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Implemented Pixeled Phosphor Detector (PPD) for laser coupled FEL beam diagnosis

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Diagnostic of free-electron laser (FEL) beam

The measure of femtosecond event requires the *pump-and-probe* technique. A precise control of spatial and temporal alignment of pump and probe sources is fundamental.

Capability of characterizing the FEL photon beam so to determine the different parameters of the emitted pulses.

Beam pulse-resolved features for diagnostics:

- beam position
- transverse beam shape

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Most common diagnostic techniques

Ablation on PMMA or Silicon

- Real beam profile
- No in-situ measurement

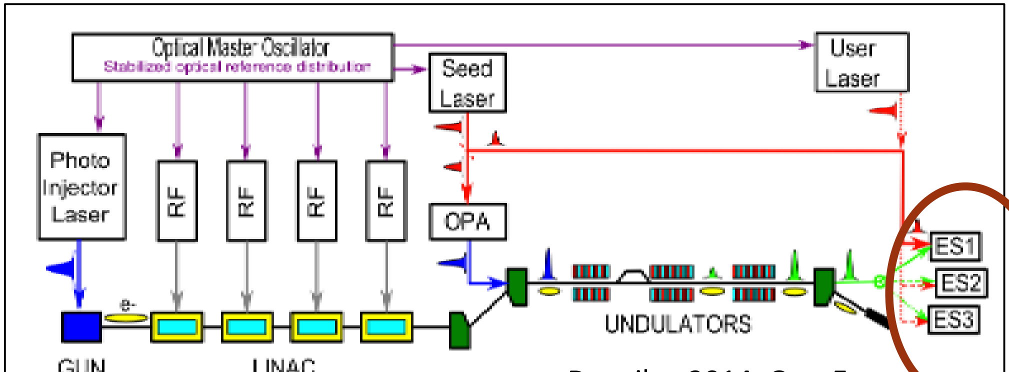
Common scintillators

- Real-time measurements
- Irradiance-dependent non linearity leads to distortion in beam profile

Wavefront Sensor

- Real-time measurements
- Limited wavelength range
- Generally expensive

Temporal alignment of user laser and FEL



Danailov 2014, Opt. Expr.

For the temporal alignment, Al_2O_3 bulk is used, because change its transmittance at λ of FEL

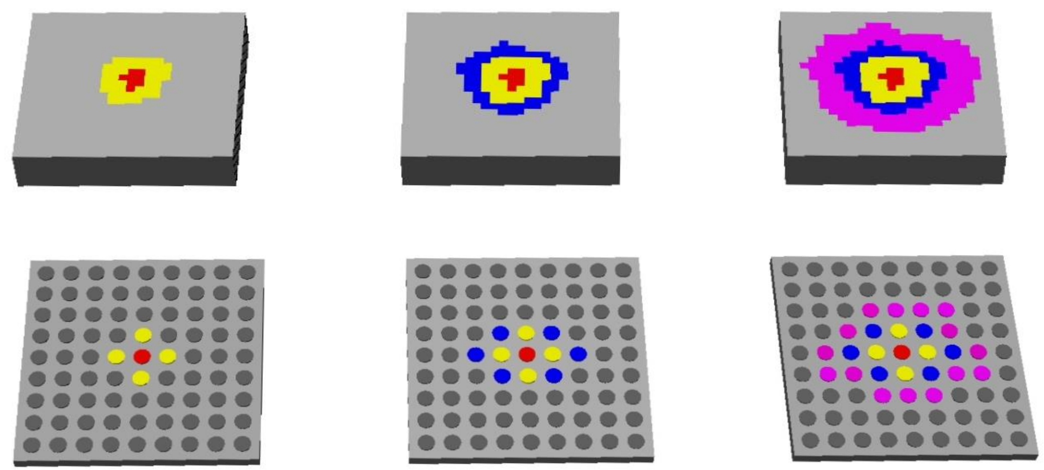
Several days or weeks are needed for time alignment in the final step

The idea: the novel Pixeled Phosphor Detector (PPD)

