Expectations from the customer (science associated with nuclear industry)

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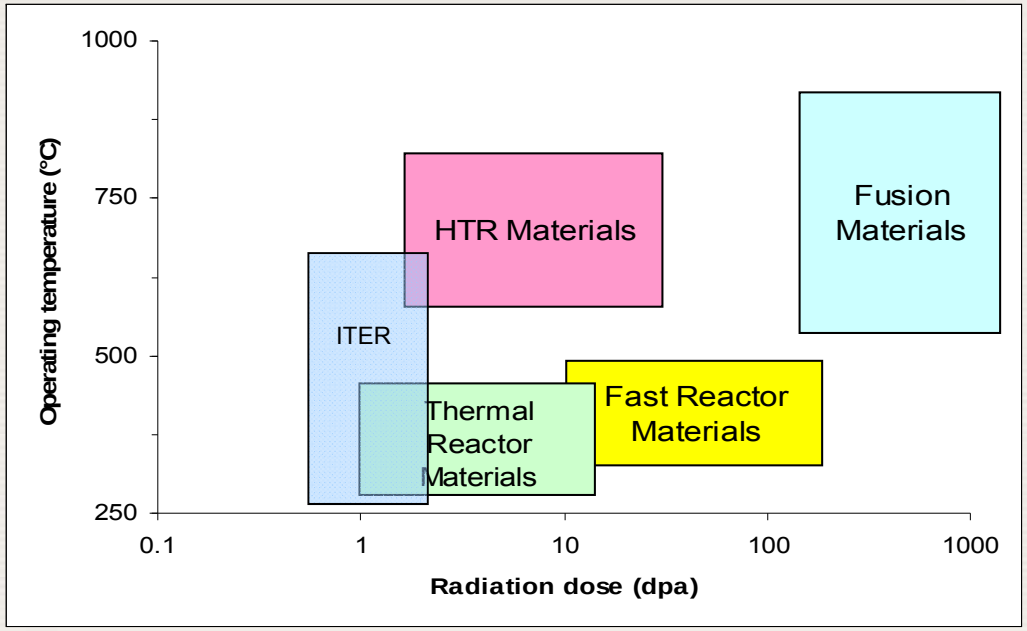
IAEA
International Atomic Energy Agency

TM on PRD, Vienna, October 2012

Need to simulate and model high-dose effects



Nuclear Technology Review, IAEA, Vienna, 2007

Reasons:

- Economically driven growth of burn-up and operational requirements
- Introduction of new fuels for advanced nuclear systems
- Insufficient basic understanding of radiation damage mechanisms

Objectives:

- enhancement of simulation capabilities for high-dose materials testing
- better physical understanding of high-dose radiation effects

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CRP FUMEX-3 (2008-2011) as a part of fuel modelling programme (1981-1985, 1993-1996, 2001-2006)

34 organizations from 21 countries

Argentina	2	India	1
Belgium	1	Italy	2
Brazil	2	Japan	3
Bulgaria	2	Korea	1
Canada	1	Romania	1
China	3	Russia	2
Czech Rep	1	Switzerland	1
Finland	1	UK	2
Germany	2	Ukraine	1
Germ/France	1	US	2
Hungary	1	ITU/JRC/EC	1

- Data from Halden Reactor Project (Norway) and from CRP participants,
- NEA-IAEA Int'l Fuel Performance Experimental (IFPE) Database

