SPECIAL INSTRUMENTATION FOR NCT

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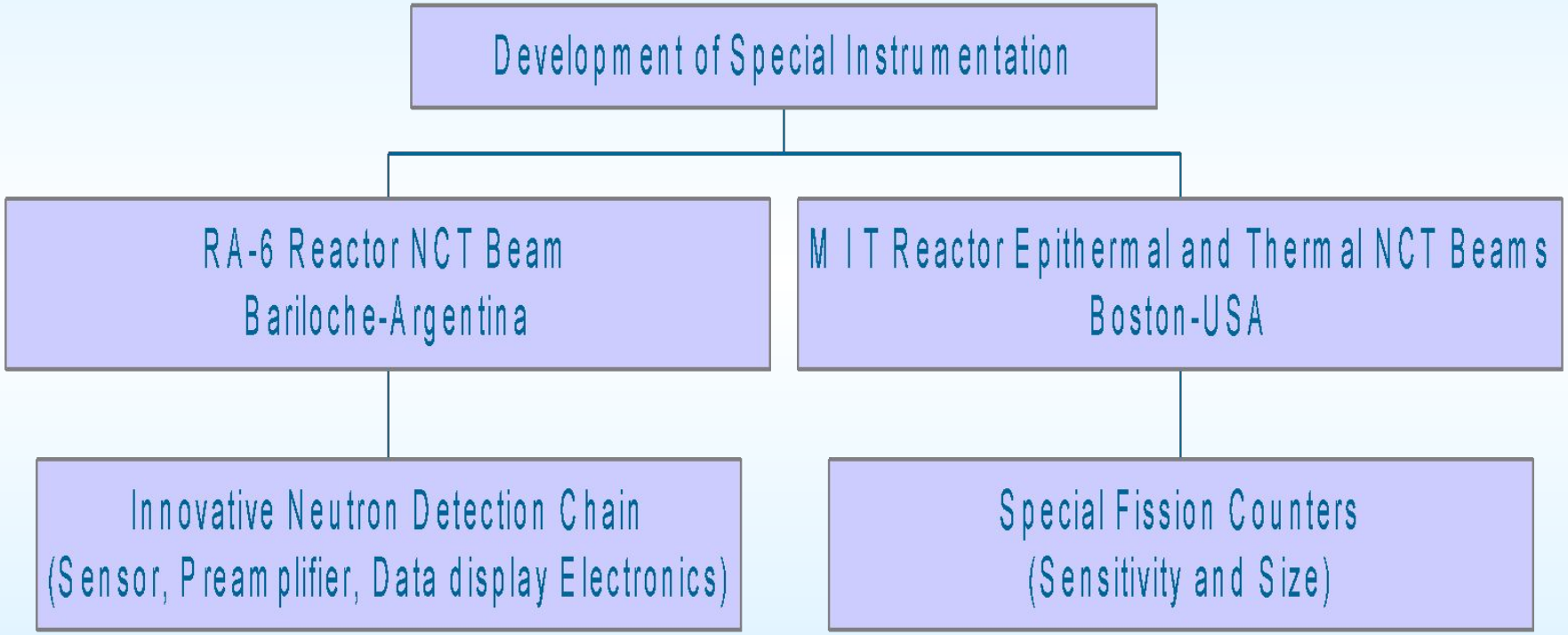
Summary


Development of Special Instrumentation
RA-6 Reactor NCT Beam
Bariloche-Argentina
M I T Reactor Epithermal and Thermal NCT Beams
Boston-USA
Innovative Neutron Detection Chain
(Sensor, Preamplifier, Data display Electronics)
Special Fission Counters
(Sensitivity and Size)

Measurement of increasing neutron flux

a) Intended to Reactors Control (very high gamma flux):

