

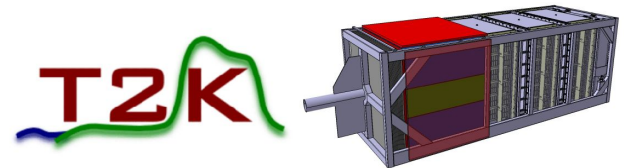
LPNHE neutrino group meeting

-

HAT t0

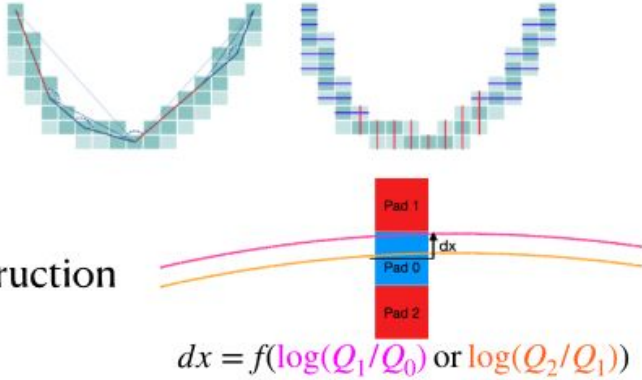
09/10/24

William Saenz



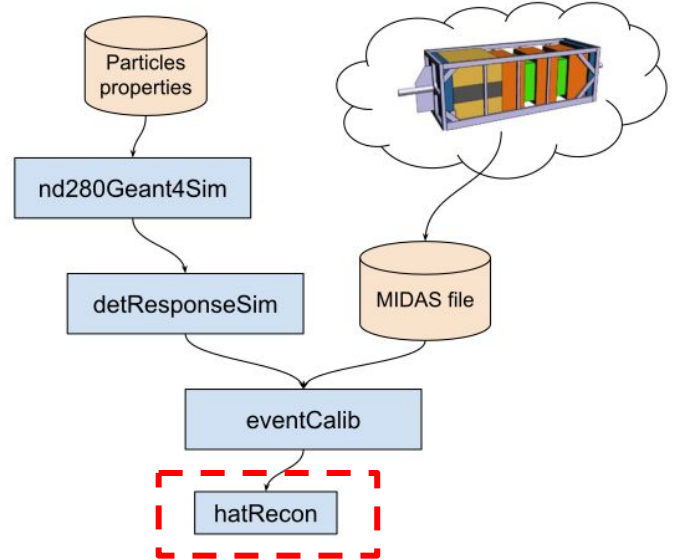
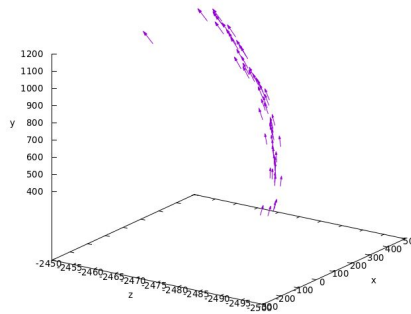
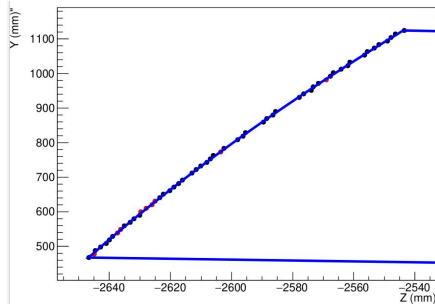
hatRecon algorithm

- Pattern reco
- Clustering
- Track merging

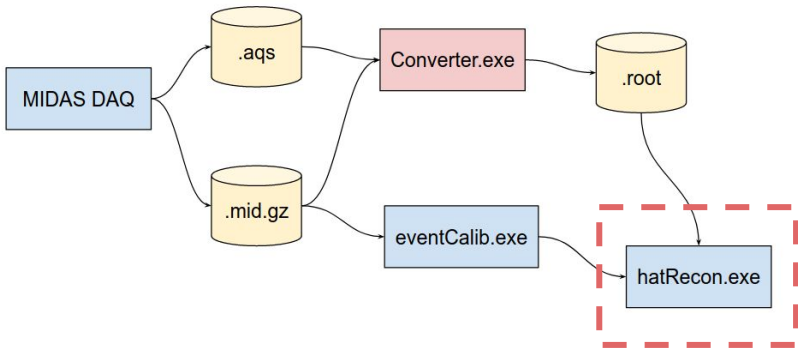


- Position reconstruction in each cluster

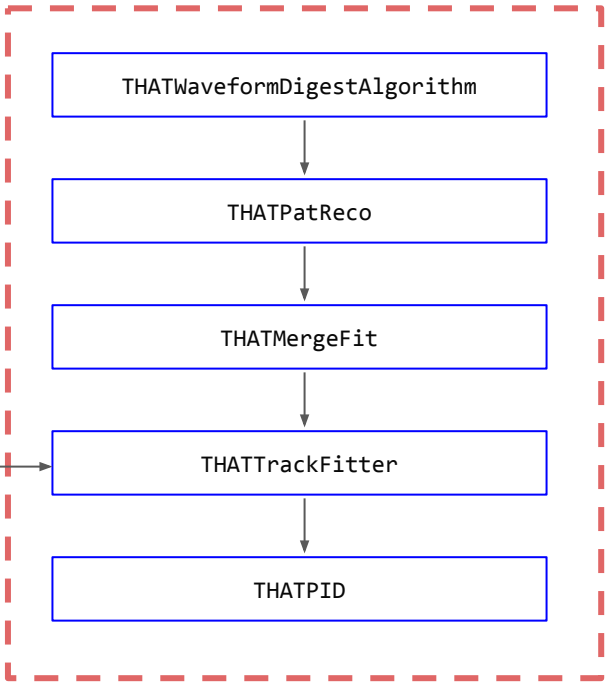
- Helix fit
- Momentum, PID...



T0 finder in hatRecon

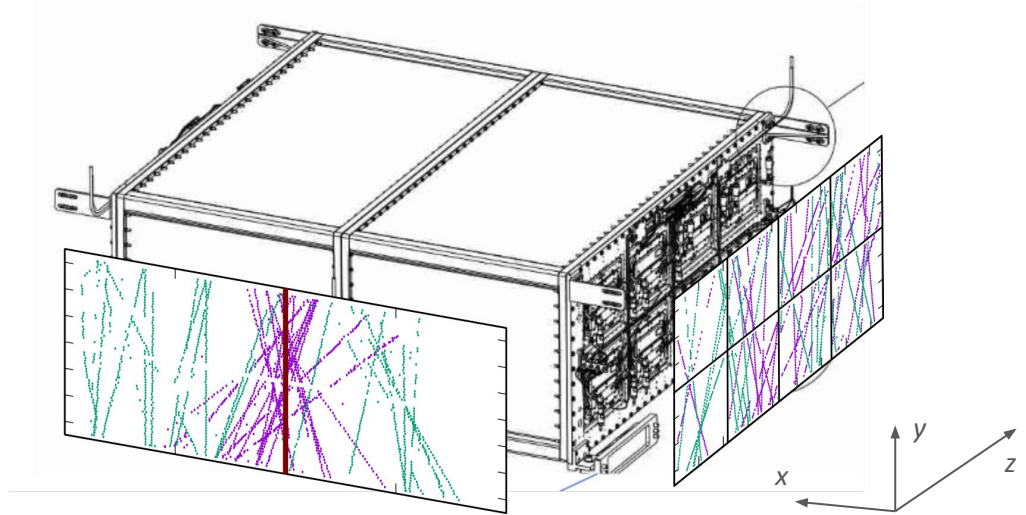


T0Finder executed once HATPC trajectories are completely defined



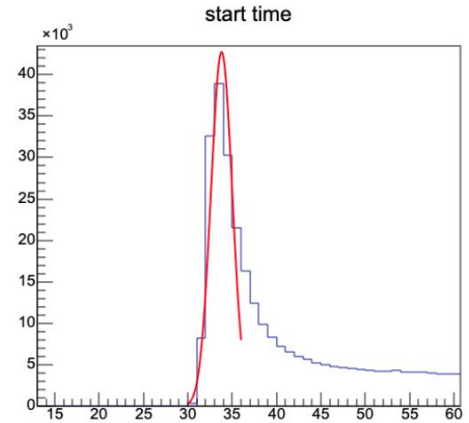
T0. What for?

