Laser based applications: Existing and Future Solutions.

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Division of Technical Support

Surveillance, Seals and Remote Monitoring

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International Atomic Energy Agency

New Challenges in Safeguards

Surveillance , containment and NDA measurements

»» »» “Continuity of Knowledge” (CoK) between 2 inspections

Facilities are getting more and more complex

- Number and complexity of facilities are increasing
- Number of inspections days should be reduced..

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New Challenges in Safeguards

➲IAEA SG needs to address these 2 challenges: continuously improve the effectiveness..

New techniques need to be:

- evaluated,
- presented to the operators
- implemented.

Laser based application present wide variety of possibilities:

- Some are already used
- Some are future – but very promising test results

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Laser based applications:
Existing and Future Solutions:

- 3 Dimensional Laser Range Finder (3DLR)
- Outdoor Verification system (OVS)
- Combined 3DLR with radiation map
- Laser Item Identification System for UF6 Cylinders,
- Laser Mapping for fuel packaging,
- Laser Surface Authentication for metal seals verification
- Light Detection and Ranging (LIDAR)
- Tunable Diode Laser Spectroscopy (TDLS)

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Laser based applications: Existing and Future Solutions.

Design Information and Verification (DIV):

- in vast and complexes facilities,
- with infrequent access possibility,
- loss of knowledge along the years,
- rotation of inspectors,
- huge amount of data…

Facilities are getting more and more complex

➲ Improving DIV activities

➲ required a “tool“.

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Laser based applications: Existing and Future Solutions.

The Tool & the Need:

Automate the capture of the design:

- To increase the accuracy of the Design Information original verification,
- To increase DIV effectiveness.

Automate the verification of the design:

- To reduce the data acquisition time at facility,
- To reduce the data processing effort.

IAEA Inspector using the 3DLR.

Courtesy of the EC/ IPSC/ JRC Ispra, IAEA SGTSR.

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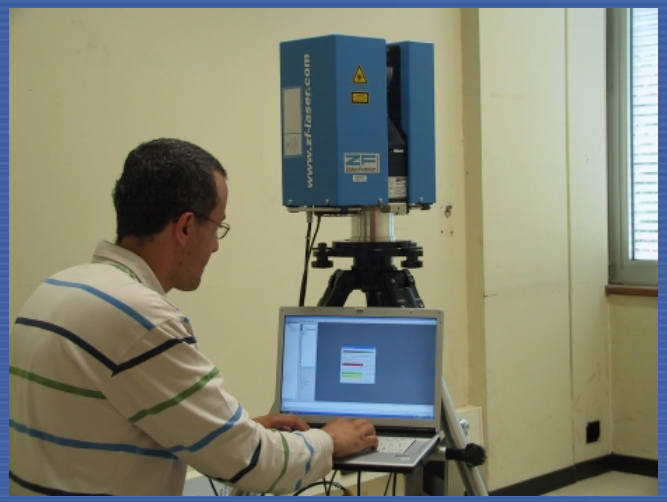
Laser based applications: Existing and Future Solutions.

Dedicated tool:



IAEA Inspector setting up the 3DLR acquisition.

Courtesy of the EC/ IPSC/ JRC Ispra, IAEA SGTSR.

-based on a 3 dimensional laser range finder,

- with safeguard adapted software (developed under the European Support Program to the IAEA).

The 3 Dimensional Laser Range finder: 3DLR.

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Laser based applications:
Existing and Future Solutions.

The 3DLR is used in Rokkasho reprocessing plant since May 2003 first demonstration.

IAEA Inspector performing a 3DLR scan.
IAEA SG- JNFL.

IAEA Inspector performing a 3DLR verification.
Courtesy of the EC/ IPSC/ JRC Ispra, IAEA SGTSR.

Cells were scanned during construction and again just before closing,

Design Information data were compared, then stored at facility under joint seals.

