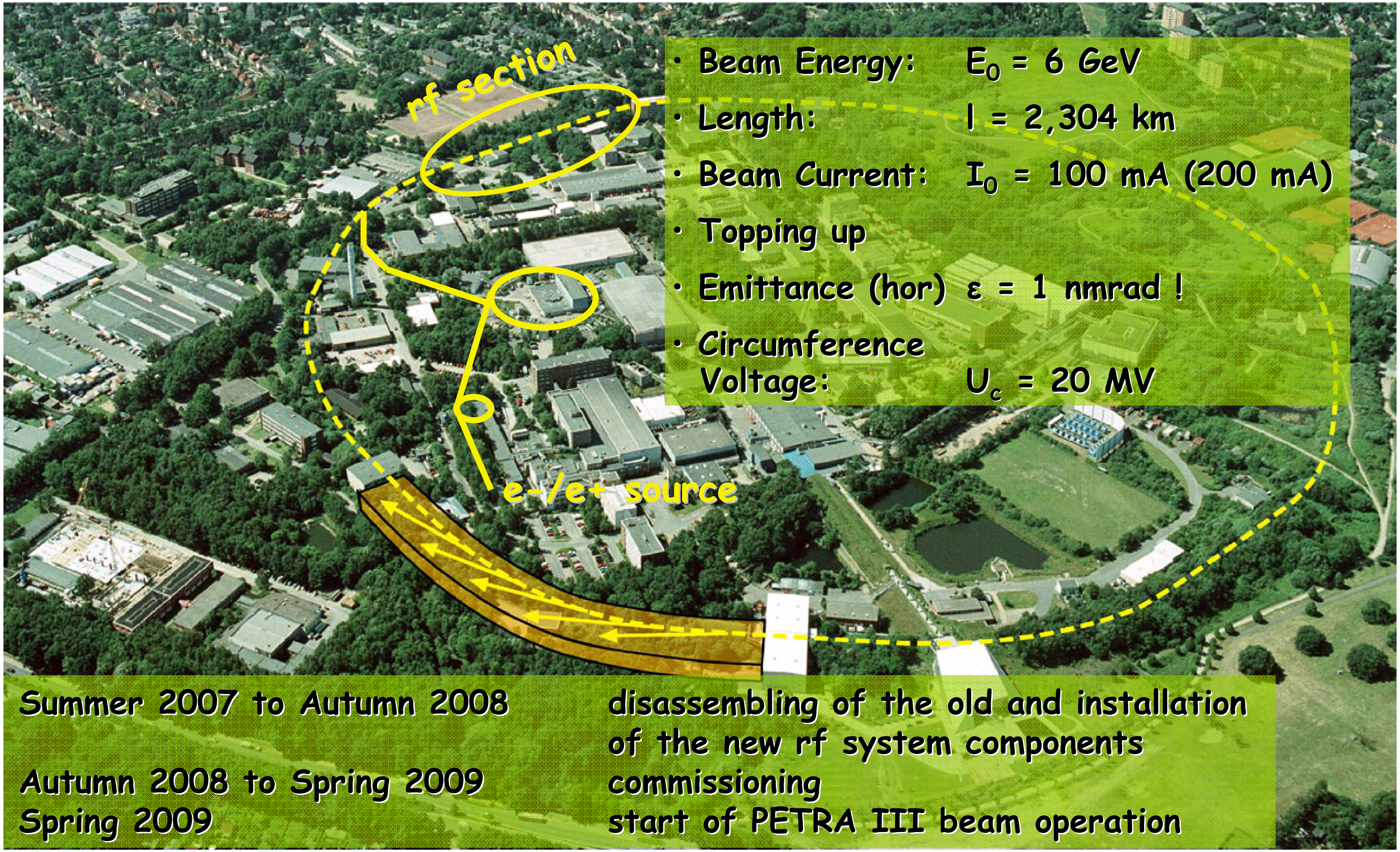
Petra III RF System Controls: A radiation resistant approach

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

PETRA II -> III



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

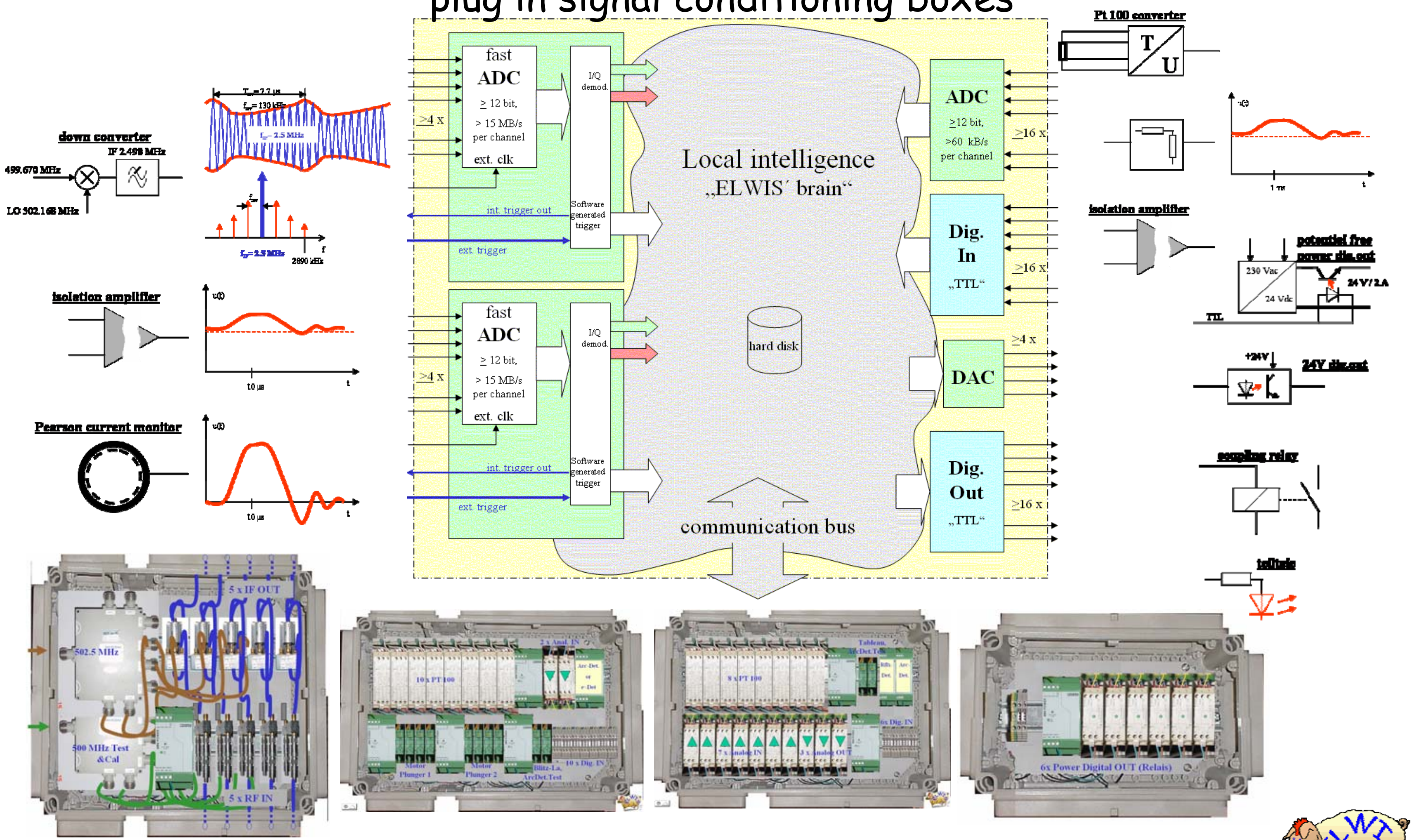
ELWIS at PETRA III RF –
a new system of control, interlock and monitoring

