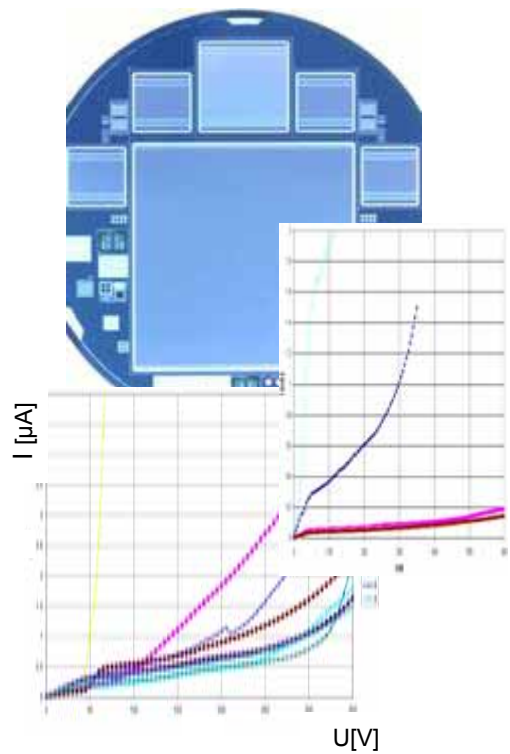
Silicon Tracking System
– Status of Development –

Johann M. Heuser,
CBM Collaboration Meeting, Dresden, 26.9.2007

- STS Workgroup Activities
- Workshop on Silicon Detector Systems
- Detector Concept & Status of Simulations
- Beginning Prototyping of Detector Components
- Work Packages, R&D Cooperations, Project Planning



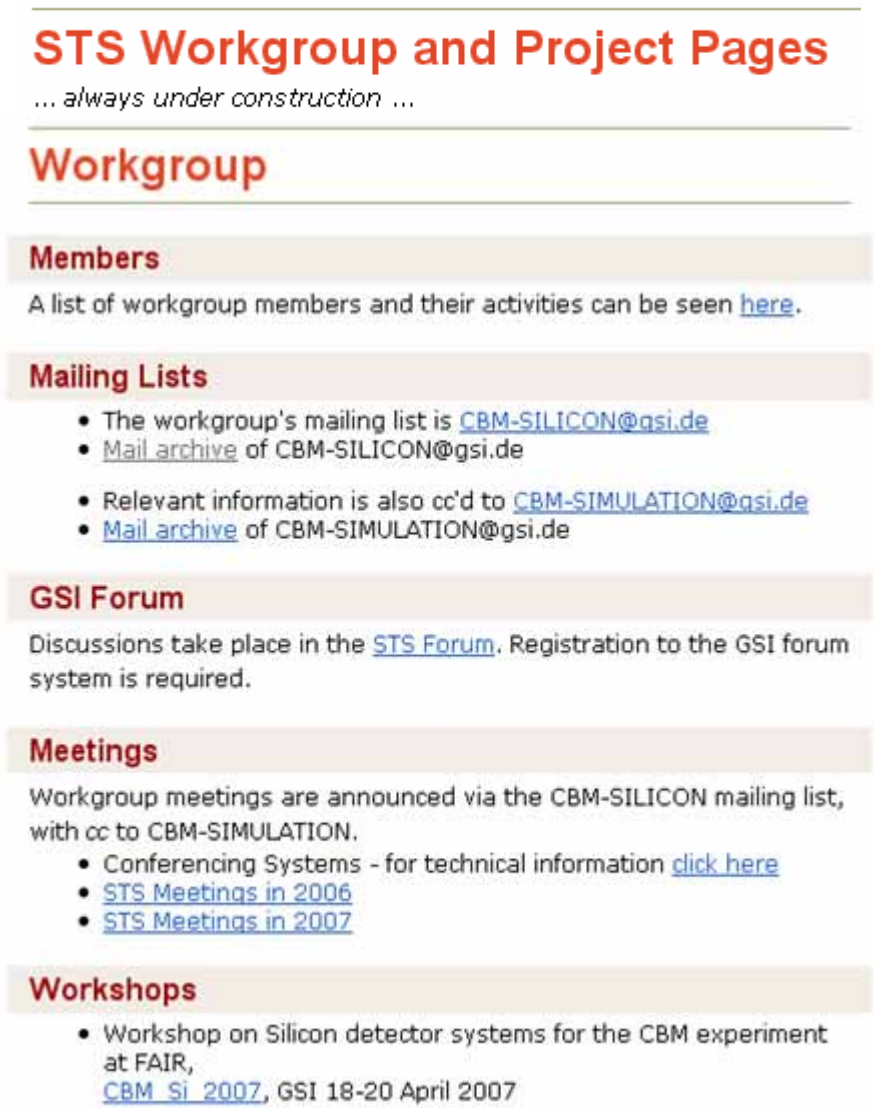
STS Workgroup

Goal:
Follow up and discuss regularly the different activities on the STS, both simulations and hardware projects.

Weekly meetings:
Thursdays afternoon – at GSI and via Video Conferencing System (EVO).
Please participate!

Mailing lists:
CBM-SILICON@GSI.DE
CBM-SIMULATION@GSI.DE

Workgroup web pages on CBM_Wiki:
http://cbm-wiki.gsi.de → STS



STS Workgroup and Project Pages

... always under construction ...

Workgroup

Members

A list of workgroup members and their activities can be seen here.

Mailing Lists

- The workgroup's mailing list is CBM-SILICON@gsi.de
- Mail archive of CBM-SILICON@gsi.de
- Relevant information is also cc'd to CBM-SIMULATION@gsi.de
- Mail archive of CBM-SIMULATION@gsi.de

GSI Forum

Discussions take place in the STS Forum. Registration to the GSI forum system is required.

Meetings

Workgroup meetings are announced via the CBM-SILICON mailing list, with cc to CBM-SIMULATION.

- Conferencing Systems - for technical information click here
- STS Meetings in 2006
- STS Meetings in 2007

Workshops

- Workshop on Silicon detector systems for the CBM experiment at FAIR,
  CBM_Si_2007, GSI 18-20 April 2007

Workgroup Meetings 2007

STS workgroup meetings 2007

January
- 11 January 2007
- 18 January 2007
- 25 January 2007

February
- 1 February 2007
- 15 February 2007
- 22 February 2007

March
- 1 March 2007
- 8 March 2007
- 22 March 2007
- 29 March 2007

April
- no meetings in April due to Easter break and CBM Workshop on Silicon Detector Systems

May
- 3 May 2007
- 10 May 2007
- 24 May 2007
- 31 May 2007

June
- 14 June 2007

July
- 5 July 2007
- no meeting on 12 July 2007 (CPOD 2007 Workshop at GSI)
- 19 July 2007

August
- 16 August 2007
- 23 August 2007
- 30 August 2007

September
- 6 September 2007
- 13 September 2007
- 20 September 2007

Thursdays
14:00 -16:00

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Goal:

Regular joint meeting
~ (bi)monthly with the MVD Workgroup, now active at Frankfurt Univ.

To be put into practice !

Workgroup meeting one week ago

STS Workgroup Meeting, 20 September 2007

- STS Workgroup Meeting, 20 September 2007
  - Invitation
  - Participants
  - Agenda
  - Uploaded contributions/material
  - Minutes
  - Jump to

Invitation

E-mail to CBM-Silicon@gsi.de and CBM-Simulation@gsi.de: here

Participants

- **At GSI:** J. Heuser, V. Friese, A. Lymanets
- **Remote:** I. Kisel, M. Merkin

Agenda

1. Approval of minutes from the last meeting: (All)

http://cbm-wiki.gsi.de/cgi-bin/view/STS/13Sept2007

2. Report on Microstrip detector prototypes (Michael)
3. L1 tracking studies & dimensions of MVD stations (Ivan, Radek)
4. STS presentations at CBM Meeting Dresden (again) (Johann, all)
5. A.o.b.

Uploaded contributions/material

on agenda item 3: (by Ivan Kisel)

- I am working on track finding and see a strange thing, probably related to the second maps station - see attached pdf files: registered tracks (pdf) with at least one hit, accepted tracks (pdf) with at least 4 hits and mom larger 100 MeV. All tracks are primary. I expected that most tracks start at the first station, this is true, and others at the second station, which is not - they start at the third station. Has the second maps station a too large inner radius?
- Here is a distribution of those MC tracks with the first mc hit in the 3rd STS station: (2D pdf), (LEGO pdf)
- Attached is a hit density as a function of radius for all stations (you can easily find correspondence from the inner radius). Hit density at large radii seems very low. What if we increase strip length in the outer region? (pdf)

Minutes

written by J. Heuser, 20.9.2007

ad 1) I forgot to ask if anybody read the minutes of the last meeting. I will request approval at the next meeting.

ad 2) Michael reported:

- Double-sided microstrip sensor prototypes have been produced at ELMA. They seem not to work. This is currently being investigated and will be reported later.
- Michael is designing a new sensor, similar to the GSI-CIS design, based on discussions during J's visit to MSU in June.

ad 3) Ivan reported that he sees a suppressed number of tracks starting at the 2nd MVD station (standard STS in September version of CbmRoot). We should check the inner acceptance radius of the 2nd MVD station and of the 1st STS station. We should also check the STS geometry in the latest CbmRoot version Aug07.

