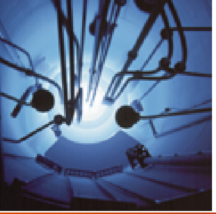

Institut für Kernchemie

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Actinide targets for superheavy element production

Klaus Eberhardt

University of Mainz, Germany

- Target production
- Target characterization
- New developments
- Future tasks

GSI

HELMHOLTZ Institut Mainz

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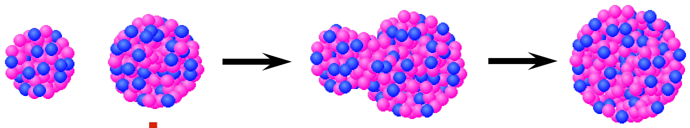
SHE production with actinide targets



- E114 ⇒ $^{244}Pu(^{48}Ca,xn)$
- E115 ⇒ $^{243}Am(^{48}Ca,xn)$
- E116 ⇒ $^{248}Cm(^{48}Ca,xn)$
- E117 ⇒ $^{249}Bk(^{48}Ca,xn)$
- E119 ⇒ $^{249}Bk(^{50}Ti,xn)$
- E120 ⇒ $^{248}Cm(^{54}Cr,xn)$
- E120 ⇒ $^{249}Cf(^{50}Ti,xn)$

Target thickness: 500 µg/cm^2

Requirements:

- Chemical purification prior to deposition (if necessary)
- Recovery of used target material (sooner or later……)
- Small and simple set-up
- High deposition yield

Target production techniques:

- Painting
- Sputtering (^{238}U)
- Molecular Plating

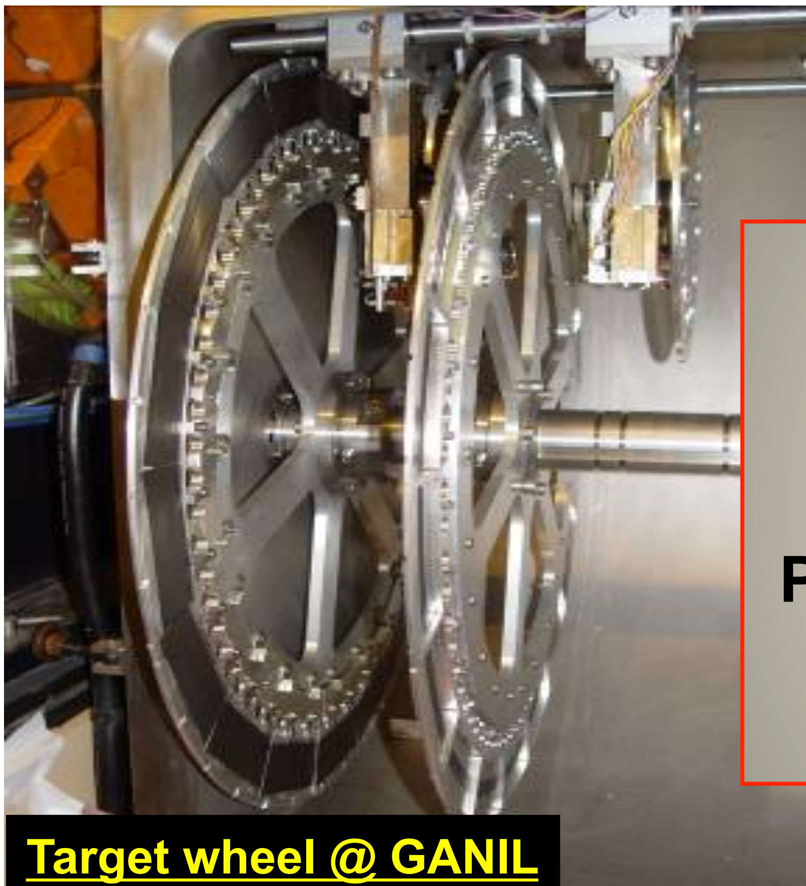
Rotating target wheels for high beam intensities

Backing:

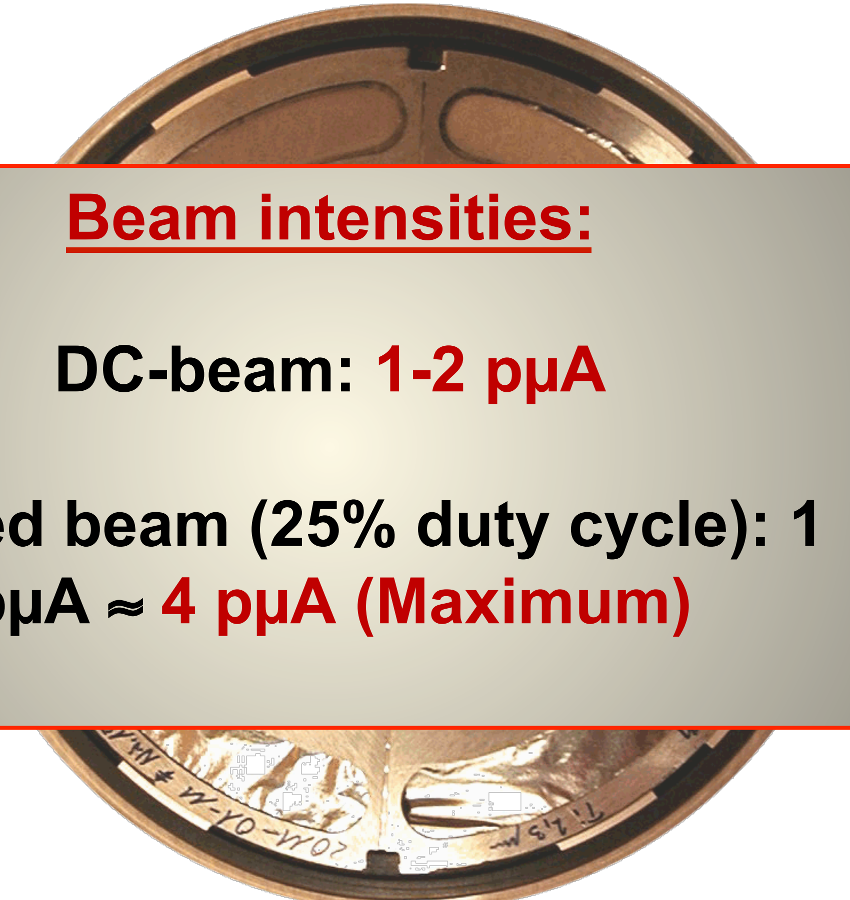
- Ti-foils (2 µm) or C-foils
- Foils are glued onto Al-frame

TASCA target wheel @ GSI:

- Target area: 6 cm^2
- 4 targets per wheel
- 12 mg per wheel @ 500 $\mu g/cm^2$



Target wheel @ GANIL

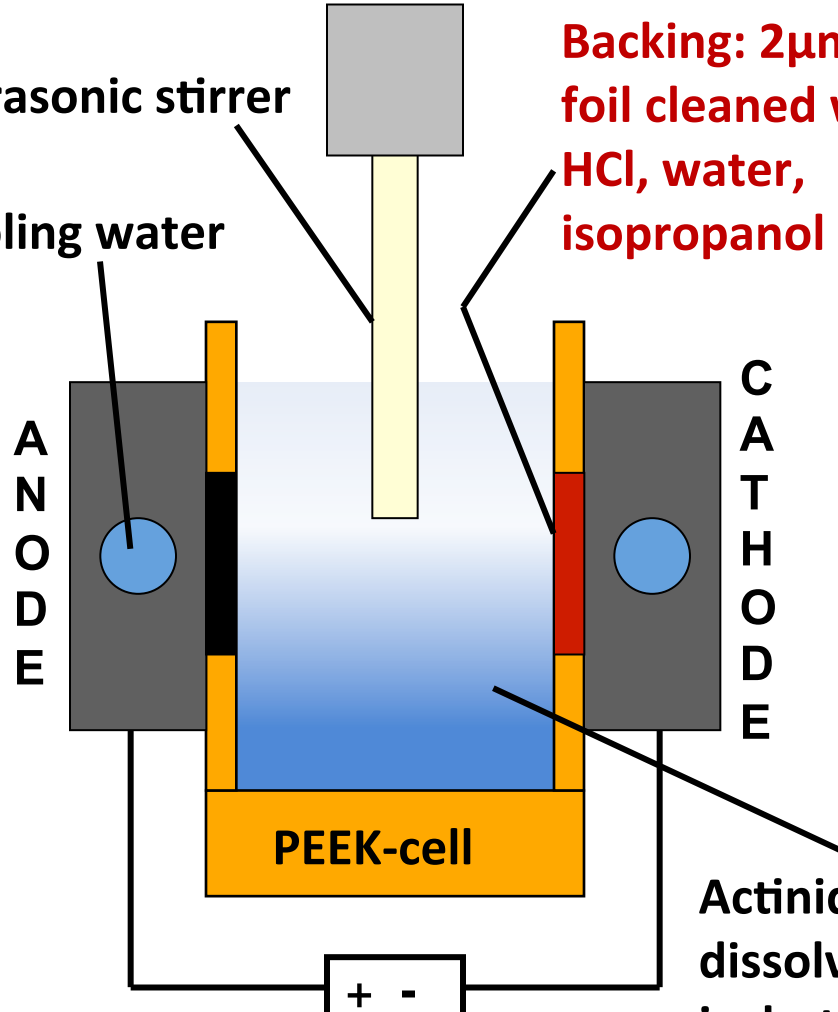


Beam intensities:

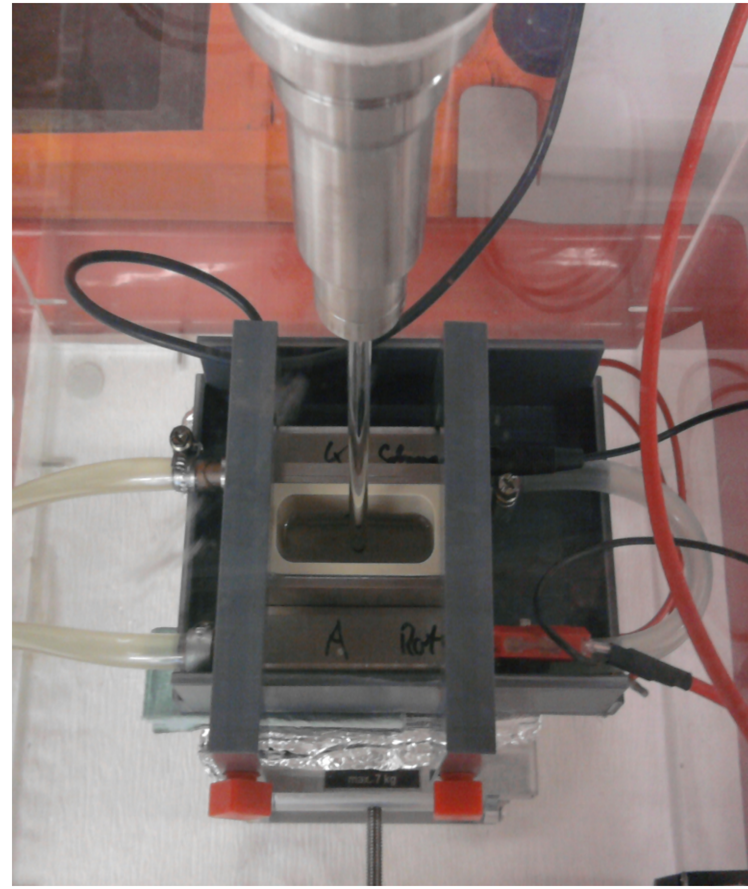
DC-beam: 1-2 pµA

Pulsed beam (25% duty cycle): 1 pµA ≈ 4 pµA (Maximum)

