# Preliminary Results of November 2021 TestBeam for Straw Tracker Prototype

Triple GEMs: Gerardo Roque (UNIANDES)

Straws: T.Enik (Dubna) / K.Kuznetzova(PNPI)

Speaker: Mikhail Demichev (JINR)

Goals of TestBeam:

1. Measure Straw detector characteristics now with VMM3(a) chip

2. Get operational knowledge of new SRS readout system

"neighbour" straws T1+T2~const

with external tracker T=f(R)
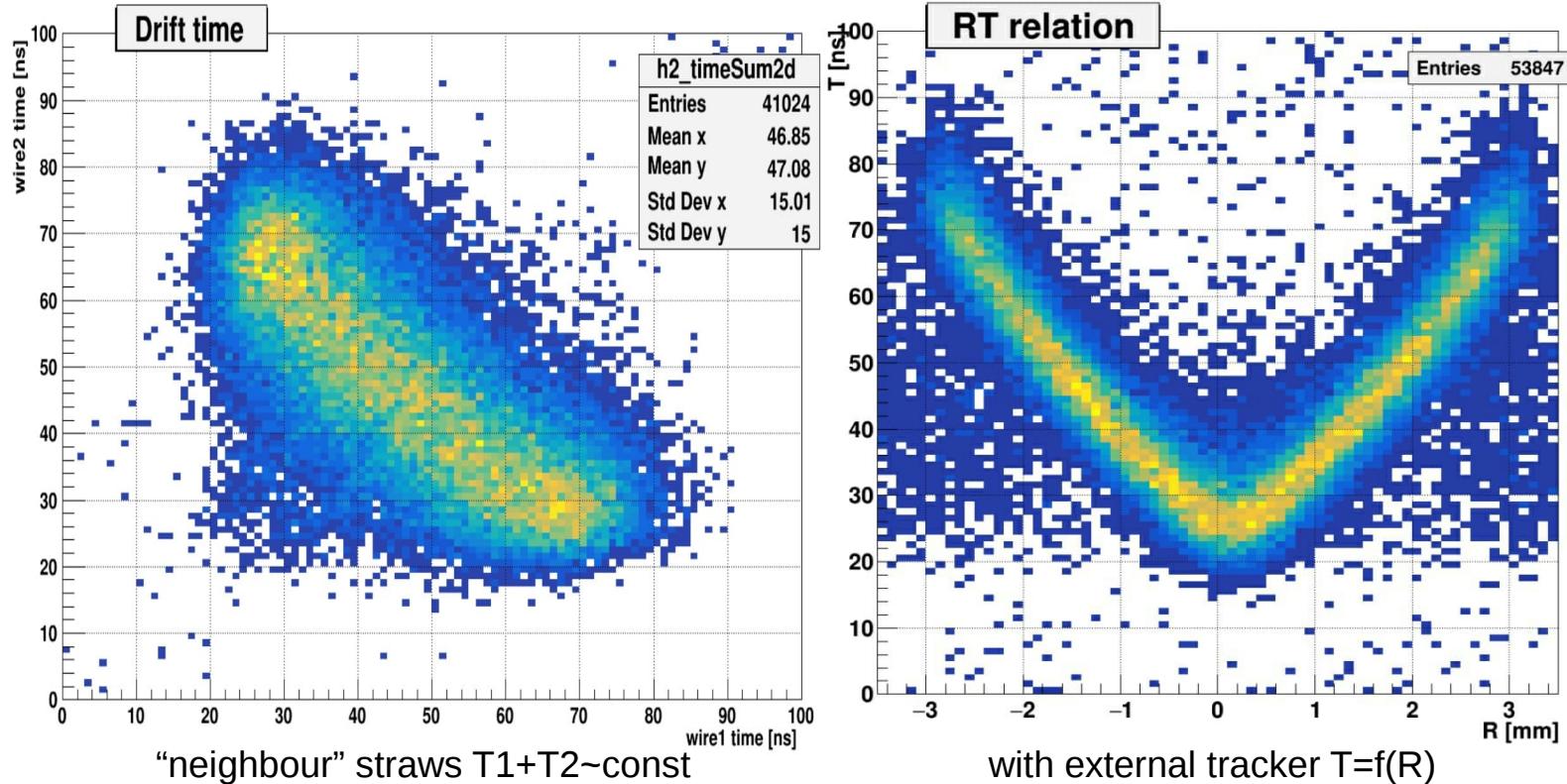
TestBeam Preparation (Dubna): VMM3 Timing Resolution

Proof of Concept:

Is VMM3 chip timing precision good enough to measure STRAW detector signals?

Mu2e board with single VMM3 is used in T@P mode

External Pulse Generator signal is splitted by 2 channels, then variable delay is introduced.

X: Setting of Delay Line Module [ns]
Y: Calibrated Time Detector Output [ns]

Calibration done by internal VMM Pulser

Time resolution is ~ 1,5 ns

p0	−2.065 ± 0.3063
p1	−0.9962 ± 0.06338

T1 vs. T2

h2T
Entries   100947

Плата Mu2e + Verso, режим Timing@Peak
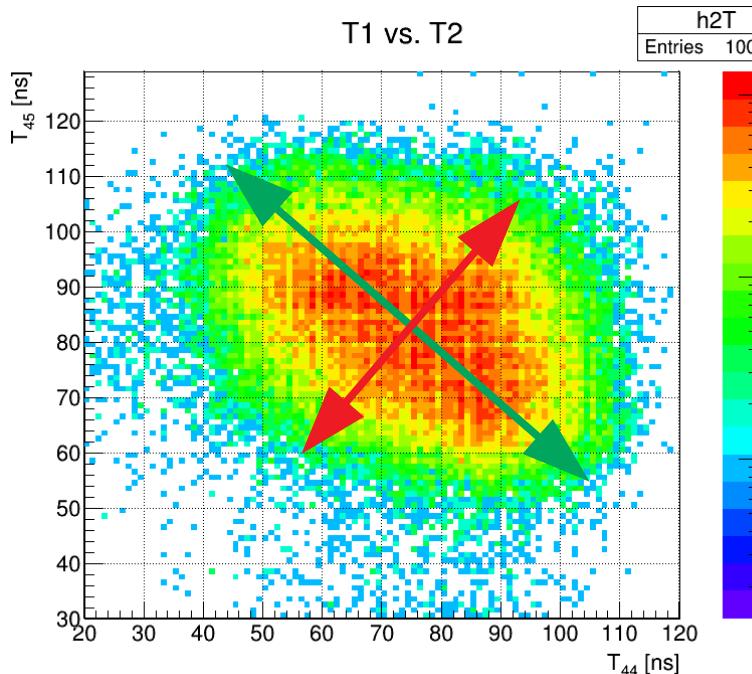
$$X = T_2 - T_0, \quad Y = T_1 - T_0$$

𝔸, Чем больше диаметр трубки, тем больше время дрейфа, тем больше растянуто по этой оси

𝔹, Чем больше джиттер триггера T0, тем больше по этой оси размазано

Наблюдаемая корреляция зависит от того, насколько оптимально заведен в VMM сигнал T0 от сцинтиллятора

Ожидается, что на пучке, для той же платы Mu2E корреляция будет заметно лучше чем на источнике, так как треки от источника Ru-106 направлены во все стороны, а не перпендикулярно плоскости детектора.

Timewalk range <4ns во всем диапазоне амплитуд

Режим работы Straw+VMM3: Gain 6mV/fC, Peak.Time 50ns, TAC 60ns, U_HV=1650V для смеси 70/30, эффективность > 75%

Скрипт с гистограммами для диагностики работы Straw

RD51 TestBeam:
SRS – Scalable Readout System

- Is developed by RD51 Collaboration, CERN
- APV25 based system is outdated, new and developing one uses VMM3a
- Front-end electronics as well as DCS, logging, monitoring and event builder
- For more info see
  - https://gitlab.cern.ch/rd51-slow-control/vmm-doc
  - https://doi.org/10.1088/1748-0221/8/03/C03015
  - Talk of Vitaly Bautin

IMPORTANT Note

The combination of VMM3a and SRS is a new system with its own pieces of software. The VMM3a is also a new chip, which works differently to previous ASICs that have been implemented into the SRS, i.e. the APV25. This means that the software for VMM3a/SRS was freshly developed. It also means that no old software for APV25/SRS was adapted towards VMM3a/SRS. It means even further, that **the user should (for the beginning) ignore all their knowledge about old or other DAQ systems** and not compare it with these previous systems.

