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ICTP 40th Anniversary

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Workshop on
Nuclear Reaction Data and Nuclear Reactors: Physics, Design and Safety

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Monte Carlo Method: Theory and Exercises (2)

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Monte Carlo simulation of a TRIGA source driven core configuration: Preliminary results

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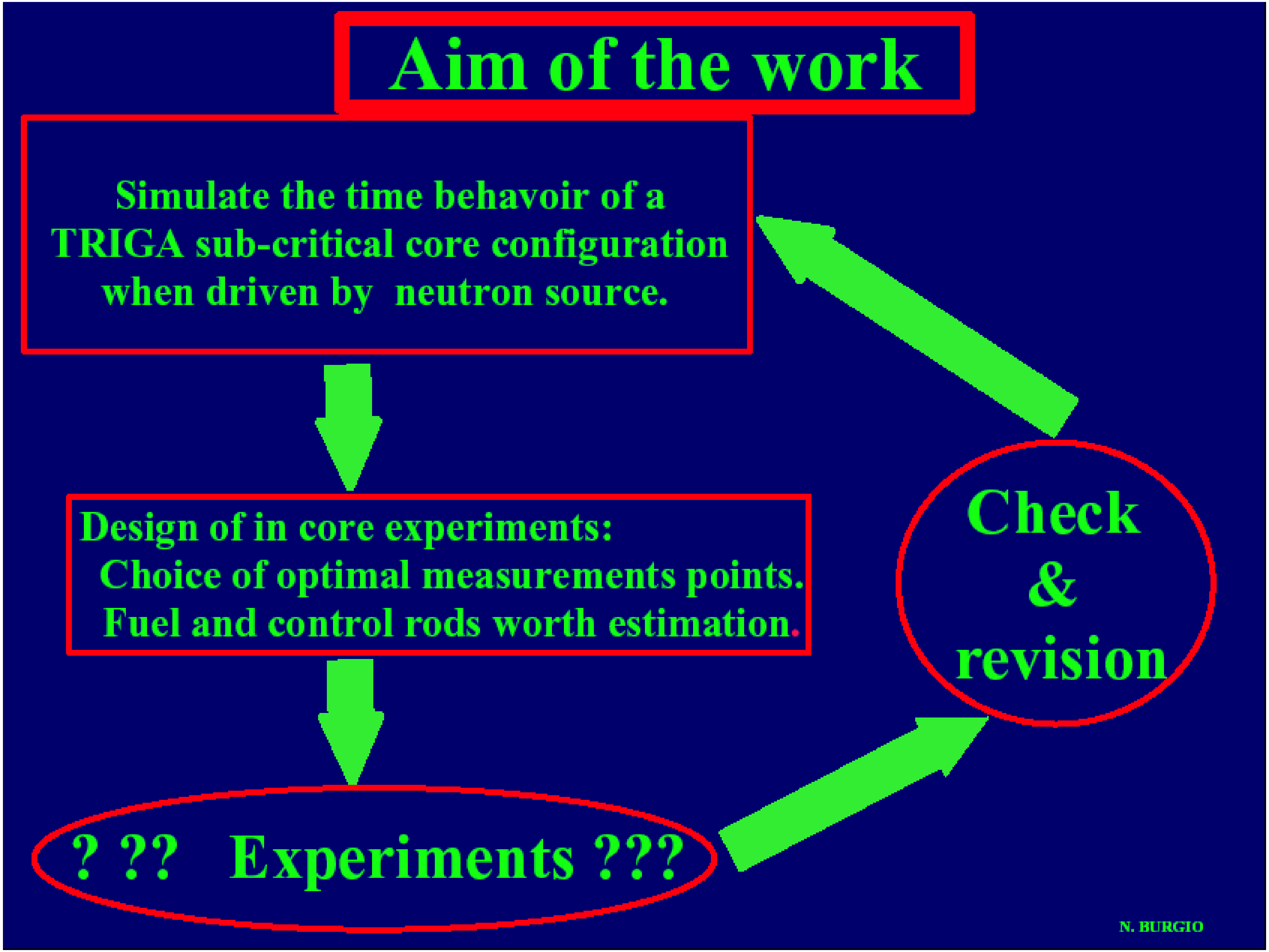
ENEA
C.R. Casaccia-Italy


Aim of the work
Simulate the time behavoir of a TRIGA sub-critical core configuration when driven by neutron source.
Design of in core experiments:
Choice of optimal measurements points.
Fuel and control rods worth estimation.
? ?? Experiments ???
Check & revision
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Monte Carlo for particles transport simulation. MCNP4c

