CREMLINplus EU project
WP2 – NICA Ion collider facility
and joint developments for NICA and FAIR

Jürgen Eschke,
CBM Resource Coordinator
and
CREMLINplus WP2 Leader
FAIR/GSI, Darmstadt

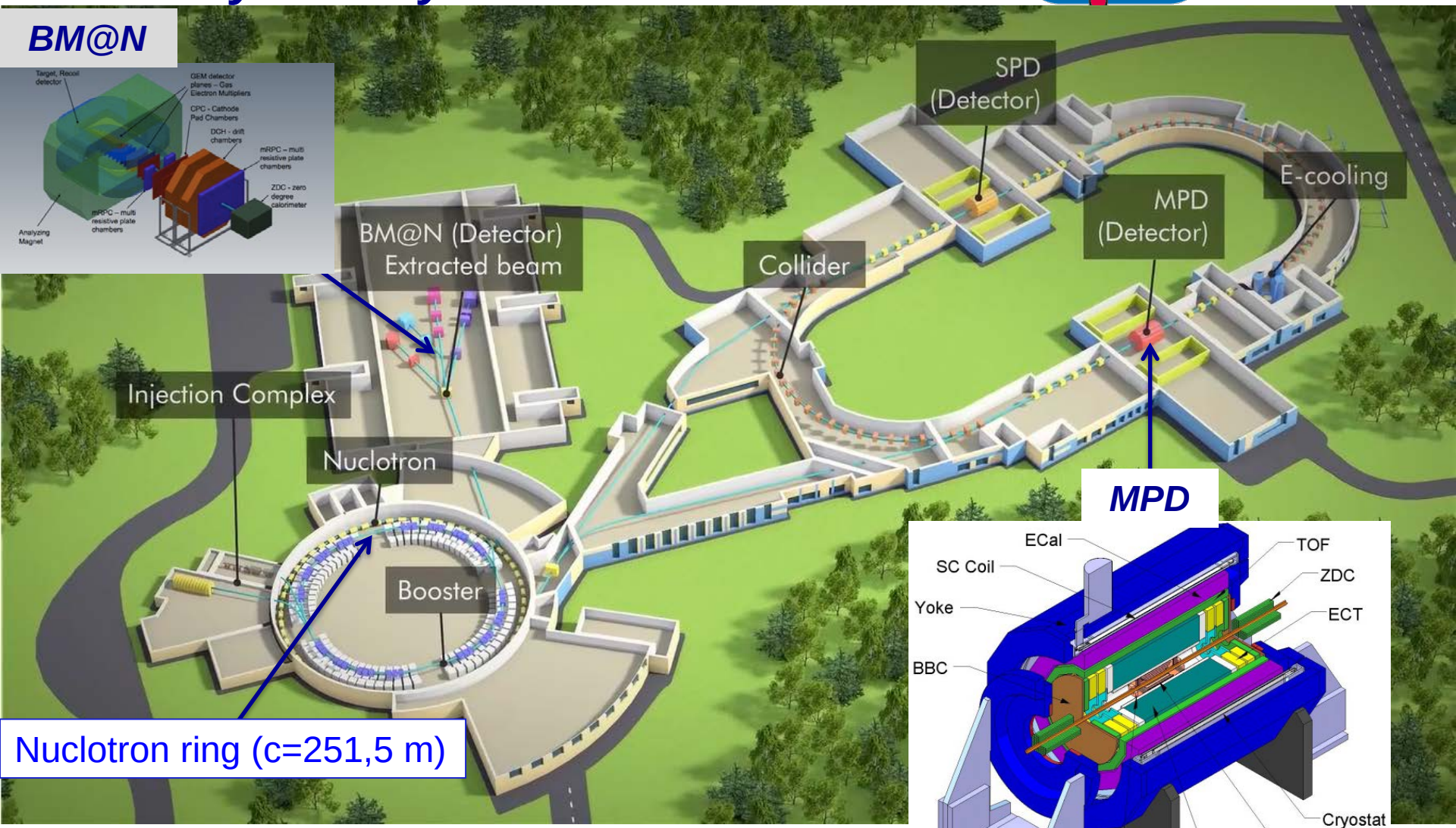
Achievements within the CREMLIN EU project (WP3 – NICA Ion collider facility)
and
Recommendations for ... joint development of instrumentation for NICA a...

CREMLIN Closing Conference, 5 June 2018, DESY, Hamburg

Tandem presentation:

- Vladimir Kekelidze, Director of Veksler and Baldin Laboratory of High Energies Physics, JINR,Dubna
- Jürgen Eschke, CBM Resource Coordinator and CREMLIN WP3 Leader, FAIR/GSI, Darmstadt

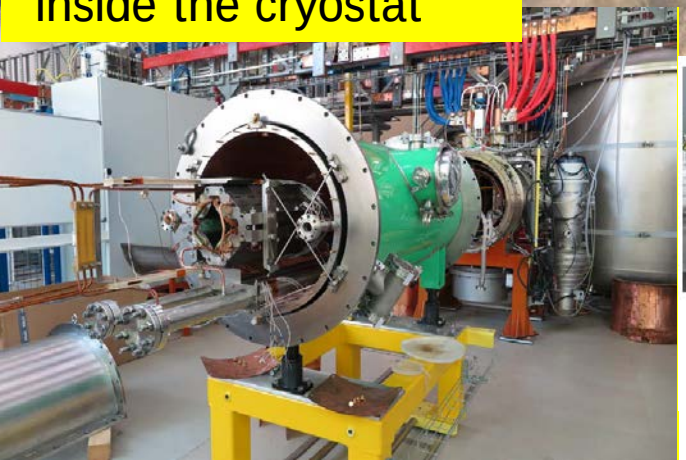
Multi Purpose Detector to study heavy-ion collisions at the NICA collider



NICA construction site 2019

RF3 resonator

Booster dipole magnet inside the cryostat



From left to right: dipole magnet, quadrupole lenses, cryostats and vacuum beam pipe of the Collider.

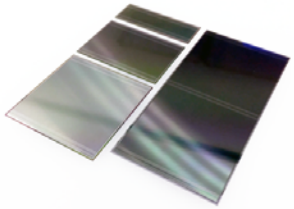
BM@N experiment

NICA

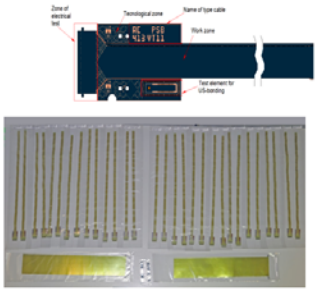
Multi Purpose Detector (MPD)

Module components readiness

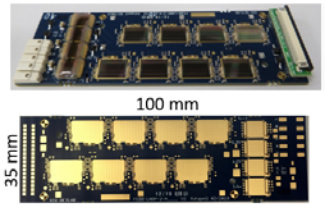
BM@N



- ✓ Design of sensors was finalized (except central sensors)
- ✓ Sensors have already been acquired in 2016 at the two vendors
- ✓ Design for the 16 central sensors is now under development at SINP MSU



- ✓ Design of micro-cables for first two BM@N stations was finalized in 2019
- ✓ First batch of 40 micro-cable sets will be delivered in the begging of 2020



New FEB8 designed by R. Kapell

- ✓ Front-end Boards prototypes of CBM geometry were designed, produced and tested
- ✓ FEB test circuit for QA is under development at GSI
- ✓ BM@N FEB design is under development at SINP MSU

