Betatron radiation as emittance diagnostics for plasma acceleration experiments

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Outline

- **Motivations**
- **Method and Experiment**
- **Results and Conclusions**

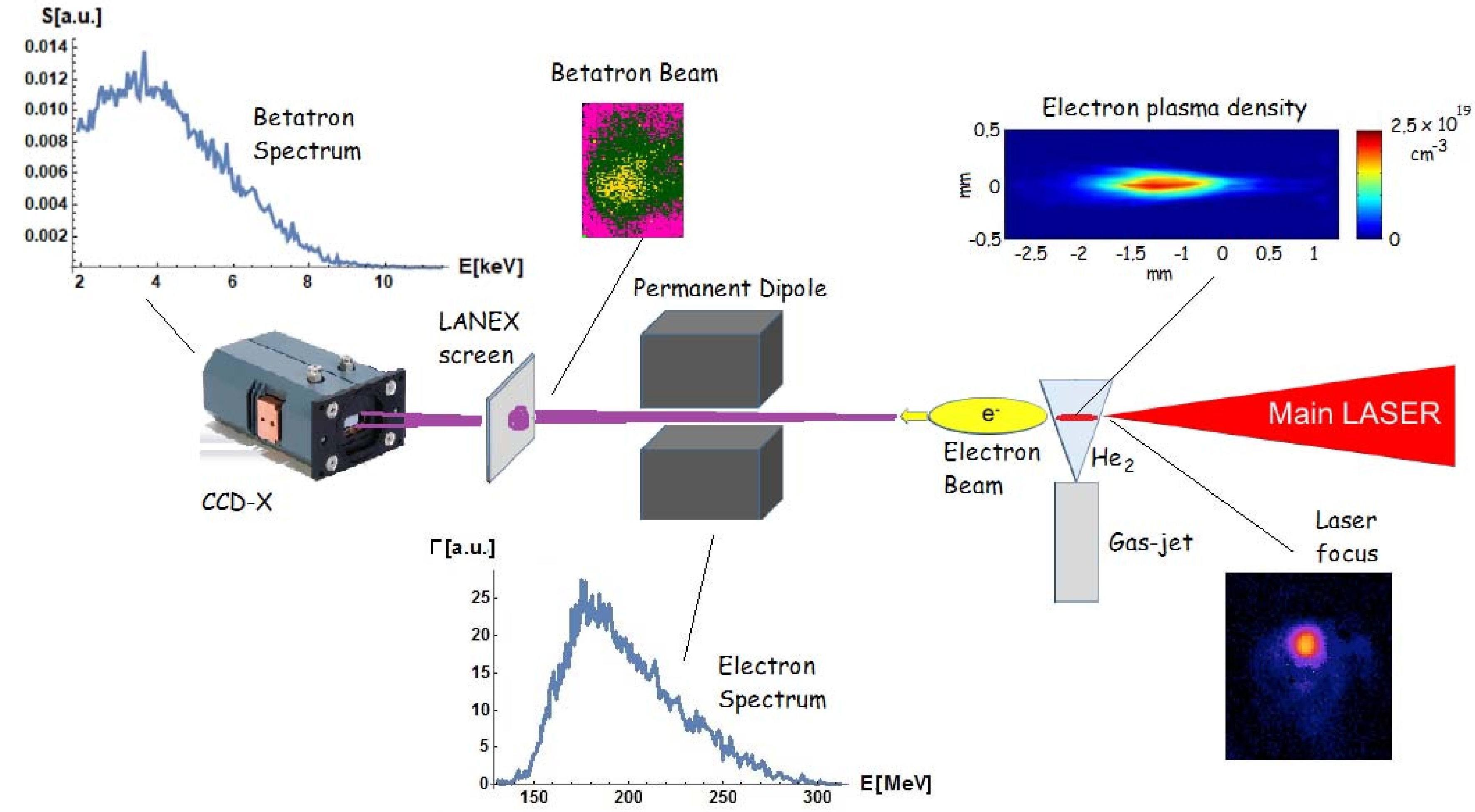
Motivations and Goals

- **Design/conceivement of a non-intercepting diagnostics for plasma accelerated electron beams**

