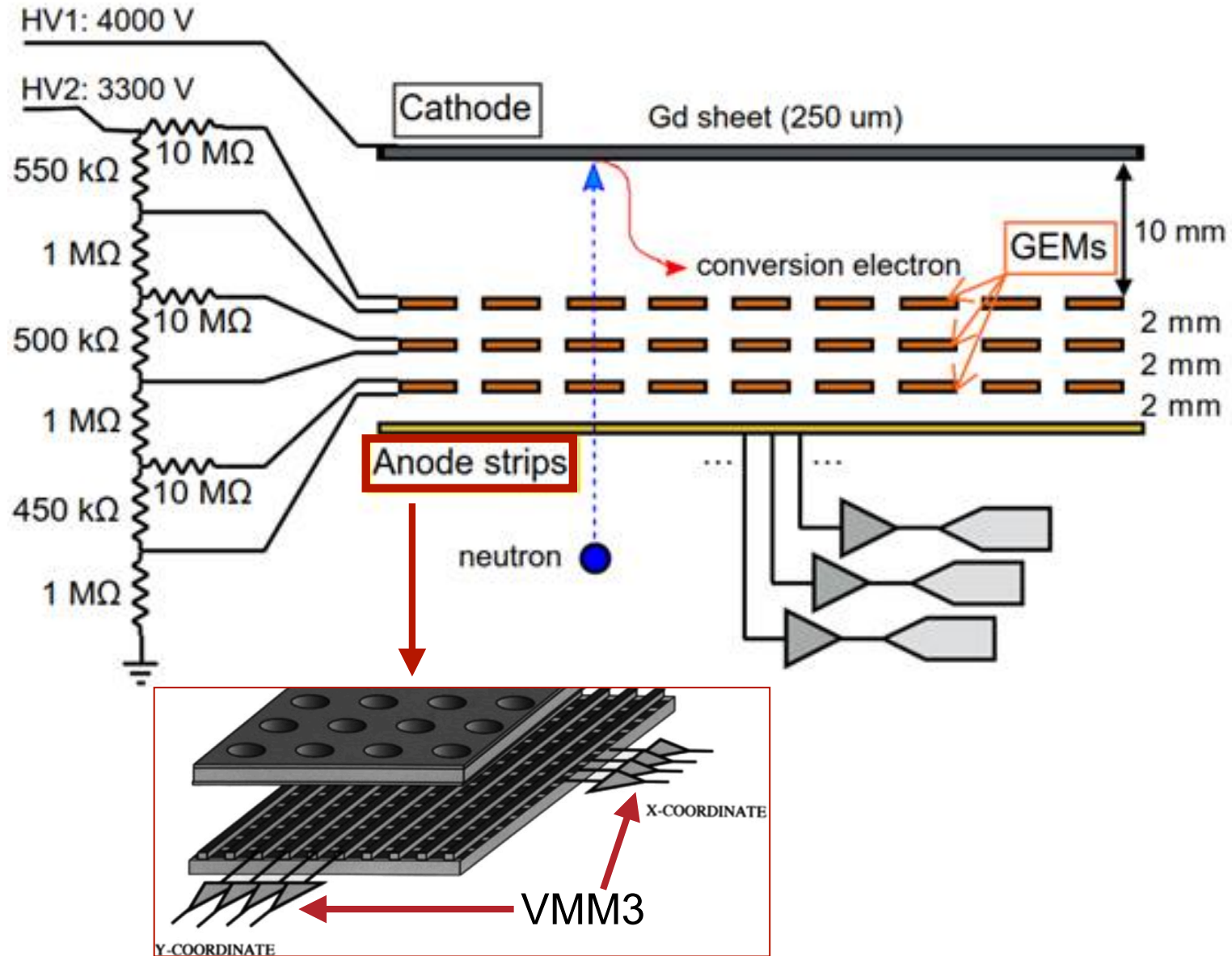


Analysis of VMM3 test beam data

Lara Bartels (CERN Summer Student)
Supervisor: Michael Lupberger
Dorothea Pfeiffer

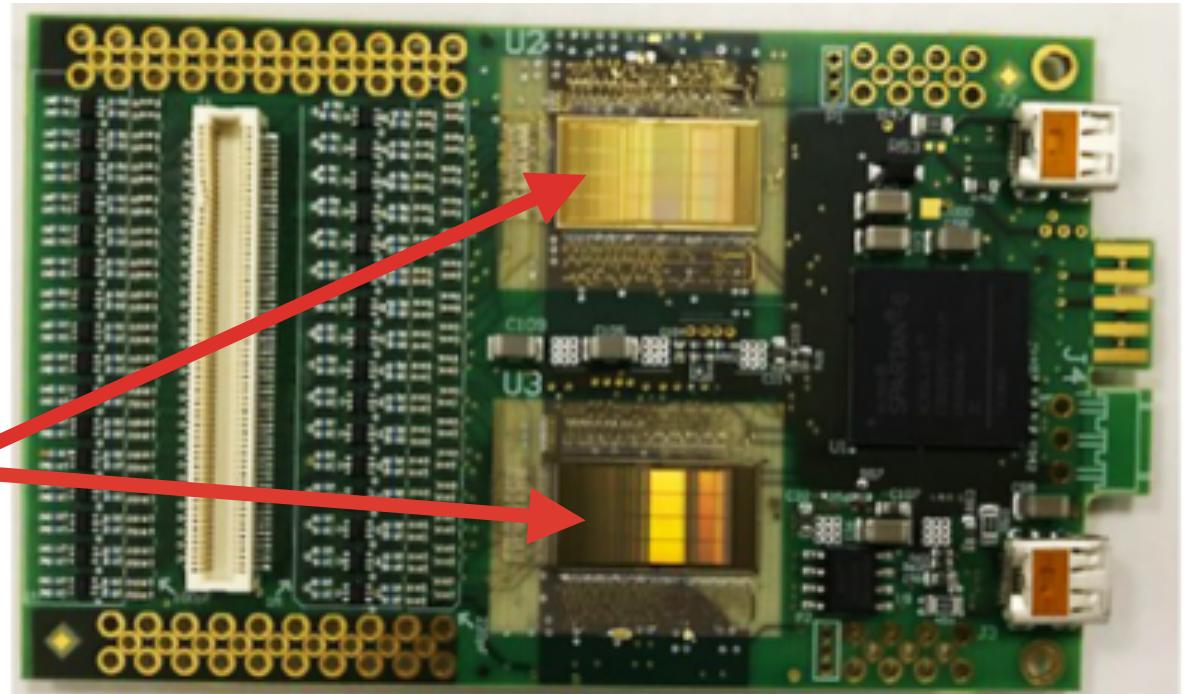
Second Joint BrightnESS WP4 and WP5 Jamboree
15th September 2017

Reminder: Gd GEM

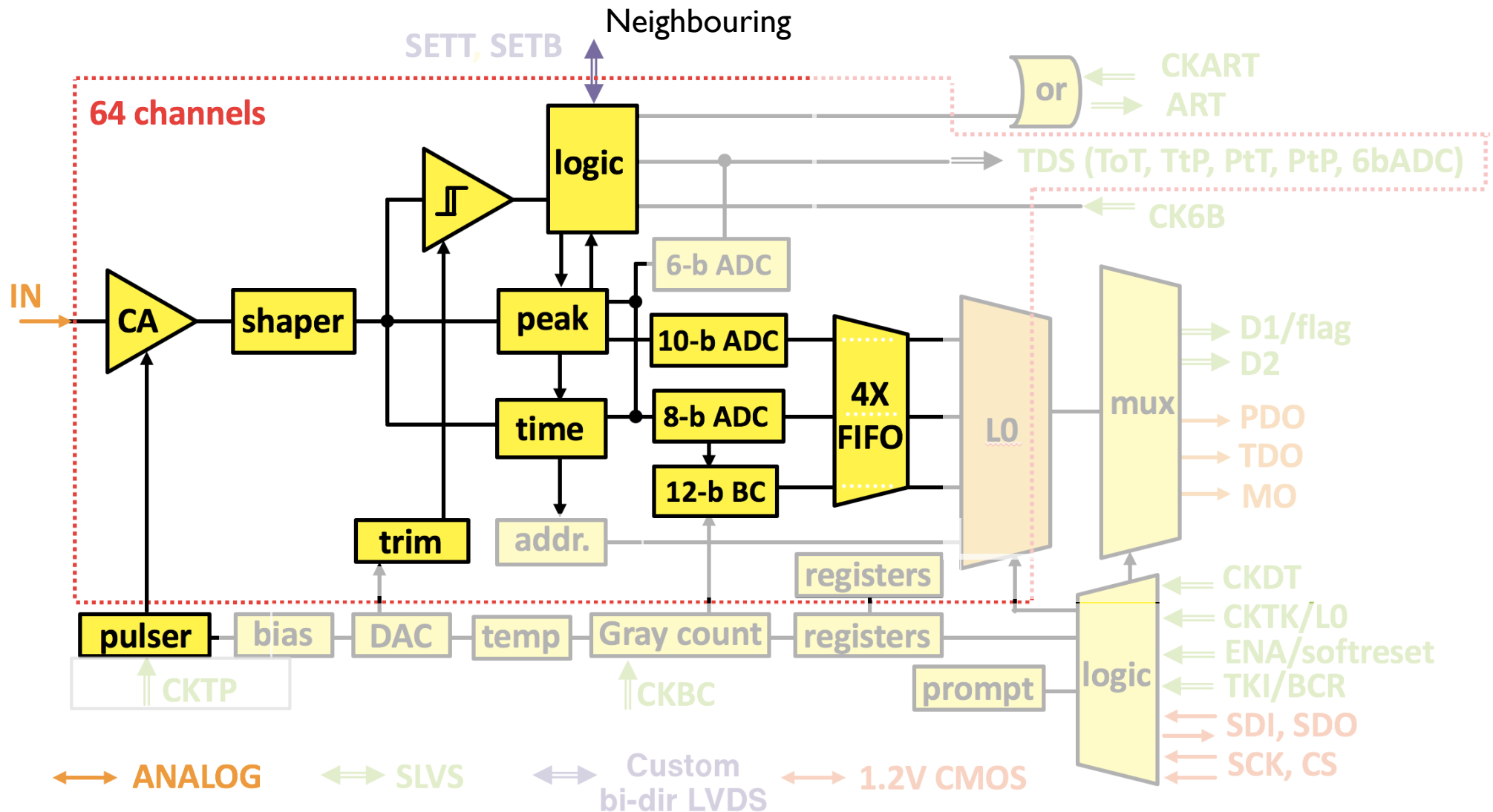


The VMM3 readout chip

- Analog Input
- Digital Output
- 2 x 64 Channels



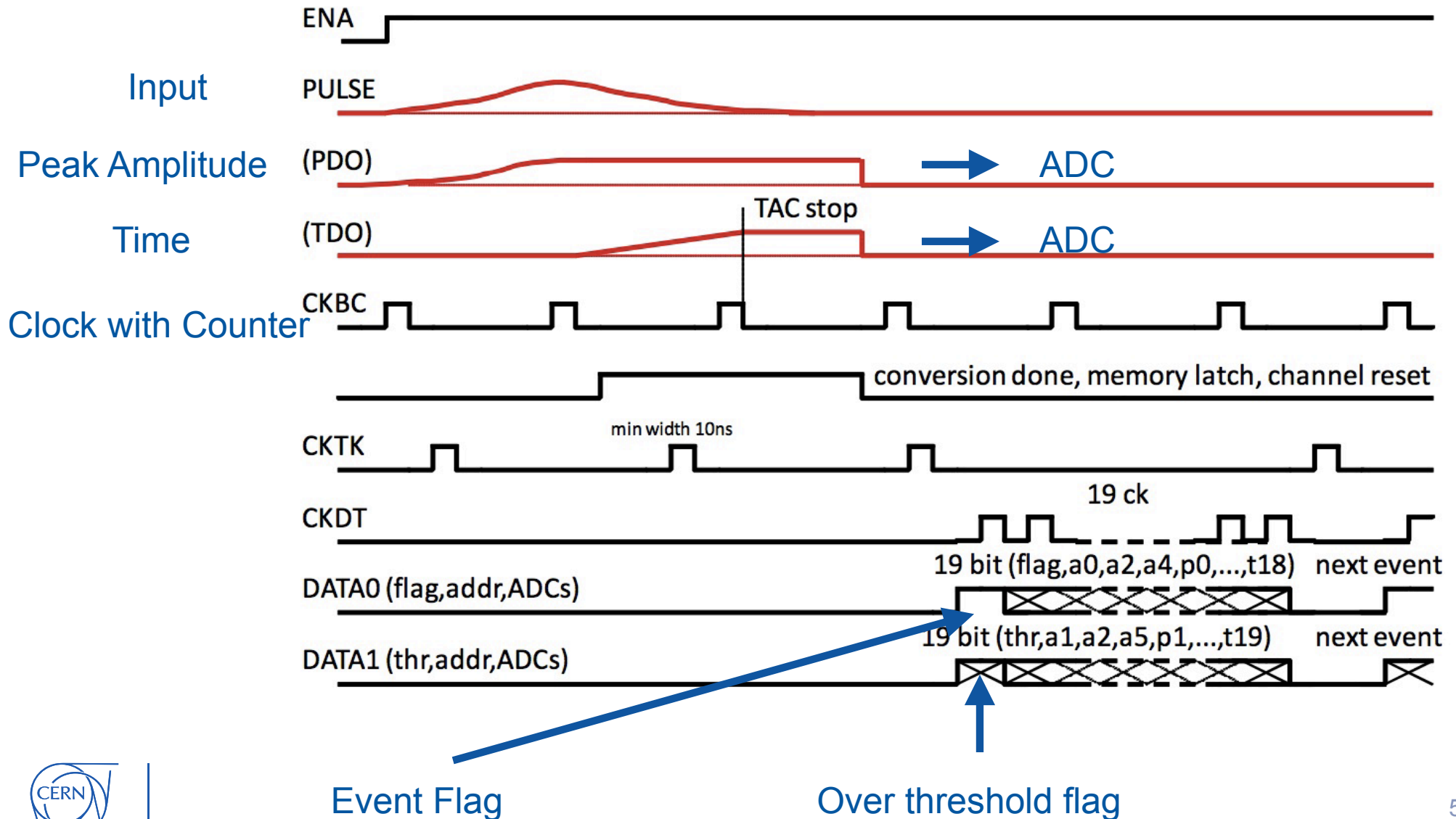
VMM3 architecture



Continuous or external trigger mode

VMM3 data readout

For each channel:



Output data format

- UDP Ethernet packages
- Monitoring using Wireshark plugin

The screenshot shows the Wireshark interface with a list of network packets. The selected packet is expanded to show the SRS Header details. The SRS Header contains the following information:

- Frame Counter: 25157104 (25121554)
- Data Id: VMM2 Data
- VMM2 ID: 0
- SRS Timestamp: 1781901520 (1781639360)
- Hit list:

Hit	ch	bcid	tdc	adc
1	29	1934	51	32
2	30	1935	41	815
3	31	1934	52	32
4	32	1935	50	896
5	33	1934	60	32

