Report: JINR Contributions to the NA62 Experiment at CERN SPS

The NA62 experiment at CERN's SPS plans to measure the branching ratio of the ultra-rare decay $K^+ \to \pi^+ \nu \nu$ with high precision. This precision measurement is vital for probing the Standard Model of particle physics, especially in understanding CP violation and quark flavor mixing. The Joint Institute for Nuclear Research (JINR) has significantly contributed to enhancing both the experimental apparatus and the scientific outcomes of this collaboration.

JINR engineered a state-of-the-art straw tracker from ultralight materials, crucial for minimizing multiple scattering and enhancing the precision of particle tracking. This technological advancement is pivotal for accurately determining the decay vertices of $K^+ \to \pi^+ \nu \nu$ events, essential for isolating these rare occurrences from background noise.

Moreover, JINR developed sophisticated Monte Carlo simulations that accurately model expected signals and background processes, playing a critical role in the experiment's design and optimization. Additionally, the institute's implementation of advanced statistical tools and machine learning algorithms has markedly improved the identification and segregation of true decay events, enhancing the overall data analysis capability.

JINR also contributed significantly to detector innovations, including enhancements to calorimetry techniques and photon detection systems, improving the experiment's particle identification and energy measurement capabilities. These upgrades, especially during the LHC Long Shutdown periods, have bolstered the detectors' ability to handle high particle fluxes, thus maintaining high operational stability and data integrity.

The technical contributions from JINR have directly enabled NA62 to achieve a branching ratio measurement precision of approximately 10%, setting a new standard for precision in particle physics experiments. This level of precision is pivotal for testing the Standard Model's predictions regarding rare kaon decays and potentially uncovering new physics. The institute's involvement has also led to numerous scientific publications and presentations, enriching the global scientific dialogue in high-energy physics.

Looking forward, the continued innovation in detector technology and data processing from JINR will be crucial for the success of NA62's upcoming experimental phases. The institute's commitment to training young scientists ensures ongoing expertise and capacity building within the high-energy physics community, further advancing the field.

In conclusion, JINR's transformative contributions to the NA62 experiment have significantly enhanced its scientific output and technological capabilities. These efforts have not only improved the precision of experimental measurements but also fostered a deeper understanding of fundamental particle interactions. Continued support and funding for JINR's role in NA62 are essential for maintaining this momentum and achieving further breakthroughs in particle physics. Thus, I recommend the extension of the project for next three years.

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