New developments of the spherical detector sensor

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On behalf of the

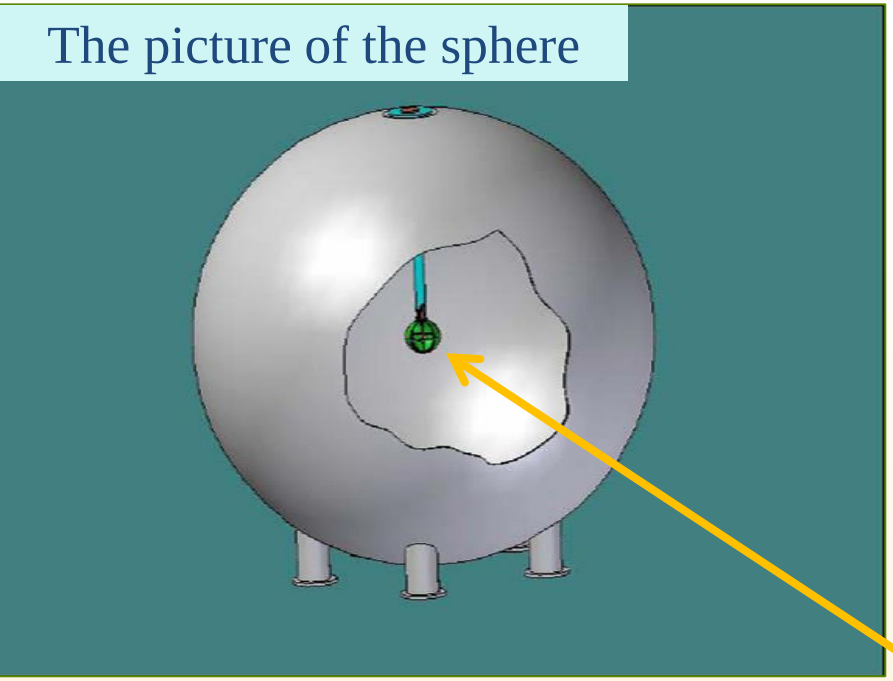
NEWs Collaboration

Outline

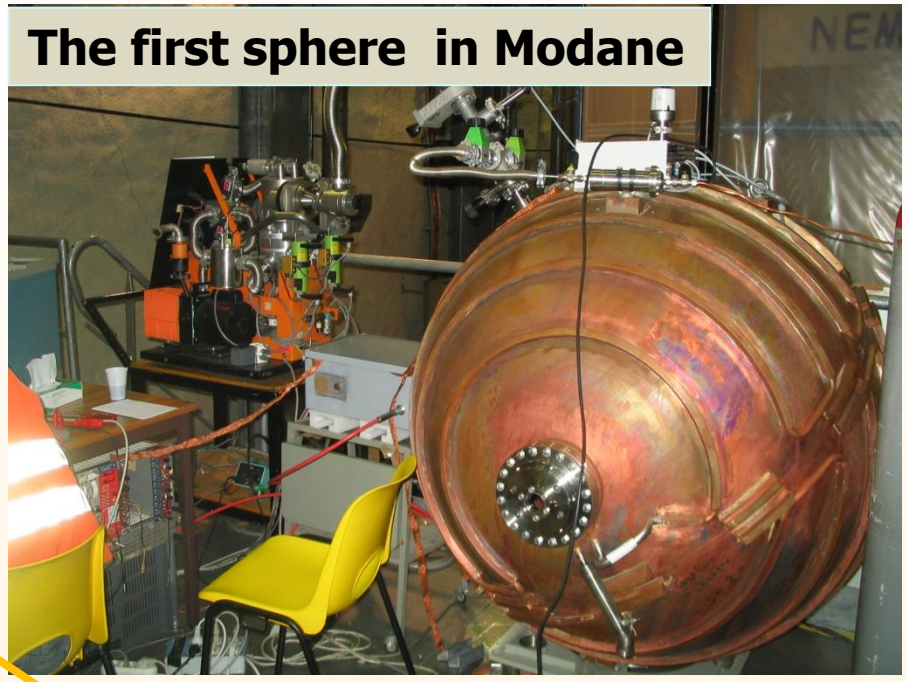
1. The status and the limits of the one ball sensor
2. The multi-ball sensor “ACHINOS”
3. The first experimental data with the first 5ball prototype.
4. The simulations and the next step

