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The Radiation Monitor PANDORA (LB 6419) at PETRA III

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PANDORA

Wikipedia:

In Greek mythology, Pandora (from Greek: Πανδώρα, "giver of all, all-endowed"[1]) was the first woman.[2] As Hesiod related it, each god helped create her by giving her unique gifts. Zeus ordered Hephaestus to mould her out of Earth (Γαῖα – Gaia) as part of the punishment of mankind for Prometheus' theft of the secret of fire, and all the gods joined in offering this "beautiful evil" seductive gifts. Her other name, inscribed against her figure on a white-ground kylix in the British Museum (illustration, right), is Anesidora, "she who sends up gifts."[3] According to the myth, Pandora opened a jar (pithos) in modern accounts referred to as "Pandora's box", releasing all the evils of mankind—although the particular evils are not specified in detail — leaving only Hope inside once she had closed it again.[4] She might have opened the jar out of simple curiosity and not as a malicious act.[5]

PANDORA

Dose-Measurement of Photons- and Neutrons in continuous and pulsed fields.

Monitoring via Ethernet.

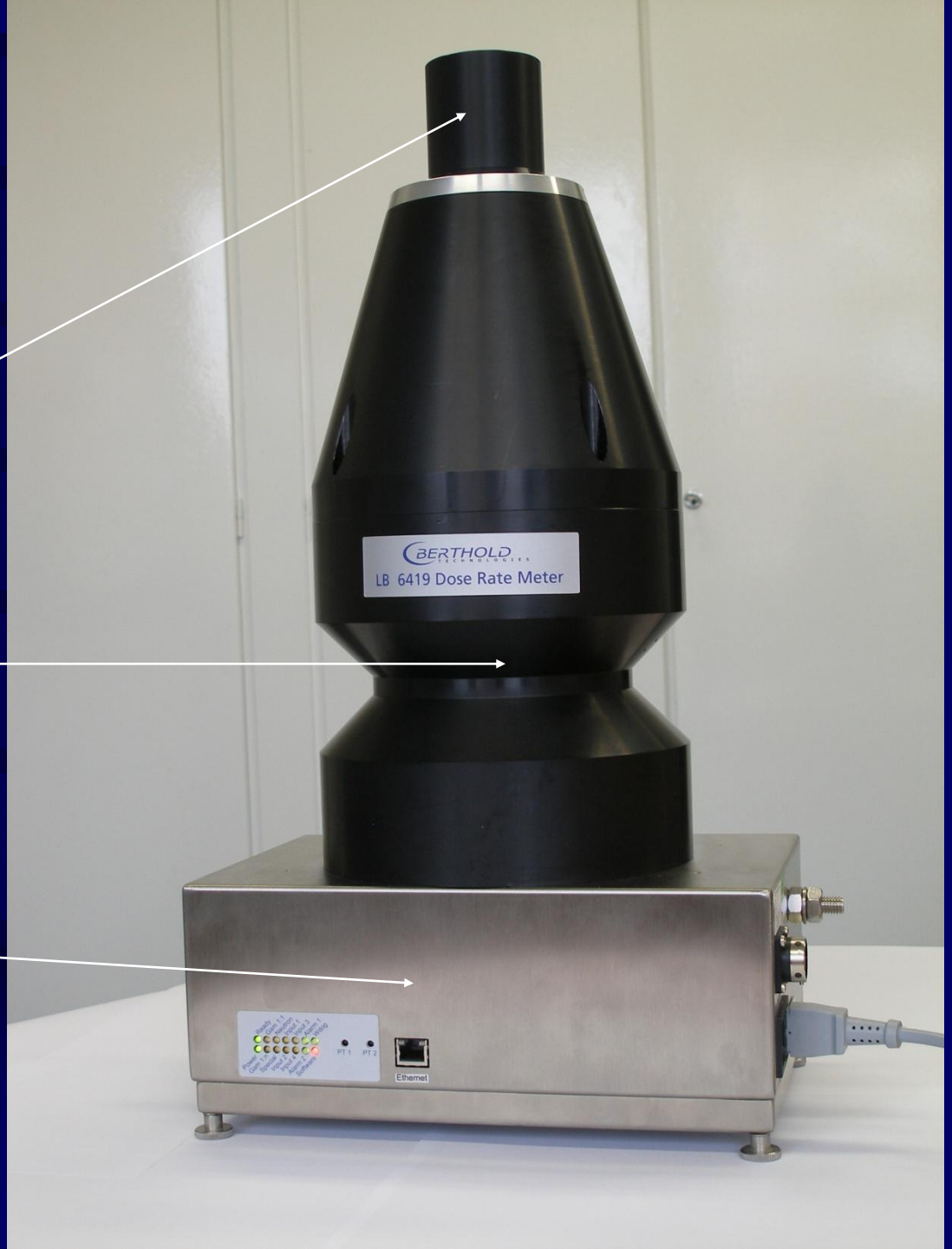
Interlock-Functionality by 2 Relays.

Detector

Plastik - Scintillator
in a 1 cm PE cover

^{3}He - Counter
rem – counter type

Electronics- Box
Power supplies
FADCRMON board (SIS)



Detector - Concept

Type of Radiation \ Time Structure	Continuous	Burst sequence
Neutrons: High - energy > 20 MeV		
Neutrons: Low - energy < 20 MeV thermal		
Photons: Bremsstrahlung > 2 MeV		
Photons: γ - Radiation		
Photons: Synchrotron Radiation		

