MC simulations of beam-beam collisions monitor for event-by-event studies at NICA

Preliminary talk for NUCLEUS-2020

Vladislav Sandul

SPbSU, LUHEP

PWG1 meeting for MPD collaboration

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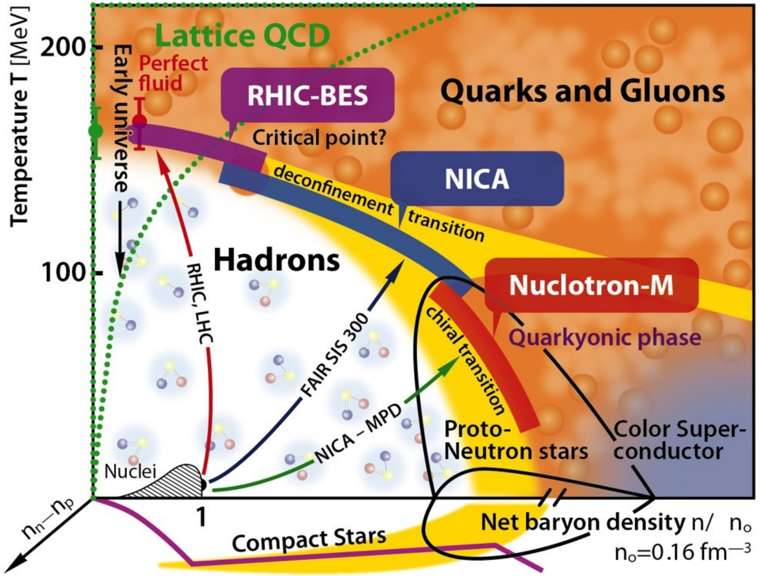
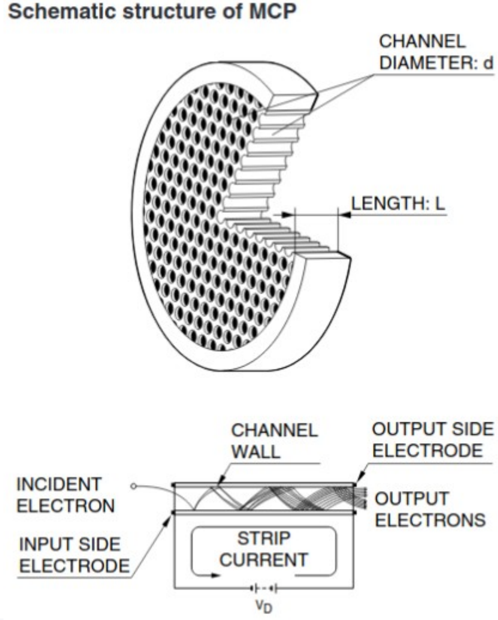


Experiments to study the QCD phase diagram in the region of high baryon densities are planned at the NICA collider.

For qualitative event-by-event analysis it is necessary to determine such event characteristics as:
- *interaction point coordinates;*
- *multiplicity;*
- *centrality;*
- *azimuth distribution, etc.*

Also for data collecting we have to build effective trigger system, which should be:
- *fast;*
- *precise;*
- *noiseless;*
- *radiation persistent;*
- *transparent.*

