# «Local polarimetry with ZDC at SPD»

*S.Shimansky*

# Калориметры нулевого угла (ZDC) - 2020

- **Назначение:**

А) Ускорительная физика:

1) Измерение светимости в точке взаимодействия пучков. Особенно важно в момент настройки сведения пучков. Независимое от других систем, в первую очередь BBC, мониторирование светимости во время набора статистики.

2) Измерение угла сведения пучков.

3) Измерение размера пучка в точке взаимодействия (Vernier scan).

Б) Физика тяжелых ионов:

1) “Minimum bias” триггер.

2) Определение центральности события.

3) Определение плоскости события по спектаторным нейтронам.

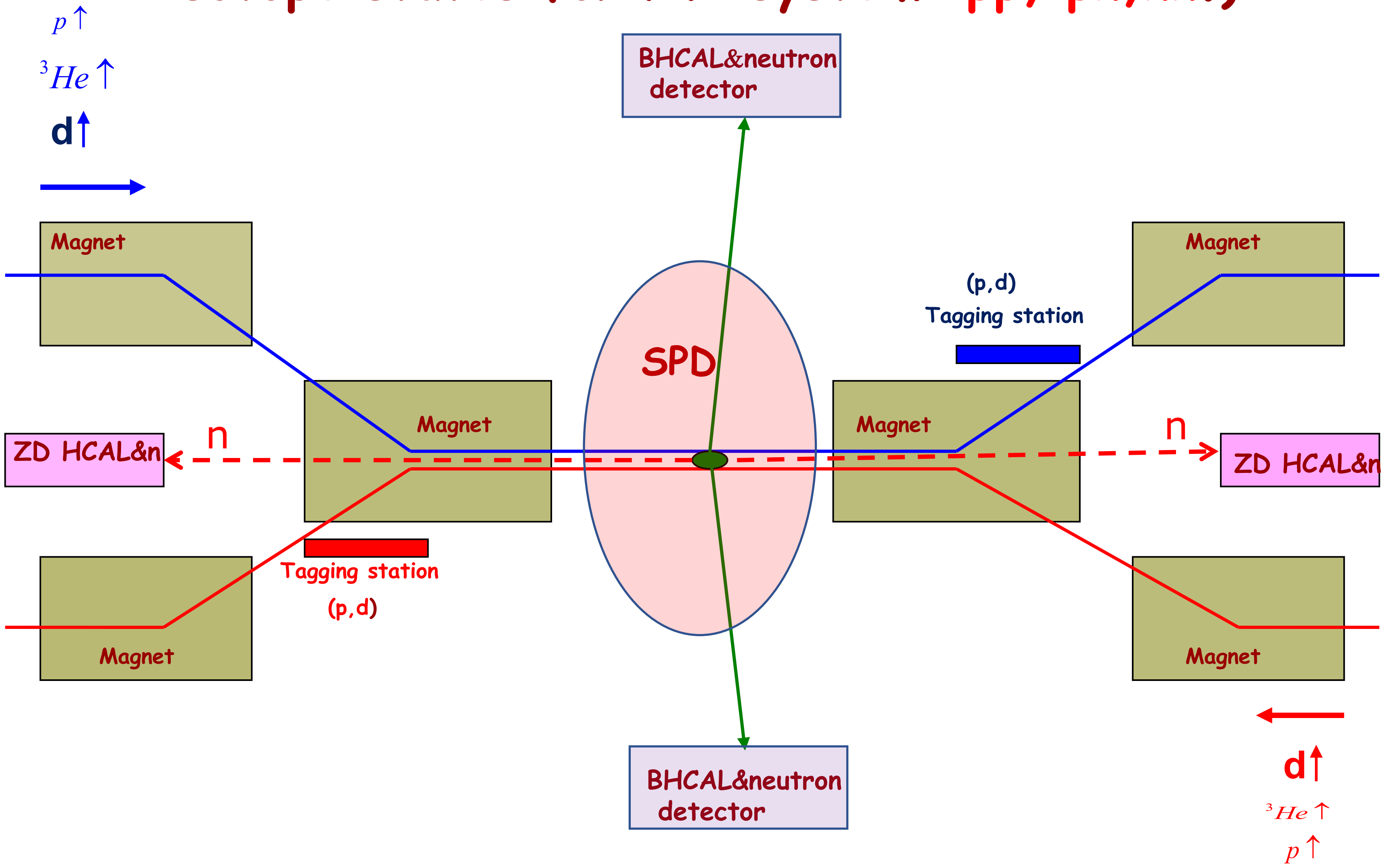
4) Абсолютное измерение светимости по процессу электромагнитной диссоциации.

В) Дифракционная физика:

1) Выделение “rapidity gap” на уровне триггера.

2) Процессы с тагированными нейтронами вперед.

# NICA Collision place for SPIN physics (deuteron and other beams, the first time all isotope states for NN system: pp, pn,nn.)




The tagging stations can be used as polarimeter too!

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Original Russian Text © S. Vokal, A.D. Kovalenko, A.M. Kondratenko, M.A. Kondratenko, V.A. Mikhailov, Yu.N. Filatov, S.S. Shimanskii, 2009, published in Pis'ma v Zhurnal Fizika Elementarnykh Chastits i Atomnogo Yadra, 2009, No. 1 (149), pp. 81–96.

PHYSICS OF ELEMENTARY PARTICLES AND ATOMIC NUCLEI. EXPERIMENT

# Program of Polarization Studies and Capabilities of Accelerating Polarized Proton and Light Nuclear Beams at the Nuclotron of the Joint Institute for Nuclear Research

