Hardware meeting of SPD
Straw-team Testbeam Report

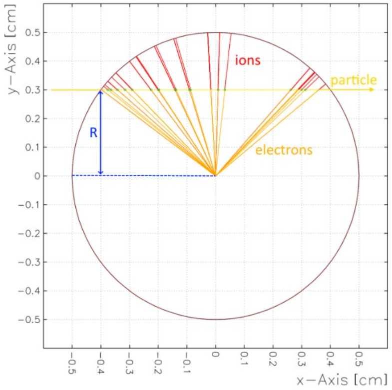
JOINT INSTITUTE
FOR NUCLEAR RESEARCH

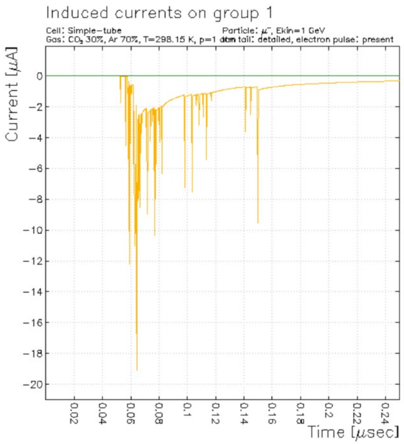
24.11.2022

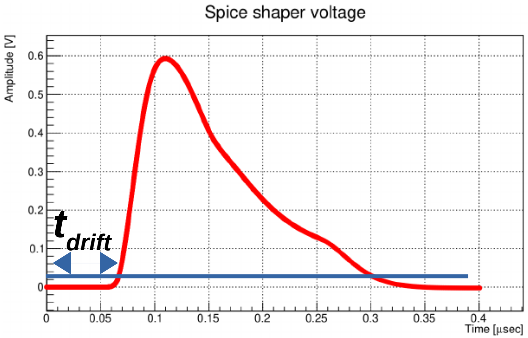
Straw tubes – operation principle

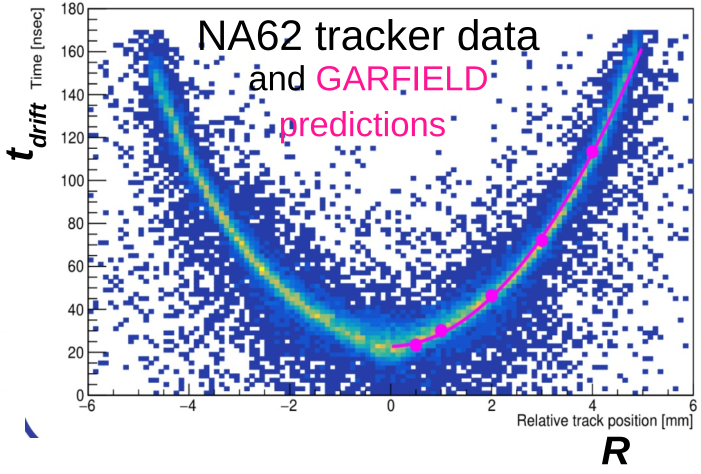
- thin wall drift tube of small (O(cm)) diameter
- proportional mode
- drift time of ~first (or ~second) closest to anode electrons represents quite well the distance between the track of the ionizing particle ***R*** and anode wire

The drift time $\boldsymbol{t_{drift}}$ is measured as the difference between time $\boldsymbol{t_0}$ when an ionizing particle crossed the straw and the time when the induced straw signal exceeded a given threshold.









GARFIELD + LTSpice allows to predict straw response for a given readout model.

See S. Nasybulin report at SPD Physics and MC meeting #21: https://indico.jinr.ru/event/2981/contributions/15896/attachments/12139/20276/MagneticInStraw_spice_results.pdf