Observed SRS Problems @ TestBeam:

1. Powering and grounding and ~~cooling~~ issues for hybrids
2. VMMs lost after non-standart detector-specific configurations
3. Some VMMs have unphysical times and amplitudes for BCID<50, affects efficiency
4. Problem with time synchronization between different FECs (External CTF/Internal Clocking)
5. Problem with time synchronization between different hybrids in one FEC

VMM3/3a Problem: Mostly at increased rate VMM channels lock in Timing@Threshold mode

Плохие и хорошие раны на SRS, Timing-at-Peak

Что видно на ~~онлайн~~-диагностике:

Соседние straw, всегда находящиеся в одном гибриде и в одном vmm, всегда укладываются в 50 ns на полувысоте.

А ширина корреляции между straw и триггером, из разных гибридов но из одного FEC – меняется произвольным образом от 50 до 500 ns.

Было предложено проводить измерения в режиме Timing@Threshold
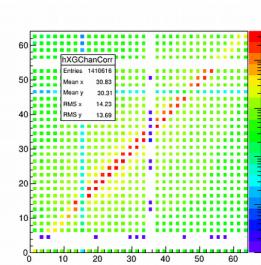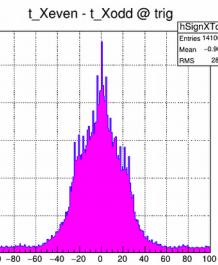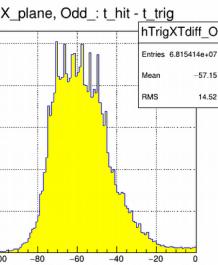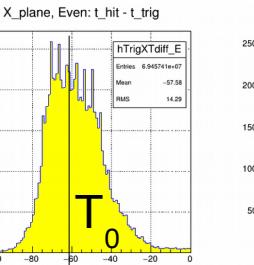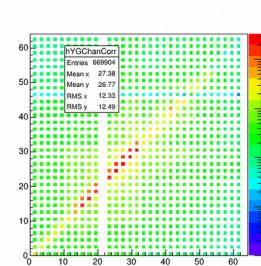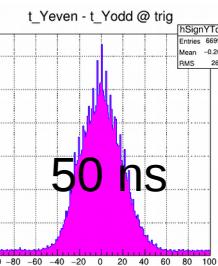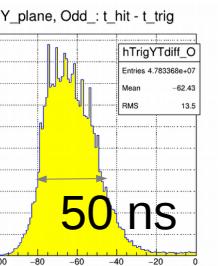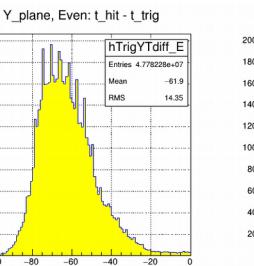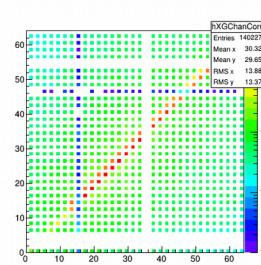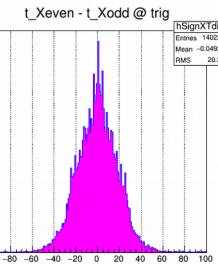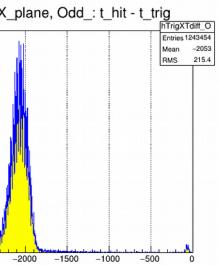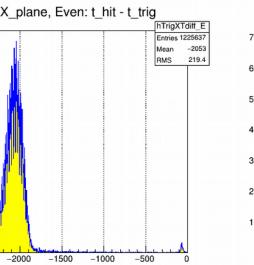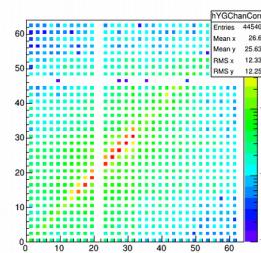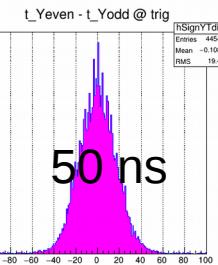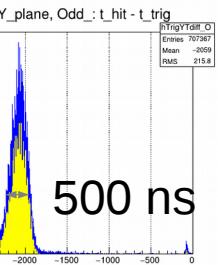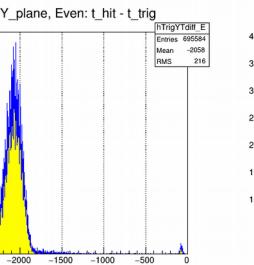
RD51 GEM
Telescope
vs.
Scintillator

(from
Lucian`s
slides)

Straw
vs.
Scintillator

T@Peak

T@THL

12 ns

12 ns

12 ns

45 ns

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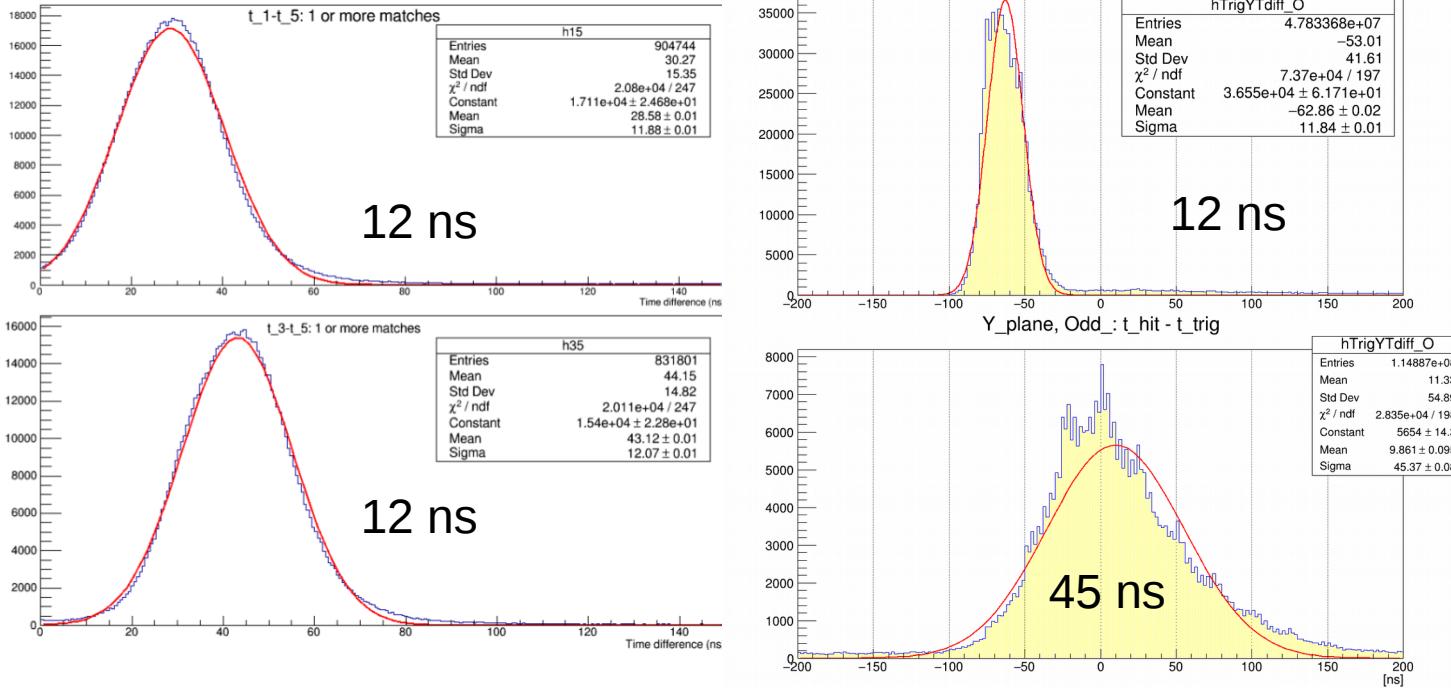
# Плохие и хорошие раны на SRS, Timing-at-Peak

