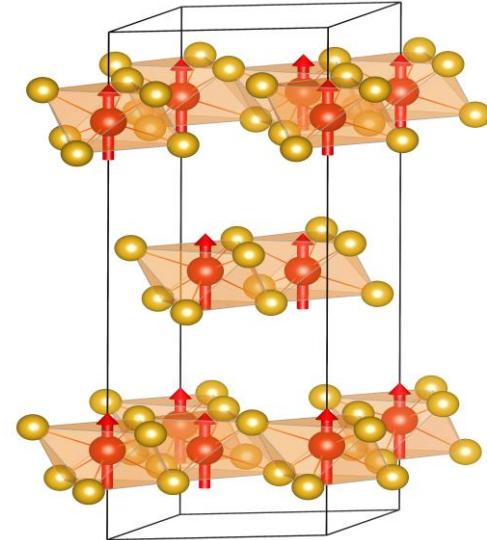
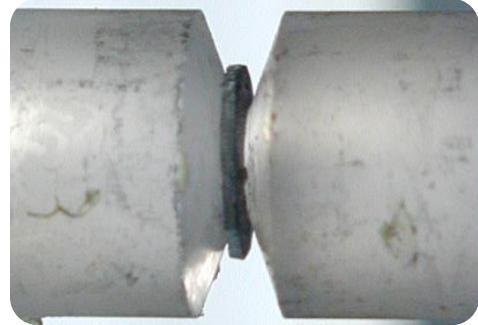
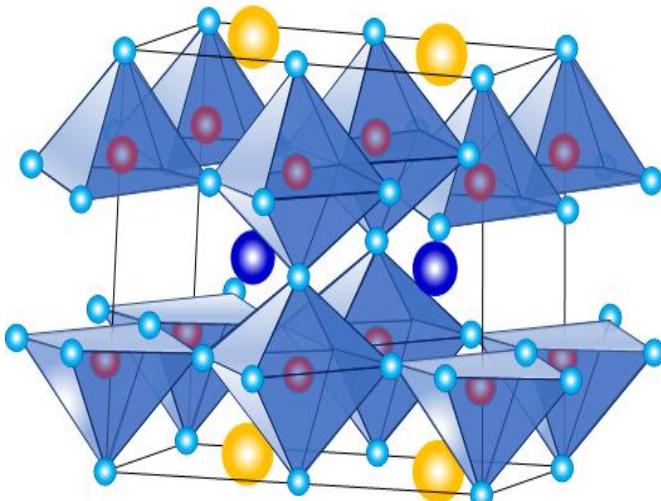
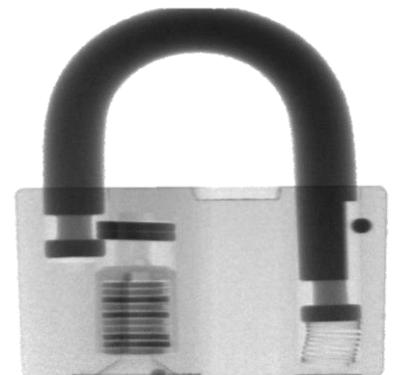
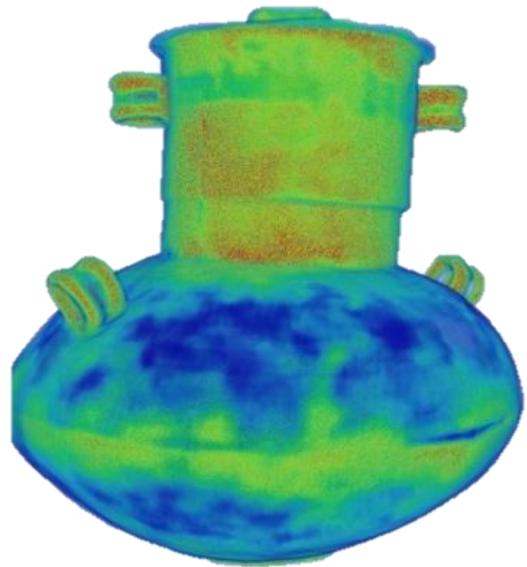
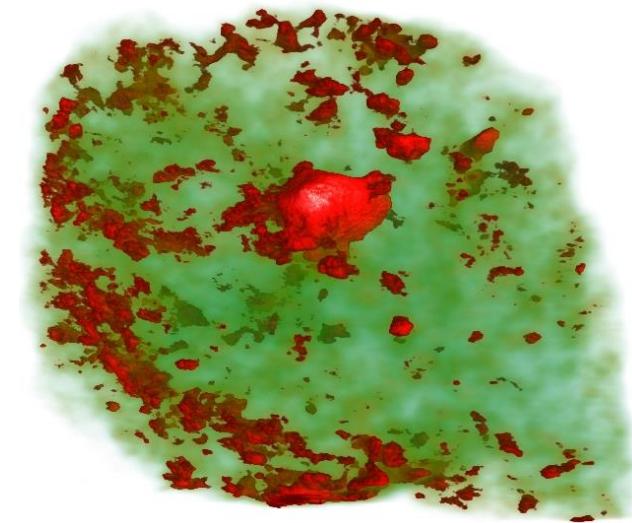


# High Pressure Diffraction and Imaging at the IBR-2 and Science



Kichanov Sergey

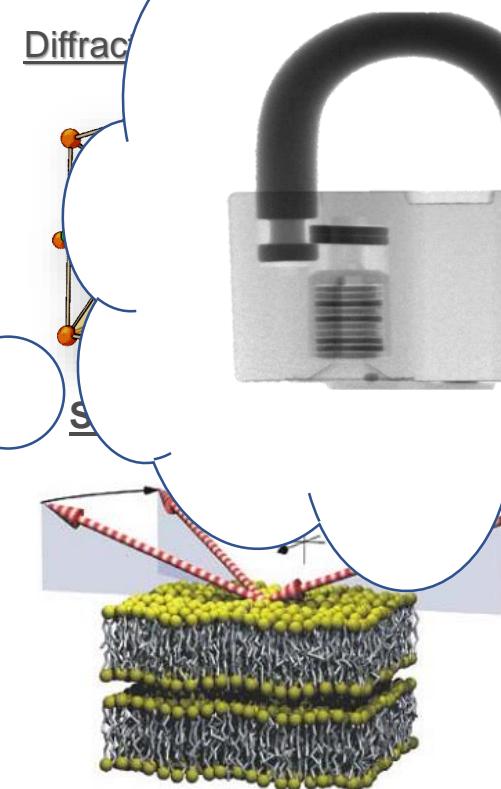
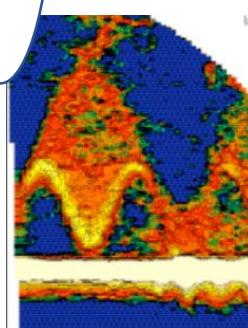


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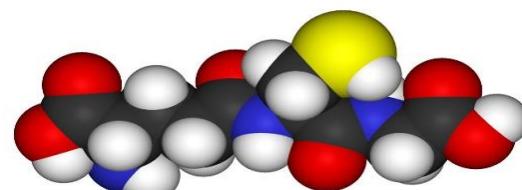
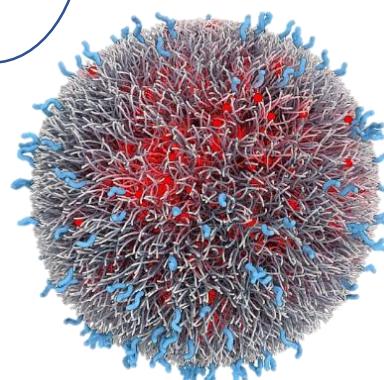
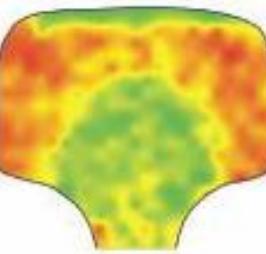


Reflectometers: [REMUR](#), [REFLEX](#), [GRAIN](#)

Inelastic scattering: [DIN-2PI](#), [NERA](#)



[ILON](#), [FSD](#), [DN-12](#)

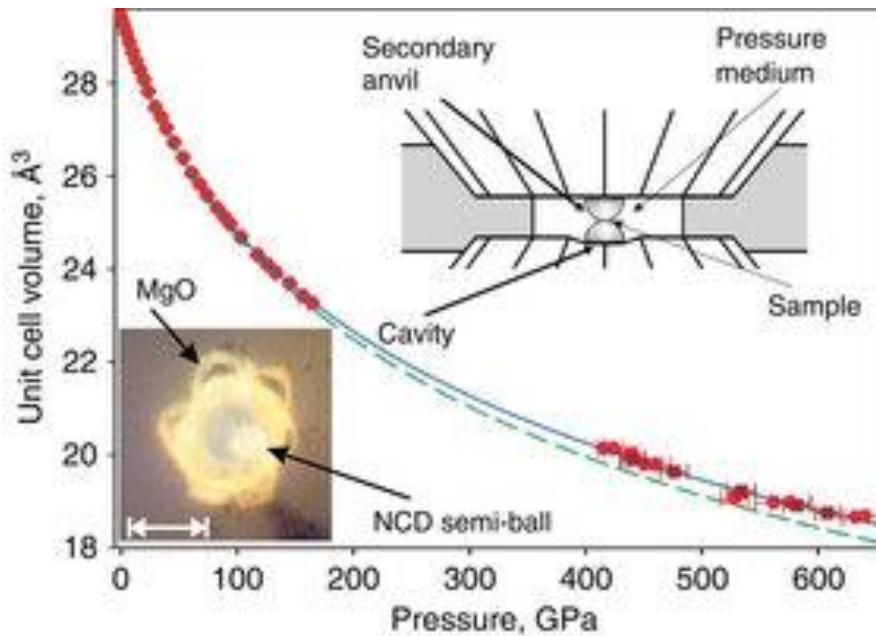
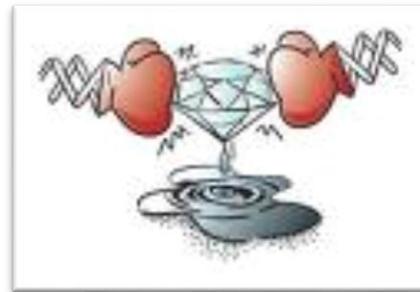




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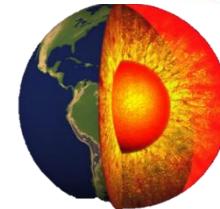


**Synchrotron radiation source**  
**Flux on sample**  
 $\sim 10^{16}-10^{18}$   
 $V \sim \mu\text{m}^3$   
*Exposition time*  $\sim 1 \text{ sec}$

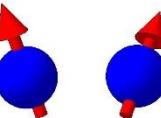


Dubrovinsky, L. et al. Implementation of micro-ball nanodiamond anvils for high-pressure studies above 6 Mbar. *Nat. Commun.* 3:1163 doi: 10.1038/ncomms2160 (2012).

