DUNE-PRISM Physics Goals

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DUNE-PRISM Engineering Meeting

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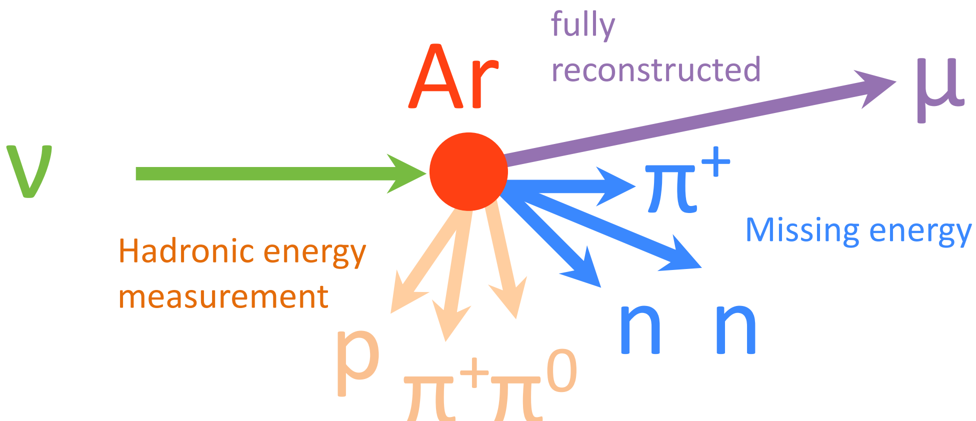
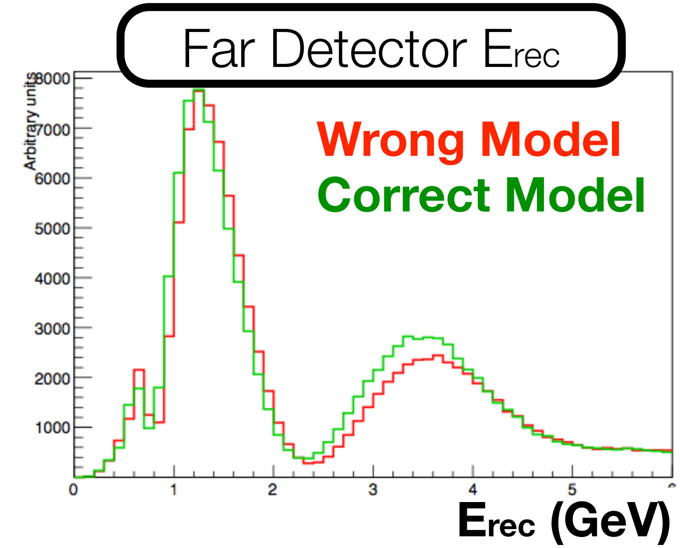
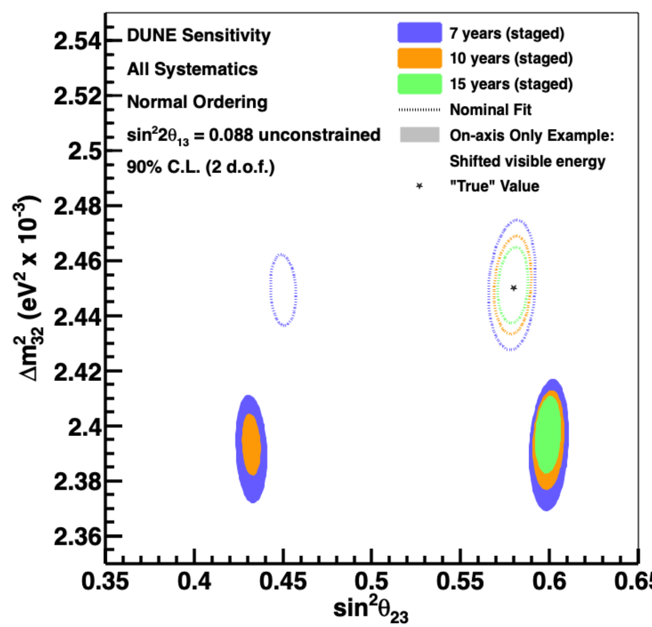
The E_ν Measurement Problem



