2-PMT-pulse-analysis

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1 PMT Pulse analysis

A partire dal tutorial: PMT Pulse analysis

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[1]:
```
import numpy as np
from tqdm import tqdm
import matplotlib.pyplot as plt

# This just ensures some comments in dataframes below display nicely
import pandas as pd
pd.options.display.max_colwidth = 100

from scipy import stats
import strax
import straxen
from multihist import Histdd, Hist1d

# Print out exactly what versions we are using, for reference / troubleshooting:
import sys
import os.path as osp
```

[2]:
```
st = straxen.contexts.xenonnt_online()
```

Si usa un background run di XENON1T

[3]:
```
#dsets = st.select_runs(available='raw_records', include_tags='sciencerun1',␣
 ↪run_mode='background_stable')
#run_id = dsets.name.min()
st.select_runs()
```

```
Fetching run info from MongoDB: 100%|      | 1312/1312 [00:01<00:00,
726.98it/s]
Checking data availability: 100%|      | 2/2 [01:54<00:00, 57.00s/it]
```

[3]:

	name	number	mode	\
0	007158	7158	xenonnt_commissioning_noise	
1	007159	7159	xenonnt_commissioning_noise	

```
2     007160   7160             xenonnt_commissioning_noise
3     007161   7161             xenonnt_commissioning_noise
4     007162   7162           xenonnt_commissioning_pmtgain
…       …    …                                       …
1307  008465   8465  xenonnt_selftrigger_commissioning_lowe
1308  008466   8466  xenonnt_selftrigger_commissioning_lowe
1309  008467   8467  xenonnt_selftrigger_commissioning_lowe
1310  008468   8468  xenonnt_selftrigger_commissioning_lowe
1311  008469   8469  xenonnt_selftrigger_commissioning_lowe

                        start                       end   tags        livetime  \
0    2020-03-18 17:41:37.343 2020-03-18 17:42:43.982        00:01:06.639000
1    2020-03-19 08:37:22.348 2020-03-19 08:38:41.183        00:01:18.835000
2    2020-03-19 08:39:17.522 2020-03-19 08:40:48.522               00:01:31
3    2020-03-19 08:41:12.806 2020-03-19 08:44:42.178        00:03:29.372000
4    2020-03-19 10:47:10.153 2020-03-19 10:50:39.279  messy 00:03:29.126000
…                        …                       …    …            …
1307 2020-06-29 01:31:13.623 2020-06-29 02:31:15.909        01:00:02.286000
1308 2020-06-29 02:31:30.990 2020-06-29 03:31:32.176        01:00:01.186000
1309 2020-06-29 03:31:46.259 2020-06-29 04:31:48.534        01:00:02.275000
1310 2020-06-29 04:32:02.619 2020-06-29 05:32:03.966        01:00:01.347000
1311 2020-06-29 05:32:19.051 2020-06-29 06:32:21.380        01:00:02.329000

     tags.name  raw_records_available  peak_basics_available
0          NaN                   True                  False
1          NaN                   True                  False
2          NaN                  False                  False
3          NaN                  False                  False
4          NaN                  False                  False
…        …                      …                      …
1307       NaN                  False                  False
1308       NaN                  False                  False
1309       NaN                  False                  False
1310       NaN                  False                  False
1311       NaN                  False                  False

[1312 rows x 10 columns]
```

[4]:
```
run_id = '007208'
wf_len_recorded = 98404
```

Questo run dura un'ora e non si possono caricare tutte le raw waveform data, prendiamo i primi 30 secondi:

2 RAW RECORDS

Selection dei **raw records**, che sono presi in input del plugin pulse_processing.

