Toward a Monitoring of Ultra-Short Beams From Laser-Plasma Acceleration ?

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Marc Verderi,
Laboratoire Leprince-Ringuet, Ecole polytechnique,
For the PEPITES-UltraFlash Team

Introduction

- **Spoiler Alert : we will not present here results on the monitoring of ultra-short beams from laser-plasma acceleration !**
  - But we will present the just starting attempt on which we are today to get such monitoring...
- **Context:**
  - We developed an **ultra-thin beam monitor using Secondary Electron Emission** (SEE) as the signal
    - Ultra-thin to minimize the perturbation to the beam
    - We were initially motivated by protontherapy, with continuous beams
    - We installed a **first prototype** @ **ARRONAX** (St Herblain/Nantes, France) in May 2022
    - Name **PEPITES** = **P**rofileur à **E**lectrons secondaires **P**our **I**ons **T**hérapeutiqu**ES**
  - With the **recent advent of FLASH therapy research**, we realized PEPITES is a very good candidate to monitor the high intensity (“classical”) FLASH beams !
    - (“classical”) FLASH beams = typical O(1 – 100 ms) duration beams
  - But what about the **extremely short beams from laser-plasma acceleration ?**

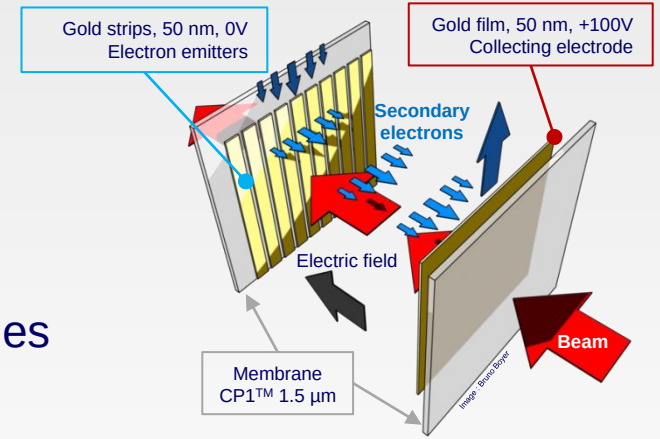
Overview

- PEPITES & related projects
- PEPITES-UltraFash : PEPITES vs Laser-Plasma Beams

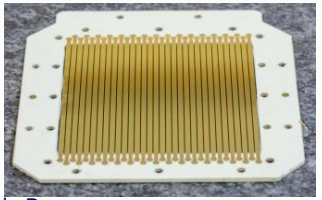
PEPITES & related projects

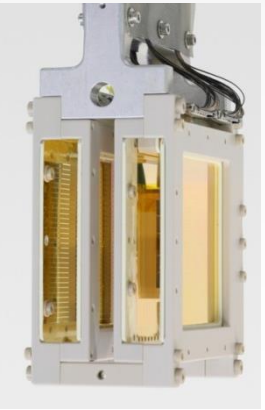
PEPITES in a nutshell

- **Ultra-thin Secondary Electron Emission (SEE) beam profiler**
  - SEE used for signal because:
    - Tiny amount of material needed (~10 nm)
    - Very linear (at least up to O(A) beams)
      - BTW : suitable for FLASH !
  - Sensitive Area build using « Thin Film » techniques
  - Operates in vacuum



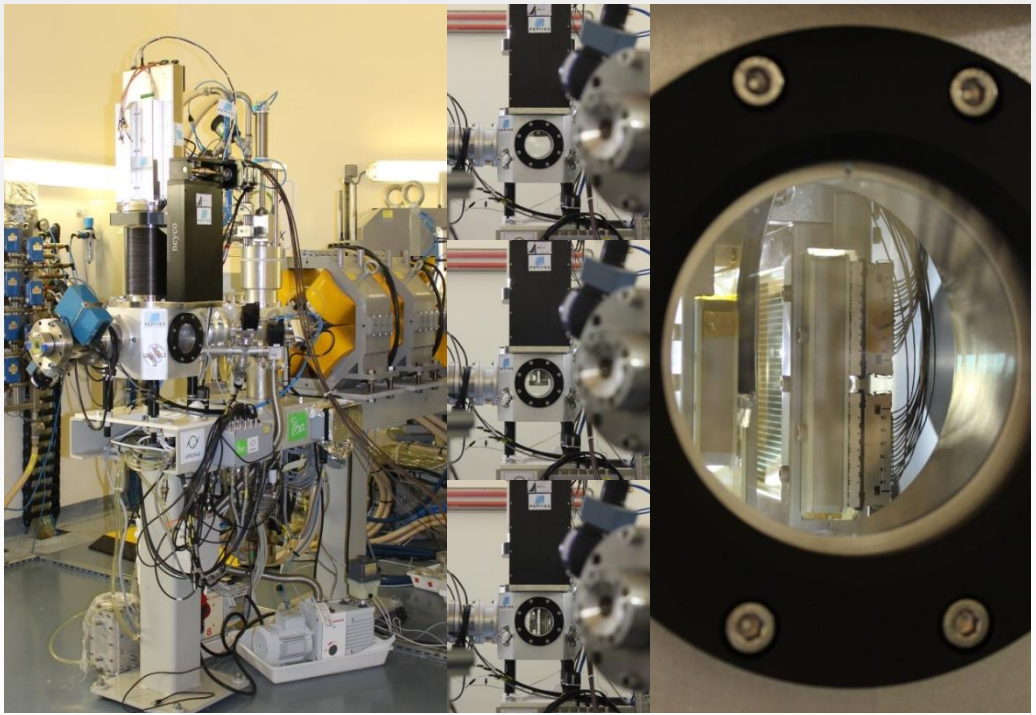
- **Current version:**
  - 10 µm WET
  - Low noise & high range read-out electronic
    - For continuous current beams
    - Designed by our CEA partner
  - 2 × 32 channels (X & Y beam sampling)



