LAr+MPD acceptance vs. E_ν-q0-q3

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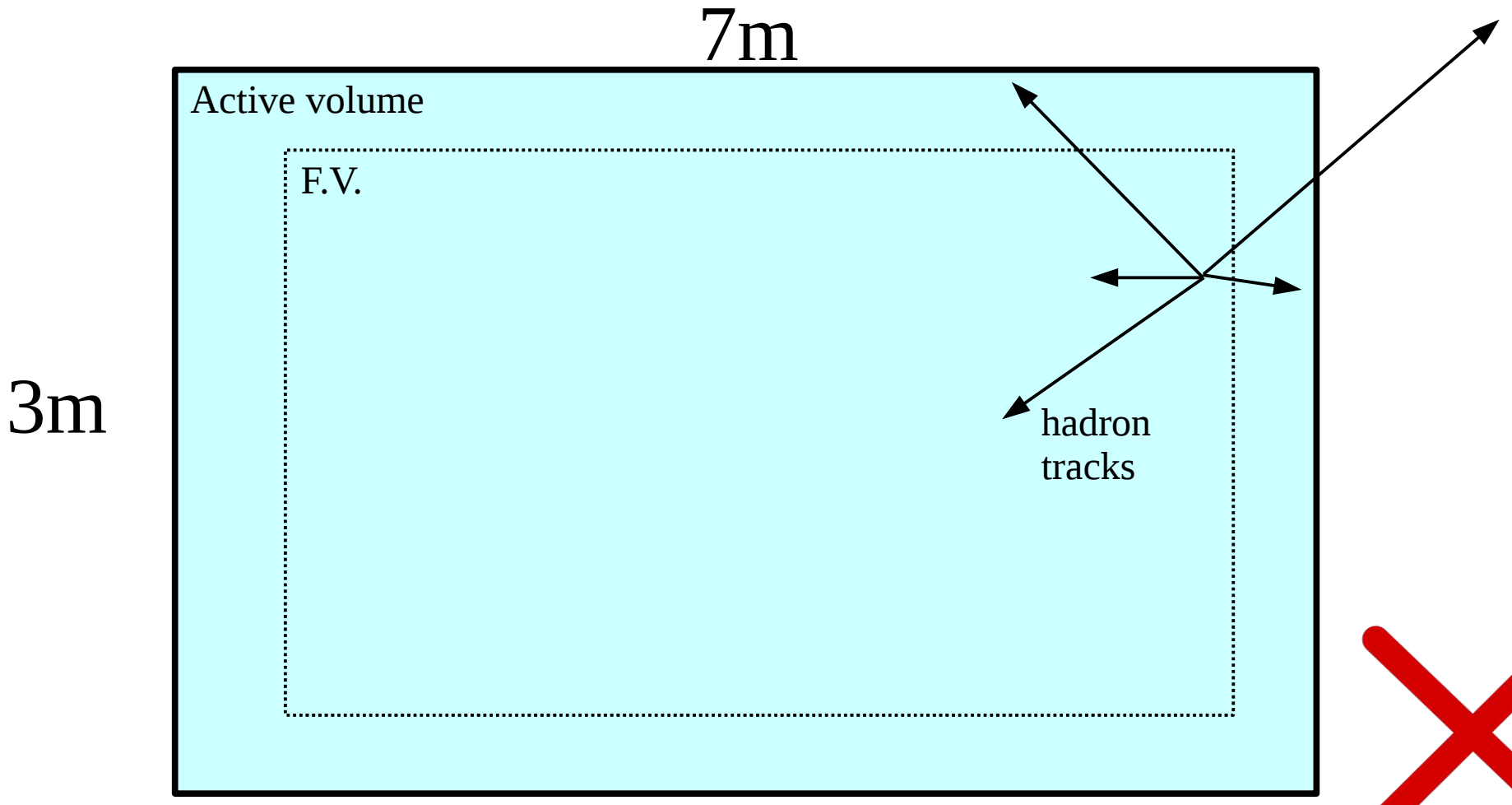
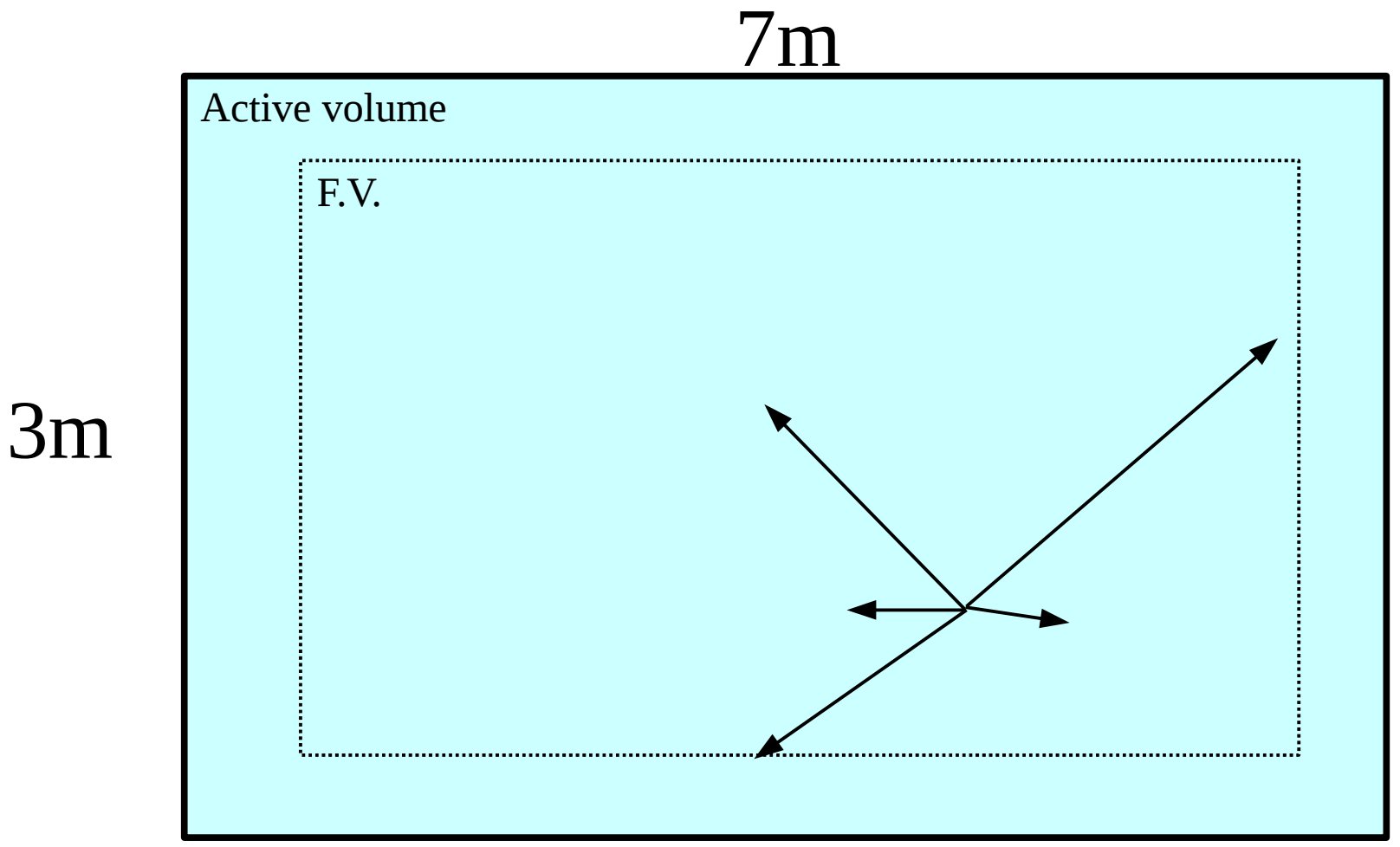
Reminder: LAr acceptance

- LAr detector will have very high event rate, and does not necessarily need high acceptance
- However, it would be very bad if a particular region of phase space had zero acceptance, because then we would have no constraint on that phase space
- Important question is not what is the acceptance, but what fraction of events have non-zero acceptance
- We also want acceptance to be slowly varying vs. kinematics so that it is not sensitive to detector modeling

