

The Joint Research Activity “*ULISI*” of EU-FP7 HadronPhysics2

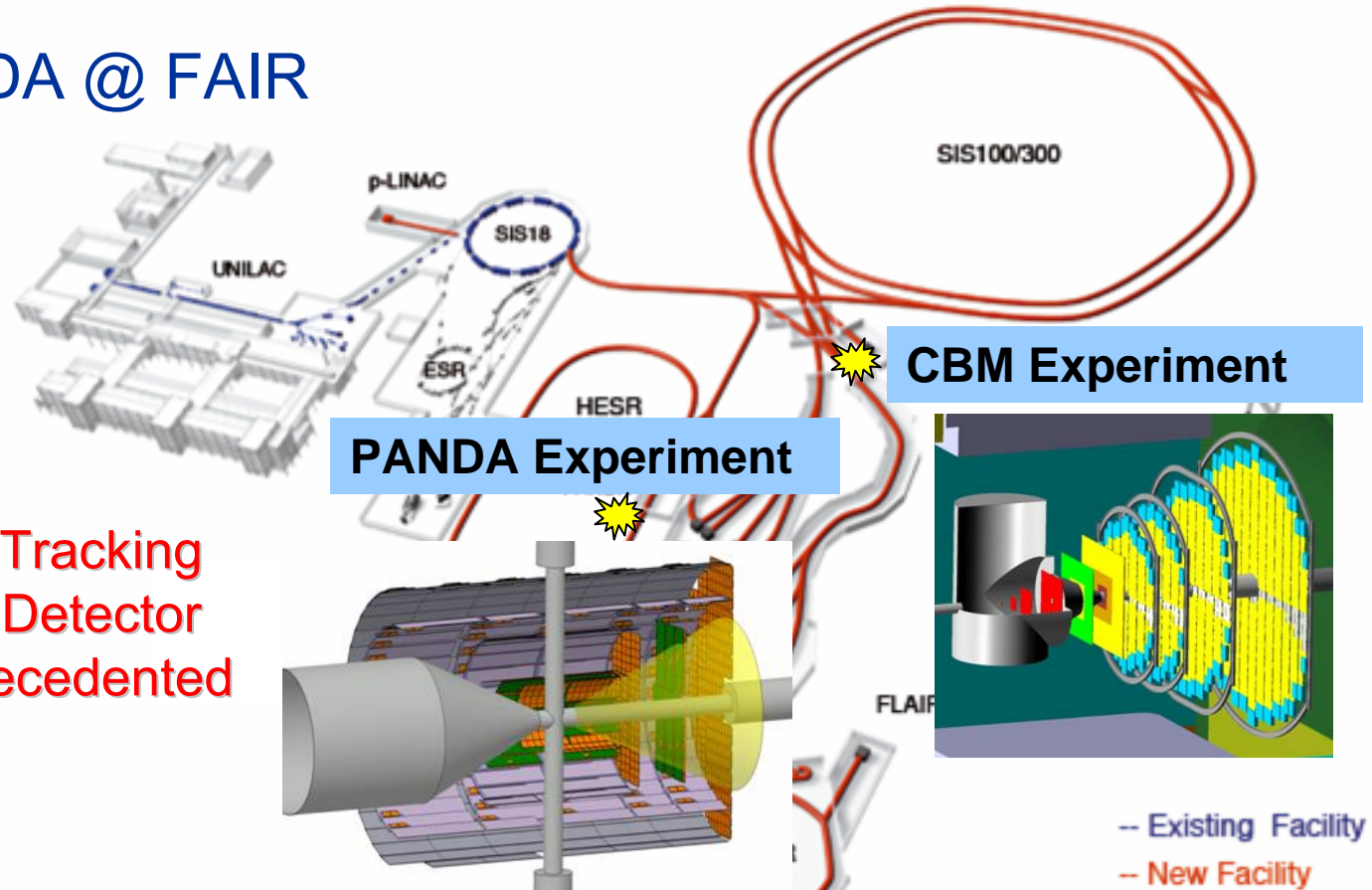
“Ultra-light silicon tracking and vertex detection systems
for frontier precision experiments“