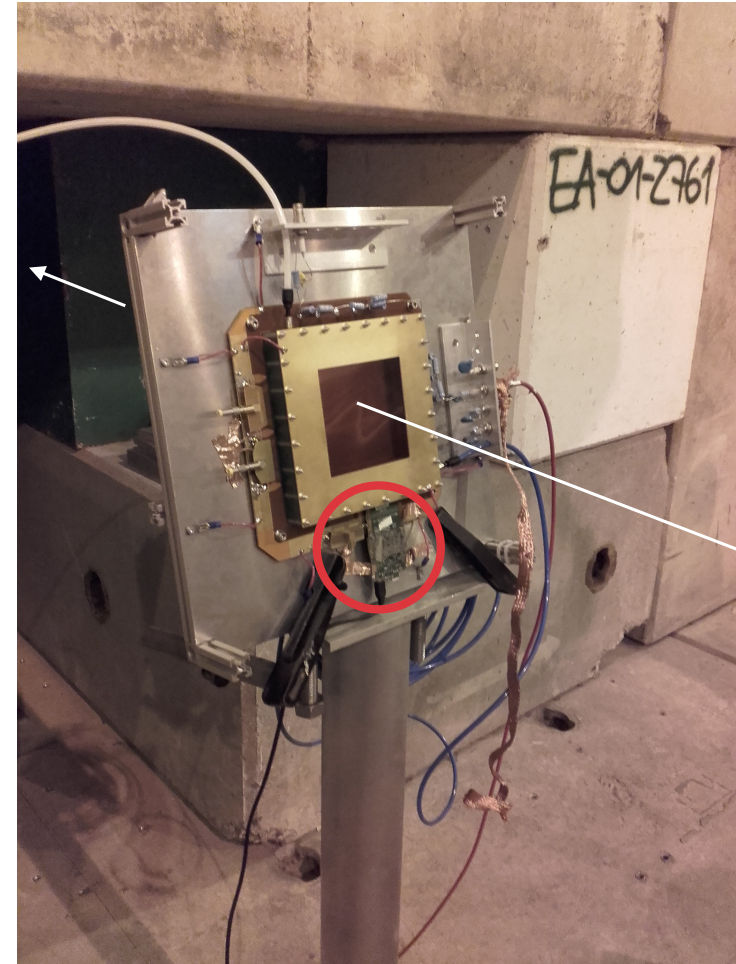
Output data format

- Data in .csv file, hdf5 format also possible
- FEC, VMM number, SRS Timestamp, Channel, BCID, TDC, ADC, Over Threshold Flag

```
Run78_VMM3_2017-08-15-14-02-55.csv
Tue Aug 15 14:02:55 2017
# fec, chip_id, srs timestamp, channel, bcid, tdc, adc, overthreshold
1, 1, 2031190019, 51, 1806, 96, 94, 0
1, 1, 2031190019, 52, 1806, 56, 224, 1
1, 1, 2031190019, 53, 1806, 60, 208, 1
1, 1, 2031190019, 54, 0, 0, 80, 0
1, 0, 2052423683, 21, 445, 88, 107, 1
1, 0, 2052423683, 22, 445, 104, 49, 0
1, 0, 2052423683, 19, 445, 112, 52, 0
1, 0, 2052423683, 20, 445, 95, 96, 1
1, 0, 2093744131, 51, 0, 0, 79, 0
1, 0, 2093744131, 40, 3458, 96, 219, 0
1, 0, 2093744131, 41, 3458, 117, 73, 1
1, 0, 2093744131, 42, 3458, 88, 67, 0
1, 0, 2093744131, 43, 3458, 74, 80, 0
1, 0, 2093744131, 44, 3458, 78, 139, 1
1, 0, 2093744131, 45, 3458, 64, 205, 1
1, 0, 2093744131, 46, 3458, 81, 179, 1
1, 0, 2093744131, 47, 3458, 98, 100, 1
1, 0, 2093744131, 48, 3458, 111, 94, 1
1, 0, 2093744131, 49, 0, 0, 91, 1
1, 0, 2093744131, 50, 0, 0, 86, 1
1, 14, 2093744131, 0, 0, 0, 73, 0
1, 14, 2093744131, 1, 3457, 72, 118, 1
1, 14, 2093744131, 2, 3458, 88, 570, 1
1, 14, 2093744131, 3, 3458, 82, 480, 1
1, 14, 2093744131, 4, 3458, 121, 302, 1
1, 14, 2093744131, 5, 3458, 130, 0, 0
1, 14, 2093744131, 6, 3457, 88, 158, 1
1, 14, 2093744131, 7, 3457, 75, 64, 0
```

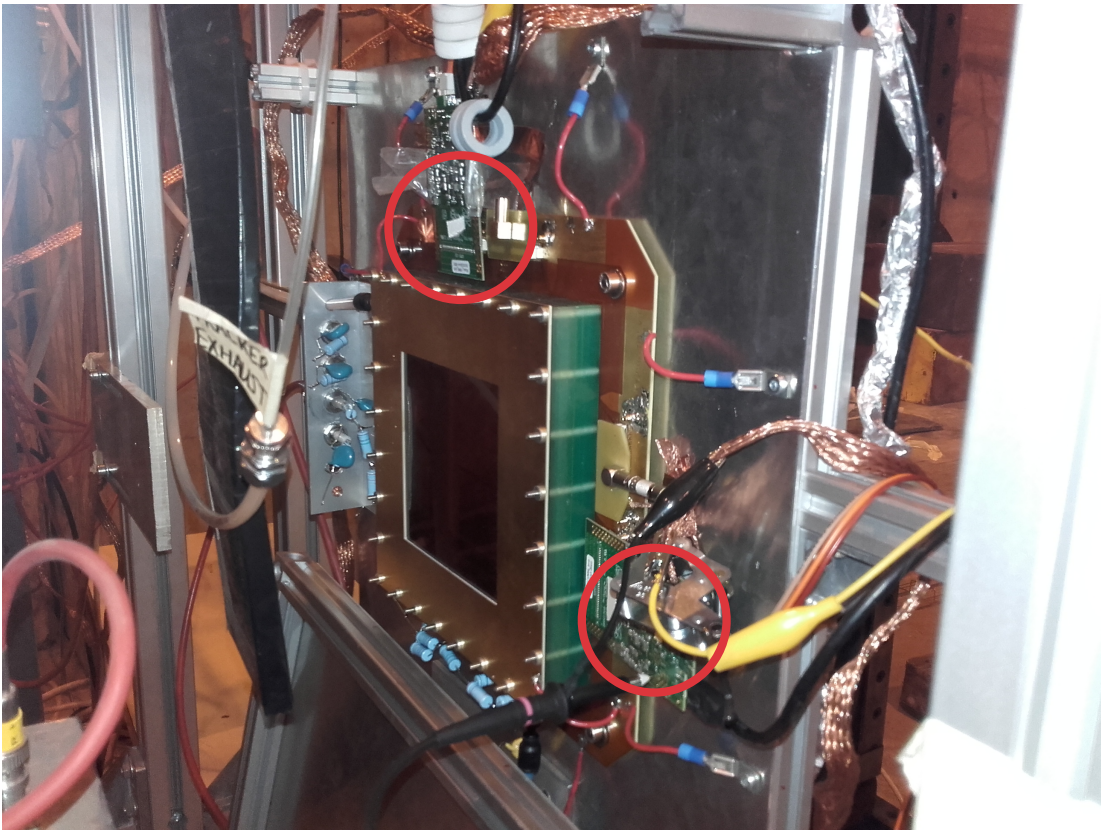
Test beam in July

- SPS muon beam in CERN North Beam area
- Standard triple GEM detector
- First Data taken using one VMM3 hybrid
- Goal for August test beam:
 - Take data using two hybrids in two different dimensions

