

Camere Monitor per fasci di alta intensità

WP 7 (INFN-RDH) Multi-gap ionization chamber
M 6 (INFN-IRPT) New TERA09 chip development

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INFN e Università di Torino



Rivelatore multi-gap: risultati

- Tesi di Dottorato di L. Fanola Guarachi
- NIM A 798 (2015) 107- 110 (caratterizzazione del readout)
+ articolo in preparazione per risultati si fascio
- Camera doppio gap realizzata da De.Tec.Tor per ELIMED

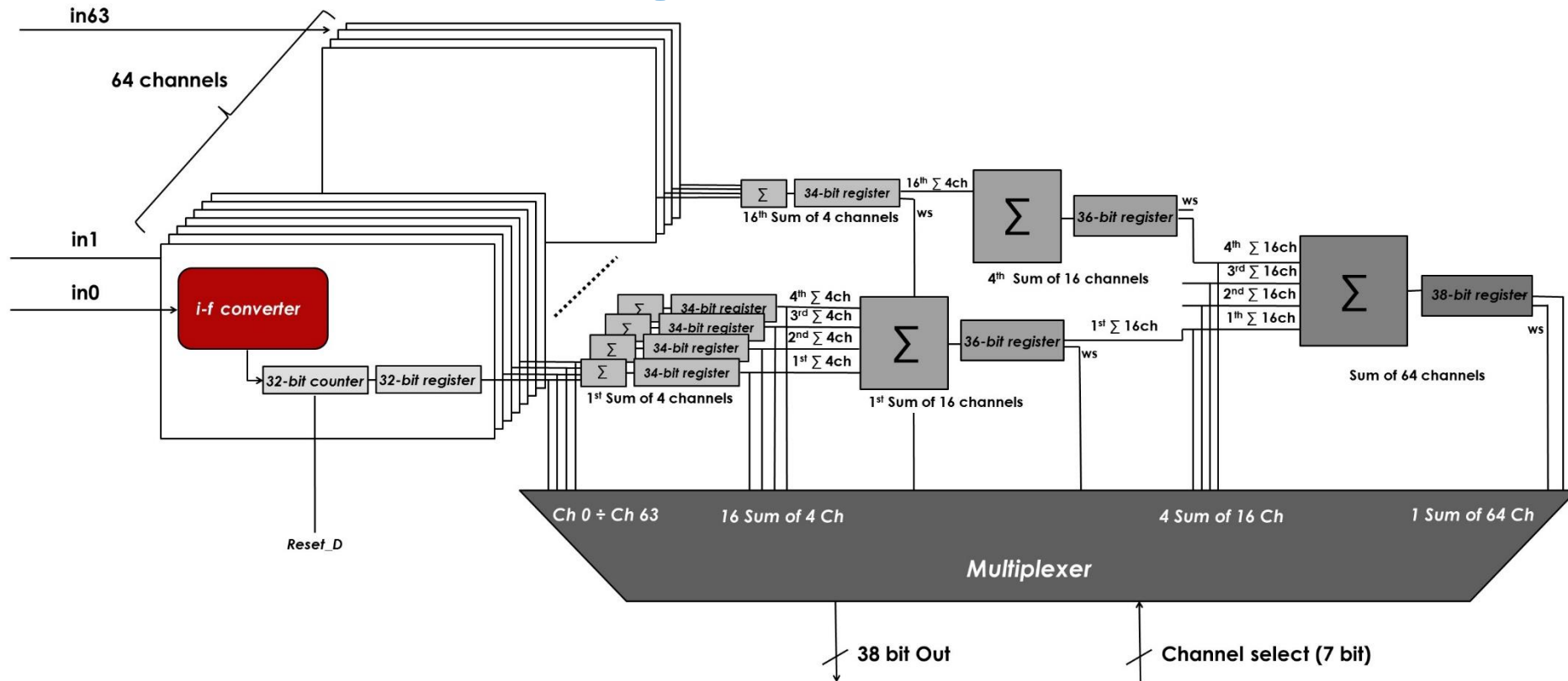


TERA09

Based on the architecture of TERA08:

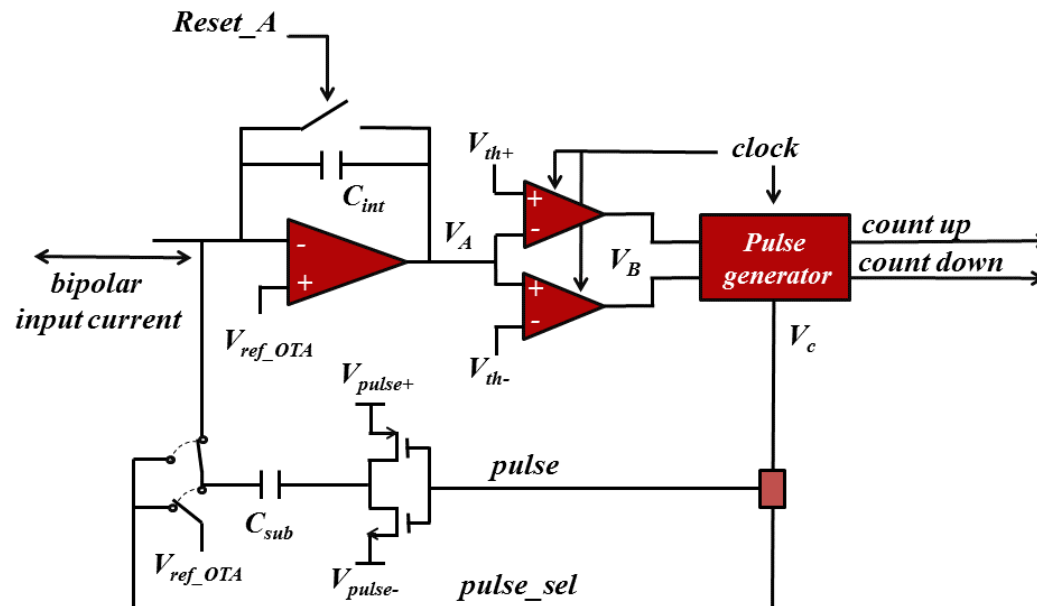
- Same process technology AMS CMOS 0.35 μm
 - Increase clock from 100 to ~ 300 MHz
 - Max count frequency ~ 80 MHz (20 MHz in TERA08)
 - Counters sums are integrated in the chip
 - Max backward compatibility with TERA08
- Development funded through *progetto premiale IRPT* (~ 30 kE)
 - Cooperation agreement signed with De.Tec.Tor S.r.l for the development of the new chip $\rightarrow$ PhD Federico Fausti (~ 65 kE);
 - A joint patent INFN/UniTo/De.Tec.Tor has been submitted;
 - Premio Marconi della SIF 2015 a Federico Fausti (De.Tec.Tor) e Simona Giordanengo (INFN)

Block diagram of TERA09



- Sums of 4, 16, 64 channels provided on-chip
- sums triggered by *latch* signal
- all registers multiplexed to 38 bit output
- half-full register warning signal provided