The complete assembly of the MPD solenoid has been finished in September 2019

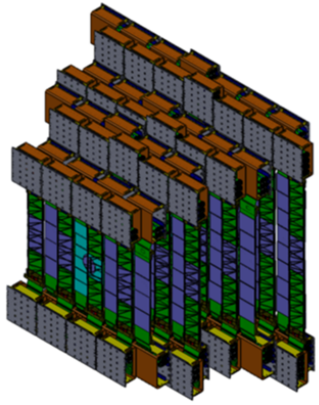
BM@N

Baryonic Matter at Nuclotron

Technical Design Report

The Silicon Tracking System

as part of the hybrid tracker of the BM@N experiment



Dec. 2019

The BM@N STS group:

A. V. Baranov[4], D. Dementev[1], V. Elsha[1], J. Heuser[2], P. I. Kharlamov[1,4], I. M. Kovalev[4], A. Kolzhvari[1], I. A. Kudryashov[4], A. A. Kurganov[4], E. Lavrik[3], V.V. Leontyev[4] T. Lygdenova[1], M. M. Merkin[4,1], Y. Murin[1], J. Panasenko[5], M. Protsenko[1], C. J. Schmidt[2], H. R. Schmidt[2,5], A. Sheremetev[1], A. Sheremeteva[1], A. Senger[3], P. Senger[3,6], N. Sukhov[1], M. Shitenkov[1], A. Voronin[1], A. G. Voronin[4], W. Zabolotny[7], A. Zinchenko[1]

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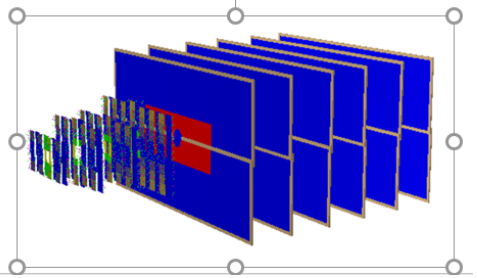
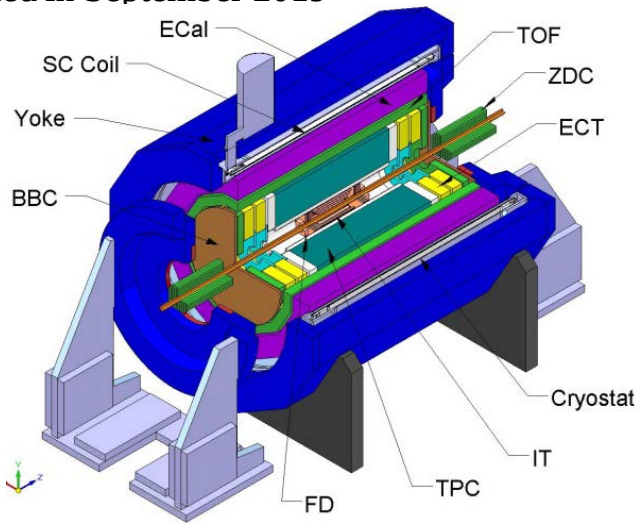
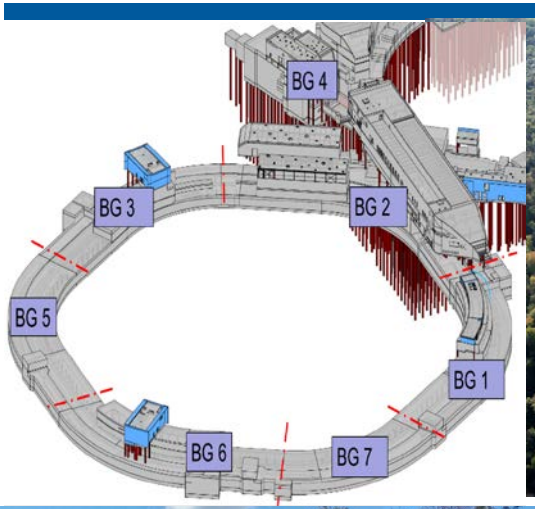
[2] GSI Helmholtzzentrum, Darmstadt, Germany
[3] FAIR Darmstadt, Germany
[4] SINP MSU, Moscow, Russia
[5] University Tübingen, Germany
[6] NRNU MEPhI, Moscow, Russia
[7] Warsaw University of Technology, Warsaw, Poland

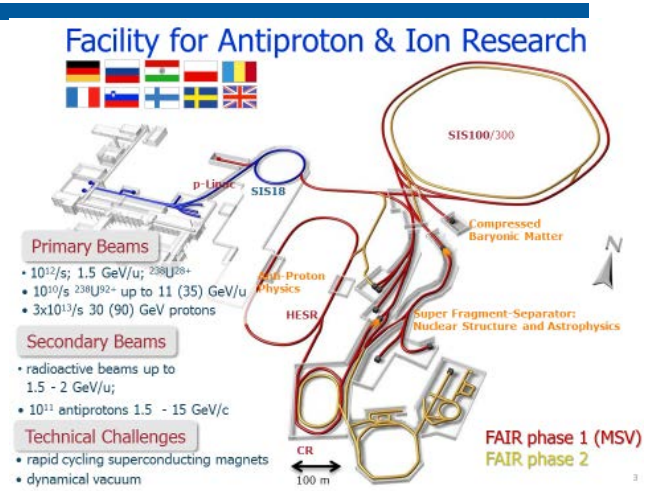
Editors: Dmitrii Dementev, Peter Senger





Status of FAIR Project: Progress Civil Construction

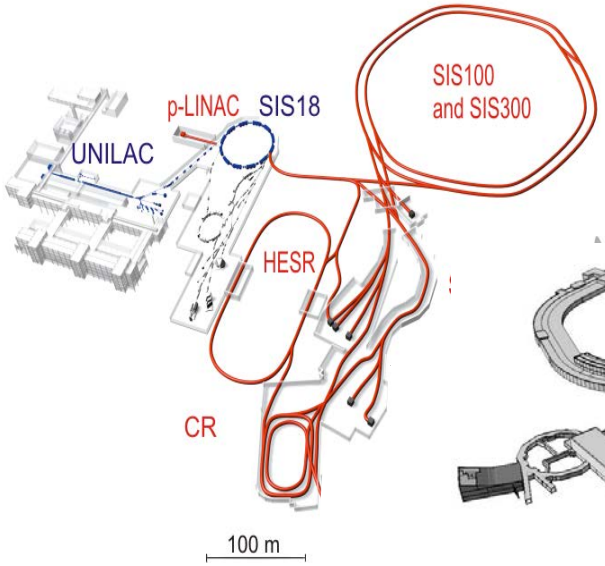




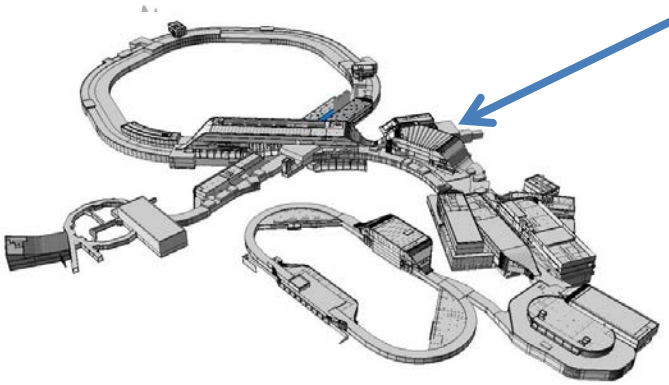
Facility for Antiproton and Ion Research