- T0 defines the x coordinate of clusters
- ExB effect depends on x (need to compute x before global reconstruction)
- We want to study diffusion effects (spatial resolution & dEdx vs. x)
- x coordinates of clusters are needed for detector alignment studies



T0 finder algorithm

- Previous implementation:
 - Cosmics:
 - Look at the distribution of start_time
 - Identify the peak associated to ERAM crossing hits
 - Pass as input parameter to hatRecon (**fTOffset**)
 - Compute the drift distance for clusters as

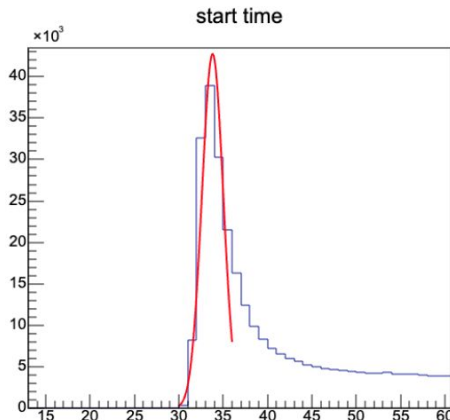


```
x_drift = ( time - fTOffset ) * fSamplingTime * ND::hatCalibration().GetDriftVelocity();
```



T0 finder algorithm

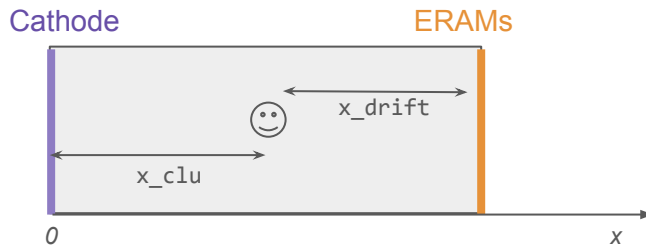
- Previous implementation:
 - Cosmics:
 - Look at the distribution of `start_time`
 - Identify the peak associated to ERAM crossing hits
 - Pass as input parameter to `hatRecon` (`fTOffset`)
 - Compute the drift distance for clusters as



```
x_drift = ( time - fTOffset ) * fSamplingTime * ND::hatCalibration().GetDriftVelocity();
```

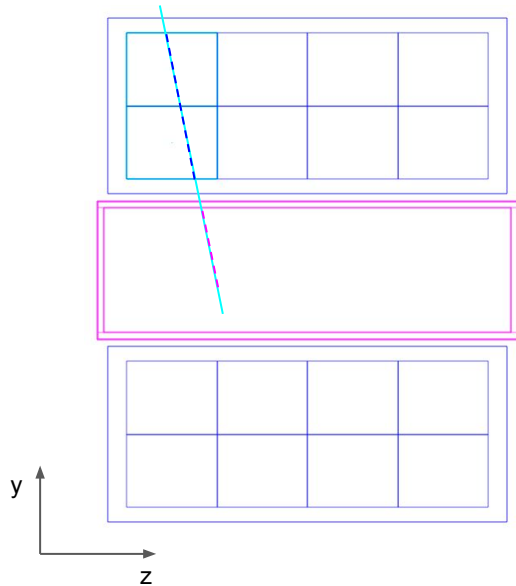
- Define the x coordinate as

```
x_clu = EndPlate_length - x_drift
```

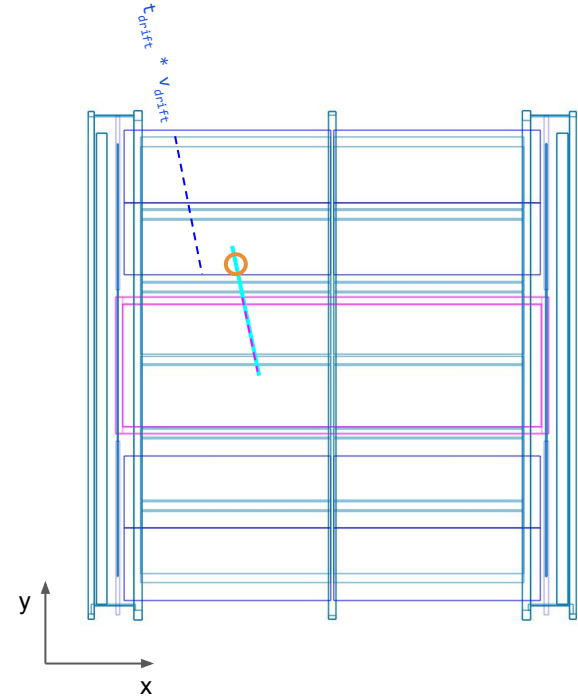


T0 finder algorithm

- Previous implementation:
 - Cosmics
 - Beam:
 - Look for x-coordinates of other upgrade detectors (only implemented for SFGD)



If HAT and SFGD
match in zy,
extrapolate SFGD
in xy

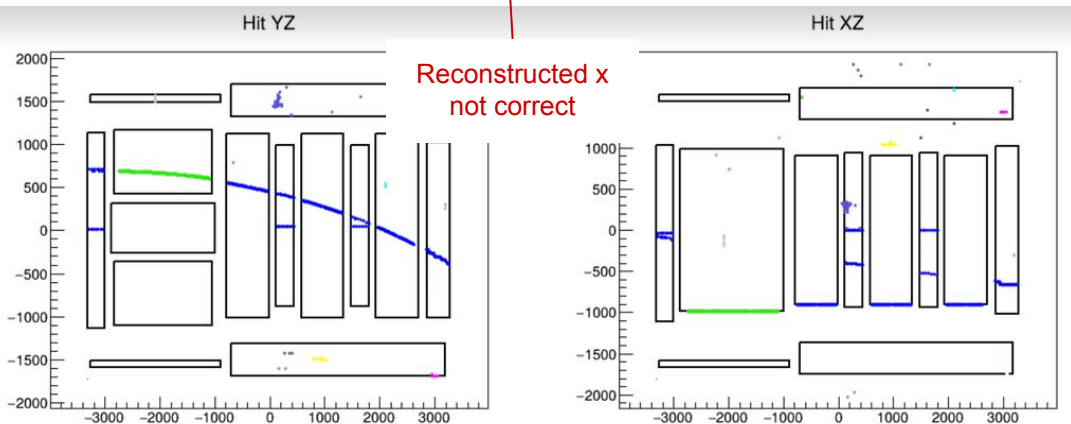


T0 finder algorithm

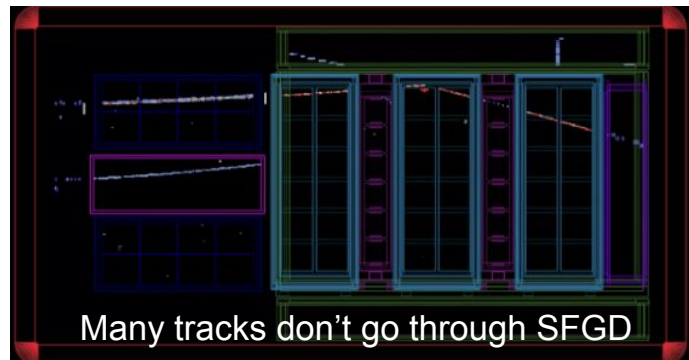
- Previous implementation:
 - Cosmics
 - Beam:
 - ...but...

