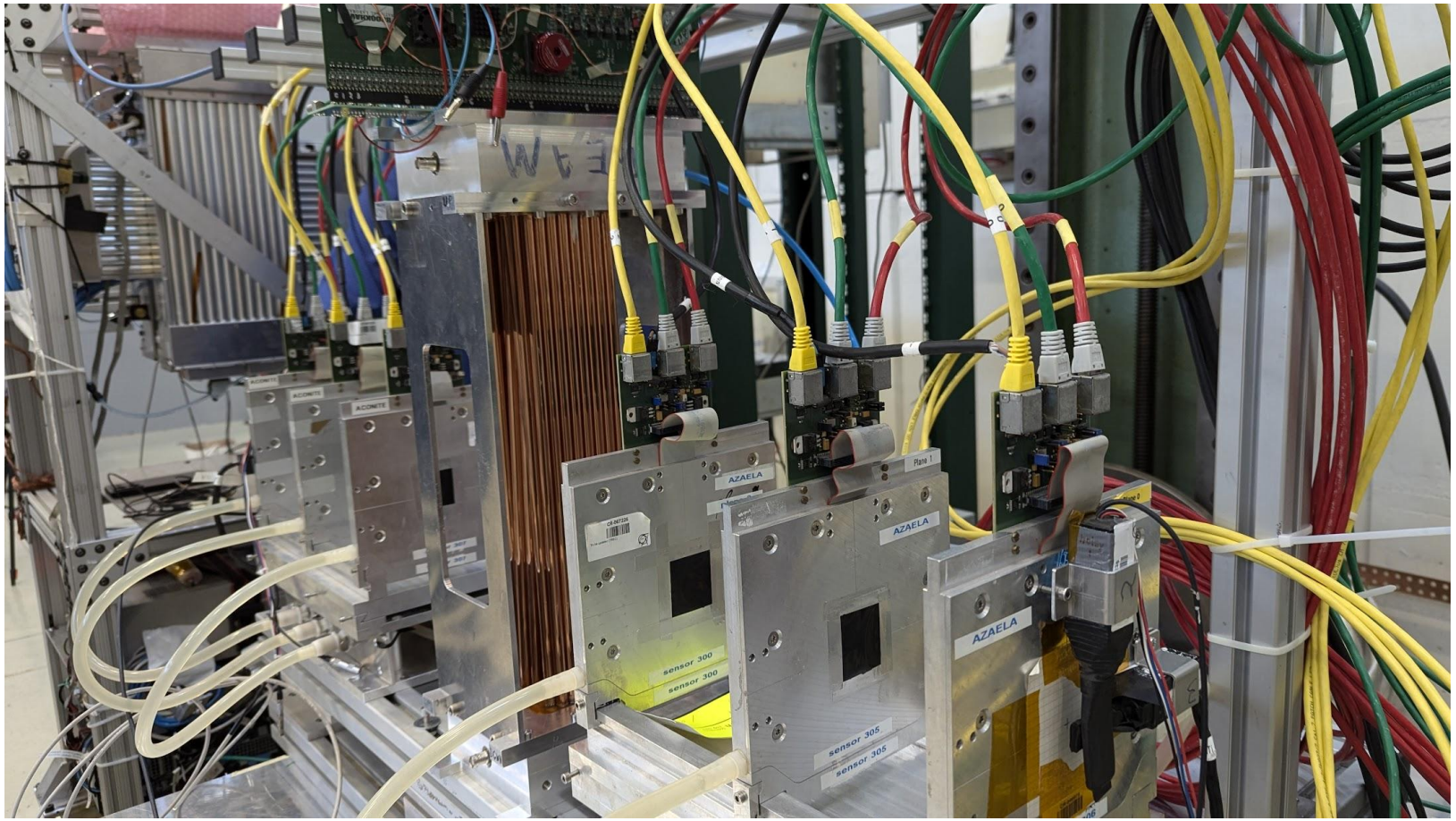
Straw-Barrel status report



Temur Enik on behalf of Straw Tracker Team **13/05/2025**

Straw Tracker Team

mechanics

- engineering
- modeling
- prototyping
- component production
- assembling
- testing
- longevity studies
- gas system development
- thermostability studies
- infrastructure development
-

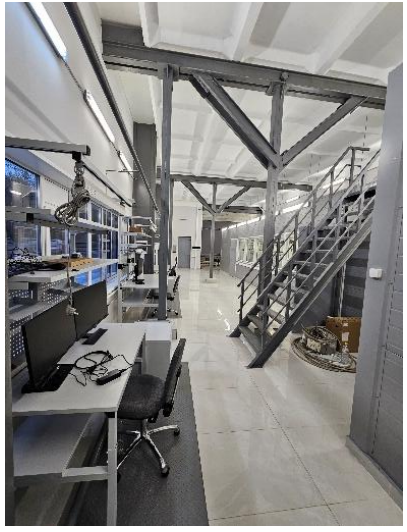
readout electronics

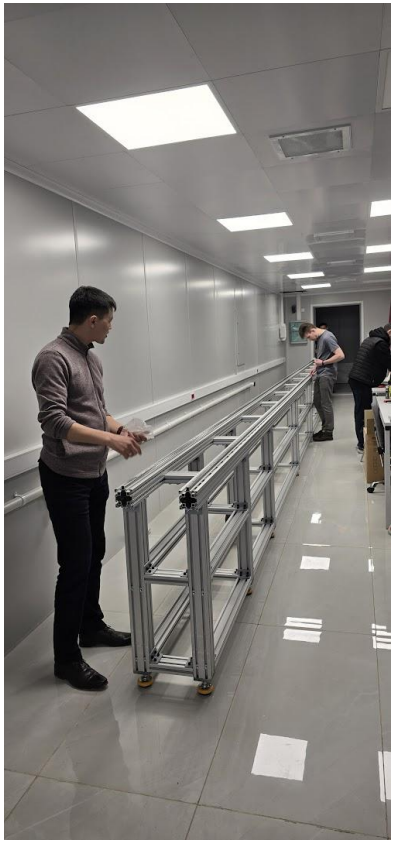
- specification
- modeling
- simulation studies
- prototyping
- testing
  - test beam
  - cosmics setups
- slow control development
- HV
- LV
- DAQ integration
-

software

- SPDroot - realistic simulation and hit reconstruction
- geometry optimization
- alignment
- Garfield/LTSpice
- Geant4 standalone (test beam)
- test beam data taking
- data quality monitoring
- data analyses

Constraction new Straw production line and the Assembling lab at JINR together with INP





- Area ~200 sq.m., clean room~100 sq.m, machine shop and assembling hall~50 sq.m and 8,5 m high are ready.
- Production line length(12m) has began
- Commissioning works the begins in May 2025
- Planned production ~60km straw
- All necessary materials and equipment have been purchased

New Straw production line and assembling place at INP

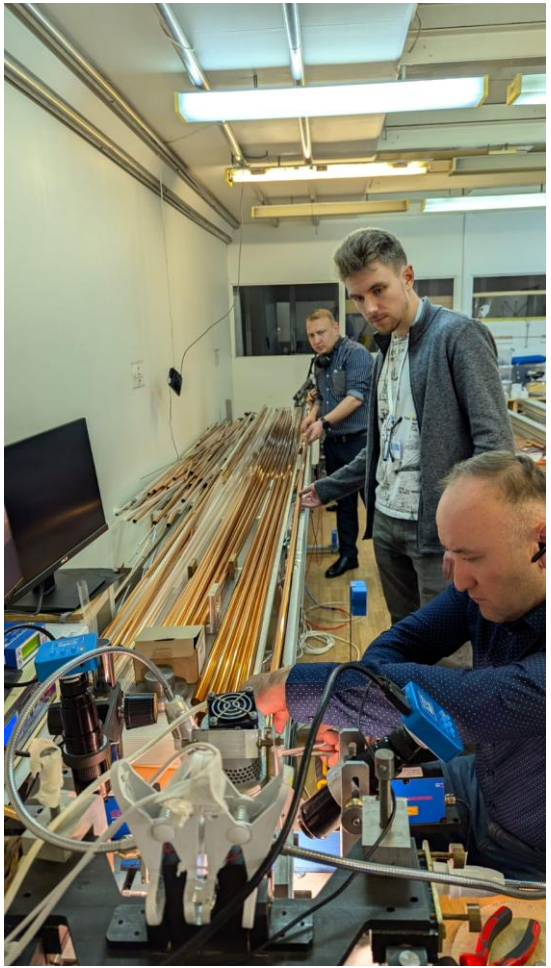
«Big» room

- Area ~250 sq.m., clean room~100 sq.m and 6,7 m high
- Double Production line length~12m
- Room renovation started in 2024
- Necessary materials and equipment have been purchased