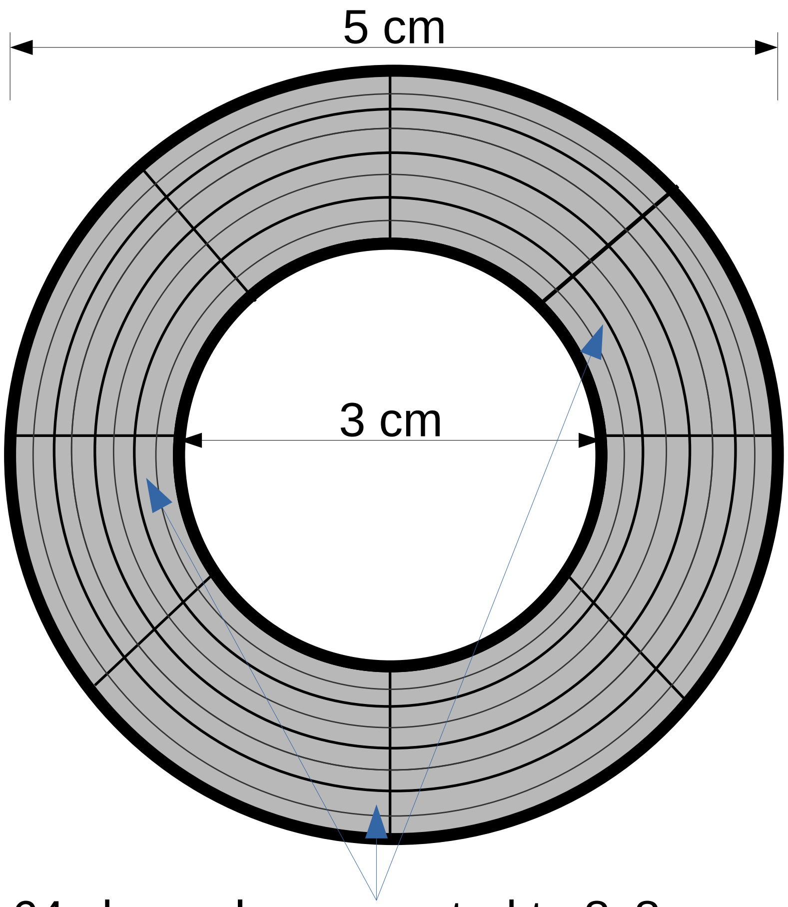


https://hamamatsu.su/products/mikrokanal-nye-plastiny/

We suggest a detectors on **MicroChannel Plates (MCP)** as the system for trigger signal generation, finding of interaction point and, perhaps, centrality class determination in MPD and/or SPD experiments.

<u>MCP advantages:</u>

- high counting speed (~ 50 ps);
- low level of noise;
- ability to work in strong magnetic fields;
- high radiation persistent;
- low amount of matter (transparency) .



64 channels, connected to 8x8 sectors of plate

We suggest the next MCP design:

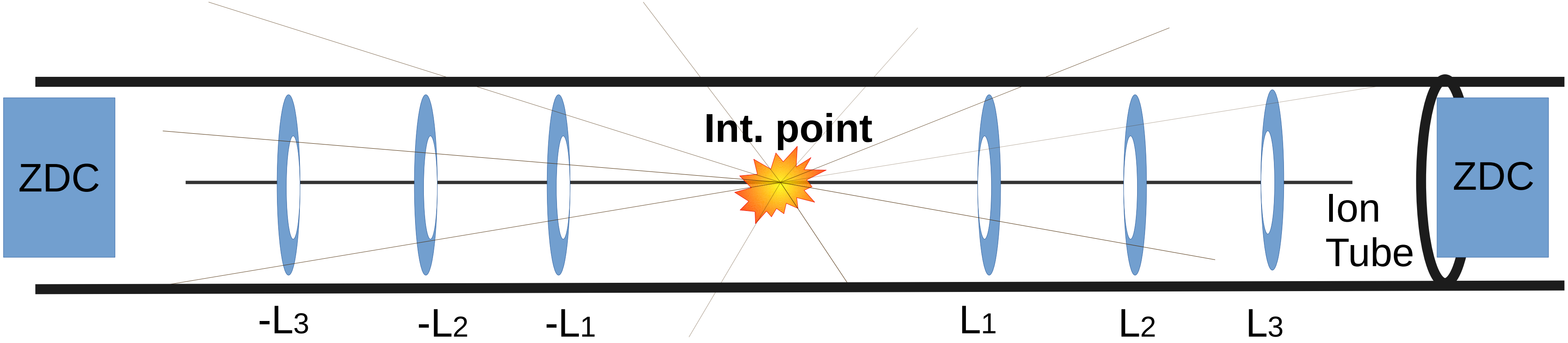
Geometry form: ring

Inner radius = 15 mm

Outer radius = 25 mm

8 equal radial sectors and 8 equal azimuth sectors = 64 sectors (channels)