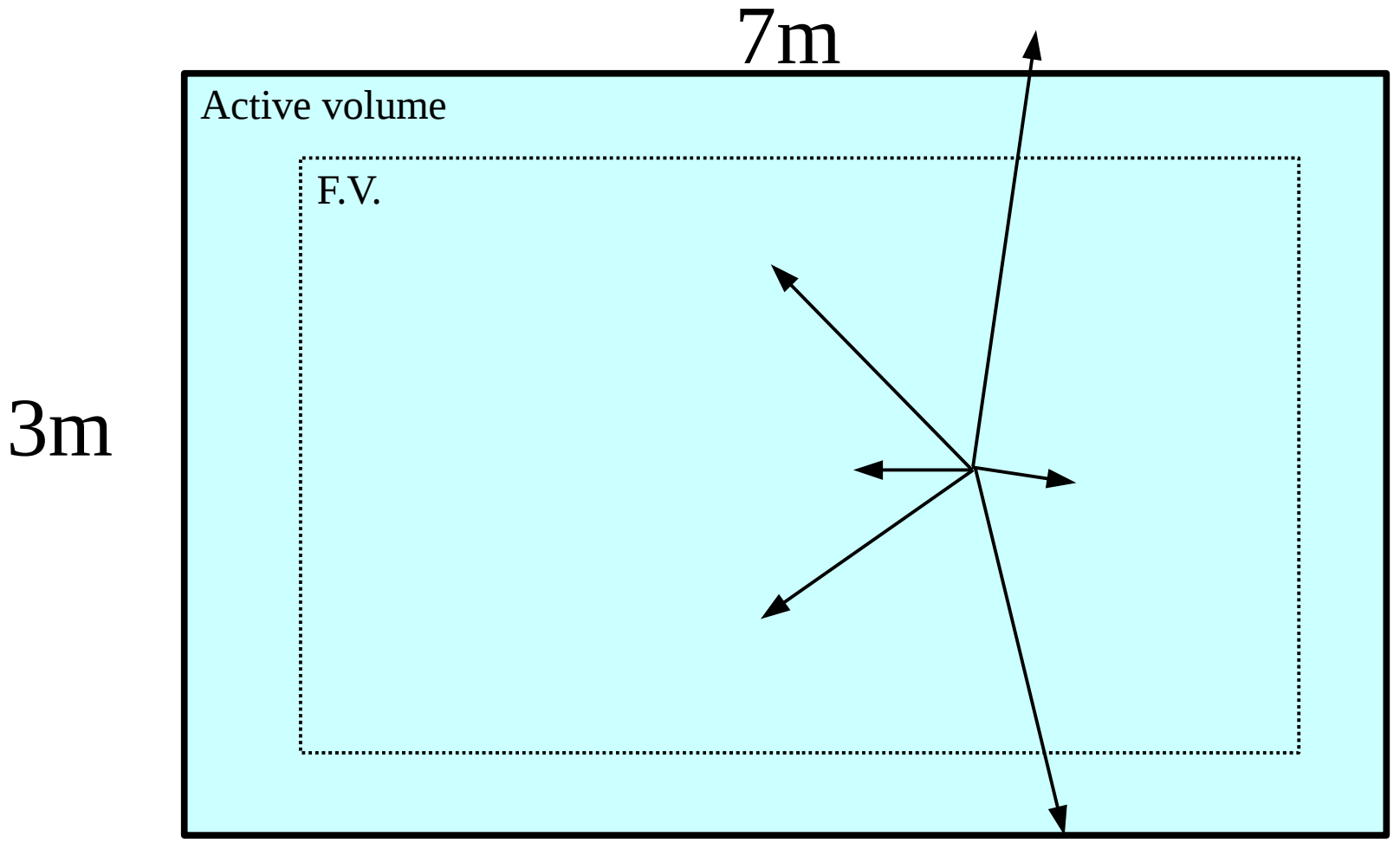
Detector as seen by ν beam (XY projection)



