



NATIONAL RESEARCH CENTRE

«KURCHATOV INSTITUTE»



PETERSBURG NUCLEAR PHYSICS INSTITUTE

Russia, 188300, Leningrad District, Gatchina, Orlova Roscha

Development of neutron detectors for PIK

CREMLIN PLUS

Connecting Russian and European Measures
for Large-scale Research Infrastructures



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072



Current activities

- Design of neutron instruments at PIK research reactor
– *Founded by Ministry of science of Russian Federation*
- Research and development of neutron detector systems in accord to the request of PIK research reactor
- Renovation of the production line
- Manufacturing of the detectors for neutron instruments – *Founded by Ministry of science of Russian Federation*



Instruments at PIK reactor

- 20 Instruments to be built before 2025:

Condensed matter physics:

1. Triple axis spectrometer – IN1 – single counter
2. Triple axis spectrometer – IN2 – single counter
3. Triple axis spectrometer – IN3 – single counter
4. TOF-TOF spectrometer – IN4 – 1260 charge division (CD) based counters, 2000 x 25,4 mm² in size
5. Spin-echo spectrometer – SES – multi-wire proportional chamber (MWPC) position sensitive detector (PSD), 400 x 400 mm² aperture



Instruments at PIK reactor

6. Reflectometer with vertical scattering plane – HARMONY – MWPC PSD, 250 x 500 mm² aperture
7. Reflectometer with horizontal scattering plane – SONATA – MWPC PSD, 500 x 300 mm² aperture
8. Polarized small-angle diffractometer (SANS) – Tenzor – CD based PSD, 1000x1000 mm² aperture
9. Chopped small-angle diffractometer (SANS) – Membrana – 4xMWPC based PSD, 400 x 200 mm² aperture + 1 CD based PSD, 1000x1000 mm² aperture



Instruments at PIK reactor

10. Spin-echo SANS – SESANS – MWPC based PSD, 300 x 300 mm² aperture
11. High resolution powder diffractometer – D1 – 180 proportional counters
12. High intensity powder diffractometer – D3 – 72 CD based counters, 900 x 8 mm² in size, 128 degrees aperture
13. Single-crystal diffractometer – DC1 – MWPC PSD 256x256 mm² aperture



Instruments at PIK reactor

- 20 Instruments to be built before 2025:

Fundamental physics:

1. Neutron EDM – DEDM – MWPC PSD 200 x 200 mm²

2-7. Others... - Liquid scintillators and charged particles detectors.



Overall request of PIK

Detectors to be built before 2025:

- MWPC PSD – 8 detectors
 - CD based counters – 3 detectors, ~2000 counters
 - Single proportional counters – ~250 counters
 - Neutron monitors – ~20 detectors
- ... Detectors for charged particles



Directions for detector development

1. Renovation of the production line for MWPC PSD.
2. Development of the CD based counters and proportional counters.
3. Development of the scintillator based proportional and position sensitive counters with low gamma sensitivity.
4. Development of the electronics.



