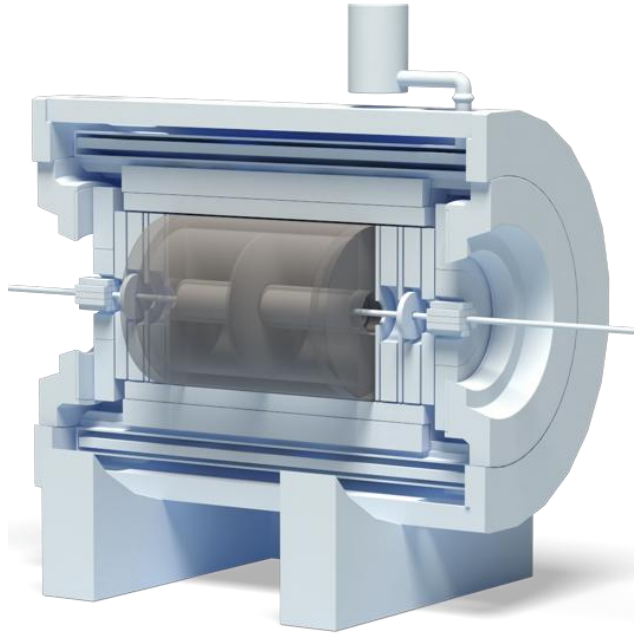
Engineering the TPC&ECAL Cooling and Thermal Stabilization System: Practices and Management



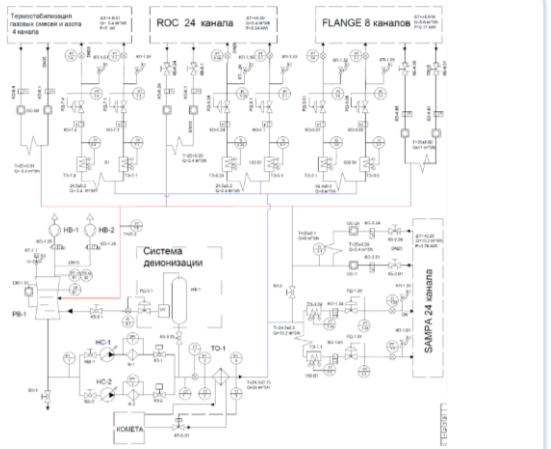
Kiril Levkov
TurboEnergy / ArcoLab / INP BSU collaboration
MPD Collaboration Meeting, Dubna

From engineering practice to a working detector support system

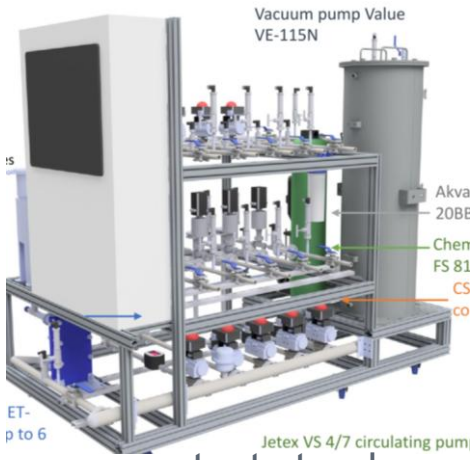
Why This Talk Is About Engineering Practice, Not Only Status

- The project is still in progress
- The focus is the engineering logic behind the system
- MPD cooling and thermal stabilization is a real case of complex system development

- 118 independent circuits
- More than 1000 sensors
- 3 sub systems
- More 20 km of cabeiling
- More than 5 km of tubes
- 10 PLC



Engineering scheme



test stand



Site installation

Why This Project Required a Multidisciplinary Team

- Thermal, hydraulic, mechanical, control, and safety tasks are tightly coupled
- No single discipline is sufficient for such a project
- Different specialists are needed at different stages
- The main challenge is to organize all contributions around one working system



The team (over 20 specialists):

- Design engineers;
- Researchers and programmers;
- Process engineers.



Project exemples:

- Test benches
- Physical Calculations for System Design
- Creation and installation of energy systems
- Repairs of complex technological equipment
- Metal machining of complex profile products
- Assembly and testing of complex devices