Design Goals for high reliability:

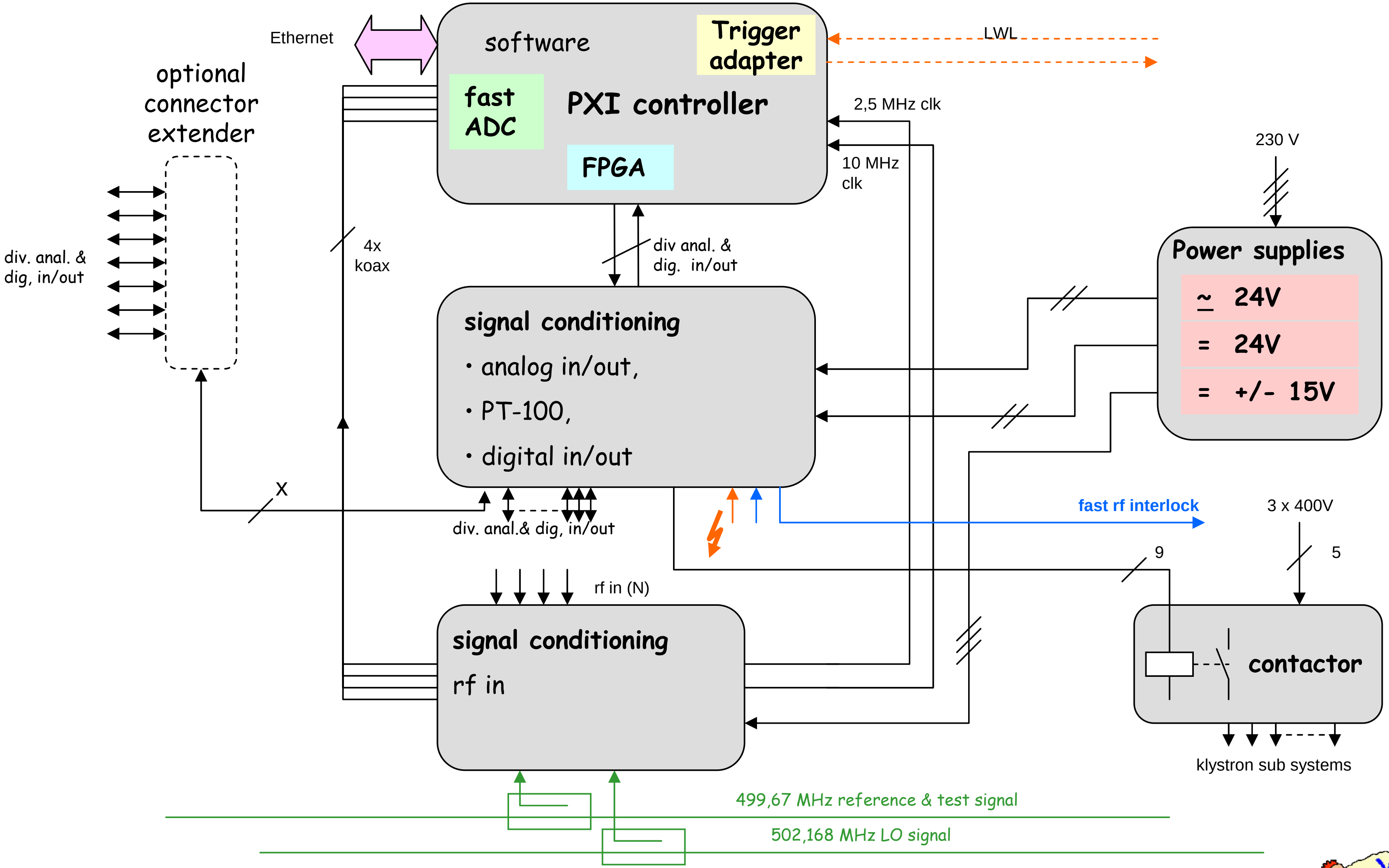
- construction of few different universal modules
- error detection of a module must be as easy as possible
- maintenance by plug and play (replacement of module)
- no expert knowledge is needed
- no detailed documentation is needed (except block diagrams)
- avoid long cables
- extensive post-mortem analysis
- no special components (spare parts must be available in 20 years)

ELWIS module:

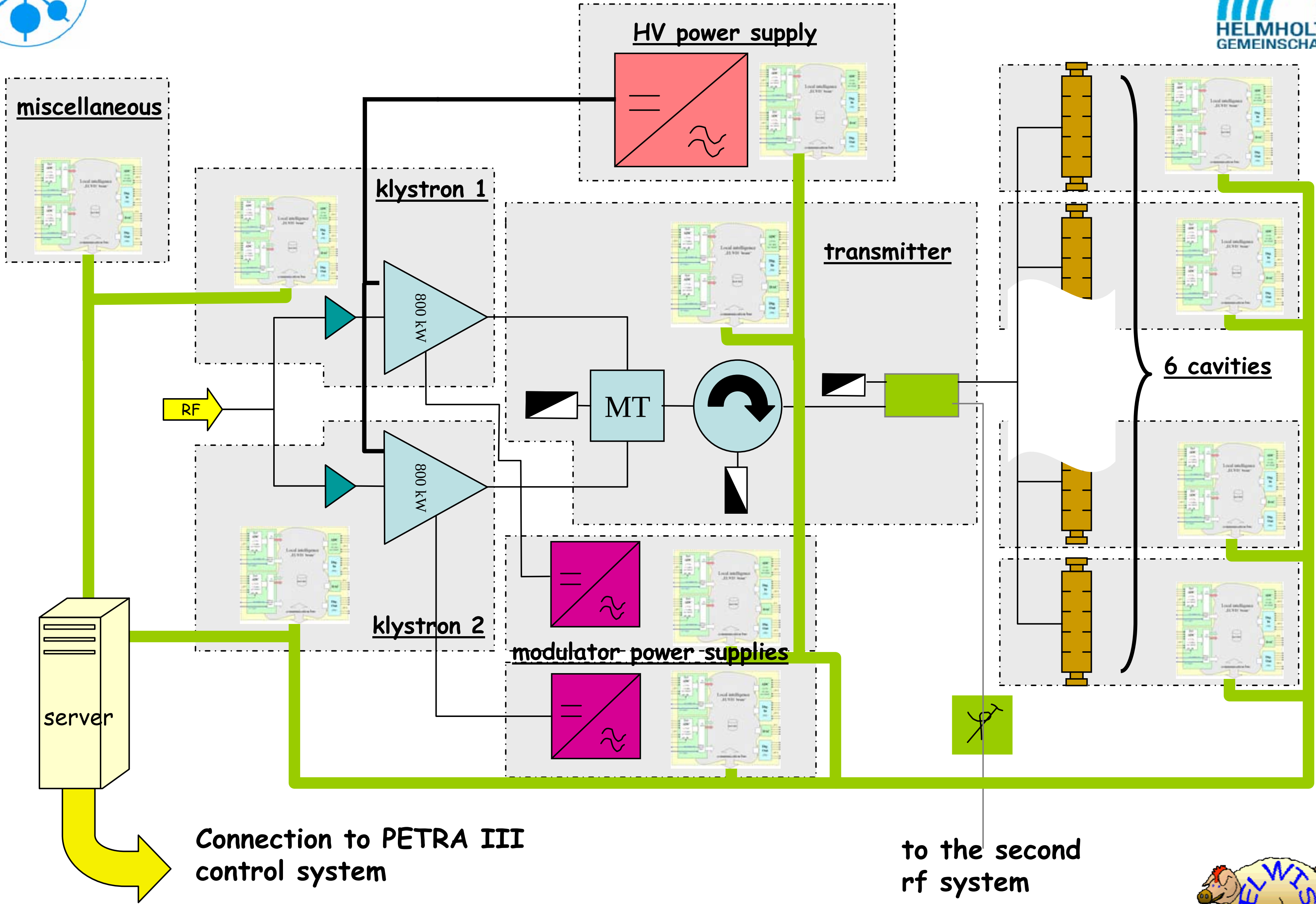
PXI crate with analogue & digital in/out channels and plug in signal conditioning boxes



example: klystron ELWIS



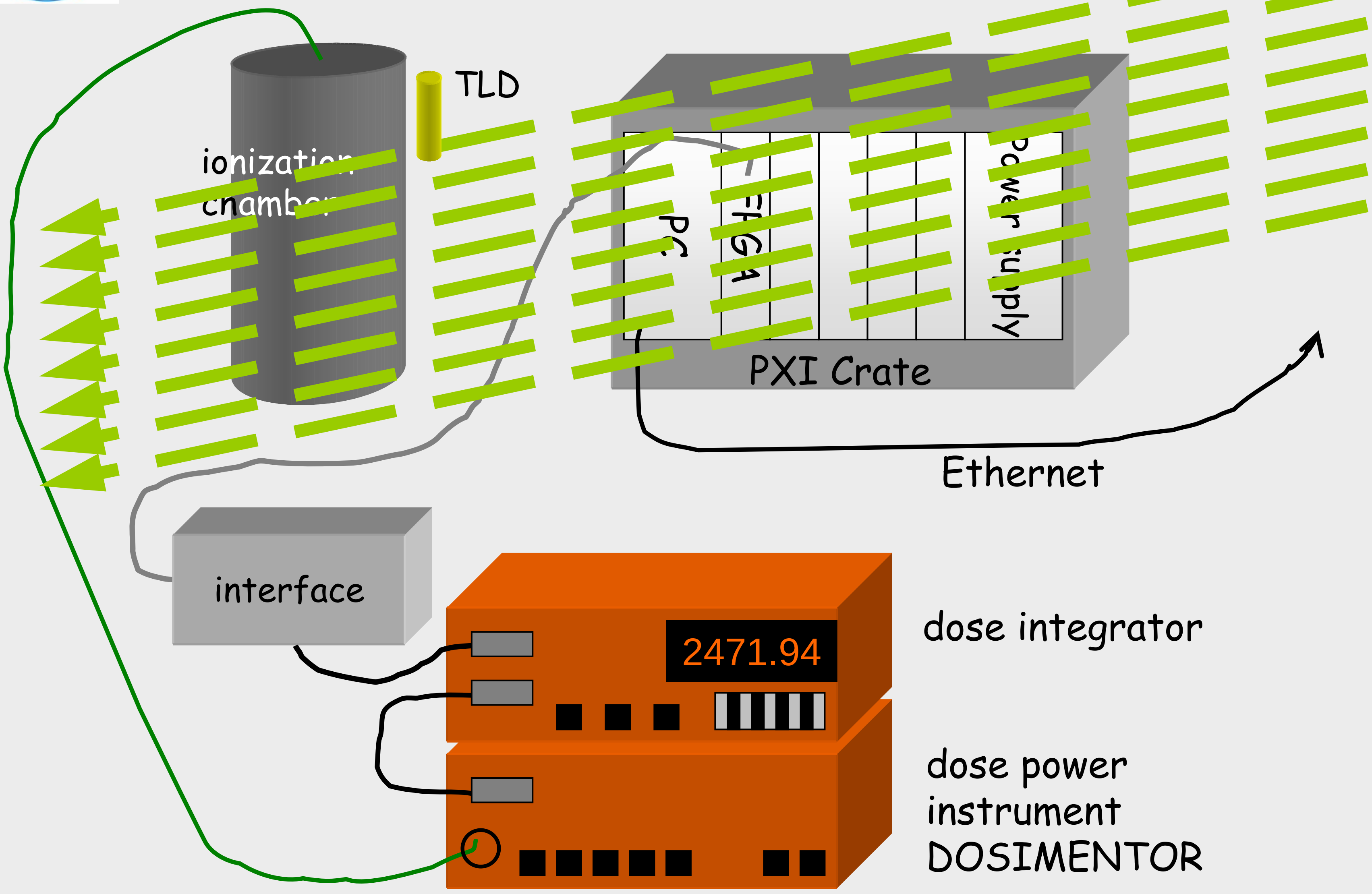
The „ELWIS"-Concept of RF system in PETRA III



