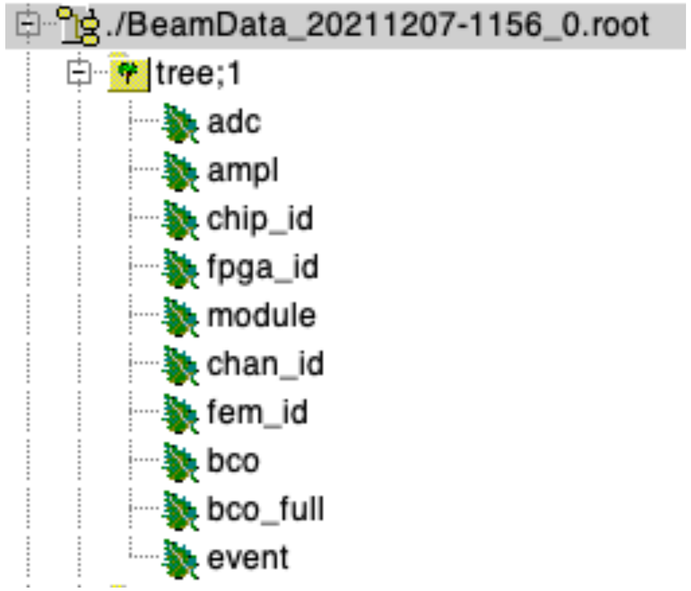
The 3rd Test Beam Experiment @ELPH in Tohoku Univ.

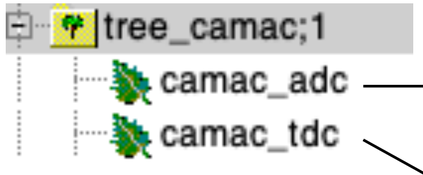
G. Nukazuka (RBRC)

What we obtained

1. the standard INTT data



2. CAMAC data

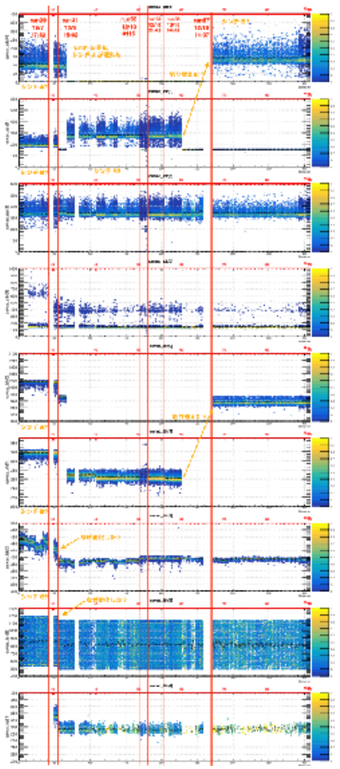


→ trigger scintillators' ADC

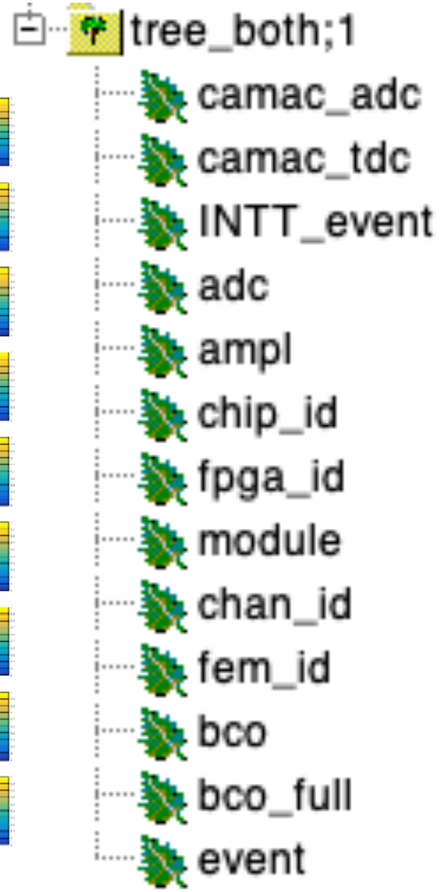
vector <int>, [0], …, [3]

→ trigger scintillators' TDC and BCO phase

vector <int>, [0], …, [6]???



3. CAMAC data (trigger data) and associated INTT data



What we obtained

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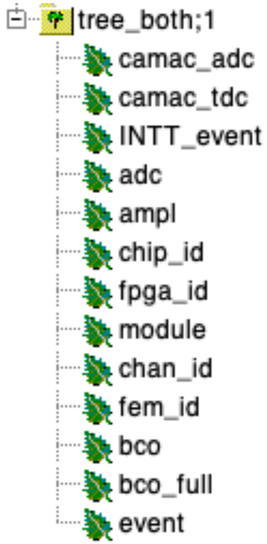


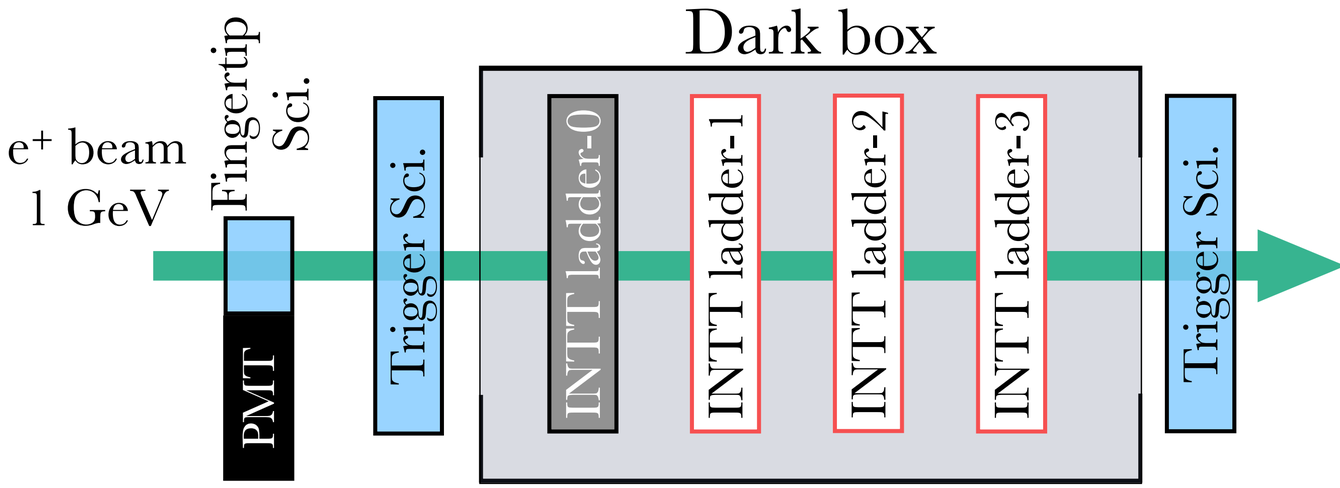
We expected to get, for example:

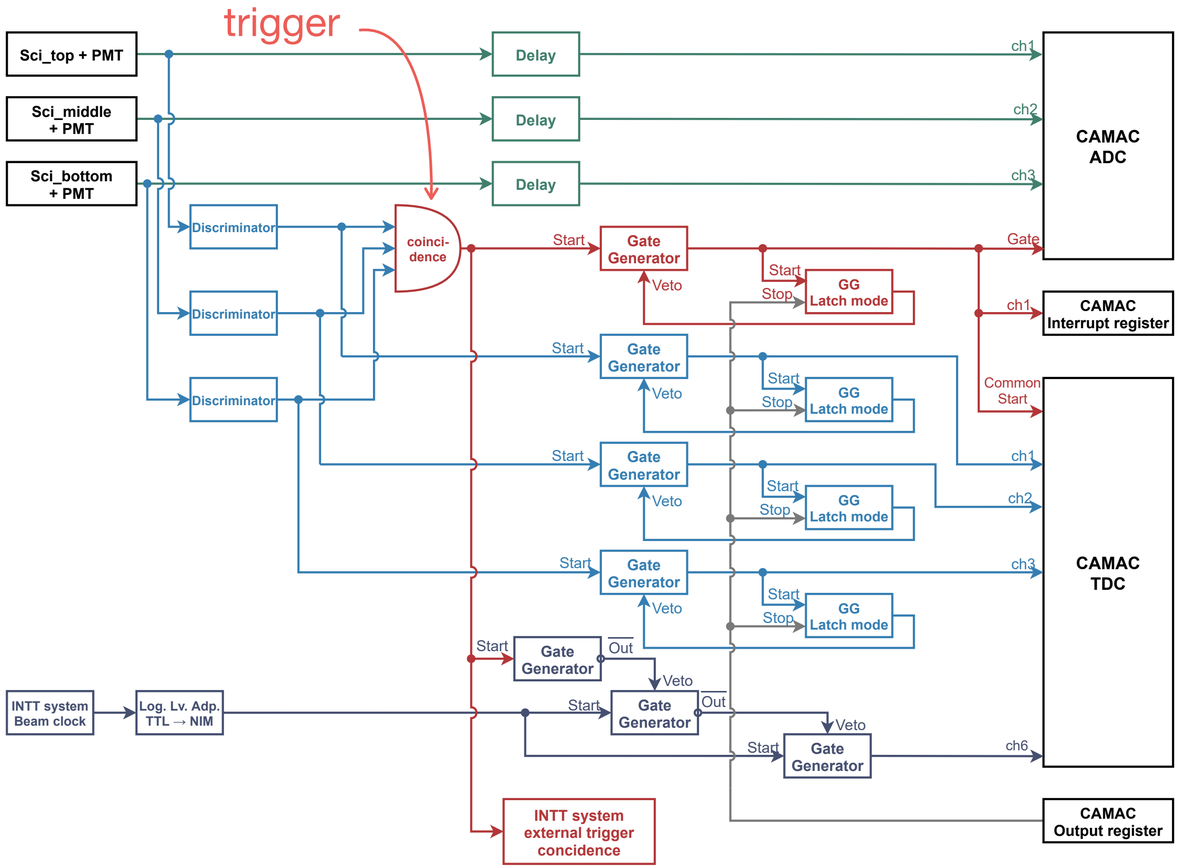
```
├── trigger_1
│     ├── INTT_hit_1
│     ├── INTT_hit_2
│     └── INTT_hit_3
├── trigger_2
│     ├── INTT_hit_1
│     ├── INTT_hit_2
│     └── INTT_hit_3
└── trigger_3
      ├── INTT_hit_1
      ├── INTT_hit_2
      └── INTT_hit_3
```

triggered by the beam particle

triggered by the beam particle

triggered by the beam particle

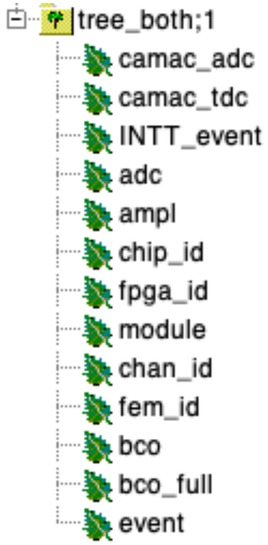




NIM/CAMAC circuit (not latest version)

