Le webinaire va commencer, veuillez patienter …

Vous êtes en écoute seule, posez vos questions dans la partie « discussion »

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Modérateurs :

Agnès PIEDNOIR
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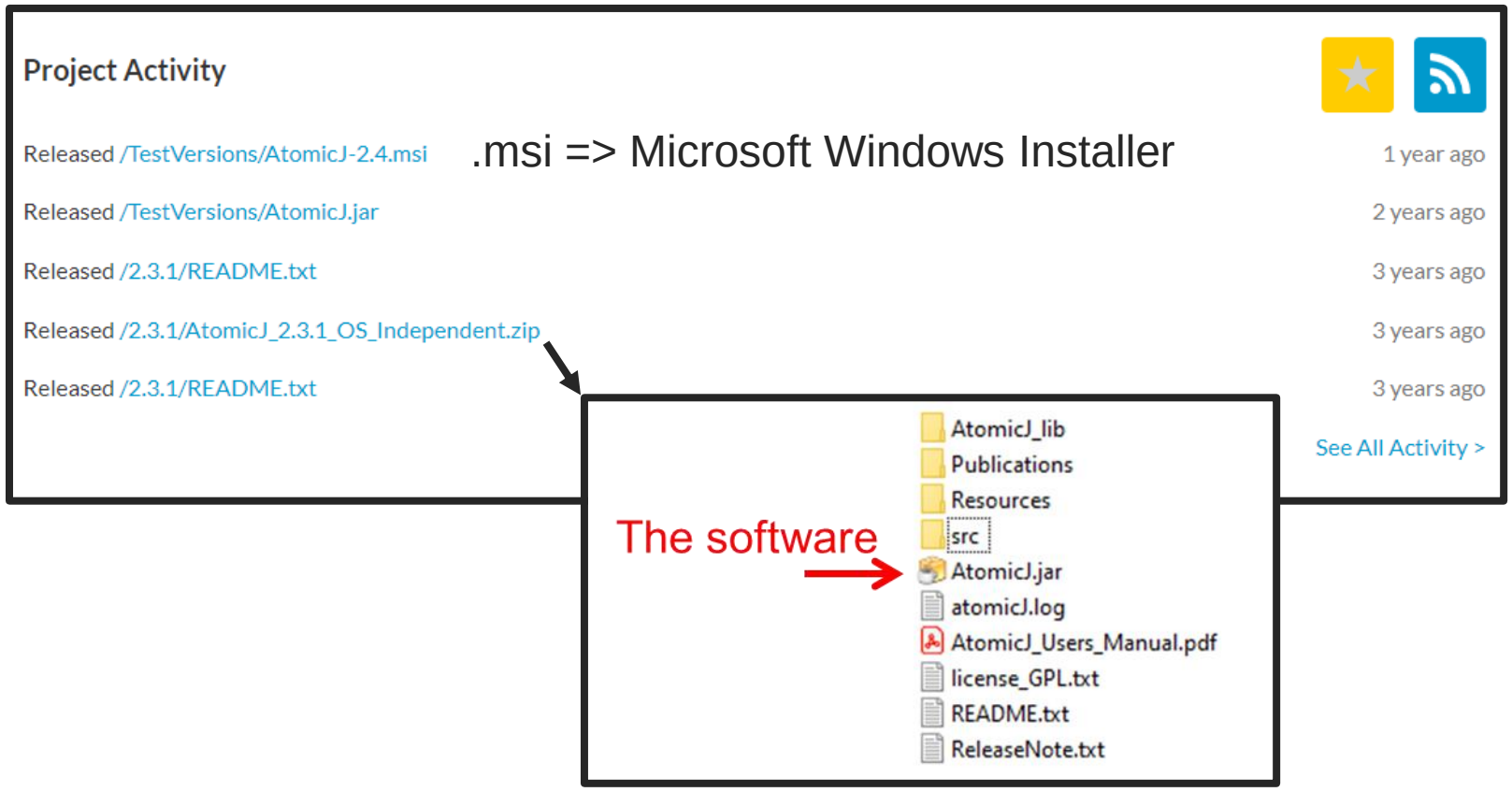
ATOMIC J FOR MECHANICAL ANALYSIS OF SPM EXPERIMENTS

