Advancement and Innovation for Detectors at Accelerators

Status of DMAPS (WP5) Activities

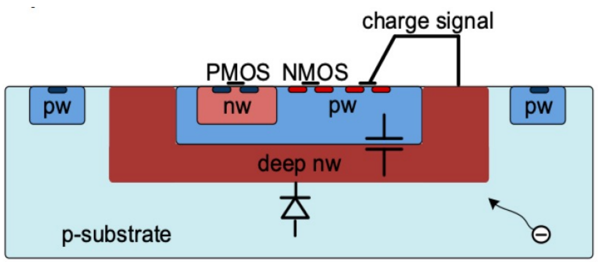
S. Grinstein (IFAE-Barcelona) and F. Hügging, N. Wermes (Bonn)

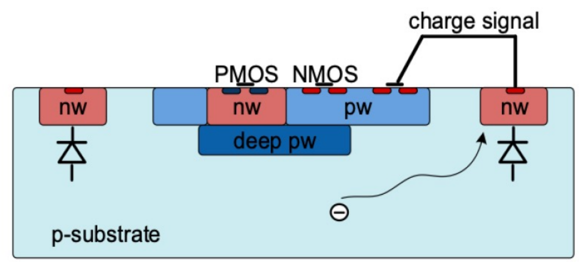
3rd Annual Meeting Valencia – 20 Mar 2024
https://indico.cern.ch/event/1307202/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004761.

- **7 projects** are (partially, not exclusively) supported by the AIDAinnova framework using 4 different processes provided by 2 foundries: **LFoundry** (Wuxi Xichanweixin Semiconductor) and **TowerJazz** → Tower Semiconductor (Intel as of 2022)
- All developments have samples, characterisation in full swing

large electrode (radhard)





small electrode (high granularity)

Submission	Process	Availability	Target	Comments	Contact Institute	Task Contact
TJ-MALTA 2 /3	TowerJazz 180 nm	Beginning 2021 MPW Q1 2022	High-gran./ Rad. hard Task 5.2/5.3	LHC	CERN	Carlos Solans Sanchez
TJ-Monopix 2 /3 (OBELIX)	TowerJazz 180 nm	Spring 2021 Initiating design	High-granularity Task 5.2	Belle II	Bonn	Jochen Dingfelder
TJ 65	TowerJazz 65 nm	September 2021	High-granularity Task 5.2	Generic R&D / ALICE	IPHC	Jerome Baudot
ARCADIA	LFoundry 110 nm	Summer 2021	High-granularity Task 5.2	Demonstrator chip	INFN	Manuel Rolo
LF-Monopix 2	LFoundry 150 nm	Beginning 2021	Radiation hard Task 5.3	High granularity foreseen	Bonn/CPPM	Marlon Barbero
RD50-MPW 3 /4	LFoundry 150 nm	Spring 2022/ late 2023	High-granularity/ Radiation hard Task 5.3	R&D	Liverpool	Eva Vilella
MiniCactus 1 / 2	LFoundry 150 nm	Beginning 2021 / 2024	Radiation hard Task 5.3	Timing R&D	IRFU	Philippe Schwemling

AIDA innova

WP5 Deliverables

April 2021

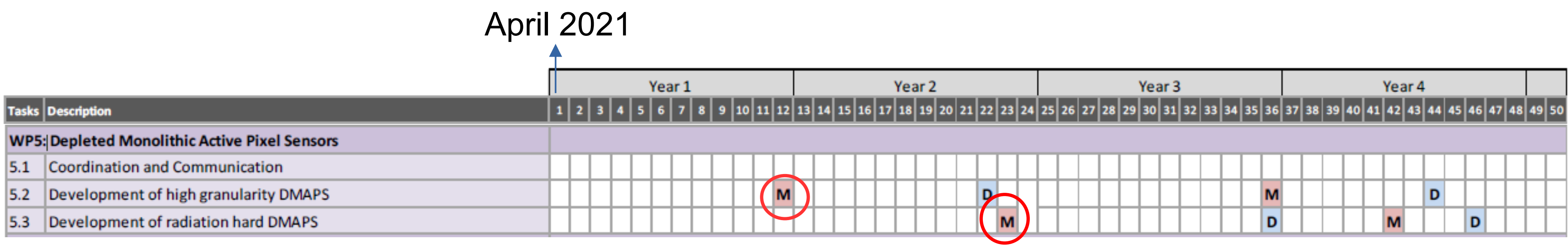
		Year 1												Year 2												Year 3												Year 4													
Tasks	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
WP5:	Depleted Monolithic Active Pixel Sensors																																																		
5.1	Coordination and Communication																																																		
5.2	Development of high granularity DMAPS												M										D														M								D						
5.3	Development of radiation hard DMAPS																							M													D						M				D				

WP5 Deliverables consist of reports, which are the responsibility of the institutes in the last column.

- Next deliverable is D5.3 in April: sufficient material from TJ-Malta and LF-Monopix projects are available, see later slides

Deliverables related to WP5			
D5.1: Report on performance of high granularity DMAPS Version 1 *Report on performance of high granularity monolithic pixel sensor 1 (task 5.2)*	22	CNRS-IPHC	✓ *March 2023*
D5.2: Report on performance of high granularity DMAPS Version 2 *Report on performance of high granularity monolithic pixel sensor 2 (task 5.2)*	44	INFN	
D5.3: Report on performance of radiation-hard DMAPS *Report on performance of structures and the radiation hard monolithic pixel 1 (task 5.3)*	36	Bonn	*April 2024*
D5.4: Report of beam tests of irradiated radiation-hard DMAPS *Report of beam tests of radiation-hard devices after high irradiation (task 5.3)*	46	CERN	

See also: https://aidainnova.web.cern.ch/wp5



Milestones have short associated reports and are within the responsibility of the institutes in the last column.

- Next Milestone is MS19 in April: structures from Arcadia project are available.

April 2022 ✓ *Feb 2023* ✓

MS18	High granularity prototype fabrication 1	5.2	M12	Devices available	CNRS-IPHC
MS19	High granularity prototype fabrication 2	5.2	M36	Devices available	INFN ⇐ *April 2024*
MS20	Radiation hard prototype fabrication	5.3	M23	Devices available	Bonn
MS21	Test beam of the radiation hard monolithic pixel 1	5.3	M42	Test beam with prototypes measured	CERN

See also: https://aidainnova.web.cern.ch/wp5

Publications & Meetings

TJ-MALTA

- JINST 2021 https://doi.org/10.5281/zenodo.6951327
- TWEPP 2021 https://doi.org/10.1088/1748-0221/17/04/C04034
- IEEE TNS 2022 https://doi.org/10.1109/TNS.2022.3170729
- NIM A 2022 https://doi.org/10.1016/j.nima.2022.167390
- NIM A 2022 https://doi.org/10.1016/j.nima.2022.167226
- NIM A 2023 https://doi.org/10.1016/j.nima.2022.167809
- EPJ-C 2023: https://doi.org/10.1140/epjc/s10052-023-11760-z
- JINST 2023: https://doi.org/10.1088/1748-0221/18/03/C03011
- JINST 2023: https://doi.org/10.1088/1748-0221/18/03/C03013
- EPJ-C 2023: https://arxiv.org/abs/2308.13231
- HSTD23 proceedings in preparation

TJ-Monopix

- NIM A 2022 https://doi.org/10.1016/j.nima.2022.167189
- arXiv 2023 https://doi.org/10.48550/arXiv.2301.13638
- IEEE proceedings PACET2024 submitted

LF-Monopix

- NIM A 2022 https://doi.org/10.1016/j.nima.2022.167224
- NIM A 2022 https://doi.org/10.1016/j.nima.2022.166747
- Vertex 2022 proceedings accepted, to be published
- Vertex 2023 https://doi.org/10.22323/1.448.0043
- HSTD23 Submitted, under revision

CACTUS

- NIM A 2022 https://doi.org/10.1016/j.nima.2022.167022
- NSS 2022: IEEE Trans.Nucl.Sci. 70 (2023) 11, 2471-2478

TJ 65nm

- NIM A 2022 https://doi.org/10.1016/j.nima.2022.167213

RD50-MPW

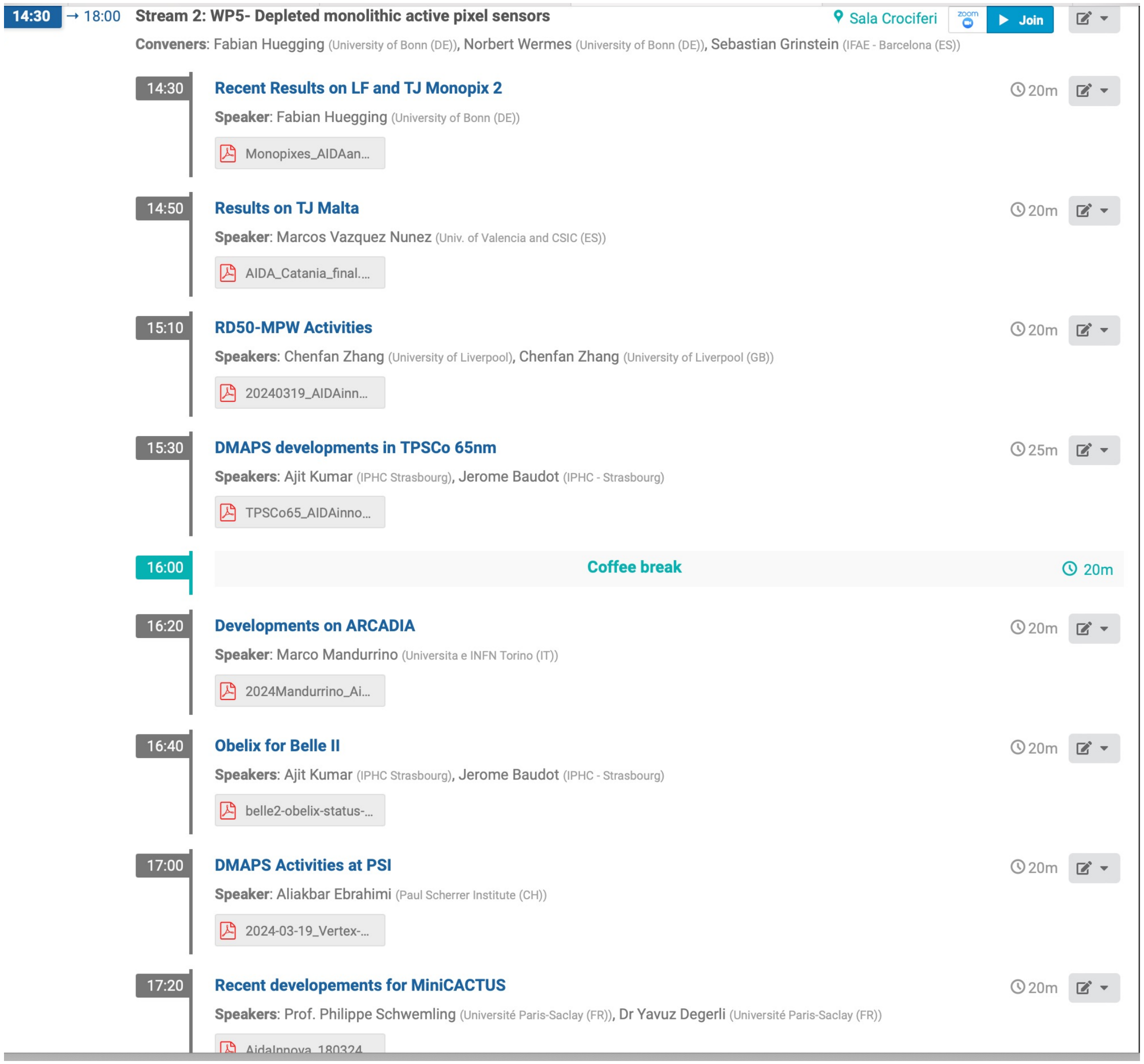
- NIM A 2022 https://doi.org/10.1016/j.nima.2022.166826
- NIM A 2022 https://doi.org/10.1016/j.nima.2022.167020
- JINST 2023 https://doi.org/10.1088/1748-0221/17/12/C12017

- 27 publications
  - 9 new since Sept. 2023 published or in work
- Update of web-site and database in progress

WP5 meetings at:
https://indico.cern.ch/category/13503/

Summary of Activities

- Next slides are a brief summary of recent achievements as presented during our session yesterday
- See more details on the WP5 session agenda on indico:
  - https://indico.cern.ch/event/1307202/



14:30 → 18:00 **Stream 2: WP5- Depleted monolithic active pixel sensors** Sala Crociferi Join

Conveners: Fabian Huegging (University of Bonn (DE)), Norbert Wermes (University of Bonn (DE)), Sebastian Grinstein (IFAE - Barcelona (ES))

14:30 **Recent Results on LF and TJ Monopix 2** 20m
Speaker: Fabian Huegging (University of Bonn (DE))
Monopixes_AIDAan...