What we obtained

3. CAMAC data (trigger data) and associated INTT data



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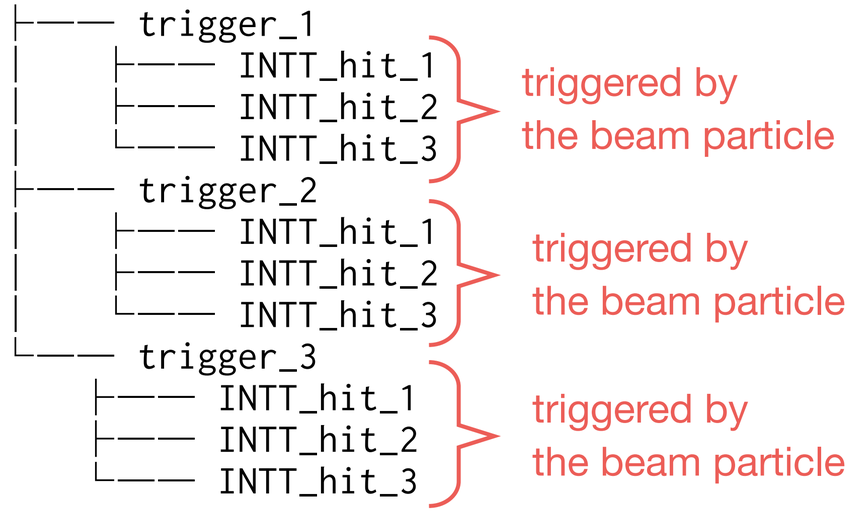
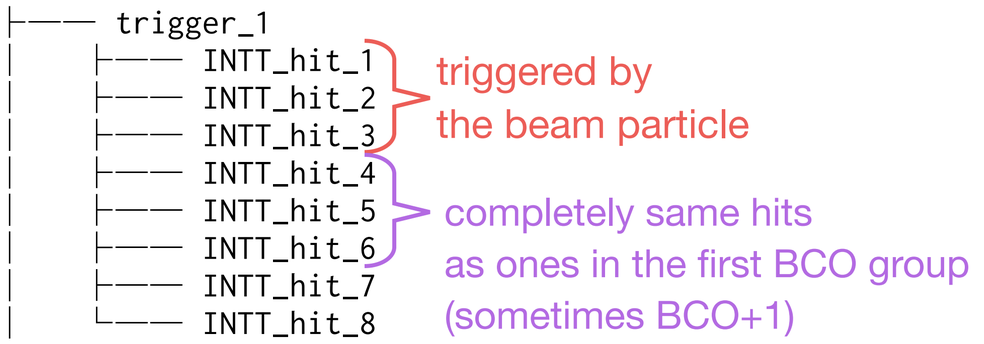


But actually, we could get



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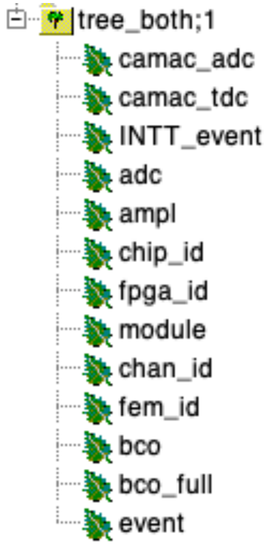

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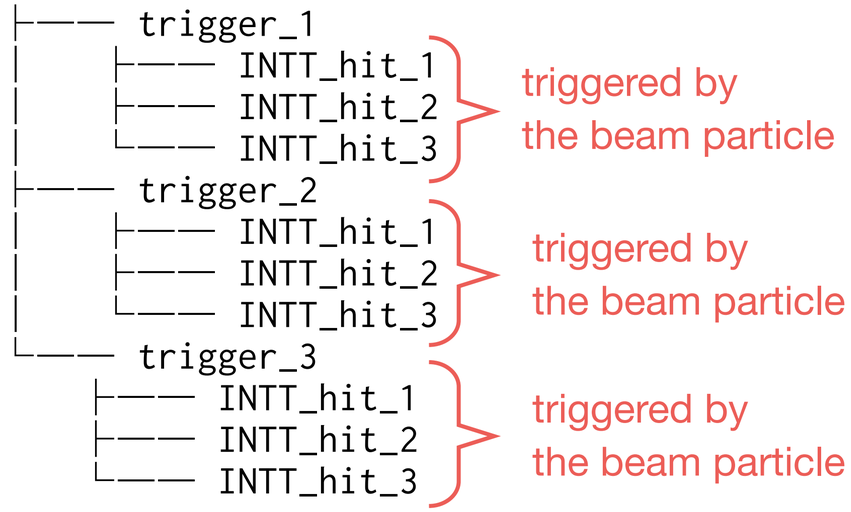

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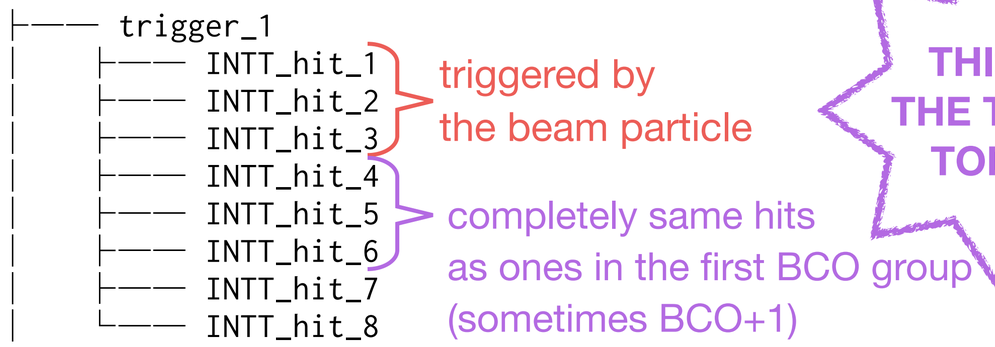

THIS IS THE TOPIC TODAY

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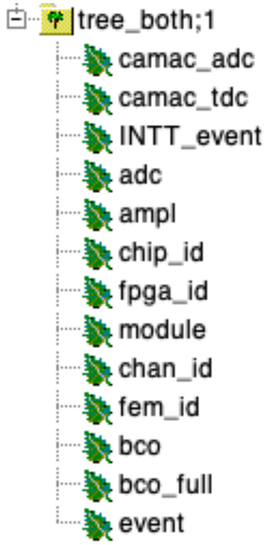

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- trigger_1
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle
- trigger_2
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle
- trigger_3
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle

But actually, we could get

- trigger_1
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle
  - INTT_hit_4
  - INTT_hit_5
  - INTT_hit_6

  completely same hits as ones in the first BCO group (sometimes BCO+1)
  - INTT_hit_7
  - INTT_hit_8
- trigger_2
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle
  - INTT_hit_4
  - INTT_hit_5
  - INTT_hit_6
  - INTT_hit_7
  - INTT_hit_8
  - INTT_hit_9
  - INTT_hit_10
  - INTT_hit_11

  made by another beam particle they can be identified with their BCO i.e. these hits are not associated with the trigger

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What we obtained

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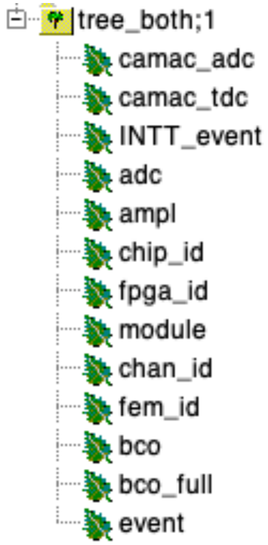

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  triggered by the beam particle
- trigger_3
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle

Such clones were observed
in cosmic-ray measurements as well.

But actually, we could get

THIS IS THE TOPIC TODAY

- trigger_1
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle
  - INTT_hit_4
  - INTT_hit_5
  - INTT_hit_6

  completely same hits as ones in the first BCO group (sometimes BCO+1)
  - INTT_hit_7
  - INTT_hit_8
- trigger_2
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle
  - INTT_hit_4
  - INTT_hit_5
  - INTT_hit_6
  - INTT_hit_7
  - INTT_hit_8
  - INTT_hit_9
  - INTT_hit_10
  - INTT_hit_11

  made by another beam particle they can be identified with their BCO i.e. these hits are not associated with the trigger
- trigger_3
  - INTT_hit_1
  - INTT_hit_2
  - INTT_hit_3

  triggered by the beam particle
  - INTT_hit_4
  - INTT_hit_5
  - INTT_hit_6
  - INTT_hit_7
  - INTT_hit_8
  - INTT_hit_9
  - INTT_hit_10
  - INTT_hit_11

  made by another beam particle they can be identified with their BCO i.e. these hits are not associated with the trigger
  - INTT_hit_12
  - INTT_hit_13
  - INTT_hit_14

  another group(s)…

The clone hits (aka. double saving)

Definition: Hits on INTT that

- belong to the same trigger event
- have the following parameters are the same as the other hit:
  - adc
  - ampl
  - chip_id
  - fpga_id
  - module
  - chan_id
  - fem_id

but BCO (full) is slightly different (± ?)

```
// loop over all hits
for( int i=0; i<adc->size(); i++ )
  {
    bool flag_clone_found = false;

    // loop over other hits to compare hit-i and hit-j
    for( int j=i+1; j<adc->size(); j++ )
      {
        int bco_diff = (*bco_full)[i] - (*bco_full)[j];

        // search range is here
        // if BCOs are different a lot, skip this
        if( abs(bco_diff) >= thre )
          continue;

        // check whether this hit (j) has the same parameters as the hit (i)
        if( (*adc)[i] != (*adc)[j] )
          continue;

        if( (*ampl)[i] != (*ampl)[j] )
          continue;

        if( (*chip_id)[i] != (*chip_id)[j] )
          continue;

        if( (*fpga_id)[i] != (*fpga_id)[j] )
          continue;

        if( (*module)[i] != (*module)[j] )
          continue;

        if( (*chan_id)[i] != (*chan_id)[j] )
          continue;

        if( (*fem_id)[i] != (*fem_id)[j] )
          continue;
```

