Technical and engineering provision of operating 100 MeV linac LUE-40 and beam testing of dielectric materials

Volodymyr Kushnir

- ***Arrangement of installation at electron linac on energy 100MeV for beam testing of some dielectric patterns***
    - enhancement of the accelerator to improve the parameters of the electron beam (energy spectrum, stability, emittance)
    - development of special devices for testing dielectrics
- ***Beam testing of dielectrics***
    - *to study the induced activity of* zirconia ceramic
    - *to study* the effect of electron irradiation *on* ε *and tg*δ

ELECTRON LINAC LUE-40

A linear S-band accelerator LUE-40 consists of electron gun, injector system, two accelerating sections and ancillaries (waveguide system, water cooling system, focusing system, control and timing system, vacuum system, system of diagnostics of beam parameters etc.). RF power of linac is supplied from two S-band klystrons with maximal pulse power to 16 MW.

Main parameters of the beam :

- energy of electrons	up to	95 MeV;
- width of energy spectrum for 70% particles		2- 3 %;
- length of beam pulse		1.5 μs;
- pulse repetition rate	up to	50 Hz;
- pulse current	up to	70 mA;
- average current	up to	6 μA;
- minimum beam size at the output		3 mm

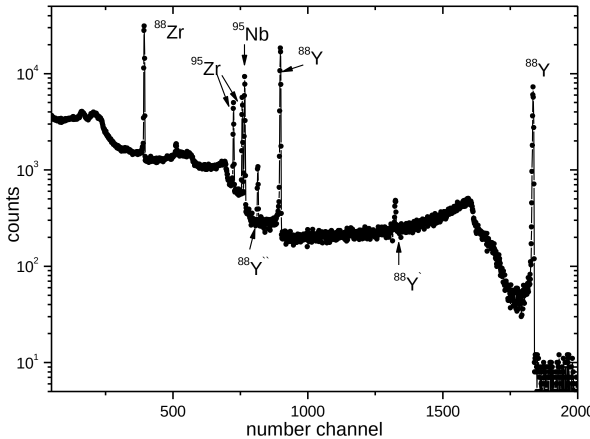
The samples of nanoceramics of ZrO_2+4%MgO and ZrO_2+8%Y_2O_3 have been irradiated with high energy electrons (up to 100 MeV)