Manufacturing of MWPC PSD

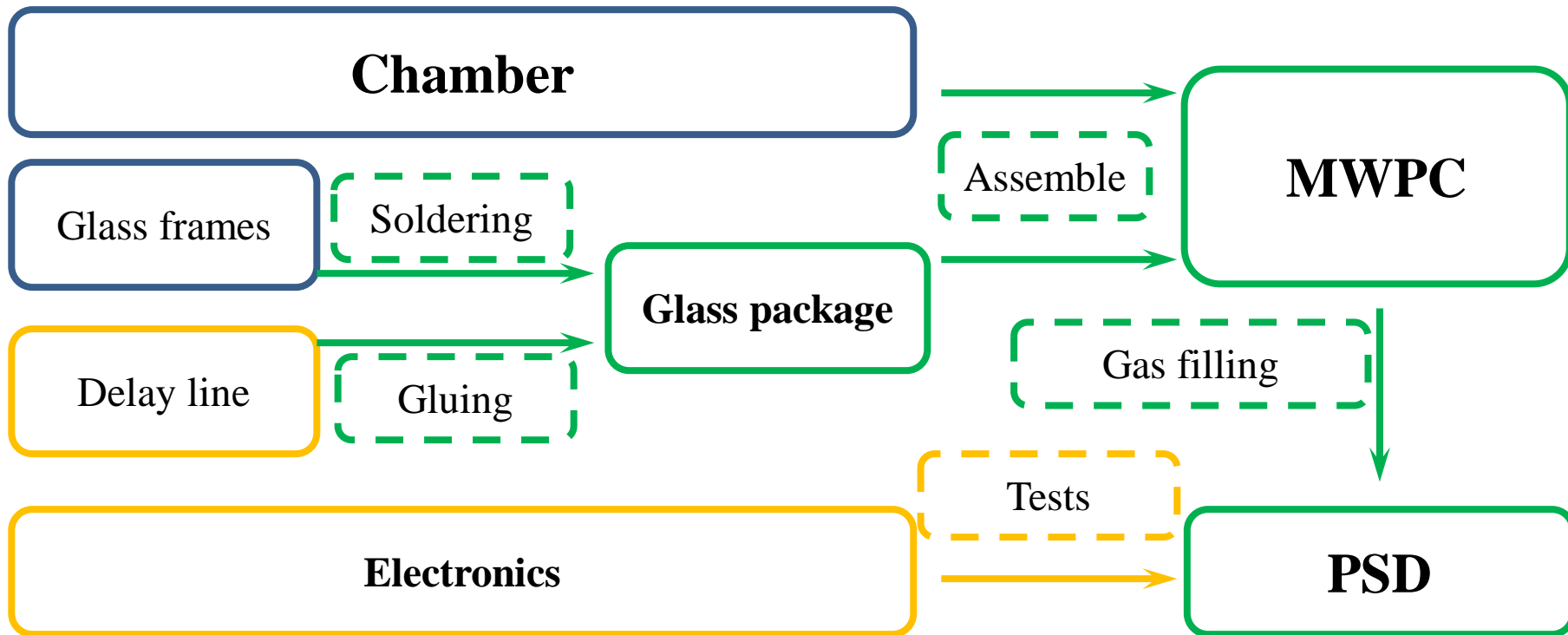
In 2019 the delay line MWPC neutron detector is designed to be installed on SANS instrument of IR-8 reactor in Moscow in 2020.

- Sensitive area: $600 \times 600 \text{ mm}^2$
- Spatial resolution: $3 \times 3 \text{ mm}^2$
 - Gas pressure: 3.5 bar
- Count rate: 150 kHz per pixel / 150 kHz overall.
 - Efficiency: ~65% for 1 angstrom.





