Towards the Detector Control System for the STS/CBM

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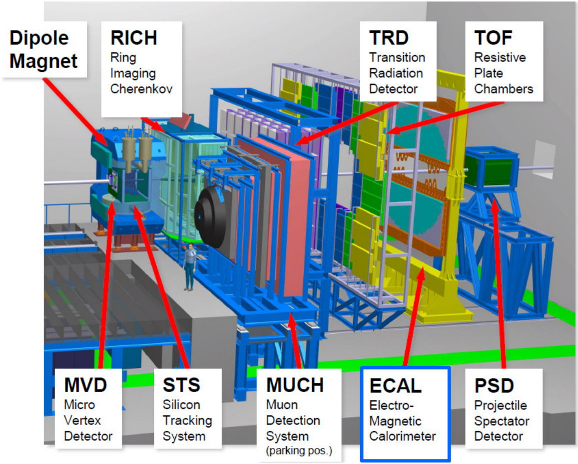
CBM at FAIR


FAIR
CBM EXPERIMENT
• Ions 10⁹/s, 2-14GeV/u
• Protons 10¹¹/s up to 29GeV

Silicon Tracking System in the CBM experiment

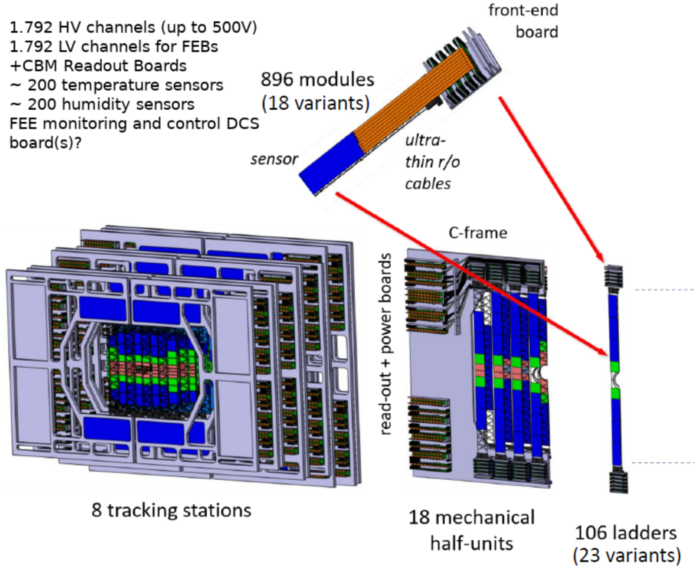


- Tracking acceptance:
  $2.5^o < \theta_{lab} < 25^o$
- Free streaming DAQ:
  $R_{int} = 10MHz(Au + Au)$
- Software based event selection
- ECAL is no longer part of the project

Figure: Subsystems of the CBM experiment

Silicon Tracking System in the CBM experiment

1.792 HV channels (up to 500V)
1.792 LV channels for FEBs
+CBM Readout Boards
~ 200 temperature sensors
~ 200 humidity sensors
FEE monitoring and control DCS board(s)?



mCBM@SIS18

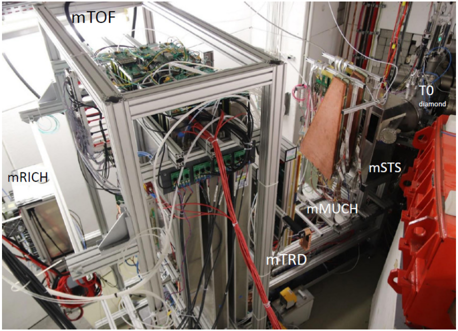
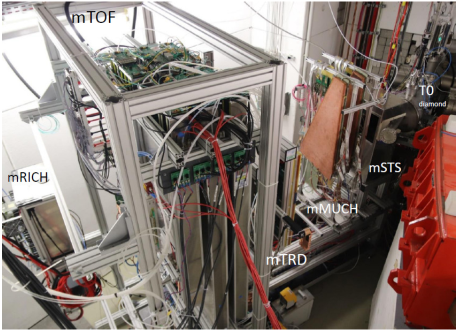


