Answers to the Questions from the SPSC Referees to the NA62 2012 Status Report

NA62 Collaboration, 02/04/2012

We thank the SPSC referees for carefully reading the NA62 status report and for providing a detailed set of questions. For convenience the questions are reproduced below in *italics*, while our answers are in roman typesetting.

1. ***Our impression, after reading the report, is that a lot of excellent work has been done, however the schedule is getting tight and perhaps a more detailed plan for 2012 would be useful.***

   A detailed plan will be presented in the "Technical Co-ordination & Schedule" presentation during our SPSC-NA62 interaction on Monday, April 2.

2. *On p. 3: after Step 2, the signal acceptance is above 10%; it is unchanged after Step 3, while Step 4 (muon rejection) gives 90% pion acceptance, what is then the current estimate for the signal acceptance?*

   The 90% is a factor (0.9) to be multiplied to the signal acceptance after Step 2 and Step 3. However, since the muon identification studies using calorimeters are still very preliminary, we do not consider them for the current evaluation of the signal acceptance. We are working for the proper optimization of the muon-ID. The message from the muon-ID studies is that there is no physical process which prevents to reach a 10^{-5} muon rejection inefficiency using the calorimeters.

3. *On p. 4: about pileup (accidentals) in Gigatracker and Straw spectrometer: OK for the intended use of Technical Run (TR) info for the Straw spectrometer, what about the Gigatracker? What are its expected timing performances and multi-track capabilities?*

   The Gigatracker (GTK) time resolution which is used in the simulation is 200 ps per station, which is in line with test beam performance obtained with the prototypes [1]. The simulation of the correct beam shape is especially important to quantify the impact of the accidentals and of the kinematic rejection on the $K^+ \to \pi^+\nu\bar{\nu}$ sensitivity. The collaboration has identified a programme of measurements for the TR to measure the beam profile at various positions along the beam; this will enable an important check of the MC beam simulation. Detailed studies about the accidentals are ongoing and the current status will be presented in the presentation "Preparations for the $K^+ \to \pi^+\nu\ \bar{\nu}$ Analysis" on Monday.

4. *On p. 5 & 8: (for the TR) CHOD will use readout from LAV or RICH, when will the final decision be taken? see also p. 26 (HV of RICH used for CHOD) & p. 27 (LAV readout used for CHOD)*

   The LAV front end is the baseline option. The final decision will be taken by the dry run (July 15). The use of the RICH high voltage system is not related to the choice of the front end but simply to the fact that this system has already been procured and is not needed for the RICH this year.

5. *On p. 8 & 24: Please confirm whether Milestone 7 (LAV 6-8 Ready) is expected by April 2012.*

   Yes: A8 will arrive at CERN on April 12 and A6-A8 will be installed by the end of April.

6. *On p.8, it says that there are limitations due to CERN manpower; is this CERN technical staff who are needed? What about people from outside institutes? Or hiring fellows, having visitors, etc.?*

   First of all we wish to acknowledge the great support received from CERN and from the Collaborating Institutes. Competition for the allocation of human resources is of course very high, not only on the detector and electronics side, but also:

   - Technical Staff in EN/MEF were very occupied during the shut-down and the accelerator start-up.
   - Most critical seems to be the situation in EN/CV. The schedules for consolidation of HVAV system in ECN3 and B918 as well as the target cooling system are on the critical path, and have no contingency.

   Concerning CERN fellows, one expects that moving towards the data taking phase of the experiment their number should increase significantly, but the competition from the rest of the CERN scientific programme proves to be very strong.

7. *Can the collaboration clarify exactly what part of the CEDAR detector will be installed? On p.10, it says one half will be constructed. What physical half? On p.5, it then says 30-50% will be equipped; why not 50% and if only 30%, why (what is the issue) and physically, what does this mean? What is the plan for the other 50%?*

   In the 2012 technical run (TR) the full KTAG enclosure will be available. The light guides, electronics and cooling plates will be installed for four out of eight light spots. Each light spot will be read out by 32 instead of 64 photomultipliers (PMs). In 2012 the optics will be tuned by suitable lenses and mirrors to concentrate the light on 32 PMs per light spot instead of 64. This solution is acceptable for low particle rates.

