STRAW Setup

Future large Straw Trackers and requirements for read-out

- **SHiP** ~20k channels, **time** (~ns), optional **Q** (signal vs noise, signal (*mu*) vs BG (*e*))
- **DUNE** ~200k channels, **time** (~ns), **Q** (PID)
- **SPD** ~20k channels, **time** (~ns), **Q**(PID)

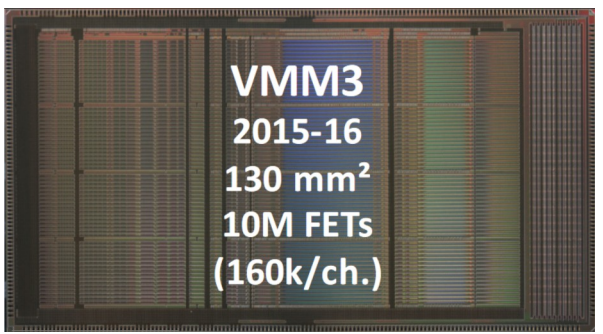
DEEP UNDERGROUND NEUTRINO EXPERIMENT

SHiP
Search for Hidden Particles

Multifunctional Application Specific Integrated Circuit (ASIC)
VMM3 [6]
•widely used as readout of micro-pattern gas detectors
•was a base for the production VMM3a version for the
•ATLAS New Small Wheel readout

•flexible settings of analogue input circuitry
•charge measurements (nominally 10b ADC)
•time measurements (nominally 8b TDC)

•time-at-threshold (T@T)
•time-at-peak (T@P)