В редких случаях наблюдается временная корреляция (хорошие раны),

а в основном нет, (плохие раны)

В том числе и при <u>одинаковых</u> параметрах набора данных: Scintillator+CFD, 1650V, 3/200, Timing-at-Peak


"плохой"

"хороший"
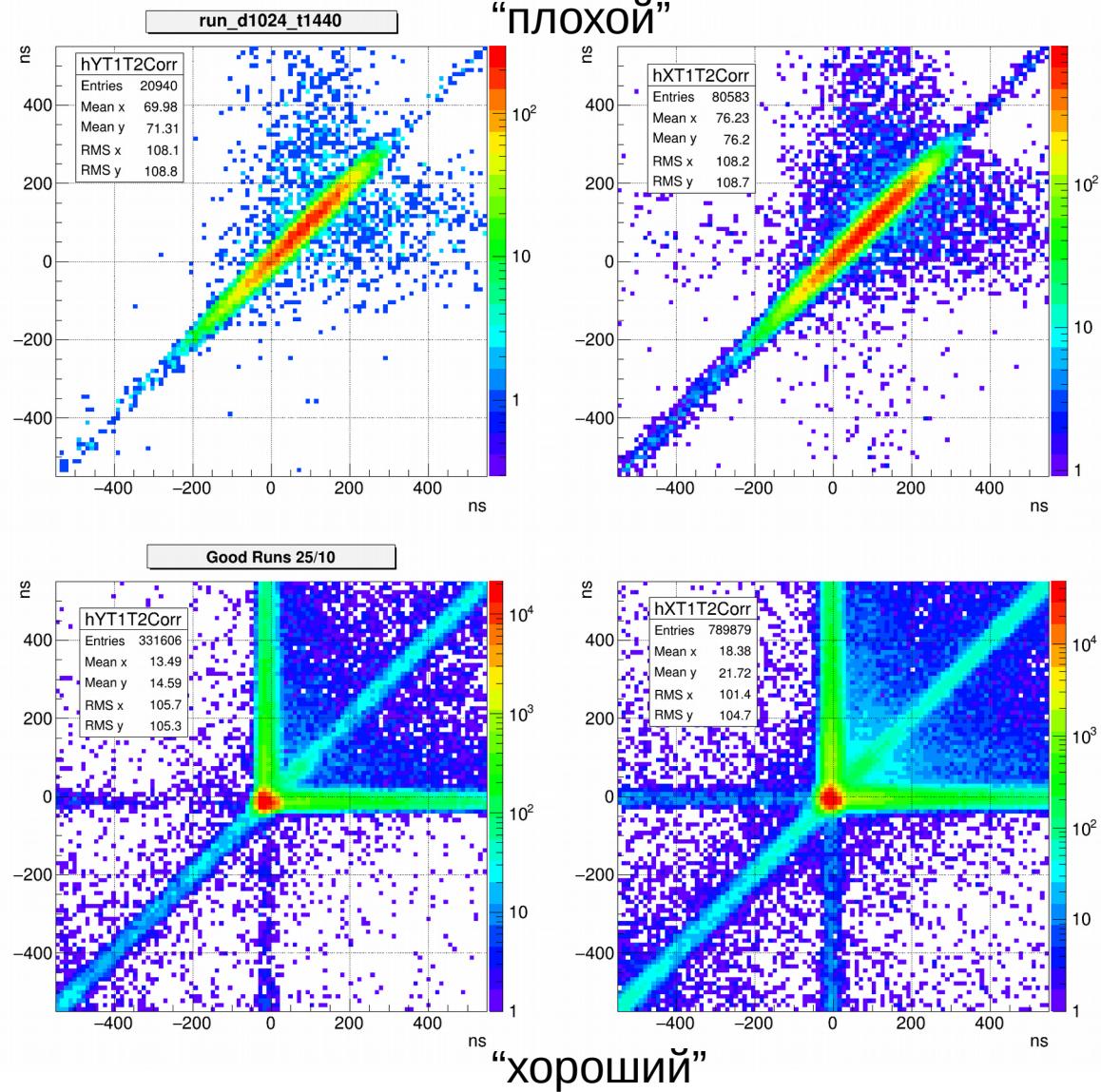
Количественная мера корреляции, xygauss: b/a

X(31,32): T1 vs. T2, b/a = 1.36

hXT1T2_31	
Entries	12451
Mean x	5.718
Mean y	0.1148
RMS x	11.88
RMS y	10.82
χ^2 / ndf	5506 / 9994
p0	15.97 ± 0.2031
p1	18.28 ± 0.1165
p2	-35.65 ± 0.8411
p3	13.52 ± 0.0859
p4	5.719 ± 0.1069
p5	0.1191 ± 0.0972

X(33,32): T1 vs. T2, b/a = 1.28

hXT1T2_32	
Entries	21913
Mean x	-3.918
Mean y	-3.232
RMS x	12.61
RMS y	13.34
χ^2 / ndf	1.045e+04 / 9994
p0	21.16 ± 0.2033
p1	20.49 ± 0.09911
p2	-51.8 ± 0.7863
p3	16.02 ± 0.07701
p4	-3.919 ± 0.08563
p5	-3.237 ± 0.09071
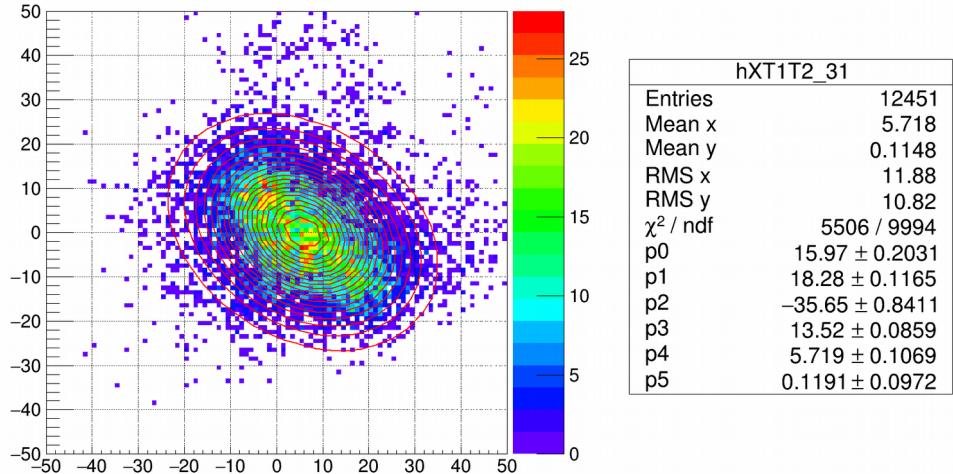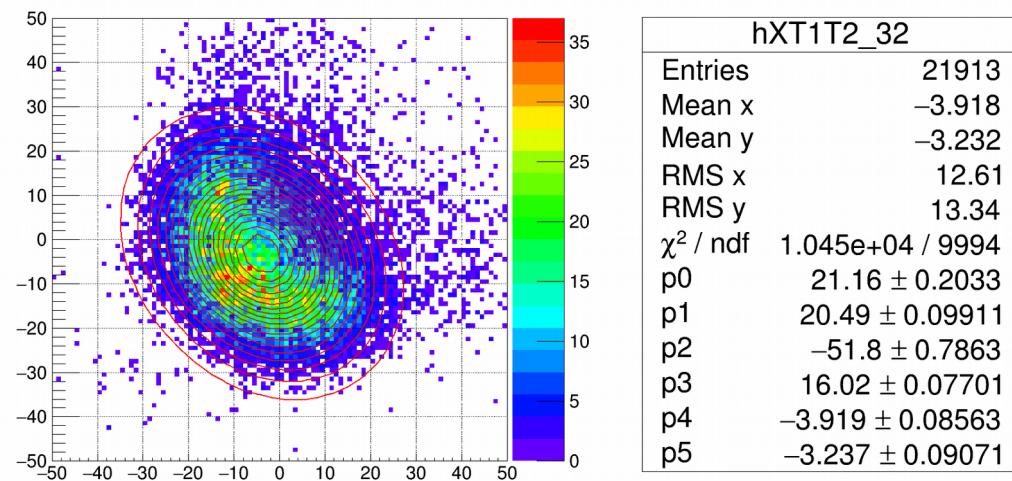
Фит двойным гауссом с поворотом: p0 - нормировка
p1 = b, p3 = a: большая и малая полуоси,
p2 = поворот осей в градусах,
p4 и p5 – смещения центра гаусса