Belarusian State university

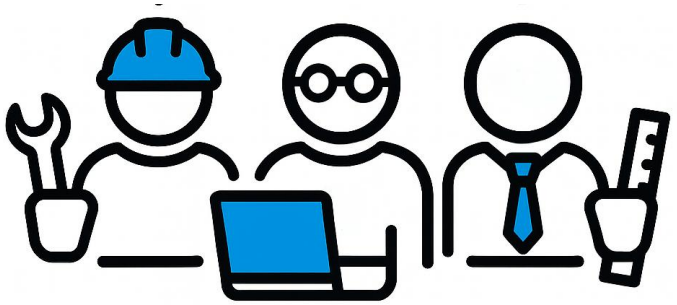
БНТУ

МУЛЬТИПРОФИЛЬНАЯ ЛАБОРАТОРИЯ ARCOLAB

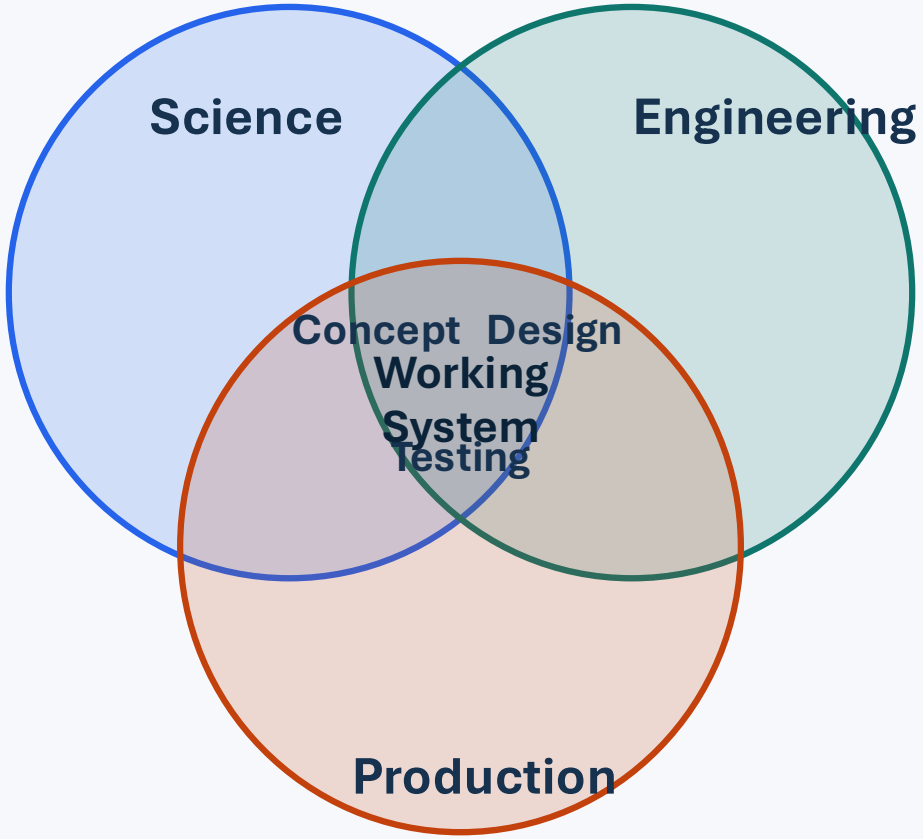
INSTITUTE FOR NUCLEAR PROBLEMS BELARUSIAN STATE UNIVERSITY

TurboEnergy LLC

Science, Engineering, and Production in One Workflow

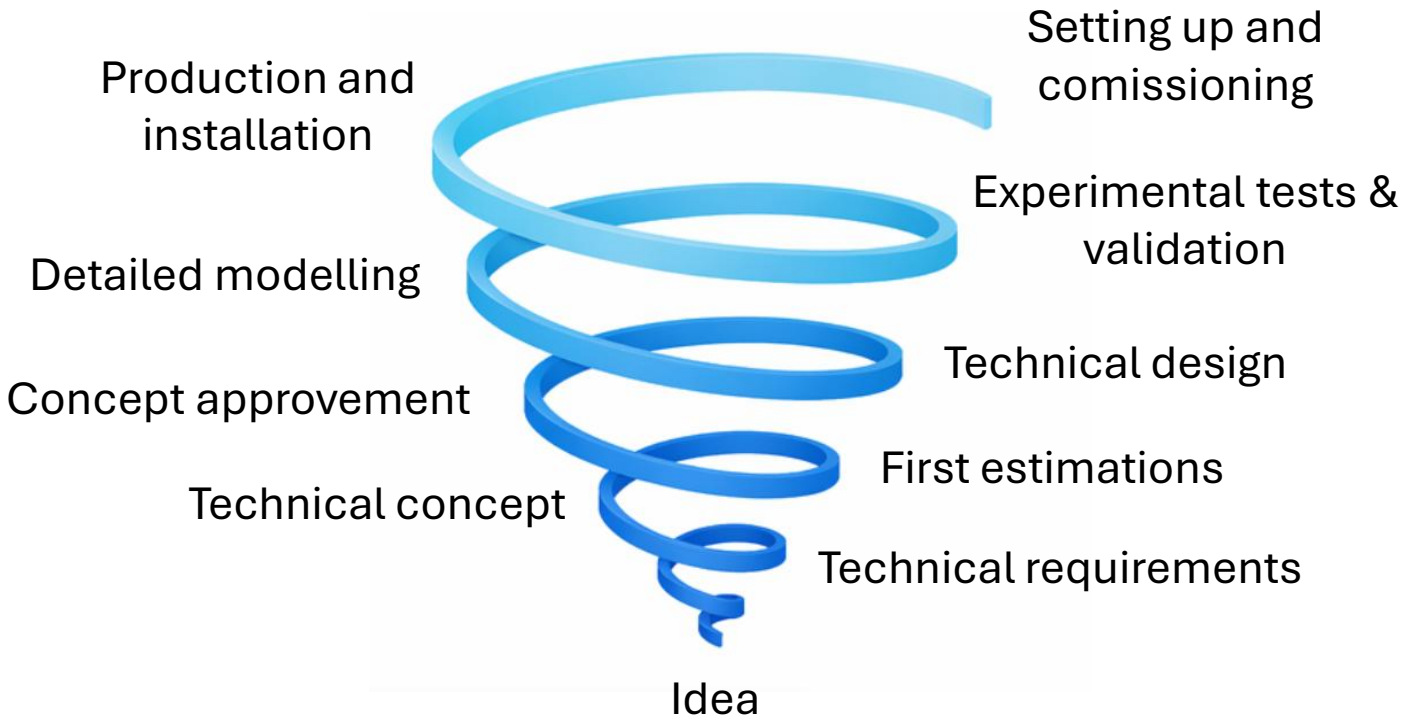


- We work at the interface of science, engineering, and manufacturing
- This reduces iteration time between concept, design, fabrication, and testing
- The workflow is especially effective for one-of-a-kind systems
- In MPD cooling system, it helped connect analysis, hardware, testing, and site integration



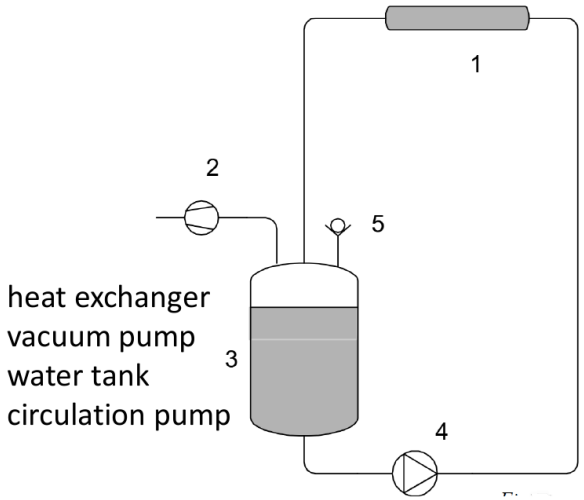
Complex System Development as an Iterative Process

- A complex system is not developed linearly
- Each stage adds detail and reveals new constraints
- Calculations, layout, testing, and feedback refine the design
- Development moves from uncertainty toward a working solution

