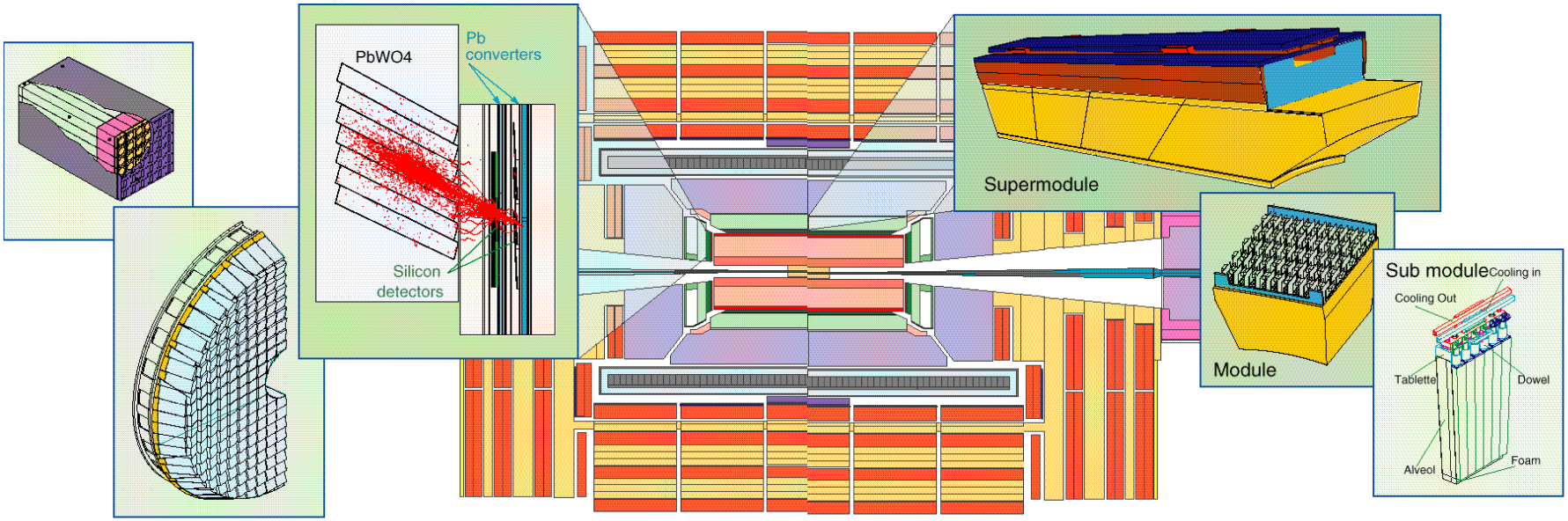
CMS

ELECTROMAGNETIC CALORIMETER

ELECTRONICS

Pierre DEPASSE

IPN Lyon

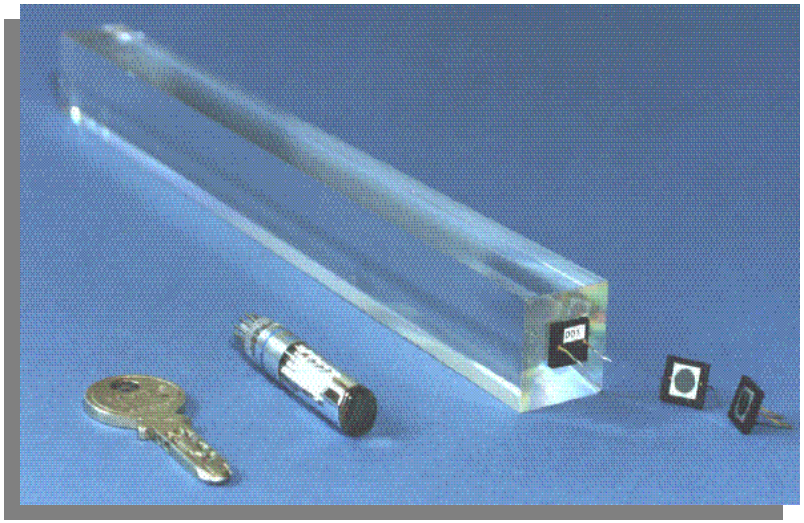


IXth International Conference on Calorimetry In Particle Physics

Calor 2000, Annecy, October 9-14

CMS ECAL PERFORMANCE

- magnetic field of 4 T
- LHC beam crossing at 40 MHz
- radiation rates : 0.15-0.3 Gy/h in the barrel, up to 15 Gy/h in the endcaps



Choice of : lead tungstate crystals (fast, rad hard, compact)

+ Avalanche PhotoDiodes (APD) in barrel (B-insensitive, gain, rad hard)

