FToF Digitization update

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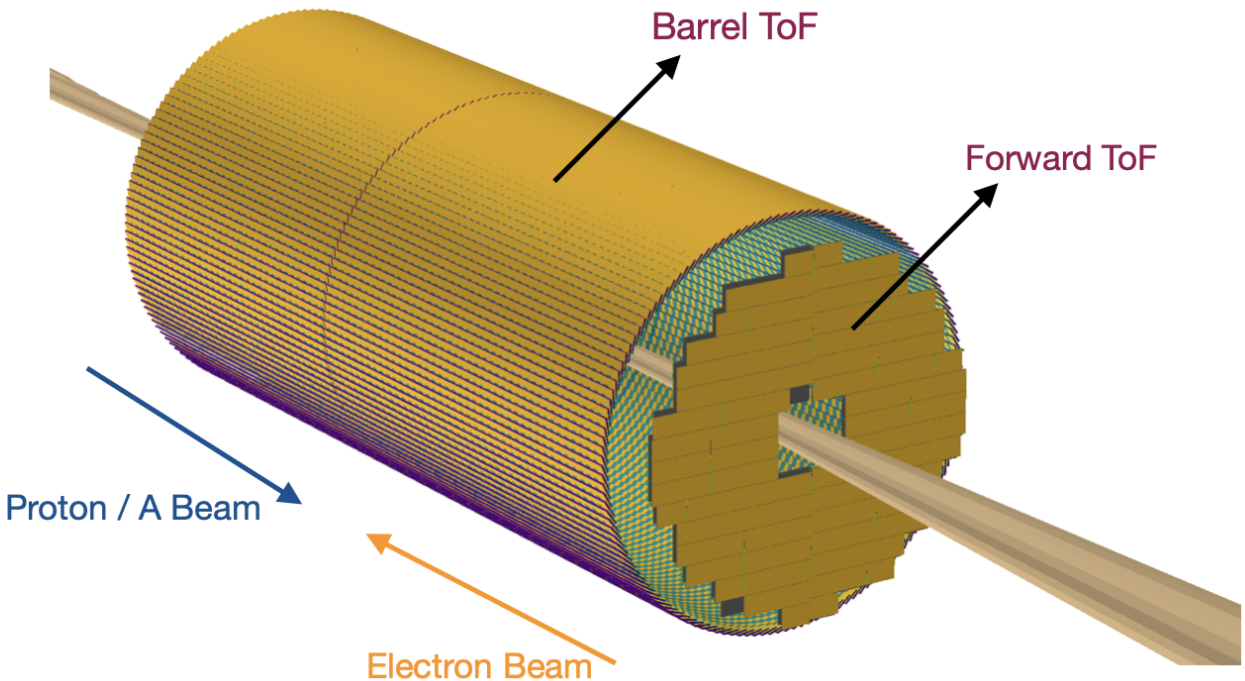
Time of flight detector



ToF Endcap (Charge sharing among neighboring cells)

Particle - pi^+, momentum.Min = 1 GeV, gun.momentumMax = 10 GeV, No. of events = 2000

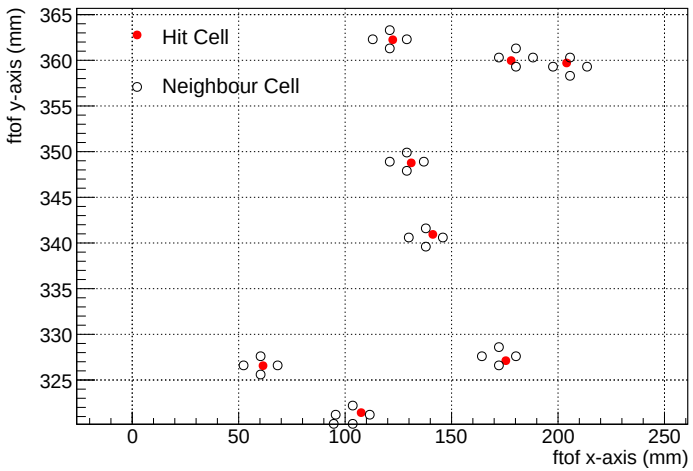
- Implementation of SiliconChargeSharing.cc in ECTOF.cc.