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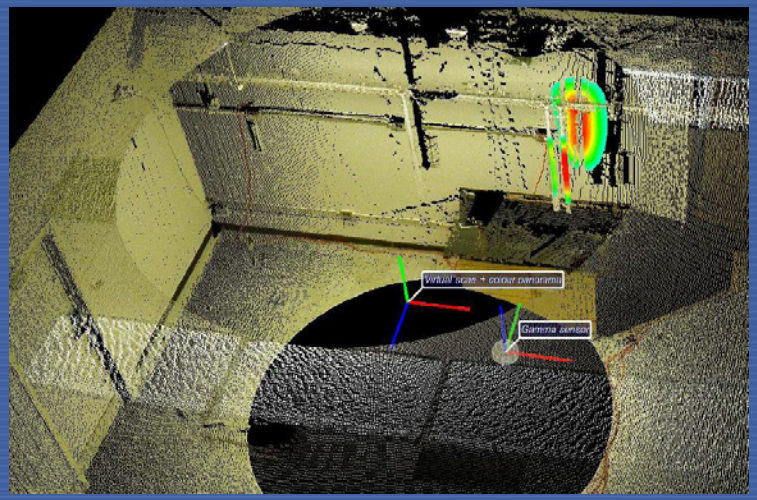
Laser based applications: Existing and Future Solutions.

In 2007, what is new ?

◎ Combined 3DLR with radiation map



Courtesy of the EC/ IPSC/ JRC Ispra, LLNL and ORNL.
-AVI animation can be presented after the presentation-

Merging 3D models with:

- Gamma ray map,
- Infra red map…

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Laser based applications: Existing and Future Solutions.

In 2007, what is new?

◎ Outdoor 3DLR ?

Perform eventual outside facilities building DIV.

Use the same concept:

- 3-Dimensional laser range finder
- with broader range,
- coupled to digital camera
- linked to a positioning system ➔enabling scanning in movement

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◎ Outdoor 3DLR

The 3D-laser scanner

image of the reflection of the object function of the light intensity

Entrance from the Vienna International Center ; IAEA head quarters
Scan courtesy of the EC/ IPSC/ JRC Ispra

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◎ Outdoor 3DLR

Entrance from the Vienna International Center ; IAEA head quarters
Picture courtesy of the EC/ IPSC/ JRC Ispra

The digital camera mounted on the top of the laser scanner captures 7 pictures at each scanning point,

During the data processing overlaid on top of the 3D data.

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◎ Outdoor 3DLR

3D data **Set of pictures**

Entrance from the Vienna International Center ; IAEA head quarters

Courtesy of the EC/ IPSC/ JRC Ispra

Construction of a 3D model :

virtual but almost real !

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Laser based applications: Existing and Future Solutions.

➲Outdoor 3DLR demonstration:
IAEA head quarters in Vienna

11 range scans
77 colour pictures,

Making of movie
Can be presented
After the presentation.

Courtesy of the EC/ IPSC/ JRC Ispra IPSC, V Sequeira.

