The NAPLIFE project

– nanoplasmonic fusion targets –

T.S. Biró[1, 2, 3] et.al.

[1]NKFIH NAPLIFE research project
Wigner Research Centre for Physics, Budapest

[2]Complex Science Hub, Vienna

[3]Universitatea Babeş-Bolyai, Cluj

Particles and Plasmas, Budapest, June 9-th, 2023

project sponsoring

2022 Oct 1 - 2026 Feb 28

WIGNER FIZIKAI KUTATÓKÖZPONT

2022-2.1.1-NL-2022-00002

NANOPLAZMONIKUS LÉZERES FÚZIÓ KUTATÓLABORATÓRIUM

A TÁMOGATÁS ÖSSZEGE:

1 127 964 898 FORINT

NEMZETI KUTATÁSI, FEJLESZTÉSI ÉS INNOVÁCIÓS HIVATAL

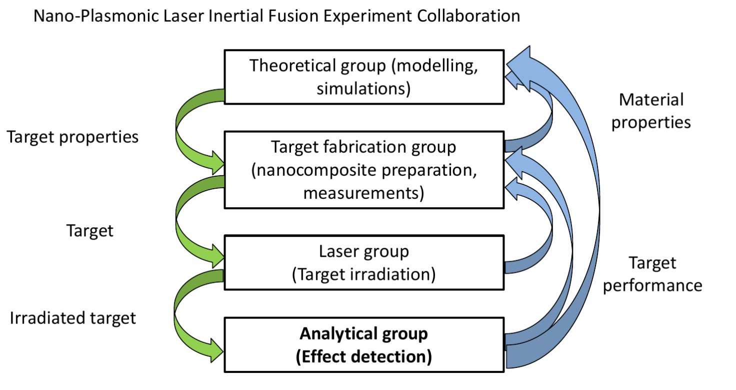
AZ NKFI ALAPBÓL MEGVALÓSULÓ PROJEKT

Lab Structure

organogram

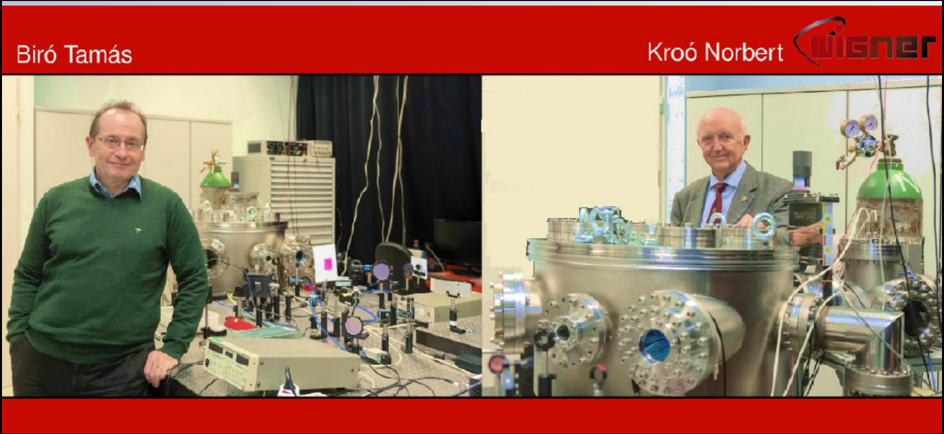
Group Structure

cooperation



NAPLIFE devices

laser table, vacuum chamber



NAPLIFE individual features

1. Plasmonic collectivity, energy concentration, threshold lowering, lifetime cca. $20 - 30$ fs
2. Non-equilibrium, simultaneous ignition with lightspeed
3. Nanoantennas in target, ultrashort, great contrast laser pulses (10^6, 40 fs @ Wigner, $-- >$ ELI)
4. Energy balance and products: microcraters, SERS, LIBS, MS, CR39

