

The MEGAPIE Operation Synthesis

by
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Spallation Neutron Source Division
Paul Scherrer Institute, Switzerland

on behalf of the MEGAPIE collaboration
and the operation team at PSI

MEGAPIE

A liquid metal target for SINQ



MEGAwatt Pilot Experiment:

- Joint international initiative to design, build, licence, operate and explore a liquid metal*) spallation target for 1 MW beam power

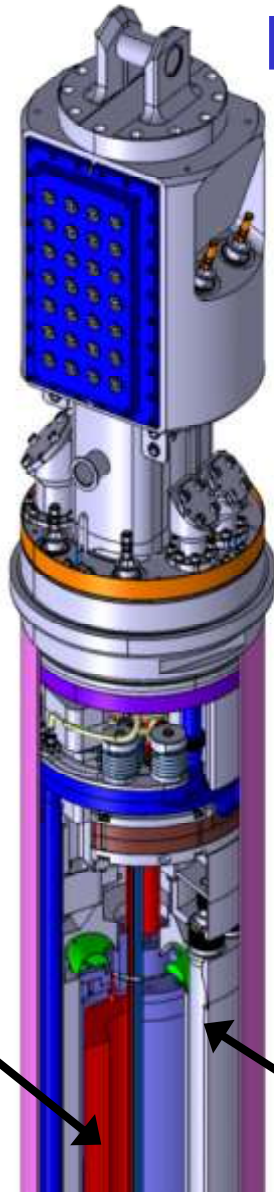
- *) Lead-Bismuth-Eutectic (LBE)
 $T_m=125^\circ\text{C}$

Goals of MEGAIE:

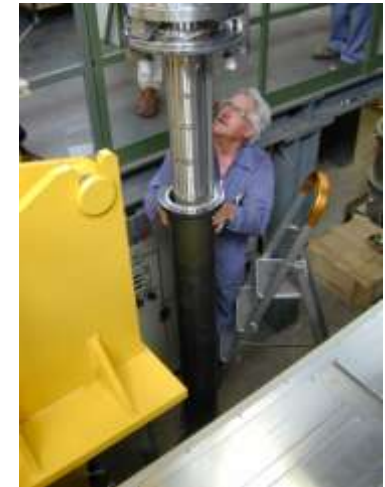
- Increase the neutron flux at SINQ
- Demonstrate the feasibility of a liquid metal target for high-power spallation and ADS applications

MEGAPIE target features

target head



lower target assembly



central flow guide tube



electro-magnetic pumps

heat exchanger

safety hull



beam window

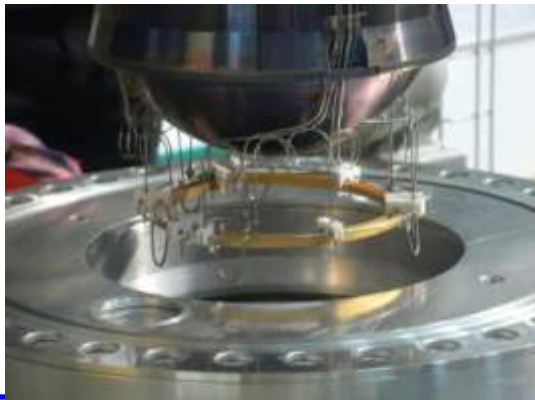
final
assembly



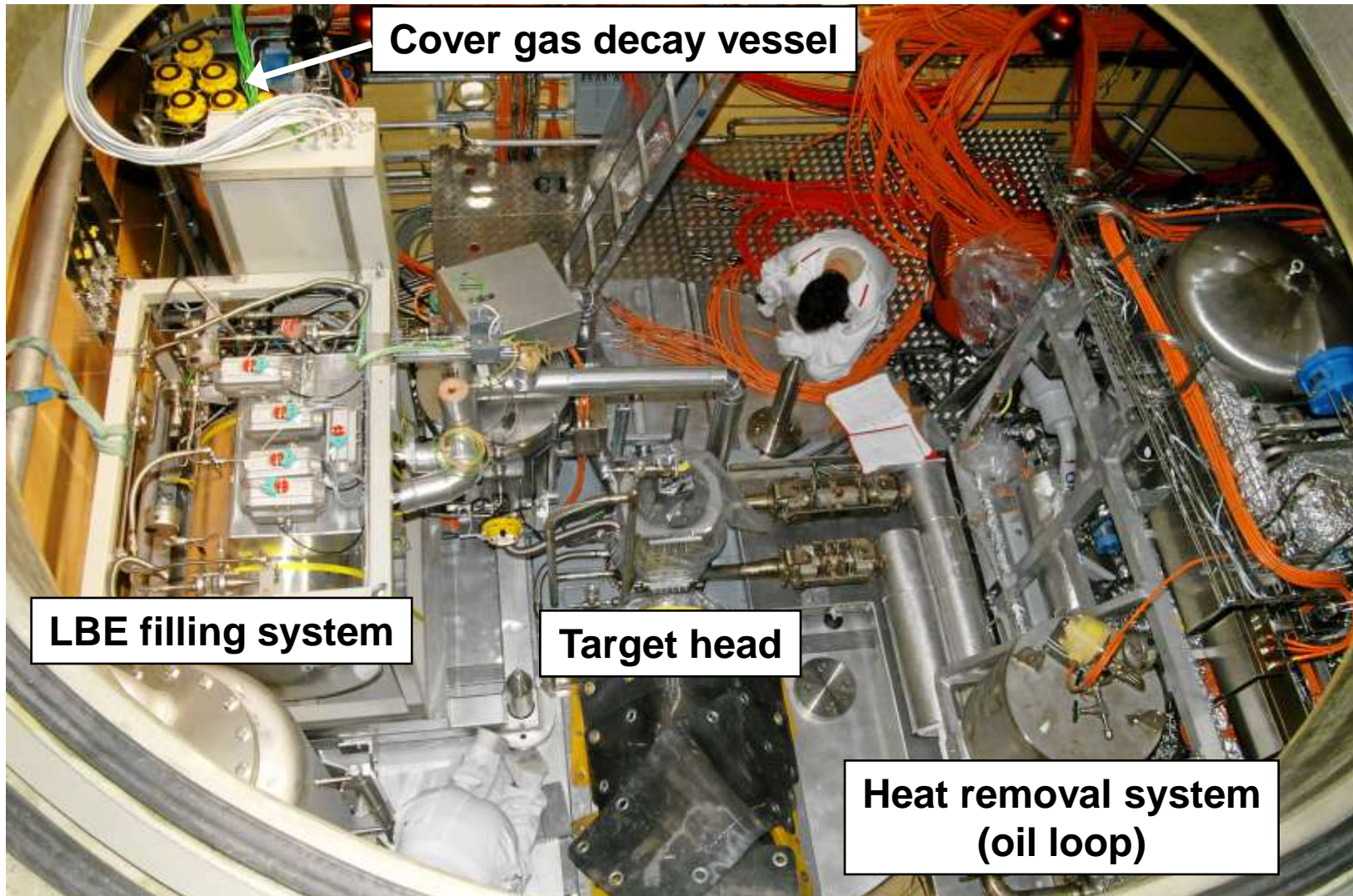
inserting the target into SINQ
with the exchange flask



