

# ProtoDUNE bad channels

## DUNE Single-phase TPC Electronics Consortium

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BNL

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# Introduction

Bad channel study shown last week has been extended

- Now covers the full protoDUNE running period 2018-2020
- Includes pulser runs so we can distinguish before and after amplifier
- Try to get 1 run/week during beam and 1/moth thereafter
- Bad channels are identified and categorized

# Survey

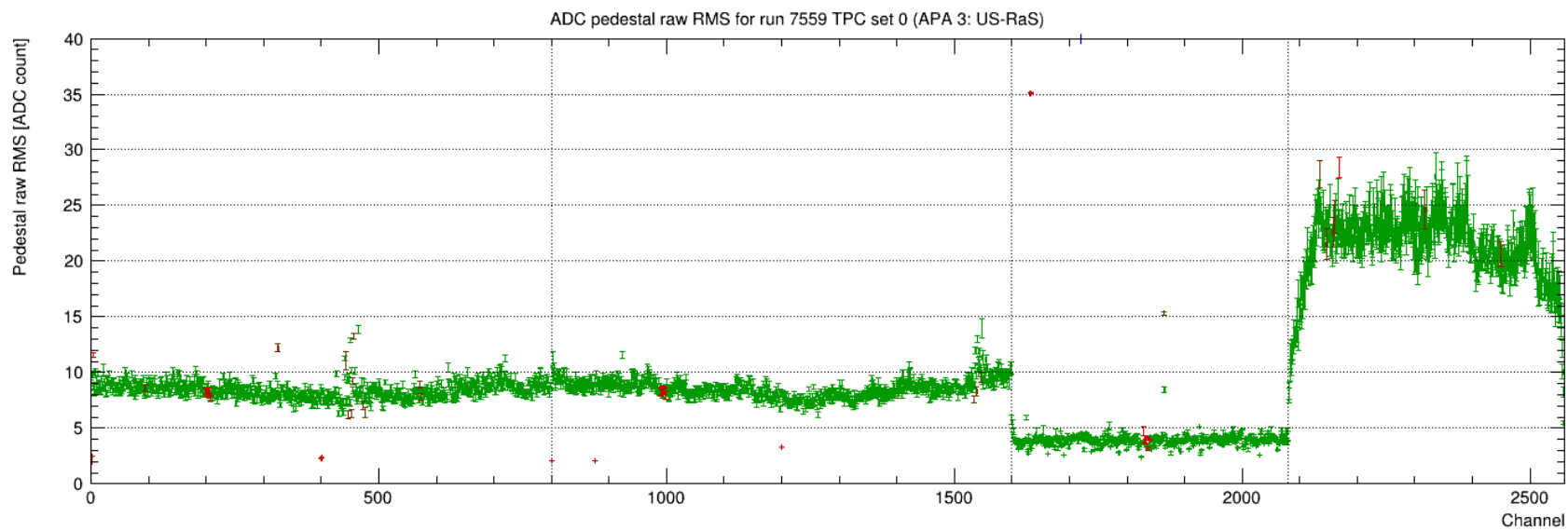
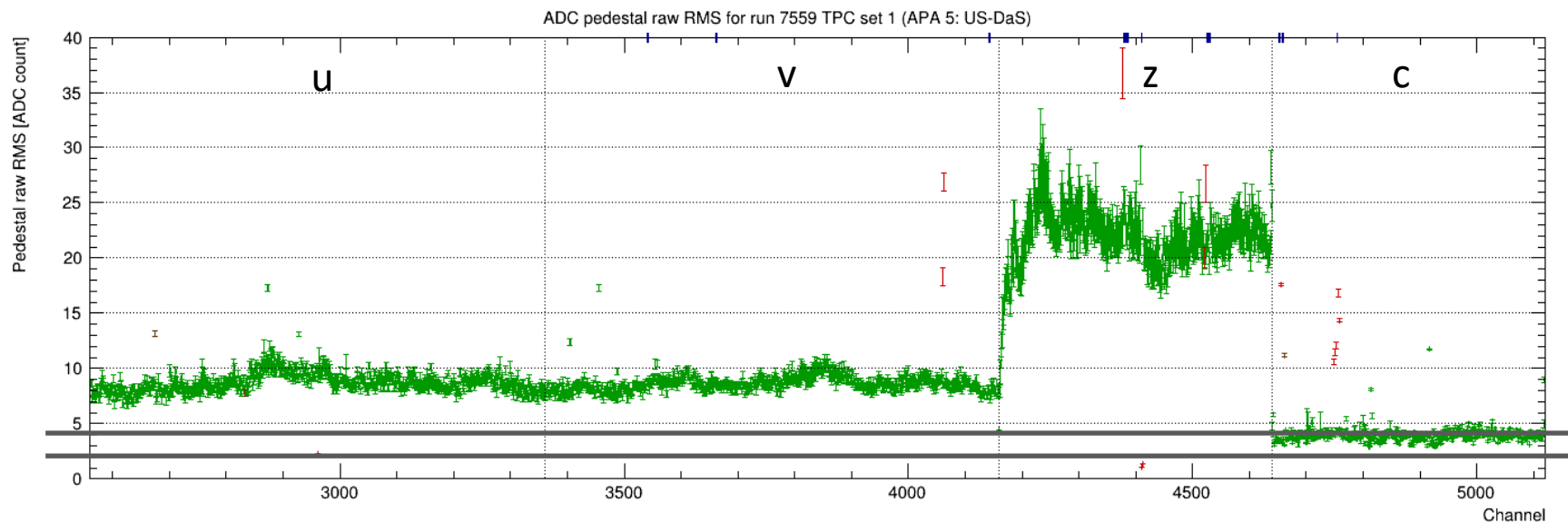
Survey done using runs from Sep 2018 to Jul 2020

- Search for "good runs"
  - HV on, purity high, all FEMBs read out, Most WIBs working
  - Had to compromise on the latter in a few cases
- For each channel and run, evaluate RMS with 100 events
  - After mitigation and tail removal are performed
  - See configuration on following slide
- Search for low RMS values as symptom of bad channel
  - Low is below threshold of 4 ADC counts for normal cosmic signals
  - Threshold is decreased to 2 ADC counts for cryostat-side wires
- Results plotted separately for each APA plane
  - All RMS values for any channel with low RMS for any run
  - Green bands show limits for the central 90% channels in the plane
- Code is in github:  
<https://github.com/dladams/pdbadchan>

# Dataprep configuration used here

```
services.RawDigitPrepService.AdcChannelToolNames: [  
    "digitReader",  
    "pdsp_sticky_codes_ped",           Flag sticky codes  
    "pd_adcPedestalFit",             Find pedestal  
    "adcSampleFiller",              Subtract pedestal; no calibration  
    "pdsp_adcMitigate",             Mitigate sticky code  
    "pdsp_timingMitigate",  
    "adcCorrectUndershootAdc",      Remove tails (old algorithm)  
    "pdmtps_adcChannelPedestalRawRmsPlotter"  Make RMS plots →  
]
```

