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## Lab-on-Chip for DNA Analysis With Resolution Length of 3 bp and Concentration of 10 nM

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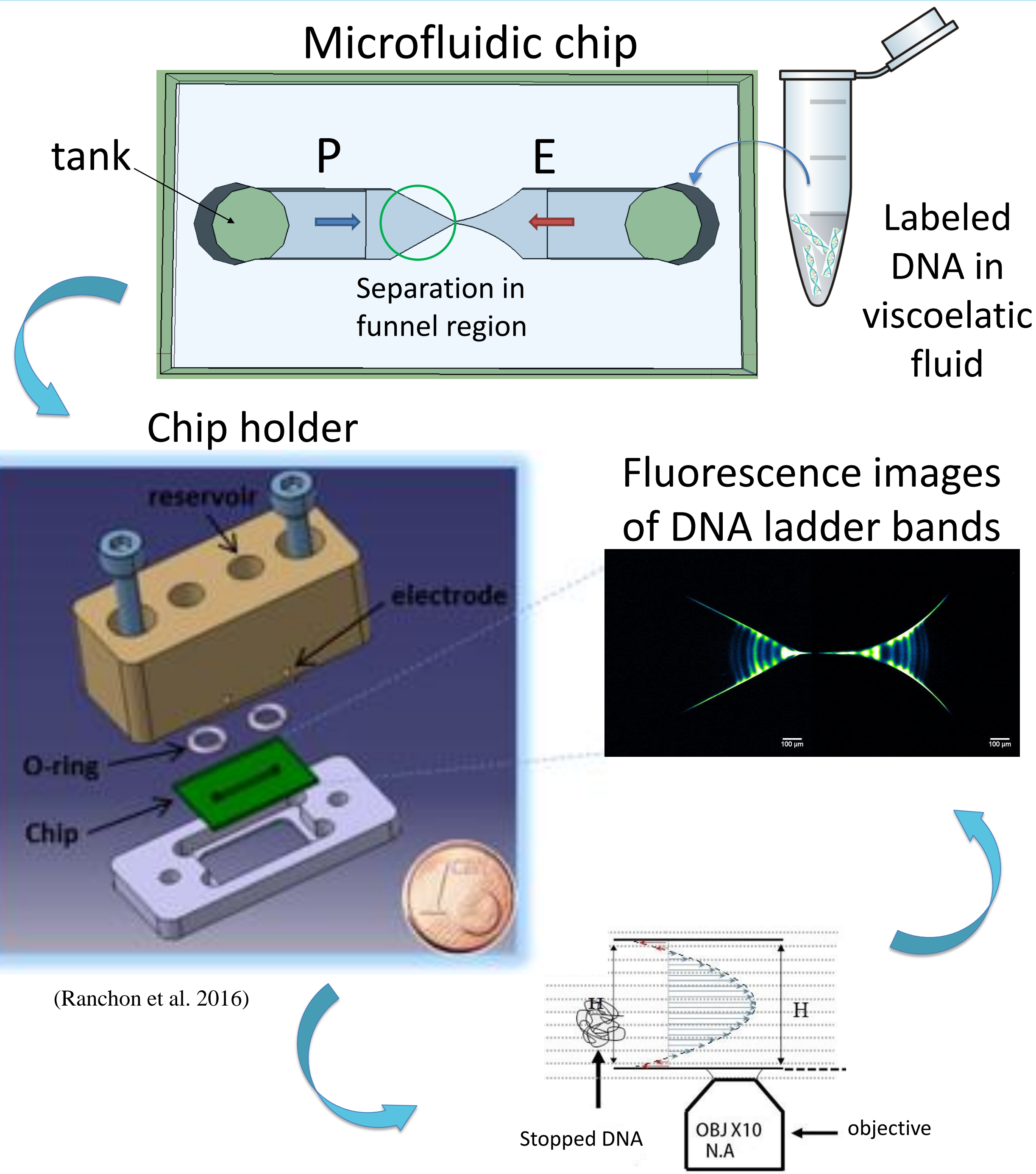
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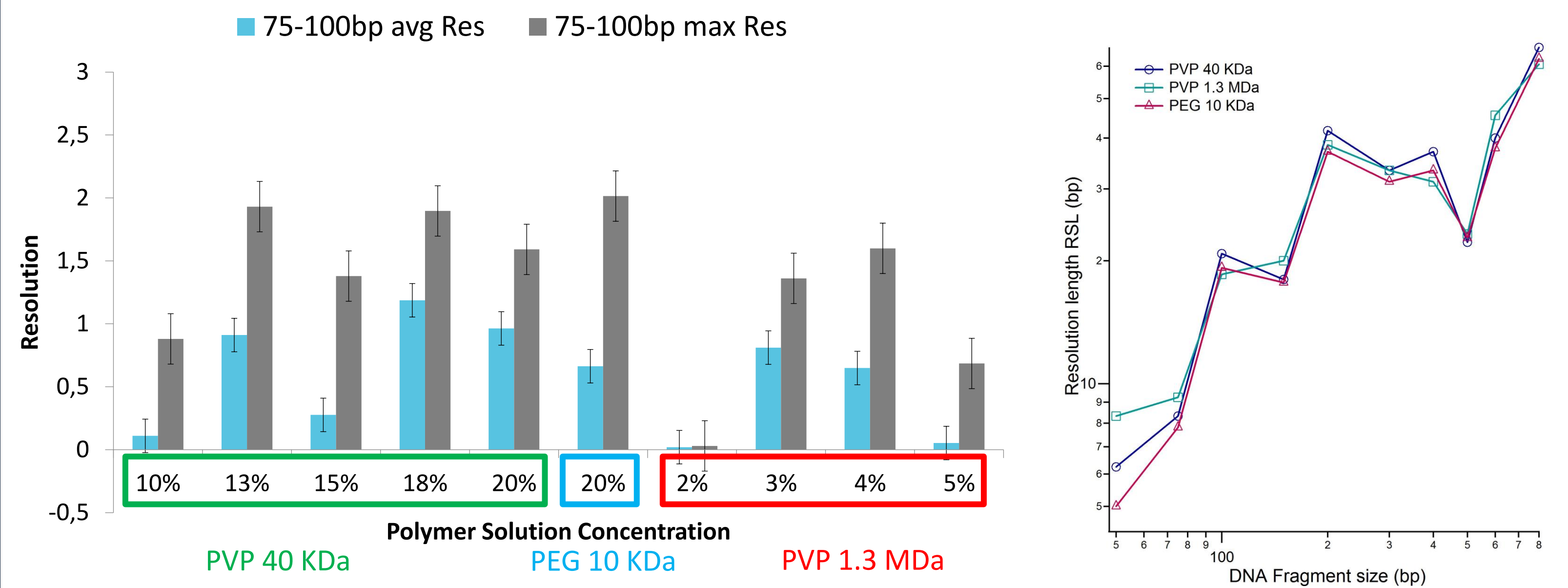
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**Objective:** Analyze circulating DNA by size for the detection of cancer

