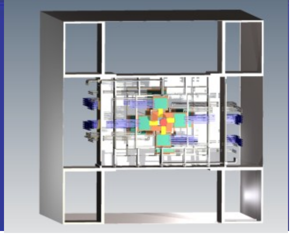
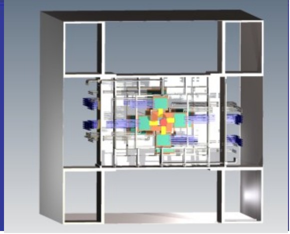


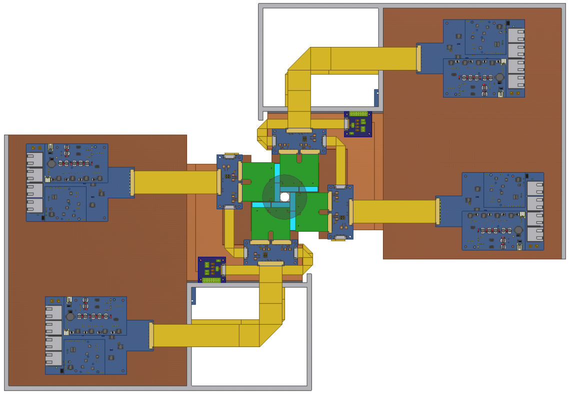
CBM Micro Vertex Detector mechanical integration and cooling

Tobias Tischler for the CBM-MVD Collaboration

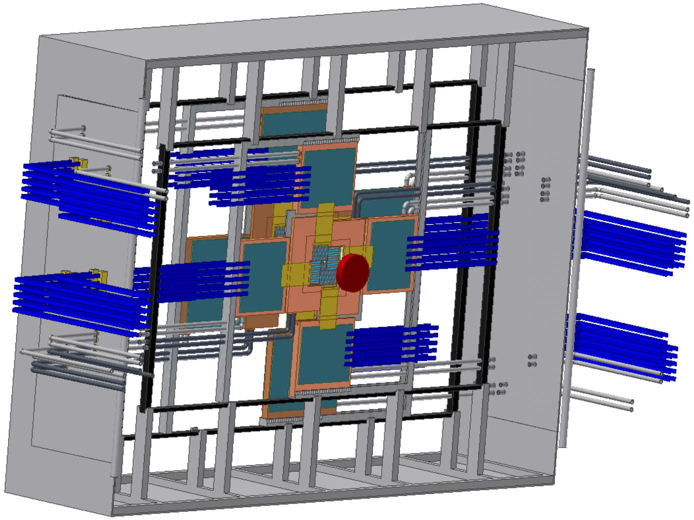


Outline

- MVD for CBM
  - Basic requirements
    - detector position
    - “ultra” low material budget
    - vacuum operation
    - operation in magnetic field

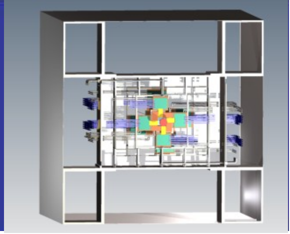


- Projects
  - Demonstrator ✔
  - Prototype Version 1 (MIMOSA-26)
  - Prototype Version 2 (MISTRAL)
  - SIS-100 MVD



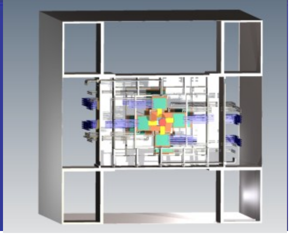
- Open questions

MVD for CBM - basic requirements



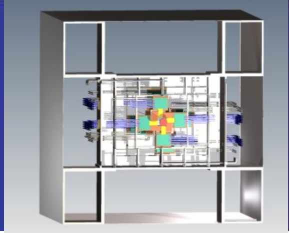
- Detector position
  - inside vacuum chamber
    - compact arrangement
    - hard to access (e.g. for remote positioning)
    - cooling
  - close to the fixed target (5, 10, 15 cm downstream)
    - radiation hardness
      - sensors and materials of the MVD are exposed up to $3 \cdot 10^{13} n_{eq}/cm^2$ and $3\,Mrad$ per CBM year
  - moveable
    - possibility of moving the MVD stations in and out of the beam area during beam tuning and beam focusing (restoration of precise alignment)
  - detector acceptance
    - active detector area ± 2.5 ° to ± 25 °
- Vacuum operation
  - efficient cooling of MAPS (max. 2 W/cm²) to create an uniform temperature distribution over the sensor surface to set the optimum operation parameters
    - concept of conductive cooling
      - use of low mass but high heat conductive materials (active area)
      - use of Cu/Al for heat sinks and support structures (passive area)
  - low out-gassing materials required, e.g. glue EP21TCHT-1 (NASA approved)

MVD for CBM - basic requirements



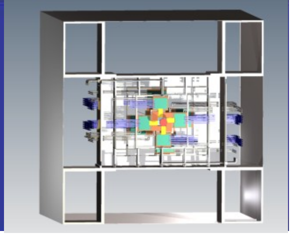
- "Ultra"-low material budget
  - minimum multiple scattering to allow for precise determination of the secondary decay vertex (open charm reconstruction)
  - material budget within active detector area is limited to a few ‰ X_0
    - use of thinned sensors (50 µm)
    - thin but mechanical stable support structure, which accommodates effective cooling
- Magnetic field
  - impact of Lorentz angle on data quality not studied yet

