Radiotracers for micro-measurement of wear (Thin Layer Activation)

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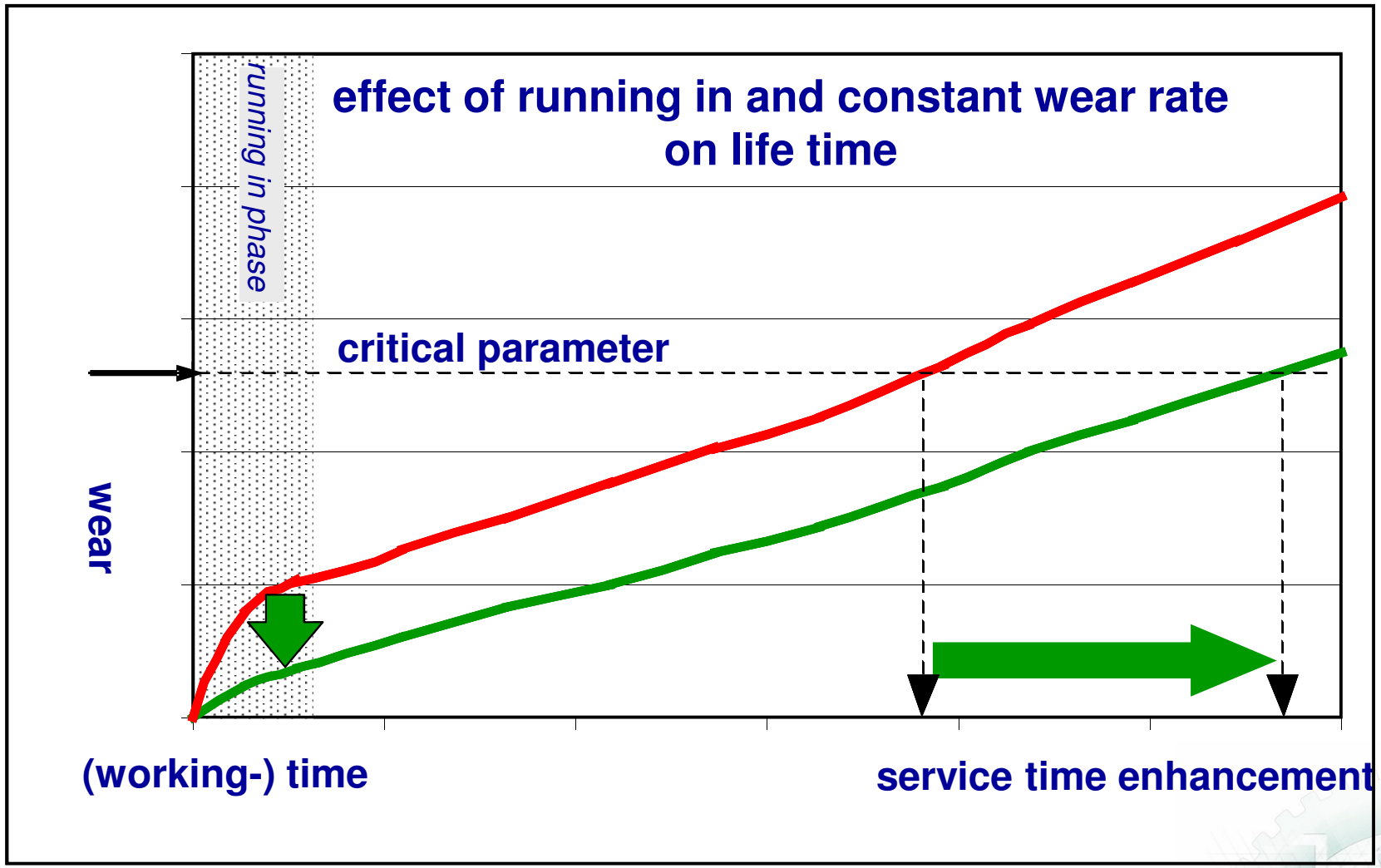
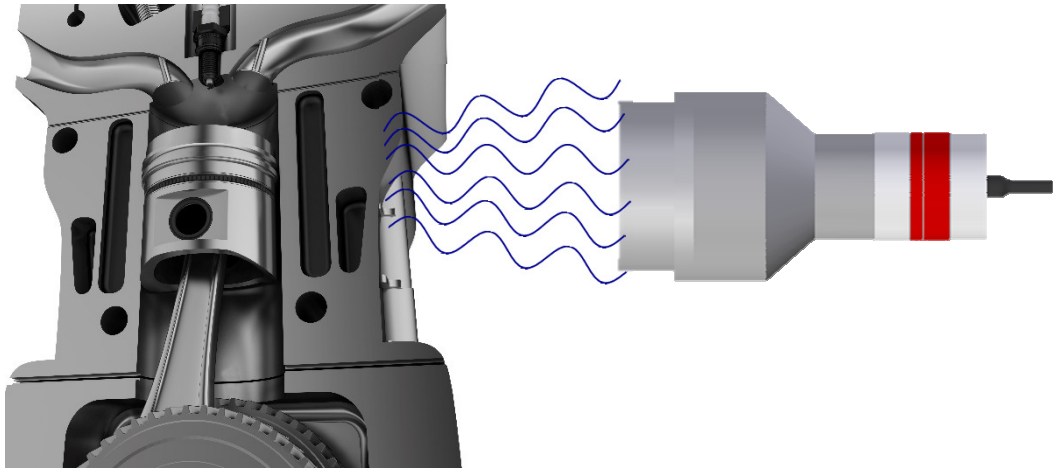
International Atomic Energy Agency Scientific Forum
ATOMS IN INDUSTRY
Radiation Technology for Development
15–16 September 2015, Vienna, Austria