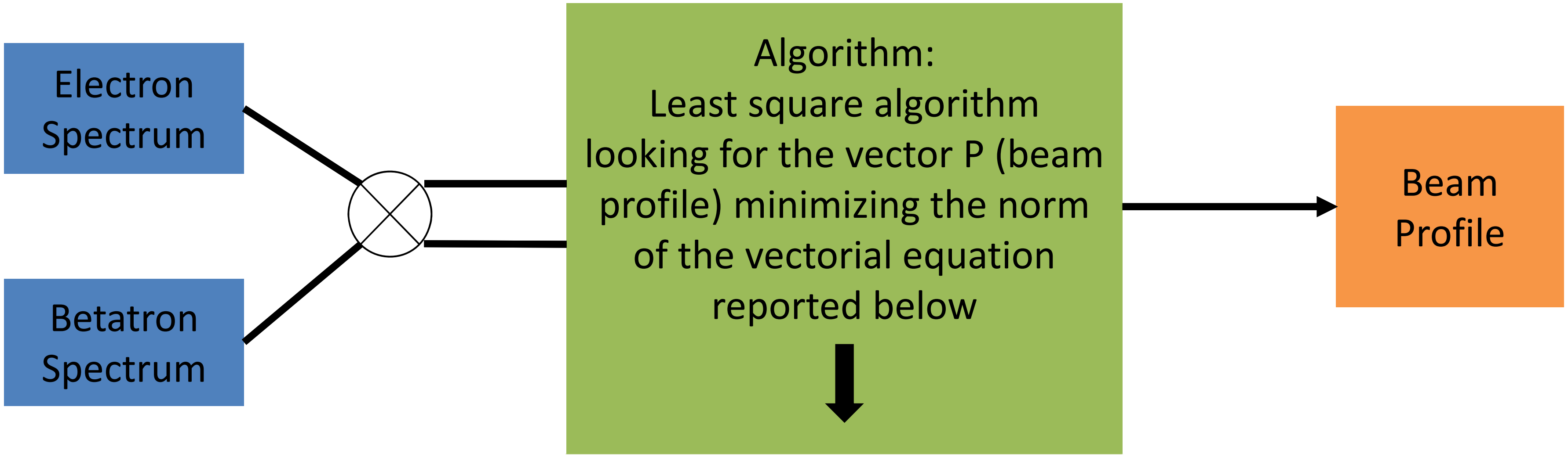
- **Infer information about the electrons when they are still inside the plasma accelerating structure**

