

RADSYNCH09, May 2009, ELETTRA, Trieste

# 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 (Γαίη – 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]

5/25/2009

Albrecht Leuschner et al.



# PANDORA

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

Monitoring via Ethernet.

Interlock-Functionality by 2 Relays.

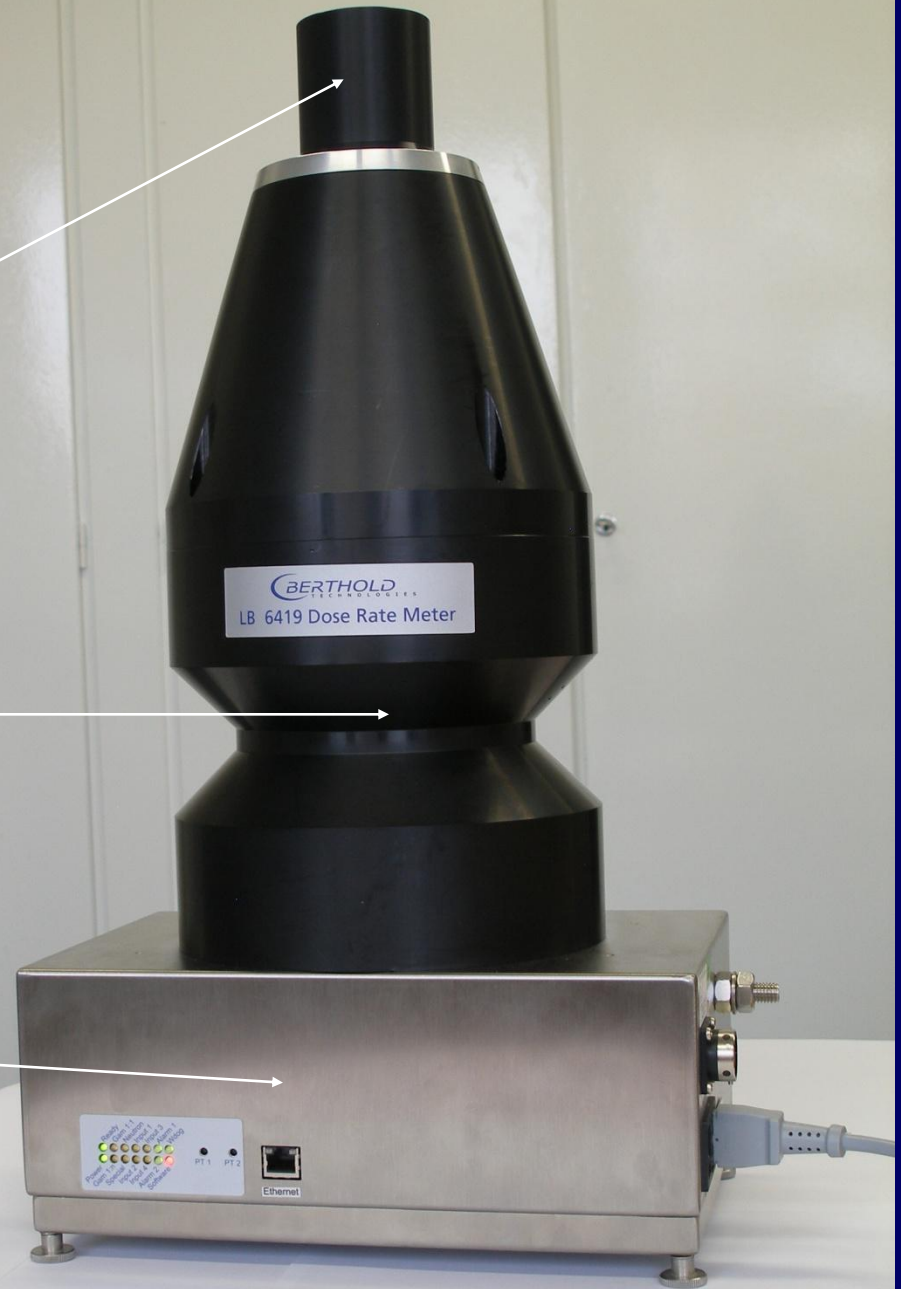


# Detector

Plastik - Scintillator  
in a 1 cm PE cover

$^3\text{He}$  - Counter  
rem - counter type

Electronics- Box  
Power supplies  
FADCRMON board (SIS)



# Detector - Concept

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

# Detector - Concept

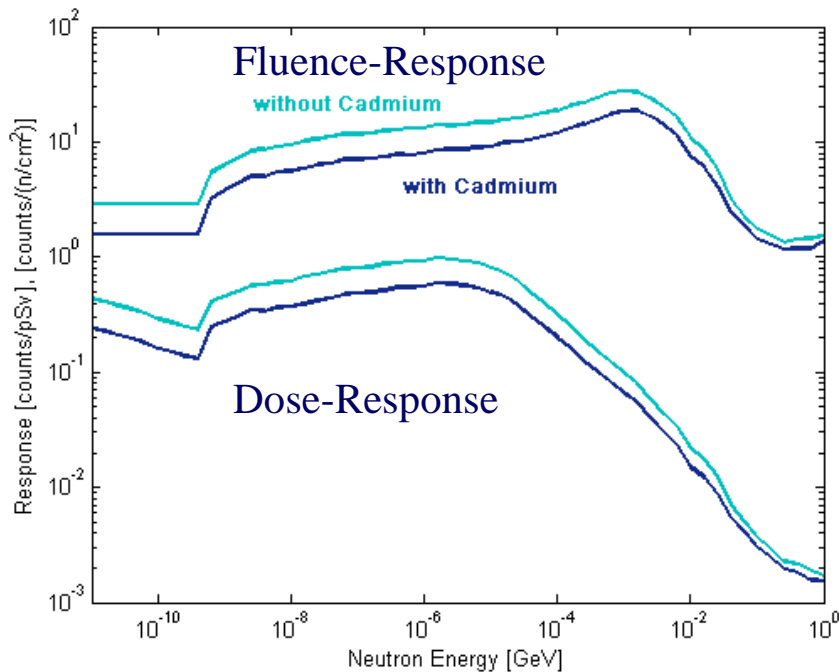
Time Structure		Continuous	Burst sequence
Type of Radiation			
Neutrons	High - energy > 20 MeV		
	Low - energy < 20 MeV thermal	<u><sup>3</sup>He Counter /</u> <u>Scintillator</u>	
Photons	Bremsstrahlung > 2 MeV		
	$\gamma$ - Radiation		
	Synchrotron Radiation		

