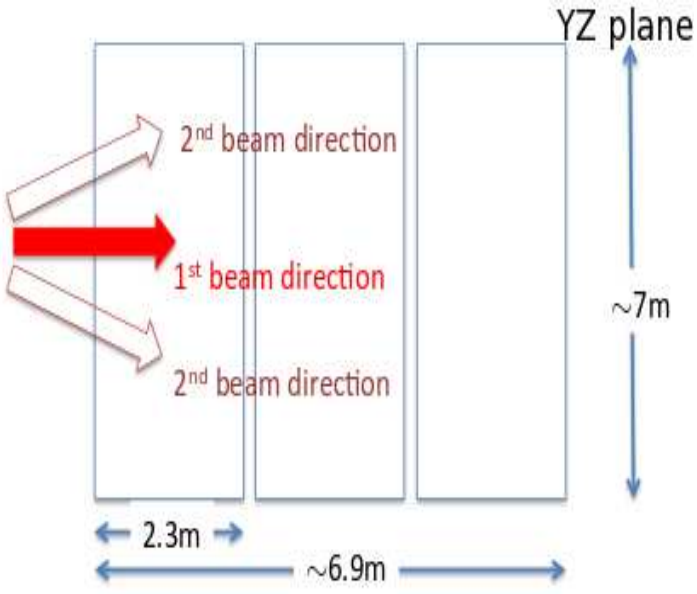
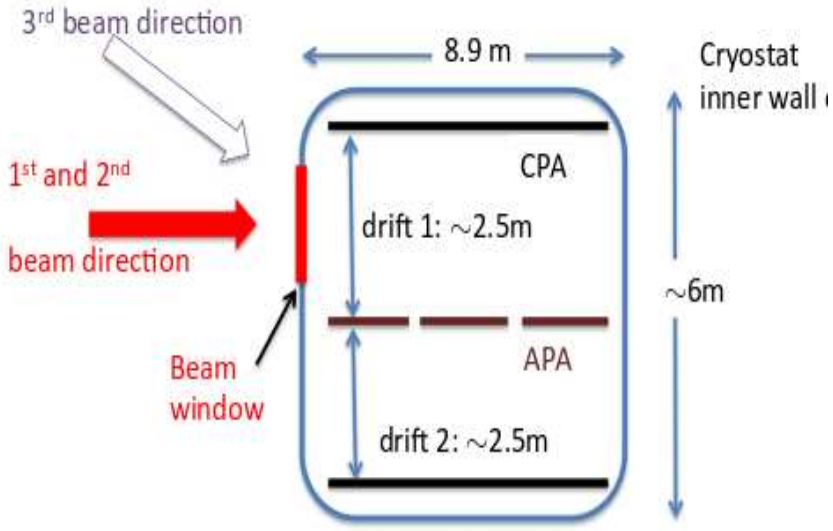
Discussion of Default Geometry





Specify default configuration

- Working assumption: Primary beam direction is horizontal and normal to drift direction (angle in YZ plane possible).

Are there reasons for a different default configuration?

- Containment (NO).
- Reconstruction (YES) - nominal beam direction should not be parallel to APA plane. Design in a small (few degrees) out of plane angle.

Default Geometry (Containment)

Comparison of three studies:

- JI - Jonathan Insler DOCDB 10023, 10115 (based on all truth information).
- JH - Junting Huang (Lariat design paper arXiv:1406.5560)
- TJ - Thomas Junk (DOCDB 10108) adapted Lariat code.

Longitudinal Shower Containment (95% value by eye $\pm$20cm).

Particle type	E=4 GeV (JI)	E=4 GeV (JH)	E=4 GeV (TJ)	E=10 GeV (TJ)
pions	200	420	340	400
kaons	200	440	340	450
protons	180	380	340	440
electrons	25	180	160	180

- JI always gives significantly better containment.
- JT and TJ are in reasonable (but not perfect).

Conservative: add Z_{MAX}+100 cm for 100% containment

Longitudinal size requirement 550 cm (Two modules is 460cm)

Default Geometry (Containment)

Transverse Shower Containment (95% value of Radius by eye $\pm$10cm).

Particle type	E=4 GeV (JI)	E=4 GeV (JH)	E=4 GeV (TJ)	E=10 GeV (TJ)
pions	80	150	150	150
kaons	80	140	140	150
protons	80	160	160	160
electrons	5	30	25	30

Conservative: add R_{MAX}+50 cm for 100% containment

Transverse size requirement (Radius) 210 cm

Default Geometry (Beam Angle)

See T. Junk DOCDB 10157

- Reconstruction has a ’blind spot’ for tracks traveling exactly perpendicular to drift direction.
  - ► Identical hit timing from all events limits ablility for 3D track reconstruction.
  - ► Purposely design in a small offset to nominal beam angle relative to APA plane.

T. Junk also brought up the issue of defining detector requirements.

- Alignment (/calibration systems)
- noise
- etc.

Overlap: Need to interface with FD/35t studies group (many of the requirements will be the same).

Angular Effects Studies

Do we need test beams at a range of angles (with respect to the drift direction)?

