AIDA innova

Advancement and Innovation for Detectors at Accelerators

Second Project Review Meeting

20 June 2024

CERN

WP5

Depleted Monolithic Active Pixel Sensors

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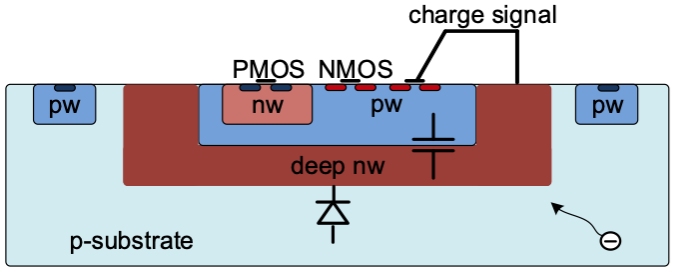
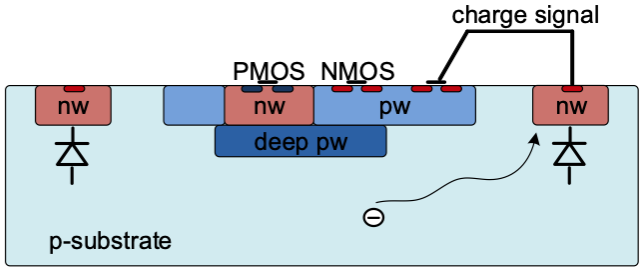
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004761.

Objectives

- Two basic approaches to Depleted Monolithic Active Pixel Sensors (DMAPS)
  a) Large charge collecting electrode, with electronics inside n-well
  b) Small electrode with the electronics separated





- Within the structure of WP5
  a) Large electrode mostly targets *radiation hardness*
  b) Small electrode primarily aims to *high granularity* lower noise and power
- *Categories are only an approximation:* large electrode efforts try to reduce pixel sizes while small electrode approach also targets large depletion regions
- Since the initial proposal DMAPS for **timing** started to be investigated
- The objective of the WP5 is to design, fabricate and test (before and after irradiation) DMAPS on these lines

Highlights: Radiation hardness

Past and future submissions that will be, or have been, *partially* supported (with person-power) by AIDAinnova. These are the core of the WP5 activities.

Submission	Process	Time-scale	Target	Main Institute	Comment
LF-Monopix 2	LF 150 nm	v2 produced	rad. hard	Bonn/CPPM	Follow from ATLAS R&D
RD50-MPW 3/4	LF 150 nm	v4 produced	rad. hard	Liverpool	R&D
CACTUS	LF 150 nm	mini-CACTUS v2 produced	timing, large electrode	CEA	LHC upgrade & beyond
TJ-Monopix 2	TJ 180 nm	v2 produced, OBELIX next	high granularity	Bonn	Belle II, follow up by Obelix
MALTA 2/3	TJ 180 nm	MiniMALTA3 produced	high granularity, rad hard	CERN	LHC upgrade & beyond
ARCADIA	LF 110 nm	new submission 2024	high granularity	INFN	Demonstrator
TJ 65 nm	TJ 65 nm	ER2 to be submitted	high granularity	IPHC	R&D, ALICE

Note:

TJ: Tower

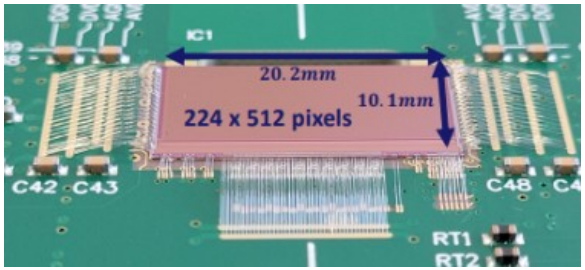
LF: LFoundry

- All activities produced device/prototype during the first phase of the project
- All lines already characterized devices produced and most are on second iteration