# Response to Neutrons

Calculated by means of the Monte Carlo Code FLUKA

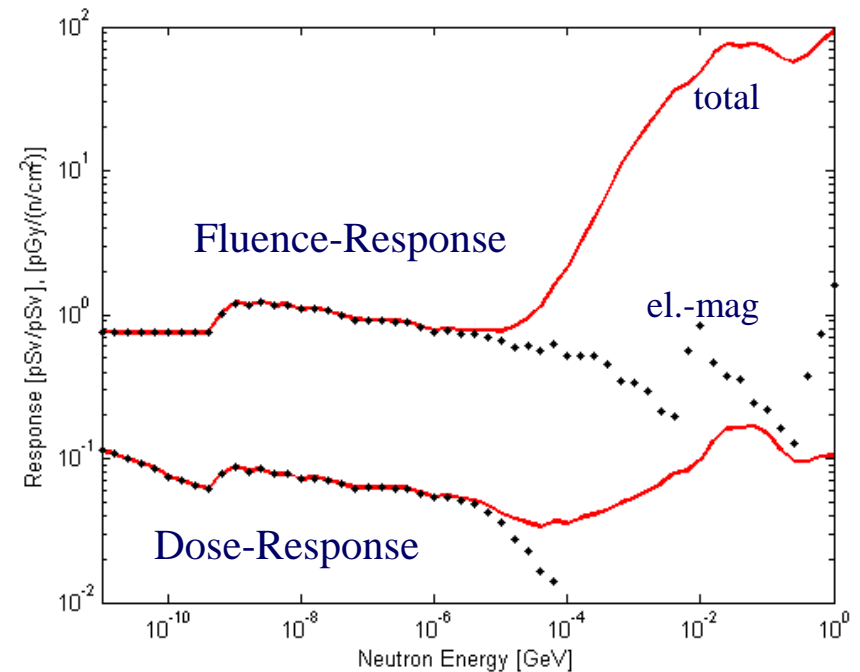
## <sup>3</sup>He Counter

counts = number of  $^3\text{He}(n,p)^3\text{T}$  reactions



## Scintillator

Energy dose = Energy deposited in the scint.



# Detector - Concept

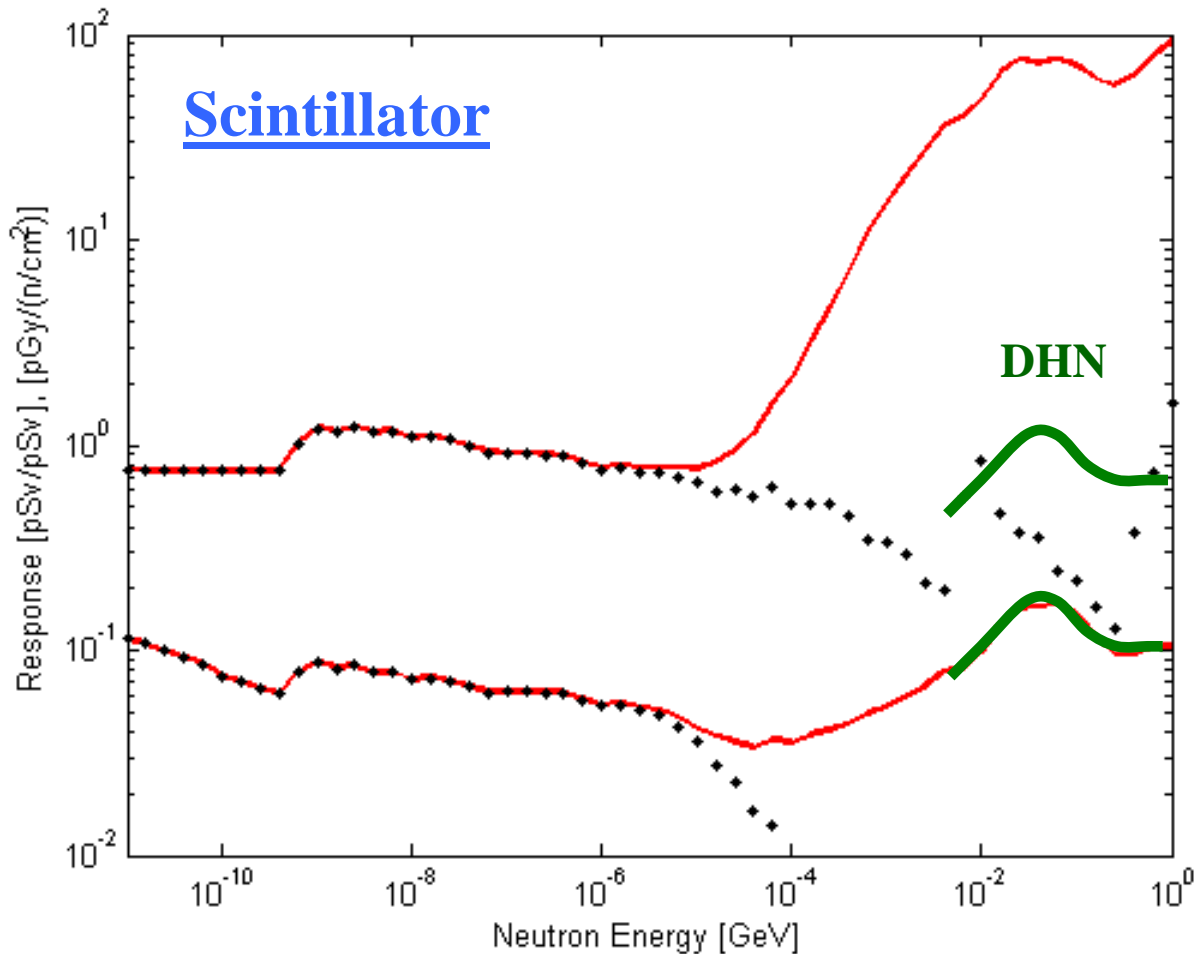
Time Structure		Continuous	Burst sequence
Type of Radiation			
Neutrons	High - energy > 20 MeV	<u>Scintillator</u> Pulse height > MIP Recoil Protons	
	Low - energy < 20 MeV thermal		
Photons	Bremsstrahlung > 2 MeV		
	$\gamma$ - Radiation		
	Synchrotron Radiation		



