PPGP CMS QUESTIONS

1. Please provide a list, including value, of in-kind M&O contributions negotiated during the previous CG period.

M&O B	[kCHF]	2012	2013	2014	2015
In-kind	Tracker	44.6	45.0	45.0	25.0
	Trigger	24.0	14.0	14.9	15.0
	ECAL	21.8	59.6	33.5	0
Cash	Tracker	44.6	44. 6	50.0	52.9
	Trigger	37.8	37.8	37.8	37.8
	ECAL	59.5	0	13.4	44.6

Source: totals from the CMS RRB documents October each year

The Tracker in-kind contributions represent the expected cost of maintaining 500 Front End Driver boards (440 + 60 spares) using RAL TD staff effort, which is considerably less than a commercial maintenance contract for power supplies for example. For 2015, the reduced total M&O B cost and the high reliability of the boards and the associated firmware explains the lower in-kind allocation.

The Trigger in-kind contributions represent the annual estimated cost of maintaining the GCT system, which we are requested to keep operational until LS2 in 2018.

The ECAL in-kind contributions from 2012-14 include the following specific expenditures: (1) consumables (liquid helium) for the magnet cryogenic systems of the VPT test facilities and nitrogen for the storage of VPTs (2) consumables for the repair of the inoperable region of EE during LS1, (3) purchase of electronics components and spares (incl. EE HV system components), (4) contribution to CERN-based manpower for essential EE installation/HV system work. The 2015 ECAL contribution is expected to be cash-only. (The variation in the proportion in earlier years is related to cash contributions to two large value purchases essential for detector operation: HV mainframes and a new laser.)

2. Please provide named organograms of the international CMS Tracker, ECAL and computing management structures.

Appended at the end of the document.

3. What is the financial cost increase in M&O per year caused by the increase in trigger from 8.5% to 12.6%? What drives this increase? What in-kind reduction has been negotiated from the UK Trigger hardware contributions and operations staff?

The L1 trigger is a complex, multinational project where it is hard to devise an equitable algorithm for cost sharing. Up to now each agency has been responsible for its own hardware and some valuation has been attributed to the in-kind resources needed to provide that. As can be seen from the table above, this amounts to ~£10k per year for the UK, which is probably reasonable. However the biggest cost of maintaining the trigger is in

effort, and Imperial has had one full time engineer (G. Iles) based in CERN so that 100% trigger availability is guaranteed. Several other agencies also base staff in CERN for the same reason. The counting of individuals is done in all projects, even though it is often not easy to specify precisely, e.g. for those who are contributing to analysis as well as detector operations, and the UK head count has evolved mainly because of the large effort which was required to deliver and operate the GCT, including evaluation of performance and studies and implementation of improved trigger algorithms (not upgrades).

The largest share of the trigger M&O cost is actually cash required to maintain sufficient online software effort, which has been hard to find. In the last year, partly because of the upgrade requirements, the UK has taken a larger role. The overall trigger M&O B budget is now under review and must reflect the needs for operation from 2015 onwards, as well as existing and new hardware maintenance requirements. It is not easy to predict the detailed outcome, at this stage, although the contributions from the UK will certainly be very visible.

4. proposal is to expand trigger activities, and UK contributions on this so far have been very successful. In context of flat funding, if preserve 12% trigger contribution (up from 8%) in this round, what would you cut?

As explained in the previous answer, this is a complex issue, and the overall cost sharing is based on a head count of CMS authors and their attribution, by their own institutes, to the detector projects. In the case of the UK, the trigger represents a significant contribution, without which CMS would be in severe difficulty. However, if the next PPGP allocation were to be insufficient to cover the full expected UK M&O B share, then the most natural response would be to discuss reducing the cash contribution to the trigger project, especially as our own online software effort has increased, funded by our upgrade project grant.

5. why not assume 50% of tracker cash contribution will be remitted as in previous years? Will the in-kind contribution of TD effort for FED maintenance cease?

It has already been discussed and the table above (Q1) reflects the actual agreement. Since the FEDs have been so reliable, it is hard to argue that a large in-kind contribution is justified indefinitely, especially when the overall M&O B budget will decrease (and should remain flat) – partly because of a new algorithm which better reflects the pixel-silicon tracker cost sharing from which the UK benefited - but the Tracker has expressed great gratitude for the cost-effective maintenance contributions made by the UK. In addition this year, the sudden fall in the value of the euro against the CHF affected many European agencies far more than the UK.

