



CPPM experience with CMOS sensors

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Intro

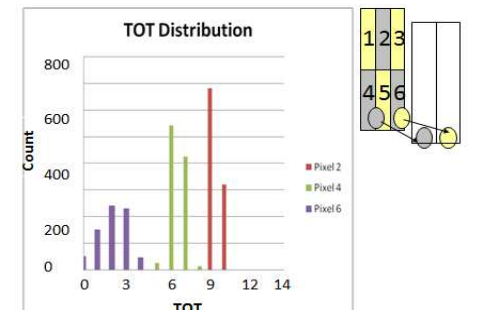
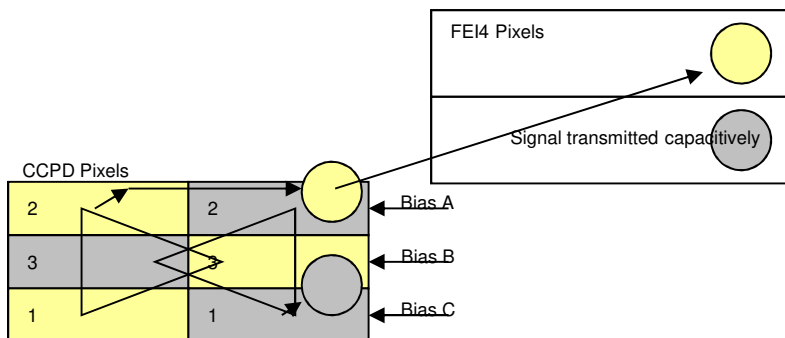
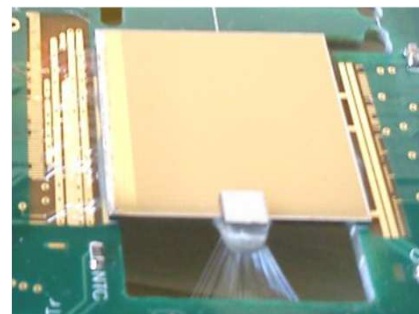
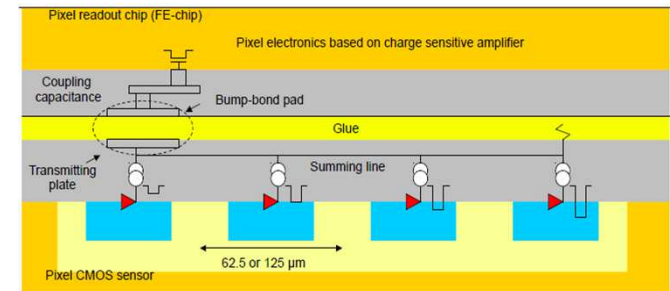


- CPPM experience with CMOS sensors, domains of expertise; focus on LF in particular.
- Manpower.
- Conclusion & plans.



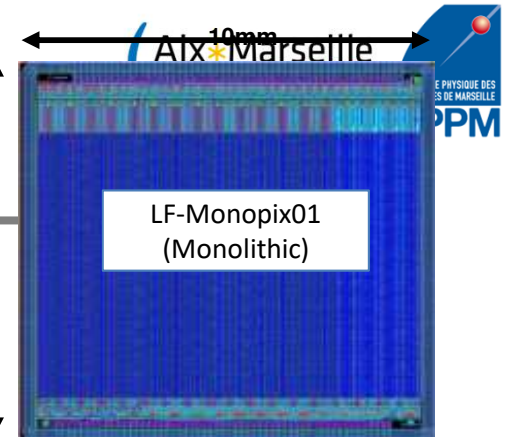
Experience with CMOS sensors

- CPPM has started **in ~2012** studying feasibility of using **CMOS sensors for ATLAS ITk** (Heidelberg-Berkeley-Bonn-CERN-Geneva-CPPM)
- Initial involvement **AMS 180nm** and **GF BCDlite 130nm** technologies.
- **First focus:** hybrid stack / pseudo-3D integration with Capacitively Coupled Pixel Detectors (**CCPD**).
- AMS: HV2FEI4, bond by gluing.
- GF: HV2FEI4 like.
- Both technos >400 MRad → electronics ~OK.
- TCAD simulations.



CCPD pixel "2", "4" and "6" are read with weighted outputs to a single FE-I4 pixel.