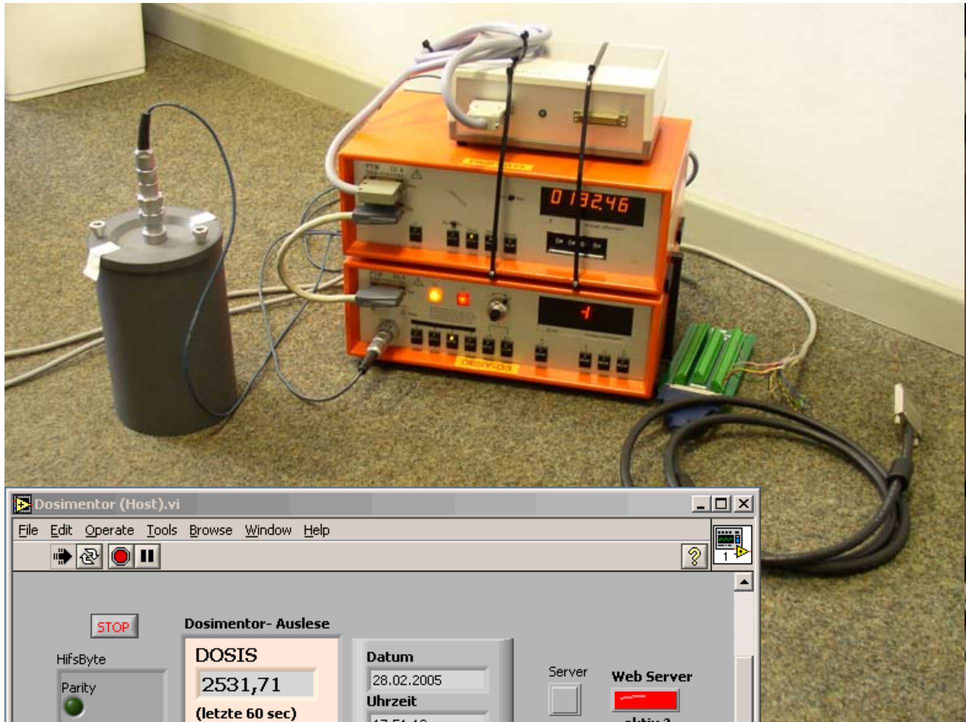
radiation test of electronics

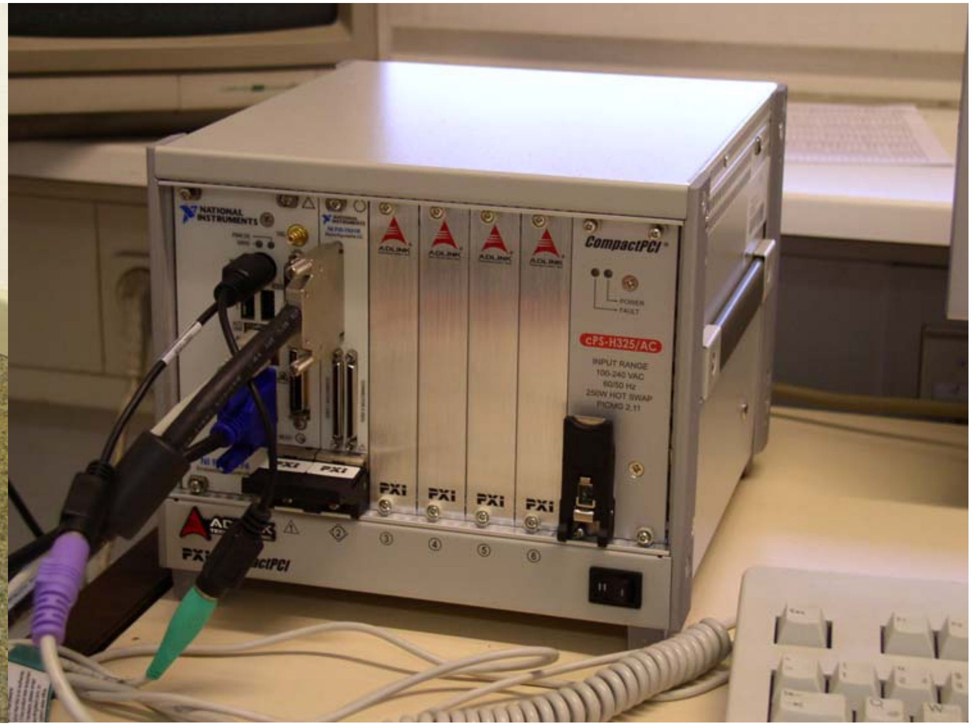
- Is it possible to install electronics near the cavities in the tunnel of PETRA III to avoid long cables and documentation?
- Experience with PLC at DORIS since more than 9 years
- Rough test with a desktop PC in PETRA II tunnel:
  It hangs after proton operation.
- Decision to test PXI crate electronics (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.

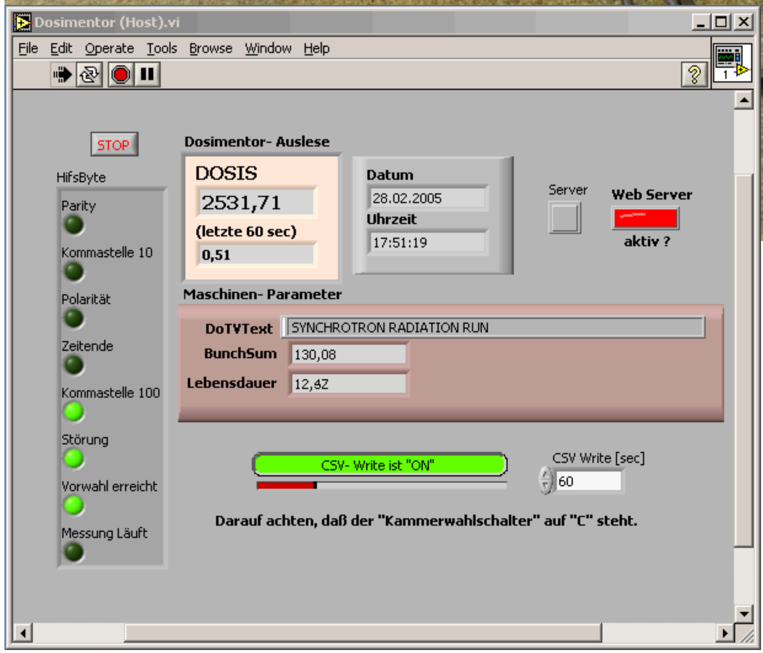
assembly

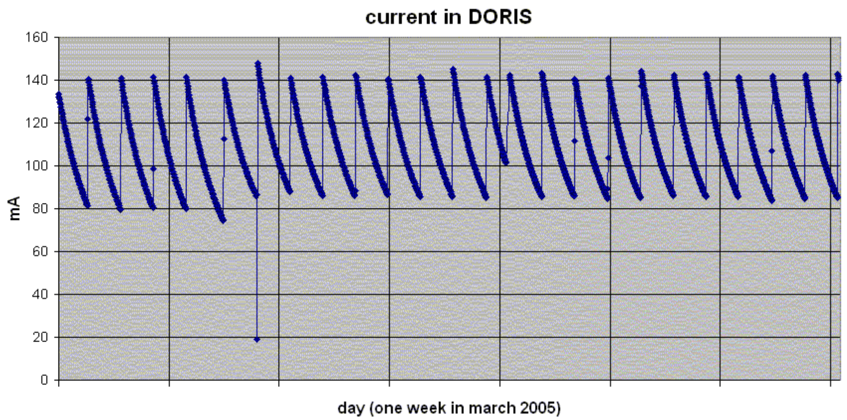

TLD
ionization chamber
PC
FPGA
Power supply
PXI Crate
Ethernet
interface
2471.94
dose integrator
dose power instrument DOSIMENTOR