Workshop on Silicon Detector Systems for the CBM experiment

GSI, April 18-20, 2007

www-aix.gsi.de/conferences/CBM_Si_2007

Goal:

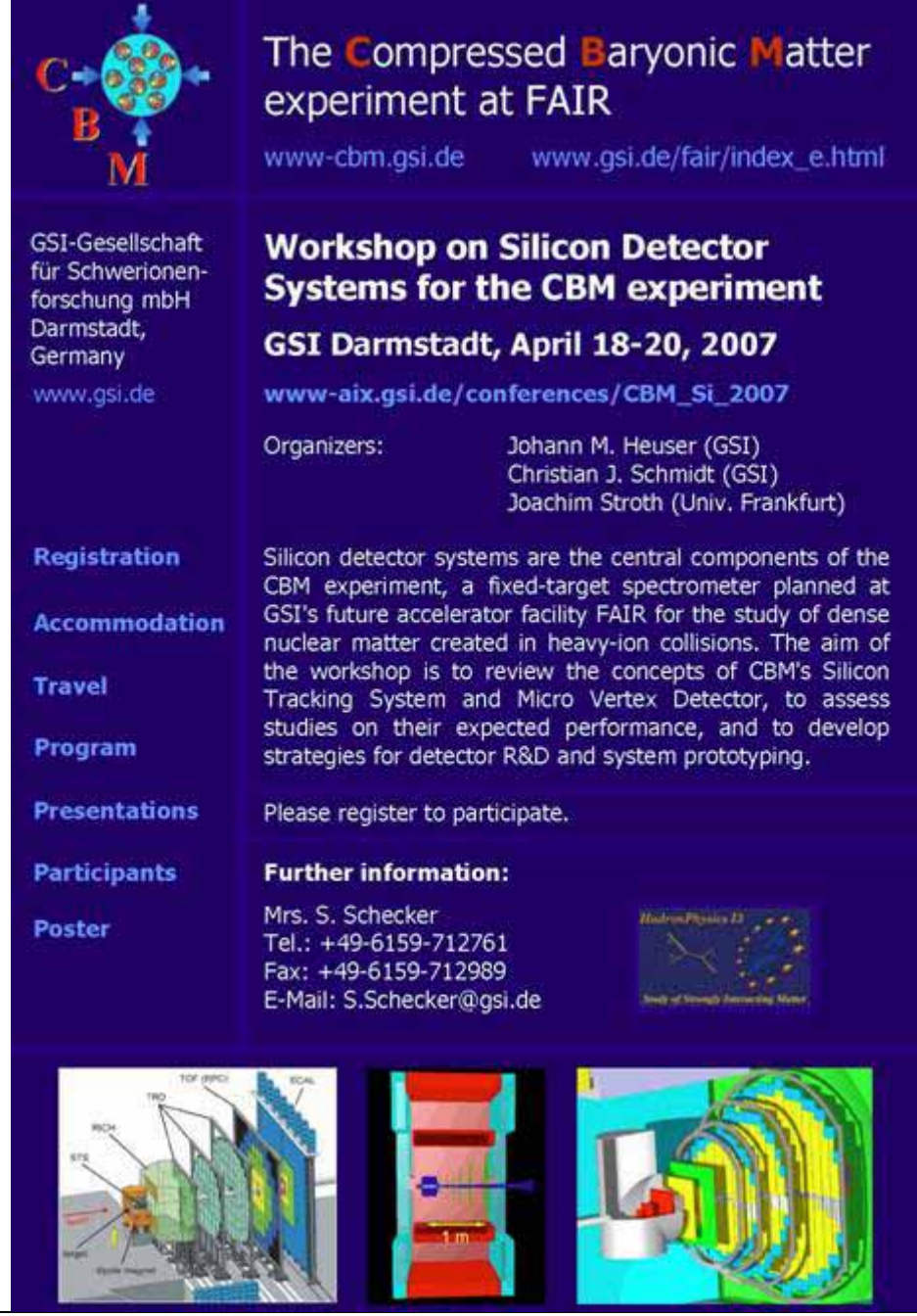
"Review the concepts of STS and MVD, assess studies on their expected performance, develop strategies for detector R&D and system prototyping."

- CBM overview talks
- Presentations from other FAIR groups (PANDA, Nustar)
- Presentations from external experts.

More than 80 participants.

Discussions, input, important event. Base for continued/new activities.

More (focused) workshops planned.



FAIR Newsletter No. 6
http://www-win.gsi.de/Fair-Newsletter
June 2007

FAIR Experiments

Workshop on Silicon Detector Systems for the CBM experiment at FAIR

Johann M. Heuser (GSI), Christian J. Schmidt (GSI) and Joachim Stroth (Univ. Frankfurt)

More than 80 silicon detector experts, CBM collaboration members and guests from GSI groups and other FAIR experiments participated in the three-day *"Workshop on Silicon Detector Systems for the Compressed Baryonic Matter experiment"* last month at GSI.

http://www-aix.gsi.de/conferences/CBM_Si_2007

The meeting was intended to initiate a critical review of performance expectations and the conceptual design of CBM's silicon detector systems, the central components for charged-particle tracking and micro-vertex detection.

The program covered a wide spectrum of topics:

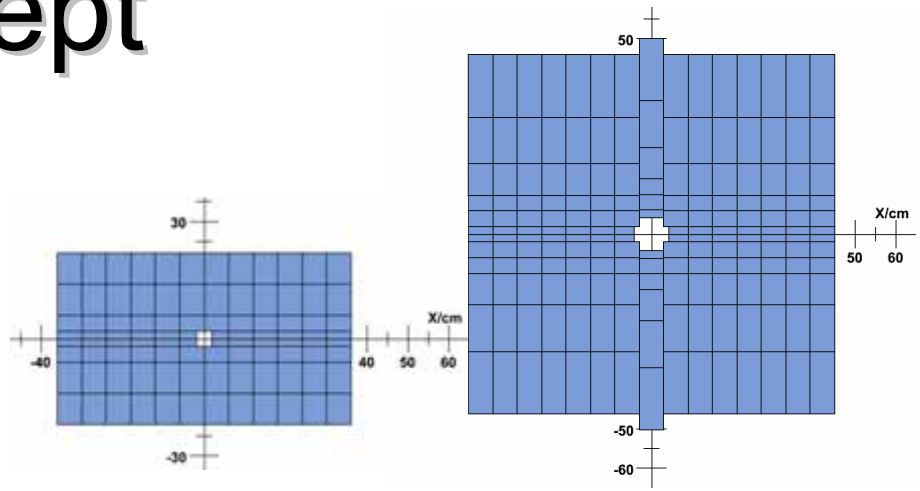
- silicon detector applications in the planned experiments CBM, PANDA and of NUSTAR at FAIR,
- experiences with the development and commissioning of silicon trackers at LHC,
- the status of established and new silicon detector technologies, as well as
- developments in readout electronics, mechanics and system integration aspects.

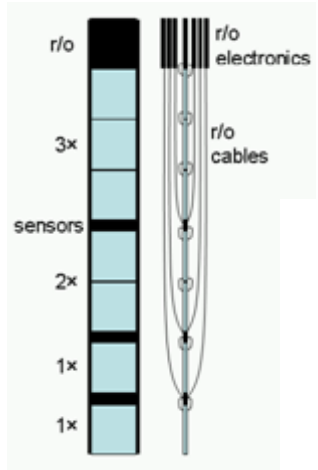
It also included review talks about Hybrid-Pixel Detectors (Norbert Wermes, Univ. Bonn and member of the ATLAS collaboration), and about novel 3-D technologies (Hans-Guenther Moser, MPI "Halbleiterlabor", Munich).

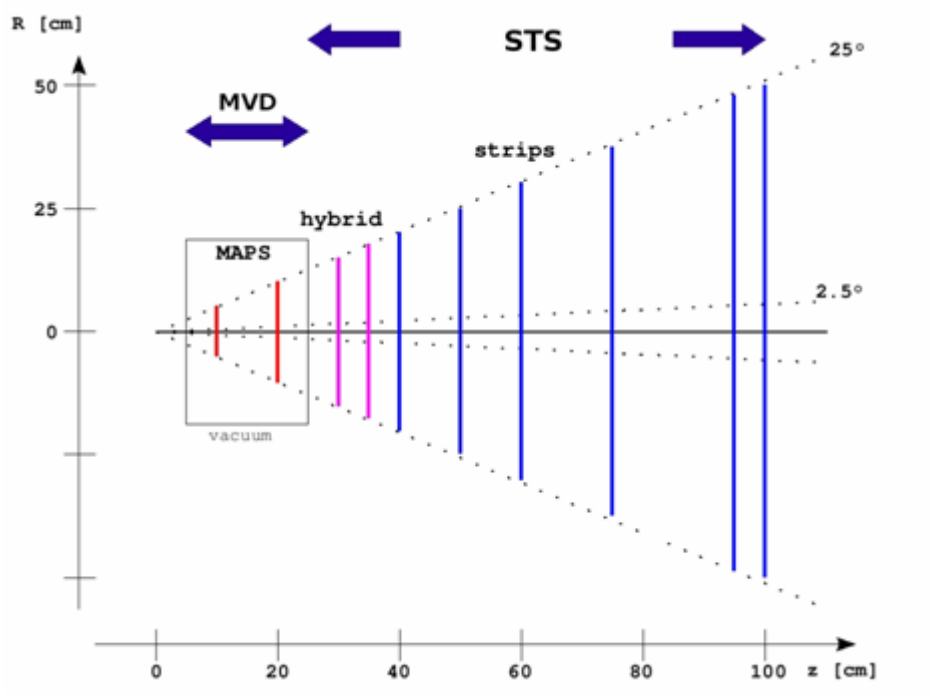
Valuable input and ideas enable the CBM collaboration to refine the systematic feasibility studies of its experiment and to structure the CBM silicon projects towards detector R&D and system prototyping.

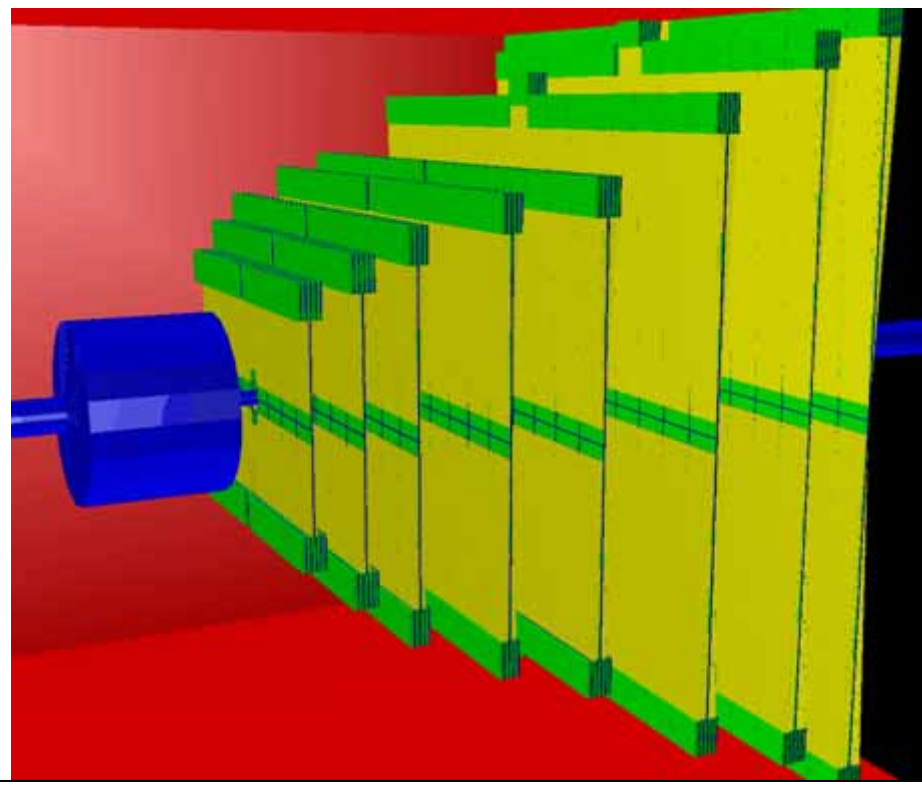
STS Concept

- Layout studies
- Performance evaluation
- Realistic sensors, support, material
- Detector system R&D









Where are we?

