Subpicosecond Electron Bunch Train Production Using a Phase-Space Exchange Technique

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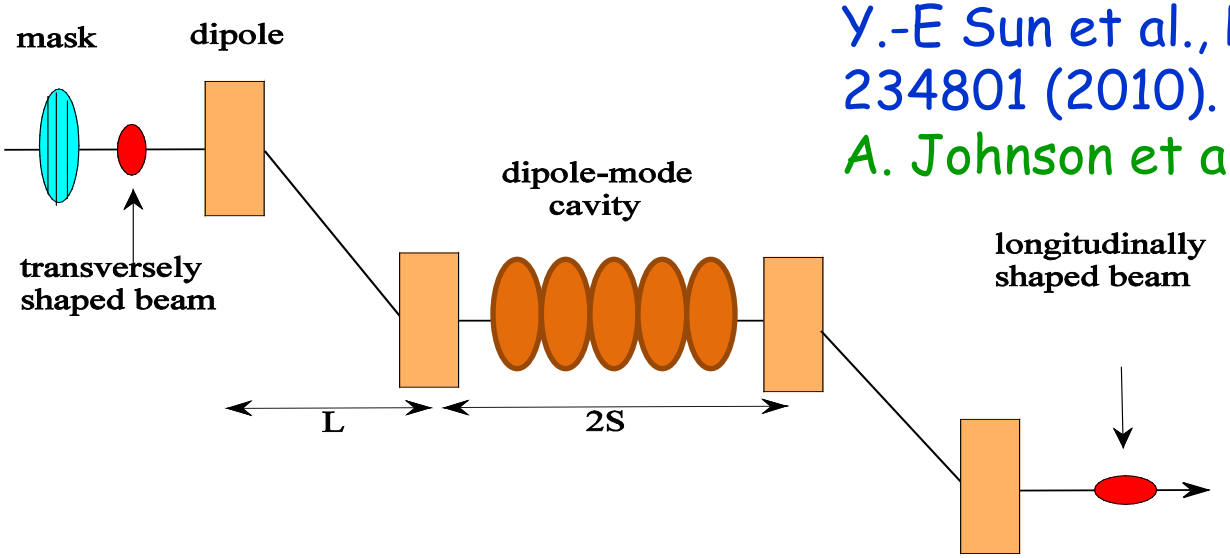
bunch train generation using transverse-longitudinal phase-space exchange



Y.-E Sun et al., Phys. Rev. Lett. **105**, 234801 (2010).

A. Johnson et al., WEP024@PAC2011

initial horizontal beam intensity modulation → final beam current/energy modulation

