

# Development of a beam hodoscope based on scintillating fibres for spatial and temporal labelling

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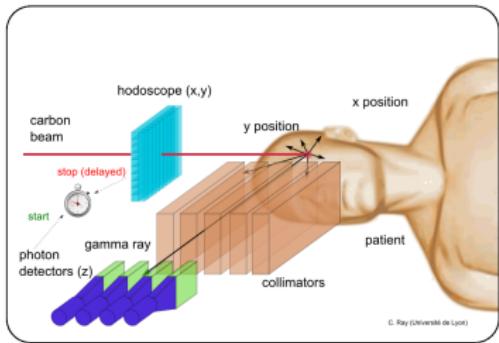
<sup>1</sup>IPNL, <sup>2</sup>K.U. Leuven,

Journée de réflexion sur la Tomographie Proton  
14 novembre 2012  
CPPM Marseille

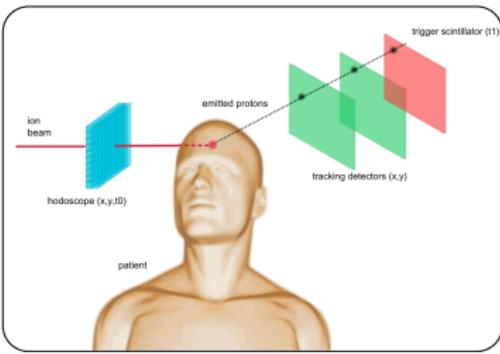


## Usage of the hodoscope

## Collimated camera



IV



goal

- ▶ transversal beam position
  - ▶ timing information (TOF)

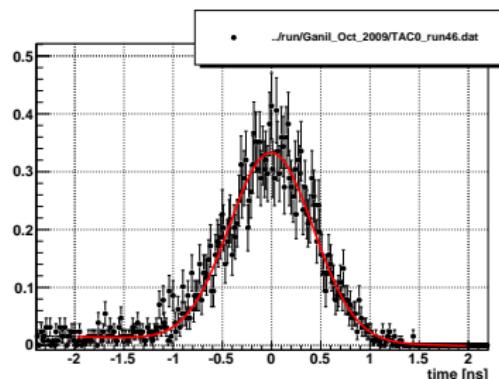
# Hodoscope: hardware

- ▶ scintillating fibres  
( $1\text{ mm} \times 1\text{ mm}$ )  
BCF10 or BCF12
- ▶ 2 prototypes:  $2 \times 32$   
and  $2 \times 128$  fibres
- ▶ coated optical fibre  
FORETEC
- ▶ 64 channel PM:  
**MCP-PMT XP-85012**  
PHOTONIS  
**MA-PMT H-8500**  
HAMAMATSU
- ▶ **goal:**  $10^7 - 10^8$  cps  
 $\Delta t < 1\text{ ns}$

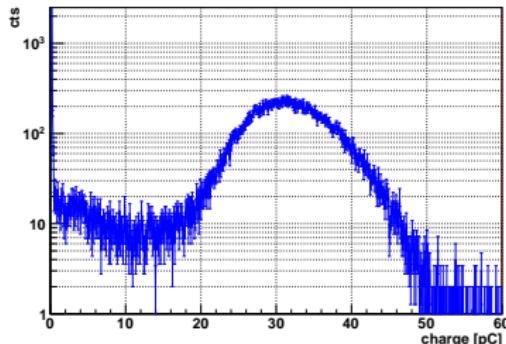


# Performance tests

- ▶ GANIL 2009:  $^{13}\text{C}$  ions, 75 MeV/u, small hodoscope ( $2 \times 32$ )
- ▶ use of standard electronics: **NIM & VME**
- ▶ **TAC** measurements
- ▶ coincidence with accelerator HF
- ▶ time resolution:  
**1 ns FWHM**



