Instrumentation for EURISOL: the FAZIA project

Luigi Bardelli

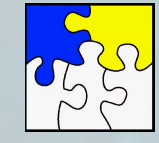
I.N.F.N. and University of Florence, ITALY

for the FAZIA collaboration

EURISOL Design Study Town Meeting 2006

Outline


The FAZIA Project


The basic detection module


Electronics and signal processing: new solutions


Some experimental results


Conclusions

FAZIA (Four π for A and Z Identification Array)

is an R&D project for a new detector for charged particles, planned to operate in heavy-ions induced collisions around and below the Fermi energy (10-100 MeV/nucleon), using also the expertise gained in the $AZ4\pi$ french-italian project.

An internal organization has been defined:

Physics Coordinators G. Poggi, R. Bougault

Technical Coordinator P. Edelbruck

Project management board

Working groups 9 WGs to handle the various tasks

WEB site: `http://fazia.in2p3.fr`

The FAZIA project

An international and open collaboration:

FRANCE INPO (Orsay), GANIL, LPC (Caen), IPNL (Lyon), ANR

ITALY Bologna (INFN & University), Firenze (INFN & University), Catania (INFN), LNL (INFN), Napoli (INFN & University), LNS

SPAIN Huelva, Sevilla

Eastern Europe Cracow, Katowice, Warsaw, Bucarest

CANADA University of Laval, Quebec

USA Western Michigan University

INDIA Variable Energy Cyclotron Centre - Calcutta

Current phase: R&D study solutions for getting:

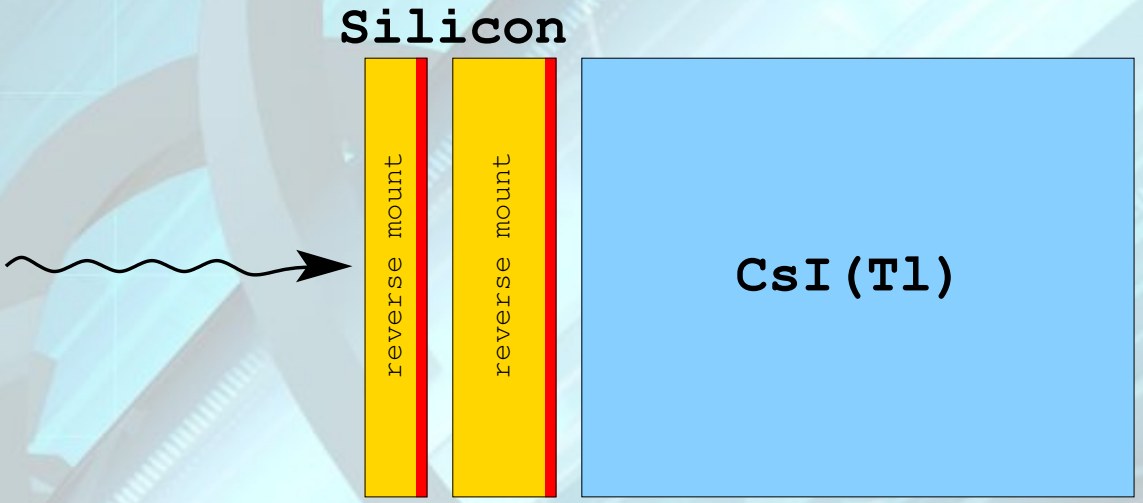
- Large solid angle coverage with high granularity (nuclear interferometry)
- Extension of the Z and A identification performances
- Lowering the detection-identification thresholds
- QP, QT fragment detection capability (coupling with spectrometers?)
- Good timing $\rightarrow$ good time structure of the beam needed
- Compactness of the device, to allow for neutral detection
- Easy future upgrading towards higher energies
- Ease of calibration
- Transportability

Next step (2008?) build a small prototype array

Final step (2011?) if our solutions are validated by experimental tests, build a 2π or 4π device.

The basic detection module

Two NTD silicon and one CsI(Tl) detectors:



Characteristics: *(other solutions are also being investigated. . .)*

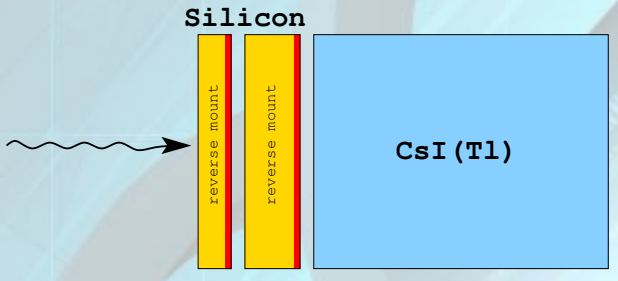
First Si (ΔE) NTD, 300 μm thickness, reverse mount

Second Si (E) NTD, 500/700 μm thickness, reverse mount

CsI(Tl) Few cm thick, depending on beam energy

Area Current prototypes: 20×20 mm^2

The basic detection module (2)



Why this configuration?

Ion Energy high resolution with Si detectors (∼1mm total thick.)

Ion Time of Flight high resolution ToF using the first Si detector

Ion A/Z identification :

stopped in first Si **(“low” energy)**
pulse Shape Analysis (PSA) of silicon current signal + ToF
→ **low thresholds!**

stopped in second Si standard ΔE-E method with two silicon detectors (+ rendundant PSA)

higher energies (mainly light particles) Si-CsI ΔE-E + pulse shape in CsI

Electronics and signal processing: new solutions

We are studying and developing the following:

- Current- and charge-sensitive preamplifiers

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- **Full** digital signal processing
  - Electronics (fast analog pipeline, digitizers, online processing)
  - Digital Pulse Shape Analysis algorithms
  - Digital high resolution energy measurements over a wide dynamic range
  - Digital high resolution timing measurements (i.e. with inter-channel synchronization)
  - Digital Time of Flight (with an accelerator time-mark?)

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- Compact CsI readout (Single Chip Telescope)

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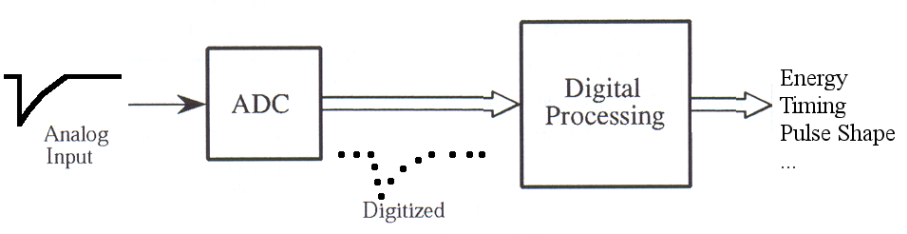
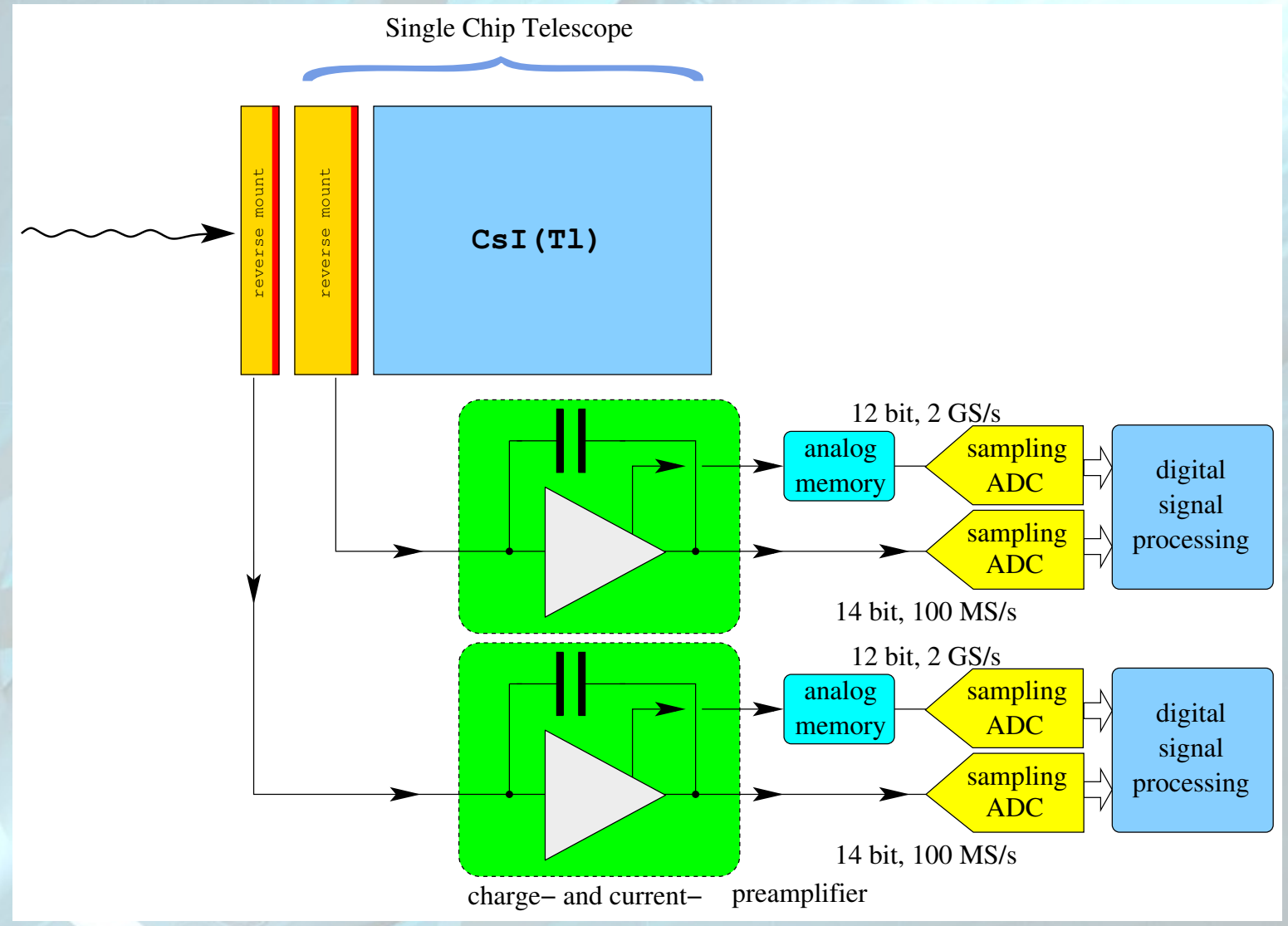
- Simulation/characterization of Si and CsI detectors response
- Dedicated experiments

Why digital sampling methods?

