Istituto Nazionale Fisica Nucleare
Commissione Scientifica Nazionale 5

Experiment Proposal 2018

finFeT16

“Low-power rad-hard design in finFeT16 technology”

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List of Participant Research Units

Unit			Name	Title	% in finFeT16	FTE	Total FTE
1	INFN	Milan-Bicocca	BASCHIROTTO Andrea	Associate Professor	50%		
1		Milan-Bicocca	DE MATTEIS Marcello	Research Fellowship	40%		
1		Milan-Bicocca	CICIOTTI Fulvio	PhD student	30%		
1		Milan-Bicocca	PIPINO Alessandra	Post-Doc student	80%		
1		Milan-Bicocca	RESTA Federica	Post-Doc student	40%		
1		Milan-Bicocca	D'AMICO Antonio	PhD student	40%	2.90	
2		Padova	BISELLO Dario	INFN Senior Associate	0%		
2		Padova	PACCAGNELLA Alessandro	Full Professor	20%		
2		Padova	MATTIAZZO Serena	Researcher	20%		
2		Padova	GERARDIN Simone	Researcher	25%		
		Padova	BONALDO Stefano	PhD Student	40%	1,05	
3		Pavia	MALCOVATI Piero	Associate Professor	40%		
3		Pavia	GRASSI Marco	Research Fellowship	40%		
3		Pavia	ELKHAYAT Moataz	PhD student	100%	1.80	
4		Torino	MAZZA Giovanni	Tecnologo	30%		
4		Torino	RIVETTI Angelo	Dir. Tecnologo	10%		
4		Torino	WHEADON Richard James	Tecnologo	10%		
4		Torino	OLAVE Jonathan	PhD student	50%		
4		Torino	PANATI Serena	PhD student	50%	1,50	7.25
5	External	CERN	MARCHIORO Alessandro		20%	0.20	
5		EPFL	ENZ Christian	Full Professor	20%		
5		EPFL	TBD	Post-doc	40%		
5		EPFL	TBD	PhD student	100%	1.60	1.80

Unit organization

Unit	Unit Responsible		FTE Unit	No. members	WP participation
1	INFN@Milan-Bicocca	BASCHIROTTO Andrea	3.20	6	WP1, WP2, WP3, WP4
2	INFN@Padova	MATTIAZZO Serena	1.60	6	WP2
3	INFN@Pavia	MALCOVATI Piero	1.60	3	WP2, WP3
4	INFN@Torino	MAZZA Giovanni	1.50	5	WP2, WP5
5	EPFL	ENZ Christian	1.6	3	WP2, WP5

