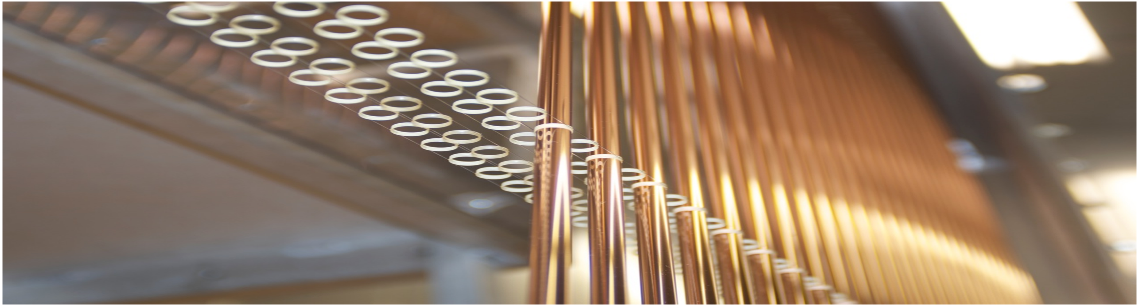
Garfield++ / LTSpice for modelling response of Straw Tubes with custom readout

2nd DRD1 Collaboration Meeting & Topical Workshop on Electronics for Gaseous Detectors

Assel Mukhamejanova, Sofia Bulanova, Vitaly Bautin for Straw Tracker RD

INSTITUTE OF NUCLEAR PHYSICS



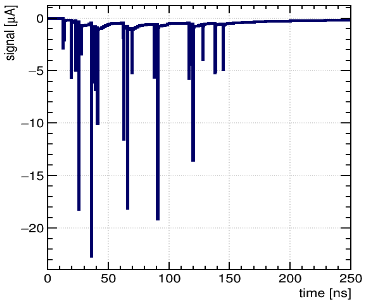
Straw Tube Trackers are important detectors in a number of operating and future experiments. The advantage of such trackers is their large area and small material budget. Examples of already existing trackers: the ATLAS TRT (straw winding technology) and the NA62 tracker (ultrasonic welding). Future trackers, for example STT of DUNE, should also measure signal charge for particle identification

INSTITUTE OF NUCLEAR PHYSICS

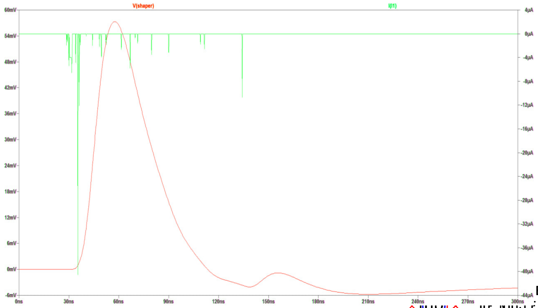
- ***Simultaneous precise measurements of signal timing and charge is a challenging task***
- ***Existing ASICs tested at the StrawTrackerRD setup: VMM3/3a and Tiger, both options can not be a final solution for straw readout***
- ***Currently several ASIC developments dedicated for straw readout are ongoing***
- ***The goal of our study:***
  - to develop a procedure which allows to predict performance of the time and charge measurement
  - to validate it with straw performance measurements done with VMM3 and Tiger ASICs
  - to use the procedure to predict performance of the readout under development

INSTITUTE OF NUCLEAR PHYSICS

- The straw signals are obtained using Garfield++ simulation. Then those signals are processed with LTSpice. LTSpice is one of the best software for analysis and design of electronics circulates. It is easy to use, widespread, and free product with very good convergence. The straw signals processed with LTSpice are used for further analysis.



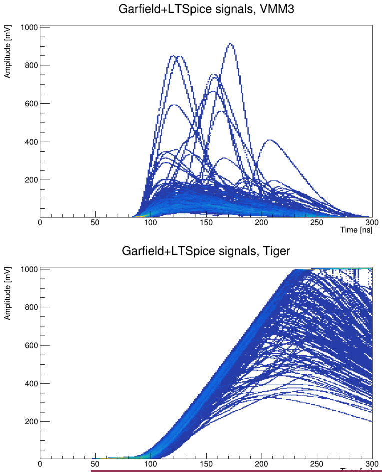
a) Signal from straw tube simulated by Garfield++



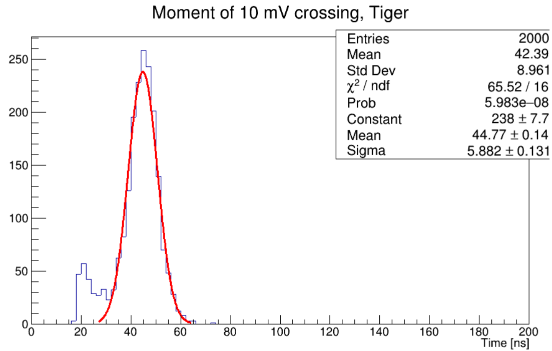
b) Garfiled signal - green and the corresponding signals processed with LTSpice (red)