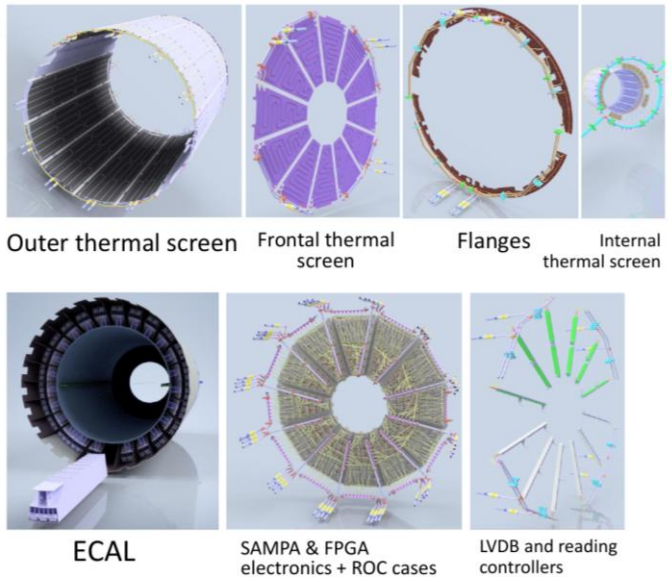


From Requirements to System Architecture

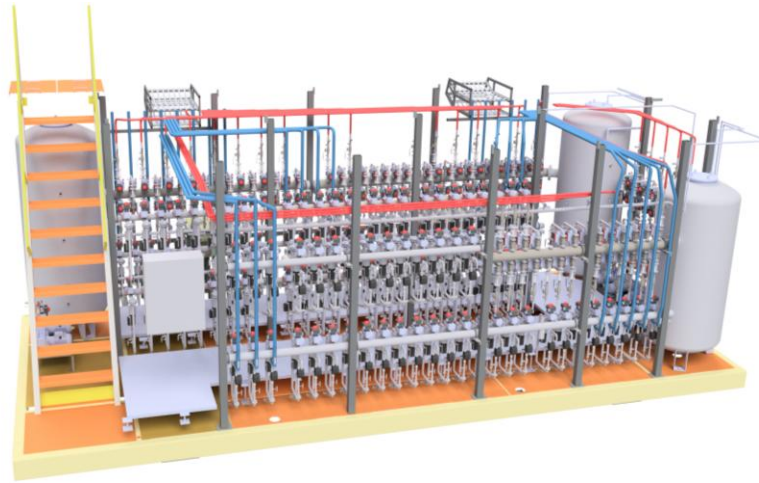
- Development starts from the whole system
- Main functions, elements, and links are defined first
- Mass and heat balances set the operating boundaries
- Preliminary equipment capacities come from system-level analysis



