High Intensity Beams and Radiation Issues

Session 3 of ATOP Days 2009

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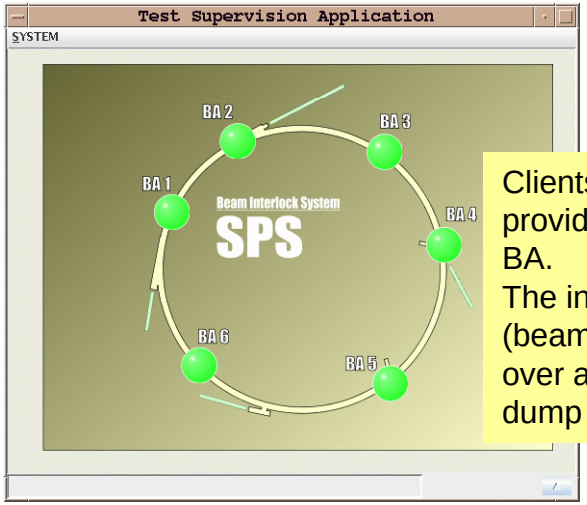
Presentations of Session 3

- Review of the machine protection system in the SPS
  J. Wenninger, BE-OP
- Review of the machine protection system in the PS complex
  K. Hanke, BE-OP
- RF limitations while running at high intensities in the injectors
  E. Jensen, BE-RF
- ISOLDE radioactive air handling
  R. Catherall, EN-STI
- Status of RAMSES and ARCON radiation monitoring systems
  M. Widorski, DG-SCR
- Supercycles in the SPS – towards full ppm operation and impact on the equipment
  J. Wenninger, BE-OP
- Where do we stand 3 years after the recommendations from the BLRWG
  S. Gilardoni, BE-ABP

Review of the Machine Protection System in the SPS

Bubble = BIC module



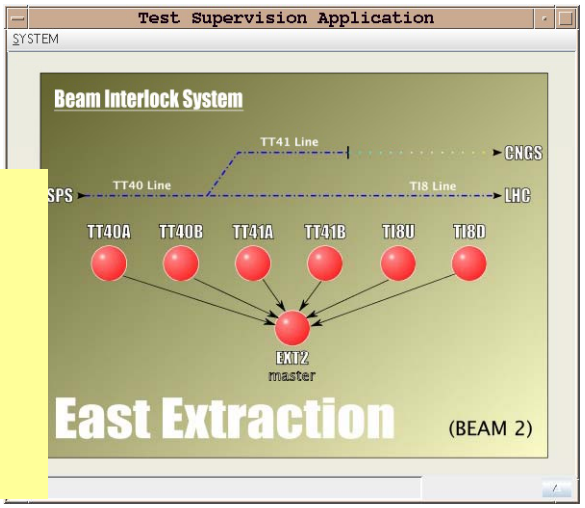
Clients (= interlock providers) connect in each BA.
The interlock summary (beam permit) is carried over a loop to the beam dump system in BA1.

All SPS Machine Protection issues are handled together with the LHC in the (LHC) Machine Protection Panel (MPP)
-> Coherent approach

1 Ring beam permit loop, 2 extraction interlock systems based on BIC modules (same hardware as in LHC)

SPS Hardware Interlock Systems:
experience with the new interlock hardware is excellent

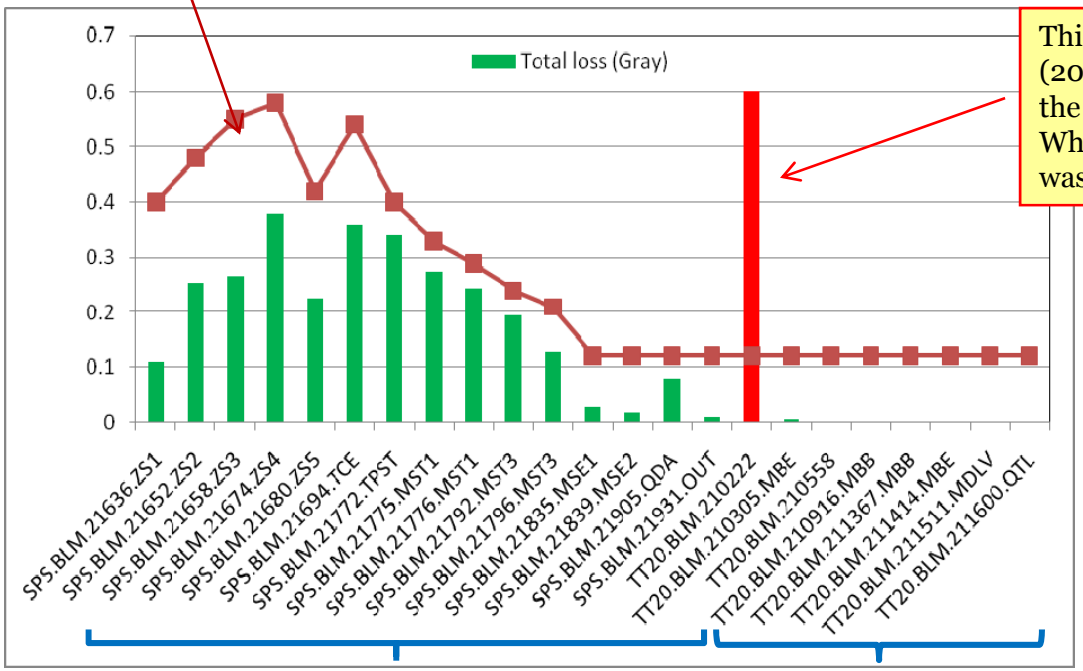
SPS Software Interlock System:
experience with SIS is excellent