Under evaluation by IAEA SG operations

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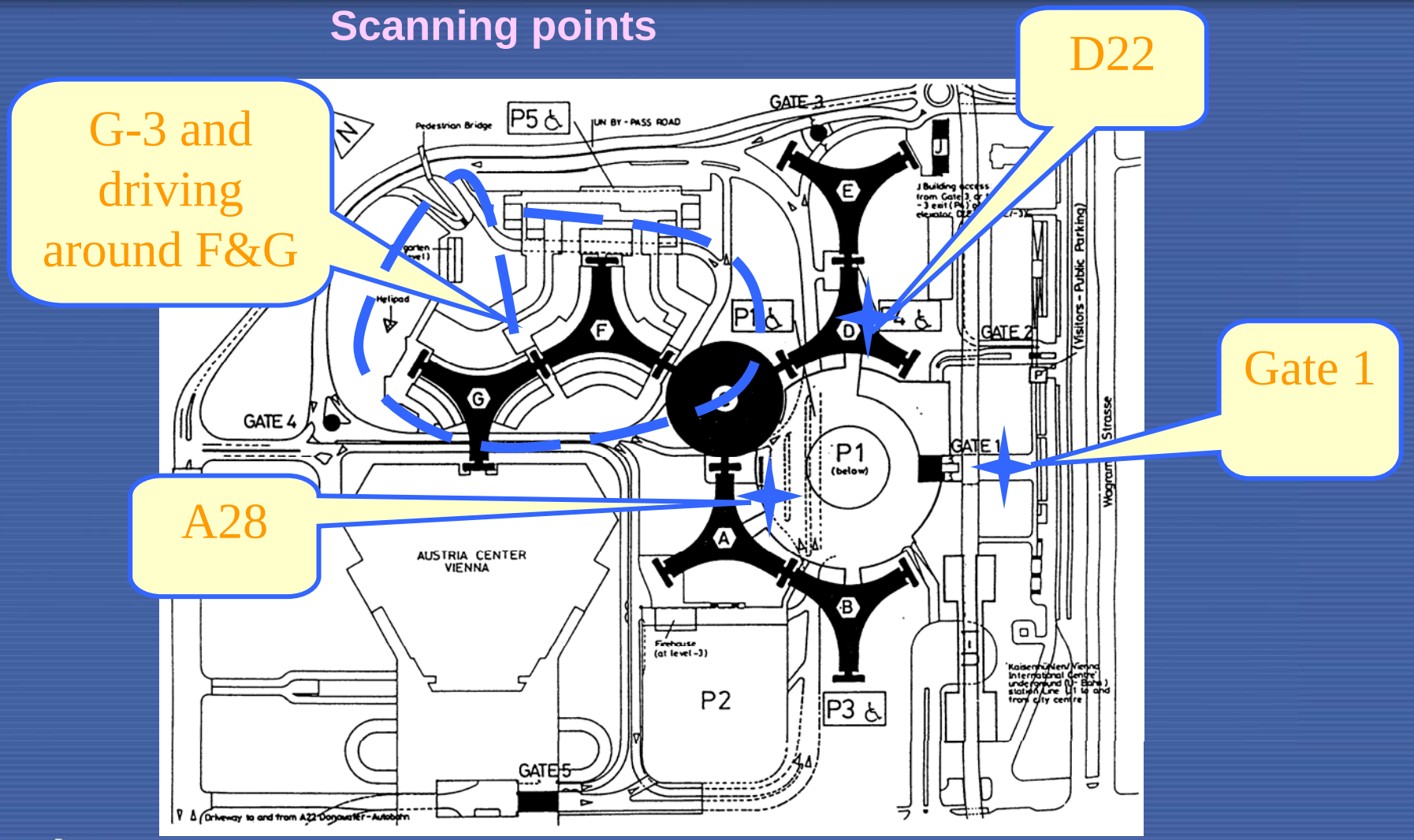
◎ Outdoor 3DLR

Scanning points



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Laser based applications: Existing and Future Solutions.

Item tracking

- Number of facilities is increasing
- Number of inspections days should be reduced..

➲Develop or improve

➲new surveillance and containment techniques

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Laser based applications: Existing and Future Solutions.

Item tracking :UF6 cylinders identification:

- in Enrichment facilities,
- monitoring the UF6 cylinders movement,
- without relying on any
  - ✓existing or
  - ✓additional tagging.

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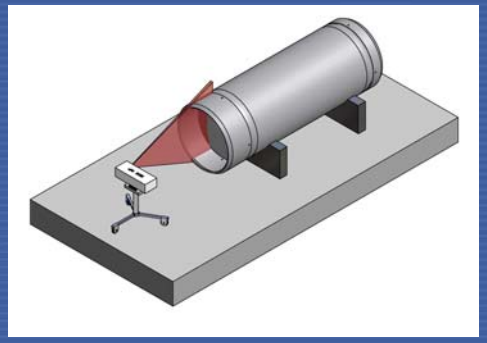
UF6 cylinders identification:

Systematically referencing of all UF6 Cylinders:



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- delivered (shipping in)
- declared to be used in the coming months.

Unattended scan of transported cylinders entering and exiting the process area.

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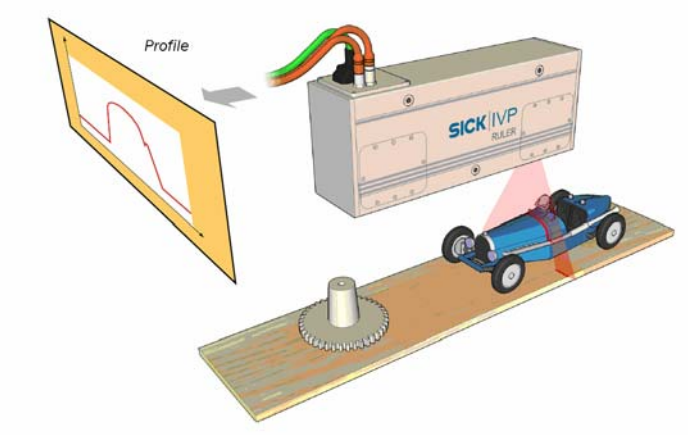
UF6 cylinders identification:

The Technique:



Triangulation concept- source SICK Laser Reference Manual.

