Apparati di irraggiamento per SEE indotti da neutroni a ISIS e misure del campo neutronico

(Irradiation facilities for neutron induced SEE tests at ISIS and measurements of the neutron field)

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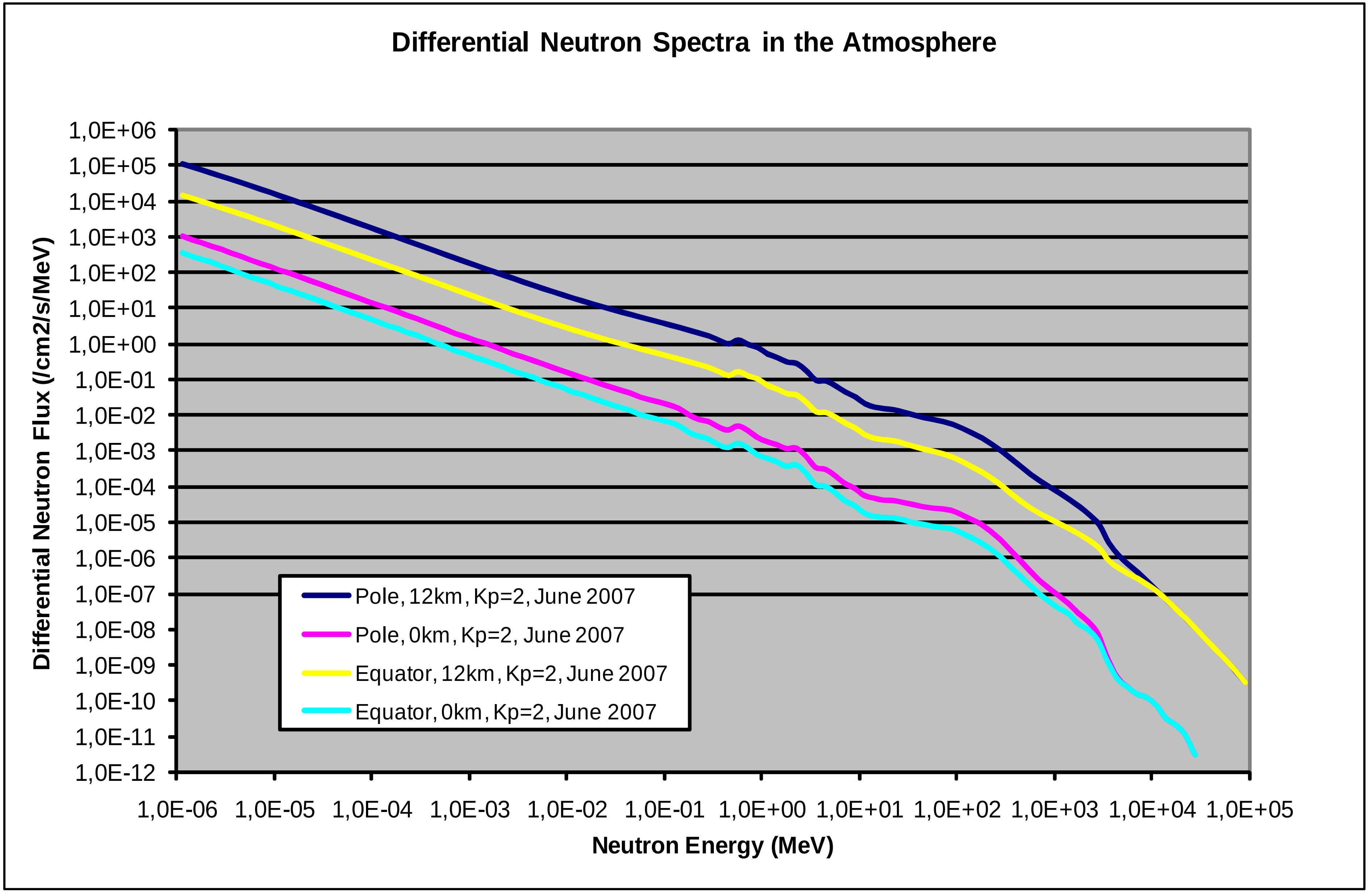
Science & Technology Facilities Council ISIS

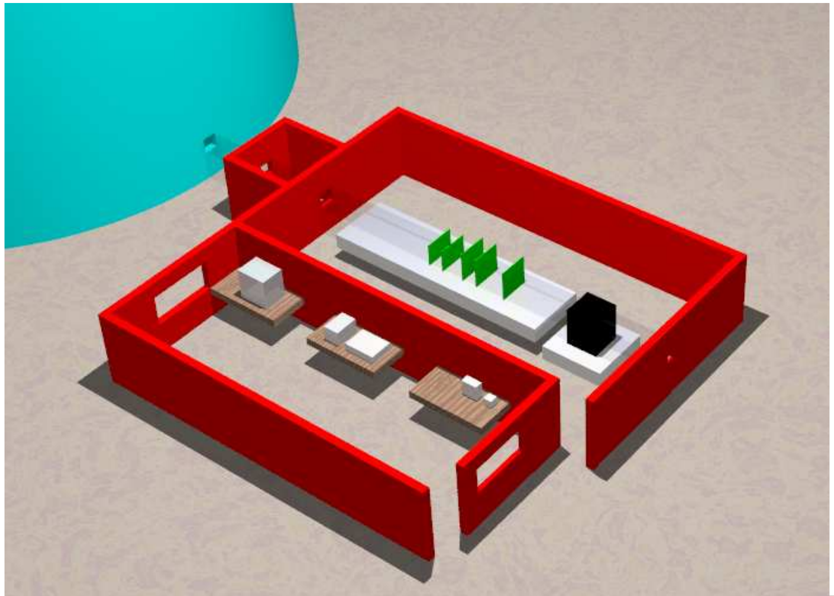
OUTLINE

- The **ChipIr** beam line at ISIS-TS2
- Detectors for epithermal neutron beams and monitors for ChipIr
- Tests and results
- Conclusion

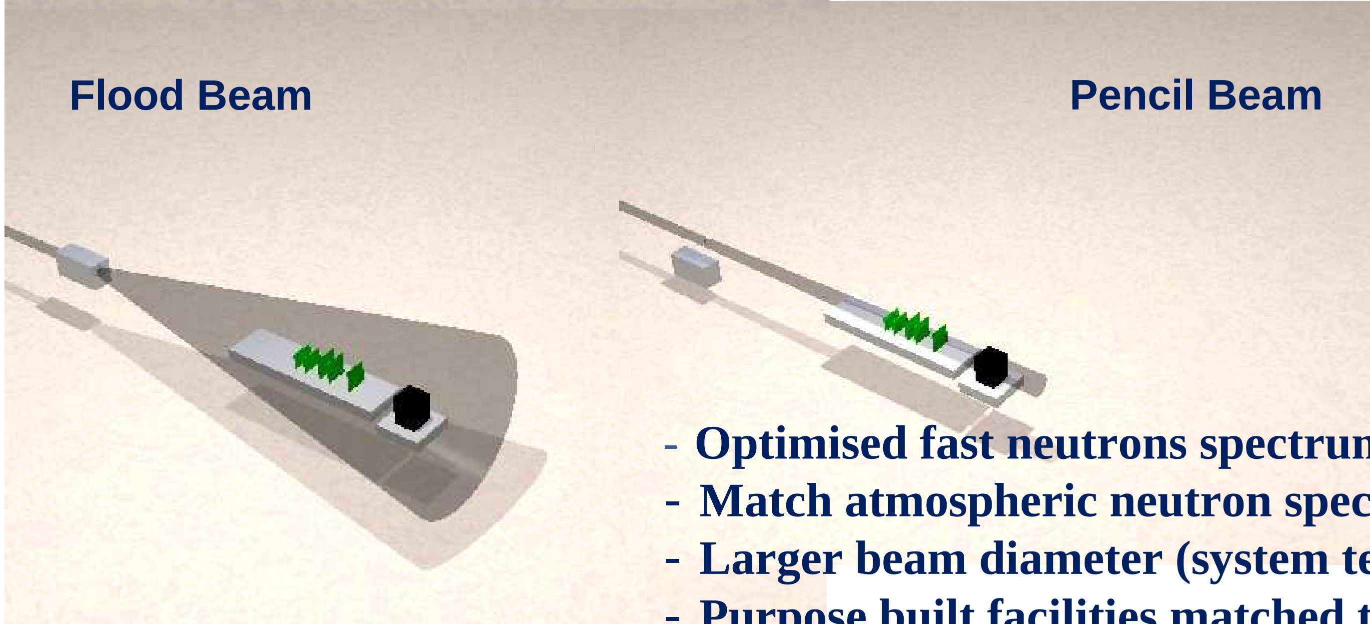
Neutron Radiation from primary cosmic rays



A Fast Neutron Beamline: CHIPIR (ISIS-TS2)



LANSCE	4.1x10^5 n/cm^2/s	800 Mev
TRIUMF	3.4x10^6 n/cm^2/s	500 MeV
ISIS TS1	6.6x10^4 n/cm^2/s	800 MeV
ISIS TS2 Pencil Flood	4 x10^7 n/cm^2/s 3 x10^5 n/cm^2/s	800 MeV 800 MeV

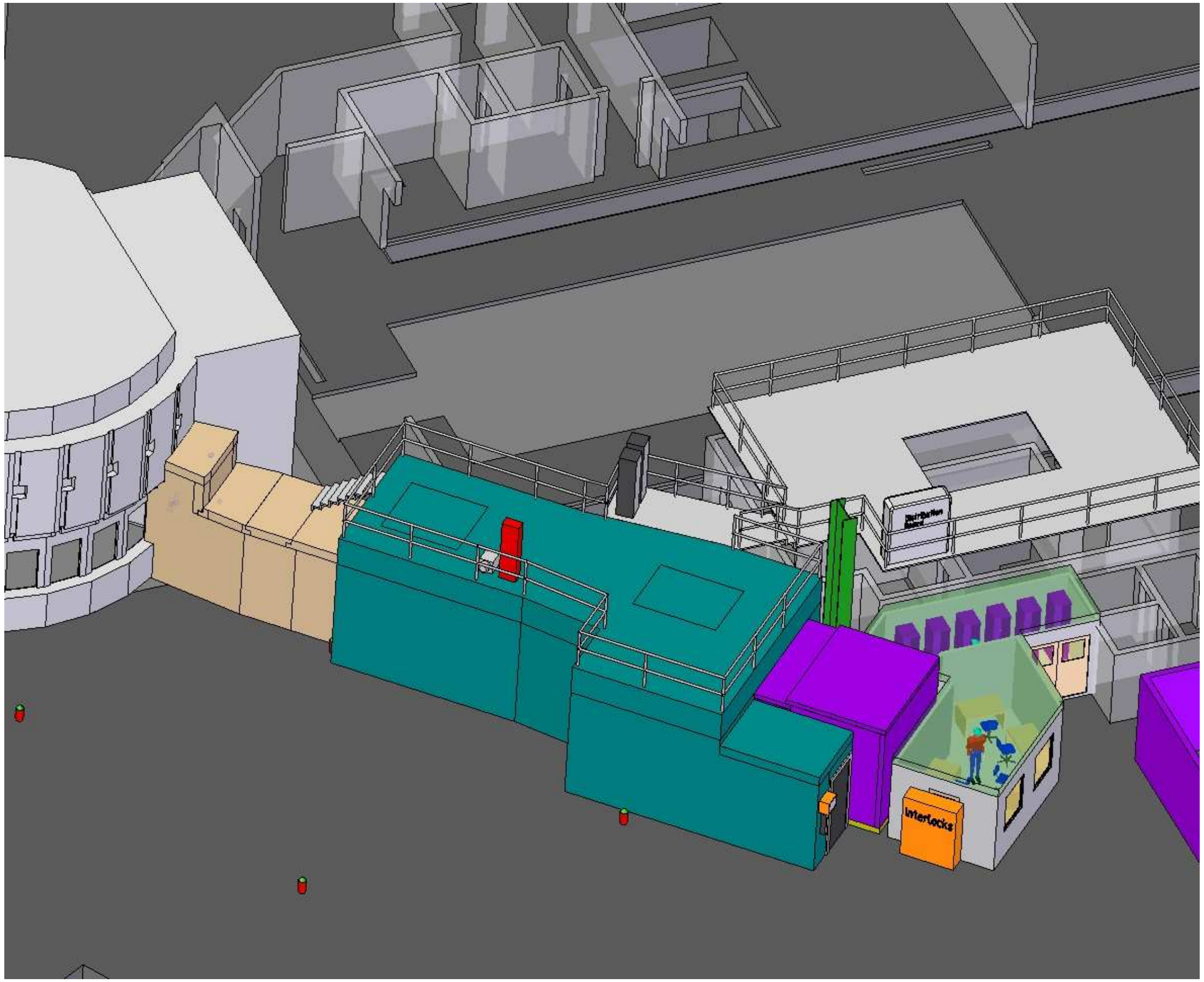


- Optimised fast neutrons spectrum (up to 800 MeV)
- Match atmospheric neutron spectrum
- Larger beam diameter (system testing)
- Purpose built facilities matched to users needs

