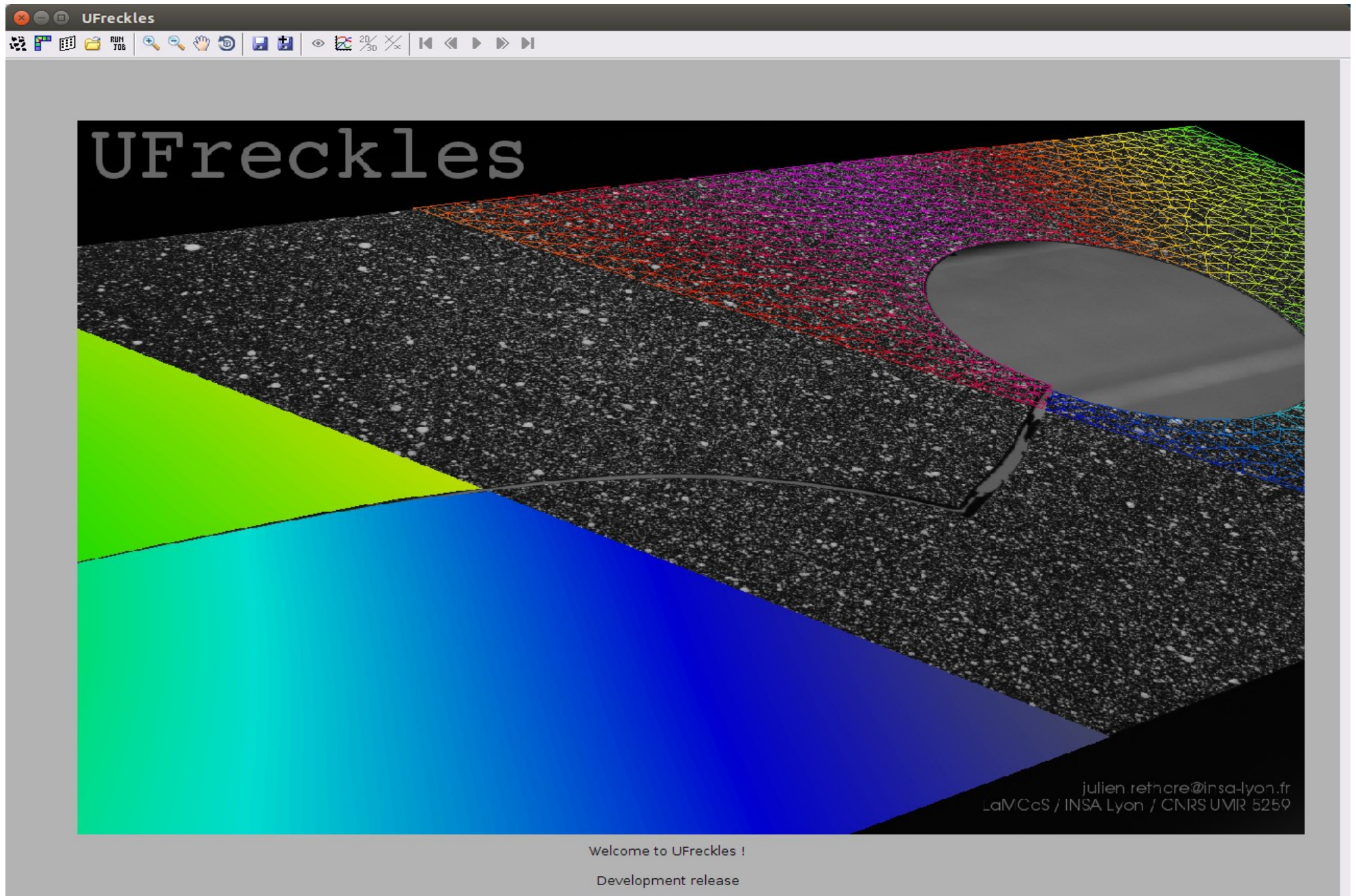# UFreckles' documentation

Introduction…

- Digital image correlation or image registration is based on the optical flow equation:

$$f(x)=g(x+u(x))$$

  where f is the reference image, g the deformed picture and u the searched displacement field.

- Using Ufreckles, this equation is solved using a non-linear least-squares algorithm, further referred to as **solver**. The following cost function is minimized:

$$Er^2=\Sigma[f(x)-g(x+u(x))]^2$$

  in practice gray level are normalized to minimize the influence of lighting variation.

