HORIZON 2020

Call: INFRASUPP-01-2018-2019
Policy and international cooperation measures for research infrastructures

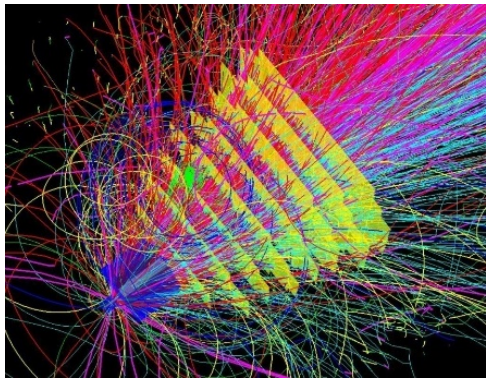
A Research and Innovation Action (RIA)

CREMLIN-Plus
WP7-DETEC
at the Kick-Off Meeting

Feb. 19 - 20, 2020
DESY, Hamburg
Christian J. Schmidt

Connecting **R**ussian and **E**uropean **M**easures for **L**arge-scale Research **IN**frastructures - plus

WP7- DETEC: horizontal activity on development of detector technologies



Charge: Develop beyond state of the art detector technologies

Aim to foster
- **cooperation, ideas and technologies-interchange**
- as well as **education of young scientists** in the field of particle detectors and related technologies

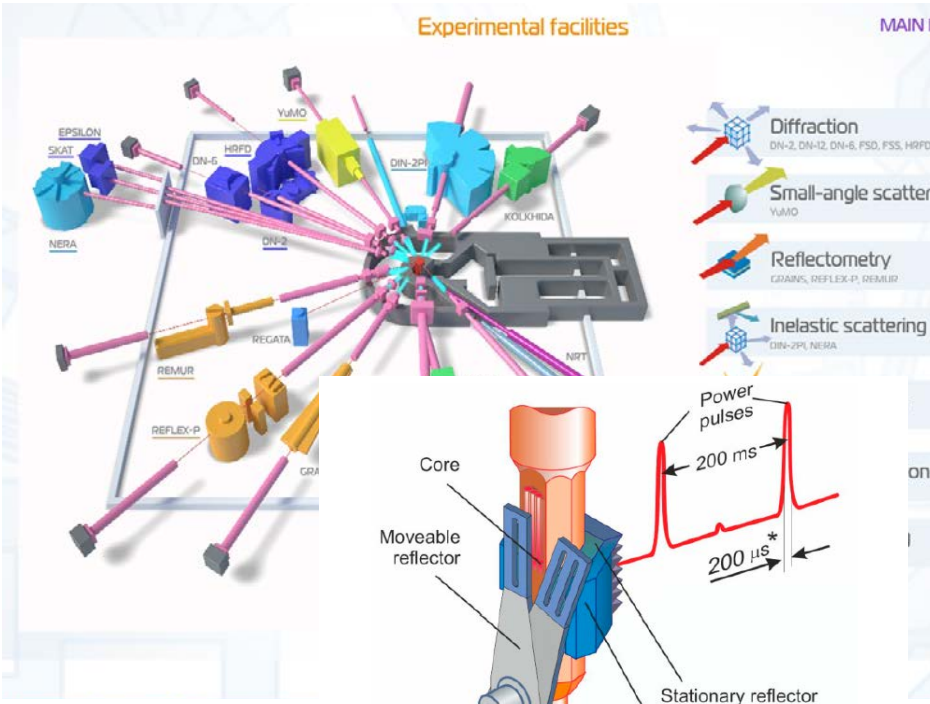
Joining two fields that typically have only few links:

- ❖ CMOS pixel sensors for nuclear- and high energy physics tracking applications
- ❖ Detector technologies for thermal neutrons

