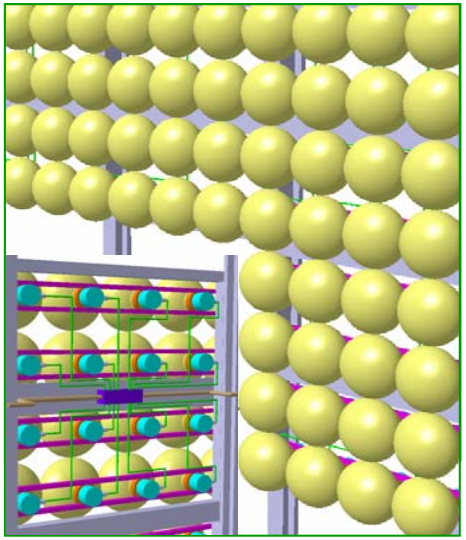


PMm² proposal: Front end electronics

Pierre BARRILLON, Jean-Eric CAMPAGNE, Christophe de LA TAILLE, Nathalie SEGUIN-MOREAU
(LAL ORSAY)

Joel POUTHAS, Bernard GENOLINI
(IPNO IN2P3)

UNIVERSITÉ PARIS-SUD 11

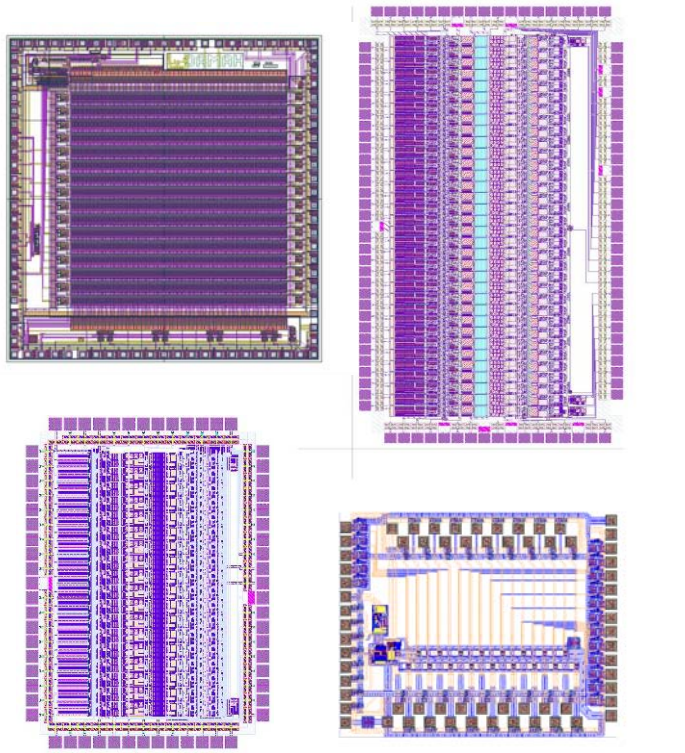
CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

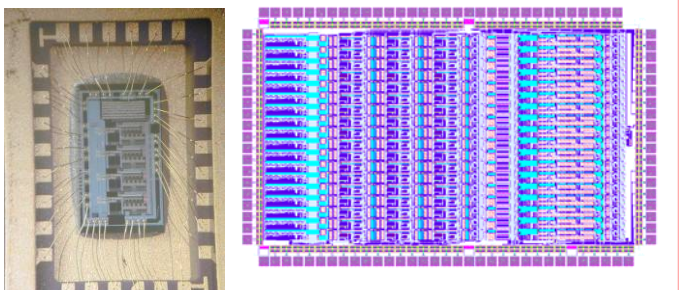
IN2P3 INSTITUT NATIONAL DE PHYSIQUE NUCLÉAIRE ET DE PHYSIQUE DES PARTICULES

LAL LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Orsay Micro-Electronics Group

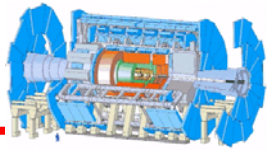
- **A strong team of 9 ASIC designers…**
  - = 20% of in2p3 designers
  - = 60% of department research engineers
  - A team with critical mass
  - Expertise in low noise, low power high level of integration ASICs
  - 2 designers/ project
  - 2 projects/designer
  - Regular design meetings
- **…Within an electronics department of 55**
  - Support for tests, mesaurements, PCBs…
- **A strong on-going R&D**
  - Building blocks SiGe 0.35µm
- **A steady production**
  - 1-2 large productions/year



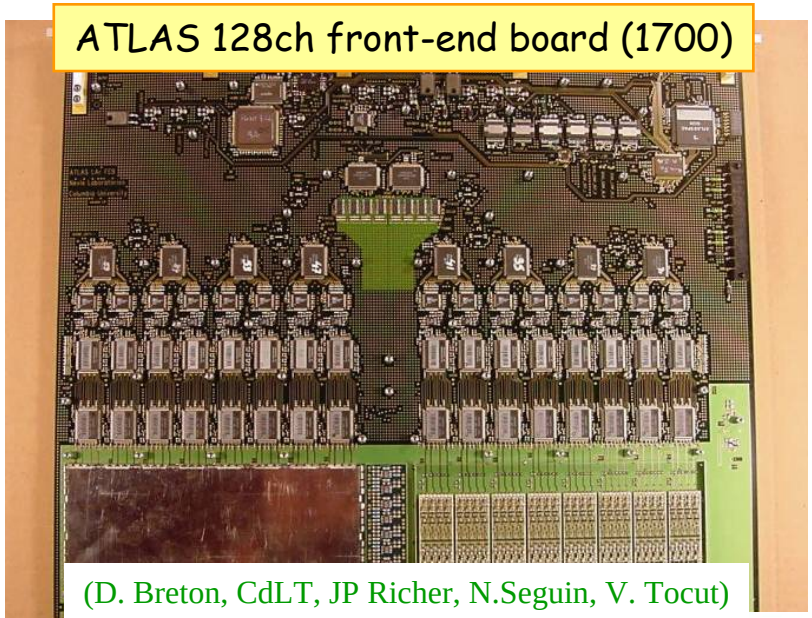


(S. Blin, M. Bouchel, R. Chiche, J. Fleury, CdLT, G. Martin, L. Raux, N.Seguin, V. Tocut)

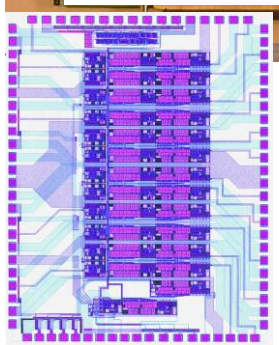
ASIC production for ATLAS LAr calorimeter

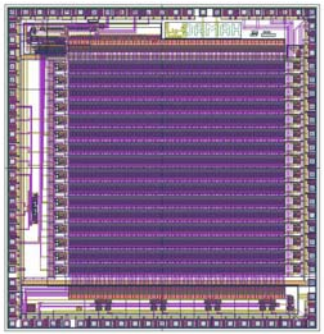


ATLAS 128ch front-end board (1700)



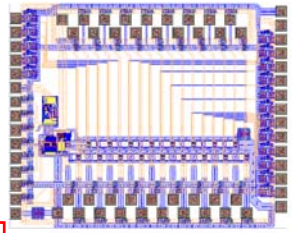
(D. Breton, CdLT, JP Richer, N.Seguin, V. Tocut)





ATLAS 128ch calibration board (135)

(CdLT, N.Seguin, JP Richer)



SHAPER_V3 (1999)
4 ch. tri-gain (1,10,100)
fast-shaper (30ns)
BiCMOS 1.2µm
70 000 chips

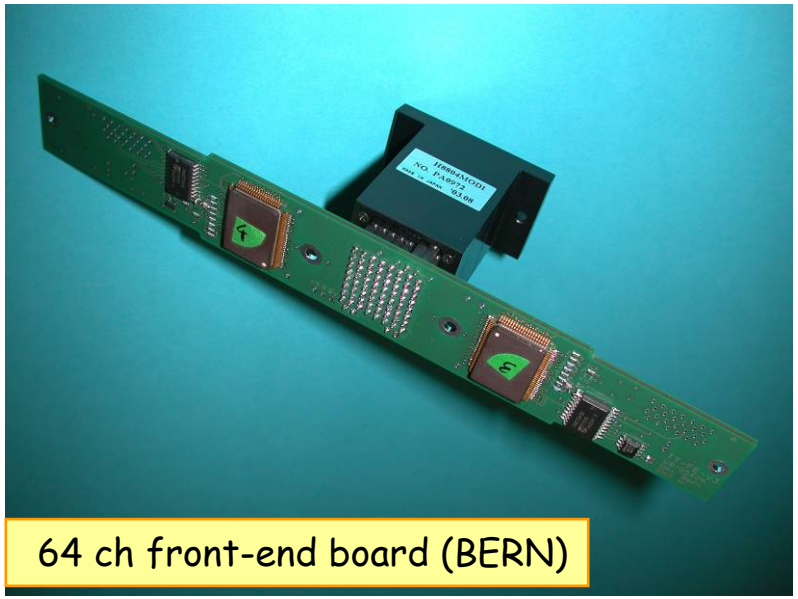
HAMAC (2000)
16 ch 12 bits analog memory
Ecriture/lecture : 40/5Mhz
DMILL 0.8µ
84 000 chips

LOANA (2002)
Low offset opamp (<10 µV) +
switch HF (50µV →5V à 1‰)
DMILL 0.8µ
40 000 chips

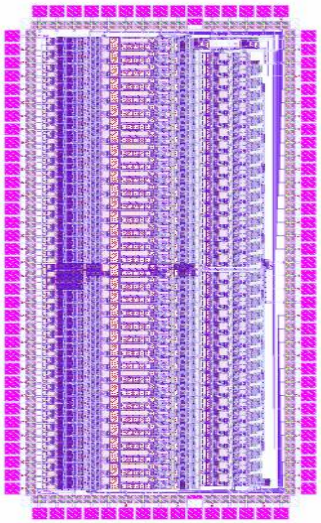
DAC (2003)
R/2R 16 bits
DMILL 0.8µ
8 000 chips

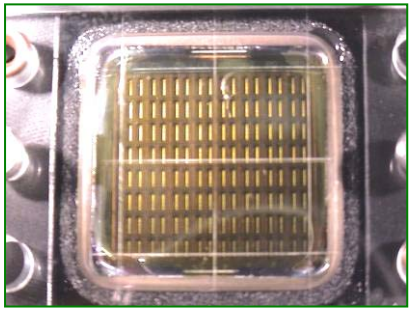
ASIC production for OPERA target tracker

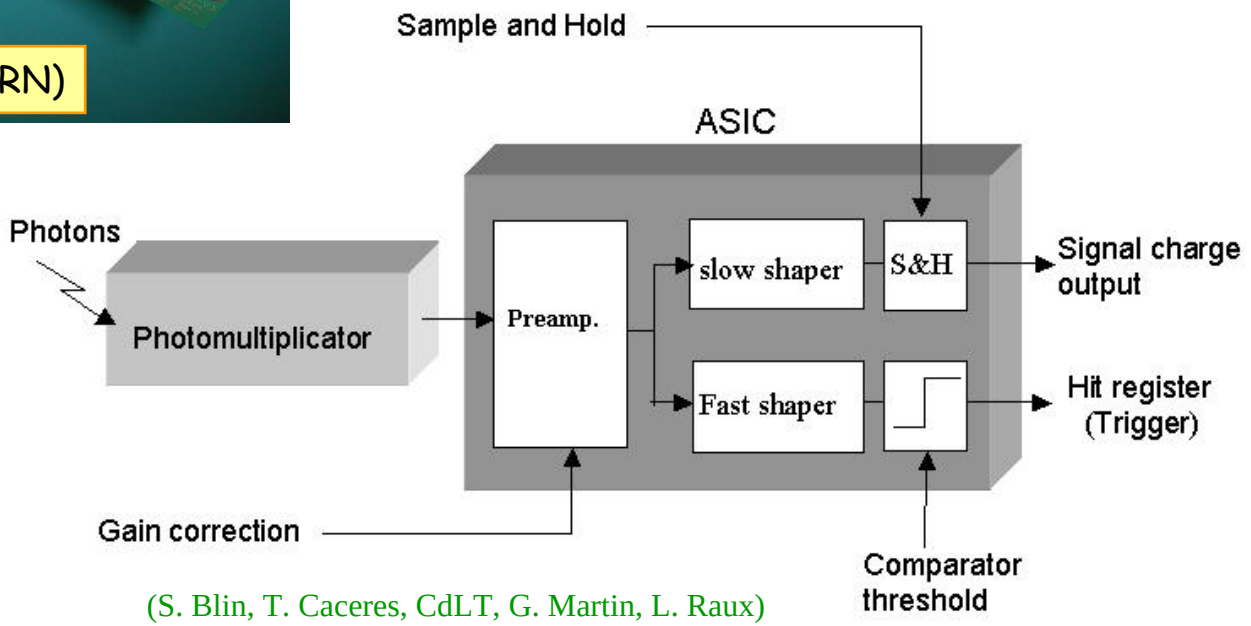
- **Readout ASIC for multi-anode Photomultiplier (Hamamatsu)**



