impetux
The Force of Light

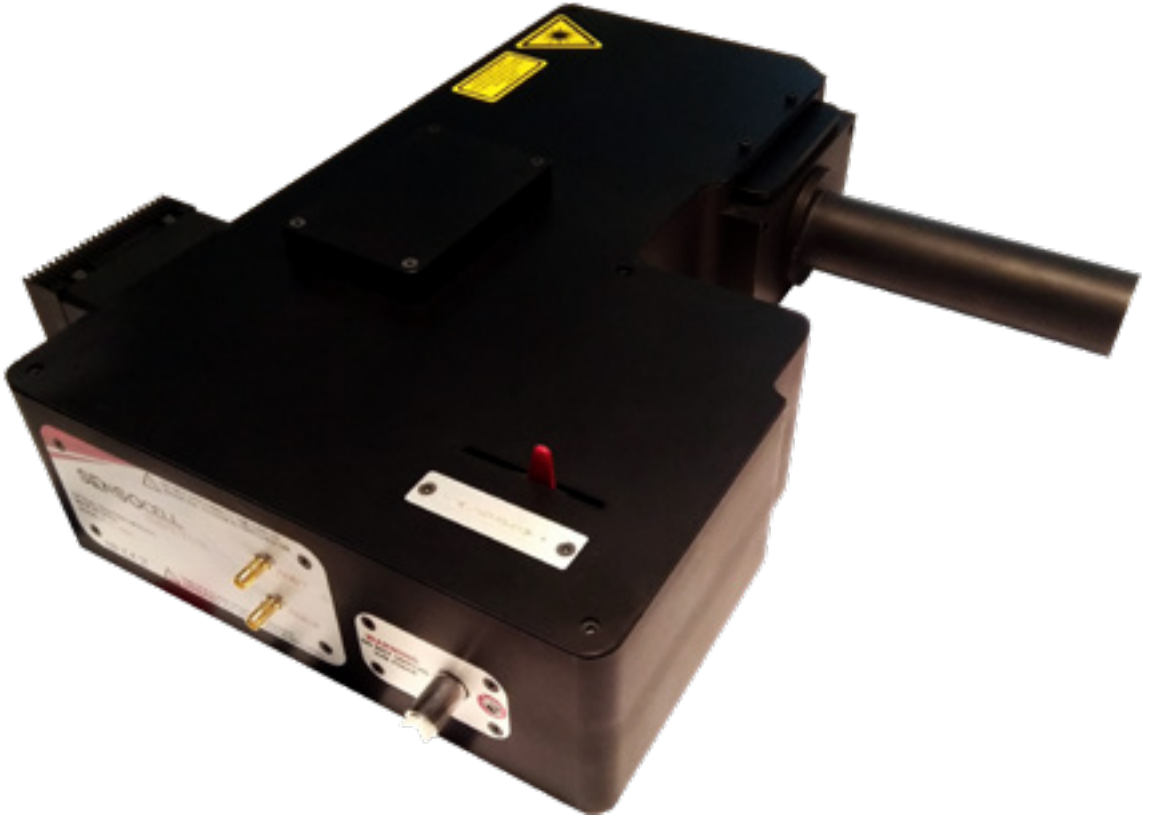
SENSOCELL™

Optical Tweezers for Cell and Tissue Mechanobiology

SENSOCELL™ is the only optical tweezers platform that allows measuring biological forces within living cells and tissues without needing any previous calibration by the user

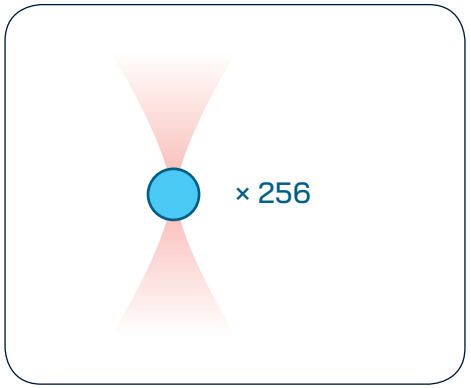
Optical manipulation

Accurate, extensive and flexible control over multiple traps

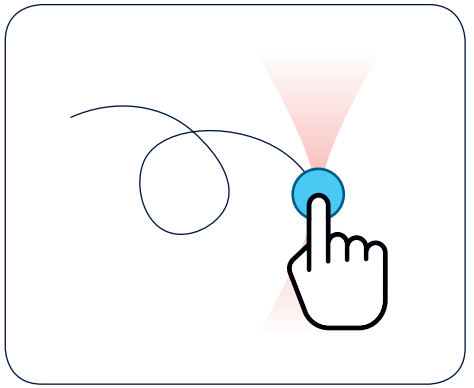


SENSOCELL™'s optical manipulation module allows generating **up to 256 simultaneous traps** over a working field of 80×80 µm (for a 60× objective) reaching trapping forces up to 500 pN. Based on acousto-optic deflection technology, the system allows trap steering at high frequency (25 kHz).