14:50 **Results on TJ Malta** 20m
Speaker: Marcos Vazquez Nunez (Univ. of Valencia and CSIC (ES))
AIDA_Catania_final....

15:10 **RD50-MPW Activities** 20m
Speakers: Chenfan Zhang (University of Liverpool), Chenfan Zhang (University of Liverpool (GB))
20240319_AIDAinn...

15:30 **DMAPS developments in TPSCo 65nm** 25m
Speakers: Ajit Kumar (IPHC Strasbourg), Jerome Baudot (IPHC - Strasbourg)
TPSCo65_AIDAinno...

16:00 **Coffee break** 20m

16:20 **Developments on ARCADIA** 20m
Speaker: Marco Mandurrino (Universita e INFN Torino (IT))
2024Mandurrino_Ai...

16:40 **Obelix for Belle II** 20m
Speakers: Ajit Kumar (IPHC Strasbourg), Jerome Baudot (IPHC - Strasbourg)
belle2-obelix-status-...

17:00 **DMAPS Activities at PSI** 20m
Speaker: Aliakbar Ebrahimi (Paul Scherrer Institute (CH))
2024-03-19_Vertex-...

17:20 **Recent developements for MiniCACTUS** 20m
Speakers: Prof. Philippe Schwemling (Université Paris-Saclay (FR)), Dr Yavuz Degerli (Université Paris-Saclay (FR))
AidaInnova_180324...

Tower 180 nm

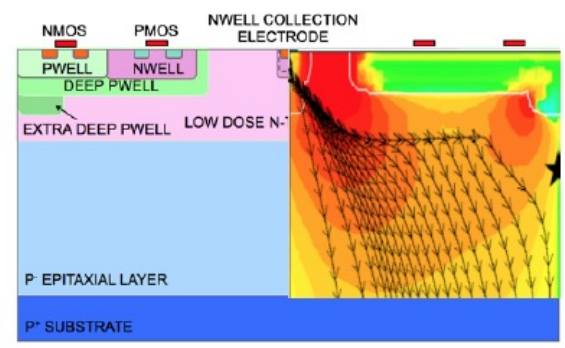
TJ-MALTA-2&3

TJ-Monopix-2

TJ-MALTA
High granularity, small electrode

Goal: large (1x2 cm^2 (Malta2) -> 3x2 cm^2 (Malta3)) radhard sensor/chip w/ small electrode and high granularity, HL-LHC-layer-5 compatible with low power asynchonous readout architecture. Sensor&FE same as TJ-Monopix.

CERN and others (Bonn, CPPM, Oxford ...)
- 180 nm technology -



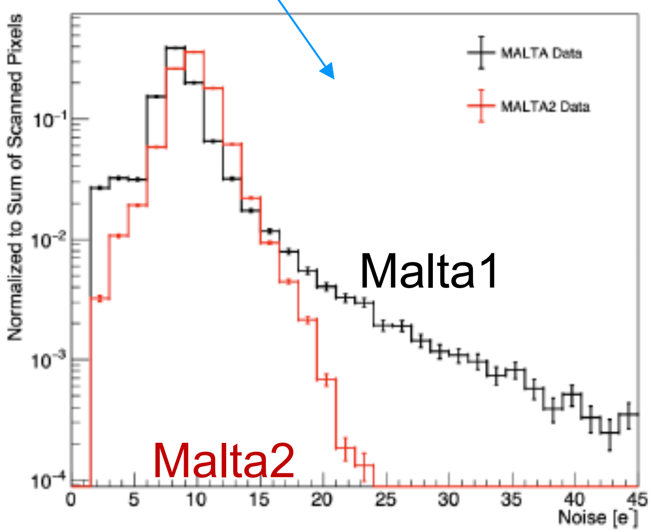
- main objective of **TJ-MALTA2**:
  - make design radhard (> 1e15 neq/cm2):
    1. shape charge collection geometry
    2. optimize FE against RTS noise
    3. use high resistive Cz-Si substrate (100 µm) rather than epi-Si (25 µm).
  - improve asynchronous readout

- objective **TJ-MALTA3**:
  - exploit full reticle size: 3x2 cm^2
  - improve on remaining MALTA2 issues
  - add 1.28 GHz local clock
  - target: mini-MALTA MPW in Q2 2023

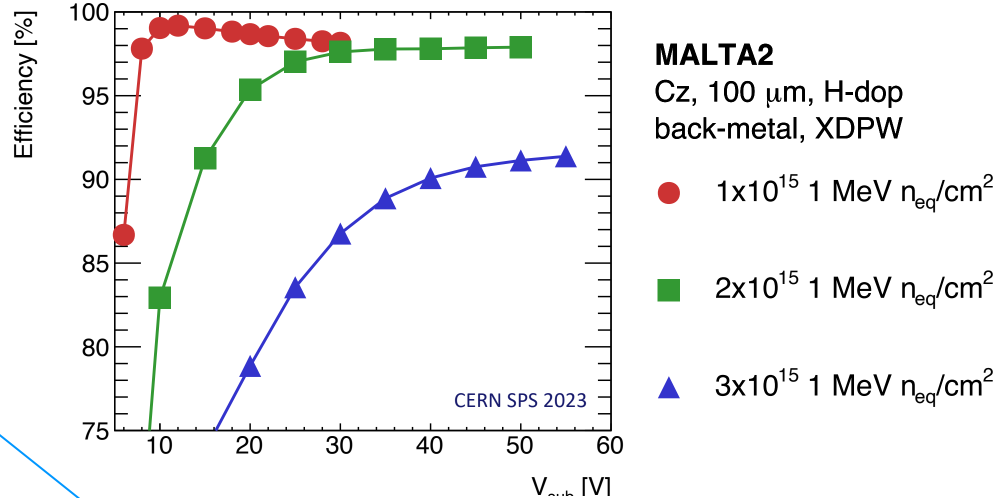
M. Vazques et al.

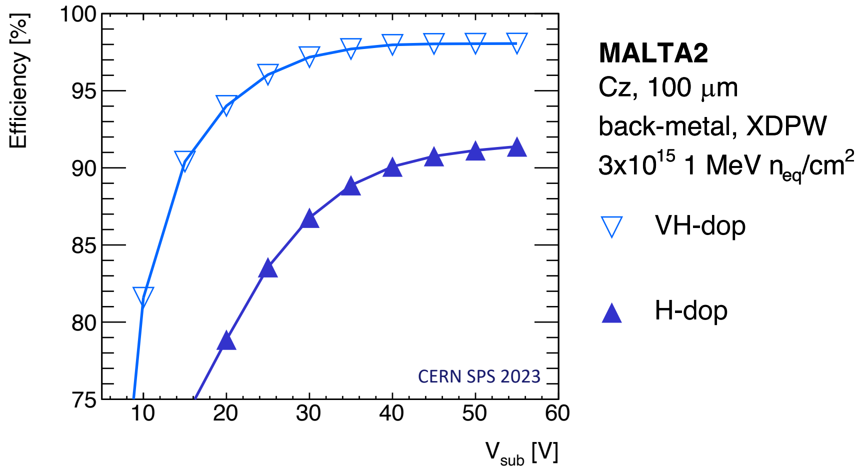
Goals of MALTA2 achieved:

- radhard up to 3E15 n_{eq}/cm^2 (at least)
- Higher doping of n-layer helps
- RTS noise mitigated



- excellent matrix homogeneity

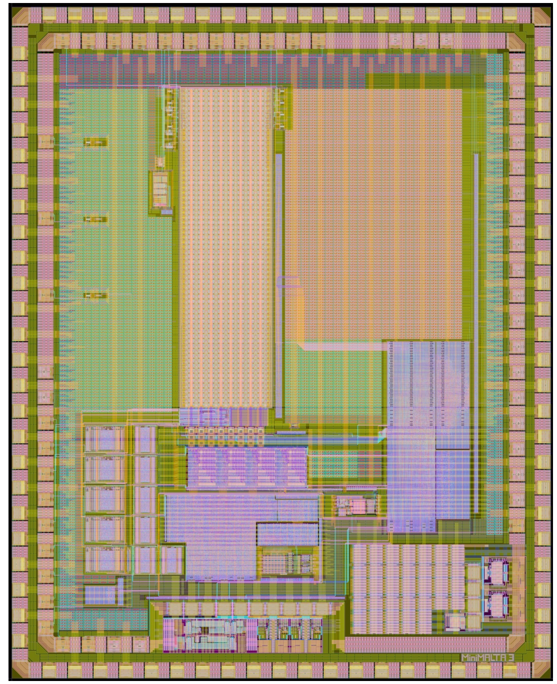


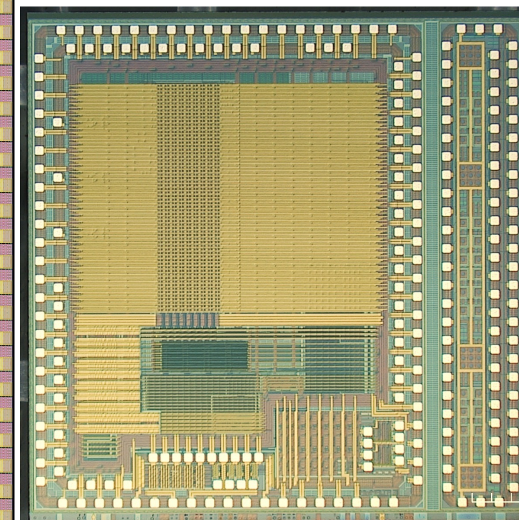


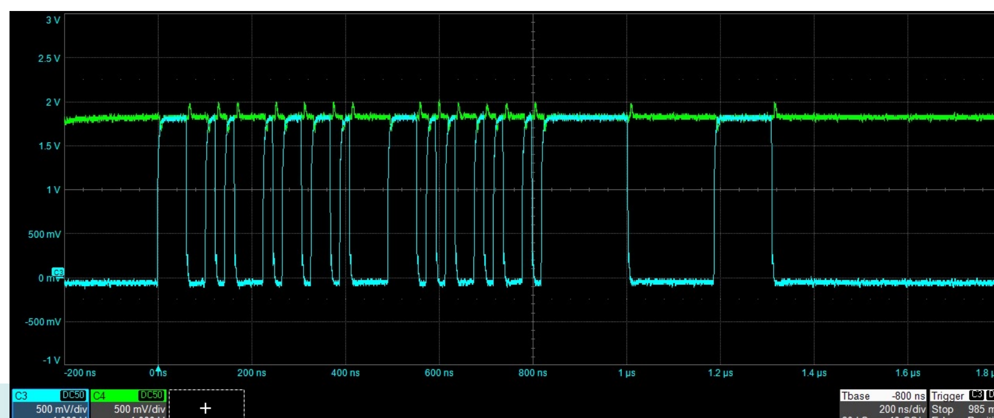
M. Vazques et al.

