



# Time of flight spectroscopy of fission fragment with single crystal diamond

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**Marc Olivier Frégeau, Stephan Oberstedt**

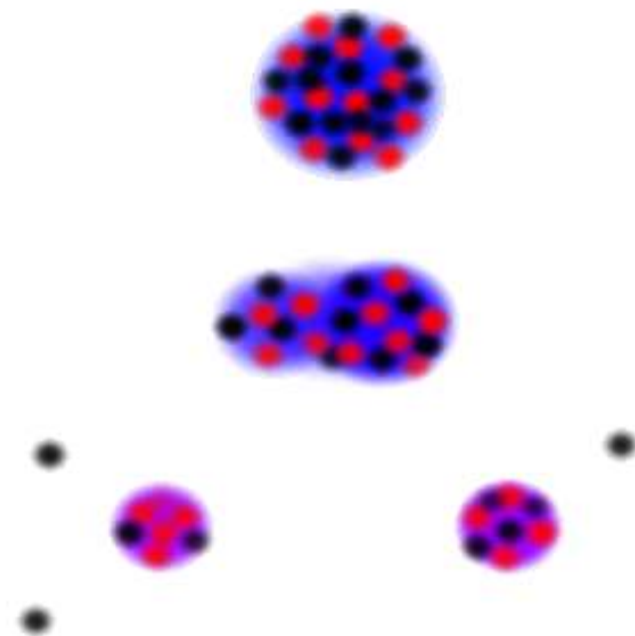
European Commission, Joint Research Centre, Institute for reference material and measurements



# **European Commission – Joint Research Centre Institute for reference materials and measurement**

Policy support to the European commission  
Production of certified reference material for :  
GMO  
Nanoparticle  
etc.  
Nuclear data:  
n,xn cross section  
n,f cross section  
fission yield measurements