- Insight that the minimal detector system of earlier studies has been far too idealistic and insufficient:
- 6 tracking/vertexing stations
  → 2 vertexing + 8 tracking stations
- GEANT silicon discs + digitized sectors → realistic detector stations made from microstrip/pixel detectors.
- Microstrip sensors optimized.
- Tracking algorithms optimized.
- Gaps and support structures added. Material budget studied. Tools created: e.g. (STS) event display
- Realistic setup in CbmRoot Aug07.

→ detailed presentation by R. Karabowicz

Open questions

In particular:

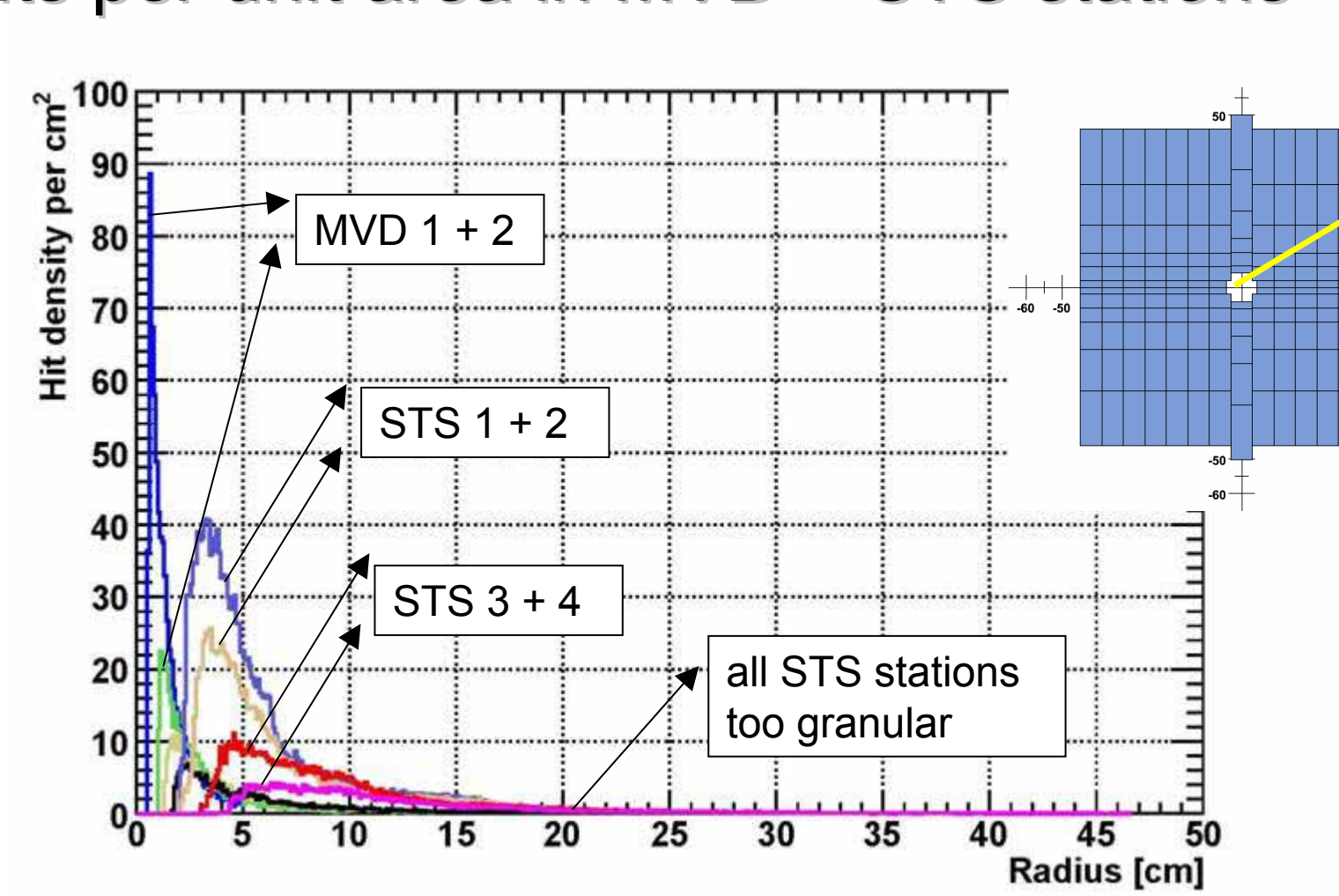
- What material budget per tracking or vertexing station is really realistic? And tolerable for physics?

"Microscopic" details important :

- Microstrips: Signal creation, strip cluster formation – when do we win in spatial resolution, when do we loose due to high occupancy.
- Are pixel detector stations required in the upstream STS?
- Station design not yet optimal: too many channels in outer regions.

To be addressed in simulation studies and hardware R&D

Hits per unit area in MVD + STS stations

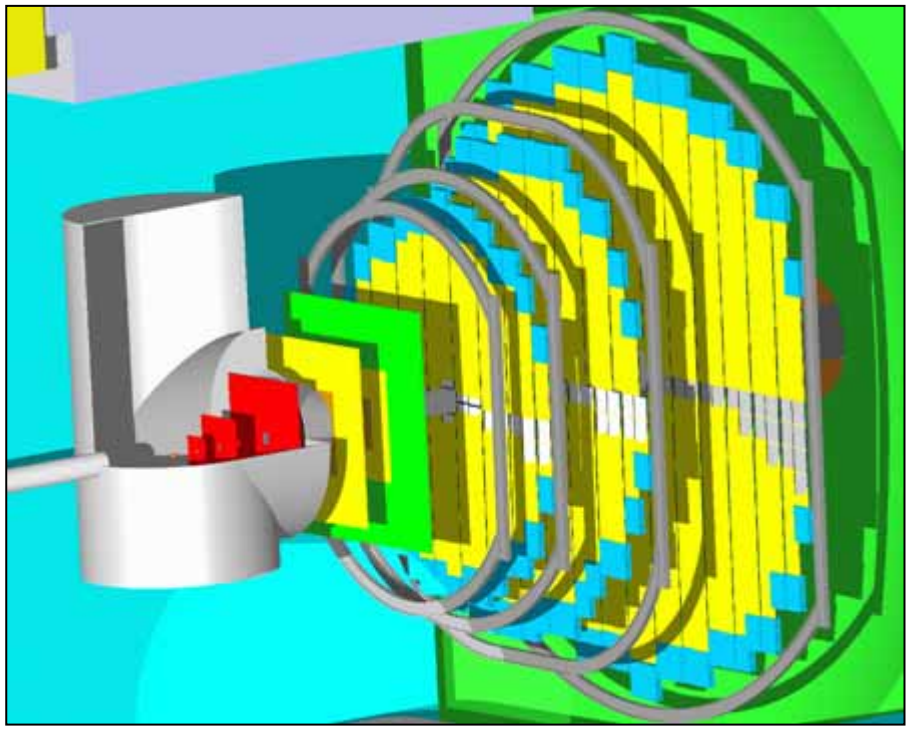


(plot: I. Kisel)

Beginning Detector Prototyping

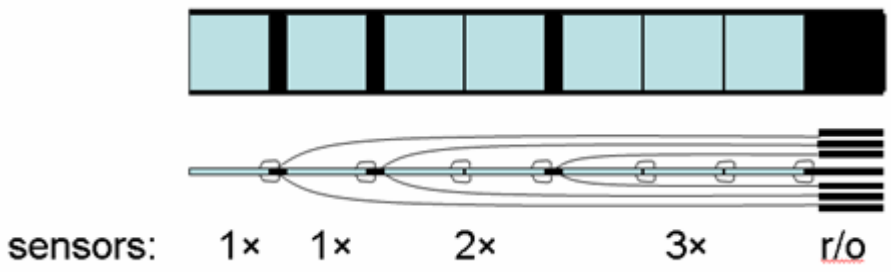
- Mechanical design study at ITEP
- Microstrip detectors at GSI-CIS
- Microstrip detectors at MSU
- Microcables from Kharkov
- Mechanical module support/ testing station from Kiev

Mechanical Design Study



CAD conceptional study,
S. Belogurov et al., ITEP, Fall 2006

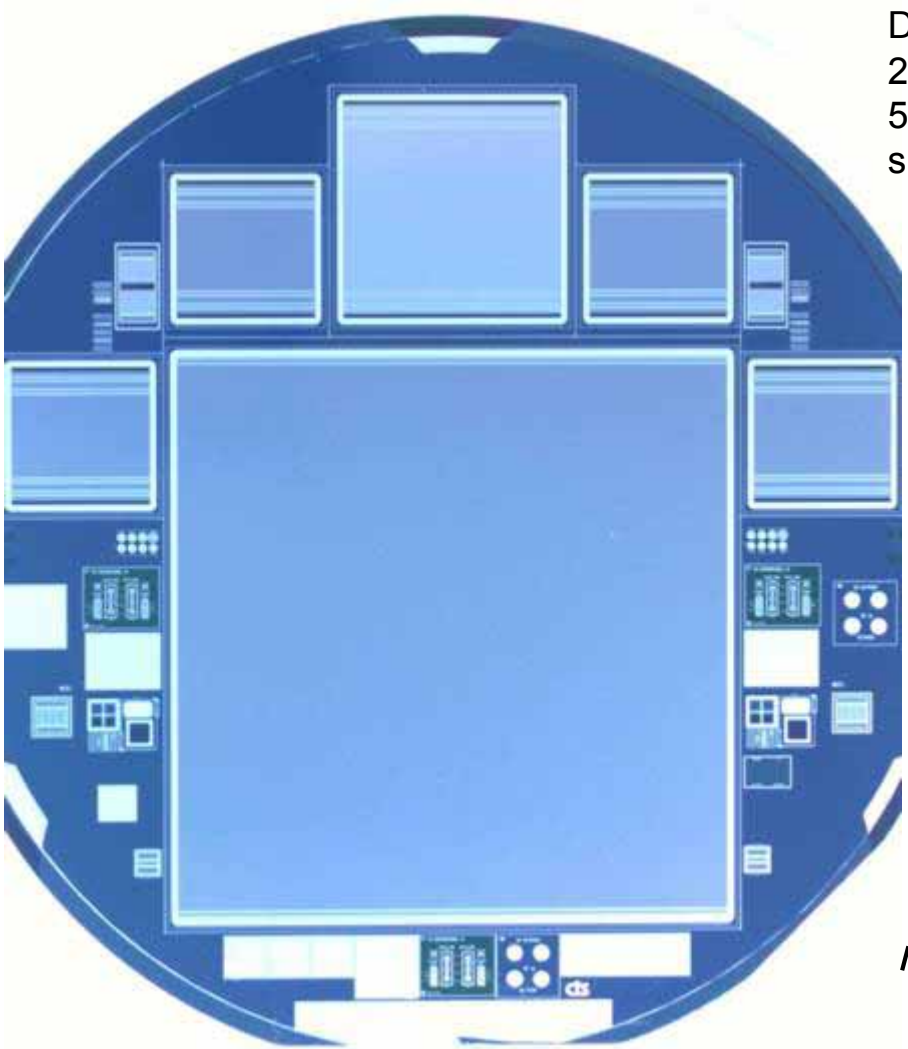
Two options for microstrip detector modules considered then.
Study finalized with one particular readout cable option.



