



Radiation Protection Design of the FRM II

Wolfgang Dittrich and Helmut Zeising

*AREVA NP GmbH
and
Technical University of Munich –
Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM II)*



Radiation Protection Design of the FRM II

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Radiation Protection Design of the FRM II Introductory Remarks

- > Moderator: D₂O, Coolant: H₂O, 20 MW, reactor with moderator tank arranged in pool*
- > General contractor: Siemens KWU, work done by AREVA NP GmbH*
- > Operator: Technical University of Munich (TUM)*
- > Concept design: 1990 - 1995*
- > Construction: 1996 – 2001*
- > Phase of intensive review by authorities (1999 – 2003)*
- > Commissioned during 2004*
- > Full power reached in August 2004*



Radiation Protection Design of the FRM II Zoning – Type of Zones

- > *Public Area:*
 $\leq 1 \text{ mSv/y}$ without consideration of real presence (at fence)
- > *Monitored Area:*
 $1 \text{ mSv/y} < \dots \leq 6 \text{ mSv/y}$ considering real presence, entire area inside the fence
- > *Restricted Area:*
 $> 6 \text{ mSv/y}$, only in the reactor building: In the reactor hall, in the cellar, in the experimentation hall, in activity monitoring room of vent stack, in neutron guide tunnel
- > *Exclusion Area (as part of the restricted area):*
 $> 1 \text{ mSv/h}$, chamber for primary circuit, filters of H_2O and D_2O purification, chamber for cooling of D_2O , He-gas system, depending on dose rate: buffer stores for radwaste



Radiation Protection Design of the FRM II Zoning – Room Classes

- > 0 ... $\leq 5 \mu\text{Sv/h}$, no contamination, unlimited presence, no specific protective clothes – experimentation hall
- > 1 ... $\leq 5 \mu\text{Sv/h}$ (locally $\leq 10 \mu\text{Sv/h}$), potential low contamination, unlimited presence, protective clothes required – maintenance floor below experimentation hall
- > 2 ... $\leq 1 \text{ mSv/h}$, potential contamination, limited presence without special radiation protection permission
- > 3 ... $> 1 \text{ mSv/h}$, potential contamination, normally locked, access only with special rad. prot. permission – chamber of primary pumps and coolers, pump rooms of purification systems, purification D_2O system