ON-LINE MEETING
Monday 4th December 2023

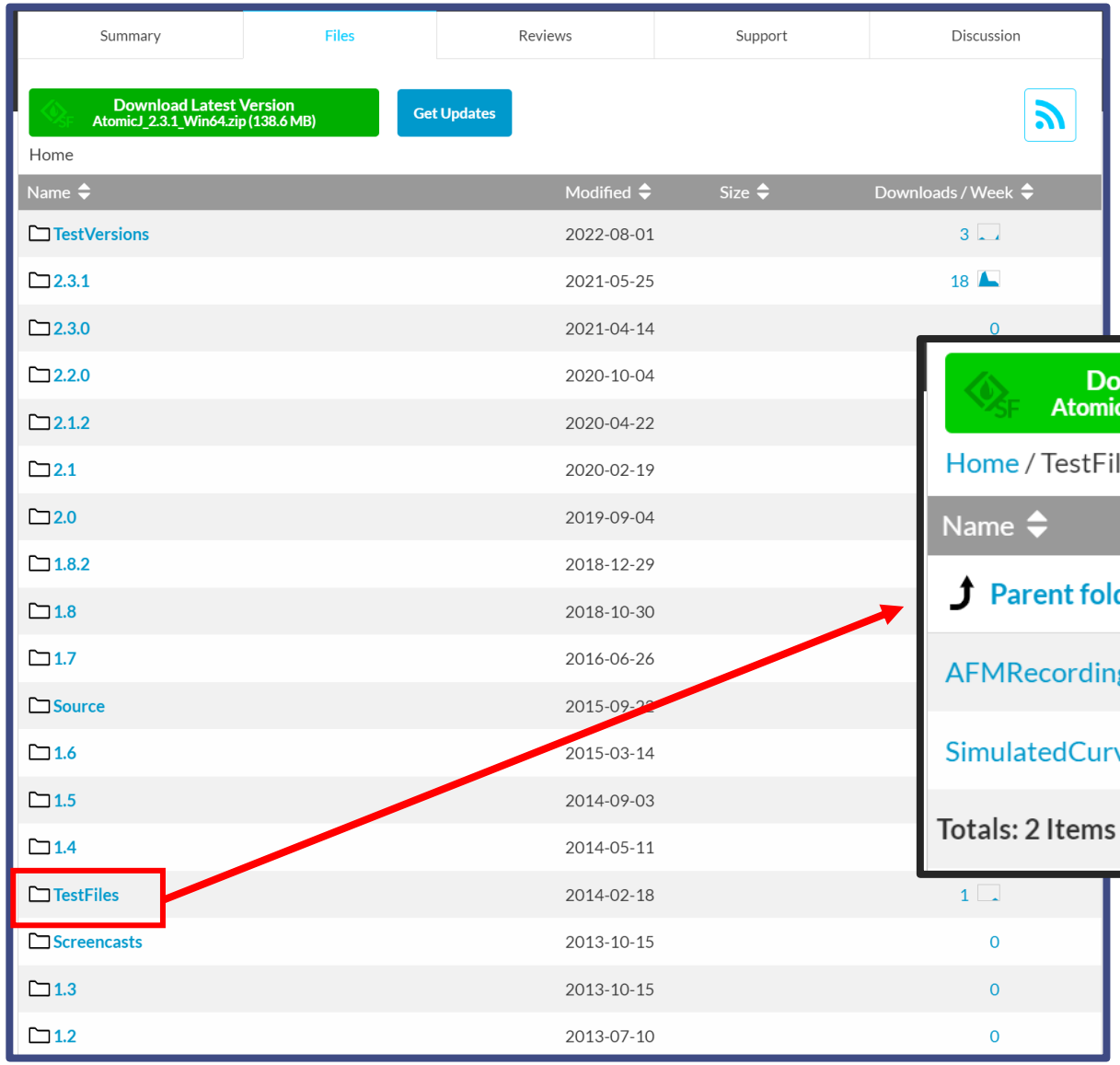
https://indico.mathrice.fr/event/516/

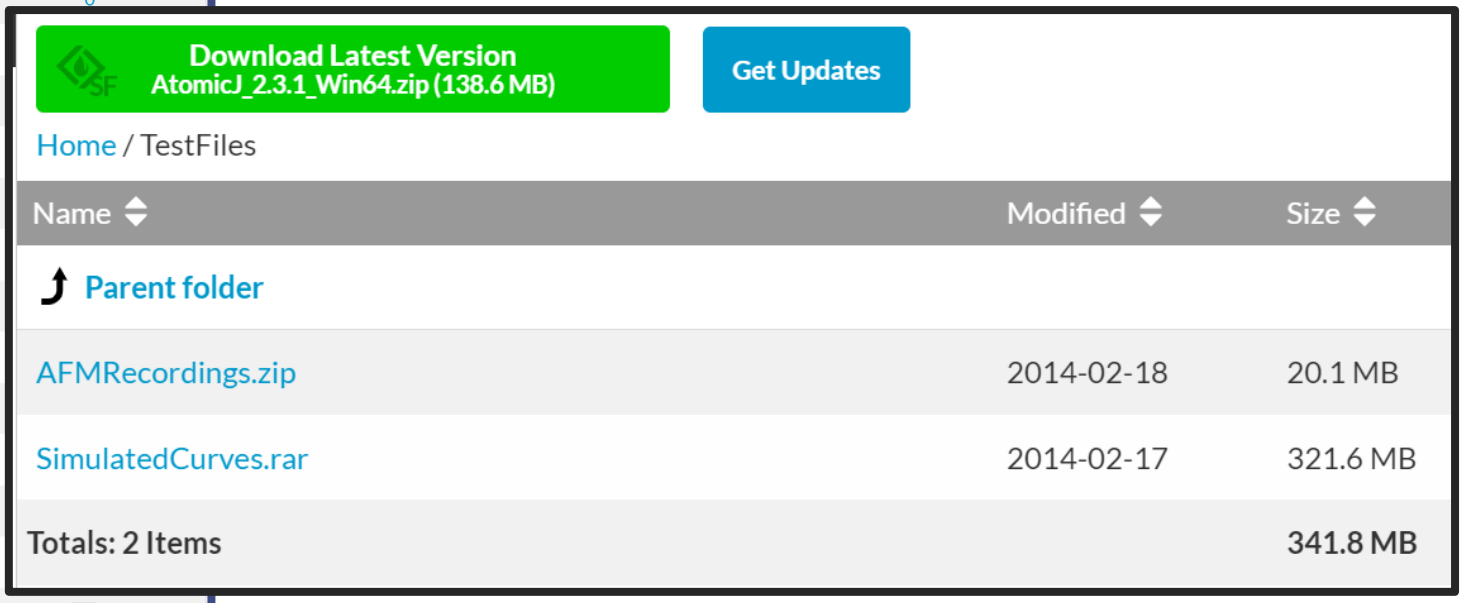
ATOMICJ : SOURCE FOR INSTALLING (I)

https://sourceforge.net/projects/jrobust/



ATOMICJ : SOURCE FOR INSTALLING (II)





https://sourceforge.net/projects/jrobust/files/TestFiles/

ATOMICJ – COMPUTER PLATFORM COMPATIBILITES

AJ is written in JAVA SE 7 (JFreeChart, JAMA, Commons Math, FreeHELP, Sanse-lan,

Commons Compress, Bio-Formats and iText® 2.1.5)

⇒ Windows (7 & 10) 64 bits with JAVA run time environment

⇒ OS independent (MAC OS, Linux, older Windows)

⇒ Memory allocation

⇒ Default needed RAM is 3Gbits

⇒ Reallocate more memory using the shell command (win) :

java –Xmx*memoryMaximum****m -jar AtomicJ.jar***

(*memoryMawimum* in Mbits / see AJ manual, page 6)