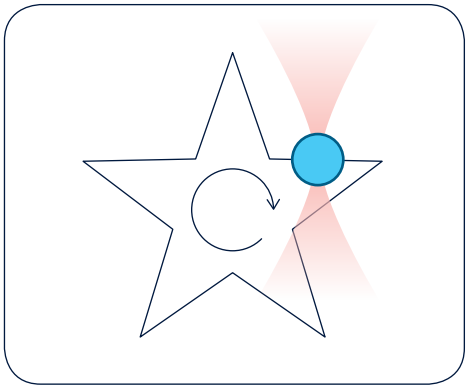
Owing to its **customizable & automatized routines**, our control software suite LightAce enables precise, extensive and flexible control over multiple traps. Apply predefined **oscillations and/or trajectories over multiple traps** or control them using the ***click & drag*** mode.



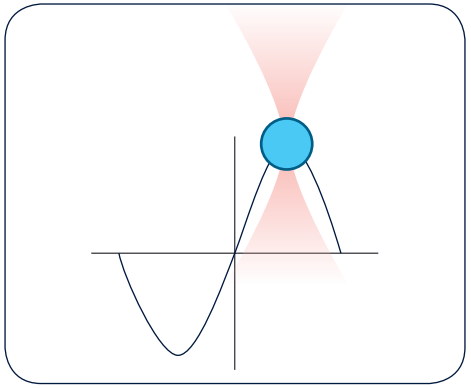
Up to 256 traps



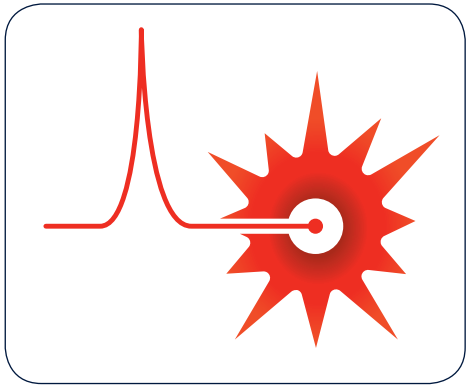
Click & drag mode



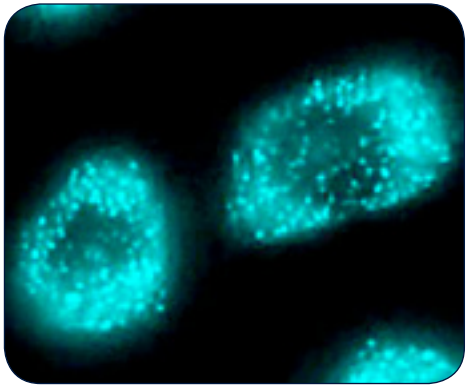
Custom trajectories



Custom oscillations



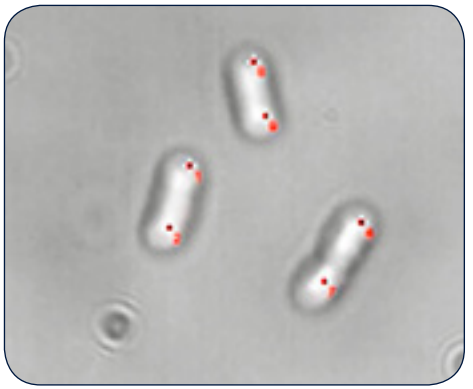
5W, 1064nm laser source



BF, epi-FL, confocal, DIC, TIRF

SENSOCELL™ is **compatible with a wide variety of imaging techniques** simultaneously working during trap manipulation and force measurement experiments.

The system includes a racked case with all electronics and an ultra-low noise single frequency laser source (5W, 1064 nm).