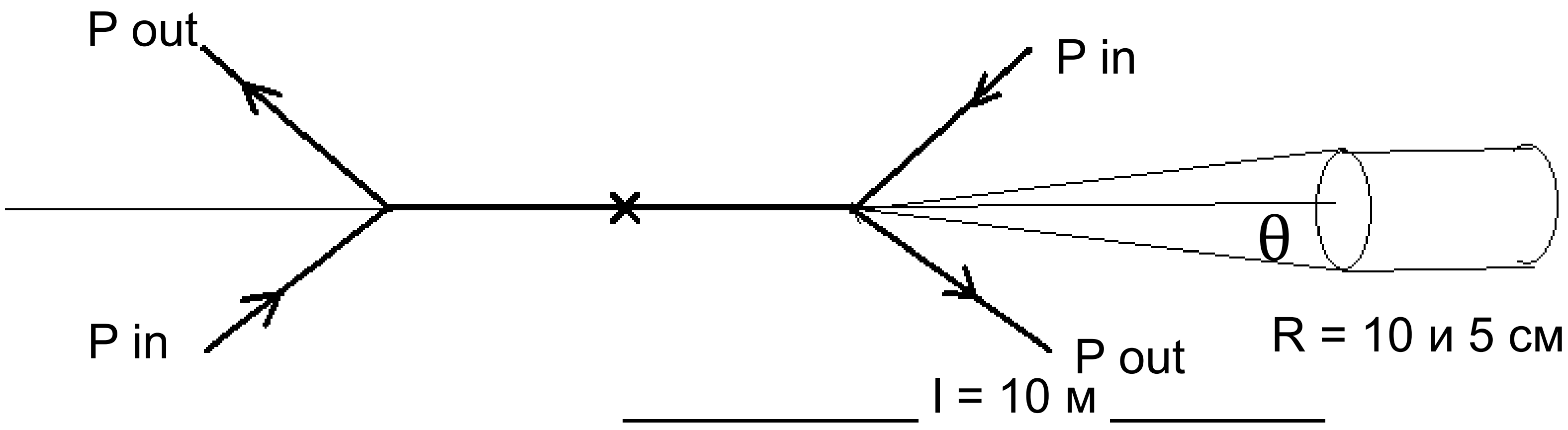
S. Vokal[a], A. D. Kovalenko[a], A. M. Kondratenko[b], M. A. Kondratenko[b], V. A. Mikhailov[a], Yu. N. Filatov[a], and S. S. Shimanskii[a]

(i) investigate *pp*, *pd*, *dd*, $p^3$He, $d^3$He, $^3$He$^3$He collisions with polarized beams, which will allow one to solve the puzzles of the spin structure of nucleons and lightest nuclei and elucidate the specific features of the spin structure of interaction in the region of nonperturbative QCD; it is especially important that it will be possible for the first time to study the interaction of polarized nuclear matter whose properties may determine the structure of the core of massive stars with great magnetic fields;

(ii) elucidate the nature of strong polarization effects in *NN* interactions at $p_{\rm lab} > 6$ GeV in the region of limiting large $p_T$, which has not been explained yet, and find out how these specific features are related to the change of behavior of valence quarks in this kinematic region; the availability of polarized nuclei at a collider will allow one to study the complete isotopic set of states of nucleon–nucleon system (*nn*, *pn*, and *pp*) for the first time;

# FTF model simulation of pp and dd interactions for estimation of SPD forward calorimeter load

V. Uzhinsky, A. Galoyan, S. Shimansky 13 May 2020




Рассмотрены dd- и pp-столкновения при энергиях $\sqrt{s_{NN}} = 6\ GeV$ и $\sqrt{s_{NN}} = 10\ GeV$.

Для каждого случая моделировалось $10^6$ столкновений, с использованием FTF в SPDroot

Table 3: dd-столкновения при энергии $\sqrt{(s_{NN})}$=6 GeV

| $tg(\theta)$ | No hit | Hit=1 | Hit=2 | neutrons |
|---|---|---|---|---|
| 0.01 | 950 т. (95.0 %) | 45 т. (4.5 %) | 100 (0.01 %) | 24 т. (2.4 %) |
| 0.005 | 999 т. (99.9 %) | 10 т. (1.0 %) | 3 | 6 т. (0.6 %) |

# FTF model: DD interactions

Табл.1 Данные по потокам нейтронов в области расположения нейтронного детектора для dd-взаимодействий.

| Reaction | $\sqrt{s_{NN}}(GeV)$ | $\tan(\theta)$ | All neutron/$10^6$ int | Spect. neutron/$10^6$ int |
|---|---|---|---|---|
| dd | 6 | 0.01 | 24023 | 22187 |
| dd | 6 | 0.005 | 6226 | 5759 |
| dd | 10 | 0.01 | 64975 | 63478 |
| dd | 10 | 0.005 | 18645 | 18241 |

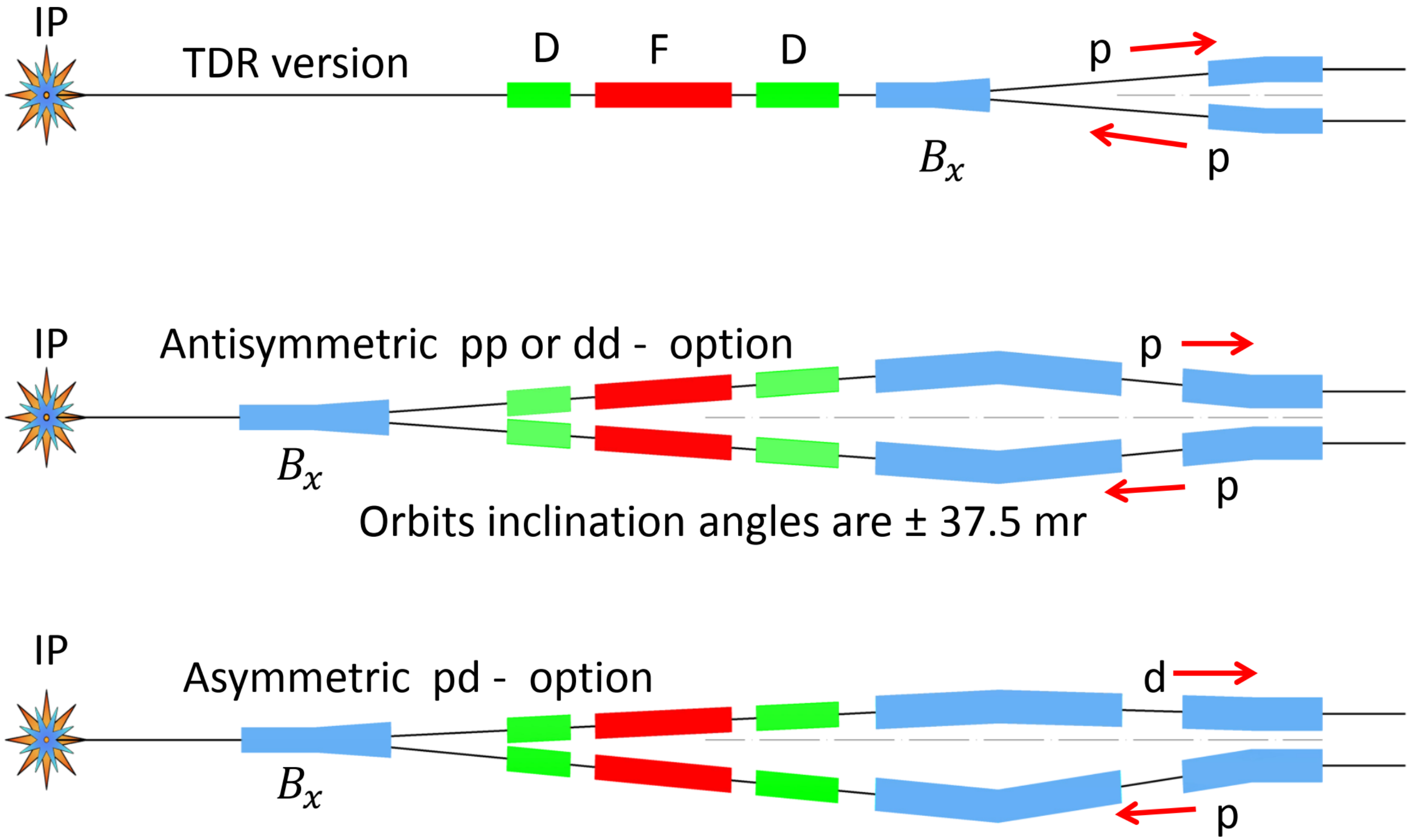
Табл.2 Данные по потокам нейтронов в области расположения нейтронного детектора для pp-взаимодействий.

