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LMJ x-ray streak cameras vulnerability to EMP

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LMJ XRSC – EMP

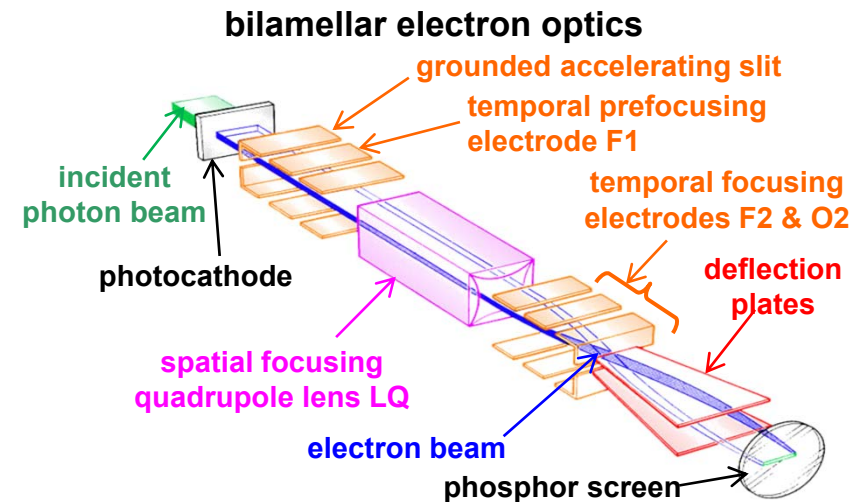
2016.06.29-30

Estimated EMP during LMJ & PETAL shots

- **LMJ**, 176 laser beams, **gain shot**: 100 kV/m in the EC
→ ~10 kV/m in front of an inserted streak camera (SID ~ DIM)
- **PETAL**: 1 MV/m in the EC
→ ~100 kV/m in front of an inserted streak camera
- Orientation: ~isotrope in front of the XRSC (multiple reflections in the EC)
- Spectral width: several GHz
- Contemporary with the observed phenomenon, decay time: several 100s ns

Electron optics

- Voltage tolerances:
 - a few V on photocathode, F1, F2&O2
 - a few 100 mV on LQ
- Dimensions:
 - streak tube 48 cm long
 - electrodes a few cm long