MWPC PSD for SANS



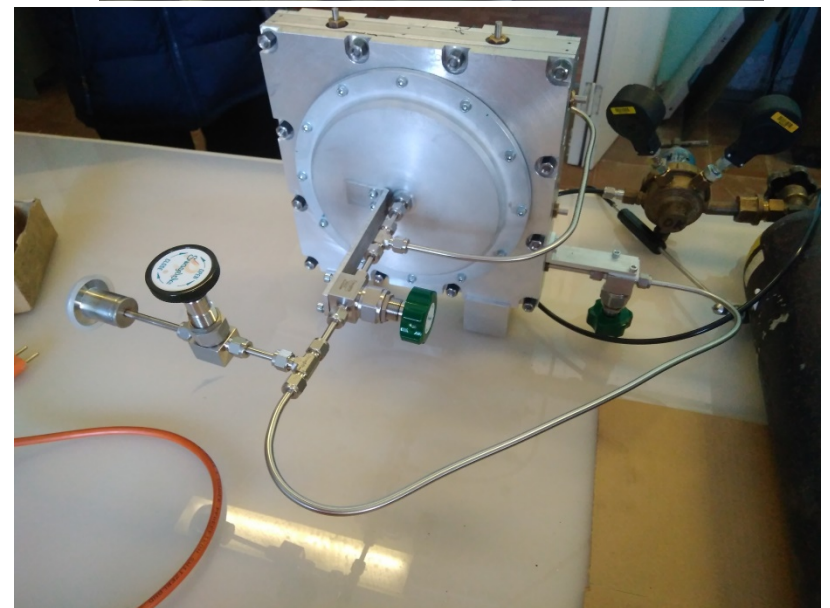
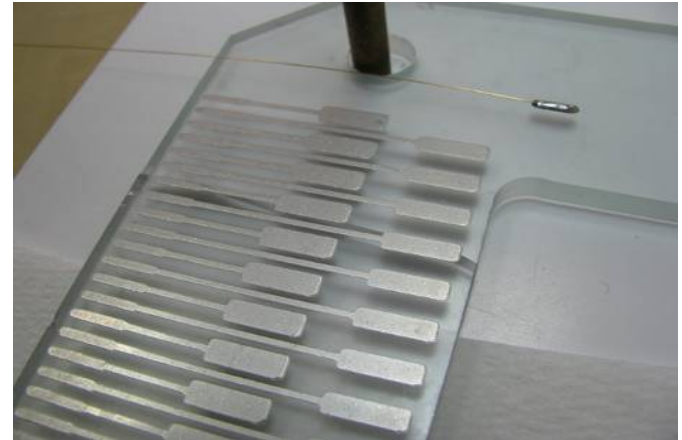


Manufacturing of neutron monitors

In 2019 the neutron monitors have been created on the basis of:

1. Delay line based MWPC neutron detector:

- Sensitive area: $100 \times 100 \text{ mm}^2$
- Spatial resolution: $2 \times 2 \text{ mm}^2$
 - Gas pressure: 1 bar
- Count rate: 150 kHz per pixel / 150 kHz overall.
- Efficiency: $>0.01\%$ for 1 angstrom.
- Transmission: 99% for 1 angstrom

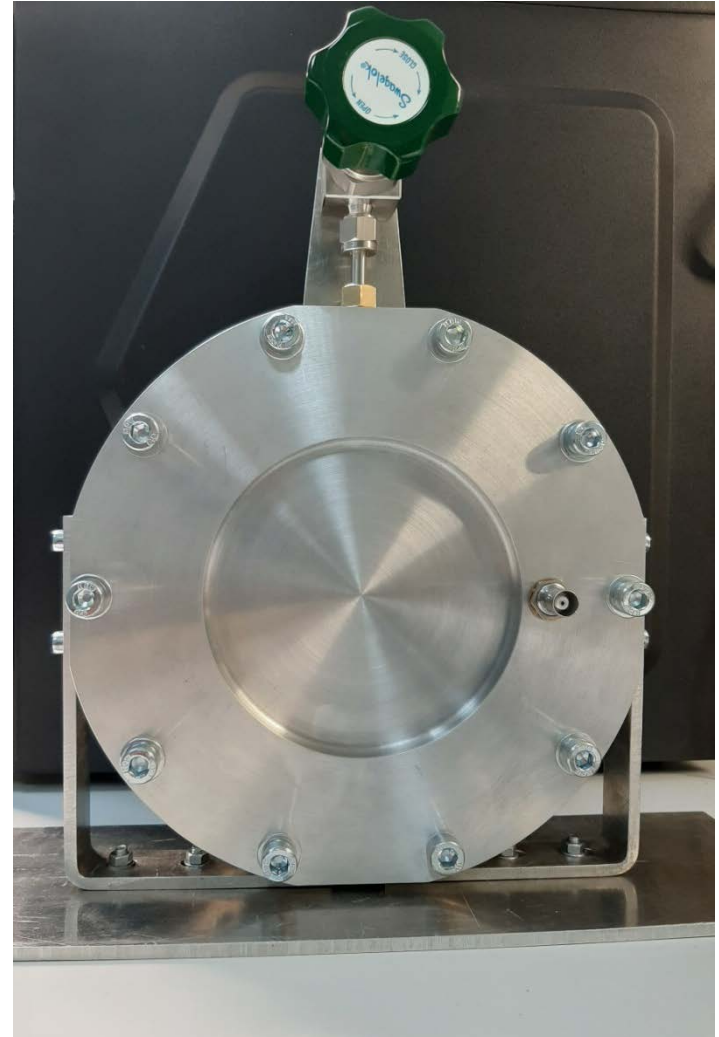




Manufacturing of neutron monitors

In 2019 the neutron monitors have been created on the basis of:

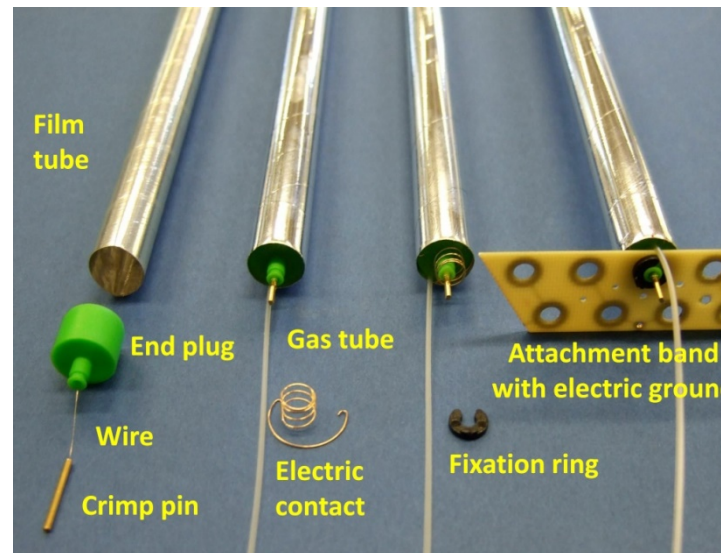
2. Proportional U-235-based counter:
 - Sensitive area: $100 \times 100 \text{ mm}^2$
 - Gas pressure: 1 bar
 - Count rate: $\sim 1 \text{ MHz}$.
 - Efficiency: $> 0.1\%$ for 1 angstrom.
 - Transmission: 98% for 1 angstrom.
 - Voltage: $\sim 300 \text{ V}$





CD based counters

In 2019 the counters to be used as CD based PSD have been developed and manufactured in collaboration with commercial partner. Warranty period – 8 years.

