Report of the Scrutiny Group to the LHC RRB, October 2023

Membership of the Scrutiny Group

The membership of the Scrutiny Group in 2023 was: Ariane Frey (Göttingen), Joel Goldstein (Bristol), Thierry Gys (CERN), Edoardo Mazzucato (CEA/IRFU), Monica Pepe (INFN, Perugia), Kevin Pitts (Fermilab), Roman Pöschl (IJCLab, IN2P3 & Université Paris-Saclay), Agata Rozycka (CERN; Service Contracts), Heidi Sandaker (Oslo; chair), Burkhard Schmidt (CERN; Secretary), Christoph Schwanda (HEPHY), Jan Troska (CERN), James Yeck (BNL).

At the end of 2022 Hans Danielsson (CERN) retired from the group. The Scrutiny Group (SG) wishes to thank him for his dedicated service over many years.

1 General remarks

2023 is the second year of running (Run3) after Long Shutdown 2 (LS2). The p-p physics run started mid-May and continued to the end of September. In October, a month of Pb-Pb running is planned. The YETS will start early, end of October. During stable LHC beam the operation of the experiments is very successful, resulting in a high efficiency of data taking. The high-quality scientific output of all experiments continues.

The continued war in Ukraine has serious implications for the maintenance, operation, data taking and analysis work of the existing experiments as well as the upgrades, both for computing and detectors. Work is ongoing to mitigate the additional costs and lack of manpower. Although no large additional power costs were reported for 2023, the continued uncertainty in the energy situation may lead to future increases.

The Scrutiny Group congratulates the LHC and the experimental collaborations for all their efforts and achievements in 2023.

2 Scrutiny process and general matters

Following the RRB meeting from April 24-27 the SG held its Spring meeting from May 16-17. Both in the RRB and SG meeting summary reports on 2022 expenditures and 2024 requests were presented by the collaborations. The SG met with the LHC experiments ATLAS, ALICE, CMS, LHCb, represented by their respective Resource Coordinators and other members of the senior management. The SG and experiment representatives discussed the closing of the 2022 accounts, the status of the 2023 spending, the budget request for 2024 as well as plans for the

future. Additional in-depth discussions with each experiment took place in June and July. During these meetings each experiment was reviewed by a subgroup of the SG, who summarised the findings in internal reports. The Scrutiny Group met again in September 19-20 with the collaborations to discuss and resolve any outstanding matters. In addition to the scrutiny of the M&O A and B budgets, the SG also discussed the status and spending profiles of the Upgrade Common Funds (Phase-1 and Phase-2) with the experiments, following the agreement in 2015 (see RRB-2015-086).

The SG thanks the Resource Coordinators and the collaborations as a whole for the excellent cooperation and the constructive spirit of the discussions.

As a follow up of the RRB discussions in April 2023 and previous years, a few specific items where discussed in more depth with each experiment; the details are in the respective experiments' section:

- A follow-up on long-term projections for the special online computing replacement account. These accounts are allowed to go negative, and should not accumulate excessive cash reserves.
- In RRB-2017-070 it was agreed that carry-over on subdetector M&O B accounts should aim to stay below approximately 30% of the yearly budget. The SG continues to follow these developments and reduction is progressing for all subprojects where substantial reserves are present.
- Tracking of entry fees: ALICE, ATLAS and CMS charge "entry fees" for new institutes that wish to join the collaboration, to compensate for the lack of contribution to the original detector construction. In the interest of transparency, the SG has asked the experiments to report the status of and plans for these funds. These fees are not subject to the same level of scrutiny as M&O expenditures.
- Common funds: The SG was asked to evaluate if the collection of Common Funds is proceeding according to plan or if it represents a risk.
- During LS2, the experiments, in particular ALICE and LHCb, have been installing new upgraded detector systems. This results in changes in maintenance and operation costs during LHC Run 3. Such changes have been discussed with the experiments during 2020-2023. The SG will monitor the evolution of these costs closely in the years to come until the transition has been completed.

The following specific items came up during this year's scrutiny cycle:

- As a result of the continued war in Ukraine, in the April RRB and the May SG meetings the experiments presented their plans to ensure the continued safe operation and the upgrades of the experiments. The CERN Council decision to terminate the International Cooperation Agreements with Russia and Belarus at their expiration dates in 2024, and for JINR in January 2025 has been the baseline for this year's SG review. Up until now funds have been received, however this remains an uncertainty for the experiments starting 2024.

- Over the last three years the SG has noted a general development of late payment of contributions affecting several of the experiments, this trend continued in 2023 but we see some improvements.

3 Budget requests for 2024

Table 1 gives a global overview over the 2024 budget requests of the experiments. The requests are detailed in the relevant experiment subsections.

Table 1: M&O requests for 2024 in kCHF, without and with power costs.

Experiment	without power	with power
ALICE M&O A	5,064	7,764
ALICE M&O B	1,456	1,456
ALICE M&O A+B	6,520	9,220
ATLAS M&O A	13,108	15,308
ATLAS M&O B	6,092	6,092
ATLAS M&O A+B	19,200	21,400
CMS M&O A	13,554	15,254
CMS M&O B	7,005	7,005
CMS M&O A+B	20,559	22,259
LHCb M&O A	3,070	3,970
LHCb M&O B	1,290	1,290
LHCb M&O A+B	4,360	5,260

4 ALICE

ALICE M&O A closing report for 2022
The ALICE M&O A closing report was submitted to the RRB meeting in April (CERN-RRB-2023-020). The 2022 budget as approved in 2021 and the closing report presented in 2023 are shown in Table 2.

Comments on spending: Total expenditure in 2022 excluding power was 5,063 kCHF, 81 kCHF above the budgeted sum of 4,982 kCHF. Including power, the total expenditure was 7,230 kCHF of which the NMS power share was 584 kCHF. There was a further 24 kCHF in open commitments. The small overspend is due to previous commitments (mainly software) and some additional effort required at the end of LS2.