# Neutron induced fission



## Fragment

Mass  $A \in [75, 170]$

$Z \in [30, 66]$

Kinetic Energy  $\in [50, 110]$

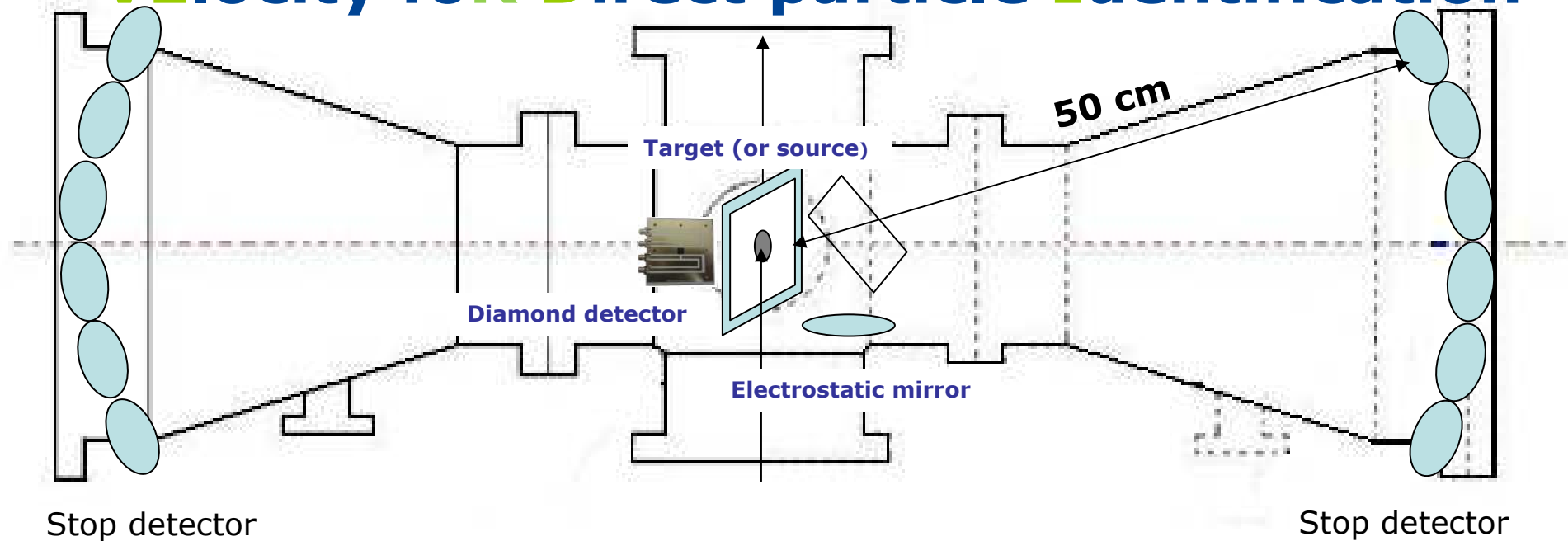
MeV

## Simultaneous emission of neutron and gamma rays

Target may show **high activity**

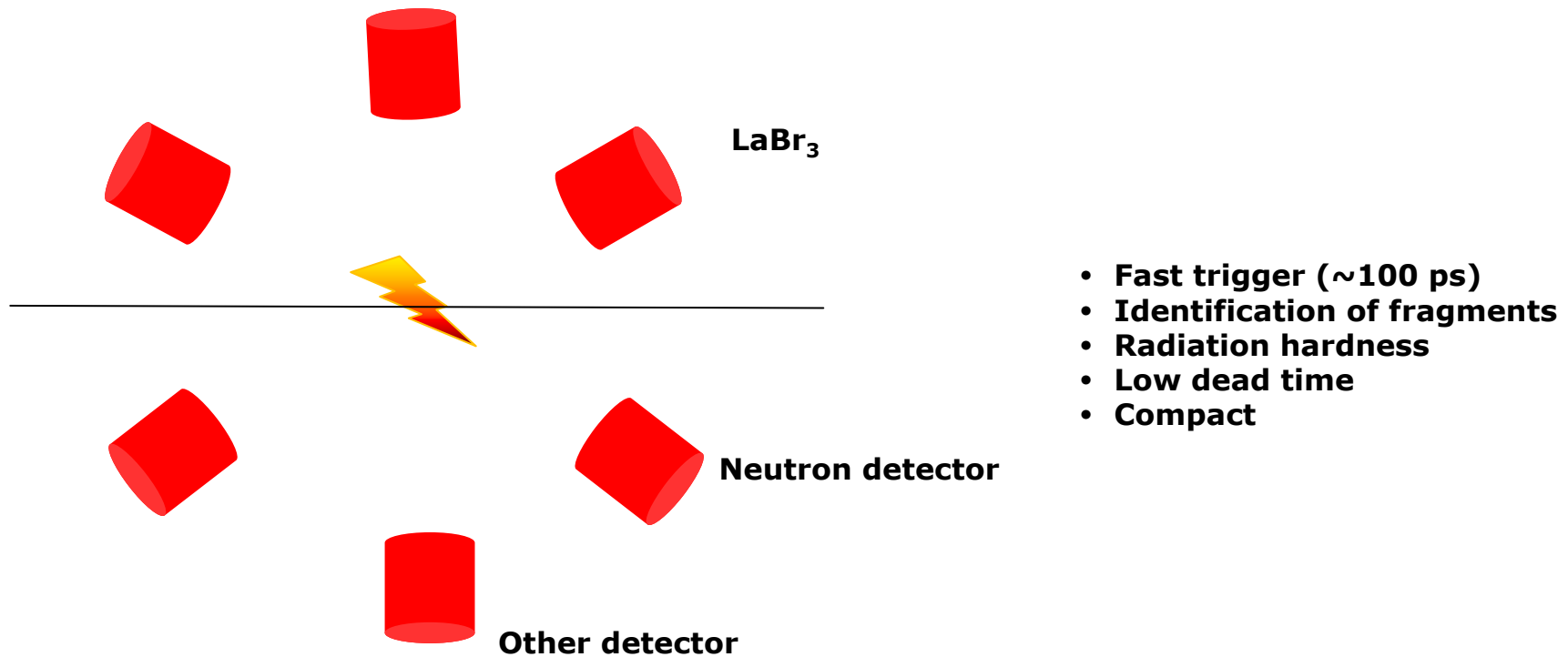
**High neutron flux** to nearby  
detectors (typical  $1e6 \text{ s}^{-1}\text{cm}^{-2}$ )

# Velocity for Direct particle Identification



**Determination of both fragments mass and neutron multiplicities in neutron induced fission**

## Other applications, fast fission trigger



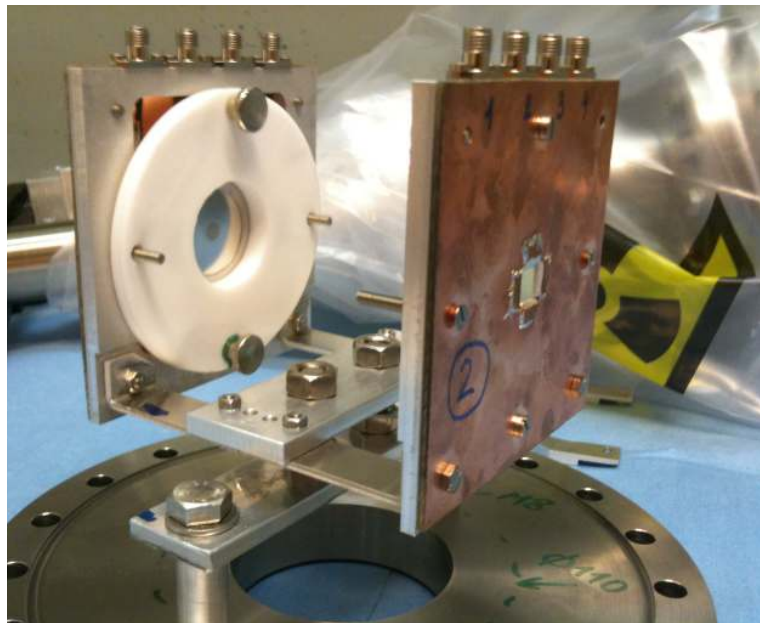
Fast trigger for measurements of  $\Upsilon$  or neutrons