Figure: View at the mCBM experiment

mCBM@SIS18 - a CBM full system test-setup for high-rate nucleus-nucleus collisions at GSI/FAIR

- CBM prototype detector systems

mCBM@SIS18



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- CBM prototype detector systems
- free-streaming read-out and data transport to the mFLES

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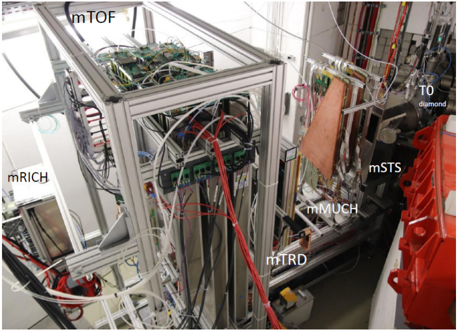

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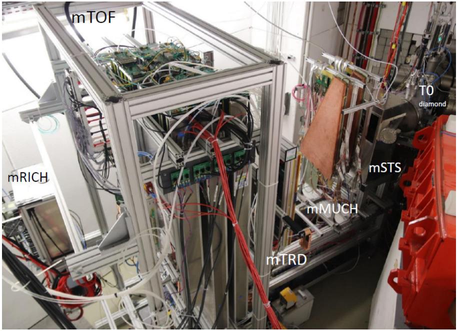

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- online event reconstruction and selection
- up to 10 MHz collision rate

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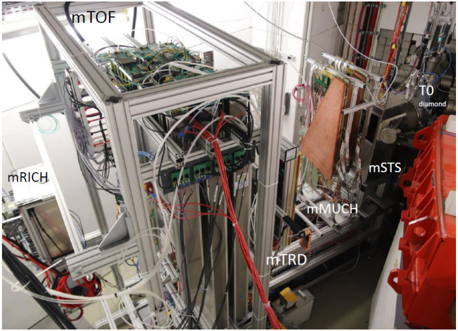

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mCBM@SIS18 - a CBM full system test-setup for high-rate nucleus-nucleus collisions at GSI/FAIR

- CBM prototype detector systems
- free-streaming read-out and data transport to the mFLES
- online event reconstruction and selection
- up to 10 MHz collision rate
- first successful commissioning with beam 12/2018 and 3/2019

mSTS

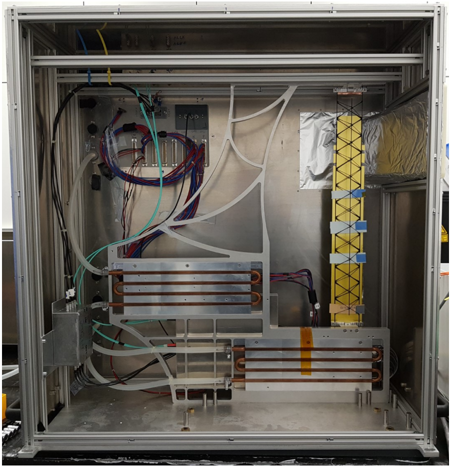


Figure: The mSTS's design for the 2020 beam campaign

mSTS

- 2 silicon sensors
- 4 FEBs
- 1 CROB
- 4 PT100 sensors
- Lauda Eco Cooling
- A prototype of the Detector Control System based on containers