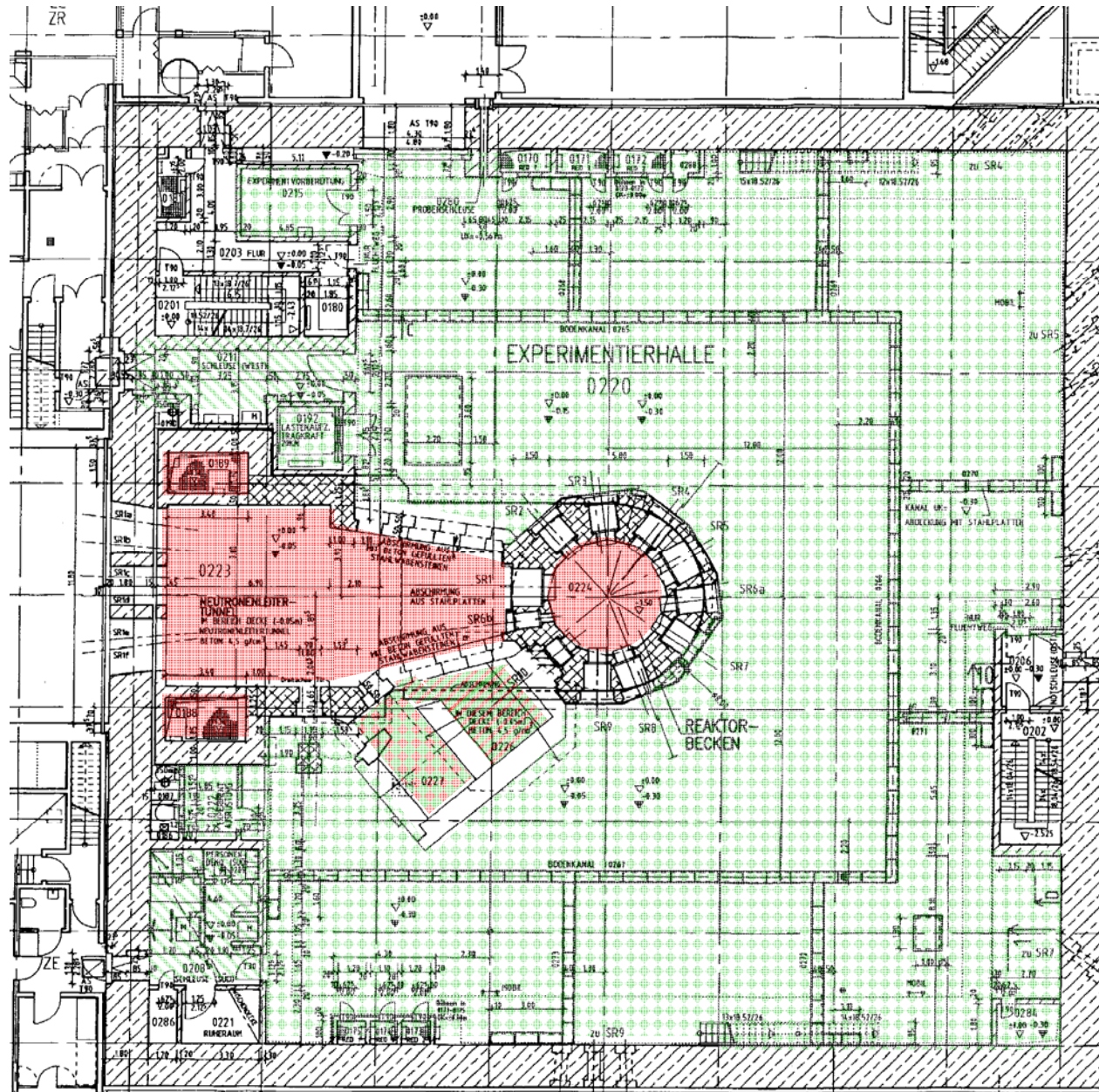







Radiation Protection Design of the FRM II Shielding Materials

- > *Normal concrete, 2.1 g/cm³ - in general*
- > *Hematite concrete, 3.6 g/cm³ - upper wall sections of reactor pool, lower wall sections of fuel pool, ceiling of the chamber with primary pumps and coolers*
- > *Hematite concrete with steel shroud, 4.5 g/cm³ - lower sections of reactor pool, operator's side of hot cell, walls of neutron guide room in reactor building*
- > *Steel and lead plates – 2 floor sections of fuel pool, operator's side of hot cell, fuel transfer duct, active zones of D₂O filters, heavy concrete wall sections of neutron guide tunnel*
- > *Water – reactor and fuel pools*



