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Addendum to input to the EPPS: Prospects for exploring the Dark Sector physics and rare processes with NA64 detector at the CERN SPS

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[1] http://webna64.cern.ch

Contents

1 Timeline

Our plans to construction and running of the experiment are shown in Fig.1 and discussed in more detail below

1.1 NA64e: measurements at H4 beamline

NA64 has been running well at the H4 beamline over the last three years. The running in 2018 has shown that for most of the high-intensity runs with $\simeq 7-8\times10^6$ e^-/spill and average number of 3500 spills /day about 2×10^{10} e^- EOT/day can be accumulated. To achieve our goals for the $A'\to invisible$ decay and sub-GeV DM searches the accumulation of $\simeq 5\times10^{12}$ EOT or 6-7 months of running is required. A similar running period and statistics are needed for reach the planned sensitivity for the searches for the $X, A'\to e^+e^-$ decays. Assuming 2.5 months of running at H4 per year, at least five years are needed to achieve our goal, as shown in Fig. 1.

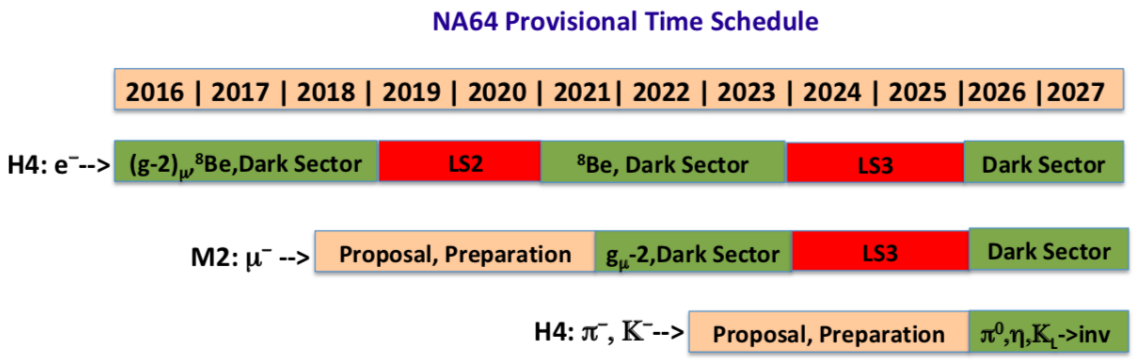

Figure 1. Plan for the construction and running of the NA64 experiment.

1.2 NA64μ: possible running scenario at M2 beamline

To achieve the physics goals described in Ref.[1] we would request the following two periods of running time:

(i) 10 weeks to search for a new state weakly coupled to muons that could resolve the longstanding muon (g-2)$_\mu$ anomaly. For this study accumulation of $\simeq 10^{11}$ MOT would be a good number. It will be in particular important to achieve this goal if FNAL confirms the muon (g-2)$_\mu$ discrepancy in 2019. In this case, to be ready for measurements in 2021 or 2022 we plan to prepare a detail proposal and start the detector design in 2019, produce the main setup components in 2019-20, and to complete the assembly in summer 2021 or 2022;

(ii) 6 months of light Dark Matter search and covering the DM parameter space with $\simeq 5 \times 10^{12}$ MOT. Here it is assumed running with $\simeq 10^7$ μ^-/spill. Running time of 2-3 years would be needed to collect $\simeq 5 \times 10^{13}$ to search for e.g. millicharged particles. For the second period of the signal search, a more detailed study of the apparatus design might be required. The experience and knowledge gathered in the first period of this experiment will certainly help to improve the design and the sensitivity of the experiment.

1.3 NA64h: searches with hadron beams

To achieve our goals for the $M^0 \to invisible$ decays of neutral meson searches two years of running at a π, K beam will be needed. The plan is to start these measurements after LS3.

2 The detector cost estimation

The breakdown of the construction and operating cost estimates for the NA64e, NA64μ, and NA64h setups described earlier is shown in Tables 1-4. The cost estimate is based on our experience in NA64e and does not include contingency or manpower expenses. In order to complete the required upgrades (NA64e) and construction of new subdetectors (NA64μ, NA64h) in time for the 2021 run, timely finding is of critical importance.

2.1 The NA64e detector upgrade and operating costs

The preliminary cost estimation of the setup for the NA64 upgrade and operating costs at the H4 beam is presented in Table 1 and Table 2, respectively.

Item	Institute	Invest, kCHF			
		2018	2019	2020	total
New em-calorimeter	IHEP, INR, JINR, ETH		70	80	150
Veto system	INR, IHEP	3	7	10	20
New scintillator hodoscopes	UTFSM	8	12	12	32
2 GEM station	Bonn		10	10	20
New MM station	ETH		20	20	40
Upgrade SRD	IHEP, INR		5	10	15
Straw	JINR	10			10
Upgrade DAQ, electronics	All		35	35	70
PPE144 zone	CERN	91	143		304
	IHEP, INR	10	30	30	
Total					671

Table 1: Cost estimate for the upgrade of the NA64e experiment.

Item	price, CHF	
Gases	**1800**	
$Ar+CO_2$	600	tests, beam run
N_2	1200	winter shutdown
Installation	**3000**	crane, materials, tools
Electronics	**3600**	crates, NIM, scalers ...
Diverse	**1500**	
Total	**9900**	

Table 2: Provisional operating cost of the NA64e experiment per two months of running.

2.2 Construction and operating costs of the NA64μ experiment

The preliminary cost estimation of the setup for the NA64μ detector construction and its operating costs at the M2 muon beam is presented in Table 3 and Table 4, respectively.

Item	Institute	Invest, kCHF			
		2018	2019	2020	total
New hadron calorimeter	IHEP, INR, JINR, UTFSM, ETH		85	90	175
Veto hadron calorimeter	IHEP, INR, UTFSM, ETH		45	50	95
New scintillator hodoscopes	UTFSM, IHEP,INR		35	35	70
8 GEM station	Bonn		40	40	80
8 MM station	ETH		40	40	80
Veto counters	IHEP, INR, UTFSM		10	10	20
Straw	JINR		70	80	150
DAQ, electronics	All		70	70	140
M2 line	CERN		170	180	350
Total					1160

Table 3: Cost estimate for the upgrade of the NA64μ experiment.

Item	price, CHF	
Gases	**2400**	
$Ar+CO_2$	2400	tests, beam run
Installation	**5000**	crane, materials, tools
Electronics	**1800**	crates, NIM, scalers ...
Diverse	**1500**	
Stores	**3000**	
Total	**13700**	

Table 4: Provisional operating cost of the NA64μ experiment per two months of running.

2.3 Construction and operating costs of the NA64h experiment

As we plan to use the same NA64e based apparatus for the searches for invisible decays of neutral mesons, the preliminary cost estimation of the setup for the NA64h detector construction and its operating costs at a hadron beam is presented in Table 1 and Table 2, respectively. A possible additional contribution to the construction cost at the level of 50 kCHF is expected due to fabrication of a new Veto system completely surrounding the target region.

References

[1] D. Banerjee et al., NA64 Collaboration, " Prospects for exploring the Dark Sector physics and rare processes with NA64 at the CERN SPS" , Input to the European Particle Physics Strategy, 2018.