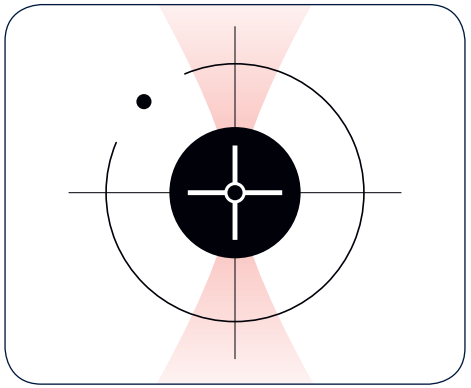
Trapping of multiple *E. coli* bacteria. Using two traps per specimen allows controlling their orientation

Direct force measurements

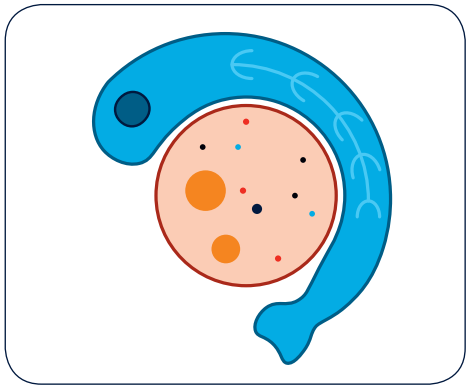
A unique force sensor based on light momentum analysis

Our unique force sensor technology based on **light momentum analysis** directly yields the force applied by the optical tweezers via a constant that is unique, permanent and calibrated at factory. **No calibrations** by the user are required to start measuring. The sensor can be installed and set in operation through a simple procedure even by non-expert users.

Forces can be measured on trapped exogenous spherical particles or directly on endogenous trappable cellular structures such as lipid vesicles, membranes, nuclei or whole cells, **even inside living tissues**.

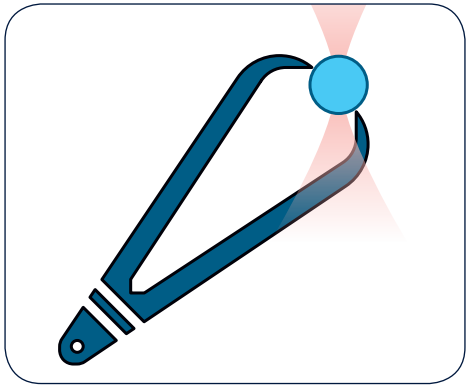


No calibrations

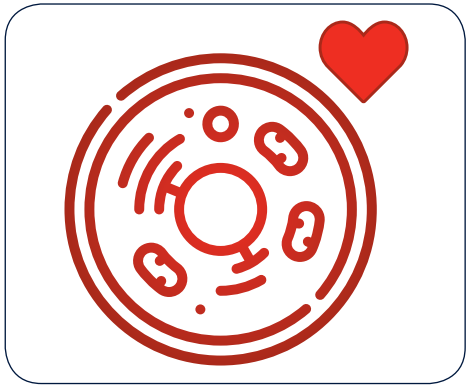


In vitro & in vivo

Force resolution	< 50 fN
Accuracy (typ.)	< 5 %
Position resolution	< 1 nm



Force clamp mode



Prevent cell damage

Perform simultaneous **direct force measurements** in the X-Y or Z plane over multiple independent traps and obtain accurate determination of the trapped particles positions.

Use our implemented **Force Clamp** mode to have absolute control of pulling and pushing force rates.

The sensor continuously monitors laser power at the sample plane giving **maximum control** over the irradiation levels imposed on your samples.

