Time Projection Chambers for Nuclear Fission Experiments

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Nuclear Pole - IJCLab

Content

- Introduction to the Physics Case and Experimental Features
- Fission Event Reconstruction Arsenal
- Ongoing Project: ICETEA
- Outlook and Perspectives

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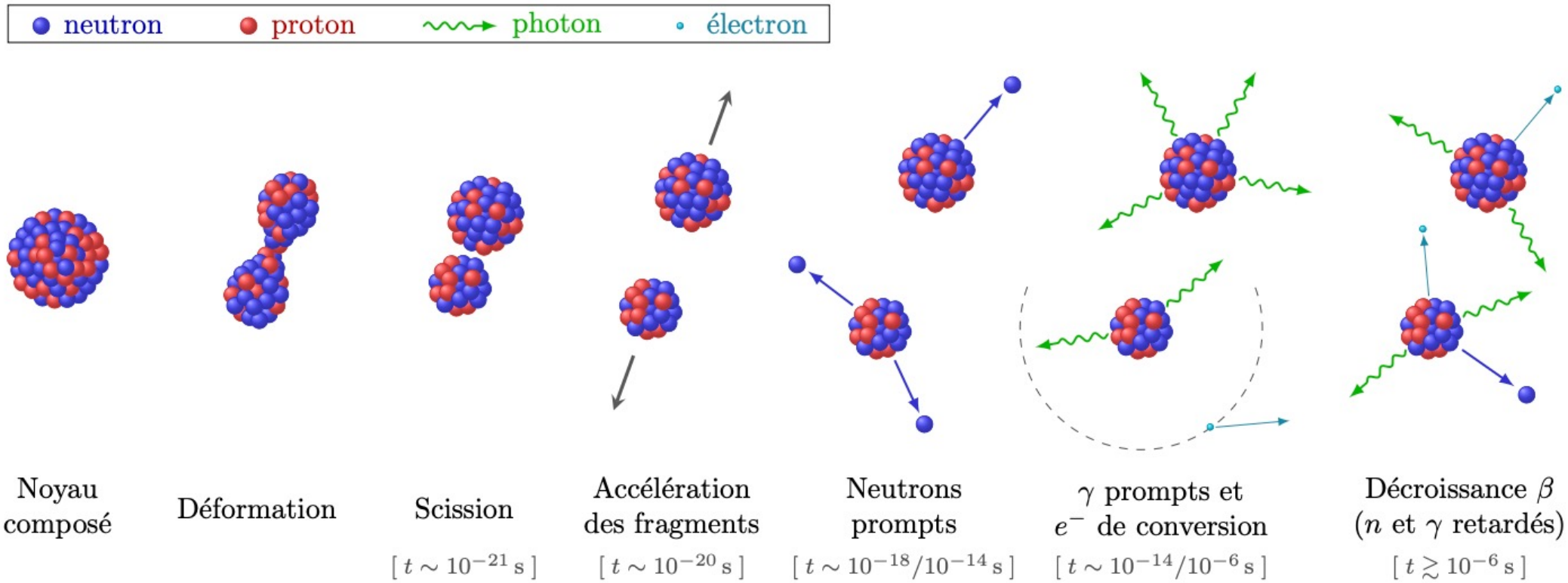
Nuclear Fission



V.Piau, PhD thesis 2022

- ~160-180MeV kinetic energy shared between the 2 fragments
- Mass 90 < A < 160 amu , High charge Z+, 28 < Z < 64

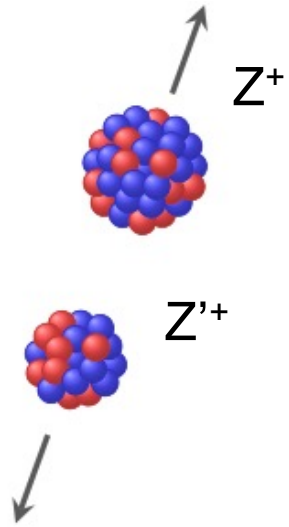
Experimental Features

- Tagging the fission events/ Kinematics of the fission fragments
  - Ionization chamber: Twin Frisch-Grid ionization chamber
- Measuring γ rays
  - Spectroscopy/Counting with scintillators: HPGe, La(Ce)Br_3,PARIS arrays ($LaBr_3$+NaI phoswiches)
- Measuring neutrons
  - Counting (neutron counters), spectroscopy with liquid scintillators

