Straw simulation studies and tests measurements

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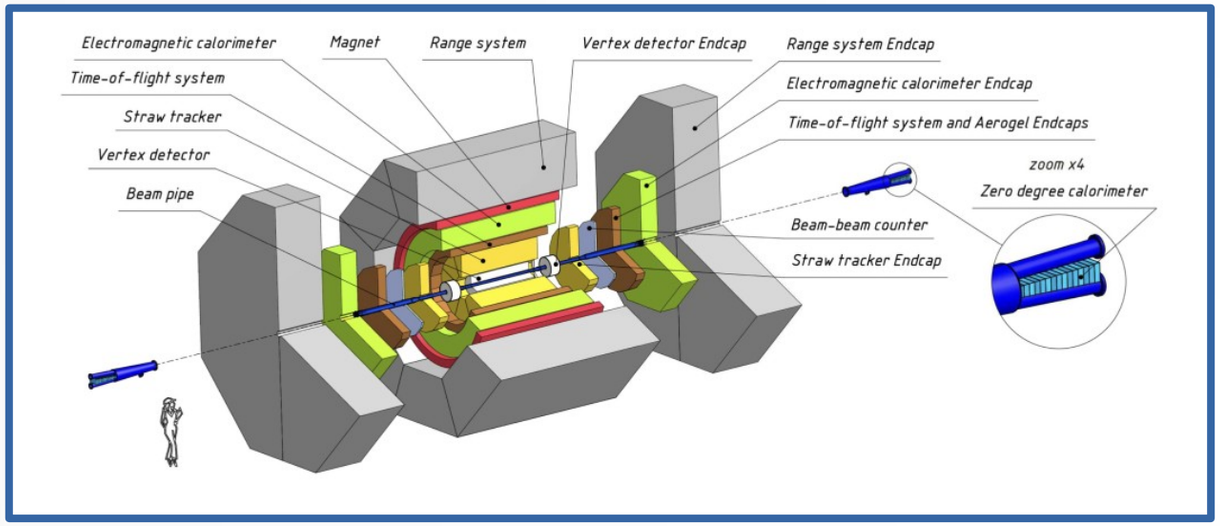
Physics Sensitivity and measurement precision

