

Real-time monitoring of the ion range during hadrontherapy: An update on the beam tagging hodoscope

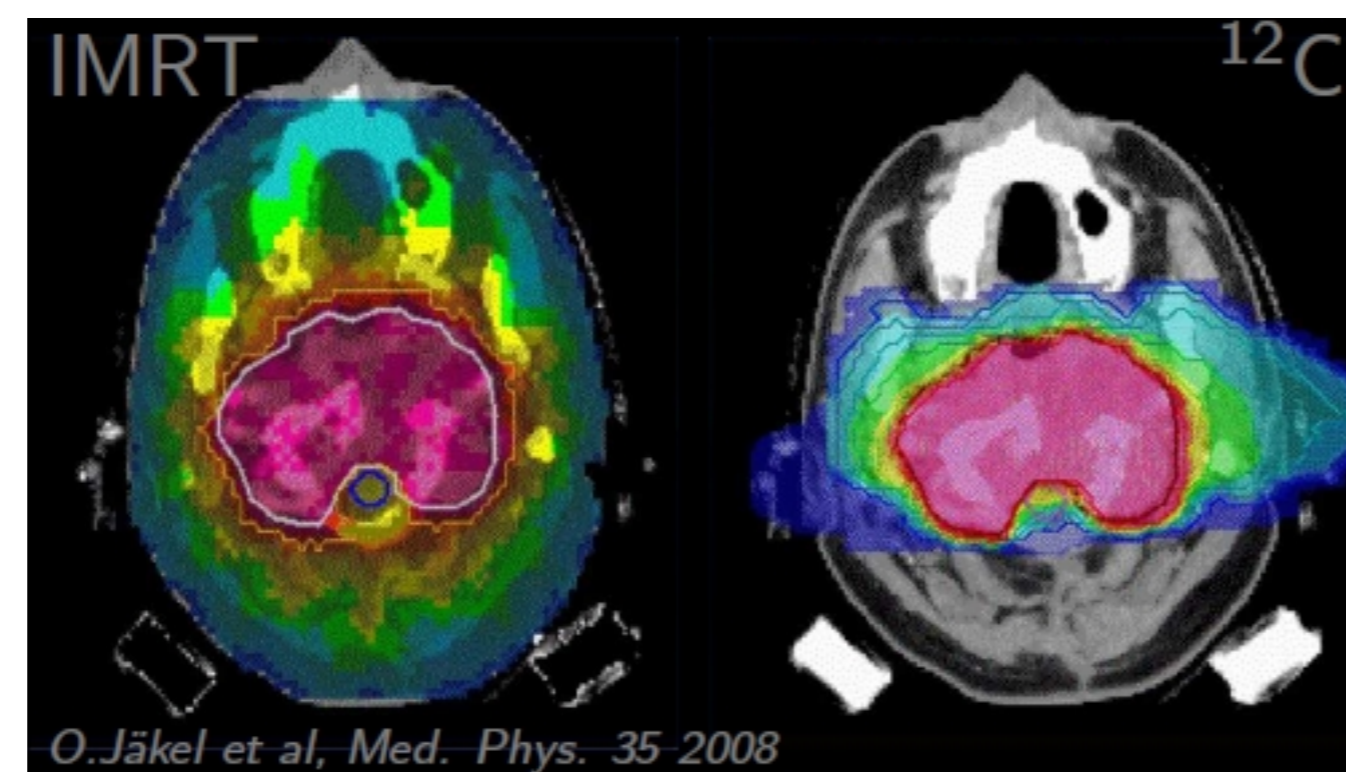
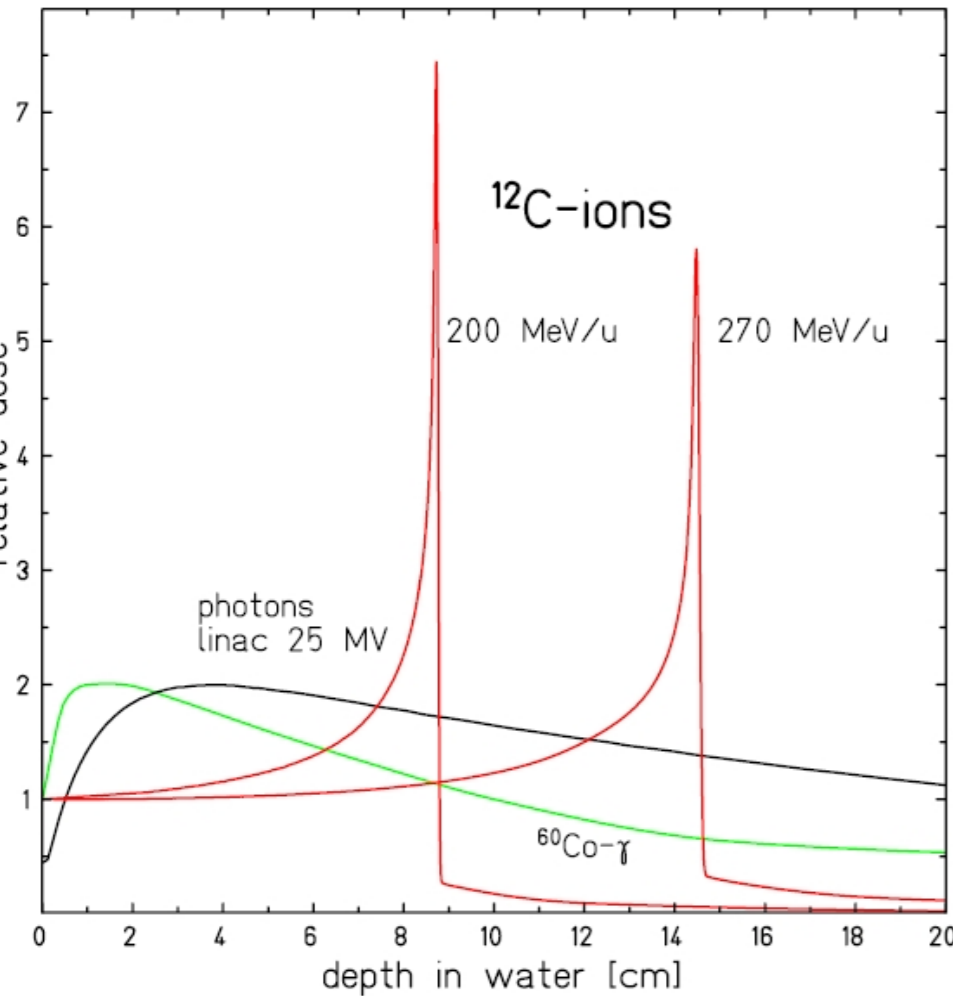
J. Krimmer¹, L. Caponetto¹, X. Chen¹, M. Chevallier¹, D. Dauvergne¹, M. De Rydt^{1,2}, S. M. Deng¹, J.-L. Ley¹, H. Mathez¹, C. Ray¹, V. Reithinger¹, E. Testa¹, Y. Zoccarato¹