OPERA_ROC (2002)
32 channels
Variable gain preamp
Autotrigger on ¼ p.e.
BiCMOS 0.8µ
3 000 chips



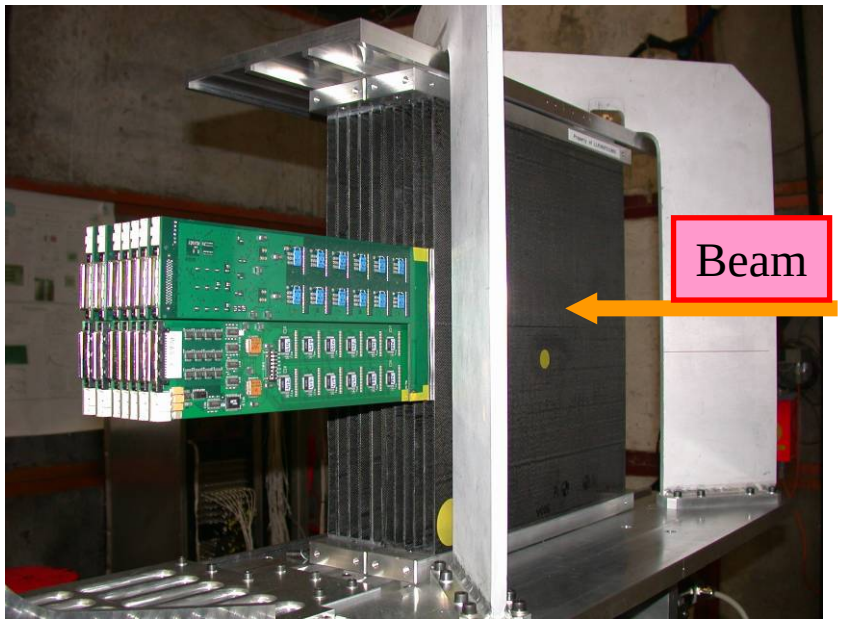




(S. Blin, T. Caceres, CdLT, G. Martin, L. Raux)

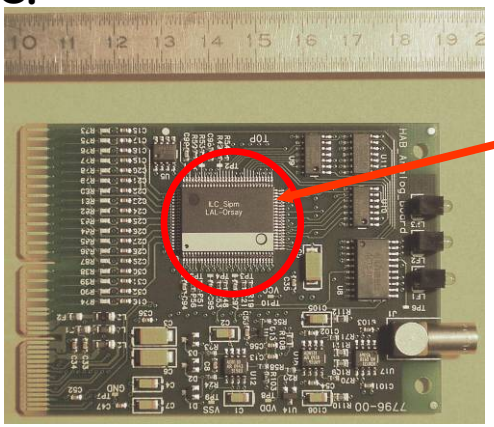
ASIC production for CALICE calorimeters

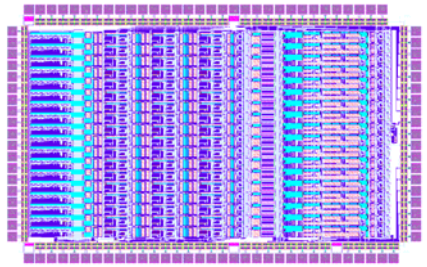
- **Readout of W-SI ILC calorimeter**



(J. Fleury, CdLT, T. Caceres, G. Martin)

Analog-HCAL 18ch amplifier board (DESY)

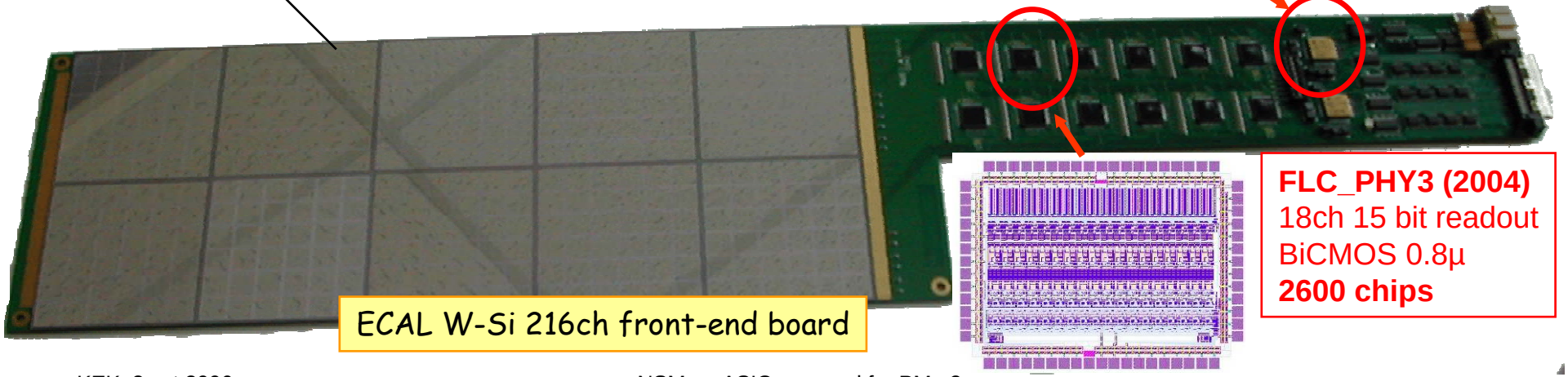




FLC_SiPM (2005)
18ch 8bit DAC + readout
CMOS 0.8µ –**1000 chips**

(S. Blin, T. Caceres, G. Martin, L. Raux)

FLC_CALIB (2004)
Calibration switch HF
BiCMOS 0.8µ - 120 chips



ECAL W-Si 216ch front-end board

FLC_PHY3 (2004)
18ch 15 bit readout
BiCMOS 0.8µ
2600 chips

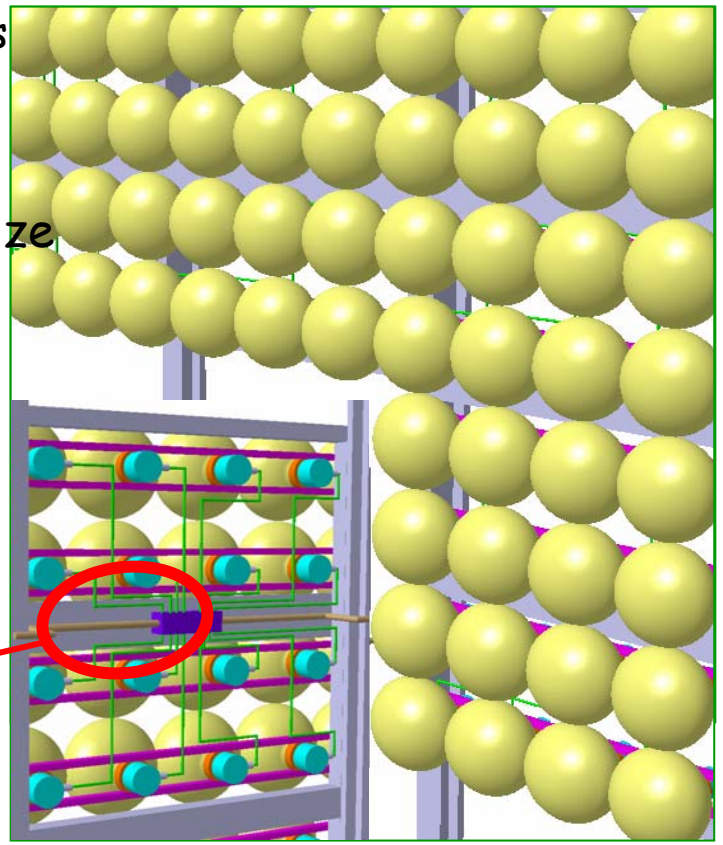
R&D PROGRAM FOR MENPHYS

- **"PMm2" (2006 – 2009), funded by the ANR (National Agency for Research)**
  LAL Orsay, IPN Orsay, LAPP Annecy and Photonis

Joël Pouthas IPN Orsay

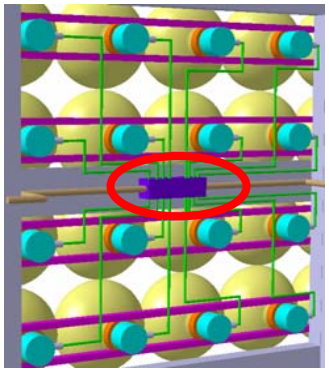
- **Megaton water tanks**
  - Large number of very large PMTs: 20" size

- **Proposal (Menphys)**
  - Replace large PMTs (20") by groups of smaller ones (12")



Integrated electronics (Multichannel, close to the PMTs)

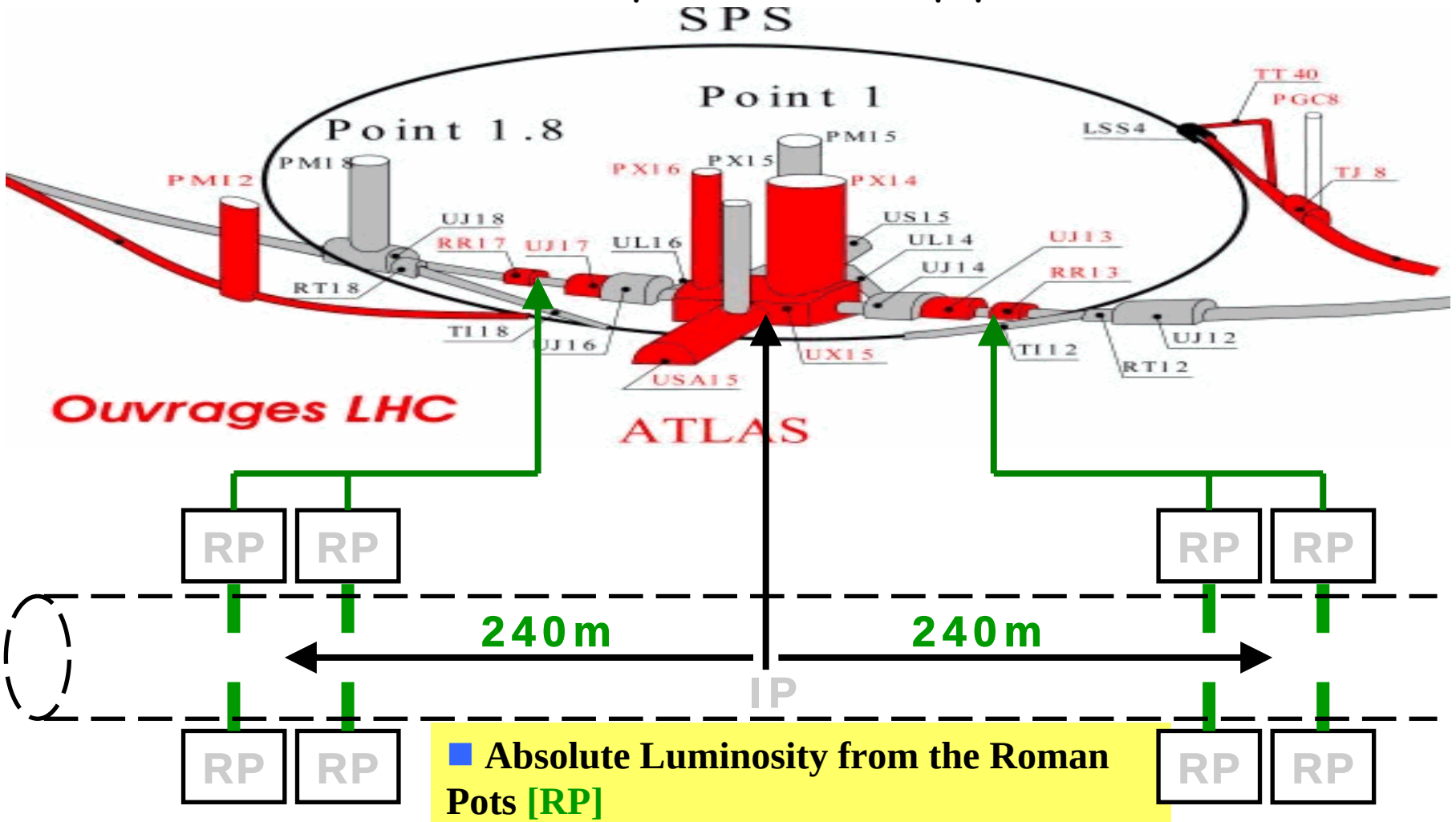
MENPHYS ELECTRONICS REQUIREMENTS



- Need of a multichannel ASIC close to the detector
- To reduce the cost, we need to operate with a common high voltage and thus need of variable gain to equalize PM response.
- High speed discriminator to autotrigger on single photoelectron
- Digitization of charge (over 12 bits ?)
- Digitization of time of arrival to provide nano-second accuracy
- Data out: wireless or power wires?