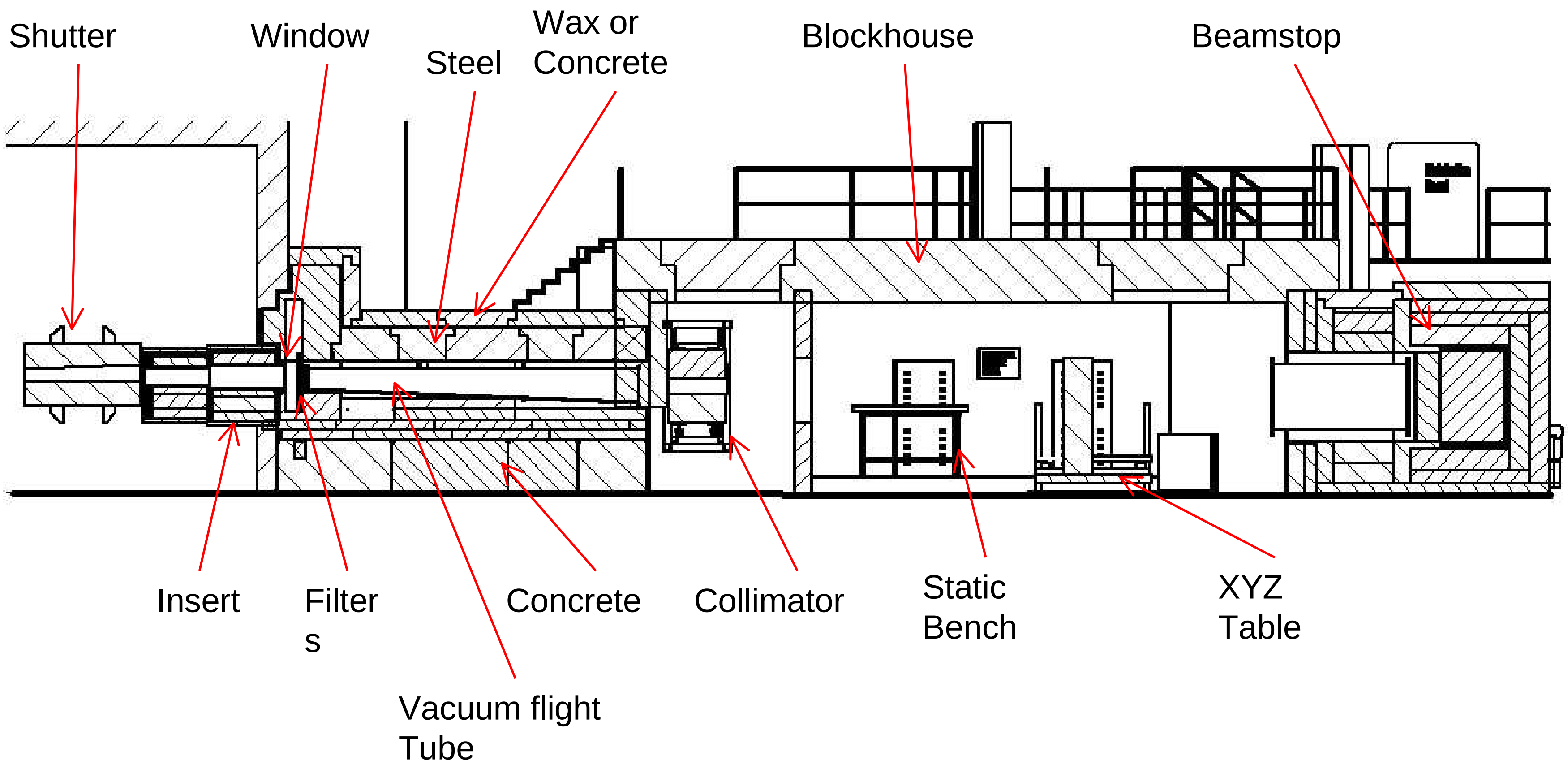
ChipIR

- **Chip Irradiation**: small Chips, to Full racks and electronic systems

- **Using higher integrated Flux** than previously used on ISIS (above 10 MeV)

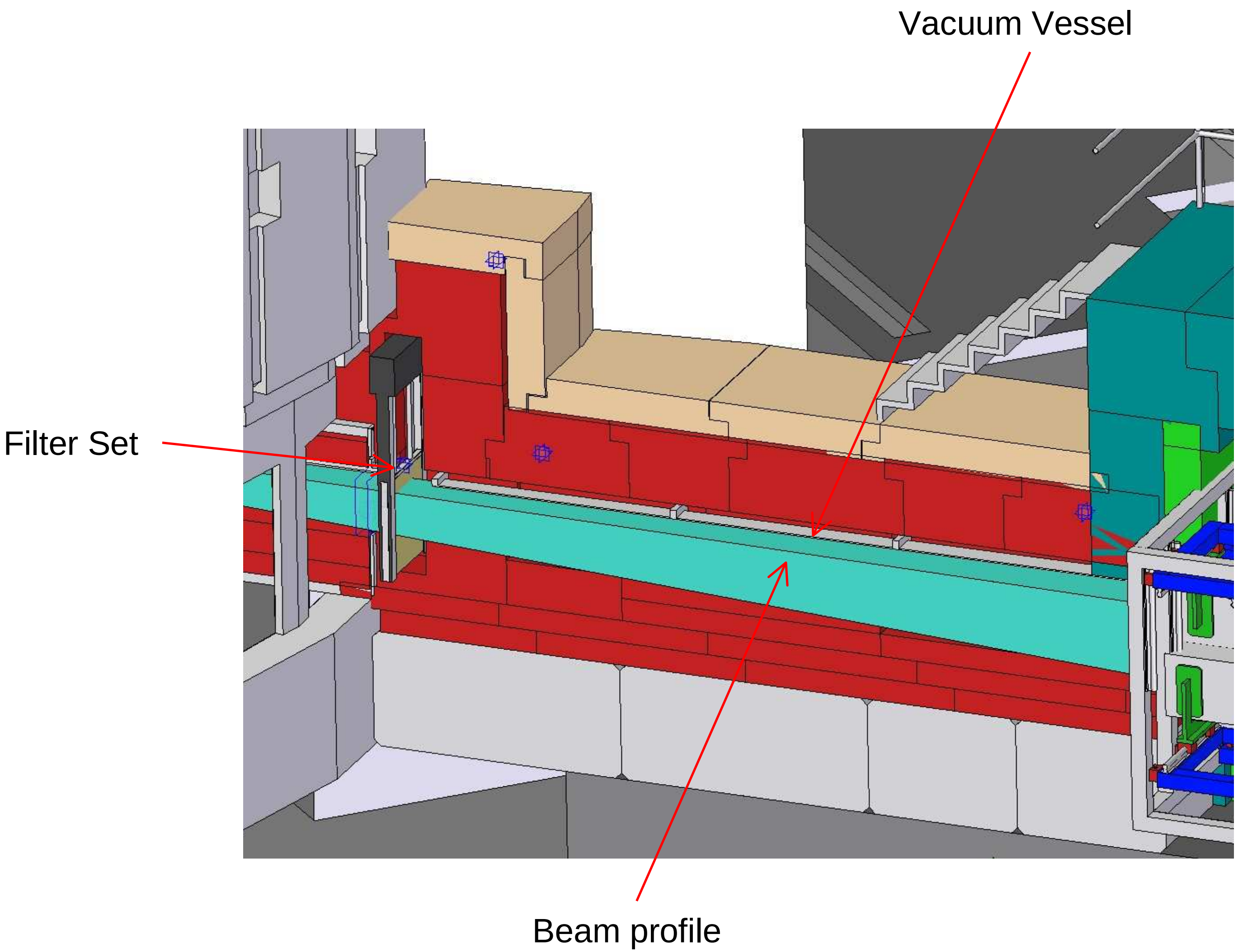


Layout

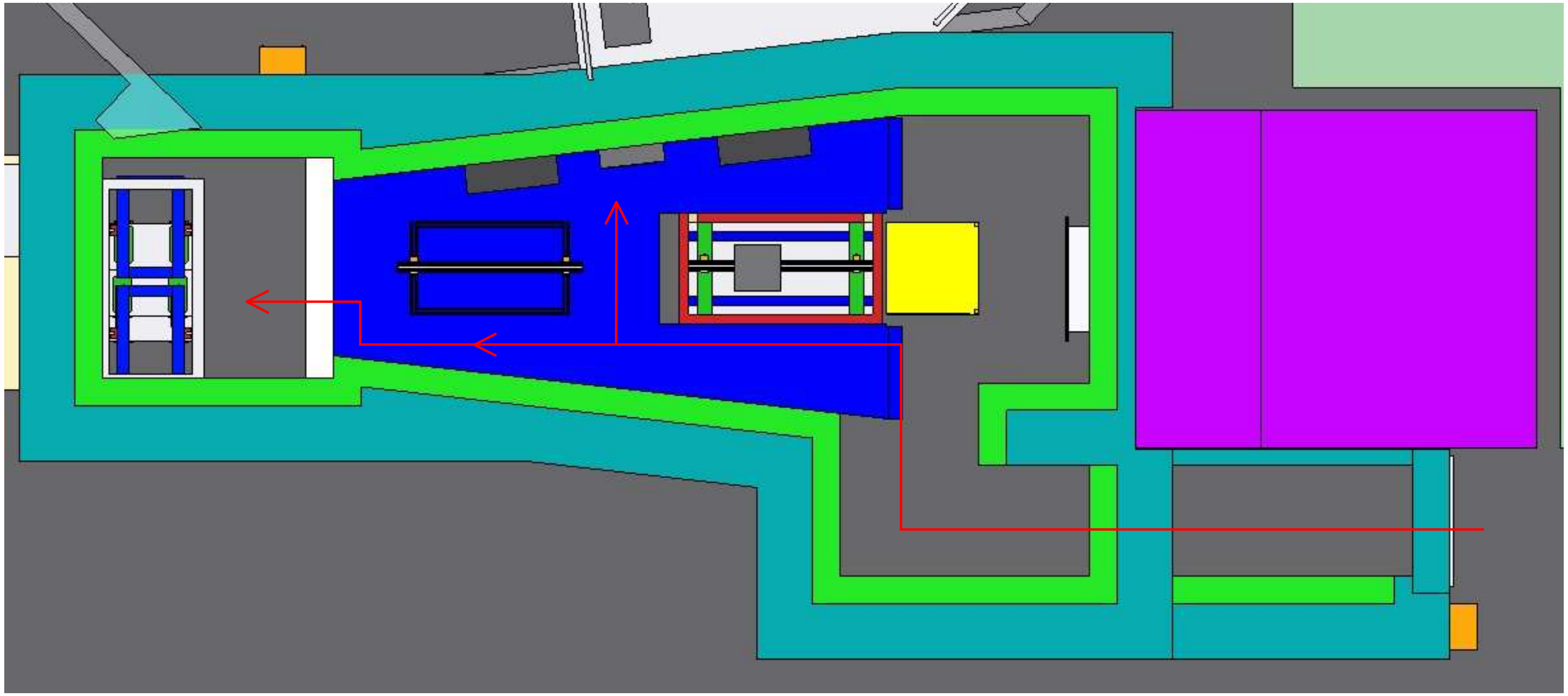


Shutter
Window
Steel
Wax or Concrete
Blockhouse
Beamstop
Insert
Filters
Concrete
Collimator
Static Bench
XYZ Table
Vacuum flight Tube

