

STUDY OF RADIOACTIVITY BY THE MEASUREMENT OF THE IONIZATION CURRENT DEVELOPED BY MARIE AND PIERRE CURIE

E. Daubie¹, N. Demasy², S. Devouge¹, A. Quenon³, M. Spagnolo¹



Caricature de Pierre et Marie Curie parue dans Vanity Fair, le 22 décembre 1904.

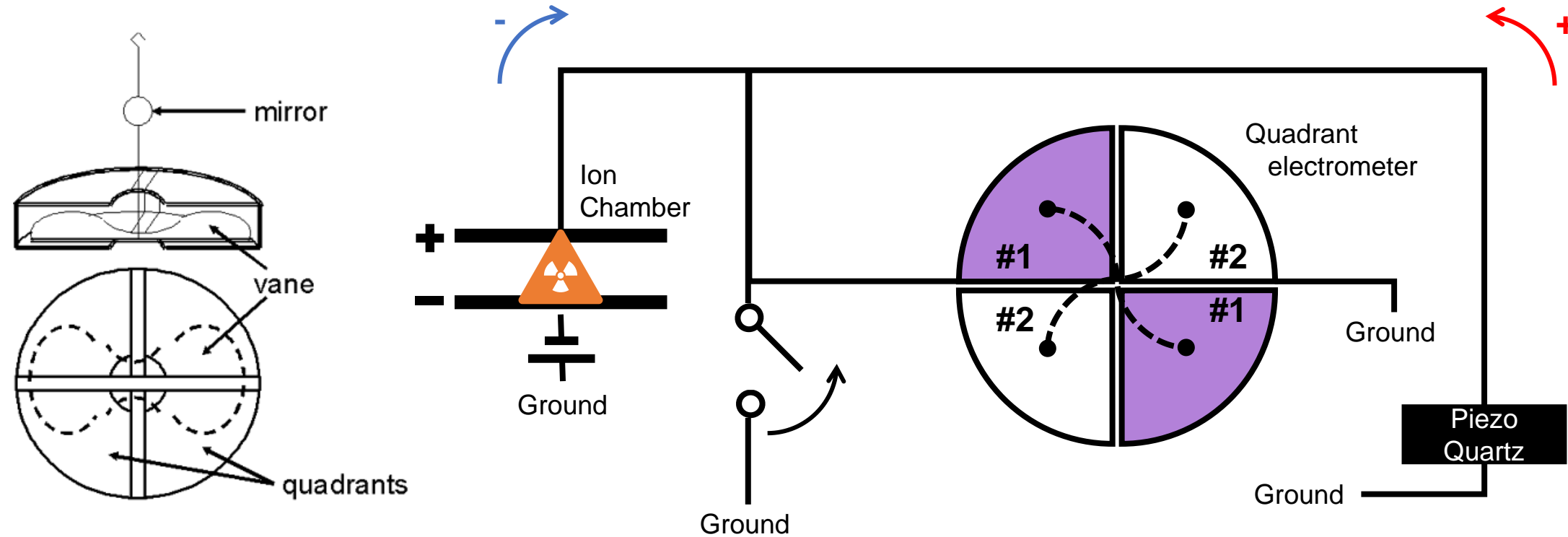
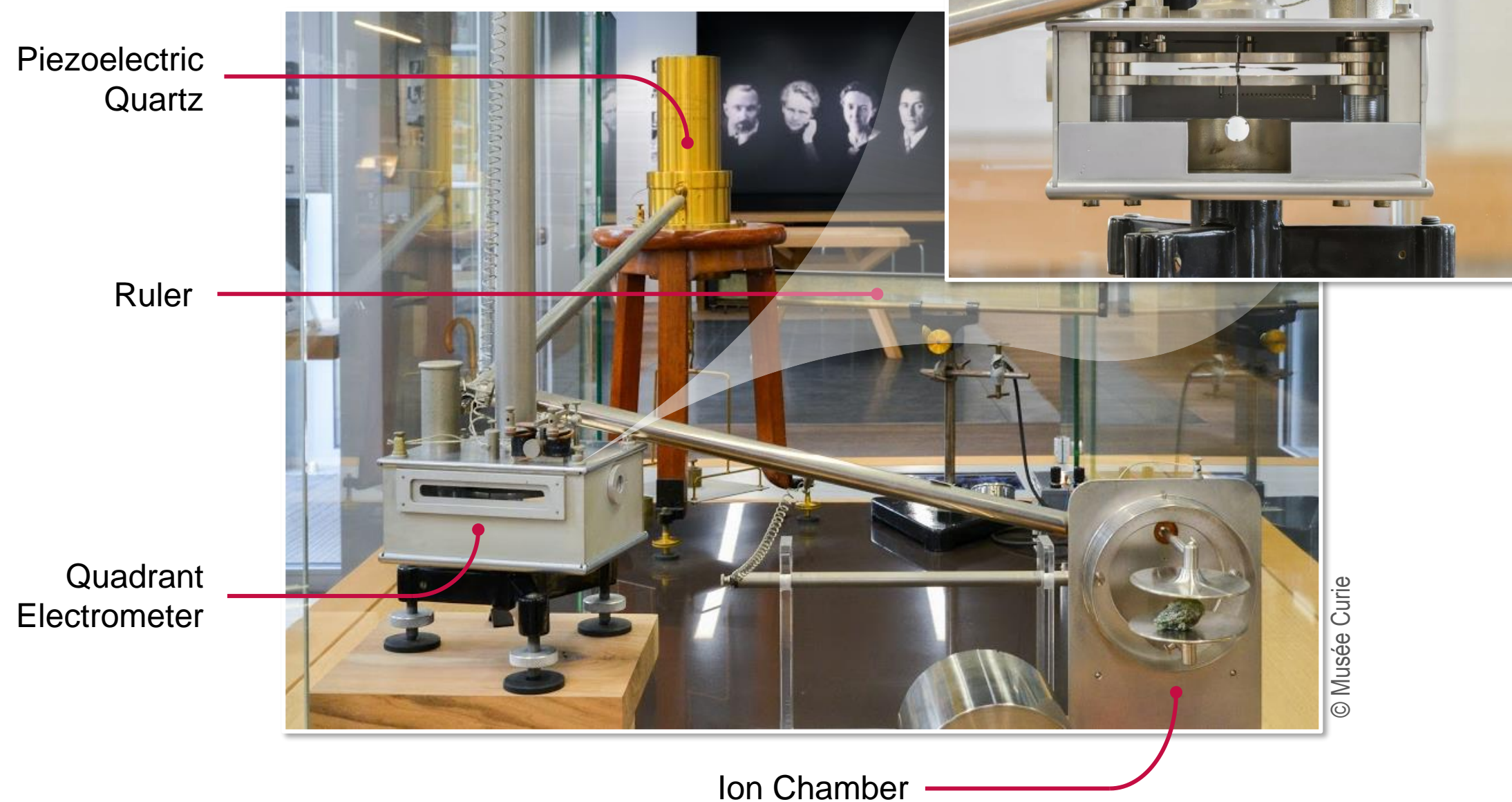
History