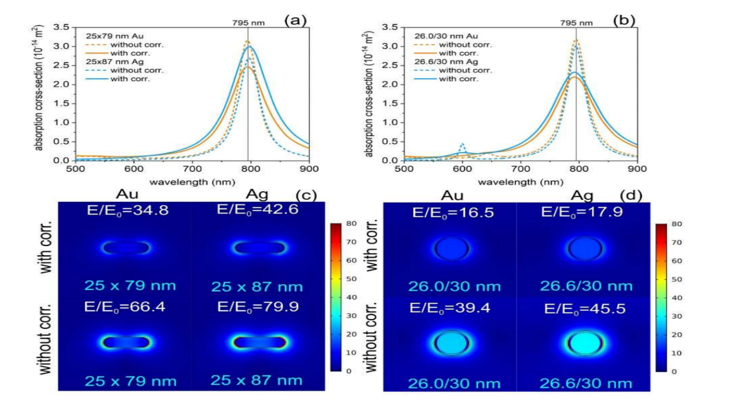
Nanofusion

plasmons: barrier lowers, energy hot spots

The Lycurgus Cup 1958,1202.1 in reflected (a) and transmitted (b) light. Scene showing Lycurgus being enmeshed by Ambrosia

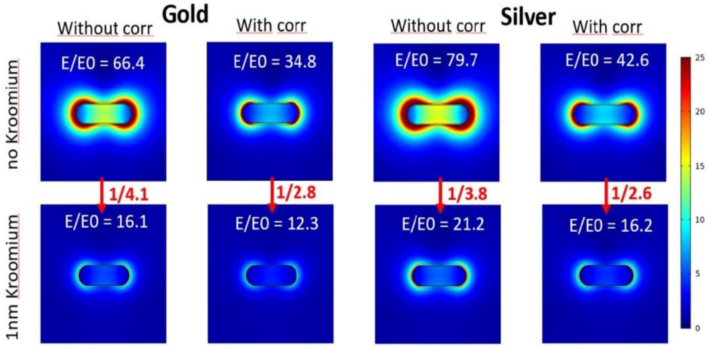
Plasmonics at work

simulations (M. Csete group)



Plasmonics at work

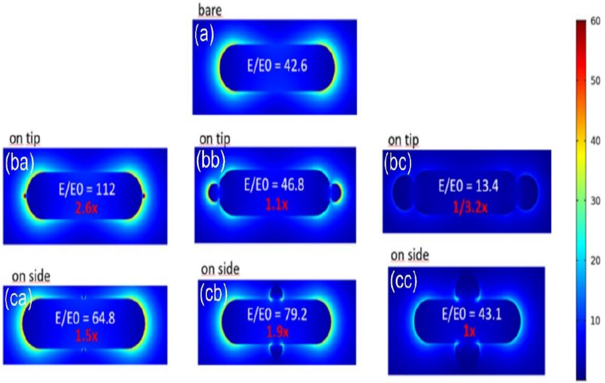
NFE (near field enhancement) (M. Csete group)



1.1.2. ábra A vizsgált rendszerek közeltér erősítés eloszlása ($|\mathbf{E}|/|\mathbf{E}_0|$).

Plasmonics at work

doped nanoantennas (M. Csete group)

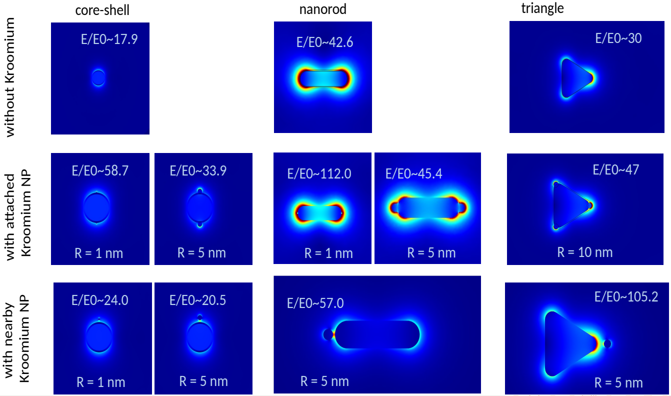


1.1.5. ábra A vizsgált ezüst (korrigált ε(ω) függvény) rendszerek közeltér erősítés eloszlása ($|\mathbf{E}|/|\mathbf{E}_0|$). (a) Kroómium nélküli eset, (ba-bc) on-apex és (ca-cc) on-side konfigurációk 1 nm – 10 nm KNP mérettel.

