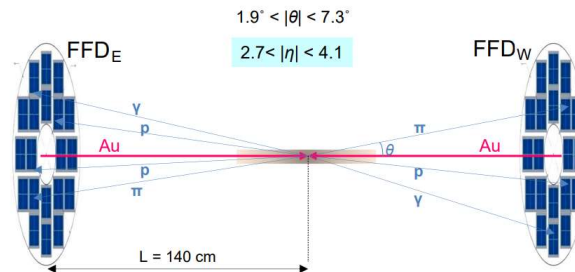


FFD Tutorial

v.1 (January, 2023) by V. Riabov

1. Geometry.

The latest version of FFD geometry is v.8. The FFD consists of two sets of Cherenkov counters located at ± 140 cm from the nominal interaction point. Each set has 20 physical detectors with 4 read-out channels each. As a result, the total number of read-out channels is $2 \text{ sides} \cdot 80 \text{ channels} = 160$ channels.



FFD geometry.

2. Running ECAL simulations.

Simulation of FFD signals is included in the default versions of the runMC.C and reco.C macro codes:

```
MpdFfdHitProducer* ffdHit = new MpdFfdHitProducer("FFDHitProducer");  
fRun->AddTask(ffdHit);
```

However, please be advised that reliable simulation of the FFD signals requires event generators that realistically describe particle production at forward rapidity (DCM-SMM, PHQMD, etc.). Only one version of the code for simulation of the FFD is available in the MpdRoot.

3. Data handling

Produced DST files have FfdHit branch with the simulated FFD responses for each track that leaves signal(s) in the detector. In general, it means that any channel in the FFD can be fired by a few tracks and the signals from such tracks should be summed up to get the total signal in the channel. Please find below a simple example how to get access to the hits:

```
#include "MpdFfdHit.h"  
.....  
TTree *inTree;  
inTree = (TTree*) inFile->Get("mpdsim");  
.....  
TClonesArray *mpdFFDHits;  
MpdFfdHit* FFDHit;  
inTree->SetBranchAddresses("FfdHit",&mpdFFDHits);  
.....  
for(Int_t j=0; j<mpdFFDHits->GetEntries(); j++){  
  FFDHit = (MpdFfdHit*)mpdFFDHits->At(j);
```

```
// do whatever you need with a given FfdHit here ...
}
```

4. FfdHit variables

For each FfdHit, one can extract the following variables:

```
FFDHit->GetSec(); // channel number, [1-160] !!!
FFDHit->GetNumPhot(); // number of Cherenkov photons registered in the channel for the track
FFDHit->GetTime(); // time of the first Cherenkov photon arriving at photodetector
map<Float_t,Float_t> contribTimesFfd = FFDHit -> GetFFDTimes(); // Cherenkov photons sorted by time of
                                                                    arrival to the photodetector
```

There are no methods to extract channel coordinates, which are needed, for example, for evaluation of the event plane. Instead, please use the following table to obtain coordinates of the centers of the fired channels. Please be aware that the argument for conversion are in the range [1-160]:

X[1] = 5.58614; Y[1] = 7.56604; Z[1] = 143.25;	X[53] = -14.0007; Y[53] = 6.6468; Z[53] = 143.25;
X[2] = 3.60624; Y[2] = 5.58614; Z[2] = 143.25;	X[54] = -15.9806; Y[54] = 4.6669; Z[54] = 143.25;
X[3] = 5.58614; Y[3] = 3.60624; Z[3] = 143.25;	X[55] = -14.0007; Y[55] = 2.68701; Z[55] = 143.25;
X[4] = 7.56604; Y[4] = 5.58614; Z[4] = 143.25;	X[56] = -12.0208; Y[56] = 4.6669; Z[56] = 143.25;
X[5] = 10.253; Y[5] = 12.2329; Z[5] = 143.25;	X[57] = 14.0007; Y[57] = -2.68701; Z[57] = 143.25;
X[6] = 8.27315; Y[6] = 10.253; Z[6] = 143.25;	X[58] = 12.0208; Y[58] = -4.6669; Z[58] = 143.25;
X[7] = 10.253; Y[7] = 8.27315; Z[7] = 143.25;	X[59] = 14.0007; Y[59] = -6.6468; Z[59] = 143.25;
X[8] = 12.2329; Y[8] = 10.253; Z[8] = 143.25;	X[60] = 15.9806; Y[60] = -4.6669; Z[60] = 143.25;
X[9] = -5.58614; Y[9] = -3.60624; Z[9] = 143.25;	X[61] = 4.6669; Y[61] = -12.0208; Z[61] = 143.25;
X[10] = -7.56604; Y[10] = -5.58614; Z[10] = 143.25;	X[62] = 2.68701; Y[62] = -14.0007; Z[62] = 143.25;
X[11] = -5.58614; Y[11] = -7.56604; Z[11] = 143.25;	X[63] = 4.6669; Y[63] = -15.9806; Z[63] = 143.25;
X[12] = -3.60624; Y[12] = -5.58614; Z[12] = 143.25;	X[64] = 6.6468; Y[64] = -14.0007; Z[64] = 143.25;
X[13] = -10.253; Y[13] = -8.27315; Z[13] = 143.25;	X[65] = 4.6669; Y[65] = 15.9806; Z[65] = 143.25;
X[14] = -12.2329; Y[14] = -10.253; Z[14] = 143.25;	X[66] = 2.68701; Y[66] = 14.0007; Z[66] = 143.25;
X[15] = -10.253; Y[15] = -12.2329; Z[15] = 143.25;	X[67] = 4.6669; Y[67] = 12.0208; Z[67] = 143.25;
X[16] = -8.27315; Y[16] = -10.253; Z[16] = 143.25;	X[68] = 6.6468; Y[68] = 14.0007; Z[68] = 143.25;
X[17] = -5.58614; Y[17] = 7.56604; Z[17] = 143.25;	X[69] = -14.0007; Y[69] = -2.68701; Z[69] = 143.25;
X[18] = -7.56604; Y[18] = 5.58614; Z[18] = 143.25;	X[70] = -15.9806; Y[70] = -4.6669; Z[70] = 143.25;
X[19] = -5.58614; Y[19] = 3.60624; Z[19] = 143.25;	X[71] = -14.0007; Y[71] = -6.6468; Z[71] = 143.25;
X[20] = -3.60624; Y[20] = 5.58614; Z[20] = 143.25;	X[72] = -12.0208; Y[72] = -4.6669; Z[72] = 143.25;
X[21] = -10.253; Y[21] = 12.2329; Z[21] = 143.25;	X[73] = 14.0007; Y[73] = 6.6468; Z[73] = 143.25;
X[22] = -12.2329; Y[22] = 10.253; Z[22] = 143.25;	X[74] = 12.0208; Y[74] = 4.6669; Z[74] = 143.25;
X[23] = -10.253; Y[23] = 8.27315; Z[23] = 143.25;	X[75] = 14.0007; Y[75] = 2.68701; Z[75] = 143.25;
X[24] = -8.27315; Y[24] = 10.253; Z[24] = 143.25;	X[76] = 15.9806; Y[76] = 4.6669; Z[76] = 143.25;
X[25] = 5.58614; Y[25] = -3.60624; Z[25] = 143.25;	X[77] = -4.6669; Y[77] = -12.0208; Z[77] = 143.25;
X[26] = 3.60624; Y[26] = -5.58614; Z[26] = 143.25;	X[78] = -6.6468; Y[78] = -14.0007; Z[78] = 143.25;
X[27] = 5.58614; Y[27] = -7.56604; Z[27] = 143.25;	X[79] = -4.6669; Y[79] = -15.9806; Z[79] = 143.25;
X[28] = 7.56604; Y[28] = -5.58614; Z[28] = 143.25;	X[80] = -2.68701; Y[80] = -14.0007; Z[80] = 143.25;
X[29] = 10.253; Y[29] = -8.27315; Z[29] = 143.25;	X[81] = 5.58614; Y[81] = 7.56604; Z[81] = -143.25;
X[30] = 8.27315; Y[30] = -10.253; Z[30] = 143.25;	X[82] = 3.60624; Y[82] = 5.58614; Z[82] = -143.25;
X[31] = 10.253; Y[31] = -12.2329; Z[31] = 143.25;	X[83] = 5.58614; Y[83] = 3.60624; Z[83] = -143.25;
X[32] = 12.2329; Y[32] = -10.253; Z[32] = 143.25;	X[84] = 7.56604; Y[84] = 5.58614; Z[84] = -143.25;
