PAUL SCHERRER INSTITUT

PSI

Wir schaffen Wissen – heute für morgen

Feedback on HLM Facilities Licensing

MEGAPIE Final TRM, Bregenz, October 2014

K. Thomsen

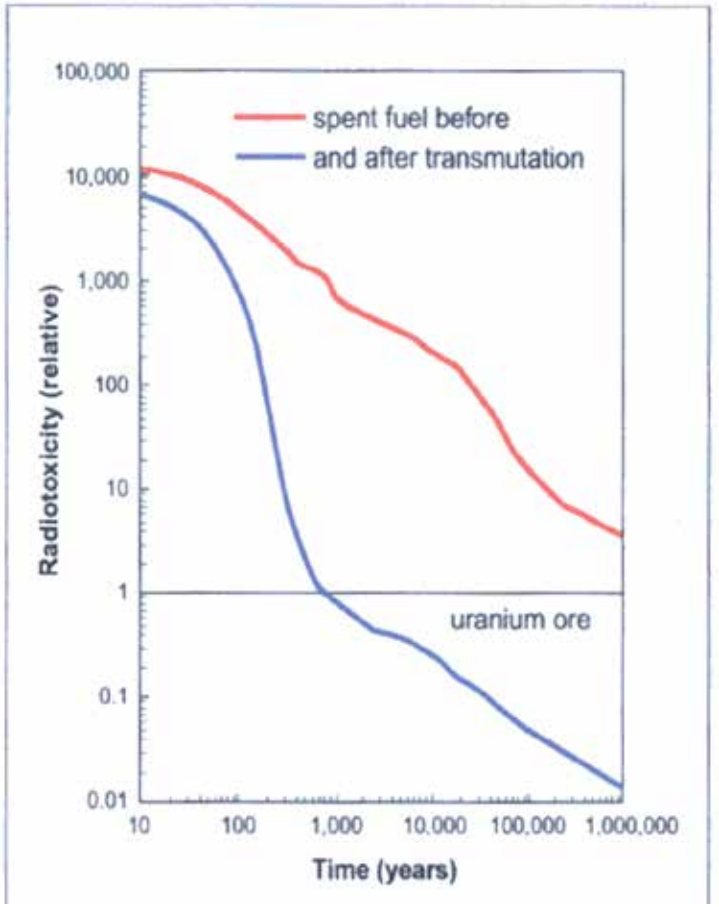
Paul Scherrer Institut

MEGAPIE, a liquid metal target for SINQ

MEGAwatt Pilot Experiment:

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

*) **LBE: Lead-Bismuth-Eutectic T_m=125°C**



à **Increase neutron flux for SINQ**

„If MEGAPIE only clearly demonstrates that such a facility is not licensable in Switzerland, the project is fully worth 10 Million.“

Project President M. Salavdores
at Megapie SC Meeting December 2002

„We are a little more ambitious than that !“

K. Thomsen in reply

SINQ – Balancing User Operation, Development Projects and Spin-off Support

Ø we want(ed) new challenges

Ø we need(ed) new challenges

- to strengthen our expertise
- to improve the level of performance
- to remain an attractive user facility
- to participate at the forefront of new developments and technologies

Ø we do not want to endanger the facilities

- trade-off between (partly) conflicting interests

Several Licensing Authorities Involved over Time

BAG OFSP UFSP SFOPH — Swiss Federal Office of Public Health

BFE OFEN UFE SFOE — Swiss Federal Office of Energy

HSK — Swiss Federal Nuclear Safety Inspectorate

nagra — National Cooperative for the Disposal of Radioactive Waste

The main licensing partner for MEGAPIE certainly was (at least in the earlier phases)

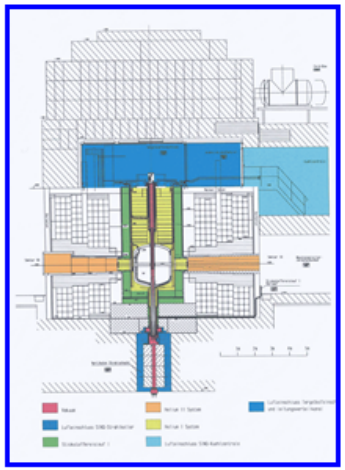
The Swiss Federal Office of Public Health (SFOPH)