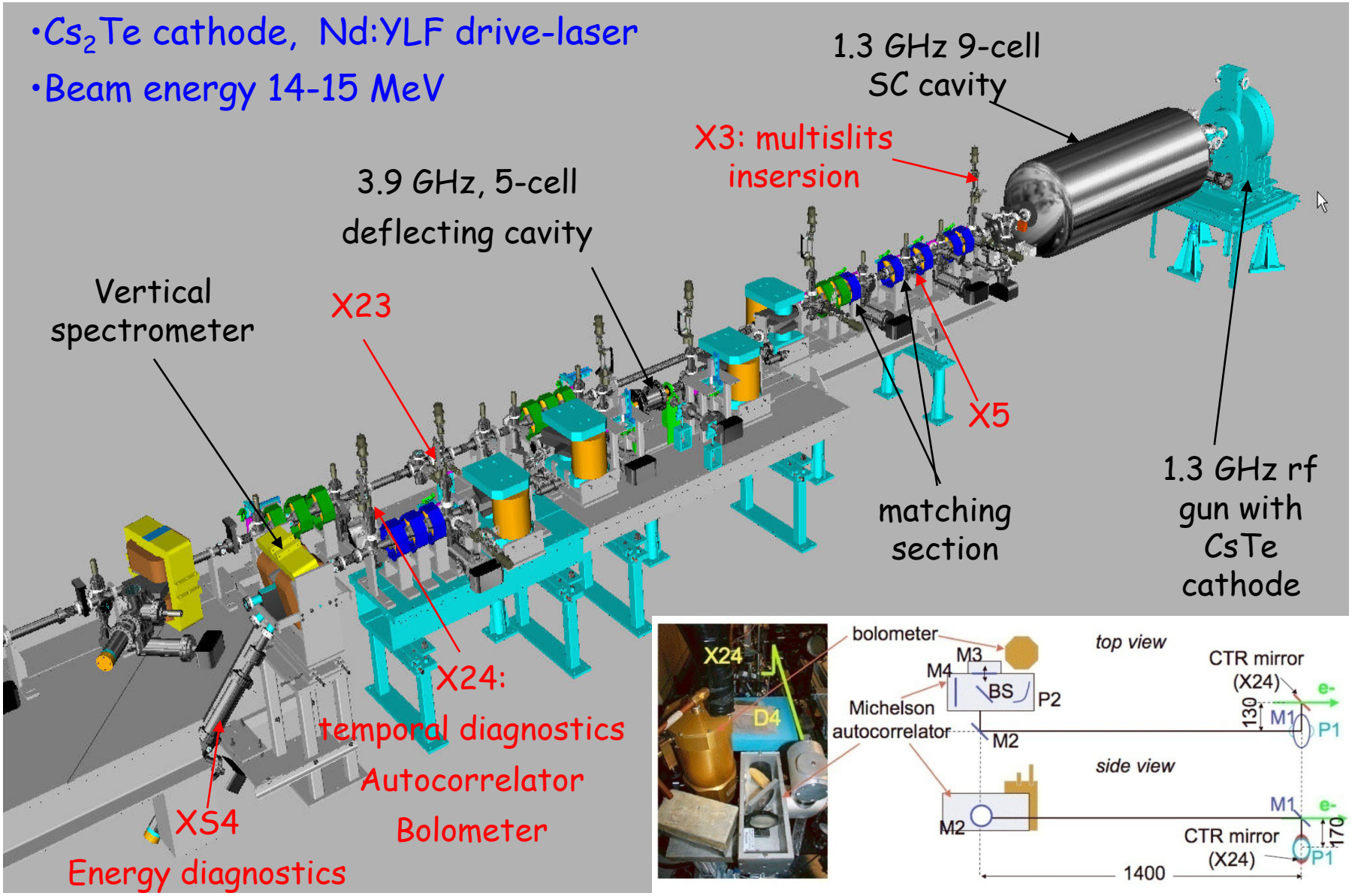
$$\begin{pmatrix} x \\ x' \\ z \\ \delta \end{pmatrix}_{out} = \begin{pmatrix} 0 & 0 & \frac{L+S}{\alpha L} & \alpha S \\ 0 & 0 & \frac{1}{\alpha L} & \alpha \\ \alpha & \alpha S & 0 & 0 \\ \frac{1}{\alpha L} & \frac{L+S}{\alpha L} & 0 & 0 \end{pmatrix} \begin{pmatrix} x \\ x' \\ z \\ \delta \end{pmatrix}_{in}$$

For A0 photoinjector:

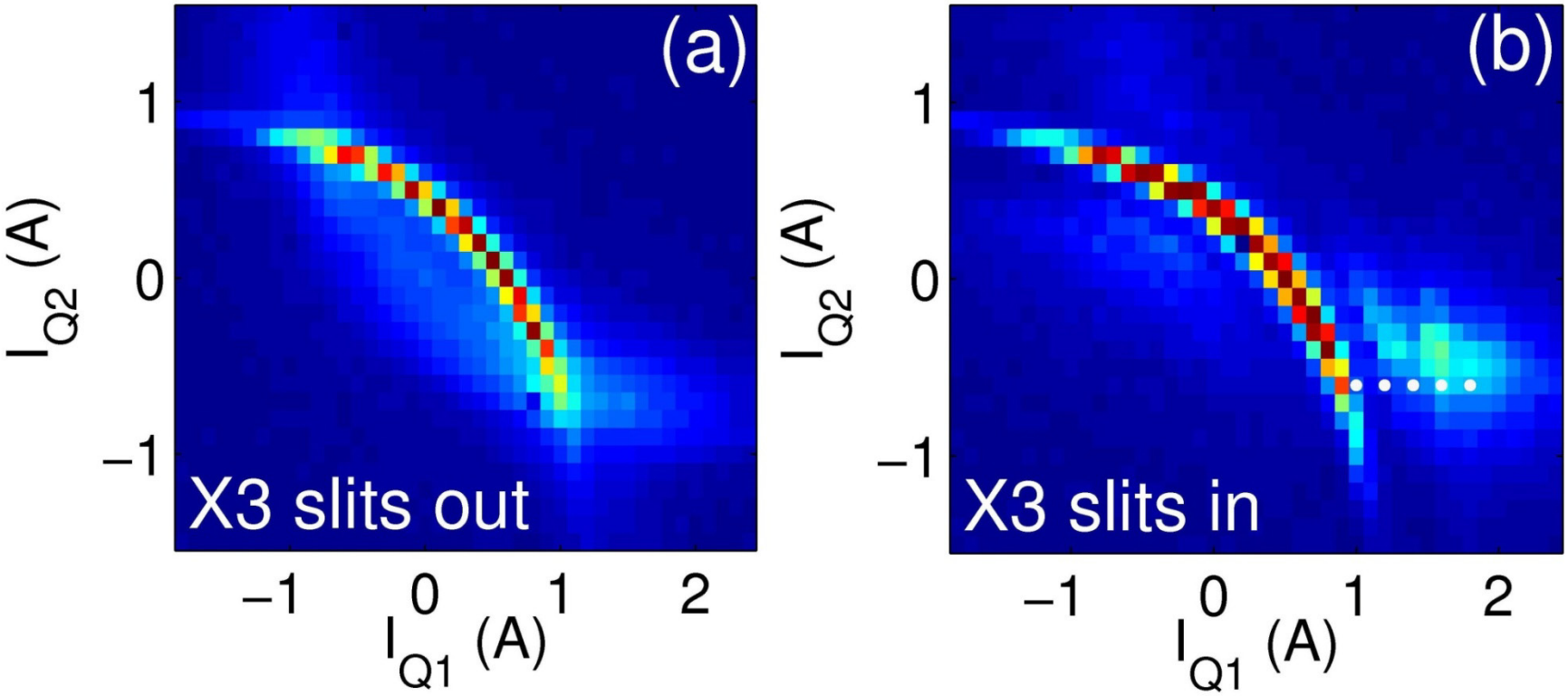
α=22.5 °
L=803 mm
S=764 mm

The A0 photoinjector

- Cs_2Te cathode, Nd:YLF drive-laser
- Beam energy 14-15 MeV



Final bunch length control

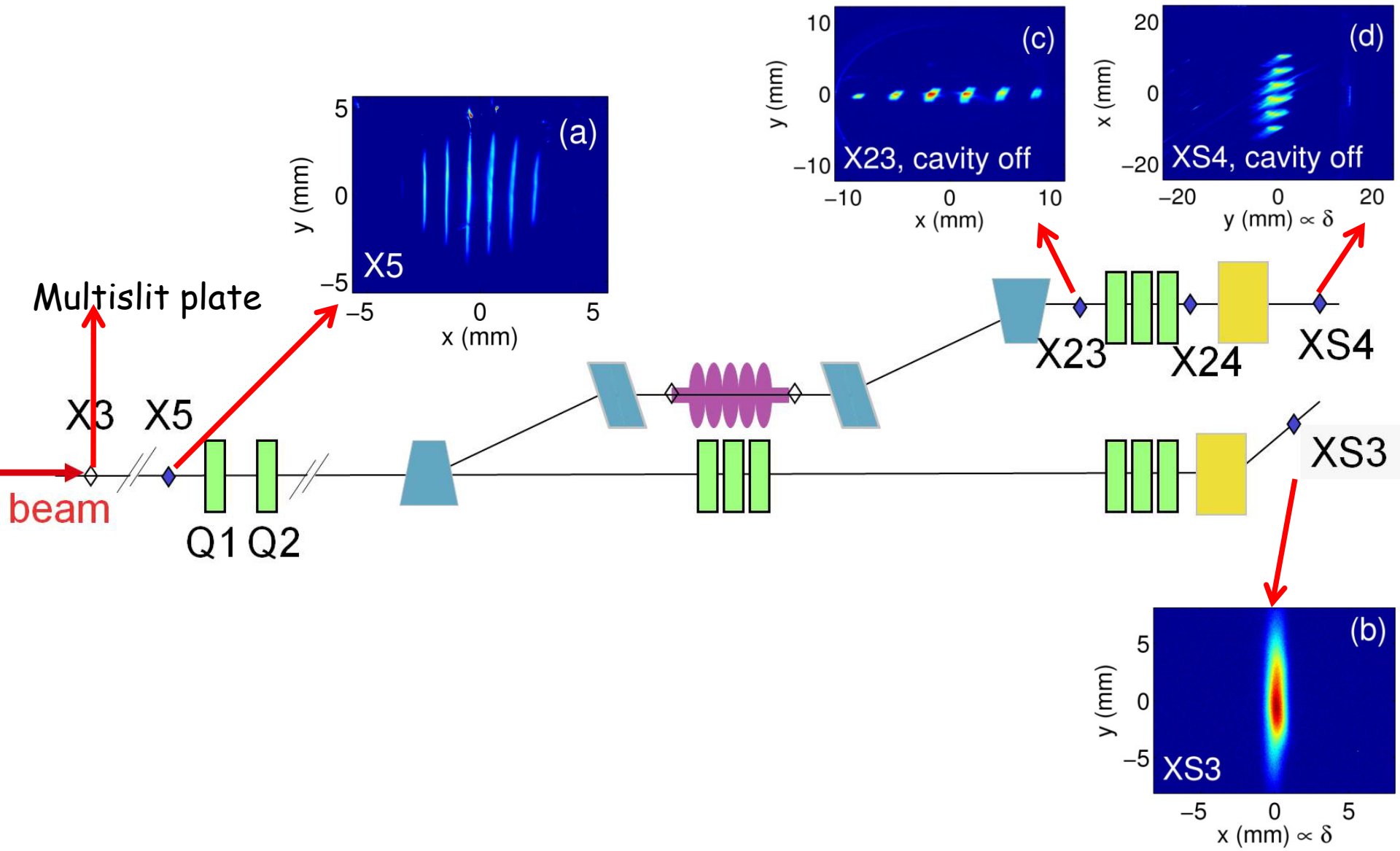


no slits