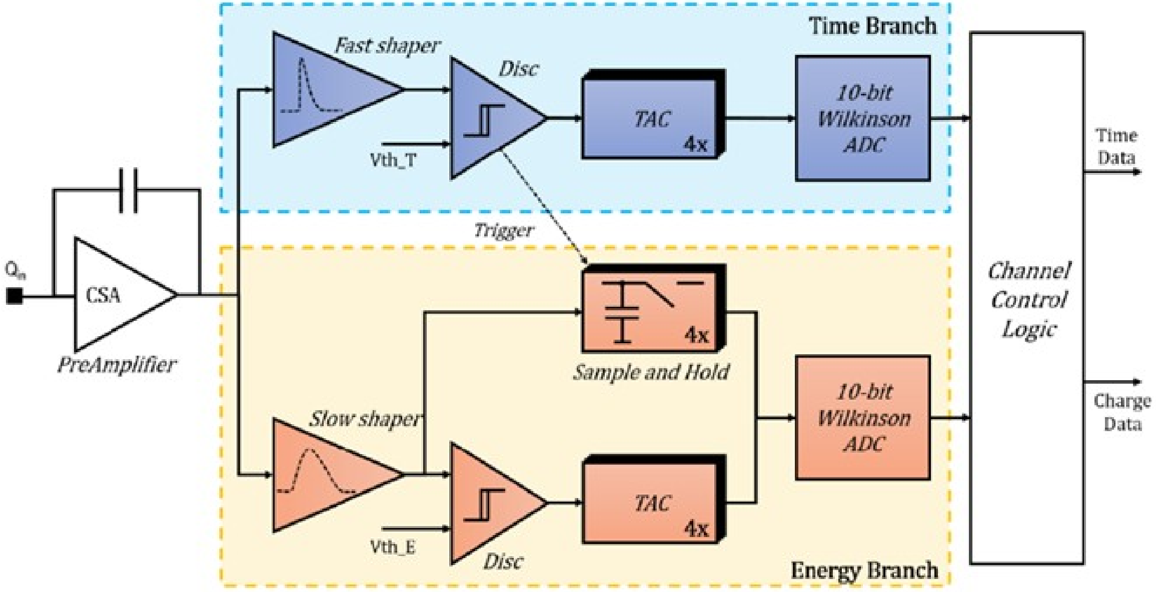
Summary table of SPD Straw Tracker parameters

Detector type	barrel	end-cap
Detector tasks	dE/dx	xy coordinates, dE/dx
Working mode	triggerless	triggerless
Detector inner diameter, mm	540	
Detector outer diameter, mm	1700	
Number of layers	30 (double layer)	2x, 2y, 2u, 2v
Number of stations, sections	8 sections	12 stations
Number of channels	32288	8192
Tube diameter, mm	10	10
Maximum tube length, mm	2400	1700
Central core diameter, mm	0.03	0.03
Maximum detector capacitance, pF	26	18,5
Gas detector	70 Argon, 30 CO_2	70 Argon, 30 CO_2
Operating voltage, V	+1650	+1650
Multiplication factor, HV=1750	4.5E4	4.5E4
Charge from the first electron, fC	7.7	7.7
Electron drift velocity, μm/ns	65	65
Electron drift time, ns	120	120
Ion drift time, μs	100	100
Spectral resolution, μm	150	150
Maximum load, kHz per tube	150	

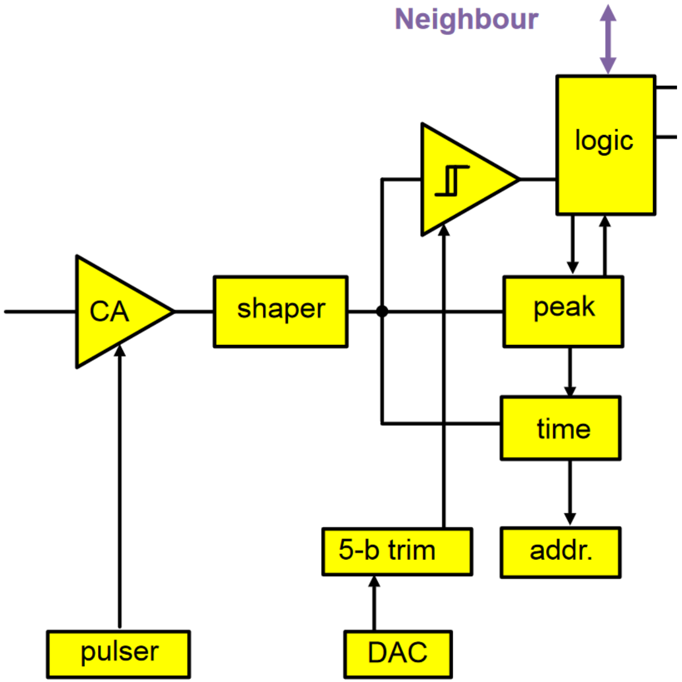
See A. Solin report at SPD Coll. Meeting: https://indico.jinr.ru/event/3189/contributions/17520/attachments/13230/22121/14_Development%20of%20an%20ASIC%20for%20straw%20and%20micromegas%20detectors%20of%20the%20NICA-SPD.pdf