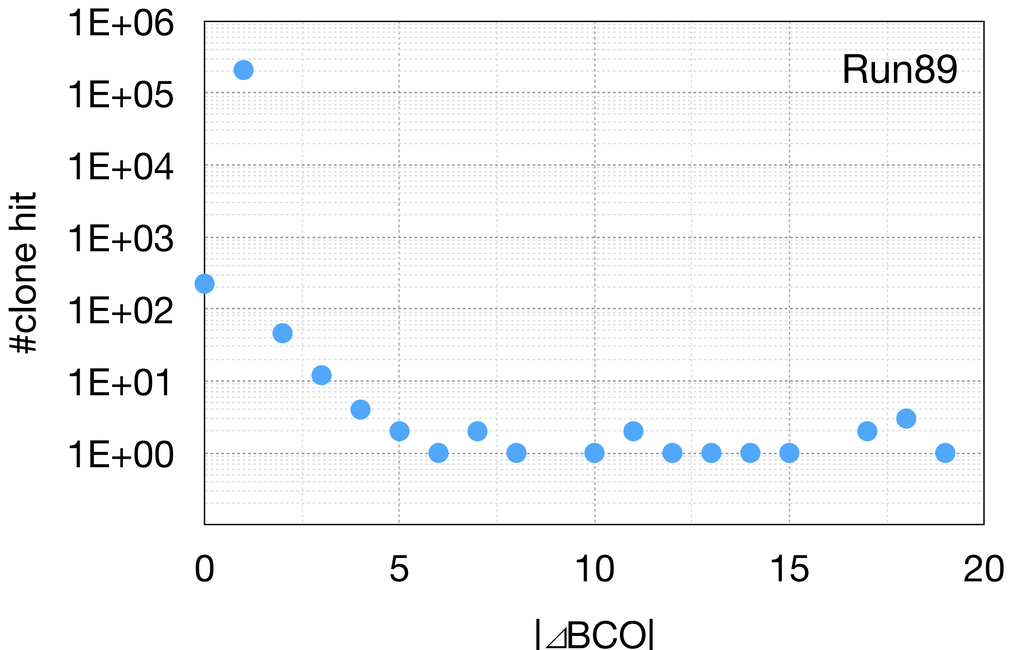
Quite simple codes to judge whether this hit is clone or not

The clone hits (aka. double saving)

Definition: Hits on INTT that

- belong to the same trigger event
- have the following parameters are the same as the other hit:
  - adc
  - ampl
  - chip_id
  - fpga_id
  - module
  - chan_id
  - fem_id

but BCO (full) is slightly different (± ?)



BCO ± x	#INTT hit	オリジナルのヒット	clone hit	clone hit の割合
BCO ± 0	1127176	1126952	224	0.02%
BCO ± 1	1127176	918303	208649	18.51%
BCO ± 2	1127176	918257	46	0.00%
BCO ± 3	1127176	918245	12	0.00%
BCO ± 4	1127176	918241	4	0.00%
BCO ± 5	1127176	918239	2	0.00%
BCO ± 6	1127176	918238	1	0.00%
BCO ± 7	1127176	918236	2	0.00%
BCO ± 8	1127176	918235	1	0.00%
BCO ± 9	1127176	918235	0	0.00%
BCO ± 10	1127176	918234	1	0.00%
BCO ± 11	1127176	918232	2	0.00%
BCO ± 12	1127176	918231	1	0.00%
BCO ± 13	1127176	918230	1	0.00%
BCO ± 14	1127176	918229	1	0.00%
BCO ± 15	1127176	918228	1	0.00%
BCO ± 16	1127176	918228	0	0.00%
BCO ± 17	1127176	918226	2	0.00%
BCO ± 18	1127176	918223	3	0.00%
BCO ± 19	1127176	918222	1	0.00%
BCO ± 20	1127176	918222	0	0.00%

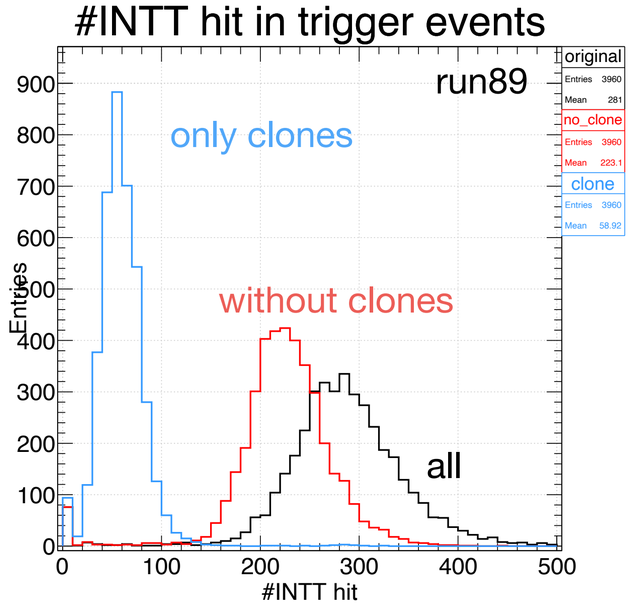
The clone hits (aka. double saving)

Survival rate in various search range.

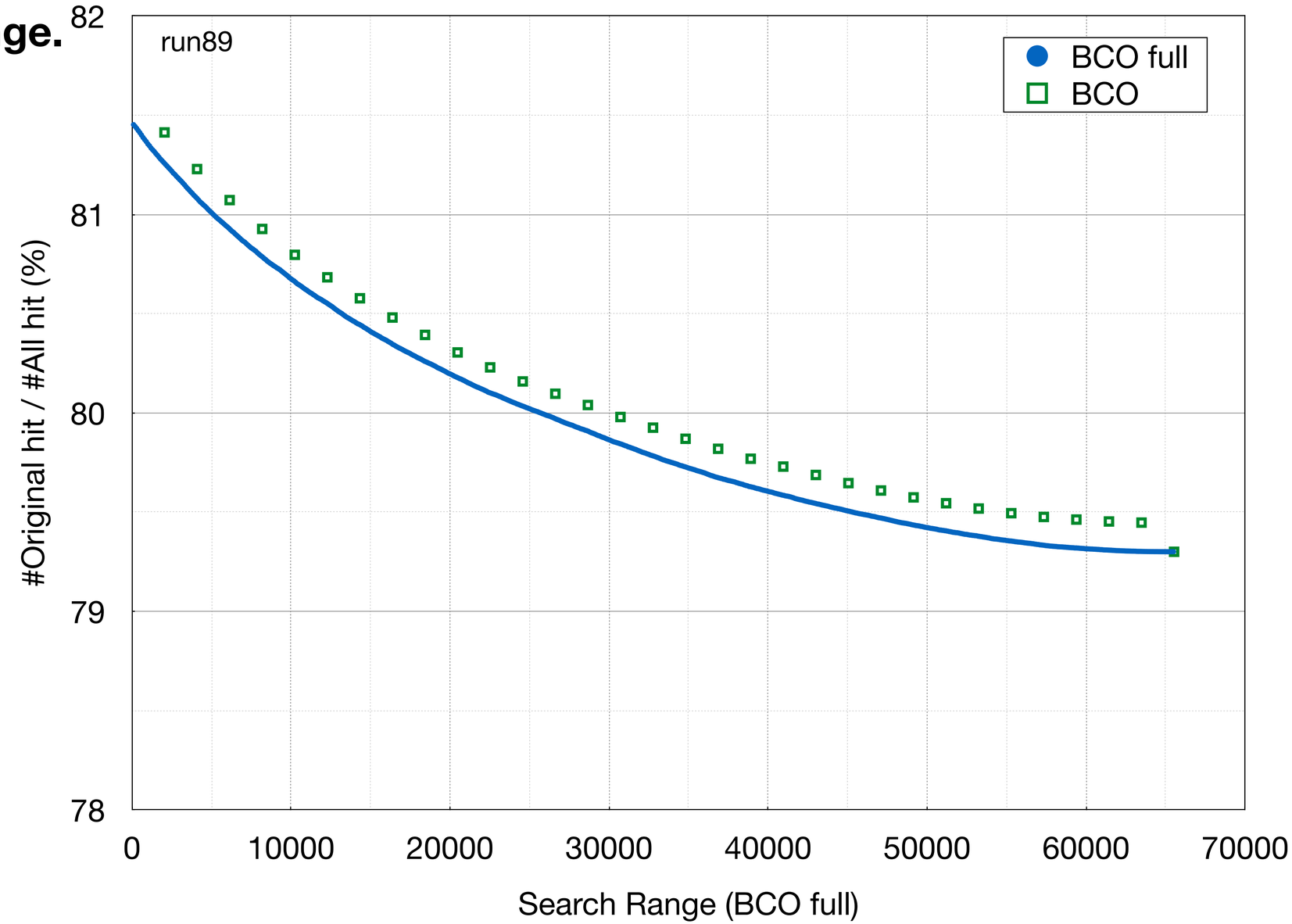
- x-axis: search range
- y-axis: servival rate

● : comparison of BCO full

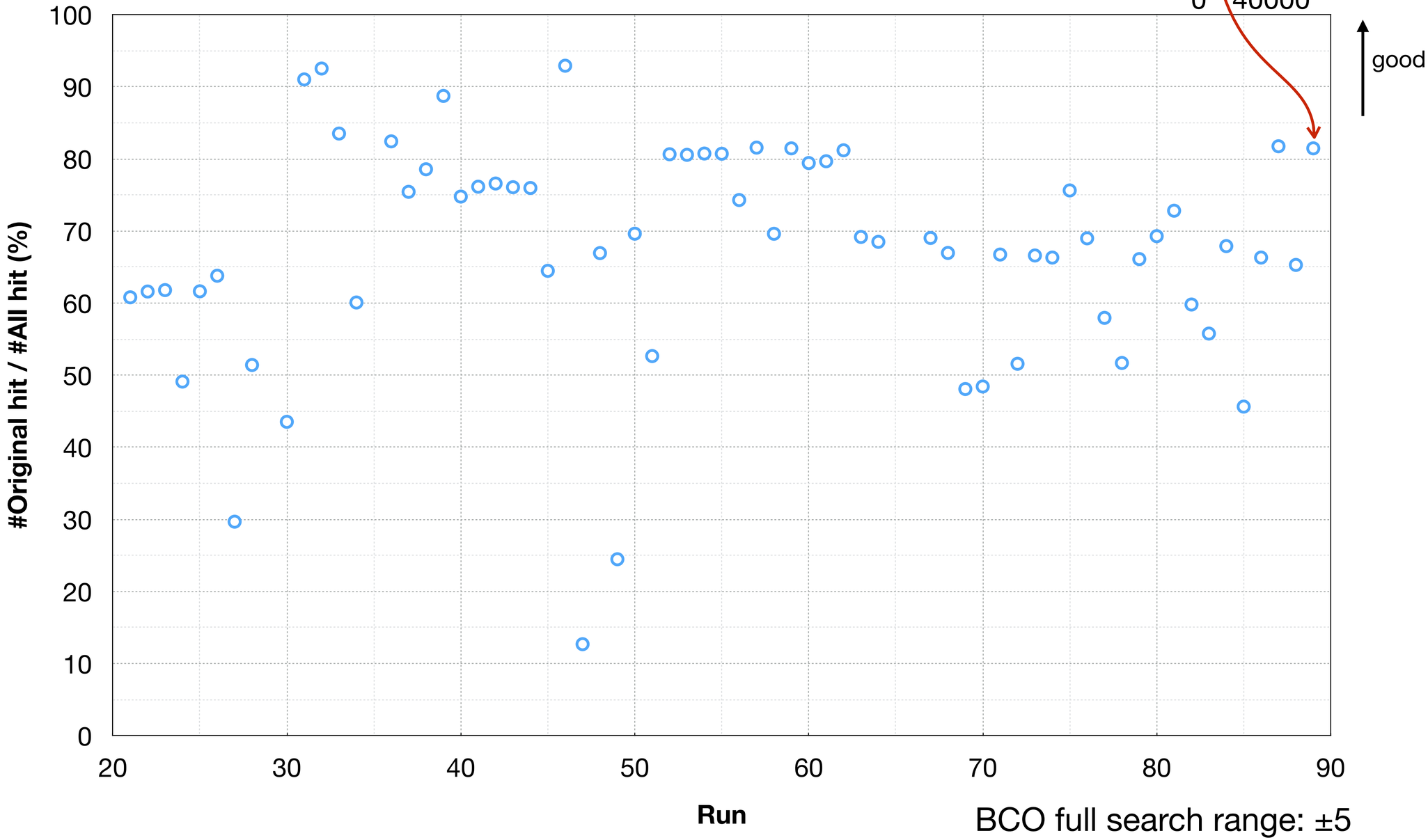
□ : comparison of BCO (scaled)