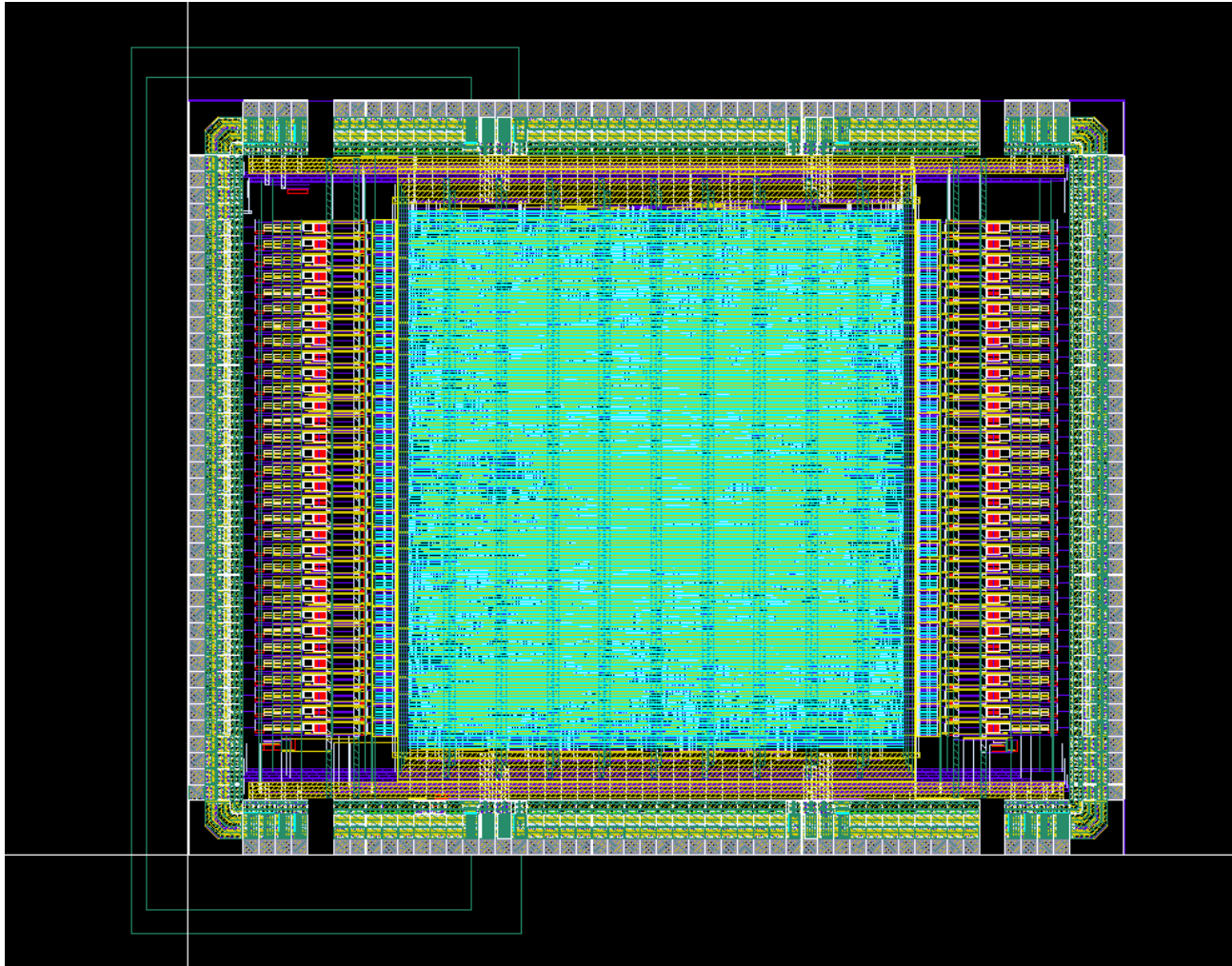
The current to frequency converter



Compared to TERA08

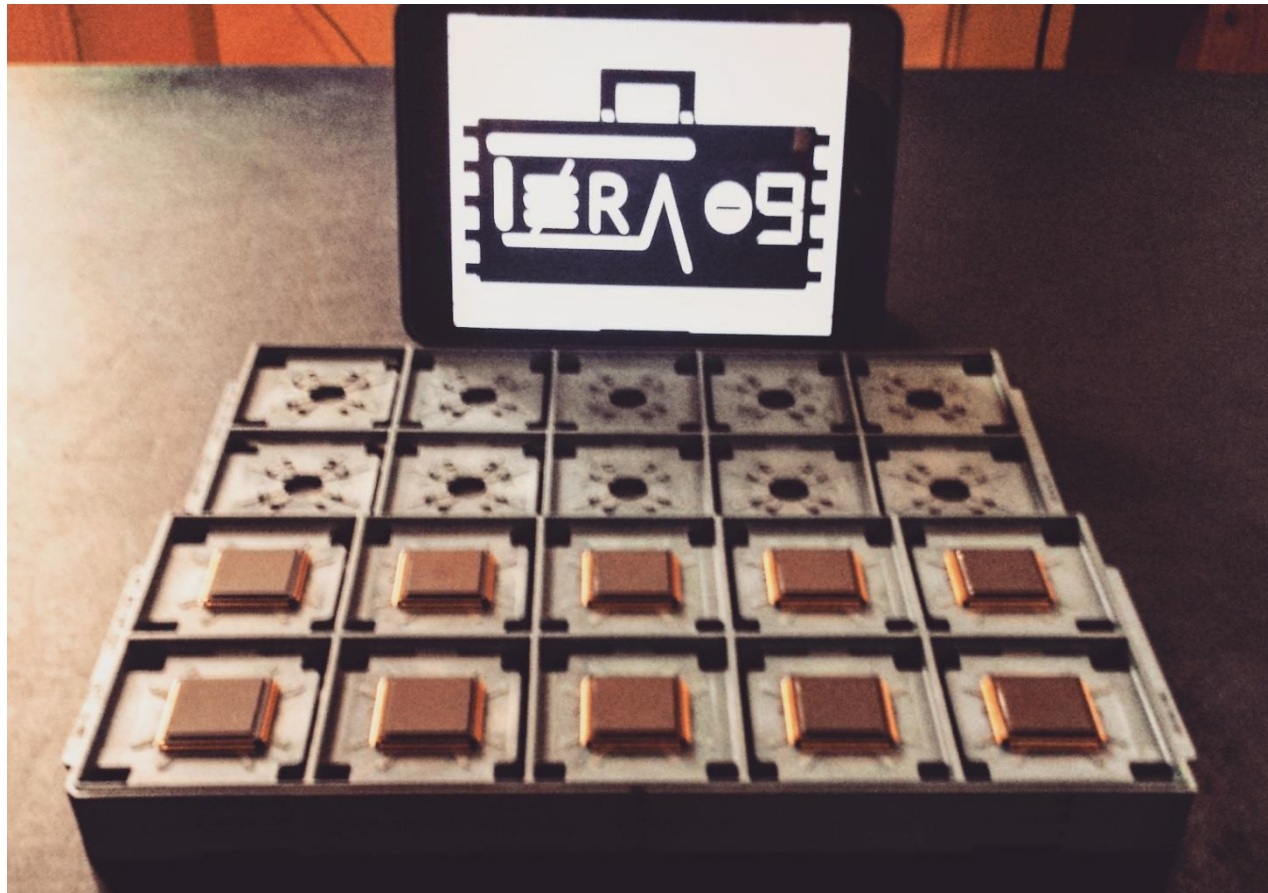
- feedback capacitor C_{int} 600fF $\rightarrow$ 1,2 pF
- OTA bias current 200 μ A $\rightarrow$ 800 μ A
- clock cycle saved in the FSM, single 200 fF C_{sub}
- charge quantum 50 $\div$ 660 fC
- post-layout simulations 100 MHz $\rightarrow$ 320 MHz clock

