ETHERNES: an innovative way to produce homogeneous and extended thermal neutron fields

R. Bedogni
INFN – LNF
Divisione ricerca

NEURAPID (2014-2016)
NEUtron RAPId Diagnostics
Website *csn5neurapid*

Summary

1. State of art
2. Break with tradition
3. Computational
4. Experimental

Usual way to produce very stable thermal neutron fields for testing and calibrating neutron sensitive devices:

Embedding one ore more radionuclide fast neutron sources in large moderating blocks (polyethylene, graphite).

PTB (Braunschweig, Germany)

- 4 m^3 graphite assembly
- Thermal fraction 99%
- Homogeneity figure 10% in a 20 cm x 20 cm area
- Useful flux 80 $cm^{-2}s^{-1}$
- FOM = 6E+7 n/s / 80 $cm^{-2}s^{-1}$ ≈ 7E+5 cm^2

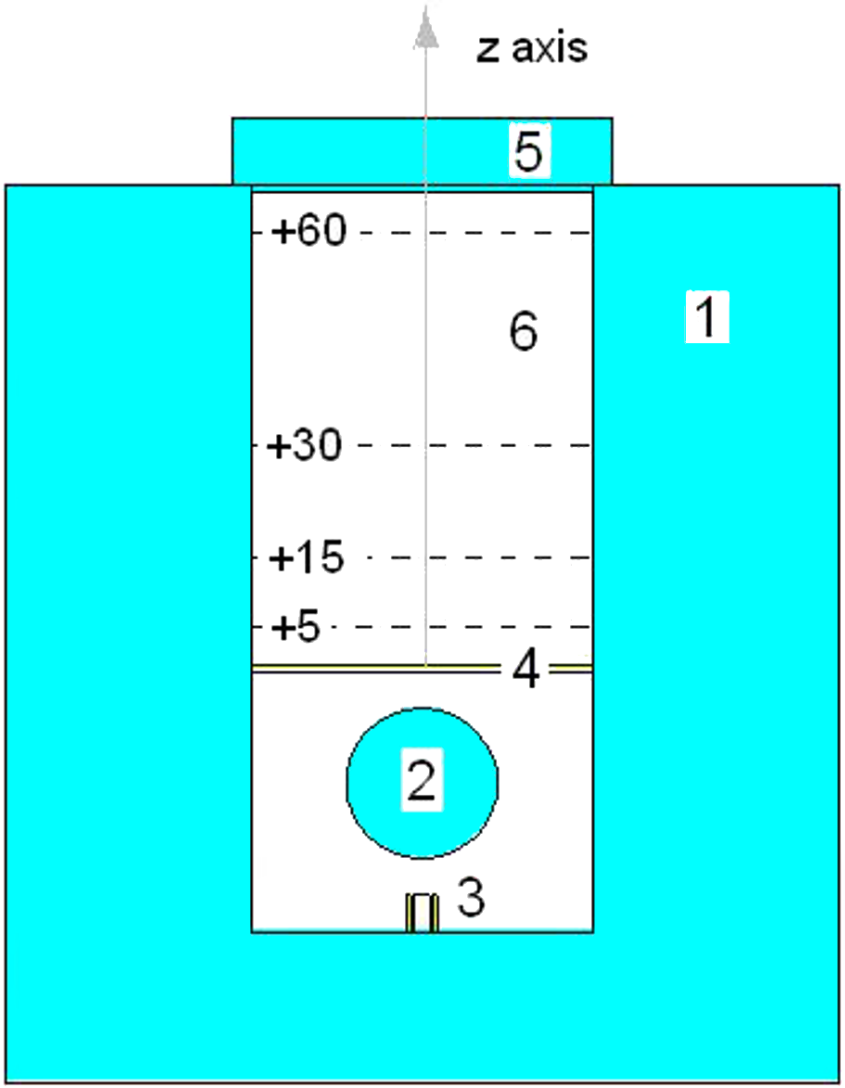
SIGMA (IRSN Cadarache) – decommissioned

- 3.3 m^3 graphite assembly
- Thermal fraction 88%
- 6 neutron sources with total emission 2E+8 n/s
- Useful flux 1500 $cm^{-2}s^{-1}$ at 50 cm from facility wall.
- FOM = 1.3E+5 cm^2