Highlights: Radiation Hardness

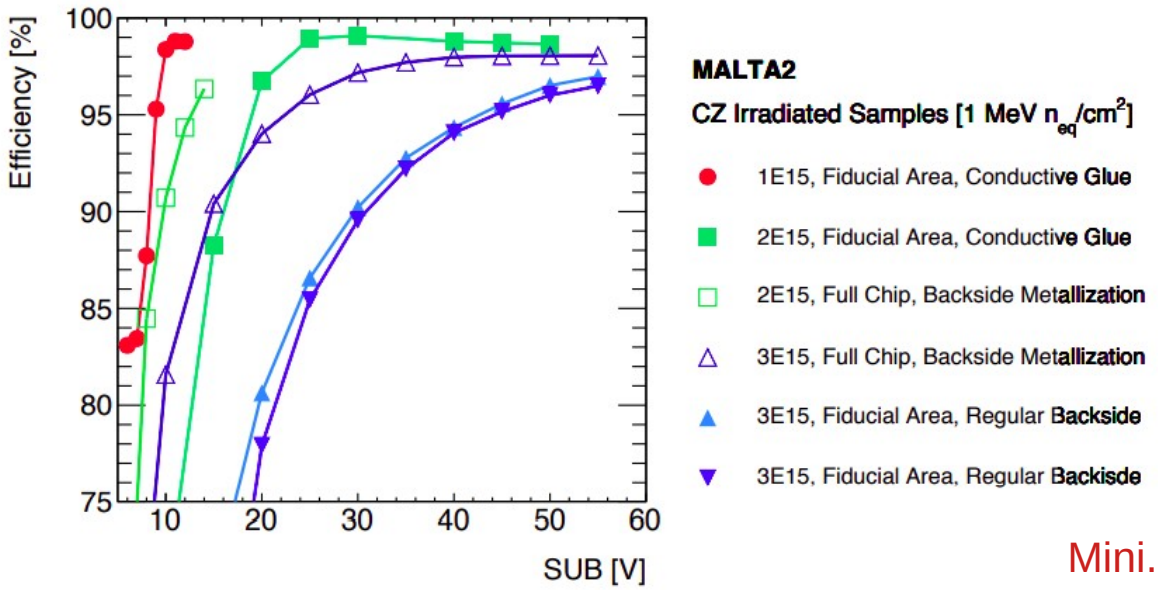
MALTA2

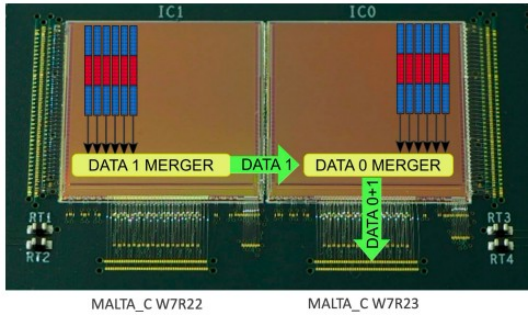
- Excellent results after **3E15 neq/cm2**
  - Efficiency (>95%)
  - In-time (>95% in 25ns)



Pixels:
36.4 x 36.4 µm2

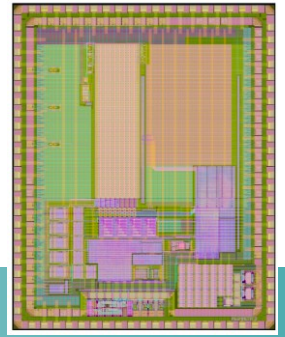
LeBlanc M., et al., NIMA 1041 (2022) 167390





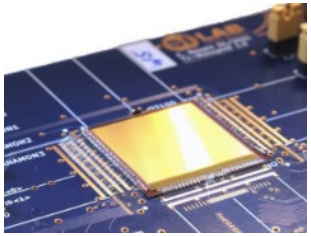
- Recently produced **MPW4** works well, plan to irradiate later this year