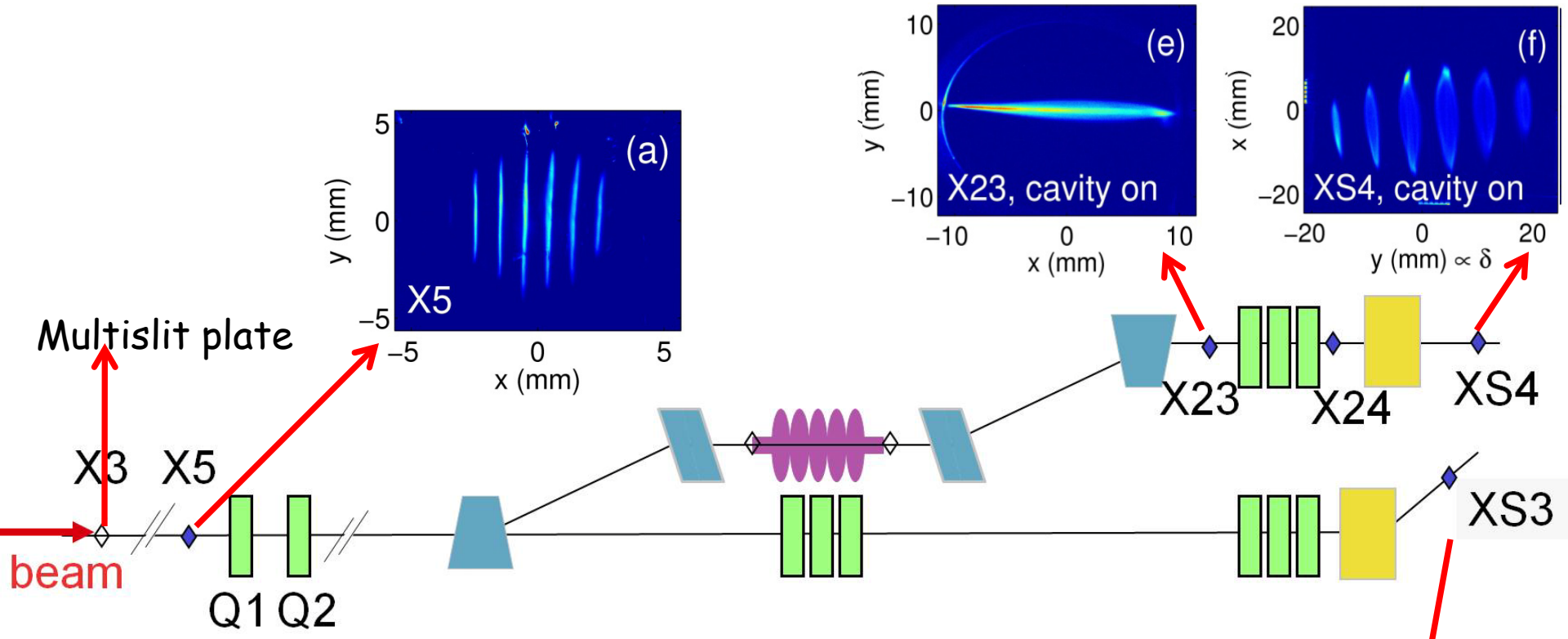
with slits

→ quadrupoles currents
→ initial horizontal beam C-S parameters
→ final longitudinal properties

sub-ps bunch train experiment : energy domain

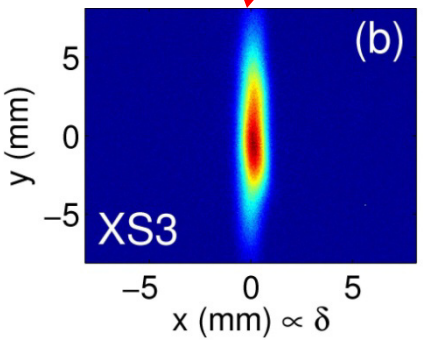


sub-ps bunch train experiment : energy domain



(1) cavity off: horizontal modulation on X23 and XS4;
but no energy modulation on XS4;

(2) cavity on: NO horizontal modulation on X23 and XS4;
but clear energy modulation appears on XS4