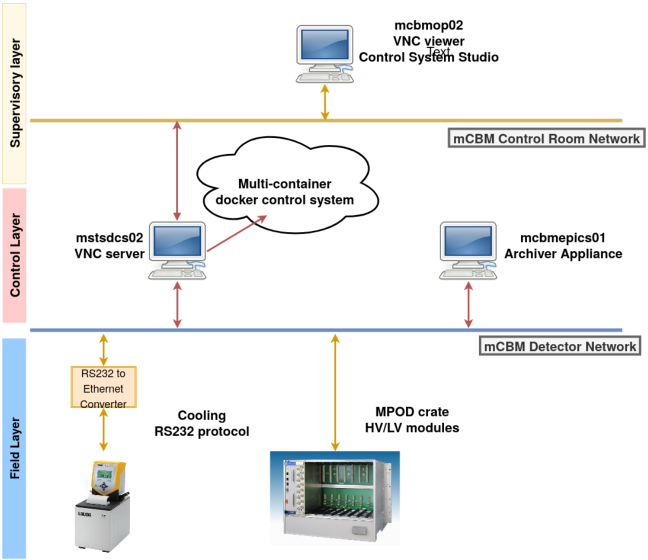
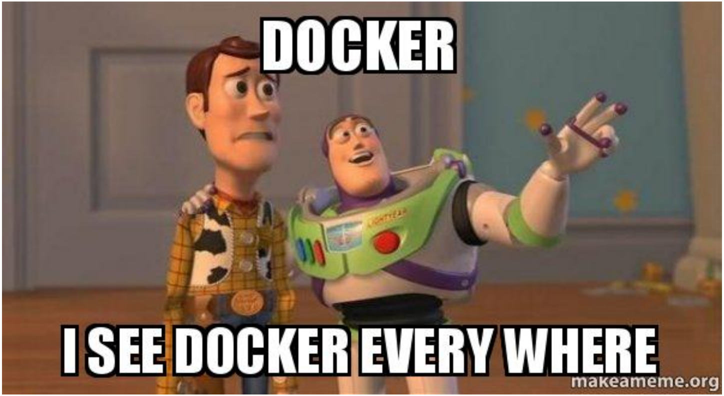
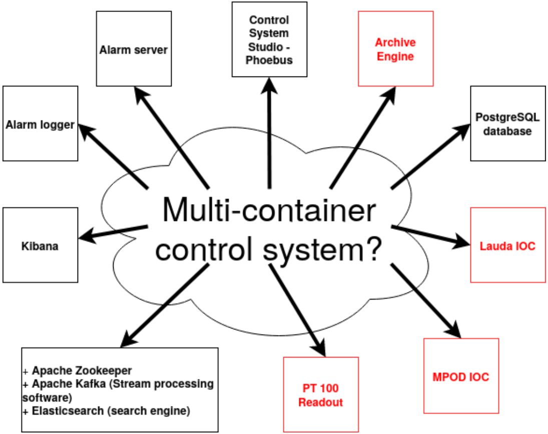


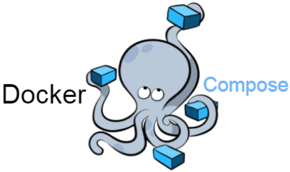
Figure: mSTS's DCS structure in the mCBM


DOCKER
I SEE DOCKER EVERY WHERE
makeameme.org


Alarm server
Control System Studio - Phoebus
Archive Engine
Alarm logger
PostgreSQL database
Multi-container control system?
Kibana
Lauda IOC
+ Apache Zookeeper
+ Apache Kafka (Stream processing software)
+ Elasticsearch (search engine)
PT 100 Readout
MPOD IOC

How does it work?

1. All containers deployed using docker-compose tool (docker-compose.yaml)



How does it work?

