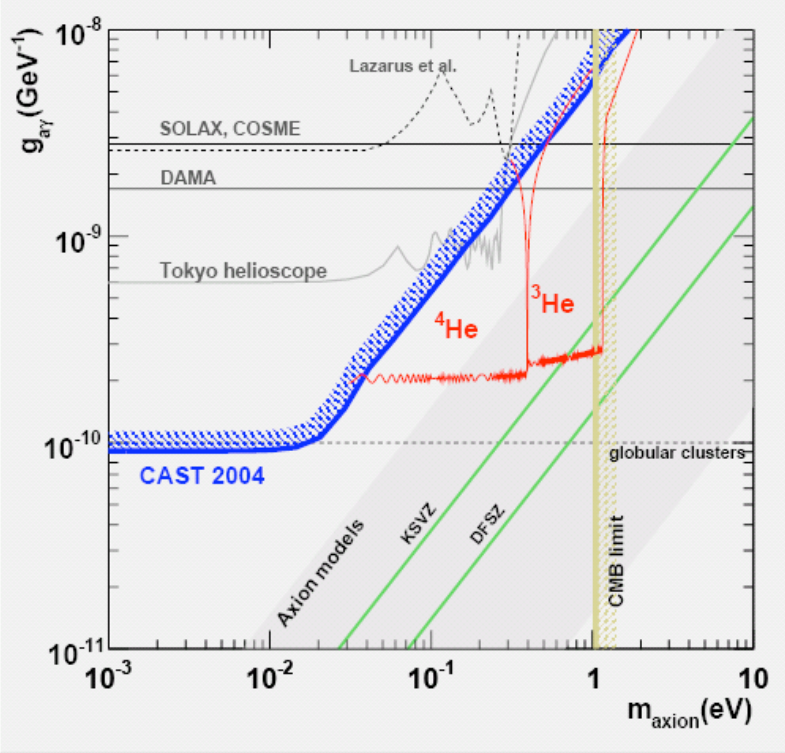

Figure 1: CAST prospects, scan up to 120 mbar @ 1.8 K. The ^{4}He signed range has been completed already. The following range, which can be covered by with ^{3}He buffer gas is shown in a log-lin scale in Figure 2.

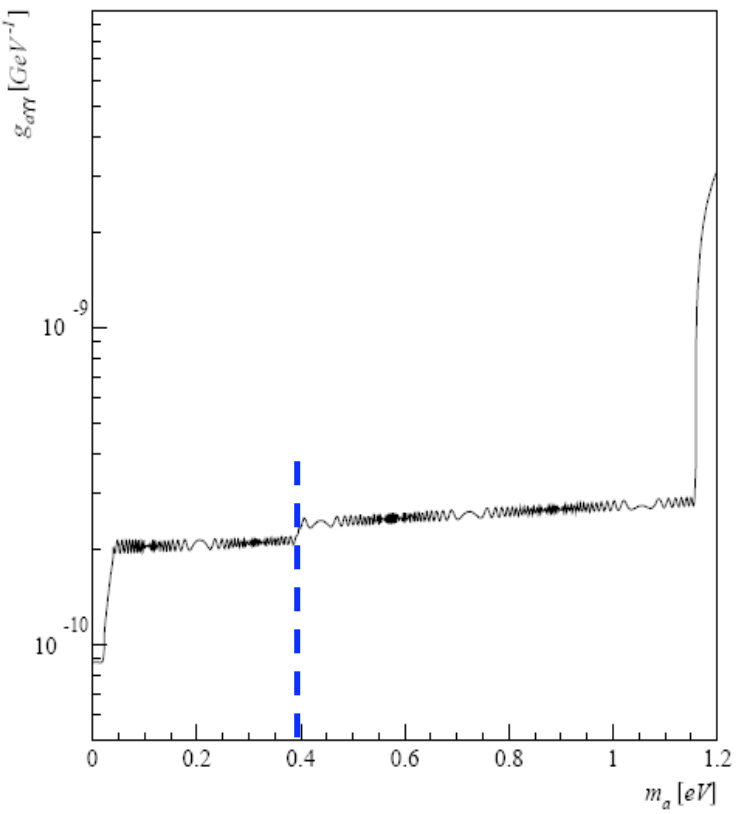

Figure 2: CAST exclusion plot in log-linear scale. The blue dashed line shows on the left side the so far scanned axion rest mass range in 2006. The prospects for a scan up to 120 mbar @ 1.8K in 2008-2010 are shown on the right side of the blue dashed line.