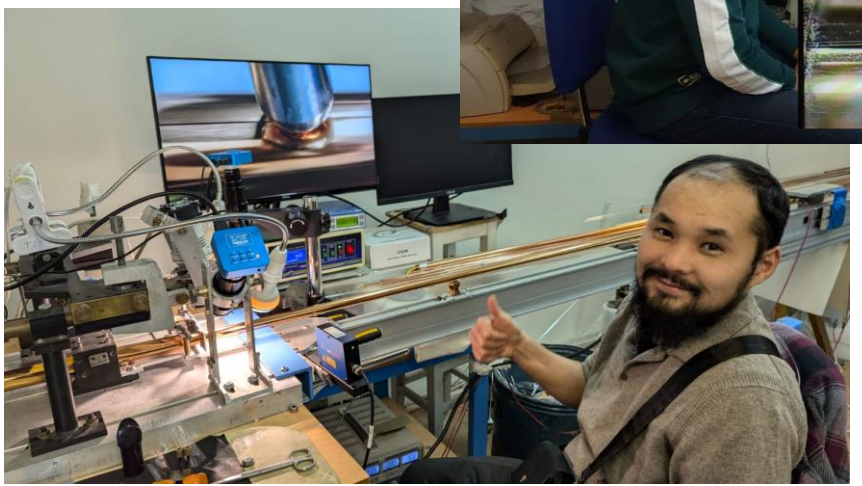
«Small» room

- Area ~60 sq.m., clean room~30 sq.m,
- Room renovation has been finished in June 2025
- Clean room is being built
- 5m straw welding machine will be installed
- The machine and related equipment is purchased

INP Personel traning at JINR Straw Production Site



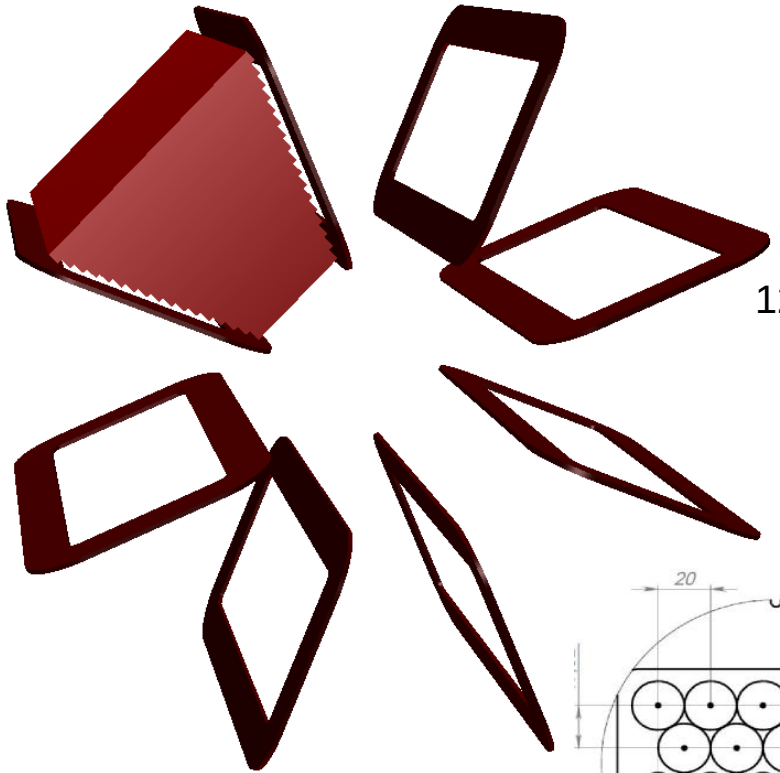
- added a new microscope with better resolution for visualization
- improved the seam positioning system
- production line speed ~3 km/month
- active work is underway in the field of R&D with colleagues from the INP
- One sextant requires about ~6 km of straws

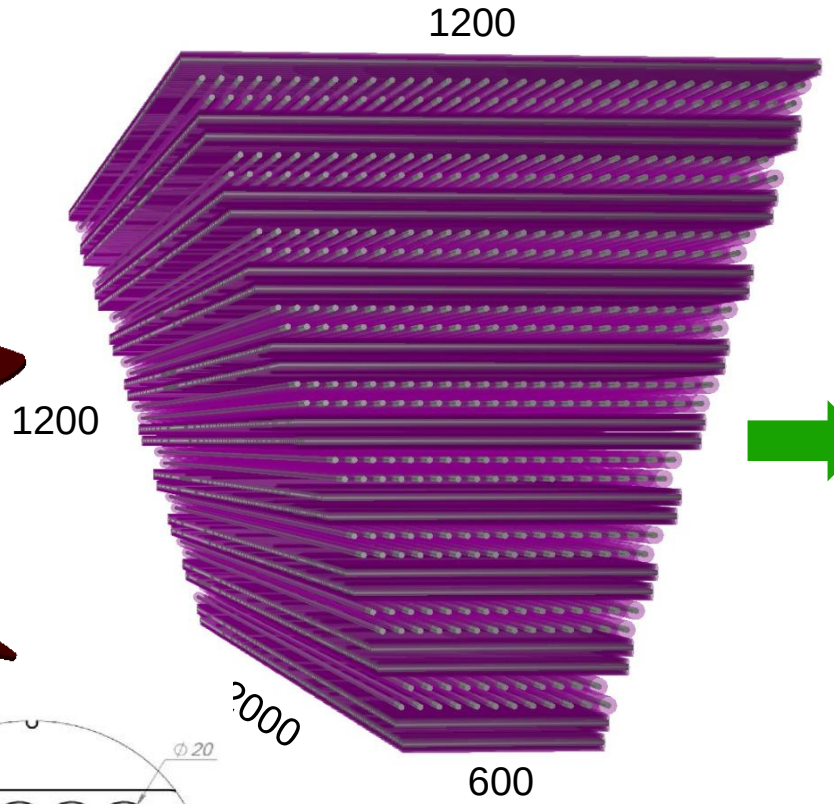


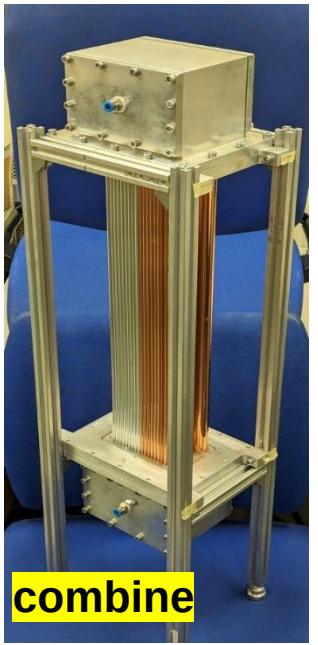
BARREL STRAW TRACKER

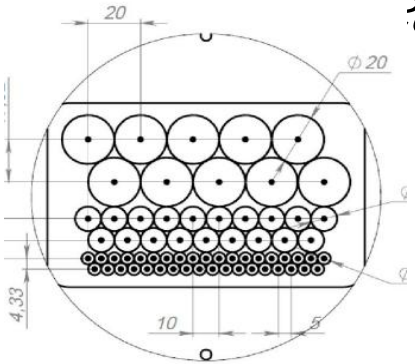
2020

8 XY(optional UV) wedge-shaped straws stations inside the toroidal magnet







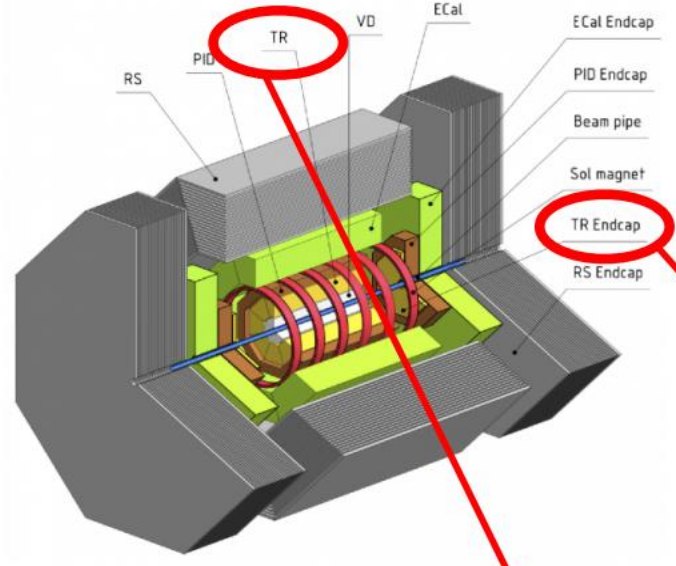


Prototype 1: 5 mm,10 mm, 20 mm tube 6 planes

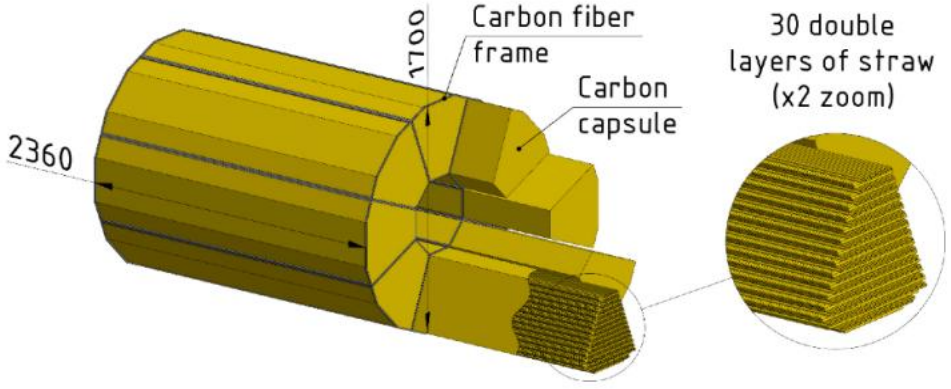
- Two planes of 5 mm
- Two planes of 10 mm
- Two planes of 20 mm