Layout TERA09



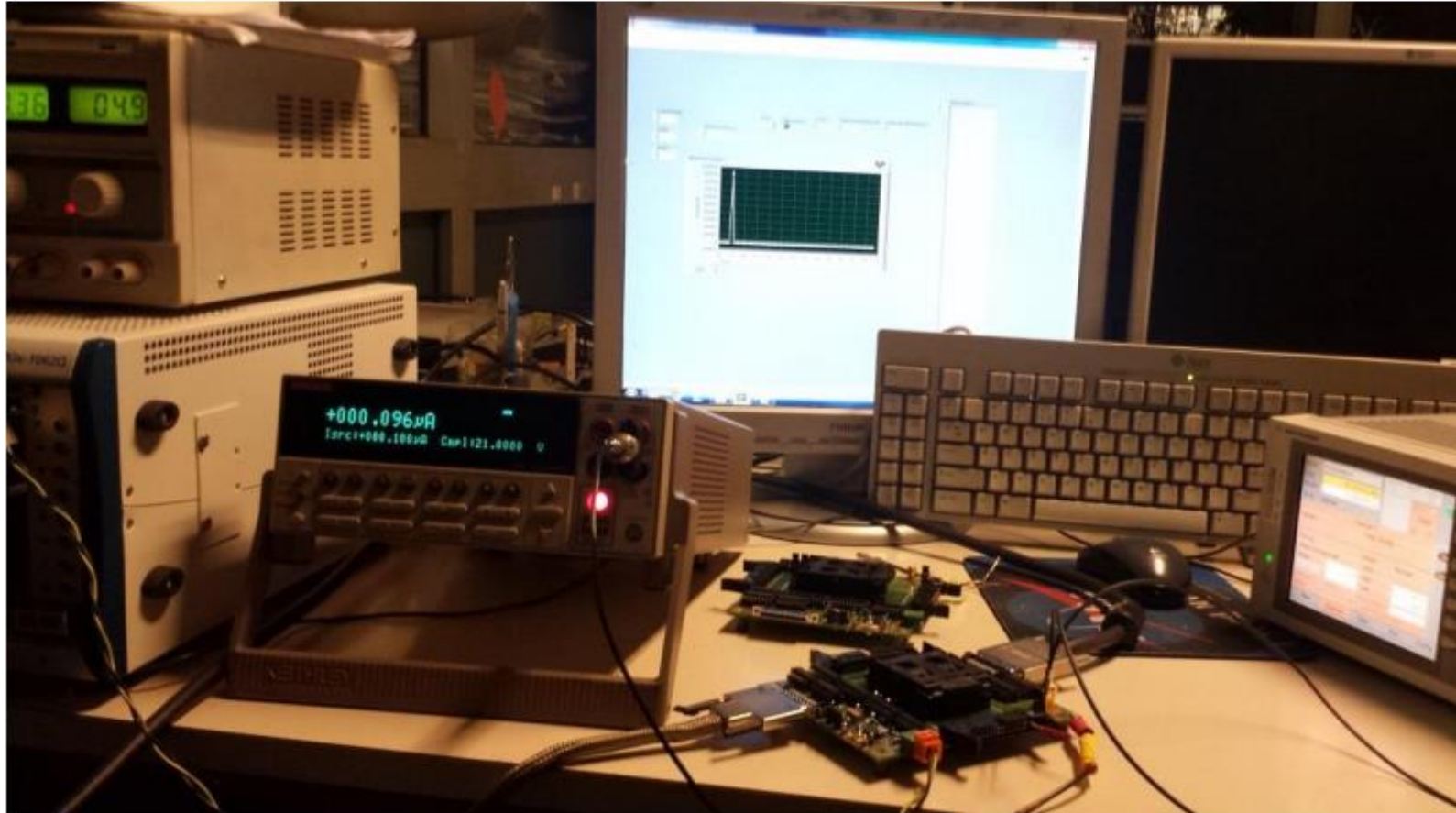
Size 4.68 x 5.8 mm²

TERA09 (23/11/2015)



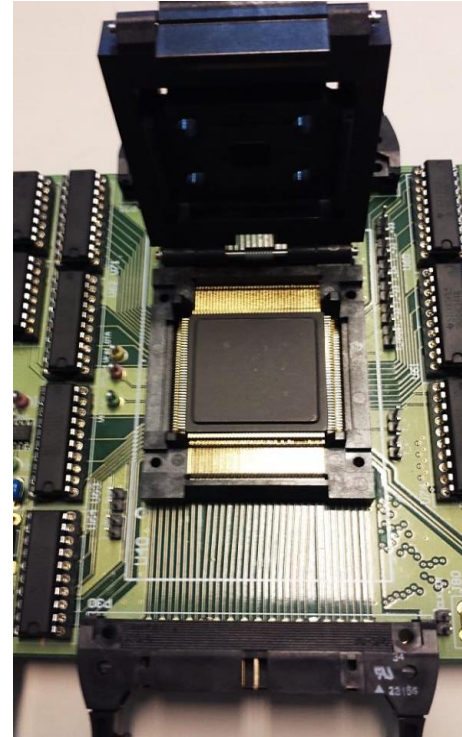
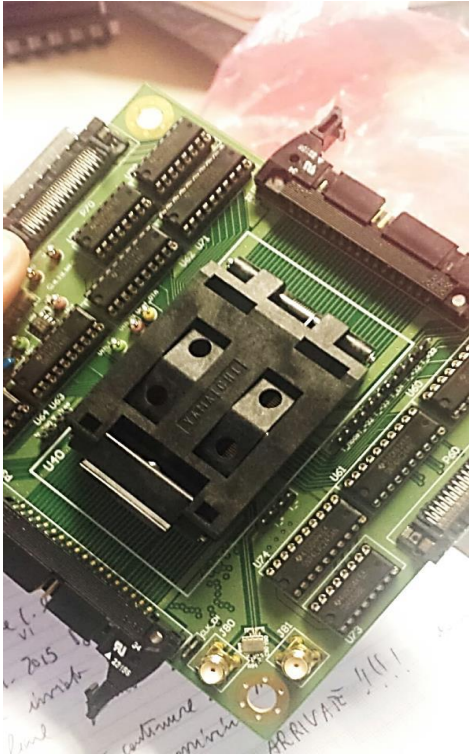
- Multiproject run through Europractice
- 40 chips delivered (MQFP 160 package)