ESFRI Landmark

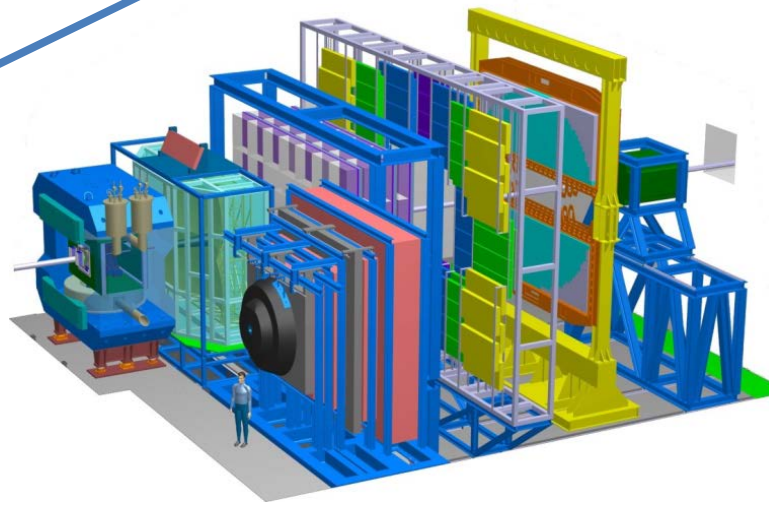
in Darmstadt, Germany



FAIR accelerator complex

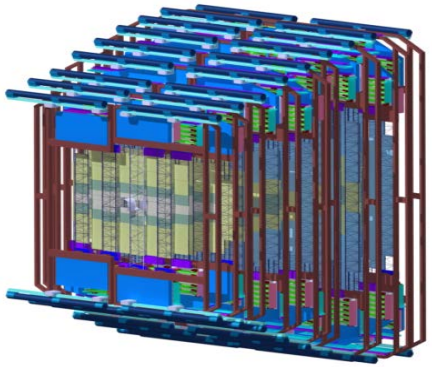


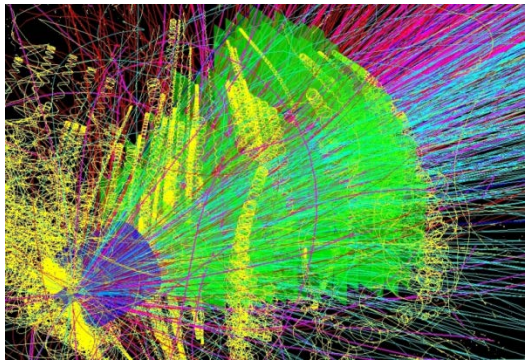
Compressed Baryonic Matter experiment (CBM)



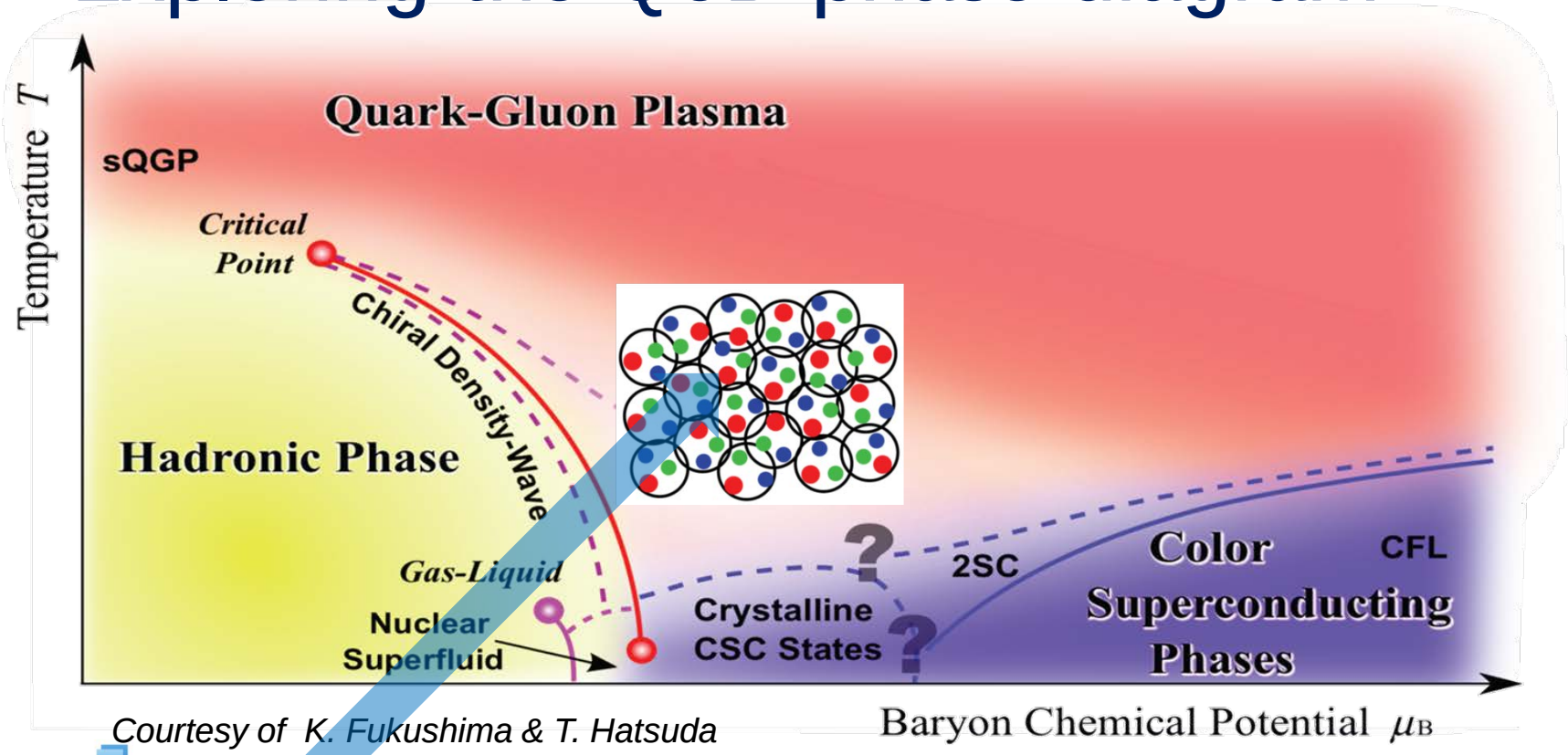
FAIR civil construction – October 2019

CBM Silicon Tracking System (STS)