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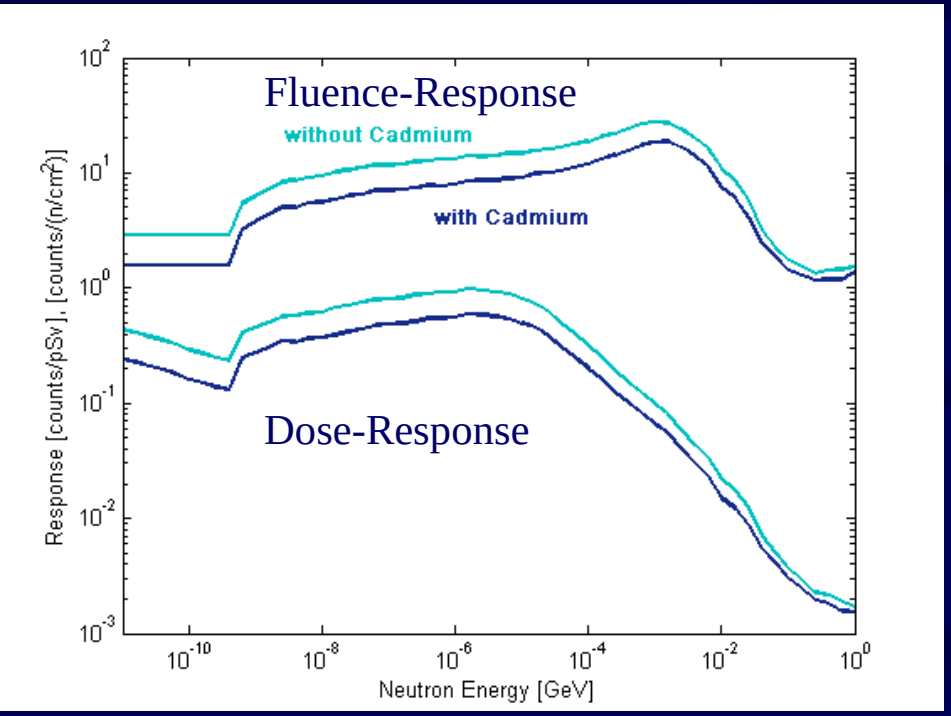
Response to Neutrons

Calculated by means of the Monte Carlo Code FLUKA

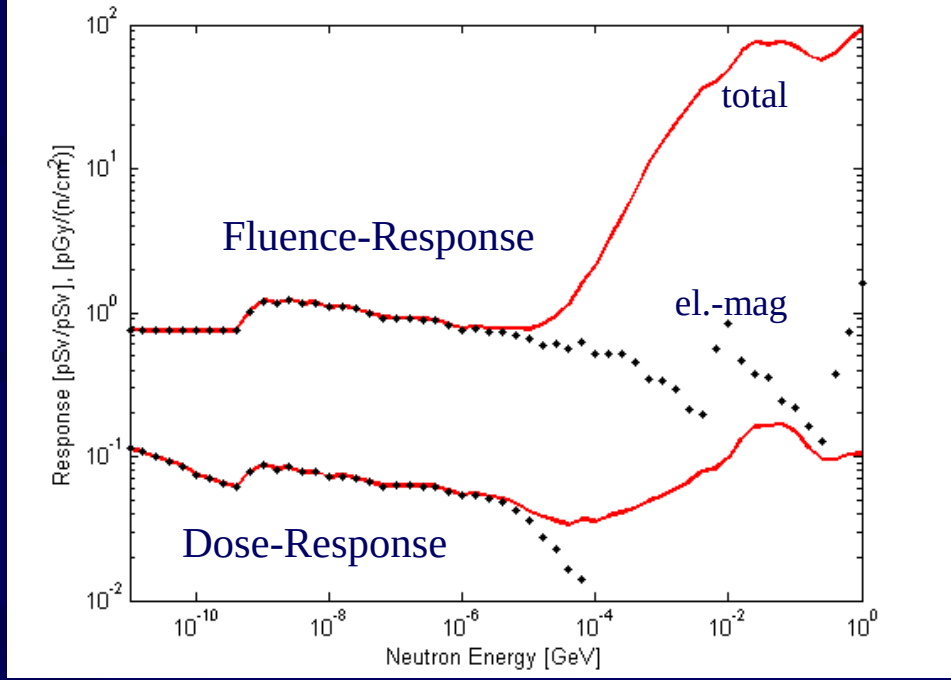
^{3}He Counter

counts = number of $^3He(n,p)^3T$ reactions



Scintillator

Energy dose = Energy deposited in the scint.