TERA09 test setup



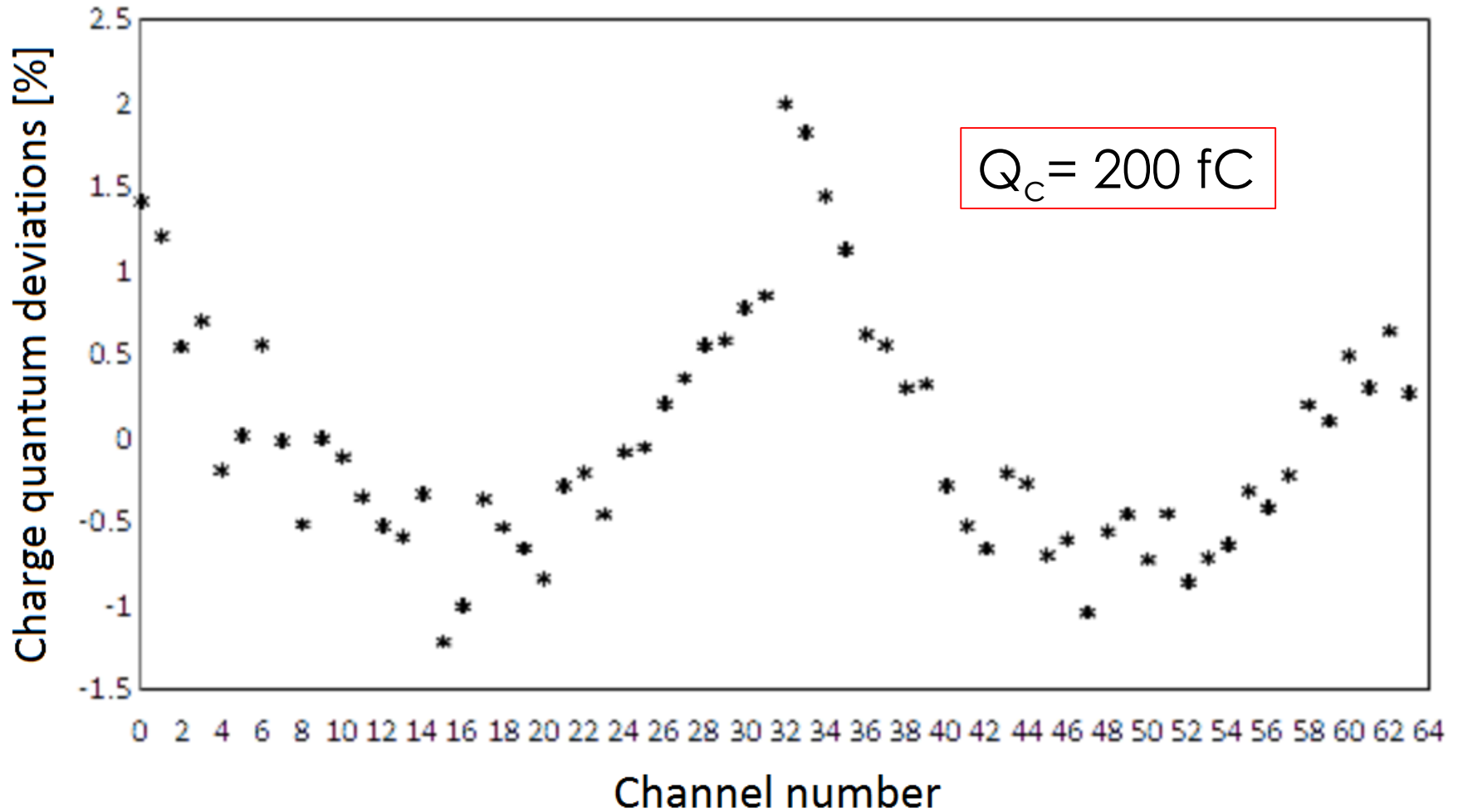
- NI PXI system with 7813R FPGA board, LV software
- Keithley 2400 current generator
- Test board with chip mounting socket