Plasmonics at work

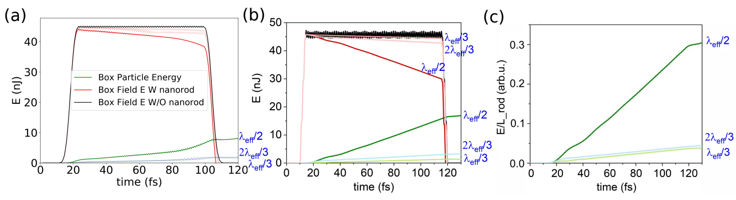
nanoantenna shape variations (M. Csete group)

Near-field enhancement with individual plasmonic nanoresonators & Kroomium nanoparticles



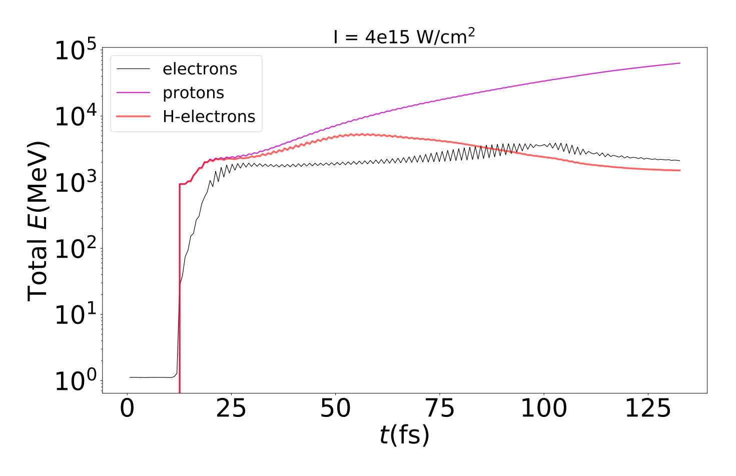
Kinetic model: PIC

Single nanorod resonating length (I. Papp)



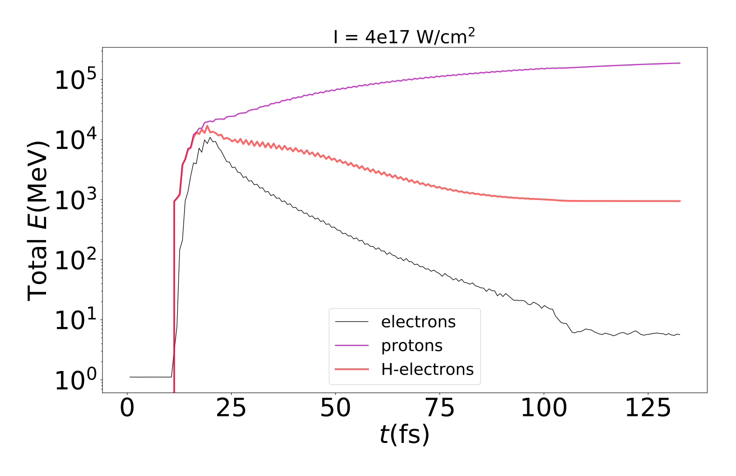
Kinetic model: PIC

Low intensity energy sharing (I. Papp)



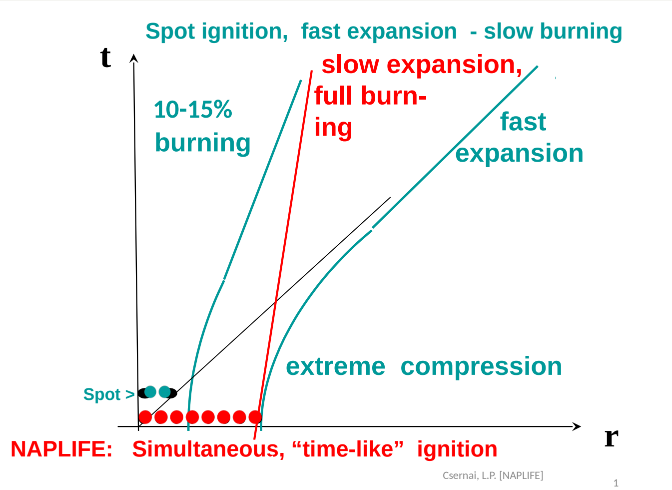
Kinetic model: PIC

Higher intensity energy sharing (I. Papp)



NAPLIFE (25 mJ, 40 fs) vs NIF (1 MJ, 10 ns)

Rapid vs slow ignition (L. Csernai)



NAPLIFE NANO

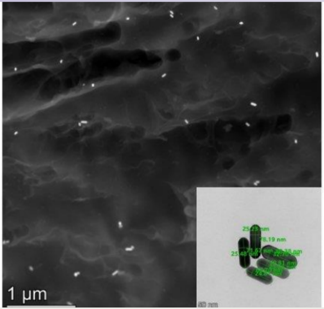
Au nanoparticles under microscope, absorption (Bonyár group)