1) Counters Pulse mode	2) Special Techniques	3) Ionization Chambers Current mode

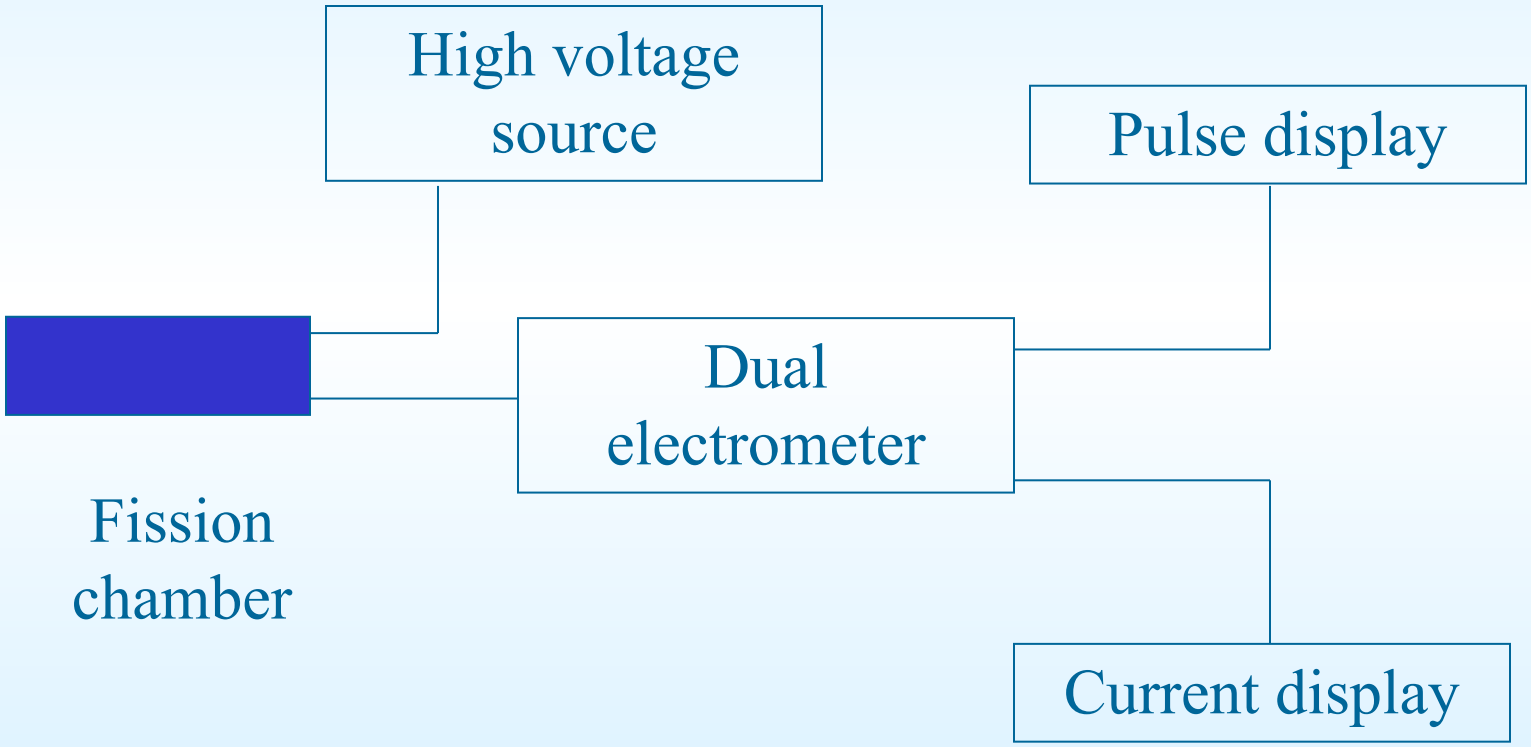
b) Intended to NCT beams (low gamma flux):

1) Counters Pulse mode	2) Ionization Chambers Current mode

It was the instrumentation concept adopted fot the RA-6 beam.

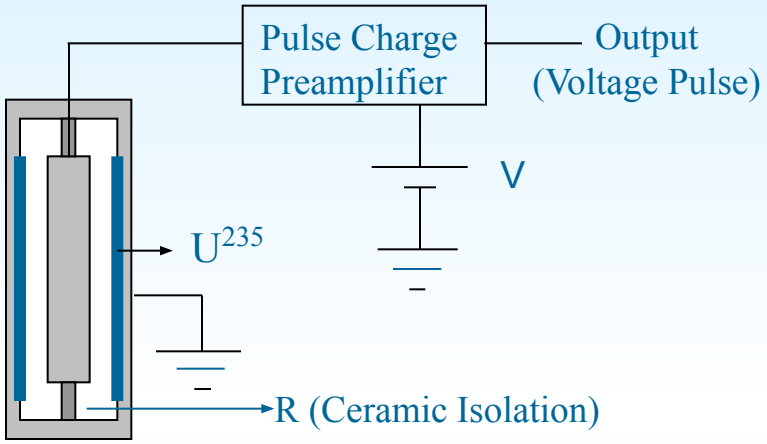
Sensor: only one special fission chamber
(fission counter and ionization chamber at the same time)