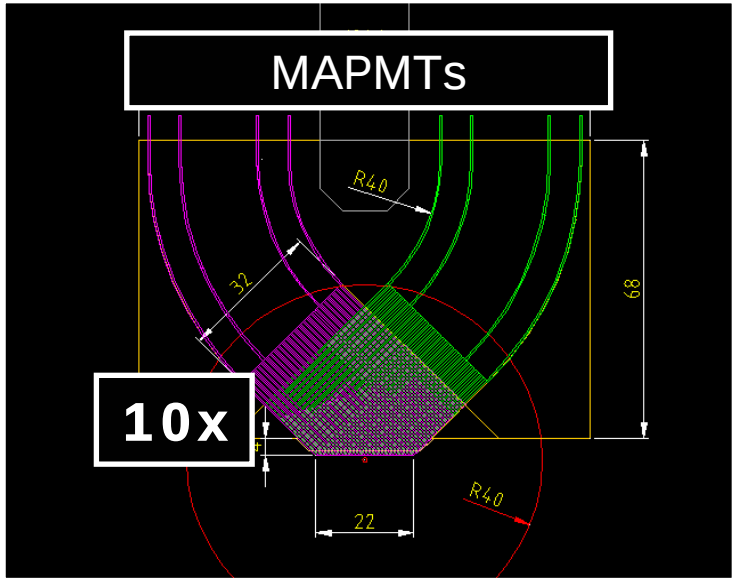
ELECTRONICS FOR MENPHYS

- Chip MAROC (Multi Anode ReadOut Chip) designed for the readout of the 64 channel PM of the ATLAS luminometer Roman Pots
- MAROC fullfills most of the requirements of Menphys FE electronics



- **Absolute Luminosity from the Roman Pots [RP]**
- **LUCID Calibration**

Scintillating Fiber Tracker



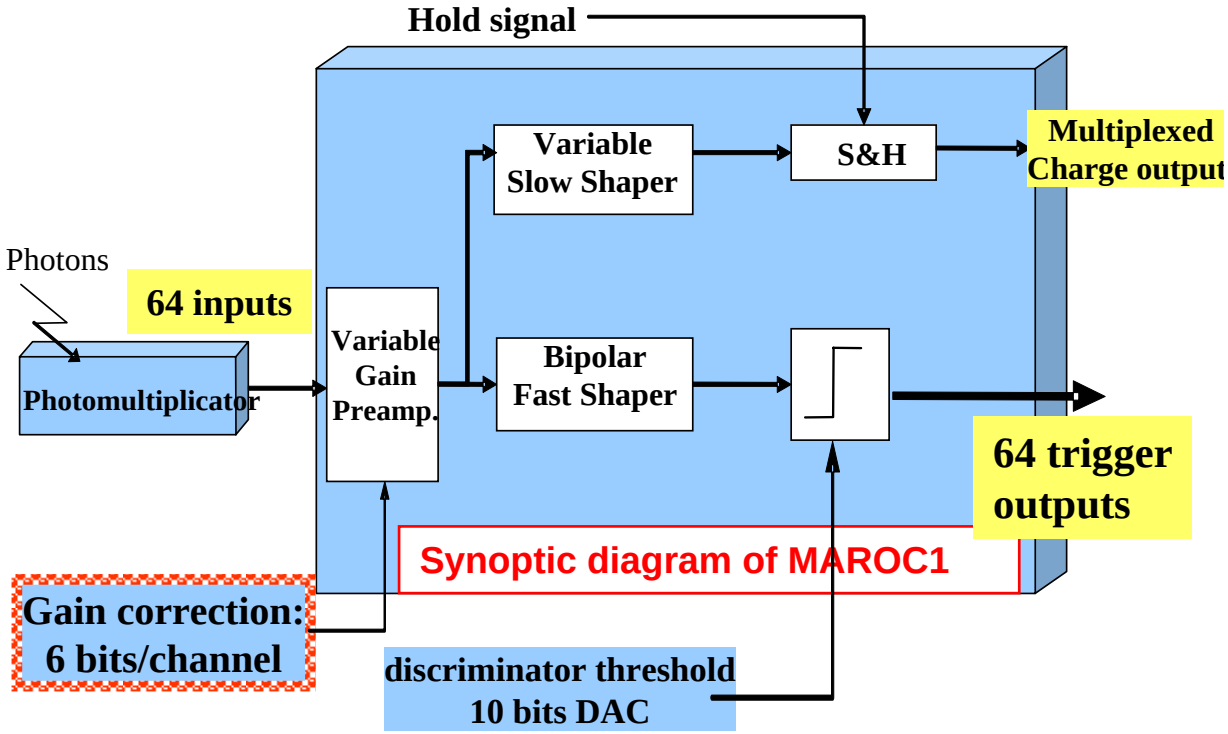
@S. Ask

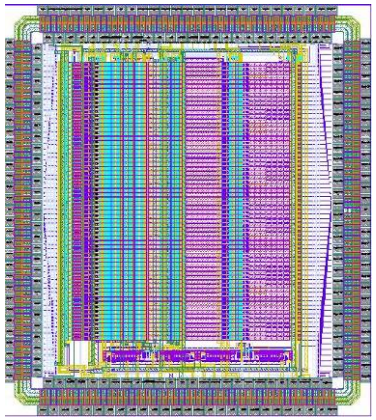
Current Design

- 2x64 0.5 mm^2 fibers / plane
- 45 deg UV configuration
- 10 staggered planes / detector with a 50 μm layer offset
- => 1 RP = 10 * 64 fibers (U) + 10 *64 fibers (V)

MAROC : 64 ch MAPMT chip for ATLAS lumi

- Similar to OPERA ROC
- Low input impedance (50-100 Ω)
- 6 bits gain adjustment (G=0-4) per channel
- 64 discriminator outputs
- 100% sensitivity to 1/3 photoelectron (50fC). Counting rate up to 2 MHz
- Common threshold loaded by internal 10bit DAC (step 3mV)
- 1 multiplexed charge output with variable shaping 20-200ns and Track & Hold.
- Dynamic range : 11 bits (2fC - 5 pC)
- Crosstalk < 1%





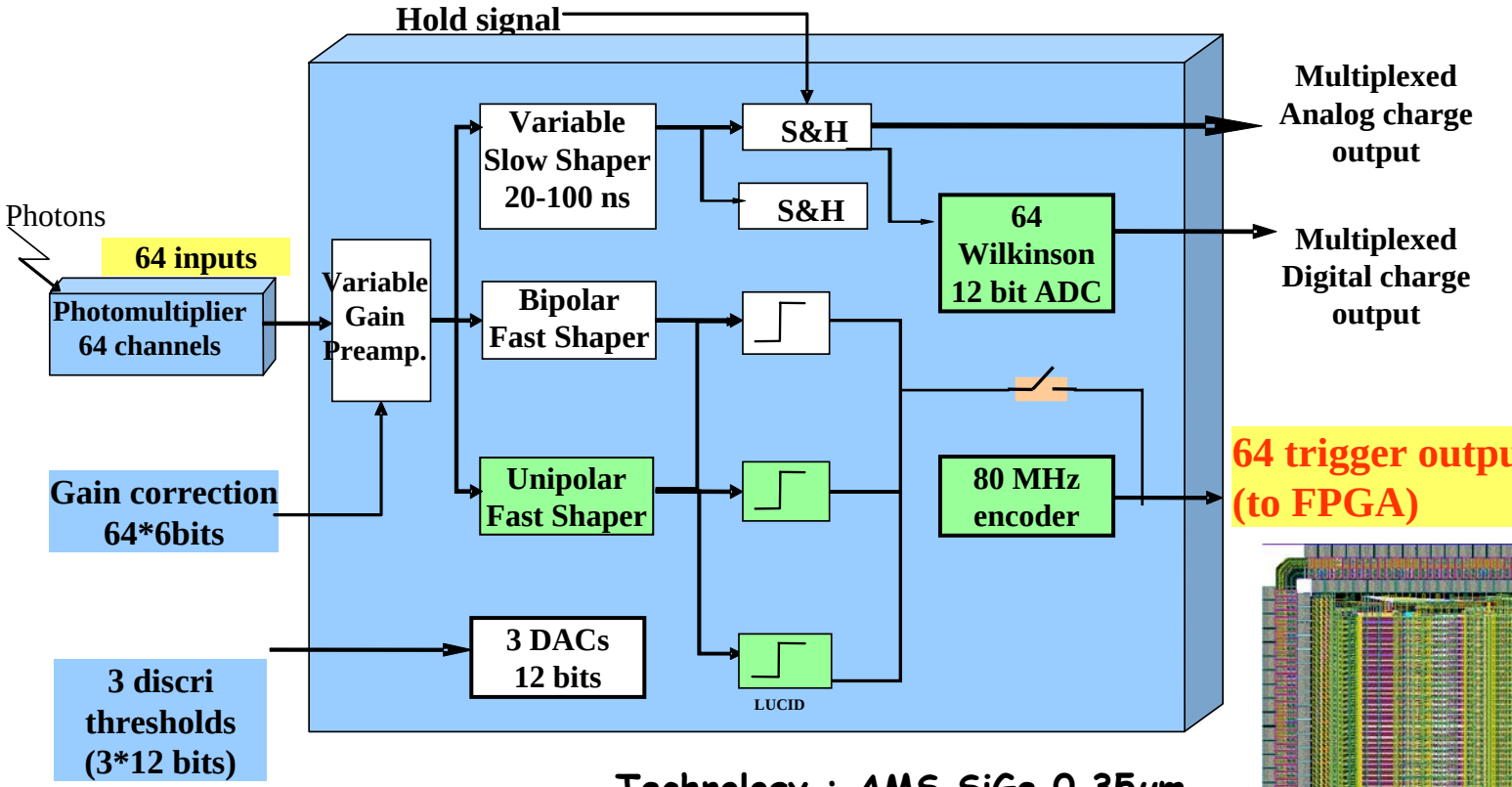
MAROC1

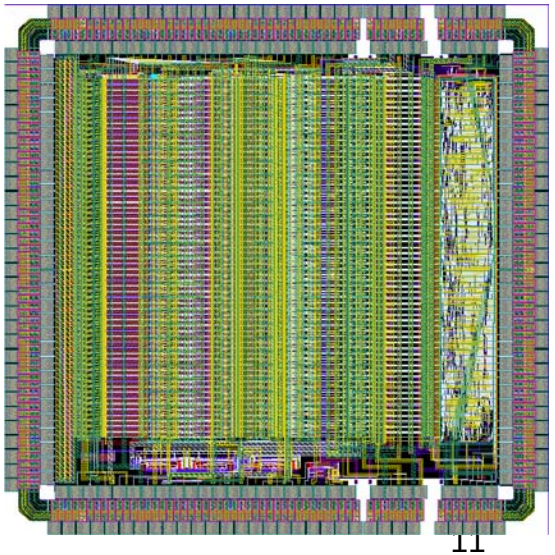
Technology : AMS SiGe 0.35µm

- Submitted 13 june 05
- Area 12 mm²
- Received in november 05
- Dissipation 130 mW @VDD=3.5V

MAROC2 architecture

- **MAROC2 = MAROC1 + additionnal features (WILKINSON ADC, 3 discriminators, Encoder)**





