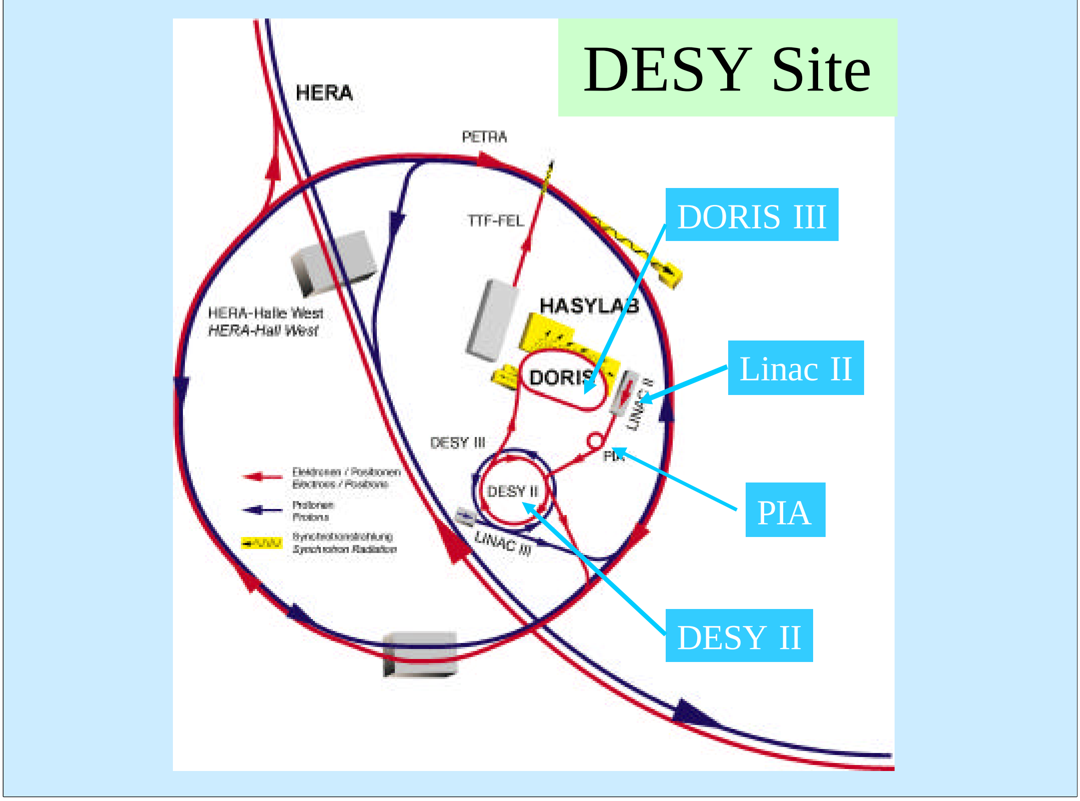
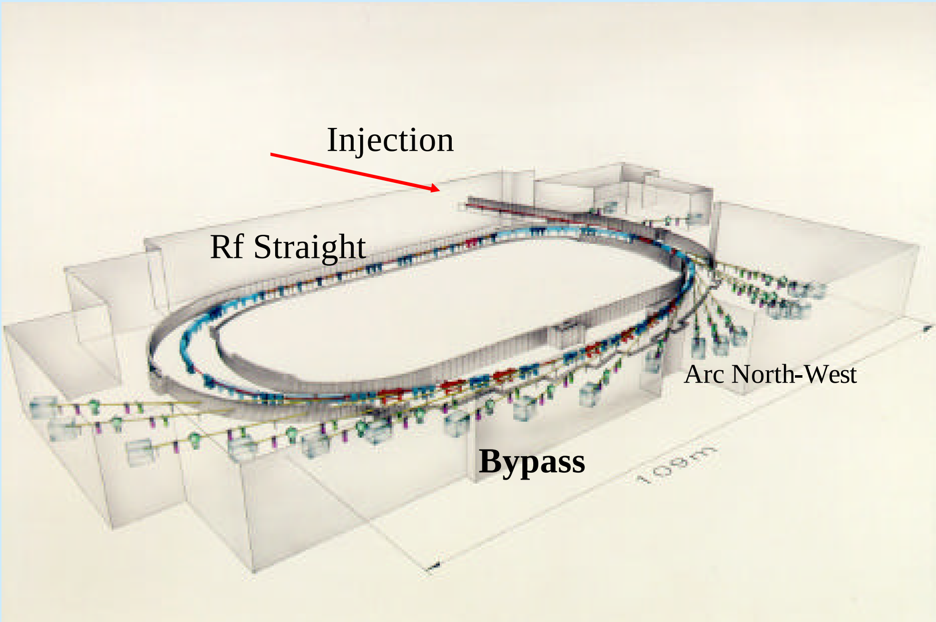


The DESY site with **PETRA**, **DESY** and **DORIS** and a part of **HERA**. Electrons or positrons are generated in **LINAC II**, after then they are transferred via **PIA** to **DESY II**, where they are accelerated up to 4.5 GeV and ejected into **DORIS**.