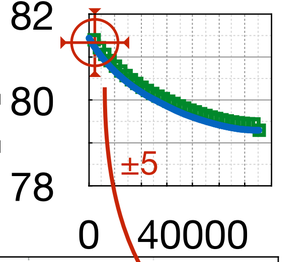


#hit in trigger events



Survival rate over the experimet





good

BCO full search range: ±5

run	total	no clone	ratio	INTT rate	CAMAC rate
21	585666	356095	60.80	133.0	11.0
22	3310908	2039391	61.60	1260.0	91.2
23	3189858	1971282	61.80	1060.0	75.8
24	4886681	2399713	49.11	1130.0	84.9
25	3008482	1854191	61.63	983.0	72.2
26	1923849	1227270	63.79	984.0	69.0
27	15546513	4614718	29.68	1650.0	114.0
28	4816344	2476068	51.41	1320.0	96.3
29		-			
30	13877722	6041322	43.53	1380.0	98.1
31	2605297	2371336	91.02	1240.0	49.4
32	527192	487793	92.53	772.0	32.9
33	725462	605819	83.51	299.0	20.7
34	700160	420648	60.08	216.0	14.5
35	0	0			
36	153921	126882	82.43		
37	621654	468943	75.43	255.0	11.4
38	153687	120740	78.56	201.0	9.6
39	36144	32071	88.73	175.0	7.9
40	1979018	1479650	74.77	742.0	2.5
41	1651584	1257517	76.14	672.0	2.6
42	197708	151404	76.58	97.3	0.4
43	369188	280847	76.07	452.0	1.9
44	983697	747209	75.96	547.0	0.9
45	101492	65429	64.47	2100.0	9.1
46	2924	2717	92.92	67.4	11.8
47	100514	12760	12.69	10.1	2.4
48	170816	114322	66.93		
49	76733	18779	24.47	50.2	2.7
50	2059624	1433979	69.62	3380.0	22.7
51	2354489	1239735	52.65		
52	973113	784759	80.64	511.0	2.5
53	1218612	981655	80.56	639.0	3.2
54	1249669	1009044	80.74	547.0	2.6
55	1240519	1001279	80.71	543.0	2.6
56	176744	131301	74.29	500.0	2.5
57	1225967	999958	81.56	525.0	2.6
58	1773635	1234615	69.61	606.0	2.6
59	1220162	993893	81.46	540.0	2.7
60	105777	84006	79.42	342.0	1.5
61	391751	312095	79.67	339.0	1.4
62	44971	36512	81.19	199.0	0.9
63	447232	309368	69.17	324.0	1.5
64	482833	330673	68.49	354.0	1.4
67	91474	63140	69.03	184.0	1.4
68	37315	24982	66.95	83.0	1.6
69	127577	61338	48.08	196.0	1.5
70	109785	53174	48.43	84.4	1.6
71	33691	22481	66.73	74.7	1.6
72	16019	8263	51.58	27.2	1.6
73	5638	3755	66.60	12.5	1.6
74	3422	2269	66.31	7.6	1.7
75	379470	286943	75.62	857.0	1.6
76	128506	88645	68.98	280.0	1.5
77	141774	82162	57.95	264.0	1.7
78	110632	57190	51.69	186.0	1.5
79	2053921	1357706	66.10	3220.0	1.8
80	127807	88546	69.28	285.0	1.5
81	113305	82492	72.81	269.0	1.6
82	146866	87831	59.80	283.0	1.6
83	137682	76781	55.77	247.0	1.7
84	88106	59823	67.90	197.0	2.0
85	59317	27073	45.64	88.6	1.9
86	25493	16905	66.31	5.61E+01	1.9
87	1275810	1042963	81.75	564.0	2.4
88	827469	540244	65.29	288.0	1.3
89	1127176	918241	81.46	497.0	2.2

Impact of removing clone hits (±5 BCO full)

