UNIVERSITAT DE BARCELONA

Institut de Ciències del Cosmos

Technical Capabilities: University of Barcelona

David Gascon on behalf of ICCUB

Universitat de Barcelona

Gamma-400 workshop – 29-30 June 2015 – Barcelona

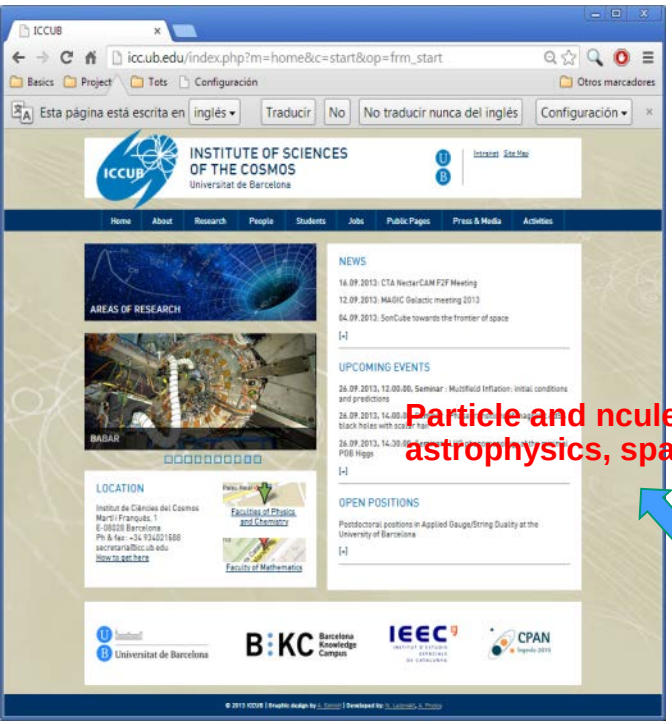
Introduction

- ICCUB has been involved in several projects and scientific collaborations since its foundation:
  - High energy physics: LHCb, Babar, Hera-B
  - Astroparticles: Magic, CTA
  - Space misions: Gaia, Solar Orbiter, Euclid, Corot
  - Ground instrumentation: LSST, SDSS
- J. M. Paredes will provide the ICCUB scientific perspective about Gamma-400
- The ICCUB has a long record of instrumentation development, based on a strong collaboration with Electronic department & others:
  - For particle physics experiments (LHCb, Babar, HERA-B): Calorimetry, Tracking
  - For astroparticle experiments: Cherenkov Telescope Array
  - Basic detector R&D (Aida, ILC, etc)
  - Medical imaging
- Since 2013 a new service unit (SiUB) joins the experience of ICCUB engineers with other institutes and groups @ UB

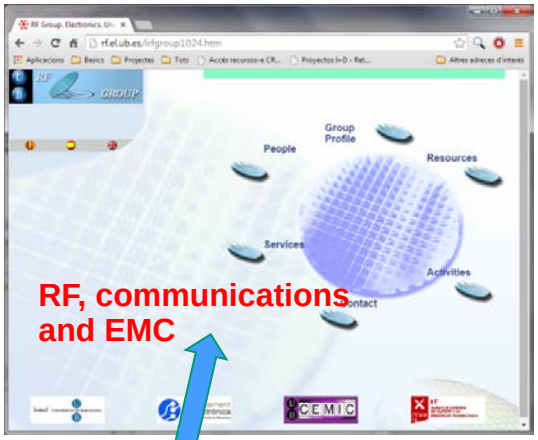
Introduction

Research

icc.ub.edu



rf.el.ub.es



Particle and nculear physics, astrophysics, space

RF, communications and EMC

Bioelectronics and harvesting (D2in)

Service

siub.ub.edu

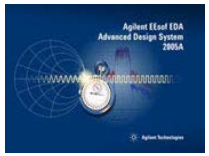
ASICs, FPGA, PCB, control systems, etc

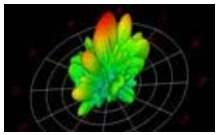
www.ibecbarcelona.eu

(µ)electronics design

- **Resources and experience on design**
  - Physical simulations
  - Microelectronics: ASIC and FPGA
  - Cards and systems
  - RF electronics: discrete and ASIC
- **Experience with many ADE design tools**
  - IC design: Cadence Design FrameWork II
  - Digital Design: Synopsys, Altera
  - PCB design: Altium, PCAD, Mentor
  - RF design: ADS
  - Physical simulators: Ansys and ADS momentum
  - Signal processing: Matlab, Octave
- **Access to many more tools via Europractice:**
  - www.europractice.stfc.ac.uk/software/software_packages.html
  - Tools are for non-commercial use
    - *However it is possible to negotiate use for technology transfer*: www.europractice.stfc.ac.uk/software/commercial_use.html

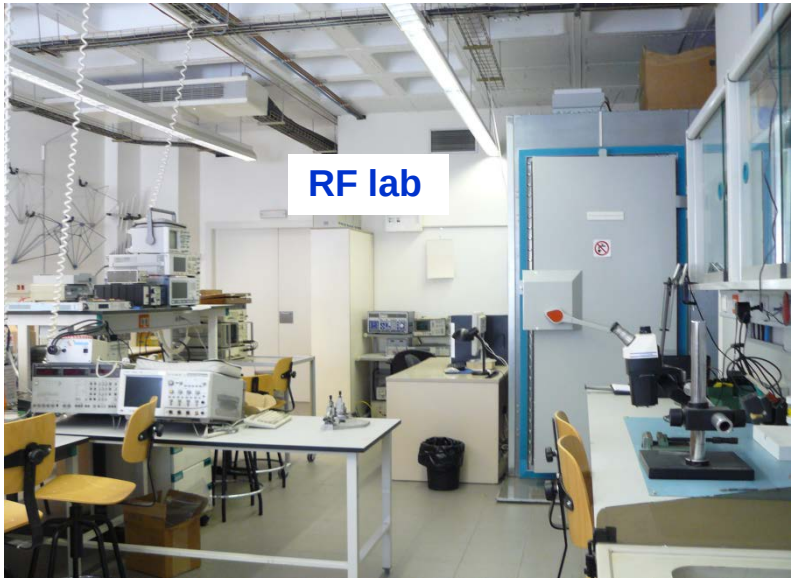
- **Options to transfer a design**
  1. Europractice special agreement
  2. Using commercial license
  3. Direct transfer of the knowledge: schematics, RTL code, gds layout…

