

## INFN-LNS, a new group in n-TOF

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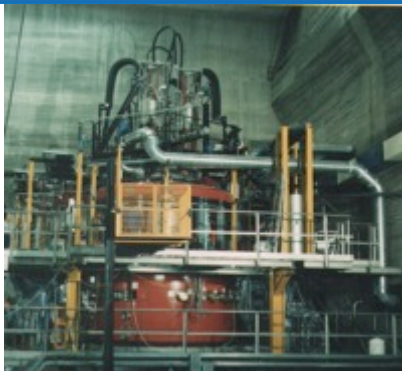
**INFN Laboratori Nazionali del Sud, Catania, Italy**

**where is it?**

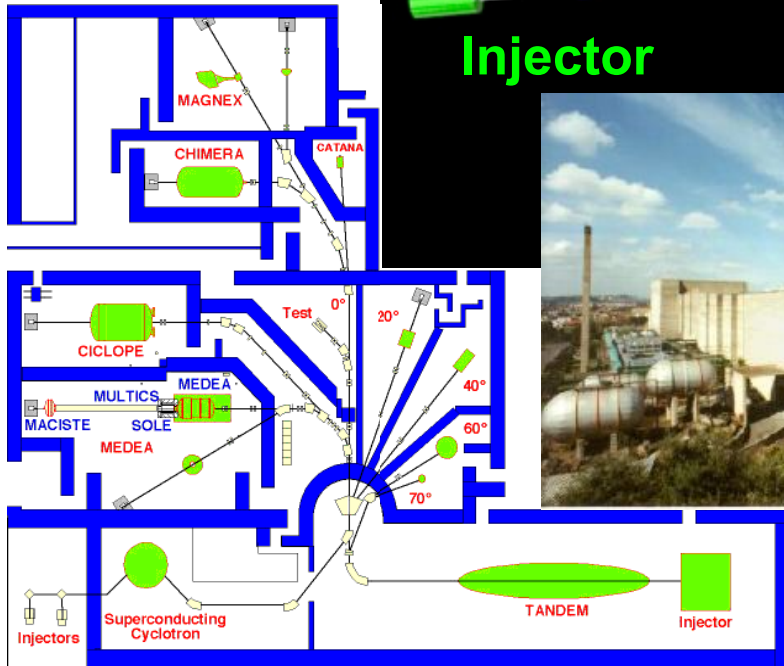
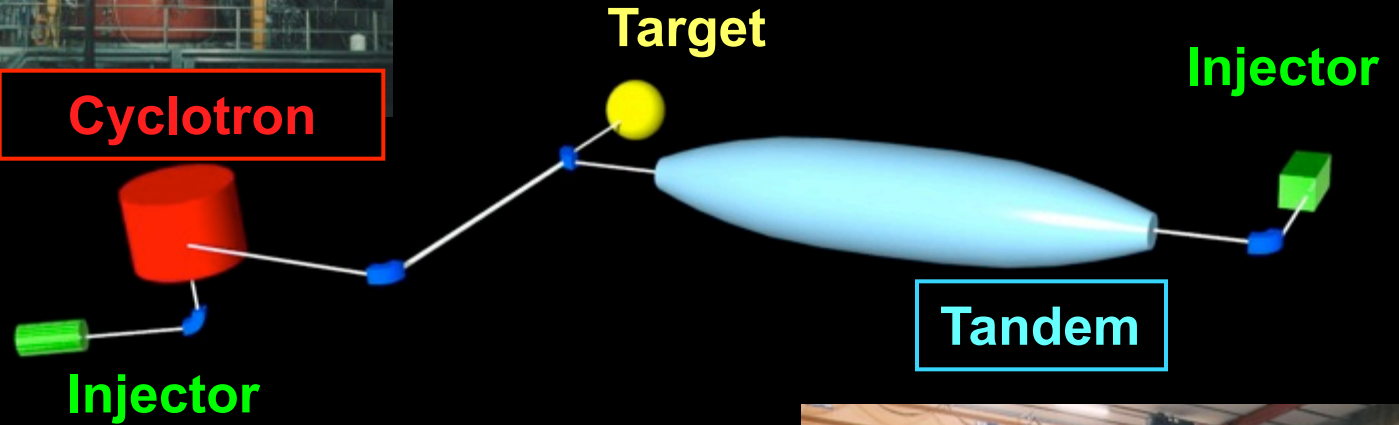


A large version of the INFN LNS logo, with "INFN" in dark blue and "LNS" in a lighter blue, set against a white background with a large blue arc above the text.

- nuclear physics experiments
- multidisciplinary applications



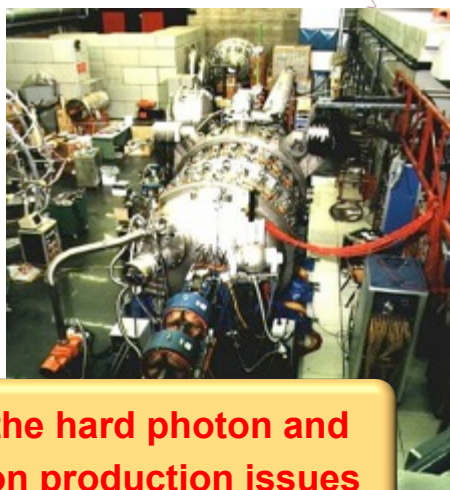
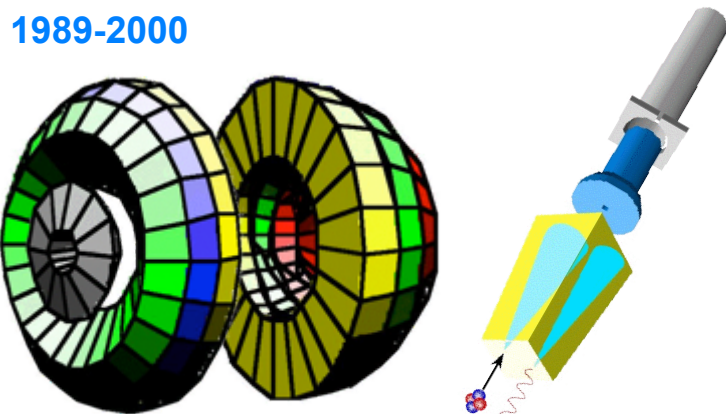
Cyclotron



# LNS accelerators

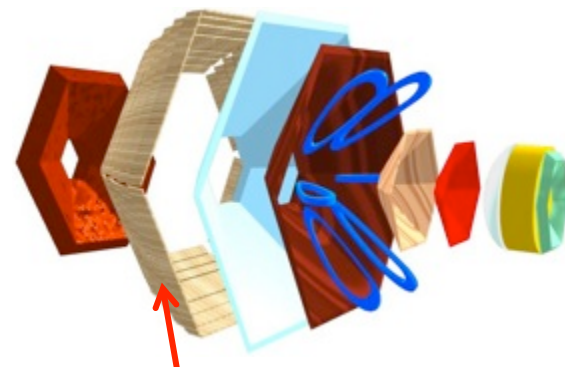
# Our background

Heavy Ion collisions at intermediate energy with the **MEDEA Multi Element DEtector Array at LNS** (Catania) 1989-2000