Starting point for our beginning R&D on the detector system.
Iterations when more details on sensors/components are known.

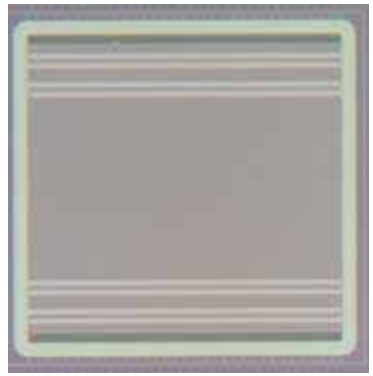
Microstrip detector prototype, GSI-CIS, 8/2007

4" wafer CBM01, 285 µm Si



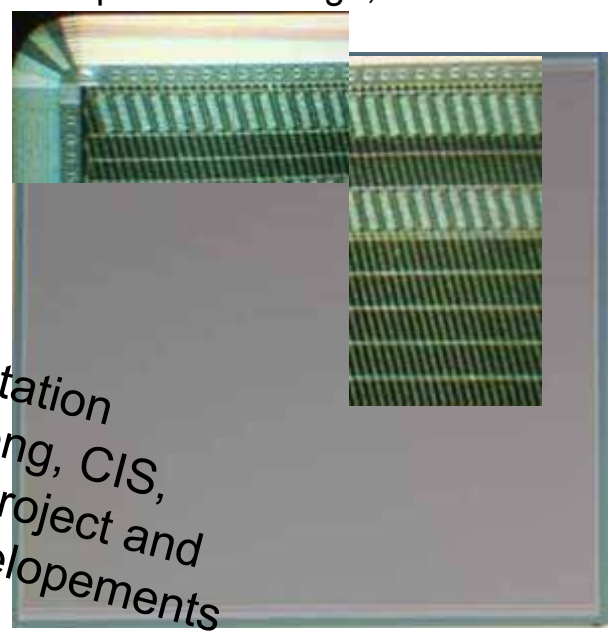
Test sensors

Double-sided, single-metal,
256×256 strips, orthogonal,
50(80) µm pitch,
size: 14×14 (22 ×22) mm^2



Main sensor

Double-sided, double-metal, 1024 strips per side,
50 µm pitch, 15° stereo angle, full-area sensitive,
contacts at top + bottom edge, size: 56×56 mm^2



Presentation by L. Long, CIS, on this project and new developements

CBM01 detectors, 8/2007

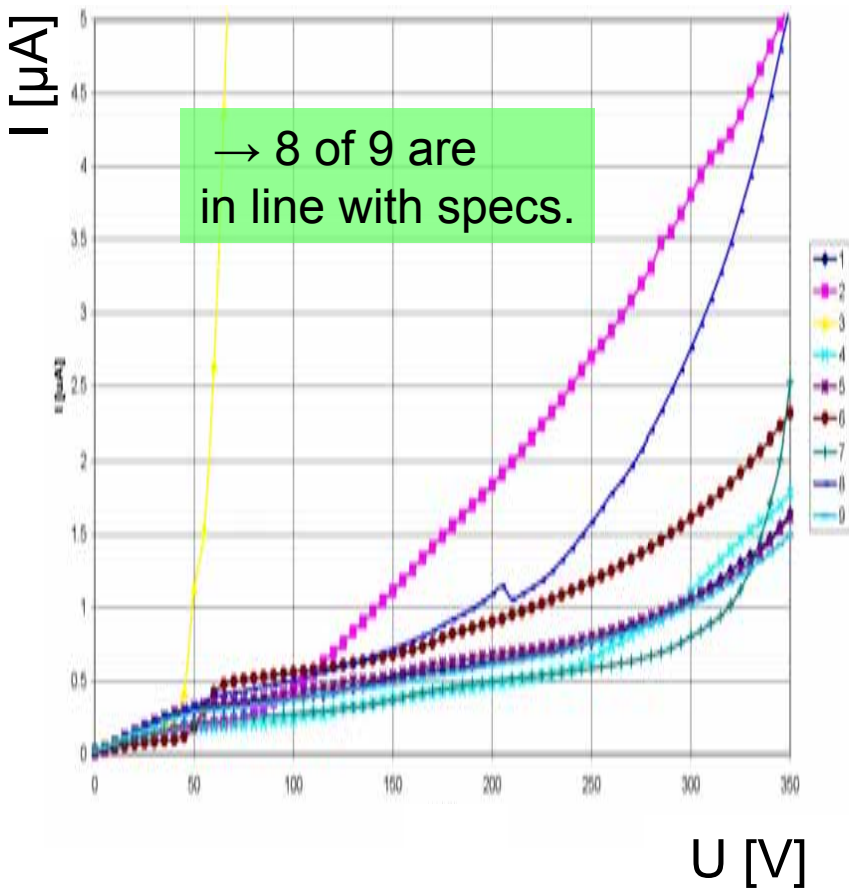
GSI – CIS Erfurt

Characterization CBM01 (I)

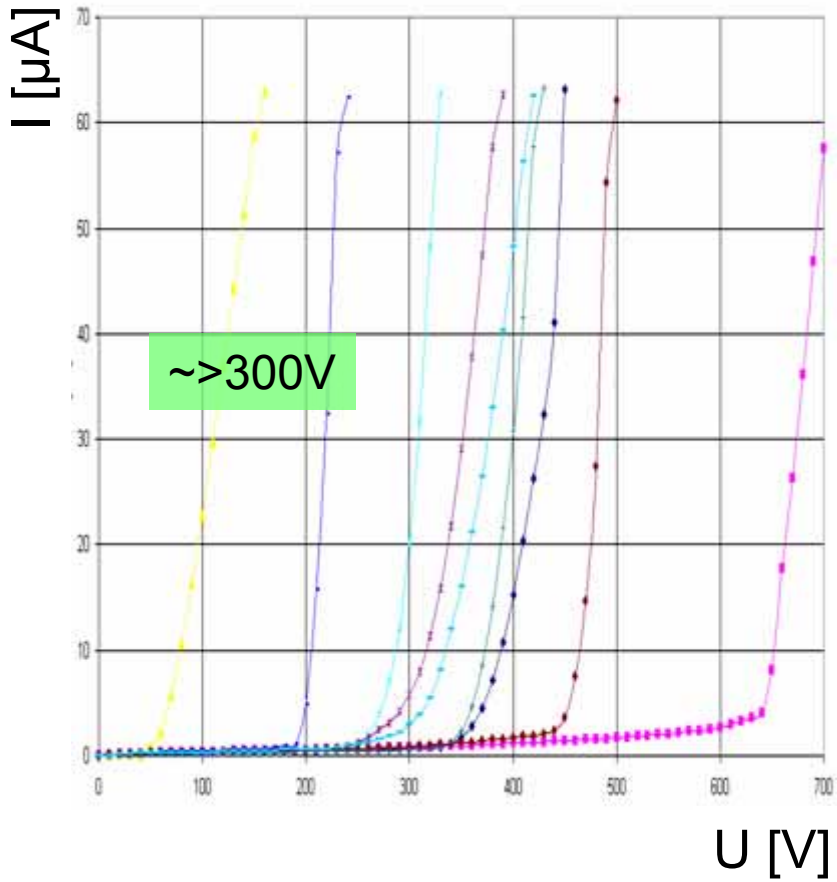
"Current-Voltage"

on-wafer results @ CIS, July 2007

"low voltage range"



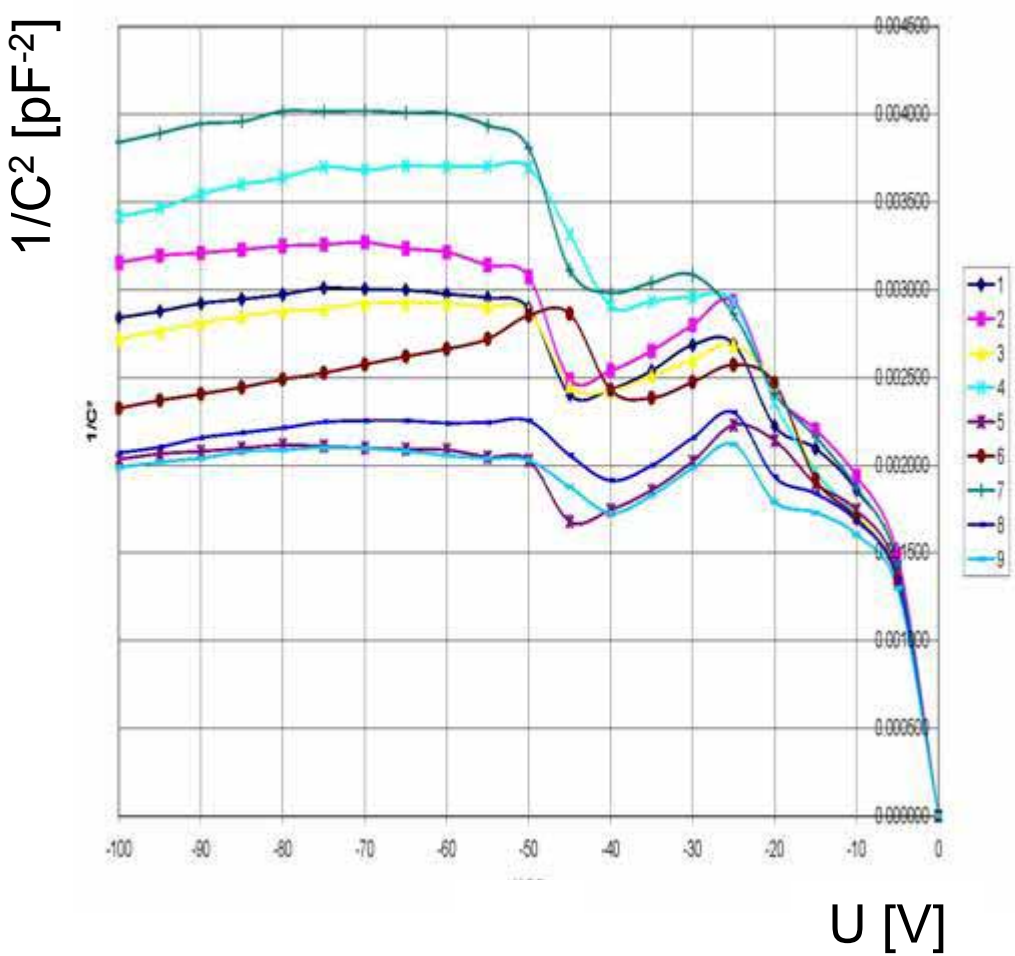
"find breakdown voltage"



