R&D Pixel Fase-2
Attività CMS

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a nome di

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Incontro Referee RD_fase2
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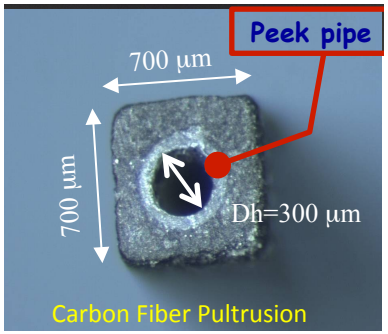
R&D in CMS

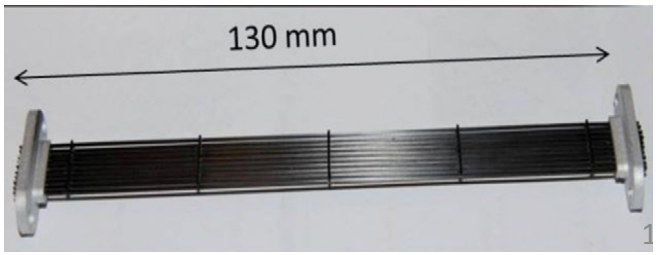
- Linee di azione specifiche R&D CMS-IT:
  - Sensori Planari standard e Active Edge
  - Micro-channel cooling
  - Possibile utilizzo di ROC chip di generazione intermedia tra gli attuali ROC e i prototipi RD53
  - Studi di BB di rivelatori irraggiati su ROC non irraggiati
  - Tecniche di Isolamento contro le scariche ROC-sensore
  - Partecipazione ai batch comuni della coll. CMS previsti nel 2015
- Risorse
  - 37 ricercatori coinvolti su 6 sedi, per un totale 11.1 FTE
  - Esperienza dalla costruzione dello Strip Tracker CMS e attualmente del Pixel Fase-1, prototipi di cooling per altri esperimenti

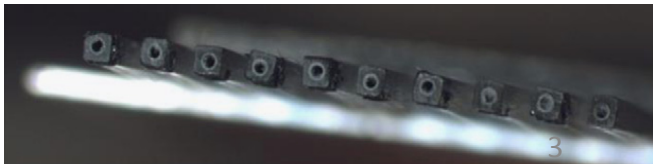
Micro channel cooling R&D

Implementation of evaporative CO_2 cooling on CFRP (Carbon Fiber Reinforced Plastics) with low temperature working point (-20°C).

- Application to small hydraulic diameter
  - ≤300 μm
- Design of realistic cooling channel length
  - 300-600 mm
- Optimization of Cooling system material budget: goal of 0.15% X_0.
- Optimization of material budget vs. temperature working point.

