A Dedicated Beam Interrupt System for the safe Operation of the MEGAPIE Liquid Metal Target

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MEGAPIE Safety Systems:

Transmission Monitor
Slit KHNY30
VIMOS

Beam Losses

EFFECTORS

TC LBE Leak Detector
Stripe LBE Leak Detector
Requirements:

The beam has to be switched off

- within 100 ms if 10 % of the protons by-pass Target E (corresponding to factor 2 in peak intensity)

- within 1 sec if LBE leaks out of the Liquid Metal Container
For Megapie, three (new) Systems watch for correct scattering in Target E and proper Beam Transport

- Improved Transm. Monitor (intensity)
- Slit KHNY30 (beam energy / path)
- VIMOS (beam footprint & intensity)
- Distribution of Losses along Beam Line
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
Long Term Stability of Current Monitor

transmission vs MHC4M for Megapie

- Standard upper limits
- Standard lower limits
- Expected transmission
- Measured transmission

Target Transmission [%]

MHC4M [microamp.]

0 200 400 600 800 1000 1200 1400 1600 1800 2000
Slit KHNY30

- Path for improperly scattered protons will be blocked, current of jaws will be 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
Effect of 0.1 % beam by-passing Target E

- well centered beam
- beam shifted 1.5 mm
  - appr. 0.1 % protons by-pass Target E
VIMOS

- Beam intensity distribution 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
VIMOS saw wrong Parameter File

\[ I = I_0 \times 3.5 \]
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.
Administrative Measures were applied and Rules were strictly adhered to
End-to-end Test @ 40 μA, Δt < 40 ms

Proof of Functionality and Sensitivity at Very Low Signal Level

- MHC4 & MHC5 beam current
- KHNY30 current
VIMOS triggered correctly @ 900 μA

Proof of Functionality and Sensitivity at Very Low Signal Level (frames enhanced)
VIMOS Alarm on 15 September

BSR-SINQ-6

Record 11 hrs
1. New Mask,  2. New Camera
Third Camera: 22 November

21 December 2006
2 Sensor Types in LBE Leak Detector:

**Thermocouples**
(9 individual and independent sensors, 3 electrically preheated) as main leak sensor

**Stripe sensors**
type “AC impedance” (3 separate units) as additional secondary instruments
Initial Difficulties
Partly unexpected Results:

Failure of one Thermocouple

CTP14 shows negative Temperature
New Criterion: \[ S < |T_i(t) - (T_0 + k_i (\text{Av}(t) - T_0))| \]

<table>
<thead>
<tr>
<th>Temp.</th>
<th>(k_i)</th>
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<tr>
<td>TC911</td>
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<tr>
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</table>
Average-Temperature Algorithm refined

Stripes with reduced sensitivity
TC based LBE Leak Detectors make the most sensitive Beam Diagnostic
Variable Behavior of Stripe Signals during the MEGAPIE Irradiation Period
IG (and CG) pressure development since start

leaking oil into the insulation gap:
"Strange" response of Stripe Sensors from the beginning most likely caused by cracked oil (O₂) in IG: People do make different sensitive gas sensors out of ZrO₂ (!)

Ethanol sensors based on nano-sized α-Fe₂O₃ with SnO₂, ZrO₂, TiO₂ solid solutions

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Abstract

Nano-sized α-Fe₂O₃ based solid solutions with different compositions of SnO₂, ZrO₂ and TiO₂, were prepared using high-energy ball milling technique. Their structural properties and ethanol gas sensing properties were characterized using XRD and gas sensing measurements. The experimental results show that the mechanical alloying processes for these powders are the same. The screen-printed thick film gas sensors made from these mechanically alloyed materials demonstrated very high relative resistance. A non-equilibrium structural model was proposed to explain sensing mechanism. The comparison of gas sensing properties was performed for different α-Fe₂O₃ based solid solutions with optimized compositions of SnO₂, ZrO₂ and TiO₂. Among these three sensors, xTiO₂(1-x)α-Fe₂O₃ type of gas sensor has much lower relative resistance value for ethanol. This can be elucidated by the different valence states exhibited by titanium ions.

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Keywords: Sensors; Ethanol; Non-equilibrium; Nanostructured; XPS

(...highly selective ZnO:Al₂O₃ based thick film hydrogen sensors) !!
Results:

Transmission Monitor  a few interlocks
Slit KHNY30  very few interlocks
VIMOS  2 interlocks, 2 BSRs
Beam Losses  nothing special
EFFECTORS  initial inconvenience
TC LBE Leak Detector  2 interlocks, 1 TC failed
Stripe LBE Leak Detector  2/3 worked all the time
Life for VIMOS et al after MEGAPIE secured
Starting operations 2007
Acknowledgements:

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