

CARTE D'ACQUISITION 256 VOIES POUR UN TOMOGAPHE A EMISSION DE POSITRONS

Journées VLSi / FPGA / PCB / Outils – Juin 2010

Christian FUCHS pour le groupe ImaBio

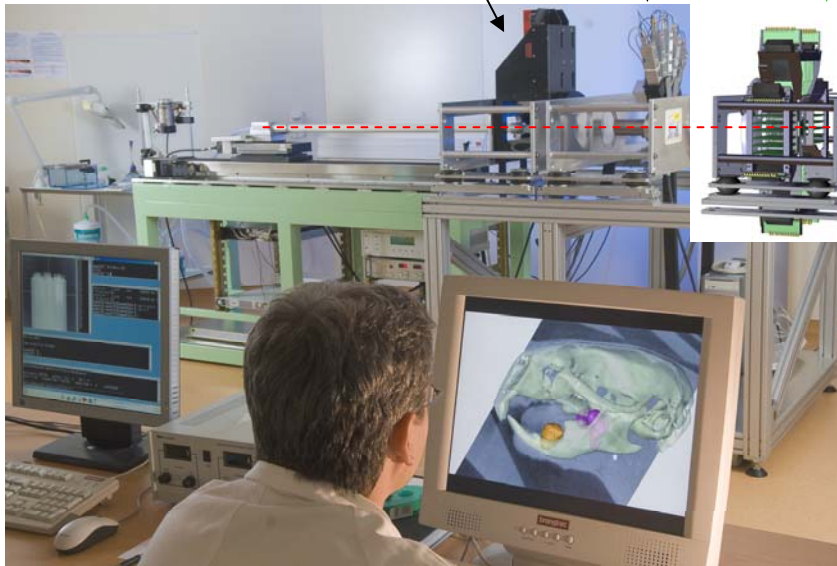
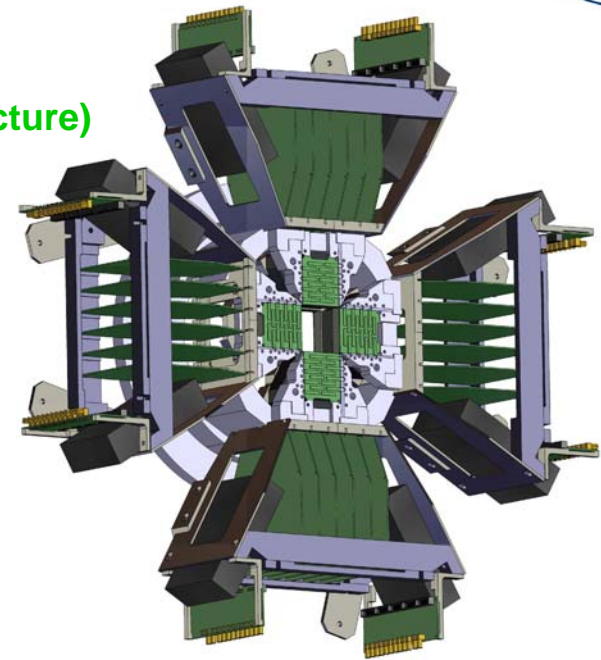
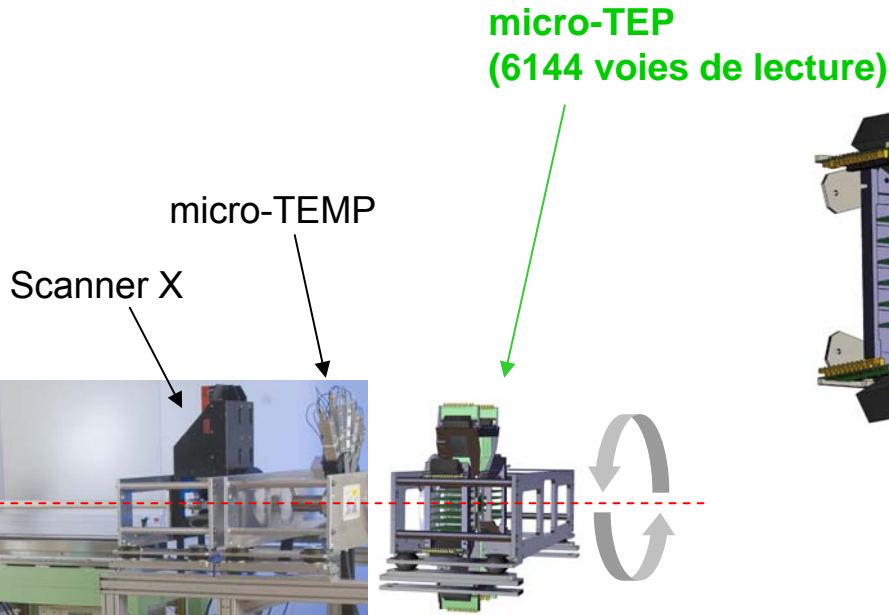
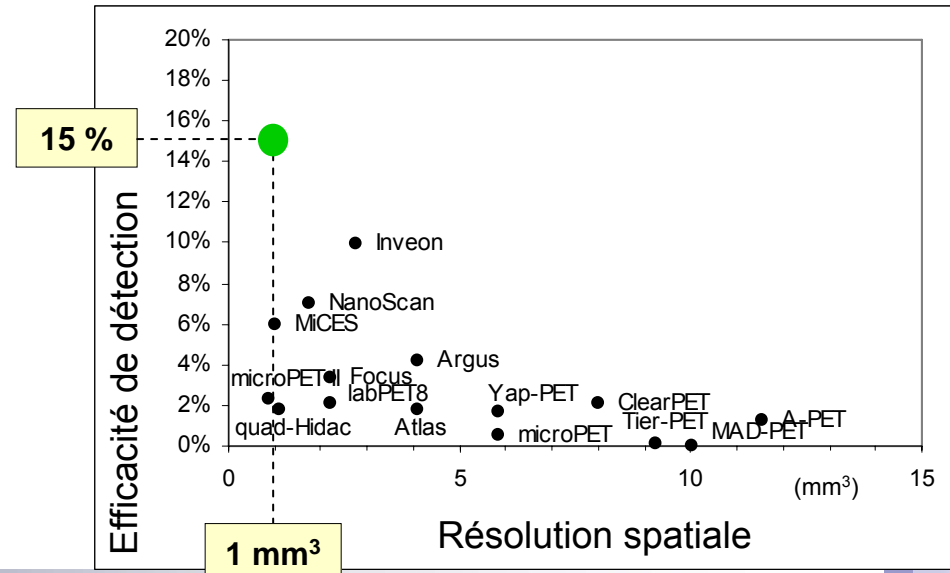
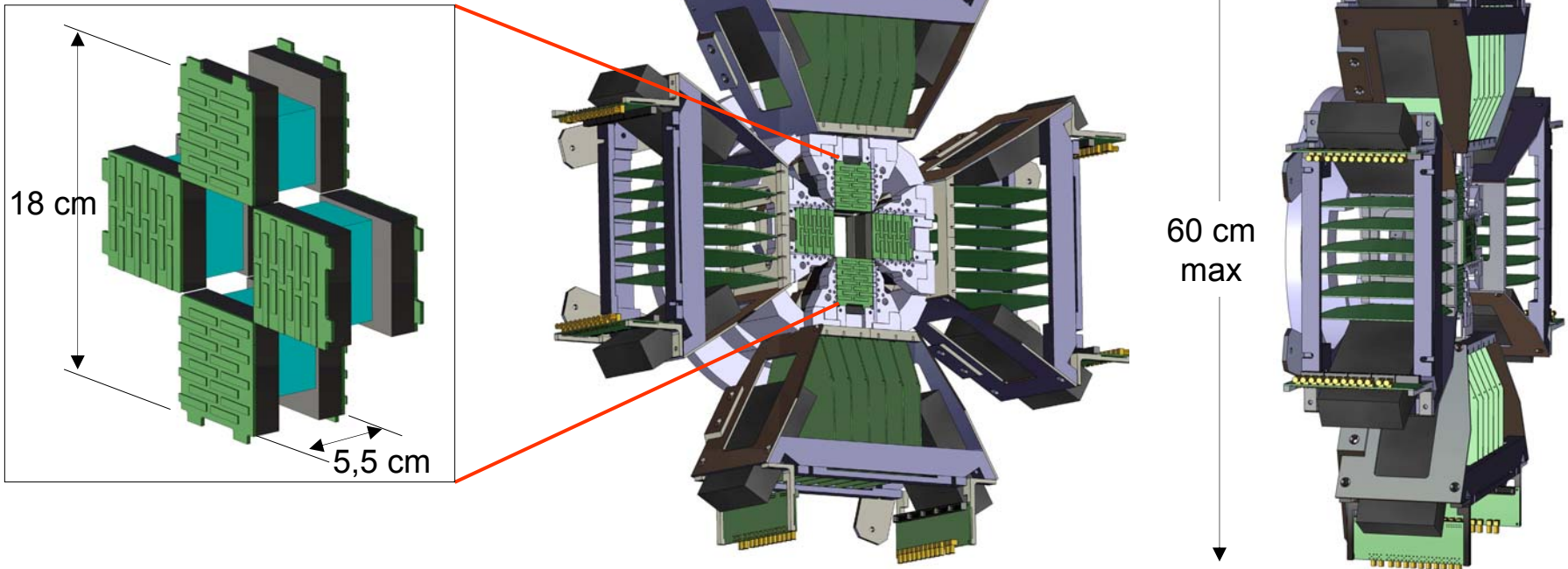