ScalTech28 publications

1. A.Pipino, A. Pezzotta, F. Resta, M. De Matteis and A. Baschirotto, "A Rail-to-Rail-Input Chopper Instrumentation Amplifier in 28nm CMOS", 2015 IEEE International Conference on Electronics, Circuits, and Systems (IEEE-ICECS15), Cairo, Egypt, December 06-09, 2015 – pp.73-76
2. A.Annovi, A.Baschirotto, M.M. Beretta, N.Vladi Biesuz, S.Citraro, F. Crescioli, M. De Matteis, F.Fary, L.Frontini, P. Giannetti, V. Liberali, P. Luciano, F. Palla, A. Pezzotta, S. Ruhollah Shojaii, C.-L. Sotiropoulou, and A. Stabile, "A XOR-based Associative Memory Block in 28 nm CMOS for Interdisciplinary Applications", 2015 IEEE International Conference on Electronics, Circuits, and Systems (IEEE-ICECS15), Cairo, Egypt, December 06-09, 2015 – pp.392-395
3. F. Resta, M. De Matteis, G. Rota, A. Pezzotta, A. Pipino, A. Baschirotto, "IC-PIX28: a 28nm read-out channel for pixel detector", 2015 IEEE International Conference on Electronics, Circuits, and Systems (IEEE-ICECS15), Cairo, Egypt, December 06-09, 2015 – pp.384-387
4. Donno, S. D'Amico, M. De Matteis, and A. Baschirotto, "A 150MHz 3rd-order Single Opamp Continuous time Analog Filter in 28nm CMOS technology", 2015 IEEE International Conference on Electronics, Circuits, and Systems (IEEE-ICECS15), Cairo, Egypt, December 06-09, 2015 – pp.161-164
5. A.Pezzotta, C.-M. Zhang, F. Jazaeri, C. Bruschini, G. Borghello, F. Faccio, S. Mattiazzo, A. Baschirotto, C. Enz, "Impact of GigaRad Ionizing Dose on 28 nm Bulk MOSFETs for Future HL-LHC", ESSDERC16
6. S. Mattiazzo, M. Bagatin, A. Baschirotto, D. Bisello, S. Gerardin, A. Marchioro, A. Paccagnella, D. Pantano, A. Pezzotta, C.-M. Zhang, "Total Ionizing Dose effects on a 28nm Hi-K metal-gate CMOS technology up to 1 Grad", Oral presentation at TWEPP16
7. F. Resta, A. Pipino, A. Pezzotta, M. De Matteis, A. Baschirotto, "IC-PIX28: Pixel Detectors Read-Out in Bulk-CMOS 28nm", Oral presentation at TWEPP16
8. C.-M. Zhang, F. Jazaeri, A. Pezzotta, C. Bruschini, G. Borghello, F. Faccio, S. Mattiazzo, A. Baschirotto, and C. Enz, "GigaRad Total Ionizing Dose and Post-Irradiation Effects on 28 nm Bulk MOSFETs", IEEE Nuclear Science Symposium (IEEE-NSS16)
9. F. Resta, A.Pipino, A.Pezzotta, M. De Matteis, A. Baschirotto, "A 4.3μW 28nm-CMOS Pixel Front-End with Switched Inverter-Based Comparator", IEEE Sensors
10. M. Elkhayat, S. Mangiarotti, C. De Berti, M. Grassi, P. Malcovati, D. Albano, A. Baschirotto, "Device Matching Measurements in 28nm Technology for High Energy Physics Experiments", IEEE ICECS2016
11. S. Mattiazzo, M. Bagatin, D. Bisello, S. Gerardin, A. Marchioro, A. Paccagnella, D. Pantano, A. Pezzotta, C-M. Zhang, and A. Baschirotto, "Total Ionizing Dose effects on a 28 nm Hi-K metal-gate CMOS technology up to 1 Grad", Journal of Instrumentation, 2 February 2017
12. M. De Matteis, A. De Donno, S. D'Amico, A. Baschirotto, "0.9 V third-order 132 MHz single-opamp analogue filter in 28 nm CMOS" Electronics Letters, 2017, pp. 77 – 79
13. F. Ciciotti, M. De Matteis, A. Baschirotto, "A 0.9V 75MHz 2.8mW 4th-Order Analog Filter in CMOS-Bulk 28nm Technology", IEEE ISCAS2017 – Baltimore (USA), May, 28-31, 2017
14. J.P. Jansson, P. Keranen, J. Kostamovaara, A. Baschirotto, "CMOS Technology Scaling Advantages in Time Domain Signal Processing", IEEE-IMTC2017
15. F. Ciciotti, M. De Matteis and A. Baschirotto, "A 0.9V 600MHz 4th-Order Analog Filter with Feed-Forward Compensated OPAMP in CMOS 28nm", IEEE-PRIME2017
16. M. Elkhayat, M. Grassi, P. Malcovati, and Andrea Baschirotto, "A Low Power 14-Bit 1MS/s Extended-Range Incremental ADC for High Energy Physics Experiments in 28nm Technology", IEEE-PRIME2017
17. F. Resta, S. Gerardin, S. Mattiazzo, A. Paccagnella, M. De Matteis and A. Baschirotto, "1GigaRad TID Impact on 28nm HEP Analog Circuits" IEEE-PRIME2017
18. F. Fary, L. Mangiagalli, A. Pipino, F. Resta, M. De Matteis and A. Baschirotto, "A 200MHz 0.65fJ/(Bit·Search)1.152kb Pipeline Content Addressable Memory in 28nm CMOS", IEEE-PRIME2017
19. *A. Beckers, F. Jazaeri, A. Ruffino, C. Bruschini, A. Baschirotto, C. Enz, "* Cryogenic Characterization of 28 nm Bulk CMOS Technology for Quantum Computing", ESSDERC 2017, Leuven, September, 11-14, 2017
20. *C.-M. Zhang, F. Jazaeri, A. Pezzotta, C. Bruschini, G. Borghello, S. Mattiazzo, A. Baschirotto, C. Enz, "*Total Ionizing Dose Effects on Analog Performance of 28 nm Bulk MOSFETs", ESSDERC 2017, Leuven, September, 11-14, 2017

Project Implementation

Work Package		Leader	Unit
WP1	Project management (including chip integration)	Andrea BASCHIROTTO	Milan-Bicocca
WP2	Radiation Hardness	Serena MATTIAZZO	Padova
WP3	Digital/Mixed-Signal Electronics	Piero MALCOVATI	Pavia
WP4	Analog FE Electronics & Optical Transceiver	Marcello DE MATTEIS	Milan-Bicocca
WP5	Electronics for high speed data transmission and precise timing measurement	Giovanni MAZZA	Torino
WP6	Radiation Damage Modeling	Christian ENZ	EPFL