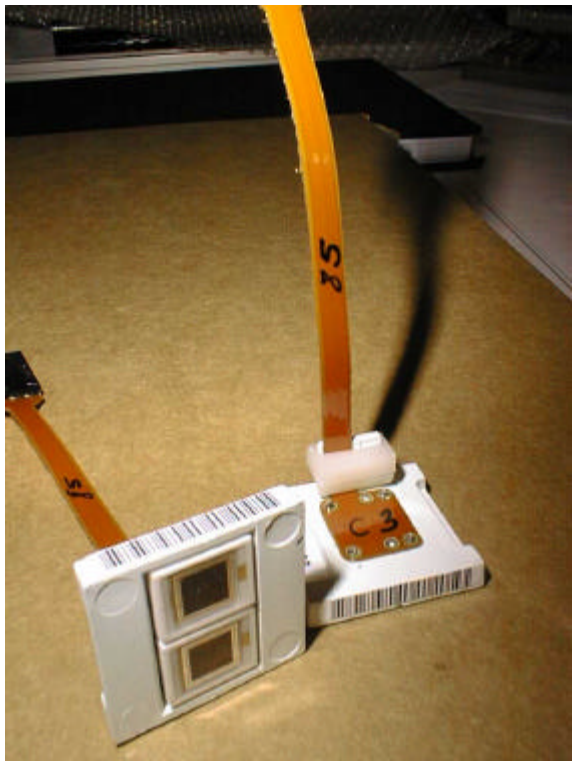
+ Vacuum PhotoTriodes (VPT) in endcaps (rad hard, gain)

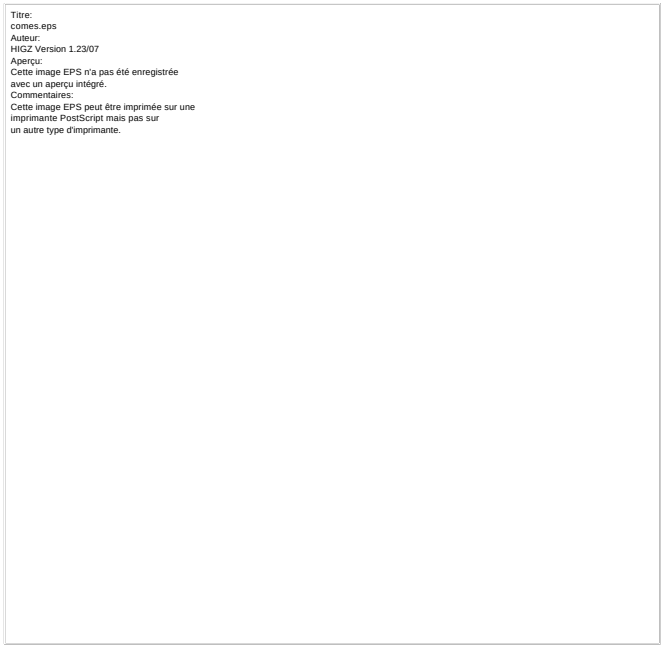
LEAD TUNGSTATE : $PbWO_4$

- Scintillation : 85% of the light in 20 ns, $\lambda \sim 440$ nm
- LOW Light Yield : about 70 photons/MeV for a crystal (PMT)

  Readout with APDs (gain 50) and VPTs (gain 6-9 in 4T)

PHOTODETECTORS





APD gain curve

READOUT OF PHOTODETECTORS

On-Detector Light-to-Light Readout

40 MHz Clock / > 15 bits range / ~10 bits precision

Upper-Level VME Readout Card (in Counting Room)

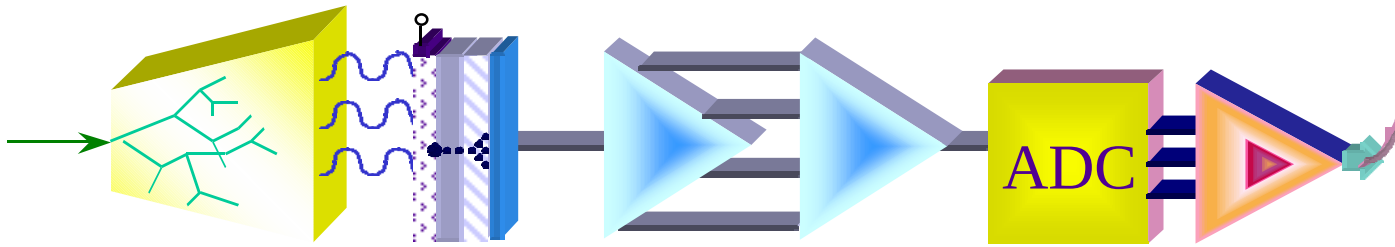
Pipeline

To DAQ

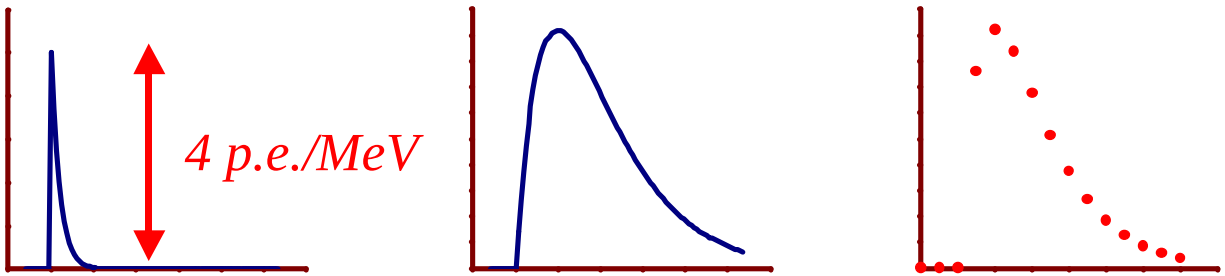
Σ

Digital Trigger Σ

Energy ® Light | **Light ® Current** | **Current ® Voltage** | **Voltage ® Bits** | **Bits ® Light**