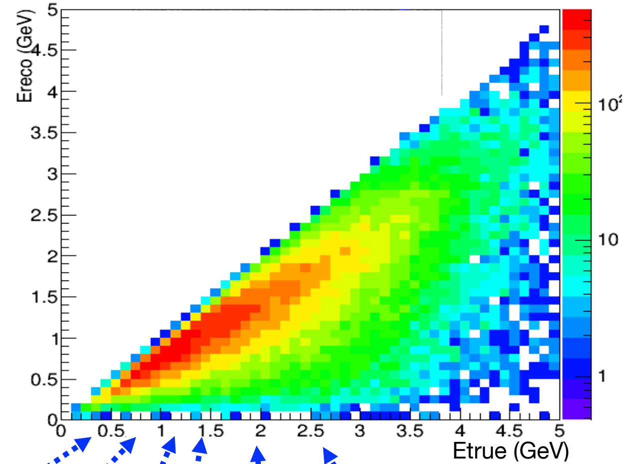


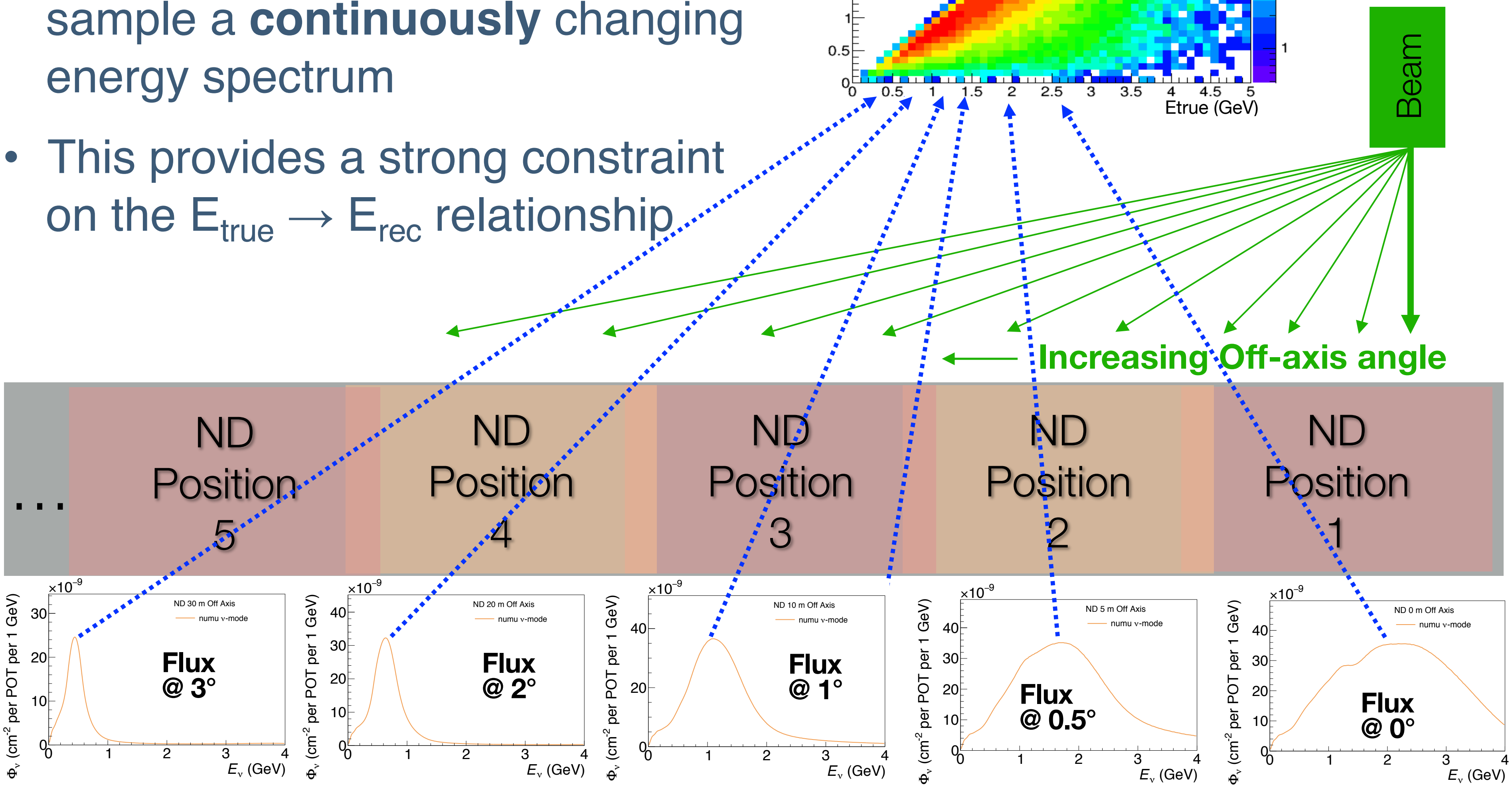
- It is very difficult to measure neutrino energy (E_ν) by looking at the particles we can measure
  - Much of the energy is missing
- We try to model the relationship between E_ν and what we see, but our models are not very accurate
- With a near detector that only sits in 1 position, it is possible to construct a model that matches our near detector data, but still incorrectly predicts what we should see at the far detector
  - This causes us to get the wrong answer for the main parameters we are trying to measure



