Fission Multiplicity Detection with Temporal Gamma-Neutron Discrimination from Higher Order Time Correlation Statistics

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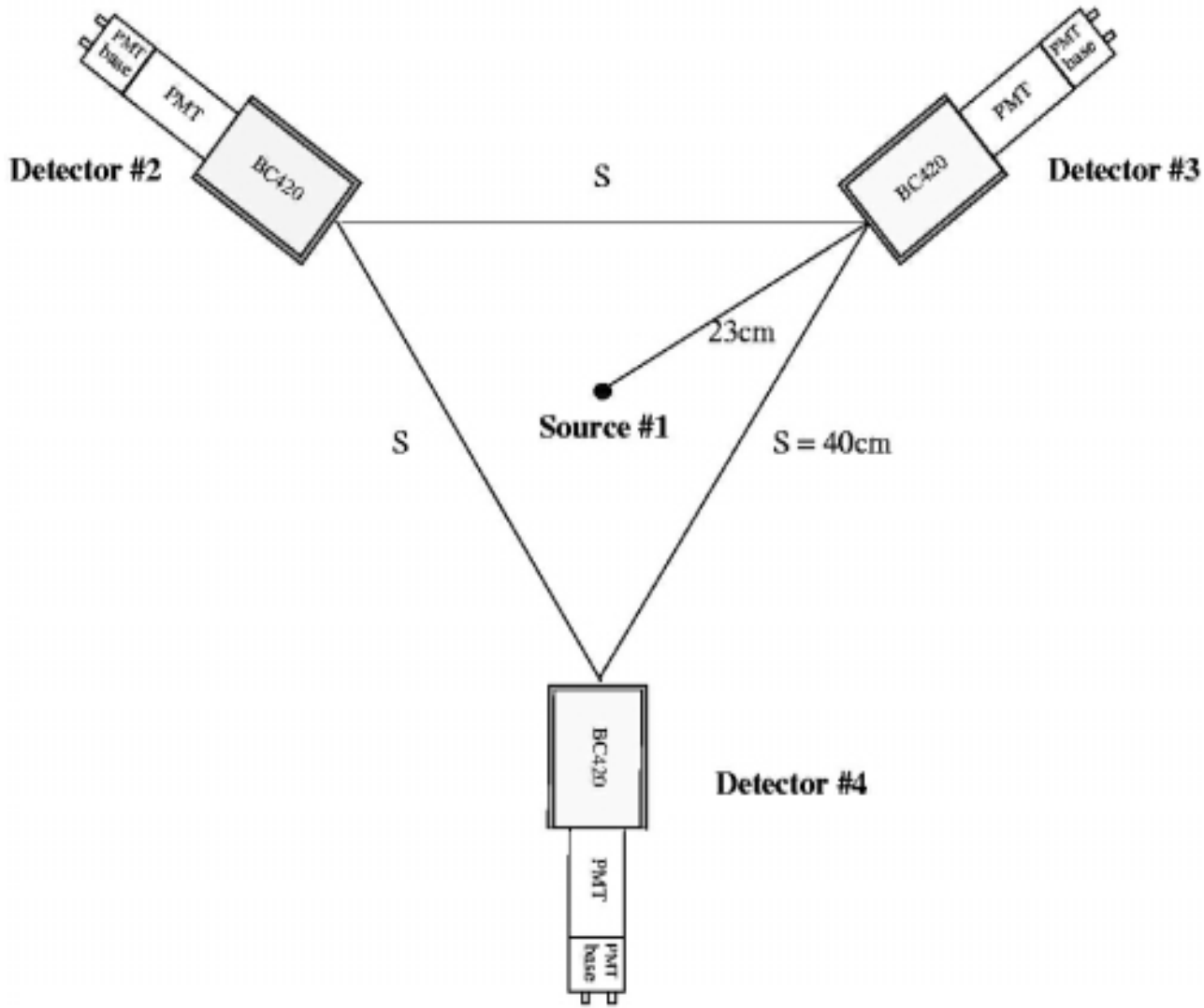
Fission Multiplicity Detection

- Popular in the '60s and '70s.
- Several commercially available systems
  - Isotopic Source Assay System (ISAS) developed Gulf General Atomics
  - Isotopic Source Adjustable Fissionometer (ISAF) designed by IRT Corporation formerly Gulf Radiation Technology
  - Random Driver Los Alamos Scientific Laboratory and National Nuclear Corporation