MVD for CBM - basic requirements



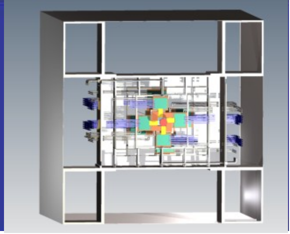
- Materials
  - combination of low mass but high heat conductive materials calls for the use of high performance materials
    - TPG (Thermal Pyrolytic Graphite)
    - CVD (Chemical Vapor Deposit) diamond

	TPG	CVD diamond
Heat conductivity [W/mK]	1500	2000
Radiation length X_0 (cm)	19.03	12.22
Material surface	graphite	polished
Price [€/mm³]	0.03	up to 15
Thickness [µm]	below 300 difficult	120 – 300 ok
Project	Demonstrator / back-up	Prototype / SIS-100



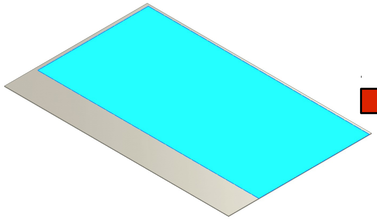
CBM Micro Vertex Detector Prototype

MVD for CBM - Prototype



Sensor of choice for the MVD Prototype

MIMOSA-26

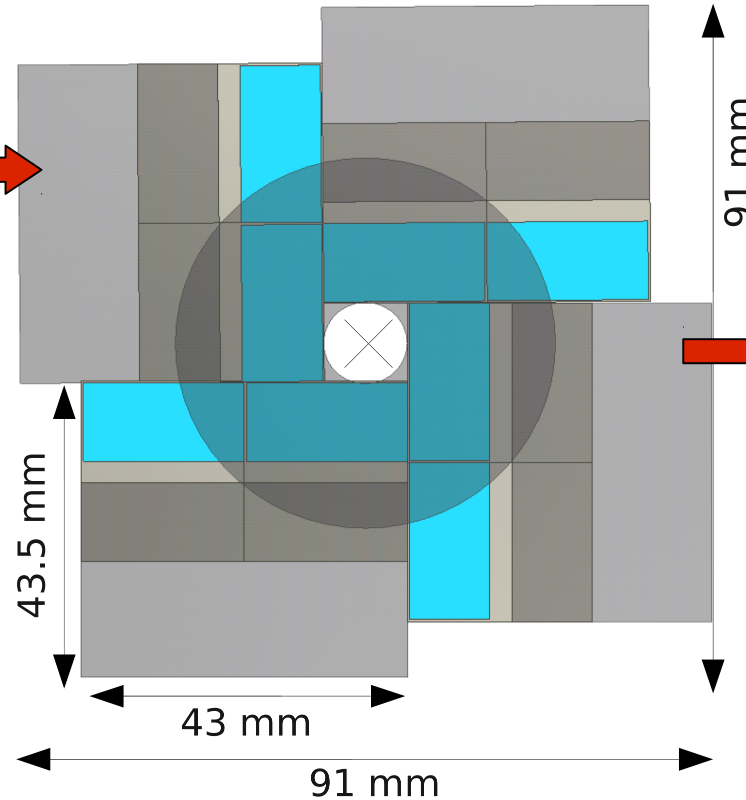


Dimensions
13.7 x 21.5 mm²

Active area
10.6 x 21.2 mm²

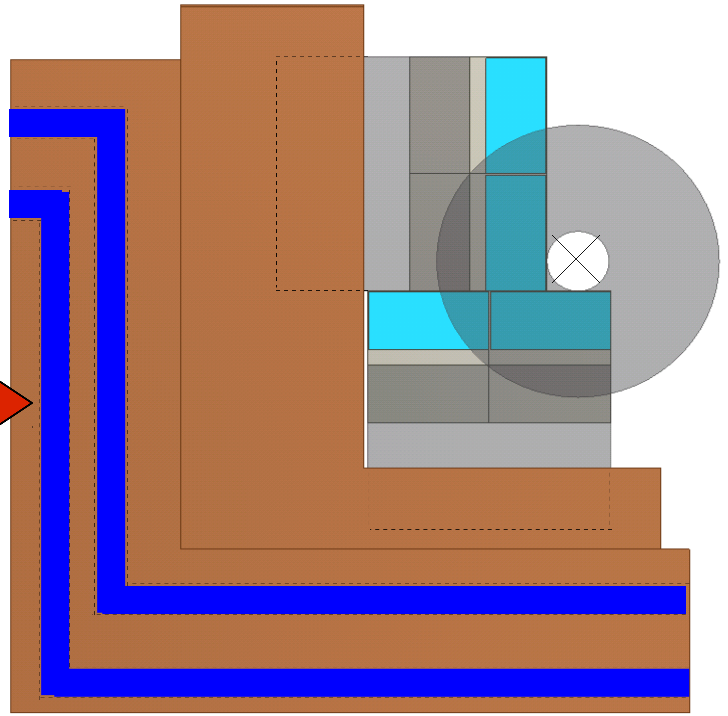
Acceptance coverage for the first MVD station

4 quadrants with 4 sensors each mounted on CVD diamond



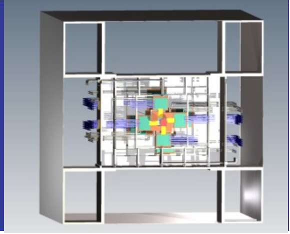
Heat sink (copper) for sensor cooling positioned outside of the acceptance