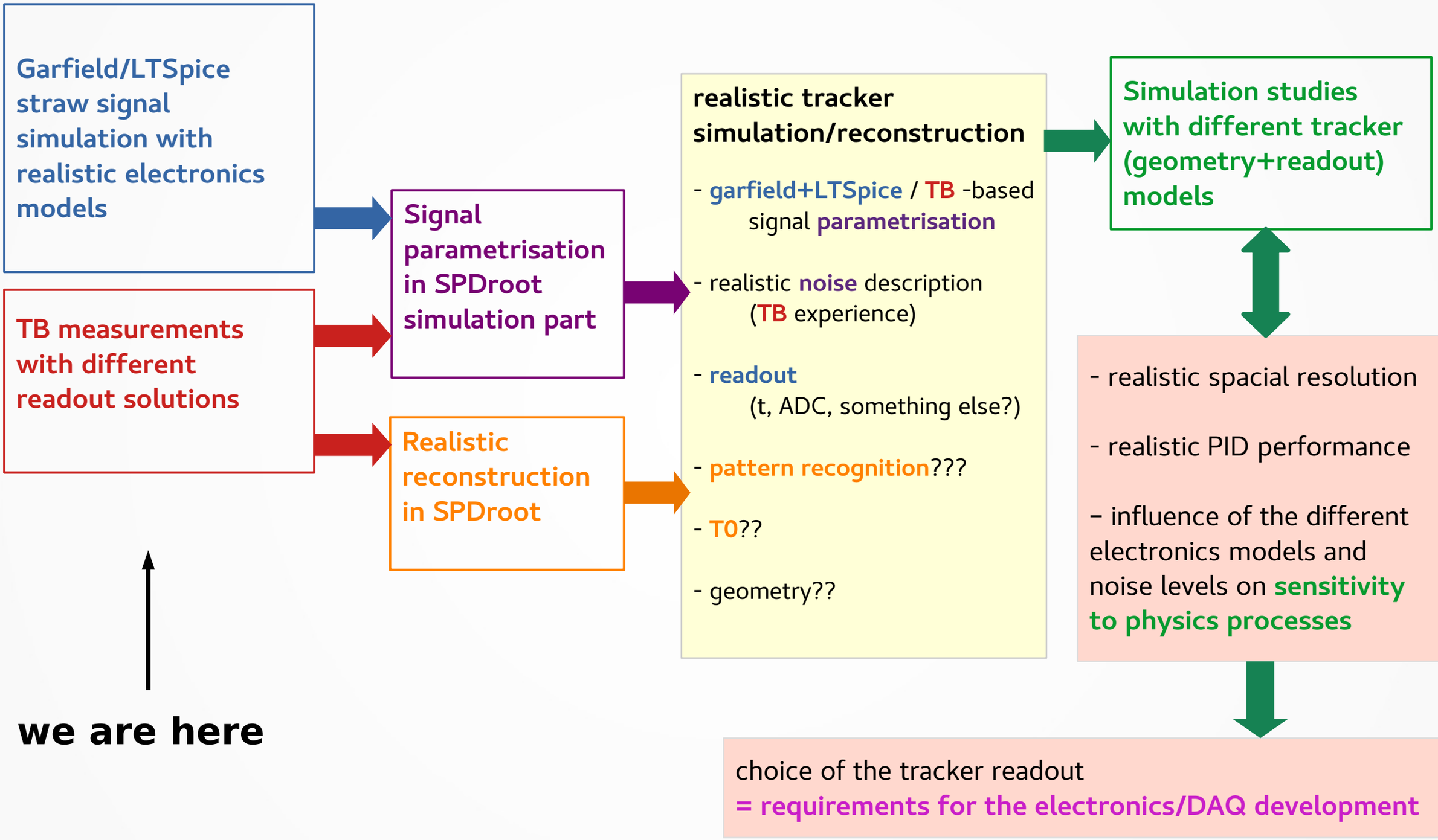


= detector+readout + reconstruction

realistic simulation

prototyping and performance studies

Final Design and Cost


Garfield/LTSpice straw signal simulation with realistic electronics models
TB measurements with different readout solutions
Signal parametrisation in SPDroot simulation part
Realistic reconstruction in SPDroot
realistic tracker simulation/reconstruction
- garfield+LTSpice / TB -based signal parametrisation
- realistic noise description (TB experience)
- readout (t, ADC, something else?)
- pattern recognition???
- T0??
- geometry??
Simulation studies with different tracker (geometry+readout) models
- realistic spacial resolution
- realistic PID performance
– influence of the different electronics models and noise levels on sensitivity to physics processes
choice of the tracker readout
= requirements for the electronics/DAQ development
we are here

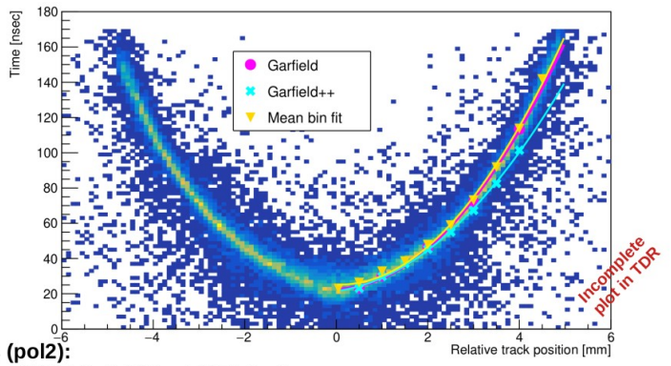
GARFIELD+LTSpice simulation

Simulation dedicated for SPDroot straw signal parametrisation started in the spring:

Straw response – Garfield/Garfield++
Electronics (VMM3) – LTSpice
In more details presented at SPD Ph&MC March22 (*link*)

- mean: good agreement with NA62
- width:
  - **defined by the readout electronics**
  - **no noise introduced at this stage**

Comparison simulation and NA62 measurements



Fit curves (pol2):