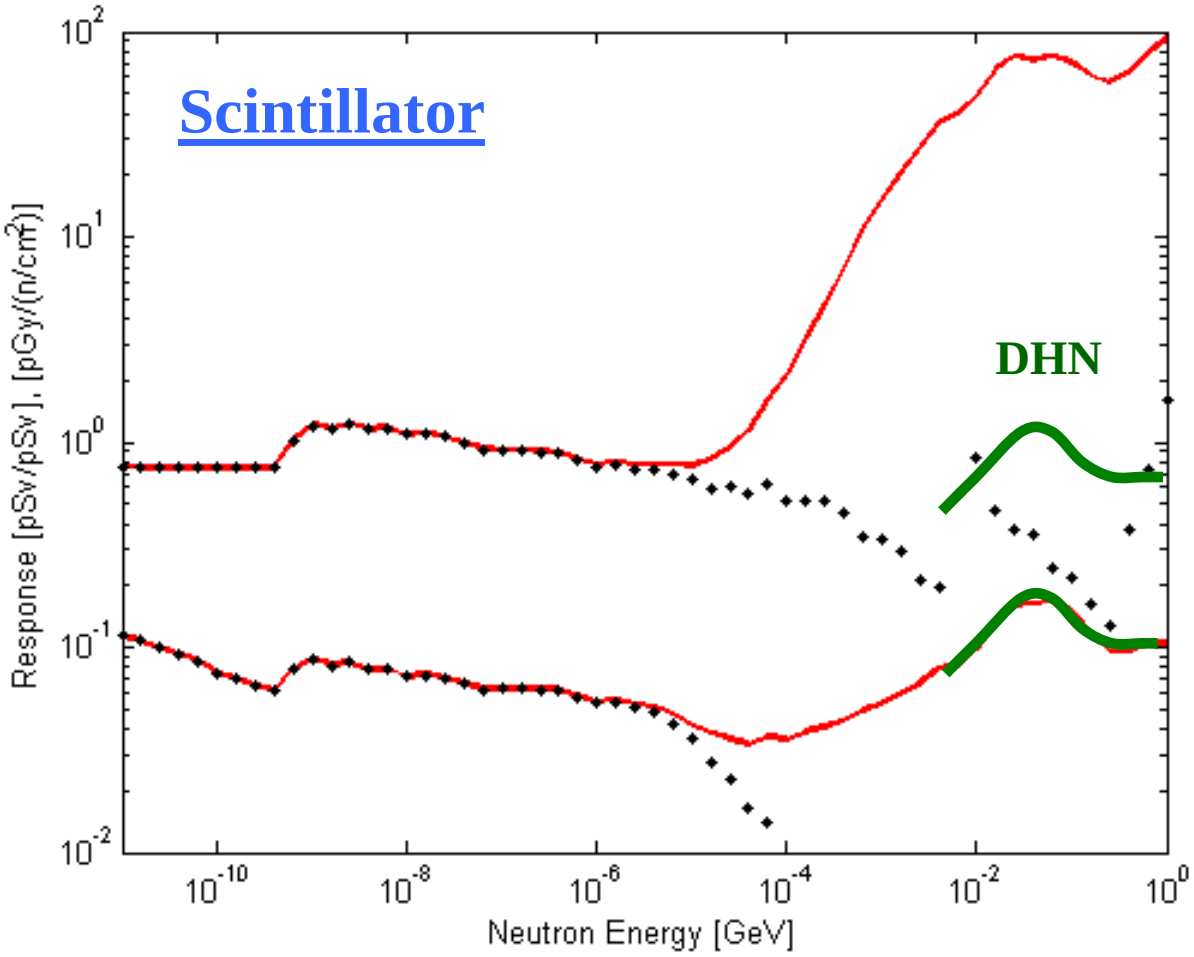


Detector - Concept

Type of Radiation \ Time Structure	Continuous	Burst sequence
Neutrons: High - energy > 20 MeV Low - energy < 20 MeV thermal	**Scintillator** Pulse height > MIP Recoil Protons	
Photons: Bremsstrahlung > 2 MeV γ - Radiation Synchrotron Radiation		

Inheritance: DHN

Fast dose meter for high energy neutrons
Dinter, Tesch: NIM A 376(1996)



Idea:
In the scintillator hadrons are capable to depose much more energy compared to el.-mag. radiation.

Method:
Energy discrimination,
Light yield correction,
Radiation weighting factor

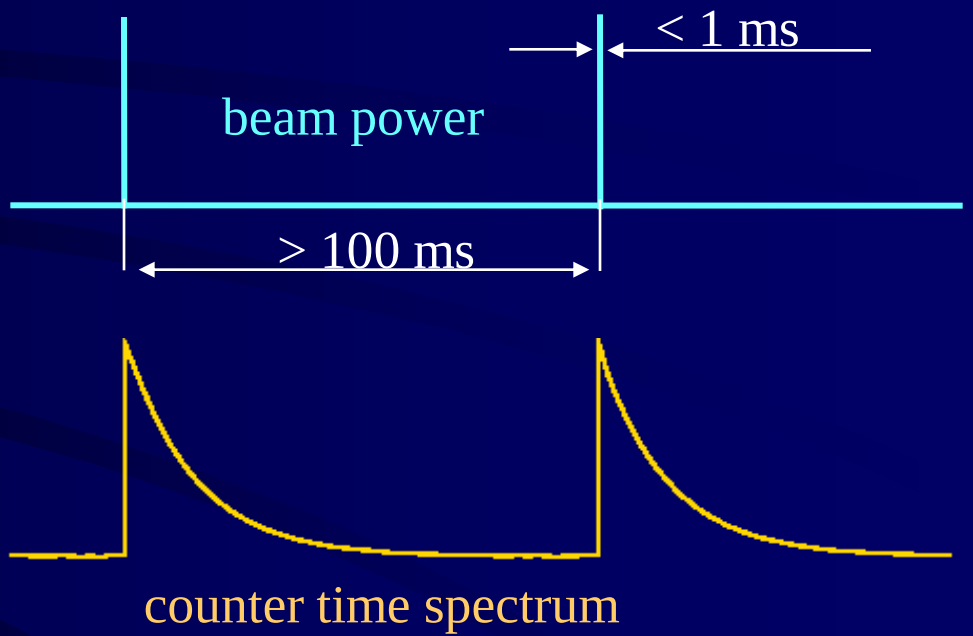
Detector - Concept

Type of Radiation \ Time Structure	Continuous	Burst sequence
Neutrons: High - energy > 20 MeV		**Scintillator**: $^{12}C(n,p)^{12}B$ **^{3}He Counter**: $^{12}C(n,x)^{9}Li$
Neutrons: Low - energy < 20 MeV thermal		**^{3}He Counter**: TOF **Scintillator**: TOF capt. γ
Photons: Bremsstrahlung > 2 MeV γ - Radiation Synchrotron Radiation		

Detection Principle

The information on the neutron fluence is stored during the beam pulse...

and released as a time pattern later on.