Research unit competence & roles in the project

- INFN-MiB — Management & Analog front-end design & Optical Transceiver
- INFN-Padova — Radiation damage analysis
- INFN-Pavia — Mixed-Signal design
- INFN-Torino — Mixed-Signal design for particle detectors, high speed design
- EPFL — Radiation damaged simulation environment

Activity description

The project will be composed by several tasks and activities as follows:

- design a set of basic single devices (NMOS, PMOS, simple digital cells) as done for previous technologies
- measure their performance before and after irradiation to establish their radiation robustness characteristics for TID and SEU
- modify the fab SPICE model to include the effects of radiation to be used in simulation environment
- develop few basic analog circuit blocks designed for rad-robustness (using the above information) and for low-power to be embedded in these target devices:
  - Low-power Analog Front-Ends
  - Analog filters and amplifiers
  - 10b-ADC
  - high-speed communication circuits
- evaluate the radiation damage on these elementary blocks
- demonstrate the achievements of the target performance in term of signal processing quality and power consumption, before and after irradiation

GANTT Chart

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
INFN-MiB	1	1	1	1														8	8	8	8	8	8	8
			4	4	4	4	4	4	4	4	4	4	4	9	9	9	9							
INFN-PD	1	1	1	1		9	9	9	3	3	3	6	6	6				3	3	3	8	8	8	8
INFN-PV			4	4	4	4	4	4	4	4	4	4	4	9	9	9	9	8	8	8	8	8	8	8
INFN-TO			4	4	4	4	4	4	4	4	4	4	4	9	9	9	9	8	8	8	8	8	8	8
EPFL	1	1	7	7	7	7	7	7	7	7	4	4	4	7	7	7	7	7	7	7	7	7	7	7
External Europractice					2	2	2	2						5	5	5	5							

1st prototype Layout	1
1st Silicon Fabrication	2
Prototype irradiation	3
2nd prototype Design&Layout	4
2nd Silicon Fabrication	5
1st Prototype measurement	6
Radiation damage model development	7
2nd Prototype Measurement	**8**
Board design	**9**

Milestones

Milestone	Time	Kind	Short description	Participants
01	Month 02	Report	Definition of the simple devices for 1st prototype	All
02	Month 04	PGtape	1st PGtape	MiB
03	Month 07	Report	Definition of the circuit target specification	MiB PV
04	Month 08	Samples	1st PGtape prototype delivery	MiB
05	Month 11	Report	Non-Damaged & Rad-Damaged devices characterization	PD
06	Month 12	Model	Preliminary SPICE Model for the Non-Damaged & Rad-Damaged devices	EPFL
07	Month 14	PGtape	2nd PGtape	MiB
08	Month 18	Samples	2nd PGtape prototype delivery	MiB
09	Month 21	Model	Final SPICE Model for the Non-Damaged & Rad-Damaged devices	EPFL
10	Month 22	Report	Rad-Damaged & Non-Damaged circuits characterization	MiB PD PV
11	Month 23	Report	Simulation vs. measurement for target circuit using developed SPICE Model	EPFL
12	Month 24	Report	Wrap-up report and future prospectives	All

Work Program & Financial Plan

Type of Cost	2018					2019					Total	%
Prototype Fabrication	MiB	PD	PV	TO	Tot	MiB	PD	PV	TO	Tot		
Prototype fabrication (Europractice quotation on June17 is for 106k€ for a single 4mm^2 MPW prototype It is expected to be reduced by -20% for the end of 2018 when the prototype will be produced) 22% VAT has been added *A further 20% reduction is assumed for the 2nd year*	125.0	=	=	=	133.0	100.0	=	=	=	114.0	**247.0**	**78%**
Prototype packaging	8.0	=	=	=		14.0	=	=	=			
Consumables & Services												
Board for IC testing	2.0	6.0	2.0	2.0	22.0	4.5	6.0	2.5	4.5	17.5	**39.5**	**12%**
Irradiation Consumables	=	10.0	=	=		=	=	=	=			
Travels												
Project meetings	1.5	1.5	1.5	1.5	16.0	1.5	1.5	1.5	1.5	16.0	**32.0**	**10%**
Conference participations	2.5	2.5	2.5	2.5		2.5	2.5	2.5	2.5			
Total	**141.0**	**20.0**	**6.0**	**6.0**	**171.0**	**122.5**	**10.0**	**6.5**	**8.5**	**147.5**	**318.5**	**100%**

The amounts are in k€

Budget PV

Voci di Costo	2018
Missioni	4.0 (Meeting e Conferenze)
Consumo	2.0 (Componenti e PCB)
Inventario	0.0
Licenze	0.0
Servizi	0.0
Manpower	**2018**
Piero Malcovati	40%
Marco Grassi (Assegnista)	40%
Marco Croce (Dottorando)	100%