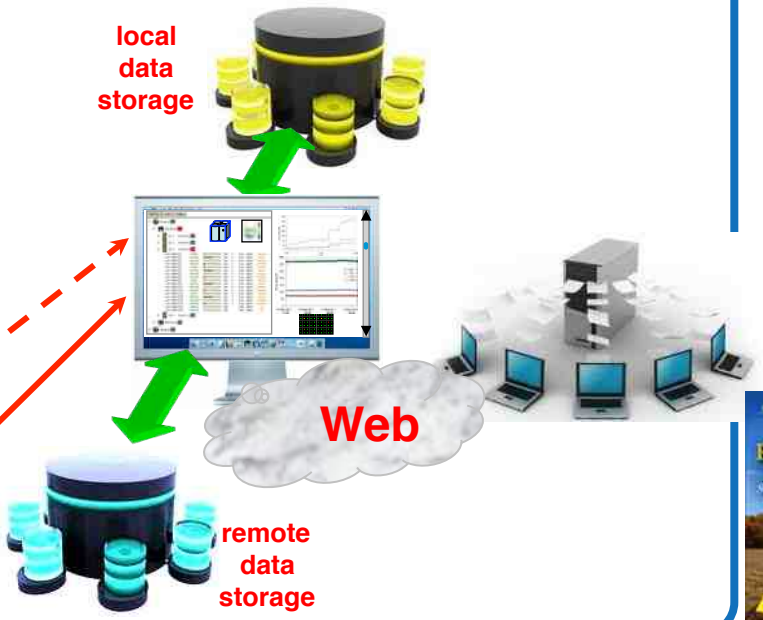
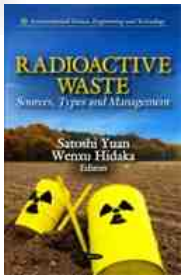
DMNR
LNS

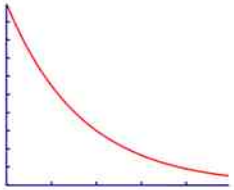
Detector Mesh for Nuclear Repositories

Real-time online monitoring of radioactive waste

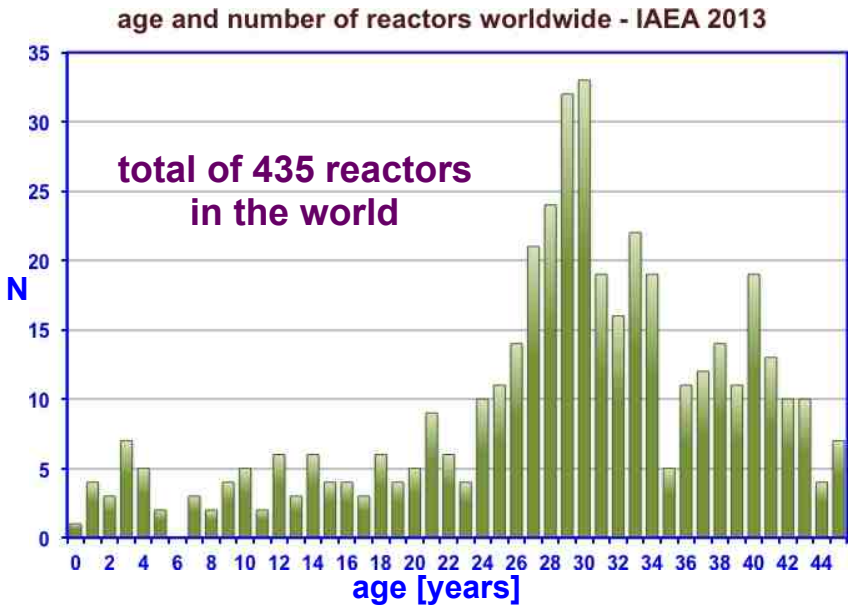




we (scientists) trust the exponential decay law of radioactivity



what about laypersons?
environmentalists?



sooner or later decommissioning will take place

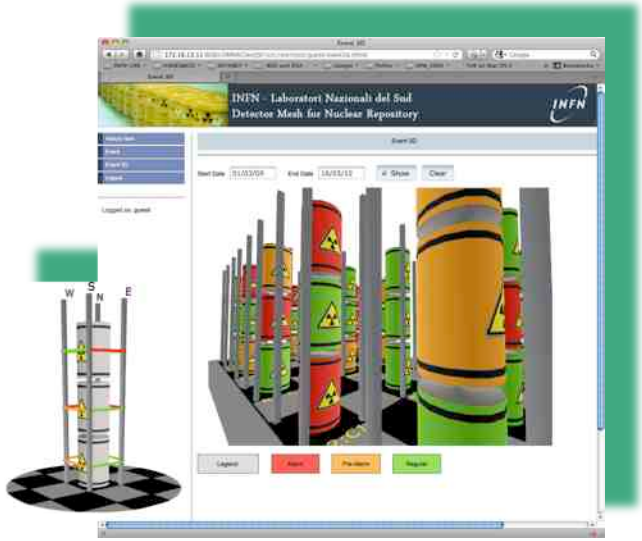
temporary and permanent storage required

where? acceptability for populations?

we proposed to set-up a system
for in-place storage monitoring

Technology transfer

collaboration agreement
INFN - SOGIN
signed on 8-Nov-2012
duration: 2 years



implementation of a prototype DMNR monitoring system in a new radwaste repository (Garigliano former power plant)