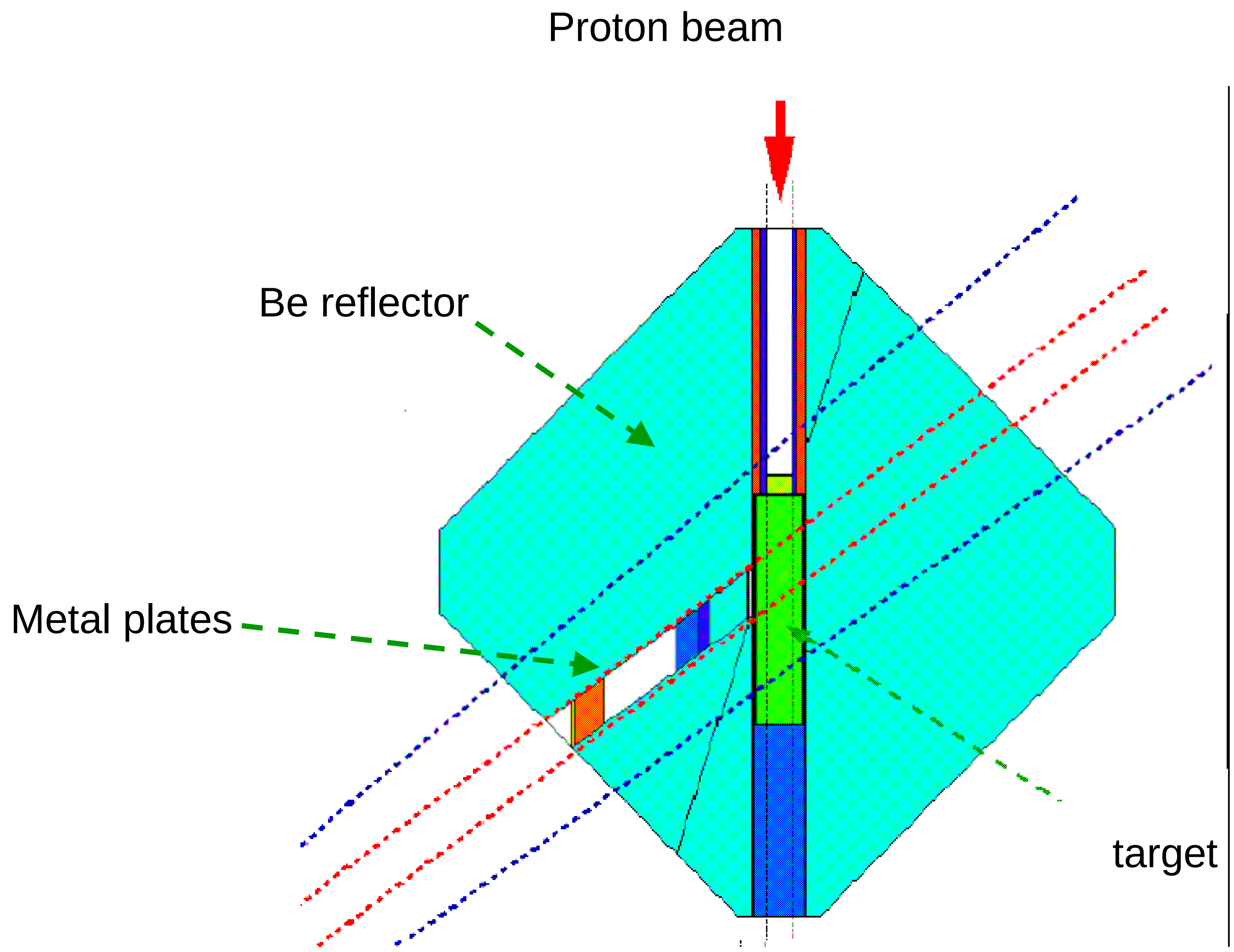
Front End



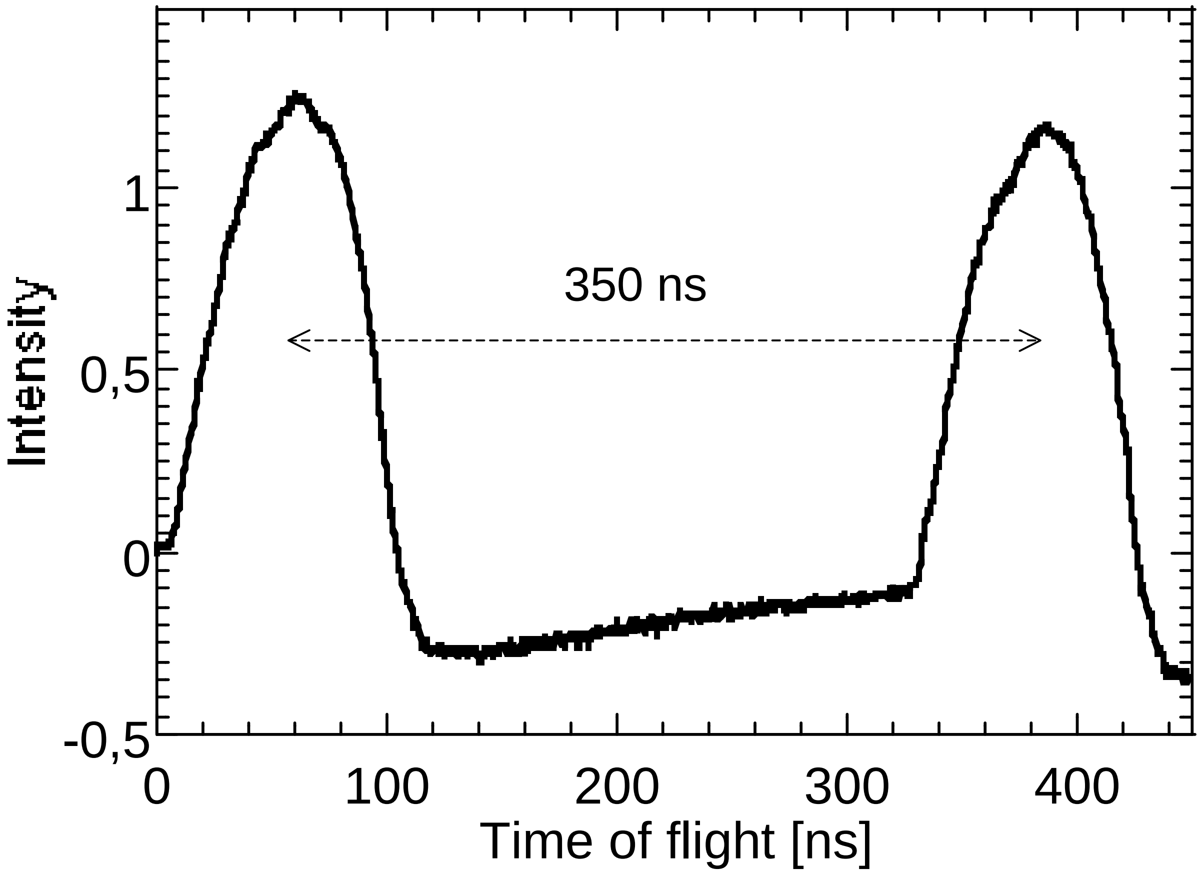
Blockhouse



The *chef 's secret*: how to make a perfect fast neutron beam......



ISIS accelerator proton bunch



E_p = 800 MeV

Duty cycle = 50 / 4 Hz

....while engineers are working.......

VESUVIO

ROTAX

Undermoderated neutron flux with epithermal neutrons with flux ~ $E^{-0.9}$

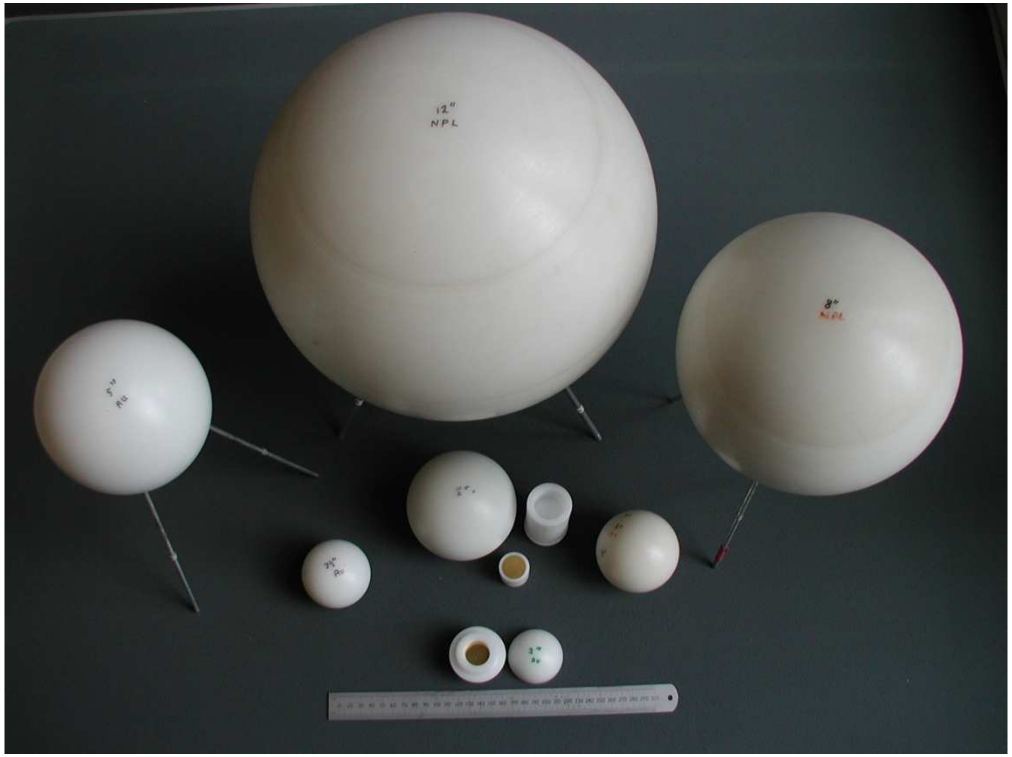
Adequate for testing of detectors and techniques for ChipIr

Neutron spectrum assessment techniques for ChipIr

Bonner spectrometer

Thin Film Breackdown Counters

The Bonner Specrometer



INFN-LNF

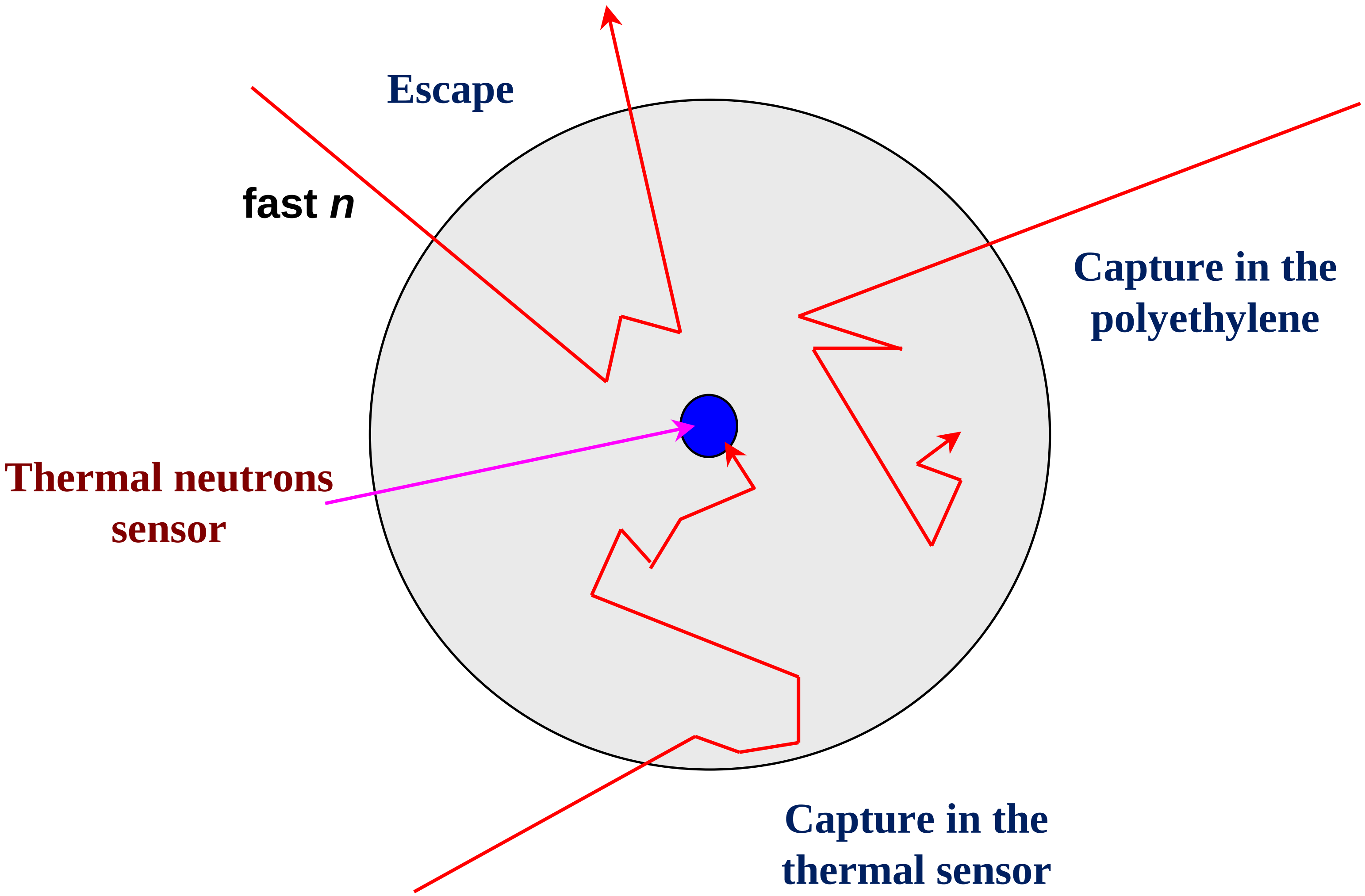
A. Esposito – R. Bedogni

10 Bonner spheres of different diameters

GEOMETRY → ENERGY

Response of the Bonner sphere calculated through **MCNPX** simulations with VESUVIO-like conditions
Experimentally validated in the low-energy part (Cf sources, GSI, etc.)

The Bonner Sphere



From the measured activity on the sensor after a period of irradiation the neutron flux at the selected energy range is found

Extending measurements above 20 MeV

Modified Bonner Spheres by including metal inserts (Cu, Pb) to allow for *n(x,n)* reactions to occur

The Bonner Sphere

The INFN-LNF spectrometer can be used with different detectors.

For measurements at ISIS:

Dy activation foils (25 μm x 12.7 mm diam.)

