The (5%) R&D Program on Scientific Equipment

R&D on Scientific Equipment

A three years program launched in 1998 to promote R&D on items critical for big INFN experiments.

Collaboration between INFN and Industries, funded from three sources:

• Research Ministry	4.1 M €
• INFN	1.8 M €
• Industry	1.1 M €

The Projects

Six projects selected:

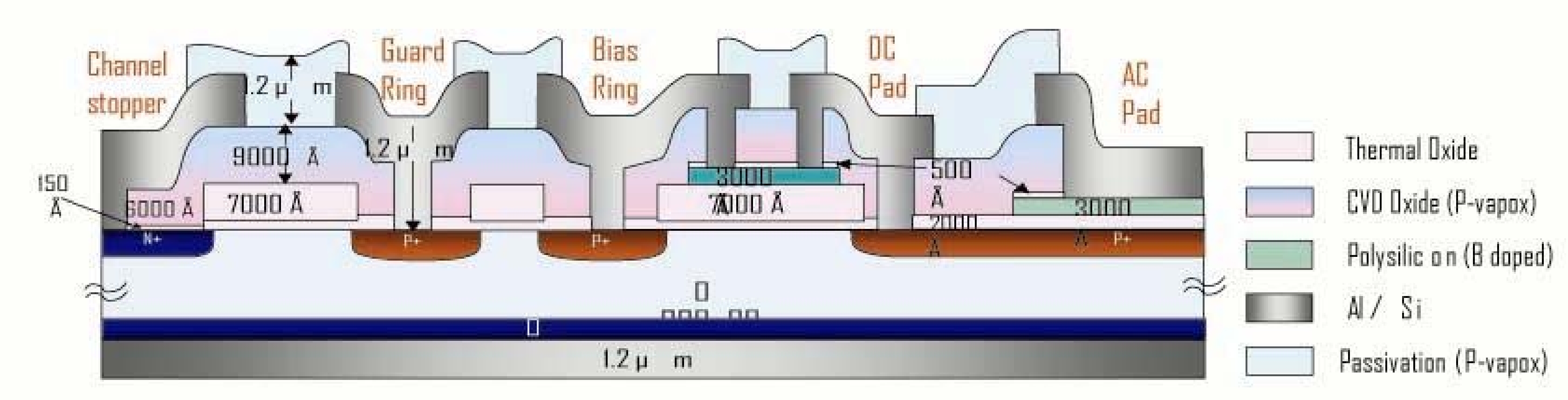
1. Microstrip silicon detectors
2. High density bidimensional bonding (Bump Bonding)
3. Microstrip gas detectors
4. Trigger-Readout electronics for LHC experiments
5. HV power supplies for LHC environment
6. Trigger-RO electronics for a liquid Ar TPC (ICARUS)

1) μ-strip silicon detectors

Industry: ST Microelectronics

Goal: Develop a technology to mass produce silicon micro-strip detectors with the quality required by the large tracking systems of the LHC experiments at an affordable price.

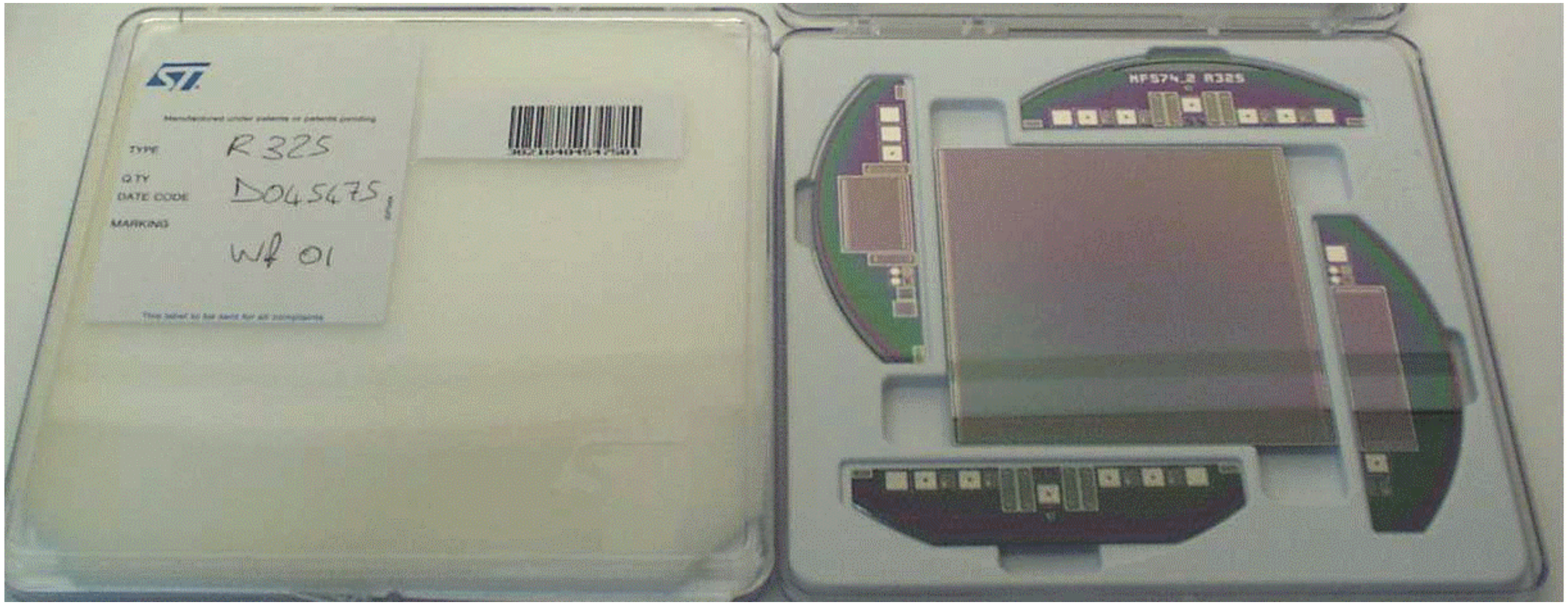
The fabrication technology requires state-of-the-art processing lines with low defect rate on wafer size devices (90 cm^2).



