SEARCH FOR EXOTIC DECAYS WITH NA62

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NA62 Experiment

- Fixed-target experiment at CERN SPS (north area).
- Main goal: measure ultra-rare $K^+ \rightarrow \pi^+\nu\bar{\nu}$ with 10% precision.
- Primary $p^+$ beam 400 GeV/c impinges Be target, set of apertures (TAX) selects 75 GeV/c secondary beam (750 MHz with $\sim 6\%$ of $K^+$).
- $K^+$ tagged by KTAG (70 ps time resolution) and 3-momentum determined by Si pixel beam spectrometer GTK.
- $K^+$ decay-in-flight in 60 m long decay region.
- Decay products’ 3-momenta are measured by STRAW tracker. RICH identifies $\pi^+$ and further hadron ID is given by combination of calorimeters LRk, MUV1, MUV2. Muon ID is provided by MUV3 placed behind iron wall.
- Photons can be vetoed by LRk and by LAV at large angles or by SAC/RIC at small angles.
- Overall experimental time resolution reaches $\mathcal{O}(100)$ps.


Dark sector searches at NA62

Thanks to high energy primary beam, hermetic detector system and the first-rate timing resolution allowing collecting of large statistics NA62 is competitive in the search for BSM particles (HNL, dark photons, ALPs). Dark sector searches can be performed at NA62 in three different ways:

- $K^+$ decays into weakly interacting exotics (search for bump in missing invariant mass).
- Non-interacting $p^+$ from primary beam can interact in copper front of TAX and produce weakly interacting exotics. If these reach the decay volume and decay out of the main beam they can be recorded using dedicated ‘parasitic’ trigger running simultaneously with the main kaon trigger.
- ‘Beam-dump (BD) mode’: beryllium target is removed and primary beam is impinged directly onto TAX (cannot be operated simultaneously with kaon physics mode).

New preliminary NA62 result based on $\sim$ lightest asymmetry and SM neutrino masses, where the $K^+$ mass is expected $\mathcal{O}(10)$ KeV/c$^2$ (DM candidate) and $N_{2,3}$ masses $\mathcal{O}(1)$ GeV/c$^2$.

Search for HNL in decays $K^+ \rightarrow \mu^+N$ and $K^+ \rightarrow e^+N$ measured on 2016-2017 data sample at NA62 led to new exclusion limit in the ($|U_{14}|^2$,HNL mass) plane shown in fig.2.

Heavy neutrals (HNL)

$\nu$MSM introduces 3 additional right-handed neutrinos $N_i$ in order to explain the baryon asymmetry and SM neutrino masses, where the lightest $N_1$ mass is expected $\mathcal{O}(10)$ KeV/c$^2$ (DM candidate) and $N_{2,3}$ masses $\mathcal{O}(1)$ GeV/c$^2$.

Axion-like particles (ALP)

General pseudoscalar (in most models pNGB after SSB of axial U(1)) with possible coupling to all SM fields.

Charged lepton final states (e.g. $ALP \rightarrow \mu \bar{\nu}$) can be searched in the ‘parasitic mode’.

Case of predominant coupling to $\gamma$ must be searched in ‘Beam-dump mode’ (no charged particles in decay volume allowed), where dominant $ALP$ production at TAX is via Primakoff effect with decay $ALP \rightarrow \gamma\gamma$ in decay volume. For expected NA62 sensitivity see fig.3.

Study of DP production via other meson decays ($D, \eta, \eta', \phi, \rho, \omega$) and in Bremstrahlung-production directly at the beryllium target will be performed in the future, for expected sensitivity see fig.5.

References


Figure 1: NA62 experimental setup.

Figure 2: NA62 result for HNL exclusion limits ($690\%$ CL) from 2016-2017 data sample [2].

New preliminary NA62 result based on $\sim 1/3$ of the data set.

Figure 3: NA62 result for $\sigma$ ($690\%$ CL) from 10$^8$ POT ($\sim 3$ months of data-taking) in ‘Beam-dump mode’ for ALPs coupled to 2$\gamma$ [3].

Figure 4: NA62 result for DP exclusion limits ($690\%$ CL) from decay $\pi^0 \rightarrow \gamma\gamma$ [4].

Study of DP production via other meson decays ($D, \eta, \eta', \phi, \rho, \omega$) and in Bremstrahlung-production directly at the beryllium target will be performed in the future, for expected sensitivity see fig.5.

Figure 5: NA62 prospect on sensitivity ($690\%$ CL) for DP (based on DP production at Be target for $10^8$ POT from meson decays and Bremstrahlung).