-based on a triangulation laser scanner

- with safeguard adapted software (developed under the European Support program to the IAEA).

The Laser Item Identification System (L2IS)

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UF6 cylinders identification:
Laser Item Identification System (L2IS)

First application: trial in Rokkasho enrichment plant
September 14th – November 9th 2007.

UNIT 1	Records & Identifies all cylinders declared to be “used” by the operator
UNIT 2	Verifies that all cylinders “used*” by the operator are matching the declaration list of operator’s declaration.

L2IS at REP-09/2007
Courtesy of the JNFL

Under Trial

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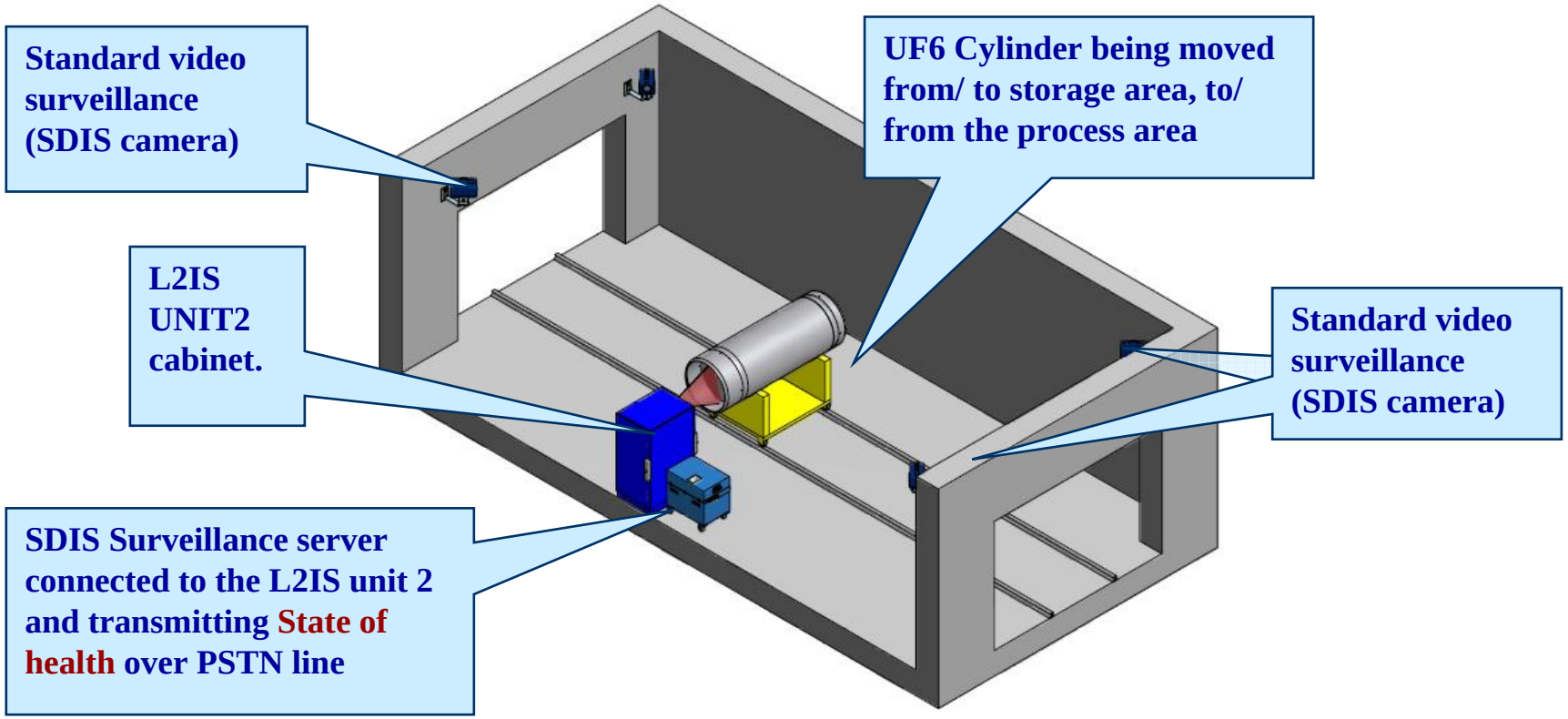
UF6 cylinders identification:
Laser Item Identification System (L2IS)



IAEA/ SGTS/ M Lang.