2. Master branch of tofRecon **not ready** for beam/MC events

```
% TOF      :      T,      X,      Y,      Z
% cluster 1 : 7822.55, -1416.53, 592, -947.903
% cluster 2 : 7816.4,  1160.81, 722, -2965.25
```



1. SFGD only is not enough



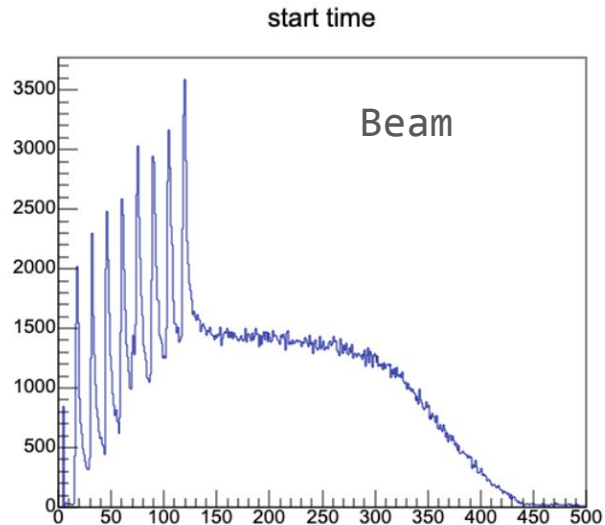
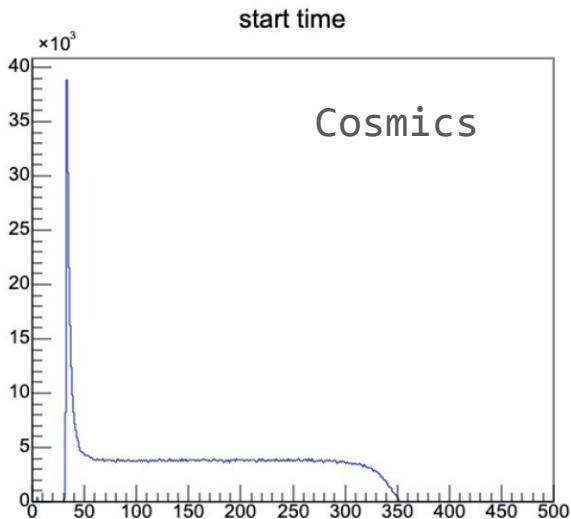
3. Also, we might want to avoid running tofRecon and sfgRecon within hatRecon (if there is a faster way for T0 identification)

T0 finder: New alternative for beam events (Claudio's idea)

- As for cosmics, we would just need to know **fTOffset**

```
x_drift = ( time - fTOffset ) * fSamplingTime * ND::hatCalibration().GetDriftVelocity();
```

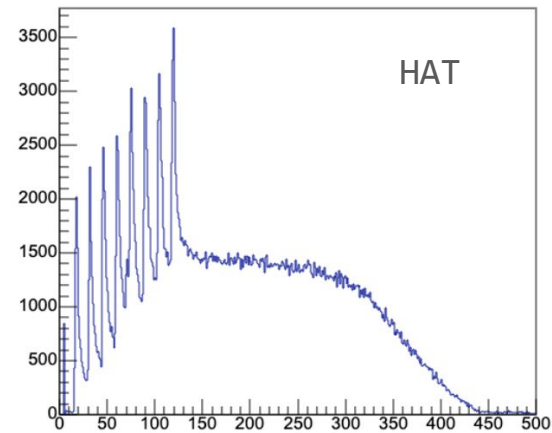
- However, since the beam bunch separation < average drifting time, HAT only cannot determine which of the 8 bunches generated the event



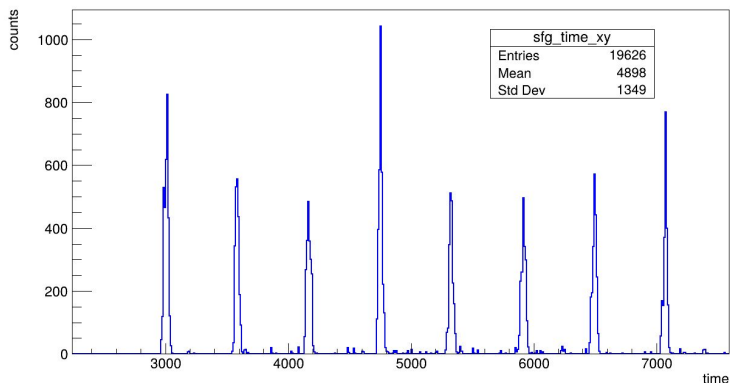
T0 finder: New alternative for beam events (Claudio's idea)

- As for cosmics, we would just need to know **fTOffset**
$$x_drift = (time - fTOffset) * fSamplingTime * ND::hatCalibration().Ge$$
- However, since the beam bunch separation < average drifting time, HAT or of the 8 bunches generated the event
- Let's use TOF and SFGD for bunch identification

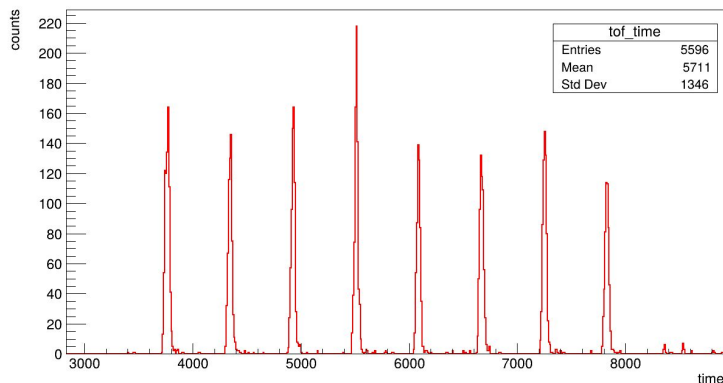
start time



SFG hits time



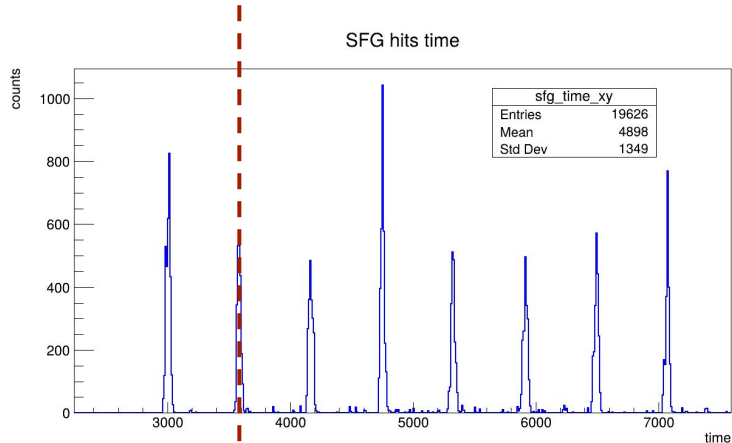
TOF hits time



T0 finder: New alternative - algorithm

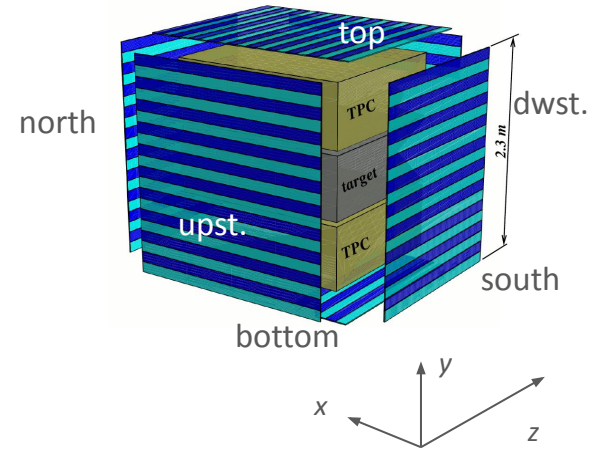
1. Identify bunch from SFGD hits mean time (`type = 1`)

