Fast scanning systems for Laser-wires

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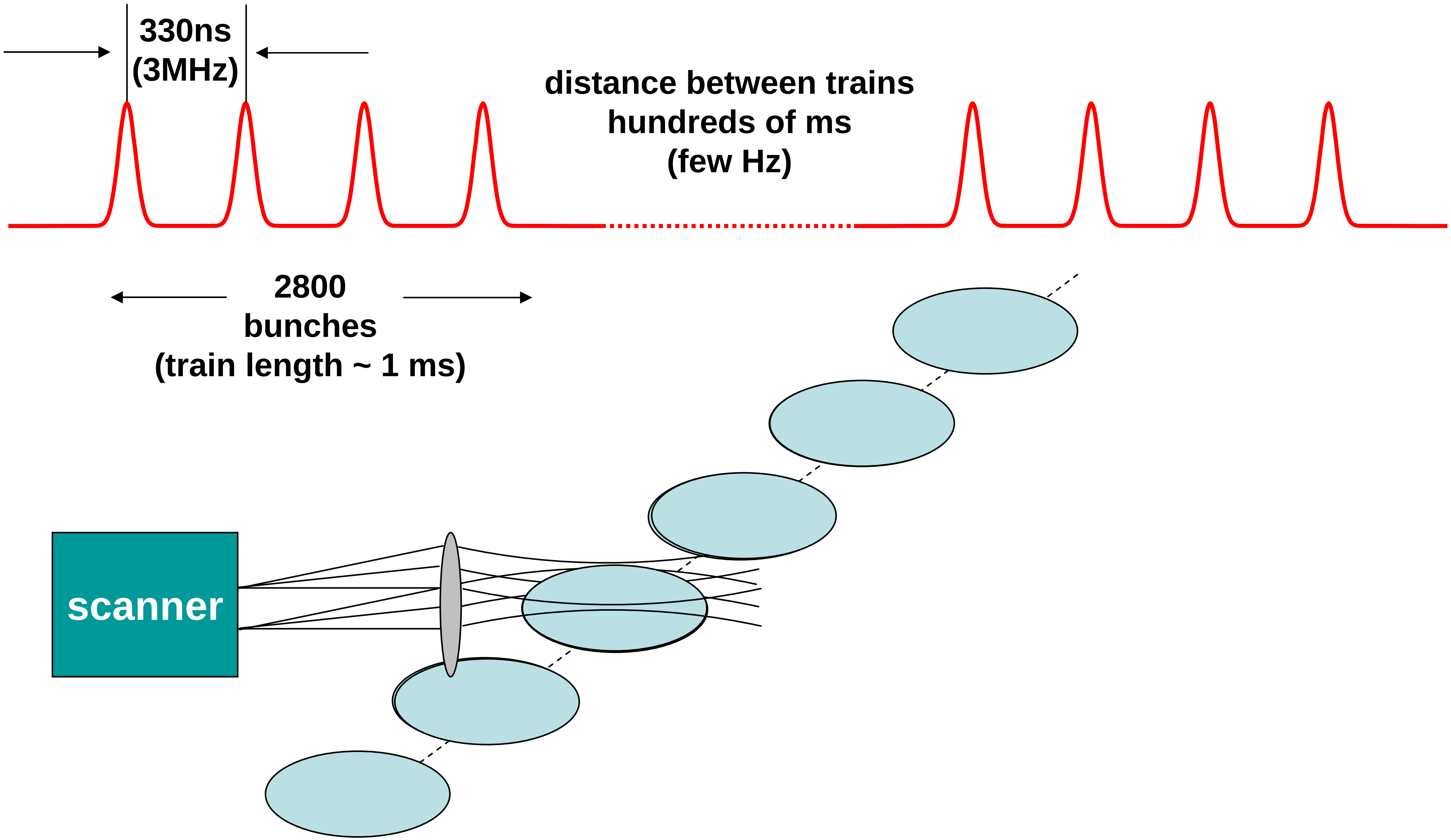
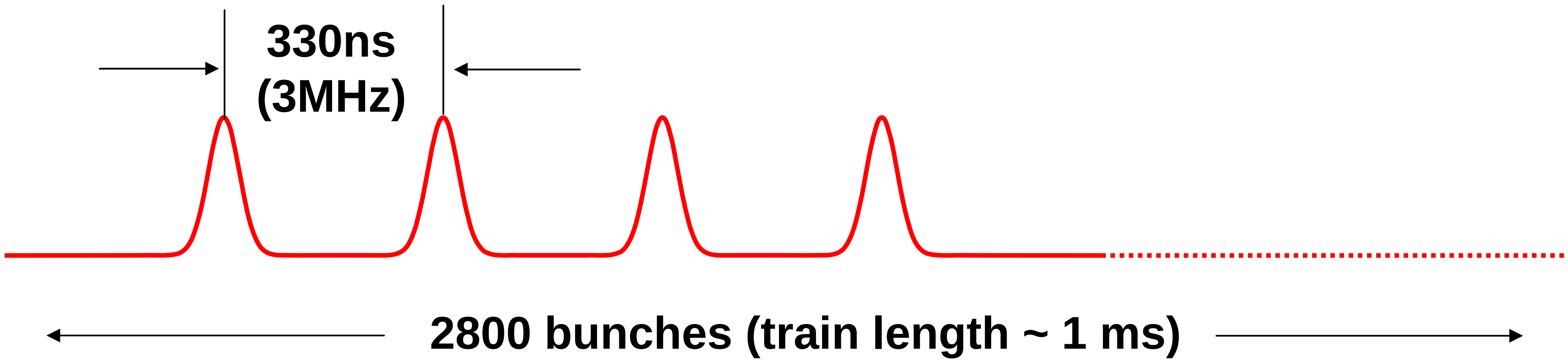
Task: scan over 10 consecutive bunches