$PbWO_4$ Crystals	APD VPT	Floating-Point Preamp (FPPA)	ADC	Fiber Readout

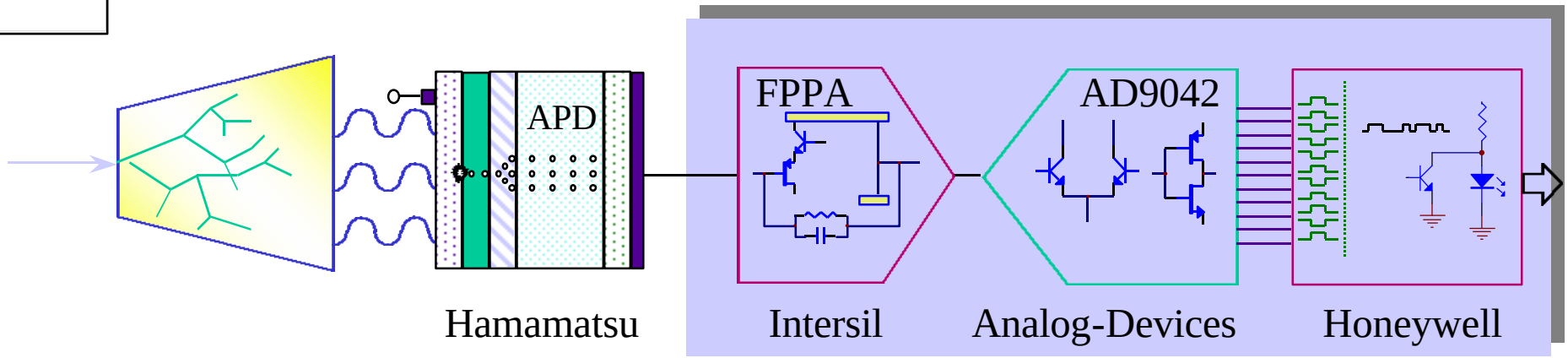


Barrel : 61200

EndCaps : 15632

Lyon, Princeton

FRONT-END ELECTRONIC CHAIN

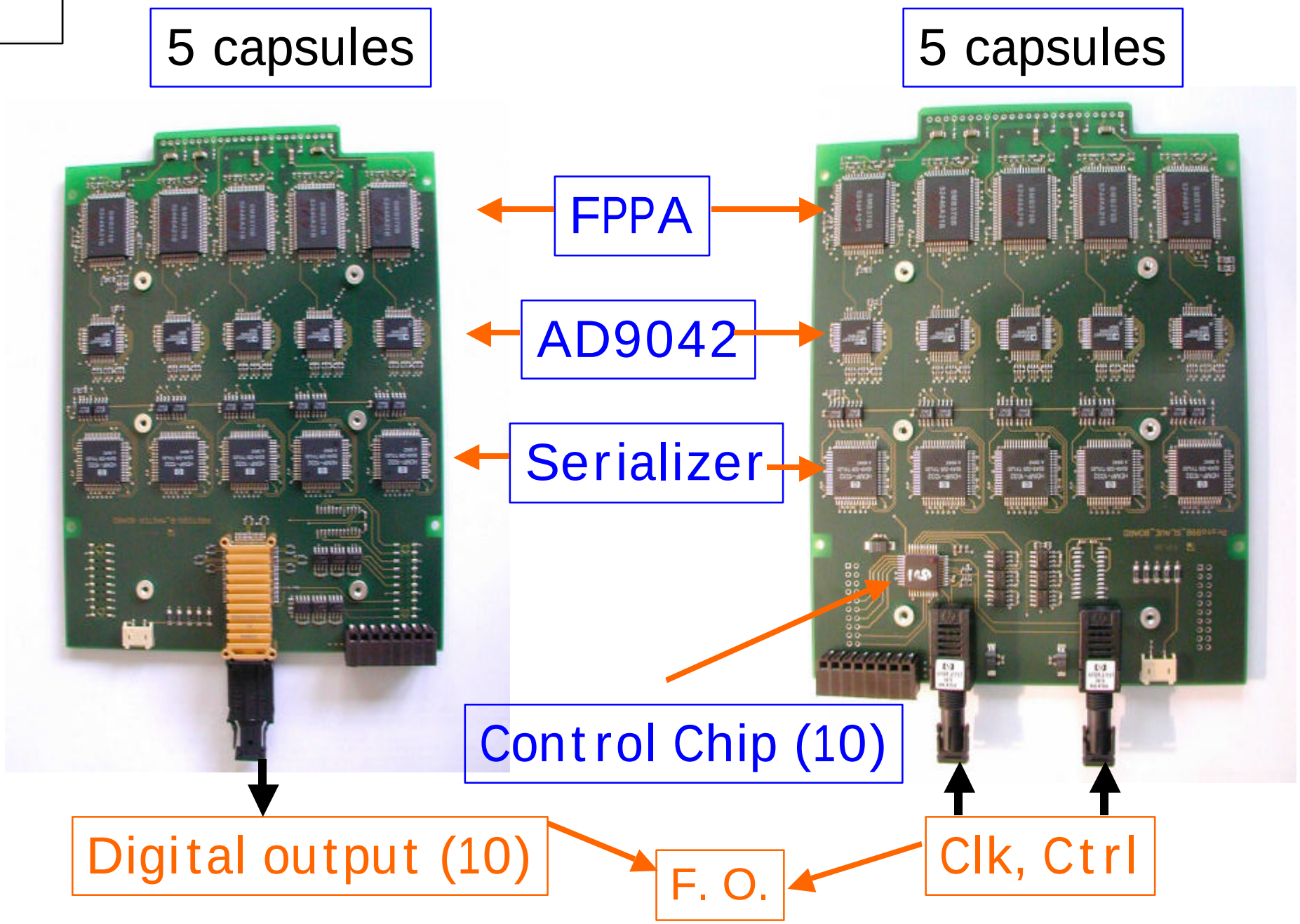


Full custom Ctrl Chip (not shown)	Type of IC	Full custom ASIC	Commercial ADC	Full custom ASIC
DMILL	Process	UHF1X	XFCB	CHFET