ENEA Bologna – decommissioned

- 1m^3 HDPE assembly
- Thermal fraction 60%
- 6 neutron sources with total emission 2E+8 n/
- Useful flux 500 $cm^{-2}s^{-1}$, homogeneity 10% on 20 cm diam.
- FOM = 7E+4 cm^2

A multiple scattering cavity



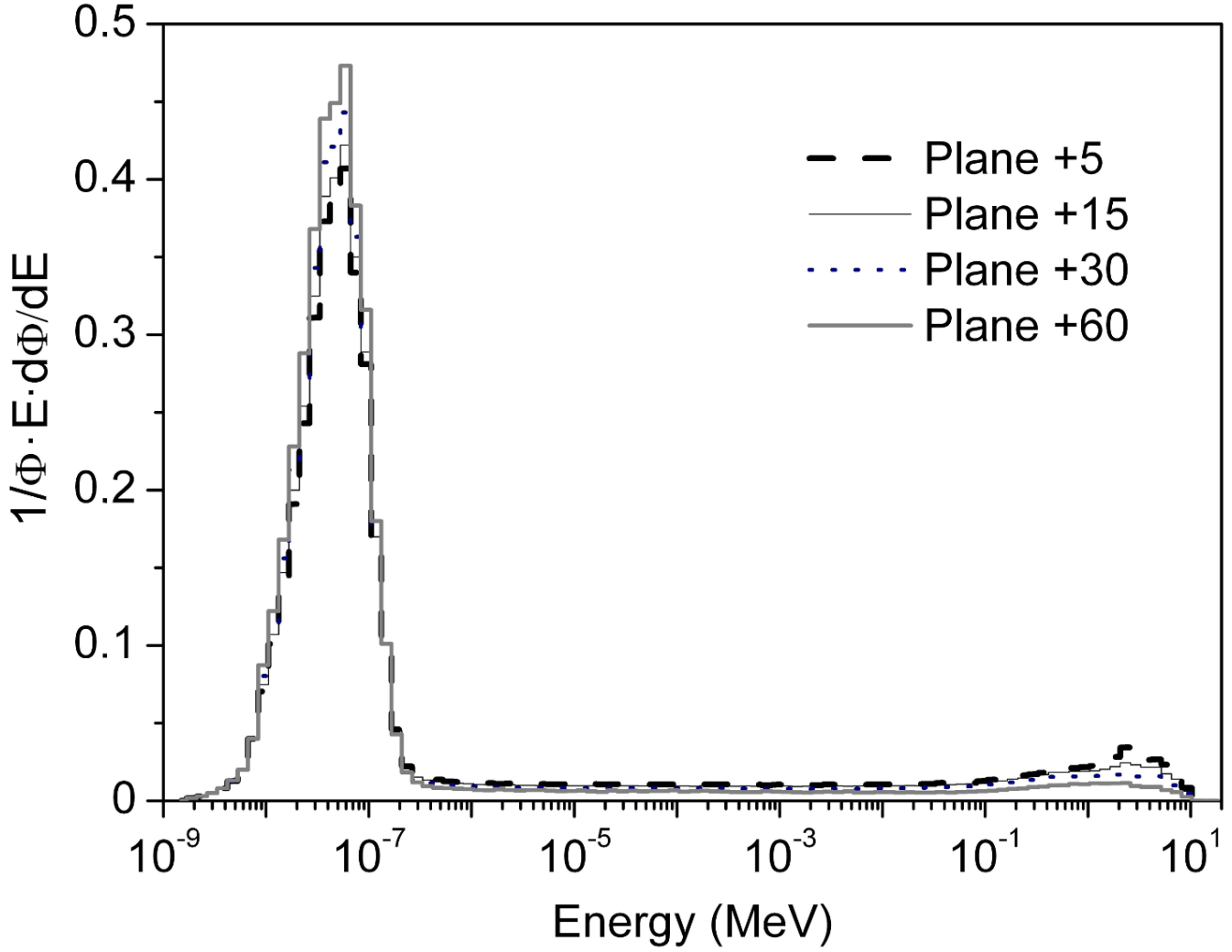
Irradiation cavity (6)
45 cm × 45 cm × 63 cm