Technology : AMS SiGe 0.35µm

- Submitted March 06
- Area 16 mm2
- Received in june 06
- 240 pins

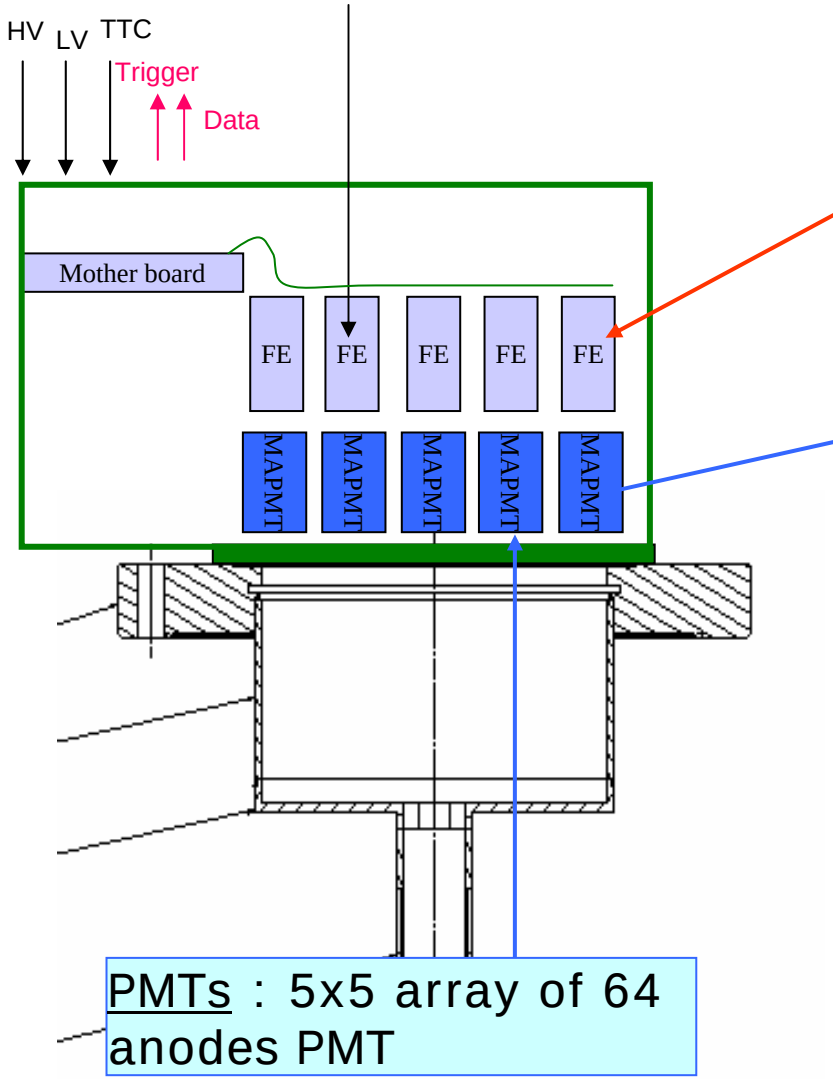
MAROC

- MAROC1 and 2 have been extensively measured

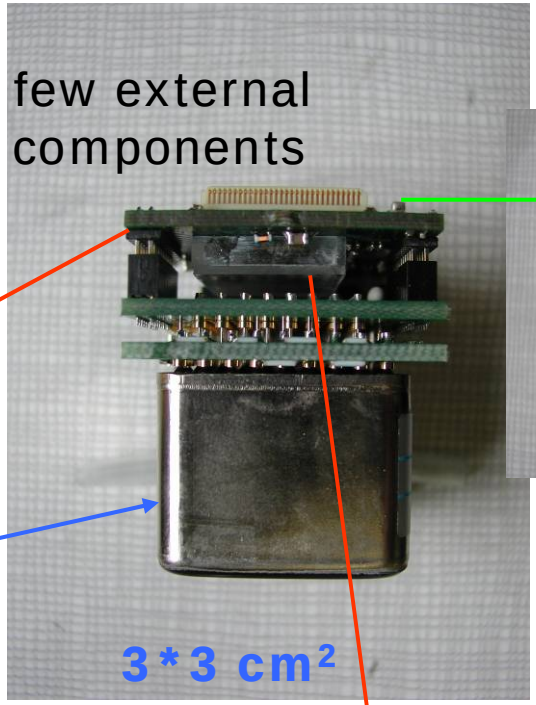
- MAROC1 will be used in october 06 at CERN for beam tests of ATLAS luminometer prototype(s) (CERN+Lund+Orsay+… collaboration)

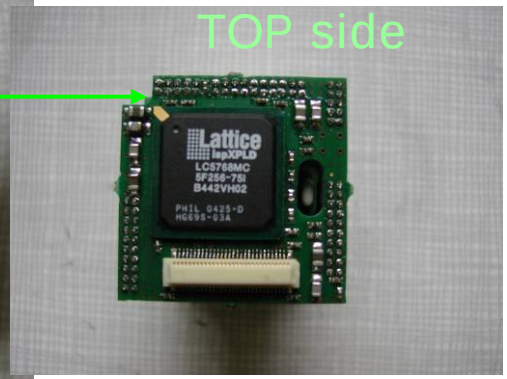
MAROC testbeam setup

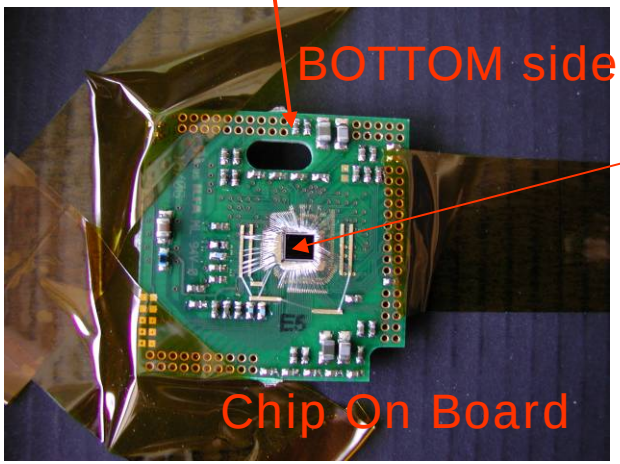
PMT Frontend : one chip per PMT (64 channels)