One heat sink is dedicated to cool 2 quadrants



Software used: Autodesk Inventor

MVD for CBM - Prototype

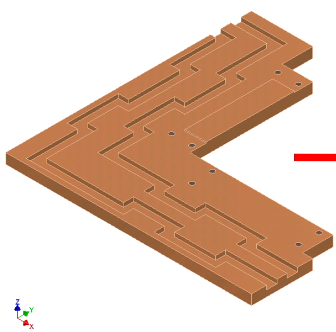


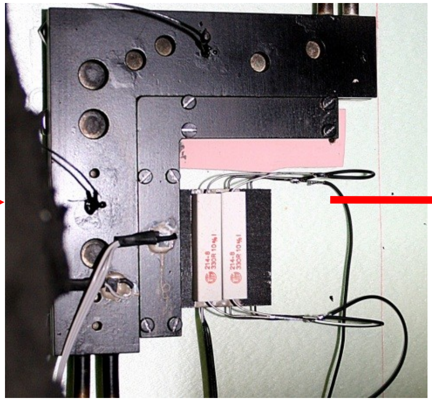
Optimize heat sink geometry in order to minimize

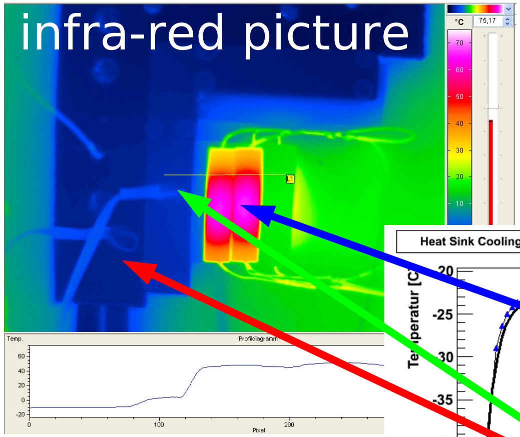
- T_{abs} the absolute operation temperature of the sensors (T_{abs} in the order of – 20 °C)
- ΔT the temperature gradient over the sensor surface (ΔT in the order of 10 K)

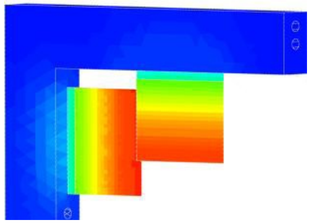
Include safety margin for the power dissipation of the sensors (max. 2 W/cm²)
due to sensor's design and geometry,
assumption: maximal power dissipation of 100 W for the first station.

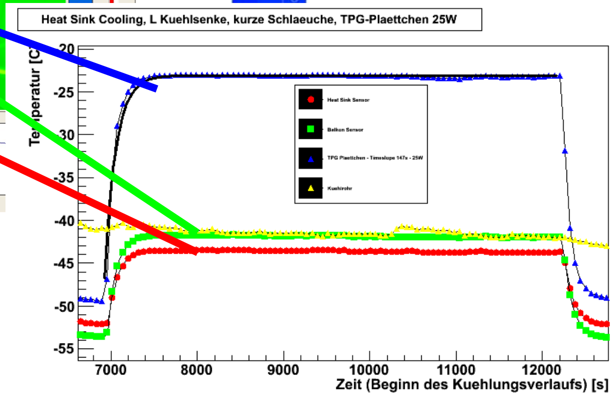
→ Temperature gradient: difficult, depending on support thickness
Absolute temperature: value reached (- 20 °C with – 70°C cooling fluid)







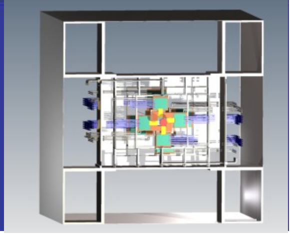




Four resistors used to simulate
an expected power dissipation (25 W)
of one quadrant (300 µm TPG)

