



Wire-Cell ProtoDUNE Local Meeting

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May 06, 2026 (Wed)

Wire-Cell 3D Imaging & Clustering

BlobDepoFill Debugging

Checking LAr Parameters in Gen/Drift step

```
// Parameters relevant to the bulk liquid argon volume.
lar : {
  // Longitudinal diffusion constant
  DL : 7.2 * wc.cm2/wc.s,
  // Transverse diffusion constant
  DT : 12.0 * wc.cm2/wc.s,
  // Electron lifetime
  lifetime : 8*wc.ms,
  // Electron drift speed, assumes a certain applied E-field
  drift_speed : 1.6*wc.mm/wc.us, // at 500 V/cm
  // LAr density
  density : 1.389*wc.g/wc.centimeter3,
  // Decay rate per mass for natural Ar39.
  ar39activity : 1*wc.Bq/wc.kg,
```

```
<Drifter:> Qi = -50000
<Drifter:> respx = 3430.465 mm
<Drifter:> x = 1500 mm
<Drifter:> respx - x = 1930.46500000000001 mm
<Drifter:> dt = 1206.540625 us
<Drifter:> Inital dL = 0 , dT = 0
<Drifter:> dQ = -6950
<Drifter:> scale_factor = 1
<Drifter:> Qf = -43050
<Drifter:> after dL = 1.3181117175717694 , dT = 1.7016749101987723
```

$$Q_i = 50000 e^-$$

$$Q_f = Q_i \exp(-dt/\tau_{life})$$

$$dt = \frac{(3430.465 - 1500)mm}{1.6 us/mm} = 1206.54025us$$

$$\text{➤ } Q_f = 43000.23 e^-$$

➤ In Gen/Drift step, charge is well conserved.

Wire-Cell 3D Imaging & Clustering

BlobDepoFill Debugging

<https://github.com/WireCell/wire-cell-toolkit/blob/41e4b7ec9d06bfc195b18c8d4db7f016f202061b/img/docs/talks/blob-depo-fill.org>

The true charge from BlobDepoFill is came from 3D integration of:

1. drift direction (for one chosen time slice),
2. pitch direction (for one chosen plane),
3. wire direction (bound by each blob).

For each sensing wire,

$$Q_{true} = (1. "sd weight") \times (2. "dw weight") \times (3. "w weight") \times Q_{depo}$$



- How slices divided the charge in the **longitudinal direction**.
- Considering slices in $[t_{mean} - 3\sigma_L, t_{mean} + 3\sigma_L]$
 - t_{mean} : center time of depo + time offset
 - σ_L : Longitudinal extent of a depo at anode
 - nsigma= 3 : The number of sigma of depo Gaussian to consider

```
// first we slice
{
    const double tmean = idepo->time() + time_offset;
    const double tsigma = idepo->extent_long()/speed;
    const double tmin = tmean - tsigma*nsigma;
    const double tmax = tmean + tsigma*nsigma;
    const Binning tbins = subset(sbins, tmin, tmax);
    const auto ntbins = tbins.nbins();
    if (ntbins) {
        std::vector<double> weights(ntbins);
        gaussian(weights.begin(), tbins, tmean, tsigma);

        for (int it=0; it<ntbins; ++it) {
            const idweight::vdesc_t sdesc = sbins.bin(tbins.center(it));
            boost::add_edge(sdesc, ddesc, {weights[it]}, gr);
        }
    }
}
```