**Technique:** Microfluidic lab-on-chip ( $\mu$ LAS) with *Bidirectional flows* in *Viscoelastic* polymer solution induce *transverse forces* that stop the DNA fragments by size in the funnel region



## Optimizing the Polymer Solution

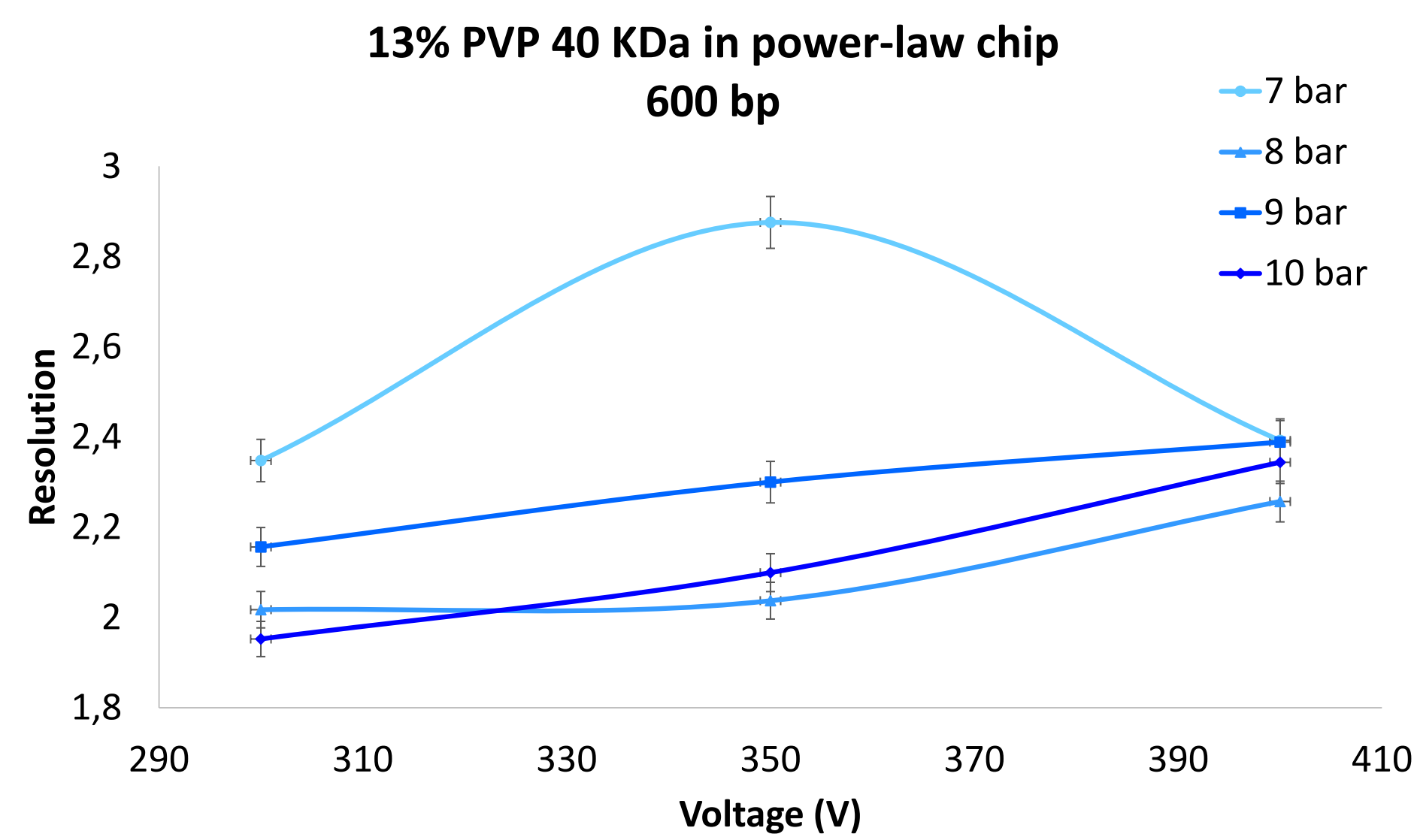


The average and maximum resolution obtained for a 75 bp band in a power-law geometry for different