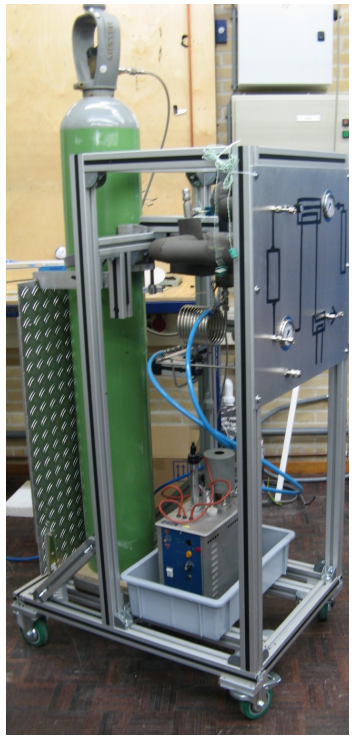




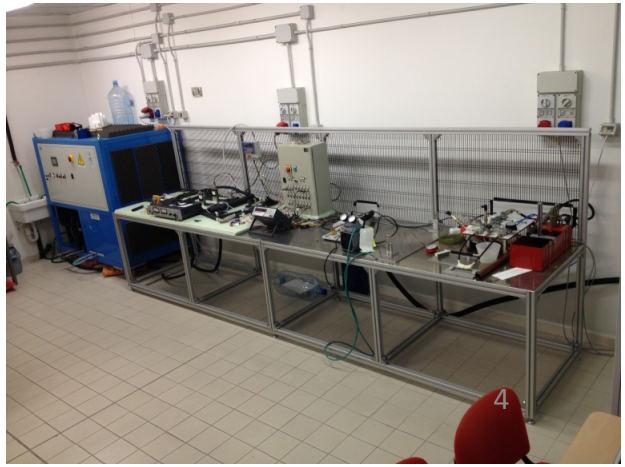


Micro channel cooling plans for 2015

- Step to assess Phase transition cooling in micro-channel
  - CO_2 cooling unit (Nikhef) + safety system
  - Boro-silicate + CFRP channel length 50-60 cm
  - CAD design and simulations
  - Micro-channel assemby optimization:
    - CFRP needs specific optimizations a the level of design, micro-channel device processing and functional interconnections.
  - Measurements, qualification and calibration in laboratory including structural and endurance tests.
  - System integration with dedicated equipment
  - Focusing on Phase II Pixel
    - Both Planar and 3D pixel detectors
    - Custom development of interconnections, high pressure rated



200 w at -30 C



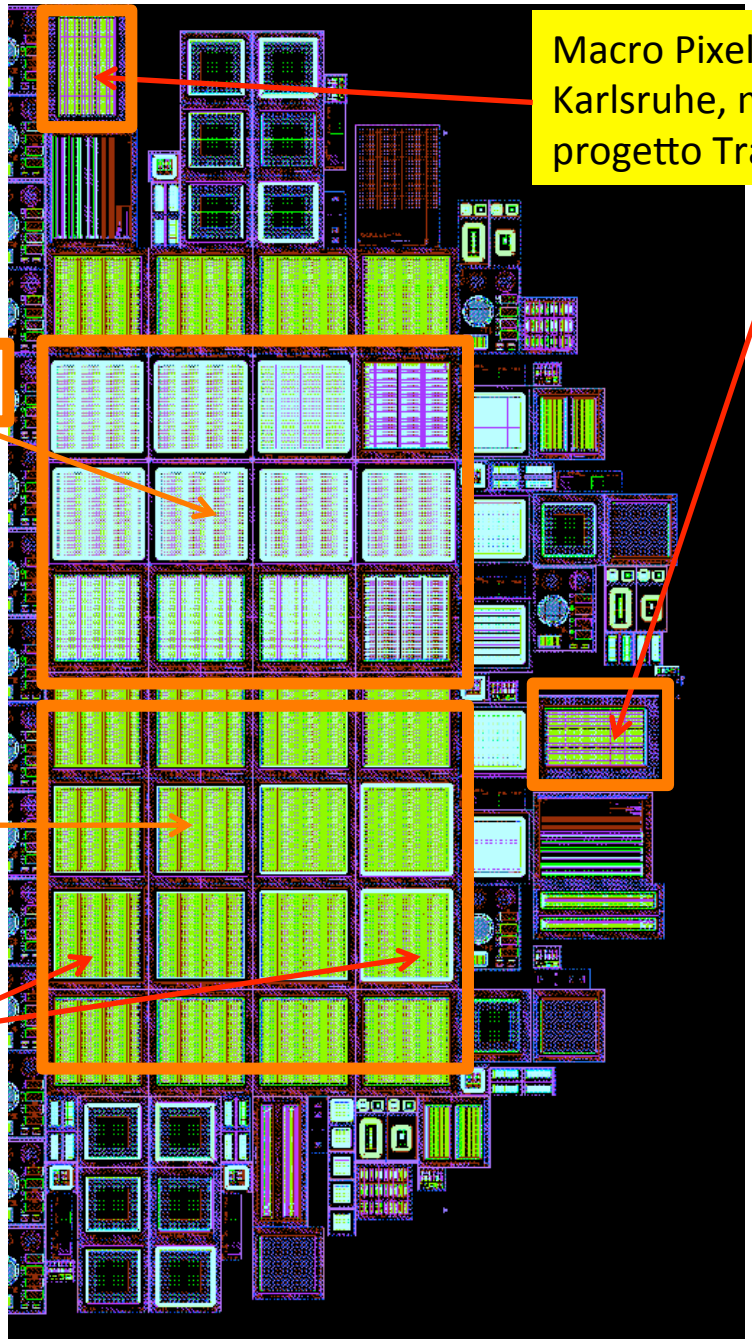
Batch Planari: 32 Sensori CMS_PSI + 5 small pitch test sensors

