Common Integration & Infrastructure Projects CBM-STS and BM@N-STS

within scope of:

German-Russian Roadmap &

(CREMLIN+)

German-Russian Roadmap (GRR)

signed Jan. 2020

PREAMBLE

The Ministry of Education and Science of the Russian Federation (MON) and the Bundesministerium für Bildung und Forschung (BMBF) have agreed upon a co-operation in the "German-Russian Roadmap for Cooperation in Education, Science, Research, and Innovation", resting on 4 pillars:

I. Cooperation in the area of large research infrastructure development (Research infrastructure pillar)

→ FAIR/CBM
NICA/BM@N

II. Joint Research and vocational education projects in the fields of scientific and technological cooperation and education priorities by both countries (Priorities Pillar)

III. Organization of mutual beneficial developments of the scientific talent pool in both countries (Young Talents Pillar)

IV. Science and research to build bridges both in society and business and between both countries (Pillar of Innovation, Science and Society)

This Cooperation Agreement focuses within pillar I on the instrumentation and scientific exploitation of the Nuclotron-based Ion Collider (NICA) in terms of an international research facility. The collaboration described in this document is subject to the availability of funds from the respective ministries.

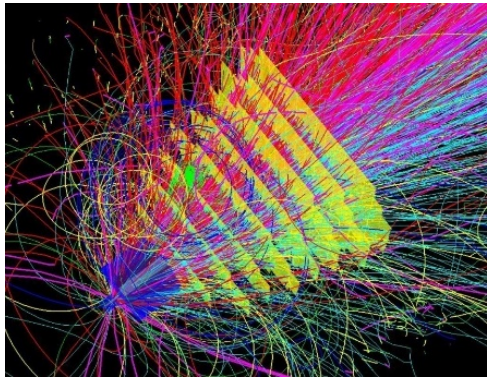
Cremlin Connecting Russian and European Measures for Large-scale Research Infrastructures

EU project CREMLINplus

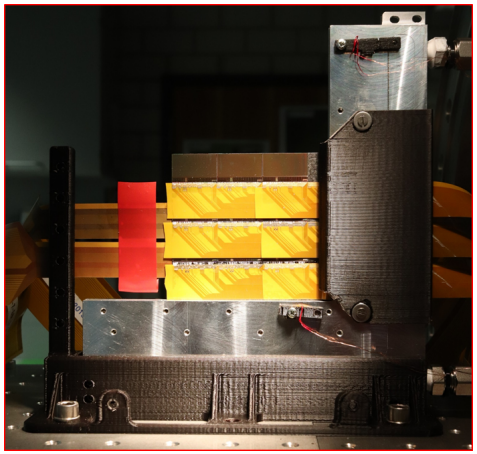
European Commission

Science Cooperation between European Research Infrastructures and the Russian megascience projects (NICA, PIK, USSR, SCT and EXCELS)

Proposal approved: 4-year-project – starting 1.2.2020, **Total Budget: 25 M€**
Consortium: 35 participants from 12 countries - 25 European laboratories 10 Russian laboratories
10 working packages (WPs), GSI/FAIR and JINR involvement in WP2 and WP7



WP2: Collaboration with NICA - Development of instrumentation for NICA and FAIR/CBM (WP leader: J. Eschke)
Engineering and construction of fast detectors,
Development of high rate data acquisition chain and software packages for simulation and data analysis, PSD, beam pipe design
Budget 4.61 M€
Participants: JINR (9 FTE), FAIR (8.3 FTE), U Tübingen (1 FTE), WUT Warsaw (2 FTE), Wigner Budapest (2 FTE), MEPhI (4 FTE),
INR Moscow (1 FTE), NPI Prague (2 FTE)



WP7: **Joint development of detector technologies**
Develop a beyond state of the art CMOS pixel sensors (MAPS) for high-rate Silicon trackers for several particle physics and heavy-ion research communities in Europe and Russia for the potential upgrade of many experimental setups (WP leader: C. Schmidt)
Development of neutron detectors, detector school at BINP
Budget 1.8 M€ (~1.0 M€ for MAPS (CBM Institutes only)
Participants: JINR (0,75 FTE), FAIR (0,8 FTE), DESY (0,52 FTE),
U Frankfurt (0,75 FTE), IPHC Strasbourg (1 FTE), KINR Kiev (0,75 FTE),
ESS (0,75 FTE), PNPI (0,38 FTE), JINR (0,38 FTE), BINP