LF



- 2016: Bonn-CPPM-IRFU collaboration

CCPD LF:

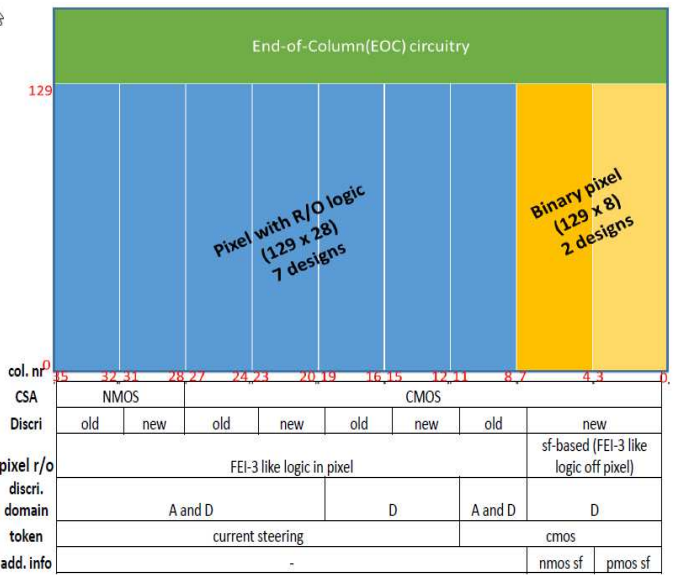
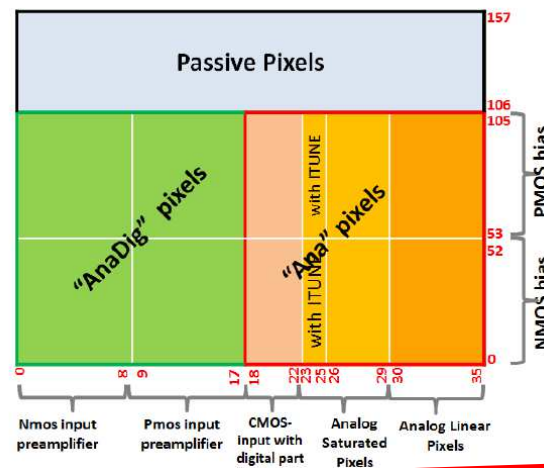
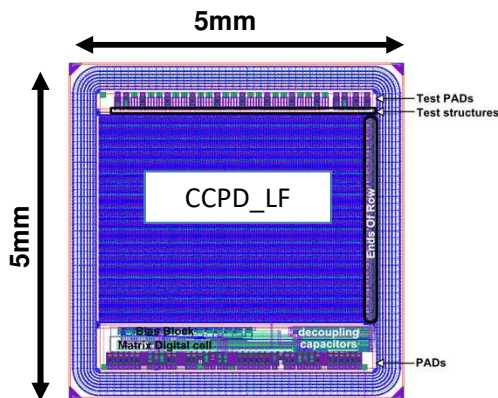
Subm. Sep 2014
 33×125μm² pix ; 6pix → 2 FEI4 pix
 5×5 mm² IC, **bondable to FE-I4**
 Bonn / CPPM / KIT

LF-CPIX:

Subm. Mar 2016
 50×250μm² pix ; diff. pix flavors
 10×10 mm²; **2 versions -Guard-Ring-**
 Bonn / CPPM / IRFU

LF-Monopix:

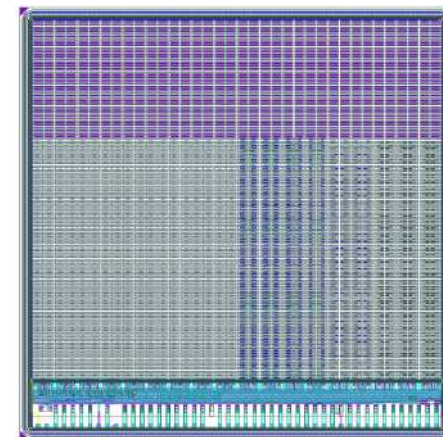
Subm. Aug 2016
 50×250μm² pix
 10×10 mm²; **1st full monolithic**
 Bonn / CPPM / IRFU



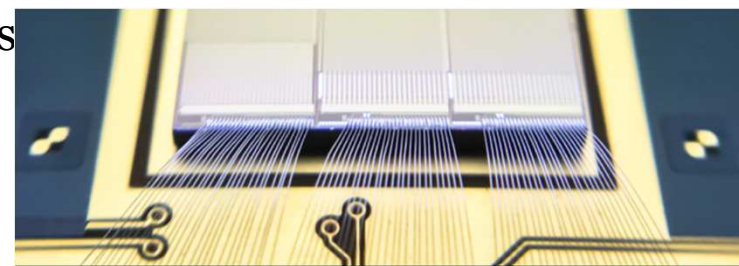
CPPM involvement: Analog design + testing + irradiation