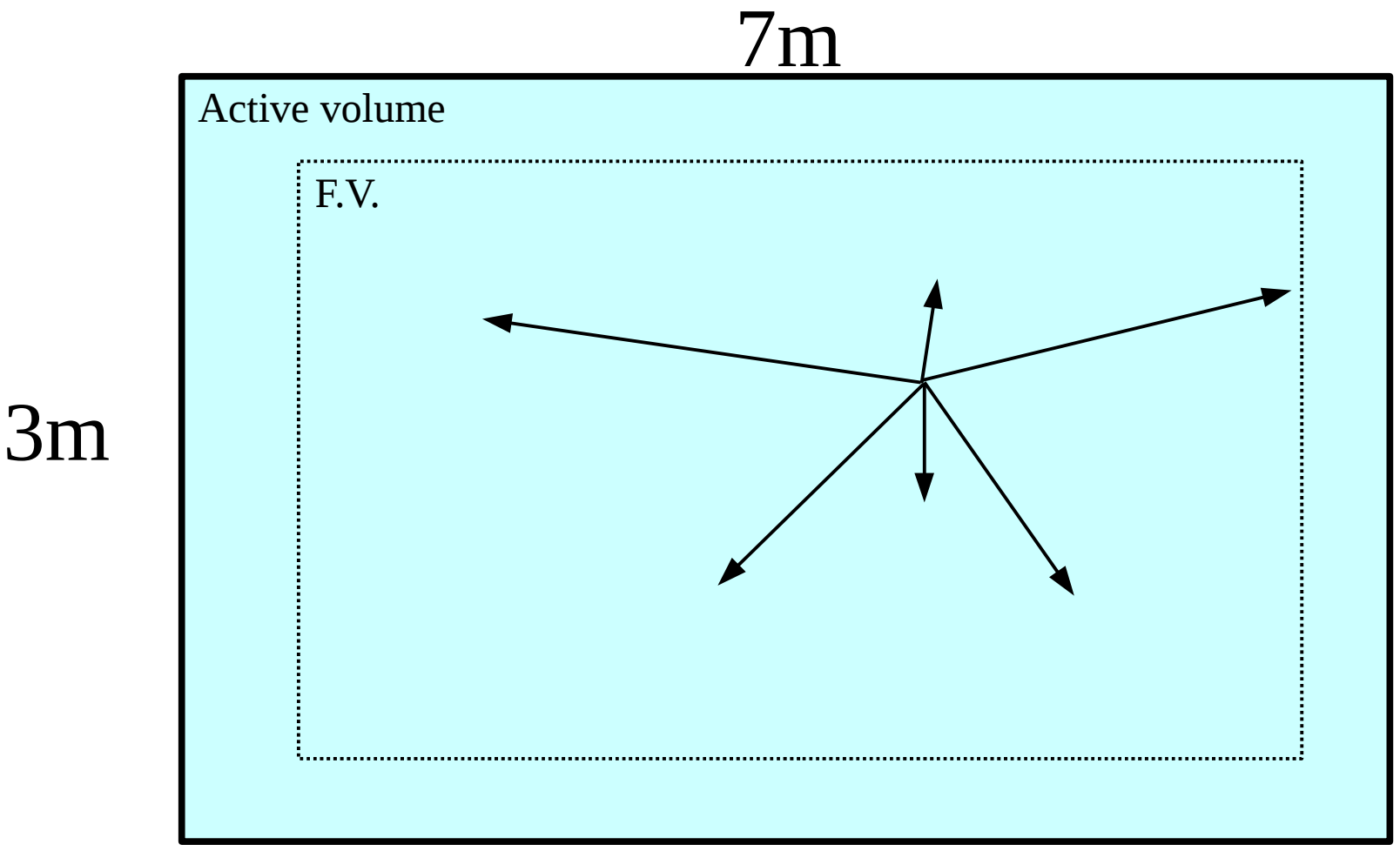
Same event, translated



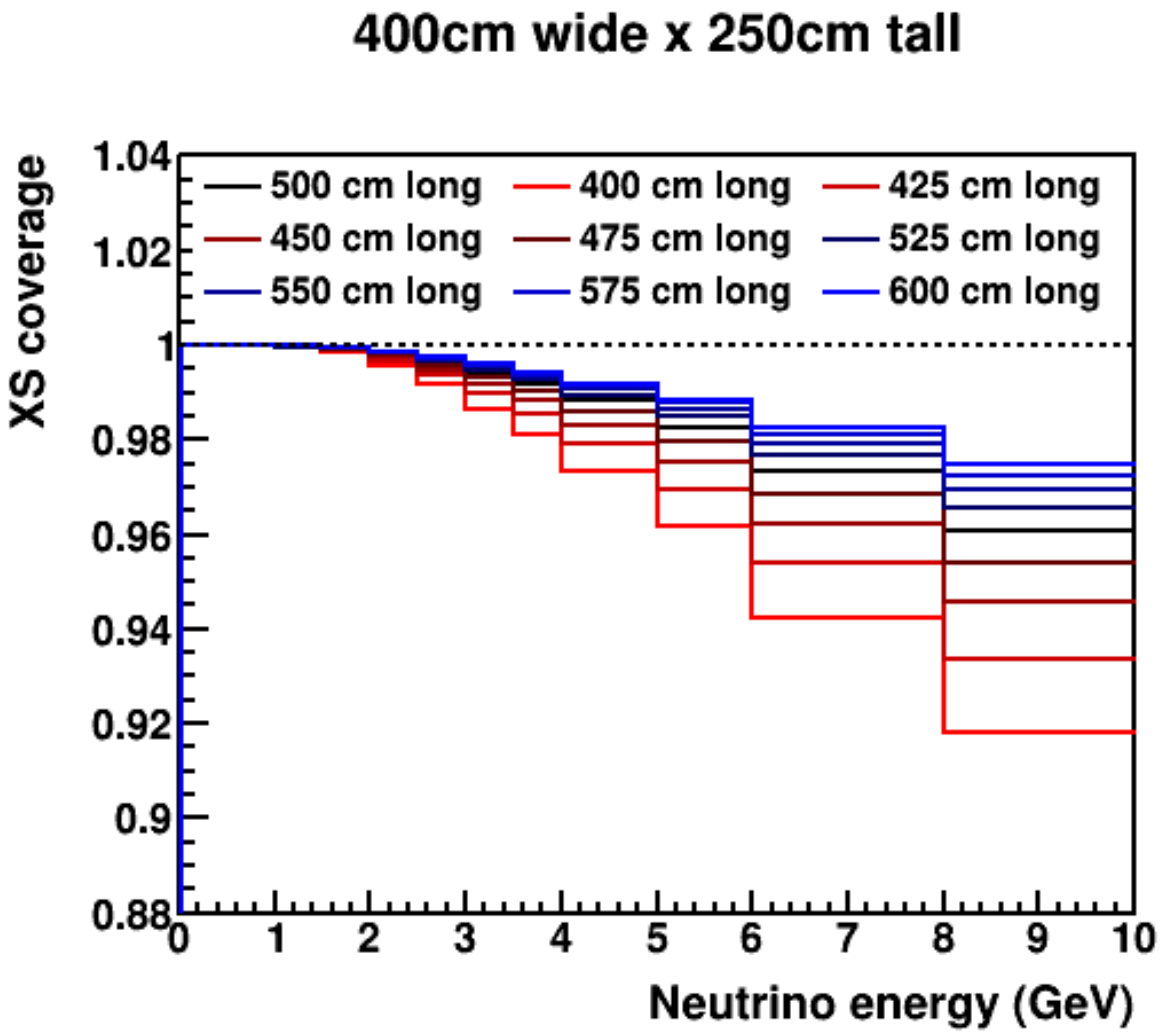
Event that is not contained with any translation



But is using phi symmetry



Plot from previous study



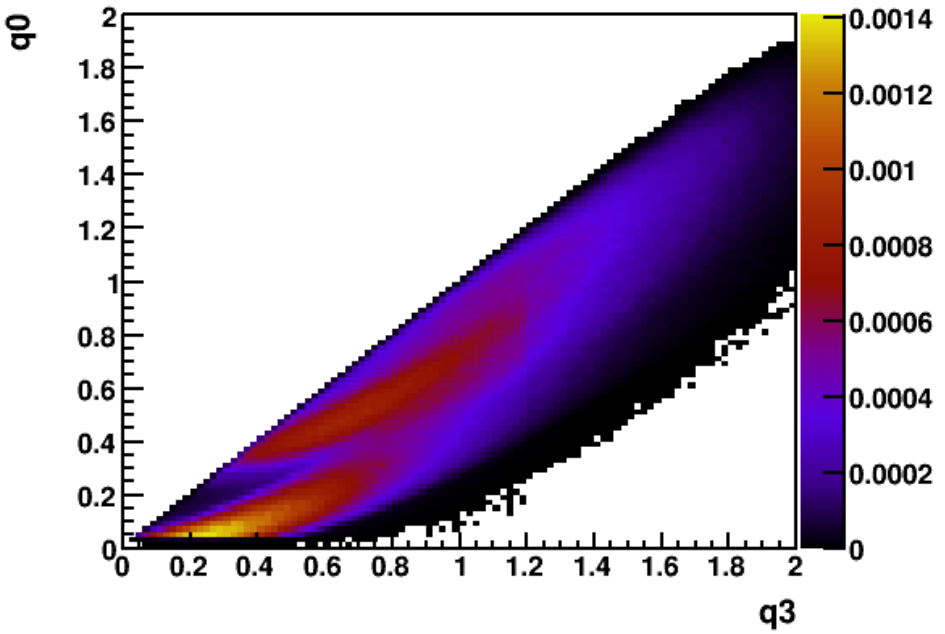
- Shows that cross section coverage is high, and slowly varying vs. neutrino energy for detectors that are >450cm long
- Implies that there are no acceptance holes in the flux peak, because >99% of cross section has non-zero acceptance

Acceptance vs. q0-q3

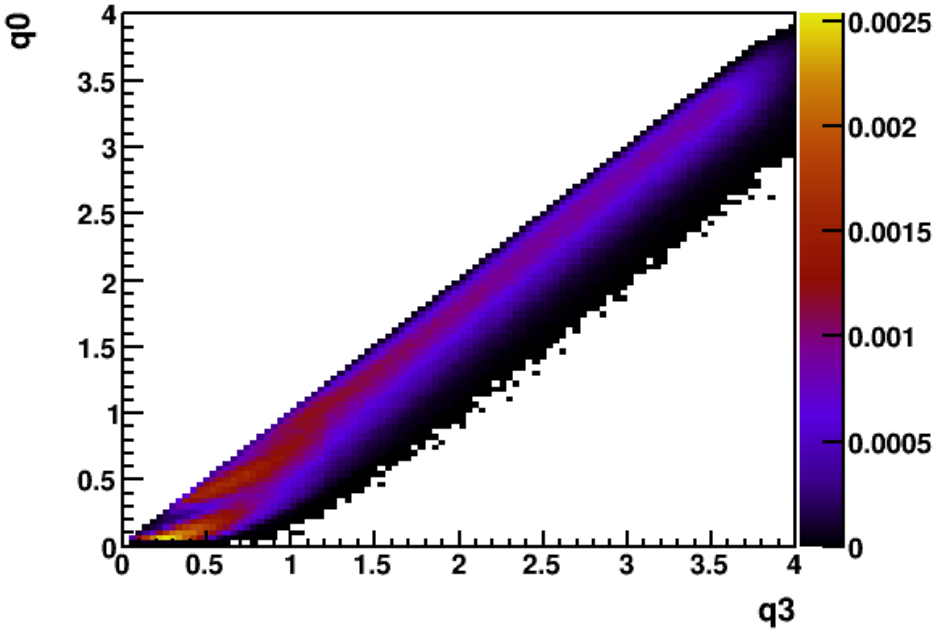
- Reviewer of the ND CDR-lite document suggested that what we should show is acceptance vs. q0-q3 in slices of neutrino energy
- q0 = energy transfer to nucleus
- q3 = 3-momentum transfer to nucleus