**Neutron source**  
**Flux on sample**  
 $\sim 10^6-10^9$   
 $V \sim 10-100 \text{ mm}^3$   
*Exposition time*  $\sim 2-10 \text{ h}$



- Magnetic structure



**Magnetic phase transitions or spin-reorientation transitions**

- Compounds contained light elements:  
**H, D, Li, O ...**



**Structural phase transition in molecular crystals, in hydrides, hydrate, pressure induced ice forms and others....**

- **High penetrating effect: pressure cells, ovens, magnets, refrigerators...**



**Flux at sample:**

$1.5 \times 10^6 \text{ n/sm}^2/\text{s}$

**TOF distance:**

26.0 m

**Ranges:**

wavelengths

0.8 - 10 Å

scattering angles

45° - 135°

d-spacing

0.6 - 13 Å

**Resolution :**

at  $2\theta=90^\circ$

0.022

at  $2\theta=135^\circ$

0.012

**Sample volume:**

0.5-3 mm<sup>3</sup>

**Pressure range:**

0-8 GPa

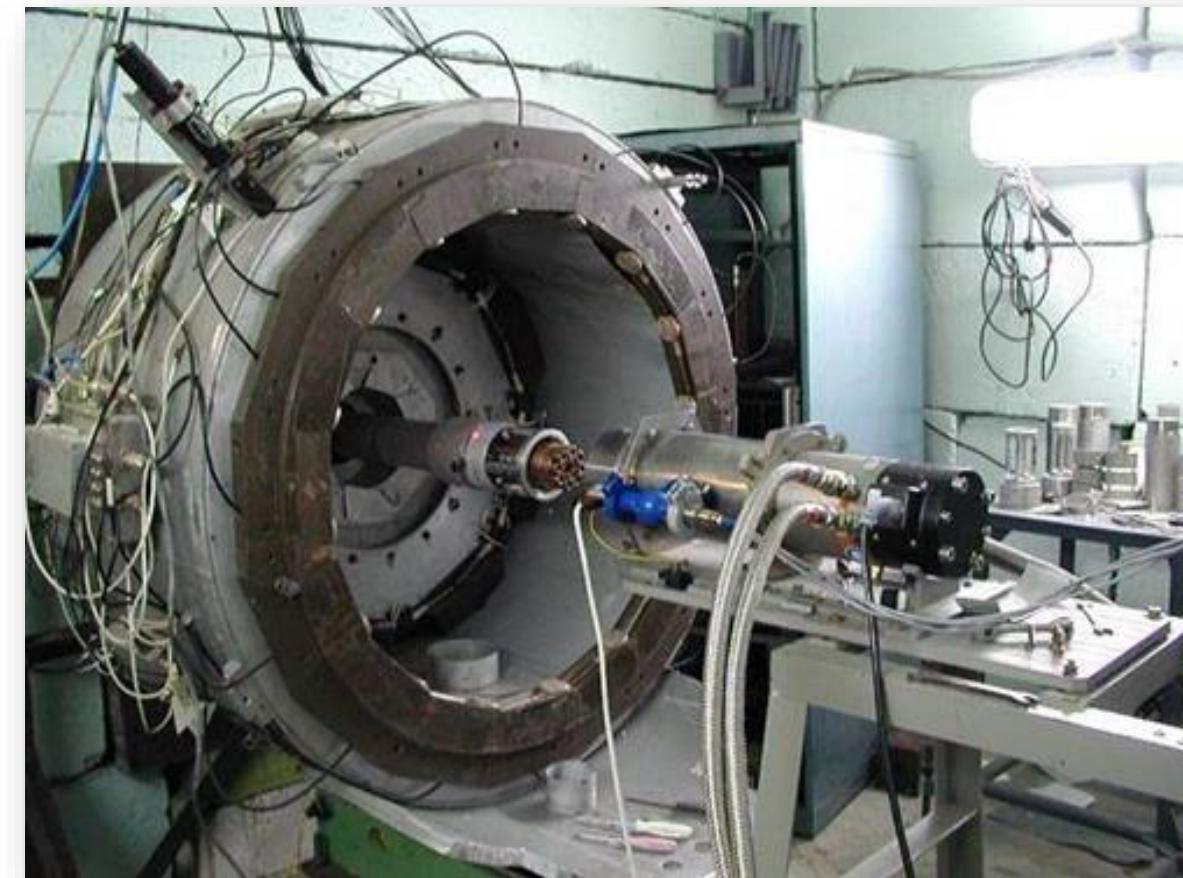
**Temperature range**

10 - 300 K

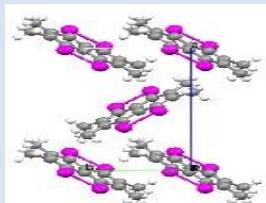




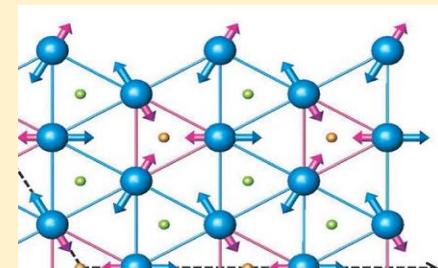
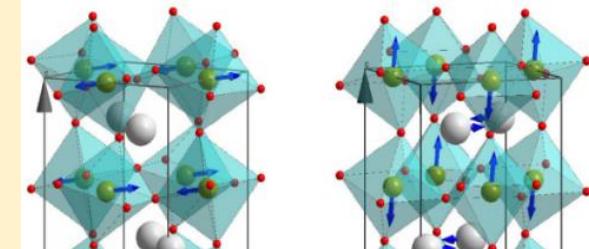
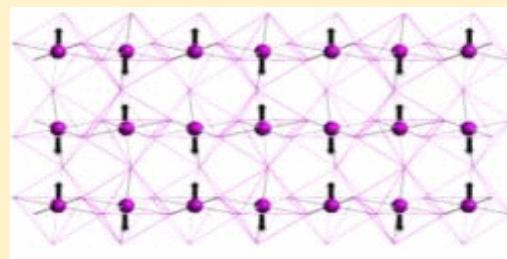
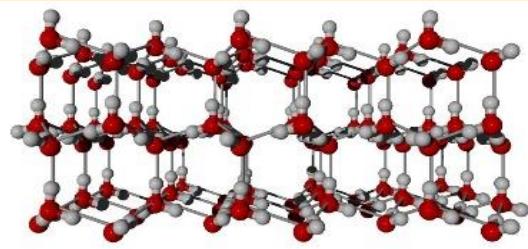
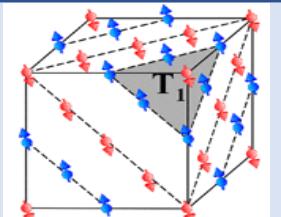
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## Investigations of crystal and magnetic structures of materials at high pressure using neutron powder diffraction



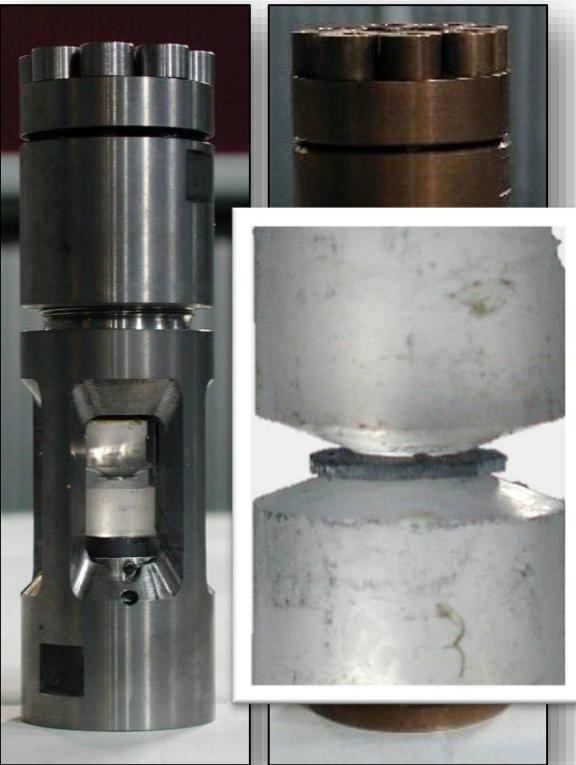
- Structural and magnetic phase transitions at high pressure
  - P-T phase diagrams of materials
- Changes in magnetic structures of materials at high pressure



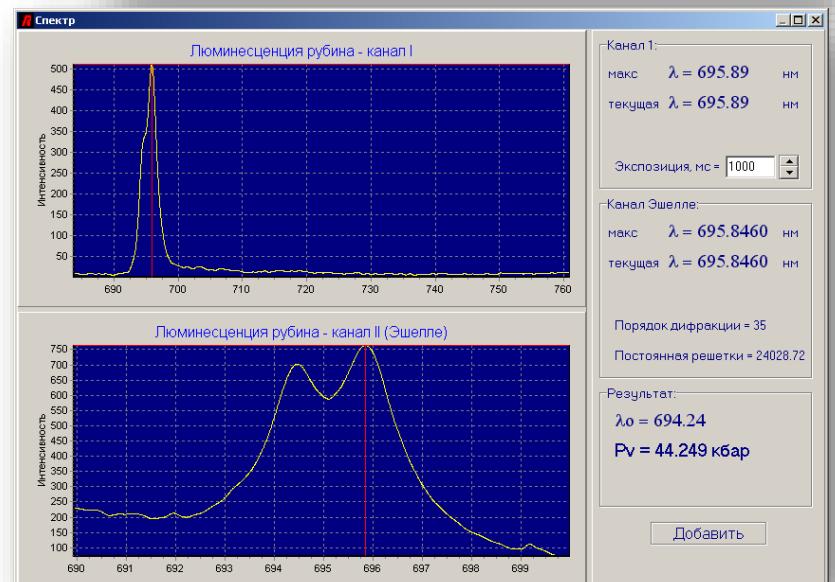
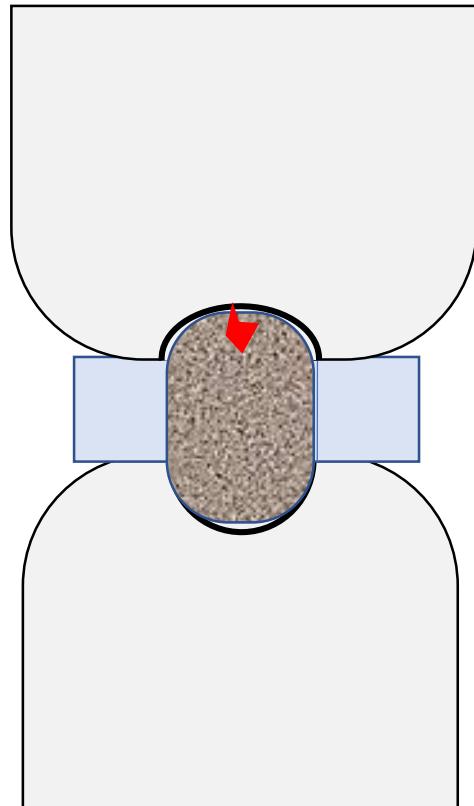
## Investigations of crystal and magnetic structure of microsamples ( $V \leq 20 \text{ mm}^3$ ) using neutron powder diffraction method

- hard synthesised materials
  - HP-HT synthesis

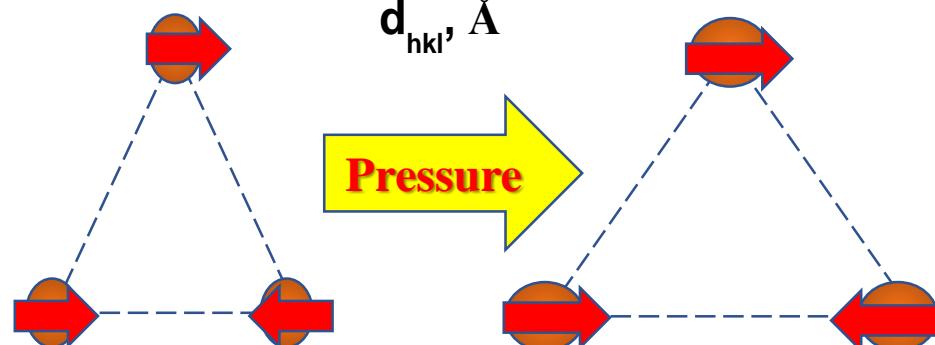
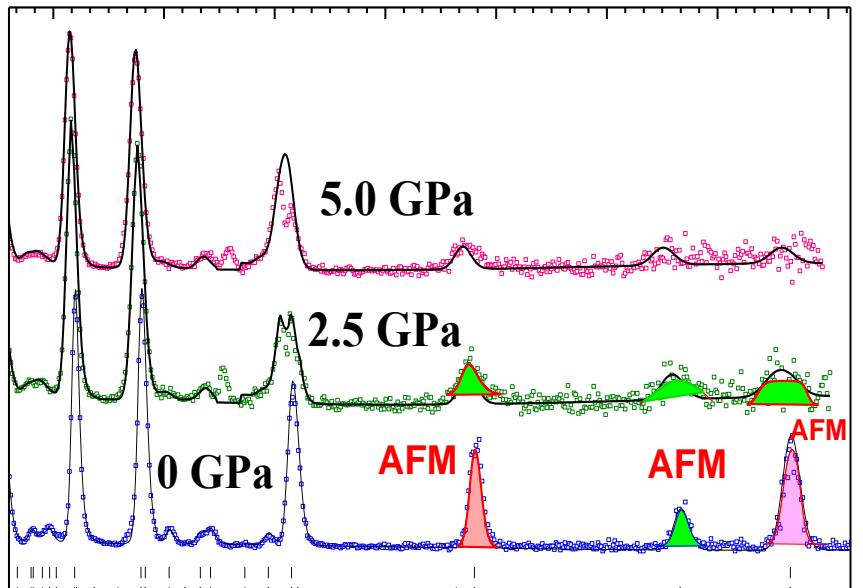