huge delays from SOGIN burocracy, change of governing body

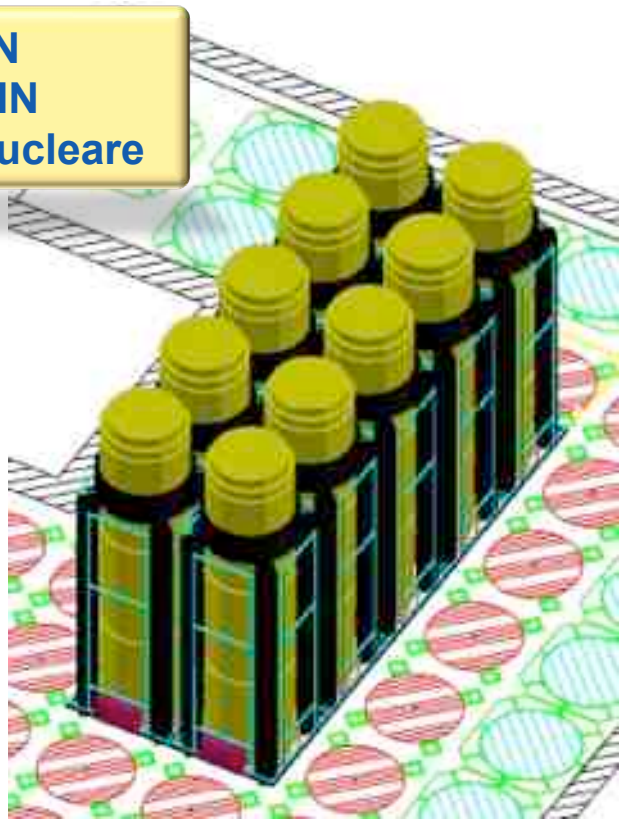
to be installed next week at the Garigliano former power plant

13-Jun-2014
INFN president met SOGIN president

collaboration agreement
INFN - SOGIN
under renewal for 2 more years

new system: patent in preparation

INFN
SOGIN
Ansaldo Nucleare



electronics: contacts with CAEN and SITAEL

RadSieve

P.Finocchiaro
L.Cosentino, A.Pappalardo, S.Scirè, C.Scirè, G.Vecchio,
C.Greco, S.Grillo, C.Calì, P.Litrico
INFN Laboratori Nazionali del Sud, Catania, Italy

- Radwaste sorting table for decommissioning
- Radwaste package fill optimization
- Radwaste drum rough characterization

CONFIDENTIAL

RadSieve

Sorting table for hot spots detection in decommissioning

patent in preparation

CONFIDENTIAL

Radwaste drum characterization

Radwaste drum fill level optimization

same electronics
same low-level software
different application-level software
(Graphical User Interface)

CONFIDENTIAL

HELNEM

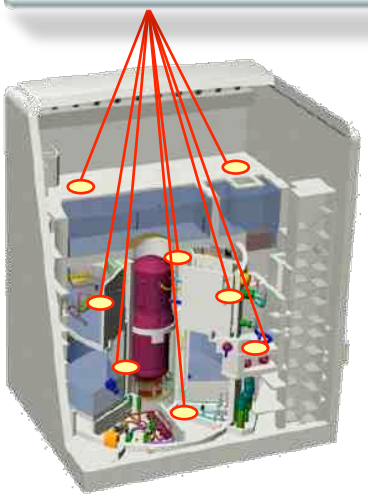
P.Finocchiaro
L.Cosentino, A.Pappalardo, S.Scirè, C.Scirè, G.Vecchio,
C.Greco, S.Grillo, C.Marchetta
INFN Laboratori Nazionali del Sud, Catania, Italy

^{3}HE-Less NEutron Monitors

HELNEM
LNS

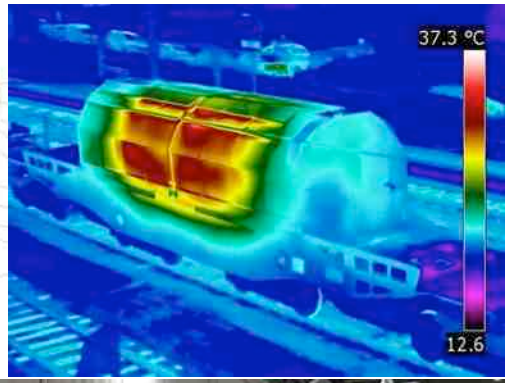
Collaboration with JRC & Euratom: neutron detection

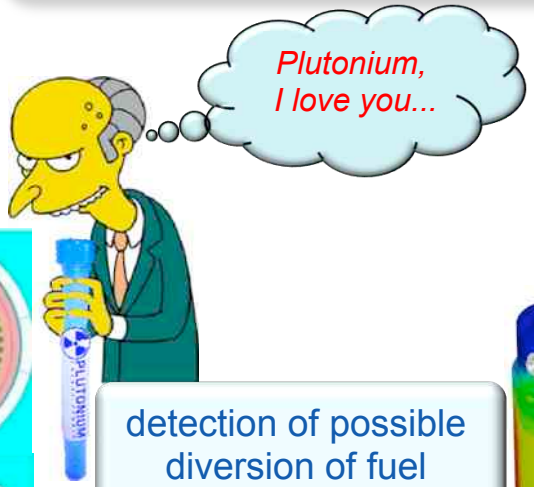
out-of-core monitoring in NPP

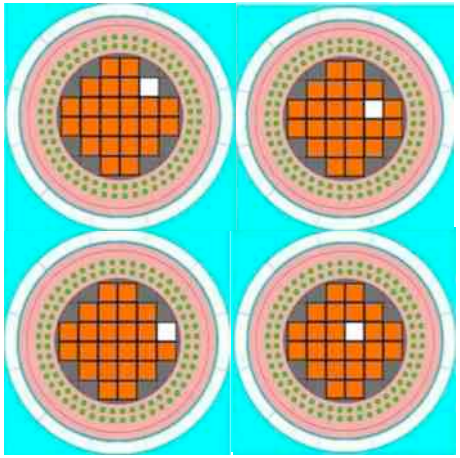


why neutrons?