DUNE-PRISM

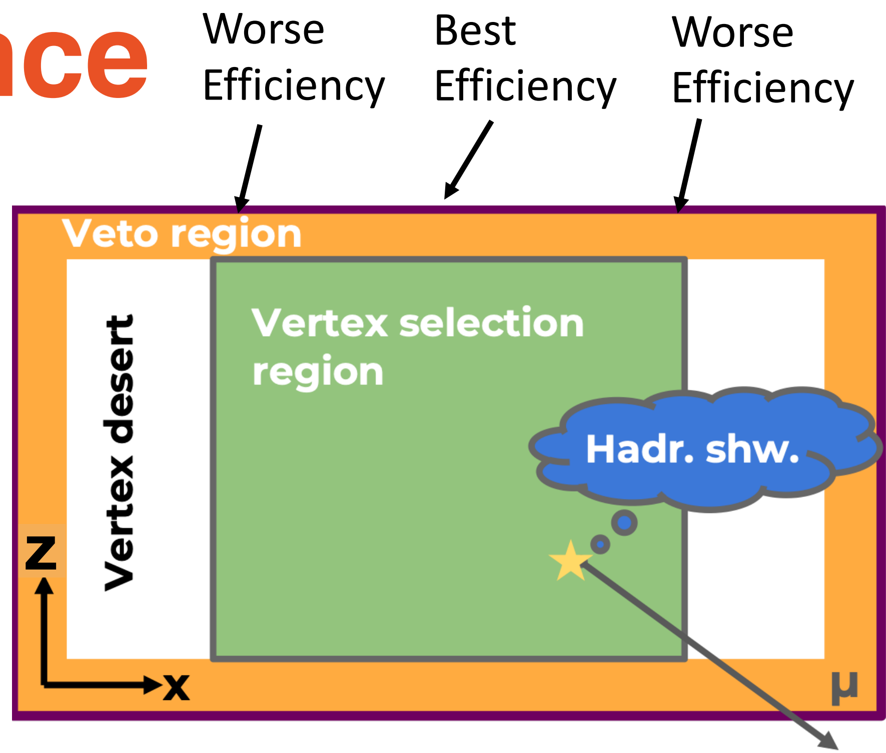
- By changing the off-axis angle of the detector, it is possible to sample a **continuously** changing energy spectrum
- This provides a strong constraint on the $E_{true} \rightarrow E_{rec}$ relationship