ATOMICJ – THE LICENSING

A. AtomicJ License agreement

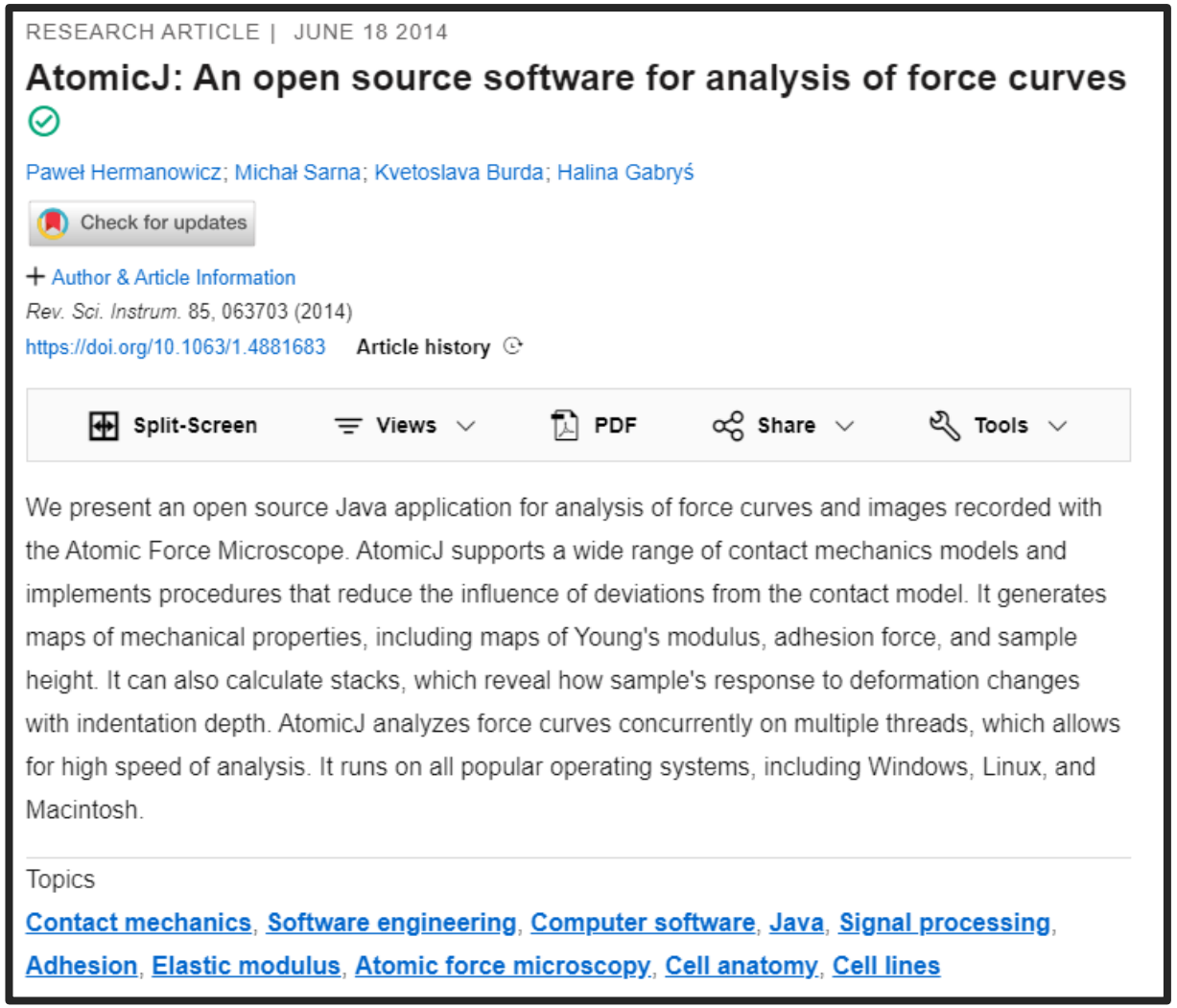
(C) Copyright 2013-2021 by Paweł Hermanowicz.

AtomicJ is an application for analysis of Atomic Force Microscopy recordings, in particular extracting mechanical properties from force curves and analysis of AFM images recorded on biological samples.

AtomicJ is a non-commercial, open source application, licensed under the terms of the GNU General Public License (GPL). The whole text of the license in distributed with the software.

Please note that AtomicJ is distributed WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. Please refer to the license for details.

ATOMICJ : THE ORIGINAL PUBLICATIONS



RESEARCH ARTICLE | JUNE 18 2014

AtomicJ: An open source software for analysis of force curves

Paweł Hermanowicz; Michał Sarna; Kvetoslava Burda; Halina Gabryś

Check for updates

+ Author & Article Information

Rev. Sci. Instrum. 85, 063703 (2014)

https://doi.org/10.1063/1.4881683 **Article history**

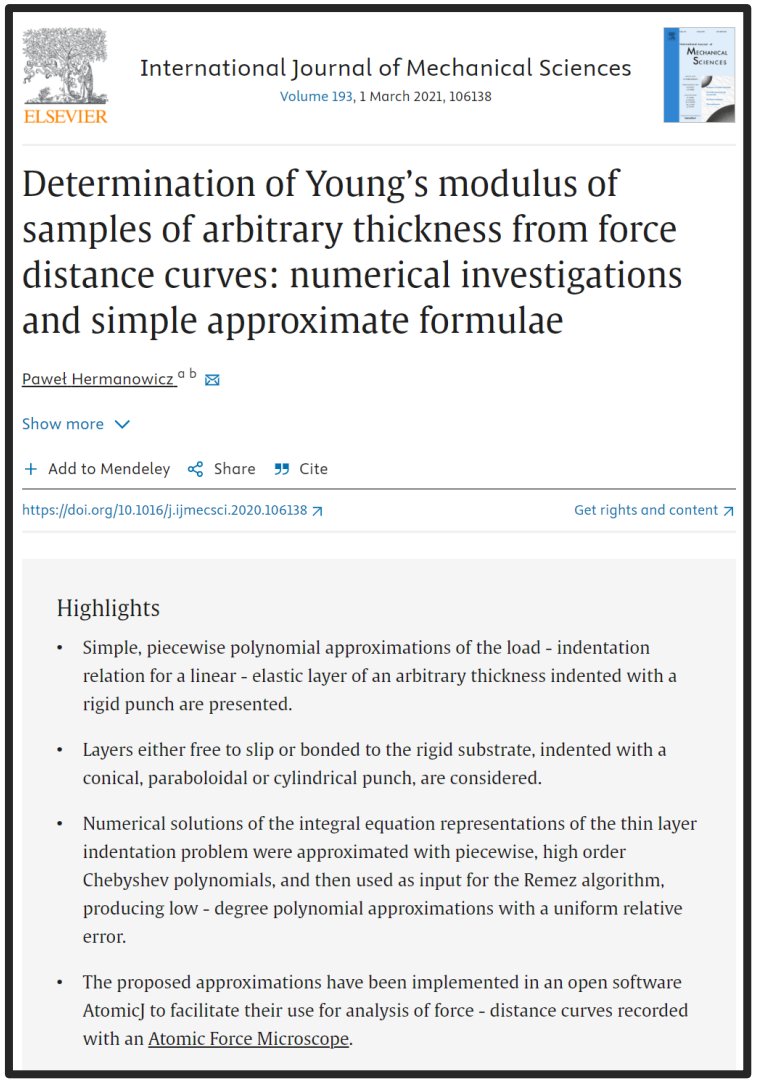
Split-Screen Views PDF Share Tools

We present an open source Java application for analysis of force curves and images recorded with the Atomic Force Microscope. AtomicJ supports a wide range of contact mechanics models and implements procedures that reduce the influence of deviations from the contact model. It generates maps of mechanical properties, including maps of Young's modulus, adhesion force, and sample height. It can also calculate stacks, which reveal how sample's response to deformation changes with indentation depth. AtomicJ analyzes force curves concurrently on multiple threads, which allows for high speed of analysis. It runs on all popular operating systems, including Windows, Linux, and Macintosh.

