NA-64 experiment at SPS CERN

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1. Goal of the experiment:

1a. goals

One of the biggest puzzles in physics is that 95% of the matter in our universe is "dark": it does not interact with photons of the conventional electromagnetic force and is therefore invisible to our eyes and telescopes.

Several dark matter models suggest the existence of dark sectors consisting of $SU(3)_C$ x $SU(2)_L$ x $U(1)_Y$ singlet fields. These sectors of particles do not interact with the ordinary matter directly but could couple with it via gravity. In addition to gravity, there might be another very weak interaction between the ordinary and dark matter mediated by U'(1) gauge bosons A' (dark photons) mixing with our photons. In a class of models, the corresponding dark gauge bosons could be light and have the γ-A' coupling strength laying in the experimentally accessible and theoretically interesting region.

If such A' mediators exist, their di-electron decays A' → e+e- could be searched for in a light-shining-through-a-wall experiment looking for an excess of events with the two-shower signature generated by a single high energy electron in the detector.

Our experiment aims to probe the so far unexplored area of the mixing strength $10^{-5} < \varepsilon < 10^{-3}$ and masses $M_{A'} < 100$ MeV using 50-150 GeV electron beams from the CERN SPS.

1.b what project adds to the international scenario

NA-64 is a fixed-target experiment at the CERN SPS utilizing the active beam dump combined with the missing energy approach to the searches of invisible decays of dark photons (A') with the mixing strength $10^{-5} < \varepsilon < 10^{-3}$ and masses $M_{A'} < 100$ MeV, invisible decays of (pseudo)scalar mesons, in particular K_S , K_L -> invisible, and hadron and muon interactions resulting in invisible final states due to production of new penetrating particles. The experimental signature of this process has never been experimentally tested before.

The advantage of our approach is that the sensitivity (or number of signal events) of the experiment is roughly proportional to the Z' coupling squared ε^2, associated with the Z' production in the primary interaction in the target. While in a classical beam dump experiment, it is proportional to ε^4, one ε^2 came from the Z' production, and another ε^2 is either from the probability of Z' decays or their interactions in the detector located at a large distance from the beam dump. The sensitivities of these two methods depend on the region under study in the (ε^2 ; m_Z') parameter space, background level for a particular process, available beam intensity, etc. In some cases, in order to observe a signal event with our approach much less running time and primary beam intensity.

2. Contribution of the JINR group:

2a. An itemized list of contributions

The JINR group is responsible for the tracking sub-system: coordinate detectors based on the thin-wall drift tubes (straw tubes).

The documentation on the manufacturing of double-layer straw tube (2 and 6 mm diameters) chambers with the 20x20 cm^2 working area has been developed;

Six frames for 2mm and eight frames for 6mm straw tube chambers have been manufactured;

The documentation on the read-out from both type of chambers (2mm and 6mm, 96 channels and 64 channels) has been developed;

600 6mm straw tubes and 800 2mm straw tubes have been manufactured;

all chambers were assembled, equipped and successfully tested with ion sources and with a real beam;

on-line monitor and visualization for the straw tube chambers, decoding and data acquisition software have been prepared; chambers were included in the NA-64 data-base;

straw tube chambers have been described and included in the MC and reconstruction software of NA-64 experiment;

JINR team participated in 3 NA-64 data taking runs and was responsible for straw tube chambers.

2b. Scientific program development – Victor Matveev. Theoretical contribution to the experiment motivation, participation in the preparation of the 1st stage of the proposal (with electron beam)- - approved at CERN, participation in the preparation of the 2nd stage of the proposal (with muon and hadron beams) – in preparation;

Responsibility on the straw tube chambers manufacturing and putting in operation– Dmitry Peshekhonov for the 1st stage, participation in the 2nd stage proposal

Deputy JINR team leader at CERN – Vladimir Karjavin

3.Plans

At the end of 2018, NA-64 experiment got its own experimental zone at H4 channel of the SPS and we plan to move and install all our equipment during 2019.

In the frames of the extending program with electron beam and preparation for the data taking with muon beam we plan to start to develop new large area straw tube chambers.

R&D with cosmic and ion-sources aimed at the improvement of the chamber characteristics, tests of electronics and DAQ modernization.

Data analysis: participation in MC simulation and reconstruction;

Participation in the preparation of the proposal for the 2nd stage of the experiment

4. Publications

1. Search for invisible decays of sub-GeV dark photons in missing-energy events at the CERN SPS, NA64, Phys. Rev. Lett. 118 (2017) 011802;

2. High purity 100 GeV electron identification with synchrotron radiation, NA64, Nucl. Instrum. Meth. A866 (2017) 196;

3. Search for vector mediator of Dark Matter production in invisible decay mode, NA64 collaboration, Phys.Rev. D 97 (2018) 072002;

4. Search for a new X(16.7) boson and dark photons in the NA64 experiment at CERN, NA64, Phys. Rev. Lett. 120, 231802 (2018)

5. JINR team participated in the detector preparation, data taking and analysis. 9 papers were published: besides mentioned above - 5 theoretical.

5. PhD theses --- not yet

6. No talks

7. *Group size, composition and budget*

Authors: T.Enik (researcher) 0.3; V.Karjavin (researcher) 0.1; G.Kekelidze (researcher) 0.5; V.Kramarenko (researcher) 0.3; V.Lysan (researcher) 0.5; V.Matveev (researcher) 0.1; D.Peshekhonov (researcher) 0.3; P.Volkov (researcher) 0.3

Non-authors: A.Feschenko (researcher) 0.3; S.Parzhitski (engineer) 0.5; A.Savenkov (technical staff) 0.5; I.Zhukov (technical staff) 0.7; A.Ivanov (researcher) 0.3

Total 49 memebers

we are looking for students and PhD students

budget for 2019: 20 k$ - materials and equipment; 10k$ - common funds; 30 k$ - travel.