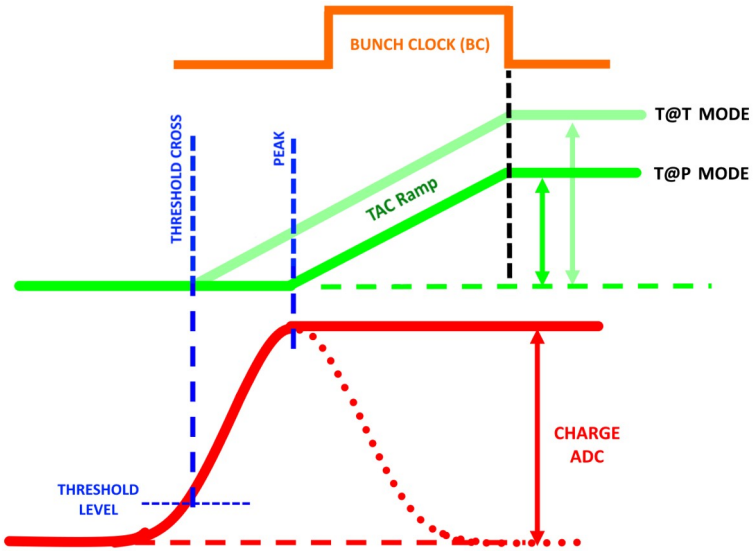
April - May 2022, Testbeam

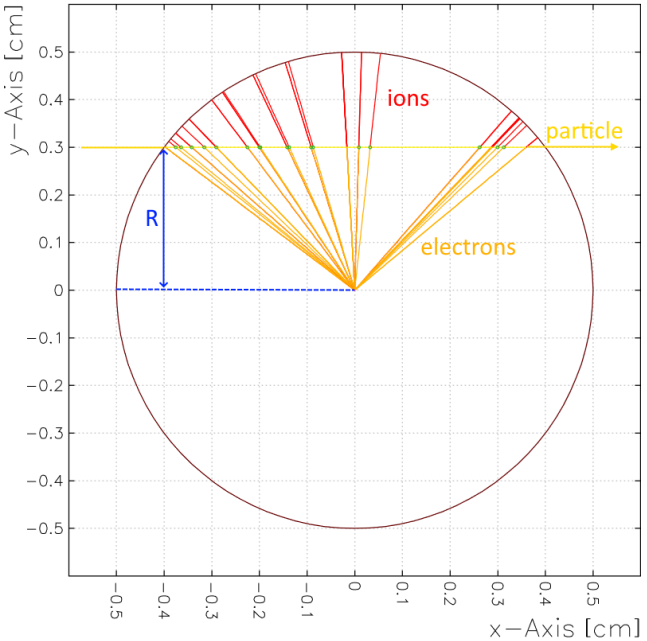
Studies and Setup

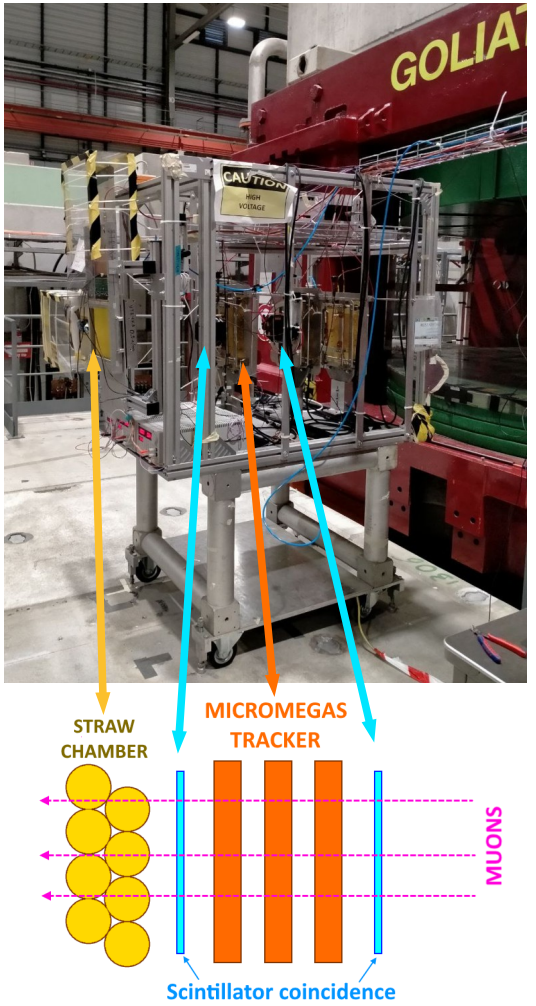
Track coordinates are reconstructed on the measured signal arrival time defined by the drift time of primary electrons from the track to the anode wire.

The drift time $time_{drift}$ is measured as a difference between the time when a particle crossed the straw and the time of straw signal crossing a low threshold.

Last testbeam showed inability of using T@T mode with VMM3a







The distance between the track and anode wire is obtained from a measured or simulated $r(time_{drift})$ dependence

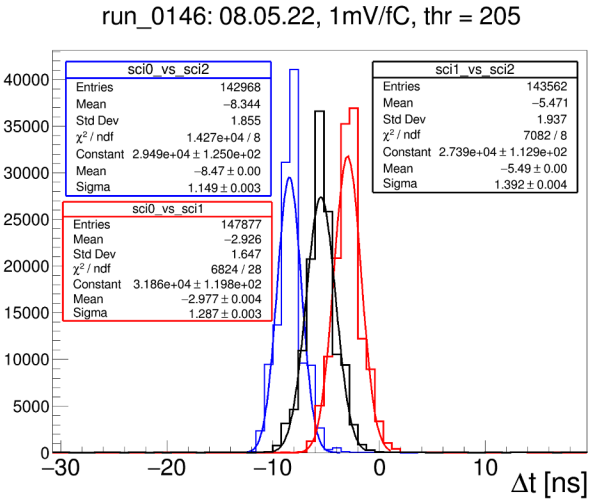
READOUT

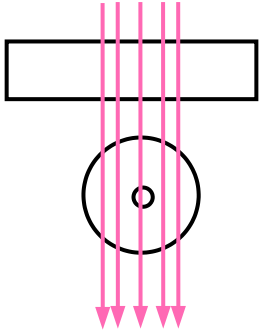
- Straw and reference MM tracker are read out with independent DAQs (VMM and APV based)
- No way for hardware synchronisation out of box
- Testbeam datatacking was implemented in several stages
- Stage 0 – Mu2E readout stability
- Stage 1 – Mu2E + scintillator correlation
- Stage 2 – Mu2E + APV25 double readout for one of MMs