Supposed detector design



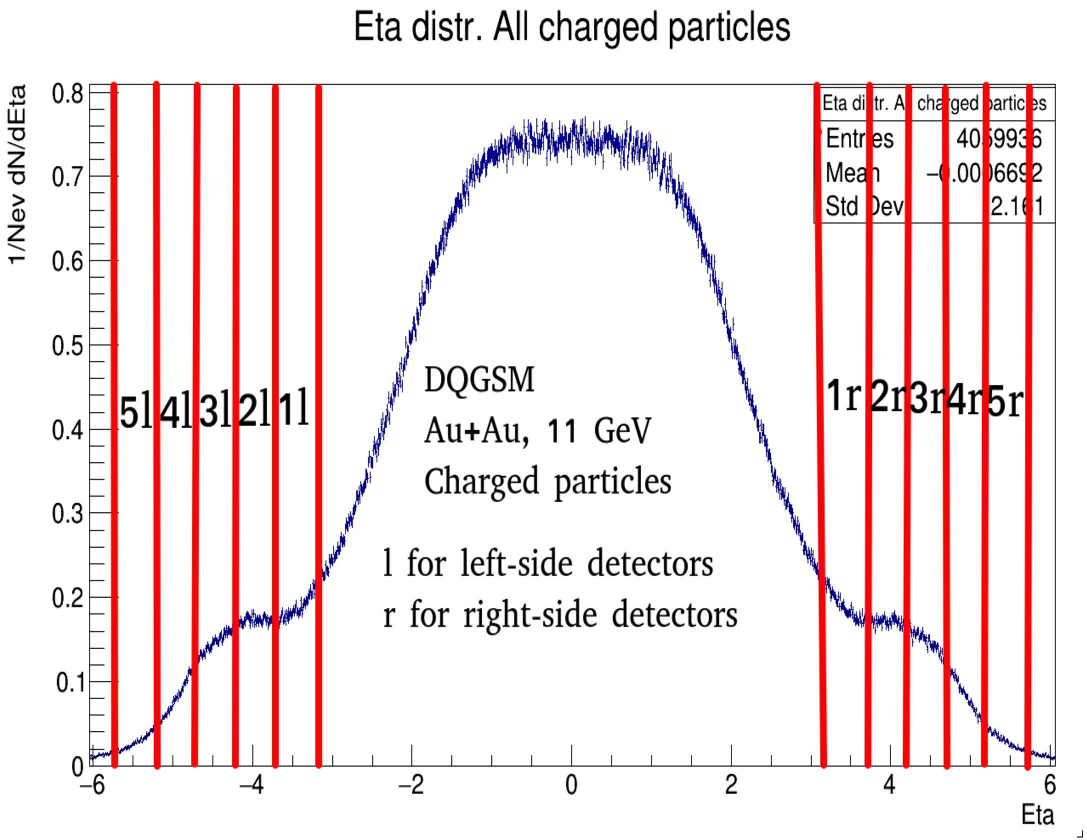
Supposed number of MCPs: from 6 (3 right+3 left) to 10 (5 right+5 left);

Distances L1, L2, L3,… from Int. point to MCPs: depends on a variety factors (other detectors mainly);

MCPs are **inside** the ion tube.