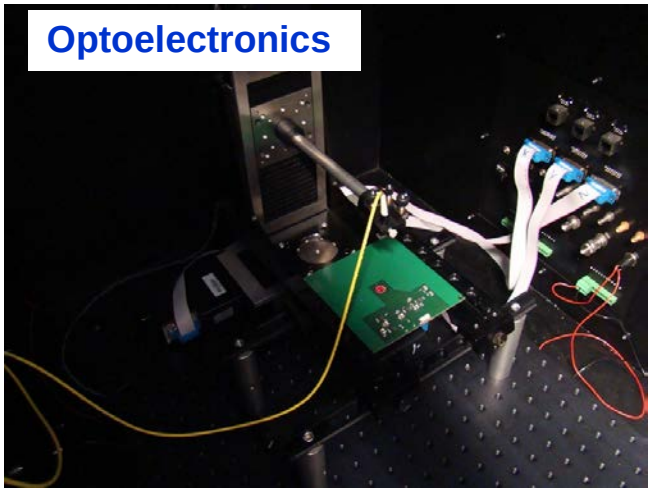


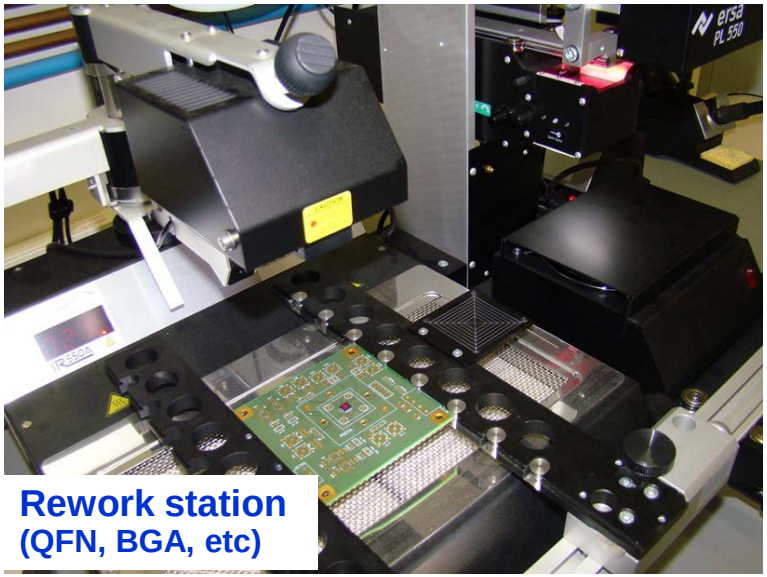


Resources: several electronics labs and…

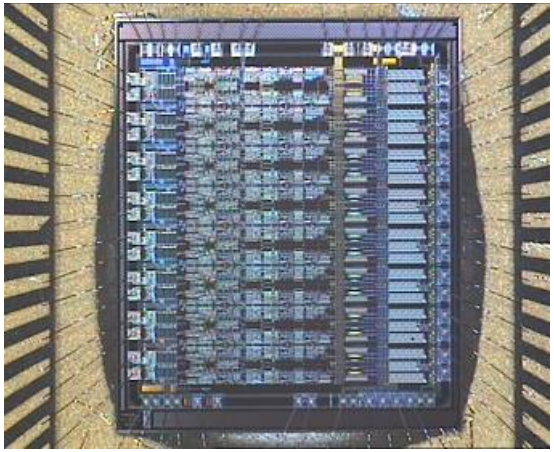
- **Fully equipped electronics labs and …**



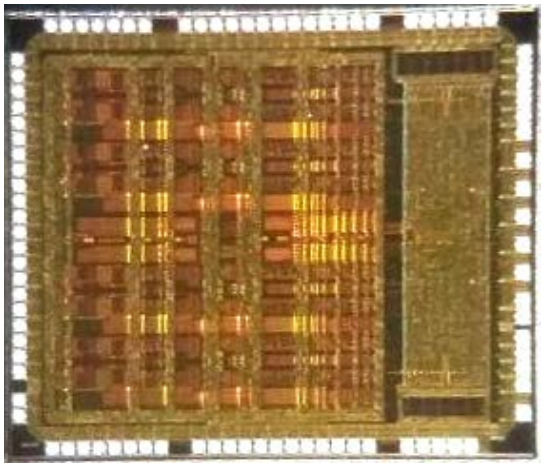




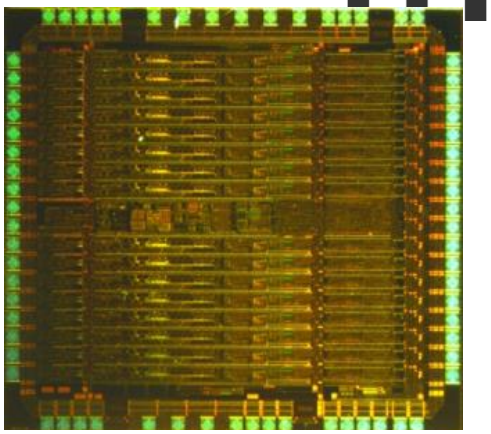
ASICs



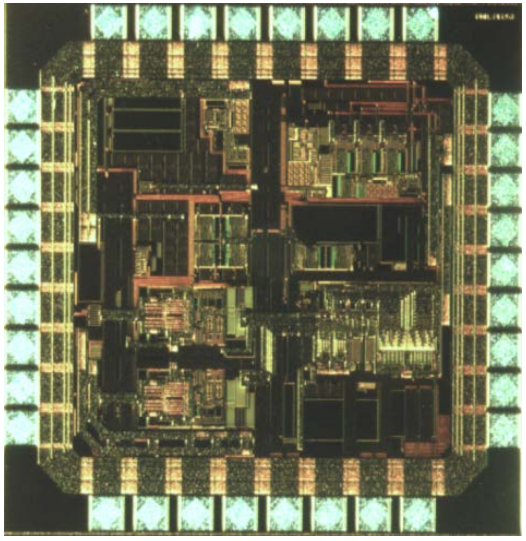
LHCb SPD: amplification, shaping, and discrimination.
AMS BICMOS 0.8 um, radiation tolerant



LHCb calo upgrade: analog signal processing. Radiation tolerant
AMS SiGe BiCMOS 0.35 µm



FlexToT
Readout circuit for SiPM arrays
SiGe BiCMOS 0.35um

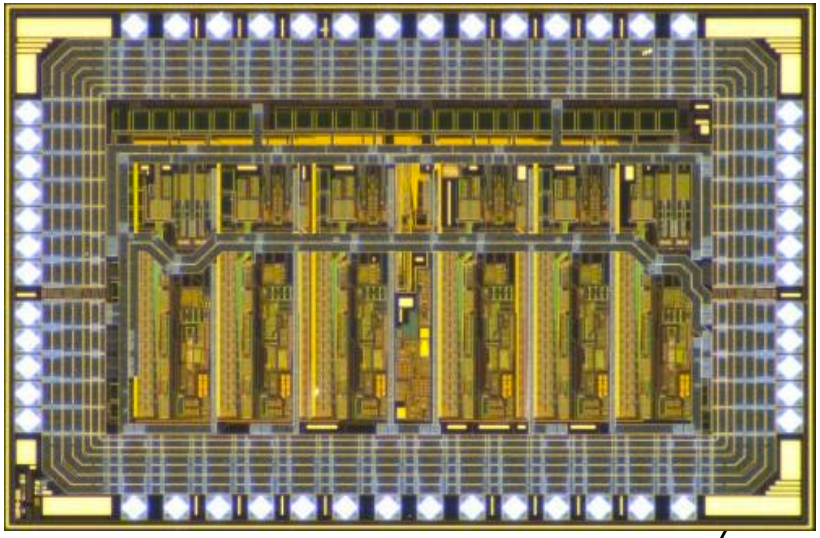


ASICs for CTA:
← Low noise and high dynamic range preamplifier for photomultiplier tubes