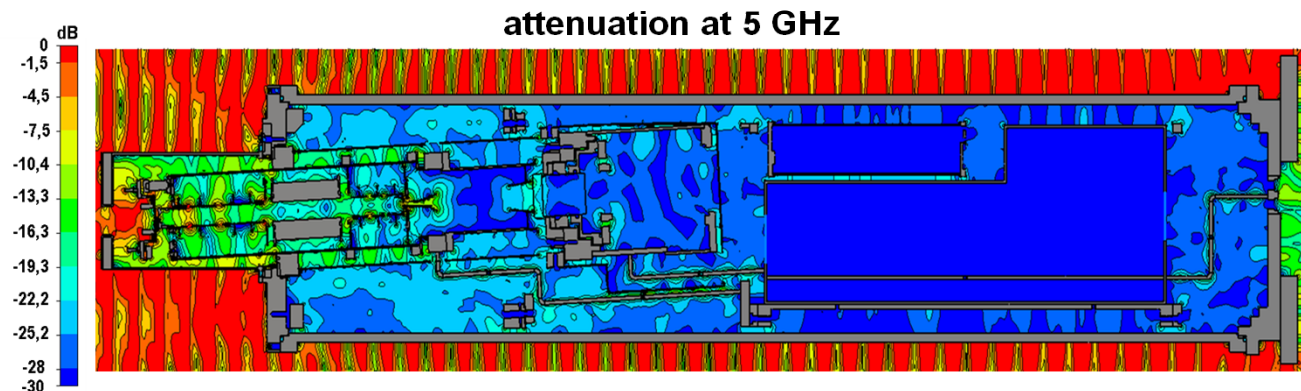
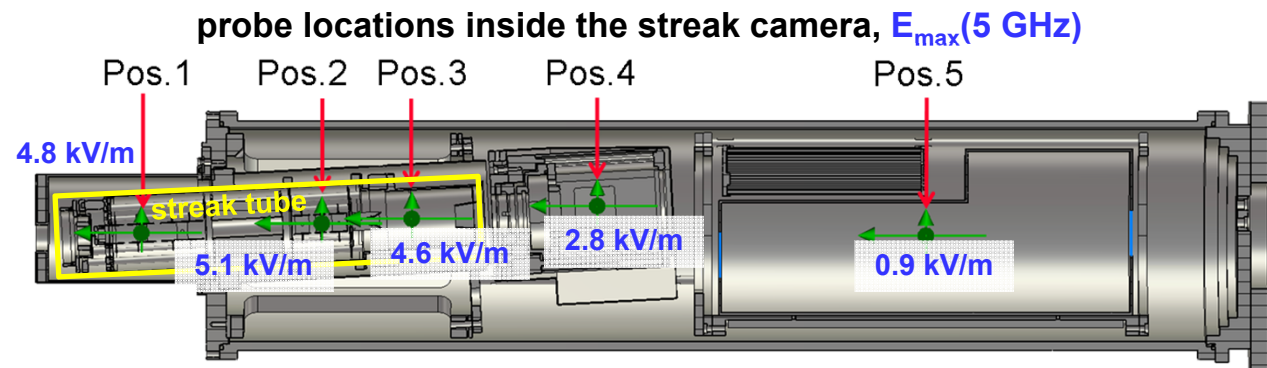
- CST Micro Wave Studio
- EMP: intensity 100 kV/m at t_0 , frequency 1, 5 and 10 GHz, damped sinus, planar wave
- Simplification of XRSC geometry (suppression of complex photocathode holder)

- Evaluation of E field intensity inside the air box, for a 5 GHz EMP:

→ up to 5 kV/m inside the air box and the streak tube

→ up to 3 kV/m inside the CCD camera

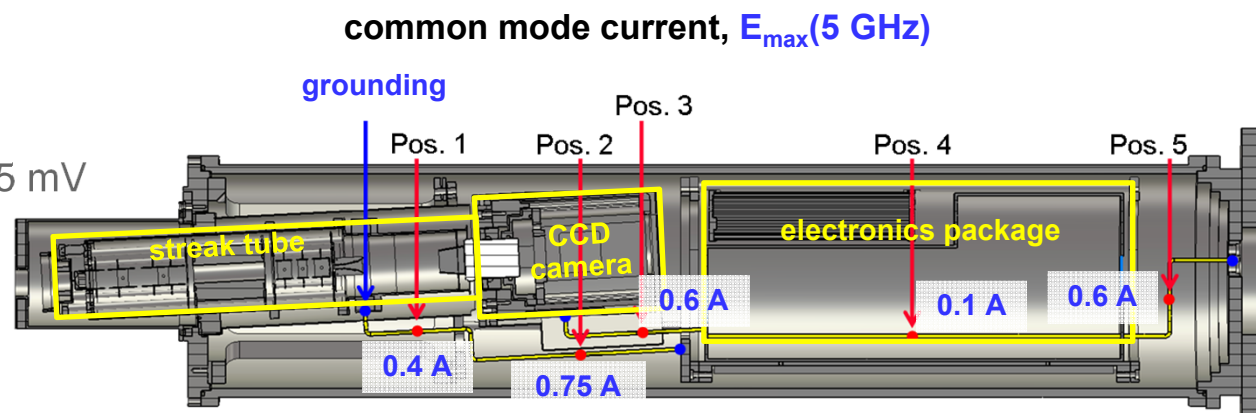
→ < 1 kV/m in the electronics package only