- 1880** Discovery by Pierre and Jacques Curie : piezoelectric effect
- 1896** Discovery by Henri Becquerel : ionization of air by uranic rays using a gold leaf electroscope.
- From 1898** Marie and Pierre Curie measure the ionization current of radioactive ores inventing the Curie method.
- 1898** Discovery of Ra and Po by Marie and Pierre Curie ⇒ word « radio-activity ».

The Curie Method

A high accuracy method for measuring the radioactivity / ionization current produced by a substance: measurement of the **time necessary to cancel the unknown ionization charge quantity Q_0** produced by another adjustable **and known charge quantity Q_p** created by a piezoelectric quartz [1,2].

EXPERIMENTAL SETUP



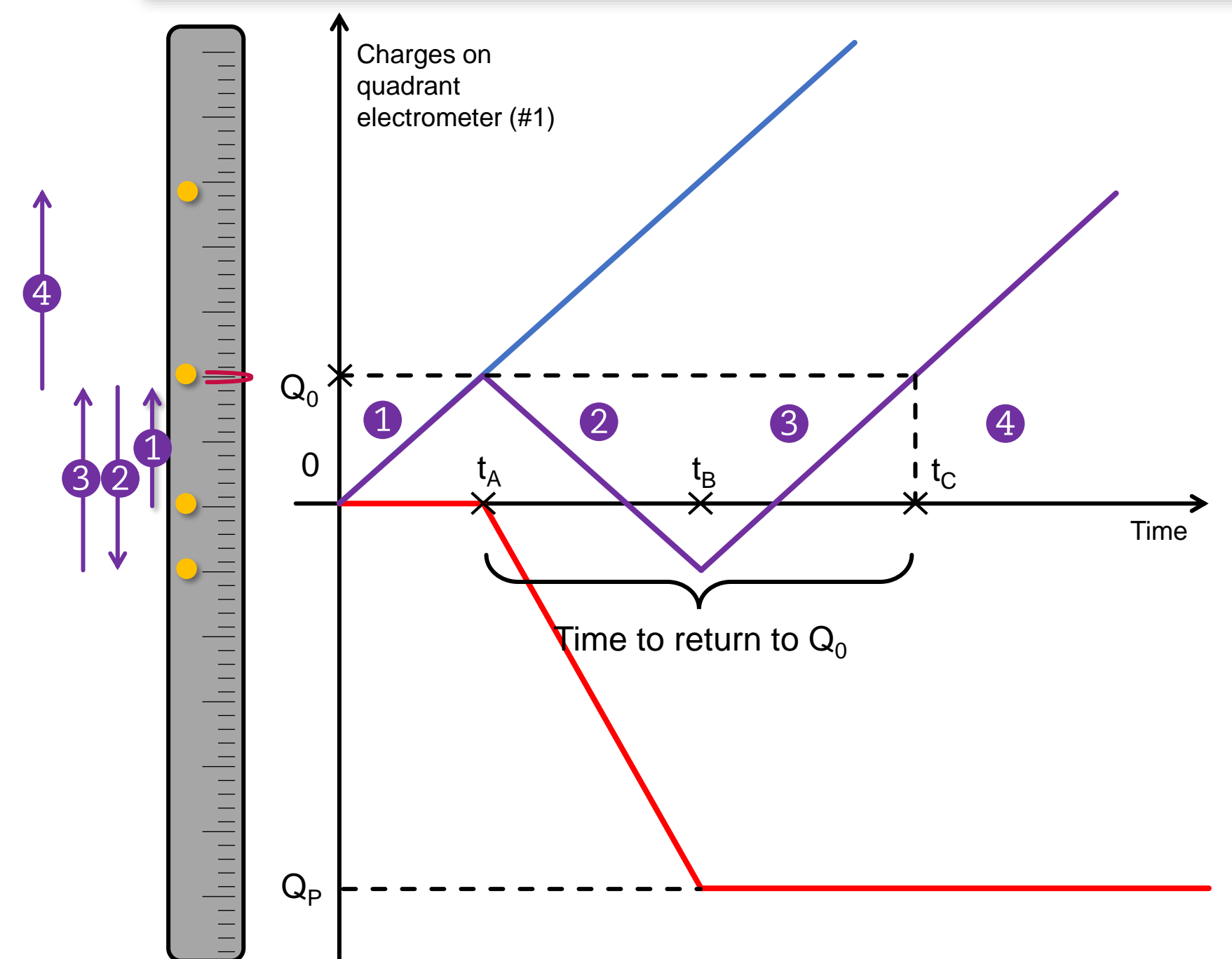
QUADRANT ELECTROMETER [3,4]

- **4 fixed quadrants** : 2 grounded (#2) and 2 at a variable potential (#1) connected to ion chamber and piezoelectric quartz.
- **1 mobile electrode vane**, spinning and linked to a mirror on which light is sent and then reflected onto a ruler.

⇒ **position of the light point = indication of the electrometer charge**



MEASUREMENT PRINCIPLE



CHARGES ON QUADRANT ELECTROMETER (#1)

- $t = 0$ Switch OFF ⇒ ion chamber liberating charges.
 - 1** $0 \rightarrow t_A$ Q from ion chamber increases linearly until Q_0 .
 - $t = t_A$ START chrono & START of piezoelectric quartz deformation.
 - 2** $t_A \rightarrow t_B$ Sum of **liberated quartz charges Q_p** and **Q from ion chamber**.
 - 3** $t_B \rightarrow t_C$ **Compensation of Q_p** by **Q from ion chamber** until Q_0 .
 - $t = t_C$ STOP chrono.
- Ionization current of the radioactive source = $\frac{Q_p}{t_C - t_A}$**
- 4** $t_C \rightarrow \infty$ Ion chamber still liberating charges to electrometer until Switch ON.

