Microprobe Metadata: Application to IBIC and TRIBIC experiments

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The following document outlines the proposed perspective and content regarding the metadata required for future users of experimental data files obtained through IBIC and TRIBIC techniques to reconstruct the experiment and contextualize the measurements.

1. Project Description:

The Ion Beam Induced Current (IBIC) technique is primarily used to characterize semiconductor materials and electronic devices by directing a focused ion beam onto a sample, it generates electron-hole pairs within the material. The resulting current, induced by the ion beam, provides insights into the material's properties, such as charge carrier mobility, lifetime and the presence of defects. This technique is particularly useful for evaluating the quality of semiconductors and understanding their response to radiation.

The Time-Resolved Ion Beam Induced Charge (TRIBIC) technique is employed to investigate the dynamic behavior of charge carriers in semiconductor detectors by using a pulsed ion beam. This method allows for the precise measurement of charge collection as a function of time, providing detailed information about charge carrier transit times, mobility, and recombination processes. TRIBIC is particularly valuable for understanding the temporal response of detectors to ionizing radiation, making it a powerful tool for characterizing semiconductor devices used in radiation detection applications.

2. Metadata Description:

To accurately contextualize the experimental measurements, it is essential to have detailed information about the experimental setup, which depends on several parameters described below.

2.1. General Information

2.1.1. Proposal:

- **Proposal Code:** The code used for the beam time proposal submitted to the relevant facility. Established by the facility (ej. CNA-2024-001)
- **Proposal Name:** A sentence with a meaningful description of the proposal.
- **Abstract:** A brief description of the experiment and its applications, as stated in the beam time proposal. Suitable to be publically dsiplayed.
- **Relevant Dates:** Submission, Approval, Planning, Execution.
- **Key words:** Suitable key words for the search catalog. Stated in the proposal.

2.1.2. Principal Investigator:

- **Name:** The name of the principal investigator who submitted the beam time proposal.
- **Institution:** The institution of the principal investigator.

- **Email:** The email address of the principal investigator.
- **Optional Personal information:** Gender (Male, Female, Other/ND), Year of birth, Professional status (PhD, Postdoc, staff)

2.1.3. Experimental Team:

- **Name:** Names of the additional experimental team members involved in the experiment.
- **Institution:** Institutions of the additional team members.
- **Email:** Email addresses of the additional team members.
- **Optional Personal information:** Gender (Male, Female, Other/ND), Year of birth, Professional status (PhD, Postdoc, staff)

2.2. Experiment Setup

2.2.1. Beam Settings

- **Element:** The element used to generate the particle beam.
- **Mass:** The mass number of the ion used (isotope).
- **Charge State:** The charge state of the ion used.
- **Energy (keV):** The energy applied to the particle beam in keV.
- **Shape of Incident Beam:** Shape of the beam, which can be circular or rectangular. If circular, specify the diameter; if rectangular, specify the side lengths.

2.2.2. Additional Beam Settings:

- **Terminal Potential (kV):** The potential applied to the stripper terminal on the tandem accelerator in kV.
- **Injection Energy (keV):** The energy applied to the ions to introduce them into the circuit in keV.
- **Magnetic Field (G):** The magnetic field applied in the selector magnet to deflect particles with undesirable energies in gauss (G).
- **Calculated Energy from Terminal Potential (keV):** The beam energy calculated from the terminal potential applied to the stripper terminal in keV.
- **Calculated Energy from Magnetic Field (keV):** The beam energy calculated from the magnetic field applied to the selector magnet in MeV.
- **% Difference:** The percentage difference between the energies calculated from both equations.
- **Average Energy (keV):** The average energy calculated from both values in keV.
- **Intensity (μA):** The beam current measured at various Faraday cups along the accelerator. FC1 is located before pre-acceleration, FC2 at the entrance of the selector magnet, FC3 after the selector magnet, and FC4 before the sample, measured in microamperes.
- **Modifications:** Additional comments on any modifications made to the experimental setup.

2.3. Electronic Chain:

2.3.1. High Voltage Source: Identifier of the high voltage source used.

2.3.2. Preamplifier resistance: Preamplifier resistance in megaohmios.

2.3.3. Amplifier:

- **Gain:** Amplifier scale ratio.
- **Shaping time:** Time value that corresponds to 61% of the peak amplitude.
- **Peaking time:** Time value that corresponds to almost 100% the peak amplitude.

2.3.4. Analogic-Digital Converter:

- **Gain:** ADC scale ratio.

2.3.5. Scan:

- **Scan Size:** Scale of the bidimensional map.
- **Real Scan Size:** Real resolution of the bidimensional map in micrometers squared.
- **Time per pixel:** Time in which each pixel is irradiated in microseconds per pixel.

2.4. Detector: Description of the detector used.

- **ID:** Identifier of the detector used.
- **Polarity:** Detector polarity, can be positive or negative.
- **BIAS:** Voltage applied to the detector for polarization in volts.
- **Inverse intensity:** Loss of current intensity in the detector in microamperes.
- **Count rate:** Number of ions per second colliding with the detector ratio in herzios.
- **α (º):** The angle between the surface normal of the detector and the incident beam in the horizontal plane, in degrees.
- **β (º):** The angle between the surface normal of the detector and the incident beam in the vertical plane, in degrees
- **Temperature:** Detector temperature in kelvins.
- **Notes:** Extra information of the measurement.

Those parameters are common between IBIC and TRIBIC techniques, but for the second one extra parameters are needed.

TRIBIC extra parameters:

- **File range:** Idicates the number of spectrums generated in the experiment by 2 parameters, “Initial” and “Final”.
- **Displacement:** The distance between the measurement point and the reference point. It is specified by two parameters, x and y, to indicate along which axis the displacement is occurring.
- **Net distance:** The net distance between the measurement point and the reference point.
- **Averaging:**
- **Notes:** Extra information of the measurement.

3. Raw Data Description:

In this files, which are bidimensional maps, we can find four columns with the following meaning:

- **ADC:** Identifier indicating which of the seven possible connections to the data acquisition system. It does not provide information for further analysis.
- **Energy:** Channel in which the event was generated. The system has a resolution of 12 bits, so there will be a total of 4096 channels, each corresponding to a certain energy (0-8 MeV).
- **X:** X coordinate where the event occurred.
- **Y:** Y coordinate where the event occurred.

4. Related Publications:

4.1. Related Publications: Links to publications related to the data file.

4.2. Related Files: Callibration file. Raw data file.