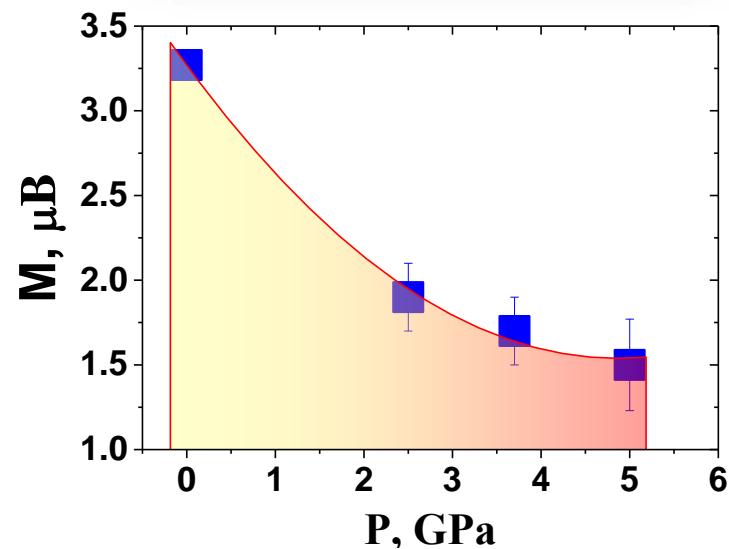
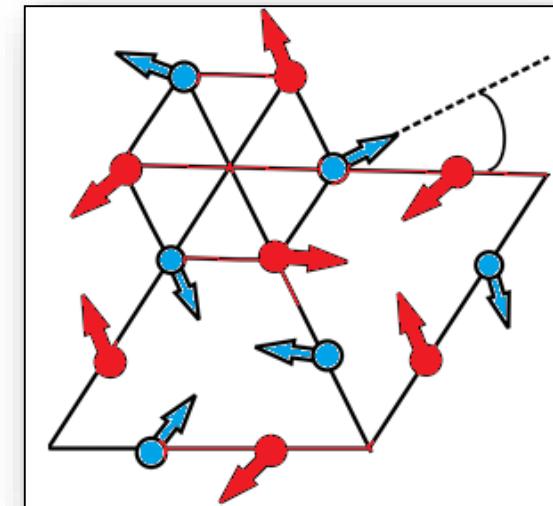
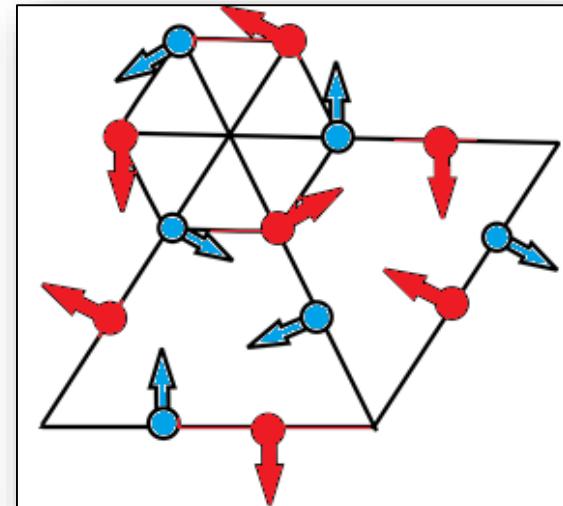
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**Pressure effect on magnetic structure of hexagonal magnetite  $YMnO_3$  and  $LuMnO_3$**



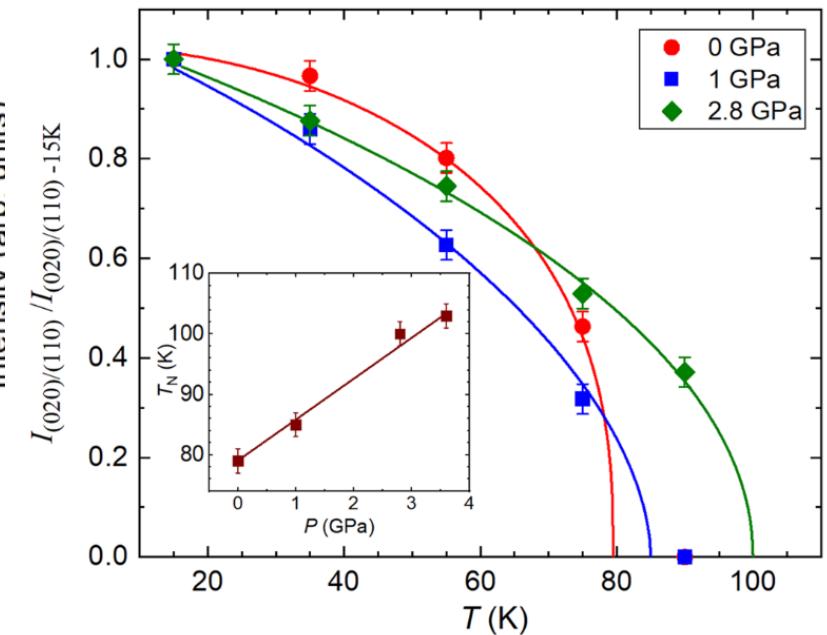
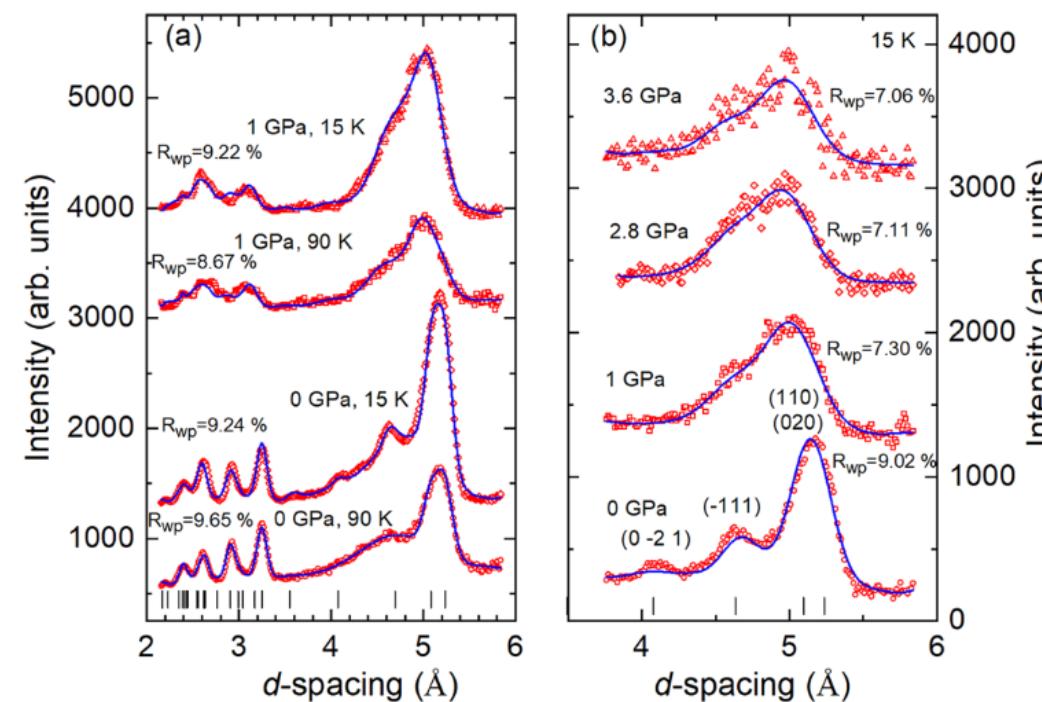
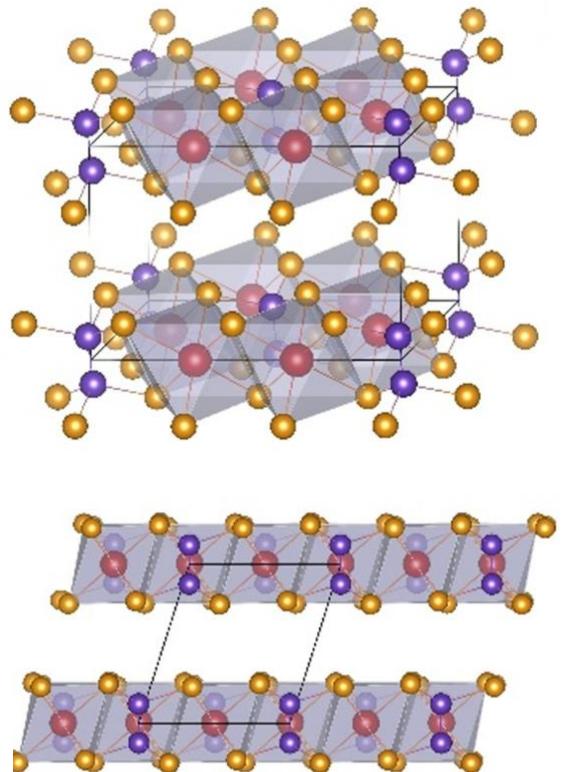
**Spin-reorientation transition**



Kozlenko, D.P., Kichanov, S.E., Lee, S. et al. High-pressure effect on the crystal and magnetic structures of the frustrated antiferromagnet  $YMnO_3$ . *Jetp Lett.* 82, 193–197 (2005).