[5]:
```
st.data_info('raw_records')
```

[5]:

	Field name	Data type	Comment
0	time	int64	Start time since unix epoch [ns]
1	length	int32	Length of the interval in samples
2	dt	int16	Width of one sample [ns]
3	channel	int16	Channel/PMT number
4	pulse_length	int32	Length of pulse to which the record belongs (without zero-padding)
5	record_i	int16	Fragment number in the pulse
6	baseline	int16	Baseline determined by the digitizer (if this is supported)
7	data	('<i2', (110,))	Waveform data in raw ADC counts

2.1 Plot dei primi records del run

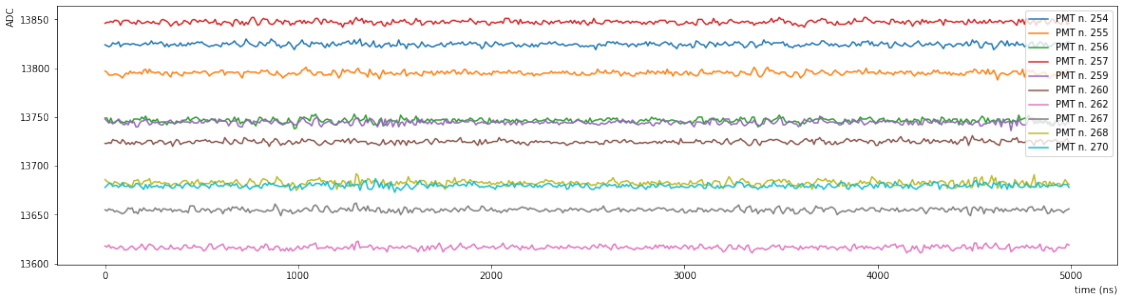
Si selezionano i record soltanto per i primi 30 secondi del run.

[46]:
```
rr = st.get_array(run_id, 'raw_records', seconds_range=(0, 10))
#rr_he = st.get_array(run_id, 'raw_records_he', seconds_range=(0, 2))
```

[50]:
```
def plotRecords(rr,nn,llim,rlim,dlim,ulim):
    dt = rr['dt'][0]
    print('run',run_id,'total number of records',rr['data'].shape[0])
    dts = np.arange(0,rr['data'].shape[1]*dt,dt)
    plt.figure(figsize=(20,5))
    for i in range(nn):
        plt.plot(dts,rr['data'][i],label=f"PMT n. {rr['channel'][i]}")
    plt.legend()
    plt.xlabel("time (ns)", ha='right', x=1)
    plt.ylabel(f"ADC", ha='right', y=1)
    if rlim is not 0: plt.xlim(llim,rlim)
    if ulim is not 0: plt.ylim(dlim,ulim)
```

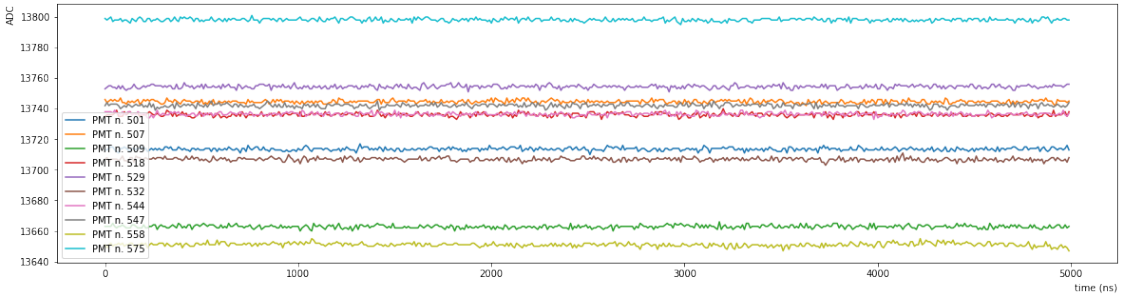
[51]:
```
plotRecords(rr,10,400,0,15500,0)
```

```
run 007208 total number of records 1133538
```



[52]:
```
plotRecords(rr_he,10,0,0,0,0)
```

```
run 007208 total number of records 149523
```