Ex: SFGD **mean time** in 2nd bunch



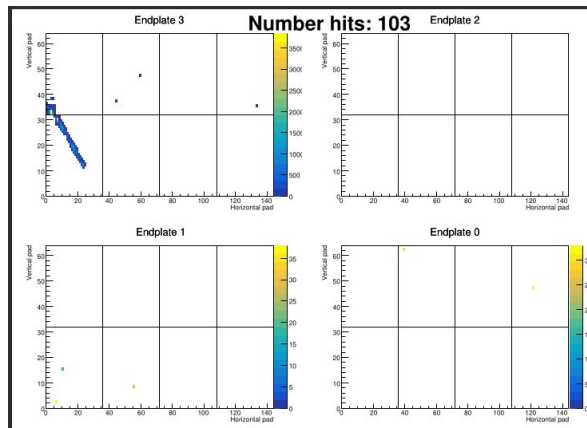
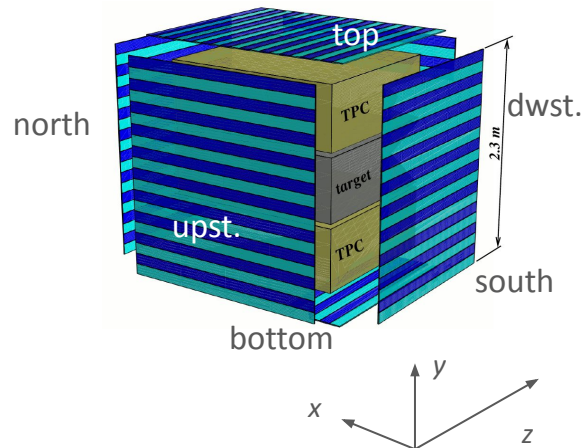
T0 finder: New alternative - algorithm

1. Identify bunch from SFGD hits mean time (`type = 1`)
2. Identify bunch from TOF hits
 - a. Try upstream and downstream planes (`type = 20`)
(rough match evaluation is possible in zy w.o. tofRecon)

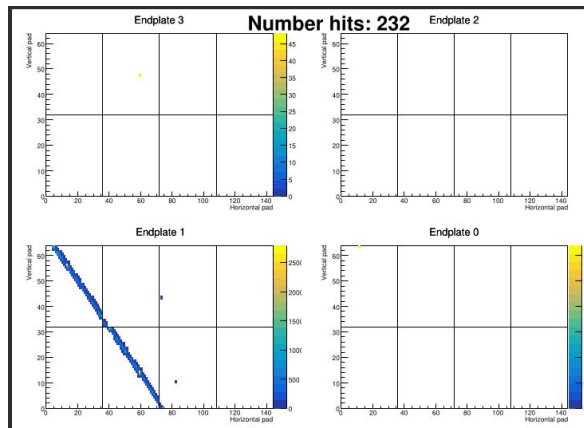


T0 finder: New alternative - algorithm

1. Identify bunch from SFGD hits mean time (`type = 1`)
2. Identify bunch from TOF hits
 - a. Try upstream and downstream planes (`type = 20`)
(rough match evaluation is possible in zy w.o. tofRecon)
 - b. Try top (21), bottom (22), north (23) & south (24) if HAT pattern suggests



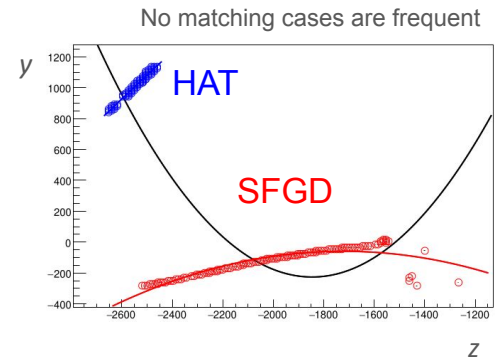
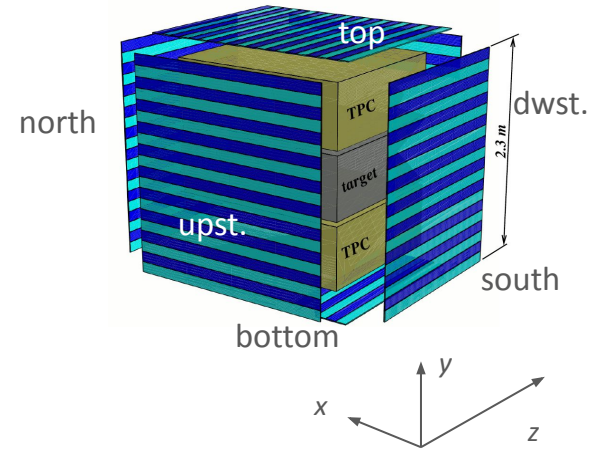
Suggests north



Suggests bottom

T0 finder: New alternative - algorithm

1. Identify bunch from SFGD hits mean time (`type = 1`)
2. Identify bunch from TOF hits
 - a. Try upstream and downstream planes (`type = 20`)
(rough match evaluation is possible in zy w.o. tofRecon)
 - b. Try top (21), bottom (22), north (23) & south (24) if HAT pattern suggests
3. If steps 1 & 2 give no bunch candidate, return false (`type = 0`)
4. If TOF candidates 2.a == 2.b, keep result from 2.a
Else, keep the TOF candidate == SFGD
5. If no TOF candidates, keep SFGD candidate *iff* HAT and SFGD match in zy
Else, return false



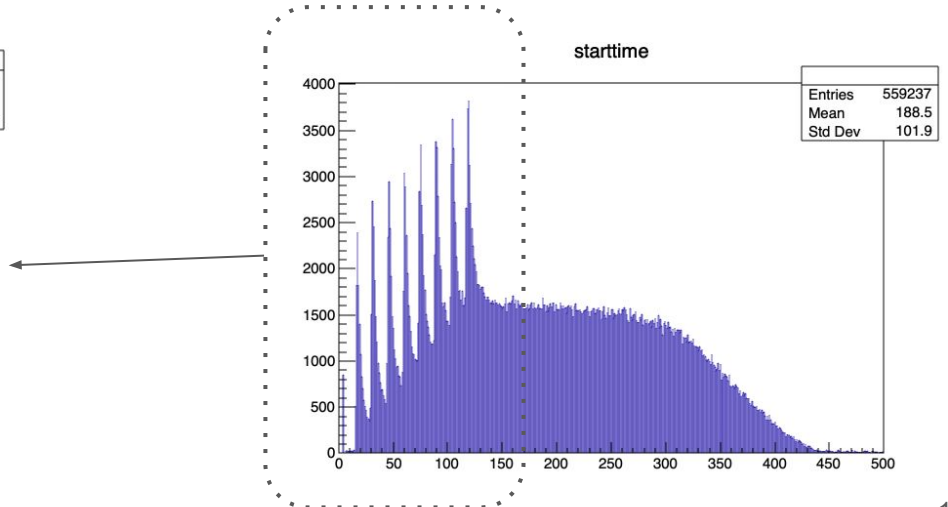
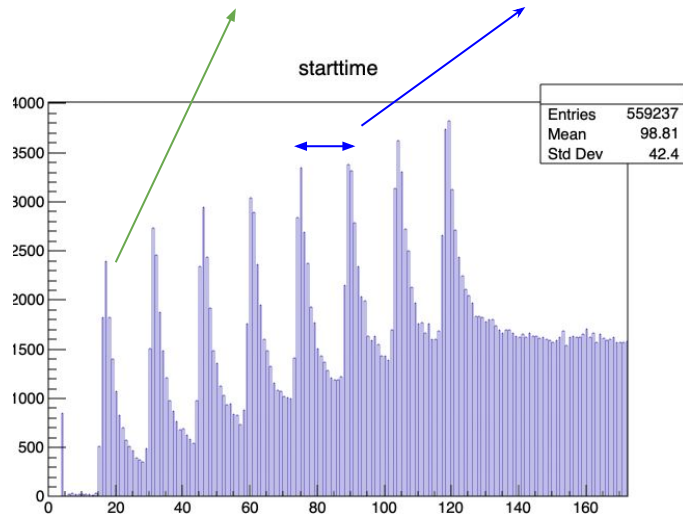
T0 finder: New alternative - algorithm