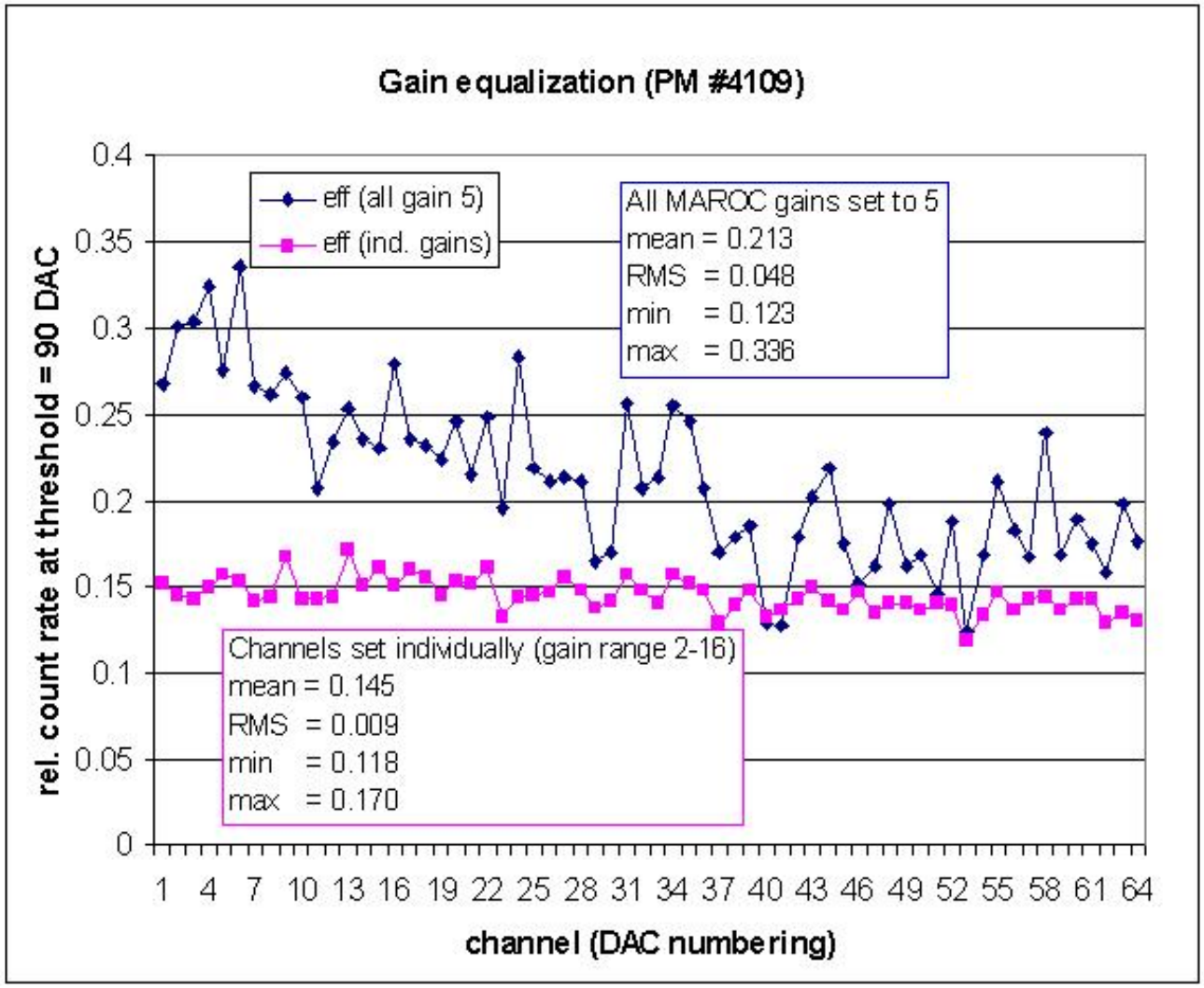
PMTs : 5x5 array of 64 anodes PMT

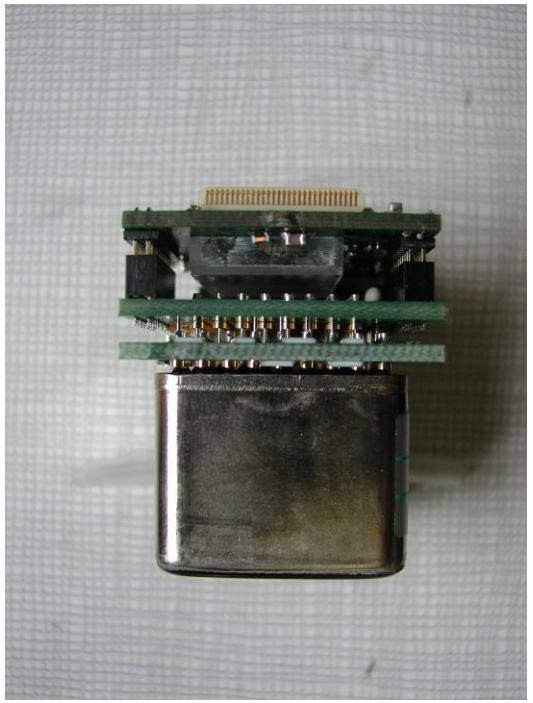




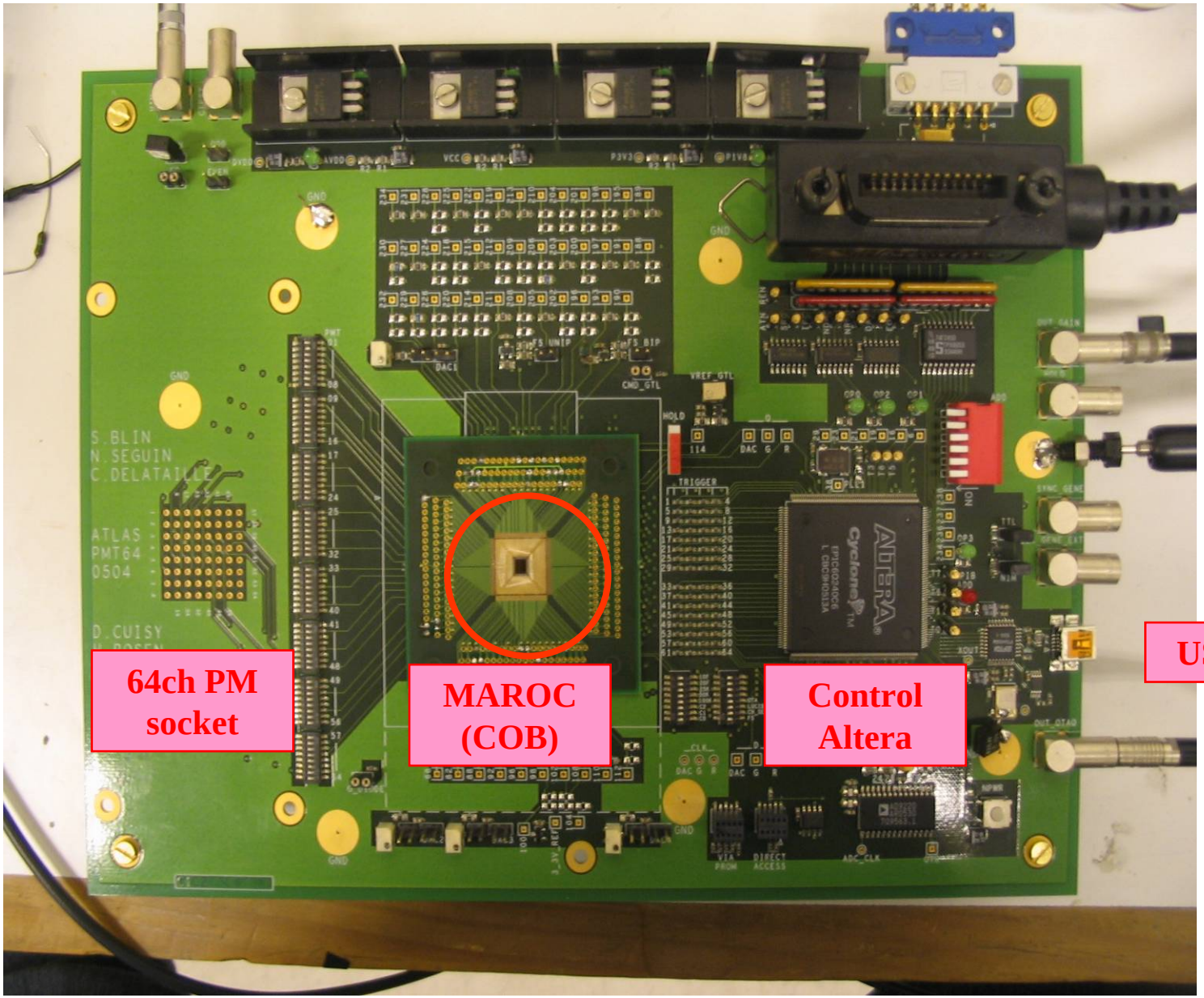


MAROC1: Gain equalization

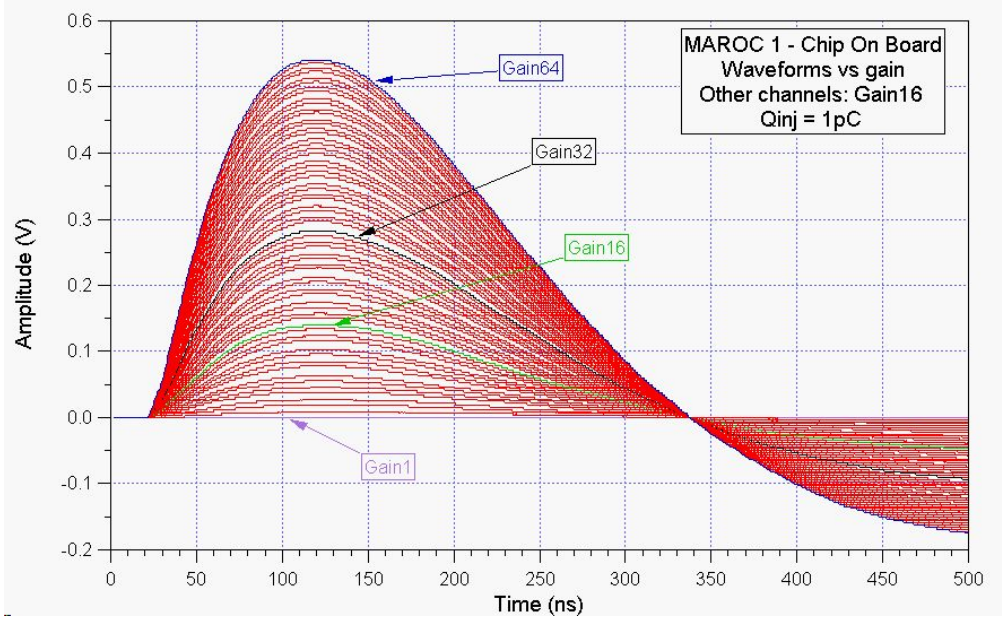


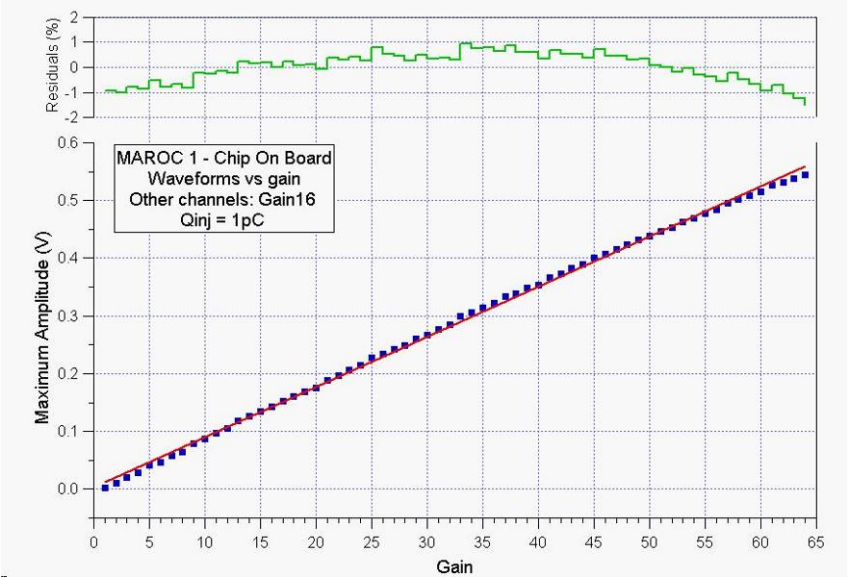


TEST BOARD



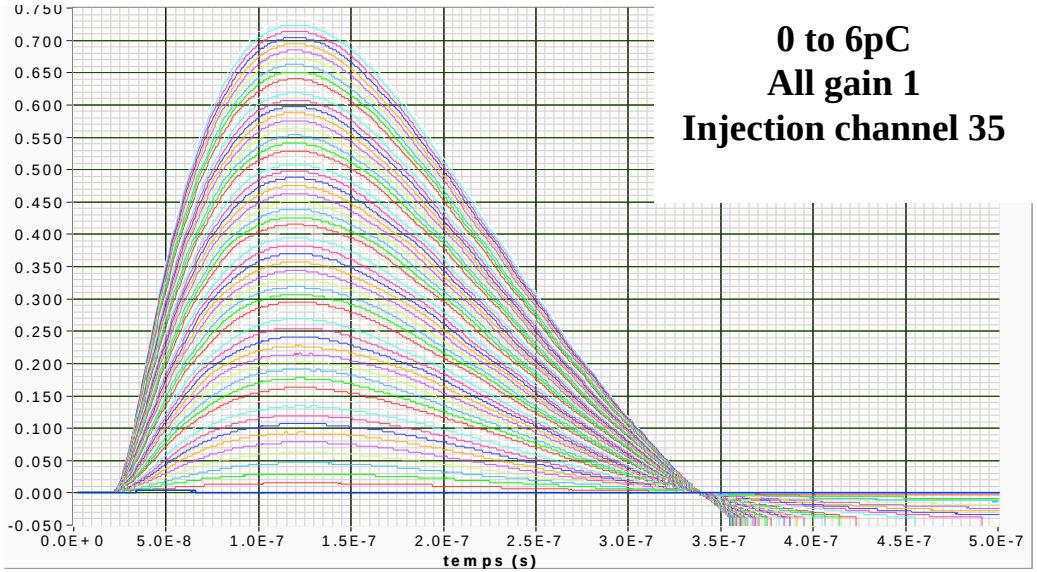
MAROC1: SLOW SHAPER Wfms vs gain (measurements)





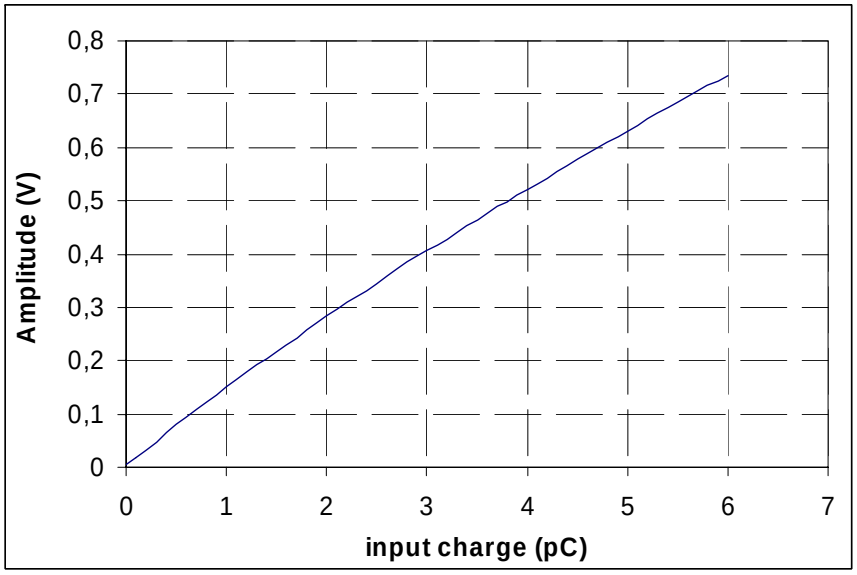
- **Wfms with Qin=1pC for different preamp gains**
- **Preamp gain G=1:**
  - 150 mV/pC
  - 24 mV/pe @ 10^6
  - Noise = 500 uV
  - Max output : 1 V
- **Pedestal dispersion**
  - Rms 3 mV (~1/10 pe)
  - Pk to pk +/-5 mV

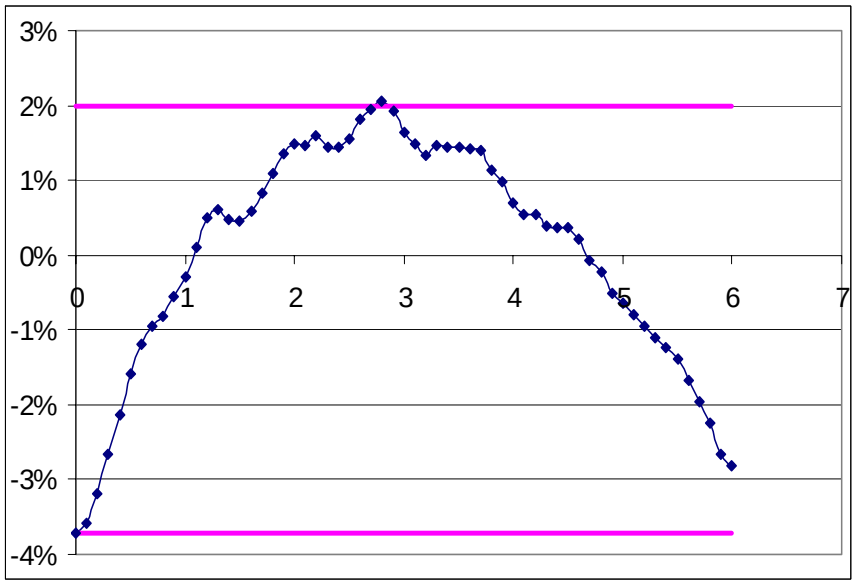
MAROC1: SLOW SHAPER Waveforms vs input charge



0 to 6pC
All gain 1
Injection channel 35

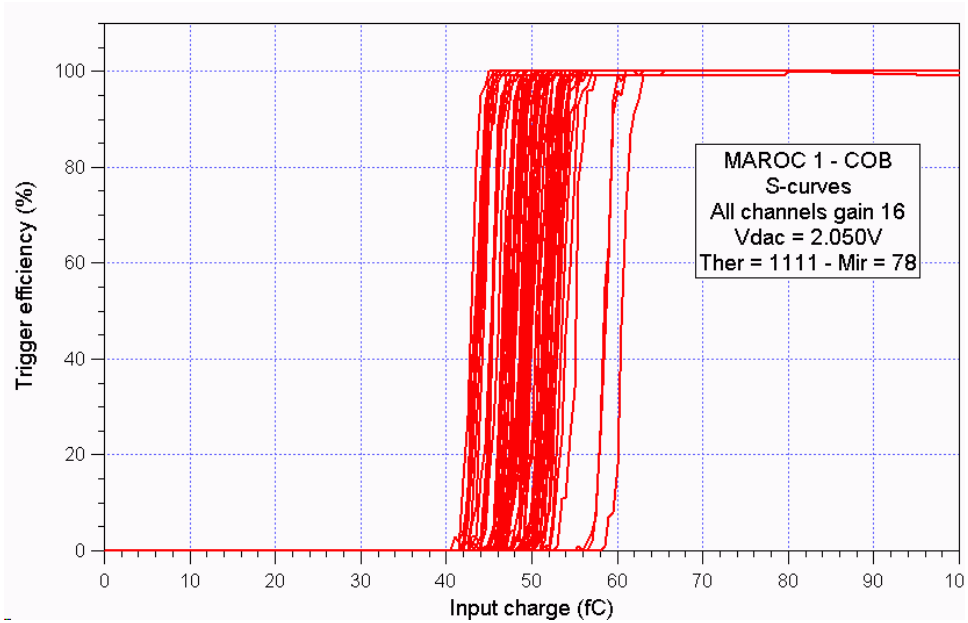
- Wfms with all gain = 1 for various charge inputs
- Linearity within +/- 3% (to be further studied)
- Full scale ~1 V
- Noise 500 μV