6. Why has M&O FTE increased from 3 months/year to 4 months/ year if the experiment is becoming more efficient at operations?

This is another simple question with a complex answer! The 3 months/year estimate was made several years ago, even before CMS operations had fully begun. Since then, there have been many debates about the M&O effort actually needed, which it should be recalled covers a wide range of tasks and not only detector hardware maintenance. Everything which is not physics analysis is essentially included as a "service" activity. CMS has constantly found that there are tasks which are not sufficiently covered and appeals are made to do so. They include many software tasks providing support for physics, but which are not analysis, as well as many detector operations duties, including things like safety shifts. One problem is that many such tasks require expertise which is not quickly gained.

In view of this, and to ensure fairness within the distribution of service work, the previous, and especially the present, management team have undertaken a lengthy exercise to evaluate the essential tasks, and investigate the sharing. The conclusion was that the actual effort required is close to 4 months/author and that up to now this has mostly been provided because many CMS members and institutes were actually delivering more than their formal commitments. (This includes UK groups.)

We believe CMS operations are a well managed activity, as efficient as they could be, in areas where there are many more non-professionals, where real technical tasks are concerned, than professionals. However, it must be remembered that CMS does rely on a significant number of technical support staff on short term contracts paid partly from M&O B funding, and that there are many tasks where turnover is inevitable (e.g. maintenance of calibration and alignment, or physics, tools, often carried out by PhD students or postdocs) and therefore need regular replenishment, including continuous training.

7. What drives the decrease in estimated M&O B cost after 2017?

CMS has attempted to reduce M&O B costs for several years, and continues to do so. However there were, e.g., significant costs for the Tracker during LS1 which were partly covered by using cash savings which had been accumulated as well as from regular annual contributions. The most notable costs were in the cooling system, including cooling plant and improved dry air provision, as well as the costs of effort needed to seal the tracker for operation at -20°C, and other maintenance. Other costs involved electronics, power supplies, and various mechanics costs but the largest part of the overall budget is still manpower at CERN, which accounts for 60% in 2016. However, hardware has generally been very reliable and it seems that the major challenges of the cooling system have been covered, so expenses should decline further in future.

The ECAL has also made significant, successful efforts to reduce M&O B for several years. There have been a few large expenditures in the last few years. New lasers have been bought and the HV system is being upgraded to reduce the level of manual intervention required for calibration. There was also an unexpected repair to the PS although with modest expenditure. As for the Tracker, the hardware has been reliable and there is little further opportunity for major interventions.

CMS does not have estimates for M&O B costs after 2017. However, in our tables a small decrease of £8k, from a baseline of £120k, was thought possible, based on current trends in CMS and the absence of interventions until LS2. However, it is true that there is no solid basis for certainty. Of late, the biggest impact has come from recent exchange rate changes, which is not excluded in future.

8. The suggestion to harmonise the CMS pixel and strip DAQ was approved prior to CG-2012. Please report on the progress that has been made.

Indeed we made a proposal in 2012 to try to do this which was positively received by the Tracker. The benefits would have been felt in long term maintenance of the system, possibly with fewer people, as a significant effort would have been needed to build the common system. However, the proposal was based on the assumption that the UK would join the pixel upgrade project and take a role in the DAQ, both hardware and software, as well as continue our existing contributions to the silicon microstrip tracker DAQ.

However, at the end of 2012 we were told that the pixel part of our upgrade proposal would not be funded so we were unable to contribute to such a long term initiative. Given the small number in the silicon tracker DAQ team and the rather large load on them, as well as the evolution of the pixel system, which is a completely new detector, it was not really possible to continue this activity.

9. What efficiencies in manpower have been obtained by sharing expertise across multiple components of (tracker/trigger/ECAL) subsystems or multiple subsystems?

In central operations at Point 5, the shift crews have been minimised by good coordination and using remote on-call experts, but it hard to claim that sharing expertise has led to manpower reductions across subsystems. It is doubtful that this is possible. Individual DAQ teams are already small, with few experts stretched, and it is a very large job to maintain the sub-system DAQs, and they are by no means identical, even if based on the same core software. Similar considerations apply to hardware, where there is even more diversity. For example the power supplies for tracker and ECAL are very different, and made by different companies, to different requirements.

10. Over what timescale has the 4T VPT facility been running? What further data are required that has not been obtained over that operation period?