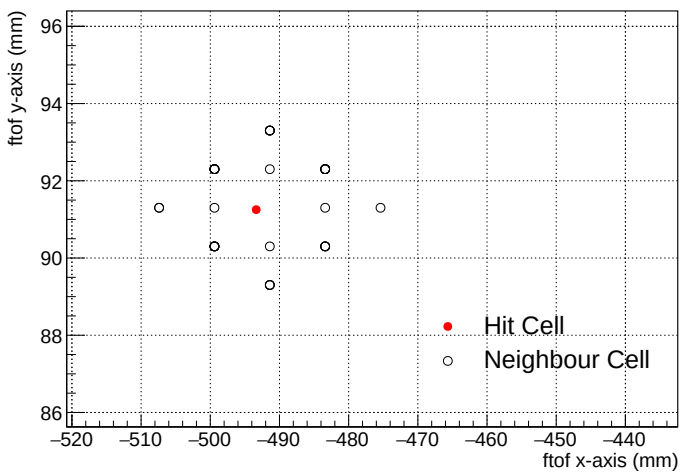
```
app->Add(new JOmniFactoryGeneratorT<SiliconChargeSharing_factory>(
    "TOFEndcapSharedHits", {"TOFEndcapHits"}, {"TOFEndcapSharedHits"},
    {
        .sigma_sharingx = 0.1 * dd4hep::cm,
        .sigma_sharingy = 0.1 * dd4hep::cm,
        .min_edep       = 0.0 * edm4eic::unit::GeV,
        .readout        = "TOFEndcapHits",
    },
    app));
```

- Includes finding all neighbour cells of the hit cell and saving it.
- Smearing edep into 2-D Gaussian with $\sigma_{x,y}$ = 1mm.
- Calculation of integral

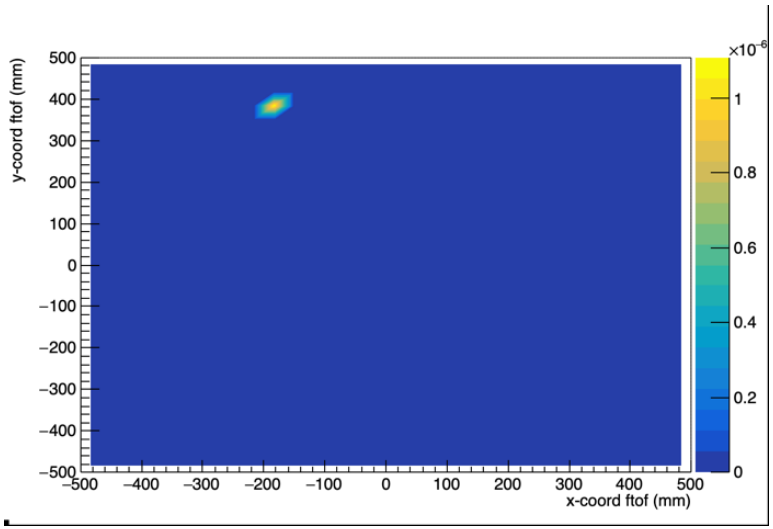
ToF Endcap (Charge sharing among neighboring cells)

Neighbour finding





2D Gauss edep



$$f(x,y) = par[0] \times Exp(-\frac{((x - par[1])^2 + (y - par[2])^2)}{2 \times par[3] \times par[4]}) \quad (1)$$

- par[0] = Amplitude = edep
- par[1] = central position of x = x-pos of hit
- par[2] = central position of y = y-pos of hit
- par[3] and par[4] = $\sigma_{x,y}$ = 1.0 mm.

Landau Pulse generation

- Implementation of Pulse generation in ECTOF.cc

```
app->Add(new JOmniFactoryGeneratorT<PulseGeneration_factory<edm4hep::SimTrackerHit>>(
    "TOFEndcapSmoothPulses", {"TOFEndcapSharedHits"}, {"TOFEndcapSmoothPulses"},
    {
        .pulse_shape_function = "LandauPulse",
        .pulse_shape_params   = {gain, sigma_analog, offset},
        .ignore_thres         = 0.05 * adc_range,
        .timestep             = 0.01 * edm4eic::unit::ns,
    },
    app));
```

- Landau pulse is generated with height of gain and sigma_analog width and considered as hit.

Pulse Combiner

- Implementation of Pulse Combiner in ECTOF.cc

```
app->Add(new JOmniFactoryGeneratorT<PulseCombiner_factory>(
    "TOFEndcapCombinedPulses", {"TOFEndcapSmoothPulses"}, {"TOFEndcapCombinedPulses"},
    {
        .minimum_separation = 25 * edm4eic::unit::ns,
    },
    app));
```

- If pulses are closer than 25 ns they are merged.