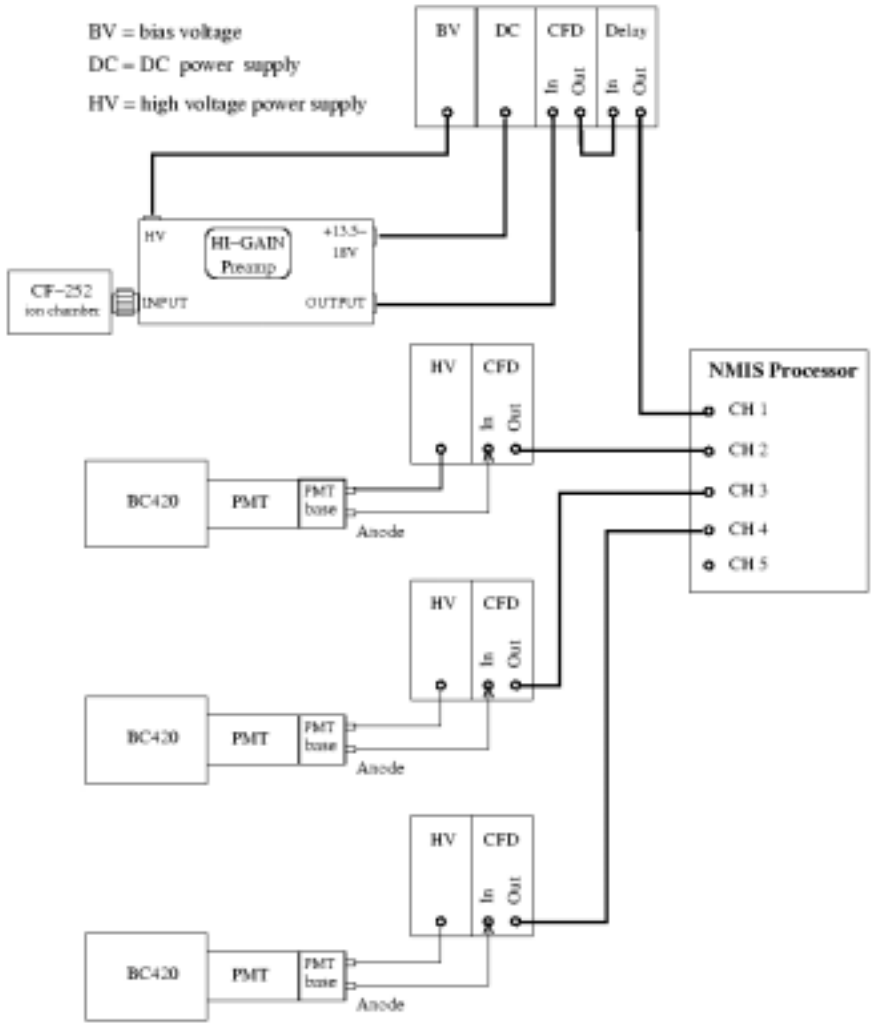
Fission Multiplicity Detection (cont'd)

- 2 to 4 fast plastic detectors sensitive to both fast neutrons and gamma rays
- Coincidences were counted between detectors

Experimental setup



Block diagram



Source correlation (for analysis)

