

# NMQC

System pro hodnocení kvality obrazové informace  
*nejen* v nukleární medicíně

# Motivace

- Radiační ochrana v nukleární medicíně - systém kontrol detekční a zobrazovací techniky
  - K dispozici r. 2019 jako pracovní dokument
  - [www.sujb.cz](http://www.sujb.cz) →
    - Radiační ochrana →
    - Lékařské ozáření →
    - Doporučení SÚJB týkající se nukleární medicíny

# Motivace

- Nástroje pro QC jako součást pracovních stanic
  - Často *black box*
  - Mnohdy chybějící základní funkce
  - Optimalizované pro daný přístroj
- Nástroje nezávislé
  - ImageJ ← IAEA plugin
  - Uživatelsky diskomfortní
  - Chabá až nulová podpora, dokumentace ...

# Cíle

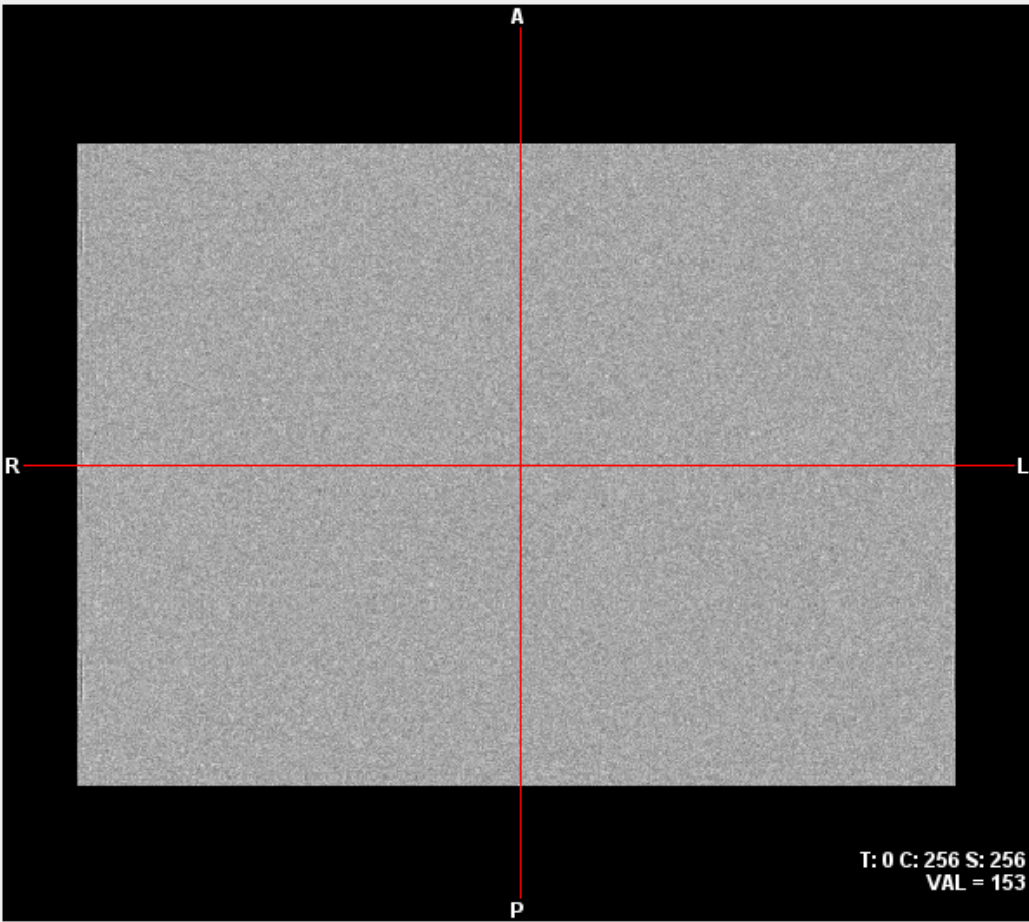
- Jednoduchý a maximálně univerzální nástroj pro hodnocení kvality obrazu
- Uživatel není vázán na konkrétní přístroj, způsob akvizice a/nebo postupy v doporučení
- Uživatel má celý proces plně pod kontrolou
  - Software není chytřejší než uživatel
  - Analýza na úrovni jednotlivých pixelů / voxelů
- Automatizace
  - Dávkové zpracování, makra

# Koncepce

- Základní modul pro
  - Načtení dat
  - Předzpracování (transformace, filtrace, úpravy hodnot)
- Hodnotící moduly
  - Analýza ROI, VOI
  - Homogenita
  - Prostorové rozlišení
  - ...

# Základní modul – načtení dat

NMQC



T: 0 C: 256 S: 256  
VAL = 153

HL: 261 WC: 130.50  
LL: 0 WW: 261  
Change: coarse

Show navigation ALT+N  Invert colors ALT+I  
 Show voxel value ALT+V  Hardened cross ALT+D  
 Show annotations ALT+A Interpolation ALT+P

TRA ALT+T  
 COR ALT+C  
 SAG ALT+S

Edit voxel sizes mm  
T: 1.00  
C: 1.10  
S: 1.10

Load Image Transform Filter  
ImCalc Macro Image Info  
Save Image Run App Exit

Image file path  
tní nemocnice v Praze\Science\\_Data\SPECTQC\Homog.dcm  
Browse