| Reaction | $\sqrt{s_{NN}}(GeV)$ | $\tan(\theta)$ | All neutron/$10^6$ int |
|---|---|---|---|
| pp | 6 | 0.01 | 500 |
| pp | 6 | 0.005 | 103 |
| pp | 10 | 0.01 | 819 |
| pp | 10 | 0.005 | 193 |

**Проведённое исследование показывает, что загрузка детекторов нейтронов от частиц, идущих непосредственно из исследуемых взаимодействий, далека от критических значений.**

# Proposed new vertical separation scheme for different ions

Individual triplets of the final focus lenses open possibility to collide ions with different magnetic rigidity. In particular, protons and deuterons with equal gamma-factors!




In the asymmetric pd-option the horizontal field bends deuterons and protons by + 25 and - 50 mr, correspondingly. So, full block of two triplets is rotated in the clockwise direction by 12.5 mr relative to the symmetric setup.

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NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH
Section A

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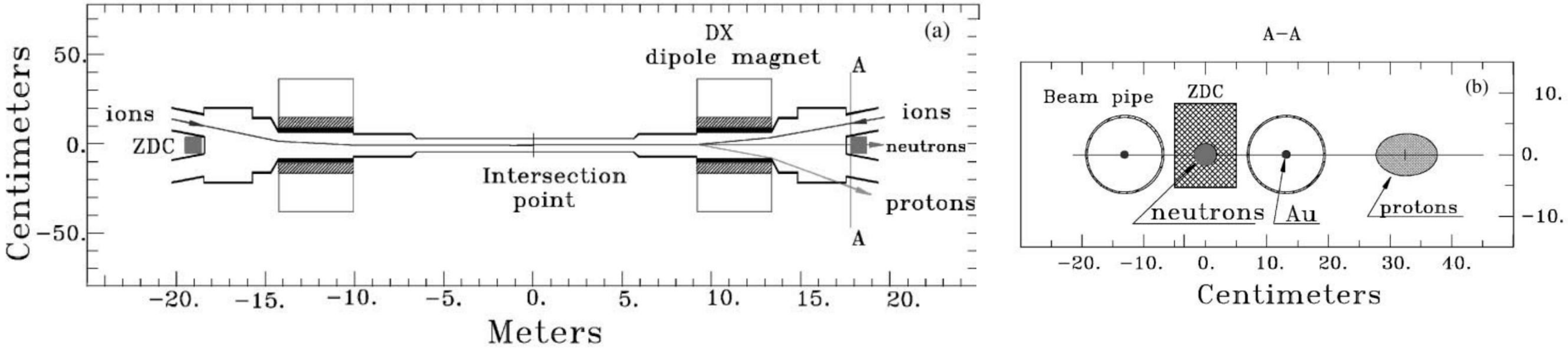
# The RHIC zero degree calorimeters

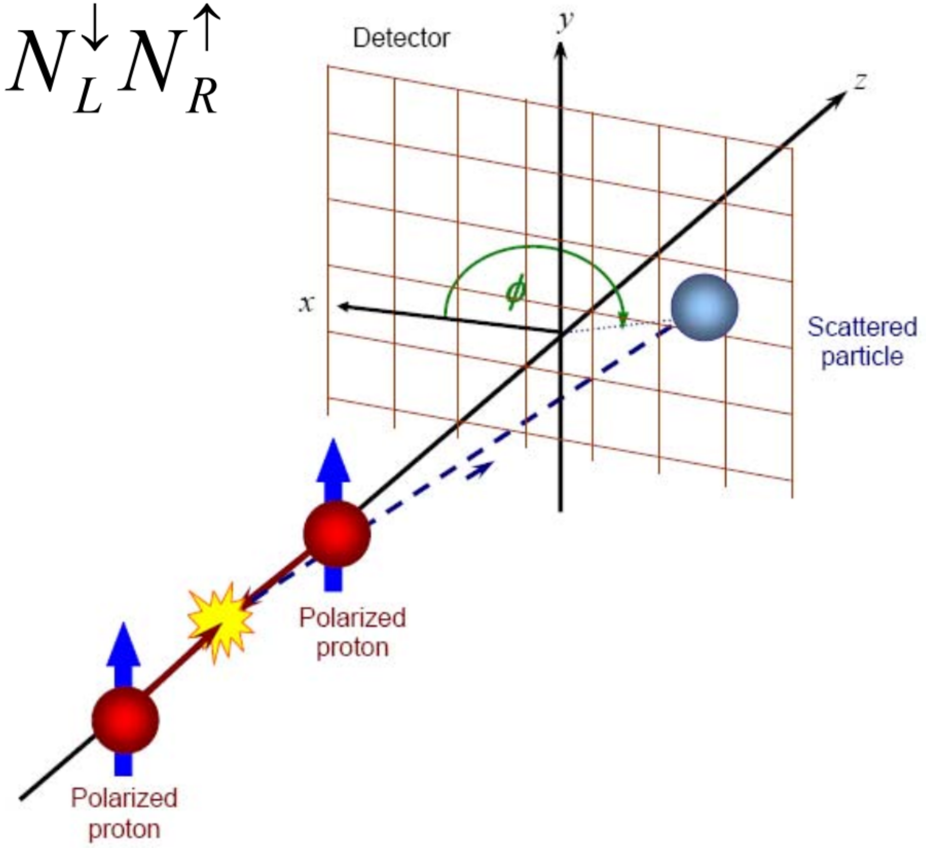
C. Adler[a], A. Denisov[b], E. Garcia[c], M. Murray[d], H. Stroebele[a], S. White[e,*]