WP7 – DETEC Conjoined Neutron Detector Competence

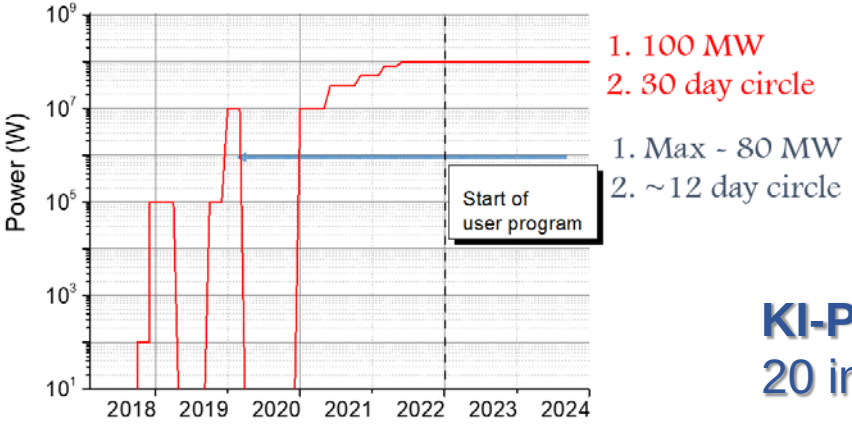
ESS Detector Group

Instrument Facilities at **JINR IBR-2** reactor, supported by facility detector development lab



NATIONAL RESEARCH CENTRE «KURCHATOV INSTITUTE»
PETERSBURG NUCLEAR PHYSICS INSTITUTE

Reactor PIK: commissioning and operation



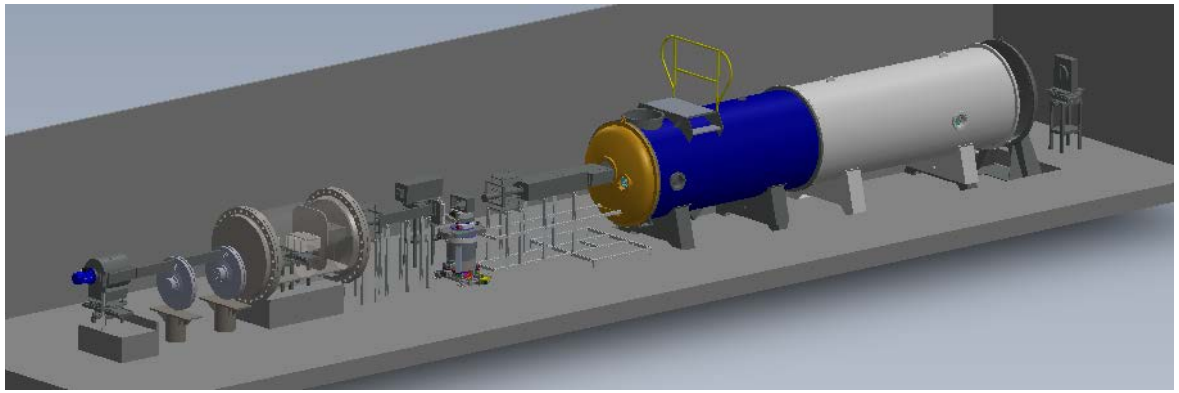
100 MW Research Reactor PIK, Gatchina, Russia

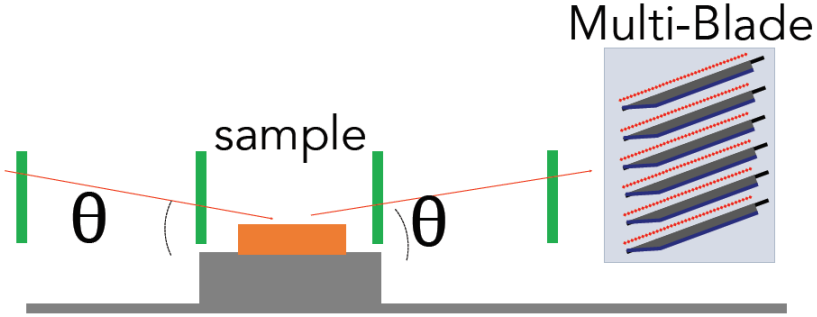
KI-PNPI aims to set-up and commission 20 instruments with detectors until 2024 at PIK

Figure 2. Core of the IBR-2 reactor with a movable reflector.