Reduction of wear for increasing service time

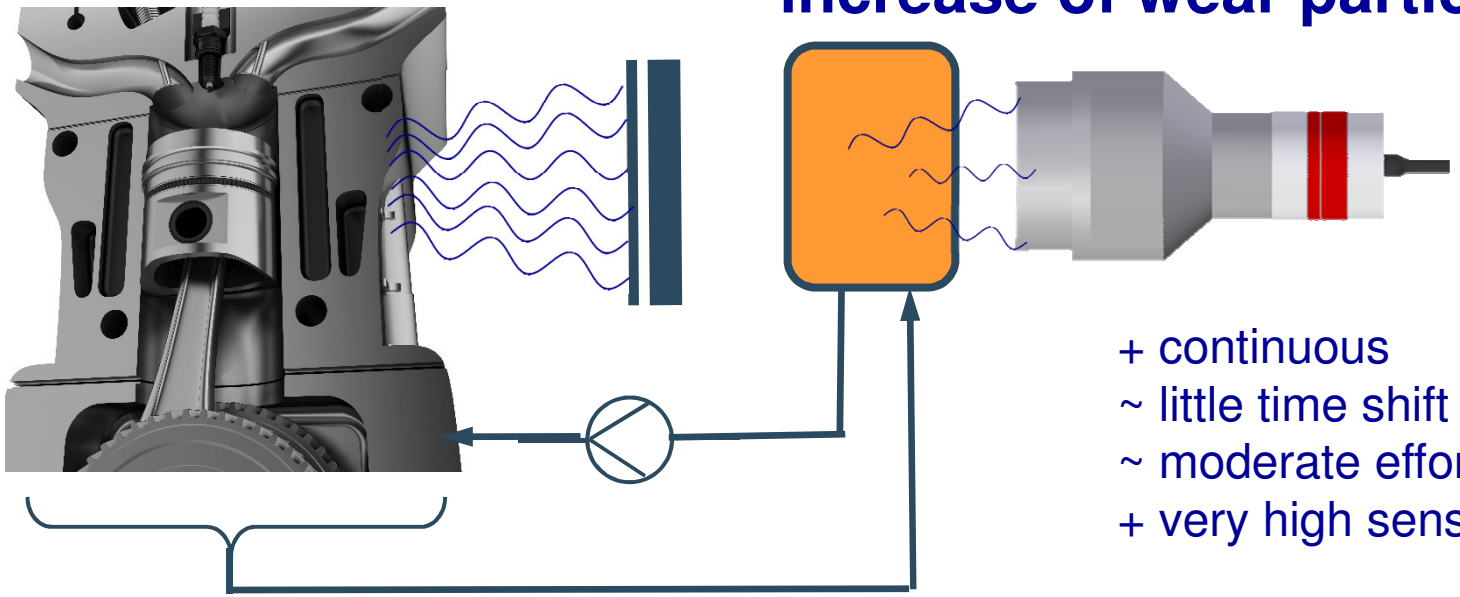


Direct measurement – loss of activity of specimen



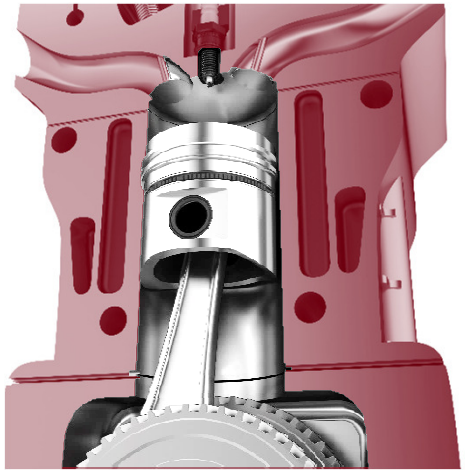
+ continuous
+ real time
+ easy to install
~ good sensitivity

Indirect measurement – tracer technology increase of wear particles in oil



+ continuous
~ little time shift with oil transport
~ moderate effort to install
+ very high sensitivity