The Large Volume (1m3) Spherical Proportional Counter

The picture of the sphere



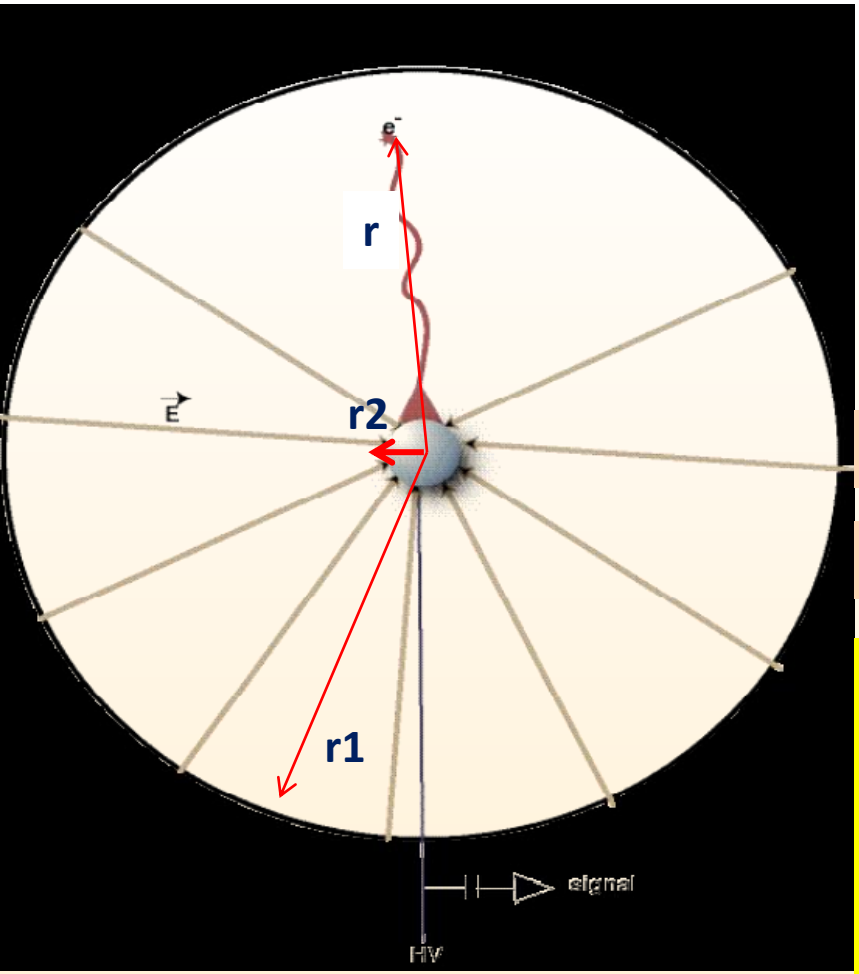
The first sphere in Modane



Sensor: small ball (anode for charge amplification)

Volume = 1 m3, Cu 6 mm
Gas leak < 5x10-9mbar/s.
Gas mixture Argon + 2%CH4
.Pressure up to 5 bar
Internal electrode at high voltage.
Read-out of the internal electrode 15 mm

The electric field of a spherical capacitor



$$E(r) = \frac{V_0}{r^2}\frac{1}{1/r_2 - 1/r_1}$$

$$V = V_0\frac{1/r - 1/r_1}{1/r_2 - 1/r_1}$$

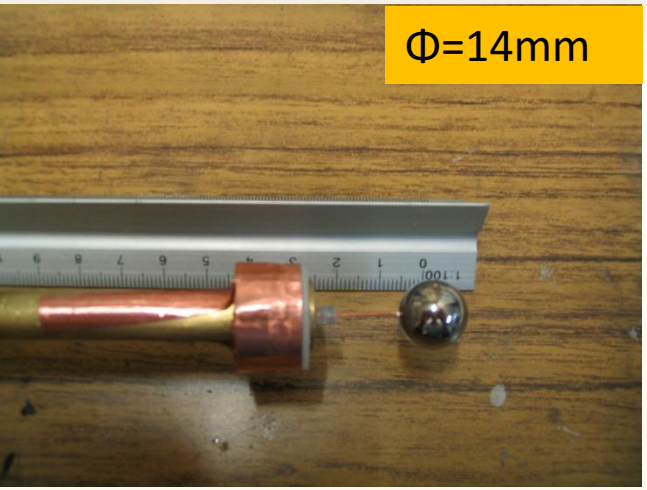
r2=ball radius

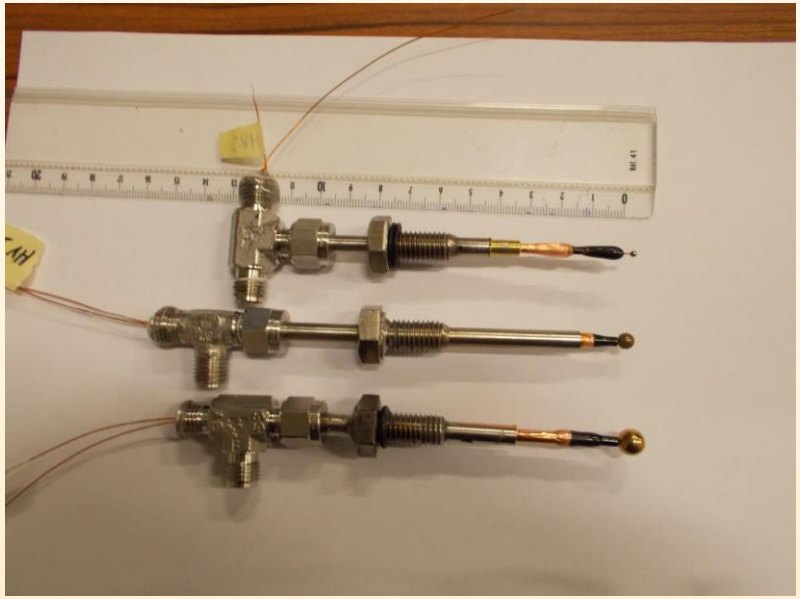
r1=sphere radius

* In a big sphere, Φ=130, the electric field far from the center is very low.

* Additionally, if we go to high pressure (several bars), we must use small balls (r2=1mm or 0.5mm) and the field is more less.

Several sensors with different ball diameters, which have been used

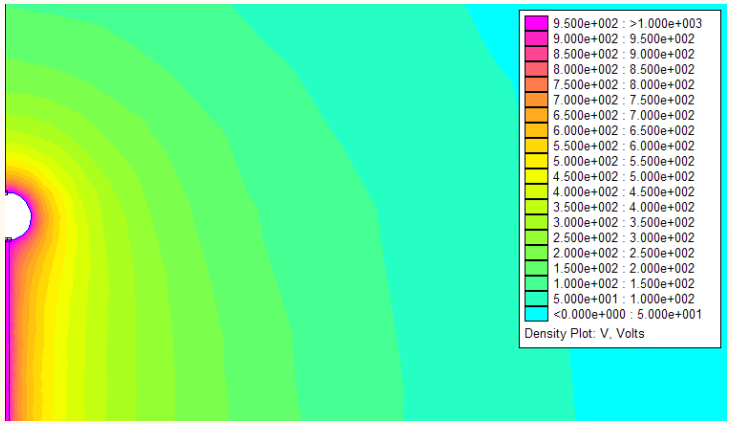




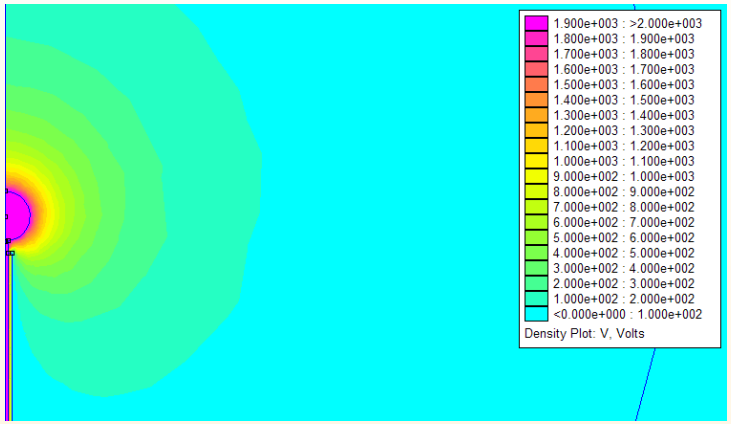
Electrostatic field (simulation results)