Image format  
 DICOM  ASCII  RAW binary

Number format  
 int8  int32  float32  LE  
 int16  int64  float64  Unsigned  BE

Image dimensions  
Only for loading, they do not indicate actual values

Frames: 1  
Rows: 512  
Columns: 512

Auto detect  
Including voxel sizes

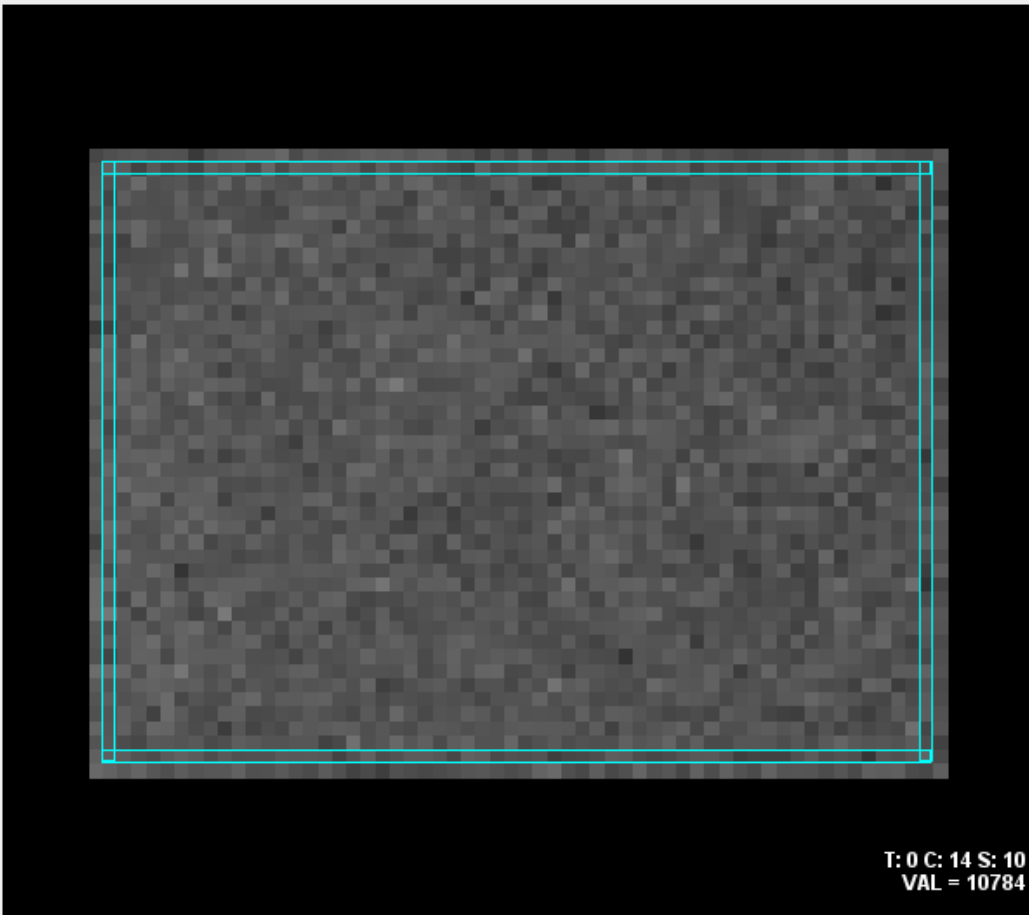
Load Cancel

Done

Undo 21/254 M 254/2048 M View log

# Základní modul - transformace

NMQC



T: 0 C: 14 S: 10  
VAL = 10784

HL: 13049. WC: 11489.  
LL: 9929.3 WW: 3119.6  
Change: coarse

Show navigation ALT+N  Invert colors ALT+I  
 Show voxel value ALT+V  Hardened cross ALT+D  
 Show annotations ALT+A Interpolation ALT+P

TRA ALT+T  
 COR ALT+C  
 SAG ALT+S

Edit voxel sizes mm  
T 1.00  
C 8.80  
S 8.80

Load Image Transform Filter  
ImCalc Macro Image Info  
Save Image Run App Exit

**Orientation**  
Sup <-> Inf  
Ant <-> Post  
Left <-> Right  
COR -> TRA  
SAG -> TRA  
Rotate volume 90  
Rot 0.0 deg

**Shift**  
U  
L R  
D  
 fast mode

**Resolution**  
 2.5D  3D  
Subsample by 2  
Stack 3D->2D  
 Average

**Crop**  
TRA 0 0  
COR 11 52  
SAG 3 60  
Crop values  
 In  Out  
Pad value 0.0  
Crop dimensions  
 Crop mode CTRL+R

Cancel

OK

Undo (2) 154/254 M 254/2048 M View log

# Základní modul - filtrace

NMQC

— □ ×

Load Image Transform Filter

ImCalc Macro Image Info

Save Image Run App Exit

**Filter type**

2D  2.5D  3D

**Filter algorithm**

Gaussian (spatial) FWHM  mm

Median (spatial) Matrix size  pixels

Butterworth (freq) Cutoff  Nyquist

LowPass Order

HighPass

**Discrete convolution**

Standard  Base  pixels

Custom

T: 0 C: 21 S: 29  
VAL = 10917.

HL: 11152. WC: 10980.  TRA ALT+T

LL: 10808. WW: 344.07  COR ALT+C

Change: coarse  SAG ALT+S

Show navigation ALT+N  Invert colors ALT+I

Show voxel value ALT+V  Hardened cross ALT+D

Show annotations ALT+A Interpolation ALT+P

Edit voxel sizes mm

T

C


S

Done



# Základní modul – manipulace s daty

NMQC



T: 0 C: 21 S: 29  
VAL = 10917.

HL: 11152. WC: 10980.  
LL: 10808. WW: 344.07  
Change: coarse

Show navigation ALT+N  Invert colors ALT+I  
 Show voxel value ALT+V  Hardened cross ALT+D  
 Show annotations ALT+A Interpolation ALT+P

TRA ALT+T  
 COR ALT+C  
 SAG ALT+S

Edit voxel sizes mm  
T: 1.00  
C: 8.80  
S: 8.80

Buttons: Load Image, Transform, Filter, ImCalc, Macro, Image Info, Save Image, Run App, Exit