- For solving this problem, a basis function describing the displacement is selected u. In Ufreckles, it is named **model**. It can be selected among: FEM, NURBS, BEAM et GAGE
    - FEM finite element basis function
    - NURBS B-splines functions having a high level of continuity
    - BEAM use beam kinematics having the neutral axis displacement described using B-splines
    - GAGE is a strain gage

In pratice…

- Most of the software functions can be accessed with contextual menus

- Parameters are adjusted by scrolling

- For adjusting zone position

    - Rectangle
        - Clic close to a corner to rotate
        - Clic close the center of an edge to stretch
        - Shift+Clic ou middle clic to move
    - Circle
        - Clic on the circle to stretch
        - Shift+Clic ou middle clic to move
    - Polygon
        - Clic on a corner to move it
        - Shift+Clic ou middle clic to move the polygon

- When FEM or NURBS model is selected, a "smoothing" function can be activated. It is nothing but a regularization of the initial minimization problem allowing to remove spurious high frequency oscillations. This regularization can be based on strain or elastic energy or on a median filter. In the latter case a number of neighbor has to be defined whereas in the first two cases a cut-off wave length is required (note that the value entered is actually half the cut-off wave length, its minimum meaningfull value being the size of the elements).

FEM model:
- Zone of interest is defined either :
    - Manually with boolean operations on elementary shapes(rectangle, circle, polygon)
    - Automatically by element erosion based on a image entropy criterion. The threshold can be adjusted.
- A contextual menu is defined for the elementary zones, it allows to set the following zone properties:
    - inclusion or exclusion
    - Mesh attractor, if yes:
        - Finite element mesh size
        - Is there any node lying on the contour
- In the case when a unstrcutured mesh is used, the local mesh size can be adjusted by using « mesh attractors ». They are elementary geometrical shape (line, rectangle, circle, polygon). In their contextual menu, on can define:
        - The mesh size
        - If there are nodes lying on the contour

- The mesh can be exported in VTK or INP (Abaqus) format.
- A crack can also be inserted.

NURBS model:
- The zone of interest is defined in the same way as for the FEM model. The degree of the shape functions is also defined.
- WARNING, this mesh is only to define the zone of interest, the anlaysis is actually performed over the smallest rectangle containing this mesh. The NURBS mesh is a structured grid have its step size defined in the « Mesh size » menu. Regularization is mandatory in order to prevent any divergence of the analysis over the zone out of the zone of interest. The solution (projected from the NURBS discretization space)is presented on the mesh defined in the zone definition.

BEAM model:
- The zone if interest is a rectangle.
- Euler-Bernoulli beam kinematics is adopted.
- Deflection variation are described using B-splines functions.
- A additional axial strain field can be considered to account for a shift of the beam neutral axis.

GAGE model:
- A rectangular zone is analyzed.
- Constant strain are searched for.
- The longitudinal direction is defined by the longer edge of the rectangular zone.