LEFT: 15 mm sphere, 1mm Cu cable covered with 3mm PE
RIGHT: 15 mm sphere, 1mm Cu cable covered with 3mm PE + graphite (ground). Distance sphere to graphite 4mm

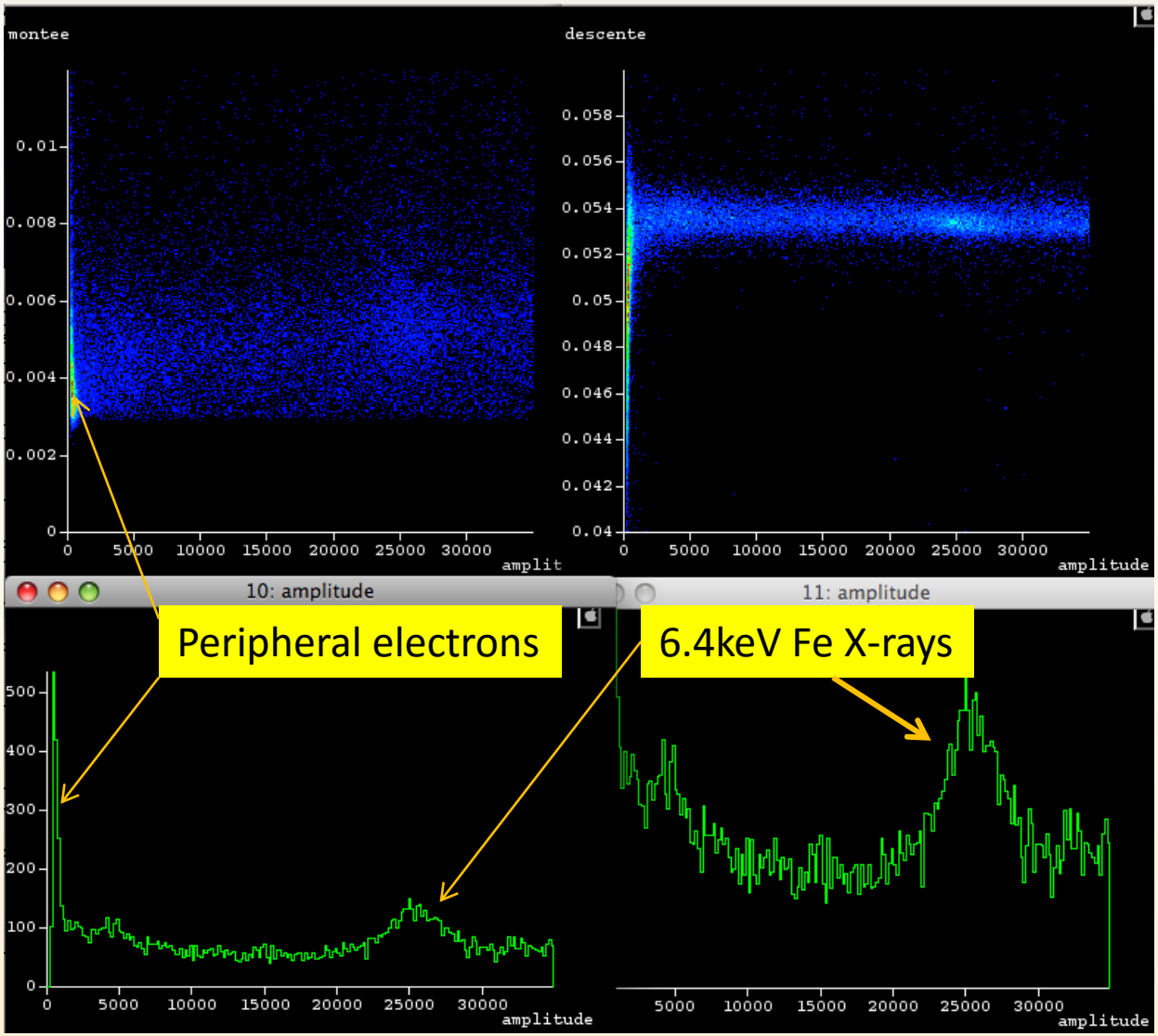
No field correction



With field correction



6.4keV X-rays from the Fe of the Φ=30cm Fe-sphere
P=1bar Ar+2%CH4, Am-Be neutron source



The limits of the one ball sensors

The electric field at a distance r from the center approximately is:

$$E(r) = \frac{V_0 r_2}{r^2}$$

* The use of small balls, **1mm or 2mm** in diameter, helps to have **high gain** with **lower high voltage** at high gas pressure(several bars).
* But….. far from the center, close to the surface of the sphere, at high pressure we have recombination and the signals disappear.