TJ-MALTA
High granularity, small electrode

- Mini-MALTA 3
    - 5x4 mm2 demonstrator for full MALTA3
    - Same FE as MALTA2
- Chip arrived in late 2023
- Chip is alive and systematic testing including test beams starts now







M. Vazques et al.

TJ-Monopix 2
High granularity, small electrode

Goal: mature large (2x2 cm^2) high granularity (small electrode) fully functional, HL-LHC compatible (5th layer) DMAPS sensor with column drain readout, w/ low noise and low power consumption

	TJ-Monopix1	TJ-Monopix2
Chip Size	1x2 cm^2 (224x448 pix)	2x2 cm^2 (512x512 pix)
Pixel size	$36 \times 40\ \mu m^2$	$33.04 \times 33.04\ \mu m^2$
Total matrix power	130 mW/cm^2	170 mW/cm^2
Noise	≅11 e^-	< 8 e^- (improved FE)
LE/TE time stamp	6-bit	7-bit
Threshold Dispersion	≅ 30 e^- rms	< 10 e^- rms (improved FE + tuning)
Minimum threshold	≅ 300 - 400 e^-	< 200 e^-
In-time threshold	≅ 350 - 450 e^-	< 250 - 300 e^-
Efficiency at 10^{15} n_{eq}/cm^2, 30 μm epi	≅ 87 %	> 97 %
Efficiency at 10^{15} n_{eq}/cm^2, Cz	≅ 98.6 %	> 99 %

- Clear improvements wrt TJ-M1 before and after irradiation

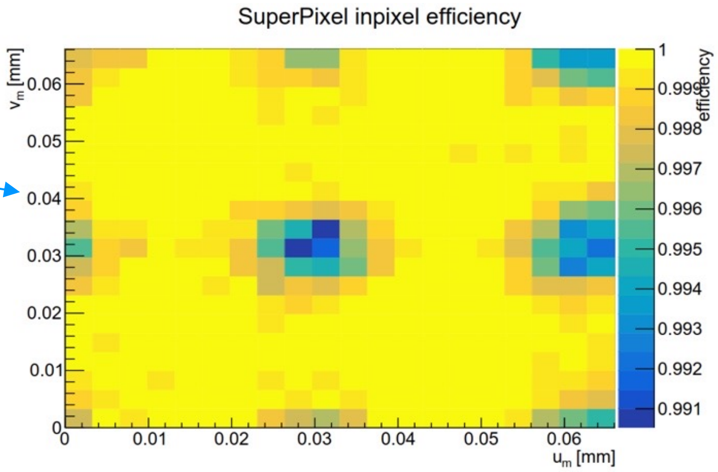
Bonn, CERN, CPPM, IRFU
- 180 nm technology -

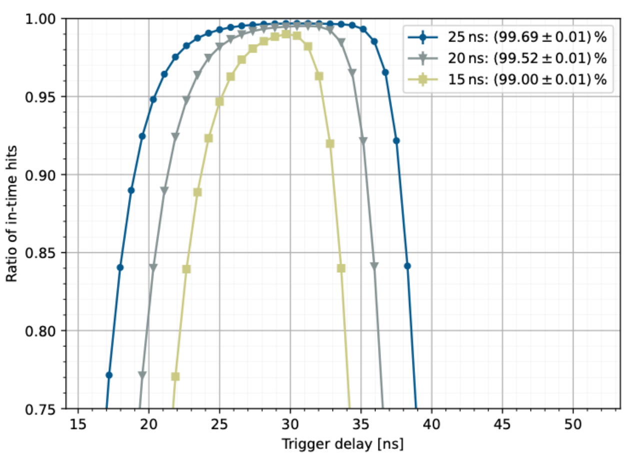
- sensor and chip working
- assembly problems (wire bonding sensibility) reduce yield, is now manageable, but still problematic
- a temporary major problem at 5 MHz BC-ID clock interfering now understood and circumvented
- characterisation finally in full swing
- baseline for Belle II VTX upgrade → Obelix chip:
  - Uses analog part from TJ Monopix 2
  - New digital periphery with several additional features

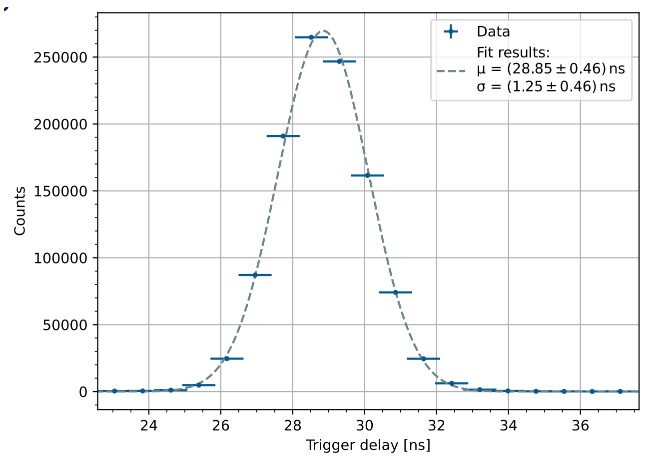
TJ-Monopix 2
High granularity, small electrode

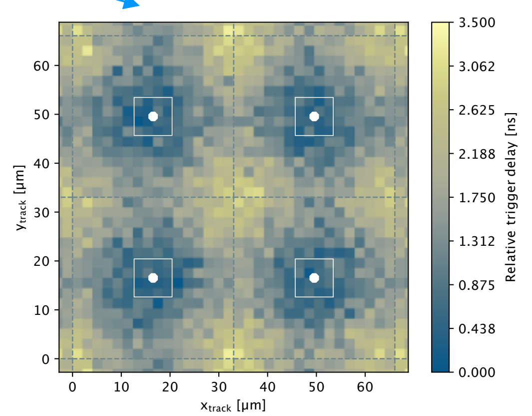
Most recently added detailed timing performance and post irradiation measurements:

- >99% eff. after $5E10^{14} n_{eq}/cm^2$ irradiated with 24 MeV p
- ~1-2 ns time resolution limited by TDC (1.5625 ns bin size, 93.7 ps time resolution from FE)
- > 99% in-time efficiency for 25 ns window and for 15 ns window for epi-Si (26 µm depl. volume)
- Delay difference of up to 3.5 ns depending on in-pixel track position





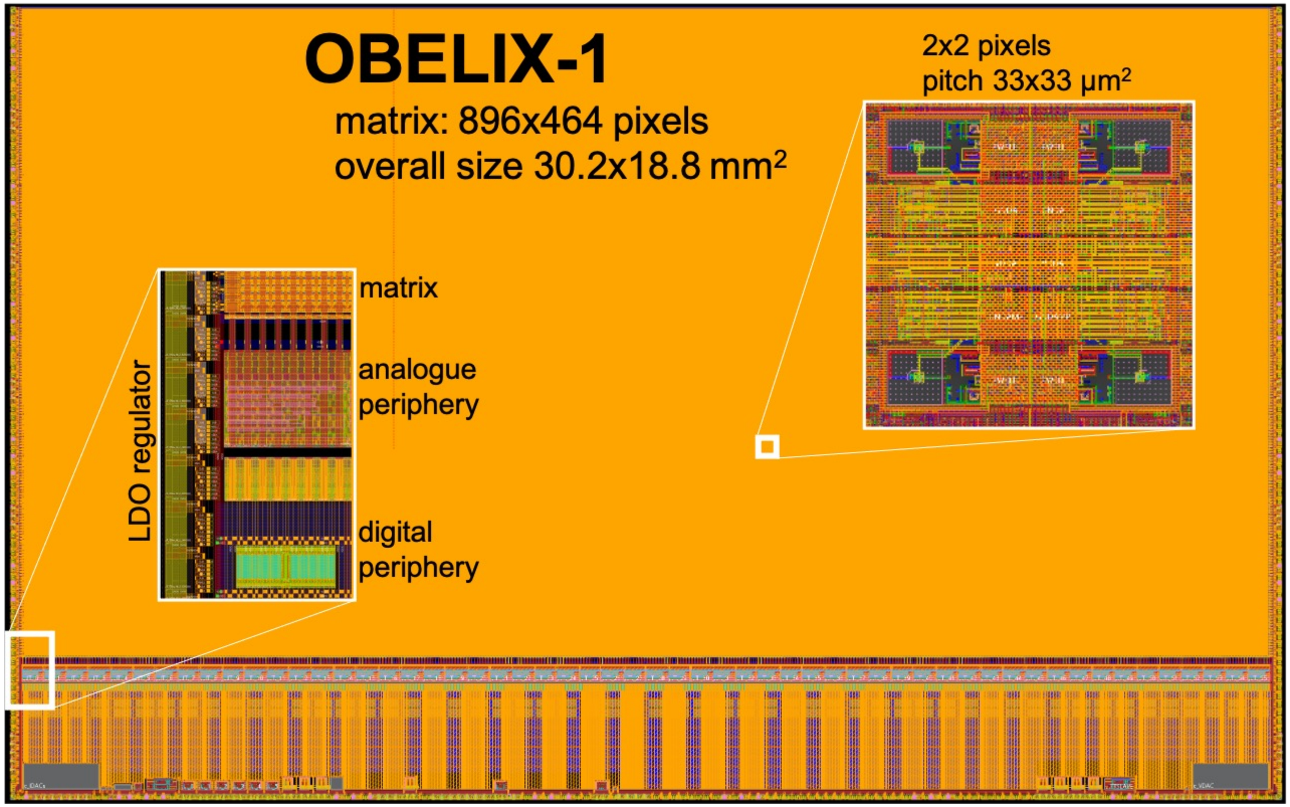




C. Bespin, J. Baudot, A. Kumar et al.

TJ-Monopix 2 → OBELIX for BELLE 2
High granularity, small electrode

Pitch	33 µm
Signal ToT	7 bits
Integration time	50 To 100 ns
Time stamping	~5 ns for hit rate < 10 MHz/cm^2
Hit rate max for 100% eff.	120 MHz/cm^2
Trigger handling	30 KHz with 10 µs delay
Trigger output	~10 ns resolution with low granularity
Power (with hit rate)	120 to 200 mW/cm^2 (1 to 120 MHz/cm2)
Bandwidth	1 output 320 MHz



TPSCo 65 nm process of Tower
(new window of opportunity)

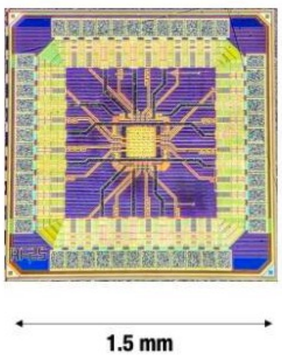
Tower 65nm

TPSCo 65 nm (Tower)

Goal: exploring the new technology (large collaboration effort, CERN + 24 institutions) including stitching, ... small electrode designs