Block diagram of the measuring system

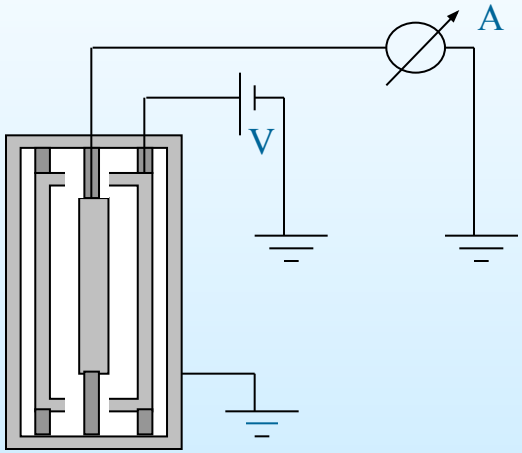


Electrically guarded fission chamber.

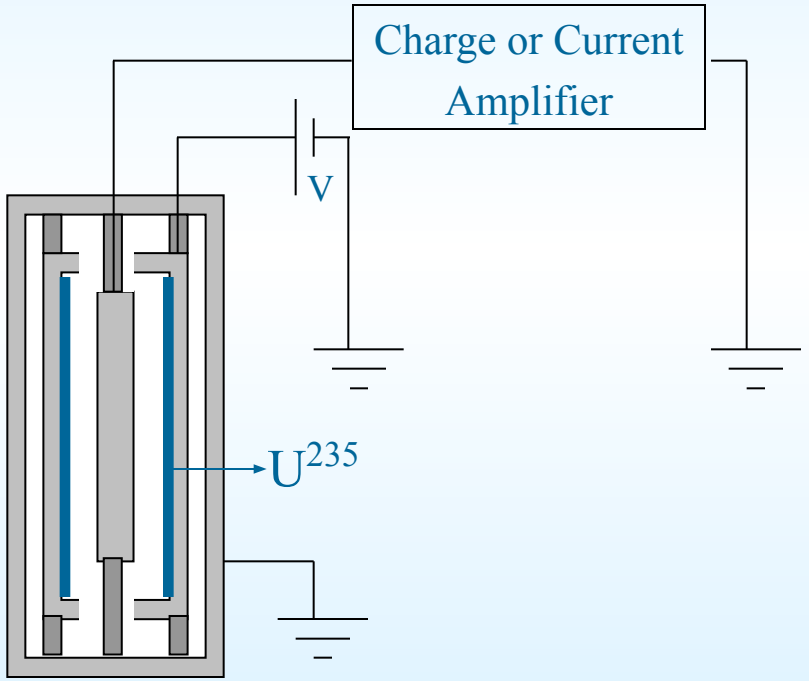
Conventional Fission Counter



Conventional Ionization Chamber



Special Fission Chamber Design



Electrically guarded fission chamber.

Length ≈16-cm

Diameter ≈ 2-cm.