Carry over: The cumulative balance between the budgeted amount and the actual expenditure at the end of 2022 was 767 kCHF (without power or open commitments). Including the NMS power contributions, it increases from 1,598 kCHF at the end of 2021 to 1,620 kCHF at the end of 2022. Taking into account received advance contributions, the cash balance at the end of

Table 2: Summary of the 2022 book closing of ALICE, listing the M&O A budget as approved in 2021 and the actual spending report in this year's scrutiny cycle. All numbers in kCHF.

M&O A Categories	**Budget for 2022**	**Actual in 2022**
Detector related	1,192	1,169
Secretariat	193	196
Communications	0	0
Offline computing	776	780
Online computing	2,022	2,064
Test beams & calibration facilities	50	52
Laboratory operations	245	256
General services	504	547
TOTAL without power	**4,982**	**5,063**
Power (MS + NMS)	2,546	2,167
Grand Total	**7,528**	**7,230**

2022 was -132 kCHF.

Contributions: The invoiced total for 2022 was 5,673 kCHF; of this 457 kCHF were outstanding at year end from the funding agencies for 2022, with cumulative outstanding contributions at the end of 2022 of 876 kCHF. This is a significant improvement over the previous year (almost 2 MCHF cumulative outstanding contributions end of 2022) as a number of funding agencies have paid overdue contributions.

CERN finance report: The SG confirms that the numbers reported by the experiment are in perfect agreement with the figures reported by CERN finance.

The Scrutiny Group recommends approval of the ALICE 2022 M&O A closing report.

ALICE M&O B closing report for 2022

The M&O B budget for 2022 was 1,418 kCHF, while the actual spending reached 1,352 kCHF with 17 kCHF open commitments. This corresponds to an underspend of 66 kCHF of the approved annual budget. All subsystems are maintaining their cash reserves at less than 30% of their annual budget, as agreed with the SG.

The Scrutiny Group recommends approval of the ALICE 2022 M&O B closing report.

ALICE M&O situation in 2023

The spending of the 2023 M&O A budget proceeds according to plan. As of September 11, 2,596 (53%) of the budget of 4,935 is spent. The planned withdrawal from the online replacement account in 2023 is 614 kCHF.

Special topics 2023

War in Ukraine:

The impact of the war in Ukraine was discussed at the May and June meetings with the experiment. The ALICE collaboration has waived the contribution from Ukraine. There is a sizeable contribution from Russia and JINR (around 8% of the total; the PHOS subdetector is to 100% under the responsibility of Russia and JINR). A plan is in place consisting of a change in M&O costs to allow another institute to take over the FIT detector and the closing of the PHOS detector.

EPN increase:

In early 2023 ALICE requested approval to spend an extra 1.4 MCHF from the online replacement fund to buy extra EPN servers, due to an underestimation of the resources required to take data at the full trigger rate. The spend was approved by the SG and Directorate.

The collaboration is now requesting approval from the RRB to increase the annual M&O A budget by 74 kCHF to pay off this extra money and still reach zero balance at the nominal end of the experimental lifetime in 19 years, without changing the planned spending on replacements.

Conclusion EPN increase: The SG has reviewed the proposal from ALICE and agree that the extraordinary EPN uplift may be considered M&O A. We would not object to the money being paid off via an increase in M&O A if the funding agencies agree, but given the uncertainties in both timescale and cost of online server replacements as well as the large positive balance in the ALICE online account presently, we do not consider it necessary to do so.

ALICE M&O A budget request for 2024

The budget request for 2024 is shown in Table 3 together with the previously approved budget for 2021 and the projections up to 2027.

Table 3: ALICE M&O A budget request for 2024, shown together with the 2023 budget and the projections up to 2027. All numbers in kCHF.

M&O A Categories	**2023**	**2024**	**2025**	**2026**	**2027**
Detector related	1,207	1,265	1,265	1,475	1,475
Secretariat	193	193	193	193	193
Communications	0	0	0	0	0
Core computing	776	776	776	776	776
Online computing	1,930	1,933	1,933	1,581	1,581
Test beams & calibration facilities	30	30	30	0	0
Laboratory operations	245	245	245	255	255
General services	553	623	623	785	785
TOTAL without power	**4,935**	**5,064**	**5,064**	**5,064**	**5,064**
Power (MS + NMS)	2,502	2,700	2,700	444	444
Grand Total	**7,437**	**7,764**	**7,764**	**5,508**	**5,508**

The M&O A budget request for 2024 is 5,064 kCHF excluding power. The total power cost is 2,700 kCHF of which the NMS share is 709 kCHF. The estimated power costs have increased by 20% over the past few months. There are also small increases due to changes to the CERN Service Level Agreements. The increase of 0.5 MCHF per year for Run 3 in the overall computing budget (split between offline and online), due to the new O2 data centre as agreed in 2018, will continue.

The Scrutiny Group recommends approval of the ALICE 2024 M&O A budget request.

ALICE Online Replacement Account

During LS2, the online system was replaced by the substantially bigger O2 system ($\sim$9 MCHF), resulting in a significant increase of replacement costs in the long term (this differs from other experiments). These costs are partially funded through the online replacement account, consistent with direct replacements. The sum of 2,991 kCHF was spent during LS2 as planned,

In 2022, 376 kCHF was spent from the account. With a transfer of M&O A of 1,078 kCHF into the account, the balance increased from 3,888 kCHF (Dec 2021) to 4,590 kCHF (Dec 2022).

After LS2, the online account accumulates funds until the O2 system will be replaced in 2028 (8 MCHF), when the balance according to the latest projection is expected to go to negative 672 kCHF. It is planned for this fund to again go negative after significant payments in the late 2030s.

ALICE M&O B budget request for 2024

The budget requests for 2024 is shown in Table 4 together with the 2023 budget and projections up to 2027. The M&O B budgets of each system are scrutinised internally in the collaboration and also at the national level during approval of the relevant budgets. The SG has discussed the requests with ALICE in detail.

The requested M&O B budget for 2024 is 1,456 kCHF. This request takes also into account changes in major subsystems due to the upgrade of detectors in LS2.

The Scrutiny Group recommends approval of the ALICE 2024 M&O B budget request.