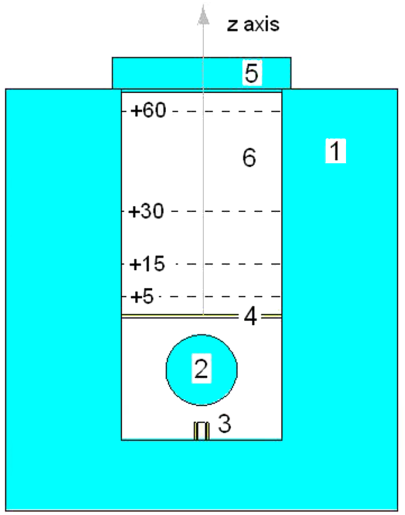
(1) HDPE
(2) shadow sphere;
(3) neutron source;
(4) lead plate;
(5) cover.

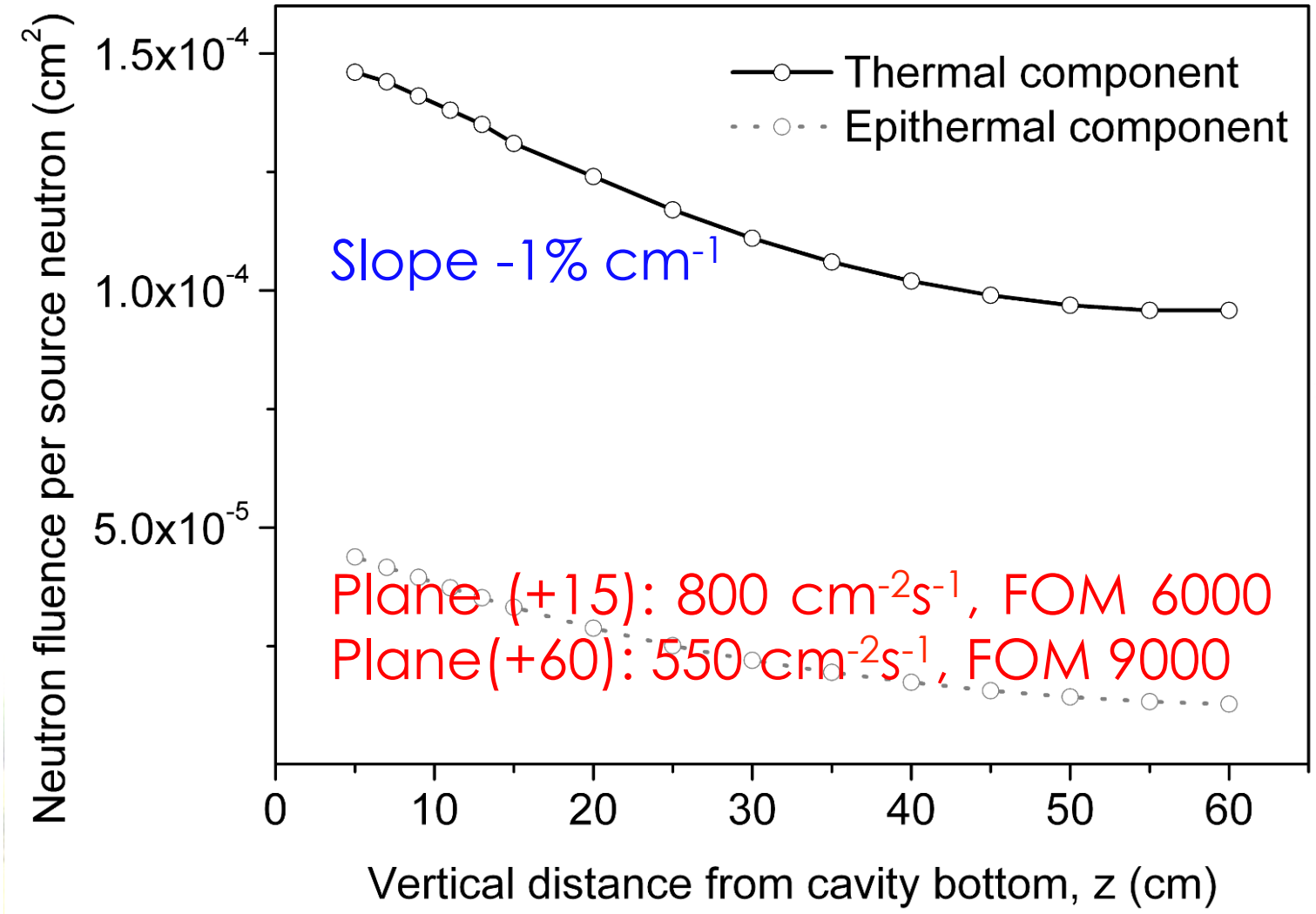
Irradiation planes: +5, +15, +30 .... (cm from bottom)