Gamma-spectrum of ceramic samples after irradiation

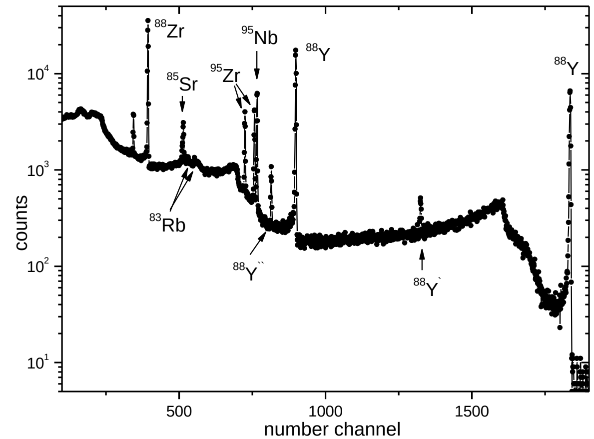
$2\cdot10^{16}$ e

ZrO_2+8%Y_2O_3

43 MeV

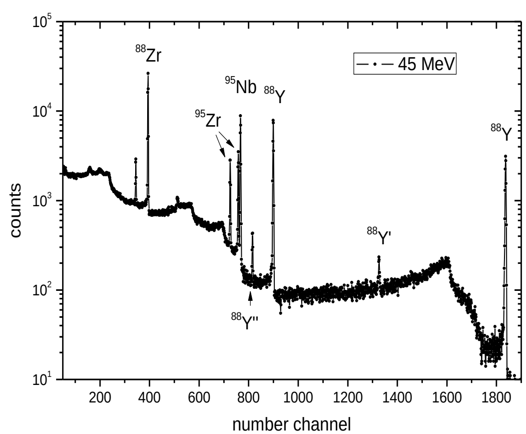


96 MeV

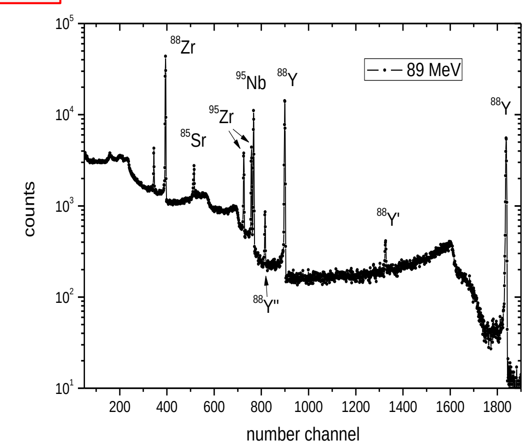


ZrO_2+4%MgO

45 MeV

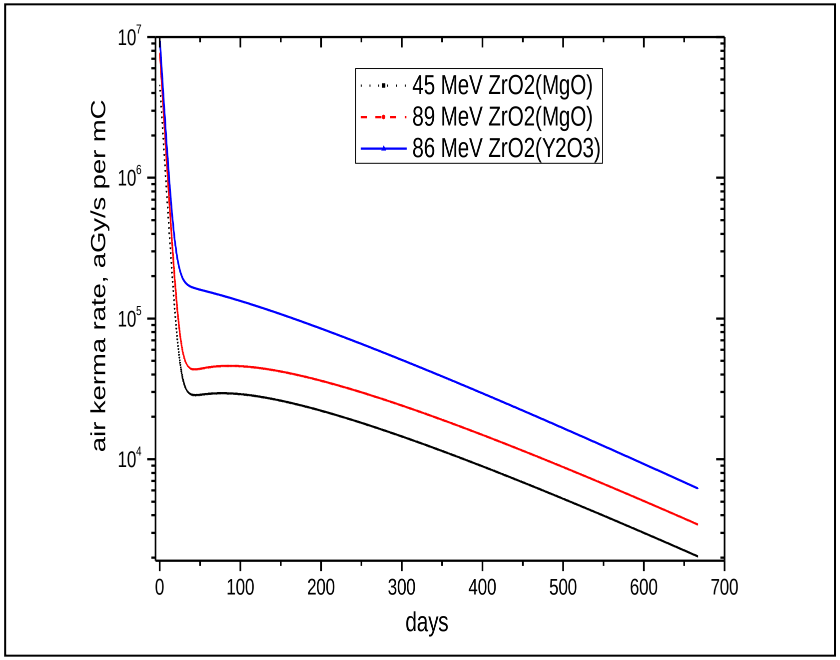


89 MeV

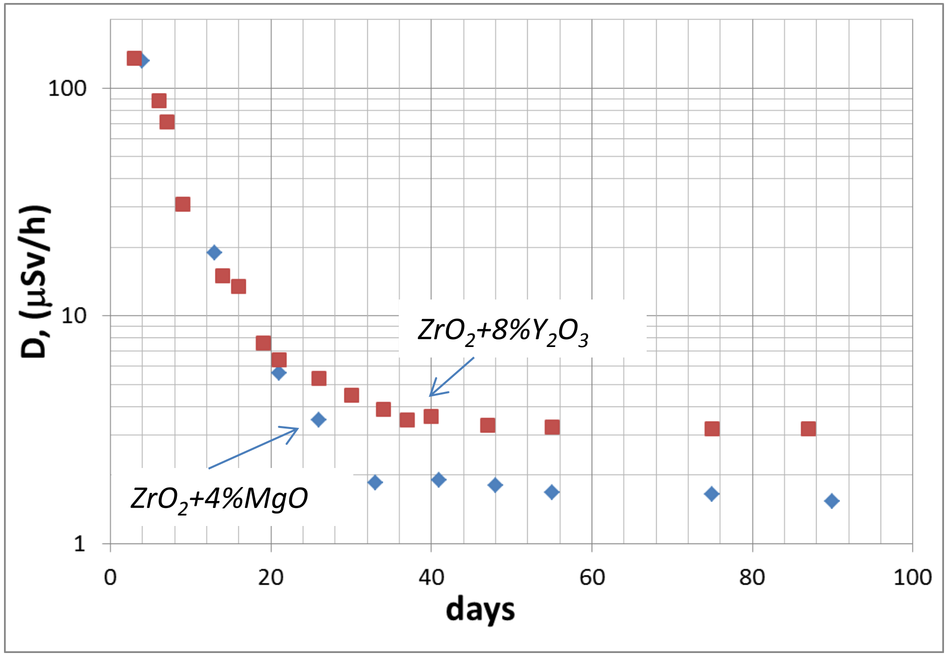