Upgrade Common Fund and Entry Fees

Phase-1 Upgrade Common Fund: The ALICE Phase-1 upgrade Common Fund budget is 5.8 MCHF. By September 2023, contributions of 5.2 MCHF were invoiced and 70 kCHF outstanding. The total spending has been 5.9 MCHF, including an additional 402 kCHF from entry fees. A cash balance of 681 kCHF remains. It is proposed that this cash balance is moved into a new budget to seed the ALICE3 upgrade common fund. The SG recommends the approval of the transfer of the remaining cash from the upgrade common fund to the ALICE3 common fund.

Entry fees: ALICE collects entry fees from new members which are accumulated in the Common Fund account. These funds are normally used for upgrade-related projects or other projects not covered, or going beyond, the Common Fund. In 2022, no entry funds were received. The total fees received by December 2022 were 967 kCHF with a further 91 kCHF still owed.

Table 4: ALICE M&O B budget planning for the years 2023–2027. All numbers except the last row in kCHF. The last row is in staff-months.

M&O B Categories	**2023**	**2024**	**2025**	**2026**	**2027**
Mechanics	37	83	83	52	42
Gas Systems	23	19	19	7	7
Cooling Systems	50	49	53	44	42
FEE Spares	76	61	58	54	54
Standard Electronics LV/HV PS	142	155	155	131	131
Standard Electronics Crates	38	41	41	42	42
Standard Electronics R/O modules	72	69	69	145	145
Controls (DCS & DSS)	29	24	24	24	47
Sub-Detector Spares	38	13	13	14	14
Areas	51	47	47	52	42
Communications	106	105	105	98	98
Store Items	76	69	76	81	69
Technical Manpower@CERN: Industrial Support	9	9	19	32	7
Techn. Manp.@CERN from Collaborating Institutes	639	713	713	694	669
Grand Total	**1,385**	**1,456**	**1,474**	**1,470**	**1,409**
Techn. Manp.@CERN from Col. Instit.(staff months)	213	226	226	236	236

5 ATLAS

ATLAS M&O A closing report for 2022

The ATLAS M&O A closing report was submitted to the RRB meeting in April (CERN-RRB-2023-029). The 2022 budget as approved in 2021 and the closing report presented in 2023 are shown in Table 5.

Spending: The 2022 M&O A budget without power costs amounted to 13,982 kCHF. The total power costs were budgeted at 2,200 kCHF including a NMS share of 735 kCHF. The total budget was thus 16,182 kCHF. The actual expenditure in 2022 excluding power was 14,734 kCHF, 16,934 kCHF including power costs. This corresponds to an overspending of 752 kCHF. The category with the largest overspending of about 1,3 MCHF is online computing due to the scheduled replacement of the HLT servers. This overspending is covered by a transfer from the TDAQ online account of 1,337 kCHF. Deducting this from the overspending results in a actual underspending of 585 kCHF which is well aligned with 655 kCHF outstanding commitments.

Carry over: The cash status went from 3,327 kCHF to 1,858 kCHF, which corresponds to 11,5% of the 2022 total budget (including power). The level of carry over is going down.

TDAQ online account: In 2022, in sum 1,337 kCHF were withdrawn from the TDAQ online account. The cumulative cash balance amounted to 625 kCHF at the end of 2022.

Table 5: Summary of the 2022 book closing of ATLAS, listing the M&O A budget as approved in 2021 and the actual spending report in this year's scrutiny cycle. All numbers in kCHF.

M&O A Categories	**Budget for 2022**	**Actual in 2022**
Detector related	4,806	4,297
Secretariat	410	544
Collaborative tools	173	230
Core computing	2,354	2,276
Online computing	4,681	5,966
Test beams & calibration facilities	220	168
Laboratory operations	90	15
General services	1,248	1,239
TOTAL without power	**13,982**	**14,734**
Power (MS + NMS)	2,200	2,200
Grand Total	**16,182**	**16,934**

Contributions: The contributions received from Funding Agencies in 2022 were 12,663 kCHF, 86% of the due contributions of 14,717 kCHF. The outstanding contributions in 2022 slightly increased to 1,903 kCHF compared to 1,189 at the end of 2021.

CERN financial report: There is very good agreement between the Finance Department report (CERN-RRB-2023-027) and the numbers from the experiment.

The Scrutiny Group recommends approval of the ATLAS 2022 M&O A closing report.

ATLAS M&O B closing report for 2022

The M&O B budget was 5,258 kCHF, with an actual spending of 5,645 kCHF including 4,180 kCHF for hired manpower at CERN. At the end of 2022 the open commitments were 105 kCHF. With a net overspending of 387 kCHF in 2022, the carry-over, summed over all sub-systems at the end of the year, has decreased from 2,638 kCHF in 2021 to 2,252 kCHF in 2022, reduced by the open commitments to 2,147 kCHF. Globally, the M&O B carry-over is thus 41% of the annual budget and hence above the target limit of 30%. The large carry-over stems from the Inner Detector and TDAQ. ATLAS plans to return the carry-over above the 30% limit to the respective Funding Agencies during the years 2023-26. The SG is pleased to see this return of funds.

The Scrutiny Group recommends approval of the ATLAS 2022 M&O B closing report.

ATLAS M&O situation in 2023

The amount spent so far on August 31st, 2023 on M&O A budget, including open commitments, is 9,306 kCHF, i.e. 70% of the 2023 approved budget of 13,230 kCHF (without power). A deposit to the TDAQ online account of 2,465 kCHF is foreseen.

Special topics 2023

War in Ukraine:

ATLAS has a strong participation of Russian institutes, JINR and Belarus with 374 members. The proposal from last year presenting a M&O budget sharing starting in 2025 at the end of the ICAs remains the plan unless the situation changes. The contribution of Russia, JINR and Belarus to the Phase II upgrade CORE amounts to 7.91 MCHF (844 kCHF expected in kind) which is about 3% of the total CORE. In addition, contributions of 1.08 MCHF are expected to the Phase II Common Fund up to 2026, corresponding to 4%. Unless the situation changes the 2024 Scrutiny Cycle will review the details to prepare for 2025.