Leakless principle



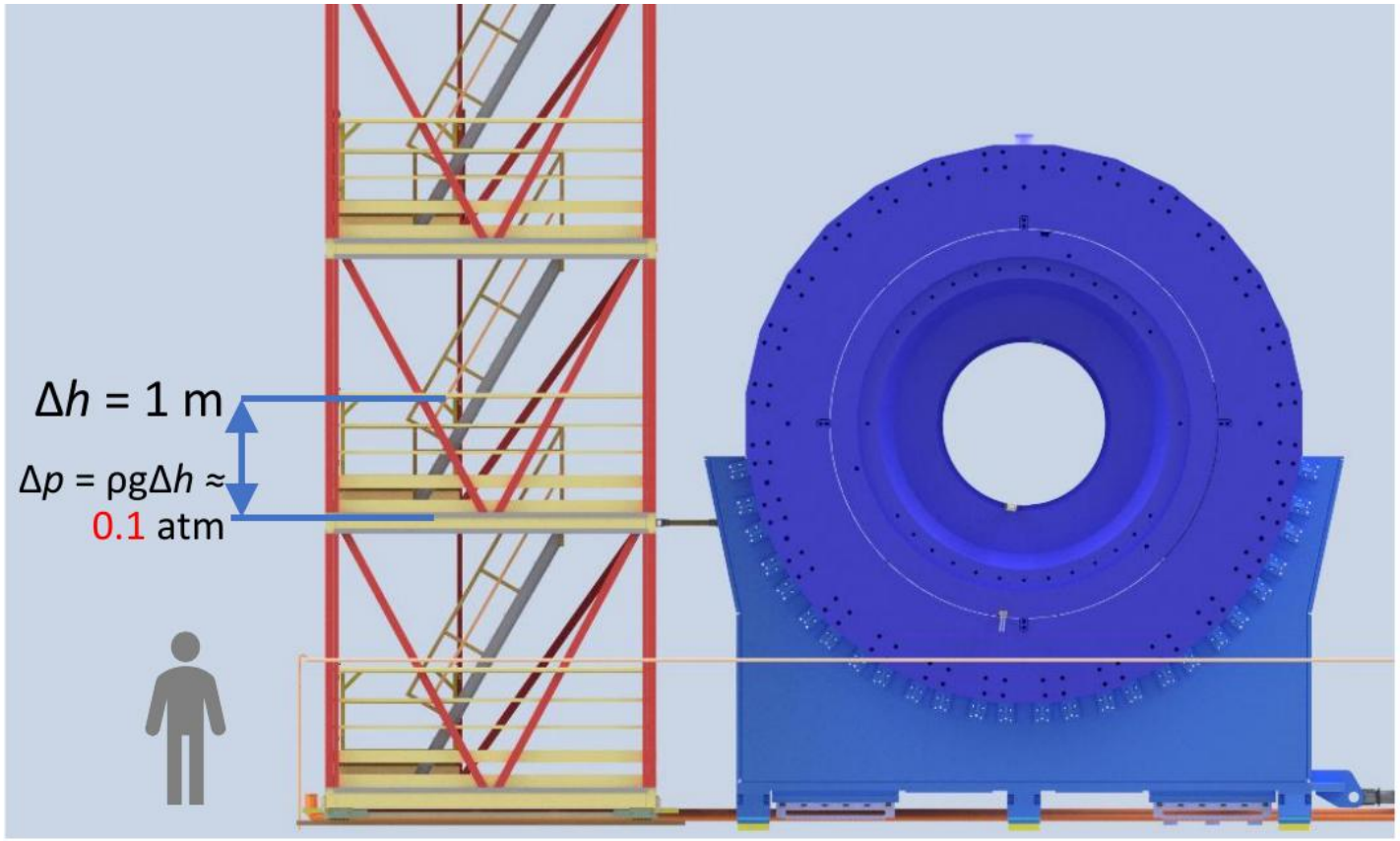
System parameters



Engineering design

Managing Critical Constraints and Operating Limits

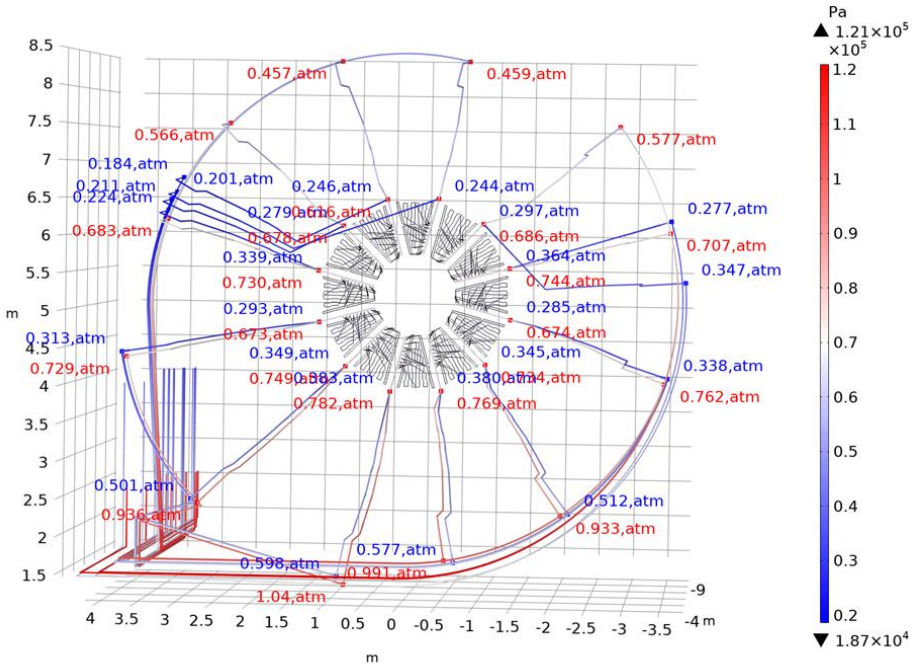
- Leakless operation is a key system requirement
- The allowed pressure range is narrow
- Detector height strongly affects hydrostatic pressure
- Too high pressure may cause leaks
- Too low pressure increases cavitation risk

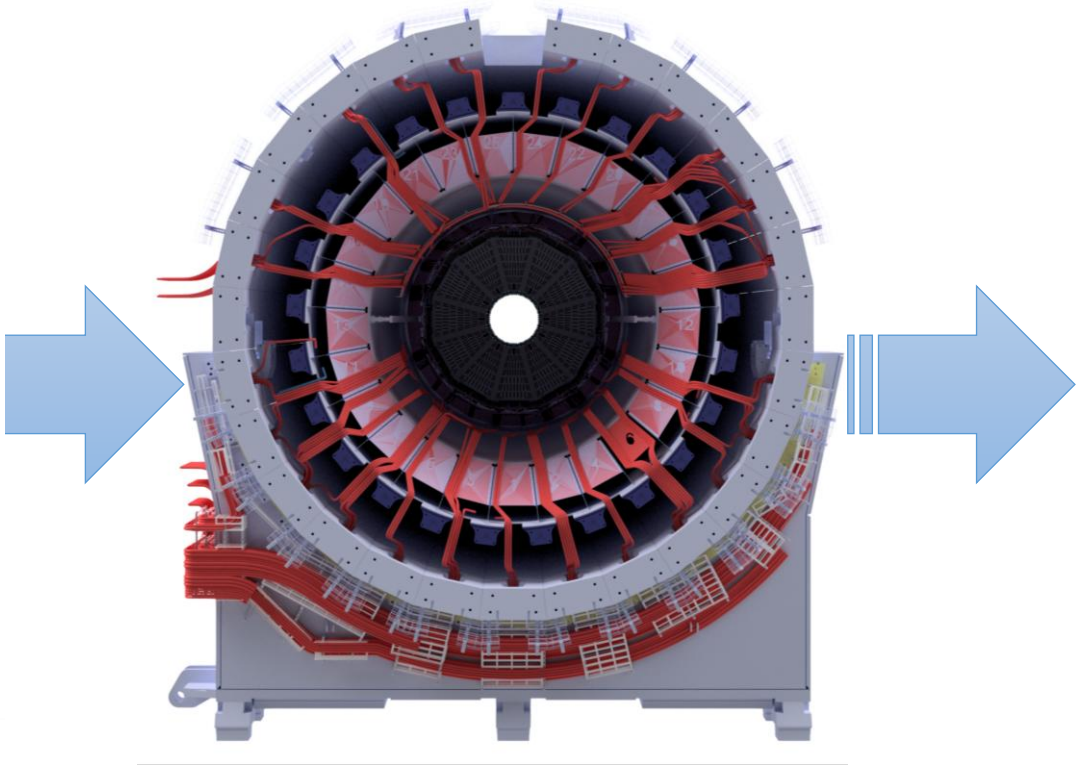


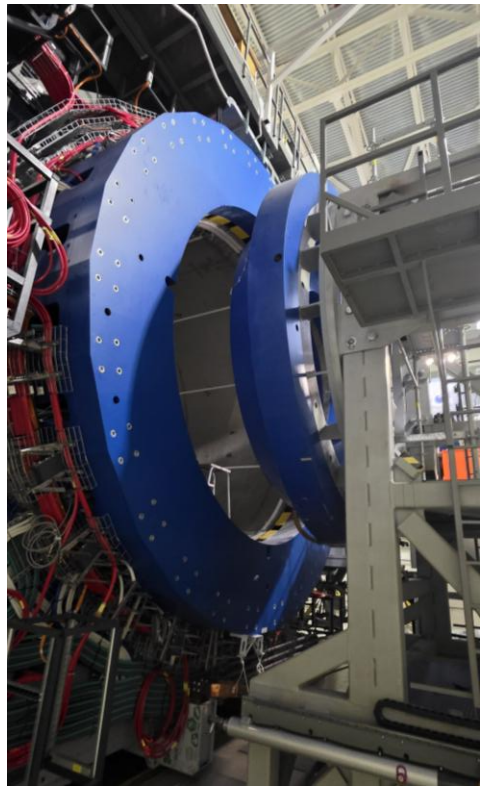
MPD and a platform

Design Refinement Through Modelling and Feedback

- System balances alone are not enough
- Critical zones require local analysis and detailed modelling
- Modelling helps refine the design and operating regime
- Measurements and monitoring validate assumptions
- Engineering updates are a normal part of development