# 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

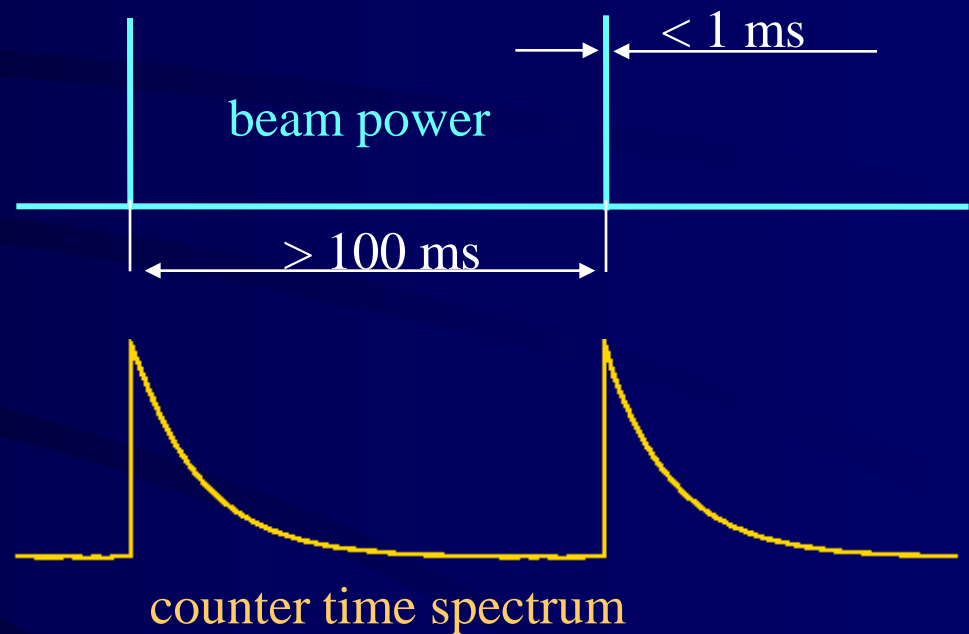
# Detector - Concept

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

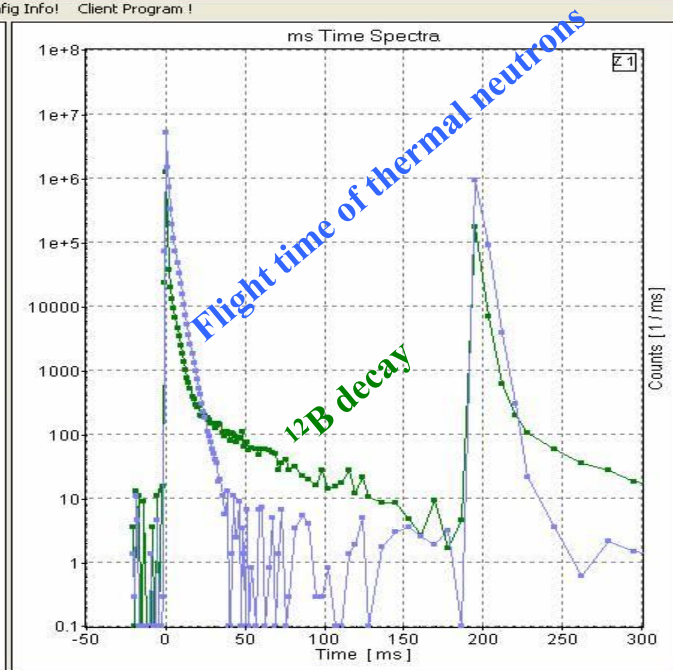
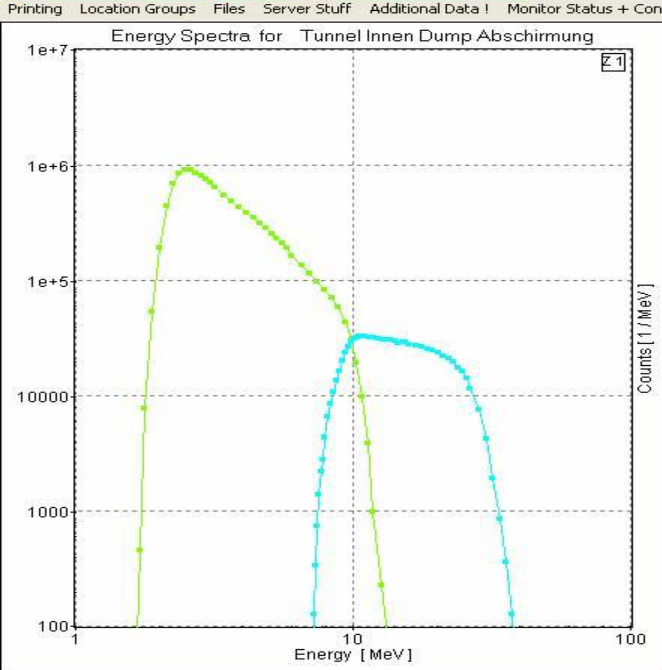
1. Neutrons are **moderated** in the Polyethylene body of the rem-counter. 0.1 ms
2. Thermal neutrons are **transported** from the source region to the detector with their speed of 2.2 m/ms. 2 ms
3. **High-energy n/ $\gamma$  - radiation produce radioactive nuclides in the detector** > 20 ms

# Production and Decay Data

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

\* cross-section taken @ neutron energy 100 MeV

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



History

- Archived-Sum Spectra (click to select time)
- Diff-Sum Spectra (click to select time)
- Interval Sum Spectra (click to set Start+Stop)

DeltaT: 85561,0

April 2009						
Mo	Di	Mi	Do	Fr	Sa	So
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3
4	5	6	7	8	9	10

Today: 06.05.2009

Cursor:

Autoscale  Cursor  Relative Scale

Sub Zero

Start-Stop Times

Click Start: Sun Apr 26 00:04:15.000 CDT 2009 Delta T: 85563

Click Stop: Sun Apr 26 23:50:18.000 CDT 2009

Duty factor: 0.001

Controls

Live Data  Archive

Monitor Selection

- F-050 : H-3 (28) Innen Bunch Compr 3 bei xy m
- F-051 : H-3 (28) Aussen Bunch Compr 3
- F-052 : Geb.(49) Raum xy
- F-053 : Tunnel Innen Dump Abschirmung

