PEPITES

A NEW TRANSPARENT PROFILER BASED ON SECONDARY ELECTRONS EMISSION FOR (CONVENTIONAL AND) FLASH-RT CHARGED PARTICLE BEAMS

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Disclosure

X	No, nothing to disclose

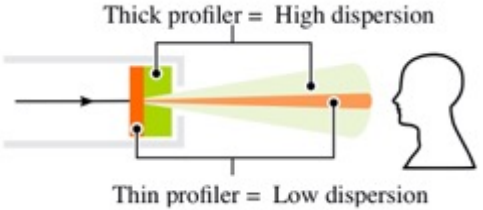
PEPITES

The origins

Hadrontherapy dose delivery requires continuous and precise measurement of beam properties (intensity, position, profile) with a minimal beam perturbation

Goals

- Continuous beam monitoring during patient treatment
- Simple operation and long detector lifetime



Challenges

Beam minimal perturbation
→ Material budget: 10 µm WET

Minimum deposited dose 10^8 Gy
→ Radioresistance

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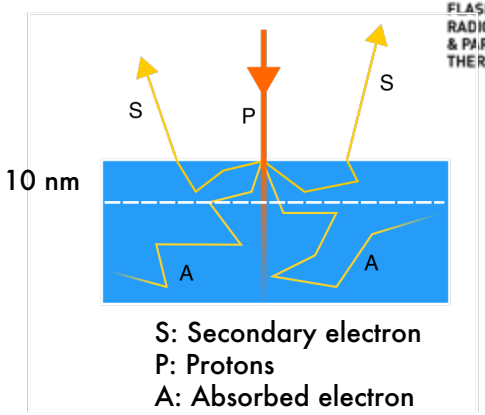
Ultra-thin profiler



S: Secondary electron
P: Protons
A: Absorbed electron

Solution

- Secondary Electron Emission (SEE) for signal
  - Surface phenomenon
- Built with thin-film techniques
  - ➠ **Adaptation to the specificities of the beam**
- Sensitive area
  - 50 nm thick gold strips
    - deposited on 1.5 μm insulating polymer membrane
  - Emits electrons
  - ➠ **Current in each strips → signal**

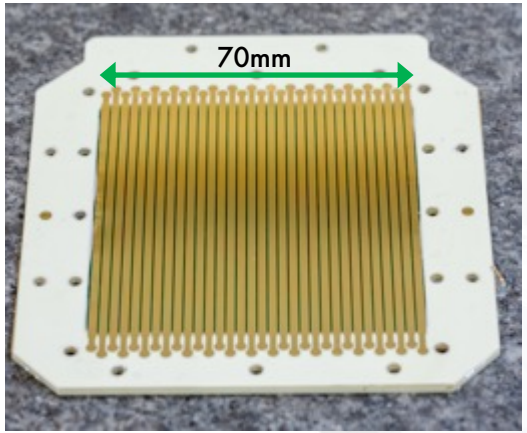


Photo © Sylvaine Pieyre LLR

Cathode with gold strips

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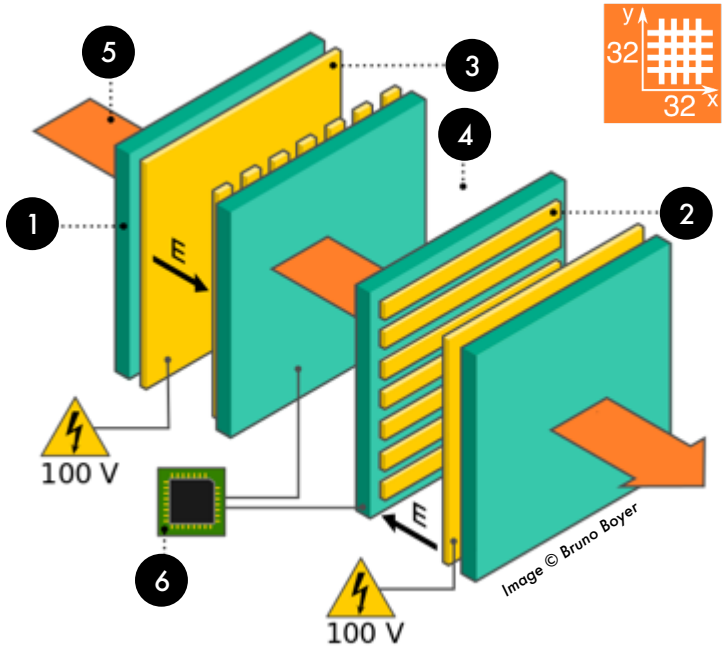
Detector layout