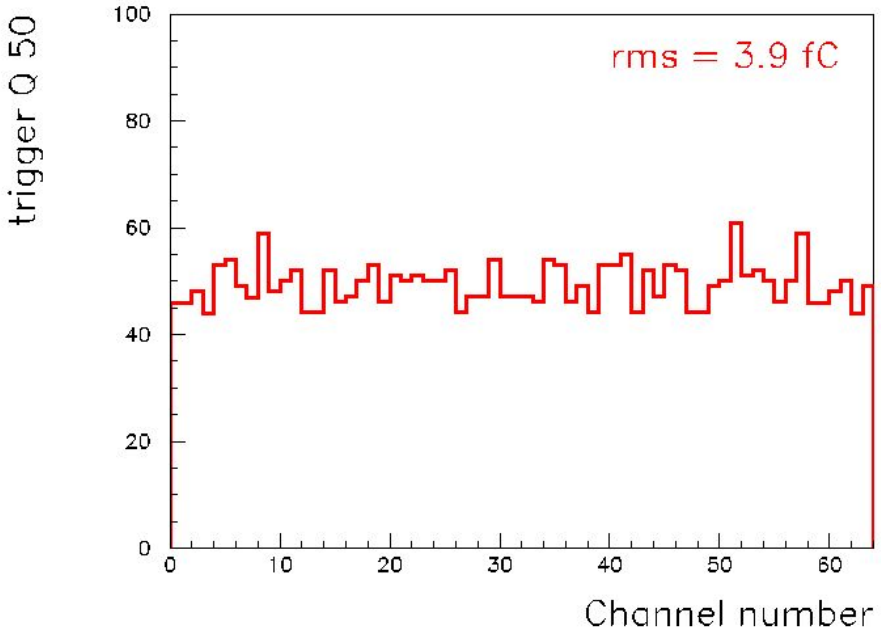




Efficiency curves MAROC1

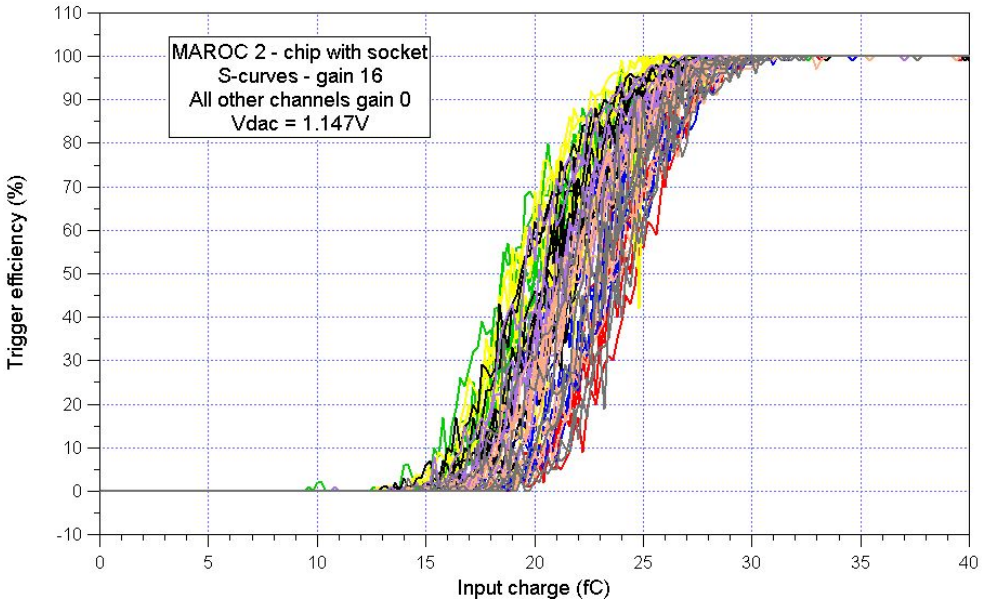
- **Threshold : 50 fC = 1/3 photoelectron**
  - Dispersion : 4 fC rms ~ 0.03 pe
  - Noise : ~ 1 fC

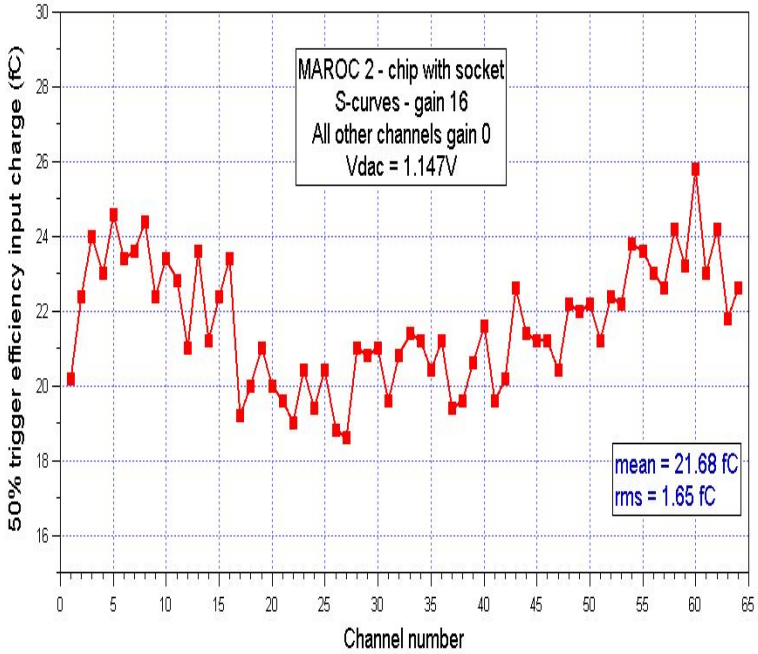




Efficiency curves: MAROC2

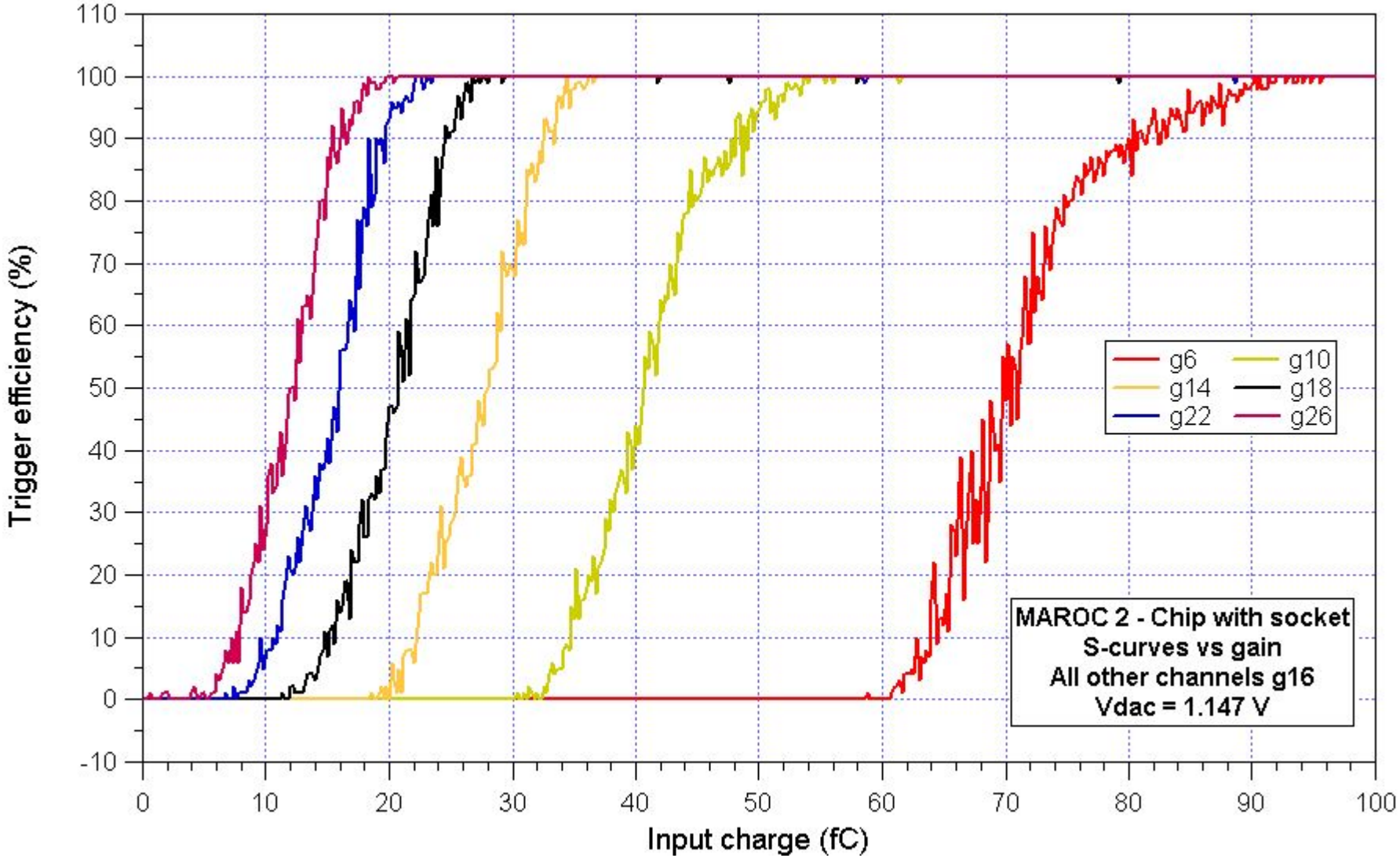
- **Threshold : 22 fC**
  - Dispersion : +/- 1.6 fC
  - Noise : ~ 2 fC