the tested hardware

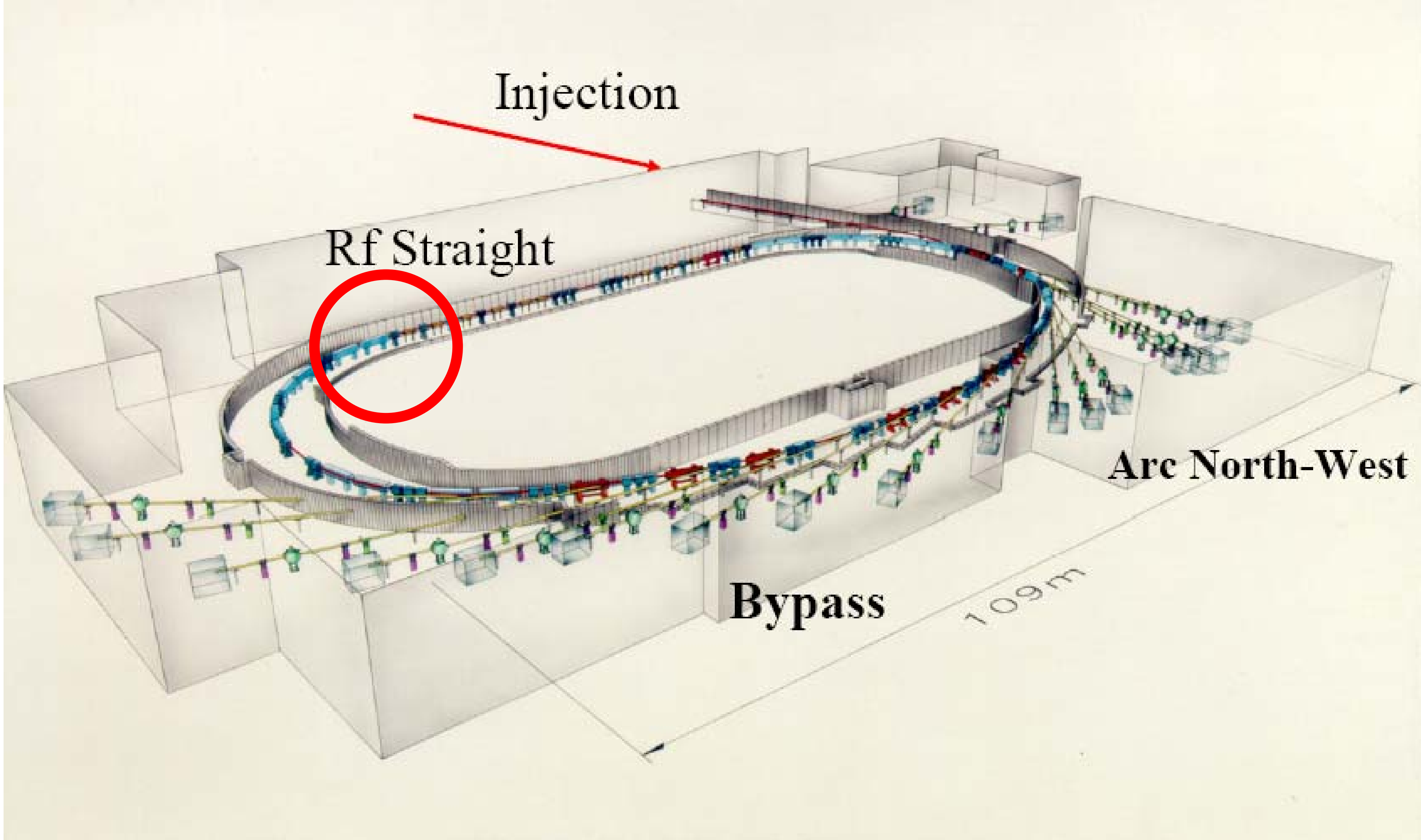








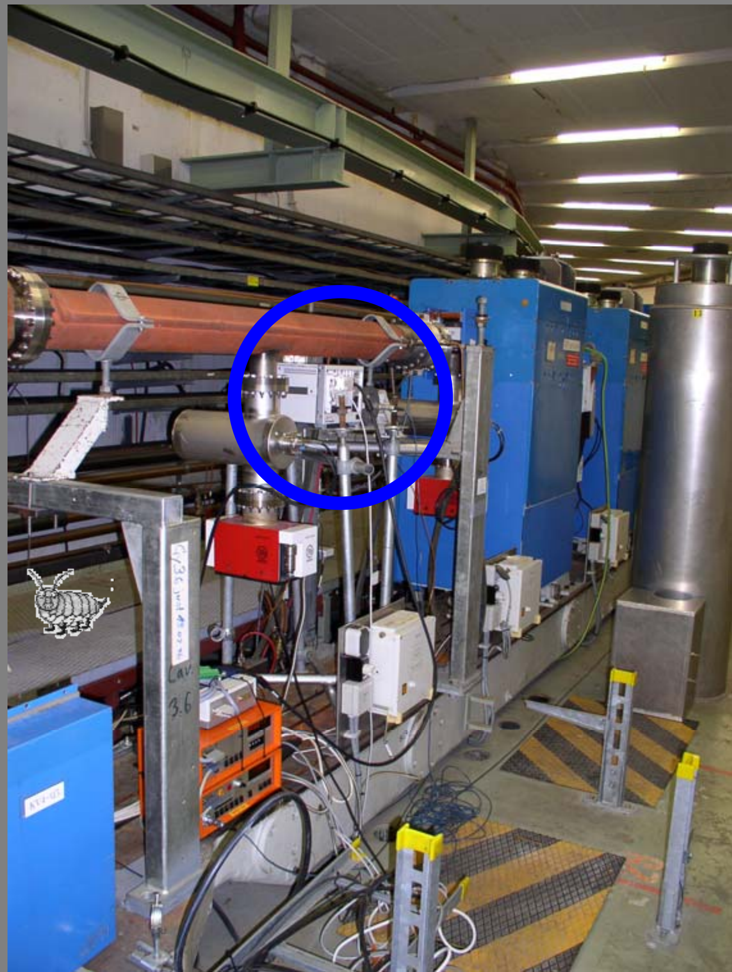
locality of test in DORIS III



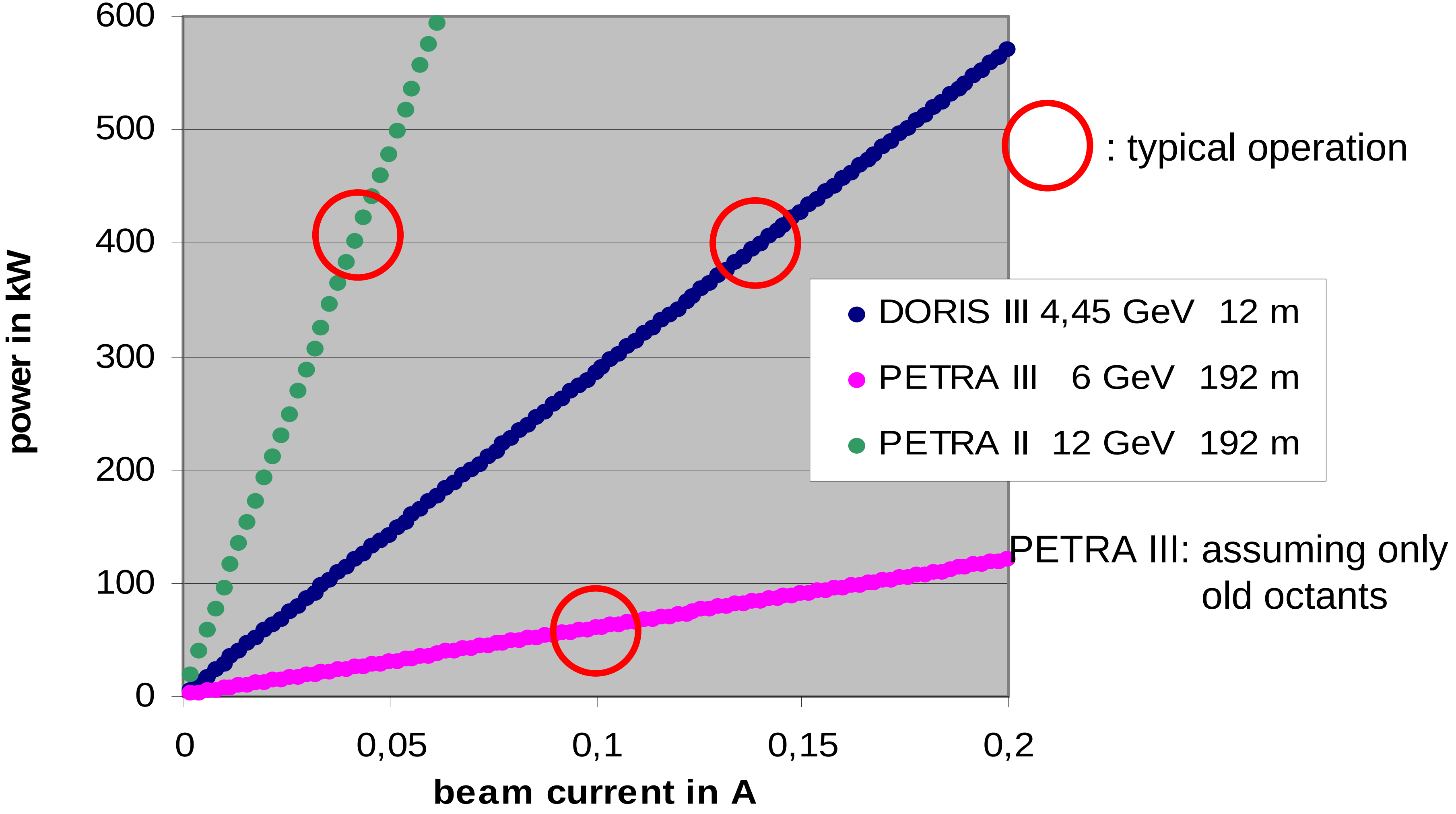