D P Kozlenko et al 2007 *J. Phys.: Condens. Matter* 19 156228

## Pressure effect on the magnetic structure of van der Waals antiferromagnet $\text{MnPS}_3$



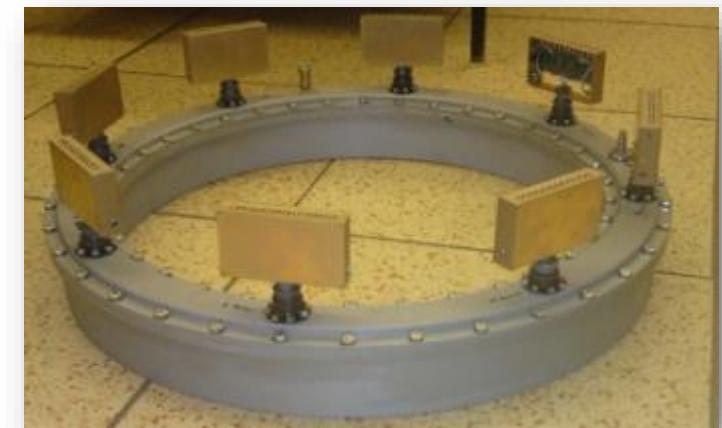
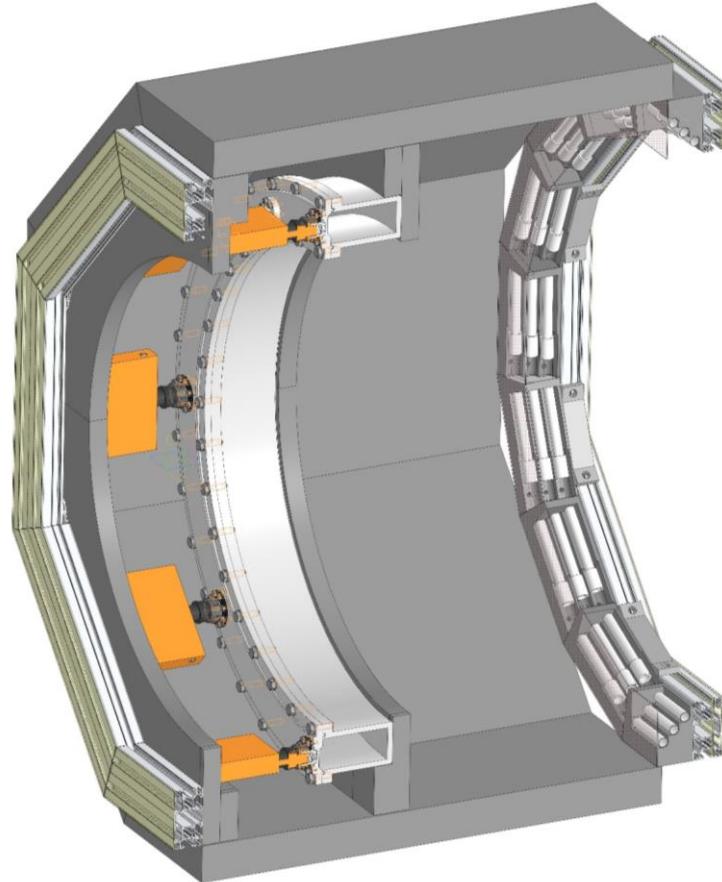
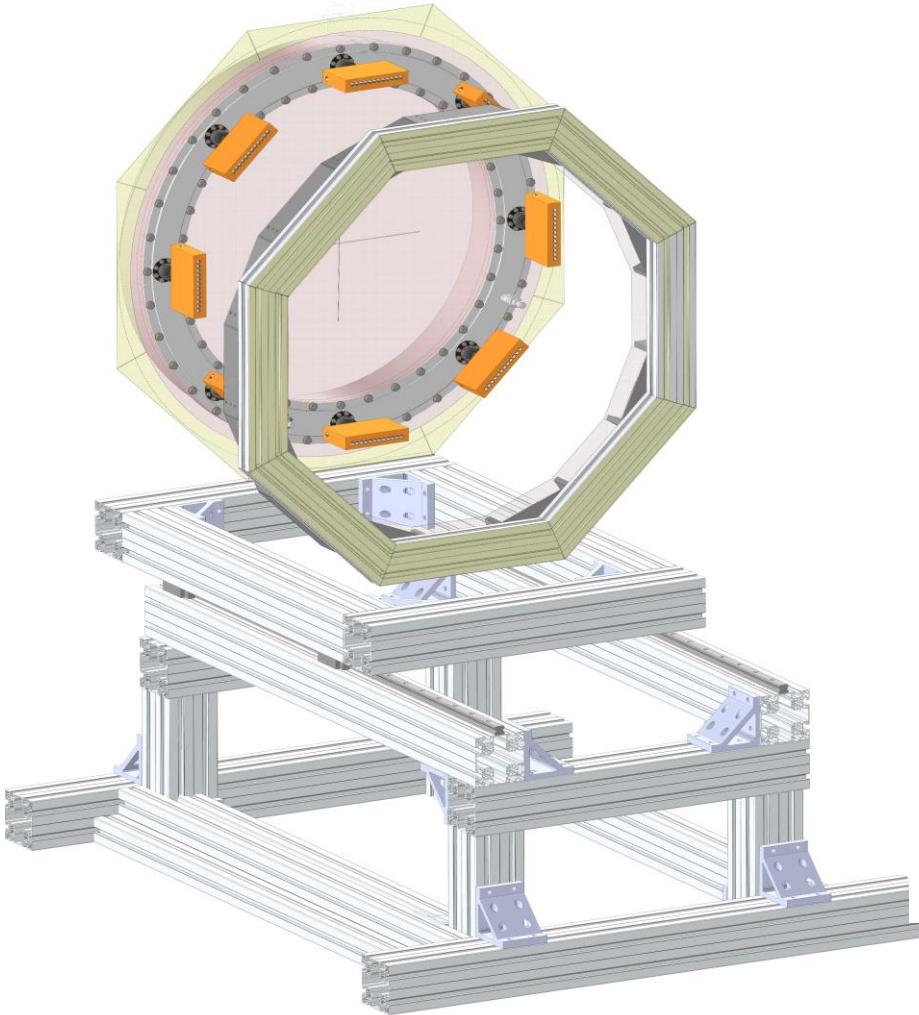
D. P. Kozlenko, O. N. Lis, N. T. Dang, M. Coak, J.-G. Park, E. V. Lukin, S. E. Kichanov, N. O. Golosova, I. Yu. Zel, and B. N. Savenko "High-pressure effects on structural, magnetic, and vibrational properties of van der Waals antiferromagnet  $\text{MnPS}_3$ " Phys. Rev. Materials 8, 024402 (2024)



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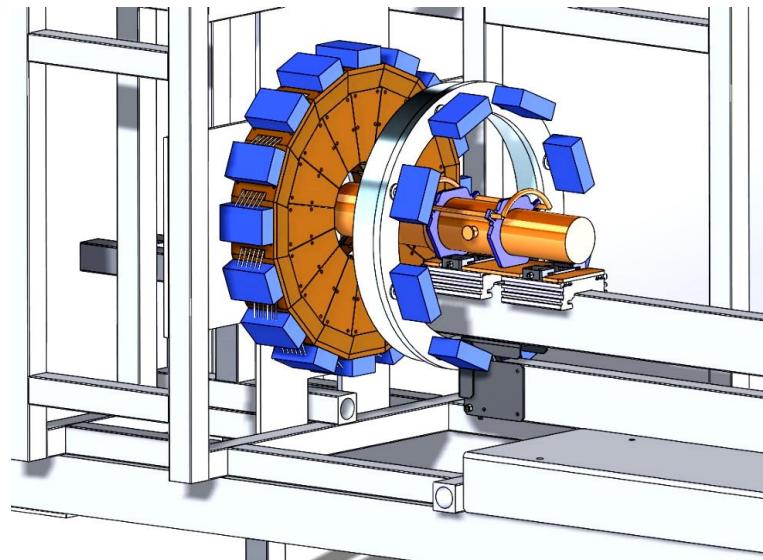
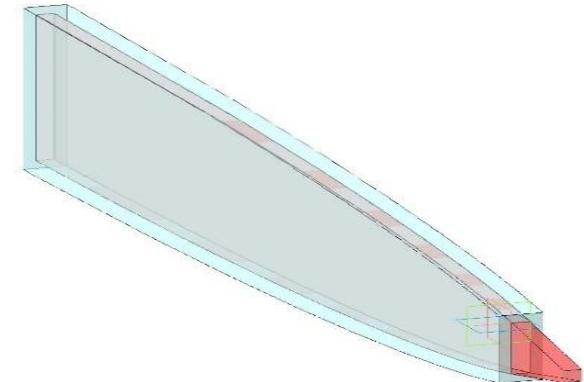


## Future update of DN-12 diffractometer

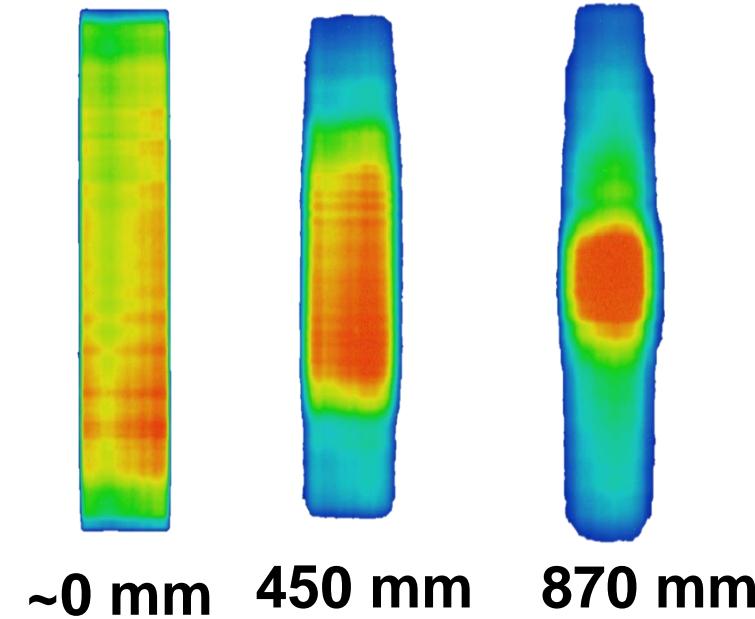
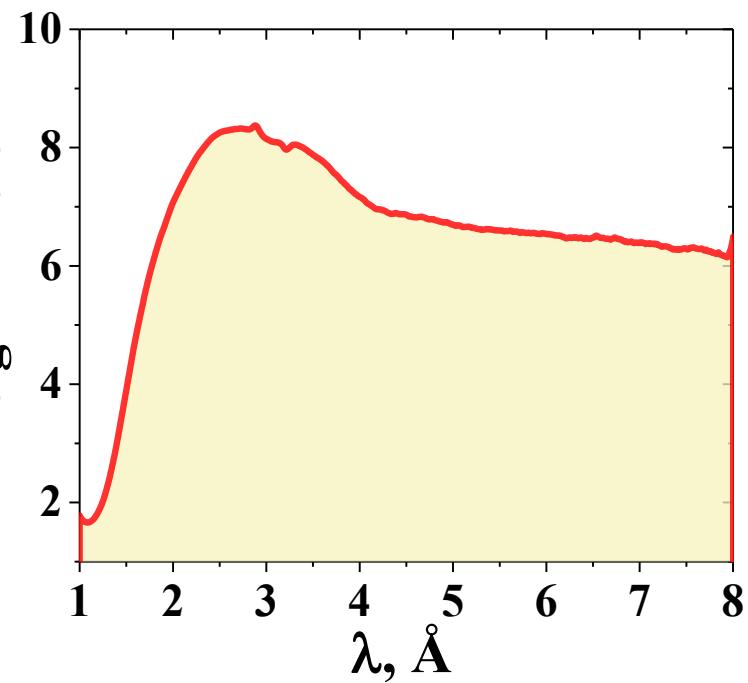




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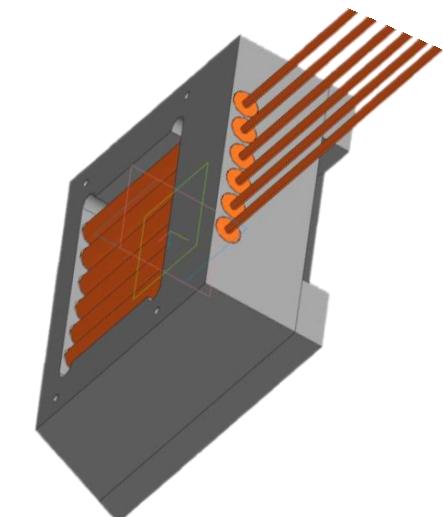
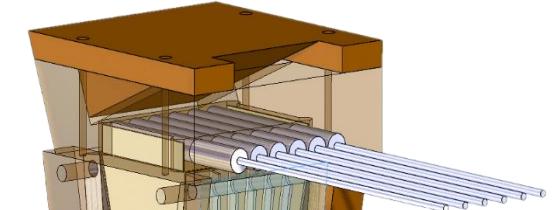
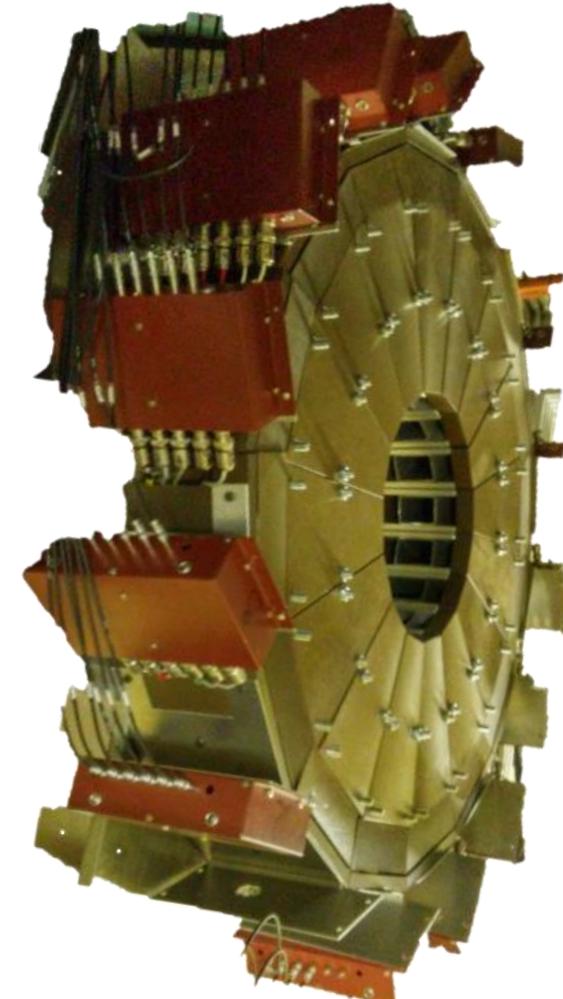
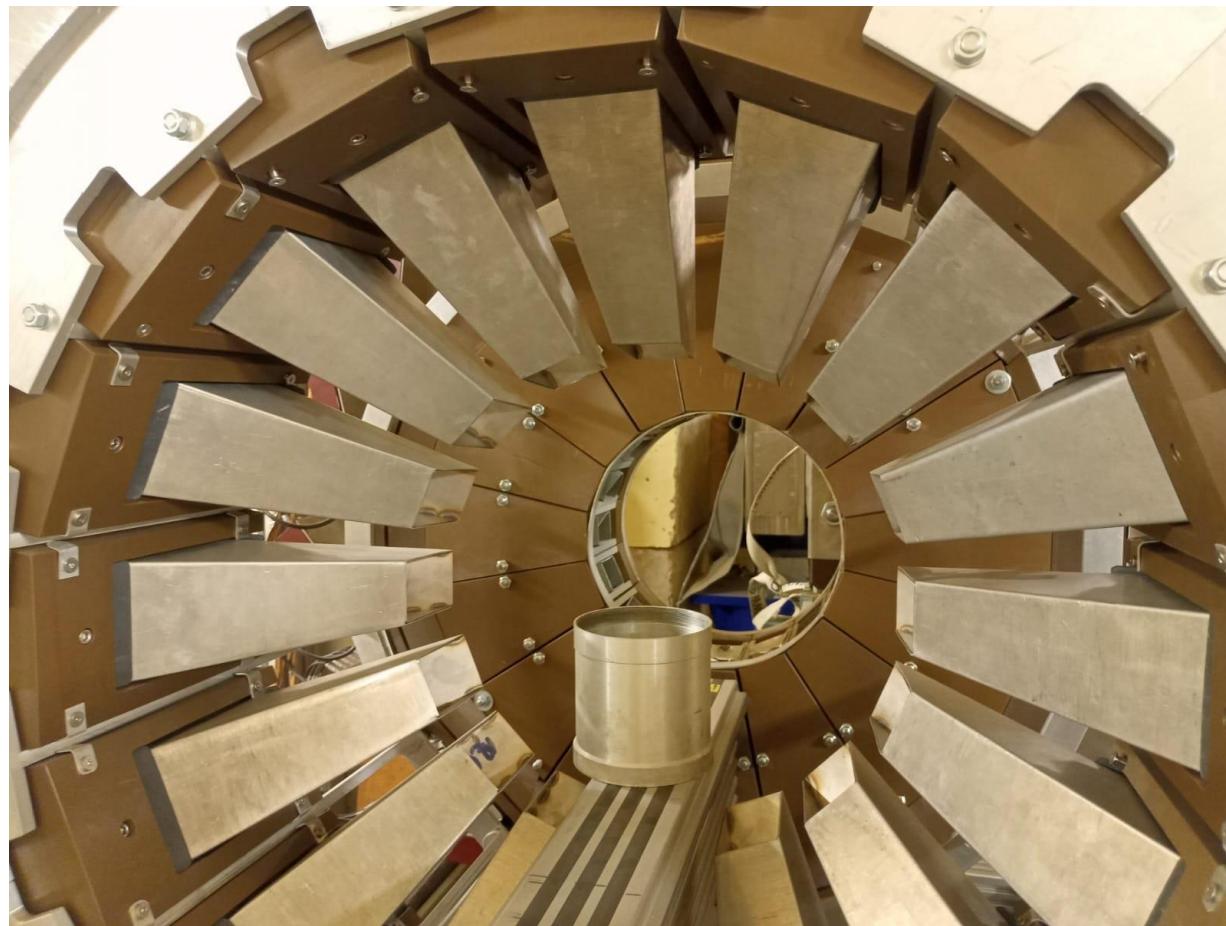