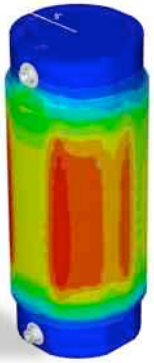
spent fuel monitoring in place and/or during transportation







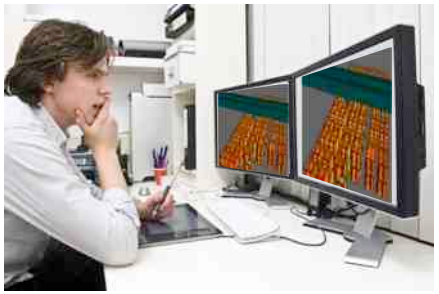
detection of possible diversion of fuel elements from Castor containers

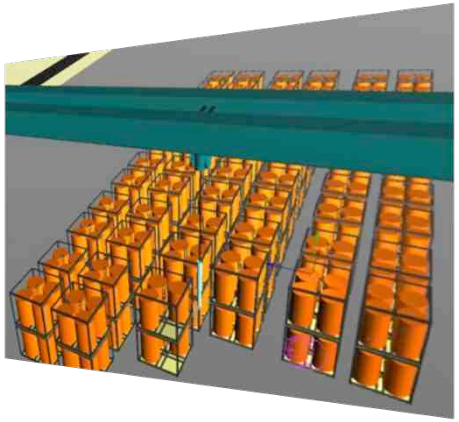


(P.Peerani, M.Galletta, Nuclear Engineering and Design 237 (2007) 94-99)

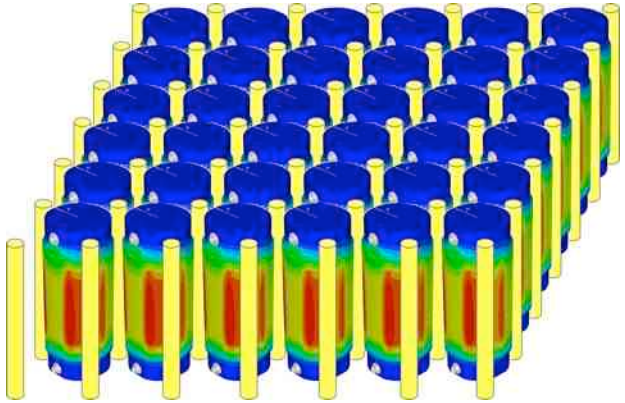
preventing the smuggling of nuclear fuel

ensuring continuity of knowledge





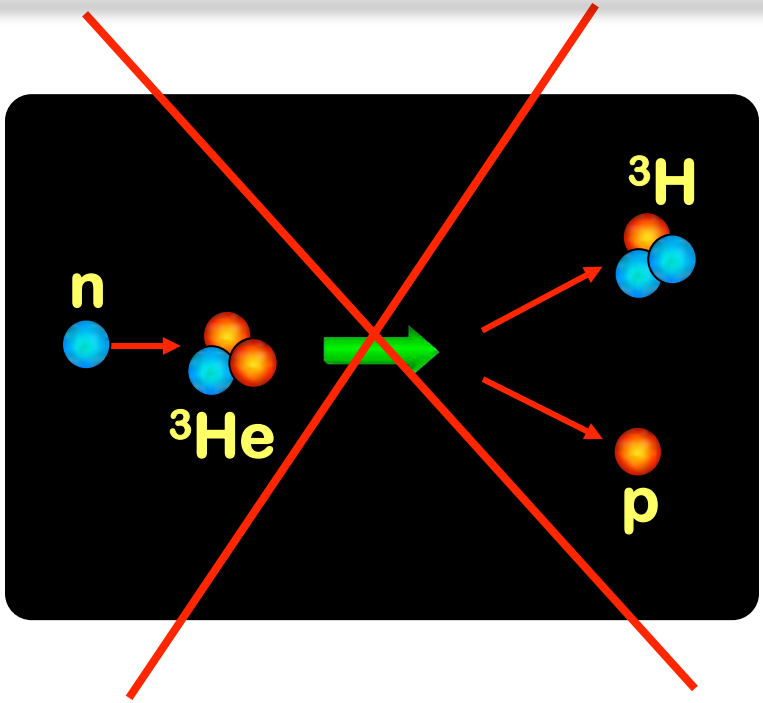
current monitoring method: video camera



our idea: granular, real time, automatic

How?

materials for thermal neutron conversion: ^{3}He



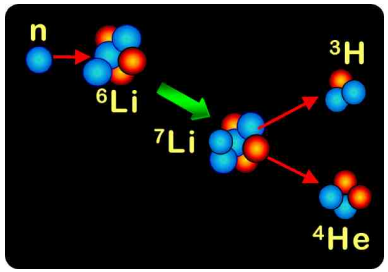
σ(0.025) ≈ 5330 b

available energy
0.76 MeV
no gamma rays

perfect gas detector but... worldwide lack of ^{3}He

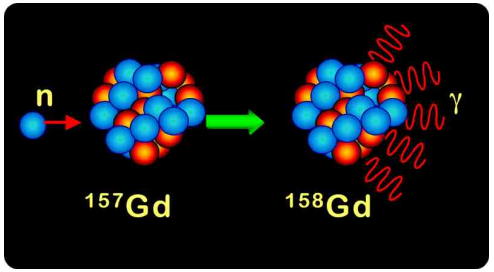
materials for thermal neutron conversion: which one?

^{6}Li



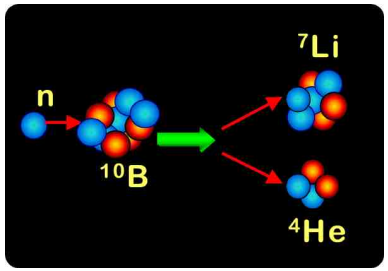
σ(0.025)
≈ 940 b
available E
4.78 MeV

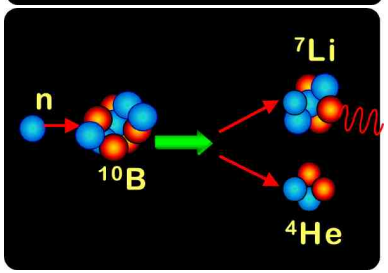
^{157}Gd



σ(0.025)
≈ 240 kb

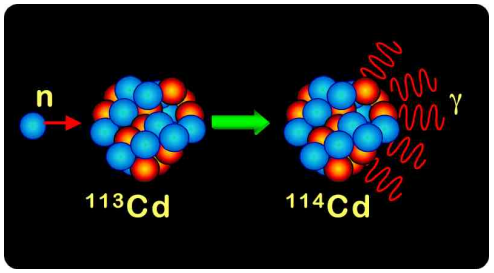
^{10}B





σ(0.025)
≈ 3840 b
available E
2.79 MeV
(and gamma rays)