Mini.MALTA3 demonstrator fabricated and being tested



Highlights: High Granularity

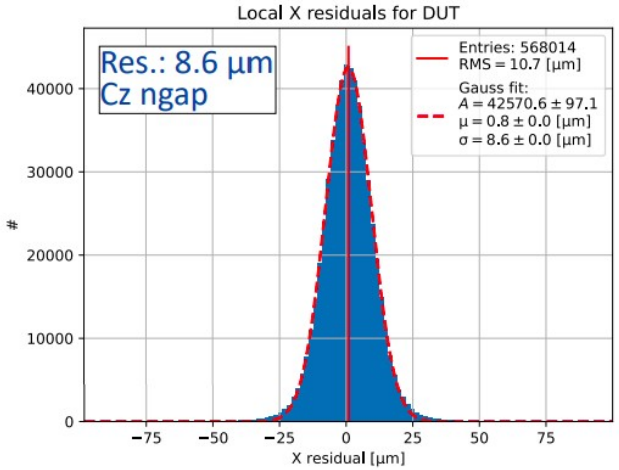
TJ-Monopix 2

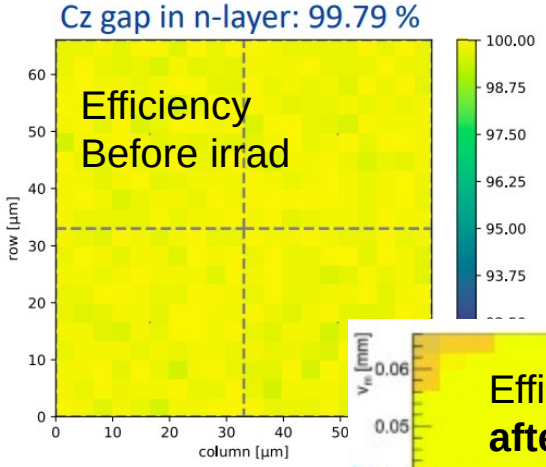


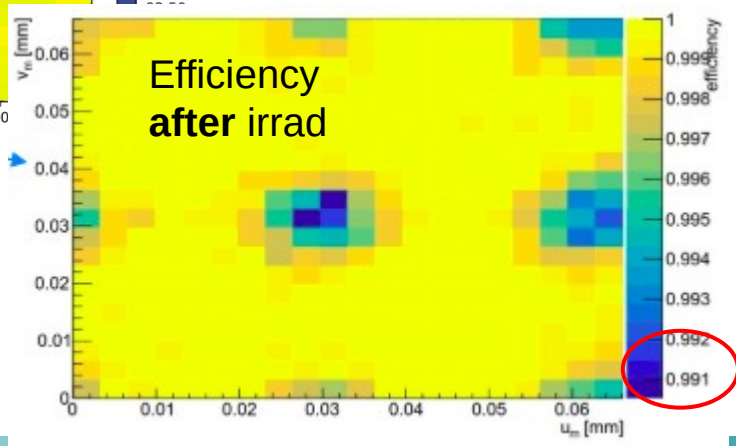
Pixel size: 33x33 µm^2
Chip size: 2x2 cm^2

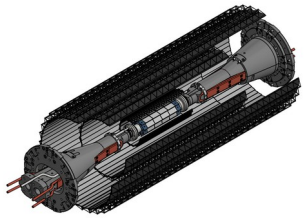
- About 9 µm position resolution (<cluster size> ~ 2, Cz)
- Excellent efficiency before and after (5E14 neq/cm2) irradiation