Plot Variables: Energy

- Index
- Channel
- Ch - Baseline
- Energy
- Lethargy
- E \* Lethargy

Log-Y  Skip 1-10  Cursor

Plot Variables: Time

- Index
- Channel
- Ch - Baseline
- Time
- Lethargy

Skip+3  Sub  Cursor

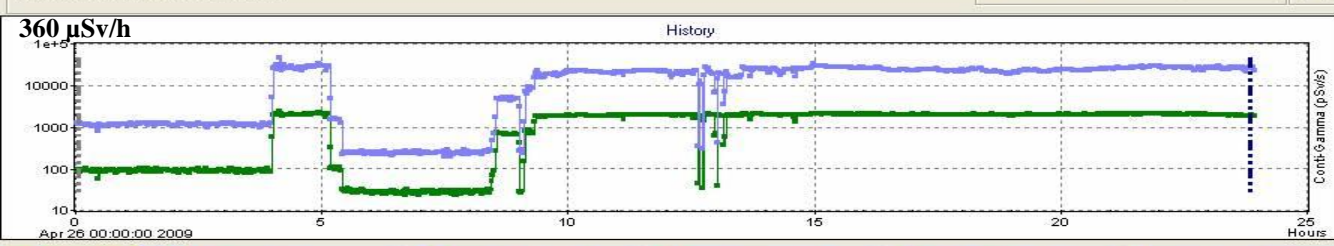
Alarm Status

Inputs: 1 2 3 4

Alarms: 1 2

Taster: 1 2

High Rate: [Red Circle]



Archive Data

Alarm Dose [Dropdown]  Total Sums

Select	Remove	Integral	
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Conti-Gamma	1.1422E+08 pSv
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Conti-Neutro	1.3742E+09 pSv