WP7 – DETEC
Neutron – preparatory meeting at JINR-FLNR Jan. 23rd, 2020

- Pick demonstrator application among 20 instruments projected for PIK: Detector for reflectometer SONATA





- Very challenging specifications (resolution, efficiency, intensity)
- Boron-based Multi-Blade-Technology envisioned

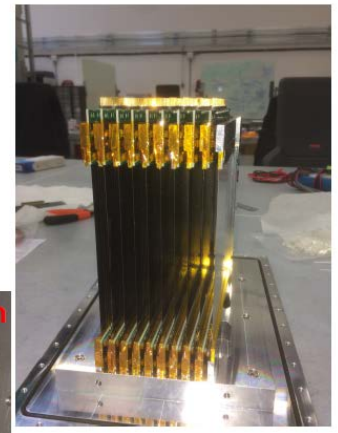
WP7 – DETEC Neutron – Detector

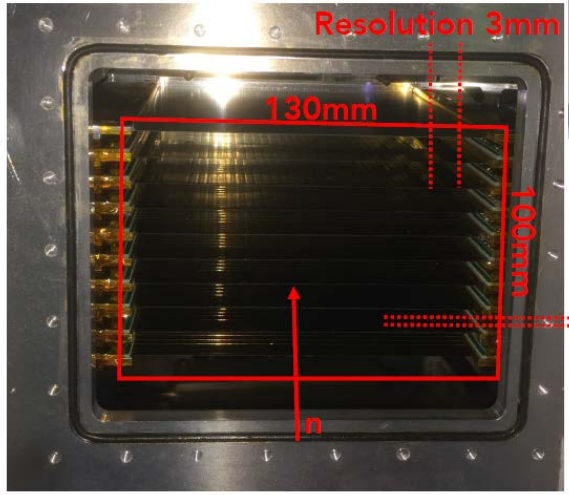
- JINR-FLNR → experience with ^{10}Boron coating together with Dubna University
- ESS Detector Group → deeply involved in Multi-Blade Detector development
- KI-PNPI at PIK → primary stake holder, brings-in detector laboratory

granularity and signal intensity make modern readout electronics indispensable: CMOS ASICs, FPGA data processing etc.

→ synergy with heavy-ion and high energy physics techn.

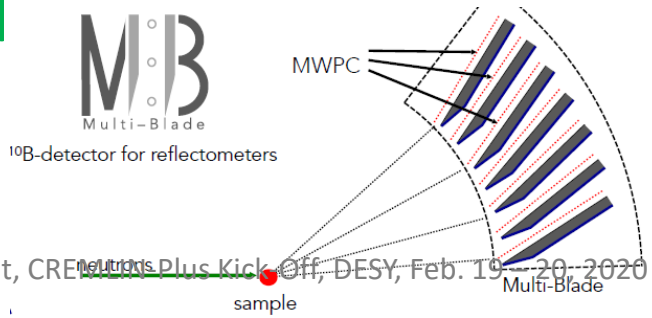
F. Piscitelli et al, Journal of Instrumentation 12, P03013 (2017) - doi: 10.1088/1748-0221/12/03/P03013 , arXiv:1701.07623





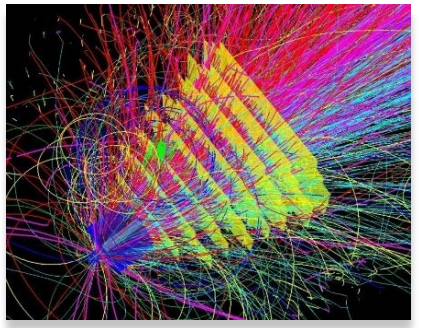
The cassettes (units) are placed horizontally

