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INFN Proposal (Gr. 5)
Milano-Bicocca, Padova, Pavia + EPFL (& CERN)
June, 30th, 2014

Low-power rad-hard circuit design in scaled technologies

… send some scouts in advance

The problem

- Future Experiments read-out will have to face two key problems
- An extremely large radiation dose
- Up to 1Grad in 10years
- Much larger than in any previous situation
- An extremely large number of channels
- Increasing power consumption
  - ➔ New electronics has to be designed
  - To guarantee rad-hard performance
  - To reduce power consumption
- Open questions
  - Which technology to be adopted ?
  - Which circuit solutions to be used in scaled technologies ?
  - Circuit solutions depend on adopted technology

Radiation damage vs. technology choice

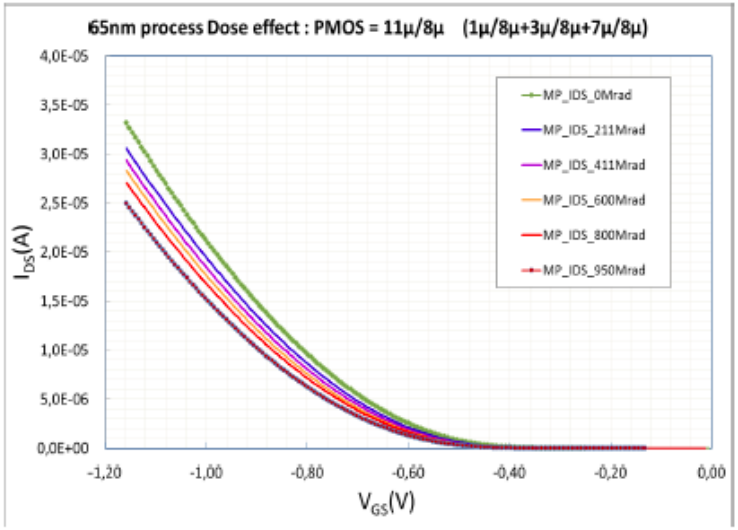
- ➔ Technology scaling helps Radiation Hardness
- ➔ Research activity to investigate scaled technology potentiality
- Present CERN installation ➔ 130nm
- ➔ Research activity 90nm and 65nm
- ➔ INFN-Chipix65 & CERN-RD53

- Parameter for technology choice
  - Transistor analog features
  - Proper design techniques
  - Technology access
  - Robustness
  - Availability
  - Costs
  - Rad-hard performance

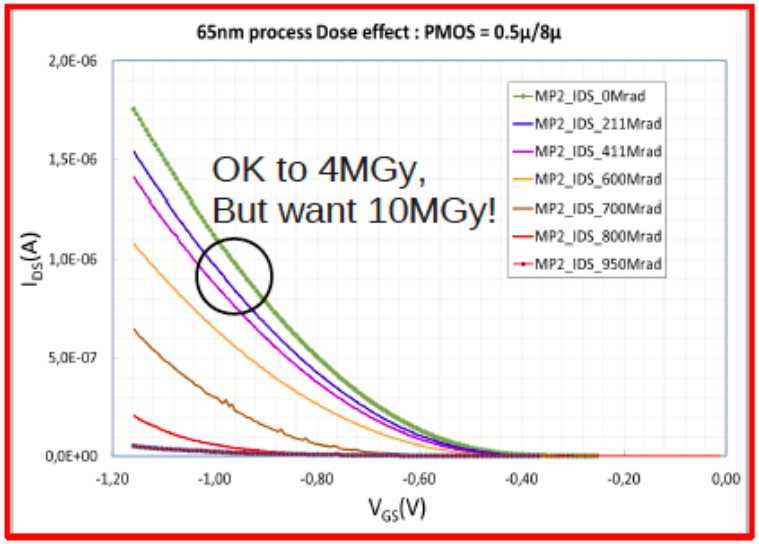
Rad-hard performance in 65nm technology

65nm could be not sufficiently rad'hard (at 1Grad)