viscoelastic polymer solutions. Low molecular weight solutions produce higher resolutions.

The Resolution length as a function of DNA size obtained for each polymer solution in the same chip geometry.

Polymer Elasticity plays an important role!

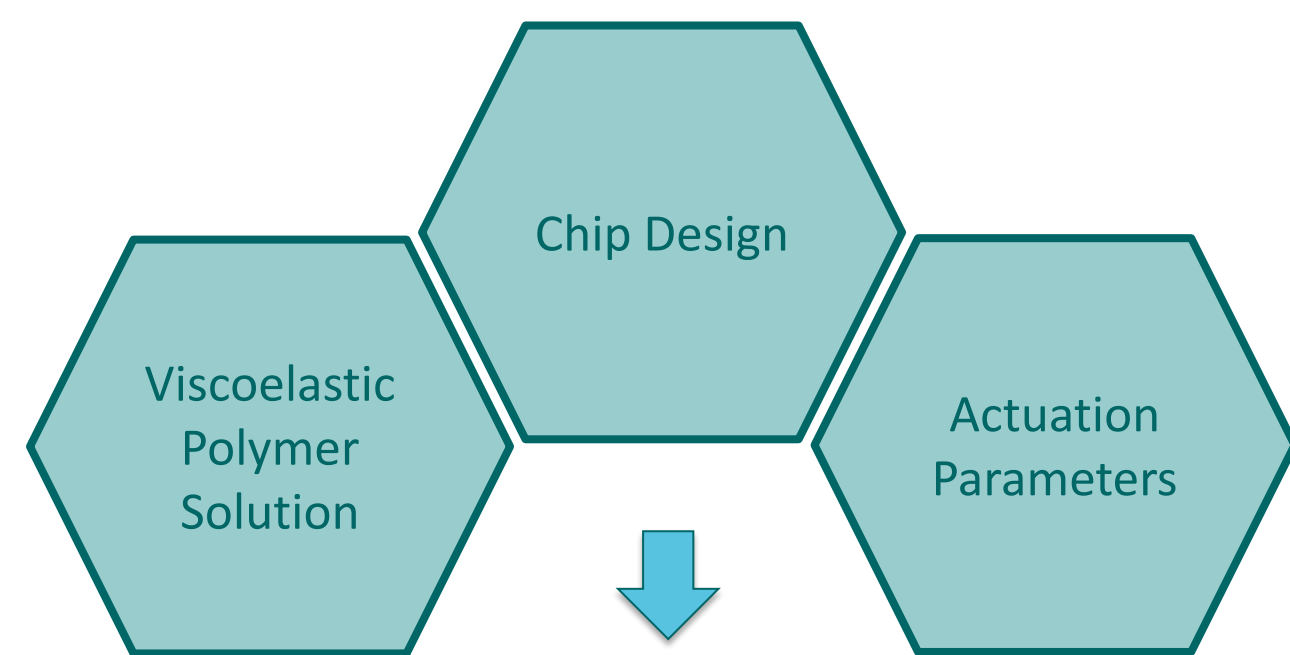
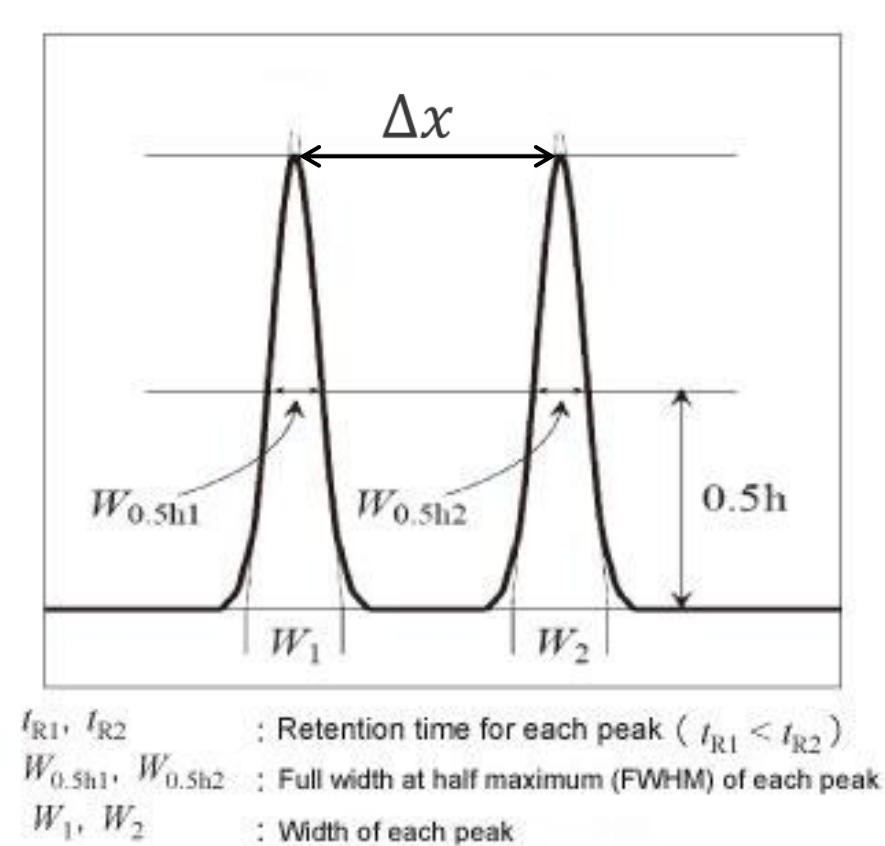
## Optimizing the Actuation Parameters