- Once the bunch is identified, the drift distance is defined as

$$x_{\text{drift}} = (\text{time} - \text{BeamOffset}) * f_{\text{SamplingTime}} * \text{ND}::\text{hatCalibration}().\text{GetDriftVelocity};$$

with

$$\text{BeamOffset} = \text{fT0_beam_offset} + \text{fT0_DeltaT_bunch} * \text{fT0Algo} \rightarrow \text{GetBunch}()$$

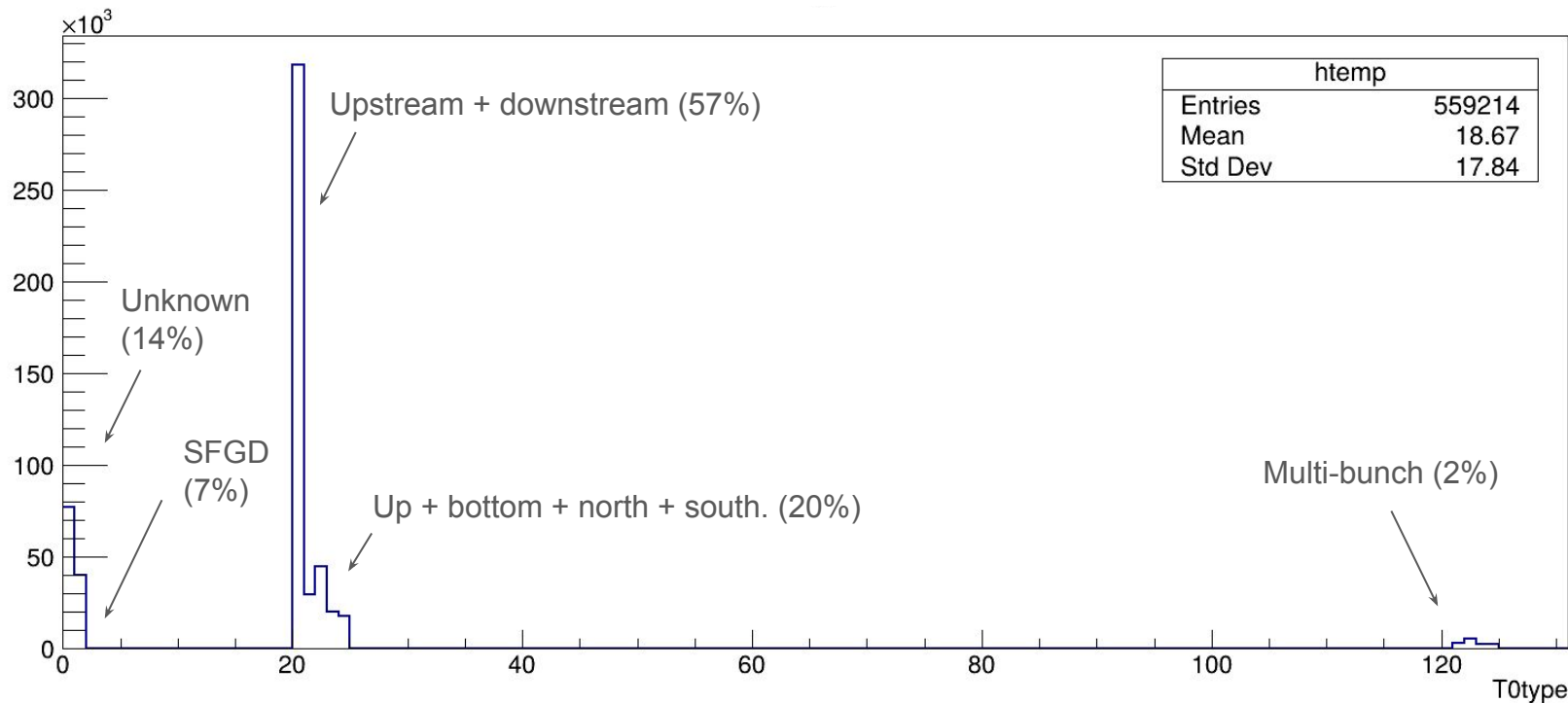


T0 finder: New alternative - result

- Analysis of ~700k events of beam events

[/sps/t2k/Jparc/May_2024/beam/hatTree_1425/hattree_beam_1425.root](#) (cc-lyon)

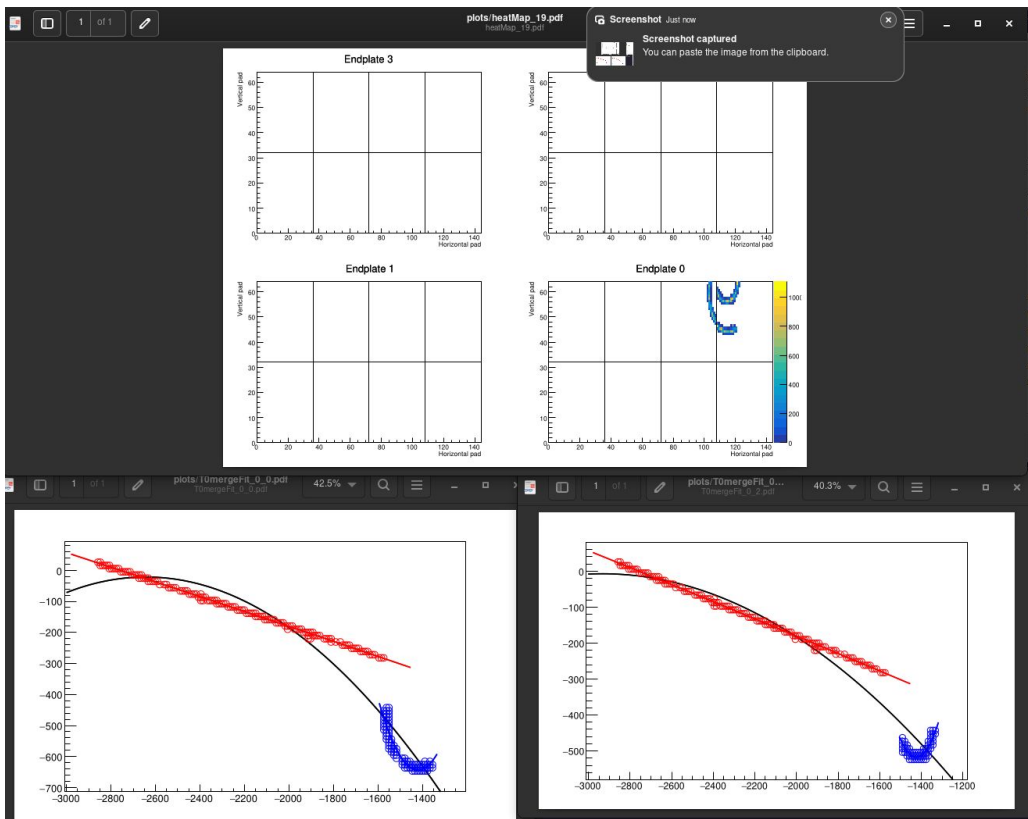
- ~550k reconstructed HAT tracks



T0 finder: New alternative - analysis

- 'Unknown' sample event 19:
 - SFGD & HAT do not match, although they seem correlated
 - No TOF hits