**solved the hard photon and hard pion production issues**

Dilepton production in Heavy Ion collisions at **GSI** (HADES collaboration Darmstadt Germany) 1995-2010



we built the TOF wall



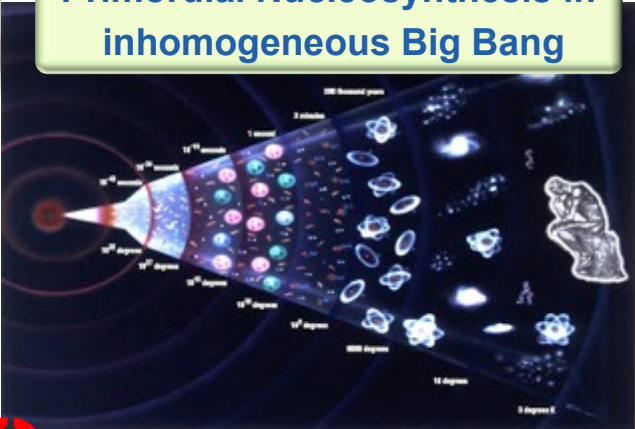
**solved the DLS puzzle...  
...and several other issues**

**Our background**

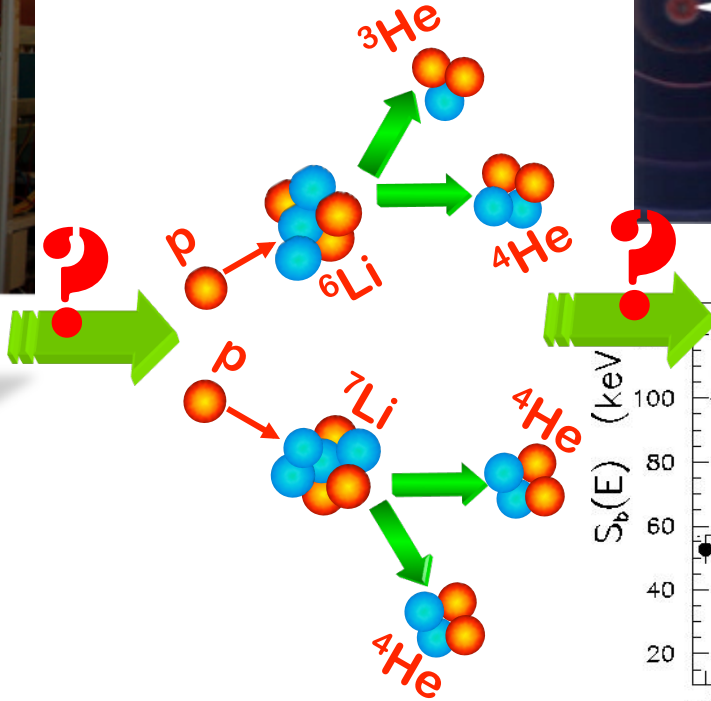
nuclear astrophysics:  
low-energy cross section  
measurements by direct and  
indirect (THM, ANC) methods

$^8\text{Li}(\alpha, n)^{11}\text{B}$  cross-section  
measured at LNS-EXCYT  
using  $^8\text{Li}$  radioactive beam

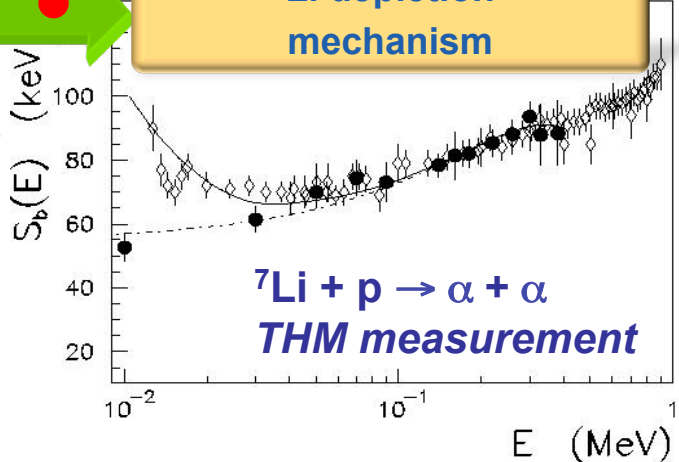
Primordial Nucleosynthesis in  
inhomogeneous Big Bang



Li production  
mechanism in stars

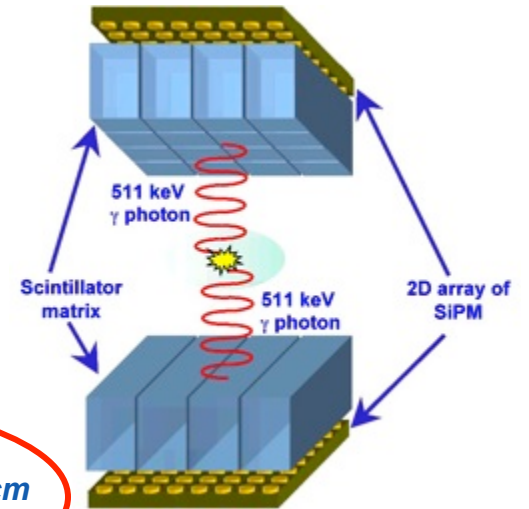


Li depletion  
mechanism



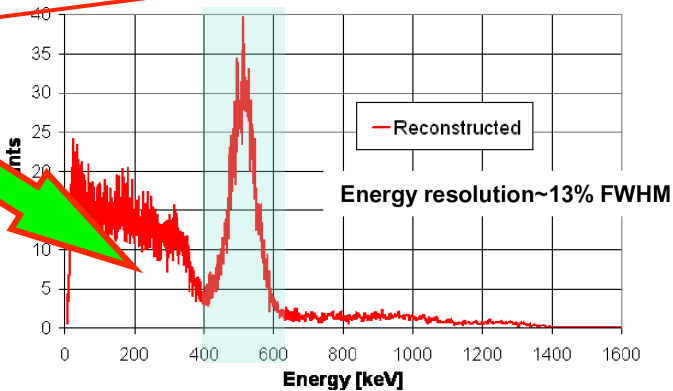
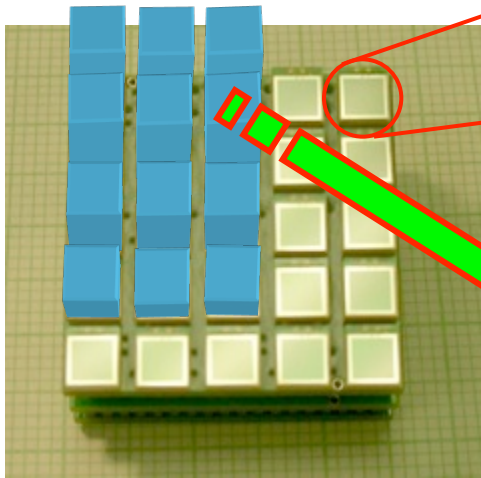
**Our background**

miniature detectors for **TOF-PET**:  
prostate tumor diagnosis and follow-up



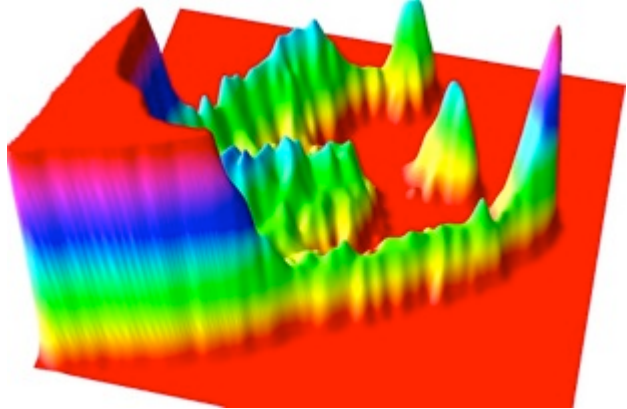
**SiPM**  
time resolution  $\approx 200\text{ps} \approx 6\text{ cm}$   
DOI resolution  $< 1\text{mm}$

scintillators ( $1.5 \times 1.5 \times 10\text{ mm}^3$ )



