Beam in HCANA

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Contents

1 Introduction

For most purposes in Hall C data analysis, the beam apparatus that is used is THcRasteredBeam and the beam detector is THcRaster. A sample in the replay script is :

```
THaApparatus* beam = new THcRasteredBeam("H.rb", "Rastered Beamline")
```

This is for when the HallCSpectrometer is defined as ”H” (for SHMS it is custom to be defined as ”P”) . The beam object is given the name ”H.rb” and can be used later in physics modules:

```
THcReactionPoint* hrp = new THcReactionPoint("H.react", "", "H", "H.rb");
THcExtTarCor* hext = new THcExtTarCor("H.extcor", "", "H", "H.react");
THcPrimaryKine* hkin = new THcPrimaryKine("H.kin", "", "H", "H.rb");
```

Methods for getting the information on the beam positions and direction that are calculated in *THcRaster.cxx* .

2 Raster and EPICS BPMs

The Hall C raster consists of two sets of X and Y coils which are labeled in the code as ”A” and ”B”. For each event, the raster voltage for all four coils is sampled in a FADC250. This voltage is proportional to the magnetic field in the raster coils which is directly related to the deflection of the beam at the target. The two X (Y) coils are in sync and give enough deflection so, for 11 GeV beam, the maxiumum deflection at the maximum voltage in the supplies is about 5x5mm (5mm is the full width, 2.5mm is the half-width). The raster voltage only gives the relative deflection compared to the average beam position. In Hall C, there is presently no measure of the beam position on an event-by-event basis. The EPICS data is used to give the average beam position with the assumption that the average beam position has a small variation over the course of a run. The EPICS data is in units of mm and the coordinate system has +X pointing beam right and +Y pointing up.

The *THcRaster.cxx* reads in the raster current data. The *Init* method sets *THcTHcRasterRawHit* based on the detector map:

```
! HRASTER_ID=18    ::  ADC
DETECTOR=18
ROC=1
SLOT=18
12,   1,   1,   0  ! FR-YA
13,   1,   2,   0  ! FR-XA
14,   1,   3,   0  ! FR-YB
15,   1,   4,   0  ! FR-XA
```

with a similar setup for the SHMS detector map.

The *Decode* method reads in the raw ADC values for each event. The internal variable names and the names in the output tree are given in Table 1. If

Variable Name	Tree name	Comment
frxaRawAdc	FRXA_rawadc	
frxbRawAdc	FRXB_rawadc	
fryaRawAdc	FRYA_rawadc	
frybRawAdc	FRYB_rawadc	

Table 1: Raster Raw ADC variables

the EPICS handler is initialized in the replay script, then the "RAW" EPICS X-Y position data for the three BPMS along the girder before the target is read to the variables: BPMXA_raw, BPMXB_raw, BPMXC_raw, BPMXA_raw, BPMXB_raw and BPMXC_raw. The raw variables are not available in the output tree. One could get them from the EPICS tree if the definition file is setup properly.

The *Process* method converts the raw raster ADC and EPICS BPM data into calibrated positions. The variable raster ADC (listed in Table 2) is calculated by subtracting an offset from the raw raster ADC. The offsets are parameters : gfrxa_adc_zero_offset, gfrxb_adc_zero_offset, gfrya_adc_zero_offset, gfryb_adc_zero_offset.

The relative raster position is calculated as:

$$\text{fXA\_pos} = \frac{\text{fXA\_ADC}}{\text{fFrXA\_ADCperCM}} * \frac{\text{fFrCalMom}}{\text{fgpbeam}} \tag{1}$$

Variable Name	Tree name	Comment
frxaRawAdc	FRXA_rawadc	
frxbRawAdc	FRXB_rawadc	
fryaRawAdc	FRYA_rawadc	
frybRawAdc	FRYB_rawadc	

Table 2: Raster ADC variables

Variable Name	Parameter name	Comment
fFrXA_ADCperCM	gfrxa_adcpercm	Scale factor Counts per cm
fFrXB_ADCperCM	gfrxb_adcpercm	Scale factor Counts per cm
fFrYA_ADCperCM	gfrya_adcpercm	Scale factor Counts per cm
fFrYB_ADCperCM	gfryb_adcpercm	Scale factor Counts per cm
fFrCalMom	gfr_cal_mom	Beam energy that calibration was done
fgpbeam	gpbeam	Beam energy in kinematics file

Table 3: Raster Parameters

The parameters are explained in Table 3. The desire was to have the raster position is the EPICS coordinate system (+X beam right and +Y up). To achieve this the positions for the Y variables had to be multiplied by -1.