CPPM CMOS sensors in 2017/18

- LF chips:
 - **Test LF-CPIX:** charact. @CPPM / irradiation @CERN
 - **Test LF-MONOPIX:** charact. @CPPM
 - Collaboration with Bonn and IRFU (weekly meeting)
- AMS chips:
 - **MuPix8 characterization** since December
 - **Designed AMS SEU-hard structures**
 - Collaboration with KIT and others
- TJ chips:
 - **Design Shunt LDO regulator** for Serial Powering
 - **Design sensor biasing** structure for Serial Powering
 - **Design SEU-hard structures**
 - Collab with CERN / Bonn / IRFU and others



} MPW planned mid-Aug

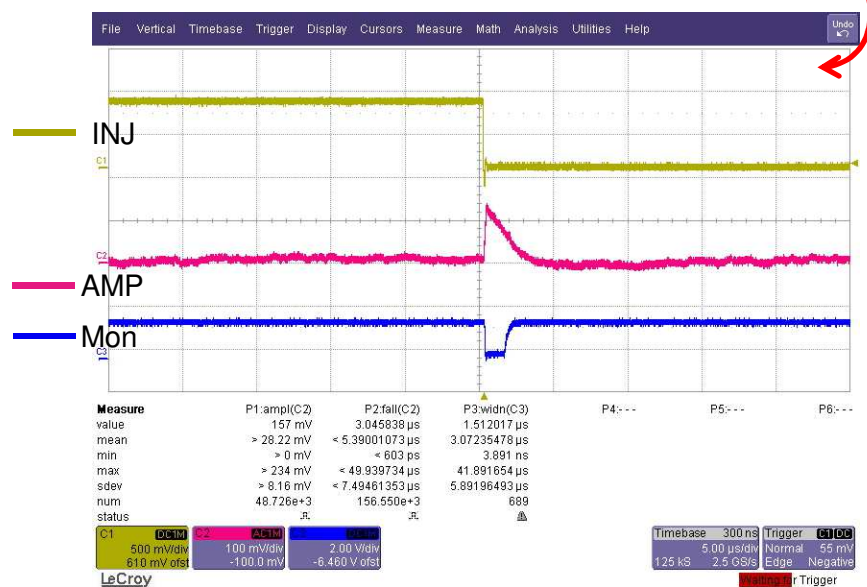
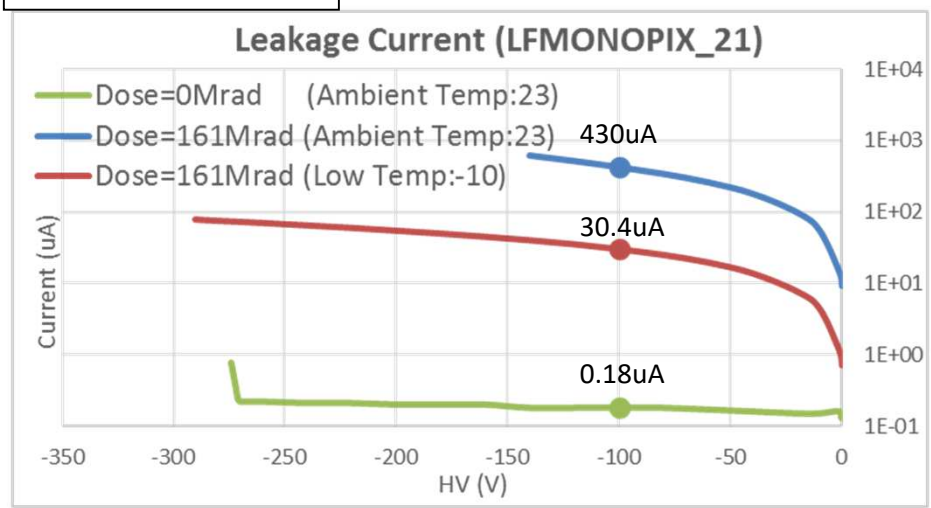


Irrad at PS, LF-Monopix @ 160 MRad

June 2018 test beam:
preliminary!