Other items:

A small overcharging of M&O A was discovered in 2023 linked to an error in the planned repayment of excess LAr funds. The accumulated funds, 650 kCHF, currently reside in the TDAQ account. ATLAS proposed to the SG that these funds will be used to reduce the impact of war in Ukraine. The SG agrees with this proposal.

The SG commends the ATLAS collaboration to stick to the flat budget profile of 21.4 MCHF.

ATLAS M&O A budget request for 2024

The budget request for 2024 is shown in Table 6 together with the approved budget for 2023 and the projections up to 2027.

Table 6: ATLAS M&O A budget request for 2024, shown together with the 2023 budget and the projections up to 2027. All numbers in kCHF.

M&O A Categories	**2023**	**2024**	**2025**	**2026**	**2027**
Detector related	4,897	4,842	6,212	5,511	5,437
Secretariat	440	440	440	440	440
Communications	173	173	173	173	173
Core computing	2,354	2,354	2,354	2,354	2,354
Online computing	4,000	3,819	1,991	2,009	2,557
Test beams & calibration facilities	145	145	495	900	900
Laboratory operations	90	90	140	140	140
General services	1,131	1,246	1,207	1,810	1,660
TOTAL without power	**13,230**	**13,108**	**13,012**	**13,337**	**13,661**
Power (MS + NMS)	2,200	2,200	2,200	2,200	2,200
Grand Total	**15,430**	**15,308**	**15,212**	**15,537**	**15,873**

The ATLAS M&O A budget request without power for 2024 is 13,108 kCHF, down by 122 kCHF compared to the corresponding budget approved for 2023. The power cost is 2,200 kCHF of which the NMS share is 729 kCHF. This total request for 2024 has increased slightly, by 239 kCHF, from the 2024 budget anticipated in autumn 2022. Some changes in the distribution between different items has been done following the re-evaluation of the long term experience. The projections for the M&O A budgets for the years 2024-2027 show a slightly

decreased budget for 2025 with a rise in budget from 2026 on due to LS3. In 2024, a deposit of 2,465 kCHF to the TDAQ online account is planned.

The Scrutiny Group recommends approval of the ATLAS 2024 M&O A budget request.

ATLAS Online Replacement Account Projections

At the end of 2022, the online replacement account had a positive balance of 625 kCHF. After the replacement of the HLT server, the online account will accumulate funds in the years 2023 to 2025 up to around 5.5 MCHF with large deposits foreseen in 2023 and 2024 of 2,465 kCHF and 2,354 kCHF, respectively. In 2026 the balance will be decreased to around 4.1 MCHF. The account is projected to go substantially negative in 2028.

ATLAS M&O B budget request for 2024

The actual and planned budgets from 2023 to 2027 are given in Table 7. The M&O B budgets of each subsystem have been scrutinised internally in the ATLAS collaboration and discussed with the SG during the June meetings.

The M&O B budget request for 2024 is 6,092 kCHF, compared to 6,331 kCHF planned last year. The budget invoiced to the funding agencies for 2024 is slightly lower: it amounts at 5,749 kCHF due to the return of funds from ID and TDAQ carry-over over the period from 2023 to 2026 and a return of testbeam and irradiation funds for ITk from 2023 in the amount of 50 kCHF. The budget reduction since last year's meeting is mainly due to reduced funds for SCT and ITk while the FD budget is slightly increased.

The cost overlap of ID and ITK from 2023 to 2026 will result in an increased budget peaking in 2025 at around 2.8 MCHF and expected to fall below the level of the current ID budget from 2027 on.

The Scrutiny Group recommends approval of the ATLAS 2024 M&O B budget request.

ATLAS Upgrade Common Funds and Entry Fees

Construction Common Fund: This Common Fund has been used to cover Phase-1 Upgrade spendings and also to deposit the entry fees of new institutions. At the end of 2021 this account had 2,983 kCHF in cash balance. 2,409 kCHF were spent during 2022, finishing all Phase-1 activities. New member institution fees of 138 kCHF have been received, bringing the balance at the end of 2022 to 711 kCHF with outstanding contributions of 89 kCHF. The account will be kept to collect new member entry fees.

Phase-2 Upgrade Common Funds: For Phase-2 upgrades, a dedicated Common Fund account is used with a total budget of 24.4 MCHF, to be collected over 9 years from 2018 to 2026 with a flat profile of 2.7 MCHF per year. The spending profile peaks in the years 2025 to 2027. As of end of year 2022, 11,147 kCHF of contributions have been received (2,418 kCHF outstanding contributions) and 976 kCHF spent (549 kCHF in 2022).

Entry fees: ATLAS collects entry fees from new collaborating institutes. The funds are accumulated in the Construction Common Fund account (see above). Theyare used for detector and upgrade-related projects that extend beyond the original scope of the Common Fund.

Table 7: ATLAS M&O B budget planning for the years 2023 - 2027. All numbers except last row in kCHF.

M&O B Categories	**2023**	**2024**	**2025**	**2026**	**2027**
Mechanics	50	52	47	177	82
Gas Systems	58	63	63	70	20
Cryo System	0	0	0	0	0
Cooling System	18	188	217	282	473
FE Electronics	102	95	88	85	97
Std Electronics LV/HV PS	948	948	992	1,085	1,184
Std Electronics Crates	403	252	267	208	223
Std Electronics R/O modules	168	105	118	91	117
Controls (DCS & DSS)	115	100	115	111	116
Sub-Detector Spares	58	127	105	80	80
Areas	439	310	340	360	290
Communications	44	44	44	46	32
Store Items	215	254	261	246	203
Hired Manpower @ CERN	3,352	3,554	3,531	3,022	2,622
Hired Institute Manpower @ 90 kCHF/FTE	0	0	0	0	0
Total expenditure	**5,970**	**6,092**	**6,188**	**5,863**	**5,539**
Return to FAs	-216	-343	-293	-203	0
Total to be invoiced to FAs	**5,754**	**5,749**	**5,895**	**5,660**	**5,527**
Technical Manpower OTP (FTE)	239	266	279	291	182

6 CMS

CMS M&O A closing report for 2022

The CMS M&O A closing report was submitted to the RRB meeting in April (CERN-RRB-2023-038). The 2022 budget as approved in 2021 and the closing report presented in 2023 are shown in Table 8.