Investigating existing readout solutions

TIGER vs VMM3



TIGER Architecture



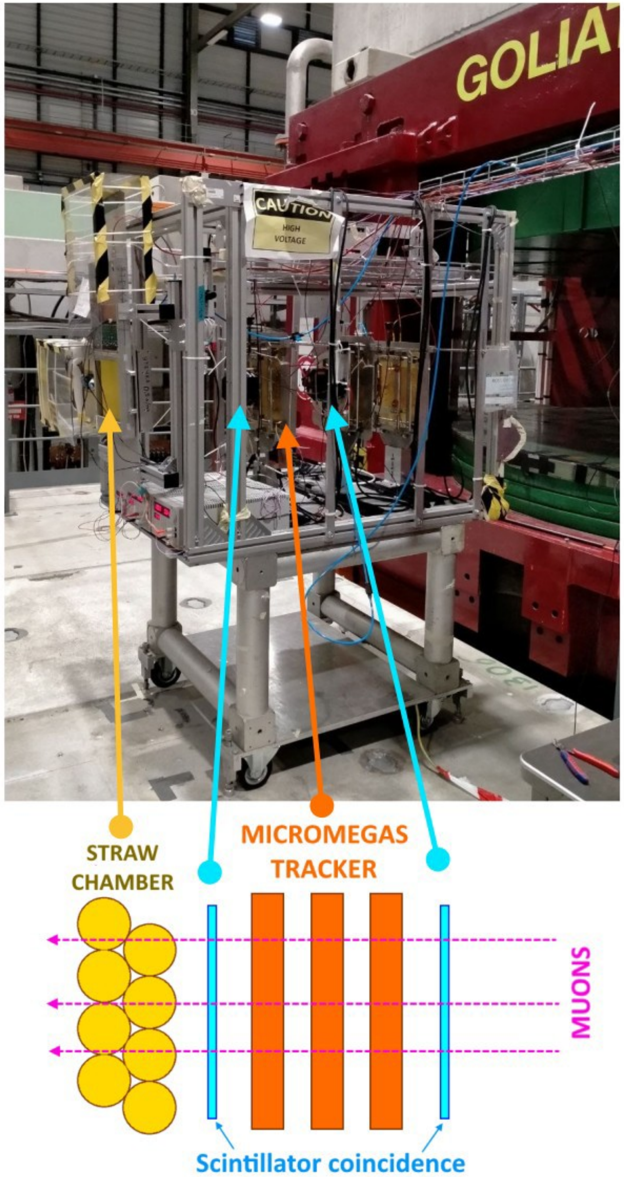
VMM3 Architecture

TIGER architecture seems to be more reasonable, because of having two different shapers for Time and Energy measurements. Two threshold levels are also possible.

TIGER vs VMM3

	VMM3	TIGER
Number of channels	64	64
Clock frequency	10...80 MHz	160...200 MHz
Input capacitance	<300 pF	<100 pF
Dynamic range	Linearity within ±2% up to 2 pC	50 fC
Gain	0.5, 1, 3, 6, 9, 12, 16 mV/fC	12 mV/fC
ENC (energy branch)	<3000 e^-	<1500 e^-
TDC binning	~1 ns	50 ps
Maximum event rate	140 kHz/ch	60 kHz/ch
Consumption	15 mW/ch	12 mW/ch