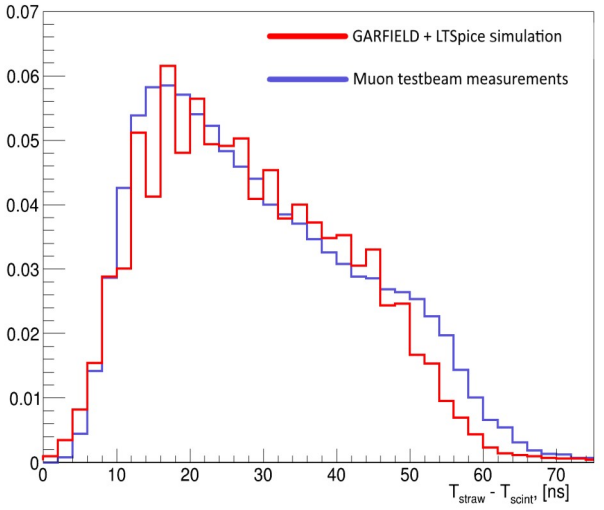
Stage 0: Straws + scintillators, common mu2e read out (time@threshold mode)

Goal:

- Read-out validation, including VMM3 operation in **t@t**
- Choice of optimal straw/VMM3 operation parameters
- Straw HV (scan) - **done**
- Gain and thresholds of the VMM3 - **done**
- Scintillator timing validation - **done**
- Validation of the reconstruction procedure — **done**







Stage 0 preliminary results :

- reconstruction validation
- event synchronization
- straw-scintillator and straw-straw time correlations

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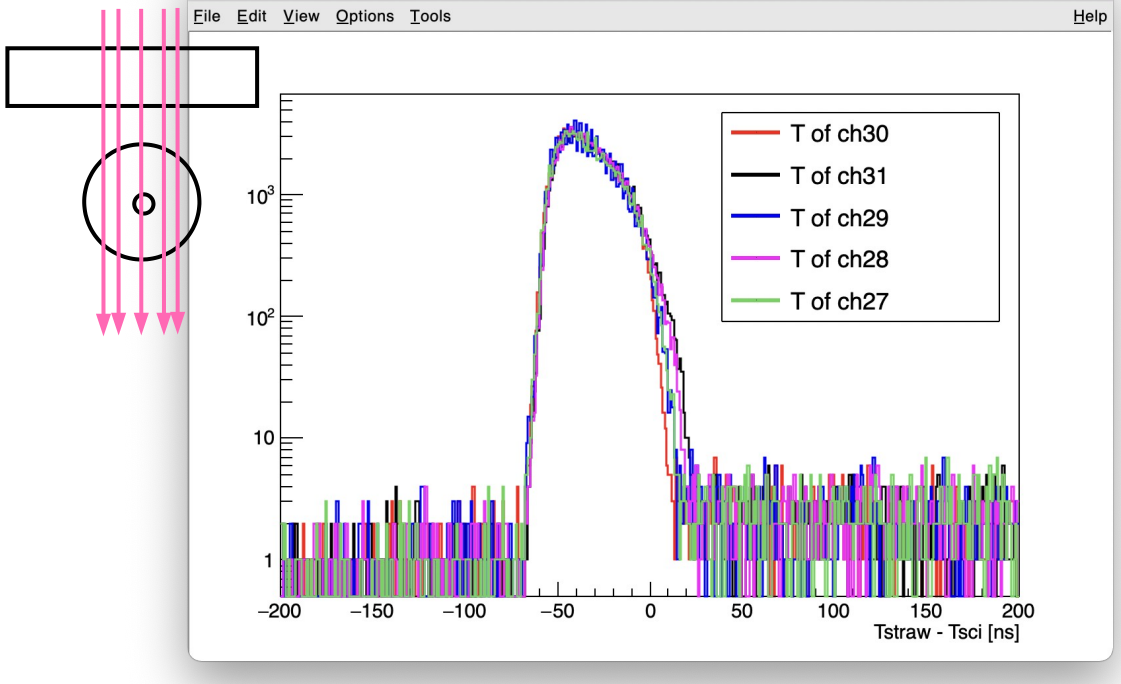
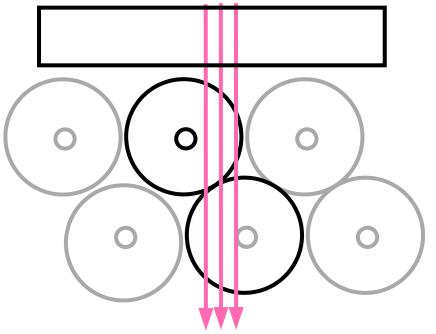
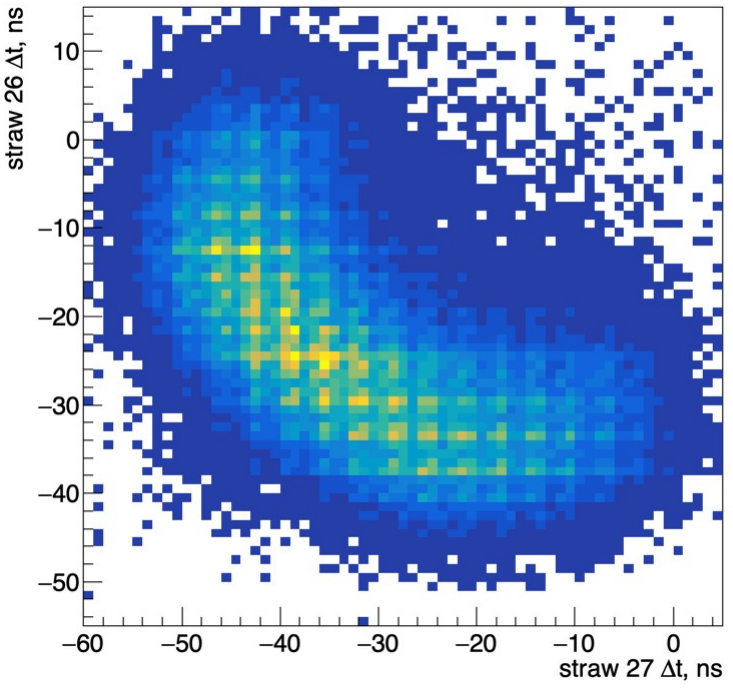
reconstruction validation, event synchronization,