Main menu
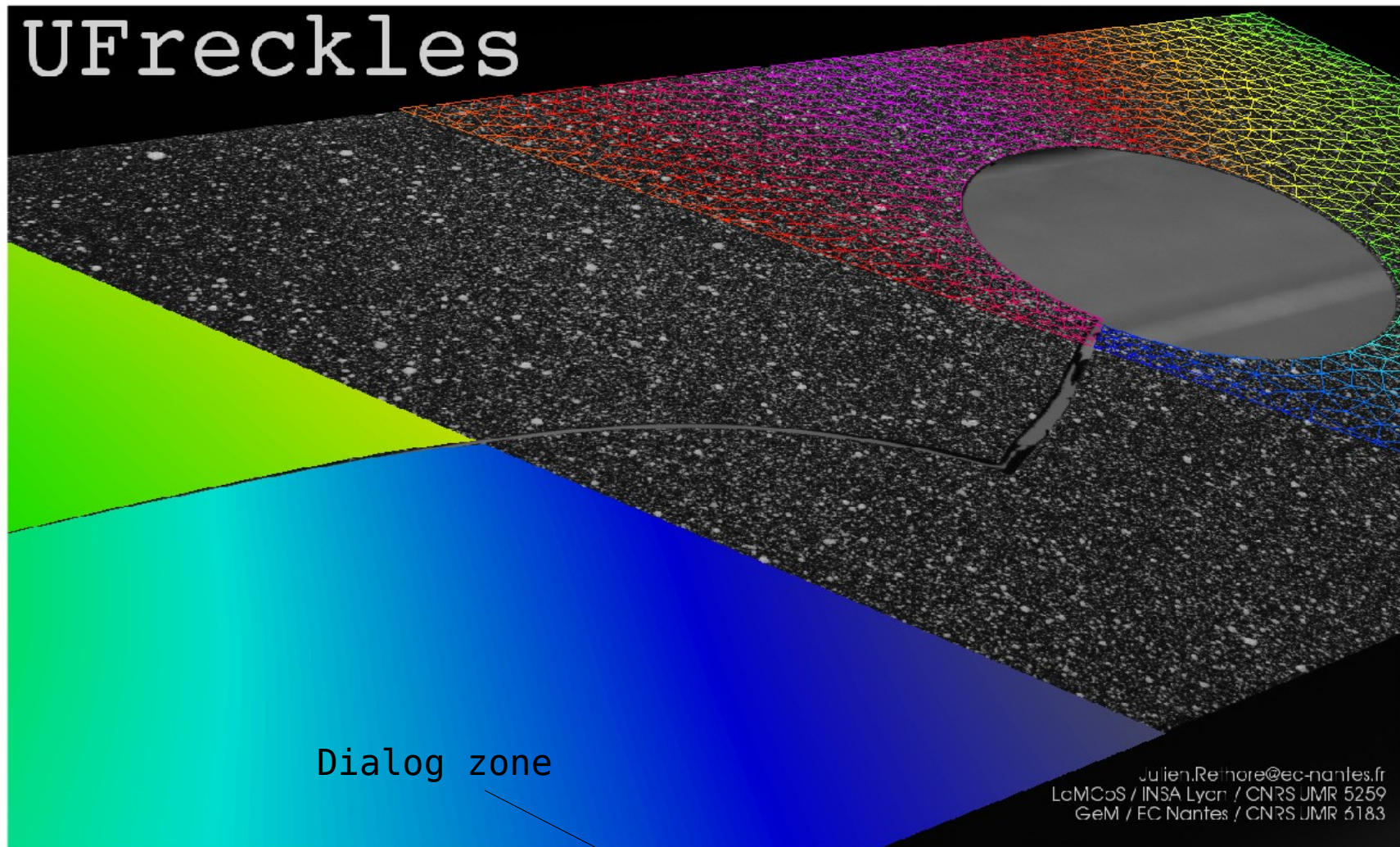
Dialog zone

Welcome to UFreckles !
Development release

Main menu bar…
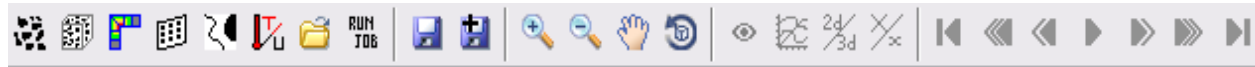
Main functions:

 new DIC analysis

 new DVC analysis (volumetric DIC)

 new FEA

 new calibration for stereo DIC

 new Virtual IC analysis (contour detection)

 open result or data file

 open job manager

Save:

 save or save as.