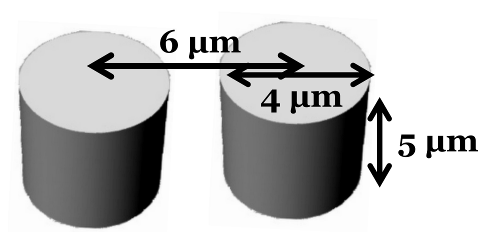
Scintillators

versus

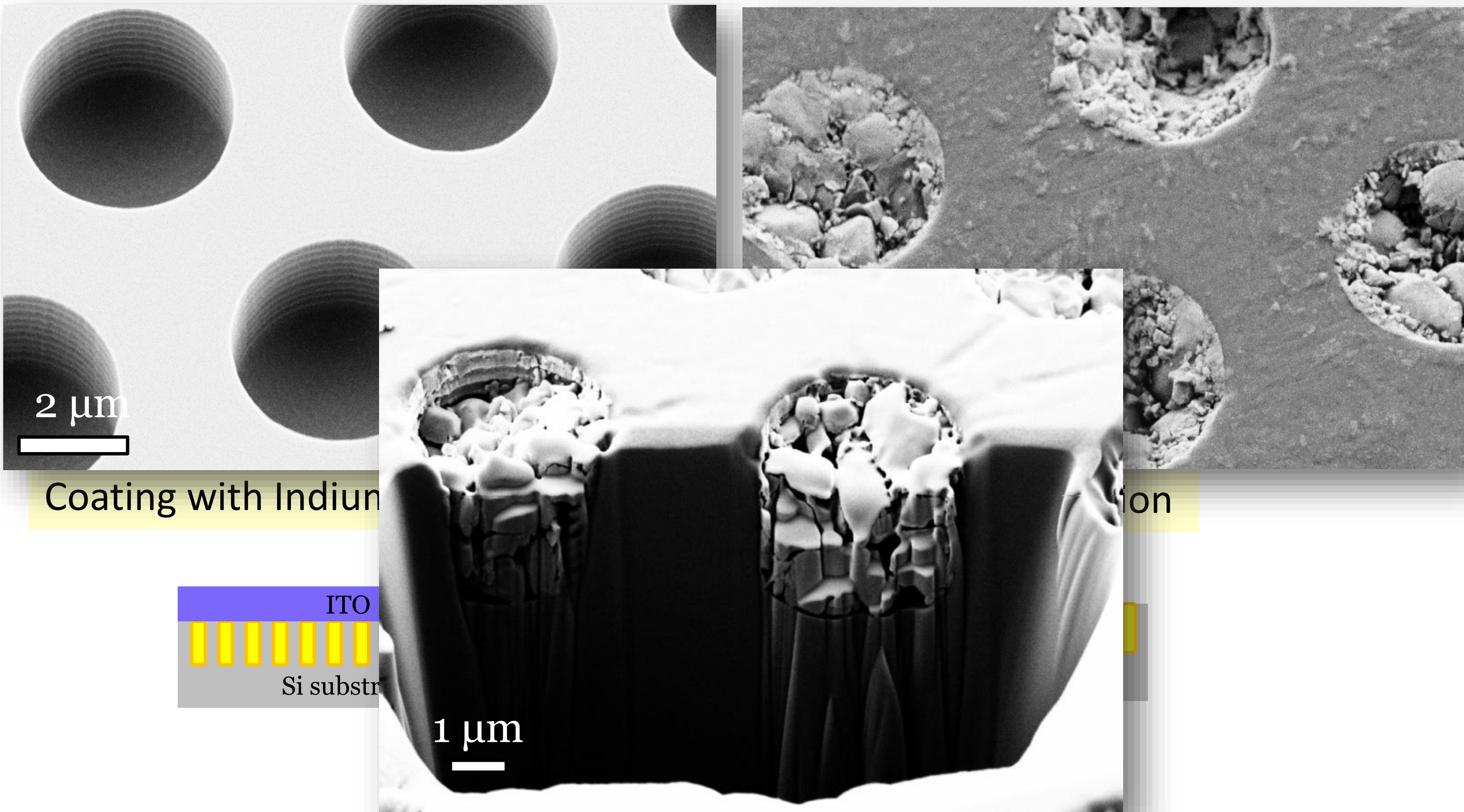
PPD



<u>Pixeled Phosphor Detector PPD</u>: a Silicon periodic lattice of micrometric pixels arranged in a honeycomb geometry; phosphors are confined in the cavities produced in a silicon bulk sample.