Silicon μ-strip results

Excellent results of the collaboration

- High quality prototypes produced so-far.
- Significant improvements in yield.
- Important reduction on costs which allowed STM to win part of the tender for sensors of the CMS silicon tracker (~18.000 silicon detectors)



Final CMS detector

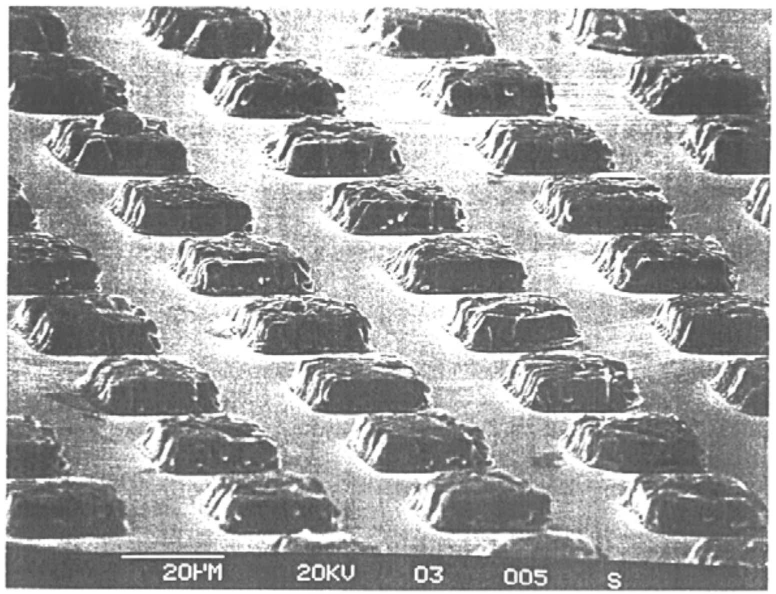
2) Bump Bonding

Industry: Alenia Marconi Systems

Goal: improve existing technology to connect bi-dimensional pixel detectors to the amplification electronics.

LHC experiments need high contact density (pixel dimensions in ATLAS 50 μm x 300 μm) on large surfaces.

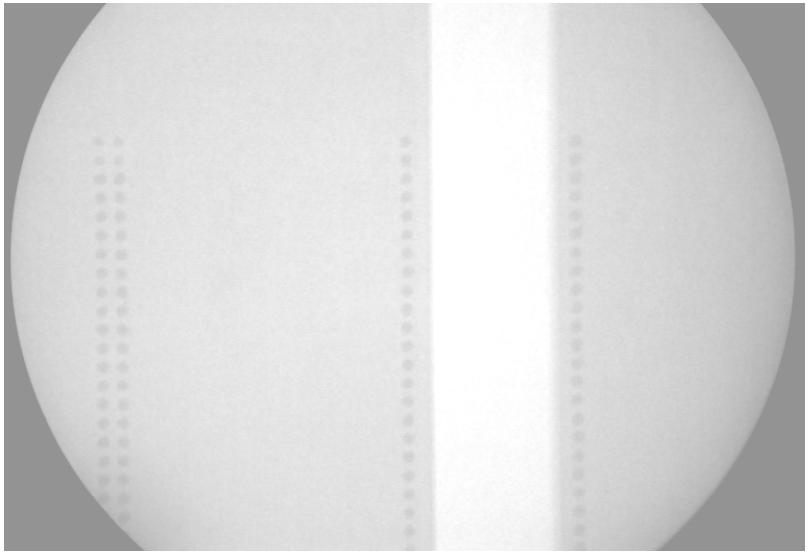
The technique is based on the deposition of a matrix of bumps of soft metals. The connection between sensors and electronics is made by pressure.