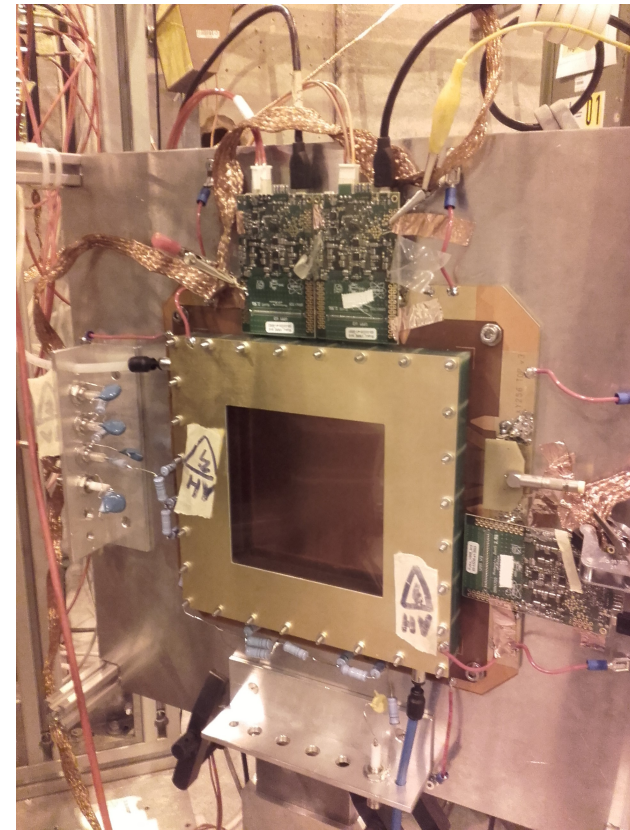


Set-Up test beam in August

2 Hybrids (1 X, 1 Y)

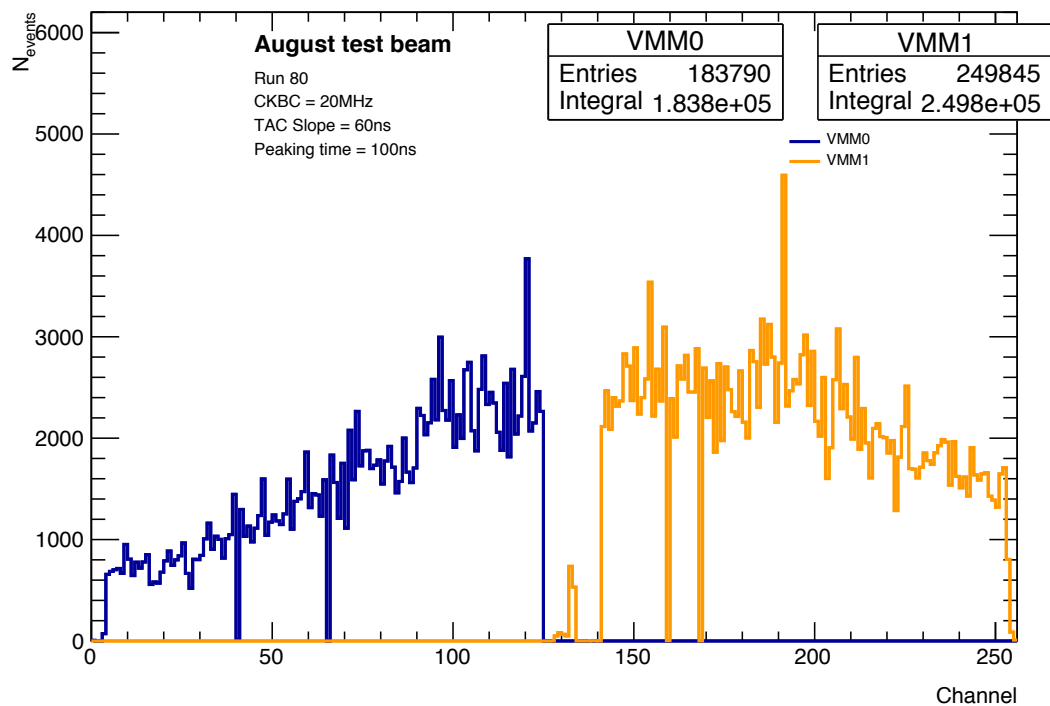


3 Hybrids (2 X, 1 Y)

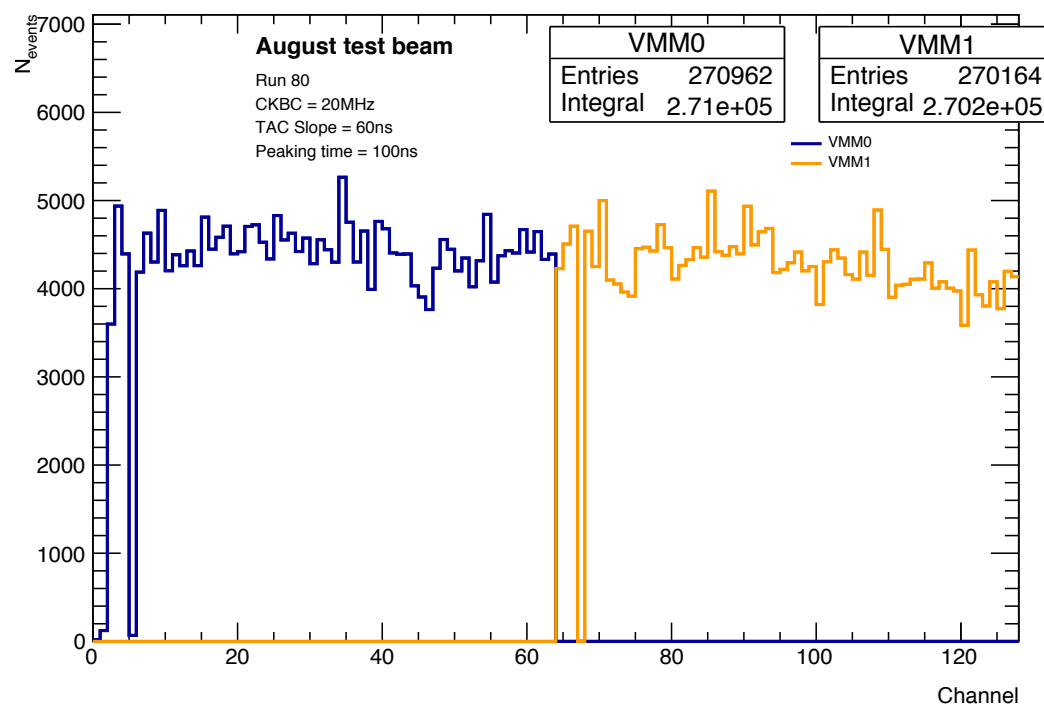


Hits vs Channels

X - two hybrids



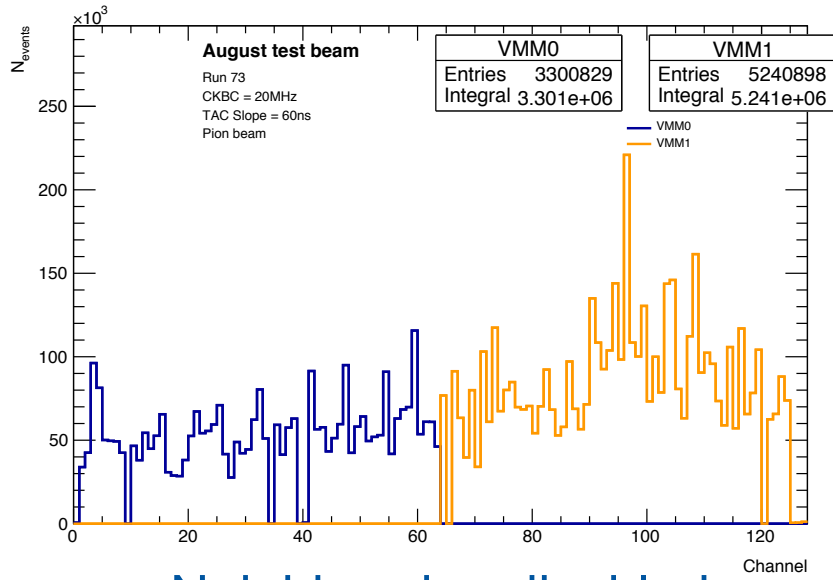
Y - one hybrid



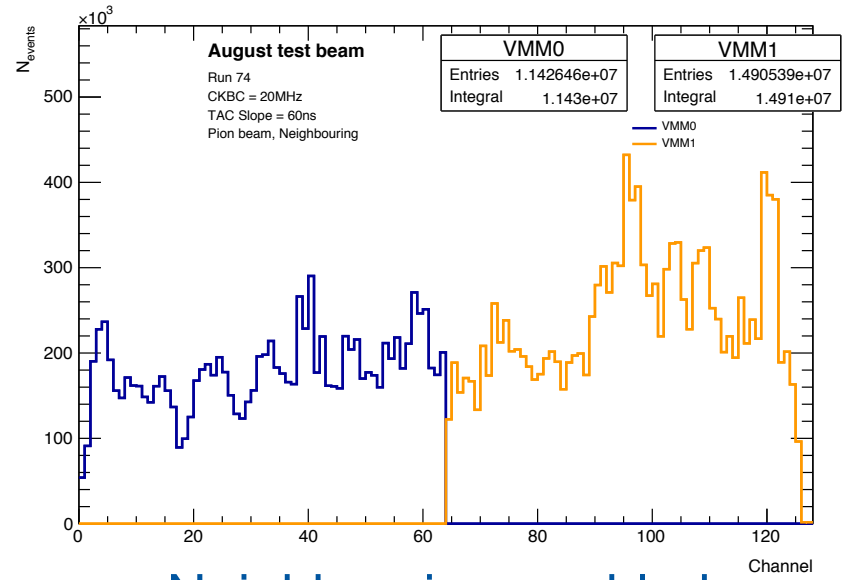
Channel trimming to be performed

Neighbouring

X

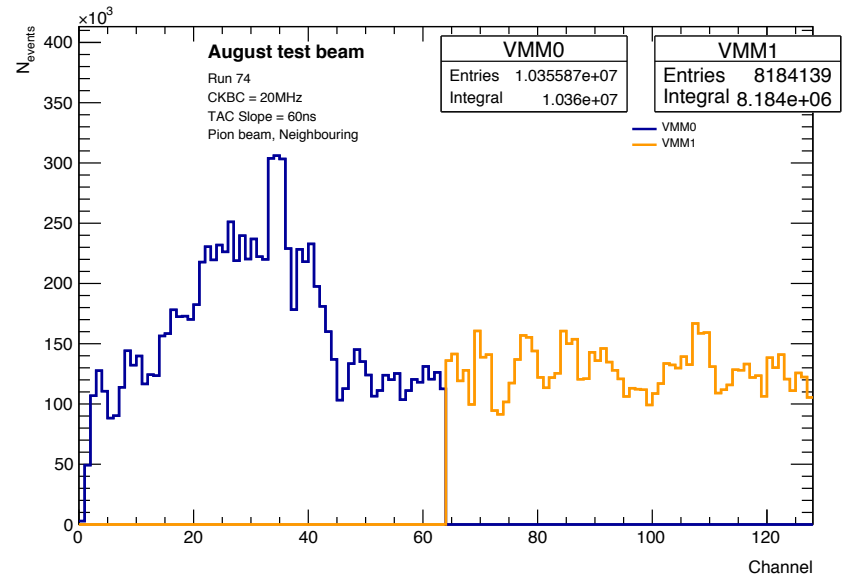
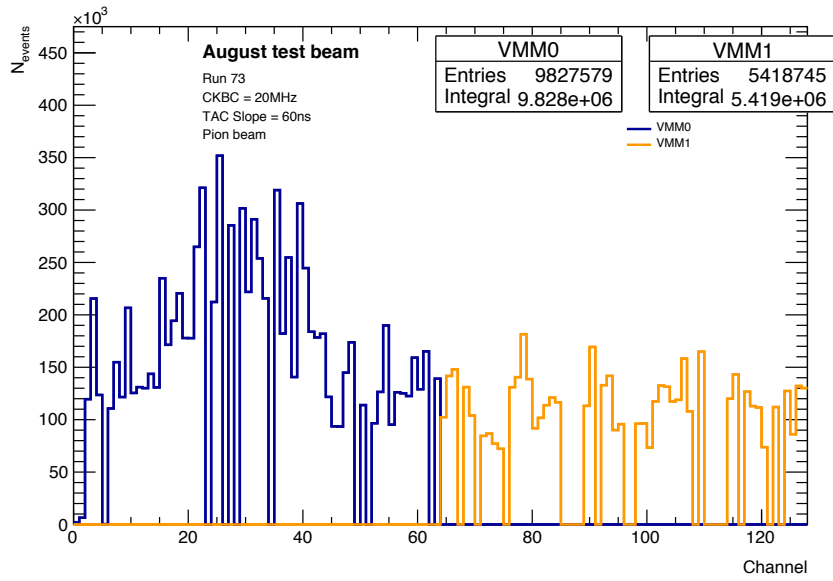


Neighbouring disabled

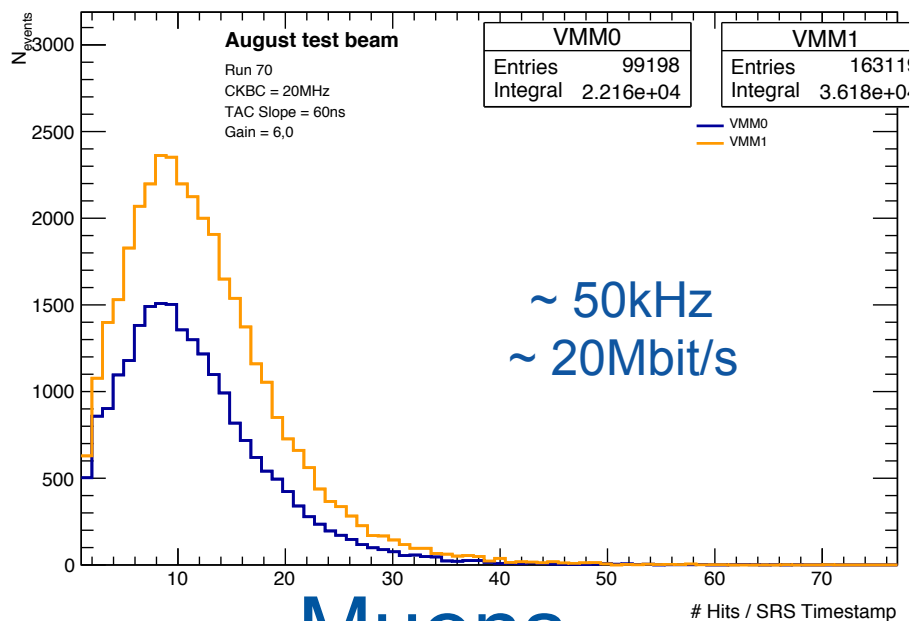


Neighbouring enabled

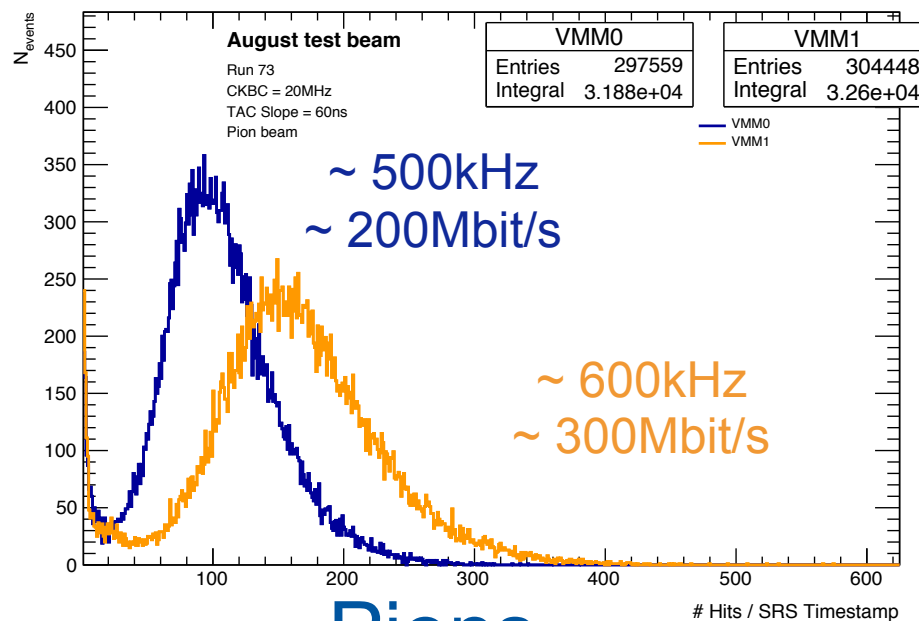
Y



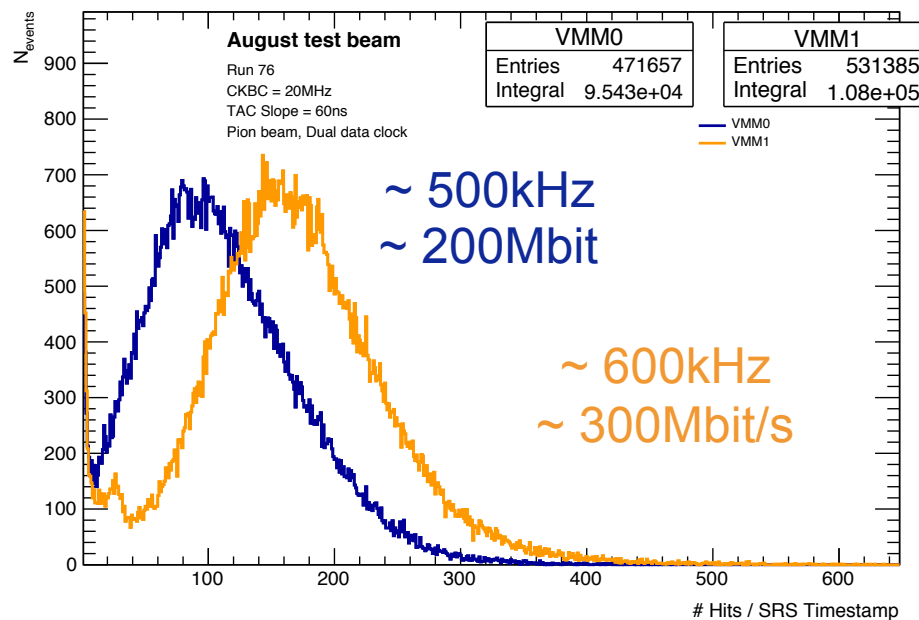
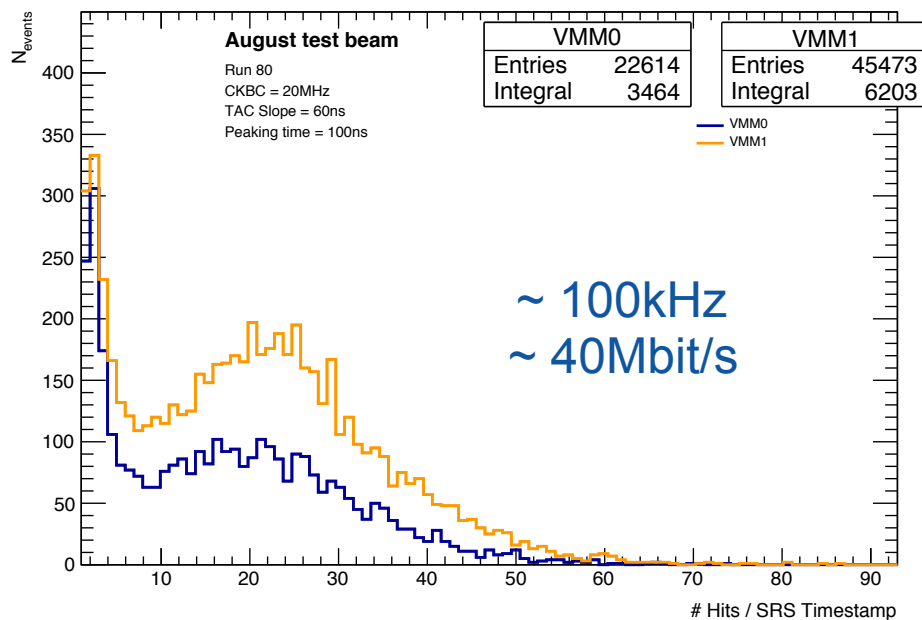
Rates in muon and pion beam



Muons



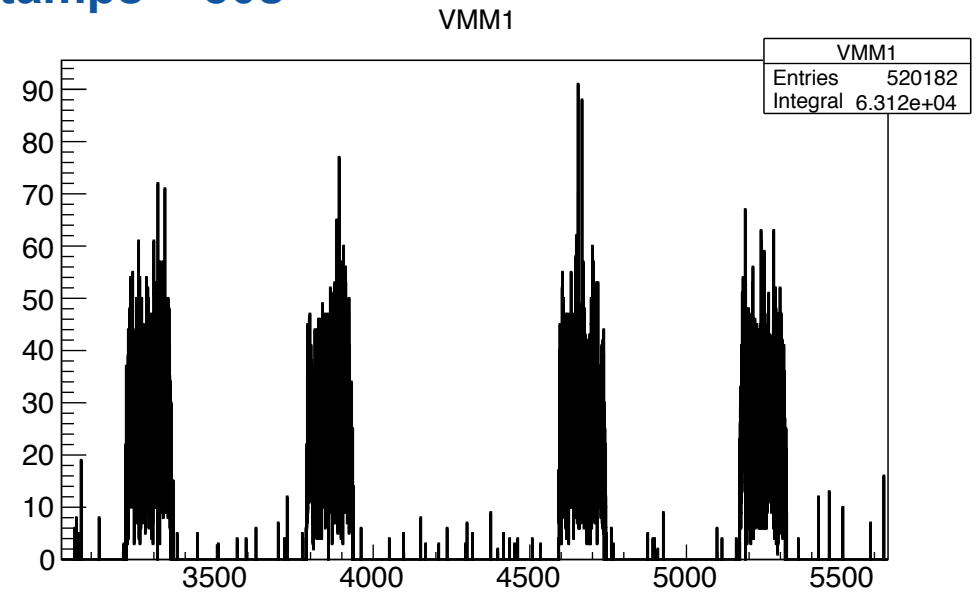
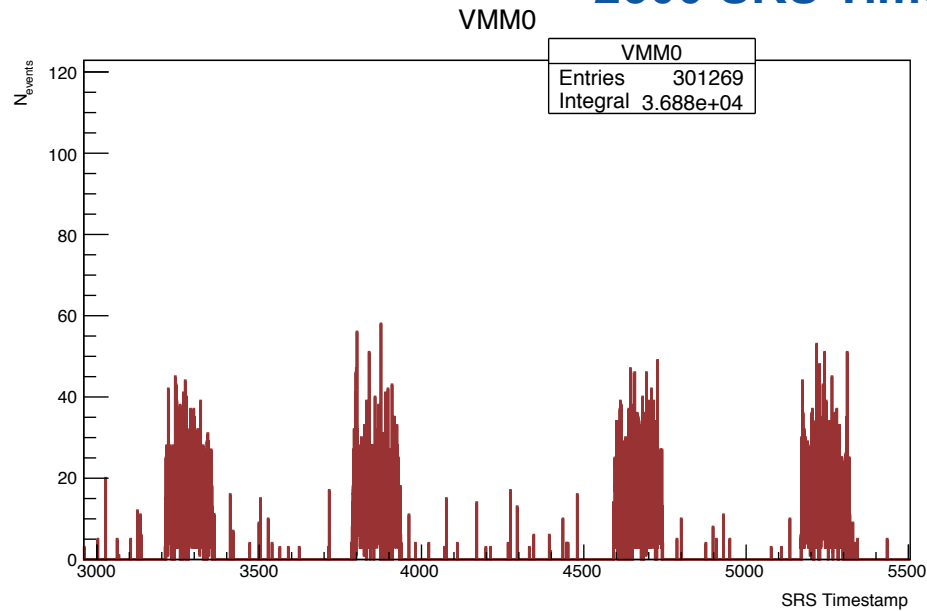
Pions