Adjusting FOV :
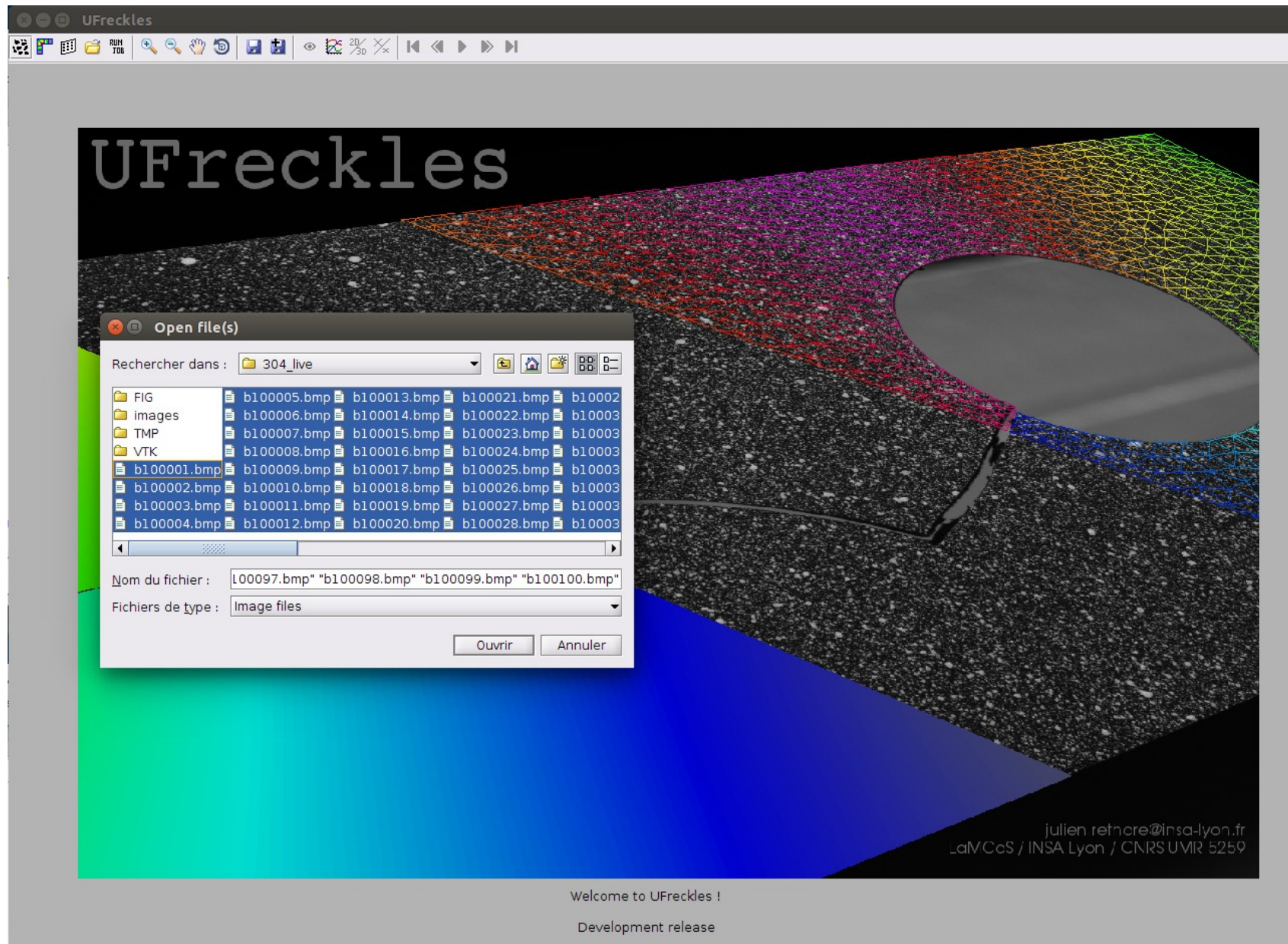
 Zoom/unzoom, pan, rotate (allowing for a 3D rendering)

Visualization:

 make field data visible