q0-q3 distributions

$1 < E_\nu < 2$ GeV

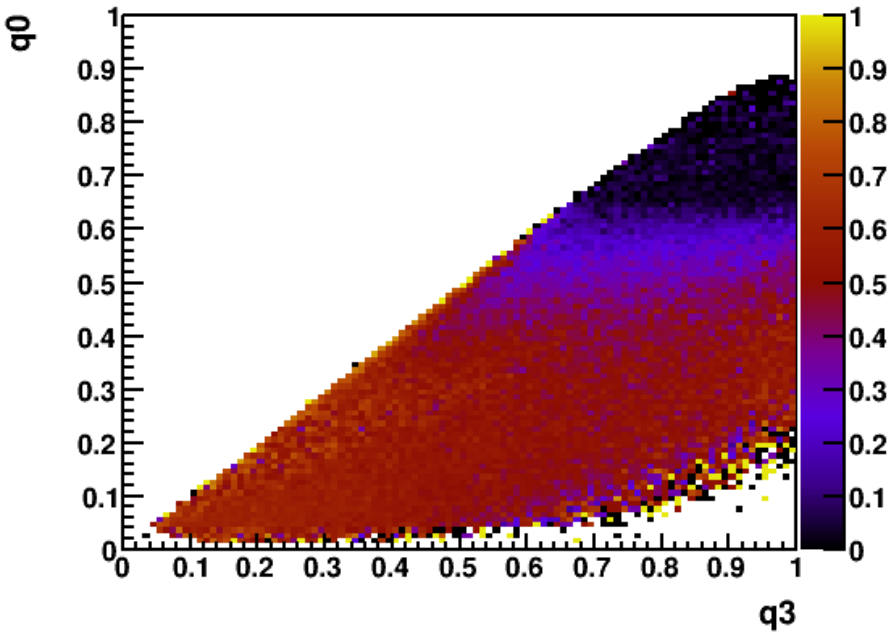


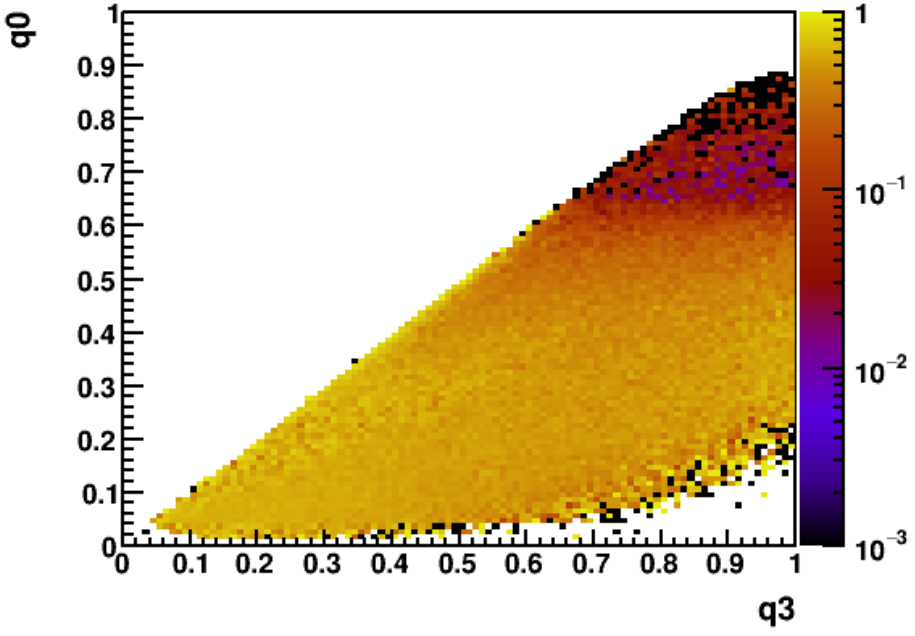
$3.5 < E_\nu < 4$ GeV



- True q0-q3 distributions in GENIE for two slices of neutrino energy
- Two populations at low momentum transfer are CCQE and Δ resonance
- q0=q3 is $Q^2 \rightarrow 0$ kinematic limit
- Lower-right corner is high muon angle

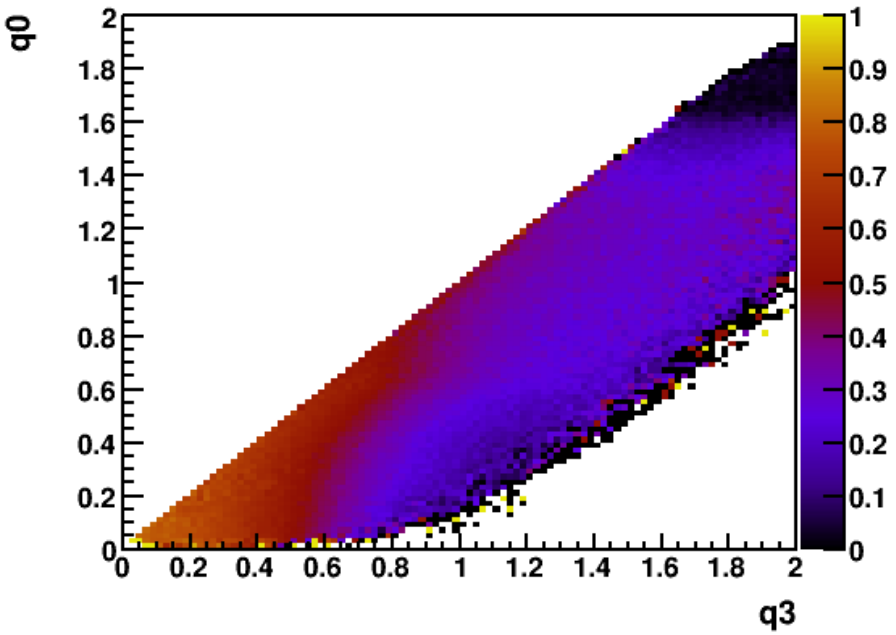
Acceptance: 0 < Eν < 1 GeV

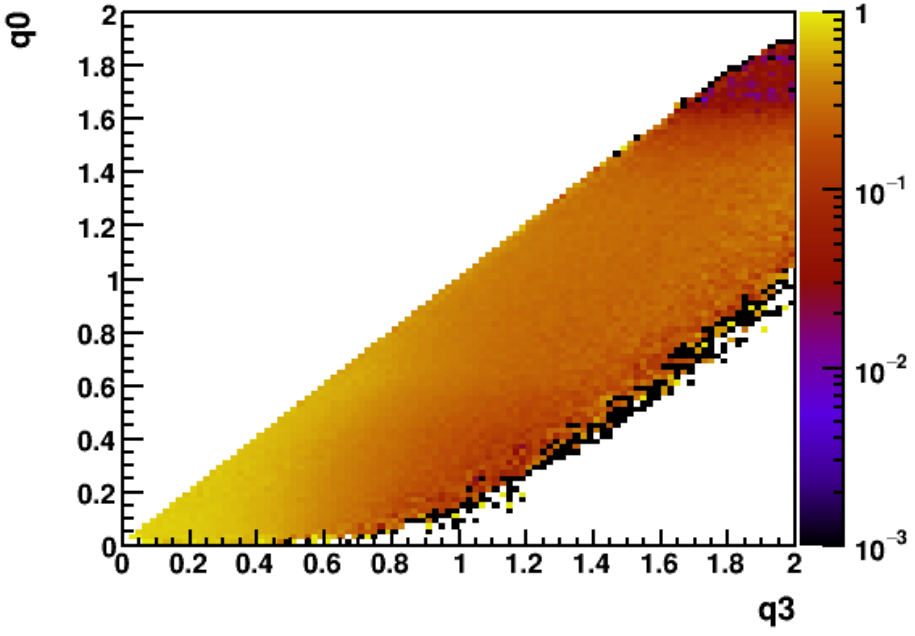




- Caveat: this is actually selected CC ν_μ events, so there is an additional requirement that isn't related to acceptance: the muon must be long enough to identify as a muon and not a pion
- Upper-right corner efficiency is low because muon is very soft

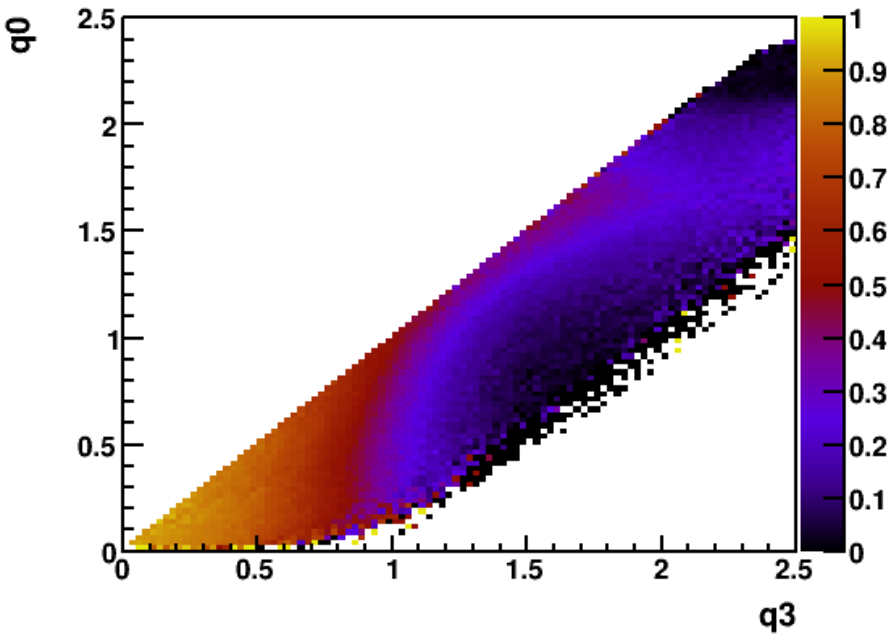
Acceptance: 1 < Eν < 2 GeV

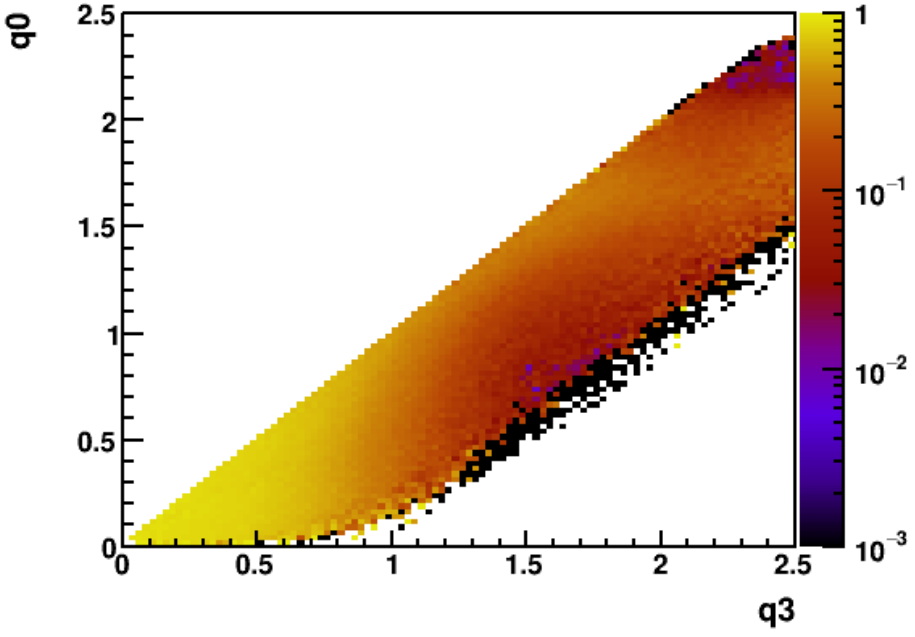




- Black regions on the right plot (log scale) are basically <1% acceptance
- These are effectively “acceptance holes”, but we can't say if it's 1% or 0 with this level of MC statistics