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UF6 cylinders identification:
Laser Item Identification System (L2IS)

◎Current stage of the trial:

- Portable unit1 is operational,
- Installed unit 2 needs to be adapted to:
  - Cope with the distance between scanner and smaller cylinders
  - Scan cylinders without stopping the transported cylinders

◎Milestones:

November 2007:	data retrieval after 60 days initial trial period ➔ analyse
March 2008:	Upgrade of unit 1 and unit 2 to cope with the facilities geometrical constraints (REP)
April 2008:	Second phase of aging test

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Laser based applications: Existing and Future Solutions.

Develop and implement new containment verification techniques

- between fuel fabrication plant
- and receiving plant
- verifying the surface and welding .

Laser surface mapping

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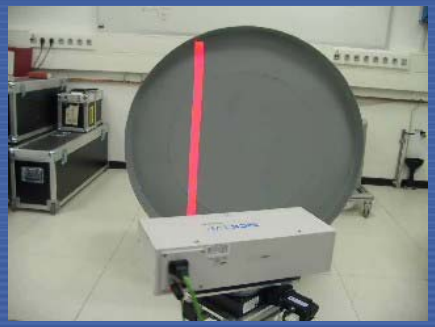
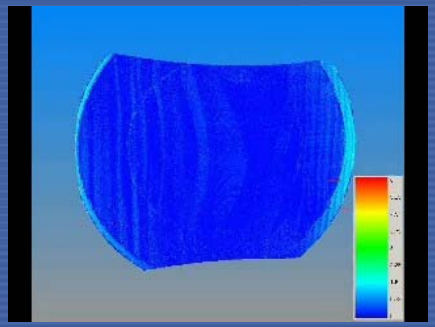
Laser based applications: Existing and Future Solutions.

Laser surface mapping for fuel packaging

- Systematically referencing all packaging
  - meant to be used for the fuel shipment
  - Part of sealing arrangement
  - Proof of integrity of the entire container surface incl. welds
- Random verification
  - at receiving facility
  - the surface,
  - and welding





Courtesy of the EC/ IPSC/ JRC Ispra IPSC, V Sequeira.

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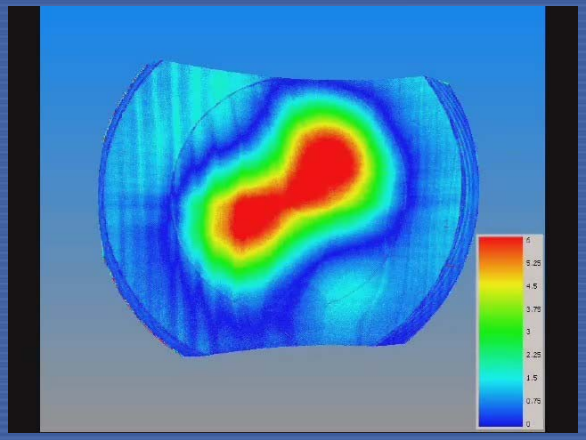
Laser surface mapping for fuel packaging

1. Tampering

2. Re-welding

3. Painting



4. Verification scan: impossible to hide the surface deformation

Pictures Courtesy of the EC/ IPSC/ JRC Ispra IPSC, V Sequeira.

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Laser surface mapping for fuel packaging

◎Current stage :

- Demonstration performed September 2007 PFPF.

◎Milestones:

- November 2007: expected report from EC/JRC Ispra.

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Laser based applications: Existing and Future Solutions.