straw-scintillator and straw-straw time correlations

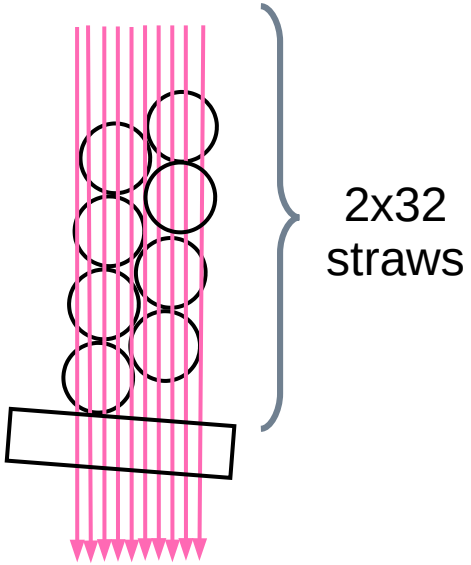




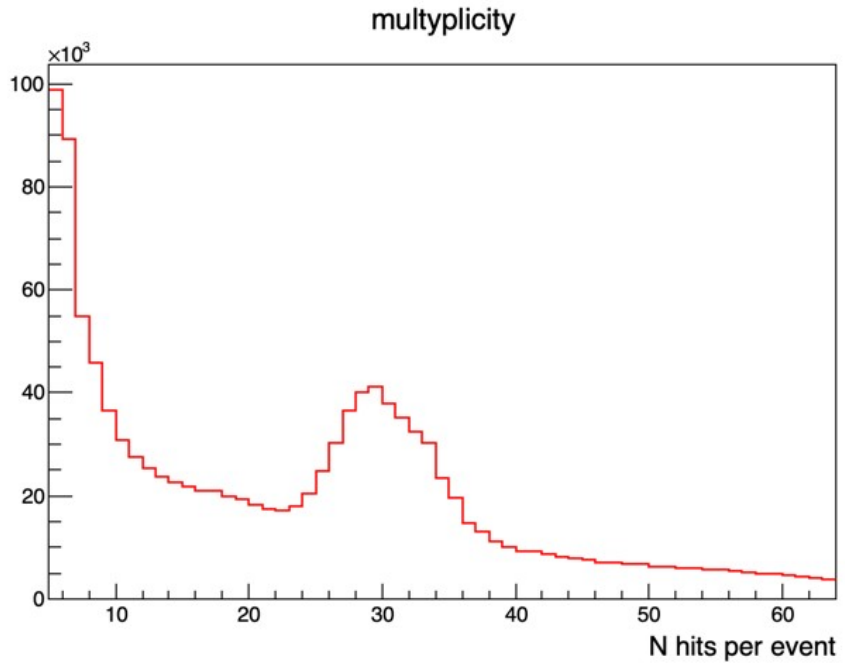
straw26_vs_straw27_banana



Stage 1: Straws + scintillators, common mu2e read out at t@t with the ROTATED SETUP



- **Goal:**
- Minimalistic (self)tracking with 32 straws – possibility to get rough(?) coordinate information from straws themselves
- Possibility to get rough R-T dependence
-



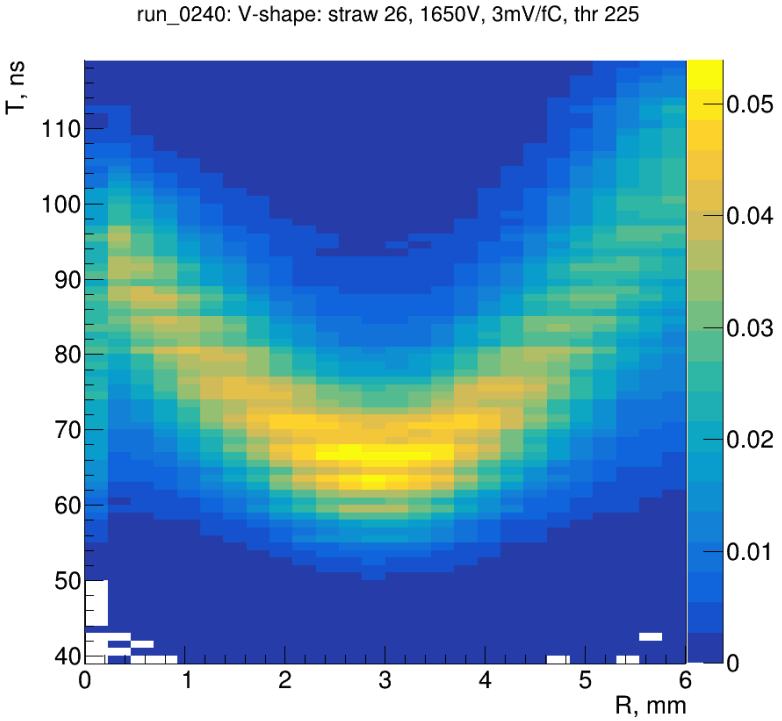
Very rough estimate: O(100k) tracks for every HV and gain settings