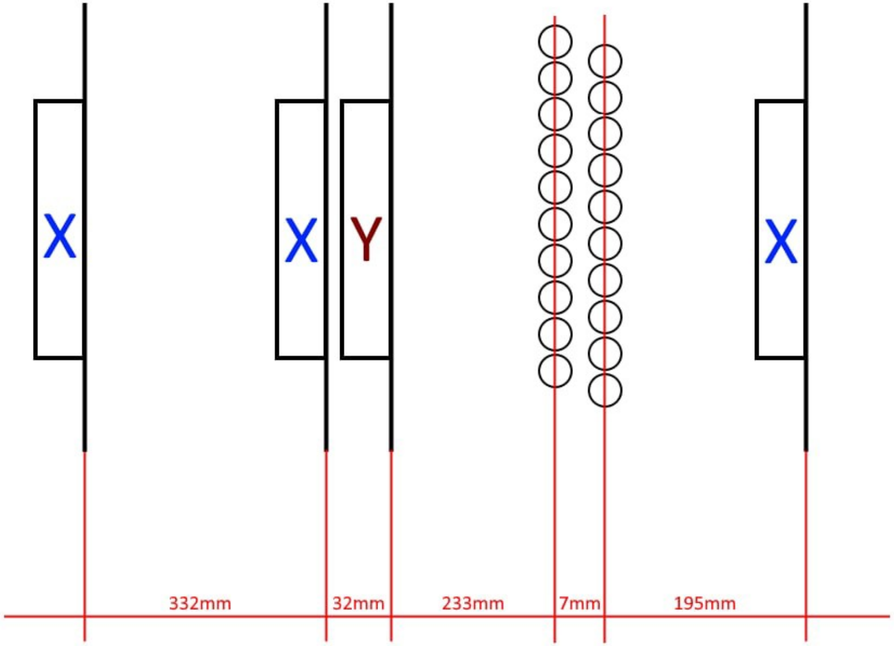
The Testbeam Setup



The existing readout options we study with SPS Testbeam

For efficient data taking the following setup was developed:

- Reference tracker: 4 MicroMegas (3 X + 1 Y axis) with pitch of 250 μm
- Reference timing: scintillator coincidence (two scintillators)
- Straw chamber with 6mm straw



Test beam data taking periodes

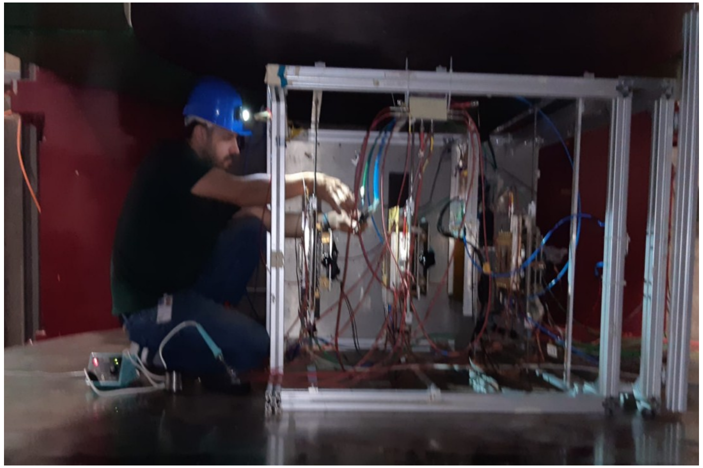
Setup 1

CERN, H4 (Nov 2021)
3 GEMs + straw station
VMM3a readout

Setup 2

CERN, H4 (April–May + July 2022)
4 MMs w/ APV25 readout + straw station w/ VMM3 readout

Setup 3

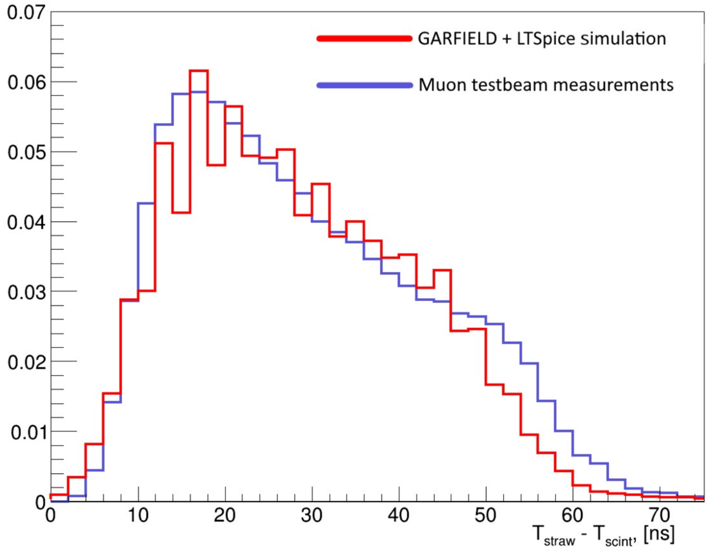


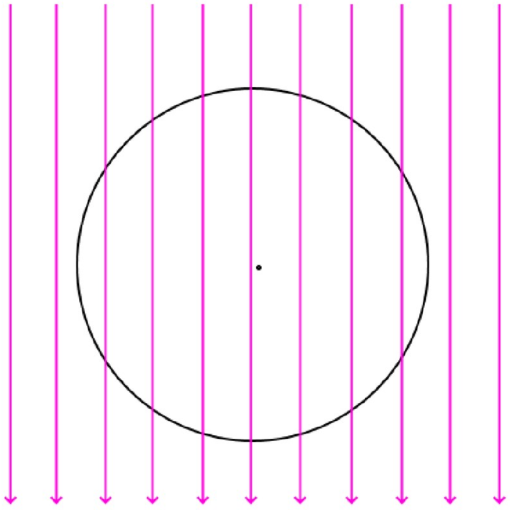
CERN, H8 + H4 (Aug – Nov 2022)
4MMs + straw station
TIGER readout