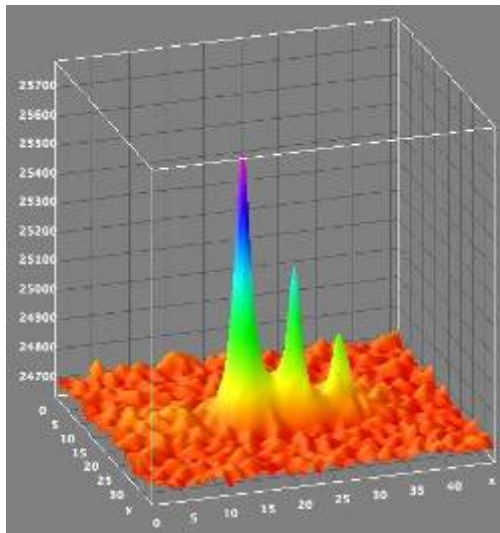
annihilation gamma spectrum (511 keV)

Energy resolution  $\sim 13\%$  FWHM

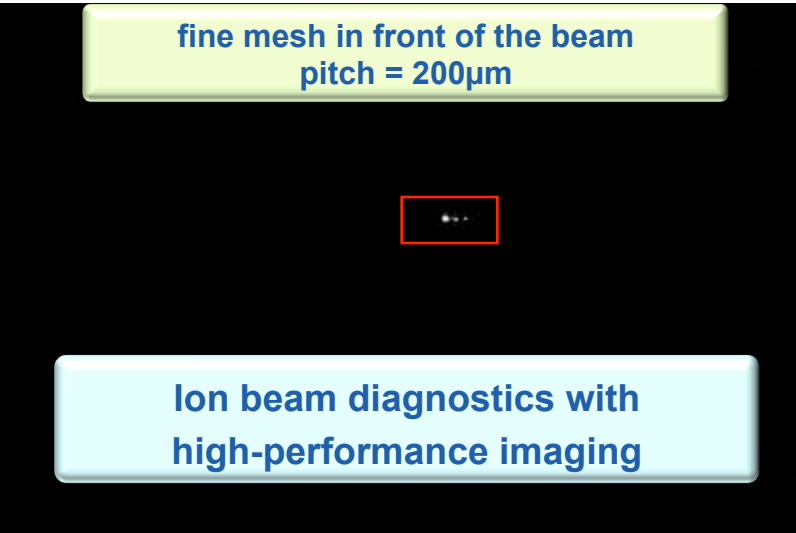


# Our background

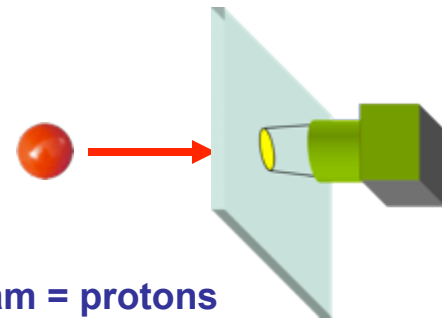
## Pushing scintillator imaging to the limits...



fine mesh in front of the beam  
pitch = 200 $\mu$ m



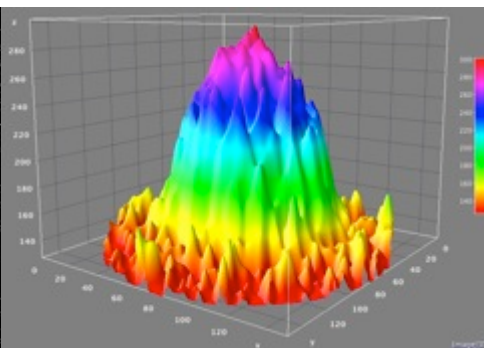
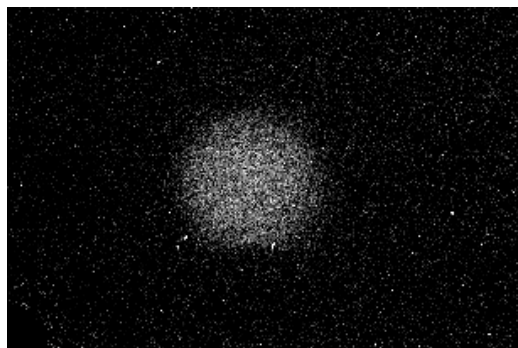
Ion beam diagnostics with  
high-performance imaging



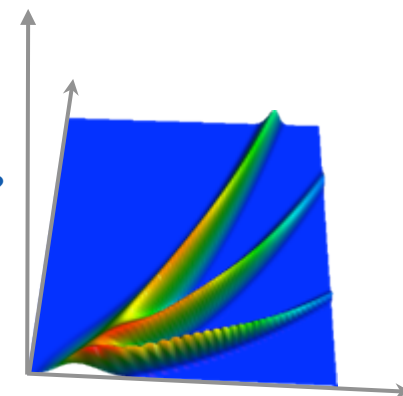
beam = protons  
E = 200keV  
I < 2.5fA  
t<sub>exposure</sub> = 20s

DITANET, oPAC, LA<sup>3</sup>NET  
EU networks

*alpha source imaging - 250 particles per second*

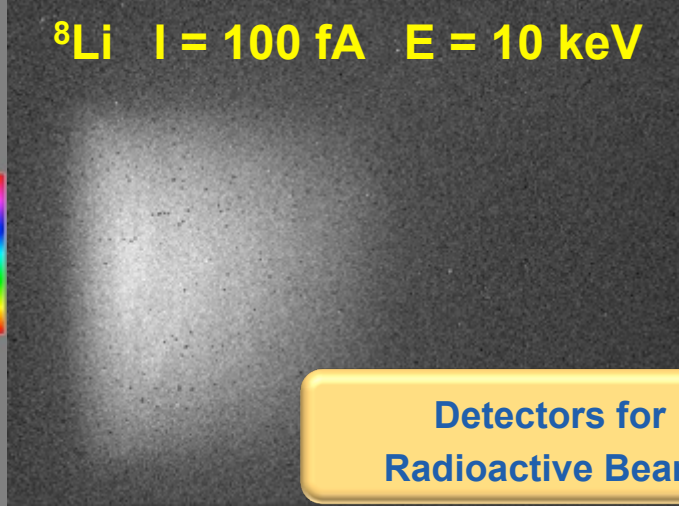
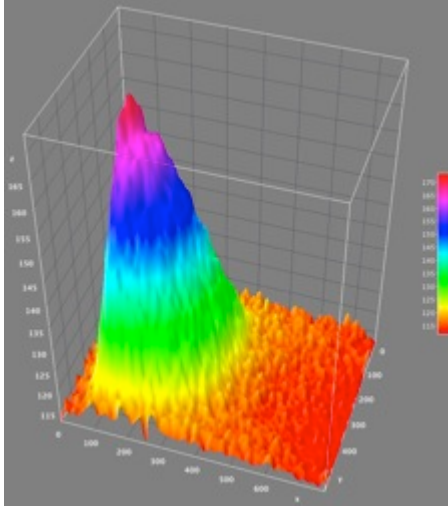


- nuclear reactions in laser-induced plasma?
- plenty of particles produced all at once
- **particle identification**
- **energy spectrum**