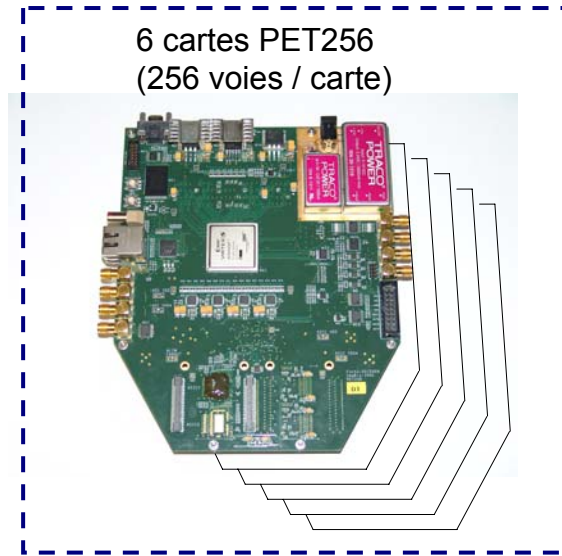
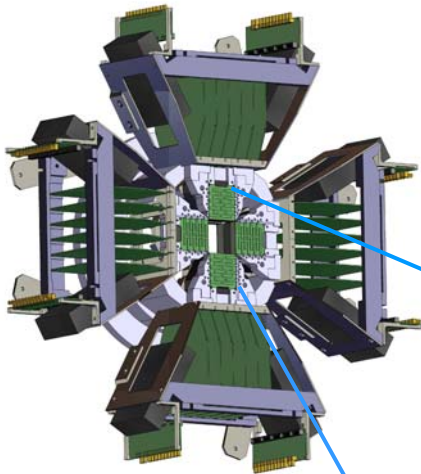
Plate-forme d'imagerie multimodale AMISSA



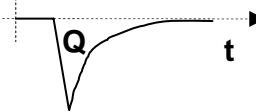
- **Système tournant**
- **Un minimum de connexion entre partie fixe et tournante**
- **Encombrement réduit**
- **6144 voies de lecture à traiter**
- **Débit total de ~ 1 GiB / s (2^{30} octets / s)**
- **Consommation < 500 W**



micro-TEP
6144 voies de lecture



1536 voies
par module



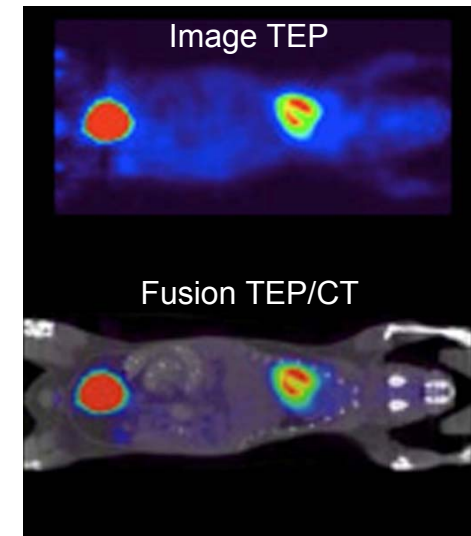
Gigabit Ethernet
(35 MiB/s / carte)