# Single Spin Asymmetry

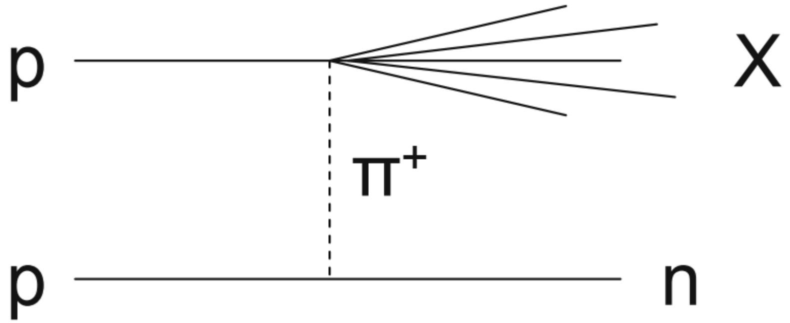
$$\varepsilon_{phys} = \frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\uparrow}} \approx \frac{\sqrt{N_L^{\uparrow} N_R^{\downarrow}} - \sqrt{N_L^{\downarrow} N_R^{\uparrow}}}{\sqrt{N_L^{\uparrow} N_R^{\downarrow}} + \sqrt{N_L^{\downarrow} N_R^{\uparrow}}}$$

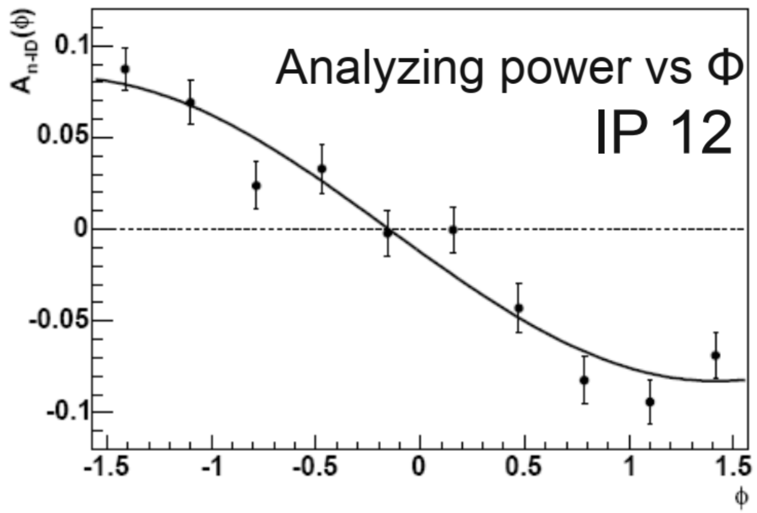
$$A_N = \frac{\varepsilon_{phys}}{P}$$



# *Lead Neutron Production*

- The ZDC detects very forward neutrons
  - Small contamination from $K_L^0$, photons
    - *IP 12 experiment measured photon $A_N$ consistent with 0*
    - *$K_L^0$ fraction ~3-4%*
- Cross section of forward neutrons is understood
- However, source of spin asymmetry is not well understood

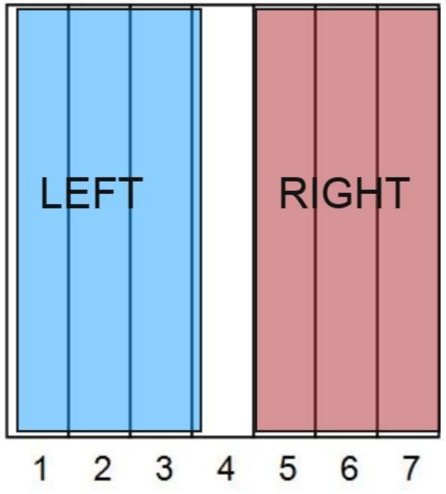



Phys. Let B 650, 325-330 (2007)

# ZDC Asymmetry

ZDC Shower Max Detector (SMD)



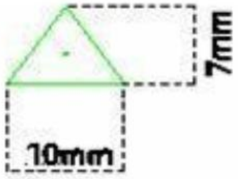

Vertical slats (X)

(21 strips)


Horizontal slats (Y)

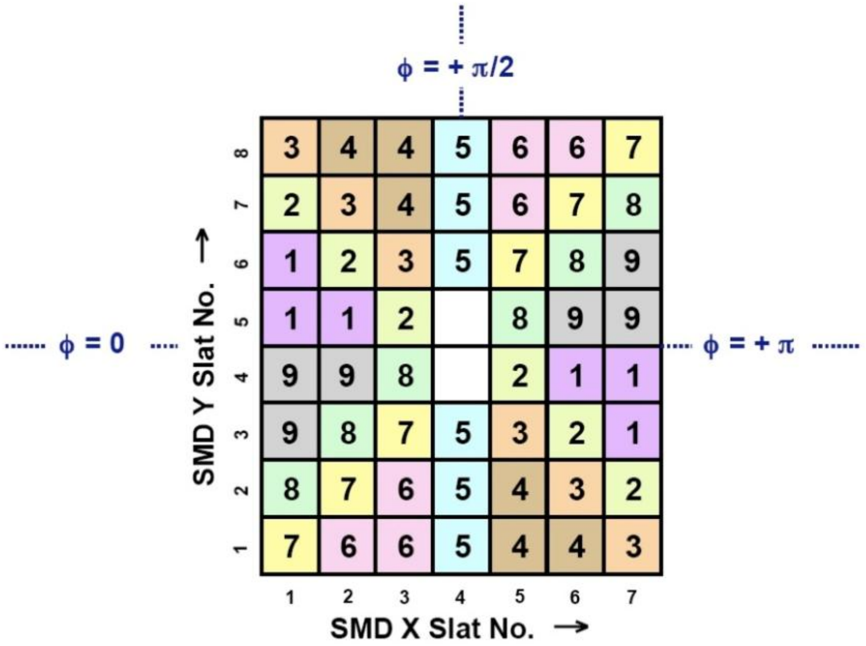
(32 strips)