Data treatment requites a quite sophisticated analysis

Stage 2 :
6 straws + 2 scint + 56 MM1 strips with VMM3 read out
And (MM1), MM2, MM3 with APV read out

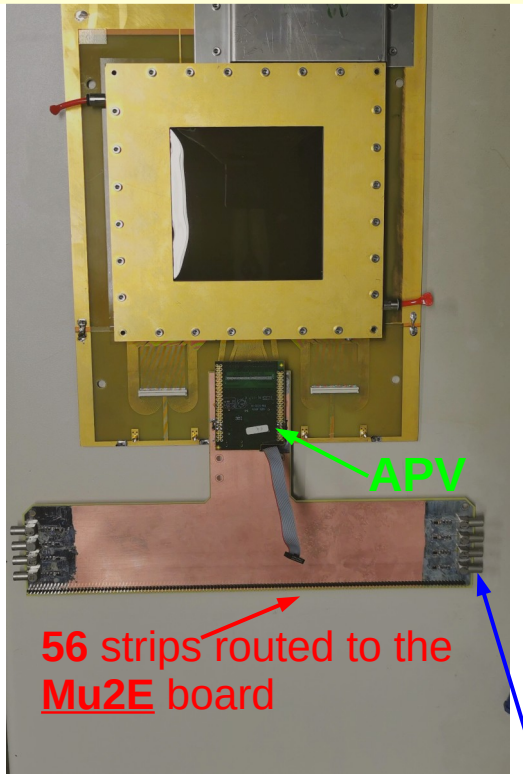
- **Goal:**
- To get **hits from 50 MM1 strips** synchronized with **hits from 6 straws and two scintillators** via the VMM3 read out
- **The same 50 MM1 strips** to be read-out **via APV** within the standard MM1+MM2+MM3 DAQ chain (optional)

The cross-board with the double readout option has been produced!



