Measurement of anomalies in the angular correlation of electron and positron internally produced in excited ^{8}Be and ^{4}He

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Objective

Construction of a spectrometer for the tracking and measurement of the energy of light charged particles and study of the ^{8}Be decay.
The spectrometer will be composed of:

- Timepix3 (TPX3) [1]
- Multi-Wire Proportional Chamber (MWPC) [2]
- Time Projection Chamber (TPC) [3]

Setup under construction at the IEAP's Van de Graaff accelerator facility.

^{8}Be decay

a) Hadronic (≈ 100%)
b) Electromagnetic (≈ 1.5 x 10^{-5})
c) Internal Pair Creation (≈ 5.5 x 10^{-8})

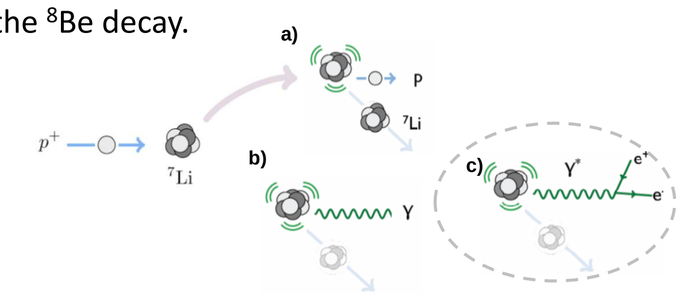


Figure 1: ^{8}Be decay reaction.

ATOMKI: Observed anomalies in e+e- emission from ^{8}Be and ^{4}He

ATOMKI Institute, in Debrecen, Hungary, measured a 6.8σ anomaly in the opening angle of e+e- pairs produced in ^{8}Be M1 transition to the ground state [4,5].
Possible explanations:

- Unidentified nuclear reactions;
- Experimental effects;
- Production of a new boson [6].

Independent measurements of such anomaly are crucial.

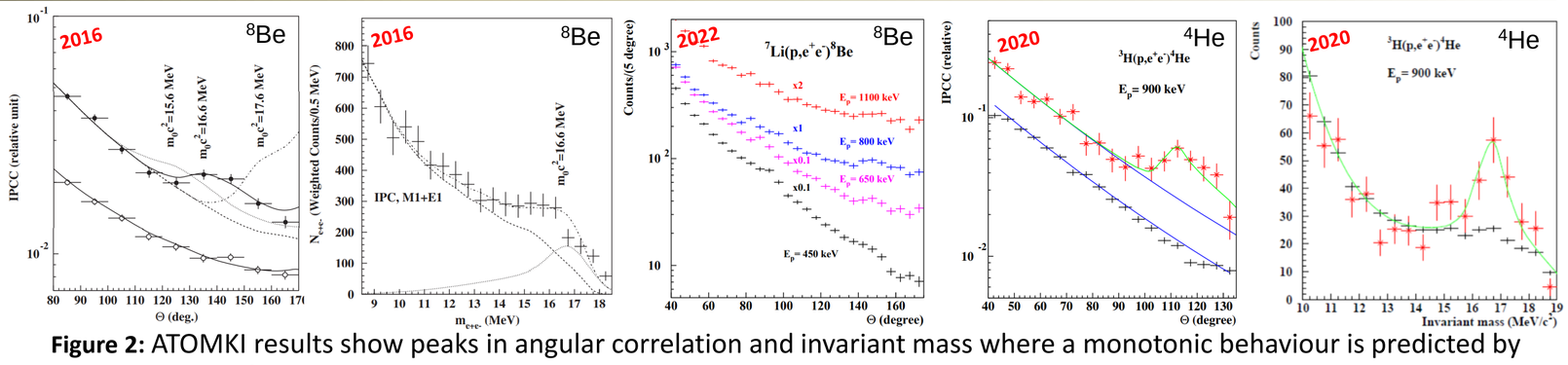


Figure 2: ATOMKI results show peaks in angular correlation and invariant mass where a monotonic behaviour is predicted by theory for both ^{8}Be (**Left**) and ^{4}He (**Right**).

IEAP Spectrometer – Optimization Studies

Timepix3 (TPX3)

- Event-driven pixelated detector (fast response);
- 256x256 55-µm pixels (high granularity);
- 1.6-ns time resolution;
- 14x14 mm^2 (fits inside the vacuum tube).