- **Measurement of the rms emittance, comprising the correlation term**

LWFA Setup at FLAME



First step: beam profile retrievement/1



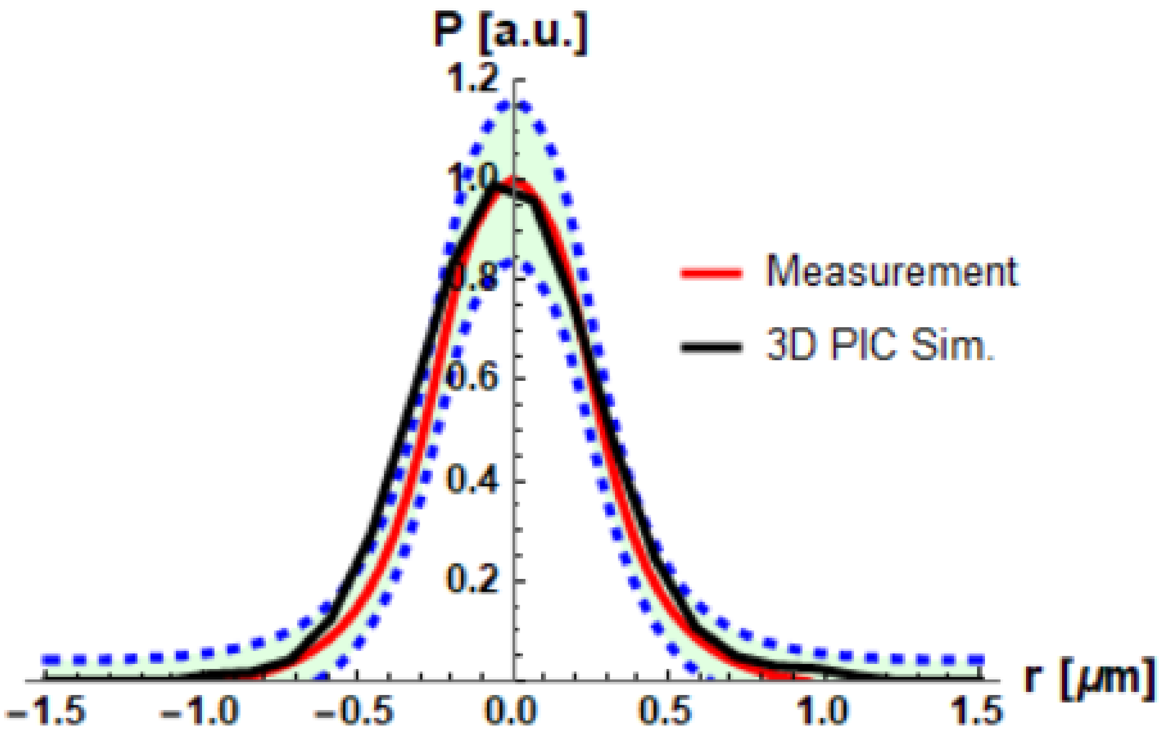
$$r^i P^i S_{ij} - \Sigma(E_j) = 0$$

Theoretical spectrum:
Depending on measured plasma density and electron spectrum

Measured betatron spectrum:
To be corrected accounting for X-ray absorption before detection

For details on the matrix S, see Ref. Curcio, A., et al. "Trace-space reconstruction of low-emittance electron beams through betatron radiation in laser-plasma accelerators." *Physical Review Accelerators and Beams* 20.1 (2017): 012801.

First step: beam profile retrievement/2

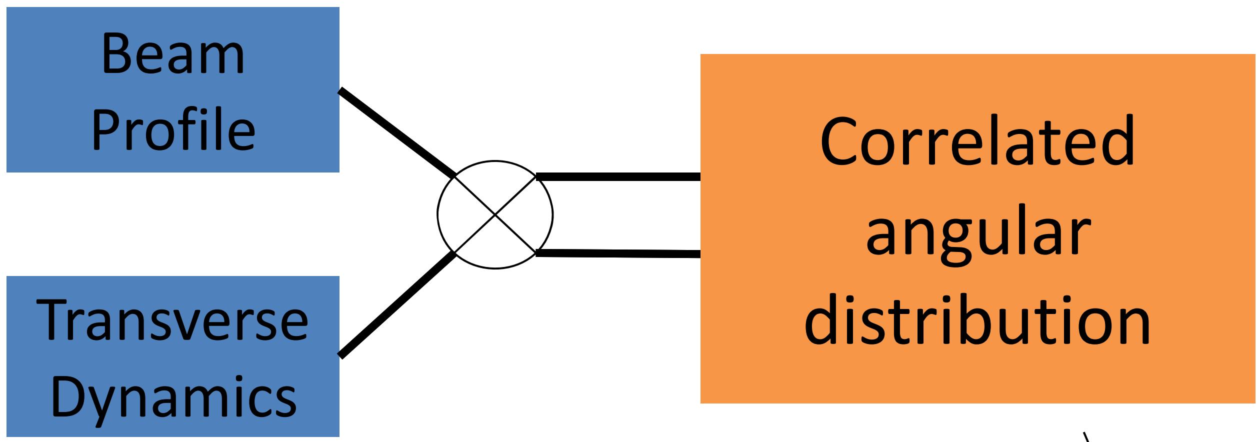


Electron beam radial profile detected (red curve) and simulated (black curve). The blue dashed curves delimit the error region (light green-shadowed).