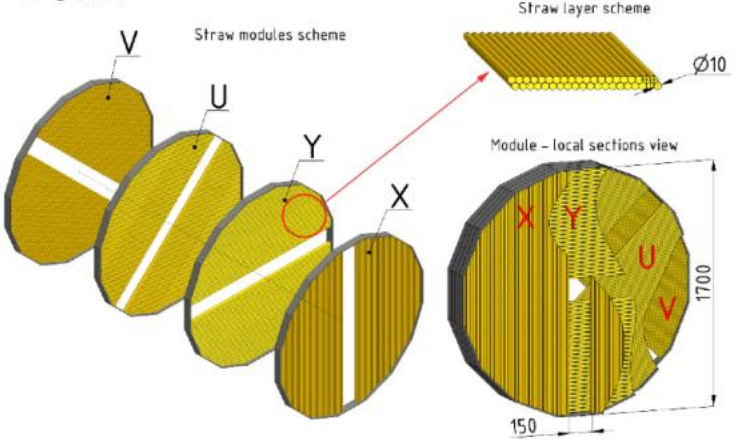
Straw tracker

2022



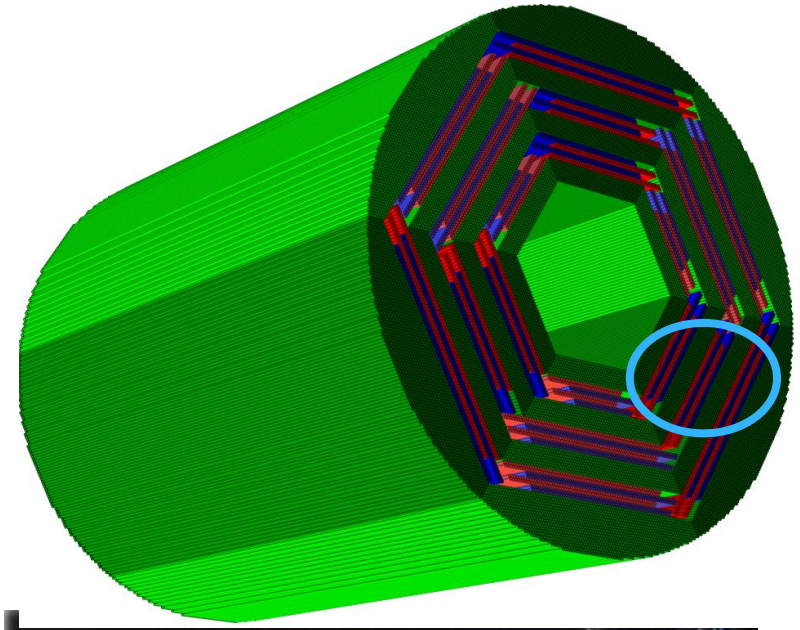
- Main tracker system of SPD
- Straw diameter 10mm thickness 36mkm PET
- Spatial resolution of 150mkm
- Barrel is made of 8 modules with up to 30 double-layers, with the ZUV orientation
- Endcaps are made of 12 double-layers with the XYUV orientation
- Vast experience in straw production in JINR for several experiment: COMPASS, NA-62, NA-64, SVD-2; prototypes for: CREAM, SHiP, COMET, DUNE.

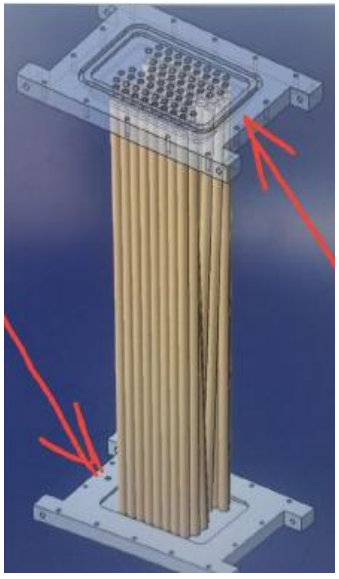


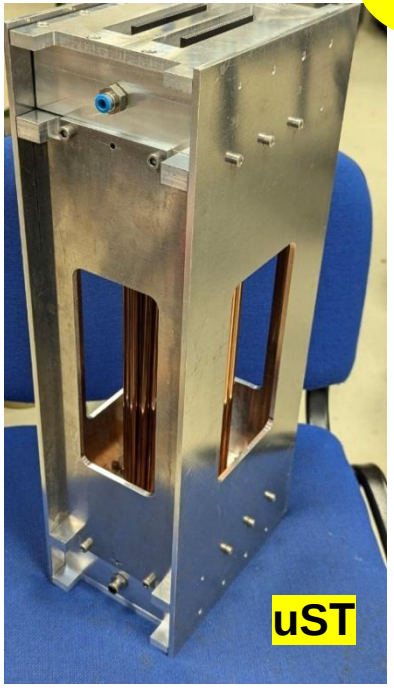


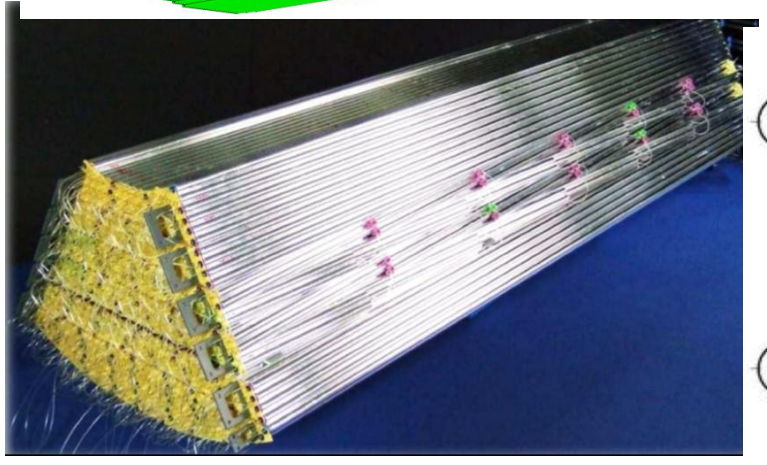
“Kosoy" prototype (uST)

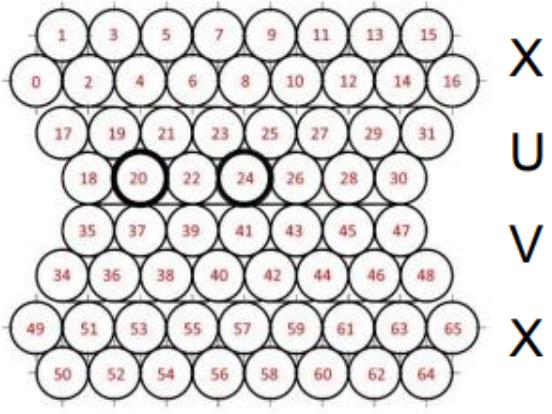
2024











Prototype 2: 10 mm tube 8 planes

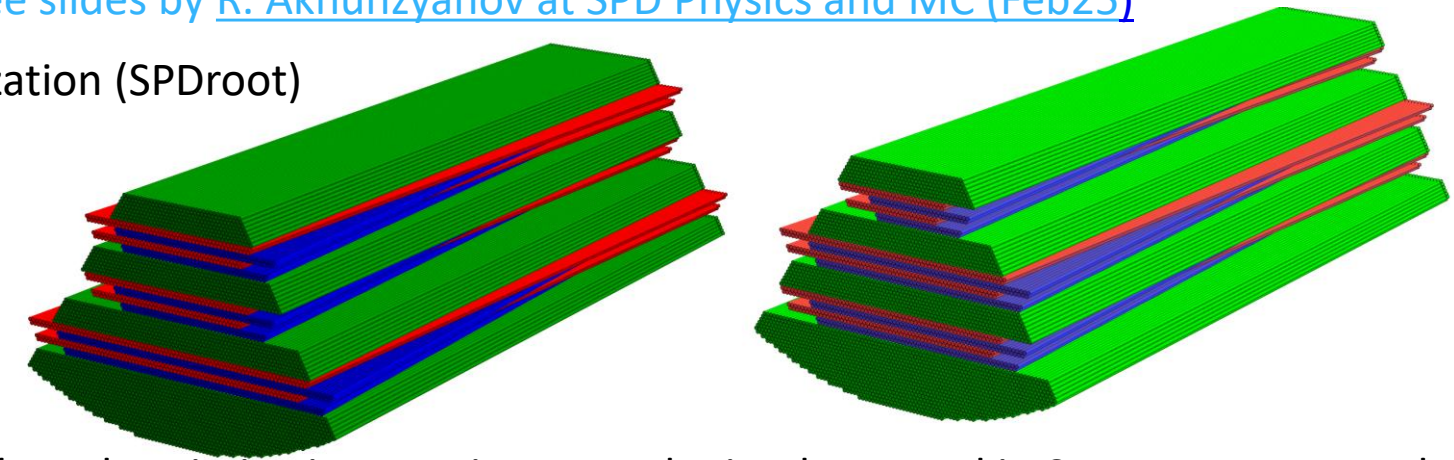
- Two planes of X(0^0)
- Two planes of U($+2^0$)
- Two planes of V(-2^0)
- Two planes of X(0^0)