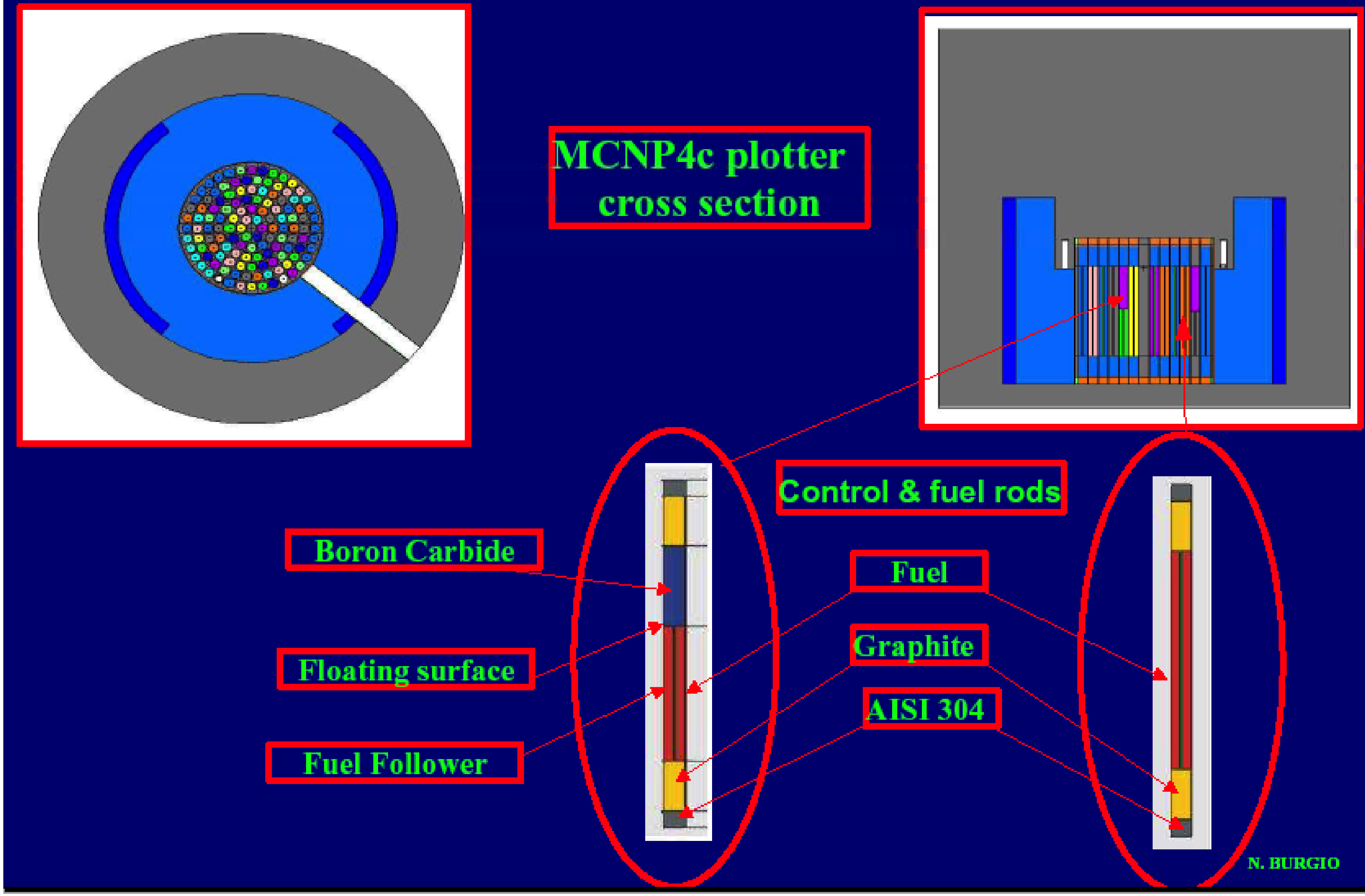
Points of strenght:

- "Continuos" Cross Section database
- High detailed geometrical description.
- Multi level source setup.
- Statistical checks for tally convergence.
- Variance reduction schemes.

Points of weakness:

- Long calculation time (parallel computer highly recommended)
- Uncertainities in the time dependent cross sections
- False tallies convergenge in time.

Main components of the MCNP model of the 1 MW TRIGA reactor of Casaccia.



Criticality calculation methodology (kcode)

- Fresh fuel in the reference core configuration (235)
- Temperature field related to the desired power level.
- Control rods position compatibles with the desired power level.
- Iterative refiniment of the criticality source (scrtp file).
- Fix source calculation for flux tallies (wssa file).
- ENDF/B-VI cross sections
- ENDF data for molecular binding effect in thermal neutron scattering (Light Elements).

K_{eff} estimations

Power 20 Watt

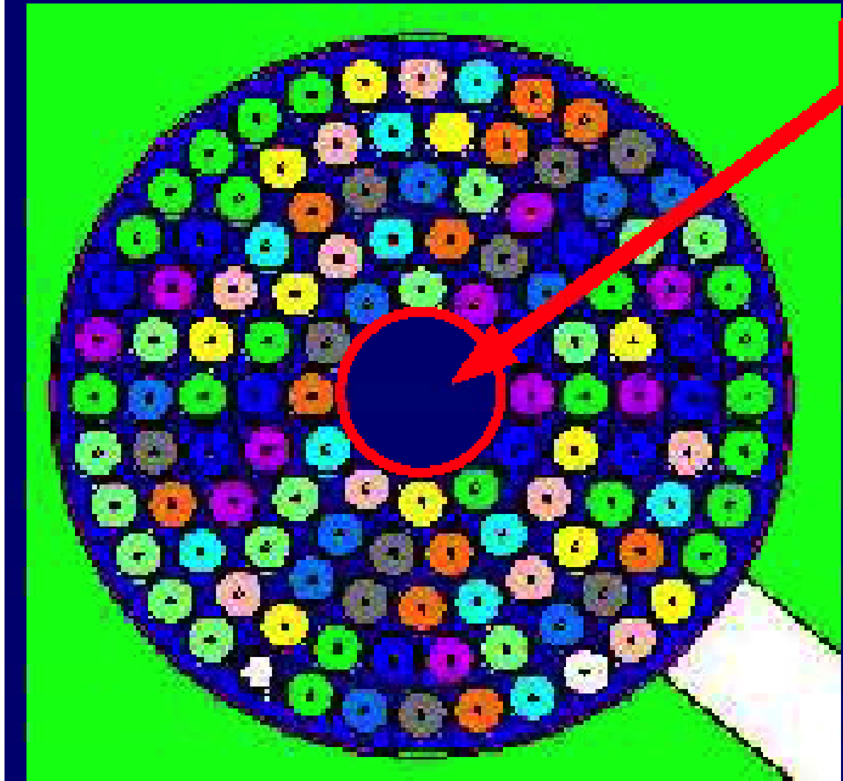
K_{eff}=1.00972 ± 0.00044 (no burnup taken into account)