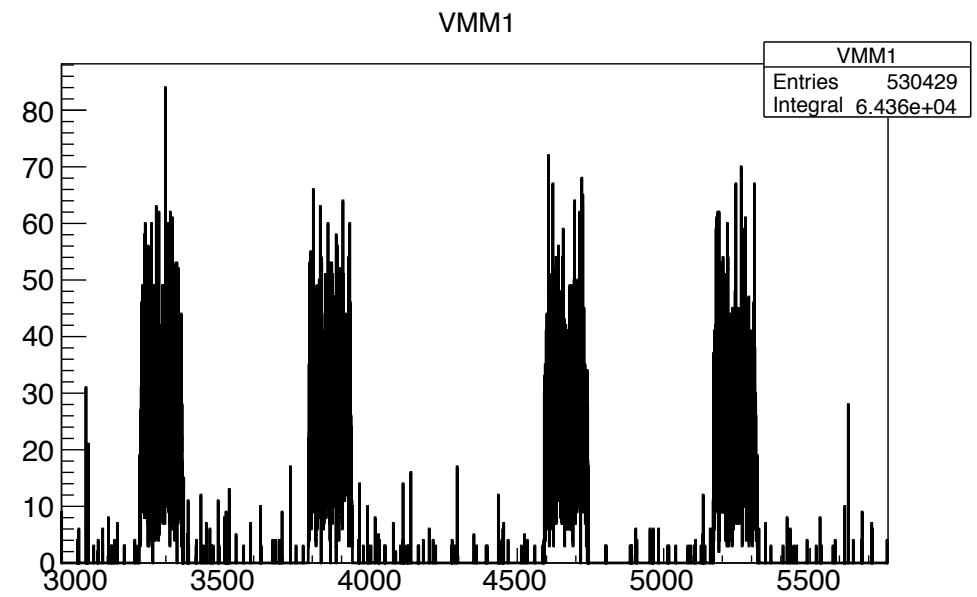
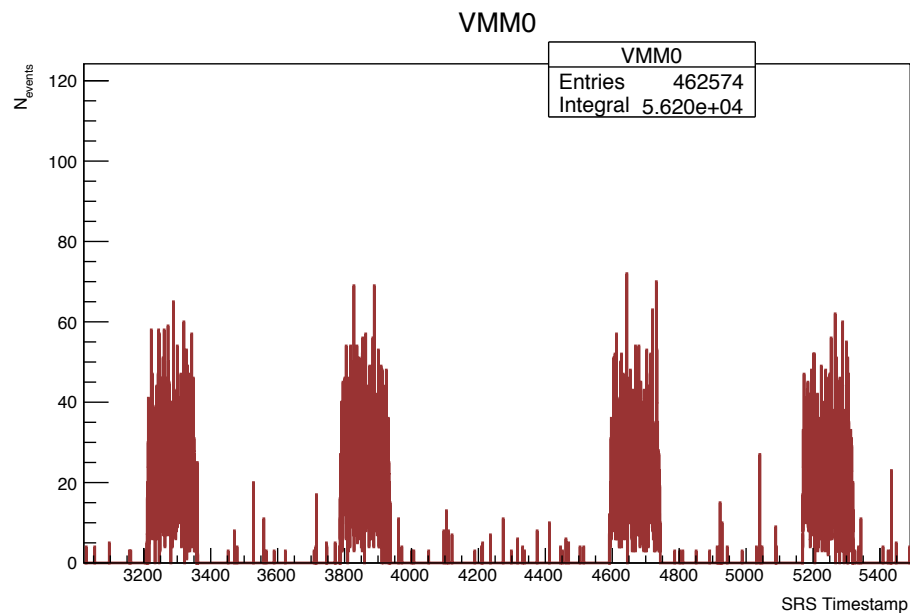
Muon Spill - Dual data

2500 SRS Timestamps \triangleq 80s

X



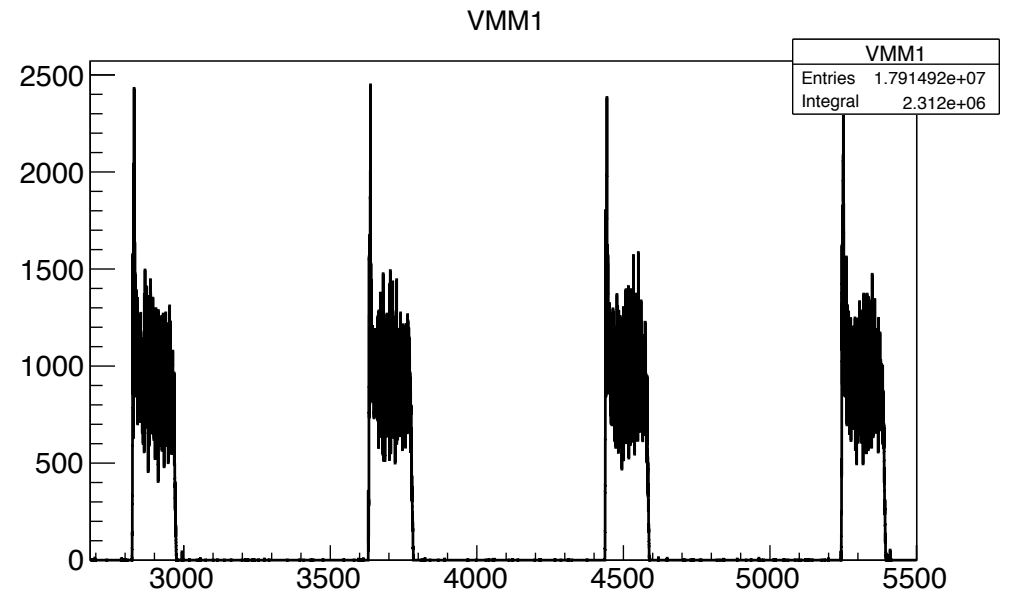
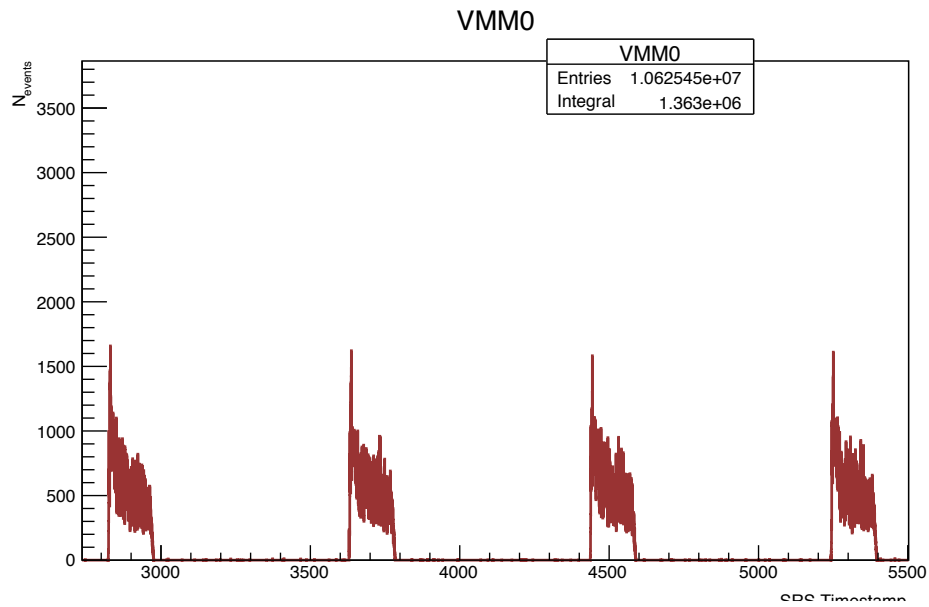
Y



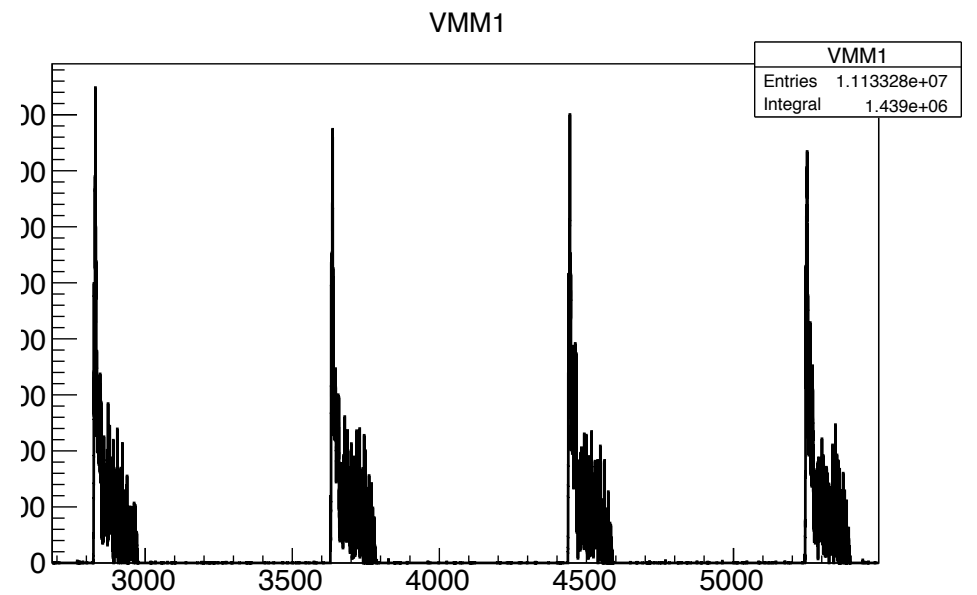
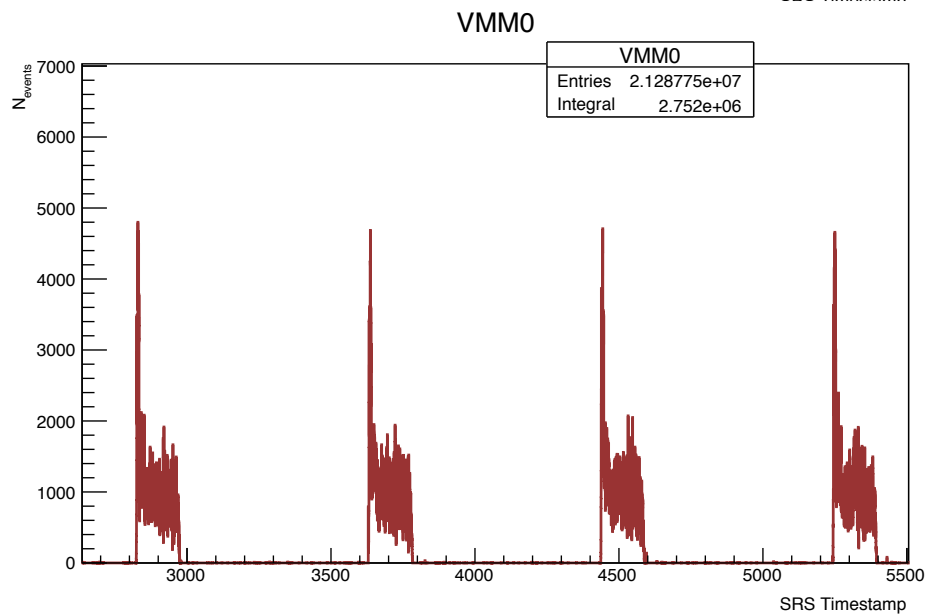
Pion spill