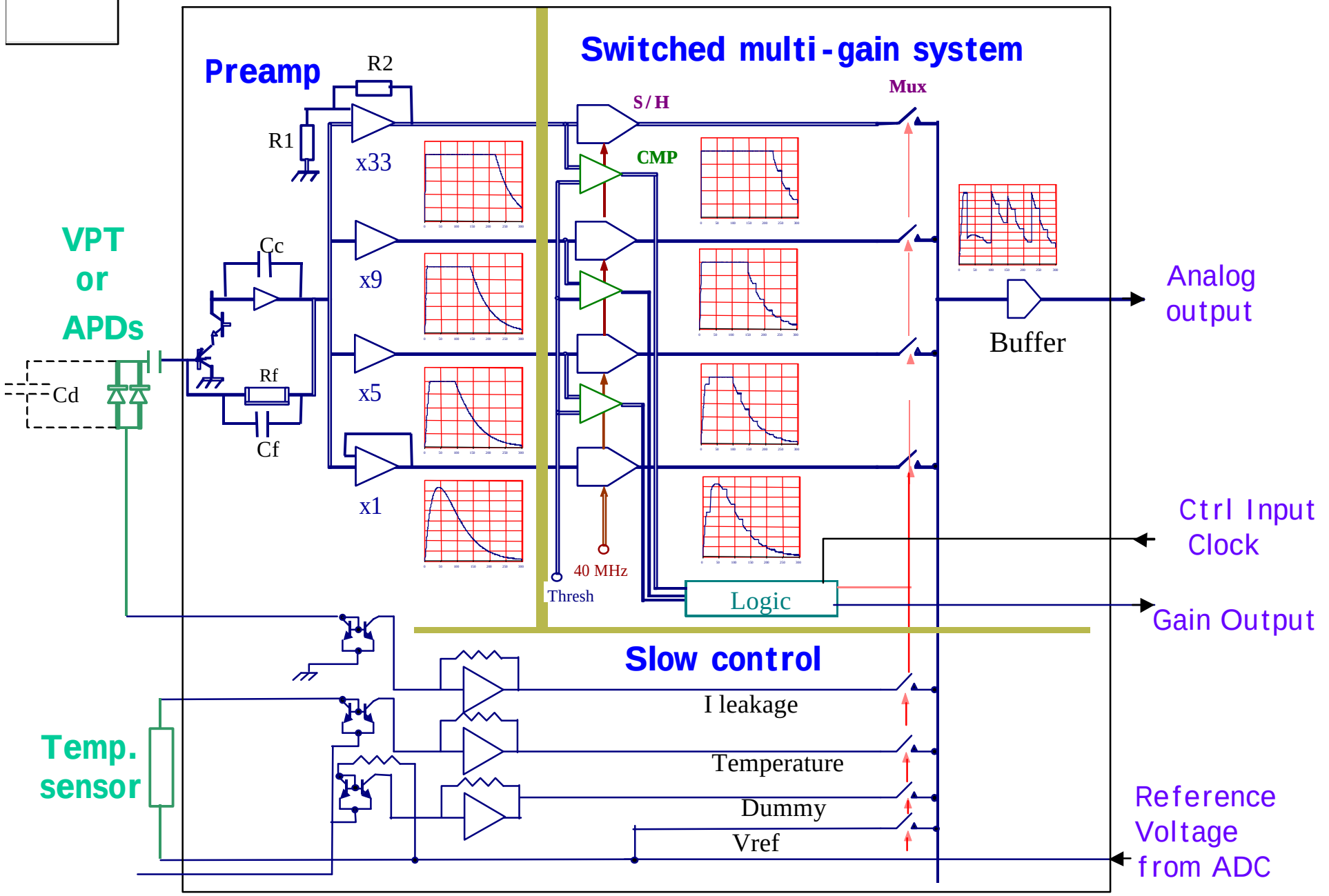
RAD HARD ELECTRONICS, Power dissipation: 1,2 W/channel

- Transimpedance P.A. (> 90 dB range)
- FPU : Compression in gains (1,5,9,33) to have better resolution
- Sampling ADC : 40 MHz, 4096 channels (A.D. 9042)
- One serializer per channel (800 Mbit/s) to bring out the SADC samples with digital optic link