Power 1 Mwatt

K_{eff}=1.00309 ± 0.00068 (no burnup taken into account)

Estimated	Experimental
$P_{max}/P_{av} = 1.57$	$P_{max}/P_{av} = 1.55$
$\phi_{rabbit} = 1.86 \cdot 10^{13}$ n cm^{-2} sec^{-1}	$\phi_{rabbit} = 1.91 \cdot 10^{13}$ n cm^{-2} sec^{-1}
$\phi_{ct} = 4.30 \cdot 10^{13}$ n cm^{-2} sec^{-1}	$\phi_{ct} = 6.35 \cdot 10^{13}$ n cm^{-2} sec^{-1}

Hypothesys of subcritical core configuration



No ring B

The subcritical configuration were achieved by removing ring B and setting different control rods position.

The keff values, obtained running MCNP KCODE, give a relative estimation of the subcriticality level of each configuration.

*Results:

shim1 (C10)	shim2 (C7)	safety (C4)	Keff	σ
100%	45%	100%	0.9806	$7*10^{-4}$
40%	0%	100%	0.9602	$7*10^{-4}$
0%	0%	0%	0.9308	$8*10^{-4}$

*Control rod insertions are reported as % of fuel follower in core

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The neutronic source (driver) in the central thimble.

Deuterium – Tritium source.

Neutron energy : 14 MeV (mean) , σ = 0.8 MeV

Spectrum : gaussian distribution.

Intensity : $2x10^8$ n /sec /4π

Pulse rate : up to 20 kHz.

Pulse width : from 5 ms to continuos mode.

An MCNP point source with same spectrum and suitable time behaviour was placed in the central thimble on the core middle plane (SDEF routine) of the model.

A transport calculation (non kcode) in the core multiplicative media was executed on each of the three configuration with a source statistics of at least 2 milions neutron source.

Flux and energy tallies vs time were accumulated on all fuel rods of each configuration.

All the time range of the simulation are well below the feedback effects time scale!

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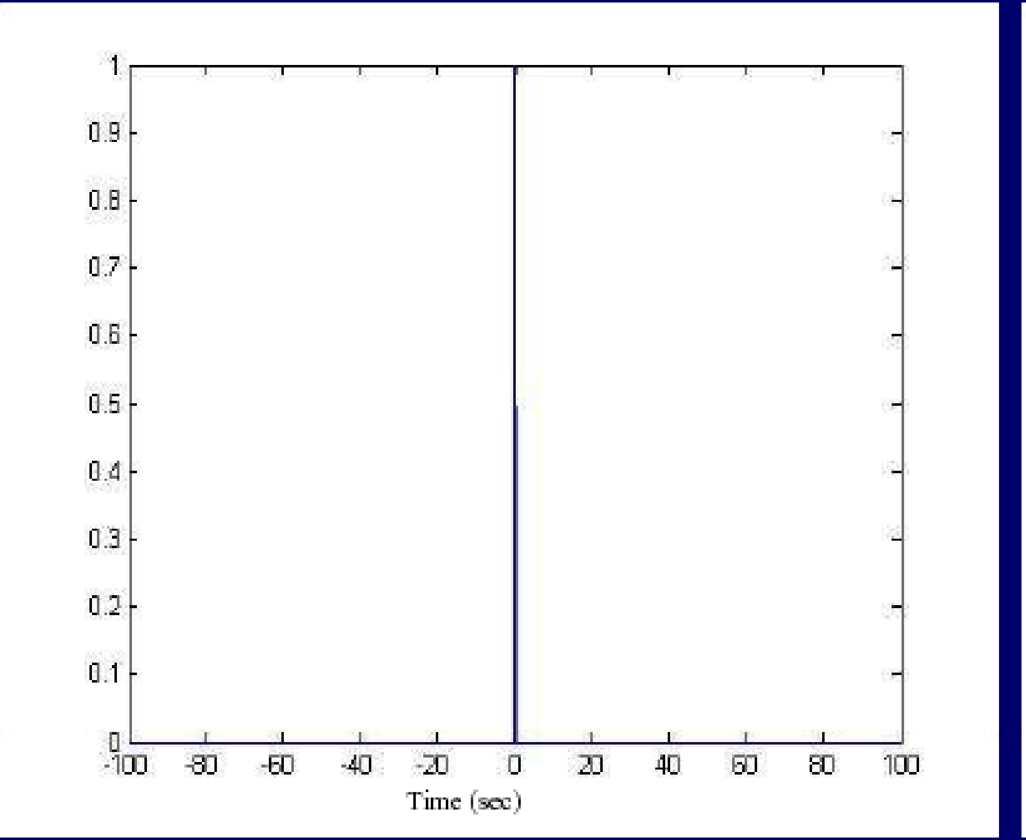
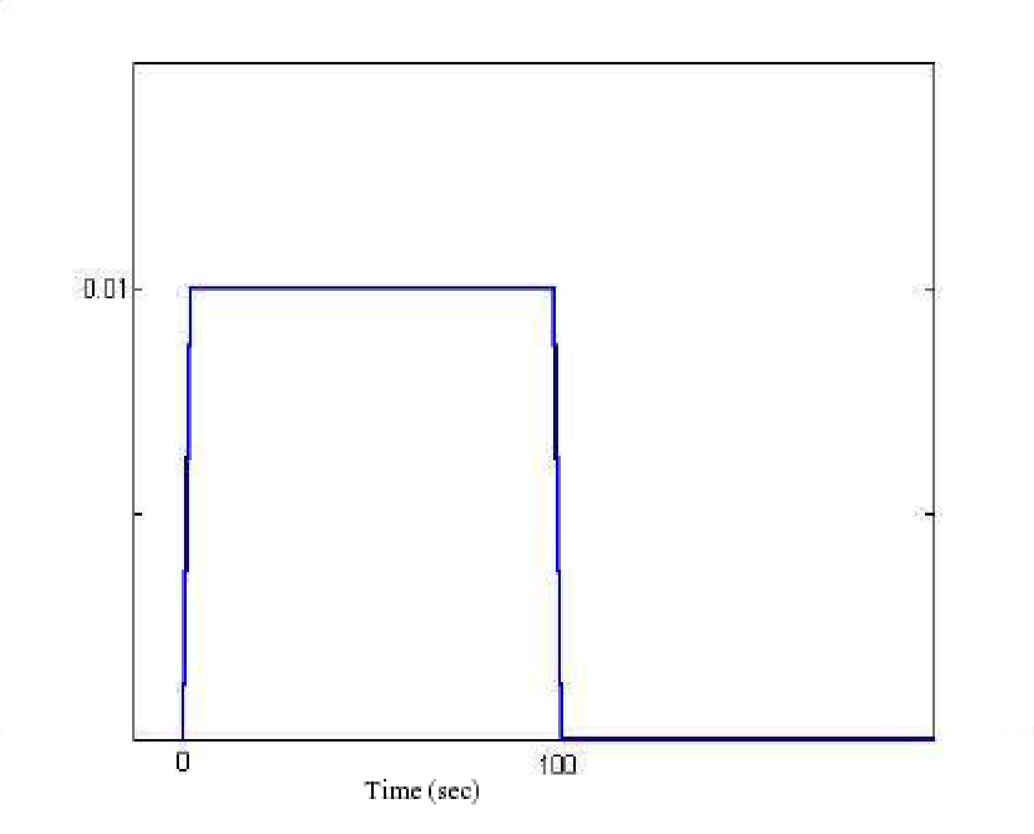
Test responses for TRIGA source driven system .