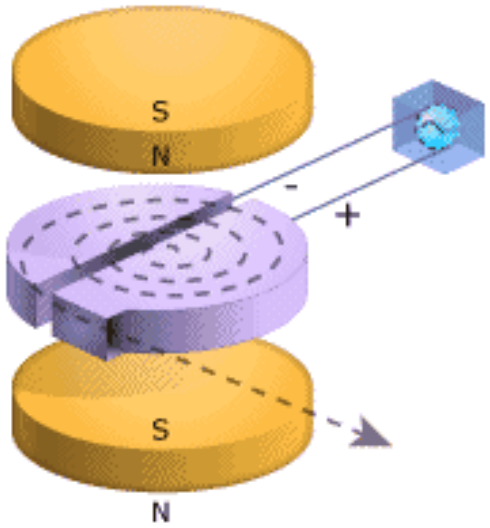
Bulk activation

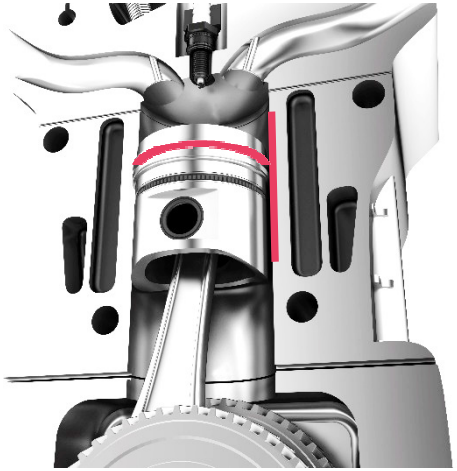


Whole component irradiated with neutrons in nuclear reactor

+ high number of gainable isotopes
~ easier wear calculation due to constant concentration
- handling and waste

Thin layer or surface layer activation (TLA / SLA)