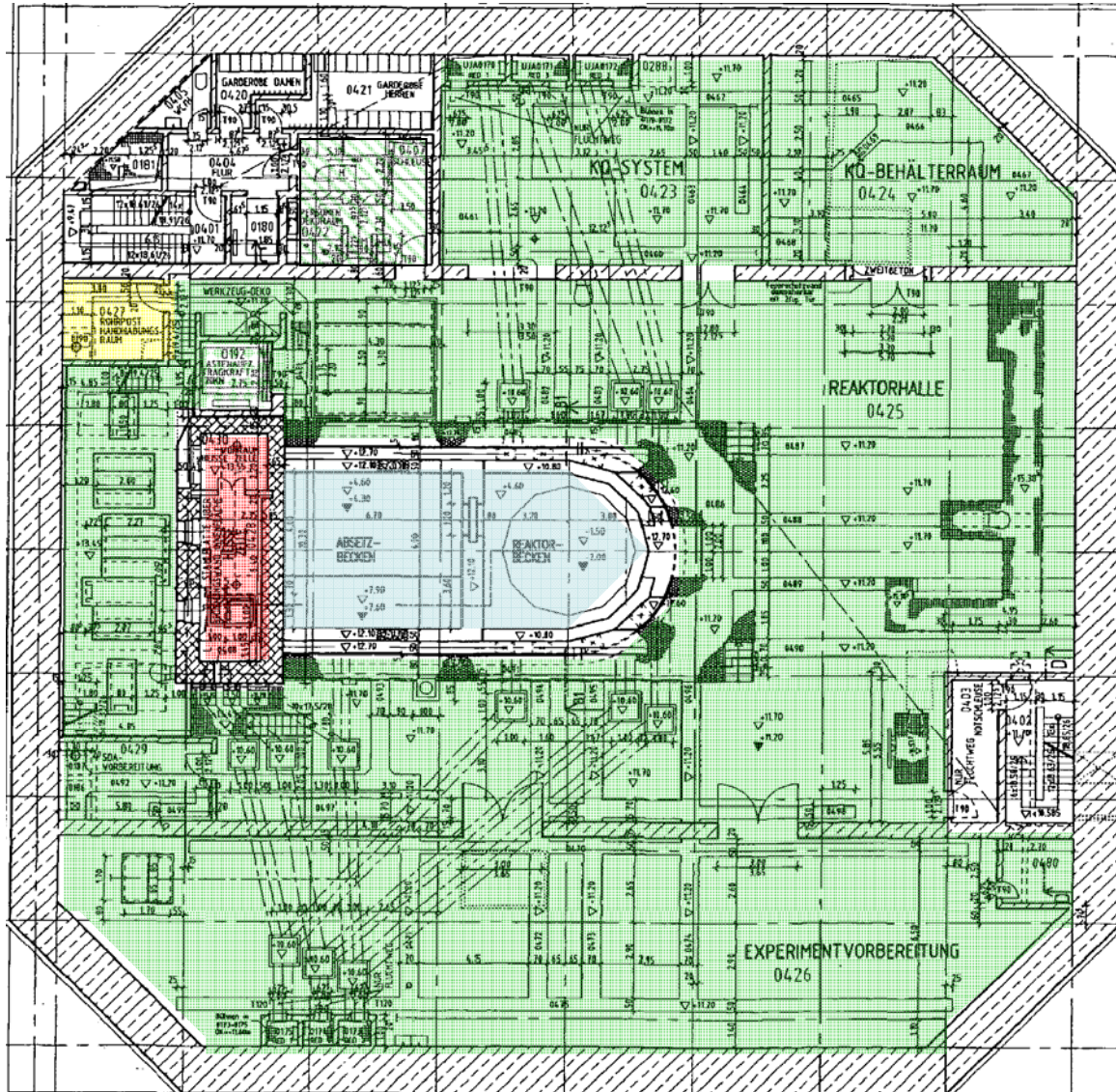
Radiation Protection Design of the FRM II Level of Experimentation Hall (Level 02)





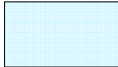


-  Personnel Lock
-  Class 0
-  Class 3
- Rooms for Cancer Treatment (depend. on operation) :*
-  Classes 0/3
-  Classes 1/3