# Example RMS vs channel plots

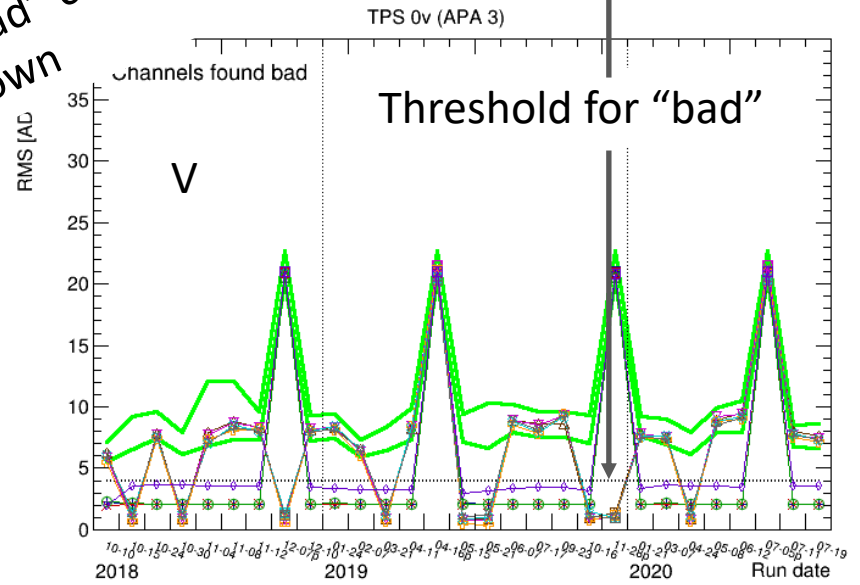
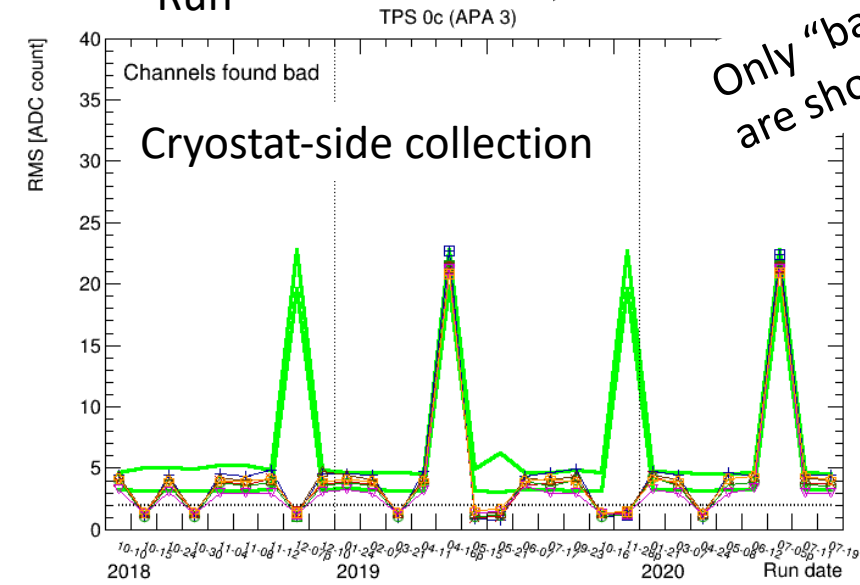
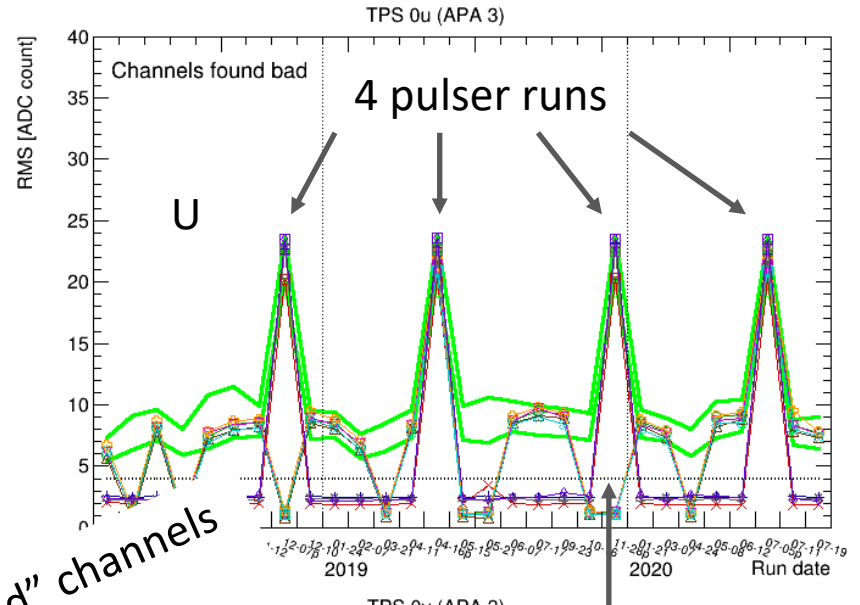
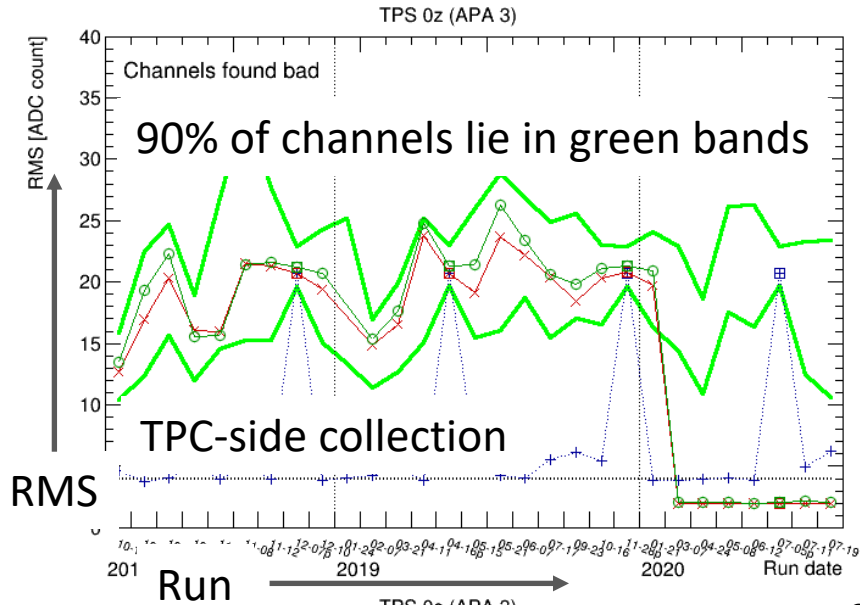


# Runs used in survey here

```
5141    beam 10-10
5308    beam 10-15
5461    cosmic 10-24
5700    cosmic 10-30
5777    cosmic 11-04
5810    beam 11-08
5844    beam 11-12    # Last beam run
6068    pulser 12-07p  # Pulser
6118    cosmic 12-10   # End of 2018
##### 2019 #####
6535    cosmic 01-24   # Missing FEMBs
6700    cosmic 02-07
7277    cosmic 03-21   # Missing FEMBs
7559    cosmic 04-11
7604    pulser 04-16p
7912    cosmic 05-15   # Missing FEMBs
7936    cosmic 05-21
8193    cosmic 06-07
8902    cosmic 07-17   # Just before LAr contamination
9701    cosmic 09-23   # Purity recovered
9852    cosmic 10-16
10489   pulser 11-28p
##### 2020 #####
10778   cosmic 01-21
11036   cosmic 03-07   # Missing FEMBs
11142   cosmic 04-24
11204   cosmic 05-08
11526   pulser 07-05p  # DAC=1
11653   cosmic 07-11   # 160 V/cm
11775   cosmic 07-19   # 160 V/cm
```