1. Polyimide (CP1™ 1.5 μm)
2. Cathode strips (Au 50 nm)
3. Anode (Au 50 nm)
4. Vacuum
5. Beam
6. Electronique readout

CP1™ : www.nexolvematerials.com

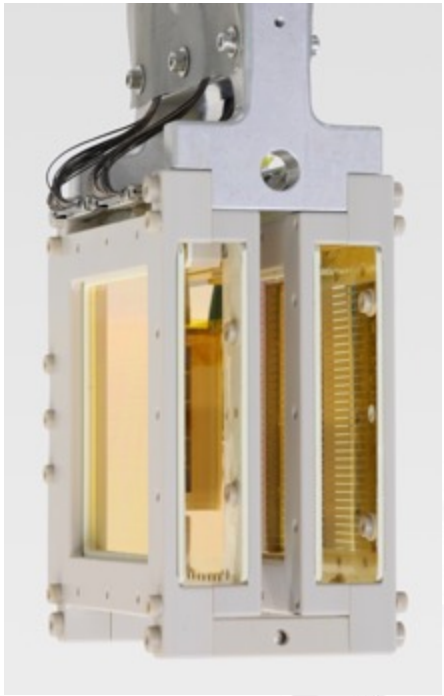


Photo © Sylvaine Pieyre LLR

PEPITES sensitive block

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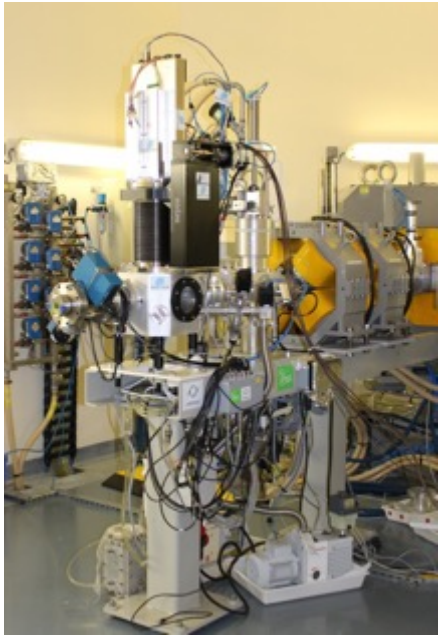
At ARRONAX

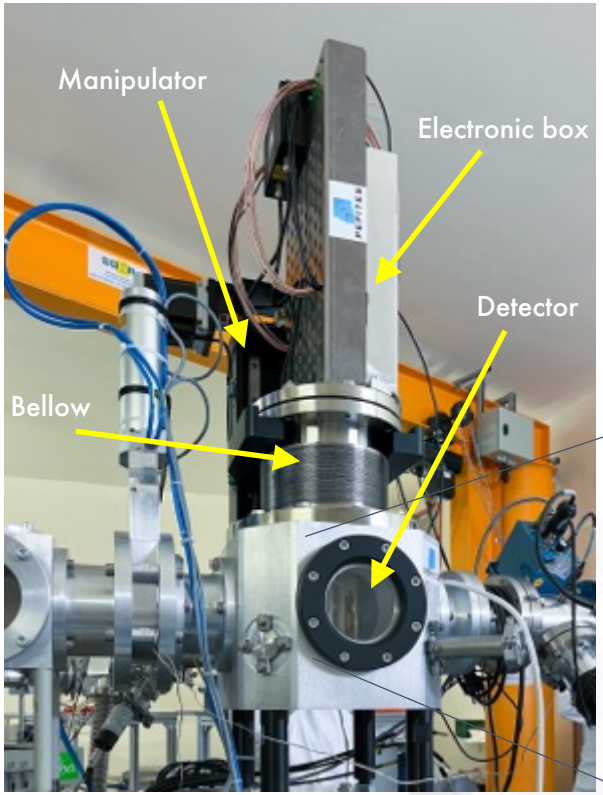


ARRONAX cyclotron
(St Herblain, France)

70 MeV protons
CONV and FLASH

Detector on insertion module
➠ON and OFF beam

Dedicated readout
➠ PEPITA (© CEA)