 rmake charts visible

 switch between 2D and 3D rendering

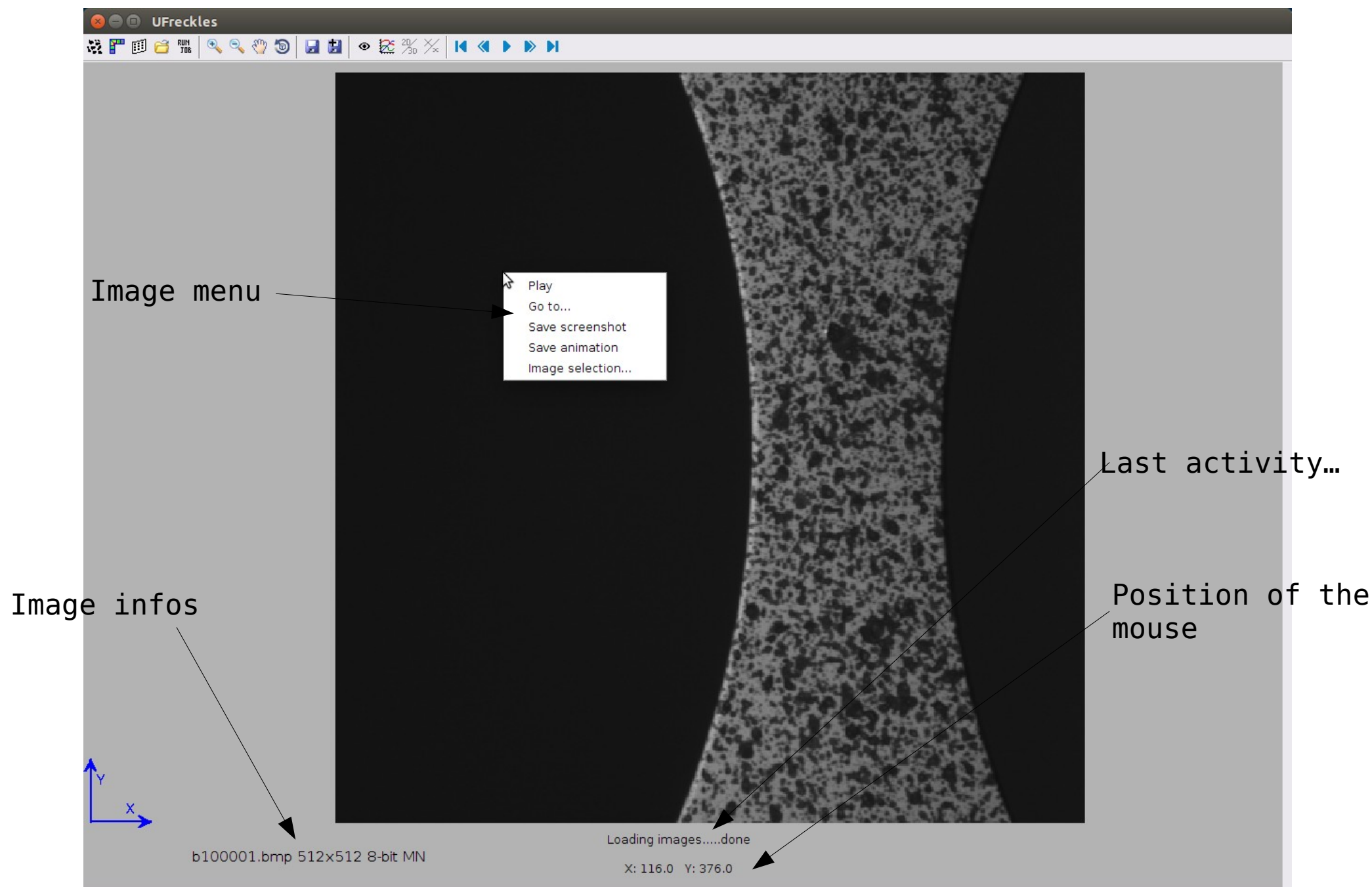 switch between physical and image frame (for stereo DIC)