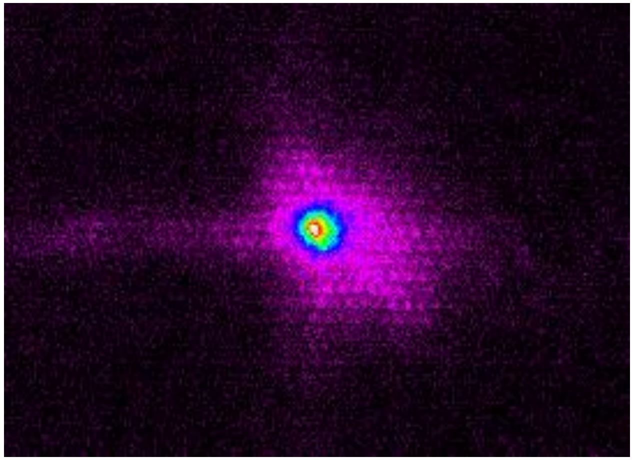
PPD: fabrication process



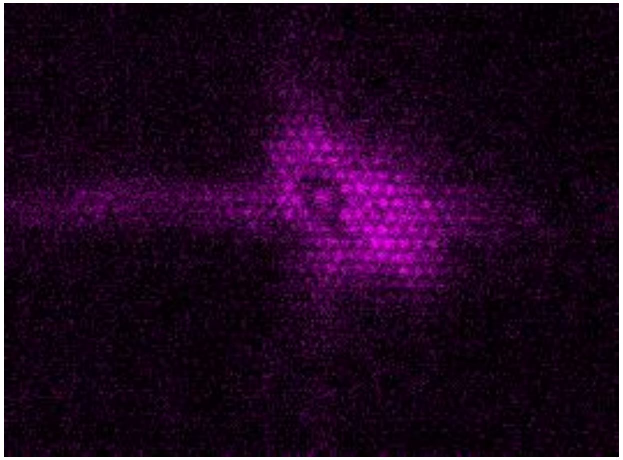
Experimental results: P46 phosphor PPD

Measurements by TIMEX beamline at FERMI@Elettra. Intensity = 7 µJ; λ = 30.5 nm (E= 40.7 eV)

PPD - P46 phosphor

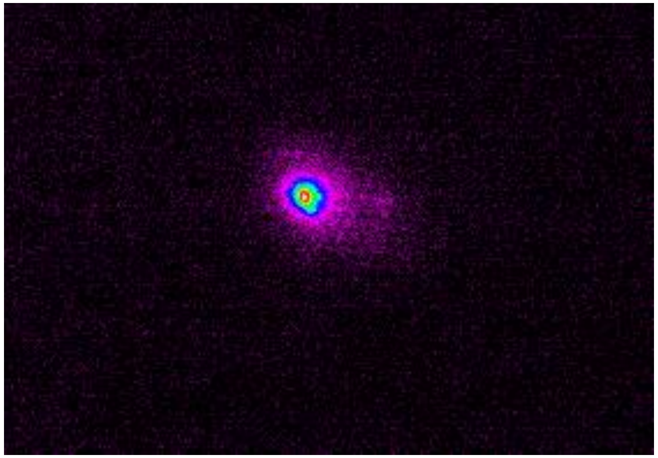


PPD - P46 phosphor after 100 FEL shots

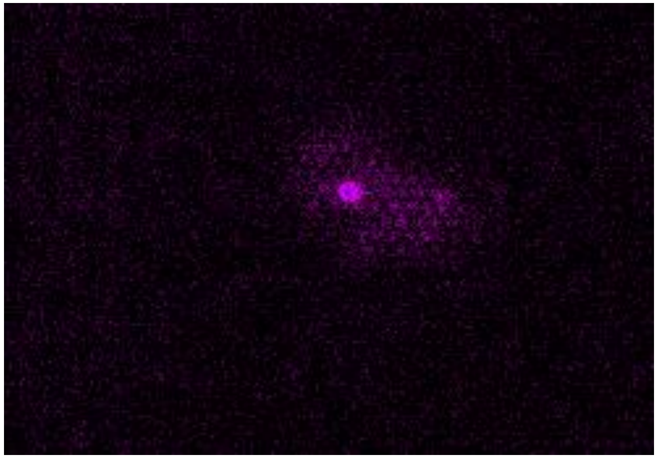


Is possible to estimate the dimension of the beam counting the number of pixels destroyed.

