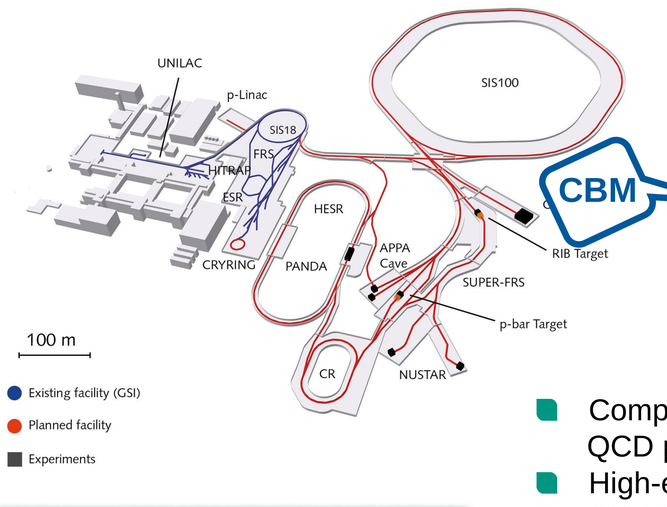
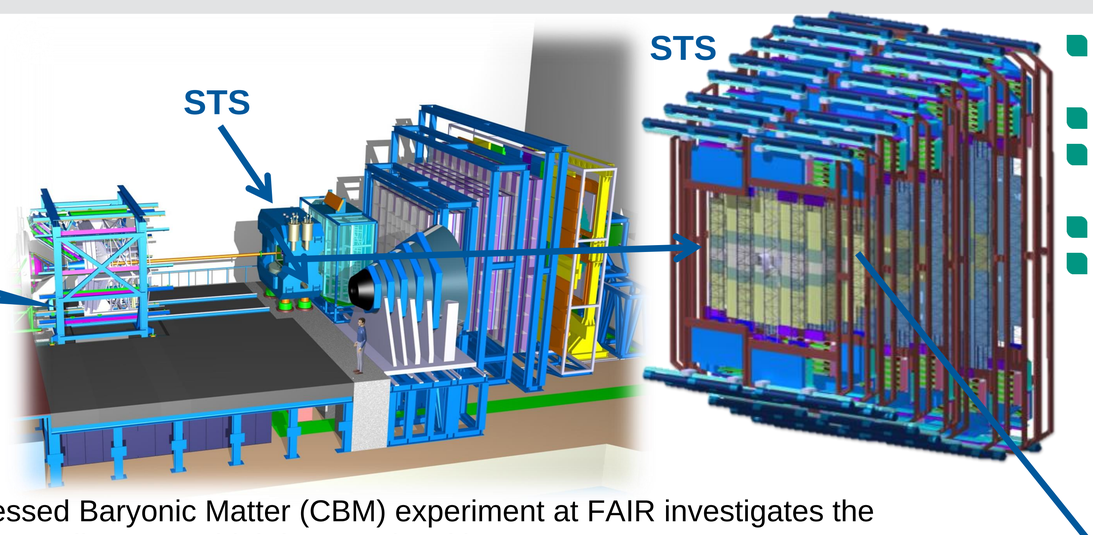
Module assembly technologies for the Silicon Tracking System of the CBM experiment at FAIR

P. Pfistner, M. Caselle, T. Blank, for the CBM collaboration

Contact: Patrick.pfistner@kit.edu

CBM at FAIR, GSI





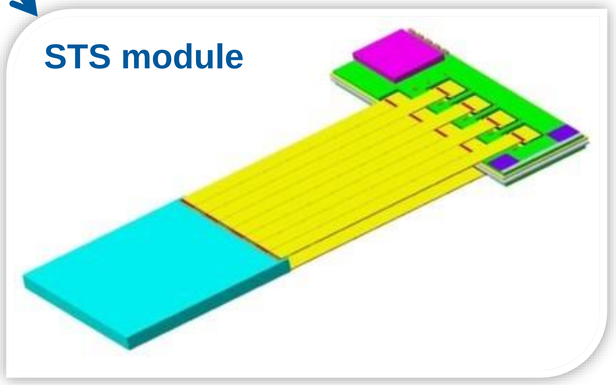
- Compressed Baryonic Matter (CBM) experiment at FAIR investigates the QCD phase diagram at high baryon densities
- High-energy nucleus-nucleus collisions ($10^5 - 10^7$ Au-Au collisions/s)
- SIS100: ion beam energies between 2 and 14 AGeV, protons up to 29 GeV
- SIS300: ion beam energies up to 45 AGeV, protons up to 90 GeV