2500 SRS Timestamps \triangleq 80s

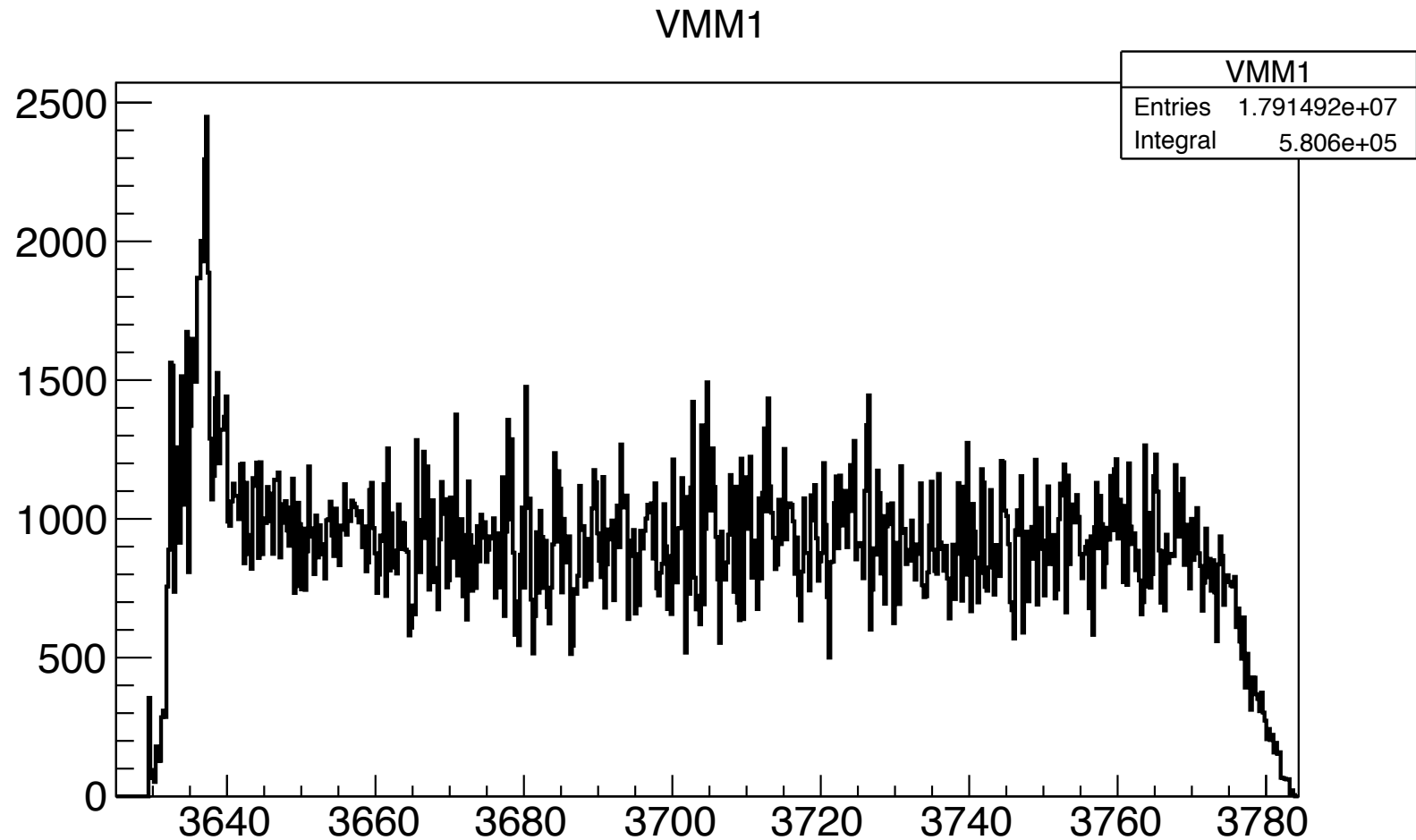
X



Y

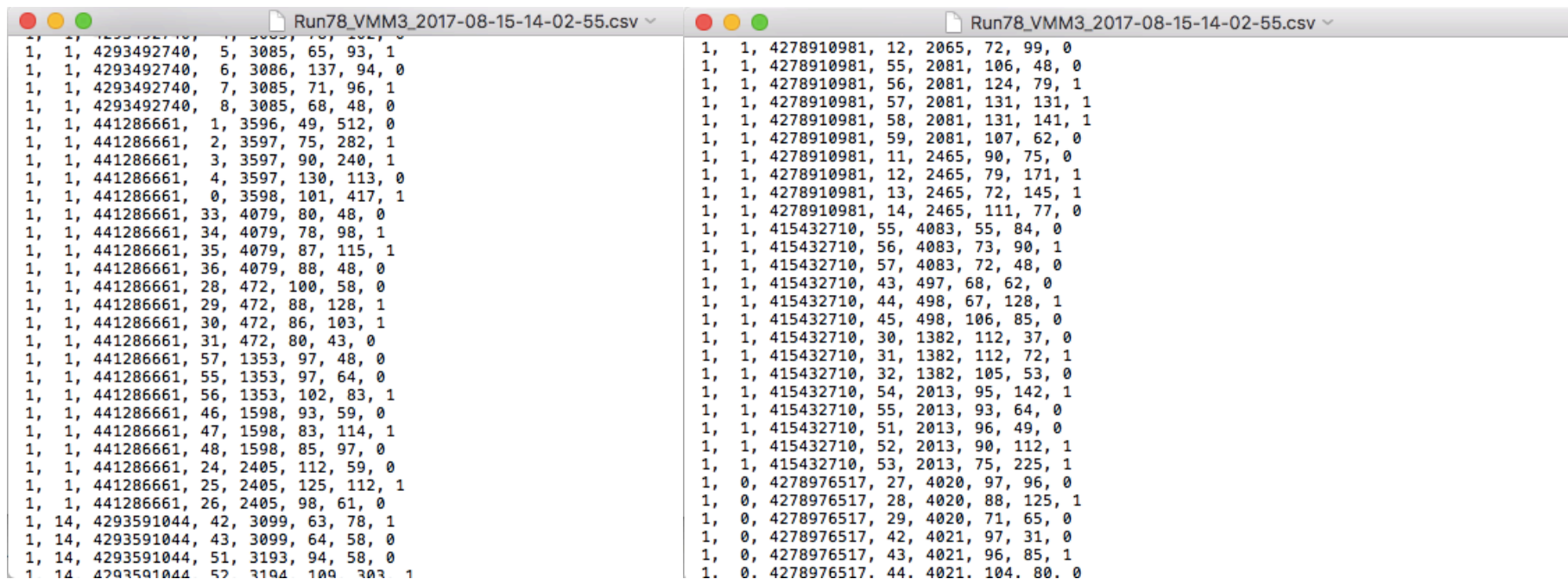


Pion spill



SRS Timestamps

- Overflow of SRS Timestamp every 13 seconds
- High data rates during run in pion beam



```
Run78_VMM3_2017-08-15-14-02-55.csv
1, 1, 4293492740, 5, 3085, 65, 93, 1
1, 1, 4293492740, 6, 3086, 137, 94, 0
1, 1, 4293492740, 7, 3085, 71, 96, 1
1, 1, 4293492740, 8, 3085, 68, 48, 0
1, 1, 441286661, 1, 3596, 49, 512, 0
1, 1, 441286661, 2, 3597, 75, 282, 1
1, 1, 441286661, 3, 3597, 90, 240, 1
1, 1, 441286661, 4, 3597, 130, 113, 0
1, 1, 441286661, 0, 3598, 101, 417, 1
1, 1, 441286661, 33, 4079, 80, 48, 0
1, 1, 441286661, 34, 4079, 78, 98, 1
1, 1, 441286661, 35, 4079, 87, 115, 1
1, 1, 441286661, 36, 4079, 88, 48, 0
1, 1, 441286661, 28, 472, 100, 58, 0
1, 1, 441286661, 29, 472, 88, 128, 1
1, 1, 441286661, 30, 472, 86, 103, 1
1, 1, 441286661, 31, 472, 80, 43, 0
1, 1, 441286661, 57, 1353, 97, 48, 0
1, 1, 441286661, 55, 1353, 97, 64, 0
1, 1, 441286661, 56, 1353, 102, 83, 1
1, 1, 441286661, 46, 1598, 93, 59, 0
1, 1, 441286661, 47, 1598, 83, 114, 1
1, 1, 441286661, 48, 1598, 85, 97, 0
1, 1, 441286661, 24, 2405, 112, 59, 0
1, 1, 441286661, 25, 2405, 125, 112, 1
1, 1, 441286661, 26, 2405, 98, 61, 0
1, 14, 4293591044, 42, 3099, 63, 78, 1
1, 14, 4293591044, 43, 3099, 64, 58, 0
1, 14, 4293591044, 51, 3193, 94, 58, 0
1, 14, 4293591044, 52, 3193, 100, 303, 1

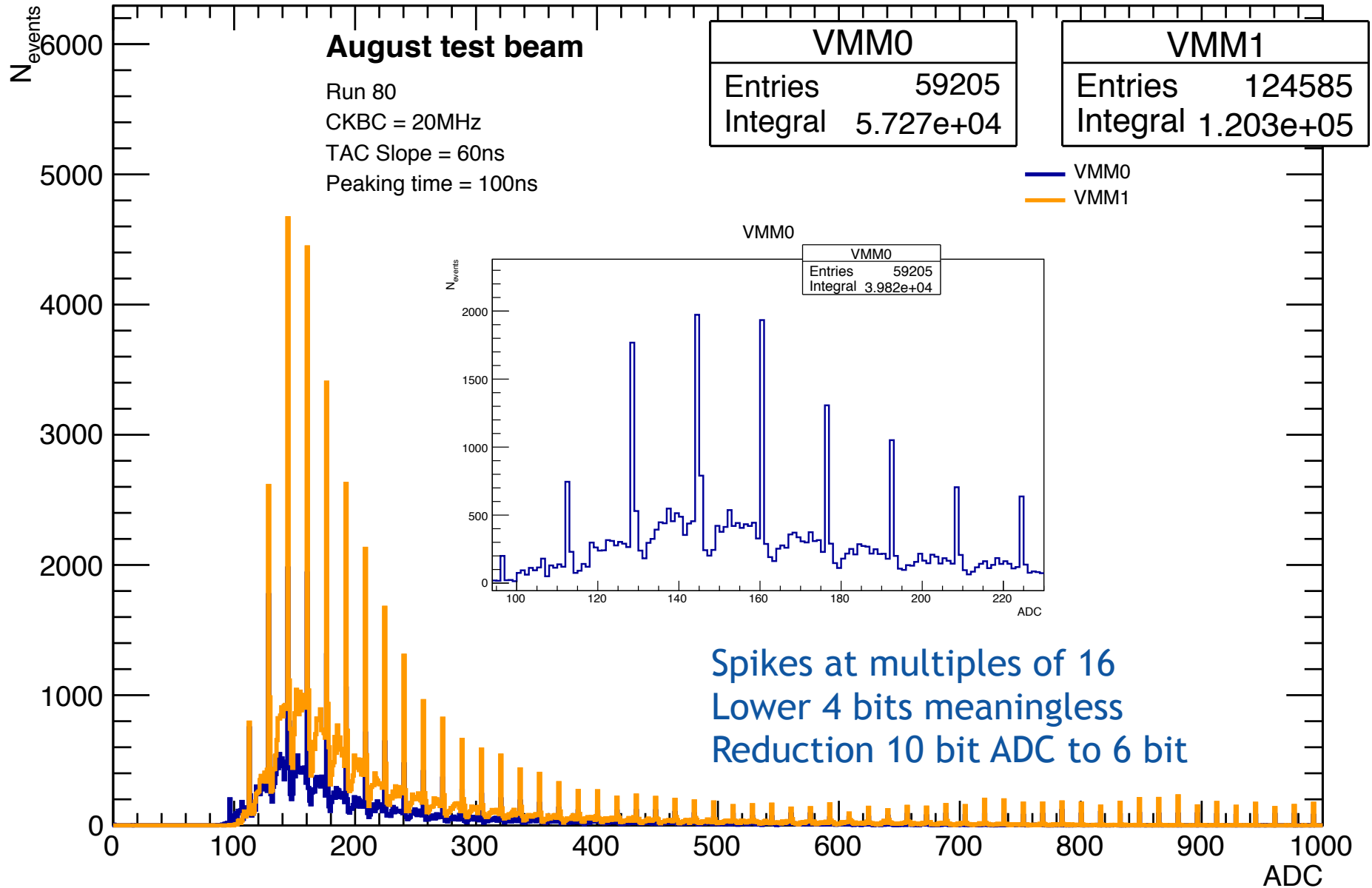
Run78_VMM3_2017-08-15-14-02-55.csv
1, 1, 4278910981, 12, 2065, 72, 99, 0
1, 1, 4278910981, 55, 2081, 106, 48, 0
1, 1, 4278910981, 56, 2081, 124, 79, 1
1, 1, 4278910981, 57, 2081, 131, 131, 1
1, 1, 4278910981, 58, 2081, 131, 141, 1
1, 1, 4278910981, 59, 2081, 107, 62, 0
1, 1, 4278910981, 11, 2465, 90, 75, 0
1, 1, 4278910981, 12, 2465, 79, 171, 1
1, 1, 4278910981, 13, 2465, 72, 145, 1
1, 1, 4278910981, 14, 2465, 111, 77, 0
1, 1, 415432710, 55, 4083, 55, 84, 0
1, 1, 415432710, 56, 4083, 73, 90, 1
1, 1, 415432710, 57, 4083, 72, 48, 0
1, 1, 415432710, 43, 497, 68, 62, 0
1, 1, 415432710, 44, 498, 67, 128, 1
1, 1, 415432710, 45, 498, 106, 85, 0
1, 1, 415432710, 30, 1382, 112, 37, 0
1, 1, 415432710, 31, 1382, 112, 72, 1
1, 1, 415432710, 32, 1382, 105, 53, 0
1, 1, 415432710, 54, 2013, 95, 142, 1
1, 1, 415432710, 55, 2013, 93, 64, 0
1, 1, 415432710, 51, 2013, 96, 49, 0
1, 1, 415432710, 52, 2013, 90, 112, 1
1, 1, 415432710, 53, 2013, 75, 225, 1
1, 0, 4278976517, 27, 4020, 97, 96, 0
1, 0, 4278976517, 28, 4020, 88, 125, 1
1, 0, 4278976517, 29, 4020, 71, 65, 0
1, 0, 4278976517, 42, 4021, 97, 31, 0
1, 0, 4278976517, 43, 4021, 96, 85, 1
1, 0, 4278976517, 44, 4021, 104, 80, 0
```

(Short-term) Solutions

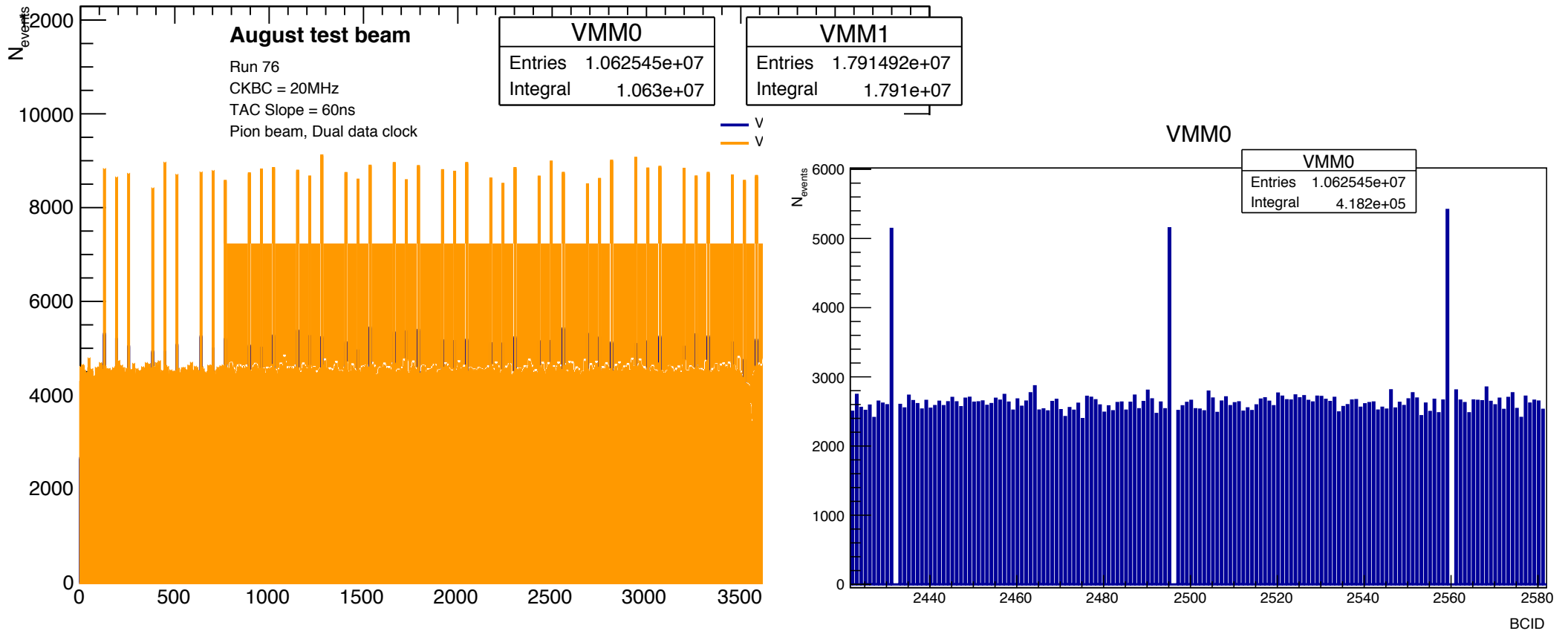
- manually remove all out of place data
- add a UNIX Timestamp, change SRS settings, change to hdf5 format



ADC Structure



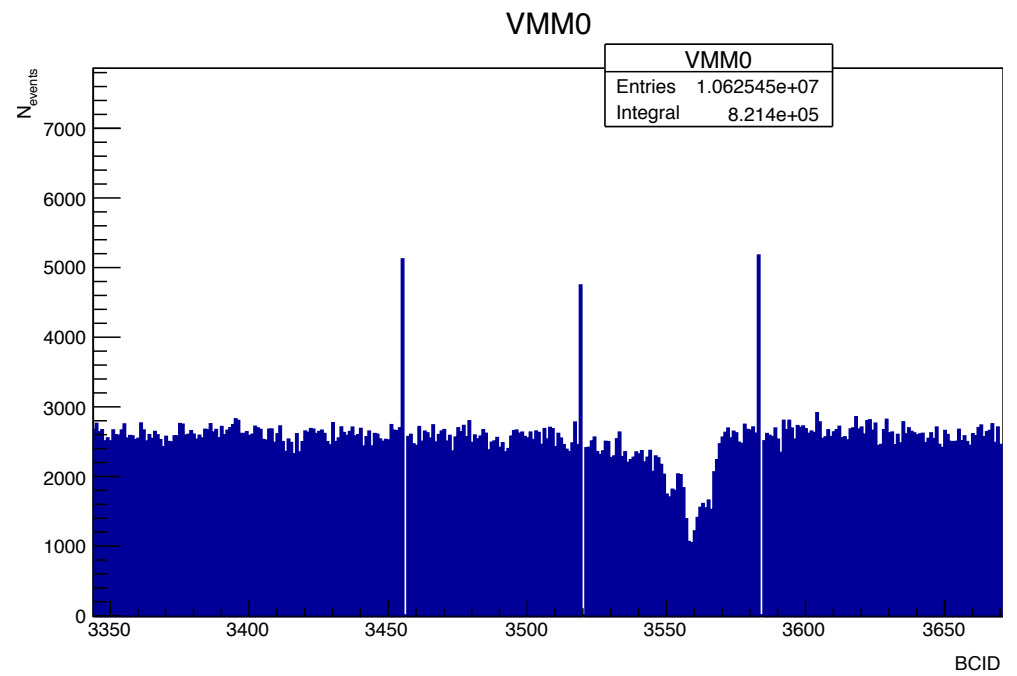
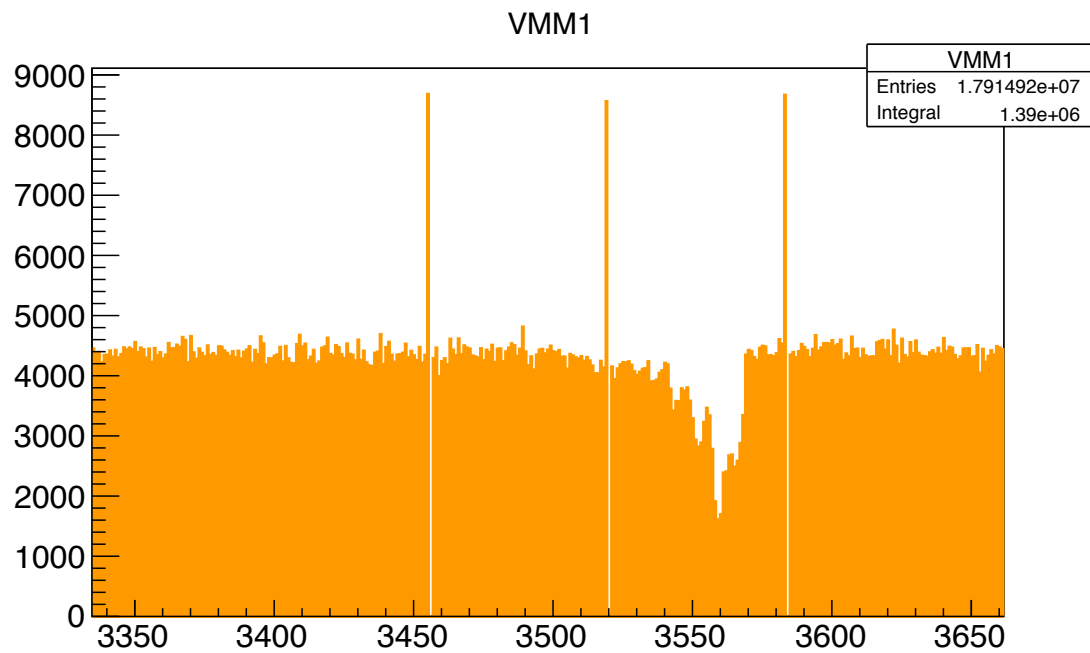
BCID Structure