DORIS



The 3 dimensional picture shows the race-track geometry of **DORIS**. Before 1993 **DORIS** was mainly running for **HEP** (**H**igh **E**nergy **P**hysics) with at last one detector (**ARGUS**) placed in the Rf-Straight region in the south. The bypass with 7 wigglers was installed in 1991. In the North-West arc you will find most of our dipole beamlines.

History of DORIS

1973 :	**Start as Double-Ring e^+e^- - Collider at 2.5 GeV**
1982 :	**DORIS II – Single Ring at 5.3 GeV**
1991 :	**Bypass with 7 wigglers**
1993 :	***Dedicated Synchrotron Radiation Source.***
1996 :	**Removal of the vertical bend.**

Some Parameters of DORIS III :

Circumference	**289 m**
Bending Radius	**12.2 m**
Energy	**4.45 GeV**
Emittance	**400 nm * rad**
Insertion Devices	**10**
Dipole Beamlines	**30**
Radiated Power	**450 kW at 150mA (bending magnets)** **6 KW/meter in the Arcs (150 mA)**
Stored Particles	**Positrons**

DORIS III : Reconstruction, Regeneration, Improvements.

93: *Dedicated Synchrotron Radiation Source*

94: **Positrons as stored particles because of lifetime problems**
Comissioning of the transverse and longitudinal feedbacksystem, in order to store 200mA in 10 bunches.

95/96: **Removal of the Vertical Bend. Replacement of the vacuum chamber in the Rf-Straight section.**

97: **Exchange of all wiggler outlet-chambers in the bypass region (Improvement of the beamposition stability)**
Modernisation of the main magnet powersupplies.
Comissioning of a PC-based controlsystem.

99: **Replacement of the steerer magnet powersupplies.**
Comissioning of a PC-based beam position control software.

2000: **Replacement of all vacuumchambers in the arcs to improve the reliability and the beamposition stability effectively.**
Modification of the DORIS watercooling-system.

02/03: **Modernisation of all kicker magnets**

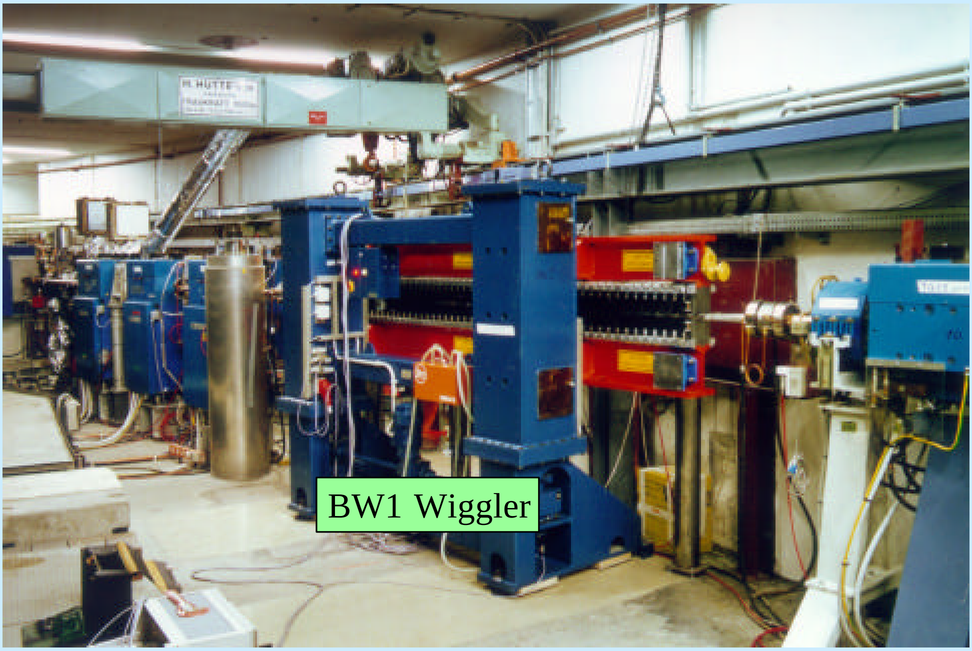
Feedbacksystem: Two fast feedback-kicker are installed for the transverse feedback. Maximal working frequency is 10Mhz for 10 stored bunches. For the longitudinal feedback two 1Ghz cavities are used.

Wiggler outlet-chamber (bypass): Because of the asymmetric heating by synchrotron radiation, the bending radius of these chambers was changed. This caused a horizontal movement of the quads, because these chambers touched their iron pole surfaces. As a consequence the orbit was distorted.

Vacuum-chambers in the arcs: They are exchanged due to the same reasons for the modernisation of the wiggler chambers.