Resolution 0.5mm



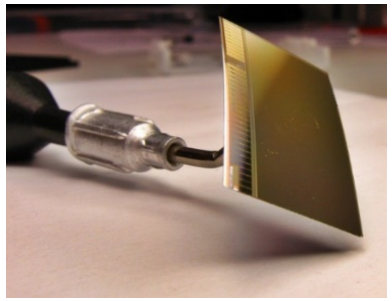
WP7 – DETEC CMOS Active Pixel Detectors

Ongoing decade-old grand, joint research activity pushed forward by the entire tracking detector community in High-Energy-, Nucl. and Heavy-Ion Physics → HL-LHC, FAIR, NICA etc.



CREMLIN-Plus WP7 aims to

- very actively corroborate the field
- broaden knowledge base to expert personnel facing the integration challenge
- disseminate technology to other science fields and eventually to societal benefit



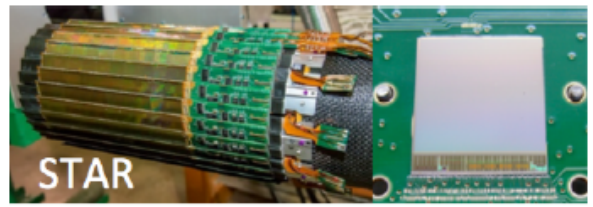
CMOS pixel sensor

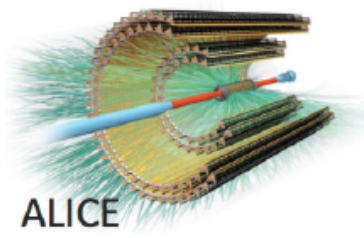
CMOS PIXEL DETECTORS

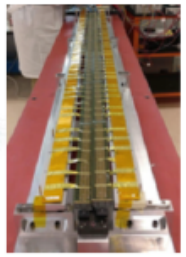
UNIVERSITÄT BONN

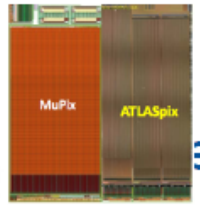
ARE THE FUTURE !

- for particle physics
- for high energy pp
- for pCT
- for imaging appl.
- other ...









	RHIC STAR	ALICE-LHC	ILC / CLIC	HL-LHC Outer	HL-LHC Inner
	coming next: Belle II upgrade				
Req. time resolution [ns]	110	20 000	350 / 156	25	25
Particle Rate [MHz / cm^2]	0.4	< 10	< 3	100-200	2000
Fluence [n_{eq} / cm^2]	> 10^{12}	> 10^{13}	< 10^{12}	10^{15}	2 x 10^{16}
Ion. Dose [MRad]	0.2	< 3	< 1	80	> 1000

MAPS (e.g. ALPIDE)

