Processing of triggerlessly acquired detector's data

PREPROCESSING

Load and pepare the dataset inside a Pandas' DataFrame

In [69]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from os import listdir
from os.path import isfile, join

%matplotlib inline
```

Load the entire dataset:

In [95]:
```
# Load the entire dataset inside the directory
# Prepare the path to the file
directory = "/home/cattapaa/data_1/"
file_names = [file for file in listdir(directory) if isfile(j
oin(directory, file))]

# Create dataframe by appending the data fromeach file
data = pd.read_csv(directory + file_names[0])
for i in range(1, len(file_names)):
    data = data.append(pd.read_csv(directory + file_names[i
]))
data.head(10)
```

Out[95]:

	HEAD	FPGA	TDC_CHANNEL	ORBIT_CNT	BX_COUNTER	TDC_MEAS
0	1	1	45	1920954526	2363	4
1	1	1	77	1920954526	2357	29
2	1	1	20	1920954526	2361	20
3	1	1	40	1920954526	2364	28
4	1	1	96	1920954526	2358	29
5	1	1	27	1920954526	2362	28
6	1	1	97	1920954526	2363	9
7	1	1	16	1920954526	2370	9
8	1	1	42	1920954526	2370	19
9	1	1	83	1920954526	2363	29

Load the dataset from only one file:

In [71]:
```
# Prepare the path to the file
# Load the dataset
data = pd.read_csv(directory + file_name)

# Useful constants
Tmax = 390 # ns
L = 42 # mm
Vd = L/(2*Tmax) # mm/ns
pos_offset = 21 # mm

# Add column of time (ns)
# There is a problem with the precision of the measures
# Real time: data['TIME_NS'] = data["ORBIT_CNT"]*3564*25 + da
ta["BX_COUNTER"]*25 + data["TDC_MEAS"]*25/30
data['TIME_NS'] = data["BX_COUNTER"]*25 + data["TDC_MEAS"]*25
/30

# Show first 5 rows
data.head(5)

def compute_t0(tR1, tR2, tR3):
    return (tR1 - tR3)/2 + tR2 - Tmax

# To get the layer we must get the remainder of the TDC_CHANN
EL with 4
# Then we must reoder the result as described above
data['LAYER'] = data['TDC_CHANNEL'] % 4

# Create mask to adjust labels
mask = data == 'inf' # Trick: I want an equivalent DataFrame
 with all False

# Map 1 --> 4
data.loc[data['LAYER'] == 1,'LAYER'] = 4

# Map 0 -> 1
data.loc[data['LAYER'] == 0,'LAYER'] = 1

# Check the correctness
data.head(5)

# Create column for chamber
# Create mask to adjust labels
mask = data == 'inf' # Trick: I want an equivalent DataFrame
 with all False

# Before create empty column
data['CHAMBER'] = 0

# Detector 1
# Select all rows with FPGA = 0 and TDC_CHANNEL <= 64
mask['CHAMBER'] = ((data['FPGA'] == 0) & (data['TDC_CHANNEL']
<= 64))
data[mask] = 1

# Detector 2
# Select all rows with FPGA = 0 and  64 < TDC_CHANNEL <= 128
mask['CHAMBER'] = ((data['FPGA'] == 0) & (data['TDC_CHANNEL']
> 64) & (data['TDC_CHANNEL'] <= 128))
data[mask] = 2
```

```
mask['CHAMBER'] = ((data['FPGA'] == 1) & (data['TDC_CHANNEL']
<= 64))
data[mask] = 3

# Detector 4
# Select all rows with FPGA = 0 and  64 < TDC_CHANNEL <= 128
mask['CHAMBER'] = ((data['FPGA'] == 1) & (data['TDC_CHANNEL']
> 64) & (data['TDC_CHANNEL'] <= 128))
data[mask] = 4

# Check the correctness
data.head(5)

# Create column for chamber
data['CELL'] = ((data['TDC_CHANNEL']%64)/4).apply(np.ceil)

# Check the correctness
data.head(5)
```

Out[71]:

	HEAD	FPGA	TDC_CHANNEL	ORBIT_CNT	BX_COUNTER	TDC_MEAS	T
0	1	1	45	1920954526	2363	4	5
1	1	1	77	1920954526	2357	29	5
2	1	1	20	1920954526	2361	20	5
3	1	1	40	1920954526	2364	28	5
4	1	1	96	1920954526	2358	29	5

PART 1

To Detect the events we can use the trigger 139

In [48]:

```
# Silence warning
pd.options.mode.chained_assignment = None  # default='warn'

# Search all the orbit with the trigger 139
orbit = data.loc[data['TDC_CHANNEL']==139,'ORBIT_CNT']
list_orbit = orbit.values.tolist()
events = data.loc[data['ORBIT_CNT'].isin(list_orbit)]