Spending: The 2022 M&O-A budget without power costs was 13,366 kCHF. The total power costs were budgeted at 1,700 kCHF with the non-member share (NMS) of 705 kCHF. The total budget was thus 15,066 kCHF. The actual expenditure in 2022 amounted to 13,544 kCHF without power costs, and 15,244 with power.

CMS gave a detailed justification for the 1.7% overspending (effects of the war in Ukraine and related personnel cost, Stasi Lab and ECAL laser lab re-location). The overspending could be reduced by savings in other categories. For example the SLA for cooling systems were not invoiced for 2022.

The cash balance as of 31/12/22 was 161 kCHF with outstanding committments amounting to 1,011 kCHF. The amount of commitments, related to DAQ equipment is 17.6 kCHF. Of the remaining amount of 993 kCHF, 37% is related to industrial support contracts and 63% for consumables and goods to be delivered in 2023.

Table 8: Summary of the 2022 book closing of CMS, listing the M&O A budget as approved in 2021 and the actual spending report in this year's scrutiny cycle. All numbers in kCHF.

M&O A Categories	**Budget for 2022**	**Actual in 2022**
Detector related	4,663	4,757
Secretariat	312	314
Communications	130	122
Core computing	1,964	1,899
Online computing	3,665	3,658
Test beams & calibration facilities	96	103
Laboratory operations	533	603
General services	2,003	2,089
TOTAL without power	**13,366**	**13,544**
Power (MS + NMS)	1,700	1,700
Grand Total	**15,066**	**15,244**

Carry over: There is no significant accumulation of funds. The carry over including open commitments from 2022 into 2023 is negative 1189 (-178-1011) kCHF. The accumlated carry over at the end of 2022 was 436 kCHF. The cash balance at the end of 2022 was 162 kCHF.

Online account: In 2022, the DAQ Expenditures amounted to 3,735 kCHF. Out of these 2,700 kCHF were budgeted and 1,035 kCHF were taken from the special online account. This account is now negative by 1,192 kCHF. This commensurates with the actual policy of these special online account.

Contributions: The amount of outstanding contributions is smaller than in previous years, i.e. 6.7% for 2022 in May 2023 compared with 12.4% in May 2022 for 2021. The SG joins CMS in their satisfaction about this observation and hopes that this trend will continue in the coming years.

CERN finance report: There is perfect agreement between the Finance Department report and the numbers from the experiment.

The Scrutiny Group recommends approval of the CMS 2022 M&O A closing report.

CMS M&O B closing report for 2022

M&O B in CMS is organised around detector subsystem groups with varying practices. Certain systems operate completely on an in-kind basis. The total allocated M&O B budget for 2022 was 6,089 kCHF (3,905 kCHF as cash + 2,183 kCHF as in-kind contribution). The expenditures in 2022 were 3,274 kCHF in cash (84% of allocated budget) and 2,360 kCHF as in-kind (108% of allocated budget).

The lower cash expenditure can be largely explained by an underspending of the HGCAL

due to the delays in the HL-LHC upgrade. Also the Tracker reported an underspending of around 260 kCHF. This underspending is explained by lower hired man power and expected to get back to normal in the coming years. The savings will be used to buy Phase-2 Spares and for the refurbishment of Tracker infrastructure (e.g. in Building 186). In view of this clear planning for the carry over and the efforts by all CMS subsystems, the Scrutiny Group is pleased to see that CMS strictly observes the convention to keep the carry over below 30% of the annual budget.

The SG recommends approval of the CMS 2022 M&O B closing report.

CMS M&O situation in 2023
The M&O A for 2023 is of 13,653 kCHF without power. As of June 2023 55% of the 2023 budget has been spent which represents a normal spending profile. CMS informed the scrutiny group that some overspending is to be expected for 2023. Among others overspending might occur due to the CERN person power indexation. Further items are the consolidation of the water mist system that could not be completed, the forward shielding due to higher raw material prices, the safety system of the for CO_2 detection and additional need of person-power for the CO_2 cooling system.

Special topics 2023
War in Ukraine: CMS is heavily exposed to the consequences of the war in Ukraine both M&O and upgrade, with the HGCAL being the most critical system.

Detector Upgrade Fund: During the Scrutiny Cycle 2023 the SG was informed about the creation of a so-called "Detector Upgrade Fund" (DUF). This funds compensates short falls in core costs from RDMS (Russian Federation and JINR) and Belarus. The additional cost to be shared among the remaining funding agencies is estimated to be around 10 MCHF. While the creation of the DUF is still to be approved, the Scrutiny Group is pleased to see that funding agencies actively compensate already now for shortfalls caused by the War in Ukraine. CMS plans to provide a Special Upgrade status report for 2023 to the October RRB on how to deal with difficult situation due to the WiU and the Scrutiny Groups endorses this plan.

Review of the increased M&O A and Upgrade Common Fund needs:
Toward the end of 2022 CMS presented the need to increase the budget significantly for M&O A (6 MCHF) and upgrade common fund (5 MCHF). Consequently, the Scrutiny Group performed in 2023 a more detailed review of this proposal, the results of this review is the following:

Concerning M&O A, CMS has identified extra needs of 6 MCHF for work that is under the responsibility of Technical Coordination. These concern e.g. electrical infrastructure and the power supply of CMS. Out of these 6 MCHF 4 MCHF have already been found thanks to good cooperation between CMS Technical Coordination and CERN as the host lab.