LBE leak
detector:
last view

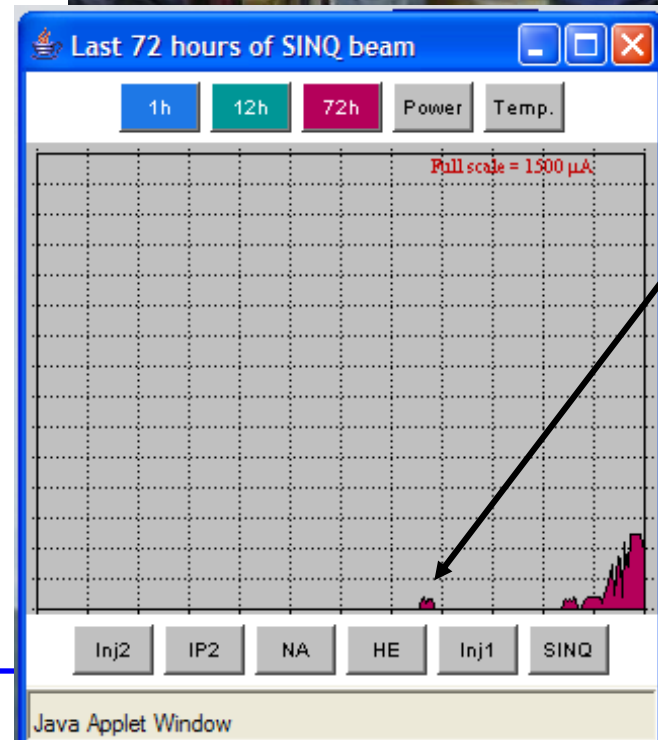


View into the TKE (May 2006)



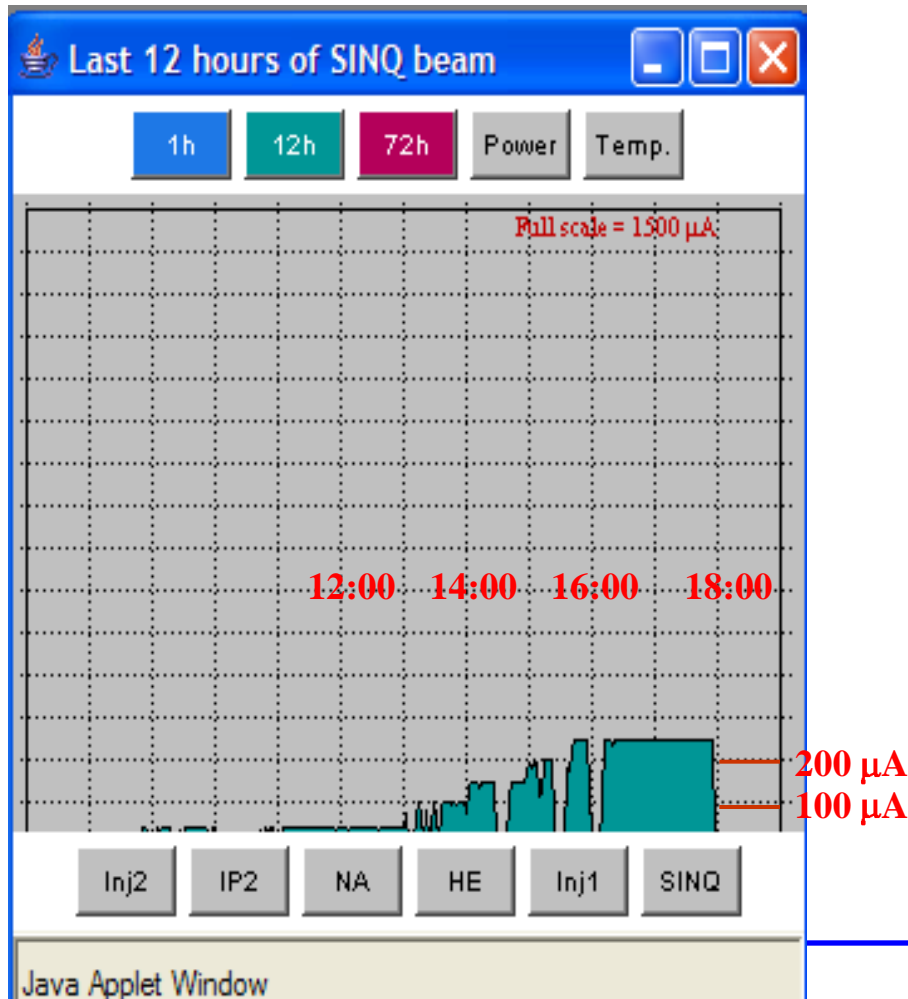
MEGAPIE start-up and beam-on operation

Start-up: First beam on Target: Aug. 14, 2006

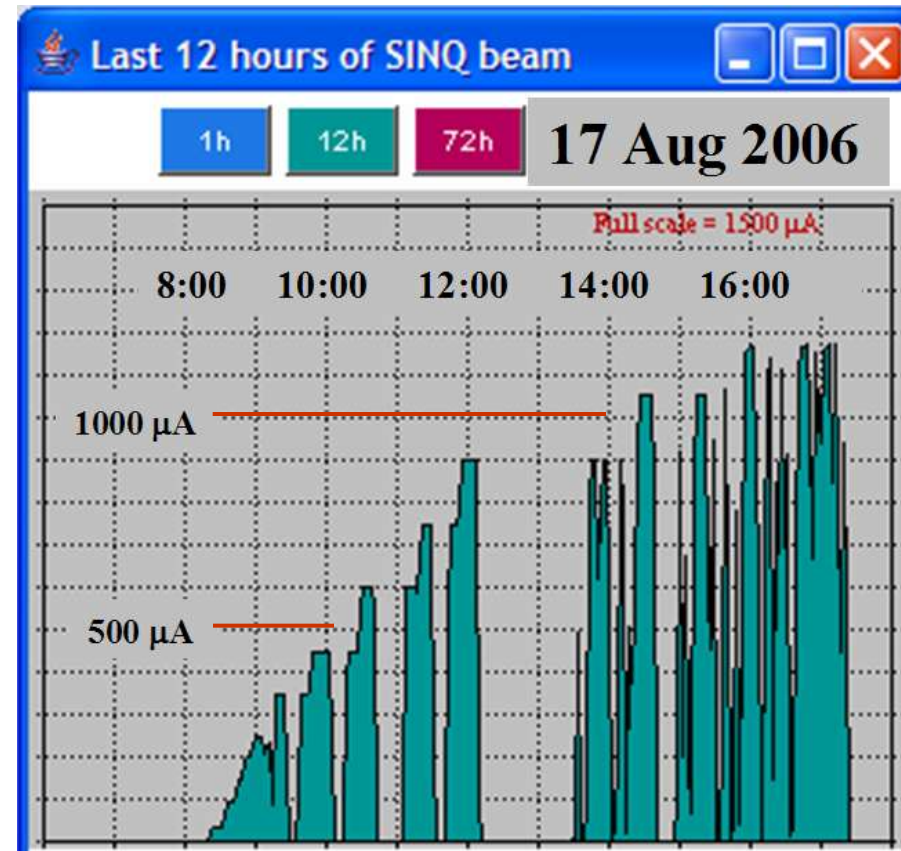


MEGAPIE start-up (cont.)