Institute for Nuclear Physics, Goethe University Frankfurt

MVD for CBM - Prototype

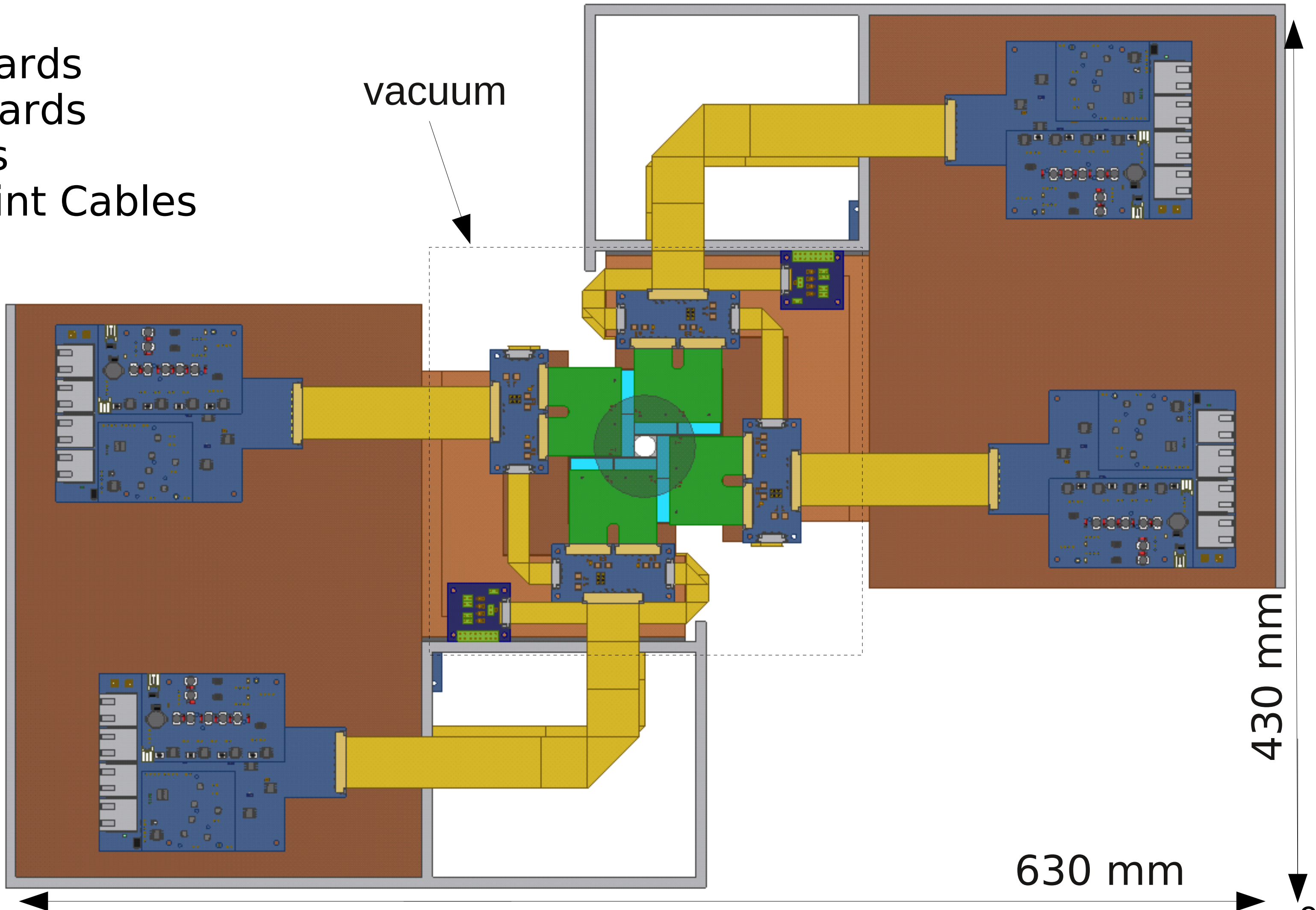


Institute for Nuclear Physics, Goethe University Frankfurt

First MVD Prototype station

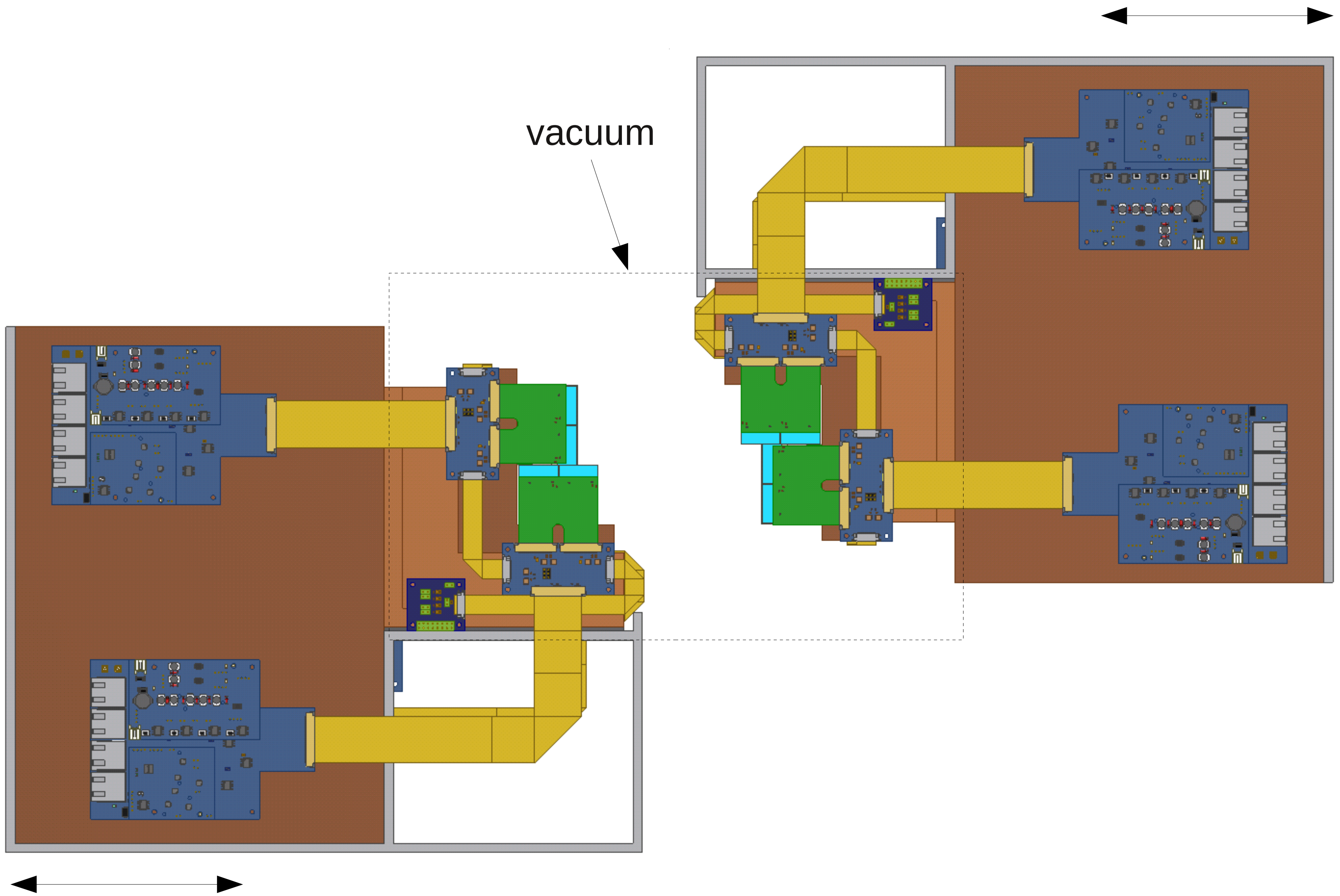
components

16 MIMOSA-26
8 Front-End boards
8 Converter boards
2 Driver boards
several Flex-Print Cables



For the electronics see talk of Christoph