**Apply threshold**  
Threshold: 0.0 Pad value: 0.0  above  below Apply

**Replace**  
What: 0.0 With: 0.0 Replace

**Arithmetic**  
add 0.0 Calculate

**Decay correction**  
Time: 0.0 hours Tc-99m Correct

**Special**  
Logarithmic Absolute

Cancel

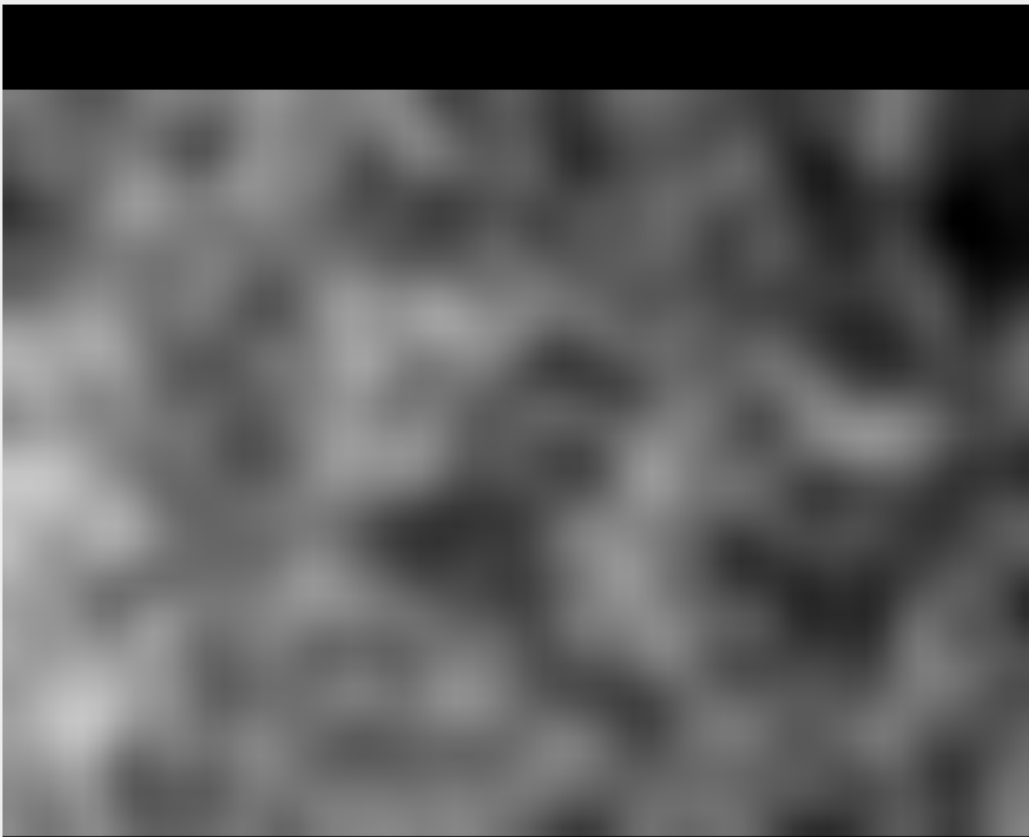
Ready

Undo (4) 44/254 M 254/2048 M View log

# Vyhodnocovací moduly

NMQC

— □ ×



T: 0 C: 21 S: 29  
VAL = 10917.

Load Image Transform Filter  
ImCalc Macro Image Info  
Save Image Run App Exit

**Built-in tools**

2D ROI analysis  
3D VOI analysis  
Planar homogeneity  
Center of rotation  
Spatial resolution  
Distance measurement

**External plug-ins**

Run

Cancel

Ready

Undo (4) 44/254 M 254/2048 M View log

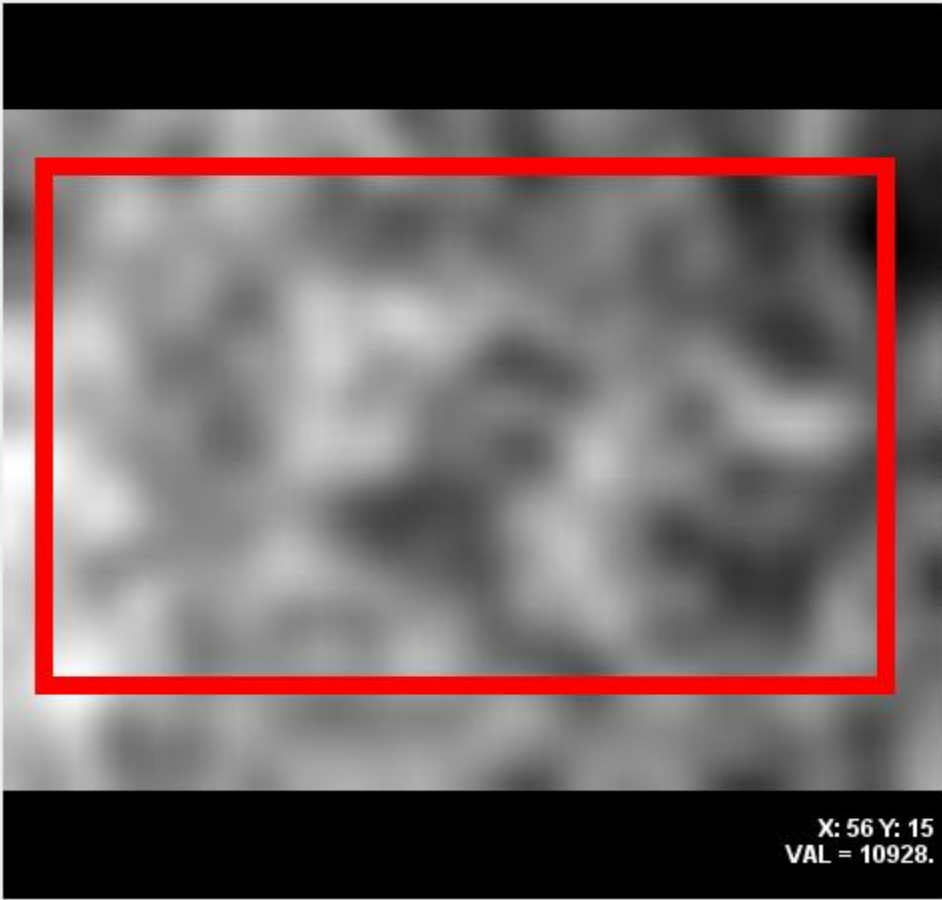
HL: 11152. WC: 10980.  TRA ALT+T  
LL: 10808. WW: 344.07  COR ALT+C  
 SAG ALT+S  
Reset Change: coarse

Show navigation ALT+N  Invert colors ALT+I  
 Show voxel value ALT+V  Hardened cross ALT+D  
 Show annotations ALT+A Interpolation ALT+P

Edit voxel sizes mm  
T 1.00  
C 8.80  
S 8.80

# Homogenita pole (NM)

NMQC: Planar homogeneity



**Planar homogeneity**

Min	10802.
Max	11077.
Average	10946.
Standard deviation	43.283
Coefficient of variation [%]	0.4
Integral homogeneity [%]	1.3
Diff. homogeneity X [%]	0.5
Diff. homogeneity Y [%]	0.6