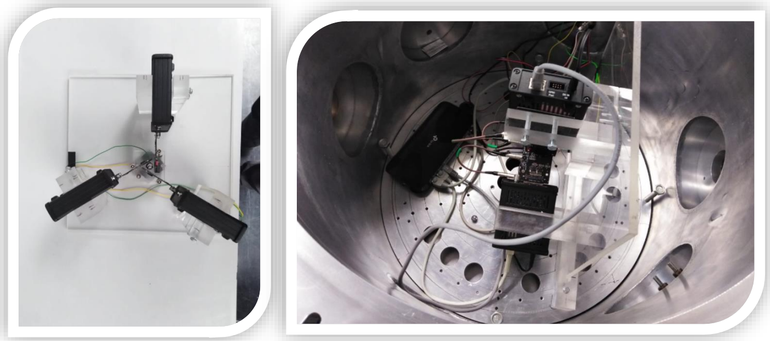


Figure 3: TPX3 triangle pilot experiment at Van de Graaff (**Left and Centre**). Data monitoring of the experiment (fluoride-containing compounds used as target – LiF/CeF_3) (**Right**).

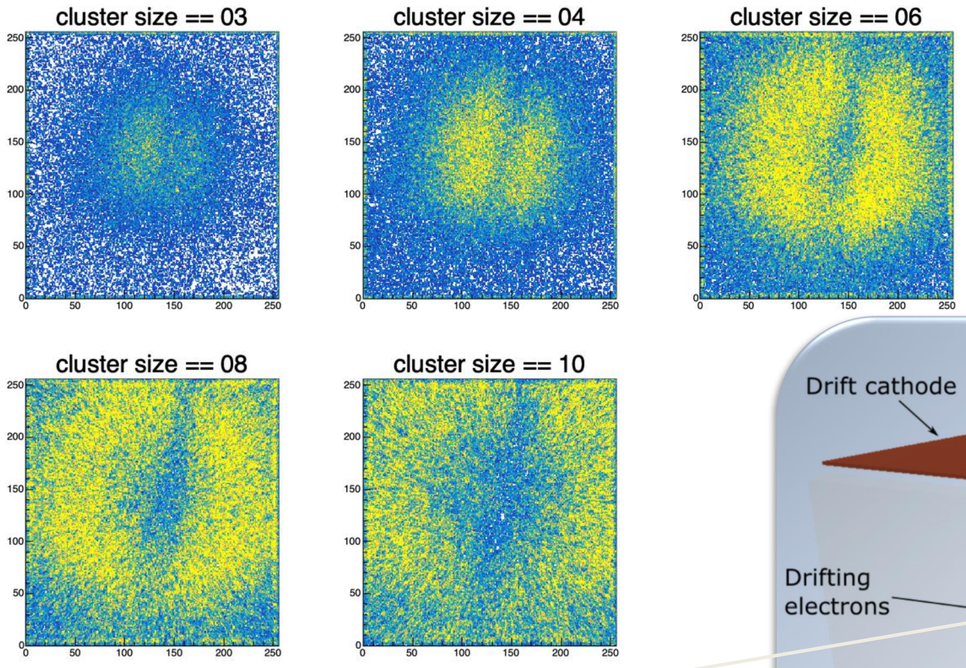


Figure 4: Projection of the e+e- tracks in one of the detectors.

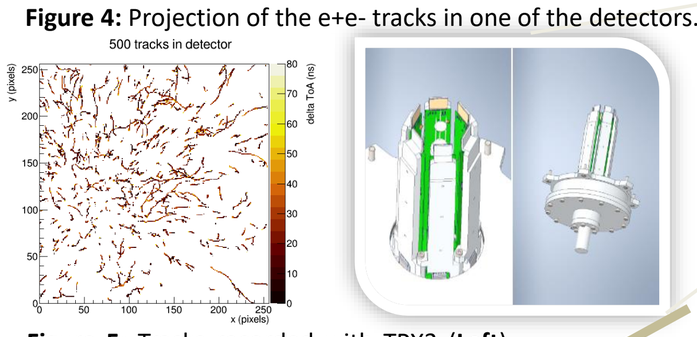
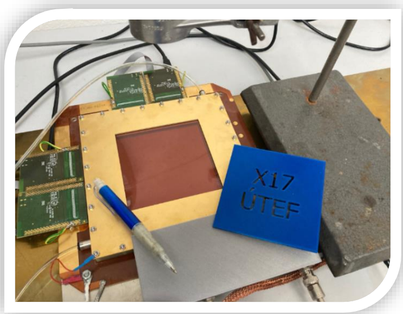


Figure 5: Tracks recorded with TPX3 (**Left**). TPX3 Hexagon under construction at the FEE UWB, Pilsen (Czech Republic) (**Right**).