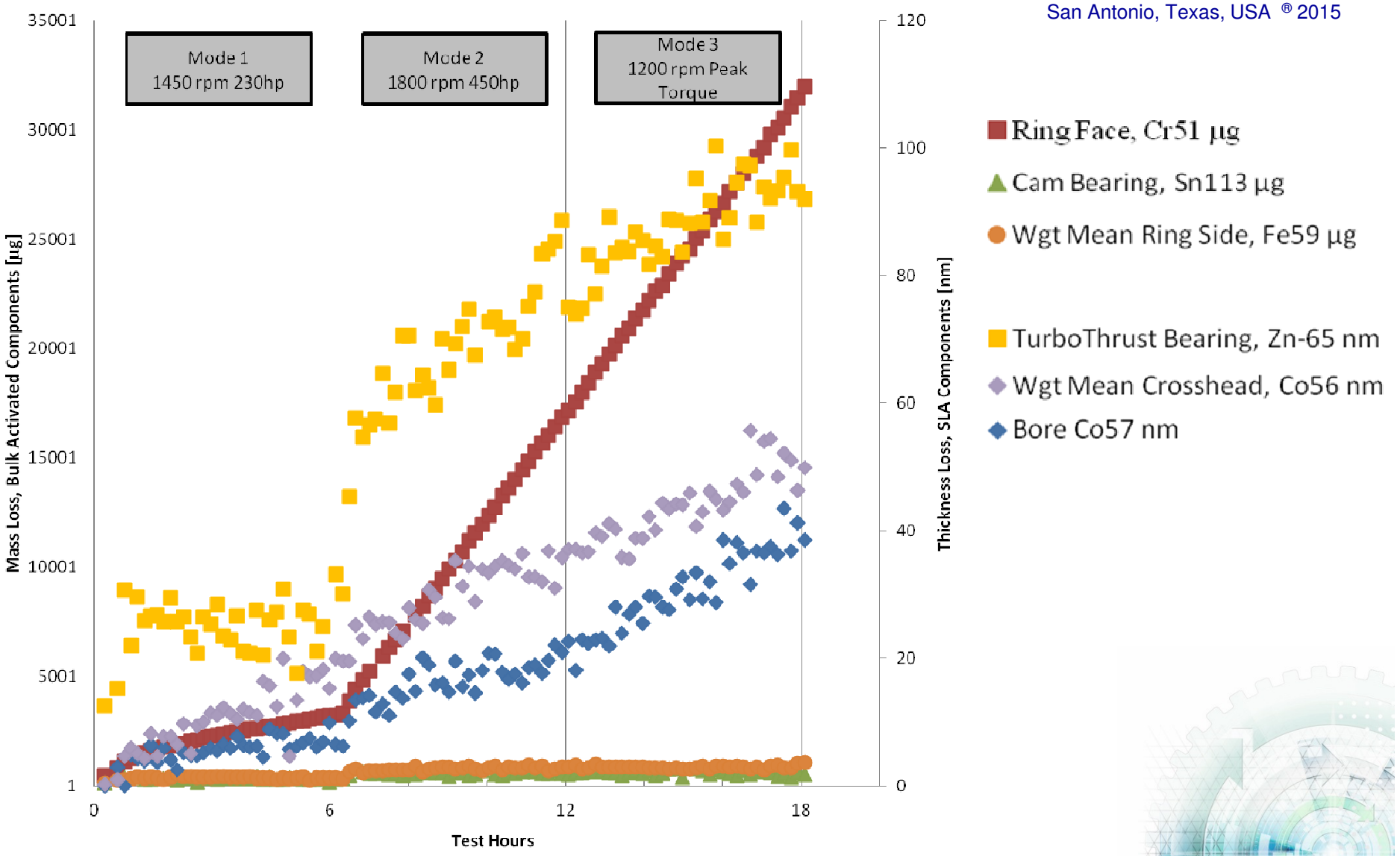




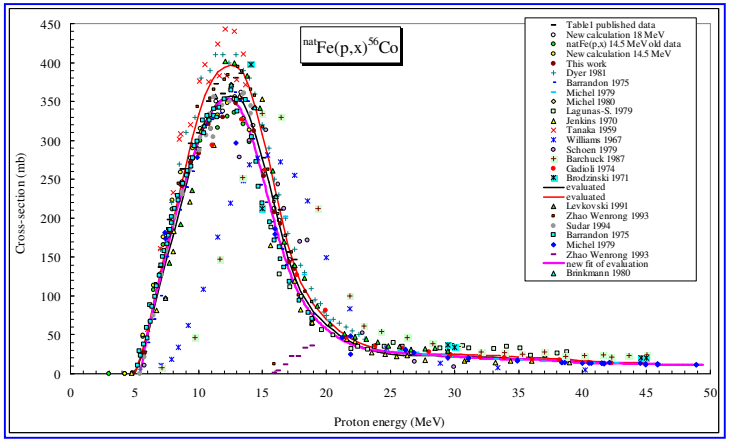
Surface of component irradiated by ions (protons or deuterons) in cyclotron

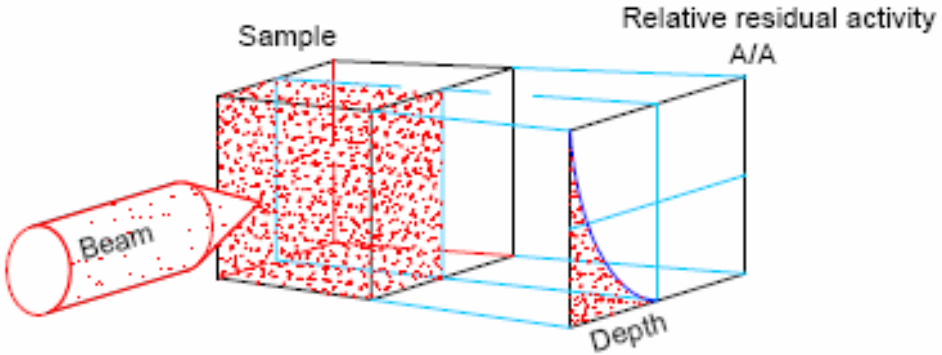
+ activity, where wear happens
-> higher sensitivity
+ selection of isotopes by beam parameters

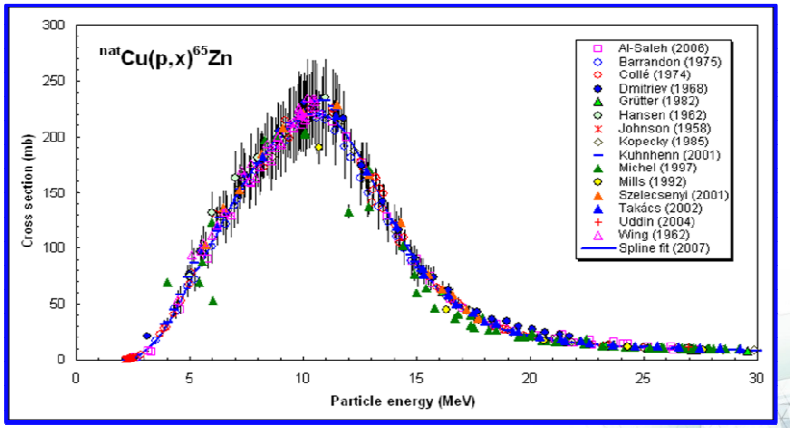
Bulk and Surface Layer Activation (SLA) Heavy Duty On-Highway Cycle