MVD for CBM - Prototype

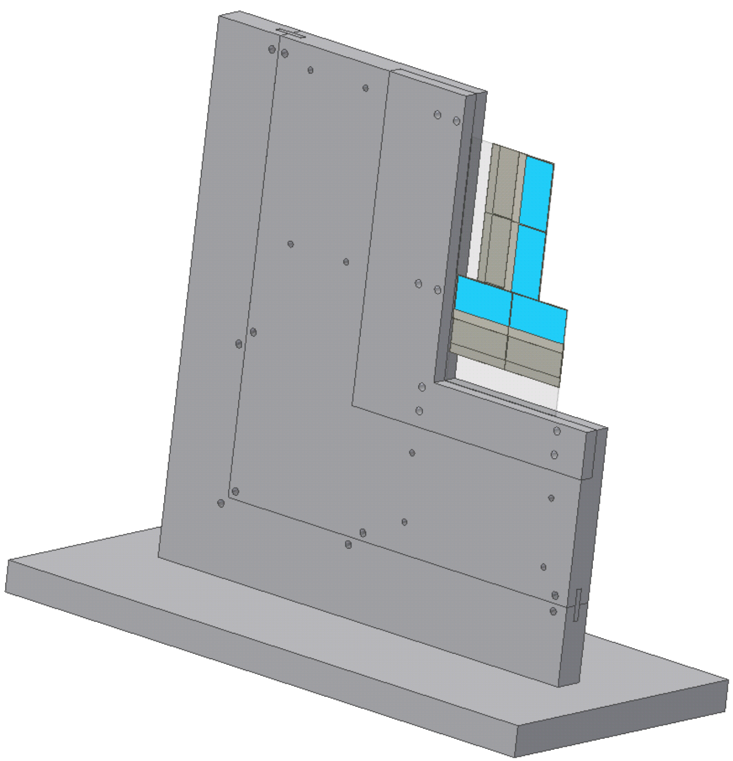


MVD for CBM - Prototype Mock-up

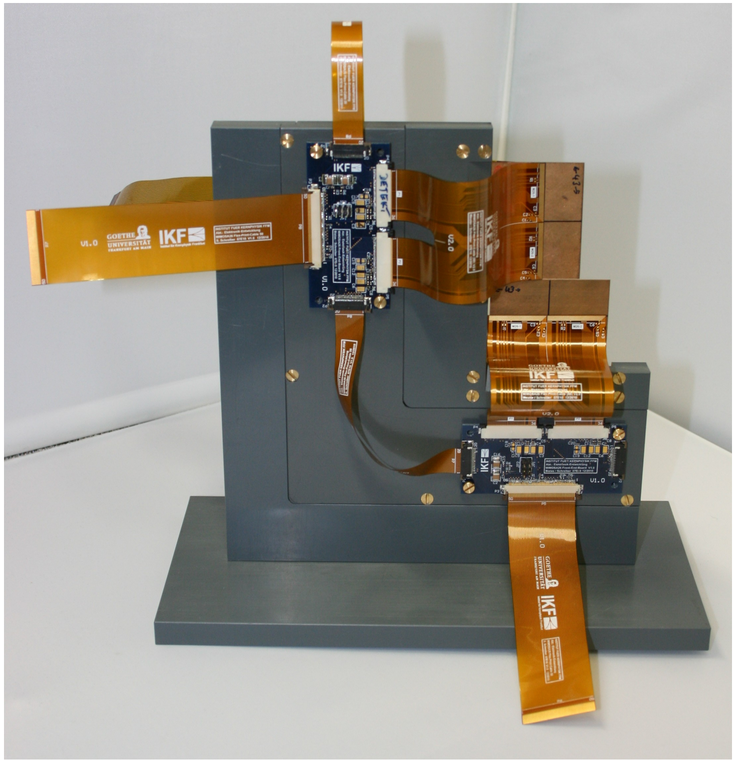
A 1:1 Mock-up of the MVD Prototype has been build in order to

- test the positioning and arrangement of all parts needed
- test the positioning of the Front-End read-out boards with respect to the sensors
- replace dummy parts with the real detector parts successively