1. All containers deployed using docker-compose tool (docker-compose.yaml)
2. In the first step Apache Kafka topics are created for the communication of alarm server, alarm logging instance and Phoebus (broker ignored)

```yaml
kafka-setup:
  image: confluentinc/cp-kafka:5.1.1
  container_name: kafka-setup
  network_mode: host
  depends_on:
    - kafka
    - zookeeper
  command: "bash -c 'echo Waiting for Kafka to be ready... && \
                   cub kafka-ready -b localhost:9092 1 20 && \
                   kafka-topics --create --if-not-exists --zookeeper localhost:2181 --partitions 1 --replication-factor 1 --topic STS && \
                   kafka-configs --zookeeper localhost:2181 --entity-type topics --alter --entity-name STS \
                   --add-config cleanup.policy=compact,segment.ms=10000,min.cleanable.dirty.ratio=0.01,min.compaction.lag.ms=1000 && \
                   kafka-topics --create --if-not-exists --zookeeper localhost:2181 --partitions 1 --replication-factor 1 --topic STSCommand && \
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                    kafka-topics --create --if-not-exists --zookeeper localhost:2181 --partitions 1 --replication-factor 1 --topic STSTalk && \
                   kafka-configs --zookeeper localhost:2181 --entity-type topics --alter --entity-name STSTalk \
                   --add-config cleanup.policy=compact,segment.ms=10000,min.cleanable.dirty.ratio=0.01,min.compaction.lag.ms=1000 \
                   '"
  environment:
    # The following settings are listed here only to satisfy the image's requirements.
    # We override the image's `command` anyways, hence this container will not start a broker.
    KAFKA_BROKER_ID: ignored
    KAFKA_ZOOKEEPER_CONNECT: ignored
```

How does it work?

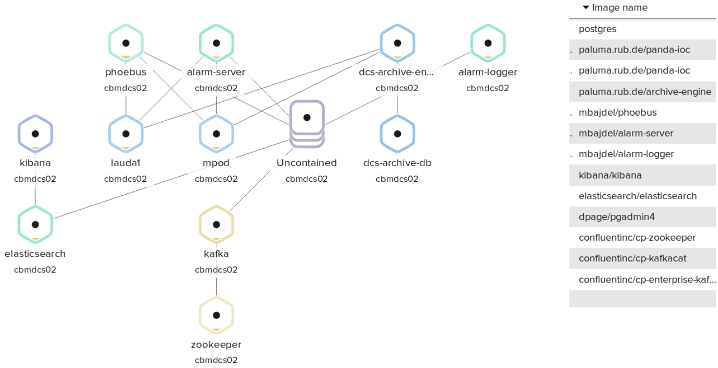
1. All containers deployed using docker-compose tool (docker-compose.yaml)
2. In the first step Apache Kafka topics are created for the communication of alarm server, alarm logging instance and Phoebus (broker ignored)
3. Alarm logger and alarm server are waiting for the Apache Kafka service to be ready
   - Apache Zookeeper manages service discovery for Kafka Brokers (in our case only 1 broker)
   - Apache Kafka stores messages and allows consumers to fetch them by topic
4. elasticsearch indexes are being created + Kibana is used to visualize them (logging),
5. All the remaining services, databases are starting...
   - scalability
   - partial deployment of services (e.g. Phoebus + IOC + archiver + engine)
   - easily maintainable (fallback options, starting with daemon, restart if closed)

How does it work? - video

Multi-container control system

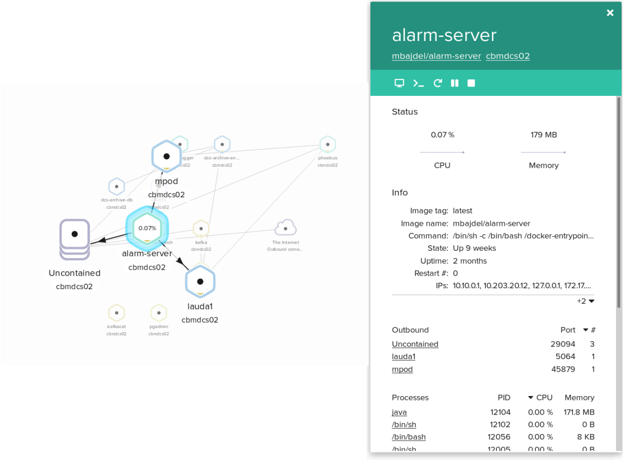
- Automatic topologies and intelligent grouping