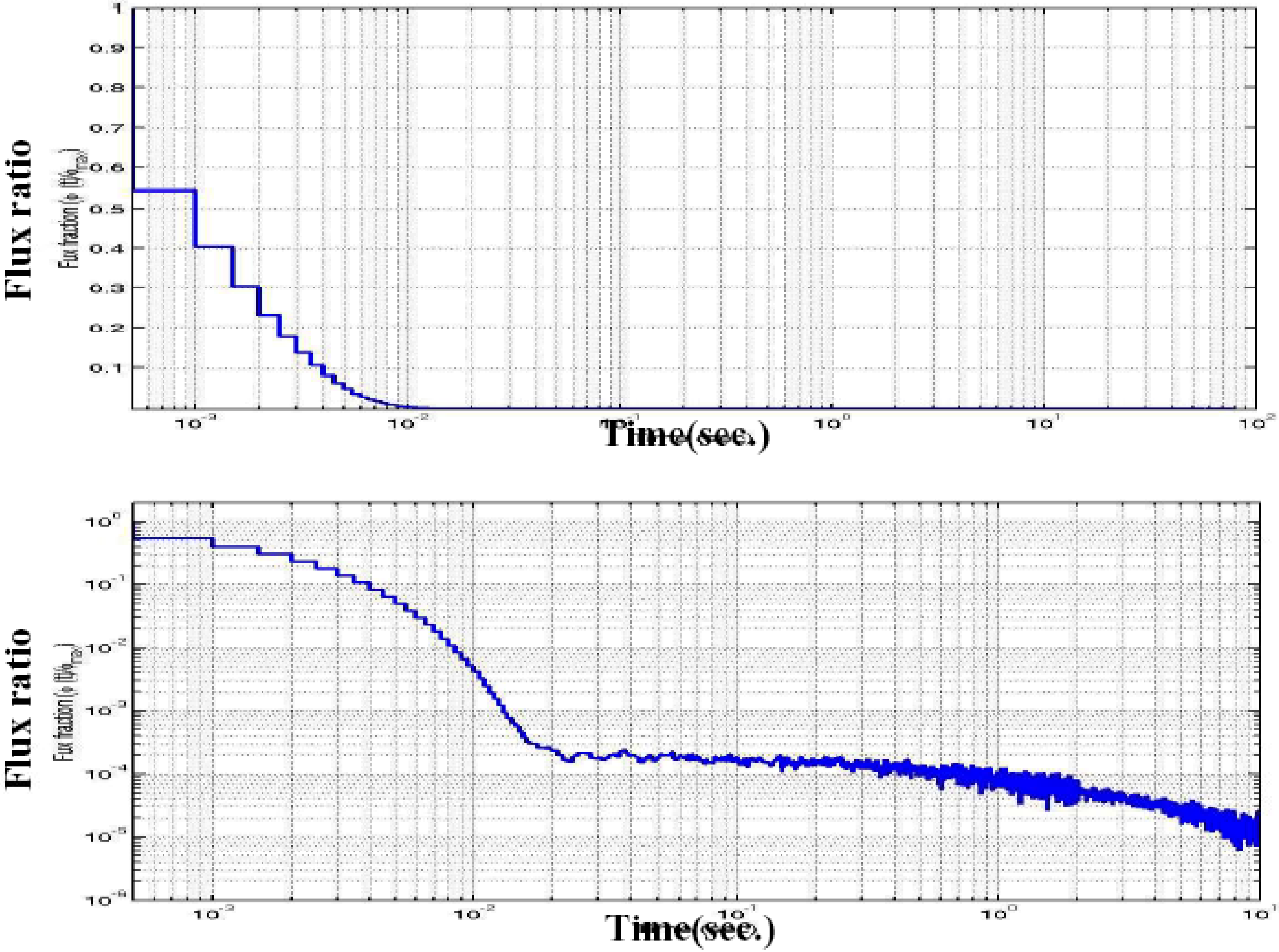


Delta Pulsed Source



Source Jerk like

Flux response at fuel rod c1 with a time delta shaped source (keff=0.9806, M=30)



