Measuring $K^+ \rightarrow \pi^+\nu\bar{\nu}$ decay with 10% of precision as a probe for New Physics

SM theoretical framework

- FCNC loop process, short distance dominated
- hadronic matrix element from the (isospin rotated) semileptonic decay
- theoretically clean $|V_{ud}|$ dependence

Perfect probe for New Physics, still complementary to LHC

<table>
<thead>
<tr>
<th>BR x 10^{-9}</th>
<th>SM prediction</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K^+ \rightarrow \pi^+\nu\bar{\nu}$</td>
<td>0.781 ± 0.075 ± 0.029</td>
<td>1.73 ± 1.0</td>
</tr>
<tr>
<td>$K^0_\ell \rightarrow \pi^0\nu\bar{\nu}$</td>
<td>0.243 ± 0.039 ± 0.006</td>
<td>&lt; 260</td>
</tr>
</tbody>
</table>

Background rejection

- 92% separated from signal by kinematic cuts
- 8% not separated by kinematic cuts

Goal: measure BR with 10% accuracy

- O(100) SM events + systematics control at % level
- statistics = high intensity kaon beam + large signal acceptance
- systematics = large background rejection + redundancy

Measurement principle

- technique: high momentum kaon decay in flight
- basic ingredients: precise timing & kinematic cuts
- signal signature: one $K^+\pi^0\nu\bar{\nu}$ track, one $\pi^+\nu\bar{\nu}$ track
- kinematic variable: $m_{\pi\nu\bar{\nu}}^2 = (P_\pi - P_\nu)^2$
- momentum measurement + particle-identification + veto

Momentum
- Kaon Tracker (GTK)
- Pion Tracker (STRAW)

Veto against
- Beam induced accidentals (CHANTI, CEDAR)
- Multiple charged particle decays (STRAW, CHOD)
- Photons and Muons (LAV, Lkr, IRC, SAC, MUV)

Including particle ID and vetos

- L0 (Hardware level) ~ 10 MHz
- L1 (single detector Software level) ~ 1 MHz
- L2 (multi detector Software level) ~ few kHz

Schedule

- R&D completed in 2010
- 2010-2014: construction
- October-November 2014: Pilot run
- July 2015-2018: Physics runs

THE NA62 EXPERIMENT AT CERN

Birmingham, BNL, Bratislava, Bristol, Bucharest, CERN, Dubna, Fairfax, Ferrara, Florence, Frascati, Glasgow, Liverpool, Louvain, Mainz, Merced, Moscow, Naples, Perugia, Pisa, Prague, Protvino, Rome I, Rome II, San Luis Potosi, Stanford, Sofia, TRIUMF, Turin

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