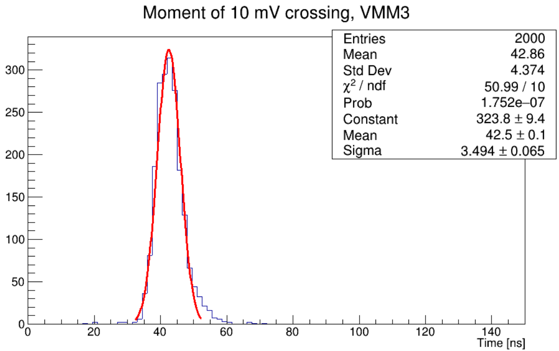
Simulation Parameters

- Straw diameter: 10 mm
- Anode diameter: 30 mkm
- HV: 1750 V
- Gas mixture: Ar+CO2 / 70:30 [%]
- Gas mixture temperature: 20 celsius
- Gas mixture Pressure: 1 atm
- Ionizing particle: muon 1 GeV
- LTSpice models: VMM3 and Tiger
  (see talk tomorrow at WG7)
- Noises: VMM3(1500e), Tiger(2000e)



INSTITUTE OF NUCLEAR PHYSICS





INSTITUTE OF NUCLEAR PHYSICS

Comparison to NA62 data (without noises)

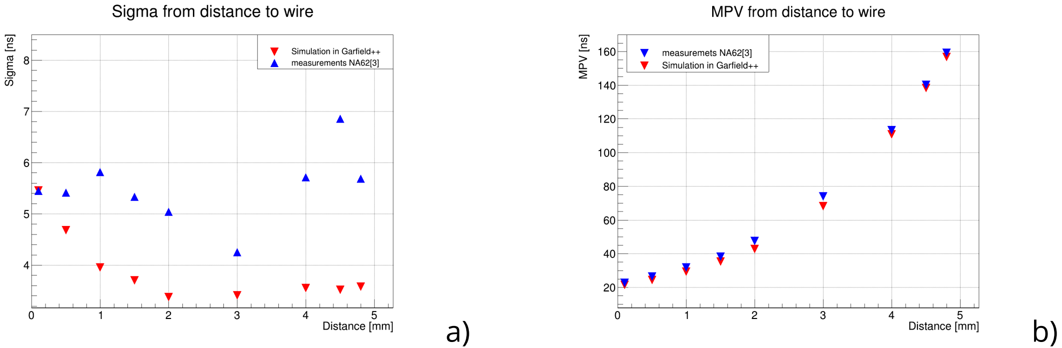
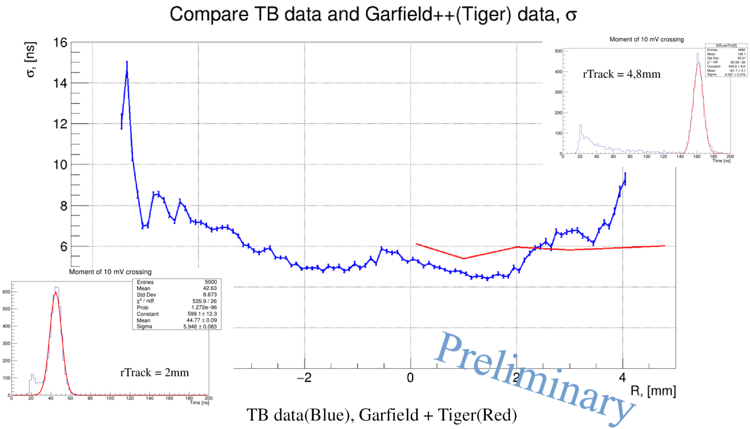
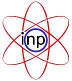


Figure: (a) The width of the threshold crossing time distribution. (b) The most probable value of the threshold crossing time
The values are shown as functions of the distance between a track and the anode wire and compared to the performance of the NA62 straw tracker readout with CARIOCA chip.