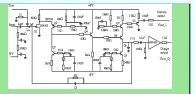
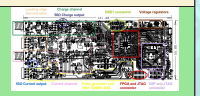
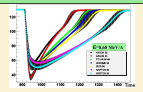
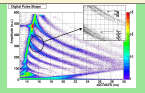
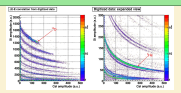
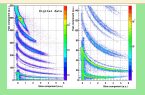
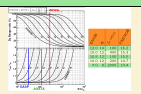
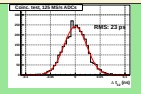
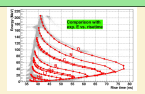
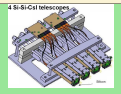


- Compactness
- Flexibility in terms of signal treatment
- Feasibility of digital energy, digital pulse shape and digital timing, with at most two digital channel per sensitive element (current and charge)
- High dynamic ranges
- Improved transportability
- Possible implementation of on-line DSP-based calibration procedures for E and ToF
- Estimated very much lower cost

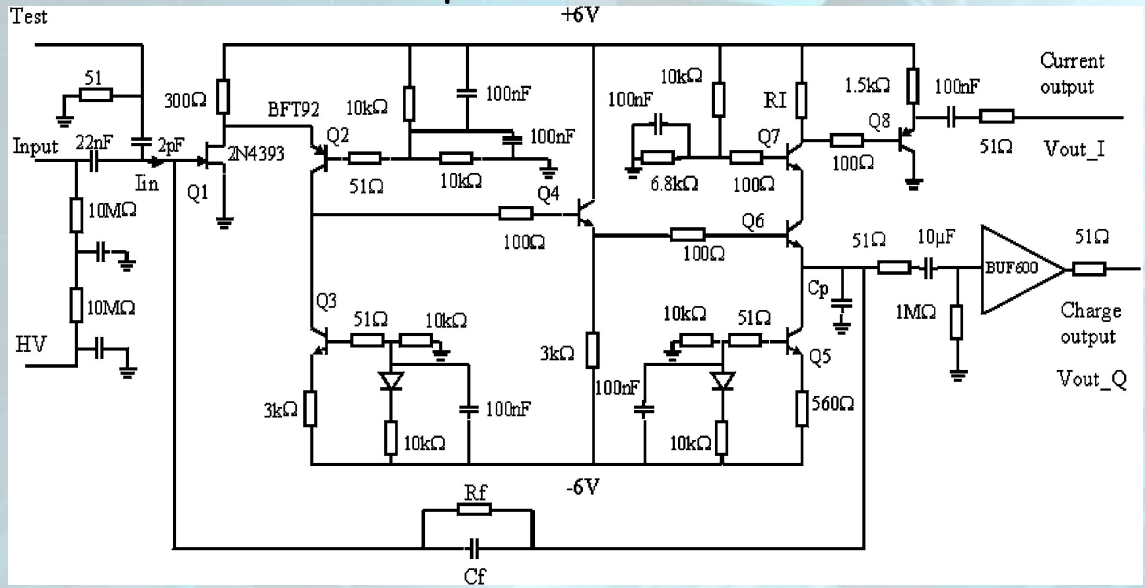
Detection module and electronics

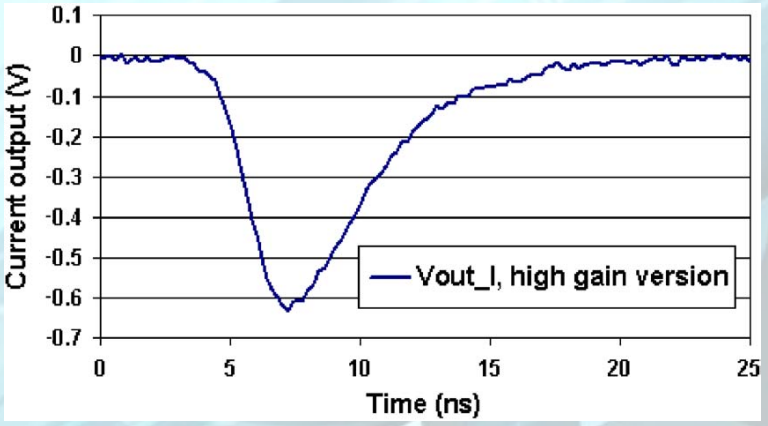


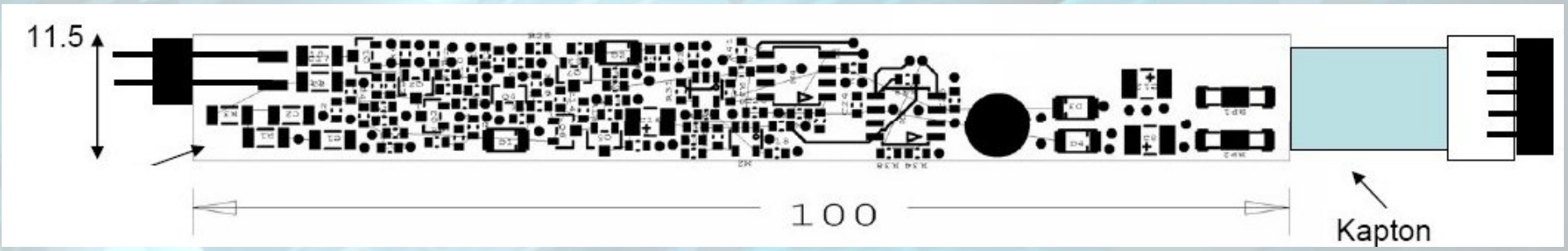
– Active topics –

Charge/Current preamplifier	
Fast current digitizer	
Prototype sampling board	
Exp. meas. of silicon pulse shapes	
Particle identification: PSA (i and q)	
Particle identification: Digital ΔE-E	
Single Chip Telescope	
Energy measurements with digital systems	
Timing measurements with digital systems	
Detector simulation	
Preparation of new experiments	

The fast preamplifier PACI having both charge and current outputs has been developed and tested:

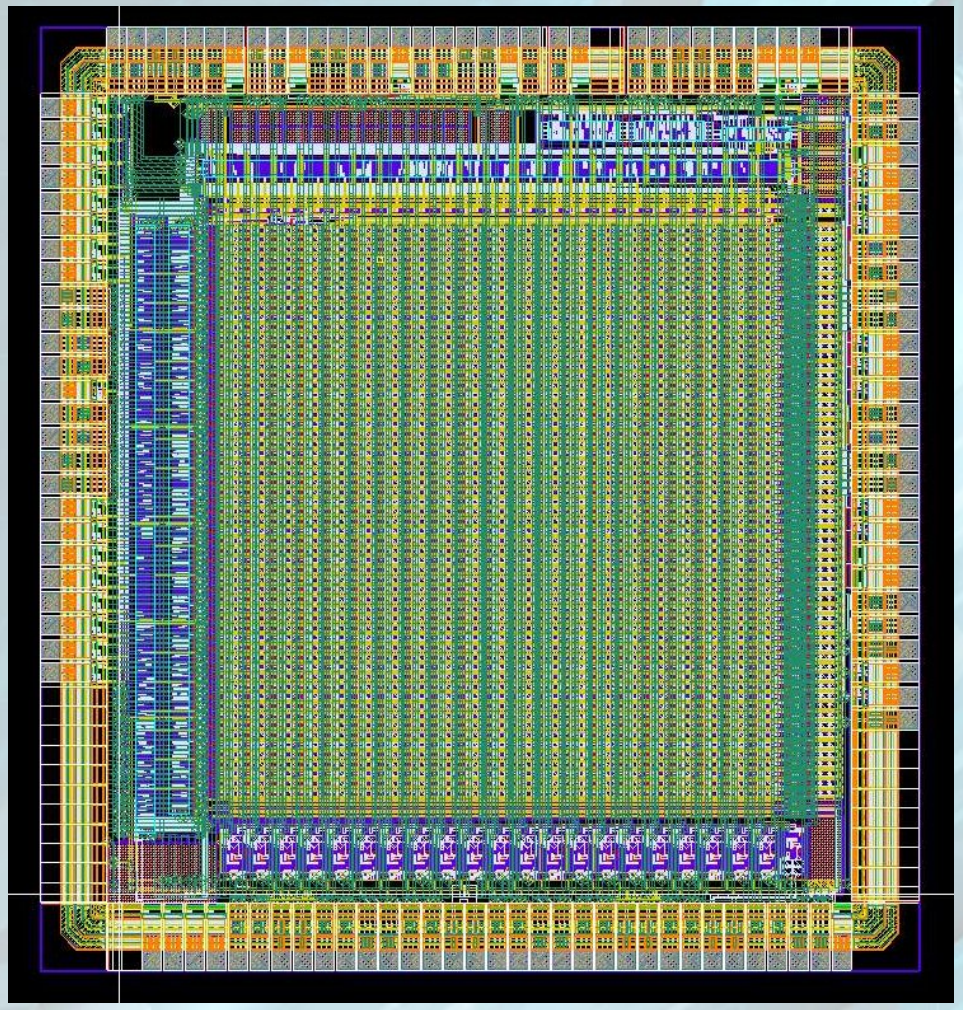






First version: H. Hamrita *et al.*, NIM**A** 531 (2004) 607.