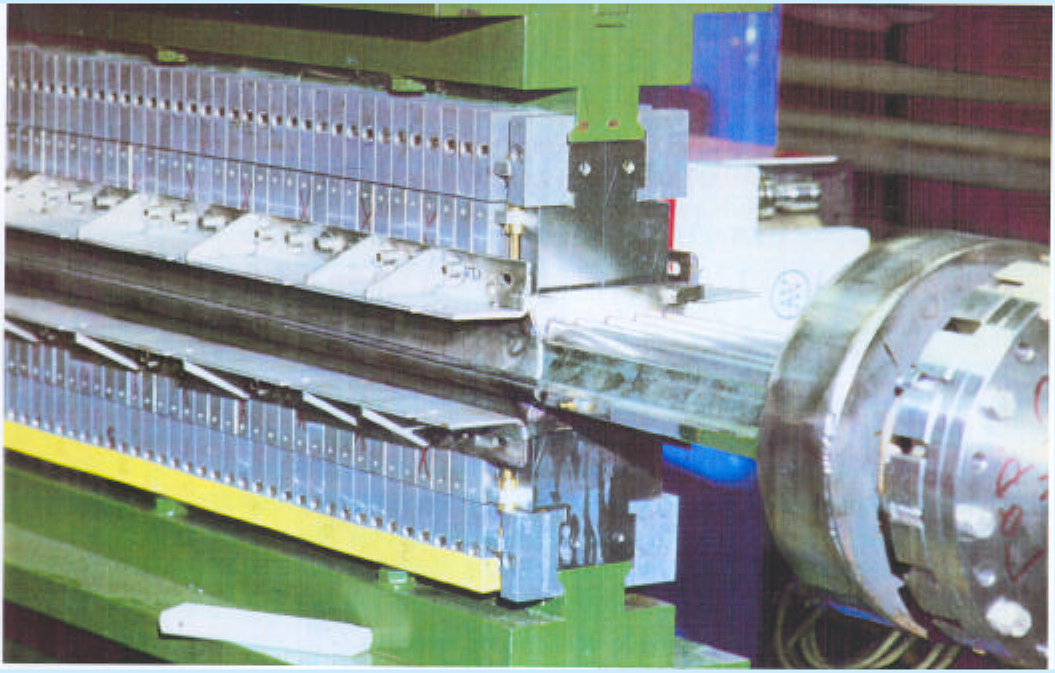
Kicker magnets: Our kicker magnets are placed in the inside of some quads in order to safe space. They are made out of stainless-steel vacuum-chambers, which also touch the quads. Due to this metal we observed an even stronger bending, when hit by the synchrotron radiation.

DORIS Bypass



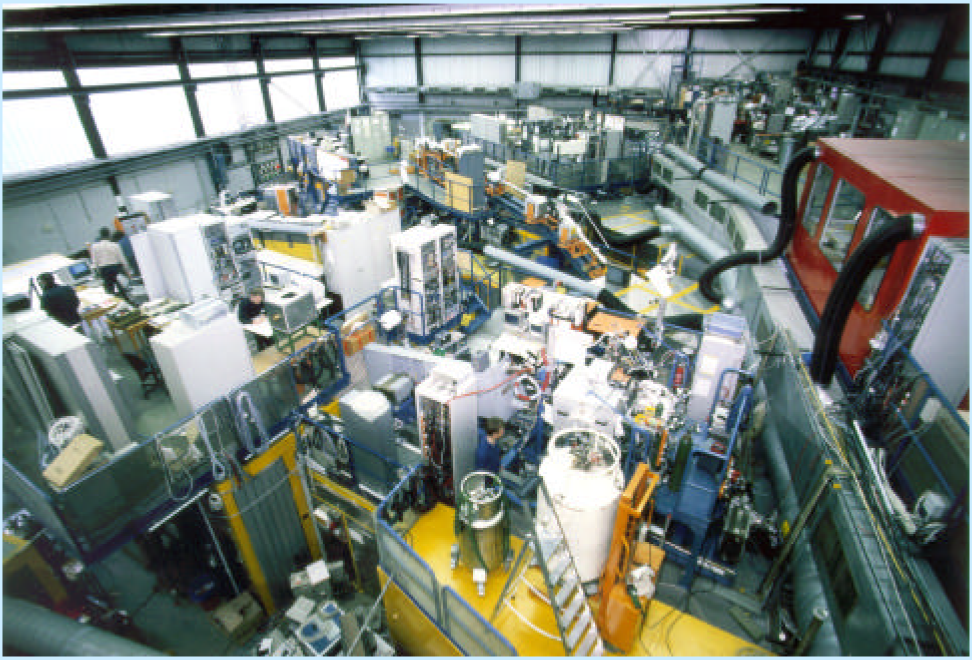
This picture shows BW1, an undulator situated on the left side of the bypass, if you are looking from the middle of the ring. The smallest magnet gap is 15.6mm.