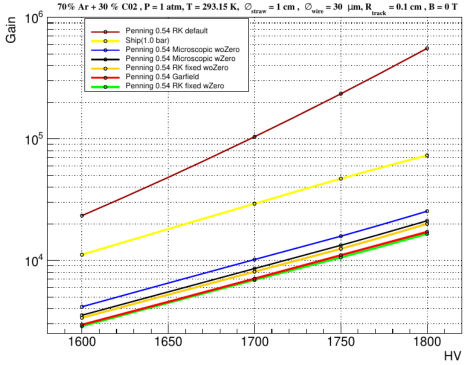
INSTITUTE OF NUCLEAR PHYSICS

Comparison to our test beam measurements

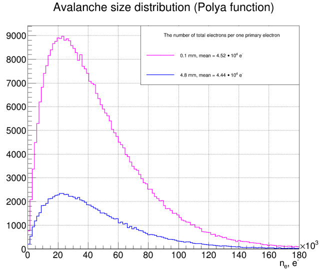




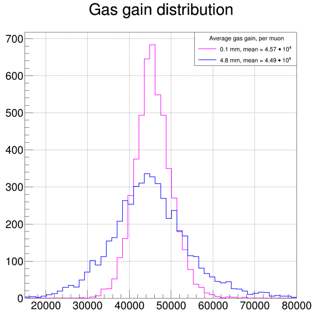
We did not succeed to reproduce the charge in an avalanche originating from a single electron (gas gain) as it is measured by NA62 and SHiP for 10 mm. Compared: data, **old Garfleld**, **RK** and **microscopic** methods for Penning coefficient of 0.54. RK method with the gain fixed to the average value predicted by the microscopic method reproduces values of the microscopic methods. Currently we use a quick fix: take the average gain value from measurements, compensate for the expected attachment and set penning to 0. We use Polya function **(drift.SetGainFluctuationsPolya(1,5700,true))** and RK. We plan to resume investigating the discrepancy soon



To check the quick fix for gas gain we plot the total charge from a single electron and the ratio between the total charge and the number of primary electrons for a muon track. The check is done for different distances to the anode wire



a)The number of total electrons per one primary electron (Polya function)



b)The total charge divided by primary charge for muon track

INSTITUTE OF NUCLEAR PHYSICS

Studies for PID with StrawTracker

To study requirements for PID at low particle momenta (peaking time, dynamic range) we generate signals from different particles (under development)

- *validate energy losses predicted by Garfield with Geant4*
- *define thresholds for MIP*
- *define the most probable and maximal charges for proton signals*

INSTITUTE OF NUCLEAR PHYSICS

Garfield++ and Geant4 validation

Comparison of the energy loss predicted with Garfield++ and Geant4

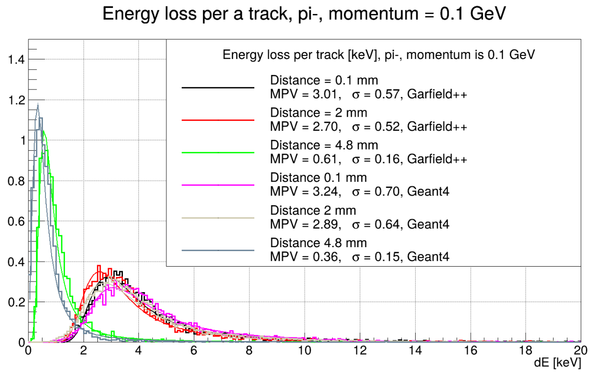


Figure: quite good agreement even for low momenta

Rough dynamic range estimate with ionization energy losses

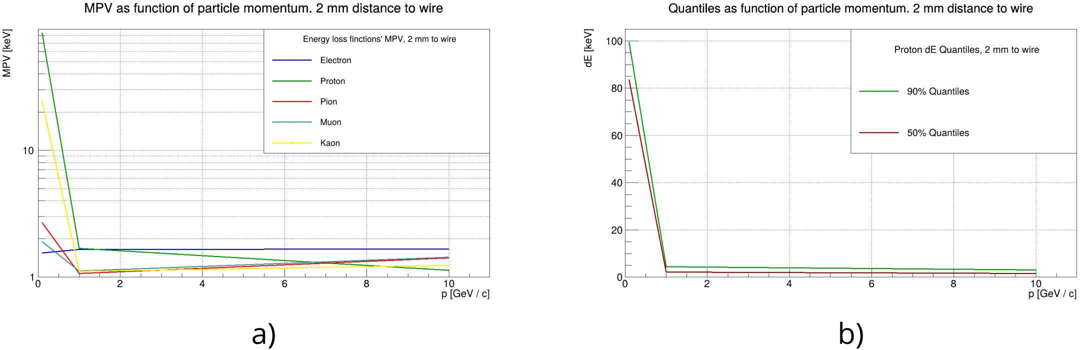


Figure: (a) M (a) The most probable value of the ionization energy losses as functions of particle momentum, (b) 50% and 90% quantiles for proton - 100 keV for 0.1 GeV.
Studies ongoing...

INSTITUTE OF NUCLEAR PHYSICS

Conclusion

- a combination of Garfield++ and LTSpice is used to predict performance of the straw tube operated with a different readout
- a comparison of the Garfield/LTSpice prediction and measured straw performance is ongoing for VMM3 and Tiger ASICs
- studies for PID performance are ongoing

INSTITUTE OF NUCLEAR PHYSICS