Petra III RF System Controls: A radiation resistant approach

- Introduction and Overview
- PETRA III
- ELWIS
- radiation test
- results
- conclusion
PETRA II -> III

- Beam Energy: $E_0 = 6 \text{ GeV}$
- Length: $l = 2,304 \text{ km}$
- Beam Current: $I_0 = 100 \text{ mA} (200 \text{ mA})$
- Topping up
- Emittance (hor) $\varepsilon = 1 \text{ nmrad}$!
- Circumference Voltage: $U_c = 20 \text{ MV}$

Summer 2007 to Autumn 2008
Disassembling of the old and installation of the new rf system components

Autumn 2008 to Spring 2009
Commissioning

Spring 2009
Start of PETRA III beam operation
ELWIS at PETRA III RF -
a new system of control, interlock and monitoring

Design Goals for high reliability:

- construction of few different universal modules
- error detection of a module must be as easy as possible
- maintenance by plug and play (replacement of module)
- no expert knowledge is needed
- no detailed documentation is needed (except block diagrams)
- avoid long cables
- extensive post-mortem analysis
- no special components (spare parts must be available in 20 years)
ELWIS module:
PXI crate with analogue & digital in/out channels and plug in signal conditioning boxes
example: klystron ELWIS

- **signal conditioning**
  - analog in/out,
  - PT-100,
  - digital in/out

- **Power supplies**
  - ~ 24V
  - = 24V
  - +/- 15V

- **Contactor**
  - 230 V

- **Ethernet**
  - fast rf interlock

- **4x koax**

- **Software**
  - PXI controller
  - FPGA

- **Fast ADC**

- **Trigger adapter**

- **499.67 MHz reference & test signal**

- **502.168 MHz LO signal**
The „ELWIS“-Concept of RF system in PETRA III

- klystron 1
- klystron 2
- HV power supply
- modulator power supplies
- transmitter
- 6 cavities
- Connection to PETRA III control system
- to the second rf system

Miscellaneous

Server

Connection to PETRA III control system

ESLS-RF meeting Aarhus, 2005-09-21
Stefan Wilke (DESY)
radiation test of electronics

- Is it possible to install electronics near the cavities in the tunnel of PETRA III to avoid long cables and documentation?
- Experience with PLC at DORIS since more than 9 years
- Rough test with a desktop PC in PETRA II tunnel: It hangs after proton operation.
- Decision to test PXI crate electronics (PC and FPGA) in DORIS III and measure the radiation.
- We expect higher radiation in DORIS III than in PETRA III, so we are on the safe side.
- Readout of dose by the tested equipment itself!
- Calibration of measurement system by TLDs.
assembly

ionization chamber

TLD

Ethernet

PXI Crate

interface

dose integrator

2471.94

dose power instrument

DOSIMENTOR
the tested hardware
locality of test in DORIS III

Injection

Rf Straight

Arc North-West

Bypass
different positions in DORIS III

Position 1

Position 3
power of synchrotron radiation
from all dipols (= energyloss per turn of leptons)

$P[kW] = 88,46270 \times \frac{E[GeV]^4}{r[m]} \times I[A]$
Ec: critical energy (divides the photon spectrum into 2 equal halves)

We expect more than 6 times lower dipole radiation in PETRA III than in our test environment DORIS III
Dose, beam current and lifetime in DORIS III in the first 5 days of test
Dose from Dosimentor and TLD in DORIS III over the whole test time
First results

- Dosimentor calibrated by TLD: It shows units in mRad (= 0.01 mGy)
- Electronic fails after almost 22 weeks of operation in DORIS III at 3 different positions
- Probably it’s a fault in memory of the FPGA
- The accumulated dose up to failure amounts nearly 24 Gy
conclusion

- PETRA III will operate from 2009
- new rf system with ELWIS
- at PETRA III we expect low radiation
  (PETRA III / DORIS III, straight section)
- electronics in tunnel should be possible

Mange Tak!
appendix
a impression of the new hall
The existing PETRA rf-system
changes in the rf distribution

7-cell copper cavities: 16 -> 12
shunt impedance (MΩ): 368 -> 276

Normally each transmitter drives 'its' own 6 cavities. Option to run with only one transmitter on all cavities.