¹Université de Lyon, Université Claude Bernard Lyon 1, CNRS/IN2P3, Institut de Physique Nucléaire de Lyon, 69622 Villeurbanne, France, ²Instituut voor Kern- en Stralingsfysica, K.U.Leuven, Celestijnenlaan 200D, B-3001 Leuven

Introduction

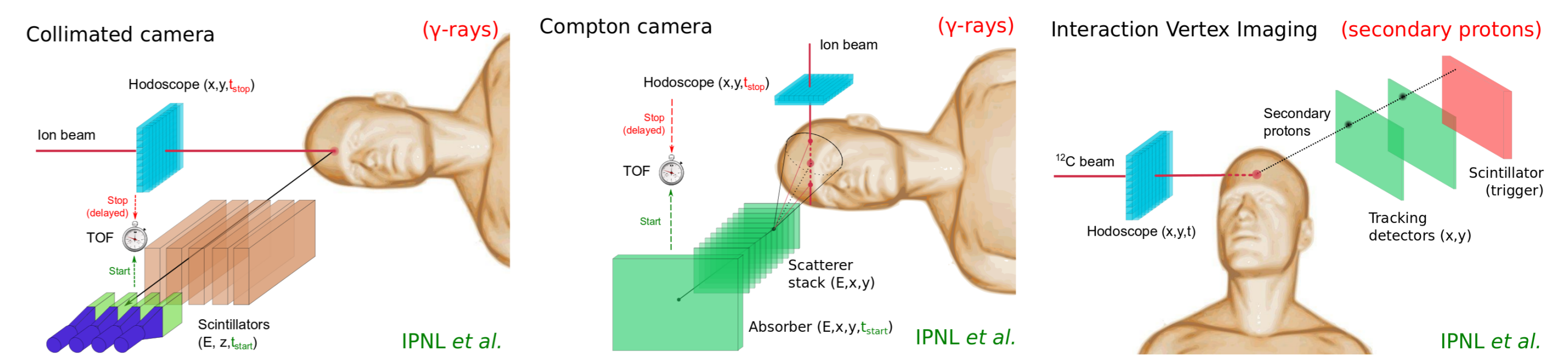
hadrontherapy

- ▶ dose concentrated in Bragg Peak
- ▶ carbon ions: higher RBE \Rightarrow treatment of radioresistant tumors
- ▶ increased sensitivity to range uncertainties \Rightarrow online monitoring highly desired



online monitoring of the ion range

- ▶ detection of secondary radiation induced by nuclear reactions
- ▶ prompt- γ rays: collimated camera [1, 2] and Compton Camera [3]
- ▶ protons: interaction vertex imaging [4, 5, 6]
- ▶ reconstruction: intersection of line with plane, cone or line, respectively
- ▶ beam tagging hodoscope: direction of incident ions, time reference