device name	goal	design available	design type	multiplicity in wafer	process comments	Dx (micron)	Dy (micron)	#	area mm2
PSI	CCE vs thickness	yes (also FBK has)	in p-type	1x8	FBK gr design	10.12	10.42	8	843.60
PSI	# of gr	to be modified FBK	in p-type	2x4	4 gr ATLAS designs: a,b,c,d	10.12	10.42	8	843.60
PSI	BPIX/FPIX to study Bias net design	yes	in p-type	5x1	g.r. alla Hamamtsu	10.12	10.42	5	527.25
PSI	BPIX/FPIX to study Bias net design	yes	in p-type	1x4	g.r. alla Hamamtsu	10.12	10.42	4	421.80
Purdue	small pixels Gino (DS design)	yes	n-type already mod by FBK	5x1		7.354	7.354	5	270.41
Rohe 2008 edge	edge -100	to be modified FBK	in p-type	1x2	10 g.r., dispositivo shift Dx Dy basso destra (100)	10.12	10.42	2	210.90
Rohe 2008 edge	edge -200	to be modified FBK	in p-type	1x2	10 g.r., dispositivo shift Dx Dy basso destra (200)	10.12	10.42	2	210.90
Rohe 2008	bias gap: 20-30	yes	in p-type	1X2	10 g.r., Dispositivo centrato	10.12	10.42	2	210.90
Rohe 2008	bias gap: 20-30	yes	in p-type	1X1	10 g.r., Dispositivo centrato	10.12	10.42	1	105.45

Batch Planari: circa 50 Test Structures CMS

device name	goal	design available	design type	multiplicity in wafer	process comments	Dx (micron)	Dy (micron)	#	area mm2
SIMS	SIMS implants	yes	in p-type	4		6600	2100	3	41.58
SIMS	bulk profile	FBK	no -type	1		10000	10000	1	100.00
c_TS	CAPACITANCE	yes	p-type	4		8160	8120	2	132.52
c_PTTS	Punch through	yes	p-typ	4		5620	5620	7	221.09
c_sheet	process	yes	p-type	3		8970	11690	2	209.72
Sheet-p-spray (TS pixel)	p-spray	yes -PSI	in p-type	4		3120	3120	7	68.14
pixel cap		yes-PSI	in p-type	2		8430	12230	2	206.20
T_PT		yes-PSI	p-type	4		2300	1800	7	28.98
HPK-Capts	process study	yes	in p-type	2		12900	5500	2	141.90
Large Diodes	Bulk study	yes	in p-type	8		7120	7120	8	405.56
MOS	Oxide study	yes	in p-type	6		7120	7120	5	253.47
GCD	surface current	yes	in p-type	6		7600	7120	4	216.45
MPA-light	long PS pixels	KIT	in p-type	4		7400	10700	2	158.36
Hall sample	PSI Hall	yes	in p-type	2		5620	2120	4	47.66