TERA09 Test board



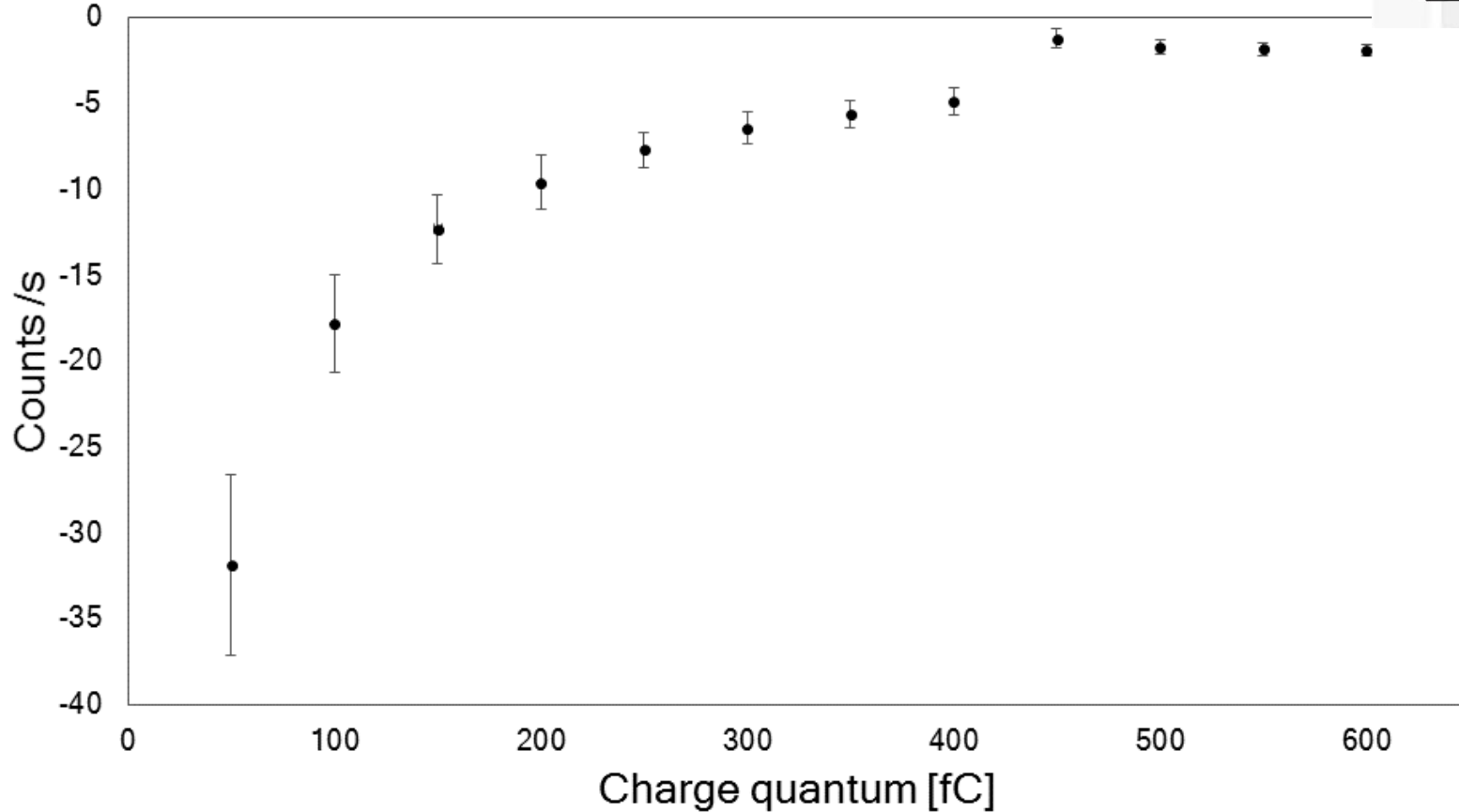
- Low quality design, cross talk between clk and digital signals
- Problems occurring at clk frequencies above 280 MHz
- Tests performed at 250 kHz
 - > max count frequency 62.5 MHz (cf. 80 MHz design)
 - > 20% reduction in dynamic range compared to design