Current digitization: analog pipeline

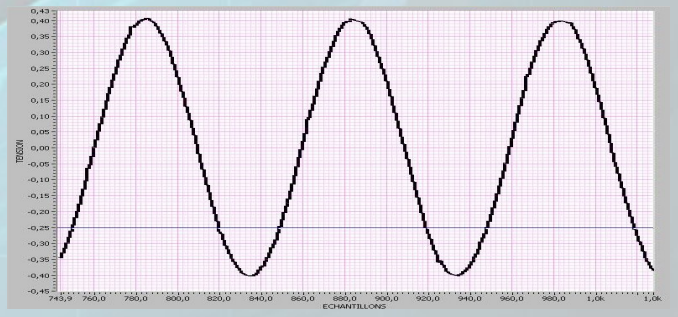


S. Drouet, J.C. Cuzon, P. Edelbruck, E. Wanlin, submitted for publication.

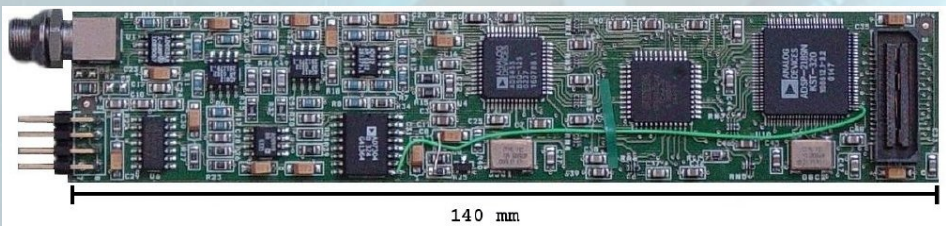
A custom **ASIC** (MAR) has been developed in order to sample the detector current signal with high speed and high resolution

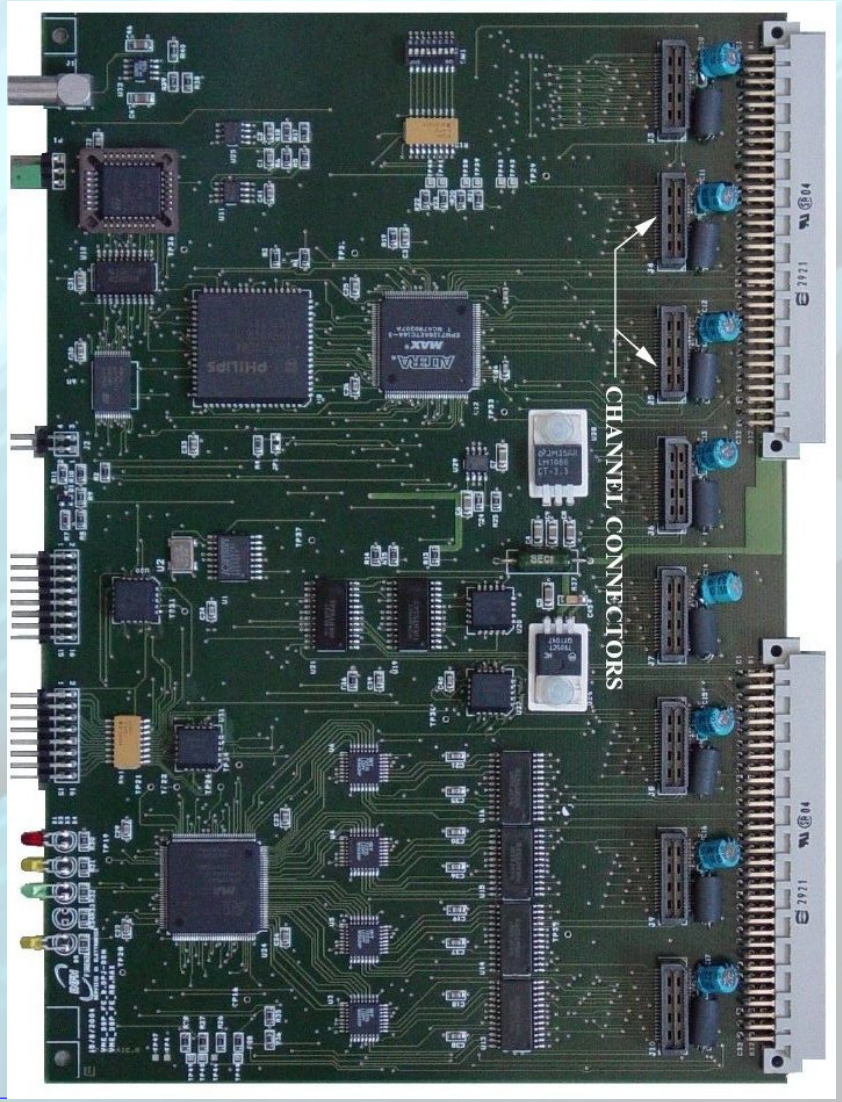
We aim at 2 GS/s – 12 bit conversion, using a low-noise analog pipeline.

The first foundry has been received and tests are under way:



First tests will be partially based on existing hardware:





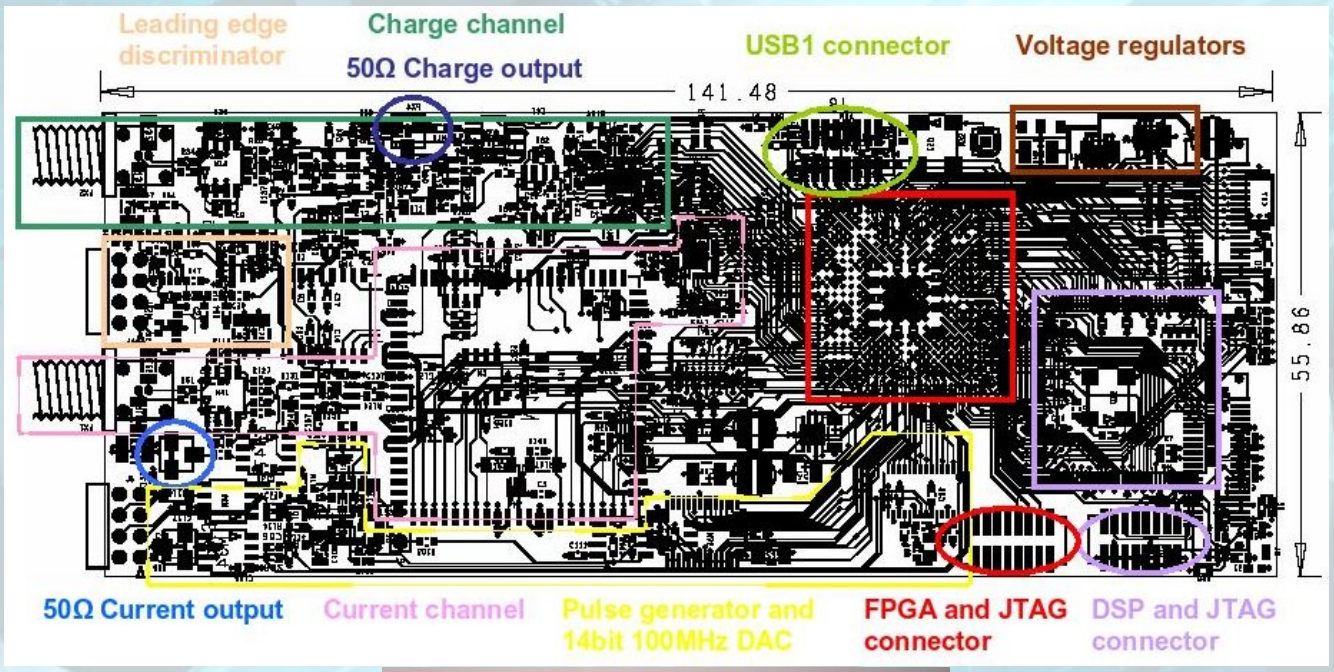
Modular VME digital acquisition system developed in Florence for the NUCL-EX collaboration

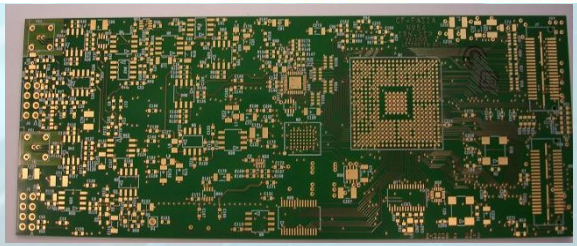
digital sampling + on-line digital signal processing.