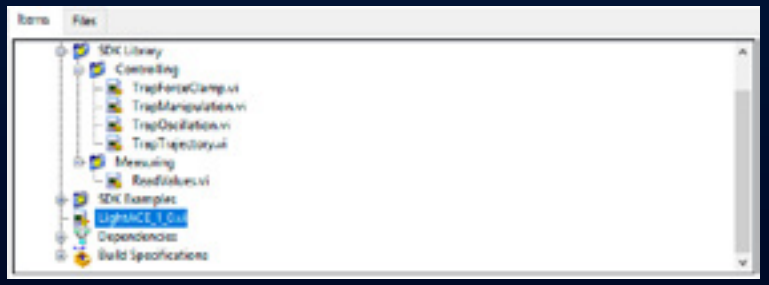
LightAce control software suite

Powerful, flexible, intuitive and user-friendly

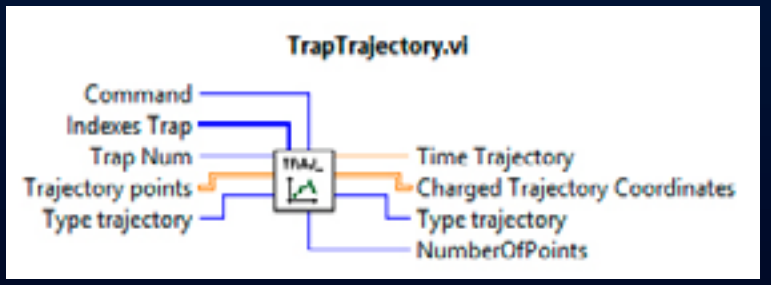
LightAce is our control software suite for **SENSOCELL™** based on the integration of LABVIEW (National Instruments), ImageJ and µ-Manager. **Easy and intuitive** to work with, our LightAce software will allow you to:

- **Take control over multiple optical traps** and read real time force & position data for each trapped target; apply force clamping or launch built-in routines. Simply selecting the different options on the interface menu, LightAce offers you an **incredible set of trapping, manipulation & measurement capabilities!**
- Use our predefined and customizable automated routines or **create your own routines** using our simple and flexible LightAce Software Development Kit (SDK) completed by a variety of examples.

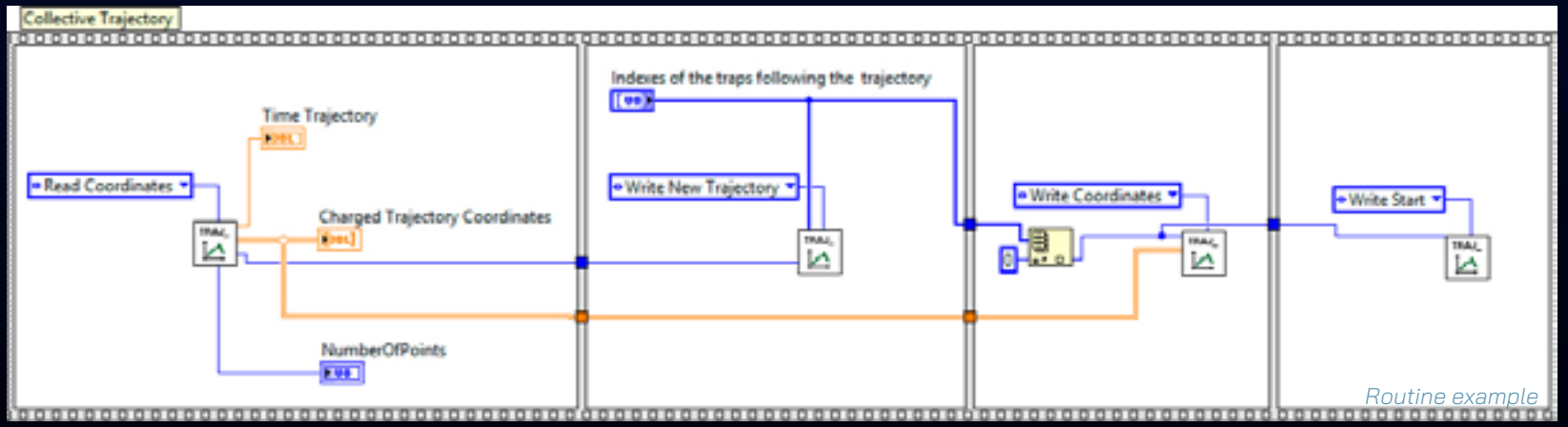
How to Create your own routines using LightAce SDK



1. Choose .vi functions among the LightAce SDK library



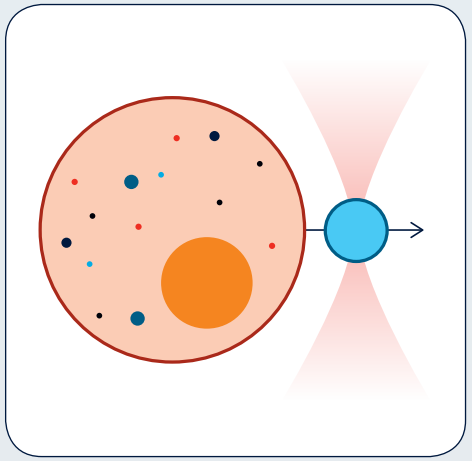
2. Customize your selected .vi functions by setting their input parameters values