There is a balance between the pressure and electric field resulting in the optimum resolution

The optimum Pressure and Voltage couple depend on the chip geometry and the polymer solution

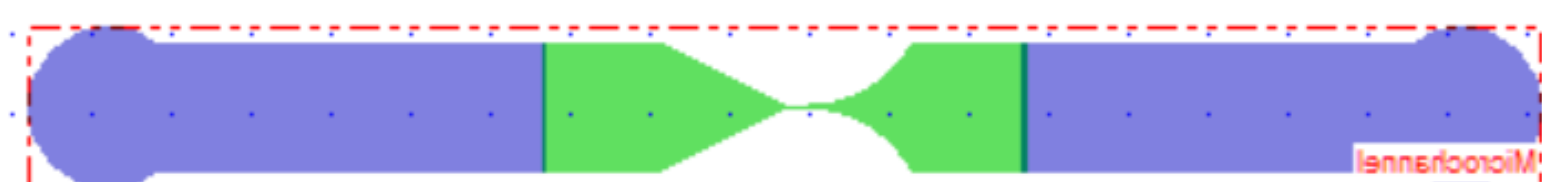
## Results: Optimizing the Separation Resolution



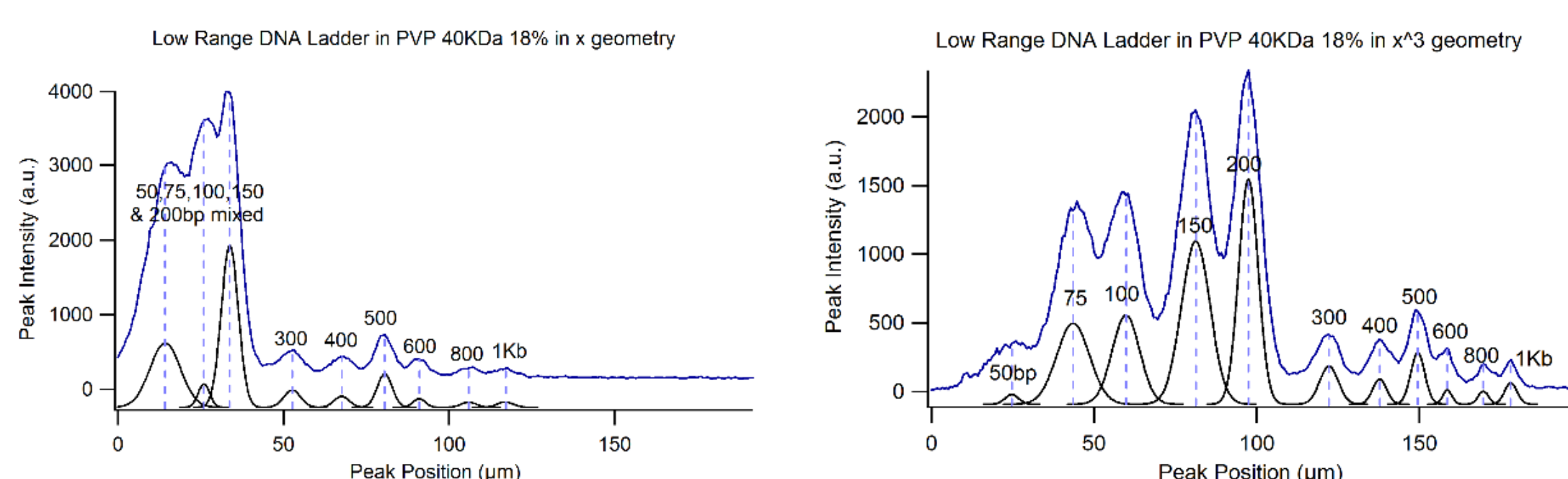
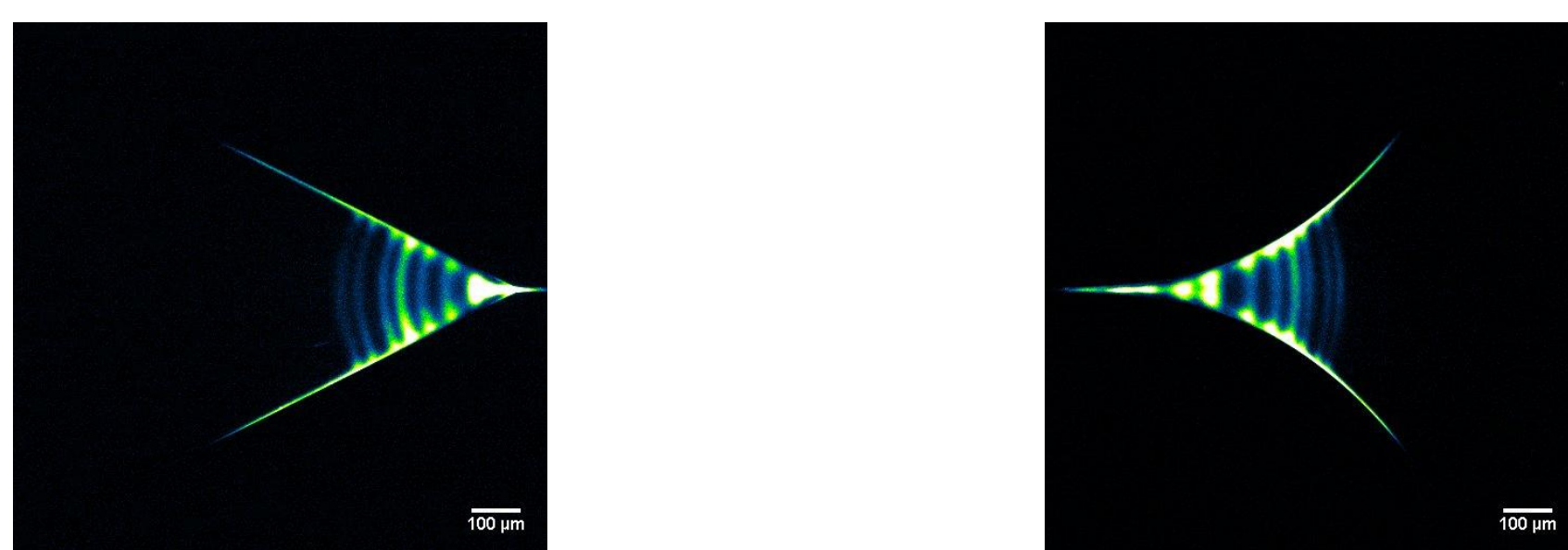
$$Res = \frac{2\Delta x}{W_1 + W_2} \quad \& \quad RSL = \frac{\Delta n}{Res}$$