SMD Strip Dimensions

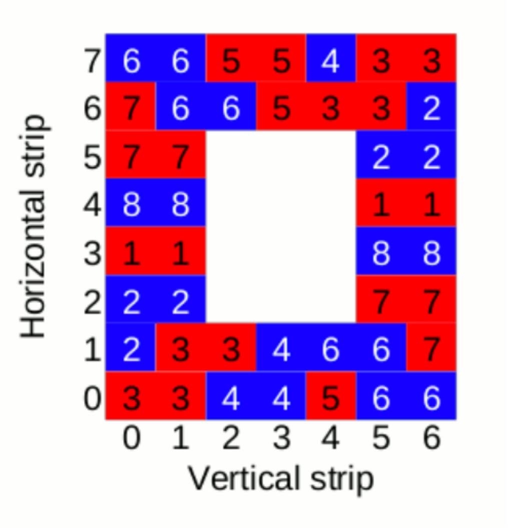



SMD Layer

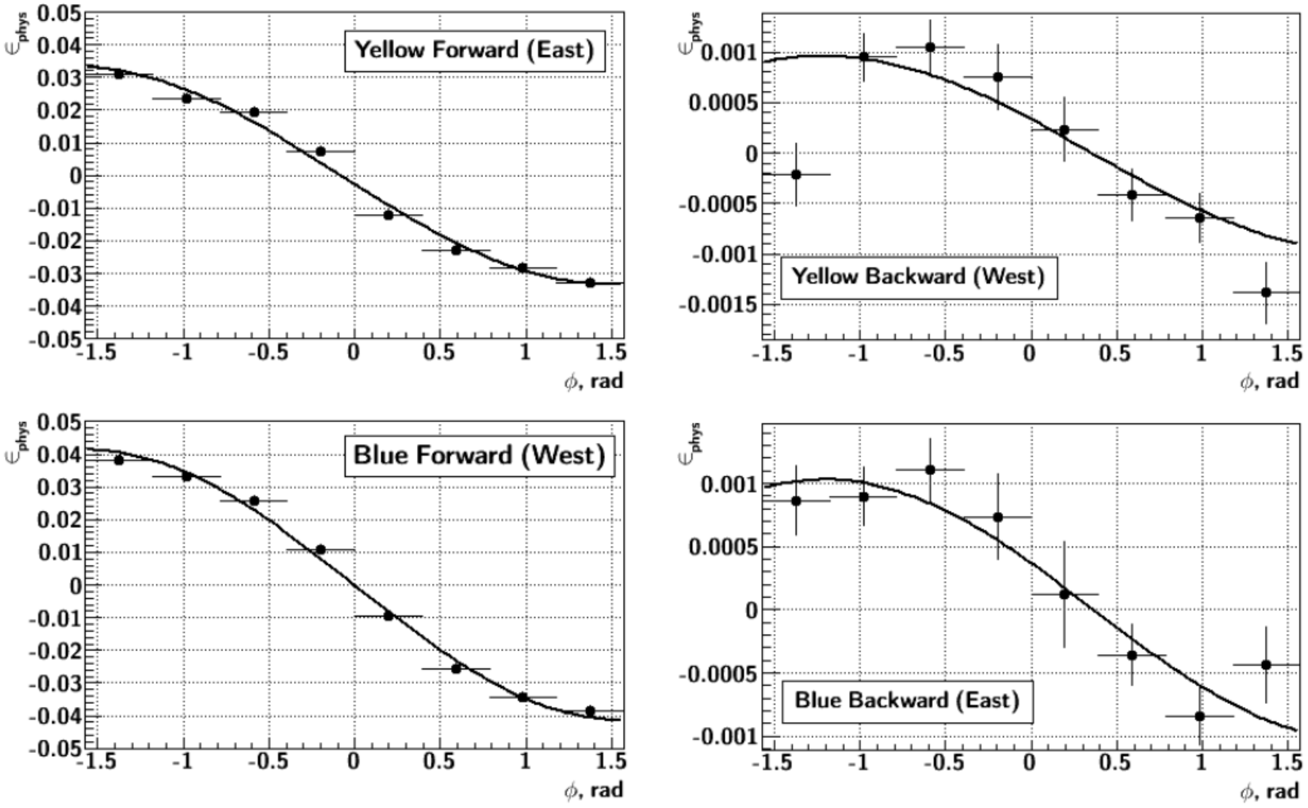
Phi Distribution



# Geometry definition




# Results for one recent fill

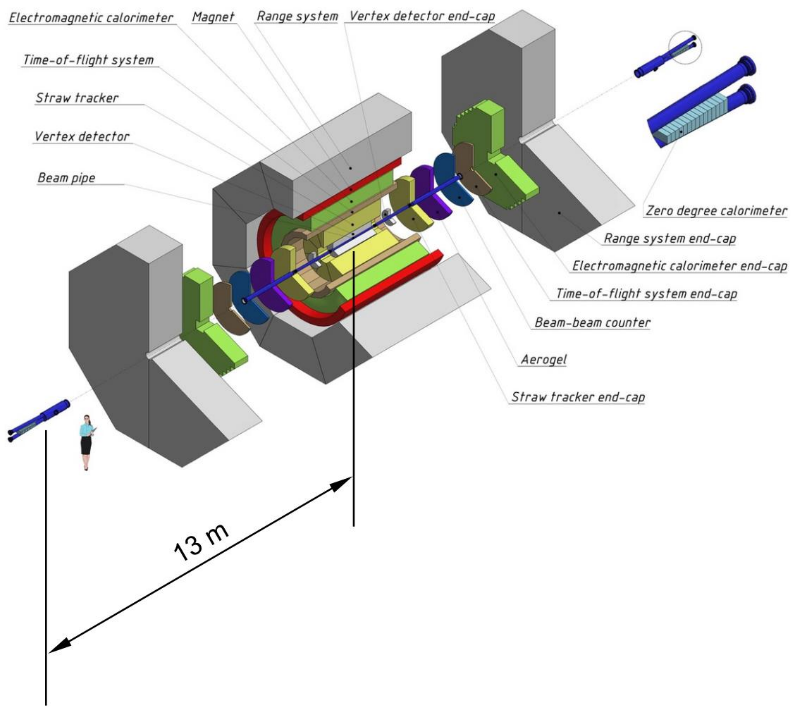



ZDC Single Spin Asymmetry (fill 15170)

With the same trigger as was used in Run 9
and with the same analysis algorithm,
a similar analyzing power of 7-8% is observed

