Beam Window Impact on Physics Program

Will degrade knowledge of incident beam properties

- Incident beam energy
  - ► Energy loss in material upstream of active volume
- Incident particle ID
  - ► MisID from untagged showering/interacting particles.
- Survival rate affects samples at lowest energies.

Requirements Table

Particle	Momenta (GeV)	Exposure	Purpose
π^+	0.2, 0.3, 0.4, 0.5, 0.7, 1, 2, 3, 5, 7	10K	hadronic cal, π^0 content
π^-	0.2, 0.3, 0.4, 0.5, 0.7, 1	10K	hadronic cal, π^0 content
π^+	2	600K	π^o/γ sample
proton	0.7, 1, 2, 3	10K	response, PID
proton	1	1M	mis-ID pdk, recombination
e^+ or e^-	0.2, 0.3, 0.4, 0.5, 1, 2, 3, 5, 7	10K	e-γ separation/ EM shower
μ^-	(0.2), 0.5, 1, 2	10K	E_μ, Michel el., charge sign
μ^+	(0.2), 0.5, 1, 2	10K	E_μ, Michel el.,charge sign
μ^- or μ^+	3, 5, 7	5K	E_μ MCS
antiproton	low-energy tune	(100)	antiproton stars
K^+	1	(13K)	response, PID, pdk
K^+	0.5, 0.7	(5K)	response, PID, pdk

Table 1: Requirements summary table (nominal beam direction).

- Response measurements in the lower energy region ($<$1 GeV) are important for the physics program and will be the most affected by upstream materials.

Impact on Measurements

What studies are needed to assess the impact on measurement capabilities and precision?

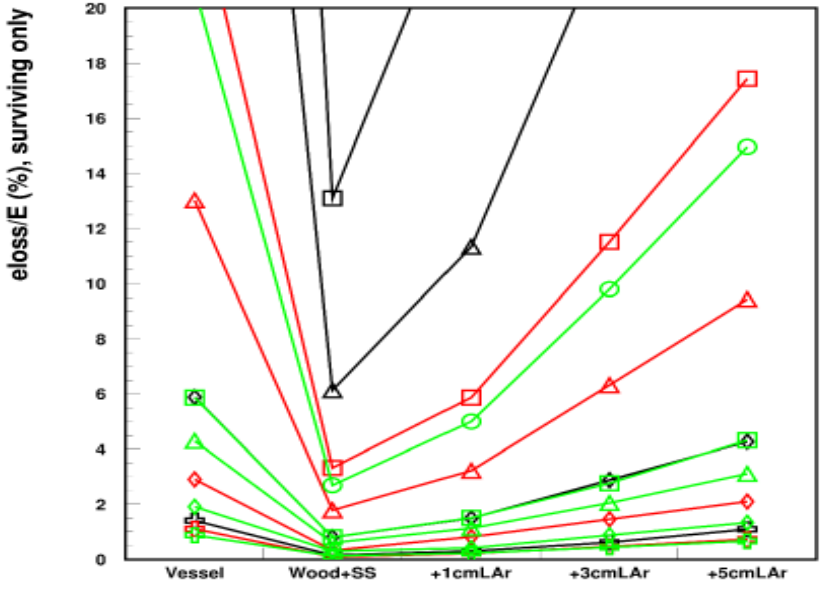
- What is a tolerable uncertainty on our knowledge of energy loss in upstream materials and can it be achieved ?
  - ▶ What will be the uncertainty on the material budget & simulation model.
  - ▶ Do we need a standalone beam window energy loss measurement?
- Can we effectively tag (and remove) particles which interact and shower upstream of fiducial volume?
  - ▶ Especially important for protons and kaons -PID studies.
- Impact of reduced particle survival fractions at low energies.

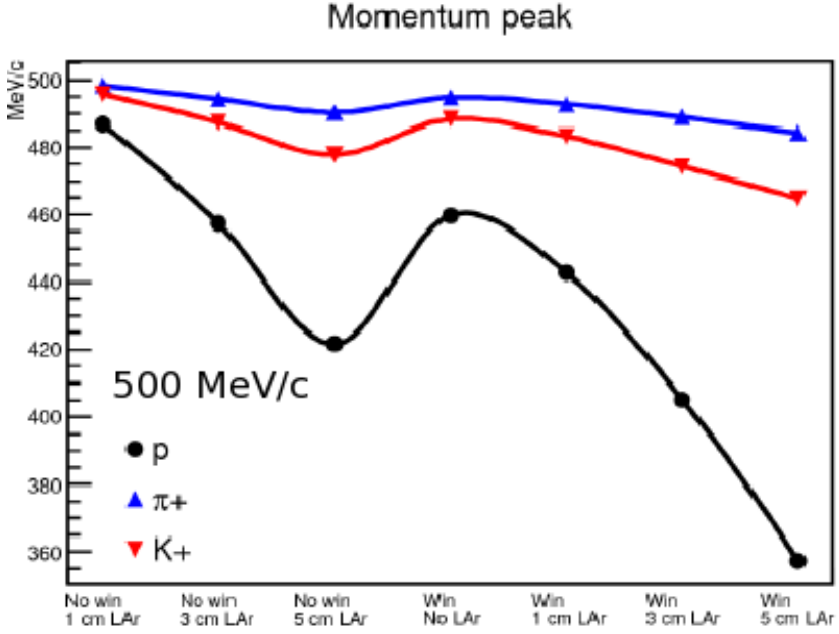
Tolerable energy loss uncertainty

- Energy scale uncertainties for DUNE oscillation measurements (effects studied for 1%, 2%, 5%) set the benchmark.
- Assumption in proposal $\rightarrow$ Beam absolute momentum scale on the order of 1% can be attained.
  - ▶ Contribution from energy loss uncertainty should be kept below this level.

Studies Underway

- P. Sala Fluka-based (left: Key △ p, △ K, △ π)) and M. Kramer GEANT4-based (right)





- Compare for 500 MeV/c particles- DIFFERENT window composition (but primary effect is from 1.2mm SS which both include) + same thicknesses LAr.

	(p)	K	π	(p)	K	π
+1 cm Ar	6%	3%	1%	12%	3%	1%
+3 cm Ar	11%	6%	2%	18%	4%	2%
+5 cm Ar	$>$20%	9%	3%	28%	6%	3%

- Design choices that minimize LAr dead space are desired.

Studies need to converge rapidly

- **Comparison with the same materials**
- **Compare relevant energies**
  - **protons: 700 MeV, 1 GeV**
  - **Kaons: 1 GeV, (500 MeV, 700 MeV)**
  - **π: 200 MeV, 300 MeV, 400 MeV, 500 MeV**
  - **e: 200 MeV, 300 MeV, 400 MeV, 500 MeV**