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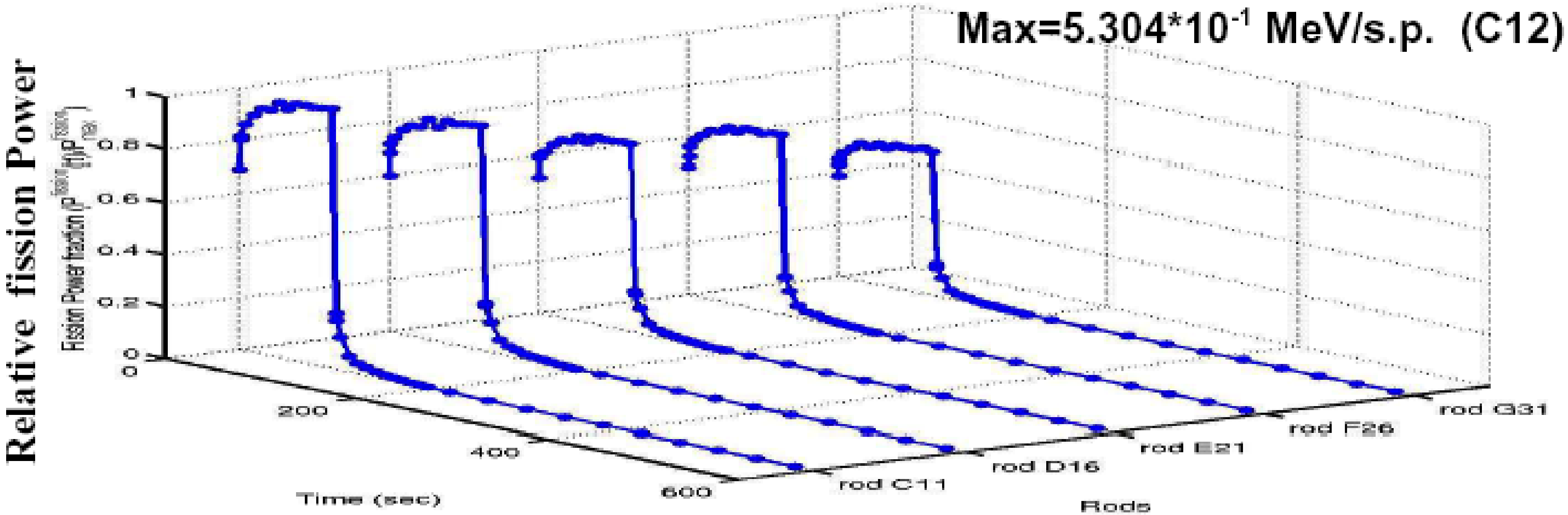
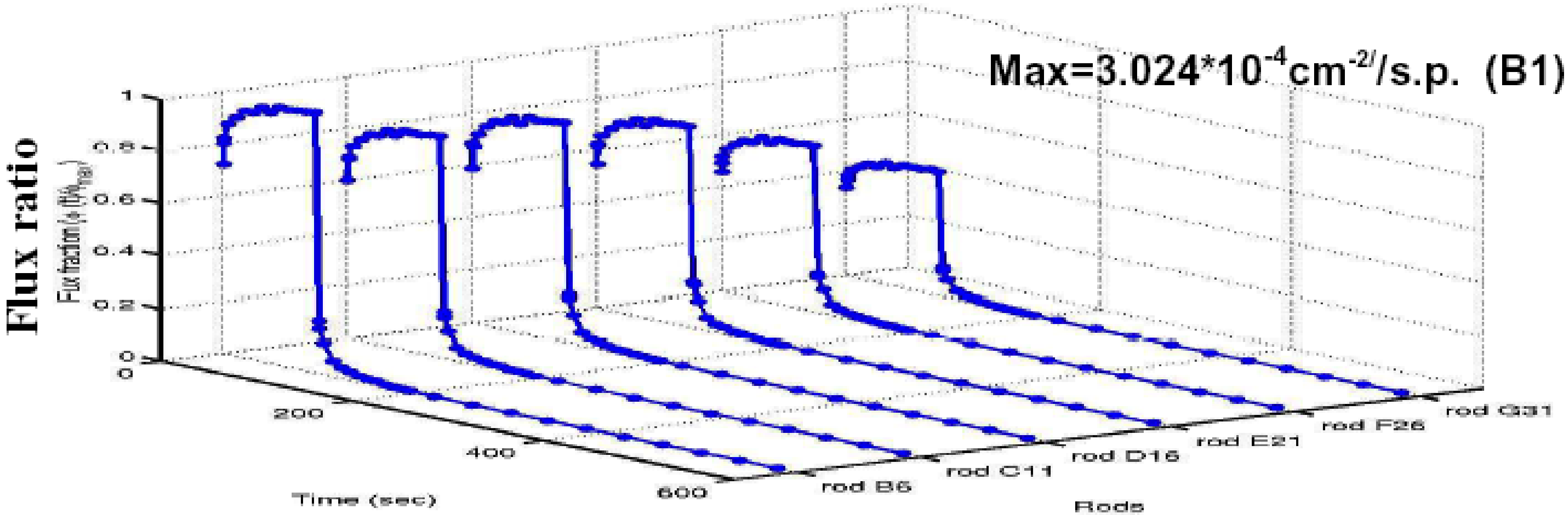
Response at rod c11,d16,e21,f26,g31 (keff=0.9806,source-jerk, M=30)