Silicon Tracking System (STS)

- core detector of CBM located inside the dipole magnet
- Track reconstruction and momentum determination of charged particles
- Track multiplicity up to 700 per central Au+Au collision in the aperture of $2.5° < \Theta < 25°$
- Momentum resolution Δp/p ~ 1%
- Lifetime fluence up to $1 \times 10^{14} n_{eq}$ in innermost region for SIS300

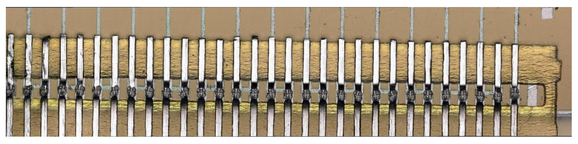
- STS: Eight tracking stations 0.3 m to 1 m downstream of the target
- Last station area: 1 m^2
- Double-sided silicon microstrip sensors (2 x 1024 channels, 58 µm strip pitch)
- Readout electronics located in the periphery
- 896 detector modules arranged in 106 ladders of 17 variations

- Detector module:
  - 1 sensor
  - 16 STSXYTER ASICs
  - 2 FEB-8 readout-boards
  - 16 or 32 low mass microcables

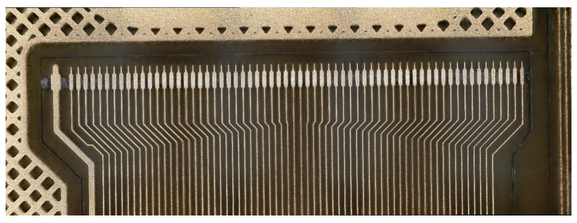


Current interconnection method: TAB bonding

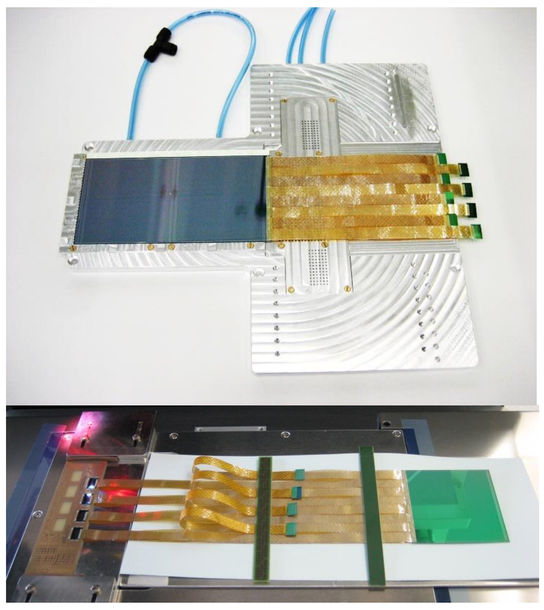
- Current interconnection technology used by GSI and JINR
- 32 Al cables per detector module
- Several test modules already built by GSI and JINR
- Tested at KIT: able to perform TAB bonding: mechanical jigs need to be adjusted to TAB bonding machine
- Copper TAB bonding cables as alternative to Al cables



TAB bonding on Al cable performed at KIT.



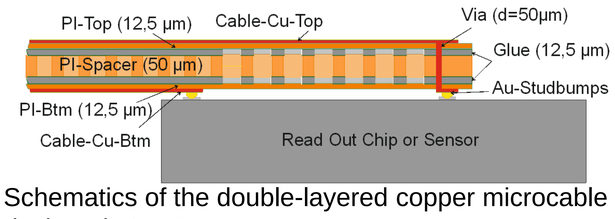
Copper microcable designed for TAB bonding.



Detector modules built with dummy sensors and dummy ASICs assembled in TAB bonding technology at GSI.