Clients (= interlock providers) are connect according to the transfer line.
The interlock summary (extraction permit) is forwarded to the extraction kicker.

ZS Ripper (2007)

BLM thresholds



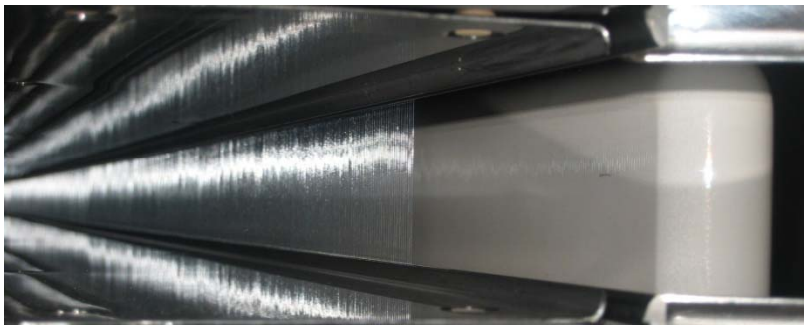
This BLM was changed from ring type (20 ms) to extraction type (μs) after the event.
When the BLM triggered the event was over.

BLD (μs)

BLRING (20 ms)

Electrostatic septum (ZS1) wires cut by slow extracted beam (~9×10^{12} p).

- Cause: controls 'problem' turned a slow into a fast-slow extraction.
- MPS issue: BLMs too slow / threshold too high (slow extraction).



Review of the Machine Protection System in the SPS - Recommendation

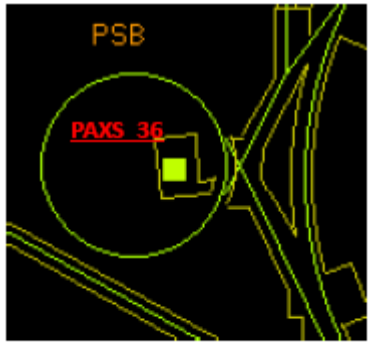
- CNGS and LHC transfer lines MPS: in good shape
  - about 50% of the SPS hardware interlocks are concentrated in those TL
  - interlock coverage is very good but not yet ideal

Recommendations:

- SPS ring and TT20:
  - Require significant improvement of the protection system:
    - New BLM electronics (faster and multiple thresholds and integration times)
    - Fast BPMs for vertical plane
- Simulations required to redefine BLM thresholds, integration times and optimum position/coverage
- Install additional BLMs to increase coverage

Review of the Machine Protection System in the PS complex

- LINAC 2, PS, AD: Interlocks work well
- Booster issues in 2008:
  - ISOLDE beam with destination DUMP sent into the PS
  - Beam to ISOLDE while Request OFF
  - Access interlock of floor –3 during beam operation (stair + elevator)
- ISOLDE:
  - Broken belt in ventilation system triggered radiation (!) alarm in CCC
  - Wrong beam received; now interlock through new VISTAR



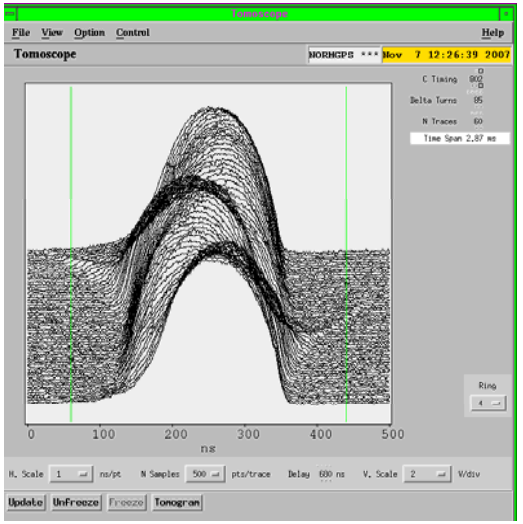
Review of the Machine Protection System in the PS Complex - Recommendation

- Study to prohibit full NTOF beam into East Area for parasitic cycles
- Implementation of new ISOLDE and LINAC2 watchdog systems to be carefully prepared (BI/CO/OP collaboration)
- Clear procedures to be provided to operation for new interlocks (PSB elevator, ISOLDE ventilation alarm, interlock during Linac4 construction)
- Extensive testing of failure scenarios for new equipment connected to interlock system or after control system changes required