Move ROI if necessary

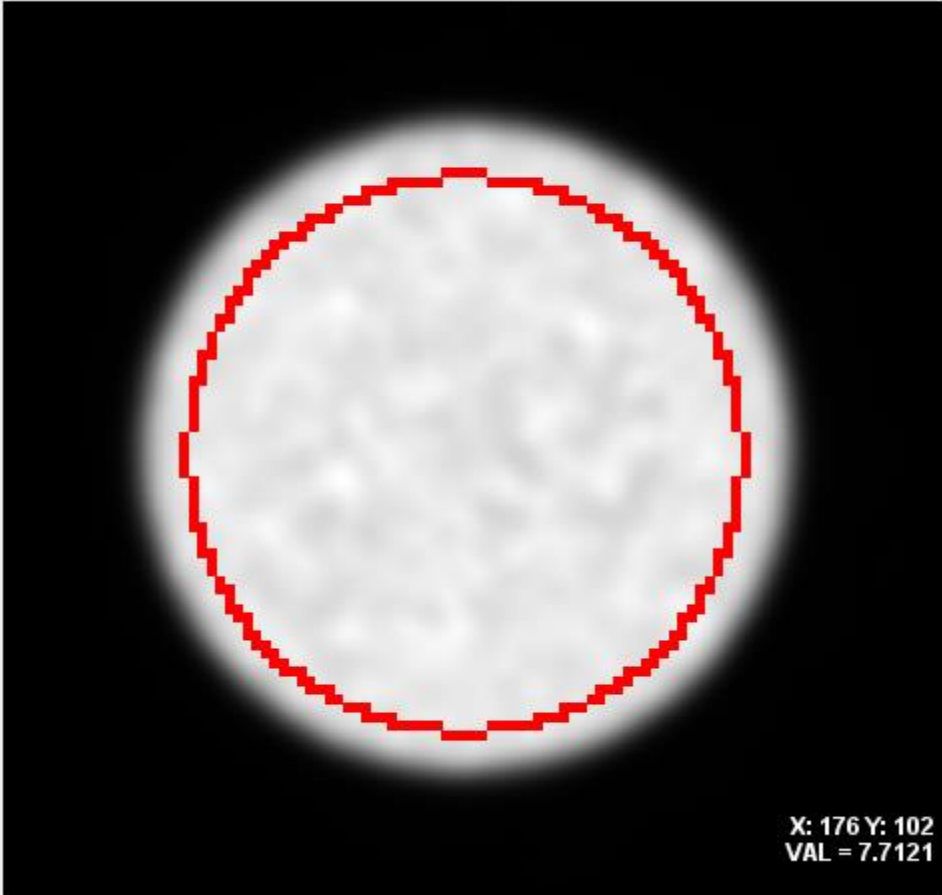
Reload    Reset    All

Close

X: 56 Y: 15  
VAL = 10928.

# 2D ROI analýza

NMQC: 2D ROI analysis



**2D ROI analysis**

Pixels	3061
Pixel size [mm]	2.73 x 2.73
Area [cm <sup>2</sup> ]	228.13
Min	12319.
Max	14865.
Sum	4.1283e+07
Average	13487.
Standard deviation	377.55
Coefficient of variation [%]	2.8
Homogeneity [%]	9.4

Move ROI if necessary

Freehand     Rectangle     Circle

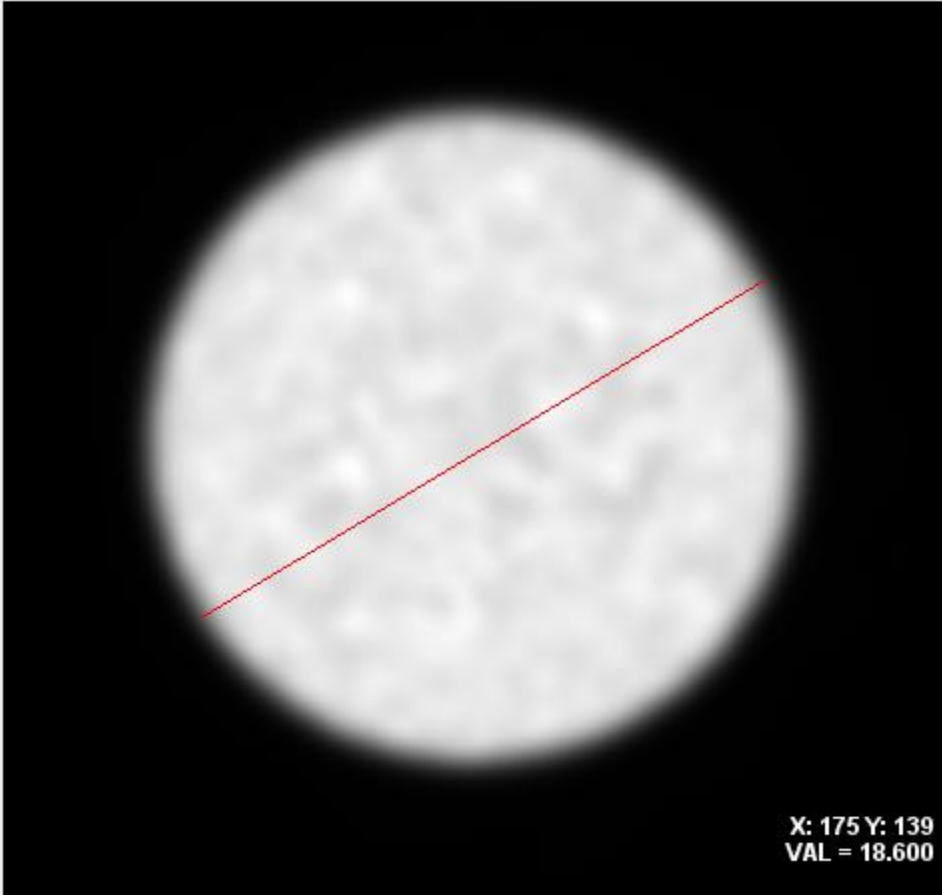
Fill ROI     Fixed size      
pixels

X: 176 Y: 102  
VAL = 7.7121

# Měření vzdáleností

NMQC: Distance measurement



X: 175 Y: 139  
VAL = 18.600

**Distance measurement**

Pixel size [mm]	2.73 x 2.73
Distance [pixels]	72.201
Distance [mm]	197.11

Click or drag to set the end point

Reload Reset Close

# 3D VOI analýza

NMQC: 3D VOI analysis

T: 34 C: 147 S: 135  
VAL = 17308.

T: 34 C: 147 S: 135  
VAL = 17308.

T: 34 C: 147 S: 135  
VAL = 17308.