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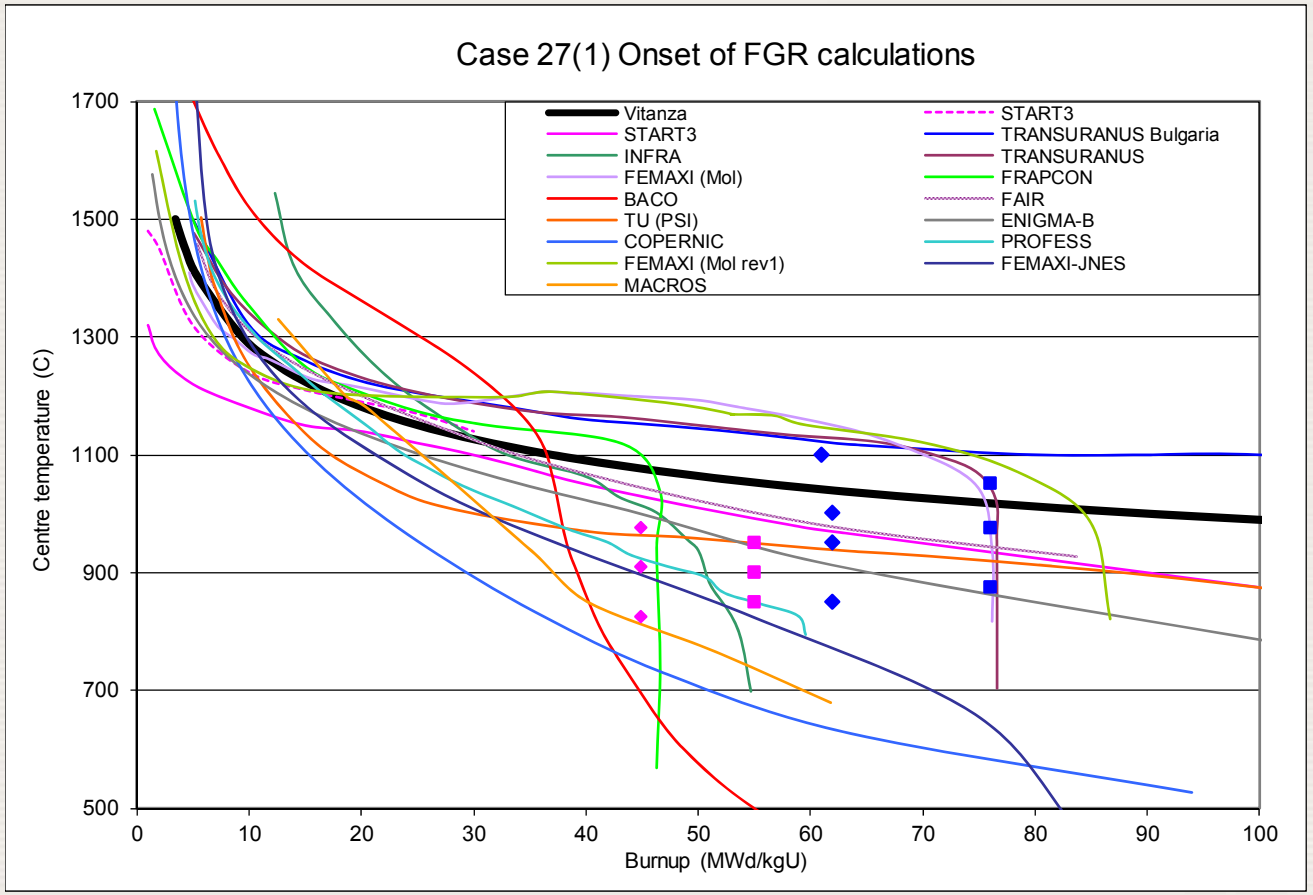
CRP FUMEX: fission gas release prediction as an example



Vitanza threshold - the T^0C of 1% FGR, experimentally derived up to around 40 GWd/tU

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CRP "Accelerator simulation and theoretical modelling of radiation effects" (SMoRE)

1. Belgium: SCK.CEN (L. Malerba) – Fe-Cr potentials, their use in MD and MC, EPA experiments;
2. China: CIAE (Sh. Zhu) – CLAM irradiation up to 85 dpa, temp. effects, tripple beam H/He synergy;
3. France: CEA (F. Willaime), EdF (G. Monnet) – MSM in Fe, Fe-Cr, ODS, Jannus tripple beam, DD;
4. India: BARC (P. V. Durgaprasad) – MD, DD in Fe, Fe-Cr, small-punch tests of T91;
5. Japan: Kyoto University (A. Kimura) – Al-added-ODS, phase stability, He-trapping, dual beam;
6. Kazakhstan: INP (O. Maksimkin) – F/M and AS, comparison with BN-350, martensite degradation;
7. Korea, Rep: KAERI (J. Kwon) – MD, DD in F/M steels, with TEM, atom probe, EPA, nano-identation;
8. Netherlands: JRC-Petten (L. Debarberis) – Fe-Cr ODSs (non-irradiated), EPA, SANS, TEP, TEM;
9. Poland: IAE (W. Szteke) – small-punch testing of non-irradiated AS;
10. Russia: IPPE (V. Pechenkin), Kurchatov Institute (A. Ryazanov) – F/M steels, neutrons, MSM, RIS;
11. Slovakia: Bratislava University (V. Slugen) – ODS MA956, ODM751and Eurofer micro-comparisons;
12. Spain: Madrid University, Institute of Fusion (J. Perlado) – Fe-Cr potentials, defect formation energies;
13. Switzerland: PSI (M. Pouchon) – micro-pillar nano-identation, single-grain analysis and modelling;
14. Ukraine: KIPT (V. Voyevodin) – super-high-dose irradiation of F/M steels, comparisons, modelling;
15. USA: LLNL (M. Fluss), LANL/UCB (P. Hosemann) – ODS MA956, MA957 and K3; micro-studies;
    Rad. Effects Consulting (F. Garner) – chief consultant of the project;