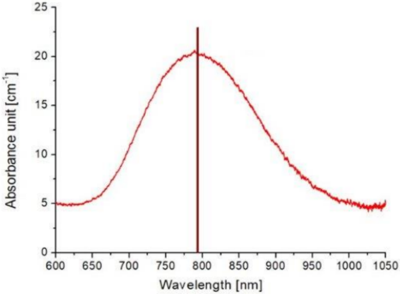
The NAPlife plasmonic fusion project

UDMA polymer with resonant gold nano-rods

Gold nano-rods embedded in polymer matrix: Transmission electron microscope image; insert shows actual nano-rods

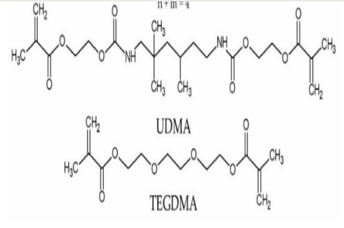
Actual absorption curve for nano composites measured by optical spectroscopy. The absorption peak is tuned to resonate with laser wavelength at 795 nm

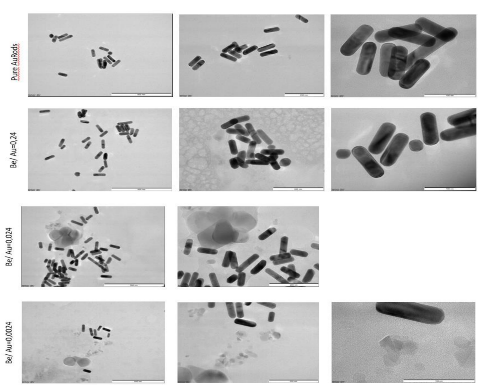




NAPLIFE NANO

Nanorod samples (Bonyár, Veres groups)



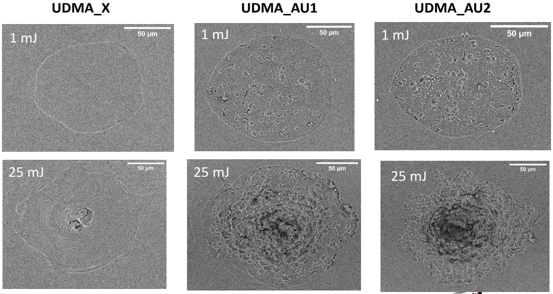


12. ábra. A különböző AuRods/ Be aránnyal rendelkező minták TEM felvételei

NAPLIFE CRATER

craters microscopic picture (J. Kámán)

7. Surface structure of the laser ablated area, investigated by SEM



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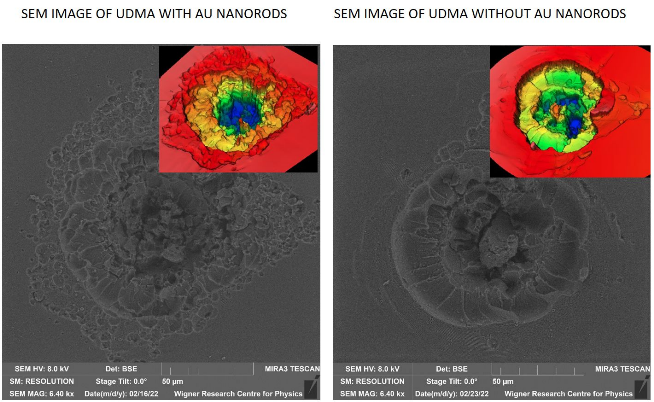
NAPLIFE CRATER

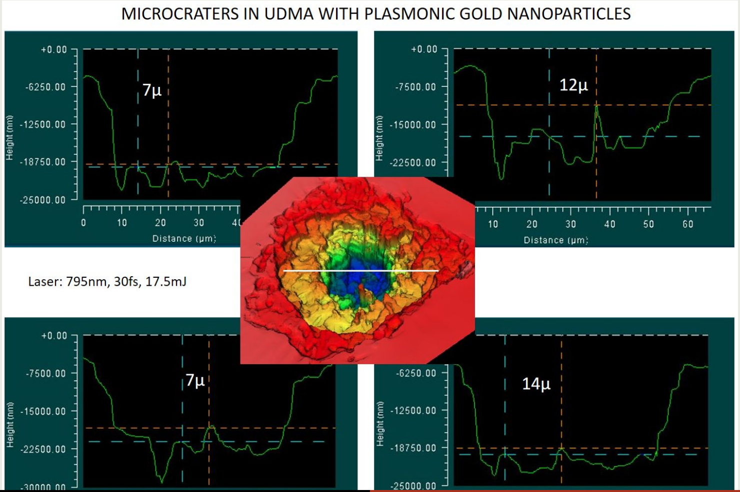
microcraters inside craters (J. Kámán)