Recruitment of Manpower
CREMLIN+ funding of personnel for institutes

CREMLINplus WP2: CBM-NICA	FAIR 7,5 FTE over 48months (360 PM)	JINR 9 FTE over 48months (432 PM)	EKUT Tübingen 1 FTE (48 PM)	WUT Warsaw 2 FTE (96 PM)	Mephi Moscow 4 FTE (192 PM	Wigner Budapest 2 FTE (96 PM)	NPI Rez 2 FTE (96 PM)	INR Moscow1 FTE (48 PM
Task 2.1: Integration, installation, and test of Silicon trackers for NICA and CBM (FAIR, JINR, EKUT)	2	4	1					
Task 2.2: Developments for the data acquisition chain, for data preprocessing and computing (WUT, FAIR, JINR)	2	2		2				
Task 2.3: Development of common software packages for simulation and data analysis, participation in physics performance studies (MEPhI, FAIR, JINR, Wigner RCP)	2							
Task 2.4: Development and construction of beam monitors, target chamber and beam pipe for NICA and CBM (FAIR, JINR)	1	1						
Task 2.5: Development and construction of Zero Degree Calorimeters for NICA and CBM (INR RAS, NPI CAS)							2	1
Coordination of joint activities	0.5							

CREMLINplus WP2 kick-off meeting
Wednesday Jul 1, 2020, 1:30 PM
https://indico.gsi.de/event/10807/

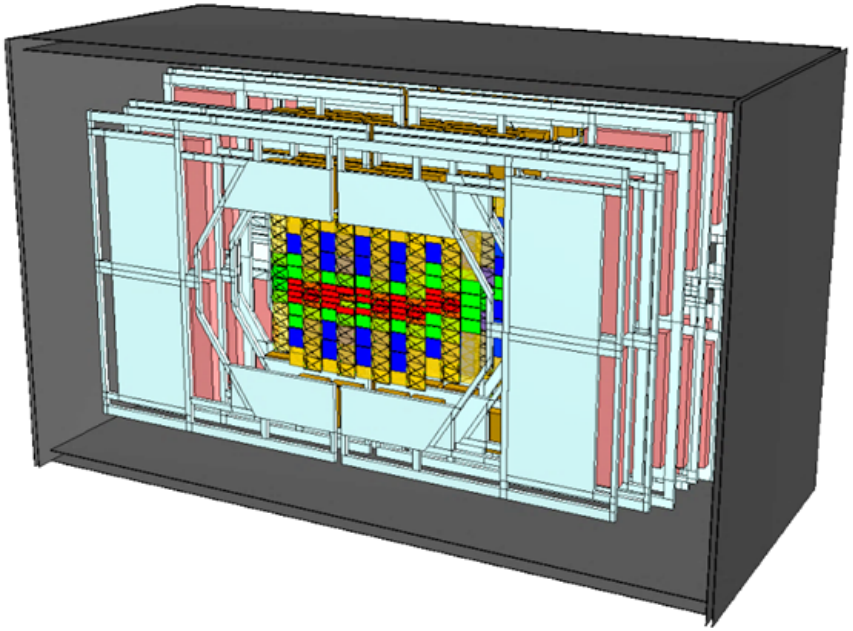
CREMLINplus WP7: MAPS	FAIR 0,8 FTE (38 PM)	GU Frankfurt 0,75 FTE (36 PM)	CNRS Straßbourg 1 FTE (48 PM)	KINR 0,75 FTE (36 PM)	JINR 0,75 FTE (36 PM)			
Task 7.1 and 7.2: Development of CMOS technologies for high-rate Silicon trackers	0,8	0,75	1	0,75	0,75			

Common integration/infrastructure Projects

- silicon tracker mechanics (this meeting)
- gas drying and cooling, distribution
- controls (e.g. temperature, humidity sensors)
- mounting tools
- sensor/ladder QA
- metrology
- front-end electronics