Johann M. Heuser
GSI Helmholtz Center for Heavy Ion Research GmbH,
Darmstadt, Germany

Concluding meeting during the
Workshop on system integration of highly granular and thin vertex detectors,
Mont Sainte Odile, France, 6-9 September 2011

Frontier precision hadron physics experiments

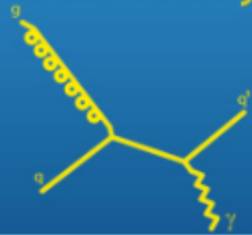
■ CBM, PANDA @ FAIR



Ultra-light Silicon Tracking and Micro Vertex Detector Systems for unprecedented new physics

- STAR, PHENIX @ RHIC upgrades
- ALICE @ LHC upgrades
- Current + future fixed-target heavy-ion experiments @ SPS

HadronPhysics2



Study of Strongly Interacting Matter

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The project "Study of Strongly Interacting Matter" (acronym HadronPhysics2) is an Integrated Activity (IA) of the Seventh Framework Programme (FP7) of EU.

The project deals with one of the most challenging problems in contemporary physics, namely the study of particles which interact through the so called "strong force" (hadrons).



Networking
Activities

Joint
Research
Activities

Transnational
Access

Work packages

WORK PACKAGES LIST/OVERVIEW

Work Package No.	Work package title	Activity type
WP1	Management of the consortium	MGT
WP2	TORIC - Theory of Relativistic Heavy Ion Collisions	COORD
WP3	TMDnet - Mapping out the Transverse Structure of the Nucleon	COORD
WP4	QCDnet - Hadron physics in non-perturbative QCD	COORD
WP5	PrimeNet - Meson Physics in Low-Energy QCD	COORD
WP6	SPHERE - Strange Particles in Hadronic Environment Research in Europe	COORD
WP7	FAIRnet - A worldwide research networking activity for experiments on QCD at FAIR	COORD
WP8	ReteQuarkonii - Testing phases and non perturbative features of QCD with quarkonium production	COORD
WP9	LEANNIS - Low Energy Antikaon-Nucleon and -Nucleus Interaction Studies	COORD
WP10	ECT* - Transnational Access to ECT*	SUPP
WP11	MAMI - Transnational Access to MAMI	SUPP
WP12	GSI - Transnational Access to GSI	SUPP
WP13	COSY - Transnational Access to COSY	SUPP
WP14	LNF - Transnational Access to INFN-LNF	SUPP
WP15	CARAT - Advanced Diamond Detectors	RTD
WP16	SPINMAP - Spin Oriented Nuclei for Structure Mapping	RTD
WP17	FPCC - Frontier Photon detectors for Cherenkov counters	RTD
WP18	FutureGas - Development of large-area low-mass self-triggered gaseous detectors	
WP19	FutureJet - Cryogenic jets of nano- to micro-sized particles for hadron physics	

WP20	DIRCs - Development of Fast, Compact Cherenkov-counters based on the Detection of Internally Reflected Cherenkov Light	RTD
WP21	SciFi - Frontier scintillation detectors: inorganic scintillating fibers and performance control	RTD
WP22	LatticeQCD - Lattice Quantum Chromodynamics	RTD
WP23	HardEx - Hard Exclusive Reactions	RTD
WP24	JointGEM - Ultra-light and ultra-large tracking systems based on GEM technology	RTD
WP25	ULISI - Ultra-light silicon tracking and vertex detection systems for frontier precision experiments	RTD
WP27	JETCAL - Electromagnetic Calorimeter for Jet Quenching Study	RTD
WP28	SiPM - Avalanche Micro-Pixel Photo Diodes for Frontier Detector Systems	RTD