Filling gas: argon

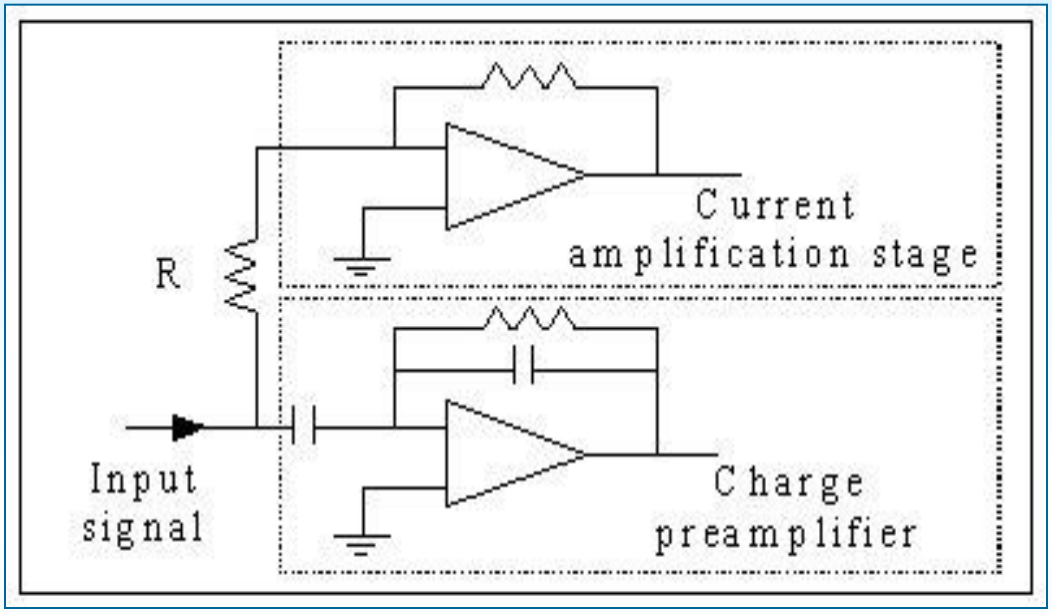
Converter material: U^{235}

Pulse mode sensitivity ≈ 0.01 cps/nv

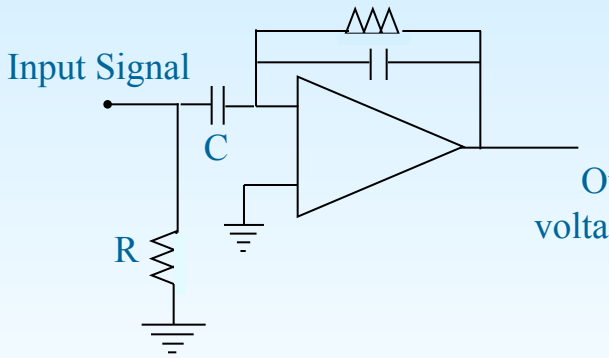
Current mode sensitivity ≈ 10^{-15}A/nv

Electrically guarded (very low level current measurement)

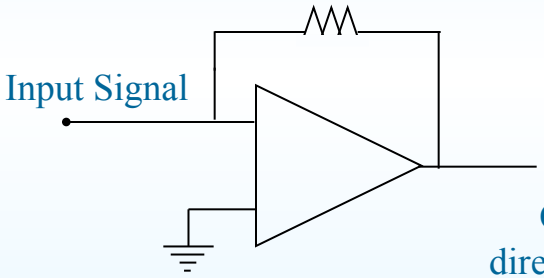
Dual electrometric unit



Conventional charge preamplifier



Conventional direct current amplifier



- Innovatively combines a pulse charge preamplifier with a direct current amplifier.
- Both signals (counts per second and direct current) are simultaneously available.
- Located inside the irradiation room, as near to the sensors as possible.
- The current signal is shown through a voltmeter module.
- The pulse signal is shown through a ratemeter module.

Eurocard rack with measuring modules

Data presentation electronics (located outside the irradiation room).

Electronics polarization source

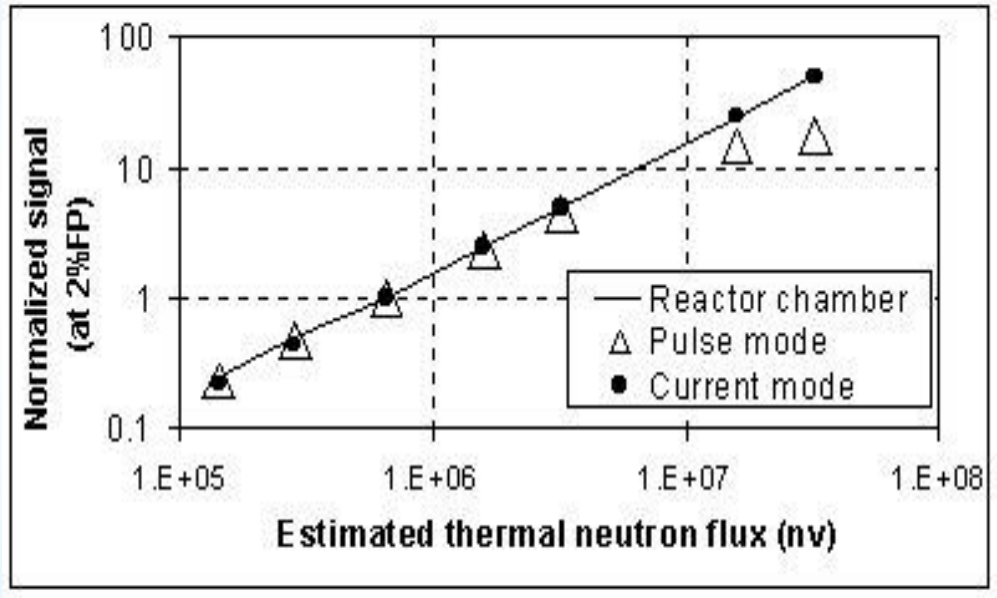
Display: It presents the result coming from the current amplifier. Current signal can be transmitted to a PC to record the instantaneous and integrated flux value, in order to evaluate the delivered dose.