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BlobDepoFill Debugging

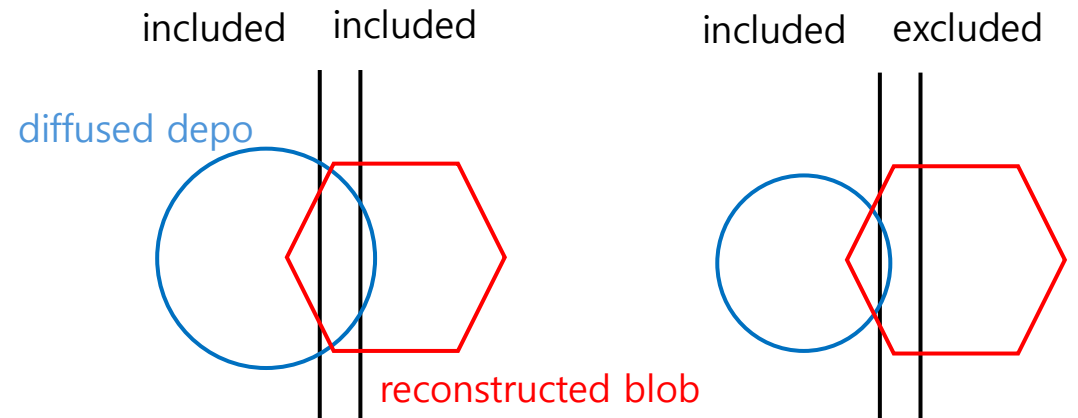
$$Q_{true} = (1. "sd\ weight") \times (2. "dw\ weight") \times (3. "w\ weight") \times Q_{depo}$$



- How wires divided the charge in the **transverse direction**.
- Considering wires in $[w_{mean} - 3\sigma_T, w_{mean} + 3\sigma_T]$ and in blob range
- σ_T : transvers extent of a depo at anode
- nsigma= 3 (share with slice part)

-> If nsigma is too small, wires carrying significant charge could be excluded.

```
// (x,y,z) -> (normal, wire, pitch);  
const auto wpos = pimpos.transform(idepo->pos());  
const double wmean = wpos[2]; // pitch  
const double wsigma = idepo->extent_tran();  
  
auto wbins = subset(pbins, wmean-wsigma*nsigma, wmean+wsigma*nsigma);  
const auto nwbins = wbins.nbins();  
if (nwbins) {  
    std::vector<double> weights(wbins.nbins(), 0);  
    gaussian(weights.begin(), wbins, wmean, wsigma);  
}
```



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BlobDepoFill Debugging

Point depo at x = 300mm

$$Q_{true} = (1. "sd\ weight") \times (2. "dw\ weight") \times (3. "w\ weight") \times Q_{depo}$$

- $\sigma_T = 0.8036$ nsigma = 3
 - only one wire was included for charge calculation.
 - $dw\ weight = 0.12874402336693608$

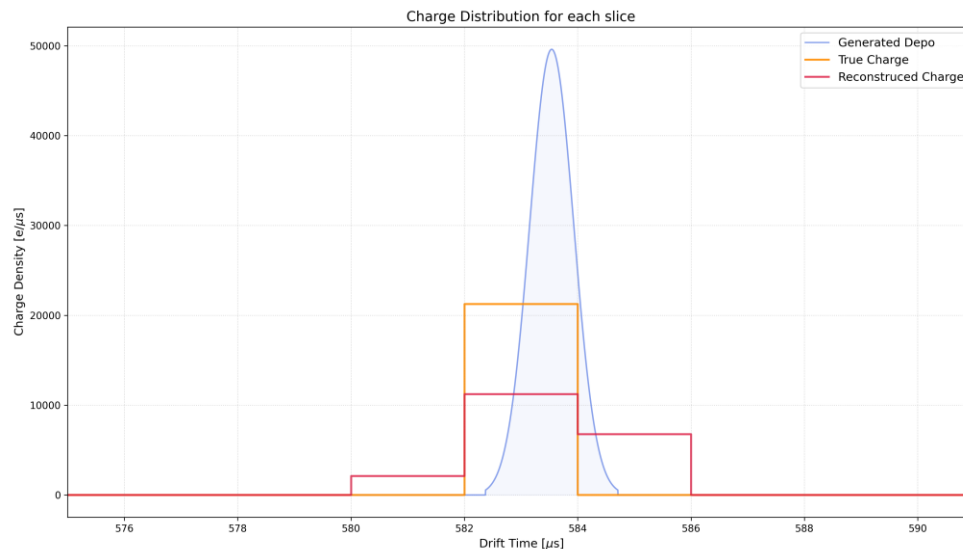
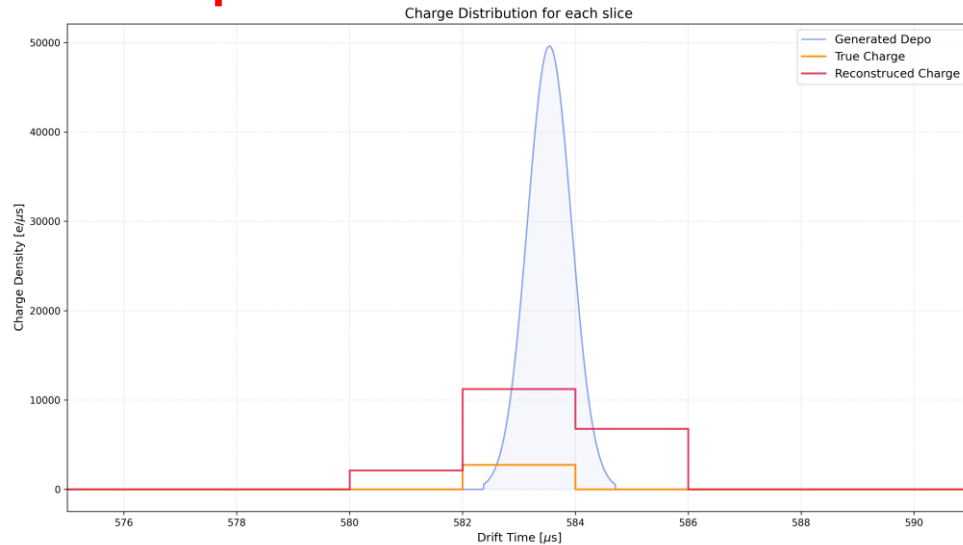
Charge in depo : 48372 e-