Ferme de PCs



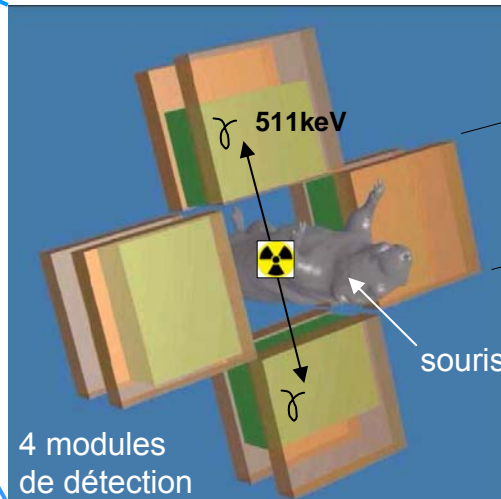
Sinogrammes



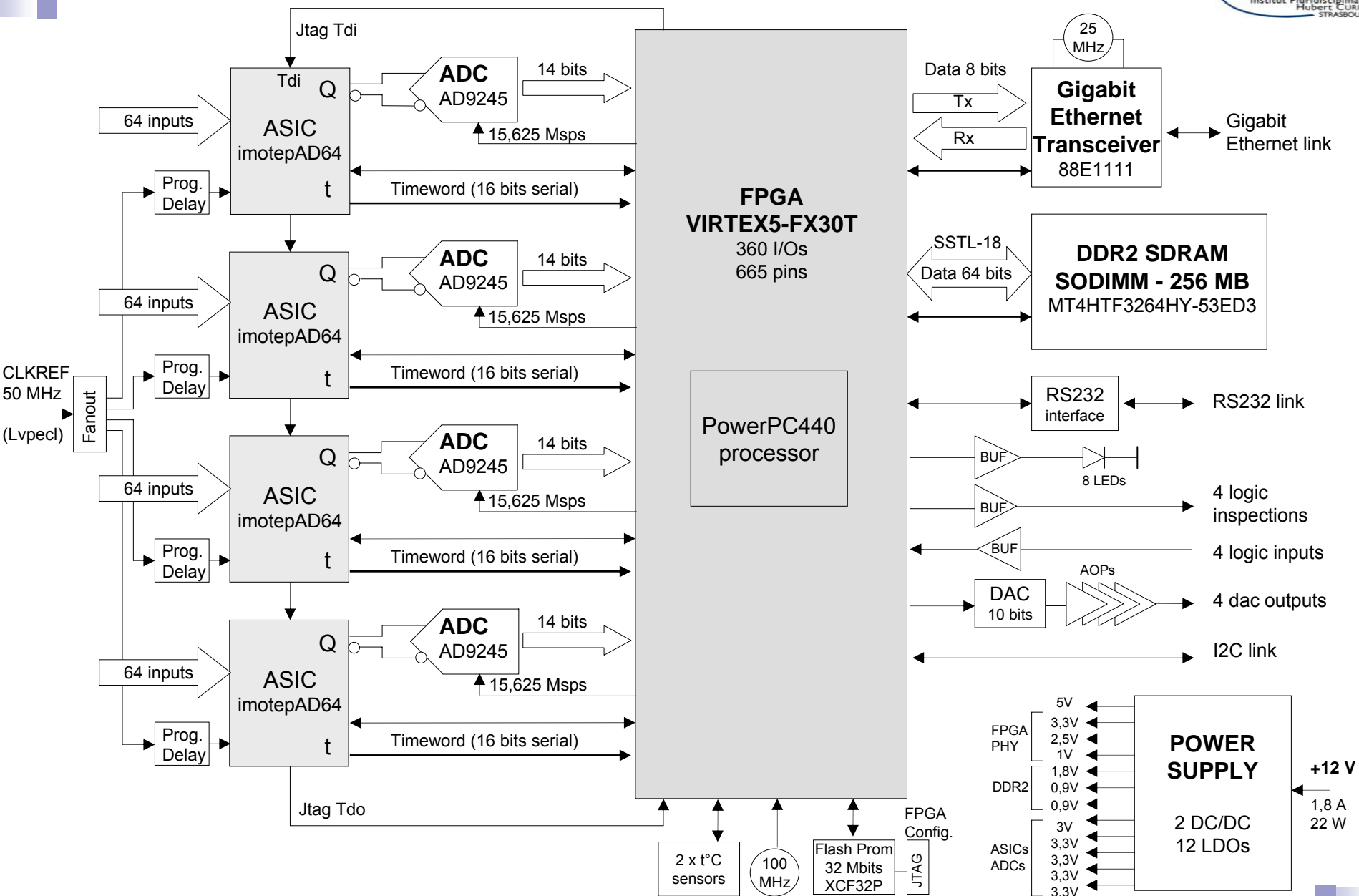
Injection du radiotracer ^{18}F -FDG



Radiotracer
émetteur de positrons



Architecture de la carte d'acquisition PET256



- Conception des schémas (logiciel ConceptHDL 15.7)
- Placement – Routage (logiciel Allegro 15.7)
- 800 composants
- 100 références
- **35 nouvelles références - CAO Cadence de l'IN2P3.**

DDR2
SDRAM

Référence CAO	Référence fabricant	Boîtier	Désignation
88E1111 (biblio)	88E1111-B1CAA1 C000 (Marvell)	BCC-96 (BGA)	Gigabit Ethernet Transceiver
XC5VFX30TFFG665 (biblio)	XC5VFX30T-1FFG665C (Xilinx)	FFG-665 (BGA)	FPGA
XCF32P (inmemory)	XCF32P-VOG48P (Xilinx)	TSOP-48	Flash PROM 32 Mbits
SUPP SDRAM DDR2 (biblio)	MM50-200B2-1E (JAE)	SODIMM-200	Connecteur pour barrette DDR2
	MT4HTF3264HY-53ED3 (Micron)	SODIMM-200	Barrette DDR2 SDRAM 256 MB
AD9245 (biblio)	AD9245BCPZ-20 (Analog D.)	QFN-32	ADC 14 bits 20MSPS
ADM1184 (biblio)	ADM1184-ARMZ (Analog D.)	MSOP-10	Quad voltage monitor
ADM3202 (biblio)	ADM3202-ARUZ (Analog D.)	TSSOP-16	RS232 line drivers/receivers
MAX1617 (biblio)	MAX1617A-MEE+ (Maxim)	QSOP-16	Remote/local Temperature sensor
NB6L295 (biblio)	NB6L295-MNG (On semi.)	QFN-24	Programmable Clock/Data Delay
NB6N14S (bilbio)	NB6N14S-MNG (On Semi.)	QFN-16	Diff input LVDS Fanout (1:4)
REF3320 (bilbio)	REF3320-AiD BZT (Analog D.)	SOT23-3	Voltage reference - 2,048 V
TLV4111 (biblio)	TLV4111-CDGN (Ti)	MSOP-8	300mA output drive AOP

Référence CAO	Référence fabricant	Boîtier	Désignation
TEN30 (biblio)	TEN30-1210 (TracoPower)		Convertisseur DC/DC 3,3V-7,5A
TEN8 (biblio)	TEN8-1211 (TracoPower)		Convertisseur DC/DC 5V-1,5A
24LC1025 (biblio)	24LC1025-i/SM	SOiJ-8	1024 kbit Serial EEPROM
MIC49200-1.0 (biblio)	MIC49200-1.0WR	SPAK-5	LDO 1V-2A
MIC5259-3.0 (biblio)	MIC5259-3.0YML	MLF-6	LDO 3V-300mA low noise
MIC5259-3.3 (biblio)	MIC5259-3.3YML	MLF-6	LDO 3,3V-300mA low noise
MIC5205 (biblio)	MIC5205-YM5	SOT23-5	LDO adj-150mA low noise
TPS51100 (biblio)	TPS51100-DGQ	TSSOP-10	3A source DDR termination regu.
CON68P (biblio/con68p_ill)	FTE-134-03-DV-A (Samtec)		Connecteur 2x34 male / pas 0,8mm
CON9P (inconnector)	83611 9006 (Molex)		Mini SUBD9 coudé male
CONRJ45 (biblio/conrj45_filtre)	HFJ11-1G01E (Halo)		Connecteur RJ45 Gigabit
EMBASE ALIM (biblio)	DC10B (Cliff)		Embase Alim 5A / 2,5 mm
PLEMO (inconnector/pcoax2sign)	EPG.00.302.HLN (Lemo)		Embase coudée 2 pins femelle
10uH (inpassive/induc-blindee)	SRU5028-100Y (Bourns)		Self blindée 100uH-1,8A
10uH (inpassive/induc-blindee)	SRU1048-100Y (Bourns)		Self blindée 100uH-4,5A
POUSSOIR (inpassive/poussoir)	B3SN-3112 (Omron)		Bouton poussoir CMS