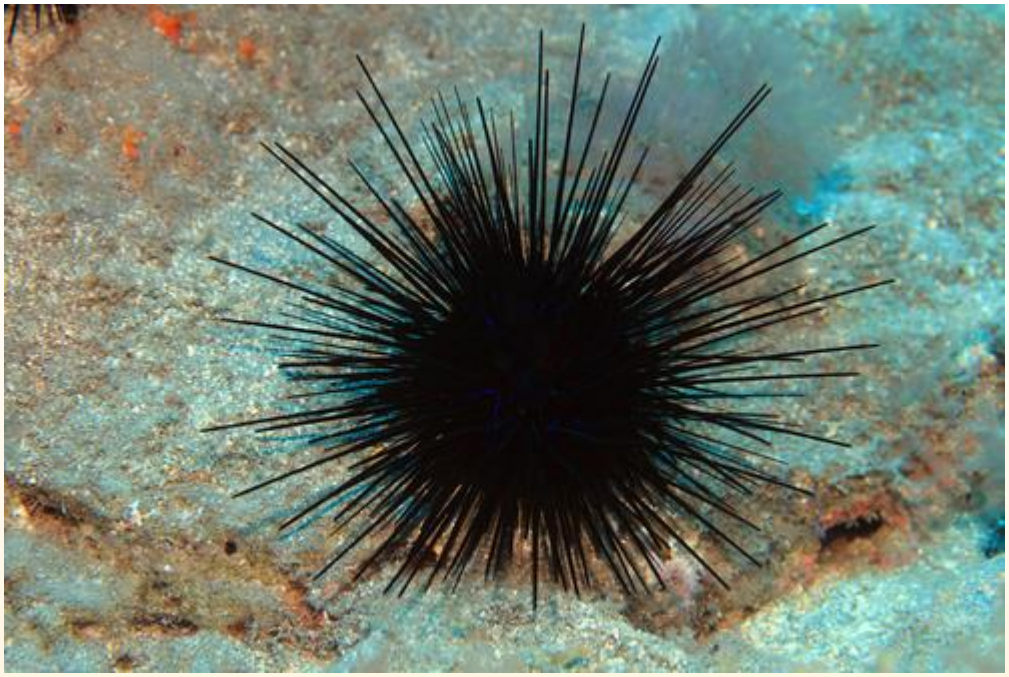
The "effective volume " of the detector is less than the volume of the sphere.

The proposed multi-ball (multi-anode) sensor "ACHINOS"

(by Ioannis Giomataris)

It is a sensor which consist of many small balls, in a spherical geometry

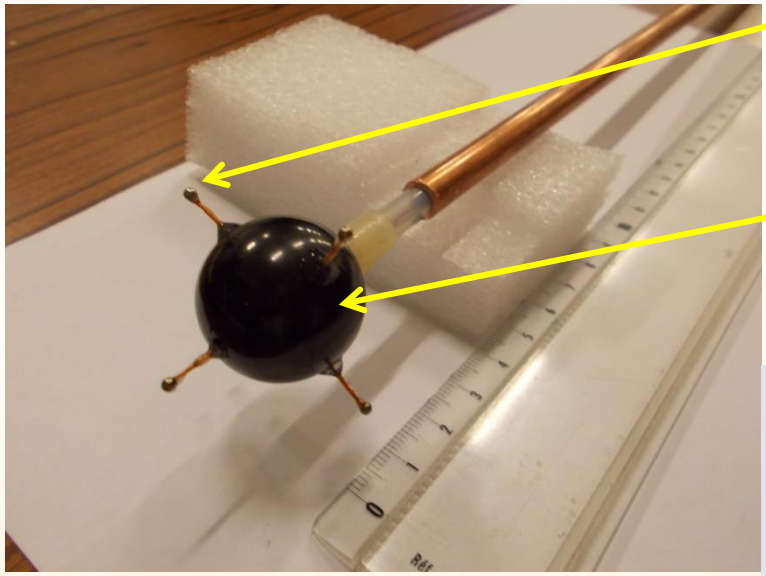
The sea “achinos”



The idea is to put small balls on the top of the pins with positive high voltage.

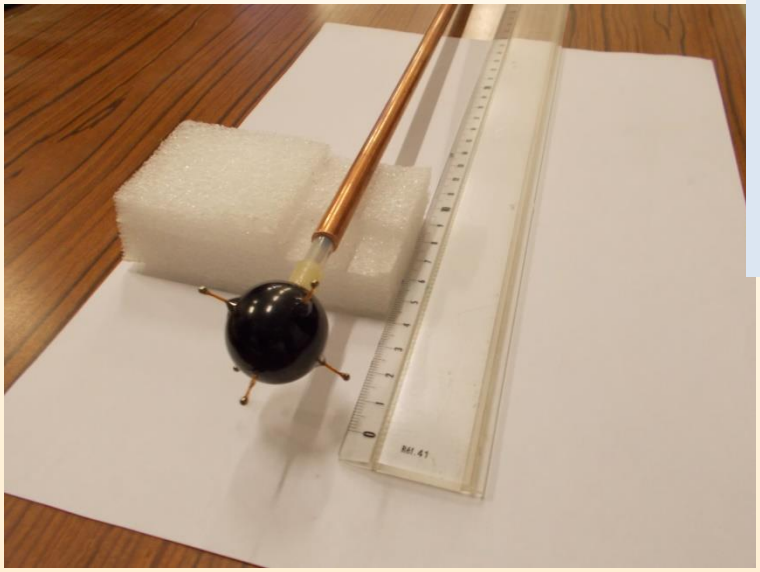
The first prototype with 5 balls of Φ=2mm, on Bakelite

(CEA-Saclay June 2016)



1mm or 2mm ball, anode, HV1

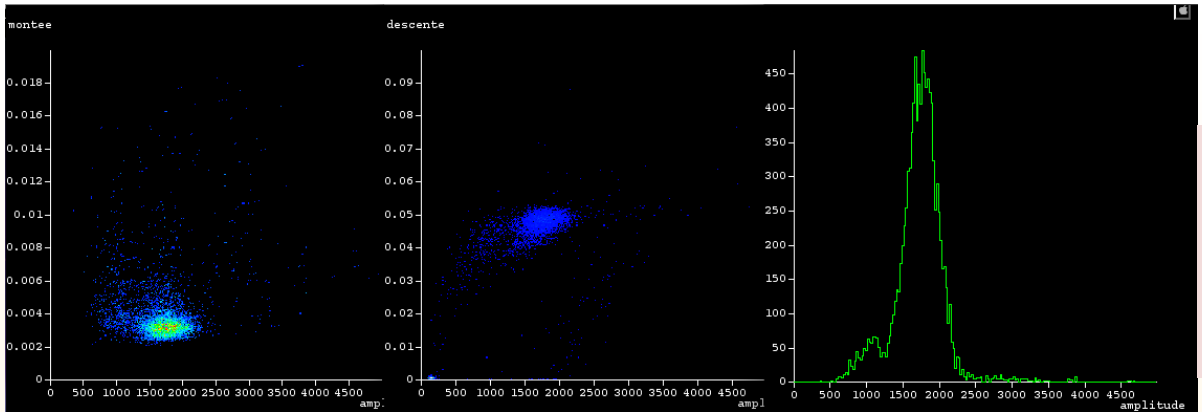
Bakelite Φ=25mm: field correction (umbrella), HV2