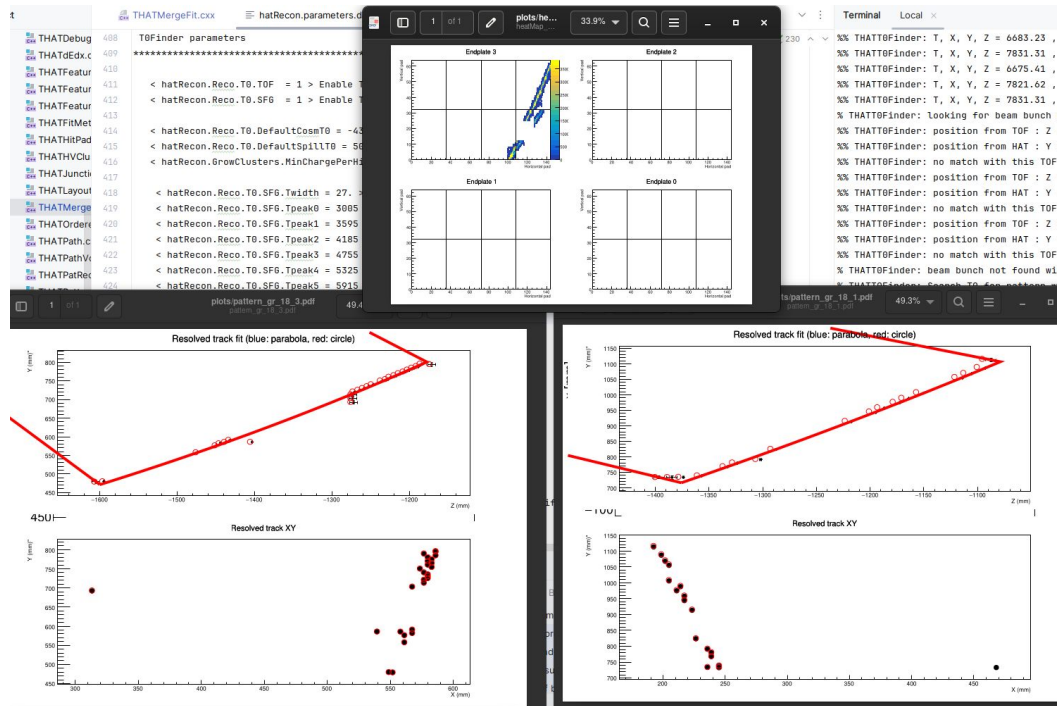
Upstream + downstream (57%)
Up + bottom + north + south. (20%)
Unknown (14%)
SFGD (7%)
Multi-bunch (2%)



T0 finder: New alternative - analysis

Upstream + downstream (57%)
Up + bottom + north + south. (20%)
Unknown (14%)
SFGD (7%)
Multi-bunch (2%)

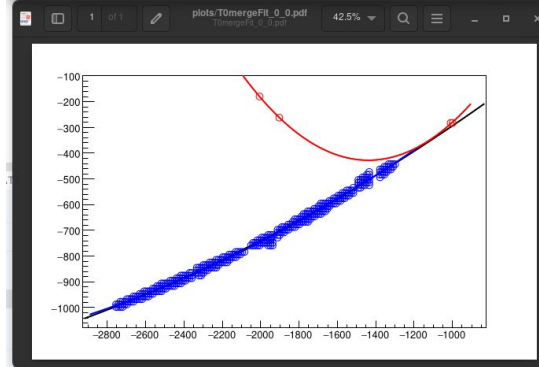
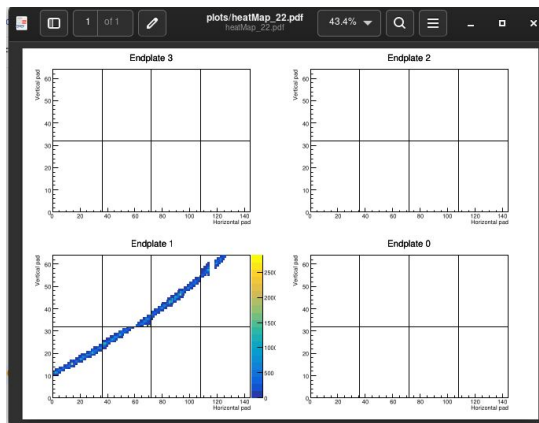
- 'Unknown' sample event 18:
 - Bad HAT reconstruction (issue of pattern recognition) makes difficult the match with TOF downstream & SFGD



T0 finder: New alternative - analysis

- 'Unknown' sample event 22:
 - Too little SFGD hits & not matching HAT
 - Even if upstream matching HAT, crazy TOF hit times do not allow bunch identification

Upstream + downstream (57%)
Up + bottom + north + south. (20%)
Unknown (14%)
SFGD (7%)
Multi-bunch (2%)



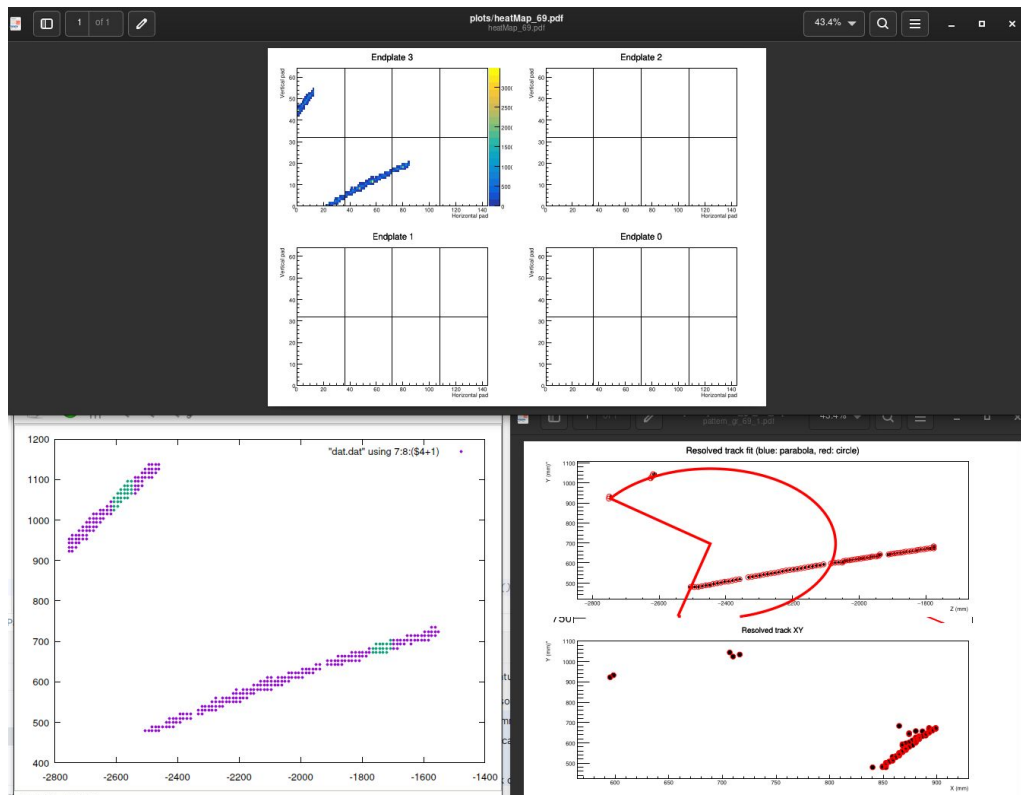
```
Terminal Local x + v
% THATT0Finder: Preparing hits in scintillator detectors.
% THATT0Finder: Preparing SFG hits
% THATT0Finder: n, t, z, y = 0, 5398.5, -2005.68, -179.525
% THATT0Finder: n, t, z, y = 1, 5391, -1992.98, -261.685
% THATT0Finder: n, t, z, y = 0, 5392, -395.295, -261.685
% THATT0Finder: n, t, z, y = 1, 5397, -395.295, -179.525
% THATT0Finder: n, t, z, y = 2, 3597, 467.385, -282.225
% THATT0Finder: n, t, z, y = 2, 3591.5, -999.215, -282.225
% THATT0Finder: n, t, z, y = 3, 3594, -1089.49, -282.225
%% THATT0Finder: not enough SFG hits for T0 finding
% THATT0Finder: Prepared SFG XY hits 3
% THATT0Finder: Prepared SFG YZ hits 4
% THATT0Finder: Preparing TOF hits
% THATT0Finder: T, X, Y, Z = 2.49442e+08, -17.5, -986, -2965.25
% THATT0Finder: T, X, Y, Z = 2.49442e+08, 17.5, -262, -947.983
% THATT0Finder: T, X, Y, Z = 2.49444e+08, 17.5, -376, -2965.25
% THATT0Finder: T, X, Y, Z = 2.49444e+08, 1399, -42.5, -1954.75
% THATT0Finder: T, X, Y, Z = 2.49442e+08, -17.5, -986, -2965.25
% THATT0Finder: T, X, Y, Z = 2.49442e+08, 17.5, -262, -947.983
% THATT0Finder: T, X, Y, Z = 2.49444e+08, 1399, -42.5, -1954.75
% THATT0Finder: Looking for beam bunch with ups/dows TOF
% THATT0Finder: position from TOF : Z = -2965.25, Y = -986
% THATT0Finder: position from HAT : Y = -1044.57
% THATT0Finder: at least a match with TOF hits
% THATT0Finder: ups/dows : 2.49442e+08 : -17.5, -986, -2965.25
% THATT0Finder: Looking for beam bunch with TOF hit time = 2.49442e+08
% THATT0Finder: beam bunch not found
% THATT0Finder: position from TOF : Z = -947.983, Y = -262
% THATT0Finder: position from HAT : Y = -254.12
% THATT0Finder: at least a match with TOF hits
% THATT0Finder: ups/dows : 2.49442e+08 : 17.5, -262, -947.983
% THATT0Finder: Looking for beam bunch with TOF hit time = 2.49442e+08
% THATT0Finder: beam bunch not found
```