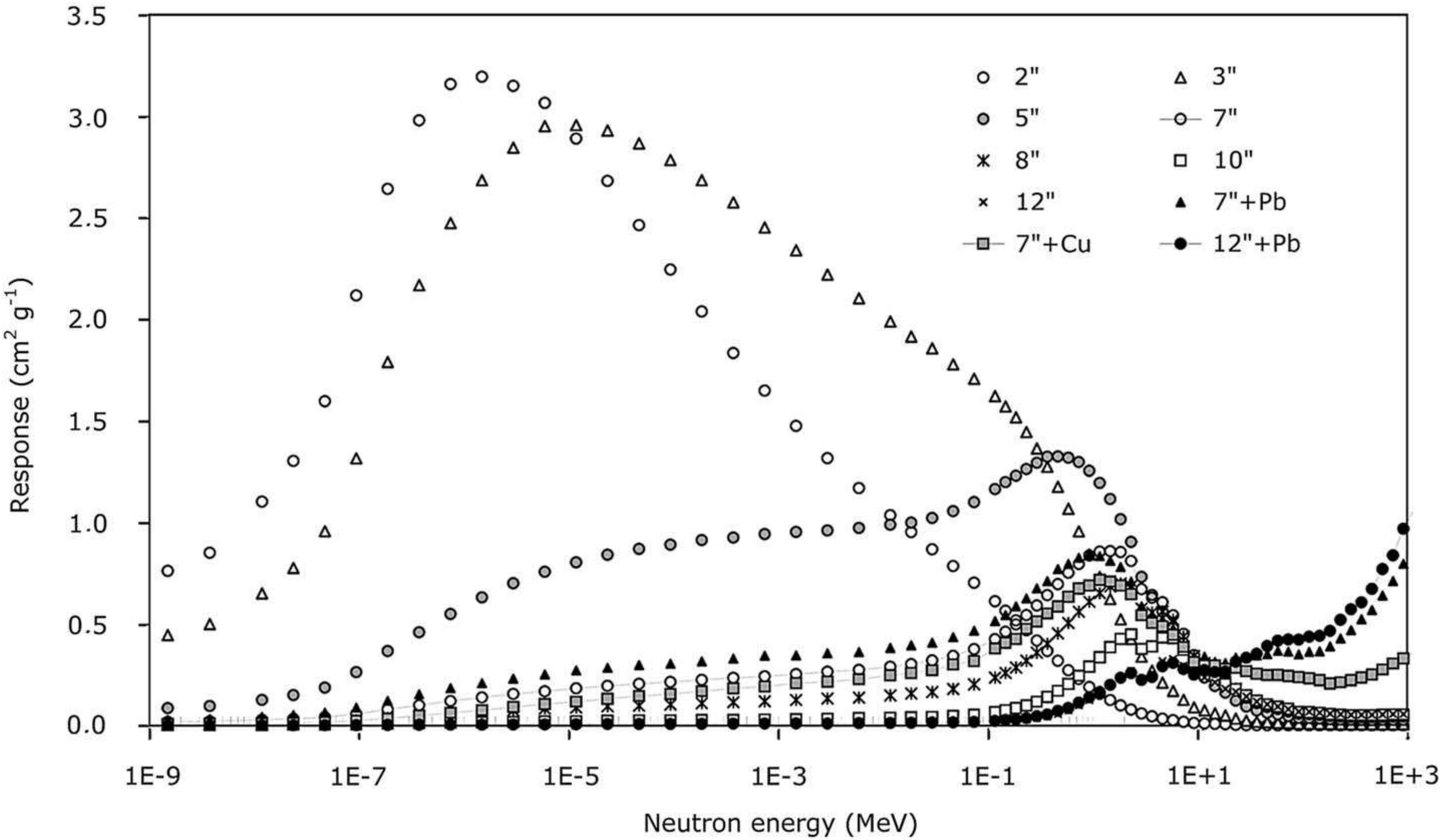
Beta emitter

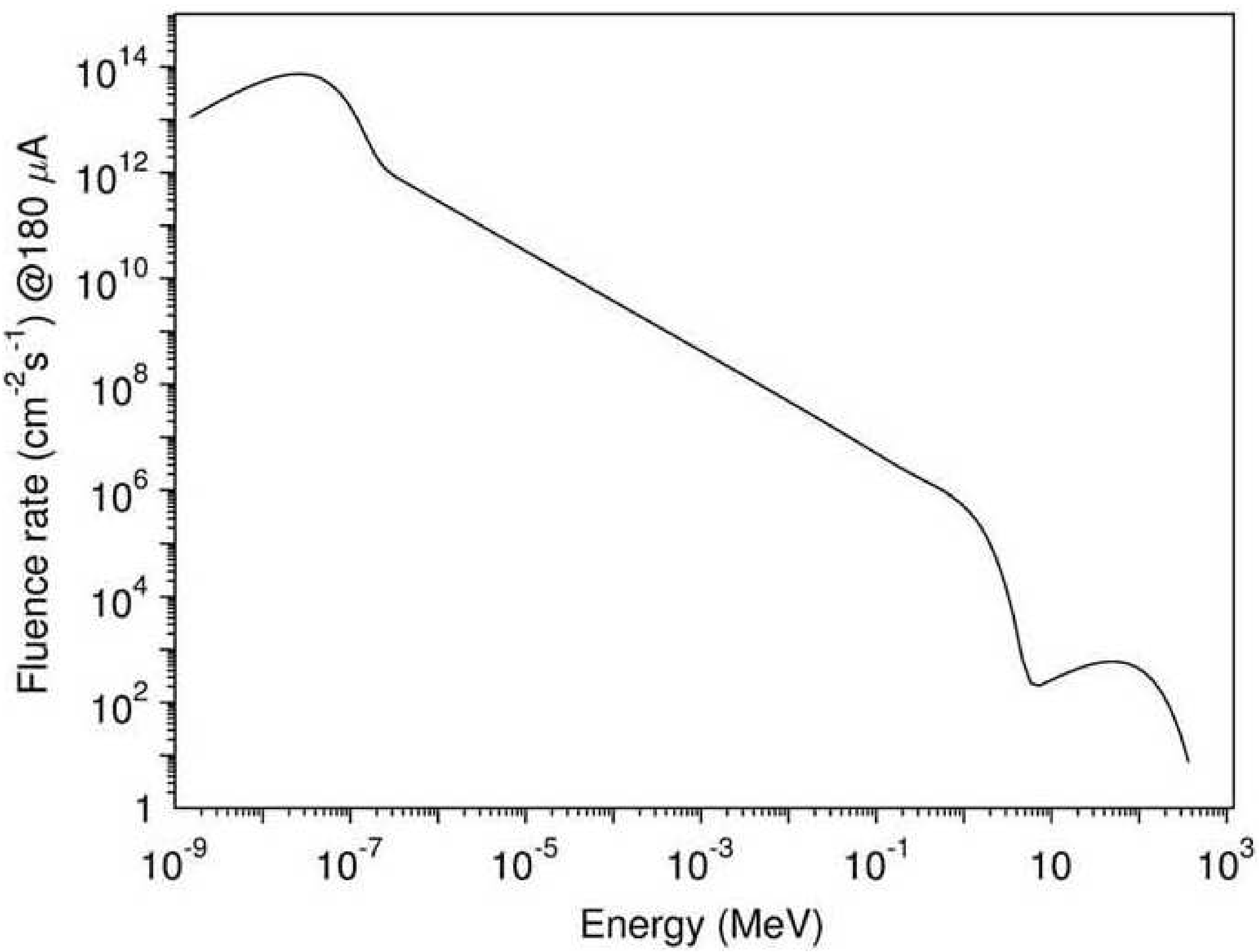
High thermal cross-section (2500 b)

Short half-life (2.334 h)

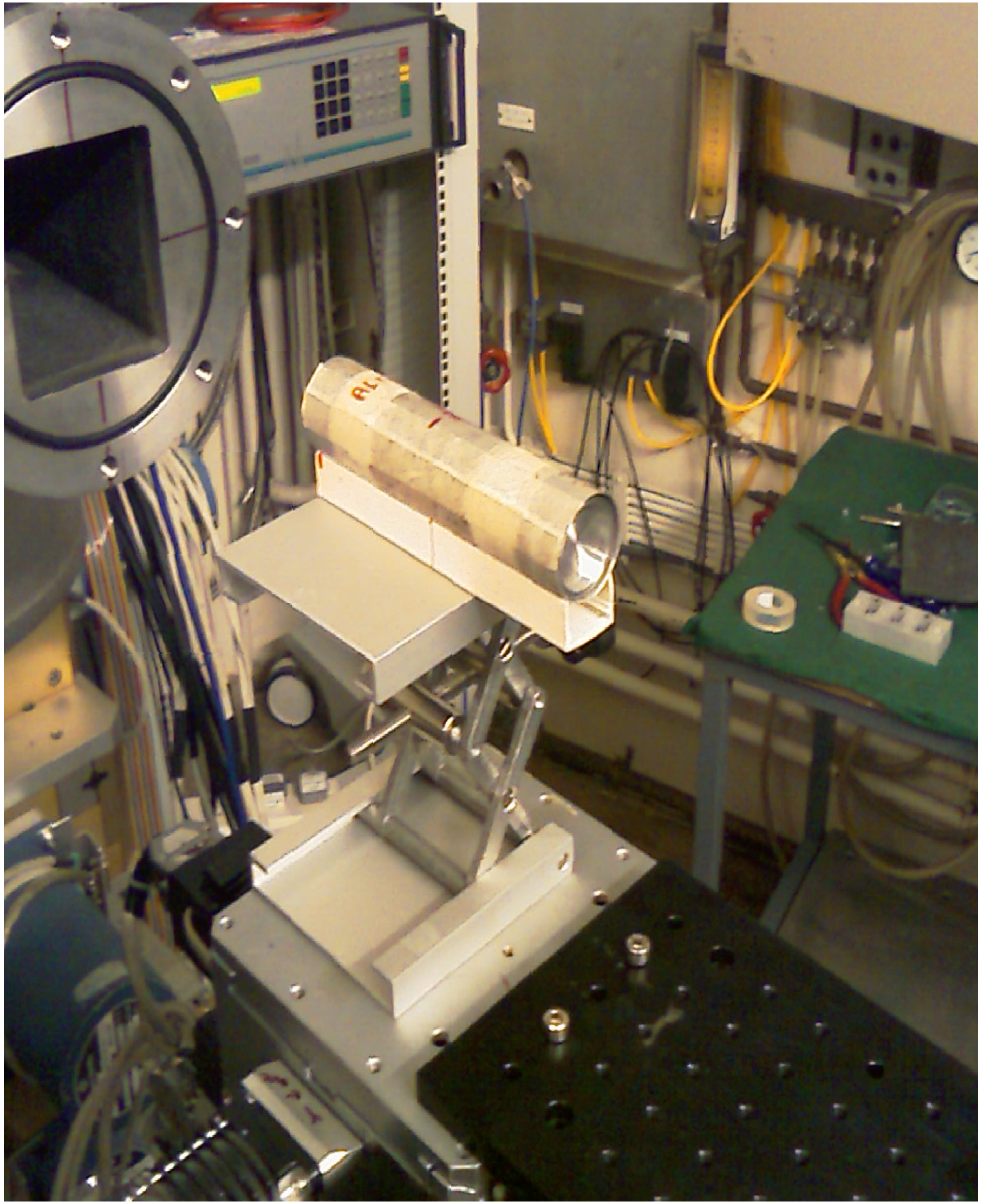
Gamma-ray insensitive

Response Functions of Bonner spheres





Energy distribution of the VESUVIO neutron fluence rate normalized to180 μA proton current



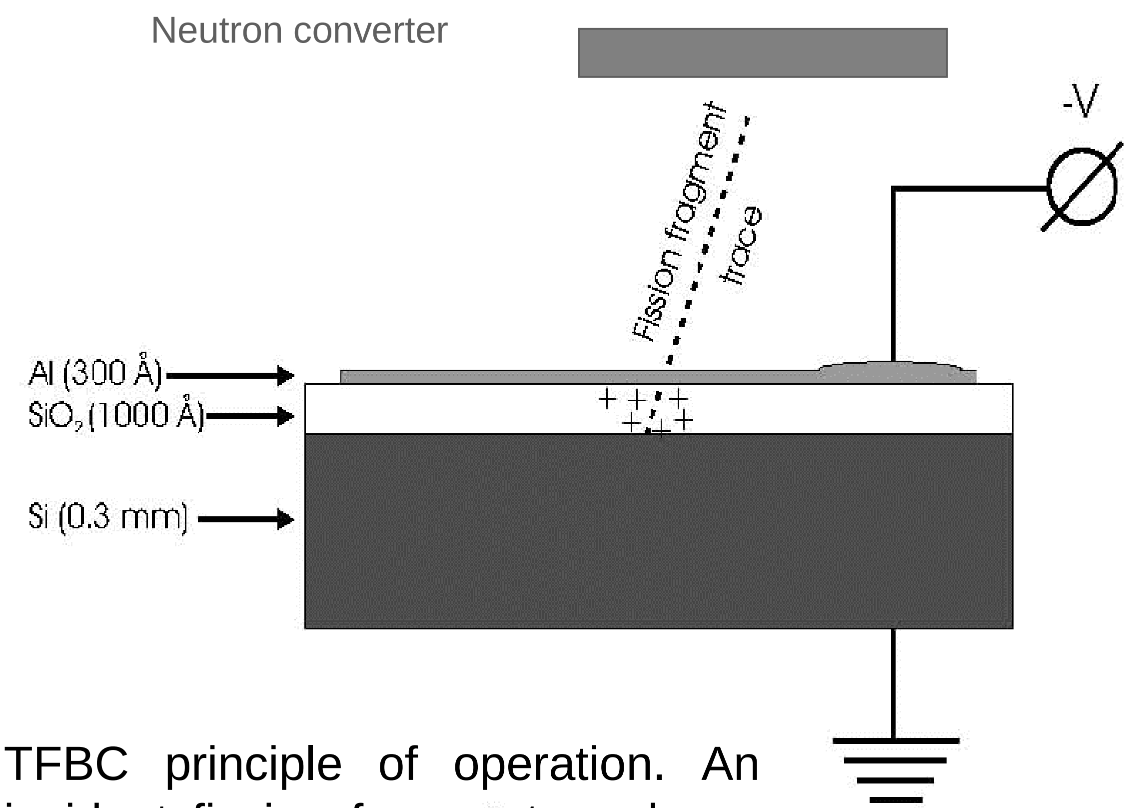
Bonner Cylinders
to maximize efficiency
in a neutron *beam*

Measurements on
Rotax (ISIS)

Simulation of the
response functions and
data analysis ongoing

Thin Film Breakdown Counters (TFBC)

A. Smirnov and A. Prokofiev



TFBC principle of operation. An incident fission fragment produces an electrical breakdown in the SiO_2 layer.