The advantages of "achinos":

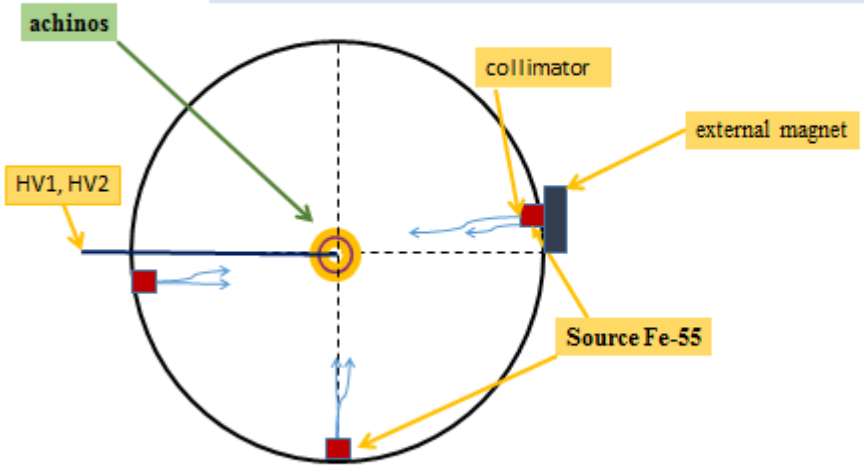
- The gain is the same as with one ball sensor
- But the electric field is stronger far from the center of the sphere and increase of the effective volume of the detector.
- Possibility to take signals independently from each ball and to have additional information about the track of the detecting particle in the sphere.

Some of the first experimental data of Fe-55 source with Φ= 2mm X 5balls "achinos"

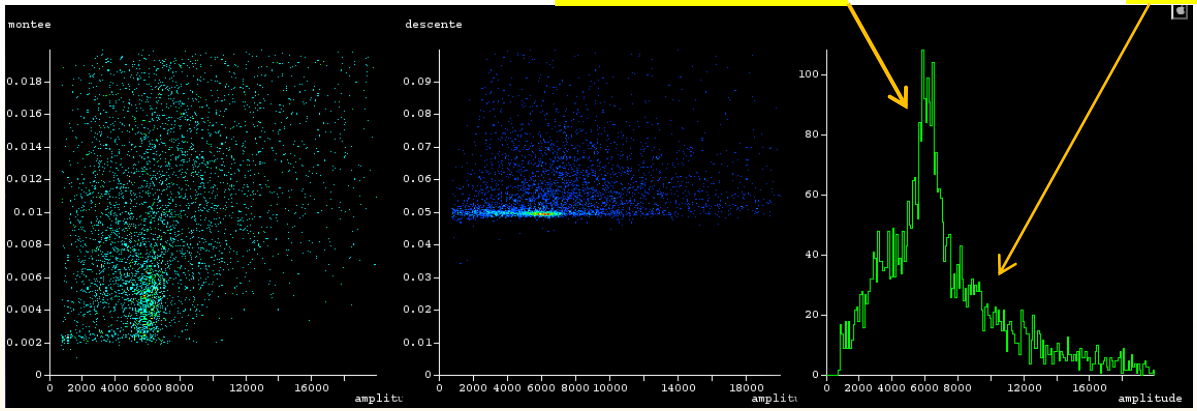


5.9keV (Fe-55),
Sensor with 5balls of Φ=2mm
P=100mbar, Ar+2%CH4
σ < 10%

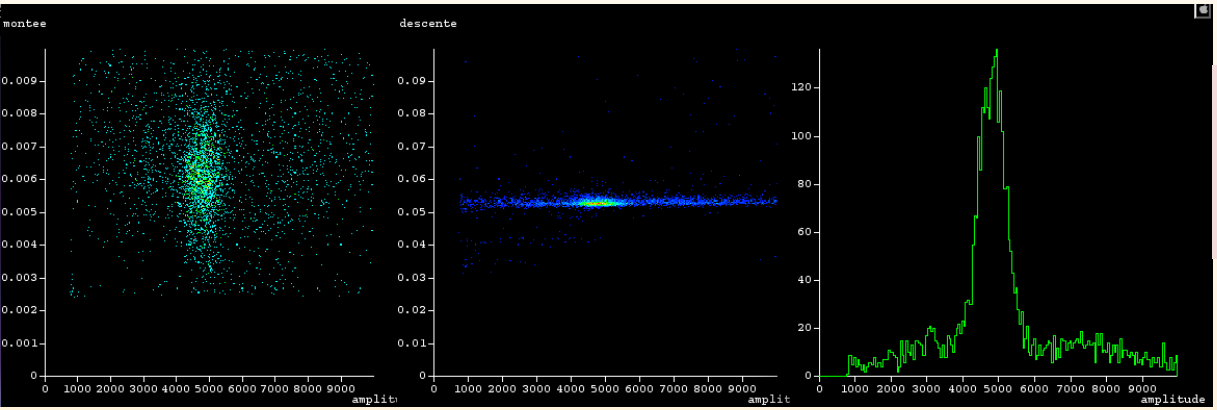
Control of the electric field with the Fe-55 source inside the sphere, moving with the help of external magnet



Some of the first experimental data of Fe-55 source with Φ= 1mm X 5balls “achinos”