different positions in DORIS III

Position3

Position1

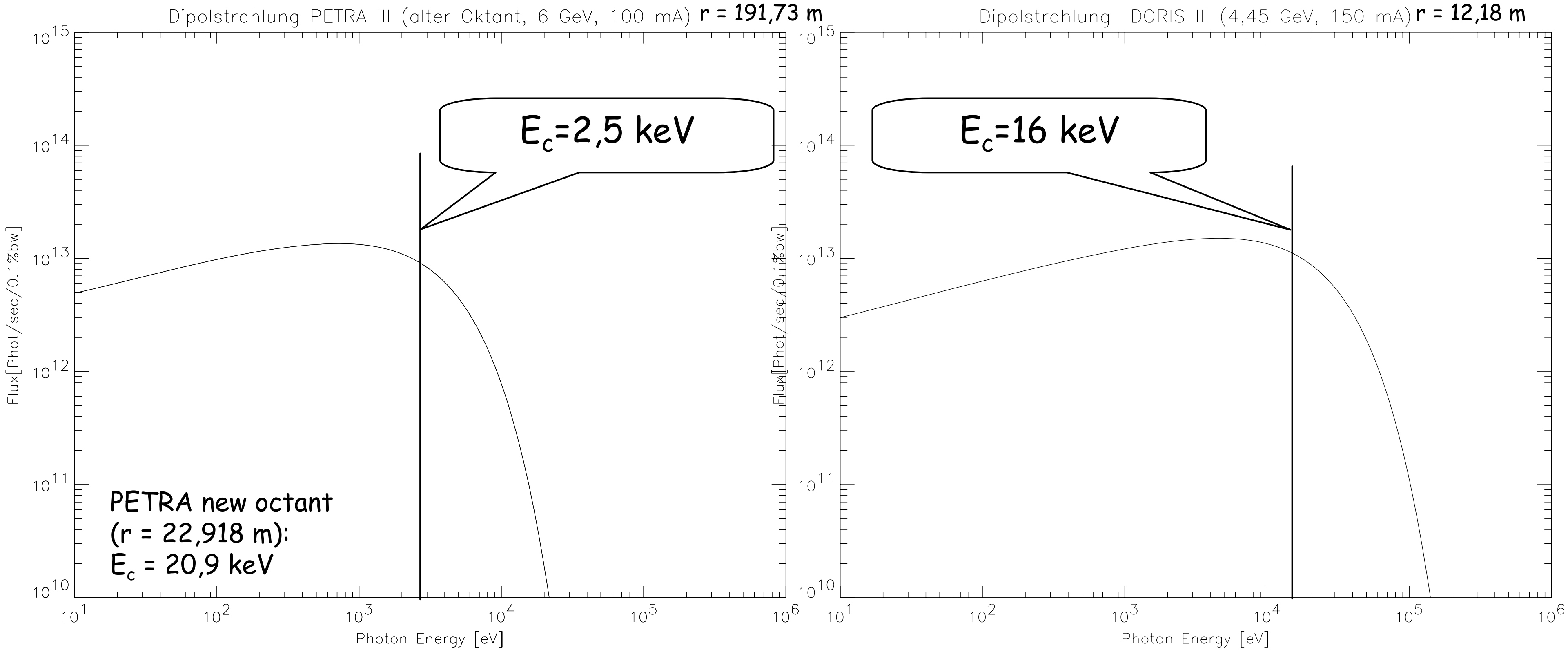


power of synchrotron radiation from all dipols (= energyloss per turn of leptons)