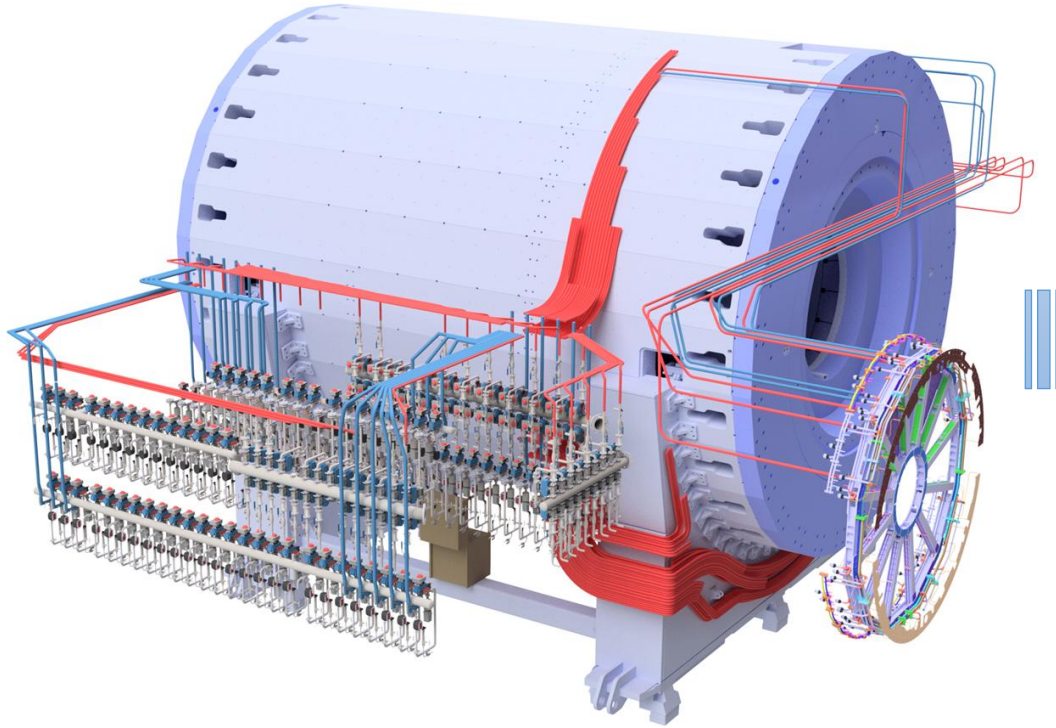


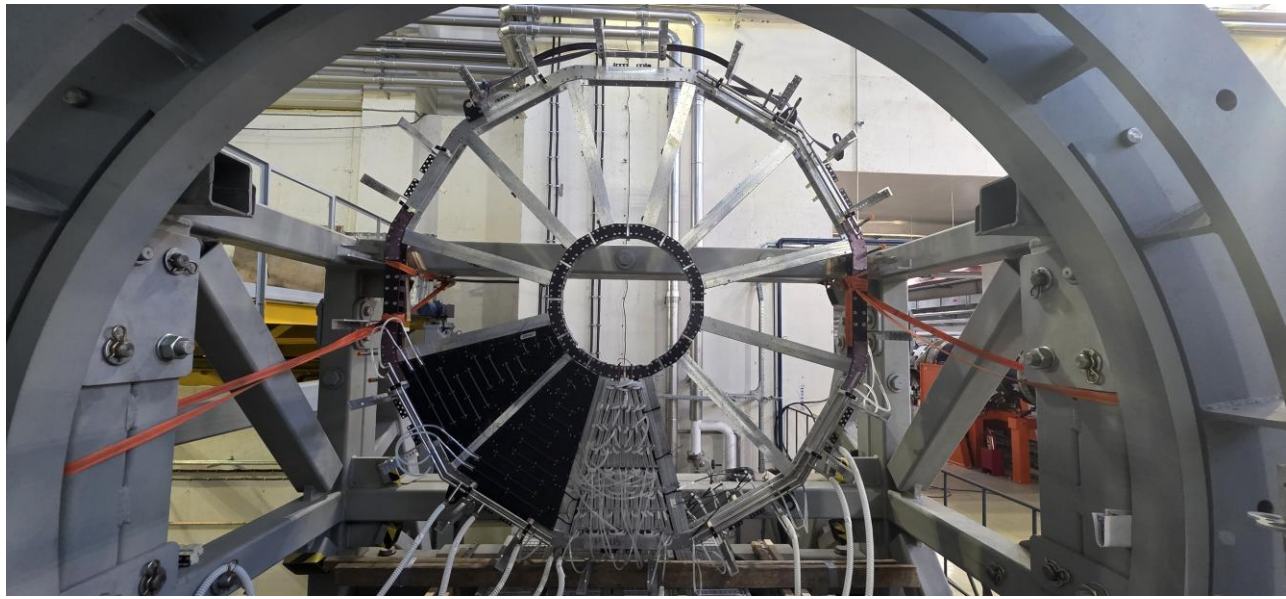




Interface and Integration Management in Real Detector Conditions

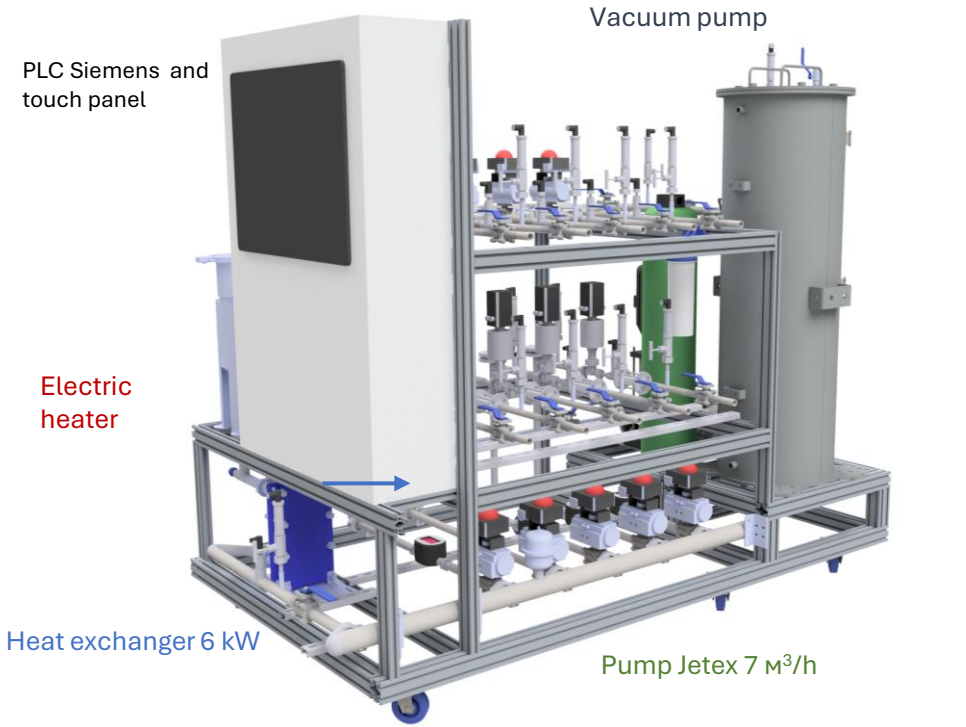
- Real integration is more restrictive than the initial concept
- Space, routing, access, and installation sequence matter
- Piping and cabling affect both layout and performance
- Integration can require recalculation and redesign
- Interface management is part of engineering, not a final formality