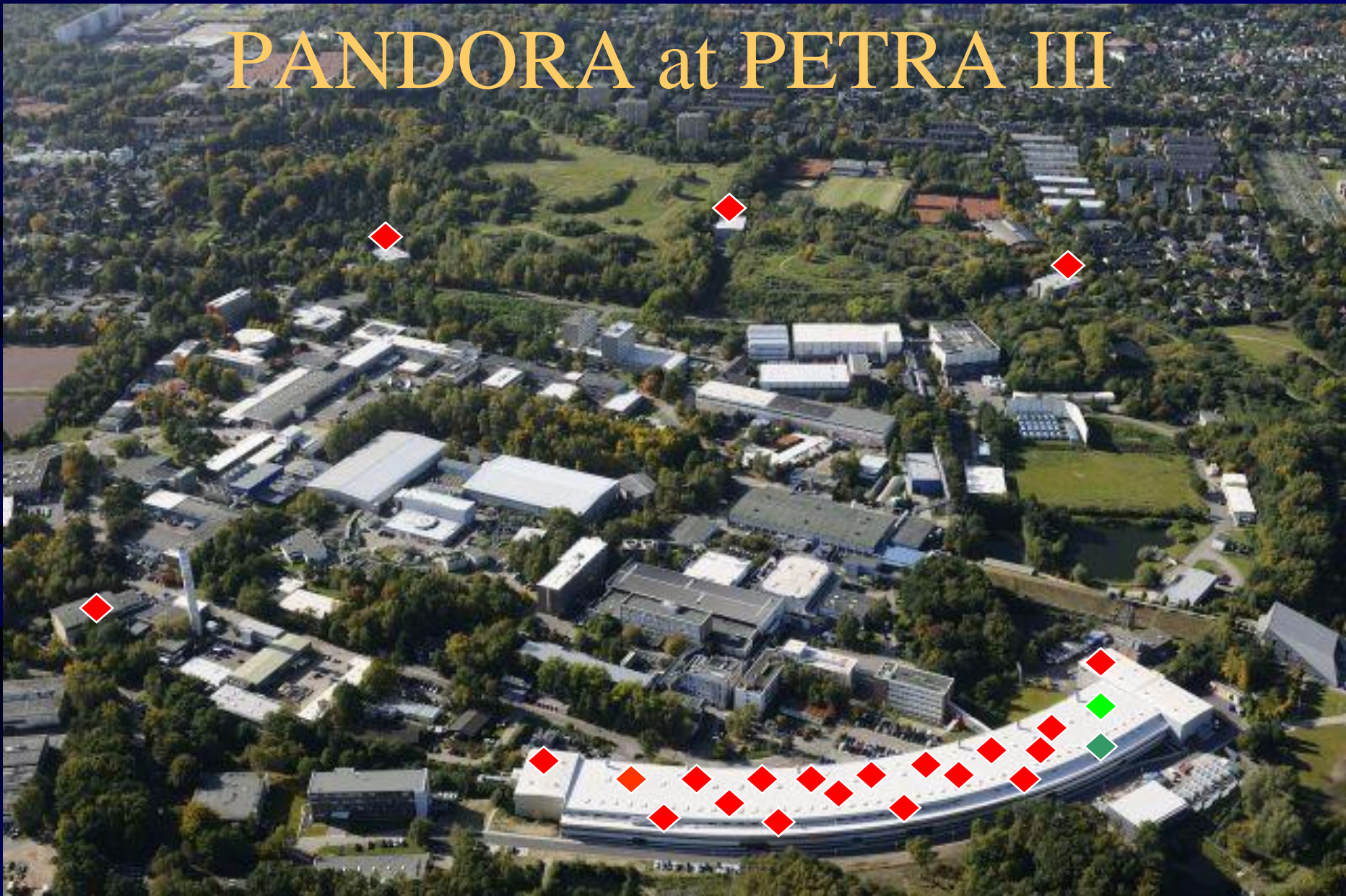
Log-Y

Cursor Click: Sun Apr 26 00:03:36.000 CDT 2009

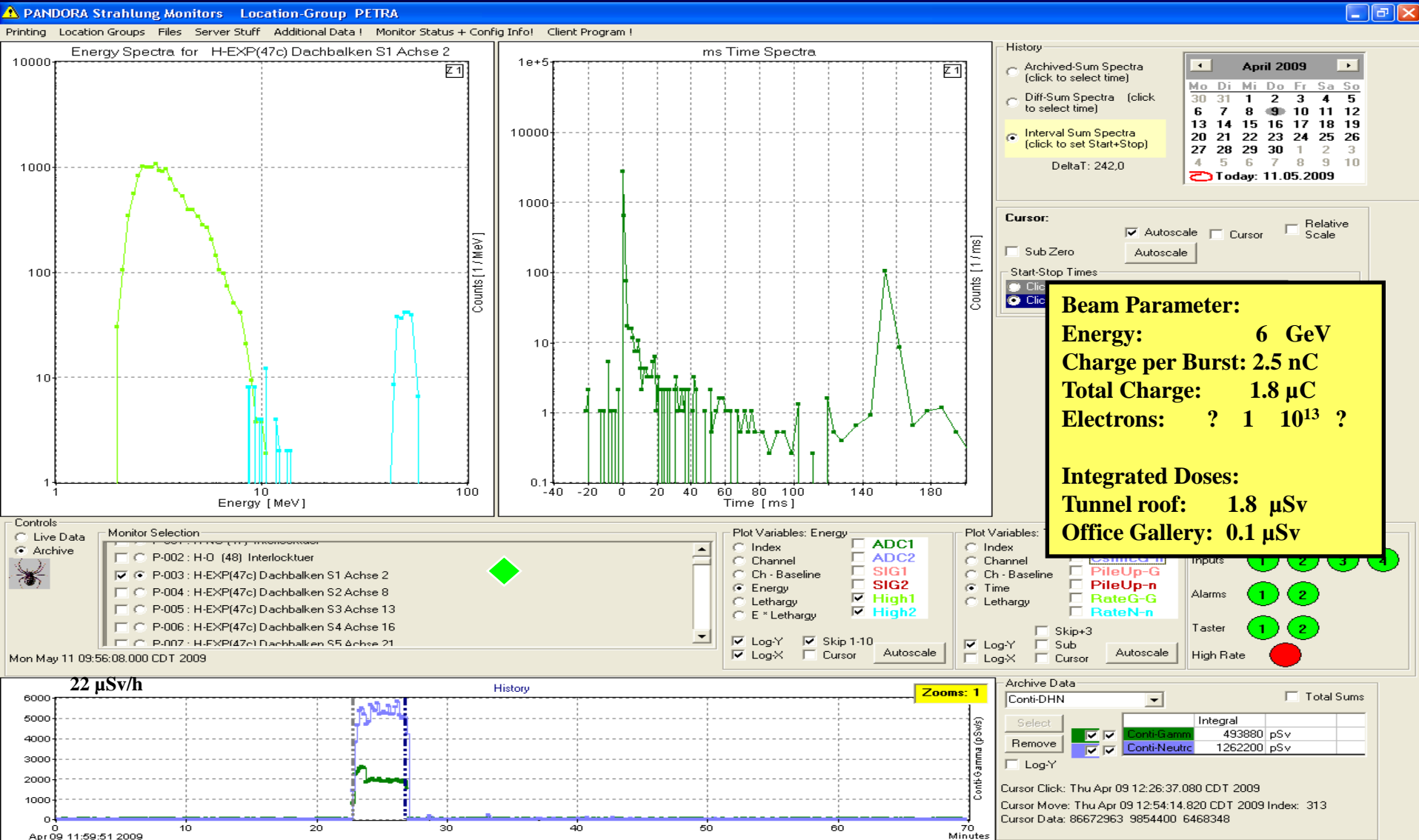
Cursor Move: Sun Apr 26 01:53:15.000 CDT 2009 Index: 71