5.9keV (Fe-55),
Sensor with 5balls of Φ=1mm
P=200mbar, Ar+2%CH4

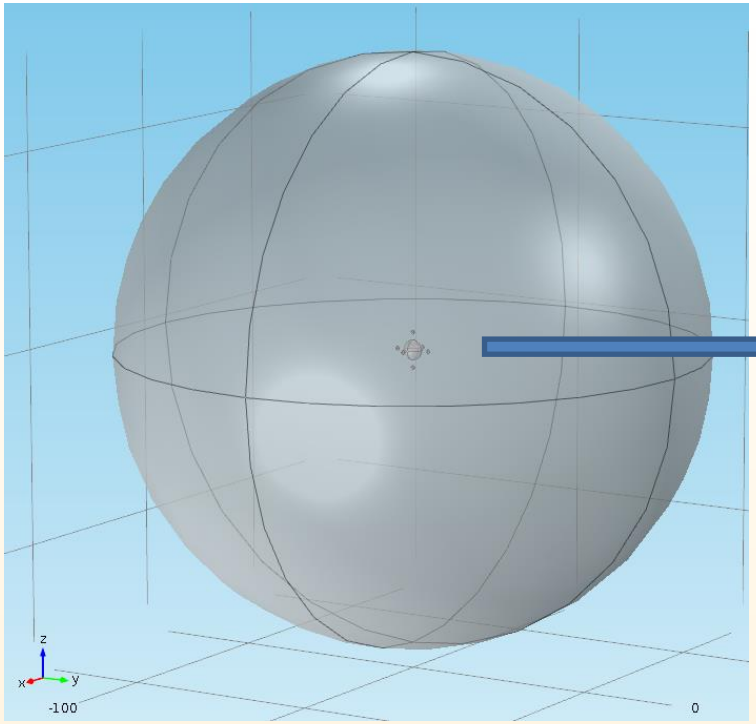


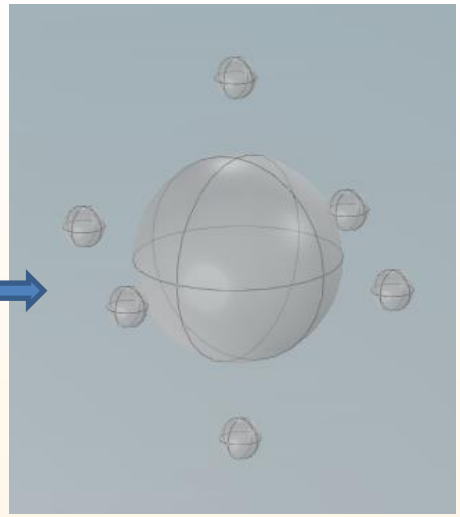
5.9keV (Fe-55),
Sensor with 5balls of Φ=1mm
P=1bar, Ar+2%CH4

Simulations of “achinos”

(without the HV wires)

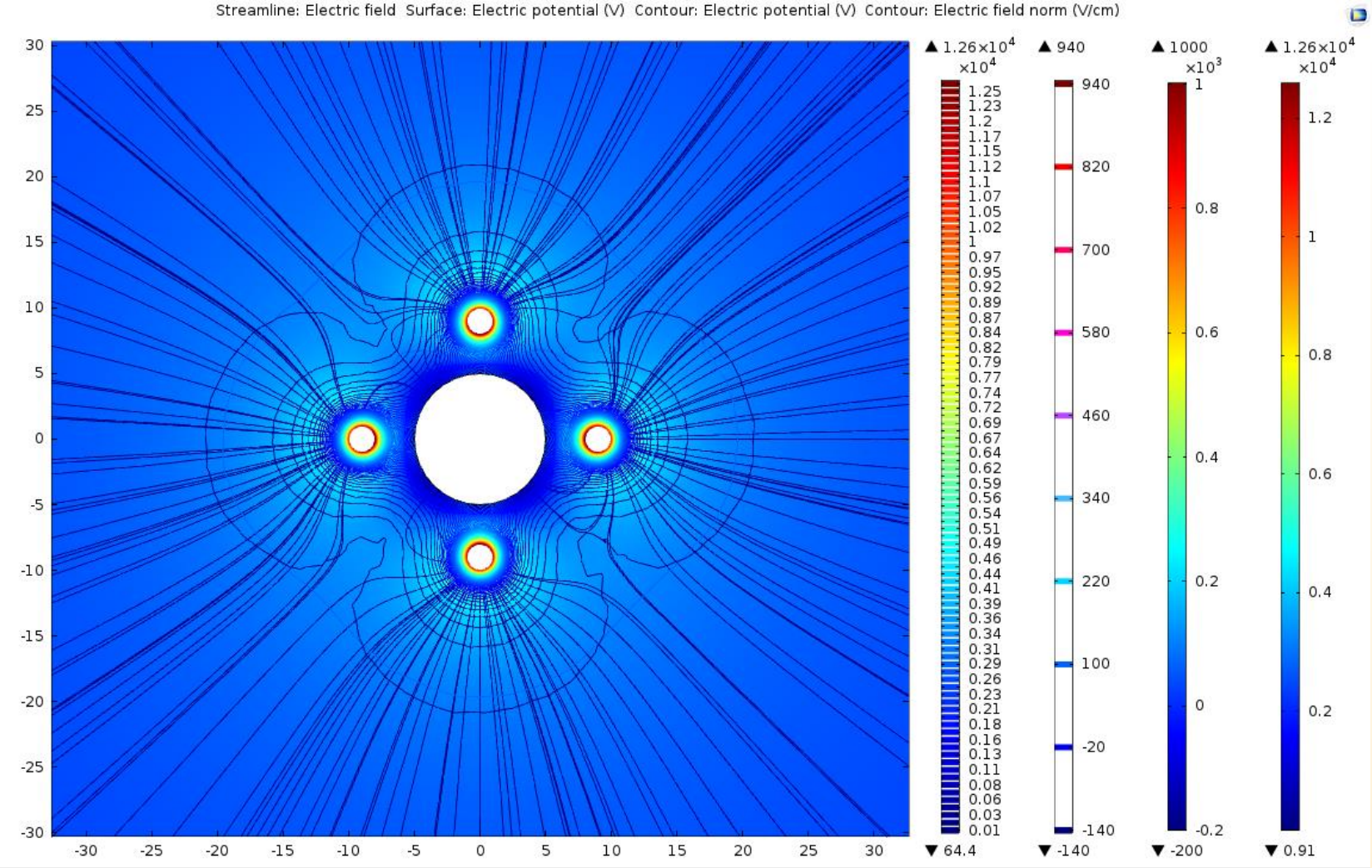
(By Tsiledakis G.)