C. Bespin et al., NIMA 040 (2022) 167189







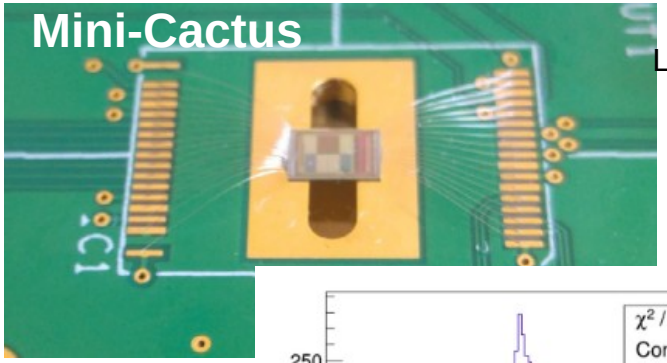


Basis of OBELIX (same analog part), prototype for Belle-II VXD upgrade

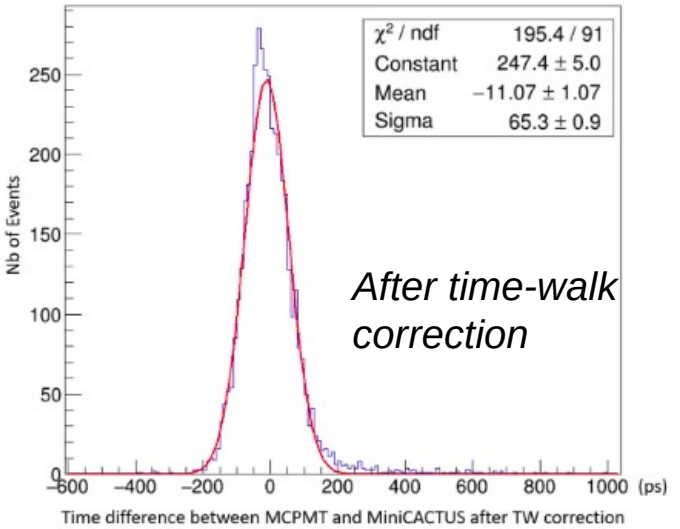
Highlights: Timing

CACTUS

- Target is ~50 ps **timing resolution**
- Large (~1x1 mm^2) pixels
- **Mini-CACTUS**
  - Small prototype to address CACTUS limitations (low S/N)
  - Implements different pixel flavors
  - Achieved ~ 65 ps resolution
- **Second iteration:** mini-cactus-V2
  - Implement different amplifiers types
  - Improved front-end (better discr.)
  - Device operational, promising initial results
    - Test-beam next week
- Also **ARCADIA** effort targeting timing with charge multiplication



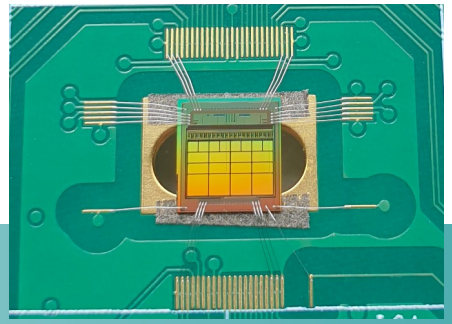
LFoundry 150 nm, thinned to 100-300 µm



After time-walk correction

Yavuz Degerli, et. al.

Mini-cactus-V2 being tested

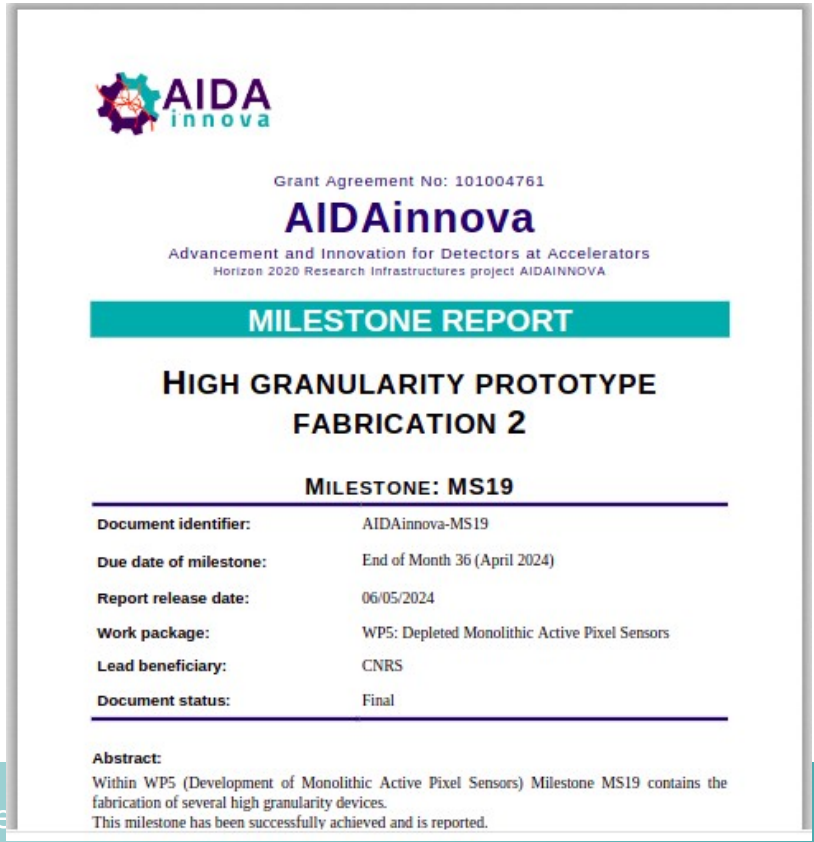


Deliverables/ Milestones

April 2021

Tasks	Description	Year 1												Year 2												Year 3												Year 4													
		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			

- Some activities with delays or need of another fabrication cycle, but others cover the commitments of the project
- Thus, all milestones and deliverables **achieved**
- Outlook is reasonably good towards final milestone and deliverables



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Grant Agreement No: 101004761

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Advancement and Innovation for Detectors at Accelerators