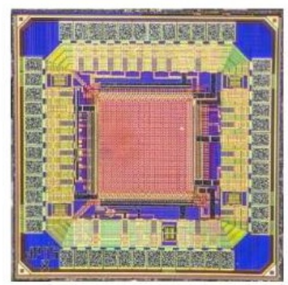
1+2 submissions so far: MLR1 (2020), ER1 (2022) each containing several structures and designs
ER2 is expected for 2025

APTS Analogue Pixel Test Structure



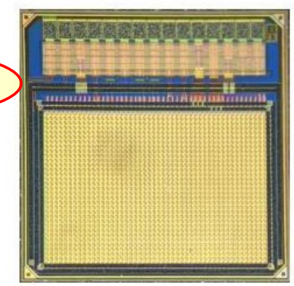
Matrix: 6x6
Readout: analogue readout of 4x4
Pitch: 10,15,20,25 µm
Process: all 3 variants

DPTS Digital Pixel Test Structure



Matrix: 32x32
Readout: async. digital with ToT
Pitch: 15 µm
Process: 1 variant (modified with gap process)

CE-65 Circuit Exploratoire 65

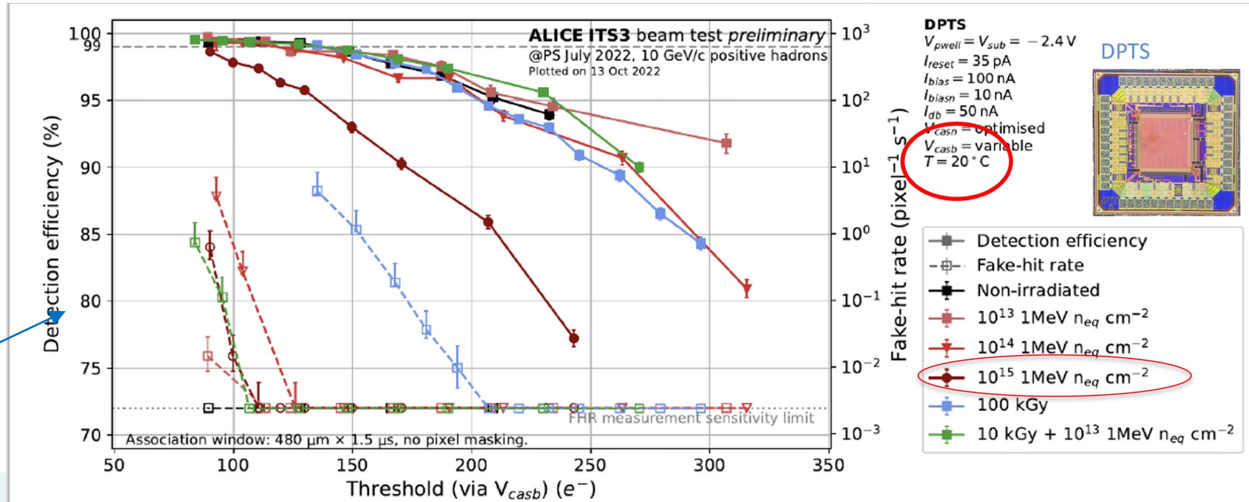


Matrix: 48x32
Readout: rolling shutter analog
Pitch: 15, 25 µm
Process: 1 variant (modified with gap process)

from MLR1

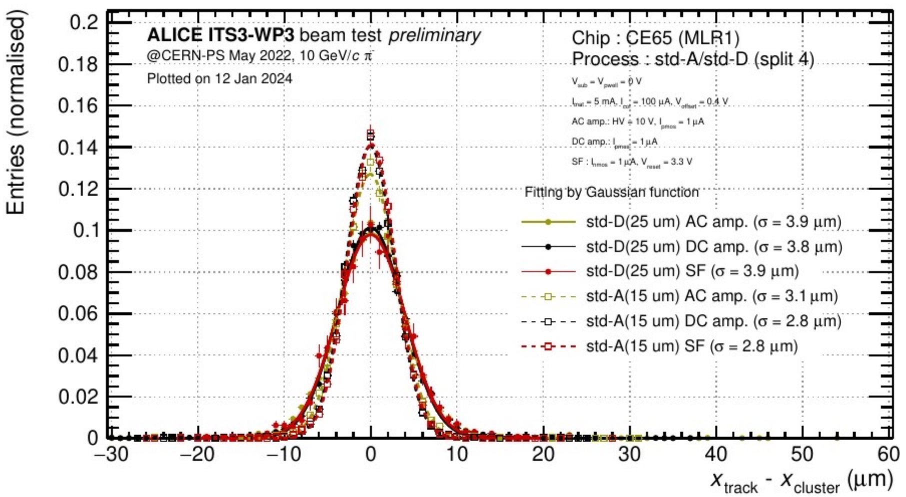
promising results from MLR1

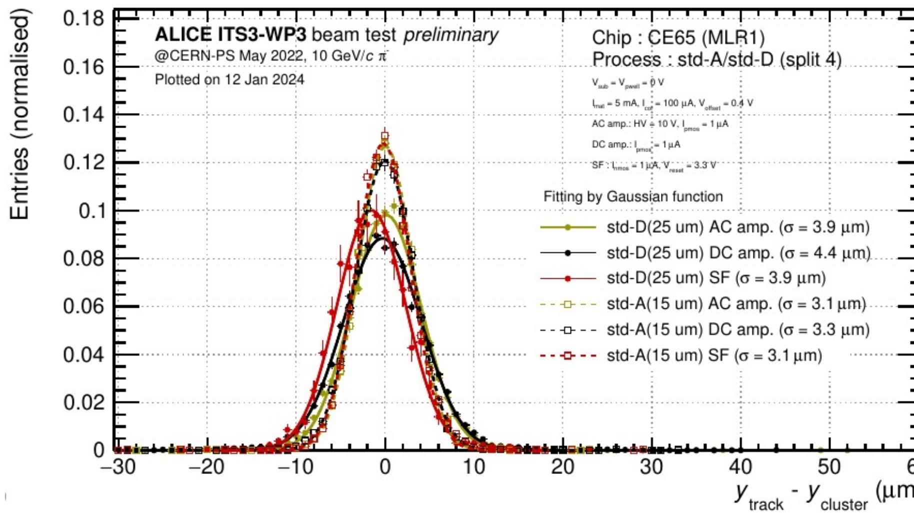
- leakage cur. ✓
- Testbeam with DPTS (digital 15 µm) proved that process modification works & radiation tolerance > $10^{15} n_{eq}/cm^2$



TPSCo 65 nm (Tower)

Detailed position resolution studies done CE65v1/v2 chip family form MLR1 and ER1





Very good results achieved:

- spatial resolution of ~2.7 +/- 0.3 μm for standard 25 μm pixel
- spatial resolution of ~1.3 +/- 0.3 μm for standard 15μm pixel
- to be compared with DPTS with modified process and 15 μm pixel: 4 – 4.2 μm

J. Baudot, A. Kumar et al.

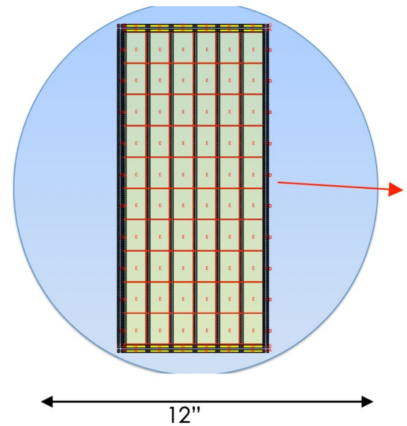
2nd submission: Engineer Run 1 (ER1)

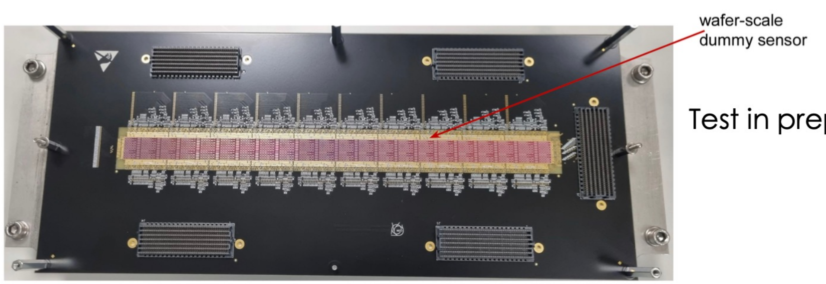
- Main goal = exercise stitching (in 1D) to assess yield
- Submission November 2022
- Back from fab April 2023

- 2 long (~26 cm) sensors
  - **MOSS:** priority-encoder readout (ALPIDE-like)
    - 1.4 cm wide
    - 18 & 22.5 μm pitch
  - **MOST:** low power asynchronous readout
    - 0.25 cm wide

- Many (51) **chiplets**
  - Pixel prototypes
  - SEU test chips
  - Functional blocks (PLL, serial links)

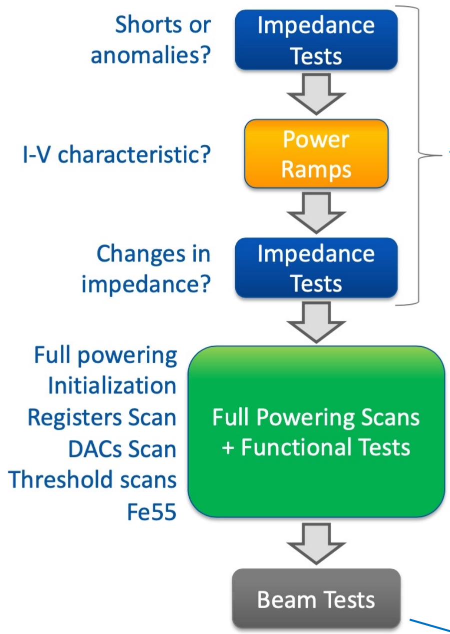
- New metal staks
- New methodology for submission
  - Digital-on-top





Test in preparation

TPSCo 65 nm (Tower)



Ramp supplies slowly and monitor currents

- OK -> all supplies ramped to full voltage and currents less than compliance *limit*
- Wafer maps reconstructed from power ramps data of MOSS on carriers

Wafer to wafer differences

Detailed investigation of units with high current ongoing

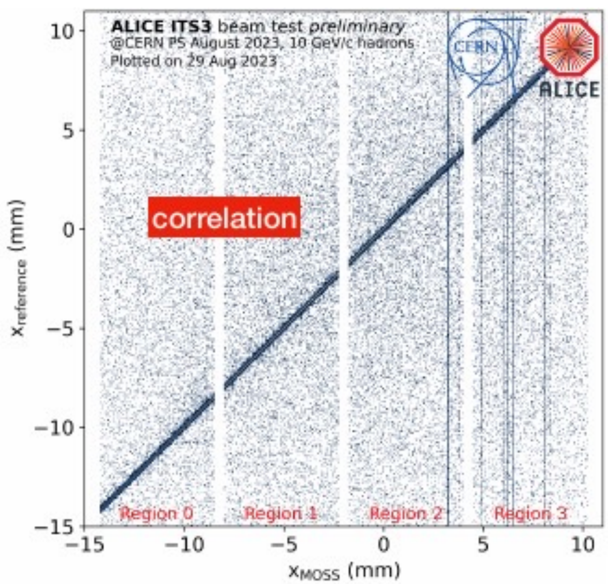
	RSU1	RSU2	RSU3	RSU4	RSU5	RSU6	RSU7	RSU8	RSU9	RSU10	
1-TOP	LIMIT	OK	OK	LIMIT	LIMIT	LIMIT	LIMIT	OK	OK	OK	60.0% OK
1-BOT	OK	OK	OK	OK	LIMIT	LIMIT	LIMIT	OK	OK	OK	
2-TOP	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	
2-BOT	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	
3-TOP	OK	OK	OK	OK	LIMIT	LIMIT	LIMIT	OK	OK	OK	50.0% OK
3-BOT	LIMIT	OK	OK	LIMIT	LIMIT	LIMIT	LIMIT	LIMIT	OK	LIMIT	
4-TOP	OK	OK	OK	LIMIT	LIMIT	LIMIT	LIMIT	OK	OK	OK	50.0% OK
4-BOT	OK	LIMIT	OK	LIMIT	LIMIT	LIMIT	LIMIT	OK	OK	LIMIT	
5-TOP	OK	LIMIT	OK	LIMIT	OK	LIMIT	LIMIT	LIMIT	OK	OK	55.0% OK
5-BOT	OK	OK	OK	LIMIT	LIMIT	OK	LIMIT	OK	OK	LIMIT	
6-TOP	OK	LIMIT	OK	OK	LIMIT	LIMIT	LIMIT	LIMIT	OK	OK	65.0% OK
6-BOT	OK	OK	OK	OK	OK	LIMIT	LIMIT	OK	OK	OK	