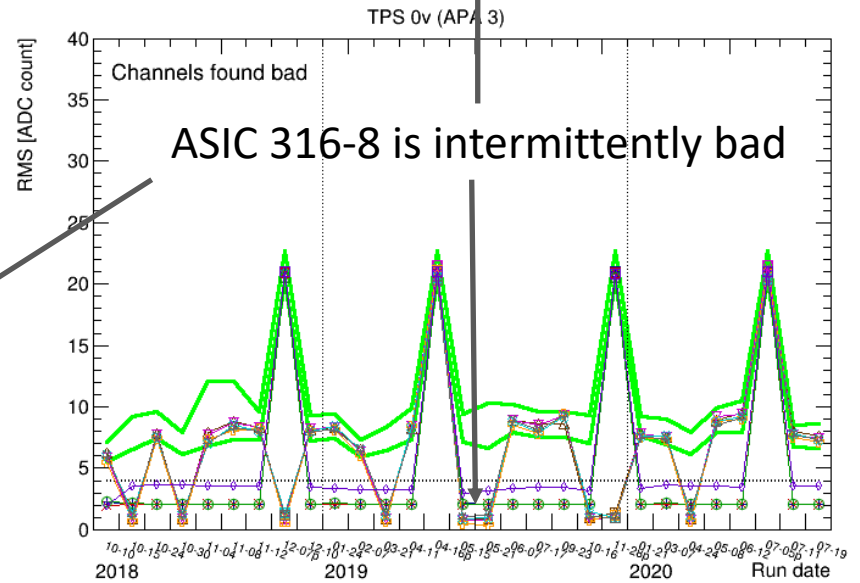
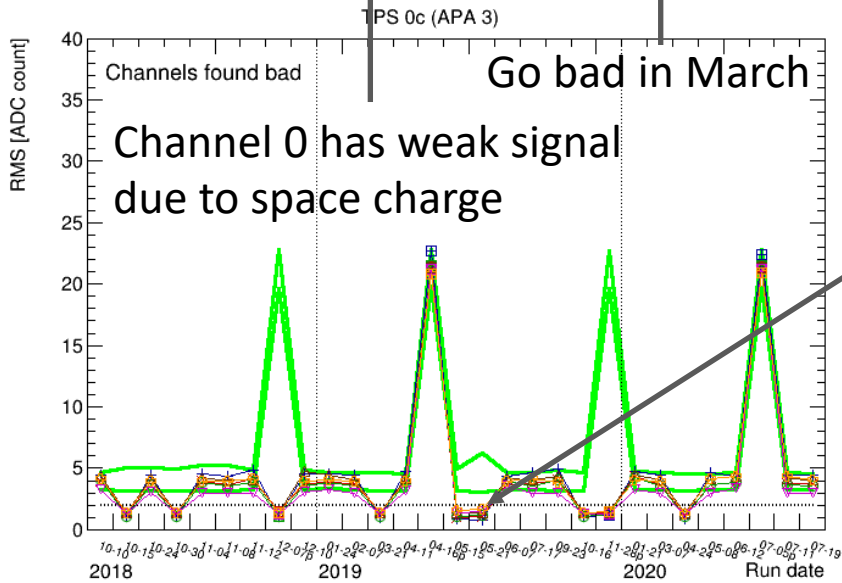
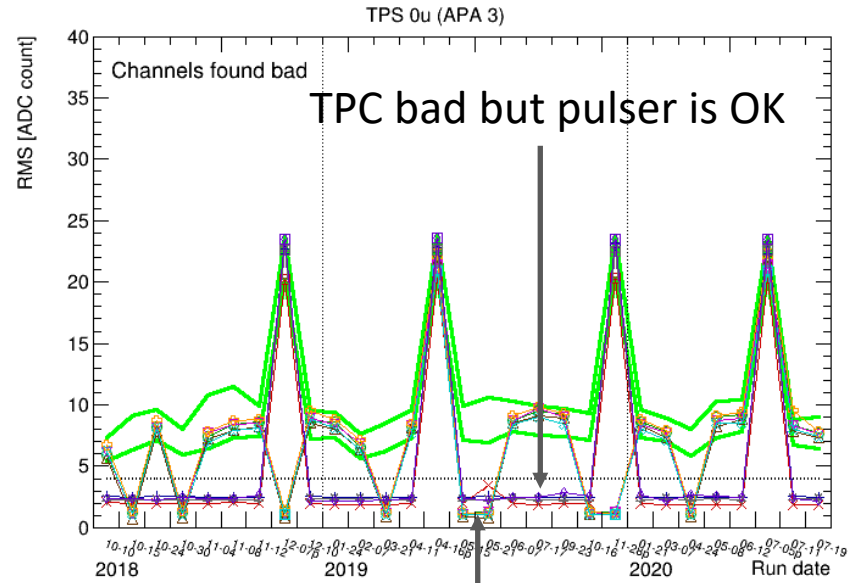
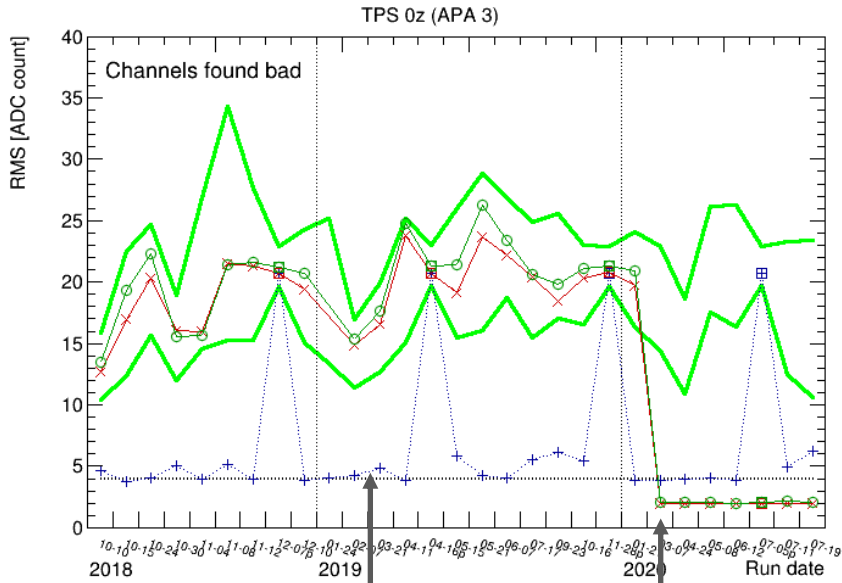
# Survey summary plots

# APA 3

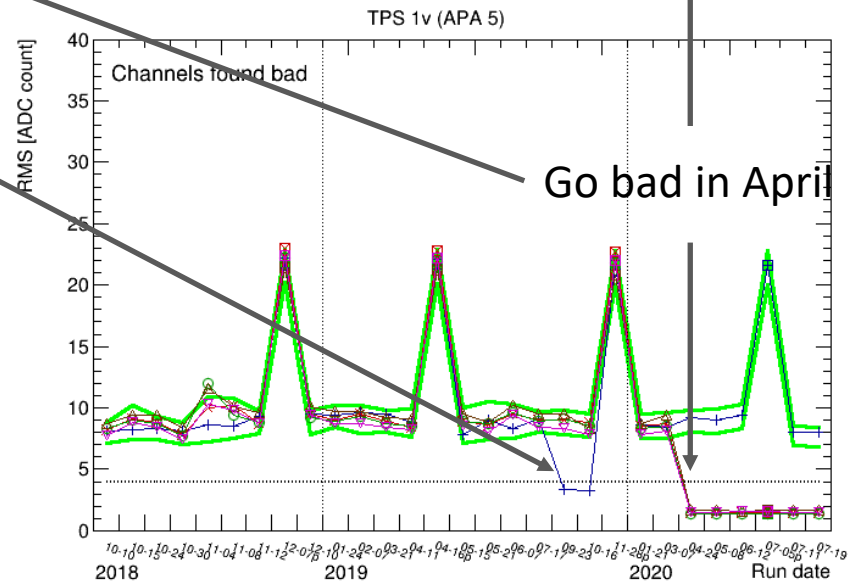
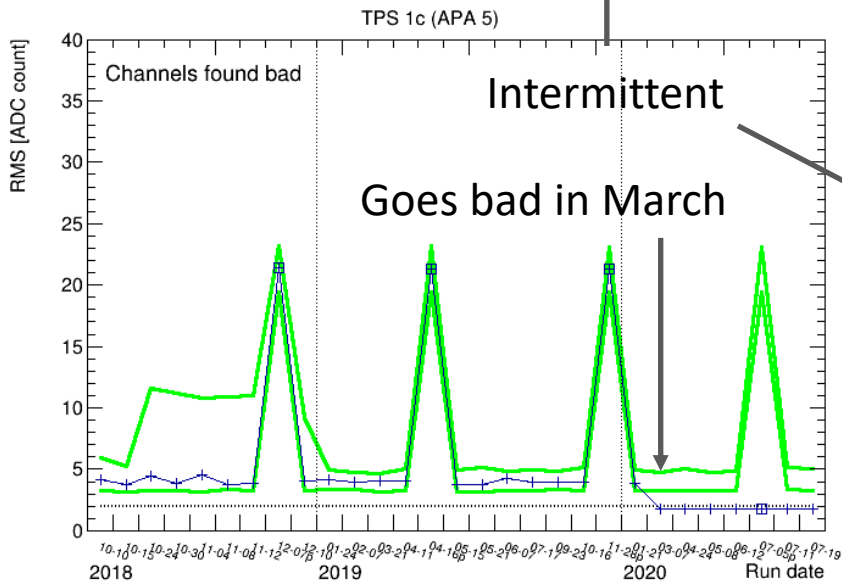
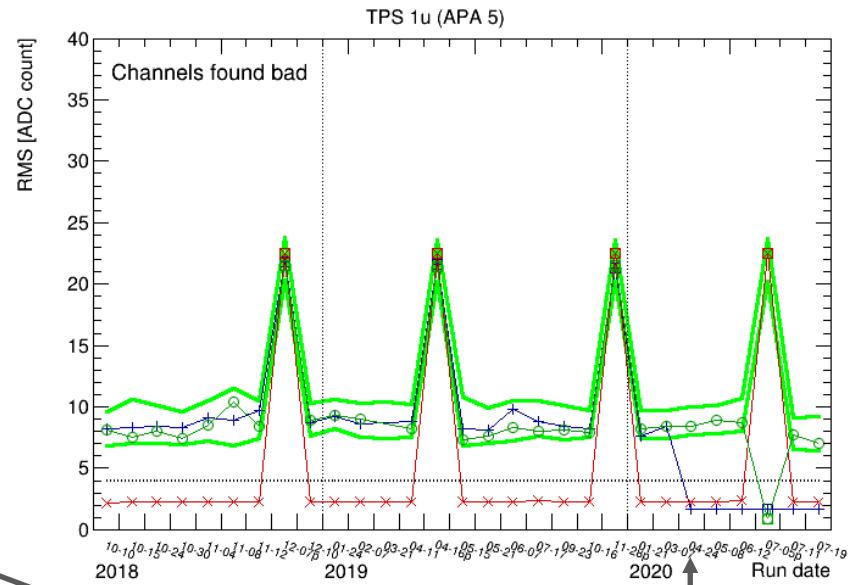
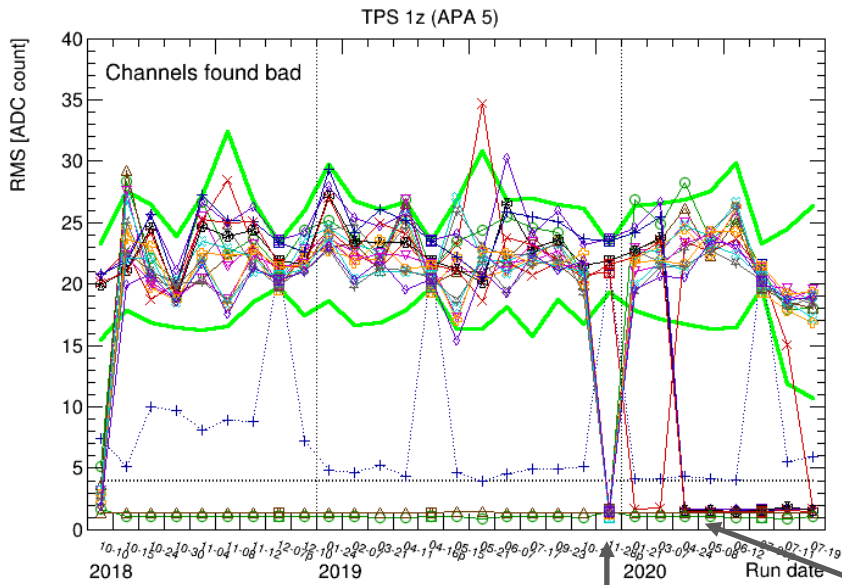