(and I happily use their slides)

Licensing in a nut shell: Stepwise Approach

Licencing procedure

- Application for authorisation
- Radioprotection plans →
- Checks
- Inspection
- Authorisation issued, with list of conditions →
- Follow-up inspections



Bewilligung für den Umgang mit ionisierender Strahlung vom 20. Juli 2001

Licensing in a nut shell: Stepwise Approach 1

MEGAPIE licencing procedure

3 essential features for the MEGAPIE Project:

- Prototype
- International
- Complex installation

Divided into subsystems / milestones

Licencing procedure

- One main general authorisation (Bewilligung) 1
- Clearing / release agreement (Freigabe) 2
- Requirements / conditions (Auflage) 3

MEGAPIE licencing procedure

Authorisation (Bewilligung)

1. PSI submits a Safety Report with request for authorisation

2. SFOPH assesses the Safety report
   issues statement / evaluation report
   clearing agreements (Freigabe)
   requirements / conditions (Auflagen)

3. Feed-back from PSI and discussions

4. Issue of authorisation for the whole installation / project

MEGAPIE licencing procedure

PSI had/have more docs. than that

Clearing agreement (Freigabe)

5. PSI submits request for agreement with relevant documentation
   - plans
   - materials
   - manufacturing processes
   - QA procedures and certifcation

6. Inspection of installation

7. Granting of clearing agreement – inspection report with additonal conditions depending on inspection findings

MEGAPIE licencing procedure

Clearing agreement (Freigabe)

Usually relates to a specific system

- Heat Removal System
- Gas System

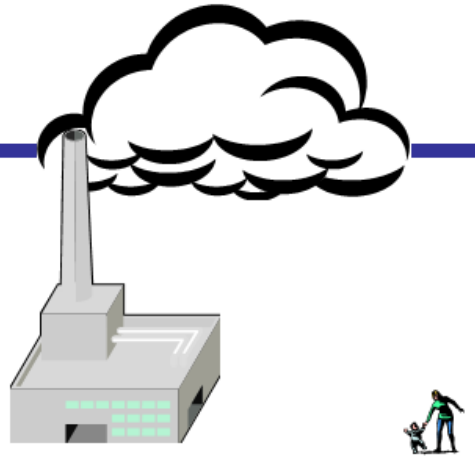
or to a critical phase

- Inactive commissioning
- Active commissioning
- Decommissioning

Part of the CGS unit

We did not argue

MEGAPIE risk assessment



Risk assessment – worst case scenario

Scenario :
accident leading to release of activity (gas) into the environment
result in dose to the workers or population

Limits:

- 1 mSv
  no additional emergency planning necessary

- 20 mSv
  additional emergency planning necessary (involving neighbouring council authorities)

Inspections / audits

Inspection / Audits

- **Inspections / audits** are part of licencing procedure

  5 over last 2 years

- **Meetings** allow regular exchange of information and discussion between PSI and SFOPH

  about 15 over last 2 years, with frequency up to 1 meeting / month since beginning of 2006

PAUL SCHERRER INSTITUT

Megapie

Prerequisite for the BAG-license to start MEGAPIE

5 clearances of BAG

- Commissioning of HRS at MITS
- Commissioning of ancillary systems
- Commissioning of target system in SINQ
- Decommissioning, dismantle and transport of irradiated target (which depends on the HSK-clearance)
- Irradiation of the target

1 clearance of HSK

- Transport (special arrangement) & **concept** for disposal

More Snapshots from PSI Perspective

March 2006

PAUL SCHERRER INSTITUT

Licensing - BAG constraints

Total constraints : 56 ***Fulfill Status: 59%**

Not started 0%	Documents available 50%	Documents at BAG 75%	Confirmed by BAG 100%
22	12	10	12
17 (incl. 4 after start of irradiation)	9	13	17 (incl. 3 with additional constraints)