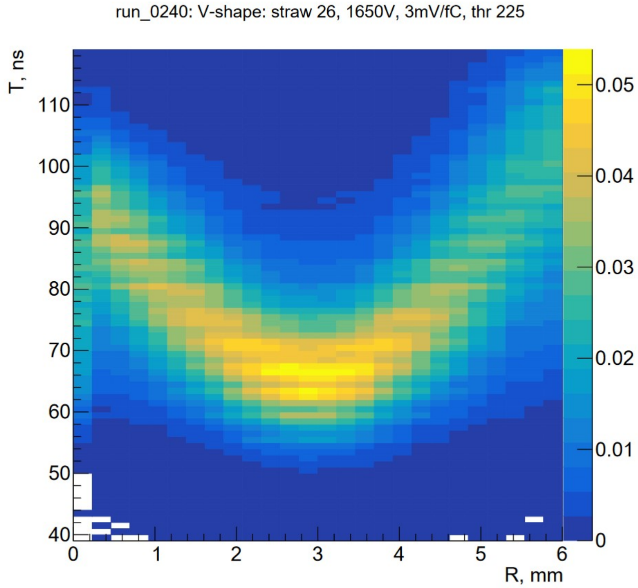
+ data taking in magnetic field

The VMM3a readout option was rejected based on testbeam 2021 results, due to a channel latching logic in Time-of-Threshold readout mode issues.

Data quality plots for VMM3 Readout



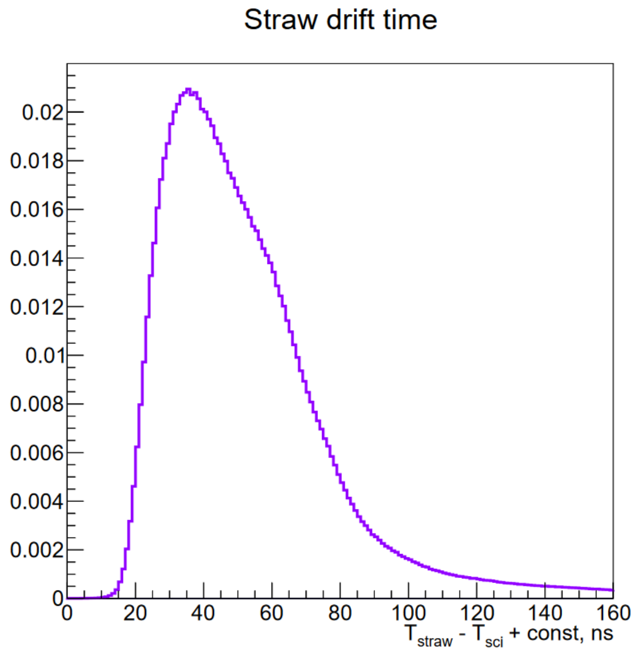




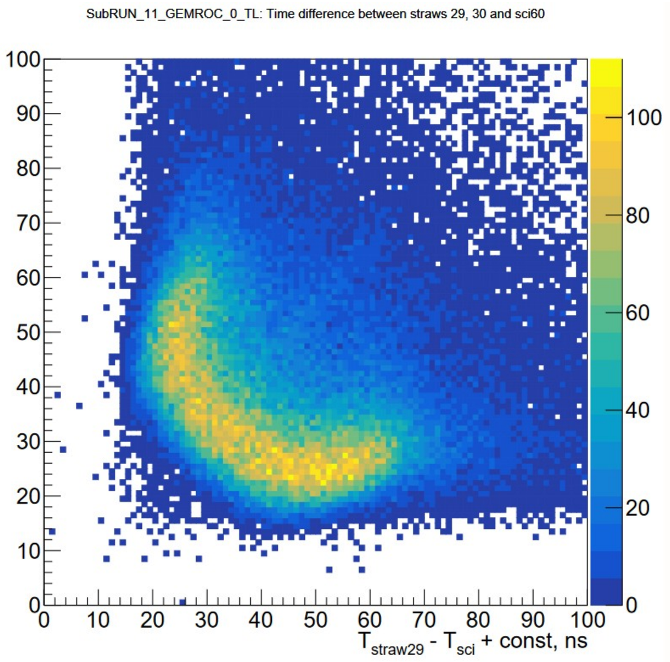
Comparison of drift time distribution from muon beam data (red) with the Garfield + LTSpice predictions (blue)