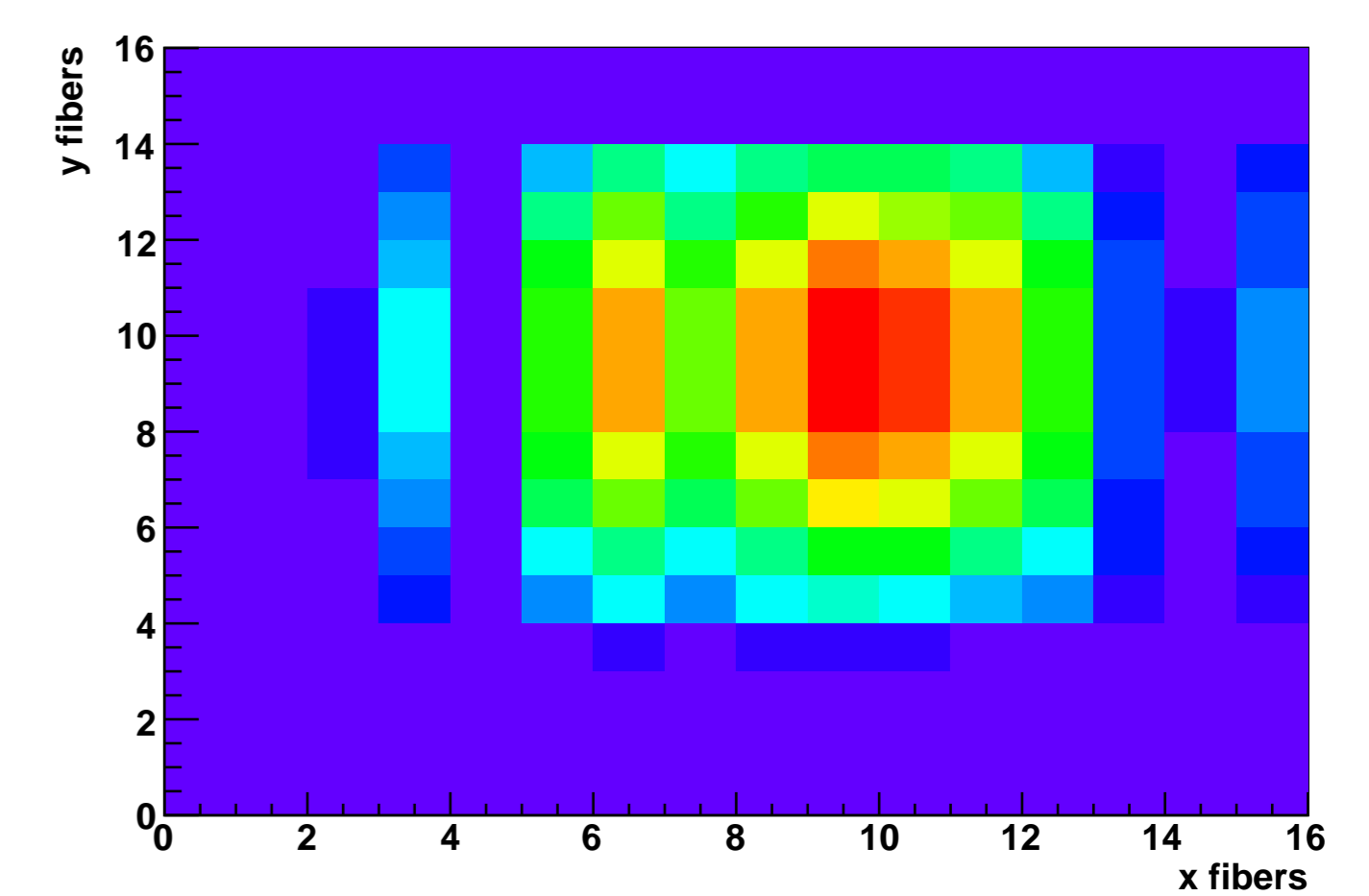