COR 147      TRA 34      SAG 135

Radius  voxels      Voxel value: 17308.

Threshold  %      Voxel size: 3.27 x 2.73 x 2.73  
TxCxS [mm]

Image extent     VOI max

**3D VOI analysis**

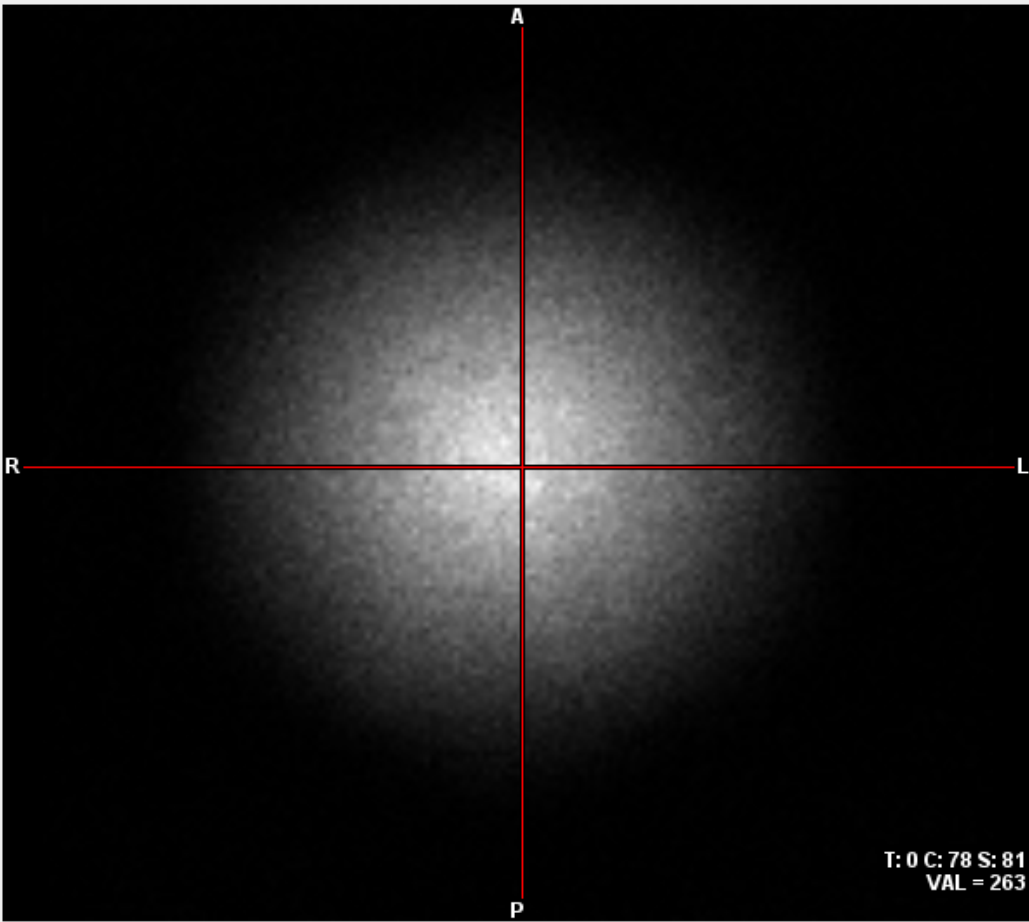
Show VOI

Show contours

VOI statistics	
Voxels	1870
Volume [ml]	45.574
Min	3856.2
Max	19268.
Sum	1.9823e+07
Average	10601.
Std. dev.	4784.1
Cf. var. [%]	45.1
Homog. [%]	66.6

# Prostorové rozlišení

NMQC



The main image shows a grayscale medical scan with a red crosshair. The crosshair is labeled with 'A' at the top, 'P' at the bottom, 'R' on the left, and 'L' on the right. In the bottom right corner of the image, the text 'T: 0 C: 78 S: 81 VAL = 263' is displayed.

**Buttons:** Load Image, Transform, Filter, ImCalc, Macro, Image Info, Save Image, Run App, Exit

**Built-in tools:** 2D ROI analysis, 3D VOI analysis, Planar homogeneity, Center of rotation, Spatial resolution, Distance measurement