Response delaying processes

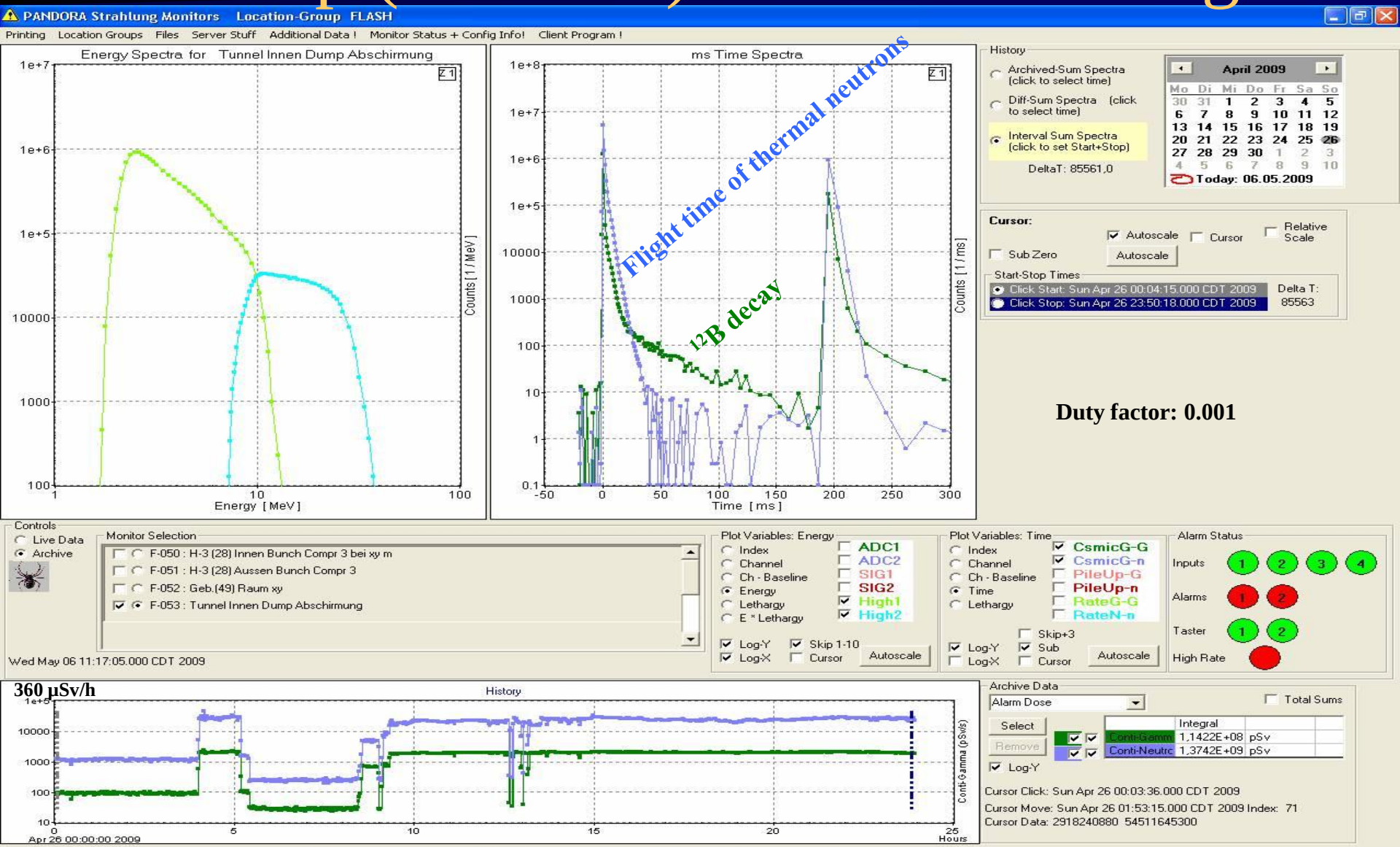
	Delay Time
1. Neutrons are moderated in the Polyethylene body of the rem-counter.	0.1 ms
2. Thermal neutrons are transported from the source region to the detector with their speed of 2.2 m/ms.	2 ms
3. High-energy n/γ - radiation produce radioactive nuclides in the detector	> 20 ms

Production and Decay Data

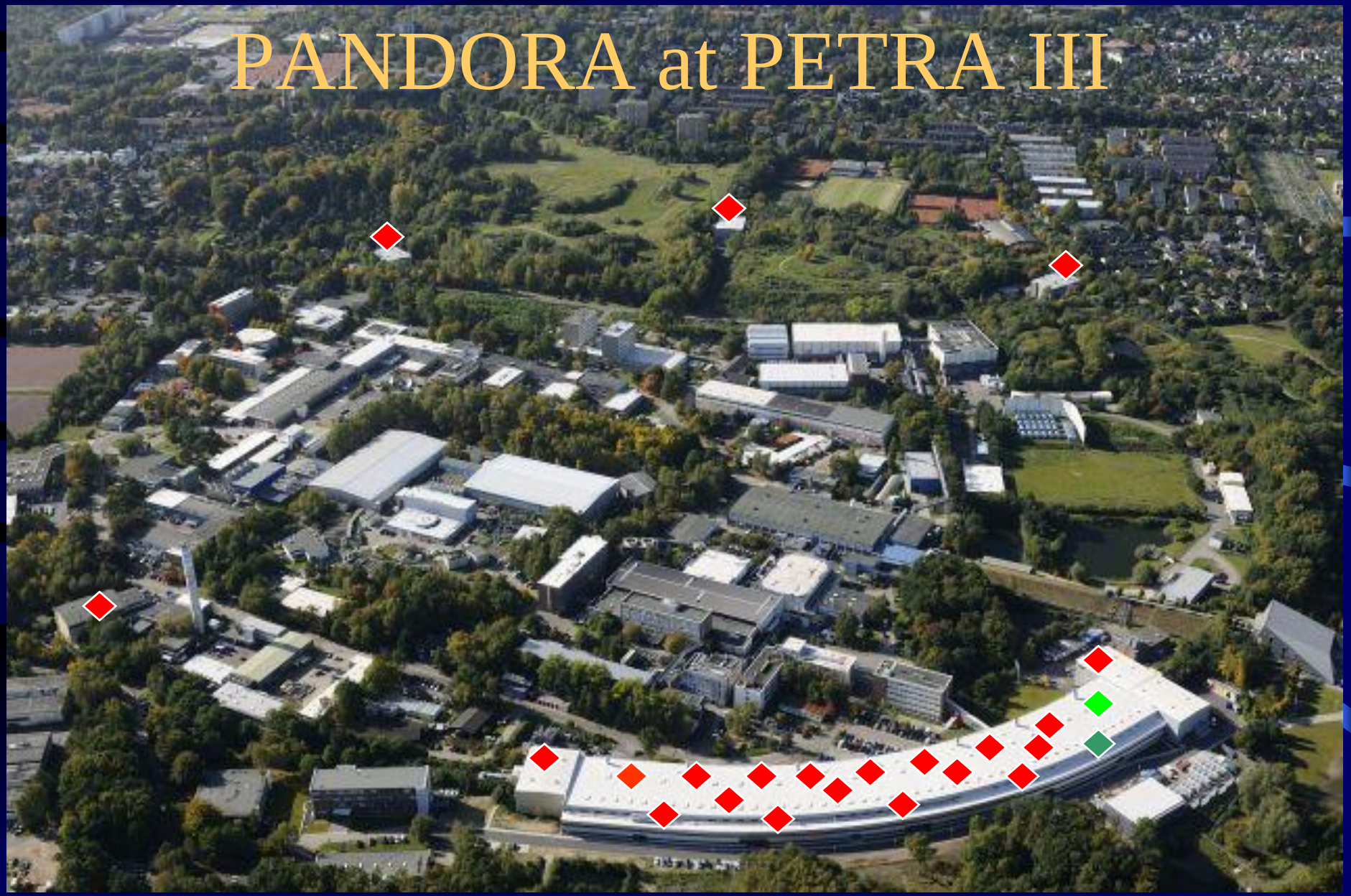
Activation of ^{12}C				Decay			
reaction	product	energy threshold [MeV]	cross-section* [mb]	type	daughter	half life	β max energy [MeV]
(n,2n)	^{11}C	19	14	β^+	^{11}B	20 min	1.0
(n,p)	^{12}B	13	18	β^-	^{12}C	20 ms	13.4
(n,pα)	^{8}Li	23	13	β^-	2α	840 ms	13.0
(n,p^{3}He)	^{9}Li	39	0.1…1	β^- n	2α	170 ms	13.5