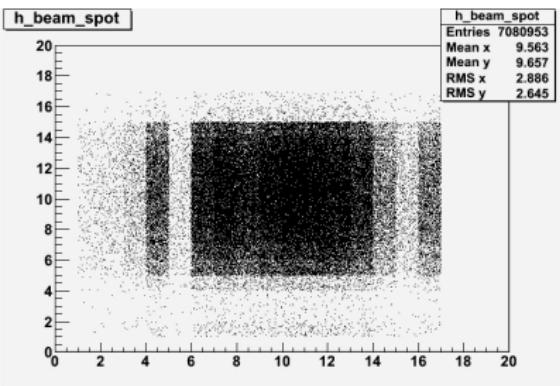
- ▶ **QDC** measurements
- ▶ max. charge  $\approx 30 \text{ pC}$
- ▶ exposure:  $10^{12} \text{ ions/cm}^2$   
efficiency can be restored  
**life time > 1 year**  
in treatment conditions



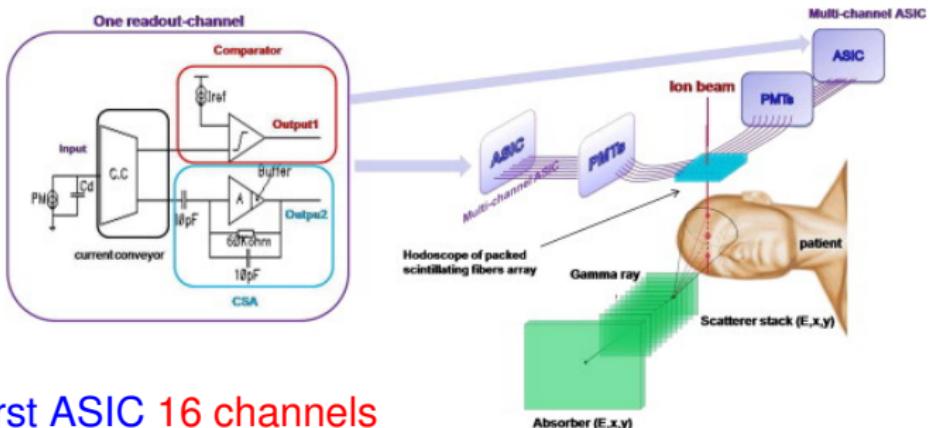
# Performance tests II

- ▶ CAL Nice (2011/2012): protons 64 MeV  
IPN Orsay (2012): protons 25 MeV
- ▶ maximum count rates of PMs (via scaler)
  - ▶ MCP-PMT XP-85012 Photonis:  $< 10^5$  1/s
  - ▶ MA-PMT H8500 Hamamatsu:  $\approx 4 \cdot 10^6$  1/s
- ▶ detection efficiency: 85 – 95 %

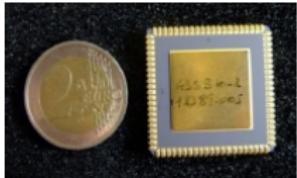
- ▶ beamprofile  
(via pattern unit)
- ▶ count rates  $10^4$  1/s
- ▶ large hodoscope ( $2 \times 128$ )



# front end electronics



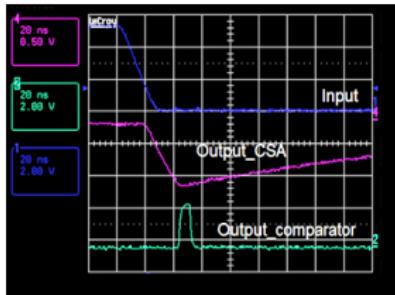
- ▶ first ASIC 16 channels
- ▶ discriminator: detect event
- ▶ CSA: measuring charge  
4 bit variable gain
- ▶ low noise and low impedance  $50\ \Omega$
- ▶ threshold of current comparator:  $100\text{-}400\ \mu\text{A}$
- ▶ input dynamics  $53\text{dB}$   $135\text{fC} - 60\text{pC}$



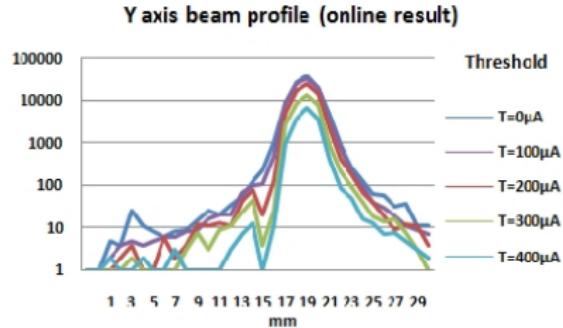
S. Deng *et al.* NIM A625 (2012) 390-393