Ratemeter: This is also an innovative module. An internal algorithm automatically balances the statistical error and the counting delay in order to optimize the overall error. Pulse rate and statistical error are displayed

Sensor polarization source: Batteries were used to supply power. This kind of sources was selected in order to diminish the noise level due to the ripple, characteristic of standard high voltages sources.

Results

A prototype system was tested at the Bariloche RA-6 facility (not at the definitive sensors positions). The figure presents the evolution of signals from one chain in both modes. The response given by a chamber that belongs to the reactor instrumentation is also shown in order to compare. A proper overlapping between modes was seen up to 10^6 nv and good linearity of the current mode in all the measuring range.



Evolution of signal with power at the Bariloche reactor

MIT Sensors Concept

Requirements:

a) Fission Counters in pulse mode at full power

b) Signal at full power $\approx 10^4$ cps

c) Small Size

Neutron Flux level:

Epithermal beam $\approx 10^{10}$ n / cm^2 s

Thermal beam $\approx 10^{10}$ n / cm^2 s

Required Neutron Sensitivity ($\sigma(E)$)

Sth $\approx 10^{-6}$ cps / n / cm^2 s (for the epithermal beam)

Sth $\approx 10^{-7}$ cps / n / cm^2 s (for the thermal beam)

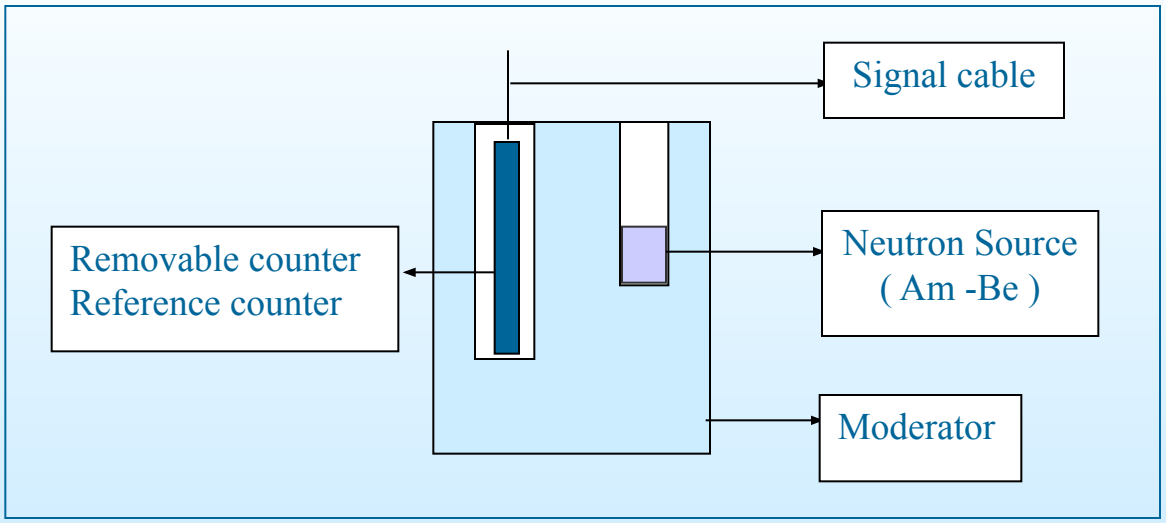
Required U^{235} Mass

m $\approx$ micrograms

Very low sensitivity obtention

a) Converter was removed from uranium lined tubes, with an initial sensitivity of 10^{-2} cps/nv, following a controlled sequence. (Tube diameter : 6 mm, tube length : 10 cm, U^{235} initial mass / cm^2 ≈ milligrams).

b) Sensitivity was determined after each removal step, by mounting the tube in a removable counter, irradiated inside an adequate moderator, with a laboratory neutron source.