Brunel provided ~ 15% sample testing at 4T of the ~ 16000 VPT (and spares) currently installed in the endcap ECAL (EE). Since then we have been running a modified facility to evaluate the long term effects on a number of VPT devices, operating at 4T field, to understand both short term response variations (LHC beam ON vs LHC beam OFF) and much longer term effects which depend on the integrated charge taken from the photocathode. In Run II the conditions under which the VPT operate will change significantly and these studies

will need to continue so that effects seen in CMS data can be understood and realistic predictions made about performance degradation up until the point at which the EE will be replaced. Until 2014 there was an additional facility available to CMS at the University of Virginia, but since then the Brunel facility, which is well understood and has operated continuously for many years, is now the only test bed available to the collaboration.

In addition, VPTs are under consideration as possible photodetectors for reworked or upgraded endcap detector solutions. A number of spare VPTs exist from the final production batch used in the existing detector but most of them have not been tested at 4T field. If such a plan were to be implemented that requires the use of these VPTs, then they would need to go through the same QA process, at Brunel, as the original installed devices. We are currently testing a small number of these VPT for use in beam tests later in 2015 to check the feasibility of one such endcap reworking scheme.

11. On p3. of the workbook, why is TD technician effort increased from 0.2 to 0.5 in actual vs provisional allocation?

The first column refers to the estimated breakdown of engineer (0.9 FTE) and technician (0.2 FTE) effort which was thought to be required in 2012, i.e. at the time of the previous grant request. Our actual usage during the last year over both ECAL and Tracker or so seems to be closer to 50:50 engineer:technician. Hence, as that leads to a lower cost, it was used for future planning as well as the likely profile of the activities. We noted that:

"In the present financial year, 2014-15, about 0.5 FTE is expected to suffice, since LS1 activities on the EE were already completed and the Tracker FEDs have not been in operation during LS1. However, once Run II begins, we expect to incur FED maintenance requests again and there are new requests from the ECAL to prepare for radiation damage to the crystals by developing maintenance tools. Hence our TD requirements will rise during the coming year."

12. Please quantify the performance improvements in the CMS detector that are attributable to the actions of the TD staff during the previous grant period.

The TD staff allocation in the previous grants round was about 1 FTE per year, and was based on the assumption that about half would be required for Tracker FED maintenance, as a mixture of technician and engineer time, to provide firmware updates and debugging, and testing, repairs and reinstallation work on the FED boards themselves. The actual Tracker TD use has declined during the grant period, but it should be recalled that CMS has not actually been operating for the last two years, so high reliability and reduced firmware effort was to be expected. It is yet to be seen if the FEDs continue to be so reliable as they and their surroundings age, and we cannot rule out accidents, such as cooling failures in the underground racks, which have occurred but fortunately without serious consequences for the Tracker. The tracker has been very reliable, especially the readout, though vigilance and monitoring are essential to ensure this. It is hard to attribute that specifically to TD staff,

especially with such a modest allocation of effort, but the high reliability is certainly due to the good design, careful planning and installation work carried out by RAL TD and Imperial College staff. CMS certainly would not welcome a withdrawal of such support and the difficulty we would then expect to encounter when inevitable problems do arise. Very high reliability and sub-detector system availability are crucial for CMS data collection.

The remainder of our request in the previous grant round was related to ECAL operations and repairs during LS1. As noted in our PPGP submission: repair of a previously inoperable EE region was completed in 2013 by Hill, Brummitt (RAL TD) and Durkin. It corresponds to a localised region of 75 channels (1% of the positive endcap) that was inoperable during the majority of Run I, and was responsible for degraded MET performance. After repair, the region is fully operational. Although small in physical terms, this is important for physics performance, and was not an easy task to fulfill.

13. is Brunel travel included in the short-term or long-term projections?

Short Term Travel abroad costs have been included for the listed travellers at Brunel University London for all the years 2015-2020 inclusive. There is no request made for Long Term Travel for a named individual from Brunel during this period.

14. 5 RAL listed as on LTA on p15 but only 4 listed in tables for long term travel (Thea missing). Why?

Alessandro Thea is currently paid from the upgrade project grant allocation and is leading the CMS L1 trigger online software, which is undergoing major revision. He is based in CERN on LTA, paid from the upgrade travel grant. While this work is associated with the upgrade at present, after 2016 it really becomes an M&O activity, and therefore it was not assumed that he would be supported indefinitely from the upgrade travel allocation which is foreseen to peak during the commissioning period of 2015-2016 and then decline. However, the trigger online software is a major task, which is crucial for CMS operations, and there are few experts available with the expertise of Thea. It is therefore possible that support from the operations travel budget may be needed for him in future, but this will become clearer only with time.