G.Pasquali *et al.*, NIM**A**,

doi:10.1016/j.nima.2006.10.008

A new card is under developement including the **MAR ASIC**, **14 bit, 100 MS/s** ADCs, **FPGA/DSP** processing:

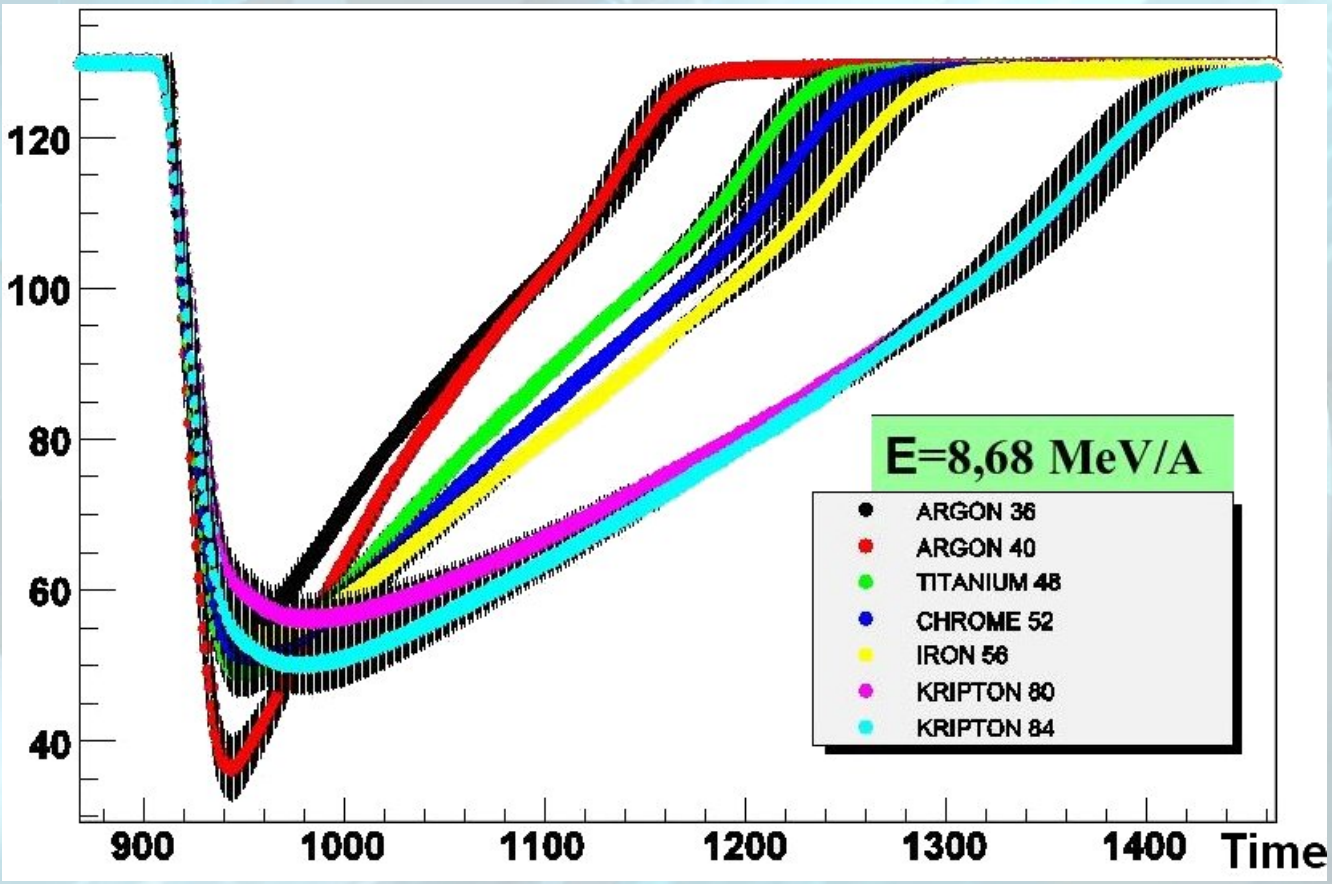




Digital sampling and processing of i and Q signals.

Experimental results: pulse shape in silicon (i)

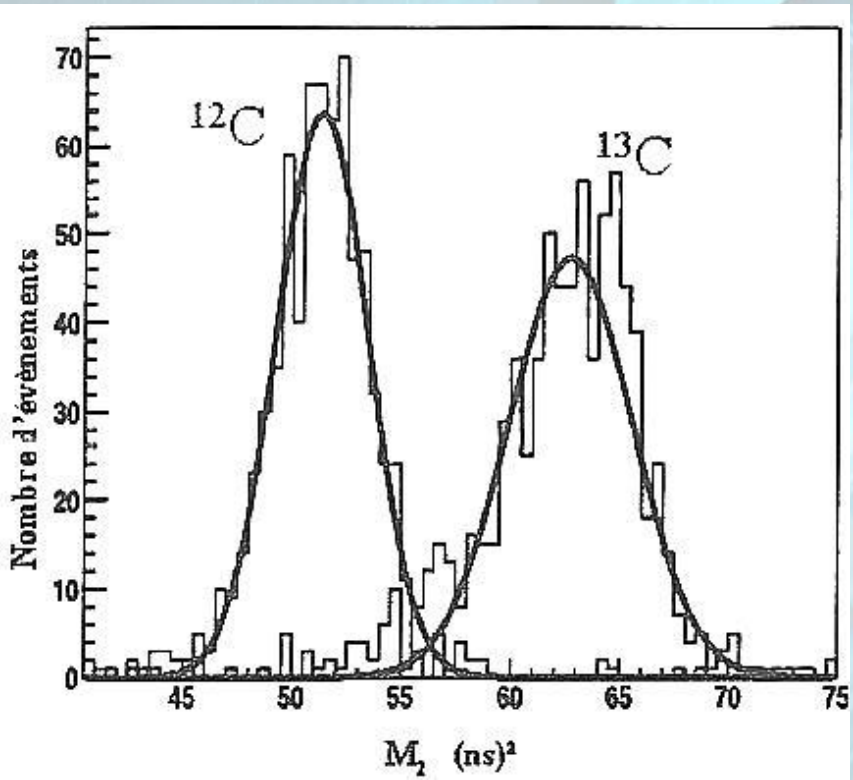
Experimental tests have been performed to study the properties of silicon current signals for heavy-ion identification:

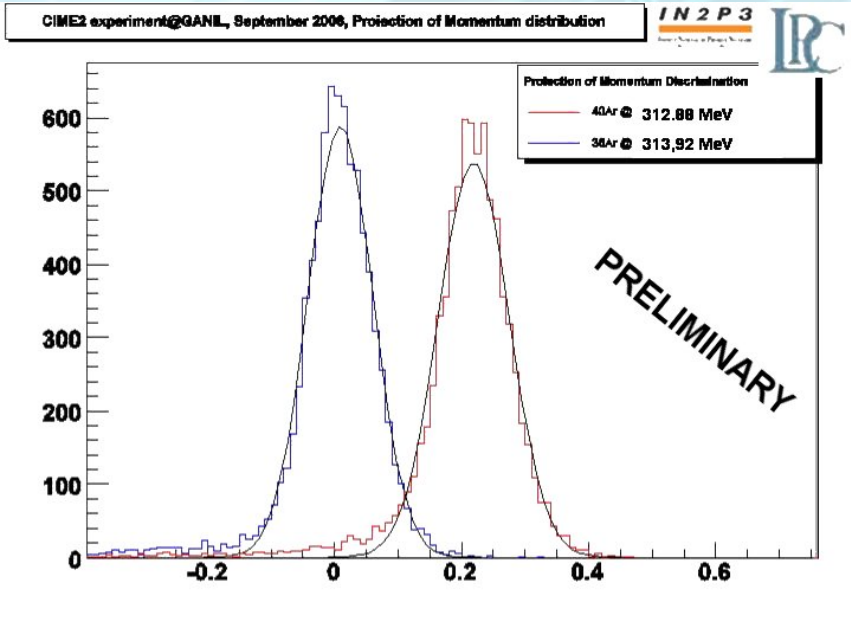


S.Barlini *et al.*

Experimental results: pulse shape in silicon (i)

. . . and identify the detected ions:

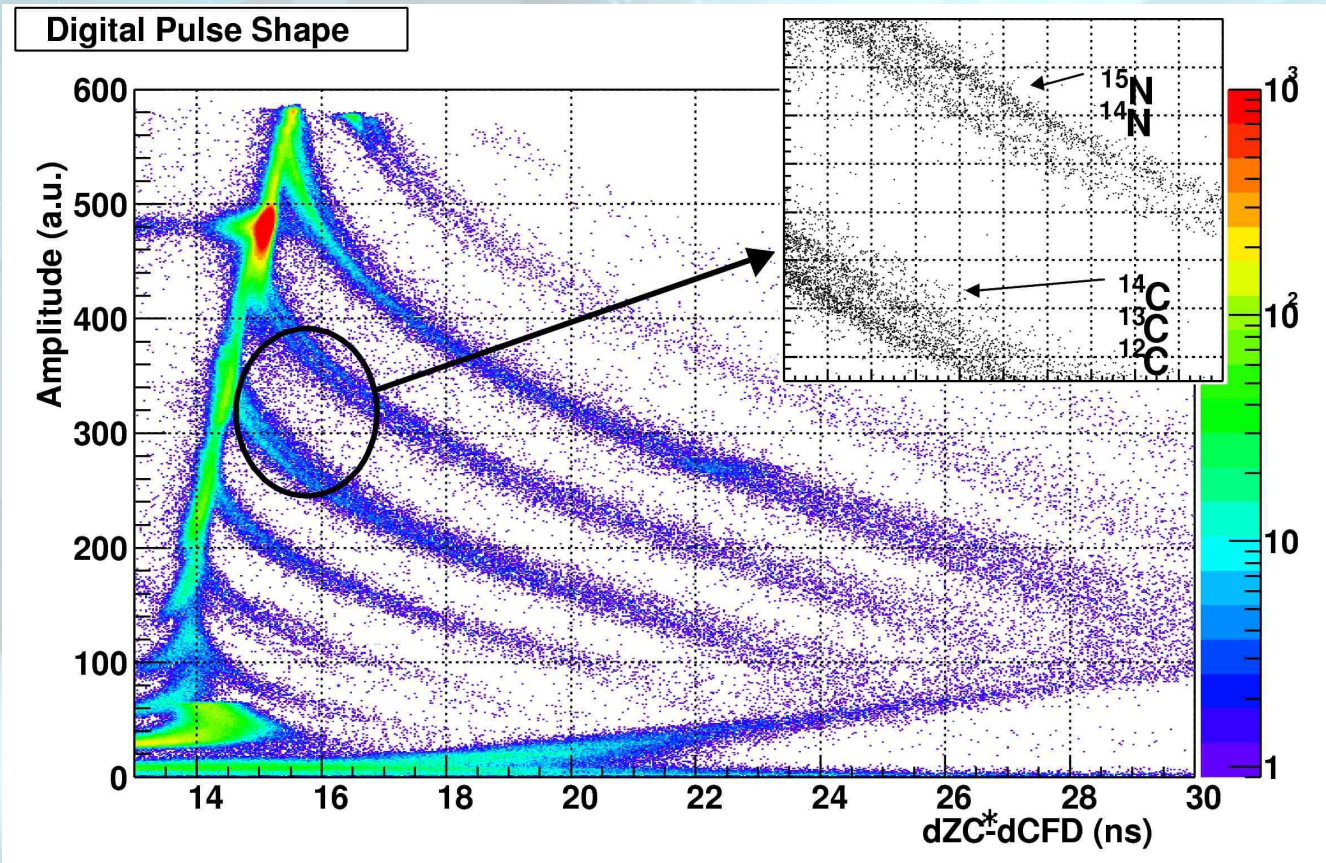




H. Hamrita *et al.*, NIM**A** 531 (2004) 607 and S.Barlini et al

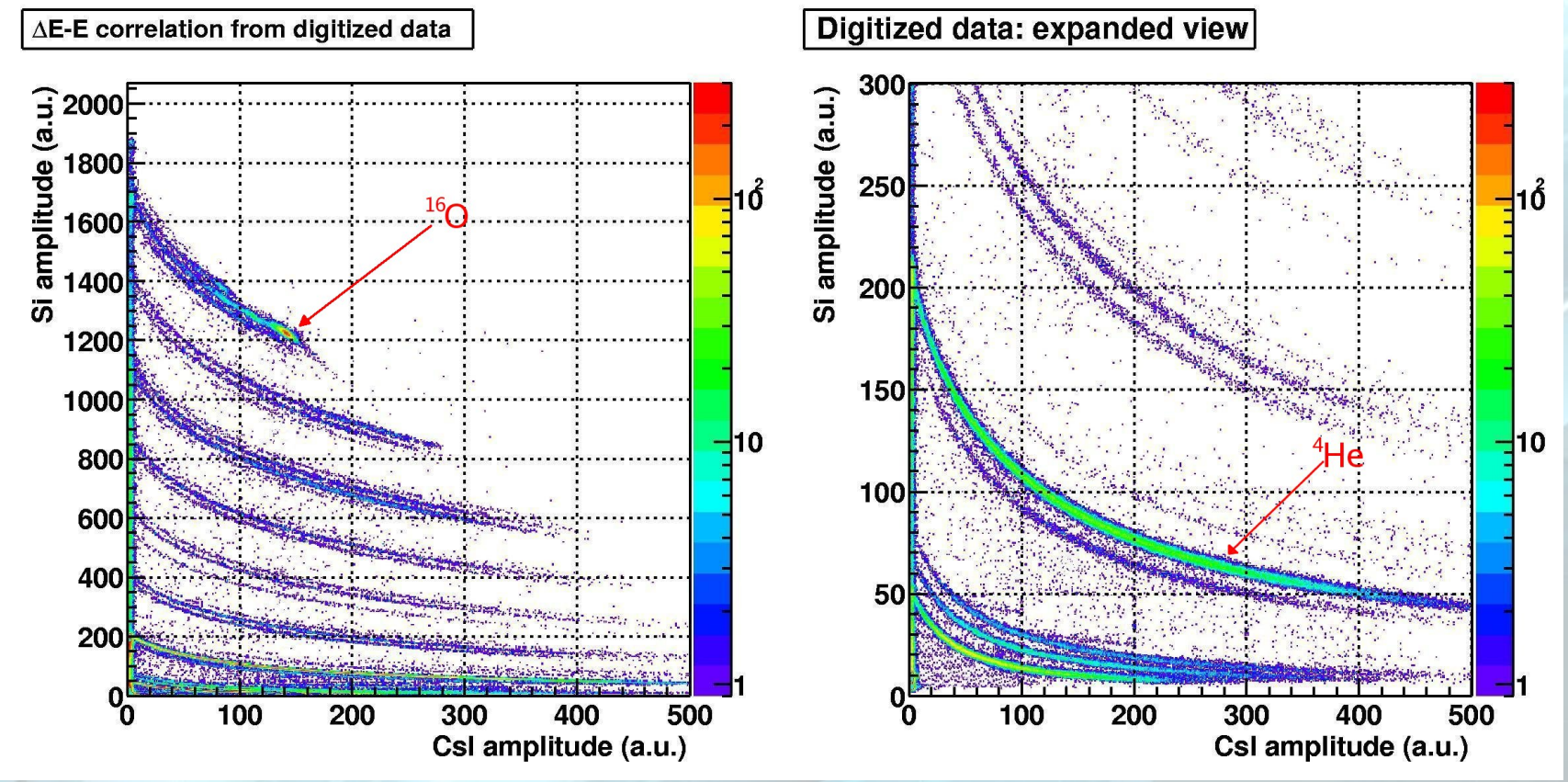
Experimental results: pulse shape in silicon (q)

It is possible to obtain particle identification also by using the charge signal (data obtained with a 12 bit, 100 MS/s digitizer):



L.B. *et al.*, NIM**A** 521 (2004) 480

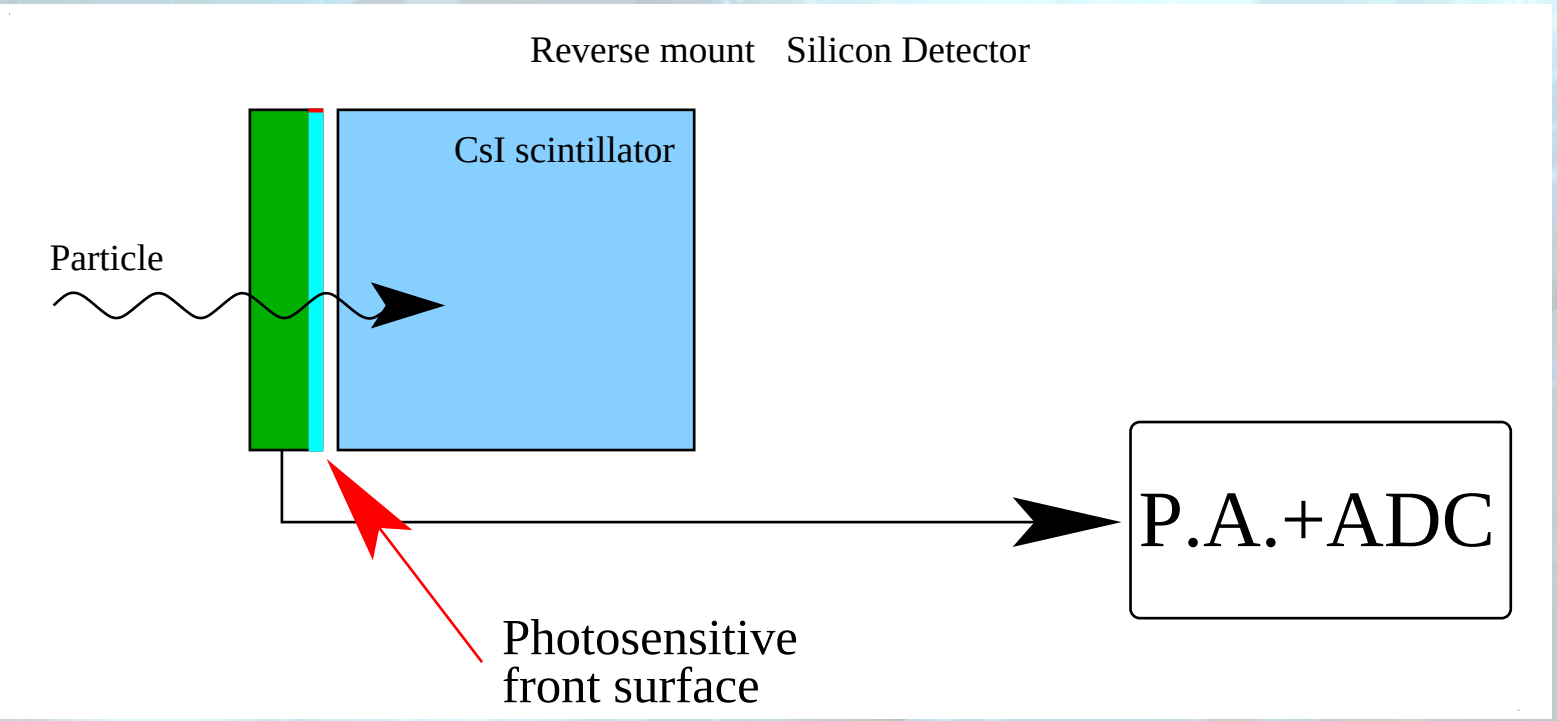
Standard ΔE-E technique with **digital filtering**:



Both pictures have been obtained using a single 12 bit, 100 MS/s digitizer for the ΔE channel.