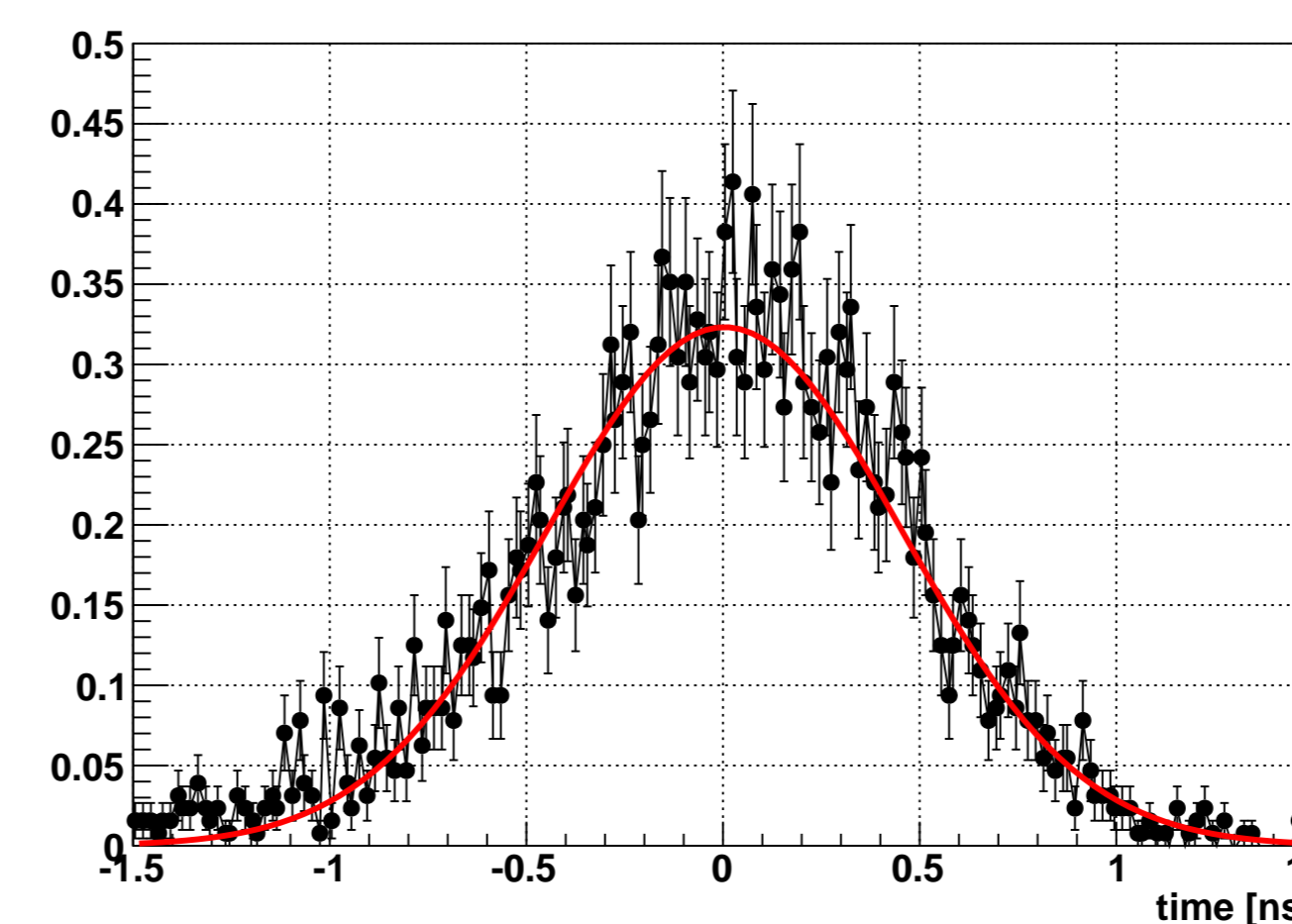
The device