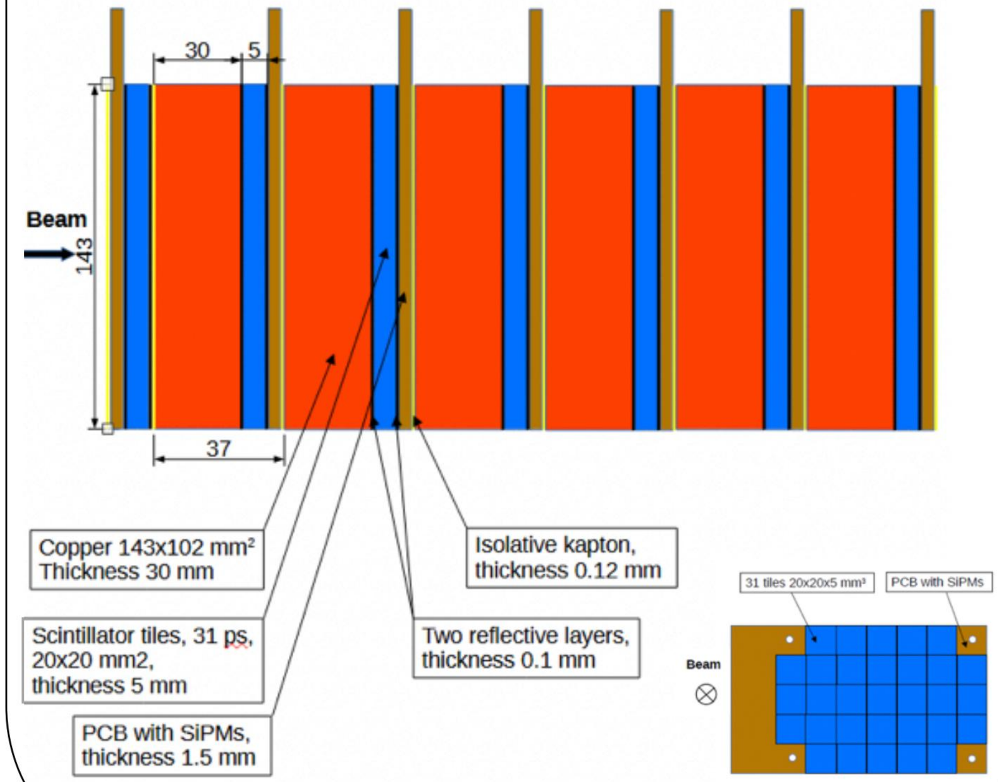
# ZDC at NICA

# ZDC for the first NICA run

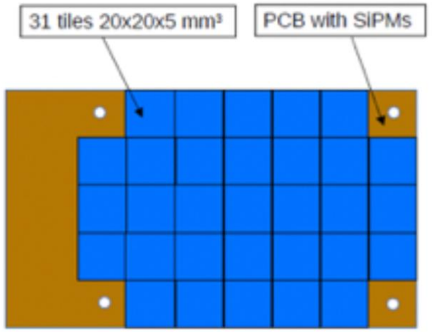



Two such prototypes are planned

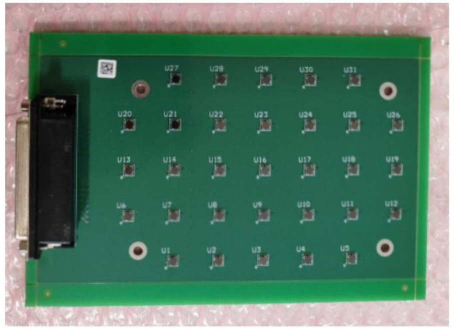
**ZDC prototype, size — 143x102 mm², length — 230 mm**

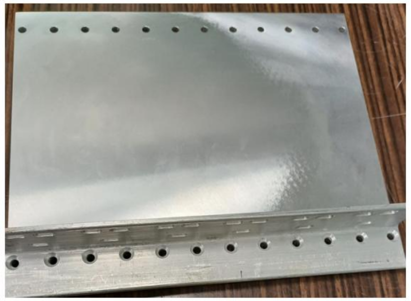


Update since the last SPD Collaboration meeting:



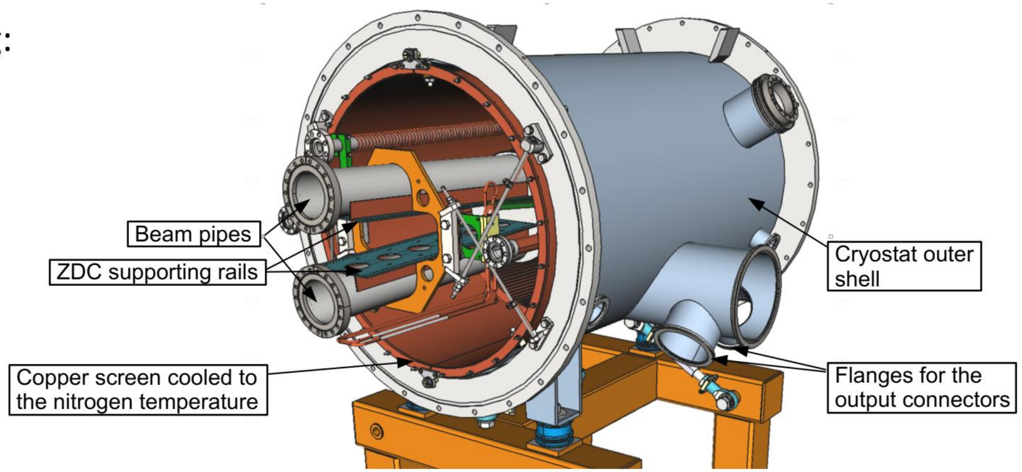

- ✓ Two boards with scintillator layers of 3 and 5 mm thickness were tested with cosmic muons.
- ✓ Six boards with SiPMs and scintillators layers were prepared by ITEP group and tested with cosmic muons.
- ✓ For the second prototype: - Six boards with SiPMs have been order to REZONIT and they should be fully ready on May/2025. – Scintillator layers are being prepared by ITEP group.
- ✓ Two sets of copper plates, substrates and corners are ready.
- ✓ Internal wiring cables are ready.



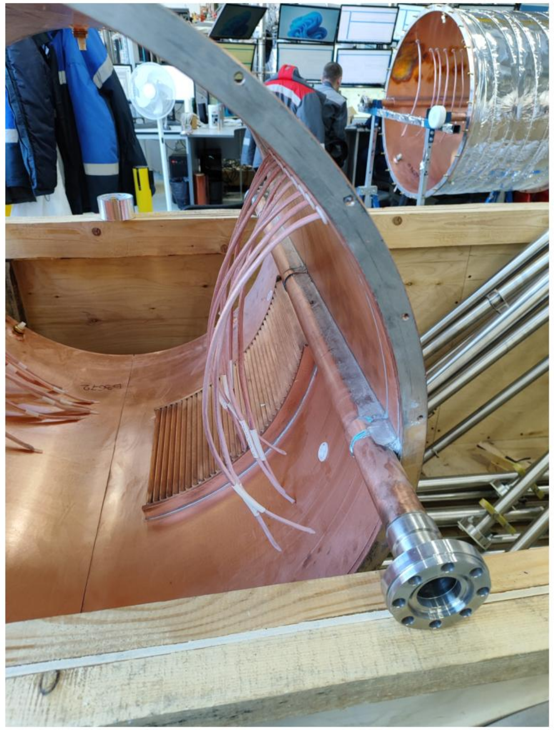


# ZDC for the first NICA run

Update since the last SPD Collaboration meeting:




- ✓ The cables were passed through the copper screen and go only on one side of the screen