NEA / OECD – observer, with many participating members, discussions at WPMM.

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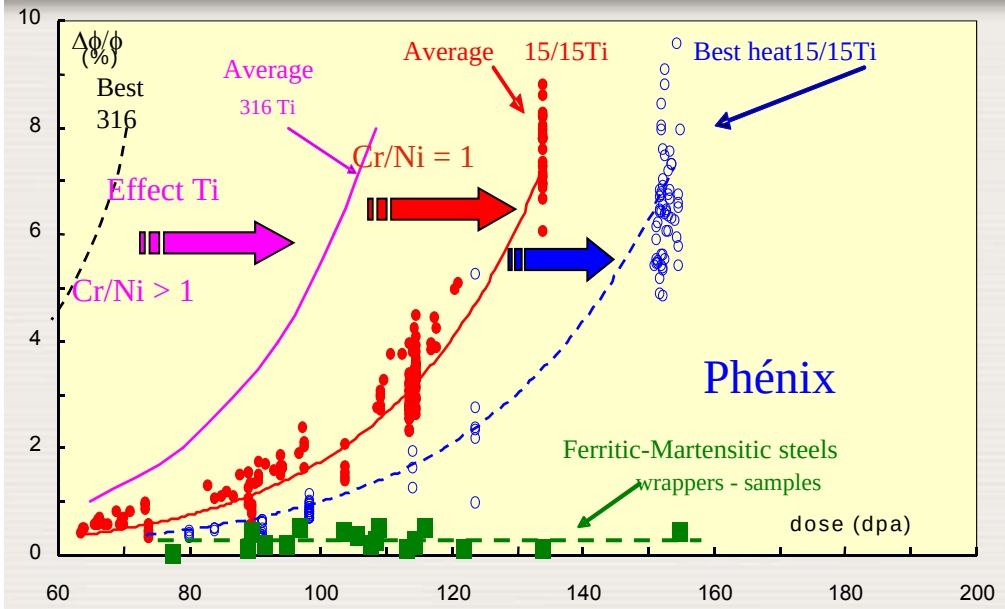
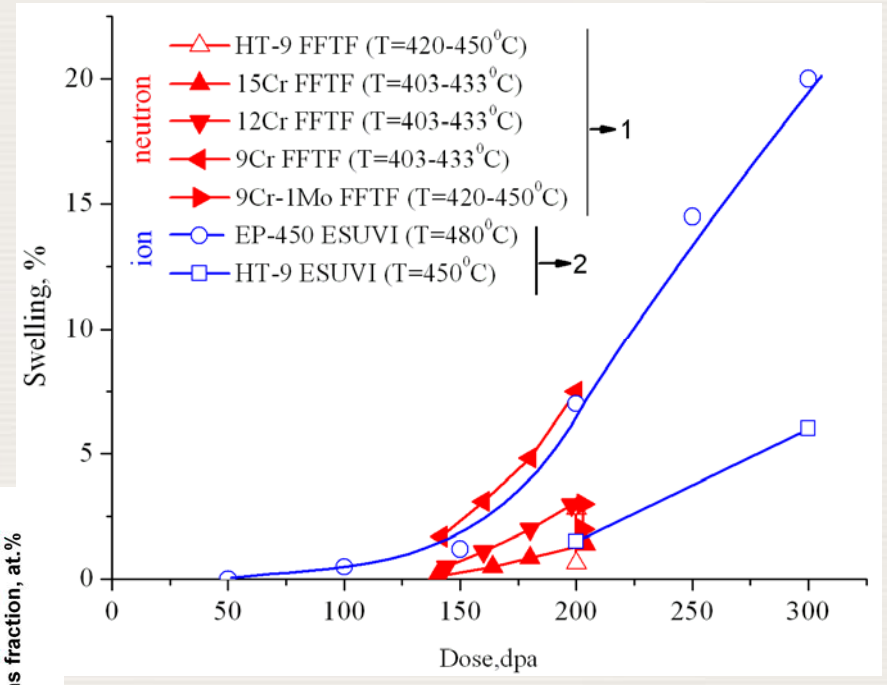
SMoRE: DO ferritic-martensitic steels NOT swell? …