Concerning Upgrade Common Fund, the analysis made by CMS shows that the Upgrade Common Fund needs to be increased from the allocated 25 MCHF to 30.3 MCHF. During the 2023 SG cycle CMS explained the extra cost in detail. The main cost drivers are:

- Detector Services: The power dissipation of subsystems cooled by CO2 has demanded a vast rework and upgrade of the upstream infrastructure, in order to guarantee the safe operation of all detectors (redundant powering, additional dry gas systems, etc).
- Assembly and installation: In particular the surface assembly and subsequent lowering large and heavy detectors needs additional funding. CMS Technical Coordination has decided to take this under TC responsibility.
- Surface facilities: The space needed by HGCAL assembly and the decommissioning of detectors (e.g. ECAL endcaps) in LS3 is larger than foreseen or had not been taken into account in the previous planning. New *temporary* buildings are needed for upgrade and operation, built on a concrete surface called "west-slab". This west-slab will cost about 1 MCHF and the cost will be shared between CERN as host lab and CMS,

In order to move on, CMS proposes to proceed with a spending profile that supposes the updated cost of 30,3 MCHF which will bring CMS to the beginning of LS3. In June 2023 CMS reported on the risk of a cash shortage at the end of 2023. It was a concern that the agreed funds for the Phase 2 Upgrade Common Fund (25 MCHF) came in very slowly. The situation has improved over Summer 2023 and the Scrutiny Group encourages to continue this positive trend.

Conclusion of the review of the increased CMS M&O A and Upgrade Common Fund costs:
1. The Scrutiny Group thanks CMS for the detailed explanation of identified additional needs for M&O A and Upgrade Common Fund costs. From what has been presented to the SG the additional needs seem to be well justified. The Scrutiny Group points out that the presented needs do not include the the decommissioning costs for outgoing detectors.

2. The Scrutiny Group advises CMS to present the updated cost estimation of the Phase-2 Upgrade Common Fund to the RRB in October 2023 to allow for an early planning of the allocation of the needed funds and again in April 2024 RRB to include the Cost and Schedule Review of the Hostlab 2 program, foreseen in January 2024. Further, the Scrutiny Group recommends strongly that a spending profile for the total costs, including decommissioning, for a defined time-period is worked out timely such that the FA can assess the total extra cost of the experiment per year. This has not yet been presented to the SG.

CMS Insurance Policy: Provisionally, 150 kCHF have been integrated into the 2023 budget and that of the out years for an insurance of detector items. The purpose of the insurance is to protect CMS from high contributions to damages or thefts. Examples are the fire in the CMS building a few years ago and a recent theft of material at P5. Details of the desired conditions were given in the September 2023 Meeting. The SG understands and endorses the need of an insurance. A meeting with a broker is planned for the beginning of October and the SG asks CMS to be informed about the outcome of this meeting. The insurance policy is a pending topic since two years and it is important that soon a conclusion will be found (2024) and if not that the accumulated collection funds for insurance (300 kCHF if the insurance starts in 2024 or 450 kCHF in the period 2022-2024 if the insurance can not be completed in 2024) be used to mitigate the proposal for additional M&O A (see above).

Table 9: CMS M&O A budget request for 2024, shown together with the 2023 budget and the projections up to 2027. All numbers in kCHF.

M&O A Categories	**2023**	**2024**	**2025**	**2026**	**2027**
Detector related	4,633	4,380	4,325	4,325	4,290
Secretariat	312	312	312	312	312
Communications	130	130	130	130	130
Core computing	1,964	1,964	1,964	1,964	1,964
Online computing	3,665	3,665	3,665	3,665	3,665
Test beams & calibration facilities	96	112	99	99	99
Laboratory operations	700	852	653	533	533
General services	2,153	2,140	2,164	2,164	2,038
TOTAL without power	**13,653**	**13,554**	**13,311**	**13,191**	**13,030**
Power (MS + NMS)	1,700	1,700	1,700	1,700	1700
Grand Total	**15,353**	**15,254**	**15,011**	**14,891**	**14,730**

CMS M&O A budget request for 2024

Table 9 shows the budget for 2023 together with the request for 2024 and the projection until 2027. The request for 2024 is 13,554 kCHF, 144 kCHF higher than presented at the RRB Meeting in October 2022 (CERN-RRB-2022-104). This cost increase is mainly explained by the indexation of the subsistence payments, additional person power for dry gas system operation and a cost increase for the operation of the CO_2 cooling system in the course of the revised service level agreements. These three items lead to a total cost increase of 208 kCHF that is compensated by savings of totally 64 kCHF in other areas. CMS pointed out that in particular the increase caused by the indexation of the subsistence payments (114 kCHF) will continue in the out years.

The Scrutiny Group recommends approval of the CMS 2024 M&O A budget request.

CMS Online Replacement Account Projections

As mentioned above, at the end of 2022 this account has been negative by 1,192 kCHF. It is foreseen to deposit in 2023 1,100 kCHF in this account brining it to -92 kCHF. As of September 2024 no withdrawals or deposits in this online account are foreseen for 2024. Minor deposits and withdrawals are foreseen for the years 2025-2027.

CMS M&O B budget request for 2024

The actual and planned budgets from 2023 to 2027 are given in Table 10. The M&O B budget request for 2024 is 7,005 kCHF, which is 40 kCHF higher than estimated in October 2022 (CERN-RRB-2022-104) and 427 kCHF more than requested for 2023. The increase w.r.t. the preliminary numbers in October 2022 is mainly explained by an increase in the request by the muon system for hired manpower at CERN and that will continue until 2027. The general large increase of 427 kCHF was anticipated in the previous years and the budget requests will continue to increase until 2027. Afterwards it will decrease again. The increase can be explained

by higher demands of the Phase 2 upgrade projects. On the other hand existing detector components like the current ECAL endcaps will be decommissioned.

The Scrutiny Group recommends approval of the CMS 2024 M&O B budget request.

Table 10: CMS M&O B budget planning for the years 2023 - 2027. All numbers except for the last two rows are in kCHF.