- ▶ goals:
 - ▶ position resolution 1 mm
 - ▶ time resolution 1 ns
 - ▶ count rate 10^8 1/s
- ▶ array of scintillating fibers (1 mm \times 1 mm) BCF10/12
- ▶ prototypes: 2 \times 32 and 2 \times 128 fibers
- ▶ readout: optical fibers FORETEC coupled to multianode PM H-8500



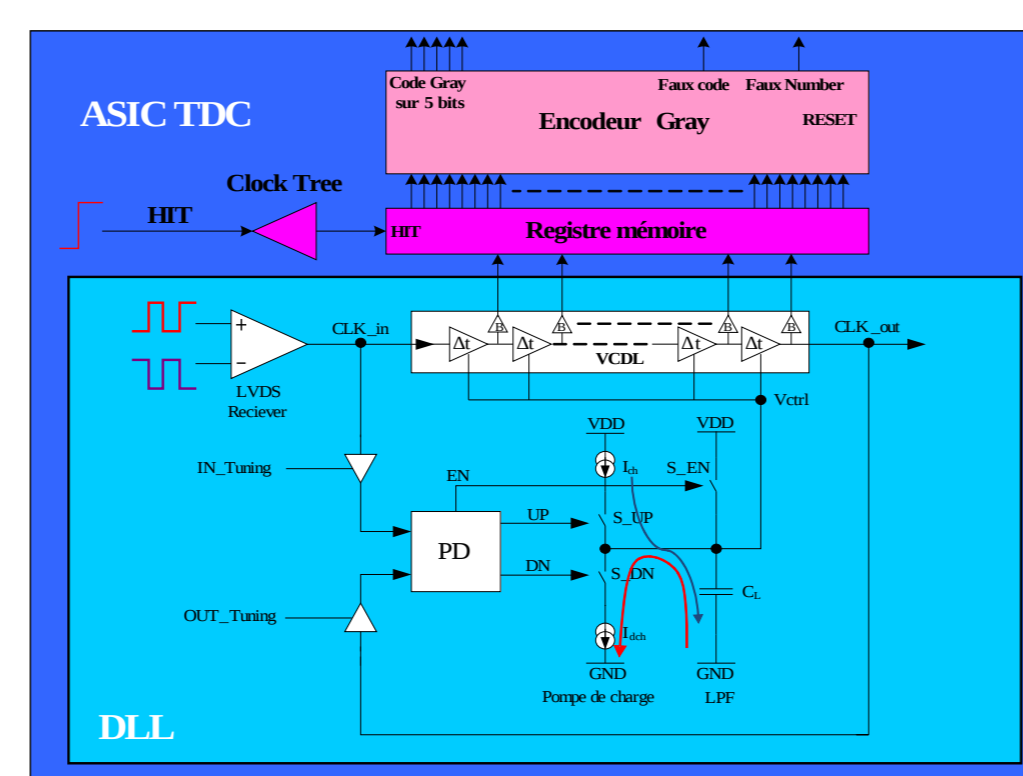
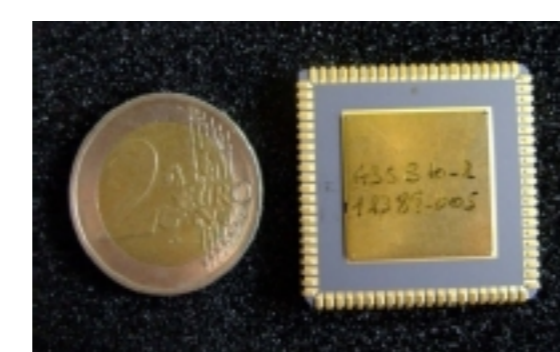
Test of hodoscope prototypes in the beam

- ▶ use of standard NIM electronics and VME DAQ
- ▶ 75 MeV/u ¹³C ions at GANIL and 25 MeV protons at IPN Orsay
- ▶ cyclotron HF as time reference \Rightarrow time resolution 1 ns FWHM
- ▶ 2D distribution of hits \Rightarrow beamspot