Simulation studies – geometry optimization

2025

see slides by R. Akhunzyanov at SPD Physics and MC (Feb25)

- basic optimization (SPDroot)



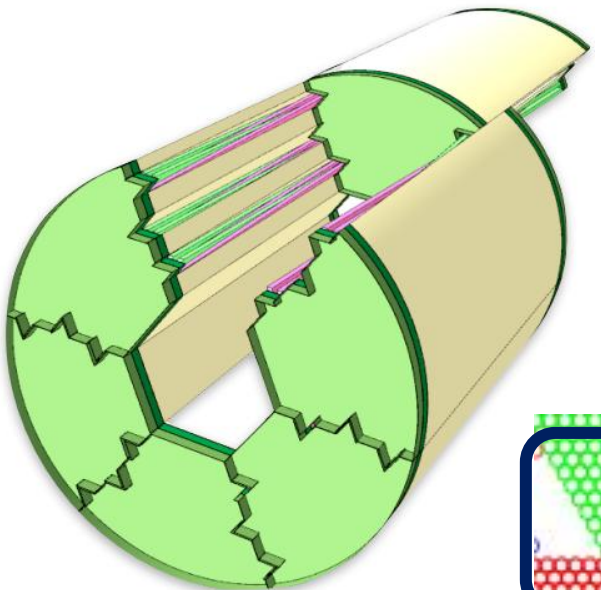
- performance-based optimization requires PR to be implemented in SPDroot – expected soon!

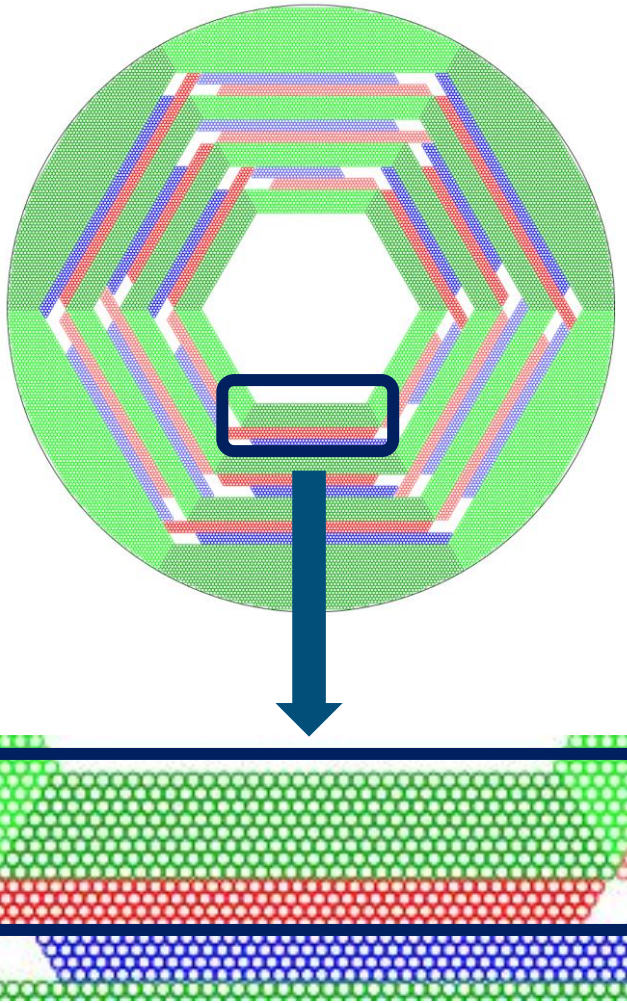
see talk by V. Andreev at SPD Physics and MC (Mar2025)

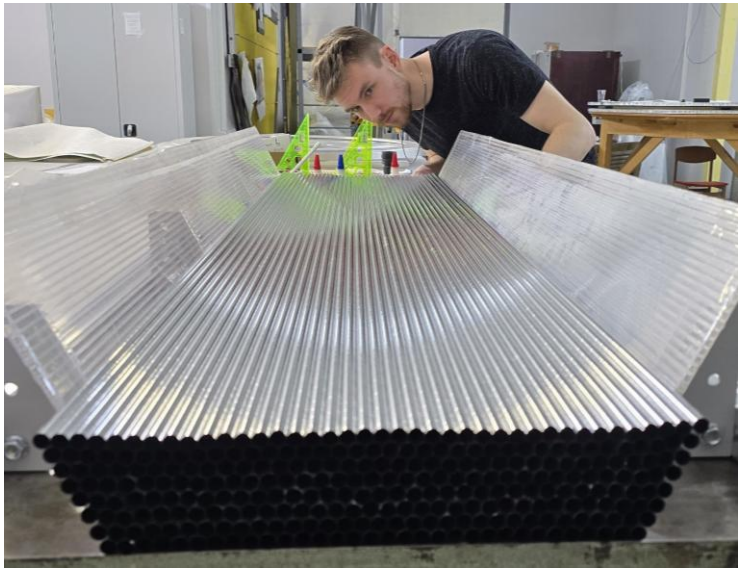
• Octants are replaced by sextant modules due to better packing ratio and also because the radial ribs can be removed.
• The power frame will be formed by an outer cylinder and a set of straw tubes in the center, which will be replaced by carbon fiber tubes of the same diameter.
• The six modules will be assembled using the Lego principle to avoid areas without layers of oblique straw-tubes.
• A full-size mockup made of styrofoam will be assembled in May
• The detailed procedure for assembling the detector is still under discussion

Mockup

~300 straws L~1,7m

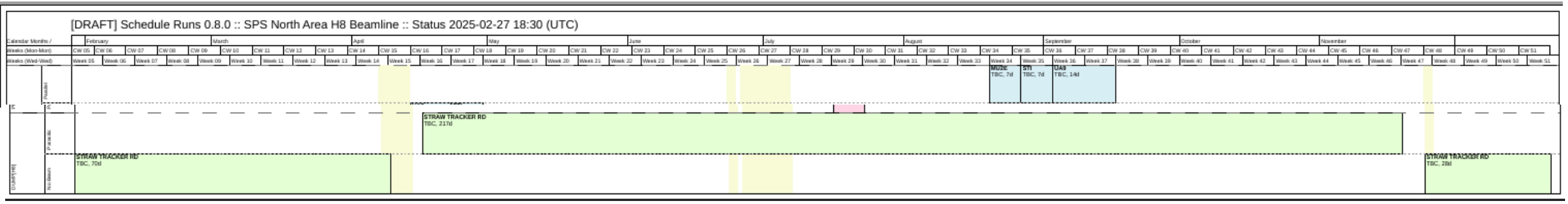




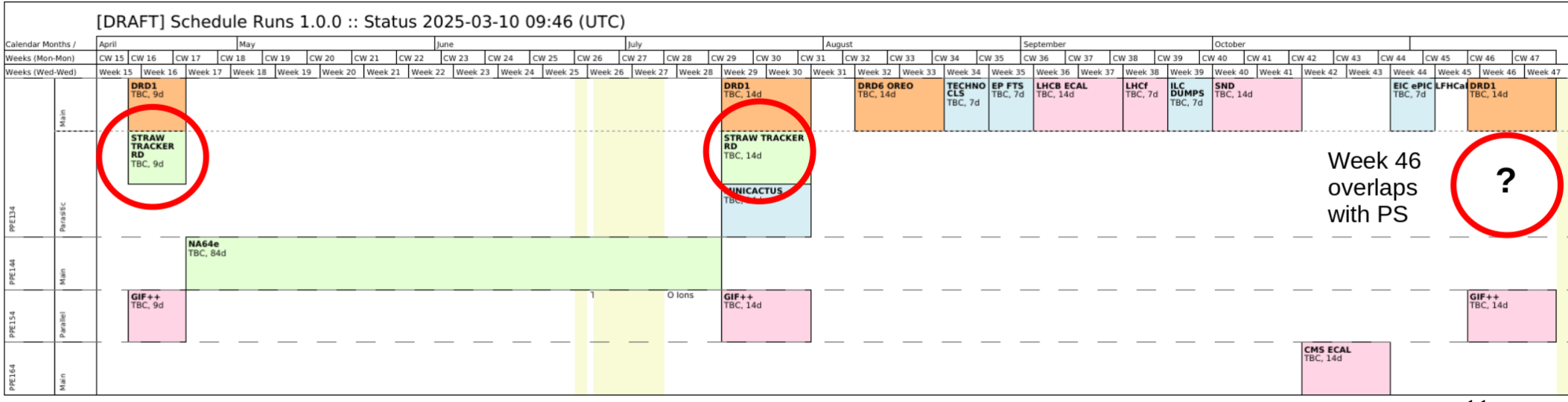


SPS beam time 2025

Permanent setup at SPS H8 beam dump (high momentum muons, low intensity)