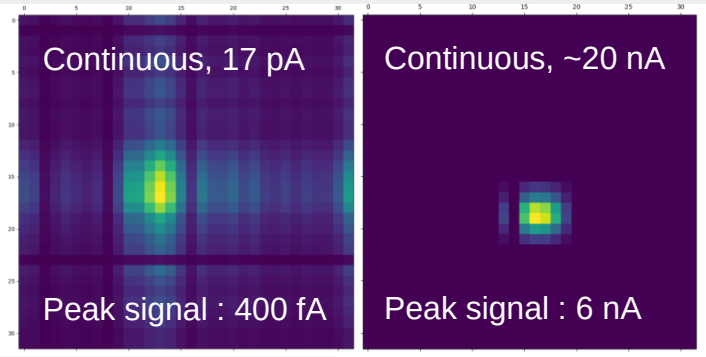


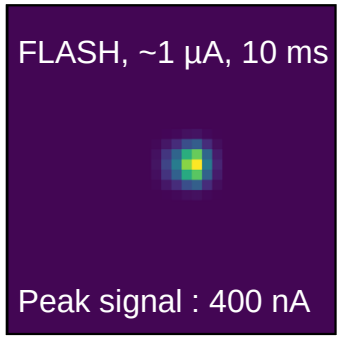
PEPITES @ ARRONAX

- Installed in May 2022



68 MeV proton beam





Other PEPITES activities

- **SPLIF :**
  - = **S**im**PL**e moniteur pour **I**ntensités **F**lash
  - **Comparing FLASH and conventional irradiations** is almost systematic these days
    - **A portable apparatus able to monitor intensities in both cases is very welcome !**
  - SPLIF is a simplified PEPITES
    - Takes advantage of the high linearity of SEE

- **PEPITES @ CNAO :**
  - CNAO (Pavia, Italy) interested in PEPITES for monitoring proton and carbon beams
  - First test beam planed this November
    - We will use a “nomad” system (copy of PEPITES @ ARRONAX, mounted in an independent vacuum chamber)
  - Anticipate that adaptation to CNAO needs will require reducing the monitor material budget
    - Long distance monitor – patient (6.5 m !)

The “nomad” system, here shows in ARRONAX

PEPITES-UltraFash : PEPITES vs Laser-Plasma Beams

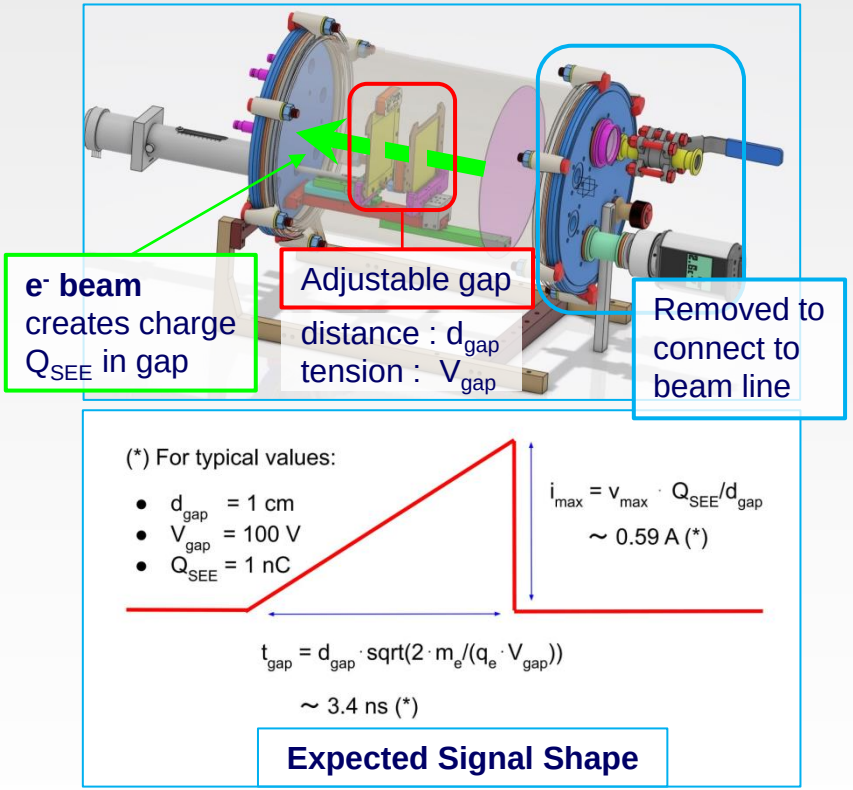
PEPITES & Laser-Plasma Beams ?