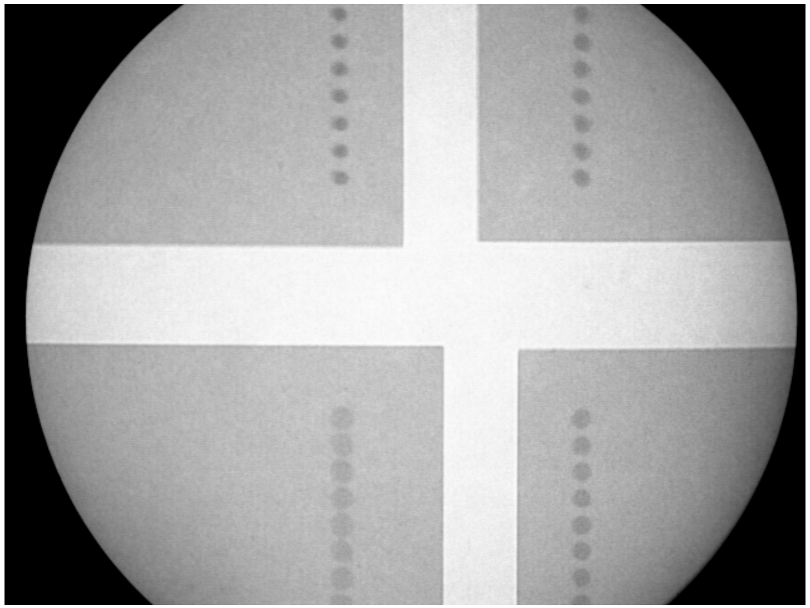


Bump Bonding results

The goal has been reached.

- X ray micro radiographies show good uniformity of contact thickness and good alignment between adjacent sensors.
- High yield (10 short circuits out of 50.000 bumps) has been obtained.
- Good performance measured on test beam :
  - low noise
  - good resolution ~12 μm
  - high efficiency ~ 99%



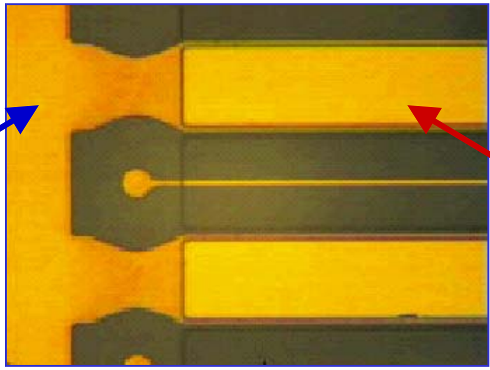


3) Micro Strip Gas Chambers

Industry : Laben +Cetev+Alenia

Goal: Development of a high resolution tracking detector for harsh radiation environments.

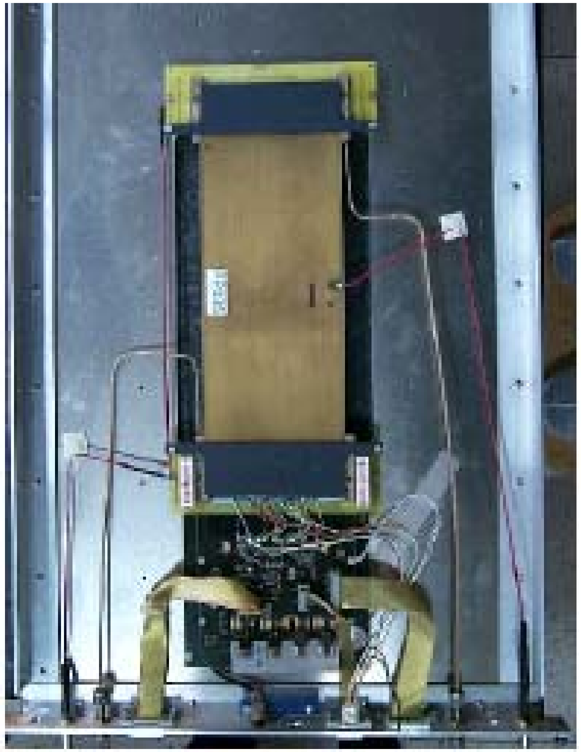
Features: Granularity, Resolution, Speed