U^{235} Removed mass

milligrams ⟶ micrograms

99.9 %

Approaching the required sensitivity, events rate become near 1 count every 100 seconds.

Very low sensitivity fission counter

Length ≈ 80 mm

Sensitive length ≈ 20 mm

External diameter = 7.6 mm

Converter material: U^{235}

Filling gas: argon

Pulse mode sensitivity ≈ 3 10^{-6} cps/nv and 10^{-7} cps/nv

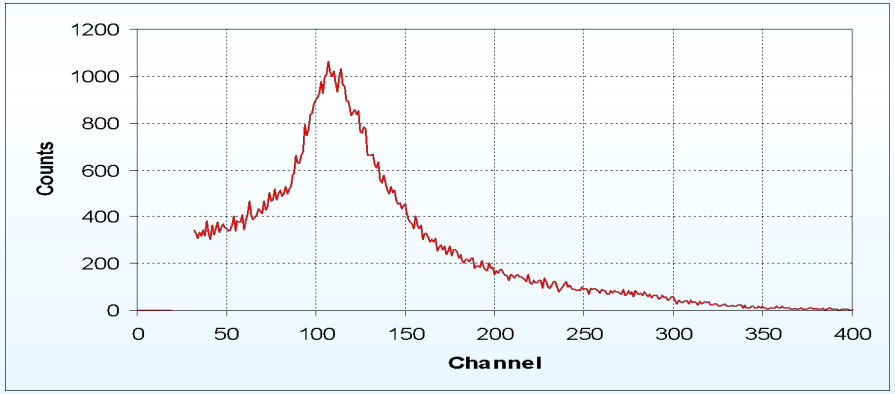
Results

These chambers were tested in laboratory and at the RA-1 test reactor, showing an adequate behavior. A private communication confirmed that preliminary tests conducted at the MIT facilities were auspicious.

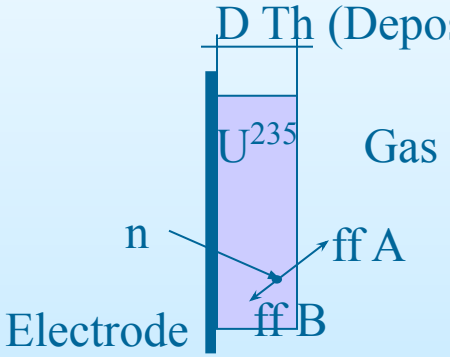
Typical spectra

Fission fragments energy distribution: double peaked function

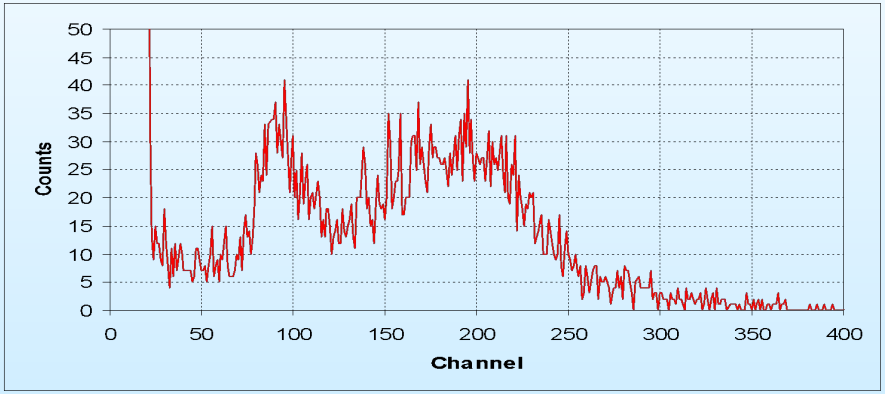
Conventional fission counter (D Th ≈ 1 μm)



D Th (Deposit Thickness)



Special fission counter (D Th ≈ 10^{-3} μm)



Conclusion

- **RA-6 instrumentation**: It was possible to obtain a complete system for NCT beams, able to follow the neutron flux in a wide range with only one sensor, in a fixed position.

- **MIT sensors**: Technological developments allowed the obtention of special -considering sensitivity and size- fission counters, adequate to use in the case that pulse mode signal were chosen to follow a high level neutron flux.

Cámara de fisión miniatura para acelerador de BNCT

Detector autoenergizado de Rh para acelerador de BNCT