X[33] = 8.88178e-16; Y[33] = 11.3137; Z[33] = 143.25;	X[85] = 10.253; Y[85] = 12.2329; Z[85] = -143.25;
X[34] = -1.9799; Y[34] = 9.33381; Z[34] = 143.25;	X[86] = 8.27315; Y[86] = 10.253; Z[86] = -143.25;
X[35] = 8.88178e-16; Y[35] = 7.35391; Z[35] = 143.25;	X[87] = 10.253; Y[87] = 8.27315; Z[87] = -143.25;
X[36] = 1.9799; Y[36] = 9.33381; Z[36] = 143.25;	X[88] = 12.2329; Y[88] = 10.253; Z[88] = -143.25;
X[37] = -9.33381; Y[37] = -1.9799; Z[37] = 143.25;	X[89] = -5.58614; Y[89] = -3.60624; Z[89] = -143.25;
X[38] = -11.3137; Y[38] = 8.88178e-16; Z[38] = 143.25;	X[90] = -7.56604; Y[90] = -5.58614; Z[90] = -143.25;
X[39] = -9.33381; Y[39] = -1.9799; Z[39] = 143.25;	X[91] = -5.58614; Y[91] = -7.56604; Z[91] = -143.25;
X[40] = -7.35391; Y[40] = 8.88178e-16; Z[40] = 143.25;	X[92] = -3.60624; Y[92] = -5.58614; Z[92] = -143.25;
X[41] = 9.33381; Y[41] = 1.9799; Z[41] = 143.25;	X[93] = -10.253; Y[93] = -8.27315; Z[93] = -143.25;
X[42] = 7.35391; Y[42] = -8.88178e-16; Z[42] = 143.25;	X[94] = -12.2329; Y[94] = -10.253; Z[94] = -143.25;
X[43] = 9.33381; Y[43] = -1.9799; Z[43] = 143.25;	X[95] = -10.253; Y[95] = -12.2329; Z[95] = -143.25;
X[44] = 11.3137; Y[44] = -8.88178e-16; Z[44] = 143.25;	X[96] = -8.27315; Y[96] = -10.253; Z[96] = -143.25;
X[45] = -8.88178e-16; Y[45] = -7.35391; Z[45] = 143.25;	X[97] = -5.58614; Y[97] = 7.56604; Z[97] = -143.25;
X[46] = -1.9799; Y[46] = -9.33381; Z[46] = 143.25;	X[98] = -7.56604; Y[98] = 5.58614; Z[98] = -143.25;
X[47] = -8.88178e-16; Y[47] = -11.3137; Z[47] = 143.25;	X[99] = -5.58614; Y[99] = 3.60624; Z[99] = -143.25;
X[48] = 1.9799; Y[48] = -9.33381; Z[48] = 143.25;	X[100] = -3.60624; Y[100] = 5.58614; Z[100] = -143.25;
X[49] = -4.6669; Y[49] = 15.9806; Z[49] = 143.25;	X[101] = -10.253; Y[101] = 12.2329; Z[101] = -143.25;
X[50] = -6.6468; Y[50] = 14.0007; Z[50] = 143.25;	X[102] = -12.2329; Y[102] = 10.253; Z[102] = -143.25;
X[51] = -4.6669; Y[51] = 12.0208; Z[51] = 143.25;	X[103] = -10.253; Y[103] = 8.27315; Z[103] = -143.25;
X[52] = -2.68701; Y[52] = 14.0007; Z[52] = 143.25;	X[104] = -8.27315; Y[104] = 10.253; Z[104] = -143.25;

```

X[105] = 5.58614; Y[105] = -3.60624; Z[105] = -143.25;
X[106] = 3.60624; Y[106] = -5.58614; Z[106] = -143.25;
X[107] = 5.58614; Y[107] = -7.56604; Z[107] = -143.25;
X[108] = 7.56604; Y[108] = -5.58614; Z[108] = -143.25;
X[109] = 10.253; Y[109] = -8.27315; Z[109] = -143.25;
X[110] = 8.27315; Y[110] = -10.253; Z[110] = -143.25;
X[111] = 10.253; Y[111] = -12.2329; Z[111] = -143.25;
X[112] = 12.2329; Y[112] = -10.253; Z[112] = -143.25;
X[113] = 8.88178e-16; Y[113] = 11.3137; Z[113] = -143.25;
X[114] = -1.9799; Y[114] = 9.33381; Z[114] = -143.25;
X[115] = 8.88178e-16; Y[115] = 7.35391; Z[115] = -143.25;
X[116] = 1.9799; Y[116] = 9.33381; Z[116] = -143.25;
X[117] = -9.33381; Y[117] = 1.9799; Z[117] = -143.25;
X[118] = -11.3137; Y[118] = 8.88178e-16; Z[118] = -143.25;
X[119] = -9.33381; Y[119] = -1.9799; Z[119] = -143.25;
X[120] = -7.35391; Y[120] = 8.88178e-16; Z[120] = -143.25;
X[121] = 9.33381; Y[121] = 1.9799; Z[121] = -143.25;
X[122] = 7.35391; Y[122] = -8.88178e-16; Z[122] = -143.25;
X[123] = 9.33381; Y[123] = -1.9799; Z[123] = -143.25;
X[124] = 11.3137; Y[124] = -8.88178e-16; Z[124] = -143.25;