8. *On p. 10 there are plans to test the TEL62 board for single-event upsets (SEUs). Is something special planned here or will you just be monitoring this during the technical run? Maybe I overlooked it, but I don't have a feel for where the board is in the experiment. Have you considered the literature on SEUs, although of course it might not be appropriate as you may have a new FPGA and no relevant tests exist.*

   Although the most exposed boards receive only a few Gray per year, we consider important to test the electronics under conditions as similar as possible to the NA62 ones. For this reason, the CEDAR group plans a test in the COMPASS muon beam environment. The TEL62 boards (as most of the digital electronics upstream of the PC farm) will sit in the experimental hall, some meters away from the beam, as it happened in NA48, and where other digitally-controlled electronics (e.g. HV distribution) will be. While all this electronics is standard and not at all radiation hard, we do not foresee significant problems with the muon beam halo. We however feel since a long time that this must be checked and demonstrated, in particular for

upstream detectors (e.g. CEDAR). This long due test is in principle rather simple: a TEL62 board with a simple self-checking firmware running for a long time in a flux of particles comparable to the one we will have.

9. *On p. 12:*

   - *1st bullet - about the prototypes used in a dedicated test-beam - could they be used in the TR as well?*

     We are not planning to integrate the GTK prototype assemblies in the TR. The read out chips were not thinned down and their insertion in the K12 beam would lead to an unrealistic thickness crossed by the beam. Moreover they would cover only a very limited fraction of the lateral beam size.

   - *3rd bullet - what is the required operational bias voltage?*

     The sensors have to be fully depleted and a reverse bias voltage of at least 300 V is required to reach the required timing performances [1].

   - *4th bullet - have the samples been delivered as expected for March?*

     Yes, and the required thinning has been achieved.

10. *In section 9:*

    - *Milestone 6 (GTK freeze sensor + chip design), is June 2012 realistic? See e.g. at p. 12-13: call for tender for final assemblies (p-in-n only?) expected this year; BTW we note the good progress on the micro-channel cooling in the last few months;*

      The sensor layout and the chip architecture are frozen. The bump-bonding of p-in-n or n-in-p does not require substantial process rework: we expect price and procedures to be very similar for the two cases.

    - *At p. 15, ASIC design: in view of the present status, what is the expected time for design completion and ASIC engineering run?*

      The schematic has been completed. The layout also has been completed for most of the blocks, though for some parts it is still underway. The layout, layout-simulation, and checks are expected to be completed in the second part of 2012. The CERN group, involved in the project, is actively working to complete it. The engineering submission will follow immediately, once all the simulation and the necessary checks will be completed.

11. *On p. 16. Surely there is some jitter for the optical signals and not completely jitter free? Can you say what the requirements are and what was measured?*

    We have several requirements for the optical signal system, which are listed below with their maximum requirement and the measured value in the test system.

    (a) Clock for the TDC
        - Required: clk_dll: 30 ps;
        - Measured: 5 ps after 300 m and 15 dB (emulates optical losses).

    (b) Clock for the digital part of the TDCpix including serialiser output
        - Required: clock_digital: 100 ps;
        - Measured: 5 ps after 300 m and 15dB (emulates optical losses).

(c) Signal for the serial stream

- Required: serial_in: 1 ns;
- Measured: 32 ps, no attenuation, 300 m of MM fibre.

(d) Reset of the coarse time measurement

- Required: reset_coarse_time (non-repetitive and non-DC balanced); 1ns;
- Measured: 24 ps after 300m of fibre.

(e) Test_pulse connected to the individual pixels

- Required: $\leq$ 30 ps;
- Measured: 24 ps after 300 m of fibre.

12. *On p. 17/18, Section 9.6. I don't have a feel for the distance between the detector and off-detector electronics; could you give a distance? Depending on the distance should I assume that signal integrity is not an issue?*

    The distance between detector and off-detector is about 250 m. All communication is done optically. No electrical signal leaves the station. Also the temperature sensors connections will be optocoupled. Thus the electrical signal integrity will not be degraded by the distance. The optical performance is not dominated by this distance. The dominant part will be the optical break points. Qualification measurements will be done with a scenario more stringent than the worst case scenario by applying a 15dB attenuator. For what concerns the HV power supply, depending on the final implementation, the HV distribution will be either 20 m or 250 m long. Experience in the ALICE detector shows that even long cables on the HV can be managed. In case the long cables pose a problem, the HV power supplies can be installed in the cavern (20 m apart from the station) with the drawback of an inferior current monitoring capability.