Short term goal - Prioritize this need and specify angular configurations.
People: R. Sulej, D. Stefan, M. Tzanov, N. Graf

Two categories (in reality they cannot fully be separated):

- Reconstruction related
  - Can largely study with Monte Carlo- data give a nice cross check.
- Recombination modeling- (underlying angular dependence).
  - If sizable- must be measured.

Angular Effects Studies (cont'd)

- Ideally we would determine the size of potential angular dependent effects from a full hit level simulation which includes different models for recombinations.
- Then propagate the effects into the oscillation parameters using fastMC to assess the importance on physics.
- Our realistic short term goal is to estimate the size of effects possible from existing information and establish a priority based on these estimates.

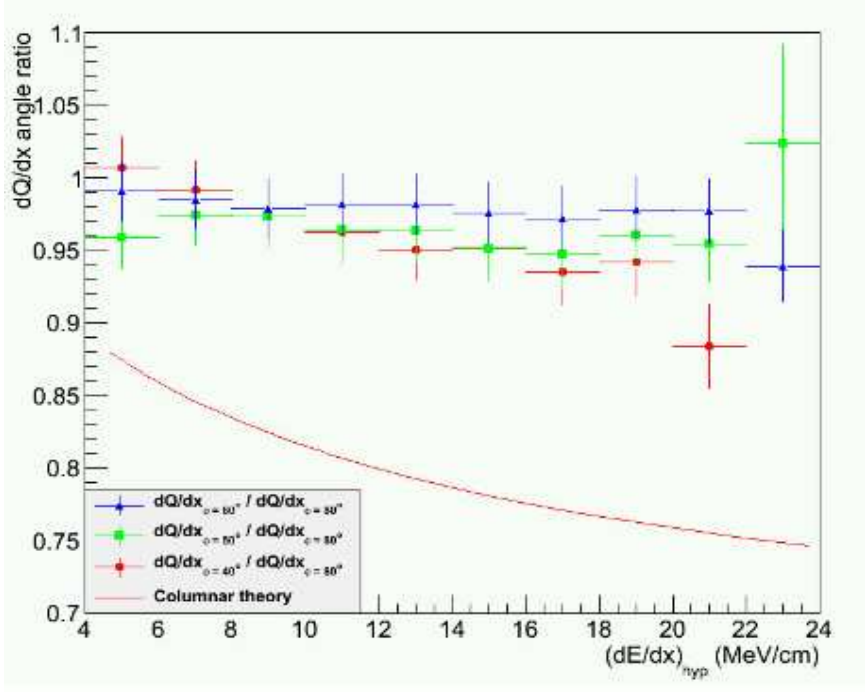
Preliminary conclusion: (Pending further discussion at next week's meeting)

- This is unlikely to be a high priority.
- If low priority then plan for the simplest design configuration that can be extended if possible.

Angular Effects

Quantify with Existing DATA

- Argoneut (arXiv:1306.1712)
  - Stopping protons from neutrino interactions (50-300 MeV with angles from 40-90°).
  - Measured angular dependence is much smaller (0-5% over range of dE/dx) than predicted by columnar theory (ranges from 12-25% for 40°).



- ICARUS Data (WIP under study by R. Sulej and D. Stefan).
  - Using long ($\sim$1 GeV) proton tracks
  - Isotropic in angle

Angular Effects in Reconstruction

Quantify size of reconstruction related effects in ICARUS and LArSoft (to the extent possible).

- Hit Level effects-angled tracks produce wider pulses. Affects hit deconvolution and processing through electronics.
  - ▶ Tracking efficiency/thresholds
  - ▶ PID efficiency
  - ▶ dQ/dX measurement.
- Neither ICARUS Monte Carlo nor LArSoft include angular dependent recombination effects.
  - ▶ Any angular dependence seen is reconstruction related.

Existing information

- Argoneut sees only small effects for measured dQ/dx $\sim$3% for tracks at 40° to drift direction. (see arXiv:1306.1712)
  - ▶ Does not specifically quantify all effects (eq. tracking efficiency and PID effects).
- ICARUS studies - A gold mine of input on these effects (mentioned in DOCDB 10114 and subsequent discussions.)
  - ▶ Quantitative input on specific effects (from R. Sulej and D. Stefan).

Extra

Angular Effects in Recombination

Recombination modeling

- Jaffe columnar theory has explicit angular dependence.

$$Q \approx \frac{Q_o}{1 + k_c(dE/dx)/\mathcal{E}\sin\phi}$$

  Q_o= ionization charge

  Q = collected charge (survives recombination).

  dE/dx is range based stopping power.

  k_c depends on LAr diffusion and mobility coefficients

  $\mathcal{E}$ = electric field strength

  ϕ is the angle relative to the Field direction.

- "Modified Box model" (Default for ICARUS and LArSoft) No angular dependence.
  - ▶ Incorporate angular dependence $\mathcal{E} \rightarrow \mathcal{E}\sin\phi$
- NEST model (hybrid of Thomas-Imel and Doke-Birks) - no angular dependence ? (M. Tzanov is investigating).

(Input on this from LAr drift simulation experts is welcome).