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Mean of b/a distribution as measure of run data quality


fout_d1025_r1432.root

hBA_E	
Entries	19
Mean	1.168
RMS	0.08374
χ^2 / ndf	0.3616 / 29
Constant	11.3 ± 3.2
Mean	1.168 ± 0.019
Sigma	0.08385 ± 0.01347

hBA_O	
Entries	17
Mean	1.357
RMS	0.07353
χ^2 / ndf	3.031 / 29
Constant	11.67 ± 3.56
Mean	1.357 ± 0.018
Sigma	0.07278 ± 0.01315
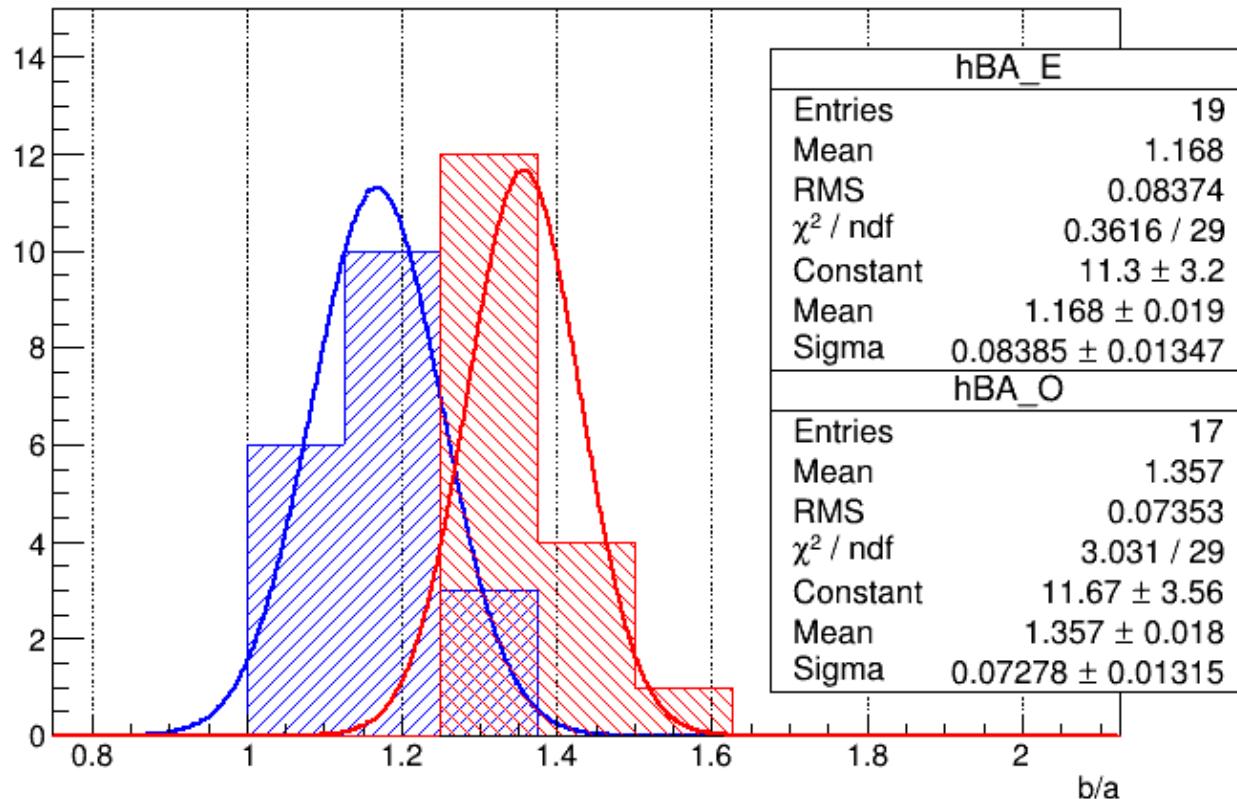
TestBeam:
SRS, October runs with CFD: b/a ~ 1.85