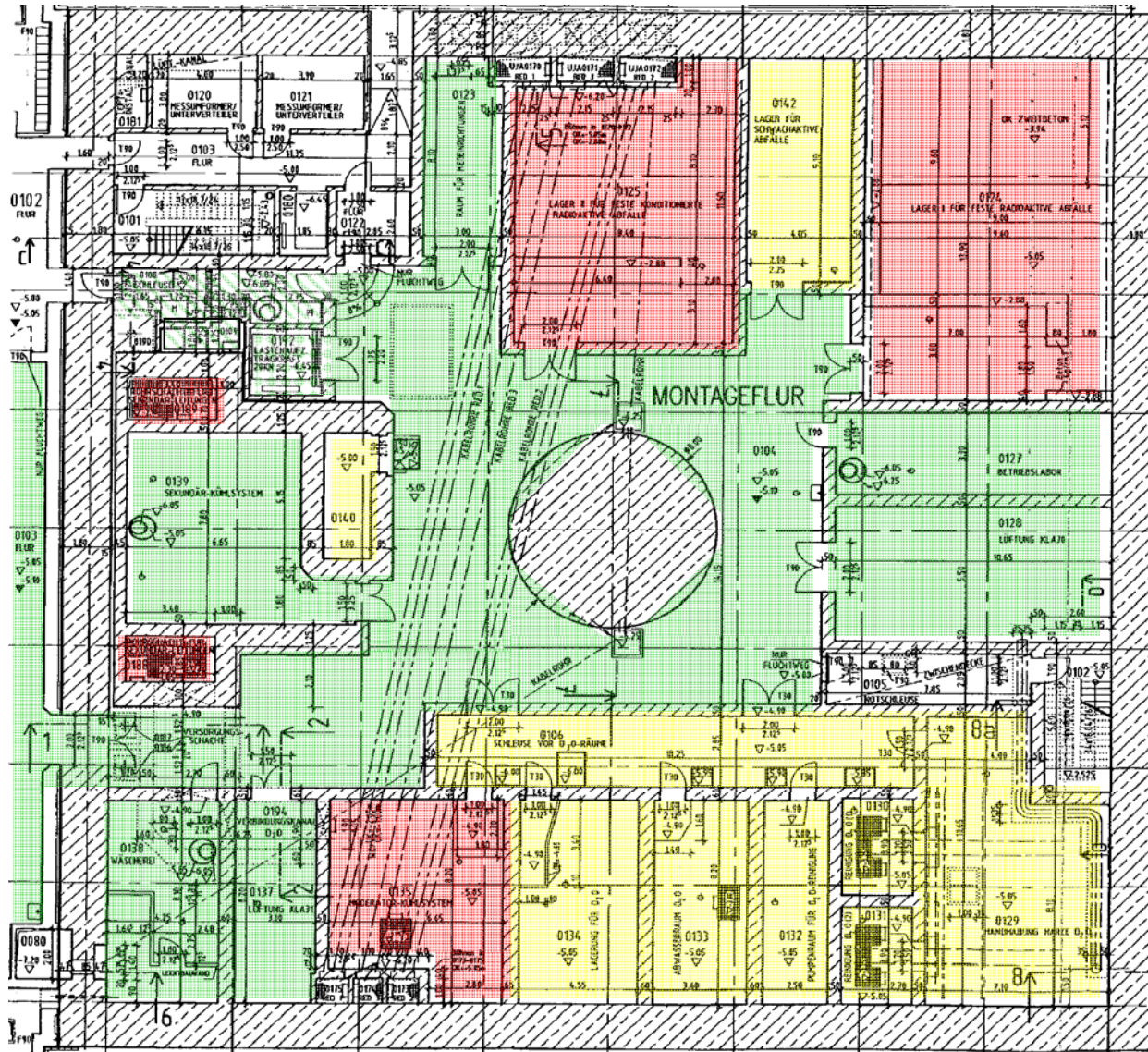
Radiation Protection Design of the FRM II Level of Reactor Hall (Level 04)