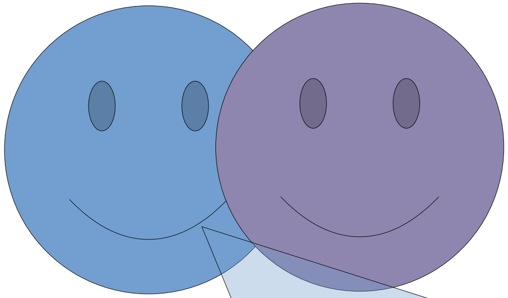
Simulations: main details

- **Used MC generators:** UrQMD, SMASH, DQGSM (without GEANT)
- **Collisions:** Au+Au, √s = 11 GeV per NN pair, impact parameter = 0 – 14 fm, 10000 events
- **Number of plates:** 5 right + 5 left;
- **L1,… , L5** = [30 / 50 / 80.3 / 138.9 / 231.5] cm
- **Covered pseudorapidity region:** 3.18 < |η| < 5.73
- **Charged particles** only



Few words about used MC generators...

SMASH and UrQMD

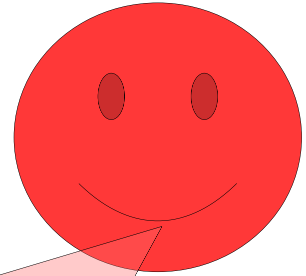


“We can tell you almost all possible info about every particle and collision (origin process, number of elastic collisions, appearance time, etc)...

...but we are see the final state isomers as just bulks of protons and neutrons :(“