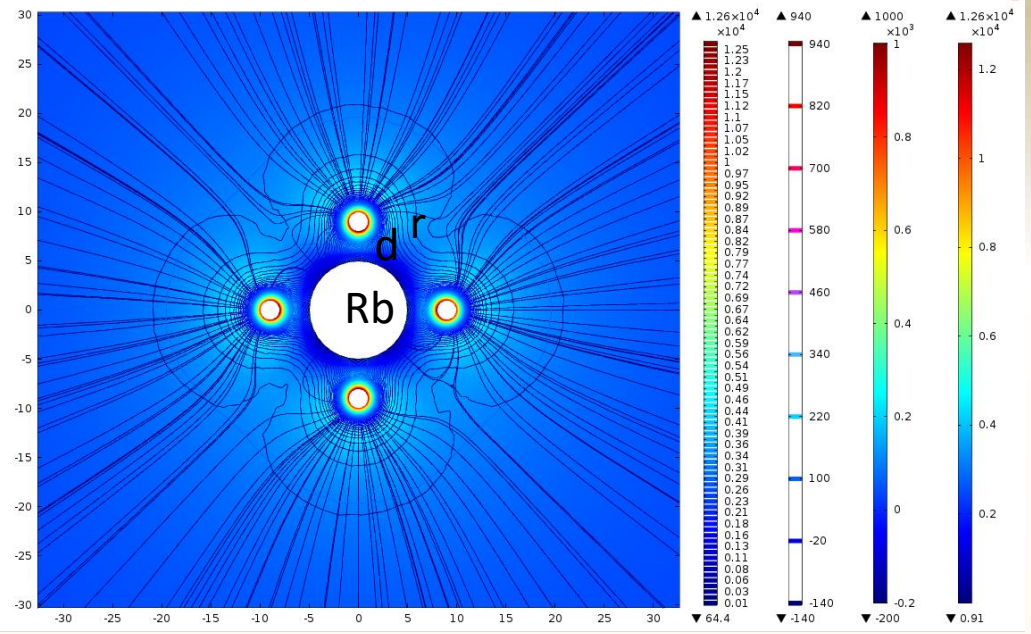


R	150	150	R external (mm)
Rb	5	5	R central ball
r	1	1	R periph balls
d	3	3	Distance Ach-centre
dc	d+Rb+r	9	Abs Distance """"
Vb	-200	-200	Volts
Vach	1000	1000	Volts

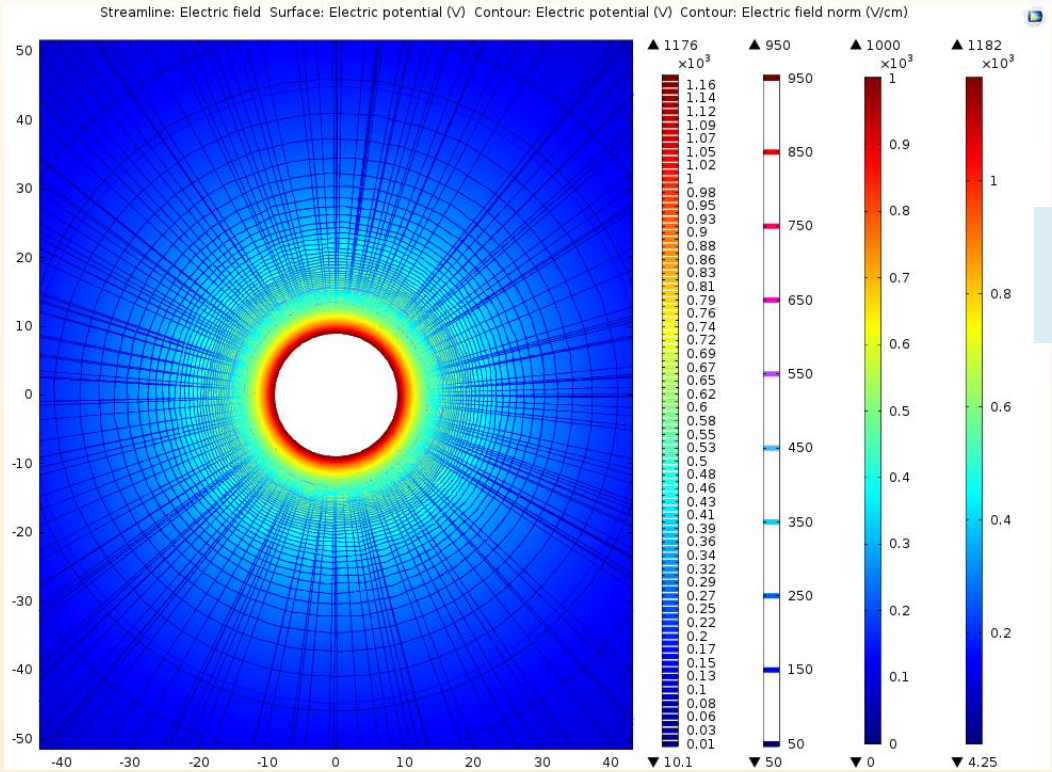
Cut plane-yz (x=0)