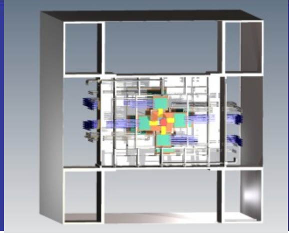
CAD-Model

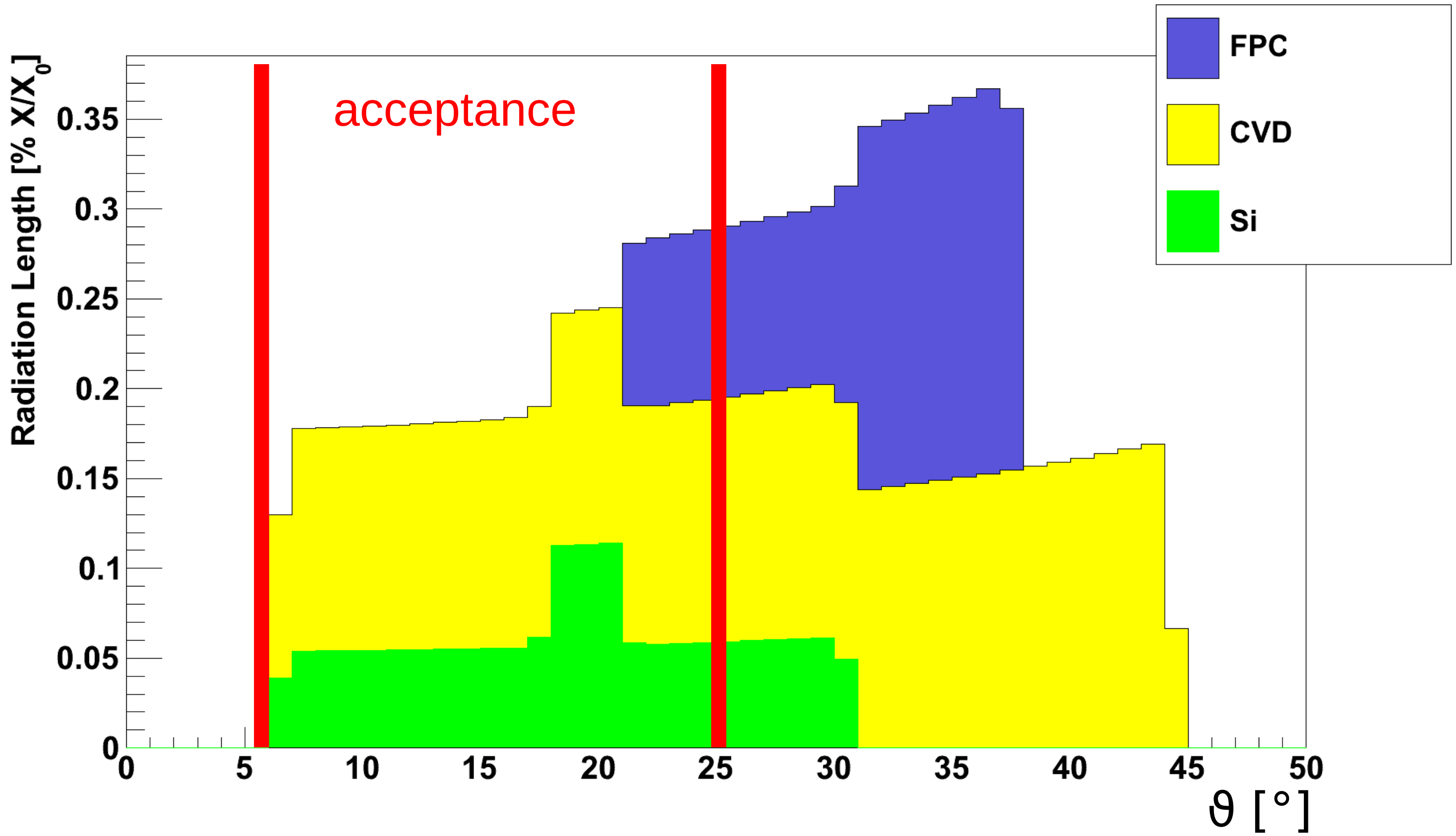


1:1 Mock-up (with read-out boards)



MVD for CBM - Prototype Simulation

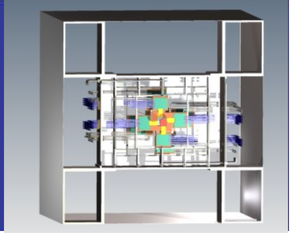




Based on the FairRadLenManager the material budget for the Prototype

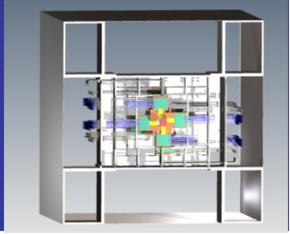
including
- 50 µm silicon
- 150 µm CVD diamond
- FPC (0.0861 % X_0)

in a φ slice 0 – 2.5° has been simulated (glue and heat sink were not taken into account).