True charge : 5472.533 e- (11%)

- $\sigma_T = 0.8036$ nsigma = 50 (extreme case),
 - 17 wires were included for charge calculation.
 - $dw\ weight = 0.8712552979400132$
 - $dw\ weight = 0.12874402336693608$
 - Other wire contributions are negligible

Charge in depo : 48372 e-

True charge : 42507.08 e- (87%)



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BlobDepoFill Debugging

Point depo at x = 150mm

$$Q_{true} = (1. "sd weight") \times (2. "dw weight") \times (3. "w weight") \times Q_{depo}$$

- $\sigma_T = 1.7017$ nsigma = 3

Charge in depo : 43050 e-

True charge : 33030 e- (76%)

- $\sigma_T = 1.7017$ nsigma = 50 (extreme case),

Charge in depo : 43050 e-

True charge : 33420 e- (77%)

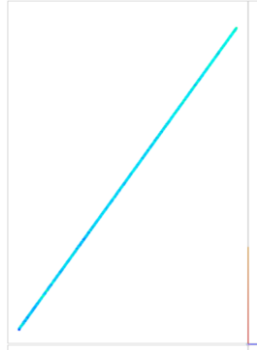
- Changing nsigma for this case doesn't impact much

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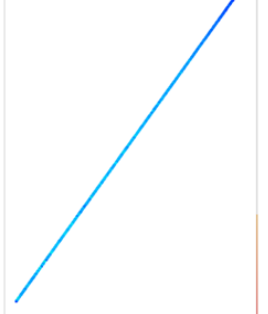
Performance Evaluation with a simple track

For a single long track (x : 10cm – 320cm)

Reco blobs



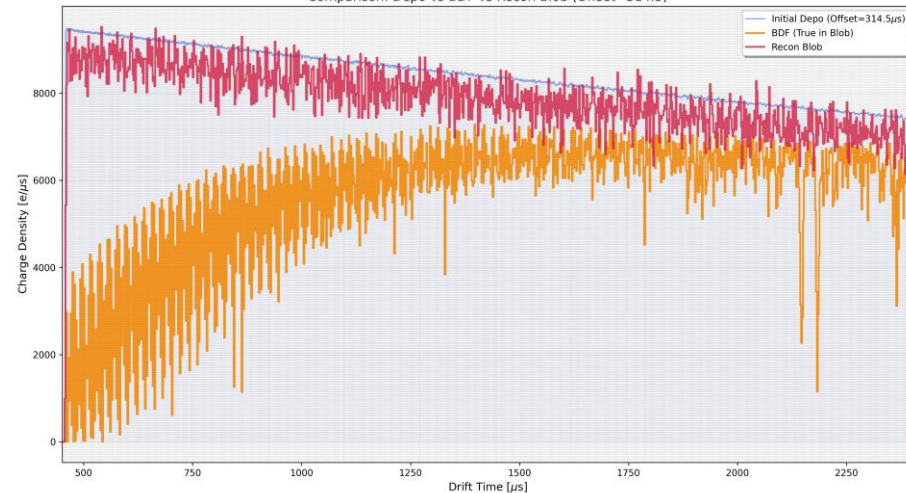
True Charge
(BlobDepoFill)