Standard passivation

Advanced passivation

Details of the electrodes

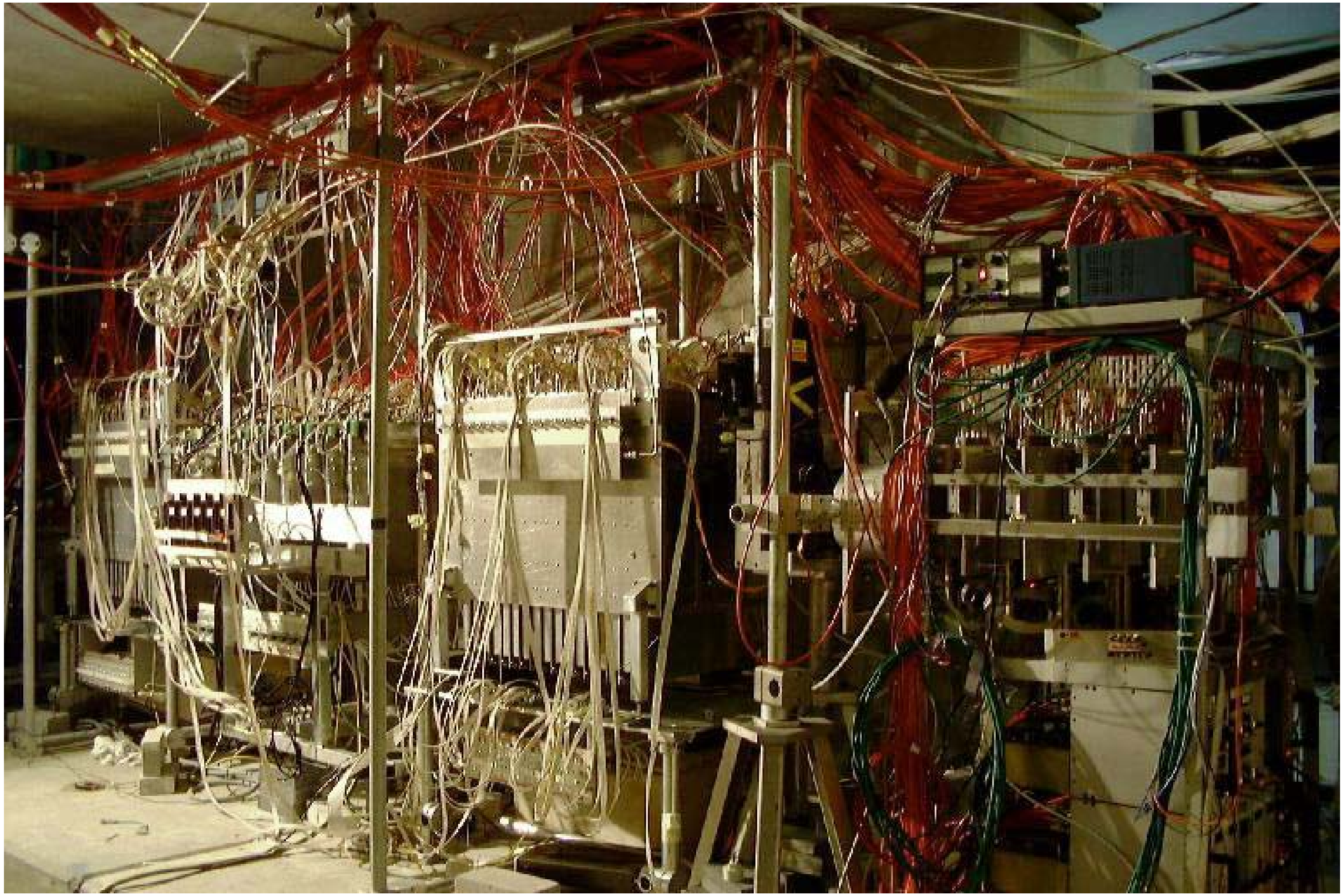


A Milestone module

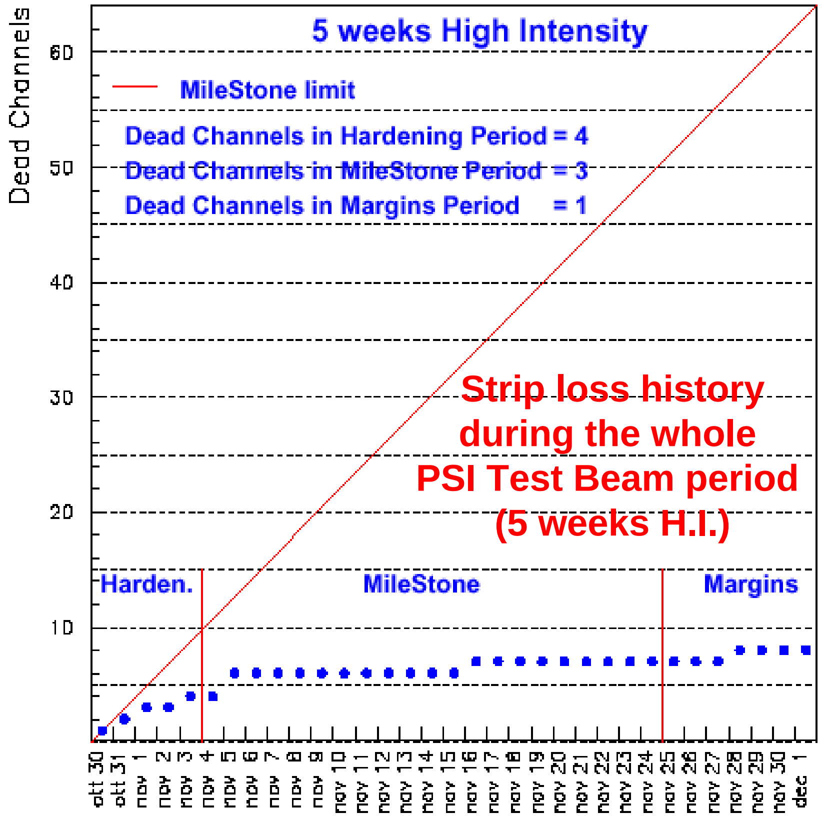
(100 modules produced, ~ 1 m^2)

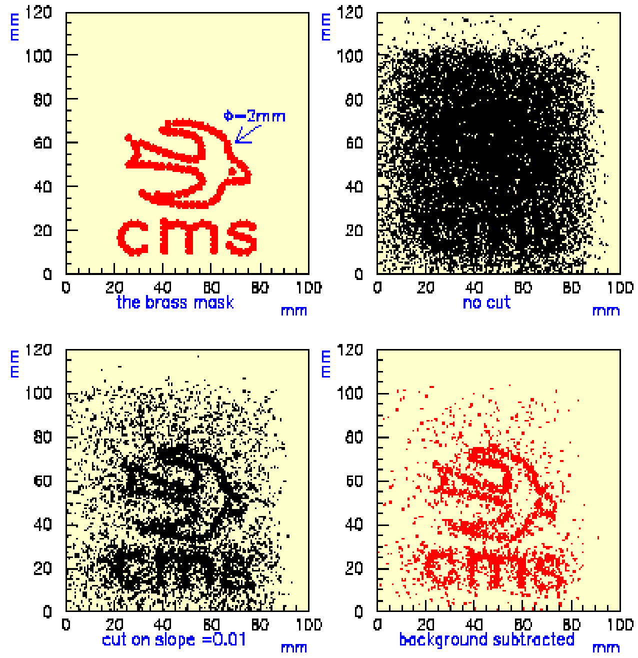
Final MSGC test

Telescope of 32 MSGCs tested at PSI in Nov 99 (CMS Milestone)



MSGC results





Technology brought to full maturity and now available for many applications

Despite the great technical success, MSGCs were not adopted at LHC because of the increased competition of silicon and great simplification of a single technology for the CMS tracking

5) Muon trigger/RO for ATLAS

Industry: CAEN

Goal: development of a complex electronic system for the readout and trigger of the ATLAS muon spectrometer

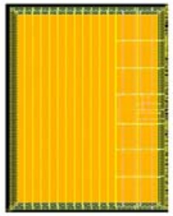
Features:

- complexity
- high frequency transmission of large data volumes
- need of fast custom VLSI (320 MHz)
- radiation resistance and immunity to neutron effects