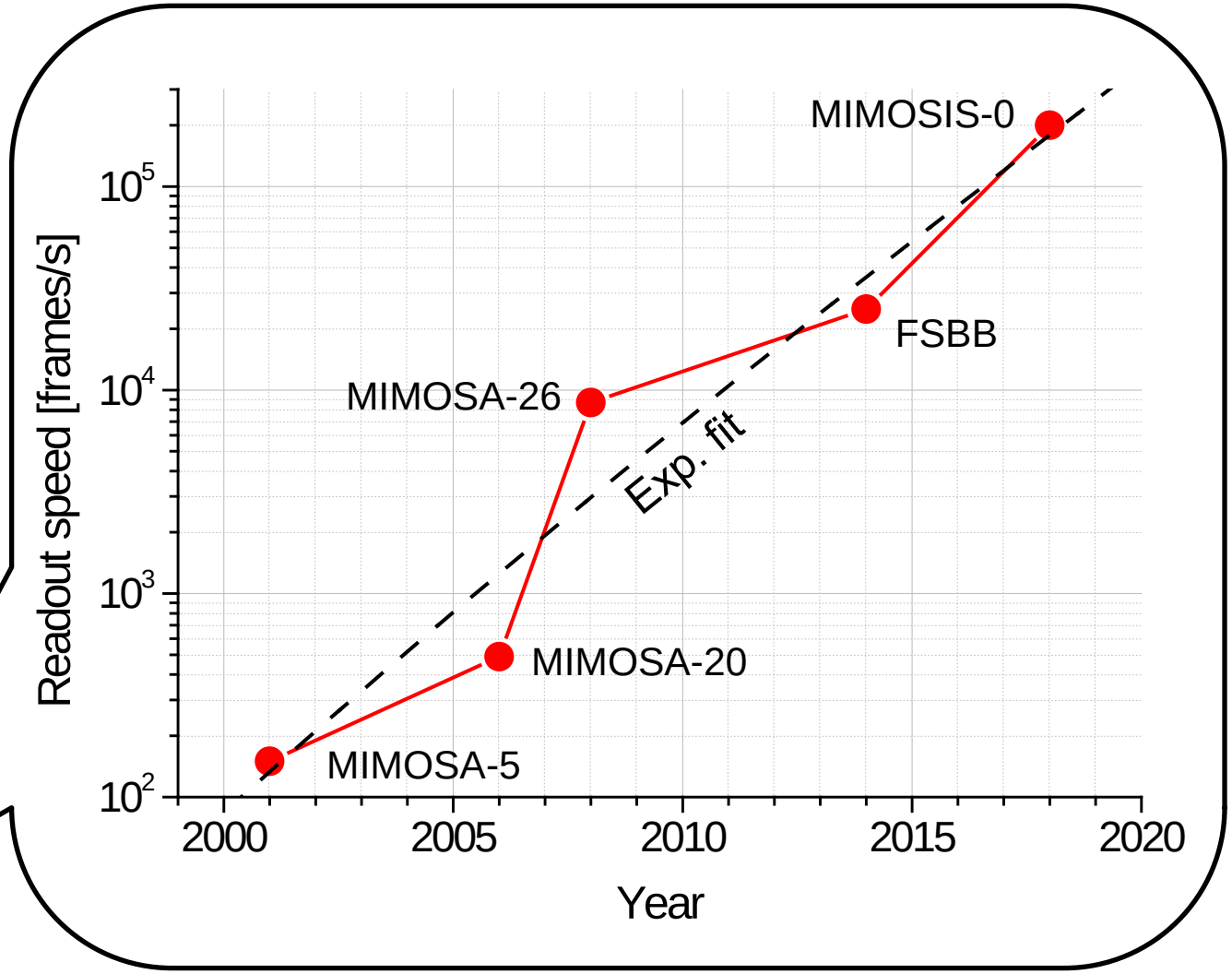
Hybrid pixels -> DMAPS rejected

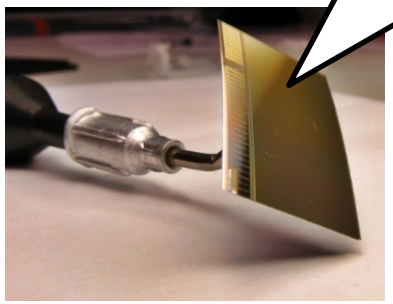
HL-LHC devm't: radhard (TID & NIEL) + fast response time + fast readout => Q coll. by drift & full R/O arch.