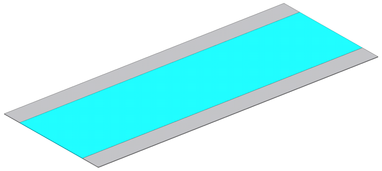
CBM Micro Vertex Detector
SIS-100 MVD

MVD for CBM - SIS-100 MVD



Sensor of choice for the SIS-100 MVD

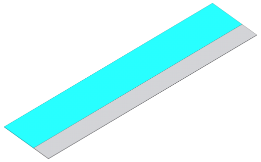
MISTRAL A



preliminary dimensions

full sensor
15 x 30 mm²
active area
10 x 30 mm²

MISTRAL B



preliminary dimensions

half sensor
7.5 x 30 mm²
active area
5 x 30 mm²

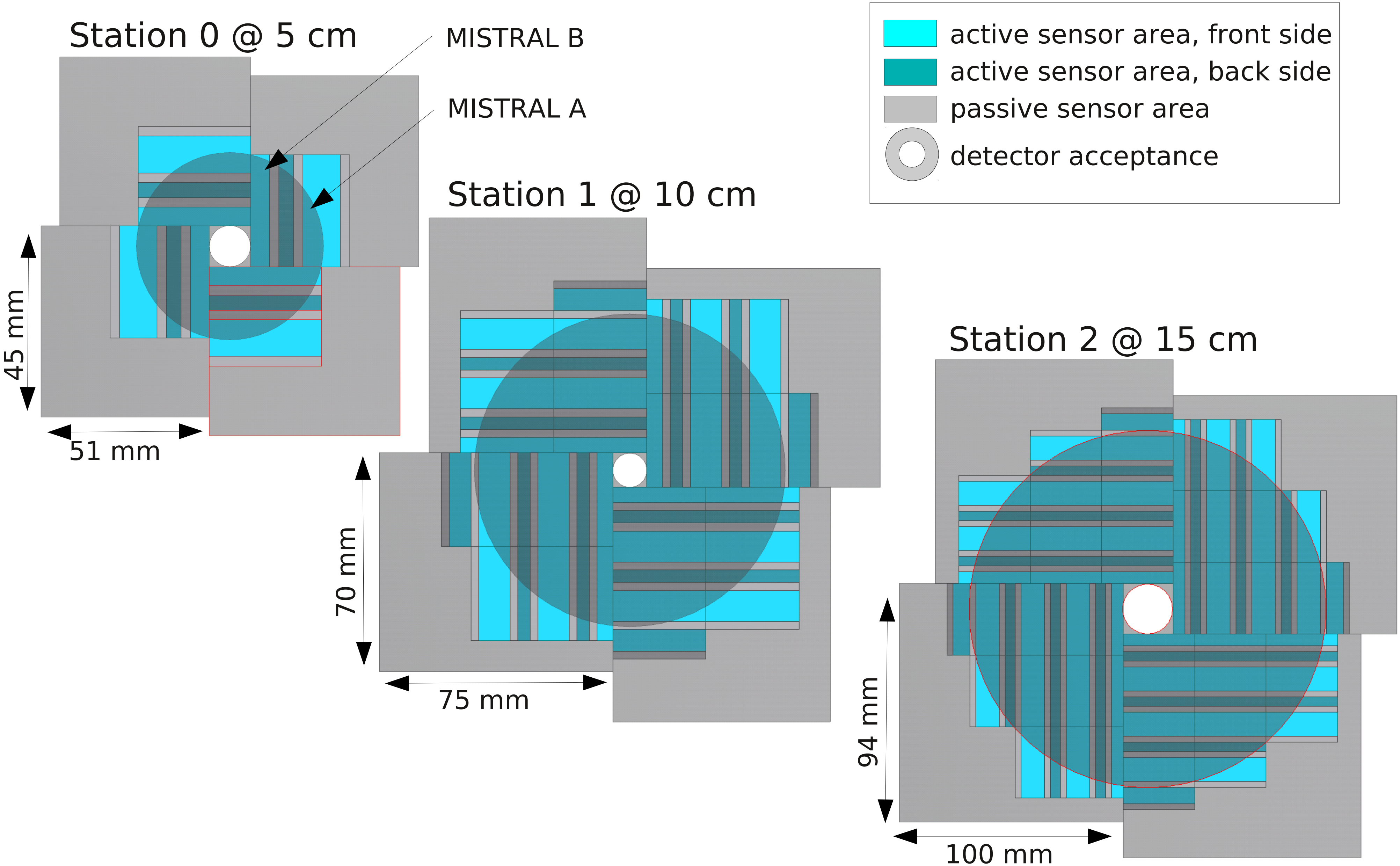
Sensor arrangement for the SIS-100 MVD

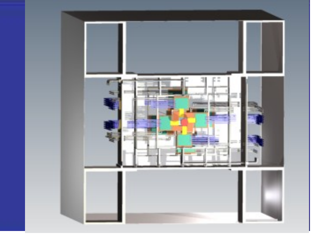
- 3 stations planned
- half sensor needed to keep integrated sensor read-out electronics away from the beam
- sensors are placed on both sides of the CVD diamond to cover the full acceptance with active sensor material

Station	Position [cm]	inner radius [mm]	outer radius [mm]	active area [mm²]	# of MISTRAL A	# of MISTRAL B
0	5	5.5	25	1868	8	4
1	10	5.5	50	7758	36	8
2	15	10.5	75	17325	68	12
Sum				26952	112	24

assuming a 50% yield (cutting, thinning,...) this asks for minimum **300** sensors

MVD for CBM - SIS-100 MVD





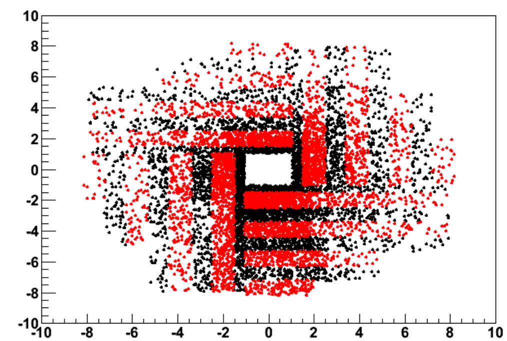
MVD for CBM - Simulation implementation

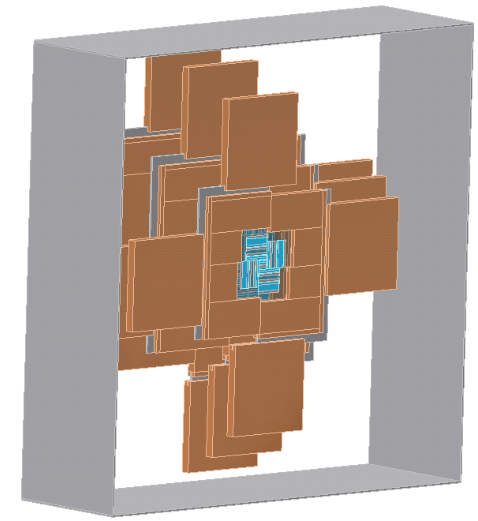
Conversion of the actual SIS-100 MVD geometry to CBMRoot was also done.