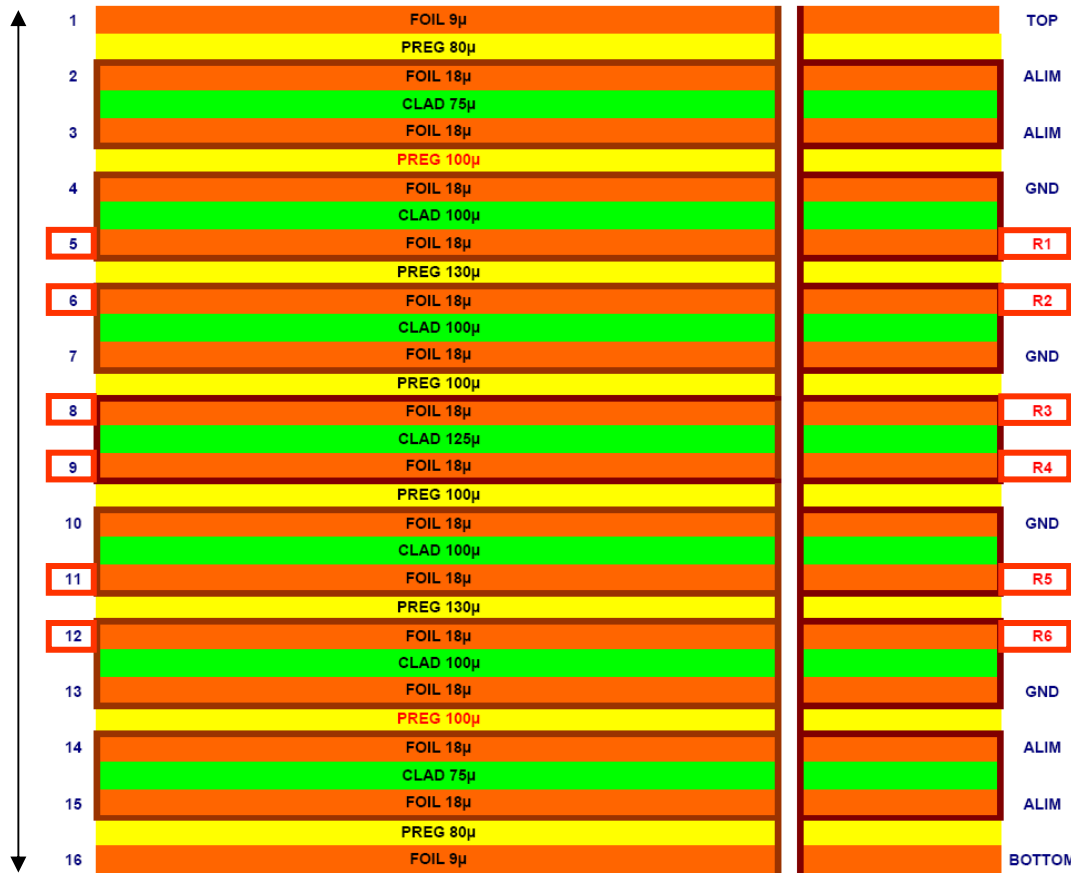
- MC 16 couches
- Classe 7 (isolements et fils mini 100µm)
- Vias traversants (perçage 300µm – pastille 550µm)

Diélectrique: FR4 HTG 170 LF

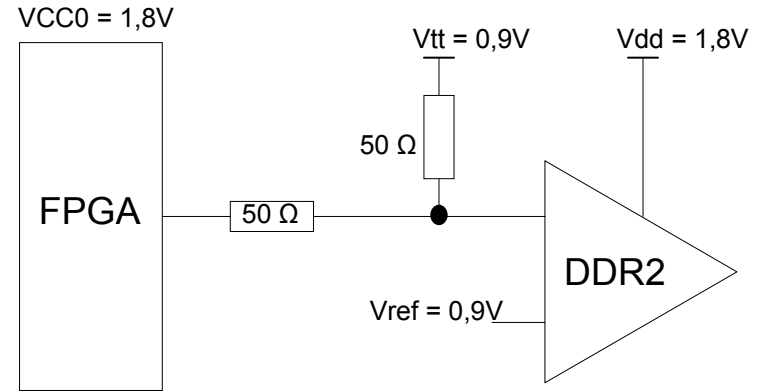
Nelco N4000-29

Advanced Lead-Free, High-Tg Multifunctional Epoxy

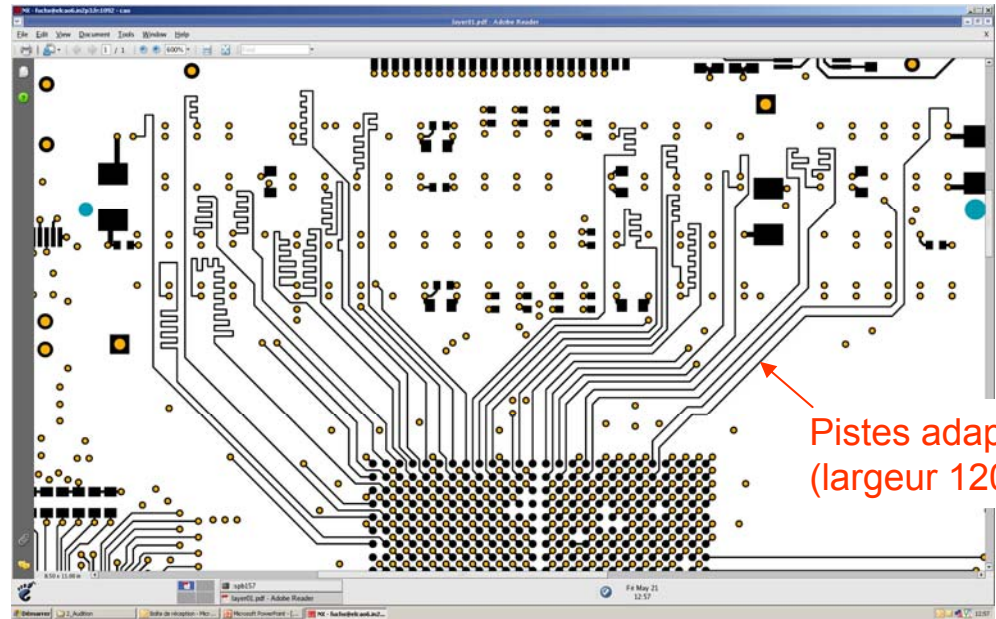
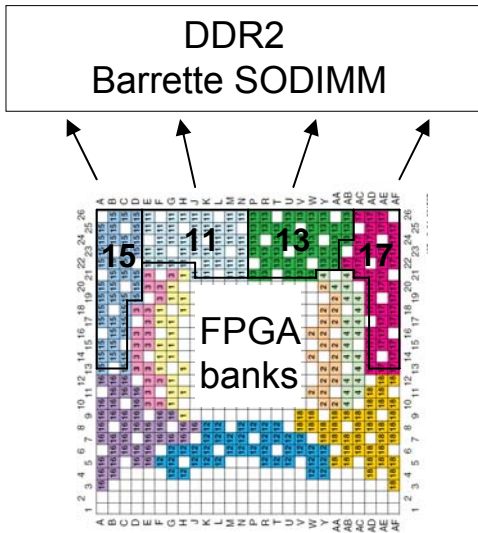
Property / Condition	Value (U.S. Units)		Value (Metric Units)	
Mechanical Properties				
Peel Strength - 1 oz. (35 micron) Cu				
After Solder Float	10.1	lb / inch	1.81	N / mm
At Elevated Temperature	8.9	lb / inch	1.56	N / mm
After Exposure to Process Solutions	9.7	lb / inch	1.73	N / mm
X / Y CTE [-40°C to +125°C]	15 - 17	ppm / °C	15 - 17	ppm / °C
Z Axis CTE Alpha 1 [50°C to Tg]	55	ppm / °C	55	ppm / °C
Z Axis CTE Alpha 2 [Tg to 260°C]	265	ppm / °C	265	ppm / °C
Z Axis Expansion [50°C to 260°C]	3.0	%	3.0	%
Young's Modulus (X/Y)	3.6 / 2.9	psi x 10 ⁶	22.6 / 18.2	GN / m ²
Poisson's Ratios (X/Y)	0.18 / 0.16		0.18 / 0.16	
Thermal Conductivity	0.46	W / mK	0.46	W / mK
Specific Heat	0.92	J / gK	0.92	J / gK
Electrical Properties				
Dielectric Constant (50% resin content)				
@ 1 MHz (TFC / LCR Meter)	4.5		4.5	
@ 1 GHz (RF Impedance)	4.3		4.3	
@ 10 GHz (Split Post Cavity)	4.2		4.2	
@ 10 GHz (Stripline)	4.0		4.0	
Dissipation Factor (50% resin content)				
@ 1 MHz (TFC / LCR Meter)	0.016		0.016	
@ 2.5 GHz (Split Post Cavity)	0.015		0.015	
@ 10 GHz (Split Post Cavity)	0.017		0.017	
Volume Resistivity				
C - 96 / 35 / 90	10 ⁷	Mµ - cm	10 ⁷	Mµ - cm
E - 24 / 125	10 ⁸	Mµ - cm	10 ⁸	Mµ - cm
Surface Resistivity				
C - 96 / 35 / 90	10 ⁶	Mµ	10 ⁶	Mµ
E - 24 / 125	10 ⁷	Mµ	10 ⁷	Mµ
Electric Strength	1100	V / mil	4.2x10 ⁴	V / mm
Dielectric Breakdown	>50	kV	>50	kV
Arc Resistance	129	seconds	129	seconds
Thermal Properties				
Glass Transition Temperature (T _g)				
DSC (°C)	>185	°C	>185	°C
TMA (°C)	>175	°C	>175	°C
Degradation Temp (TGA) (5% wt. loss)	350	°C	350	°C
Pressure Cooker - 60 min then solder dip @288°C until failure (max 10 min.)	Pass		Pass	
T ₂₆₀	>60	minutes	>60	minutes
T ₂₈₈	15	minutes	15	minutes
Chemical / Physical Properties				
Moisture Absorption	0.15	wt. %	0.15	wt. %
Methylene Chloride Resistance	0.01	% wt. chg.	0.01	% wt. chg.
Density [50% resin content]	1.99	g / cm ³	1.99	g / cm ³