ZrO_2+4%MgO or ZrO_2+8%Y_2O_3 ????

calculation

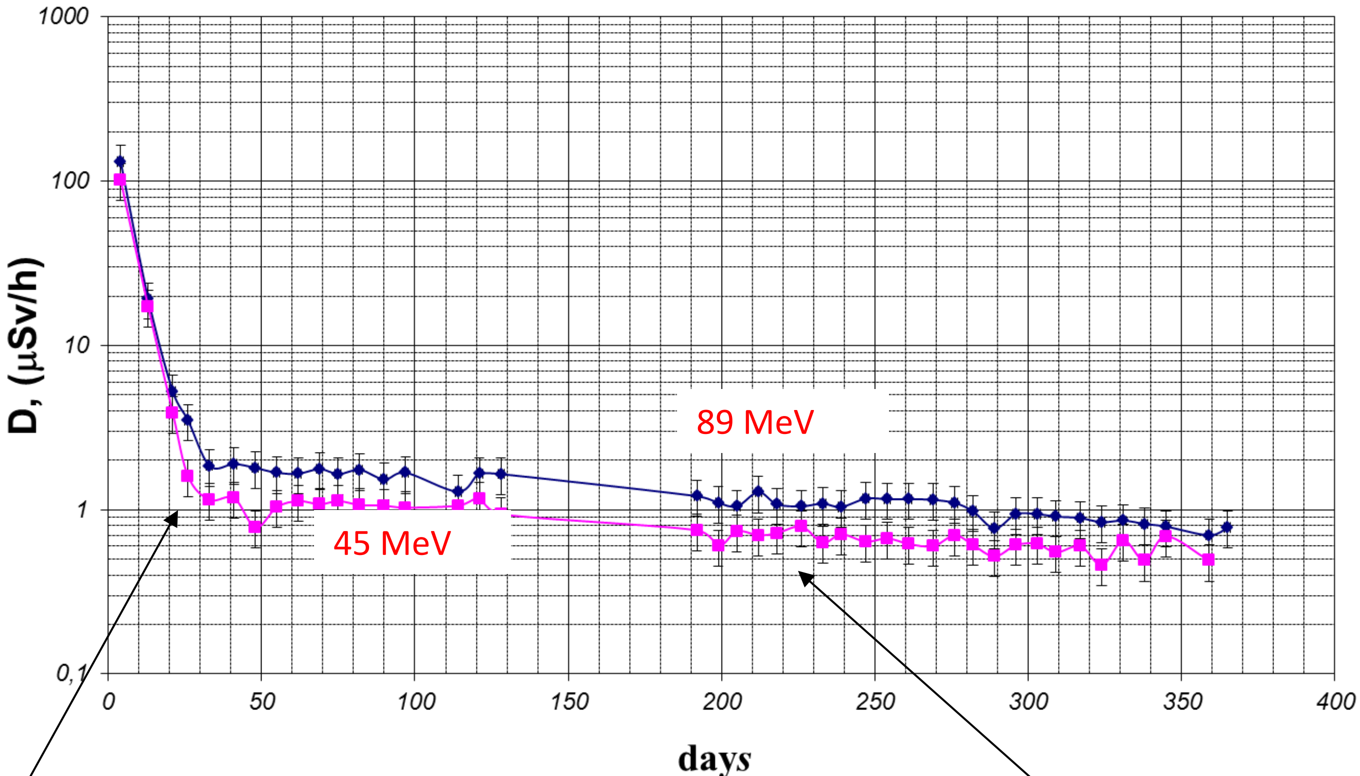


experiment



The use of nanoceramics ZrO_2, alloyed by MgO, results in diminishing of its activity as compared to nanoceramics, alloyed by Y_2O_3 for considerable time (more than 20-30 days) of the radiation cooling in 2 -3 times !!!