Muon trigger/RO status

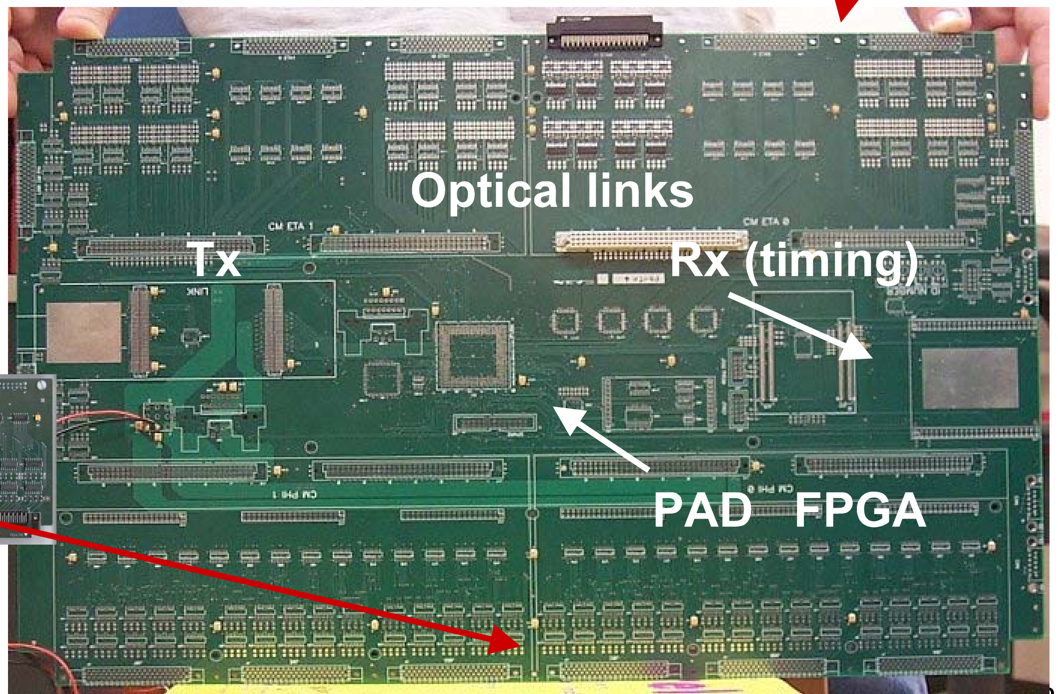
- •Prototyping phase close to completion
- •Irradiation tests (total dose + n) successful
- •System test during 2002

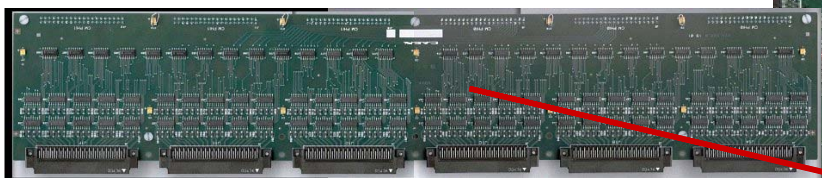
Coincidence matrix VLSI (0.18 μm techn.)



4 units

Processor board (PAD)





OR board

5) DC high voltage systems

Industry: CAEN

Goal: development of a large system to generate, control and monitor DC high voltage for the LHC experiments.

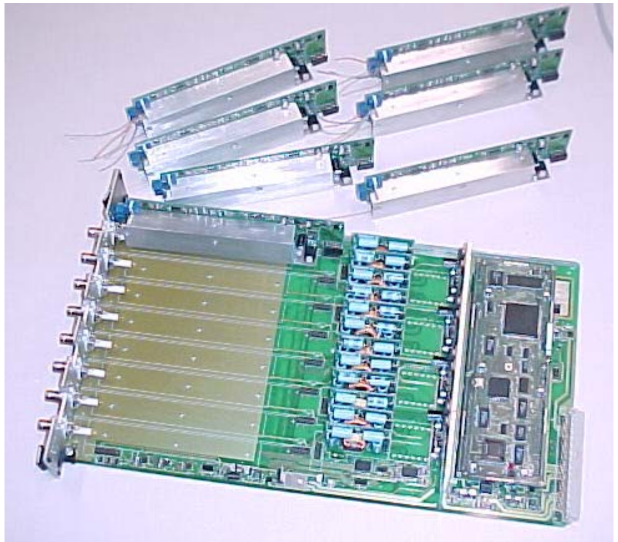
Three steps:

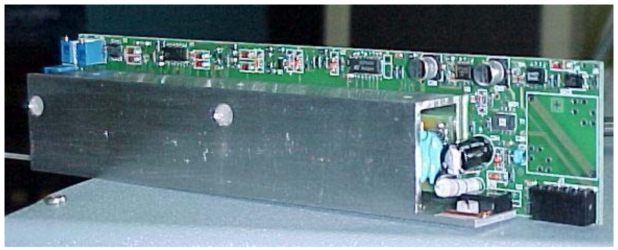
- Develop building blocks capable to operate in the LHC environment (e.m. and neutron radiation, high magnetic field)
- Build engineered prototypes for at least two different detectors (CMS barrel μ chamber + μ-strip detectors)
- Test a reduced scale prototype of the full system

HV prototypes

First two steps completed. Prototypes behave excellently, also under neutron irradiation.