# Sort data
events = events.sort_values(by = ['ORBIT_CNT','TDC_CHANNEL'])

# Compute t0
# Make three shifted copy of the LAYER column nd of TIME_NS
events['LAYER_1'] = events['LAYER'].shift(-1)
events['LAYER_2'] = events['LAYER'].shift(-2)
events['TIME_NS_1'] = events['TIME_NS'].shift(-1)
events['TIME_NS_2'] = events['TIME_NS'].shift(-2)

events.head(5)
```

Out[48]:

	HEAD	FPGA	TDC_CHANNEL	ORBIT_CNT	BX_COUNTER	TDC_MEAS

⚠ You signed in with another tab or window. Reload to refresh your session.

39	1	1	22	1920954537	2644	15
33	1	1	23	1920954537	2639	24
35	1	1	24	1920954537	2642	4

In [49]:

```
# Remove the trigger 139
events = events[events['TDC_CHANNEL']<129]

# Search pattern 1-2-3 or 2-3-4 to apply the Talete's Theorem for t0
events['temp'] = (events['TIME_NS']-events['TIME_NS_2'])/2 + events['TIME_NS_1']-Tmax

# Search pattern to get the real t0
mask_pattern_1 = (events['LAYER']==1) & (events['LAYER_1']==2) & (events['LAYER_2']==3)
mask_pattern_2 = (events['LAYER']==2) & (events['LAYER_1']==3) & (events['LAYER_2']==4)

# Compute real t0
events['t0'] = events.loc[mask_pattern_1, 'temp']
# Populate values of adiacent cell
events = events.fillna(0)
events['t0'] = events['t0'] + events['t0'].shift(1) + events['t0'].shift(2)
events = events.fillna(0)

# Compute the position
events['POSITION'] = events['t0']*Vd

events.head(10)
```

Out[49]:

	HEAD	FPGA	TDC_CHANNEL	ORBIT_CNT	BX_COUNTER	TDC_MEAS
37	1	1	21	1920954537	2645	1
40	1	1	21	1920954537	2647	25
39	1	1	22	1920954537	2644	15
33	1	1	23	1920954537	2639	24
35	1	1	24	1920954537	2642	4
34	1	1	85	1920954537	2639	19
36	1	1	86	1920954537	2639	12
38	1	1	87	1920954537	2644	20
31	1	1	88	1920954537	2634	27
41	1	1	38	1920954543	1679	1

In [58]:

```
# Map obit values to a range of int
grouped_orbit = events.groupby('ORBIT_CNT')
# Search all orbits
orbits = list(grouped_orbit.groups.keys())
```

```
# create the map
event_map = dict(zip(orbits, event_number))
# Map values
orbit_to_map = events['ORBIT_CNT']
orbit_mapped = orbit_to_map.map(event_map)
events['EVENT_NUMBER'] = orbit_mapped
events.head(10)
```

Out[58]:

	HEAD	FPGA	TDC_CHANNEL	ORBIT_CNT	BX_COUNTER	TDC_MEAS
37	1	1	21	1920954537	2645	1
40	1	1	21	1920954537	2647	25
39	1	1	22	1920954537	2644	15
33	1	1	23	1920954537	2639	24
35	1	1	24	1920954537	2642	4
34	1	1	85	1920954537	2639	19
36	1	1	86	1920954537	2639	12
38	1	1	87	1920954537	2644	20
31	1	1	88	1920954537	2634	27
41	1	1	38	1920954543	1679	1

In [63]:

```
# Final DataFrame
events_final = events[['EVENT_NUMBER','CHAMBER','LAYER','CEL
L','POSITION']]
events_final.set_index(['EVENT_NUMBER','CHAMBER','LAYER'], in
place=True)
events_final.sort_index(inplace=True)
events_final.head(10)
```

Out[63]:

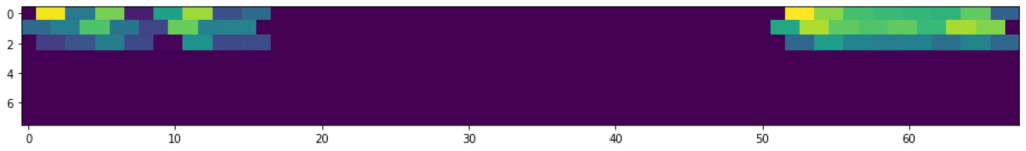
			CELL	POSITION
EVENT_NUMBER	**CHAMBER**	**LAYER**		
1	**3**	**1**	6.0	0.0
		2	6.0	0.0
		3	6.0	0.0
		4	6.0	0.0
		4	6.0	0.0
	4	**1**	6.0	0.0
		2	6.0	0.0
		3	6.0	0.0
		4	6.0	0.0
2	**3**	**2**	10.0	0.0

In [97]:

```
## SCRIVI OUT
```

```
raw_mat = np.zeros((16, 32))


plt.figure(figsize=(16,10))



rows = np.array((events['CHAMBER']-1)*4+events['LAYER']-1)
columns = np.array((events['CELL']-1)*2).astype(int)


for i in range(len(rows)):
    raw_mat[rows[i], columns[i]] = raw_mat[rows[i], columns[i
]]+1
    raw_mat[rows[i], columns[i]+1] = raw_mat[rows[i], columns
[i]+1]+1