L.B. *et al.*, NPA 746 (2004) 272

Use the second silicon detector as a photodiode collecting the CsI light:



G.Pasquali *et al.*, NIM**A** 301 (1991) 101

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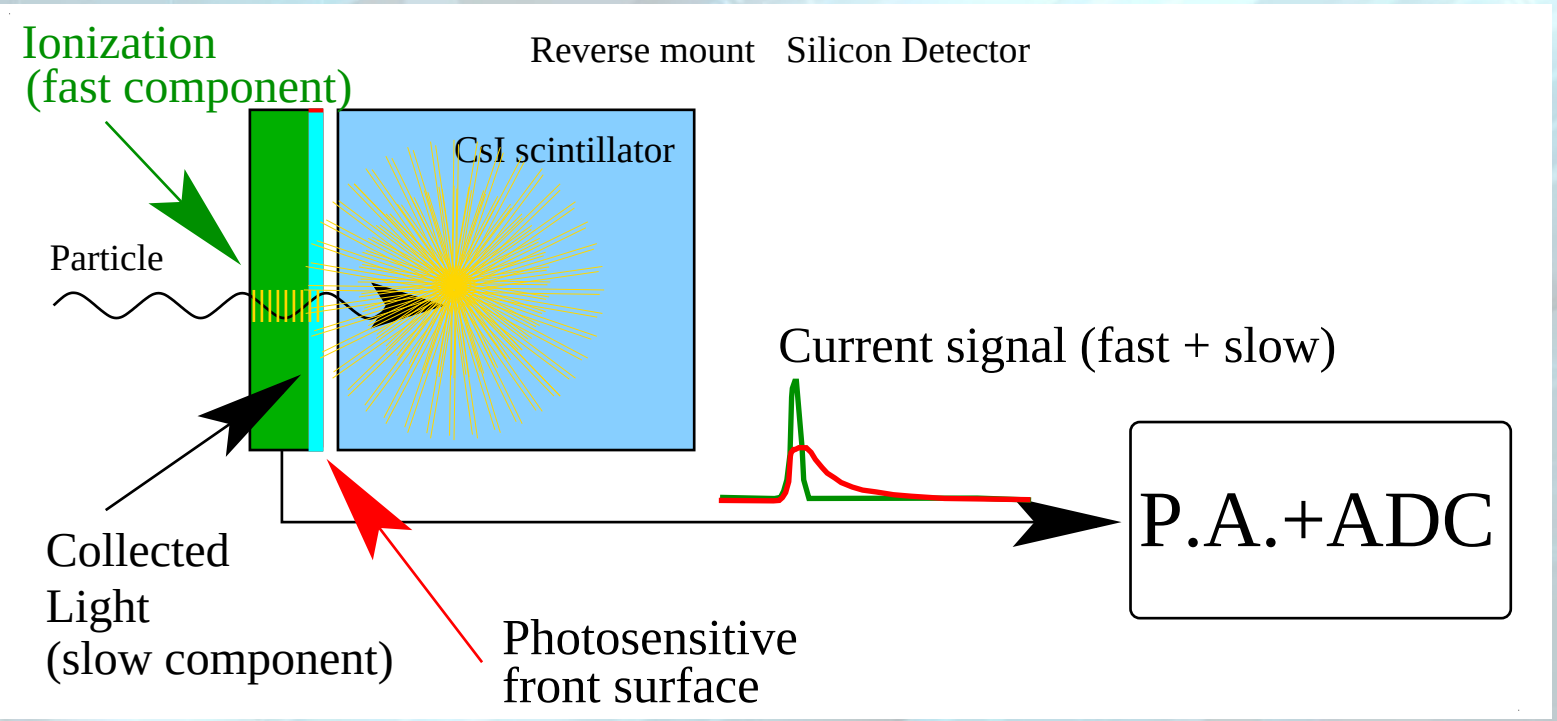
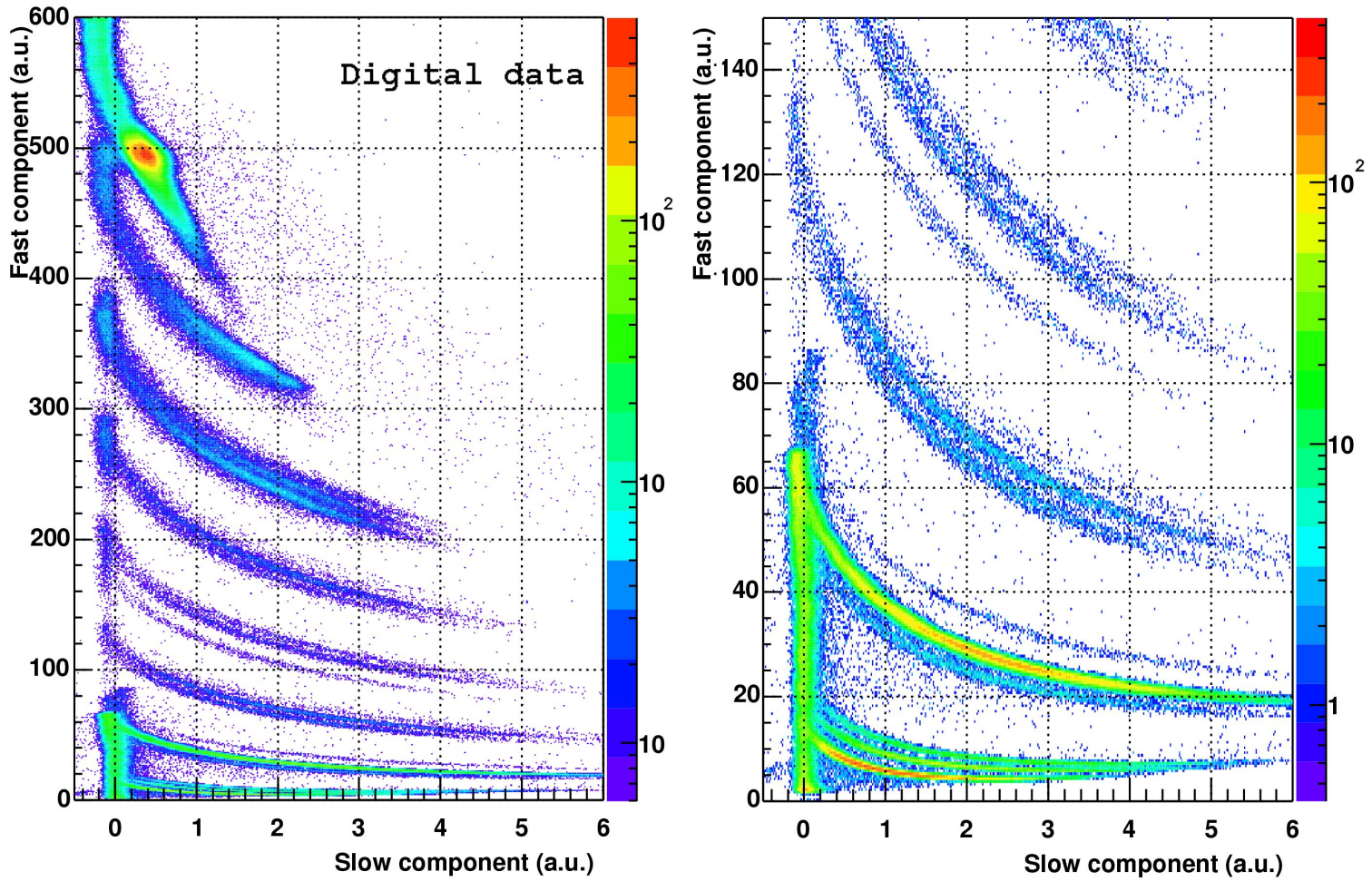


G.Pasquali *et al.*, NIM**A** 301 (1991) 101

The Single Chip Telescope (2)