## Detection of fragment close to the source

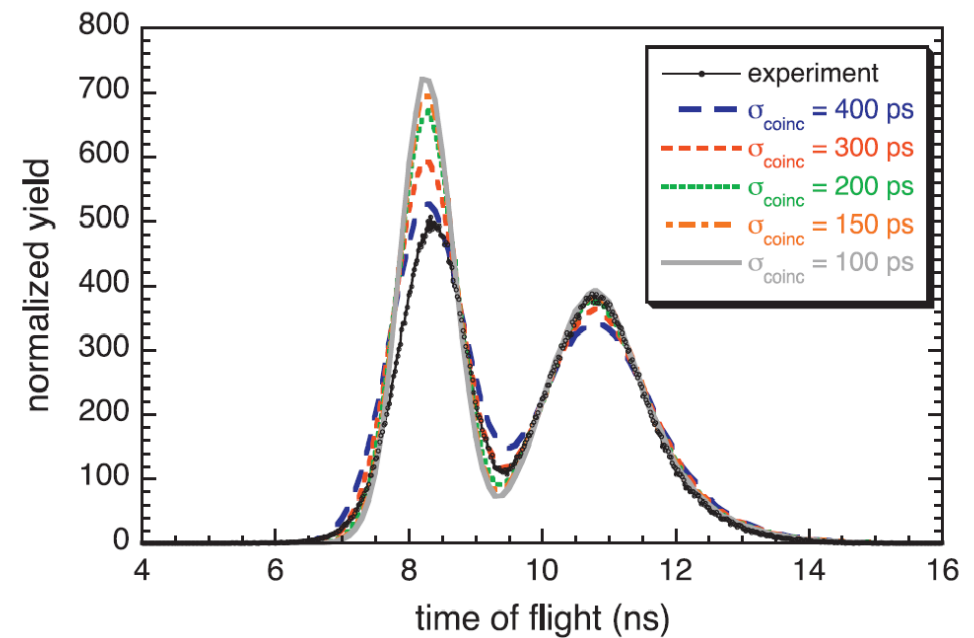
Diamond	MCP
Radiation hard	Neutron hardness uncertain
Good timing	Good timing
Energy information	No energy information
Not transparent	Transparent
	Fragile equipment

The two detectors have their different range of applications.

# pCVD detectors



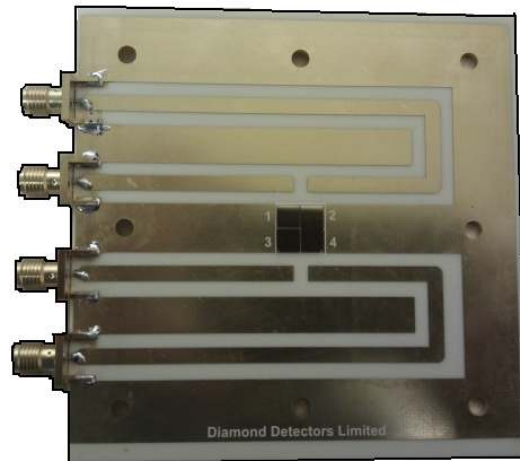
ToF for  $^{252}\text{Cf}$  spontaneous fission