TLA – irradiation and gained isotopes







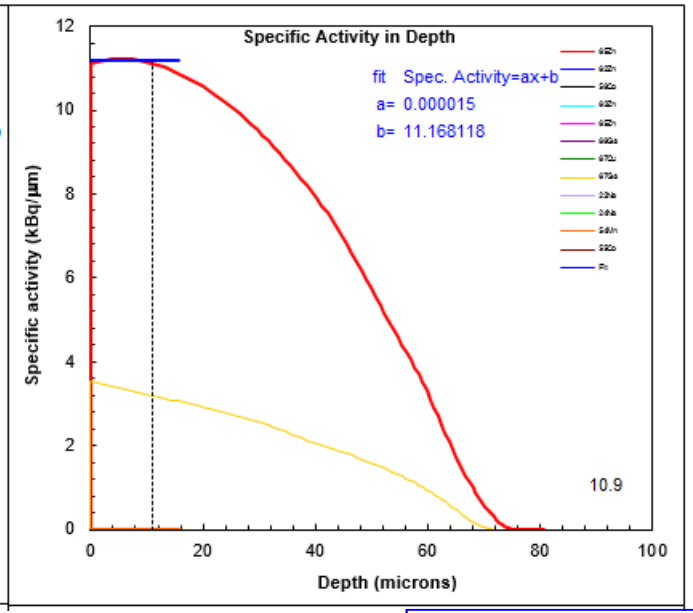
T.Sauvage, L.Vincent, G.Blondiaux

TLA2L – free tool for calculating gained isotopes and depth profile

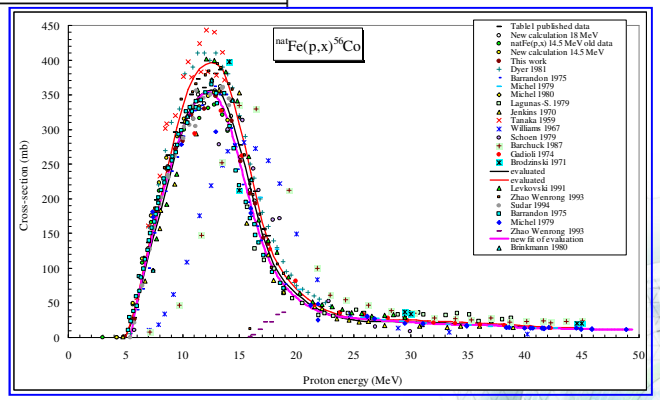
Developed 2010 by S. Takacs,
Atomki, Debrecen, Hungary

Public resource https://www-nds.iaea.org/tla/

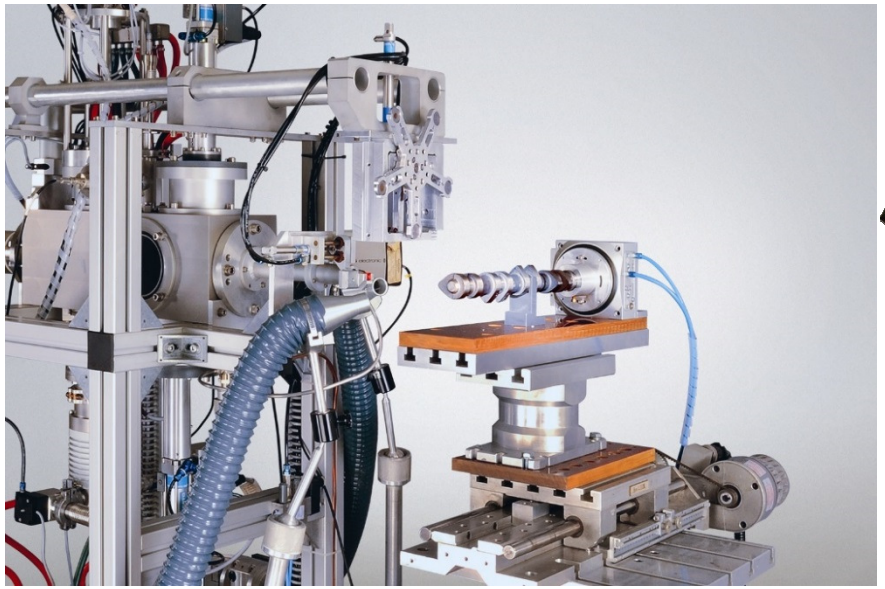
proton			
Main reaction	natCu(p,x)65Zn		
Mode	Constant		
Irradiation time	2.300		h
Beam current and counts (10uA scale)	2	16560	µA (counts)
Geometry factor	0.818		abs
Tolerance	1		%
Irradiation angle	15		degree
Selected on surface bombarding energy			MeV
Suggested bombarding energy	11		MeV
Matrix density	7.98		g/cm3
Matrix component 1	Cu	64.29	weight %
component 2	Zn	21.24	weight %
component 3	Al	7.86	weight %
component 4	Mn	3.74	weight %
component 5	Fe	2.87	weight %
component 6			weight %
component 7			weight %
component 8			weight %
component 9			weight %
component 10			weight %
total	100		