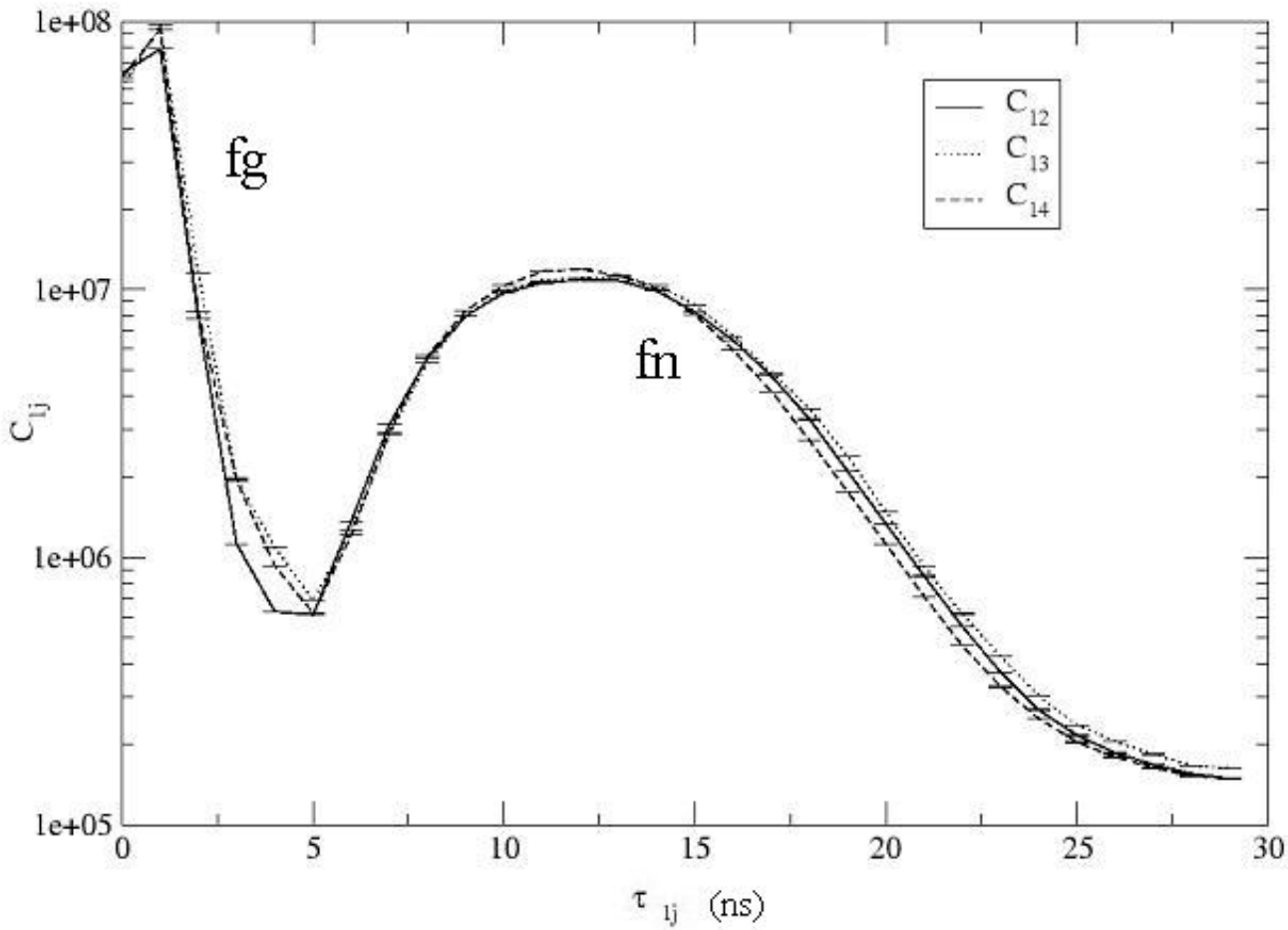
- Source-detector

$$C_{12}(\tau_{12})$$

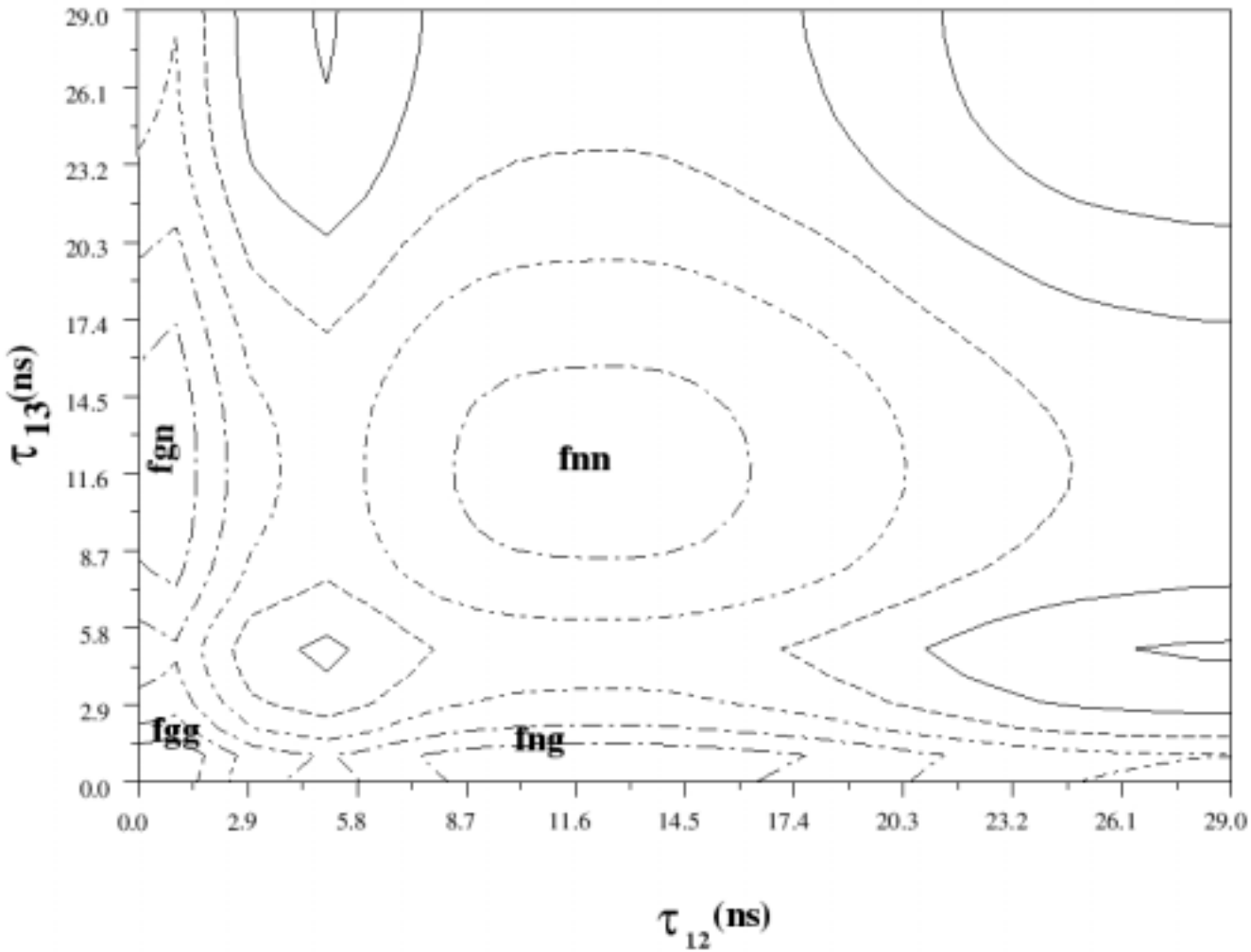
- Source-detector-detector

$$C_{123}(\tau_{12},\tau_{13}) = C_{13}(\tau_{13})C_{12}(\tau_{12} \mid \tau_{13})$$