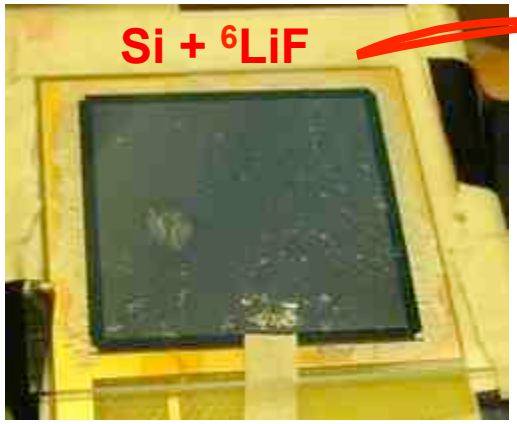
^{113}Cd

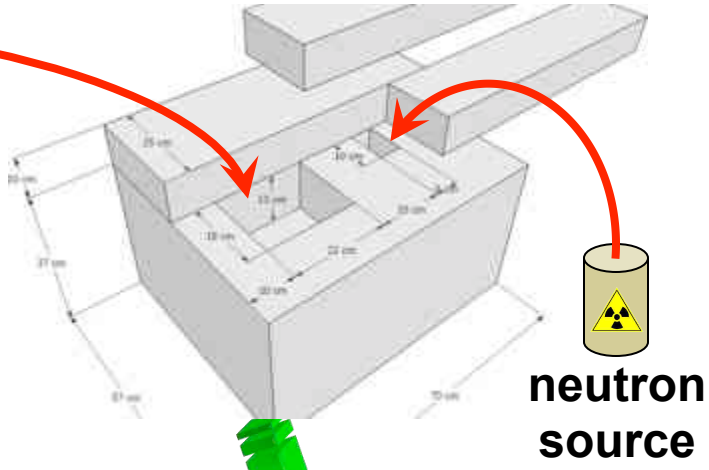


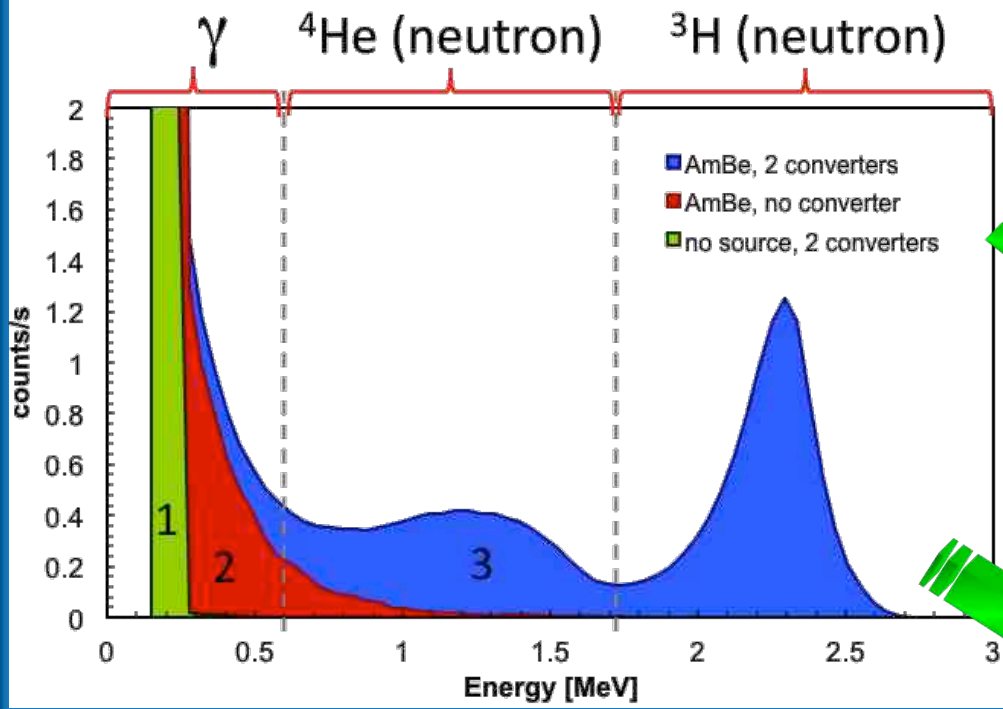
σ(0.025)
≈ 20 kb

large available E
but in form of gamma rays:
difficult neutron identification

AmBe neutron source 1.6E6 n/s thermal flux ≈ 150 n/s/cm^2







PET moderator

expected ≈ 4 cps measured 3.3

main features

- mechanically simple and robust
- reasonably cheap
- commercial solid state detectors
- strips for position measurements
- simple use (no spectrum analysis or subtraction for gamma rejection)