RF limitations while running at high intensities in the injectors

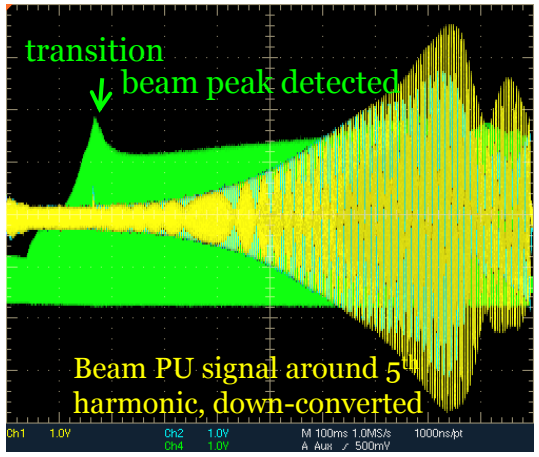
- High intensity beams will confront RF systems with a number of stability limits (or will approach machine instability thresholds).

- PSB:
  - C04 power limitations (air-cooling; issue for faster machine cycling)
  - Instability at low C04 voltage and high BL
  - "Ring 4 problem" (transverse plane)
    - Maybe due to increased impedance
    - Saturation of transverse damper due to additional power demand
  - C02 beam loading in view of Linac4
    - Intensity limit of ~1.65 10^{13} per ring with Linac4?



RF limitations while running at high intensities in the injectors

- PS:
  - Phase drift at low voltages due to beam loading
  - Over-current at γ_{tr} crossing with high beam loading (tube protection was modified in 2008)
  - Beam losses at γ_{tr} (large excursions of MRP too fast for radial loop; additional fast PU has been installed)
  - Insufficient transient beam-loading compensation for an asymmetrically filled machine
  - Coupled bunch instabilities above γ_{tr} for LHC beams (use C10 as long. kicker in feedback loop; works up to nominal intensity)
  - Bunch lengthening due to residual impedance of 40 and 80 MHz cavities



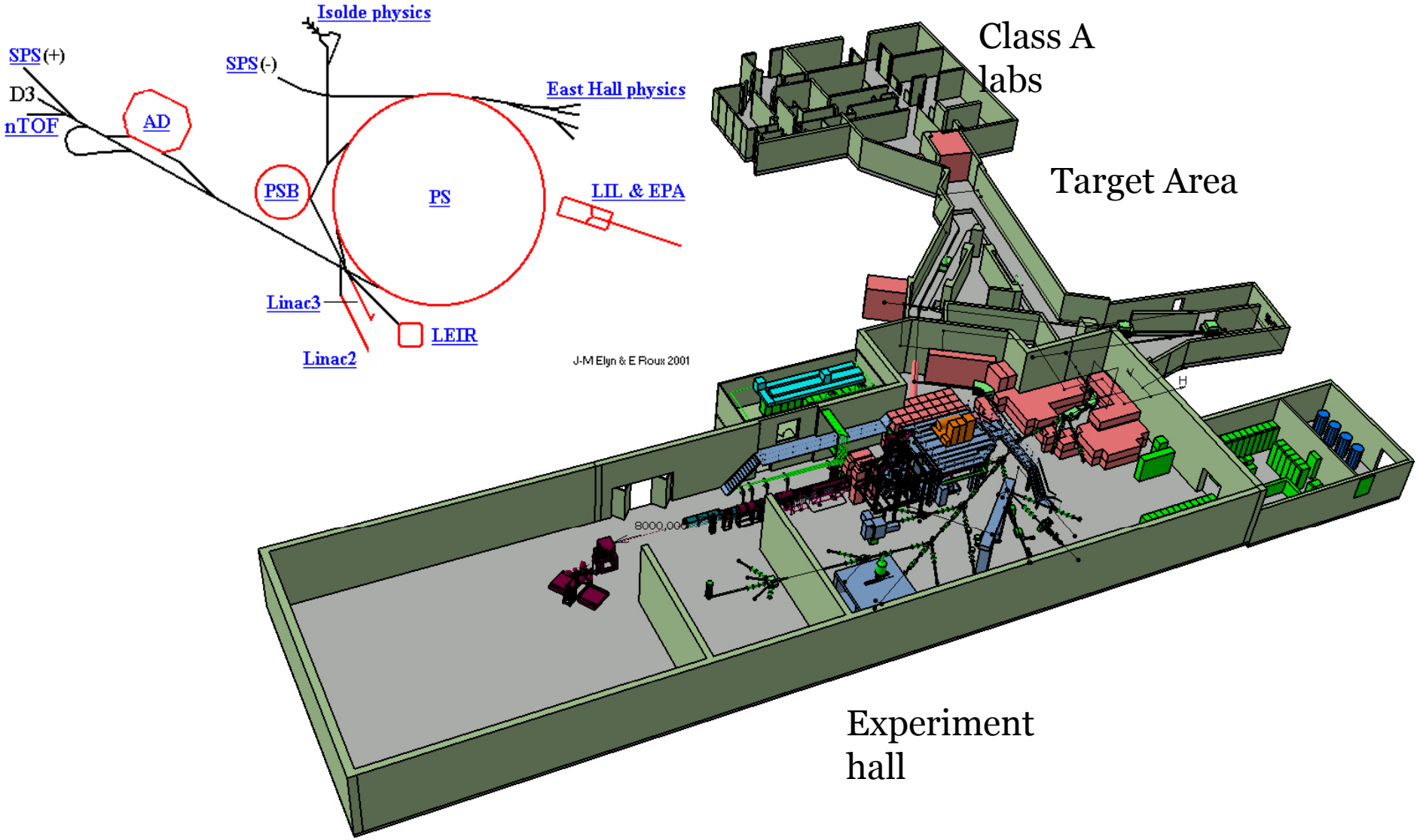
RF limitations while running at high intensities in the injectors