BW1 Chamber



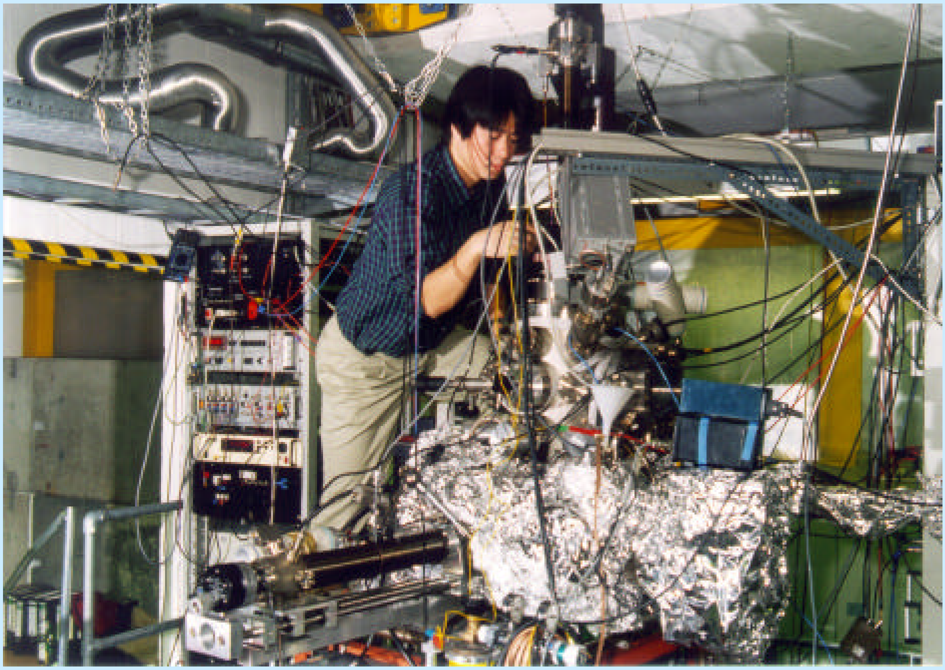
An interesting development of a wigglerchamber with a variable vertical height. During the colliding beam operation we could not accept a vertical beam stay clear less than 20mm. After **DORIS** became a dedicated Synchrotron Radiation Source we exchanged this chamber by one with a fixed vertical vacuum gap of 11mm.

HASYLAB 3

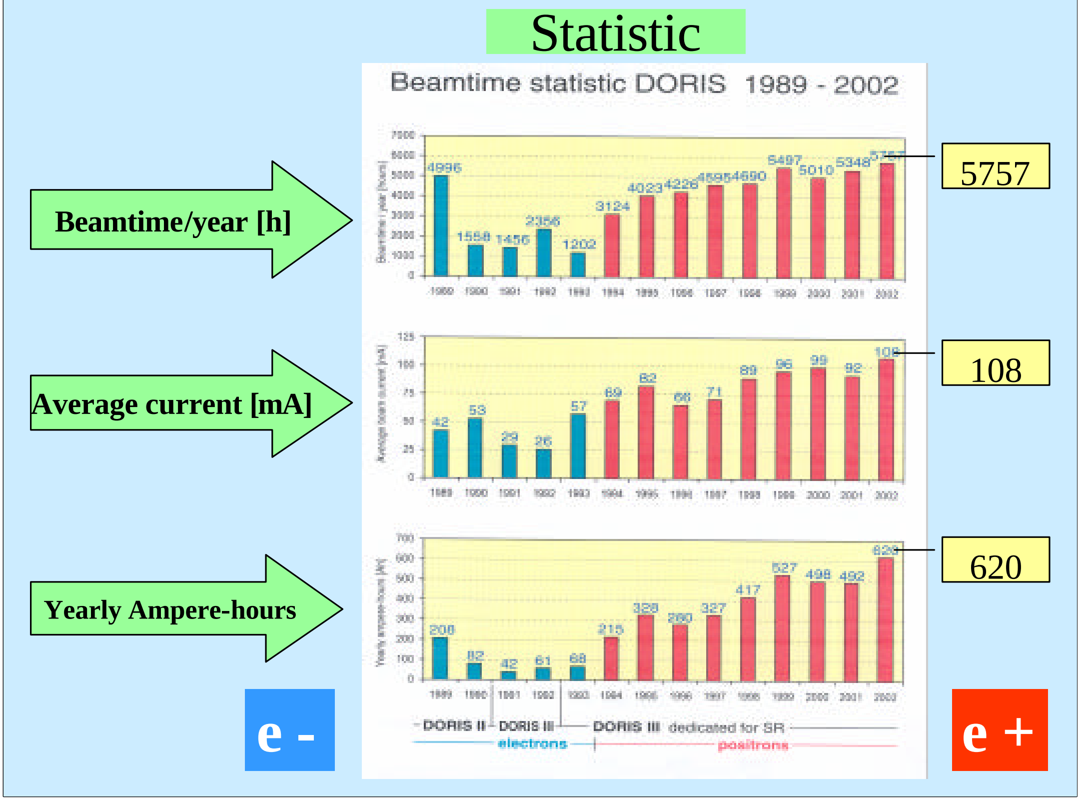


The oldest experimental hall of **HASYLAB** with most of our dipole-beamlines.

HASYLAB 3 Experiment



A physicist preparing an experiment at a dipole beamline.



The beamtime statistic covers the time from 1989 to 2002. The blue bars represent the "electron" period, while the red ones are standing for the "positron" one.

Beamtime: In 2002 we achieved the top value of 5757 hours useable beamtime for our customers.

Current: Simultaneously we could store 108mA on average, mainly in 5 bunches.

Ampere-hours: 620Ah is a record too.

