SCATTERING OF MONO-ENERGETIC KAON DECAY-AT-REST NEUTRINOS WITH NUCLEI

A. Nikolakopoulos, J. Spitz, V. Pandey, N. Jachowicz

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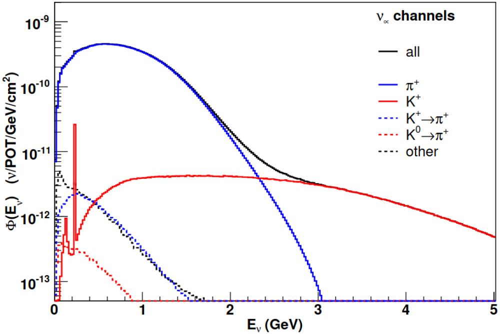
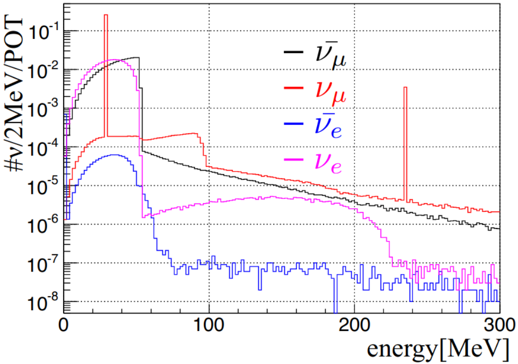
KAON DECAY-AT-REST NEUTRINOS

A stopped Kaon that decays at rest in neutrino beamline absorbers yields monoenergetic ν_μ with $E = 236\ \mathrm{MeV}$



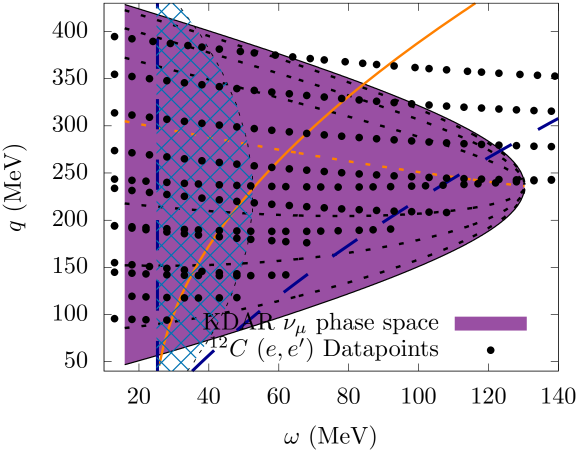
MiniBooNE flux [PRD79, 072002]



JSNS^2 flux [arxiv:1705.08629]

Phase space for CC scattering of ν_μ from KDAR

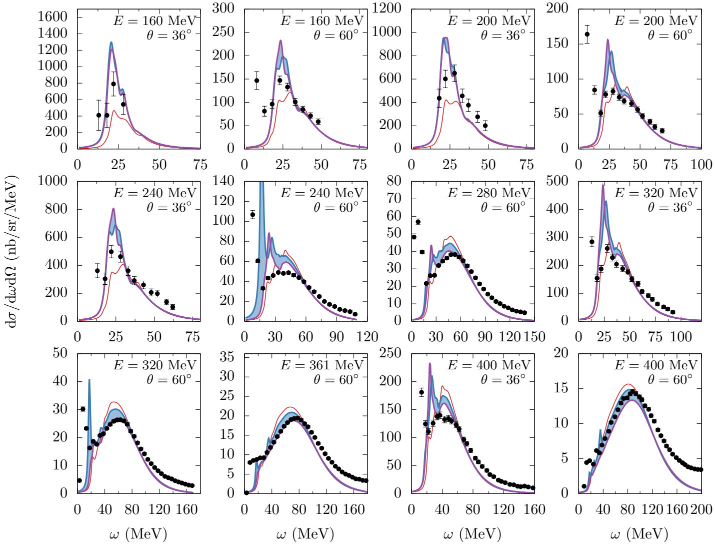
Fixed E_ν allows to determine transferred energy and momentum ω and q



Transition region between Low-energy and QE regimes

- $Q^2 \approx 0.01 - 0.2\ \mathrm{GeV}^2$
- Significant effect of Pauli-blocking (cross-hatched region)
- Threshold effects
- QE peak (orange line) for backward muons
- Large amount of (e, e') data available