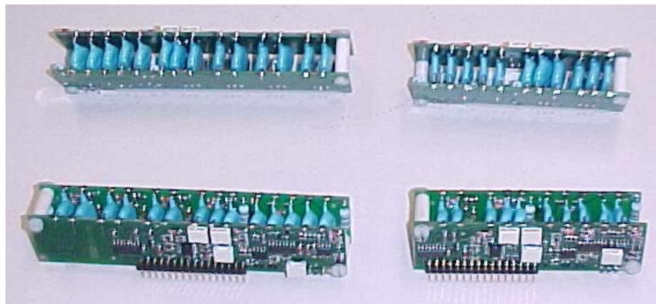
The basic building blocks are being used for other applications





Modules for HV generation in counting room

Modules for HV regulation and distribution in the experiment cavern



6) Electronics for ICARUS

Industry: CAEN

Goal: development of a large system of electronic modules, with extensive use of analog (BiCMOS techn.) and digital (CMOS techn.) custom VLSI

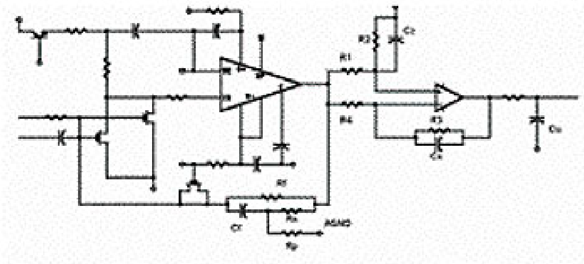
Event size of the 600 tons module

- One chamber has:
  - →Induction 1 wires: **1056 + 1056**
  - →Induction 2 wires: **5728**
  - →Collection wires: **5728**
- Full drift event size:
  - →Induction 1: **2112 x 4096 x 2B ≈ 17MB**
  - →Induction 2: **5728 x 4096 x 2B ≈ 47 MB**
  - →Collection: **5728 x 4096 x 2B ≈ 47 MB**
  - →**Total** **111 MB/chamber**

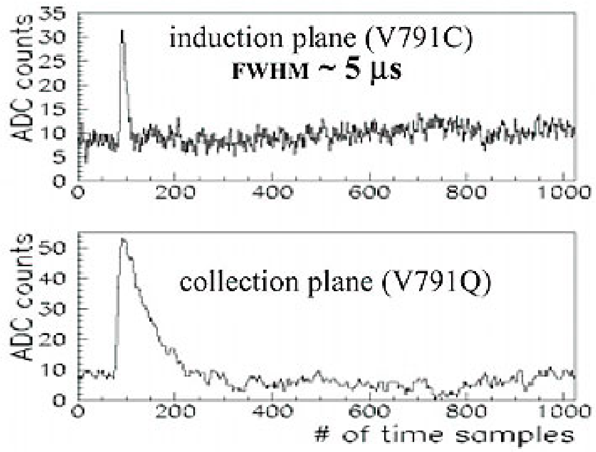
Analog boards

Analogue Boards (V791C & V791Q) features

- **S/N ratio > 10 for m.i.p.**



10 m^3 single wire waveforms (500V/cm)