Characterization CBM01 (II)

"Capacity-Voltage"

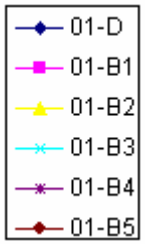
on-wafer results @ CIS, July 2007



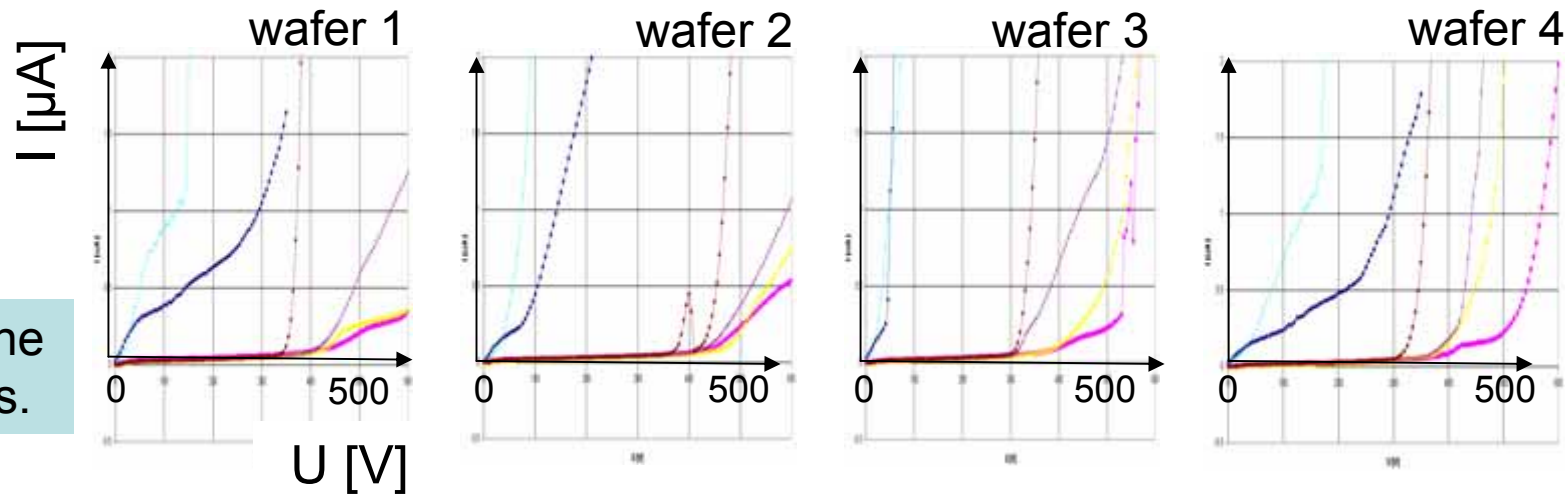
- Full depletion voltage: 50V.
- substrate ~5 kΩcm.
- Operation at 100V or less.

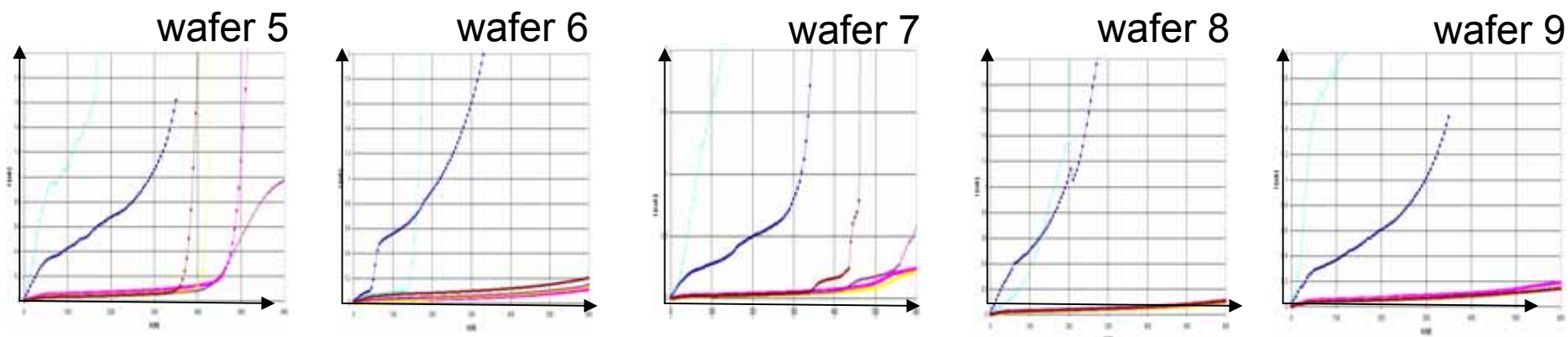
⟶ in line with specs:

Characterization CBM01 "Baby" sensors



→ most in line with specs.





Microstrip detector prototyping in Moscow

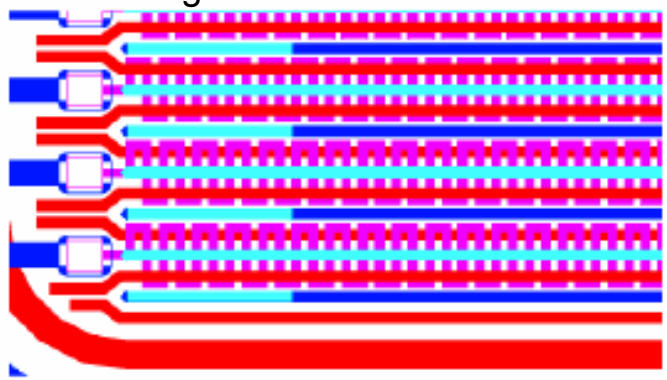
(team M. Merkin et al., MSU)

Double-sided sensors, ~6 × 2 cm.

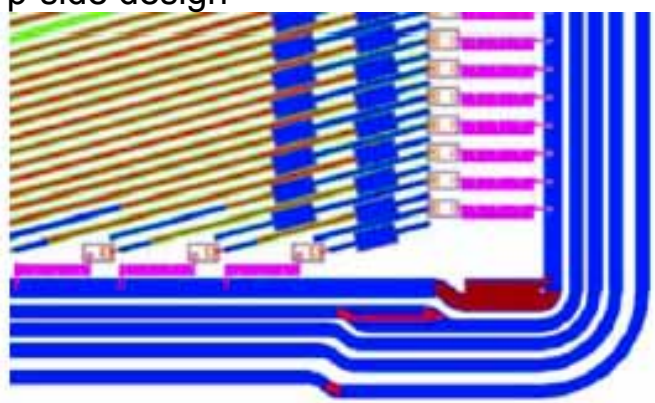
R&D program:

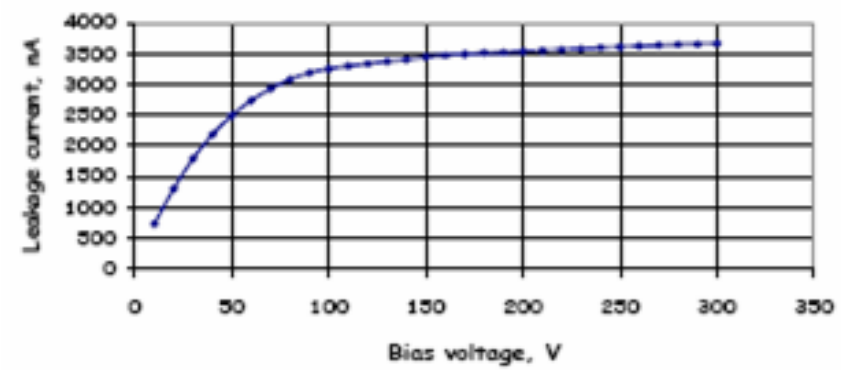
(1) Sensor design and mask production:
   a. Single-sided test detectors with 50 µm strip pitch and DC or AC readout.
   b. Double-sided sensors with 50 µm strip pitch and 15° stereo angle between front-and back sides. Strips poly-silicon biased, AC-coupled readout.
(2) Production of 250 µm sensors.
(3) Optimization of the sensor design.
(4) Technology optimization of the production process.
(5) Production of 200 µm sensors.
(6) Detailed tests of the produced sensors.