Work package number	WP26	Start date	01/01/2009		
Activity Type	RTD				
Work package acronym	ULISI				
Work package title	Ultra-light silicon tracking and vertex detection systems for frontier precision experiments				
Beneficiary number	Organization legal name <i>(in italics the Research Units)</i>	Short name	Activity leaders <i>(in bold the spokesperson)</i>	Human effort <i>(person-months)</i>	
9	Gesellschaft für Schwerionenforschung mbH	GSI	J. Heuser	10 (66)	
1	Istituto Nazionale di Fisica Nucleare	INFN		10 (81)	
	<i>INFN Sezione di Torino</i>	<i>INFN-TO</i>	<i>A. Rivetti</i>	<i>10 (81)</i>	
16	Johann Wolfgang Goethe Universität Frankfurt am Main	GUF	J. Stroth	10 (51)	
29	Centre National de la Recherche Scientifique	CNRS		38 (38)	
	<i>CNRS/IN2P3 Pluridisciplinaire Hubert Curien, Strasbourg</i>	<i>Institut CNRS/IN2P3/IPHC</i>	<i>M. Winter</i>	<i>38 (38)</i>	

Other involved institutions not receiving EC funds	Activity leaders	Estimated human effort involved in the WP
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Interuniversity Microelectronic Centre (IMEC), Louvain (Belgium)	P. De Moor	(6)
Institute for Nuclear Research (INR), National Academy of Science of Ukraine, Kiev (Ukraine)	V. Pugatch	(6)
State Enterprise Scientific Research Technological Institute of Instrument Engineering (SE SRTIIE), Kharkov (Ukraine)	V. Borshchov	(10)
Forschungszentrum Jülich GmbH	FZJ	(20)
<i>Forschungszentrum Jülich</i>	<i>FZJ</i>	<i>T. Stockmanns</i> (20)
Rheinische Friedrich-Wilhelms-Universität Bonn	UBO	(6)
<i>Universität Bonn</i>	<i>UBO</i>	<i>K.-T. Brinkmann</i> (6)

Duration:

01/01/2009 - 30/06/2011

extended to 31/12/2011 due to the delayed start

Budget: 290 kEuro

WP26: ULISI							
REQUESTED EC CONTRIBUTION PER BUDGETARY ITEM AND PER BENEFICIARY							
Contr. No	Contractor Acronym	Personnel (EUR)	Consumables (EUR)	Travel and workshops (EUR)	Total direct costs (EUR)	Indirect costs (EUR)	Requested EC contribution (EUR)
1	INFN	30.000	15.000	4.000	49.000	29.400	78.400
	<i>INFN-TO</i>	<i>30.000</i>	<i>15.000</i>	<i>4.000</i>	<i>49.000</i>	<i>29.400</i>	<i>78.400</i>
9	GSI	30.000	15.000	4.000	49.000	6.000	55.000
16	GUF	30.000	15.000	4.000	49.000	29.400	78.400
29	CNRS	30.000	15.000	3.875	48.875	29.325	78.200
	<i>CNRSAN2P3IPHC</i>	<i>30.000</i>	<i>15.000</i>	<i>3.875</i>	<i>48.875</i>	<i>29.325</i>	<i>78.200</i>
	TOTAL	120.000	60.000	15.875	195.875	94.125	290.000

3 ULISI Sub-Projects

Sub-Project	Title	Activity leader
P1	Low-mass large-area silicon microstrip detector system for particle tracking	J. Heuser (GSI)
P2	Low-mass silicon pixel detector system for particle tracking	A. Rivetti (INFN Torino)
P3	Ultra low-mass silicon pixel detector system for micro-vertex detection	M. Winter (IPHC Strasbourg)

Achieve tracking system with readout electronics only outside of the aperture.