The activity of samples ZrO_2 +4%MgO after irradiation vs. time



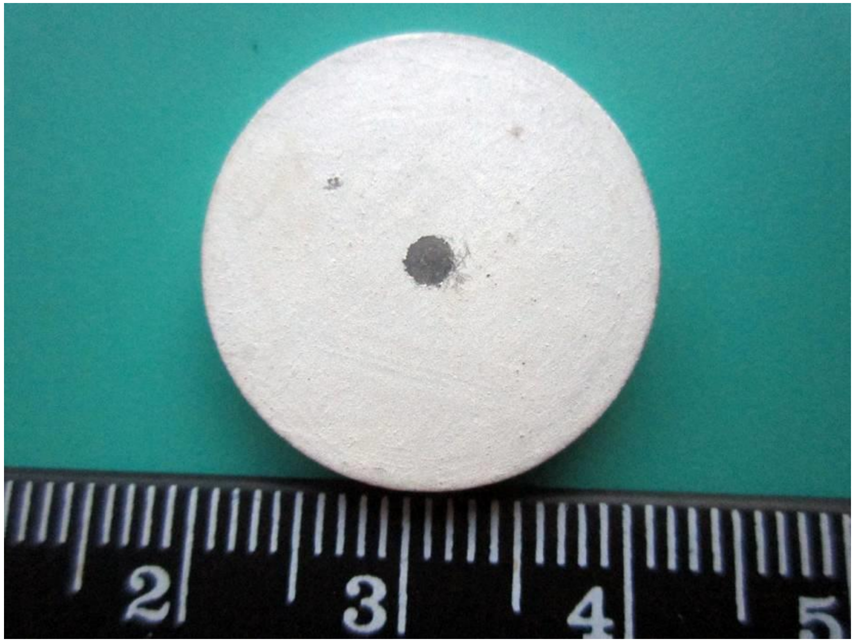
^{89}Zr ($T_{1/2}$=3.27 days)

^{88}Zr ($T_{1/2}$=93,4 days), ^{95}Zr ($T_{1/2}$=64,02 days), ^{88}Y ($T_{1/2}$=106.65 days)