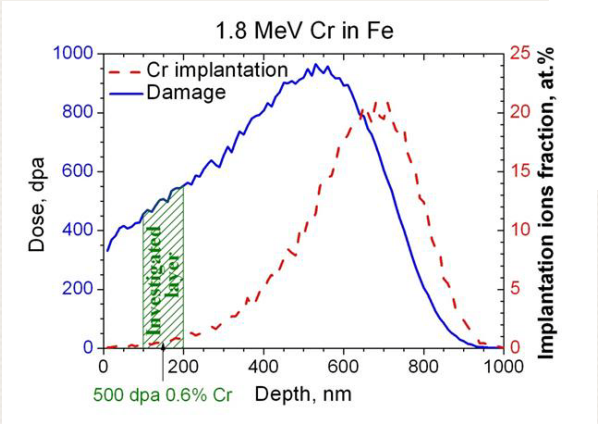


Ph. Dubuisson, CEA, France

IAEA TM on Design, Manufacturing and Irradiation Behaviour of Fast reactors Fuels, 30 May – 03 June 2011, Obninsk, Russia



Voyevodin et al, KIPT, Ukraine



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… and can Oxide Dispersion Strengthening help? (CRP on ODS Benchmarking)

Objectives : 1) to review different technologies of ODS steels fabrication,
2) to assess and characterize ODSs structures and performance,
3) to contribute to better understanding of ODSs operational properties and limits.

16 countries, JRC and JINR:

Australia – ANSTO
China –CIAE & Beijing University
Czech Rep – NRI REZ
France – CEA
Germany – KIT & HZDR
India – IGCAR
Italy – ENEA
Japan – Kyoto University
Korea Rep – KAERI
Netherlands – NRG & JRC
Romania – INR
Russia – Bochvar Institute VNIINM & JINR
Slovakia – Bratislava University
Spain – CIEMAT
Ukraine – Physico-Mechanical Institute
USA – LLNL & ORNL

Research Coordination Meetings (RCM):
RCM-1 May 2011 in Vienna / IAEA (test matrix of materials and methods)
RCM-2 October 2012 in Roma / ENEA (intermediate results)
RCM-3 Q1 2014