13. *In section 10:*

    - *How many straws contains one module?*

      Each module contains 896 straws.

    - *How much time is needed to produce all straws?*

      About 30 straws can be produced per shift. We have already about 2000 straws and we plan to make 6500 more (including spares). Assuming one shift per day, the production should last about one year.

    - *Milestone 5 (STRAW Module 1 ready): could you confirm completion by Jan 2012? (p. 20 / Fig.14);*

      This Milestone is only partly achieved: the straws insertion was completed including quality control (straightness within 100 μm) and leak test. Wiring and HV test is still ongoing. There are several reasons for this delay:

      – The Web (flex-rigid circuit to connect anode/cathode to the front end (FE) cover) was optimized (shorter signal path) in autumn 2011 to improve noise performance;
      – Further checks were required on the FE and the SRB board.

      We expect to finish the wiring in June. FE covers will be mounted in July. Due this delay we have reduced the TR setup to one module instead of two.

- *Milestone 8 (STRAW RO design completed & tested): what are the news? see also p. 31: ... some prototypes ... might be available during the runs of 2012;*

  The architecture for the Straw read out is chosen. The first version of the FE cover (including the FPGA-based with TDC) and a prototype SRB is available and is under test. The tests, in particular, on the FE cover are not finished, and it is too early to launch the full production. We plan to produce a 2nd version of the FE cover as pre-series for Module 1 only. Although the test of the prototype SRB is very promising, a full validation is only possible after the finalisation of the FE cover. We plan to produce four pieces for Module 1 this summer. The mezzanine board for the TEL62 has started. The requirements are defined and the architecture is outlined.

- *Milestone 10 (STRAW 2 modules ready): is 15/6/2012 realistic? What is the plan for the other half?*

  The plan is to couple an empty frame to Module 1 in order to assemble the first chamber for the TR. The work on the Module 2 has started but, due to the delays on Module 1 and the preparations for the TR, we are forced to slow down our efforts on Module 2.

14. *In section 11:*

    - *Milestone 4 (RICH design mirror supports & wall): is it finally completed?*

      Not completed yet but quite advanced. Engineers are working on it.

    - *On p. 21 RICH vessel, tendering is expected May 2012; please confirm that mirror support honeycomb has been manufactured?*

      The mirror support honeycomb has not been manufactured yet, it must be ready by when the vessel will be installed next year. The panel will be placed inside the vessel.

    - *On p. 22, do I understand correctly that the mirrors will be finished soon and then not installed, i.e. not used for another year? I guess this is okay, but it does seem odd to have these ready so early and so wonder if there is a reason?*

      All the mirrors are at CERN in boxes ready to be aluminized; the aluminization has been delayed to second half of 2012. One year ago there was still the possibility to have the RICH in the technical run and the mirror preparation was scheduled accordingly.

    - *Same page. I wonder why 2000 PMs were ordered and then 150 extra? How many are needed for the detector and how many are spares? Why was there a second order; did something go wrong?*

      PMs were ordered in several batches in the previous years according to cash flow and production rate; 150 PMs are just the very final batch including mostly spares. Nothing went wrong.

15. *In section 12, Figure 17. I am not quite sure what to make of the comparison of the MC with data: at low ToT, 10-20 ns, the MC matches the 8 mV data well. They start to deviate at around 26 ns and then around 40 ns, the MC matches the 6 mV data. Then at around 50 ns, the MC is again in agreement with the 8 mV data. The MC may also agree with the 6 mV data, but I can not really tell. It seems that the 8 mV data has some strange behaviour.*

Thank you for pointing this out. The MC simulation used to generate the plot presented in the status report was not the most complete one, the PMT capacity was wrong and some resistors were not taken into account. The correct plot is presented in Fig. 1: in this version the agreement is good.