    Parasitic TestBeam:
SRS, runs 15_0026 и 15_0045:   b/a ~ 1.15-1.25

Both cases: Timing@Peak, 1650V

No good correlations for Timing@THL

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Straws Signal Amplitude vs. applied High Voltage
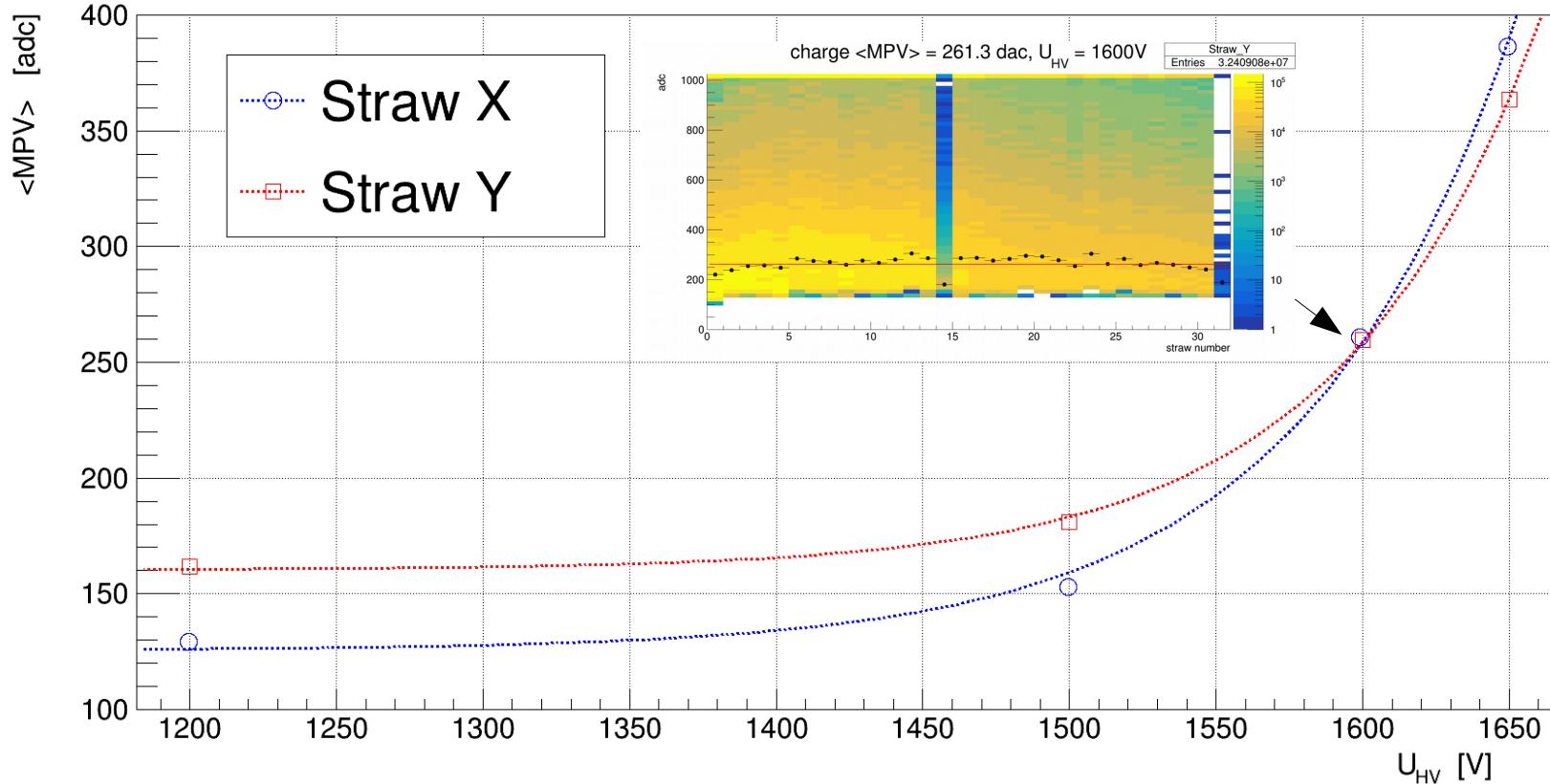
Beam Profiles: 'Good' Runs
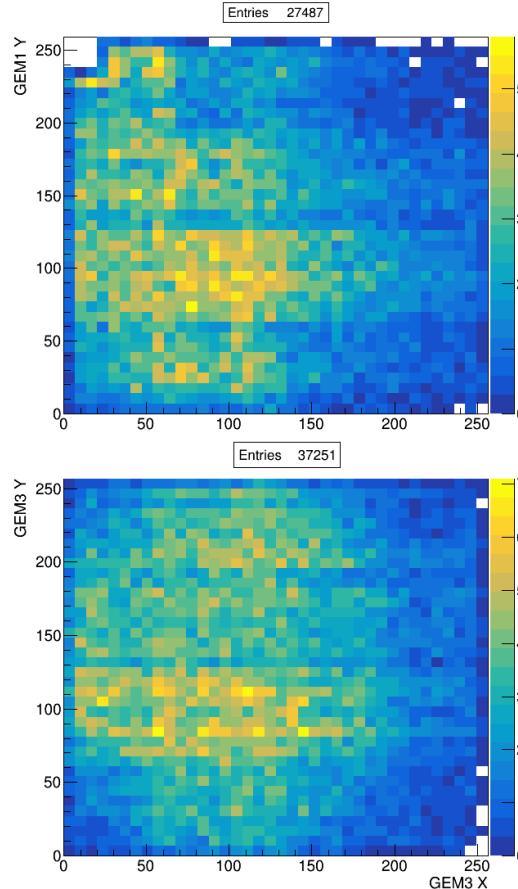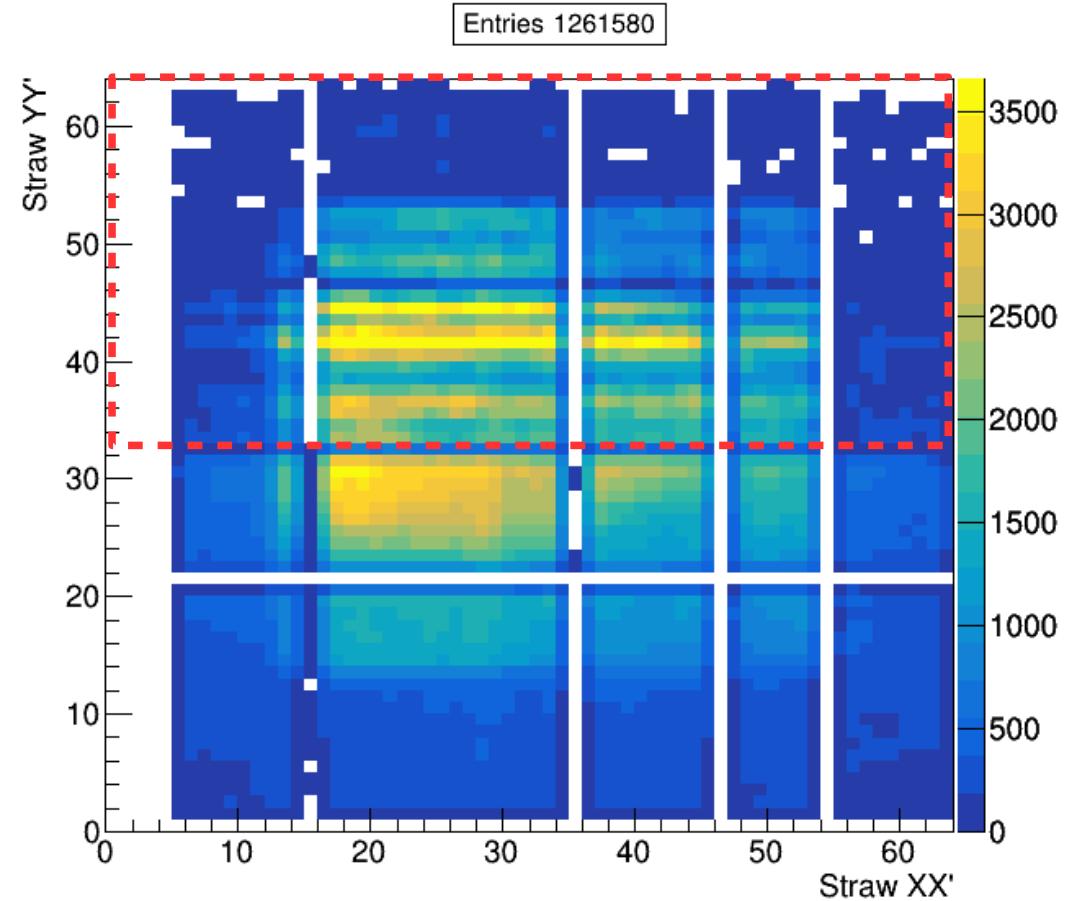
Scintillator: **12x12** cm,
1ch. SiPM+CFD

Straws: **20x20** cm,
(32+32)x(32+32) channels.
Time coincidence for
Scintillator+X+X'+Y+Y'

Straws – 1 out of 4 VMMs
suffers from "BCID<50" bug,
data acquisition deficiency,
statistics scaled.

GEMs: **10x10** cm,
256x256 channels,
Time coincidence for X+Y

Low Efficiency (Low HV)

GEM2 – VMMs affected by
same "BCID<50" bug

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GEM vs. Straw spatial correlation

Run **1522**, collected 14.11.2021 at 15:22.
Parameters: **timing:_at peak_,**
HV: 1550V, threshold: 265 mV,
shaping time: 200 ns, gain: 1 mV/fC
10 spills: 6-142 seconds

"Clusters" in GEM

Slide by
E.Kuznetzova (PNPI)

STRAW ID	SCINT ID	GEM3Y ID	GEM3Y CH	GEM – SCINT dT, ns	GEM – STRAW dT, ns
185056	185054	185053	156	125	41
		185057	157	124	40
		185059	158	123	39
185376	-1	185377	131	-1	38
		185380	132	-1	37
		185382	133	-1	35
186124	-1	186122	15	-1	36
188404	-1	188405	61	-1	50
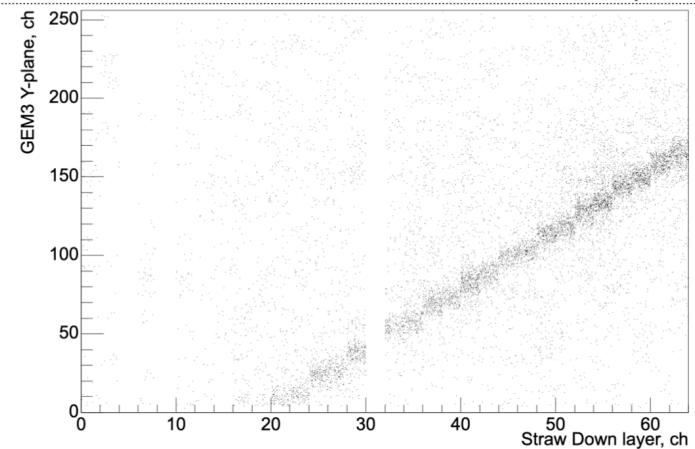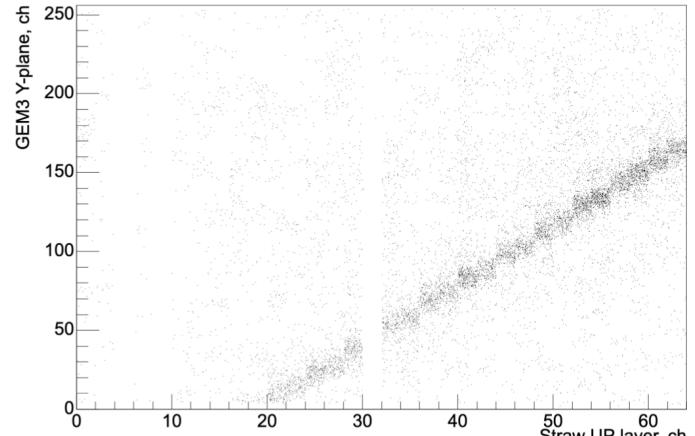
Post TestBeam Checks:
VMM3 Timing Resolution (Pulse Generator)