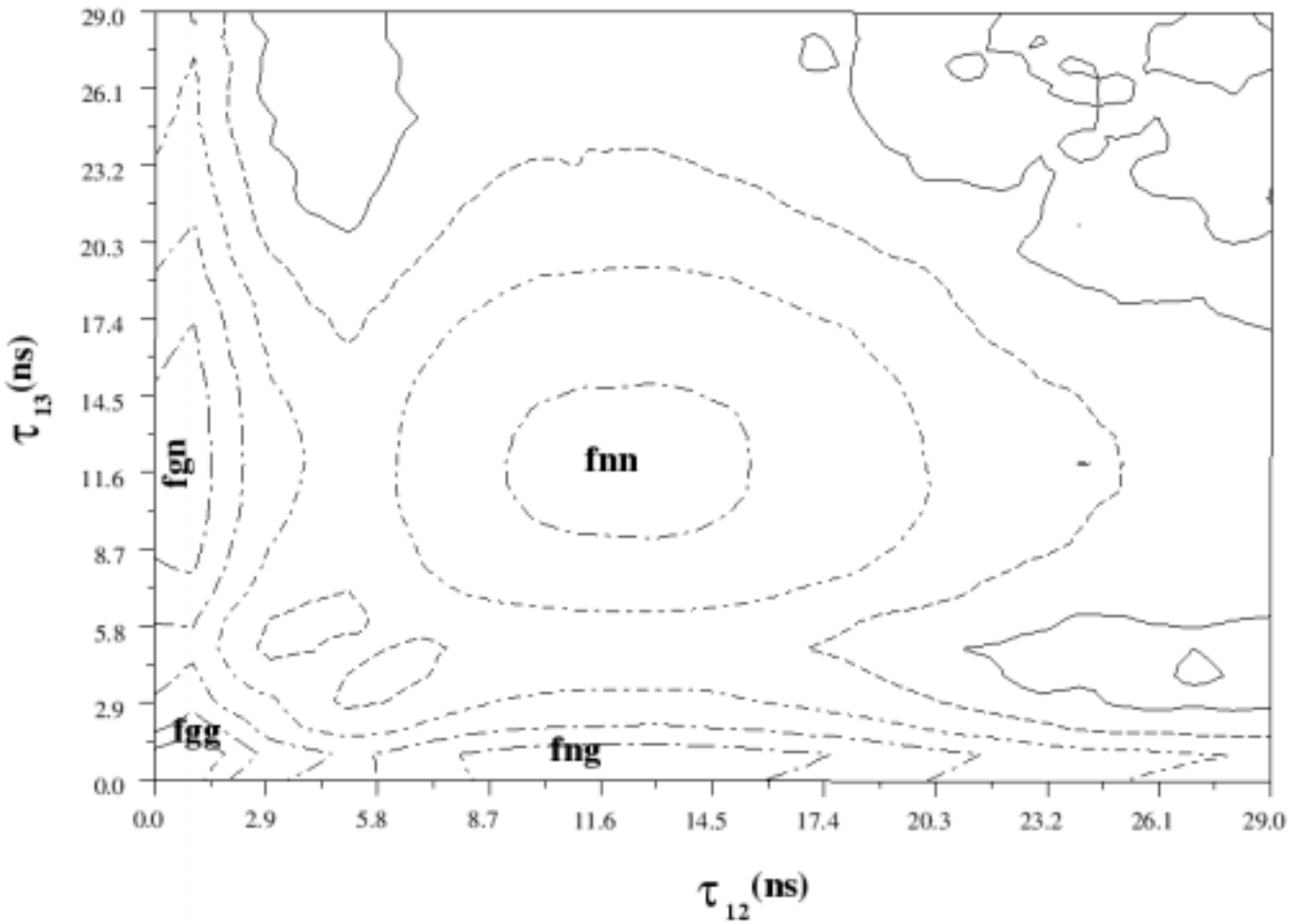
Source-detector Correlation



Source-detector-detector Correlation



Source-detector-detector Correlation



Detector-detector Correlation

- Detector-detector $\tau_{23} = \tau_{13} - \tau_{12}$

$$C_{23}(\tau_{23}) = \int C_{123}(\tau_{12}, \tau_{23} + \tau_{12}) d\tau_{12}$$