Images at 17.5mJ laser energy, $1{,}16.10^{17}$ W/cm² laser intensity.The volume of the crater of the sample with nanorods is 1.98 times that of the sample without rods.

NAPLIFE CRATER

microcrater contours (J. Kámán)

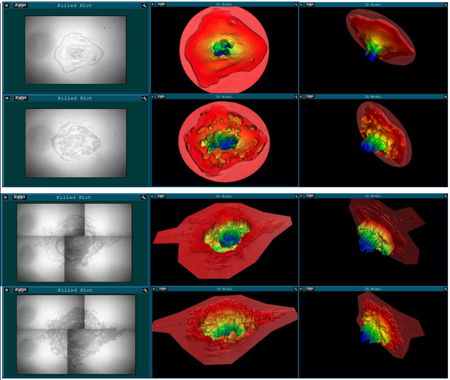


NAPLIFE CRATER

shot craters (Á. Nagyné Szokol)

Preliminary measurements

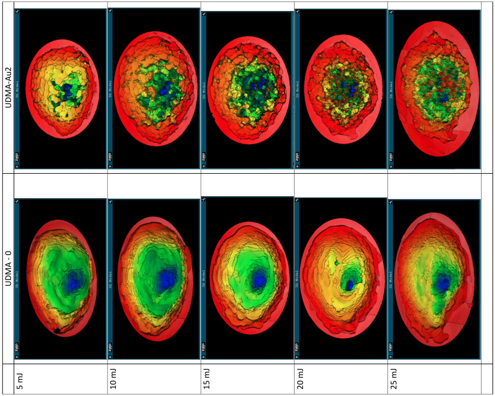
2,5 mJ	Without gold	
	With gold nanorods	
25 mJ	Without gold	
	With gold nanorods	



ICNFP 2022 - Ágnes Nagyné Szokol - 7 September 2022

NAPLIFE CRATER

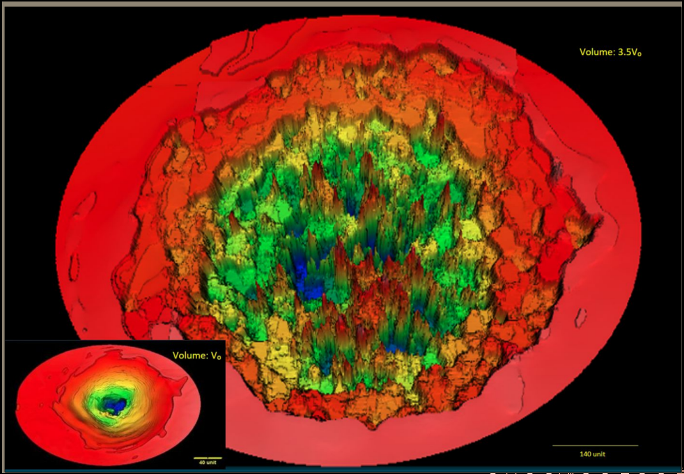
craters w/o Au nanorods (A. Nagyné Szokol)



12. ábra: A Spektroszkópia csoport Zygo interferométerrel végzett mérési eredményei a belövési kráterekről UDMA-Au0, valamint UDMA-Au2 mintákról 5-25 mJ impulzusenergiák között.