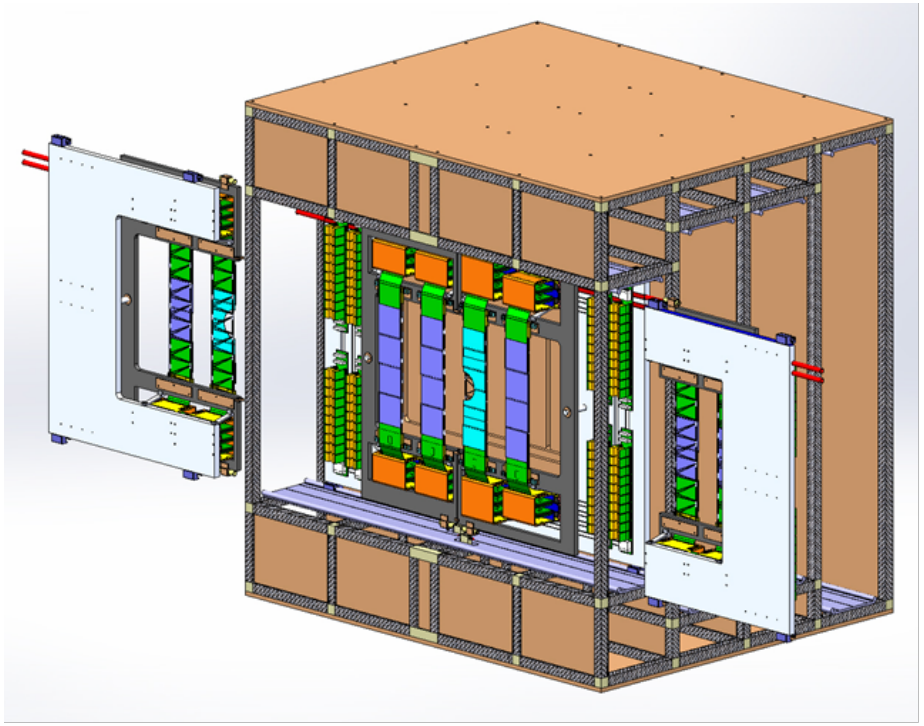
Silicon Tracker Mechanics

CBM Mainframe (8 layers)



-> more in Oleg's presentation

BM@N Mainframe (4 layers)



-> more in Mikhail's presentation

Gas Cooling CBM vs BM@N

CBM

- environmental temperature -10 deg C
- additional cooling of inner sensors (radiation damage compensation) by gas stream (-40 deg C)
- gas flow 1200 l/min
- RH << 1% @20 deg C (dew point < -40 deg C = T of liquid cooling - NOVEC)