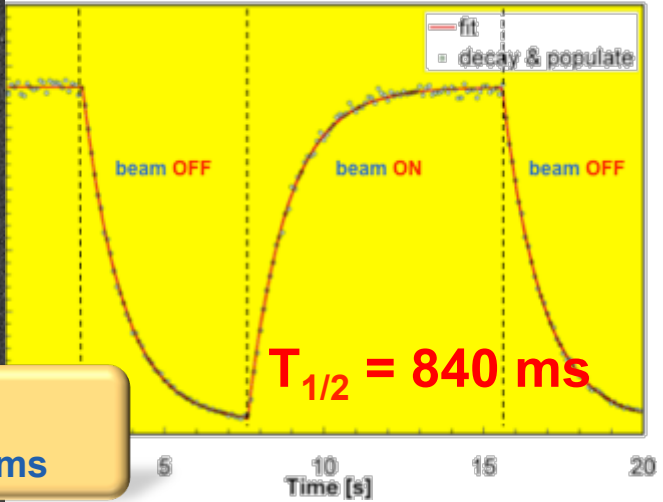




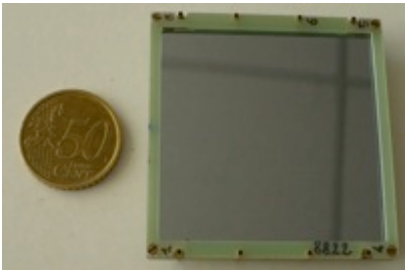
**Our background**



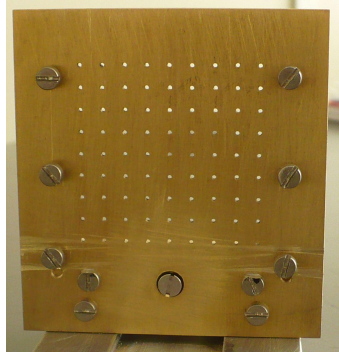
**Detectors for  
Radioactive Beams**



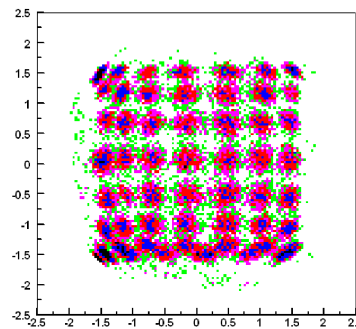
**5cm x 5cm Si detector**



**multi-hole mask**



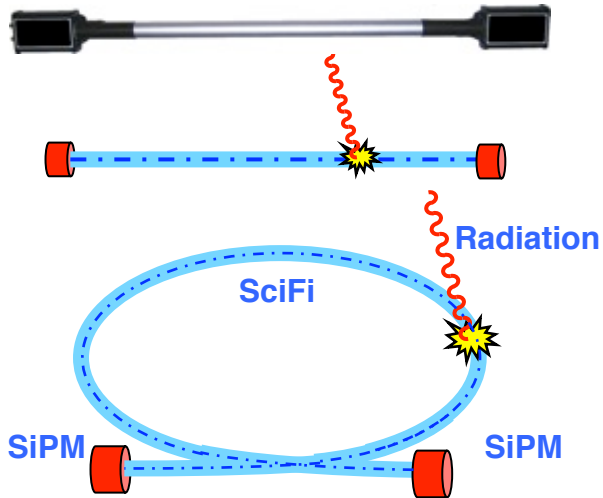
**beam profile**



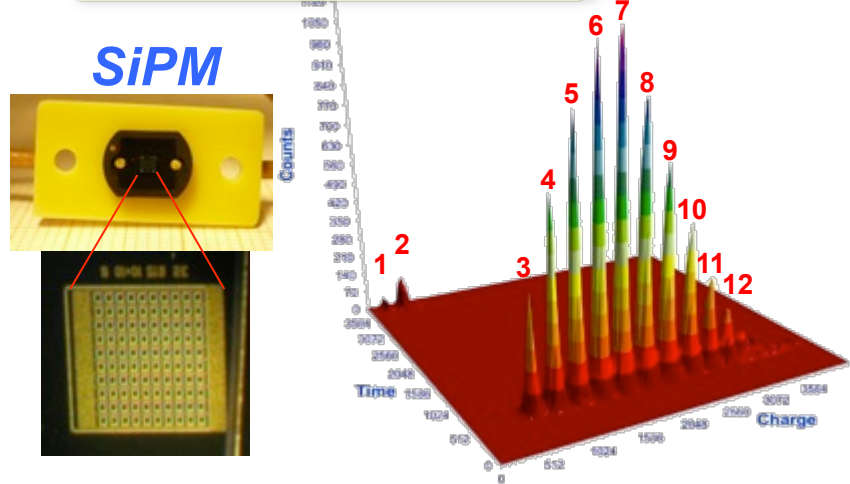
**position sensitive silicon  
telescope for RIB  
identification and  
profiling**