Test Stands as a Tool for Risk Reduction

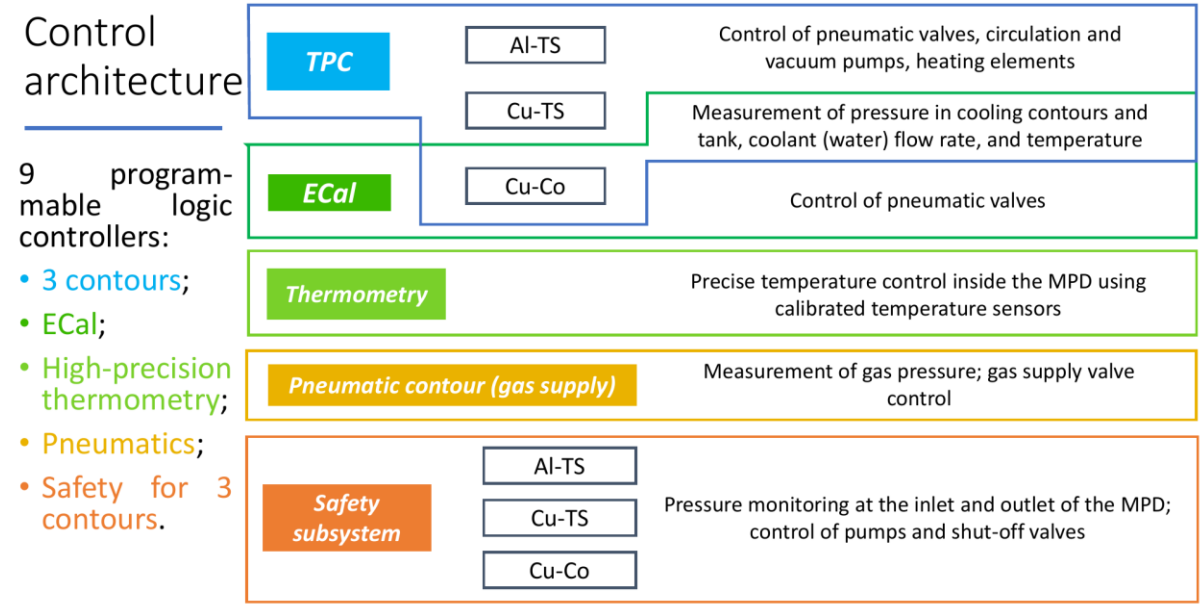
- Full-scale validation should not be postponed to final assembly
- Dedicated stands allow early verification of key decisions
- Stands refine calculations and compare them with measurements
- Hidden problems can be identified before full commissioning
- Stands provide a common platform for engineers and scientists





Control, Safety, and Operating Modes

- Control architecture is part of system architecture
- Automation and safety must be developed early
- Important modes include filling, draining, start-up, and shutdown
- Semi-automatic operation helps reveal deviations and refine logic
- Reliable operation depends on both hardware and control strategy



Control architecture



Modular concept and Parallel Implementation

- The full system was divided into functional modules
- Modules could be fabricated, tested, and improved separately
- This enabled parallel work streams
- Factory-tested modules were then integrated on site
- Modular concept reduced overall project complexity