**ToF spectrum distorted by very low amplitude pulse for heavy fragments**

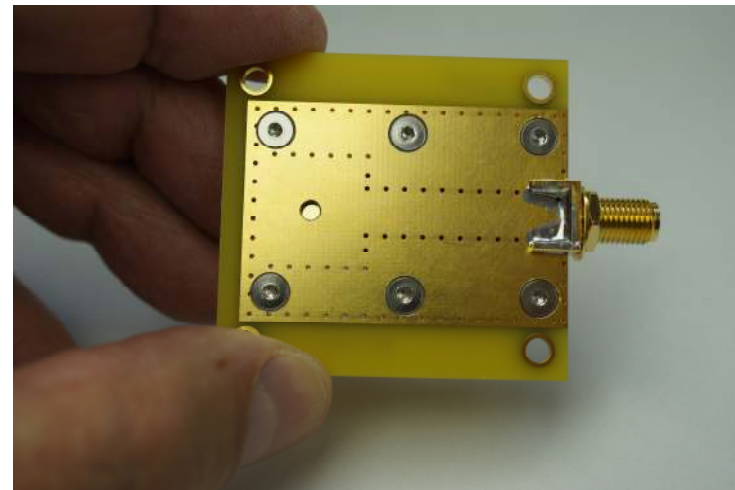
# The detectors

**Pad detector (2X2)**



**4 4.6X4.6X0.3mm**  
**sCVD**  
**1 V/ $\mu$ m**

**Spectroscopic detector**

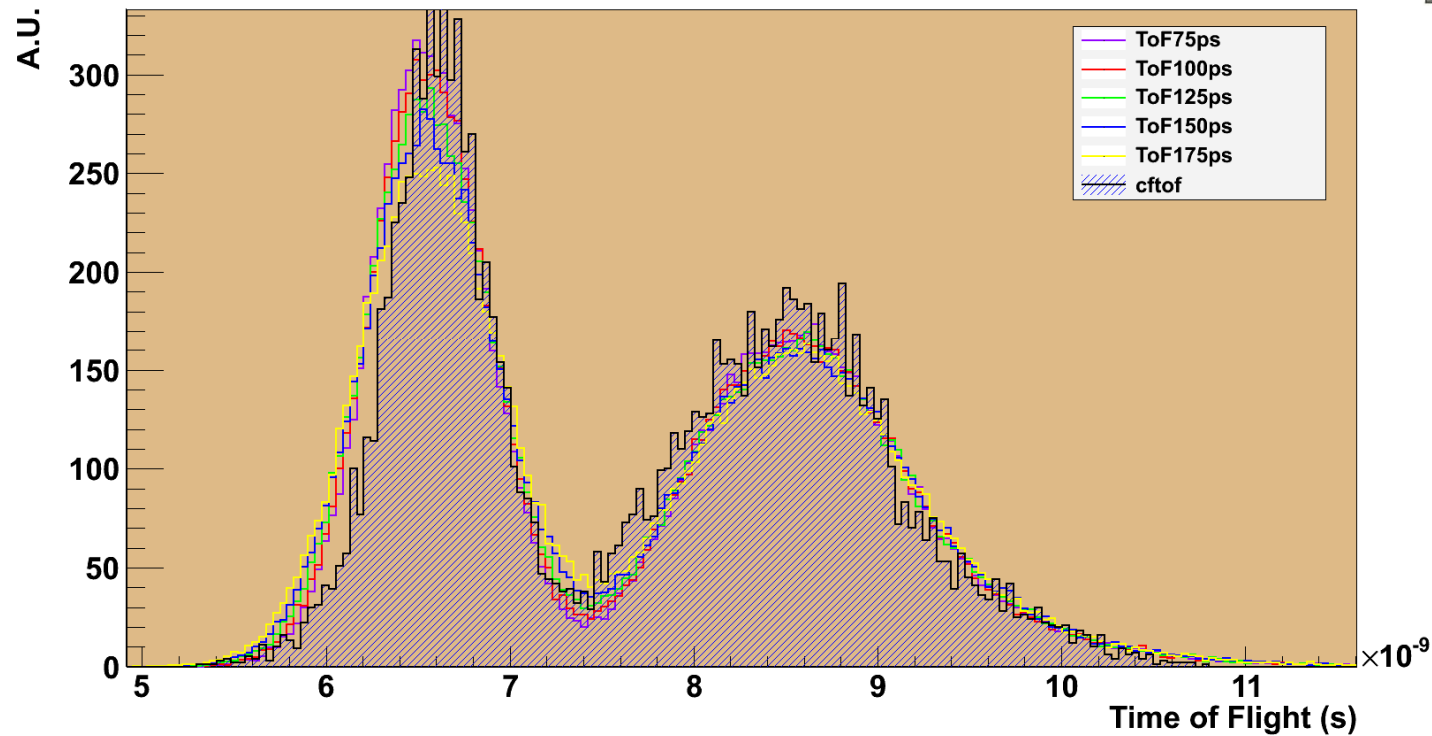


**4.6X4.6X0.15mm**  
**sCVD**  
**0.67 V/ $\mu$ m**  
**Spectroscopic casing**  
**Au and Al metallization**



# Timing resolution pad detector

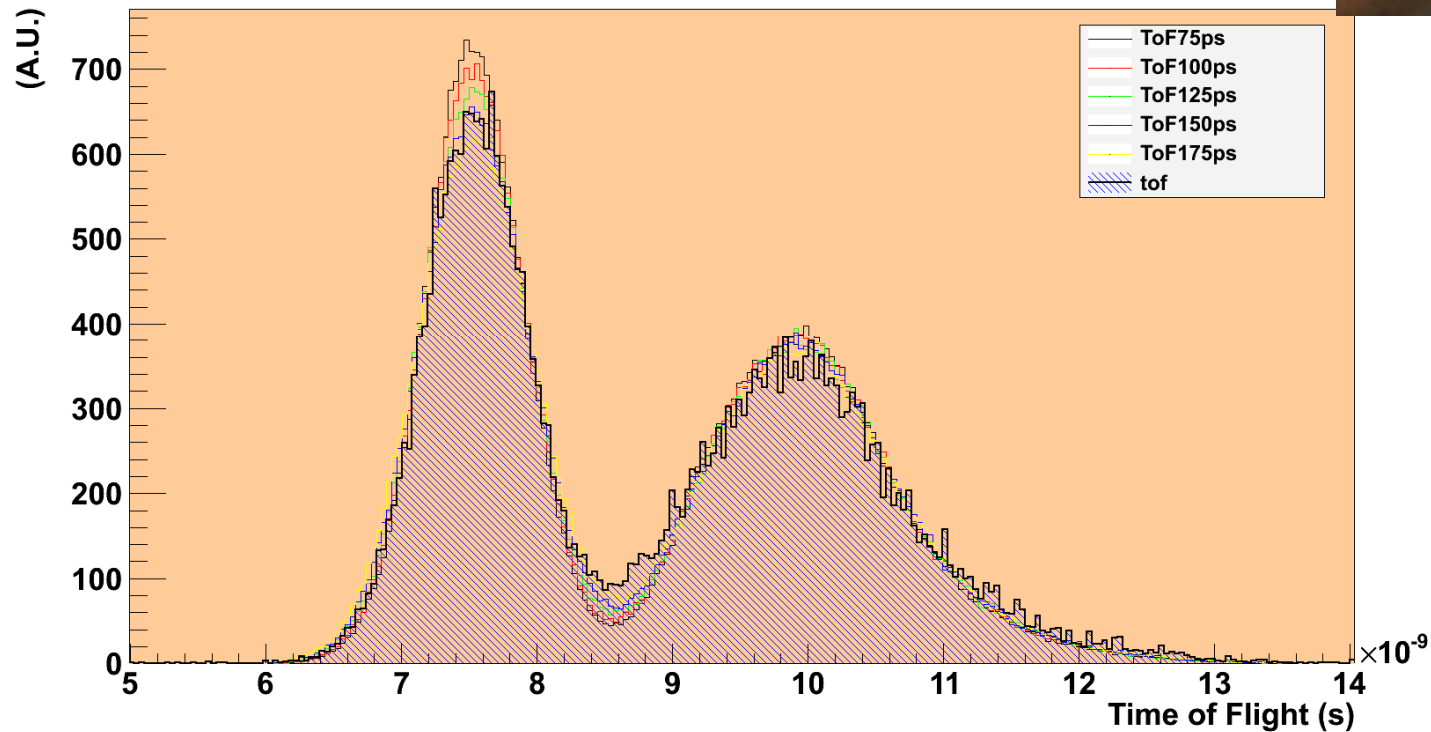