* cross-section taken @ neutron energy 100 MeV

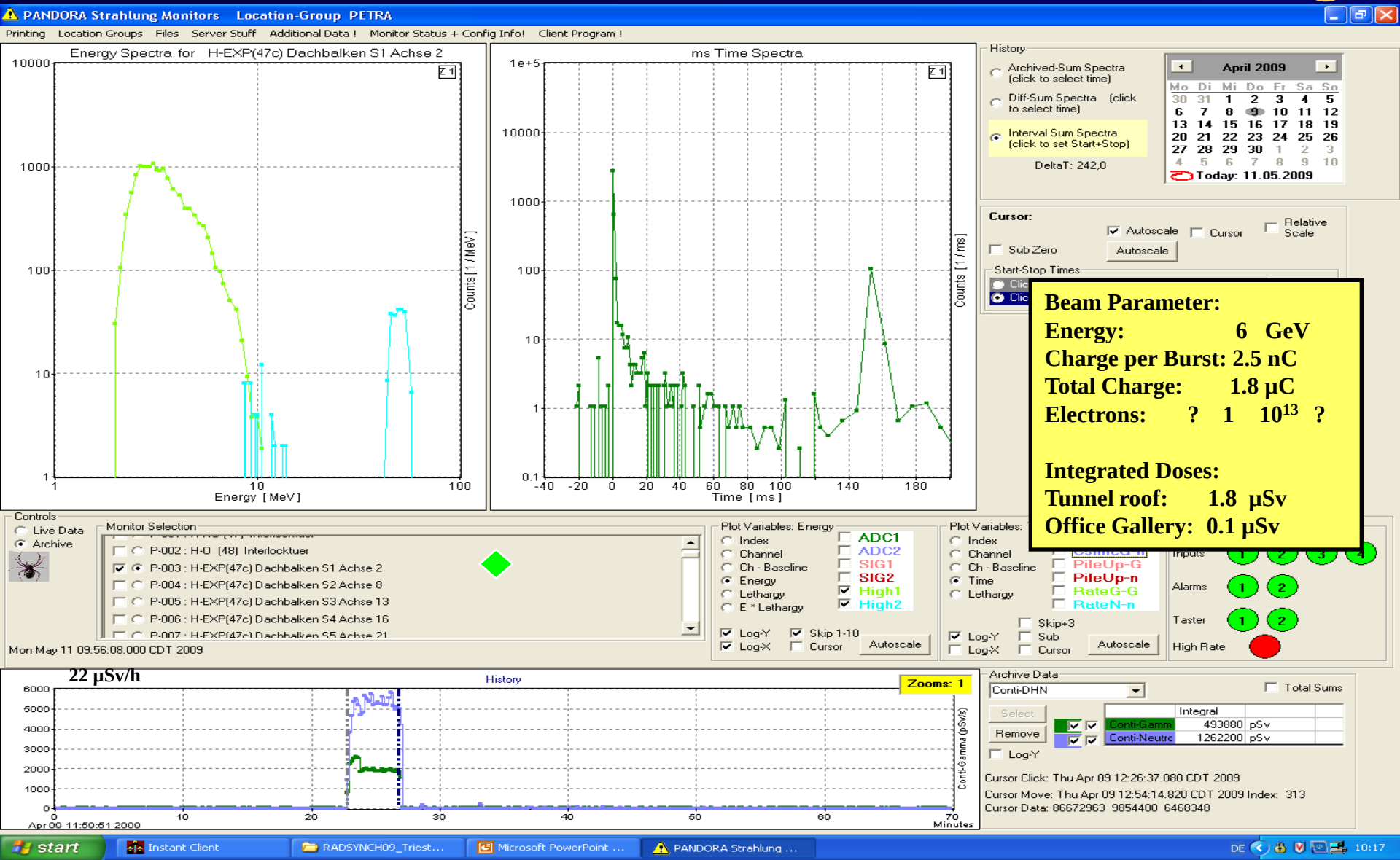
Neutron Bursts from a Electron Beam Dump (~ 1 GeV) behind Shielding