M&O B Categories	**2023**	**2024**	**2025**	**2026**	**2027**
Mechanics	168	125	220	140	135
Gas Systems	101	75	64	69	64
Cryo System	n/a	n/a	n/a	n/a	n/a
Cooling System	353	378	428	492	382
FE Electronics	57	49	54	90	73
Std Electronics LV/HV PS	241	328	348	464	428
Std Electronics Crates	79	79	89	118	133
Std Electronics R/O modules	428	586	636	414	501
Controls (DCS & DSS)	87	91	91	128	130
Sub-Detector Spares	53	33	63	78	98
Areas	204	223	223	266	241
Communications	154	164	164	177	172
Store Items	146	156	156	197	221
Hired Manpower @ CERN	4,508	4,718	4,948	5,187	5,159
Material Resources Total	**6,578**	**7,005**	**7,484**	**7,820**	**7,738**
Technical Manpower OTP (FTE)	0	0	0	0	0
Core Computing (FTE)	8	8	8	8	8

CMS Upgrade Common Funds and Entry Fees

Phase-1 Upgrade Common Fund: The Phase-1 Upgrade has been completed during LS2 and the payments for the common facilities have been finalised. CMS has received all contributions except one. This contribution is pending since a few years and the Scrutiny Group strongly encourage the debtor country to agree with CMS on a solution and to honor this solution such that the account can be closed.

Phase-2 Upgrade Common Fund: The current total budget of the Phase-2 Upgrades Common Fund is of 25 MCHF and was planned to be collected over 9 years from 2018 to 2026 with a profile dependent on individual agreements with Funding Agencies. At the end of 2022 contributions amounting to 11,846 MCHF have been collected compared with 11,591 MCHF that were due. The spending of the common fund is reported to be 7,383 kCHF.

As described above the size of this fund, around 10% of the earlier estimated total upgrade costs, is no longer tenable according to CMS, as indicated already in 2021. As planned in 2022, in 2023 a review was prepared by CMS for the SG with detailed discussions on each item and the results are presented in this report in the 2023 section above. The Scrutiny Group thanks

CMS for this effort.

Entry fees: CMS collects entry fees from new members. The funds are accumulated in a general account of the CMS management, with no dedicated accounting for the entry fees alone. They are used to cover items for which no alternative source of funding is available and that are considered urgent by the management. To a large extent, the entry fees are used to facilitate the integration of the new institute in CMS, for example by funding stays of institute members at CERN, or by supporting local facilities. At the end of 2022 the balance was approximately 10 kCHF.

7 LHCb

LHCb M&O A closing report for 2022
The LHCb M&O A closing report was submitted to the RRB meeting in April (CERN-RRB-2023-045/046). The 2022 M&O A budget as approved in 2021 and the closing figures presented for 2022 are shown in Table 11. The strategy of LHCb, as presented to the SG and agreed, is to keep an as constant budget as possible and not to add extra resources for e.g. shutdown operations.

Table 11: Summary of the 2022 book closing of LHCb, listing the M&O A budget as approved in 2021 and the actual spending report in this year's scrutiny cycle. All numbers are in kCHF.

M&O A Categories	**Requested 2022**	**Spent 2022**	**Difference**
Detector related	1,015	1,017	−2
Secretariat	190	181	9
Communications	10	10	0
Core computing	220	216	4
Online computing	1,150	811+350	−11
Test beams & calibration facilities	30	18	12
Laboratory operations	50	24	26
General services	405	438	−33
TOTAL without power	**3,070**	**3,065**	**5**
Power (MS + NMS)	300	300	0
TOTAL with power	**3,370**	**3,365**	**5**

Spending: The total spending excluding power was 3,065 kCHF. With power the spending was 3,365 kCHF, the power amounting to 300 kCHF of which the budgeted NMS share was 64 kCHF. The total expenditure without open commitments corresponds to an underspending of 5 kCHF. LHCb had 75 kCHF of open commitments by the end of 2022, which is significantly less than in the end of year 2021. The largest underspending (26 kCHF) was for laboratory costs; the largest overspending was in the category general services due to an increase in SLA costs.

Including open commitments and the transfer to the online account there is an M&O A overspending (excluding power) of 70 kCHF. The NMS power share was not paid in 2022.

Carry-over: The cumulative cash balance by the end of 2022 was 1,038 kCHF compared to 806 kCHF by the end of 2021. This balance does not reflect the open commitments and the 2022 NMS power costs mentioned above.

Online account: In 2022, 350 kCHF were transferred to the special online account and nothing was spent. The balance of this fund, which allows to purchase online computing power "just in time", has been brought up to 928 kCHF by the end of 2022 (compared to 578 kCHF at the end of 2021). Important spending from the online account is expected towards the end of 2023.

Contributions: LHCb has received M&O A contributions amounting to 3,298 kCHF in 2022. This figure is 228 kCHF above the 2022 budget as it includes late payments of contributions due in previous years and contributions paid in advance. Cumulative outstanding contributions (invoiced but not received) are 462 kCHF as of the end of 2022.

CERN finance report: The numbers reported by the experiment agree very well with the figures provided by CERN finance (CERN-RRB-2023-044).

The Scrutiny Group recommends approval of the LHCb 2022 M&O A closing report.

LHCb M&O B closing report for 2022

At LHCb, the M&O B budget corresponds to about one third of M&O A and the management of the funds, which are both cash and in-kind contributions, is under the responsibility and control of the subsystems within existing agreements. In 2022 M&O B reached to 1,270 kCHF, almost the level that should be maintained throughout run 3.

According to plan the transition to post-LS2 levels of M&O B due to the addition of new sub-detectors (started in 2021) should be ended in 2023 where the level of M&O B will reach its new level of 1,290 kCHF which is expected to remain stable in the following years.

Since 2022, LHCb is presenting more details about the spending at the subsystem level, the CERN part. Regarding the budget at CERN, LHCb reports 916 kCHF received in 2022 (including late contributions and contributions paid in advance) and expenditure from the CERN budget in 2022 amounting to 681 kCHF. In addition, a spending of 235 kCHF was reported at the collaborating institutes. In 2021, the corresponding figures were 1,052 kCHF received, 1,161 kCHF spent on CERN budget and 251 kCHF spent at the institutes.

The Scrutiny Group recommends approval of the LHCb 2022 M&O B closing report.