- original data
- no clone hits
- only clone hits

FPGA ID

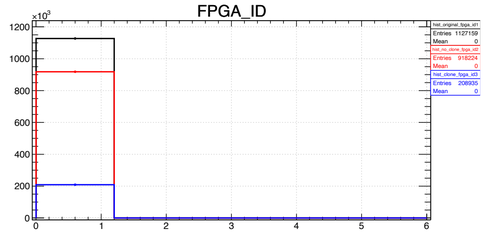
FEM ID

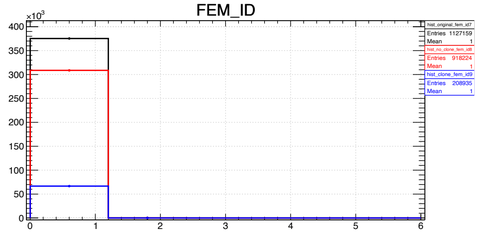
Module

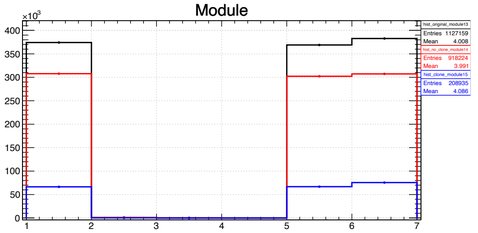
Chip ID

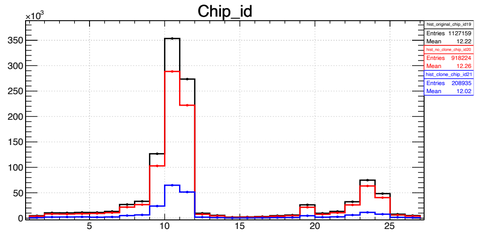
Channel ID

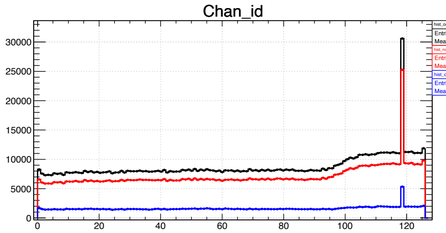
raw



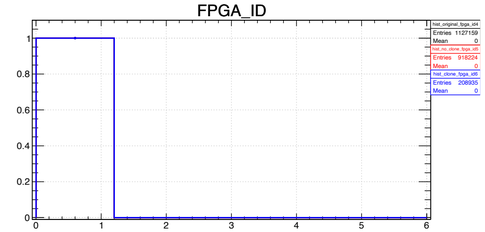


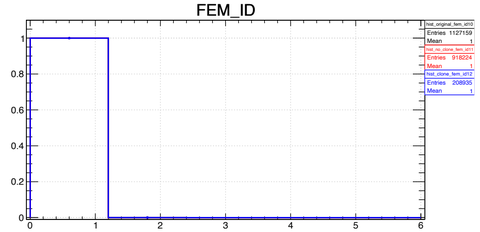


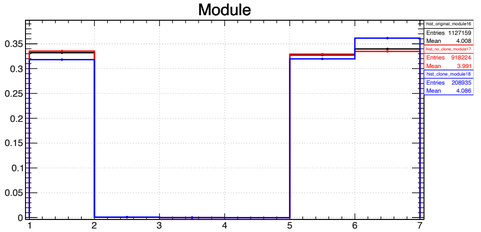


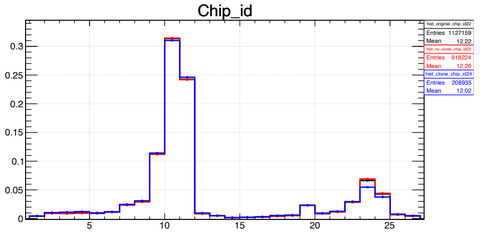


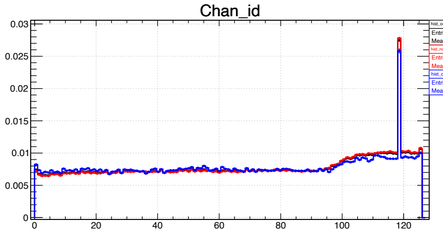
normalized









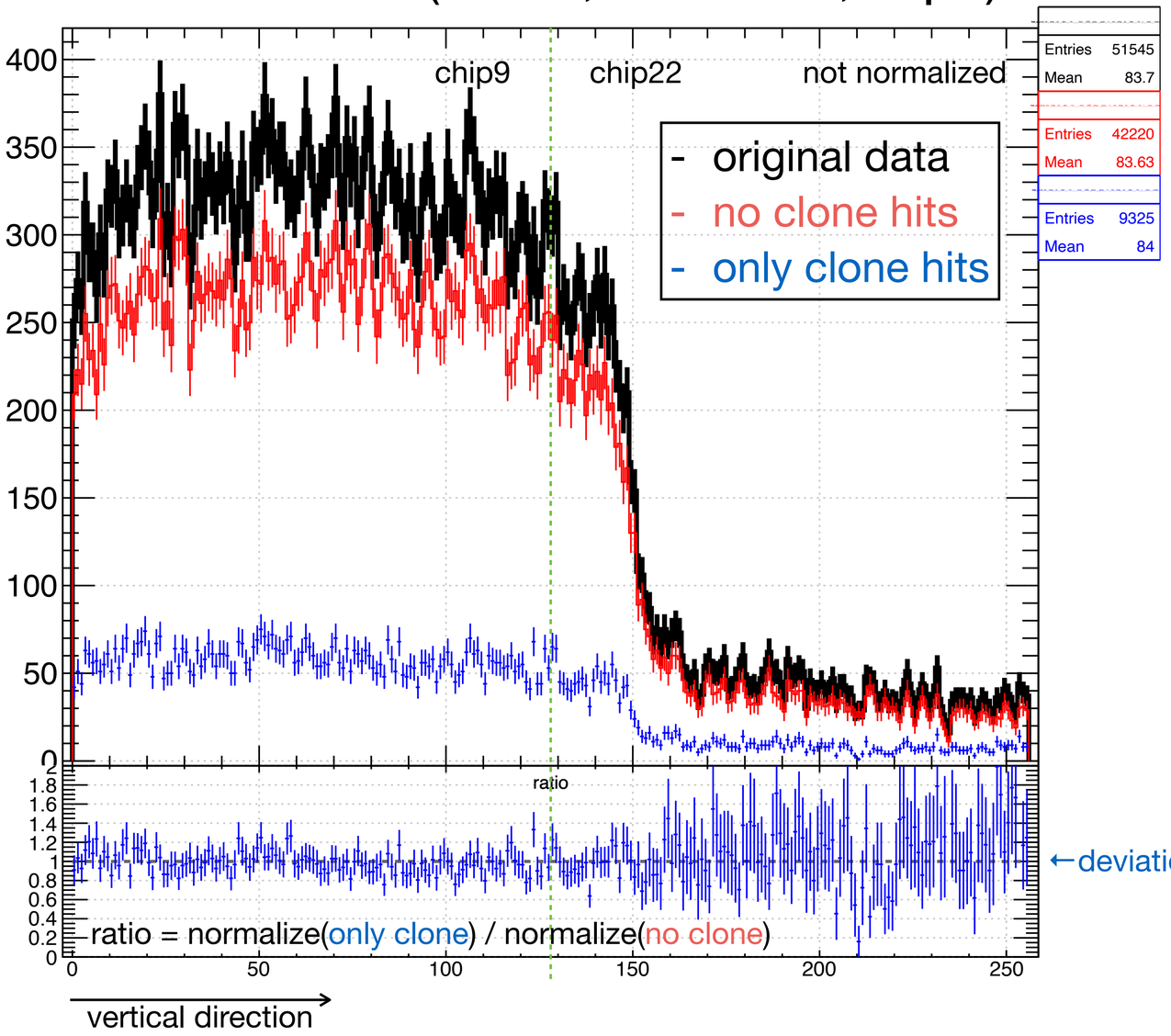


run89

cut: ampl==0

Impact of removing clone hits (±5 BCO full)

Channel dist (run89, module 1,chip9)



←deviation from 1 means distortion introduced by the removal

run89,

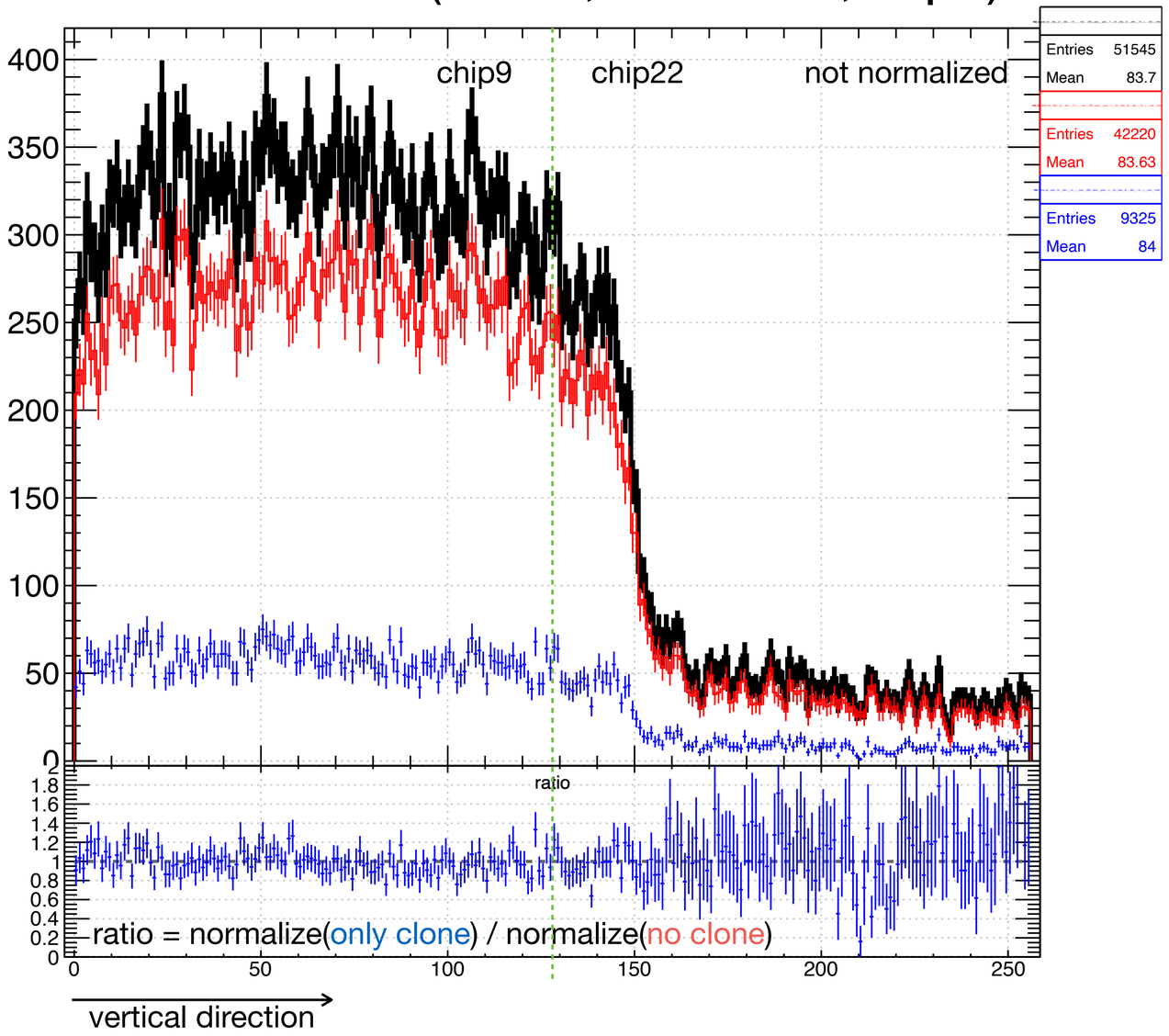
draw expression: $255 \times \mathrm{int}\left(\frac{\mathrm{chip\_id}}{14}\right) - 1^{\mathrm{int}\left(\frac{\mathrm{chip\_id}}{14}\right)} \times \mathrm{chan\_id}$

cut: ampl==0

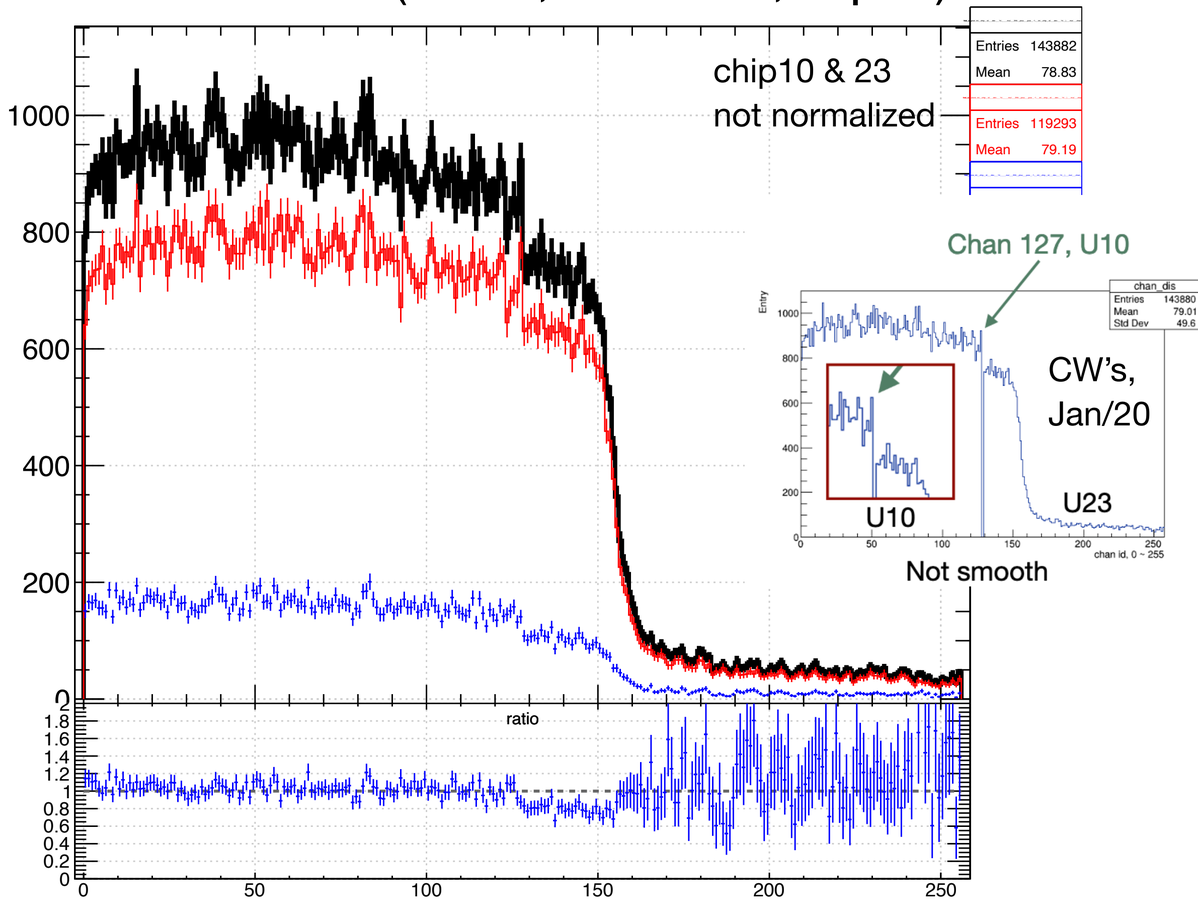
Impact of removing clone hits (±5 BCO full)

- original data
- no clone hits
- only clone hits

Channel dist (run89, module 1,chip9)



Channel dist (run89, module 1,chip10)