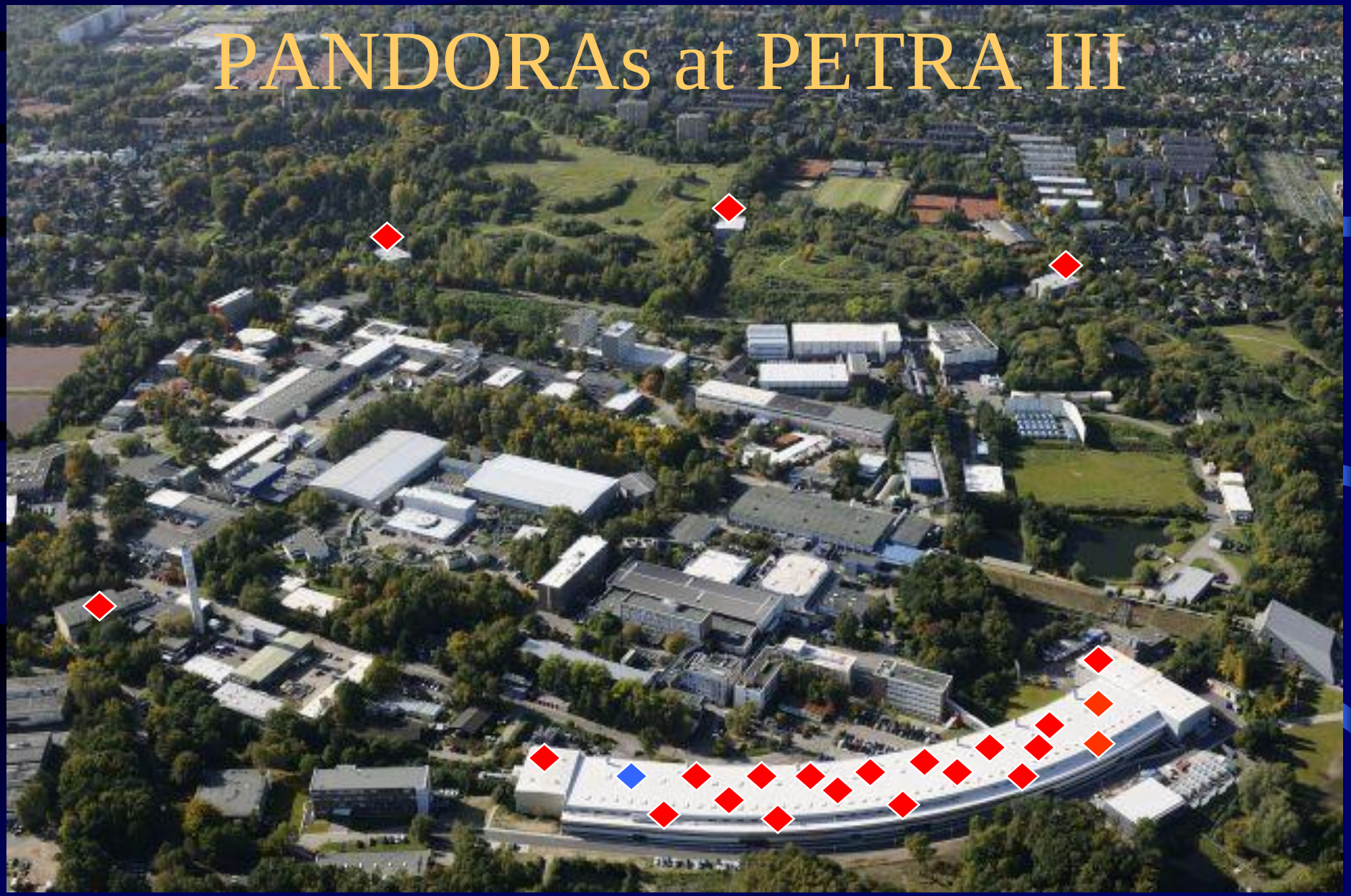
PANDORA at PETRA III



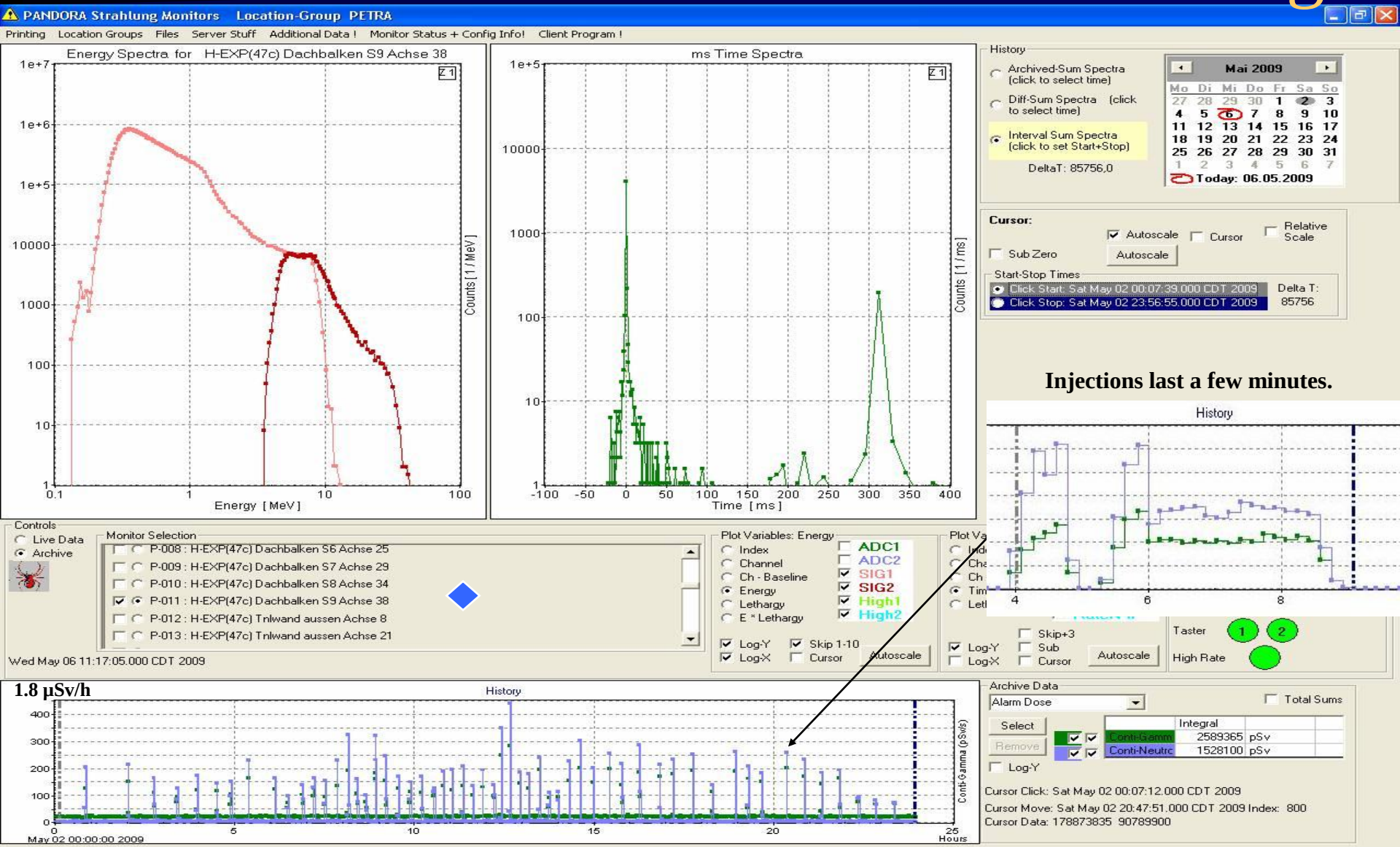
Beam Losses in Sector 2 from Injections in PETRA III measured on Roof Shielding