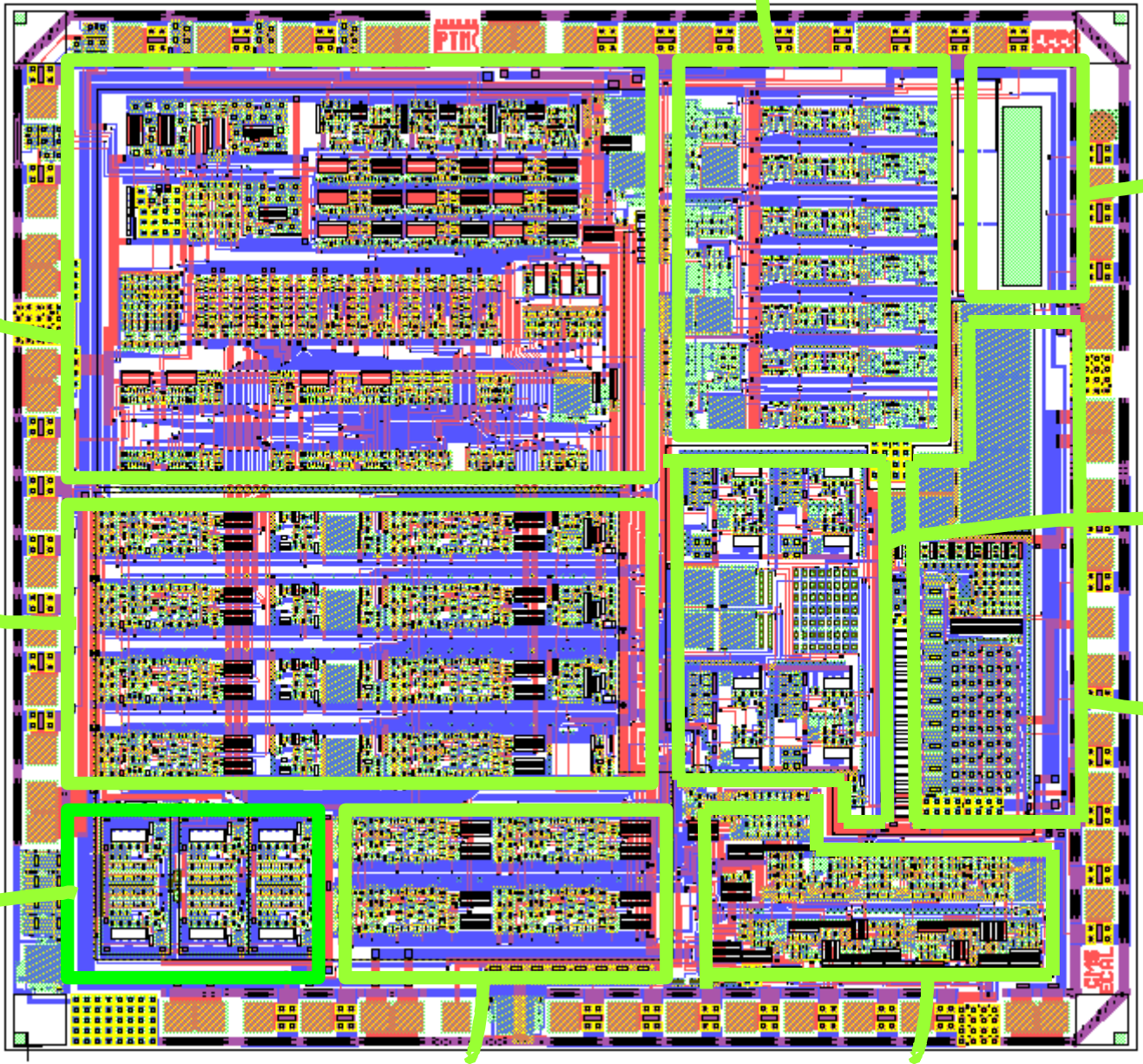
PROTO 99 ++, 10-channel READOUT



BLOCK DIAGRAM of Floating Point PreAmplifier (FPPA)