Topics

Contact mechanics, Software engineering, Computer software, Java, Signal processing, Adhesion, Elastic modulus, Atomic force microscopy, Cell anatomy, Cell lines

https://doi.org/10.1063/1.4881683



ELSEVIER

International Journal of Mechanical Sciences

Volume 193, 1 March 2021, 106138

Determination of Young's modulus of samples of arbitrary thickness from force distance curves: numerical investigations and simple approximate formulae

Paweł Hermanowicz[a b]

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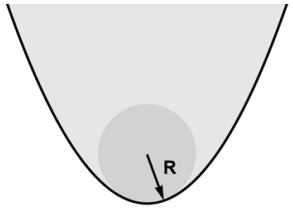
https://doi.org/10.1016/j.ijmecsci.2020.106138 Get rights and content

Highlights

- Simple, piecewise polynomial approximations of the load - indentation relation for a linear - elastic layer of an arbitrary thickness indented with a rigid punch are presented.
- Layers either free to slip or bonded to the rigid substrate, indented with a conical, paraboloidal or cylindrical punch, are considered.
- Numerical solutions of the integral equation representations of the thin layer indentation problem were approximated with piecewise, high order Chebyshev polynomials, and then used as input for the Remez algorithm, producing low - degree polynomial approximations with a uniform relative error.
- The proposed approximations have been implemented in an open software AtomicJ to facilitate their use for analysis of force - distance curves recorded with an Atomic Force Microscope.

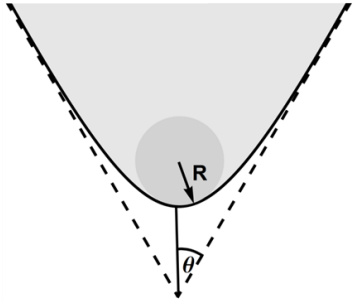
https://doi.org/10.1016/j.ijmecsci.2020.106138

SUPPORTED TIP SHAPES



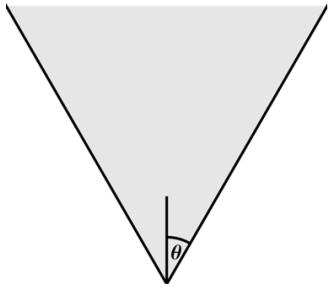
Paraboloid

that approximates sphere in the Hertz's equation. *R* – radius of curvature at the apex



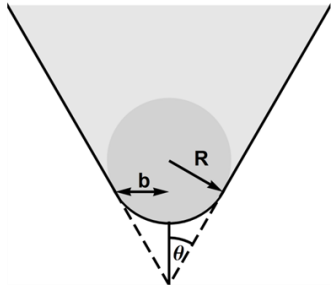
Hyperboloid

R – radius of curvature at the apex, θ – half angle between the asymptotes.



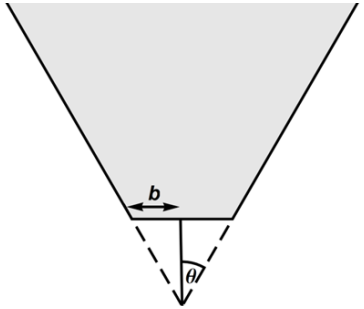
Cone

θ – half angle.



Blunt cone
(cone capped by a sphere).

R- radius of curvature at the apex, *b* – tip radius at the level of transition between the capping sphere and the cone, θ – half angle. If the transition from sphere to cone is smooth, then b = RCos[θ].



Truncated cone

b – truncation radius, θ – half angle

SUPPORTED CONTACT MECHANICS MODELS

ELASTIC MODELS

Sphere (Hertz) - 2. Sphere (Sneddon) (Sneddon 1965) - 3. Sphere, thin sample (Dimitriadis et al. 2002) - 4. Hyperboloid (Akhremitchev and Walker 1999) - 5. Cone (Harding and Sneddon 1945) - 6. Cone, thin sample (Gavara and Chadwick 2012) - 7. Power-shaped (Galin 1946). – 8. Blunt cone (Briscoe et al. 1994). - 9. Truncated cone (Briscoe et al. 1994). – 10. Pyramid, regular, four sided (Bilodeau 1992) – 11. Blunt pyramid, regular, four-sided (Rico et al. 2005) – 12.Truncated pyramid (Rico et al. 2005).

HYPERELASTIC MODELS

13. Sphere, Fung's hyperelastic model (Fung 1979) - 14. Sphere, Ogden's hyperelastic model (Ogden 1972)

ADHESIVE CONTACT

15. Derjaguin-Muller-Toporov (DMT) (Derjaguin et al. 1975) - 16. Johnson-Kendall-Roberts (JKR) (Johnson et al. 1971) – 17. Sphere, Maugis solution. Maugis (1995) – 18. Hyperboloid, Sun-Akhremitchev-Walker (SAW), Sun et al (2004) – 19. Cone Lebedev – Chebyshev, thin sample – 20. Paraboloid Lebedev – Chebyshev, thin sample

full descriptions of the models in the user's manual

- **The ease of use (very intuitive, useful manual)**
- **The large scope of embedded (elastic/hyperelastic) contact mechanics models / tip shapes**
- **The advanced mathematical computation for contact point determination**
- **The curves pre-processing (cropping, filtering)**
- **Automatic/manual contact point determination curve by curve (by a least square fit regression) without any “range” applied for ALL the curves**
- **The patching : applying different mechanical modeling on different patches of the surface.**
- **Seeing the fit on each curve (+ the R^2 map)**
- **The pointwise modulus**
- **The batch processing**
- **The statistics (& the histograms) including on ROIs, and the test-statistic (t-test)**
- **The stacks images**
- **The aim to open & treat .csv / .tsv raw data (in case of no opening of native file format)**