Comparison

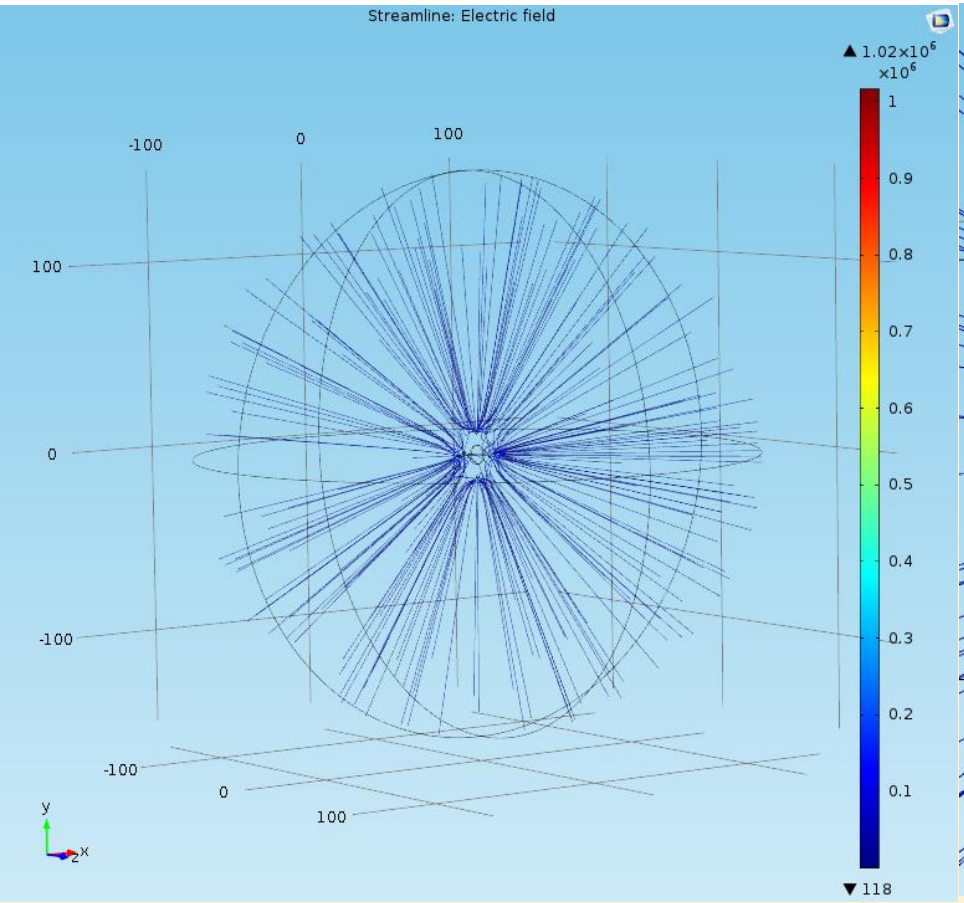


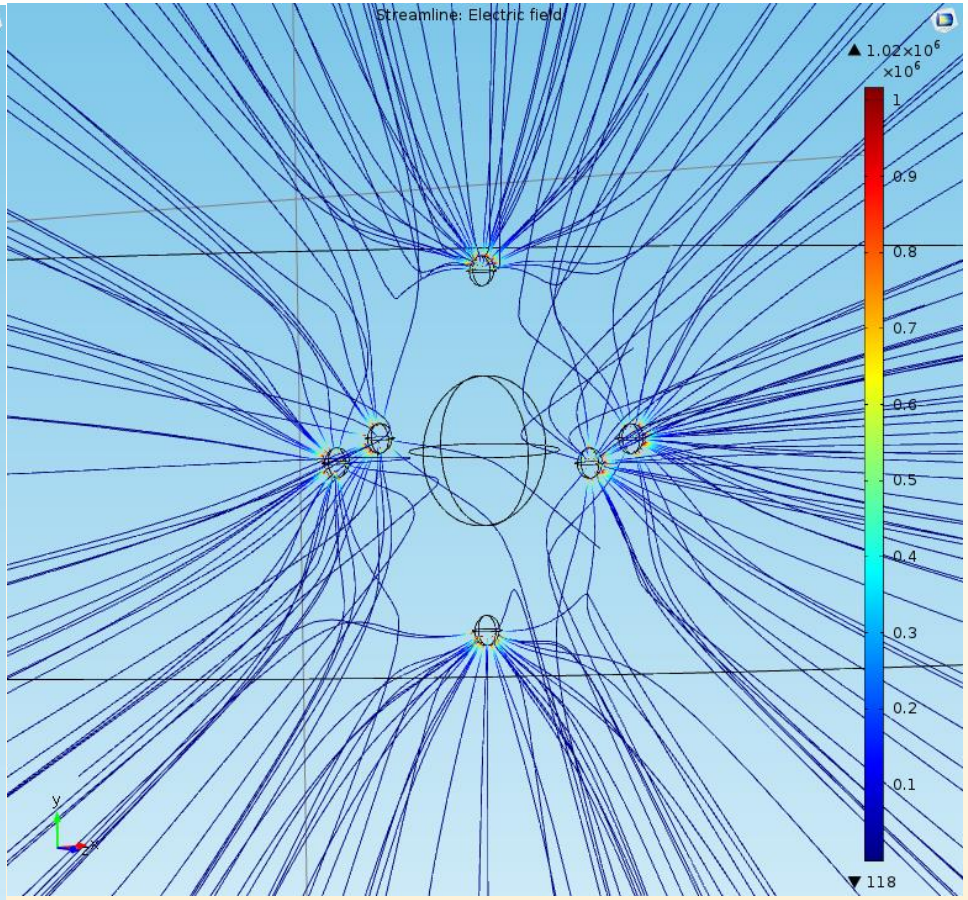
6 ball system
Vach = 1000 V
Vb = -200



1 ball system (R = Rb + d + r)
V = 1000 V

Lines that end on the ground external sphere





Conclusions

1.The one ball sensor is limited of the volume and the pressure of the gas of the detector.

2.The new 5-ball sensor “achinos” is an advance system which increase the response and the effective volume of the spherical detector

The next step

1. Many balls sensor (12+)
2. Field corrector (umbrella) better than the Bakelite to improve the spherical electric field

Thanks for your attention

Ευχαριστώ