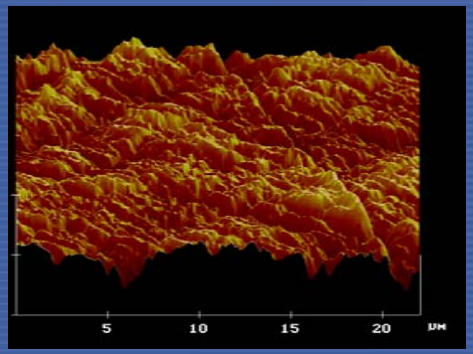
Improve existing **containment verification** techniques effectiveness

- Automate the metal seals verification
- Offer on site / on the spot verification

Laser Surface Authentication (LSA®) :

Laser beam produces speckle light from the microscopic surface

➔ **'fingerprint'**



Surface Roughness at Laser Wavelength Scales - Photo Courtesy of Ingenia Technologies Limited-.

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Laser Surface Authentication for Metal seal Verification:

- counterfeit resistant signature
- low cost
- Small amount of data

Surface Roughness at Laser Wavelength Scales -Photo Courtesy of Ingenia Technologies Limited-.

◎Current stage:

- initial feasibility assessment for LSA successfully completed ,
- third party design vulnerability assessment is in progress.

◎Milestones:

- 2008 First prototypes in IAEA HQ
- on-site and/or in-situ verification …

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Laser based applications: Existing and Future Solutions.

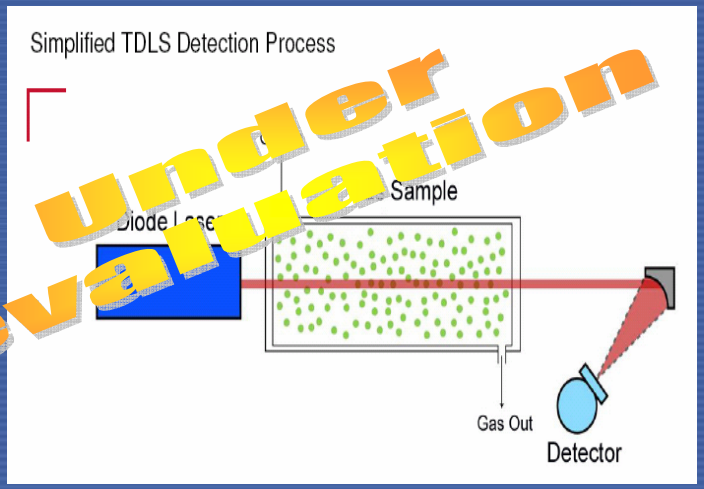
Measurement of UF6 at enrichment plants.

Development of an instrument:

- foreseen to determine in UF6 on-site
- expected accuracy < 1% for 235U

Tunable Diode Laser Spectroscopy (TDLS):

Diode lasers access specific regions of the mid-infrared spectrum where most gases of interest have strong absorption while common gases, such as oxygen and nitrogen, do not have strong absorption.



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Laser based applications: Existing and Future Solutions.

Tunable Diode Laser Spectroscopy (TDLS):

- Extreme sensitivity (~ ppb concentration range)
- quick measurements
- high spectral resolution in the IR range,
- no special safety measure for operation,
- inside and outside a facility,

➲ portable TDLS system was successfully demonstrated to detect ppb concentrations of HF.

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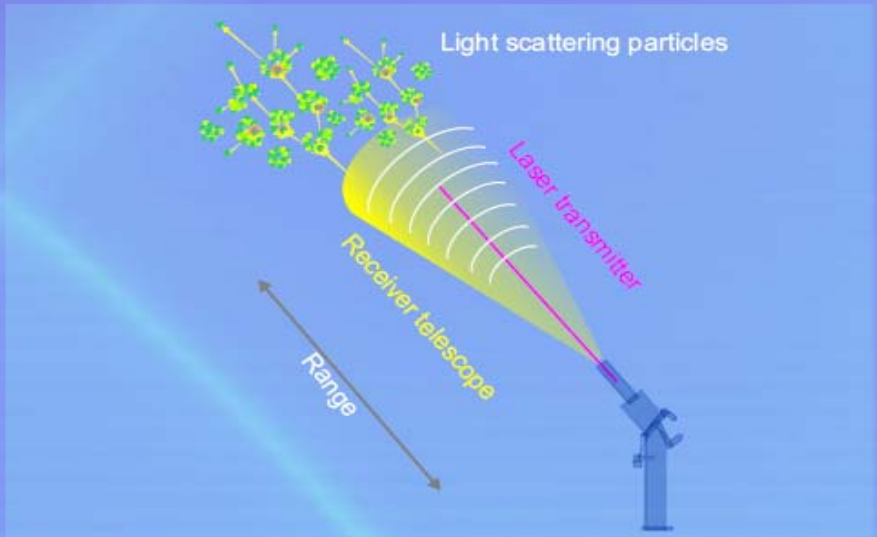
Laser based applications: Existing and Future Solutions.