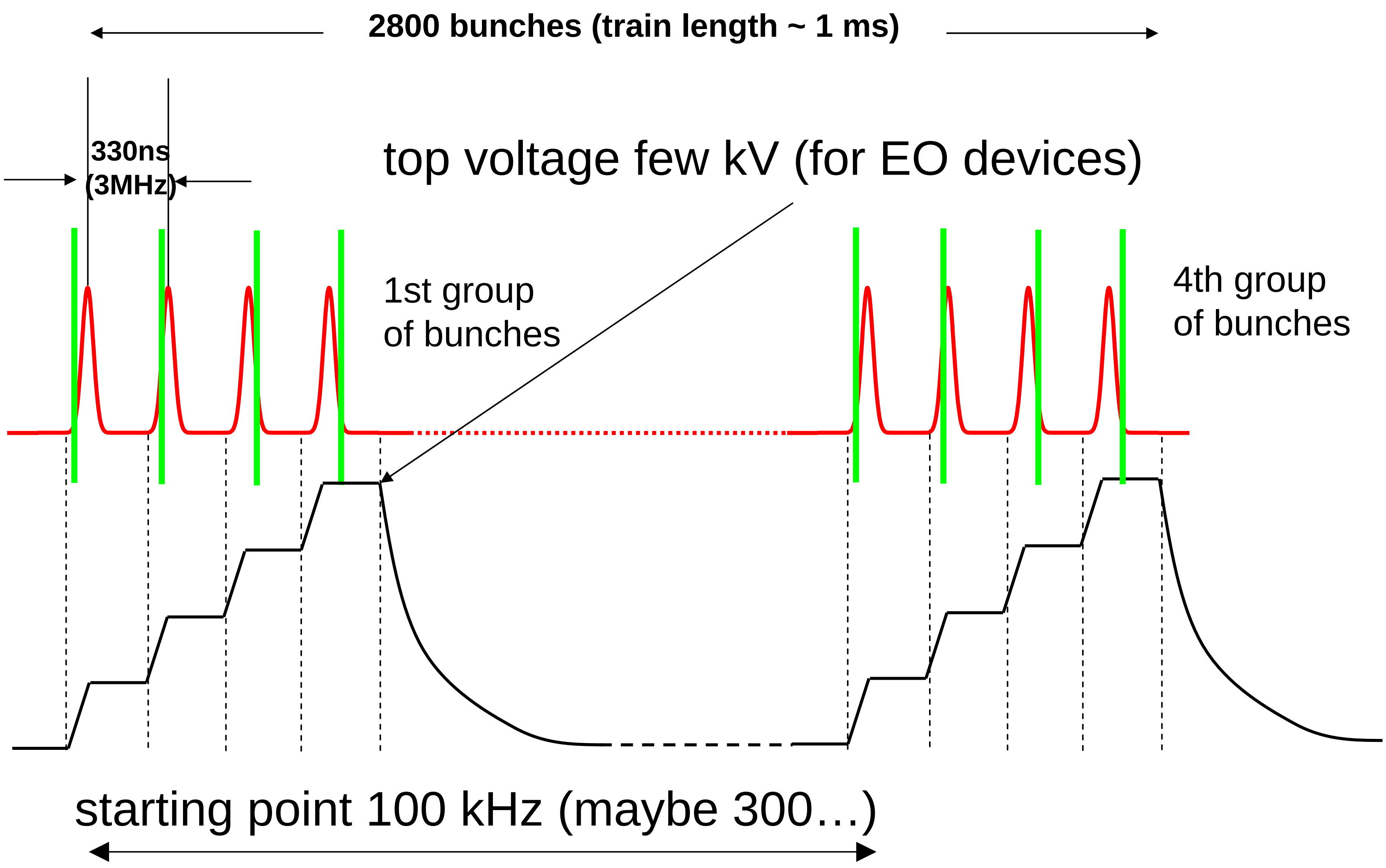
ultra-high driving frequency:

with 3 MHz laser (to be developed in Oxford)
and 100 kHz scanner (RHUL job)
we could in principle scan every 4th group of 10 bunches

time of one complete scan = 3.3 μs
number of scan within a train 100

…possible with EO to run @ 300 kHz
(scan every group of 10 bunches)

Device's driver idea:



Electro-Optic Techniques:

high repetition rates

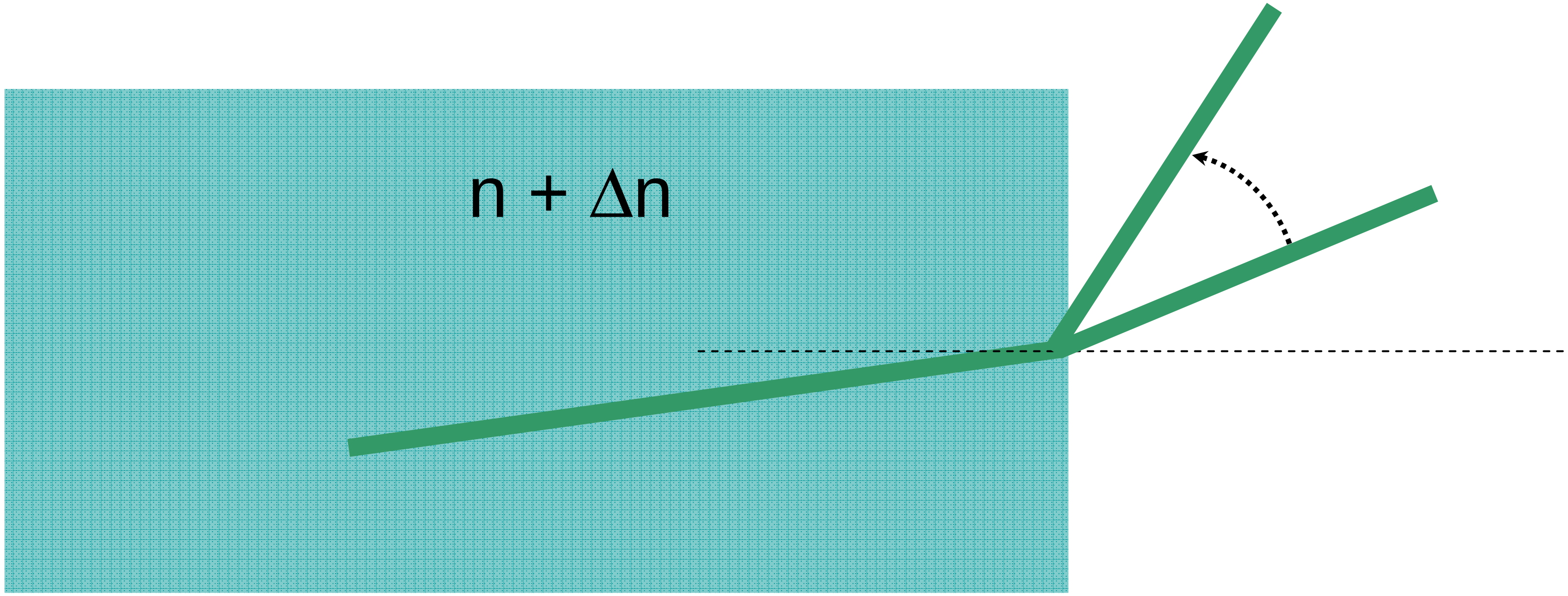
response time limited by voltage driver and electrical capacities

high reproducibility

no shifts of mirrors or other optics are needed

of course there are still many open issues…

Operation principle:



modify the refraction direction by changing the refractive index via EO effect

$$\Delta n = \frac{1}{2} n^3 \; \overleftrightarrow{r} \bullet \vec{E}$$

Some Issues:

Low Efficiency of EO devices ($\Delta n \sim 10^{-5}$ with E=1 kV/cm)

High Applied Voltage (which might limit the working frequency)

Aperture of the device should be large enough to:

- accommodate larger laser beam spot sizes
(ranged between 1 – 10 mm)
in order to have lower intensity (we aim to work with tens of MW),
better focus, less diffraction…

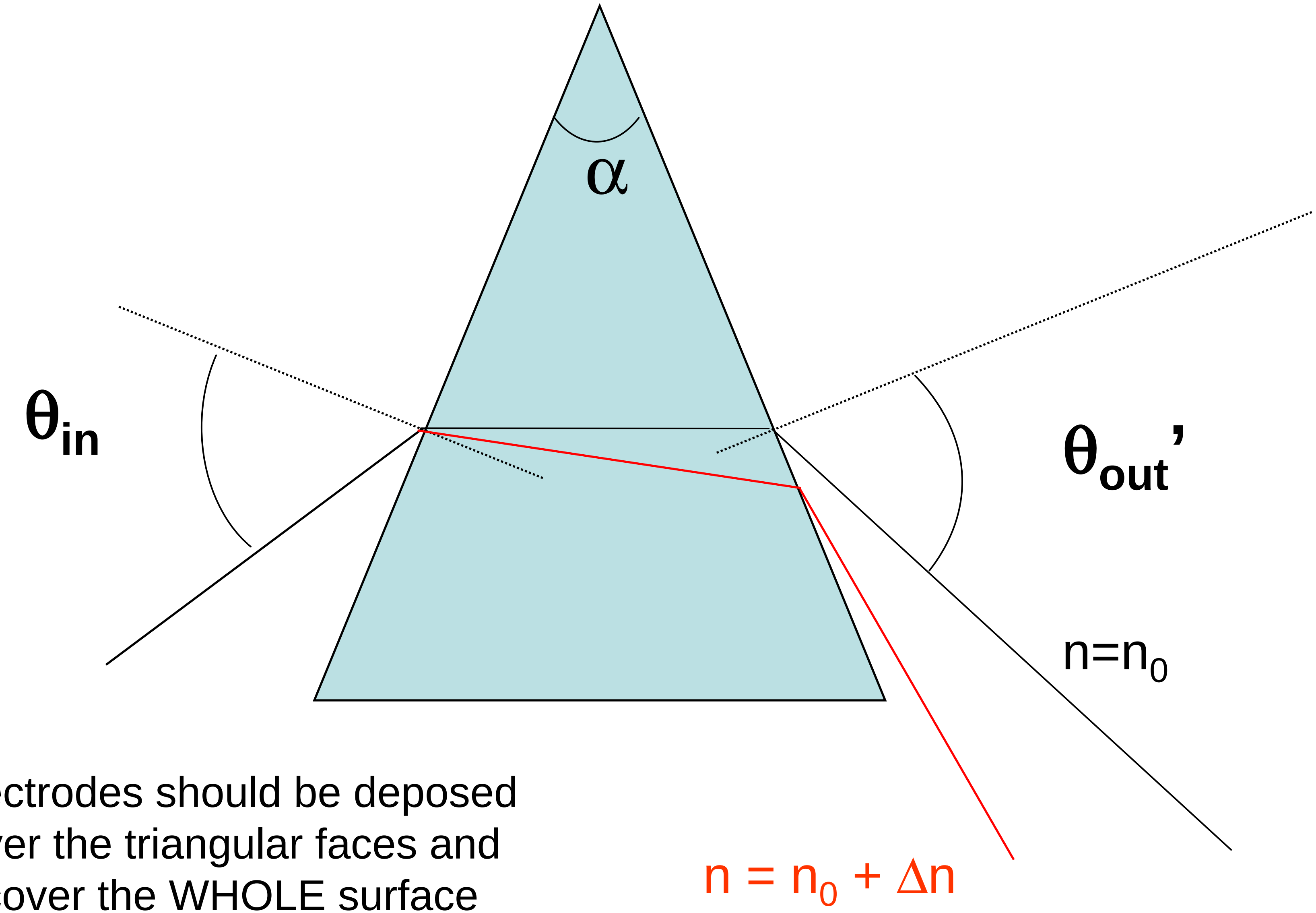
- limit the device electrical capacity (faster time response)

but Electric Field is INVERSELY dependent on the thickness

List of EO materials:

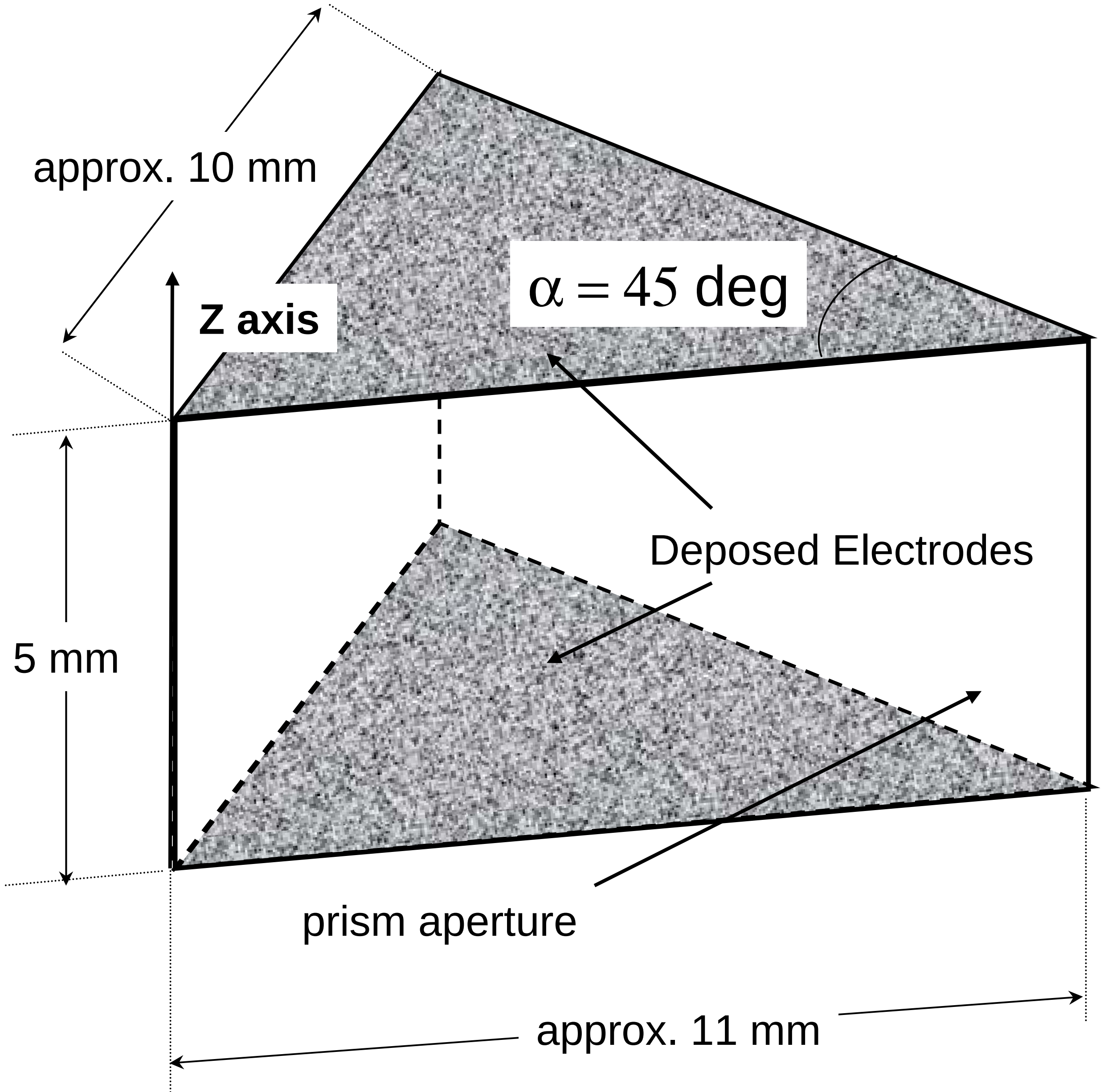
Material	Useful EO coefficient [pm/V]	n_0	Δn $0.5n^3 r_{ij} E_j$ (E=2.5kV/cm)	Damage Threshold [MW/cm^2]
$KNbO_3$	r_{42}=380	n_2 =2.28	4.5 X 10^{-4} Ey	350 (10ns)
$LiNbO_3$	r_{33}=30	n_3 =2.15	3.73 X 10^{-5} Ez	200 (10ns)
$LiTaO_3$	r_{33}=32	n_3 =2.19	4.2 X 10^{-5} Ez	500 (10ns)
SBN75	r_{33}=1340	n_3 =2.27	1.96 X 10^{-3} Ez	-
$KTiOAsO_4$	r_{33}=40	n_3 =1.86	3.11 X 10^{-5} Ez	10^4 (100ps) 10^3 (8ns)
$KTiOPO_4$	r_{33}=35	n_3 =1.90	3 X 10^{-5} Ez	500 (20ns)