- SPS:
  - 200 MHz system: Siemens (28 tetrodes) and Philips (72 tetrodes)
    - ageing tetrodes (more wear with CNGS operation; 16 tubes broken in 2008!)
    - power couplers: ceramics upgraded, but still limited (transition coupler – cavity)
    - coaxial lines limited to 750 kW
  - 800 MHz system: essential at high intensities to cope withdominant coupled bunch instability
    - The system is dying! (klystrons, transformers)
    - Was 'just' possible to supply required 800 MHz in 2008
    - ✓ System renovation underway; completion in 2013
  - Maintenance work had to be reduced from 2005; increased number of interventions

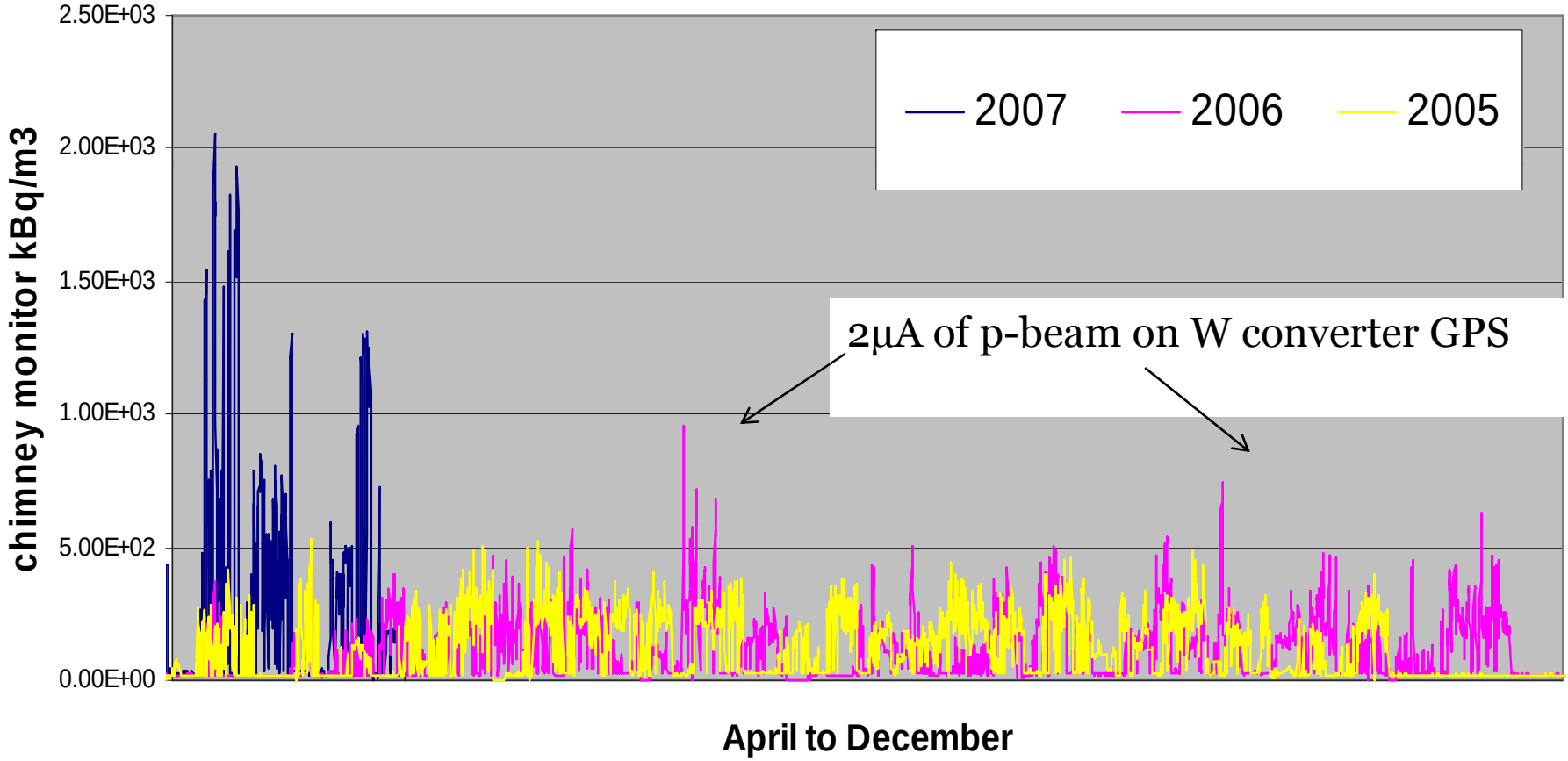
RF limitations while running at high intensities in the injectors - Recommendations