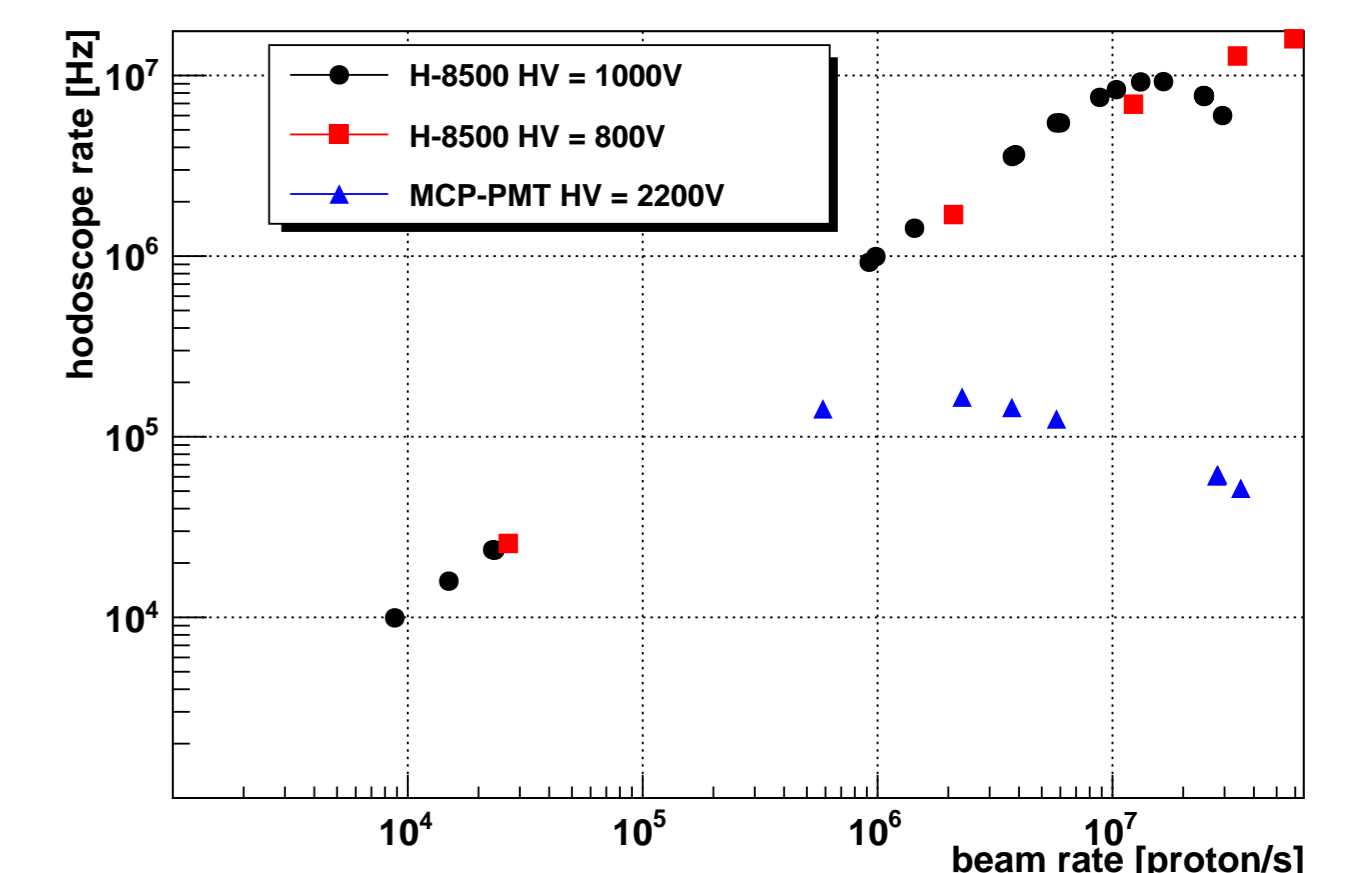
Front-end electronics

- ▶ development of ASICs
- ▶ current conveyor + comparator [7]
- ▶ charge sensitive amplifier
- ▶ new version including TDC
- ▶ 160 MHz clock + DLL Delay Locked Loop
- ▶ time resolution 140 ps
- ▶ max. count rate 10^8 1/s