Tank modules



Manifold modules



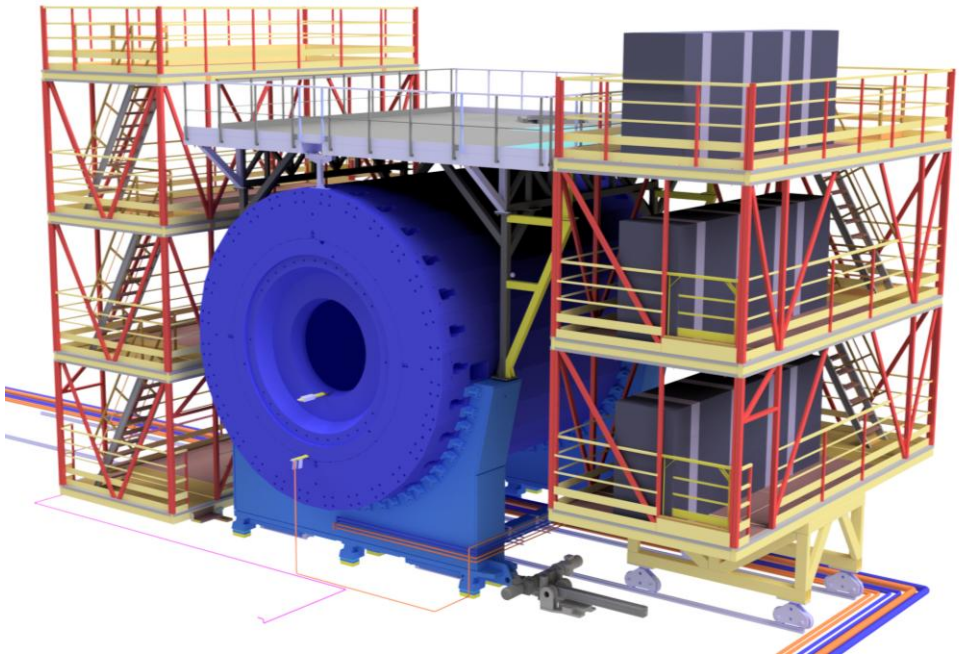
Electronics models



Pump modules

Staged Installation and Commissioning Management

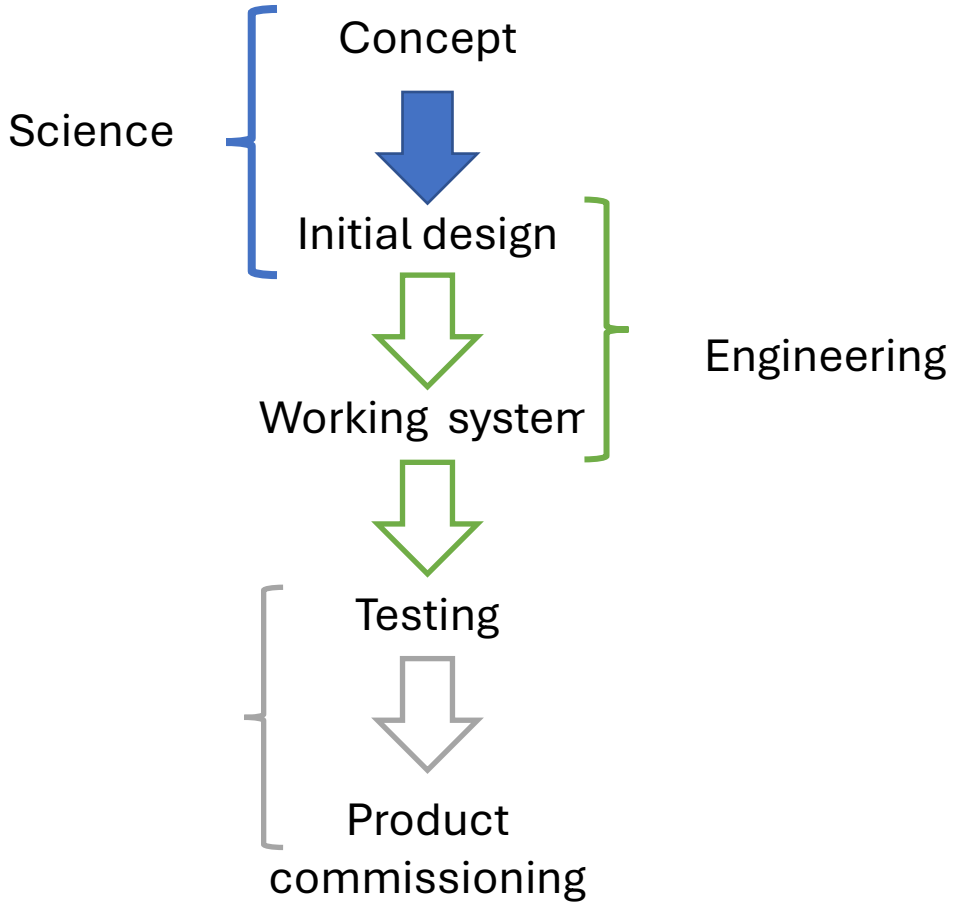
- Installation is not the end of engineering
- Commissioning is performed step by step
- Individual circuit can be tested separately
- Hydraulic and thermal tasks may be solved in separate stages
- Gradual commissioning reduces risk and improves process control





Practices That Can Be Applied to Future NICA Tasks

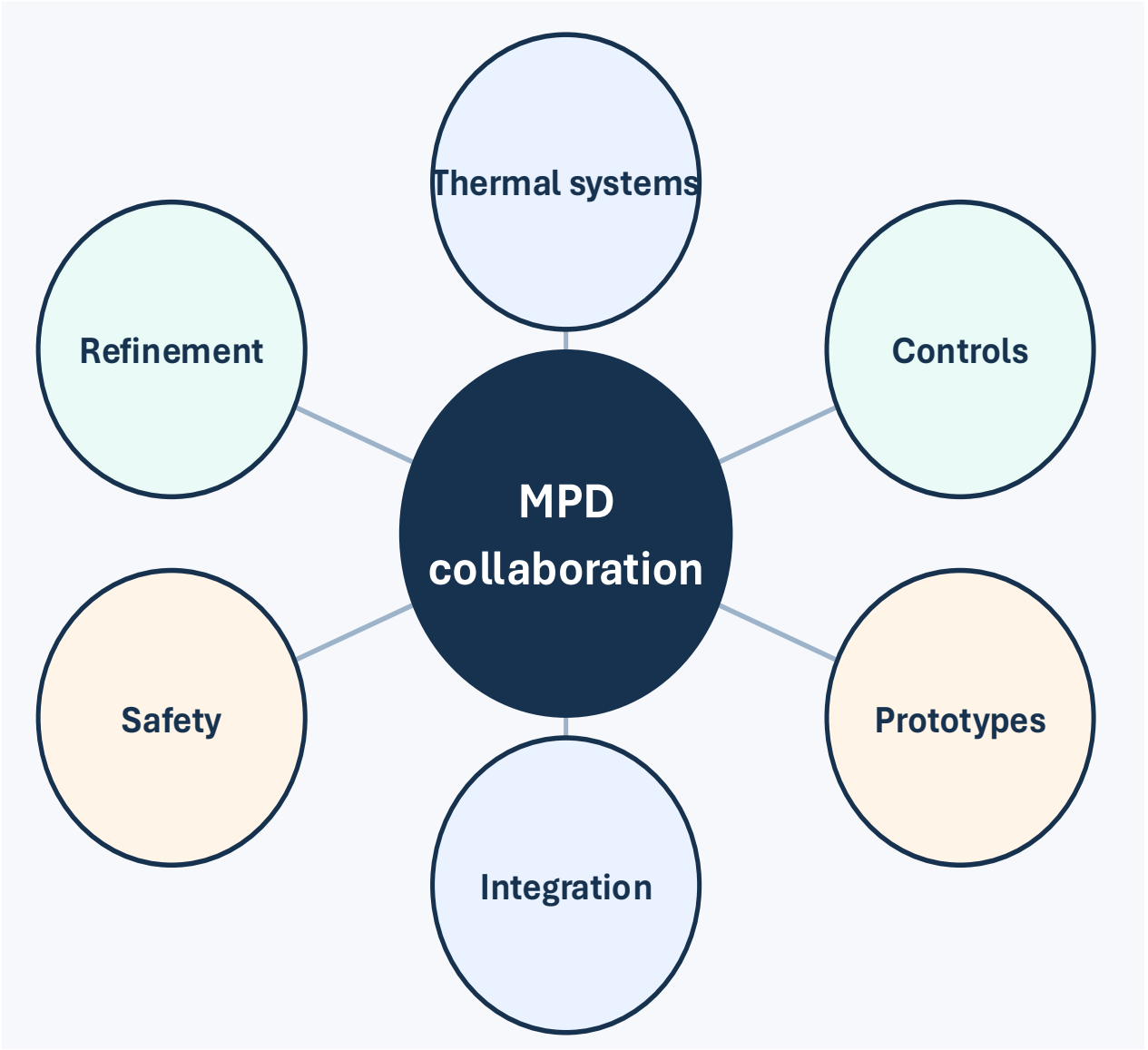
- Start from the whole system, not from isolated components
- Manage constraints and interfaces explicitly
- Use modelling as a decision-making tool
- Validate early with dedicated stands
- Develop control and safety in parallel with hardware
- Treat commissioning as part of engineering