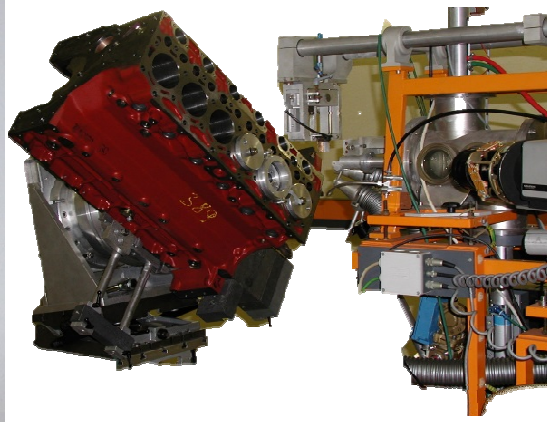


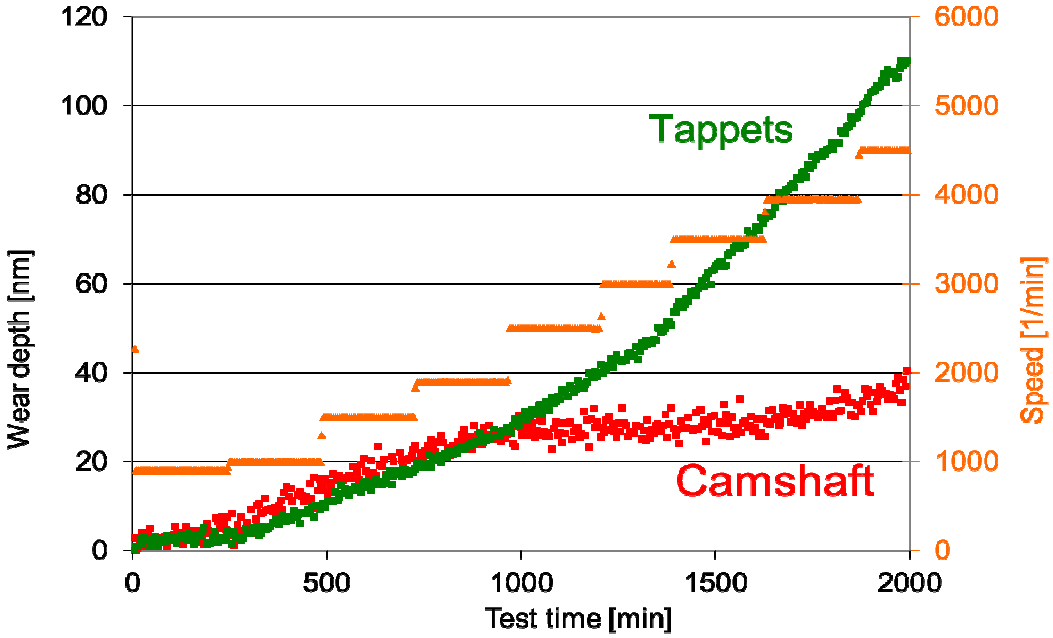
+ use in MS Excel XP or higher
+ provides specific activity in depth
+ contains database of known reactions
+ contains database of
  corresponding cross-sections

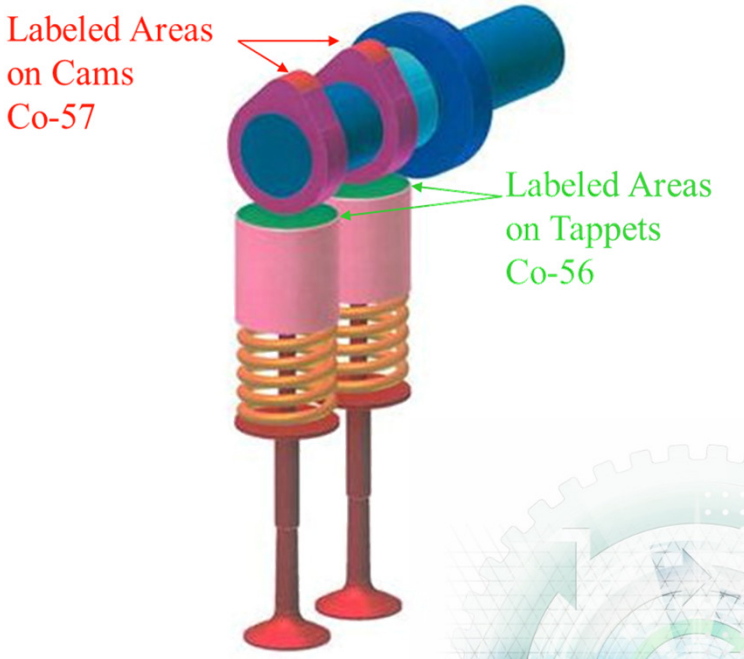


Cam and tappet wear measurement









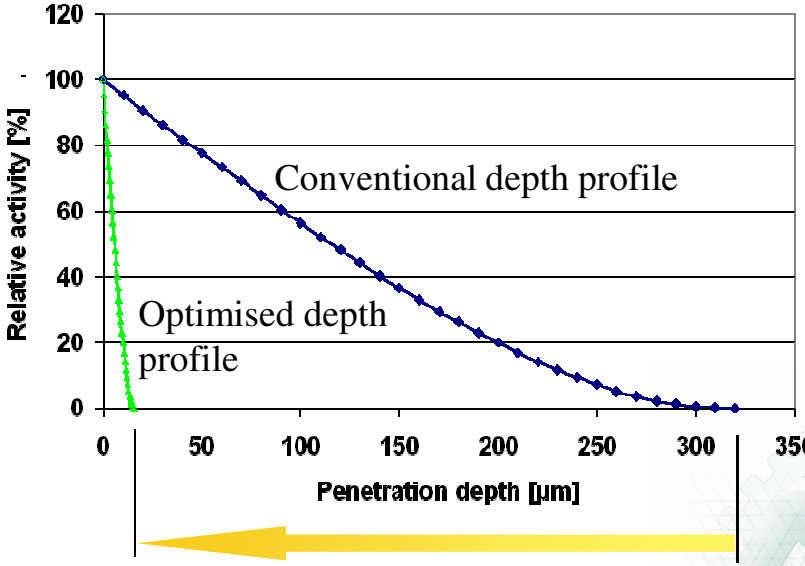
Free Handling Limit (Council Directive 96/29/EURATOM)