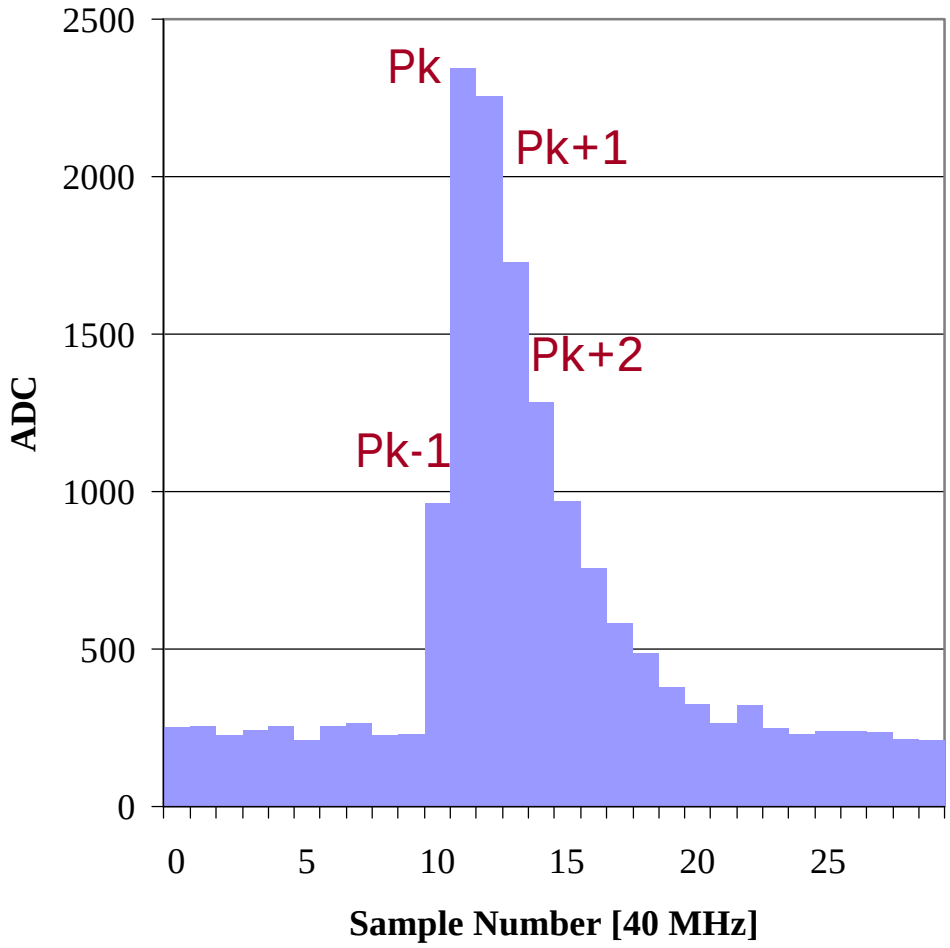


FPPA layout



25 mm^2

RADIATION-HARDNESS TESTS



FPPA Irradiation (PSI Jul. '99)

Protons 60-70 MeV
Good simulation of ionizing part. + neutrons in ECAL
Flux = 1.25 10^9 p/cm^2/s

Radiation-Induced Changes
(for 10^{13} p/cm^2 [10 LHC-years])

Gain Change:	– 0.3%
Pulse Shape:	< 0.1%

FPPA SPECIFICATIONS

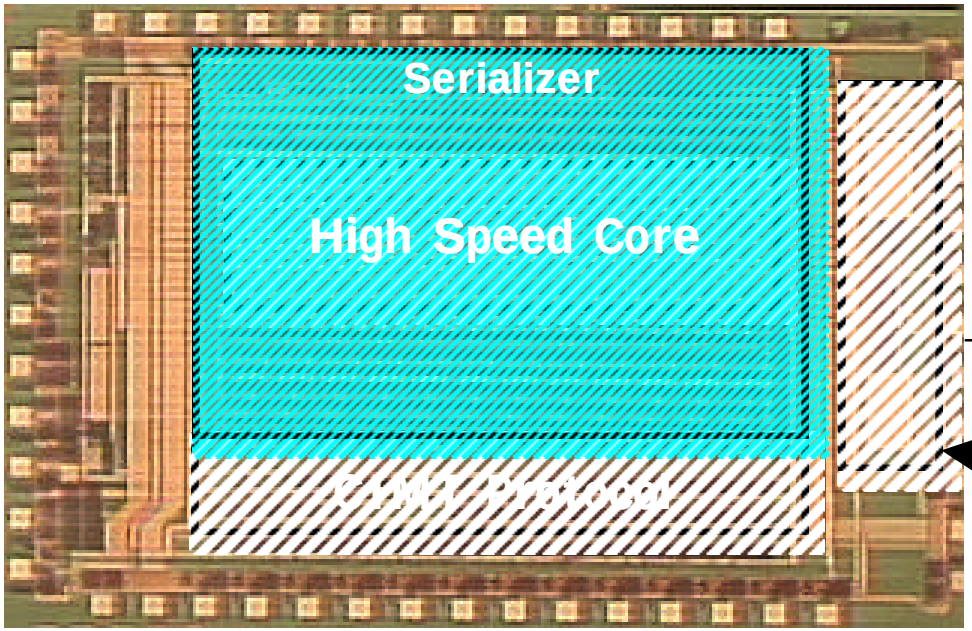
Barrel Readout FPPA			
Physics/Experminetal Parameter	**Symbol**	**Value**	**Unit**
Fullscale Energy[1]	E_{MAX}	1.5	TeV
(Target) Light Yield	LY	5	p.e./MeV
APD Operating Gain	M	50	
Spread in Photoelectron Yield	ΔLY	±10% RMS	p.e./MeV
Maximum Noise Level	E_N	40	MeV
APD Capacitance[2]	C_{APD}	<80	pF
Interconnect Capacitance	C_{KAPTON}	<30	pF
Detector Capacitance (2 APD + Interconnect)	C_{TOT}	<190	pF
FPPA Electrical Requirement	**Symbol**	**Value**	**Unit**
(*Derived*) Fullscale Charge	Q_{MAX}	60	pC
(*Derived*) Noise Equivalent Charge	ENC	10000	e^-
(*Derived*) Dynamic Range	DR	>90	dB
Fullscale Voltage (Preamp Output)	V_{MAX}	2	V
(*Derived*) Noise Voltage	V_N	50	μV