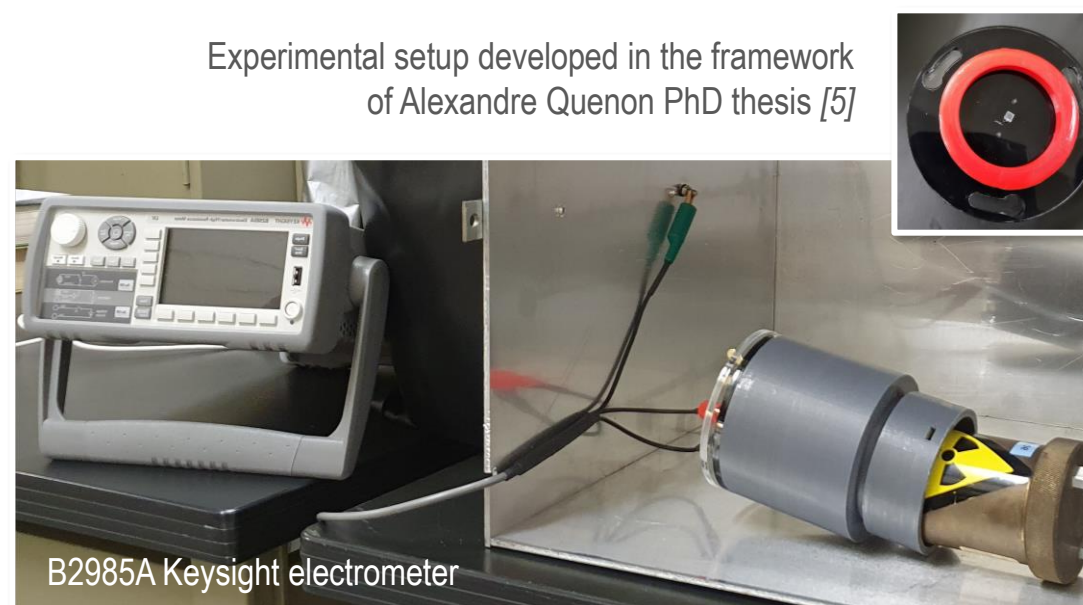
UMONS collection instruments

Our goal : to replicate the experiment of Pierre and Marie Curie utilizing period devices preserved in the collections of the University of Mons in order **to highlight the Curie method**.

Quadrant Electrometer (Leppin & Masche) from UMONS collections (1905, Faculté Polytechnique de Mons ; Service d'Electronique)

Remote measuring ruler (J. Carpentier) from UMONS collections (1905, Faculté Polytechnique de Mons ; Service d'Electronique)

Experimental setup developed in the framework of Alexandre Quenon PhD thesis [5]



PIN photodiode irradiated by a radioactive source.

⇒ liberated charges in Si ($e^- h^+$ pairs) moving under influence of the diffusion potential at junction.

Readout of the ionization current using **a high precision digital electrometer**.

[1] Musée Curie. Comment Marie et Pierre Curie mesuraient la radioactivité ? La méthode Curie https://artsandculture.google.com/story/BwWx_qy57JACKQ?hl=fr, consulté le 17-04-2023
 [2] Wikimedia Commons, Doctoral thesis by Marie Curie (1903)
 [3] P. Curie, Oeuvres de Pierre Curie, Société française de physique (Paris, France), 1908.
 [4] Philippe Molinié et Soraya Boudia, Une application méconnue et pourtant célèbre de l'électrostatique : les travaux de Marie Curie, de la découverte du radium à la métrologie de la radioactivité, Journal of Electrostatics 64, 7-9 (2006), p. 461-470.
 [5] A. Quenon et al., An Experimental Setup Based on a Printable System for the Acquisition of the Real-Time Electrical Response of Irradiated Semiconductor Devices, IEEE Transactions on Instrumentation and Measurement, vol. 72, pp. 1-8, 2023