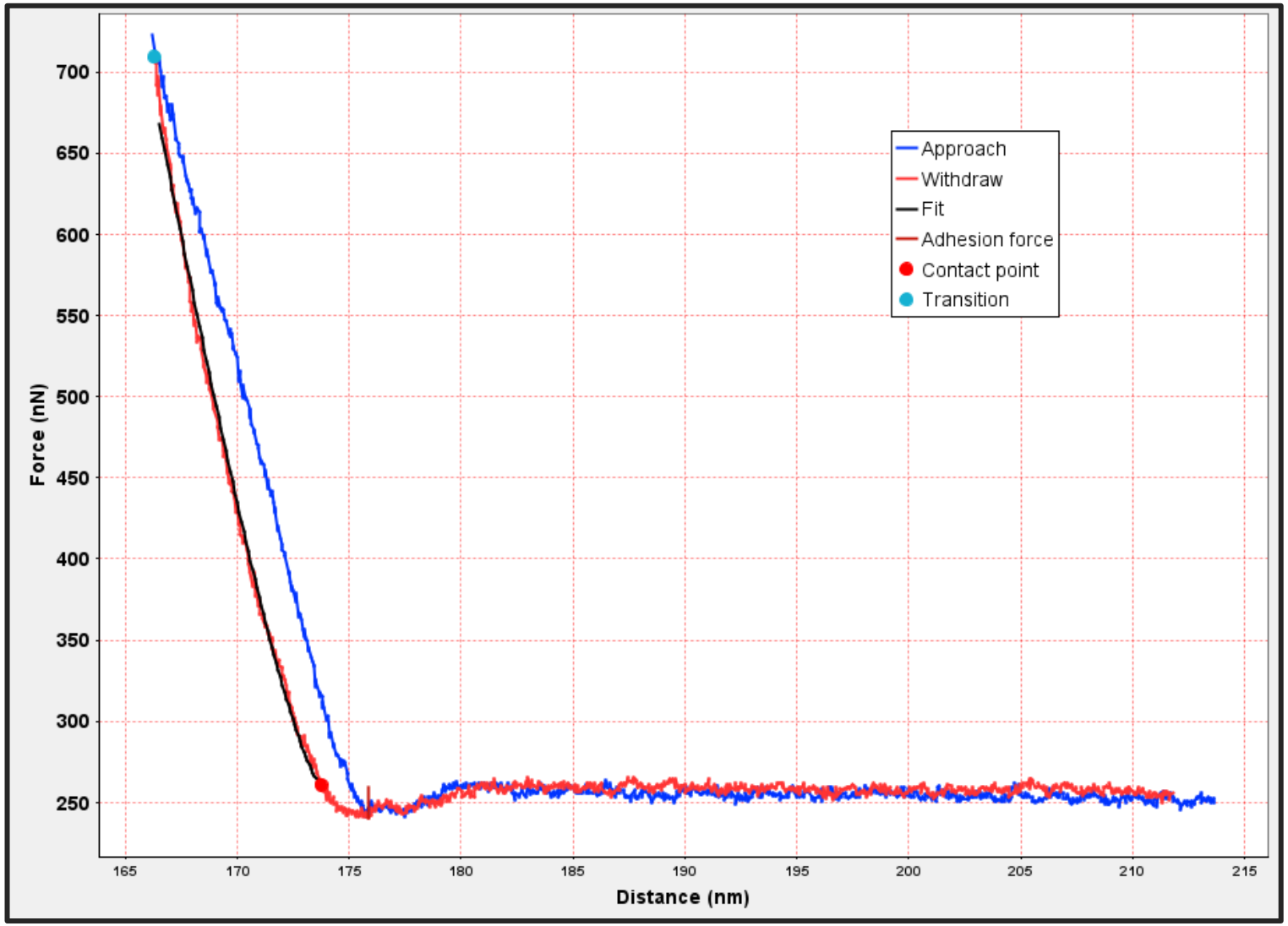
- No models on viscoelasticity / elasto-plasticity (e. g. Oliver & Pharr)
- No help to choose “best model” vs experimental data (e.g. no Tabor’s parameter computation, etc.)
- No display of the base line flattening
- Minor bugs on “live charts style”
- Next version / support ?

ALTERNATIVE TO ATOMICJ

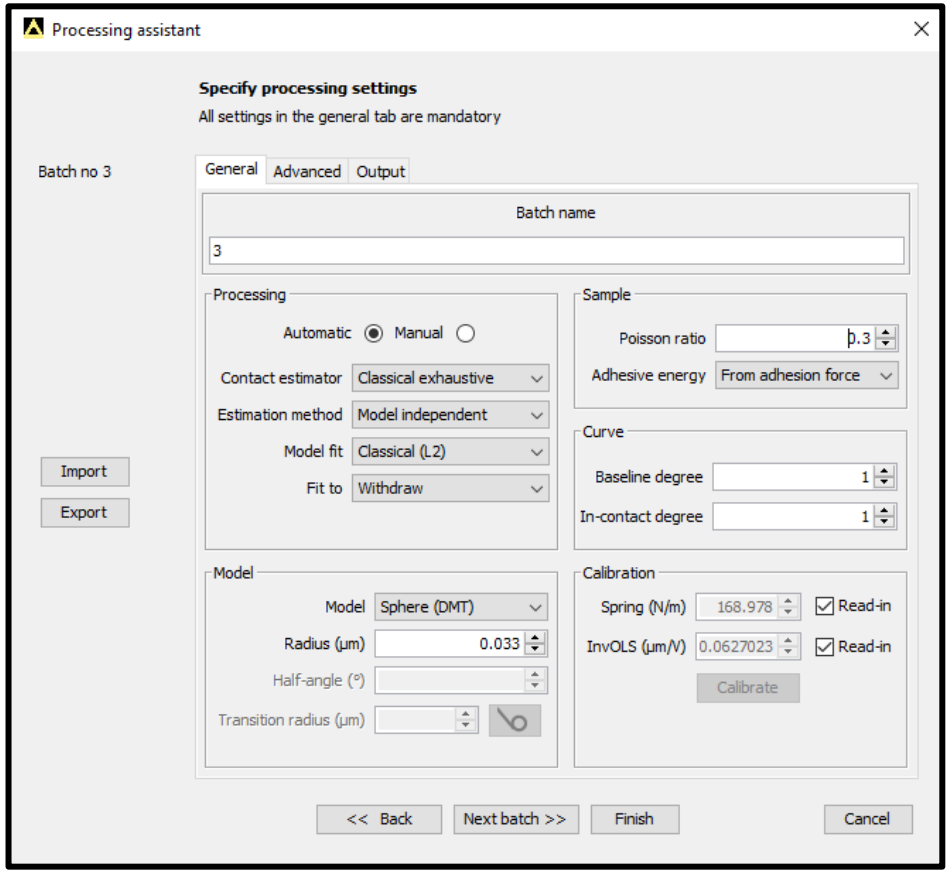
- SPM analysis software from manufacturer (Nanoscope Analysis, etc.)
- OpenFovea (2012) https://www.nature.com/articles/nmeth.2112 => freeware
- PUNIAS v.1.0r2.3 (2016) http://punias.free.fr/ / https://www.pnas.org/doi/10.1073/pnas.98.4.1565 => paid software
- Gwyddion http://gwyddion.net/documentation/user-guide-en/curve-maps-fd.html => freeware
- SPIP® (ImageMetrology) / MountainsSPIP® (Digital Surf) https://www.digitalsurf.com/software-solutions/scanning-probe-microscopy/ => paid software
- + python, + MATLAB, etc.