- CST Micro Wave Studio
- EMP: intensity 100 kV/m at t_0 , frequency 1, 5 and 10 GHz, damped sinus, planar wave
- Simplification of XRSC geometry (suppression of complex photocathode holder)
- EM disturbance coupled to the cables:
common mode current up to 3A in cable
shielding inside the air box, for
a 5 GHz EMP

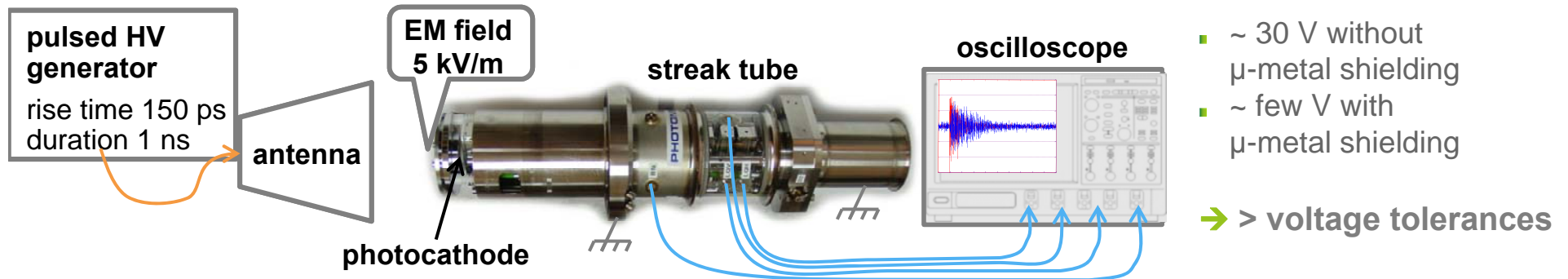
→ differential voltage up to 1.5 V
for single shielded cables
> voltage tolerances ☹️

→ differential voltage up to 15 mV
for double shielded cables
< voltage tolerances 😊