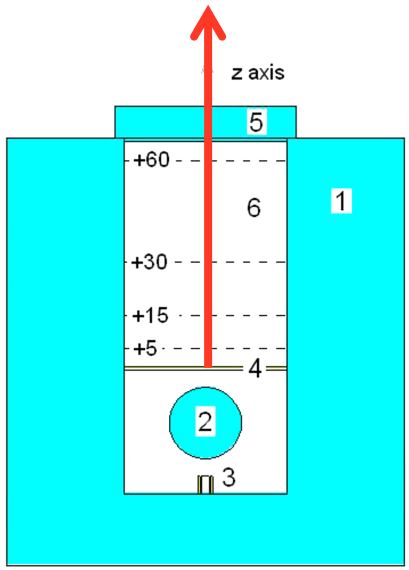
2 of 4 - Break with tradition

Monte Carlo simulations (MCNPX)





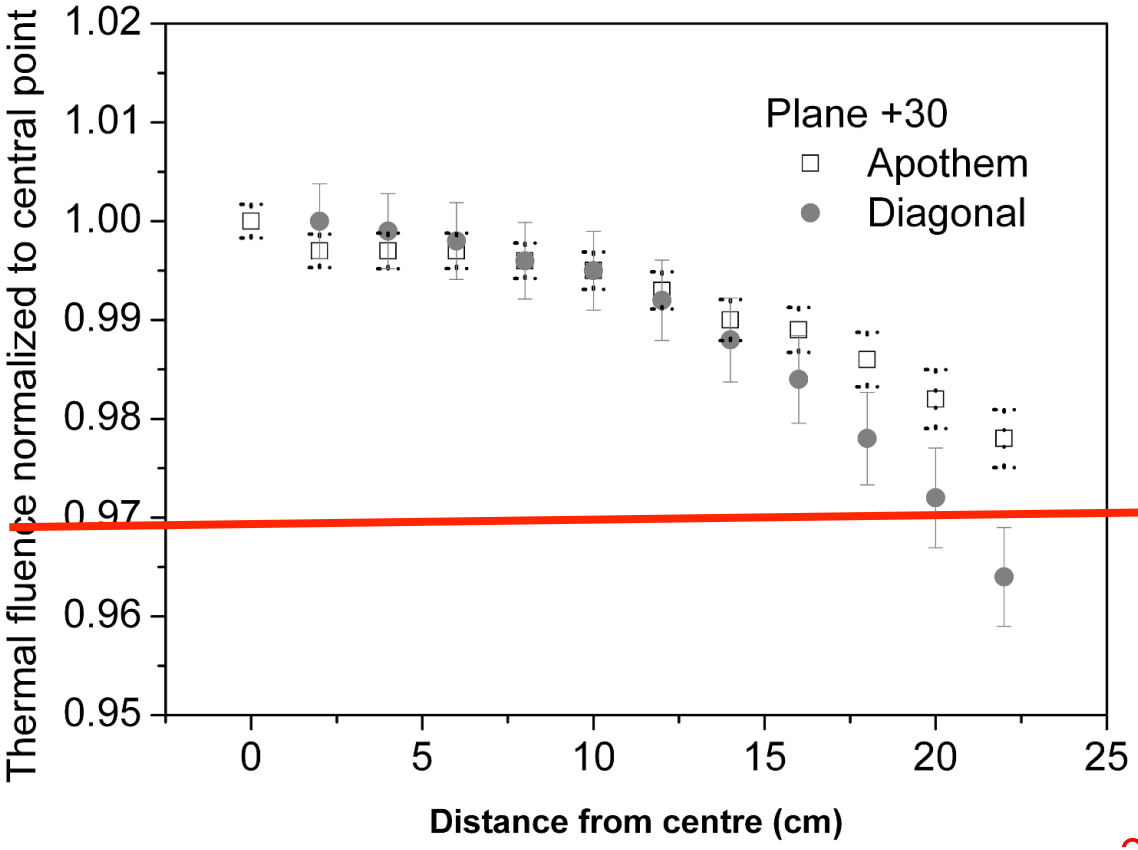

Neutron fluence per source neutron (cm^{-2})
1.5x10^{-4}
1.0x10^{-4}
5.0x10^{-5}
0
10
20
30
40
50
60
Vertical distance from cavity bottom, z (cm)
Thermal component
Epithermal component
Slope -1% cm^{-1}