Fast (response ~ ns)

Compact

Insensitive to gamma-rays

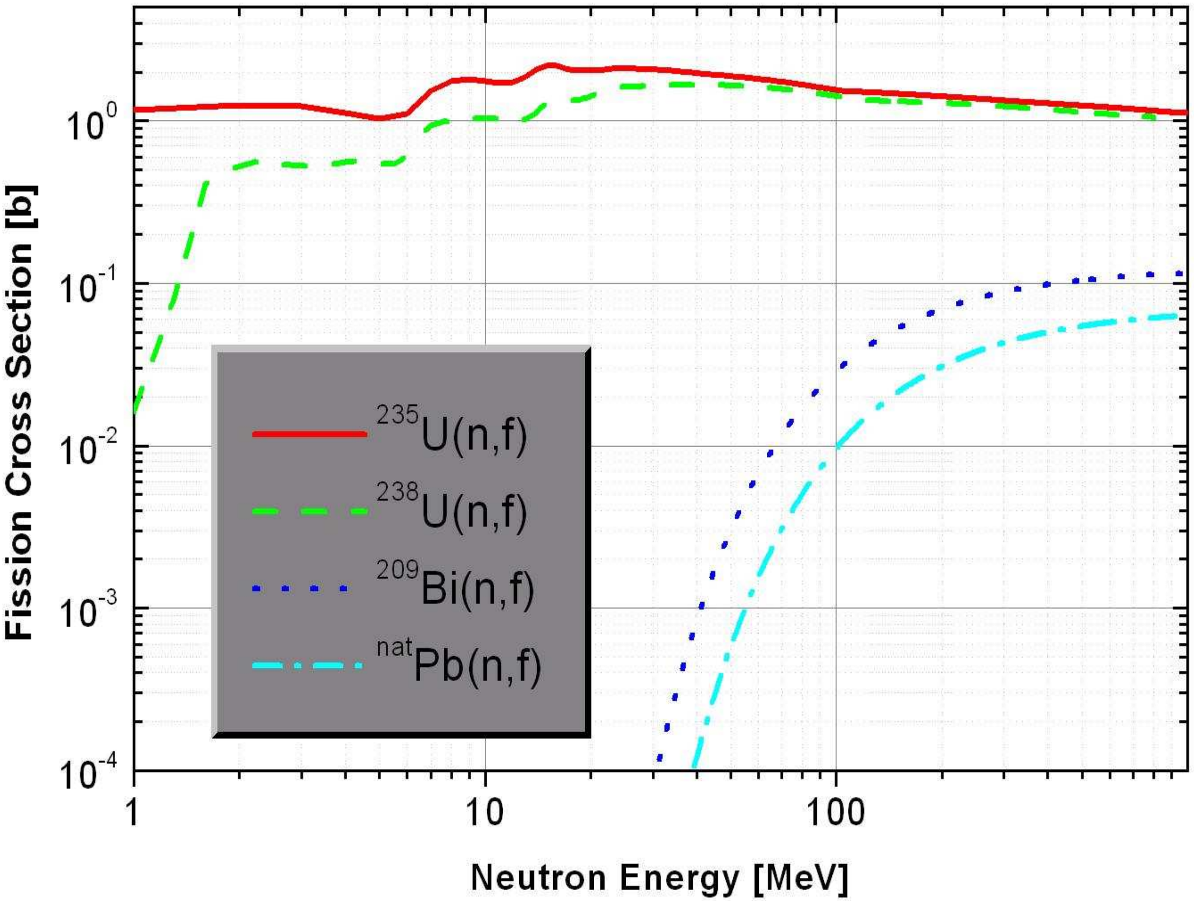
Insensitive to light particles (p, D, He)

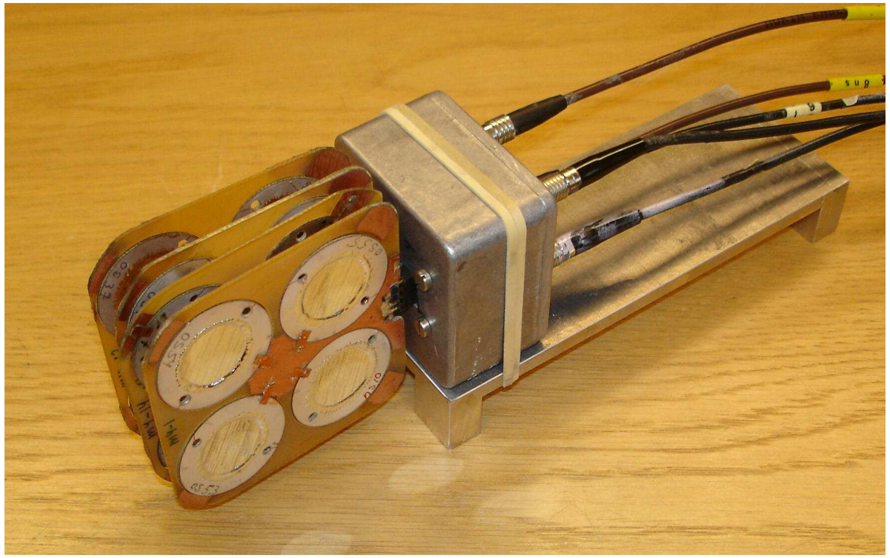
The neutron converter for TFBC

Thresholds for fission: 1 MeV (^{238}U)

30 MeV (^{209}Bi)

(n,f) cross-sections known up to about 200 MeV

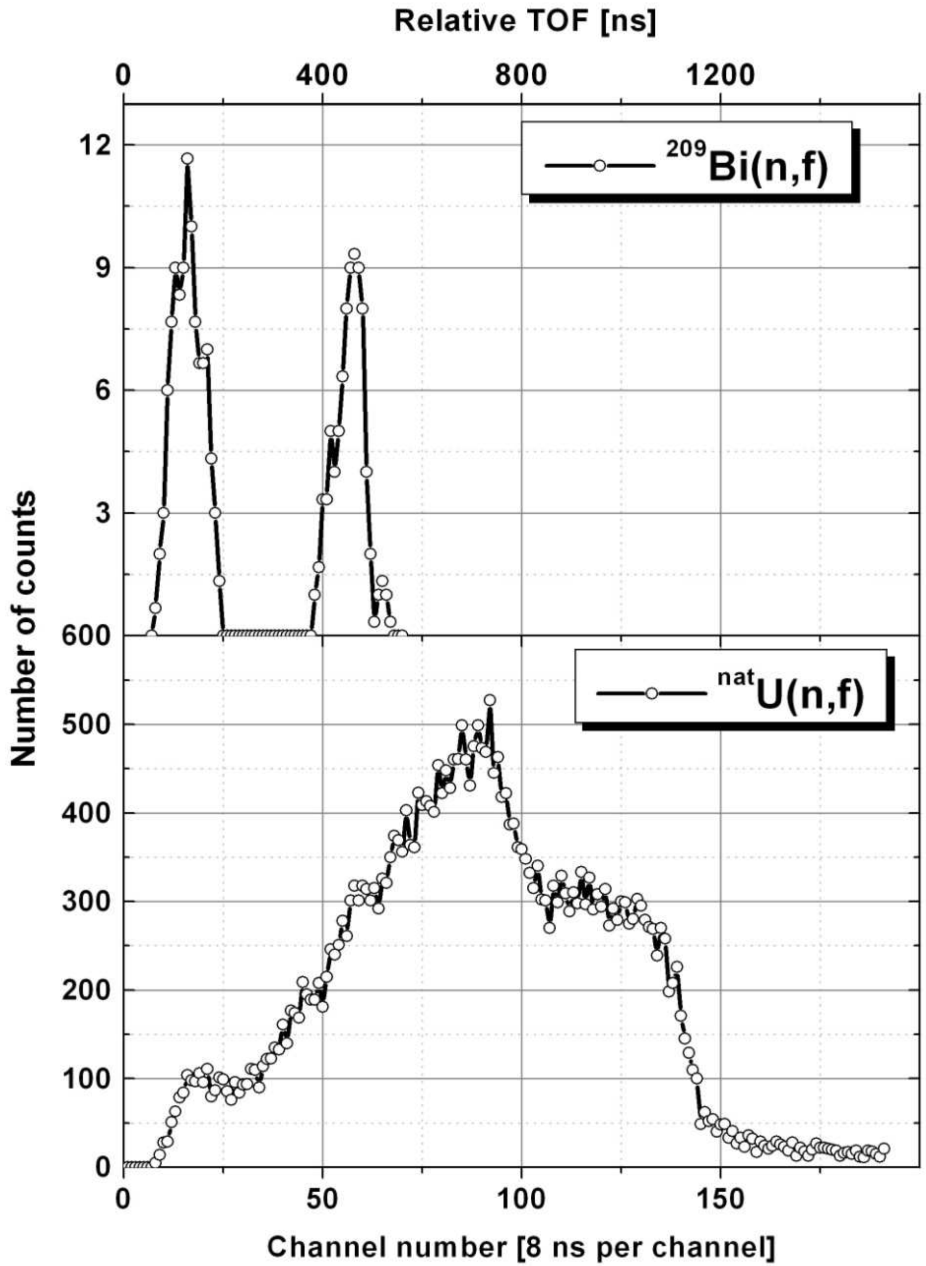




Converter foils: 1.7 cm diam.

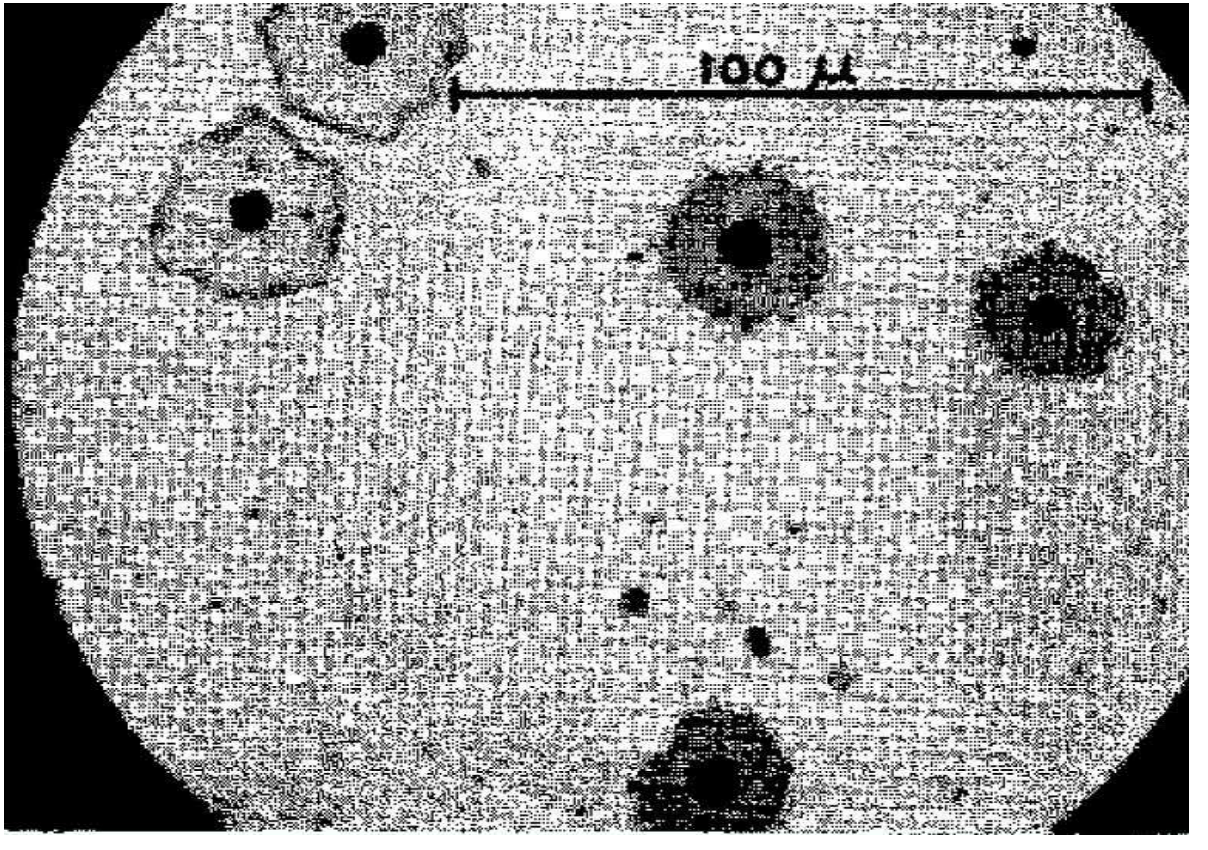
Areal density: 2 mg/cm^2

The TOF spectrum results from the convolution of the neutron flux and the fission cross-sections of converter foils



Neutron ToF spectra

TFBC have a limited *hope of life* (a few hours) in high neutron flux........