## Optimizing the Chip Design

Comparison: linear vs. power-law profile

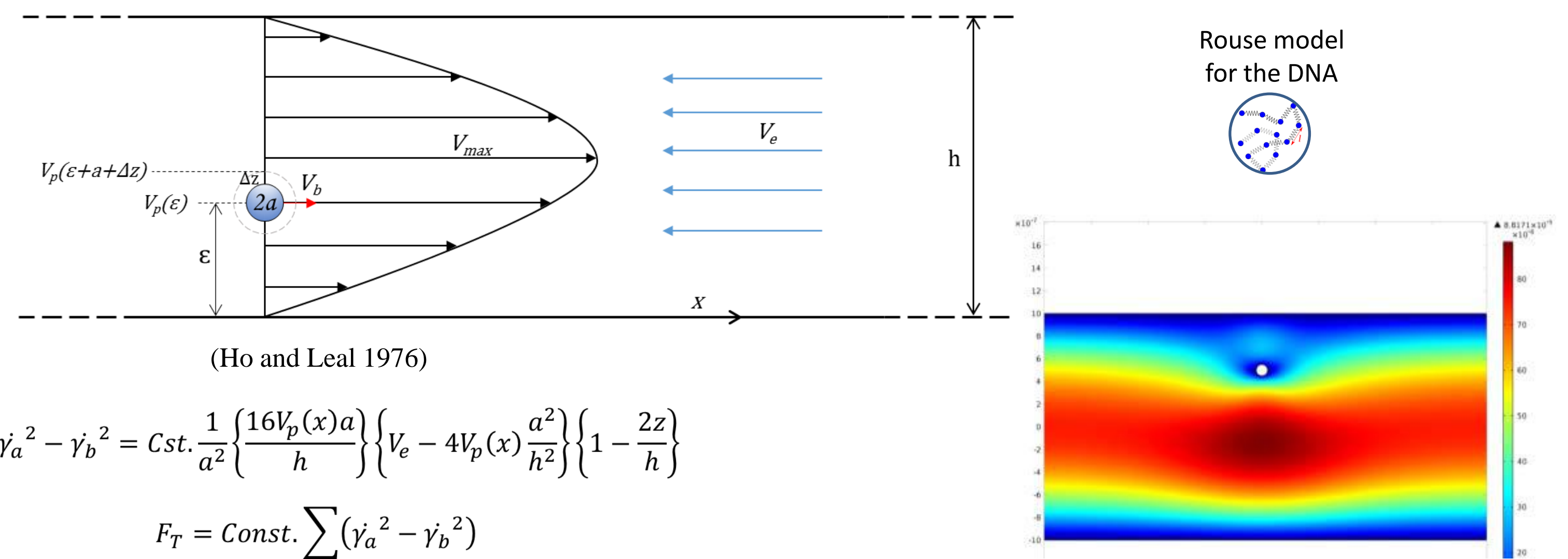


Clewin design of the microfluidic channel containing two different geometries (linear and power-law)