Generator NIM Pulses, Timing @ Peak

hch

Entries	53182
Mean	−11.51
Std Dev	0.5835
χ^2 / ndf	444.5 / 3
Constant	2.354e+04 ± 1.561e+02
Mean	−11.51 ± 0.00
Sigma	0.5497 ± 0.0021

0.6 ns

t_{15}-t_{38} [ns]
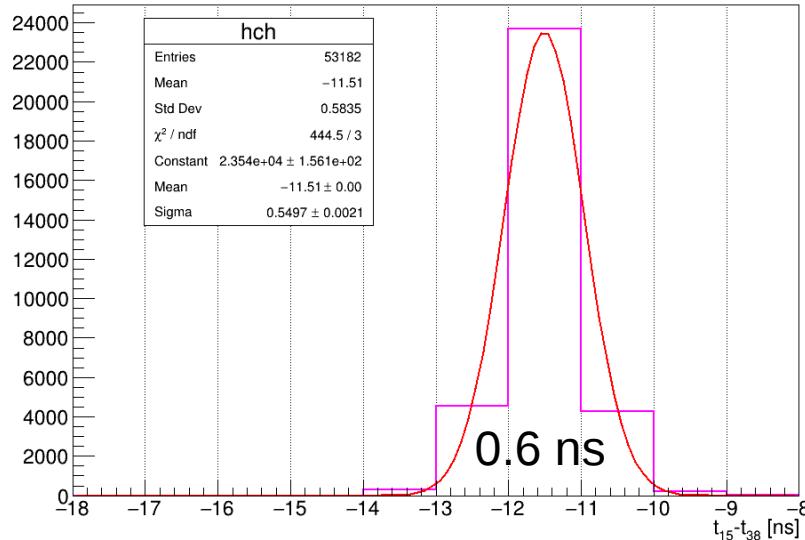
Generator NIM Pulses, Timing @ Threshold

hch

Entries	163609
Mean	−14.37
Std Dev	0.882
χ^2 / ndf	578.2 / 6
Constant	4.581e+04 ± 1.870e+02
Mean	−14.38 ± 0.00
Sigma	0.8726 ± 0.0023

0.9 ns

t_{15}-t_{38} [ns]

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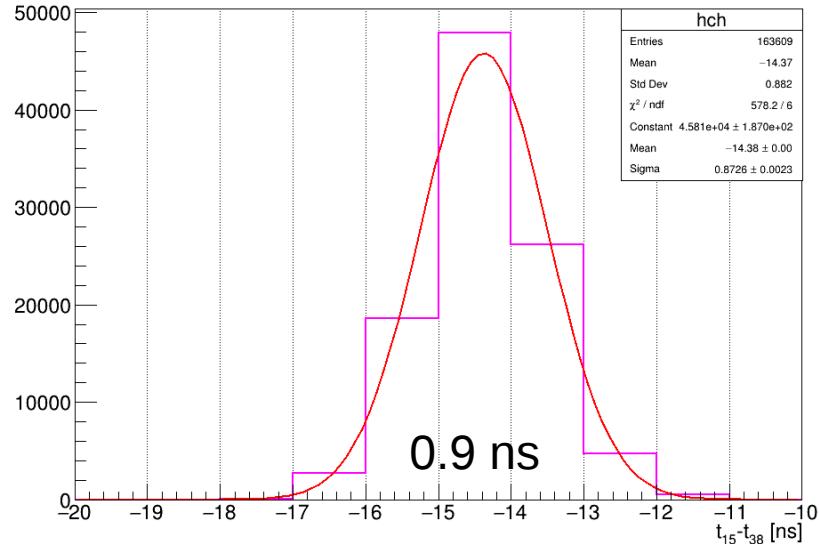
# Post TestBeam Checks:
VMM3 Timing Resolution (Cosmics + Scintillators + Discriminator)

PMTs+Discr, Timing @ Peak

hch	
Entries	1071900
Mean	−0.1339
Std Dev	2.922
χ^2 / ndf	7160 / 25
Constant	1.061e+04 ± 5.679e+01
Mean	−0.1133 ± 0.0096
Sigma	2.411 ± 0.009

2.4 ns

$t_{15}-t_{38}$ [ns]
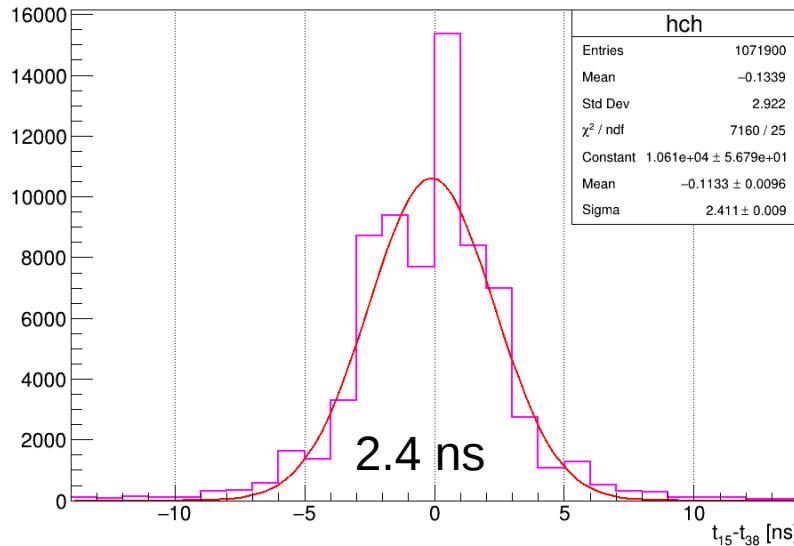
PMTs+Discr., Timing @ Threshold

hch	
Entries	4719560
Mean	−5.246
Std Dev	3.037
χ^2 / ndf	4491 / 27
Constant	6469 ± 45.0
Mean	−5.211 ± 0.012
Sigma	2.298 ± 0.011

2.3 ns

$t_{15}-t_{38}$ [ns]
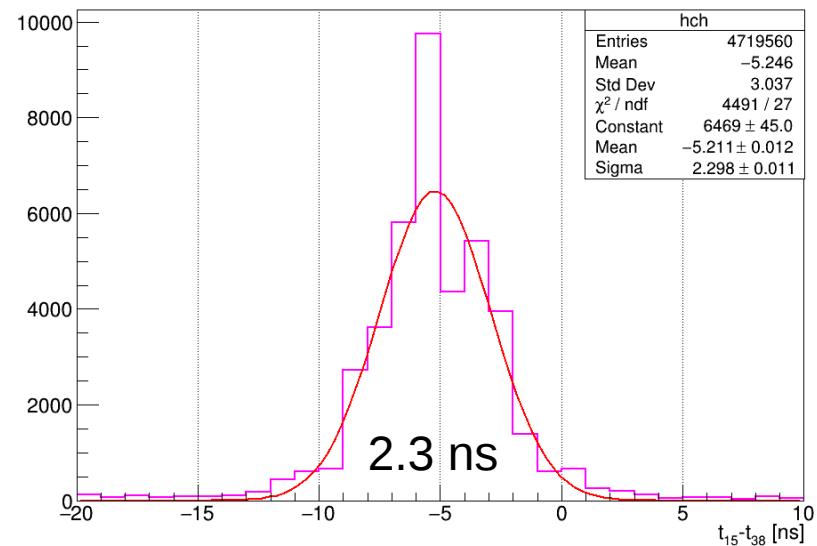
CONCLUSIONS:

- Some promising data was taken during TestBeam despite all the pitfalls
  - Time correlations between straw layers are observed
  - Spatial correlations between straws and GEMs are observed
  - Analysis is ongoing

- Timing@Threshold Mode of VMM3 is still buggy even in VMM3a
  - Timing@Peak looks as good as T@T in lab conditions
  - At testbeam time correlations in T@T mode were significantly larger than in T@P mode, for straws 50ns vs. 15ns.

- SRS System is now in Dubna: FEC + DVMM + 2 Hybrids
  - Together with 1 extra GEM detector to play with
  - SRS DCS software and RAW → ROOT conversion scripts are installed

- Straw Team is going to be fully prepared to the next RD51 TestBeam!