- PSB:
  - Study feasibility of water-cooling for PSB C04 system to prepare a possible 900 ms cycle operation
  - Clarify if C02 needs upgrade for Linac4 operation or prove that new digital LL RF system could improve situation (LL RF loops)
  - Implement power upgrade of PSB transverse damper (in white paper)
- SPS:
  - 200 MHz: Tubes are consumables. For reliable operation, purchase a sufficient number of tubes annually and keep a healthy stock
    - The exact needs are a function of CNGS 'statistics'
    - Allow for a regular 4 months annual maintenance (mandatory for reliability)
    - Improve the connections between power coupler and the 200 MHz cavities

ISOLDE radioactive air handling

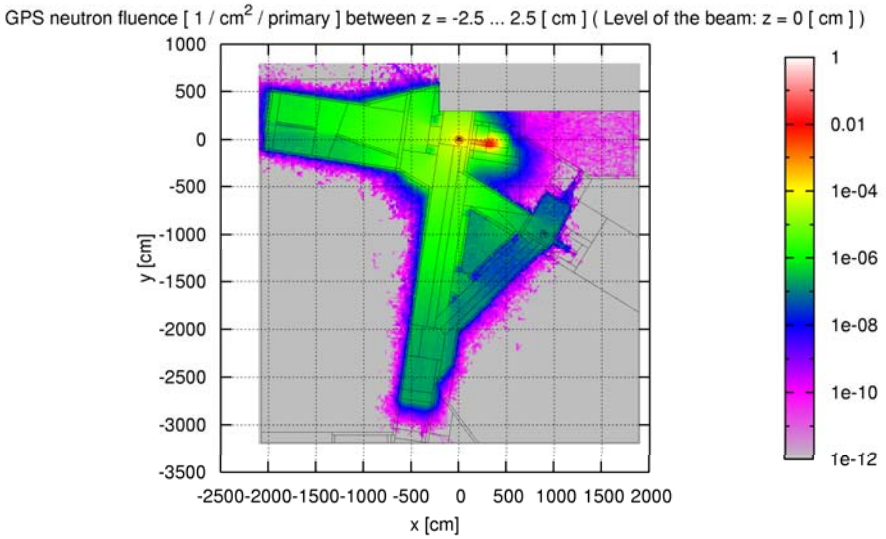


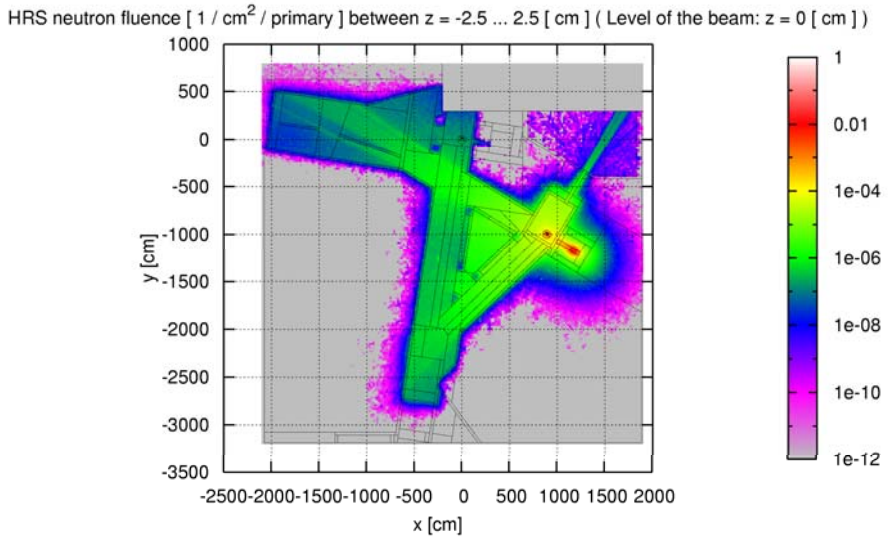
Air activation levels over 3 years as measured in chimney



Modification of the Ventilation System

- Why modify the ventilation system after 14 years of operation? (during 2007/2008 shutdown)
  - Increase delay time of activated air in target area
  - Sealing of holes to reduce air flow out of target