Pulse Discretization

- Implementation of Pulse Discretization in ECTOF.cc

```
double risetime = 0.45 * edm4eic::unit::ns;
app->Add(new JOmniFactoryGeneratorT<SiliconPulseDiscretization_factory>(
    "TOFEndcapPulses", {"TOFEndcapCombinedPulses"}, {"TOFEndcapPulses"},
    {
        .EICROC_period = 25 * edm4eic::unit::ns,
        .local_period  = 25 * edm4eic::unit::ns / 1024,
        .global_offset = -offset * sigma_analog + risetime,
    },
    app));
```

- Sampling the pulse with TDC resolution of 0.0244ns (25ns/1024)

Pulse Digization

- Implementation of Pulse Digization in ECTOF.cc

```
app->Add(new JOmniFactoryGeneratorT<EICROCDigitization_factory>(
    "TOFEndcapADCTDC", {"TOFEndcapPulses"}, {"TOFEndcapADCTDC"}, {}, app));
```

- adc_bit = 8 (range= 0 - 255) and
  tdc_bit = 10 (range = 0 - 1023)
- **ADC Conversion factor** : Assuming 3.6eV/e^- in silicon,
  slope = 1.4335×10^{-6} GeV/count
  Charge to ADC $\sim 6 \times 10^{-18}$ C/count.
- **TDC conversion factor:** 25ns/1024$\sim$ 0.0244ns/Count.