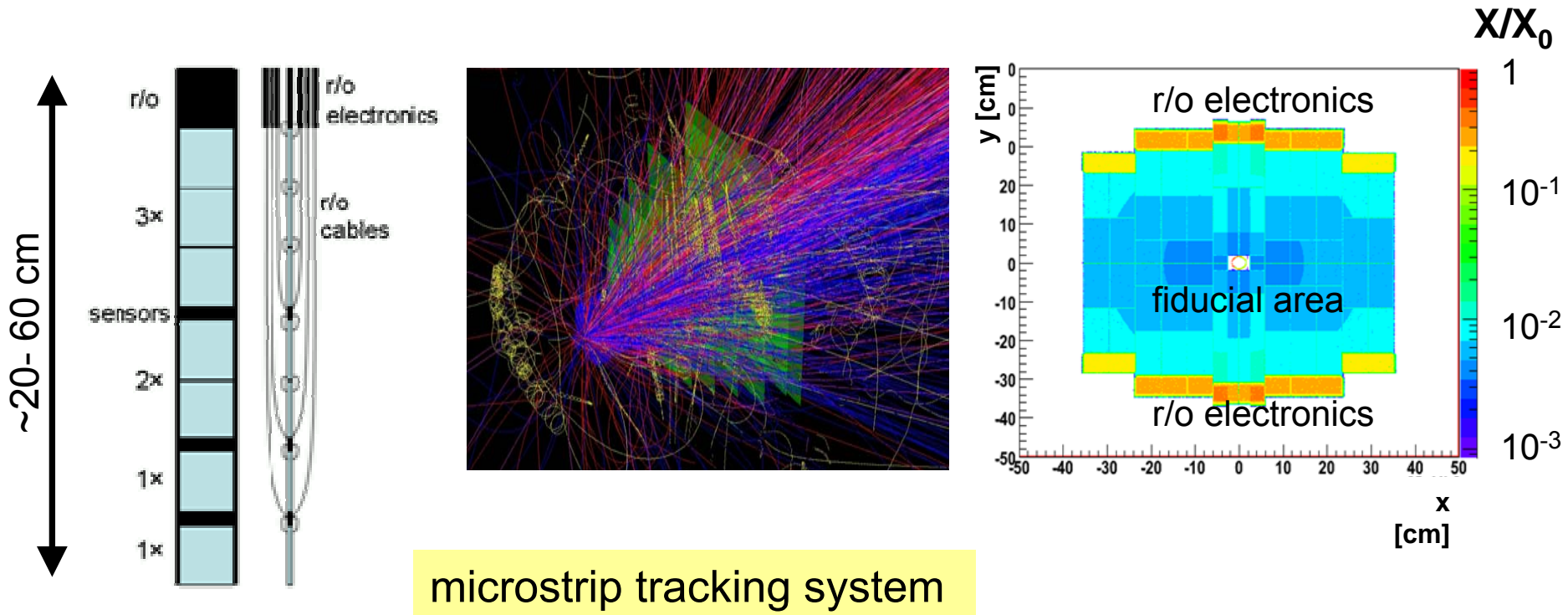
Achieve low-mass pixel tracking system in thin hybrid technologies.

Achieve ultra-thin pixel vertexing system – thin sensors on thin (diamond) carrier.

Innovations/European added value:

through synergies on high-technologies and knowledge of their application in high-energy physics, micro electronics/systems, space research, hadron physics

Low-mass large-area microstrip tracker



Development of a demonstrator tracking module with:

- Low mass carbon fiber support
- Ultra-thin Al-Polyimide readout cables
- Microstrip sensors
- High-density readout boards

Participants

GSI Darmstadt ([J. Heuser](#), activity leader), **SE SRTIIE Kharkov** (V. Borshchov),
INR Kiev (V. Pugatch), **UBO Bonn** (K.-T. Brinkmann)