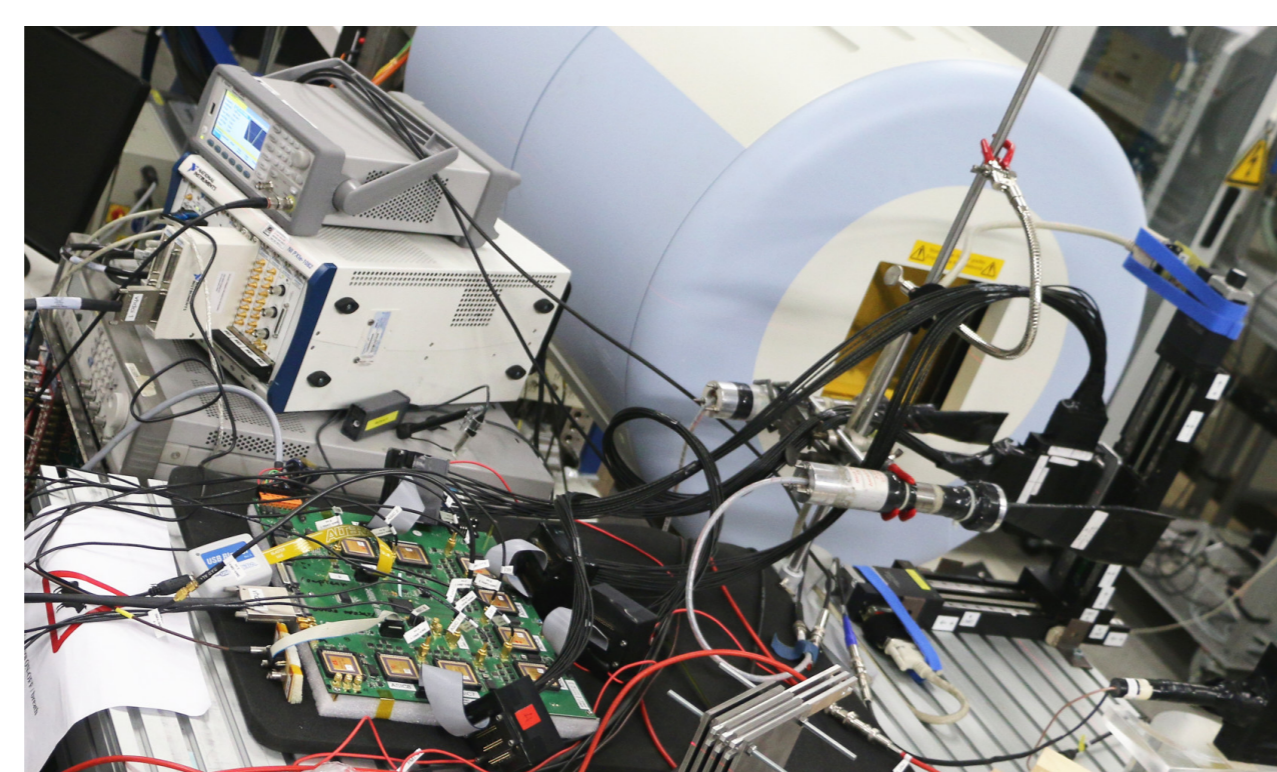
Maximum count rates

- ▶ tests with two different PMs:
 - ▶ multi-anode PM H-8500
 - ▶ micro-channel-plate PM XP-85012
- ▶ MCP-PMT needed to be operated close to maximum voltage \Rightarrow less performant than MA-PM
- ▶ maximum rate > 10 MHz