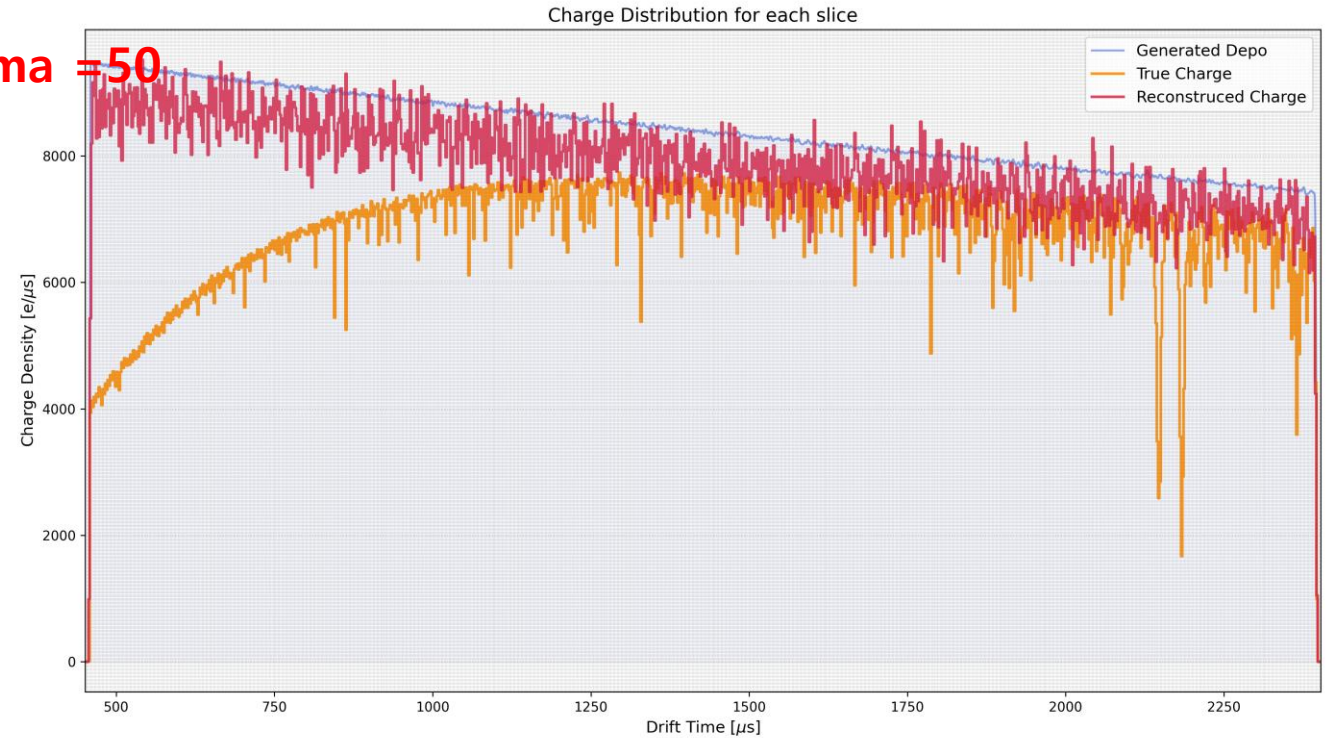
Drift

nsigma = 3 (plot from last meeting)

Comparison: Depo vs BDF vs Recon Blob (Offset=314.5)



nsigma = 50



- The discrepancy at near anode is still considerable.
- Possible point?
 - Too large nsigma?
 - With many depos, charge from several depos accumulated at a one wire -> w weight can impact?