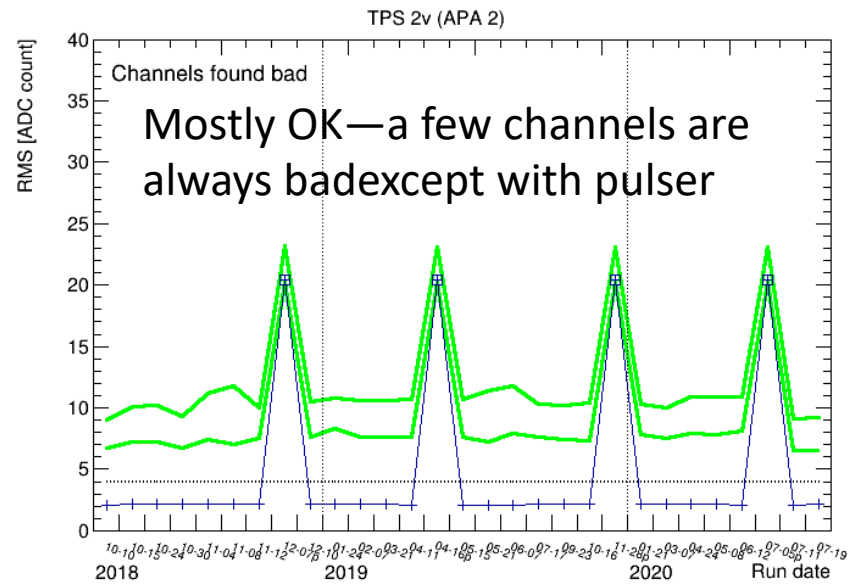
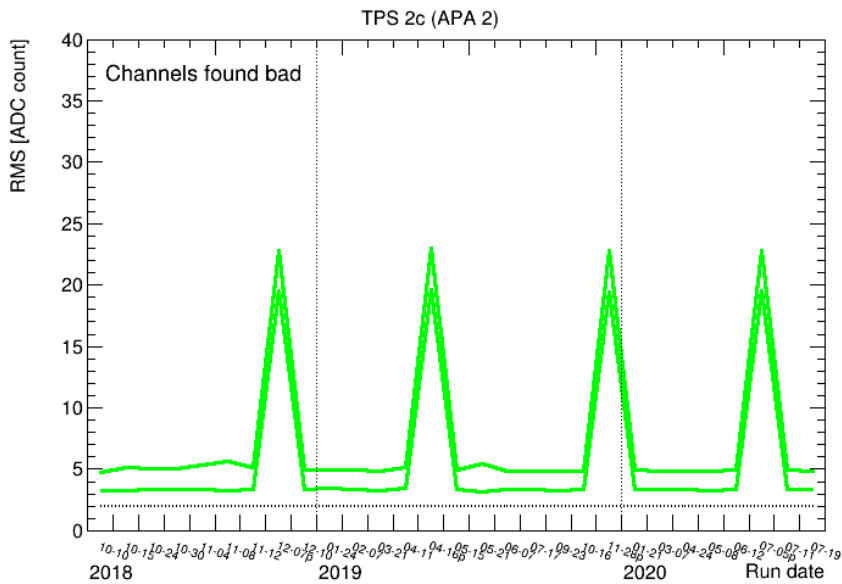
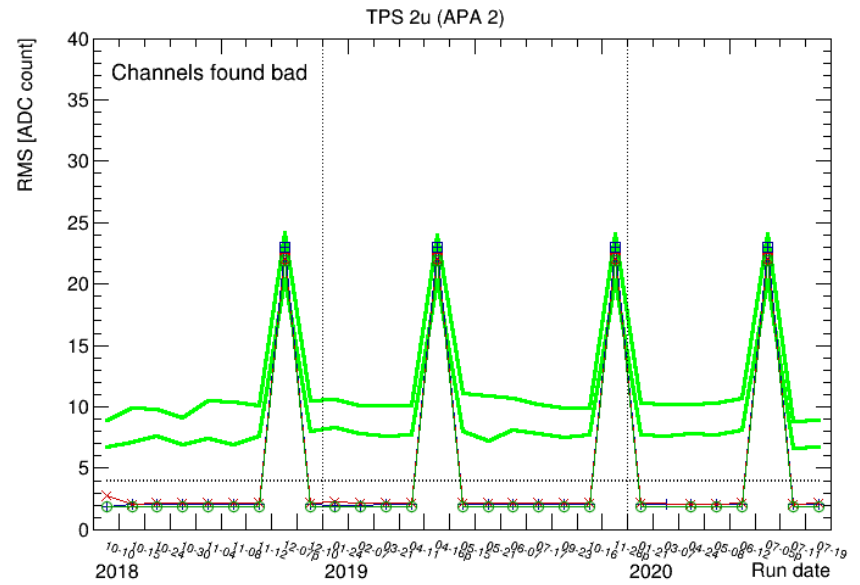
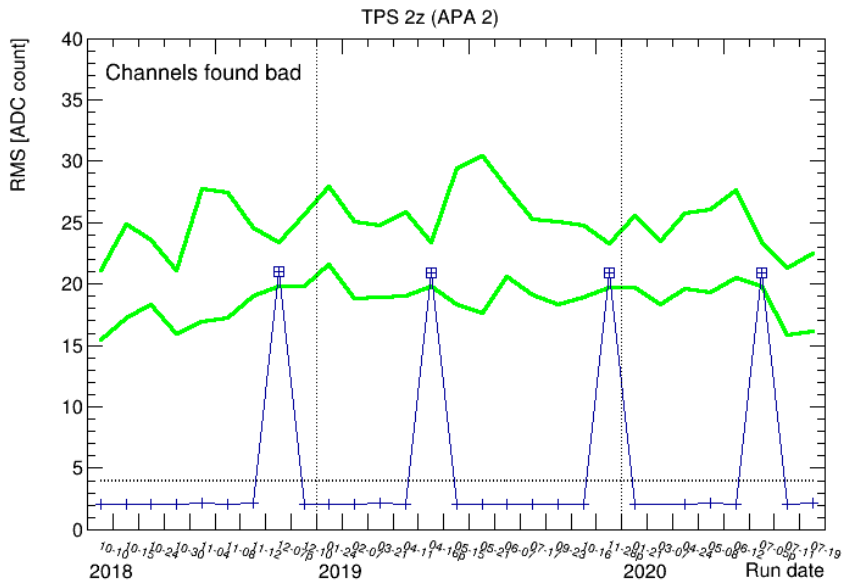
# APA 3 (again)