UMONS Université de Mons

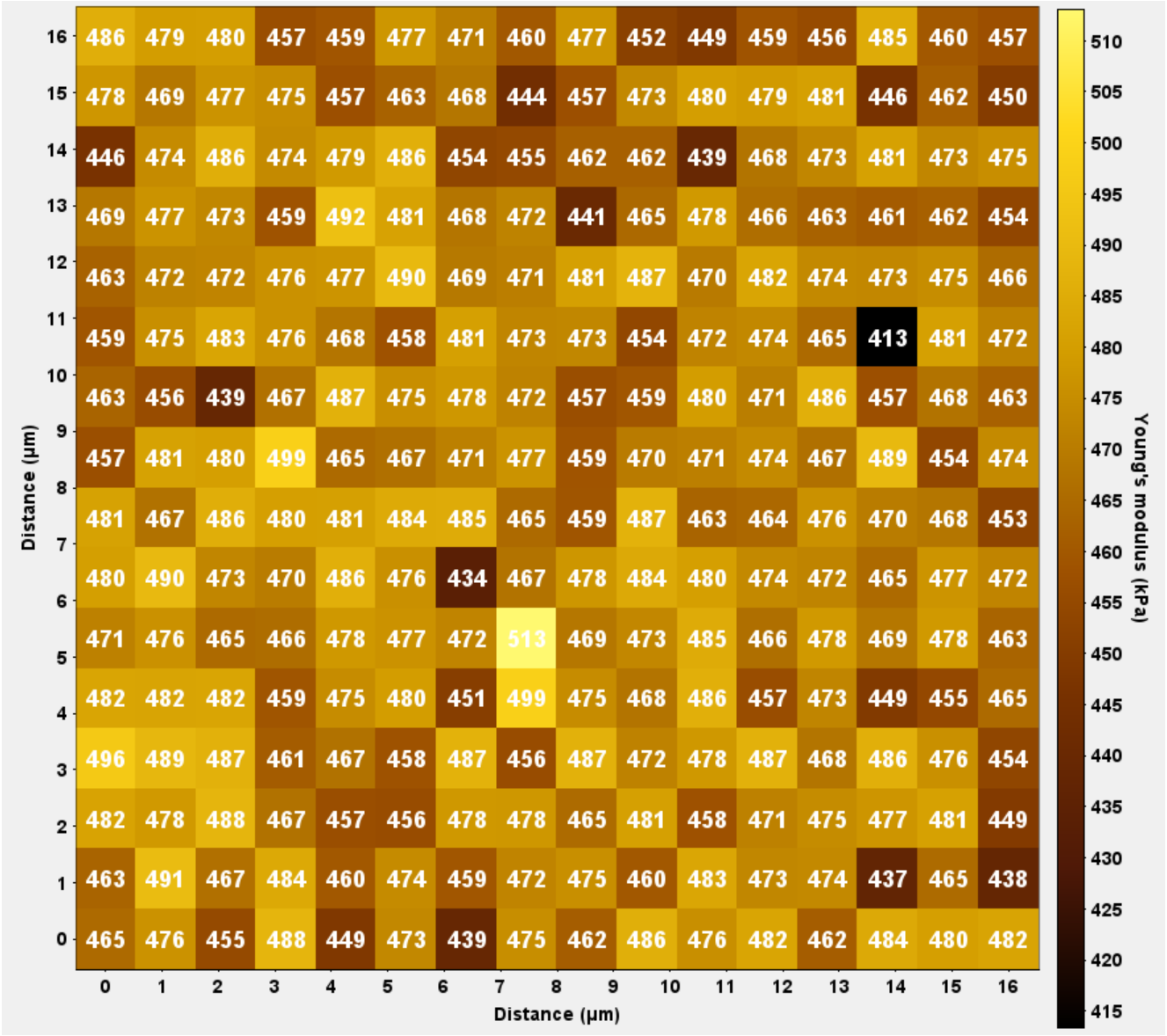
EXAMPLE #1 – SINGLE CURVE



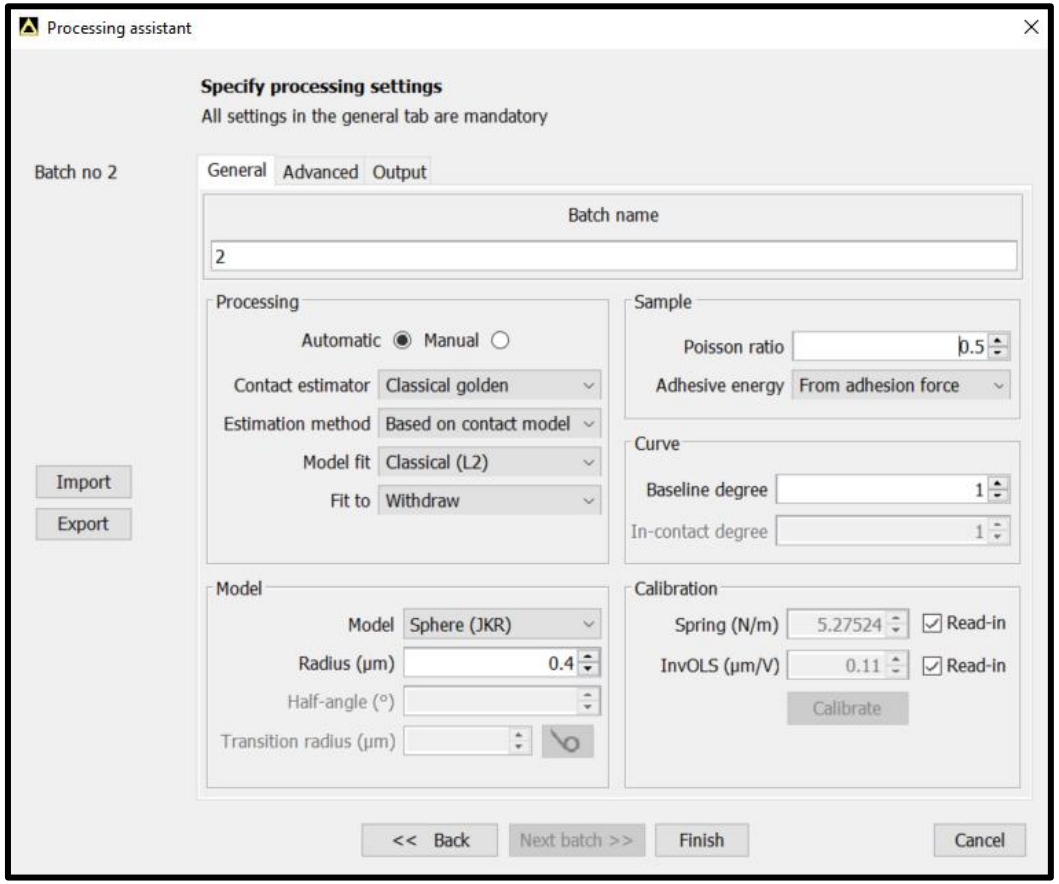
Sample: A polymer
Acquisition on Bruker Dimension ICON in air
Single curve from Force-Volume
Force setpoint = 500 nN
Tip : BRUKER RTESPA-300-30
R = 33 nm
K = 167 N/m
T = 25 °C