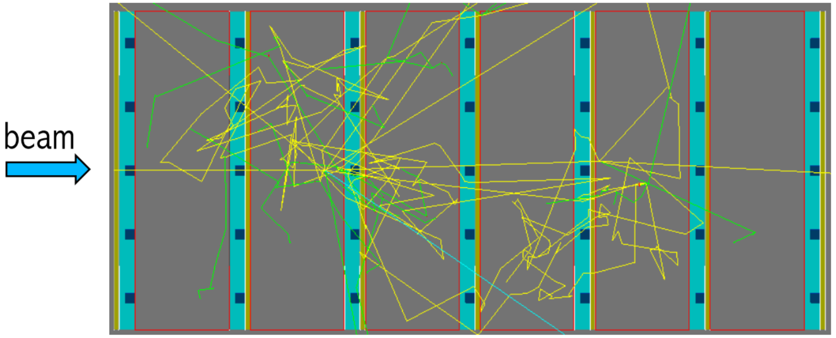
- ✓ Two barrels with print circuit boards (PCB) are ready since the beginning of February. A barrel with 30 PCBs with 78 connectors DHR-78F (DS1038-78F) will be installed on one side of the cryostat at large flanges.
- ✓ The technology of gluing the plates was tested on both barrel prototypes. It was selected epoxy resin (department of superconducting magnets and technologies).
- ✓ The preparation of the barrels with the PCB has started and it should be ready very soon (Svetlana Silneshchikova).

- ✓ The second prototype will be ready on the middle of May.