BACKUP SLIDES

THANK YOU FOR ATTENTION !

Плохие и хорошие раны на SRS, Timing-at-Peak

Распределение bcid должно быть равномерным, однако оно в обоих случаях имеет дефекты. Это пик при bcid<30, яма с горбом вблизи значения 2048, а у плохого еще и сдвинуто.

Спойлер: Катом на bcid добиться улучшения корреляции невозможно.
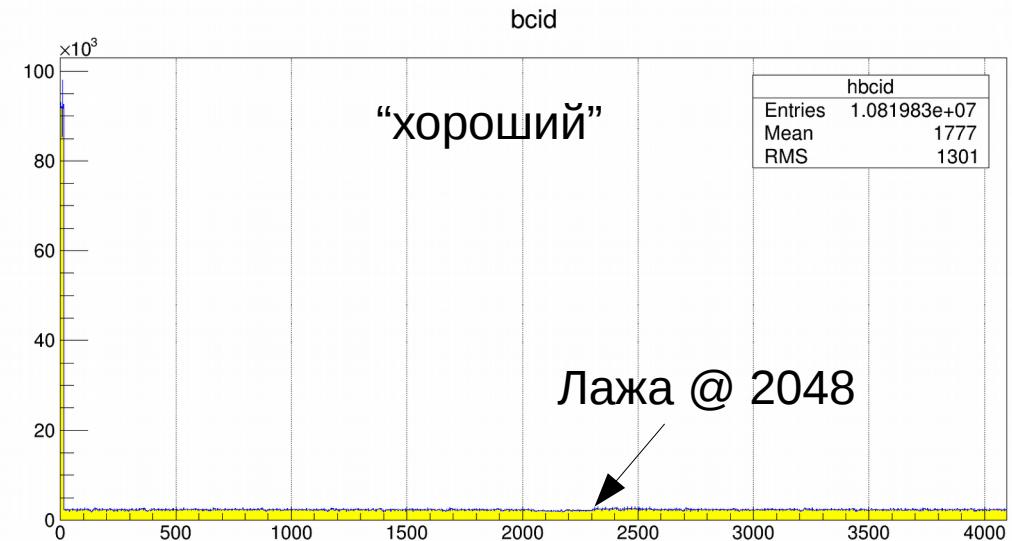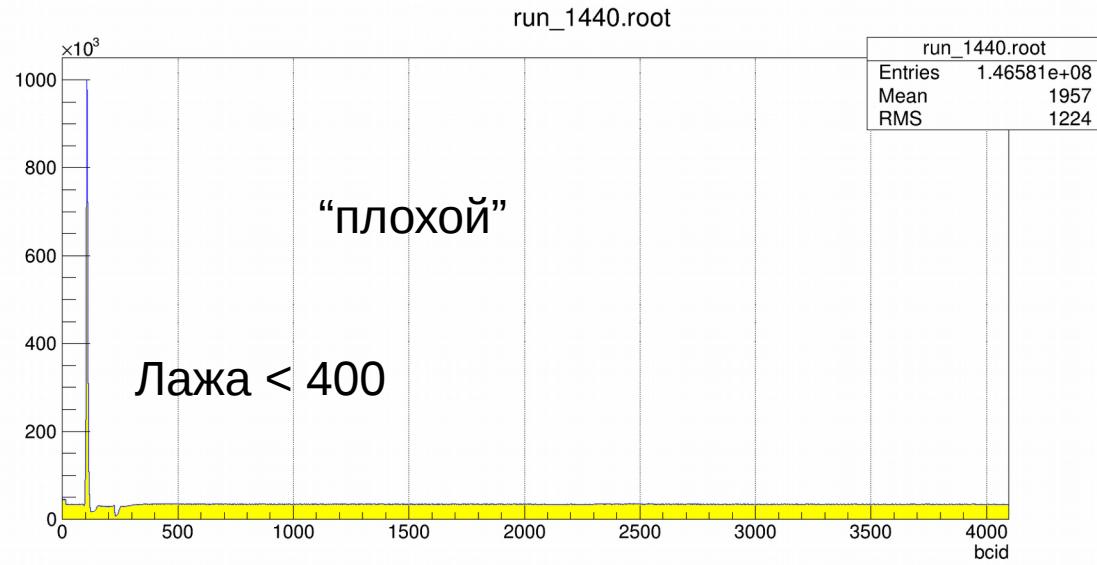
# Пример (анти)Корреляции в соседних Xstraw, хороший ран