Timeline

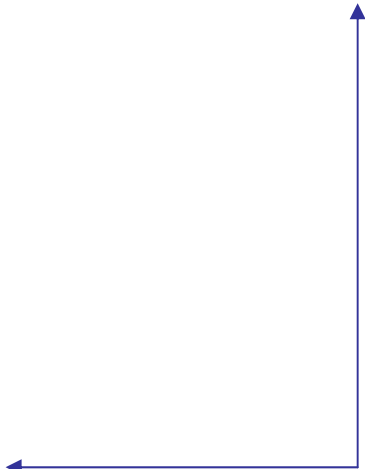
Tasks	2009				2010				2011			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Production of a low-mass support structure	X	X	X	X	X	1						
Production of ultra-thin microstrip readout cables	X	X	X	X	X	2						
Assembly of a demonstrator module	X	X	X	X	X	X	X	3				
Demonstrator low-mass tracking system	X	X	X	X	X	X	X	X	X	4		

Milestones:

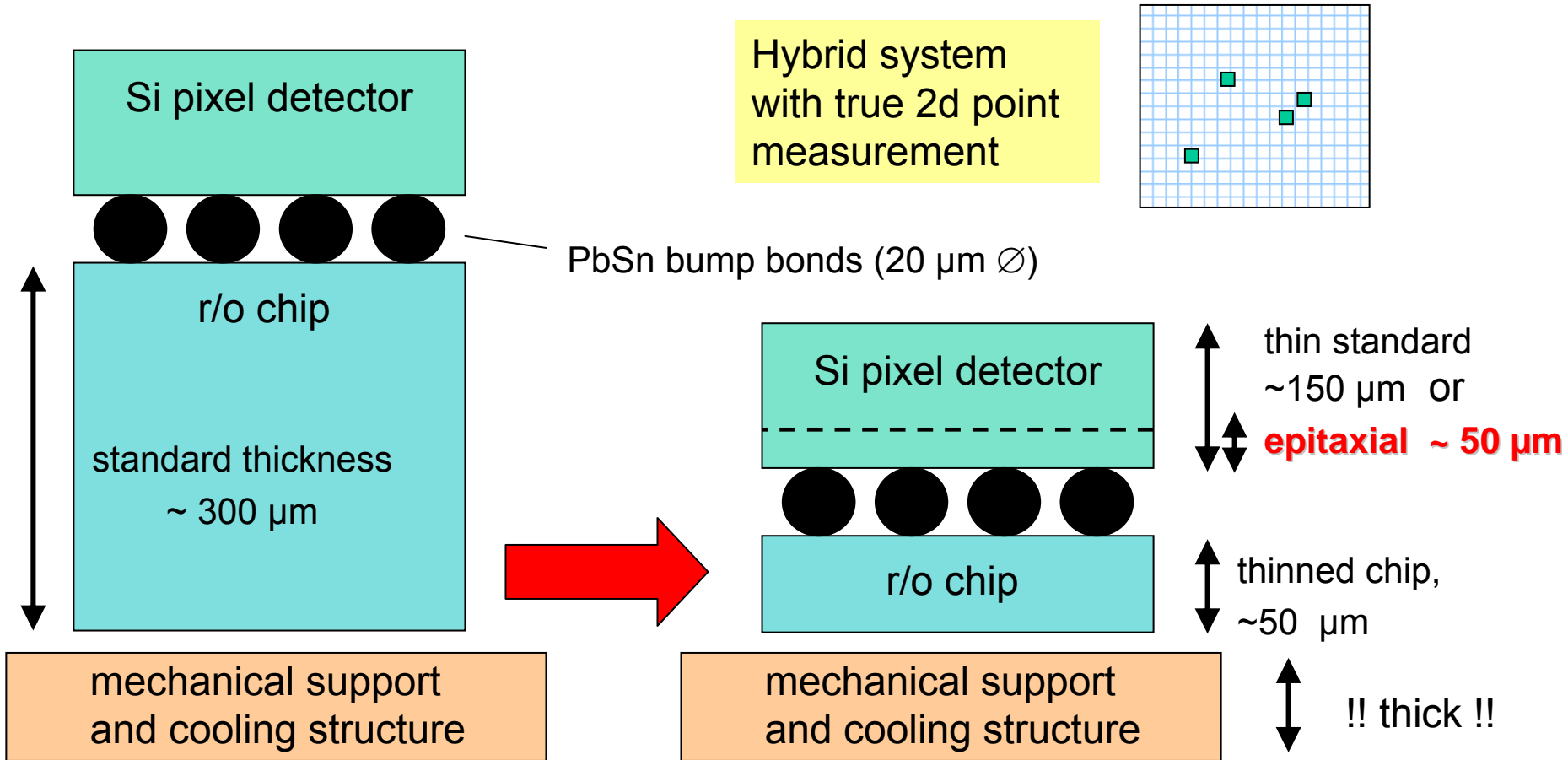
1. Production of low-mass support structure
2. Production of ultra-thin microstrip read-out cables
3. Assembly of a demonstrator module
4. Evaluation of a module demonstrator