- SSTL-18 (Stub-Series Transceiver Logic)
- $f_{clk} = 266 \text{ MHz}$ soit 533 Mcycles/s 
- Bus de données de 64 bits
- 4,26 Gbytes/s



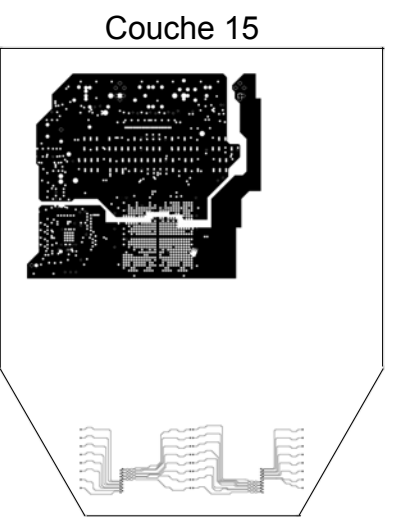
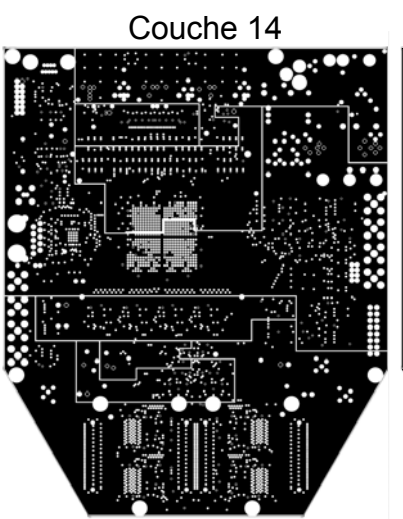
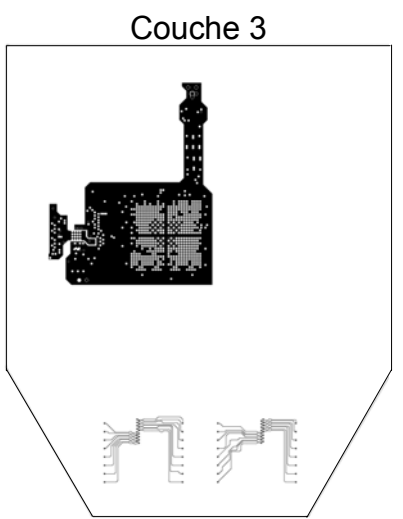
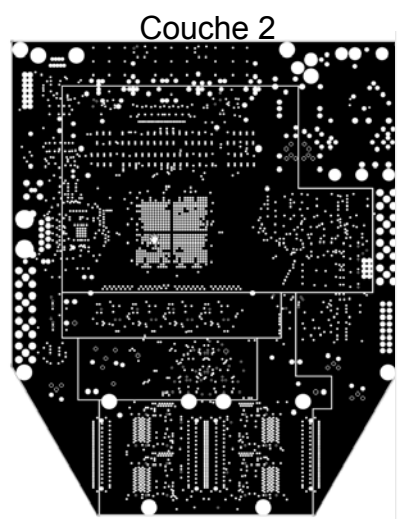
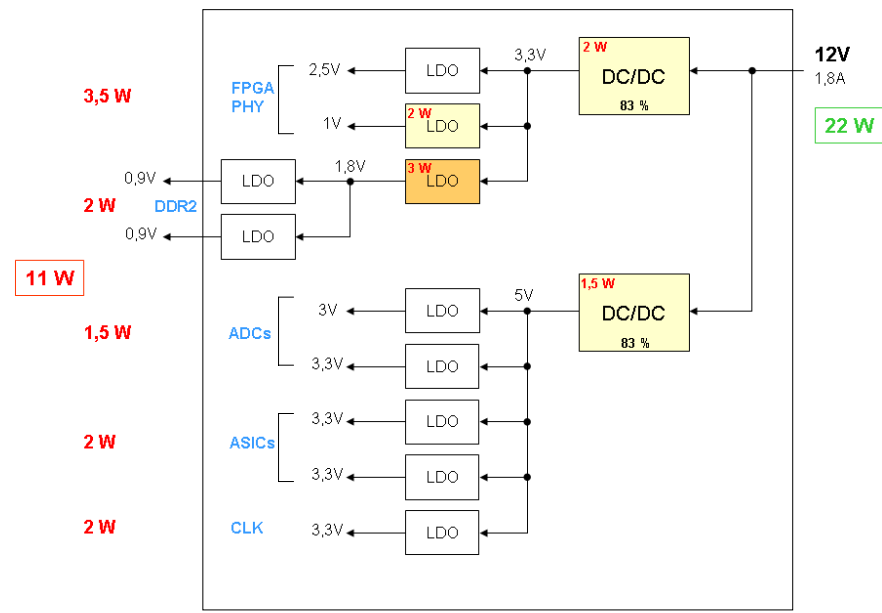
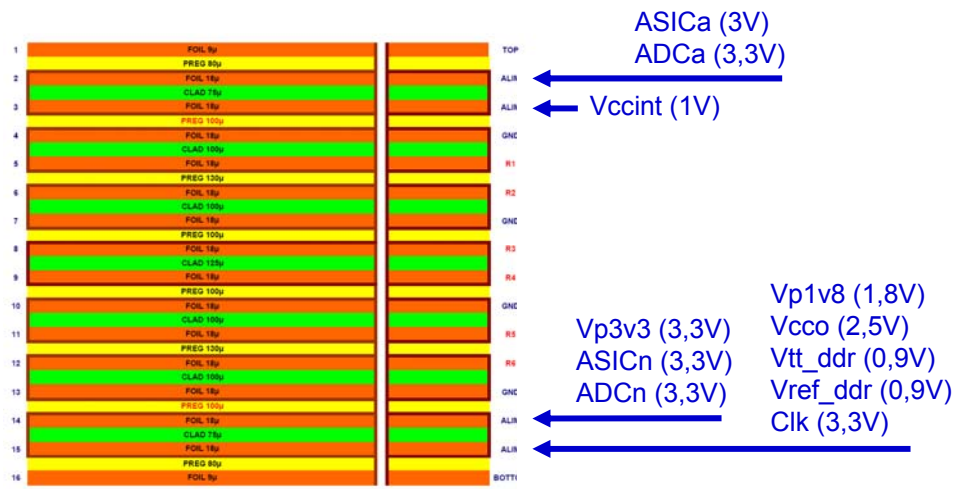
Longueurs des pistes identiques: $\Delta t_{max} = 50 \text{ ps}$