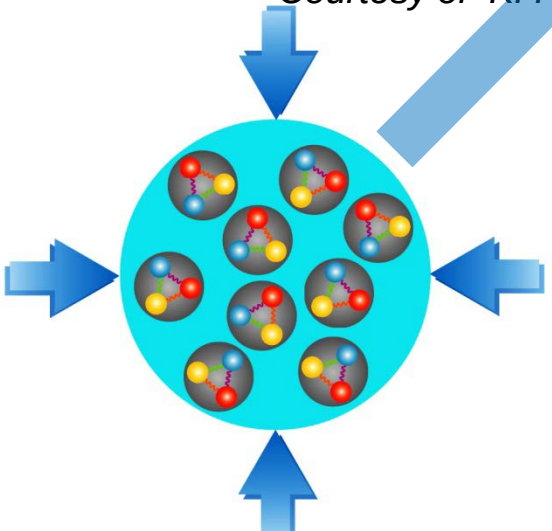




Exploring the QCD phase diagram



Courtesy of K. Fukushima & T. Hatsuda



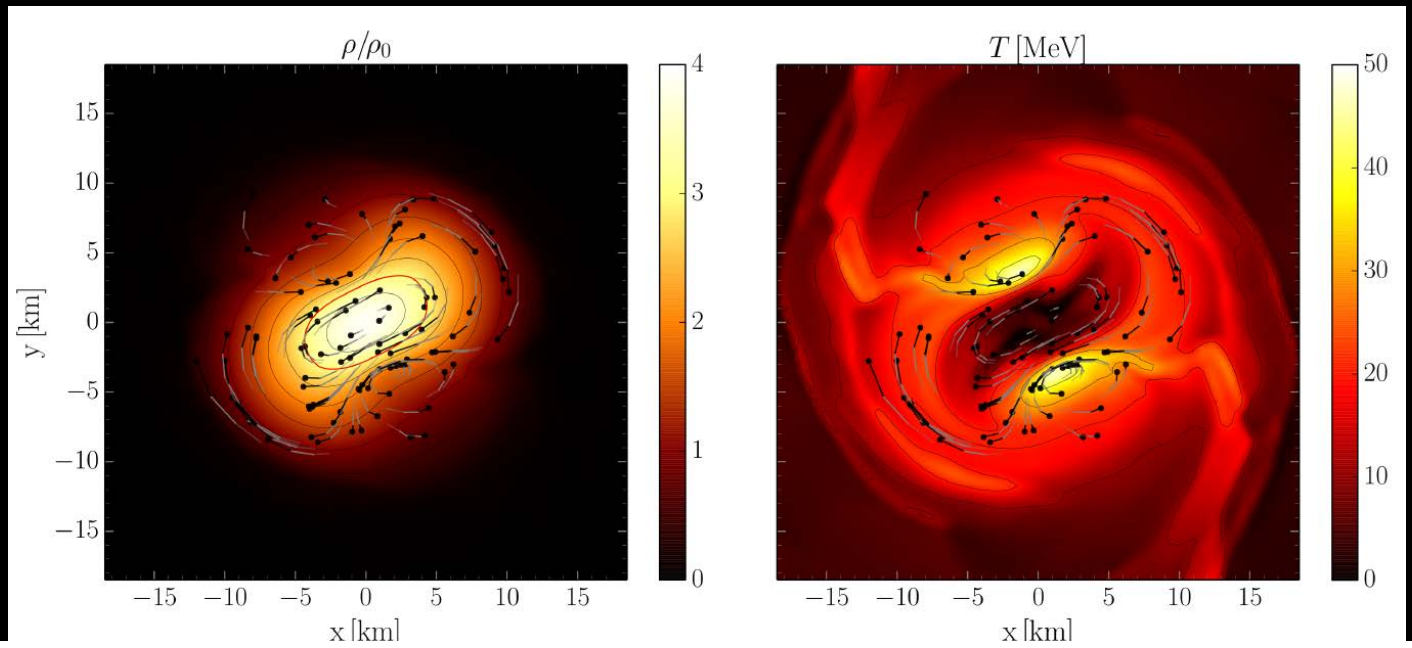
At high baryon density:

- N of baryons >> N of antibaryons
  Densities like in neutron star cores
- L-QCD not (yet) applicable
- Models predict first order phase transition with mixed or exotic phases
- Experiments: BES at RHIC, NA61 at CERN SPS, CBM at FAIR, NICA at JINR, J-PARC

Neutron star mergers and heavy-ion collisions

density

temperature

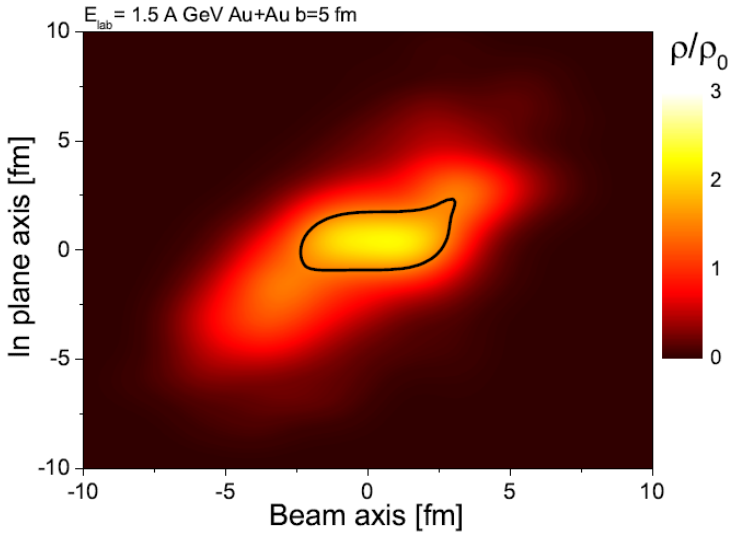


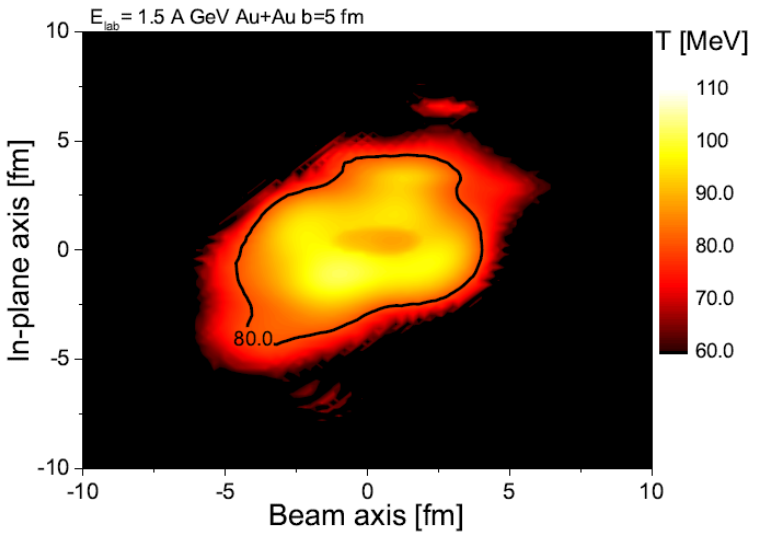
M. Hanauske et al., J. Phys.: Conf. Ser. 878 012031

n-star merger

EOS

Au +Au 1.5A GeV





Synergies between NICA experiments (BM@N, MPD) and CBM experiment at FAIR

4th Collaboration Meeting (Dubna, October 2019)
of the BM@N Experiment at the NICA Facility

Synergies in:

- Detector development
- Front End Electronics, DAQ and Computing
- Physics Performance Studies and Data Analysis