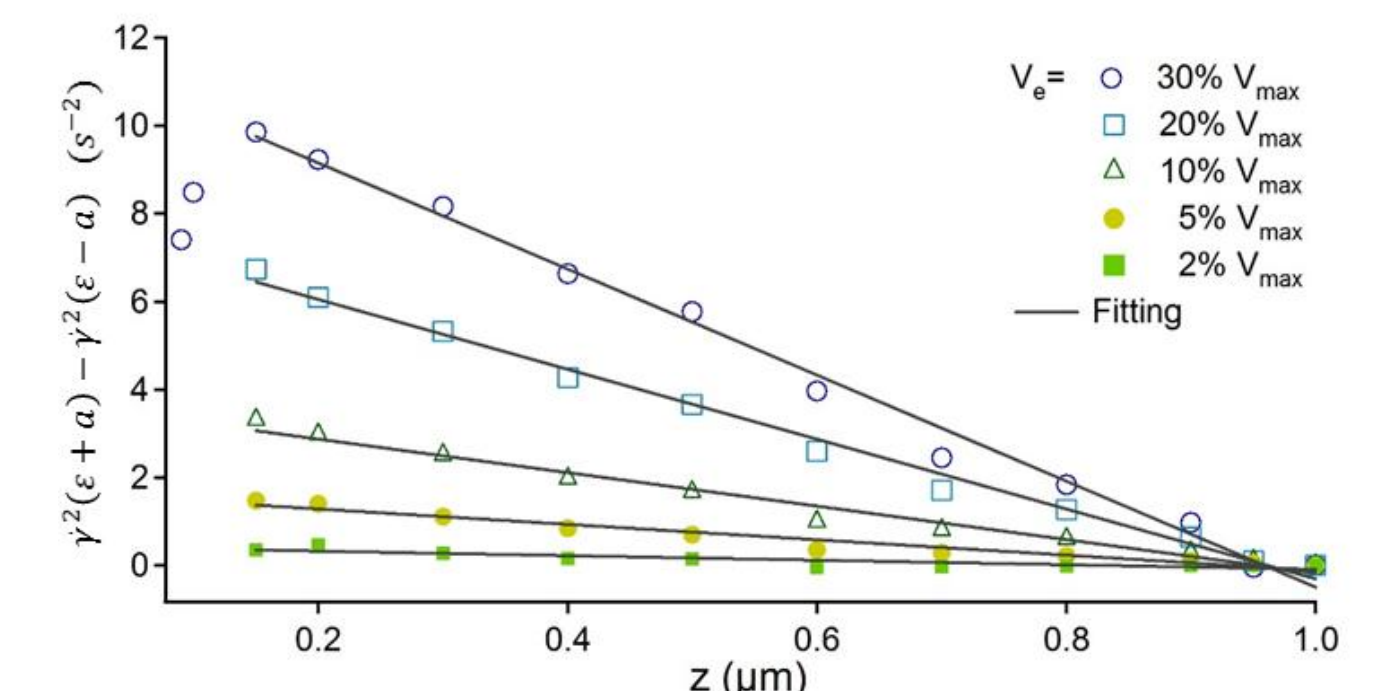


DNA separation and enrichment in the linear versus power-law geometries and their corresponding intensity profiles. In the linear profile bands below 200 bp are unresolved while they are in the power-law profile