Comparison of different Light Sources

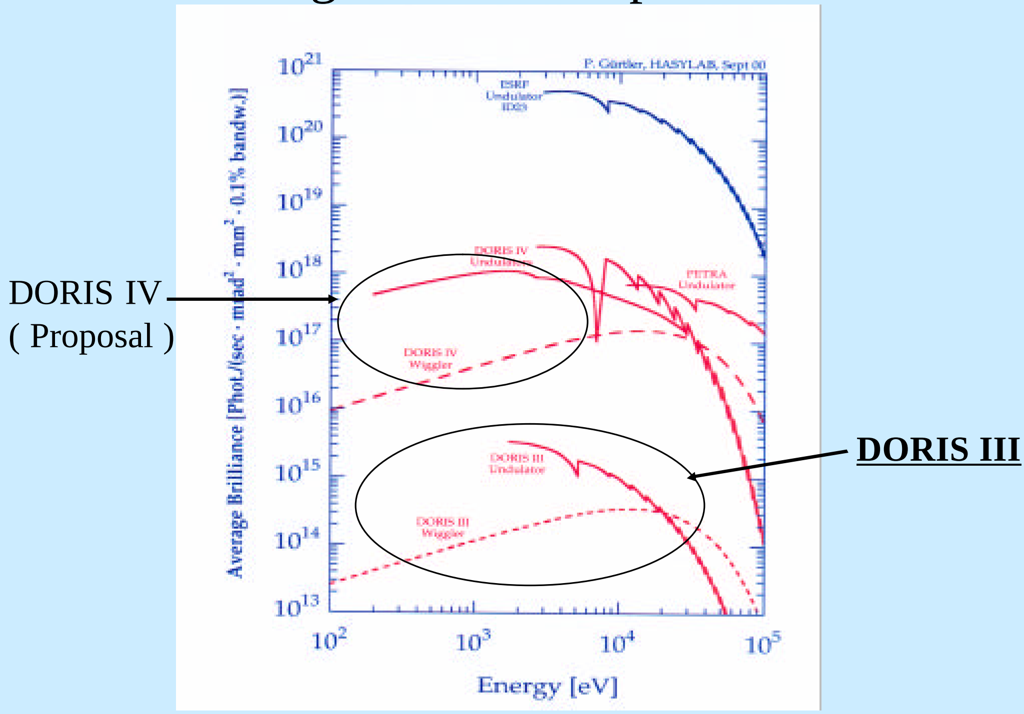
Basic Parameters of different Light Sources.

Machine	Energy [GeV]	ϵ_x [nm×rad]	ϵ_x/E^2 [nm/GeV^2]	Circumf. [m]
Petra	12/7	25/5	0.17/0.10	2304
Spring-8	8.0	5.6	0.088	1436
APS (Argonne)	7	8.2	0.16	1104
ESRF	6	4	0.11	844
DORIS III	4.5	450	22	289.2
DORIS IV (Propos.)	4.5	66	3.2	291.6
Spear-2	3.0	160	17.8	234
Spear-3	3.0	18	2.0	234
Photon Factory2	2.5	36	5.8	187
ANKA	2.5	40-70	6.4-11	110.4
SLS (SwissLS)	2.4	4.8	0.83	288
Elettra	2.0	7.0	1.75	259.2
BESSY II	1.7	6.0	2.1	240
ALS (Berkeley)	1.5	4	1.8	196.8
Diamond	3	2.5	0.28	489.2
USRLS	7	0.3	0.006	2000

Spear-3 : Upgrade from Spear-2
Diamond : Planned Lightsource in Great Britain
USRLS : Study of ESRF

The picture shows some essential parameter of existing Light Sources. The machines are arranged according to their energy. At the top is **PETRA** with its maximal energy of 12GeV. Concerning the energy **DORIS III** can be found in the upper third of this table. The emittance of 450nm*rad is an obvious indication that **DORIS** is a First Generation Light Source. The main reason is the short circumference, which corresponds to the small bending radius of 12m, in combination with the relative high energy.

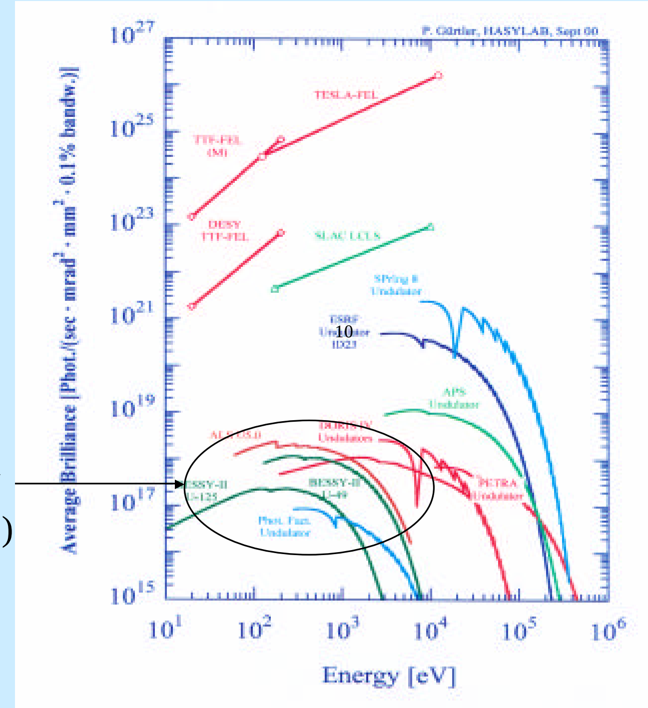
Average Brilliance up to 10^{21}



The brilliance is one of the most important quantities, which characterisizes modern Synchrotron Radiation Sources. The transverse beam-dimensions play the essential roll, when calculating this number. Because of the relatively large emittance of **DORIS III** the maximal brilliance will not exceed $3*10^{15}$. The proposed machine **DORIS IV** would achieve 10^{18}.