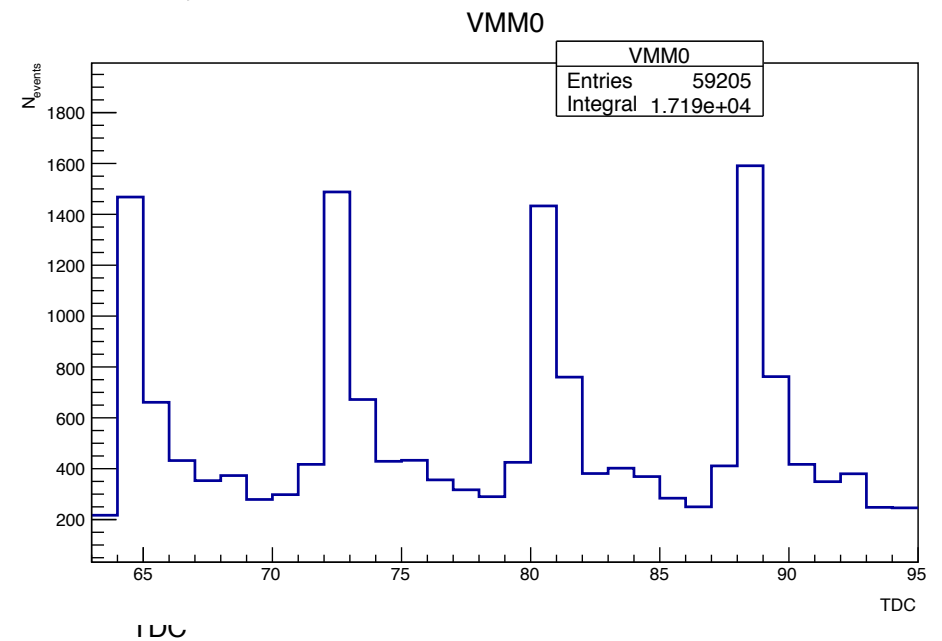
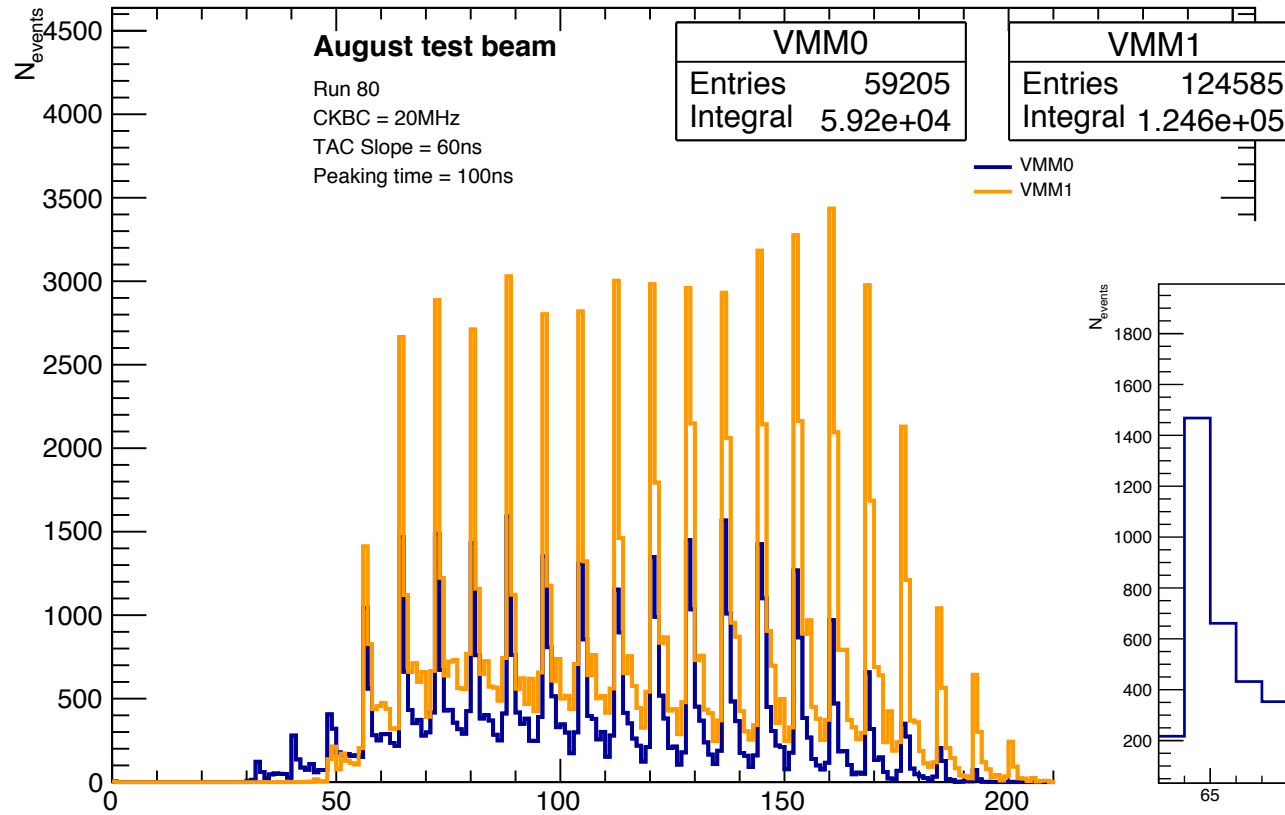
- BCID 12 bit: range $4096 * 50 \text{ ns} = 205 \text{ us}$
- Data has to be read out with $\geq 5 \text{ kHz}$ trigger rate to avoid overflows

Spike followed by trough
 multiples of 64 (not always present)

BCID - Structure

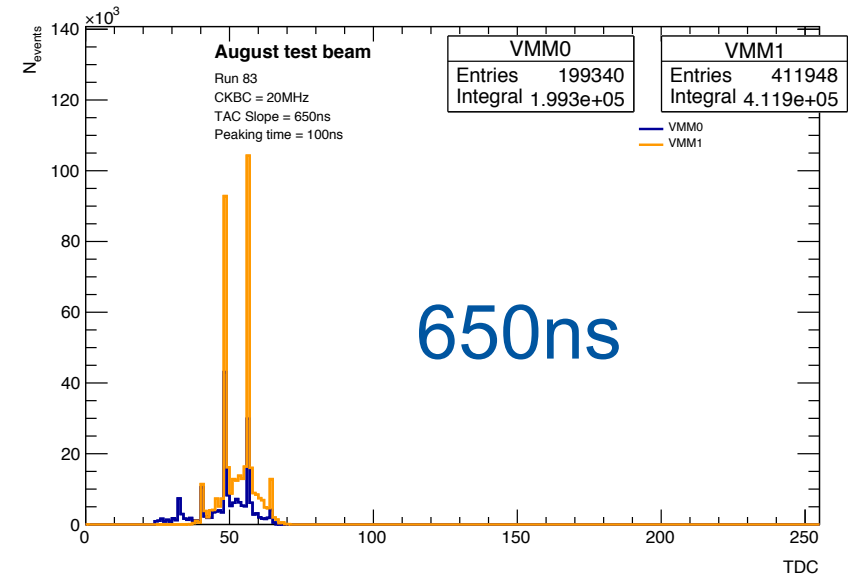
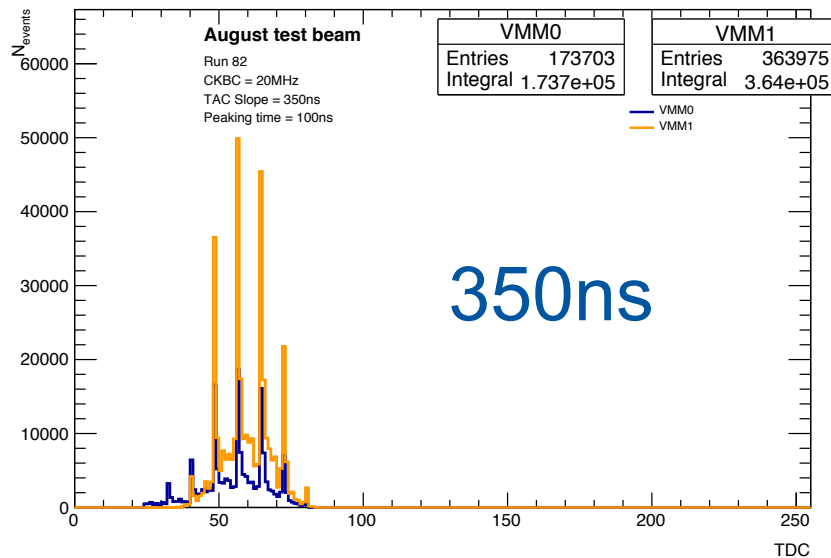
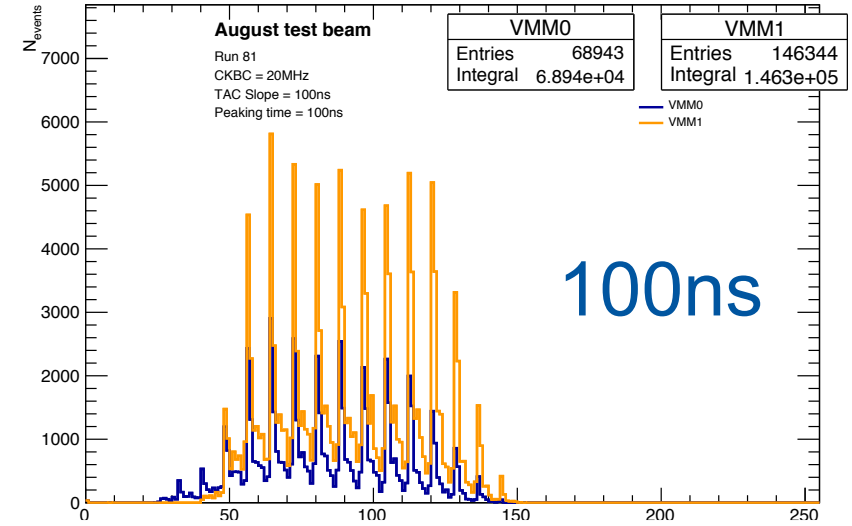
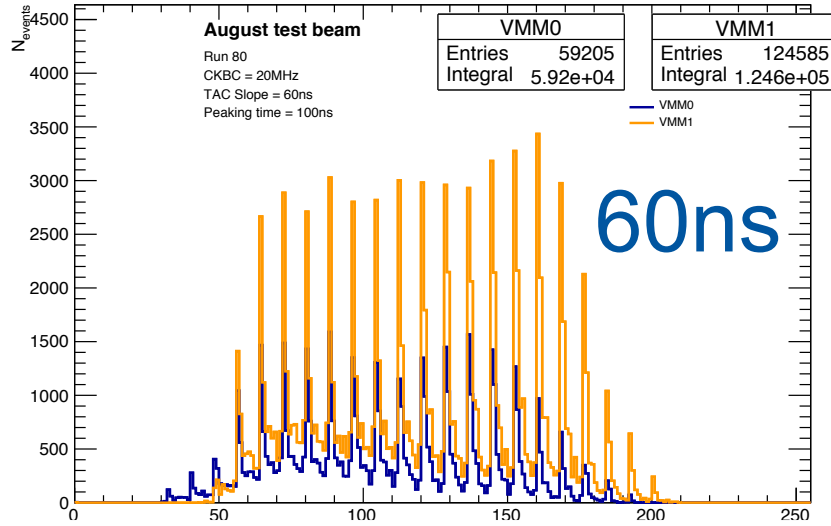


TDC - Structure

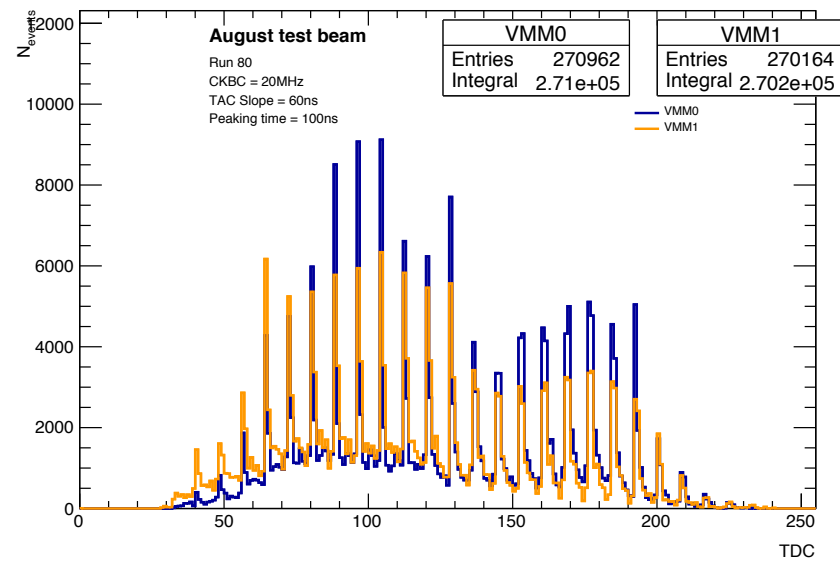
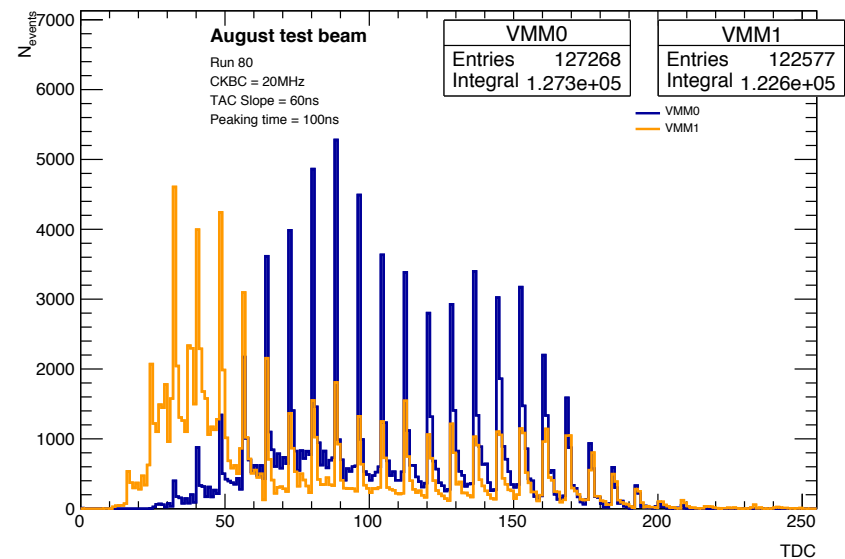
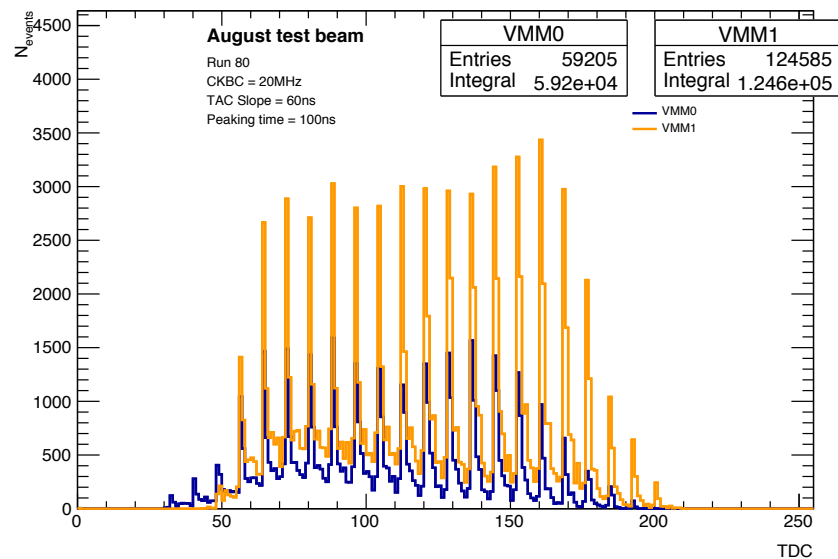