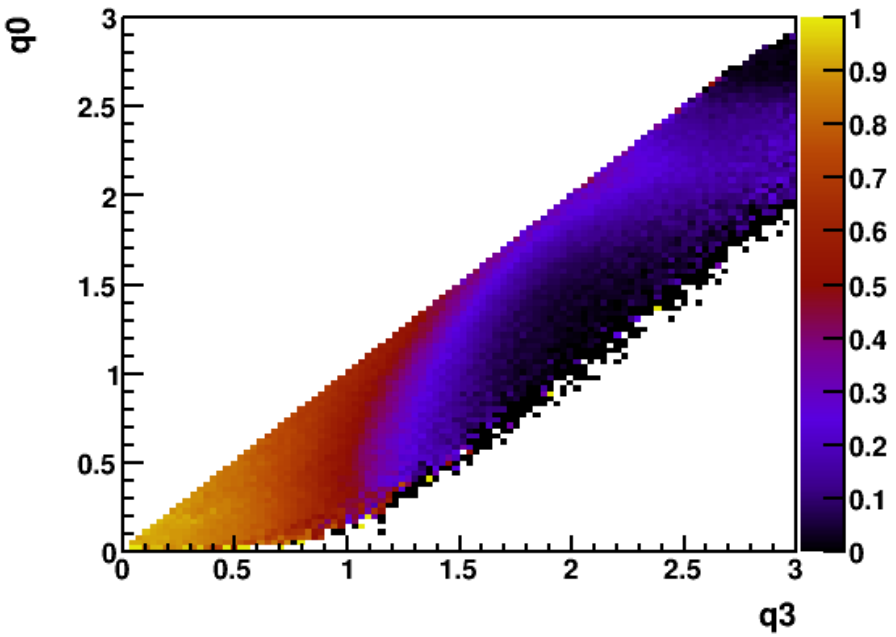
Acceptance: 2 < Eν < 2.5 GeV

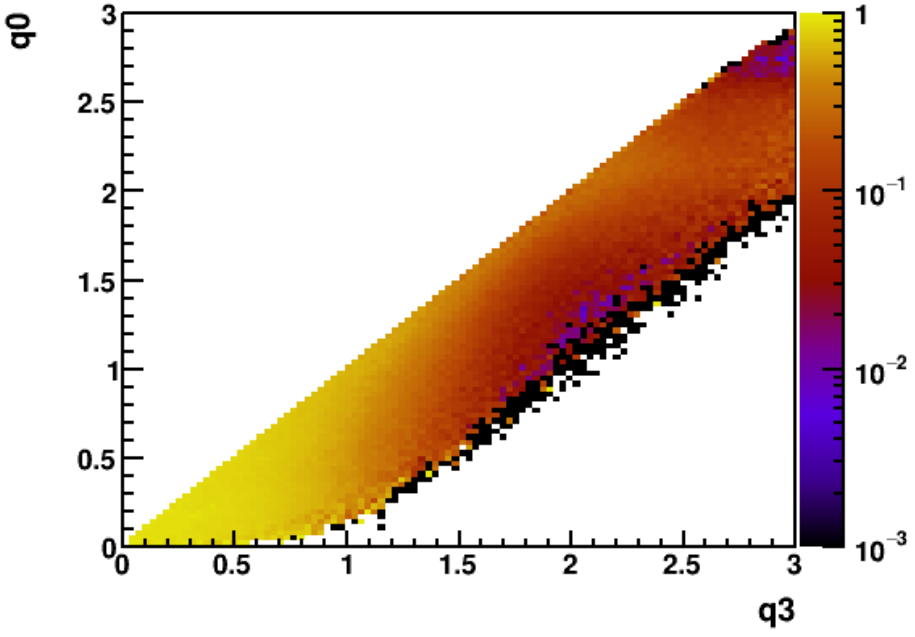




- Basically > few% acceptance everywhere, and very high acceptance at low momentum transfer

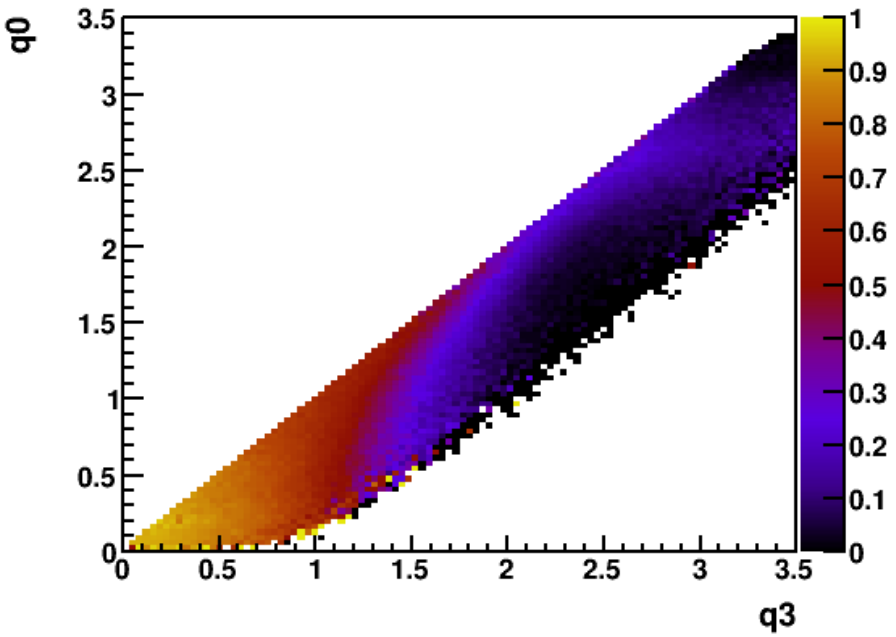
Acceptance: 2.5 < Eν < 3 GeV

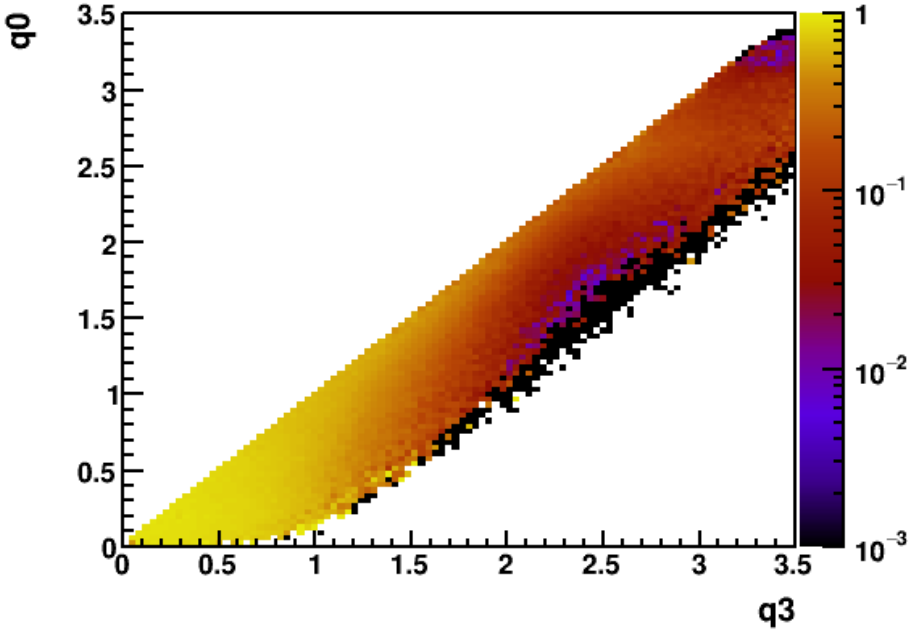




- Basically > few% acceptance everywhere, and very high acceptance at low momentum transfer