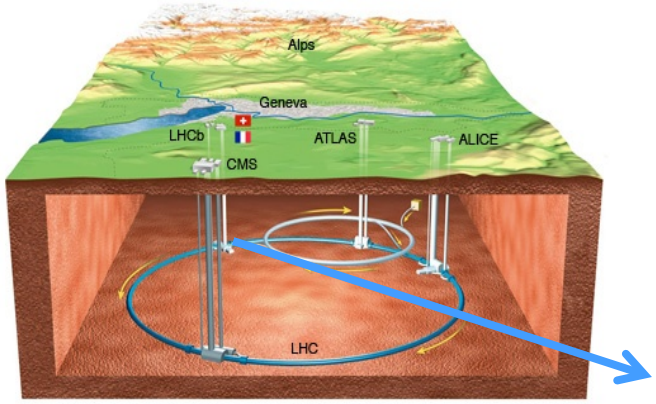
AMS SiGe BiCMOS 0.35 µm

Signal conditioning and → amplification

AMS CMOS 0.35 µm



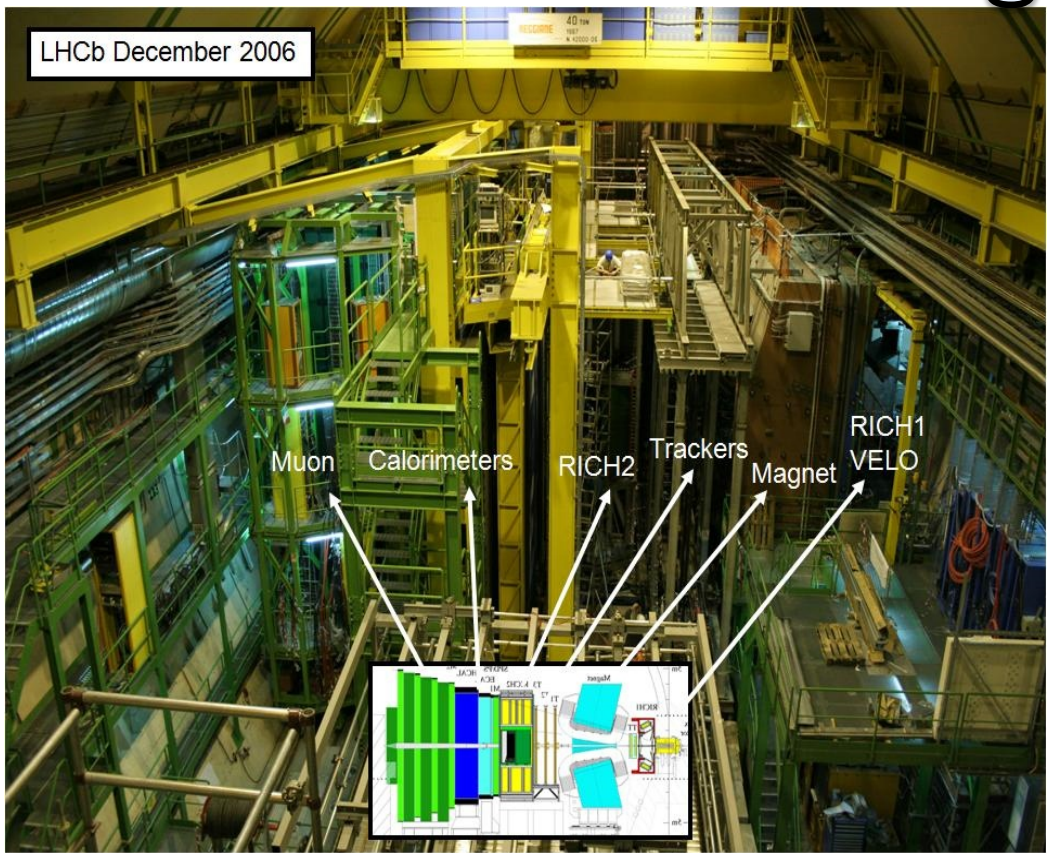
Key projects: LHCb-SPD



http://lhcb-public.web.cern.ch/lhcb-public/

SPD is the front end of the calorimeter system and it is vital for the L0 trigger

Installed and working



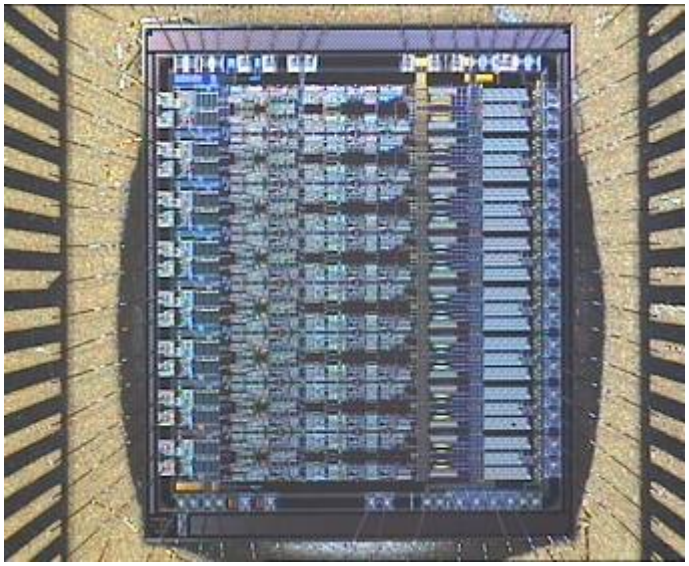
•Design of the Front End electronics of the first detector of the calorimeters:

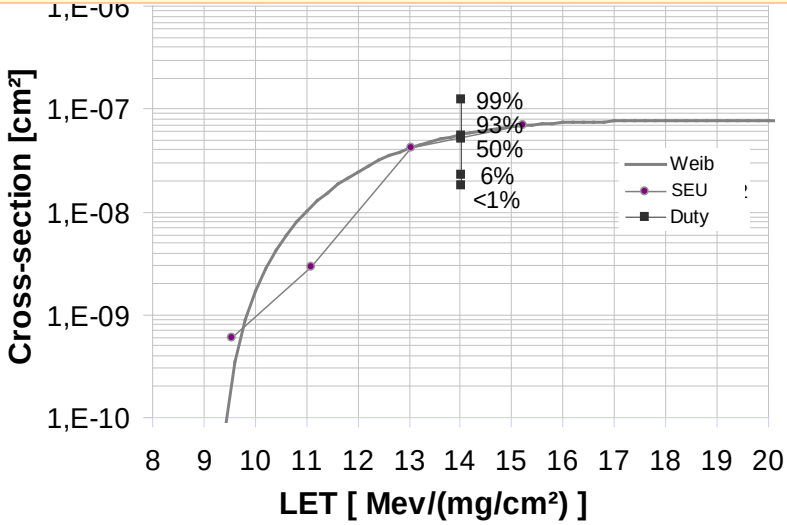
- **100 acquisition cards of 64 channels**
- **800 ASICs (8 ch)**
- **Slow control system**
- **High speed links (2.5 GB/s)**

Key projects: LHCb-SPD

- *Analog Processing + Digital Control*
- *Signal range: 1 pC* (1 V)
  (1 MIP ~ 30-100 fC)
- *Electronics resolution 2 fc*
- *Radiation tolerant design*
  - **Guard rings for SEL prevention**
  - **Triple Voting Register (TVR) for SEU.**

- ***Radiation qualification:***
- **Using a krypton beam we have qualified this ASIC**
- **TID: tested up to 20krad: OK**
- **After extrapolation to LHCb environment:**
  - **SEU rate is acceptable (3 SEU/year for 6Kch)**
  - **No SEL (<1 SEL/20 years)**





