Short Update on Proton Calorimetric Reconstruction

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Track Pitch Calculation

- One bug was found by Glenn, Ajib, and Heng-Ye
- Track pitch calculation in Calorimetry_module.cc

```
diff --git a/larreco/Calorimetry/Calorimetry_module.cc b/larreco/Calorimetry/Calorimetry_module.cc
index b8455e02..6481f7eb 100644
--- a/larreco/Calorimetry/Calorimetry_module.cc
+++ b/larreco/Calorimetry/Calorimetry_module.cc
@@ -382,7 +382,7 @@ void calo::Calorimetry::produce(art::Event& evt)
               const geo::Vector_t& dir = tracklist[trkIter]->DirectionAtPoint(vmeta[ii]->Index());
               double cosgamma = std::abs(std::sin(angleToVert)*dir.Y() + std::cos(angleToVert)*dir.Z());
               if (cosgamma){
-                pitch = geom->WirePitch(0)/cosgamma;
+                pitch = geom->WirePitch(vhit[ii]->View())/cosgamma;

               }
               else{
<dunebuild02.fnal.gov> git commit -a -m'Fix a bug spotted by Glenn, Ajib and Heng-Ye.'
[develop eff904d1] Fix a bug spotted by Glenn, Ajib and Heng-Ye.
 1 file changed, 1 insertion(+), 1 deletion(-)
<dunebuild02.fnal.gov> git push
```

Always use the wire pitch of induction plane

- The bug has been fixed and pushed by Tingjun (will be updated in the next LArSoft production)

Track Pitch Calculation

- Impact of this bug: Calorimetry calculation

$$\sum_j \Delta E_j \cong \sum_j \frac{dE_j}{dx_j} \Delta x_j$$

Won't be affected by this bug

4.67 mm for induction plane
4.79 mm for collection plane
} 2.5 %

- Temporary solution to fix this bug:
  track pitch value*(4.79/4.67)

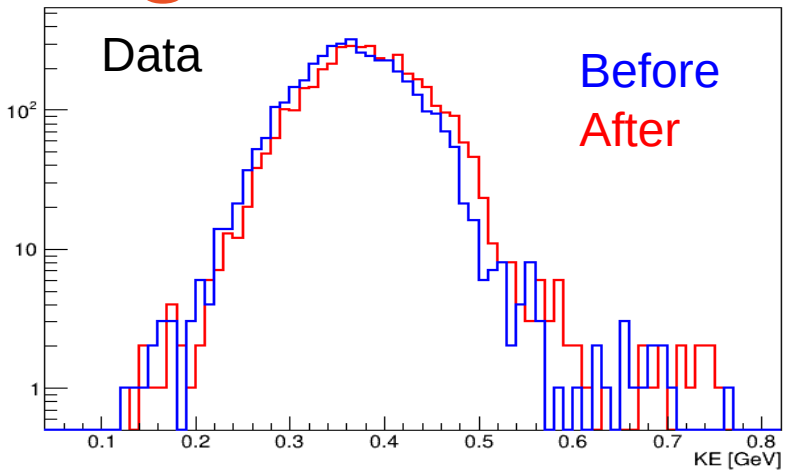
- Expectation after fixing this bug:
  Increase of KE_{calo}

Prod. 2

KE^{calo} After Fixing the Bug

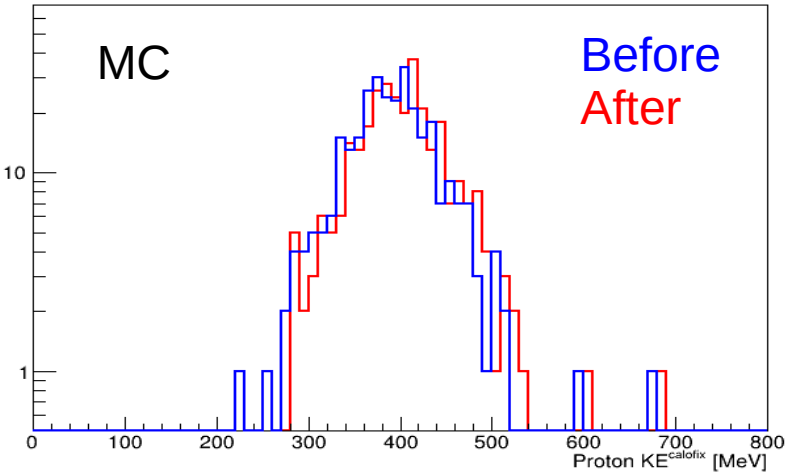
Data (after SCE calibration)

	Mean [GeV]	*FWHM [GeV]*	*ΔE/E (sigma)*
$KE^{caloFIX}$	0.367 → 0.381 (+14 MeV)	0.129 → 0.133	15.0 % → 14.8 %



MC (after SCE calibration)

	Mean [GeV]	*FWHM [GeV]*	*ΔE/E (sigma)*
$KE^{caloFIX}$	0.389 → 0.400 (+11 MeV)	0.097 → 0.104	10.6 % → 11.2 %



- KE_{calo} after fixing the bug is roughly† consistent with expectation:
  ~10 MeV (432 MeV*2.5 %)
  † : Nonlinear conversion from range to KE

*Details of $KE^{caloFIX}$ in:
https://indico.fnal.gov/event/22661/contribution/3/material/slides/0.pdf

KE Ratios - Data/MC [Prod. 2]

	Data	MC
$KE^{caloFIX}/KE^{range}$	0.923 → 0.958 (0.025) → (0.026)	0.940 → 0.963 (0.030) → (0.031)
$KE^{caloFIX}/KE^{beam}$	0.861 → 0.893 (0.046) → (0.049)	0.891 → 0.921 (0.017) → (0.030)
$KE^{caloFIX}/KE^{ff}$	0.907* → 0.940 (0.049) → (0.053)	0.934 → 0.952 (0.032) → (0.023)
KE^{range}/KE^{beam}	0.924 (0.045)	0.953 (0.012)
KE^{range}/KE^{ff}	0.975* (0.053)	0.988 (0.013)

- KE^{calo} is lower than KE^{range}

* Assume an average energy loss (21.72 MeV) in data (from beamline to TPC front face)

- KE^{ff}: Assume no extra material between FC and cryostat wall
  If we assume 1 cm Lar in between FC and cryostat, +~1.3 % in the KE^{range}/KE^{ff} column

Each column, fitted mean (sigma) of the distribution
No overlapping & high dE/dx cut applied

Summary

- A bug in track pitch calculation found & fixed
- After fixing this bug:
  - KE^{calo} enhances by 14 MeV [data] / 11 MeV [MC]
  - Better agreement between KE^{calo} and KE^{range} (increase ~3 % in the KE^{calo}/KE^{range})