KIT copper microcable

- Low mass, low capacity copper microcable designed at IPE
- Double-layered design: 16 instead of 32 cables per module
- Several bond pad surface finishes possible
- Delivered in sheets of 8 cables



Schematics of the double-layered copper microcable designed at IPE.

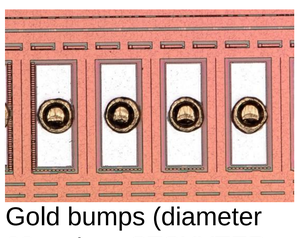
Close-up view on the head of the copper microcable. Two rows of 64 EPIG bond pads match the layout of the ASIC and the sensor. Fiducial marks are implemented for proper alignment during the bonding step.

Sheet of 8 copper microcables as delivered by Dyconex.

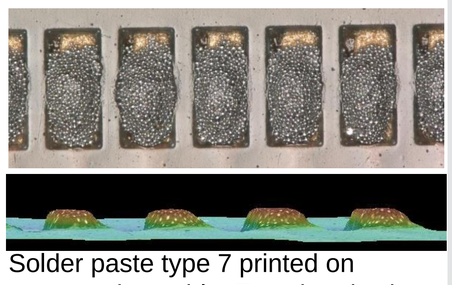
Novel approach: Bonding of die on flex
Gold stud bump bonding + solder paste printing

Production steps

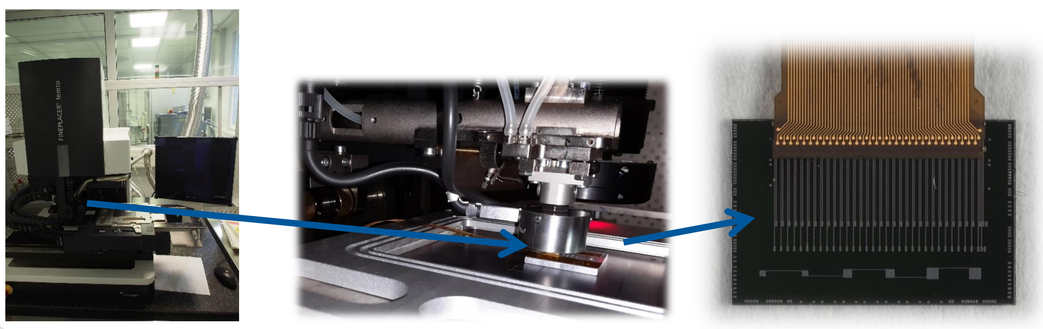
- Printing of fine-grain solder paste type 7 (2-11 µm grain size) on double-layered copper microcable
- Gold stud bumping (60 µm) on ASIC and sensor
- High-density die on flex interconnection of ASIC to cable with Femto fineplacer
- High-density die on flex interconnection on sensor side with in-house bonding machine
- Underfill application for spark protection and mechanical stabilization



Gold bumps (diameter 60 µm) on STSXYTER.



Solder paste type 7 printed on copper microcable. Top view (top) and 3D side view (bottom) showing the uniformity of the print.

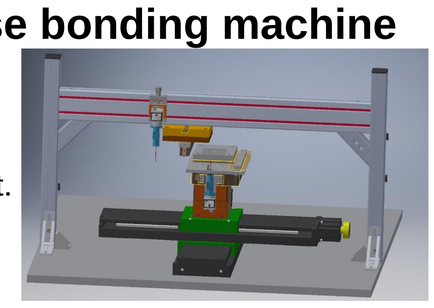


Advantages

- Fast production method
- Half the amount of cables: facilitates production
- Potentially better production yield
- Possibility of reworking the module

Sensor-side: in-house bonding machine

- Two-camera system
- Four stepper motors in x, y, z and phi with sub-micron accuracy for precise alignment.
- Underfill application possible



Summary/Outlook

- Bonding of die on flex is a promising high-density interconnection technology that might also be interesting for other future experiments
- Two production methods under development:
  - TAB bonding
  - Bump bonding
- Build-up of complete proto module (1 sensor + 16 cables + 16 ASICs)
- Electrical tests and comparison of the two interconnection technologies
- KIT is one of three production centers of STS for CBM
- Production will start 2019/2020, production volume is about 300 (1/3 of whole volume) detector modules