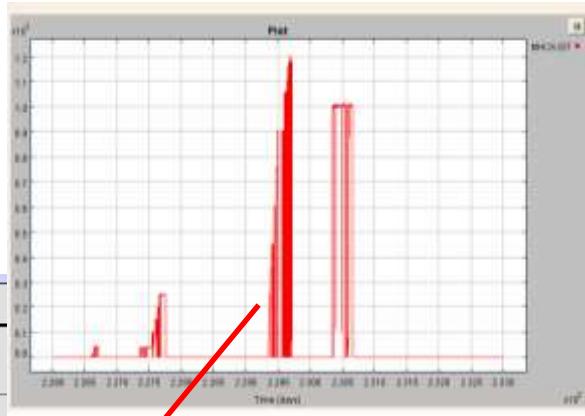
Phase 2: Tue., Aug 15, 2006



Phase 3: Thu., Aug 17, 2006

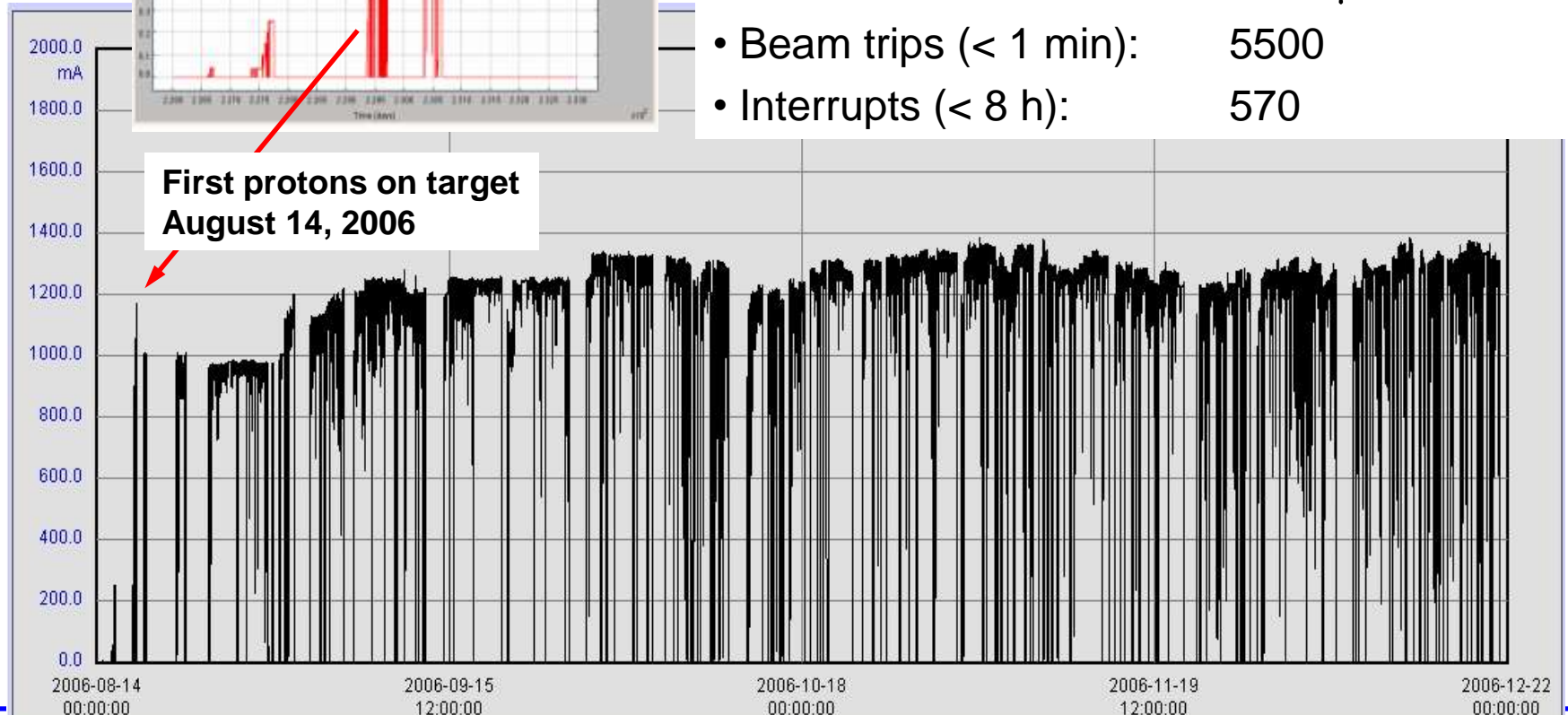


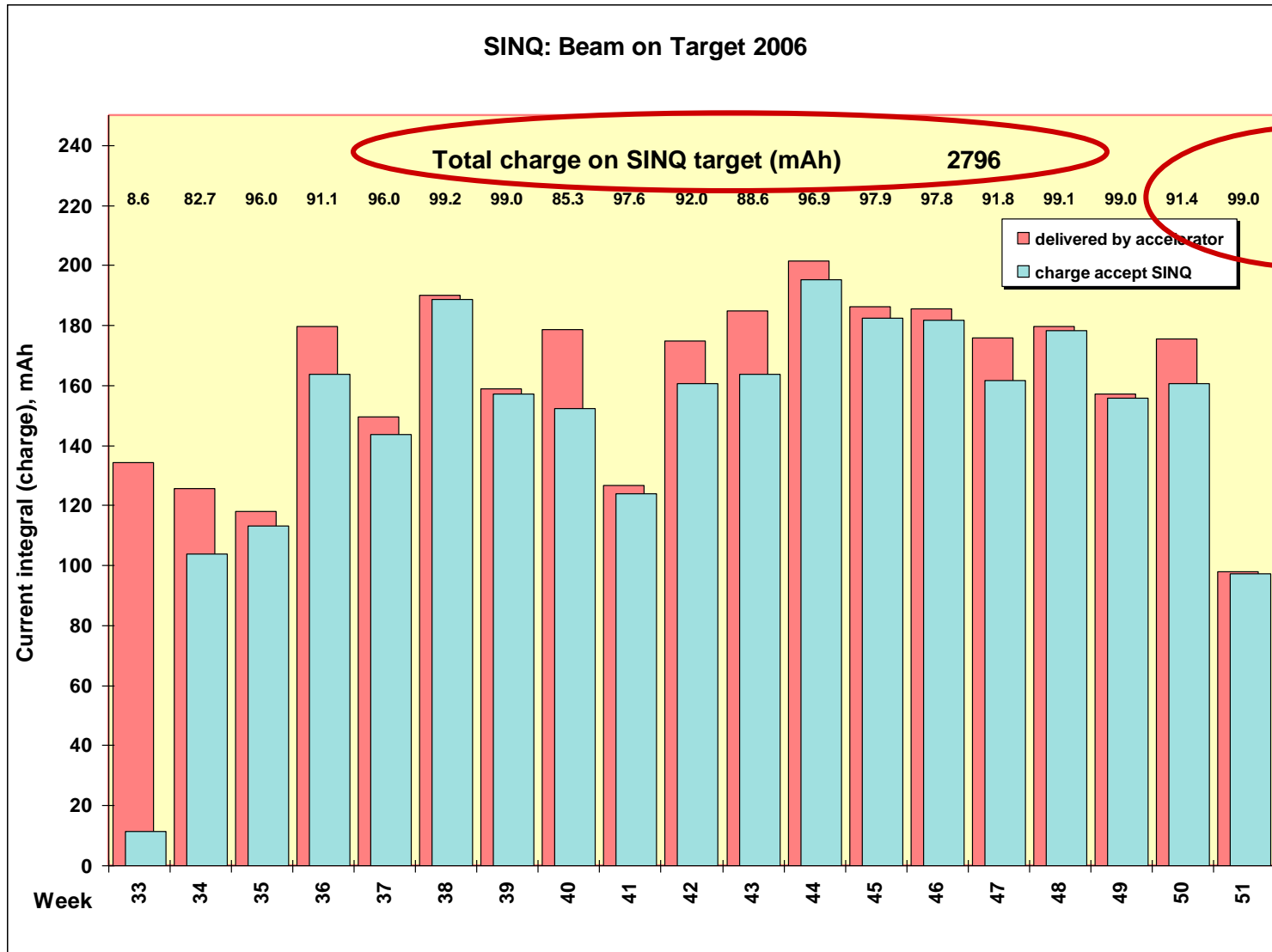
MEGAPIE Target Operation: full history



On beam: August 14 – December 21, 2006

- Accumulated charge: 2.8 Ah
- Peak Current: 1400 μA
- Beam trips (< 1 min): 5500
- Interrupts (< 8 h): 570





1RNQ55	°C
CT003	30.2
CT004	83.9
CT007	35.7
CT006	29.8
CT006	46.2
CT008	106.8

Del Leak I

1RNQ52	°C
CT020	
Sollwert H	BH001

XANA

INDUMO SOFTWARE & ENGINEERING AG

MP_1RNQ51_FT003 Temperatur Mittelwert

Zustand

GW-Überw. Eingeschaltet

Befehle

Störung quittieren [SF8]