***Only valid if dose rate <1mSv will be achieved**

May 2006

PAUL SCHERRER INSTITUT

Licensing Process with BAG

Status of fulfilment of the 56 prerequisites

Date	Not started 0%	Doc. available 50%	Doc. at BAG 75%	Confirmed by BAG 100%
19.01.2006	22	12	10	12
09.03.2006	17	9	13	17
04.05.2006	3	12	24	17
30.05.2006	0	9	28	**19**

- **Analysis of the MITS data**
- **Operating regulations / manuals**
- **Planning of dose rate measurements**

up to now we got **43 additional conditions** to be fulfilled before irradiating the target

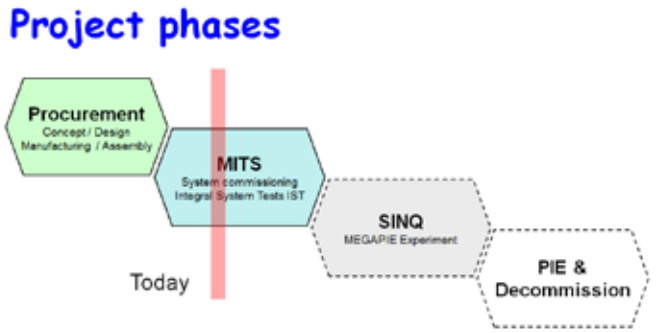
Fulfill status of all 99 conditions: 84 %

«Reasonable» Quality Assurance from an Early State

- General global common aim, i.e., (in my memory)

„Develop and Operate a Safe LM Target for SINQ“

- Stepwise procedure with well defined Milestones & Reviews
- Clear Established Procedures
- Priority on Safety
- Documentation as required



PAUL SCHERRER INSTITUT

Annex to MPR-QA-ME88-179

Megapie Quality System

Q-Policy: Having a safe and functioning liquid metal target at the 1 Megawatt region

Systems:

- Liquid Metal Target **LMT** ★
- Cover Gas System **CGS**
- Isolation Gas System **IGS**
- Heat Removal System **HRS**
- Water Cooling Loop **WCL**
- Control System **CTS**
- **LBE Leak det.**
- **VIMOS**
- **SLIT QHJ30**
- **p- Beam**

Q-Management

Project- and Task-Leader determine with Subtaskleader(s):

- Goals, Responsibilities concerning Q-Policy
- Implementation and quality level for the different systems

Q-Planning

- Megapie Safety Analysis Report (SAR)
- Quality Assurance Rules (QAR)
- Norms and standards

Q-Control
Q-Assurance
Q-Improvement

- Project Steering Committee (PSC)
- Technical Advisory Committee (TAC)
- Project Control Group (PCG)
- Peter Ming - Megapie Quality Assurance officer
- Self-responsibility of each project member / supplier

PAUL SCHERRER INSTITUT

Annex to MPR-QA-ME88-179

MITS - Integral System Test (IST)

Tasks:
- Performing integral tests
- Operation & Safety Manual
- *Check Safety Systems (SFS)*

Review

Ready for SINQ?

Deliverables
- Mechanical Tests fulfilled
- Prel. IST results acceptable

Megapie to SINQ

Apply for Active Operation 60.M24

Ready for Irradiation?

Review

Deliverables
- *SFS* & IST reports
- SAR update & requirements achieved
- BAG Allowance
- **Operation & Safety** Manual for SINQ
- NCR's closed

PSI

Review

! PSI Directorate: go / no go !