Time Projection Chamber (TPC) Readout Optimization

1st Prototype

- 10x10 cm^2 sensitive area;
- 3 mm drift volume;
- Standard triple-GEM;
- Strip readout (256 X, 256 Y);
- DAQ based on CERN's SRS with APV25 ASIC.



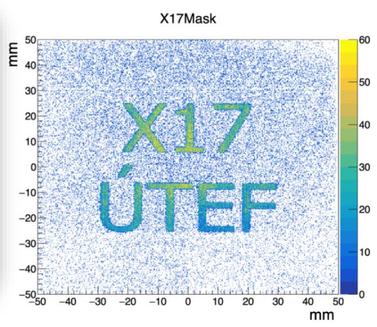


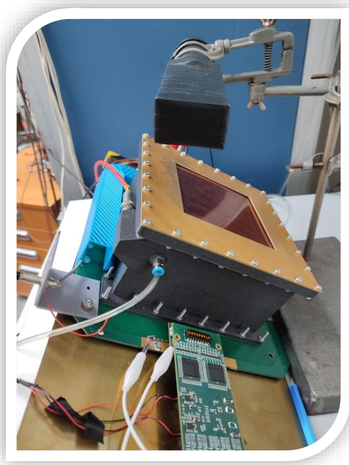
Figure 6: 1st prototype of the triple-GEM readout with APV25 (**Left**). X-ray image of the X17 mask acquired with the prototype (**Right**).

2nd Prototype

Implementation of the SAMPA chip [7] with SRS (RD51/CERN).

- 10x10 cm^2 sensitive area;
- 8 cm drift volume;
- Standard triple-GEM;
- 120 pad readout;
- SAMPA integration in SRS DAQ.

Check the QR code for more details.



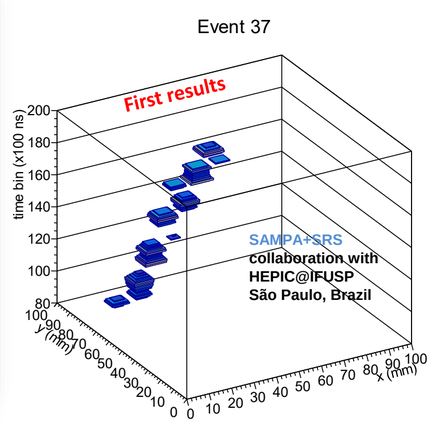
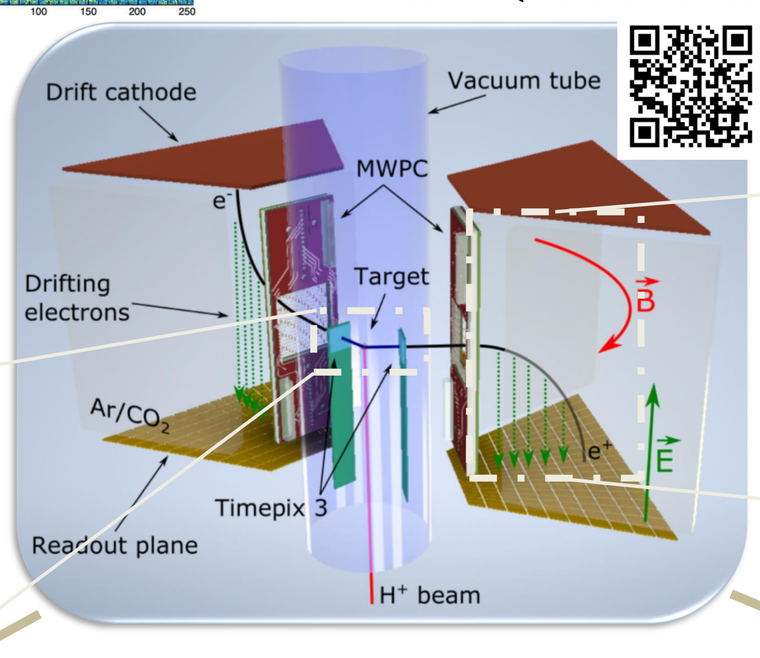
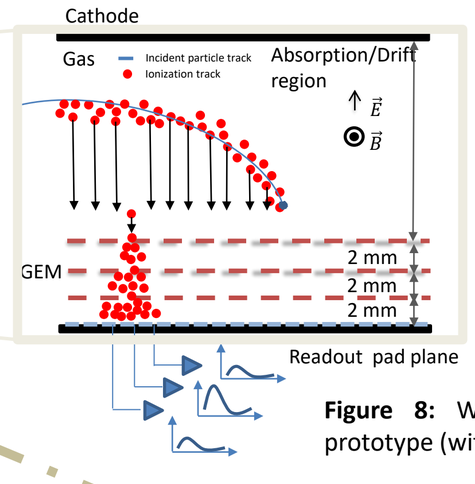