Gain uniformity vs channel



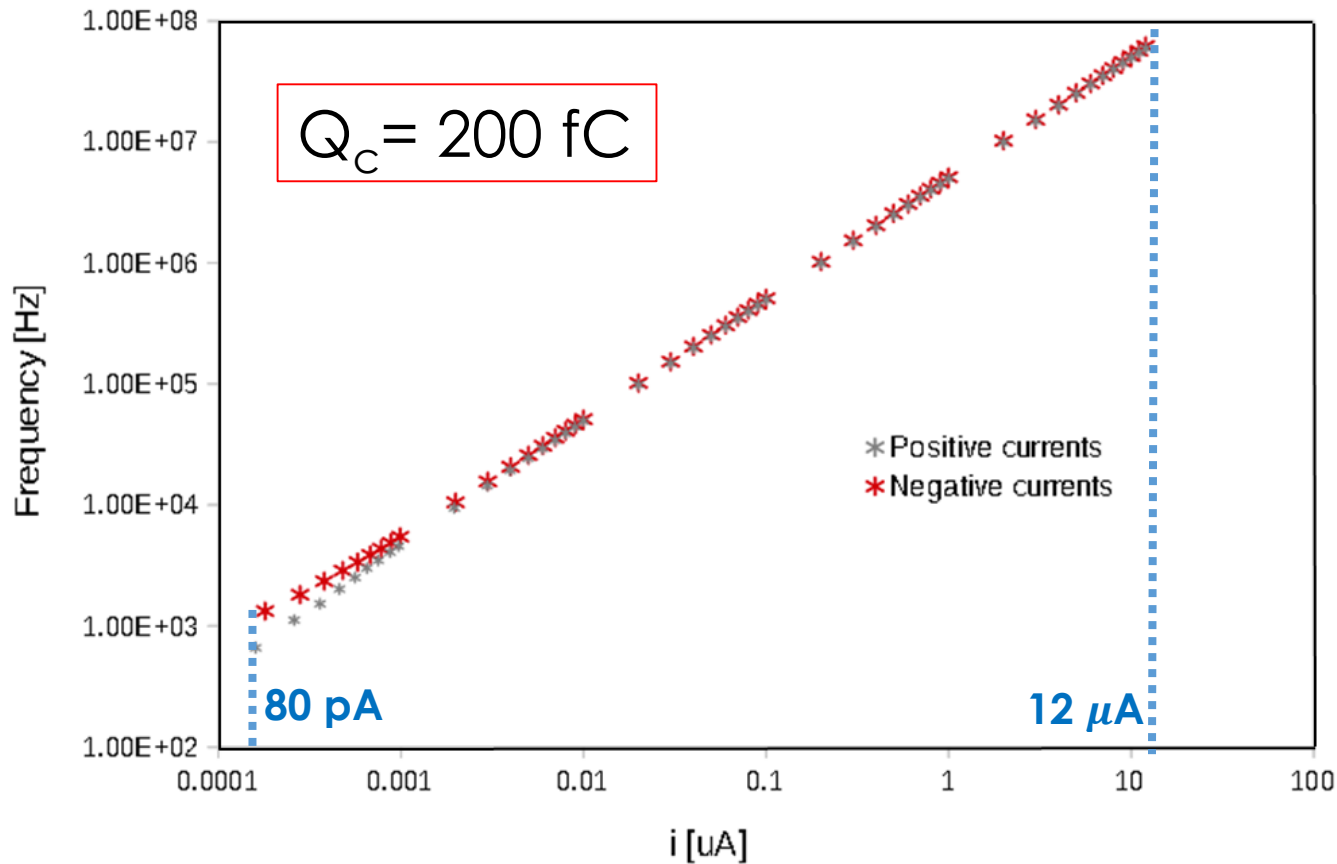
Gain uniformity across channels $\pm 1,5 \%$

Background current



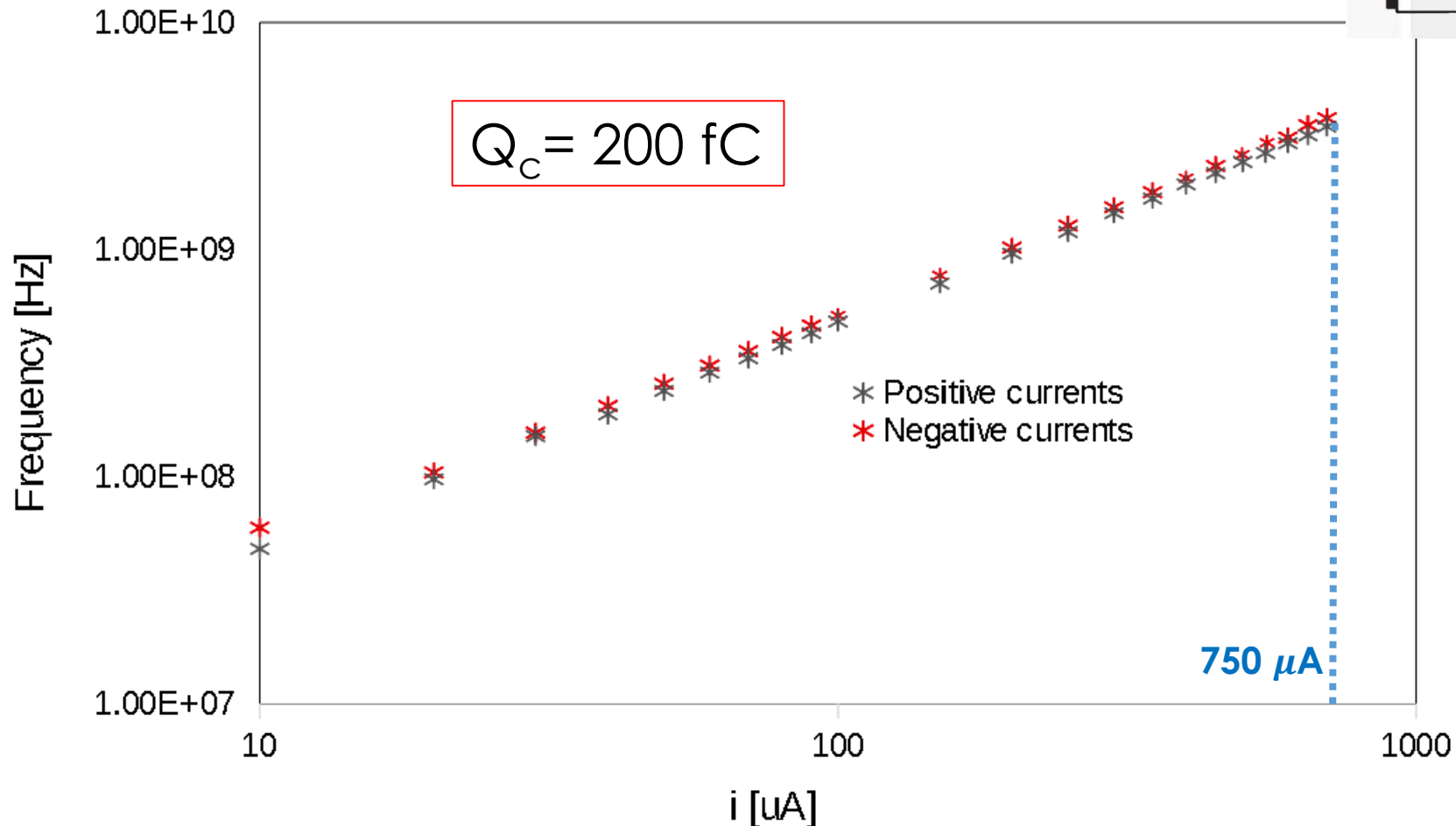
- at 200 fC, ~ -10 counts/s ($\rightarrow 2$ pA)
- approx. 2 orders of magnitude smaller than minimum current in clinical applications (1% pedestal subtraction)
- ... but a factor 10 larger than TERA08