ELECTRON SCATTERING OFF ^{12}C



CRPA blue band

HF red lines

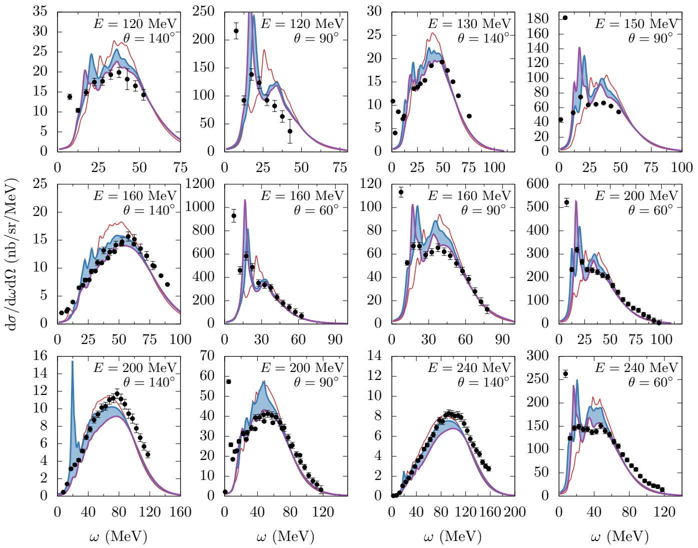
[PRC92, 024606,arXiv:2010.05794]

Validate models with (e, e')

- Test of nuclear model
- Direct test of the vector current
- Test of A-dependence

Combined analysis of (e, e') and KDAR data in terms of ω and q $\rightarrow$ clean view of axial current (separate 2p2h)

Electron scattering off ^{40}Ca



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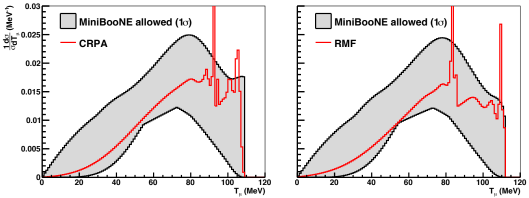
MEASUREMENTS OF KDAR ν_μ CROSS SECTION

First measurement of KDAR ν_μ cross section in MiniBooNE [PRL120, 141802]

- Extracted T_μ shape dependent on threshold
- Large allowed region
- Hard to separate KDAR from π-in-flight

Possible future measurements:

- MicroBooNE, ICARUS, ^{40}Ar, broad π-in-flight background
- JSNS^2 at J-PARC MLF, ^{12}C low background but limited capabilities of measuring μ kinematics.



- Shape only comparison to MiniBooNE data `www-boone.fnal.gov/for_physicists/data_release/kdar/`

MEASUREMENTS OF KDAR ν_μ CROSS SECTION

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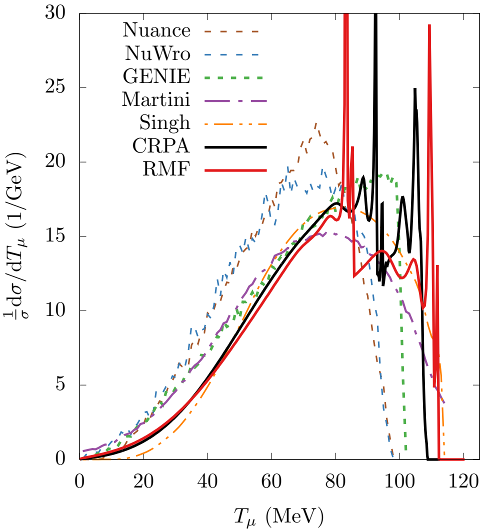
- Shape-only comparison of different models
- Not possible to discriminate between models due to limited statistics

From inclusive standpoint: even modest resolution of $\cos\theta_\mu$ ($\leftrightarrow$ q) can be useful

JSNS^2 particularly sensitive to hadronic + lepton energy ($\leftrightarrow$ missing energy)