NAPLIFE CRATER

craters w/o Au nanorods (A. Nagyné Szokol)

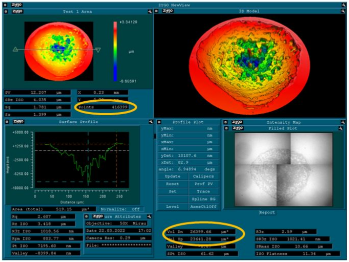


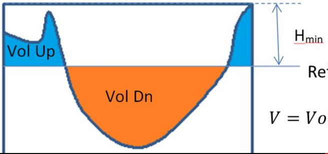
NAPLIFE CRATER

crater volume determination method (Á. Nagyné Szokol)

Volume determination method

1. Setting of the reference plane
2. Mesuring of the H_{min} value on 4 different points, and averaging them
3. Recording the values VolUp, VolDn and the number of the points
4. Calculating the area of the pixels
5. Calculating the volume of the cylinder over the reference plane





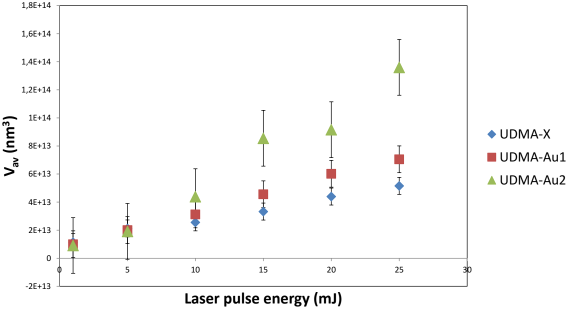
$$V = VolDn + T_{pixel} \cdot Points \cdot H_{min} - VolUp$$

NAPLIFE CRATER

crater volume vs laser energy (Á. Nagyné Szokol)

Crater volume

The analysis of the crater volumes – in 5 different points for every energy and target



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NAPLIFE RAMAN

UDMA - TEGDMA copolymer (Veres group)

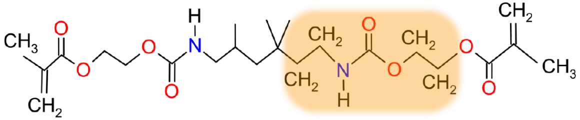


Figure 1. Chemical structure of UDMA monomer together with the selected part used for further modeling and calculations.

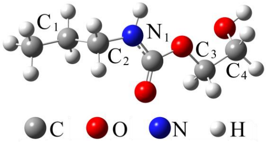
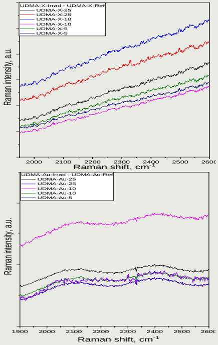
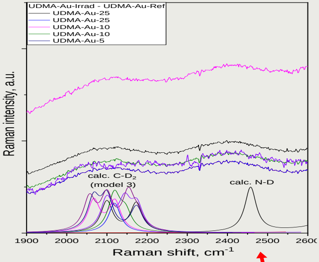


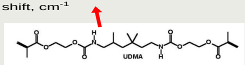
Figure 2. Optimized (B3LYP/6-311++G(d,p)) geometry of UDMA model (C_1H_2-C_2H_2 and C_3H_2-C_4H_2 groups are in anti and gauche conformational states, respectively).

NAPLIFE RAMAN

Raman signs: molecular vibrations (Veres group)



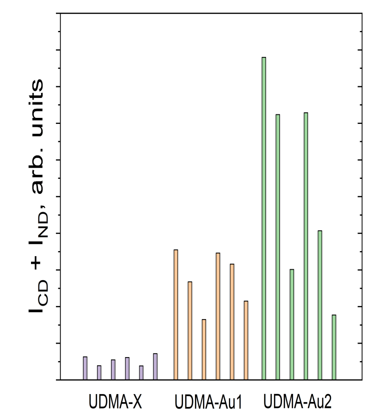


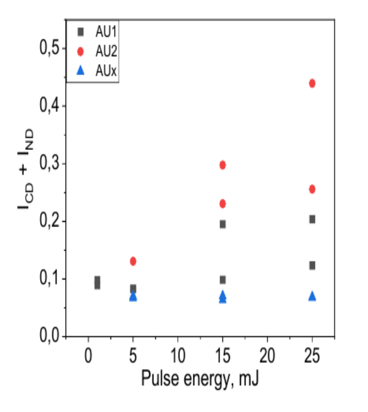


$I_{laser} > 10^{16}$

NAPLIFE RAMAN

SERS from several points in a crater





NAPLIFE LIBS

LIBS: plasma plum (Aladi group)