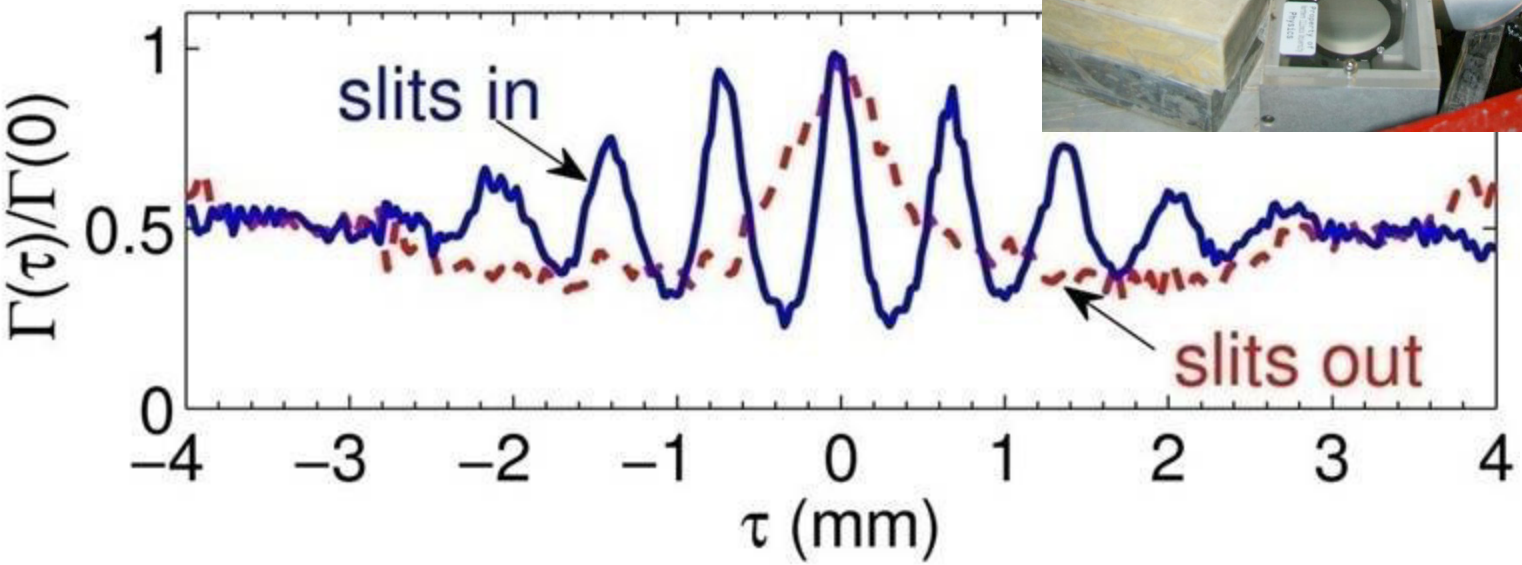


transverse-longitudinal phase-space exchange !

sub-ps bunch trains: time domain

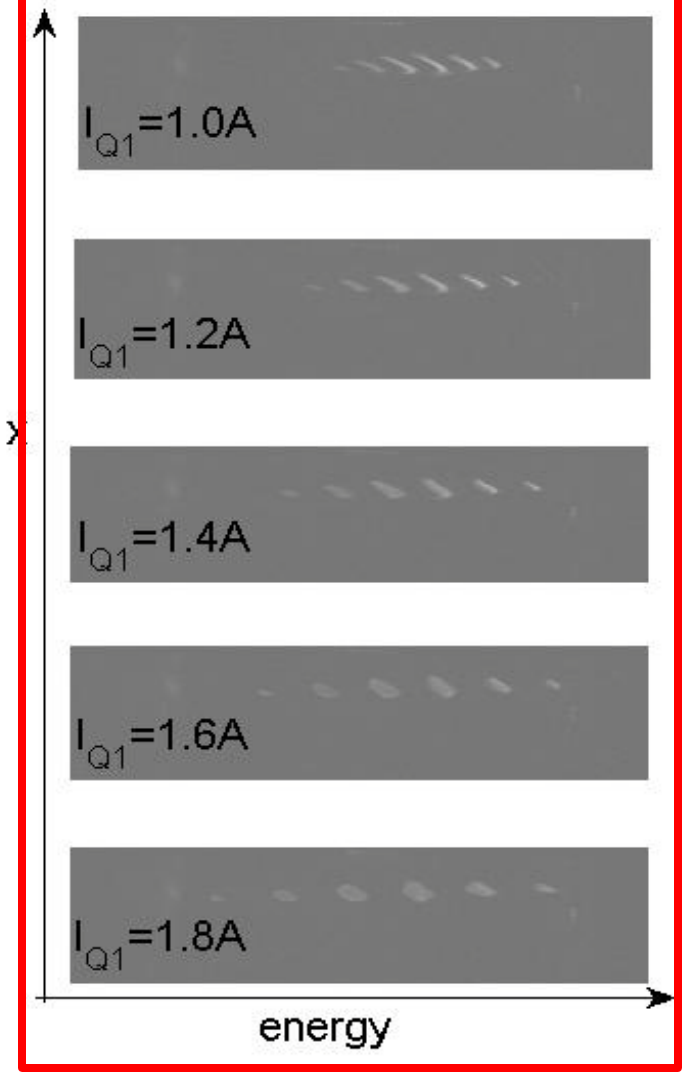
autocorrelation function measured using autocorrelator+bolometer:

slits-in →multipeaks
slits-out→ single peak

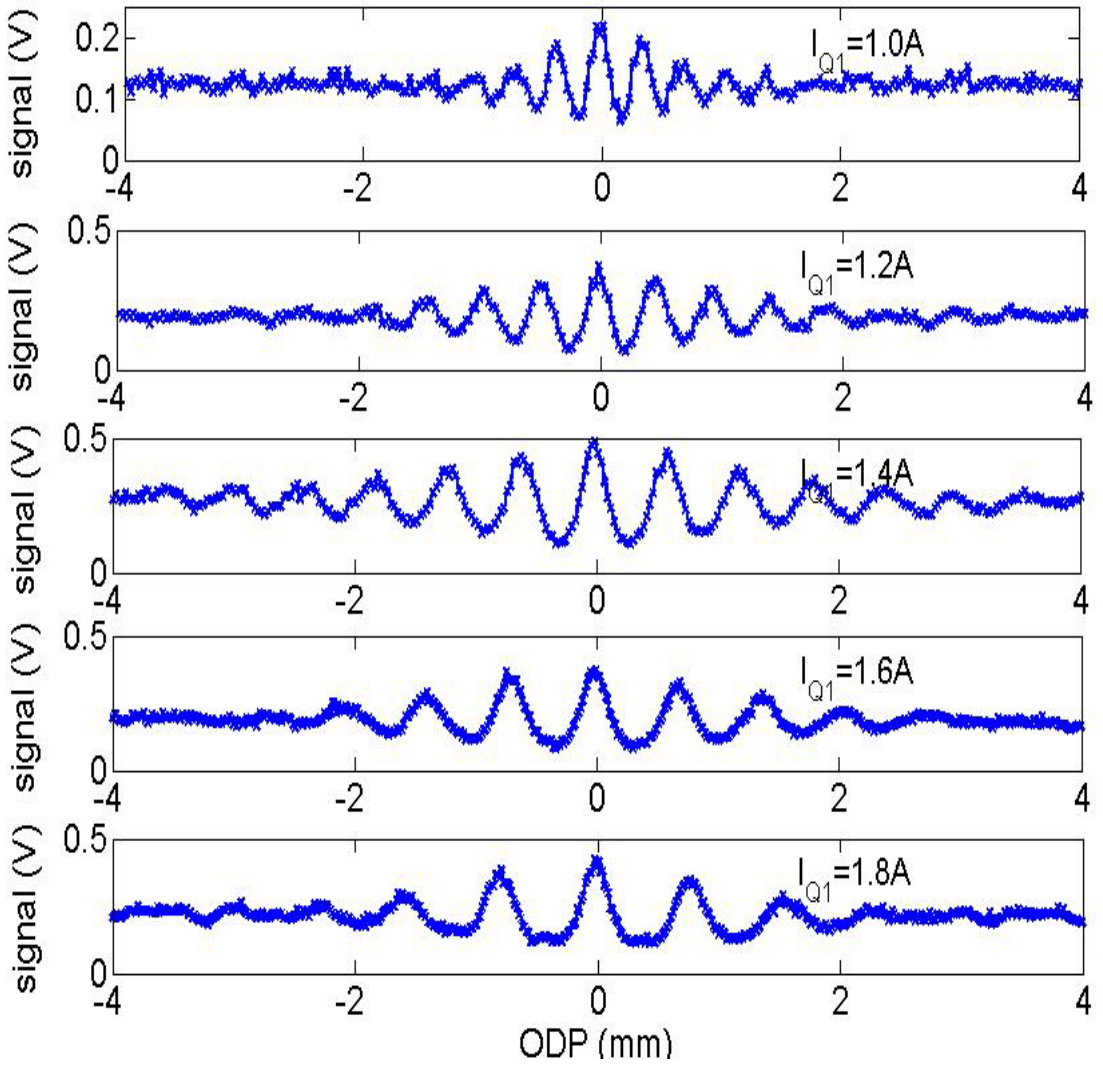


sub-ps bunch train measurements

momentum profile

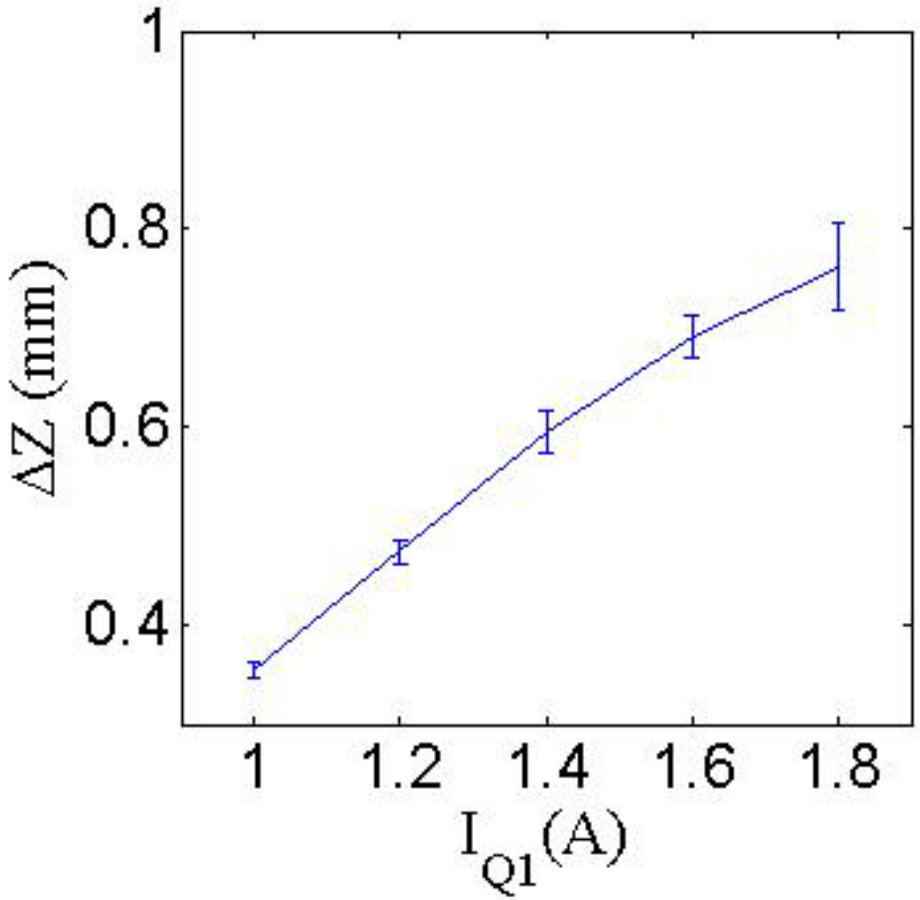


time structure



sub-ps bunch train: results

The minimum bunch separation ~350μm;
Assuming Gaussian distribution, σ_z<300 fs.



Summary

- experimentally demonstrated the generation of subps electron bunch train using a complete phase-space exchange technique.
- The bunch train separation and individual bunch duration can be tuned over a relatively large range by simply tuning one single quadrupole's current.
- Wider range can be achieved using either more quadrupoles upstream of the phase-space exchanger, or using different multislit configurations.
- Recently, we have replaced the single quartz window at X24 by a diamond window, this should allow CTR signals of shorter wavelength to be transmitted to the autocorrelator, therefore improve the resolution of our temporal measurement system.

Acknowledgements

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