Garfield	22.74 +	0.46 * x + 5.51 * x * x
Garfield++	21.52 +	3.53 * x + 4.04 * x * x
MeanGauss (data)	25.18 -	0.82 * x + 5.81 * x * x

*We are grateful to **Dosbol Baigarashev** (JINR) for sharing the experimental data*

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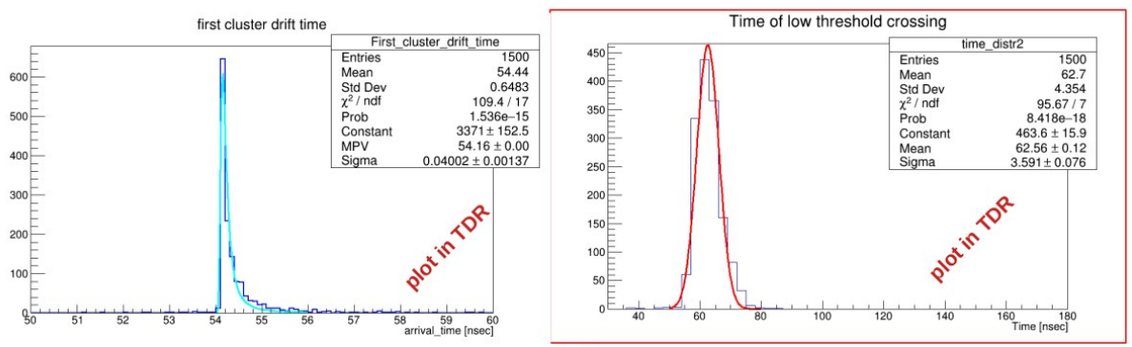
Time distribution for 3-3.1 mm bin



To be updated

But:
no noise
gas gain MAGBOLTZ
amplification 3 mV/fC

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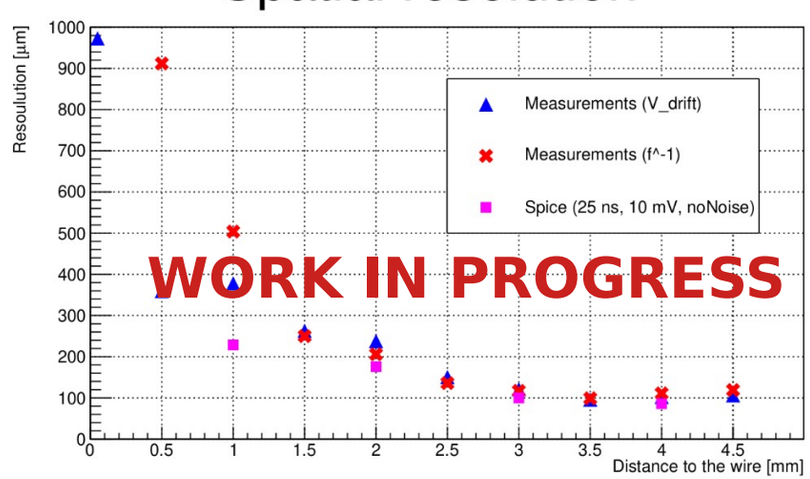
Spatial resolution



TB/lab measurements

Readout defined by the requirements of simultaneous time and charge measurements (coordinates + PID)

Existing readout solutions are based on:

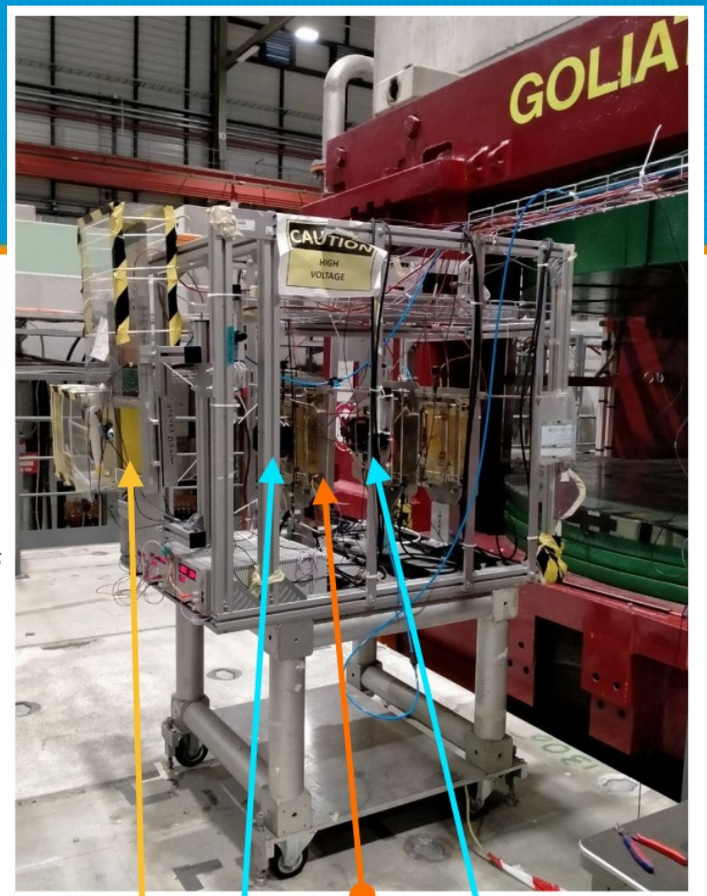
- VMM3a – rejected with October21 TB + JINR lab studies

- VMM3 - May22 + July22 TBs – data analysis ongoing

- TIGER - preparation started in July, measurements scheduled for October22 TB
  - available readout allows test in magnetic field (tbc)

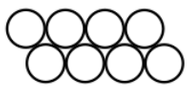
- other options?...

TB22 with VMM3 (mu2e board)



Available equipment:

- **DUT** : a **straw chamber** (~20x20 cm2) read out with a mu2e **VMM3**-based board



Dstraw = 6 mm, Dwire =30 um, gas Ar(70%)+CO2(30%), 2 layers of 32 straws

time-at-threshold mode

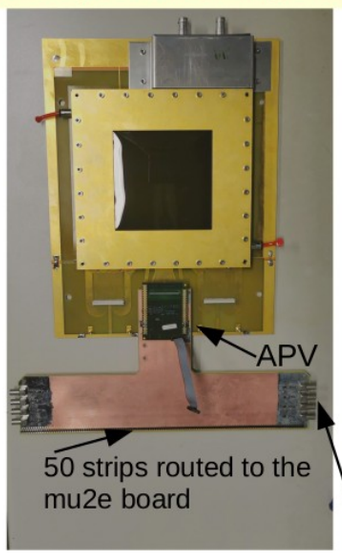
- **Timing**: 3 scintillators (~10x15 cm2) + SiPM, read-out with the mu2e
- **Tracking**: a lab tracker telescope of 3 MM (~15x15 cm2) with an APV-based read out, triggered with the scintillator coincidence

Bottleneck: read out synchronization pf two independent DAQ systems

Solution: - offline synchronization

The TB program has been divided in several stages, from a minimalistic datataking (straws + scintillator) toward the complete read out with offline synchronization

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



4+4 LEMO inputs for straw and scintillator readout

GARFIELD/LTSpice vs TB

The comparison performed at the early stage of TB data analysis:

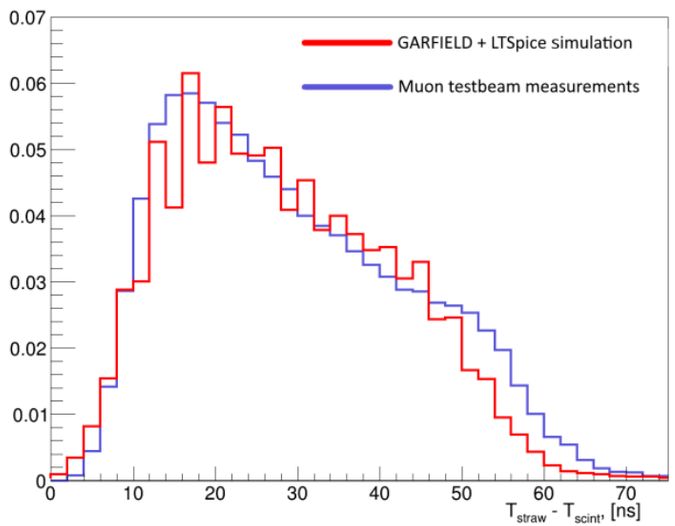
- use rough R-T dependencies obtained with a single MM of the tracking system (no synchronization technique at that time)
  => 250 um R-resolution
  ***TBD**: synchronized data allow to get full tracking info*