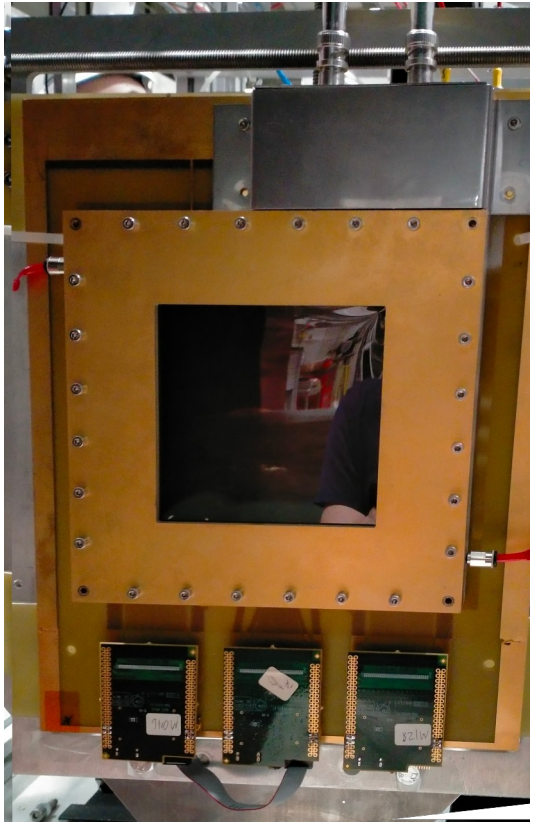
Offline analysis:
Merging two events from different DAQs according to hit positions in the "double readout" MM1 area mapping the MM1 hits in mu2e with MM2+MM3 APV DAQ
(minimalistic option)

Expected result:
A high precision R-T curve



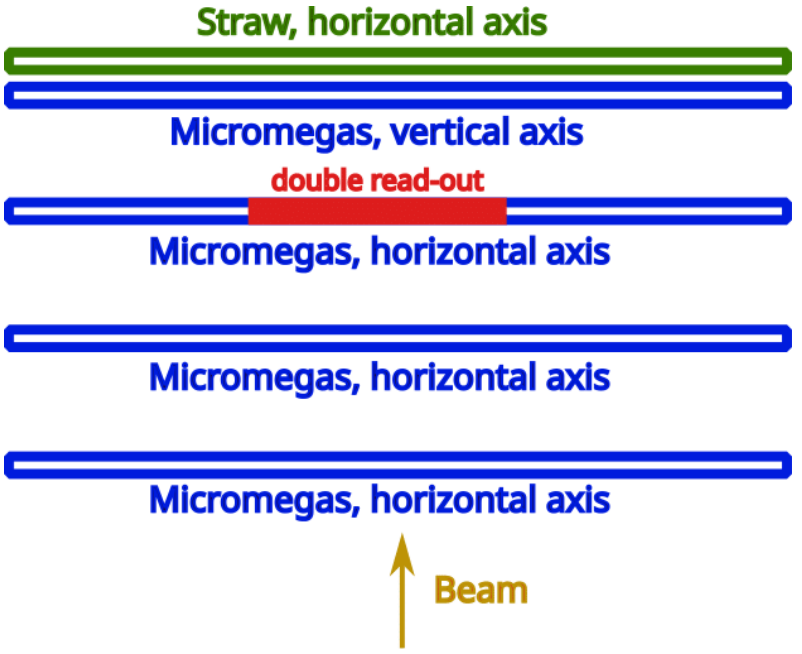
4+4 LEMO inputs for Straw and scintillator readout