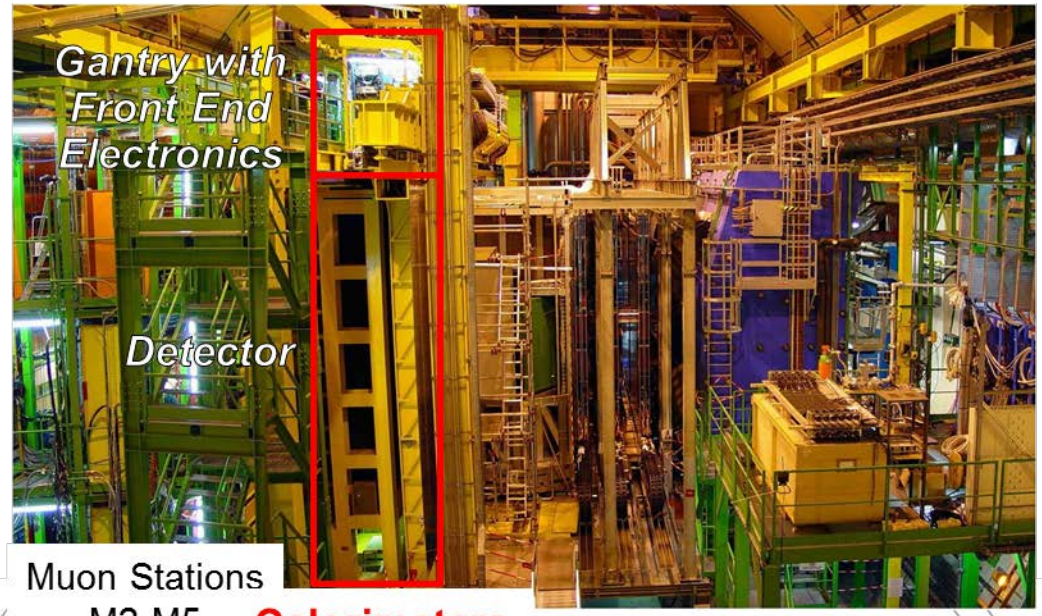
NIM (A, 551/2-3 2005)

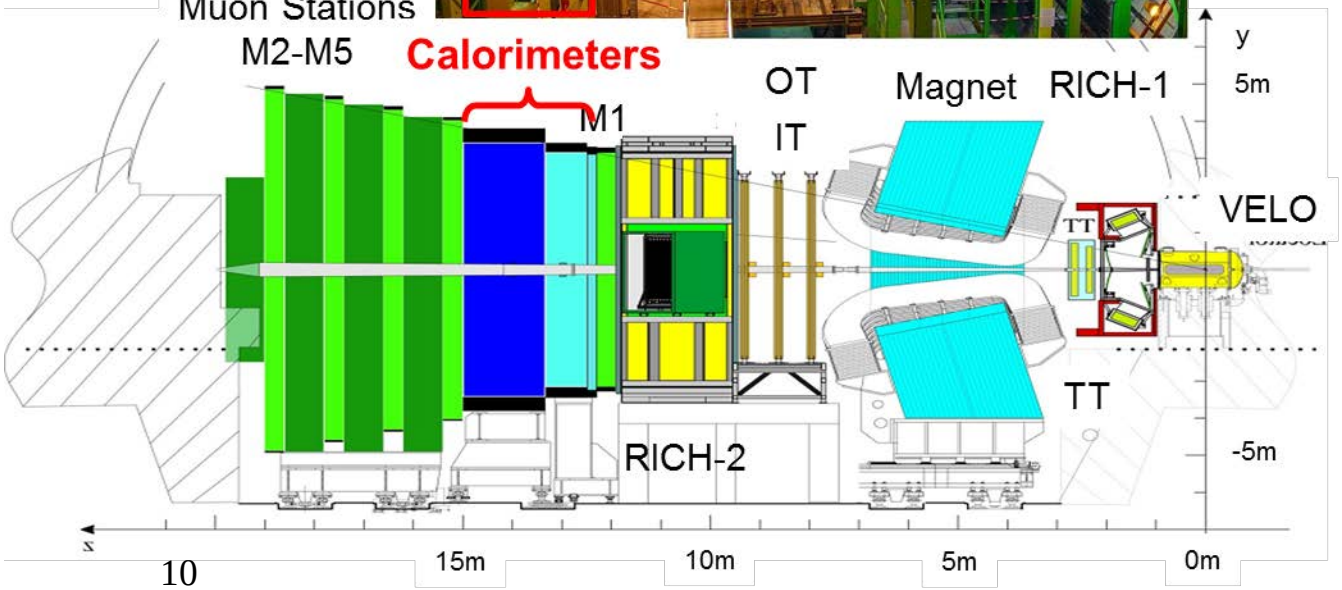
1500 ASICs produced and tested

AMS BiCMOS 0.8μm - 8 dual channels – 30mm²

Designed in collaboration with the electronics department (UB)

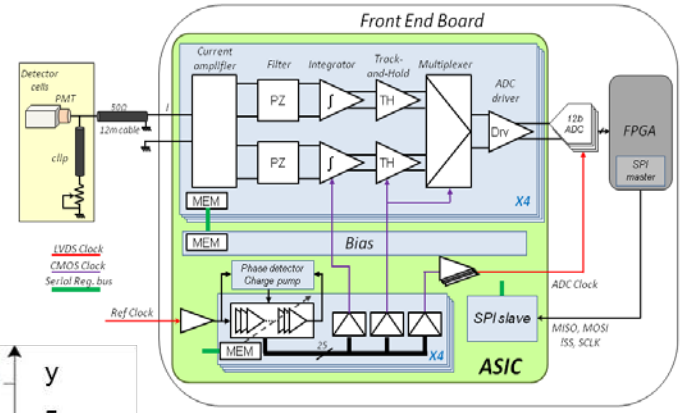
Key projects: LHCb upgrade-ICECAL

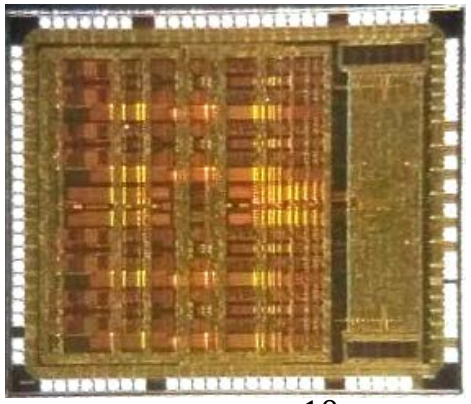




ICECALv3 chip:

SiGe BiCMOS 0.35um
AMS 10.5 mm^2
12 bit resolution @ 40 MS/s





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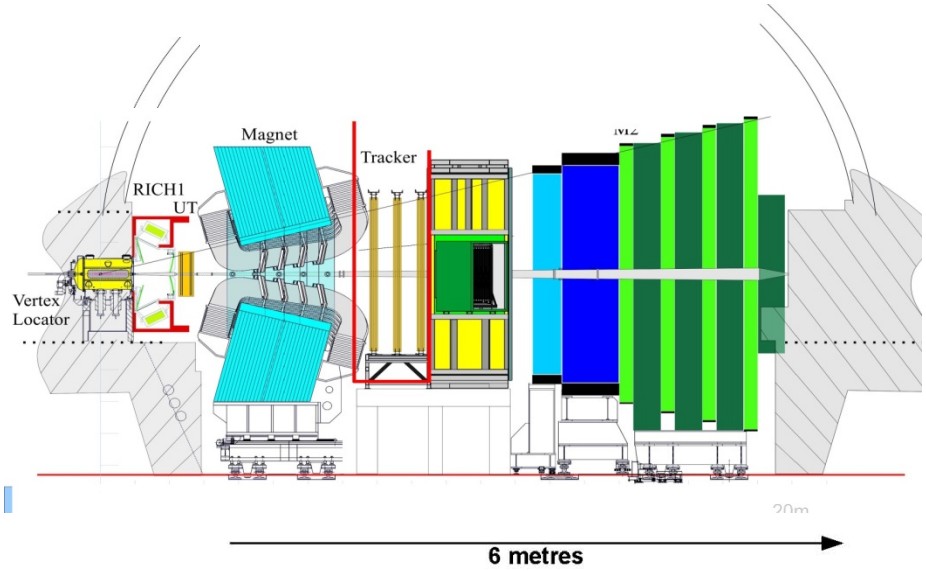
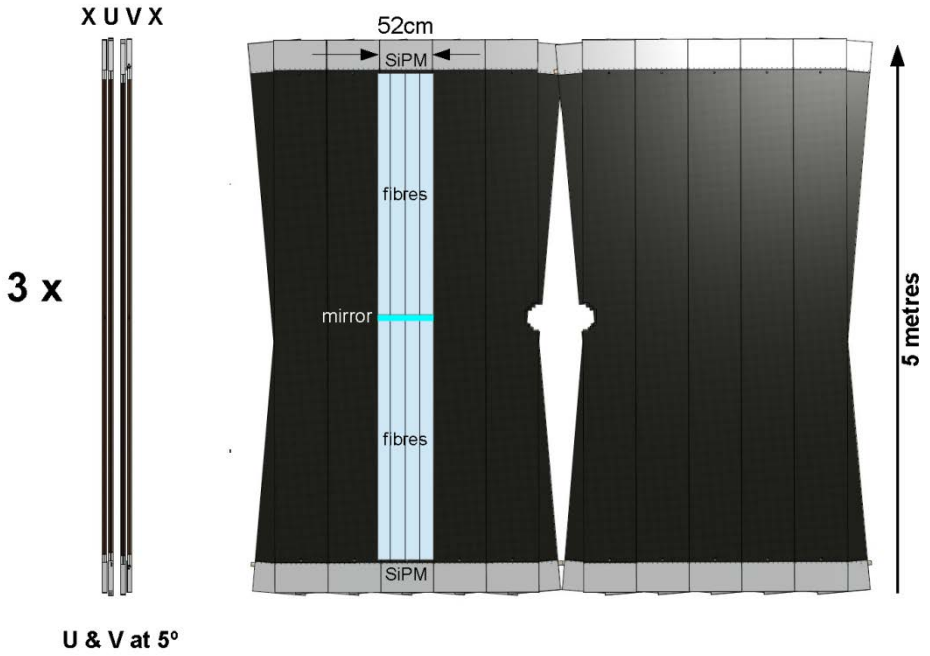
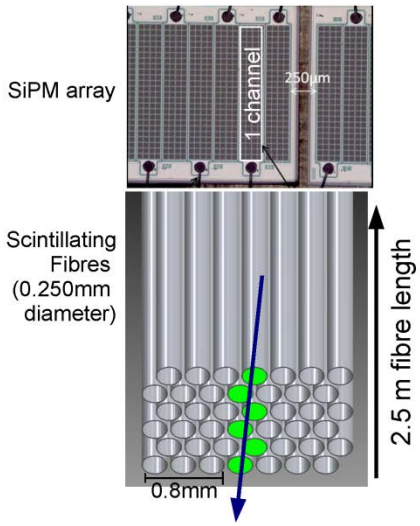
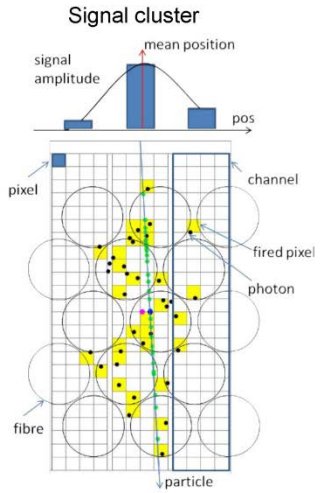
Key projects: LHCb upgrade: SciFi

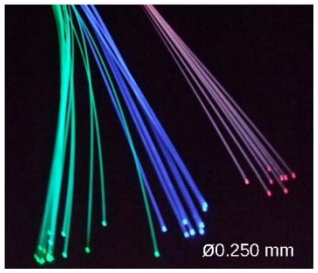






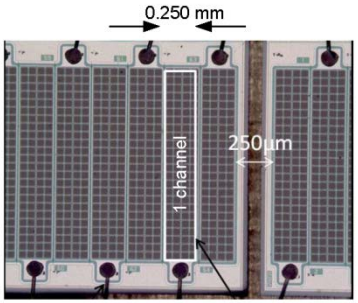


Typically one observe 15-20 photoelectrons for 5 layers of fibre



Scintillating fibres

-fast decay time (2.8ns)
-good light yield and attenuation length

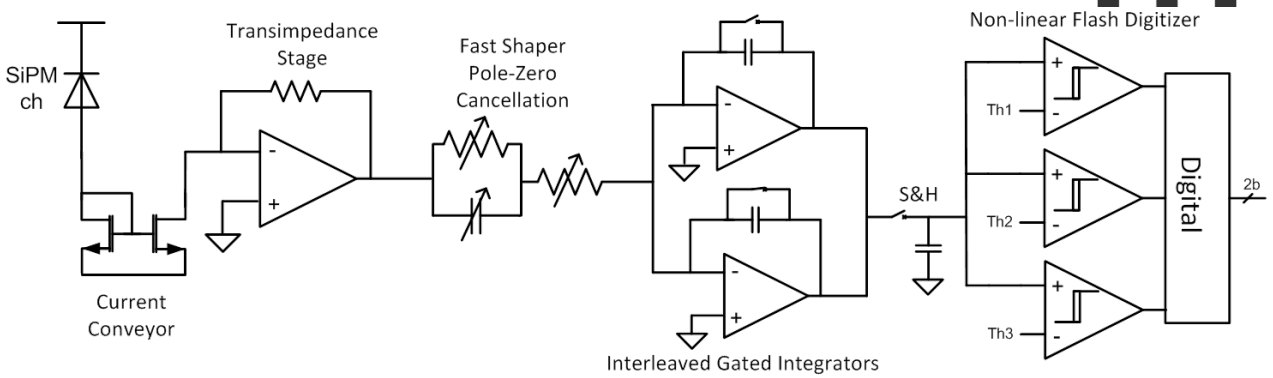


An array of pixelated silicon photomultipliers

-fast signals
-high photon detection efficiency (40+%)
-compact channel size

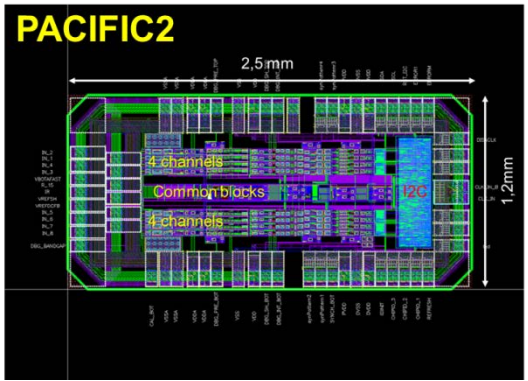
Key projects: LHCb upgrade: SciFi

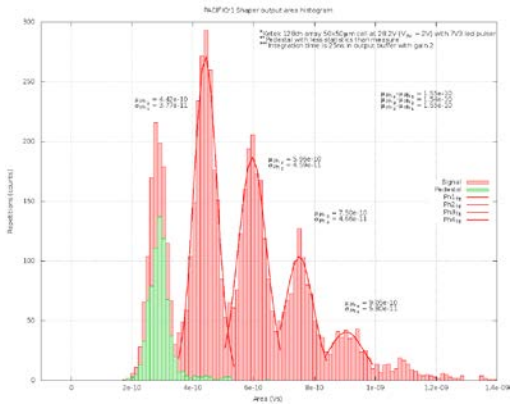
- Replace current silicon tracker by a scintillating fiber tracker
  - Fiber pitch: 250 um
  - More than 300K channels
- Development of a 128 ch chip
  - ICC-UB
  - LPC
  - IFIC
  - Heidelberg