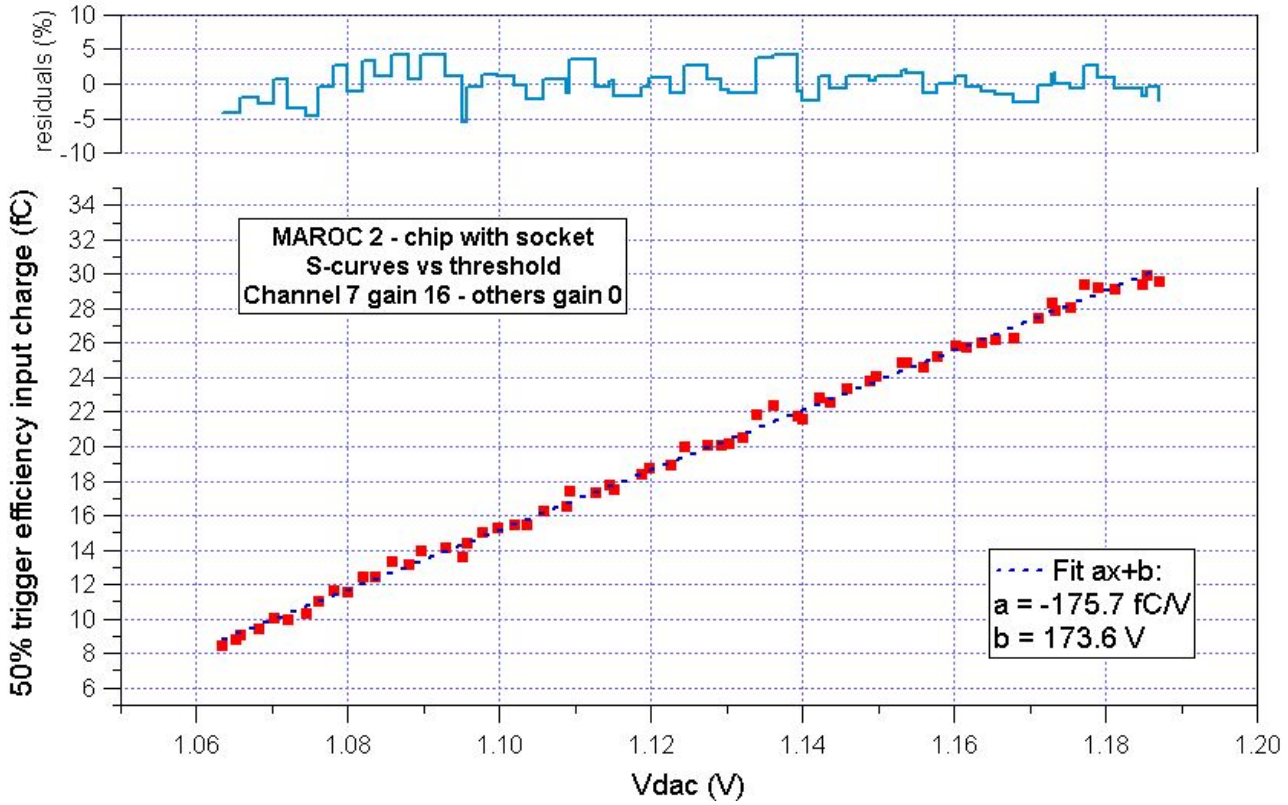
Trigger efficiency vs gain

- 50% trigger efficiency scales linearly with gain preamp



Trigger efficiency vs Threshold: MAROC2

- Good linearity
- Good operation with threshold down to 10 fC

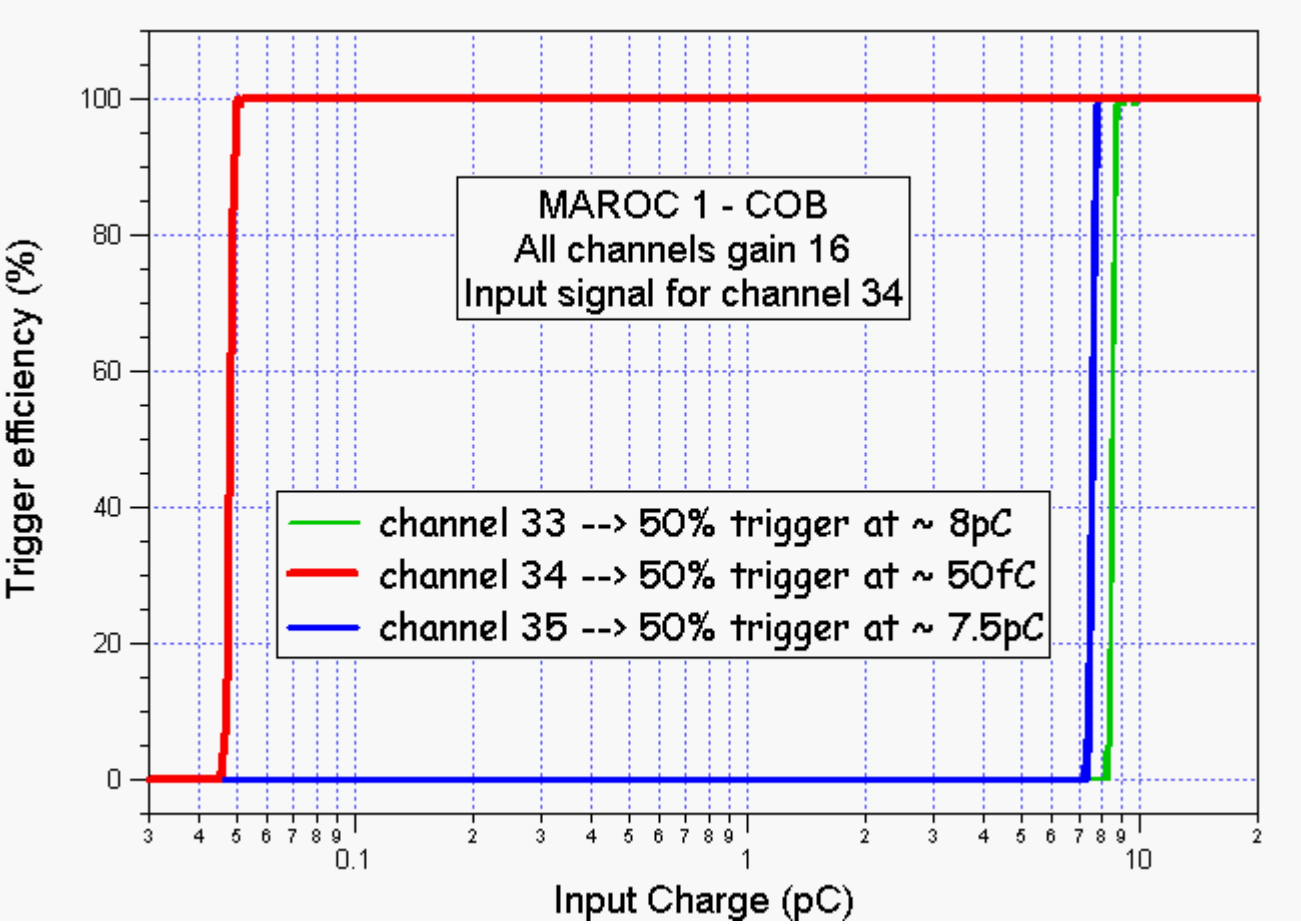


Crosstalk

- Injection in ch 34 (up to 10 pC): 50% trigger at 50 fC

- Direct neighbours: 50% trigger at 8pC

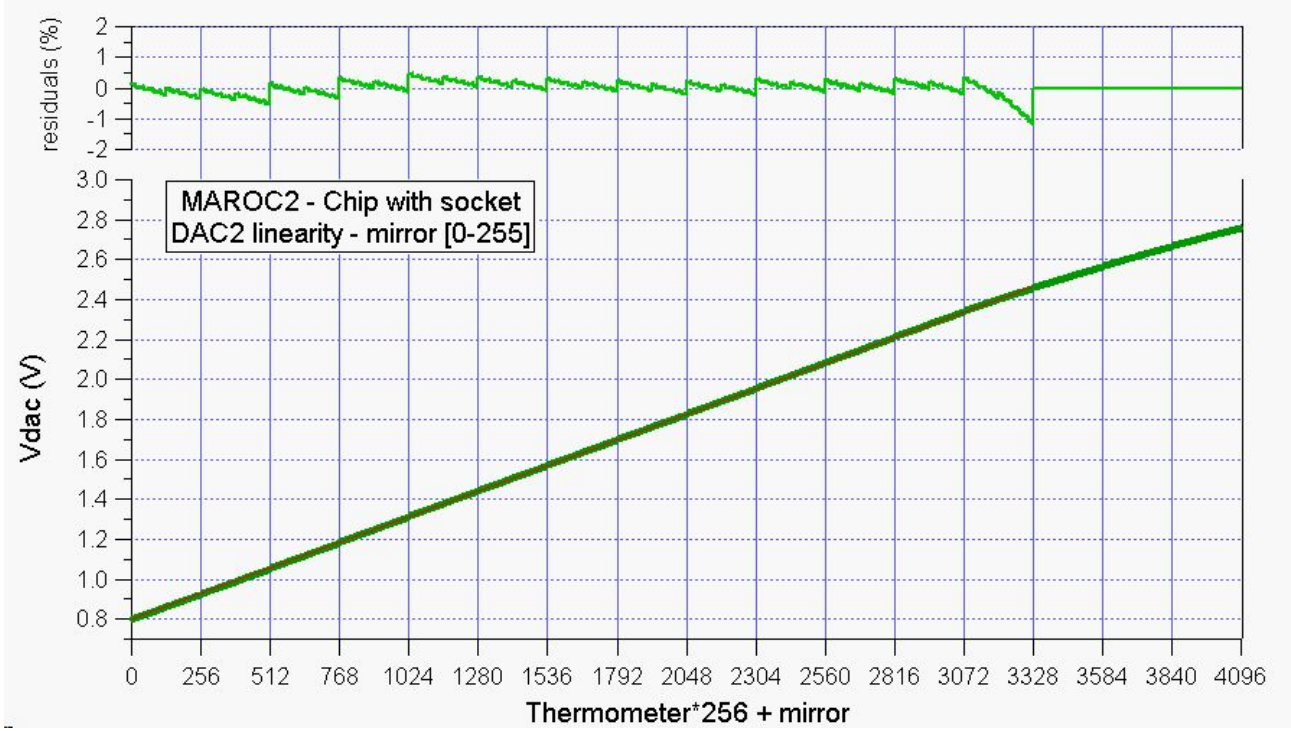
→ Cross talk < 1%



DAC MAROC2

- 10 bit DAC integrated to set the dicriminator thresholds

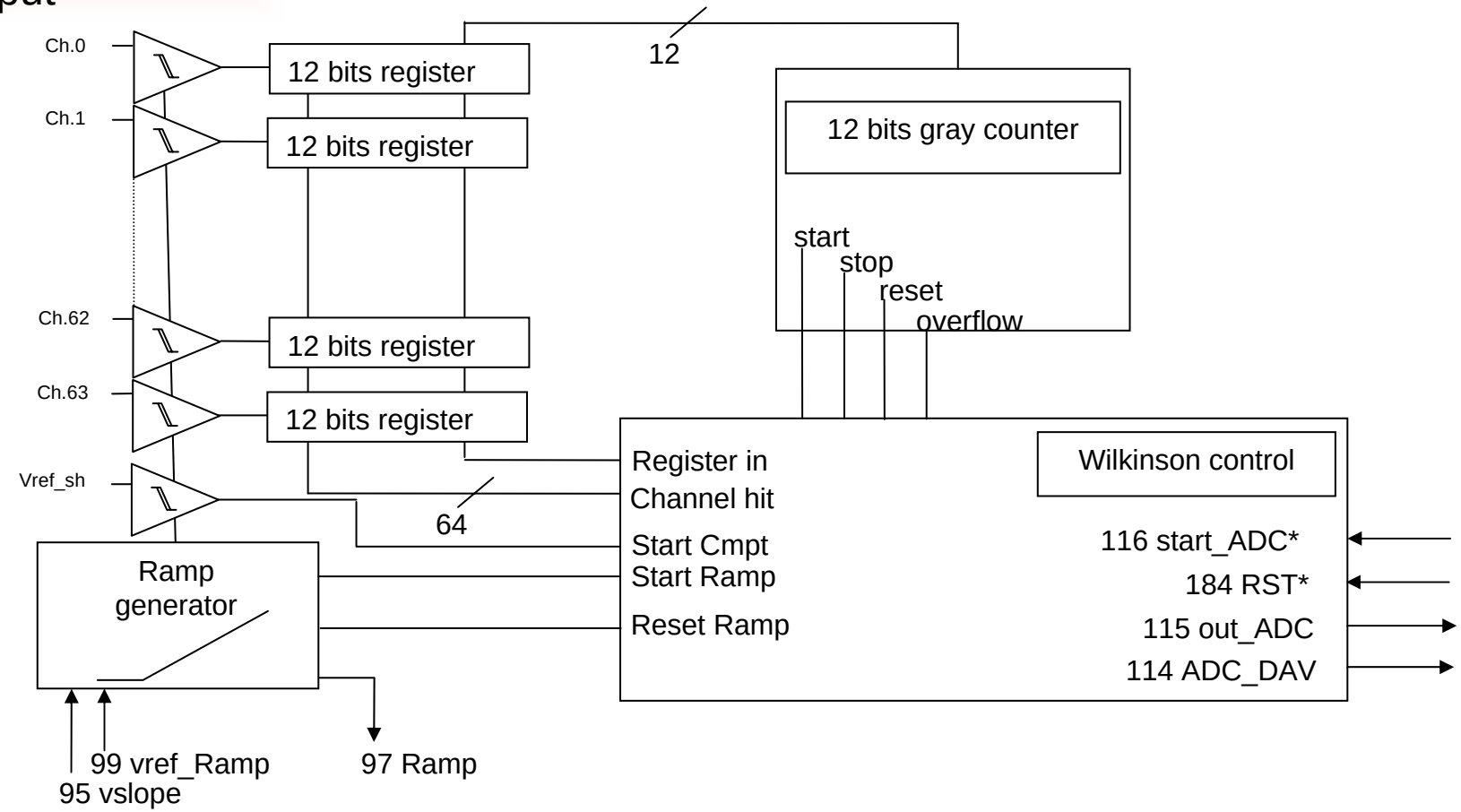
- DAC linearity
  - Step: 2mV (0.5 fC)



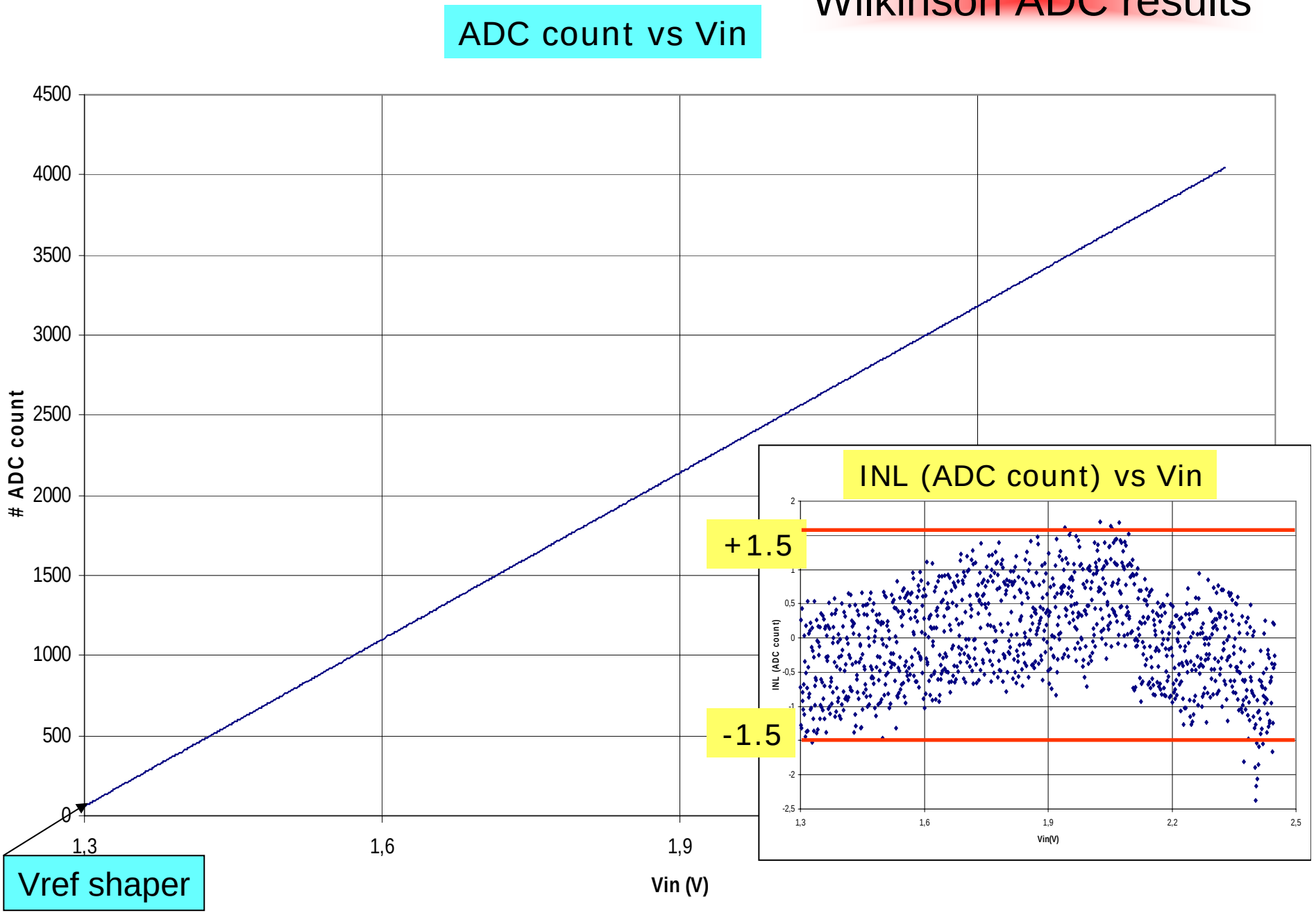
Wilkinson ADC description

Description :
- 12 bits
- 64 channels
- conversion time < 80µs
- clock 40 MHz
-Serial output