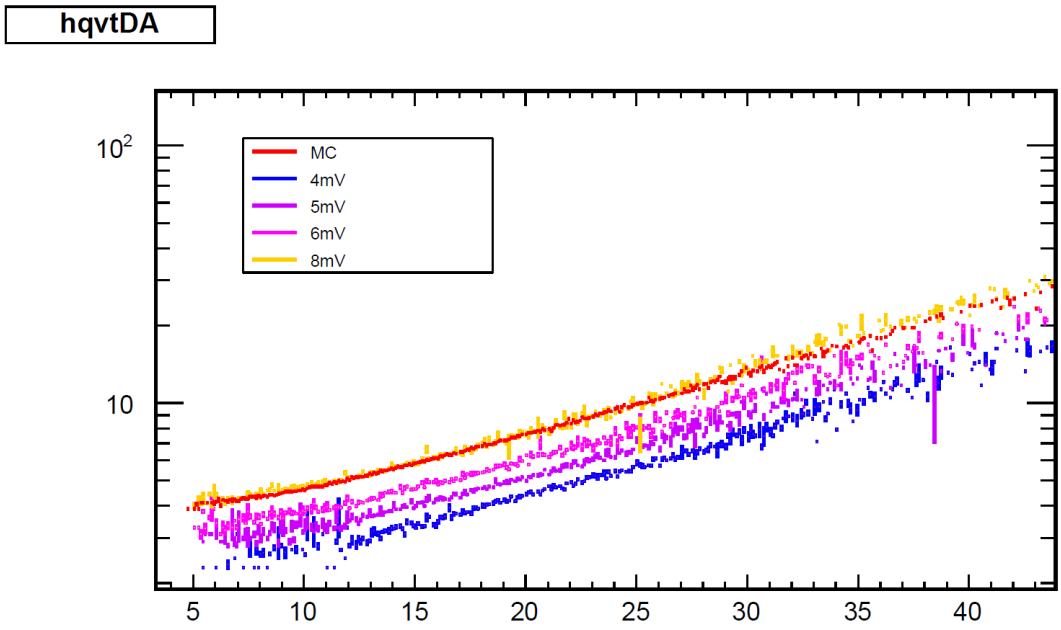

Figure 1: LAV: Data vs. Monte Carlo comparison for the Time over Threshold response as a function of input charge.

16. ***Given some of the questions above, we think it would be useful for the Collaboration to show Figure 3 and state where each component is with reference to that, what is experiencing delays and by how much, etc..***

    The status will be presented in the "Technical Co-ordination & Schedule" presentation on Monday.

17. *Photon Vetoes at p. 24 , last par., "...the MC simulation will be validated ..... with data from test beam...": It is not clear to me, which data will be used for this.*

    The text refers to the data already accumulated with electron beams at the BTF facility at LNF (Frascati) and at the T9 beam at the CERN-PS.

18. *In section 14.2 at p. 28 there is a typo: September 2011 is meant; in section 14.3, p. 29: I think this may just be the text, but I am not 100% sure that the valve has been replaced and that it has been a success?*

Thank you for pointing out the typo, "September 2012" should indeed read "September 2011". Yes, the downstream guillotine valve has been successfully replaced by an industrial gate valve. The upstream guillotine valve must stay in place; an industrial valve would spoil the material budget in front of the calorimeter.

19. *At p. 30, Section 15.1 on MUV1. Could more be said about the additional muon suppression factor of 5-10, which sounds interesting?*

    We will evaluate this possibility better in the future. The additional rejection power may be useful to keep the signal efficiency as high as possible.

20. *About the TDAQ system:*

    - *p. 31, 3rd bullet. Why have the Straw group decided to develop a dedicated DAQ system? Is this then in competition with the main DAQ? What are the issues related to having this separate DAQ?*

      There is no competition with other systems: the Straw DAQ will employ the TEL62 board for the back end side of the DAQ like most of the other detectors. For the front end part, the Straw team has chosen the on-detector solution. The choice is motivated by technical reasons, including a simplified distribution of the services and the avoidance of long analog signal cables. It should also be stressed that the time resolution requirements for the Straw are much relaxed with respect to the performance needed for some of the other detectors (e.g. the RICH) for which the off-detector solution has been designed.