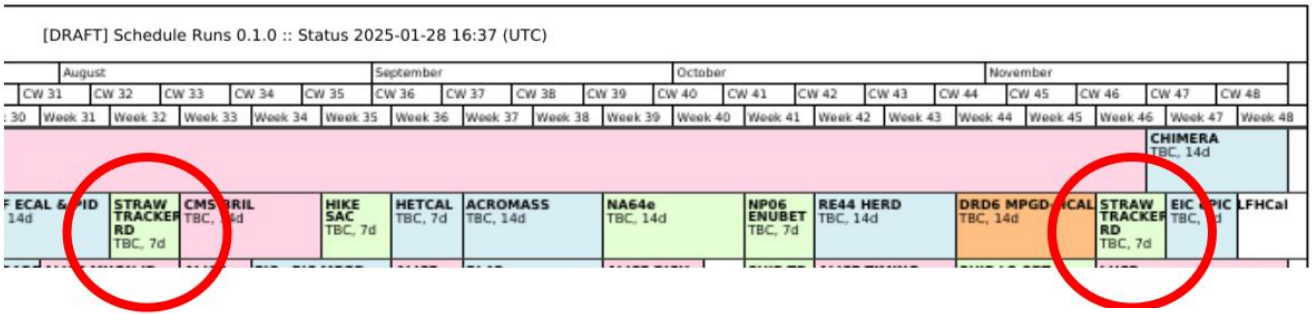


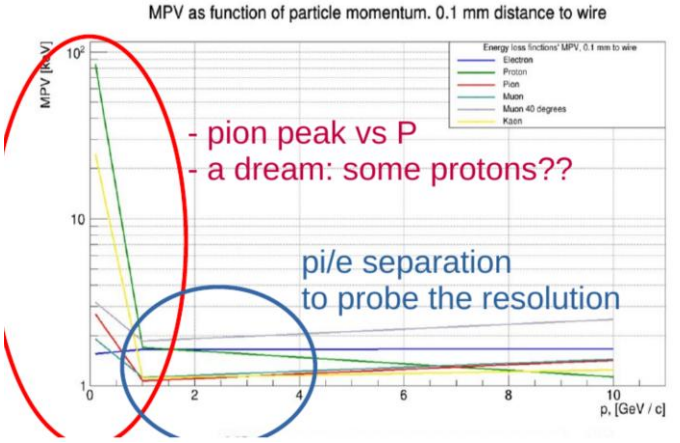
Three periods at SPS H4 (high momentum muons, high intensity)



PS beam time 2025

Two periods at PS T09 (low momenta hadrons and electrons)

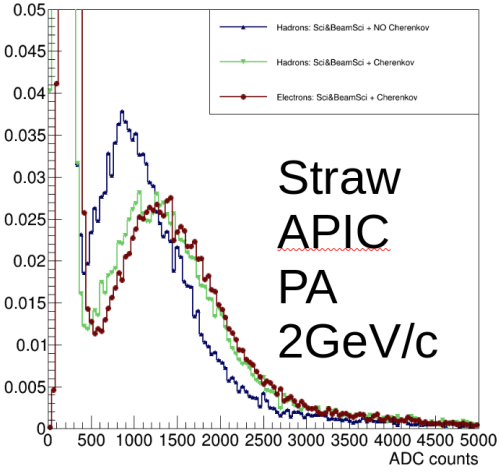


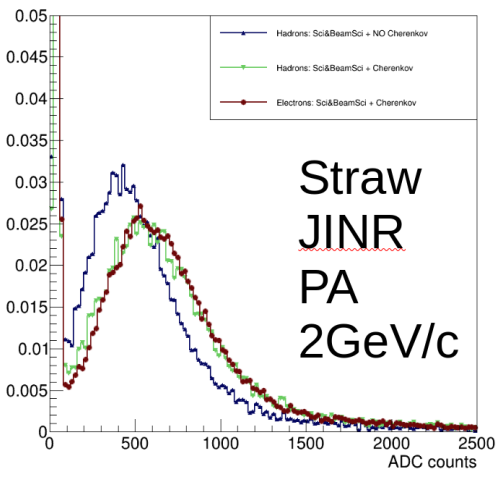


- ok for general charge resolution studies

- no low momenta protons for the dynamic range studies

=>

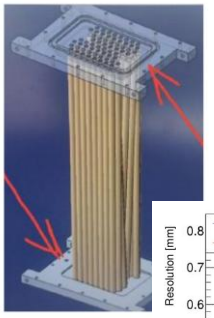




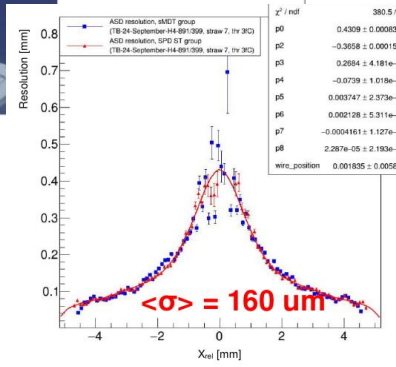
Low momenta protons at PNPI synchrocyclotron (June 2025)

Test beam measurements - muon beam (SPS)

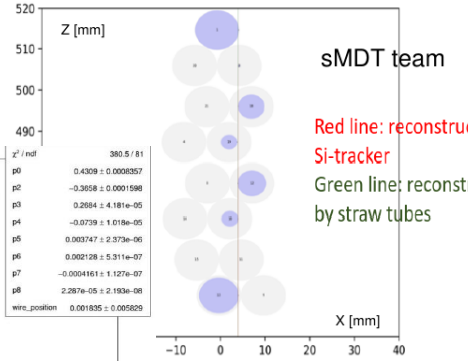
- Prototyping
  - stereo-angle
  - HV/readout interface



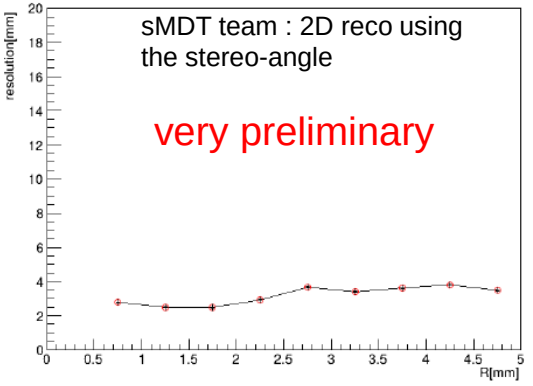
- Test of readout electronics
  - known performance - ATLAS sMDT ASD readout (autumn 2024, together with University of Michigan, analysis ongoing)



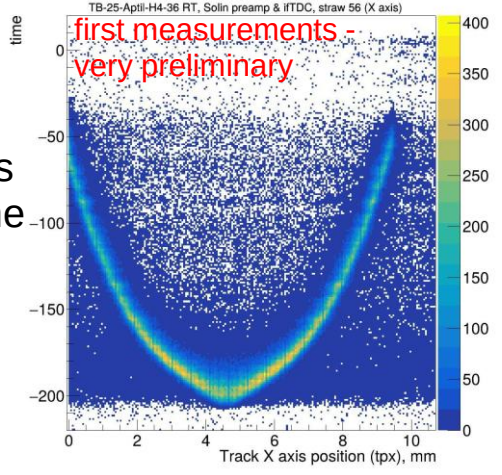
Event display



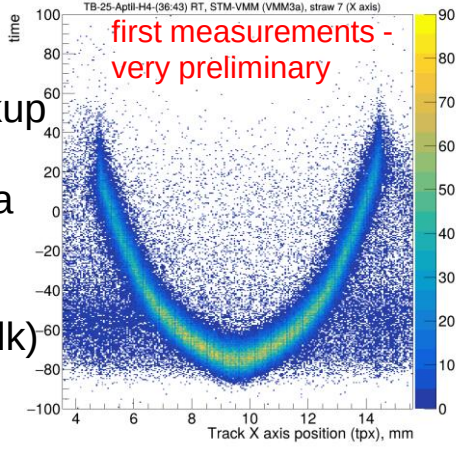
Width of residual vs. radius (2nd coordinate)



- TB-2025 : NA64 straw readout - as predecessor of the future S.Solin's readout (time branch)



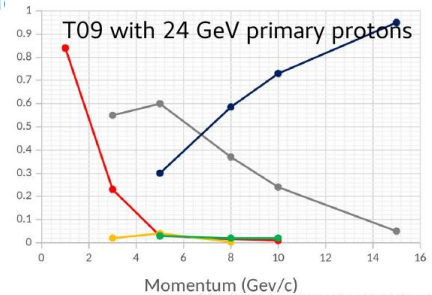
- TB-2025 : backup SPD readout option - VMM3a with external digitizer (see Vitaly Bautin talk)