Flavor No	1	2	3	4	5	6	7	8	9
R/O logic	Out		In-Pixel						
Amplifier	CMOS							NMOS	
Discriminator	V2	V1	V2	V1	V2	V1	V2	V1	

PS proton irradiation
→ ~160MRad

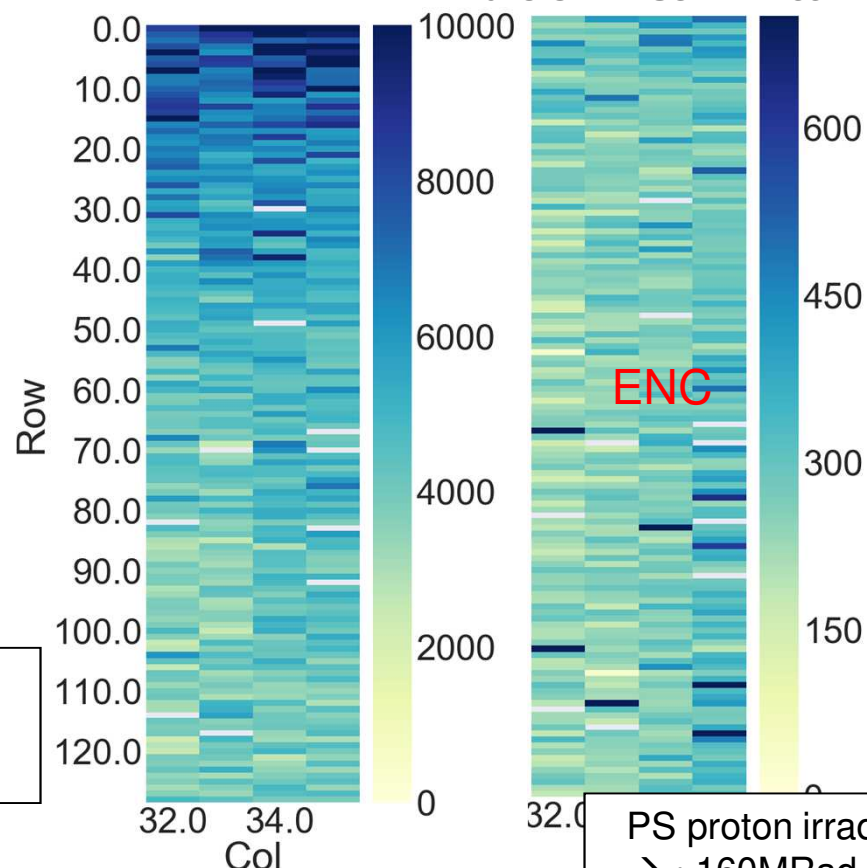


Latest results, LF-Monopix @160MRad



June 2018 test beam:
preliminary!

- After 161Mrad Radiation
- Th=0.85V
- HV=-20V
- Temp=-10 C
- VPFB=63
- Flavor9: NMOS+V1 Disc



PS proton irradiation →
~160MRad : recovered S-curve – VPFB parameter

PS proton irradiation → ~160MRad :
threshold map

PS proton irradiation → ~160MRad :
ENC map

CPPM staff: CMOS sensor only

Who		CMOS	else	
IC DESIGN & TESTING				
Marlon Barbero	Staff Scientist	20%	80%	Organization
Alessandro Calandri(***)	Staff Scientist	20%	80%	Performance w. CMOS
Patrick Pangaud	Engineer - Designer	50%	50%	Designers
Stephanie Godiot(*)	Engineer - Designer	100%		
Amr Habib	Designer (temporary position)	90%	10%	Instrumentalists
Patrick Breugnon	Engineer - Instrumentation	25%	75%	
Pierre Barrillon	Engineer - Instrumentation	50%	50%	PhD
Siddharth Bhat	PhD student	100%		
Zongde Chen	PhD student	100%		
(**)	Staff scientist	???	50%	

*: Maternal leave → Sept. 2019

** : Start date Oct. 18

***: Finishing post-doc

Beside this activity, not shown here, we have staff involved in performance studies, RD53 / 65nm and mechanics / production

Conclusion

- CPPM expertise & CMOS sensors:
 - **Analog design & full ASIC dvp, regulators, design for irradi...**
 - **Testing, test setup dvp, test under irradiation...**
 - **TCAD simulations**
- Our goal:
 - A strong collaboration to make a **CMOS sensor design (LFF or SFF) for high hit rate, high radiation environment**.
 - **LF** excellent technology to do so.
 - Plan to **develop next generation IC**:
 - Investigate **small pixels**.
 - Reduced capacitance and Xtalk.
 - Develop **building blocks** for large IC.
 - Develop **architecture** for large IC.