ETOF - ADC vs event edep and TDC vs event time

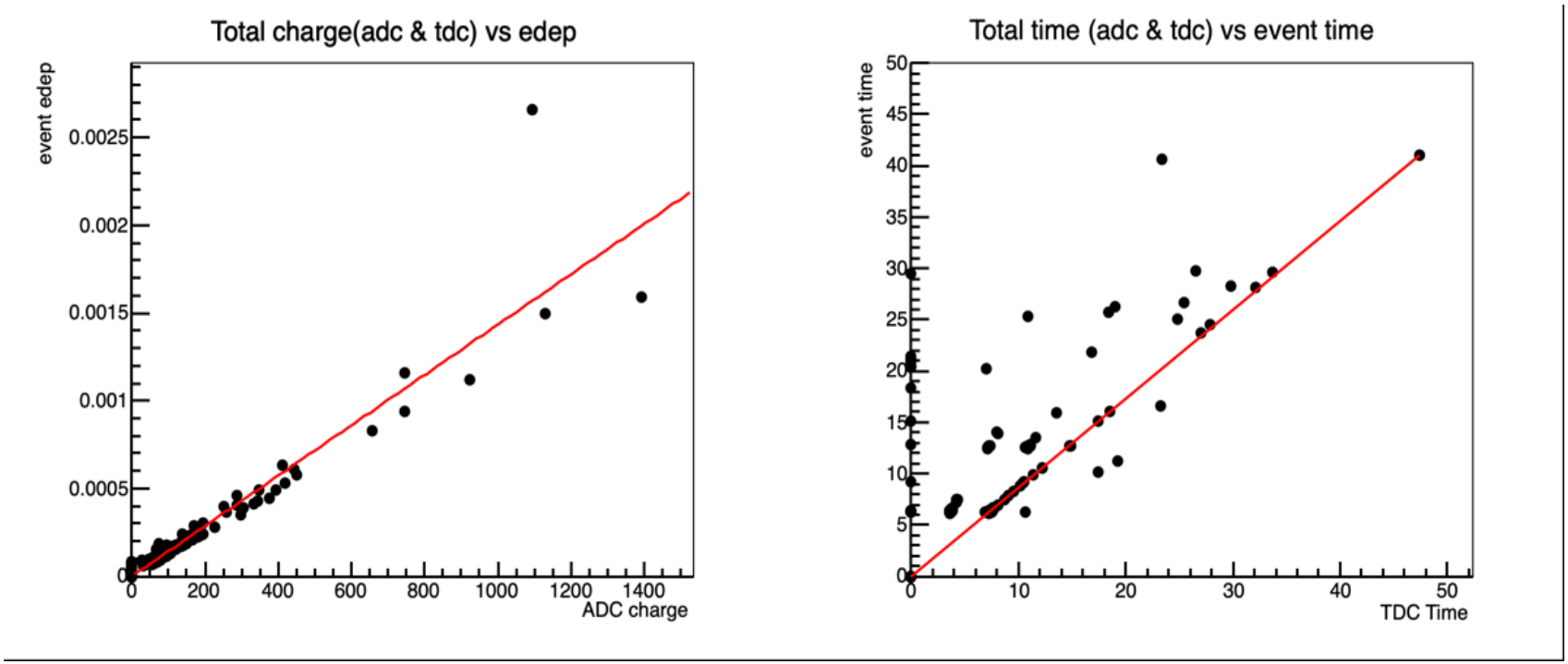
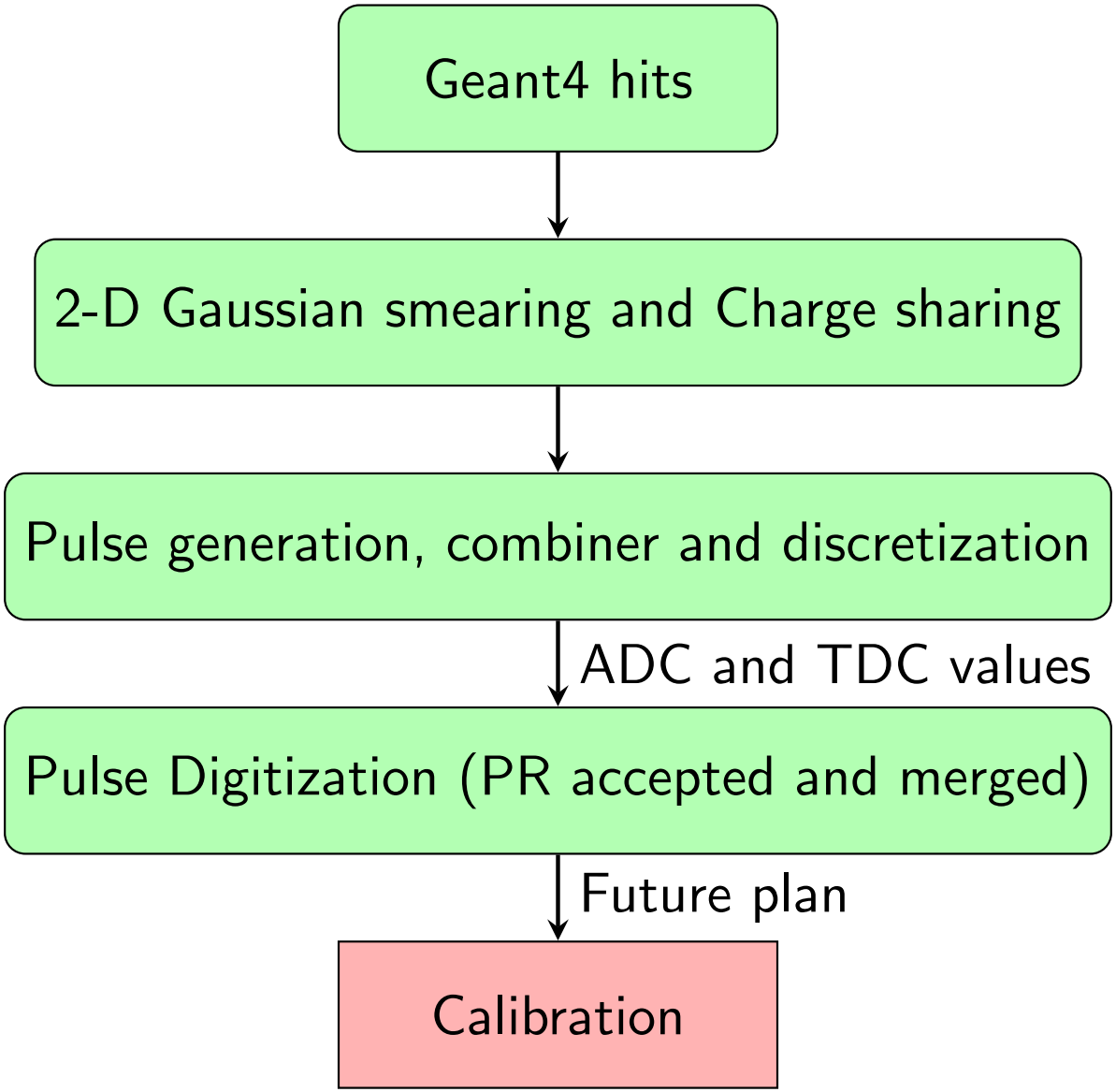


Figure: Left: Charge (ADC) Right: Time (TDC)

Summary for FToF simulation:-



Back Up:-

"TOFEndcapADCTDC" is stored as following:-