- Alignment information is not accounted for (vertical straw-MM misalignment was measured later during the data taking)
  ***TBD**: data available after introducing additional MM*

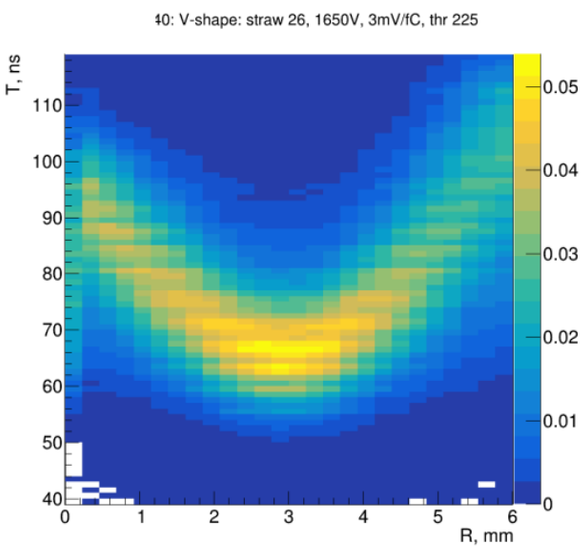
- Electronics noise is not implemented in the simulation, in the data may be defined by the x-board (analysis ongoing)
  ***TBD**: realistic noise to be introduced to the simulation*

- very preliminary data (6mm straw, D_{wire} = 30um, HV = 1650V)

Preliminary measurements result
Work in progress



Measured drift time distribution compared to Garfield + LTSpice simulation results



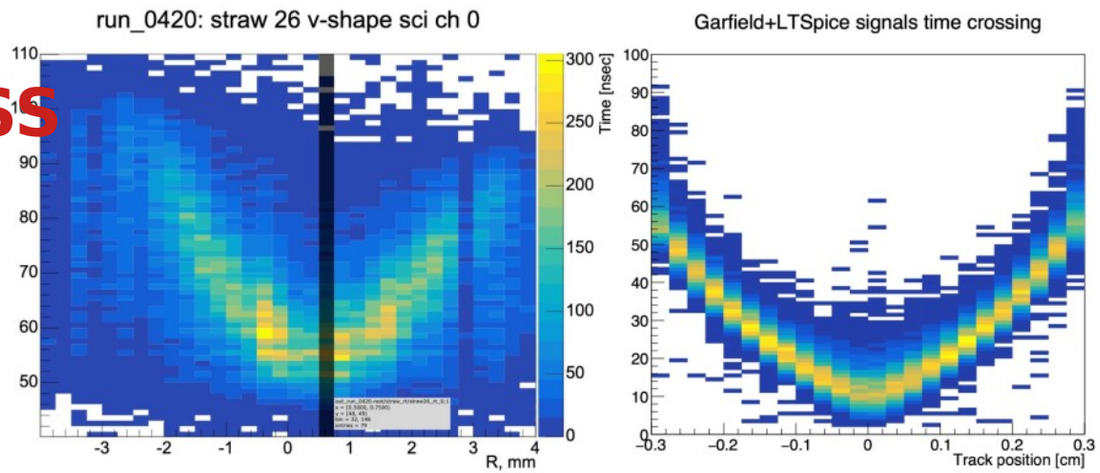
Measured ***r(time$_{drift}$)*** dependence (reduced tracking information)