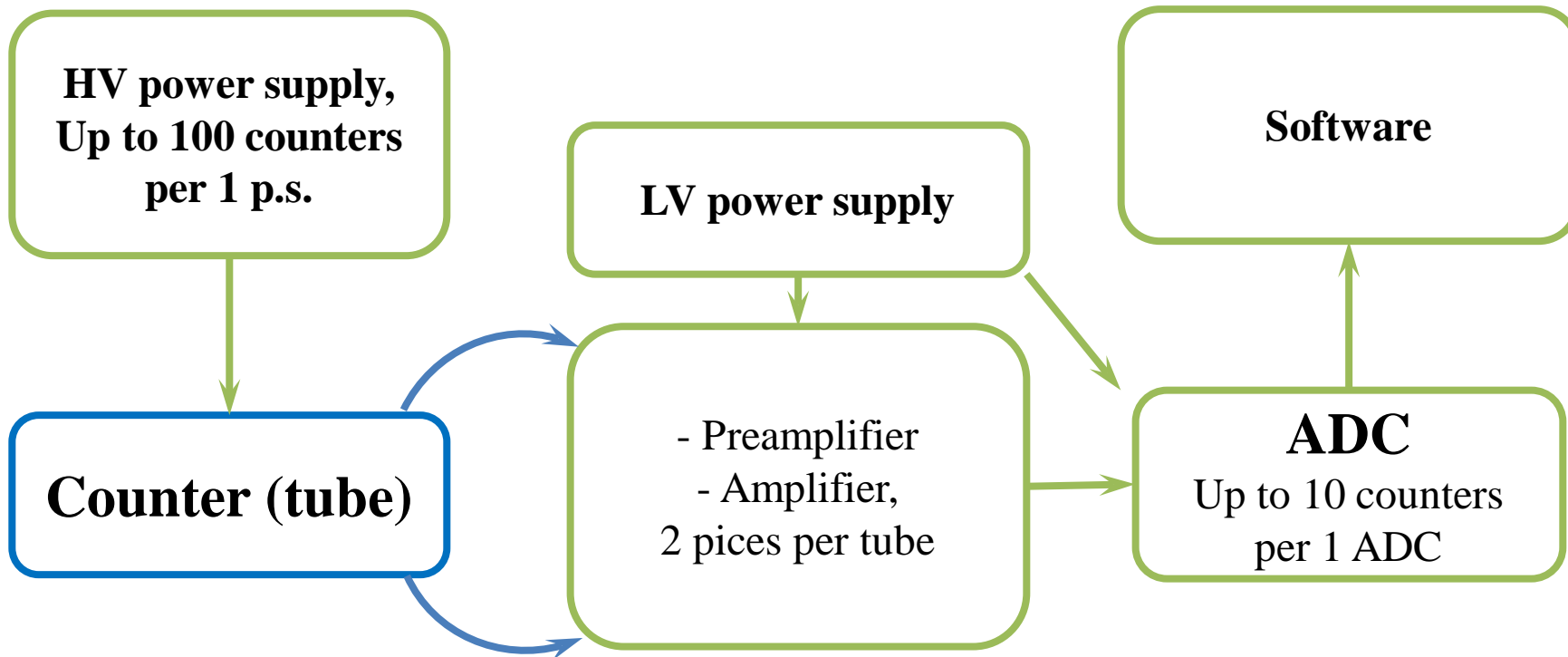


Parameters

- Sensitive area: 1000x10 mm²
- Gas pressure: 10 bar
- Efficiency: ~75% for 1 angstrom.