Ex: He^4_2 = 2d = p+p+n+n = d+n+p

DQGSM

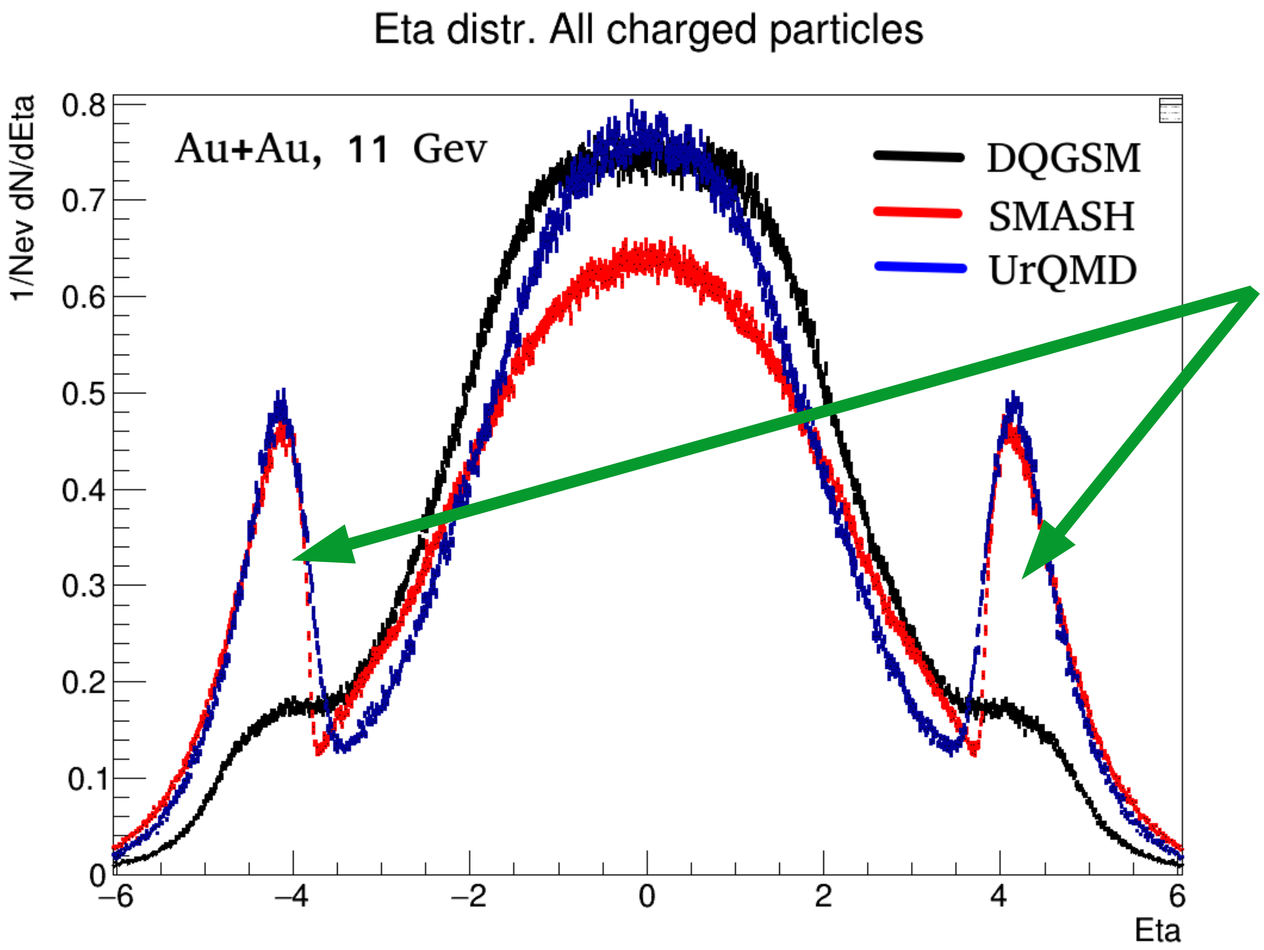


“All that I know about final particles is PID, charge, mass and momentum projections (px, py, pz)…

… but I can distinguish nuclei and just bulks of protons and neutrons in massive of final particles!”

Ex: He^4_2 = ‘1000020040’ (PID code)

Pseudorapidity distributions: comparison



Here we can see the huge bumps in the regions **3.5 < |η| < 5** for SMASH and UrQMD and the one small bump for DQGSM. This bumps correspond to spectators.

The huge bumps for SMASH and UrQMD illustrate the fact that this MC generators assume **final composite nuclear fragments just as lot of protons and neutrons**.