- Current conveyor with very low impedance input (≈ 30Ω)
  - Adjustable gain / dynamic range
  - Input voltage adjustment
- Fast tunable shaper
  - Pole-zero cancellation to cancel slow SIPM time constant
  - A FWHM of 5 ns is achieved for single-cell signal
- Dual interleaved 25ns gated integrator
  - Almost no dead time
  - Average photo-statistical fluctuations
  - Maximize charge collection (25 ns integration)
- 2 bits 40MS/s flash non-linear ADC
- Power consumption < 8mW/channel @ 1.2 V

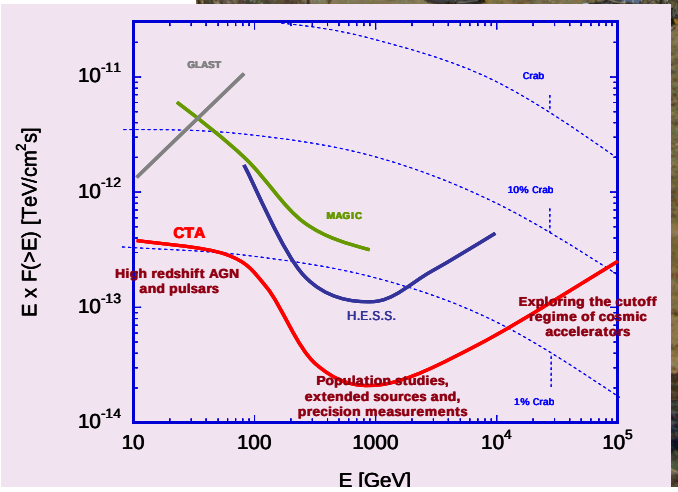
CMOS 130 nm





Key projects: CTA

- **How CTA aims to extend energy range and increase sensitivity?**
  - **Large array (>1 km^2)of Cherenkov telescopes (50-100)**
  - **Different sizes: dish from 6 to 24 m**
- **Camera and electronics must be optimized in terms of**
  - **Performance**
  - **Cost and reliability: integration**



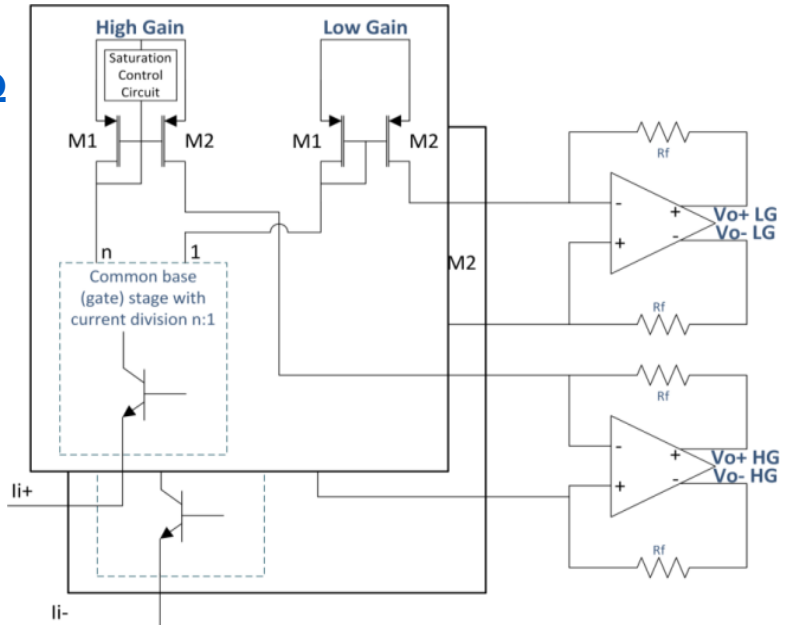
Under design

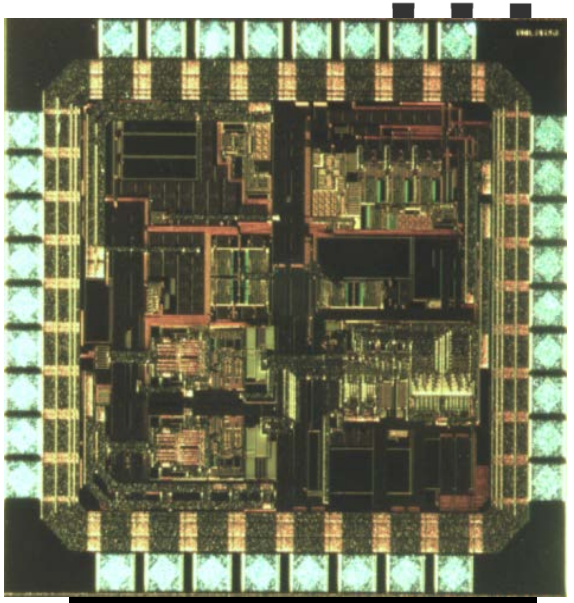
Artist view of CTA-North
Kari Nilsson

http://www.cta-observatory.org

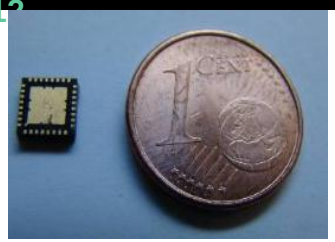
Key projects: CTA

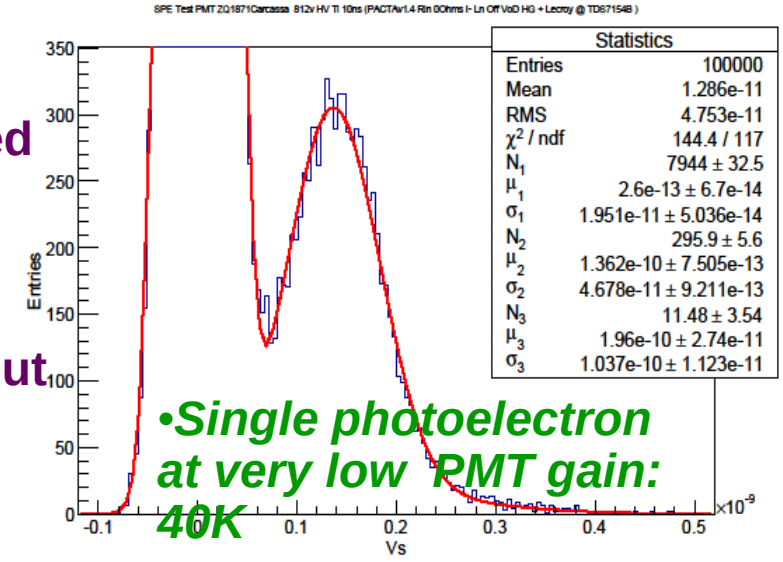
- **Double transimpedance gain: 1.2kΩ (HG) and 80 Ω (LG)**
- **Dynamic range > 15 bits**
- **-3 dB bandwidth of 450 MHz**
- **Low input referred noise: 10 pA/√Hz**
- **Noise (ENC): 4700 electrons (at 10 ns of integration time)**