Results from 2008

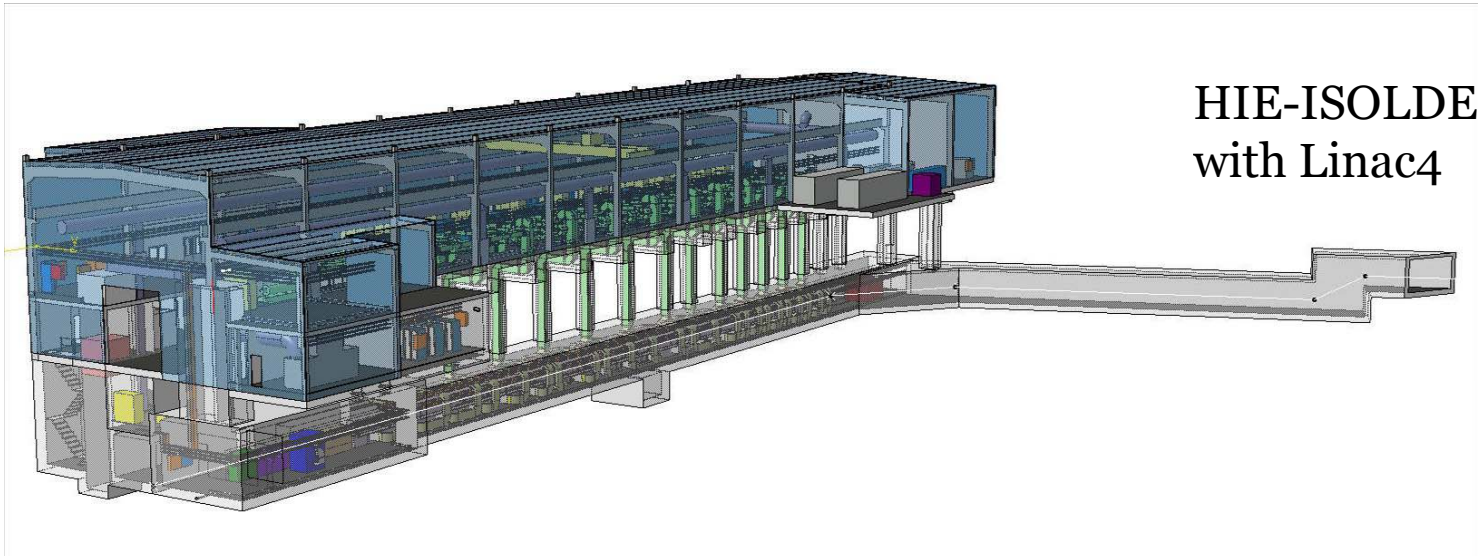
		Release of short-lived gases		
Year	P on target (10^{19})	Measurement (TBq)	Prediction (TBq/10^{20}p)	Released radioactivity (μSvy^{-1})
2004	7.78	5.52	7.1	1.6
2005	9.67	6.76	7.0	2.0
2006	7.9	7.03	8.9	2.04
2007	6.3	11.1	17.6	3.23
2008	5.3	5.48	10.3	1.6

- 2μA was available for each separator as from July 2008
  - Tests showed that at 2μA, a maximum of 520kBqm^{-3} was being released
  - No gate monitor alarms triggered
- The reason for the increase in 2007 is not completely understood but probably due to the opening of cable passages between the hall and the target area.

Recommendations

- All activities exceeding operational limits as defined at ISOLDE start in 1993 need Radiation Safety and Radiation Protection assessment and approval. Same principle will be applied to other CERN installations

- Radiation Safety and Radiation Protection studies similar to SPS, CNGS and LHC are required as part of HIE approval procedure

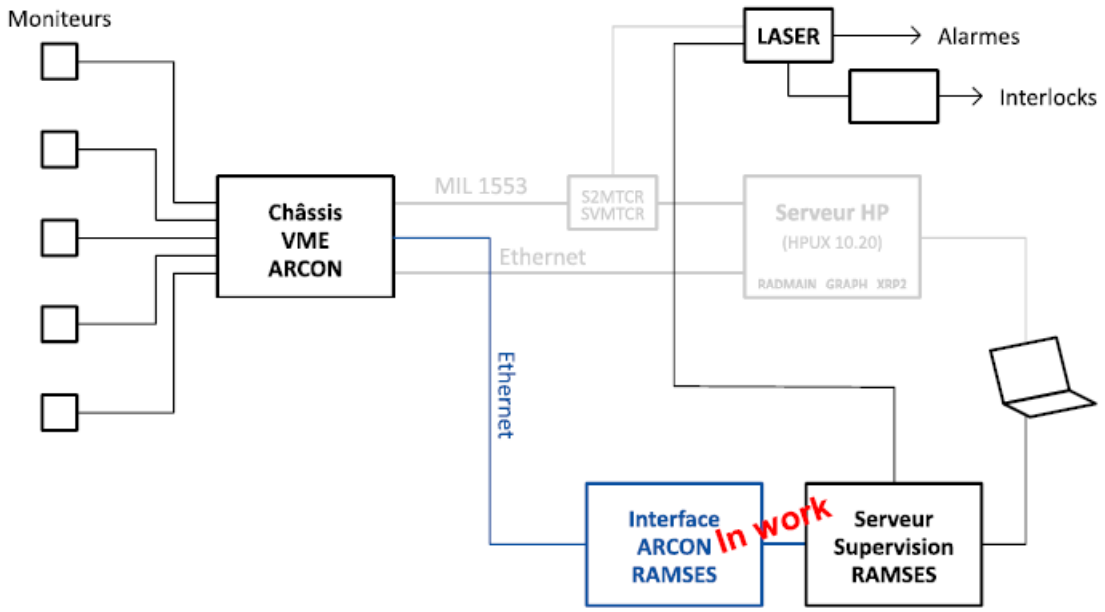


HIE-ISOLDE
with Linac4

Status of RAMSES and ARCON radiation monitoring system

DG-SCR operates two different radiation monitoring and alarm systems:
- ARCON for the injector chain and experimental areas
- RAMSES for LHC, CNGS, CTF3