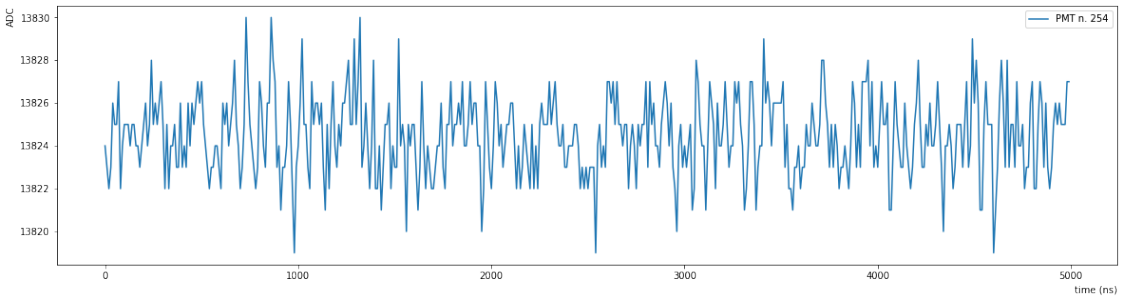


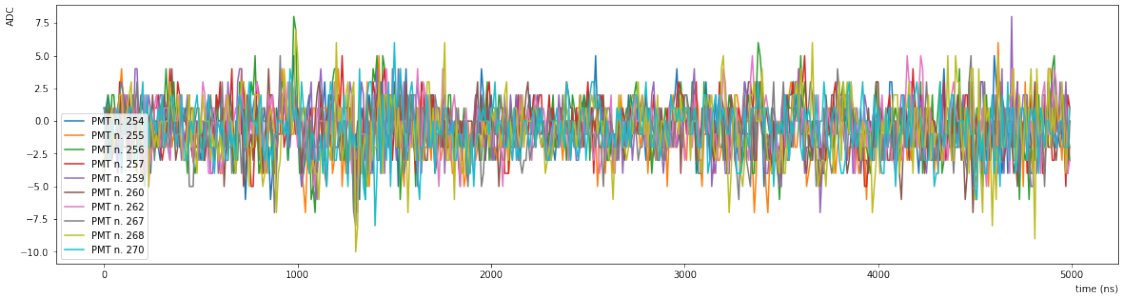
2.2 Sottrazione della baseline

[53]:
```
rr0 = strax.raw_to_records(rr)
strax.baseline(rr0)
plt.figure(1)
plotRecords(rr,1,0,0,0,0)
plt.figure(2)
plotRecords(rr0,10,0,0,0,0)
```

```
run 007208 total number of records 1133538
run 007208 total number of records 1133538
```

```
<Figure size 432x288 with 0 Axes>
```





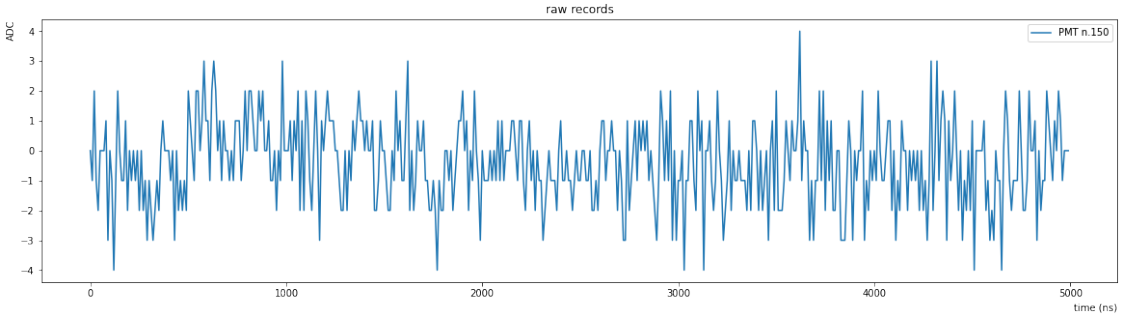
2.3 Selezione di record e studio del noise per i primi PMT