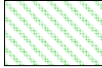





-  *Personnel Lock*
-  *Class 1*
-  *Class 2*
-  *Class 3*
-  *Water*



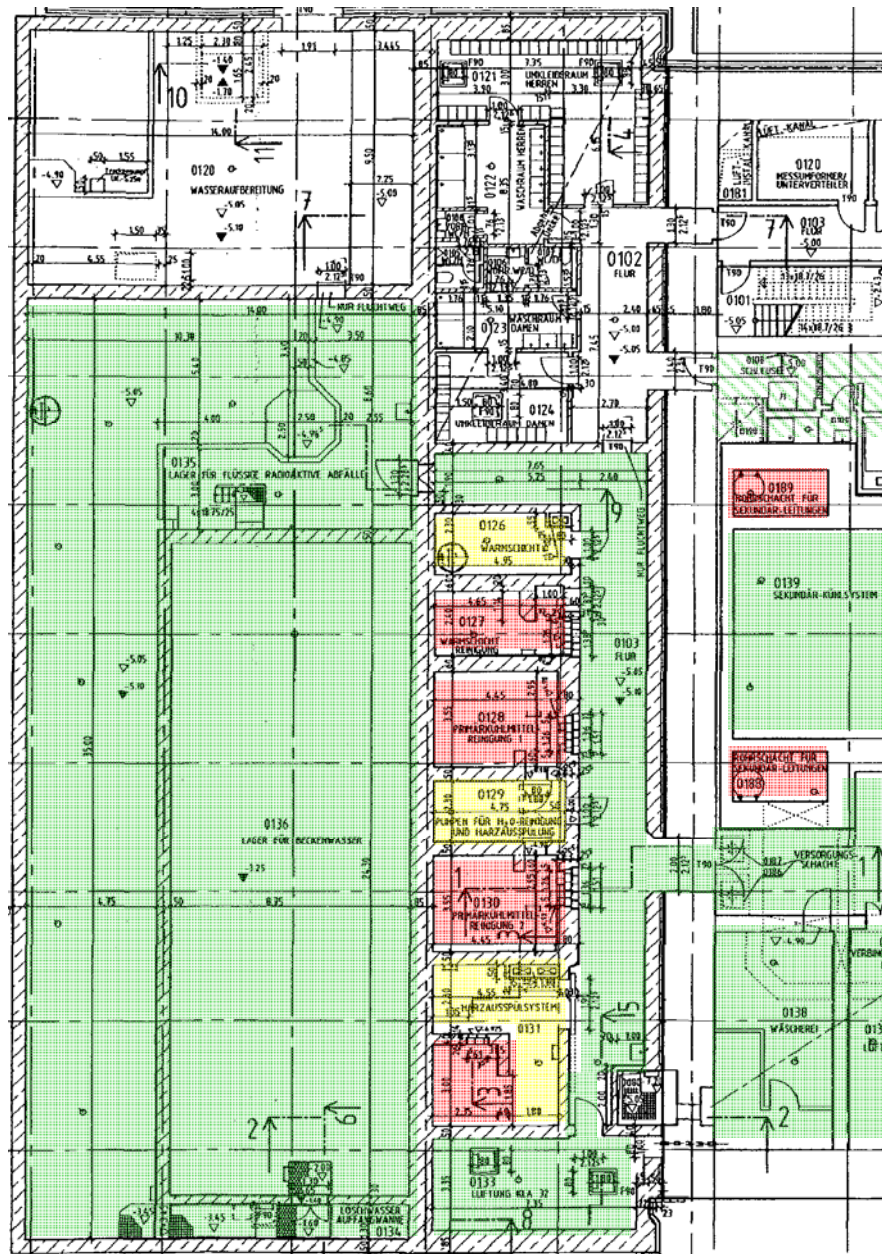
Radiation Protection Design of the FRM II Level for D₂O Purification, Solid Waste (Level 01)



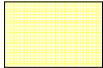



-  Personnel Lock
-  Class 1
-  Class 2
-  Class 3



Radiation Protection Design of the FRM II Area for H₂O Purification, Waste Water (Level 01)