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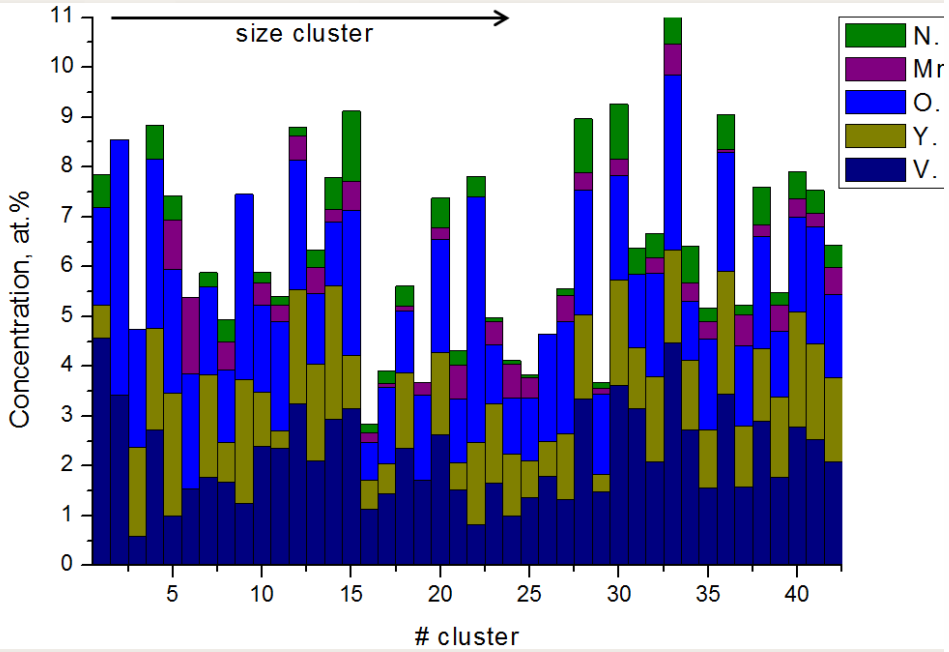
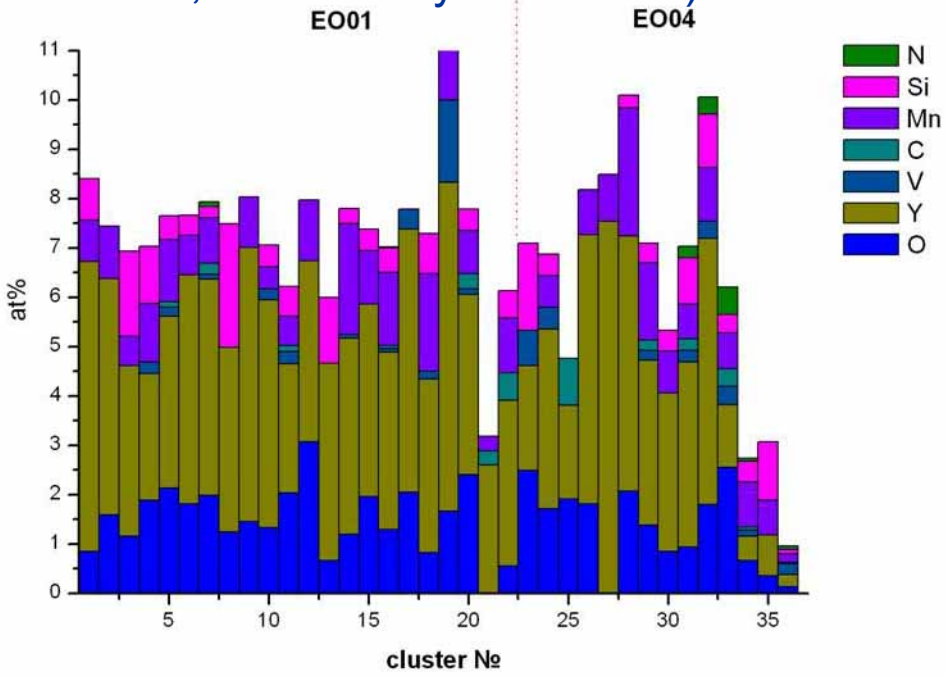
Clusters composition in ODS EUROFER un-irradiated and irradiated in BOR-60 (atom probe)

Material	C	Si	Mn	Cr	B	N	V	W	Ta	Y	O
0.5% (w) Y_2O_3	0,51	0,16	0,38	9,65	0,0	0,03	0,21	0,33	0,27	0,25	0,37

Mechanical alloying the master steel with yttria, hot isostatic pressing (1000ºC, 100Mpa) and two-step heat treatment (980°C/30 min, followed by 760°C/2 h)