Experimental Features

- Tagging the fission events/ Kinematics of the fission fragments

  - Mass identification from total kinetic energy-> Energy resolution (675keV<-> ~0.54 amu)
  - Angle of emission
  - Charge identification Z (ideally 1 charge unit)
  - Timing resolution <1ns to establish correlations with gamma-ray measurements



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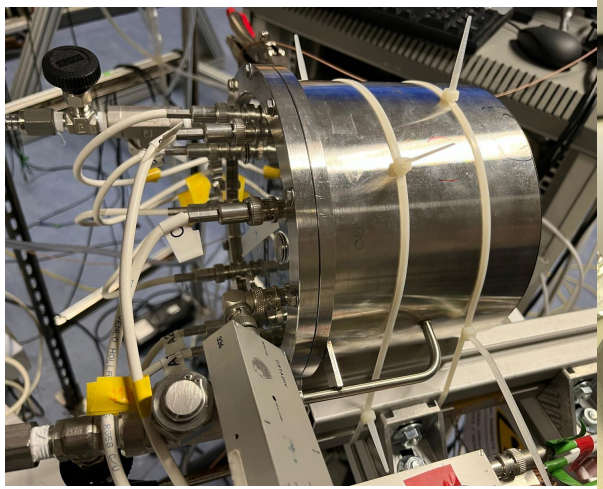
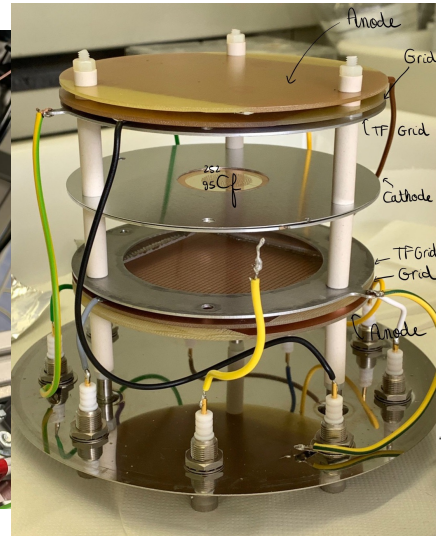
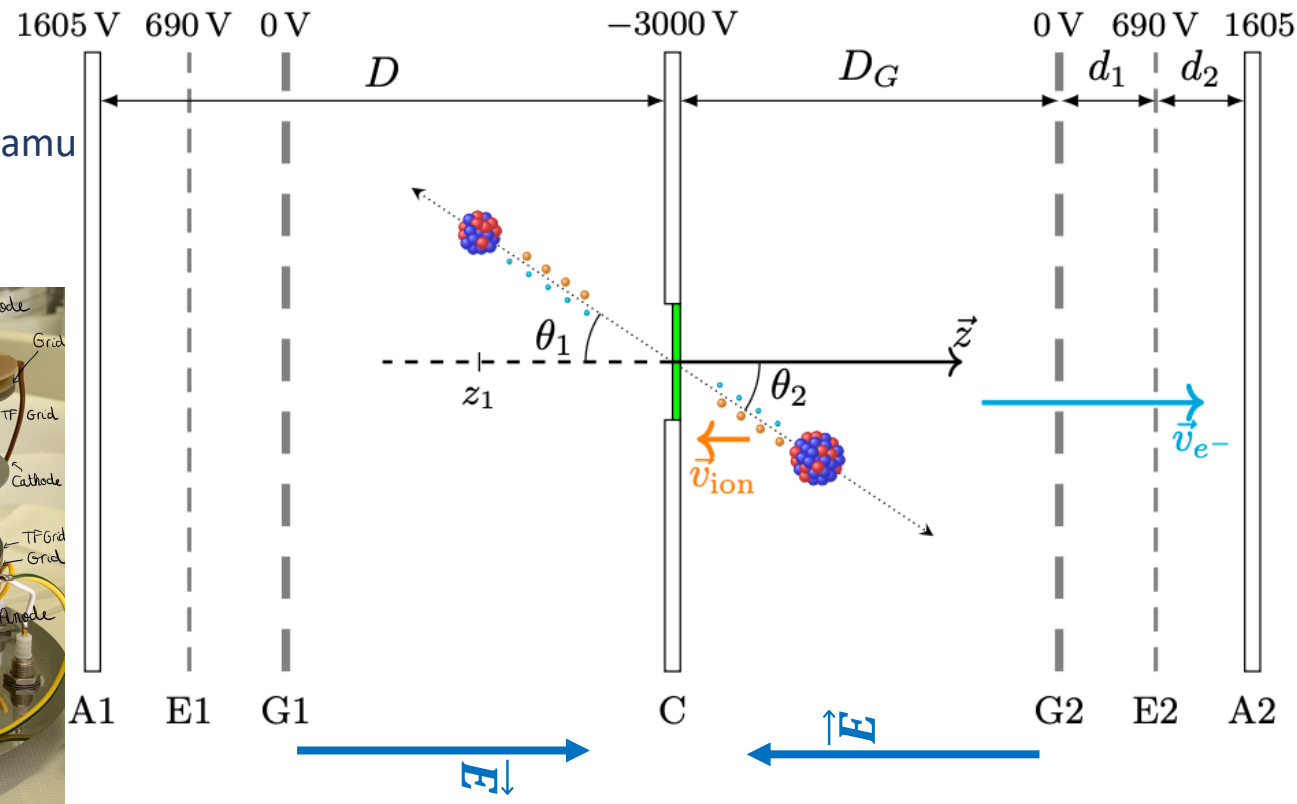
Twin Frisch-Grid ionization Chamber