 animation

New DIC analysis 1/7
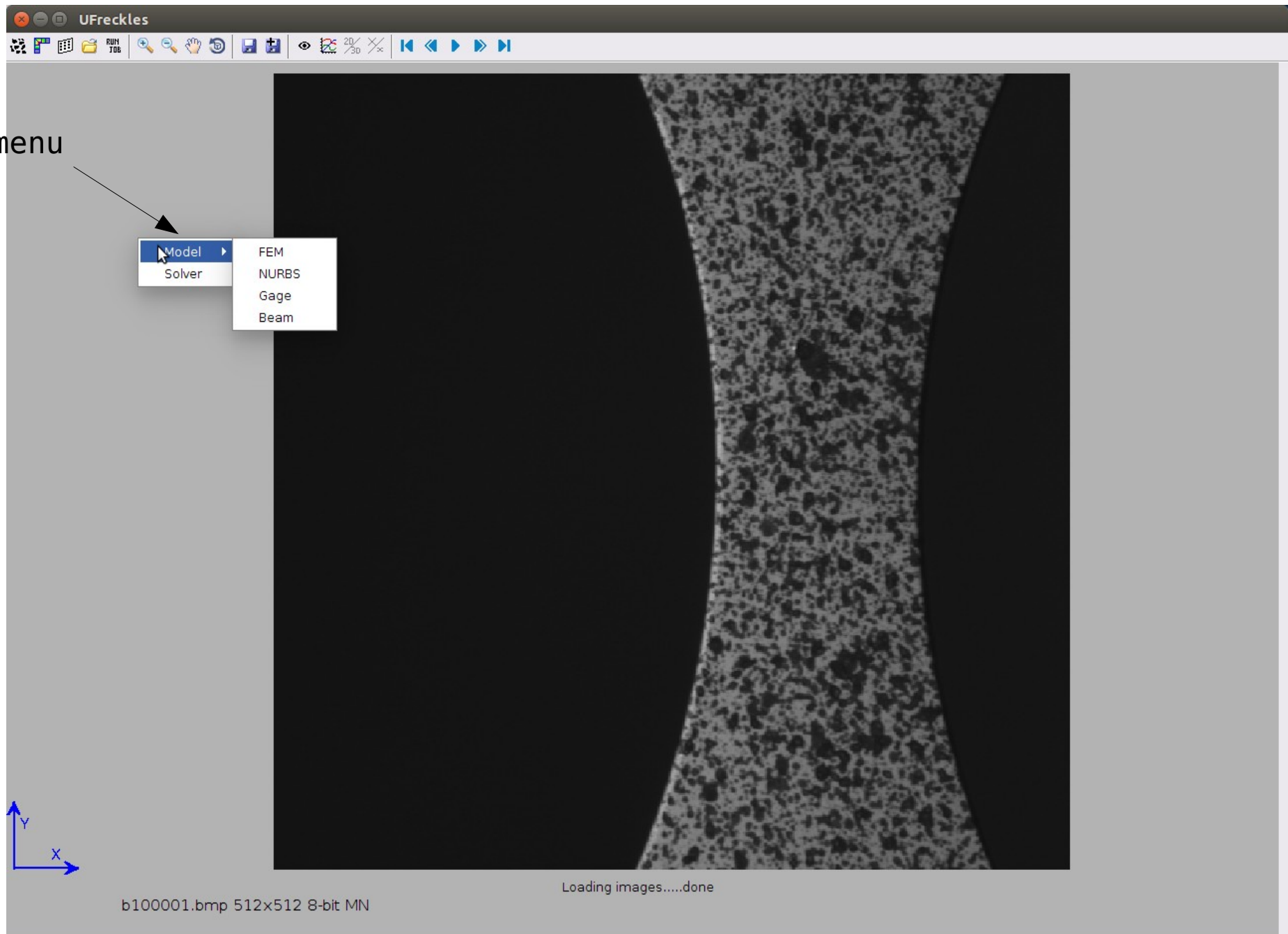   - selecting images : select your images, they are sorted to define the reference image.