Ersatzwert AUS [SF7]

Ersatzwert EIN [SF6]

Grenzwerte

HH [SF4]	1'372.00
H [SF3]	1'372.00
L [SF2]	-270.00
LL [SF1]	-270.00

Ersatzwert

EW [SF5]	199.94
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242.47 °C

MP_TREND.MP_LMT.LMT_199F

Level Detektor

1RNQ51	Z	LBE	Sollwert Heizung
T045	408.0	HH	37.0 %
T044	405.0		34.0 %
T043	408.0		35.0 %
T042	249.2		38.0 %
T041	246.9		42.0 %
T040	246.2	LL	42.0 %

Level Alarm

1RNQ53	°C
CT010	41.2
CT011	36.4

1RNQ53	°C
CT020	214.1

1RNQ51	°C
CT024	242.3
CT025	242.3
CT026	242.3
CT027	242.3
FT003	242.3

THX inlet

1RNQ51	°C
FT002	12.6

1RNQ51	°C
CT001	230.2
CT002	231.3
CT003	230.2
CT004	231.3
CT005	230.2
CT006	230.2
CT007	230.2
CT008	230.8
CT009	229.7
CT010	229.0
CT011	230.2
CT012	229.7

Del Leak I

1RNQ52	°C
CT031	
Sollwert H	BH011

Del Leak Detektor

1RNQ52	°C
CT030	258.9
Sollwert Heizung	BH010 100.0 %

Target Strahlstrom

1CFD01	mA
FR001	151.0

1RNQ51	°C
CT001	230.2
CT002	231.3
CT003	230.2
CT004	231.3
CT005	230.2
CT006	230.2
CT007	230.2
CT008	230.8
CT009	229.7
CT010	229.0
CT011	230.2
CT012	229.7

1RNQ51	°C
CT079	243.9
CT082	242.3
CT090	244.6
CT081	245.3

1RNQ51	°C
CT082	249.5
CT081	249.2
CT080	249.1

1RNQ51	°C
CT085	235.4

1RNQ51	°C
CT052	245.8
CT051	245.8
CT050	246.2

1RNQ51	°C
CT076	240.0
CT078	238.2
CT072	235.9
CT073	235.9
CT074	238.2
CT075	234.3

1RNQ51	°C
CT077	238.9
CT070	235.9
CT071	238.9

MP_1RNQ51_FT003 HL

Soll

Sergej Dementjev

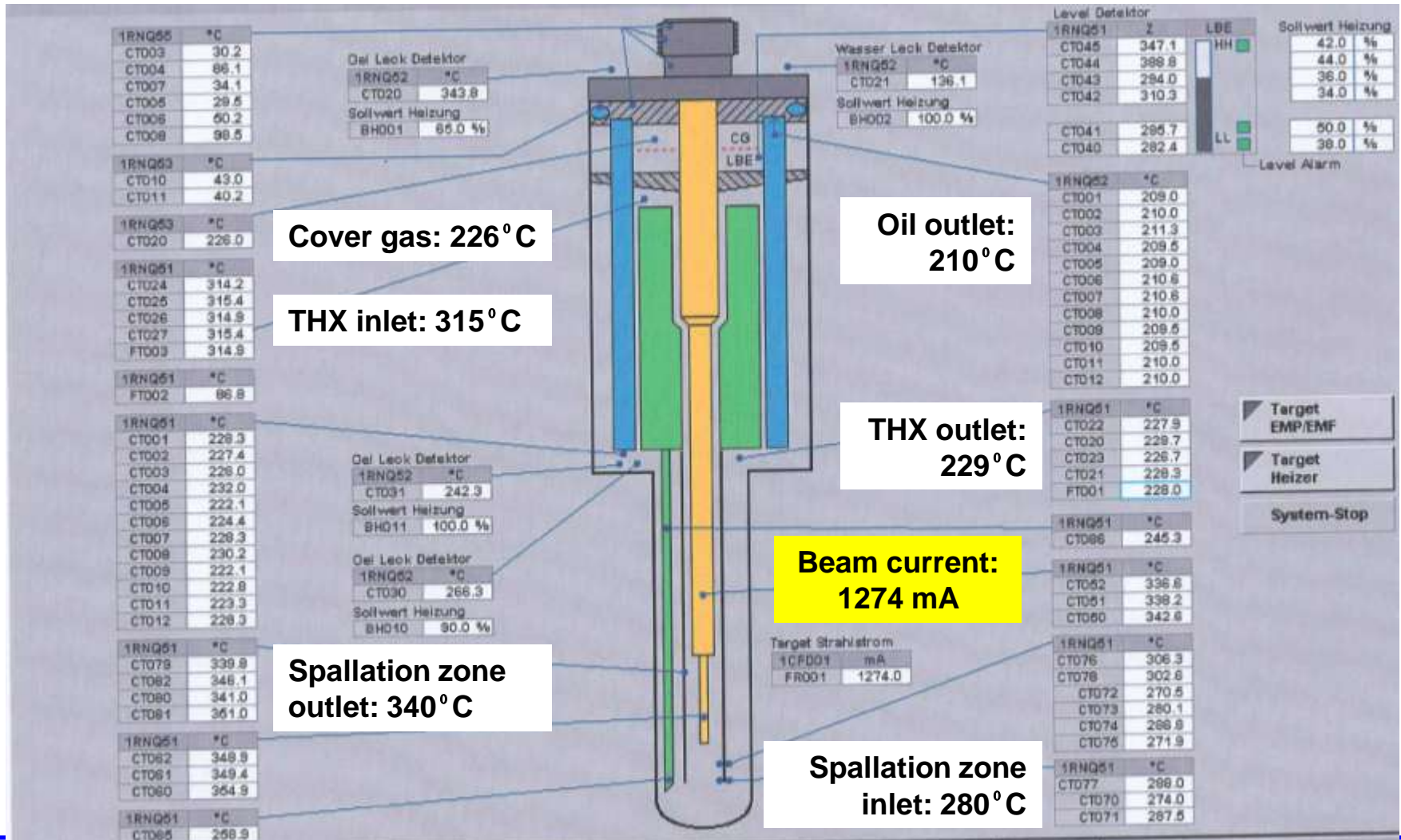
MSR

1 2 3

EXP

Operation of the target with low beam.