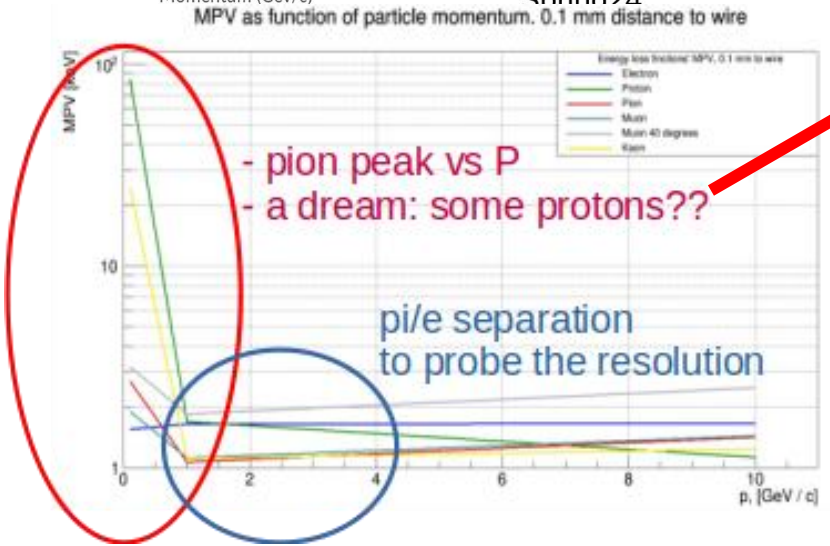
Test beam measurements - low momenta hadrons (upcoming data taking at PS and PNPI)

- **PS: hadrons (mostly pions) + electrons**

data-taking: August + November 2025

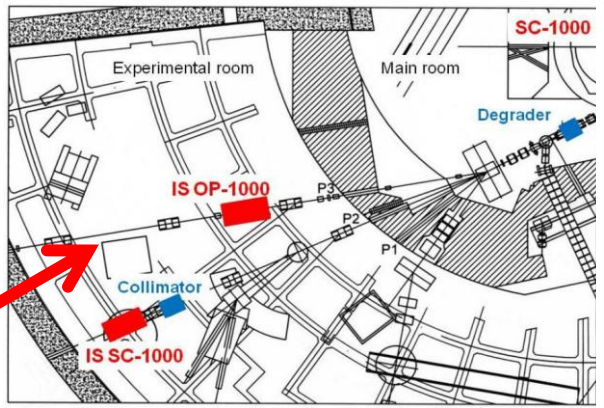


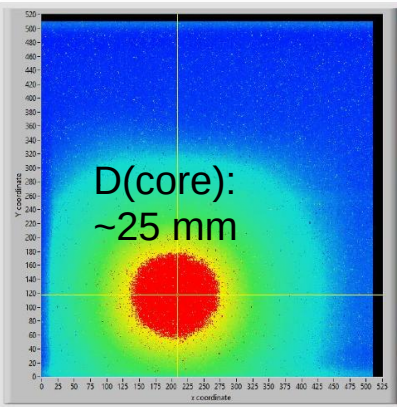
also track measurements (Si tracker as a reference tracker)



- **Proton beam at PNPI: 0.1-1 GeV**

expected mid June 2025





Normally a very intense beam (up to 10^9Hz/cm^2) - special tuning down to 10^4-10^5 Hz/cm^2) is expected

kindly provided by E.M. Ivanov (PNPI)

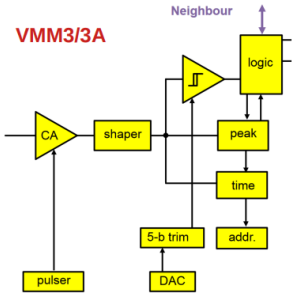
Measurements of the straw performance and choice of the readout electronics parameters

- **Spatial resolution** (**SPS**)
  - – influence of the readout parameters
    - electronics noise, threshold
  - influence of the wire displacement
  - different operation conditions (gas gain, pressure dependence)
  - measurements in the magnetic field (H4)

- **Charge measurements (PS**, low momentum pi, mu, e)
  - charge distribution for different particle momenta
  - multiple scattering probability
  - electronics dynamic range for PID (protons are required, under discussion)
  - measurements at PNPI

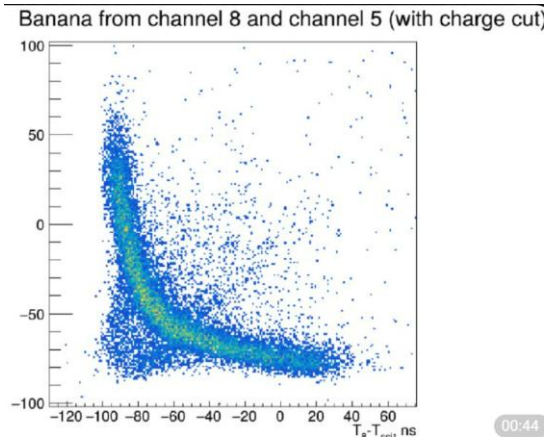
FEE for Straw Readout talk by Vitaly Bautin

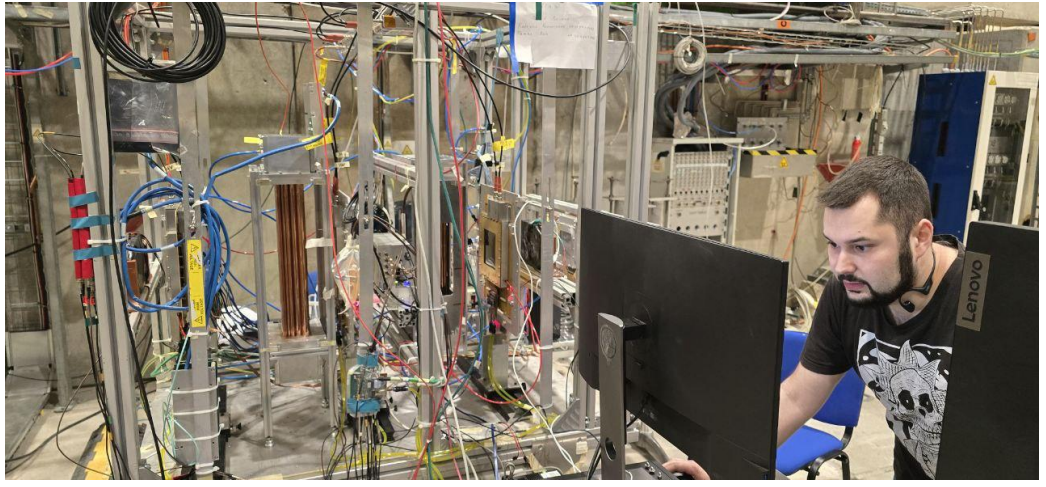
Investigating existing readout solutions

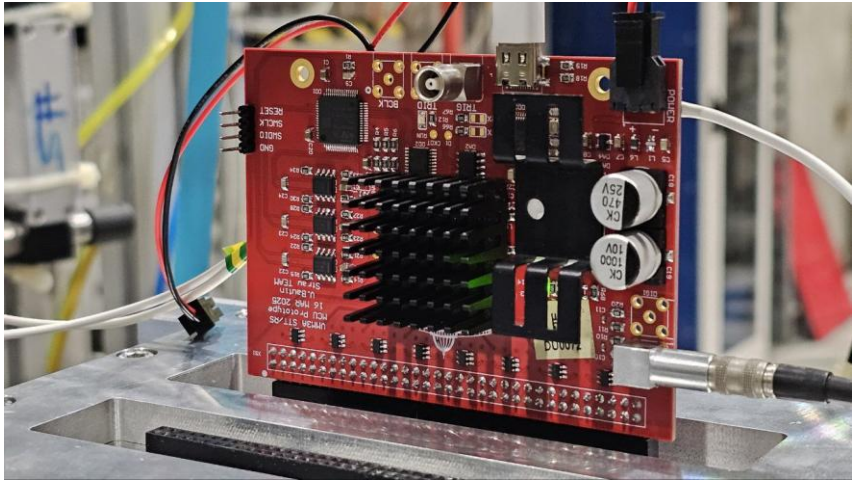


Number of channels	64
Clock frequency	10...80 MHz
Input capacitance	<300 pF
Dynamic range	up to 2 pC
Gain	0.5, 1, 3, 4.5, 6, 9, 12, 16 mV/fC
Peaking time	25 / 50 / 100 / 200 ns
ENC (energy branch)	<3000 e^-
TDC binning	~1 ns
Maximum event rate	140 kHz/ch
Consumption	15 mW/ch

VMM3/3A ASIC is well known chip for gaseous detectors. It has amplifier and shaper adjustable in a wide range. But it was not really done for the timing measurements so fastest shaping is 25ns and ToA mode has some issues.