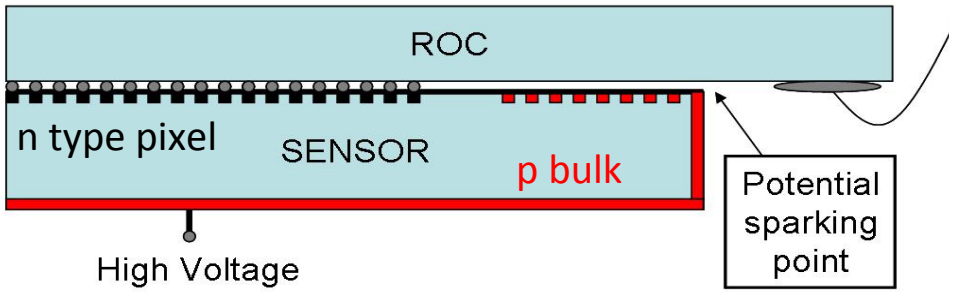
Zona CMS del wafer pixel planari



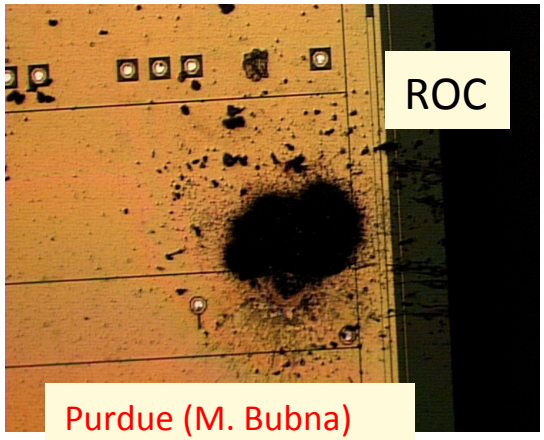
Molteplicità di ciascuno dei sensori variabile tra 1 e 5 nel wafer

Elevato numero sia di sensori che di strutture da misurare :
→ richieste BB e assemblaggi

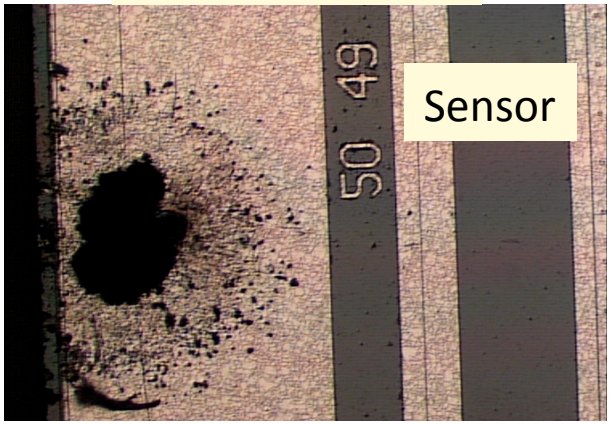
R&D against Sparks



ROC at Ground

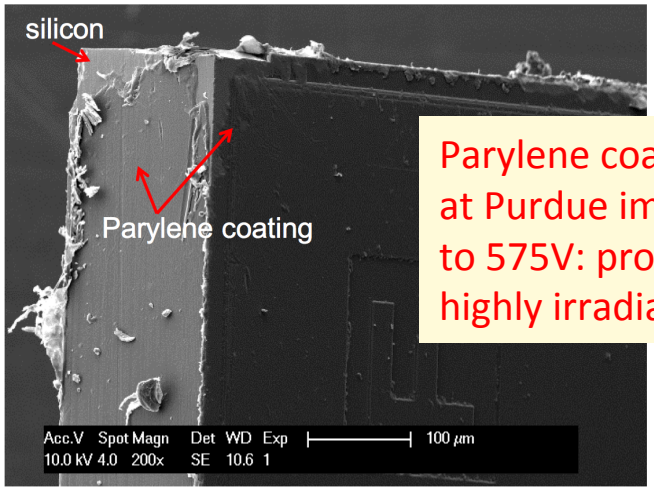


Purdue (M. Bubna)



Air gap between sensor and ROC can be as low as 10μm with Indium Bump Bonding: high spark probability