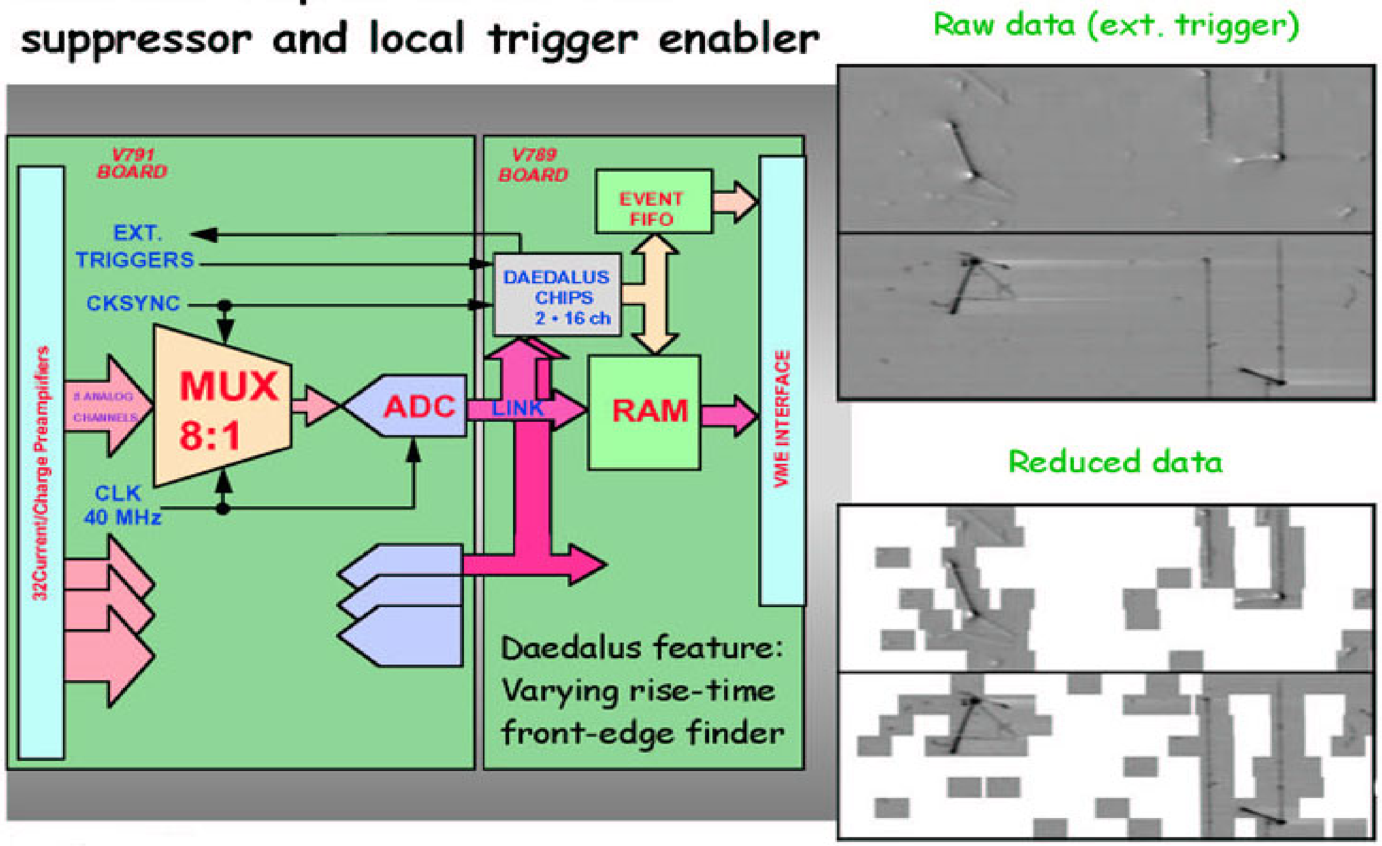
Model	Rf	Cf	Rp	Ra	R1	R2	R3	R4	Cs	Cu	Cz
V791C	10 MΩ	3.3 pF ±10%	1.2 kΩ	22 kΩ	100 kΩ	270 kΩ	27 kΩ	10 kΩ	39 pF	2.2 nF	1 µF
V791Q	100 MΩ	1 pF ±10%	∞ Ω	0 Ω	33 kΩ	270 kΩ	270 kΩ	33 kΩ	3.9 pF	2.2 nF	1 nF

Overall decay time constants: ≈ 3 µs (V791C) , ≈ 40 µs (V791Q)

Analogue board based on a analogue BiCMOS ASIC very low noise.

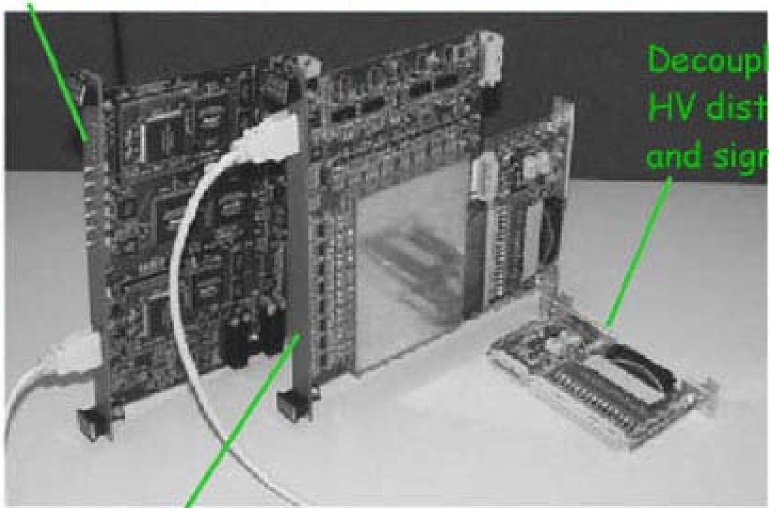
Digital boards

Daedalus chip as on-line zero suppressor and local trigger enabler



Digital board based on a digital CMOS ASIC for data reduction (DAEDALUS)

The ICARUS readout chain



Air tight rack with heath exchangers for 576 channels

About 55.000 channels are needed for one 600 t module.

The system has shown excellent performance during the recent test of the first ICARUS module