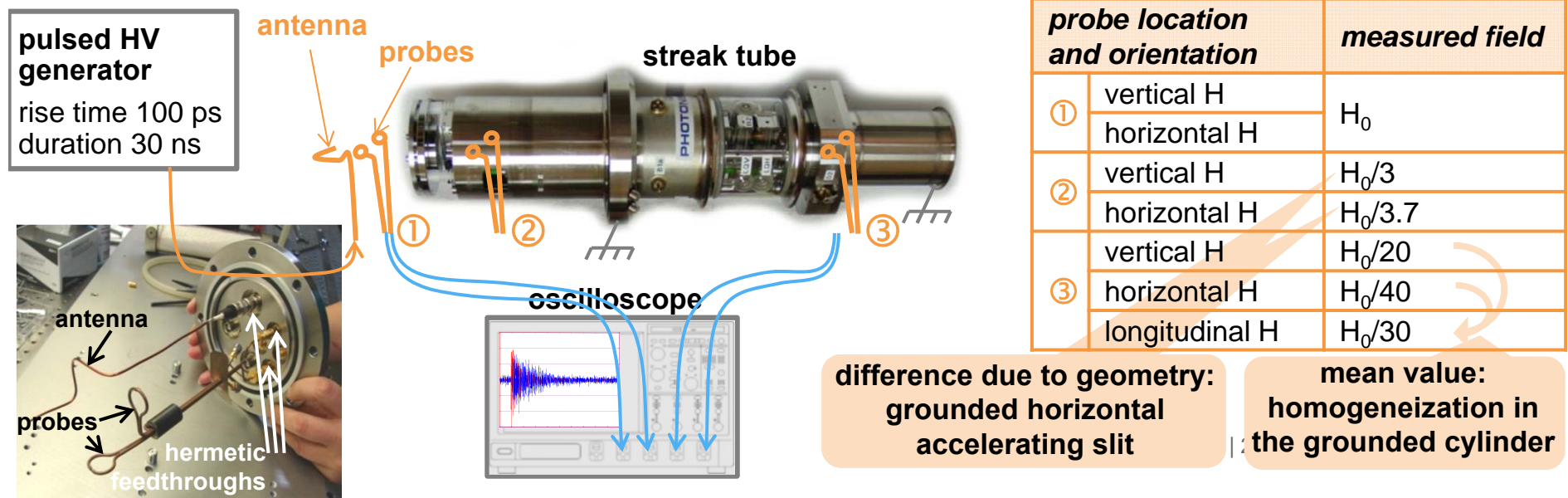


EMP COUPLING TO THE ELECTRODES

■ EMP coupling to the streak tube

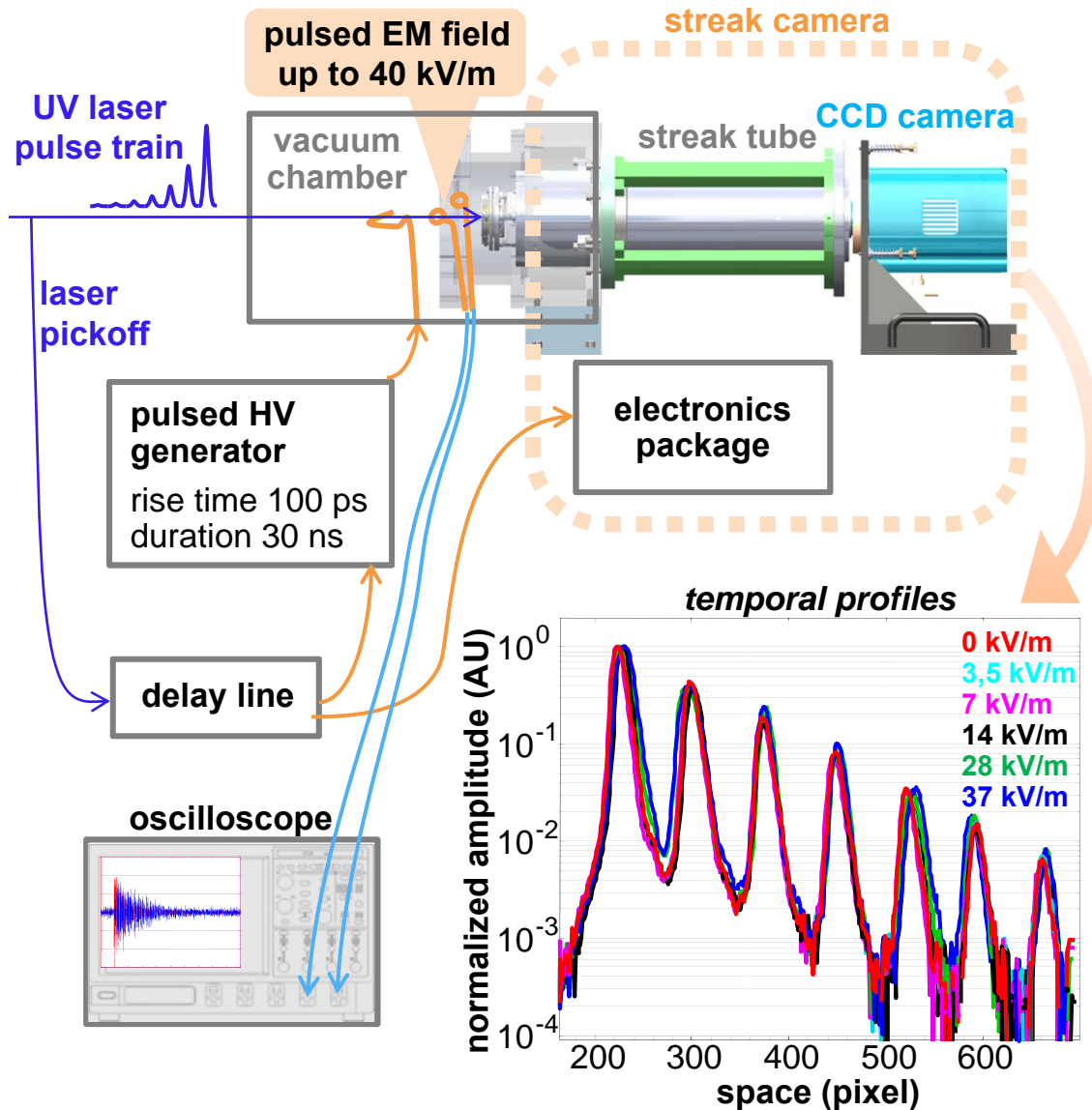


■ EMP attenuation inside the streak tube

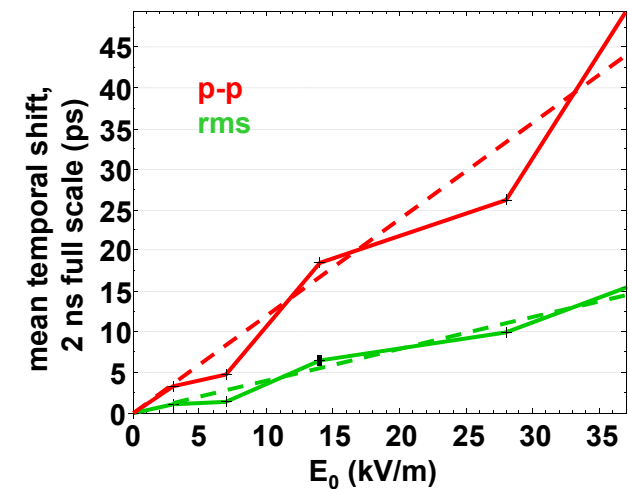
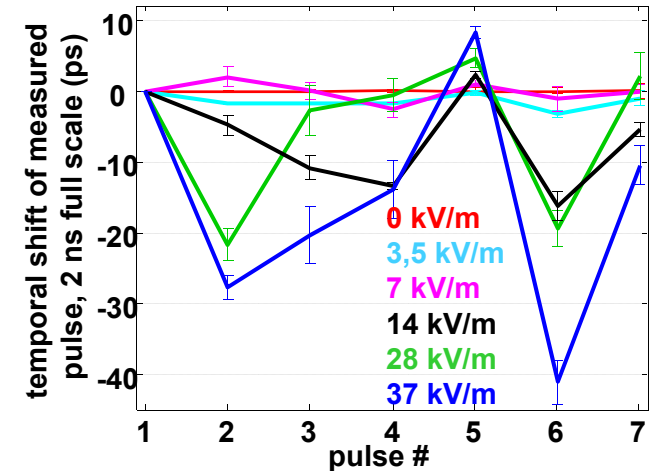