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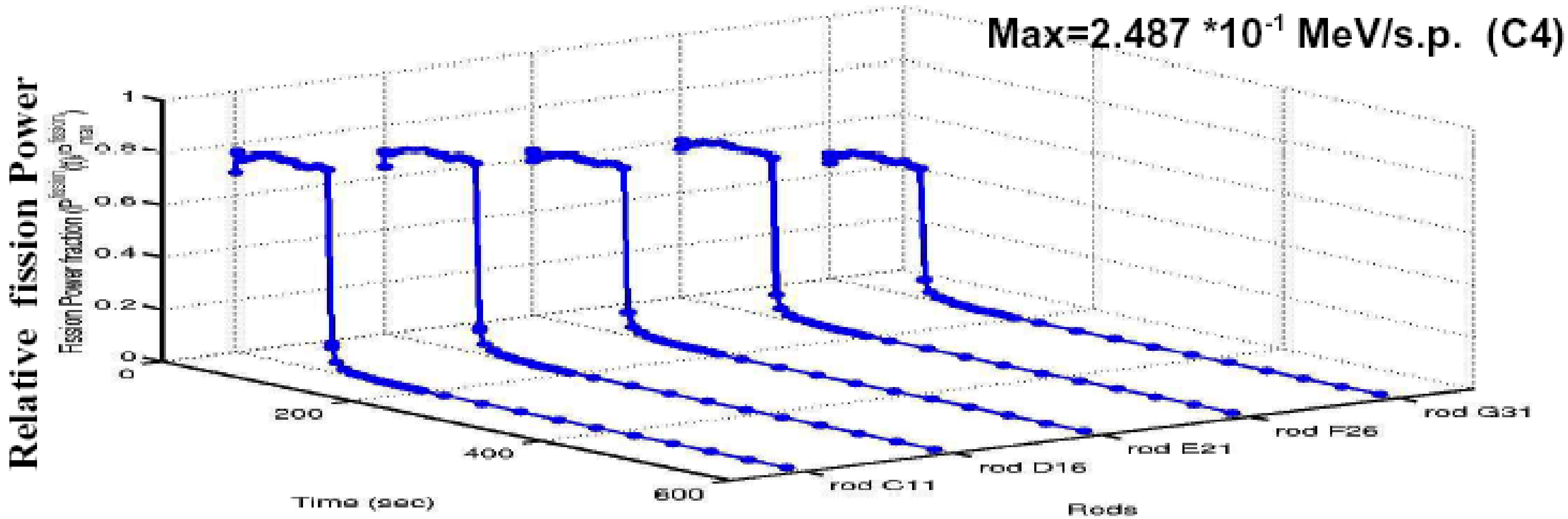
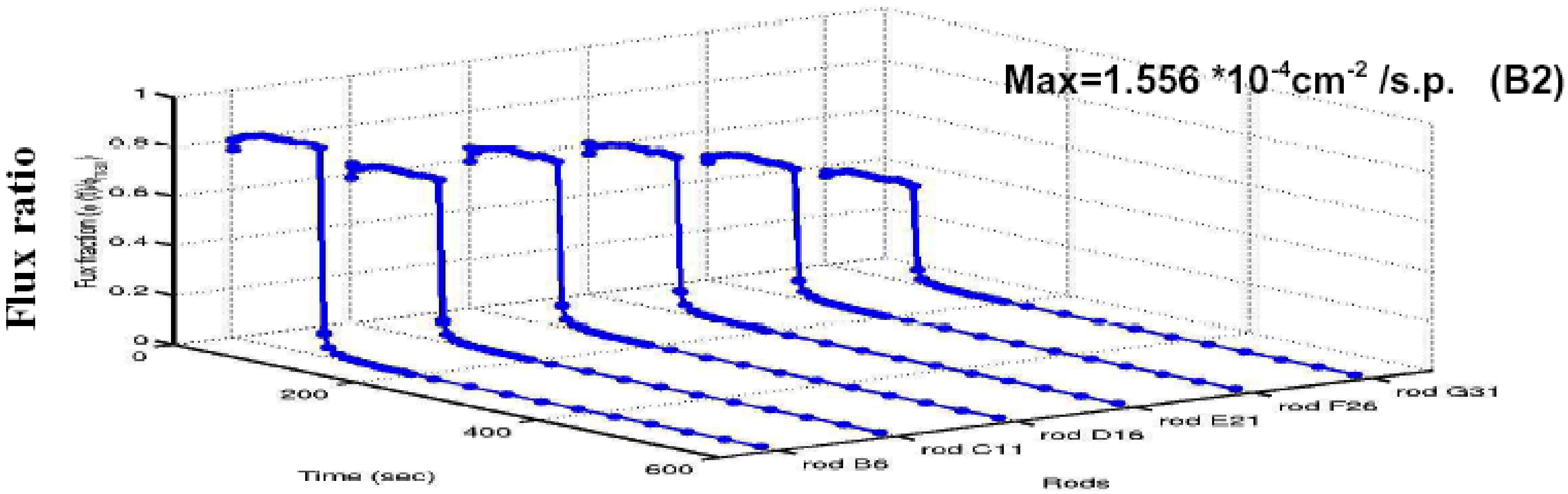
Response at rod c11,d16,e21,f26,g31 (keff=0.9602,source-jerk, M=14)