BS and TFBC are good for the general characterisation of the beam but cannot be used as localised beam monitors:

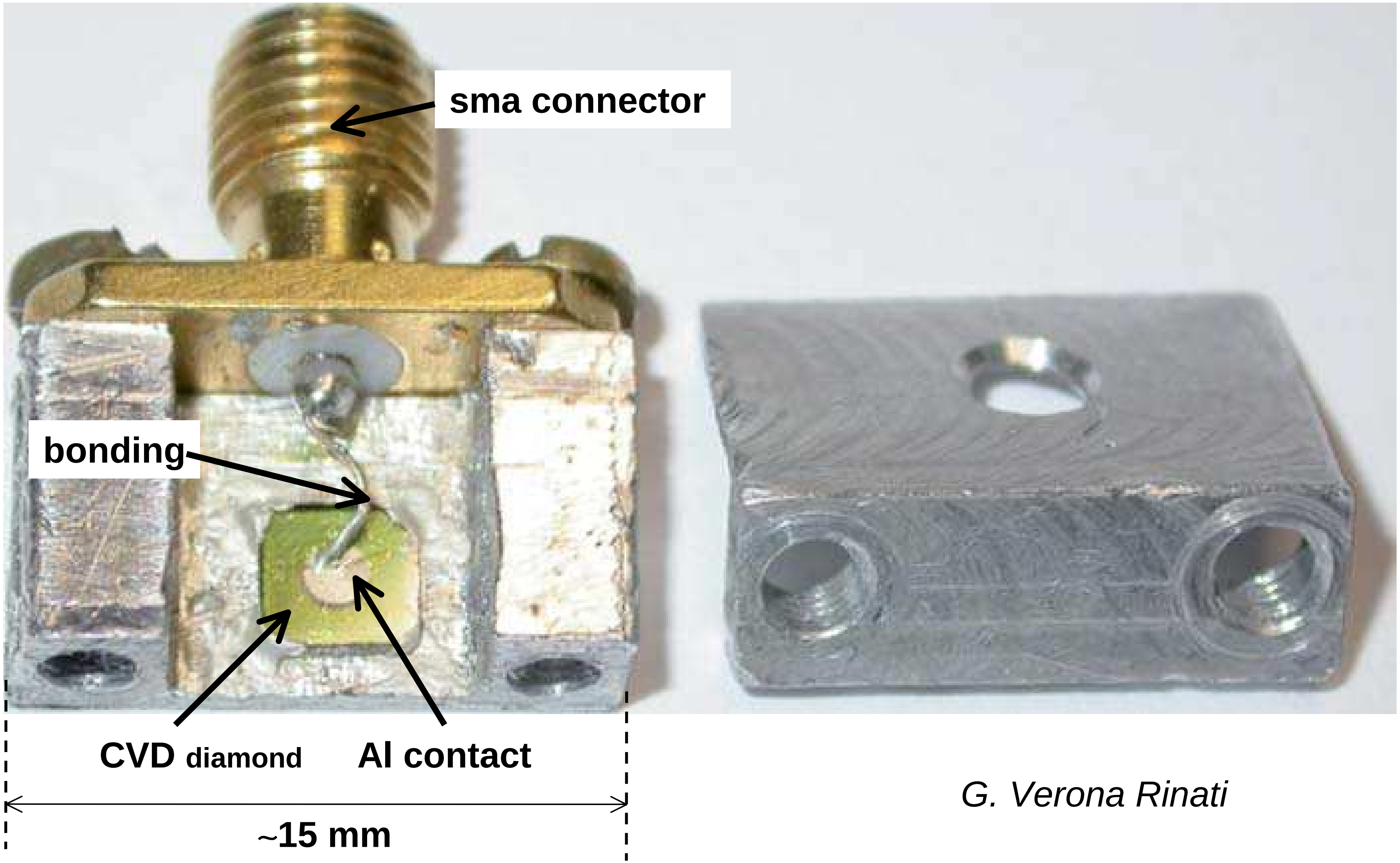
-BS are too big

-TFBC are damaged by fission fragments

The proposed monitors:

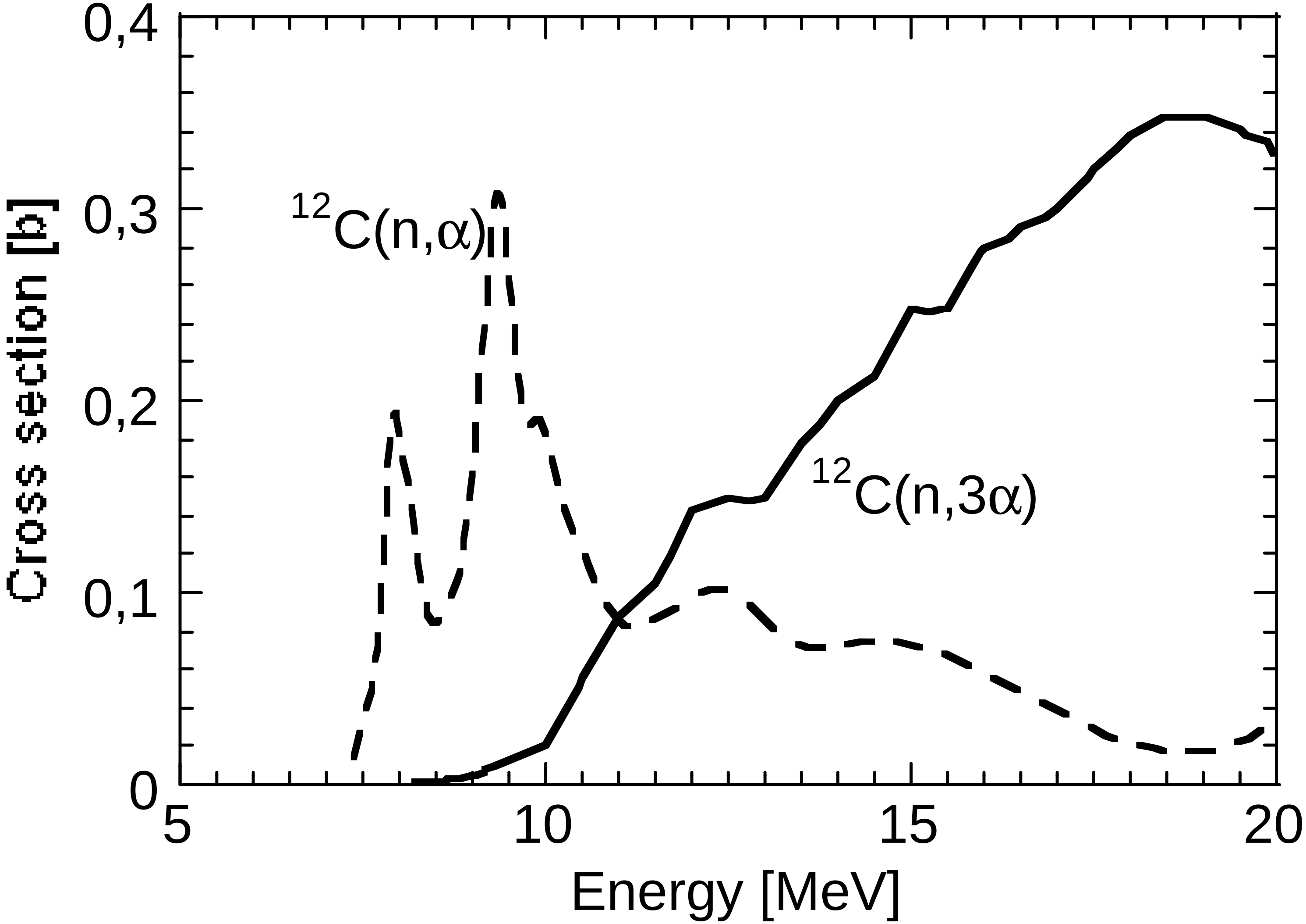
Single Crystal Diamonds for localised flux monitoring

SCD by Chemical Vapor Deposition

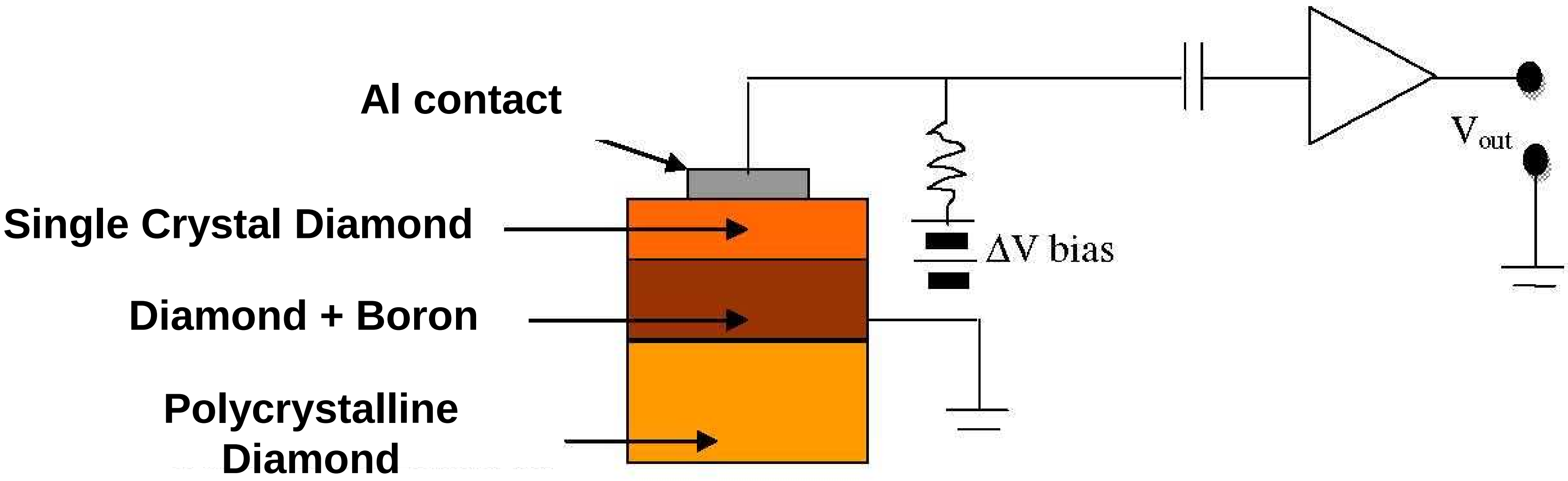


G. Verona Rinati

Carbon neutron cross sections



Diamond Detectors



Active medium main characteristics:

A = 12 amu	ρ = 3.5 g cm^{-3}
t = up to 500 μm	S = 10-30 mm^2
$E_{e\text{-}h}$ = 12 eV	Y=10^5 (e-h)$_{pairs}$/MeV

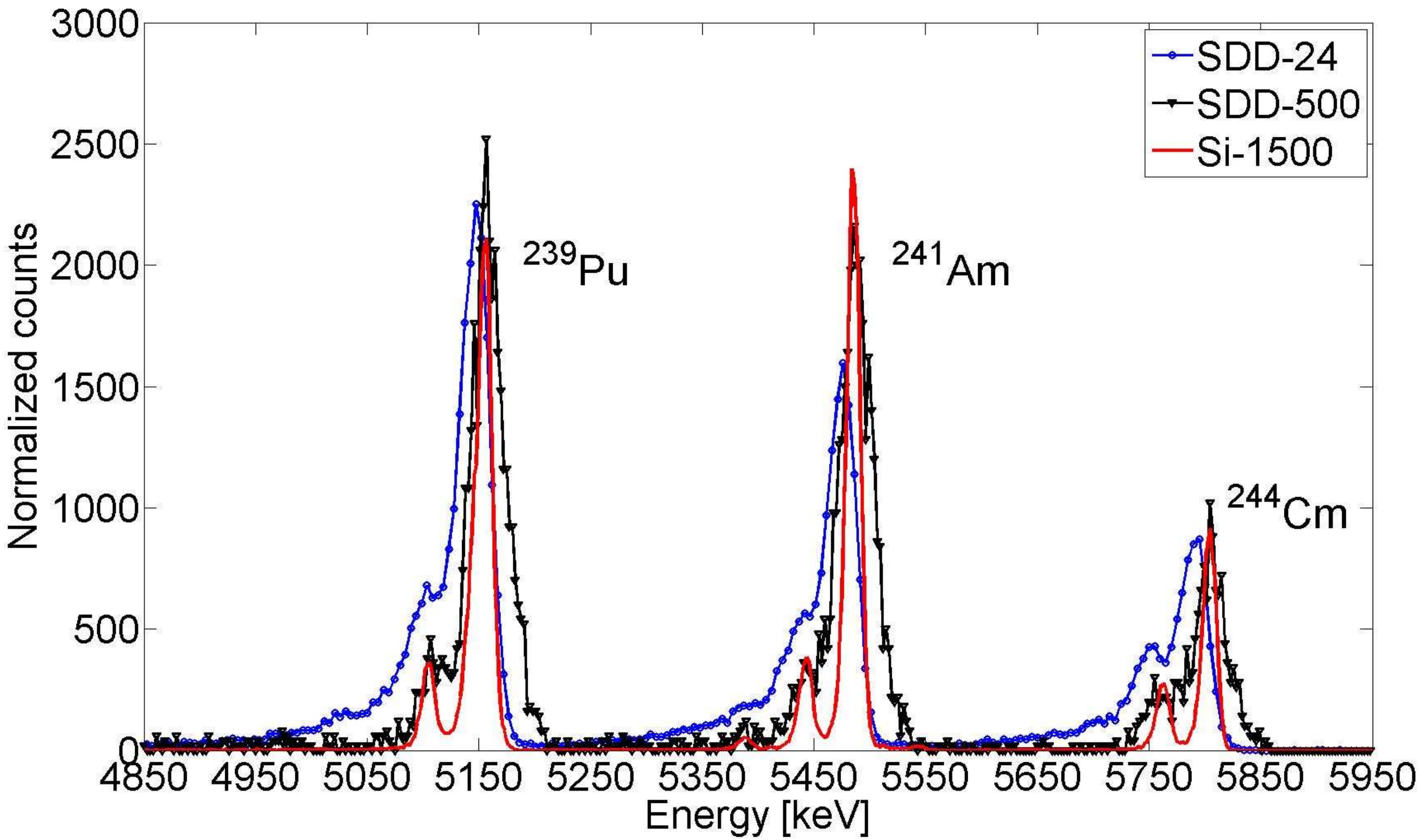
Diamond detector	Thickness	Producer
SDD-24	24 μm	Dip. di Ing. Meccanica Università degli Studi di Roma Tor Vergata
SDD-150	150 μm	Dip. di Ing. Meccanica Università degli Studi di Roma Tor Vergata
SDD-500	500 μm	Diamond Detectors Ltd.