pm_TOF	User	Date	Paths	
ificatic	.i10_from_TOF	wsaenz		9/21/24 10:25 AM
		wsaenz		9/19/24 5:05 PM
		wsaenz		9/19/24 4:43 PM
		wsaenz		9/13/24 12:19 PM
		wsaenz		9/5/24 5:33 PM

T0 finder: New alternative - analysis

- 'Unknown' sample event 69:
 - Bad HAT reconstruction (issue of pattern recognition) makes difficult the match with TOF & SFGD

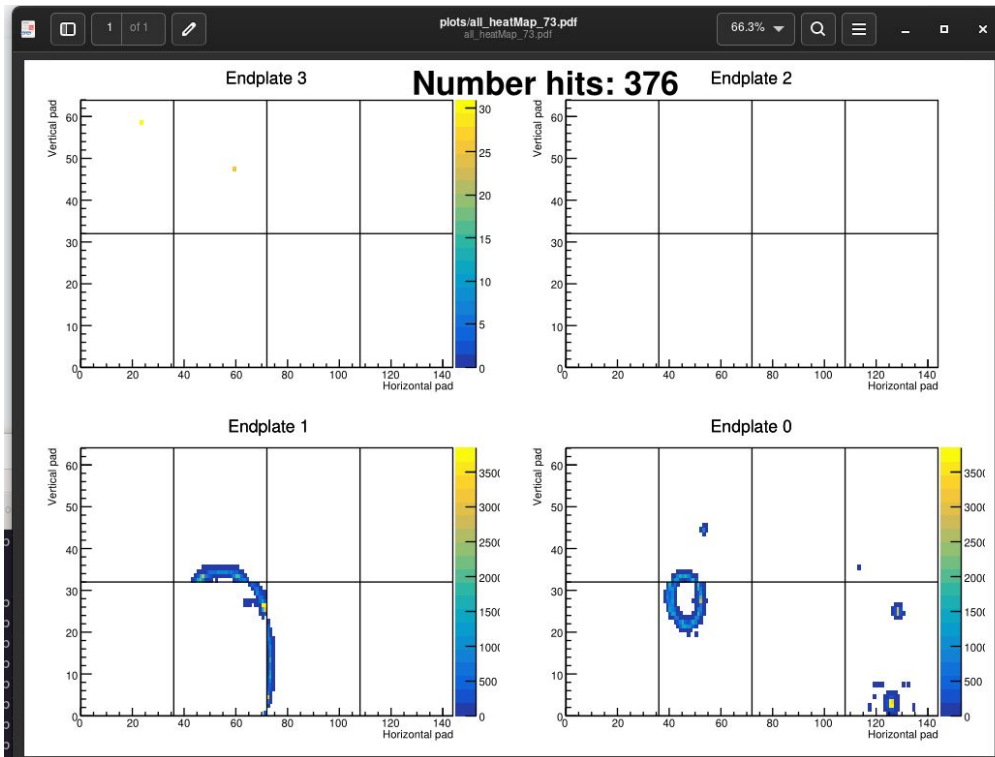
Upstream + downstream (57%)
Up + bottom + north + south. (20%)
Unknown (14%)
SFGD (7%)
Multi-bunch (2%)



T0 finder: New alternative - analysis

- 'Unknown' sample event 73:
 - HAT fully contained track

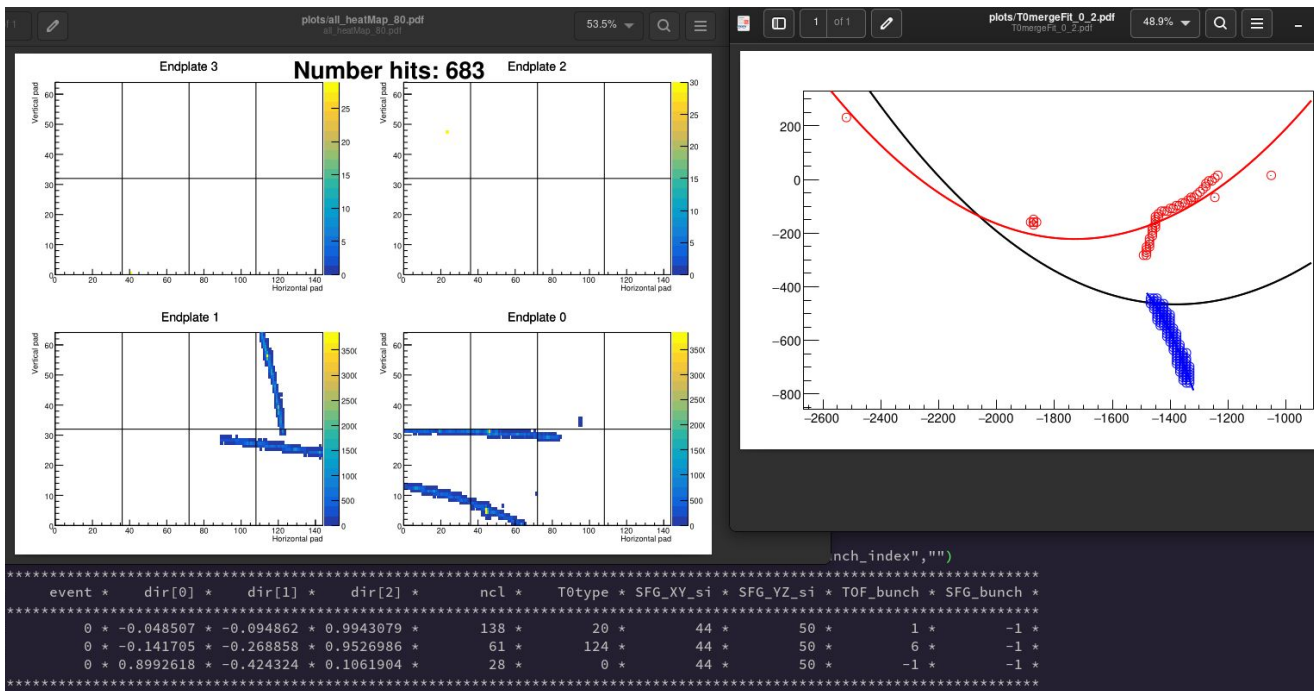
Upstream + downstream (57%)
Up + bottom + north + south. (20%)
Unknown (14%)
SFGD (7%)
Multi-bunch (2%)