PACTAv1.4 chip 2 mm²
QFN32 package
Back from foundry Oct. 2012





•Single photoelectron at very low PMT gain: 40K

2400 ASICs to be received and tested for first LST camera

For full observatory about 100000 ASICs would be produced

•NSS11 & JINST

•Patented

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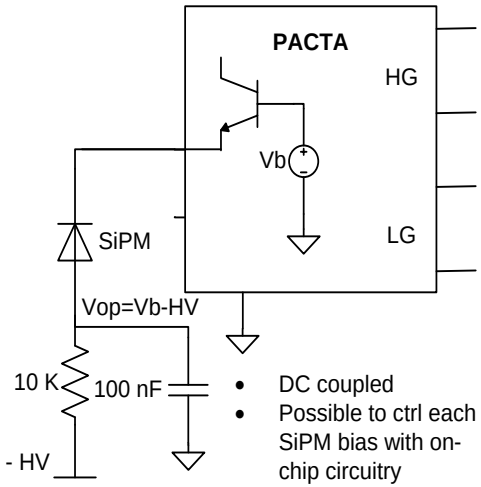
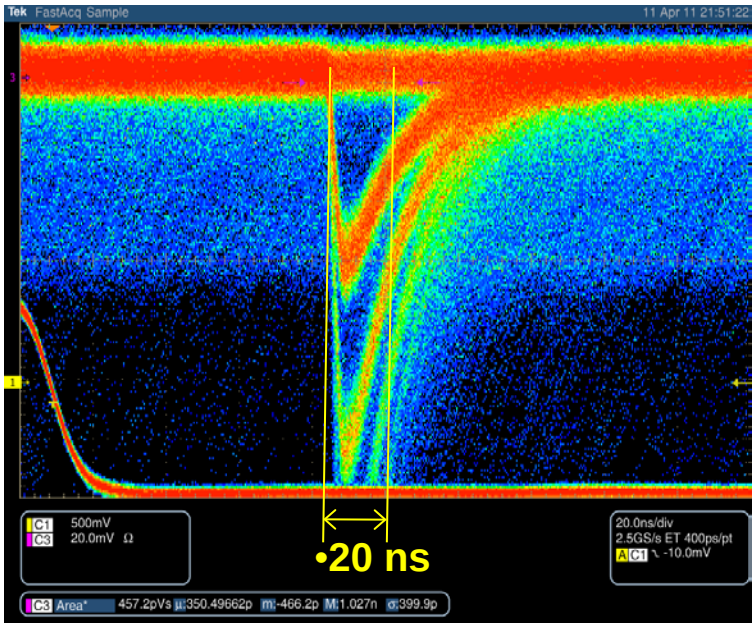
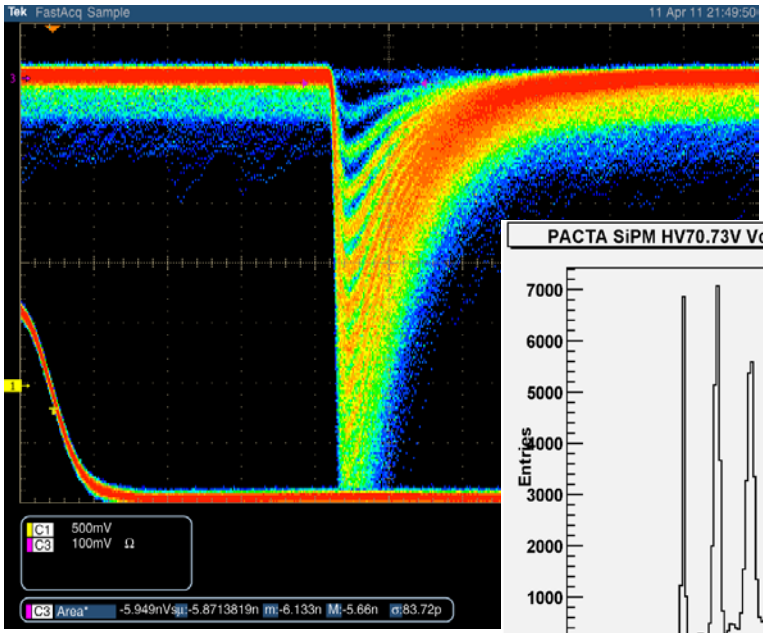
Key projects: CTA

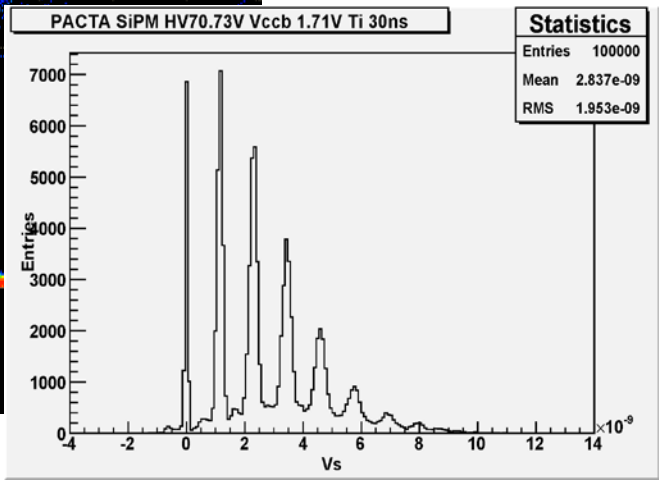
- Tests with SiPM
  - Low Zin current mode circuit are well suited for SiPM readout
    - DC coupling without external components
  - We just took an available MPPC (S10931-050P)
    - 1 V overvoltage
  - Recovery time seems to be dominated by internal SiPM time constant