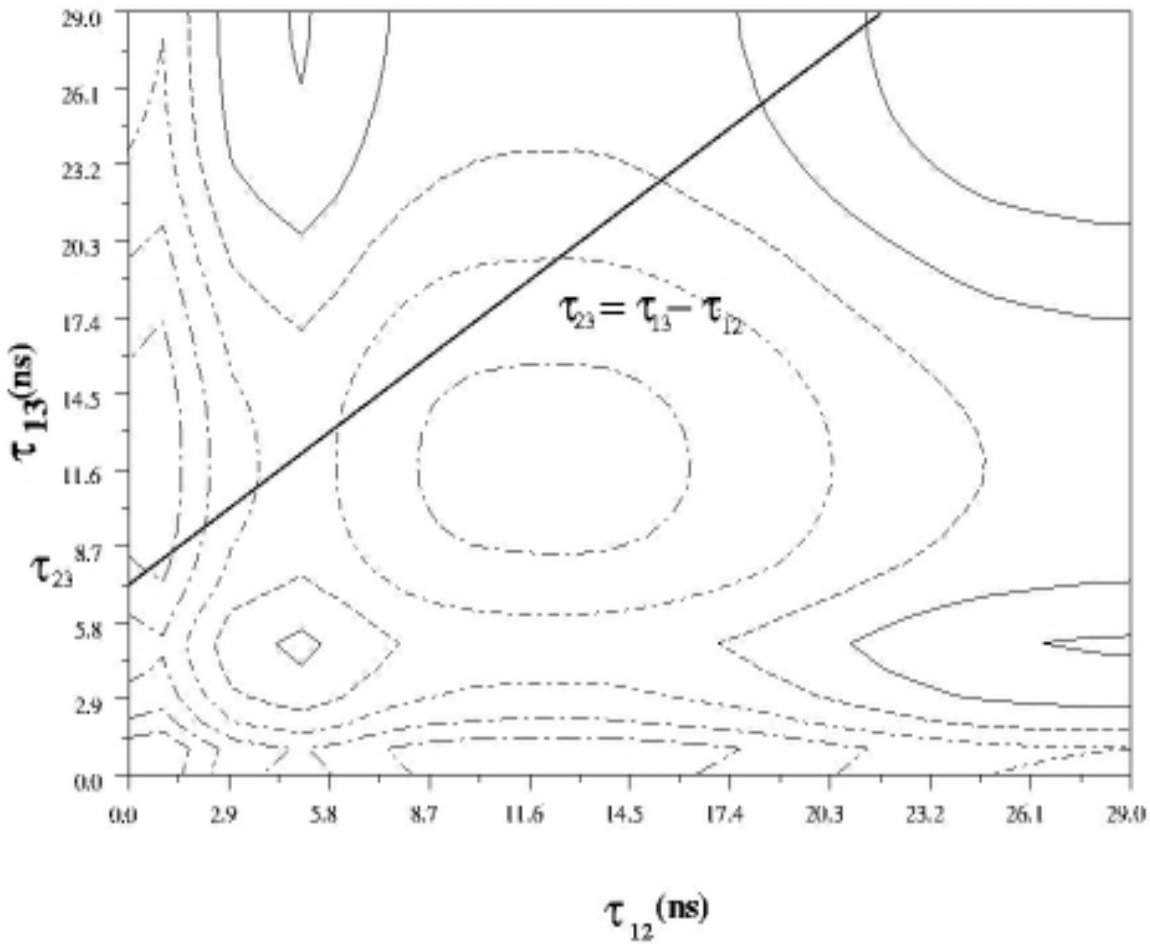
- Detector-detector-detector $\tau_{23} = \tau_{13} - \tau_{12}$