Horizon 2020 Research Infrastructures project AIDAINNOVA

MILESTONE REPORT

HIGH GRANULARITY PROTOTYPE FABRICATION 2

MILESTONE: MS19

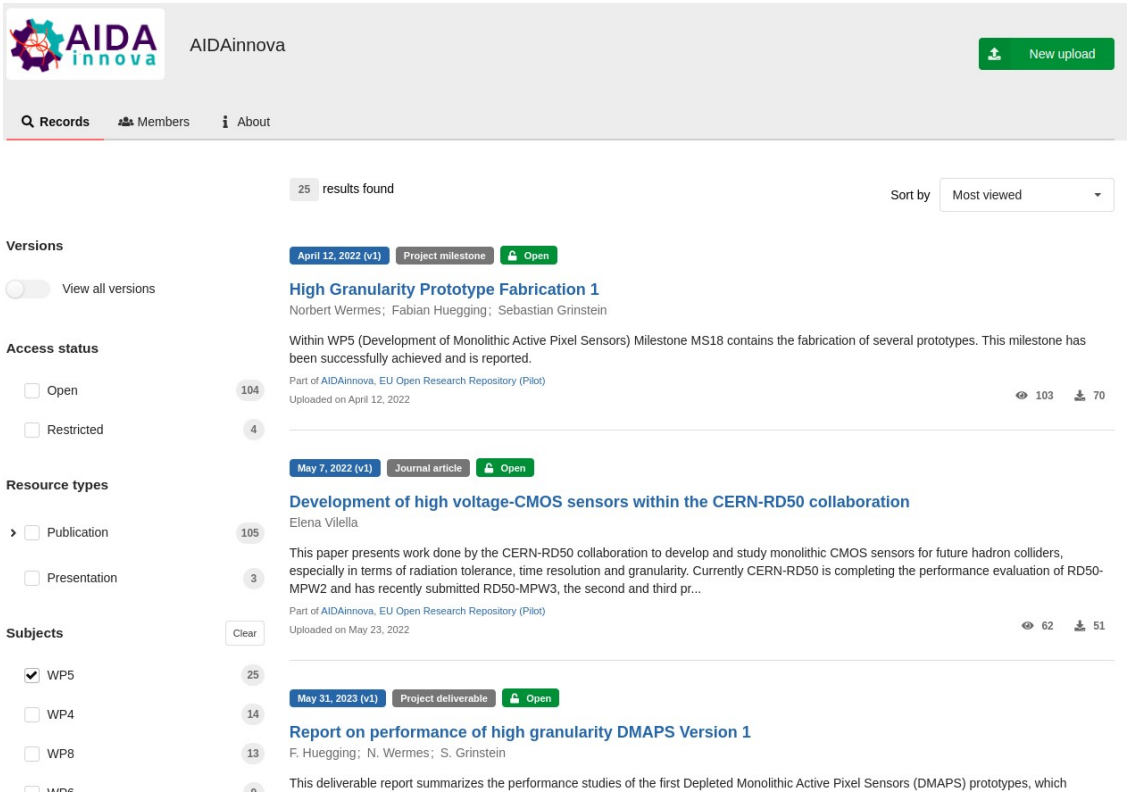
Document identifier:	AIDAinnova-MS19
Due date of milestone:	End of Month 36 (April 2024)
Report release date:	06/05/2024
Work package:	WP5: Depleted Monolithic Active Pixel Sensors
Lead beneficiary:	CNRS
Document status:	Final

Abstract:

Within WP5 (Development of Monolithic Active Pixel Sensors) Milestone MS19 contains the fabrication of several high granularity devices.
This milestone has been successfully achieved and is reported.

Publications

- WP5/DMAPS activities results in many publications
- About 20 currently loaded into AIDAinnova database (thanks Sabrina!)
  - Zenodo link to WP5
  - 25 listed include AIDAinnova reports



Conclusions

- Lots of activity at all fronts: high granularity, radiation hardness and timing
- **Fabrication of devices completed** in all lines
- **Characterization** of devices also completed, lines in final characterization and/or fabrication cycles
- Milestones (MS18, MS19 and MS20) and Deliverables (D5.1 and D5.2) **achieved**
  - Some delays in certain activities (eg RD50-MPWX, ER2 in 65 nm) would benefit from project extension, however these do not really risk the overall success of the work-package
- **Many publications!**

Back Up Slides

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