The gain factor





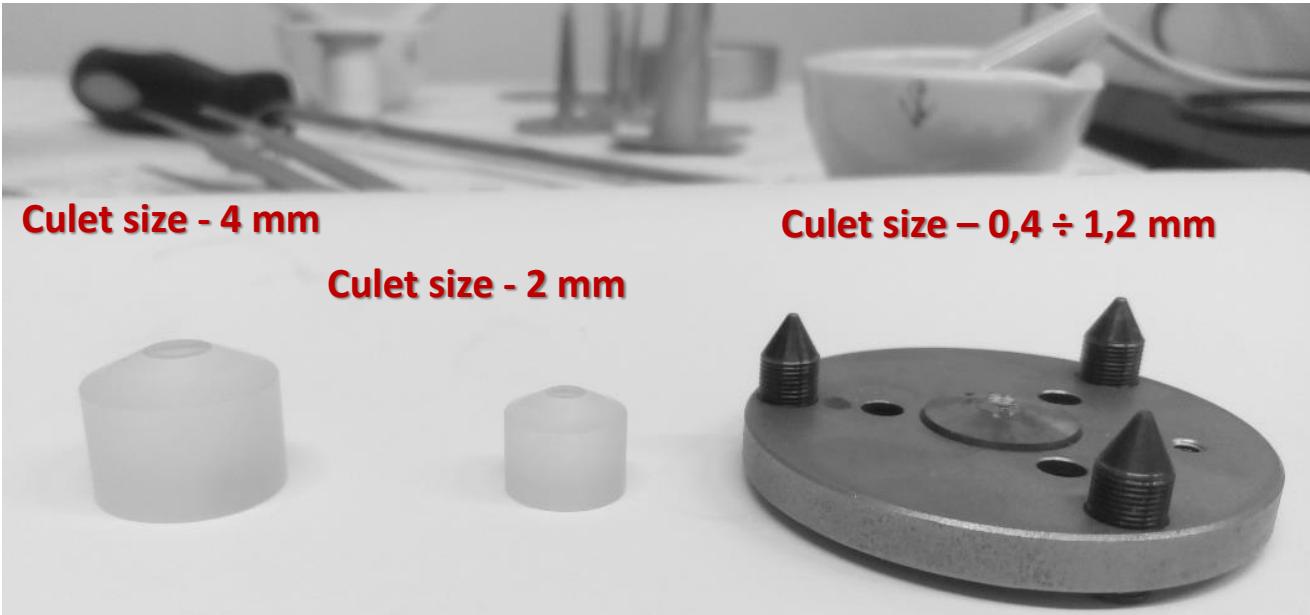
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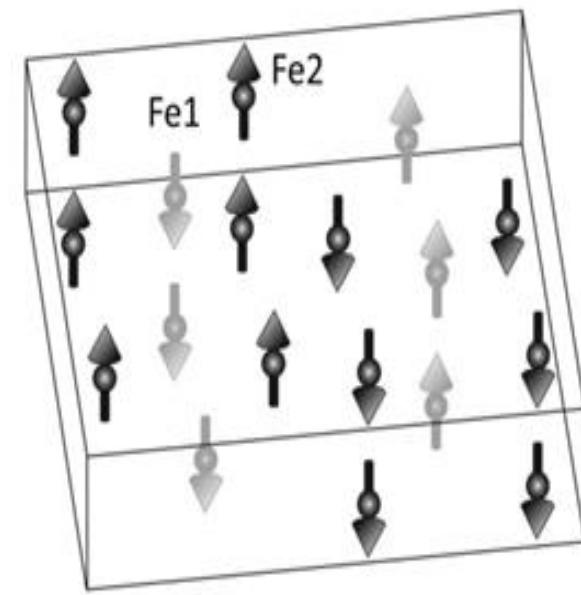
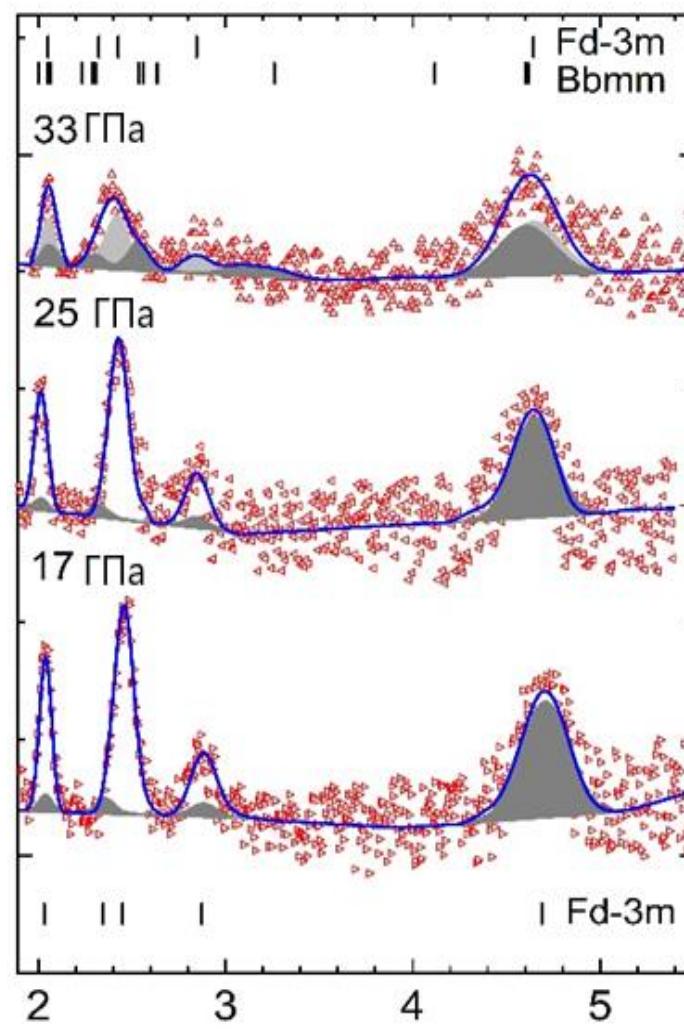
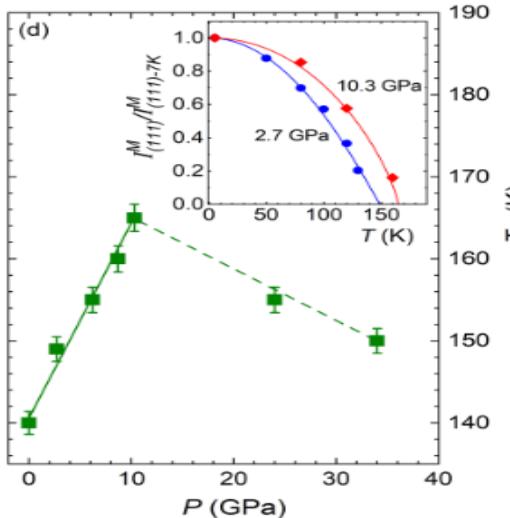
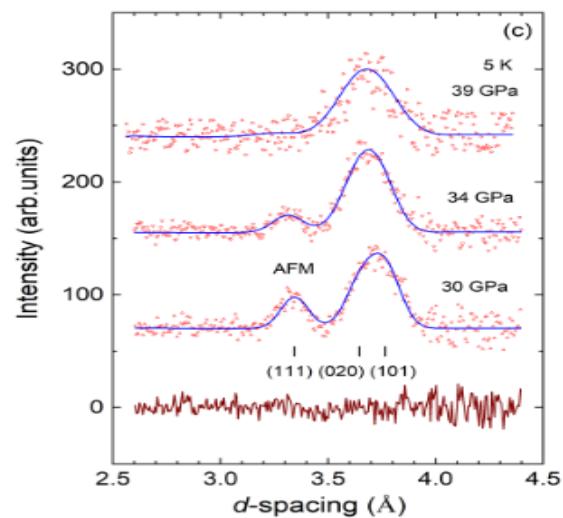
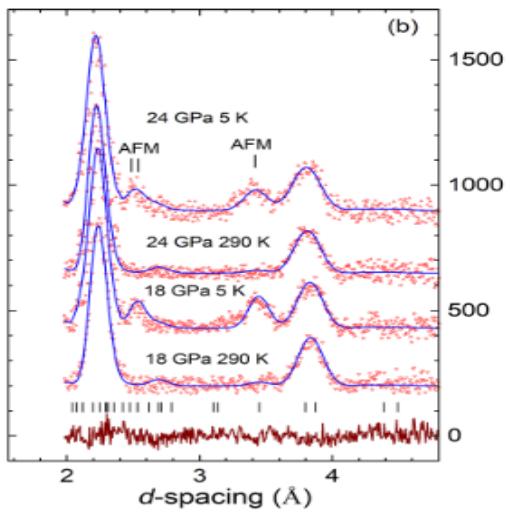
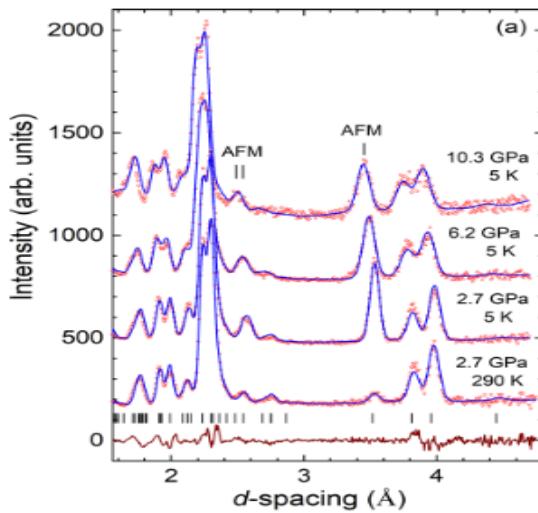