Several MAPS Technologies being elaborated and followed

- ALPIDE for ALICE at CERN (W. Snoeys et al)
- MuPix for Mu3e and PANDA at KIT (I. Peric et al)
- MIMOSA and MIMOSIS at IPHC (M. Winter et al) for CBM Micro Vertex Det.
- MONOPIX DMAPS at Universität Bonn (N. Wermes et al)

Status of the sensor R&D for CBM





CMOS sensor

Slide by Michael Deveaux

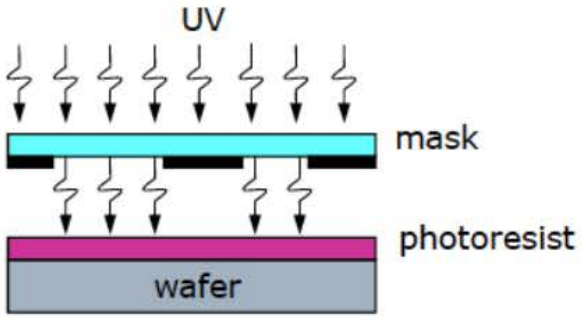
MAPS – Challenges: Stitching, create wafer scale size sensors

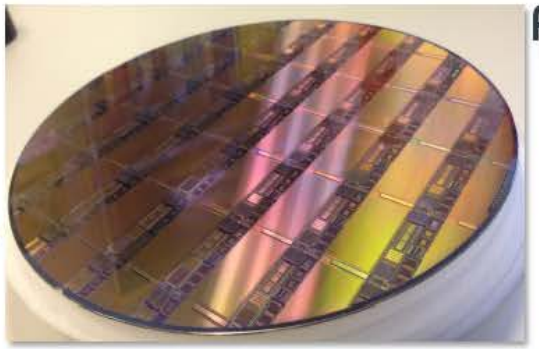
Stitching allows the fabrication of wafer scale sensors

CMOS photolithographic process defines wafer reticles size

⇨ Typical field of view O(2 x 2 cm^2)

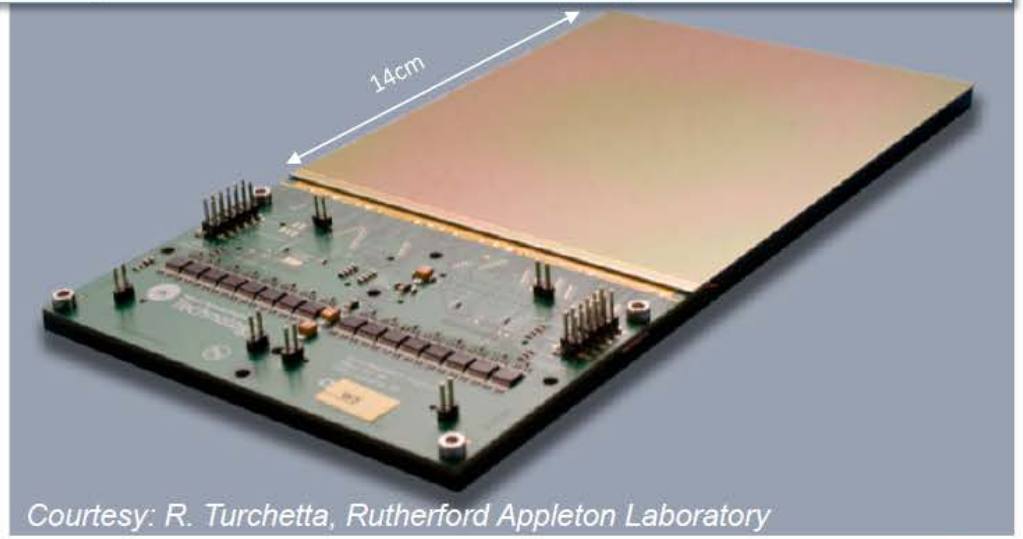
Reticle is stepped across the wafers to create multiple identical images of the circuit(s)