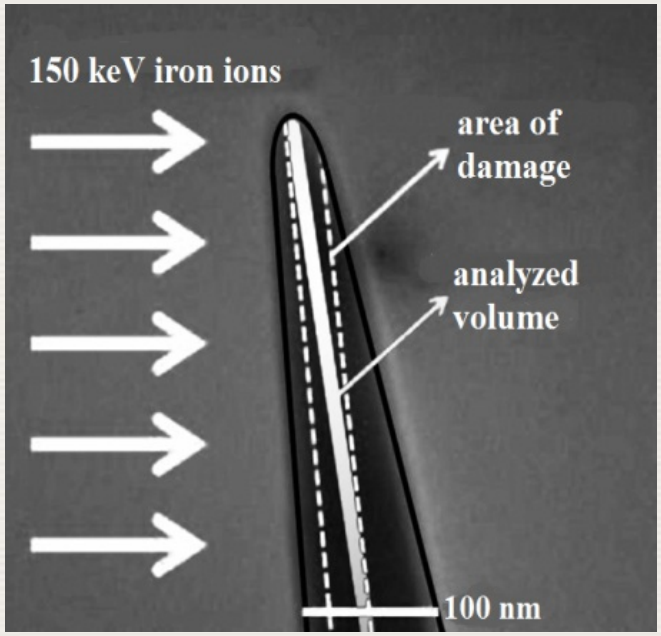


un-irradiated

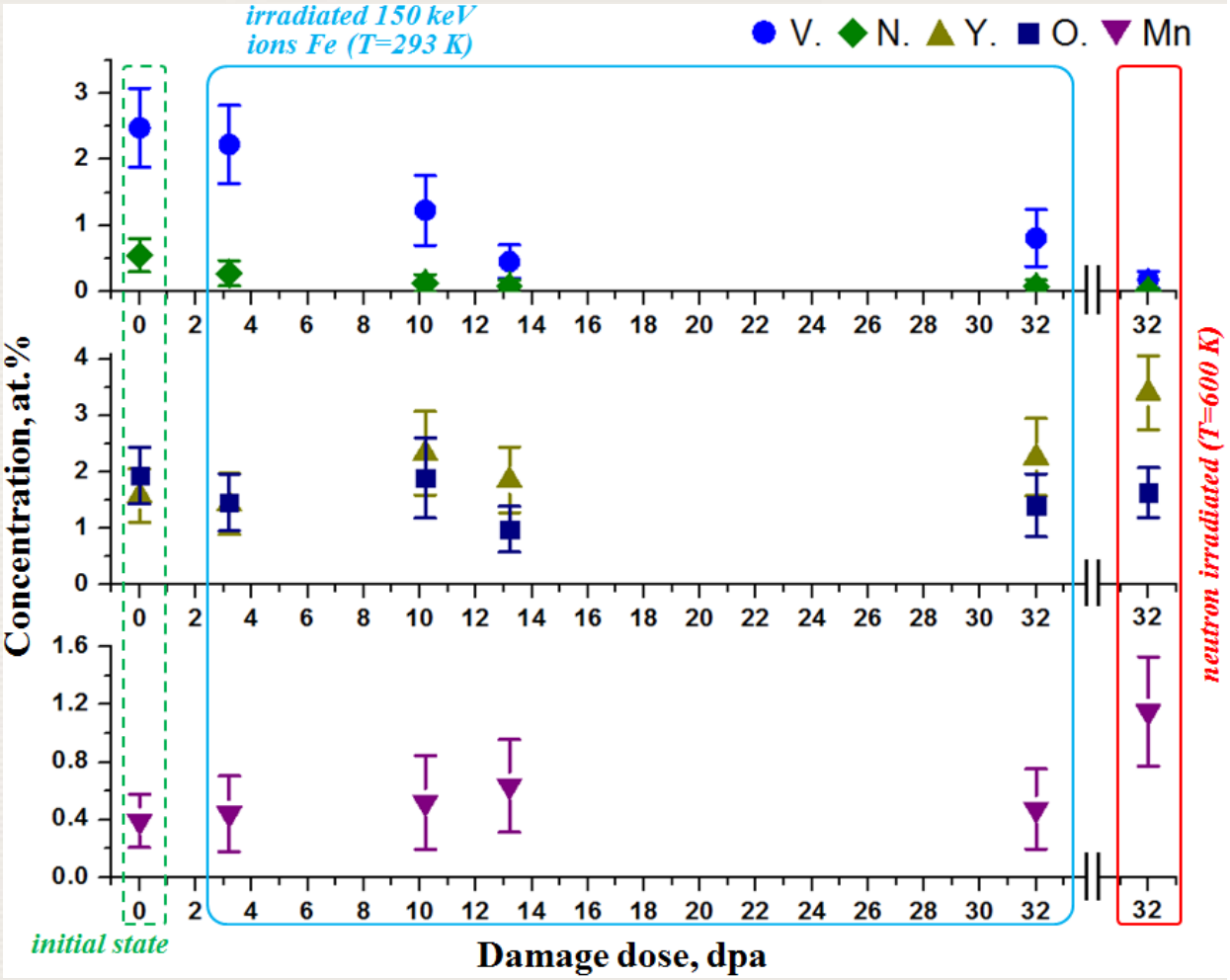


irradiated 32 dpa, V-Y-O-N → Y-O-Mn

Comparison of clusters in ODS EUROFER un-irradiated and ion-irradiated (atom probe)



Experimental set-up for
Fe ion irradiation of a sample
for atomic probe tomography



S. Rogozhkin, XX Alushta, September 2012