Deliverable

Demonstrator of an innovative low-mass microstrip tracking system.



Low-mass pixel detector for tracking



- R&D goals:**
- a) Development of a **low-power self-triggering r/o chip**
 - b) Explore limits of **bump bonding for thin systems**

Participants

INFN Torino ([A. Rivetti](#), activity leader), FZJ Jülich (T. Stockmanns)

Timeline

Tasks	2009				2010				2011			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Design, fabrication, test of chips	X	X	X	X	X	1						
Production & test of epi sensors	X	X	X	X	X	2						
Assembly of chips and epi sensors	X	X	X	X	X	X	X	3				
Demonstrator thin hybrid pixel module	X	X	X	X	X	X	X	X	X	4		

Milestones:

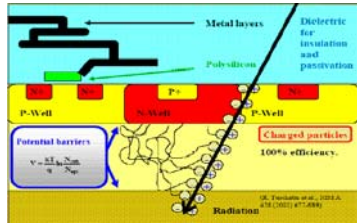
1. Production of front-end chips prototype
2. Production of epitaxial sensors prototype
3. Assembly of front-end chips with epitaxial sensor
4. Evaluation of a thin hybrid pixel module

Deliverable

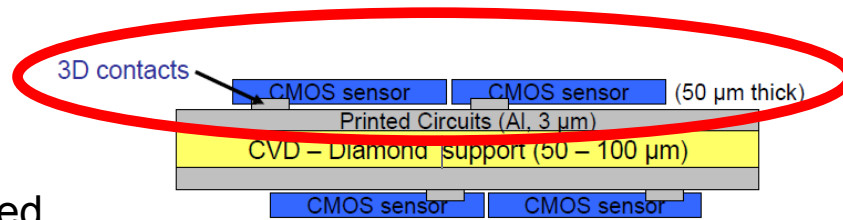
Demonstrator of a thin hybrid pixel detector module.



Thinned monolithic pixel module



- granularity: pixels of $10 \times 10 \mu\text{m}^2$
- sensitive volume $\sim 10 - 15 \mu\text{m}$
- thinning down to $\sim 30 \mu\text{m}$ permitted



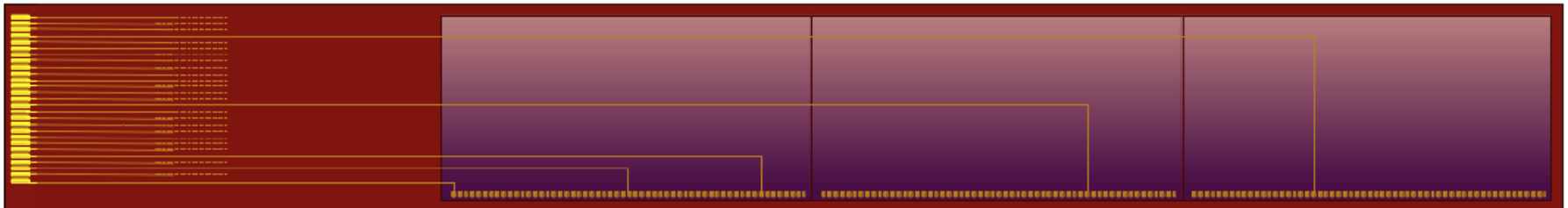
Concept: \equiv **SE**nsor **R**ow **W**rapped In an **E**xtra-**T**hin **E**nvelope (**SERWIETE**)

