



STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

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SCK•CEN Mol

The role of SCK•CEN in the MEGAPIE project

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Why did SCK•CEN decide to join the MEGAPIE project?

- SCK•CEN wants to design, build and operate an Accelerator Driven System (ADS)
- MYRRHA (SCK•CEN) → XT-ADS (Europe)
- MYRRHA / XT-ADS = accelerator → 600MeV protons → liquid Pb-Bi target → neutrons → sub-critical core

~MEGAPIE

XT-ADS

- **XT-ADS**: eXperimental demonstration of Iransmutation in an Accelerator Driven sub-critical System
- part of **EUROTRANS**, a European 6th framework project
- **ADS** demonstrator
- **transmutation** studies
- **fast spectrum irradiation** device
- replacement of BR2 reactor as **MTR** @ SCK•CEN
- **isotope** production

MEGAPIE & XT-ADS specifications

	Megapie	XT-ADS target
Coolant / target	liquid Pb-Bi	liquid Pb-Bi
Beam energy	595 MeV	600 MeV
Beam current	1.4 mA max	3 mA
Lifetime	4 months	9 months
Accumulated charge	2.8Ah	20Ah
Target diameter	Ø20 cm	Ø10 cm
Accumulated charge / m ²	90 Ah/m ²	2500 Ah/m ²
Beam interface	window	windowless

Why is MEGAPIE so important for the roadmap towards XT-ADS ?

- MEGAPIE is the first liquid Pb-Bi spallation target that ...
- has been experimentally demonstrated ...
- to be operating safely ...
- during an extended time period ...
- with a proton beam in the range of XT-ADS requirements



MEGAPIE experience as input for XT-ADS target design

- **Licensing:** a megawatt liquid Pb-Bi spallation target has been shown to work
- **Design:** although there are specific differences (geometry, window) there is a generic correspondence (coolant, structural material, Pb-Bi pumping, Pb-Bi heat removal, Pb-Bi conditioning, beam monitoring, ...)
- **Safety:** MEGAPIE safety file as input for XT-ADS spallation target safety assessment

MEGAPIE as benchmark for neutronic calculations

- beam energy in the XT-ADS range (600MeV)
- measured neutron yield per mA
- measured spallation product inventory
- → opportunity to enhance accuracy and reliability of XT-ADS spallation target neutronic calculations

Megapie as a testbench for XT-ADS spallation loop components

- liquid Pb-Bi electromagnetic pumps
- liquid Pb-Bi electromagnetic flowmeters
- liquid Pb-Bi heat exchangers
- liquid Pb-Bi level sensors
- fill & drain system
- beam diagnostics
- spallation loop operation
- tested under XT-ADS like conditions

The MEGAPIE structural materials are also envisaged as XT-ADS structural materials

- T91 (MEGAPIE: window; XT-ADS: target nozzle + fuel cladding)
- 316L
- tested under **real conditions** (neutrons, protons, Pb-Bi, thermal stress and fatigue)
- Post Irradiation Examination (PIE) of the MEGAPIE structural materials is of **crucial importance** for the further development of XT-ADS