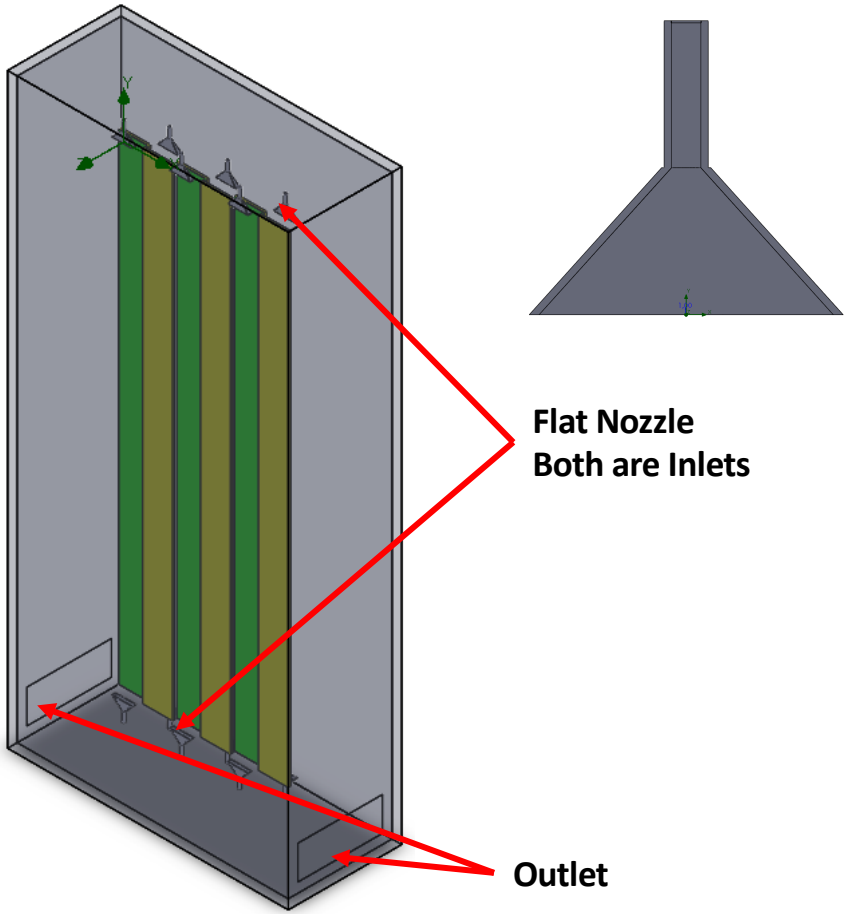
BM@N

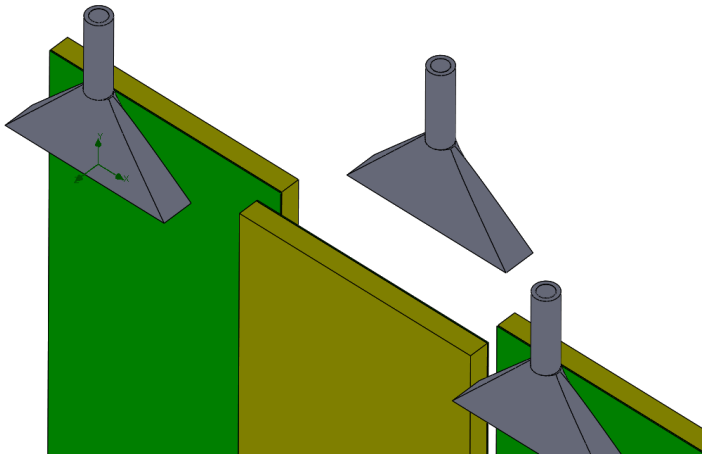
- environmental temperature +15 deg C
- temperature homogenization in box by gas stream (+15 deg C)
- gas flow ?
- RH < 50% @ 20 deg C (dew point < 10 deg C = T of liquid cooling – H2O)

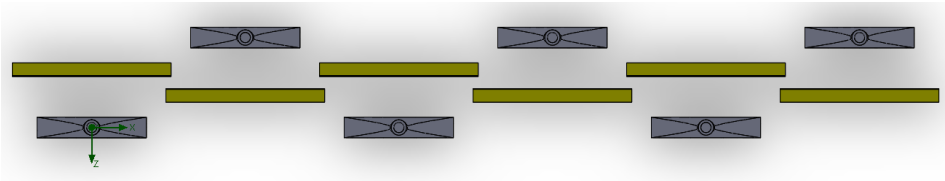
Both experiments need (though with different operational parameters):

- gas cooler/heat exchanger
- gas drying plant
- gas distribution system

CBM: Gas Distribution by Nozzles (K. Agarwal)