EMP SYNCHRONIZED WITH IMAGE ACQUISITION

Experimental setup



Results



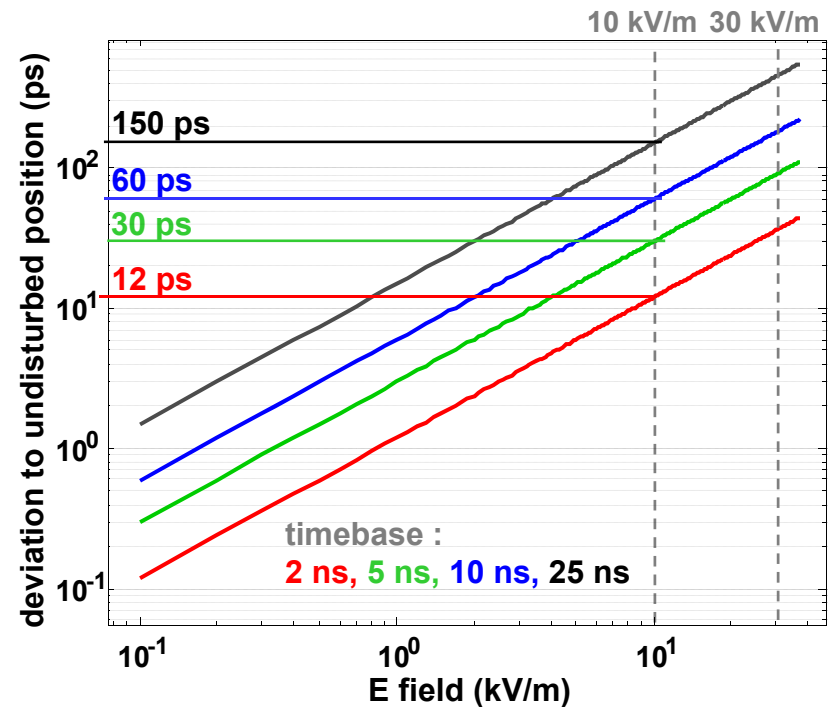
- spatial effects in the temporal direction
 - linear evolution of shift vs E_0
- $E_0 = 1 \text{ kV/m} \leftrightarrow 1 \text{ pixel} (\sim 1\text{-}25 \text{ ps}) \text{ shift}$