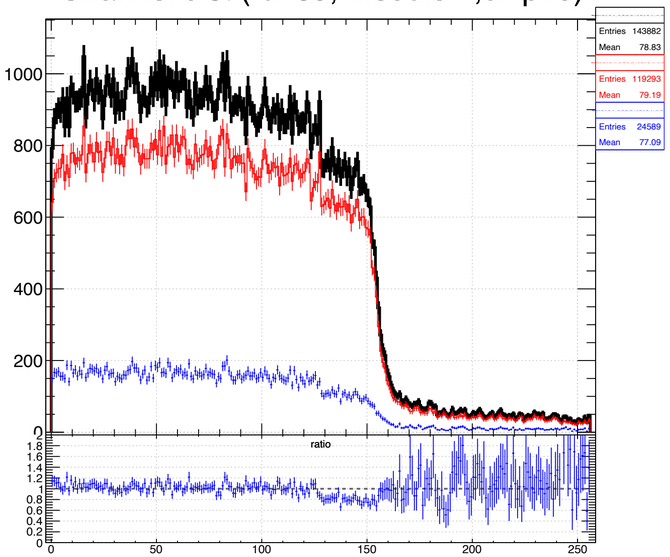


run89,
draw expression: $255 \times \mathrm{int}\left(\frac{\mathrm{chip\_id}}{14}\right) - 1^{\mathrm{int}\left(\frac{\mathrm{chip\_id}}{14}\right)} \times \mathrm{chan\_id}$
cut: ampl==0

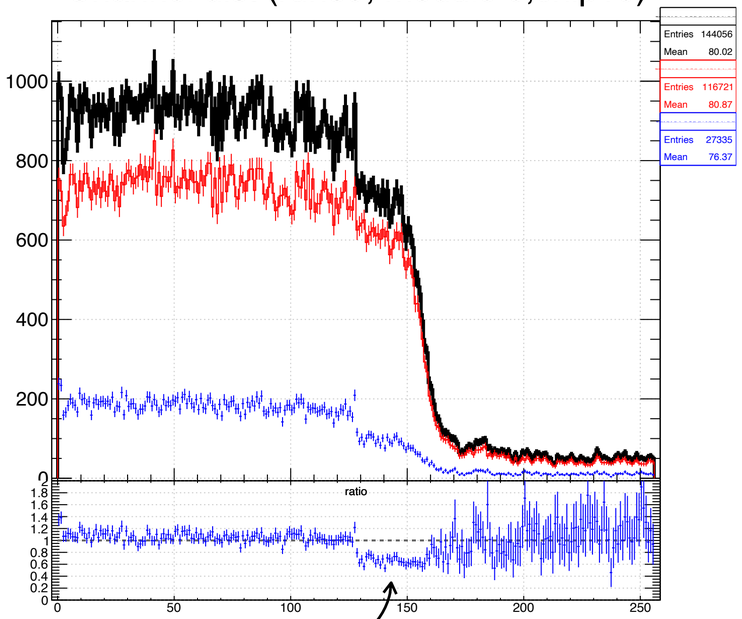
Impact of removing clone hits (±5 BCO full)

- original data
- no clone hits
- only clone hits

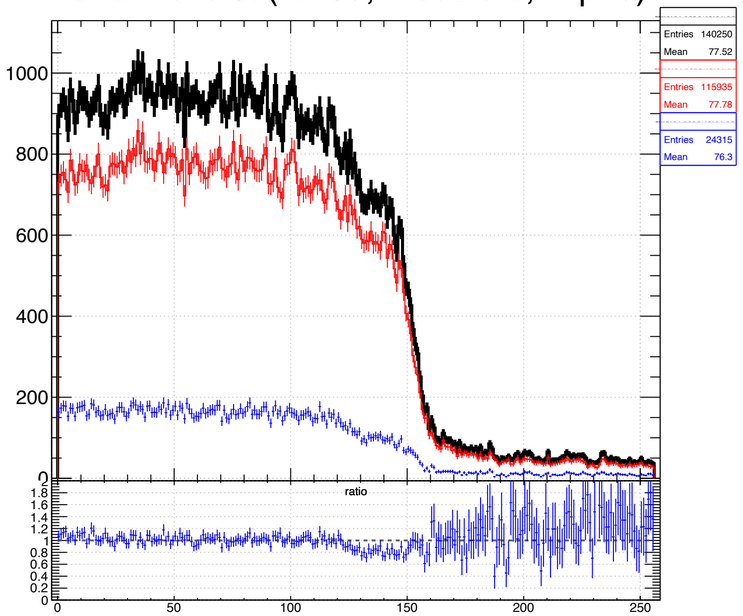
Channel dist (run89, module 1,chip10)



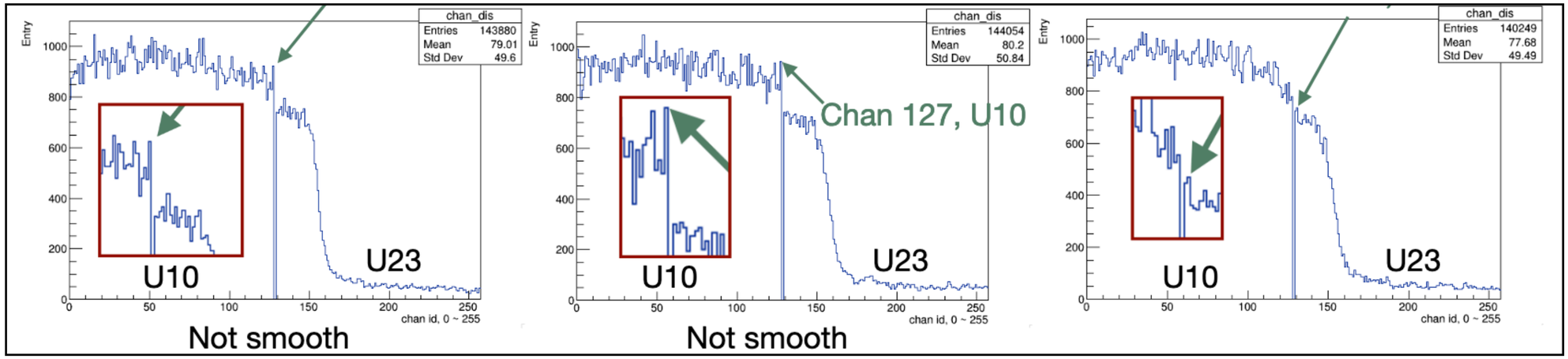
Channel dist (run89, module 6,chip10)



Channel dist (run89, module 5,chip10)



different shape of the distribution



CW's, Jan/20

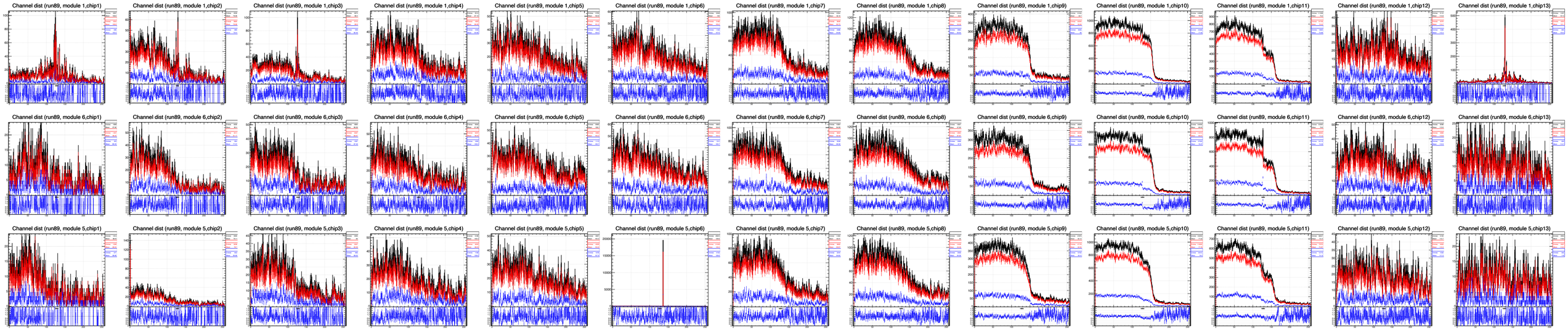
run89

Impact of removing clone hits (±5 BCO full)

- original data
- no clone hits
- only clone hits

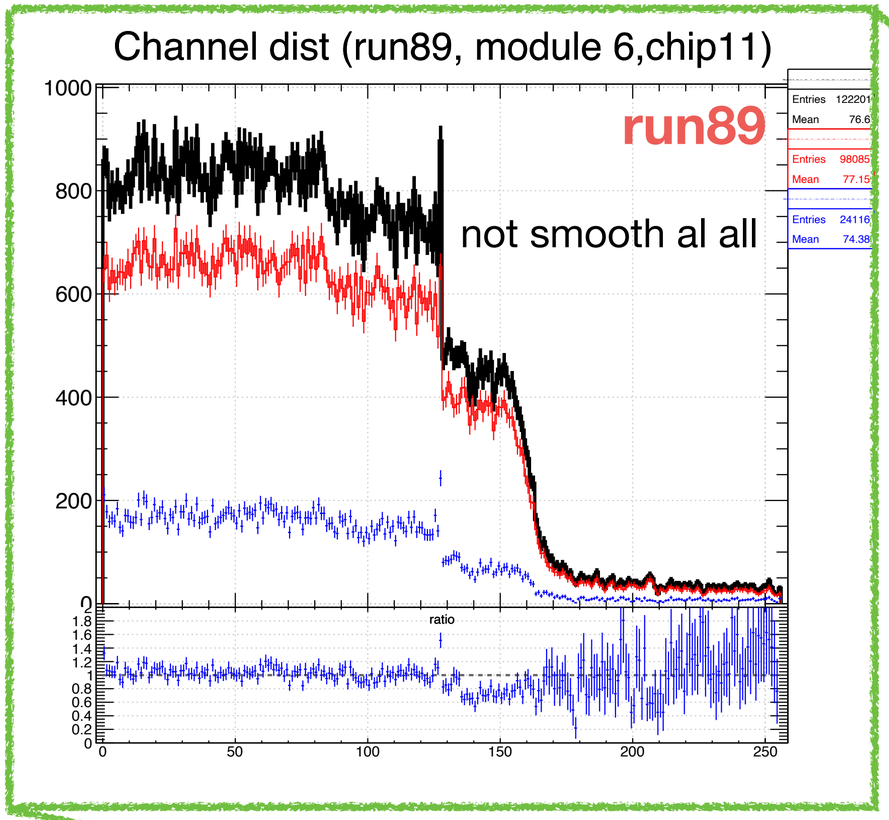
beam

run89

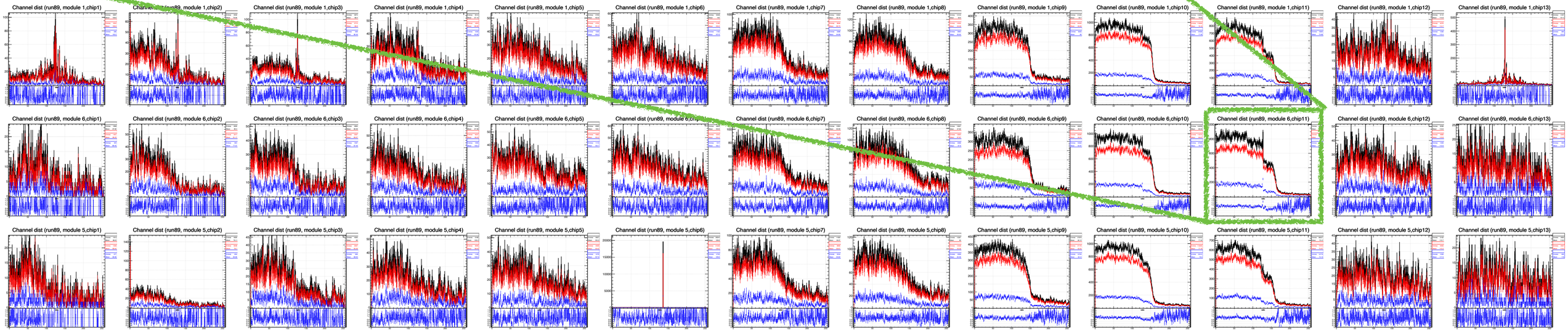


Impact of removing clone hits (±5 BCO full)