Scanner working principle:

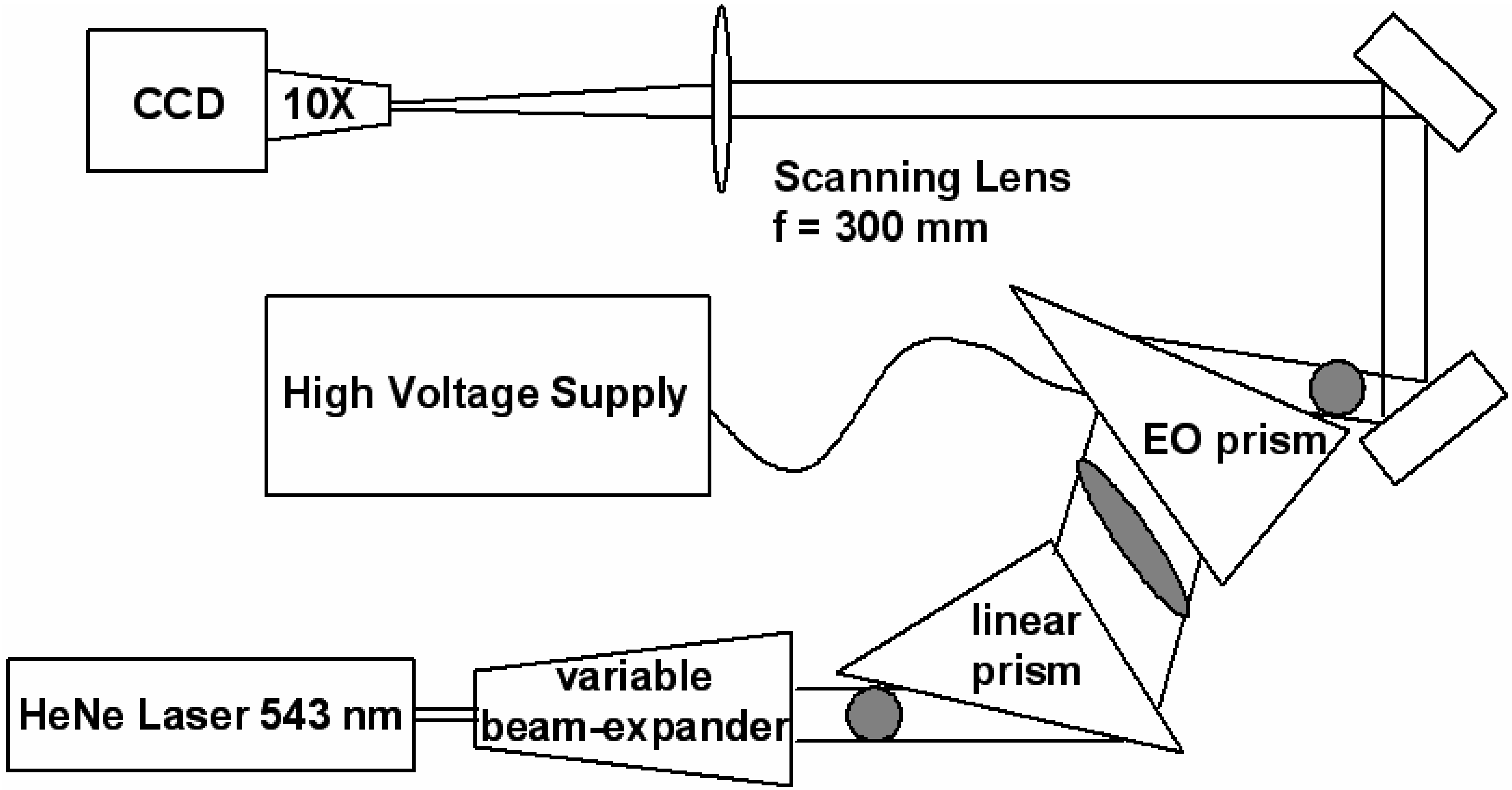


Electrodes should be deposed over the triangular faces and cover the WHOLE surface (deflection happens at the edges!)