For the data quality monitoring during the data tacking we used reduced tracking information from a single micromegas only, so the bin size in R-T curve is determined by the MicroMegas pitch

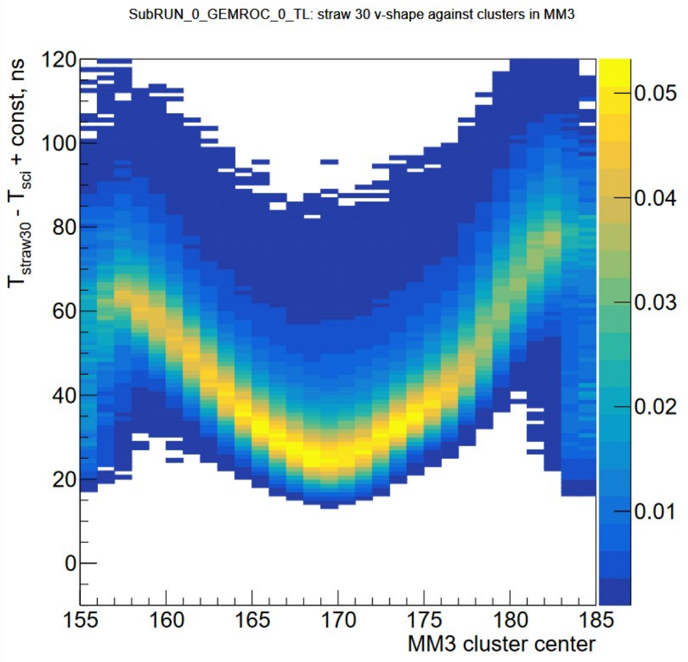
Data quality plots for TIGER Readout



HV = 1750V



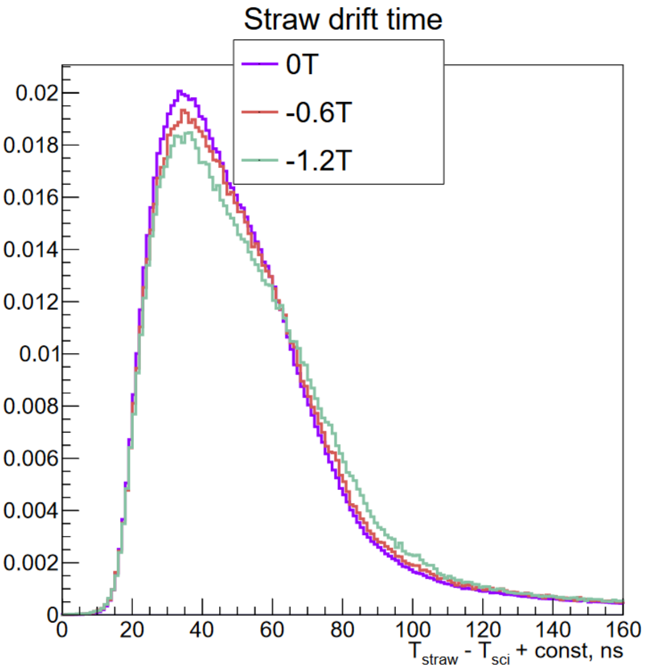
Drift time corellation for neighbour straws