We need to investigate how to avoid this kind of problems
Crucial for P-type pixel detectors to be operated at High Voltage Bias
Two chemical compounds have been tested up to know:
Parylene
Benzocyclobutene

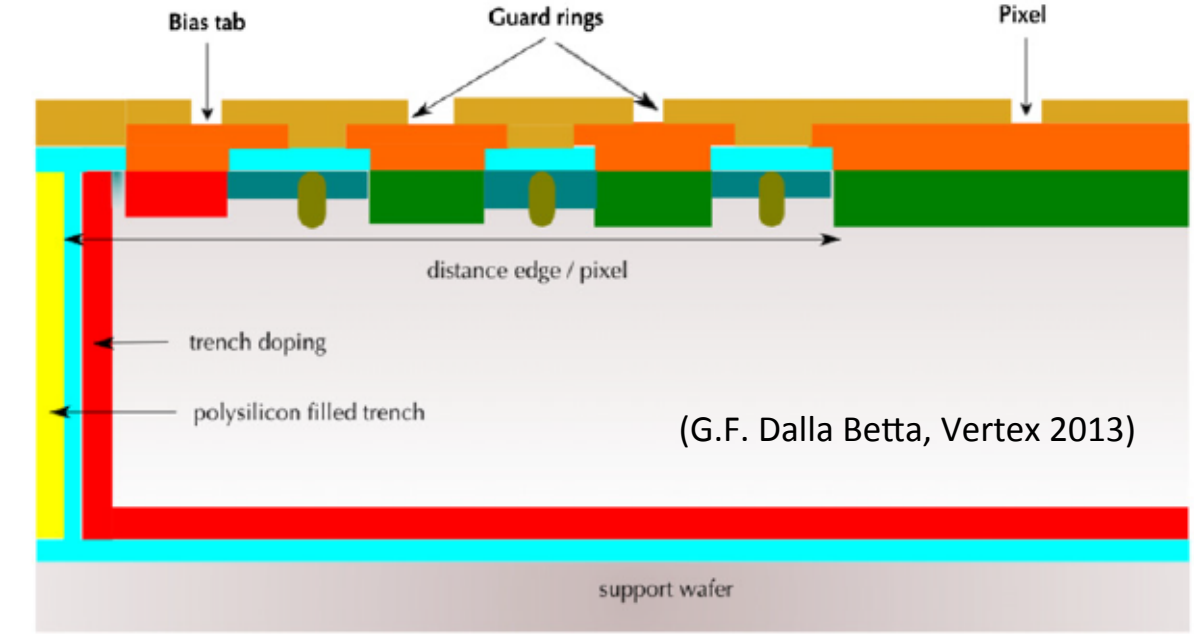


Parylene coating 2 μm thick tested at Purdue improves Breakdown up to 575V: probably not enough for highly irradiated pixel