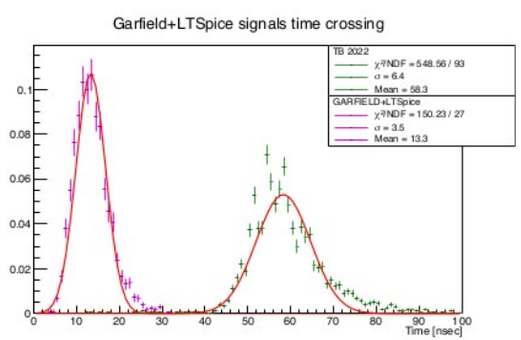
GARFIELD/LTSpice vs TB

WORK IN PROGRESS

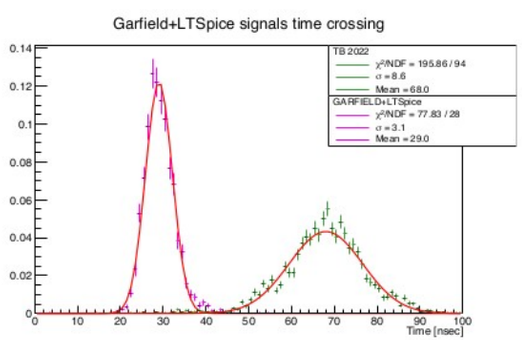
1 layer of tracker for coordinate estimation was used

Result: comparison of Garfield+LTSpice vs TB data

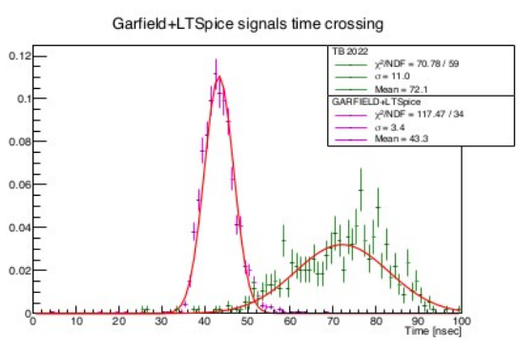




0.5 mm from apex



1.75 mm from apex



2.5 mm from apex

Extremely preliminary results!

- misalignment to be taken into account

- x-check with later data to be done

- ways for noise reduction to be studied

Advanced analysis of the TB data

Complete tracking information is available for synchronized data

- synchronization was implemented by means of the MM dual readout and common timing signals by means of external pulse generator

- offline synchronization technique was developed, first results coming soon

“After Pulser”

```
-------- APV Double ReadOut Period 462 --------- T = 4625346 [us]
0    Strip: 129
     PDO: 103
1    Strip: 145
     PDO: 51
2    Strip: 148
```

WORK IN PROGRESS

~40 events per spill are mapped

Efficiency is about 30%

2 methods were used:
- APV hits were mapped with VMM hits
- VMM hits were mapped with APV hits

```
     PDO: 85
4    Strip: 153
     PDO: 44
------- APV Layer 1 --------
0    Strip: 146
     PDO: 68
1    Strip: 147
     PDO: 171
2    Strip: 148
     PDO: 448
3    Strip: 149
     PDO: 261
4    Strip: 150
     PDO: 69
-------- VMM Period 462  (85) --------- T = 4624250[us] (dT = 634 [us])
     Strip: 147
     PDO: 97
     Strip: 148
     PDO: 156
     Strip: 150
     PDO: 194
     Strip: 151
     PDO: 141
     Strip: 152
     PDO: 62
```

It’s about how we estimate the start point

Summary

- TB measurement setup was developed in April-June 22

- Data acquired with the combined mu2e(VMM3)+apv readout are being analyzed

- Combination of GARFIELD and LTSpice signal simulation allows prompt predictions of different readout options of the straw tubes (to be continued to provide signal parametrisation for SPDroot)

- Very preliminary comparison of TB measurement and simulation study results shows a reasonable agreement

- More advanced studies to be done with the reconstructed TB data (in progress)

- As the result of detailed analysis of the VMM3a/VMM3 operation performance, a development of a new ASIC has been initiated

- Preparation for the next TB with an optional straw readout is ongoing: a long term parasitic use of the H8 SPS beam line allows to evaluate the basic performance of the TIGER readout, tune the data acquisition using permanent access to the setup, and perform remote data taking with low intensity muons

- The work is being performed in a close contact to the RD51 Collaboration. Access to the infrastructure and experience of the corresponding experts are of significant help in the carried studies