Beam rms size 0.25±0.04 um

For discussions on the profile monitor resolution, see Ref. Curcio, A., et al. "Single-shot non-intercepting profile monitor of plasma-accelerated electron beams with nanometric resolution." To be published on *Applied Physics Letters* (2017).

Second step: angular distribution retrievement/1



$$\theta_d = \sqrt{\frac{\sqrt{1+\frac{1}{2}\gamma_0^2 r_\beta^2 k_{\beta 0}^2}}{4\gamma_0}}\, r_\beta k_p$$

Correlation function between the angle and the position of a single electron of the beam in the bubble

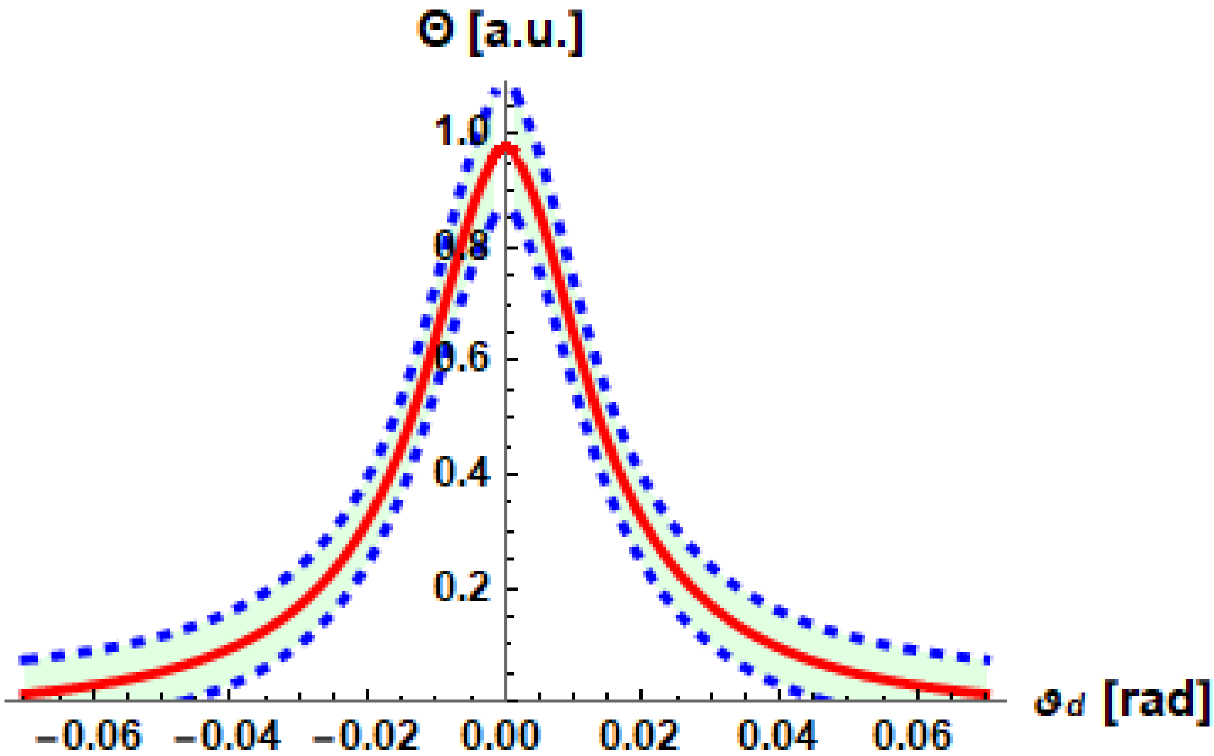
$$r_\beta = \sqrt{2}r$$

Relation between the betatron radius and the average electron radial position along the acceleration path

$$\Theta(\theta_d) \propto P[r(\theta_d)]$$

The angular distribution inside the bubble is retrieved starting from the retrieved beam profile !