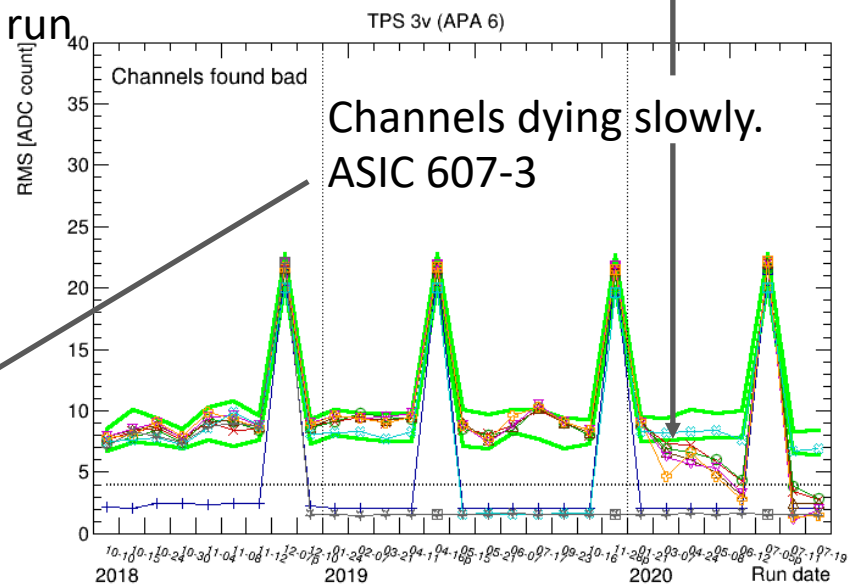
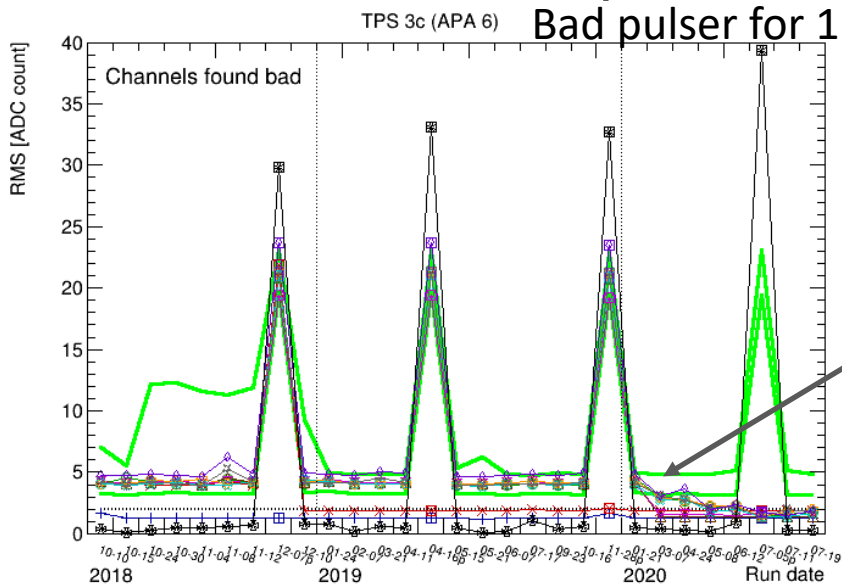
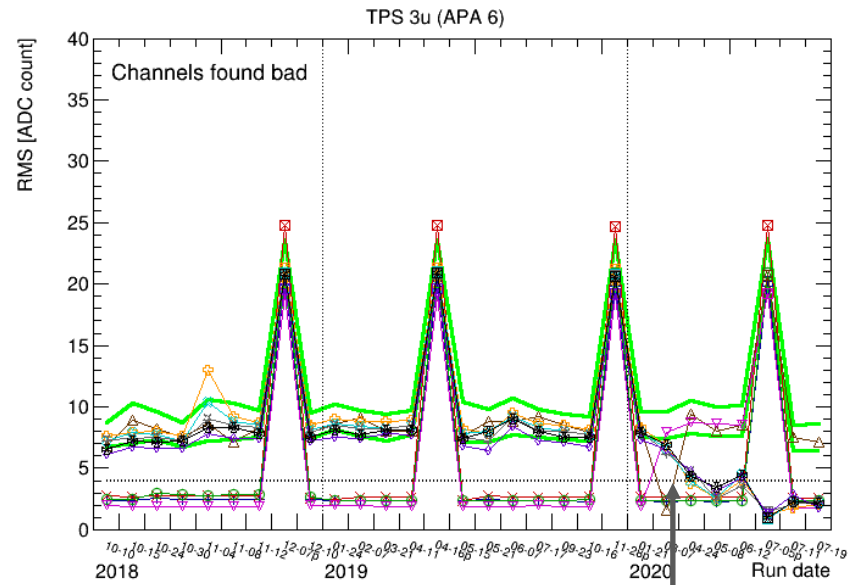
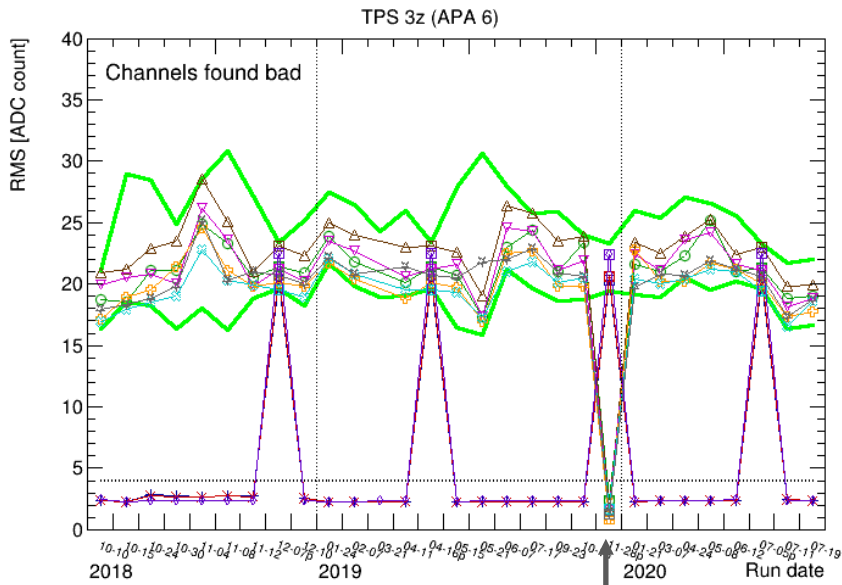
# APA 5



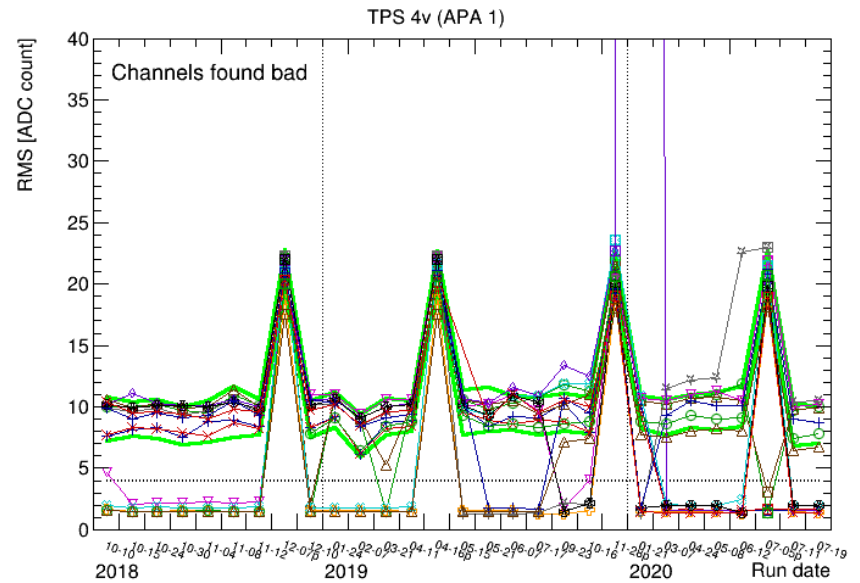
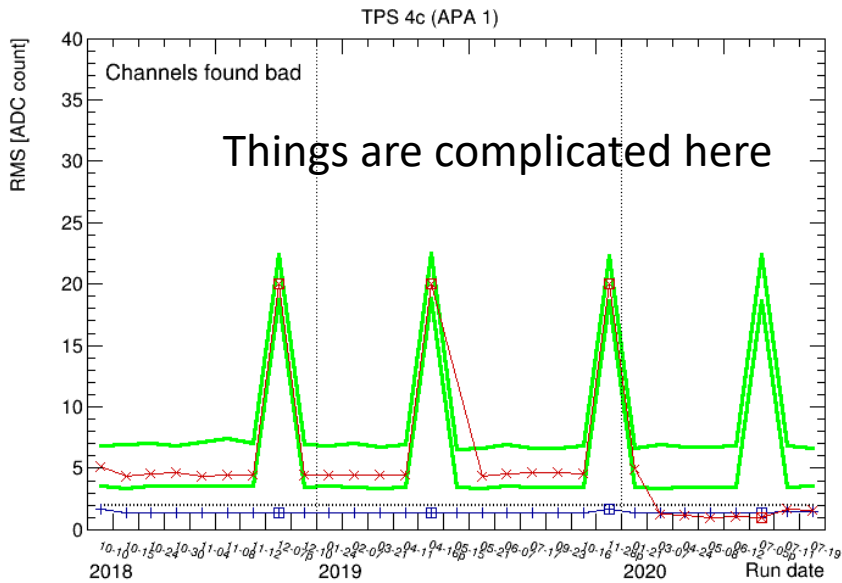
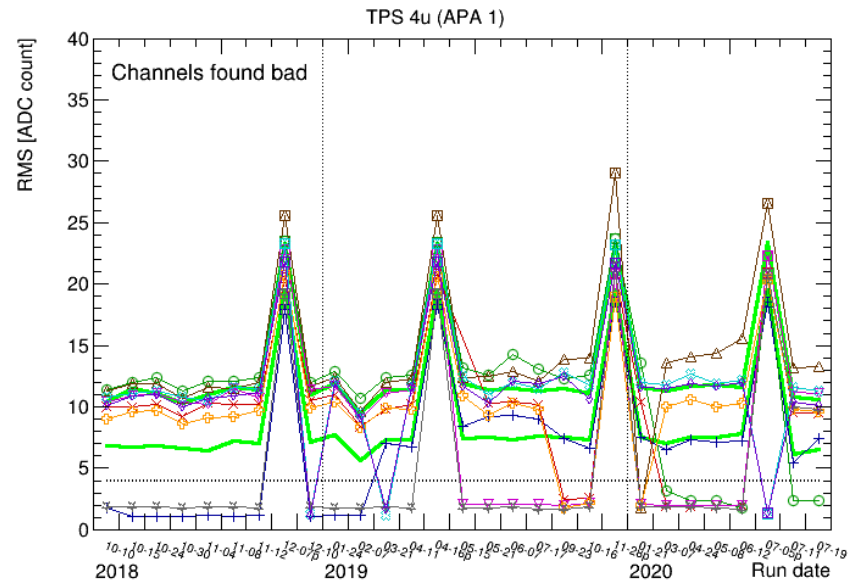
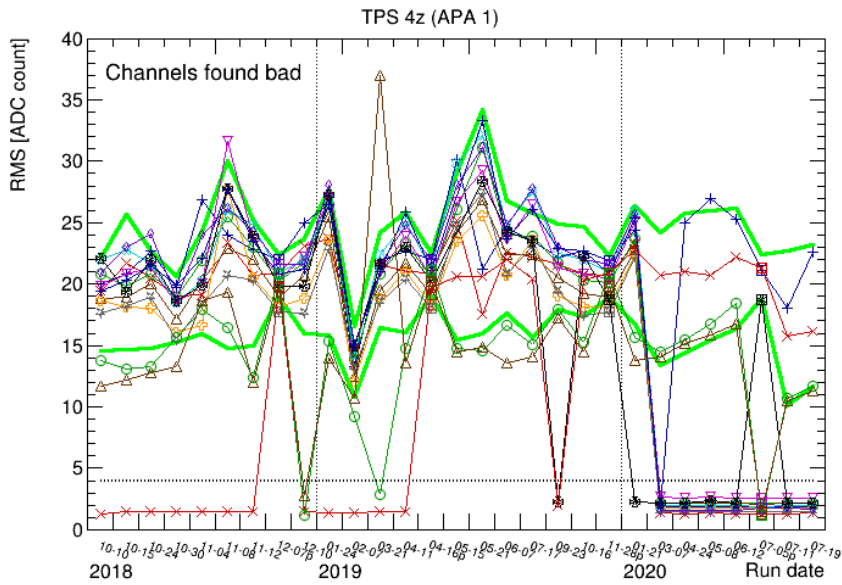
# APA 2



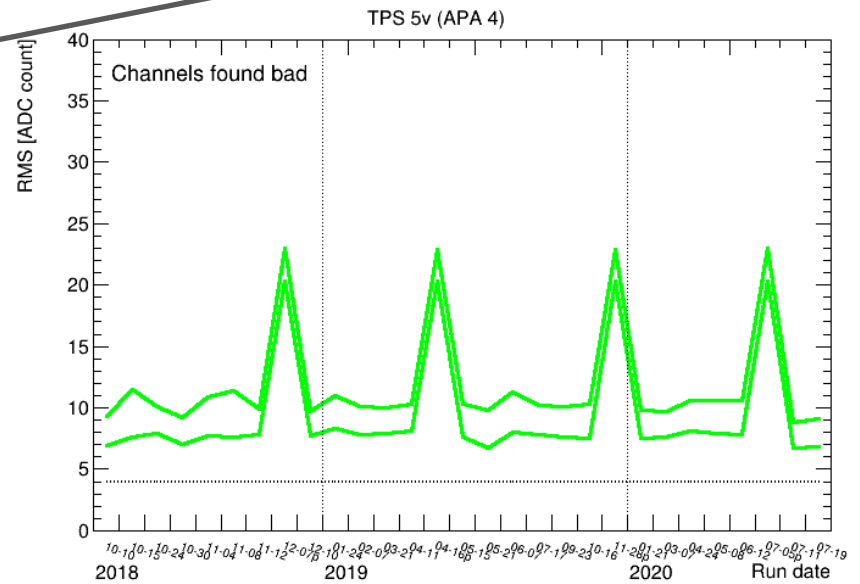
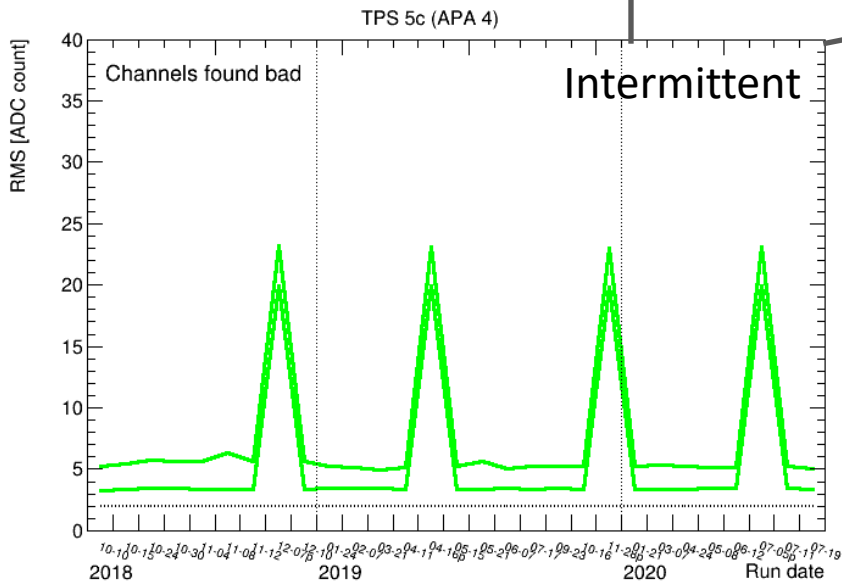
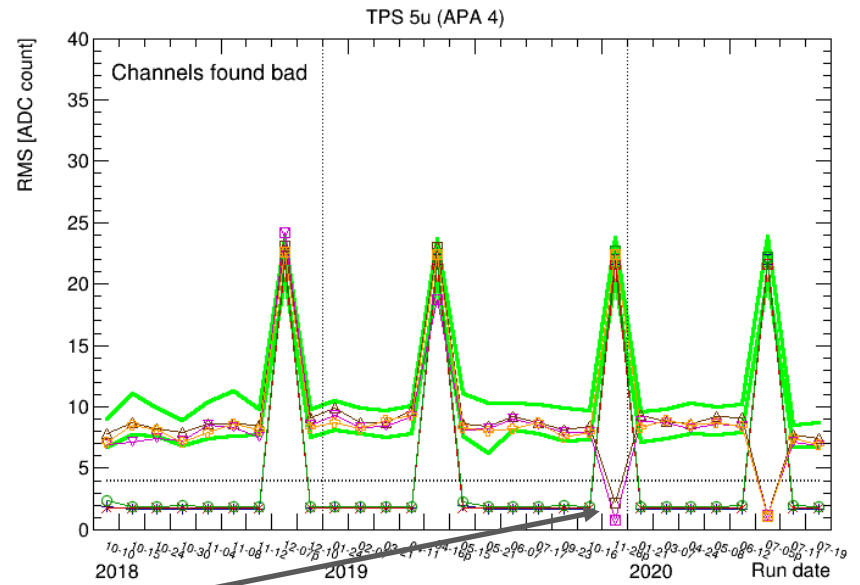
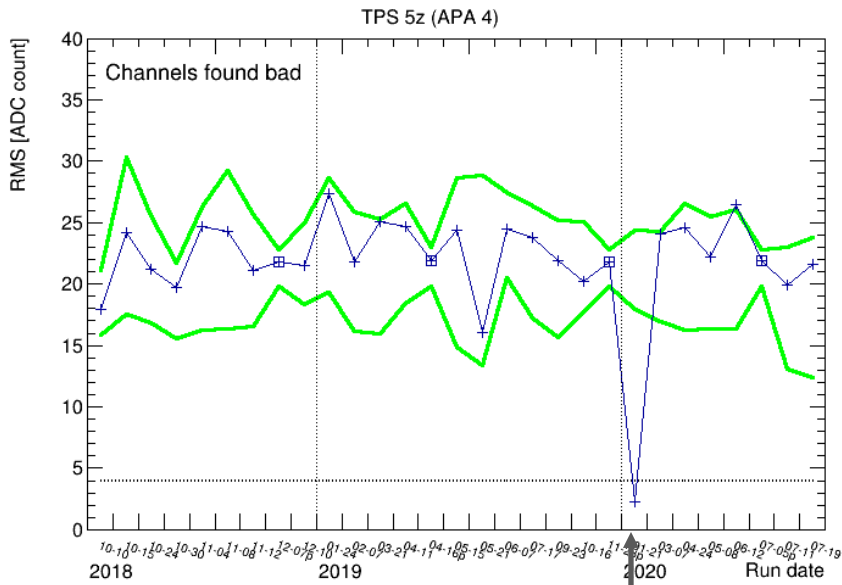
# APA 6



# APA 1



# APA 4



# Categorizing

Table summarizes results by category

- I assigned these by hand using preceding plots and following tables
- Channel with bad waveforms and too-high RMS are *not* included
  - These are mostly due to sticky codes

0	Good:	2	
1	All bad:	4	
2	All bad except pulser:	26	30 always bad
3	Intermittent bad ASIC:	16	
4	Intermittent bad channel:	37	53 intermittent
5	Intermittent bad pulser:	<del>11</del>	(OK except for pulser)
6	Bad after Dec 2018:	2	
7	Bad after Sep 2019:	1	
8	Bad after Jan 2020:	2	47 fail during run
9	Bad after Mar 2020:	33	
10	Bad after Apr 2020:	9	

130 total failures (0.8%)

# Channel results

Following slides give summary for each channel

- One page per APA
- One line per channel
  - Wire plane: offline number, orientation
    - z = TPC side collection
    - c = Cryostat-side collection
  - Offline ID, (wire number), offline ID: AFF-CXX
    - A = APA (1-6)
    - FF = FEMB (1-20)
    - C = ASCIC (1-8)
    - XX = channel on ASIC (0-15)
  - Category
  - Pattern showing result for each run
    - \_ = OK, \* = bad for cosmics or beam
    - - = OK, P = bad for pulser
    - Ordered by runs listed earlier (same as plots)
  - Leading \* denotes runs previously (Nov 2019) flagged bad in offline reco
    - Leading N denote those flagged noisy



# APA 3

* tps0u	1 ( 1)	311-600	All bad except pulser:	*****-*****-*****-*****-**
* tps0u	2 ( 2)	311-814	All bad except pulser:	*****-*****-*****-*****-**
* tps0u	200 (200)	316-815	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0u	202 (202)	316-814	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0u	204 (204)	316-813	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0u	206 (206)	316-812	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0u	208 (208)	316-811	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0u	400 (400)	301-815	All bad except pulser:	*****-*****-*****-*****-**
* tps0u	401 (401)	301-600	All bad except pulser:	*****-*****-*****-*****-**
* tps0v	800 ( 0)	320-209	All bad except pulser:	*****-*****-*****-*****-**
* tps0v	801 ( 1)	320-406	All bad except pulser:	*****-*****-*****-*****-**
* tps0v	876 ( 76)	319-606	All bad except pulser:	*****-*****-*****-*****-**
* tps0v	991 (191)	316-806	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0v	993 (193)	316-807	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0v	995 (195)	316-808	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0v	997 (197)	316-809	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0v	999 (199)	316-810	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0v	1200 (400)	310-209	All bad except pulser:	*****-*****-*****-*****-**
* tps0c	1829 (229)	316-800	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0c	1831 (231)	316-801	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0c	1833 (233)	316-802	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0c	1835 (235)	316-803	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0c	1837 (237)	316-804	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
* tps0c	1839 (239)	316-805	Intermittent bad ASIC:	_ * _ _ P _ _ * _ ** _ _ * P _ * _ -
tps0z	2080 ( 0)	301-805	Good:	_ * _ _ * _ - * _ _ _ _ _ - *** _ -
tps0z	2382 (302)	307-704	Bad after Mar 2020:	_ _ _ _ - _ _ _ - _ _ _ _ - ****P**
tps0z	2383 (303)	307-511	Bad after Mar 2020:	_ _ _ _ - _ _ _ - _ _ _ _ - ****P**

# APA 5

tps1u	2858 (298)	518-711	Bad after Apr 2020:	_____ - ____ - _____ - ****P**
* tps1u	2961 (401)	501-600	All bad except pulser:	*****-*****-*****-*****-**
tps1u	3045 (485)	503-602	Intermittent bad pulser:	_____ - ____ - _____ - _____ P__
tps1v	3400 ( 40)	519-209	Intermittent bad channel:	_____ - _____ - _____ ** - _____ - ____
tps1v	3520 (160)	516-209	Bad after Apr 2020:	_____ - _____ - _____ - ****P**
tps1v	3521 (161)	516-406	Bad after Apr 2020:	_____ - _____ - _____ - ****P**
tps1v	3523 (163)	516-407	Bad after Apr 2020:	_____ - _____ - _____ - ****P**
tps1v	3528 (168)	516-205	Bad after Apr 2020:	_____ - _____ - _____ - ****P**
tps1z	4160 ( 0)	520-215	Good:	_____ - _____ - * _____ - _____ - ____
tps1z	4216 ( 56)	519-211	Intermittent bad channel:	_____ - _____ - _____ - ** _____ - *
tps1z	4232 ( 72)	519-515	Intermittent bad pulser:	_____ - _____ - _____ P _____ - ____
tps1z	4234 ( 74)	519-514	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4236 ( 76)	519-513	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4238 ( 78)	519-512	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4240 ( 80)	519-511	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4242 ( 82)	519-510	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4316 (156)	517-115	Bad after Apr 2020:	_____ - _____ - _____ - ****P**
tps1z	4317 (157)	517-300	Bad after Apr 2020:	_____ - _____ - _____ - ****P**
tps1z	4318 (158)	517-114	Bad after Apr 2020:	_____ - _____ - _____ - ****P**
tps1z	4319 (159)	517-301	Bad after Apr 2020:	_____ - _____ - _____ - ****P**
* tps1z	4411 (251)	515-405	All bad:	*****P*****P*****P*****P**
* tps1z	4412 (252)	515-115	All bad:	*****P*****P*****P*****P**
tps1z	4472 (312)	514-515	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4474 (314)	514-514	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4476 (316)	514-513	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4478 (318)	514-512	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1z	4482 (322)	514-510	Intermittent bad channel:	* _____ - _____ - _____ P _____ - ____
tps1c	5031 (391)	509-613	Bad after Mar 2020:	_____ - _____ - _____ - ****P**

# APA 2

* tps2u	5321 (201) 216-600	All bad except pulser: *****-*****-*****-*****-**
* tps2u	5361 (241) 217-600	All bad except pulser: *****-*****-*****-* ***-**
* tps2u	5363 (243) 217-601	All bad except pulser: *****-*****-*****-* ***-**
* tps2v	6132 (212) 215-108	All bad except pulser: *****-*****-*****-*****-**
* tps2z	7295 ( 95) 202-215	All bad except pulser: *****-*****-*****-* ***-**