Cursor Data: 2918240880 54511645300

# PANDORA at PETRA III

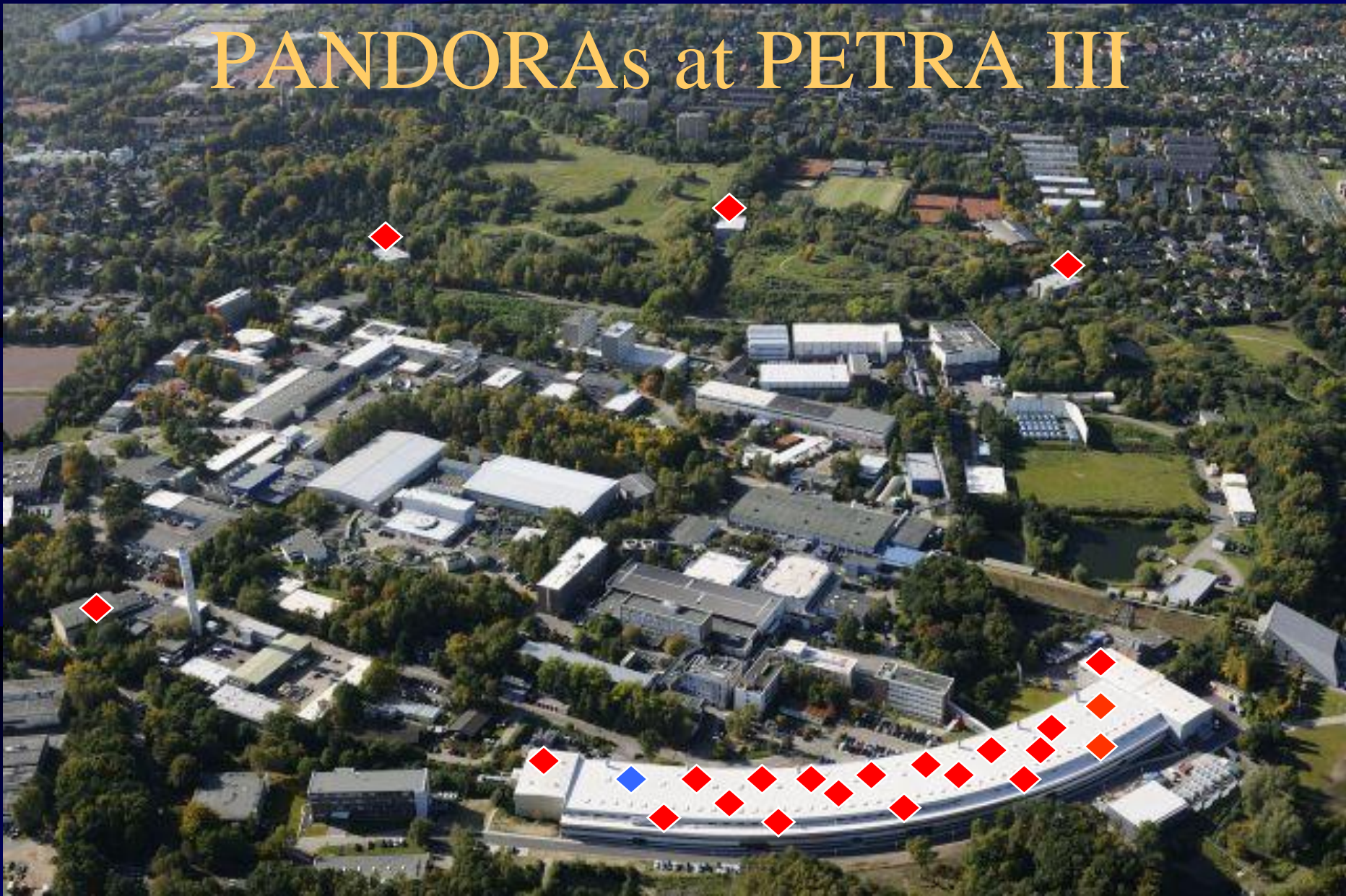


# Beam Losses in Sector 2 from Injections in PETRA III measured on Roof Shielding

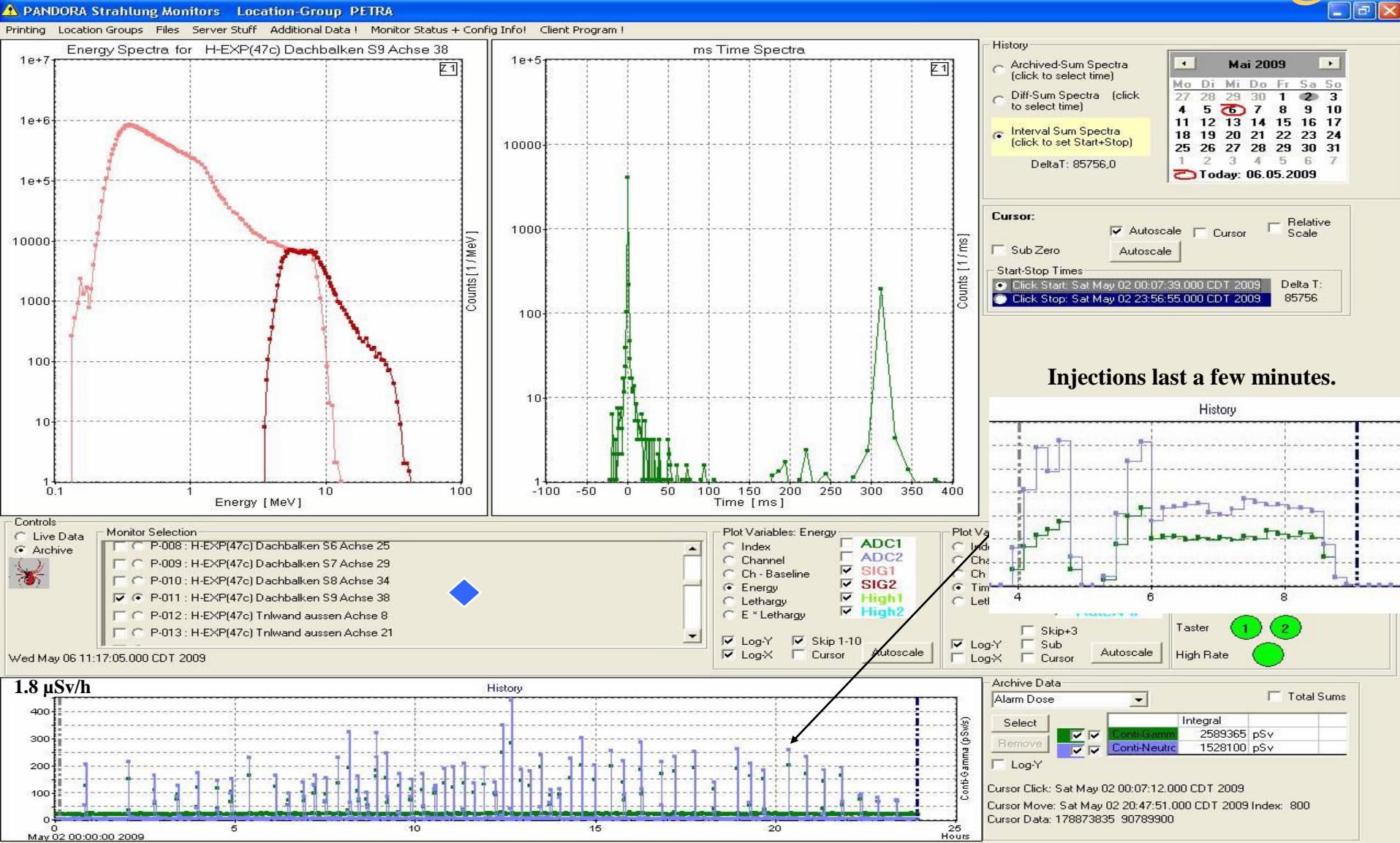




# PANDORAs at PETRA III



# 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

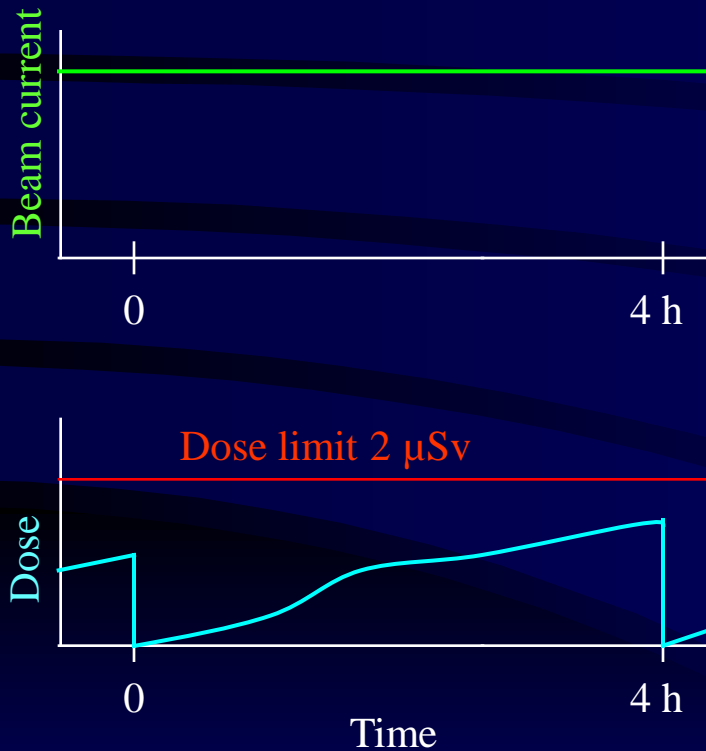
ESRF modus adopted:

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

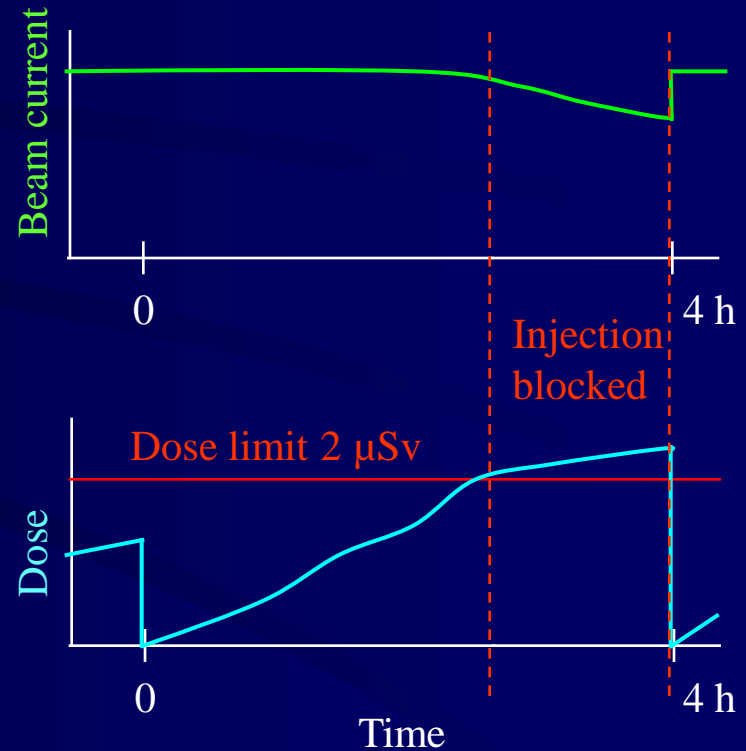
The experimental hall is a surveyed area. Personal doses are not measured. As the experiments typically take a few hours an ambient dose limit of  $2 \mu\text{Sv}$  per 4 h (1 mSv per 2000 h ) must be guaranteed. In case of exceeding the dose limit the injection is blocked until the next 4 hour interval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

# Action on PETRA III

Case: „Below limit“



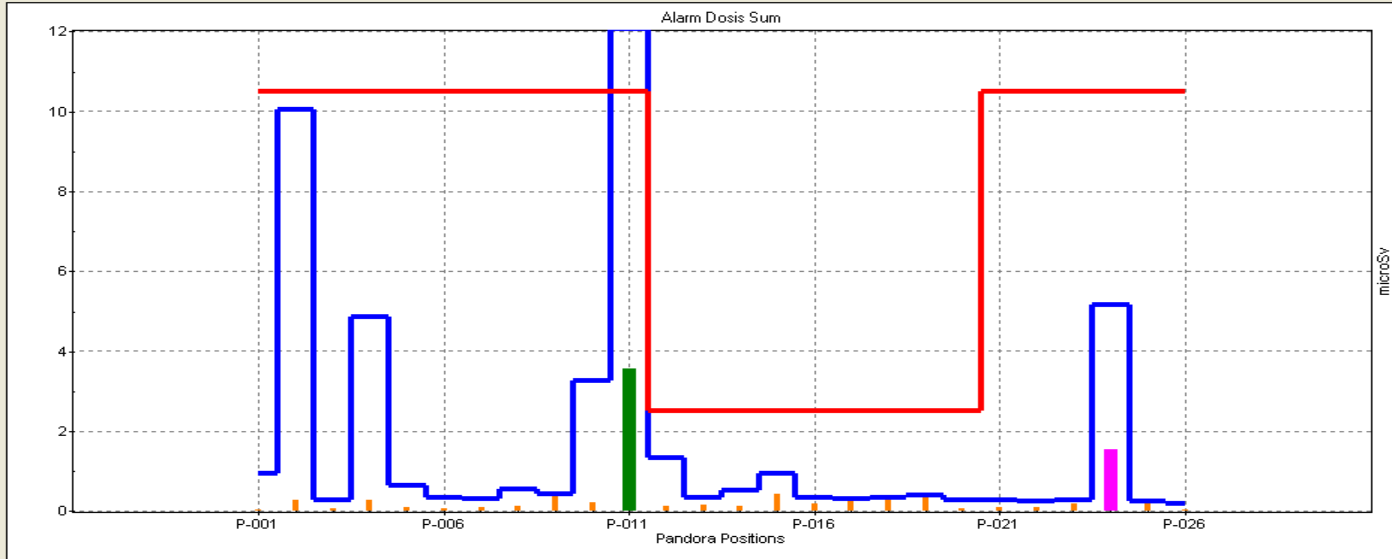
Case: „Above limit“



# Operators Look And Feel

Radiation Monitoring for PETRA

Printing Location Groups History Data Expert Program !



Dose Sums for Alarms / Interlock

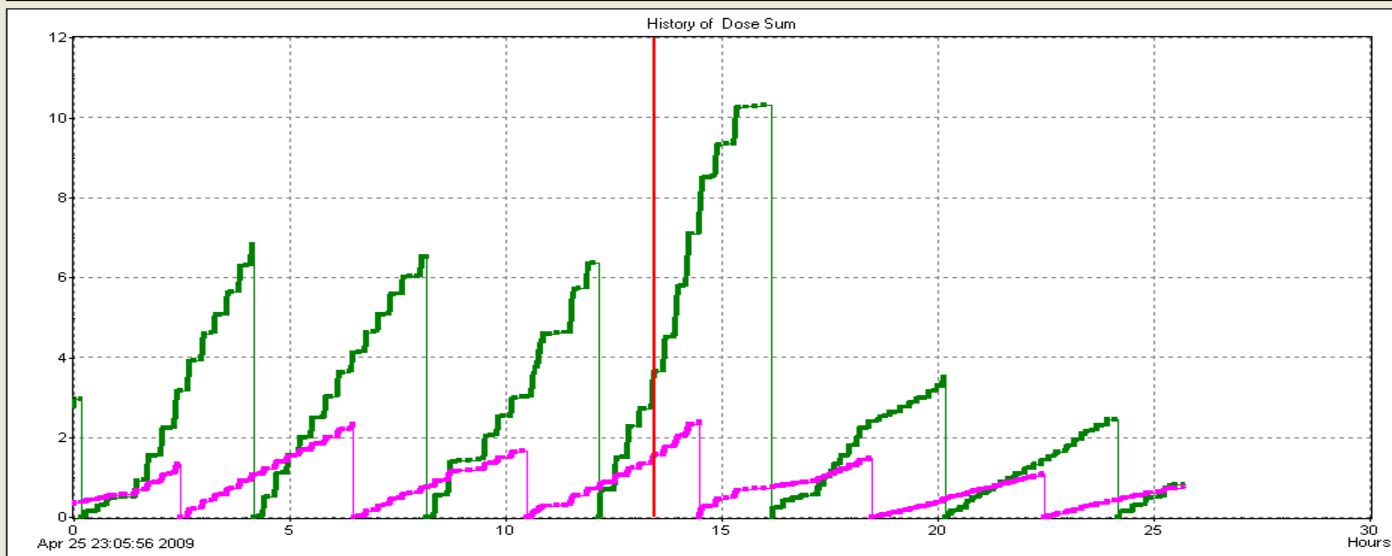
- Dose Rate
- Dose-Sum Alarm Threshold (integrated over 14400 sec)
- Time Remaining Until Dose-Sum is Reset
- Dose - Sum for Alarm
  - Sum in micro-Sv
  - Sum Scaled to Alarm Level
  - Sum Extrapolated To Clear-Time
  - Alarm Dose