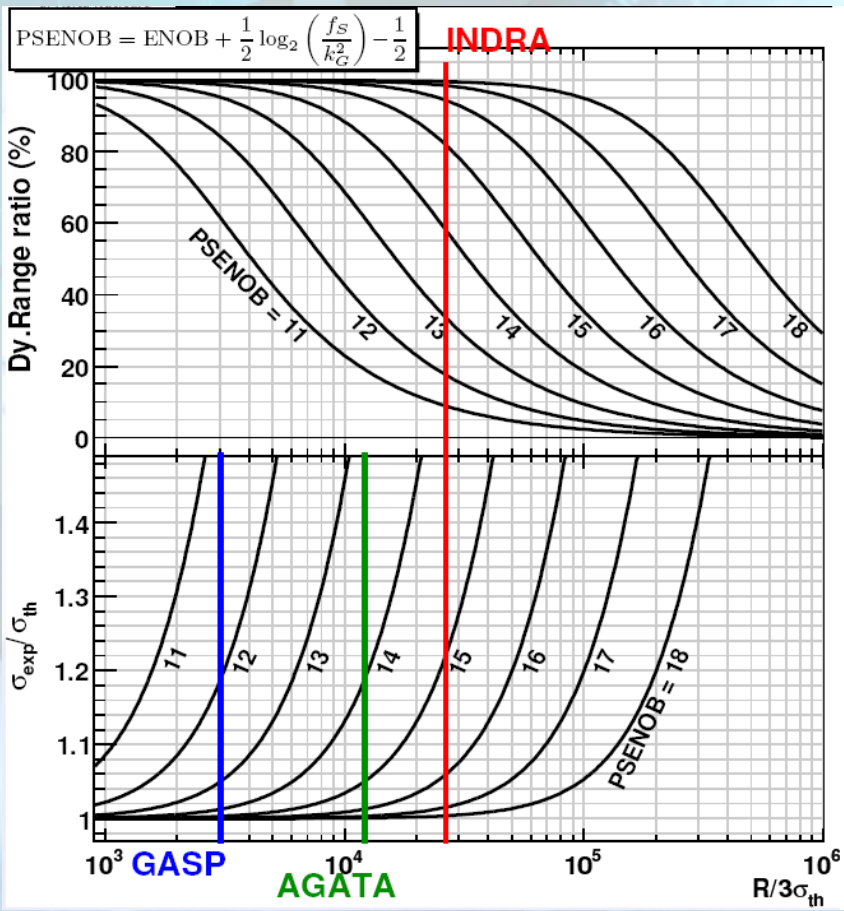
First results with digital techniques are promising:



L.B. *et al.*, NPA 746 (2004) 272

Experimental results: energy measurements

Modern fast digital sampling ADCs allow to widthstand wide dynamic ranges (about 10^4-10^5):

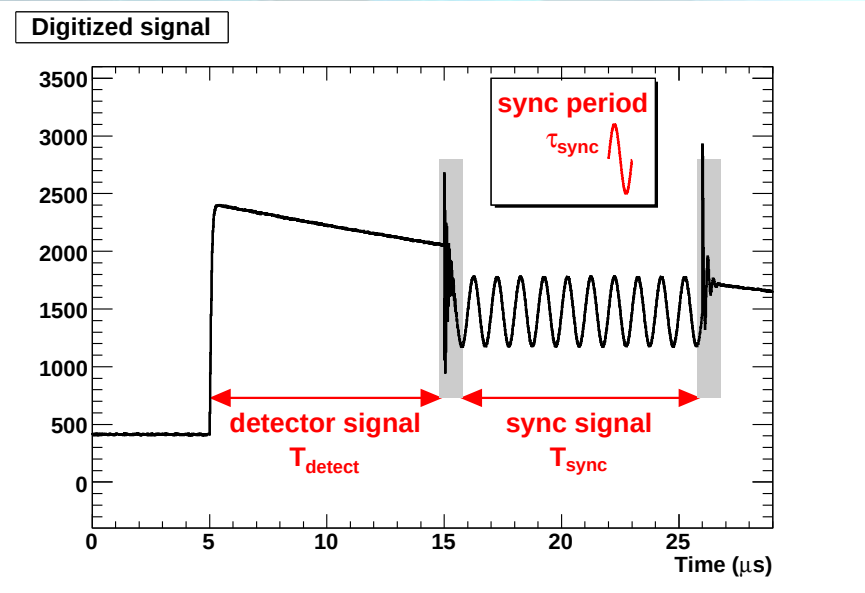


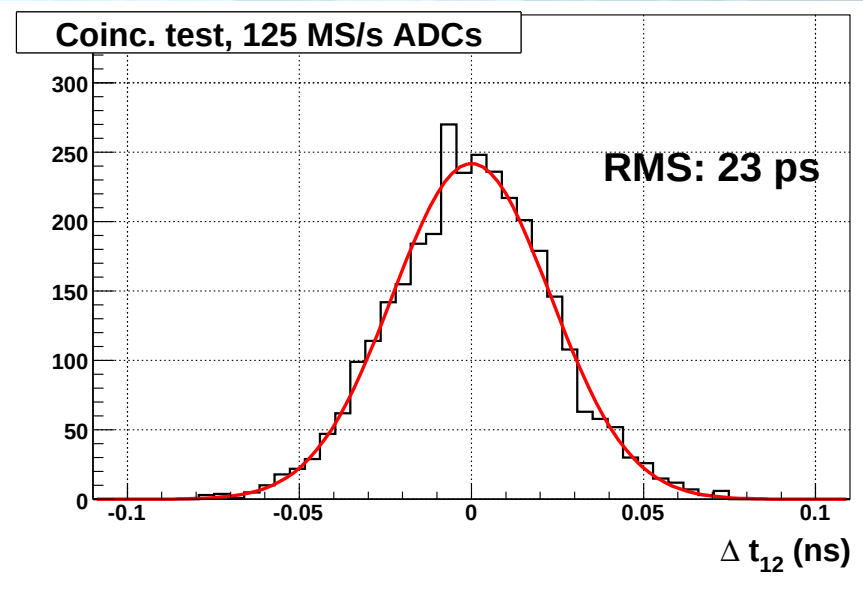
ENOB	B	f_S (MS/s)	PSENOB
12.0	14	100	16.2
10.0	12	400	15.3
10.8	12	100	15.0
10.0	12	200	14.7
7.0	8	2000	13.4

L.B. *et al.*, NIM**A** 560 (2006) 517 and 524

Experimental results: timing measurements

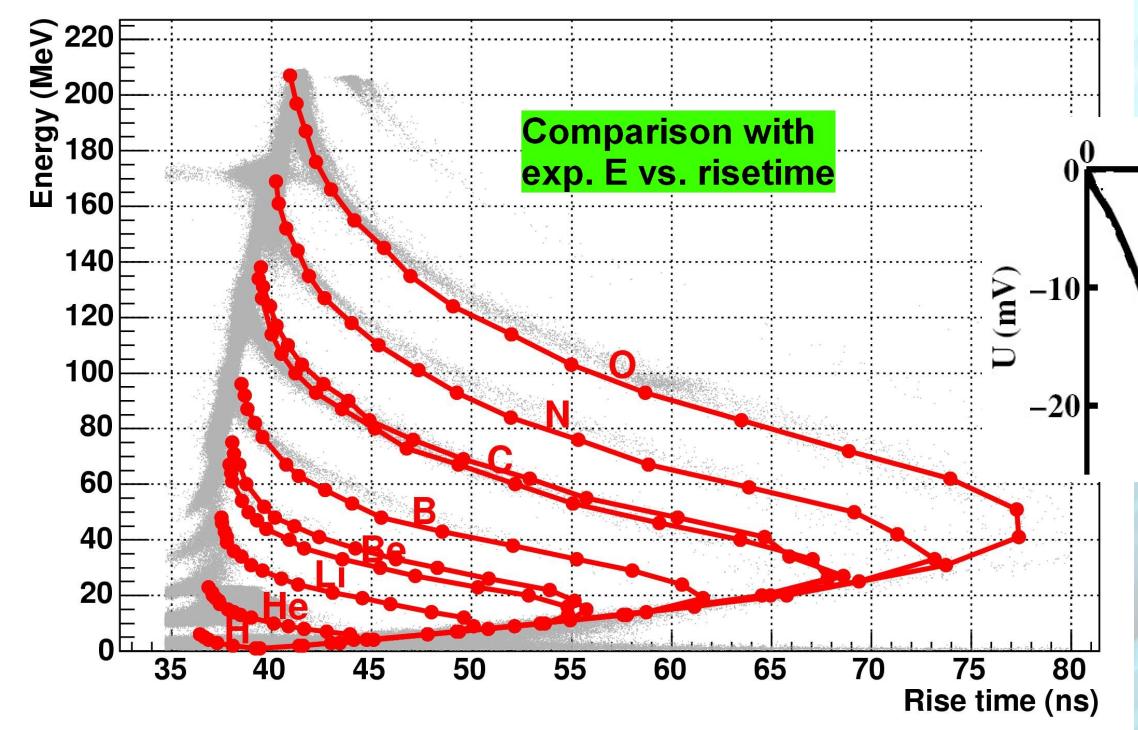
Proper algorithms and interpolation methods, allow to synchronize the various channels and obtain sub-nanosecond timing resolutions:

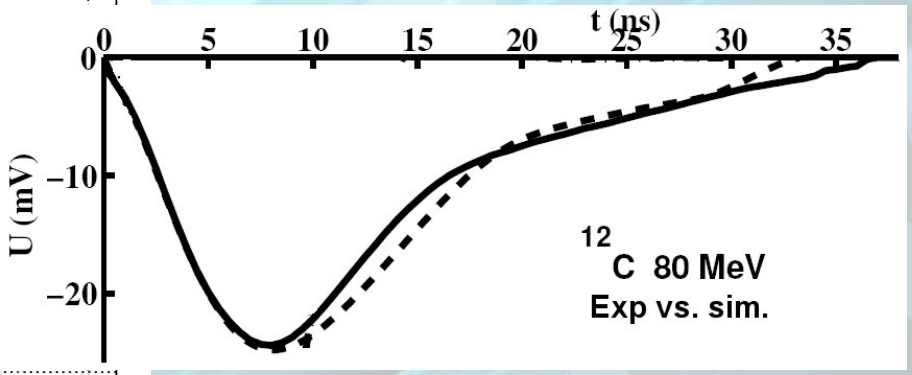




L.B. *et al.*, NIM**A** 521 (2004) 480, and L.B. *et al.* accepted for p. on NIM**A**

Understanding the detector response can aid in the Pulse Shape Identification procedures:

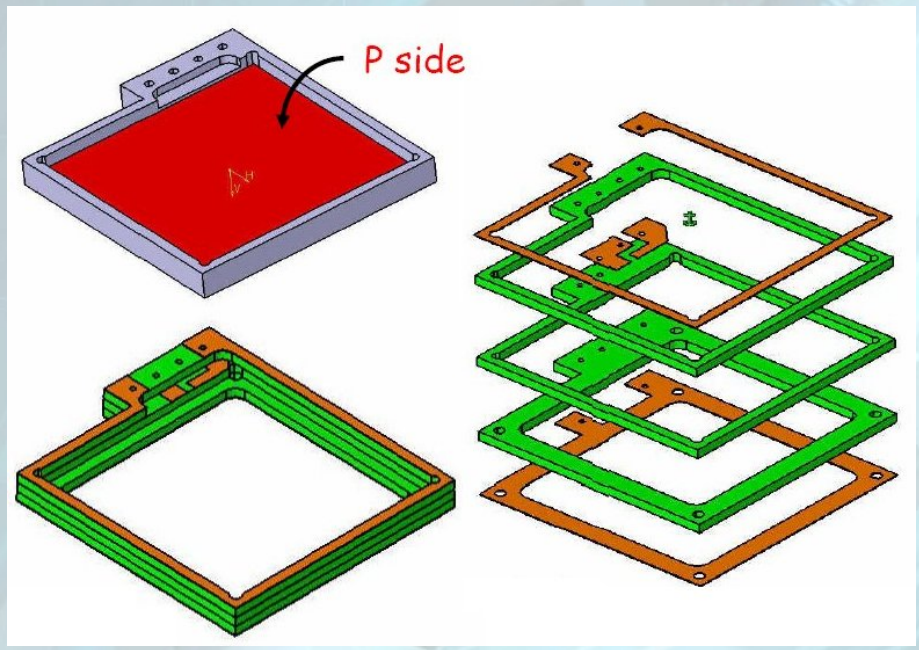


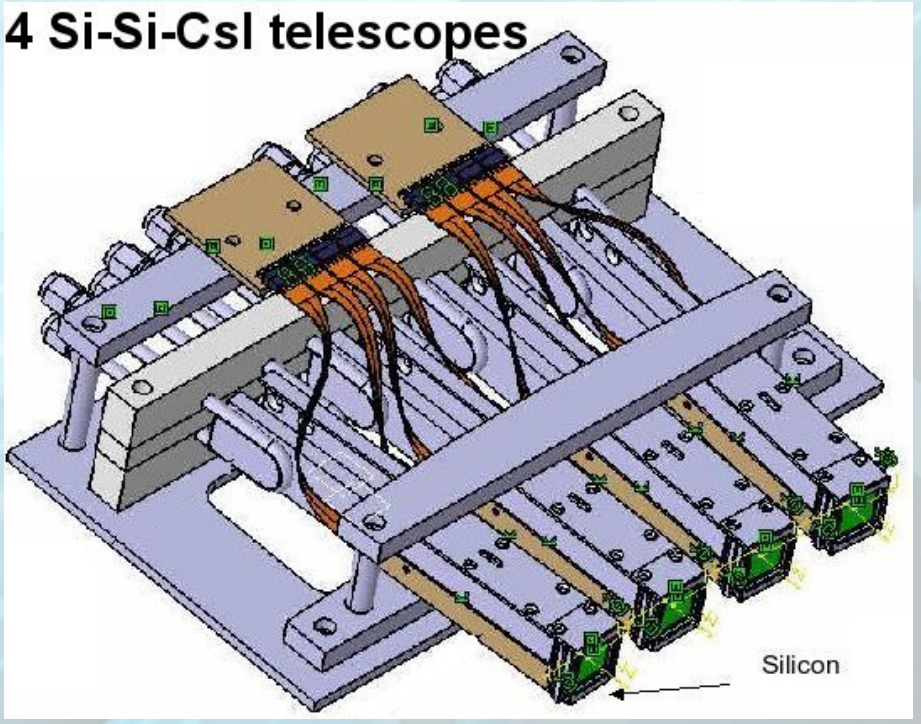


L.B. *et al.*, Proc. of IWM2005, and *in preparation*

M.Parlog *et al.*

New experiments are planned for testing new detectors, new electronics, . . . :

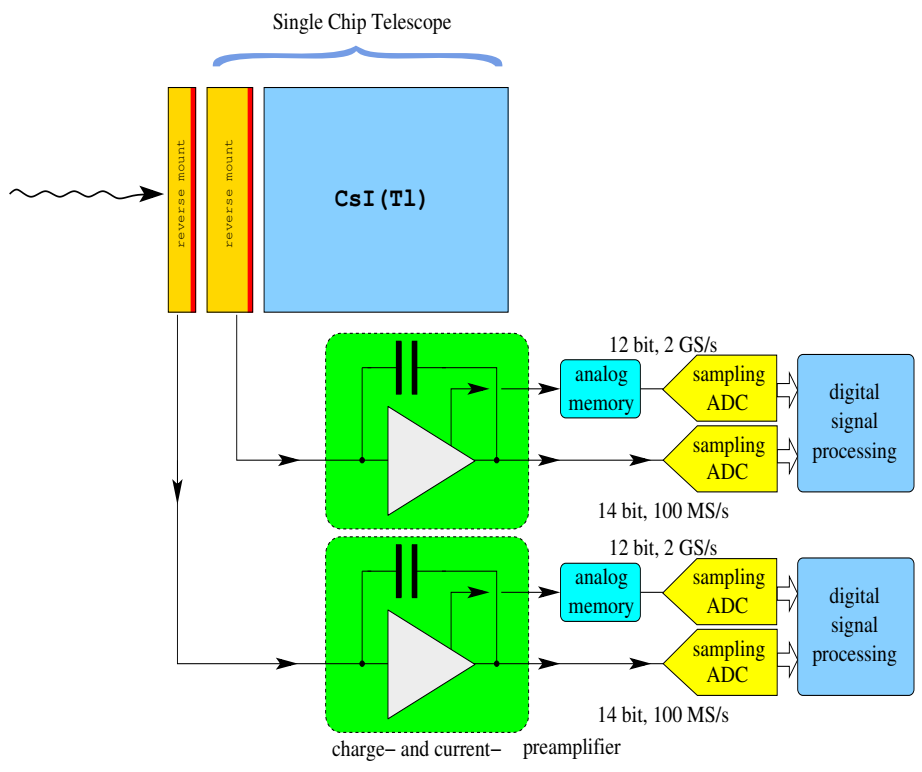


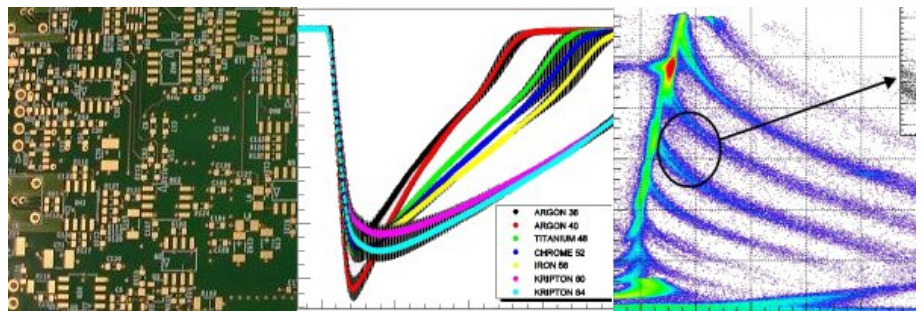


L.Lavergne, J.M.Gautier, *et al.*

The PSA is affected also by channeling, as we have demonstrated in a recent experiment at LNL.

Conclusions





The FAZIA collaboration has started an R&D phase for a next generation 4π array:

- analog and digital electronics
- digital signal processing algorithms
- detector characterization and simulation

aiming at a wide A/Z particle identification range with low thresholds and good E/t resolutions.

Additional info on
`http://fazia.in2p3.fr`


INFN
Istituto Nazionale
di Fisica Nucleare


STVDIORVM · VNIVERSITAS · FLORENTINA


INFN
Istituto Nazionale
di Fisica Nucleare


STVDIORVM · VNIVERSITAS · FLORENTINA