WAFER 23 - Power Ramp - 92/120=76.67% HUs OK

	RSU1	RSU2	RSU3	RSU4	RSU5	RSU6	RSU7	RSU8	RSU9	RSU10	
1-TOP	OK	OK	OK	LIMIT	OK	OK	OK	LIMIT	OK	OK	85.0% OK
1-BOT	OK	OK	OK	OK	OK	LIMIT	OK	OK	OK	OK	
2-TOP	OK	OK	LIMIT	LIMIT	LIMIT	OK	OK	OK	OK	OK	80.0% OK
2-BOT	OK	OK	OK	OK	OK	LIMIT	OK	OK	OK	OK	
3-TOP	OK	OK	LIMIT	LIMIT	LIMIT	LIMIT	LIMIT	OK	OK	LIMIT	60.0% OK
3-BOT	OK	OK	OK	OK	OK	LIMIT	OK	OK	LIMIT	OK	
4-TOP	OK	LIMIT	LIMIT	LIMIT	OK	OK	OK	OK	OK	OK	75.0% OK
4-BOT	OK	OK	OK	OK	OK	OK	LIMIT	LIMIT	OK	OK	
5-TOP	OK	OK	OK	LIMIT	OK	OK	OK	OK	OK	OK	75.0% OK
5-BOT	LIMIT	OK	LIMIT	OK	LIMIT	LIMIT	OK	OK	OK	OK	
6-TOP	OK	OK	OK	OK	LIMIT	OK	OK	OK	OK	OK	85.0% OK
6-BOT	OK	OK	OK	OK	OK	LIMIT	OK	OK	LIMIT	OK	

WAFER 24 - Power Ramp - 79/80=98.75% HUs OK

	RSU1	RSU2	RSU3	RSU4	RSU5	RSU6	RSU7	RSU8	RSU9	RSU10	
1-TOP	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Full MOSS
1-BOT	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	
2-TOP	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	95.0% OK
2-BOT	LIMIT	OK	OK	OK	OK	OK	OK	OK	OK	OK	
3-TOP	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	
3-BOT	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	
4-TOP	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	
4-BOT	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	
5-TOP	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Full MOSS
5-BOT	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	
6-TOP	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Full MOSS
6-BOT	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	



Stitched sensor MOSS from ER1:

- Design is functional
- Sensor works – 26 cm long!
- Learning about yield and wafer-to-wafer variations

LFoundry 150 nm

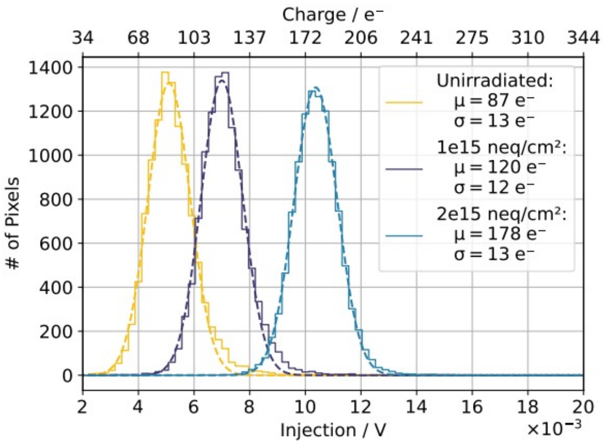
- LF-Monopix-2
- RD50 – MPW2/3
- CACTUS

LF-Monopix 2
Large electrode, radiation hardness

Goal: mature large (1x2 cm²) (very) radhard, large electrode fully functional, HL-LHC compatible (5th layer) DMAPS sensor with column drain readout

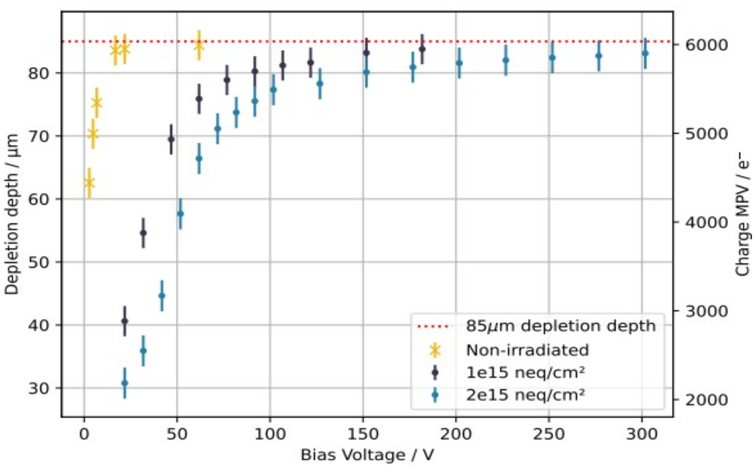
irradiated devices (1 and 2e15 n_{eq}/cm^2 @ Bonn Cyclotron)

- no significant degradation at this level except for leakage current increase



ENC distribution

Calibrated charge MPVs



- fully depleted @ ~200 V bias (15 V unirr.)

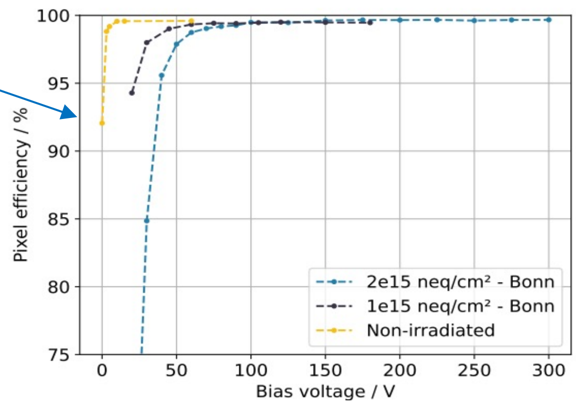
Lars Schall, C. Bespin, et al.

LF-Monopix 2
Large electrode, radiation hardness

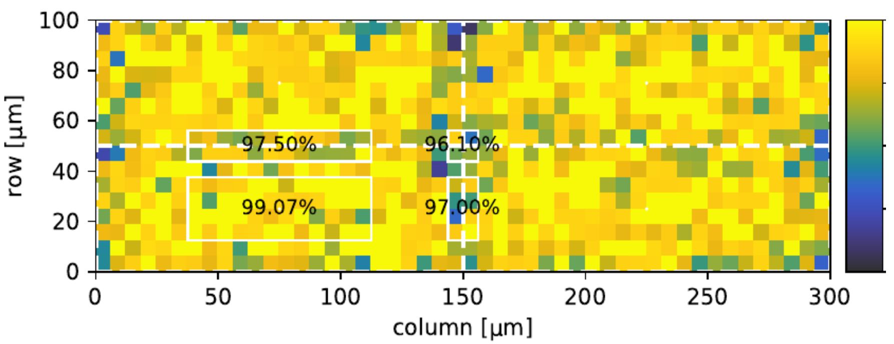
Goal: mature large (1x2 cm^2) (very) radhard, large electrode fully functional, HL-LHC compatible (5th layer) DMAPS sensor with column drain readout

- intensive test beam characterisations
- very high (>99%) efficiency (in-time) after 1 and 2e15 n_{eq}/cm^2
- ~no efficiency degradation wrt unirradiated devices
- New: devices irradiated to 2e15 n_{eq} tested:
  - still >99% efficiency but more pixel disabled due to leakage current induced ENC increase, higher gain of pre-amp helps for in-time eff.

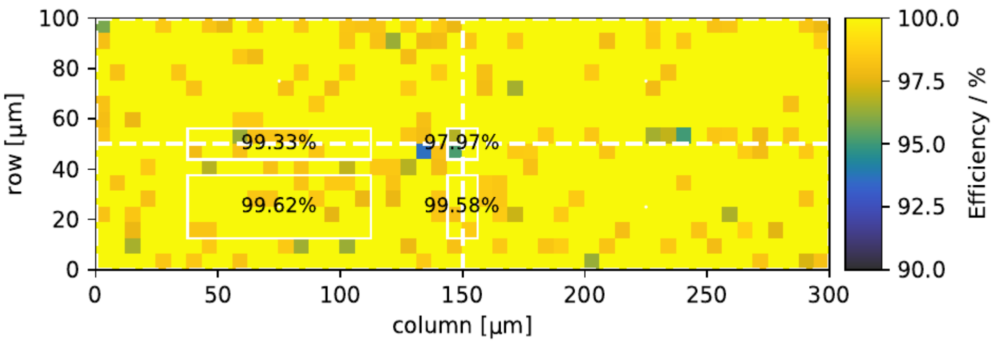
Hit-detection efficiency vs bias voltage



In-pixel, in-time efficiency
(**mean 98.35%** @ 2e15 neq/cm²)



In-pixel, in-time efficiency
(**mean 99.60%** @ 2e15 neq/cm²)



RD50-MPW2/3

Goal: series of MPWs (1 ... 4) to achieve very small pixels (60 x 60 µm^2) radhard @ HL-LHC level 5th layer by large electrode design (all electronics inside deep well)

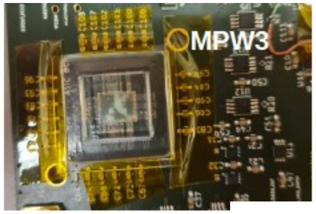
MPW2: small prototype

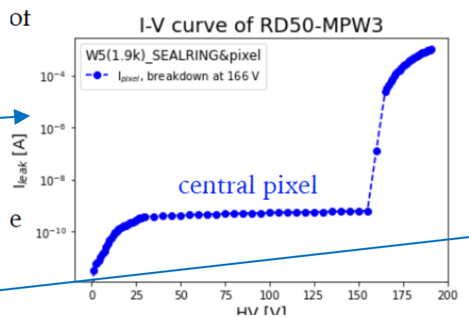
- pixels: 60 x 60 µm2
- in-pix CSA + discriminator, analog R/O
- testbeams performed
- charge collection ok

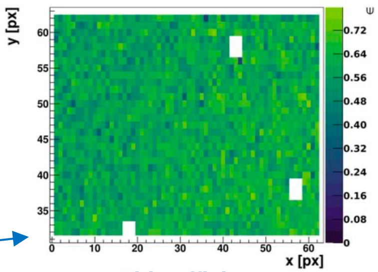
MPW3: added digital R/O (column drain)