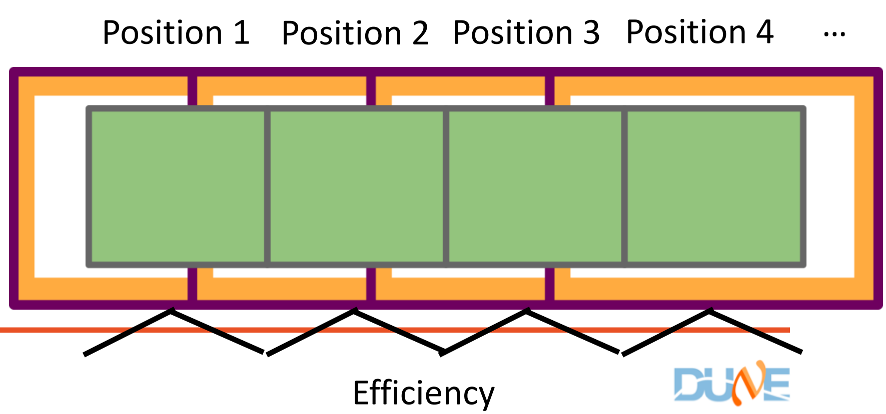


Detector Acceptance

- We have to reject events with hadronic energy in outer ~30 cm
  - Otherwise, we can't guarantee that we've contained all of the energy
- This means that events near the edge of the detector have worse efficiency
  - This is not desirable, since our ability to correct for this effect depends on the same poor models we are trying to avoid
- This means we don't want to repeatedly put the detector in the same off-axis positions
- The requirement is be able to place the detector in an arbitrary position to within 1 cm, and to be able to measure the detector position to within 1 mm



Configuration with the Least Number of Detector Stop Positions



Detector Movement

- To cover the full off-axis range in 1 year, we would likely need to move the detector weekly
  - From a physics point of view, more positions = smoother efficiency
  - In the continuum limit, we would ideally take data while the detector is moving (what is the minimum speed with which we can move?)
- Our working requirement is to be able to stop data taking, move the detector to any new position, and begin taking high quality physics data within an 8 hour shift
  - Need to minimize movement preparation time, and startup time at new location (e.g. MPD magnet may need to be ramped down and back up)
  - Design goal: avoid disturbing the detector as much as possible for a move (i.e. avoid connecting/disconnecting, shutting off systems, etc.)
- Assuming 1 hour before and after the move, this leaves 6 hours to move a maximum of 30.5 m (30 m / 5 hr = 10 cm/min)
  - Accelerations should be gentle to avoid disturbing the detectors, which helps to minimize the startup time at a new location (and to avoid sloshing)
- The LAr and MPD must maintain their relative alignment to ~1 mm

DUNE-PRISM “Wishlist” Summary

- Max speed: ~10 cm/min (30 m in 5 hours); depends on movement preparation time
  - Min speed? 1 cm/min? 1 mm/min?
- Acceleration: gentle ramp up, reaching top speed over several minutes
  - No “jerking” behavior
- Vibrations: “minimized”; minimal disruption to detector systems during movement
  - Must minimize downtime due to detector “ramp down”, and in getting detectors ready to take physics-quality data at a new location (depends on detector operation details)
  - e.g. possibly implement “brushes” to clean the rails as the detector moves
- Positioning: placement to within 1 cm; position determination to within 1 mm
  - We will almost certainly want a laser positioning system
  - Both platforms (LAr + MPD) must stay synchronized to ~1 mm
- Movement frequency: at least weekly
  - Fully automated (no person present; can be moved from the external control room)
- Monitoring: must ensure no relative displacement of detector components before/after movement

Backup

Example Run Plan

- The DUNE-PRISM run plan has not yet been optimized
  - Working assumption of 50% running on-axis (e.g. for sufficient statistics for nu-e elastic scattering flux constraint)
  - 50% off-axis, split between off-axis positions
- Low backgrounds and high statistics in each off-axis position

		Liquid				Gas
		All int.	Selected			All int.
Stop	Run duration	$N\nu_\mu CC$	NSel	WSB	NC	$N\nu_\mu CC$
0 m	1/2 yr.	22.2M	9.8M	0.2%	1.6%	590,000
4 m	1/16 yr.	2.4M	1.2M	0.3%	1.2%	63,000
8 m	1/16 yr.	1.4M	690,000	0.4%	1.1%	37,000
12 m	1/16 yr.	680,000	340,000	0.8%	0.9%	18,000
16 m	1/16 yr.	370,000	190,000	1.0%	0.8%	10,000
20 m	1/16 yr.	220,000	110,000	1.3%	0.9%	6,000
24 m	1/16 yr.	140,000	68,000	1.8%	0.8%	4,000
28 m	1/16 yr.	95,000	44,000	2.2%	0.9%	3,000
32 m	1/16 yr.	68,000	30,000	2.5%	0.9%	2,000

NSel = Number of Selected events

WSB = wrong-sign background

NC = neutral current

Geometrical Efficiency Correction

- Model dependence can be further reduced by empirically determining the efficiency of each event
- Every observed event can be rotated about the neutrino direction, and translated within a logical off-axis slice
  - “Efficiency correction” = probability to detect the event
- A model-based correction is needed for events that would never be seen in the ND
  - (applies to all near/far analyses)