**External plug-ins:** [Dropdown menu] Run

**Cancel**

**Ready**

**Undo (0)** **View log**

HL: 298 WC: 149  
LL: 0 WW: 298  
Reset Change: coarse

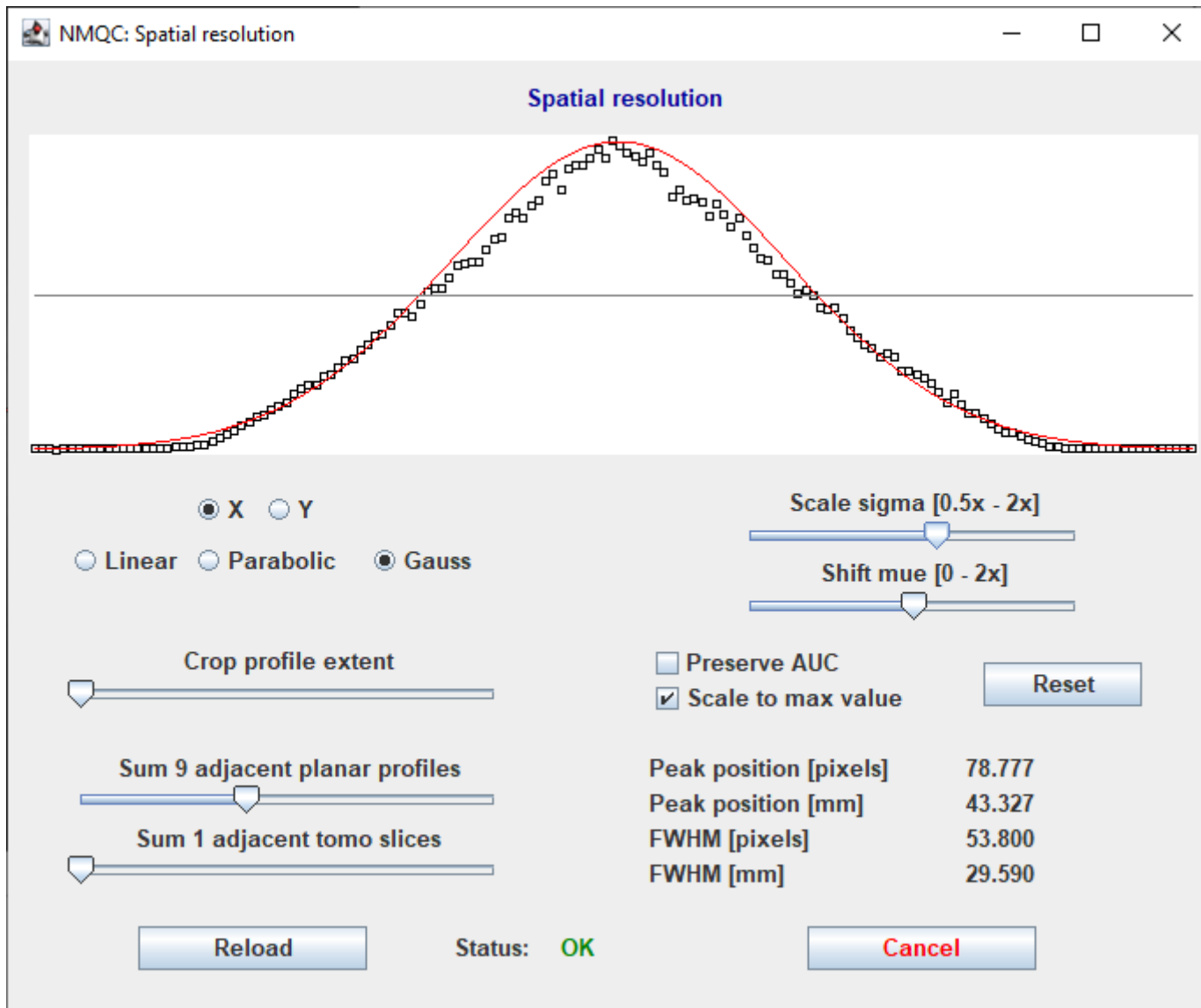
TRA ALT+T  
 COR ALT+C  
 SAG ALT+S

Edit voxel sizes mm  
T 1.00  
C 0.55  
S 0.55

Show navigation ALT+N  
 Show voxel value ALT+V  
 Show annotations ALT+A

Invert colors ALT+I  
 Hardened cross ALT+D  
Interpolation ALT+P

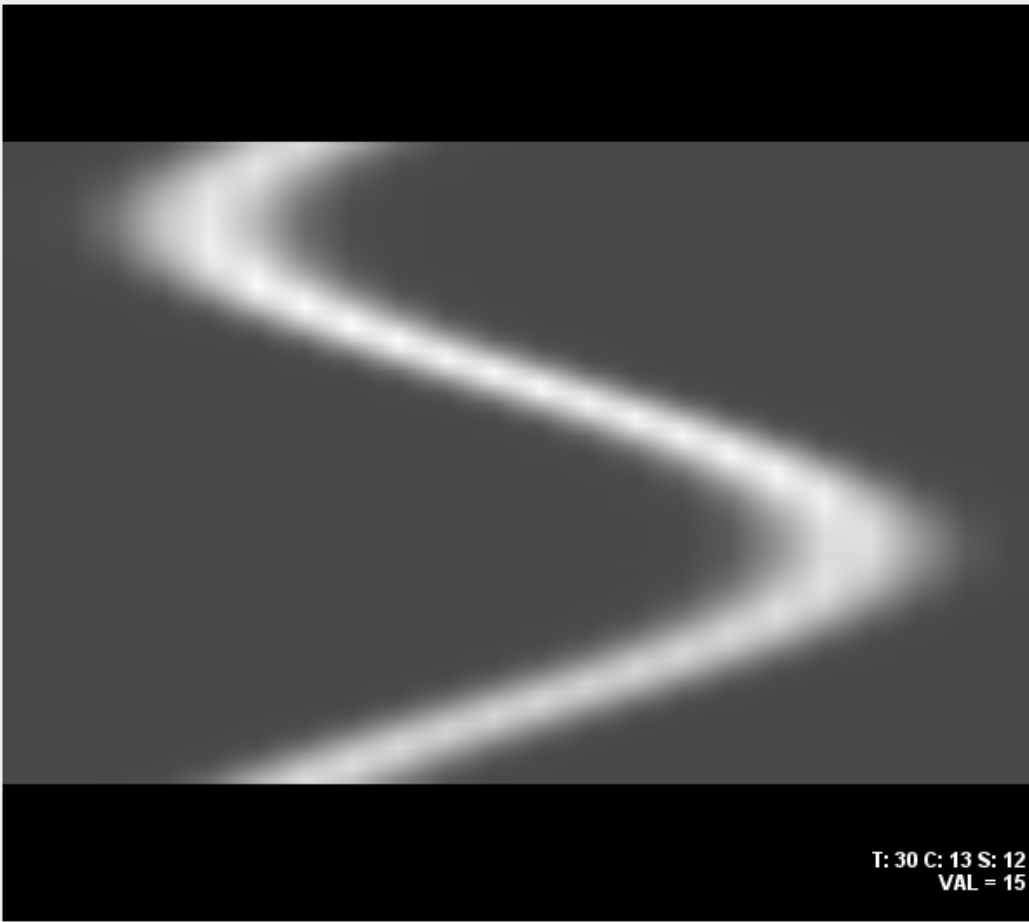
# Prostorové rozlišení





# Sinogram – centrum rotace (NM)

Window title: NMQC



T: 30 C: 13 S: 12  
VAL = 15

**Orientation**

- Sup <-> Inf
- Ant <-> Post
- Left <-> Right
- COR -> TRA
- SAG -> TRA
- Rotate volume 90
- Rot: 0.0 deg

**Resolution**

- 2.5D  3D
- Subsample by 2
- Stack 3D->2D
- Average

**Shift**

- U
- L R
- D
- fast mode

**Crop**

- TRA: 0 59
- COR: 0 25
- SAG: 0 23
- Crop values:  In  Out
- Pad value: 0.0
- Crop dimensions:  Crop mode CTRL+R

**Parameters**

- HL: 5192.2 WC: 1577.8
- LL: -2036.6 WW: 7228.7
- Change: coarse
- TRA ALT+T
- COR ALT+C
- SAG ALT+S
- Edit voxel sizes mm
- T: 1.00
- C: 4.42
- S: 4.42