Image menu

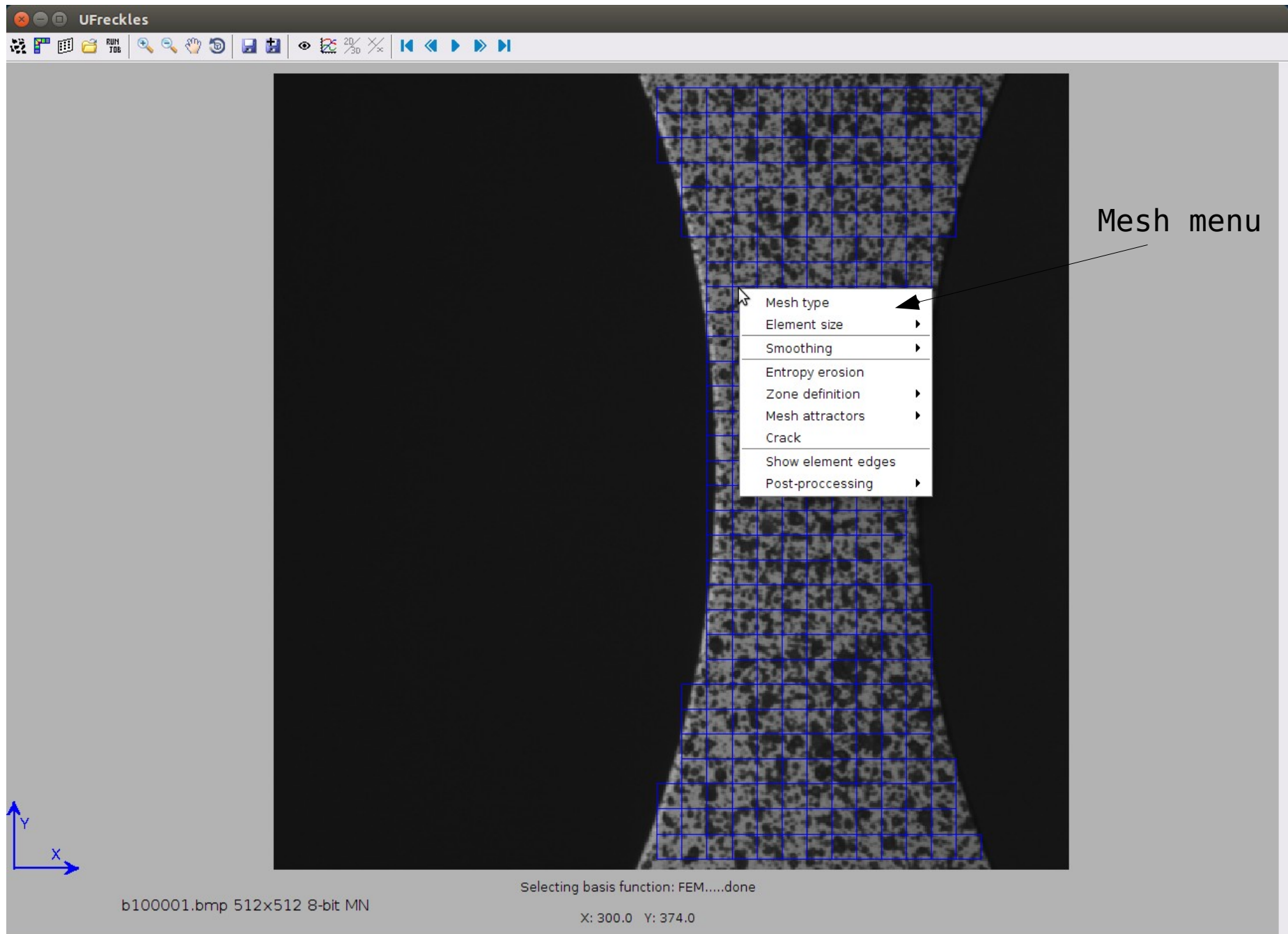Last activity…

Image infos

Position of the mouse

UFreckles

Play
Go to…
Save screenshot
Save animation
Image selection…

Loading images.....done

X: 116.0   Y: 376.0

b100001.bmp 512x512 8-bit MN
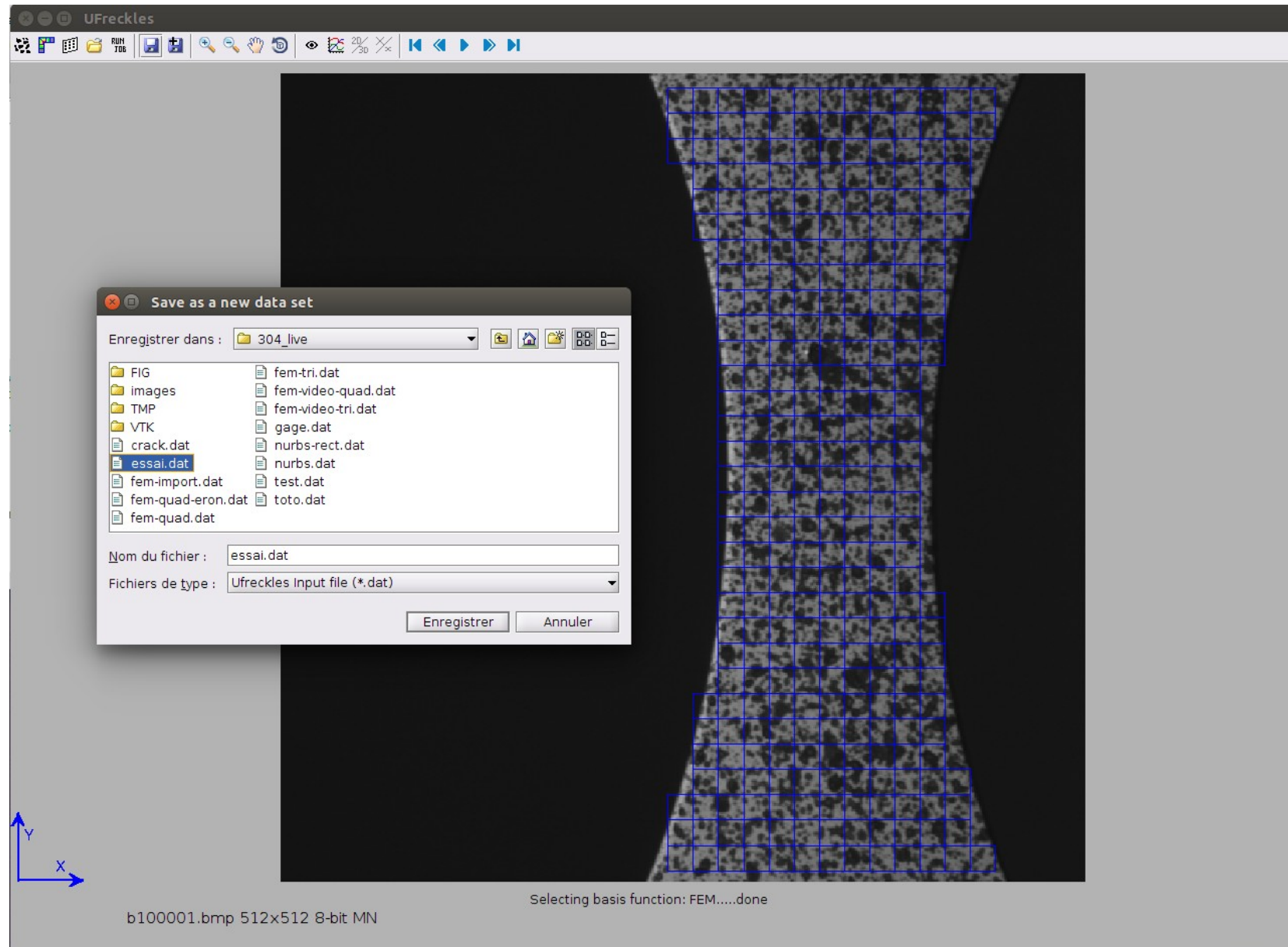