Aim:
replace ARCON by RAMSES
1st step: remove HP server



Status of RAMSES and ARCON radiation monitoring system

- Extension of RAMSES to whole LHC injector chain on good way, Finance Committee approved to increase the envelope of the initial contract
- HP server supervision replacement close to be finalised

Recommendations:

- Clear procedures to be prepared for operation to prepare for ARCON failures
- Clarify fast access to RAMSES from CCC

Supercycles in the SPS – Towards 'full' ppm operation

- Remove link between supercycle and cycle to increase flexibility
- Ensure cycles can be interchanged using a standard setting at start and end
  - *The ring will use a fixed base momentum of 13.5 GeV*
  - *Injection no longer coincides with time = 0 for FT and CNGS beams*
  - *TT10 PC functions must be started in advance (~2000 ms); PC crate needs to be triggered on different timing event*
  - *Machine offset between CPS and SPS will change by -200 ms*

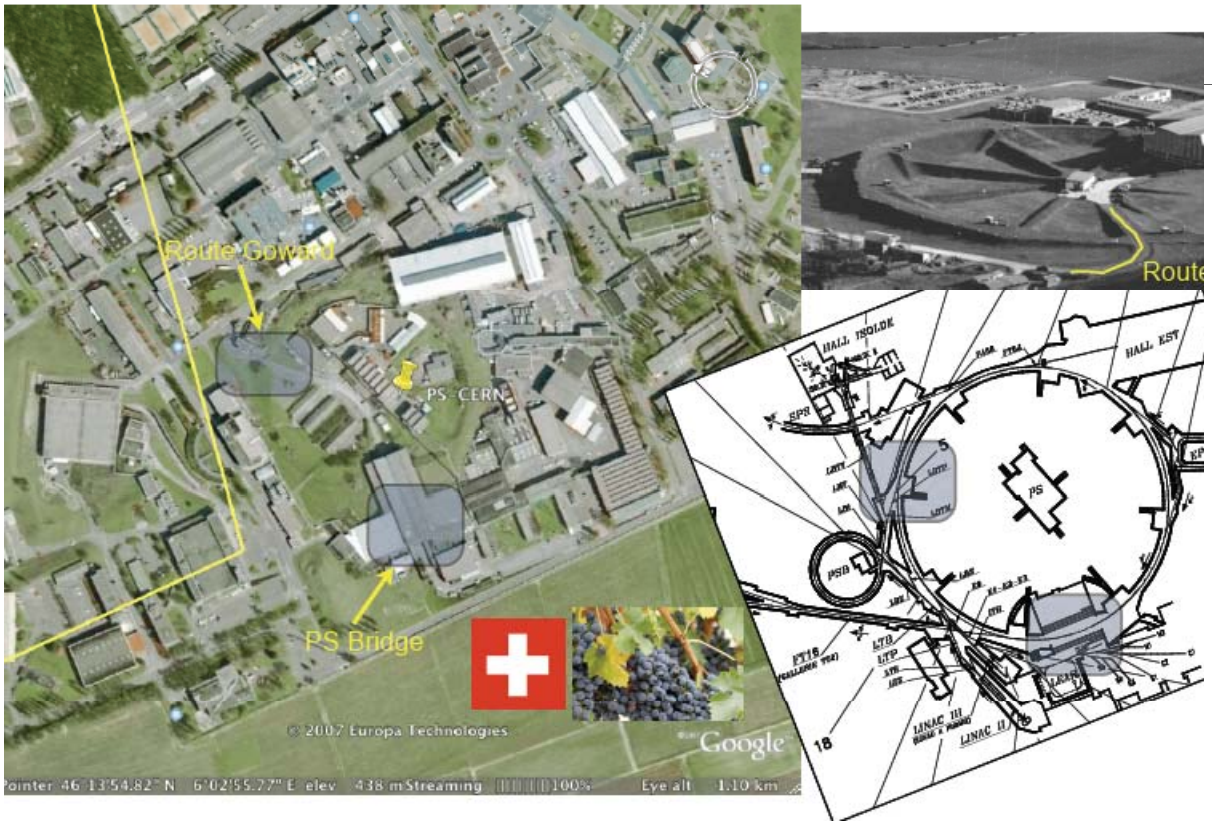
- *No special recommendations*

Where do we stand 3 years after …

PS radiation issue of Route Goward

Tunnel built at ground level, not enough shielding in some locations ....