34th CBM Collaboration Meeting, Kolkata, October 2019

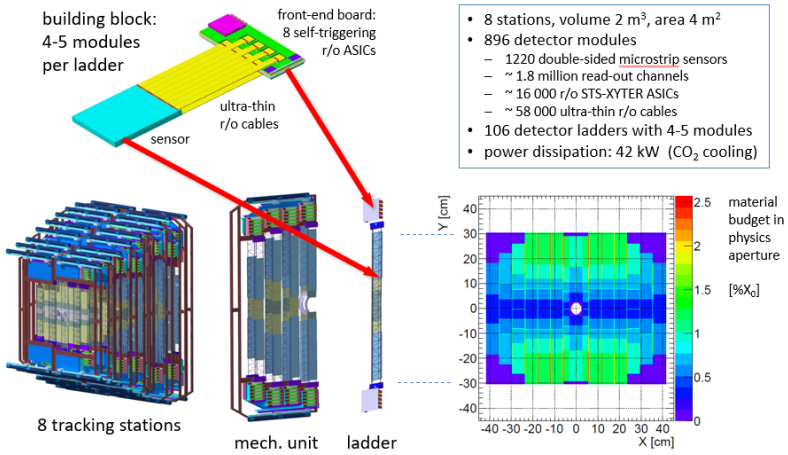
NICA Days and 4th MPD collaboration meeting, Warsaw, October 2019

Scope (tasks) and participation in WP2

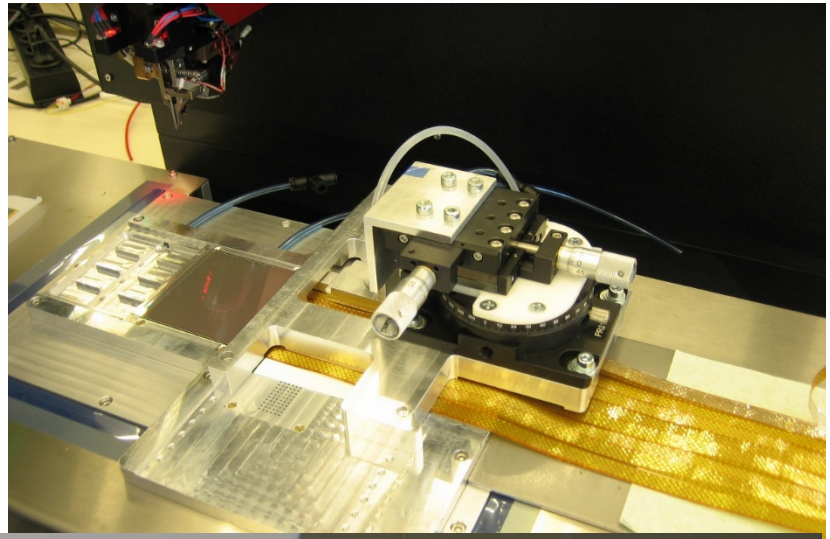
CREMLINplus **WP2:NICA-FAIR/CBM** **WP Leader: Jürgen Eschke (FAIR), Deputy WP Leader: Yuri Murin(JINR)**	**FAIR** 7,5 FTE over 48 months (360 PM)	**JINR** 9 FTE over 48months (432 PM)	**EKUT** Tübingen 1 FTE (48 PM)	**WUT** Warsaw 2 FTE (96 PM)	**Mephi** Moscow 4 FTE (192 PM	**Wigner** Budapest 2 FTE (96 PM)	**NPI** Rez 2 FTE (96 PM)	**INR** Moscow 1 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	2			4	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							

Task 2.1: Integration, installation, and test of Silicon trackers for NICA and CBM (FAIR, JINR, EKUT)

STS integration concept



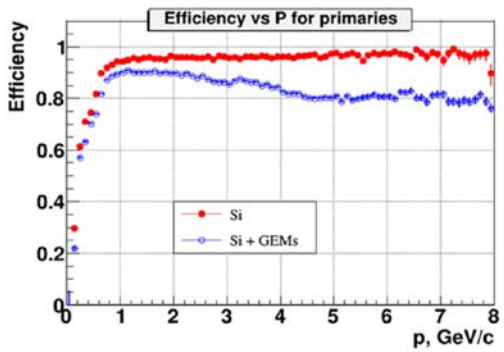
- 8 stations, volume 2 m³, area 4 m²
- 896 detector modules
  - 1220 double-sided microstrip sensors
  - ~ 1.8 million read-out channels
  - ~ 16 000 r/o STS-XYTER ASICs
  - ~ 58 000 ultra-thin r/o cables
- 106 detector ladders with 4-5 modules
- power dissipation: 42 kW (CO_2 cooling)



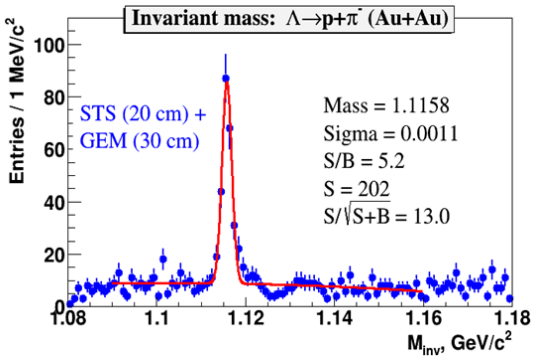
Module Assembly

Joint development of the BM@N silicon tracker

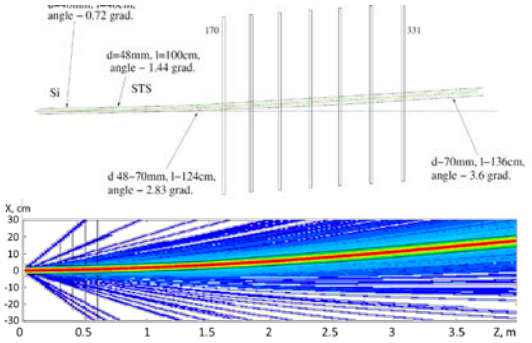
Track reconstruction efficiency



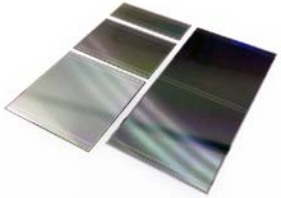
Lambda reconstruction



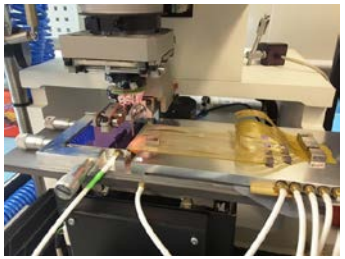
Beam pipe simulations



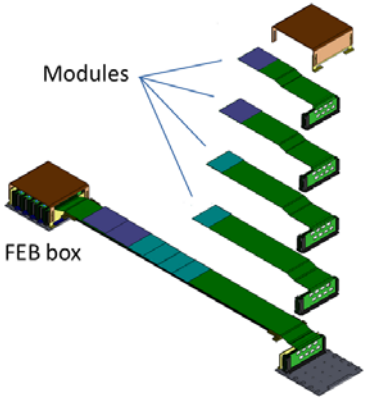
Sensors and FEE



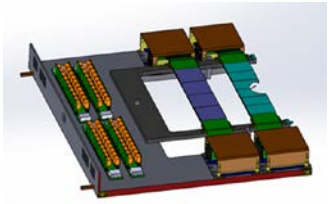
Module assembly

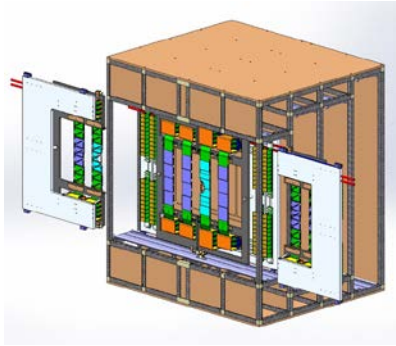


Ladder assembly



System integration and main frame





STS Module & Ladder Assembly Retreat

chaired by Hans Rudolf Schmidt (GSI, Darmstadt), Johann Heuser (GSI, Darmstadt)

from Monday, 17 February 2020 at **08:30** to Tuesday, 18 February 2020 at **16:30** (Europe/Berlin)
at **Ringhotel Siegfriedbrunnen**