PPD - P46 phosphor, ITO coated



PPD - P46 phosphor with ITO coating after 100 FEL shots

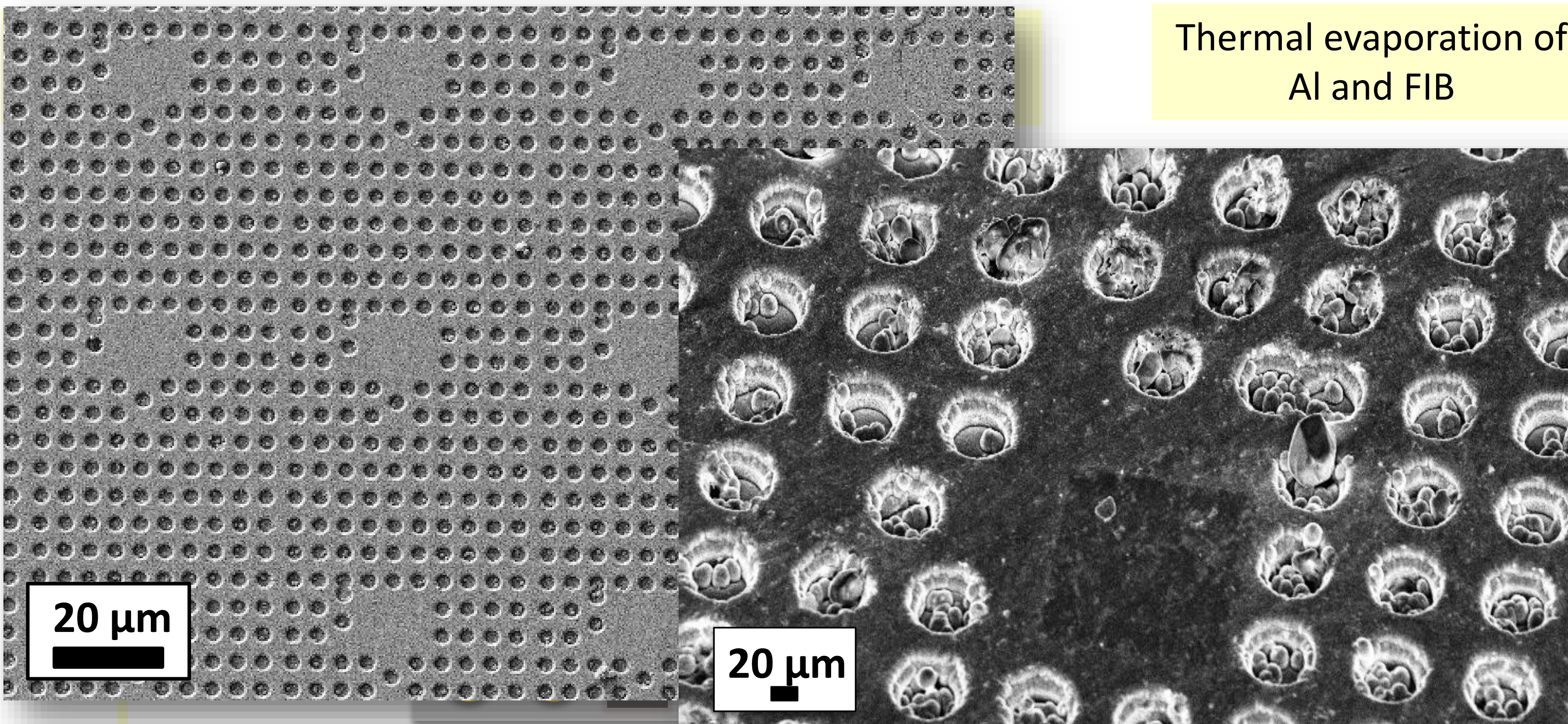


The ITO coating filters the higher energy emission.