Automatic Zoom

DIAGNOSIS No3: LIBS analysis of the laser plume plasma

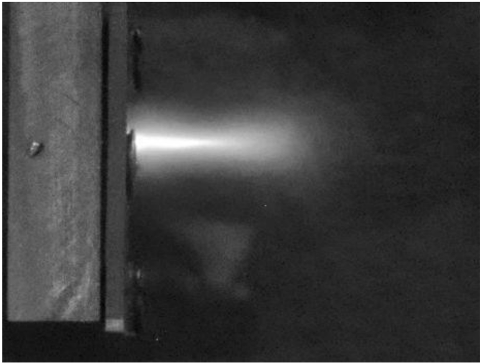
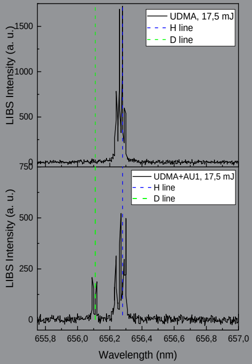
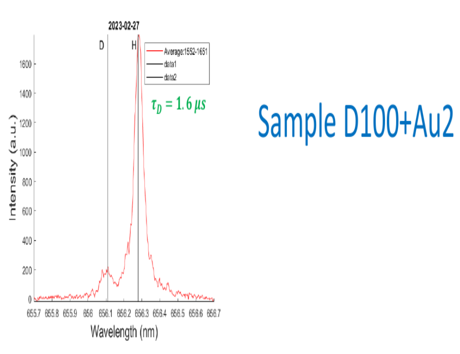


PHOTO OF A LASER SHOT INDUCED PLASMA PLUME

NAPLIFE LIBS

LIBS: atomic lines → D/H (Aladi group)

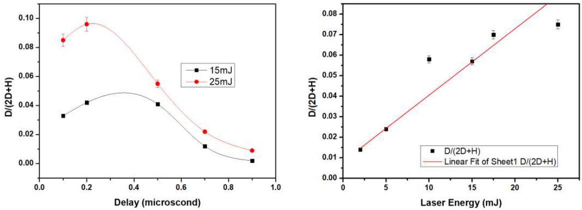




NAPLIFE LIBS+

LIBS: spectral areas → D/(2D+H) (Kroó)

Calculation of ratio; D/(2D+H)



At 17.5 mJ, D(A)=1.828, H(A)=8.32
D(A)/H(A)=0.21
D(A)/[2*D(A)+H(A)]=0.15
No. of H atoms=2.51*10^16
No. of atoms that were converted from H to D=3.765*10^15

Please refer to Agnes Nagyne Sokol's talk on Crater Data Analysis!

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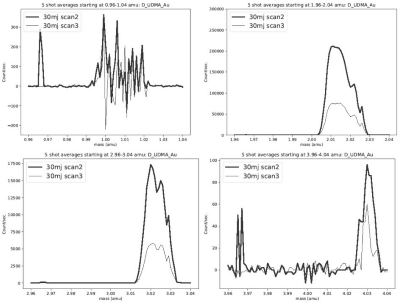
NAPLIFE MASS SPECTRO

peaks: amu1 300, amu2 230.000, amu3 17.500, amu4 100 (Aladi group)



amu=1: H
amu=2: H_2 + D
amu=3: HD + He_3
amu=4: D_2+ He_4

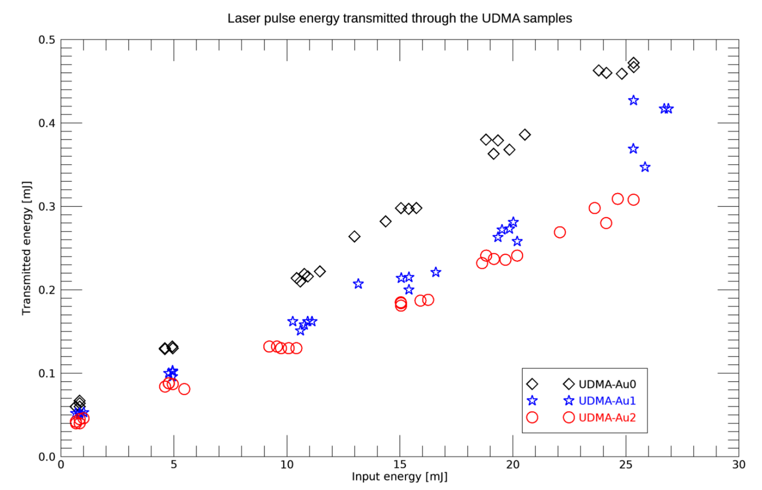
Minták:
- UDMA
- UDMA+Au2
- UDMA(30%D)
- UDMA(30%D+Au2)