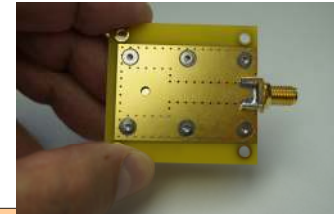
$^{252}\text{Cf}$  time of flight Spectrum 92mm



Same setup as with the pCVD Timing resolution around 100ps

# Spectroscopic diamond detector

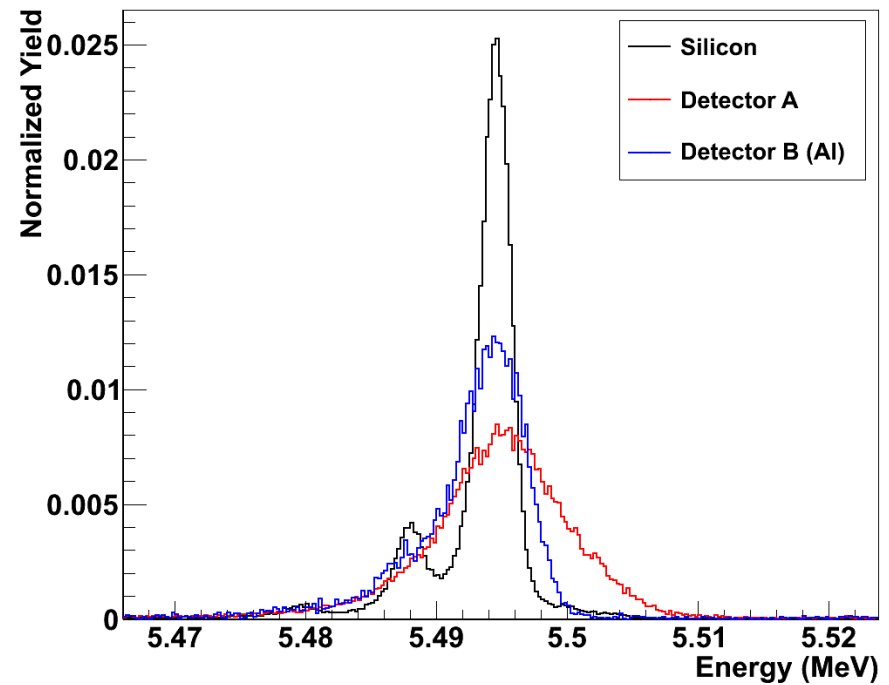
## 252Cf time of flight Spectrum



Same setup as with the pCVD Timing resolution around 125ps

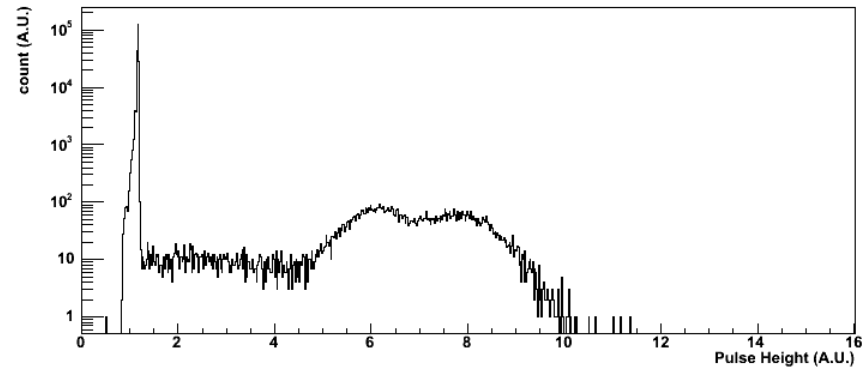
# Energy response (Alpha)