$$\tau_{24} = \tau_{14} - \tau_{12}$$

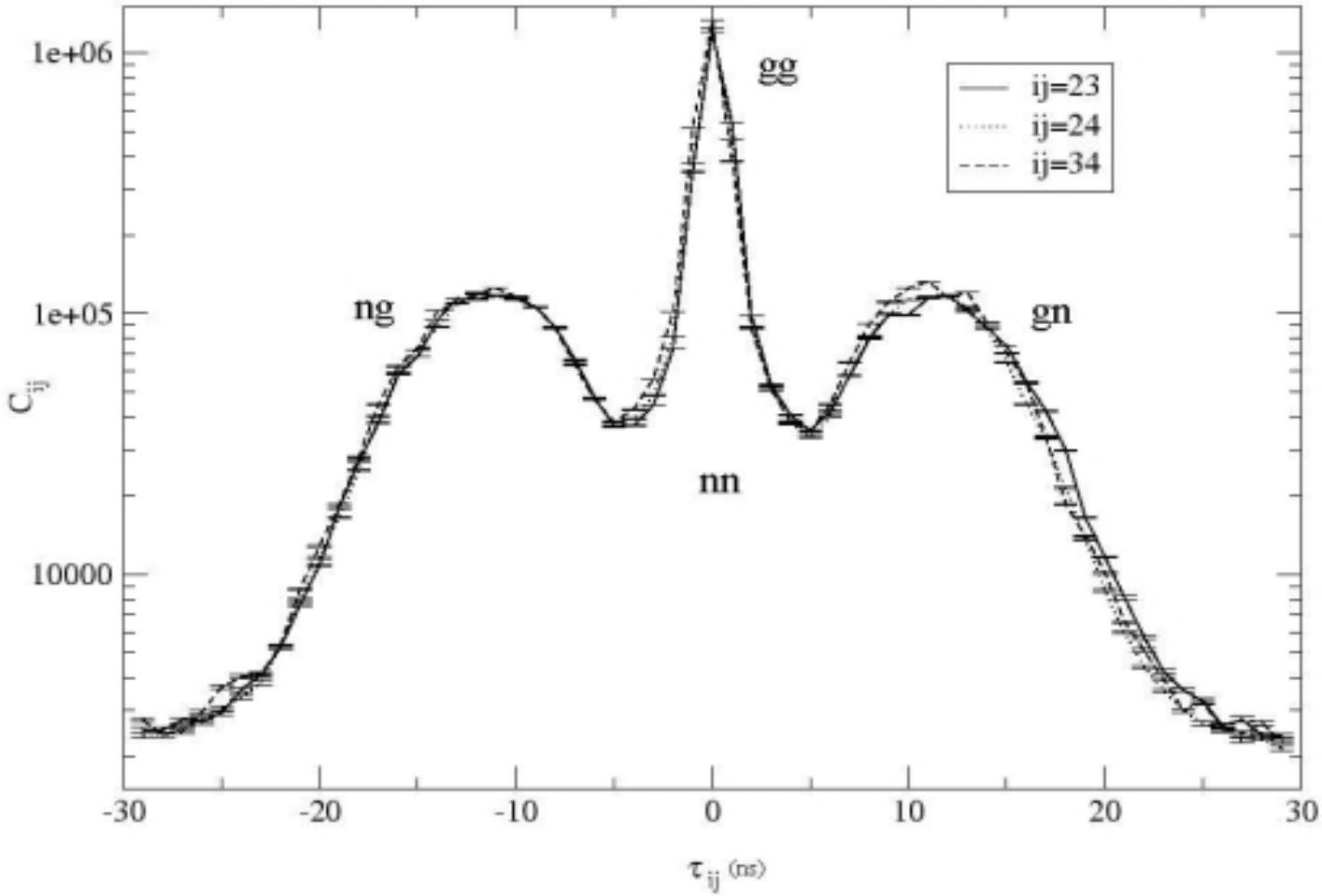
$$C_{234}(\tau_{23}, \tau_{24}) = \int C_{12}(\tau_{12}) C_{13}(\tau_{13}) C_{14}(\tau_{14}) d\tau_{12}$$

$$C_{234}(\tau_{23}, \tau_{24}) = \int C_{1234}(\tau_{12}, \tau_{23} + \tau_{12}, \tau_{23} + \tau_{12}) d\tau_{12}$$