Plane (+15): 800 cm^{-2}s^{-1}, FOM 6000
Plane(+60): 550 cm^{-2}s^{-1}, FOM 9000

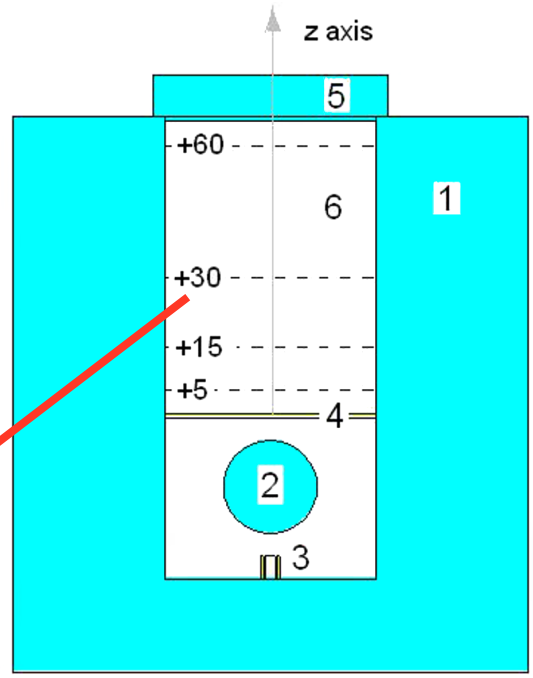

z axis
5
+60
6
1
+30
+15
+5
4
2
3

Uniformity area ($\Phi \geq 97\% \Phi_{max}$)

+5, +15, +30 cm planes: 22 cm radius

+ 60 cm plane: 15 cm radius





3 of 4 - Computational

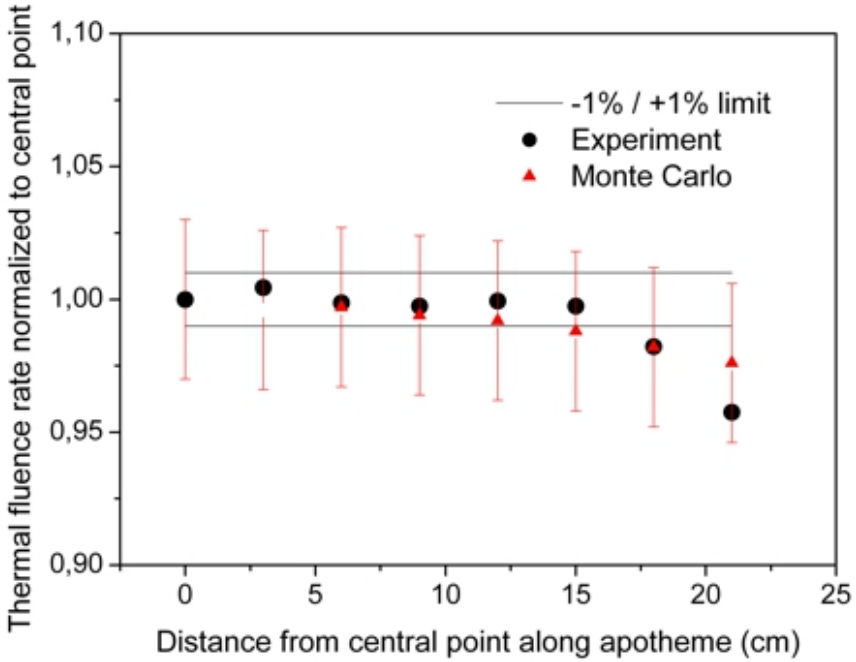
Practical facilities developed on ETHERNES design