# test of the first ASIC

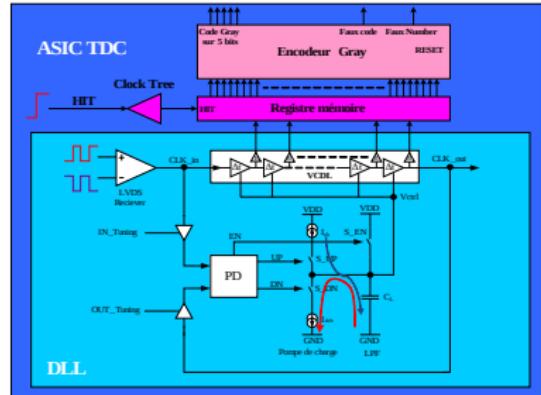
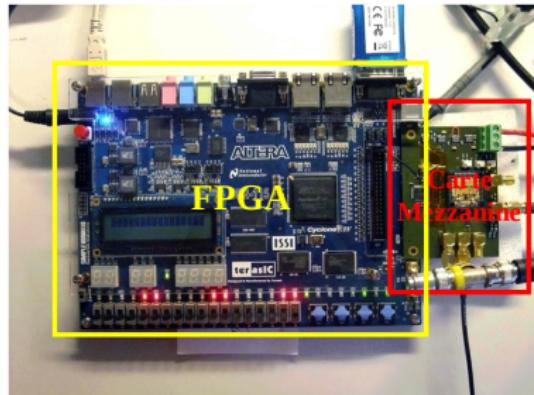
- ▶ test in the lab
- ▶ input from pulse generator
- ▶ signal recorded via scope



- ▶ HIT Heidelberg, protons and carbons up to 430 MeV/u
- ▶ ASIC in combination with NI-PXI Daq



# front end electronics II

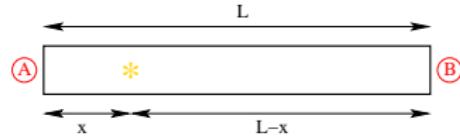
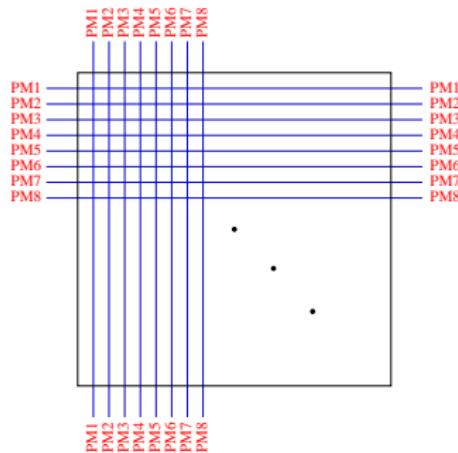


- ▶ second ASIC including timing
- ▶ clock 160 MHz with Delay Locked Loop (5 bit)  
Voltage Controlled Delay Line
- ▶ quantization step 195 ps
- ▶ time resolution 139 ps FWHM
- ▶ jitter 36 ps FWHM
- ▶ acquisition rate  $10^8$  1/s

PhD thesis Shi-Ming Deng, Université de Lyon (2012)

# work in progress

- ▶ combine ASIC with  $\mu$ TCA Daq
- ▶ distribute signals from scintillating fibres to 8 PM
  - ⇒ increase of maximum count rate
- ▶ read fibres from both sides:
  - ⇒ increase of efficiency
  - ⇒ timing independent on hit position



- ▶  $t_A = \frac{x}{c}$ ,  $t_B = \frac{L-x}{c}$
- ▶  $\bar{t} = \frac{1}{2} (t_A + t_B) = \frac{1}{2} \frac{L}{c}$

# summary and outlook

- ▶ **hodoscope**
  - ▶ (2×32) and (2×128) fibres **available**
  - ▶ time resolution: **1 ns**
  - ▶ position resolution: **1 mm**
  - ▶ to do: connection to **8 PM**
- ▶ **ASIC**
  - ▶ first ASIC with **discriminator** and **CSA** ready and **tested**
  - ▶ second ASIC with **timing** information to do: **test in beam**
- ▶ **DAQ**
  - ▶ to do:  **$\mu$ TCA** system

# hodoscope in a possible pCT system