Garfield/LTSpice simulation of straw signal + readout: talk by Sofja Bulanova on Thursday

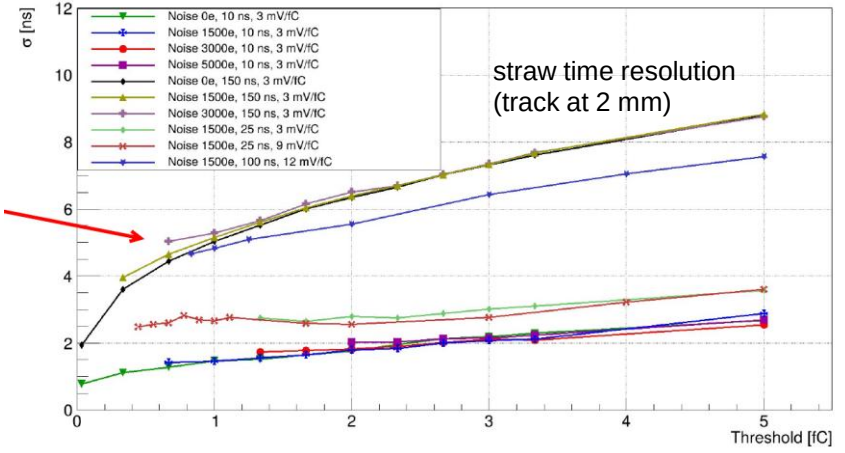
- Straw response parametrization for SPDroot: time (completed), charge (ongoing)

- Studies of the time resolution for various electronics parameters:
  - peaking time
  - gain
  - electronics noise

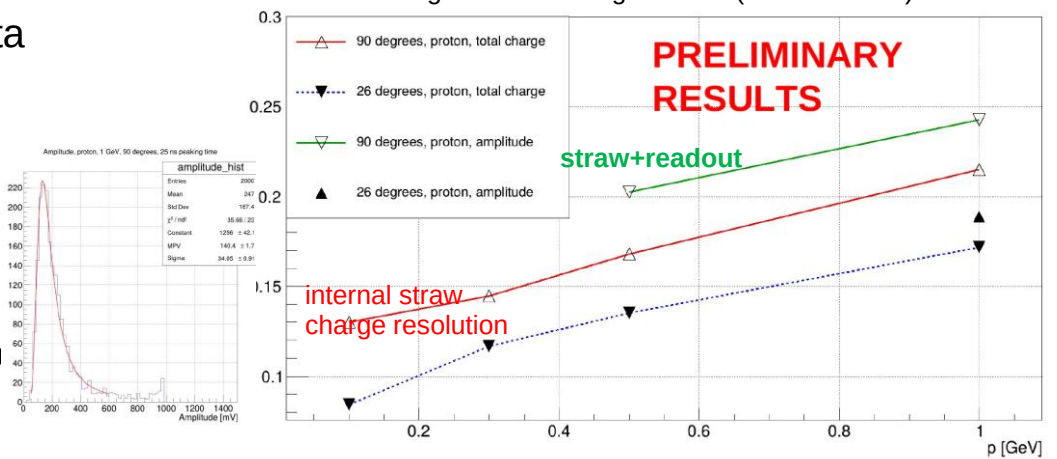
- Influence of the electronics dynamic range on proton/kaon signal measurements at low momenta

- Studies of charge resolution for various readout electronics parameters

- currently with VMM3 readout model;
  next step: Solin's m

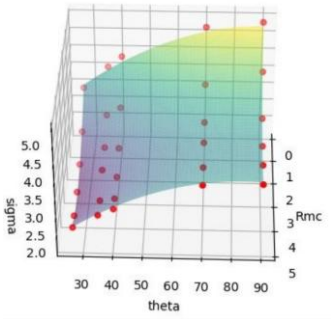


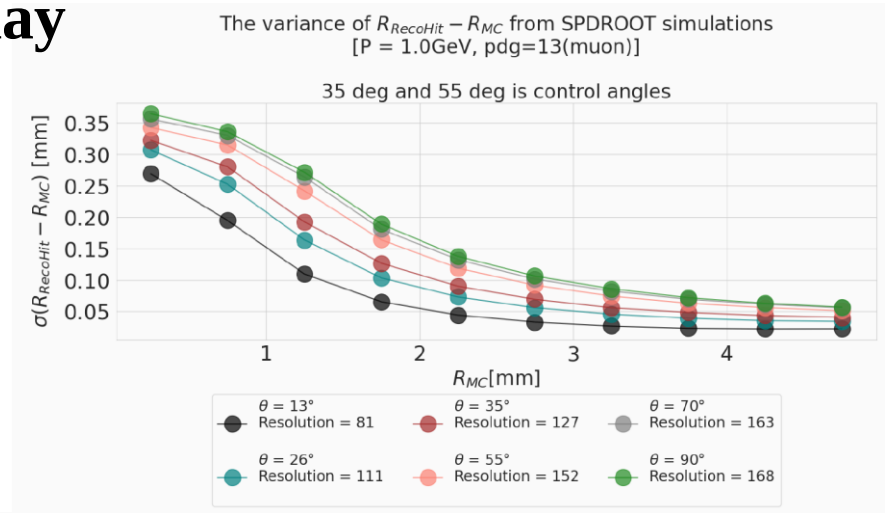
straw charge resolution: sigma/MPV (track at 2 mm)

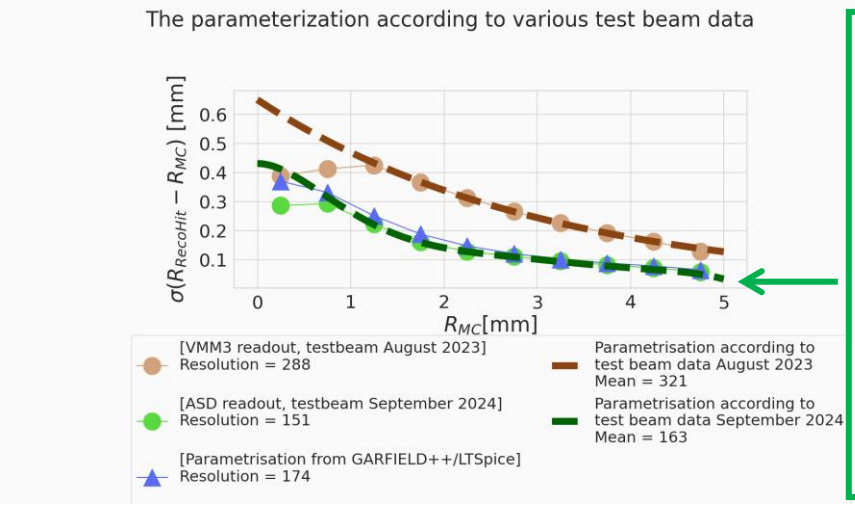


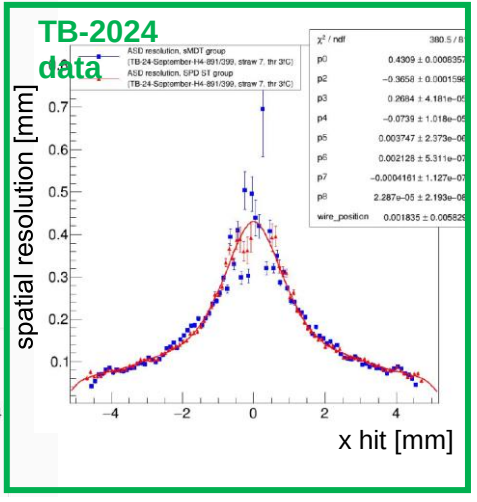
Realistic straw hit simulation/reconstruction in SPDroot: talk by Ekaterina Mosolova on Thursday

- Default SPDroot: MC hit coordinate smearing, no hit reco
- Parametrization of the straw signal time and resolution as functions of the track angle and hit position - based on Garfield/LTSpice simulation results - signal time smearing
- Hit coordinate reconstruction from measured hit time
- Validation - comparison to TB data for perpendicular tracks: good agreement between
  - **TB-2024 data (r-smearing implemented in SPDroot)**
  - **updated SPDroot version**