Pros:

- Lower activities (environment, personal, waste handling)
- No license is needed
- Easier, cheaper delivery and storage
- Cheaper activation (shorter beam time)
- Better public acceptance

Cons:

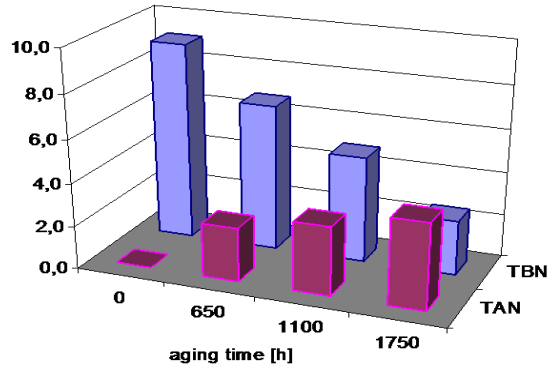
- High accuracy only in combination with TLA (activity in surface layer)

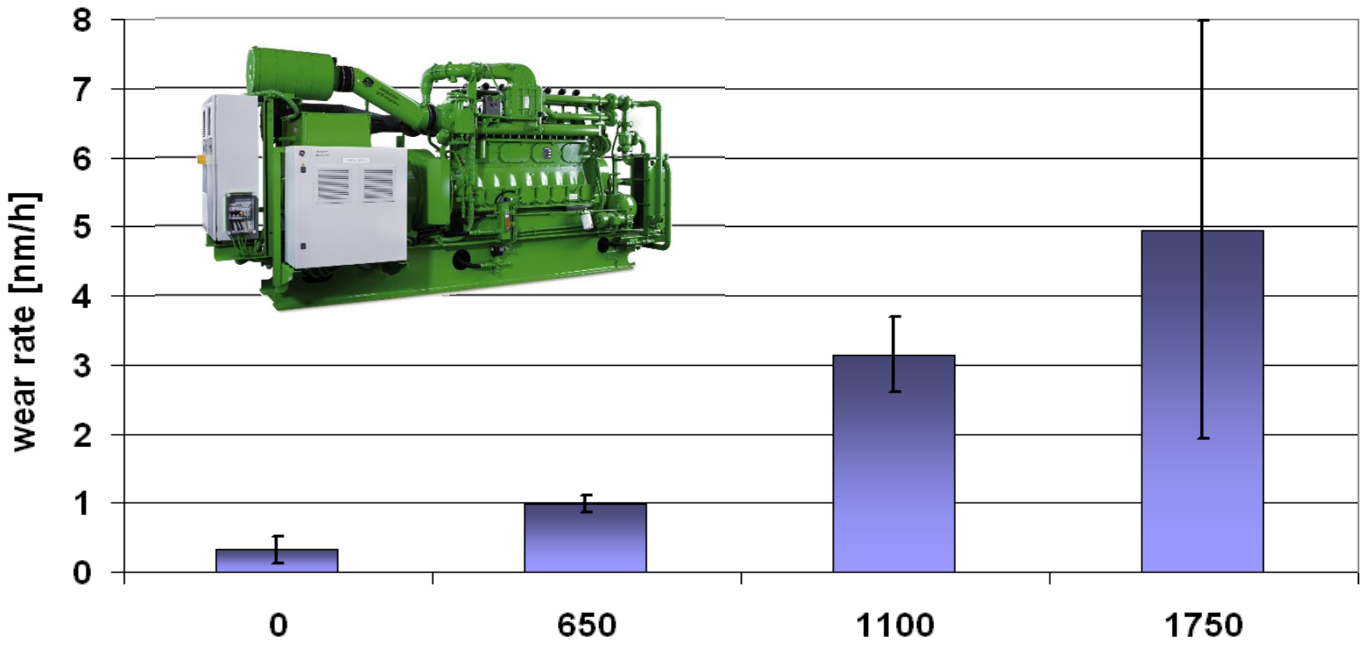


Jech M., et al.: wear measurement at nanometer scale, Viennano'09

Wear of large gas engines affected by aging of engine oil

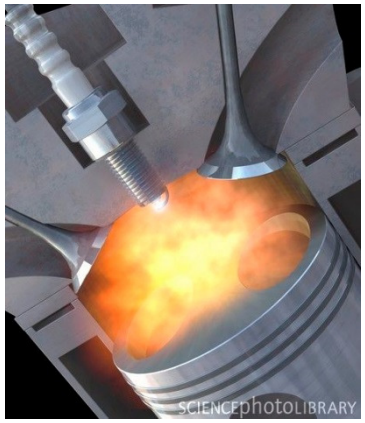
	Hours of use [h]
Lubricant 1	0
Lubricant 2	~650
Lubricant 3	~1100
Lubricant 4	~1750



