

NANOSIGHT



Seeing the Nano-scale: Nanoparticle Tracking Analysis

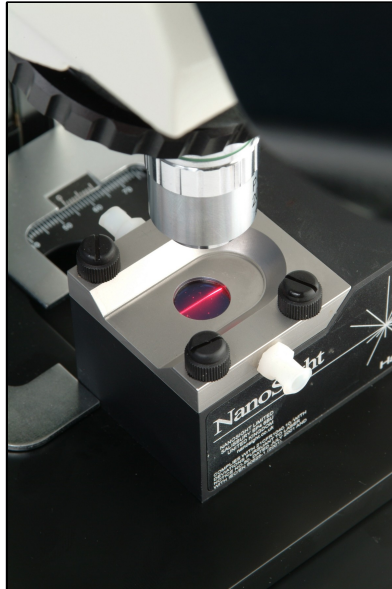
HVM MNT Expo 2006 Oxford

Jeremy Warren
CEO, NanoSight Ltd

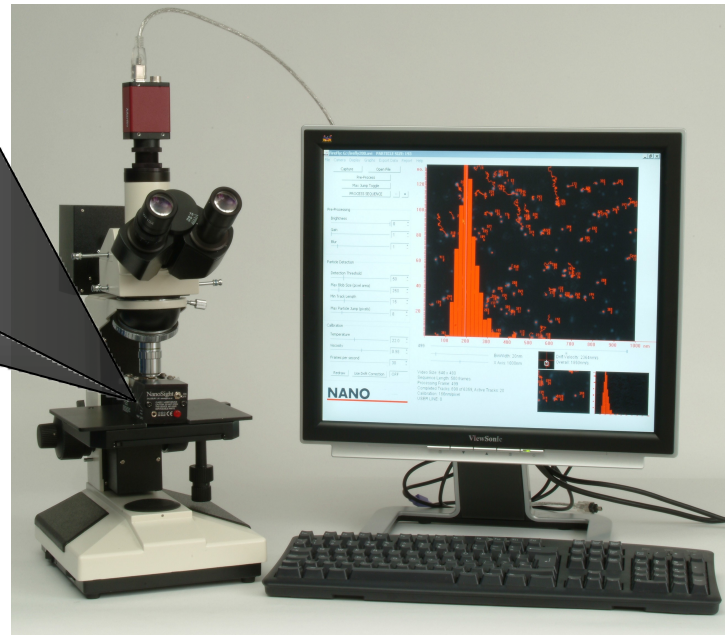


Particle Characterisation at Nano-scale:

- Electron Microscopy
- PCS (Photon Correlation Spectroscopy;
Dynamic Light Scattering)
- Others.....
- Nano Particle Tracking Analysis (NTA)

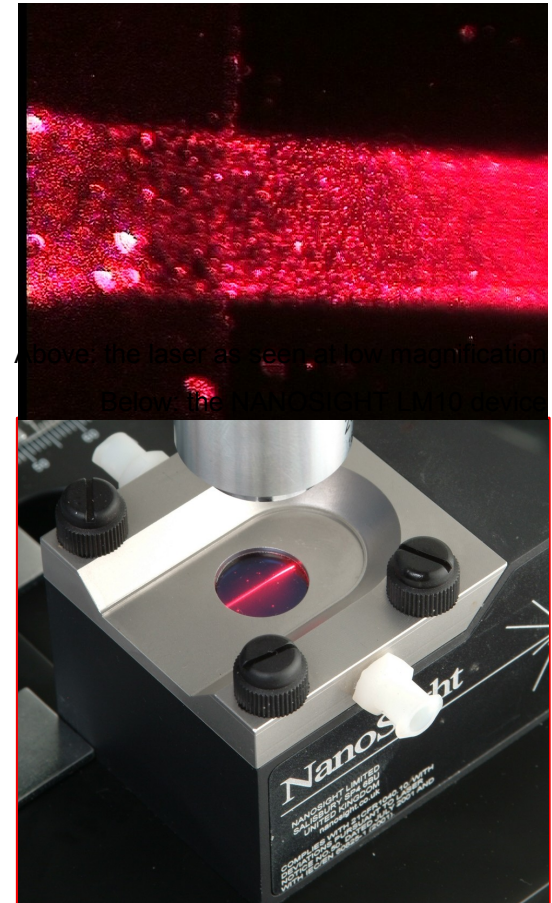
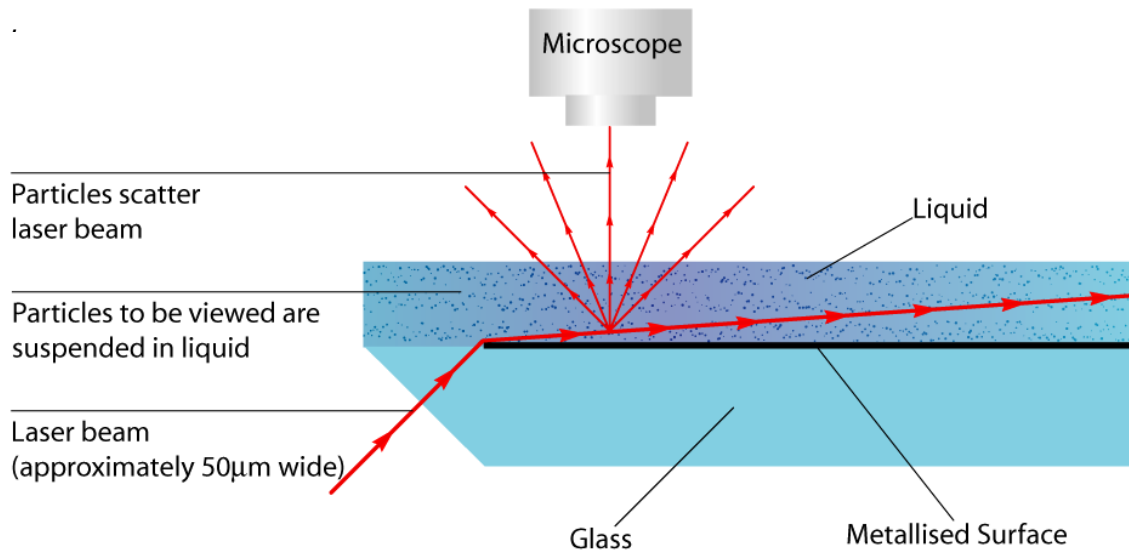


NanoSight produces a instruments for viewing and analysing nanoparticles.



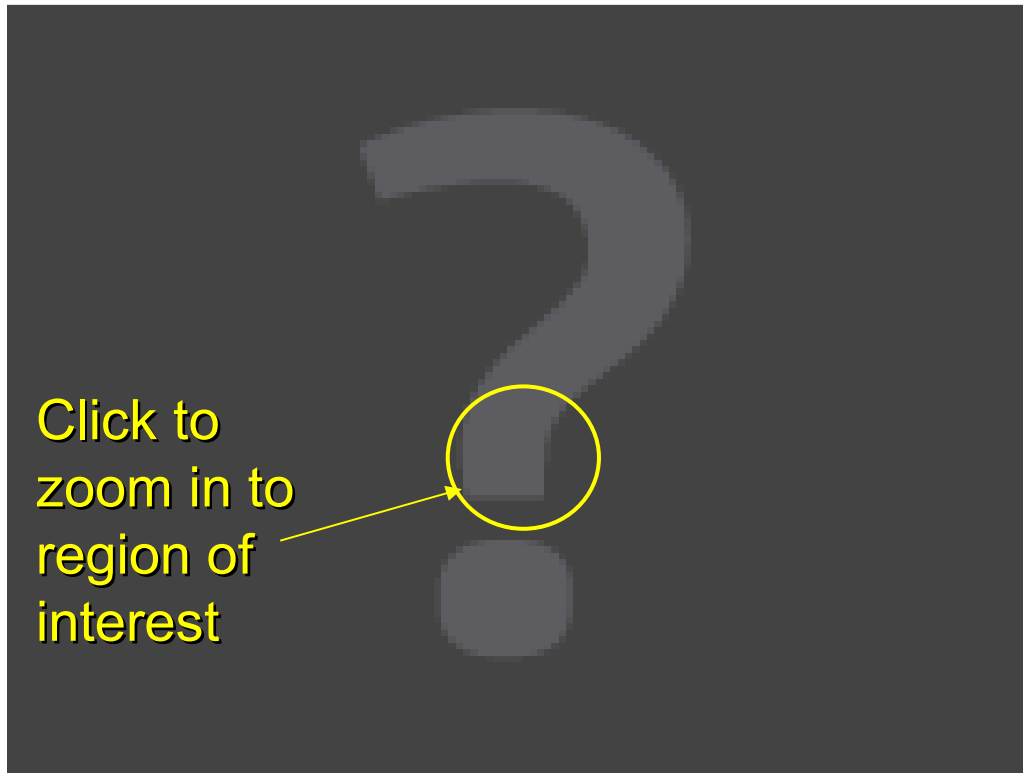


Nanoparticle Tracking Technology





NanoSight in Action:



← Region at which illumination beam emerges into sample.

← Border of sensing zone

← Region in which particles are viewed – the sensing zone.



Particles are *Visualised*, not imaged.



Particles are seen as point scatterers moving under Brownian motion. While they are too small to be imaged by the microscope, the intensity of light scattered varies strongly with particle size. This can be seen in this sample of 100nm polystyrene particles containing a small number of 200nm particles.



Visualising Particles – *Titanium Dioxide*



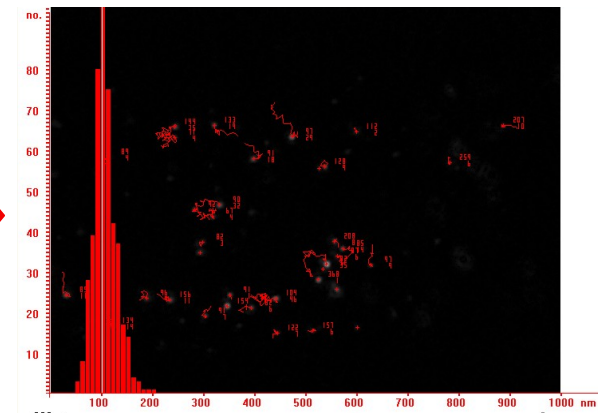
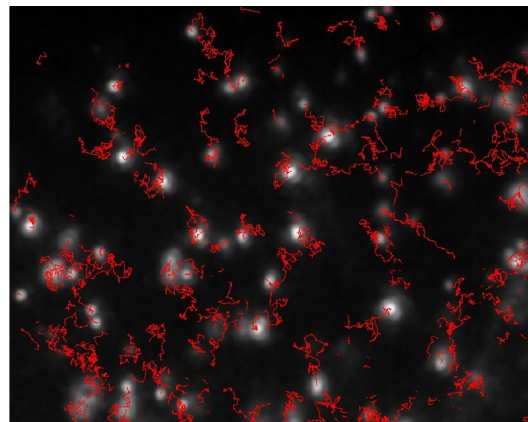
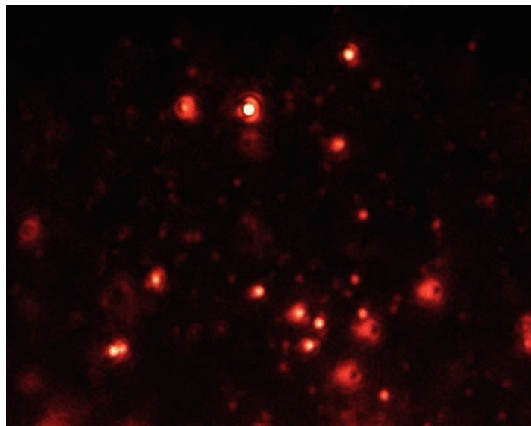
This TiO_2 sample clearly shows polydispersity.

Titanium Dioxide (in water)



Nanoparticle Tracking Analysis

Nanoparticle Tracking Analysis (**NTA**) gathers unique information through the monitoring of *individual* particles, rather than averaging over a bulk sample.



Capture video of Brownian motion

Tracking of particle trajectories in time

Size analysis



NTA Sizing... is an absolute method:

- Brownian motion of each particle is followed in real-time via video.
- Tracking software establishes particles' mean square displacement and thus diffusion coefficients (D_t).
- From the Stokes-Einstein equation the particle sphere-equivalent hydrodynamic diameter, d_h , can be obtained.

$$D_t = \frac{K_B T}{3\pi\eta d_h}$$

Stokes-Einstein equation

K_B = Boltzmann Constant
 η = viscosity



NTA Analysis in action.....



96nm polystyrene reference spheres being tracked and analysed by NTA software



NTA's Size Range:

10 – 800nm, dependent on particle type.

**8nm Silver
nanoparticles in
water.**





NTA vs. PCS – A bimodal sample



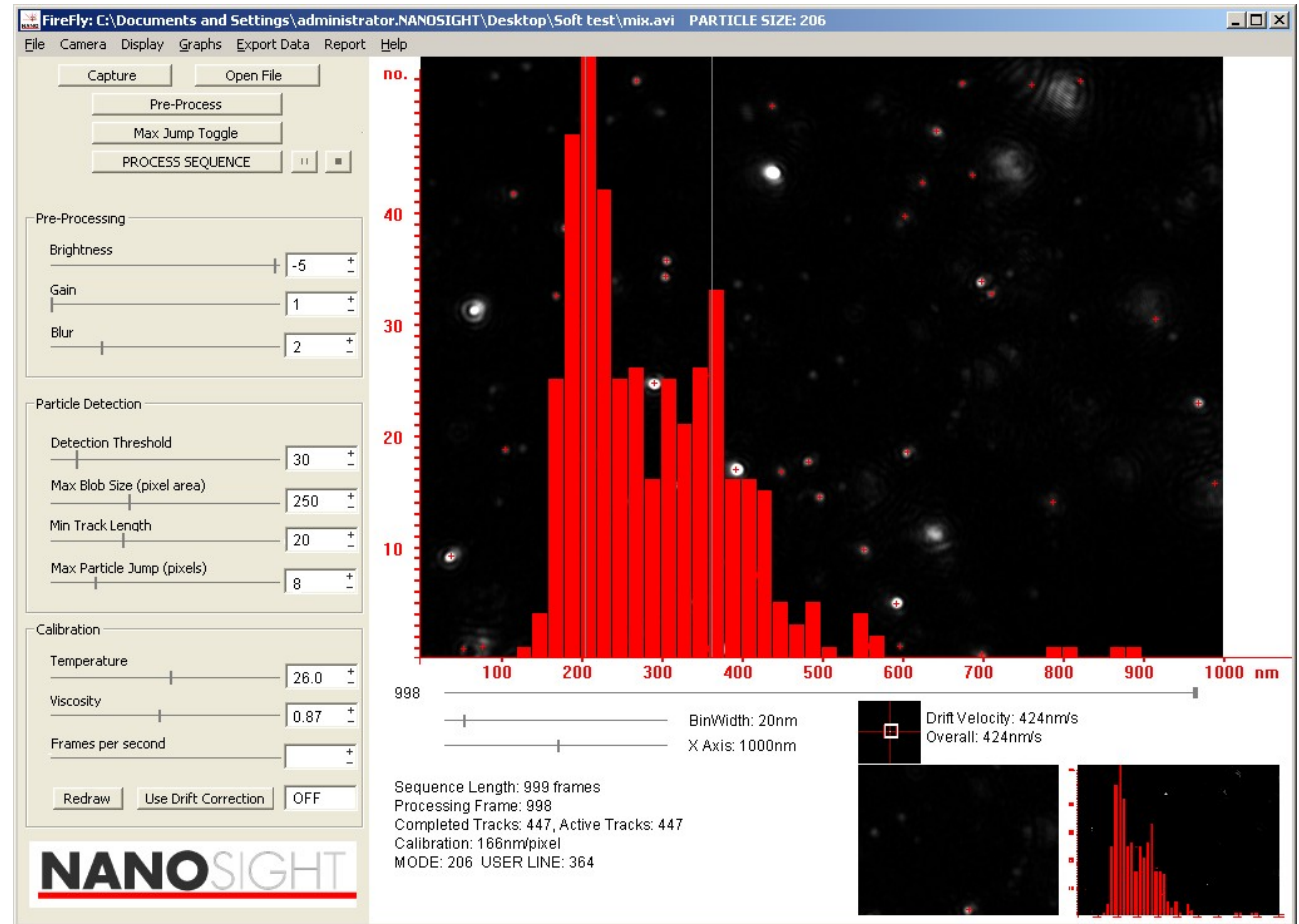
A mixed sample of 204nm and 384nm particles.

Polystyrene reference spheres in water (*204nm and 384nm*)



NTA vs. PCS – NTA 1.3 results

With NANOSIGHT,
analysis shows both
204nm and 384nm
peaks...

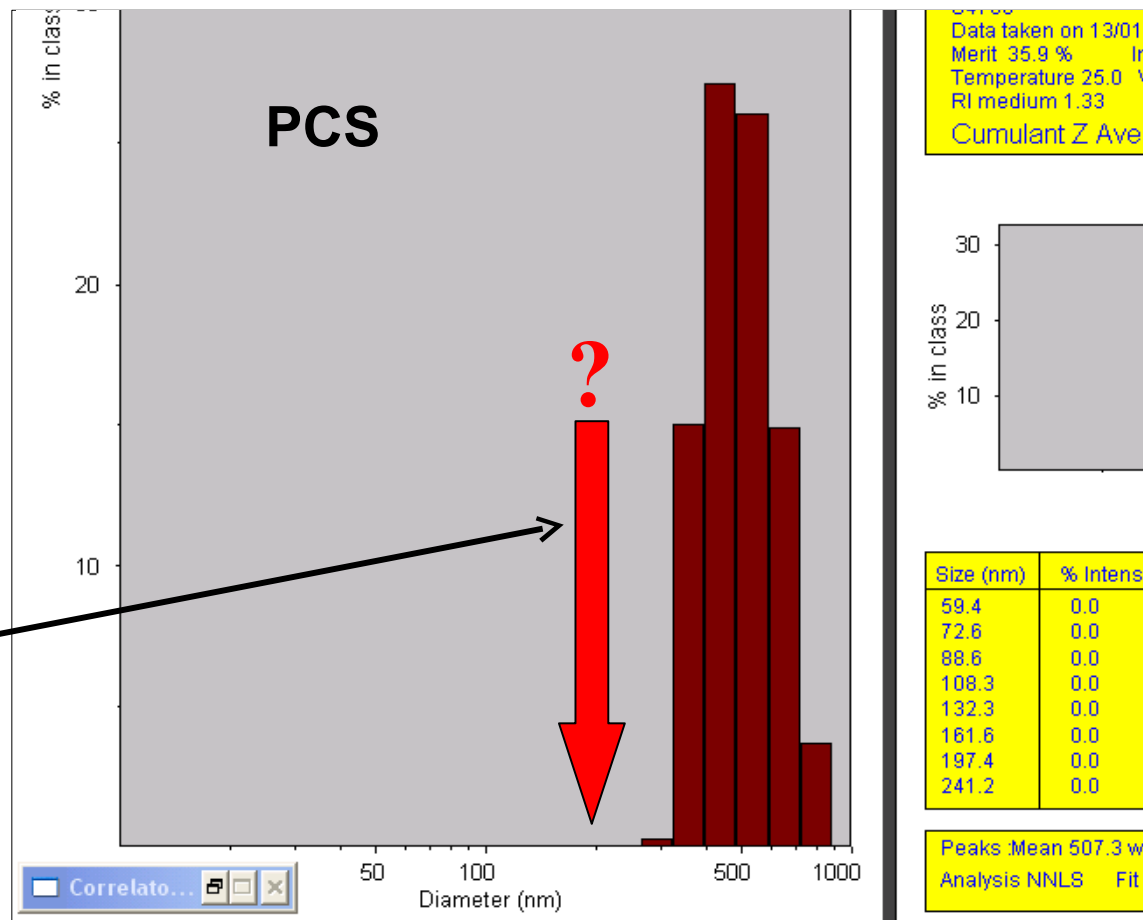




NANOSIGHT vs. PCS – PCS results

...whilst in PCS the 384nm particles can dominate the signal and data to the point where the smaller particles cannot be detected

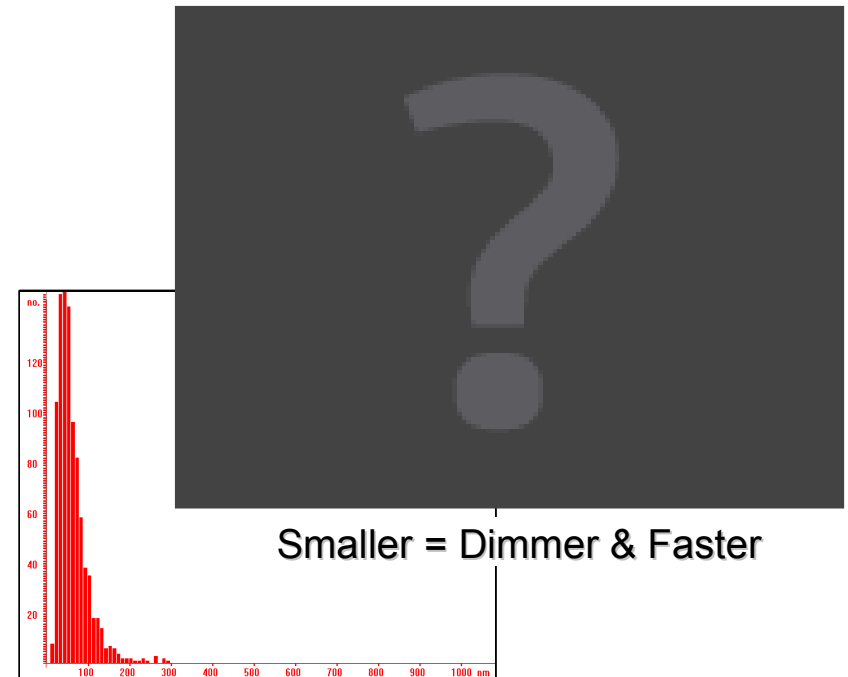
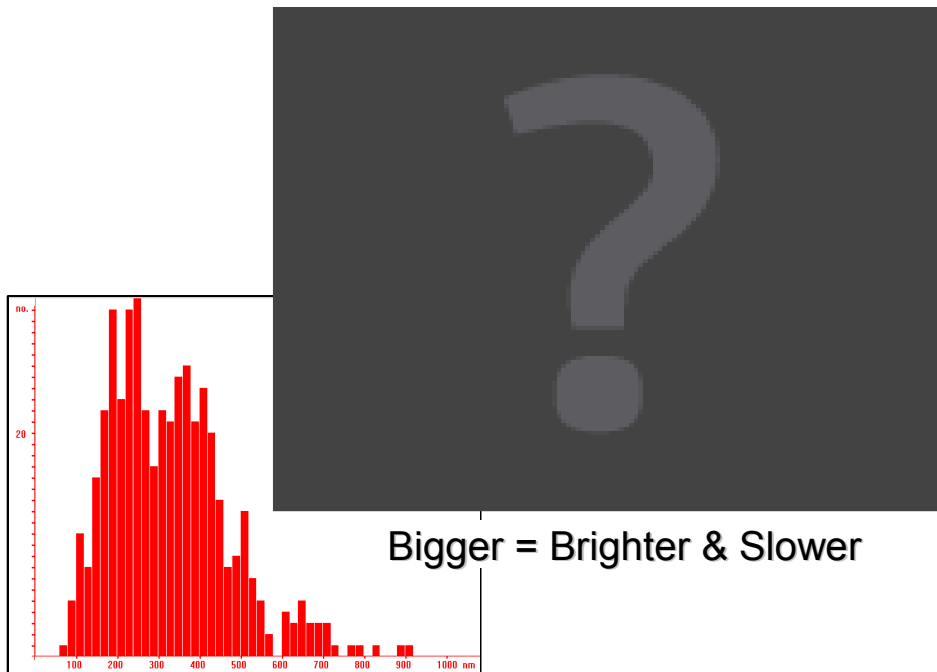
204nm not seen; intensity bias.





Example – Ink Samples

The video and graph on the left is of a standard commercially-available ink with a wider particle size distribution whereas those on the right are of a monodisperse high performance (advanced ‘digital’) nano-ink.





Example – Influenza Virus



Concentrated suspension of influenza virus containing low numbers of contaminants from allantoic culture medium



Example – Zinc Oxide in Toluene



NANOSIGHT can operate with a wide range of solvents.

Zinc Oxide in Toluene



Example – Bacterial Contamination



A video of a sample contaminated with motile bacteria in which non-Brownian motion is obvious.

Motile Bacteria in aqueous solution



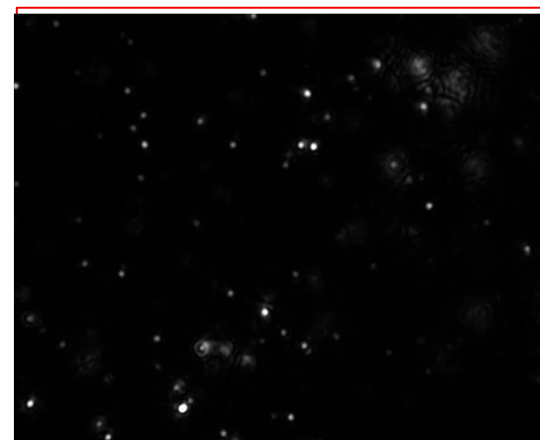
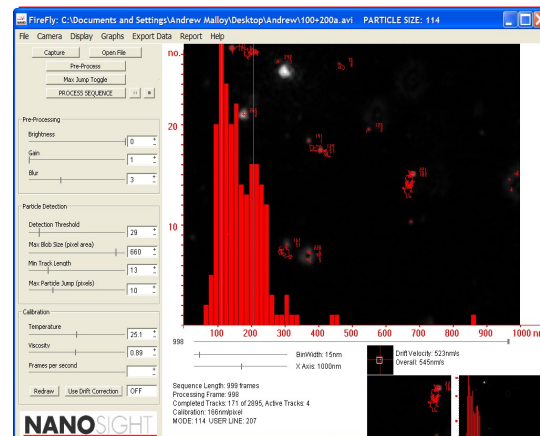
Other NTA Applications:

- ✓ **Metal oxides in magnetic storage media**
- ✓ **Fuel additives**
- ✓ **Multi-walled Carbon nanotubes**
- ✓ **Precursor chemicals for wafer fabrication**
- ✓ **Ceramics**
- ✓ **Wear debris from orthopaedic implants**
- ✓ **Cosmetics**
- ✓ **Foodstuffs**



NANOSIGHT in Summary:

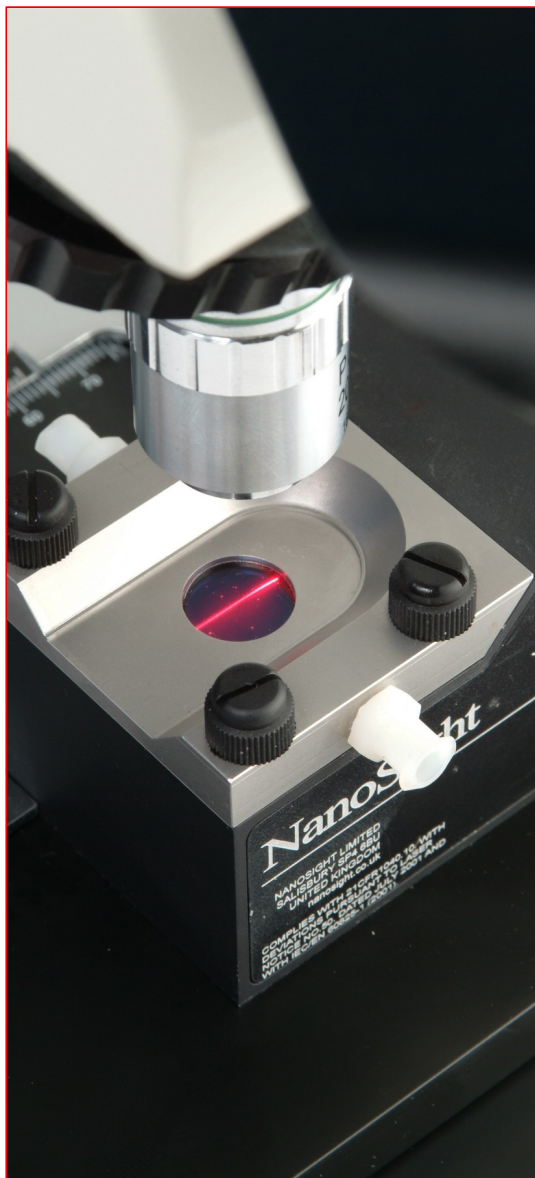
- ✓ A new characterisation tool for nanoparticles
- ✓ Widely applicable
- ✓ Single particle detection and analysis, down to 10nm, with minimal sample preparation
- ✓ Complementary to existing methods
- ✓ Real time information
- ✓ Rapid results and Low cost





Some Users to date:

- Roche, Switzerland
- Unilever, UK
- BP Castrol, UK
- Shell Oil, UK
- Schlumberger, UK
- Oxonica, UK
- Smiths Industries, UK
- BASF, Germany
- ICI, UK
- AWE (Atomic Weapons), UK
- Nestle, Switzerland



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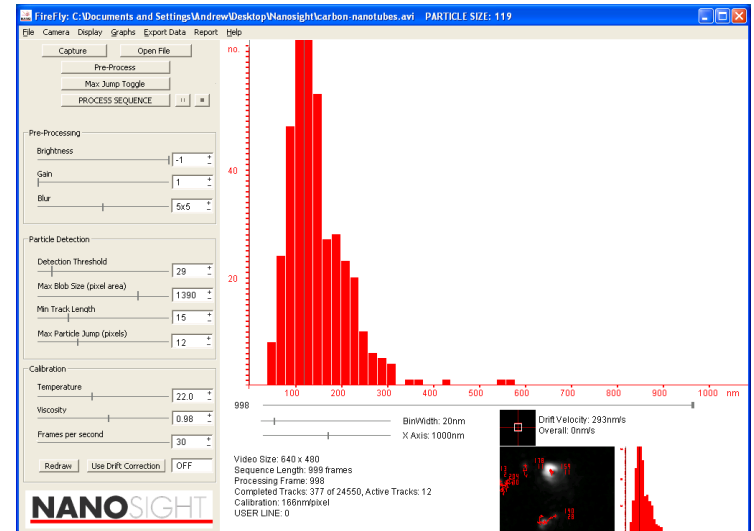


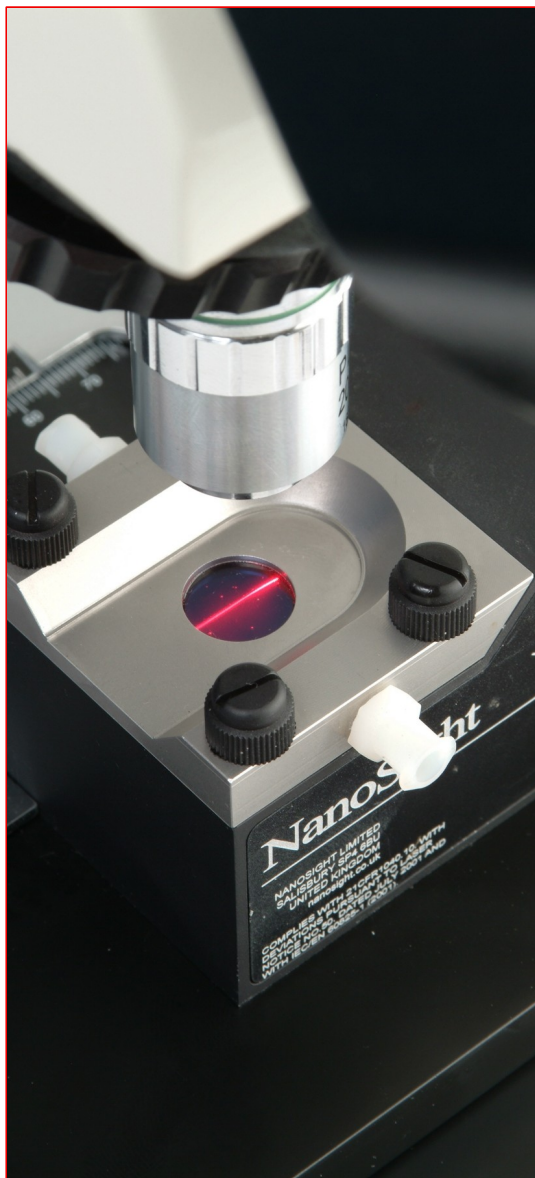
Example – Carbon Nanotubes



Single walled Carbon Nanotubes dispersed in water

The twinkling or flashing observed is thought to be due to the rotation of the high-aspect ratio (rod-like) nanotubes





NANOSIGHT

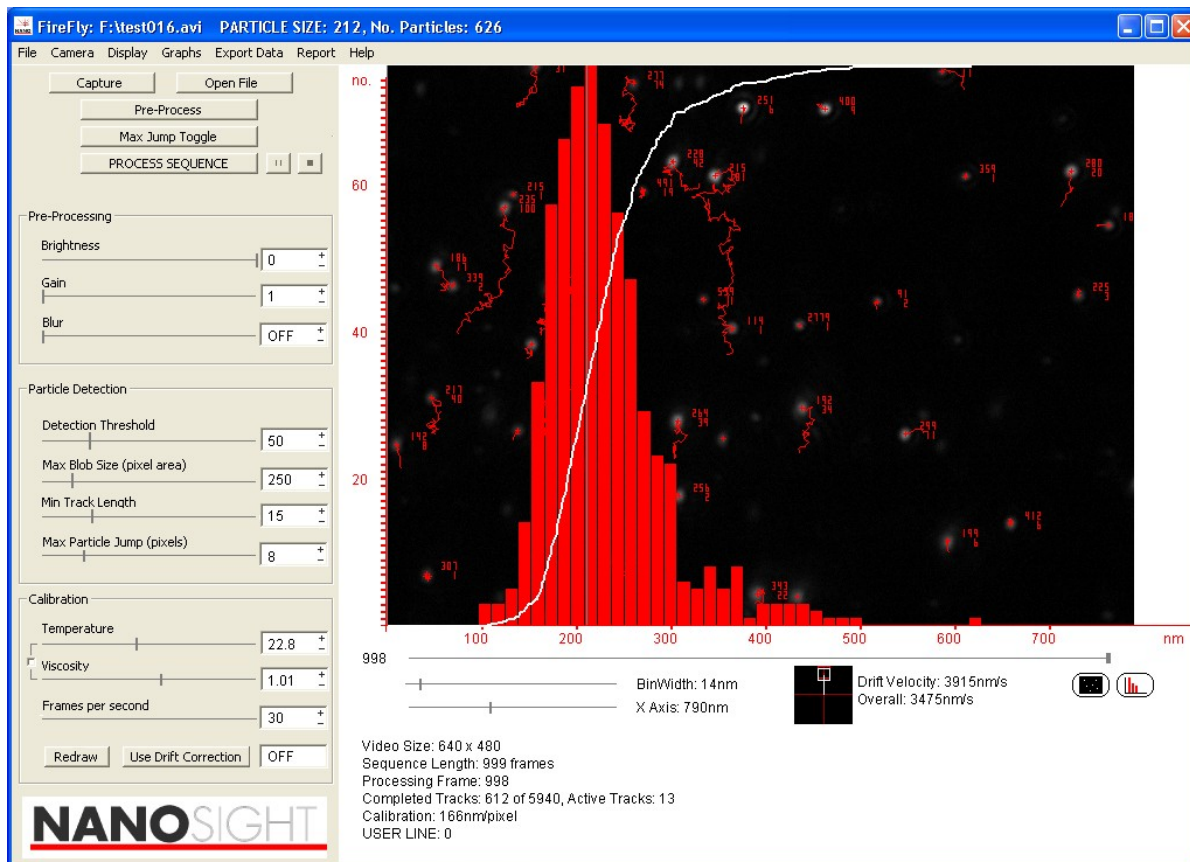


**MAKING SCIENCE
WORK.**

**Jeremy Warren
CEO, NanoSight Ltd**



Cumulative Undersize/Oversize



Software allows for curve showing cumulative undersize or oversize data to be displayed.

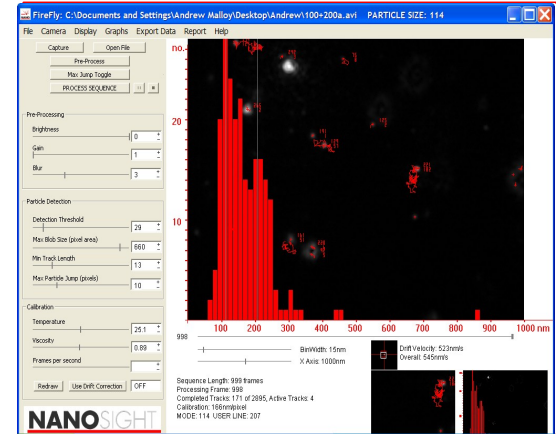
D10, D50, D90 particle size distribution is displayed.

Cumulative Undersize Particle Size Distribution



NANOSIGHT in Summary:

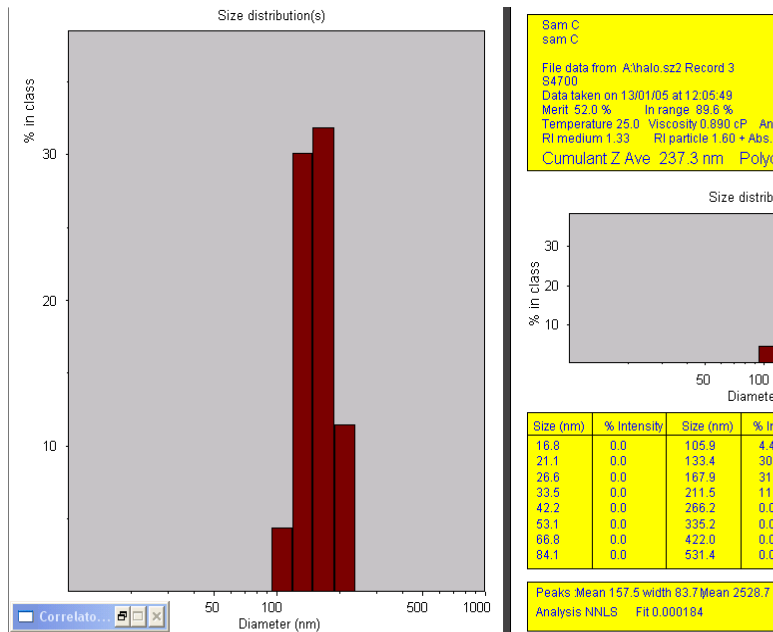
- ✓ Single particle detection and analysis
- ✓ Visualisation of particles down to 10nm
- ✓ Minimal sample preparation
- ✓ Real time information
- ✓ Particle-particle interaction analysis
- ✓ Rapid results and Low cost!



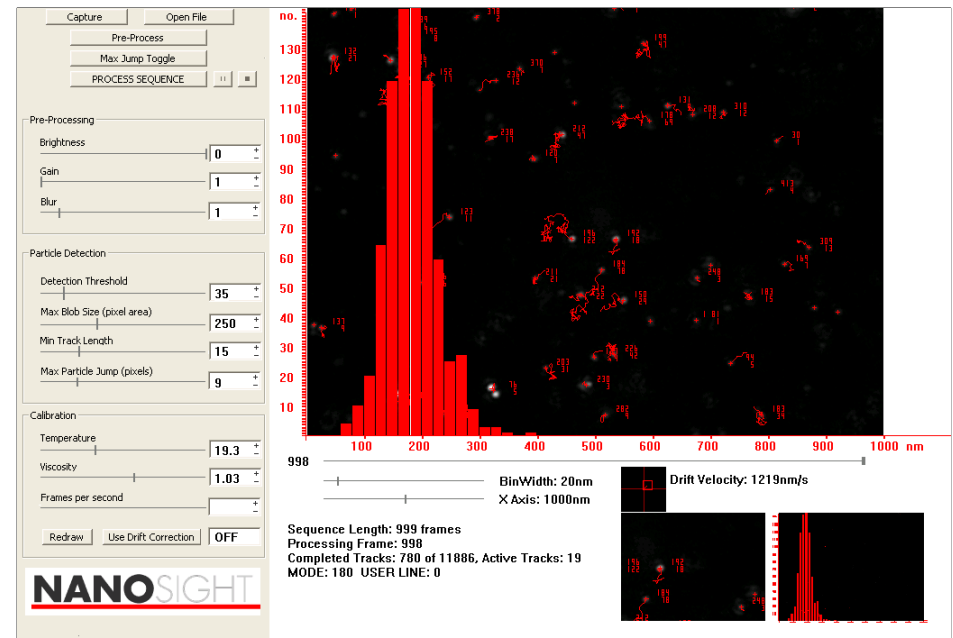


NANOSIGHT compares well to PCS*:

PCS Analysis



NTA 1.3 is equivalent for mono-disperse systems



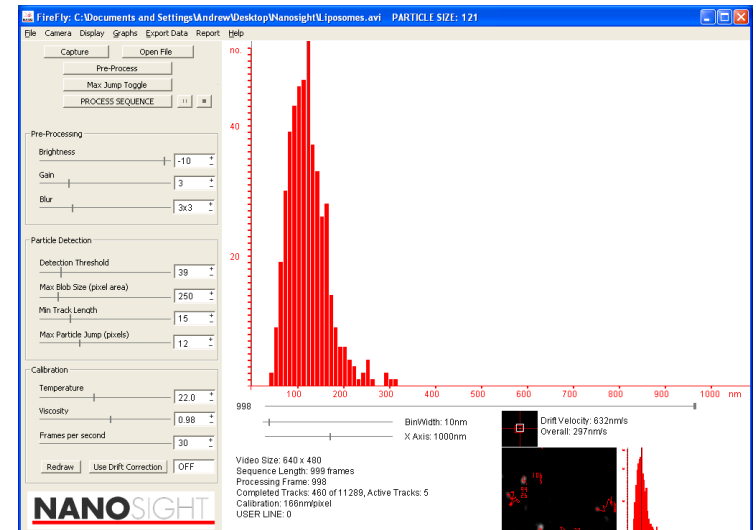
*Photon Correlation Spectroscopy, also known as DLS (Dynamic Light Scattering), is an industry standard method for particle sizing in this size regime.



Example – Liposomes



Liposomes in water (under development for drug delivery purposes).





Example: - Wear Debris in Orthopaedic Implants



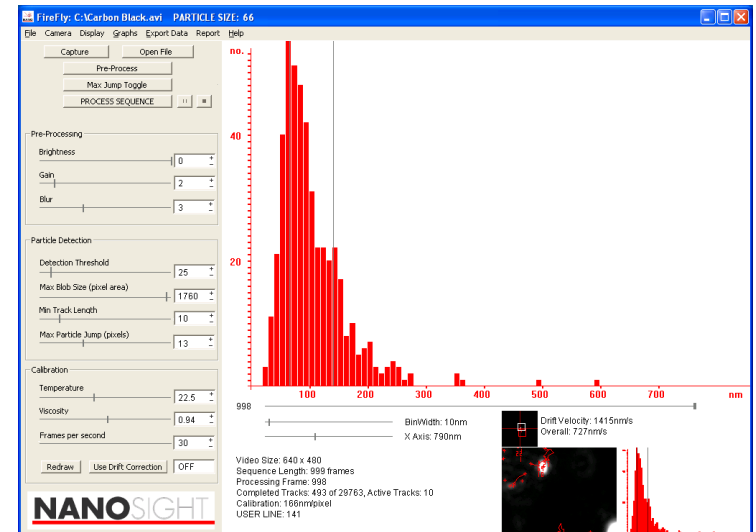
Wear debris from a ceramic coating of an orthopaedic implant during pre-clinical trials. These particles are suspended in bovine serum, following protein digestion and $0.4\mu\text{m}$ filtration



Example – Carbon Black



Carbon Black dispersed in water. Visible despite having high absorption.





Example – Anaesthetic Agent



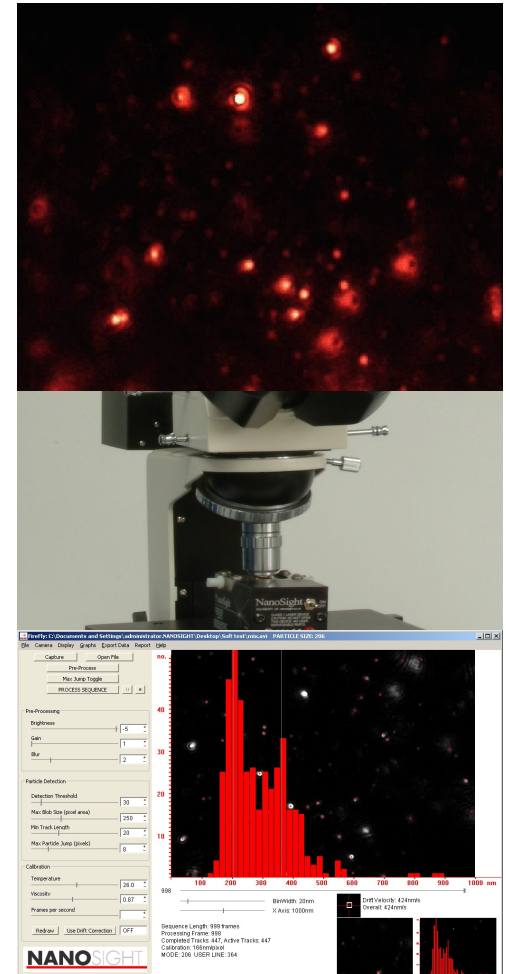
Video of a proprietary, short-acting, intravenous anaesthetic agent reformulated as an aqueous micro emulsion.

It can be clearly appreciated that the sample is monodisperse and contains no larger particles



This system provides visualisation of deeply sub-micron (nanoscale) particles:

- in liquid suspension,
- in **real time**,
- by utilising conventional optical microscopy and a matched CCD camera.

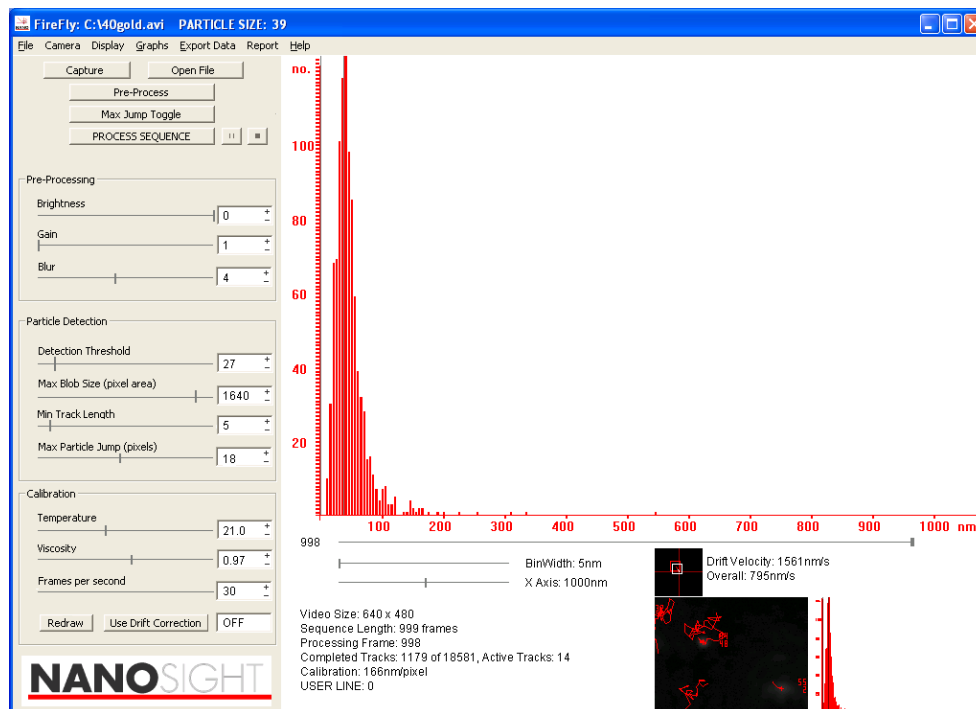




NanoSight NTA Sizing Range

NTA 1.3 Analysis software gives high resolution results for particles in the approximate range 10nm - 800nm, depending on sample type.

The ability to detect particles depends on the amount of light scattered by the particles. This is related to their size and the ratio of refractive indices between the particles and solvent.

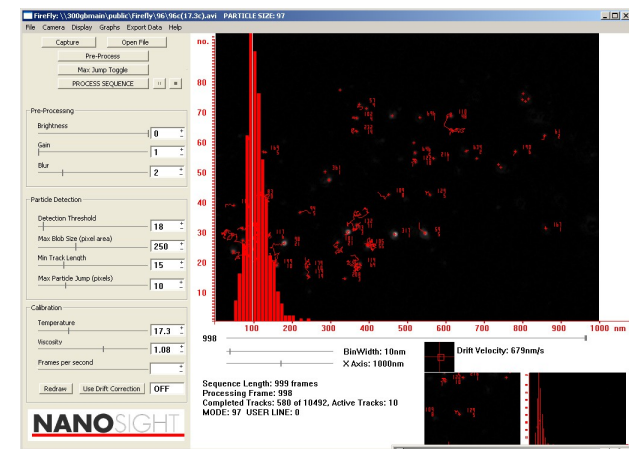
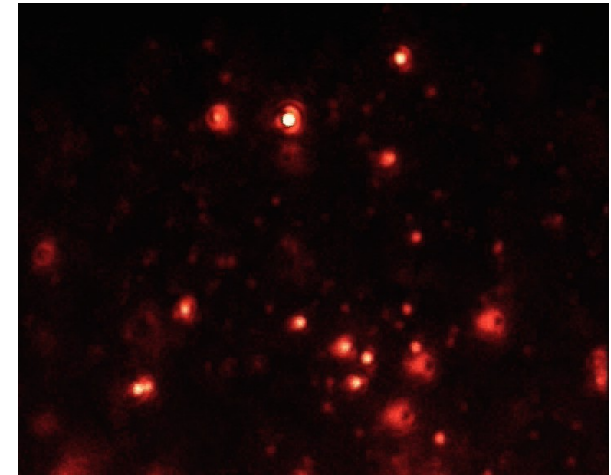


Typical particle size distribution plot taken from NTA 1.3 (40 nm Gold Colloid)



NTA complements PCS:

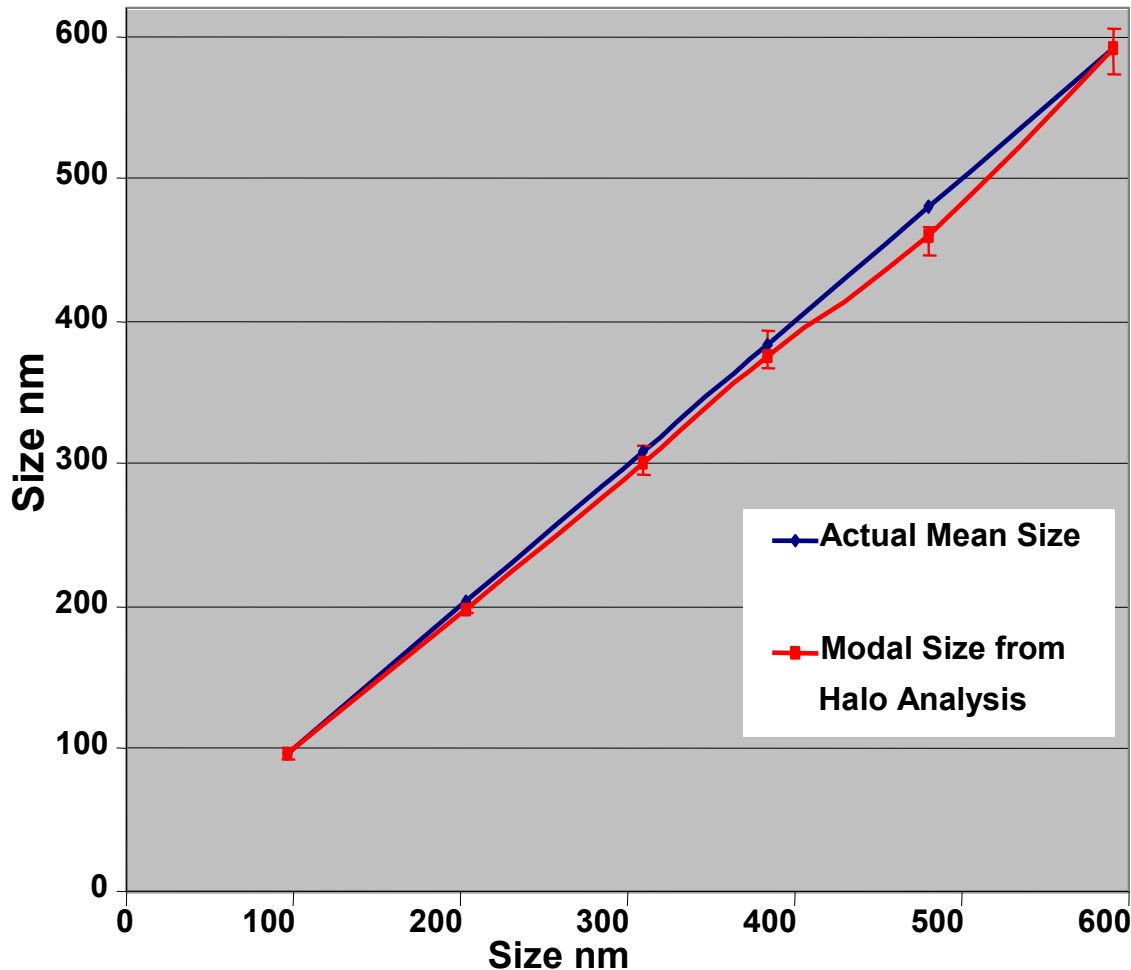
- Not an average, but a particle-by-particle count
- Not intensity weighted to larger particles
- Direct view of what is in sample





Sizing Accuracy

NANOSIGHT LM10 results show good correlation with certified reference particles.



* polystyrene reference spheres



Analysing Particles – By *Number Count*



Mixture of 100nm and 200nm polystyrene microspheres dispersed in water in a 2:1 number ratio.

The NTA particle size distribution shows the number of particles of any given size class seen in the sample.