PANDORAs at PETRA III



Beam Losses in Sector 9 from Injections in PETRA III measured on Roof Shielding



PANDORA's Alarm Modus at PETRA

No alarm: **Monitor only, not connected to a hard wired interlock system**

Soft alarm: **Monitor works properly**
AND
an alarm is detected

Hard alarm: **Monitor does not work properly**
OR
an alarm is detected

Pandora's Action on PETRA III

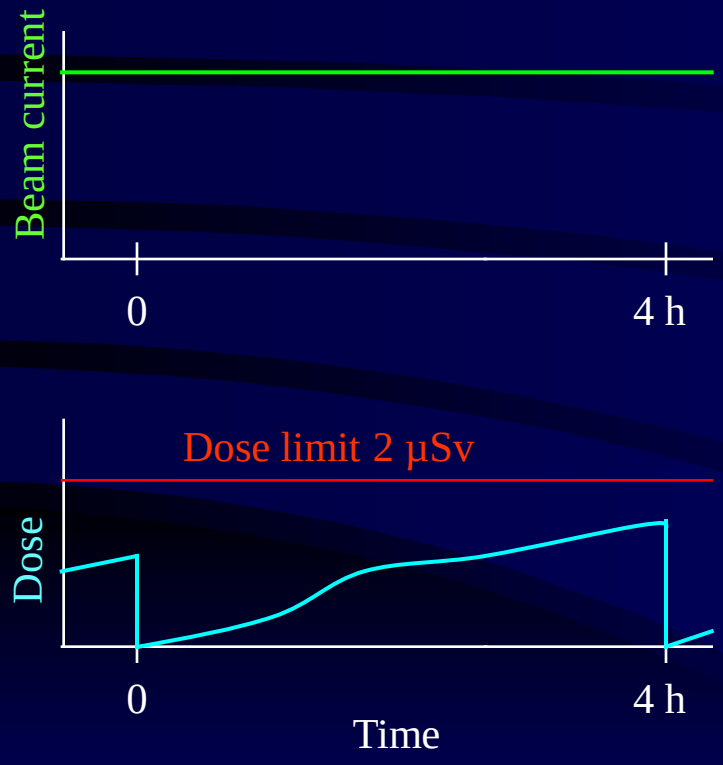
ESRF modus adopted:

Act on the beam injection but not on the stored beam.

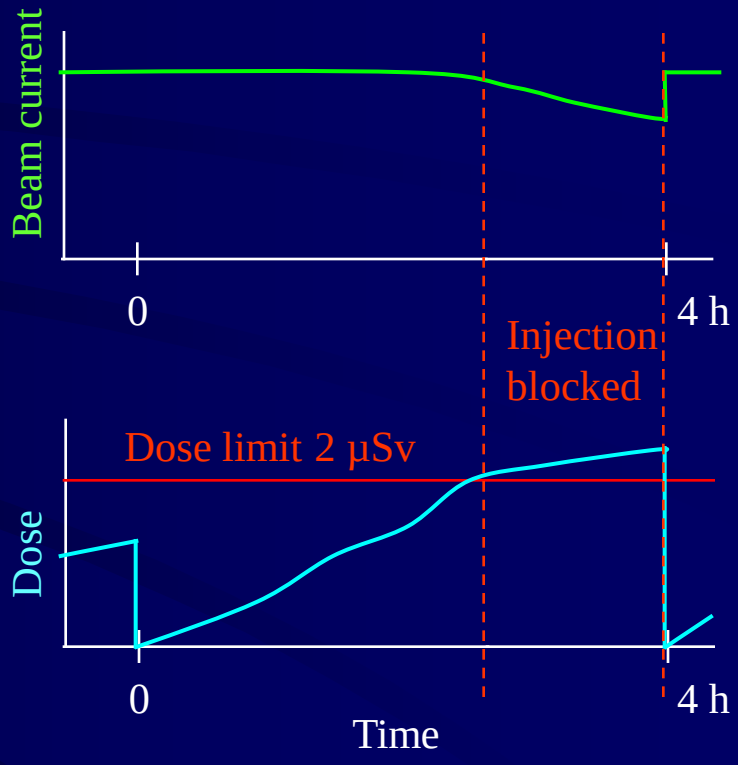
The experimental hall is a surveyed area. Personal doses are not measured. As the experiments typically take a few hours an ambient dose limit of 2 µSv per 4 h (1 mSv per 2000 h) must be guaranteed. In case of exceeding the dose limit the injection is blocked until the next 4 hour interval starts.