staves built by tiling several sensors

Stitching allows fabrication of sensors larger than the reticle size



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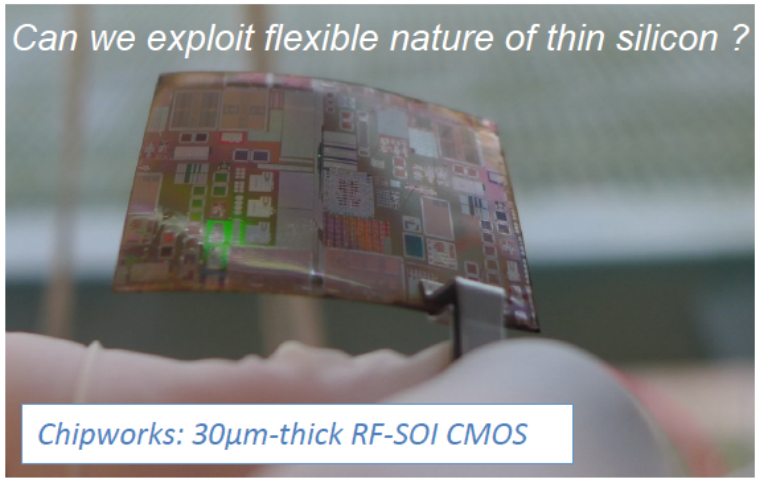
MAPS – Challenges: Thinning, minimize material budget

Ultra-thin curved silicon chips



Ultra-thin chip (<50 um): flexible with good stability

Die type	Front/back side	Ground/polished/plasma	Bumps	Die thickness (µm)	CDS (MPa)	Weibull modulus	MDS (MPa)	r_{min} (mm)
Blank	Front	Ground	No	15–20	1263	7.42	691	2.46
Blank	Back	Ground	No	15–20	575	5.48	221	7.72
IZM28	Front	Ground	Yes	15–20	1032	9.44	636	2.70
IZM28	Back	Ground	Yes	15–20	494	2.04	52	32.7
Blank	Back	Polished	No	25–35	1044	4.17	334	7.72
IZM28	Back	Polished	Yes	25–35	482	2.98	107	24.3
Blank	Back	Plasma	Yes	18–22	2340	12.6	679	2.50
IZM28	Front	Plasma	Yes	18–22	1207	2.64	833	2.05
IZM28	Back	Plasma	Yes	18–22	2139	3.74	362	4.72

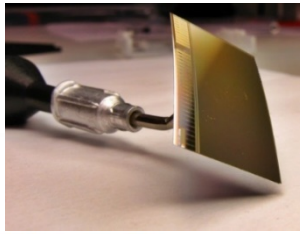
van den Ende DA et al. *Mechanical and electrical properties of ultra-thin chips and flexible electronics assemblies during bending*. Mircoelectron reliab (2014), http://dx.doi.org/10.1016/j.microrel.2014.07.125

L. Musa (CERN) – ALICE Week, 17 July 2017

Current Alice IST-2 upgrade

dream: wrap sensor around beam pipe

WP7 – DETEC CMOS Active Pixel Tracking Detector

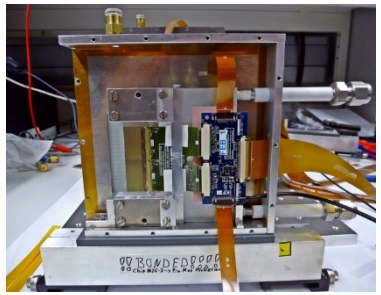


IPHC Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

MAPS sensor design

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

MAPS integration, power management



FAIR

Silicon integration, r/o electronics

GSI

technological stake holders

Kiew Institute for Nuclear Research

KINR

silicon detector characterization and evaluation

DESY.

Precision e-test-beam facility
→ characterization of telescope
→ beneficiary of resulting prototype

NICA

JINR

broaden knowledge base – widen horizon
foster young scientists to get involved
make use of WP8, WP9 and WP10 funding

Summer school on detector technologies and electronics as

„joint workshop on modern neutron and tracking detector challenges“

allow for most effective one week to three months secondment of scientists in collaborating partner institution

follow-up on integrating project: employ MAPS for neutron detection

→ master or PhD thesis