Multi-container control system



- Automatic topologies and intelligent grouping
- Contextual details and metrics

Multi-container control system



- Automatic topologies and intelligent grouping
- Contextual details and metrics
- Real-time container monitoring

Usage of Weavescope - video

weave
scope

mSTS operation - Phoebus, IOC, Archiver

1. A prototype version of the DCS for the mSTS has been in use since 2 months without any major issues

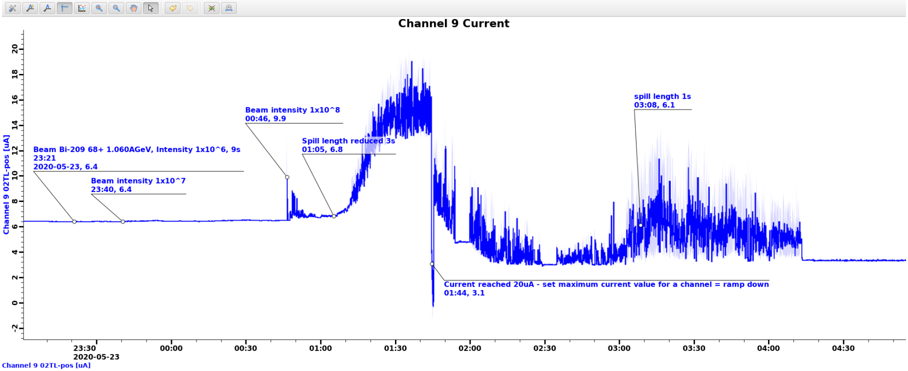


Figure: Current drawn by one side of the silicon sensor during for Bi-209 beam

mSTS operation

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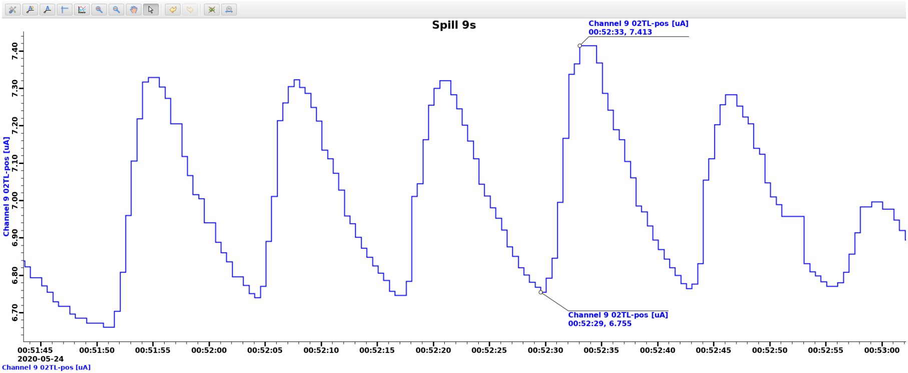
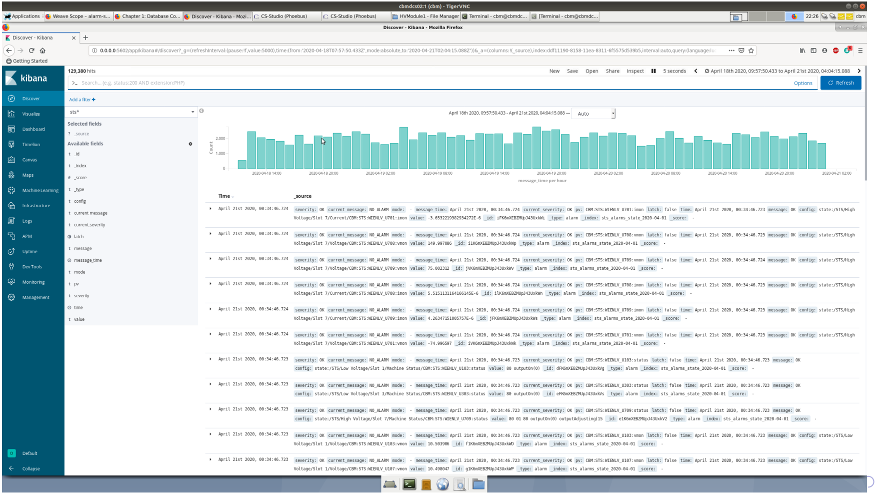