Actinide deposition by Molecular Plating

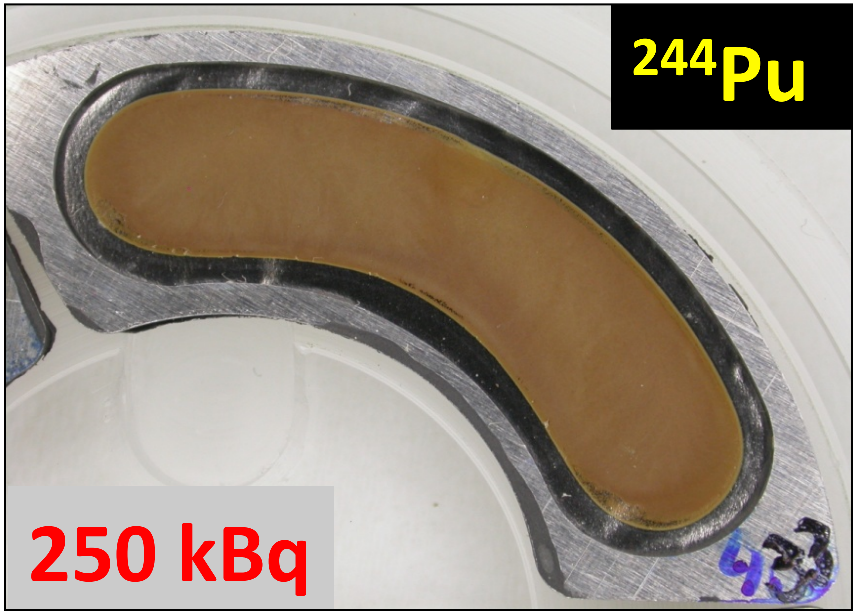


Voltage: 100 V - 1500 V



Deposition time: 3-6 hours

Deposition of actinides by MP



Deposition of actinides by MP

OAK RIDGE National Laboratory

JG|U JOHANNES GUTENBERG UNIVERSITÄT MAINZ

GSI

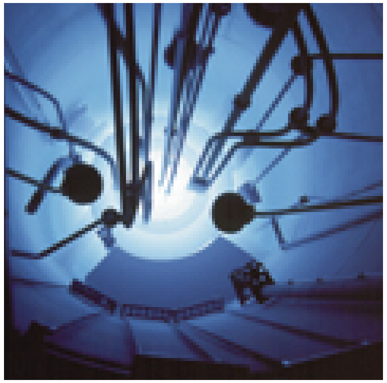
Molecular Plating

- **Deposition Yield: up to 90% for actinides**
- **Thickness: 500-1000µg/cm^2 possible in a <u>single</u> deposition step**

Standard target characterization techniques

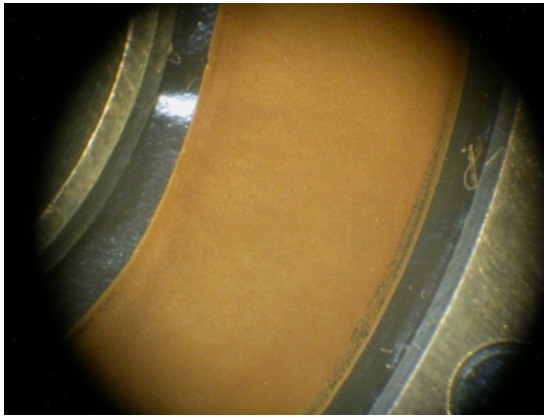
Deposition yield:

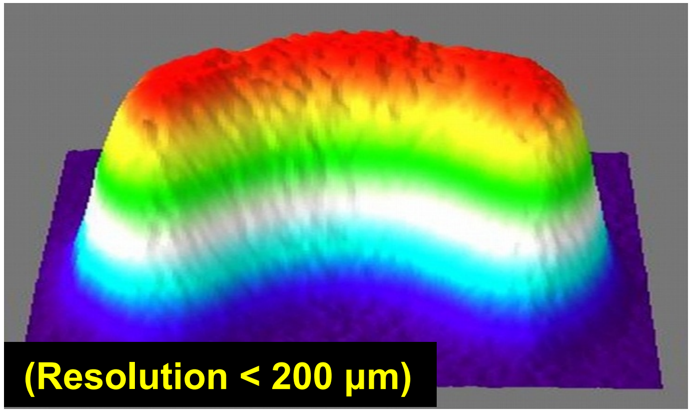
- α-particle spectroscopy
- γ-spectroscopy
- Neutron Activation Analysis



Layer homogeneity:

- α-particle spectroscopy
- Radiographic Imaging





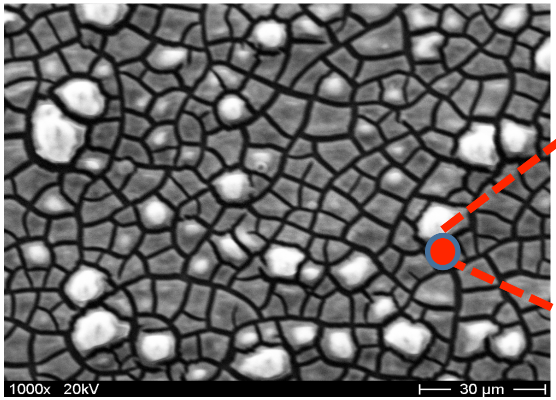
[D. Liebe et al., Nucl. Instr. and Meth.
A 590 (2008) 145]

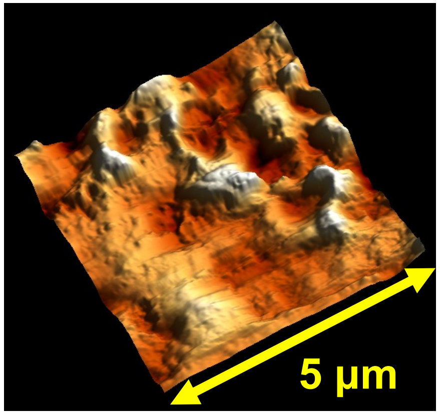
Properties of actinide layers produced by MP

Studies on layer growth mechanism:

- Scanning Electron Microscopy (SEM) ⇒ µm-resolution
- Atomic Force Microscopy (AFM) ⇒ 10-100 nm-resolution

SEM





AFM

[A. Vascon et al., Nucl. Instr. and Meth. A 655 (2011) 72]

Chemical composition:

- X-ray Fluorescence (XRF)
- Photoelectron Spectroscopy (XPS)

Alternative target production techniques I

- **Polymer-assisted deposition (PAD):**

Metal-oxide mixed with polymer solution. Spin-coating of silicon substrate with metal-organic film. Target thickness up to 600 μg/cm^2 possible. No irradiation tests with actinide elements so far.

[M. Garcia *et al.*, Nucl. Instrum. Methods A 613 (2010) 396]

- **Electrodeposition using Ionic Liquids (IL):**

Ionic organic salts that are liquid at room temperature and serve as solvent for metal ions. Electrodeposition of U from IL already performed.

Alternative target production techniques II

- **Superhydrophobic surfaces:**

Modification of a substrate with self-assembled monolayer (SAM) of alkyl chains. Homogenious deposition of metal-oxide/nitrate from aqueous solution by simple evaporation of single drops. No irradiation tests with actinide elements so far.

[D. Renisch *et al*., Nucl. Instrum. Methods A 676 (2012) 84]

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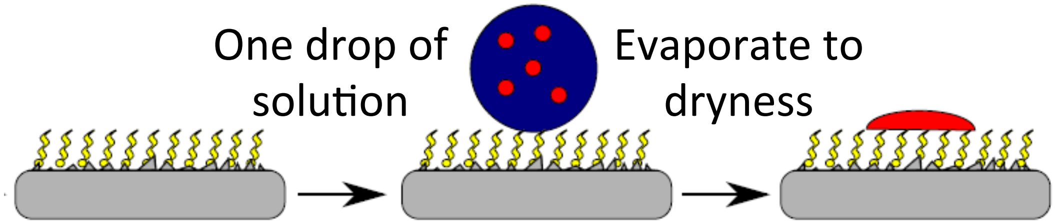
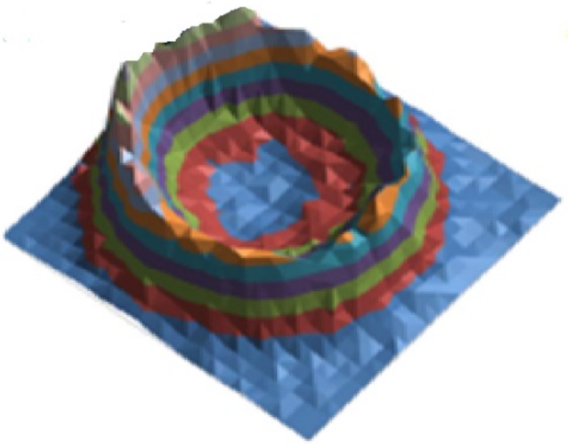
Evaporation of a single drop of Am-241(nitrate) solution. Activity distribution by RI:





Untreated Ti-surface

Modified Ti-surface

Alternative target production techniques III

- **Intermetallic targets:**

Molecular Plating of a lanthanide/actinide compound on a Pd backing. Subsequent reduction by heating the target in a hydrogen atmosphere. Formation of intermetallic Ac-Pd phases. First in-beam irradiation tests performed.