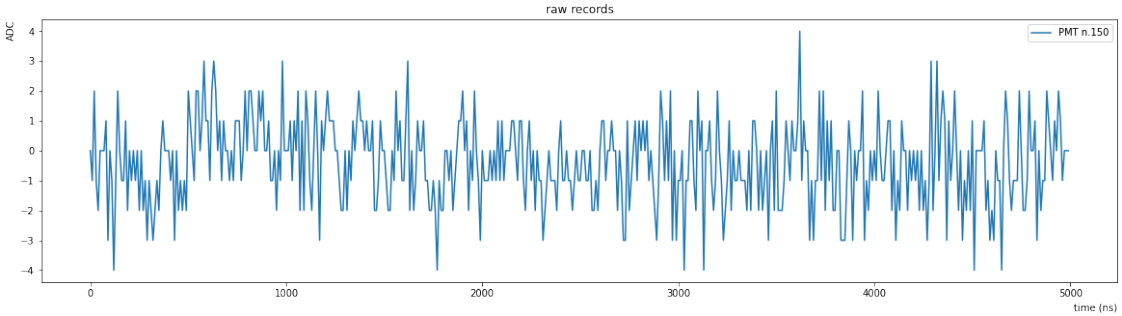
[56]:
```
def plotPMT(rr,id):
    #rrs = rr['data'][(rr['channel'] == id) & (rr['data'].min(1)>1.58e4) &
 ↪(rr['record_i']==0)] #before baseline substraction
    rrs = rr['data'][(rr['channel'] == id) & (rr['data'].max(1)<10)]# &
 ↪(rr['record_i']==0)] #before baseline substraction
    nev, rsize = rrs.shape[0], rrs.shape[1]
    print('Total number of events:',nev,'length of pulses:',rsize)
    if nev < 100: return
    dt = rr['dt'][0]
    dts = np.arange(0,rr['data'].shape[1]*dt,dt)
    plt.figure(1,figsize=(20,5))
    #for i in range(nn):
    #plt.plot(dts,rrs[i],label=f"{rr['channel'][i]} L={rr['pulse_length'][i]}")
    plt.plot(dts,rrs[0],label=f"PMT n.{id}")
    plt.title('raw records')
    plt.legend()
    plt.xlabel("time (ns)", ha='right', x=1)
    plt.ylabel(f"ADC", ha='right', y=1)

    bsize = 500
    bls = np.zeros([nev,bsize])
    for i in range(nev):
```