DECISION TABLE FOR TARGET SYSTEM - DDR2 25 / 26 FEB. 2003

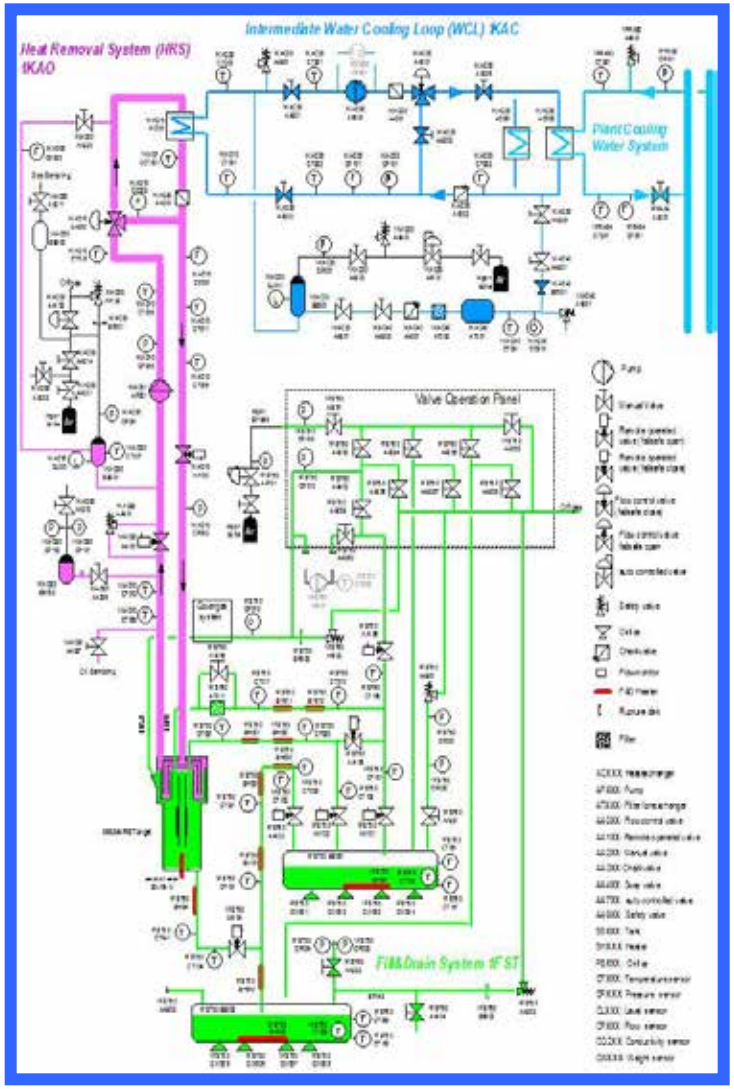
Mi = minor impact / ***Ma*** = *Major impact* / ? Impact not known

Item	**Open** Issues **/ missing** items may have **Impact*** = on **D**ESIGN / **C**OST / **S**CHEDULE	**Impact*** Mi	***Ma***	?
1. Pressure values (design / test)	**a)** *PRESSURIZED VOLUMES AT MEGAPIE 14/02/2003 Version 1 exists but not cross checked with calculation* **b)** *No Notified Body defined and restrictions/time schedule not known*		X	
2. Earthquake	**a)** No final calculations, 1. Conclusion: minimize gap between LLMC and LTE			?
3. EMPS	**a)** Connector system design outside of "Target EMP support flange", in the change area of "staff-flexible" and in the area of the target head flange **b)** Separation of work area with stainless steel (clean area) for welding and assembly **c)** *Final stress calculation* **d)** Final pump specification **e)** 3D Model of pump **f)** *notified body not defined*		X	
4. THX	**a)** *Docus: static accidental load and thermomecanical load not released* **b)** *Definition THX welds*		X	
5. LBE freezing		X		
6. Fill and Drain		X		
7. Cover Gas Sys.		X		
8. Insulation Gas System		X*		
9. Instrumentation			X	
10. Interfaces / Materials			X	
11. Drawings / written documents	**a)** 2 welds upper target enclosure **b)** coatings not defined (e.g. T91 window) **c)** lower oil leak detector (inside) **d)** *general technical specification / Test and Inspection specification not released by PSI* **e)** *level of dwgs for manufacturing not reached yet* **f)** Shielding update and check **g)** written documents not updated **h)** Lower target enclosure no CORR_B performed by PSI **i)** Seal cooling system target head		X	
12. Assembly	**a)** Assembly drawings **b)** P&ID **c)** *shielding (radiation) not checked by PSI*	X		
	Is the Target well enough defined and detailed, so ATEA can finish the manufacturing planning and cost determination?	No		

The consequence of this decision was:

The Target will be splitted in LOTs for the manufacturing!