- $V_{breakdown}$ ~ 150V
- very high noise (> 2000 e) due to noise coupling from digital periphery
- Poor test beam efficiency due to high thresholds

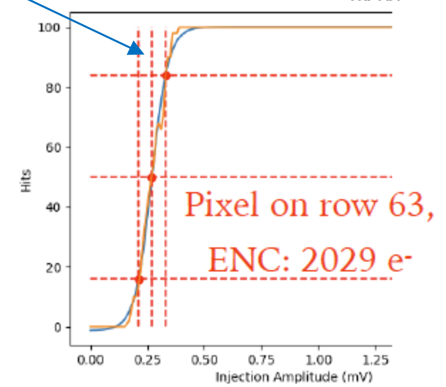
MPW4 (2023/24): backside processing to improve radiation hardness, eliminate high noise and increase breakdown

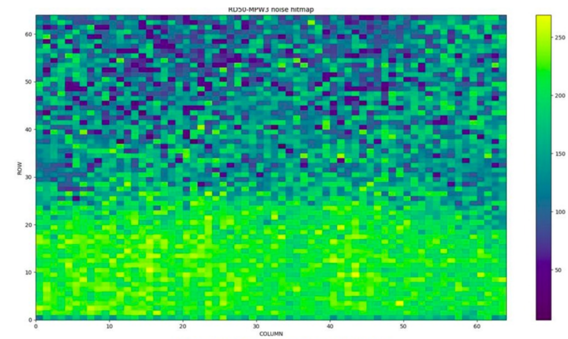






Chip efficiency





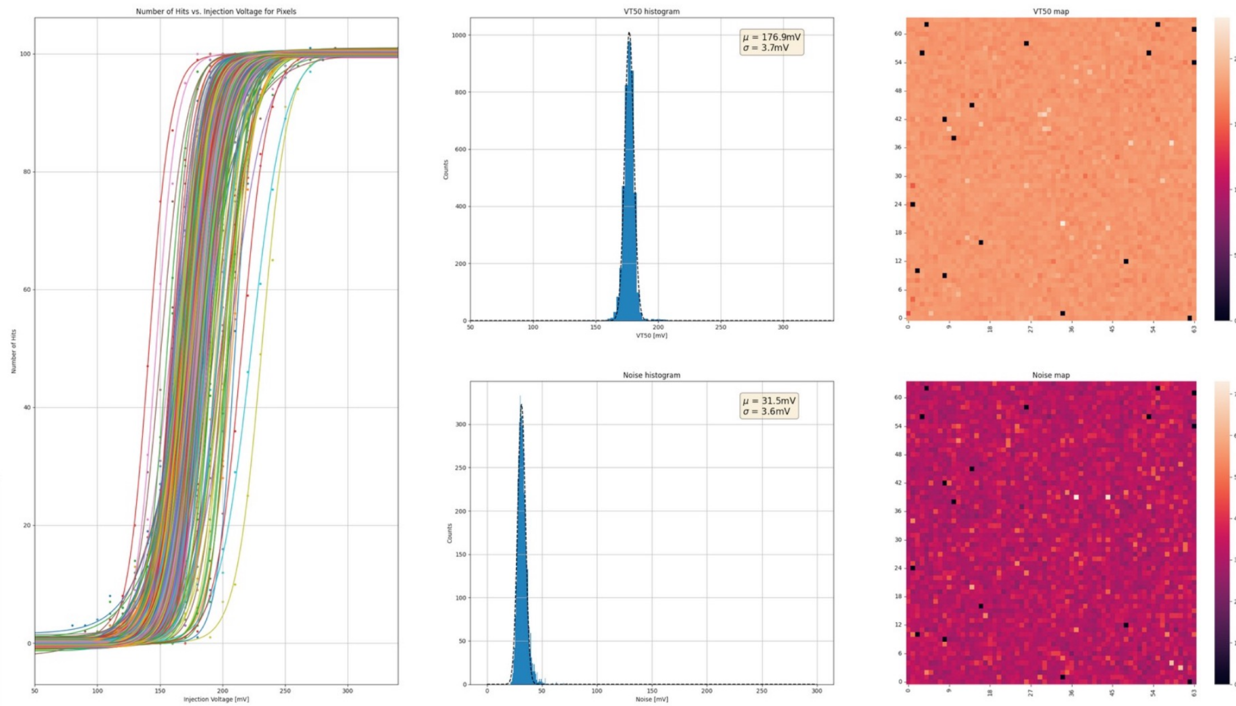
Pixel matrix noise hitmap

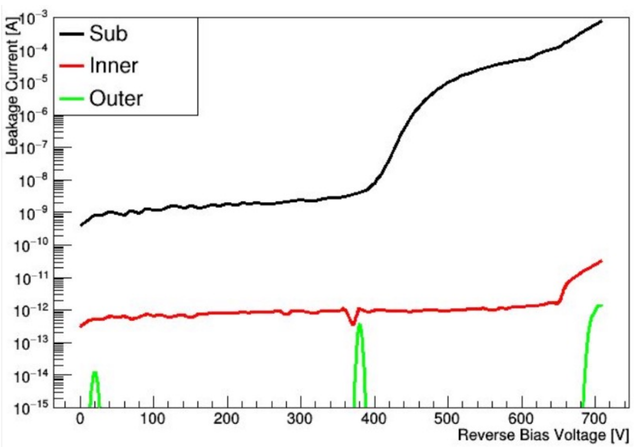
E. Vilella, C. Zhang et al

RD50-MPW2/3

MPW4 (2023/24):

- Initial tests indicate that noise elimination and breakdown voltage increase was achieved
- Tests with backside processed wafers proved improved leakage current behaviour





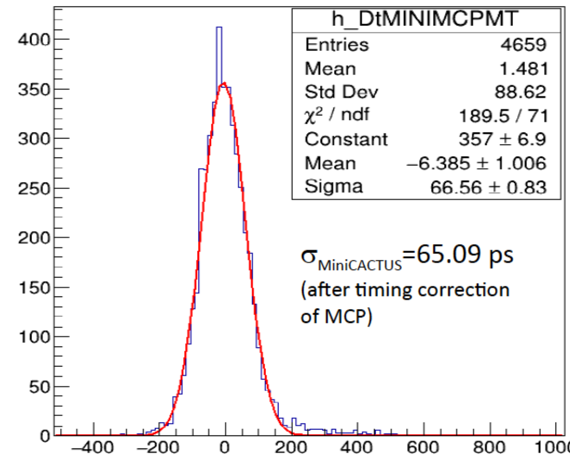
- ENC of 200e$^-$ over whole matrix and small threshold dispersion

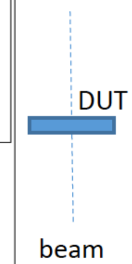
CACTUS
large electrode

Goal: Develop CMOS pixels for timing applications (~50 ps)

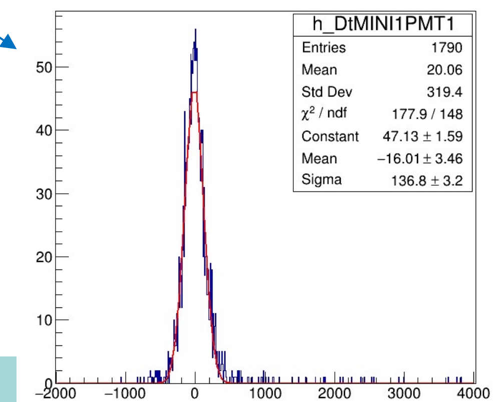
Mini CACTUS = small prototype to address limitations of CACTUS (low S/N)

- 65 ps mip time resolution achieved in test beams
- compared calibrations and resolutions using photons of different energies (^{241}Am and @SOLEIL)
  - ➢ calibrations ✓
  - ➢ σ_t for photons (understandably) worse (320 ps)
- characterisation after 1e14:
  - Time resolution worsens at room temperature but with low leakage current at -15°C recovers





Sensor	HV bias (V)	Conditions	Temp. (°C)	Time res. (ps)	MPV (mV)
Unirradiated 300 u	400	testbeam, MCPMT time reference	room	78.97 ± 1.36	201.9 ± 0.5
Unirradiated 300 u	400	90Sr, PMT time reference*	room	104.5 ± 2.30	195.7 ± 2.3
Unirradiated 300 u	280	testbeam, MCPMT time reference	room	89.11 ± 1.56	200.9 ± 0.5
Irradiated 300 u	280	90 Sr, PMT time reference	20	108.2 ± 3.2 (PMT subt.)	108.2 ± 3.2
Irradiated 300 u	320	90 Sr, PMT time reference	20	132.9 ± 5.0 (PMT subt.)	113.5 ± 0.8
Irradiated 300 u	320	90 Sr, PMT time reference	-15	87.9 ± 4.7 (PMT subt.)	132.7 ± 0.6

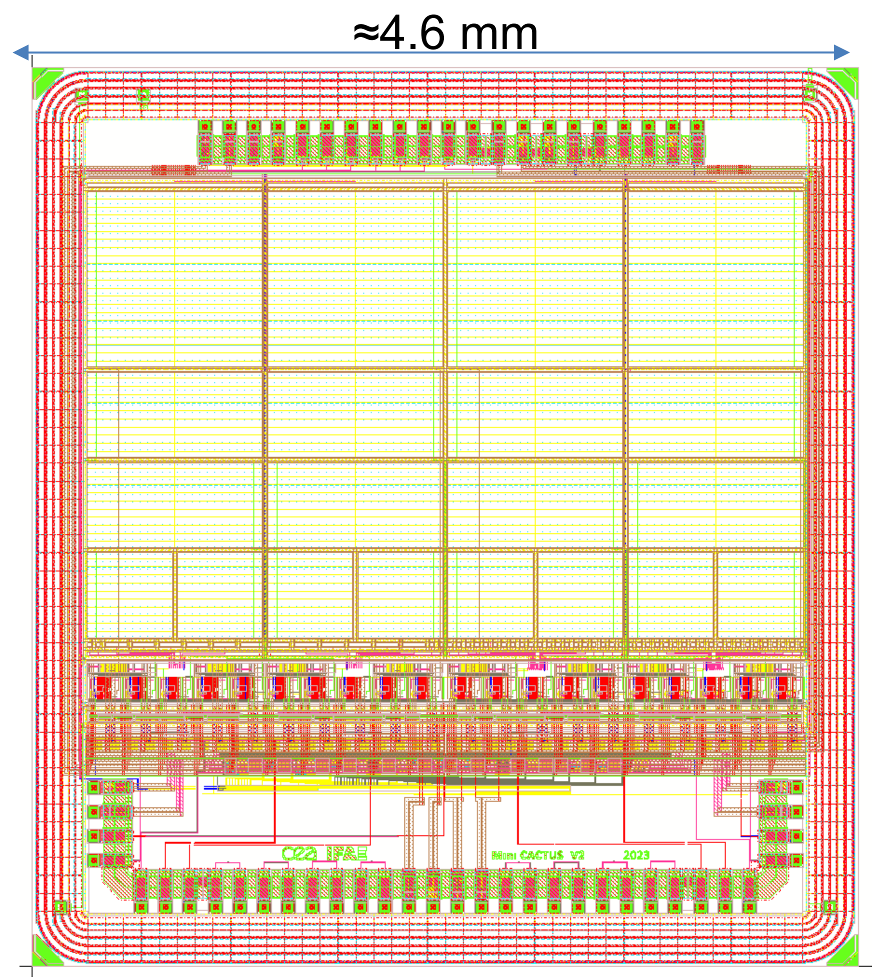


P. Schwemling, Y. Degerli et al

MiniCACTUS V2

CACTUS large electrode

- ~ 2 times larger than MiniCACTUS
- 0.5 mm x 1 mm (baseline), 1 mm x 1 mm and 0.5 mm x 0.5 mm diodes
- 50 µm x 150 µm and 2 50 µm x 50 µm small test diodes
- 3 different preamps
- New multistage discriminator with **programmable hysteresis**
- Improved layout for better mixed-signal coupling rejection
- **CEA-IRFU** & **IFAE-Barcelona** coll.
- Submitted in May 2023, waiting for samples to
- come back from post-processing