Total gain factor in comparison with DN-12 is ~100



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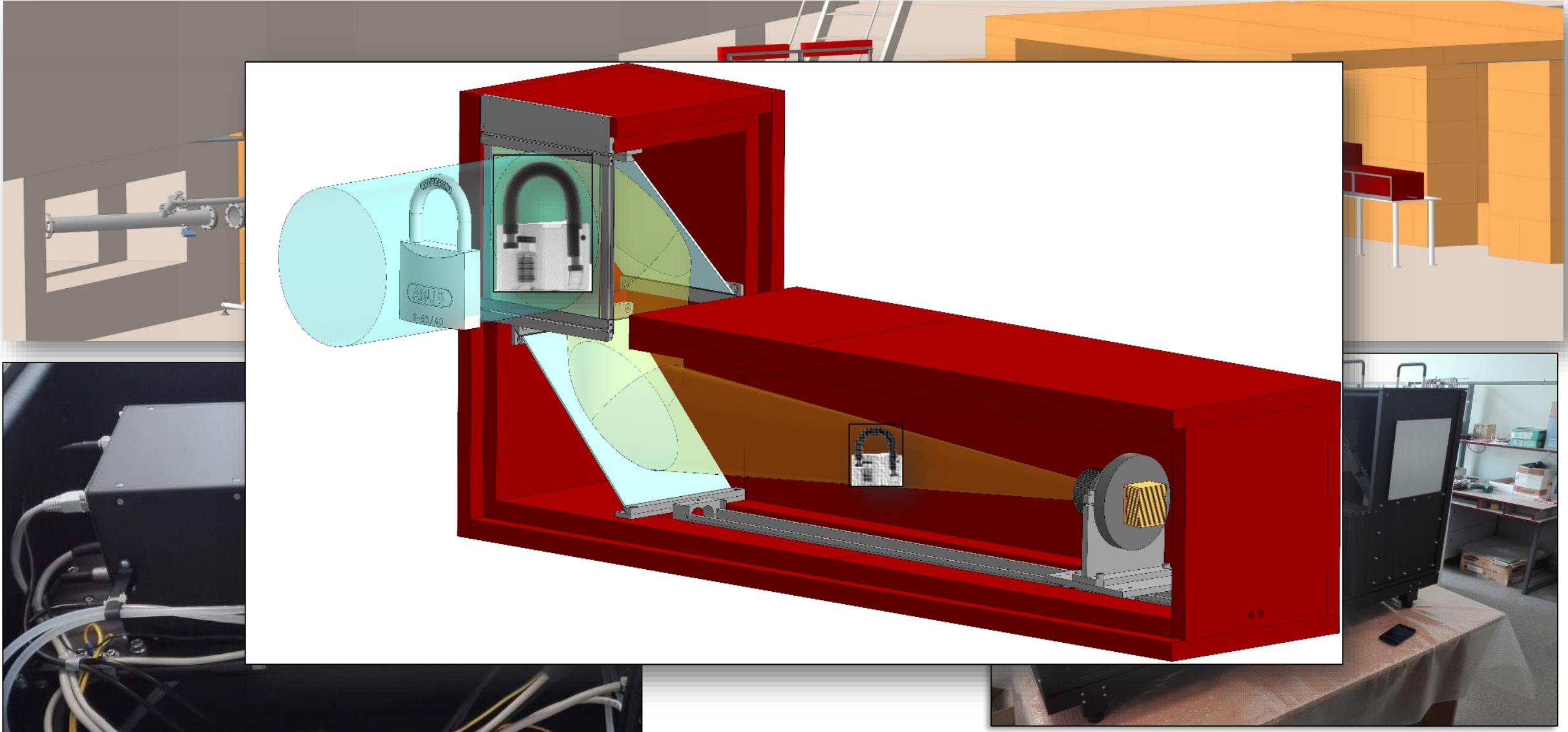


D. P. Kozlenko, E. V. Lukin, S. E. Kichanov, Z. Jirák, N. O. Golosova, and B. N. Savenko "High-pressure evolution of the magnetic order in  $\text{LaMnO}_3$ ", Phys. Rev. B 107, 144426 (2024)

Kozlenko, D.P., Dubrovinsky, L.S., Kichanov, S.E. et al. Magnetic and electronic properties of magnetite across the high pressure anomaly. Sci Rep 9, 4464 (2019).

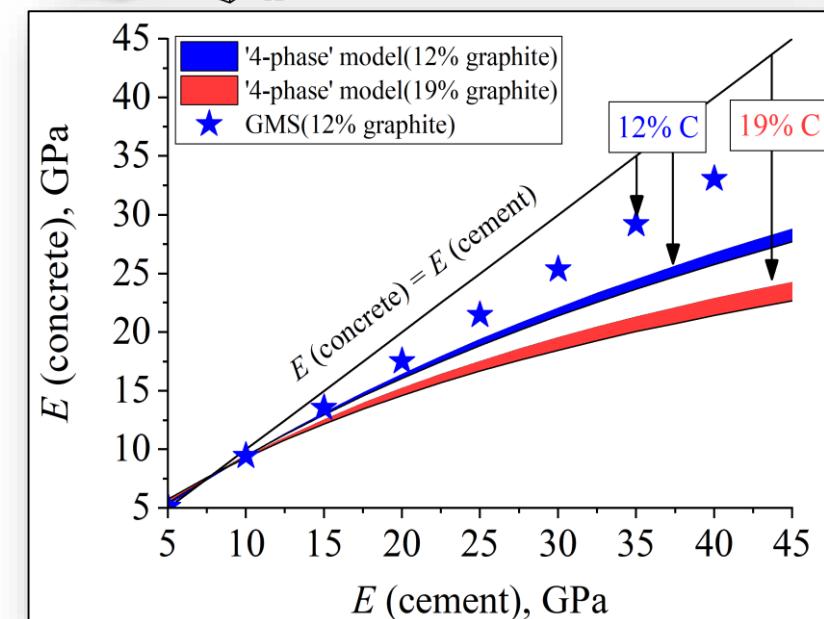
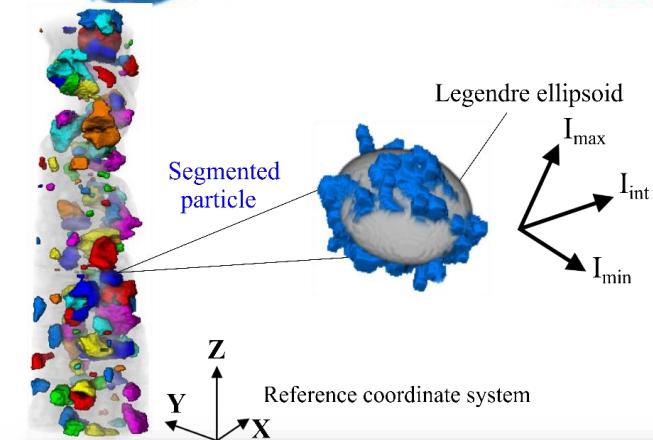
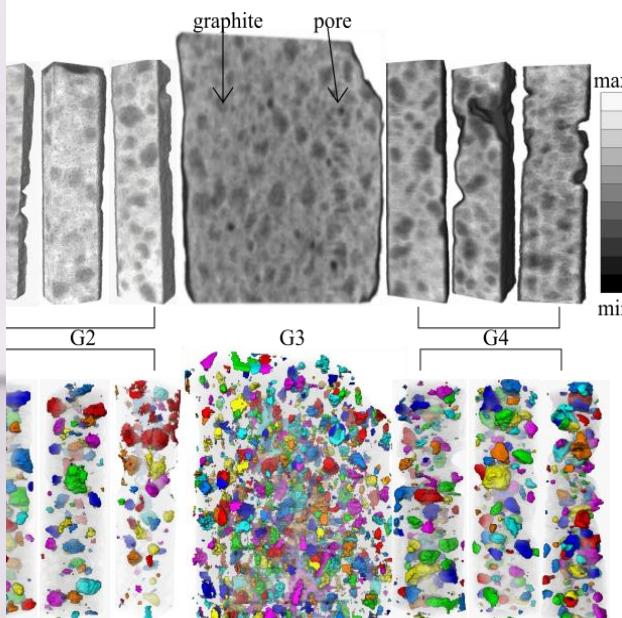
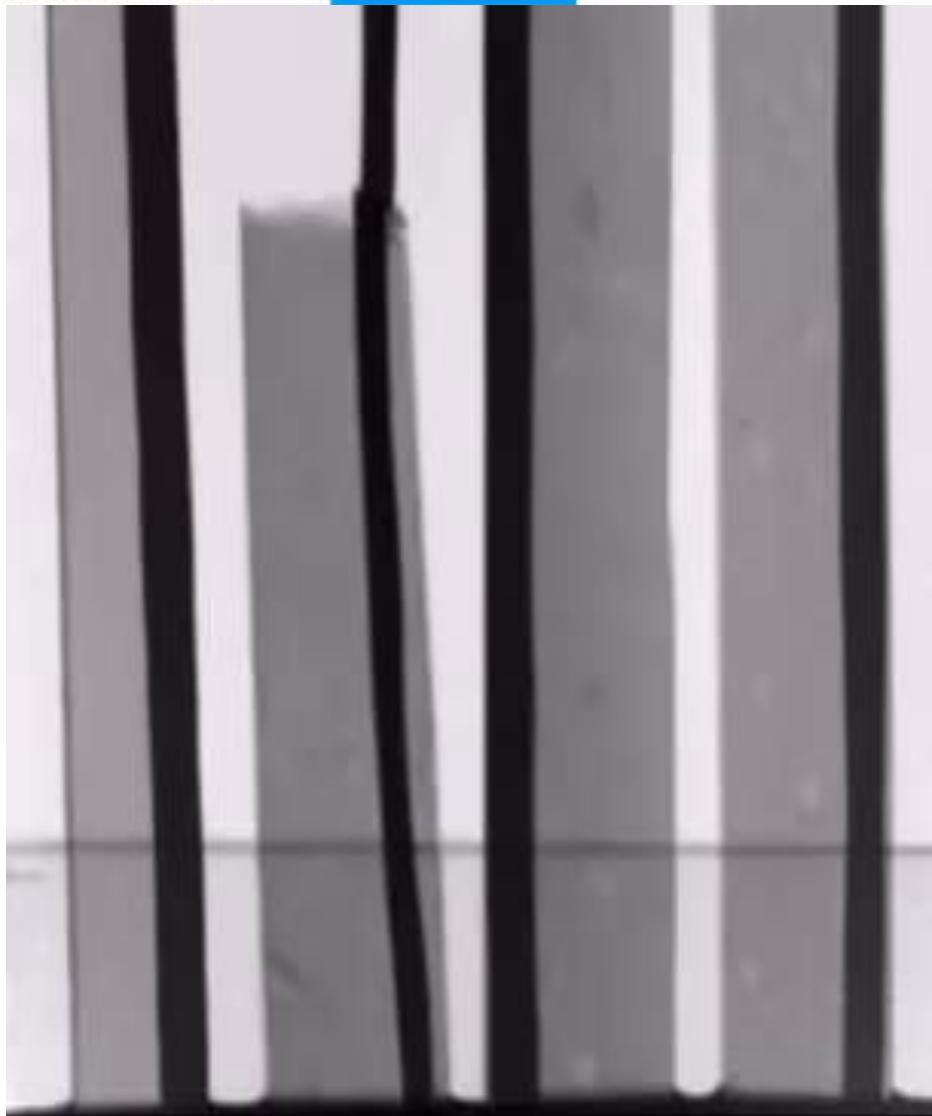


