Summary/conclusions of the NA61/SHINE Beyond 2020 Workshop
https://indico.cern.ch/event/629968/

AB, MG, EZ, PvD 30.07.2017

The workshop summarized importance of the NA61/SHINE results for physics of strong interactions, neutrinos and cosmic-rays.

All three communities requested new measurements, which should take place in the period 2021-2024, namely:

- **Strong interactions:**
  Open charm measurements in Pb+Pb collisions are needed to study onset of deconfinement:

  Open charm is expected to be sensitive to medium properties in which its production takes place, thus its collision energy and centrality dependence is expected to change when crossing the phase transition between confined and deconfined matter (Gorenstein)

  Open charm measurements are needed to interpret a reach data on charmonia production in Pb+Pb collisions at 158A GeV/c in terms of the phase transition (Satz)

  Measurements of open charm required two major detector upgrades:
  New TPC read-out and DAQ, New Vertex Detector (Feofilov, Pulawski, Tieulent, Rossi).
  Synergy with ALICE upgrade programme should allow to perform both upgrades cost-efficiently. It may also attract new institutions to NA61+ (CERN and some ITS and/or MFT institutions)

  Use of emulsion detectors developed by DsTau (Ariga) with 50 nm resolution may allow to measure open charm in p+A interactions and attract DsTau institutions to NA61+ (Aichi, Kobe, Nagoya, Bern).

  New high statistics data on Pb+Pb collisions will allow to improve quality of many previously done measurements. Examples related to the search for the critical point and study collective effects were discussed by Nikos Davis. Arguments for measurements of multi-strange hadrons were not presented at the workshop, one can consider to organize a dedicated meeting later this year or in 2018.

  NA61+ is the only experiment, which can measure open charm at the SPS energies within the next 10 years, i.e. before a luminosity upgrade of NICA (Kolesnikov) and construction of SIS300 at FAIR (Friese). The J-PARC heavy ion programme is at an early phase of planning.

- **Neutrinos:**
  The importance of hadron production measurements was strongly emphasized by all neutrino physics speakers. Many accelerator and atmospheric neutrino experiments expressed interest in thin-target measurements. These range from very low beam momenta to 120 GeV/c.

NA61's measurements for T2K have been critical for T2K to reduce flux systematic errors by a factor of two, and further improvement is expected as the long target results are added into T2K's flux model.

An idea to construct a tertiary hadron beam-line for beams at very low momenta (< 10 GeV/c) was presented by Nikolaos Charitonidis. Proponents of the measurements at very low momenta are encouraged to work together with Nikos on this proposal.
Replica targets for DUNE and HyperK will be ready only after 2025. Thus, the measurements with exact replica targets are not requested, though measurements with prototypes may be useful. The replica target runs would be very valuable even if they take place after LS3.

Whether new measurements with the T2K replica target are needed will be concluded after introducing the NA61 LT 2010 results in the T2K beam simulation.

Some new detector ideas were suggested at the workshop, including the idea of a very long target in a more downstream position. The target could be surrounded by a set of tracking detectors to pinpoint low-angle tracks from the upstream end of the target. The value of empty target and high field exposure were also emphasized.

Options other than NA61 are being considered by some collaborations. However, these would require major new detector construction and personnel commitments.

- **Cosmic-rays:**
  High precision AMS data require measurements of fragmentation cross-sections of light nuclei (Maurin) and production of anti-nuclei (Donato, Tomasseti).

  Fragmentation cross-sections can be measured using secondary ion beams, e.g. produced by fragmentation of Pb ions at the T2 target. The first feasibility study for such a measurement was presented by NA61/SHINE at the XSCR17 conference. A several-day long beam test can be requested in 2018. Proponents of the measurements are encouraged to prepare the request and included it in Status Report 2017

  Institutions from AMS are natural candidates to conduct final measurements in the period 2021-2024.

The emerging NA61+ measurements (open charm, very low momentum beams, fragmentation, anti-nuclei) are qualitatively different than the ones performed by NA61/SHINE (spectra and fluctuations of light hadrons from the (collision energy) – (system size) scan, spectra for T2K and PAO). They require major detector upgrades. All this means that a significant number of new institutions is needed to execute the NA61-future programme.
This, in turn, suggests that a new collaboration should be established, rather than running the new programme under NA61/SHINE. Of course, a decision on this is in the hands of the Collaboration Board, but everybody is encourage to contribute to the discussion.