[1]Readout in E not E_T
[2]Spread in C_{APD} ~ 10%

Endcap Readout FPPA			
Physics/Experminetal Parameter	**Symbol**	**Value**	**Unit**
Fullscale Energy[1]	E_{MAX}	3	TeV
(Target) electron Yield[3]	LY	34	e^-/MeV
Spread in Photoelectron Yield[4]	ΔLY	±20% RMS	p.e./MeV
Maximum Noise Level	E_N	100	MeV
Detector Capacitance (VPT + Interconnect)	C_{TOT}	<40	pF
FPPA Electrical Requirement	**Symbol**	**Value**	**Unit**
(*Derived*) Fullscale Charge	Q_{MAX}	16.5	pC
(*Derived*) Noise Equivalent Charge	ENC	3500	e^-
(*Derived*) Dynamic Range	DR	>90	dB
Fullscale Voltage (Preamp Output)	V_{MAX}	2	V
(*Derived*) Noise Voltage	V_N	68	μV

[1]Readout in E not E_T
[3]Hamamatsu VPT, 5.5 pC/TeV
[4]±10% LY, ±15% VPT

FIBER-OPTIC TRANSMITTER



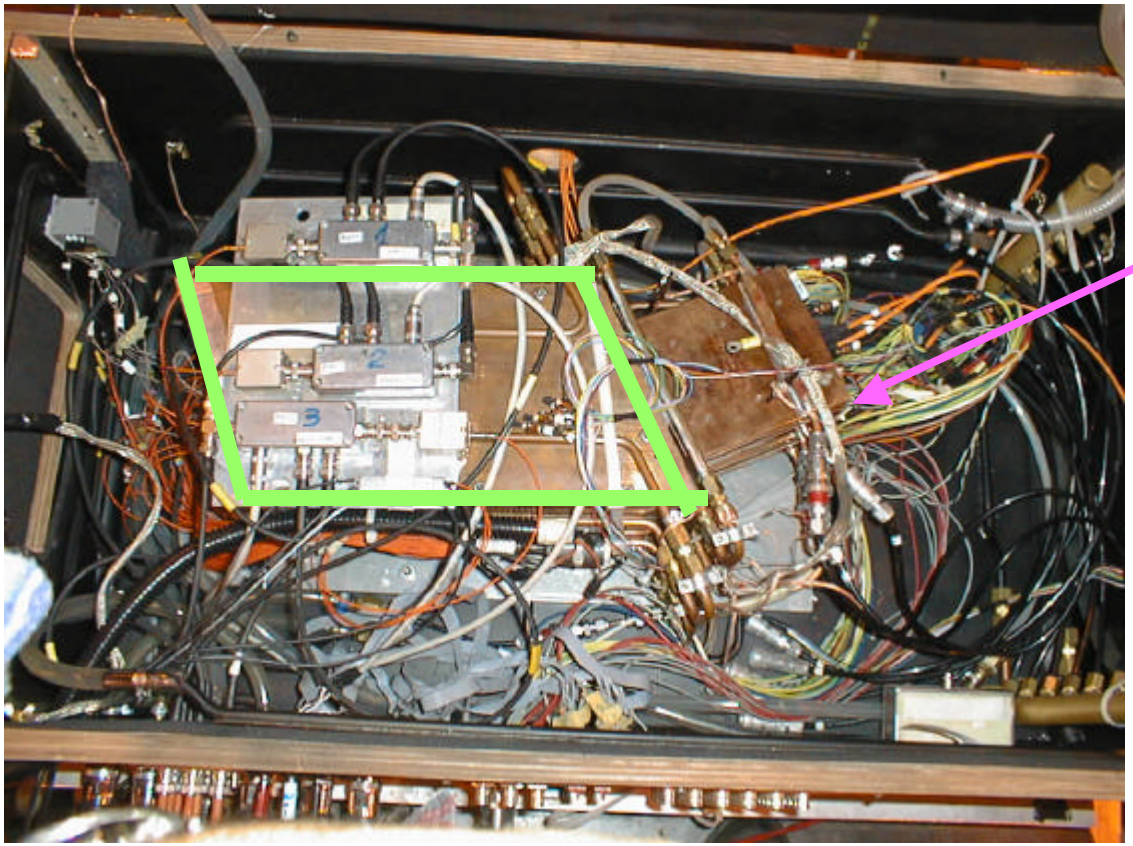
12 mm^2

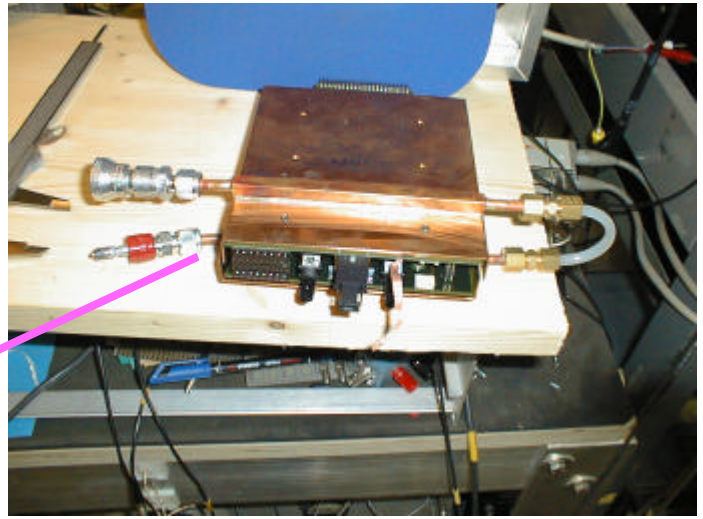
- Rad-hard complementary GaAs
- 16-bit G-Link compatible
- Integrated VCSEL driver
  500 μW modulation typ.
- 120 mW (including VCSEL)
  at 800 Mbit/s