$$P[kW] = 88{,}46270 * \frac{E[GeV]^4}{r[m]} * I[A]$$

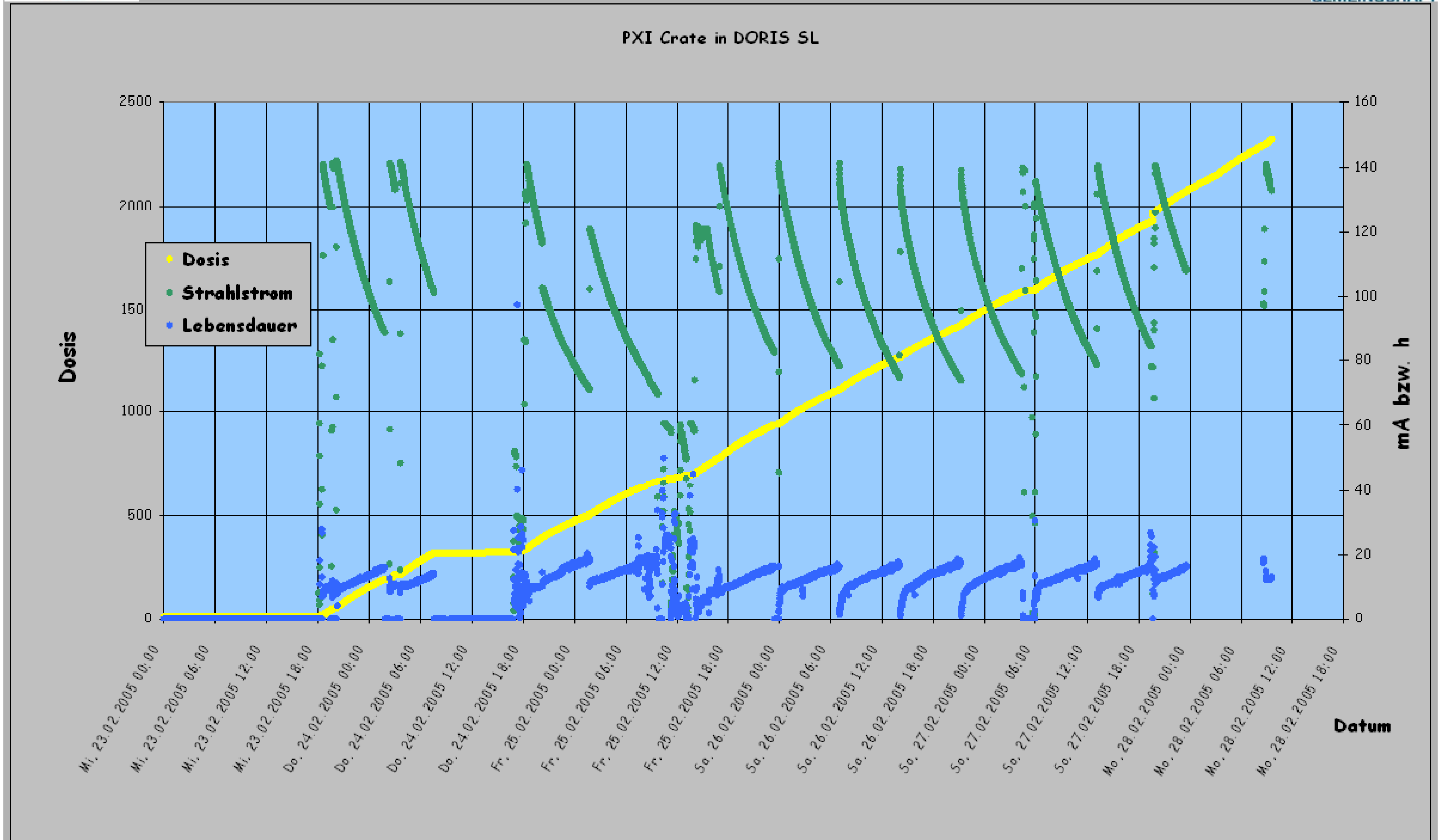
comparing radiation from bending magnets PETRA III / DORIS III



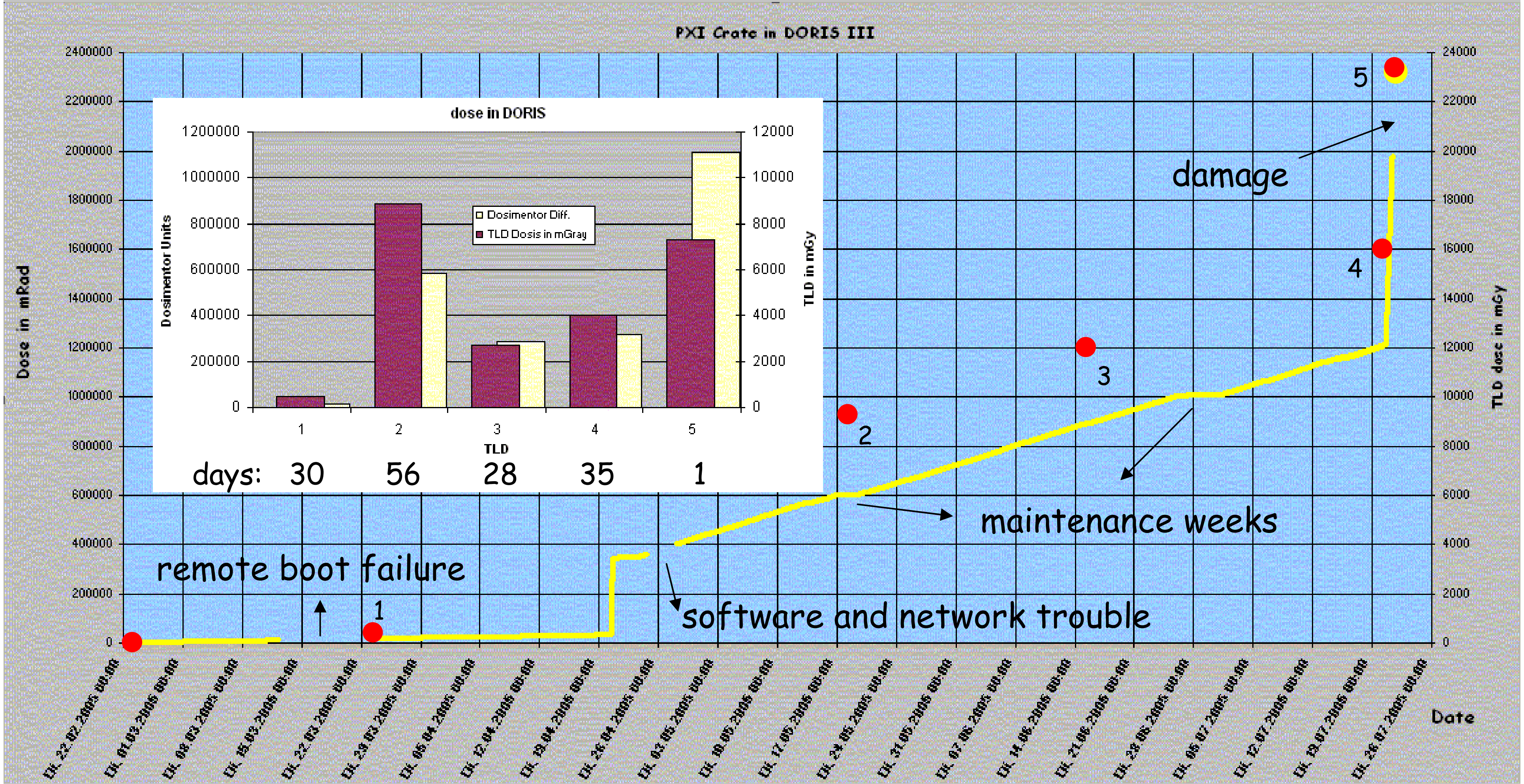
E_c: critical energy (divides the photon spectrum into 2 equal halves)