improvements

give up the alpha discrimination

increase ^{6}LiF thickness to 10-20 μm

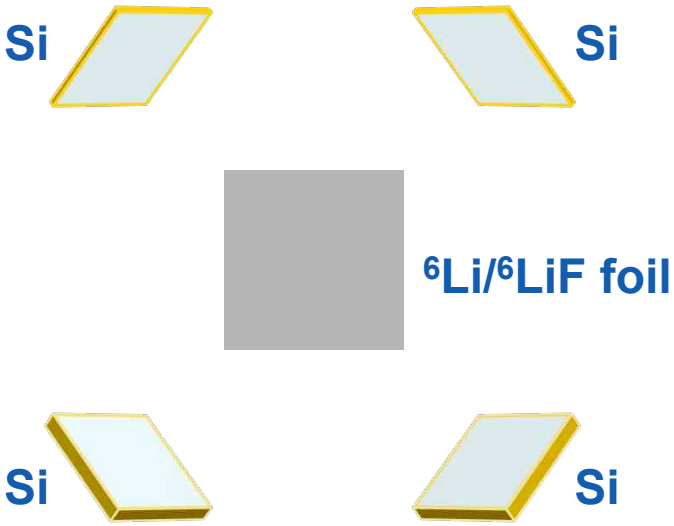
neutron efficiency 5-10%

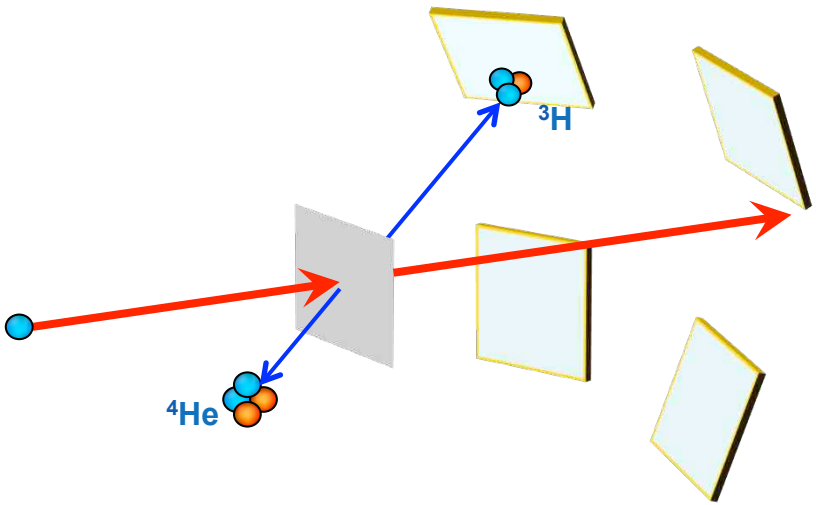
^{6}Li/^{6}LiF deposits over larger area > 15cm x 15cm

larger detectors

SiMon2: neutron beam monitor for flux normalization

Si detector + $^{6}Li/^{6}LiF$

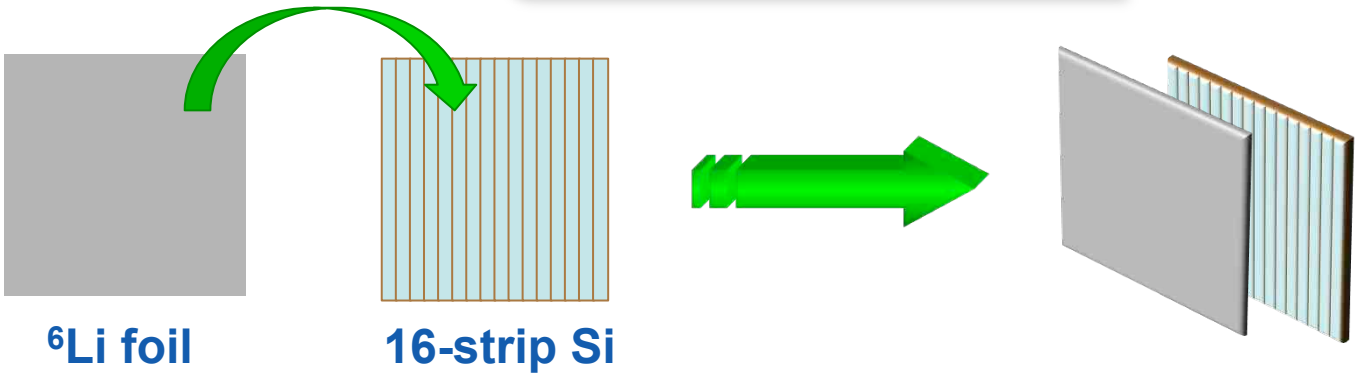




n-TOF collaboration @ CERN

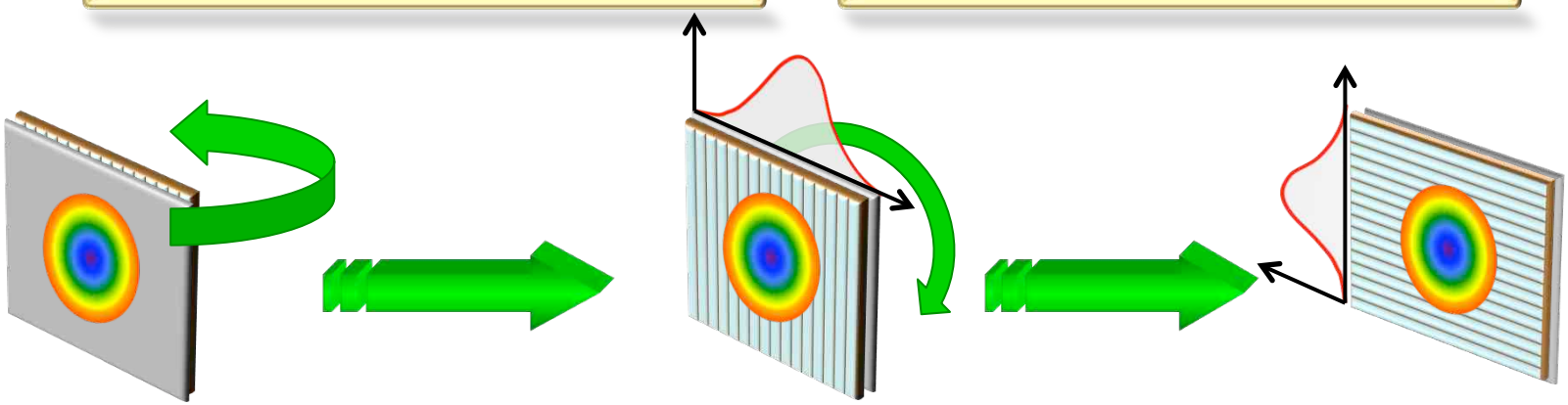
BeaMon: neutron beam characterization

Si detector + $^{6}Li/^{6}LiF$



α-t forward-backward asymmetry

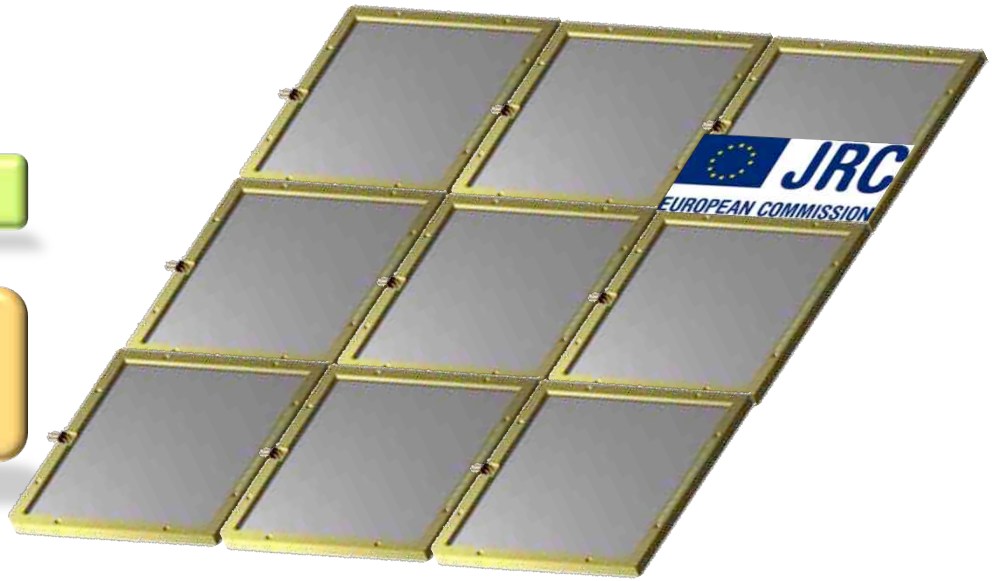
XY distribution



n-TOF collaboration @ CERN

Ongoing ollaboration with JRC & Euratom:

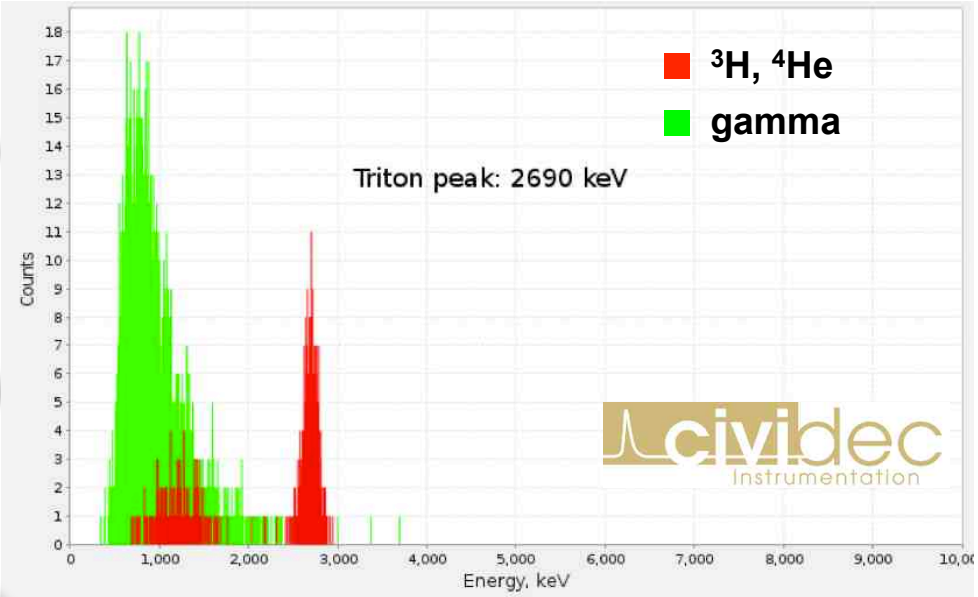
large panels for neutron coincidence measurements
as possible ^{3}He panels replacement



Recent result from collaboration with CIVIDEC (Austria):

diamond detectors for thermal neutrons outstanding results with the first test at a reactor

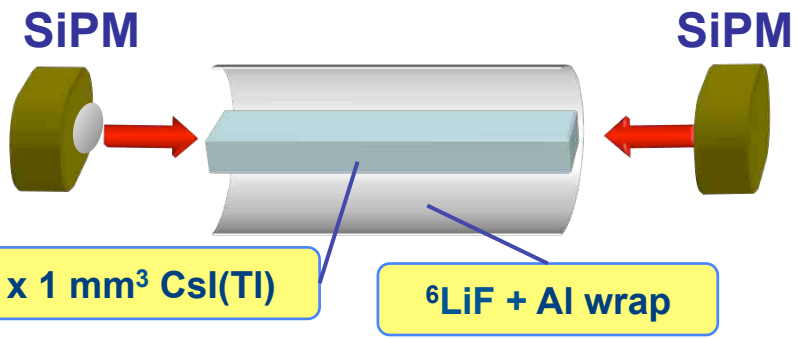
CIVIDEC purchased a few neutron converter samples from INFN-LNS in view of a possible mass production