Target temperatures at full beam



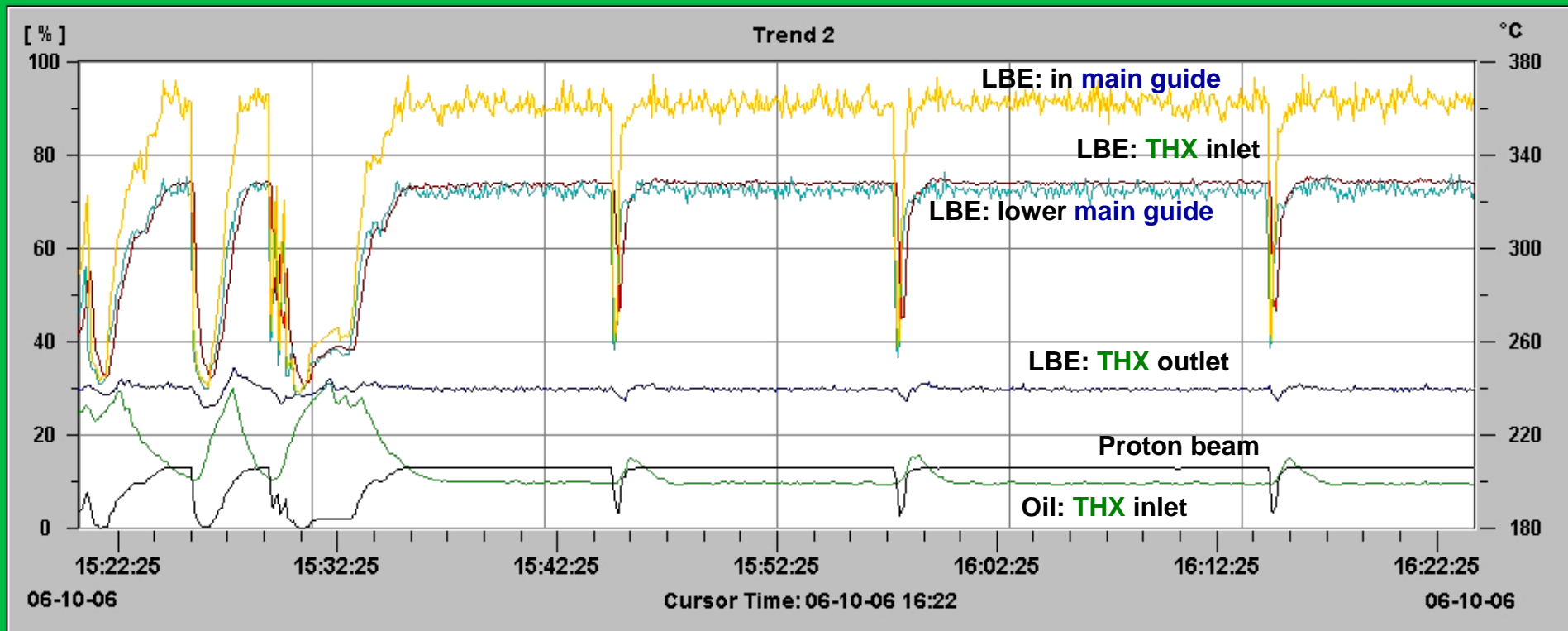
Temperature transients during beam trips

Routine 40 aktiv

Bildwahl

Trend 2

06-10-2006 16:22:39



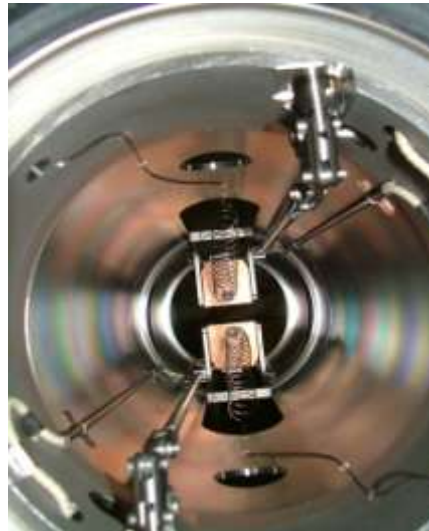
⇒ scurtinize / validate the thermo-hydraulic simulations

the new safety devices...

New safety- and diagnostic devices



VIMOS: beam footprint visualization system



Collimating slit
in proton beamline



LBE leak detector

⇒ for details contact
Knud.Thomsen@PSI.CH

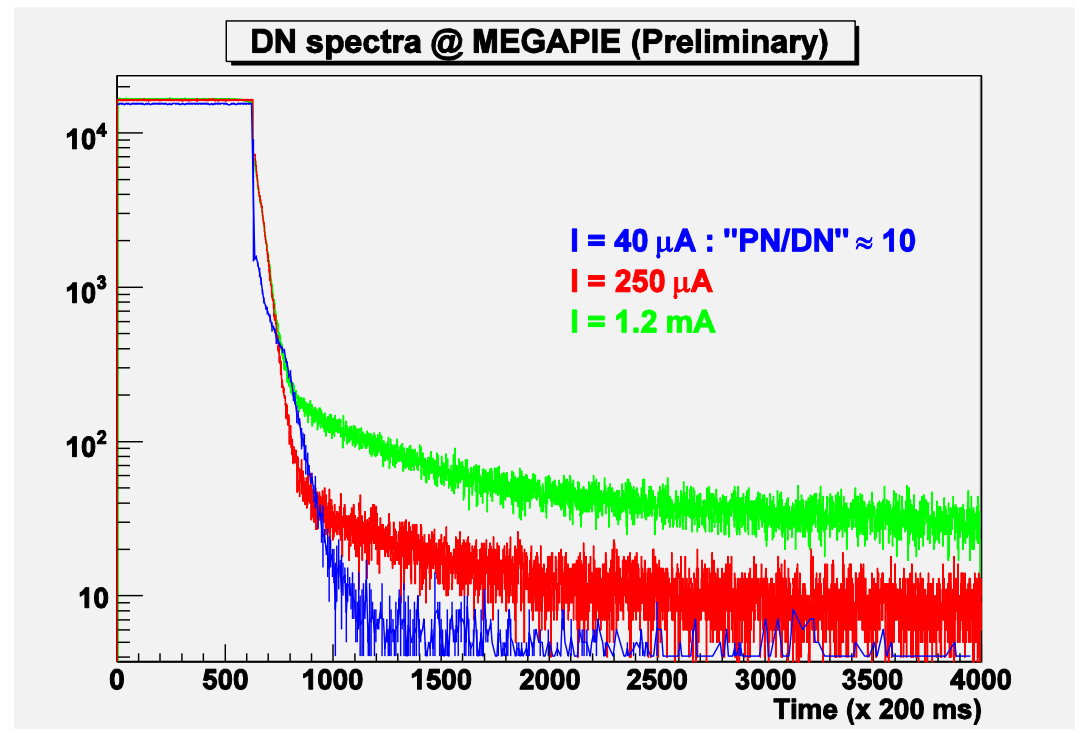
neutronic measurements and neutronic performance

Task 1: Delayed Neutron measurement (n-detector in the TKE)

D. Doré, X. Ledoux, S. Panebianco, A. Prevost, D. Ridikas, *CEA, France*

Objective:

- Investigate the spontaneous **(β n)-decay reaction** of spallation products
- **Besides general interest: Relevance** for activation and safety issues in flowing media