15. What threshold level of organisational responsibility within international-CMS (e.g. physics group convenor) has been required when proposing those LTAs which are justified primarily by their physics analysis role? Please comment specifically on each RAL staff member.

While it is correct that some past LTAs (e.g. Nikitenko, Seez, Tapper) and future (e.g. Bainbridge, Nikitenko) have been driven by physics convenorships the majority are to support detector activities, making critical contributions to the overall success of CMS (e.g. Fulcher, Iles, Petyt, Bell). Though the UK is only a small fraction of CMS we have responsibility for several key activities. In addition the majority of the other LTAs (e.g.

Harper, Magnan) are to enable individuals to make major contributions to detector activities, while also leading, and being seen to lead, high priority physics channels.

The only RAL LTA who engages in physics analysis to a significant extent is Harper. He has filled various roles over the years, most recently including CMS Exotics Trigger Convenor, CMS Exotica Physics Analysis Group: Convenor Exotic Resonances Group, CMS E/gamma Physics Object Group Trigger Coordinator. These are all roles which attract significant pressure to deliver. His primary analysis activity is on the search for Z' bosons, which is high profile and will be one of the first analysis at 13 TeV where the sensitivity will exceed the current level. RAL leads this analysis and his presence at CERN is required for this to be effective. Actually most of his time has been spent on HLT (e/gamma and Exotics) and e/gamma reconstruction activities, which are not considered as physics analysis.

16. Please give the fractions of RAL staff who will be working on combined operations plus exploitation for each year.

		2015/2016		2016/2017		2017/2018		2018/2019	
		Ops + Exploit	Upgrade	Ops + Exploit	Upgrade	Ops + Exploit	Upgrade	Ops + Exploit	Upgrade
1	Shepherd	0.6	0.2	0.5	0.3	0.5	0.3	0.6	0.2
2	Tomalin	0.8	0.2	0.7	0.3	0.7	0.3	0.7	0.3
3	Cockerill	1		1		1		1	
4	Bell	0.75		0.5		0.25			
5	Petyt	1		1		0.7	0.3	0.7	0.3
6	Harder		1		1		1		1
7	Harper	0.8	0.2	0.8	0.2	0.8	0.2	0.8	0.2
8	Olaiya	1		1		1		1	
9	Williams	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
10	Durkin		1		1		1		1
11	Thea		1		1		1		1
12	Sankey		0.5		0.5		0.5		0.5
13	Brew	0.5		0.5		0.5		0.5	
14	Lahiff	1		1		1		1	
15	Newbold		0.5		0.5		0.5		0.5