- Tagging the fission events/ Kinematics of the fission fragments
  - Position sensitive Ionization Chamber:
    - Fission tag ~ 3ns
    - Mass identification of the fragments ~ 3amu
    - CH_4 timing resolution < 1ns (electrons)
    - Kinematics





JRC Geel



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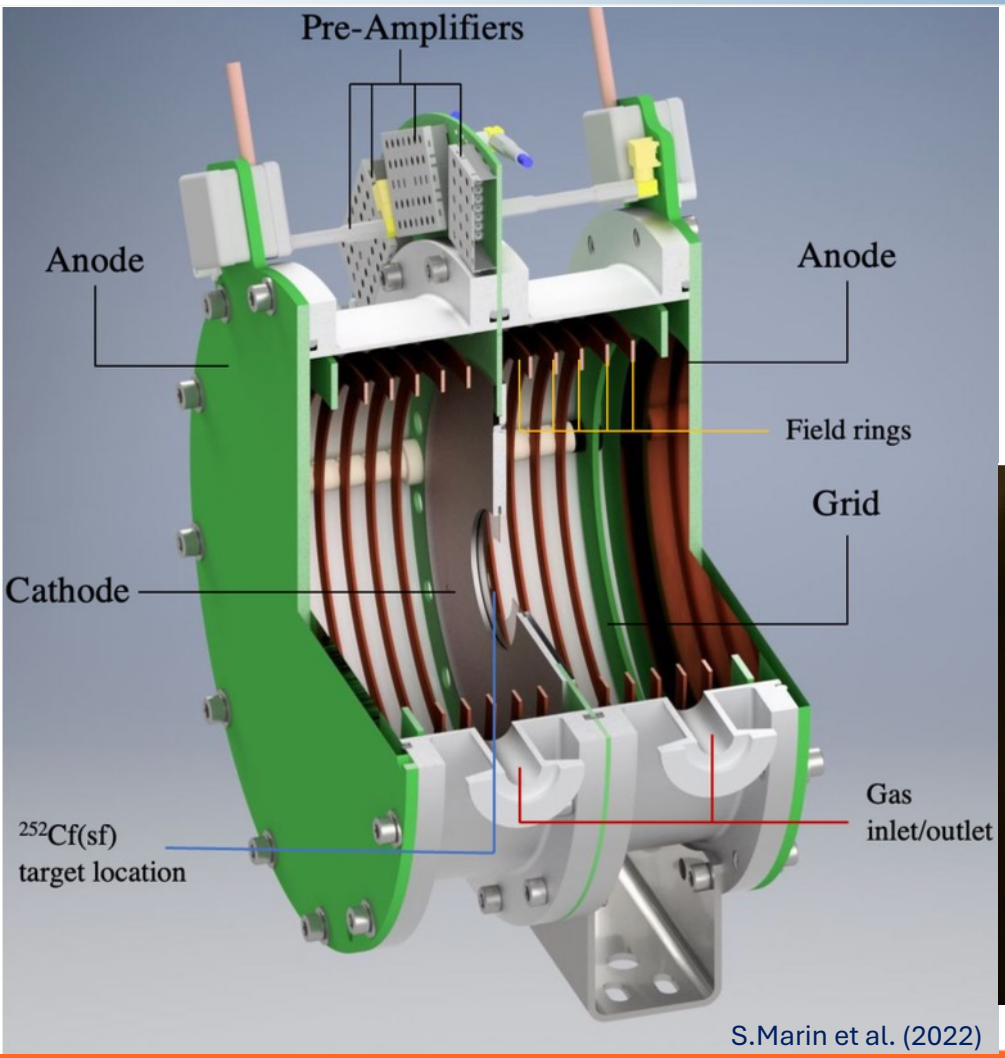
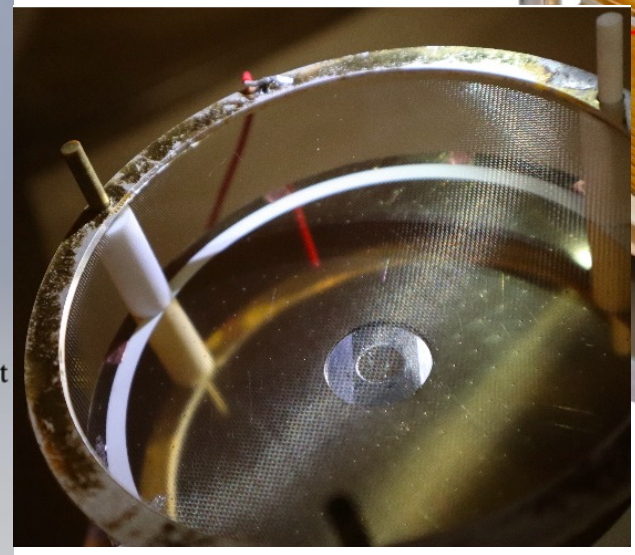
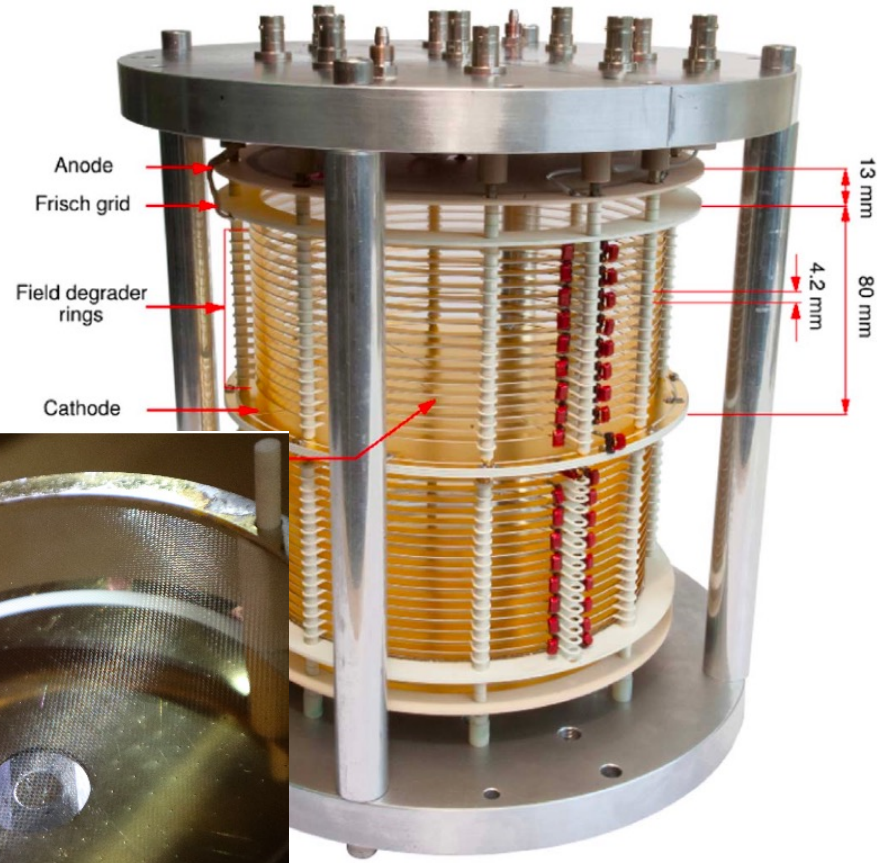
Twin Frisch-Grid ionization Chamber



S.Marin et al. (2022)