Detector	FWHM/E
Silicon	0.3%
Pad (red)	0.9%
Spectro (blue)	0.6%



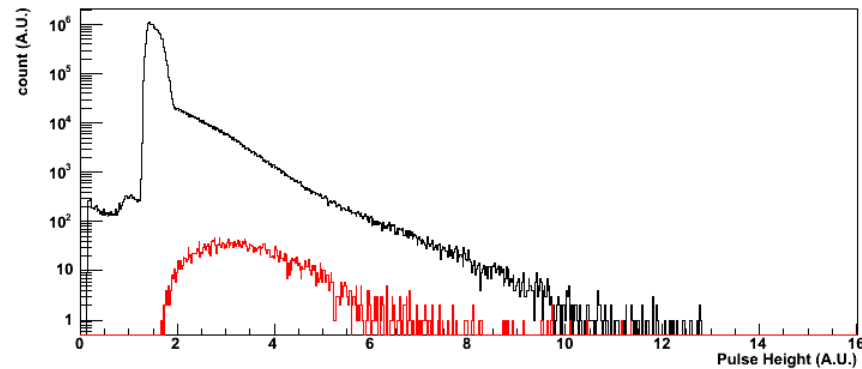
# Energy response of pad detector to fission fragments

Remote position (92 mm)



$\sim 10$  ff/s, 300  $\alpha$ /s

Close position (0.5 mm)

