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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 Transmutation 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
<table>
<thead>
<tr>
<th></th>
<th>Megapie</th>
<th>XT-ADS target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coolant / target</td>
<td>liquid Pb-Bi</td>
<td>liquid Pb-Bi</td>
</tr>
<tr>
<td>Beam energy</td>
<td>595 MeV</td>
<td>600 MeV</td>
</tr>
<tr>
<td>Beam current</td>
<td>1.4 mA max</td>
<td>3 mA</td>
</tr>
<tr>
<td>Lifetime</td>
<td>4 months</td>
<td>9 months</td>
</tr>
<tr>
<td>Accumulated charge</td>
<td>2.8Ah</td>
<td>20Ah</td>
</tr>
<tr>
<td>Target diameter</td>
<td>Ø20 cm</td>
<td>Ø10 cm</td>
</tr>
<tr>
<td>Accumulated charge / m²</td>
<td>90 Ah/m²</td>
<td>2500 Ah/m²</td>
</tr>
<tr>
<td>Beam interface</td>
<td>window</td>
<td>windowless</td>
</tr>
</tbody>
</table>
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 & XT-ADS

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
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
MEGAPIE & SCK•CEN

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.