3. Combine them to create complex routines controlling all features of SENSOCELL™

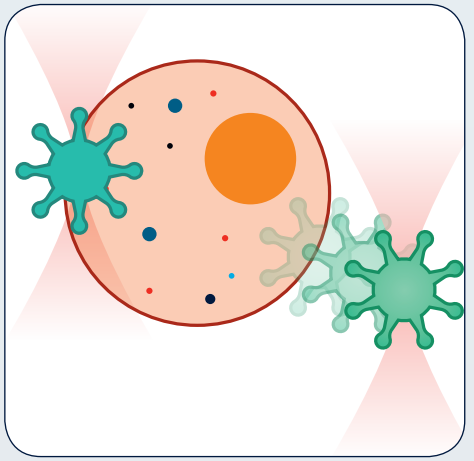
Our best efforts have been dedicated to create a **user-friendly** GUI. After a short training course given by our engineers, non-experts users can start working immediately and plan experiments from the very beginning.

Applications for cell & tissue mechanobiology



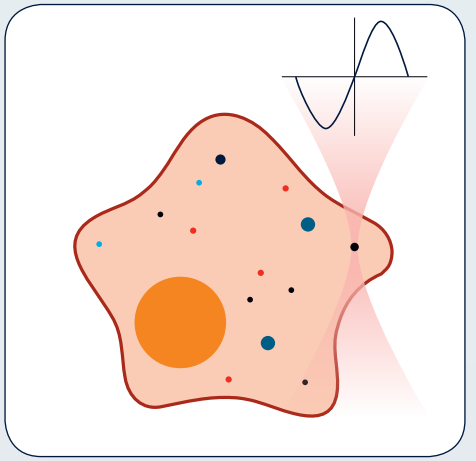
Tether pulling

Study cell membrane mechanics in cells and explants performing tether pulling experiments. Use our customizable routines or create your own tether pulling routines.



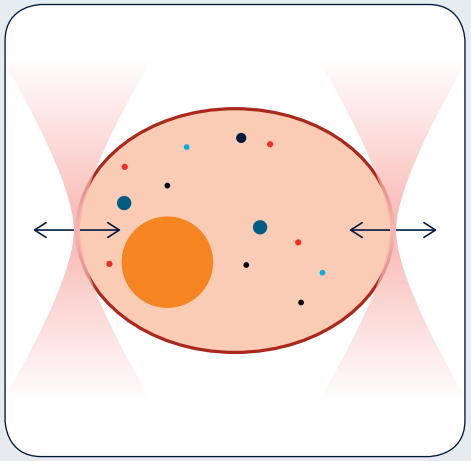
Immune Cells Interactions

Manipulate whole cells to engage cell-cell interactions and measure their interaction forces while having absolute control on cells orientation and contact time.



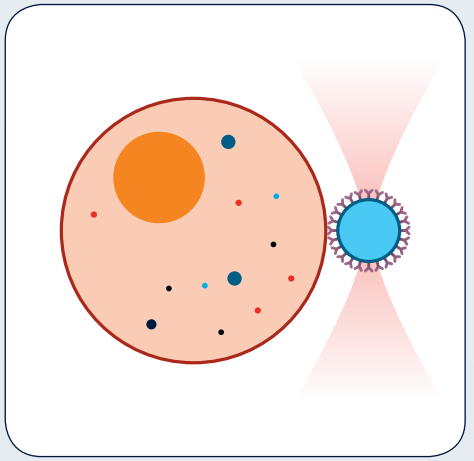
Active Micro-Rheology

Perform active & passive micro-rheology experiments in viscoelastic media like cell's cytoplasm, hydrogels or biofilms.



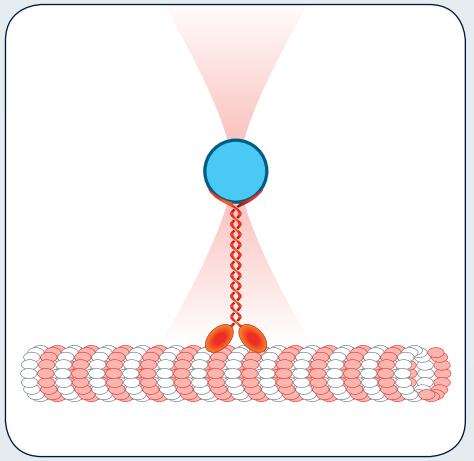
Cell & Nucleus Deformation

Study cell membrane and cell nucleus mechanotransduction pathways by stretching the cell as a whole or manipulating the cell nucleus.



Cell-ECM Mechanics

Study the dynamics and forces of transmembrane mechanoreceptors in cell-ECM interactions at the single-molecule level.



In vivo Protein Motors Activity

Study the activity and kinetics of protein motors in vitro and in vivo. Measure stall forces of protein motors and observe tug-of-war and cooperating phenomena.

Application example I

Tether pulling

Using IMPETUX's **SENSOCELL™** optical tweezers platform, a membrane tether pulling experiment was performed by adhering a 1 µm optically trapped bead to a neuron isolated from a Caenorhabditis elegans embryo *(Fig.1)*. When the adhered bead is pulled away, a lipid filament *(tether)* is extruded from the cell surface *(Fig.1)*.

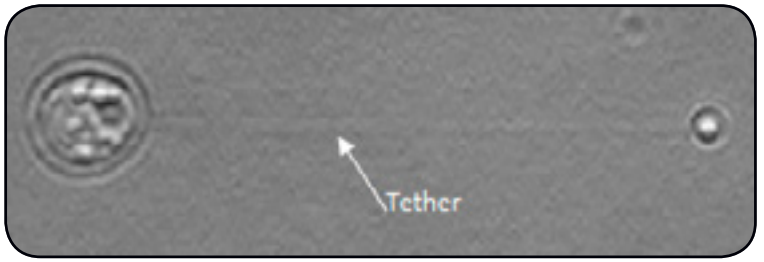


Fig.1 Cell membrane tether image. Courtesy of Dr. Michael Krieg's lab at the Institute of Photonic Sciences.

The tether is elongated at increasing speeds to produce force peaks of increasing height. Subsequently, it is kept at constant length to wait for relaxation down to the static membrane tension. Different pulling rates can be applied at subsequent steps using the system's **customizable routines**. The system also monitors the applied force at real time.

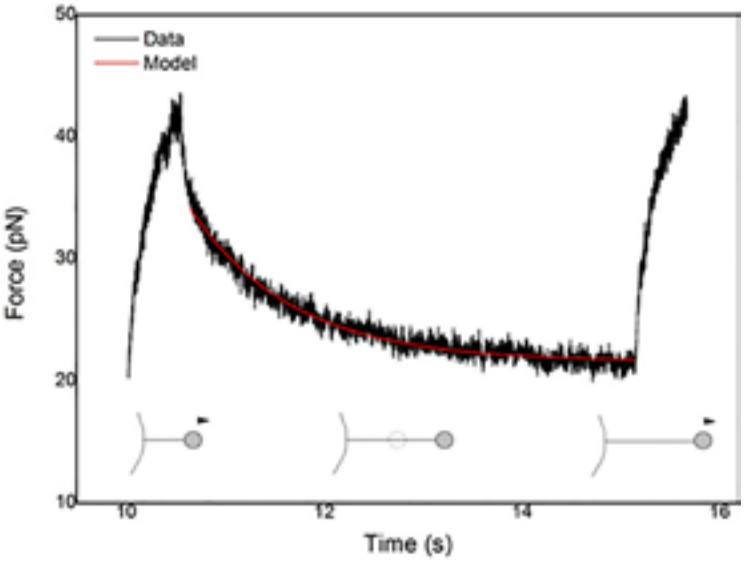


Fig.2 Shows in detail the force decay during the relaxation process after one of the pulling steps. A viscoelastic model is used to fit the force response during relaxation.

Application example II

Cancer cells & T-cells interactions

The study of cell-cell interactions is of great importance in research fields like immunophysics. Our optical tweezers platform **SENSOCELL™** allows trapping and manipulating multiple cells simultaneously in such a a way that cell-cell contacts can be easily established in a precise manner. Users can control the cells' orientation and contact time. In this example *(Fig.1)* we show how contact is engaged between a neuroblastoma cancer cell and a T-cell using two optical traps. The first trap *(trapping the cancer cell)* is fixed while the second trap *(over the T-cell)* is moved using the "click & drag" mode. The T-cell is moved towards the cancer cell and contact is established. After 10 s, the T-cell is pulled away and an **adhesion force** is measured.

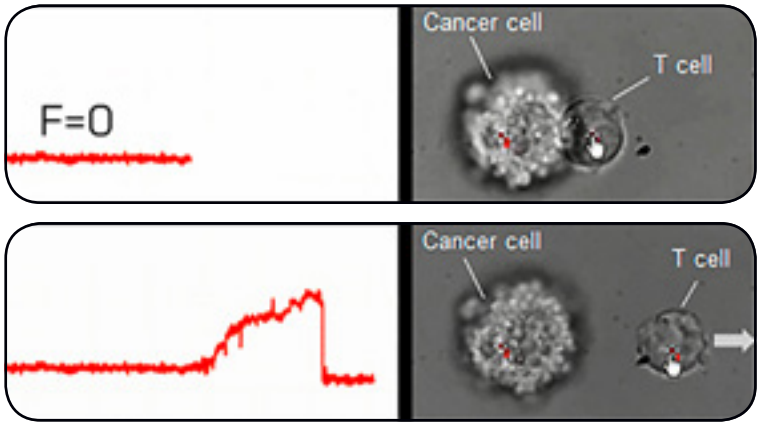


Fig.1 Cell-cell interaction established between a neuroblastoma cancer cell and a T-cell.

Initially, the measured trapping force is zero *(red curve)*. After 10 s, the T-cell is pulled away and an increasing force is measured. When the applied force is high enough to break the bond between the two cells, the measured force drops to zero. In this case **the adhesion force** was measured to be 21 pN. In collaboration with Dr. Carlos Barcia from Autonomous University of Barcelona.

The same type of experiment was carried out for **lymphoma cancer cells** and **3 immune cell** lines expressing different receptors in collaboration with Dr. Manel Juan Otero from the Hospital Clínic of Barcelona.

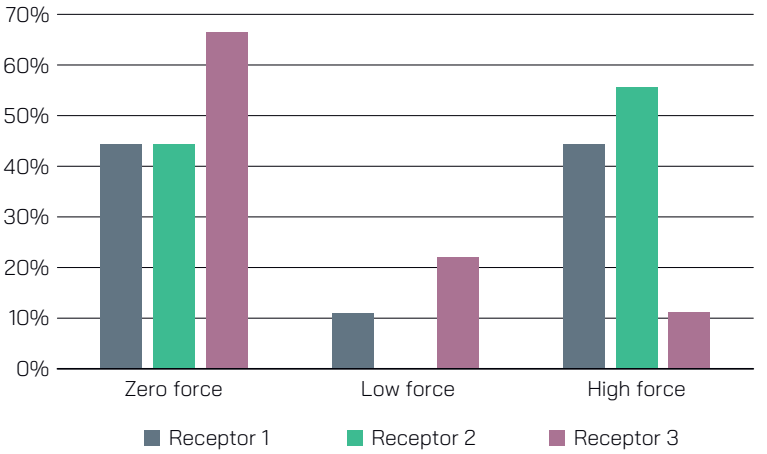
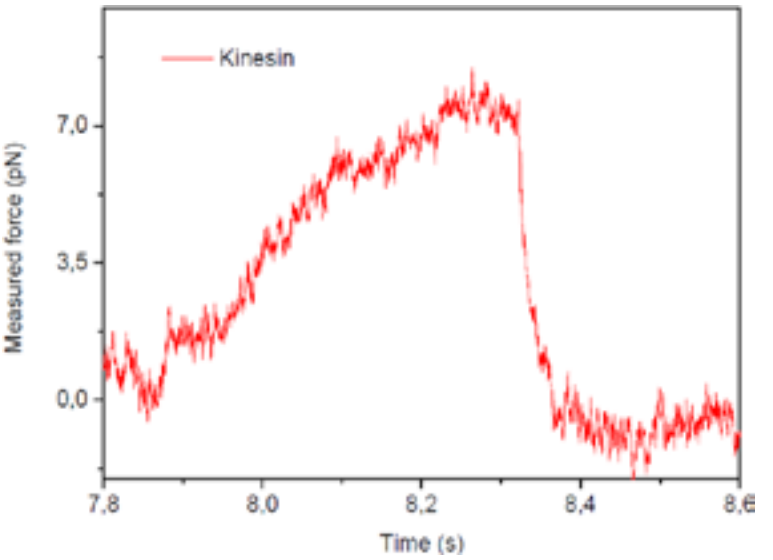