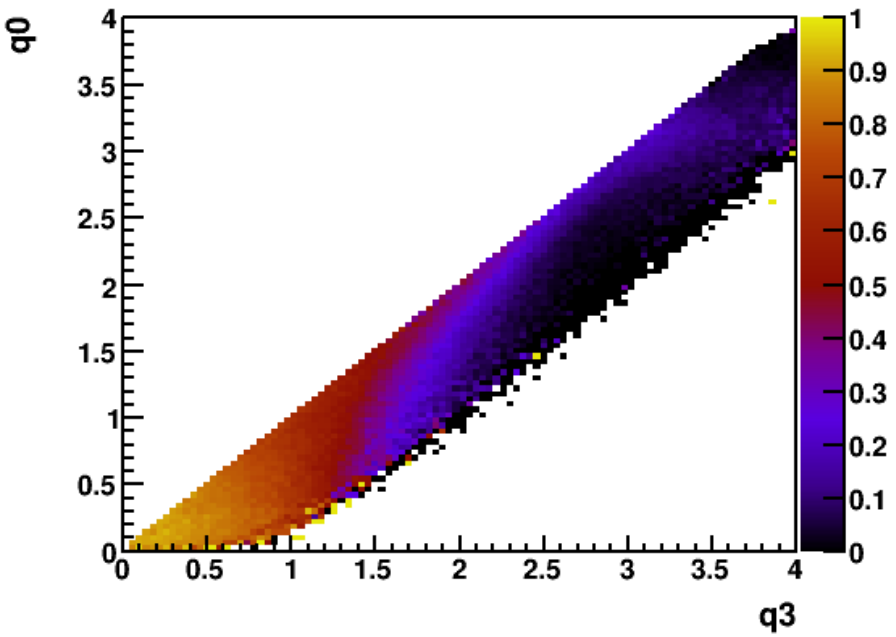
Acceptance: 3 < Eν < 3.5 GeV

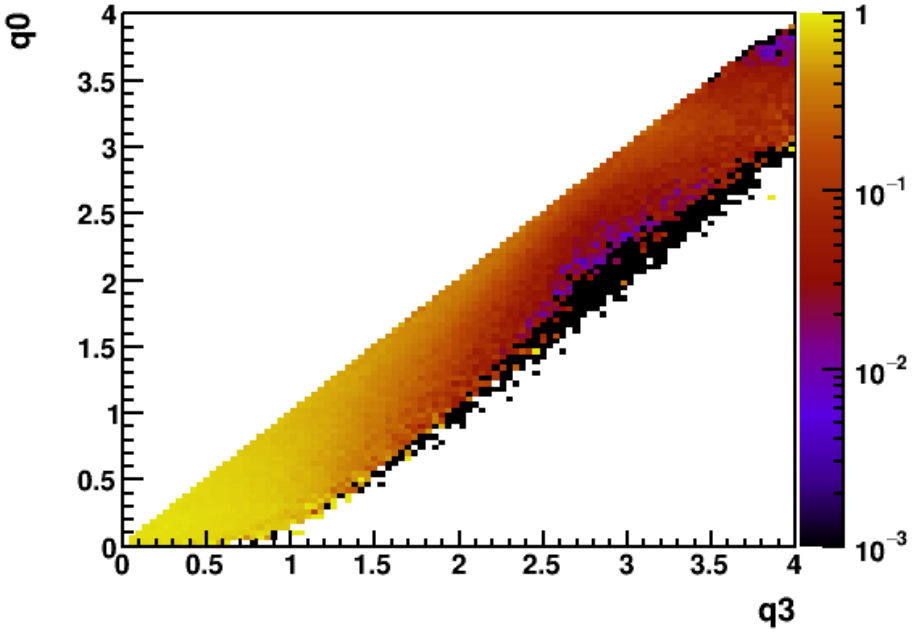




- Basically > few% acceptance everywhere, and very high acceptance at low momentum transfer

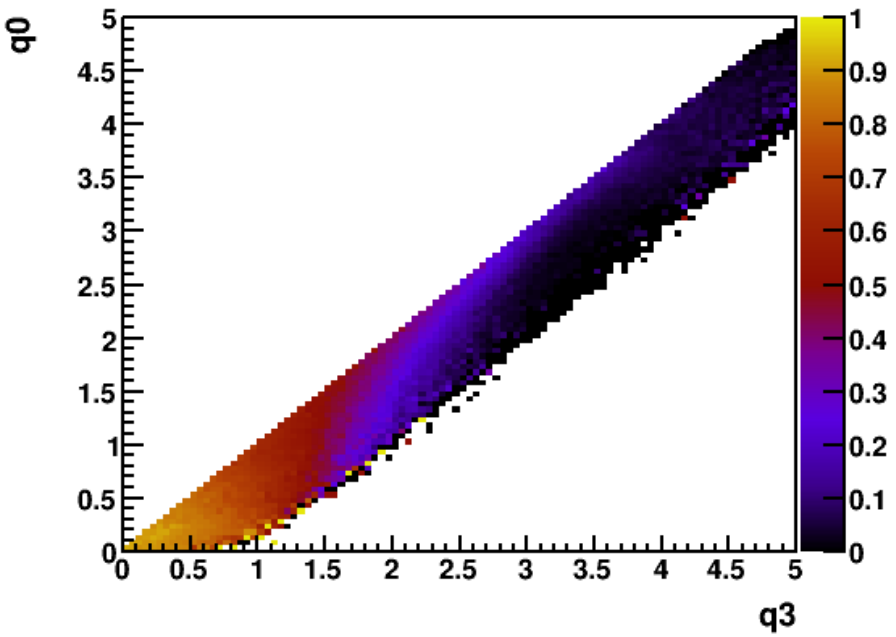
Acceptance: 3.5 < Eν < 4 GeV

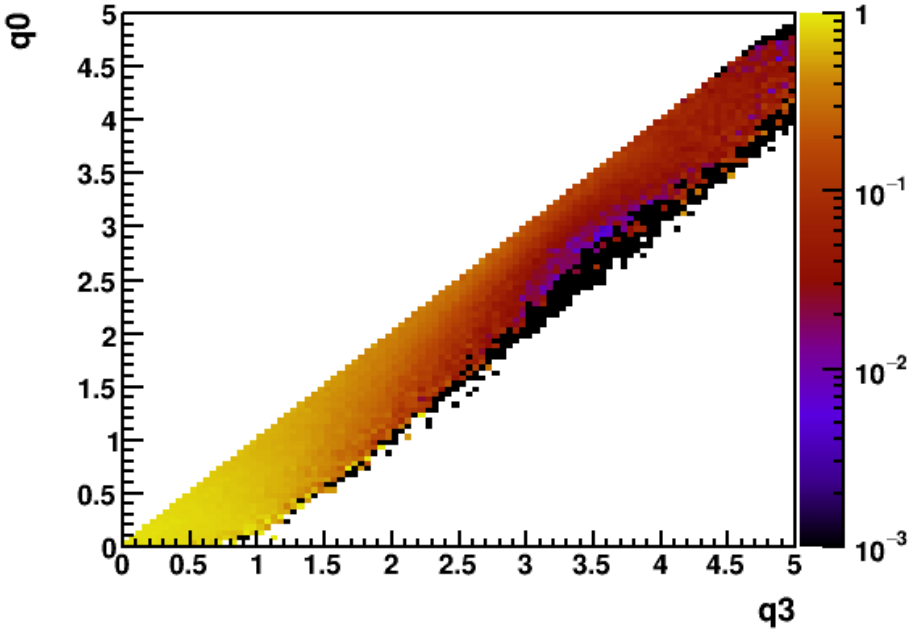




- Basically > few% acceptance everywhere, and very high acceptance at low momentum transfer