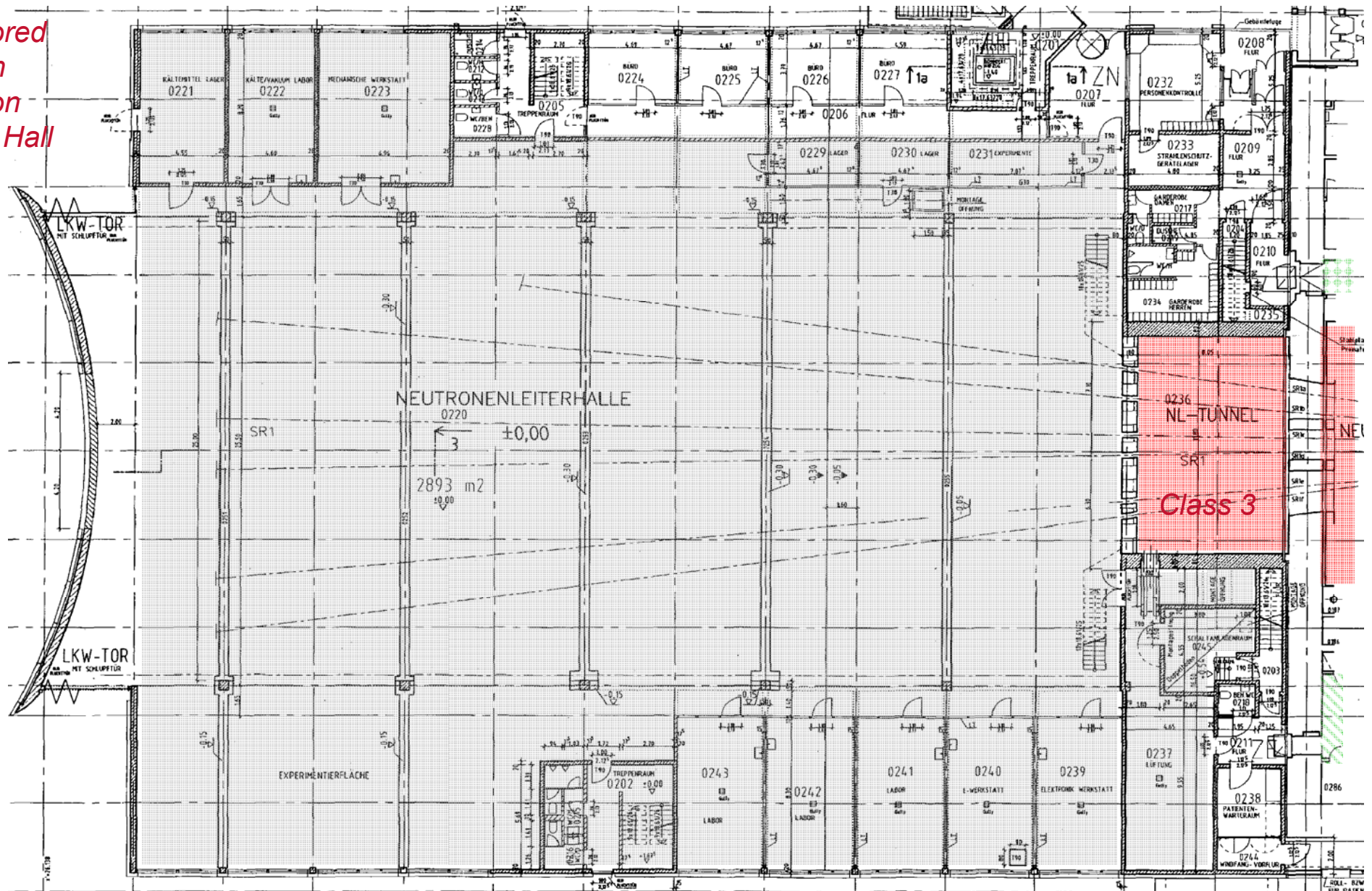


-  *Personnel Lock*
-  *Class 1*
-  *Class 2*
-  *Class 3*



Radiation Protection Design of the FRM II Neutron Guide Hall

Monitored area in Neutron Guide Hall





Radiation Protection Design of the FRM II Access Concept

- > *General security checkpoint in Access Building in front of Reactor Building*
- > *Reactor Hall (level 04): via personnel lock in NW corner*
- > *Cellar (level 01): via personnel lock in NW corner*
- > *Experimentation Hall (level 02):*
 - *Experiment operation without contamination potential – via personnel lock in NW corner, protective clothes, hand-feet contamination monitor only*
 - *Operation state with contamination – via personnel lock in SW corner (this serves in addition as access for patients receiving cancer irradiation), protective clothes, whole body contamination monitor*
- > *Neutron Guide Hall: separate entrance via Access Building, no protective clothes, hand-feet contamination monitor at the exits*



Radiation Protection Design of the FRM II Radiation Survey Program for Commissioning

- > 7 steps according reactor power level: 0.2, 2, 6, 10, 14, 18, 20 MW
- > 5 topics:
 - Dose and dose rate survey (gamma, neutron)
 - Control and evaluation of readings of dose rate and activity monitors, comparison with design values and reference thresholds
 - Activity concentration in systems– sample collection, evaluation in laboratory with high resolution gamma-spectrometry, comparison with design values
 - ^{41}Ar activity in ventilation – sample collection, evaluation in laboratory, comparison with design values
 - ^3H in D_2O and D_2 systems
- > In general the pre-determined levels for activity release via the stack and for gamma-dose rate during survey were not exceeded.
- > Exceptions were caused (and could be logically clarified) from operating conditions and unforeseen events during commissioning.



Radiation Protection Design of the FRM II Consequences of Survey Results

- > *In a few locations modification and adaptation of systems were performed to eliminate unforeseen increase of the dose rate for the operator requiring additional shielding*

Lead shielding structure in room for D₂O cooling to ease regular inspection of some local instruments



Additional protection of a concrete gap in floor of tunnel for D₂O piping





Radiation Protection Design of the FRM II Conclusion

- > *The radiation protection design fulfils the standard regulation for nuclear plants without exemptions for research.*
- > *The design allows further modifications and adaptations of the facility.*
- > *After now approx. 3 years of operation no single case of exceeding legal limits for radiation exposure of personnel, scientists and public.*