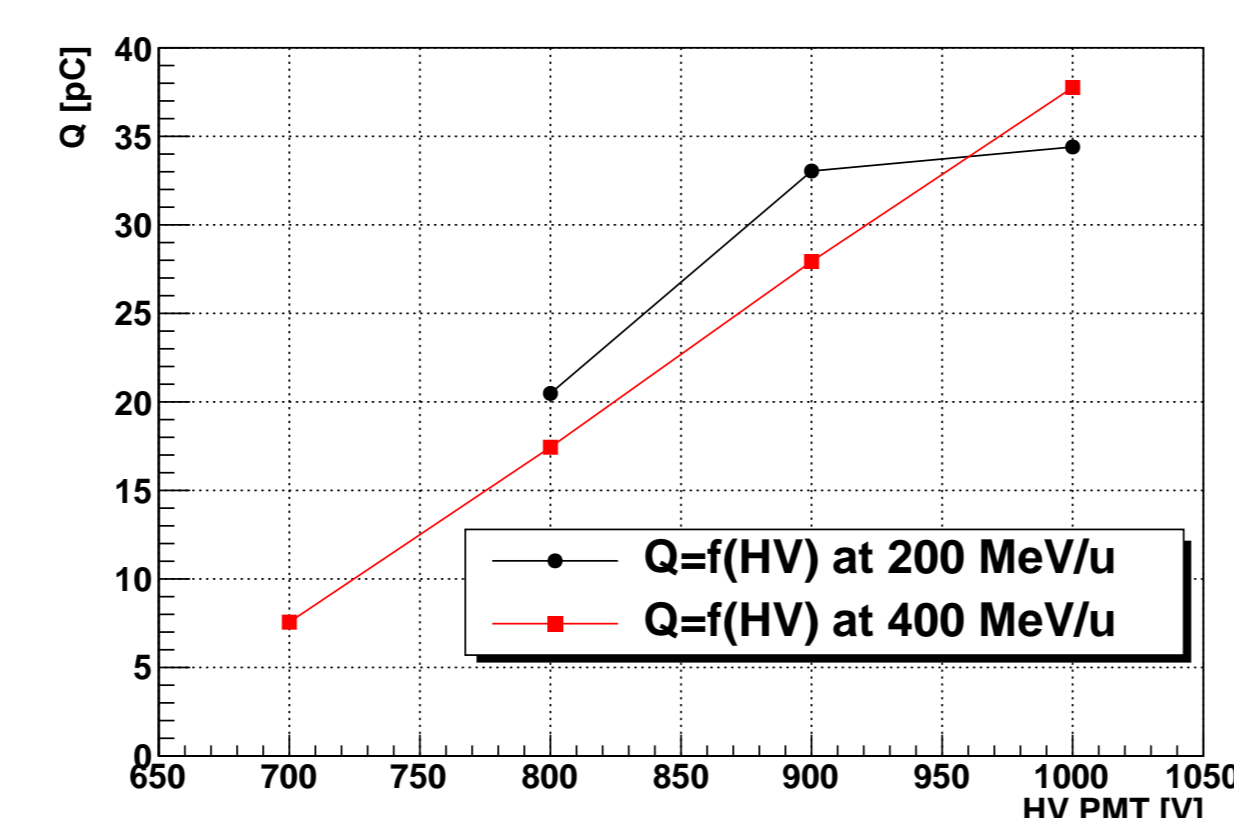
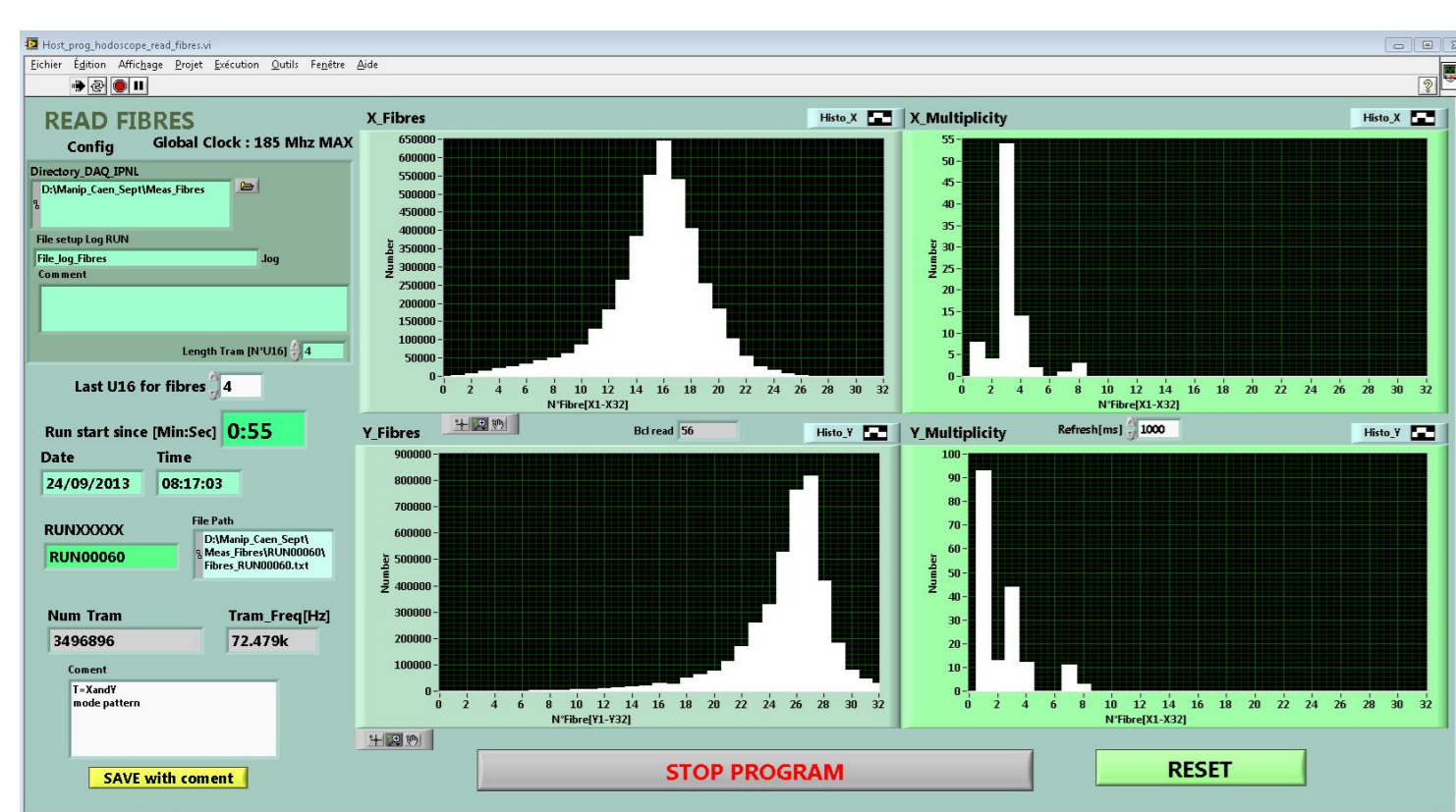


Test of ASIC (first version)

- ▶ test at GANIL and HIT
- ▶ ¹²C ions 95-400 MeV/u
- ▶ card with 8 ASICs connected to hodoscope 2 \times 32
- ▶ PXIe DAQ system + LabView



- ▶ online display of the beam profile and measured charge from a single fiber



Outlook

- ▶ characterization of MA PMs \Rightarrow adaption of gains
- ▶ test of new ASICs including TDCs
- ▶ new DAQ system \Rightarrow μ TCA
- ▶ test in beam with final system



References

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Acknowledgments

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