All active sensor areas are named individually in the way:

MVD-SX-QX-LX-CXX-PX

with SX	for station [0,1,2]
with QX	for quadrant [0,1,2,3]
with LX	for layer [0,1]
with CX	for chip [00,01]
with PX	for active area [0,1]



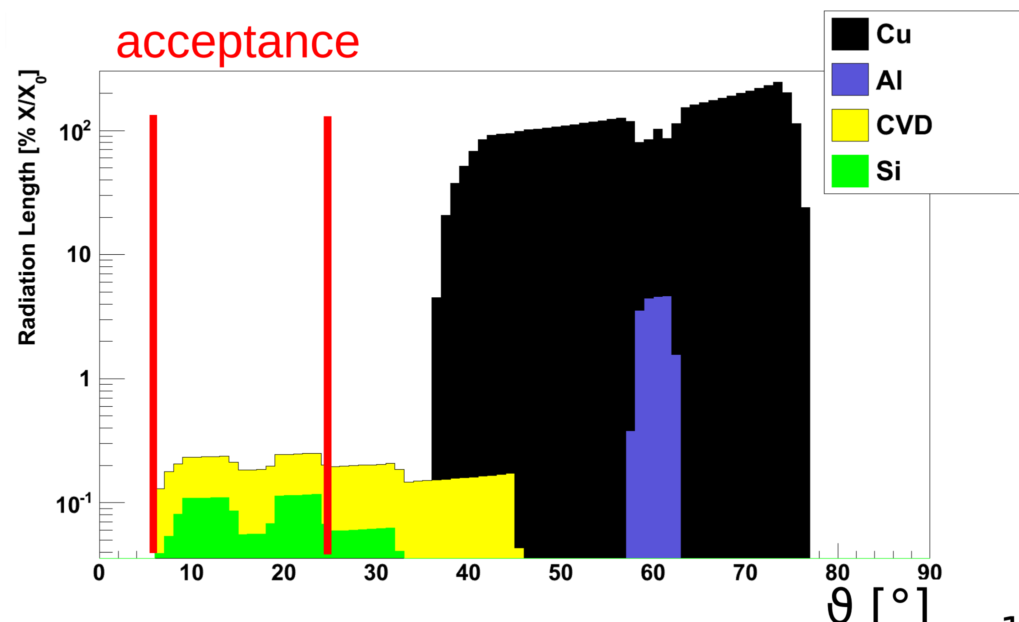


Based on the FairRadLenManager the material budget for the first Station of the SIS-100 MVD

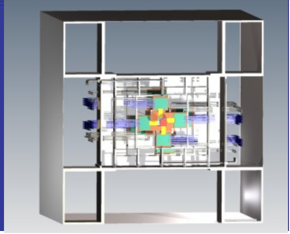
including
- 50 µm silicon
- 150 µm CVD diamond
- aluminum frame
- copper heat sinks

in a φ slice 0 – 2.5°

has been simulated.



MVD for CBM - Conclusion



Ongoing studies

for the Prototype:

- Cooling system
  - dimensions of the heat sink
  - configuration of the cooling pumps
    - number of cooling circuits

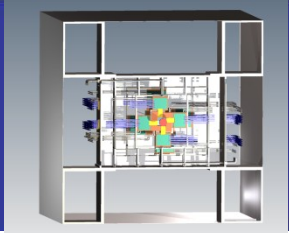
- Modular design
  - interface between Cu (heat sink) and CVD
  - dimensioning of services (besides cooling: bias, remote positioning,...)

for the SIS-100 MVD:

- Innovative solution
  - thinned sensors packed in polyimide (under study @ IMEC, Belgium and @ CERN)

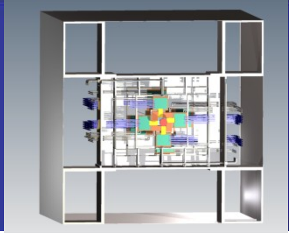
- MISTRAL A/B properties
  - final form factor(s),...

MVD for CBM - Open questions



- Materials
  - interplay between materials within the temperature range given (-20 °C ⟷ +20 °C)
  - glue(s)
- “Mass” production
  - alignment
    - precision of a (pre-)alignment of the
      - half stations
      - sensors
      - methods and techniques to simplify
    - tools and methods
      - “Fineplacer”, placing and positioning the sensors individually
      - masks for positioning and gluing more than one sensor at once
- Vacuum vessel
  - how to provide the services
  - influence of the magnetic field

MVD for CBM - Laboratory



- equipment

– probe station	PA 200	Süss MircoTec
– manual bonding machine	MEI1204W	Wagner
– 3D microscope	VHX-600	KEYENCE
– infra red camera	VarioCam HR	InfraTec
– cooling systems	cc405/cc815	huber

- in preparation
  - clean room (equipment (?))
    - class 10000 (ISO 7)
  - further equipment for producing 3 MVD stations & spares