P. Schwemling, Y. Degerli et al

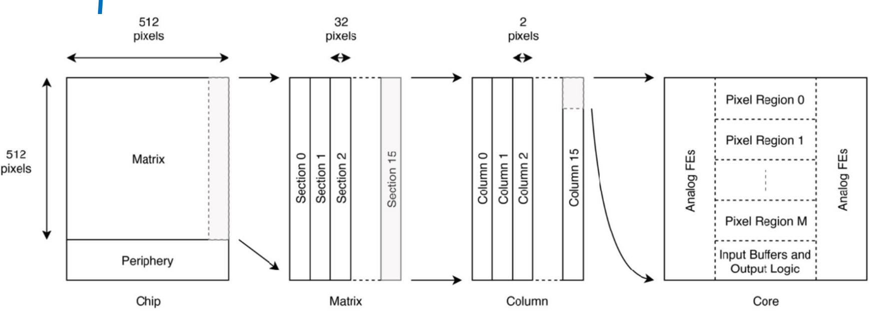
LFoundry 110 nm

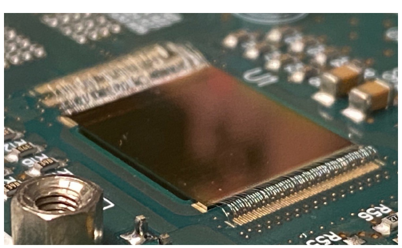
ARCADIA

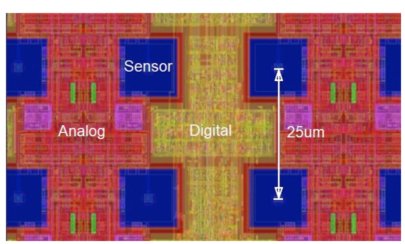
ARCADIA Tests

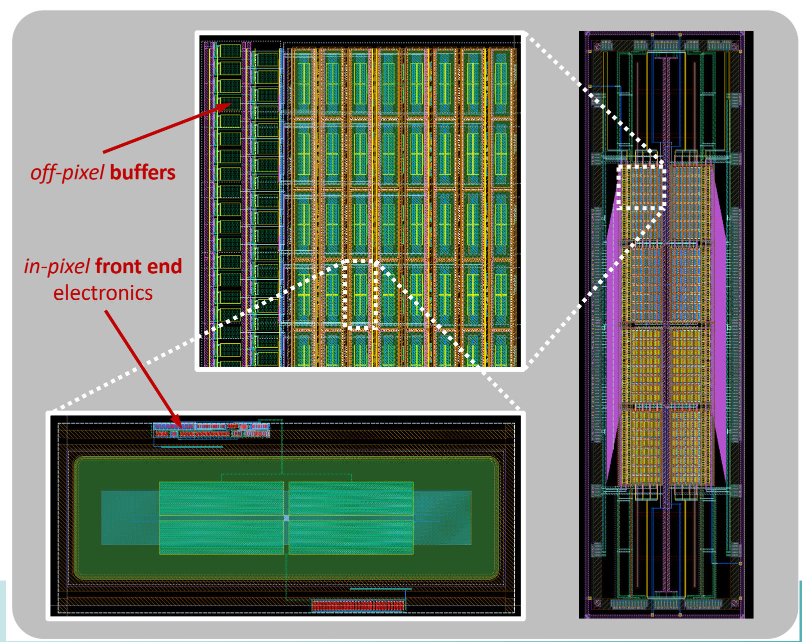
Goal: Develop DMAPS technology platform in 110 nm technology. Largely funded by INFN. Targeting small pixels, very low power, various thicknesses

- MD3 main-demonstrator with system-grade full chip Fully Depleted MAPS (FDMAPS with 512x512 pixel matrix, pitch 25 μm, low power, high event rate)
- Scalable FDMAPS architecture with very low power of 10 mW/cm^2
- adding gain layer for LC3 (MADPIX), small prototype (4 x 16 mm^2)
- Structures from both are available and first results looks reasonable



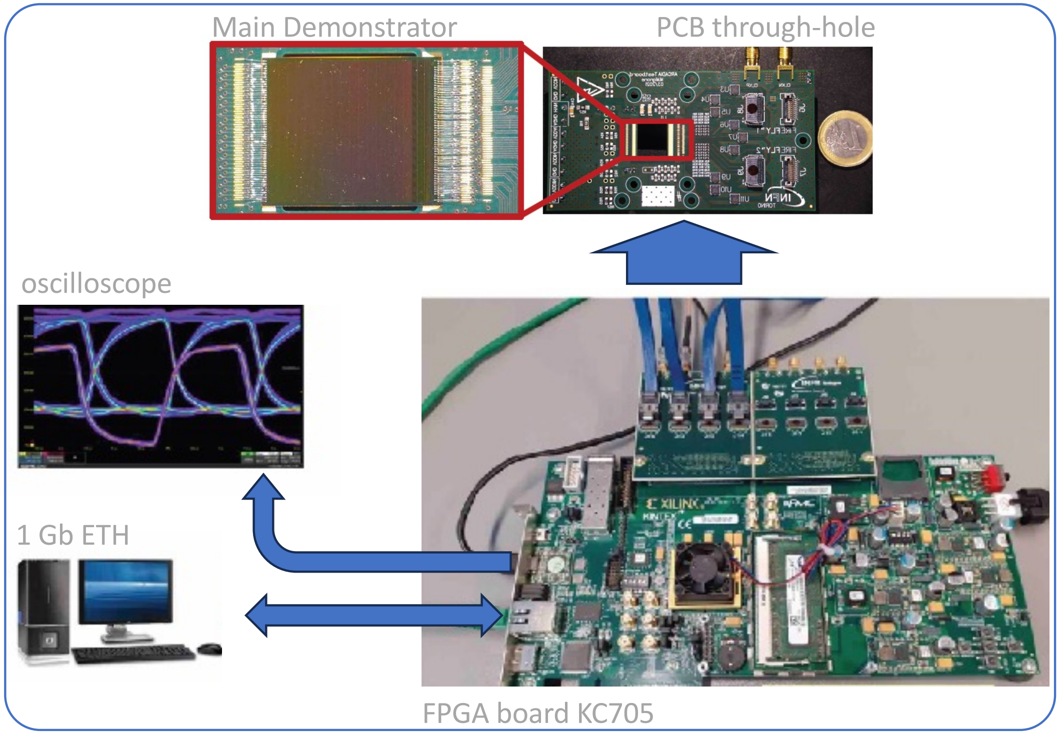


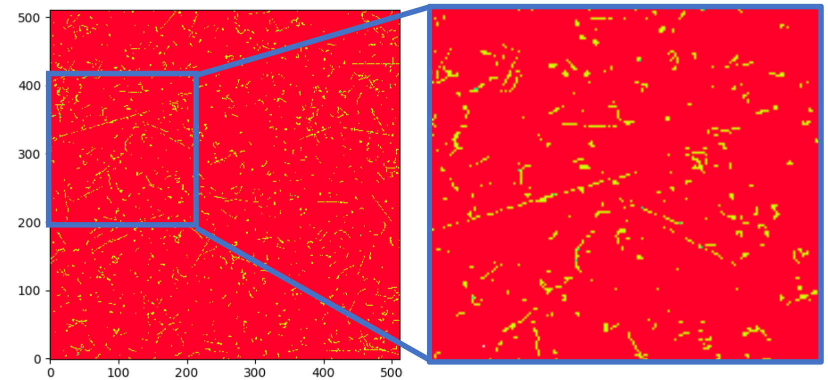




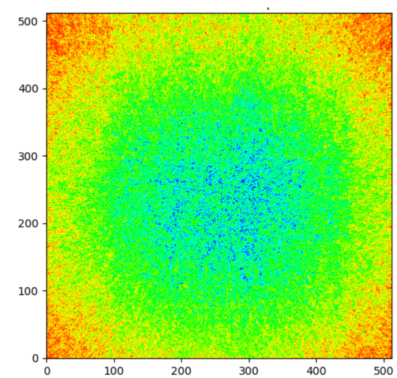
ARCADIA Tests
Main Demonstrator

Main Demonstrator - acquisition setup

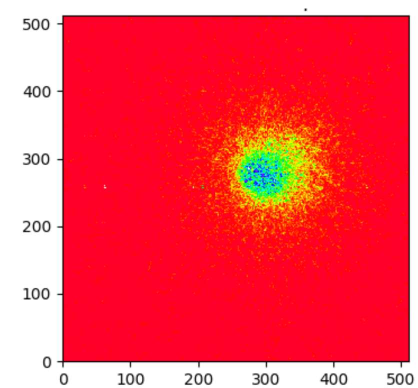




Cosmic rays acquisition (4h)



^{90}Sr beta source (1cm^2) 8 mm from the sensor surface



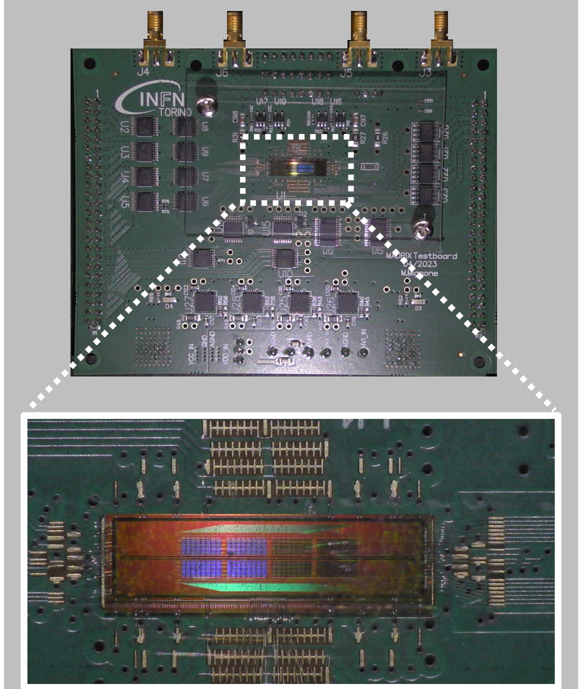
Collimated ^{90}Sr beta source
Collimator diameter: 1mm

- Total **power consumption**: **10 mW/cm^2** at low event rates
- **Design specification**: **20 mW/cm^2** at rates up to 100 Mevents/cm^2

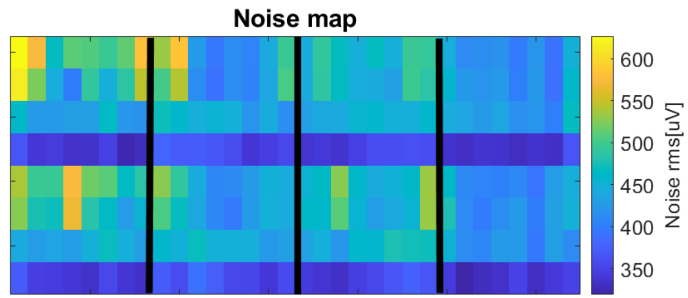
M. Mandurrino et al.