**Display Options**

- Show navigation ALT+N
- Show voxel value ALT+V
- Show annotations ALT+A
- Invert colors ALT+I
- Hardened cross ALT+D
- Interpolation ALT+P

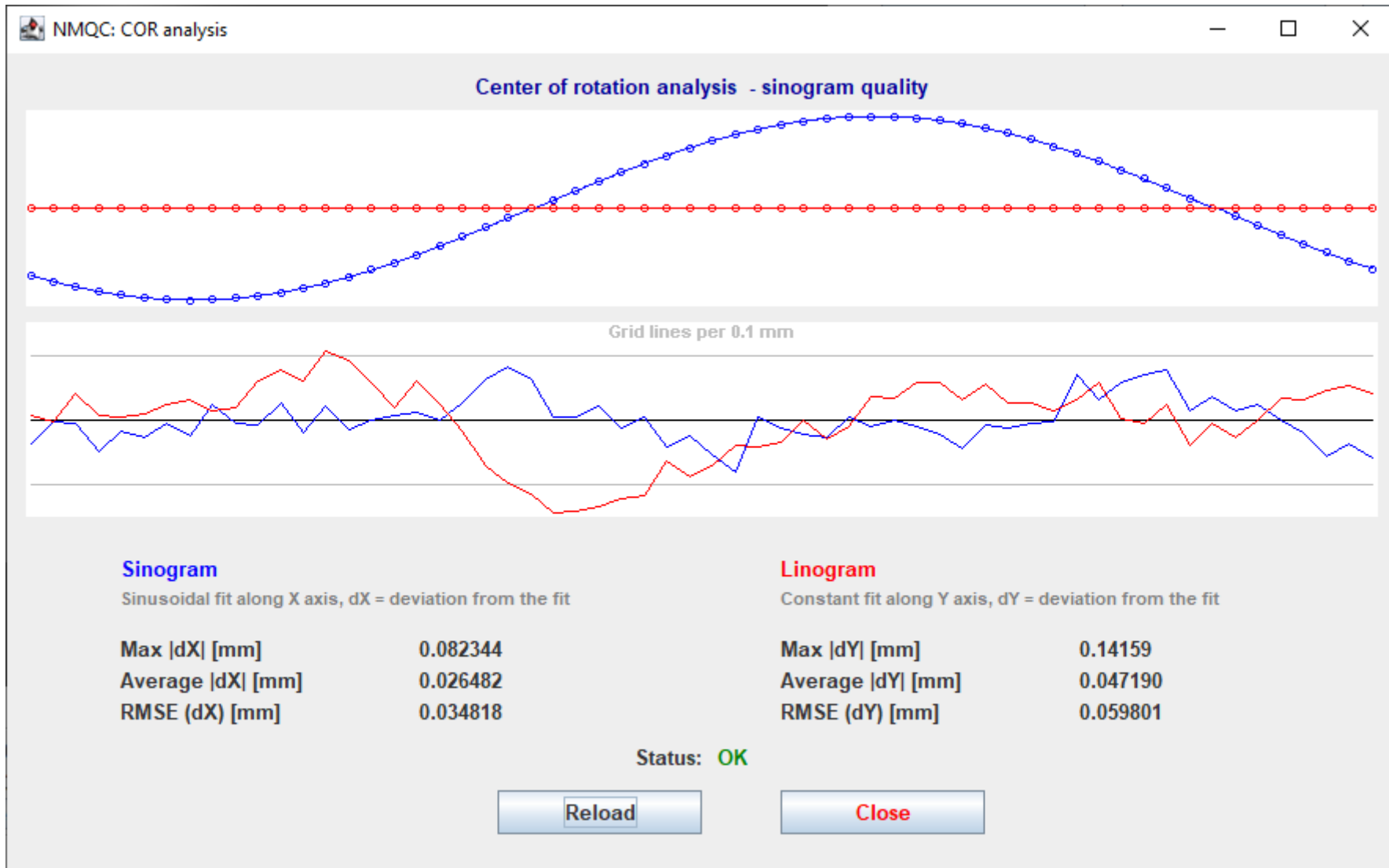
**Buttons**

- Load Image
- Transform
- Filter
- ImCalc
- Macro
- Image Info
- Save Image
- Run App
- Exit
- Cancel
- OK
- Undo (1)
- View log