    - p. *31: The lack of firmware. Is this now being worked on and there is a plan for how this will be completed? I.e. are people in place to provide it and it was just a problem of them not having time until now? By 2013, will all firmware be in place? It sounds like a concern.*

      This is indeed a concern, mainly related to the leading Pisa group suffering a 75% drop in dedicated manpower in the last 2 years, with no success in replacement from within or outside the collaboration, so far. Help from other groups was slow in coming due to other commitments, but is now starting. A downscoping of 2012 firmware goals was deemed necessary to be realistic. We are working to ensure the complete firmware will be ready for 2014, and the dry/technical runs of 2012 will be essential to assess this issue.

    - *p. 32: L0TP is the least advanced, what is the prospect for the Technical Run?*

      There is no real issue for the 2012, as a fall back solution was identified long ago: a copy of the TALK board, used to temporarily integrate the old NA48 LKr readout in the new TDAQ system, will be used as L0TP for 2012 runs. Firmware is under development and we see no major issue here. At this time this is felt as an issue for 2014. We hope that some partial prototype system of the real L0TP would be available for parasitic testing during the 2012 runs, but we do not rely on this.

21. *Section 18.2 (DCS), p. 34. I assume by "SMS" you mean a text message to a phone? I guess such a report is not too urgent and does not require quick expert action? Text messaging does not seem that reliable from my experience.*

Statistical Error ($\times 10^{-5}$)	0.007
Systematic Error	
$K_{\mu 2}$ background	0.004
$K_{e2\gamma}$ (SD+) background	0.002
K_{e3}, $K_{2\pi}$ backgrounds	0.003
Muon halo background	0.002
Thickness of the spectrometer	0.003
Acceptance correction	0.002
Spectrometer alignment	0.001
Electron identification efficiency	0.001
1-track trigger efficiency	0.001
LKr readout inefficiency	0.001
Total systematic	0.007
Total	0.010

Table 1: Breakdown of the uncertainties for the R_K measurement, full sample.

Indeed: "SMS" was meant to mean texting to a phone. This type of feedback is intended to inform the expert about a condition rather than to signal the need for urgent intervention.

22. *p. 36, the measurement of R_K. The total error is, I believe, split equally between statistical (0.007) and systematic (0.007). Could you give a breakdown for the systematics, i.e. geometrical acceptance, trigger, e/mu id, etc. and give some idea how these will be reduced in the future.*

    The breakdown of the uncertainties is given in Table 1 in 10^{-5} units. The main systematic is represented by the $K_{\mu 2}$ background. It is plausible to expect a significant reduction of this uncertainty in the new setup where the RICH will improve the electron/muon particle identification by about two orders of magnitude.

23. *Figure 24:*

    - *Can you say more about the beam simulation precision which leads to discrepancies in the M^2_{miss} distributions. Related to this, have you tried to see if there is any dependence on the M^2_{miss} distributions? I.e. if you were to do low and high $M^2_{miss}(e)$, this would have regions of low and high backgrounds.*
      The M^2_{miss} for the $K \to \pi e \nu$ decay is at least as large as the π^0 mass square. In order to enter the signal region (M^2_{miss} compatible to zero), the reconstructed missing mass must be very strongly biased. The two primary mechanisms which can bias the M^2_{miss} are Coulomb scattering of an electron by a large angle, and the kaon being in the tail of the beam momentum distribution. In the 2007 data, the kaon momentum is not measured and the beam average is used to reconstruct the M^2_{miss}. If the kaon momentum is higher than the beam average, the reconstructed missing mass is shifted towards lower values.
    - *The overall agreement between MC and data is really impressive and the discrepancies are tiny. My question is, how much the imperfections of beam simulation can deteriorate the expected sensitivity for $K^+ \to \pi^+ \nu \bar{\nu}$.*

For the $K^+ \to \pi^+ \nu\bar{\nu}$ measurement, the impact of the imperfections of beam simulation will be strongly reduced due to the measurement of momentum of each beam particle in the GTK (Note that there was no beam spectrometer in 2007, therefore the beam spectrum shape entered directly the resolution on decay kinematic variables).

References

[1] 2011 NA62 Status Report to the CERN SPSC, CERN-SPSC-2011-015 / SPSC-SR-083 22/03/2011