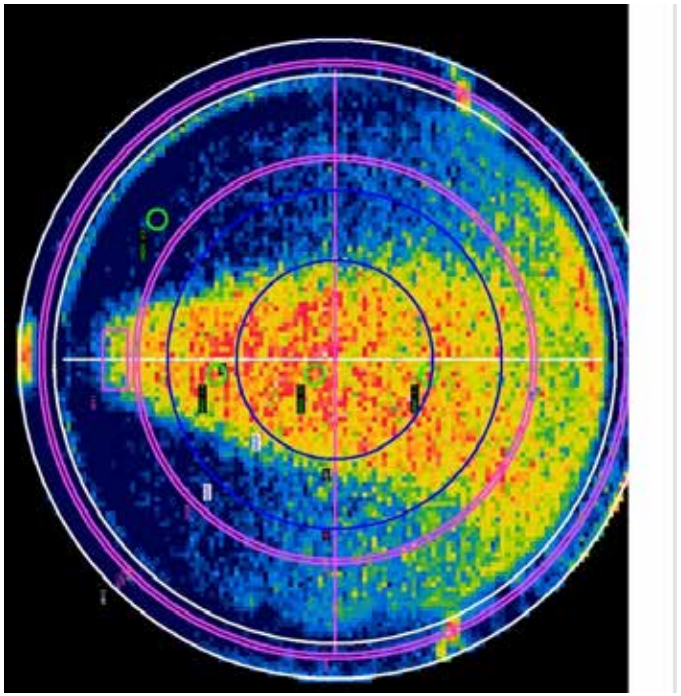
MEGAPIE Integral Test in full 1:1 geometry was essential



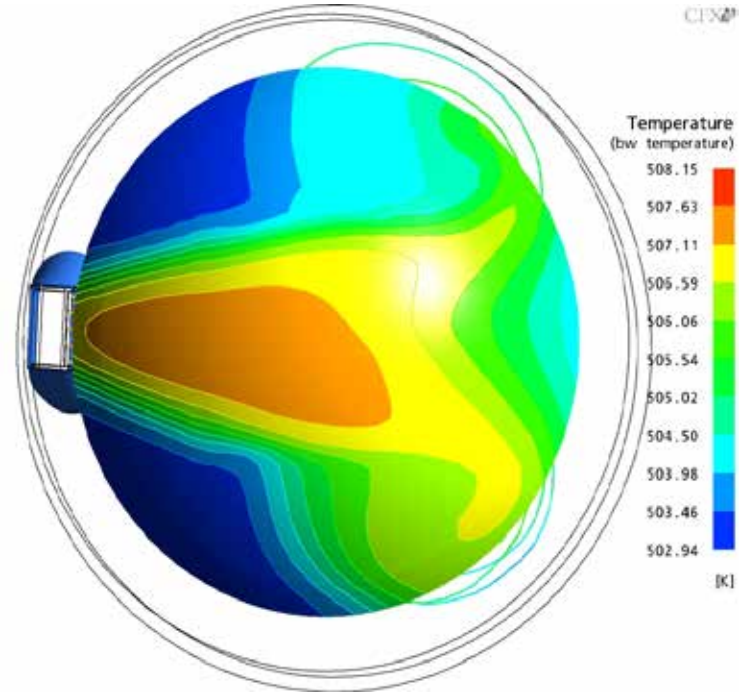
Ø EMP/EMF performance
Ø Thermal hydraulic test with 200 kW heater
Ø Beam window coolig tests
Ø September – Dezember 2005
Ø 133 hours of operation with LBE