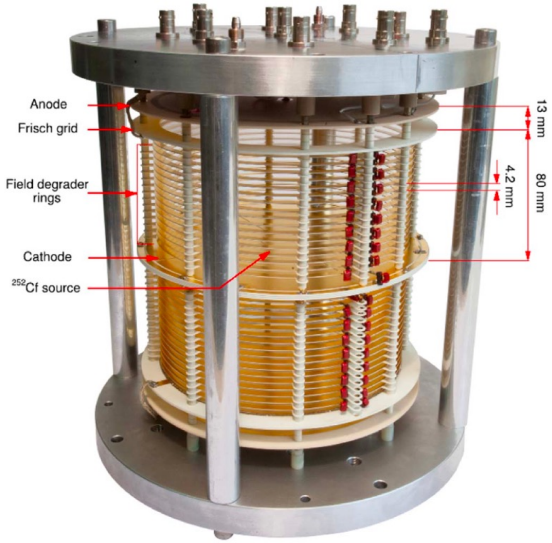
A.Francheteau, PhD thesis (2023)



L.Gaudefroy et al. (2017)
CEA DAM

Twin Frisch-Grid ionization Chamber

- Tagging the fission events/ Kinematics of the fission fragments
  - Position sensitive Ionization Chamber:
    - Fission tag ~ ?ns
    - Energy resolution ~675keV
    - Mass identification of the fragments ~ 0.54amu
    - Ar+CH_4 P =0.5bar, timing resolution~ 1ns
    - Kinematics



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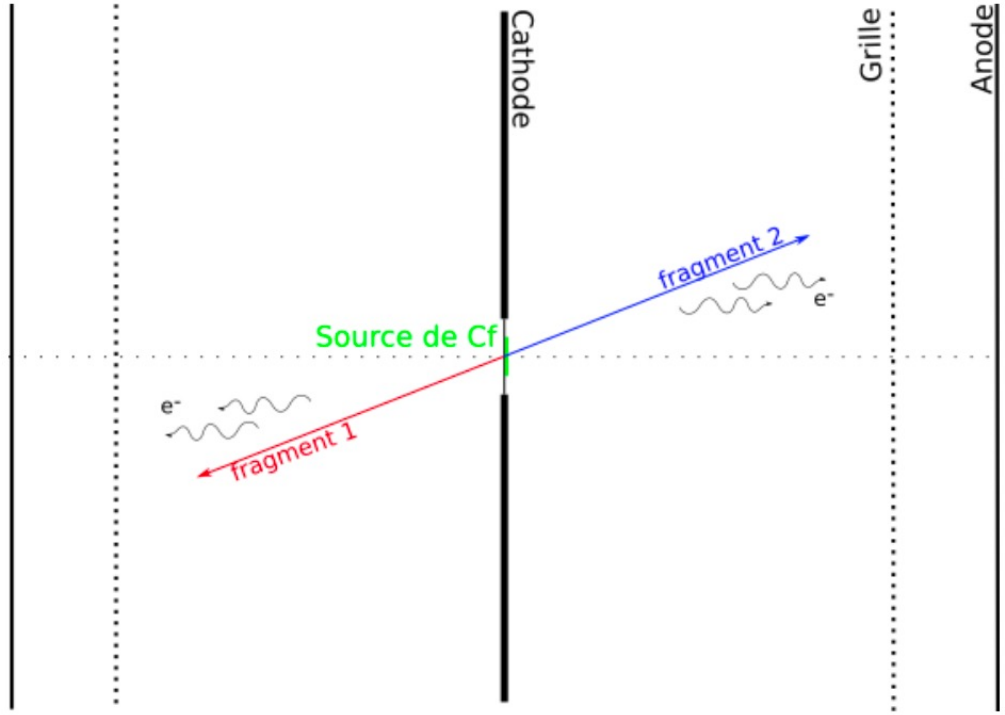
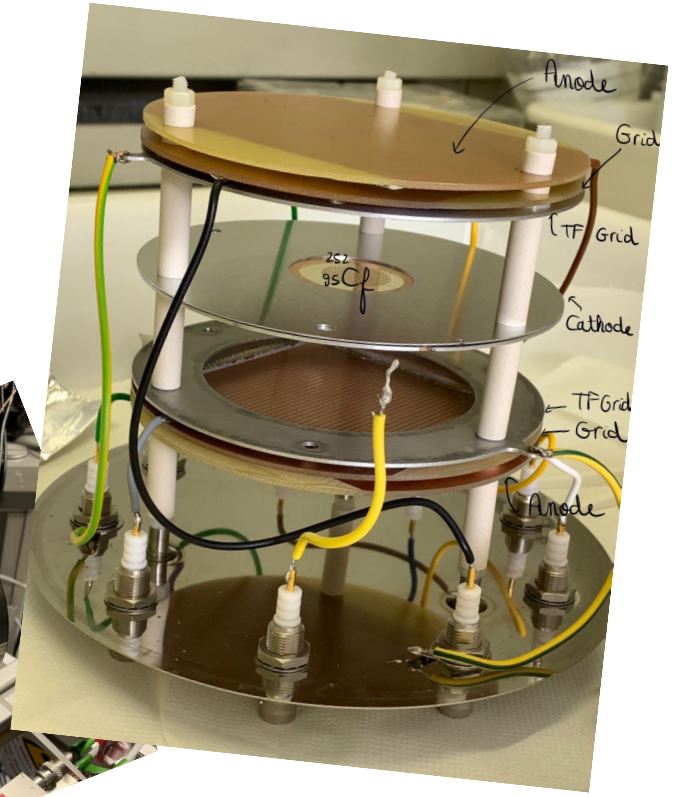