Manage

Description The workshop aims to coordinate the module and ladder assembly at the CBM assembly centers (GSI, KIT & JINR) in terms of:

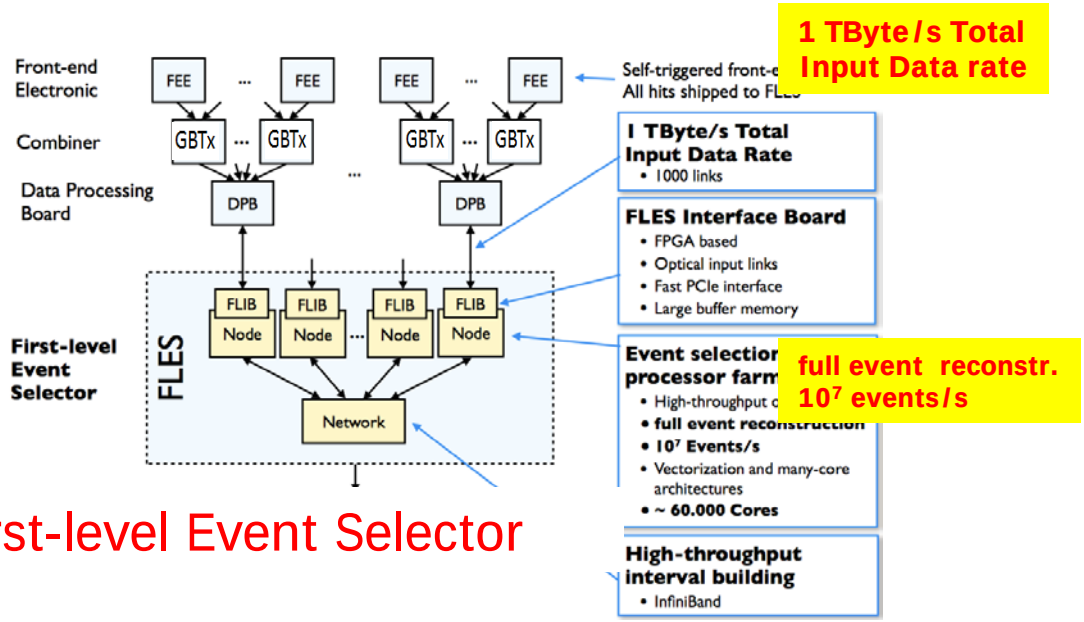
- technologies & tools
- through-put & logistics
- quality assurance & testing
- data base
- person-power
- milestones
- ...

about 50 participants
from FAIR,GSI, JINR, KIT, JU,
Tübingen, Frankfurt

This relates also to EU-H2020 project CREMLINplus, work package 2 "Development of instrumentation for NICA and FAIR/CBM".

Task 2.2: Developments for the data acquisition chain, for data preprocessing and computing (WUT, FAIR, JINR)

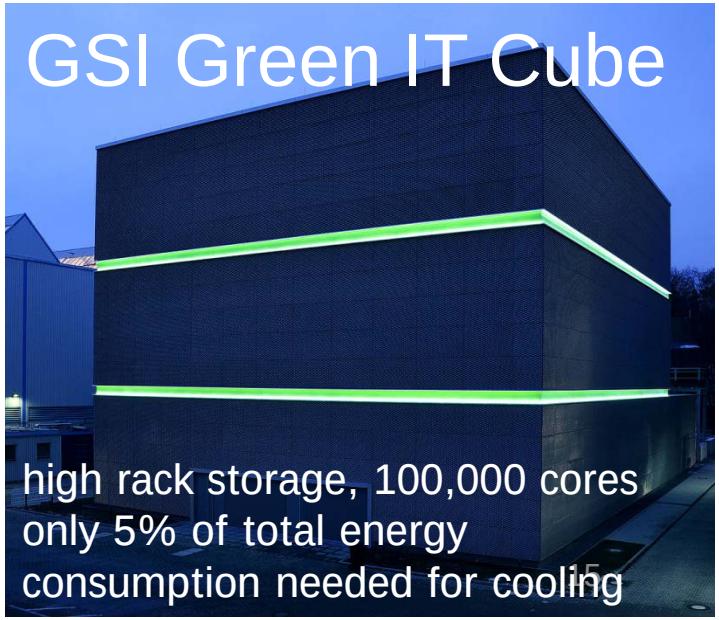
DAQ and online event selection



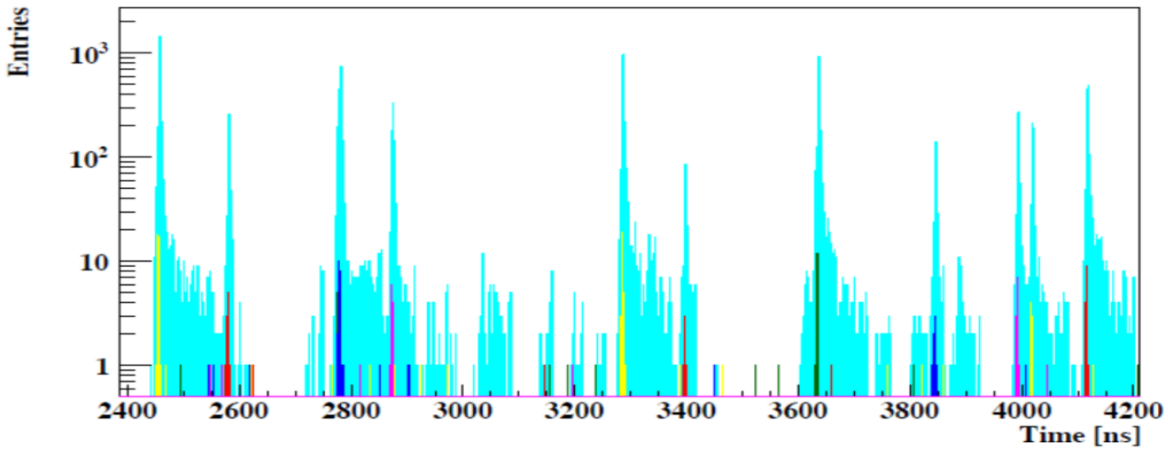
First-level Event Selector

Novel readout system:

- no hardware trigger on events
- detector hits with time stamps
- full online 4-D track and event reconstruction.