- **PEPITES can measure (“classical”) FLASH beams**, thanks to SEE signal high linearity

- **Is SEE signal able to withstand laser-plasma accelerated ultra-short beams ?**

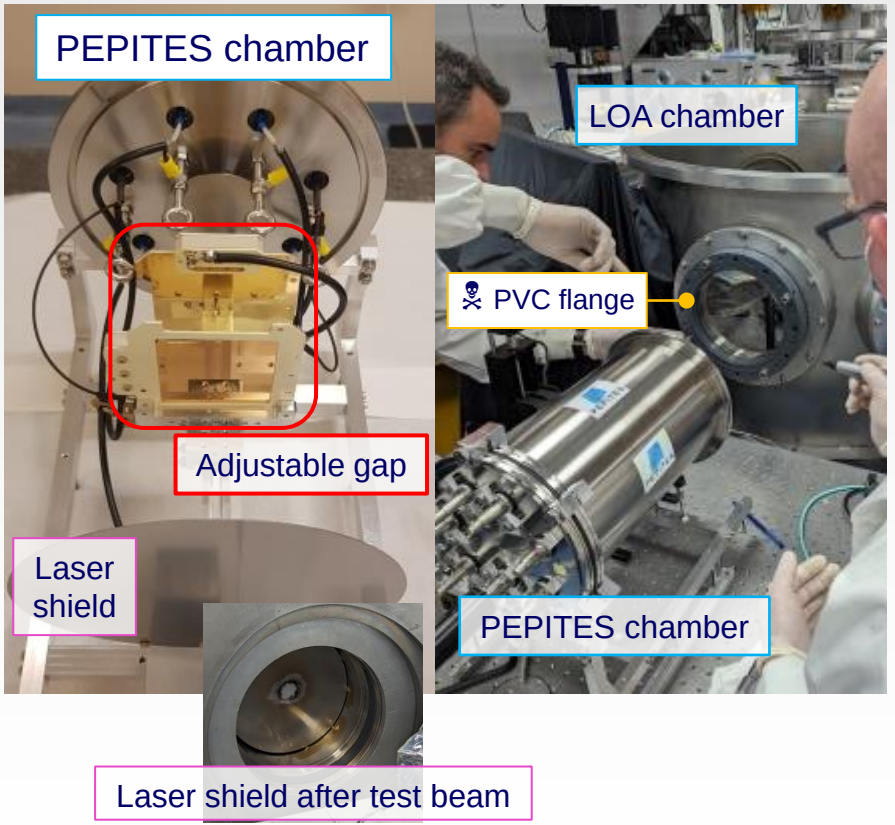
- Creation of project **PEPITES-UltraFlash**
  - Supported by French MITI
- Joint LLR – LOA project
  - **LOA = Laboratoire d’Optique Appliquée**, Ecole polytechnique, Palaiseau, France
  - LOA operates an electron beam, generated by laser-plasma, O(100 MeV)

- **First & current stage :**
  - **Try to observe the signal**
  - Design & build a simple apparatus
    - **Two planes, forming an adjustable gap**
  - Anticipate signal shape with Shockley–Ramo



First test beam, October 9th

- Connect LOA and PEPITES chambers with a PVC flange
  - Idea was to allow separating beam line ground and PEPITES chamber ground (= ground of readout)
  - or connecting them with a ground braid
- **Beam operated as:**
  - **Laser** : 1.5 J / bunch on target ; pulse duration = 30 fs ; 1 Hz rate ; λ ~ 800 nm
  - **Gas jet** : N_2/He (2%) ; laser hits a ~ 10 µm area
- We saw... **huge noise, and only that…**
  - Up to 100 V amplitude !
  - Even in cables not connected to PEPITES chamber…
  - **An unusual noise for LOA…**
- We realized afterward this was **due to the PVC flange…**
  - **Huge EM waves were leaking through it !**
  - **Spreading in the experimental area…**
- Next beam campaign planed for February 2024
  - …without this 💣!@☠&"# PVC flange…
- **Hoping to see the signal then !**



Thank you !