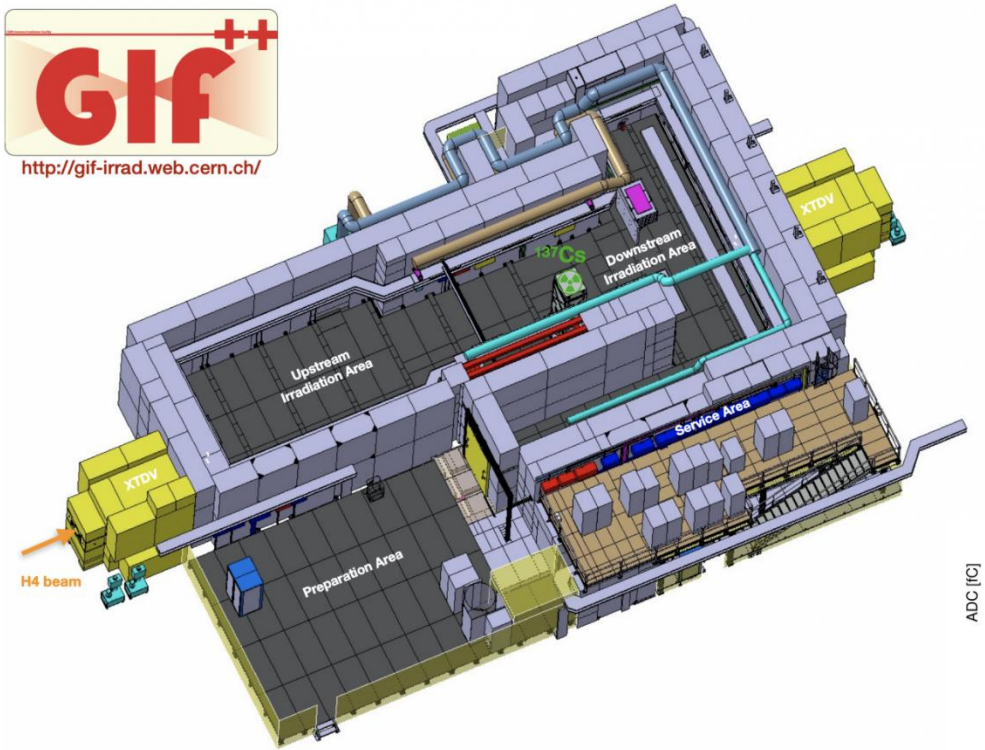


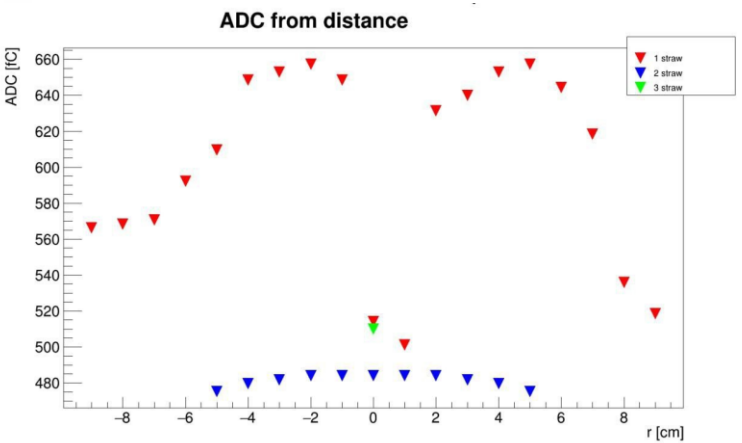






Aging





Temur Enik on behalf of STRAW TRACKER TEAM

Gas System: design requirement

Gas systems (as detectors) are subject to severe requirements on material & gas for safe detector operation:

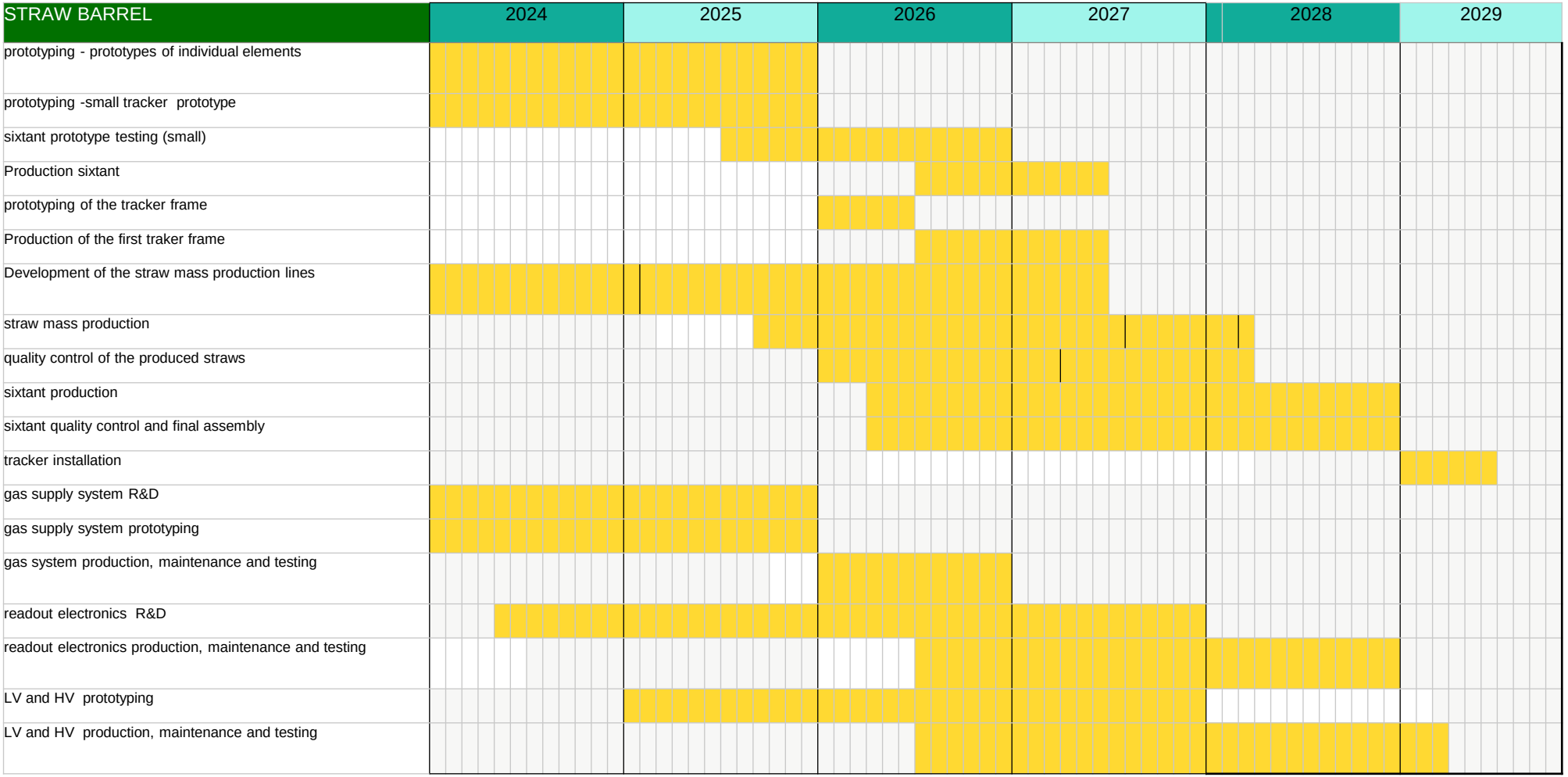
- Mainly (or exclusively) stainless steel pipe and components
- Need to validate most of the gas system components
- Documentation for QA and operation/maintenance follow up
- Monitoring of gas system operation
- Monitor of supply gases and mixture composition
- Evaluation of operational cost
- Flexible design to accommodate detector requirements/upgrades
- Careful evaluation of
  - resources for operation
  - resources for maintenance activity
  - Stability required
  - Balance requirements vs safety (as much as possible)

Straw-full system volume = 5 m3
Average gas consumption (70% Ar + 30% CO2) = 5000 liters/hour.- Operating 4 months a year, ~500 hours, total 2500 m3 per year-

Manpower of Straw-barrel project

Project leaders	T.Enik (JINR), E.Kuznetsova (PNPI), Y.Mukhamejanov (JINR, INP).
Power frame and assembling procedure	JINR: K.Basharina, Y.Ershov, A.Salamatin, S.Sukhovarov, S.Romakhov, PNPI: A. Fetisov
Gas system	JINR: V.Perelygin, V.Karjavine, D.Kozlov
Electronics	JINR: V.Bautin, M.Buryakov, N.Gorbunov, A.Golunov, V.Karjavine, I.Kapitonov, O.Minko, K.Salamatin, Y.Kovalev BSU: A.Solin, A.Solin.
Tube production and assembling	JINR: Y.Kambar, S.Romakhov, A.Rymshina. N.Saktaganov, N.Azorsky, V.Azorsky INP: O.Kalikulov, N.Yerezhep, S.Shinbulatov, Sh.Utei, A.Baktoraz, S.Adilkhan PNPI: A.Fetisov
Software and analysis	JINR: R.Akhunzyanov, A.Chukanov, A.Lapkin, A.Mukhamejanova (JINR, INP), D.Myktybekov (JINR, INP), O.Samoylov. PNPI: S.Bulanova, E.Mosolova, D.Sosnov, A.Zelenov.

Timescale


STRAW BARREL
2024
2025
2026
2027
2028
2029
prototyping - prototypes of individual elements
prototyping -small tracker prototype
sixtant prototype testing (small)
Production sixtant
prototyping of the tracker frame
Production of the first traker frame
Development of the straw mass production lines
straw mass production
quality control of the produced straws
sixtant production
sixtant quality control and final assembly
tracker installation
gas supply system R&D
gas supply system prototyping
gas system production, maintenance and testing
readout electronics R&D
readout electronics production, maintenance and testing
LV and HV prototyping
LV and HV production, maintenance and testing