n-side design



p-side design



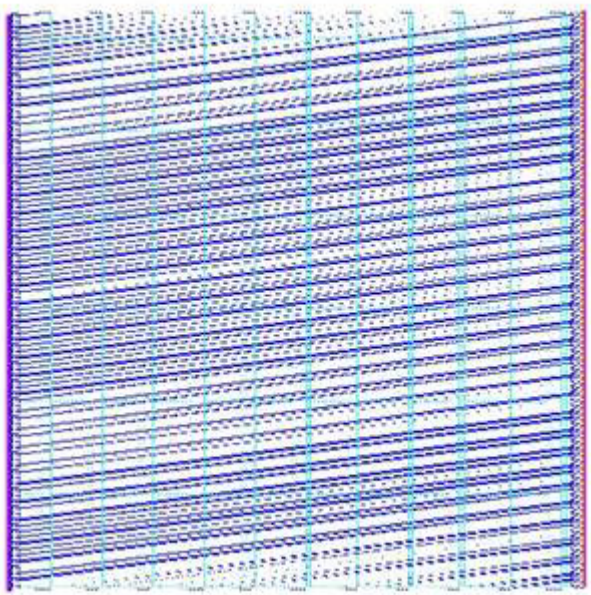


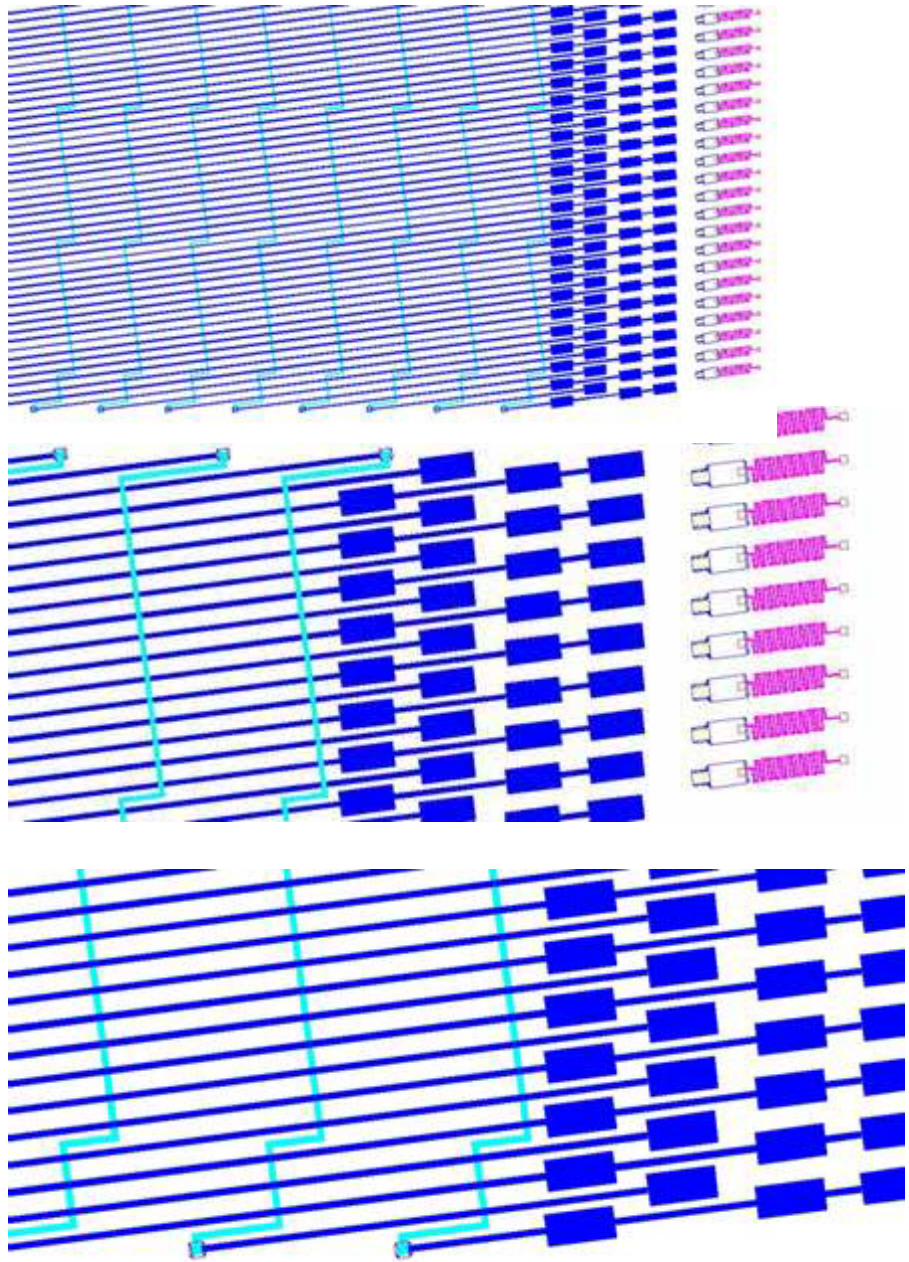
Single-sided sensors produced Spring 2007.
Current-voltage characteristik OK.

Produced 9/2007.
Not operational. Under investigation.

New MSU design

à la GSI-CIS, based on discussions at MSU in 6/2007



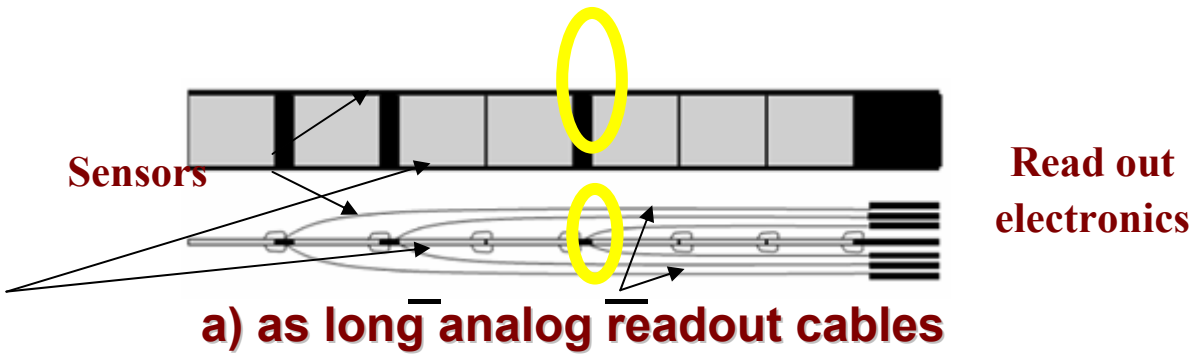


Double-sided sensor, 6×6 cm^2, 1024 ch/side, 58 µm pitch, 7.5° stereo angle, poly-silicon biassing, 2nd metal connection of corner region strips.

R&D on readout cable

Input from V. Borshchov (State Enterprise Scientific Research Technological Institute of Instrument Engineering, Kharkov Ukraine)

2 kinds of readout cables may be needed:



<u>One thinkable option:</u>

Chain sensors with a thin cable:
"daisy-chain cable"

Other possibility: wire bonding.

<u>Cable lengths, line pitch:</u>

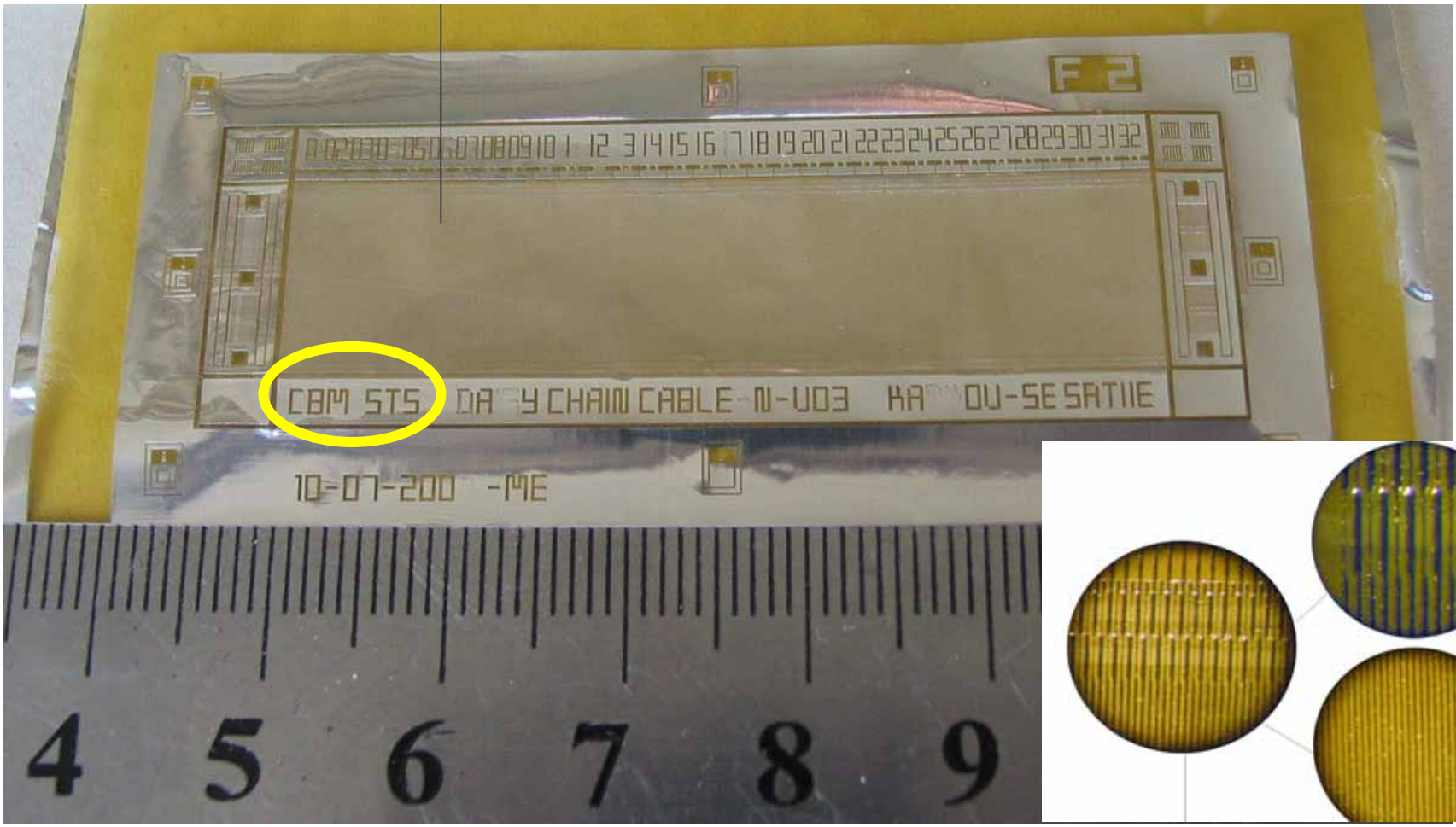
1) sensor:cable 1:1
50 µm line pitch:
Cable length limited. to <10 cm.
Candidate for daisy chain cable.

2) >100 µm line pitch: L up to 56 cm.
Two-layer cable, 100 µm
(50 µm eff). pitch for readout.

"Daisy-chain" Cable

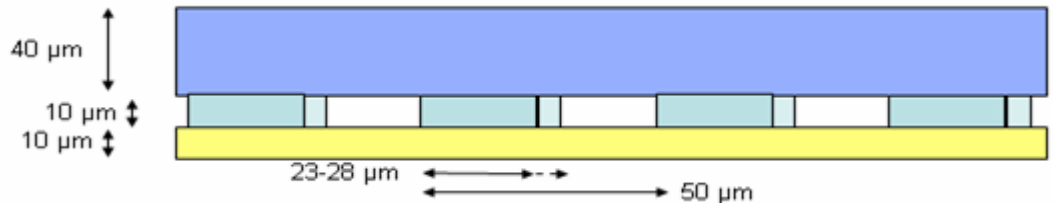
a first sample produced

V. Borshchov

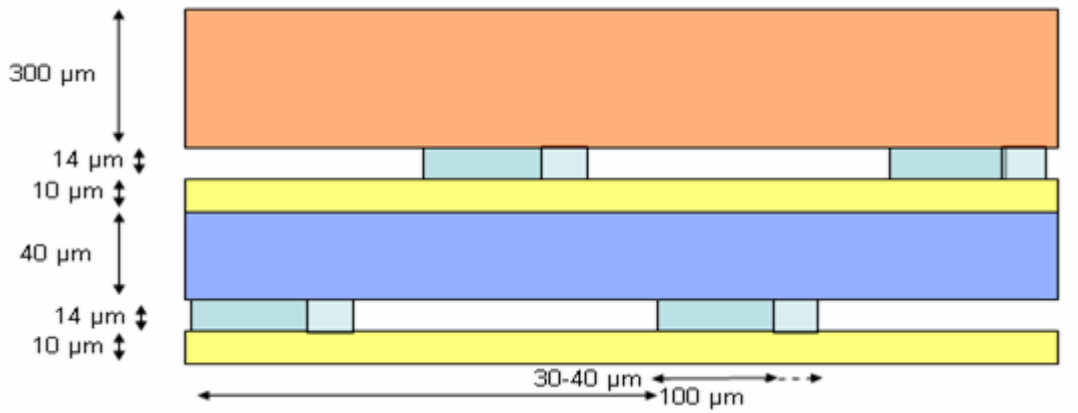


Analog readout cable – possible layouts?