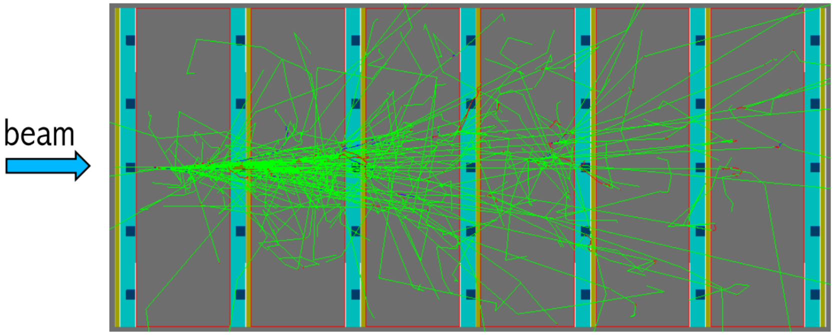
# Monte Carlo simulation - GEANT 4

## Optics applied

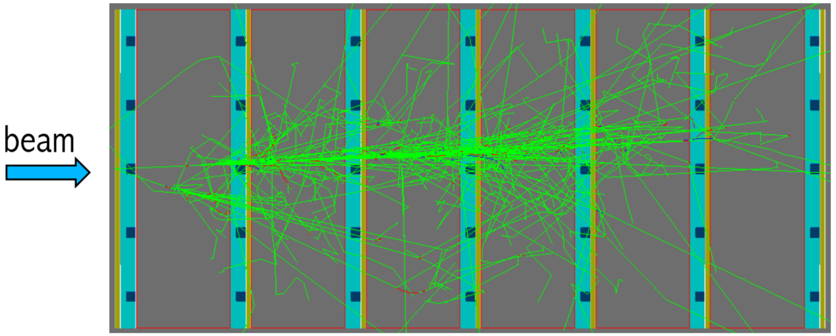
2 neutrons, $E_n = 1\ GeV$



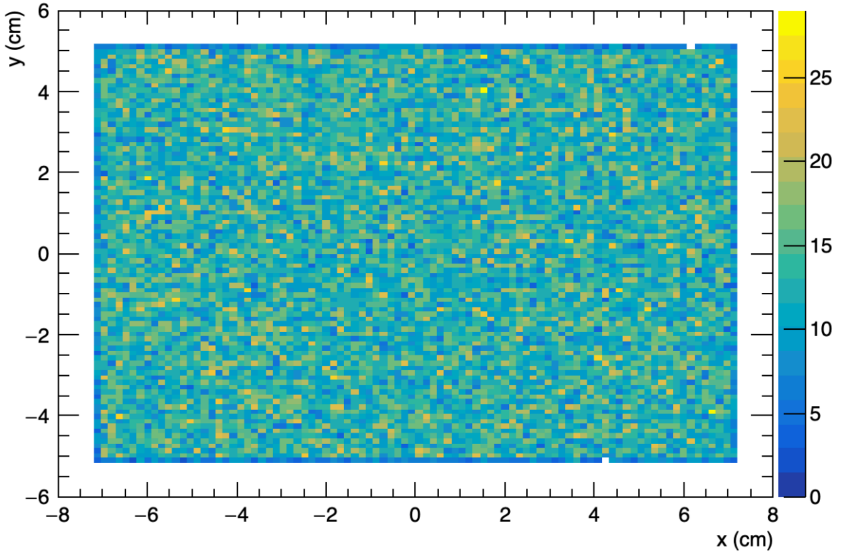

1 gamma photon, $E_\gamma = 1\ GeV$



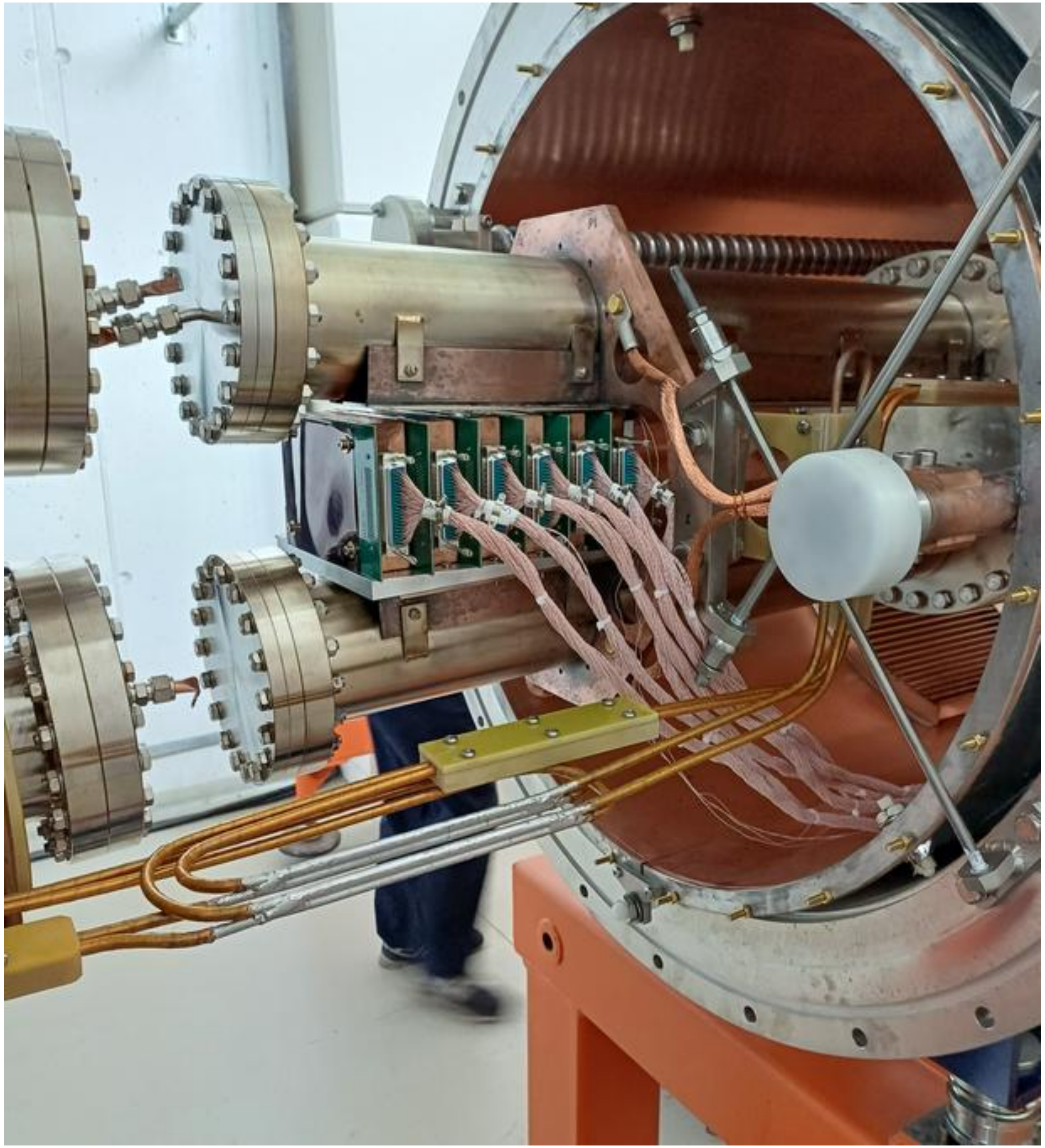

1 $\pi^0$, $E_{\pi^0} = 1\ GeV$

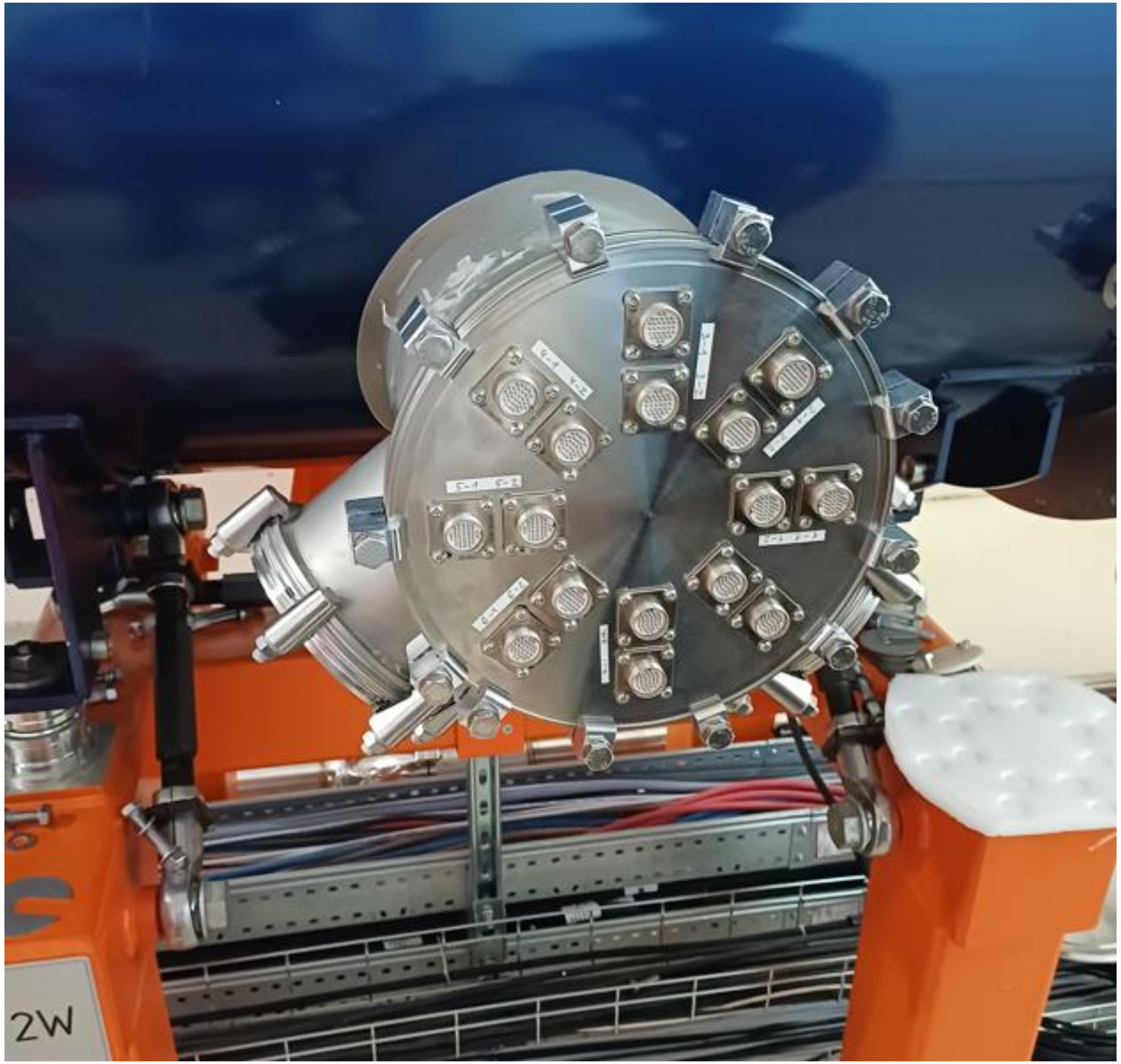



- Source particles where randomly generated with a uniform distribution in the first transverse plane of the detector, with momentum parallel to the beam axis.




- Beam: n, $\gamma, \pi^0$: 1 – 12 GeV
- Physics: FTFP-BERT-EMZ → FTF parton, Bertini and precompound models for inelastic hadron-nucleus processes and Geant4 standard EM physics
- Simple model with the following optical parameters of the scintillator:
  - Scintillator yield: 20 ph.e / MeV
  - Scintillator decay time: 2 ns
  - Measured time: arrival time of the first ph.e.

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**Спасибо за внимание!**