**Current activity: solutions for Radioactive Waste**

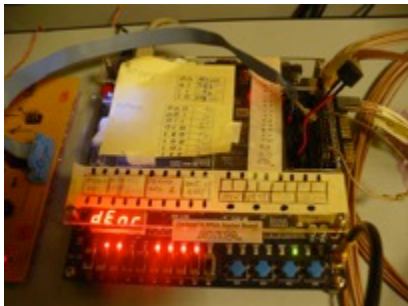
**new radiation detectors**



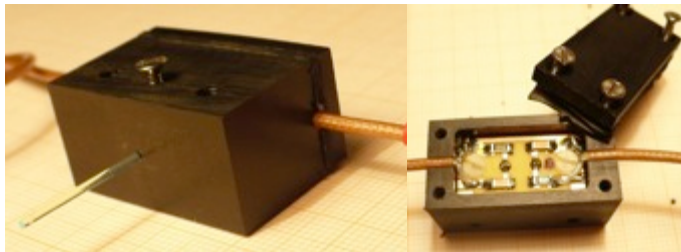
**new photosensors**



**FPGA systems**



**μ-mechanics**



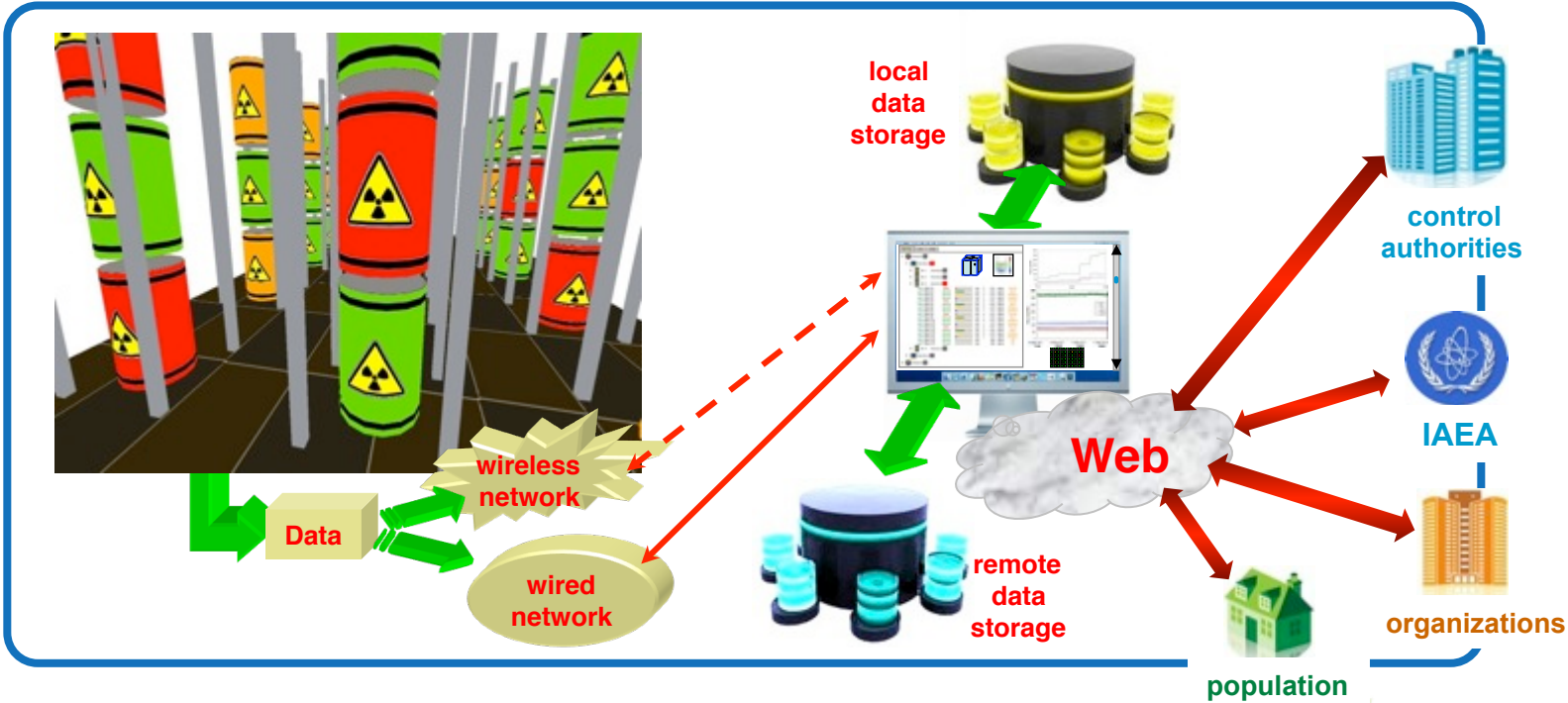
**computing**





**Radioactive waste: solutions**

in collaboration with **Ansaldo Nucleare**  
DMNR system for radwaste online monitoring



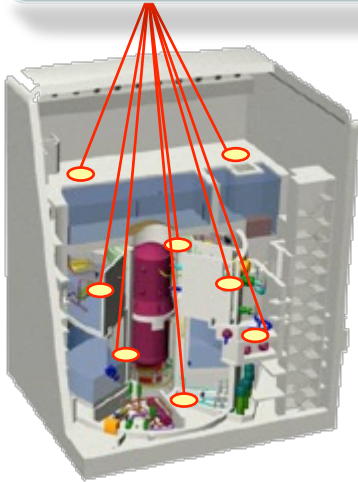
in collaboration with **SOGIN**  
a prototype being installed in a storage site



# Radioactive waste: solutions

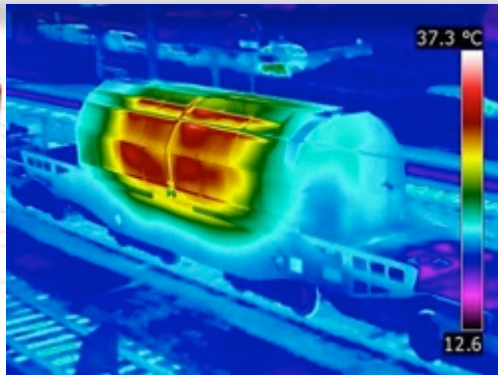
## Collaboration with JRC & Euratom: neutron detection (INFN patent pending RM2013A000254)

around reactor core  
in nuclear power plants



- ### Applications
- Homeland security
  - Radwaste and nuclear fuel production monitoring
  - Detection of lost radioactive sources

spent fuel rods monitoring  
in place and during transportation



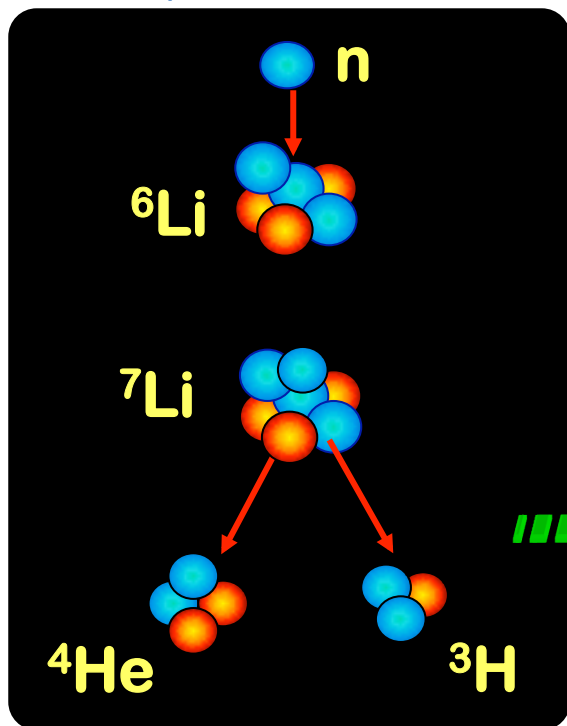
preventing the smuggling  
of nuclear fuel



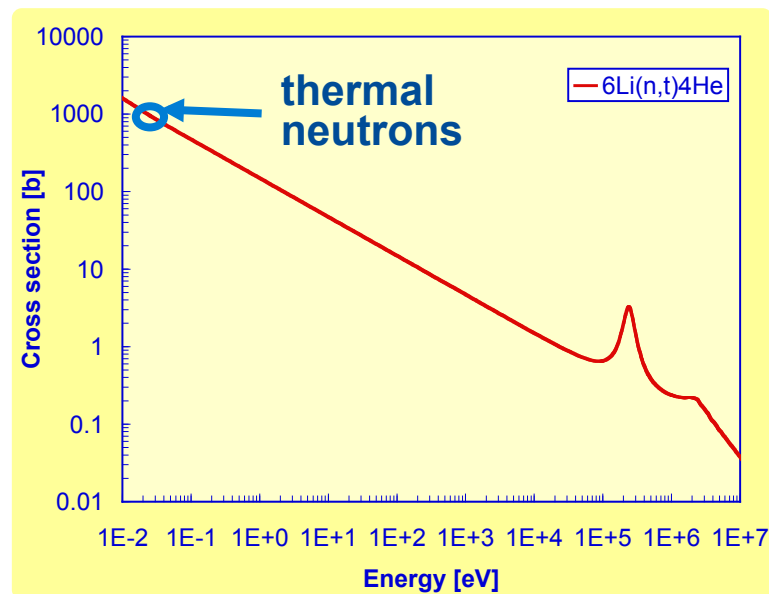
we use  ${}^6\text{Li}$

${}^6\text{Li}$  – natural abundance: 7%

a  ${}^6\text{LiF}$  converter captures a neutron...



Cross section  $\approx$   
940 b



2.05 MeV

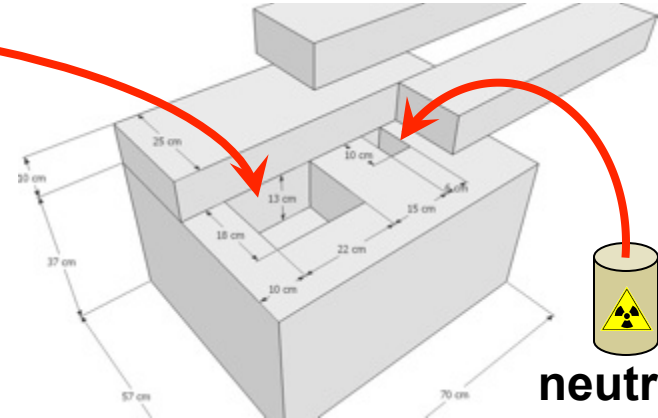
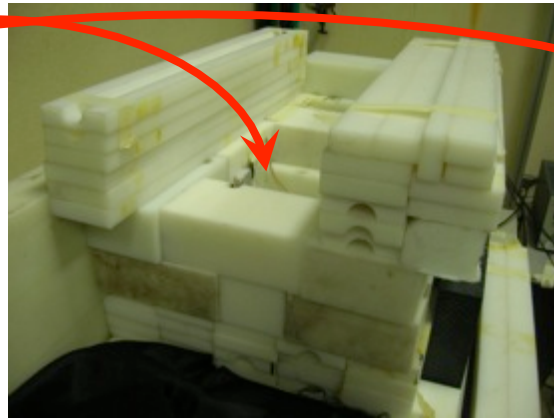
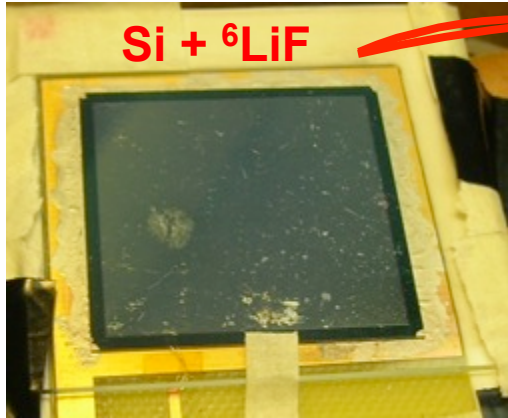
2.73 MeV