LMJ only

- DP4 (2016):
behind DMX, at 11 m from the TCC, with 1 laser chain
→ < 1 kV/m 😊
- DP2 and DP6 (2017):
inserted in an SID (~DIM), at 3.3 m from the TCC, with 2 laser chains
→ < 1 kV/m 😊

LMJ + PETAL

- First PETAL shots (2017):
depending on the target geometry, estimated to:
 - ~ 10 kV/m behind DMX, at 11 m from the TCC → > XRSC tolerance ☹️
 - ~ 30 kV/m inserted in an SID, at 3.3 m from the TCC → > XRSC tolerance ☹️



EM field measurements

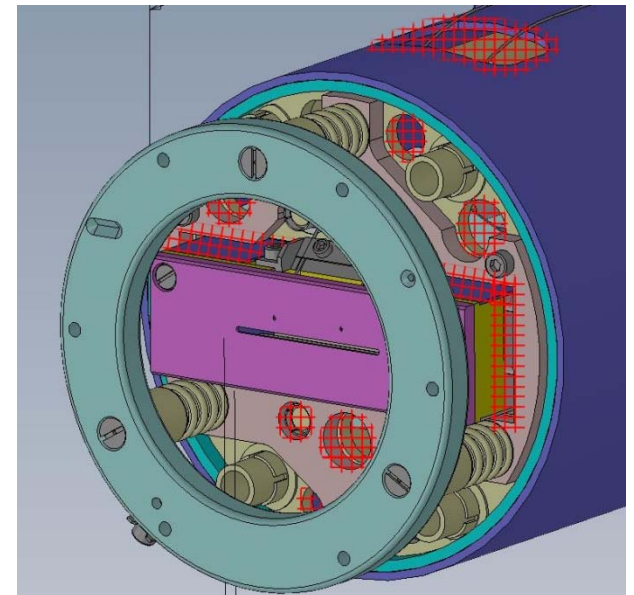
- Currently being installed in the experience chamber + hall
- Measurements in early 2017

Streak camera and plasma diagnostic prospects

- **Evaluation** of microscope / spectrometer EM attenuation
- **Timing fiducial** to monitor the EM disturbance during a shot
- **Shielding** : grounded tubing of optical paths

Streak tube evolution

- Grounded grids welded over the openings of the front flange
- Replacement of the glass envelope by a metal envelope
- Possibly coaxial, HV hermetic feedthroughs on the streak tube envelope, to minimize the unshielded cable length



Measure of x-ray streak camera EM sensitivity

- Tolerance 1 kV/m in front of the photocathode \Leftrightarrow temporal deflection 1 pixel

Estimation of EM disturbance for an integrated XRSC

- LMJ only:
→ **OK until 2 laser chains**
- With PETAL:
→ **NOK from the first shot**

Planned actions

- Measurement of EMP in the experience chamber
- Streak tube shielding
- XRSC and plasma diagnostic shielding
- UV timing fiducial for XRSC

+ how did you solve this issue ?