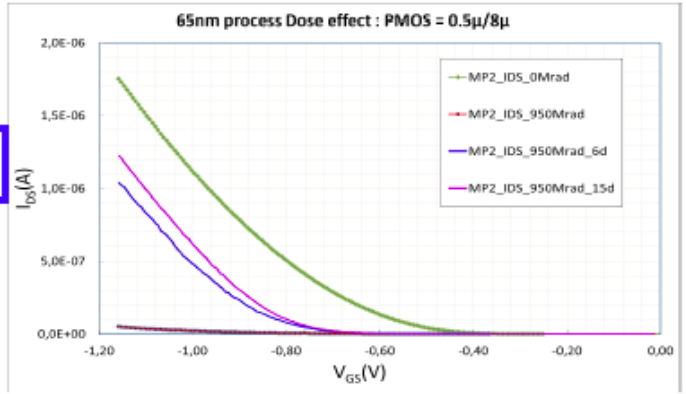
Wide PMOS



Narrow PMOS



Annealing helps

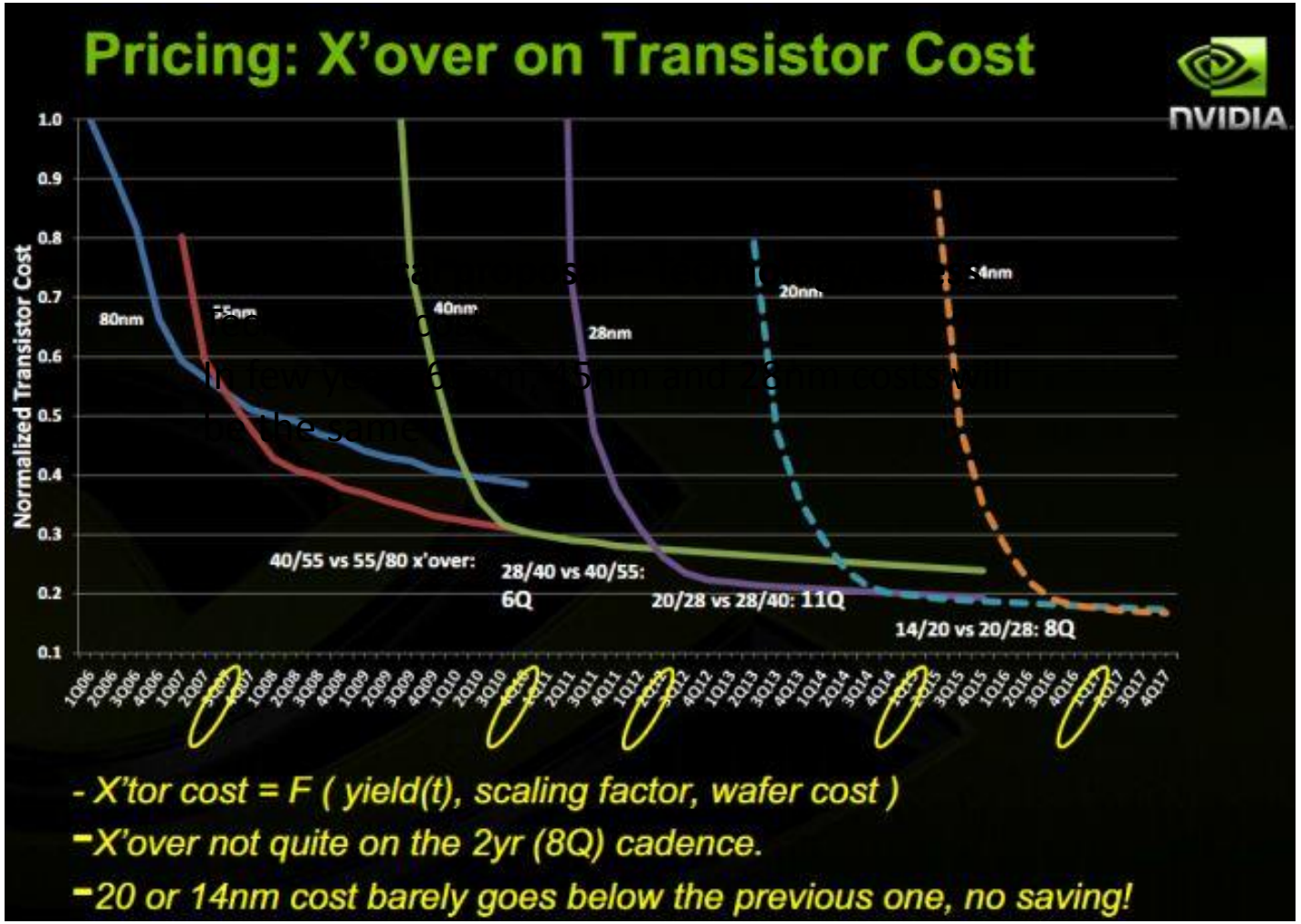


(From ATLAS UW pixel module session)