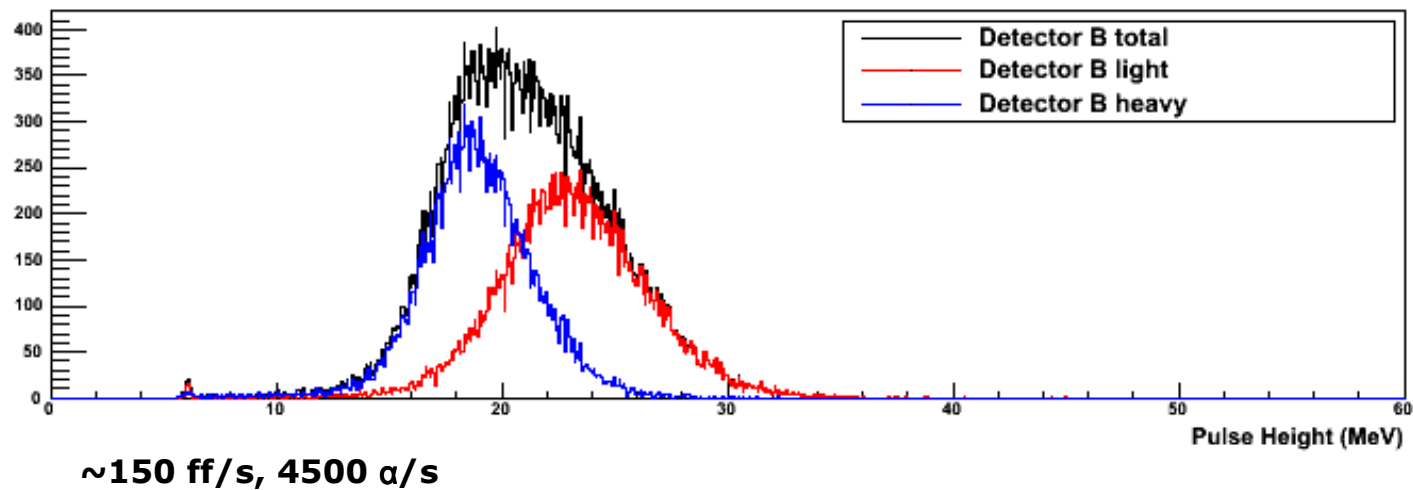


$\sim 500$  ff/s, 15000  $\alpha$ /s

Coincidence with other  
fragment

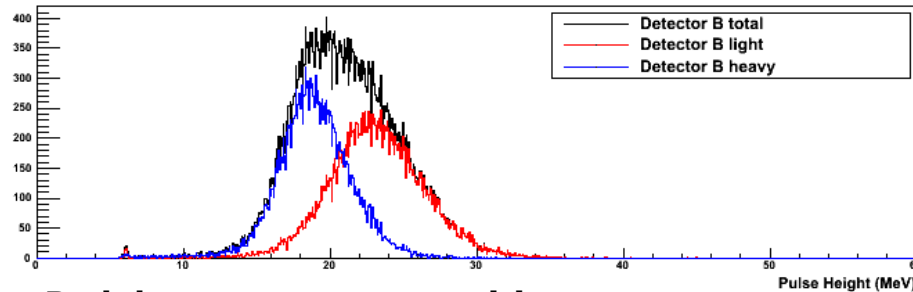
No coincidence

# Energy response of spectroscopic detector to fission fragments

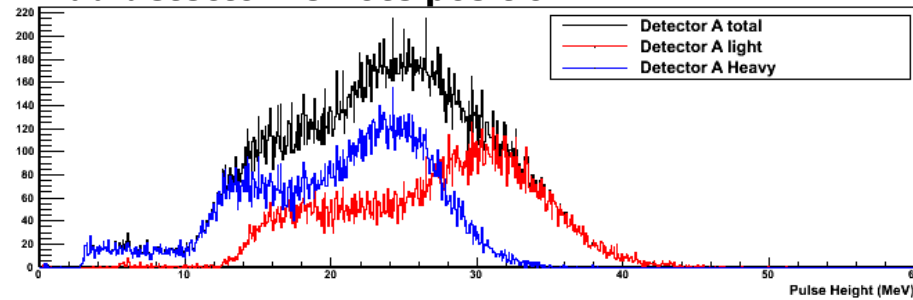


# Energy response- Comparison

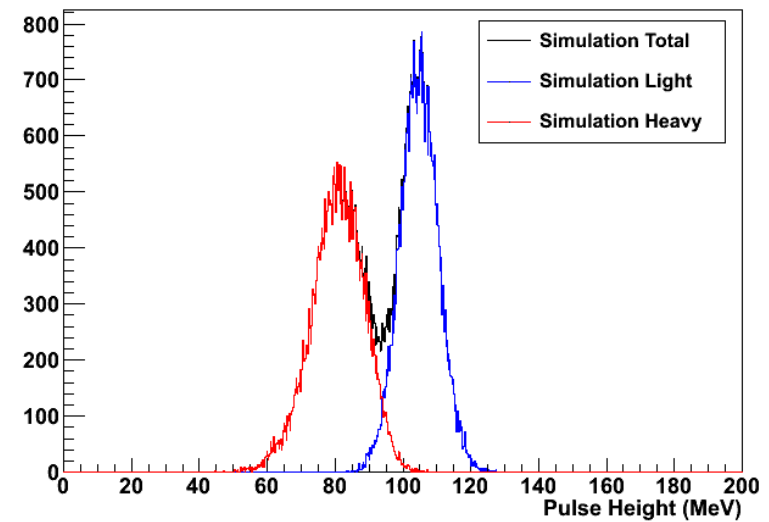
**Spectroscopic detector close position**



**Pad detector remote position**



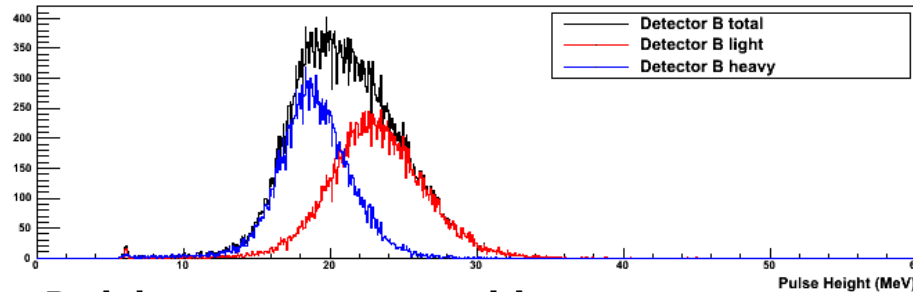
**Simulation  $\Delta E/E = 0.3\%$**



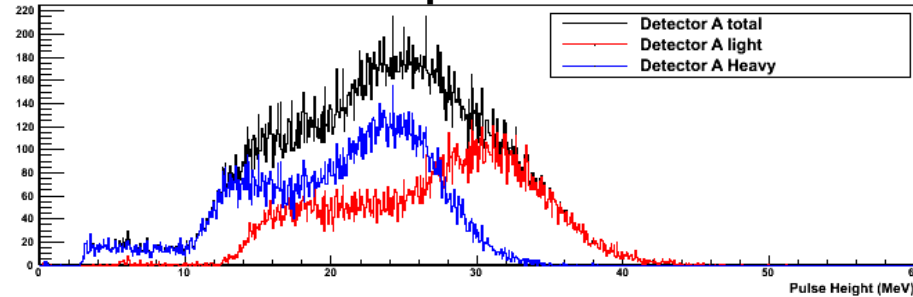
**Light fragments, Heavy fragments**

# Energy response- Comparison

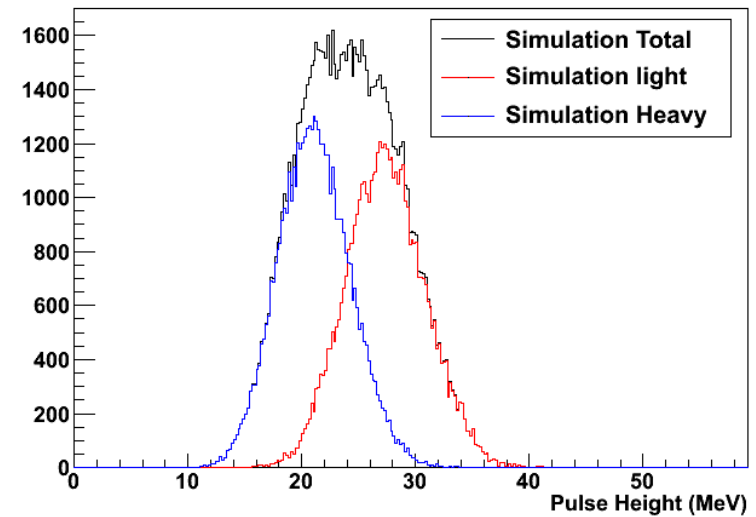
**Spectroscopic detector close position**