BIAS: about 1 V/μm

Fast preamp (shaping time 2 ns)

BI-PARAMETRIC measurements (TOF and in tensity)

3-α source characterisation of diamond detectors

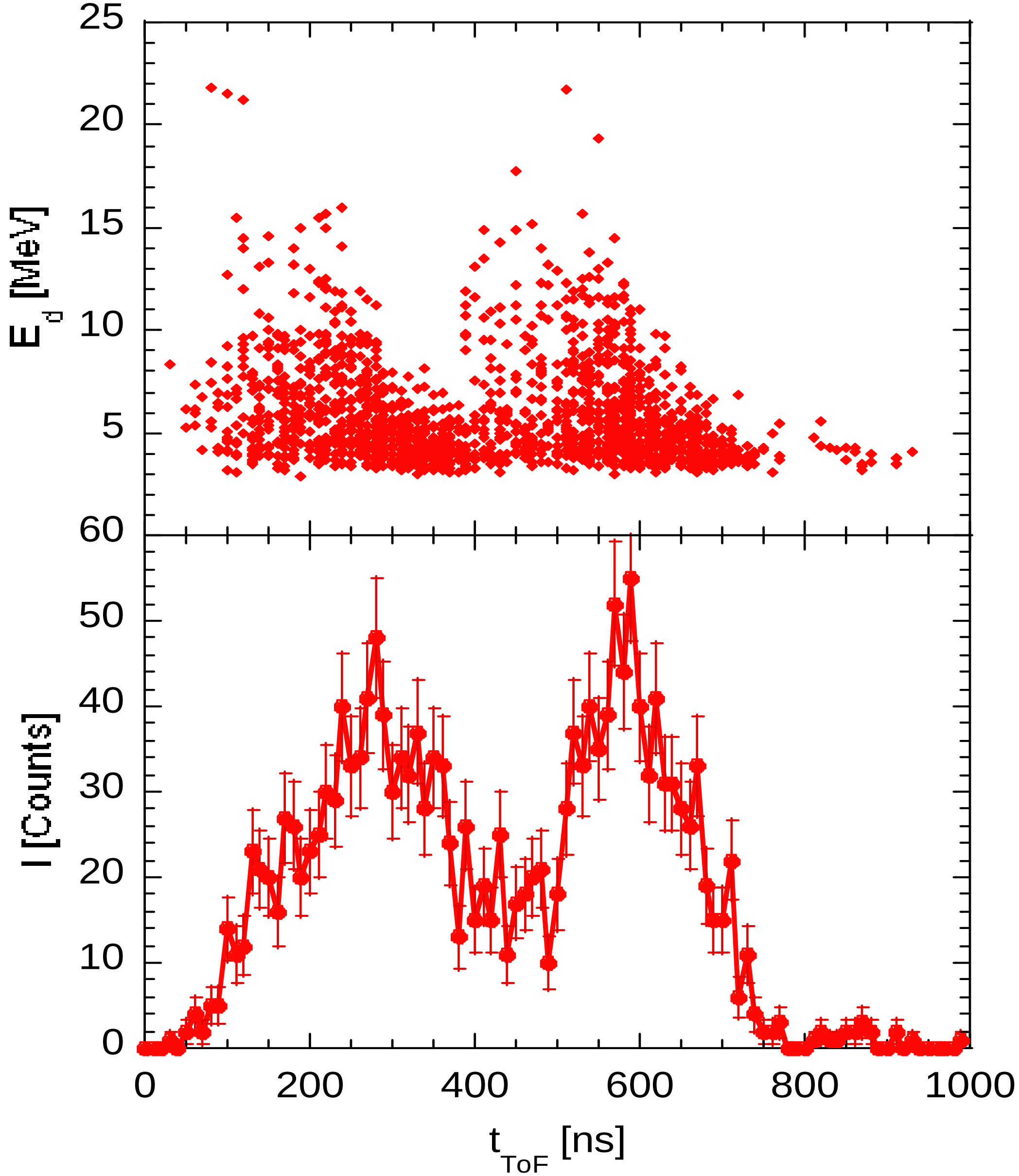


			FWHM [keV]	
Detector	Thickness	^{239}Pu	^{241}Am	^{244}Cu
SDD-24	24 μm	31.8	29.9	32.8
SDD-500	500 μm	38.2	36.6	32.8
SI-1500	1500 μm	15.0	14.2	13.8
	Eα [keV]	5156.6	5485.6	5804.8

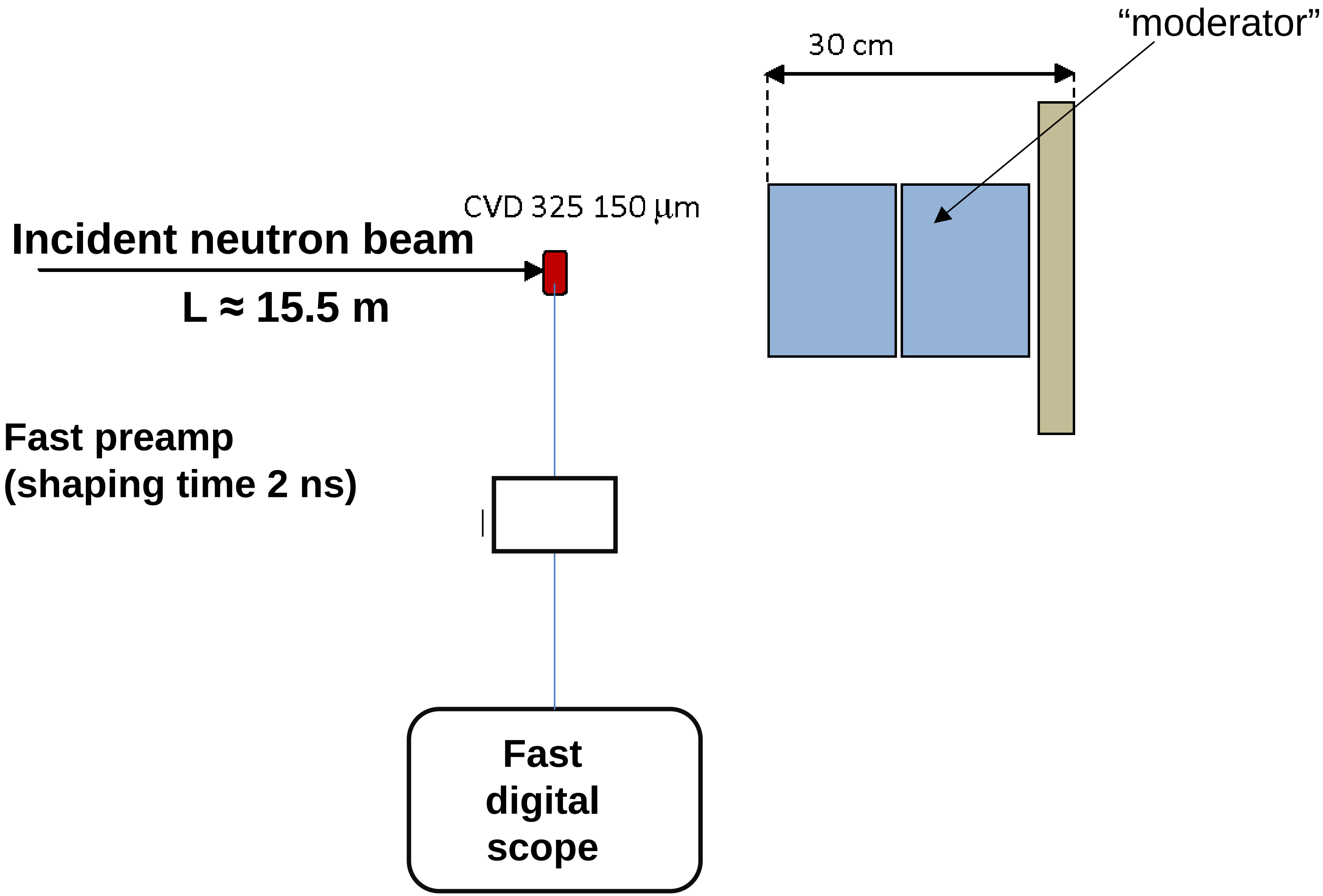
Bi-parametric measurements

Diamonds ARE sensitive to gamma-rays and electrons

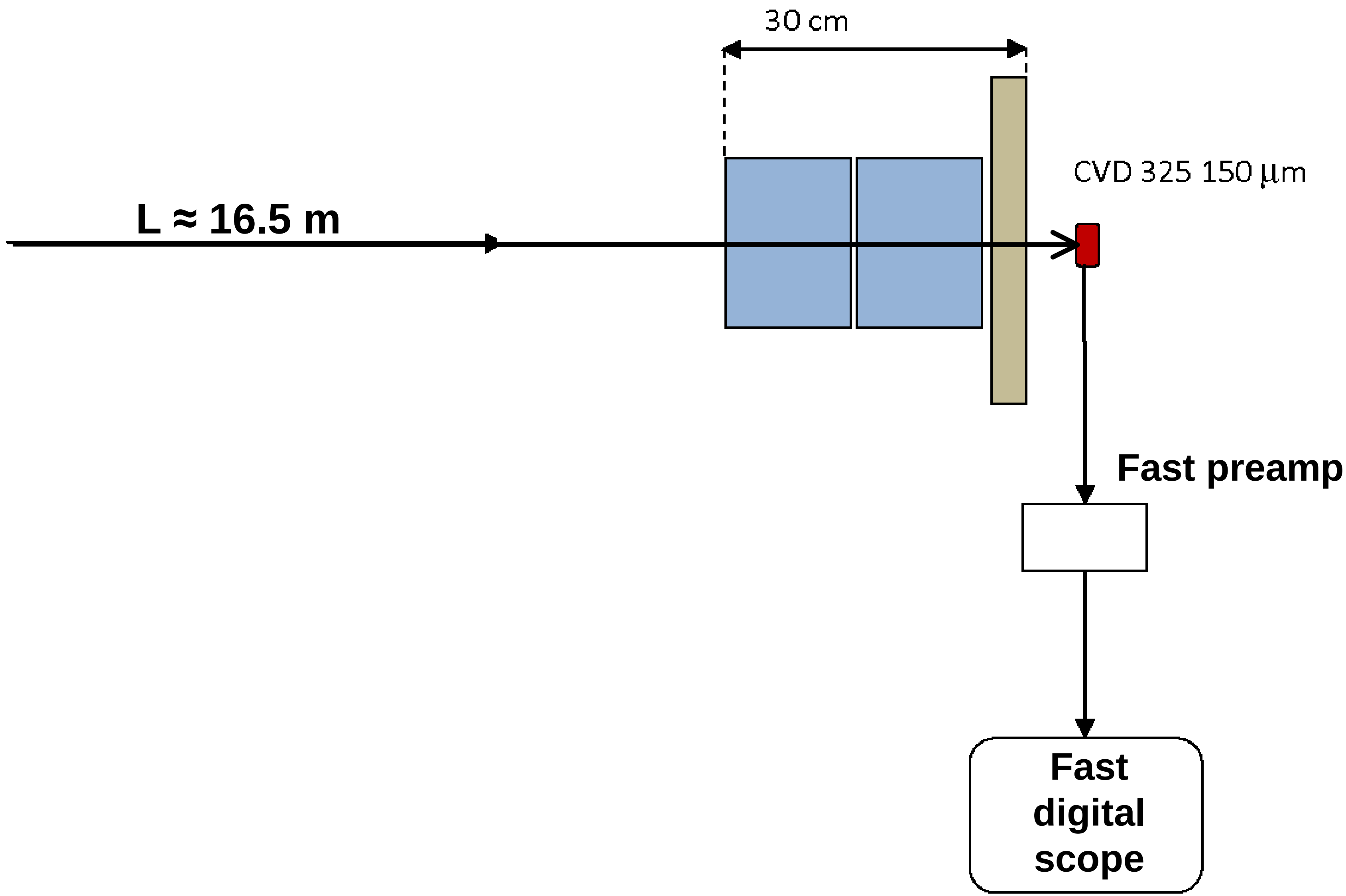
However, α particles from (n,α) reactions give more intense signals.