The technical proposal – Technology access

Technology cost

In few years 65nm, 45nm and 28nm costs will be the same



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The technical proposal – Technology access

- EUROPRACTICE
  - delivers 45nm TSMC prototypes
  - does not allow 28nm open access
  - BUT
  - Selected “Pilot sites” can access to 28nm for key project with final prototyping
  - MiBicocca is selected to be a “Pilot site”

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The technical proposal – The Research Partners

- ScalTech28 (INFN Founded project)
- **INFN-MiB (Baschirotto)** with Alessandro Marchioro (CERN) support
- Project coordination
- Prototype run coordination
- Rad-Hard LP-AFE design
- Optical link
- **INFN-PD (Bisello)**
- Prototype radiation
- Radiation damage measurement
- **INFN-PV (Malcovati)**
- Rad-Hard LP-MS/D design

- **EPFL-Neuchatel (Enz)** – Founded by Swiss NFS
- SPICE EKV model of irradiated devices for simulations

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The technical proposal

- Basic question ??
  - What is the best tech-node for future implementations in terms of
  - Radiation hardness to 1Grad
  - Low-power consumption
  - Technology access (availability, cost, etc..)
- **Proposal activity**
  - Select an advanced tech-node ➔ 28nm
  - Study radiation damage effects
  - Design *few significant blocks* in 28nm Scaled Technology
  - Rad-hard (RH) & Low-power (LP)
  - Compare the achieved results with similar activities in different nodes
  - ➔ Take the best technology node choice for final production
  - Develop a simulation environment for circuit with radiation damaged devices

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The technical proposal – Blocks & Specs

- Single devices
  - MOS (different sizes)
  - Passive (Capacitors and resistors)
- Complete blocks
  - Analog read-out Front-End (AFE)
  - Mixed-Signal/Digital (MS/D)
  - Optical link (TIA)
- To have a *fair comparison* of achieved performance in different tech-nodes
  - ➔ Target specs defined in parallel to other running activities in different tech-nodes
  - For example
  - AFE ➔ RD35/Chipix65
  - MS/D ➔ PIXFEL
  - Optical link ➔ GB-TIA link

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The technical proposal – Project management

Work Package		Leader	Unit
WP1	Project management (including chip integration)	Andrea BASCHIROTTO	Milan-Bicocca
WP2	Radiation Hardness	Dario BISELLO	Padova
WP3	Digital/Mixed-Signal Electronics	Piero MALCOVATI	Pavia
WP4	Analog FE Electronics & Optical Transceiver	Marcello DE MATTEIS	Milan-Bicocca
WP5	Radiation Damage Modeling	Christian ENZ	EPFL

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Activity scheduling – 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													8	8	8	8	8	8	8	8	8
			4	4	4	4	4	4	4	4	4	9	9	9	9									
	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10									
INFN-PD	1	1	1					3	3	3	6	6	6	6		3	3	3	8	8	8			
INFN-PV			4	4	4	4	4	4	4	4	4	9	9	9	9	8	8	8	8	8	8	8	8	8
EPFL	1	1	7	7	7	7	7	7	7	7	7	7	7	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
Optical Transceiver	10

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Budget summary (two years activity) – in k€

•Prototype fabrication	**225 k€**	**64%**
•Two runs		
•Consumables & Service	59 k€	17%
•Instrumentation (HW&SW)	28 k€	8%
•Travels	39 k€	11%

- 6.50 FTE x 2 years activity
- ➔ **9.6k €/(FTE year)**

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Padova partecipation & requests

D. Bisello	10%
A. Paccagnella	20
A. Candelori	20
L. Ding	40
L. Silvestrin	30
J. Wyss	30
X.Y.	30

Budget

Consumables	15.0 keuro
Travels	6.5 “

OM . 1m/u
LOE: 8 m/u

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INFN Advantages

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  uses reduced amount of manpower
  performs a deep investigation on the potentiality of the most advanced IC technology available for 2020 production

INFN will the 1st HEP research institute to investigate on this technology
Strategic know-how will be available
If positive feedback
➔ Larger investment will be allocated for further and more dedicated development for HEP experiments
➔ Know-how will be migrated also to other key application medical, instrumentation, etc…