Setup tracking system

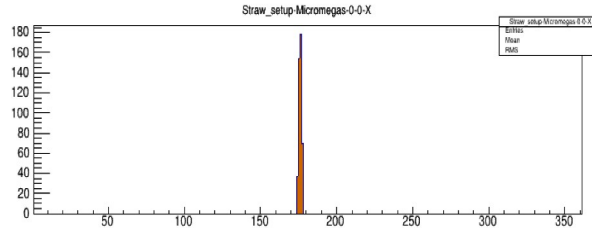


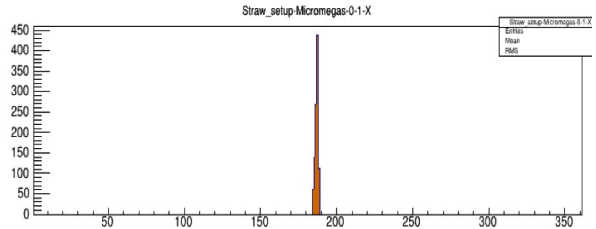
4 one-layer MicroMegas:
•3 horizontal
(same direction as straw)
•1 vertical, for alignment

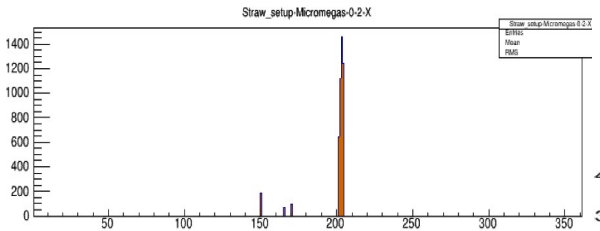
Data from each MicroMegas collected with 3 APV.
DAQ: mmdaq3

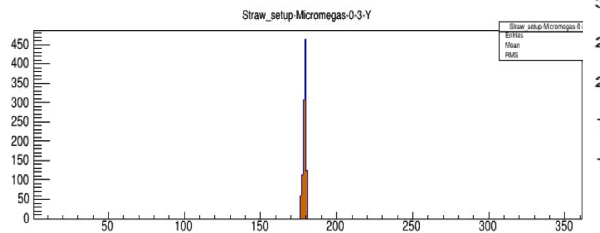


Merging Mu2E and Micromegas data





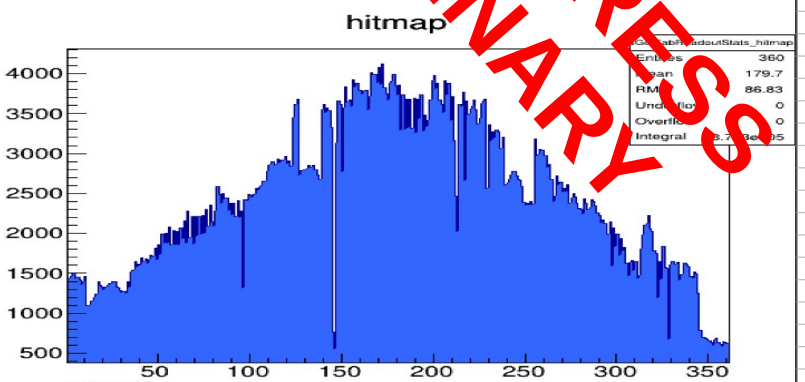




On the MicroMegas side we can see the tracks in all APV's

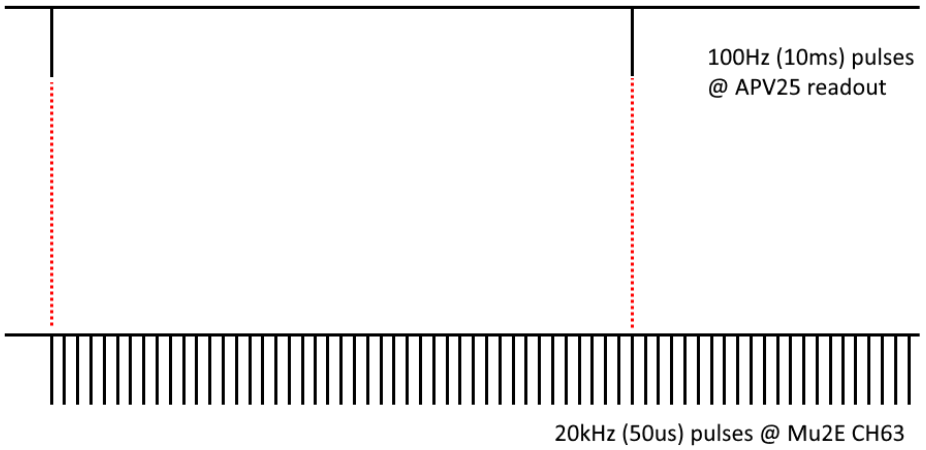
From the comparison of events in in APV and Mu2E:

- It seems it is possible to merge some events between data from two independent DAQ systems

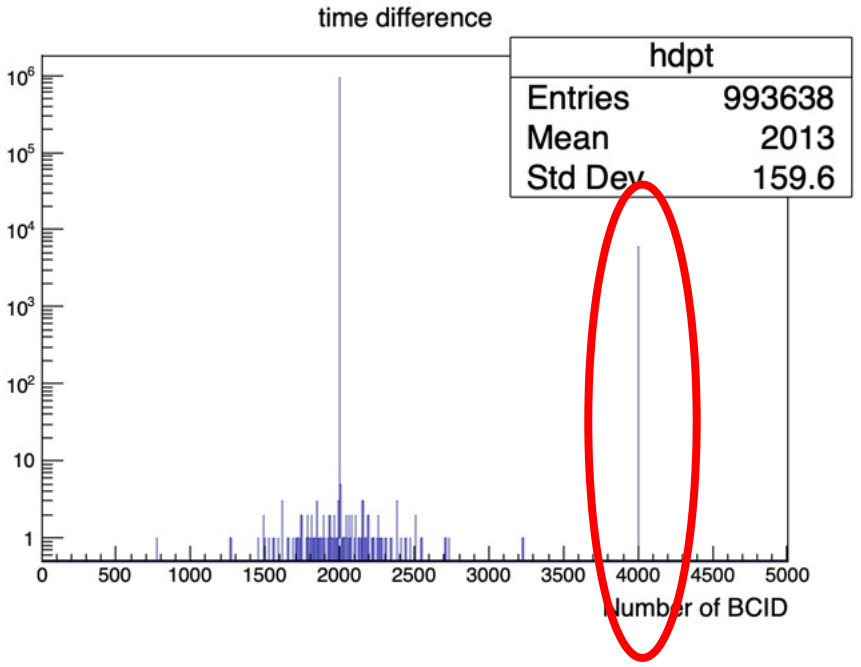


APV			Mu2E		
APV event	APV time	Hit to APV	Hit to Mu2E	Mu2E time	Mu2E event
3756	426227	186 *			
3758	**428569**	**207**	**207**	**430741**	**87169**
3782	458234	179 *			
			189	434050	87232
3788	465303	188 *	188	460216	87777
3793	471249	190 *	195	473159	87993
			196	479272	88116
			195	490451	88532
3813	**494945**	**186 ***	**186**	**502584**	**88645**
3837	499749	170	155	518210	89089
3841	528221	184 *			
3847	535183	163			
3849	537538	181 *			
3851	540159	165			
3854	543735	170			
3855	544872	188 *			
3867	558969	156			
3871	563993	167 *			
3881	**575680**	**204 ***	**204**	**577688**	**90327**
3897	594513	186 *			
3905	604222	193 *			
3912	**613173**	**167**	**169**	**615397**	**90990**
3921	624064	166			
3923	626633	205 *			
3924	**627840**	**174 ***	**173**	**626102**	**91149**
3925	629002	209 *	179	649375	91793
3930	635114	163			
3940	647376	177 *			
3949	**659581**	**208 ***	**207**	**660284**	**91650**
3951	662088	202 *	193	676909	91963
3970	685733	187 *			
3973	**689274**	**205 ***	**205**	**681688**	**92071**
3987	707368	176	208	691451	92255
3988	708737	199	168	692507	92274
3993	714998	180 *	167	699724	92379
3994	716185	186 *	157	701959	92423
4004	729505	174 *	157	712206	92580
4010	736509	179 *	189	737101	93001
4039	770846	197 *			
4040	772023	188 *			
4053	**788767**	**173 ***	**172**	**781998**	**93709**
4064	801720	208	156	818409	94263
4081	823165	177 *	168	824892	94356

Very last attempt to synchronize 2 read-outs



12bit BCID counter >> 4096 BCID x 25ns >> ~102us full circle



BinContent: 6362 events