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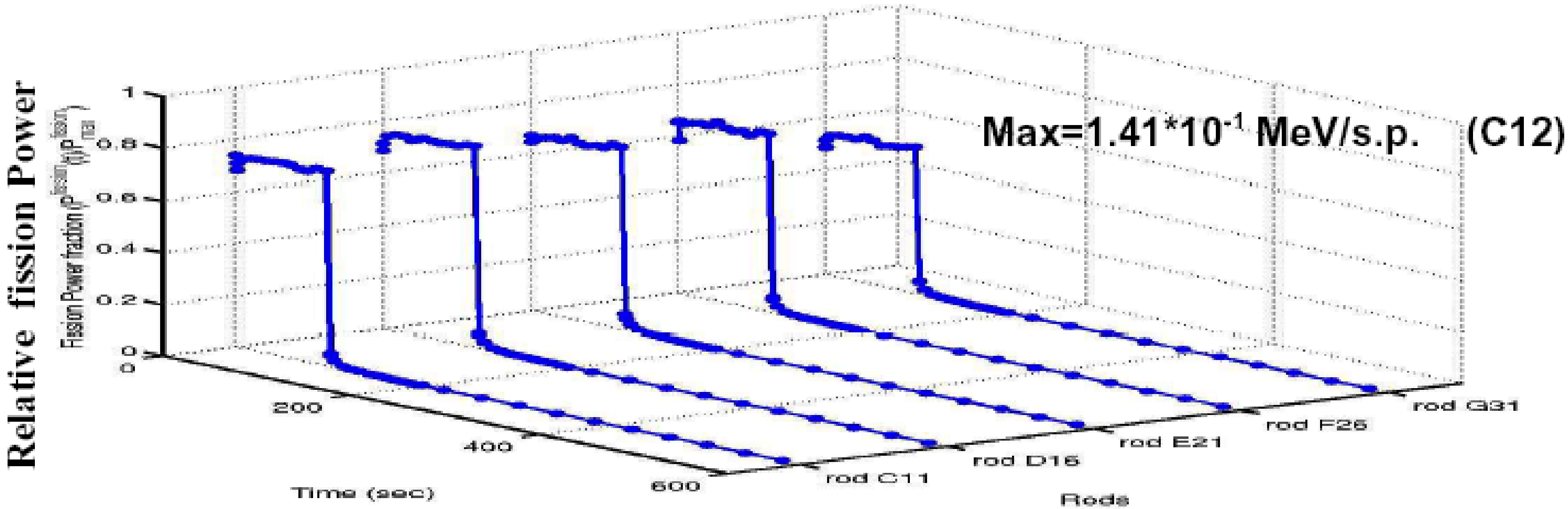
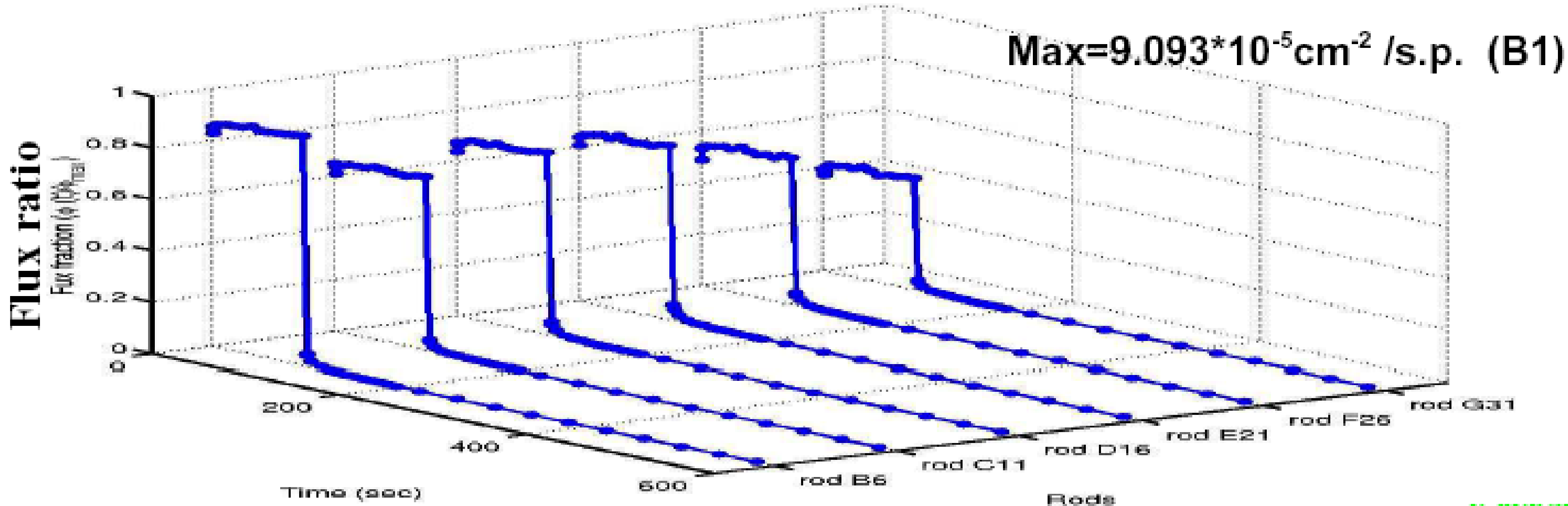
Response at rod c11,d16,e21,f26,g31
(keff=0.9308,,source-jerk, M=8)