Change of variables from Source-detector to Detector-detector



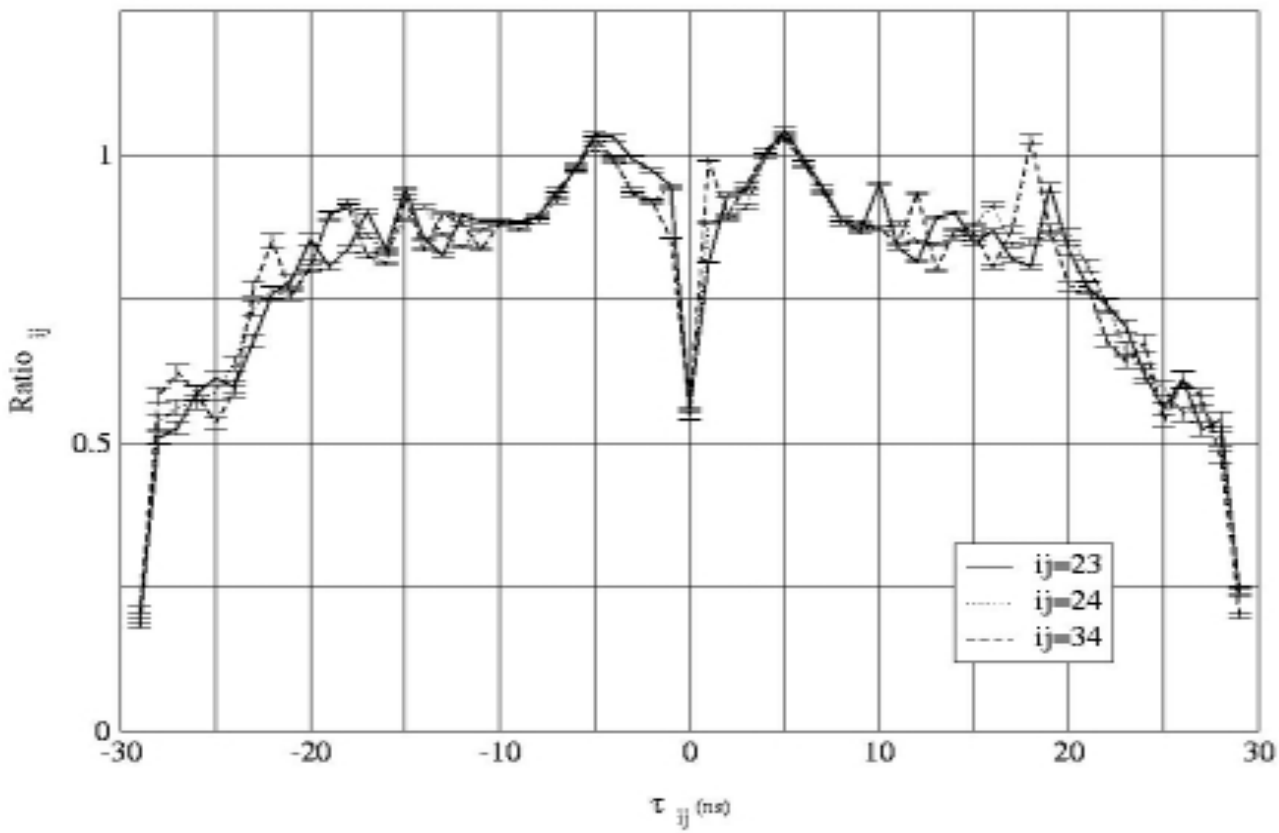
Detector-detector Correlation



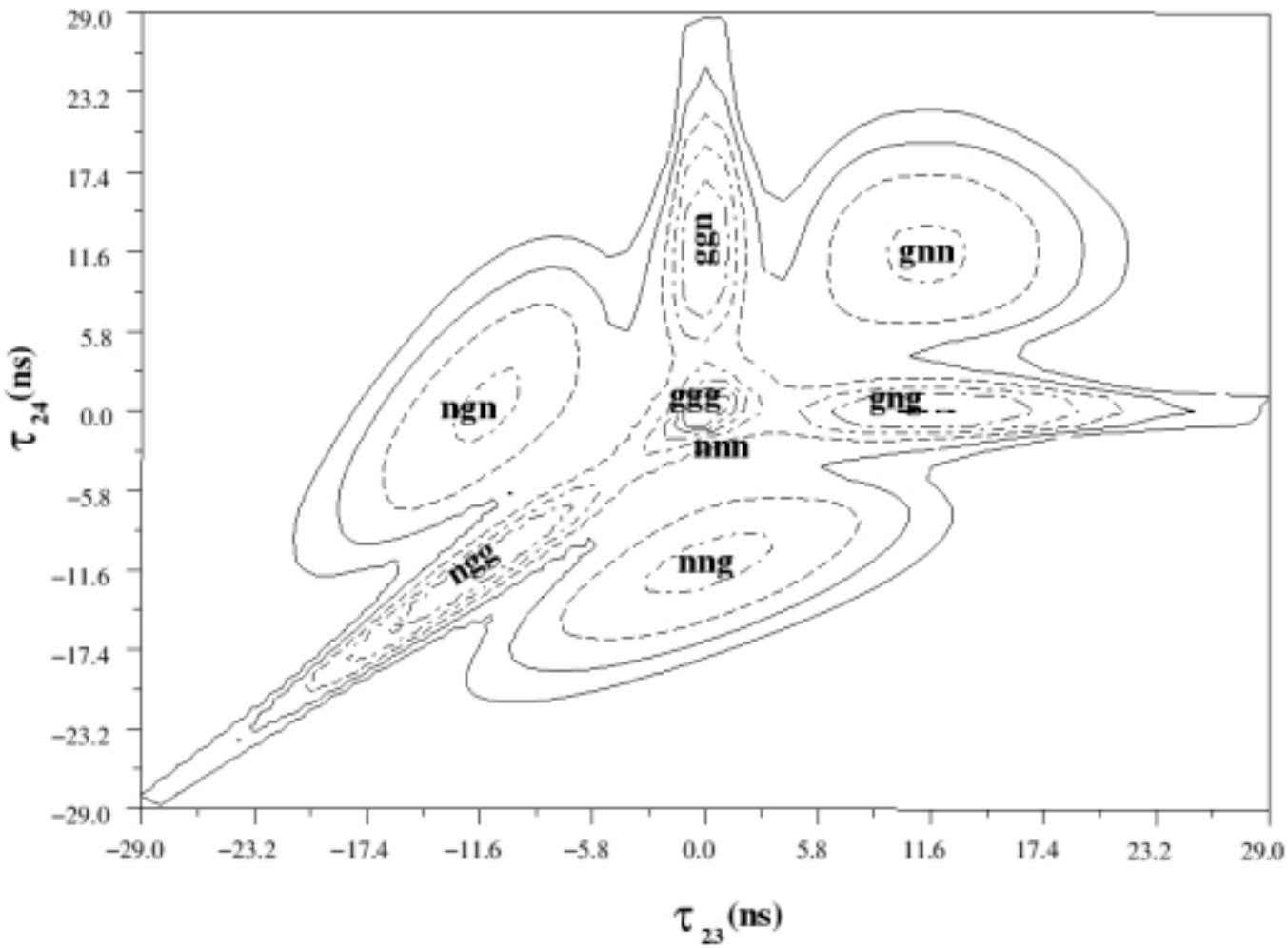
Ratio Example

$$\frac{\int C_{123}(\tau_{12}, \tau_{23} + \tau_{12}) d\tau_{12}}{C_{23}(\tau_{23})} = \frac{\varepsilon_f N_f}{N_f + N_b}$$