A.Francheteau, PhD thesis 2023

Required Performances

Existing chamber

- Fission tag ~ 4ns (ionic signal)
- Mass identification of the fragments ~ 3amu
- Poor angular reconstruction



What we need

- Fission tag <1ns
- Mass identification of the fragments <1amu⇔<600keV
- Proper angular reconstruction
- Deduce the charge of the fission fragment
- Compactness
- New technology?

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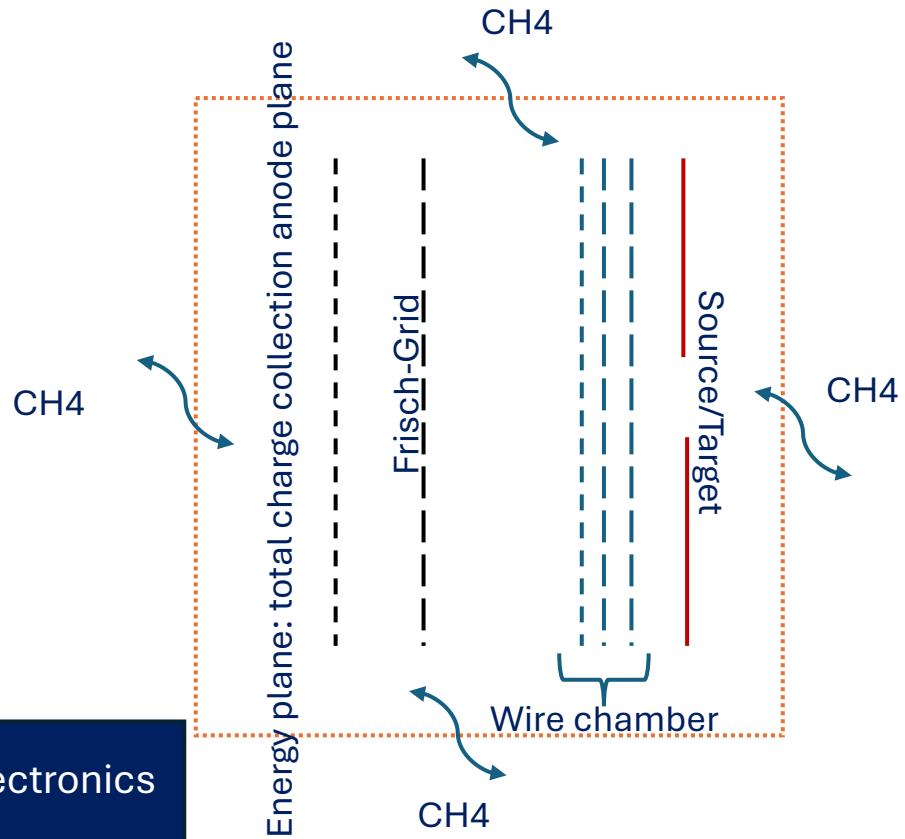
Our alternative solution!

- Gaseous ionisation chamber with included wire chamber
- Tracking and calorimetery for charged particles
- Expected timing resolution < 1ns
- Expected Energy resolution < 600keV
- Prototype to be built in 2024 – Launching mid-September
- Tests with 3-α source



M. Lebois, G. Charles, K. Pressard, M. Mehdi

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Next Step

- Development of a prototype of ICETEA by December 2024-January 2025

- Commissioning of the prototype and performing new measurements on different fissionning systems (^{252}Cf, ^{248}Cm etc…)~Early 2025

- Can we do better?