Figure 7: Upgraded prototype with SAMPA [7] (**Left**). Cosmic muon track recorded with the TPC prototype. See Poster "Operation of the SRS using the SAMPA chip: first results" from the Front-End, Trigger, DAQ Session (**Right**).



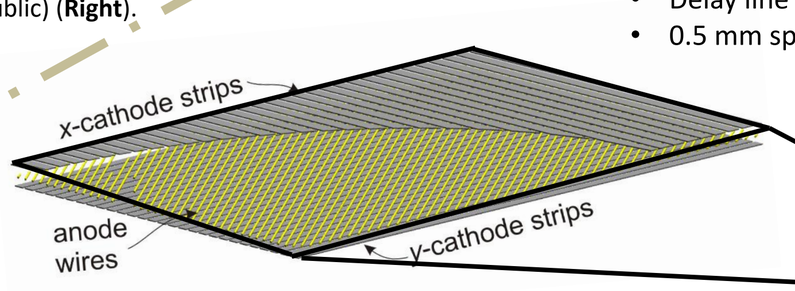


- XY position given by the readout plane;
- Z coordinate given by the charge drift time;
- 3D tracking (event topology);
- Particle ID;
- Background rejection.

Figure 8: Working principle of the TPC prototype (with a triple-GEM readout).

Multi-Wire Proportional Chamber (MWPC)

- Delay line position encoding;
- 0.5 mm spatial resolution (≈ 0.5º).



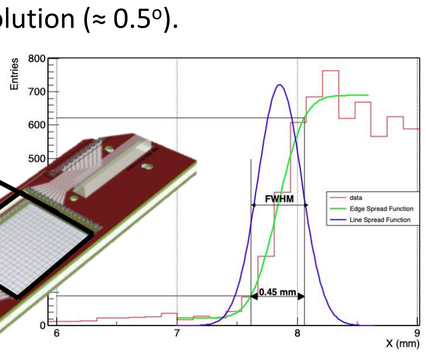


Figure 9: MWPC spatial resolution.

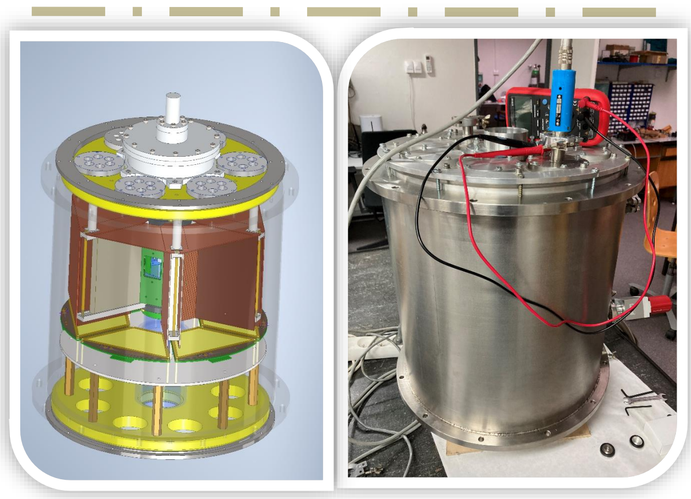


Figure 10: CAD and picture of the spectrometer currently under construction at the IEAP's Van de Graaff facility.

References

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