**Pad detector remote position**

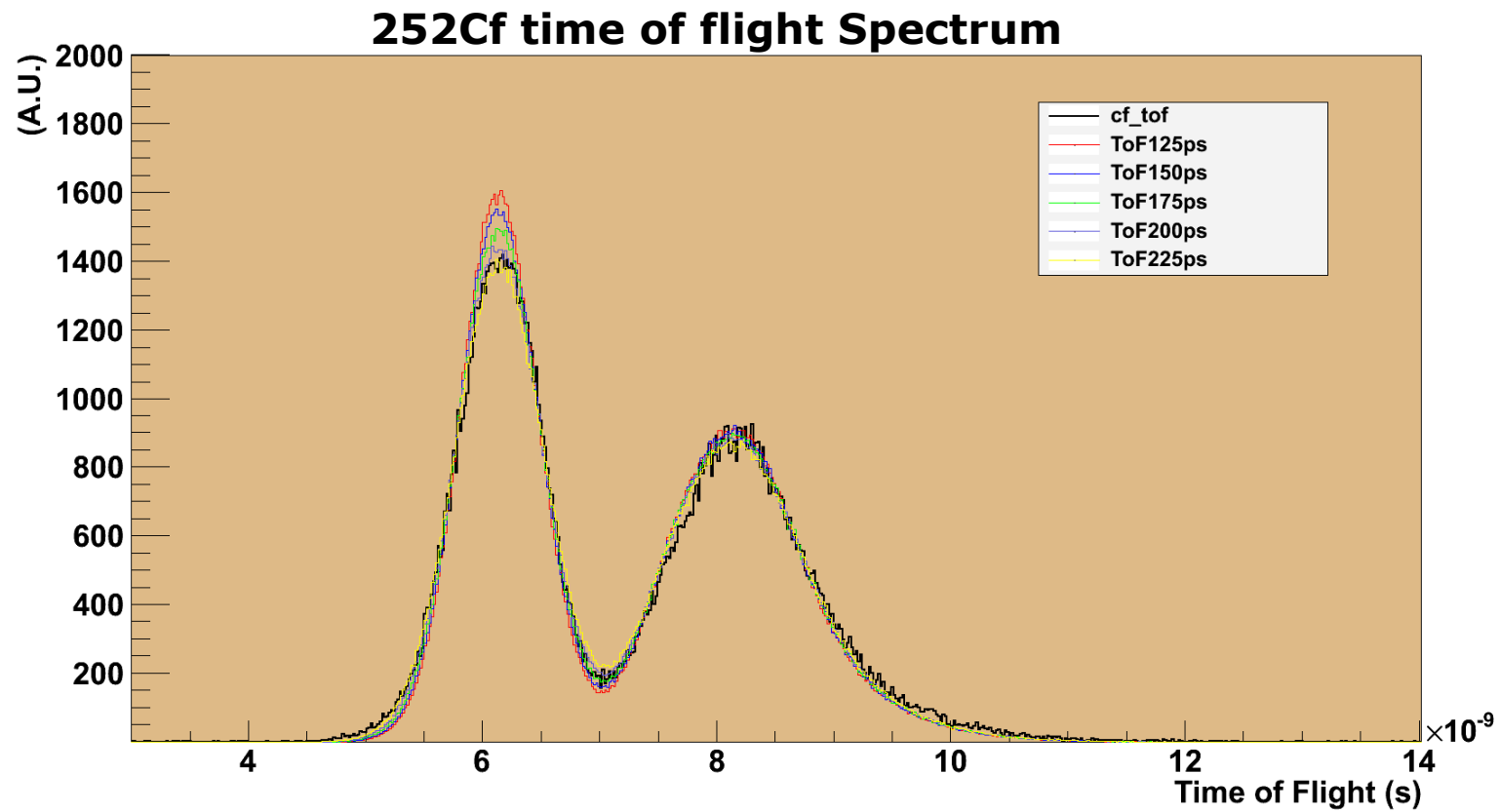


**Simulation  $\Delta E/E = 7\%$ ,  
PHD 75%**



**Light fragments, Heavy fragments**

# Diamond + Silicon





## Conclusion

- sCVD can be used in a time of flight system for fission fragment
- Diamond energy response is very sensitive to fabrication process
- Pulse height defect seriously limits possibilities to measure the energy of fission fragments

# Thank you for your attention