Temporal alignment of user laser and FEL: fabrication process

The idea → integrate the PPD configuration with a layer of Al and Al_2O_3

Thermal evaporation of Al and FIB

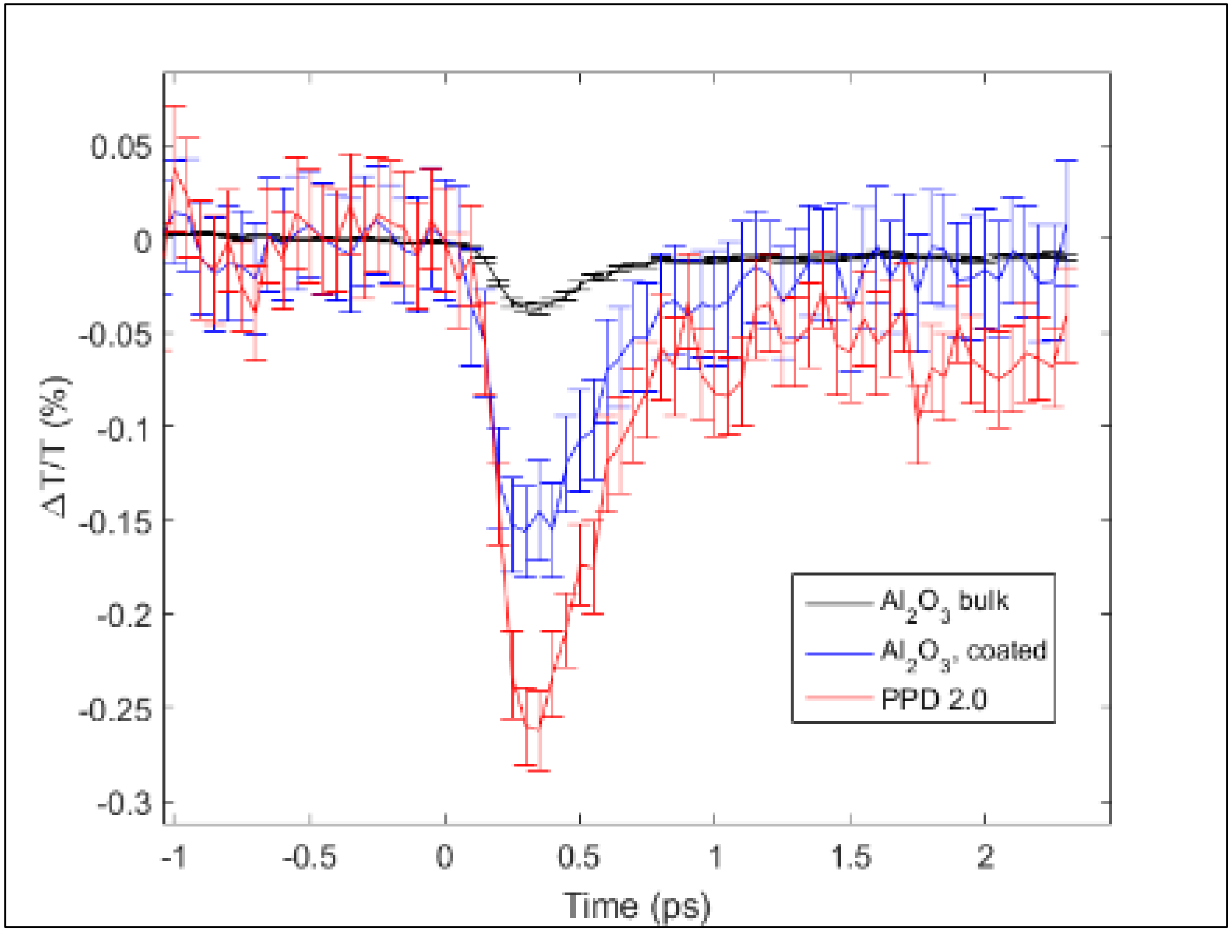


Temporal alignment of seed laser and FEL: results

Measurements by TIMEX beamline at FERMI@Elettra

- λ FEL= 17 nm
- λ user laser = 780 nm

Just few minutes to determine the delay time with high S/N ratio!



Conclusions and future perspectives

We realized a highly precise beam detector which allows to estimate the actual shot-to-shot spot size with unprecedented resolution and to determine the temporal delay between FEL and user seed laser.

- Spatial and temporal alignment of the pump and probe sources on the same device.
- Huge time saving: real time and in-situ technique.
- Survey of the actual size of the beam.
- The ITO coating helps to distinguish the contribution of the actual beam spot from higher order harmonics.
- The system can be customized to use different phosphors at different λ.
- Absorption studies on ITO can help to determine which components of energy are filtered.
- Changing the size and the periodicity of the pixels can increase the resolution.
- Other materials that change optical properties in the λ of interest.

Acknowledgments

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Thank you for your kind attention!