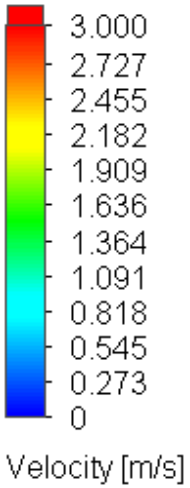


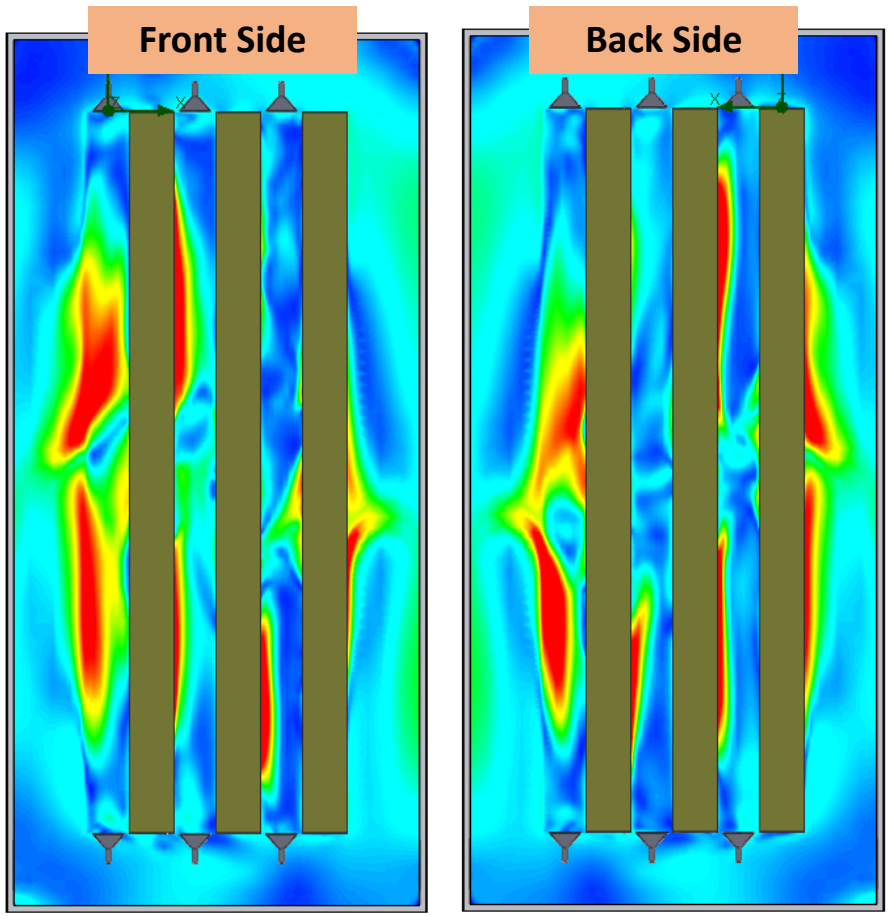




Nozzles placed as such that it faces the exposed surface of the silicon sensors (shown in green); microcables are shown in yellow

CBM: Flow Velocity Along The Sensors (K. Agarwal)





Power Dissipation: 6 mW/cm²
Area per Ladder: 100 x 6.2 cm²
Initial Temp. in the box: -10°C

Flow rate per nozzle: 40 litre/min
Flow rate per ladder: 80 litre/min

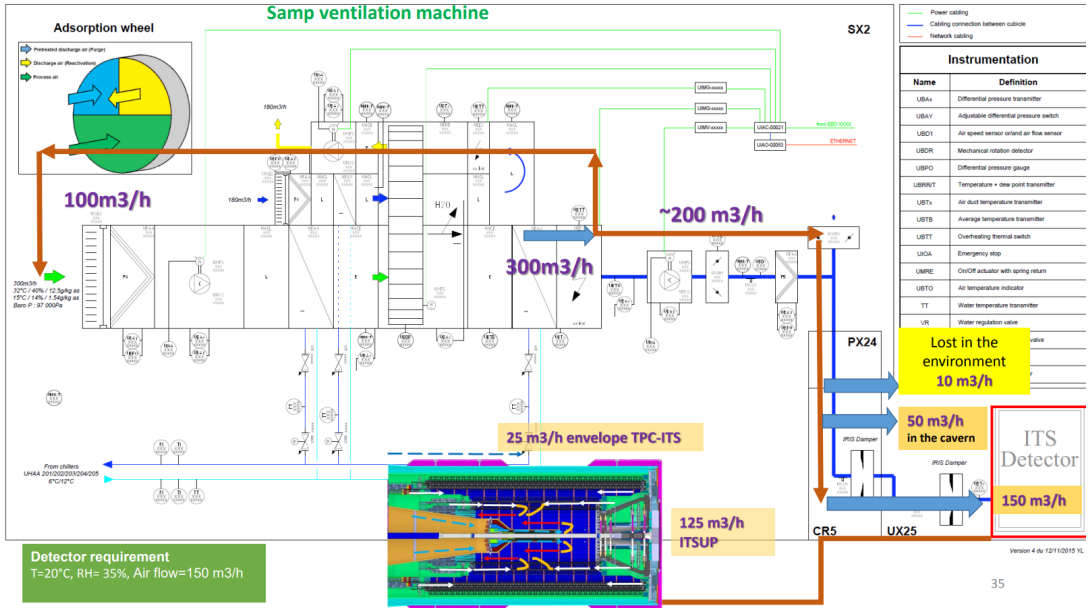
OPEN CHANNEL FLOW (NOZZLE)

- Inconsistent flow along the ladder
- Pressure differential isn't high enough to ensure a smooth flow

Nitrogen Drying Plant – Option 1 (K. Agarwal)

ALICE ITS has (mostly) similar requirements:

- **Total nitrogen volume rate = 150 m³/h**
- **Temperature = 16°C**
- **Dew Point ≤ -15°C (1 g/Kg)**
- **Manufactured be SAMP S.p.A. (Italy) (adsorption dehumidification)**



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- **First contact (20.11.18) with SAMP is positive!**
- **Installing a plant with our requirements needs a 'suitable room' – perfectly insulated**

More Info: ALICE Case Study Doc by SAMP
ALICE Cooling PRR

Nitrogen Drying Plant – Option 2 (K. Agarwal)

Atlas Copco Kompressoren und Drucklufttechnik GmbH

- **Range of products available for nitrogen generation and drying stage**
- **Temperature Regulation has to be checked**
- **Dryers also recommended by LHCb colleagues**

Desiccant air dryer range

Refrigerated air dryer range

Membrane air dryer range

NGM/NGM+ membrane nitrogen generator

Our nitrogen generators with membrane technology. Simple and compact on site nitrogen production. Purities: 95 – 99.5% Flows: 3.2 – 250 Nm³/h

NGP PSA nitrogen generator

Our industrial nitrogen generator with PSA technology. Reliable and cost efficient on-site nitrogen production. Purities: 95 – 99.999% Flows: 2 – 2650 Nm³/h

NGP+ PSA nitrogen generator

Our premium nitrogen generator with PSA technology. Fully automated on-site nitrogen production at the lowest total cost, due to a supreme energy efficiency. Purities: 95 – 99.999% Flows: 2 – 2870 Nm³/h

Sensors and Controls

Example: Humidity & Temperature Sensors

CBM:

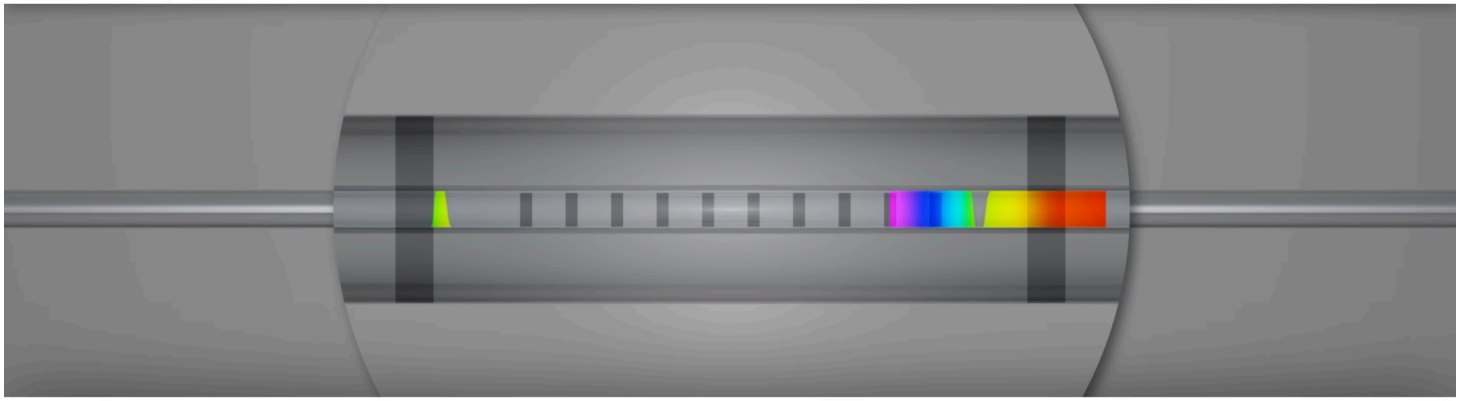
- distributed system of humidity sensors (>100)
- radiation hardness
- high precision
- working at very low RH (<< 1% at 20 deg C)

BM@N:

- distributed system of humidity sensors (>50)
- good precision
- working at “normal” RH (50% at 20 Deg c)

Solution: FiberBraggGrating

Principle of humidity sensitivity:



Water molecules absorbed by the hygroscopic coating → Coating expansion ("Swelling effect") → Strain induced on the FBG → Bragg wavelength shift ($\Delta\lambda_B$)

FBG Interrogator

commercially available: HYPERION Optical Sensing Instrument
PhD student at GSI (Marcel Bjadel) already working on FBR-RH sensors

MICRON OPTICS

Conclusion

- define details of common GRR projects
- find people (engineers, postdocs, postdocs) to work on projects both at GSI and JINR