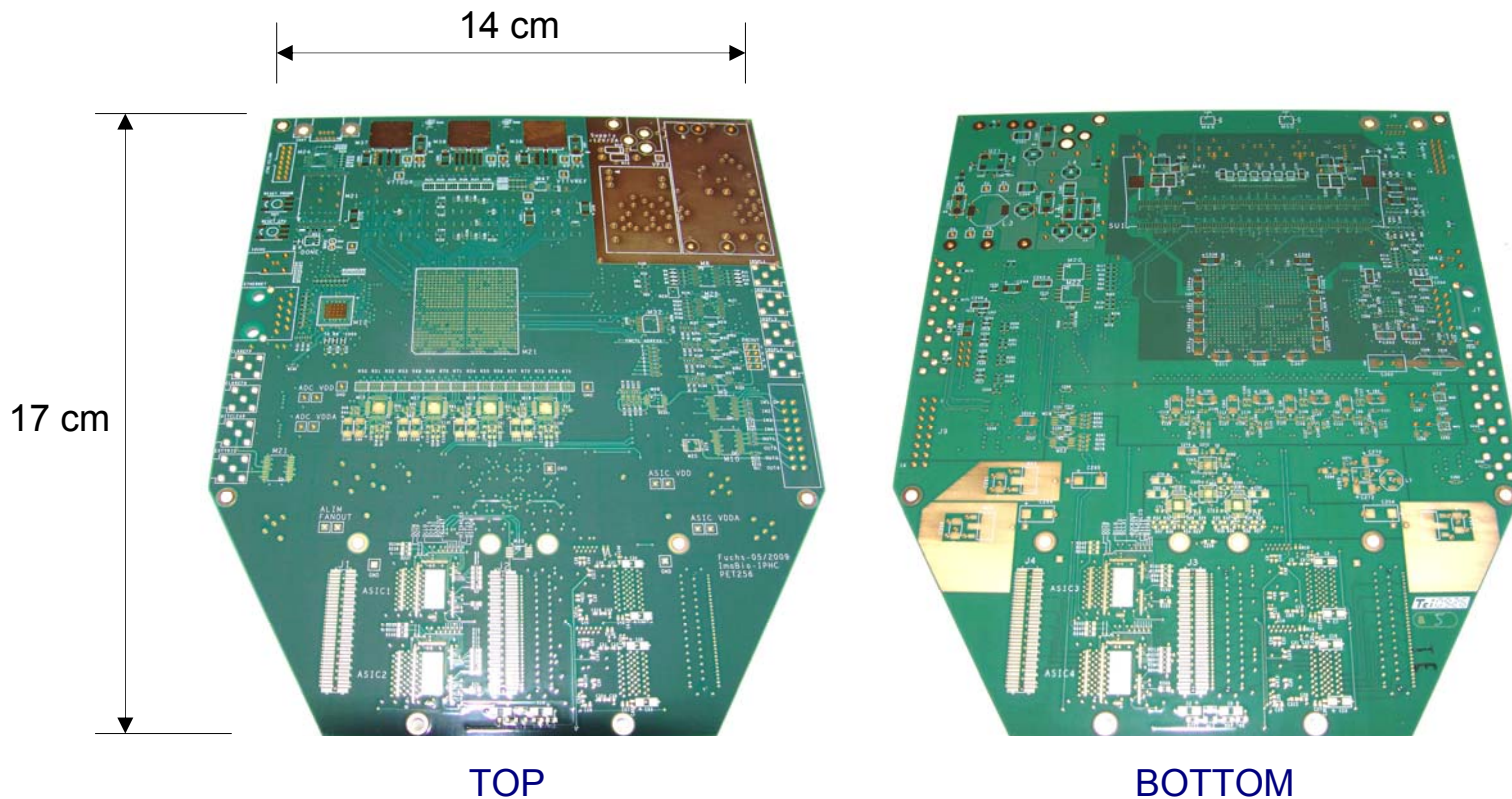
Couche 8

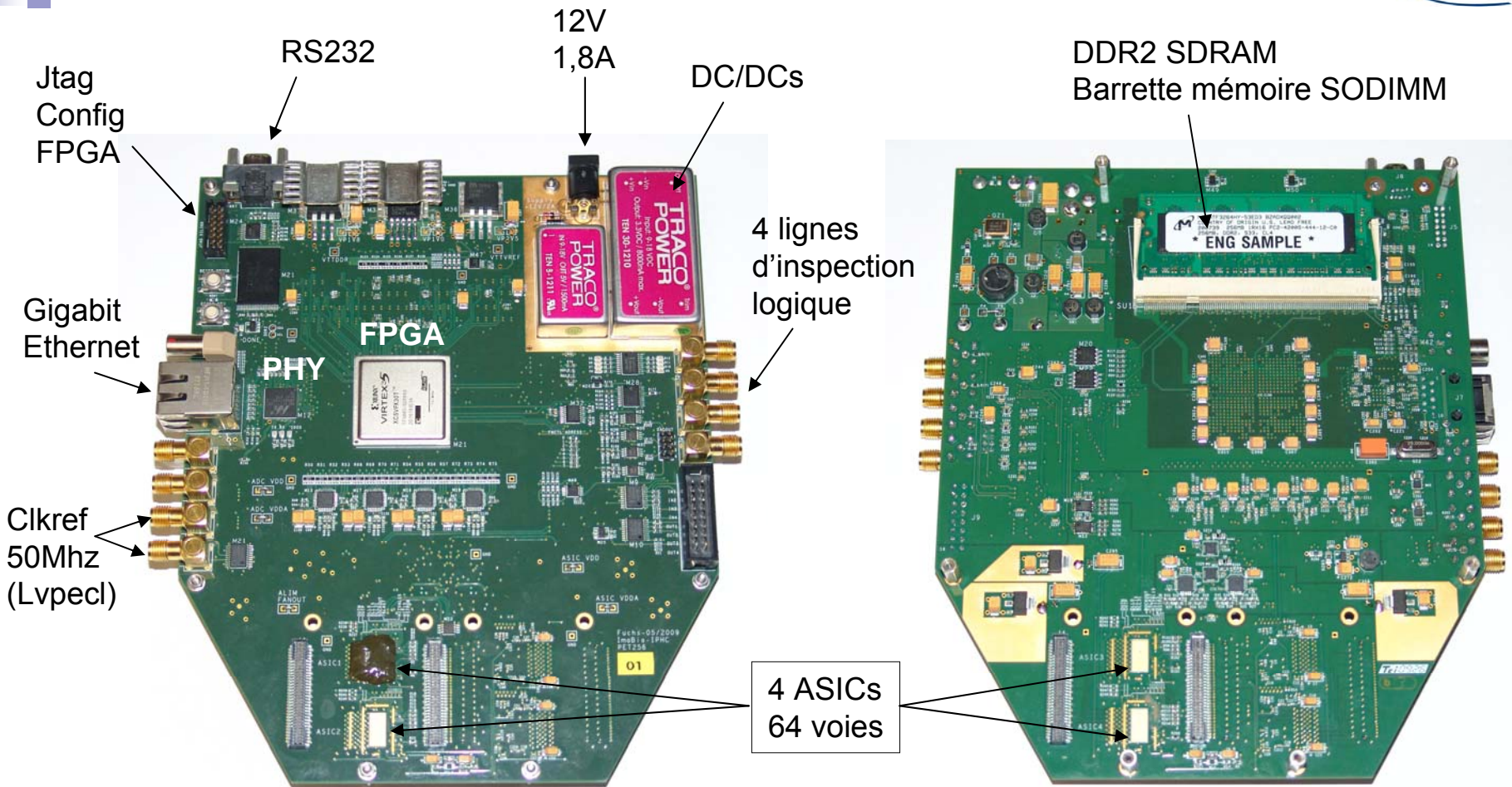
2
3

14
15

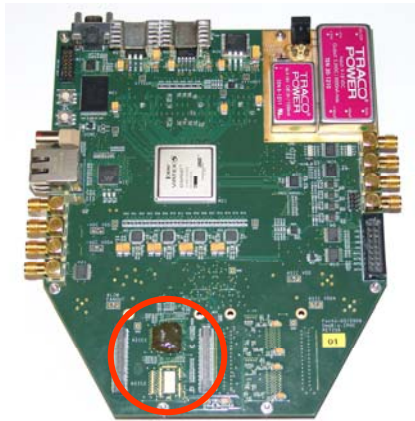


- Fabrication : société TECHCi Rhône Alpes
- Finition NiAu chimique (Ni: 5 μm / Au: 0,07 μm) \longrightarrow Bonding avec fils Aluminium
- Tests électriques avec sondes mobiles (1222 nets)
- Prix unitaire: 445 € (pour 5) + 850 € d'outillage

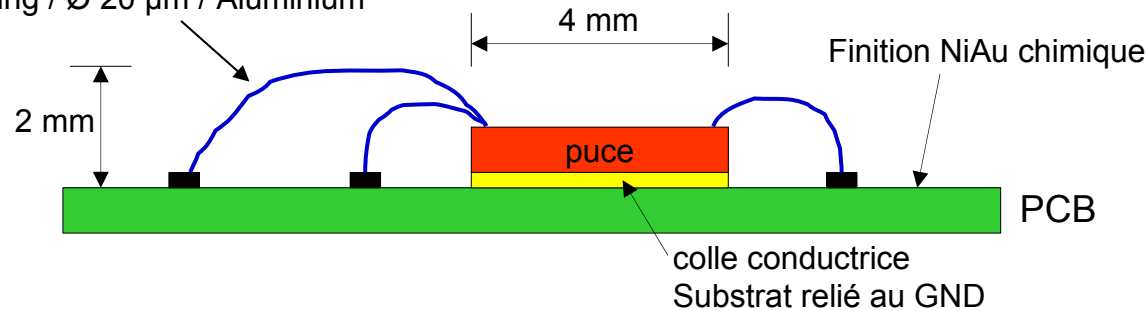




- ~ 800 composants (taille mini CMS 0402)