## The Physical Model



Comsol simulations to find the transverse force profile

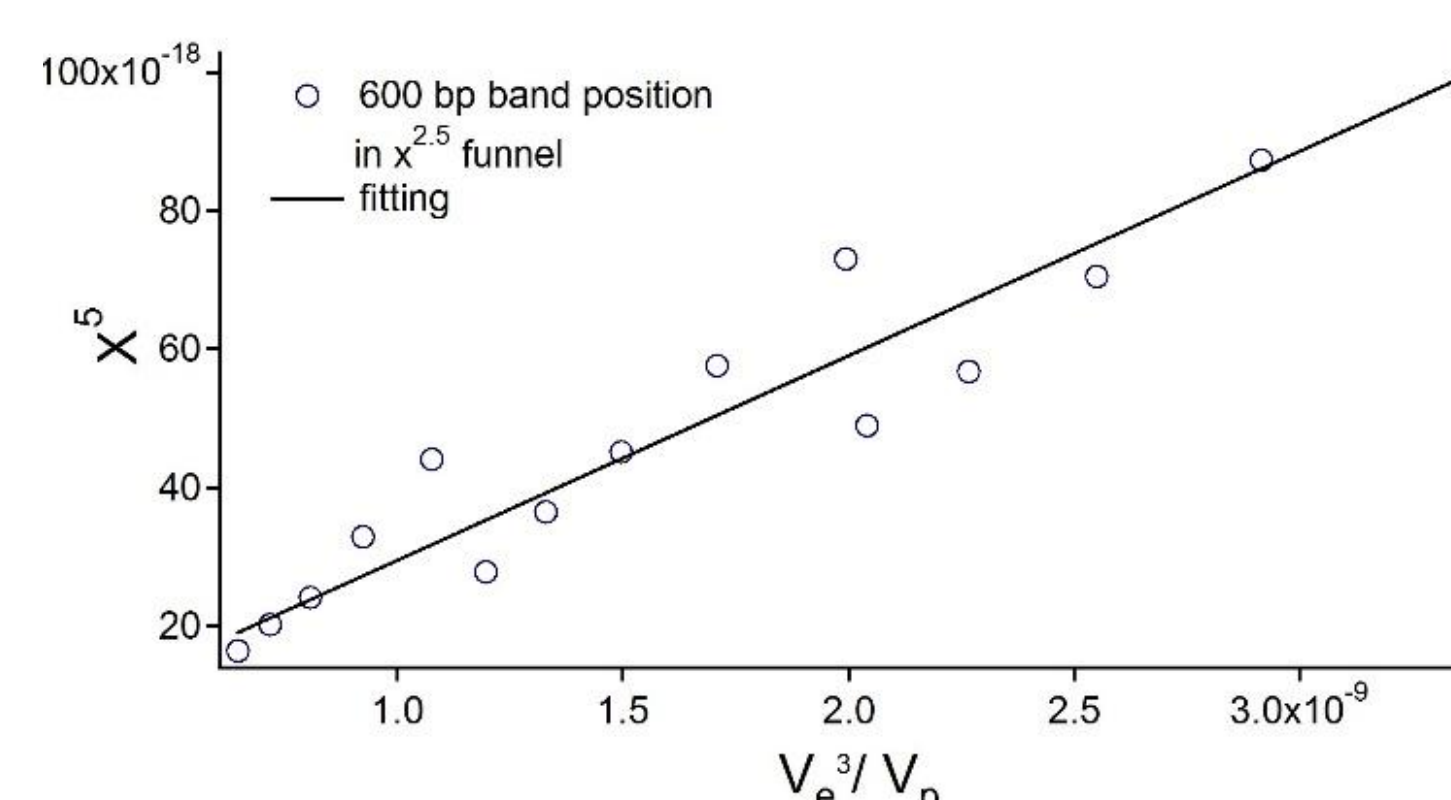


From the transverse force we can predict the position and width of the band in the constriction hence the resolution