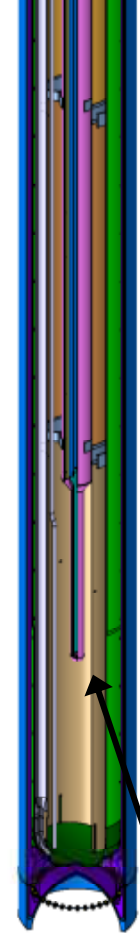
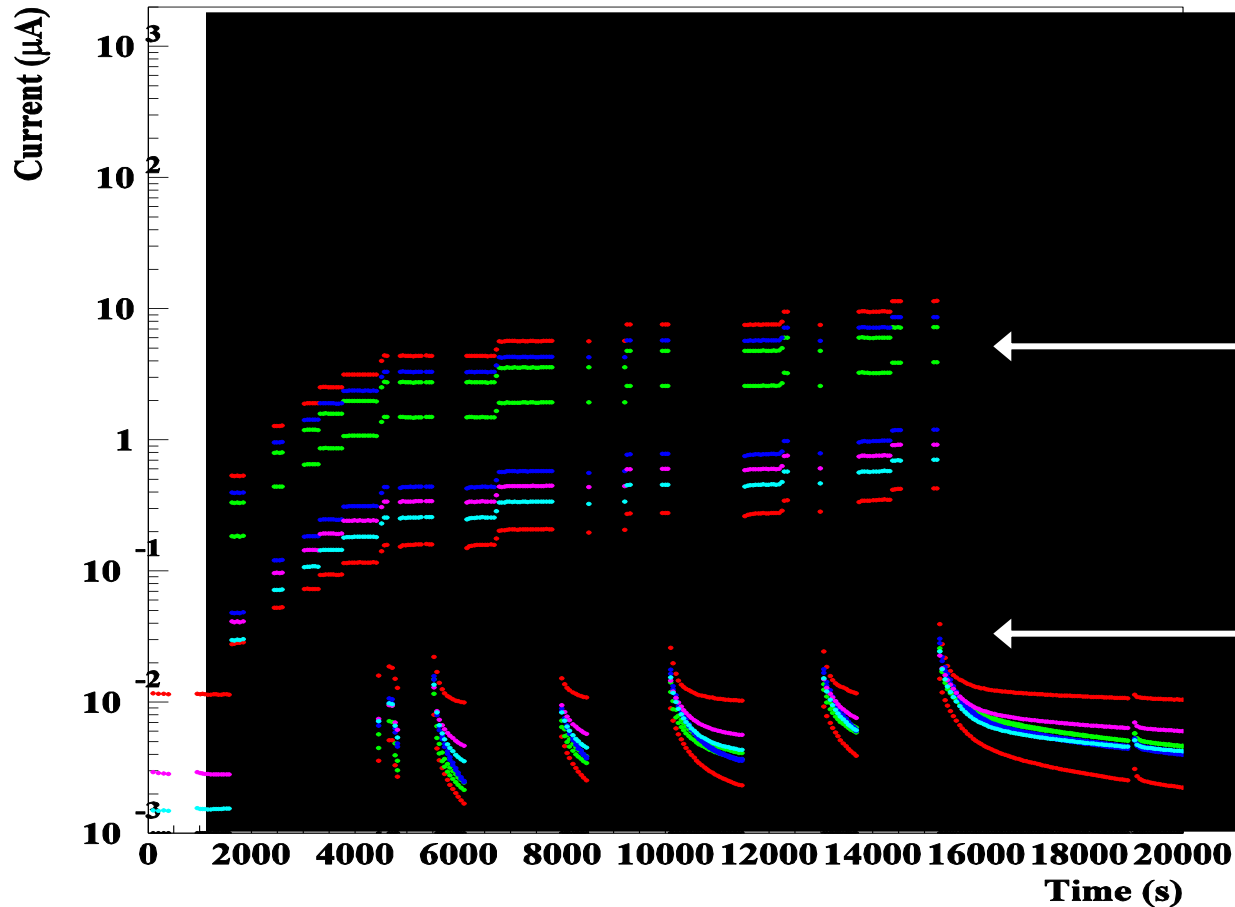


typical decay spectra from 3 different beam intensities

Task 2: Neutron flux by fission chambers

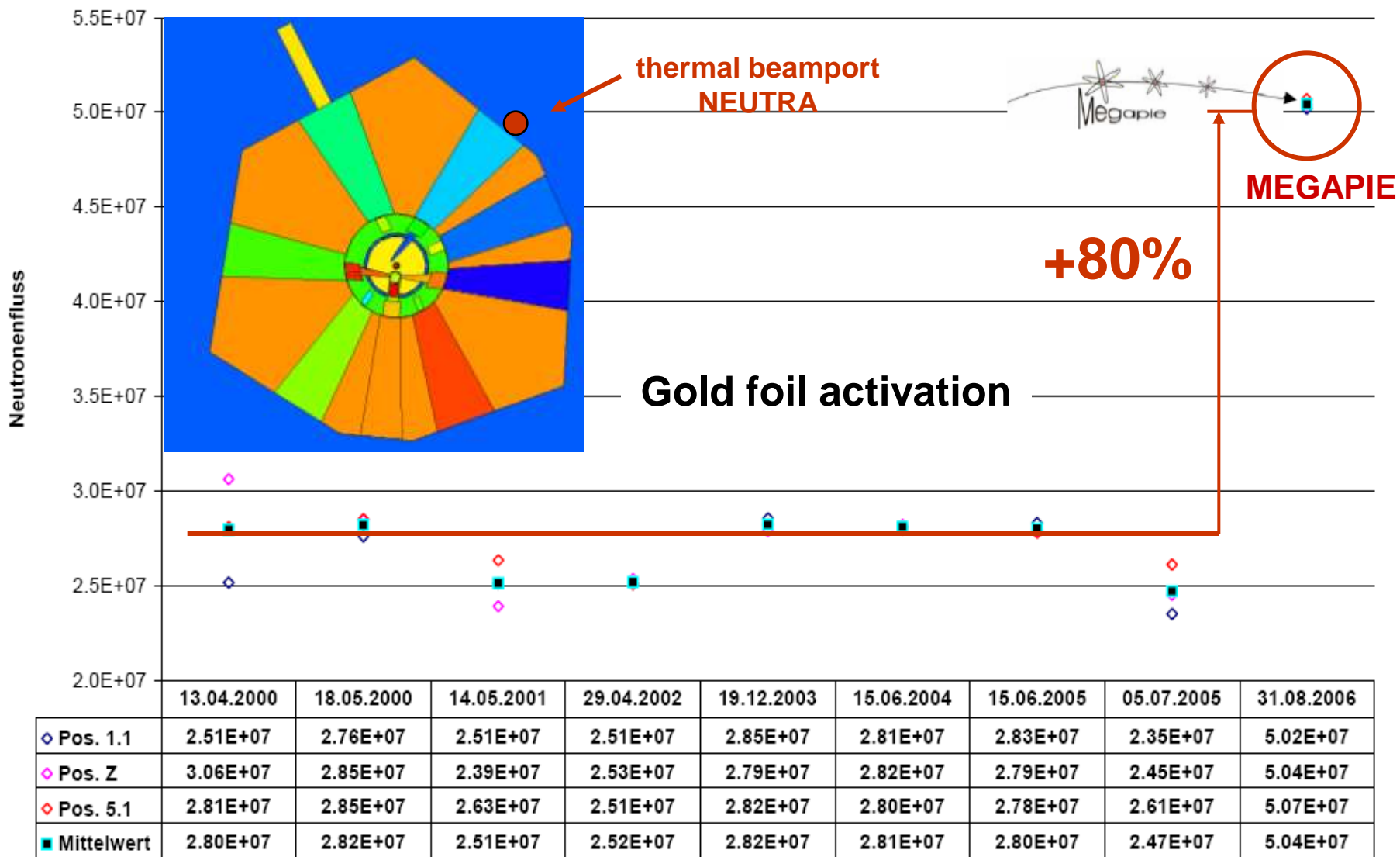
A. Letourneau, S. Chabod, Ph. Beauvais, E. Dupont, P. Lotrus, F. Molinie, S. Panebianco, J.C. Toussaint, S. Breaud, L. Oriol, F. Chartier *CEA France*

First, illustrative results



central rod
housing arrays of
miniaturized
fission chambers

Task 3: Neutron flux @ beamports



Ancillary systems: ***Lessons learned.....:***

HRS: heat removal system

HRS oil loop in TKE



Experience:

After extensive endeavors to remedy defects discovered during pre-commissioning tests:

- WCL and HRS in SINQ operated satisfactorily
- No (or little) parameter adjustments were necessary
- Heat removal capacity was (more than) sufficient (rather oversized)