#plt.imshow(raw_mat)
#plt.colorbar()

final_mat = np.zeros((8, 68))

for i in range(4):
    if (i%2 == 0):
        final_mat[i, 1:33] = raw_mat[i, :32]
    else:
        final_mat[i, :32] = raw_mat[i, :32]
for i in range(4, 8):
    if (i%2 == 0):
        final_mat[i-4, 36:68] = raw_mat[i, :32]
    else:
        final_mat[i-4, 35:67] = raw_mat[i, :32]
#final_mat[0, 1:33] = raw_mat[0, :32]
#final_mat[1, :32] = raw_mat[1, :32]
#final_mat[2, 1:33] = raw_mat[2, :32]

plt.imshow(final_mat)
```

```
128
Out[97]: <matplotlib.image.AxesImage at 0x7f234b39bac8>
```



```
In [40]: events.head(100)
         np.array(rows)
```

```
Out[40]: 8
```

```
In [ ]: # Before this we have to solve the left/right ambiguity
        # Add offset to the position
        mask_layer = (events['LAYER'] == 1) | (events['LAYER'] == 3)
        mask = mask_layer & (events['POSITION'] != 0)
        events.loc[mask, 'POSITION'] = events['POSITION'] + pos_offse
        t
```

```
triggered_orbit = grouped_orbit.filter(lambda x: x['TDC_CHANN
EL'].max()==139)
## Triggered_orbit è un dataframe contente tutti gli hit dell
e orbit che hanno il trigger 139
## Ci mette molto anche usando filter (meno di 5 minuti però,
credo...)
triggered_orbit.head()
## Le orbit sembrano già essere in ordine crescente
```

In [ ]:

```
## TEST OCIO CHE CI METTE TANTISSIMISSIMO (Per ora teniamo qu
ello di Boet)
## Lets costruiamo questo fucking dataframe
events = pd.DataFrame(columns=['EVENT','HIT','INFO','VALUE'])

## Eliminiamo le hit corrispondenti ai trigger
triggered_orbit = triggered_orbit[triggered_orbit['TDC_CHANNE
L']<137]
gr_event = triggered_orbit.groupby('ORBIT_CNT')

## Ocio che ci mette molto tempo
event_counter = 0
row_counter = 0
for orb, group in gr_event:
    hit_counter = 1
    for row, data in group.iterrows():
        events.loc[row_counter] = [event_counter,hit_counter,
'CHAMBER',data['CHAMBER']]
        events.loc[row_counter+1] = [event_counter,hit_counte
r,'LAYER',data['LAYER']]
        events.loc[row_counter+2] = [event_counter,hit_counte
r,'CELL',data['CELL']]
        events.loc[row_counter+3] = [event_counter,hit_counte
r,'POSITION',1]
        hit_counter += 1
        row_counter += 4
    event_counter += 1
events.head()
## FUCK YEAH!
```

In [ ]:

```
## Lets costruiamo questo fucking dataframe
events = pd.DataFrame(columns=['ORBIT','CHAMBER','LAYER','CEL
L'])

## Eliminiamo le hit corrispondenti ai trigger
triggered_orbit = triggered_orbit[triggered_orbit['TDC_CHANNE
L']<137]
gr_event = triggered_orbit.groupby('ORBIT_CNT')

## Ocio che ci mette molto tempo
c = 0
for orb, gr in gr_event:
    for i in range(len(gr)):
        events.loc[c] = [orb, np.array(gr['CHAMBER']), np.arr
ay(gr['LAYER']), np.array(gr['CELL']).astype(int)]
    c+=1
events.head()
## FUCK YEAH!
## --> 4 righe di altezza, 16 di larghezza
## Comincio da una matrice nulla, sommo 1 alla cella in cui h
o l'hit
## Devo ricordarmi che ho gli strati sfalsati, con riferiment
o all'immagine
## --> Conviene riempire la matrice normalmente lasciando lib
era l'ultima "mezza cella", e poi shiftare i risultati
mat_ch1 = mat_ch2 = mat_ch3 = mat_ch4 = np.zeros((32,132))
```

In [ ]:

```
## TUTTO OK FINO A QUA
# Create DataFrame for the event
events = pd.DataFrame(columns=['ORBIT','CHAMBER','LAYER','CEL
L','POSITION'])

# Sort data according their orbit and their cell
data_sorted = data.sort_values(by = ['ORBIT_CNT','TDC_CHANNE
L'])


# VERY SLOW
pattern = [1,2,3,4]
data_sorted.rolling(len(pattern)).apply(lambda x: all(np.equa
l(x, pattern)))
matched = matched.sum(axis = 1).astype(bool)
print(matched)
```

In [ ]:

```
# Now I can group hits according to the orbit
grouped_orbit = data.groupby(['ORBIT_CNT'])

index = 0
# At this point all the hits are grouped according to their o
rbit,
# so we have to distinguish which of them form an event
for key, group in grouped_orbit: # For every group
    # Check if there is the trigger inside the hits group
    flag = group['CELL'] == 139;
    # If there are more than 5 hits and there is the trigger
    if group.shape[0] >= 5 and flag.any():
        # Sort group by cell number
        group.sort_values(by = 'CELL')
        index += 1
```

PART 2

Now we have to find the events without the help of the trigger (139) and to do so we will use the mean time trigger as follow