- Spike multiples of 8
- Lower 3 bits meaningless
- Reduction TDC 8 bit to 5 bit
- Reduced time resolution $\geq 2\text{ns}$

TDC - Spectra for different slopes



TDC - Spectra

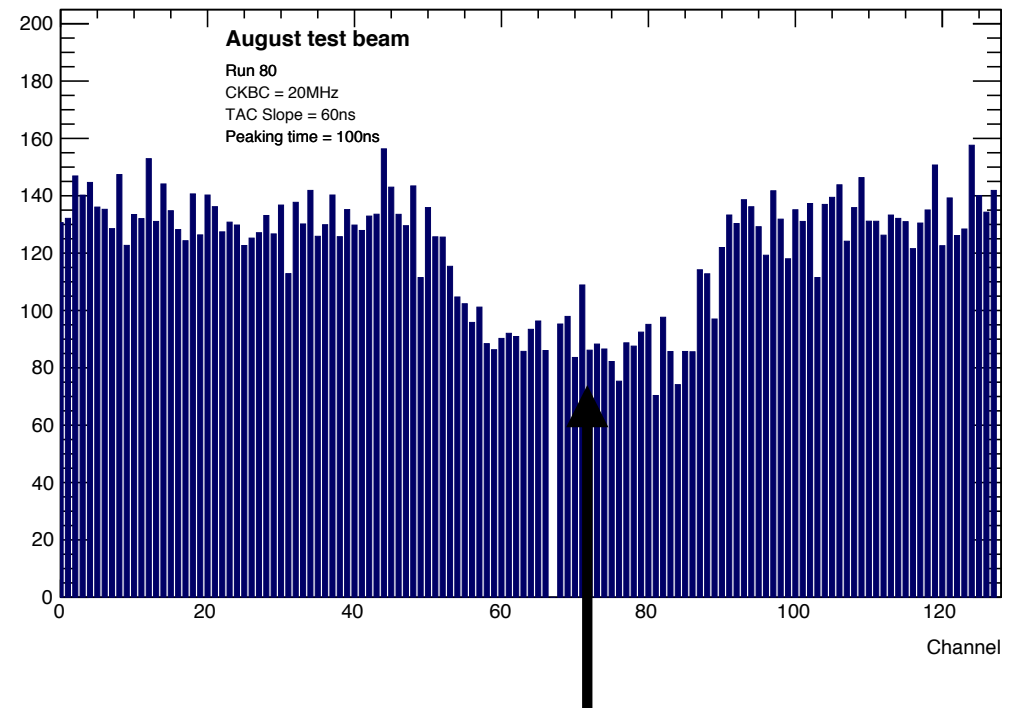
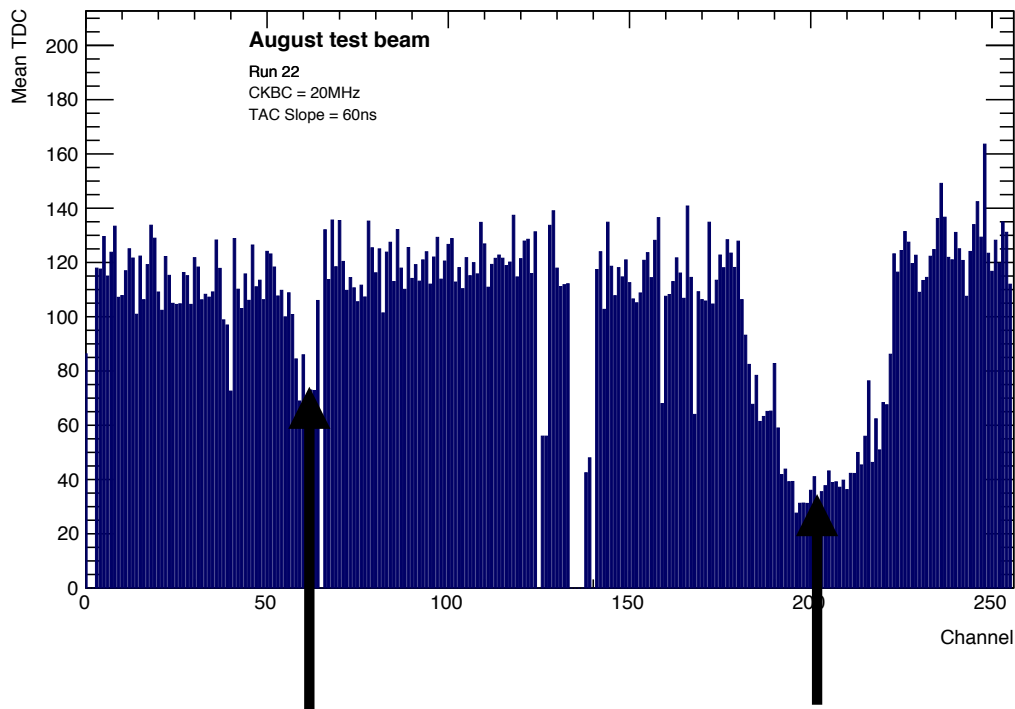


TDC - Averages

Expected: flat, uniform distribution

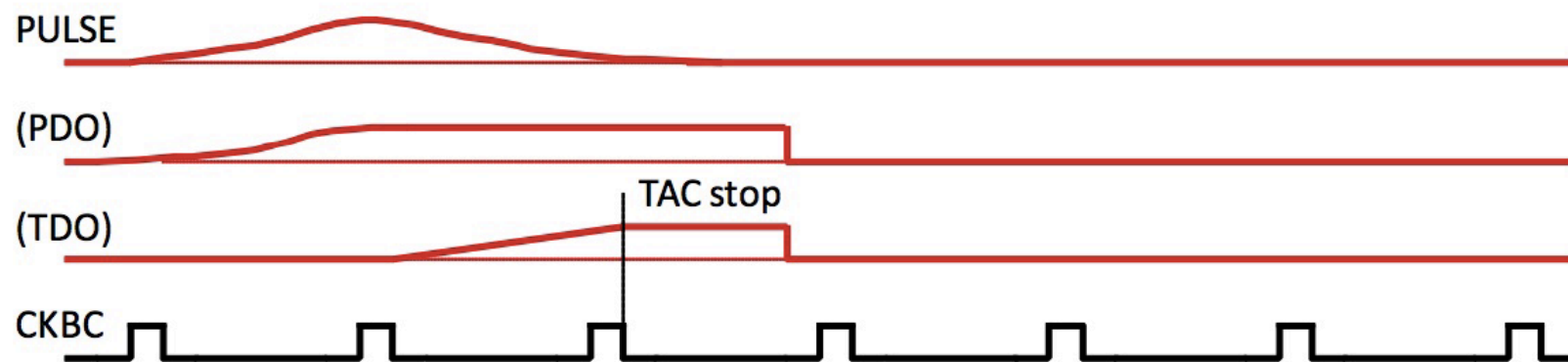
X

Y



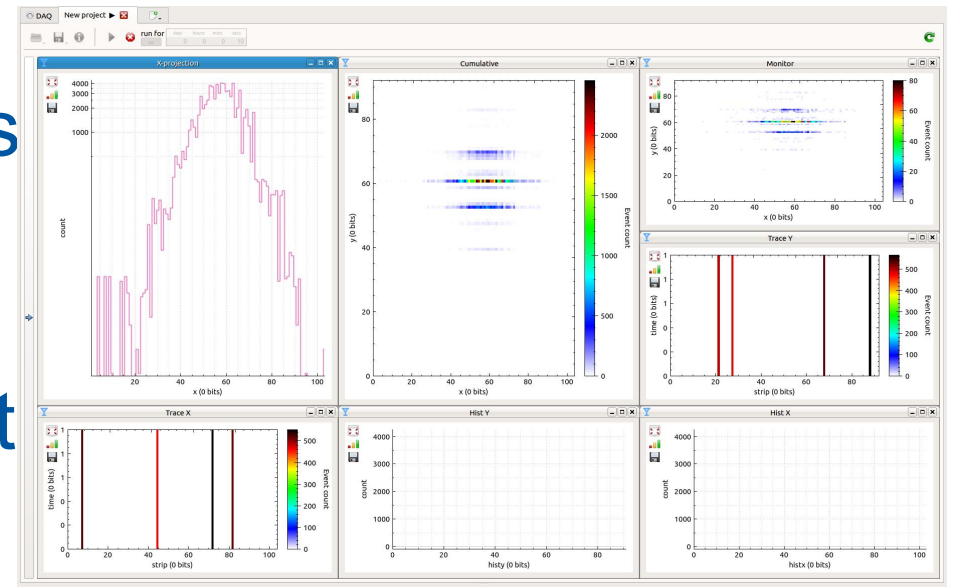
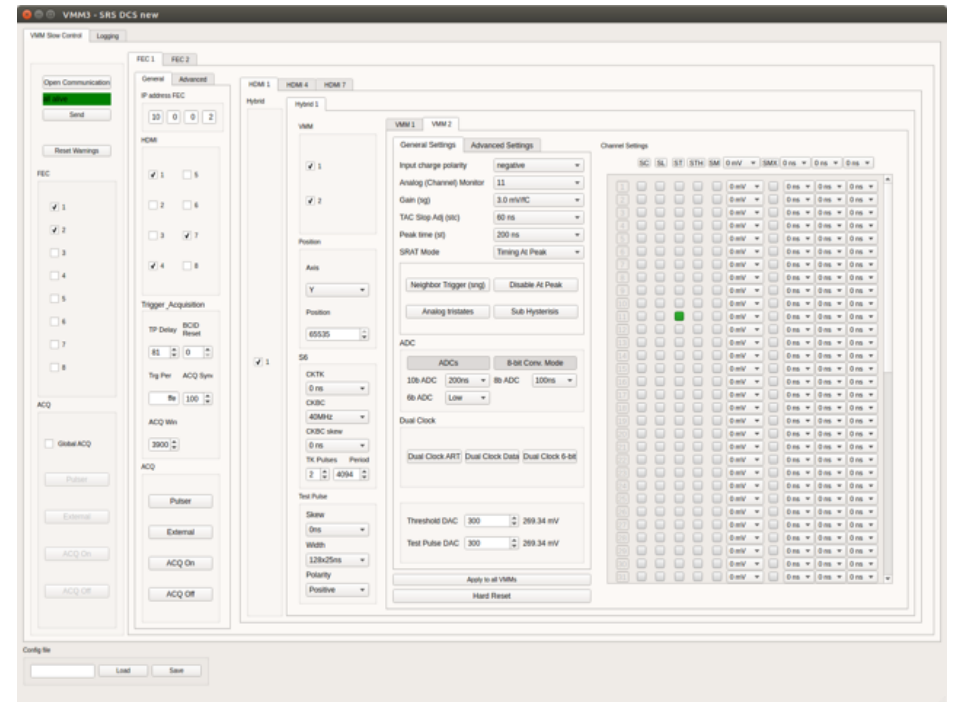
Known issues with the VMM3

- TAC voltage ramp has a pedestal
- Only explains shift
- Currently no explanation for differences in TDC Range
- Pedestal might vary between chips and channels

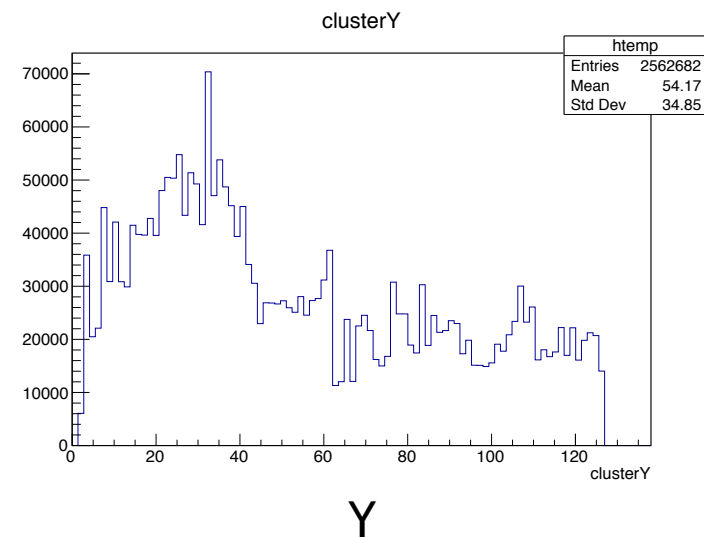
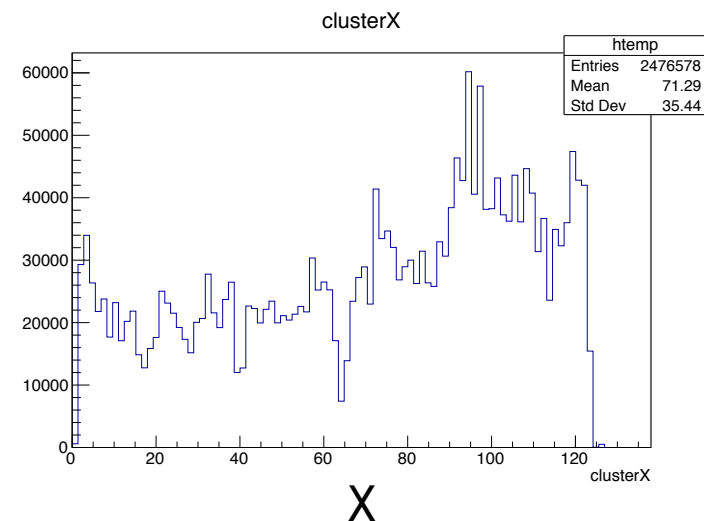
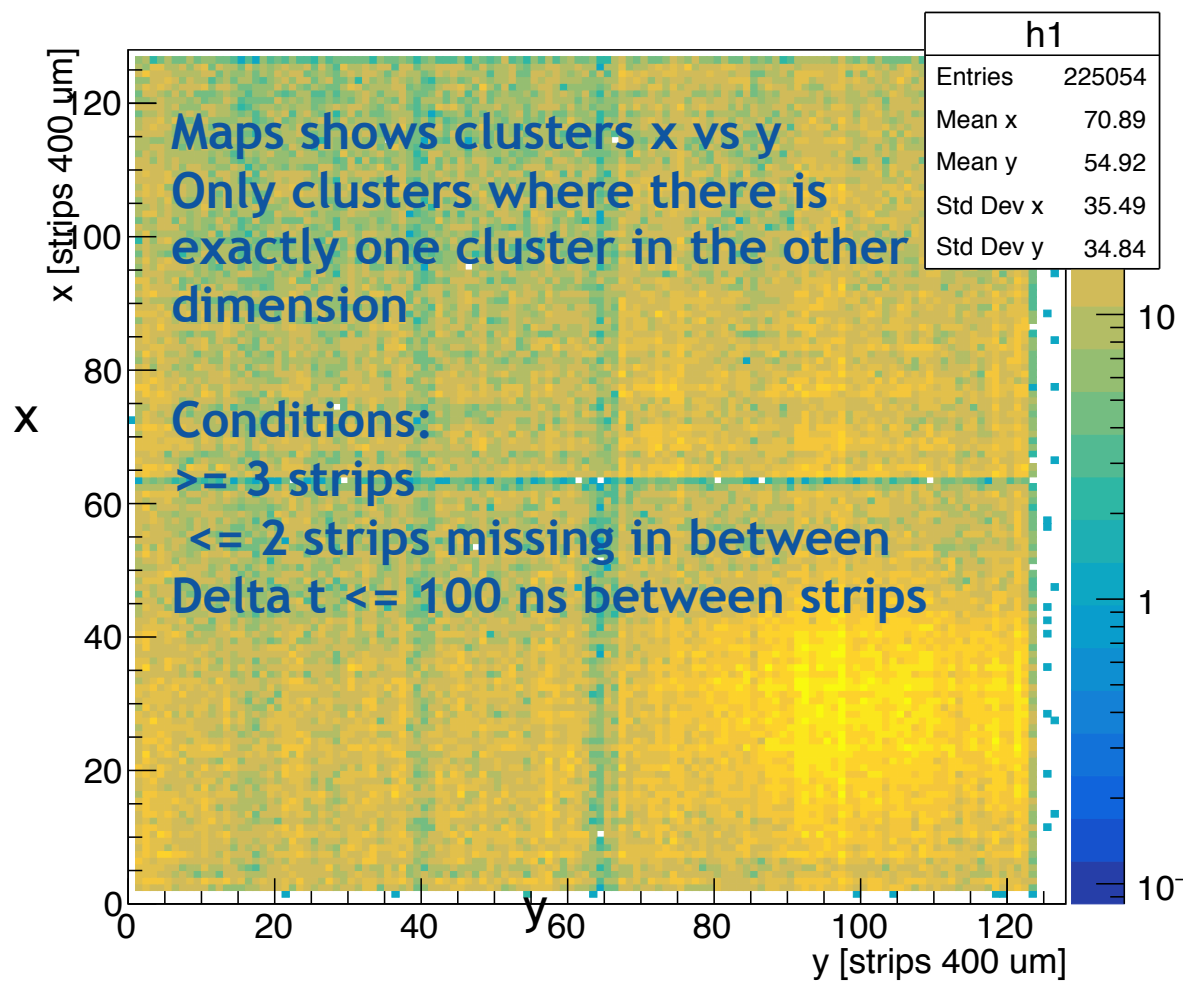