ADC= Integrated in MAROC2
and tested (stand alone version)

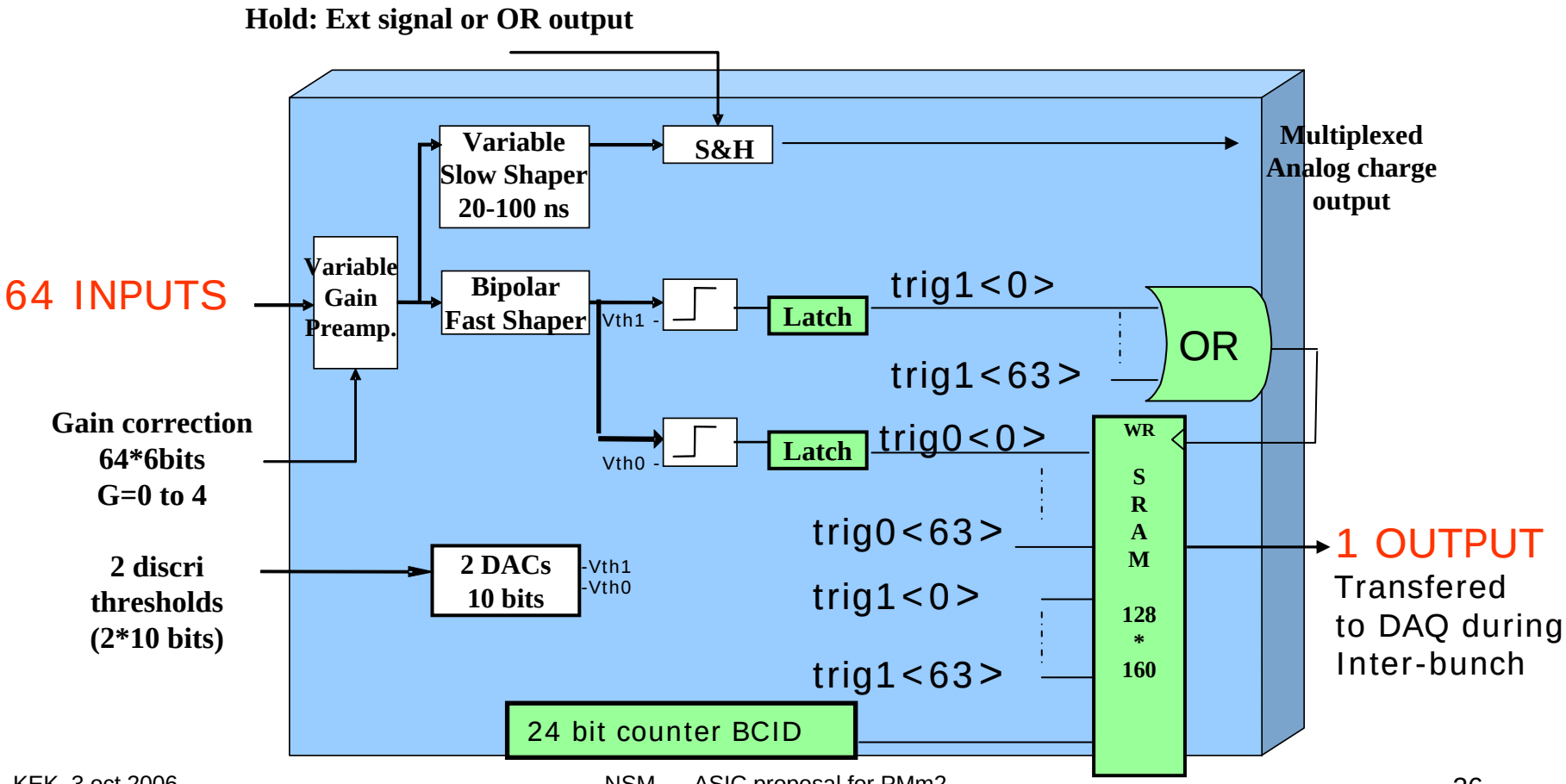


Wilkinson ADC results



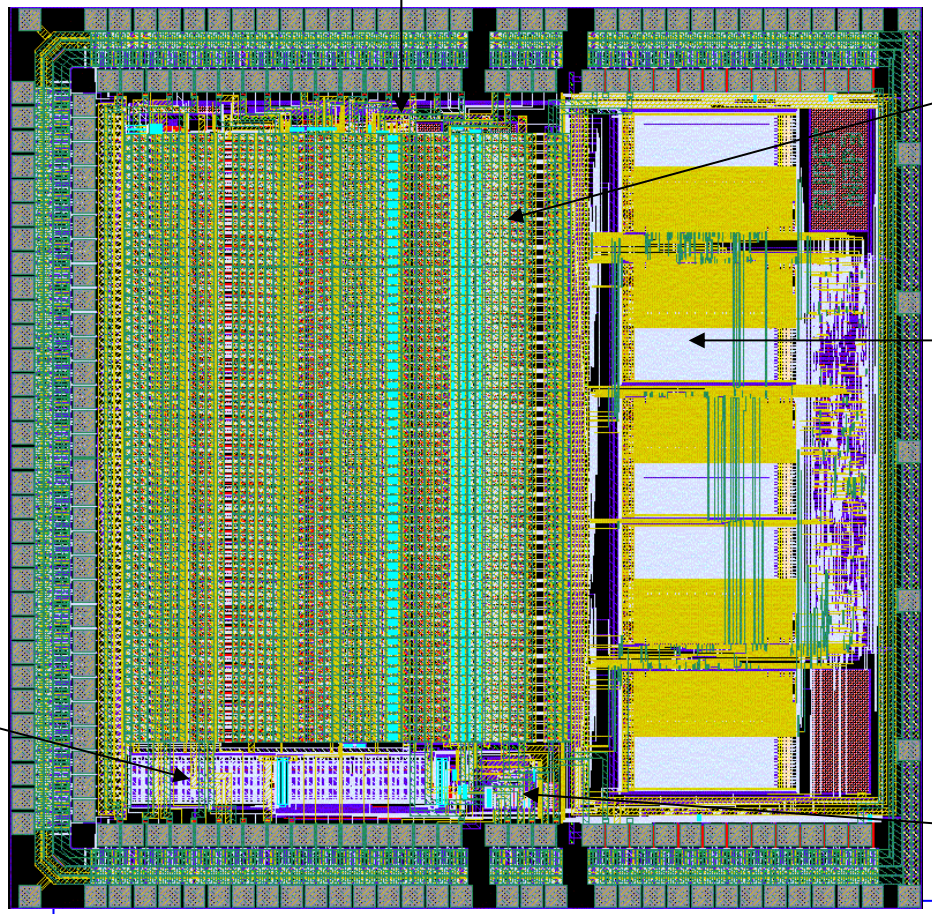
HaRDROC architecture (for CALICE DHCAL)

- Full power pulsing
- Digital memory: Data saved during bunch train. Only one serial output
- Store all channels and BCID for every hit. Depth = 128 bits
- Data format : 128(depth)*[2bit*64ch+24bit(bcid)+8bit(Header] = 20kbits
- Sequential readout @ 1 MHz

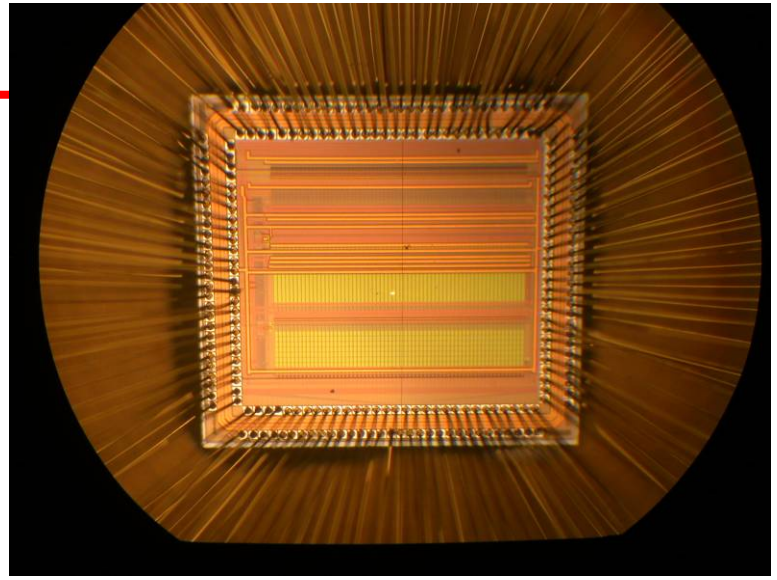


HaRDROC layout

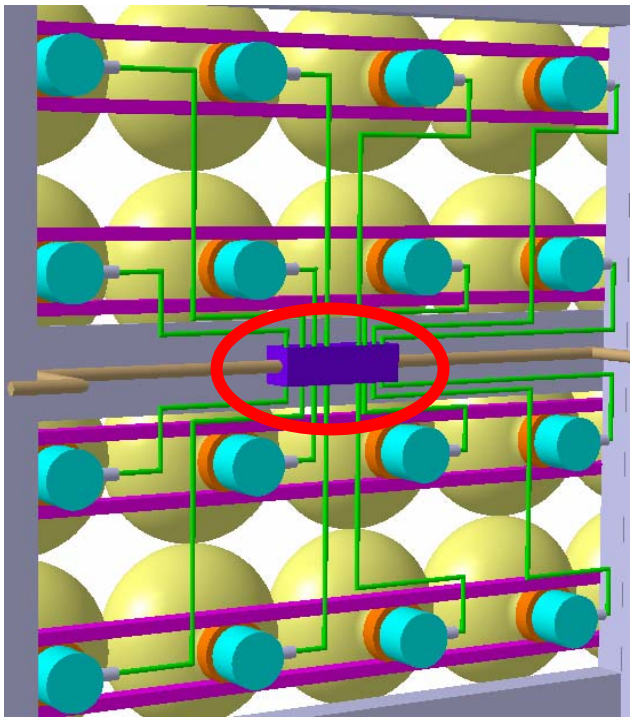
- 64 inputs, 1 data output
- Vss of the analog, mix and digital part separated
- 180 pads



CONCLUSION



- **MAROC2 fullfills most of the requirements of Menphys**
- **To be done:**
  - Time dizitization (TDC)
  - Data out: wireless to be done by Annecy
- **Open questions:**
  - Possible use of local coincidence to reduce the data rate
    - Depends on the energy threshold related to the dark noise of the PM
  - Dynamic range
  - Dizitization of all signals
- **Test on a prototype (16 PMs, 8") with MAROC2 forseen this fall**



ANNEXE

Cost approach

Photonis at NNN05

C. Marmonier, NNN05, France, April 2005
LIGHT06, Israel, January 2006

Size (Diameter)	20	20(17)	12	Inch
Photocathode area	1660	1450	615	cm^2
Quantum efficiency	20	20	24	%
Collection efficiency	60	60	70	%
Cost	2500	2500	800	€
	12.6	14.4	7.7	€ /PE_U/cm^2

Cost/cm^2 per useful photoelectron

Cost / (cm^2 x QE x CE)

12" is better in SER and timing

12" provides a higher granularity

But, the number of channels is increased