Collaboration Opportunities

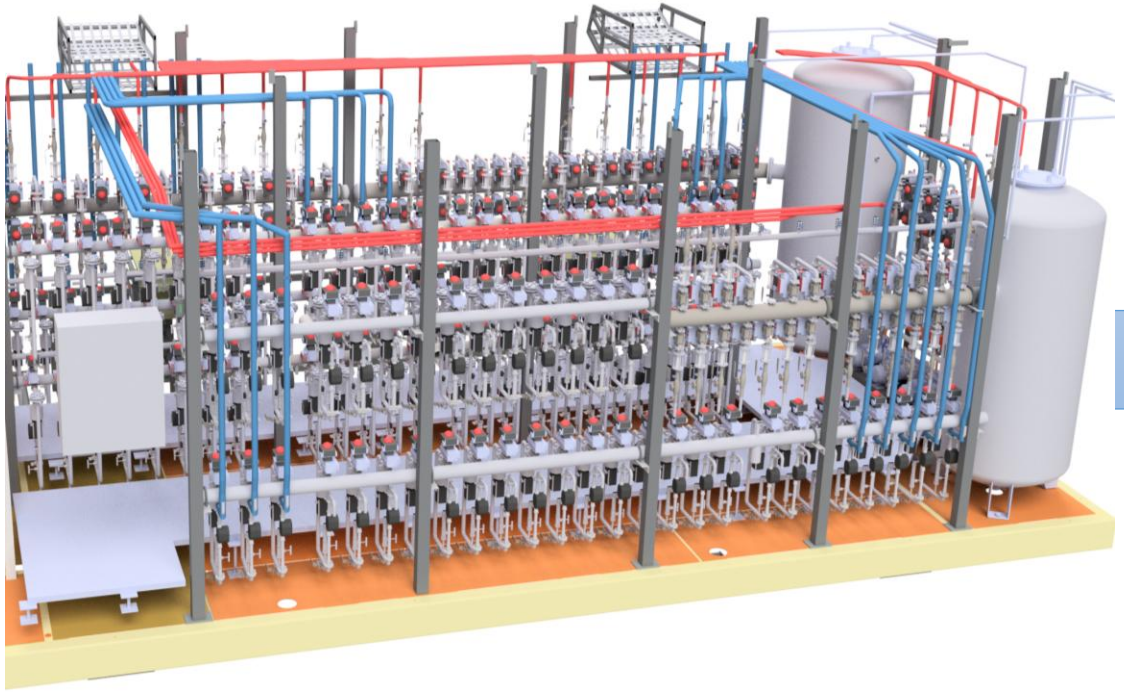
- Complex thermal and hydraulic systems
- Detector support infrastructure
- Automation, controls, and safety integration
- Prototype and stand development
- Technical refinement of existing subsystems
- And other non-standard tasks!

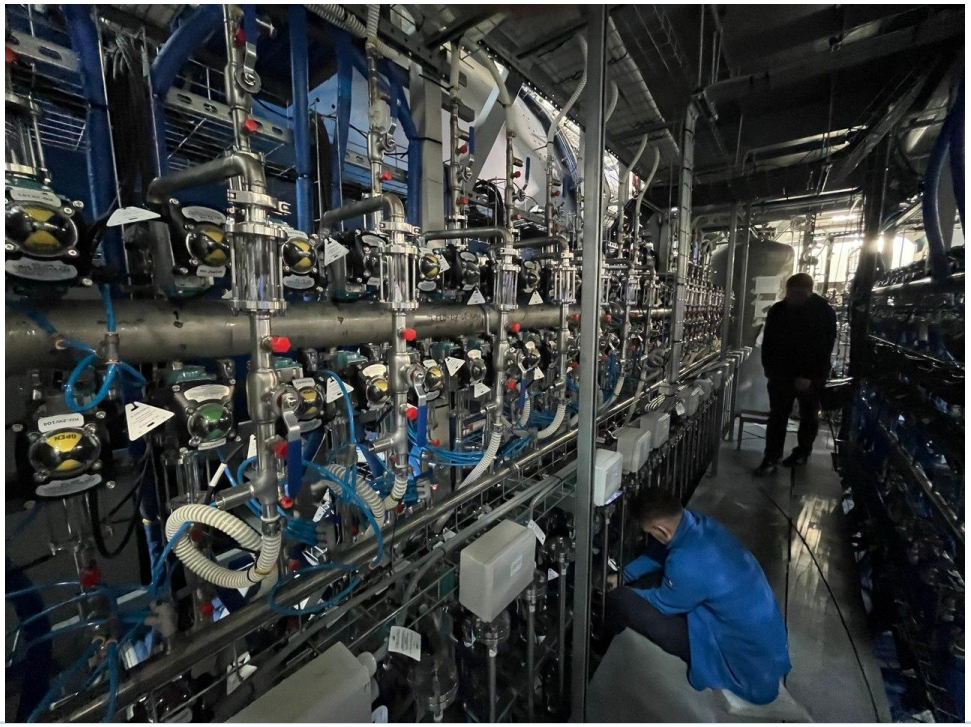




From Engineering Practice to Working System

- Complex detector infrastructure must be developed as an integrated system
- Engineering practice and management are as important as the final hardware
- The MPD case demonstrates the value of iterative system development
- The goal is to turn technical ideas into reliable working systems





Thank you for attention!

Kiril Levkov
TurboEnergy / ArcoLab / INP BSU collaboration
llc.turboenergy@mail.com

Feel free to ask any questions