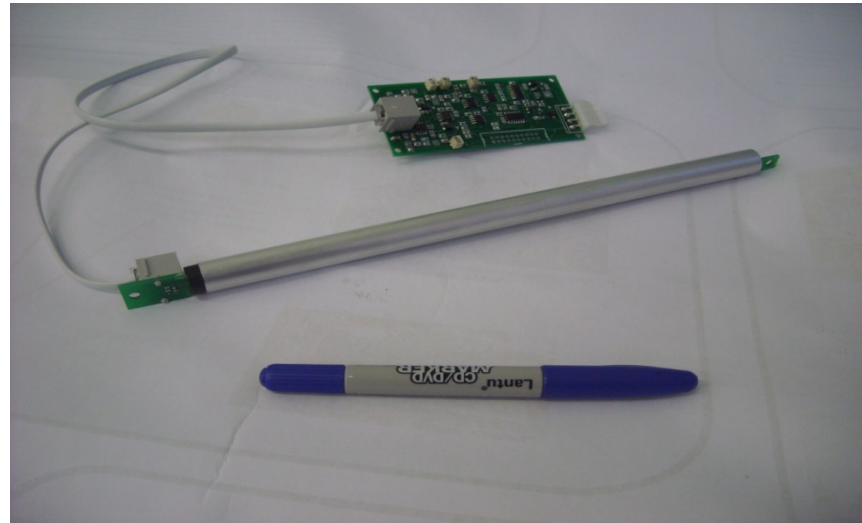


CD based PSD





ZnS (Ag) / Li⁶F based counters



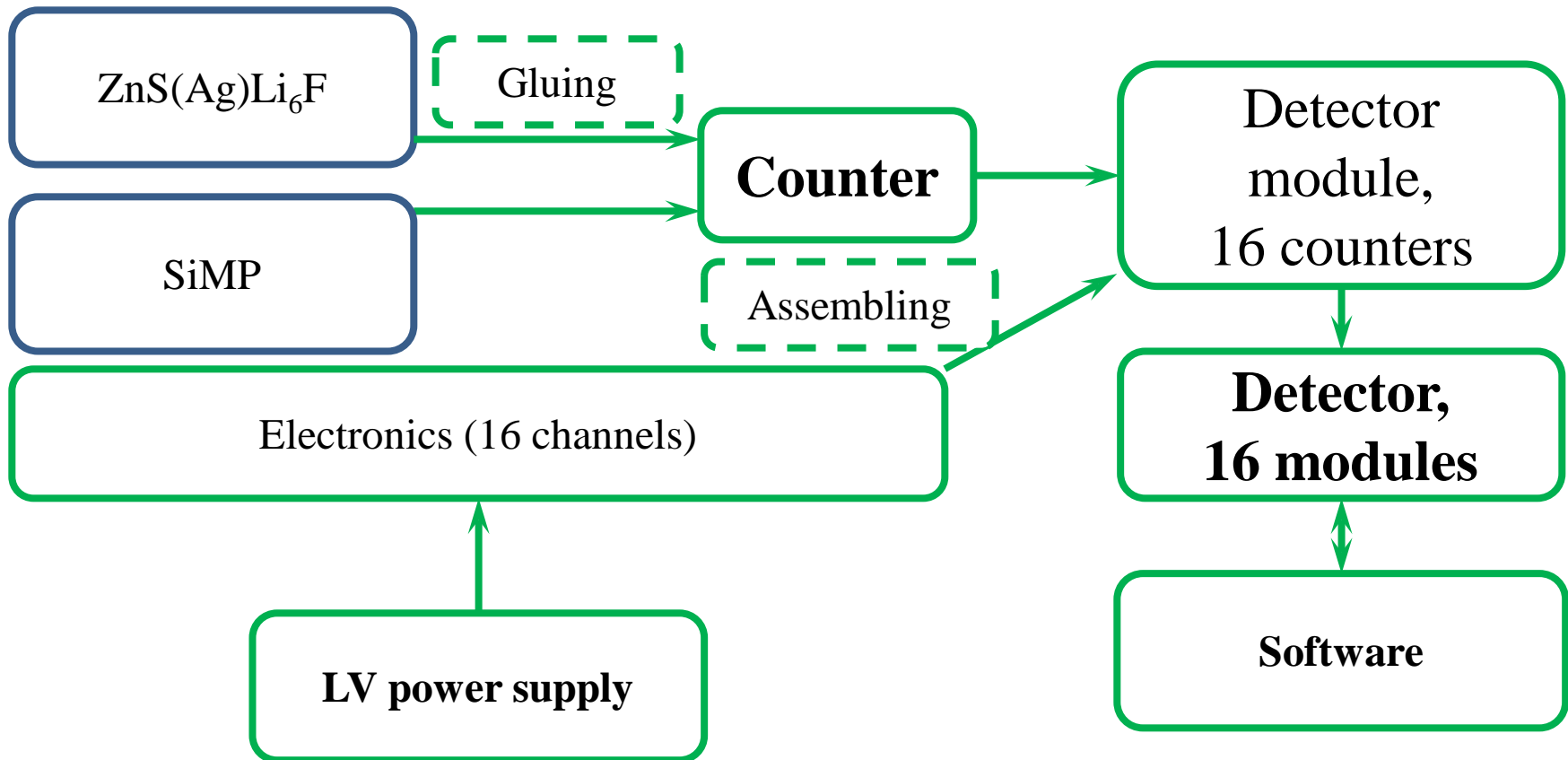
In 2019 the detector system for powder neutron diffractometer has been developed and manufactured to be installed on IR-8 reactor in Moscow in 2020. The detector system consist of 160 SiMP-based counters with sensitive area 5x50 mm².

Parameters of the counters:

- Sensitive area (5-300)x(2-50) mm²
- Efficiency 75% for 1.8 angstrom
 - Gamma sensitivity < 10⁻⁵
- Count rate – 1 MHz per counter
- Low dark noise
- Possible assembling with lack of the blind area
 - Do not require high voltage



ZnS (Ag) / Li⁶F based counters





Conclusions

The research reactor PIK might become a basement for intense collaboration in the field of development of most effective solutions for neutron instrumentation.



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Thank you for your attention!