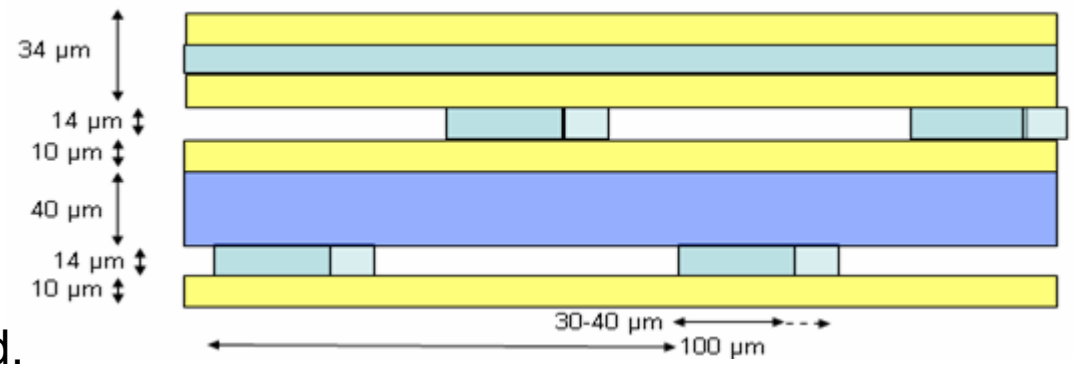
1) **Single-layer 50µm pitch**

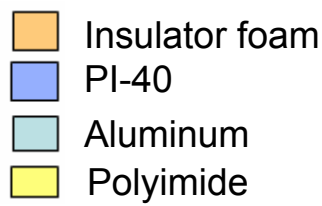


2) **Double-layer 100 µm pitch (50 µm eff.)**



3) **Double-layer with shielding**

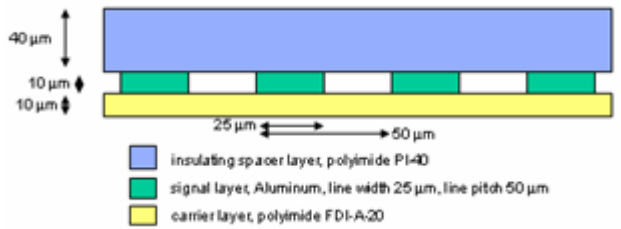


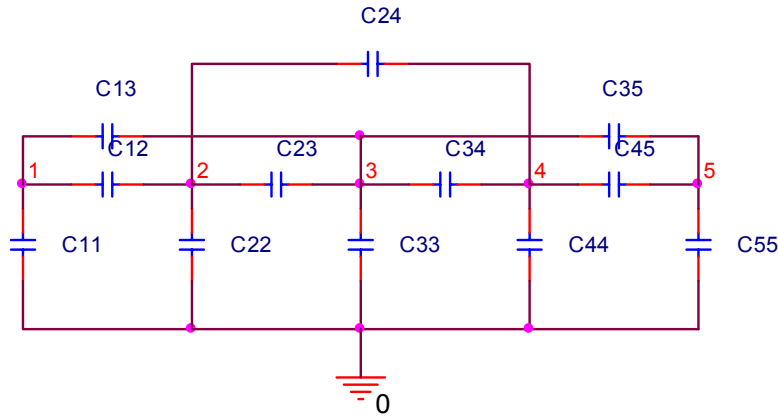


to be investigated.

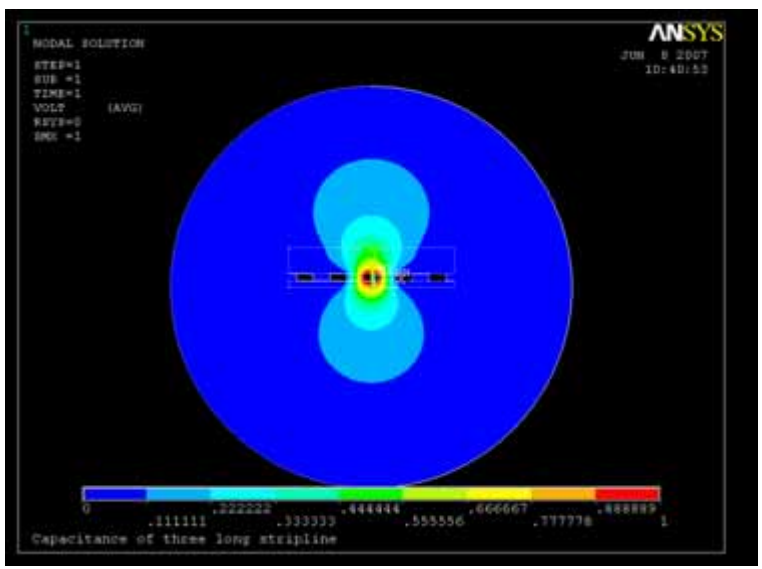
Electrical simulations

(L. Long, CIS)





Five strip lines are considered.
Middle strip 1V, all other strips 0V.



Cij	1	2	3	4	5
1	0.07771	0.4389	0.06232	0.01935	0.01271
2		0.03671	**0.3968**	0.05144	0.01935
3			0.03155	0.3968	0.06232
4				0.03671	0.4389
5					0.07771

Inter-strip capacitance represented by C23: **0.3968 pF/cm**.

Total inter strip capacitance: ~ x 2
→ **noise load for FE electronics.**

R&D on Module mechanical support

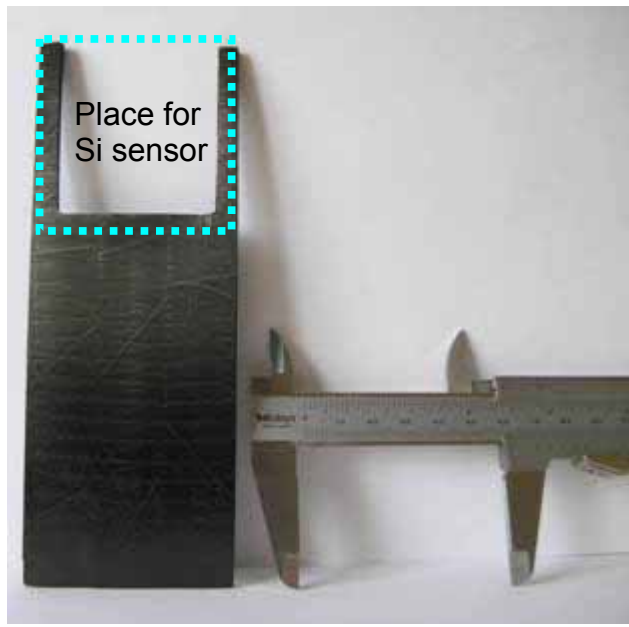
Cooperation with V. Pugatch, Kiev Institute for Nuclear Physics

First models of support frames for STS modules have been produced in Kiev at "Aeroplast" (www.agaeroplast.com).

2 types of support frames:

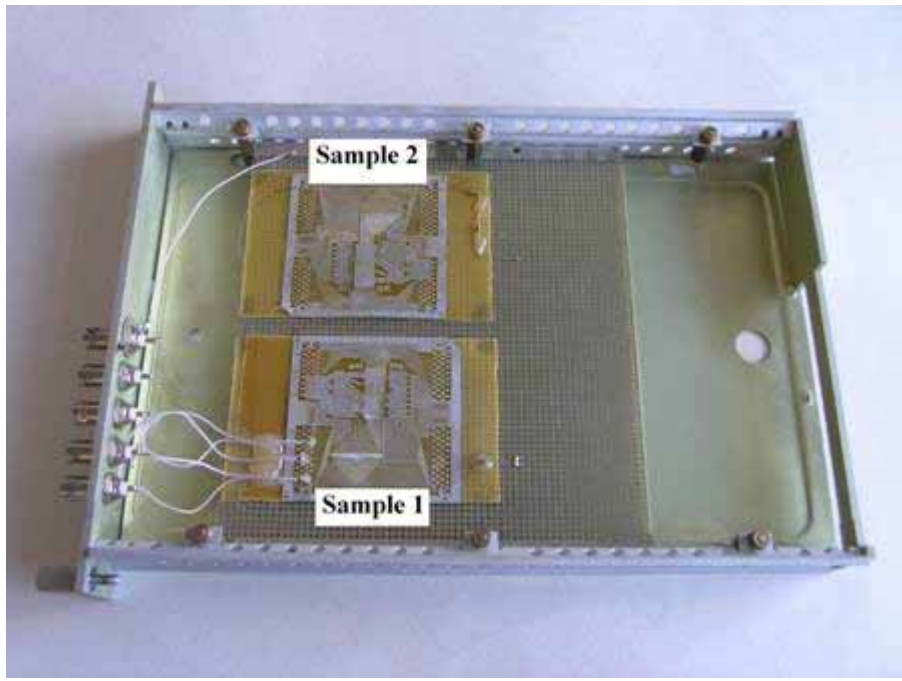
A solid rectangular plate of carbon fiber, light foams (density 0.1-0.2 g/cm^3) with small empty glass spheres, other materials with density 0.7-0.8 g/cm^3.
Size: ≈(60x200) mm^2.
Thickness: 1.65 mm

A hollow plate with channels for cooling agent inside and a "fork" at its end.
Size: (60x160) mm^2, relatively large thickness (3 mm).