LHCb M&O situation in 2023

The year 2023 corresponds to the second year of run 3 but to the first year of full exploitation of LHCb Upgrade I. Later in 2023, the experiment expects to replace old inefficient nodes of the Online System. The approved M&O Category A budget for 2023 totals to 3,070 kCHF, together with a power cost of 600 kCHF (the NMS share is 133 kCHF). In the summer meeting, the experiment did not report any significant deviation from the planned budget.

Special topics 2023
War in Ukraine: LHCb has proposed to waive the Ukraine fees from 2023 (5 kCHF to M&O A, 1 kCHF to NMS power). This is supported by the SG and approved by the RRB (October 2022). The proposed resource sharing for 2023 includes contributions from Russian funding agencies and institutes (212 kCHF) and Russian universities (96 kCHF). LHCb proposes in the case of non-payment that these costs will be shared among its members.

LHCb M&O A budget request for 2024 and beyond
2024 will be the third operation year of run 3 with the LHCb sub-detectors all operational. The budget request for 2024 is shown in Table 12 together with the approved budget for 2023 and the projections up to 2027. The requested budget corresponds to 1.23 times the pre-LS2 budget and has been maintained at this level since the year 2021. The power cost changes according to the expected operation time in a given year.

Table 12: LHCb M&O A budget request for 2024, shown together with the 2023 budget and the projections up to 2027. All numbers in kCHF.

M&O A Categories	**2023**	**2024**	**2025**	**2026**	**2027**
Detector related	1,015	1,015	1,015	1,015	1,015
Secretariat	190	190	190	190	190
Communications	10	10	10	10	10
Core computing	220	220	220	220	220
Online computing	1,150	1,150	1,150	1,150	1,150
Test beams & calibration facilities	30	30	30	30	30
Laboratory operations	50	50	50	50	50
General services	405	405	405	405	405
TOTAL request without power	**3,070**	**3,070**	**3,070**	**3,070**	**3,070**
Power (MS + NMS)	600	900	900	900	300
Grand Total	3,670	3,970	3,970	3,970	3,370

The budget request for 2024 is 3,070 kCHF without power and is unchanged from previous forecasts. The power cost is 900 kCHF of which the NMS share is budgeted to be 200 kCHF, corresponding to a year of full LHC operation. While the 2024 budget request is in line with the projections, the international situation and the increases in Energy and Service Level Agreements costs may force LHCb to adjust the M&O A requests in the coming years. A first approach to this issue was shown to the SG. The SG will follow these developments closely during the next years. The proposed resource sharing for 2024 includes contributions from Russian funding agencies and institutes. However, following its resolution of June 2022, CERN Council intends to terminate the International Collaboration Agreement with Russia at its expiration date (end of 2024). This will affect the expected sharing from 2025 onwards.

The Scrutiny Group recommends approval of the LHCb 2024 M&O A budget request.

LHCb Online Replacement Account Projections
LHCb has been accumulating funds on the online replacement account in 2021 and 2022 (350 kCHF each year) and the balance has been brought to 928 kCHF by the end of 2022. The plan is to spend 1,000 kCHF in 2023 to replace old nodes and to consolidate the farm with a new slice corresponding to 300 nodes. In 2024 the account will again accumulate funds and is expceted to go close to zero in 2026.

LHCb M&O B budget request for 2024
The budget request for 2024 and the projections until 2027 are shown in Table 13. The 2024 request is 1,290 kCHF, unchanged from the year 2023. This budget is managed by the respective detector collaborations and includes both cash and in-kind contributions. Part of the budget is spent at CERN, part at the collaborating institutes.

The Scrutiny Group recommends approval of the LHCb 2024 M&O B budget request.

Table 13: LHCb M&O B budget planning for the years 2023 to 2027. All numbers in kCHF.

M&O B Categories	**2023**	**2024**	**2025**	**2026**	**2027**
Mechanics	100	100	100	100	100
Gas System	10	10	10	10	10
Cooling System	30	30	30	30	30
FEE Spares	120	120	120	120	120
Standard Electronics (all)	200	220	220	220	220
Controls (DCS & DSS)	60	60	60	60	60
Sub-Detector Spares	200	200	200	200	200
Areas	50	50	50	50	50
Communications	30	30	30	30	30
Store Items	30	30	30	30	30
Manpower CERN	440	440	440	440	440
TOTAL budget	**1,290**	**1,290**	**1,290**	**1,290**	**1,290**

LHCb Upgrade Common Funds and Entry Fees
Phase-1 Upgrade Common Fund: The LHCb Phase-1 Upgrade Common Fund (Add. 1 to MoU, CERN/RRB 2012-119A-Rev.10.April 2014) amounts to 15,710 kCHF and is followed by the SG, while the sub-detector systems (57,243 kCHF, Add. 2 to MoU, CERN/RRB 2014-105, 5 Nov. 2014) are reported by the UCG. For Add. 1, 14.27 MCHF (June 2023) have been received with outstanding funds amounting to 1018 kCHF. A plan has been worked out and reviewed by the SG and will be presented by LHCb at the October RBB.

The experiment reports in the 2023 scrutiny cycle that about 11 MCHF of the upgrade common fund have been spent or committed. A remaining expenditure for storage and farm of 4 MCHF is planned for a ”just in time” purchase in 2023-2024.

Entry fees: LHCb currently does not collect cash entry fees from new institutes, there has been

no change to this practice since last year. In-kind contributions for the general benefit of the collaboration are considered but currently not collected.

8 SUMMARY

The LHC Resources Scrutiny Group has examined the closing reports of the four LHC experiments ALICE, ATLAS, CMS and LHCb for 2022. The LHC Resources Scrutiny Group recommends to the RRBs the approval of the 2022 M&O closing reports of ALICE, ATLAS, CMS, LHCb. The Scrutiny Group has scrutinised the requested budgets for 2024 for ALICE, ATLAS, CMS and LHCb. The LHC Resources Scrutiny Group recommends to the RRBs the approval of the 2024 M&O budget request of ALICE, ATLAS, CMS and LHCb.

The Scrutiny Group acknowledges the central role of the Resource Coordinators of the collaborations in carrying out the annual scrutiny process and wishes to thank them for their time and effort and for their positive and collegial approach.