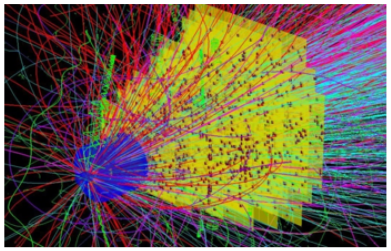
Hit and track time distribution for Au+Au 10A GeV collisions at 10 MHz (UrQMD)



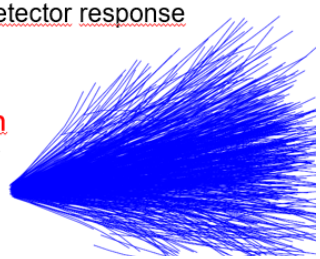
Task 2.3: Development of common software packages for simulation and data analysis, participation in physics performance studies (MEPhI, FAIR, JINR, Wigner RCP,)

Simulation and reconstruction

Event generators UrQMD 3.3
Transport code GEANT3, FLUKA
Realistic detector geometries, material budget and detector response



reconstruction

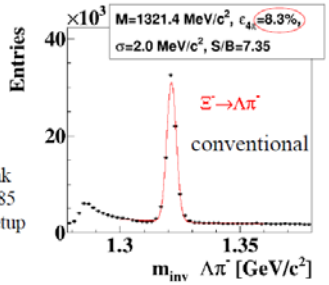


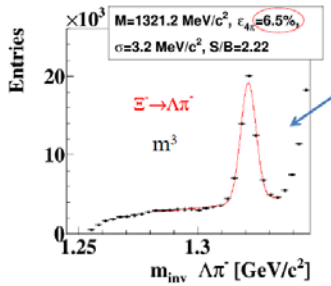
CBM

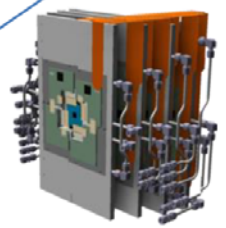
Improvement of multi strange hyperons reconstruction with missing mass method

cbmroot development
private version
M.Zyzak, P.Kisel

cbmroot/trunk
revision 14285
"electron" setup





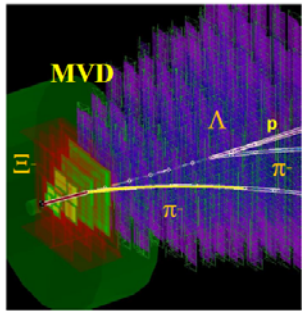


- Comparable efficiencies, better control over the systematic errors
- Σ+ and Σ- physics: completes the picture of strangeness production
- **New decays channels** of single-Λ hypernuclei that can be studied:

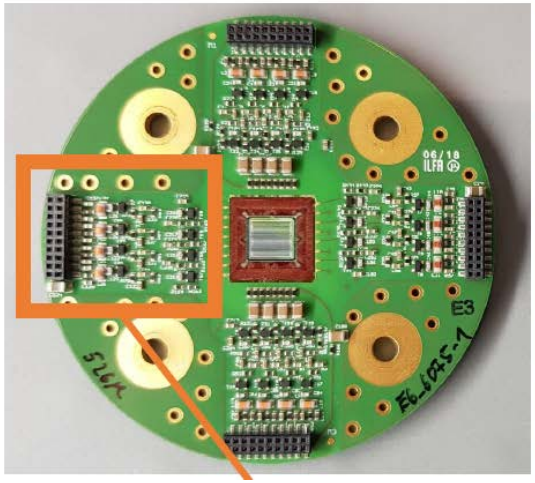
$^{3}_{\Lambda}H \rightarrow {}^{3}He\ \pi^-$, $d\ p\ \pi^-$, $p\ p\ n\ \pi^-$, $t\ \pi^0$

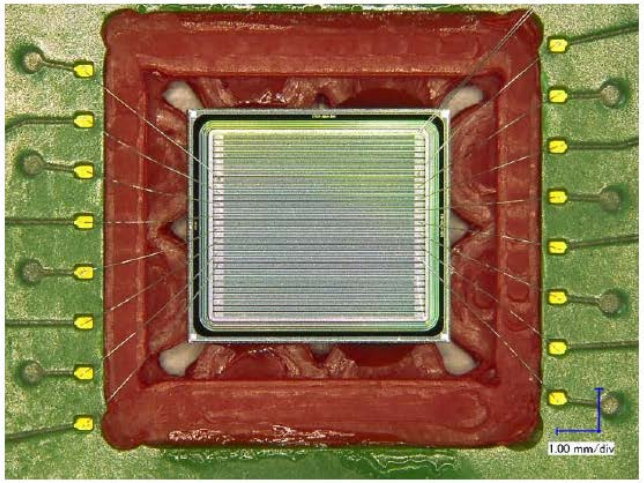
$^{4}_{\Lambda}H \rightarrow {}^{4}He\ \pi^-$, $t\ p\ \pi^-$, $d\ d\ \pi^-$, $t\ p\ \pi^0$

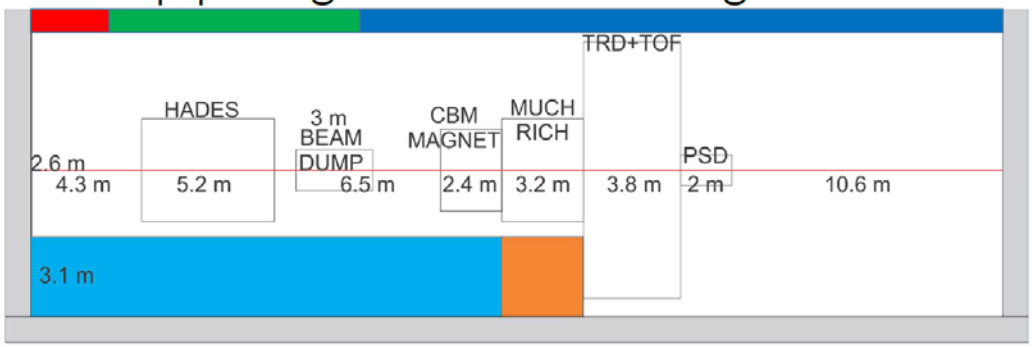
$^{4}_{\Lambda}He \rightarrow {}^{3}He\ p\ \pi^-$, $d\ p\ p\ \pi^-$, $p\ p\ p\ n\ \pi^-$

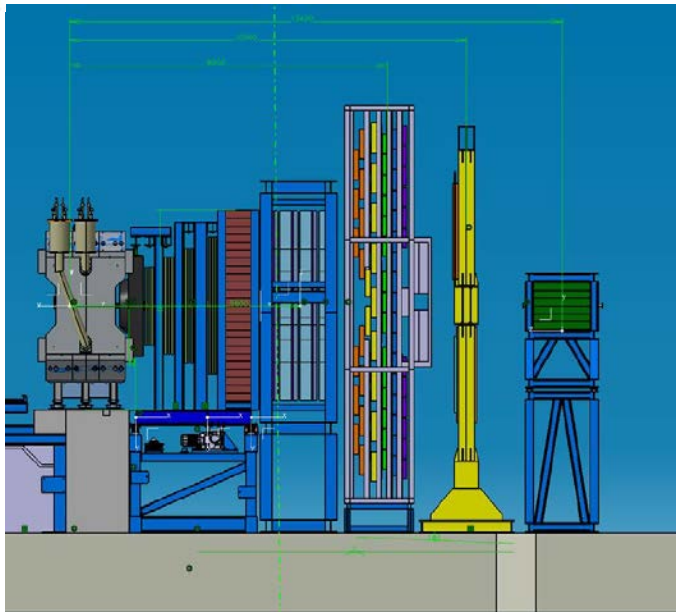


Task 2.4: Development and construction of beam monitors, target chamber and beam pipe for NICA and CBM (FAIR, JINR)