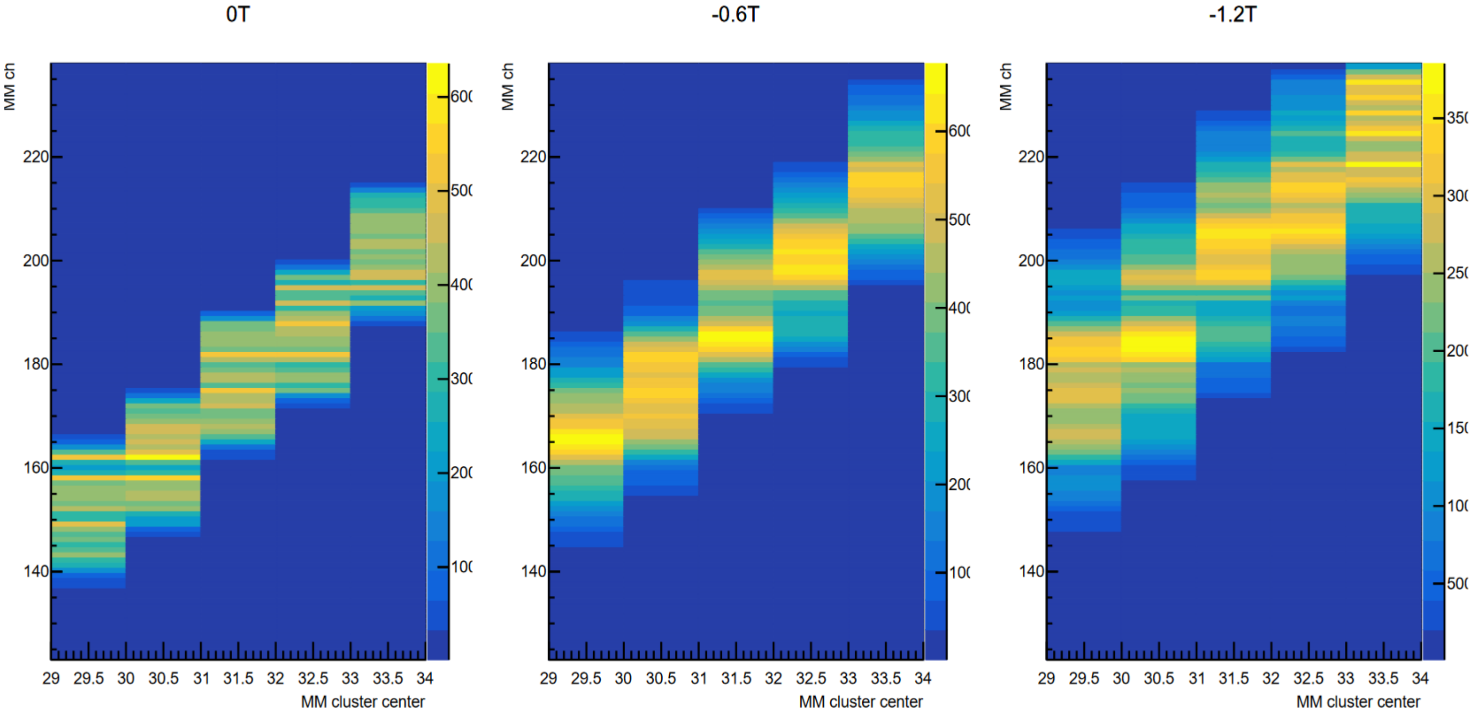
R-T dependance

First look at results for TIGER readout with magnetic field

Straw drift time distribution comparison



Spatial corellation between single MicroMegas and Straw plane



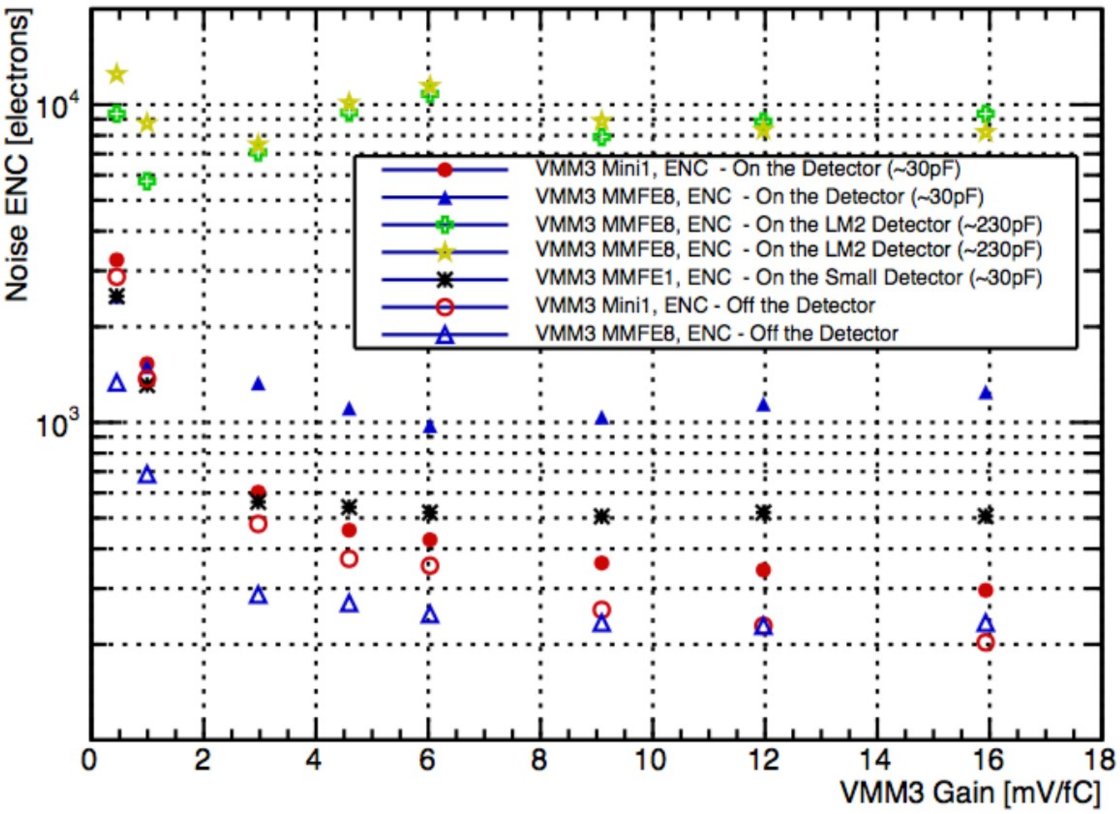
CONCLUSION

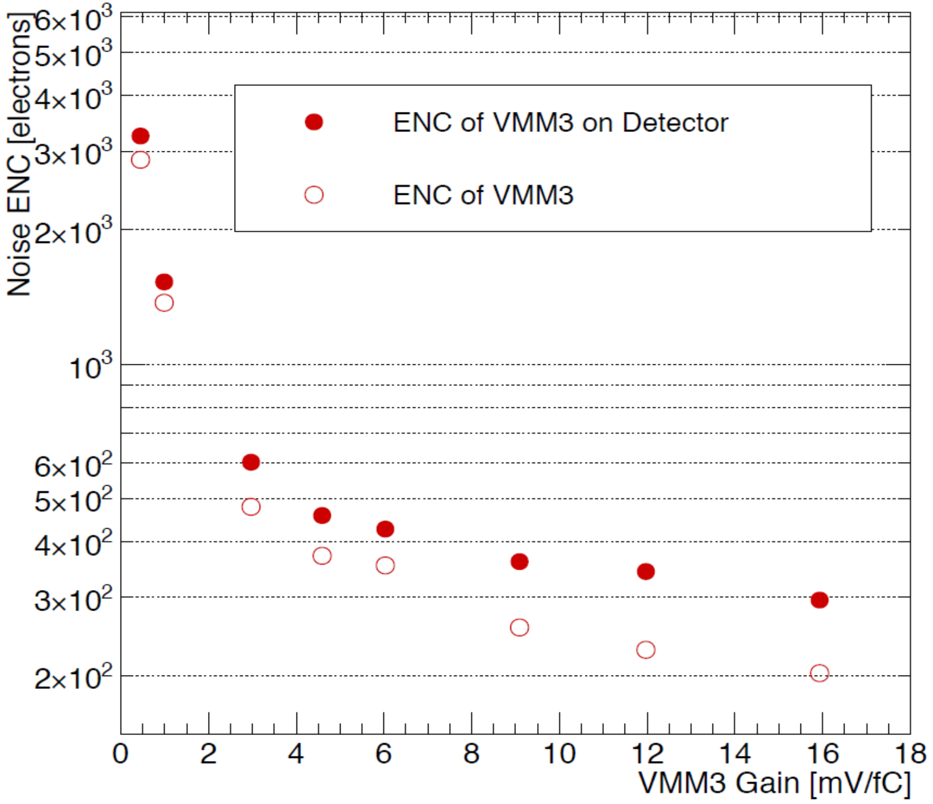
- A dedicated setup for testbeam data taking was developed
- During April and July TestBeams the data with VMM3 readout were aquired
- TIGER-based BES-III frontend boards were adapted for reading out the micromegas and straw tubes
- Data with TIGER readout were taken during October test beam for different magnetic field strength
- Data analysis is ongoing (see D. Sosnov and V. Bautin on SPD Coll. Meeting: https://indico.jinr.ru/event/3189/contributions/17492/attachments/13233/22124/spd_tb_status_sosnov-bautin.pdf)

BACKUP

VMM3 Noise Studies

by George Iakovidis





3000 e ~ 0.48 fC

April and July TestBeam data analysis status

April TestBeam:

- VMM and APV merging method is working
- Merged $\sim$ 150K events per straw (about 10% of data used)
- Working on proper tracking

July TestBeam:

- Fixing an issues with applying merging algorithm to the July data

Straw

Number of track candidates per straw

μ, 1650V : 1.7M

μ, 1700V : 390K

μ, 1750V : 12M

π^0, 1650V : a bit

μ, -0.6T, 1750V : 140K

μ, -1.2T, 1750V : 90K

μ, 0.64T, 1750V : 100K

μ, 0.86T, 1750V : 100K

μ, 1.15T, 1750V : 100K