That's why we will use DQGSM mainly for further calculations/predictions

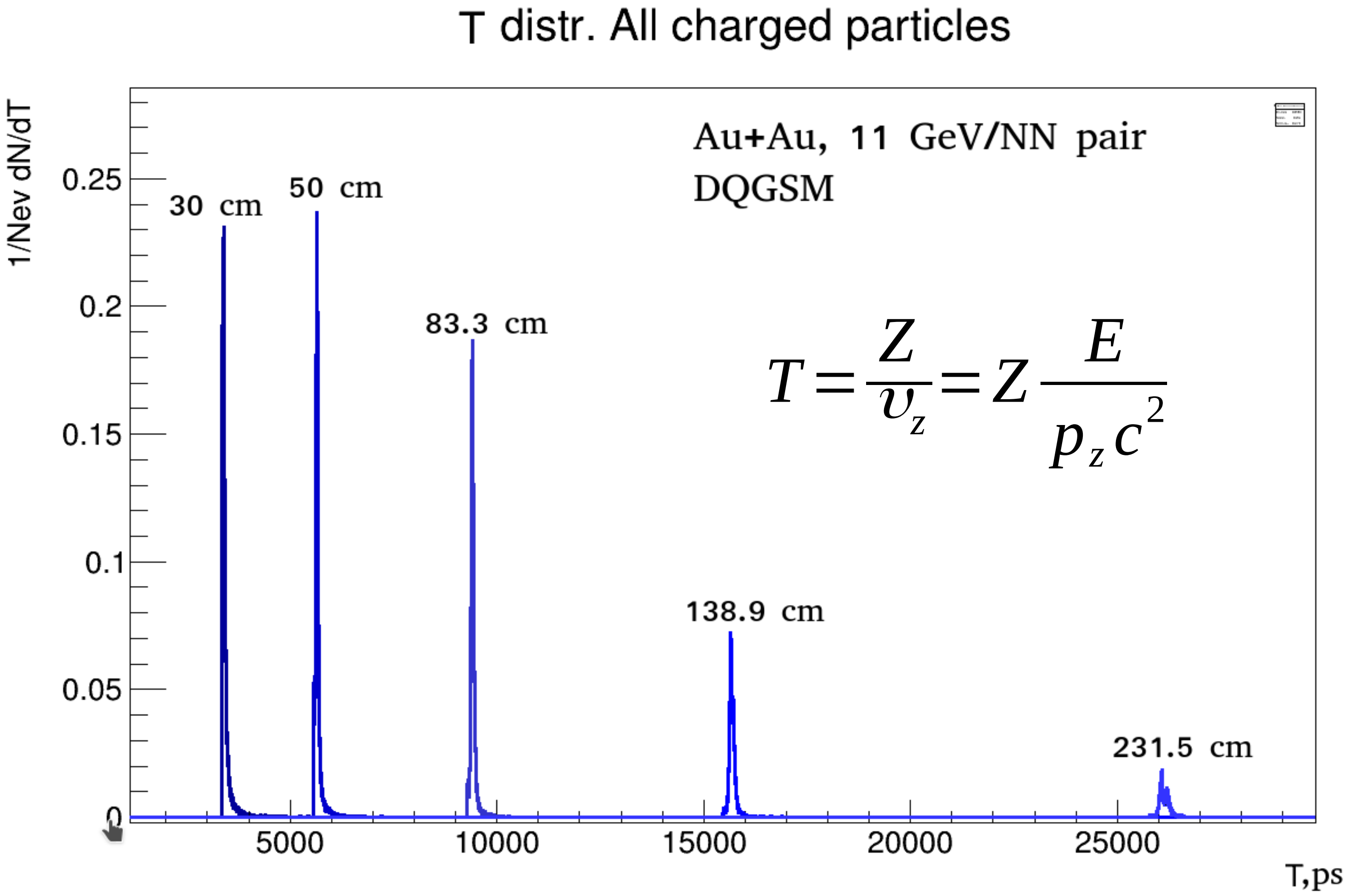
Efficiency of particle counting

- In the case of ideal MCP efficiency to register every single charged particle and for **64 microchannels** with **time precision = 50 ps** we will have these efficiencies of particle counting for single MCPs:

Distance from IP to detector	30 cm	50 cm	83.3 cm	138.9 cm	231.5 cm
η range	3.2 – 3.7	3.7 – 4.2	4.2 – 4.7	4.7 – 5.2	5.2 – 5.7
Average number of ch.part, passed through MCP in event	9.6	8.7	7.5	4.1	1.4
Efficiency ($N_{counted}/N_{all\ passed\ through}$)	0.94	0.94	0.95	0.98	0.99