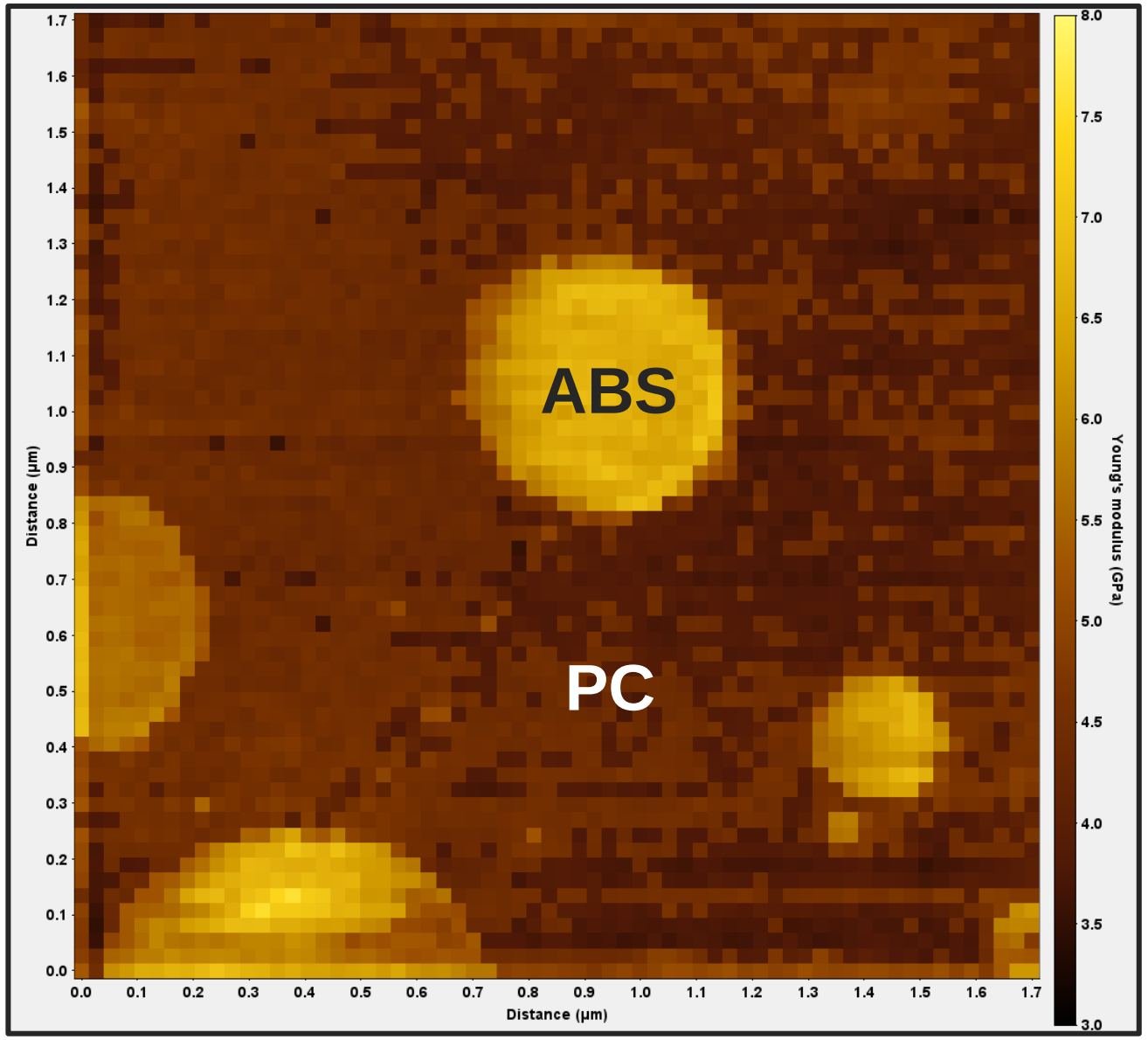
EXAMPLE #2 – PDMS



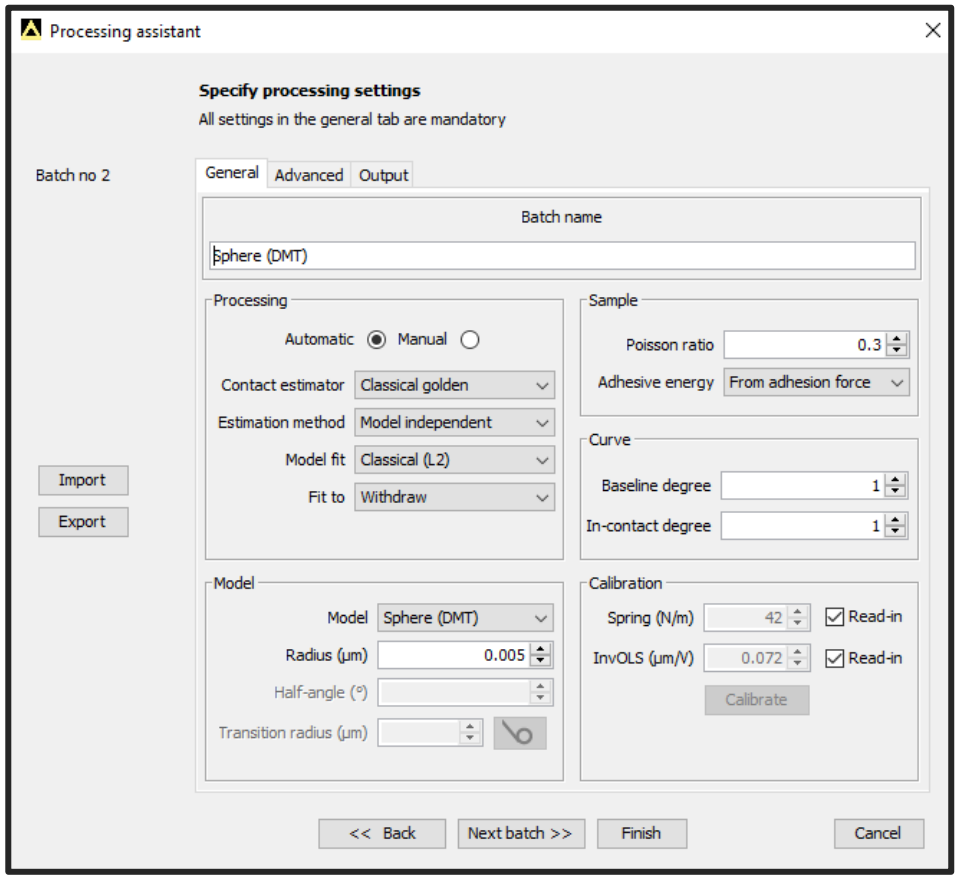
Sample: Gel-Pak®
Acquisition on Bruker Dimension ICON in air
Force-Volume (16 * 16)
Force setpoint = 10 nN
Tip : Nanosensors SD-SPHERE ; R = 400 nm
T = 25 °C