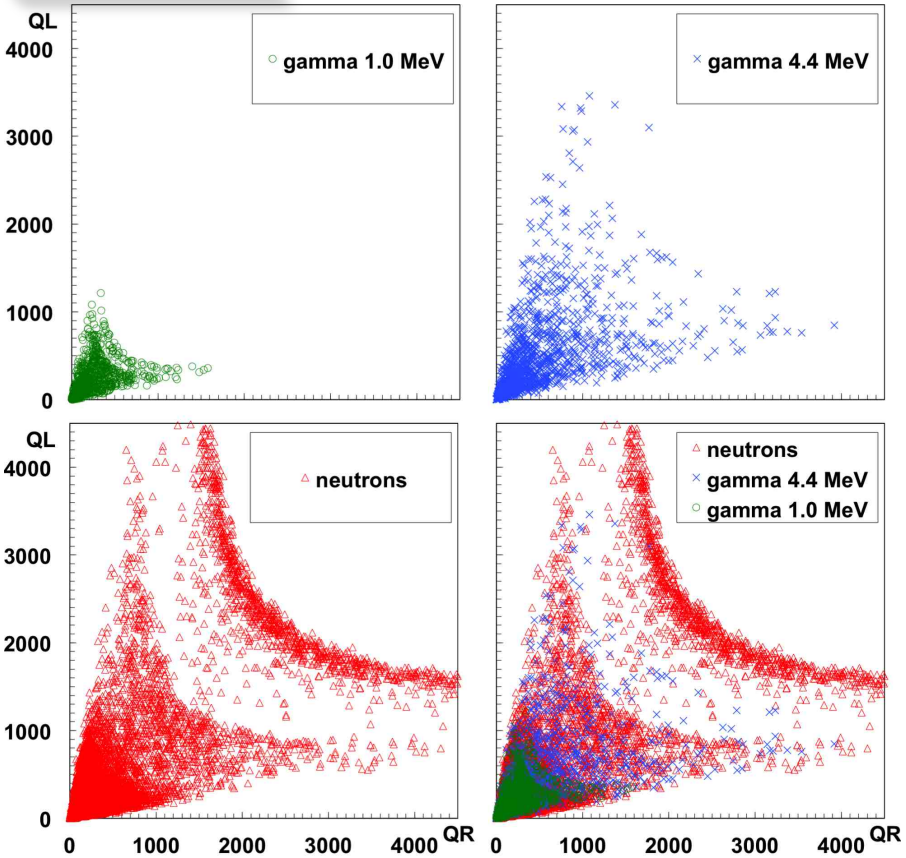
Scintillators

patent? YES

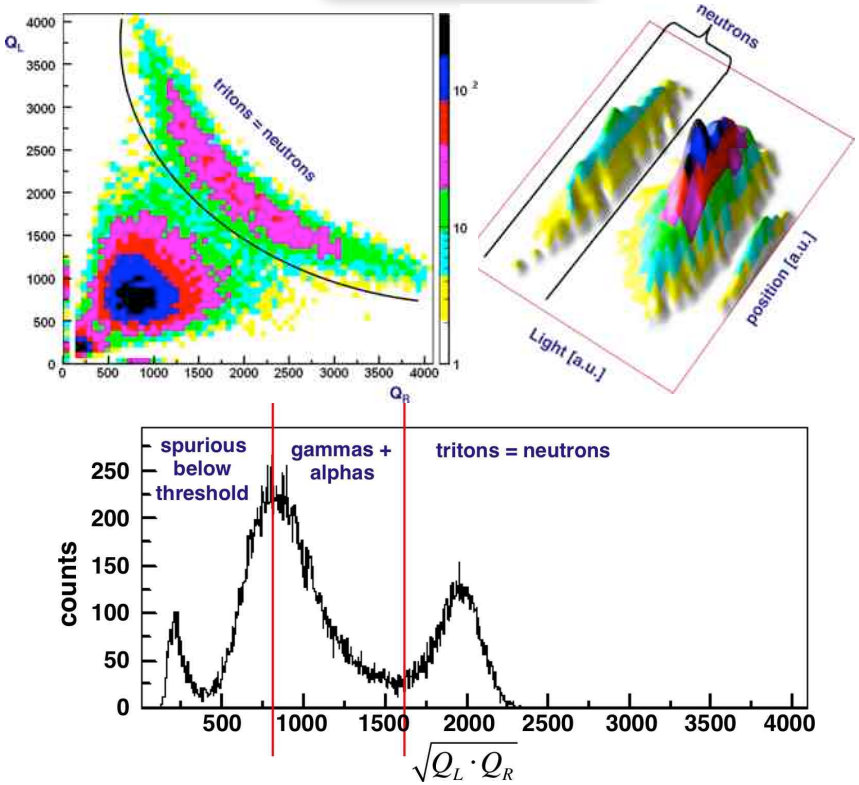
RM2013A000254

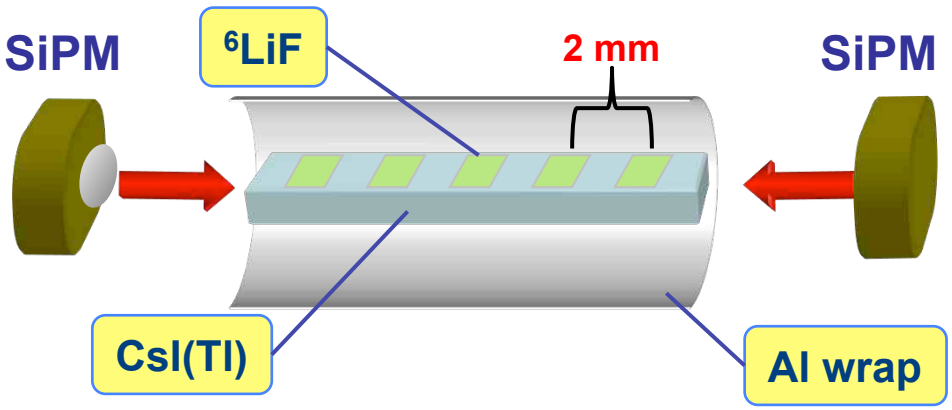


GEANT4

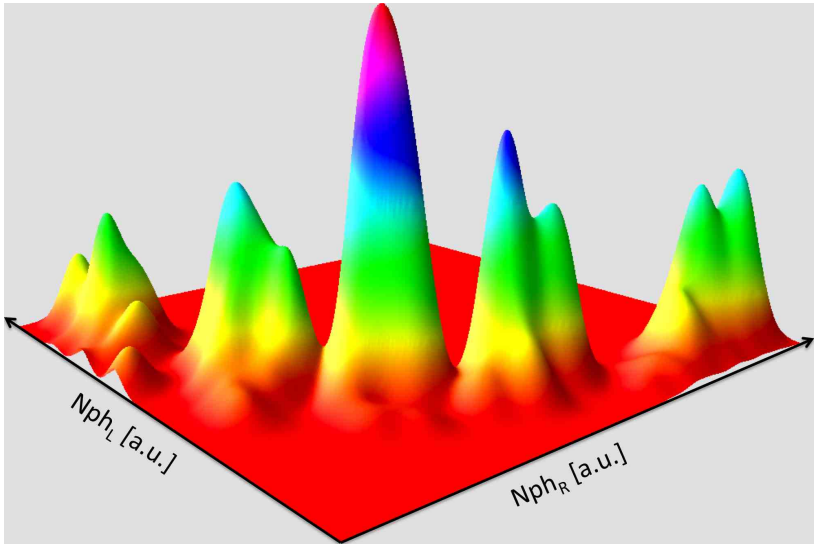


exp data

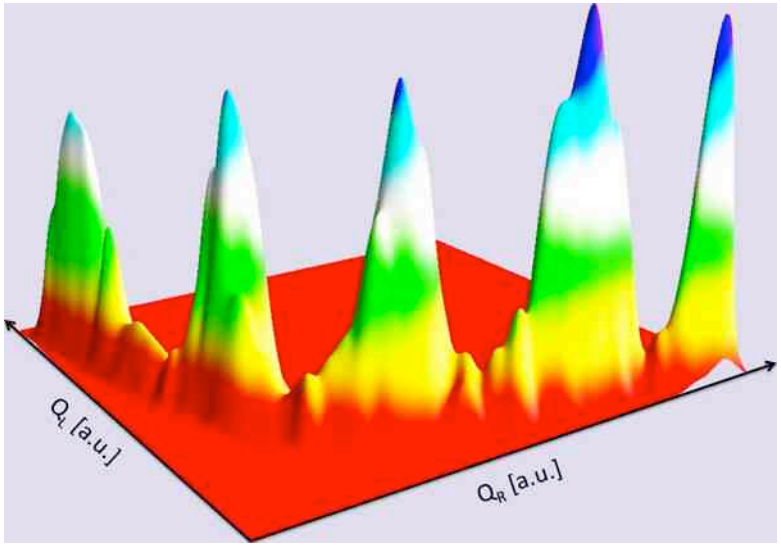




GEANT4



exp data



outlook: application fields

- Nuclear physics research
- Homeland security (nuclear material smuggling)
- Dosimetry
- Radwaste monitoring
- Spent fuel handling and storage monitoring
- Neutron beam science
- other...

ongoing developments

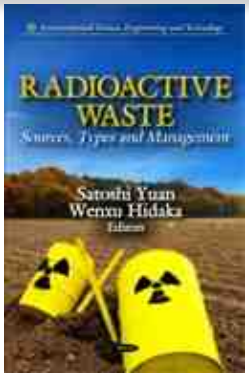
NEW!

Plastic scintillators: promising results coming soon

NEW!

INFN LNS

scientific production



theses

- L.Russo, upper level (master) Thesis (2013)
- F.Oliveri, first level Thesis (2013)
- L.Curcuruto, upper level (master) Thesis (2012)
- M.Campione, upper level (master) Thesis (2012)
- S.Scirè, upper level (master) Thesis (2012)
- C.Greco, first level Thesis (2011)
- S.Grillo, first level Thesis (2011)
- C.Scirè, upper level (master) Thesis (2011)
- V.Finocchiaro, first level Thesis (2011)
- G.Guardo, upper level (master) Thesis (2011)
- V.Febbraro, upper level (master) Thesis (2009)
- S.Scirè, LNS Stage final report (2009)
- G.Greco, upper level (master) Thesis (2009)
- M.Barbagallo, upper level (master) Thesis (2009)

- P.Finocchiaro, Nuclear Physics News, 2014 in print
- P.Finocchiaro, to be presented at NDRA 2014, Riva del Garda, July 2014
- A.Pappalardo et al., Jou. Spec. Top. Quantum Electronics, 2014 in print
- P.Finocchiaro, talk given at Position Sensitive Neutron Detectors 2014, Juelich, 2-4 June 2014
- P.Finocchiaro, talk given at the Helium-3 Replacement in Italy meeting, 2-3 december 2013
- A.Pappalardo, talk given at the 3rd European Energy Conference, Budapest, 27-30 October 2013
- P.Finocchiaro, talk given at the 3rd European Energy Conference, Budapest, 27-30 October 2013
- L.Russo, presented at the 3rd European Energy Conference, Budapest, 27-30 October 2013
- S.Scirè, talk given at the 6th International Workshop on the Application of FPGAs in NPPs, Kirovograd, 10-Oct-2013
- P.Finocchiaro, invited talk to be given at XCIX Congress of Italian Physics Society, 2013, Trieste
- P.Finocchiaro et al., presented at the 1st SCINTILLA public workshop, Budapest, 12-Sep-2013