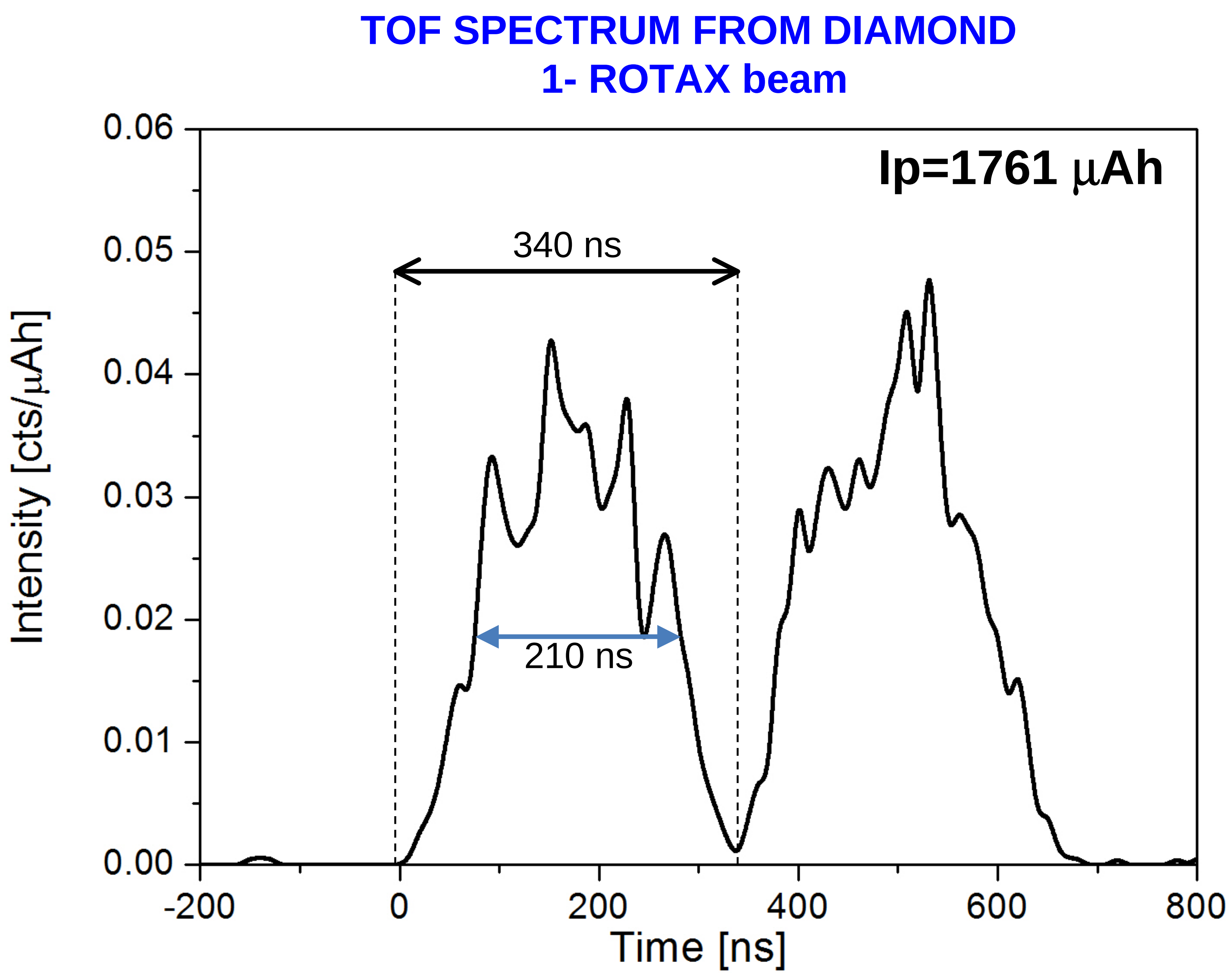


Experimental set up

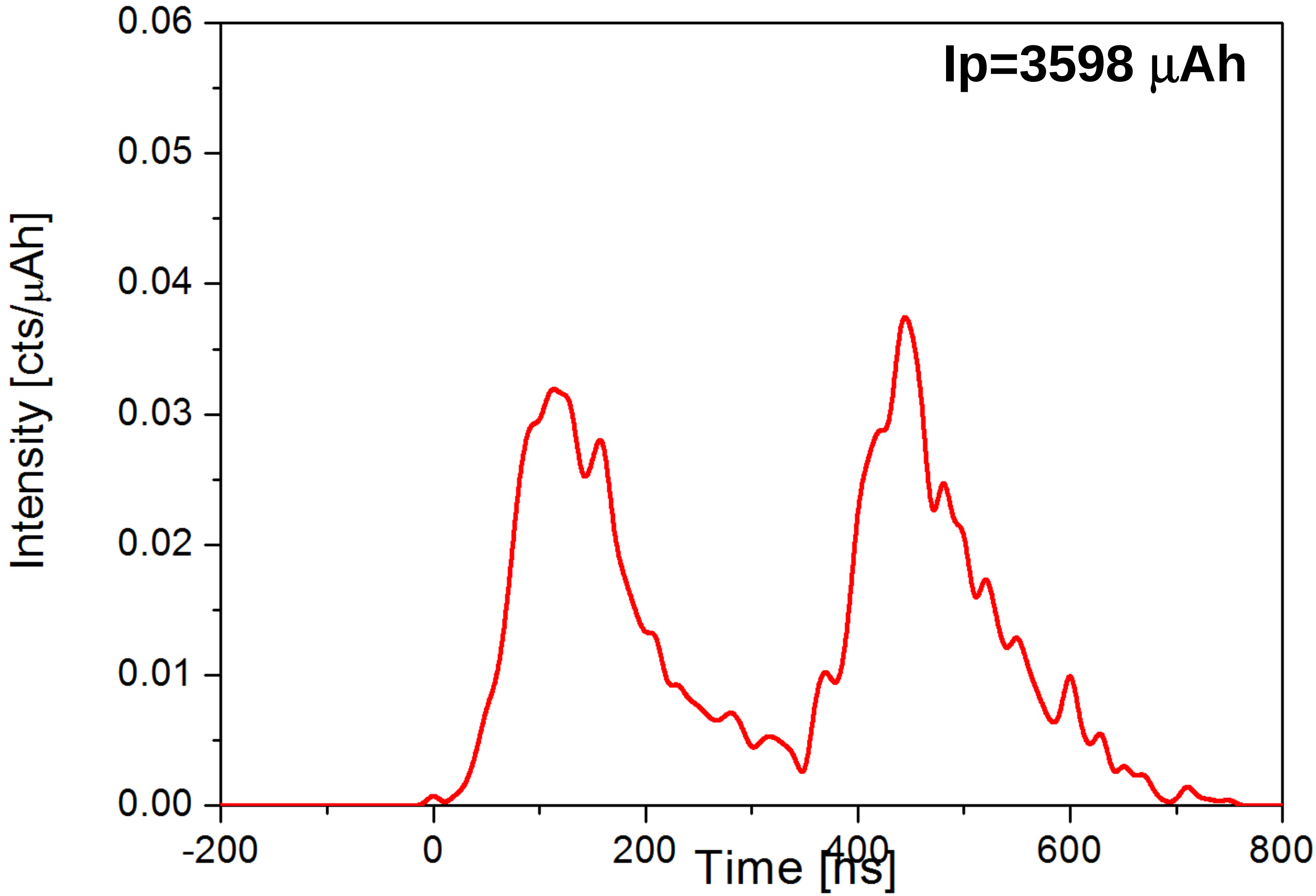


Experimental set up

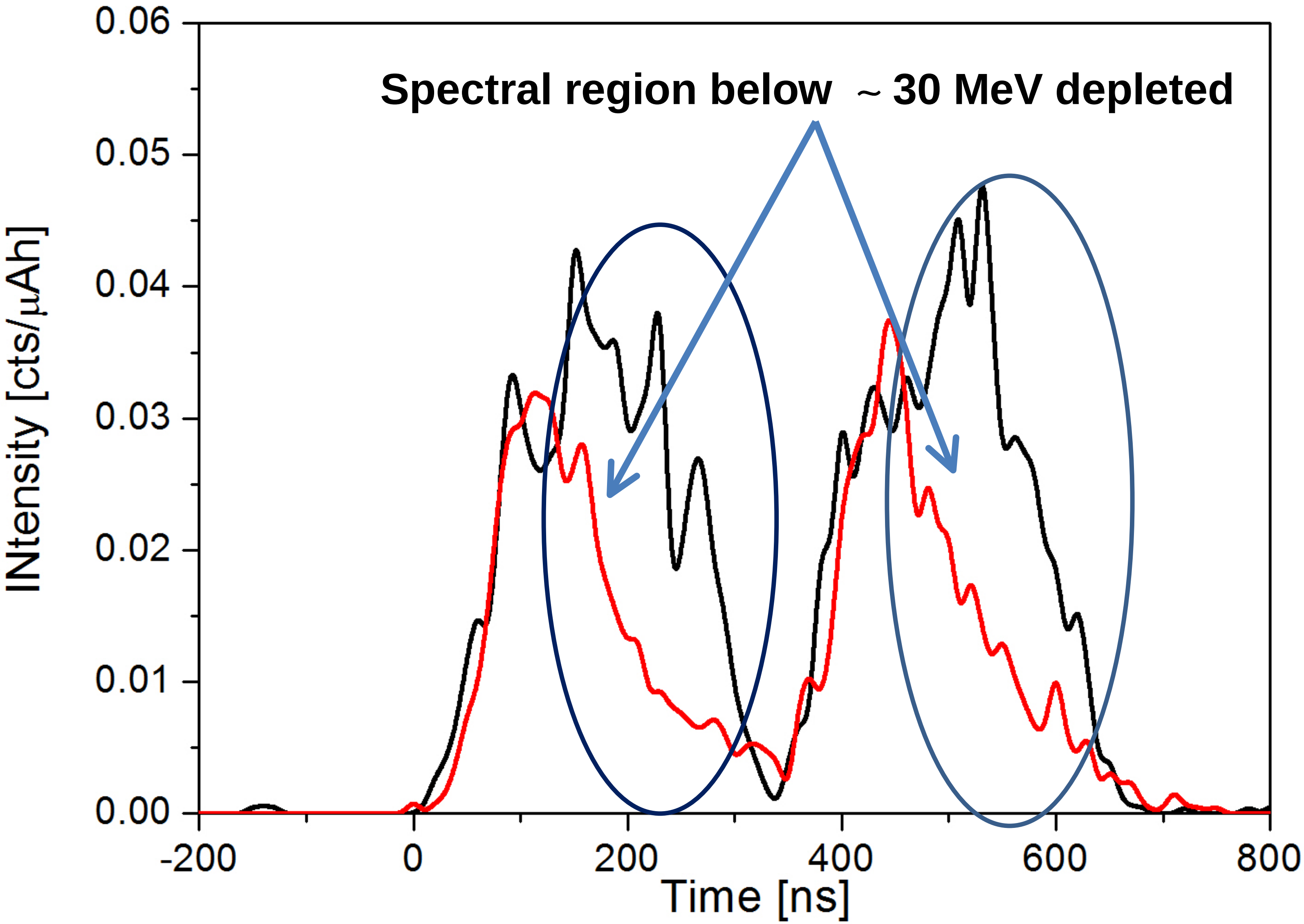



TOF SPECTRUM FROM DIAMOND
1- ROTAX beam
Ip=1761 μAh
340 ns
210 ns
Intensity [cts/μAh]
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-200
0
200
400
600
800
Time [ns]

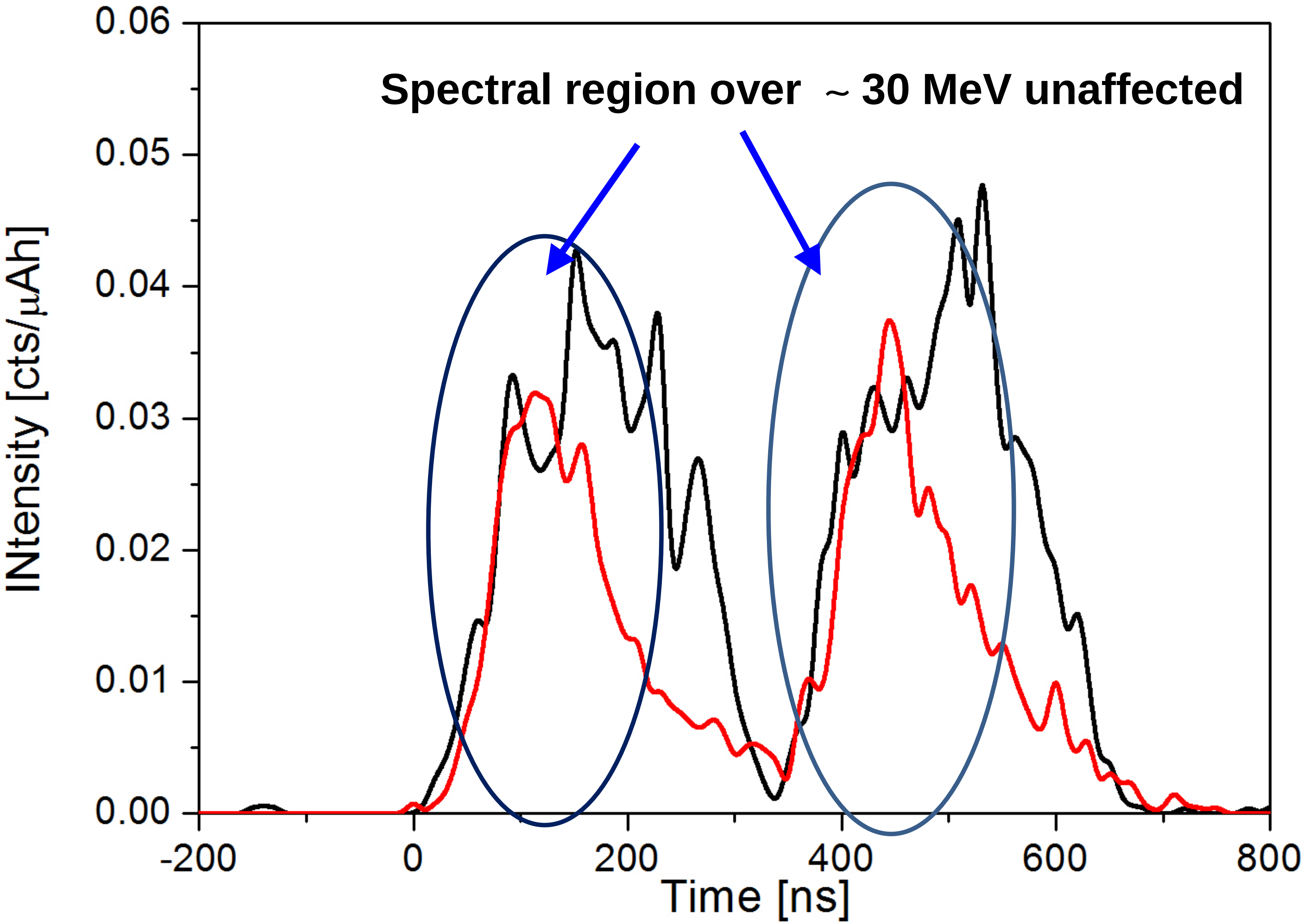
TOF SPECTRUM FROM DIAMOND
2- Moderated beam



TOF SPECTRA FROM DIAMOND



TOF SPECTRA FROM DIAMOND



CONCLUSIONS

The ChipIr beamline is under construction at ISIS-TS2

Explorative tests at ISIS TS-1 opened the way to the ChipIr beam characterization and monitoring

Fast neutron detectors are in development

For beam characterization:

- **Bonner Spheres (and Cylinders)**
- **Thin Film Breakdown Counters**

For localized beam monitoring:

- **Single Crystal Diamond detectors.**

Modifying the diamond response