EXAMPLE #3 – PC/ABS

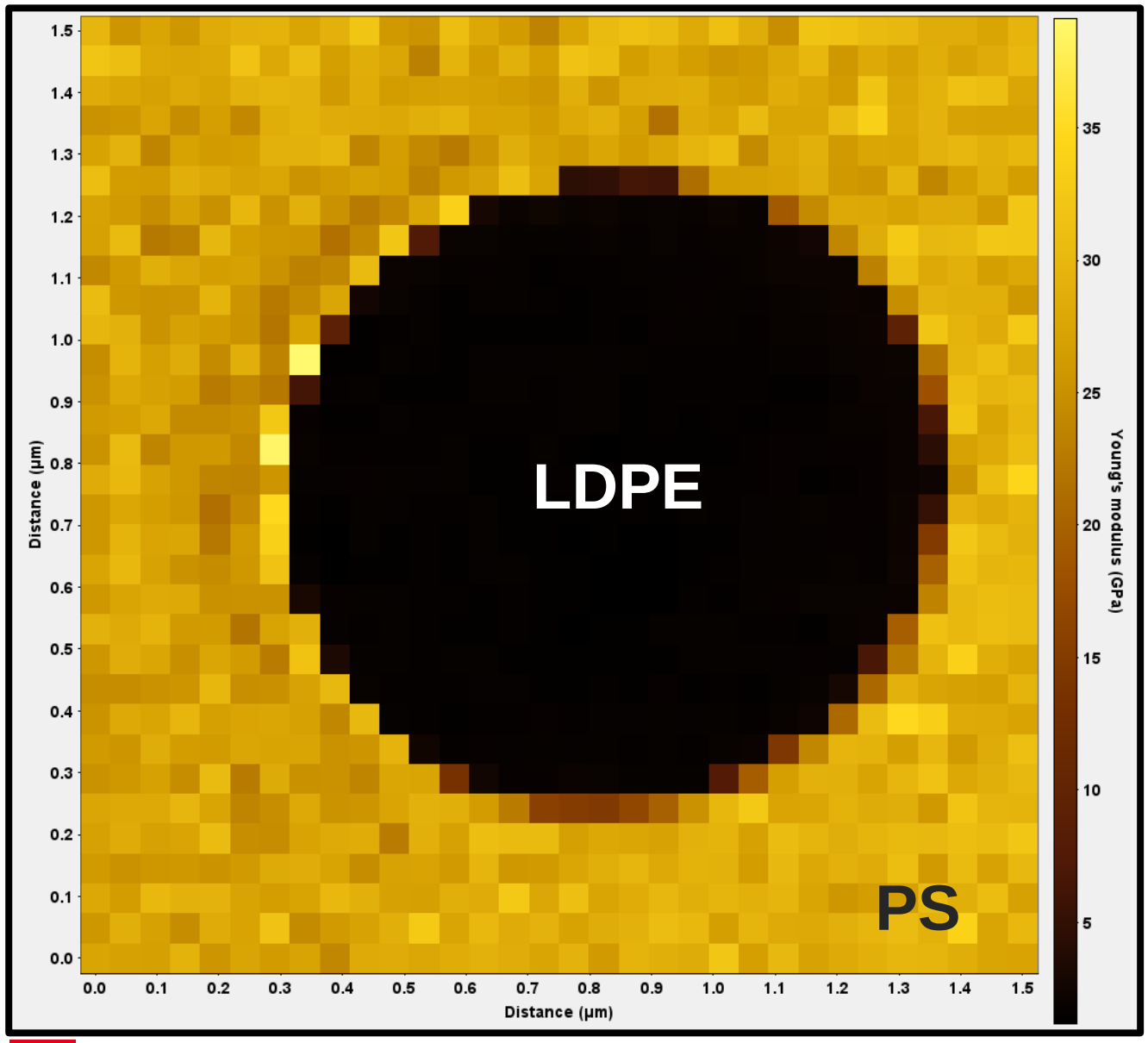


Sample: Bruker "PCABS-10S12M"
Acquisition on Bruker Dimension ICON in air
PeakForce Capture (64 * 64)
Peak Force frequency = 2 kHz (~ 156 oscillations / pixel)
Peak Force setpoint = 500 nN
Tip : Bruker VTESPA-300 ; R = 5 nm
T = 25 °C



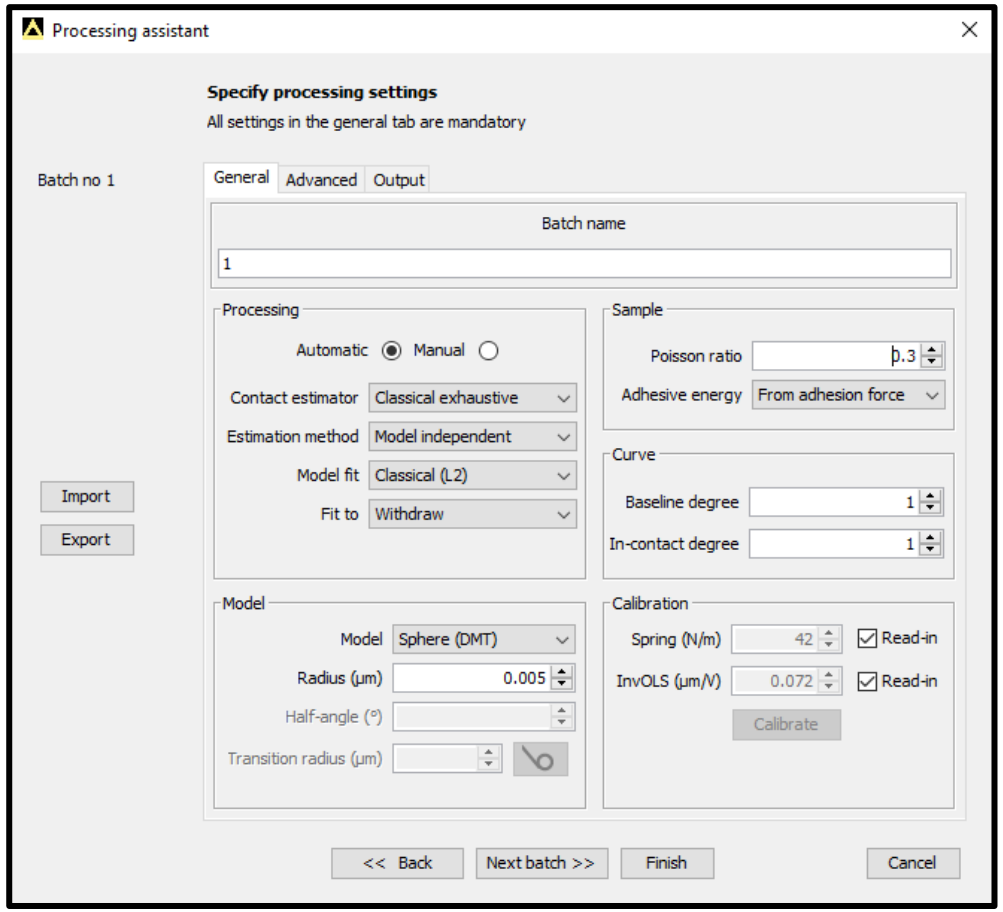
Pixel size ~ 26 nm

EXAMPLE #4 – PS/LDPE



Pixel size ~ 56 nm

Sample: BRUKER PSLDPE-12M
Acquisition on Bruker Dimension ICON in air
Force-Volume (32 * 32)
Force setpoint = 10 nN
Tip : Bruker VTESPA-300 ; R = 5 nm
T = 25 °C



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