- P.Finocchiaro, et al., Invited seminar at University of Milan 2013
- M.Barbagallo et al., Rev. Sci. Instrum 84 (2013) 033503
- G.Vecchio et al., International Journal of Nuclear Energy Science and Engineering, 10089, vol.3, issue 3, (2013)64
- G.Vecchio, P.Finocchiaro, Global Journal of Computer Science and Technology Graphics & Vision, v12, n12 (2012) 1-5
- P.Finocchiaro et al., IEEE Trans. Nucl. Sci., v59, n4 (2012) 1426-1431
- P.Finocchiaro, in “Radioactive Waste: Sources, Types and Management”, Nova Science Publishers, 2012
- A.Pappalardo et al., Nucl. Phys. B 215 (2011) 41-43
- P.Finocchiaro, invited talk given at the Low Carbon Earth Summit (LCES) 2011, Dalian
- L.Cosentino, talk given at the XXXV International Symposium "Scientific Basis for Nuclear Waste Management", 2011, Buenos Aires
- P.Finocchiaro, invited talk at XCVII Congress of Italian Physics Society, 2011, L'Aquila
- P.Finocchiaro et al., talk given at the 3rd International Nuclear Chemistry Congress, Terrasini 2011
- P.Finocchiaro et al., talk given at ANIMMA 2011, Ghent
- A.Pappalardo, presented at the 49th International Winter Meeting on Nuclear Physics, Bormio 2011
- P.Finocchiaro, invited talk at the Round Table on "Science and Technology for the solution of the Energy Supply Problems", Ekaterinburg 2010
- P.Finocchiaro, invited talk at SSEM 2010, Royal Society of Chemistry, London
- P.Finocchiaro et al., talk given at SSD16 2010, Sydney
- M.Barbagallo et al., Rev. Sci. Instr. 81 (2010) 093503
- P.Finocchiaro et al., NIM A652 (2011) 143-145
- M.Barbagallo et al., NIM A652 (2011) 355-358
- P.Finocchiaro, invited seminar at University of California Los Angeles 2010
- A.Pappalardo et al., presented at IPRD 2010
- P.Finocchiaro et al., presented at SORMA 2010
- P.Finocchiaro et al., presented at DNDO workshop 2010
- A.Pappalardo et al., presented at E2C European Energy Conference 2010
- V.Bellini, M.Capogni, V.Febbraro, and P.Finocchiaro, Appl. Rad. and Isot. 68 (2010) 1320
- P.Finocchiaro et al., Nucl. Phys. B197 (2009) 35 Proc. Supp.
- M.Capogni, presented at ICRM 2009, Bratislava, Slovak Republic, September 2009
- A.Pappalardo et al., presented at ANIMMA 2009
- L.Cosentino et al., presented at ICENES 2009
- L.Cosentino et al., presented at IPRD 2008

www.lns.infn.it/link/DMNR

etna walk
www.etnawalk.it

Thank you