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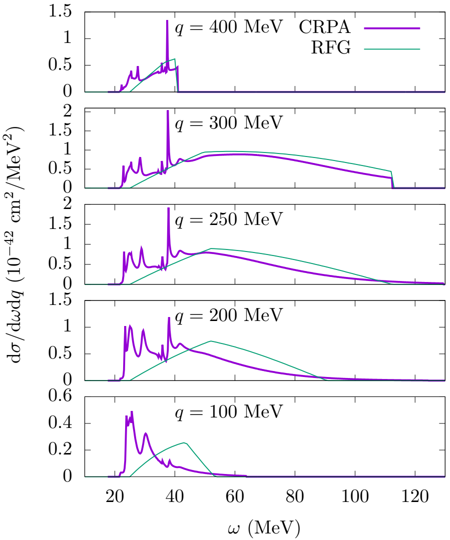
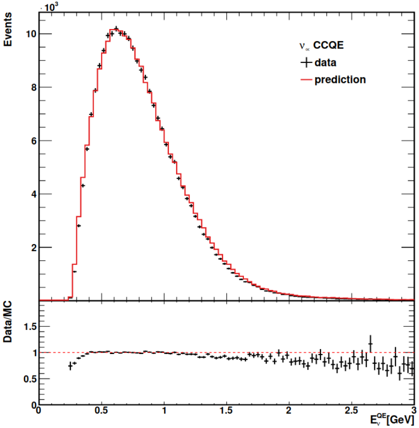


Implications for oscillation experiments

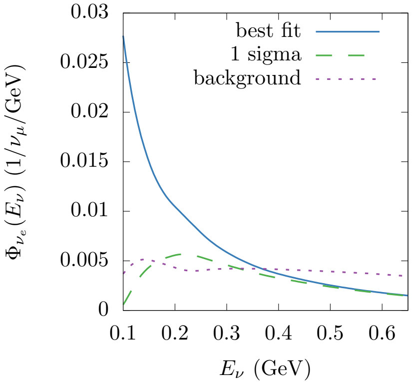
- In [arxiv:2010.05794] discussion of proposed oscillation and exotic search experiments which will rely on KDAR ν_μ and ν_e from $\nu_\mu \to \nu_e$ oscillation. These require input for $E_\nu = 236\ \mathrm{MeV}$ cross sections
- On the other hand: KDAR ν_μ cross section could provide a clean input on effective treatments in low Q^2-regime for oscillation experiments in 100s of MeV range (e.g. MiniBooNE, T2K, ...)
- Constraining model by ν_μ events in same experiment (possibly ND) allows to absorb some flux uncertainty BUT ...
  $\to$ non-trivial overlap of different interaction mechanisms
  $\to$ Oscillated signal not necessarily sensitive to same energy region



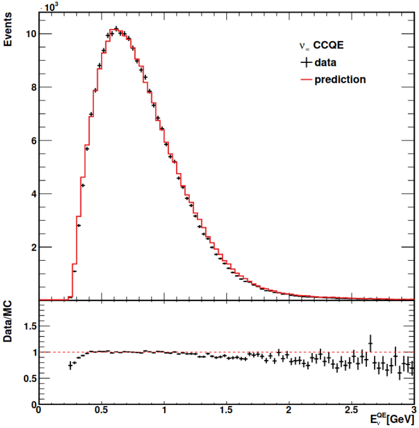
MiniBooNE fit [PRL 121, 221801]

IMPLICATIONS FOR OSCILLATION EXPERIMENTS

- Oscillated signal not necessarily sensitive to same energy region
- MiniBooNE analysis through effective ν_e flux: sensitive to low energy region



flux from best fit in MB peaks at low energy



MiniBooNE fit [PRL 121, 221801]

CONCLUSIONS

- 236 MeV ν_μ cross sections for ^{12}C and ^{40}Ar can be measured by JSNS^2 and MicroBooNE
- Non-trivial kinematic region affected by Pauli-blocking, threshold effects, nuclear uncertainties, ...
  tabularized CRPA responses can be made for several nuclei
- Large overlap with (e, e') data for multiple nuclei (^{12}C, ^{40}Ca, ^{48}Ca, ^{56}Fe, ...) a consistent combined analysis is sensitive to neutrino specific physics
- Relatively 'clean' kinematic region: no overlap of many mechanisms, can mostly be separated in ω and q. Could inform effective treatments of low-Q^2 region.

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