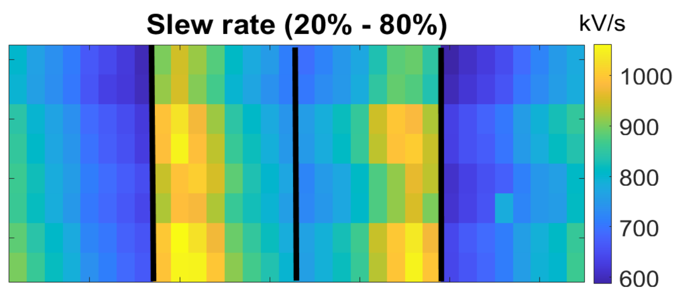
ARCADIA Tests MADPIX

MadPix testboard



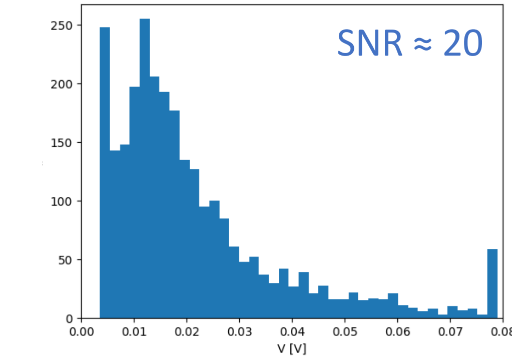
Noise and **slew-rate** characterization with external **test-pulse** injection

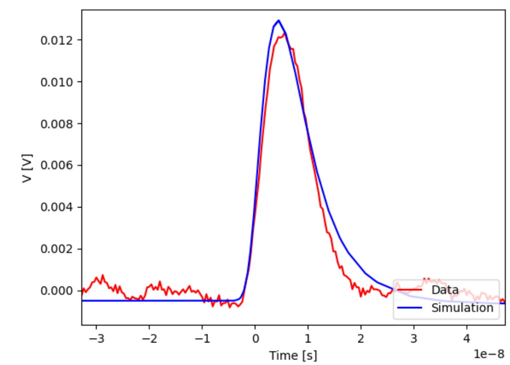




U. Follo

First data with **beta source** (^{90}**Sr**)





- But gain layer turned out to be too low (~3 instead of 10 – 30) due to mismatch in p-gain implant energy
- Will be fixed now with new short loop engineering run

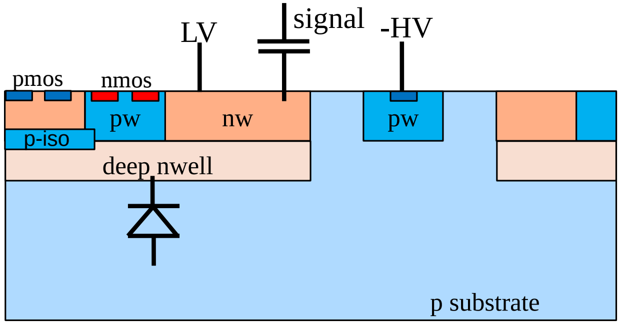
M. Mandurrino et al.

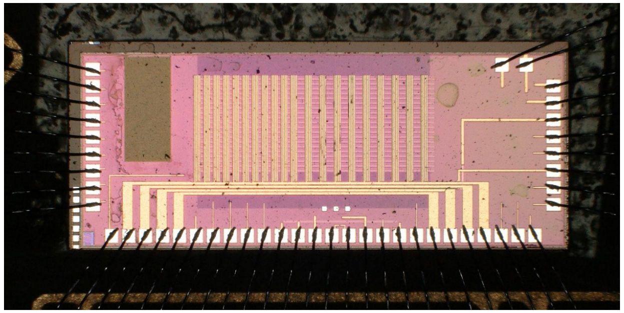
LFoundrxy 110 nm, TSI

PSI developments

Goal: Generic R&D on DMAPS with TSI and technology platform in LF 110 nm provided by ARCADIA

- 2 PSI TSI MAPS chips designed – TSI-RS4, large collecting electrode
- LF 110 prototypes designed and manufactured using the ARCADIA platform (MoTiC A & B), small collecting electrode, TDC shared by 4 pixel

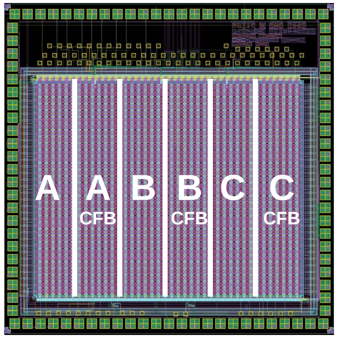




TSI-RS4

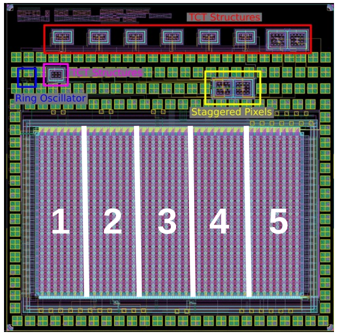
20 columns, 20 rows
50 x 100/150µm^2

Same sensor
6 different amplifiers
80 columns, 64 rows
50 x 50µm^2



MoTiC A

Same amplifier (C)
5 different sensors
80 columns, 48 rows
50 x 50µm^2

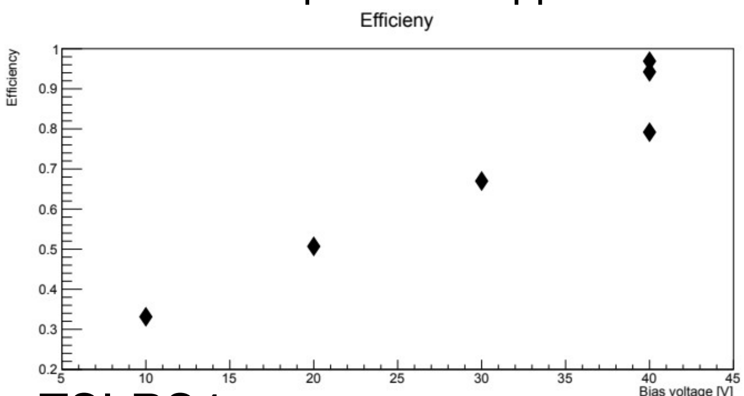


MoTiC B

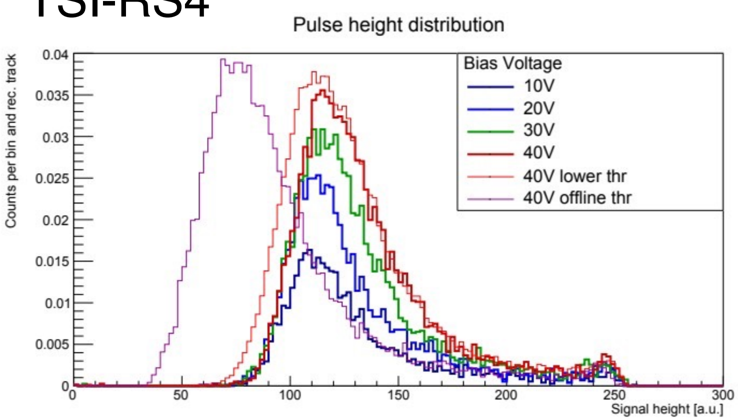
PSI developments

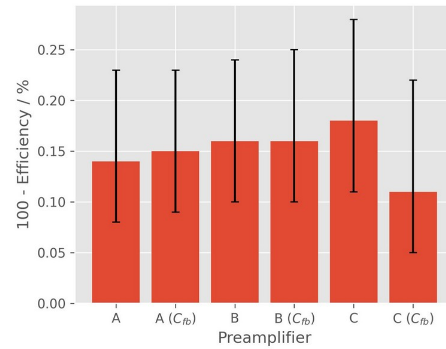
Goal: Generic R&D on DMAPS with TSI and technology platform in LF 110 nm provided by ARCADIA

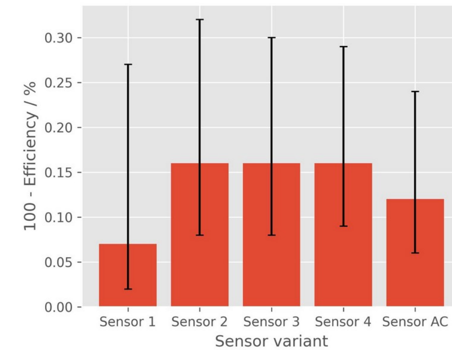
- Encouraging results achieved but still early stage
- TSI developments stopped due to foundry finishing this node



TSI-RS4

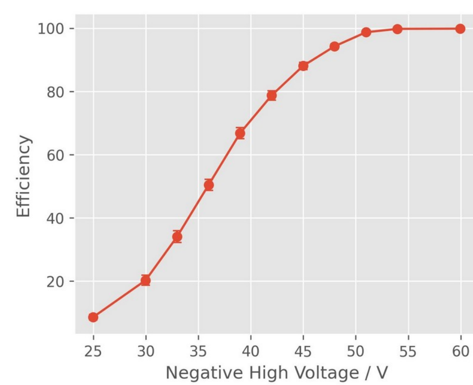


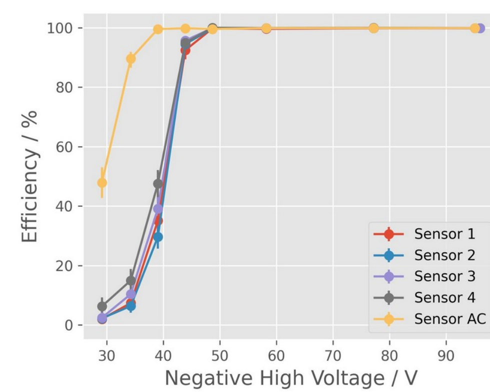




MoTiC A

MoTiC B





Summary

- Lots of activity at all fronts: *high granularity, radiation hardness and timing*
- Fabrication of devices completed in all lines
- All research lines are currently intensively characterizing their devices
- 2 Milestones (MS18, MS20) and 1 Deliverable (D5.1) achieved
- Next Milestone MS19 & Deliverable D5.3 due in April but sufficient material is already available
- Many publications

BACK UP SLIDES

Contact Persons and email list

One contact person per institution:

Carlos Solans <carlos.solans@cern.ch> – CERN
Eva Vilella Figueras <vilella@hep.ph.liv.ac.uk> – Liverpool
Jerome Baudot <jerome.baudot@iphc.cnrs.fr> – IPHC
Thomas Bergauer <Thomas.Bergauer@cern.ch> – HEPHY
Francesco Forti <Francesco.Forti@pi.infn.it> – Pisa
Marlon Barbero <barbero@cppm.in2p3.fr> – CPPM
Daniela Bortoletto <Daniela.Bortoletto@physics.ox.ac.uk> – Oxford
SCHWEMLING Philippe <Philippe.Schwemling@cea.fr> – IRFU
"C. Marinas" <cmarinas@ific.uv.es> – IFIC
Manuel Dionisio da Rocha Rolo <darochar@to.infn.it> – Torino
Attilio Andreazza <attilio.andreazza@mi.infn.it> – Milano
Valerio Re <valerio.re@unibg.it> – Pavia
F. Hügging <huegging@physik.uni-bonn.de> – Bonn
S. Grinstein <sgrinstein@ifae.es> – Barcelona

- Let us know of changes above.
- The AIDAinnova-WP5@cern.ch mailing list is used for general announcements and information.