X(31,32): T1 vs. T2

X(33,32): T1 vs. T2

X(33,34): T1 vs. T2
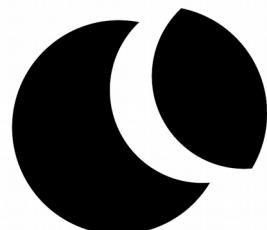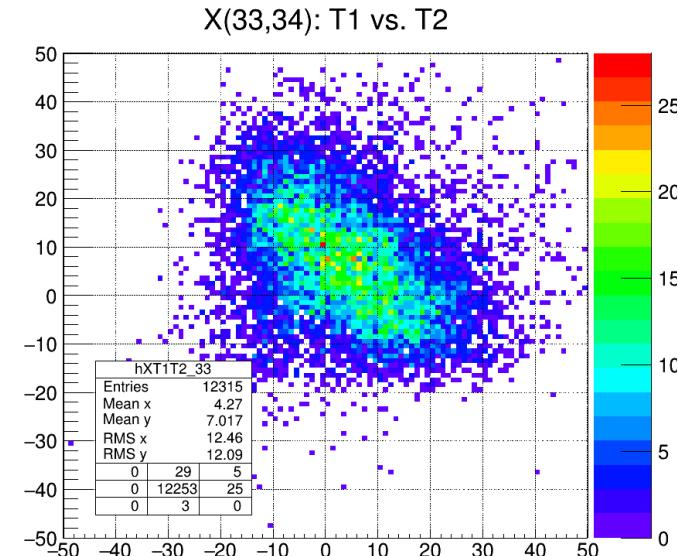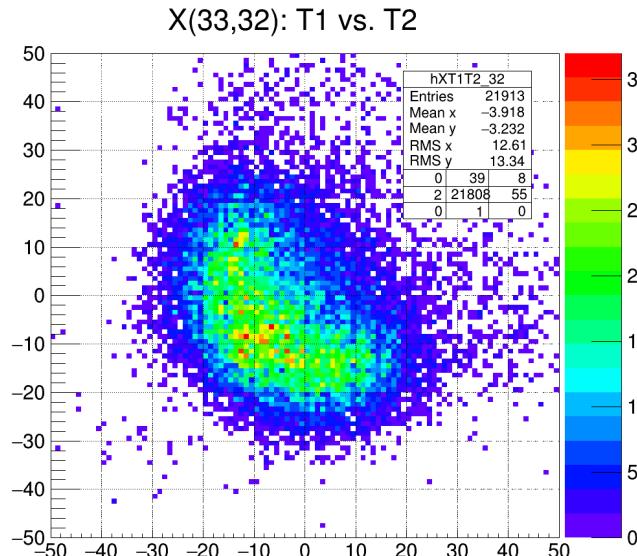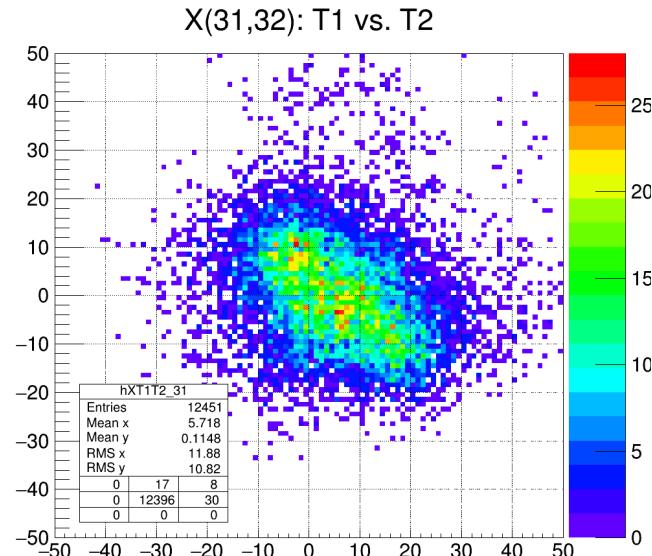
Пример (анти)Корреляции в соседних Ystraw, хороший ран
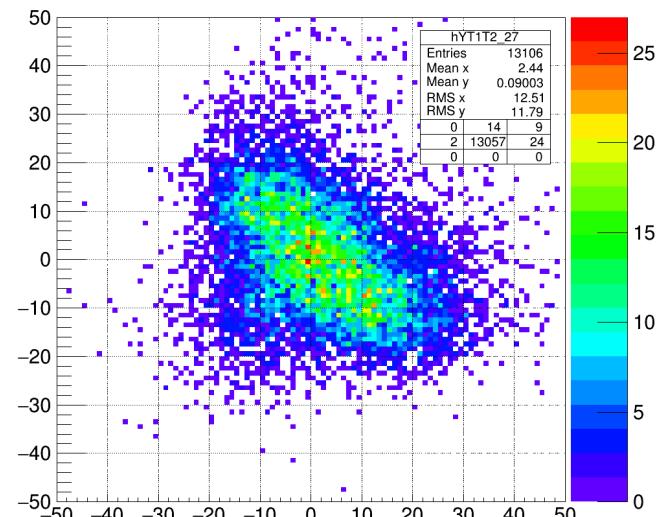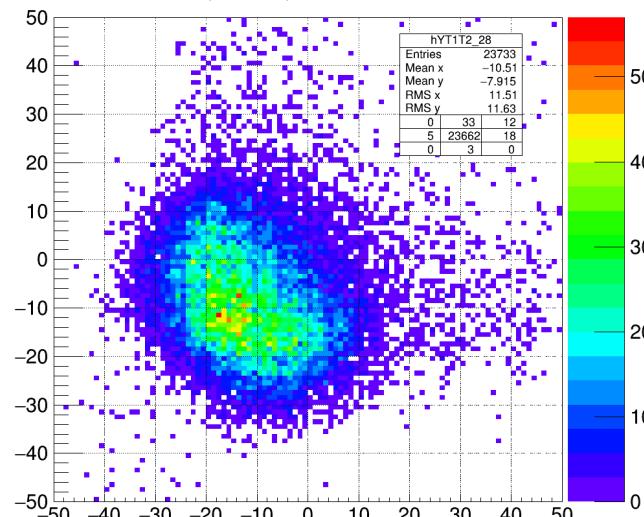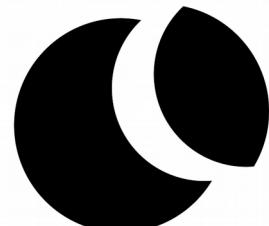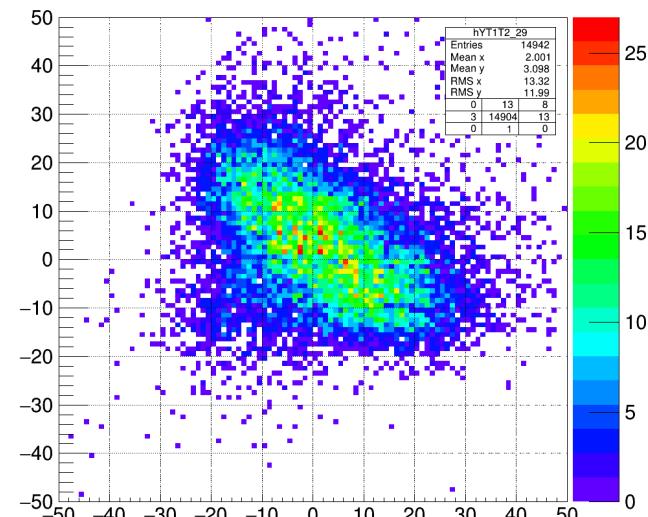
- **Some Issues** identified:
  - option to synch the two FEC causes some VMM (random) to stop sending data
    - ✉ linked to the CLOCK module in our SRS crate (no problem in other set-ups)
    - ✉ until this is solved/debugged: each of the two FEC in the setup use their own unsynch'd 40 MHz clock.
  - Found a "work-around" by connecting the n.c. to GND (the red wire in pix below)
    - to be investigated further

Test of VMM3 in T@P and T@T
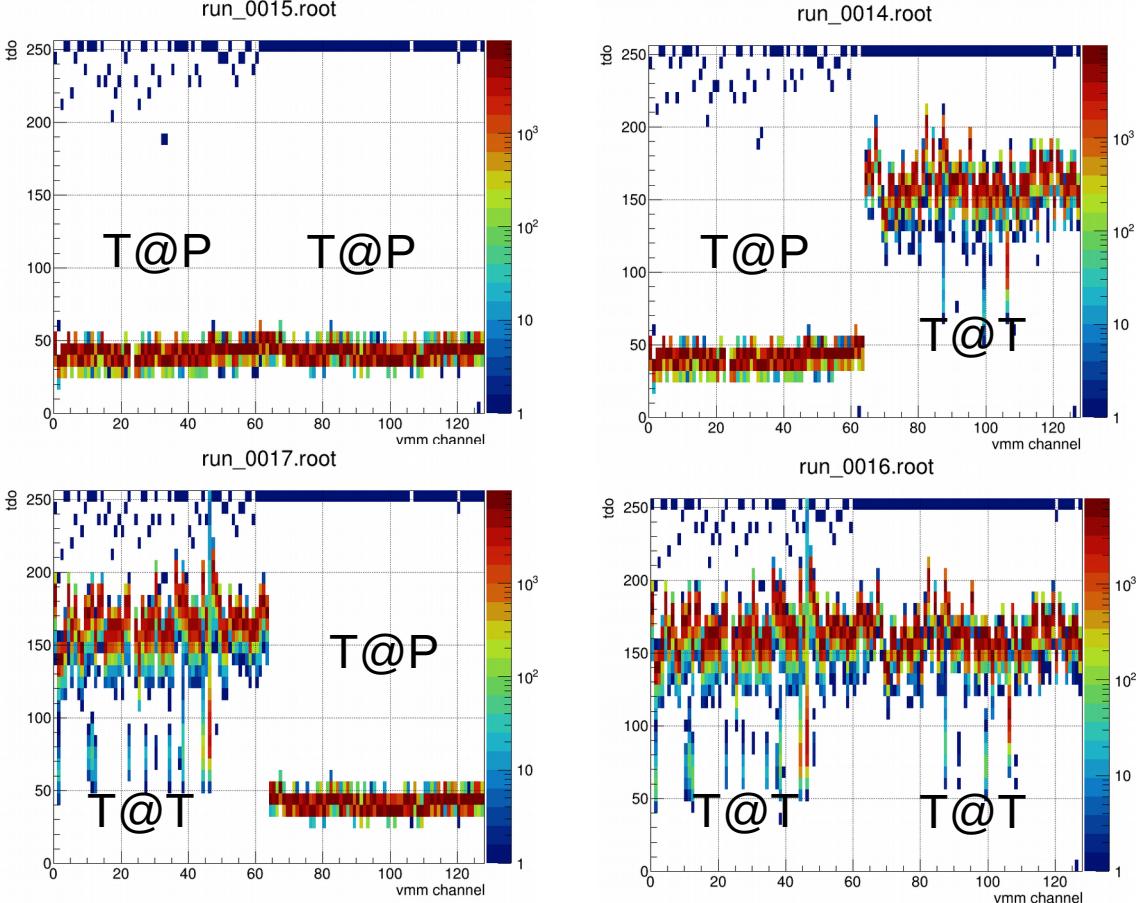
Software: Verso v4.4.0
Tested with MMFE8-0315 V2D,
S/N 175100017
Used VMMs 1 and 2, others masked
Mode: Continuous, internal timing
Test Pulses: 1ms Period, 2us Width
TAC Ramp 300ns, Gain 9X/200ns
Leakage Current = On,
Tail Cancellation+Bip.Shape = On
Direct Timing = Off, 6bitADC = Off

Timing Mode is switched with
srat = 0/1 register setting

Ramp-at-Threshold works in VMM3!

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