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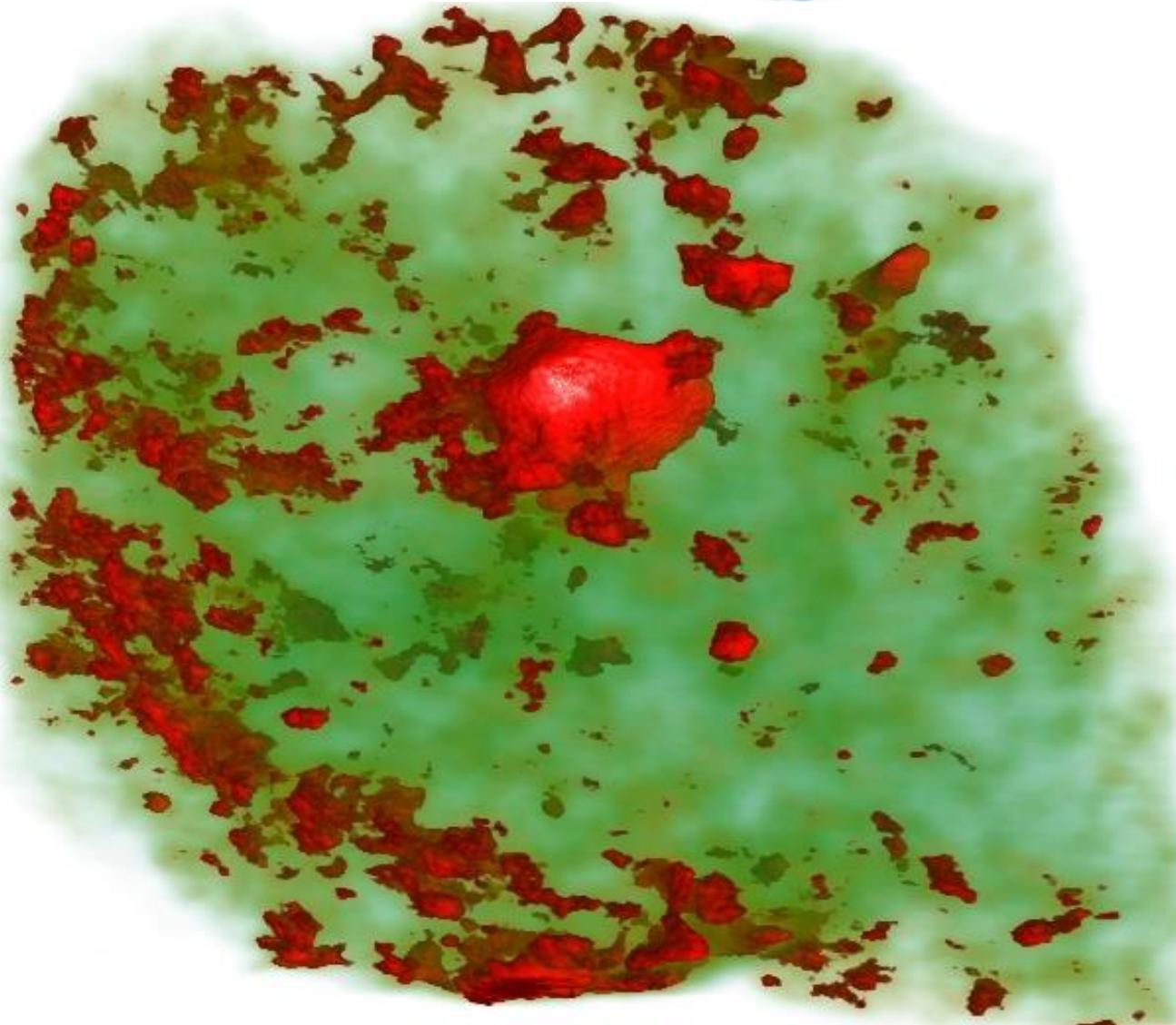
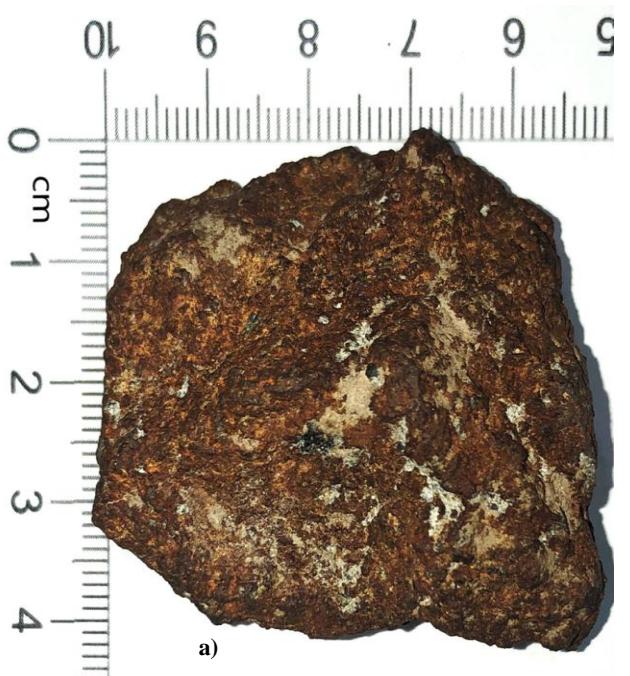




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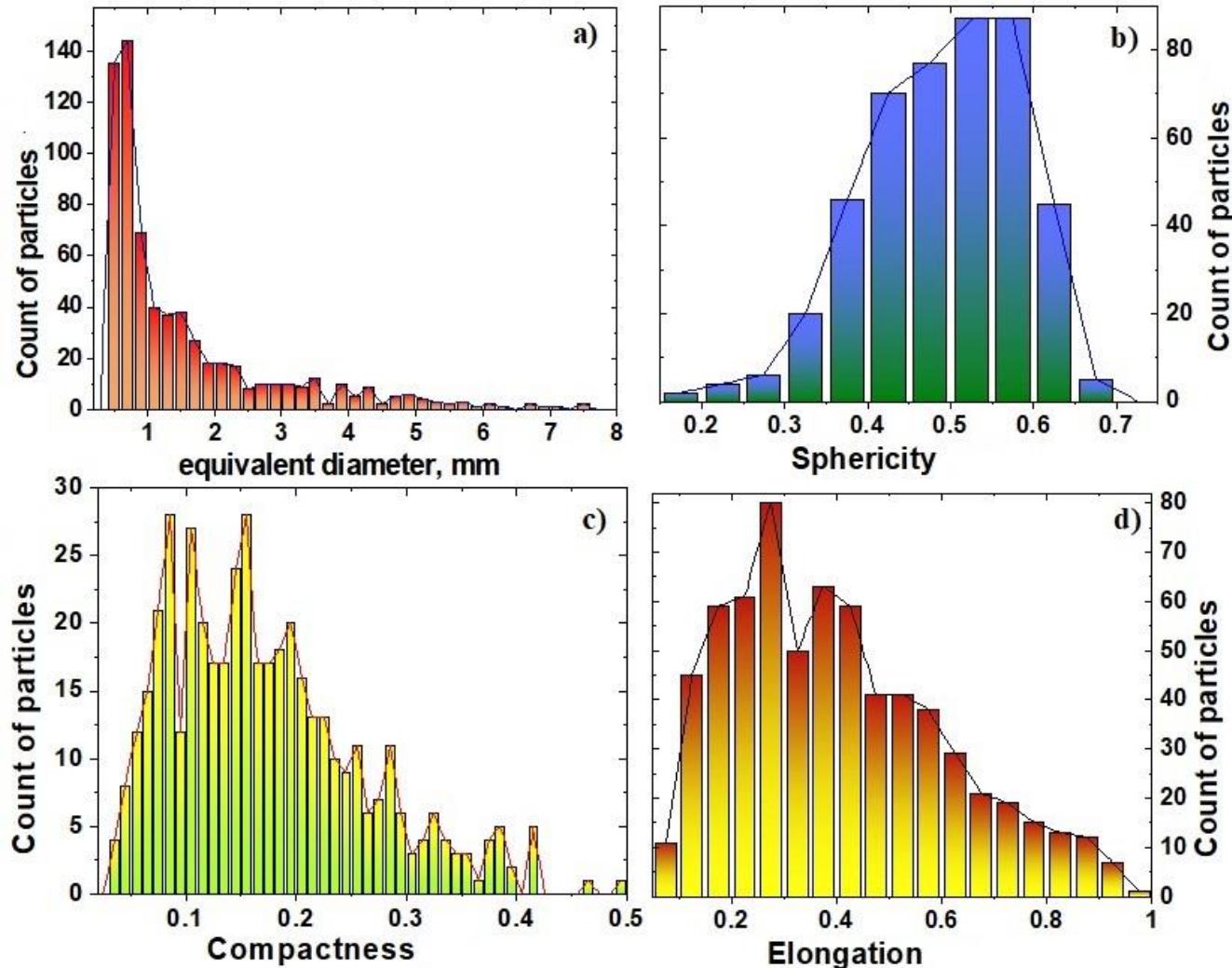
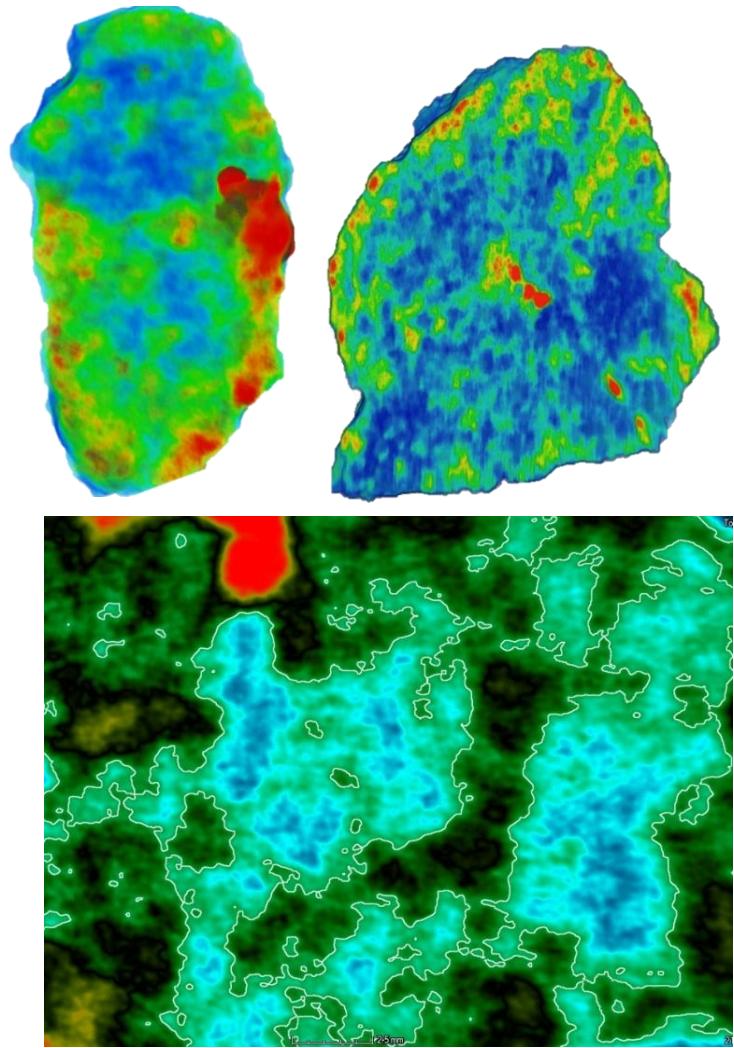


Zel I. Yu., Kenessarin M., Kichanov S.E., Balasoiu M., Kozlenko D.P., Nazarov K., Nicu M., Ionascu L., Dragolici A.C., Dragolici F. "Spatial distribution of graphite in cement materials used for radioactive waste conditioning: An approach to analysis of neutron tomography data", Cement and Concrete Composites, 119 (2021) 103993





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Kichanov, S.E., Abdurakhimov, B.A., Zel, I.Y., Kirillov, A.K., Kozlenko, D.P., Lapina, I.K. and Mentsin, Y.L. (2022), The structural analysis of Kunya-Urgench chondrite: The nondestructive neutron studies. Meteorit Planet Sci, 57: 1836-1845.