- original data
- no clone hits
- only clone hits

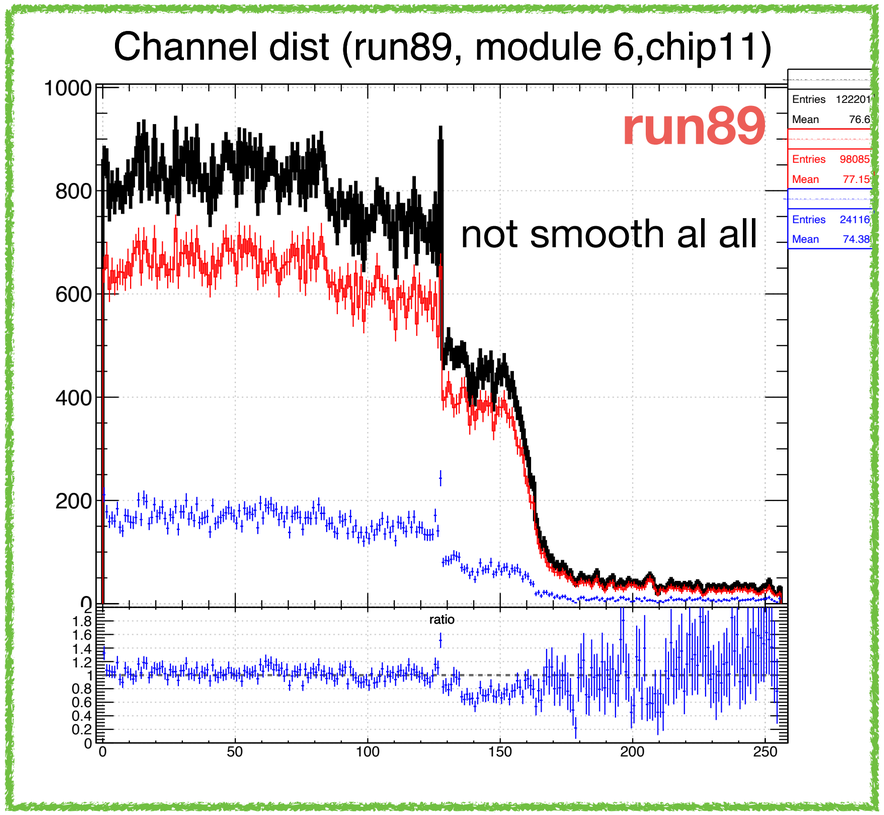


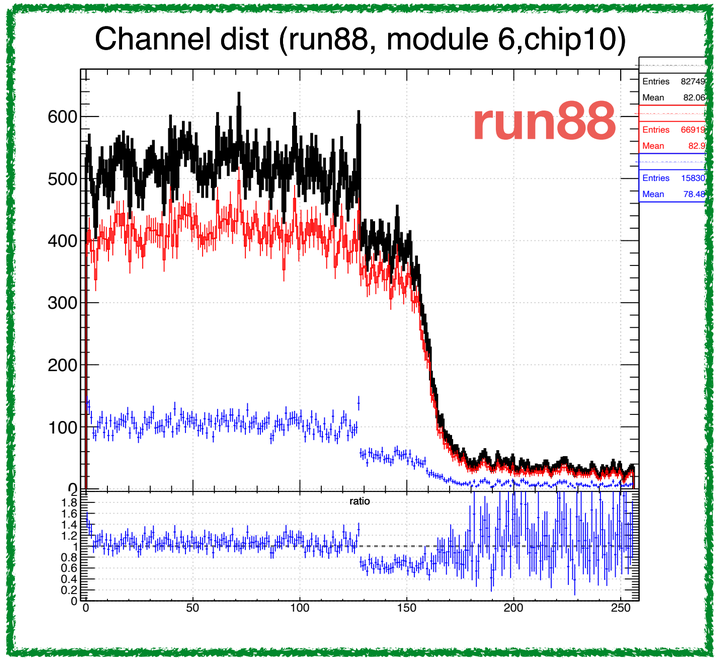
beam



Impact of removing clone hits (±5 BCO full)

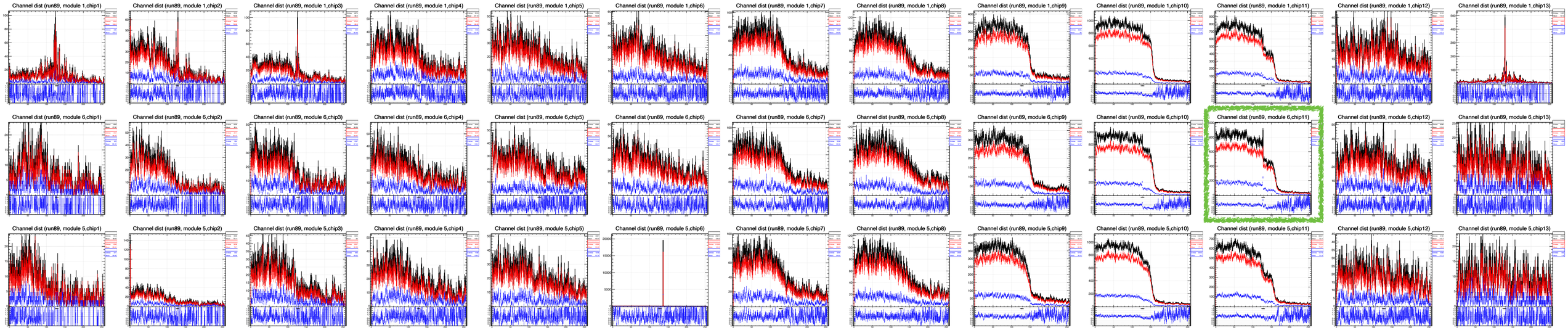
- original data
- no clone hits
- only clone hits





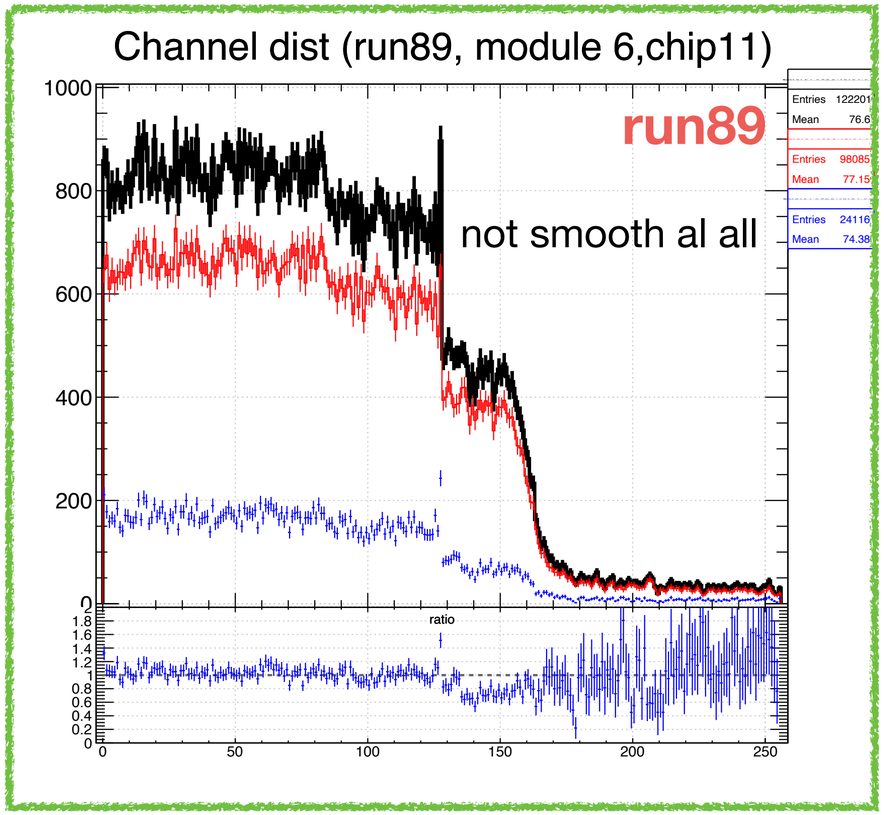
the same chip of the same module in a run before