- FPGA Virtex5 FXT: boîtier BGA 665 broches (27 x 27 mm)
- PHY Ethernet: boîtier BCC 96 broches (9 x 9 mm)
- Montage: Service Microtechniques de l'IPHC



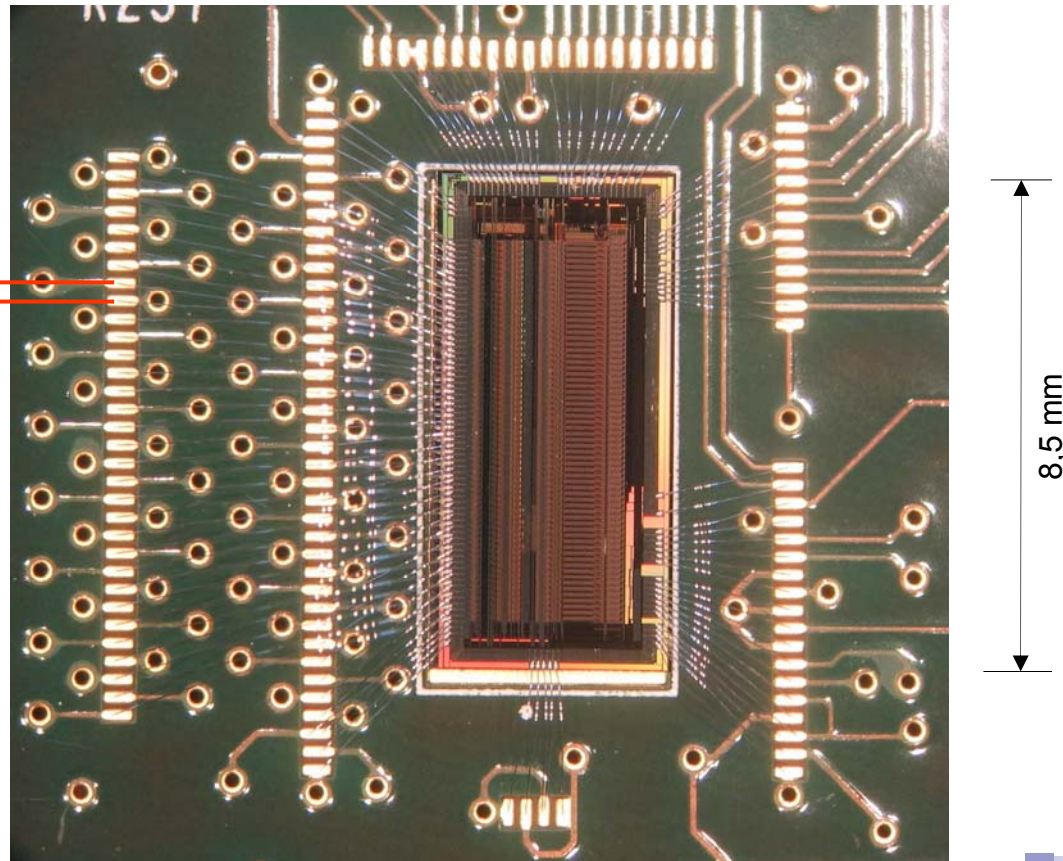
Fils de bonding / Ø 20 µm / Aluminium

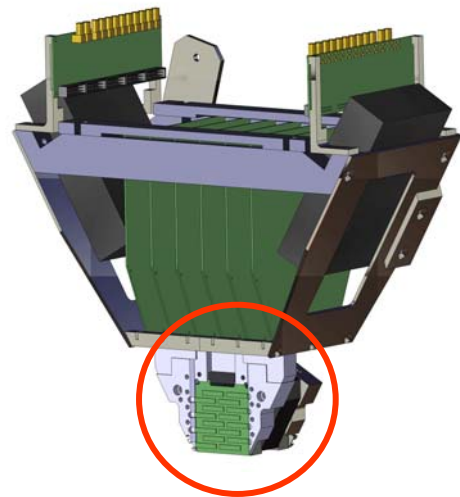


ASIC IMOTEPAD64

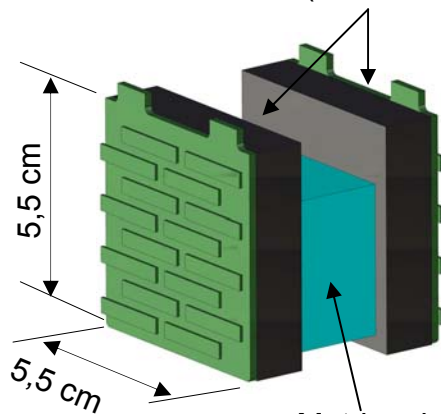
- CMOS 350 nm / 34 mm²
- 126 I/Os / pas de 100 µm
- Fabrication: AMS
- Bonding: Service Microtechniques

300 µm





2 photodétecteurs 1024 anodes
(768 anodes utilisées)