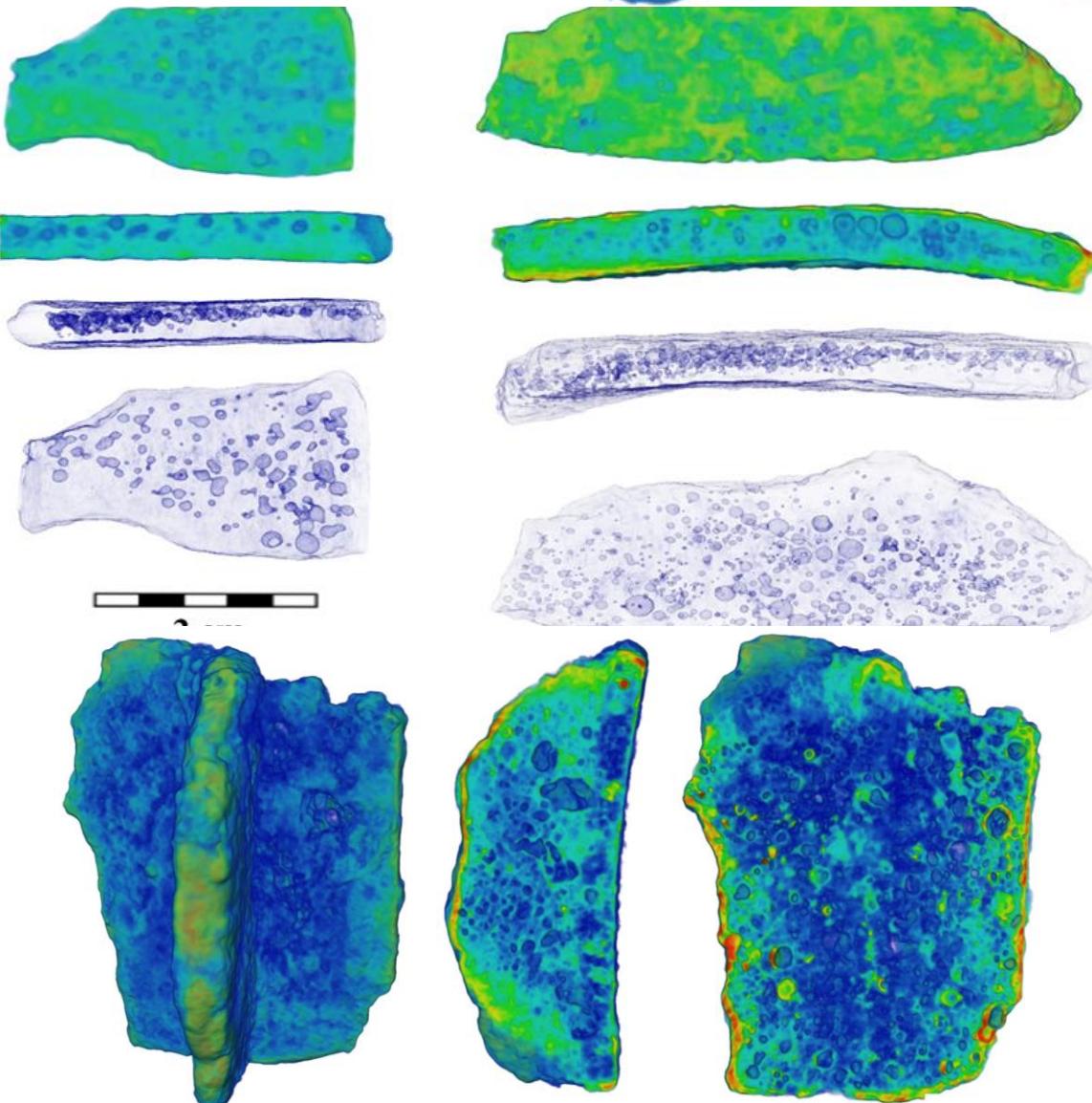
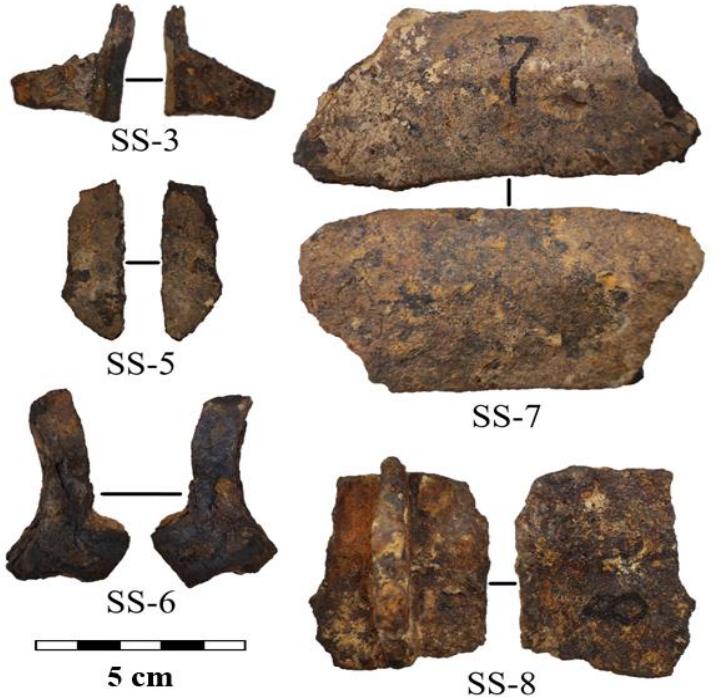
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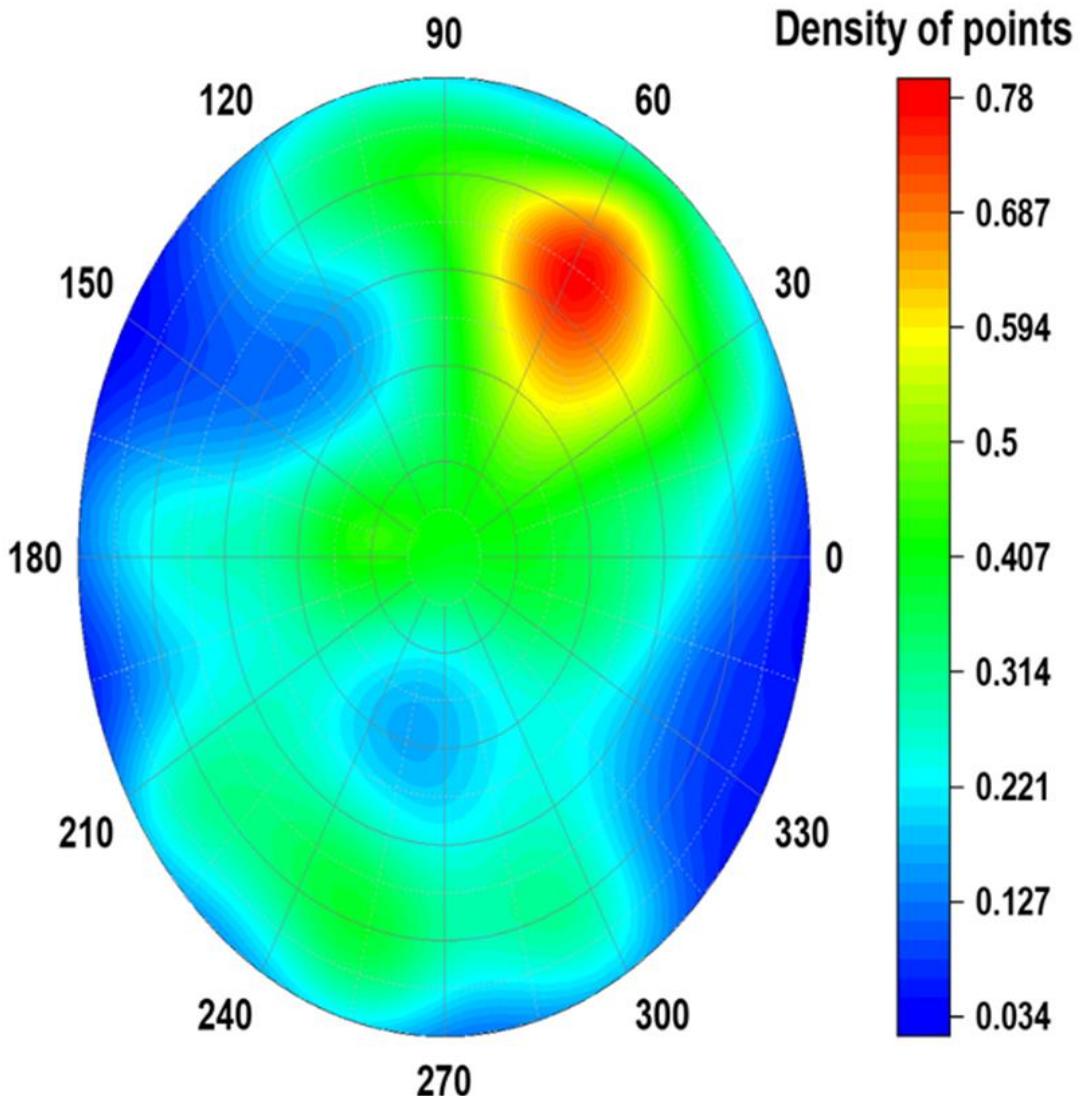
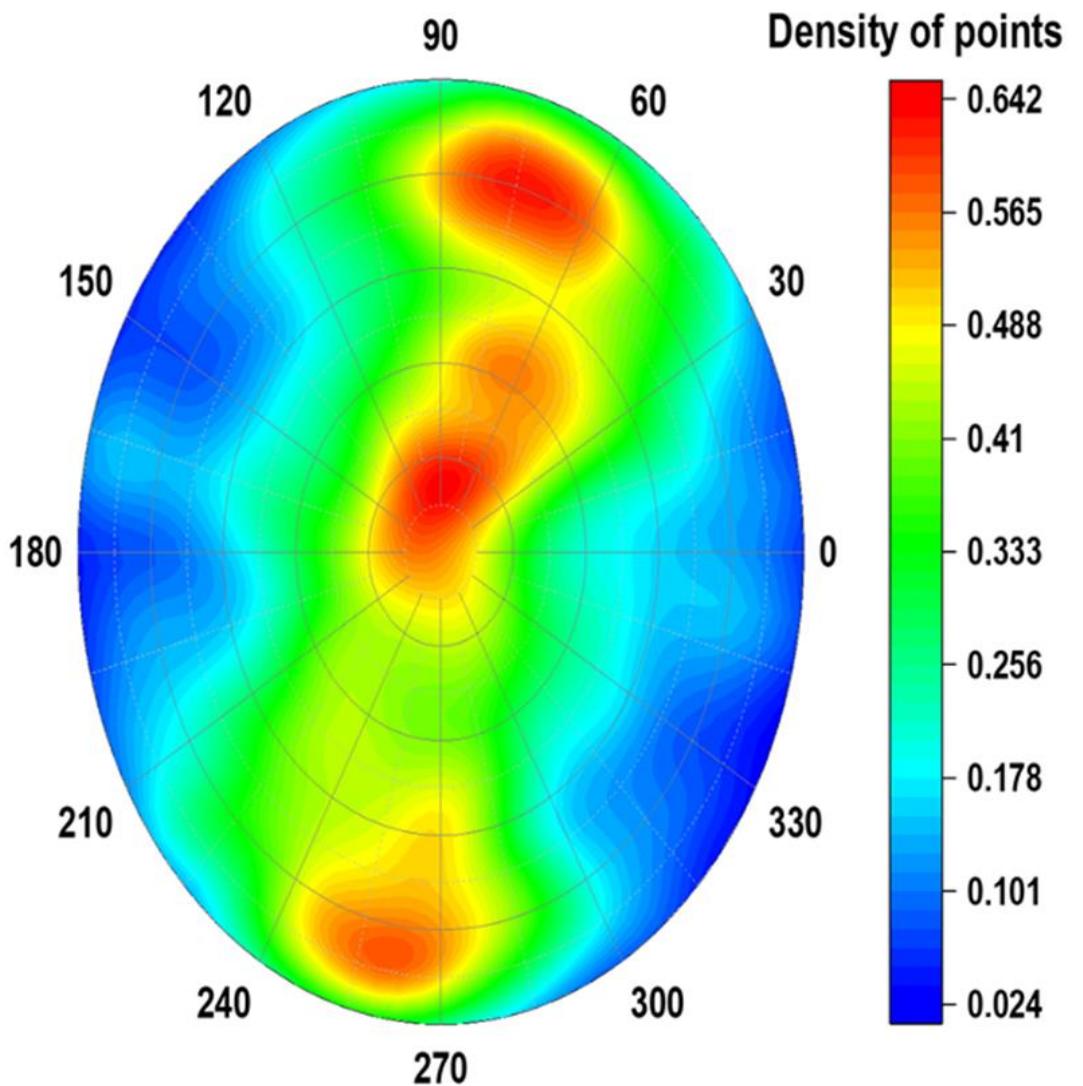


Bolgar



Saray-Batu







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**Denis Kozlenko**

**Evgenii Lukin**

**Boris Savenko**

**Natalia Golosova**

**Nadezhda Belozerova**

**Ivan Zel**

**Maria Balasoiu**

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**Asif Asadov**

**Saule Dyussembekova**

**Olga Lis**

**Gumar Aydanov**



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**Thank you for your attention**