Main components of a SERWIETE :

- thinned CMOS pixel sensors (MIMOSA series)
- thin flexible cable
- thin polyimide envelope

Deliverable:

- device made of 3 contiguous wrapped MIMOSA-26 sensors
- goal : concept proof of principle (exploratory study on cutting edge technology)



Participants

CNRS Strasbourg ([M. Winter](#), activity leader), **GUF Frankfurt** (J. Stroth), **IMEC Leuven** (P. De Moor)

Timeline

Tasks	2009				2010				2011			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Realization of support structures	X	X	X	X	X	1						
Fabrrication and thinning of CMOS detectors	X	X	X	X	X	2						
Validation of handling and alignment procedures	X	X	X	X	X	X	3					
3D assembly tests CMOS detectors on support	X	X	X	X	X	X	4					
Evaluation of 3D-assembly module prototype	X	X	X	X	X	X	X	X	5			

Milestones:

1. Production of electrical and mechanical support layers
2. Fabrrication and thinning of CMOS detectors
3. Validation of handling and precision alignment procedures
4. 3D assembly test of CMOS detectors on support
5. Evaluation of a 3D-assembled module prototype

Deliverable

Prototype of an ultra-thin 3D-assembled CMOS pixel detector module.

Milestones and deliverables

Milestone number	Milestone name	WP number	Lead beneficiary	Delivery month from start date	Delivery check
WP26.1	Production of low-mass support structure	26	GSI	18	Support structure available
WP26.2	Production of ultra-thin microstrip read-out cables	26	GSI	18	Readout cables available
WP26.3	Assembly of a demonstrator module performed	26	GSI	24	Demonstrator module available
WP26.4	Evaluation of a module demonstrator performed	26	GSI	18 ³⁰	Report
WP26.5	Production of front-end chips prototype	26	GSI	18	Prototype available
WP26.6	Production of epitaxial sensors prototype	26	GSI	24 ¹⁸	
WP26.7	Assembly of front-end chips with epitaxial sensor performed	26	GSI	18 ²⁴	Chips with epi sensor available
WP26.8	Evaluation of a thin hybrid pixel module performed	26	GSI	18 ³⁰	Report
WP26.9	Production of electrical and mechanical support layers	26	GSI	18	Support layers available
WP26.10	Fabrication and thinning of CMOS detectors	26	GSI	18	Detectors available
WP26.11	Validation of handling and precision alignment procedures	26	GSI	24	Reports
WP26.12	3D assembly test of CMOS detectors on support performed	26	GSI	24	
WP26.13	Evaluation of a 3D-assembled module prototype performed	26	GSI	30	

HadronPhysics2 and ULISI meetings:

- Open Meeting, 28 September 2007
- Collaboration Committee Meeting 4 September 2009
- Collaboration Committee Meeting 16-17 September 2010
- Workgroup meetings
- ULISI kick-off workshop 17-18 February 2010
- ULISI concluding meeting *today*

Today's agenda

1. The Joint Research Activity “ULISI” of EU-FP7 HadronPhysics2
J. Heuser 11:00 - 11:10
2. An innovative thin microstrip tracking detector system for large-area coverage
J. Heuser 11:10 - 11:30
3. A thin fast hybrid pixel detector system for tracking in high particle densities
A. Rivetti 11:30 - 11:50
4. An ultra-thin monolithic pixel detector system for decay vertex identification
M. Winter 11:50 - 12:10
5. Discussion, Completion of work in HadronPhysics3 Joint Research Activity “ULISINT”
J. Heuser 12:10 - 12:30