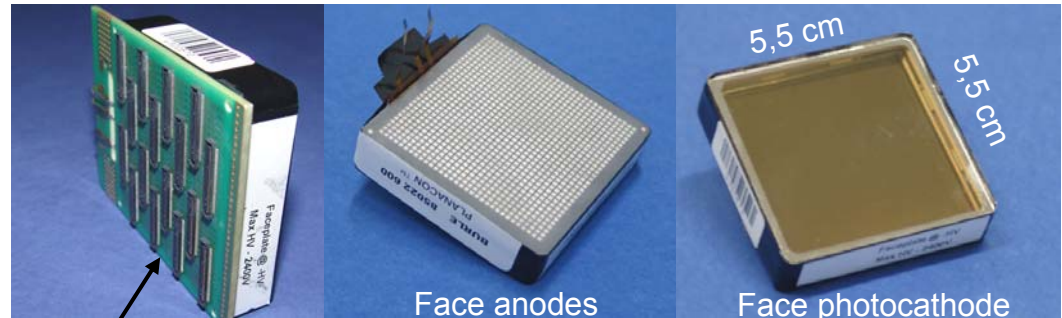


Matrice de 32 x 24
cristaux scintillants
(LYSO – 1,5 x 1,5 x 25 mm)

Photodétecteur à galettes de micro-canaux:

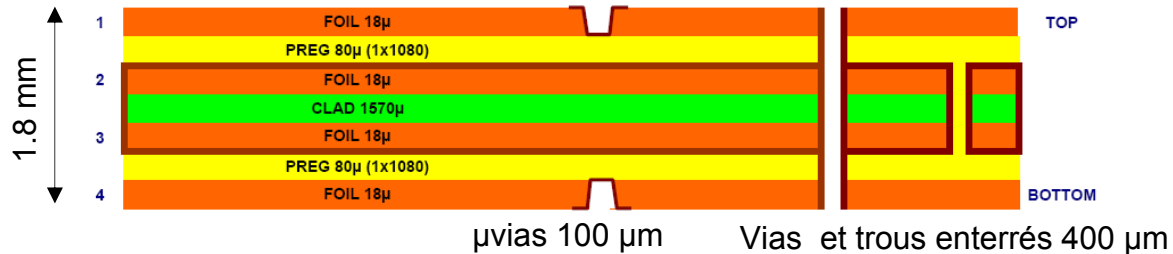
1024 anodes (pas entre anodes = 1,6 mm)

Planacon XP85023/A1 - Photonis



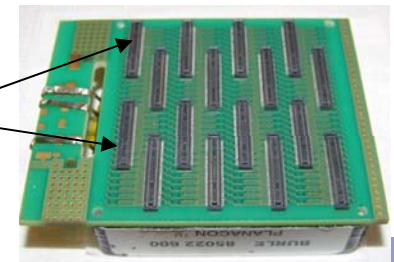
Circuit imprimé

4 couches / Classe 6 / FR4 HTG 150 LF / Société TECHCi
Collage sur le photodétecteur avec une colle Epoxy / Argent

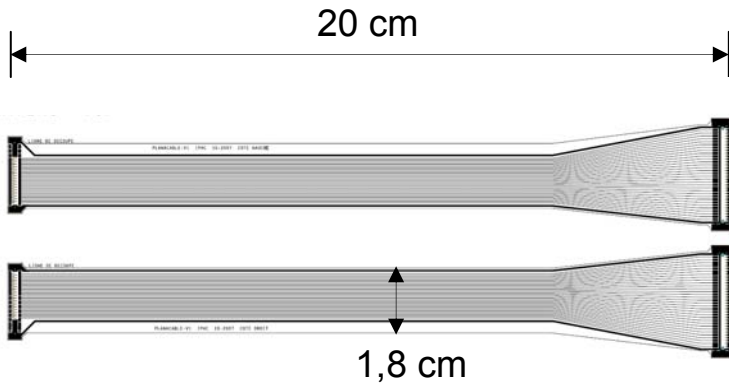


Connecteurs:

- 64 signaux / connecteur
- DF40C-80 DS-0.4V (HIROSE)
- pas entre broches : 0,4 mm
- 1,5 mm board to board



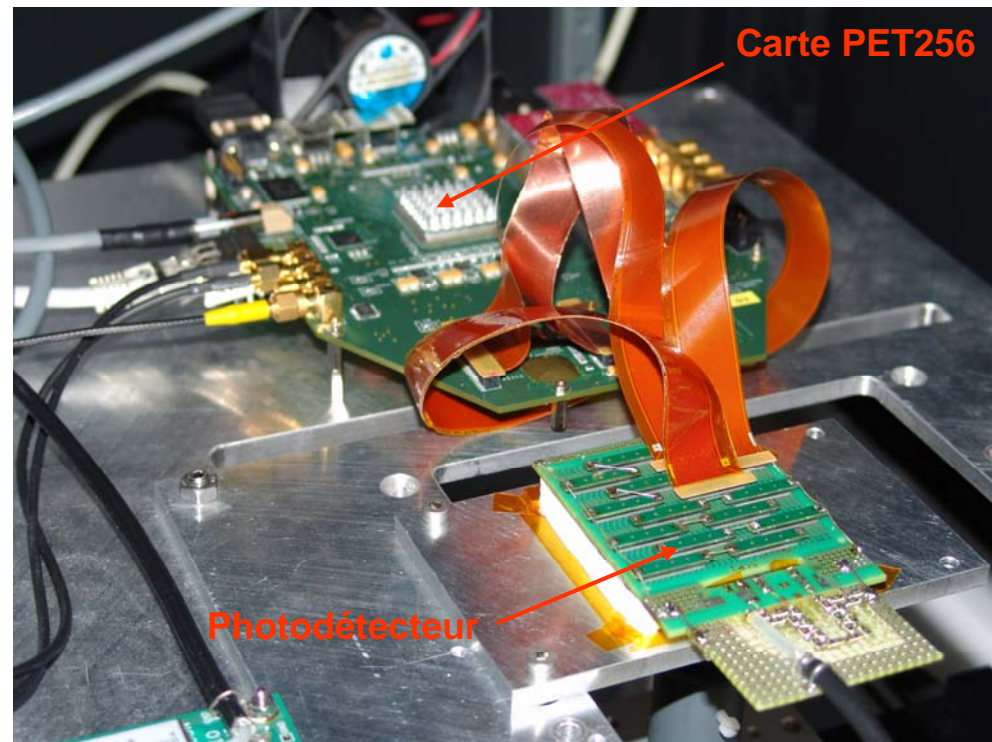
Circuits imprimés souples (Flex)



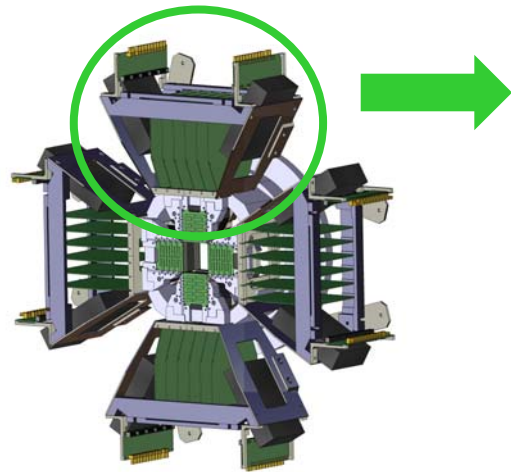
- Souple DFTM (double face)
- Kapton 50 μm / Classe 6
- Cuivre 17,5 μm / pistes 150 μm
- Finition: Ni Au chimique
- 64 signaux sur chaque Flex
- Connectique: HIRHOSE + SAMTEC
- Fabrication: CIRETEC (Groupe CIRE)

Banc de test Laser:

Caractérisation de l'ASIC + Tests photodétecteur



1 module = 1536 voies



micro-TEP = 6144 voies