- DC coupled
- Possible to ctrl each SiPM bias with on-chip circuitry

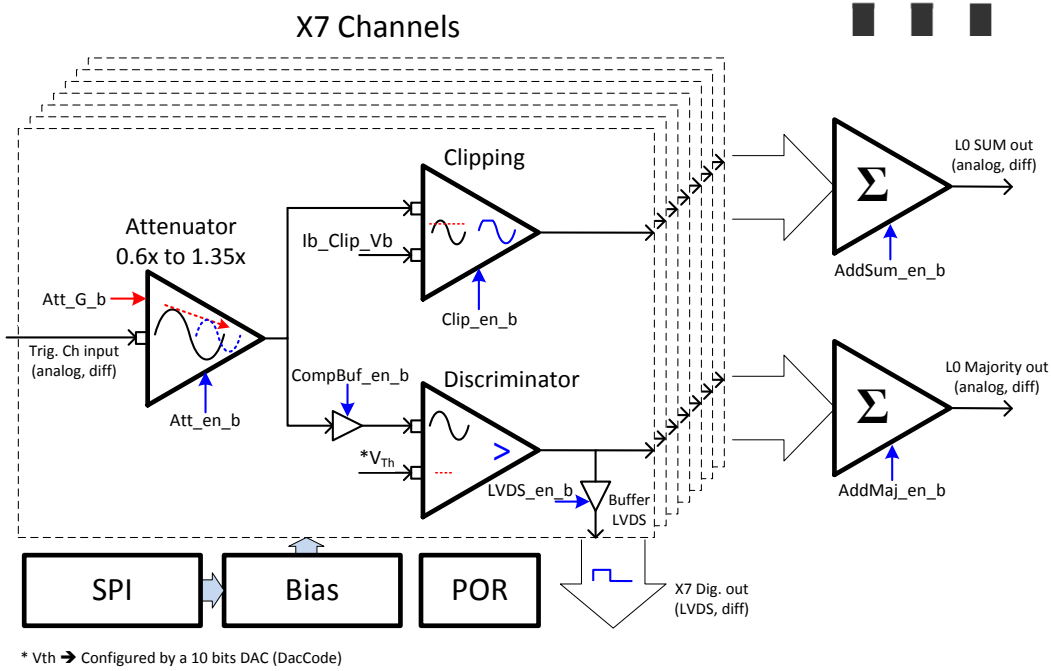




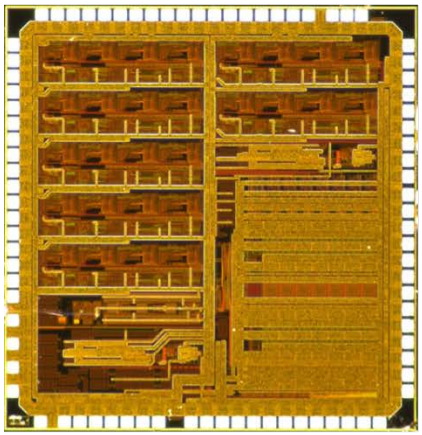


Key projects: CTA Trigger ASIC

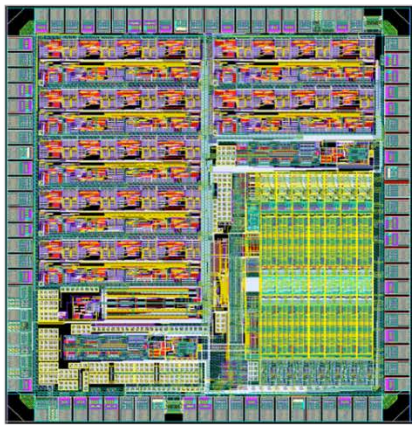
- Three different simultaneous operation modes
  - Sum trigger
  - Majority trigger
  - Discriminator outputs
- Each subsystem of each channel can be set in “power down mode”
- High speed design (>500 MHz)
- Based on a combination of open and closed loop design
- Closed loop adder with 50 Ω line driver



- **ASIC design: UB**
- **Specs and test: IFAE**



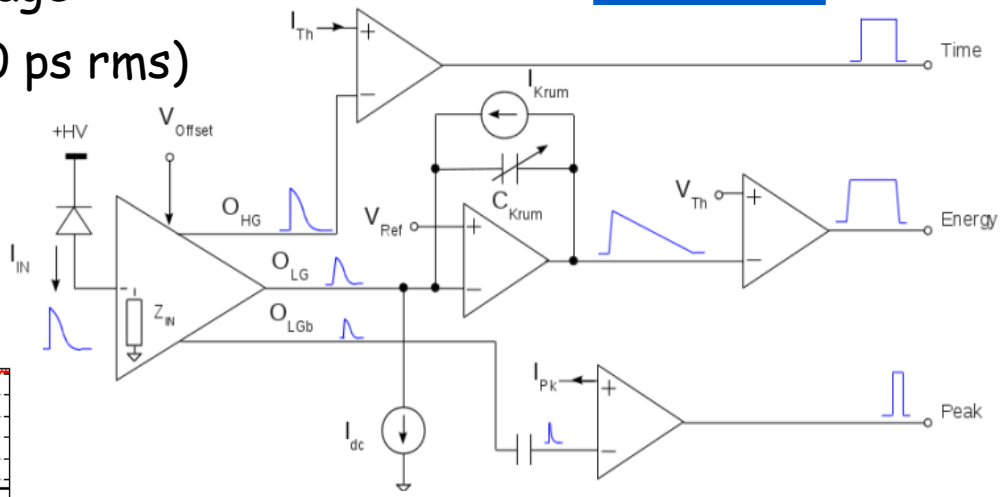
- Austriamicrosystems BiCMOS SiGe 0.35 µm technology
  - Compatibility with other CTA-Spain chips [3], [4]
- About 12 mm^2
- 7 Channels
- Majority & Sum trigger approach
- 7 LVDS digitized outputs
- SPI Slow Control Interface
- 30 samples packaged

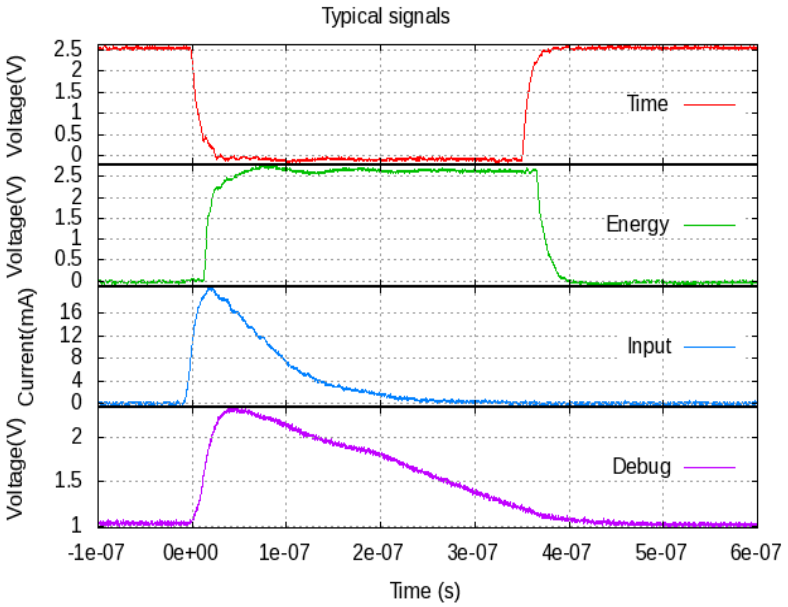


Key projects: medical imaging (PET)

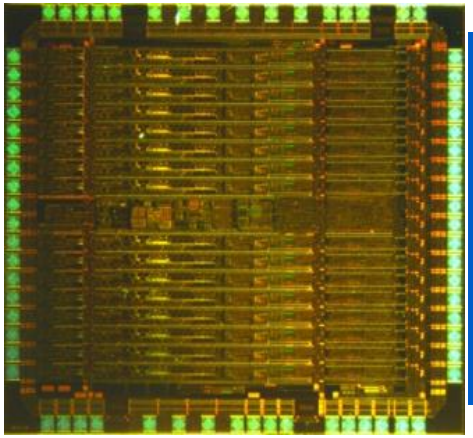
- *A Flexible ASIC for SiPM (PET, SPECT, Compton)*
  - Novel current mode input stage
  - Time resolution forToF (< 30 ps rms)
  - Time over Threshold RO
    - No ADC

Patented





COLLABORATING WITH CIEMAT



•*FlexToT*

•16 channel
•SiGe BiCMOS 0.35um
•Aaustriamicrosystem
•10 mm^2
•3.3 V (10 mW/ch)
•QFN 64

2 contributions in 2013 NSS

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Summary

- The ICCUB/SiUB has a solid expertise on:
  - ASIC design
  - Cards and system design (PCB, FPGA, etc)
  - High speed links
- Experience on electronics for:
  - Calorimeters
  - Trackers
  - Trigger system
  - Time of flight
- Experience on ASICs and COTs components qualification:
  - Test beam
  - Radiation tests: TID, SEEs, Neutron, etc
  - Burn-in
- Willing to contribute and colaborate where useful for the colaboration