Beam Window cooling

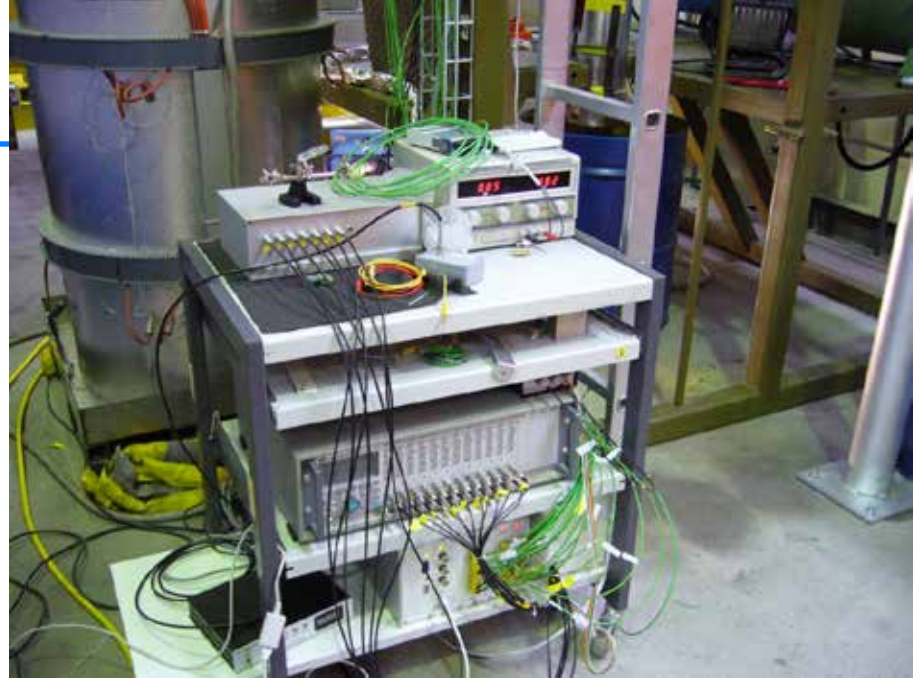
Determining the bypass jet flow rate by finding the qualitative agreement of between CFD simulation and the warm-jet infrared thermographic method (J. Patorski).