Dielectric strength:
- Parylene 280 V/μm
- BCB 5300 V/μm

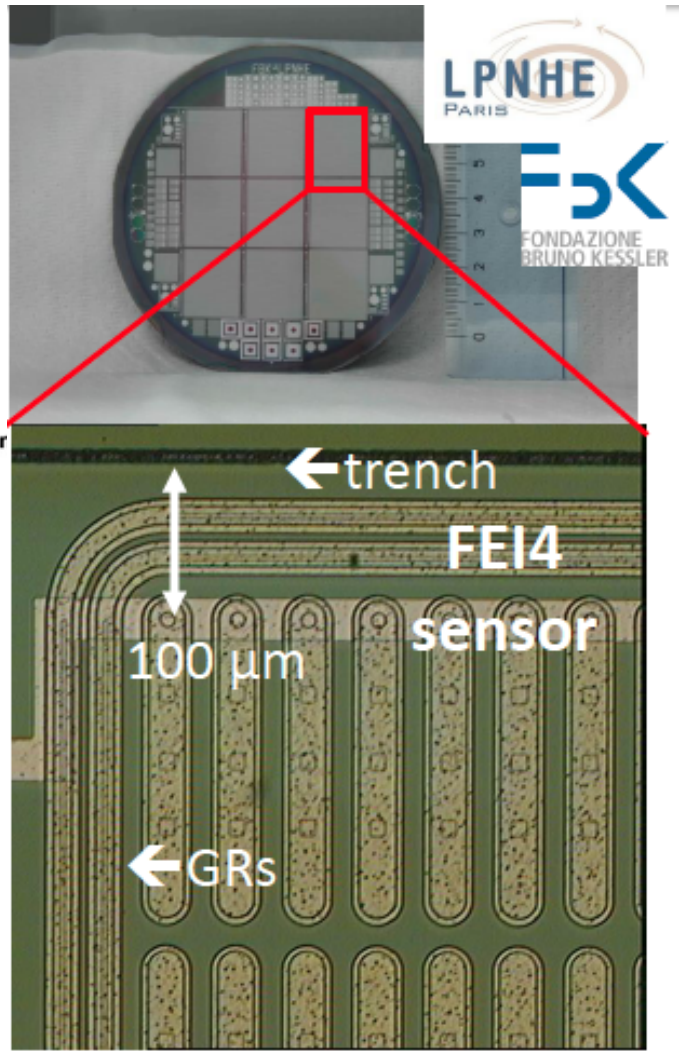
Require Industrial partners, more steps, add lithography, masking, insulator deposition. More effort, new ideas are needed. Coating can largely affect mass production and cost

Planar Active Edge con FBK



(G.F. Dalla Betta, Vertex 2013)

FBK Edgeless pixels (n-on-p) per ATLAS in collaborazione con LPNHE Paris



- Da sviluppare con FBK per CMS (basandosi sui risultati ottenuti con ATLAS):
  - 4.5 x 200 µm trench, doped by diffusion
  - Disegni diversi di edge/GR, fino a 100 – 200 µm possibili
- Layout da studiare in parallelo al 3D, affinità
- Includere anche pitch 50x50 μm^2

Altre Attività Specifiche 2015

- Nel 2015 si prevede:
  - BB del batch 3D parzialmente in comune con ATLAS
  - BB Batch Active Edge solo CMS
  - Assemblaggi moduli
  - Test Beam
  - Primi irraggiamenti planari
  - DAQ laboratorio con Digital Test Board CMS e con USBpix3 ATLAS

Richieste 2015

2015 RICHIESTE R&D PIX-CMS v. 13/7/2014		Totale	177.5	sede
Wafer necessari per produzione 2015	common with Atlas		10	FI
Batch (n.5) 3D costo 24k€ al 50% con atlas		rinviato al 2016	0	FI
Contributo Batch comune CMS			20	FI
BB 3D e Active Edge	24k common with Atlas		48	PI
Mechanical Assembly	construction of jigs for wire bonding, support structures for lab test		8	BA
Adaper interface boards	one for each ROC-sensor. About 100 pieces needed		10	PI
Test Beam mechanics and DAQ	precision mechanics, cooling contacts and piping, interface electronics (FNAL + DESY) for PSI46dig only		12	MIB
Irradiations	sample preparation, mechanical supports and facilities costs. Minimum two fluences		12	TO
USBPIX 3.0 FE-I4 lab daq board	lab test DAQ, 3 pcs.		4.5	FI
High Density pitch sensor probing	Probe Cards for qualification		6	FI
Module qualification, laser & Xray tests in cool box	Mechanics and cooling for xray test station and jigs for cooling box		7	PG
CO2 system completion			3	PI
Single microchannel cooling demonstrator			7	PI
Cooling Technical Equipment			10	PI
Cooling consumables			5	PI
Parylene or BCB Isolation	Spark prevention on det. modules		5	PI
High Density BB test	Industrial partner to be defined		10	FI