Light Detection and Ranging (LIDAR)

Detecting the presence and nature of nuclear process activities at suspected nuclear locations using light detection and ranging (LIDAR)



1 A mobile LIDAR laboratory travels to the vicinity of a suspected location.

2 A laser, tuneable to precise wavelengths, selectively stimulates specific airborne molecules that emanate as gaseous compounds from nuclear processes.

3 A light sensitive telescope scans the stimulated atmosphere, detecting the presence, or absence of the stimulated signature molecules.

4 The returned light from the atmosphere is analysed, identifying the compound type and the location of its source.

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Source: RF MSSP

Conclusions

Laser based applications

- Existing : 3DLR,L2IS
- Development / Evaluation: OVS, Gamma Ray mapping, Laser surface mapping
- Future techniques: TDLS, LIDAR.

will play an increasingly role in

- ➢ both the provision of appropriate verification
- ➢ and detection tools for current and future safeguards activities.

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Conclusions

IAEA SG Technical Support's guidelines:

- Use of the shelves equipment
- Adapt to the technical need
- Comply to the IAEA SG requirements
- Present and install at facilities

Most of these new techniques:

- Part of the SG at enrichment plant's "toolbox" project,
- Supported by Member state support programs:
    - funding,
    - research institutes and laboratories,
    - trial hosting at facilities.

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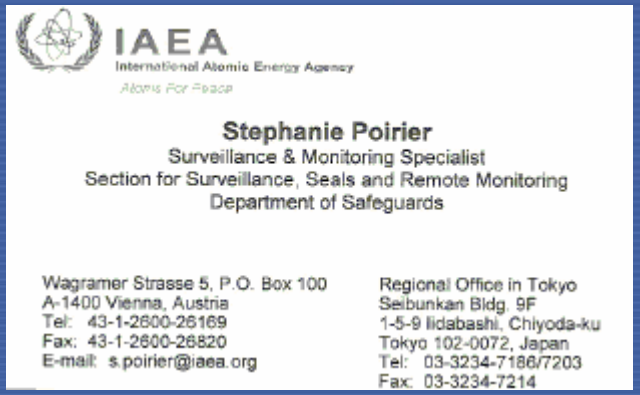

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J G.M Goncalves, V.Sequeira Institute for the Protection and Security of the Citizen, Joint Research Center Ispra Italy (EC)

• **OVS**

"Further development of laser system for design verification inside and outside nuclear facilities", Proc. 29th ESARDA Annual Meeting, Aix-en-Provence, France, 20-25 May, 2007, V. Sequeira, M. Fiocco, J. G.M. Gonçalves, B. Wishard, S. Poirier.

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C Coates,S Smith, J Hines,A C.R.Caiado:ORNL,
V Sequeira, M Fiocco, J Goncalves: ECJRC Ispra-ISPC.

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• **Laser Surface Mapping**

M. McGlade, S. Poirier, H. Undem, M. Zendel, Laser Surface Authentication for Containment and Surveillance, IAEA Symposium 2006 on International Safeguards, IAEA-CN-148/123, Vienna, Austria.

• **TDLS:**

Annual Report-WG-TDLS for IAEA SG

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Technical references 3DLR

Scan duration (for standard 360° x 182° scan)

Reference scan :

- **Super High Resolution 20,000 x 10,111 points 6m 44s**
- **High Resolution 10,000 x 5,055 points – 3m 22s Average of 6scans / cell: 1 to 2 hours (access conditions)**

Verification scan:

- **Super High Resolution 20,000 x 10,111 points – 6m 44s**
- **High Resolution 10,000 x 5,055 points – 3m 22s**
- **Middle Resolution 5,000 x 2,527 points – 1m 41s (Mostly used for IAEA SG)**

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