...and produces  ${}^4\text{He}$  and  ${}^3\text{H}$   
that can be detected

detection of  ${}^3\text{H}$  and/or  ${}^4\text{He}$

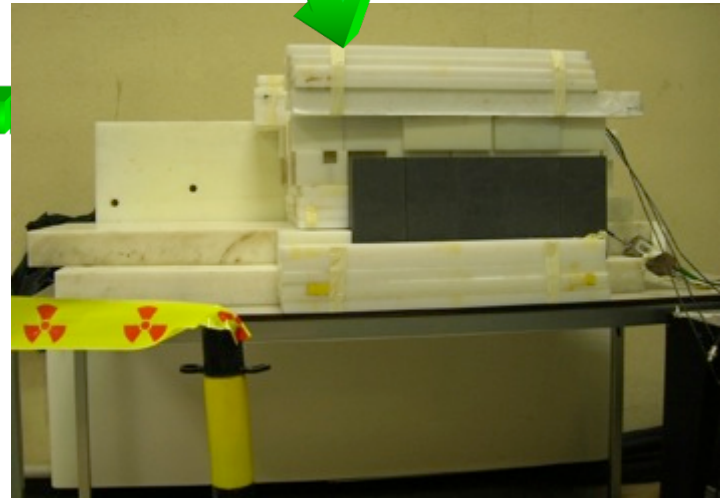
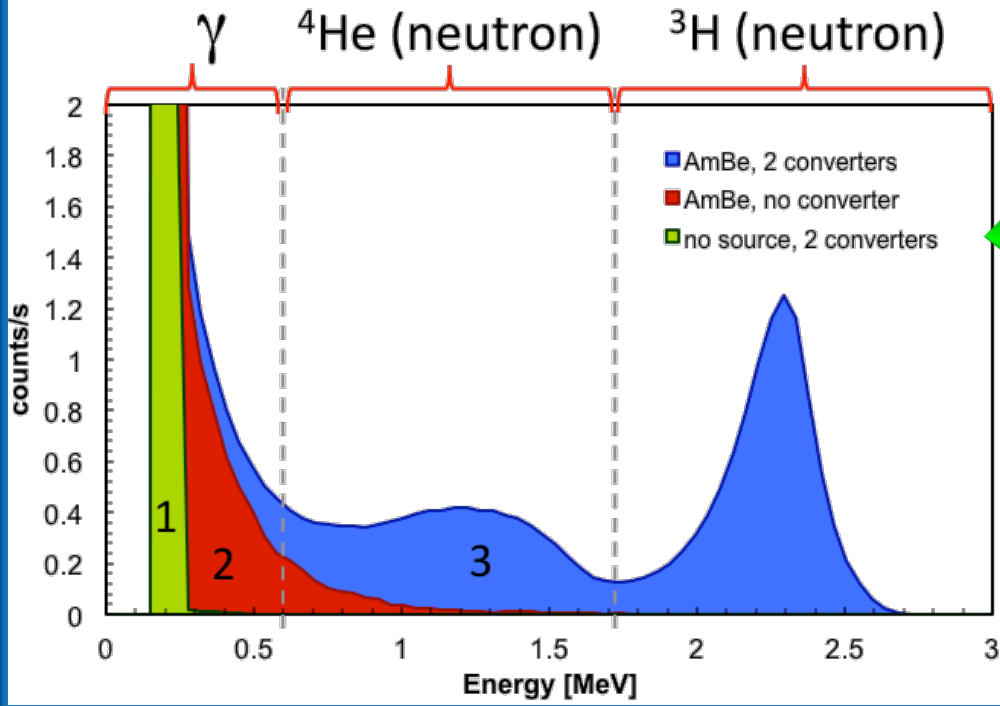
how?

test with AmBe source: Si detector +  ${}^6\text{LiF}$

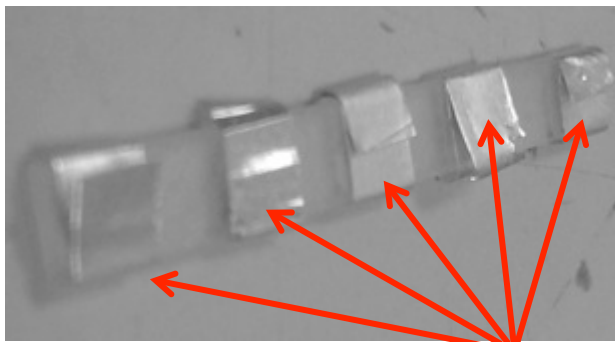
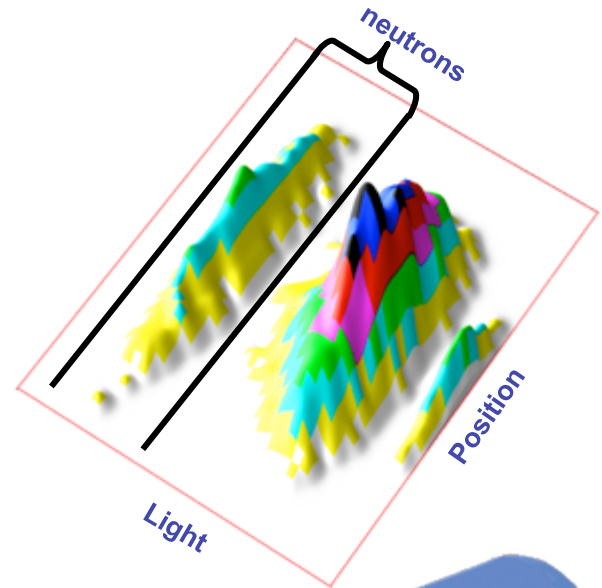
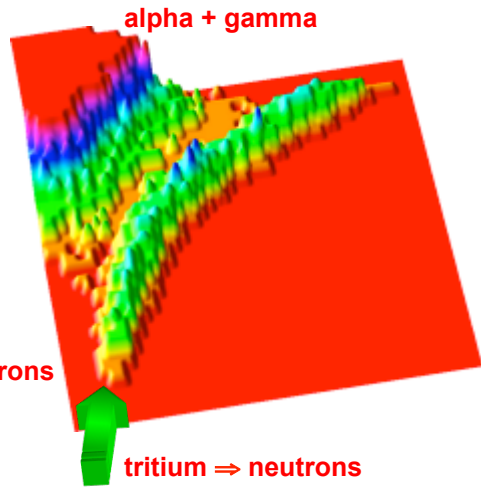
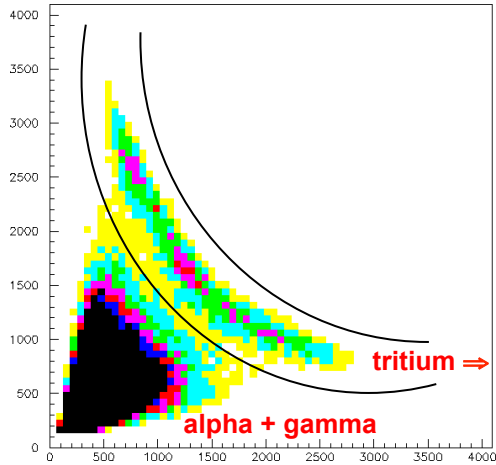