Next Steps

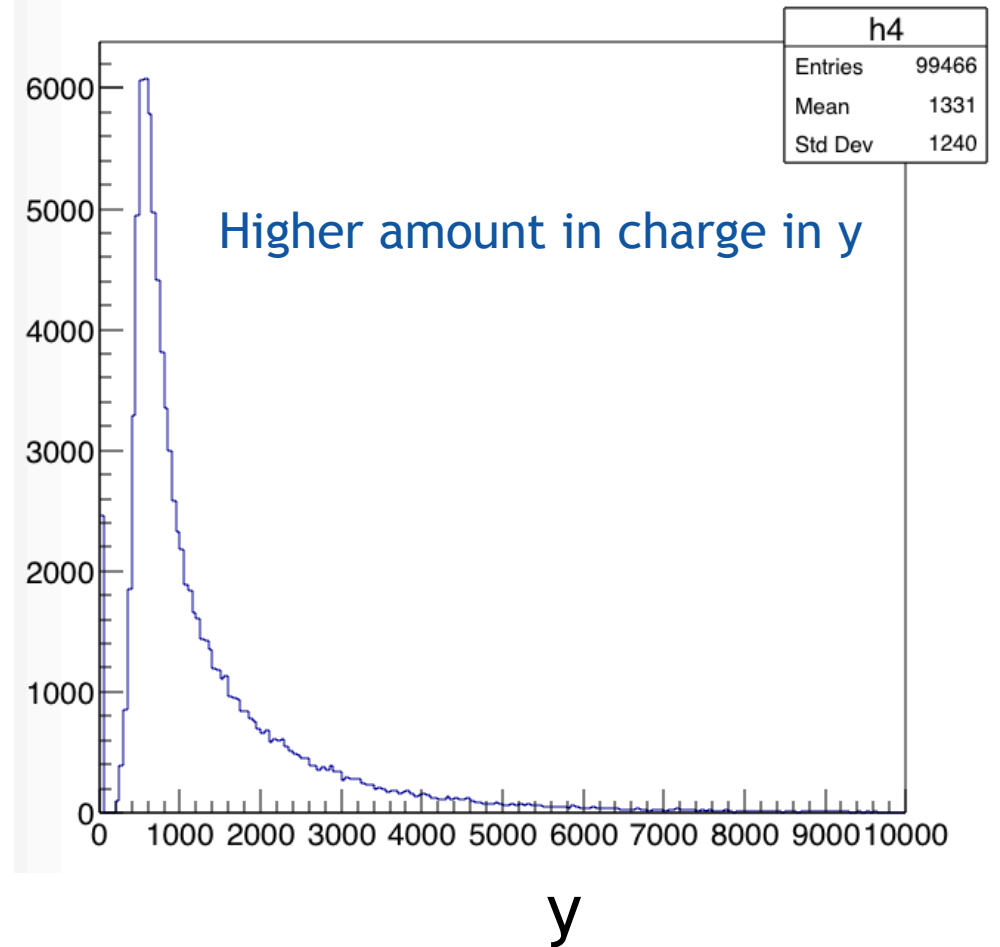
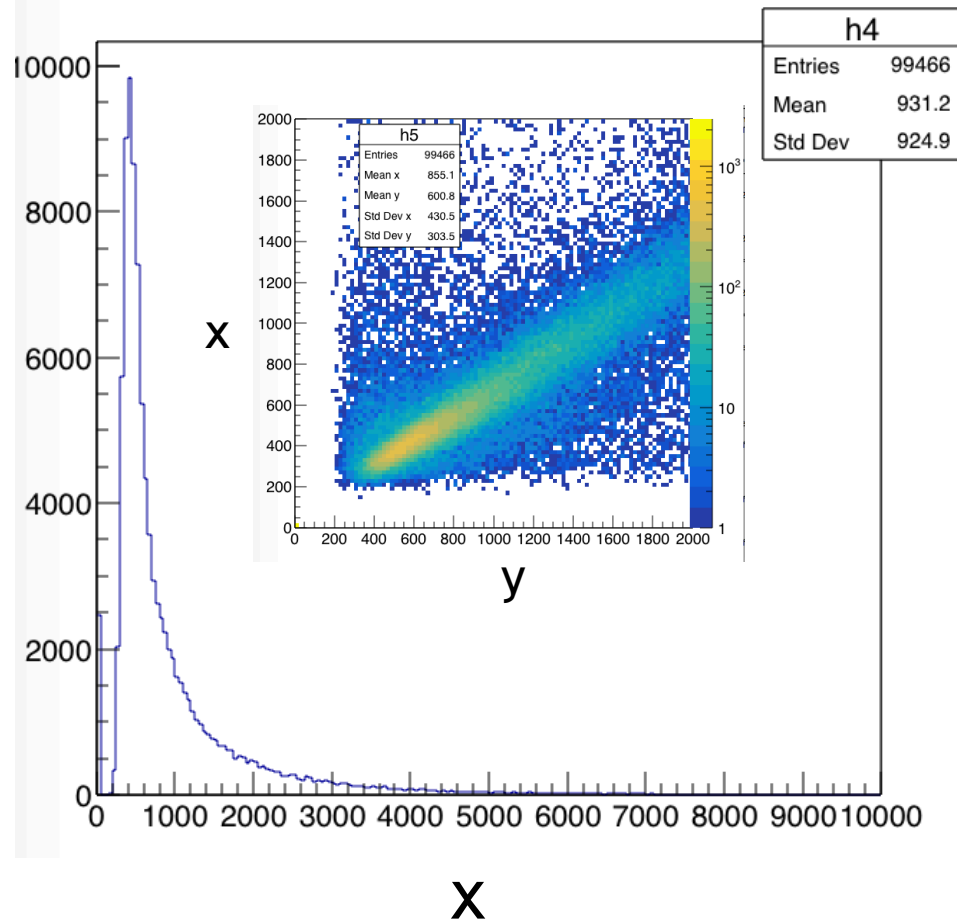
- Wide variety of settings that still need to be explored
- Cluster analysis to be performed
- New slow control enables different settings for VMMs on same hybrid
- More rigorous testing possible during next test beam in October



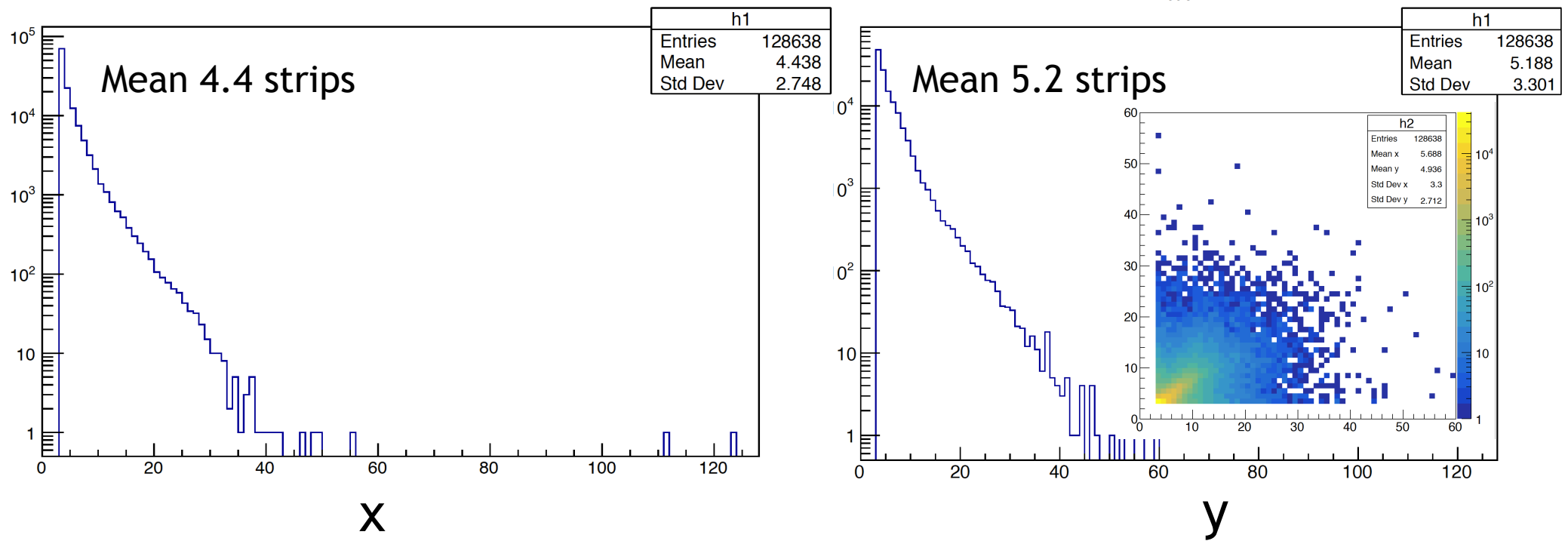
Clusters



Total cluster charge (sum of ADC)

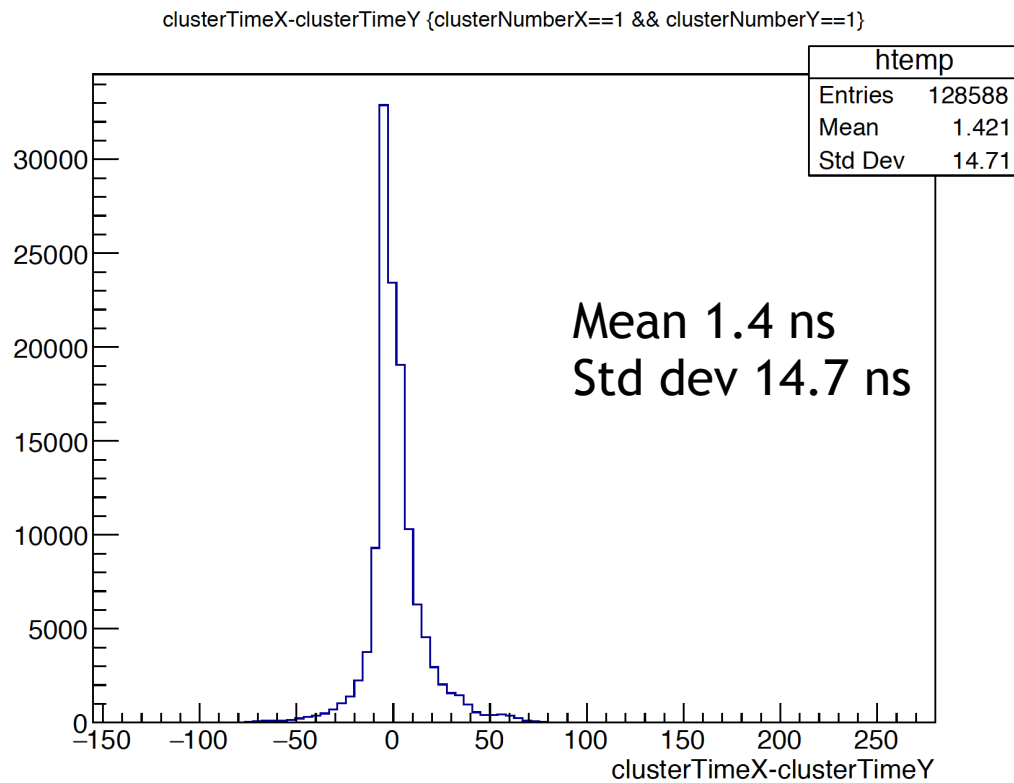


Cluster size in x and y

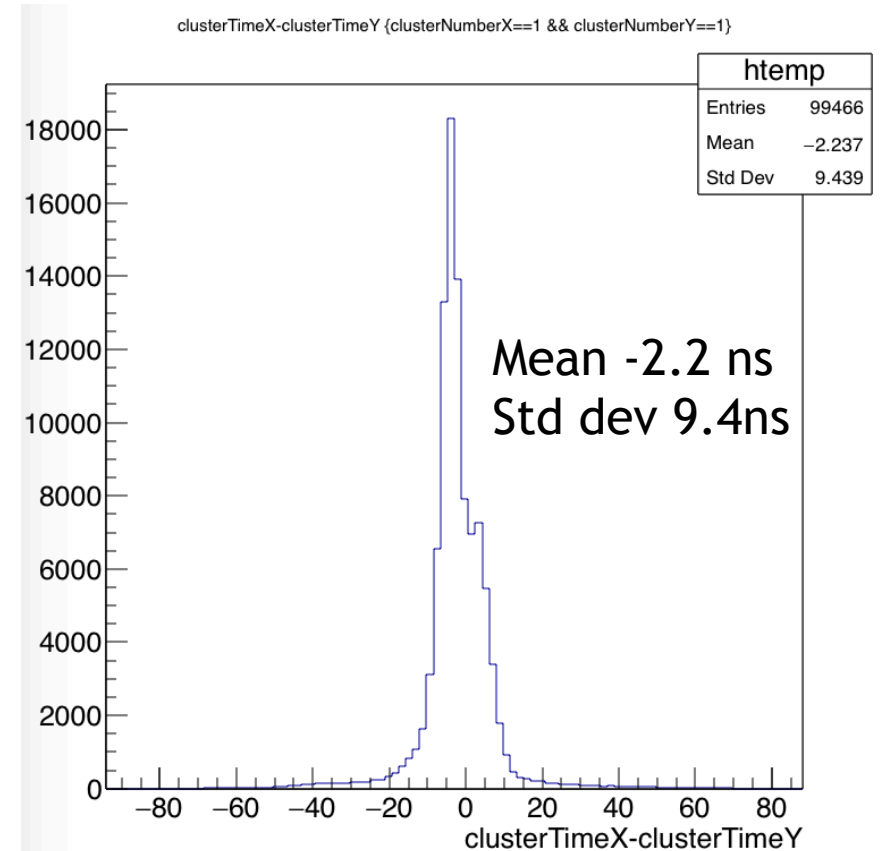


Larger cluster size in y, fits together with larger charge in y

Time difference between clusters in x and y



Maximum delta t 100 ns:
between strips and center of gravity of clusters



Maximum delta t 50 ns:
between strips and center of gravity of cl