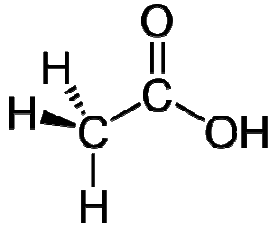


Jech M., Wopelka Th., Franek F.: nVCT - wear measurement at nanometer scale, Conference Proceedings, Viennano'09, Österreichische Tribologische Gesellschaft, 18.-20.03.2009, ISBN 978-3-901657-32-0, pp 115-120, 2009.

Wear of internal combustion engine affected by ethanol (bio) fuel

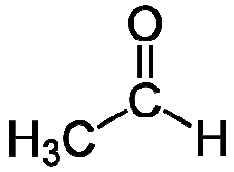


Fresh oil

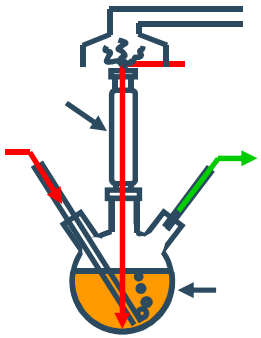


Acetic acid

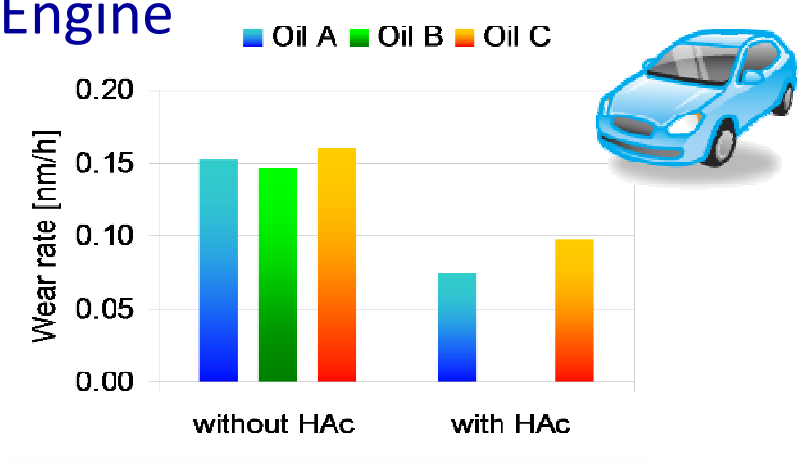
Acetaldehyde



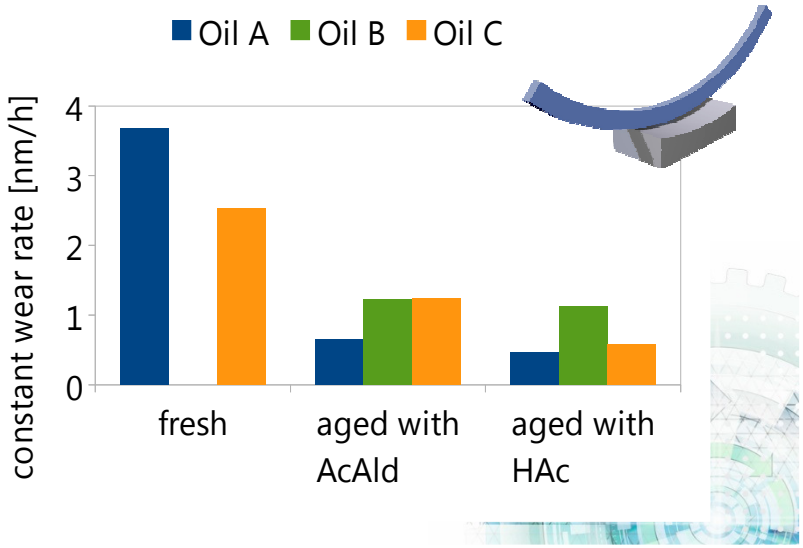
Artificial Aging



Engine



Tribometer



Radioactive isotopes for wear measurement

Production of radioactive isotopes through

- bulk activation
- thin layer activation (TLA, SLA)

Most used: indirect (tracer) measurement together with TLA

- wear of engine components: cylinder bore, piston ring, cam and tappet, bearings …
- investigation of effects influencing wear and corrosion
- monitoring of corrosion or wear at inaccessible places

Benefit

- well established real time wear measurement
- highest sensitivity of all measurement techniques (nm/h)
- continuous observation (monitoring of transients)

Thank you!