Upgrade of the NA61/SHINE TOF system based on a MRPCs for the NICA experiments

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for the MPD and NA61/SHINE collaborations

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Old NA61/SHINE TOF-LR system

NA61/SHINE TOF-LR detector:
- 2 x 891 scintillator counters
- TOF-L (JINR contribution) put into operation in 1995-96
- Time resolution: $\sim 75$ ps
Requirements for the new TOF-LR system

- high efficiency (> 95%);
- excellent intrinsic time resolution (< 75 ps);
- high granularity in order to keep the overall system occupancy below 10%;
- good position resolution to provide effective matching of the TOF hits with the Time-Projection Chambers (TPCs) tracks;
- low power dissipation in close proximity to TPCs.
BM@N TOF400 overview

With correction.
Time resolution ~ 100 ps
The wide MRPC is completely identical to BM@N-type TOF400 detector.
R&D for the new NA61/SHINE TOF-LR

\[ \sigma_{2016} \approx \sqrt{75^2 - 58^2} \approx 47.5\text{ps} \]

\[ \sigma_{2018} \approx \sqrt{76^2 - 58^2} \approx 49\text{ps} \]
R&D for the new NA61/SHINE TOF-LR

Matching of TPC tracks to MRPC hits with NINO electronics

\[ \sigma_X \sim \frac{\text{Strip pitch}}{\sqrt{12}} = \frac{1.25}{\sqrt{12}} \approx 0.36 \text{ cm} \]

\[ \sigma_Y \sim \sigma_{\text{electronics}} \]

\[ \sigma = 0.70 \text{ cm} \]

\[ \sigma = 0.60 \text{ cm} \]
R&D for the new NA61/SHINE TOF-LR

Occupancy estimation in Pb+Pb 158A GeV/c collision

Estimation
red 45 cm strip
blue 30 cm strip
green 15 cm strip

Measurement
solid blue 30 cm strip
R&D for the new NA61/SHINE TOF-LR

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Upgrade of the NA61/SHINE ToF system

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Detector engineering design / Concept

Manufacturing by "ATOM" at Dubna
Intersection with MPD mass production

- The MPD is a main priority for mass production area
- Small number of detectors for one wall (28/300). A 4w/28 are ready.
- Different technology of glass painting
- Different electronics
- Different soldering operation
- Materials are being prepared
Front-end & readout electronics

A DRS4 boards based system was considered as an optimal readout, which required new analogue front-end electronics.

**Analogue amplifier**
- Under R&D by V. Terechschenko (DLNP)

**DRS4 module**
- Custom DRS4 boards developed at University of Geneva
- Each board features 4 DRS chips, 32 analog channels in total
- 12 bit ADC is used
Gas system

Gas system will be prodused by

CERN EP-DT-FS/Gas Team (Roberto Guida)

Gas system requirements:

- Total volume \(- 1 \text{ m}^3\)
- Number of modules \(- 2\)
- Gas mixture \(- \text{C}_2\text{H}_2\text{F}_4 / \text{i-C}_4\text{H}_{10} / \text{SF}_6 (90\%/5\%/5\%) \text{ or } \text{N}_2\)
- Volume exchange/day \(- \sim 7\)
- Total flow rate \(- 300 \text{ nl/h}\)
- Fresh gas flow rate \(- 3 \text{ nl/h}\)
- Working pressure \(- < 3 - 5 \text{ mbar}\)
- Tolerable \(\text{O}_2\) content \(- 200 \text{ ppm}\)
- Tolerable \(\text{H}_2\text{O}\) content \(- 100 \text{ ppm}\)
Power supplies

HV system requirements:
- Minimum number of differential \( \pm \) channels: 24 (40 det)
- Total current through the whole system (\( \sim 5 \mu A \)) (150 nA wide)(75 nA narrow)
- Precision of the current monitoring: \( \sim 10 \) nA
- Multichannel structure
- Remote control
- Additional HV split up system

LV system is under design
Conclusion

- Upgrade of NA61/SHINE TOF system is progressing on schedule.
- BM@N-type MRPCs were tested and requested parameters were reached.
- Detectors production for NA61/SHINE established.
- DRS4 boards are suitable for data taking but new algorithms and front-end electronics are needed.
- R&D of new analogue electronics as well as LV system are under way.
- Gas system will be produced by CERN EP-DT-FS/Gas Team (Roberto Guida).
Thanks you and welcome!