T0 finder: New alternative - analysis

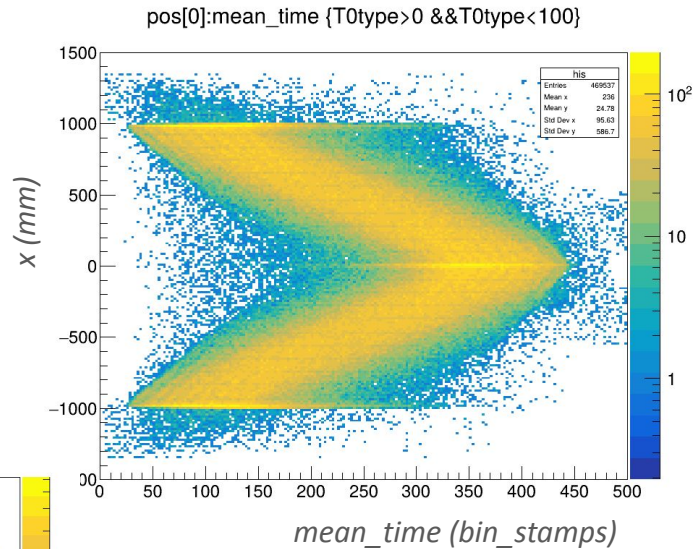
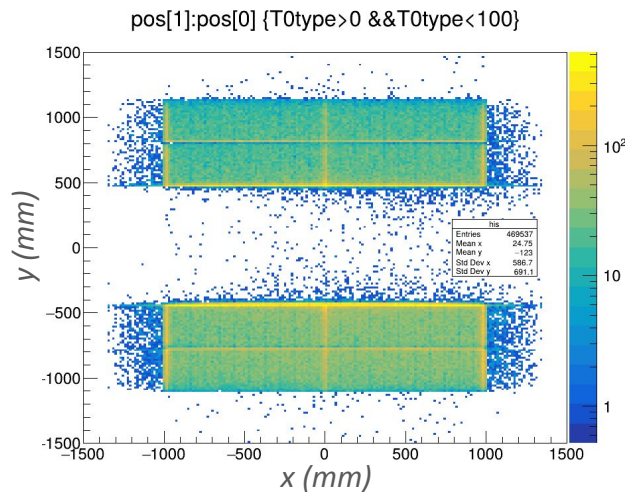
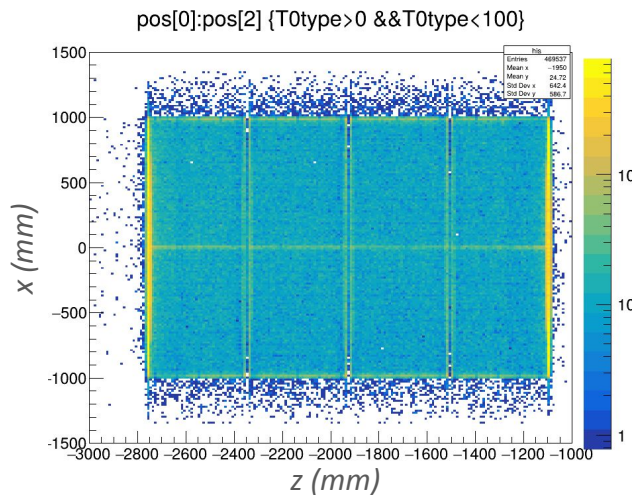
Upstream + downstream (57%)
Up + bottom + north + south. (20%)
Unknown (14%)
SFGD (7%)
Multi-bunch (2%)

- 'Unknown' sample event 80:
 - Bunch identification worked for sub-event 1 & 2, but not 3
 - Could be fixed if SFGD hits are somehow linked to HAT



T0 finder: New alternative - X reconstruction

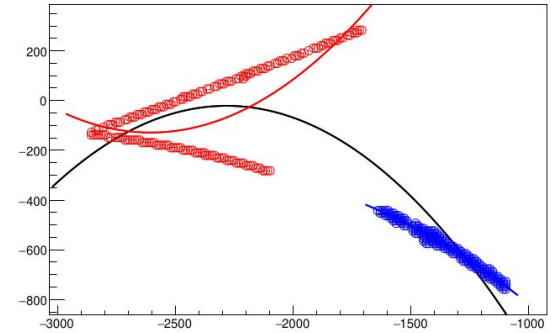
- Although analysis with more statistics is needed, preliminary result seems correct



Overview

- Alternative method for t0 identification already implemented in hatRecon master branch (tested with beam data and nd280 14.24)
- Still work to do to better know the 'unknown'
 - HAT pattern recognition tuning
 - Develop correlation method for SFGD hits other than quadratic fit
 - Talk to TOF people to debug their reconstruction
- Further analysis (resolution & dEdx) can already be done with the ~84% of tracks for which t0 is identified
 - For this, at the level of TreeMaker, apply the cut
 $T0type > 0 \ \&\& \ T0type < 100$

Upstream + downstream (57%)
Up + bottom + north + south. (20%)
Unknown (14%)
SFGD (7%)
Multi-bunch (2%)



Spare

Spare

```
% THATT0Finder: tofRecon: t, x, y, z = 7837.15, -1037.01, -384, -947.903

% THATT0Finder: TOF raw hits: T, X, Y, Z = 3861.94 , -1390, 567.5, -1954.75
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6699.76 , 1009.5, -1300, -1955.75
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6080.73 , 103.5, 1319, -1999.25
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6078.37 , 17.5, -864, -2965.25
% THATT0Finder: TOF raw hits: T, X, Y, Z = 3856.62 , -1390, 567.5, -1954.75
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6687.26 , 1009.5, -1300, -1955.75
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6072.29 , 103.5, 1319, -1999.25
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6087.75 , 17.5, -864, -2965.25
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6689.02 , 1390, -408.5, -1989.75
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6698.19 , -1390, -1140.5, -1954.75
% THATT0Finder: TOF raw hits: T, X, Y, Z = 7838.19 , -17.5, -384, -947.903
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6702.15 , 1390, -408.5, -1989.75
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6693.81 , -1390, -1140.5, -1954.75
% THATT0Finder: TOF raw hits: T, X, Y, Z = 7836.94 , -17.5, -384, -947.903
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6084.79 , -18.5, 1319, -1964.25
% THATT0Finder: TOF raw hits: T, X, Y, Z = 6074.48 , -18.5, 1319, -1964.25
% THATT0Finder: looking for beam bunch with ups/dows TOF
% THATT0Finder: ups/dows : 6078.37 : 17.5, -864, -2965.25
% THATT0Finder: beam bunch from ups/dows TOF = 4
```