**System Information**

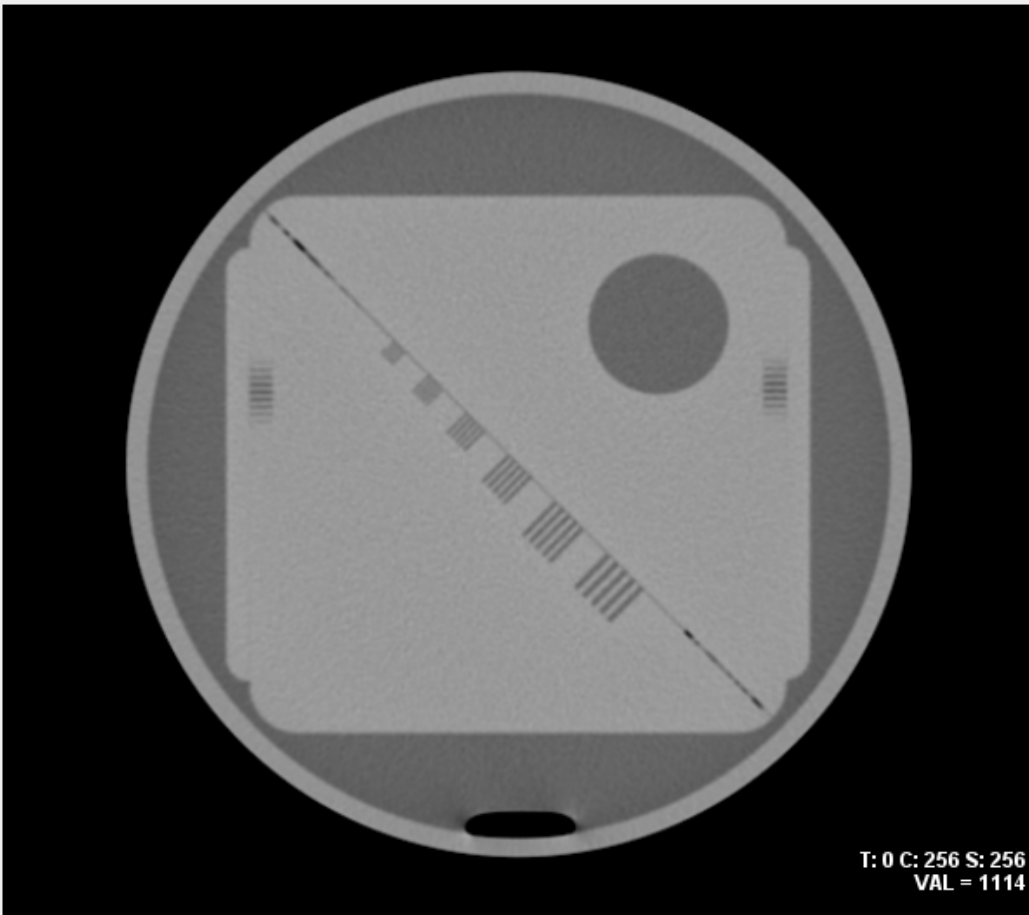
- 261/400 M
- 400/2048 M

# Sinogram – centrum rotace (NM)



# Základní modul - export

NMQC



T: 0 C: 256 S: 256  
VAL = 1114

HL: 1366.6    WC: 1086.0  
LL: 805.47    WW: 561.09  
Change: coarse

Show navigation    ALT+N     Invert colors    ALT+I  
 Show voxel value    ALT+V     Hardened cross    ALT+D  
 Show annotations    ALT+A    Interpolation    ALT+P

TRA    ALT+T  
 COR    ALT+C  
 SAG    ALT+S

Edit voxel sizes mm  
T: 1.00  
C: 0.98  
S: 0.98

Load Image    Transform    Filter  
ImCalc    Macro    Image Info  
Save Image    Run App    Exit

Image file path  
Browse

Image format  
 ASCII     RAW binary

Number format  
 int8     int32     float32     LE  
 int16     int64     float64     BE

Integer handling  
 Unsigned     Scale to maximum extent

Save    Cancel

Ready

Undo    299/400 M    View log  
400/2048 M

# Makro

```
LOAD IMAGE_PATH <string path>
LOAD IMAGE_FORMAT <DICOM | ASCII | RAW>
LOAD NUMBER_TYPE <INT8 | UINT8 | INT16 | UINT16 | INT32 | INT64 | FLOAT32 | FLOAT64>
LOAD ENDIANESS <LITTLE | BIG>
LOAD AUTO_DIM <ON | OFF>
LOAD <FRAMES | ROWS | COLUMNS> <int dimension>
LOAD IMAGE NOW

SET VOXEL_SIZES <float size_tra> <float size_cor> <float size_sag>
SET INTERPOLATION <NEAREST | LINEAR | CUBIC>
SET <REPAINT_METHOD | BUFFERED_DRAWING | HARDENED_CROSS | INVERT_COLORS> <ON | OFF>
SET VIEW <TRA | COR | SAG>

SHOW <NAVIGATION | VOXEL_VALUE | ANNOTATIONS> <ON | OFF>

GOTO <int tra> <int cor> <int sag>
GOTO <IMAGE_MAX | IMAGE_MIN>

SAVE IMAGE_PATH <string path>
SAVE IMAGE_FORMAT <ASCII | RAW>
SAVE NUMBER_TYPE <INT8 | UINT8 | INT16 | UINT16 | INT32 | INT64 | FLOAT32 | FLOAT64>
SAVE ENDIANESS <LITTLE | BIG>
SAVE SCALE <ON | OFF>
SAVE IMAGE NOW

TRANSFORM FLIP <SI | LR | AP>
TRANSFORM SWITCH <CT | ST>
TRANSFORM ROT90
TRANSFORM ROTATE <float degrees>
TRANSFORM STACK
TRANSFORM AVERAGE <ON | OFF>
TRANSFORM SUBSAMPLE <2.5D | 3D>
TRANSFORM SHIFT <VERTICAL | HORIZONTAL> <int shift>
TRANSFORM CROP PAD <float pad>
TRANSFORM CROP MODE <IN | OUT>
TRANSFORM CROP <TRA_LOW | SAG_LOW | COR_LOW | TRA_HIGH | COR_HIGH | SAG_HIGH> <int limit>
TRANSFORM CROP <VALUES | DIMENSIONS> NOW

FILTER TYPE <2D | 2.5D | 3D>
FILTER ALGORITHM <GAUSS | MEDIAN | BUTTERWORTH | CONV_STANDARD | CONV_CUSTOM>
FILTER GAUSS <float width>
FILTER MEDIAN <int size>
FILTER BUTTERWORTH <LOWPASS | HIGHPASS>
FILTER CUTOFF <float cutoff>
FILTER ORDER <float order>
FILTER CONV_TYPE <string type>
FILTER CONV_SIZE <float size>
FILTER CUST_KERNEL <string path>
FILTER IMAGE NOW

IMCALC <THRESHOLD_ABOVE | THRESHOLD_BELOW> <float threshold> <float pad>
TMCALC LOG
```

# Pluginy

```
package plugins;

/**
 *
 * @author arthur
 */
public abstract class BasePlugIn extends javax.swing.JFrame {
    ....
    protected double[][][] pixelData; ..... // data volume [frames][rows][columns]
    protected int planeView; ..... // actual view TRA | COR | SAG
    protected int[] position; ..... // actual position [frames (tra), rows (cor), columns (sag)]
    protected float[] dimensions; ..... // pixel sizes in mm [frames (tra), rows (cor), columns (sag)]
    ....
    public abstract void autoRun();
    ....
    public void setPixelData(double[][][] pixelData) {
        .... this.pixelData = pixelData;
        .... }
    ....
    public void setPlaneView(int planeView) {
        .... this.planeView = planeView;
        .... }
    ....
    public void setPosition(int[] position) {
        .... this.position = position;
        .... }
    ....
    public void setDimensions(float[] dimensions) {
        .... this.dimensions = dimensions;
        .... }
    ....
    ....
}
```

# Závěr

- NMQC je k dispozici ke stažení na [www.sujb.cz](http://www.sujb.cz)
- NMQC se průběžně vyvíjí
  - Verze ke stažení bude nejspíš zastaralá
  - Je možné se obrátit přímo na autora
- Jsou vítány
  - Hlášení objevených chyb
  - Nápady na zlepšení a nové funkce
  - Nabídky spolupráce na tvorbě dalších modulů