$$Q_{true} = (1. "sd weight") \times (2. "dw weight") \times (3. "w weight") \times Q_{depo}$$

Backup

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Blob Depo Fill: Adding true info in the conventional pipeline

Metrics

- Two metrics for 3D Imaging performance evaluations in the **Blob level**

blob size -> charge smearing
ghost evaluation
de-ghosting algorithm performance

$$\text{Purity} = \frac{\text{Number of blobs with non-zero true charge}}{\text{Total number of reconstructed blobs}}$$

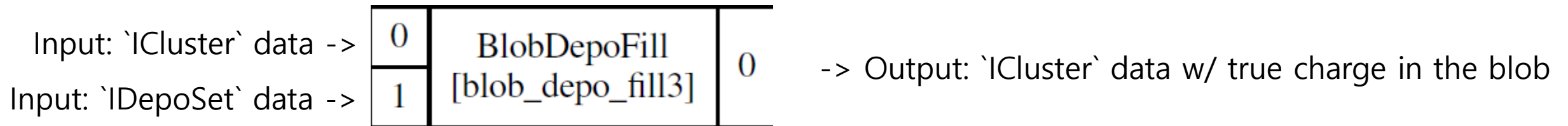
$$\text{Efficiency} = \frac{\text{Total true charge in blob}}{\text{Total true charge}}$$

BlobDepoFill

(<https://github.com/WireCell/wire-cell-toolkit/blob/18a8a5c06c8f8001e8dea5e3a577570ee473b79b/img/src/BlobDepoFill.cxx#L2>)

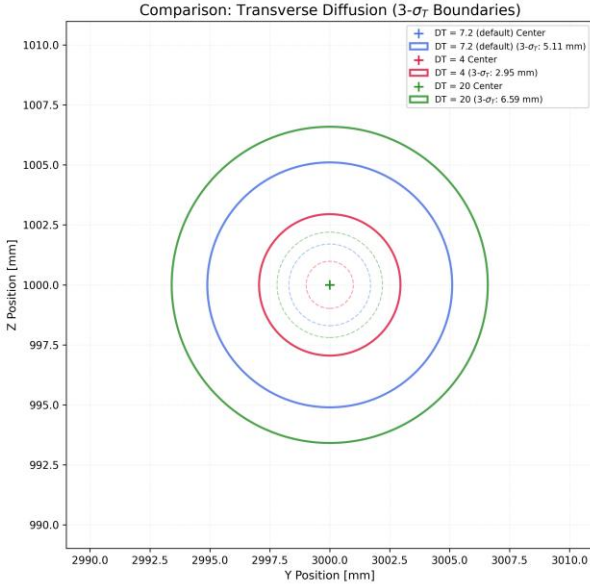
- Replace charges of reco blob with true charges in the blobs
- This node only replace the charge info, not position info, giving the position of reco blob

—> BlobDepoFill approach can be used for only evaluating about charge



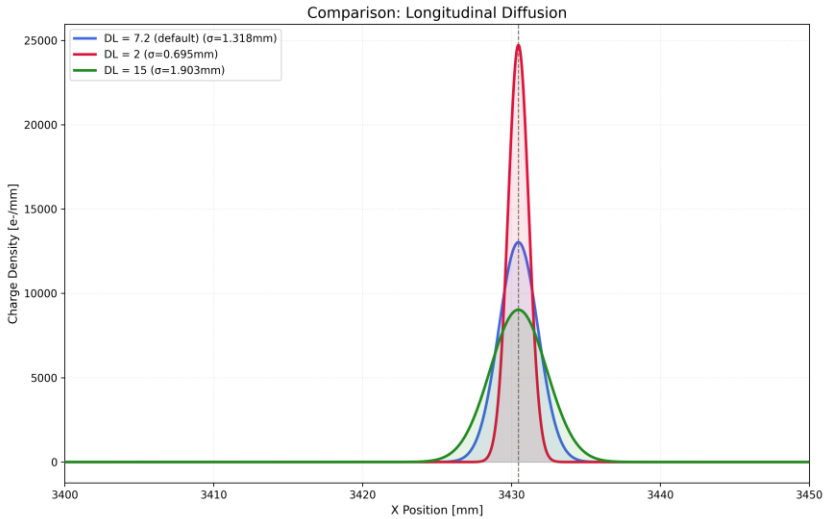
Quantity	Gen 1 (Pre-drift)	Gen 0 (Post-drift)
Total q [e-]	5.00e+04	4.30e+04
t Range [ns]	0.0 ~ 0.0	1206540.6 ~ 1206540.6
x [mm]	1500.0 ~ 1500.0	3430.5 ~ 3430.5
y [mm]	3000.0 ~ 3000.0	3000.0 ~ 3000.0
z [mm]	1000.0 ~ 1000.0	1000.0 ~ 1000.0
### [DIFFUSION SIGMA ANALYSIS (L, T)] ###		
L-Sigma (Long.)	0.0000 ~ 0.0000	0.6947 ~ 0.6947
	mean 0.0000	mean 0.6947
T-Sigma (Tran.)	0.0000 ~ 0.0000	1.7017 ~ 1.7017
	mean 0.0000	mean 1.7017