P. Denes, Princeton

TEST OF ELECTRONICS IN BEAM (H4)

• Prototype 99++ : 30 production crystals with final : capsules (60 production APDs) - alveolae - tablets - connexion system. (Aug. 2000)





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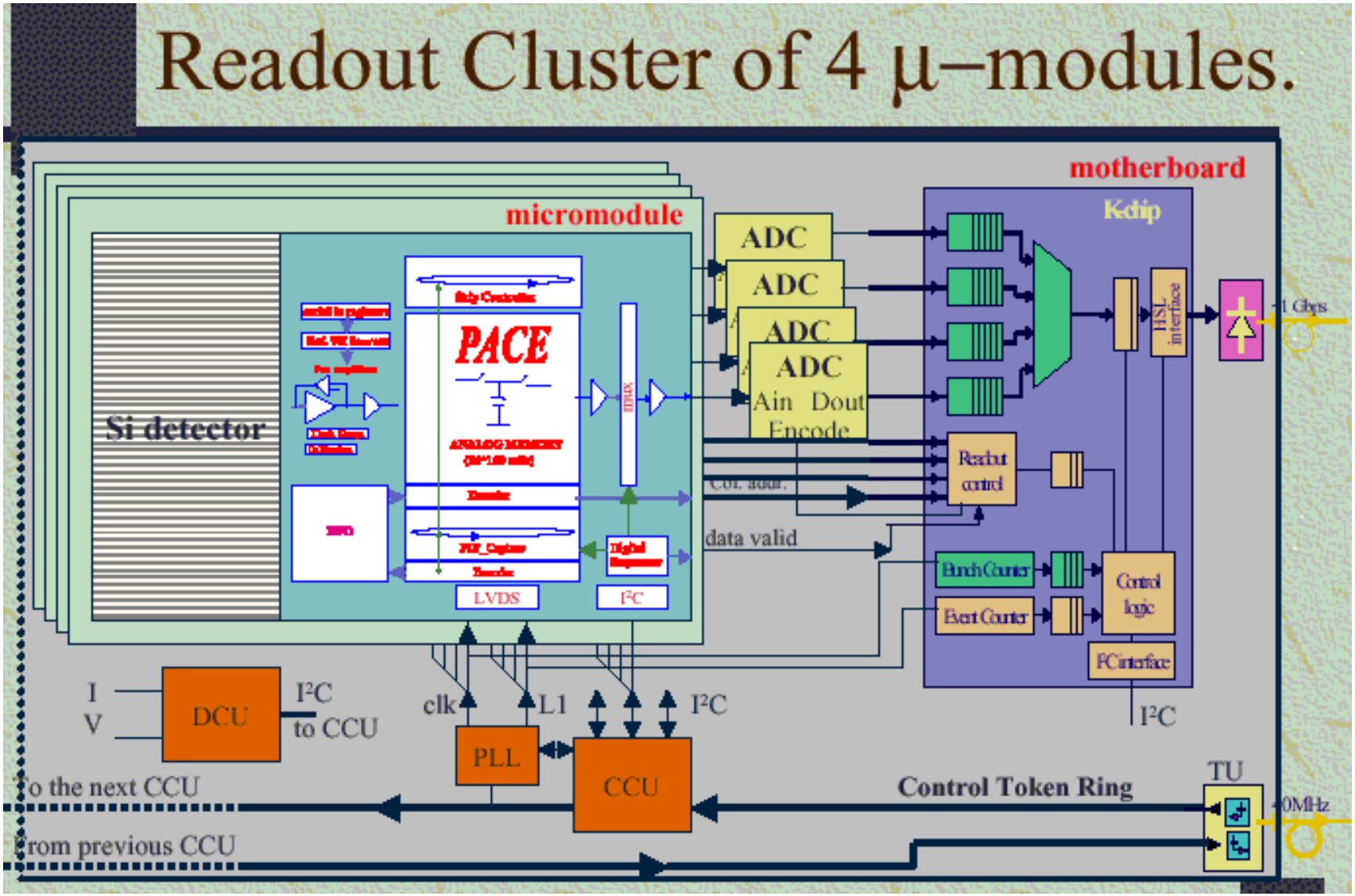
PRESHOWER ELECTRONICS



K. Kloukinas, Cern EP/CME

SCHEDULE/CONCLUSION

- **Barrel :** - pilot run FPPA (1000 chips in January 2001) then if OK (yield), 2 runs, statistics tests and production end 2001,
  - GaAs serializer prototypes in November 1999, production problems (yield), new run in November 2000 (0,25 m backup solution),
  - Control Chip (DMILL) : ready for production
  - Hamamatsu APDs, fine tuning

- **Endcaps :** can begin FPPA preproduction March 2001, contract : 500 Russian VPTs in April 2000.

- **Preshower :** electronics end 2001 for micro-modules assembly mid-2002. Delta received october 2000, Pace ready, DMILL engineering run with LHCb.