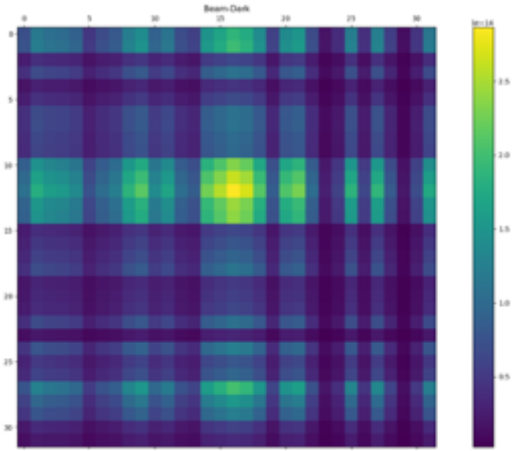
PEPITES on ARRONAX AX3 beam line

PEPITES

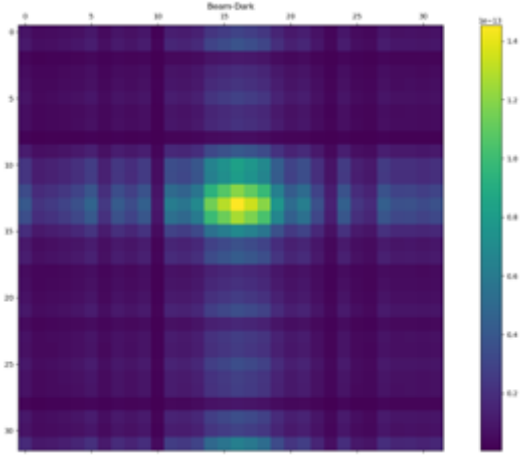
At ARRONAX

2022.05

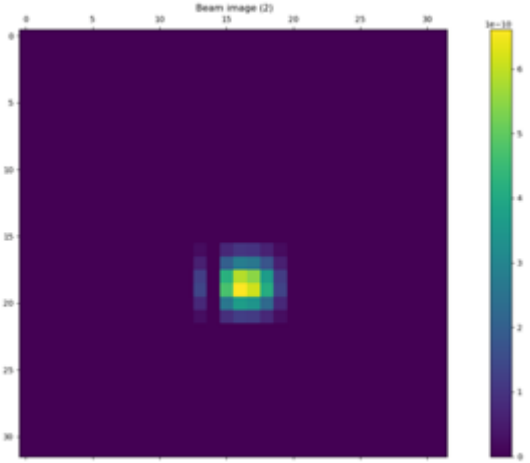
70 MeV proton beams profiles



I_{beam} = 1 pA



I_{beam} = 5 pA



I_{beam} = 20 nA

PEPITES and FLASH

Properties

Ultrathin detector

- For minimum beam pertubation

Secondary Electron Emission

- For Ultrathinness

PEPITES and FLASH

Assets for FLASH

Ultrathin detector

- For minimum beam perturbation
- Minimize heating from high intensities beams

Secondary Electron Emission

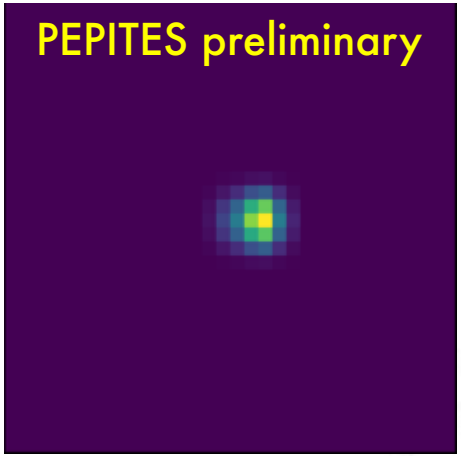
- For ultrathinness
- Linear signal, no saturation effect !
- Ready for high I_{beam}

Prototype installed at ARRONAX

- Tested with local FLASH beam

2022.06

First 70 MeV proton FLASH beam profile



T=10 ms
I_{beam} = 10 µA

UNPUBLISHED DATA – DO NOT COPY OR DISTRIBUTE

G. Saade et al, Ultra-high dose rate proton irradiation elicits reduced toxicity in zebrafish embryos (Advances in Radiation Oncology)
https://doi.org/10.1016/j.adro.2022.101124

PEPITES and FLASH

A versatile device

Toward a tool for conventional and FLASH irradiations

- Independently of pulse duration
  - Current measurements for pulses > 1 ms
  - Integrated charge below
- For protons, electrons, ions
- Adaptable to UHDR and VHEE

With already known assets

- Ultra-thinness
  - Can stay in beam during irradiations
- Sustainability
  - Gold (and signal !) not degraded by cumulative dose

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