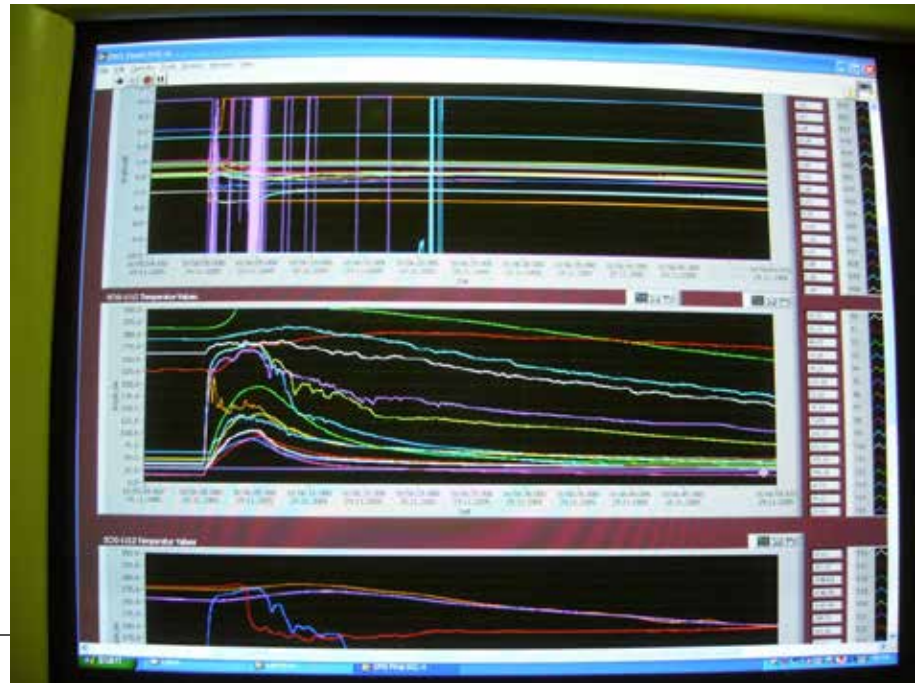
Main EMP:23 A; Bypass EMP:23 A



CFD Simulation: Main 36 kg/s (39 kg/s total)
Bypass 3 kg/s



Full Scale Leak Test FSLT



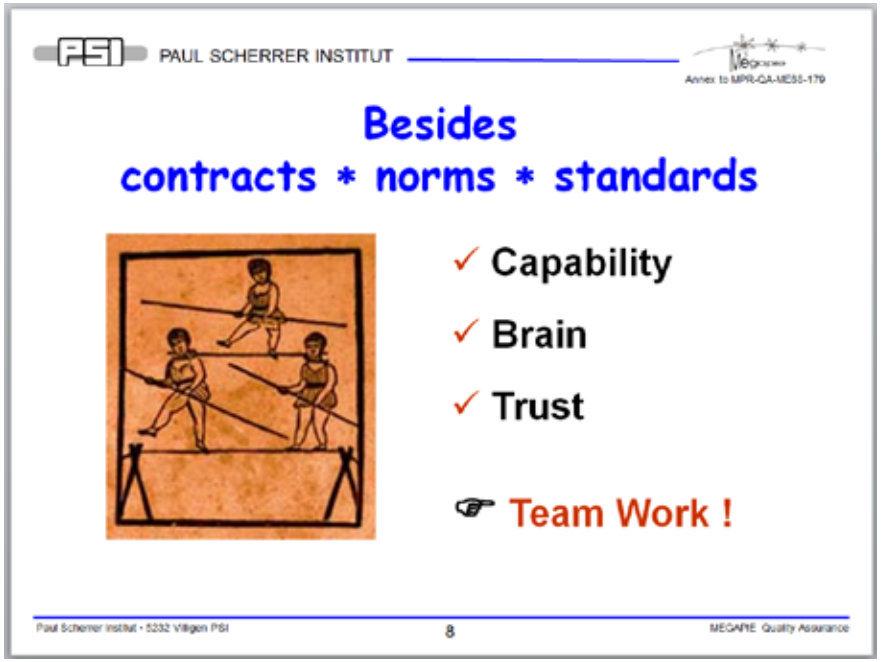
PAUL SCHERRER INSTITUT

End of MITS tests: Apero December 16, 2005

It is the people !

Thank you to the IPUL-Team making the electromagnetic pump for Megapie. November 19, 2004.

P. Ming:

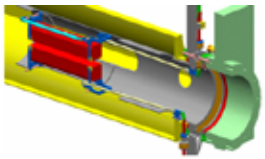


Three New Safety Devices for MEGAPIE

Transmission Monitor

- Total beam current can be measured absolutely to a few % (with calibration)
- Formerly unused signals from existing sensor hardware is employed for additional MEGAPIE current measurements (MHC4/5)
- Main improvement: new (shorter) cables
- Interlock is handled by the SINQ Schnelles AbschaltSystem SAS
- Performance compatible with 10 % threshold

Slit KHNY30



- Path for improperly scattered protons is blocked, current of jaws is monitored
- Massive copper bars provide even short-term passive safety
- Interlock is handled by the SINQ Schnelles AbschaltSystem SAS (and the machine Run Permit System)
- aided by secondary sensors (e.g. vacuum)
- Confirmed sensitivity at the 0.1 % level

VIMOS

- Beam intensity distribution is measured directly in front of the SINQ target
- Glowing of mesh monitored via special optical measurement chain and software
- Two criteria proved to be most effective:
  - Intensity in Regions of Interest (ROIs)
  - Transients in intensity ratios between ROIs
- Interlock is handled by the SINQ Schnelles AbschaltSystem SAS
- Performance demonstrated during mishap October 2004

Operational and Administrative Measures

- Narrow hardware windows enforced for settings of magnets and quadrupoles between Target E and SINQ
- Accelerator operators were especially instructed
- Remote control of jaw positions in KHNY30 are disabled and key-locked
- Beam setup is supervised by MEGAPIE
- A special effort has been undertaken to compile sufficient documentation
- End to End tests with the beam safety systems have been performed

Requirements by the Director were More Demanding than Authorities'

One more Experts Group is Checking Safety Installations:

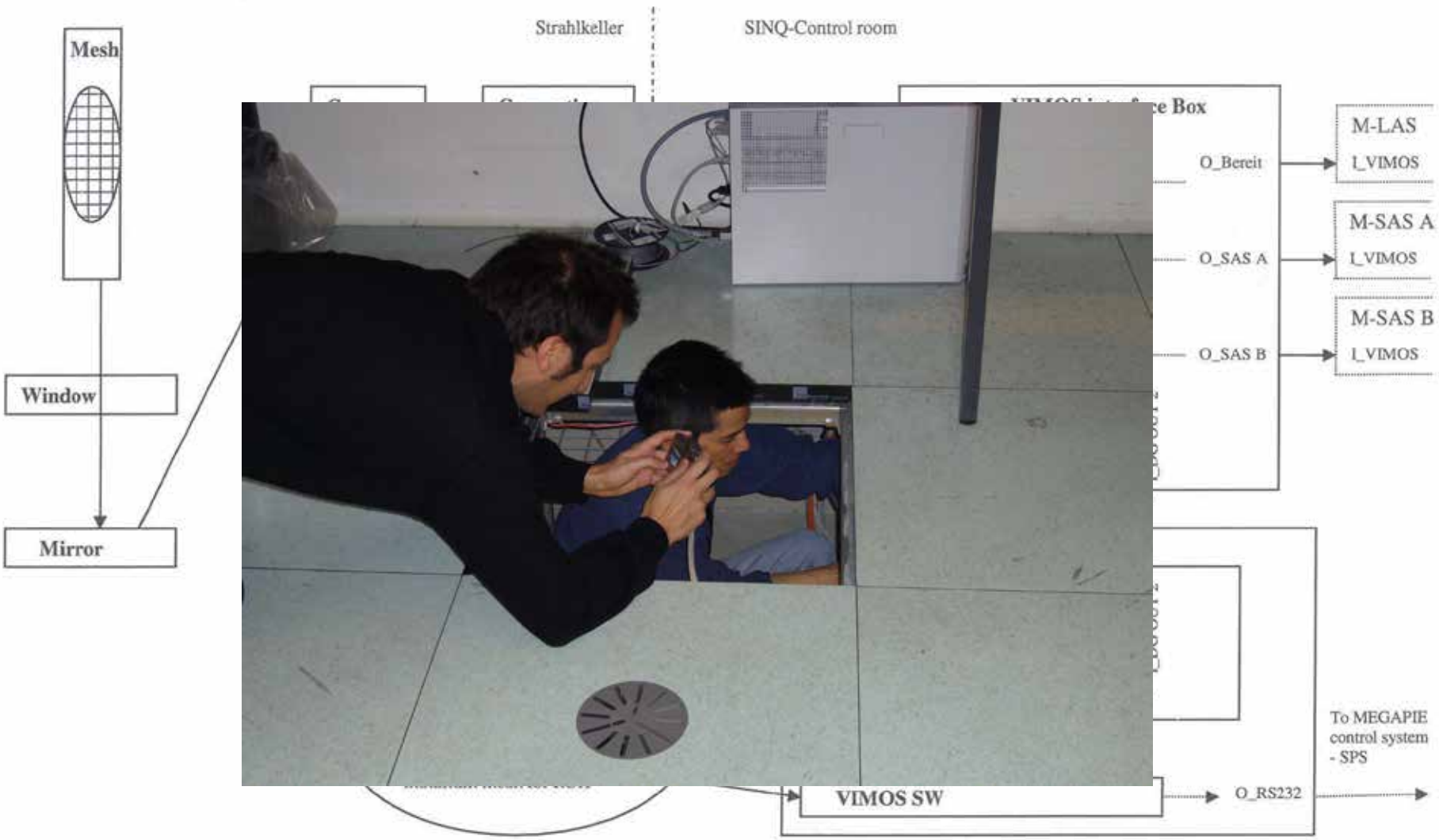


Figure A-3 PSA model of the VIMOS system. Ovals indicate parameters to be set by operator.

See welding of Calotte

.. we had a very good and tolerant design !!

We managed

Short list of attributes and attidtudes required for and showed by the MEGAPIE Project Team and the Licensing Authority:

- **Competence**
- **Effort & Dedication**
- **Good Communication**
- **Openess & Transparency**
- **Reliability & Respect**
- **Prudence & Flexibility**
- **Patience**
- **Trust**
- **Good Will**

We were certainly not perfect in any of those

PAUL SCHERRER INSTITUT

Acknowledgements to about Everyone involved in MEGAPIE