DIC menu

Mesh menu

- Double-click open a window with all the analysis parameters.
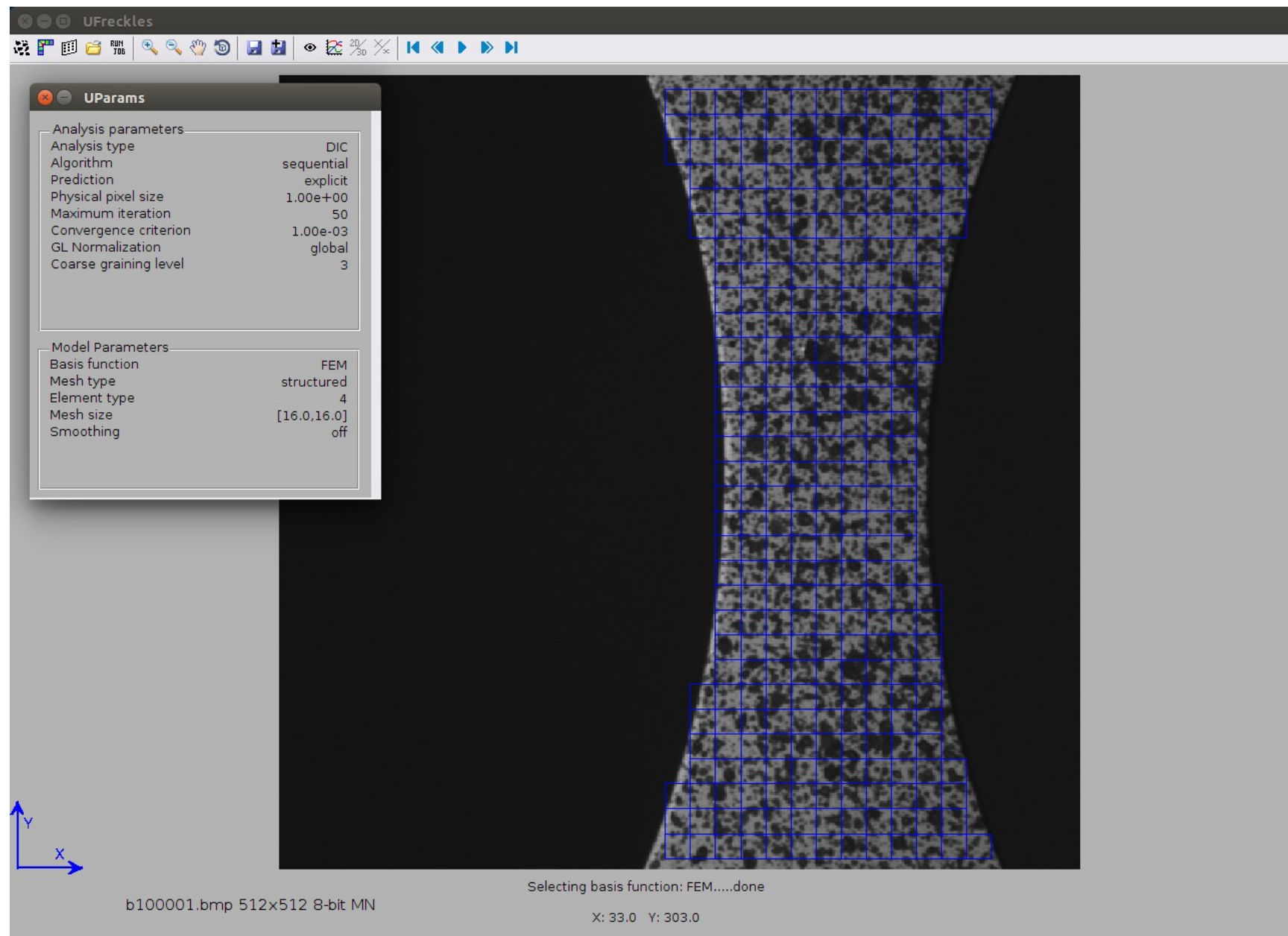
New DIC analysis 6/7
   - Save the data file (.dat)
   - Open the saved data file in the job manager and RUN

New DIC analysis 7/7
    - Open the result file (.res)