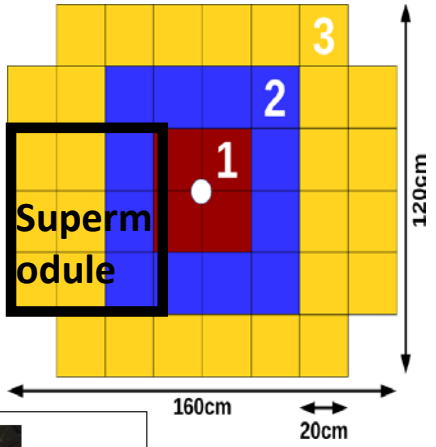


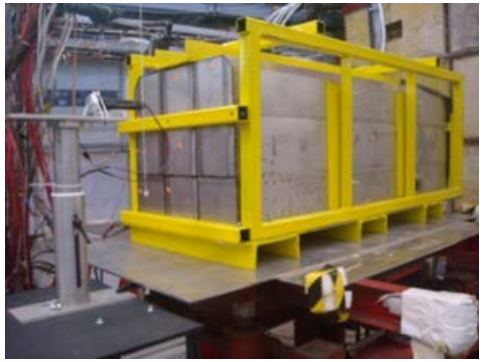




Task 2.5: Development and construction of Zero Degree Calorimeters for NICA and CBM (INR RAS, NPI CAS)

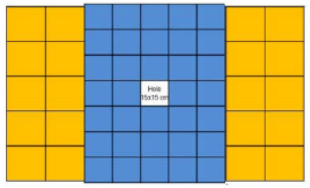
PSD – Projectile Spectator Detector.
This forward hadron calorimeter will be used at the CBM to measure centrality of interaction and reaction plane orientation.





CBM PSD supermodule tests at CERN T9/T10

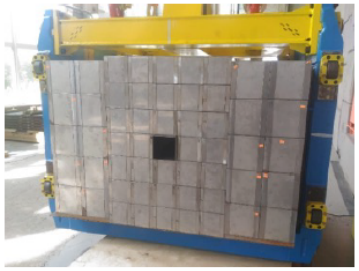
BM@N Zero Degree Calorimeter



Schematic view of new FHCAL

34 inner modules - MPD type modules
20 outer modules – CBM modules

New platform for FHCAL assembly



View of the assembled FHCAL

Installation of FEE on the rare side Of the FHCAL

CREMLINplus WP2- NICA - Collaboration with NICA
Deliverables and Milestones

D2.1 STS components assembled (M24)
D2.2 STS detectors assembled and tested (M48)
D2.3 Components of the STS data acquisition chain tested (M24)
D2.4 Full functionality tests of the STS data acquisition chain (M48)
D2.5 Simulation results for selected observables (M24)
D2.6 Full physics performance for major observables (M48)
D2.7 Design of beam monitors, target chambers, beam pipes (M12)
D2.8 Beam monitors, target chambers, beam pipes constructed and installed (M48)
D2.9 Design of ZDC detector modules (M12)
D2.10 ZDC detector modules contructed and tested (M48)

D2.1 : STS components assembled [24]

STS components assembled

D2.2 : STS detectors tested [48]

STS detectors tested

D2.3 : Components of the STS data acquisition chain tested [24]

Components of the STS data acquisition chain tested

D2.4 : Full functionality tests of the STS data acquisition chain [48]

Full functionality tests of the STS data acquisition chain

D2.5 : Simulation results for selected observables [24]

Simulation results for selected observables

D2.6 : Physics performance for major observables [48]

Physics performance for major observables

D2.7 : Design of beam monitors, target chambers, beam pipes [12]

Design of beam monitors, target chambers, beam pipes

D2.8 : Beam monitors, target chambers, beam pipes constructed and installed [48]

Beam monitors, target chambers, beam pipes constructed and installed

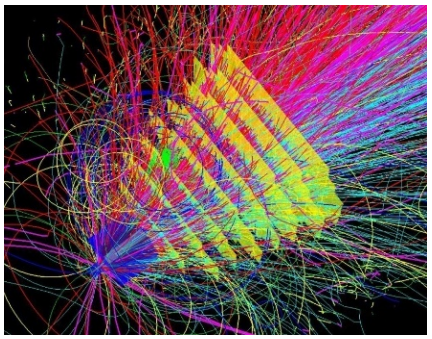
D2.9 : Design of ZDC detector modules [12]

Design of ZDC detector modules

D2.10 : ZDC detector modules constructed and tested [48]

ZDC detector modules constructed and tested

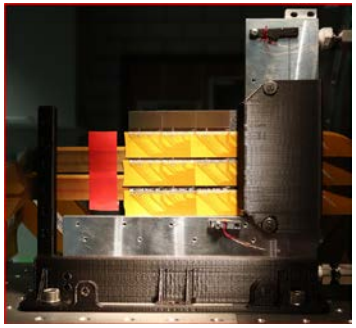
MS6	First detector ladder for BM@N	14 - FAIR GMBH	12	Test results presented
MS7	Series production of detector ladders for CBM-STS started and first batch of ladders produced	14 - FAIR GMBH	24	Test results presented
MS8	Readout concept developed	14 - FAIR GMBH	24	Evaluation by experts
MS9	Common software packages developed	14 - FAIR GMBH	24	Simulation results presented
MS10	Technical design of beam monitor etc. for NICA	14 - FAIR GMBH	36	Report
MS11	First detector modules constructed & tested	14 - FAIR GMBH	24	Presentation of test result



WP2: Collaboration with NICA - Development of instrumentation for NICA and FAIR/CBM
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

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

Development of neutron detectors, detector school at BINP



WP9 TRAIN - Staff exchange and training for RI management

Organisation annual summer schools attracting young scientists
…
additional fellowships for students from all of Europe and Russia.

Proposal for joint education of young academics within CREMLINplus WP9

1. Annual school for students and young postdocs

- Topics with relevance for NICA and FAIR: physics, experiments, theory, technology
- Duration one week
- Hosted by a member state of either NICA or FAIR.
- About 60 participants
- Financial support: 1000 € per participant (travel and acommodation)
  + 10 k€ for local organization

2. Scientific exchange

- Short-term visits of scientists at the partner institutes for joint activities with high synergy effect, such as development of common hardware or software for simulations and data analysis.
- Experience shows, that stays between one week and three months are most efficient, depending on the project
- About 20 visits per year
- Financial support: Travel about 500 €, local expenses 2000 € per month


CBM cave November 2019
DORR
DORR
Thank you for your attention

Long lasting Cooperation between GSI and JINR

Selection of events:

- Since 1990: joint experiments on the production of superheavy elements
- Since 2000: Participation of JINR groups in the development of FAIR accelerators and experiments
- Since 2006: Participation of GSI scientists in preparation of the NICA physics program
- Since 2008: MoU on scientific cooperation between GSI and JINR for FAIR and NICA
- 2008, 2013: CBM Collaboration Meetings at JINR

- 2011: BMBF-JINR Coordination Committee Meeting
- 2015: Collaboration agreement FAIR- JINR on the construction of 300 magnets
- 2016: NICA-FAIR Symposium on Joint Science and Academic Training