50% irradiation from CT extraction. ~ 0% with MTE
50% directly from beam injection



Improvements:

MTE extraction
LHC BLMs installed
Matching
PSB-BT-BTP-PS study
Trajectory study
Alignment measurements BT-BTP-PS

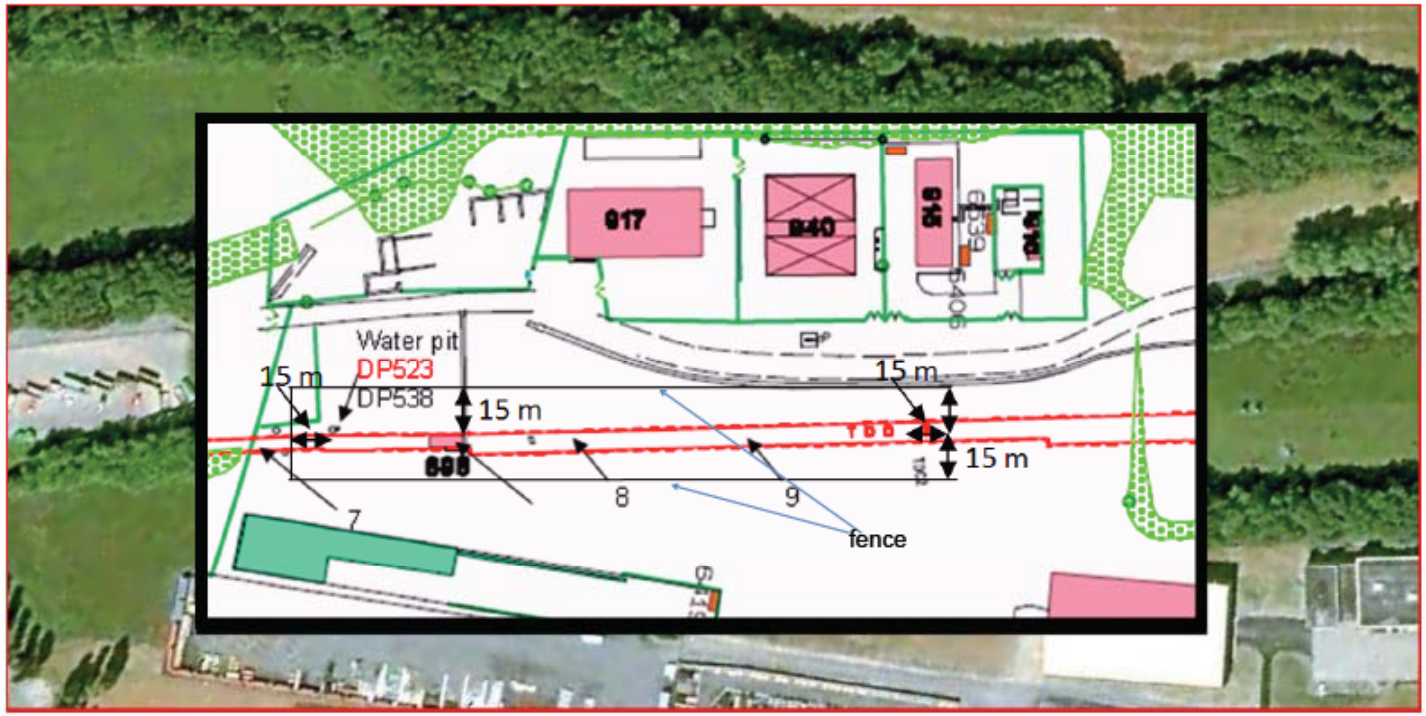
To be done:
MC simulation of injection loss
Alignment BT-BTP-PS

Where do we stand 3 years after …

Surface area on top of TT20

Area on top of TT20 needs to be classified as radiation area

- **Fence around surface area located on top of TT20 beam line encloses :**
  - Water pit DP 523
  - First and second series of splitters
  - Building 898 (ventilation building with direct connection to beam line)



Where do we stand 3 years after

Conclusions

- Recommendations status:
  - MTE commissioning will end in 2009: less radiation @ route Goward, no radiation in SS31, losses concentrated at extraction septum
  - radiation @ route Goward: injection studies ongoing
  - No additional air activation studies for TT10 in 2008 due to other priorities. Postponed to 2009
  - Surface area on top of TT20 has been fenced
  - TT10 PGC1 shaft shielding has been renovated
  - Air sniffing system in BA80 installation started but, due to other priorities, work will be finished in 2009
  - SPS-BLM readout device for residual dose rate measurements testing started
- Operation always attentive to reduce as much as possible beam losses
- Other steps taken to reduce/understand losses: machine alignment, renovation of beam loss monitor system, cross-check between radiation survey and BLMs data...

Where do we stand 3 years after - Recommendations

- Perform BT/BTP line alignment as early as possible (+BTM and BTY alignment)
- Install remote TCC2 device for visual inspections and dose rate measurements
- Publish BLRWG report and revive BLRWG (or similar) for regular inspection of beam and radiation conditions