Ancillary systems: *Lessons learned.....:*

IGS: insulation gas system

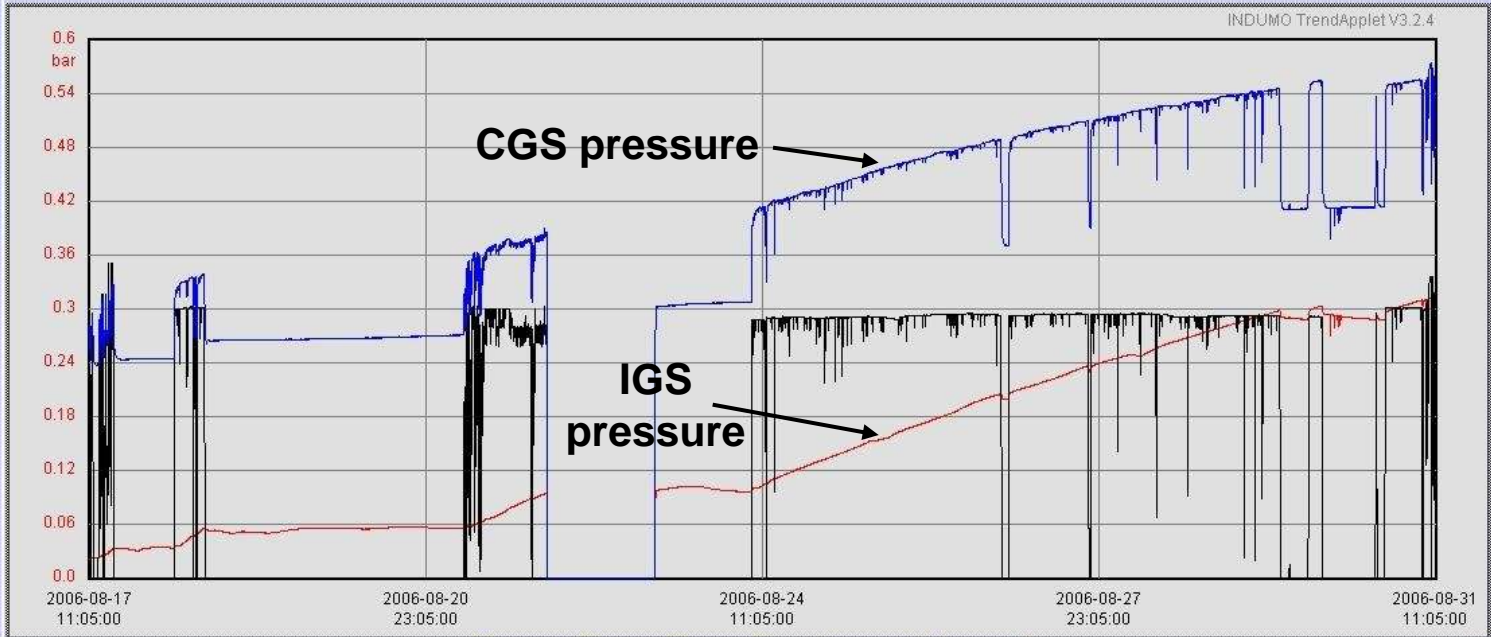


Navigation

- Home
- Login
- Trend anzeigen
- Neues Trendbild
- Linien hinzufügen oder editieren
- Trend löschen
- Help

Trend anzeigen

Bildname: [Isolatio gas pressure]



<< >> >| Print Export

Farbe	Anzeige	Name der Trendlinie	Beschreibung	Skala Min	Skala Max	Cursorwert	Einheit	Min	Max
Red	<input checked="" type="checkbox"/>	MP_1KGH71_CP001_Z400_AVG	Isolation gas pressure	0	1	0	bar	0	0.6
Black	<input checked="" type="checkbox"/>	_1CFD01_FR001_RZ400_AVG	Protonenstrahlstrom	0	2000	0	mA	0	2000
Blue	<input checked="" type="checkbox"/>	MP_1KGA10_CP001_Z400_AVG	Cover gas pressure	0	4	0	bar	0	0.6

Einstellungen speichern

Zeitdauer:

Datum bis: 31.08.2006 11:05 (TT.MM.JJJJ hh:mm)

Dauer: 14 Tage

Anfrage senden

first week



IGS: insulation gas volume

Problem:

- continuous pressure increase by ~ 5 mbar/h
- ..slightly *contaminated* by (radioactive) covergas
 - *decay period* and *gas sampling* required before venting

Mitigation measures:

- installation of 180 l decay vessel in cooling plant
- regular (weekly) venting into the exhaust system



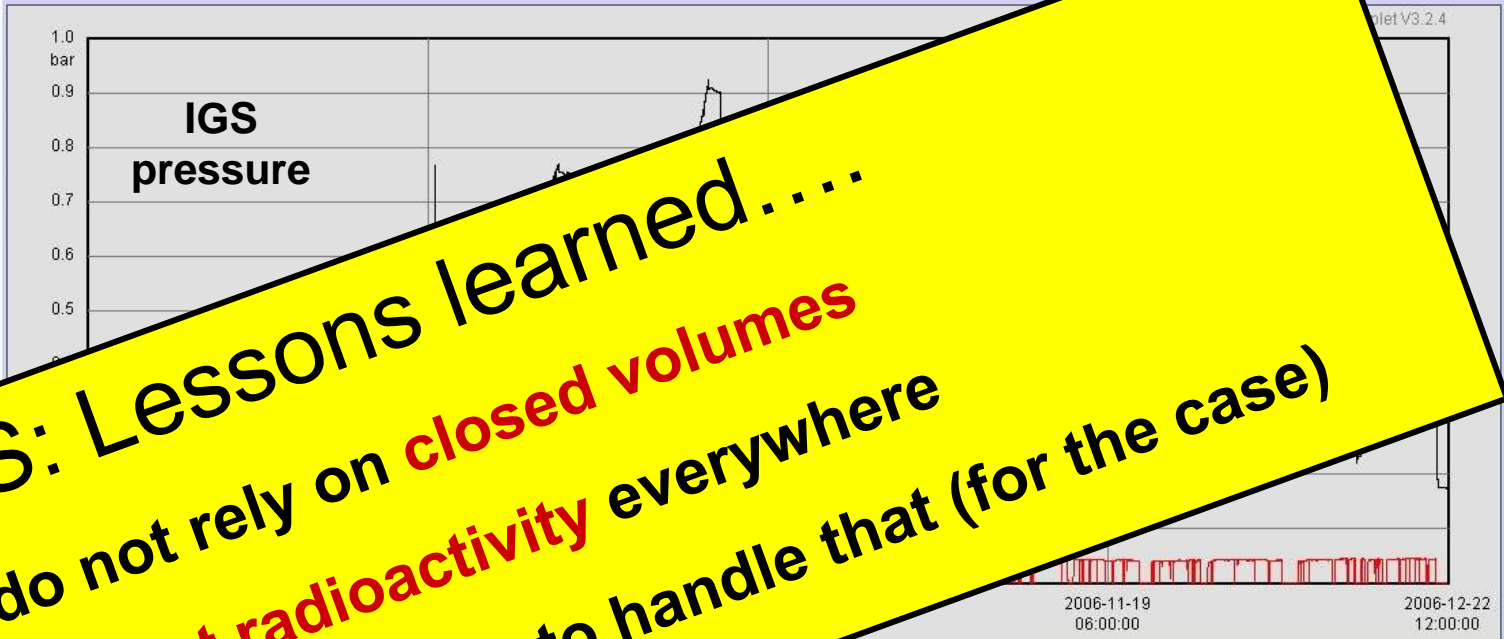


Navigation

Trend anzeigen

Bildname: [IGS Druck]

- Home
- Login
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- Trend löschen
- Help



IGS: Lessons learned....