DQGSM prediction

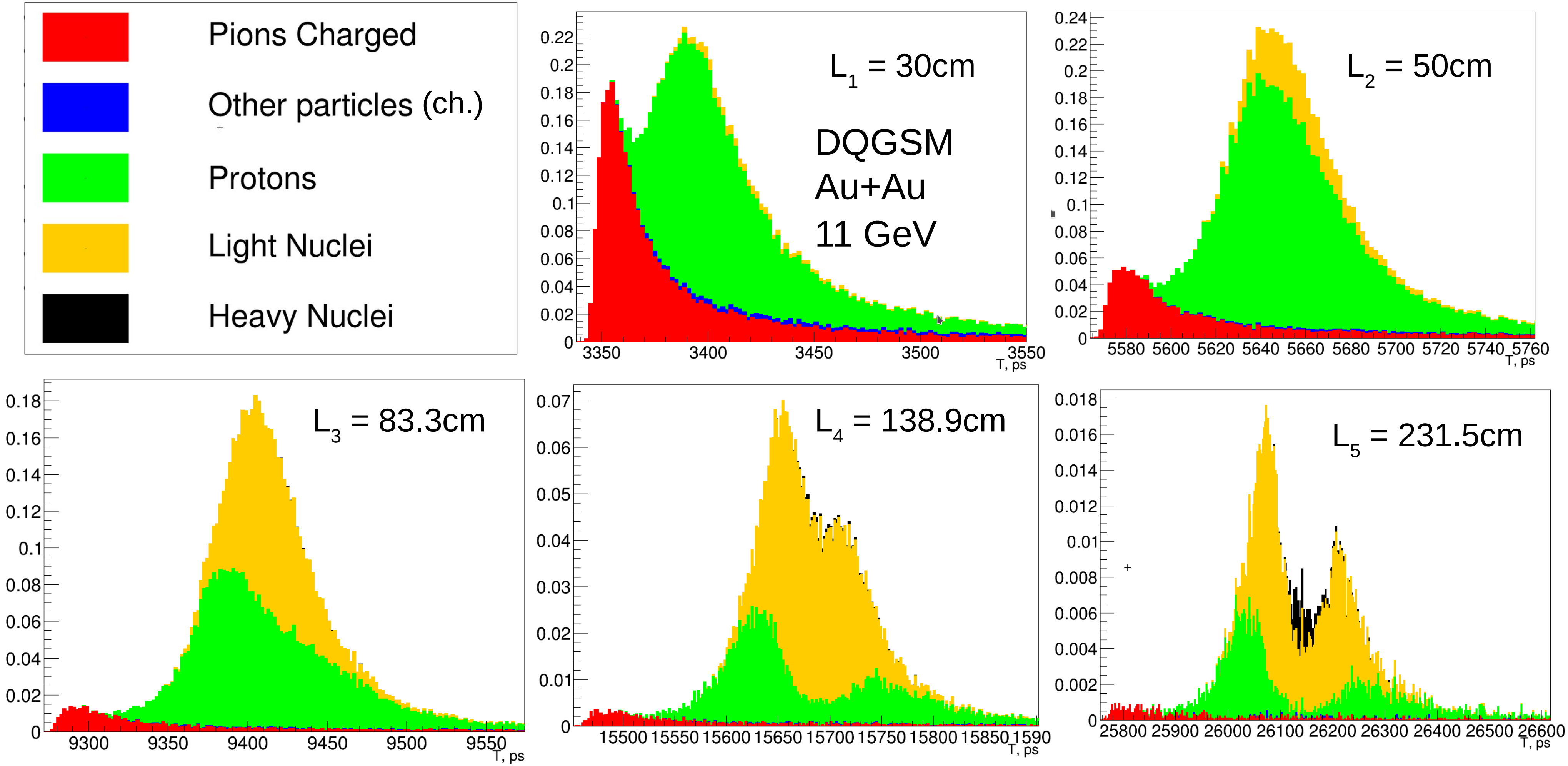
Time distributions



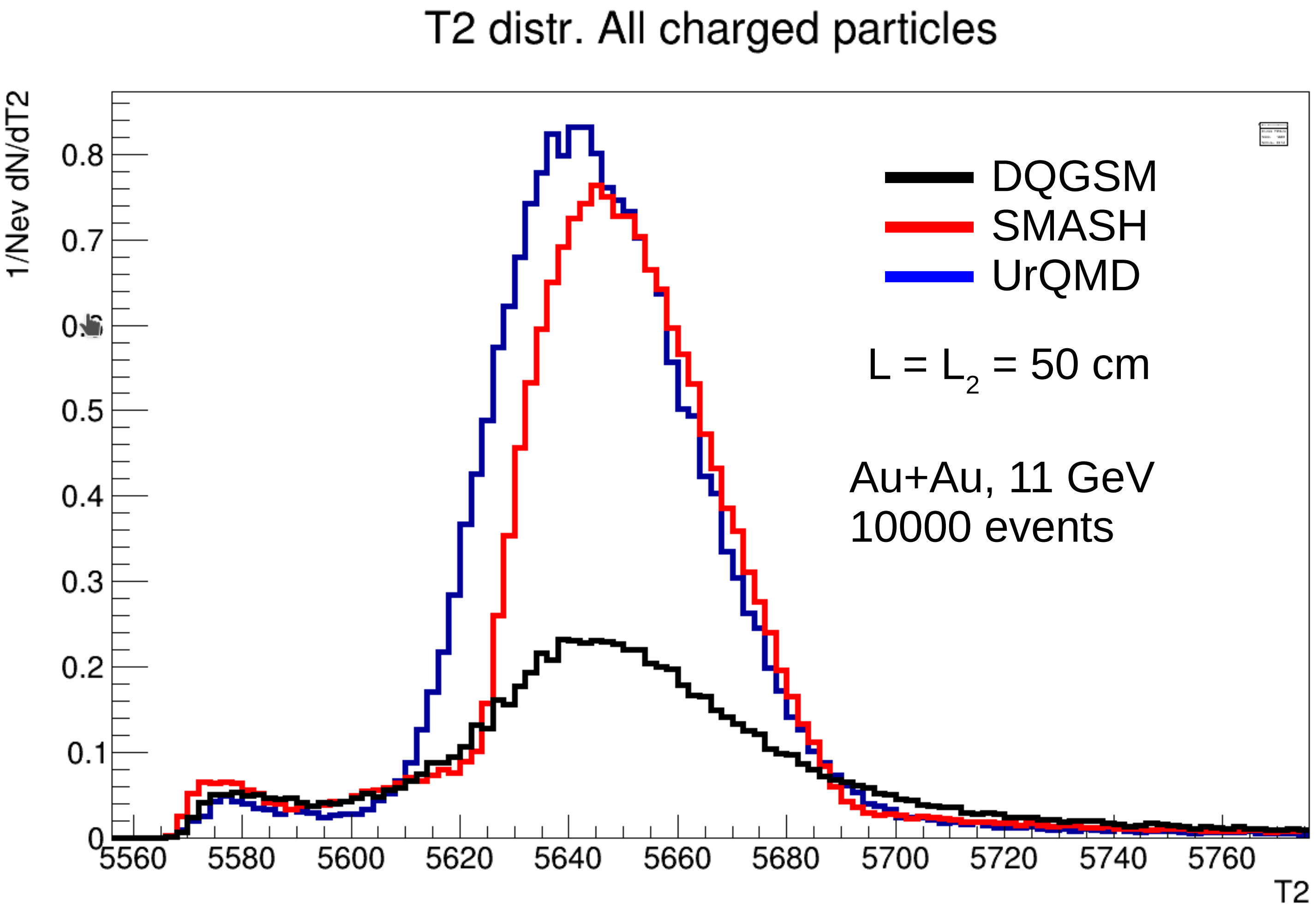
$$T = \frac{Z}{v_z} = Z\frac{E}{p_z c^2}$$

There is the distributions for 5 detectors at distances L1 - L5

Time distributions: detailed structure



Time distributions: generators comparison



This figure illustrates why we cannot clearly compare results of different MC generators since we did not create algorithm of nuclei fragments recognizing for SMASH and UrQMD outputs.

Summary

- We suggest MCPs-detector as trigger system and for IP coordinate finding
- MC simulations give us the efficiency of this facility ~ 95% * (Eff. of MCP)
- The facility shall cover $3.18 < |\eta| < 5.73$ (depends on final facility design)
- Time distributions can provide us information about IP coordinate (but this algorithm should be invented – task for future work)
- Additionally, we require an algorithm for final state nuclei recognizing for SMASH and UrQMD to compare simulation results with DQGSM clearly

Thank you!