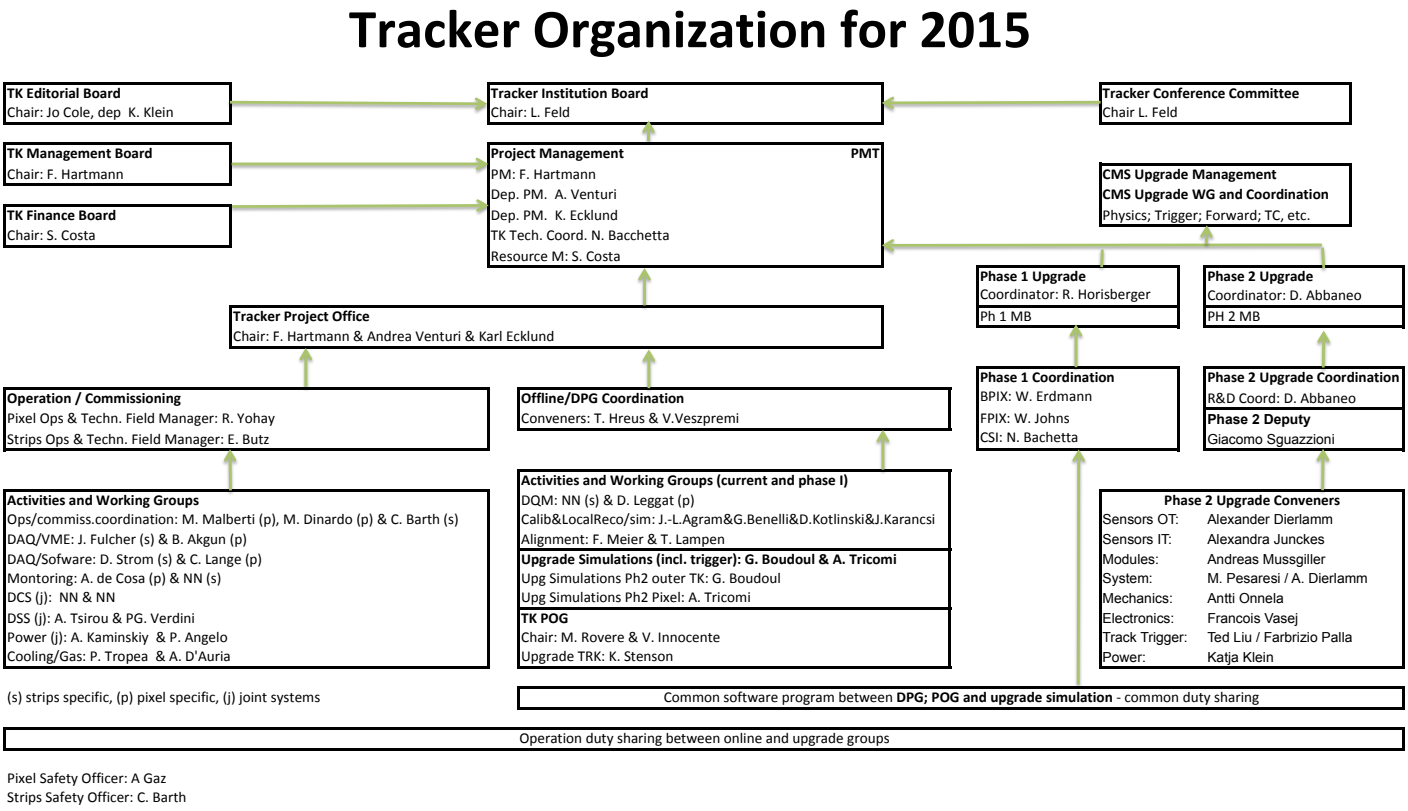
17. When costing computing, what fraction has been assumed to be chargeable to other budgets (GridPP, upgrade etc)? That is, please confirm that fractions of people working on other projects (e.g. GridPP, Upgrade) are included in travel only at the appropriate fractions when requesting LTA and short term travel here.

We have no staff in computing roles on LTA. The travel for staff primarily working on computing matters has been very limited and consists mainly in attending a very few important coordination meetings, except for the few academic staff involved, notably David Colling, whose travel is generally physics-related and combined with computing

management meetings where necessary. There is also no allocation for computing travel in the upgrade project.

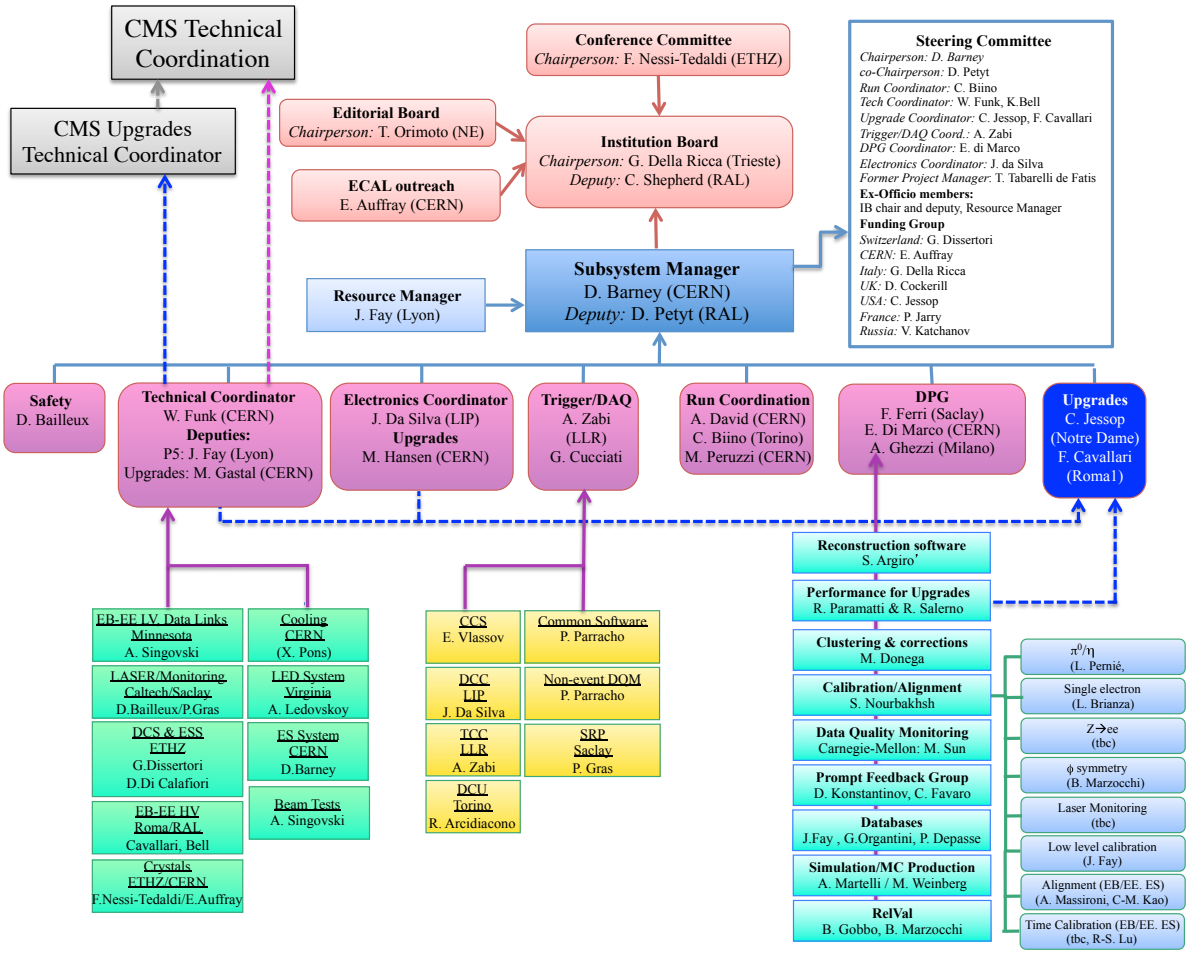
18. please separate costs for M&O B for tracker, ECAL, trigger, and computing if any.