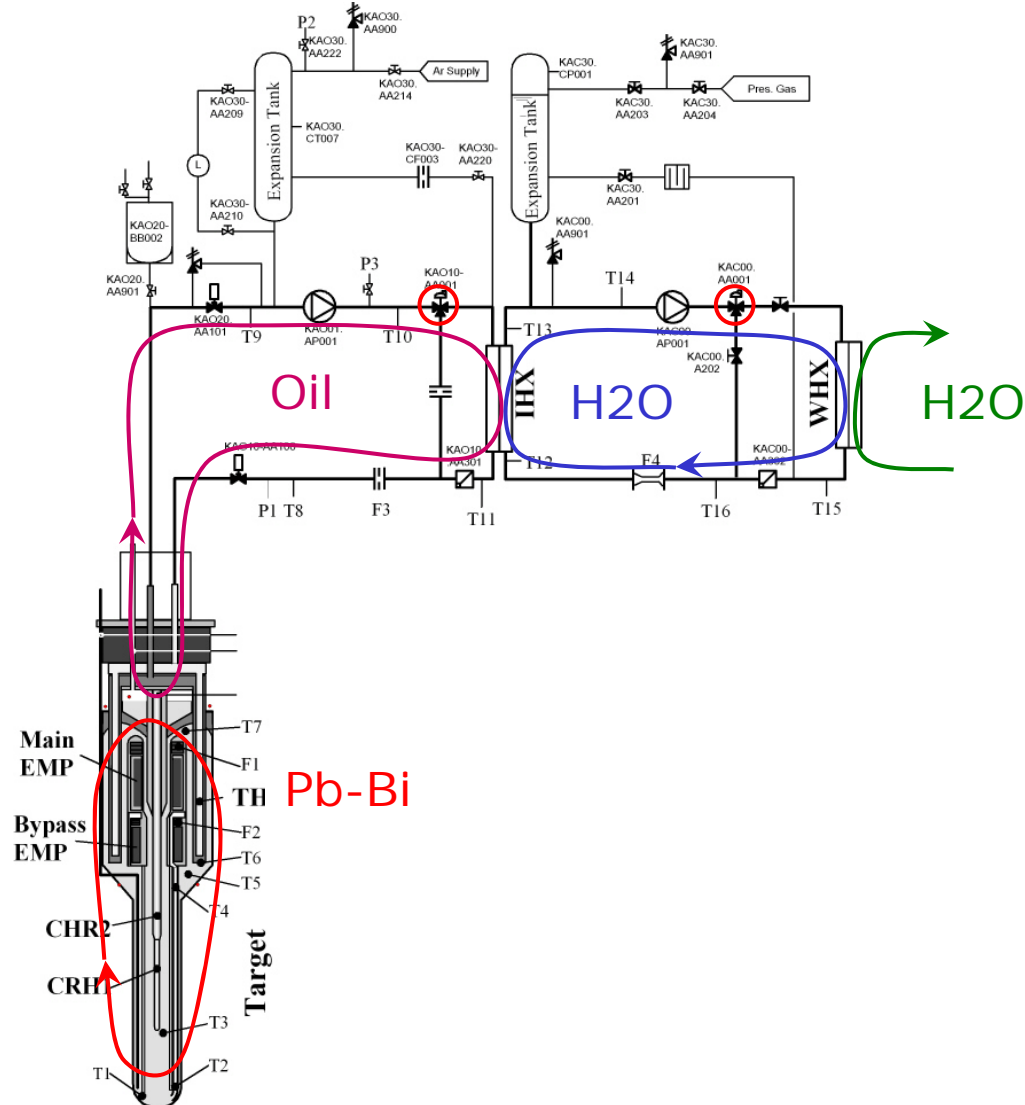
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MEGAPIE & SCK•CEN

SCK•CEN is one of the main partners in the MEGAPIE project

- SCK•CEN has 11% budget share
- contribution in the design, testing, operational and PIE phase of MEGAPIE
- scientifically SCK•CEN is mainly involved in the thermo hydraulic and materials aspects of the project

Design of target temperature control strategy

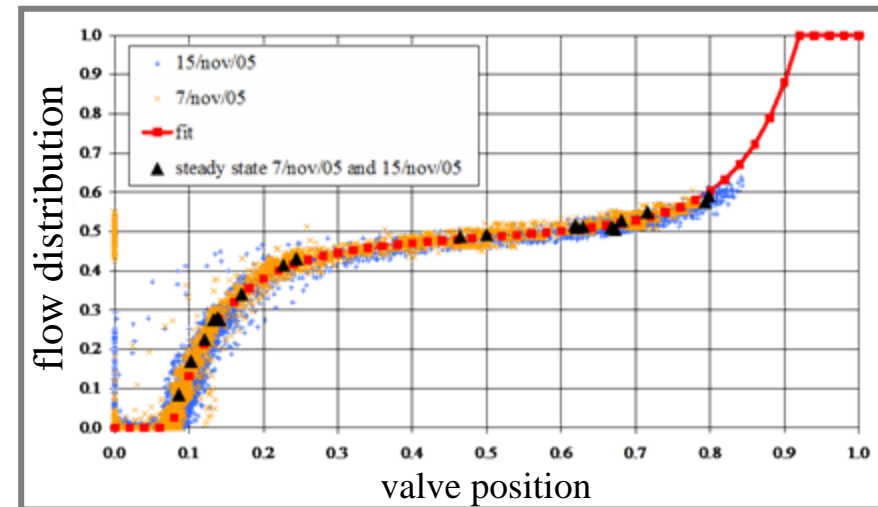


Design of target temperature control strategy

- keep target at **constant temperature** during normal operation
- limit the effect of **beam interrupts**
- **easy implementation** in MEGAPIE control system
- Matlab **Simulink** was used to deduce **system dynamics** and simulate the effect of different **control schemes**
- **verification** outside SINQ during the MEGAPIE Integral Test (MIT) phase by using **200kW** resistive heaters