Action on PETRA III

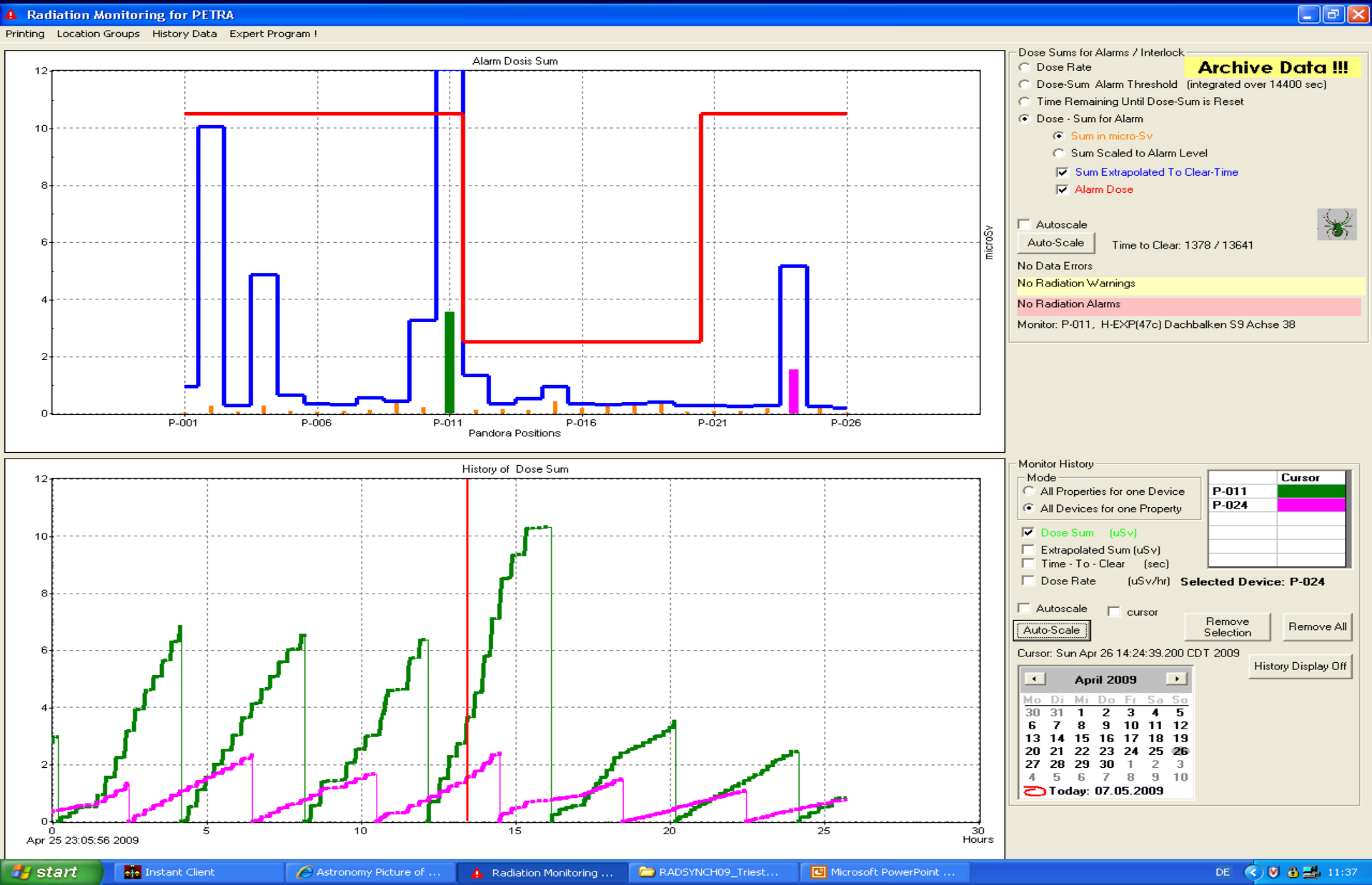
Case: „Below limit“



Case: „Above limit“



Operators Look And Feel



OUTLOOK

- Setup the table of specifications: dose and dose rate ranges, dead time behavior, sensitivities
- Implement burst dose on board
- Measurement and calculation of the energy response functions
- Upgrade FLASH with PANDORA

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Appendix

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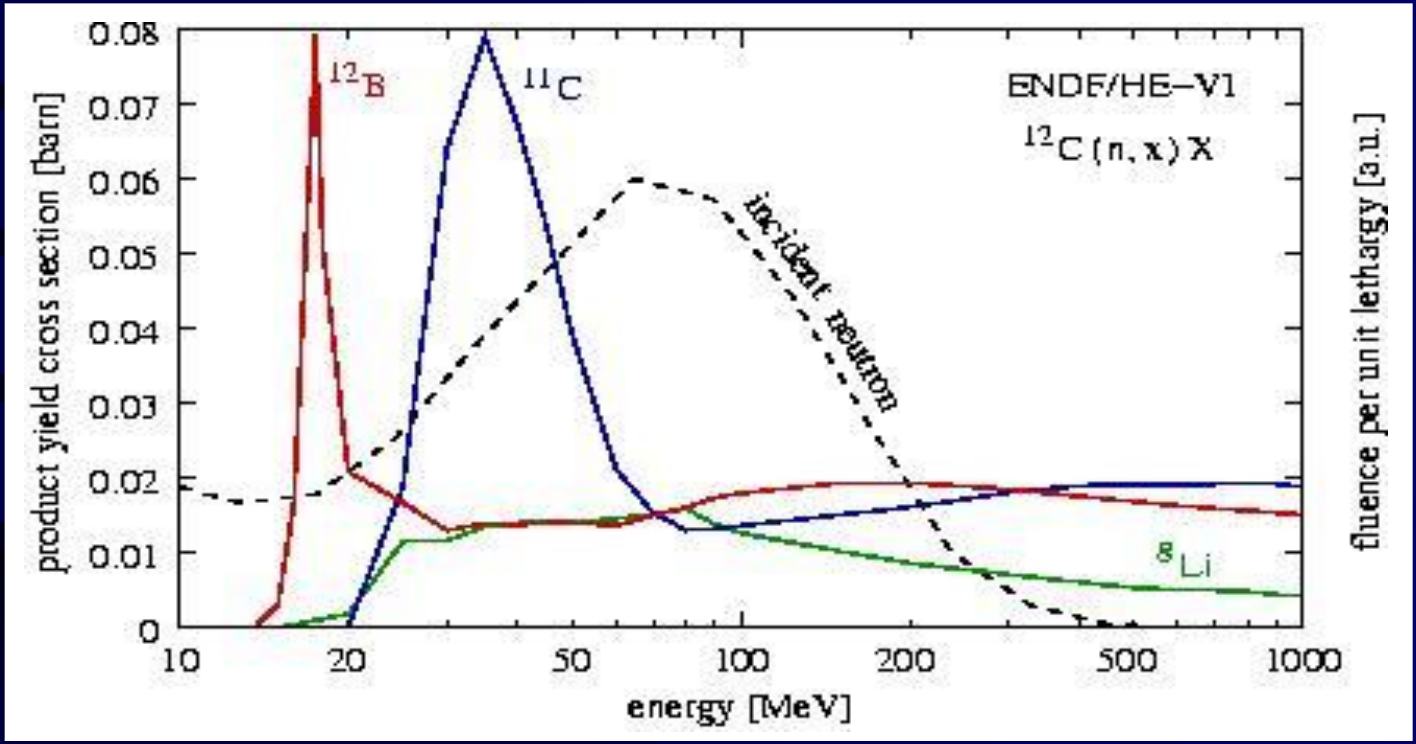
Production yield cross-sections of neutrons on ^{12}C



- - - - - - Neutron fluence spectrum from a 30 GeV electron beam on a thick target behind 80 cm lateral concrete shielding