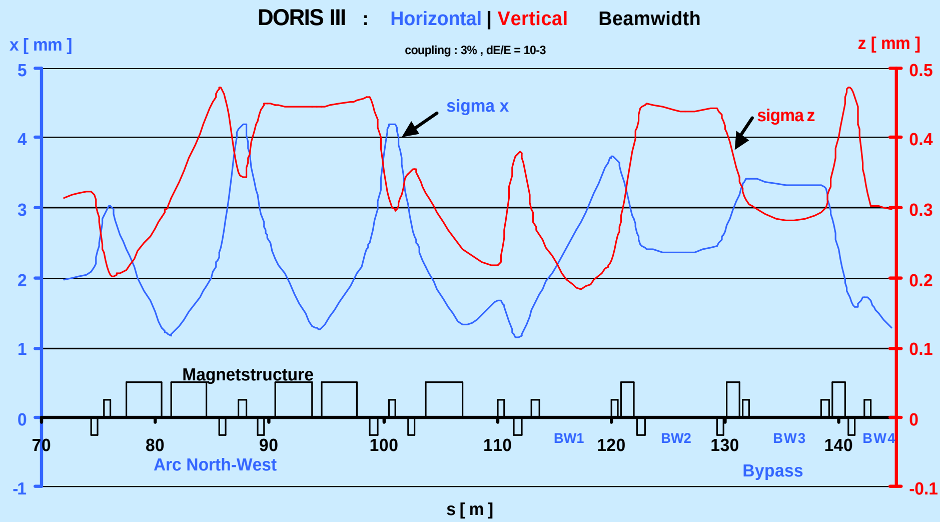
Average Brilliance up to 10^{27}

DORIS IV
(Proposal)



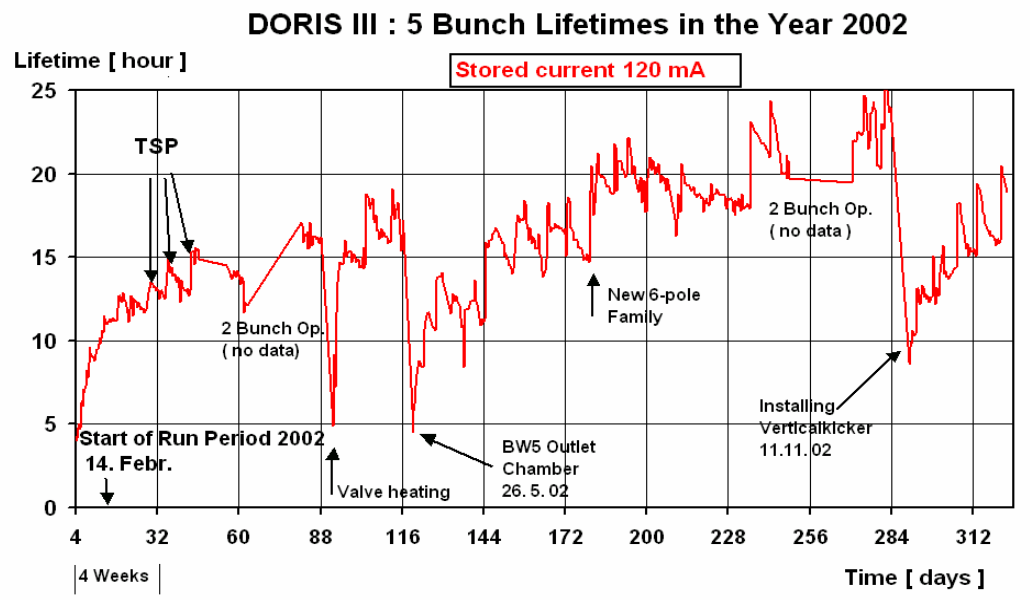
In this region of the brilliance of up to 10^{27} **DORIS III** doesnt play any roll, just the proposed **DORIS IV** would be represented at the lower part of this distribution. You will find there **PETRA II**, **APS**, **ESRF**, **SPring 8** and at the top the FEL's