neutron source

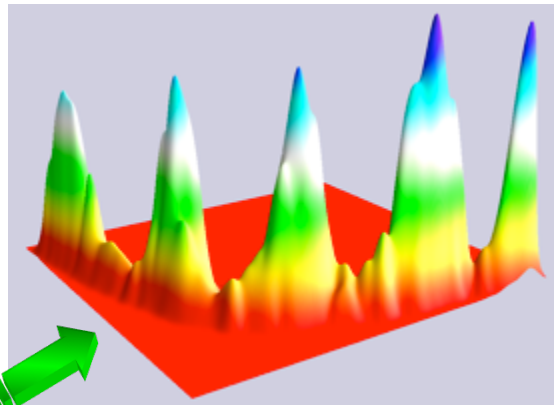
PET moderator



test with AmBe source: Scintillators +  $^6\text{LiF}$

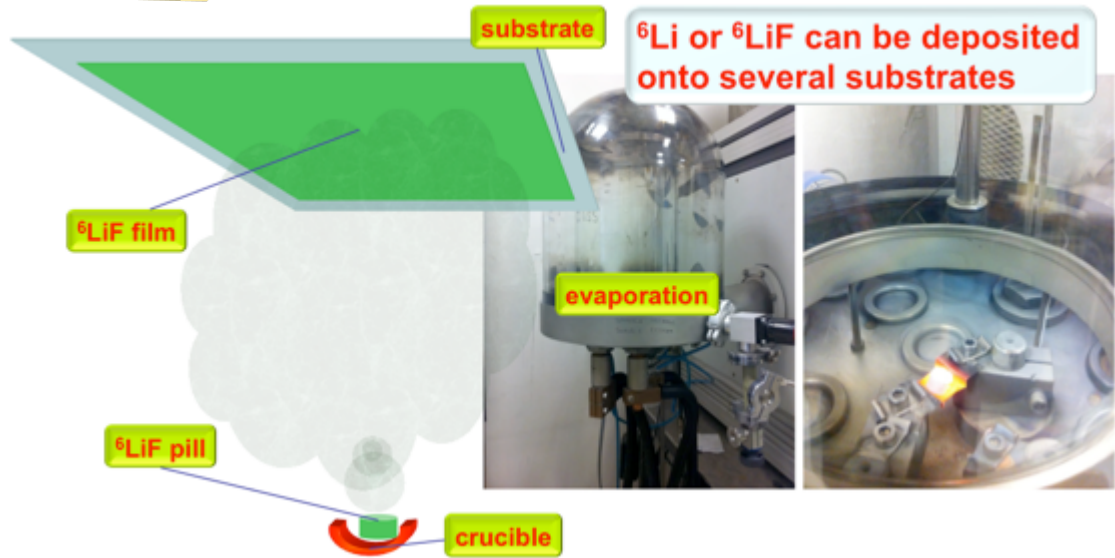
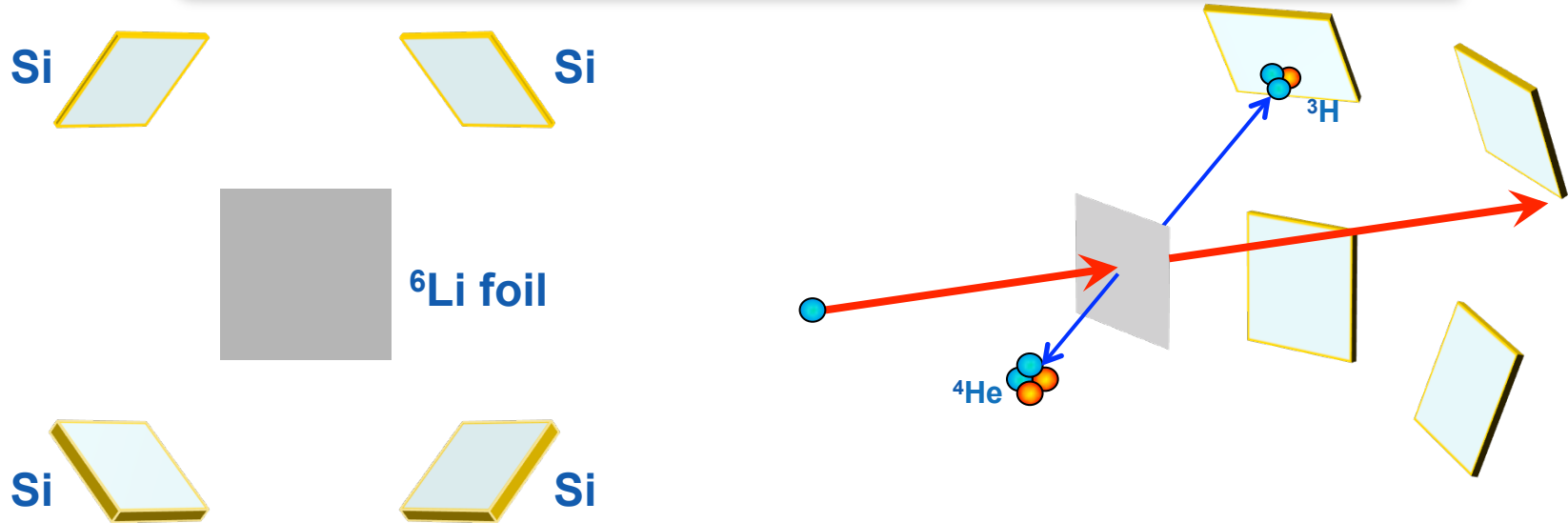