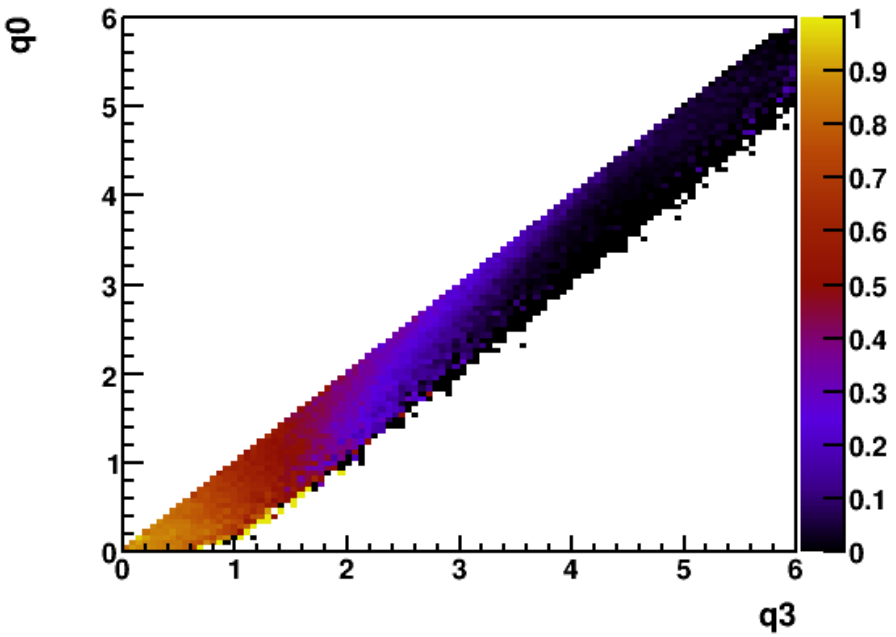
Acceptance: 4 < Eν < 5 GeV

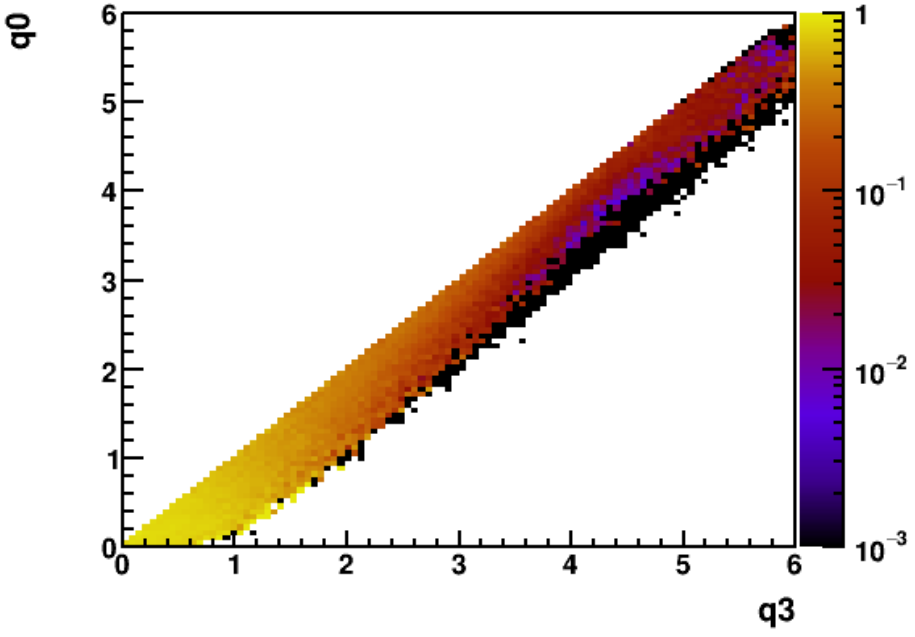




- Basically > few% acceptance everywhere, and very high acceptance at low momentum transfer

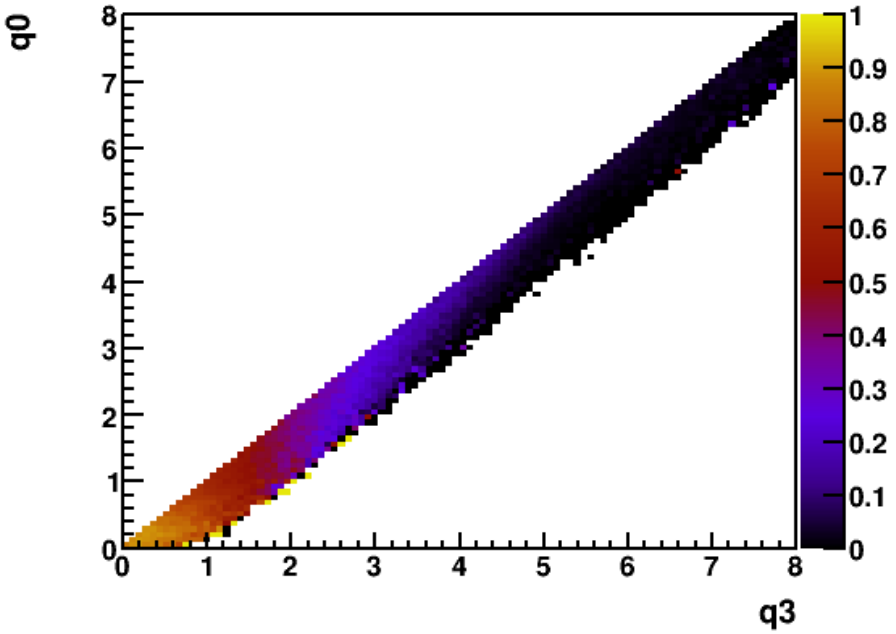
Acceptance: 5 < Eν < 6 GeV

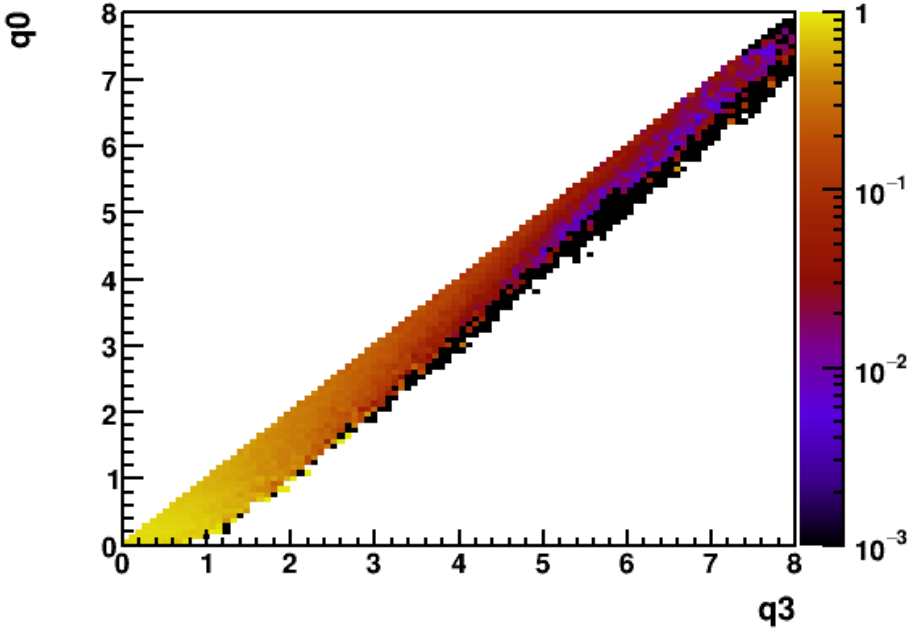




- Basically > few% acceptance everywhere, and very high acceptance at low momentum transfer
- Small hole at high muon angle, but very, very few events