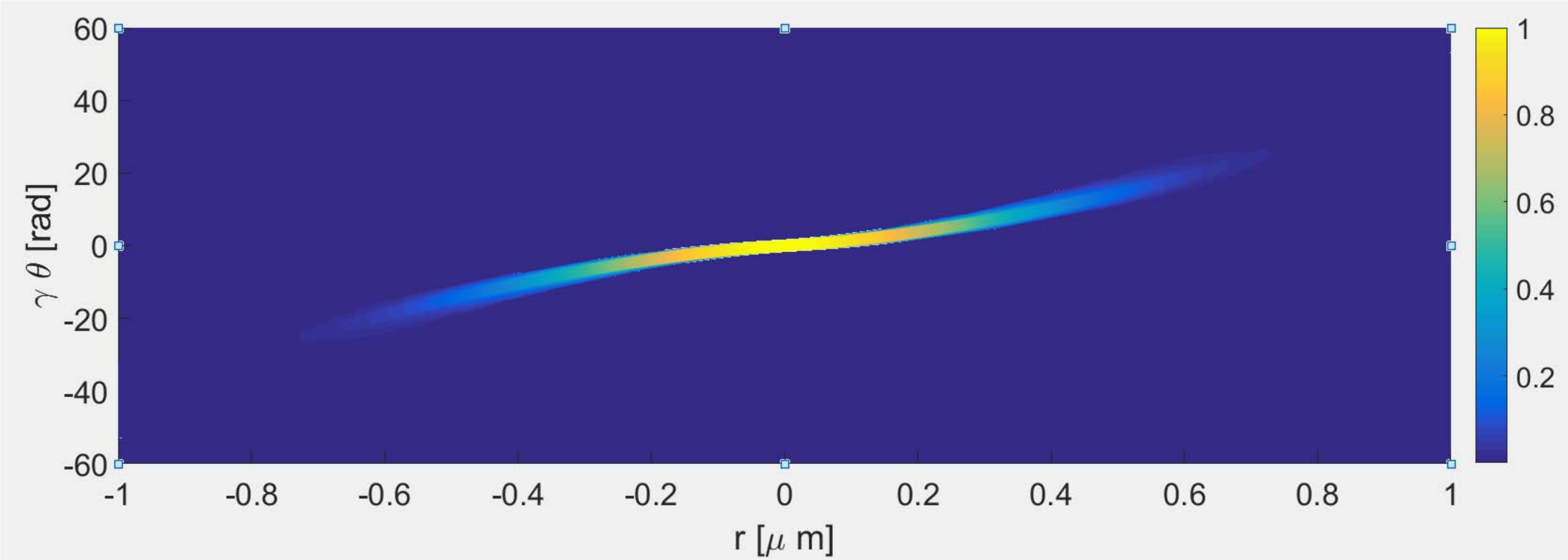
Second step: angular distribution retrievement/2



Angular distribution of the electron beam detected inside the bubble (red curve) .
The blue dashed curves delimit the error region (light green-shadowed).

Beam rms divergence 13±2 mrad.

Final step: Phase space recontruction



$$\epsilon_{r_\beta N} = \gamma_0 \sqrt{(\sigma_\gamma/\gamma_0)^2 \sigma_r^2 \sigma_\theta^2 + \epsilon_{r_\beta}^2}$$

Normalized rms emittance (correlated): 0.6 mm mrad

Normalized rms emittance (non correlated, upper limit): 1.6 mm mrad

Thanks for your attention