- do not rely on **closed volumes**
- **expect radioactivity** everywhere
- **provide devices** to handle that (for the case)

Print Export

	Skala Min	Skala Max	Cursorwert	Einheit	Min	Max
IGS Druck	0	1	0	bar	<input type="text" value="0"/>	<input type="text" value="1"/>
IGS MAX	0	2000	0	mA	<input type="text" value="0"/>	<input type="text" value="30000"/>

Einstellungen speichern

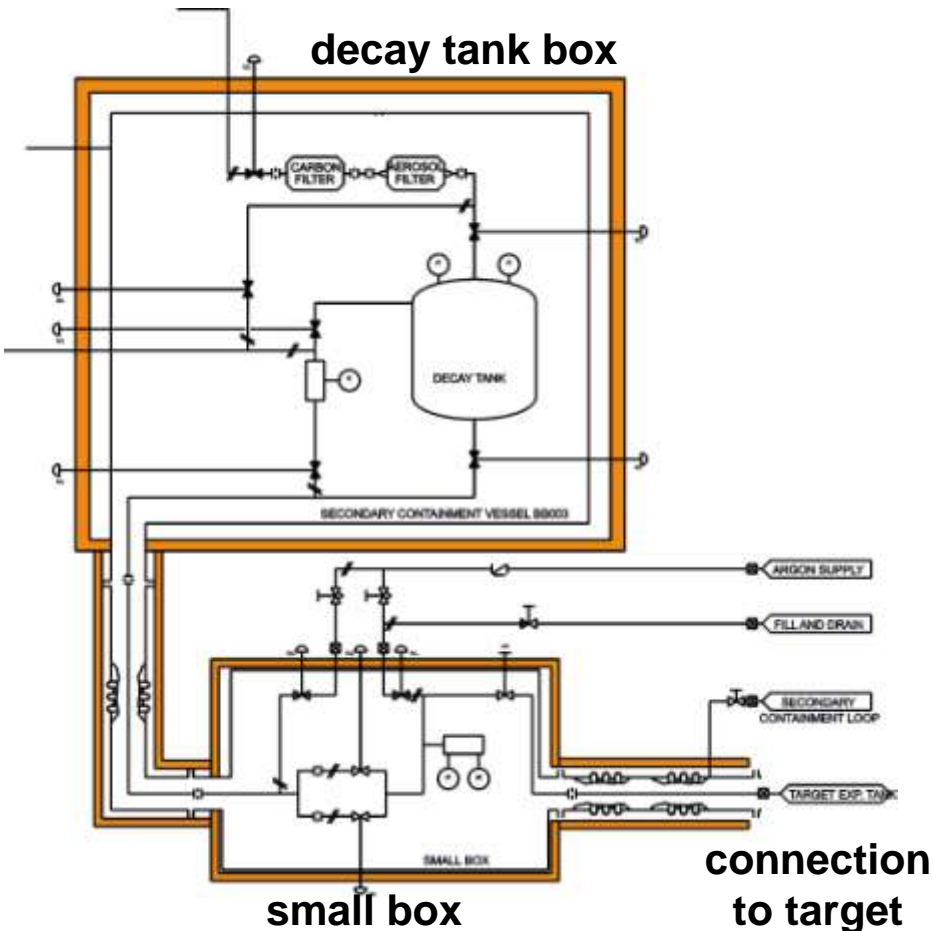
Zeitraum:
 Datum bis: (TT.MM.JJJJ hh:mm)
 Dauer:

full irradiation period: Aug.- Dec.

Ancillary systems: *Lessons learned.....:*

CGS: cover gas system

CGS schematic layout



- handling of **radioactive gases**:
⇒ **stringent requirements**

- leak tightness
- second containment
- shielding
- operation procedures

- in principle: **sustainable design**
- in practice: **complex and expensive**



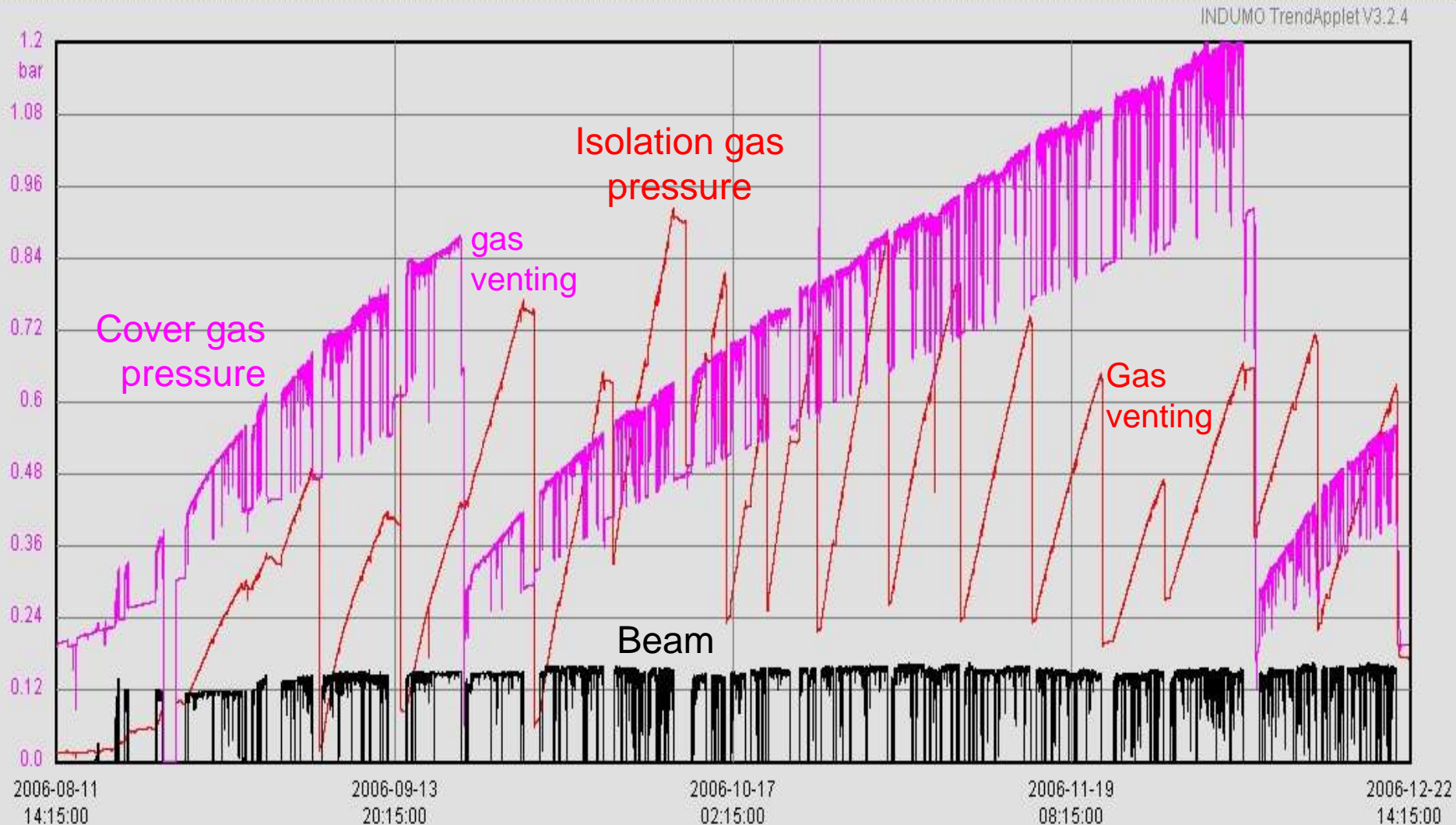
decay tank box in TKE



Cover gas & Isolation Gas pressures during Irradiation

Start of
Irradiation

End of
Irradiation



Taking gas samples in the TKE



Cover Gas
decay and
sampling tank

'small
box'

CGS: Lessons learned....



Pressure transducer

- **‘tight’ is not ‘tight’**
 - ⇒ (small) leak from decay tank to 2nd containment
 - ⇒ **Action:** regular (weekly) venting of 2nd containment into the exhaust system
- **care for (double) redundancy of crucial sensors**
 - ⇒ Failure of one pressure transducer in Small Box
 - ⇒ **Action:** switch to remaining redundancy
- **gas sampling: care for a handy and safe device**
 - ⇒ Gas sampling is a critical action and can be a nasty job

Summary:

- The **MEGAPIE liquid metal target system @ SINQ**
 - experienced a quick and successful start-up
 - operated reliably during 4 months @ ~0.8 MW
- ...was accompanied by a variety of **unique experiments**:
 - thermohydraulics, fluid-dynamics, neutronics, radiologic etc.
- **Availability** of SINQ with MEGAPIE was **at satisfactory ~95%**
- **SINQ user** were satisfied **with ~80% more neutrons**
 - awaking expectations for the future !!

All in all: a successful experiment and an exciting experience