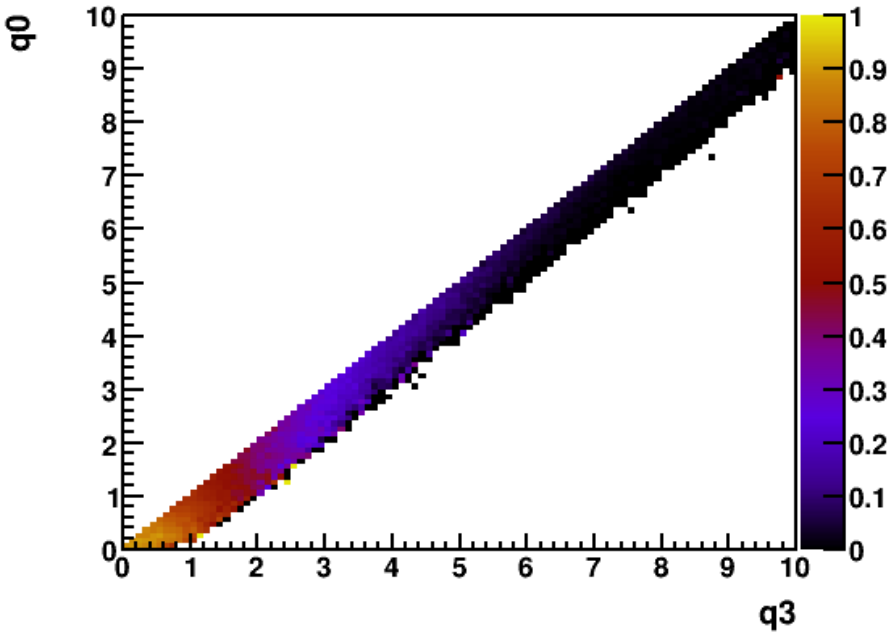
Acceptance: 6 < Eν < 8 GeV

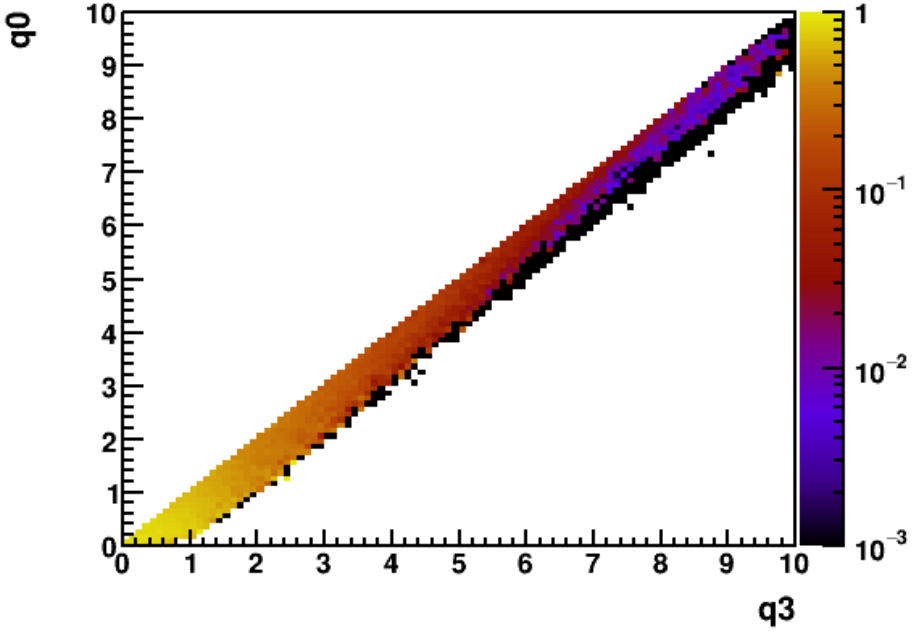




- Basically > few% acceptance everywhere, and very high acceptance at low momentum transfer
- Small hole at high muon angle, but very, very few events

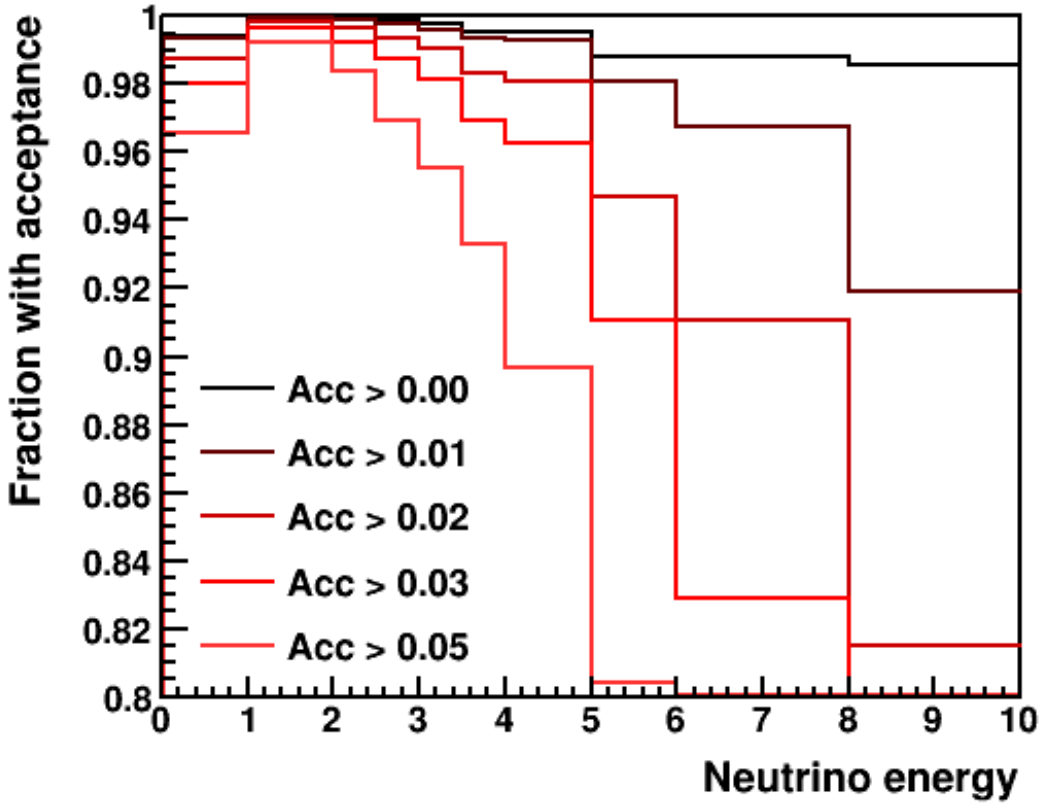
Acceptance: 8 < Eν < 10 GeV





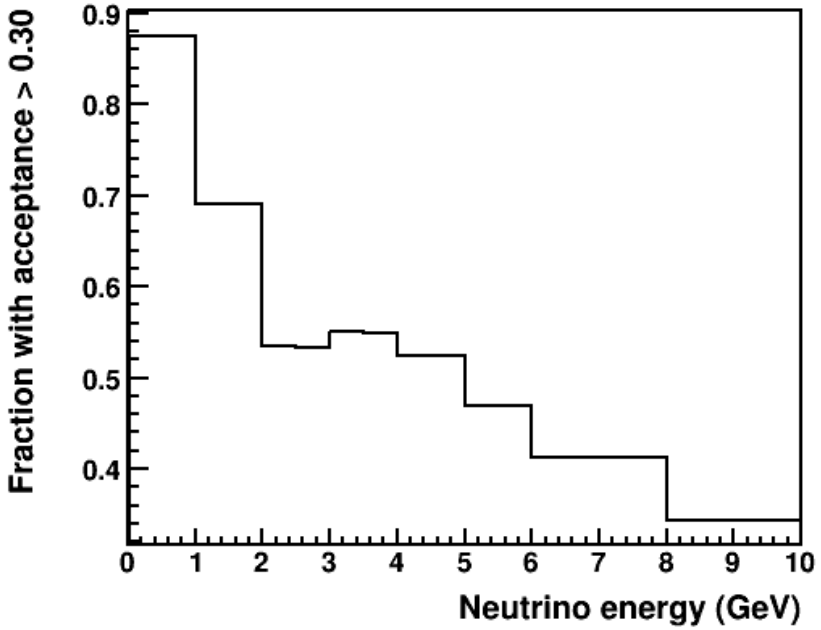
- Basically > few% acceptance everywhere, and very high acceptance at low momentum transfer
- Small hole at high muon angle, but very, very few events

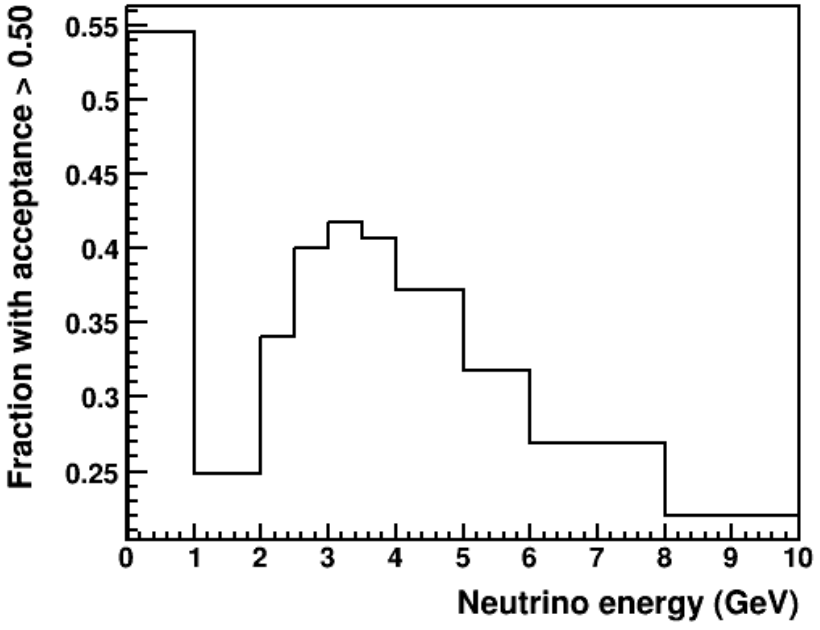
Fraction of events in Eν-q0-q3 regions with acceptance



- >99% have non-zero acceptance out to 10 GeV
- >98% have >2% acceptance out to 5 GeV

Acceptance is high in peak region





- Acceptance is >30% for most q0-q3 regions in the flux peak, and >50% for a lot of the space

Conclusions

- 7x3x5m detector has no significant acceptance holes, including muon + hadron containment
- Acceptance vs. q0-q3 is high in region where most events are, and has a region of low acceptance at high Q2 and higher neutrino energy
- Most of the cross section is in phase space with high acceptance