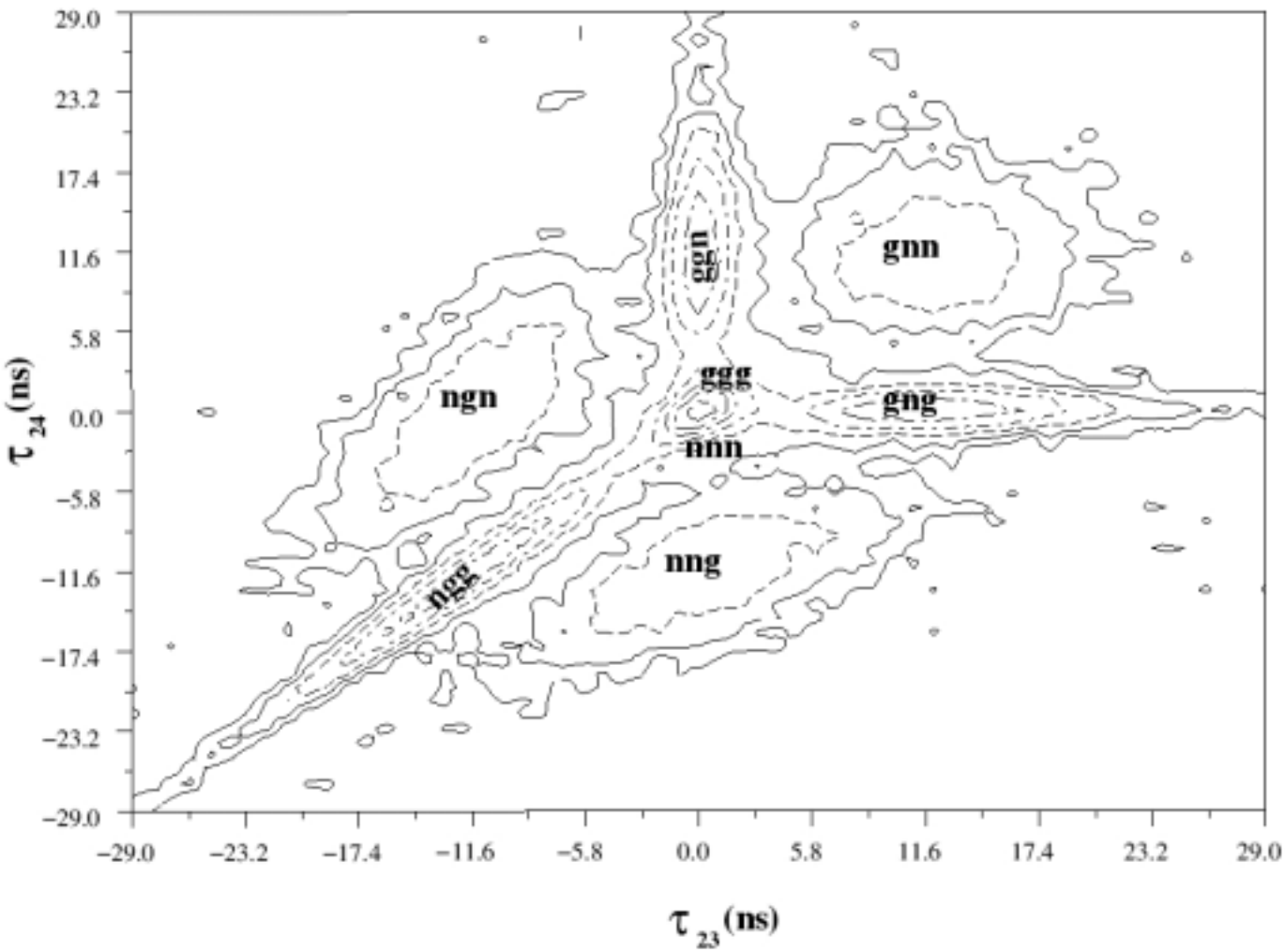
Ratio Example



Detector-detector-detector Correlation



Detector-detector-detector Correlation



Fission Multiplicity Detection

- Higher order time correlation statistics opens a great deal of new information from FMD.
- Eight new independent measurements for each triplet of detectors.