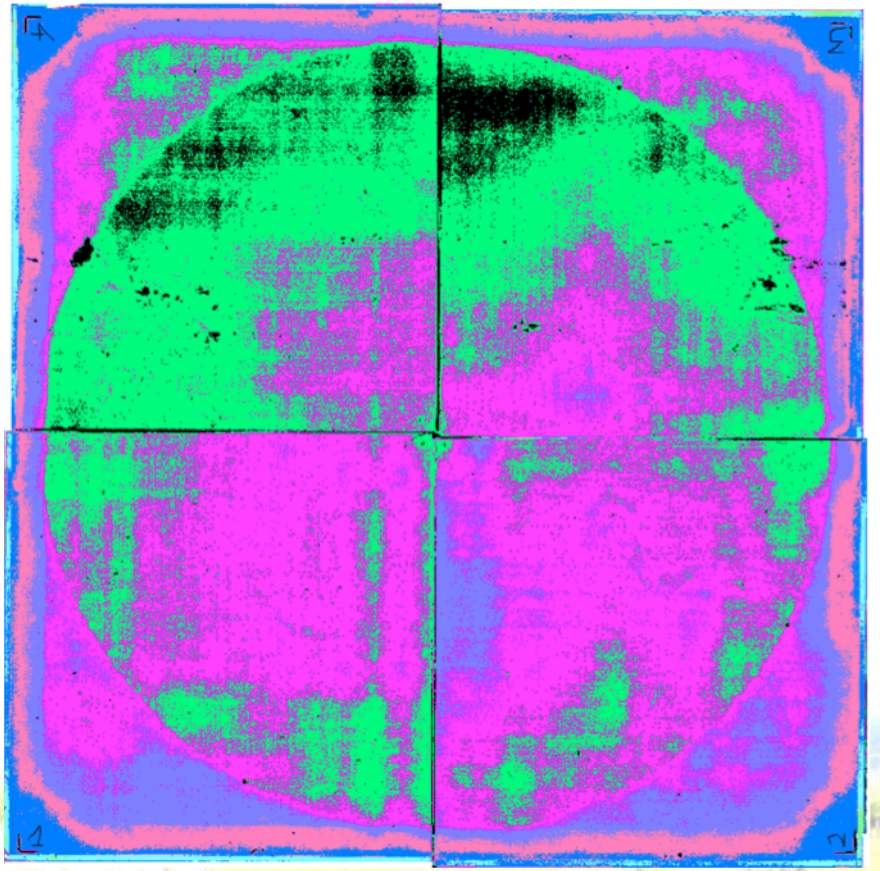
1. ETHERNES. INFN-LNF, parallelepiped cavity 63x45x45,
   Φ_{th} 550-800 $cm^{-2}s^{-1}$
   (attualmente in trasloco)

2. ESTHER. Politecnico di Milano (Prof. Pola), cylindrical cavity diam. 30 x h 60 cm,
   $\Phi_{th} \approx 500\ cm^{-2}s^{-1}$

3. HOTNES. ENEA Frascati,cylindrical cavity diam. 30 x h 60 cm,
   $\Phi_{th} \approx 700\text{-}1000\ cm^{-2}s^{-1}$

ETHERNES





4 of 4 - Experimental

Conclusions

1. ETHERNES design allows extended, homogeneous fields with attractive FOM value.
2. Possibility of different designs.
3. Preliminary experiments fully confirmed performance.
4. A range of ETHERNES-like facilities are becoming available.