Scanner prototype (LNB):



Experimental set-up
Static voltage (up to 2 kV) tests:



Experimental results:

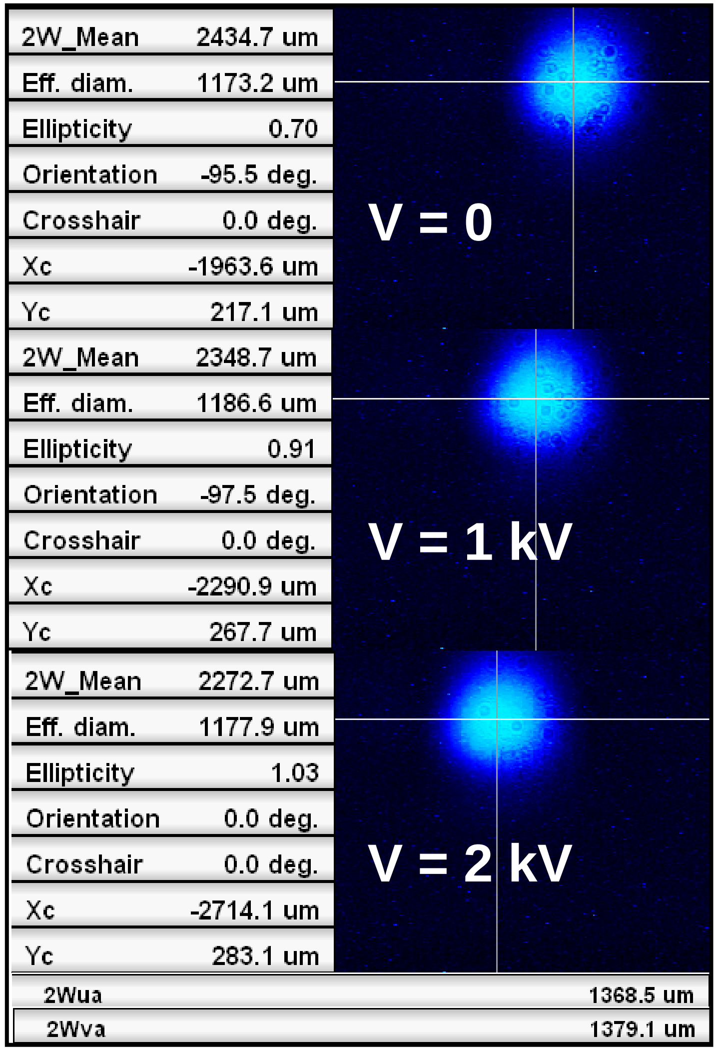
scan range @ focus VS applied voltage

input spot = 2 mm

waist = 68 μm (135 diameter)

shift = 75 μm

deflection = 0.25 mrad



Experimental results:

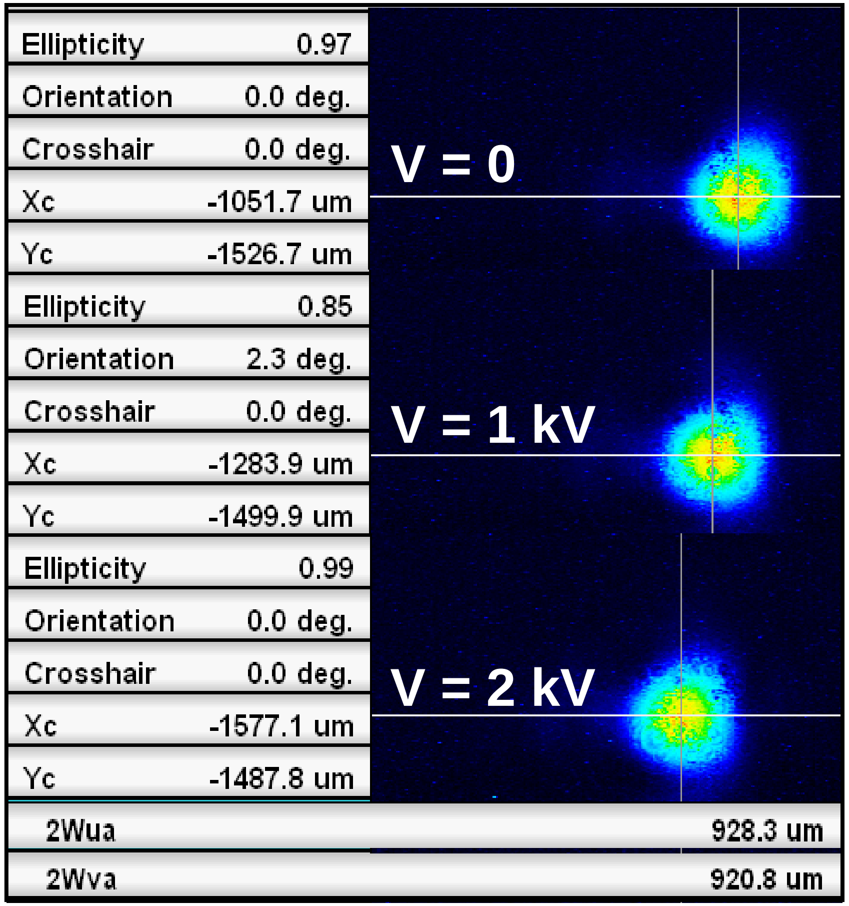
scan range @ focus VS applied voltage

input spot = 3 mm

waist = 46 μm (92 diameter)

shift = 52 μm

deflection = 0.17 mrad



Experimental results:

scan range @ focus VS applied voltage

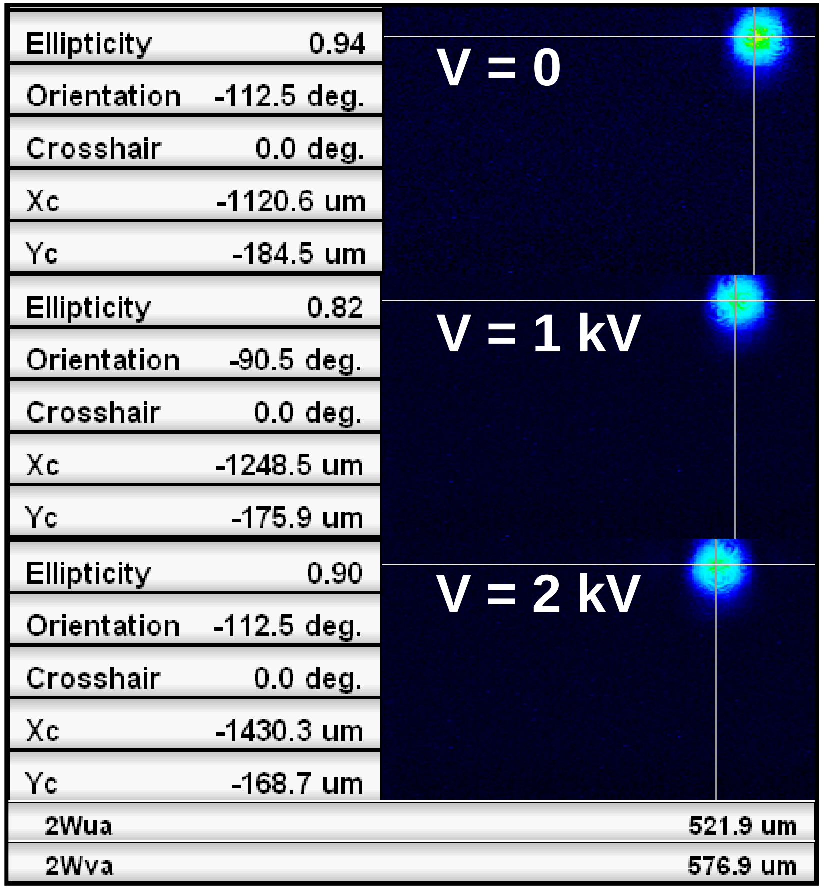
input spot = 2 mm

2.5X beam exp after the EO prism

waist = 26 μm (52 diameter)

shift = 31 μm

deflection = 0.1 mrad



RESULTS and PROBLEMS:

- **EO prism could be actually used as a scanning device.**

- **The fundamental problem of beam distortion can be solved.**

- **Deflection obtained was just one order smaller than the typical obtainable with piezo-scanner (1-2 mrad).**

- **Obtained shift ~1 times the waist; need 5-10 times the waist.**

POSSIBLE SOLUTIONS:

- **Higher EO coefficient (available on the market)**

- **Higher applied voltage – problems of high speed driving.**

- **Increase the size of the prism in order to have larger spot to be focused tighter – problem with the E-field)**