### [Single Depo Inspection (Index: 0)] ###	
Quantities	Value
Total Charge (q) [e-]	4.30e+04
Charge in 3.0sigma [e-]	4.29e+04 (99.73%)
Time (t) [ns]	1206540.62
(x,y,z) [mm]	(3430.47, 3000.00, 1000.00)
Long. Sigma (L) [mm]	0.6947
Tran. Sigma (T) [mm]	1.7017
Status	Post-drift 3D Gaussian



Quantity	Gen 1 (Pre-drift)	Gen 0 (Post-drift)
Total q [e-]	5.00e+04	4.30e+04
t Range [ns]	0.0 ~ 0.0	1206540.6 ~ 1206540.6
x [mm]	1500.0 ~ 1500.0	3430.5 ~ 3430.5
y [mm]	3000.0 ~ 3000.0	3000.0 ~ 3000.0
z [mm]	1000.0 ~ 1000.0	1000.0 ~ 1000.0
### [DIFFUSION SIGMA ANALYSIS (L, T)] ###		
L-Sigma (Long.)	0.0000 ~ 0.0000	1.3181 ~ 1.3181
	mean 0.0000	mean 1.3181
T-Sigma (Tran.)	0.0000 ~ 0.0000	1.7017 ~ 1.7017
	mean 0.0000	mean 1.7017

### [Single Depo Inspection (Index: 0)] ###	
Quantities	Value
Total Charge (q) [e-]	4.30e+04
Charge in 3.0sigma [e-]	4.29e+04 (99.73%)
Time (t) [ns]	1206540.62
(x,y,z) [mm]	(3430.47, 3000.00, 1000.00)
Long. Sigma (L) [mm]	1.3181
Tran. Sigma (T) [mm]	1.7017
Status	Post-drift 3D Gaussian



Quantity	Gen 1 (Pre-drift)	Gen 0 (Post-drift)
Total q [e-]	5.00e+04	4.30e+04
t Range [ns]	0.0 ~ 0.0	1206540.6 ~ 1206540.6
x [mm]	1500.0 ~ 1500.0	3430.5 ~ 3430.5
y [mm]	3000.0 ~ 3000.0	3000.0 ~ 3000.0
z [mm]	1000.0 ~ 1000.0	1000.0 ~ 1000.0
### [DIFFUSION SIGMA ANALYSIS (L, T)] ###		
L-Sigma (Long.)	0.0000 ~ 0.0000	1.9025 ~ 1.9025
	mean 0.0000	mean 1.9025
T-Sigma (Tran.)	0.0000 ~ 0.0000	1.7017 ~ 1.7017
	mean 0.0000	mean 1.7017

### [Single Depo Inspection (Index: 0)] ###	
Quantities	Value
Total Charge (q) [e-]	4.30e+04
Charge in 3.0sigma [e-]	4.29e+04 (99.73%)
Time (t) [ns]	1206540.62
(x,y,z) [mm]	(3430.47, 3000.00, 1000.00)
Long. Sigma (L) [mm]	1.9025
Tran. Sigma (T) [mm]	1.7017
Status	Post-drift 3D Gaussian

DL : 2, 7.2, 15
DT : 4, 12, 20