Fenti mintaspektrumok az UDMA(30%D+Au2) minta amu=1, amu=2, amu=3 és amu=4 tömegszámú csúcsait mutatják

amu=2 tömegszám terület arányok:
- UDMA/UDMA = 1
- (UDMA+Au2)/UDMA = 1.17
- UDMA(30%D)/UDMA = 0.68
- (UDMA(30%D+Au2)/UDMA = 0.89

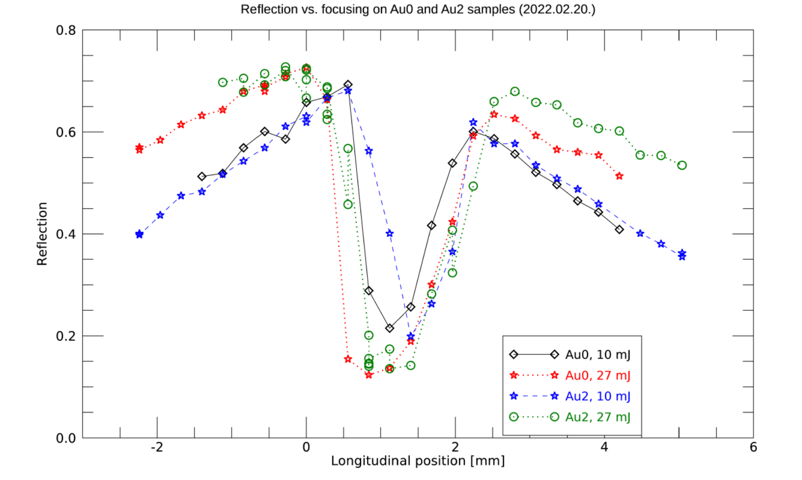
ENERGIA: transmitted light < 2 %

M. Kedves



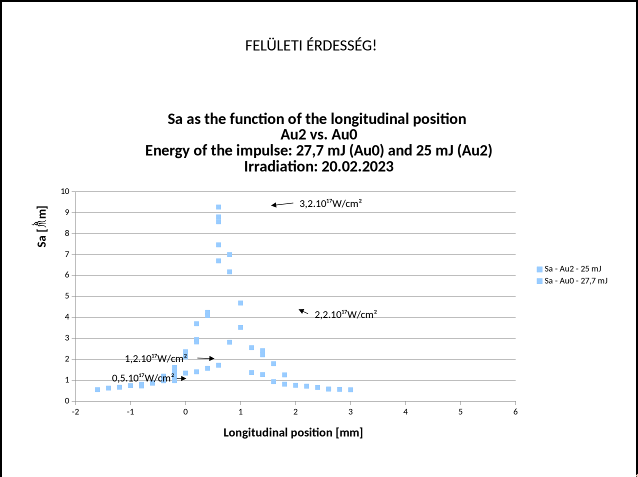
Plasma mirror: reflected light vs focus

A. Márk, M. Kedves



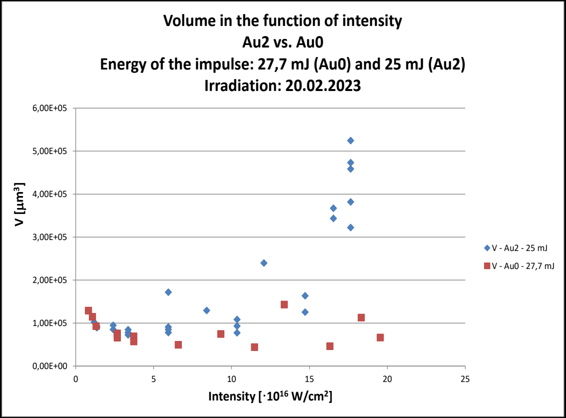
Intensity counts!

A. Márk, M. Kedves; N. Kroó



Crater volume vs intensity: Au counts!

Á. N. Szokol



NAPLIFE FUTURE

plans

Contracted with NKFIH until February 28-th, 2026.

Plans:

- Nuclear alpha detection (CR39)
- ELI shootings (shorter pulse, better contrast, similar energy, 100x intensity)
- Use of doped targets, shape variations, reflectivity vs. intensity
- Buying gamma detector