Figure: Current drawn by one side of the silicon sensor during for Bi-209 beam - spill length seen by silicon sensor

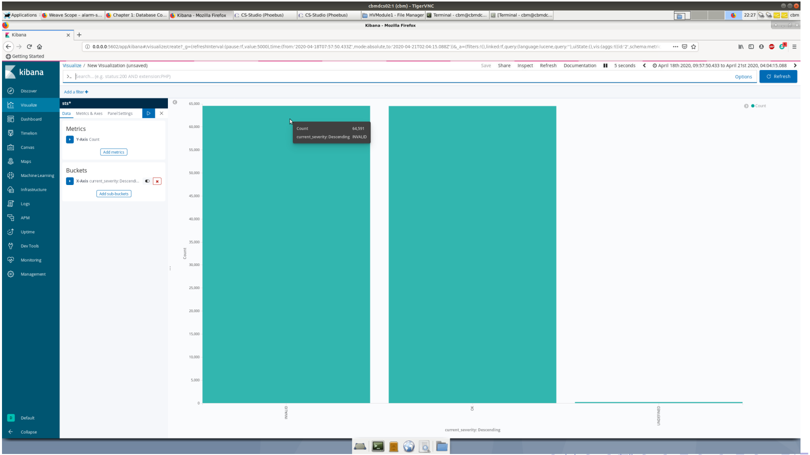
mSTS operation

1. Performance of the alarm logging seen by Kibana → huge traffic caused by unstable connection with MPOD. (snmp protocol)



mSTS operation

1. Issue resolved by increasing the maximum time that the driver should wait for the value → temporary solution. For the next campaign CC24 controller with built-in IOC will be used.



Final thoughts

1. containers safety concerns - LDAP authentication/additional hardening of the system,
2. rearrange system architecture inside the experiment networks (CA-gateway),
3. no possibility to use caget(), camonitor() from the inside of the system $\rightarrow$ EPICS on Jupyter Notebook?
4. read-out of voltages, temperature from the STS-XYTER (STS,X,Y coordinate, Time and Energy read-out) Application-specific integrated circuit using PyEpics
5. simple Grafana(interactive visualization web app) interface for showing key parameters

1. Performance evaluation of FBG-based fiber optic humidity and temperature sensors (radiation hardness, performance in the low RH range),
   - evaluation of different archivers - Cassandra, Archiver Appliance,
   - try-out Kubernetes/Redhat Openshift,

1. Performance evaluation of FBG-based fiber optic humidity and temperature sensors (radiation hardness, performance in the low RH range),

2. Further developments of the mSTS's DCS $\rightarrow$ beam campaign 2021, 2022,
   - Finite State Machine
   - Integration of FBG based humidity sensors

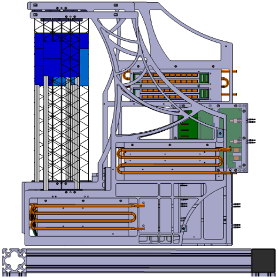


Figure: mSTS CAD design for the 2021 mCBM campaign - 11 silicon sensors

1. Performance evaluation of FBG-based fiber optic humidity and temperature sensors (radiation hardness at least 12kGy, performance in the low RH[0-5%] range),
2. Further developments of the mSTS's DCS $\rightarrow$ beam campaign 2021, 2022,
3. Thermal demonstrator:

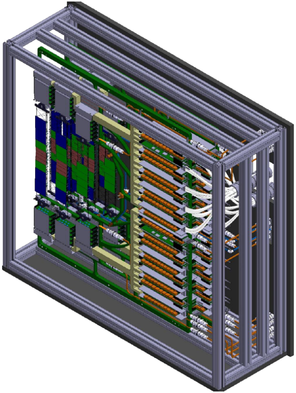


Figure: Thermal demonstrator CAD design

- 50 dummy silicon sensors - 100HV channels,
- 100 FEBs,
- 50 PT100 sensors,
- 300 DS18B20 sensors,
- few fiber wire sensors,
- 7.5kW cooling plant,
- ~2500 PVs (STS ~30000PVs).

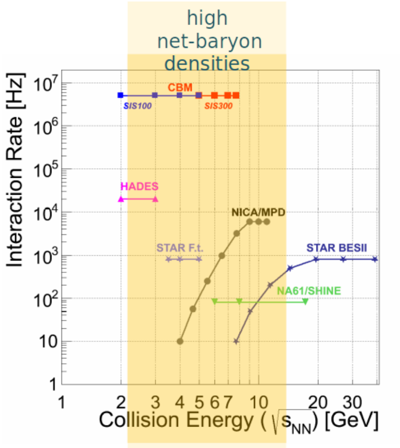
Thank You!

E-mail: mbajdel@gsi.de
CBM Gitlab: `https://git.cbm.gsi.de/m.bajdel`
Docker: `https://hub.docker.com/u/mbajdel`

HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research

JOHANN WOLFGANG GOETHE
UNIVERSITÄT
FRANKFURT AM MAIN

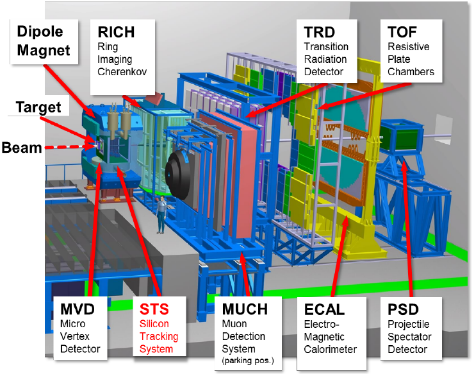
Backup - Compressed Barionic Matter Experiment



1. charged-particle tracking + momentum measurement
2. up to $\sim$ 700 charged particles per heavy-ion collision
3. $10^5 - 10^7$ heavy-ion collisions per second
4. free streaming of hit data to online computing

Conditions in the STS

- Radiation exposure over the lifetime of 12kGy in the most exposed area of station 1
- Magnetic field of 1 T
- Target temperature of $\leq$-10°C
- Volume contraints $\leq 3.5m^3$
- Relative Humidity $\sim$ 1%



Source: Technical Design Report for the CBM [1]

Sensors Technology

Characteristics of a perfect humidity sensor for HEP experiment

- Radiation resistant
- Insensitive to magnetic field
- High accuracy, especially in low humidity range [0-5]%
- Small dimensions
- Low mass
- Reliable readings across long distances
- Reduced number of wires for operation

Fibre Bragg grating sensors

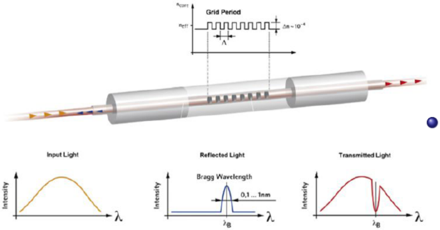


Figure: Fibre Bragg Grating structure [8]

- Fiber Bragg grating is a periodic perturbation of the refractive index along the fiber length which is formed by exposure of the core to an intense optical interference pattern [9]
- Selective filter which reflects the light signal at a certain wavelength named as Bragg wavelength λ_B [8]

$$\lambda_B = 2 n_{eff} \Lambda \qquad (1)$$

Λ - grating pitch, n_{eff} - effective refractive index