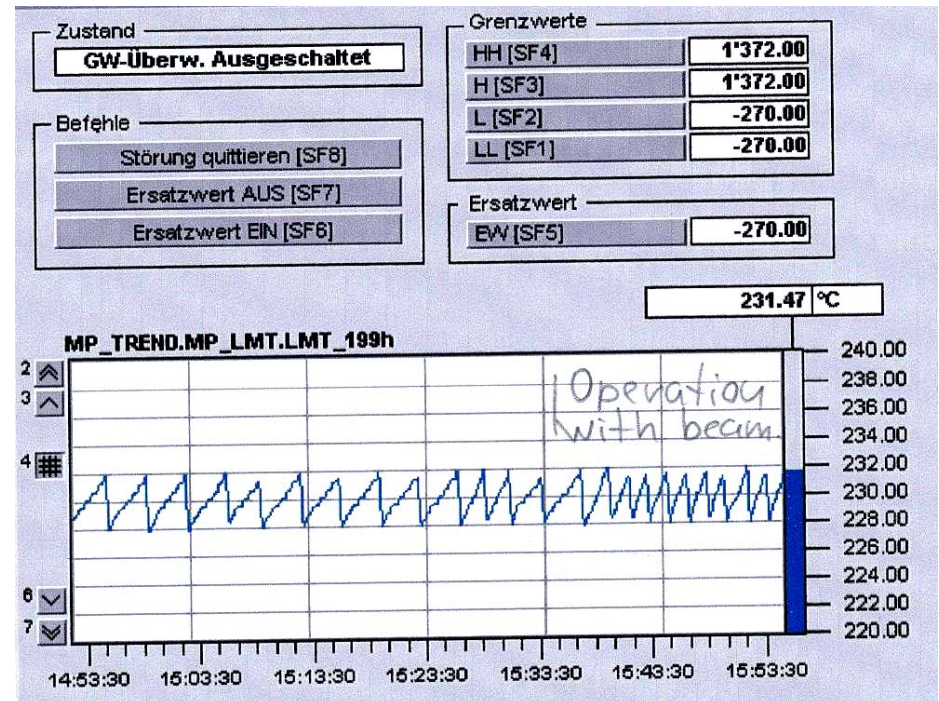
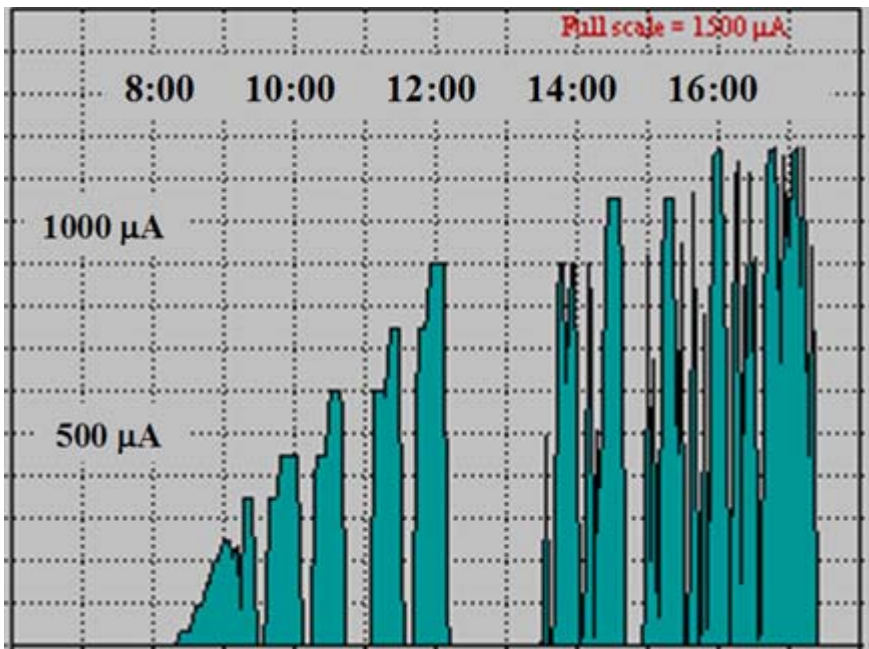
Design of target temperature control strategy

- integral tests revealed a highly **non-linear control valve** behavior which would **jeopardize stable operation** in SINQ
- the target temperature control algorithm was updated with a **linearization function** to compensate for valve behavior
- the integral tests further revealed that the **target heat exchanger** is **25% more efficient** than calculated



Design of target temperature control strategy

- target temperature control performance was closely **monitored** during the start-up of MEGAPIE in SINQ





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Material aspects

- SCK•CEN was involved in the **target lifetime assessment** (T91 window)
- **T91** material was **irradiated** and **tested** by SCK•CEN
- Part of the **Post Irradiation Examination** (PIE) of the MEGAPIE structural materials will be done by SCK•CEN

Conclusion

- 1.** With the **successful completion** of the irradiation phase **MEGAPIE** has proven that **safe operation** of a **megawatt Pb-Bi spallation target** is possible, making the **licensing** of future **ADS** systems **easier**.

- 2.** The **PIE** of MEGAPIE will be **very important** for further development **XT-ADS** as it will provide crucial information on the behavior of **XT-ADS structural materials** under **relevant conditions**.