X[125] = -8.88178e-16; Y[125] = -7.35391; Z[125] = -143.25;
X[126] = -1.9799; Y[126] = -9.33381; Z[126] = -143.25;
X[127] = -8.88178e-16; Y[127] = -11.3137; Z[127] = -143.25;
X[128] = 1.9799; Y[128] = -9.33381; Z[128] = -143.25;
X[129] = -4.6669; Y[129] = 15.9806; Z[129] = -143.25;
X[130] = -6.6468; Y[130] = 14.0007; Z[130] = -143.25;
X[131] = -4.6669; Y[131] = 12.0208; Z[131] = -143.25;
X[132] = -2.68701; Y[132] = 14.0007; Z[132] = -143.25;
X[133] = -14.0007; Y[133] = 6.6468; Z[133] = -143.25;
X[134] = -15.9806; Y[134] = 4.6669; Z[134] = -143.25;
X[135] = -14.0007; Y[135] = 2.68701; Z[135] = -143.25;
X[136] = -12.0208; Y[136] = 4.6669; Z[136] = -143.25;
X[137] = 14.0007; Y[137] = -2.68701; Z[137] = -143.25;
X[138] = 12.0208; Y[138] = -4.6669; Z[138] = -143.25;
X[139] = 14.0007; Y[139] = -6.6468; Z[139] = -143.25;
X[140] = 15.9806; Y[140] = -4.6669; Z[140] = -143.25;
X[141] = 4.6669; Y[141] = -12.0208; Z[141] = -143.25;
X[142] = 2.68701; Y[142] = -14.0007; Z[142] = -143.25;
X[143] = 4.6669; Y[143] = -15.9806; Z[143] = -143.25;
X[144] = 6.6468; Y[144] = -14.0007; Z[144] = -143.25;
X[145] = 4.6669; Y[145] = 15.9806; Z[145] = -143.25;
X[146] = 2.68701; Y[146] = 14.0007; Z[146] = -143.25;
X[147] = 4.6669; Y[147] = 12.0208; Z[147] = -143.25;
X[148] = 6.6468; Y[148] = 14.0007; Z[148] = -143.25;
X[149] = -14.0007; Y[149] = -2.68701; Z[149] = -143.25;
X[150] = -15.9806; Y[150] = -4.6669; Z[150] = -143.25;
X[151] = -14.0007; Y[151] = -6.6468; Z[151] = -143.25;
X[152] = -12.0208; Y[152] = -4.6669; Z[152] = -143.25;
X[153] = 14.0007; Y[153] = 6.6468; Z[153] = -143.25;
X[154] = 12.0208; Y[154] = 4.6669; Z[154] = -143.25;
X[155] = 14.0007; Y[155] = 2.68701; Z[155] = -143.25;
X[156] = 15.9806; Y[156] = 4.6669; Z[156] = -143.25;
X[157] = -4.6669; Y[157] = -12.0208; Z[157] = -143.25;
X[158] = -6.6468; Y[158] = -14.0007; Z[158] = -143.25;
X[159] = -4.6669; Y[159] = -15.9806; Z[159] = -143.25;
X[160] = -2.68701; Y[160] = -14.0007; Z[160] = -143.25;

```

5. Code examples

The FFD code example can be found at NICA cluster,
/eos/nica/mpd/users/riabovvg/FFD_Tutorial_Examples/FfdAnalysis.C.
This is an example of how to read the FFD branch from the DST file and to evaluate signals and coordinates for each read-out channel in the detector and to simulate the trigger signal. In order to run the code please type: `root -b -q FfdAnalysis.C`.

The code will process all events in the input file and produce a number of histograms in the output `FfdAnalysis.root` file:

- hOccupFFDE – occupancy plot for the FFD-E
- hOccupFFDW – occupancy plot for the FFD-W
- hImpAll – impact parameter distribution for all accepted events
- hImpFFD – impact parameter distribution for events with the fired FFD trigger
- hZedAll – z-vertex distribution for all accepted events
- hZedFFD – z-vertex distribution for events with the fired FFD trigger
- hVertFFD – correlation between FFD-reconstructed and true z-vertices
- hVertFFDRes – z-vertex resolution with the FFD
- hT0FFDRes – T_0 resolution with the FFD
- hNphFFD – number of Cherenkov photons in the channels

Please also see comments in the code. Please also note that not all event generators produce meaningful results for the FFD.