Linearity 1 ch.



- Deviations from linearity smaller than 1 % in most of the range
- deviations increase at low current (above 2% for $i < 3 \text{ nA}$)
- TERA08: max deviation 1,5% between 500 pA and $3 \mu\text{A}$

Linearity 64 ch.



- Deviations from linearity smaller than 3 % up to 750 μA
- increase in dynamic range compared to TERA08 of more than 2 orders of magnitude

Conclusions



- Design goals met with first chip prototypes
- Problems to reach the design clk frequency and degraded performance at low currents possibly due to a lousy test board

Outlook

- Test of resistance to SEU scheduled in March at LNL
- Design of TERA09 front-end 2 chips board in advanced stage c/o De.Tec.Tor.
- 25 chips sold to De.Tec.Tor at the production costs
- Agreement for royalties for commercial use of TERA09 in discussion with TT
- TERA09 will equip the monitor chambers for the new biophysics facility at GSI
- IRPT remaining budget for microelectronics developments for MOVE_IT

Consuntivi 2016

- **Patent** “Disposizione circuitale per acquisizione di segnali da un apparato per la misura di fasci di particelle cariche per radioterapia esterna” submitted num. 102015000022390. Inventors RS, G. Mazza and F.Fausti, acquired by De.Tec.Tor
- **Talk** of F. Fausti at Prime 2016 Conference
- **Proceedings** on IEEE Xplore
<http://ieeexplore.ieee.org/document/7519529/>
- **NIM Paper** «Design of a 64 channels current-to-frequency converter ASIC, front-end electronics for high intensity particle beam detectors” accepted for publication
- **Milestone** 31-12-2016 «progetto, sottomissione, test e caratterizzazione completa del secondo prototipo TERA09»



Workshop on Innovative Delivery Systems in Particle Therapy

23-25 February 2017 *Molecular Biotechnology Center, Torino*
Europe/Rome timezone

Overview

Scope and Topics

List of Speakers

Timetable

Contribution List

Registration

Registration Form

List of registrants

Registration Fee and
Payment instructions

Venue & Travel
information

Accommodation

Maps

✉ Organization

The workshop will take place on the 23th and 24th of February at the **Molecular Biotechnology Center** of the University of Torino, and on the 25th at the **CNAO National Center of Oncological Hadrontherapy** in Pavia. The program of the workshop will begin on Thursday 23 at 13:30 and will close on Saturday 25 at 12:00 with a guided tour to the CNAO. Bus transportation to Pavia and return will be provided for all the participants.

Presentations of 20 minutes duration (+ 10 min. discussion) will focus on the state of the art and on the new developments of dose delivery systems for Particle Therapy.

Sponsors

The Workshop is organized in the framework of the Accelerator Application Network Activity (Workpackage 4) of the EuCARD-2, a project to foster knowledge of the applications capability of accelerators co-funded by the European Commission under the FP7 Capacities Programme.



UNIVERSITÀ
DEGLI STUDI
DI TORINO

Dates: from 23 February 2017 12:30 to 25 February 2017 16:00

Timezone: Europe/Rome

Location: *Molecular Biotechnology Center, Torino*
Via Nizza, 52 - 10126 Torino
Room: Copernico