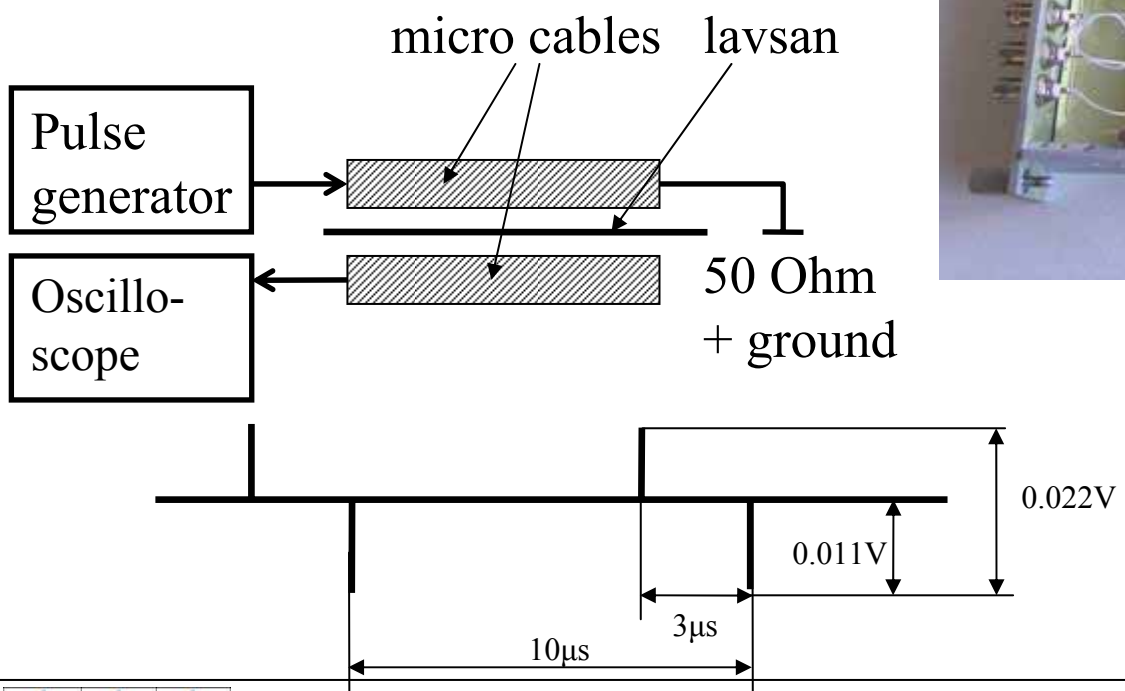


Pick-up measurements with microcables

Two samples of microcables provided by the Institute for Micro Devices



V. Pugatch et al.



One particular configuration:

pickup signal ~ 1%

Quality assurance setup for Si detectors

Goal:

Laser test stand for detector module characterization

XY scanning table, microscope,

LabView control software

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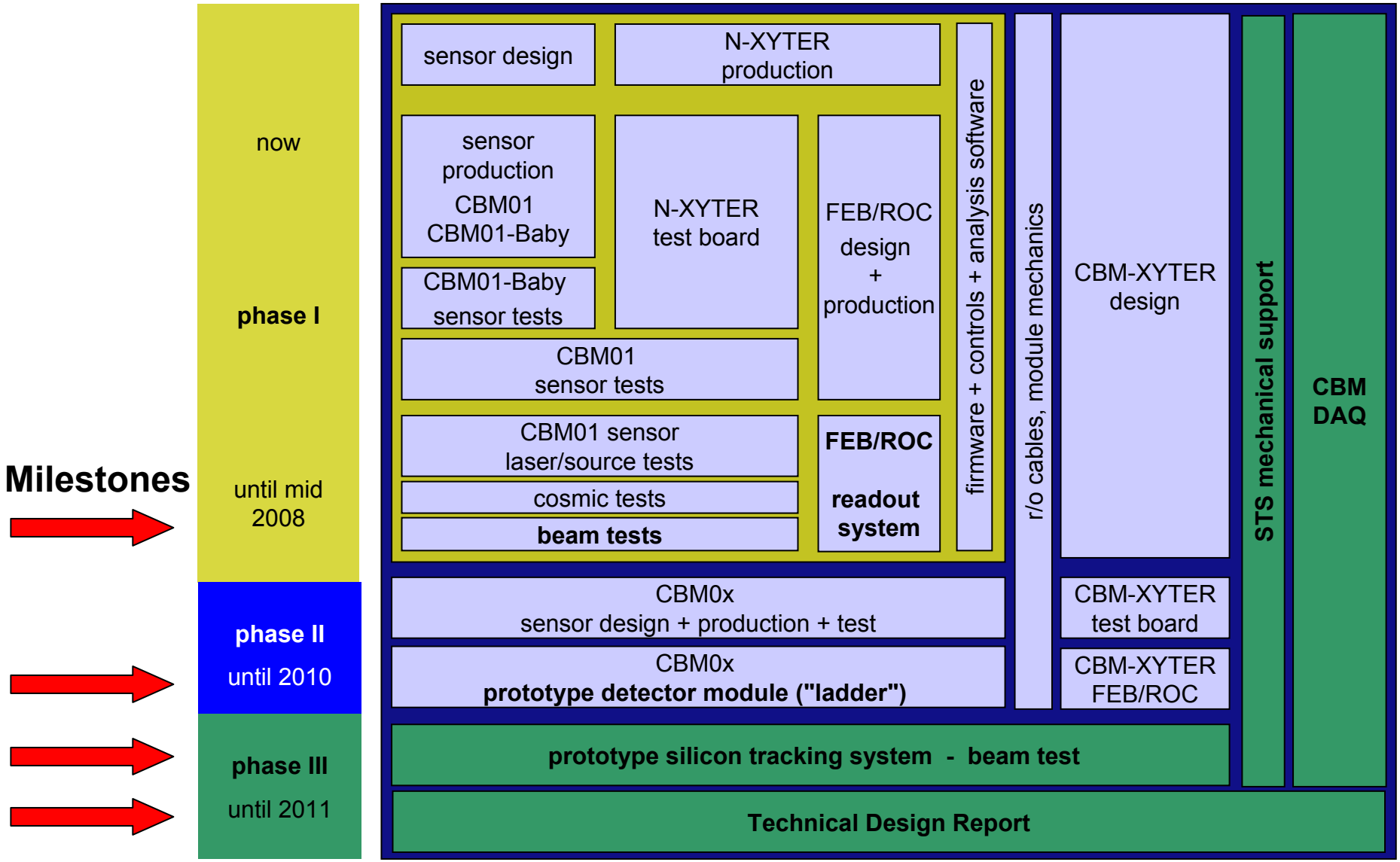
Towards a Project Planning and Milestones



Translated into tasks – Draft 20.4.2007 (I)

Task	participants	results 2007	results 2008	results 2009	results 2010
Radiation environment					
simulations: cooling of sensors required – yes or no?	GSI, ...		with FLUKA		
Detector layout					
simulations, track reconstruction	GSI	pitch, stereo angle, strip length	with realistic detector response	with fully detailed STS geometry	cross check with beam test results
design double sided strip layout	GSI, CIS, MSU	CBM01, digitizers in CbmRoot	with improved sensor, CBM02		
Sensor R&D					
CBM01	GSI, CIS	production, test	characterization		
CBM02	GSI, CIS	lessons from CBM01, plan new design	design, production, test	rad hard test, system integration	beam test prototype system
MSU01 (single sided)	MSU	production, test	rad hard test		
MSU02 (double sided)	MSU	design, production	test	rad hard test, system integration	beam test prototype system
Test boards					
test board Baby sensor & n-XYTER	HD, IFJ	production, test			
test board CBM01 & n-XYTER	IFJ	design	production	test	
test board MSU01/02 – sensor	MSU	design, production, test			
test board MSU01/02 + R/O chips	MSU		design, test	test	
Front-end board FEB					
design for 4 n-XYTER	GSI, IFJ	concept, design	production, test with CBM01	tests	
design for 8 n-XYTER or wait for the CBM-XYTER chip?	GSI, IFJ	concept	design	production, test with CBM02 or MSU02	beam test with full module including FEB

Translated into tasks – Draft 20.4.2007 (II)

Task	participants	results 2007	results 2008	results 2009	results 2010
Prototype detector					
module layout; sensor cooling if required by radiation	GSI, Kharkov, Kiev, ITEP, St. Peterburg	concept	design		
simulation of electrical properties	MSU, CIS	simulations	simulations		
cables, connections	Kharkov	R&D, design	demonstrators	prototypes	final prototypes
mechanical structure, module	ITEP, St. Petersburg, Kiev	design	refined design	demonstrators, mockup	
mechanical structure, STS station	ITEP, St. Petersburg, Kiev	pre-studies	design	refined design	mockup
demonstrator module	Kiev, Kharkov	concept, test	production		
quality assurance tests	Kiev	design laser test	production laser test stand	utilization for prototype sensors	
radiation hardness of other components: cables, connections	MSU, St. Petersburg	good and bad materials? What tests to perform.	Preparations	radiation tests	refined tests
Test beam stand at GSI, prototype tracker	GSI + CBM Collab.	design	setup, tests of demonstrators	tests of prototype module	test of proto-type tracking system
DAQ, controls, on-line, off-line software	GSI, more CBM Inst.	concept	implementation	ready	ready
Milestones:					
STS prototype	Collaborative effort of CBM	project team, project plan	source/cosmic tests with first CBM01 module	beam test with prototype module	beam test of prototype tracking system
Technical Design Report					after those steps accomplished, in 2011

R&D projects – ongoing, approved or proposed

→ find partners, funding,
establish work packages,
explore technologies ←

GSI-launced R&D cooperations:

e.g.

- GSI-Moscow State Univ.
- GSI-Polish Institutes
- GSI-Kiev Inst. for Nucl. Research

International Science and Technology Center (ISTC):

Project "CBM Silicon Tracker"
(GSI, KRI St. Petersburg,
MSU Moscow, IPHC Strasbourg)

Details to be discussed, Dubna 11/2007

Hadronphysics2 I3 JRA: 9/2007

Proposal: "Ultra-thin silicon tracking and vertex detection systems"

3 sub-projects, 10 teams

- Low-mass silicon microstrip tracking
- Low-mass pixel tracking system
- Ultra-low mass pixel vertex detector

Finnland:

FAIR member, in-kind contribution to CBM with microstrip detectors.

- Discussions at CERN 2/2007
  (J. Heuser, A. Heikkilä, J. Harkonen)
- Presentation at CBM_Si_2007
- FAIR-BMBF-Finnland negotiations 8/07
- Figure out how to make use of it.

Summary
on the status of STS development

- Simulation of detector system on a good way.
- Persistent work in STS Workgroup pays off.
- Dedicated people essential.
- Detector R&D is now important.
  Also dedicated teams required here.
  Sufficient funding required.
- We see beginning activities here but not strong enough yet.
- Clear roadmap and consequent check of milestones essential.

I ask the Collaboration & partners to join in a serious, strong effort.