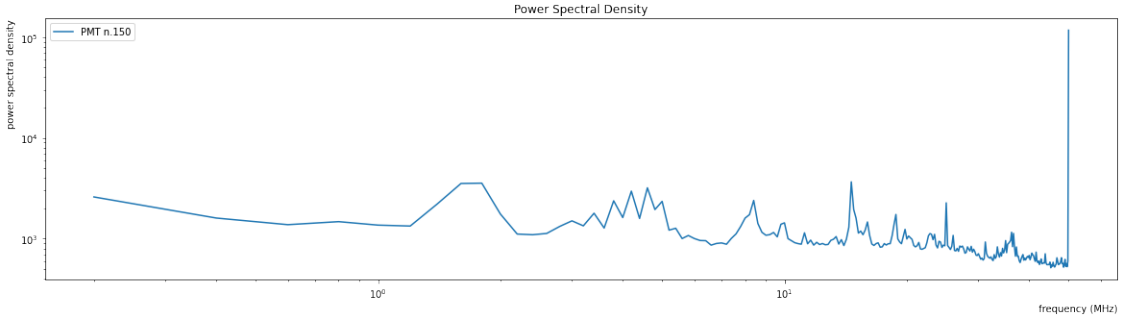
```
        for j in range(bsize):
            bls[i][j] = rrs[i][j]
    plt.figure(2,figsize=(20,5))
    #for i in range(nn):
    #plt.plot(dts[:bsize],bls[i],label=f"{rr['channel'][i]}␣
↪L={rr['pulse_length'][i]}")
    plt.plot(dts[:bsize],bls[0],label=f"PMT n.{id}")
    plt.title('raw records')
    plt.legend()
    plt.xlabel("time (ns)", ha='right', x=1)
    plt.ylabel(f"ADC", ha='right', y=1)

    sampling_rate = 1/(dts[1]-dts[0])*1000
    for i in range(nev):
        fft = np.fft.rfft(bls[i][:])
        abs_fft = np.abs(fft)
        if i is 0: power_spectrum = np.square(abs_fft)
        else: power_spectrum += np.square(abs_fft)
    power_spectrum /= nev
    frequency = np.linspace(0, sampling_rate/2, len(power_spectrum))
    plt.figure(3,figsize=(20,5))
    plt.plot(frequency[1:], power_spectrum[1:],label=f"PMT n.{id}")
    plt.title('Power Spectral Density')
    plt.legend()
    plt.xscale("log")
    plt.yscale("log")
    plt.xlabel("frequency (MHz)", ha='right', x=1)
    plt.ylabel(f"power spectral density", ha='right', y=1)

    #import scipy.signal as signal
    ref = bls.mean(axis=0)
    offset = np.mean(ref[:])
    bl = np.zeros([nev,bsize])
    for i in range(nev):
        bl[i] = bls[i][0:bsize]-np.mean(bls[i][0:bsize])
    noise_matr =  np.matmul(bl.transpose(), bl)/nev
    #noise_matr = signal.convolve2d(noise_matr,np.identity(bsize-fsize+1),␣
↪boundary='symm', mode='valid')/(bsize-fsize+1)

    fig, ax = plt.subplots()
    plt.title(f'PMT n. {id}')
    plt.imshow(noise_matr, cmap='viridis',origin='lower')
    plt.colorbar()
```

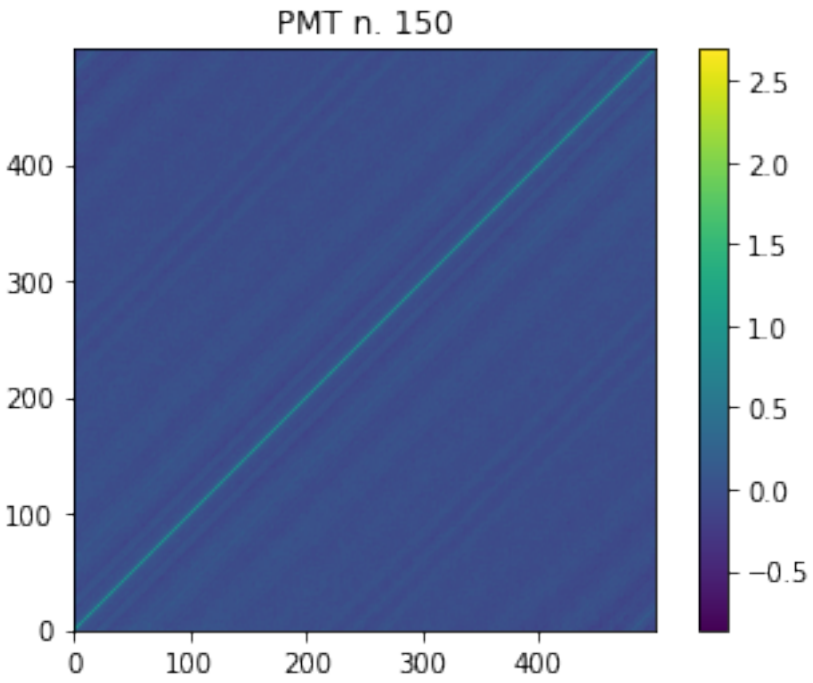
[61]:
```
for i in range(1):
    plotPMT(rr0,i+150)
```

```
Total number of events: 2161 length of pulses: 500
```








PMT n. 150
400
300
200
100
0
0
100
200
300
400
2.5
2.0
1.5
1.0
0.5
0.0
−0.5

[ ]:

[ ]: