eTOF MRPC Production Status at Tsinghua University

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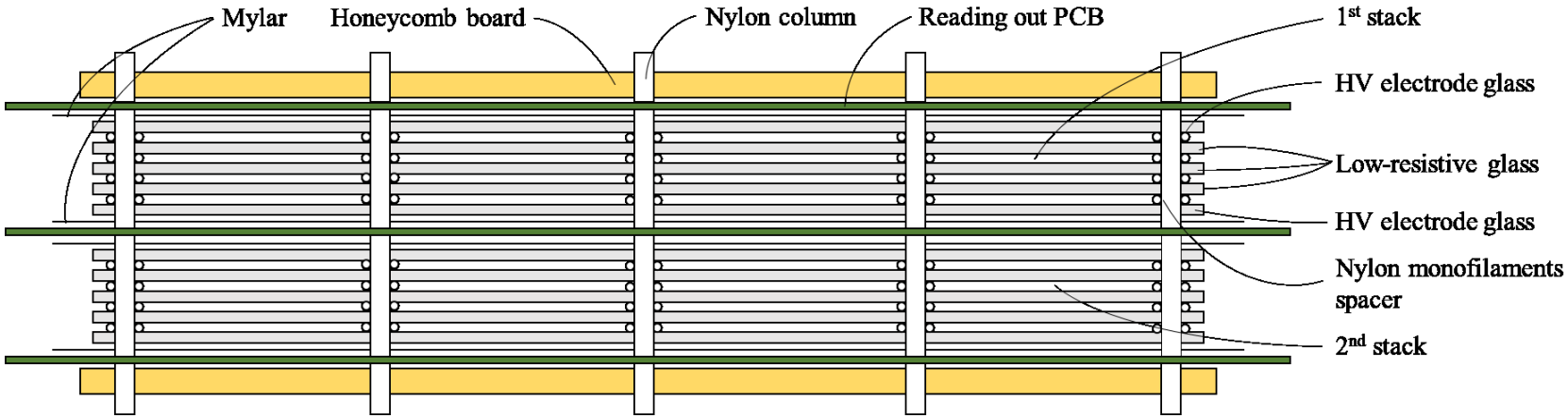
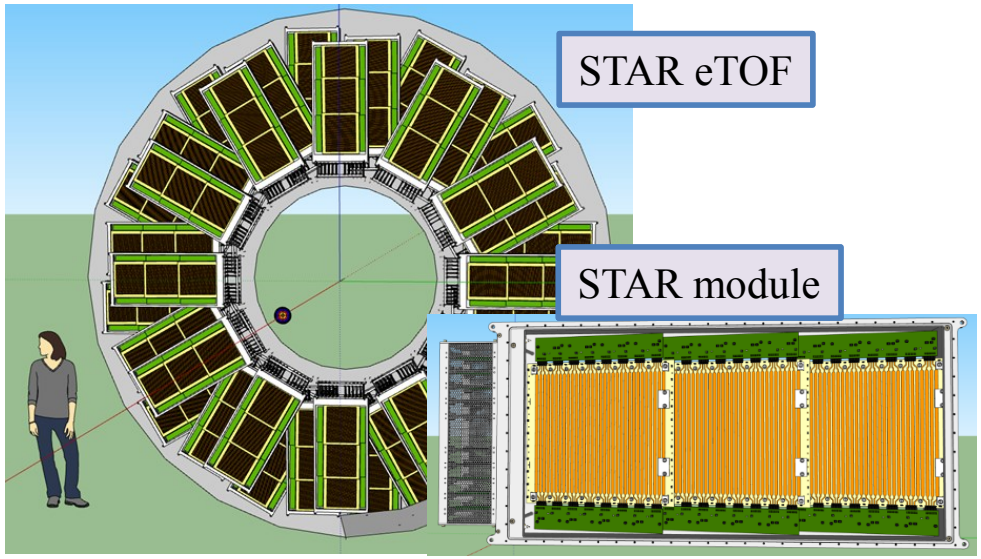
Outline

- Mass production status of MRPC3a
  - Conceptional design of MRPC3a
  - MRPC3a production procedure
  - Quality assurance results
- Preliminary test results
  - HV test
  - Cosmic test based on TRB system
- Plan and time line
- Summary

Conceptional Design of MRPC3a



The sectional sketch of the double-stack MRPC3a.

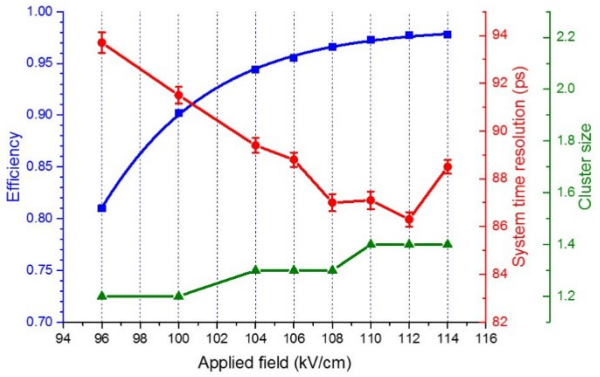


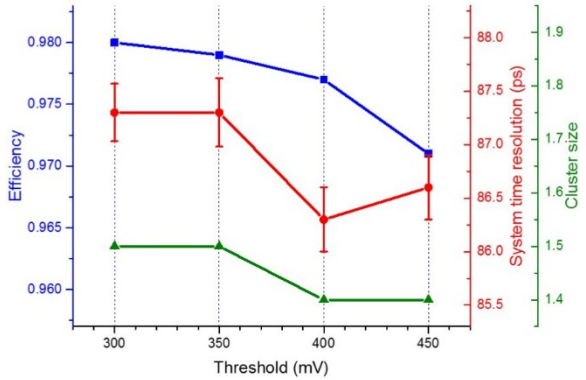
Parameter	Value
Dimension	360 × 338 mm^2
Height	26 mm
Weight	3.3 kg
Glass dimension	330 × 276 mm^2
Gas gap number	2 × 4
Gas gap width	0.25 mm
Strip pitch	7 + 3 mm
Strip length	270 mm
Strip number	32

Conceptional Design of MRPC3a

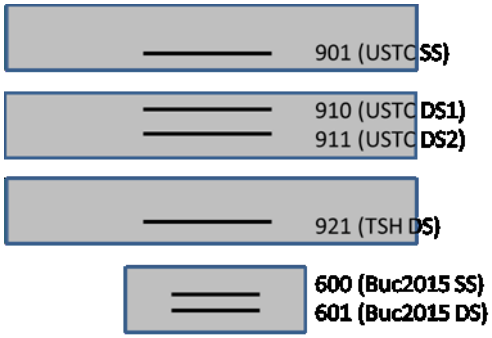
MRPC3a prototype in SPS beamtest (Nov 2015).

30 GeV Pb beam on 1mm/2mm/3mm Pb.
Flux rate up to **10 Hz/cm²**.





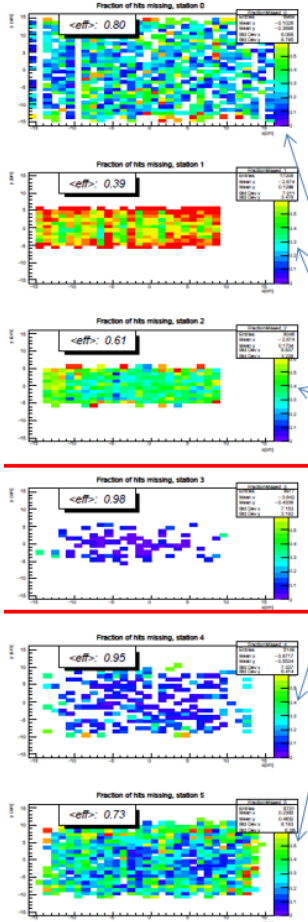
MRPC3a prototype in Heidelberg cosmic test.



	Run 33			Run 34	
	Req2	Req 3	R2 s7	Req2	Req 3
901	53 ps	55 ps	44 ps	48 ps	52 ps
601	60 ps	62 ps	62 ps	54 ps	51 ps
600	60 ps	60 ps	55 ps	53 ps	49 ps
921	80 ps	66 ps	62 ps	59 ps	57 ps
911	73 ps	67 ps	63 ps	68 ps	70 ps
910	57 ps	53 ps	58 ps	59 ps	68 ps

Performance in HV and threshold scan:
Time resolution: ~ 60 ps
Efficiency: > 98%
Cluster size: ~ 1.5

From Ingo's talk on July 5th



pl_XY_trk.pdf

Run r0033

Req3

HV set to have on all counters 1 kHz dark rate

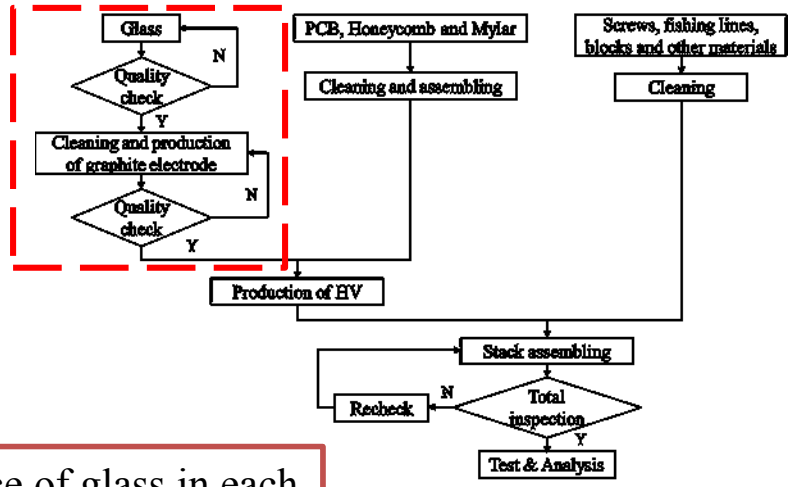
901 HV = 11000 kV
601 HV = 5250 kV
600 HV = 8500 kV
921 HV = 5400 kV
911 HV = 6800 kV
910 HV = 5500 kV

Freon: 92%
SF6: 3%
IsoBut: 5%

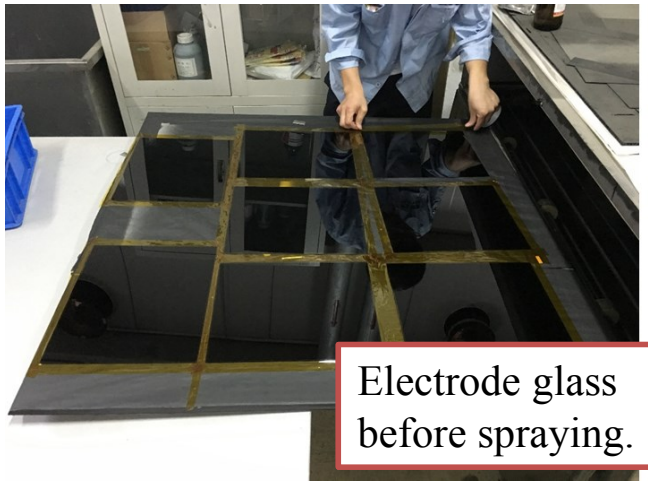
DUT: 911
Ref: 910
Bref: 901
Sel2: 921

MRPC3a Production Procedure

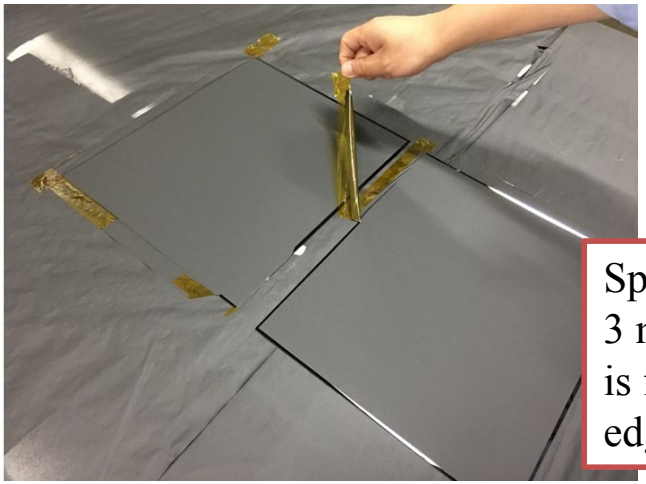
Quality check of **glass** & electrode production.



Every piece of glass in each batch has been inspected.



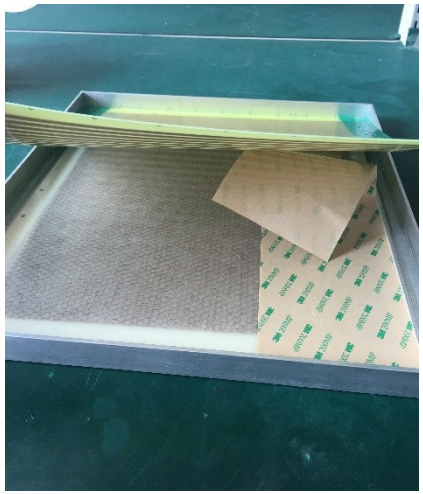
Electrode glass before spraying.

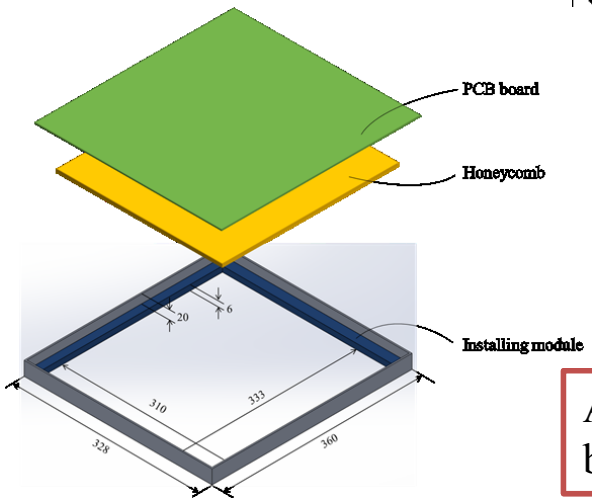


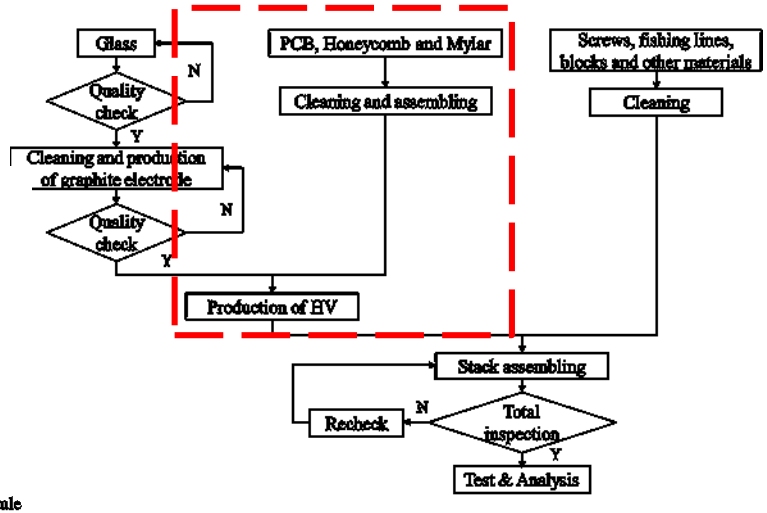
Sprayed electrode. 3 mm space on edge is for getting rid of edge effect.

MRPC3a Production Procedure

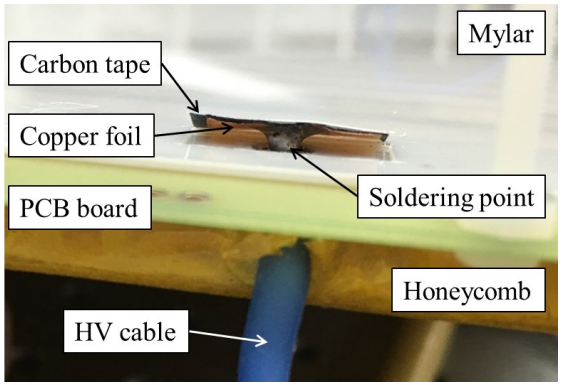
Assembling PCB board & HV production.



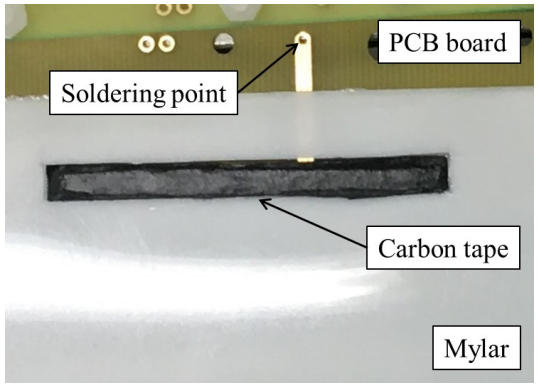




An installing module can fix the PCB board and honeycomb together exactly.



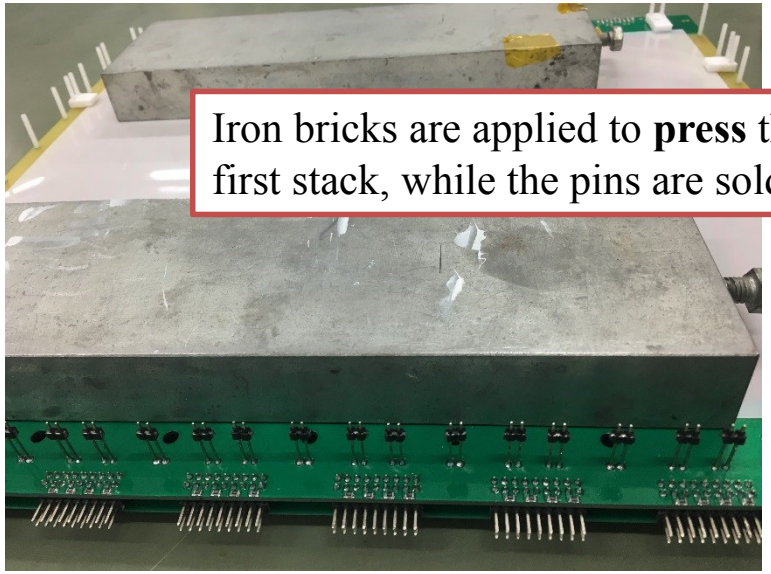
HV connection to top & bottom board. This is to avoid discharge between HV & the nearest strip.



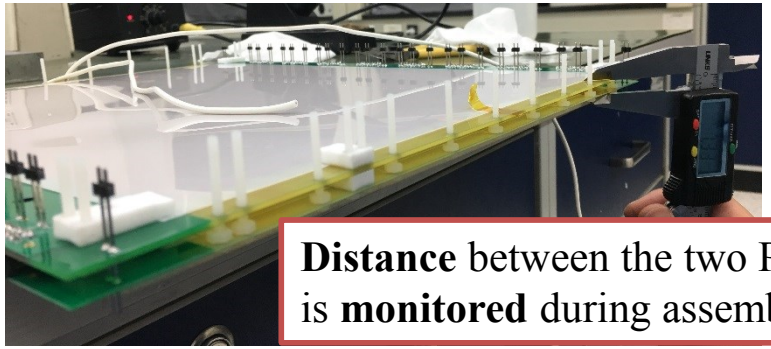
HV connection to middle board.

MRPC3a Production Procedure

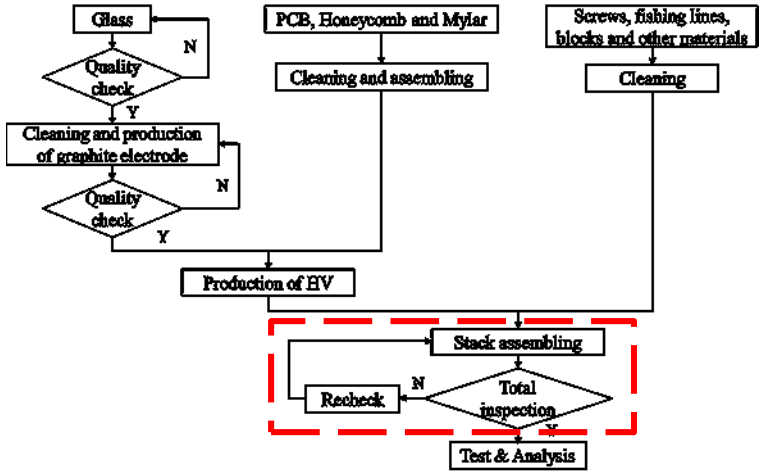
Stack assembling procedure.



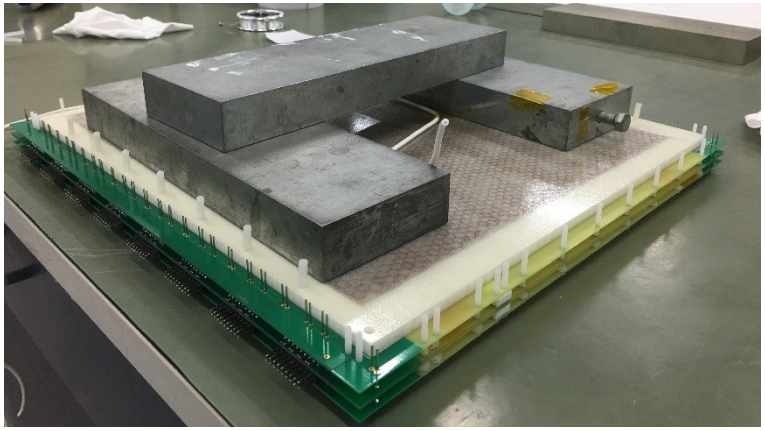
Iron bricks are applied to **press** the first stack, while the pins are soldered.



Distance between the two PCBs is **monitored** during assembling.



The same procedure is repeated when assembling the second stack.



Quality Assurance Results

Quality assurance of each type of materials and the assembling procedure is recorded.

MRPC生产记录表 / MRPC3a Quality Assurance Table

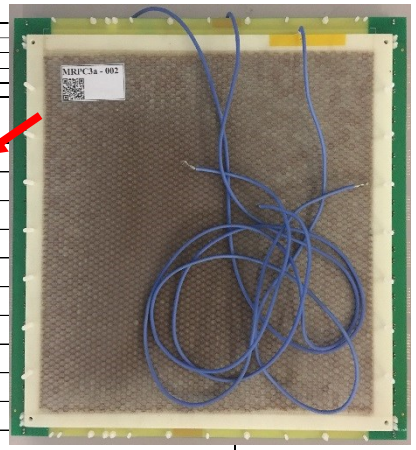
MRPC ID	MRPC3a - 005					
玻璃 / Glass	**来自箱号与批次 / Glass Batch No.**	NO.9 151225	**用料数量/Amount**			6
	来自箱号与批次 / Glass Batch No.	NO.11 151225	**用料数量/Amount**			4
	来自箱号与批次 / Glass Batch No.		**用料数量/Amount**			
电极玻璃 / Electrode	**面电阻 / Surface Resistance (MΩ/sq)**	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**
	电极玻璃1 / Electrode 1	8	2	3	7	7
	电极玻璃2 / Electrode 2	3	3	4	3	3
	电极玻璃3 / Electrode 3	5	8	5	8	5
	电极玻璃4 / Electrode 4	8	4	3	5	5
蜂窝板 / Honeycomb	√					
PCB上下板 / Top & Bottom PCB	√					
PCB中间板 / Middle PCB	**焊接保护电阻 / Protection Resistor**	**外侧64路信号与地之间电阻是否均为100kΩ / Resistance Measured on Outside Resistor**	√	**问题数量 / Unqualified**	0	
		内侧64路信号与地之间电阻是否均为200kΩ / Resistance Measured on Inside Resistor	√	**问题数量 / Unqualified**	0	
	焊接双排插针 / Connector	**16个插座与电路板的厚度是否均<6.7mm / Thickness of the connectors**	√	**问题数量 / Unqualified**	0	
Mylar膜 / Mylar	√					
PCB上下板高压 / Top & Bottom HV	√					
PCB中间板高压 / Middle HV	√					
鱼线 / Spacer	√					

厚度 / Thickness	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**	**Point 7**	**Point 8**
上下PCB / Between Top & Bottom PCB	11.44	11.47	11.44	11.41	11.57	11.45	11.59	11.52
上中PCB / Between Top & Middle PCB	4.61	4.77	4.67	4.76	4.66	4.79	4.72	4.77
下中PCB / / Between Bottom & Middle PCB	4.63	5.03	5.02	4.87	4.96	4.84	4.84	4.74
总厚度 / Total Thickness	25.98	25.92	26.11	26.12	26.03	26.13	26.15	26.05
组装人员签字 / Signature	杨泽林							
日期 / Date	08/09/2017							
备注 / Note								

Quality Assurance Results

Quality assurance of each type of materials and the assembling procedure is recorded.

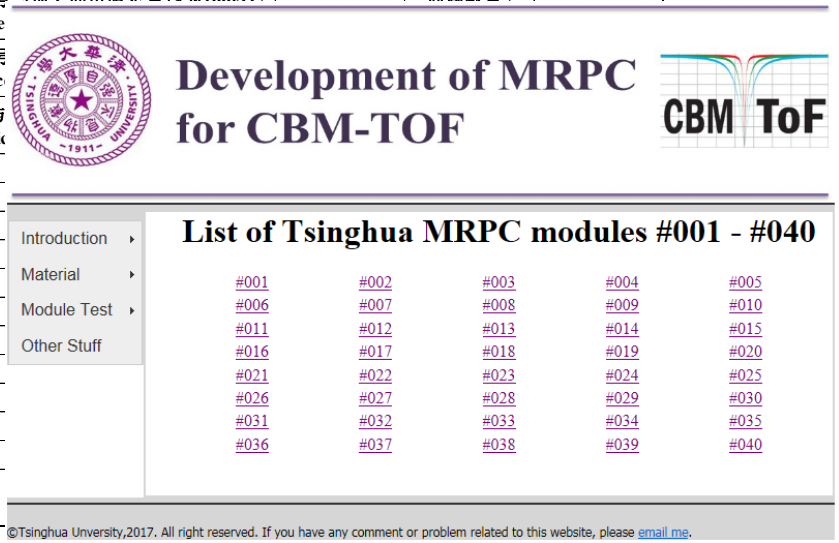
Detailed information can be found by scanning the **QR code** on it.



MRPC ID	
玻璃 / Glass	来自箱号与批次 / Glass Batch No.
	来自箱号与批次 / Glass Batch No.
	来自箱号与批次 / Glass Batch No.
电极玻璃 / Electrode	面电阻 / Surface Resistance (MΩ/sq)
	电极玻璃1 / Electrode 1
	电极玻璃2 / Electrode 2
	电极玻璃3 / Electrode 3
	电极玻璃4 / Electrode 4
蜂窝板 / Honeycomb	
PCB上下板 / Top & Bottom PCB	√

A website is developed to record all the QR information of each produced counter: http://hepd.ep.tsinghua.edu.cn/CBM_TOF/

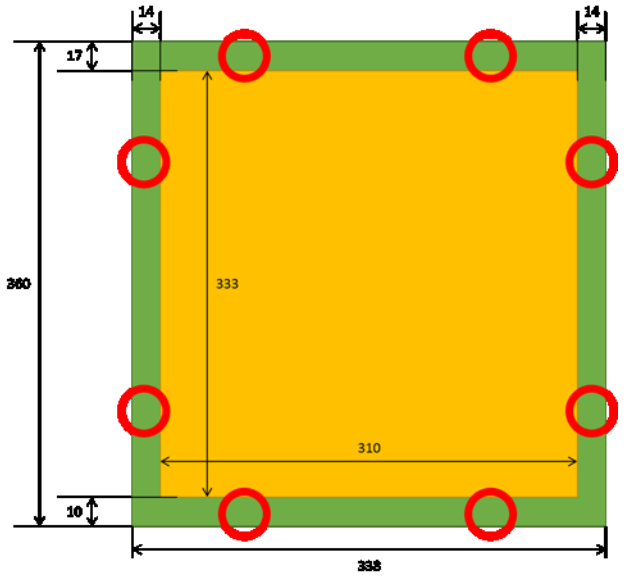
PCB上下板高压 / Top & Bottom HV			
PCB中间板高压 / Middle HV			
鱼线 / Spacer			
厚度 / Thickness	Point 1	Point 2	Point 3
上下PCB / Between Top & Bottom PCB	11.44	11.47	11.44
上中PCB / Between Top & Middle PCB	4.61	4.77	4.67
下中PCB / / Between Bottom & Middle PCB	4.63	5.03	5.02
总厚度 / Total Thickness	25.98	25.92	26.11
组装人员签字 / Signature			
日期 / Date			
备注 / Note			



Quality Assurance Results

Thickness uniformity between each PCB has been measured at **8 points** around the assemble counter.

The requirement is the thickness of two adjacent PCBs should be within **±0.2 mm** of the nominal value.



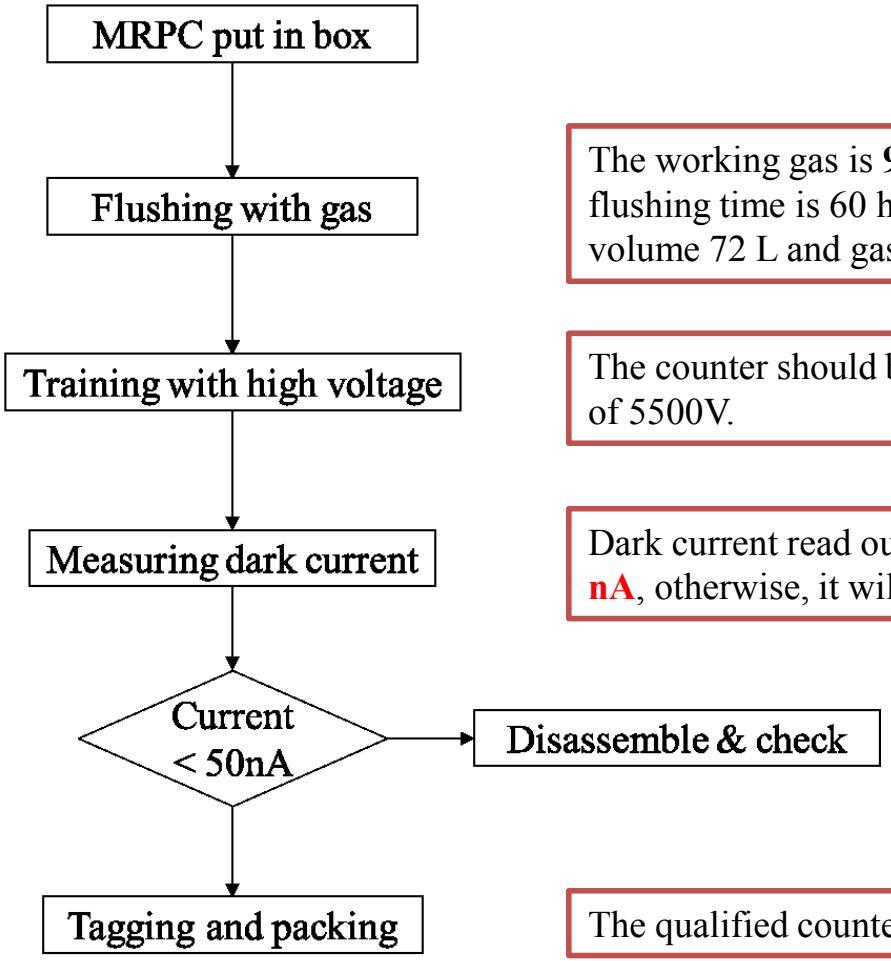
Measurement	Nominal/mm	Minimum/mm	Maximum/mm
Thickness between bottom and middle PCB (h1)	5.1	4.9	5.3
Thickness between top and middle PCB (h2)	5.1	4.9	5.3
Thickness between bottom and top PCB (h3)	11.8	11.5	12.1

MRPC3a -001	**h1**	4.89	4.94	4.74	4.79	4.65	4.81	4.87	4.95	**4.83 (mean)**
	h2	4.82	4.82	4.87	4.86	4.83	5.13	5.16	5.15	**4.96 (mean)**
	h3	11.65	11.62	11.48	11.53	11.27	11.43	11.43	11.52	**11.49 (mean)**
MRPC3a -002	**h1**	4.86	4.92	5.18	4.81	4.94	4.74	4.86	5.18	**4.94 (mean)**
	h3	4.9	5.03	5.03	4.64	5.23	5.08	4.73	4.86	**4.94 (mean)**
	h3	11.7	11.61	11.63	11.7	11.7	11.88	11.62	11.86	**11.71 (mean**
MRPC3a -003	**h1**	5.05	5.06	5.25	4.96	5.12	5.03	5.09	5.04	**5.08 (mean)**
	h2	5.07	4.99	5.02	4.92	5.1	4.79	5.15	5.03	**5.03 (mean)**
	h3	11.75	11.64	11.63	11.82	11.68	11.63	11.74	11.69	**11.69 (mean**

The distance measured at the edge is not absolutely equal to the thickness in glass & gap region, but it could be a reference.

HV Test

All the MRPC3a counters should be tested with HV.



The working gas is **90% $C_2H_2F_4$, 5% i-C_4H_{10} and 5% SF_6**. The flushing time is 60 hours (determined by 3 times of the gas box volume 72 L and gas flow 3.6 L/h).

The counter should be trained **10 hours at the nominal voltage** of 5500V.

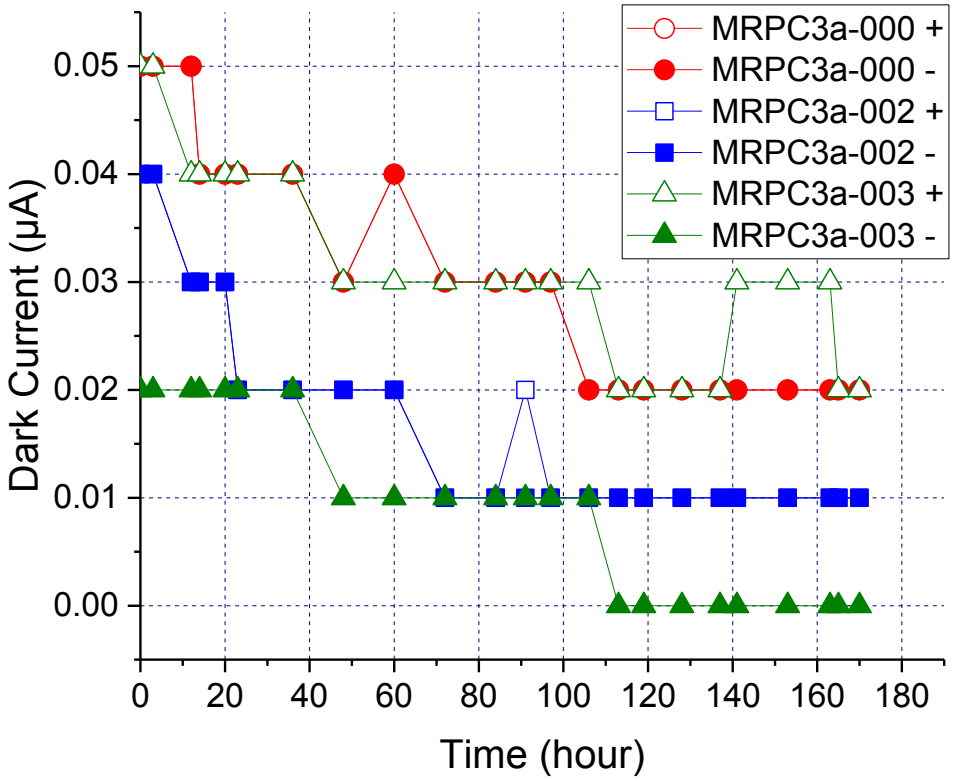
Dark current read out from HV crate should be **no more than 50 nA**, otherwise, it will be disassembled to look for the reason.

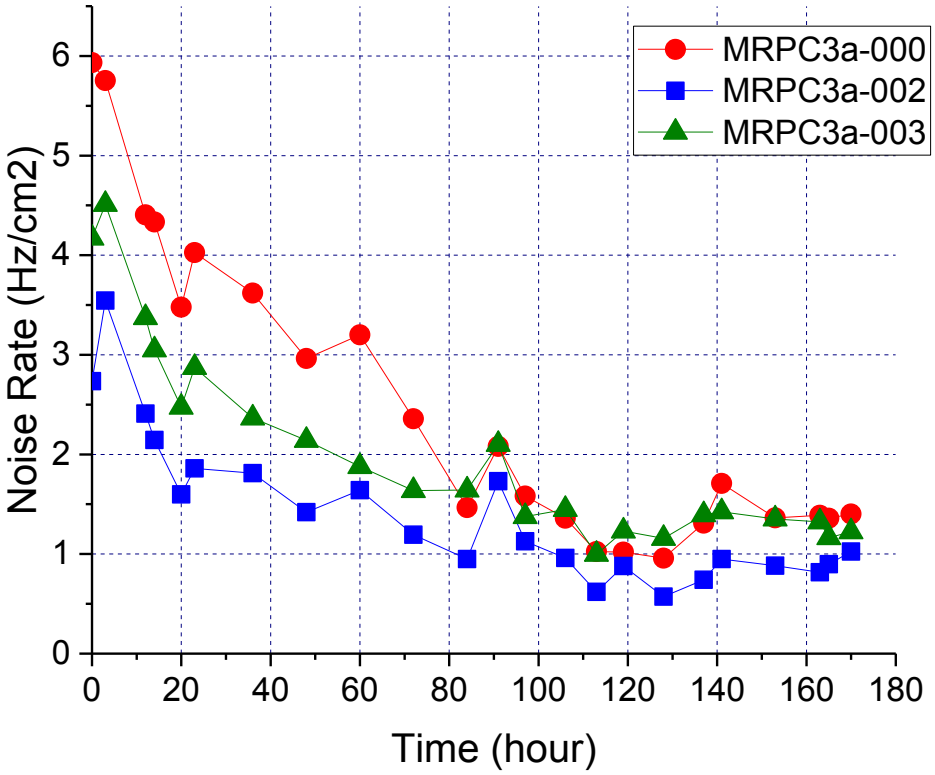
The qualified counters are ready for cosmic test.

HV Test

After 10 hours' HV training, the counter is set to 5600 V, and the PADI's threshold 300 mV.

Dark current and **noise rate** monitored in 170 hours since the MRPCs are trained.



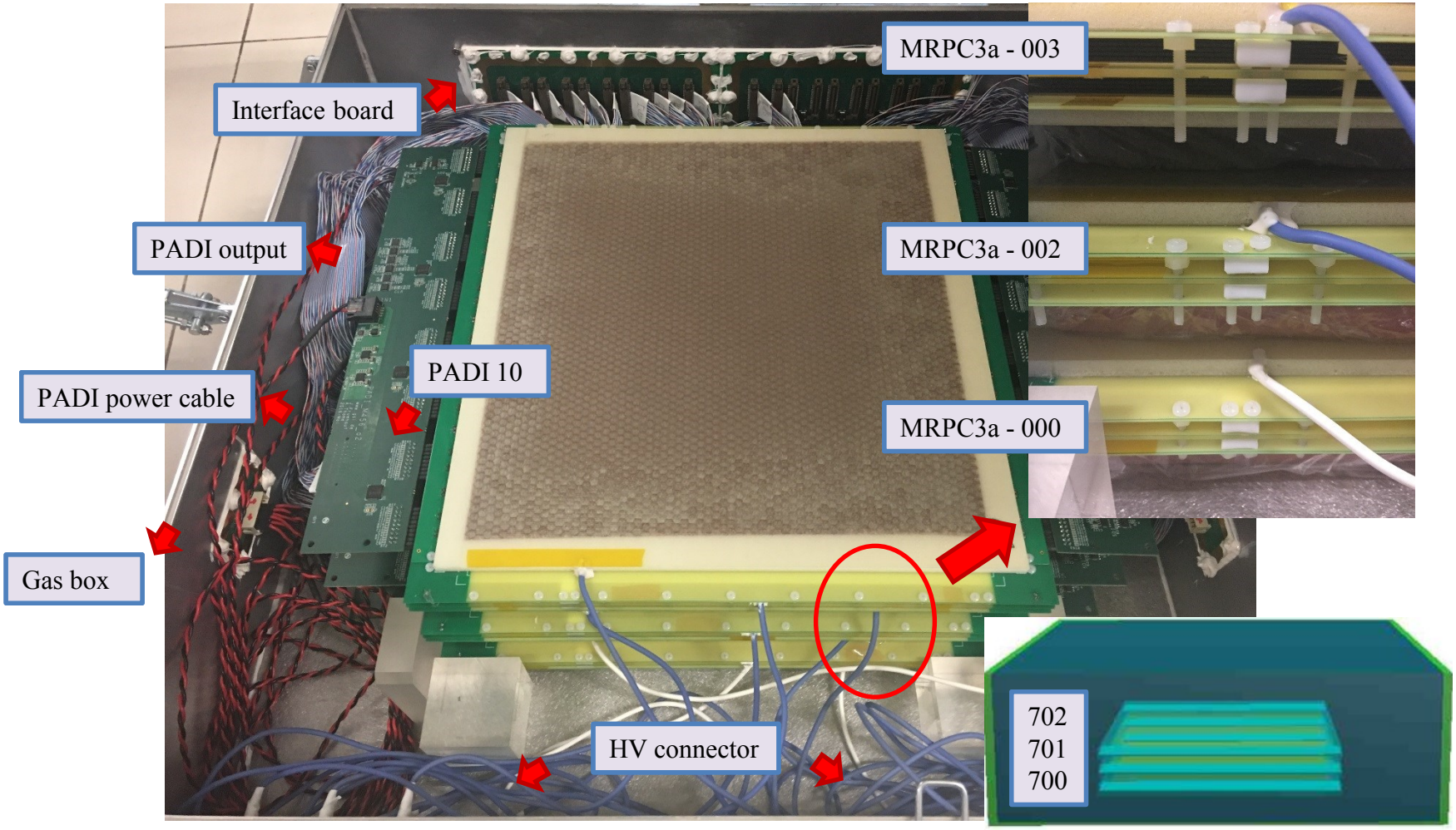


Dark current < **50 nA** √

Noise rate around **1 Hz/cm²**

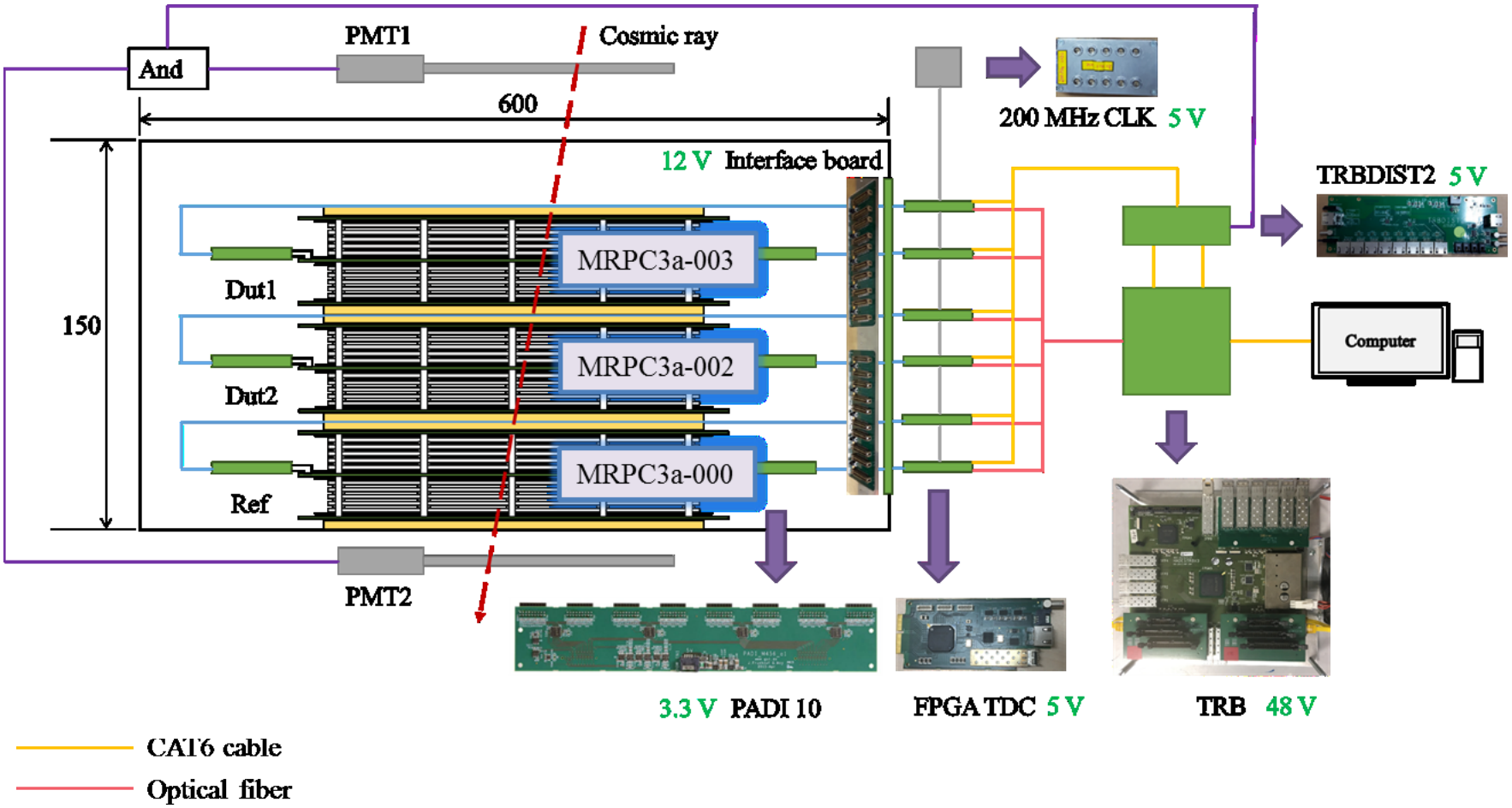
Cosmic Test Based on TRB System

MRPC setup in the gas box.



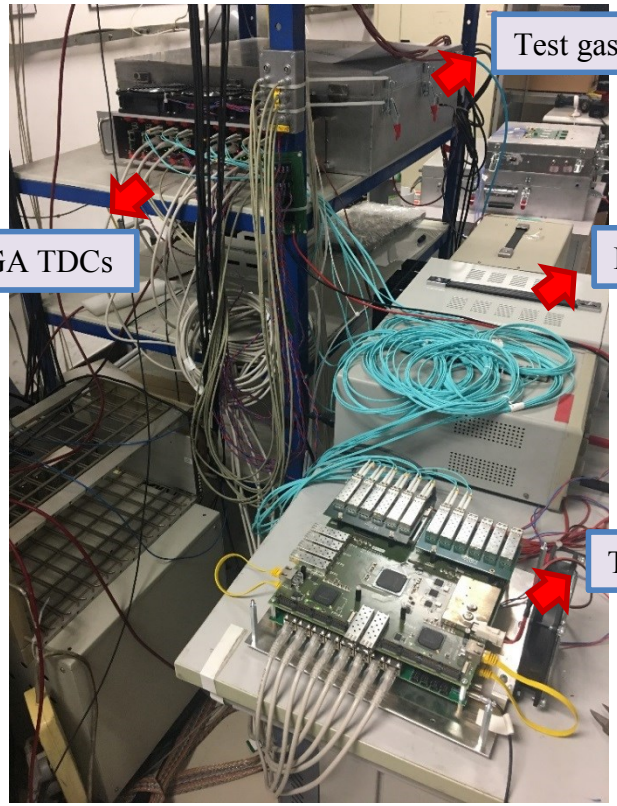
Cosmic Test Based on TRB System

TRB system setup.



Cosmic Test Based on TRB System

Photo of the TRB system setup with MRPC3a test gas box.



Reg	Channel	0901	0902	0903	0904	0905	0906
	Channel group	3 2 1 0 on on on on off off off off	3 2 1 0 on on on on off off off off	3 2 1 0 on on on on off off off off	3 2 1 0 on on on on off off off off	3 2 1 0 on on on on off off off off	3 2 1 0 on on on on off off off off
c000	0	[illegible]	0	0	0	0	0
c001	1	8686933	30942458	0	0	1	0
c002	2	8914753	33581756	0	0	2	0
c003	3	[illegible]	206	117	188	164	[illegible]
c004	4	102	206	117	189	165	10195934
c005	5	221	202	110	136	162	259
c006	6	221	203	109	137	162	260
c007	7	202	91	96	138	181	175
c008	8	203	90	95	143	184	177
c009	9	96	91	59	81	120	165
c00a	10	98	91	59	82	123	162
c00b	11	113	169	57	73	145	236
c00c	12	113	171	57	73	147	234
c00d	13	146	139	63	79	133	110
c00e	14	147	142	63	79	137	111
c00f	15	98	37	69	81	154	96
c010	16	98	37	69	81	155	95
c011	17	88	68	56	87	177	124
c012	18	87	70	56	88	180	125
c013	19	118	74	62	117	124	147
c014	20	121	74	63	118	127	151
c015	21	82	127	37	66	101	136
c016	22	82	127	37	66	102	137
c01[illegible]	23	54	89	57	89	108	144
c01[illegible]	24	56	89	56	91	109	146
c01[illegible]	25	62	109	73	36	109	144
c01a	26	64	110	72	36	112	152
c01b	27	58	80	53	41	92	76
c01c	28	60	80	54	40	93	78
c01d	29	59	89	49	95	118	100
c01e	30	60	89	50	95	119	98
c01f	31	0	115	89	74	137	127
c020	32	0	116	89	73	137	128
c021	33	112	38	63	101	127	124
c022	34	114	37	64	101	129	127
c023	35	145	58	98	40	99	97
c024	36	143	60	98	40	97	97
c025	37	91	61	35	39	139	23
c026	38	92	61	34	40	139	23
c027	39	109	64	31	90	156	10
c028	40	[illegible]	64	32	92	157	10
c029	41	5732697	49	84	3987233	146	120711
c02a	42	7537893	51	84	5630085	144	1901812
c02b	43	[illegible]	68	65	66	120	135
c02c	44	106	69	64	68	122	134
c02d	45	76	81	109	51	150	102
c02e	46	76	81	108	51	151	102
c02f	47	122	100	99	49	114	190
c030	48	118	99	99	49	115	191
c031	49	114	96	99	74	93	172
c032	50	113	97	99	75	95	173
c033	51	127	145	82	65	74	181
c034	52	126	146	82	66	76	179
c035	53	284	97	63	57	220	173
c036	54	285	97	63	57	223	176
c037	55	141	113	73	56	176	141
c038	56	144	113	74	56	182	143
c039	57	217	170	131	100	216	144
c03a	58	219	170	129	99	218	145
c03b	59	66	224	103	122	211	148
c03c	60	66	224	104	122	212	151
c03d	61	[illegible]	276022	168	130	237	174
c03e	62	188	447242	169	131	301	179
c03f	63	88	0	258	0	517	0
c040	64	[illegible]	0	258	0	518	0

Noisy and dead zones are found at both ends and middle line of each TDC.

Cosmic Test: Calibration & Analysis

Run: 24Aug1829: **Dut: 701**; **Ref: 702**; **Sel2/BRef: 700**.
Calibration mode: **701702700**.
HV: ±5600 V; Threshold: -300 mV; Gas: 90% Freon + 5% C_4H_{10} + 5% SF_6

Analysis strategy:

Unpacking
- create_calib.C (1000000,"CbmTofThu_24Aug1829")
- apply_calib.C (1000000,"CbmTofThu_24Aug1829")

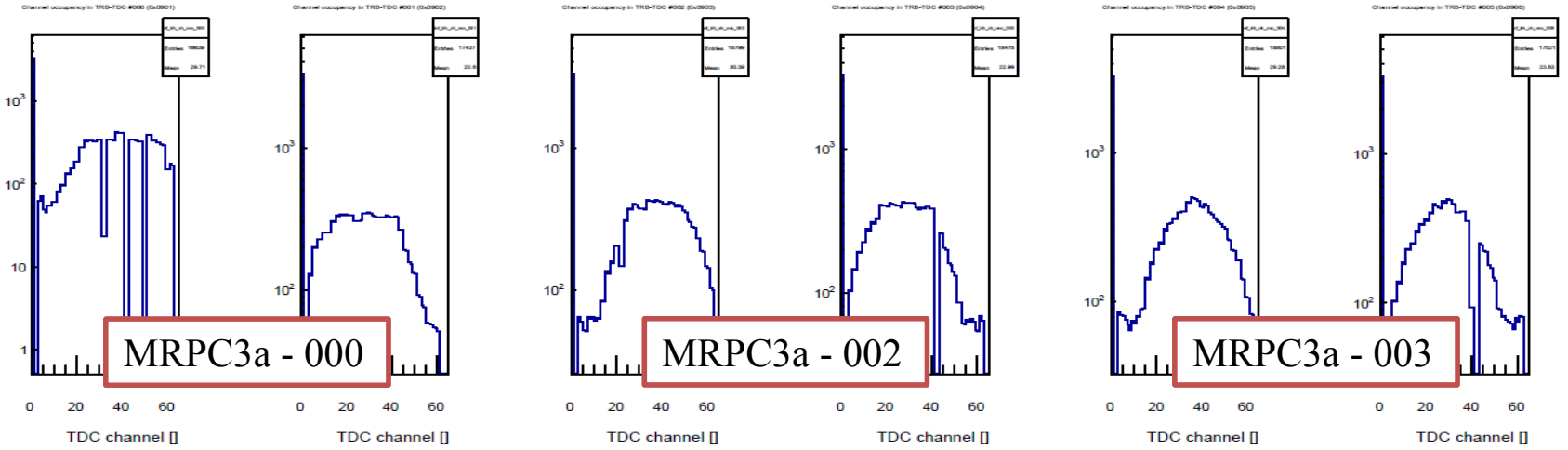
Calibration
calib_runs_batch.sh 24Aug1829 701702700 700
- init_calib_digi.sh
- iter_calib_digi.sh
- gen_calib_digi.sh

Analysis
ana_sets_batch.sh 24Aug1829 701702700_700 0.5 701 702 700
- iter_ana_hits.sh

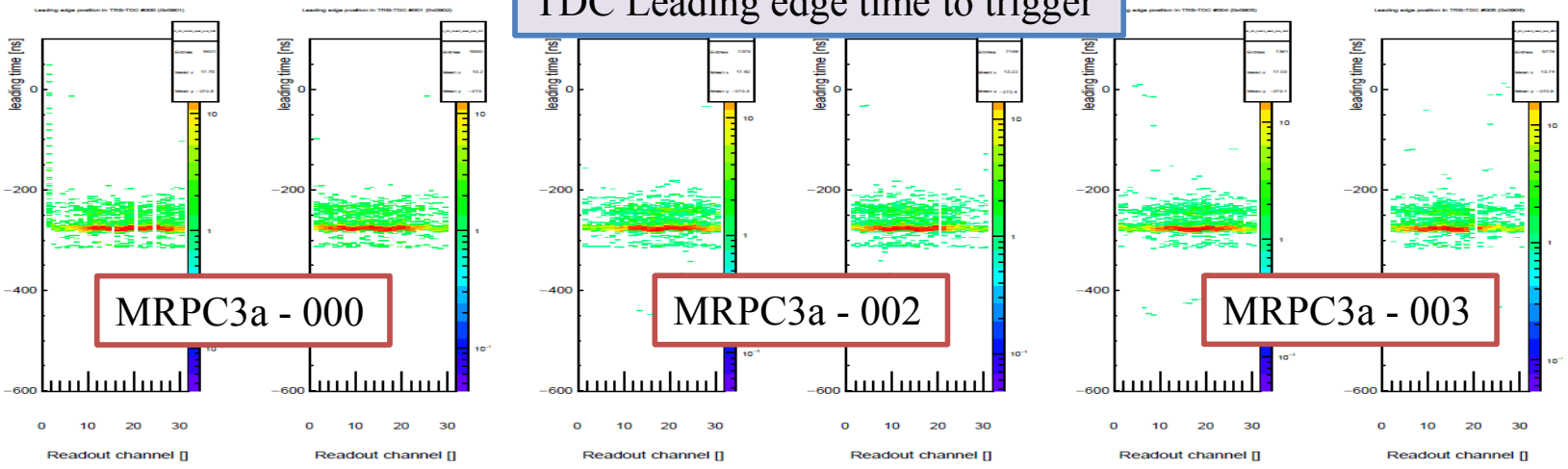
Cosmic Test: Calibration & Analysis

Unpacking:

TDC channel occupancy

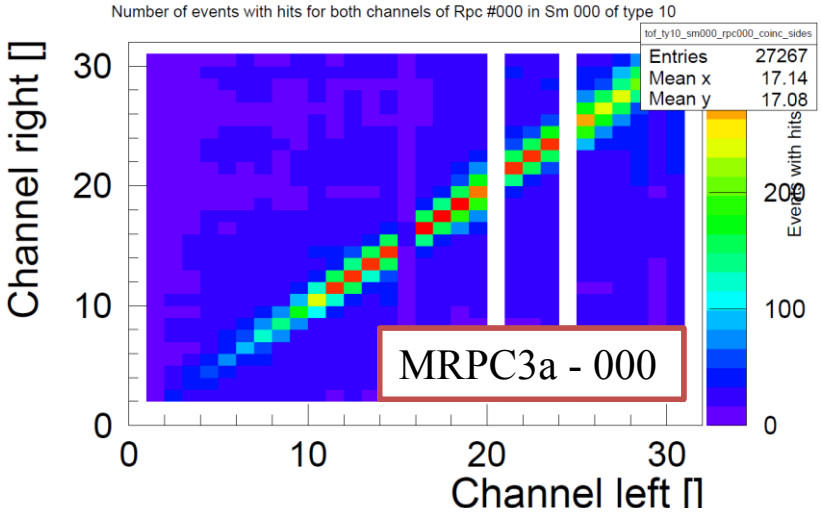


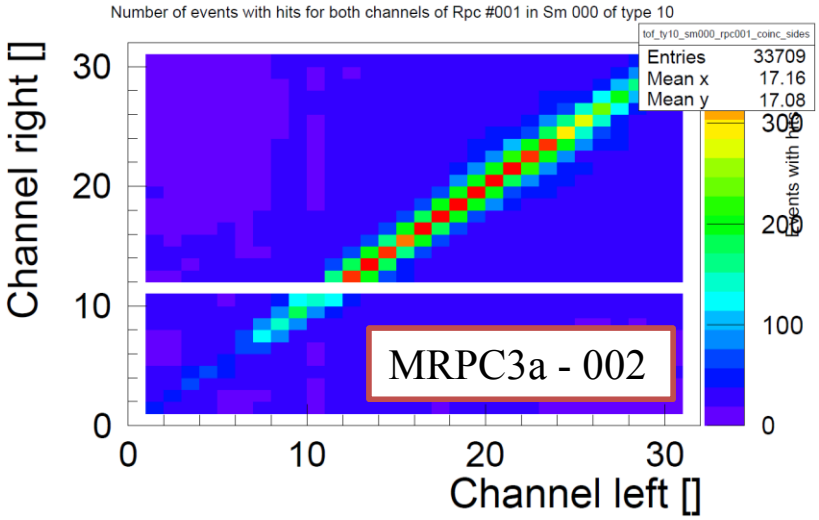
TDC Leading edge time to trigger

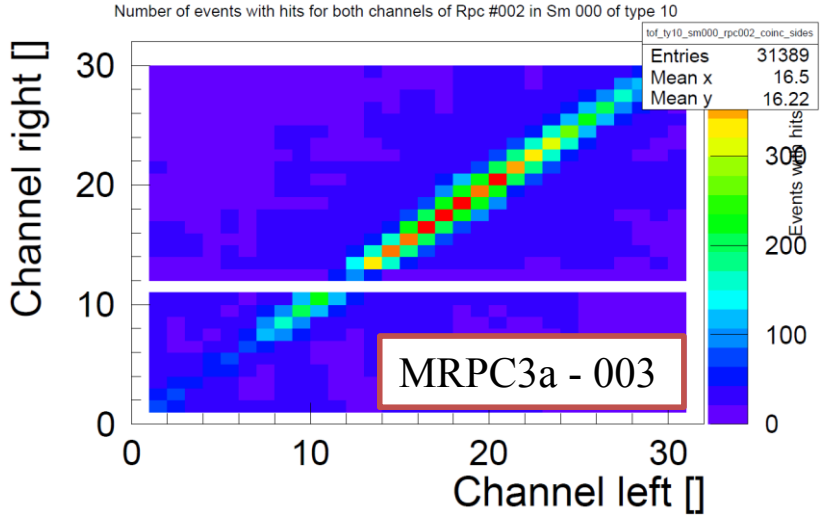


Cosmic Test: Calibration & Analysis

Unpacking:







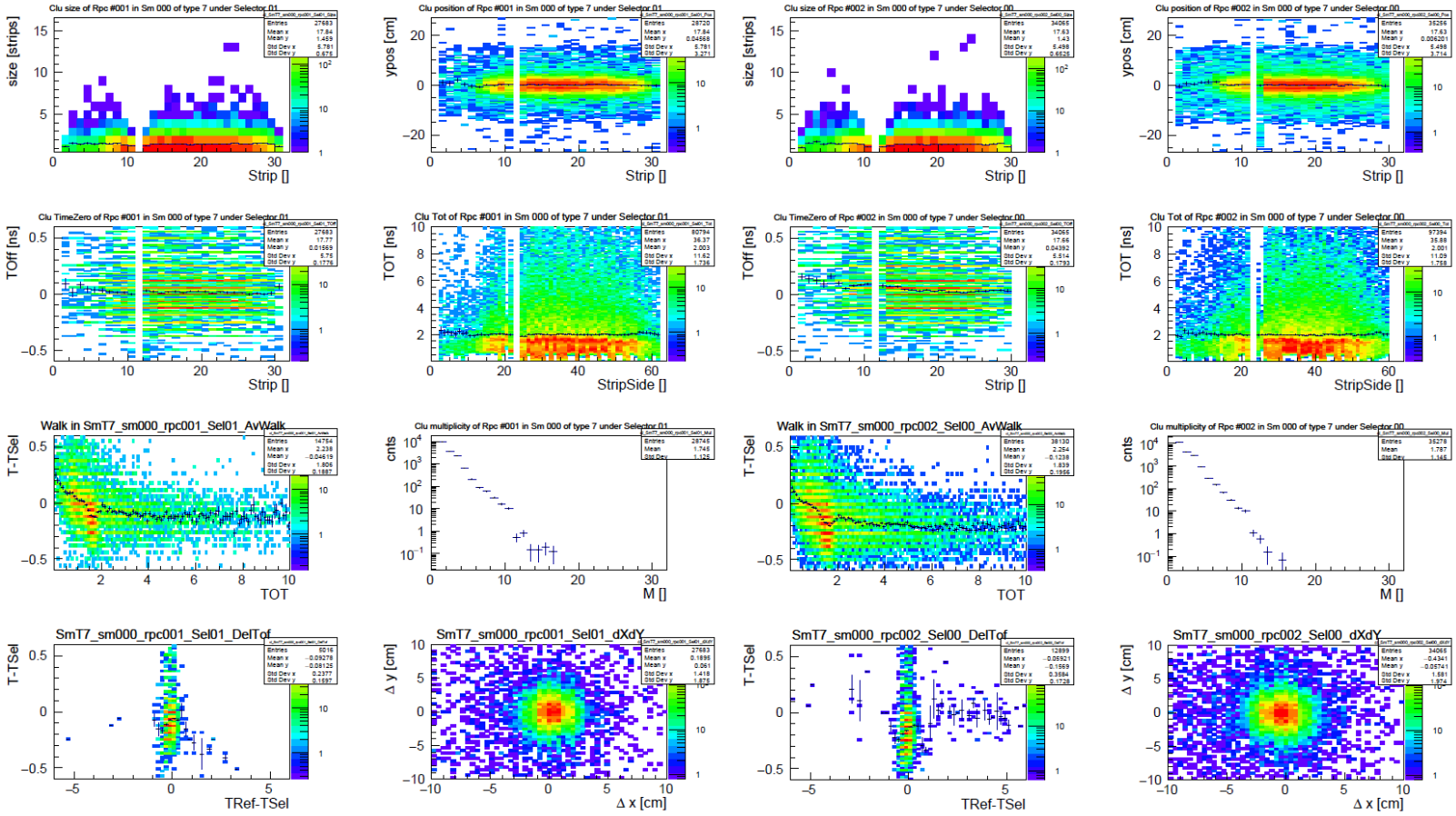
Matching of left and right side of each MRPC. It can prove the mapping file we prepare is correct.

Cosmic Test: Calibration & Analysis

Calibration: **Dut: 701; Ref: 702; Sel2/BRef: 700**

pl_over_cluSel1_7_0_1

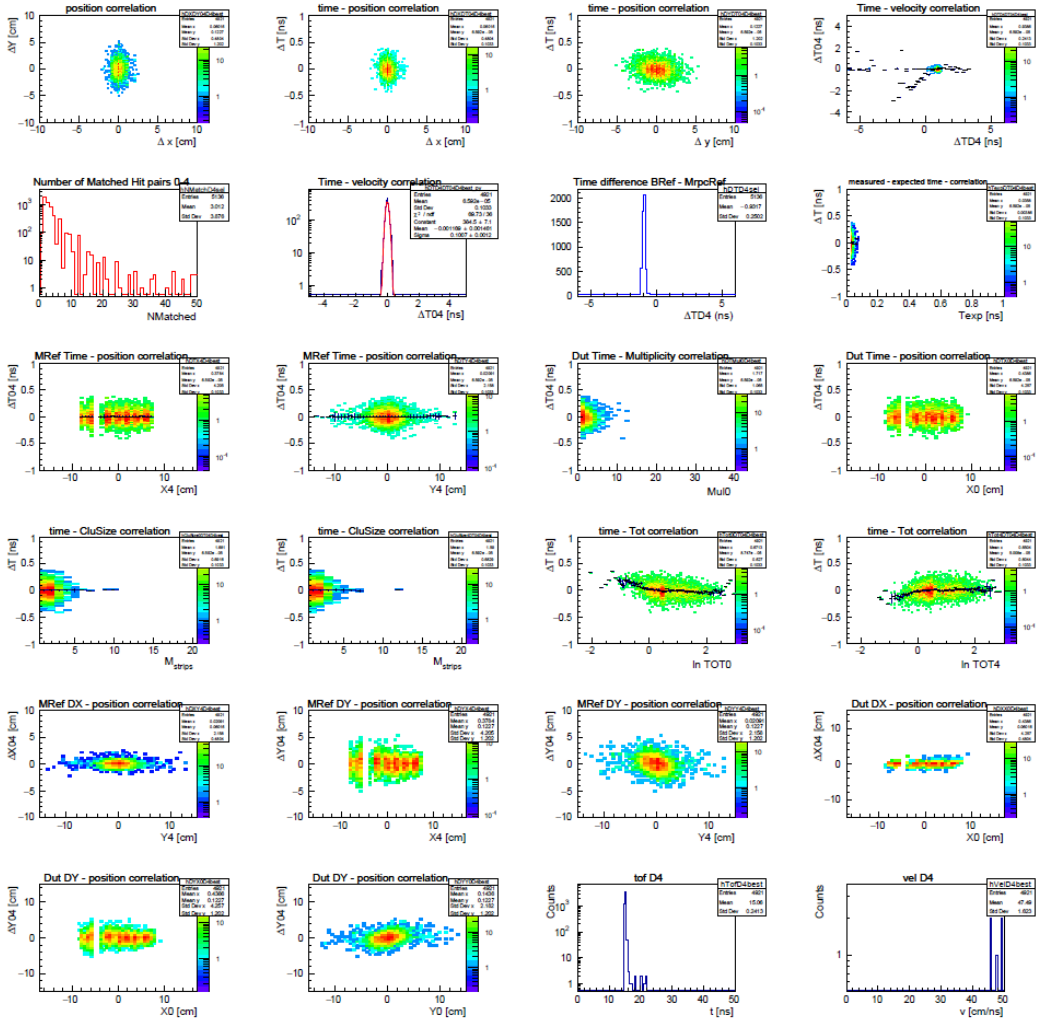
pl_over_cluSel0_7_0_2



Cosmic Test: Calibration & Analysis

Analysis: **Dut: 701; Ref: 702; Sel2/BRef: 700**

pl_over_Mat04D4best

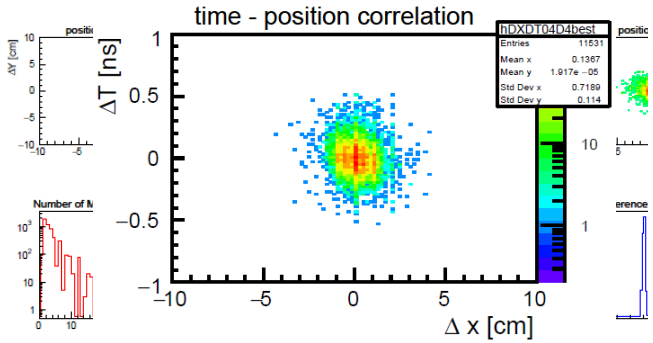


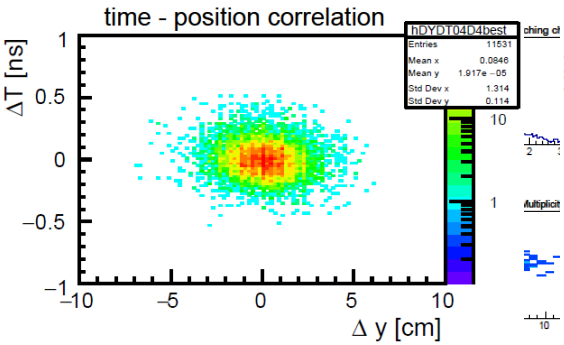

```
tofAnaTestbeam->SetDXWidth(1.2);
tofAnaTestbeam->SetDYWidth(2.0);
tofAnaTestbeam->SetDTWidth(0.15;
tofAnaTestbeam->SetPosY4Sel(1*dScalFac);
tofAnaTestbeam->SetDTDia(0.);
tofAnaTestbeam->SetCorMode(iGenCor);
tofAnaTestbeam->SetMul0Max(400);
tofAnaTestbeam->SetMul4Max(20);
tofAnaTestbeam->SetMulDMax(20);
tofAnaTestbeam->SetHitDistMin(10.);
tofAnaTestbeam->SetDTD4MAX(6.);
tofAnaTestbeam->SetPosYS2Sel(1*dScalFac);
tofAnaTestbeam->SetChS2Sel(0.);
tofAnaTestbeam->SetDChS2Sel(100.);
tofAnaTestbeam->SetChi2Lim(5.);
tofAnaTestbeam->SetChi2Lim2(2.);
tofAnaTestbeam-
>SetEnableMatchPosScaling(kFALSE);
tofAnaTestbeam->SetCh4Sel(15);
tofAnaTestbeam->SetDCh4Sel(15*dScalFac);
```

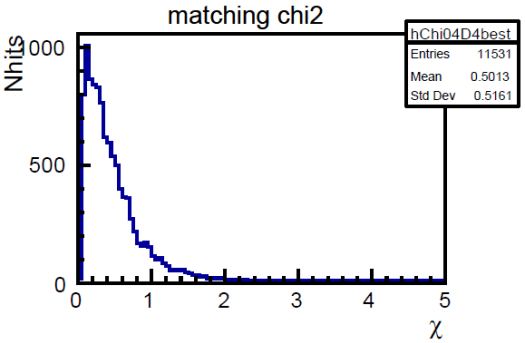
Cosmic Test: Calibration & Analysis

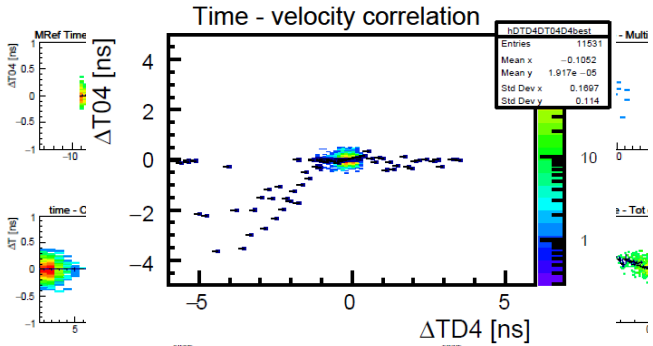
Analysis: **Dut: 701; Ref: 702; Sel2/BRef: 700**

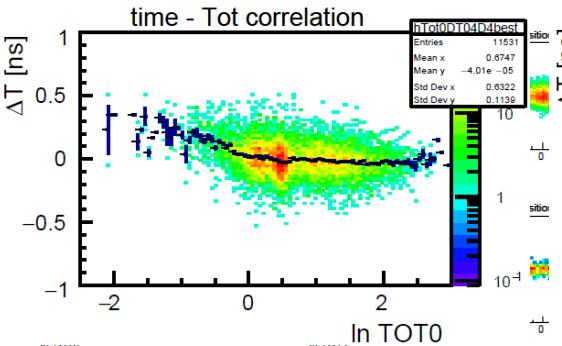
pl_over_Mat04D4best

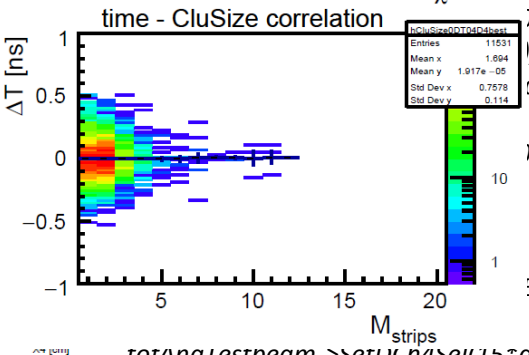


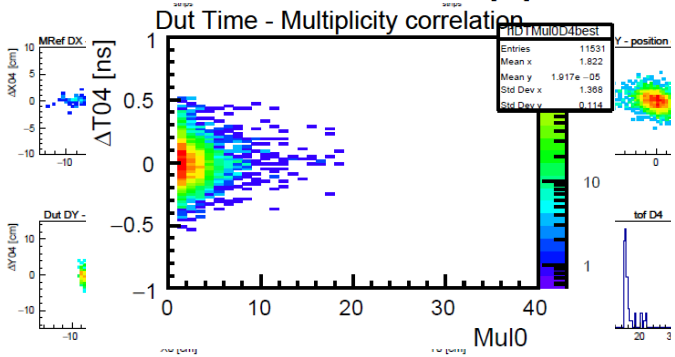


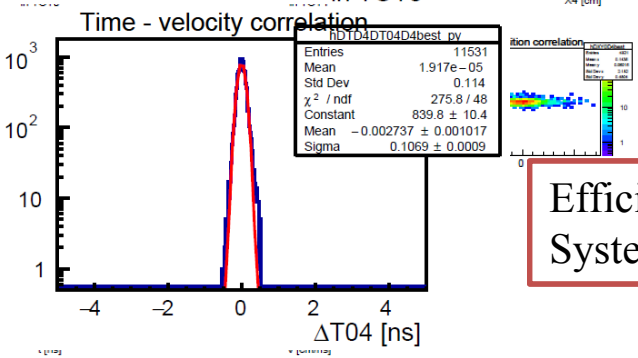













```
tofAnaTestbeam->SetDch4Sel(15*dScalFac);
```

Efficiency: 96%
System time resolution: 100ps

Cosmic Test: Calibration & Analysis

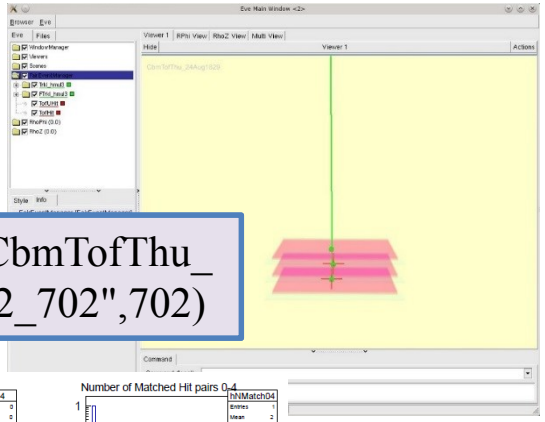
The 3 MRPCs are supposed to have the same performance. However, their behaviors are not consistent under **different calibration mode**.

Dut	Ref	BRef/ Sel2	Eff	Time Resolution/ps	Clustersize Dut	Clustersize Ref	Event number	Calibration mode
700	701	702	98.4%	35.7	1.5	1.7	14414	700701702
700	702	701	97.6%	35.5	1.6	1.7	15320	700702701
701	700	702	94.5%	153.1	2.2	1.5	973	701700702
701	**702**	**700**	**96.3%**	**106.9**	**1.7**	**1.6**	**11976**	**701702700**
702	700	701	84.0%	153.8	2.0	1.6	1336	702700701
702	701	700	92.3%	127.4	1.6	1.7	15078	702701700

When 700 is Dut, unreasonably good time resolution is got. When 700 is Ref, we lost most of the entries, and the performance deteriorates.

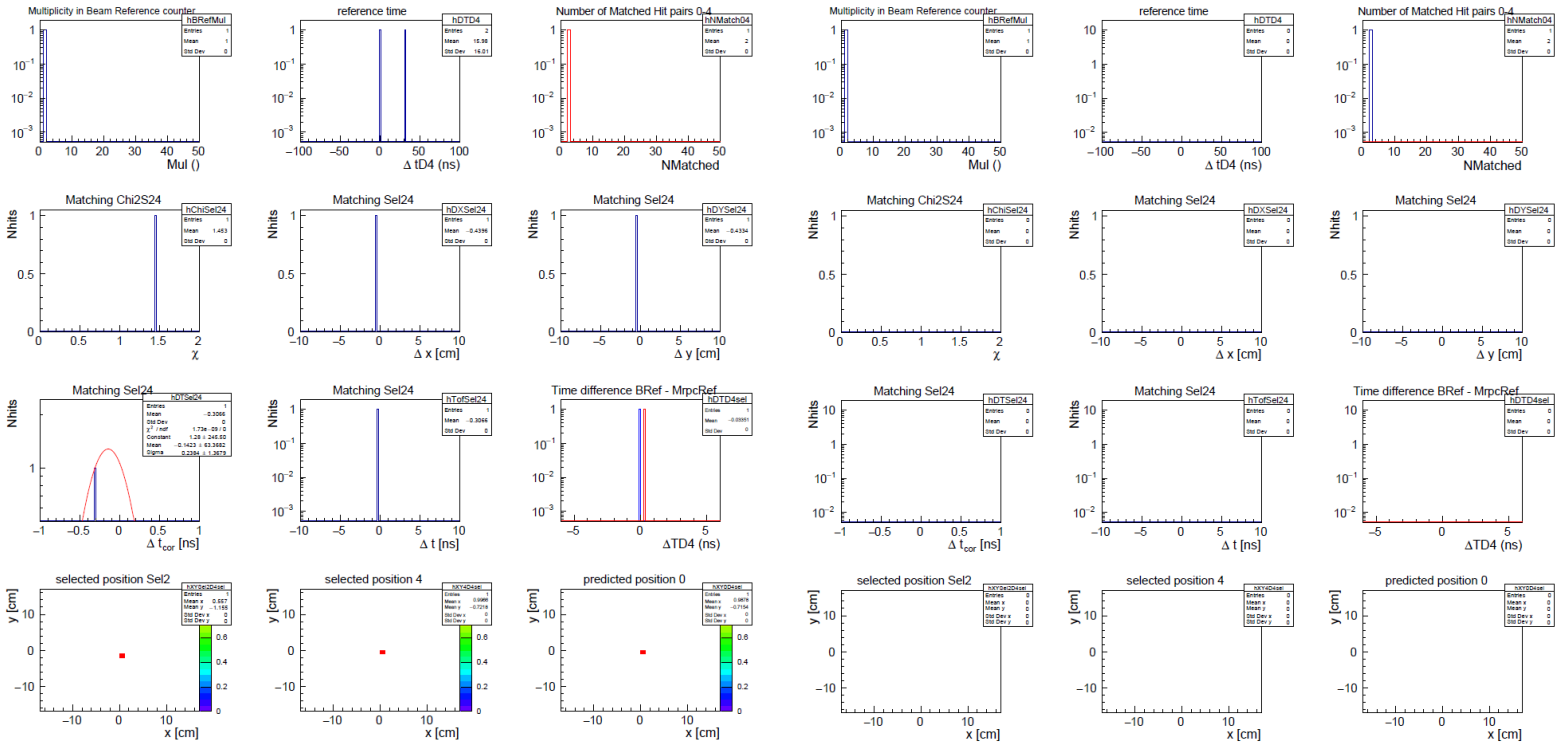
Cosmic Test: Calibration & Analysis

Tracking method is applied to find how most of the entries are lost in analysis class.



dis_hits.C(1,700701,1,"CbmTofThu_24Aug1829","**700701**702_702",702)

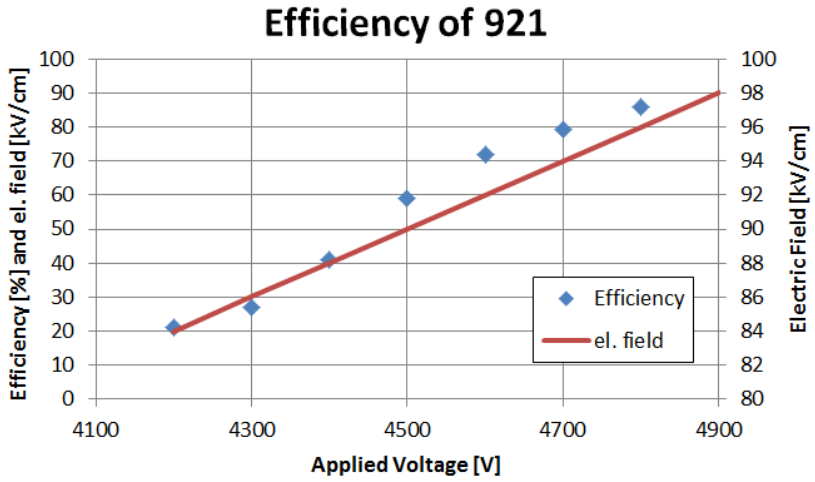
dis_hits.C(1,701700,1,"CbmTofThu_24Aug1829","**701700**702_702",702)

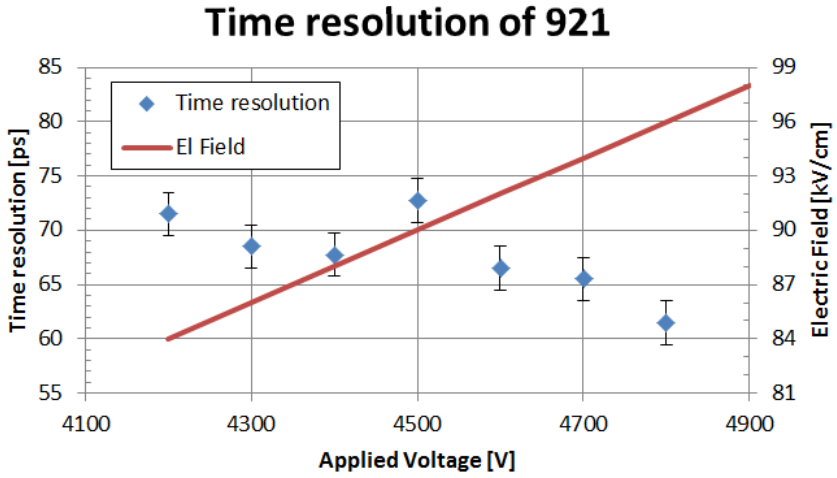


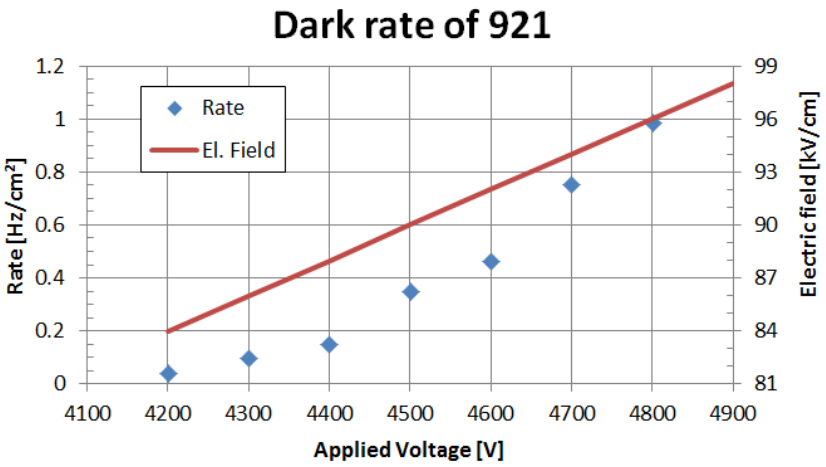
Cosmic Test: Non SF_6 Test

MRPC3a is required to work with **non-SF_6 gas mixture** at STAR.

From Ingo's talk





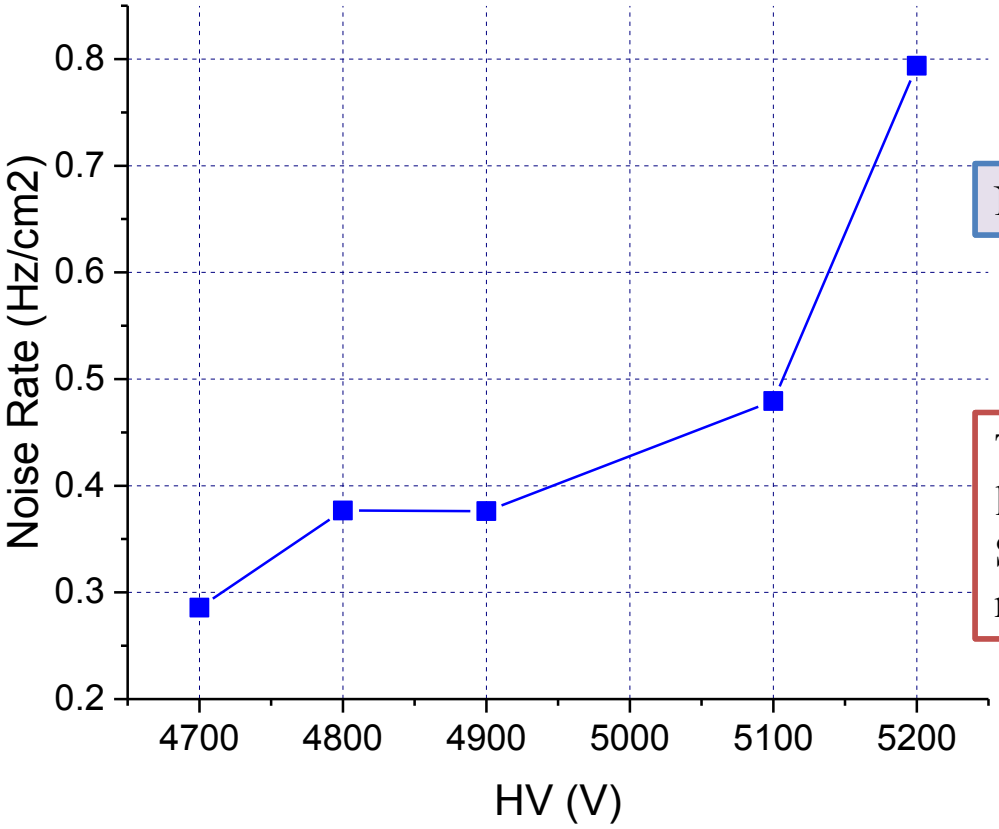


In Heidelberg's test, MRPC3a composed of low-resistive glass reaches 86% efficiency at 4800V without SF_6. Because of lower electric field, the time resolution worsens.

Cosmic Test: Non SF_6 Test

Similar non SF_6 test is repeated in Tsinghua.
Threshold: -300 mV; Gas: **95% Freon + 5% C_4H_{10}**.

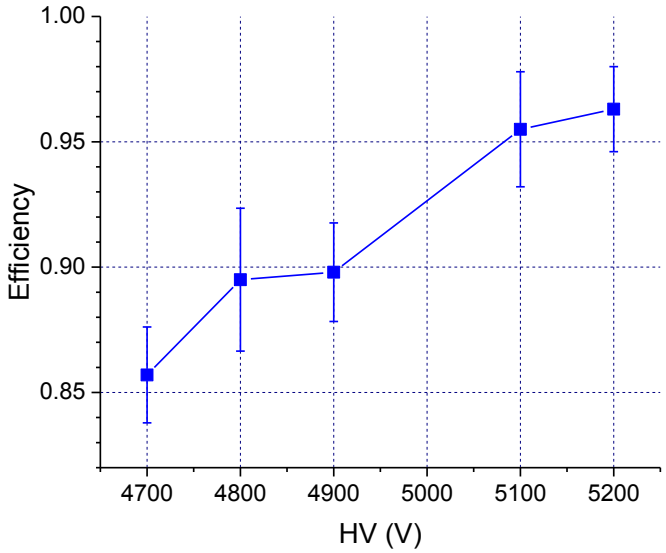
The dark current of 701 (MRPC3a - 002) always stays at **+0.01 μA / -0.01 μA** with HV increasing.

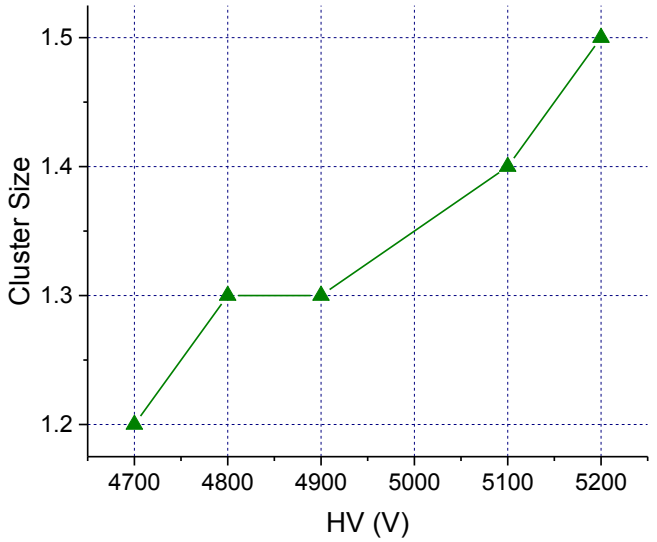


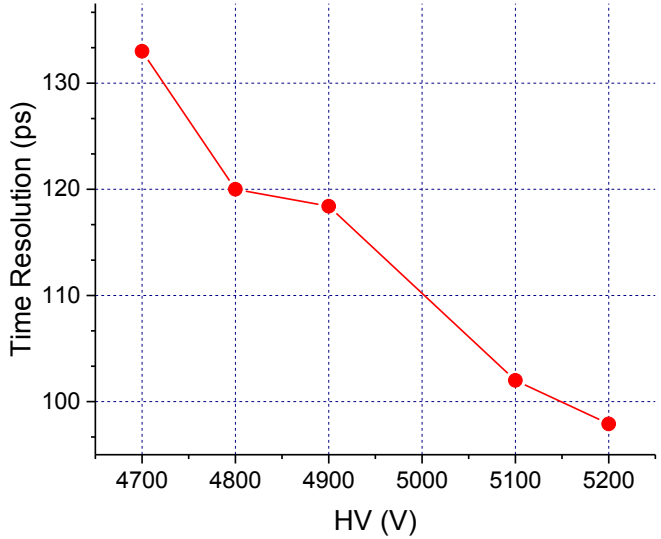
Noise rate of 701 (MRPC3a - 002)

The noise rate should be at same level to reach the same efficiency. So HV is increased to 5200 V to reach the nominal point.

Cosmic Test: Non SF_6 Test







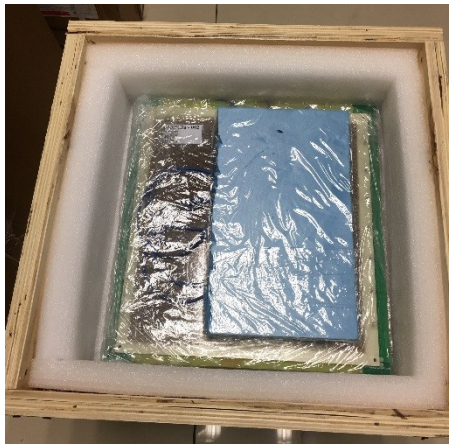
Dut: 701; Ref: 702; Sel2/BRef: 700.
Calibration mode: 701702700.

The working point without SF_6 is 400V below that with SF_6, with an efficiency of 96%, system time resolution below 100 ps and 1.5 clustersize.

Plan and Time Line

Time line for the mass production of MRPC3a.

2017	1	2	3	4	5	6	7	8	9	10	11	12
R&D												
Materials												
1st batch production (6 pieces)						1st	1st	1st				
2nd batch production (34 pieces)									2nd	2nd	2nd	
Quality assurance						1st	1st	1st	2nd	2nd	2nd	
HV & Cosmic test						1st	1st	1st	1st	2nd	2nd	
Shipment									1st		2nd	2nd



40 MRPC3a detectors will be shipped to Heidelberg in August 2017, by a conservative estimation according to the table of time line.

3 counters among the 6 are already packed and shipped to Heidelberg.

Summary

- The mass production of MRPC3a counters has begun, and the first batch 6 counters are produced.
- All these counters meet the quality assurance requirement.
- Three counters (00, 02, 03) have been tested at nominal voltage with dark current around 10 nA and noise rate around 1 Hz/cm^2.
- TRB system was established in Tsinghua lab. Data acquired from cosmic looks promising, but we are still debugging on the analysis.
- MRPC3a counter is capable to keep the performance without SF_6.
- All 40 MRPC3a counters are expected to be ready and shipped to Heidelberg by the end of December this year.

Thank You!

- Lyu Pengfei
- Department of Engineering Physics,
- Tsinghua University, Beijing, China

- September 23rd, 2017
- CBM-STAR Day,
  30th CBM Collaboration Meeting

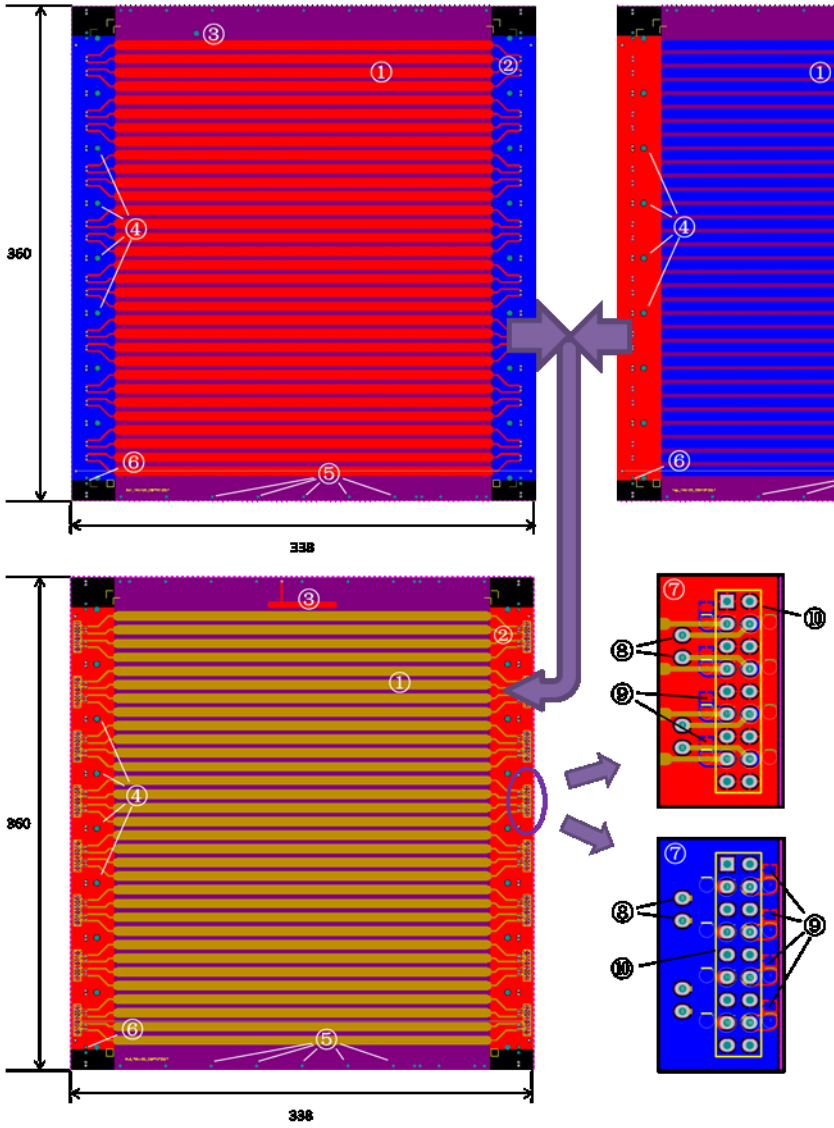
Backup

Materials for one MRPC3a counter

Material	Length/mm	Width(Diameter)/mm	Thickness(Height)/mm	Quantity	Description
Low-resistive glass	330 ± 0.2	276 ± 0.2	0.7 ± 0.02	10	~ 2×10^{10} Ωcm
HV graphite spray	324 ± 0.5	270 ± 0.5	0.005	4	< 10 MΩ/sq
Top PCB	360 ± 0.2	338 ± 0.2	0.8 ± 0.05	1	
Bottom PCB	360 ± 0.2	338 ± 0.2	0.8 ± 0.05	1	
Middle PCB	360 ± 0.2	328 ± 0.2	1.6 ± 0.05	1	
Protective resistor	/	/	/	128	200 kΩ, 0603
Honeycomb	333 ± 1	310 ± 1	6 ± 0.2	2	
Block A	23 ± 0.2	10 ± 0.2	4 ± 0.05	8	PTFE
Block B	14 ± 0.2	10 ± 0.2	4 ± 0.05	4	PTFE
Mylar	340 ± 0.2	286 ± 0.2	0.25 ± 0.02	8	
HV cable	1000	3	/	3	
Fishing line	26000	0.25 + 0.005	/	/	
M2.5 screw (nut)	40	2.5	/	32	Nylon
M4 screw (nut)	40	4	/	16	Nylon
2 × 9 connector	/	/	/	16	
Pin	19	0.6	/	100	
Carbon tape	50	50	0.13 ± 0.02	/	~ 100 kΩ/sq

CAF4 for isolating, copper foil for HV making, absolute ethanol for cleaning are not included in this list.

Materials: PCB Board



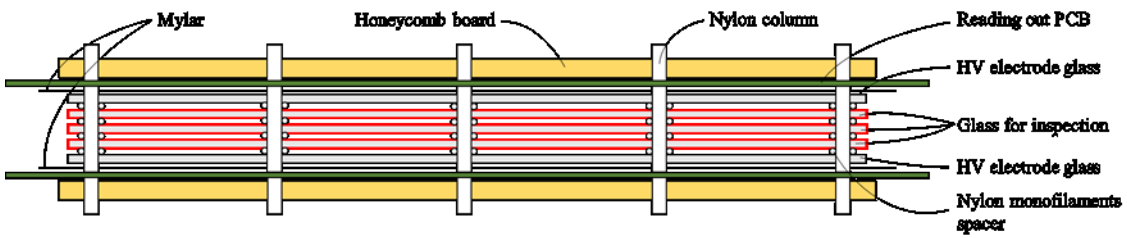
Design of **top/bottom PCB**:
① 32 readout strips on a 10 mm pitch with 3 mm interval.
② Transmission feedthrough.
③ Installing holes for HV.
④ Mounting holes.
⑤ Installing holes for fishing line columns.
⑥ Installing holes for blocks.
⑦ Copper foil.

Design of **middle PCB**:
⑧ Signal transmission pins from bottom/top readout PCBs.
⑨ 200 kΩ protective resistors.
⑩ 2×9 connectors for signal output to PADI.

Design values of these PCBs:
Copper foil thickness: 0.035 mm.
Dielectric constant: 4.6.

Quality Assurance

Material	Requirement	Measurement
Low-resistive glass	Dimension: 330 (± 0.2) × 276 (± 0.2) × 0.7 (± 0.02) mm^3	Micrometer screw caliper
	Defects: no visible scratch, fracture, and pinhole	Eye inspection in light
	Dark current: < 80 nA at 6000V	Test module for glass inspection
PCB board	Dimension: 360 (± 0.2) × 338 (± 0.2) × 0.8/1.6 (± 0.05) mm^3	Vernier caliper
	Defects: no visible scratch and spot	Eye inspection in light
	Quality: connection, no shortcut, 200 kΩ resistor	Voltmeter
Honeycomb board	Dimension: 333 (± 1) × 310 (± 1) × 6 (± 0.2) mm^3	Vernier caliper
	Defects: no visible scratch	Eye inspection in light
Mylar	Dimension: 340 (± 0.2) × 286 (± 0.2) × 0.25 (± 0.02) mm^3	Micrometer screw caliper
	Defects: no visible scratch and loophole	Eye inspection in light
Carbon tape	Height: 0.13 (± 0.02) mm	Micrometer screw caliper
	Surface resistance: ~ 100 kΩ/sq	Ohmmeter
Graphite electrode	Dimension: 324 (± 0.5) × 270 (± 0.5)	Vernier caliper
	Defects: no visible scratch and loophole	Eye inspection in light
	Surface resistance: < 10 MΩ/sq	Ohmmeter
Fishing line	Dimension: 330 (± 0.2) × 276 (± 0.2) × 0.7 (± 0.02) mm^3	Micrometer screw caliper



Test module for **glass inspection**. Each batch of glass should be examined before they are applied into assembling of counters.

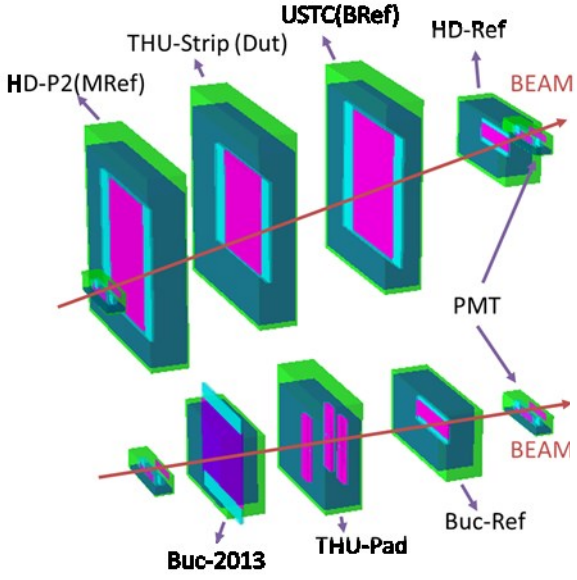
Test and Analysis: Cosmic-Ray Test

The performance requirement of the MRPC3a counter in cosmic-ray test.

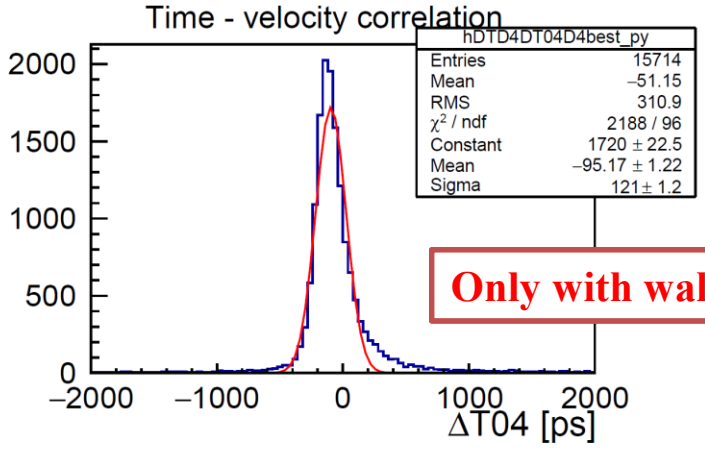
Testing conditions	Specification	Requirement
Working gas: 90% $C_2H_2F_4$, 5% i-C_4H_{10} and 5% SF_6	Dark current	< 50 nA
	Efficiency	> 95%
HV: 5500 V	System time resolution	< 125 ps
PADI threshold: 350 mV	Cluster size	< 2

Run 01Mar2217 SPS Feb 2015 (no diamond):

The time resolution in cosmic-ray can't be as good as that in beamtest (velocity correction not sufficient).



Without any cuts: 103 ps



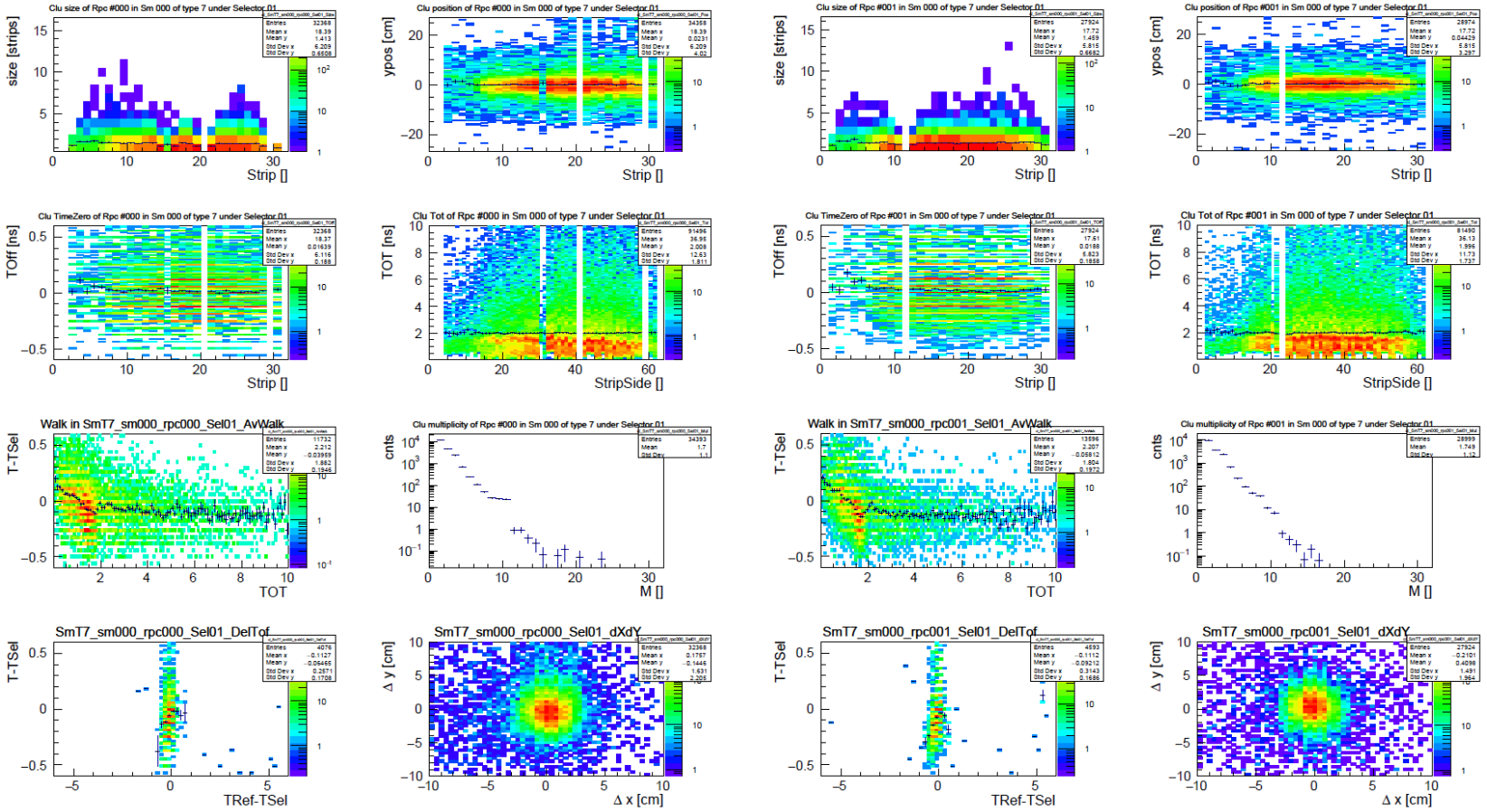
Only with walk correction: 121 ps

Cosmic Test: Calibration & Analysis

Comparison between calibration mode 700701702 and 701700702.

pl_over_cluSel1_7_0_0 **700701702**

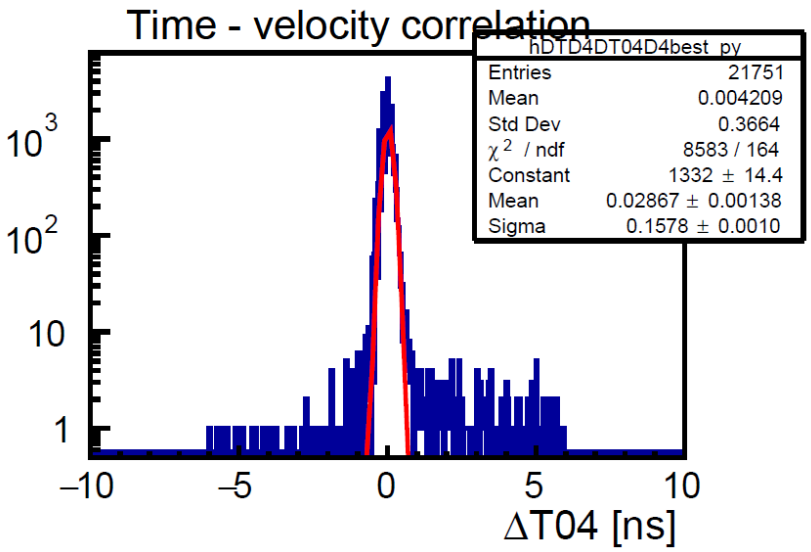
pl_over_cluSel1_7_0_1 **701700702**



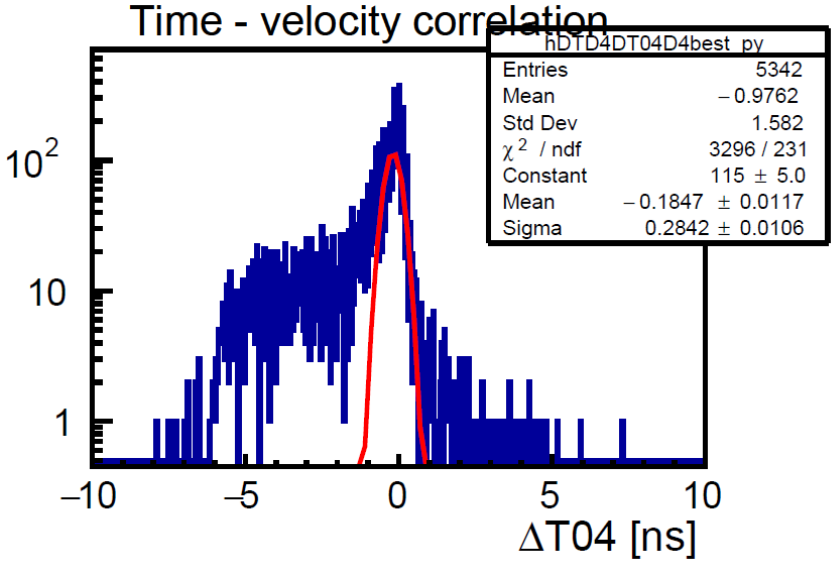
Cosmic Test: Calibration & Analysis

Comparison between calibration mode 700701702 and 701700702.

pl_over_Mat04D4best **700701702**



pl_over_Mat04D4best **701700702**



All the products have been uploaded to Kronos under path:
/lustre/nyx/cbm/users/plyu/CbmTofThu_24Aug1829