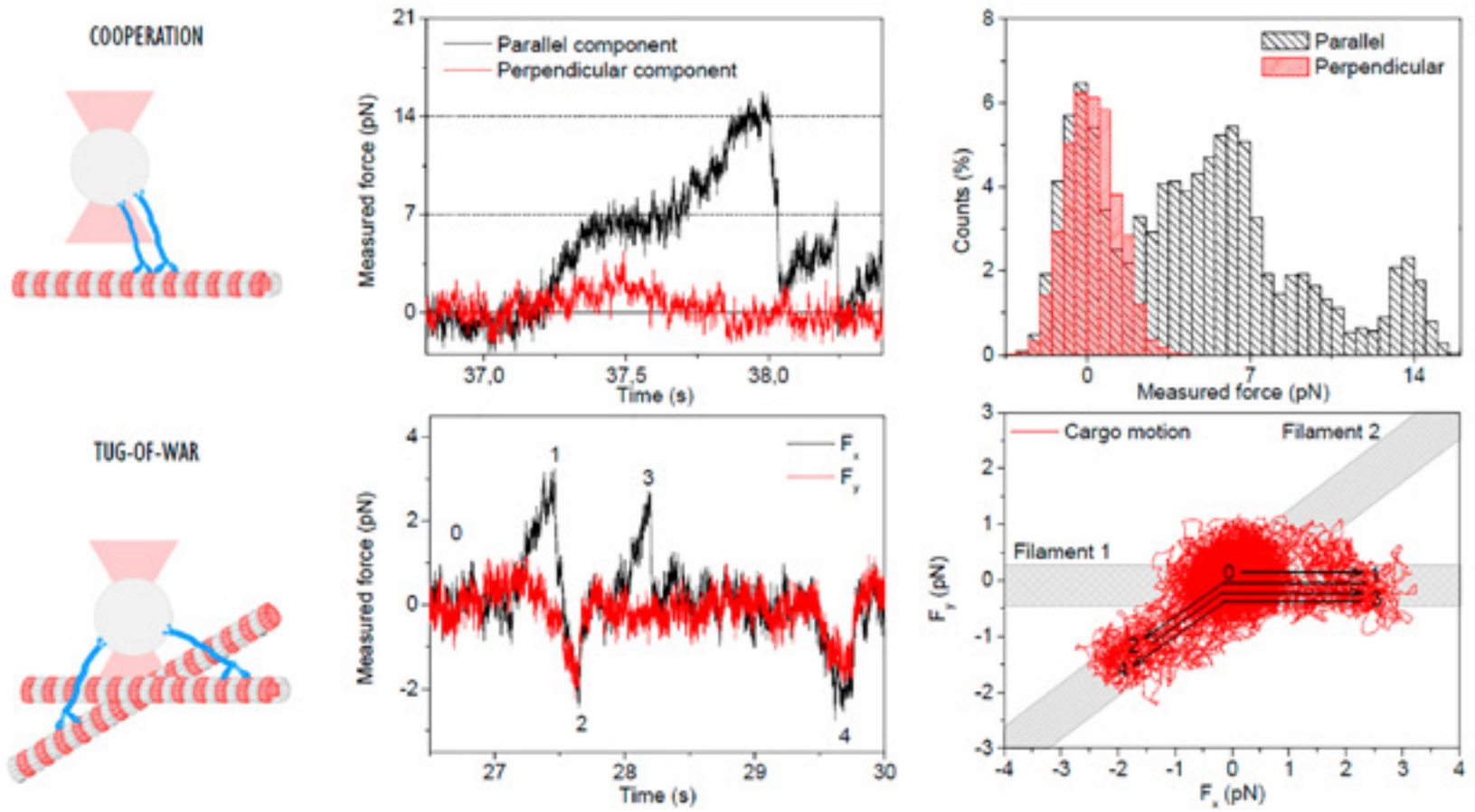
Fig.2 Statistics of cell-cell adhesion forces measured for lymphoma cancer cells in contact with immune cells expressing different receptors after a contact time of 15 s. Each bar represents the data for a set of 9 different samples of each cell type.

Application example III

Measurement of the stall force of kinesins in living cells

Motor proteins are responsible for different fundamental biological processes inside cells. One of these functions, of vital importance for the cell survival, is the intracellular transport of vesicles and organelles. Kinesin is the microtubule-based protein that performs the plus-end-directed motion. The protein generates the mechanical work required to move cargos, by means of the hydrolysis of ATP molecules. In cells, lipid droplets can be used as targets for trapping and analysis of the force of the motor proteins propelling them. Here we show the measurement of the stall force of one of these lipid droplets in an A549 cell:





Measurement of **forces inside cells** allows exploring the rich interplay between multiple motor proteins simultaneously pulling on the same vesicle/ organelle. Below is an example illustrating two opposed scenarios: cooperation and competition.

Graphics; Force curves for a lipid droplet in an A549 cell pulled by multiple molecular motors in different scenarios: in cooperation and in competition. The two components of the force *(parallel and perpendicular to the filament)* are shown.

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