Beam Dimensions



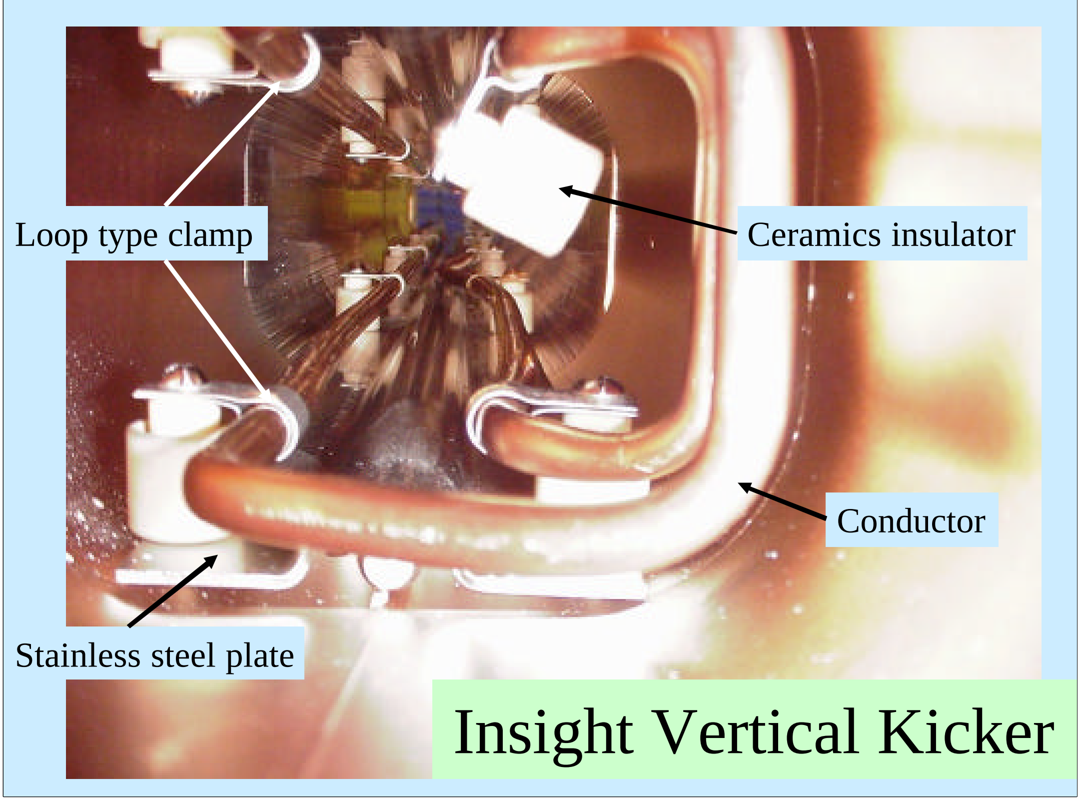
These are the transverse beam dimensions for the northern half of **DORIS III**. Drawn is one quarter of the orbit, but because of the symmetry the 2.nd part of the bypass and the North-East arc show the same characteristic. The vertical dimensions vary between 0.2mm and 0.45mm, while the horizontal component is larger by a factor of approximately ten.

Lifetimes 2002



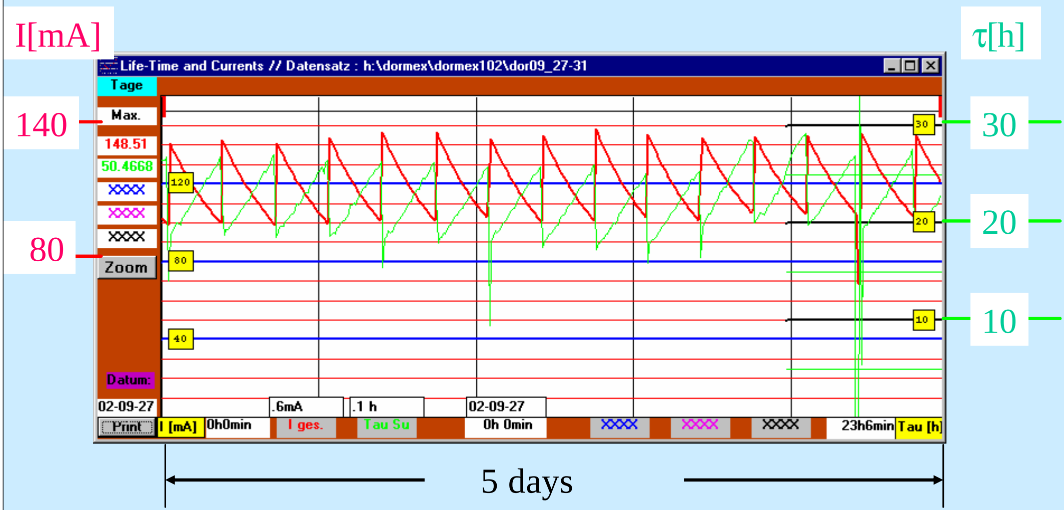
Because of the large emittance of **DORIS** we cannot compete with Third Generation Light Sources. Our main focus is reliability and beam stability. This picture shows the lifetime distribution of the last year with a stored current of 120mA. The obtained value of 20h is pretty good for a 5 bunch operation.

We have had one vacuum leak at the outlet chamber of the bypass wiggler BW5. A second collapse of the lifetime ocurred, when we installed the new built vertical kicker in a Service-Week.



Have a look into the vertical kicker along the beam direction. The conductor is a watercooled copper tube which carries the electric current. Due to the high voltage of almost 20kV, cylinders made of ceramics serve as insulator. Some broken srews led to an abrupt end of the DORIS operation (in the beginning of the year). The ceramics insulator blocked the beam. The reason for this desaster was the extremely hot stainless steel plate at a current of 150mA, the temperature went up to 700 centigrade. This plate is the supporting structure for the coil and undergoes a lengthening of 15mm. The ocurring forces were too large for the srew which fixes the ceramics to the plate.- The adopted measure was an additional cooling pipe for this plate.