[I. Usoltsev *et al*., contribution to TAN 11]

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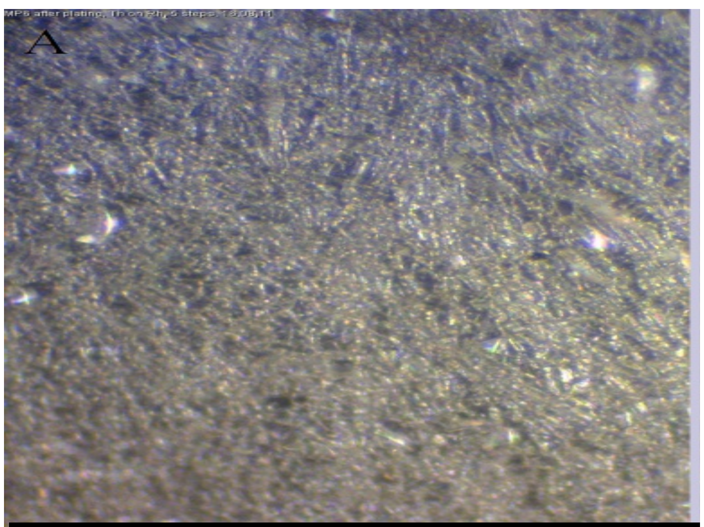
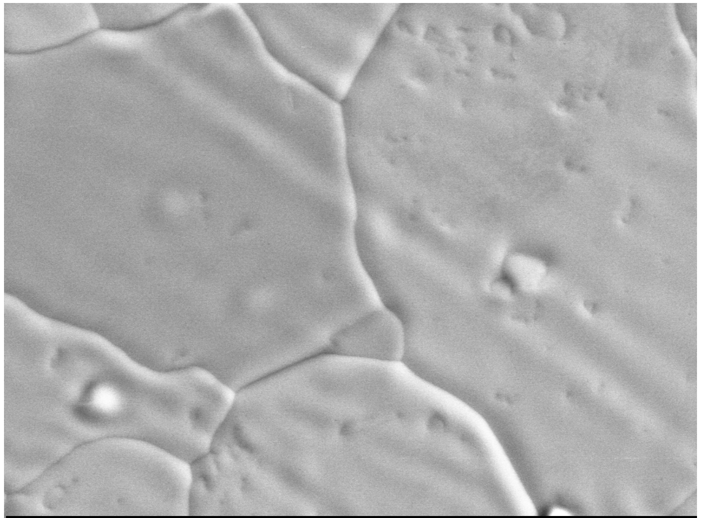
PSI



Gd-layer produced by MP



Intermetallic phase

Tasks

- **Target development for high intensity beams:**

  - Explore limits of current target technology
  - Search for alternative backing materials
  - Develop new methods target production
  ⇒ Beam time needed

- **Study interaction of target material with backing (Ti) under long irradiation conditions with high intensity beams**
  ⇒ Beam time needed

- **Availability of facilities where targets (non-irradiated and irradiated) can be characterized with modern analytical techniques e.g. XRF, XRD, XPS, SEM, AFM**

- **Design of standard target wheel that can be applied at different accelerator facilities**

INTDS 2012

26th World Conference of the International Nuclear Target Development Society

Targets for Accelerator-Based Research

Mainz, Germany, August 19 - 24, 2012

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Topics:

- Preparation Techniques for Thin Films and Foils
- Stripper Foils
- Radioactive Targets
- High Power Targets
- Liquid and Gas Targets
- Isotopic Enrichment and Materials
- Target Characterization
- Targets and Coatings for Medical Radioisotope Production

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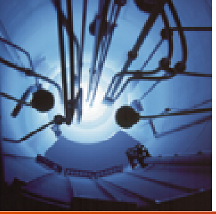

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....and you for your attention