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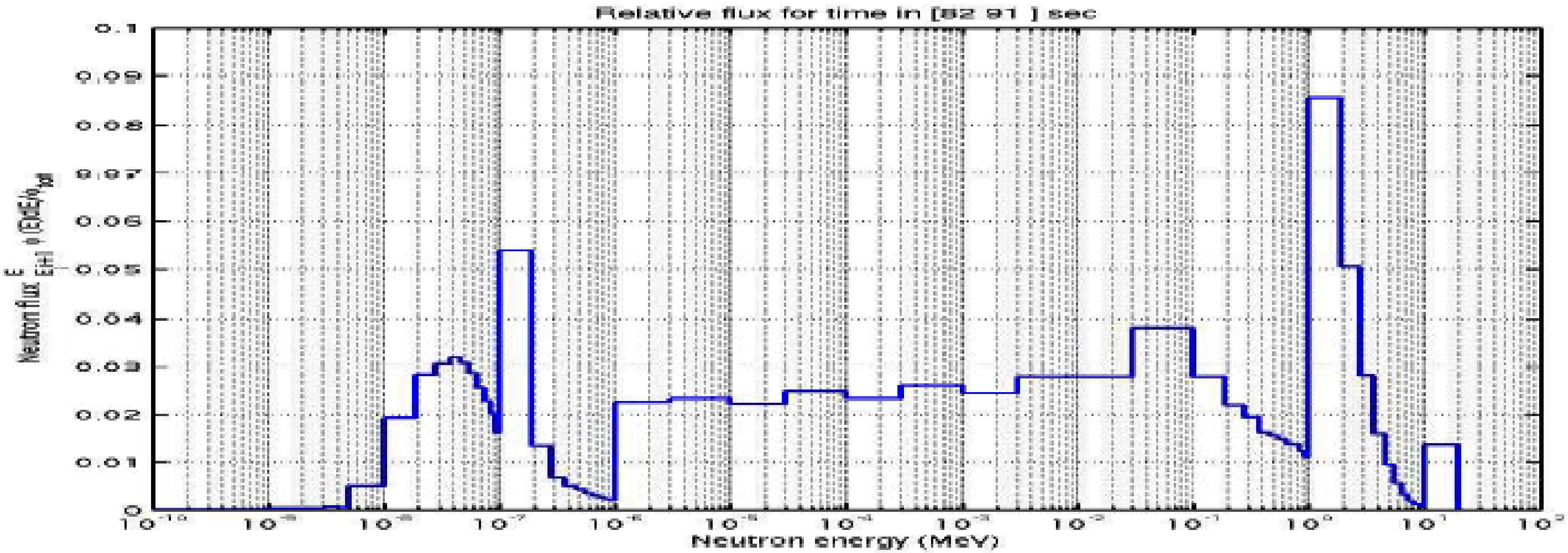
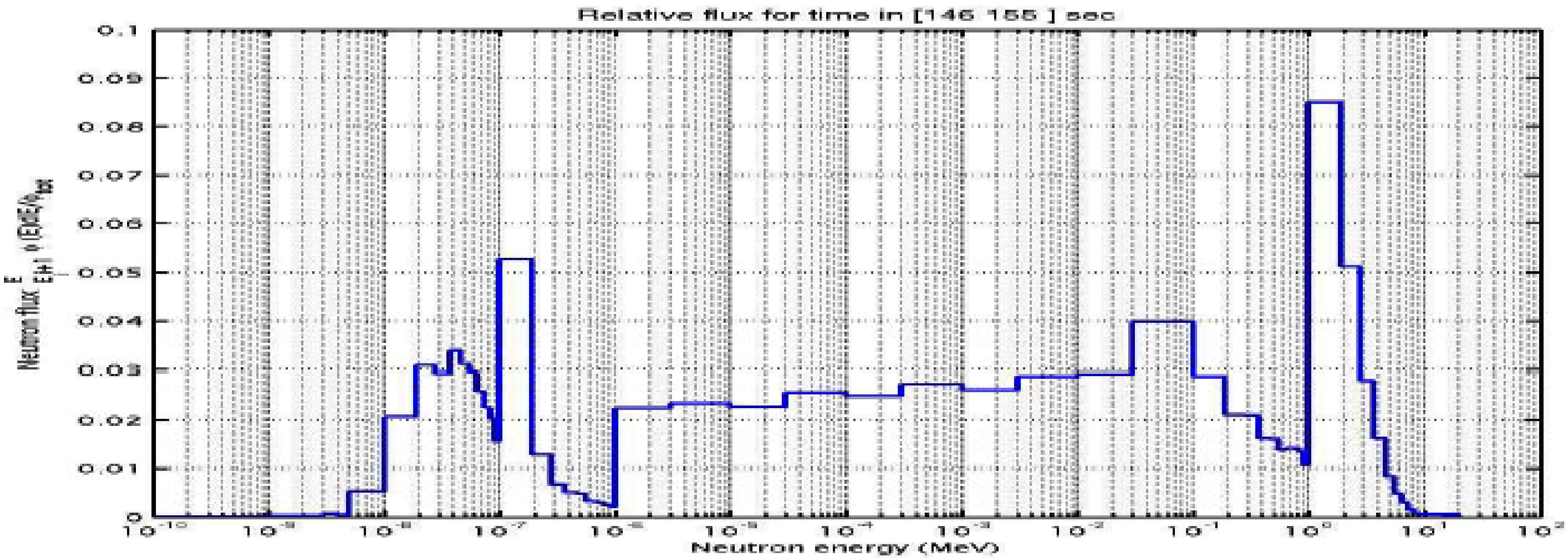
Spectrum response at rod c1 for t=90 and 150 sec. (keff=0.9806,source-jerk)





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Conclusions

- M.C. Dinamic models could help the design of time dependent neutronic experiments.
- Further calculation, with improved statistical sampling, permits more quantitatives considerations.