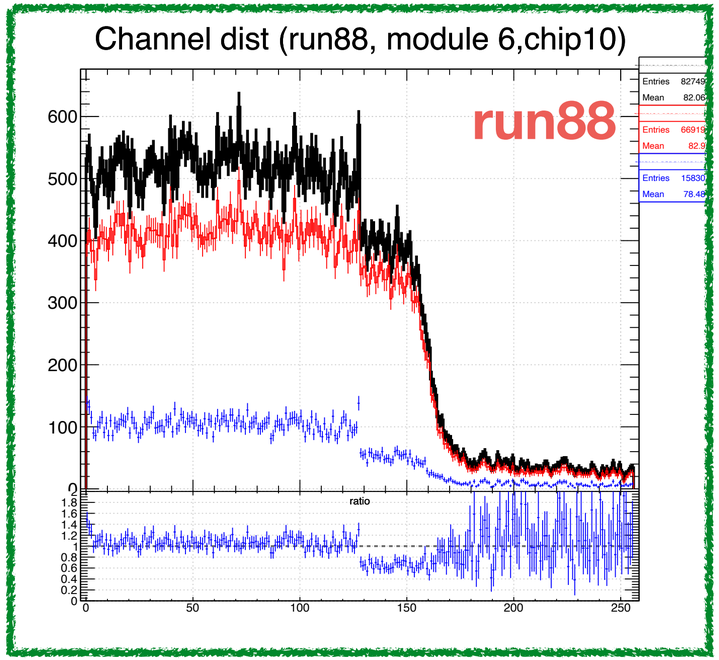
beam

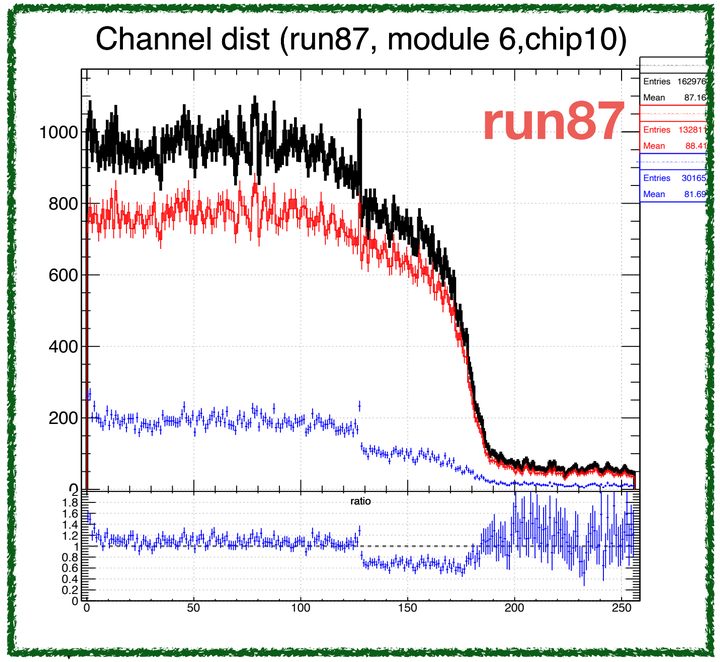


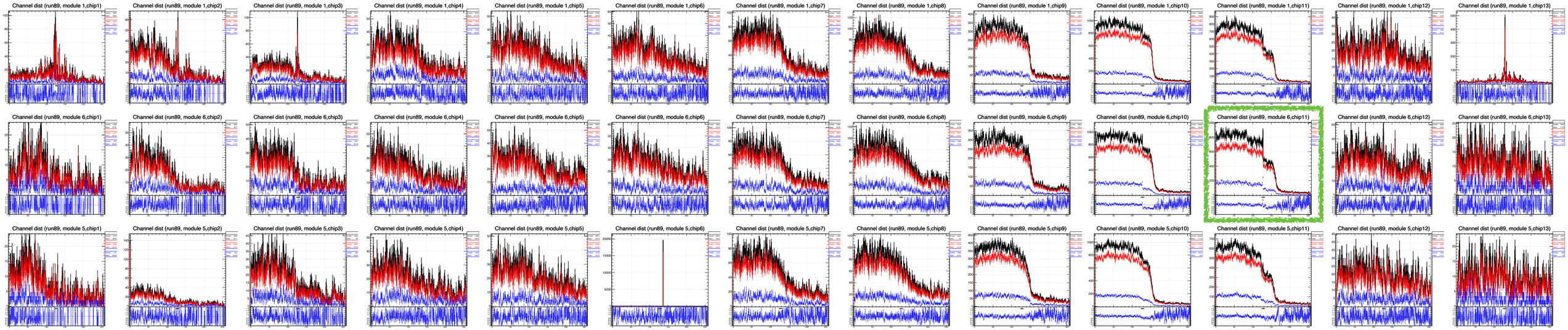
Impact of removing clone hits (±5 BCO full)

- original data
- no clone hits
- only clone hits



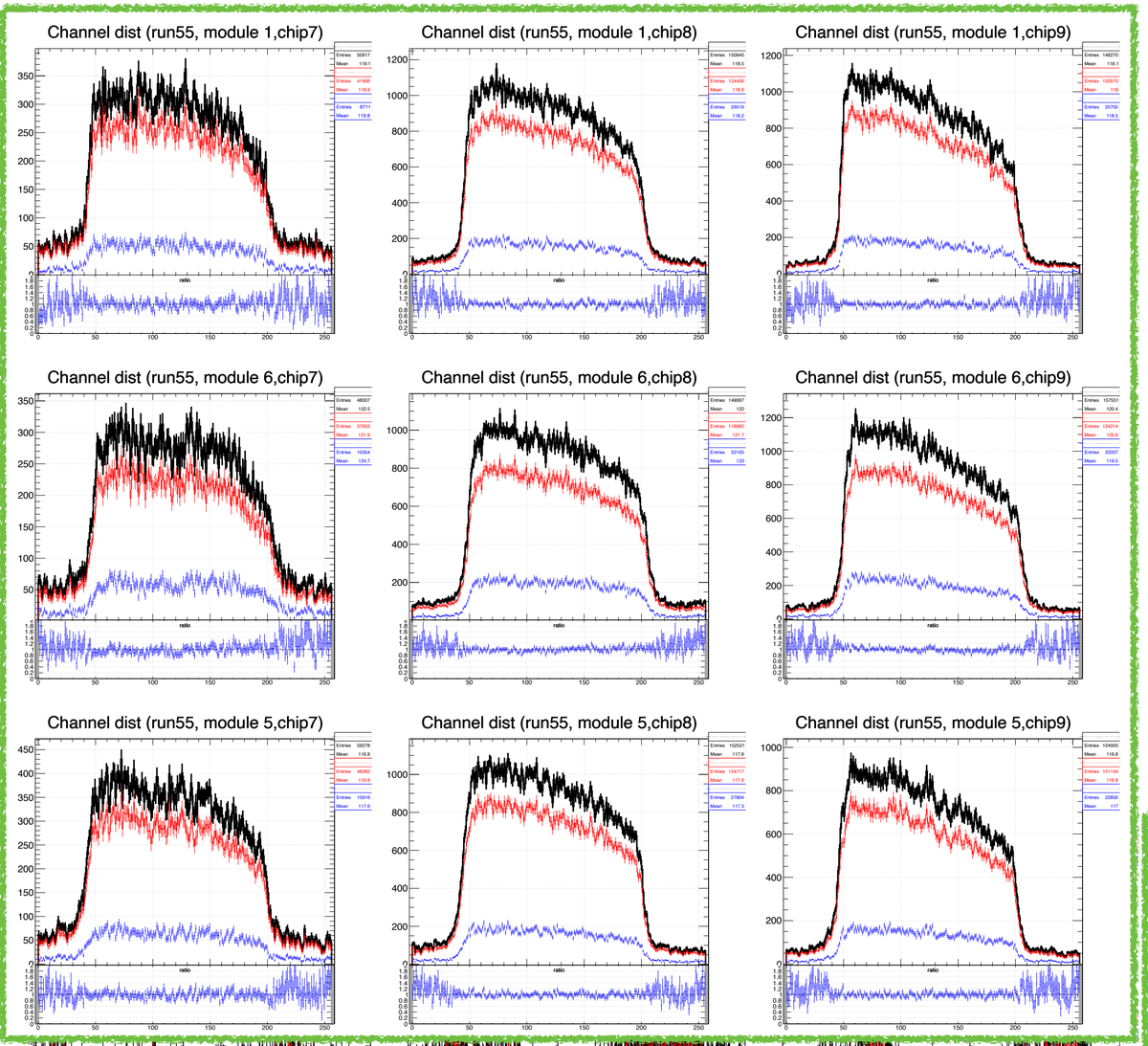


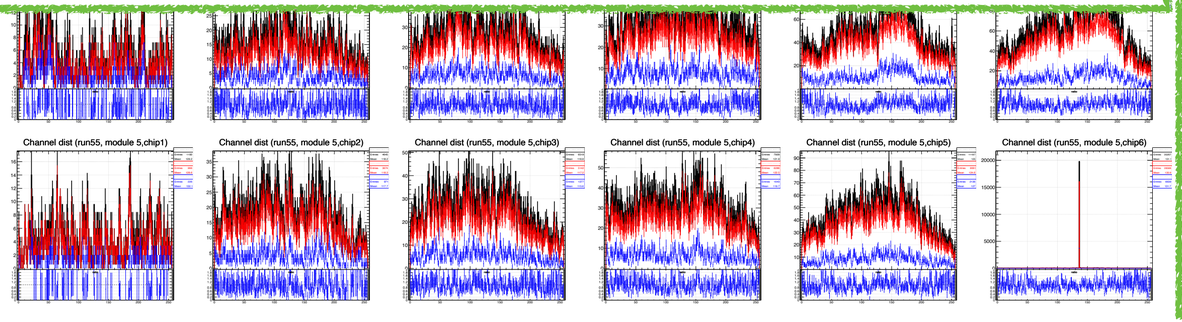




Impact of removing clone hits (±5 BCO full)

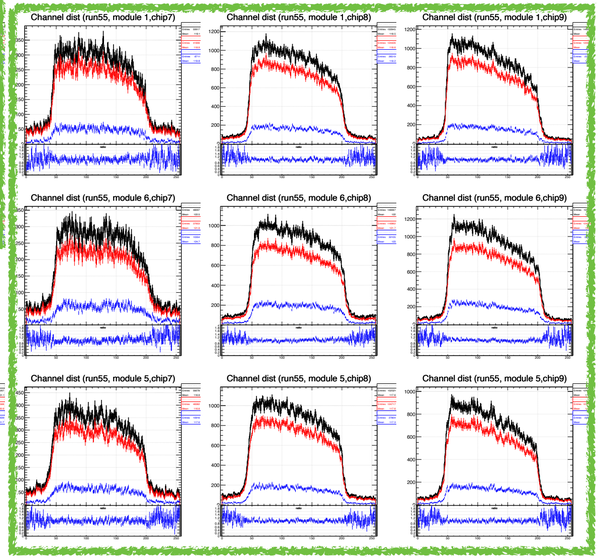
- original data
- no clone hits
- only clone hits

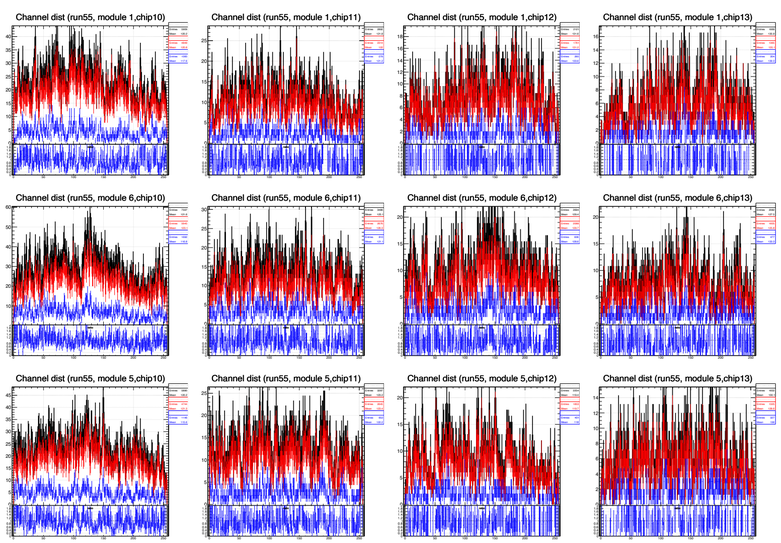




beam

run55





Conclusion

About 40% of all hits have the same parameters as the other hit.
Removal of the clone hits sometimes changes the shape of the channel distribution.
Even removing them, the channel distribution is not smooth at the chip boundary in some cases. → More investigation is needed.