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



Position2 Position2

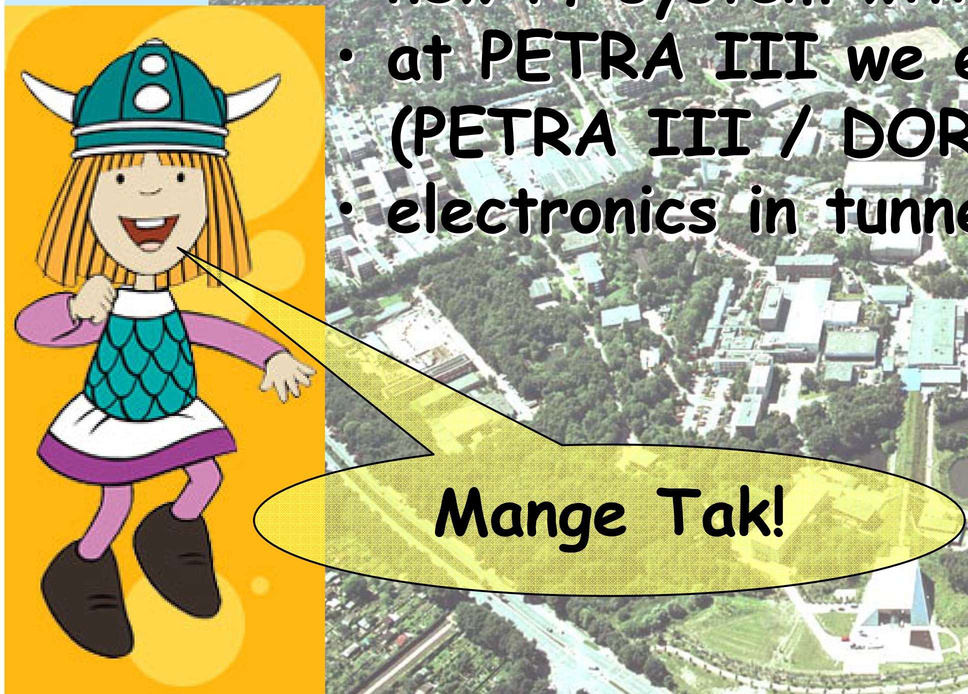
|- - - - - - - Position1 - - - - - - - -||- - - - - - - - - - - - - - - Position3 - - - - - - - - - - - - -|

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

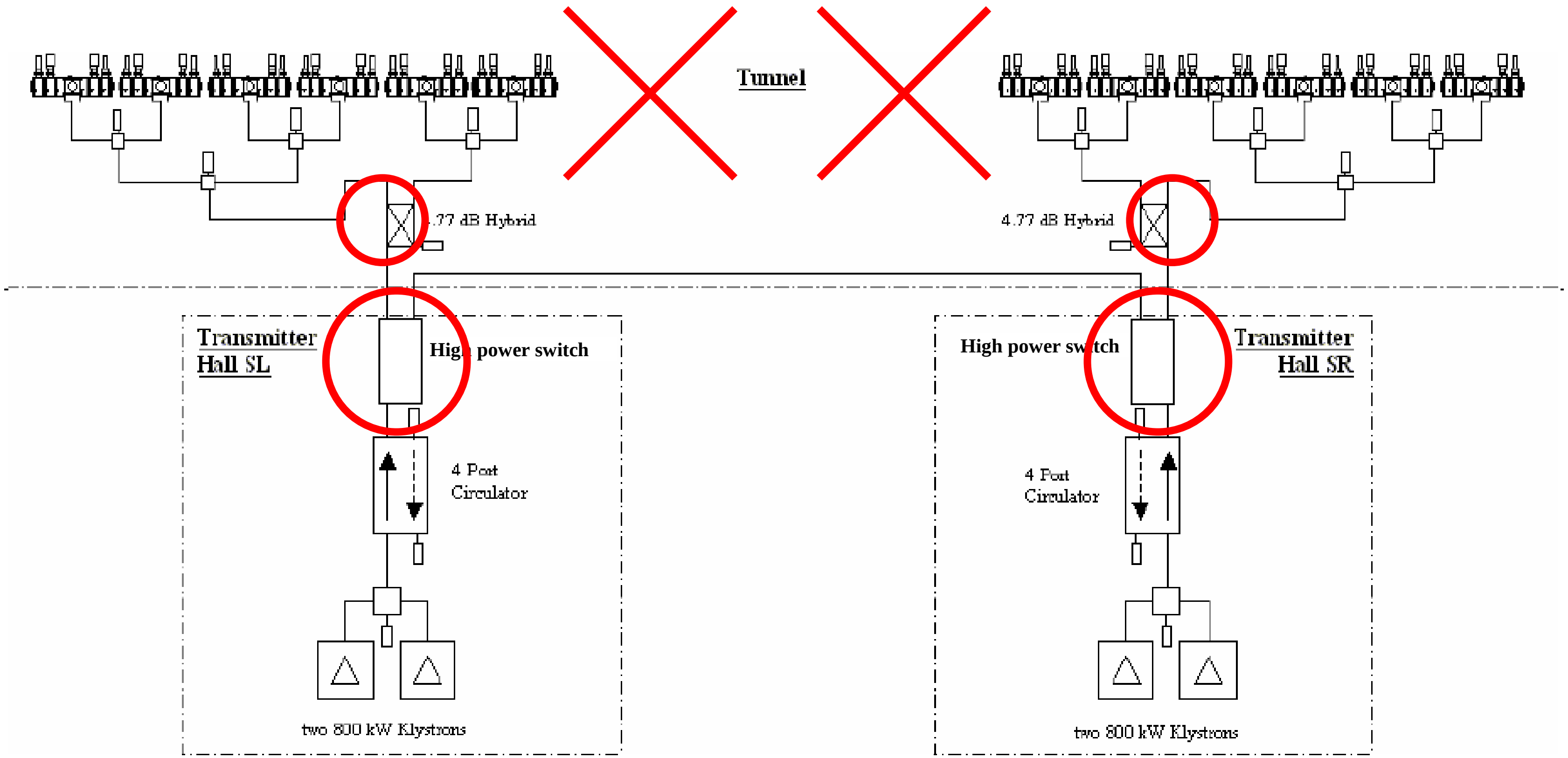


appendix

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