Calibration of the raster positions is done by looking at the raster raw ADC histograms. The lower and upper edges of the raster raw ADC can be found for each raster coil. The offset is the average of the edges and the scale factor is the difference of the edges divided by the expected full width of the raster. The size can be checked by comparison to the carbon hole size which has a diameter of 2mm.

The BPMs positions at the target can be set as parameters which are the average over the entire run or determined from the EPICS data throughout the run. The parameters are shown in Table 4. It is optional that the parameters are read in. If the code reads in the any of parameters, then the BPM target positions and angles will be all set to the parameter (if it happens that only some of the parameters are read in then the others are set to zero.). If you are using the parameter option to set the target BPM position, then it is best to do it in the *standard.kinematics* file since it can change run-to-run. A script has to be written to calculate the average target positions from the EPICS data.

The BPMs are calibrated relative to the HARPs. A script has been developed to fit a group of HARP scans to determine the calibration constants. The script and instructions are in the CALIBRATION/bpm_calib subdirectory of hallc_replay git repository. The HARP coordinate system has +X pointing beam left and +Y up. The BPM position in the HARP coordinate system is given by

$$\text{BPMXA\_pos} = 0.1 * (\text{fgbpmxa\_slope} * \text{BPMXA\_raw} + \text{fgbpmxa\_off}) \tag{2}$$

Parameter name	Variable Name	Comment
gbeam_x	fgbeam_x	Average target X position from EPICS BPMs (+X beam right)
gbeam_y	fgbeam_y	Average target Y position from EPICS BPMs (+Y beam up)
gbeam_xp	fgbeam_xp	Average target X angle from EPICS BPMs
gbeam_yp	fgbeam_yp	Average target Y angle from EPICS BPMs

Table 4: BPM Parameters

The 0.1 is to convert the calibration to units of cm. One note is that the slopes for all the BPMX should be negative to convert the EPICS raw value to the HARP coordinate system. The BPM calibration parameters are given in Table 5. The X and Y BPM position and angles at the target (in the HARP co-

Parameter name	Variable Name	Comment
gbpmxa_slope	fgbpmxa_slope	Slope of HARP fit to BPMXA data
gbpmxb_slope	fgbpmxb_slope	Slope of HARP fit to BPMXB data
gbpmya_slope	fgbpmya_slope	Slope of HARP fit to BPMYA data
gbpmyb_slope	fgbpmyb_slope	Slope of HARP fit to BPMYB data
gbpmxa_off	fgbpmxa_off	Intercept of HARP fit to BPMXA data
gbpmxb_off	fgbpmxb_off	Intercept of HARP fit to BPMXB data
gbpmya_off	fgbpmya_off	Intercept of HARP fit to BPMYA data
gbpmyb_off	fgbpmyb_off	Intercept of HARP fit to BPMYB data

Table 5: BPM Calibration Parameters

ordinate system) are calculated using the BPMA_pos and BPMC_pos positions. In the code ,these are called xbeam and ybeam and fXbpm_tar = -xbeam and fYbpm_tar=ybeam to put it in the EPICs coordinate system. If the parameters gbeam_x and gbeam_y are read-in then fXbpm_tar = gbeam_x and fYbpm_tar = gbeam_y. The tree names of the BPM positions in the EPICS coordinate system are listed in Table 6.

3 Target positions

The predicted Y target position (Y_{pred}) measured by the spectrometer depends on the target position along the beam line (Z_H), the horizontal beam position (X_H), the horizontal mispointing of the spectrometer (Y_{mis}), the central angle of the spectrometer (θ_c) and the scattering angle of the particle relative to the spectrometer coordinate system (Y').

$$Y_{pred} = X_H * (\cos\theta_c - Y' * \sin\theta_c) - Z_H * (\sin\theta_c + Y' * \cos\theta_c) - Y_{mis} \qquad (3)$$

For scattering into the HMS then θ_c should have a negative sign. The X_H is equal to the negative of P.rb.raster.fr_xbpm_tar. Y_{mis} is taken from spectrometer

Variable name	Tree Name	Comment
fXbpm_A	fr_xbpmA	
fYbpm_A	fr_ybpmA	
fXbpm_B	fr_xbpmB	
fYbpm_B	fr_ybpmB	
fXbpm_C	fr_xbpmC	
fYbpm_C	fr_ybpmC	
fXbpm_tar	fr_xbpm_tar	
fYbpm_tar	fr_ybpm_tar	

Table 6: BPM positions variables and tree names

survey. For the SHMS, $Y_{mis} = -0.06$ cm. For the HMS,

$$Y_{mis} = 0.052 - 0.0012 * abs(\theta_c) + 0.0002 * \theta_c^2 \tag{4}$$

where θ_c is in degrees and Y_{mis} in cm. $+Z_H$ is defined to be pointing beam downstream.