The answers are given in the table following Q1. There are no central M&O B costs for computing, only UK expenses, which are not reported at RRBs.

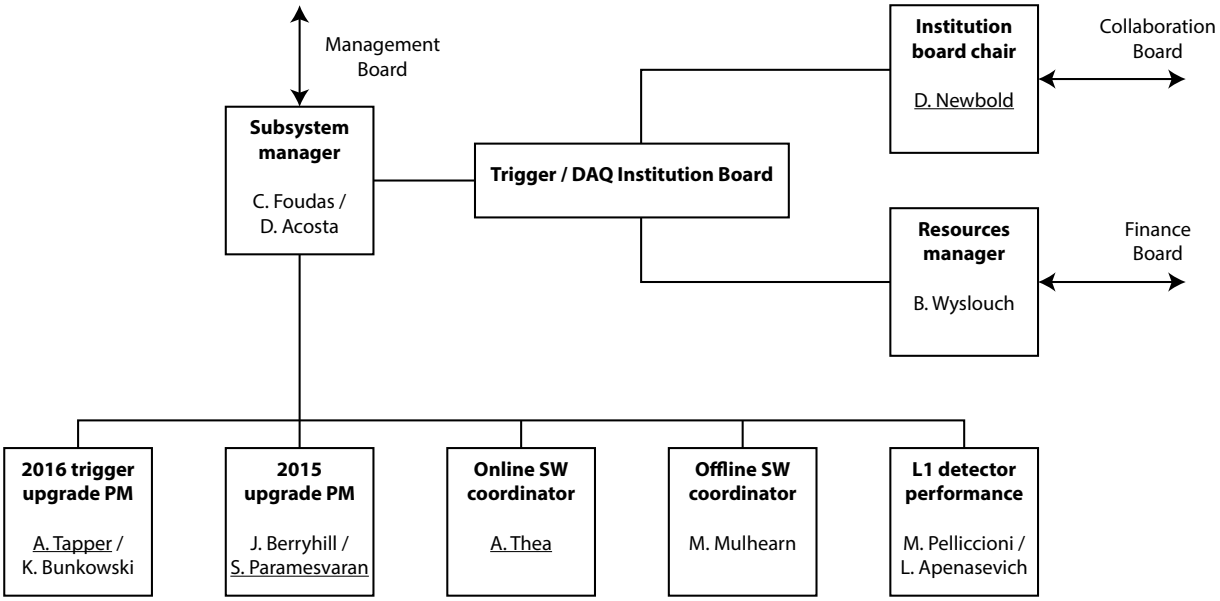


Pixel Safety Officer: A Gaz
Strips Safety Officer: C. Barth

ECAL organisation



Trigger



Computing