**Archive Data !!!**

Autoscale  
 Auto-Scale Time to Clear: 1378 / 13641



No Data Errors  
 No Radiation Warnings  
 No Radiation Alarms  
 Monitor: P-011, H-EXP(47c) Dachbalken S9 Achse 38



Monitor History

- Mode
  - All Properties for one Device
  - All Devices for one Property
- Dose Sum (uSv)
- Extrapolated Sum (uSv)
- Time - To - Clear (sec)
- Dose Rate (uSv/hr)

	Cursor
P-011	
P-024	

Autoscale  cursor  
 Auto-Scale  
 Remove Selection Remove All

Cursor: Sun Apr 26 14:24:39.200 CDT 2009  
 History Display Off

April 2009						
Mo	Di	Mi	Do	Fr	Sa	So
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3
4	5	6	7	8	9	10

Today: 07.05.2009

# 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

# Detector - Concept

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	Low - energy < 20 MeV thermal	<u><math>^3\text{He}</math> Counter</u> / <u>Scintillator</u>	<u><math>^3\text{He}</math> Counter</u> : TOF <u>Scintillator</u> : TOF capt. $\gamma$
Photons	Bremsstrahlung > 2 MeV	<u>Scintillator</u> Pulse height < MIP	<u>Scintillator</u> : $^{13}\text{C}(\gamma,p)^{12}\text{B}$
	$\gamma$ - Radiation Synchrotron Radiation		



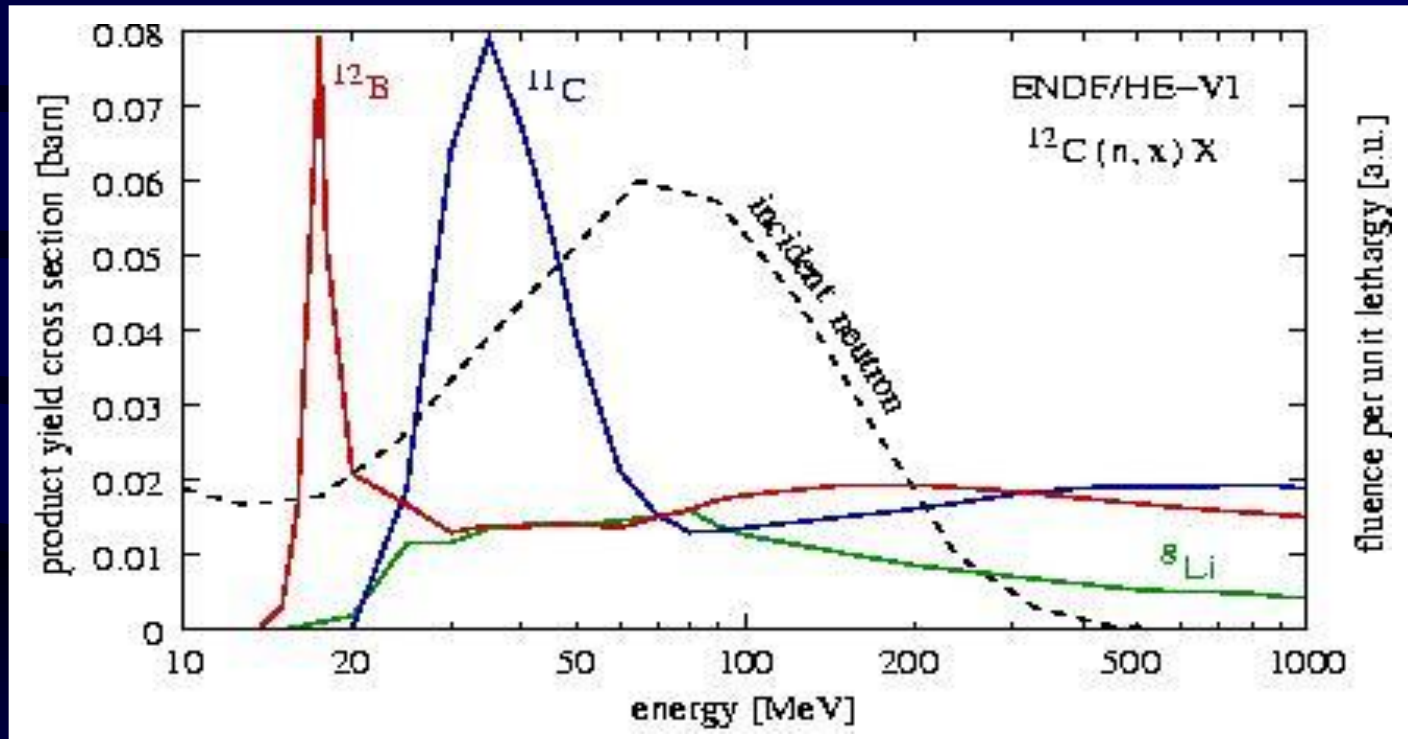
# Appendix

# Production and Decay Data

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\* cross-section taken @ neutron energy 100 MeV

# Production yield cross-sections of neutrons on $^{12}\text{C}$



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