Change ε and $tg\delta$ by electron irradiation

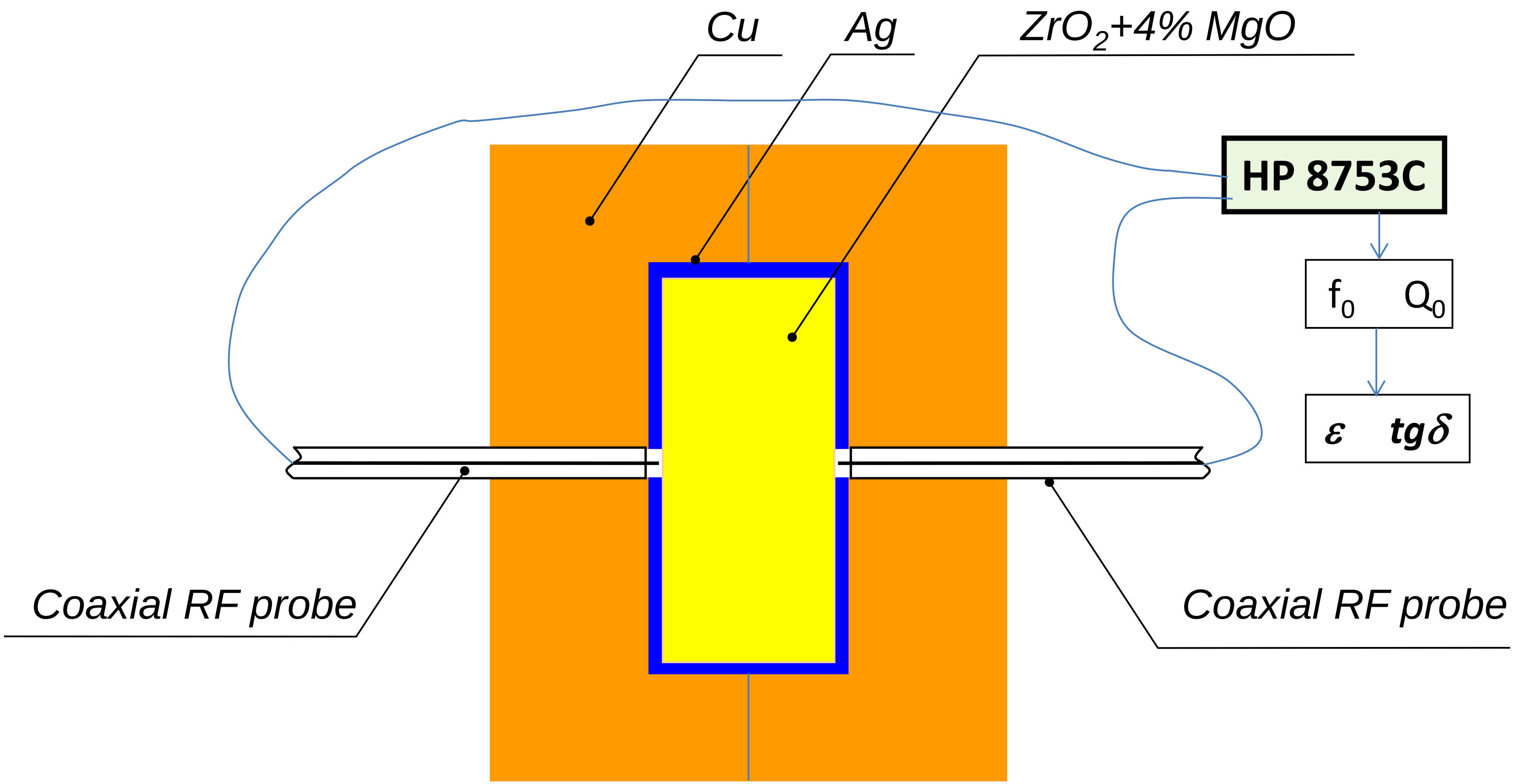
*We conducted preliminary experiments to detect changes in permittivity of ceramic after irradiation with electrons. We used the method of cylindrical RF cavity partially filled with dielectric. Because of the low accuracy of measurements (error to 10%) the data obtained do not allow to draw a definite conclusion about the influence of irradiation by the electrons with energy 40 -90 MeV and general charge of particles about 30 μA hour ($\approx 7 \cdot 10^{17}$ electrons) on the value of permittivity.

*Therefore, we decided to use most accurate resonance method for measuring with the complete filling of the resonator with dielectric. In this case determination of permittivity and tangent of the angle of dielectric losses are carried out by exact analytical expressions.



D=20 mm, h = 3mm
If ε=21, f_0= 2500MHz
$\Delta f_0/\Delta \varepsilon$ = 40 MHz

We have developed a method of coating the sample with silver.



Microwave measurements non-irradiated samples were carried out. Values of the permittivity and dielectric loss tangent were determined. $\boldsymbol{\varepsilon = 25.2 \pm 0.1}$ $\boldsymbol{tg\delta = (2.6 \pm 0.1) \cdot 10^{-3}}$

To date conducted irradiation two silver coated samples by electrons with an energy of 41 MeV. The total charge on each sample is 80 μA·hour ($1.8 \cdot 10^{18}$ electrons). After the "cooling" of the samples will be carried out RF measurements which give information about the effects of electron radiation on the permittivity and loss tangent.