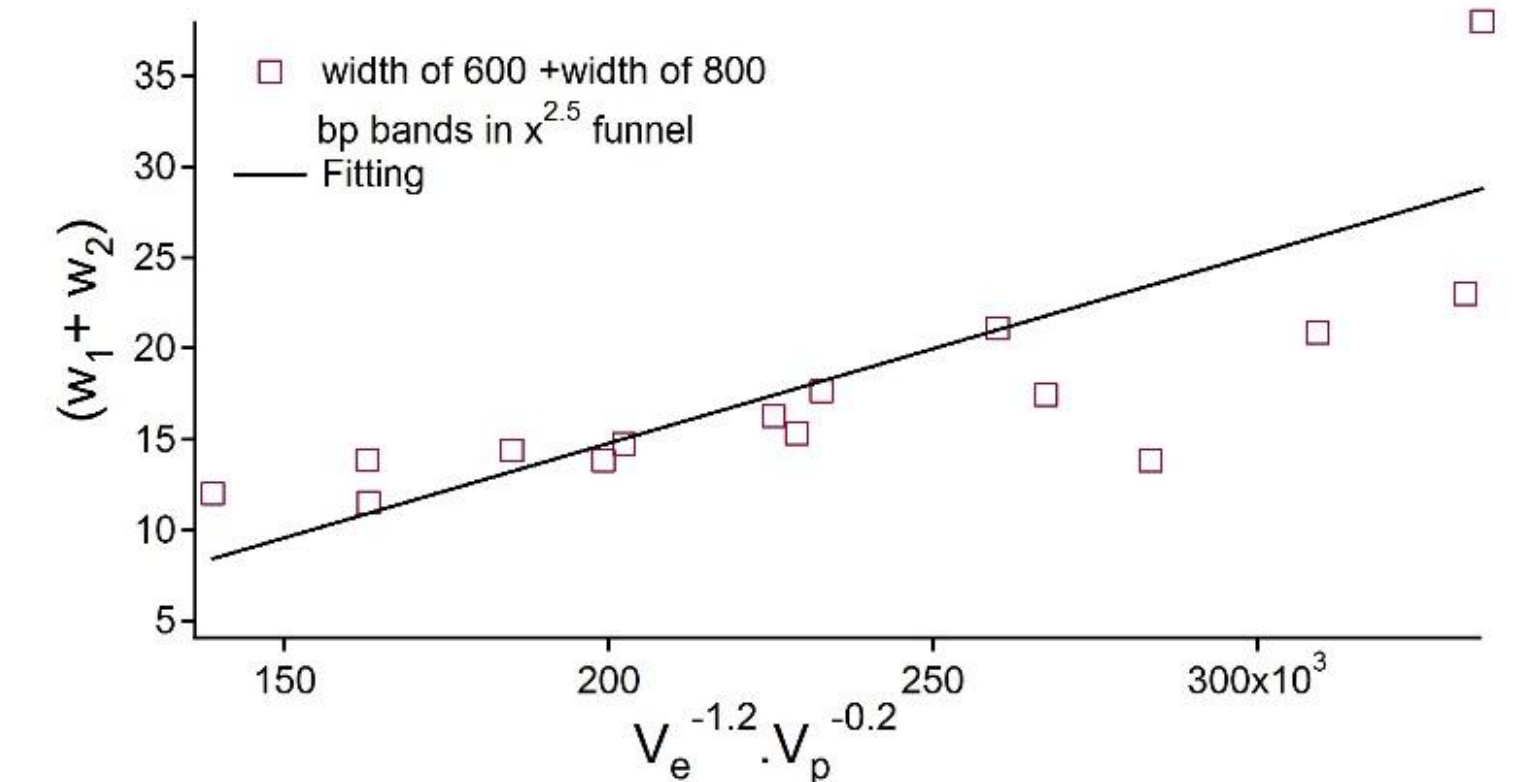
Comsol simulation; transverse force for different values of  $V_e$  as a function of bead position in  $z$

$$x^{2m} \propto F_T^\alpha \propto V_{e_{max}}^{1+\frac{1}{\alpha}} V_{p_{max}}^{1-\frac{1}{\alpha}}$$

$$(W_1 + W_2) \propto V_p^{1-3\alpha}(x) V_e^{-3\alpha}(x)$$



The position of 600 bp DNA band in the power-law ( $x^{2.5}$ ) profile funnel in 13% PVP 40 KDa at different values of  $V_e$  and  $V_p$  fitted with the model for  $\alpha = 0.4$ .



The width of 600 bp and 800 bp DNA bands in the power-law ( $x^{2.5}$ ) profile funnel in 13% PVP 40 KDa at different values of  $V_e$  and  $V_p$  fitted with the model for  $\alpha = 0.4$ .