# APA 6 (1/2)

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* tps3u 7680 ( 0) 611-815      All bad except pulser: *****-*****-*****-*****-**
* tps3u 7681 ( 1) 611-600      All bad except pulser: *****-*****-*****-*****-**
* tps3u 8080 (400) 601-815      All bad except pulser: *****-*****-*****-*****-**
  tps3u 8208 (528) 604-811      Intermittent bad channel: _____-_____-_____-_*_____-____
* tps3u 8328 (648) 607-811      Intermittent bad channel: *****-*****-*****-*_____-**
  tps3u 8340 (660) 607-315      Bad after Mar 2020: _____-_____-_____-_*__P**
  tps3u 8342 (662) 607-314      Bad after Mar 2020: _____-_____-_____-_*__P**
  tps3u 8344 (664) 607-313      Bad after Mar 2020: _____-_____-_____-_*__P**
  tps3u 8346 (666) 607-312      Bad after Mar 2020: _____-_____-_____-_*__P**
  tps3u 8348 (668) 607-311      Bad after Mar 2020: _____-_____-_____-_*__P**

* tps3v 8480 ( 0) 620-209      All bad except pulser: *****-*** *-*****-*****-**
  tps3v 9011 (531) 607-306      Bad after Mar 2020: _____-_____-_____-_*__**
  tps3v 9013 (533) 607-307      Bad after Mar 2020: _____-_____-_____-_*__**
  tps3v 9015 (535) 607-308      Bad after Mar 2020: _____-_____-_____-_*__**
  tps3v 9017 (537) 607-309      Bad after Mar 2020: _____-_____-_____-_*__**
  tps3v 9019 (539) 607-310      Bad after Mar 2020: _____-_____-_____-_*__**
  tps3v 9140 (660) 604-509      Intermittent bad channel: _____-_____-*****-_____-____
  tps3v 9260 (780) 601-509      Bad after Dec 2018: _____-*****P*****P*****P**

* tps3z 9282 ( 2) 620-214      All bad except pulser: *****-*** *-*****-*****-**
* tps3z 9283 ( 3) 620-401      All bad except pulser: *****-*** *-*****-*****-**
  tps3z 9545 (265) 615-700      Intermittent bad pulser: _____-_____-_____-P_____-____
  tps3z 9547 (267) 615-701      Intermittent bad pulser: _____-_____-_____-P_____-____
  tps3z 9549 (269) 615-702      Intermittent bad pulser: _____-_____-_____-P_____-____
  tps3z 9551 (271) 615-703      Intermittent bad pulser: _____-_____-_____-P_____-____
  tps3z 9553 (273) 615-704      Intermittent bad pulser: _____-_____-_____-P_____-____
  tps3z 9555 (275) 615-705      Intermittent bad pulser: _____-_____-_____-P_____-____
* tps3z 9736 (456) 611-515      All bad except pulser: *****-*****-*****-*****-**

```

# APA 6 (2/2)

* tps3c	9990	(230)	605-404		All bad:	*****P*****P*****P*****P**
tps3c	10033	(273)	606-114	Bad after Dec 2018:	_____ - *****P***** - *****P**	
tps3c	10072	(312)	607-305	Bad after Mar 2020:	_____ - _____ - _____ - _____ P**	
tps3c	10074	(314)	607-304	Bad after Mar 2020:	_____ - _____ - _____ - _____ *****P**	
tps3c	10075	(315)	607-111	Bad after Mar 2020:	_____ - _____ - _____ - _____ *****P**	
tps3c	10076	(316)	607-303	Bad after Mar 2020:	_____ - _____ - _____ - _____ P**	
tps3c	10078	(318)	607-302	Bad after Mar 2020:	_____ - _____ - _____ - _____ **P**	
tps3c	10080	(320)	607-301	Bad after Mar 2020:	_____ - _____ - _____ - _____ P**	
tps3c	10082	(322)	607-300	Bad after Mar 2020:	_____ - _____ - _____ - _____ P**	
* tps3c	10189	(429)	609-214	All bad except pulser:	***** - ***** - ***** - ***** - **	

# APA 1 (1/2)

* tps4u	10800	(560)	105-815	Intermittent bad channel:	*****-***	-	-	-	-
tps4u	10968	(728)	109-811	Intermittent bad channel:	-	-	**	****	-
tps4u	11000	(760)	110-815	Bad after Mar 2020:	-	-	-	****	**
tps4u	11001	(761)	110-600	Intermittent bad channel:	-	-	-	*	-
tps4u	11014	(774)	110-713	Intermittent bad channel:	-	-	*****	*****	-
tps4u	11018	(778)	110-711	Intermittent bad channel:	-	-	**	*	-
tps4u	11021	(781)	110-100	Intermittent bad channel:	-	*	*	-	P
* tps4u	11024	(784)	110-313	Intermittent bad channel:	*****	*****	*****	*****	-
tps4u	11025	(785)	110-102	Intermittent bad channel:	-	*	*	-	P
tps4v	11183	(143)	117-707	Bad after Mar 2020:	-	-	-	****	P**
tps4v	11194	(154)	117-607	Bad after Mar 2020:	-	-	-	****	P**
tps4v	11450	(410)	110-109	Intermittent bad channel:	-	*	*	-	P
tps4v	11454	(414)	110-107	Intermittent bad channel:	-	*	-	-	P
* tps4v	11457	(417)	110-309	Intermittent bad channel:	*****	-	*	-	-
* tps4v	11459	(419)	110-310	All bad except pulser:	*****	*****	*****	*****	**
* tps4v	11463	(423)	110-707	Intermittent bad channel:	*****	*****	-	****	**
tps4v	11467	(427)	110-709	Intermittent bad channel:	-	-	*****	*	-
tps4v	11468	(428)	110-505	Bad after Jan 2020:	-	-	-	****	**
* tps4v	11469	(429)	110-710	Bad after Sep 2019:	-	-	**	*****	**
tps4v	11501	(461)	109-706	Intermittent bad channel:	-	-	***	*	-
* tps4v	11517	(477)	109-809	Bad after Jan 2020:	-	-	-	*****	**
* tps4v	11669	(629)	105-710	Intermittent bad channel:	*****	-	-	-	-
* tps4v	11679	(639)	105-810	Intermittent bad channel:	*****	*****	****	-	-
* tps4c	11842	( 2)	120-214	All bad:	*****	P*****	P*****	P*****	P**
tps4c	11926	( 86)	119-614	Bad after Mar 2020:	-	-	-	****	P**

# APA 1 (2/2)

tps4z	12454	(134)	103-404	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12456	(136)	103-403	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12646	(326)	107-404	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12647	(327)	107-211	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12648	(328)	107-403	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12649	(329)	107-212	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12650	(330)	107-402	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12651	(331)	107-213	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12652	(332)	107-401	Bad after Mar 2020:	_____ - _____ - _____ - _____	****P**
tps4z	12704	(384)	109-805	Intermittent bad channel:	_____ - _____ - _____ - _____	* ****_**
tps4z	12718	(398)	109-704	Intermittent bad channel:	_____ - _____ - _____ - _____	* _ _
* tps4z	12756	(436)	110-803	Intermittent bad channel:	*****-*****-_____ - _____	* _ _
tps4z	12785	(465)	110-114	Intermittent bad channel:	_____ - * _ - _____ - _____	P _
tps4z	12787	(467)	110-115	Intermittent bad channel:	_____ - * _ - _____ - _____	P _

# APA 4

* tps5u	12801	( 1)	411-600	All bad except pulser:	*****-*****-*****-*****-**
* tps5u	13001	(201)	416-600	All bad except pulser:	*****-*****-*****-*****-**
* tps5u	13081	(281)	418-600	All bad except pulser:	*****-*****-*****-*****-**
tps5u	13573	(773)	410-501	Intermittent bad pulser:	_____ - _____ - _____ P _____ P _____
tps5u	13575	(775)	410-502	Intermittent bad pulser:	_____ - _____ - _____ P _____ P _____
tps5u	13579	(779)	410-504	Intermittent bad pulser:	_____ - _____ - _____ - _____ P _____
tps5z	14591	(191)	417-805	Intermittent bad channel:	_____ - _____ - _____ - * _____ - _____



# Conclusions

# Summary

## 130 channels appear bad here

- I.e. have low RMS in at least one run
- This is 0.8% of the channels in protoDUNE
- Not counting bad pulser, sticky codes and other waveform problems
  - At least 11 additional channels had intermittent pulser failures
- 53 are intermittent
  - One ASIC (607-3) may be oscillating rapidly between good and bad
- 47 failed during the run
  - 0.2 %/year

Thank you