$^6\text{LiF}$  converter



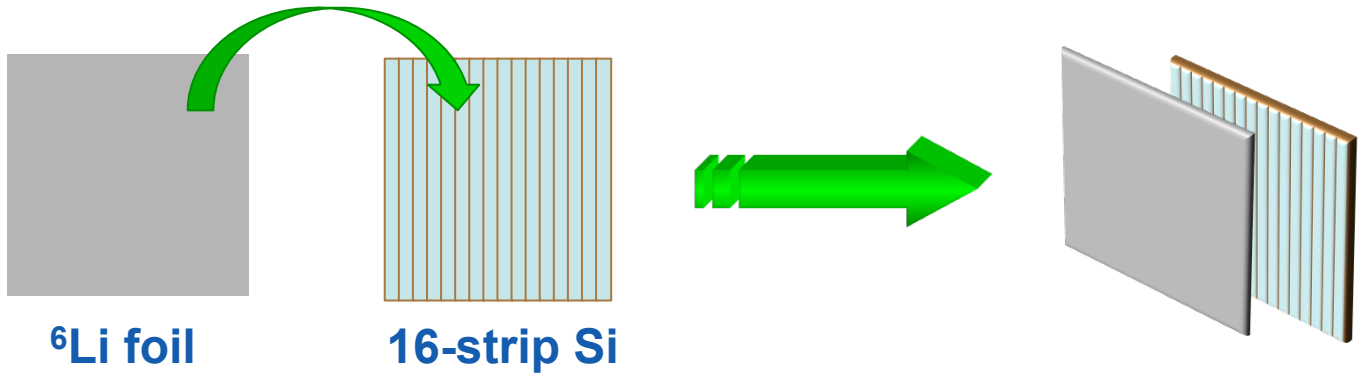
RM2013A000254

**SiMon2: neutron beam monitor for flux normalization**



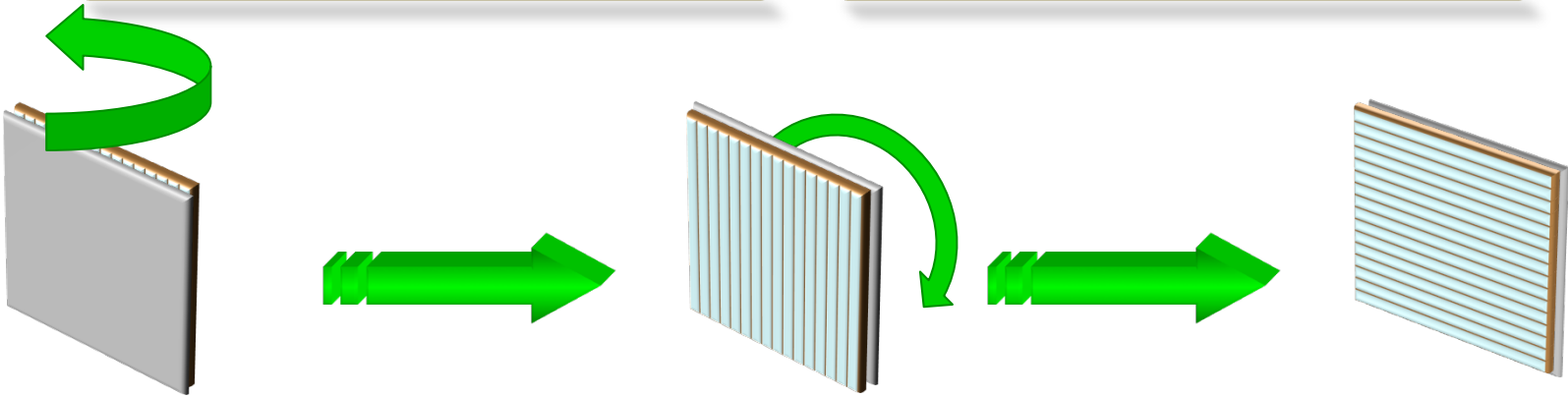


**BeaMon: neutron beam characterization**

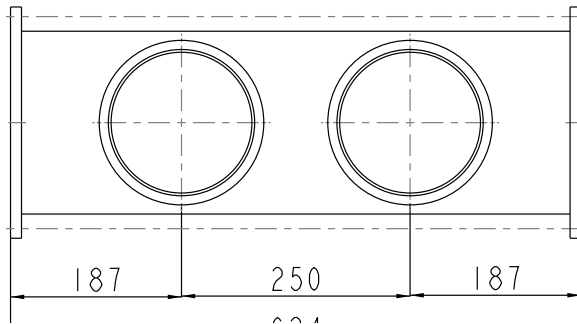
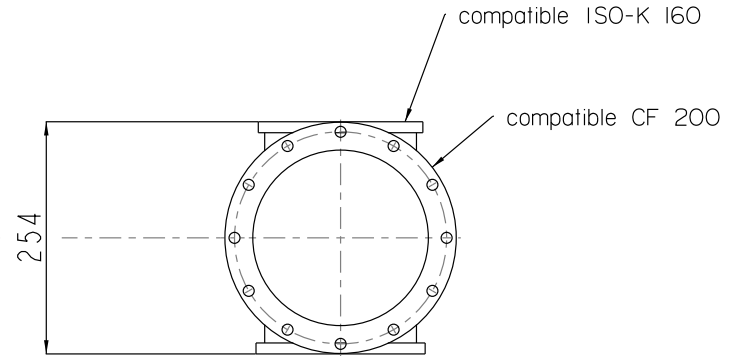
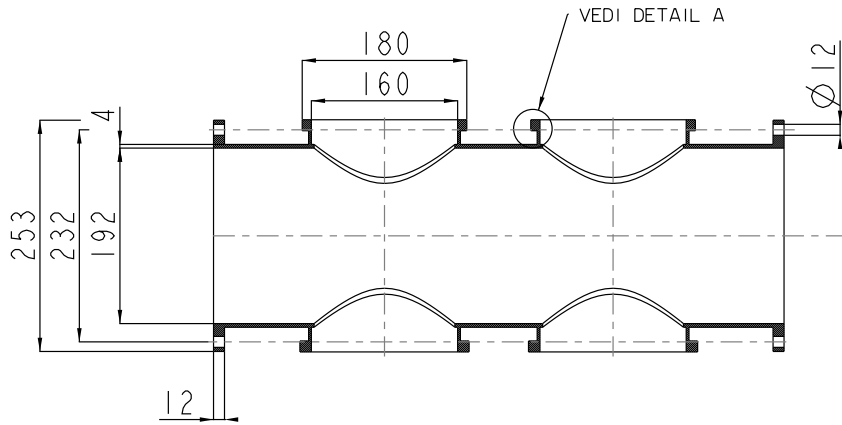


$\alpha$ -t forward-backward asymmetry

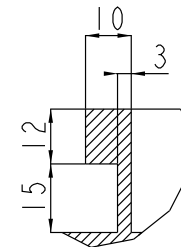
XY distribution



**EAR2 vacuum chamber in carbon fiber**

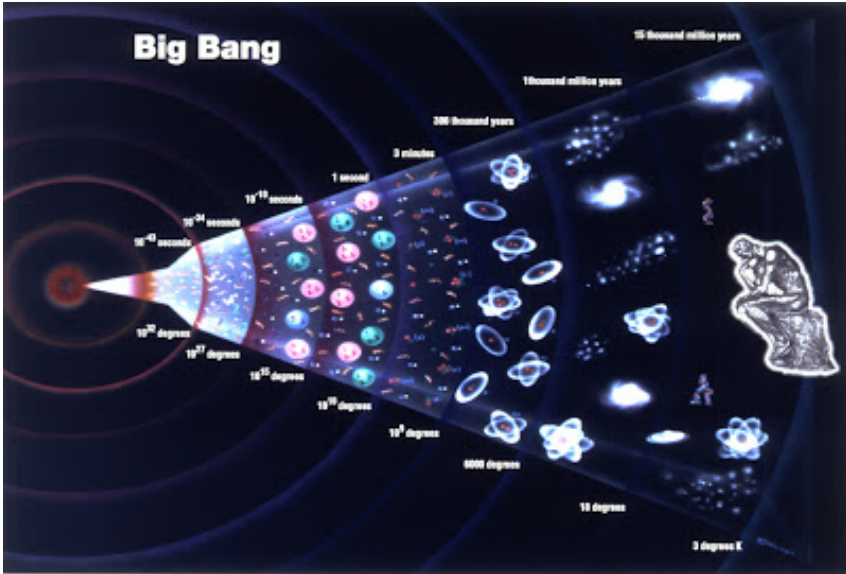


DETAIL A  
scale 1:1



**redesigned at LNS**  
by M.Piscopo

Interest in the investigation of cosmological  ${}^7\text{Li}$  problem @n-TOF



Big Bang Nucleosynthesis  
 $e^- + {}^7\text{Be} \rightarrow {}^7\text{Li} + \nu_e$

${}^7\text{Be}$  production  
 ${}^3\text{He}(\alpha, \gamma){}^7\text{Be}$



${}^7\text{Be}$  destruction  
 ${}^7\text{Be}(n, p){}^7\text{Li}$   
 ${}^7\text{Be}(n, \alpha){}^4\text{He}$



difficult measurement, can be done at EAR2 nTOF?

**Contacts at INFN-LNS**



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**Paolo Finocchiaro**      **FINOCCHIARO@LNS.INFN.IT**



**Agatino Musumarra**      **MUSUMARRA@LNS.INFN.IT**



# Thank you