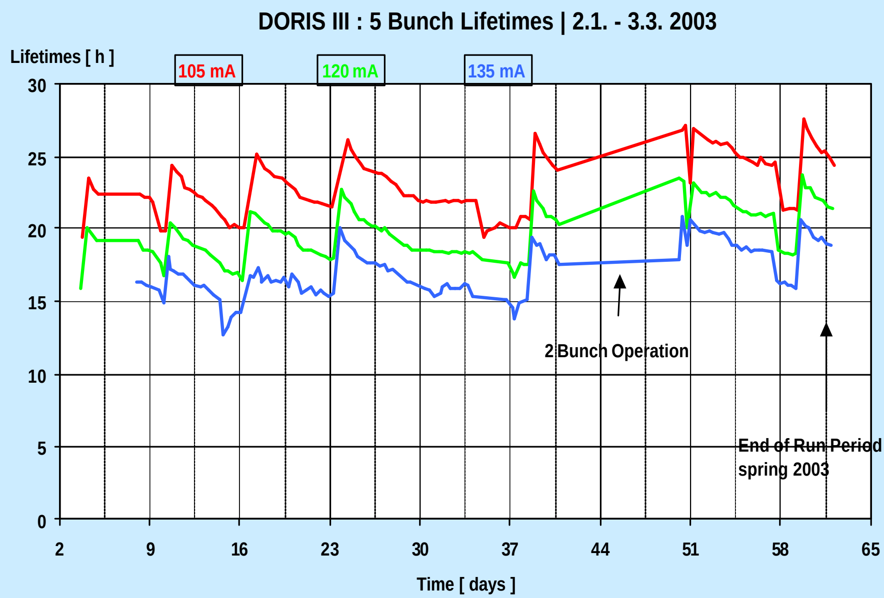
Typical Run in 2002



DORIS III : 5 Bunch Currents (red) and Lifetimes (green)
27. – 31.9. 2002

This picture demonstrates a five day run period of the last year. With our customers we have arranged a duration of 8 hours for a single run.The injected current is about 145mA and we lose 45mA within these 8 hours.

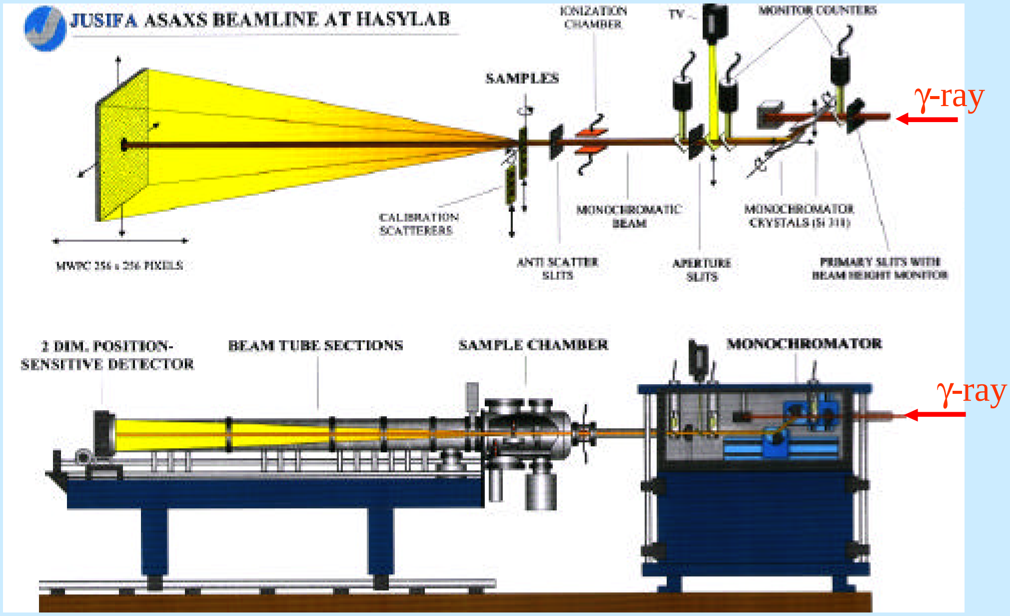
Lifetimes 2003



This picture displays a very nice operation in the first two months of this year, with the best lifetimes and availability we ever had.

Dipole Beamline B : Arc North/West

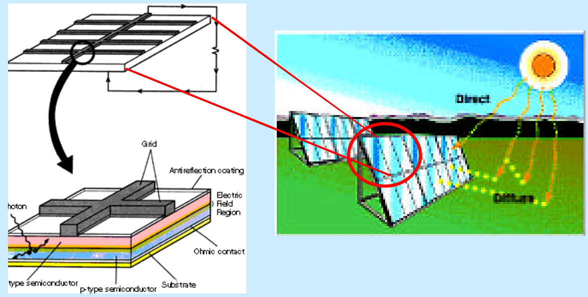
Small Angle X-ray Scattering



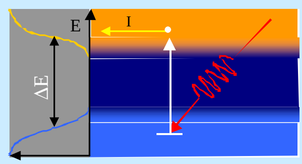
A typical synchrotron radiation beamline situated in the **HASYLAB** 3 laboratory. At the top a schematic scetch is shown. The synchrotron radiation comes from the right. After passing some horizontal and vertical faceplates only a monoenergetic beam will leave the double monochromator system. A frequently used energy is 8keV, that corresponds to a wavelength of 0.2nm. The beam hits the sample, is scattered at the grid structure and the ocurring interferences are analysed. The largest probe structure that can be solved is about 100nm (depends on the energy of the beam).

Improving the efficiency of photovoltaic cells based on amorphous silicon

Solar cell devices

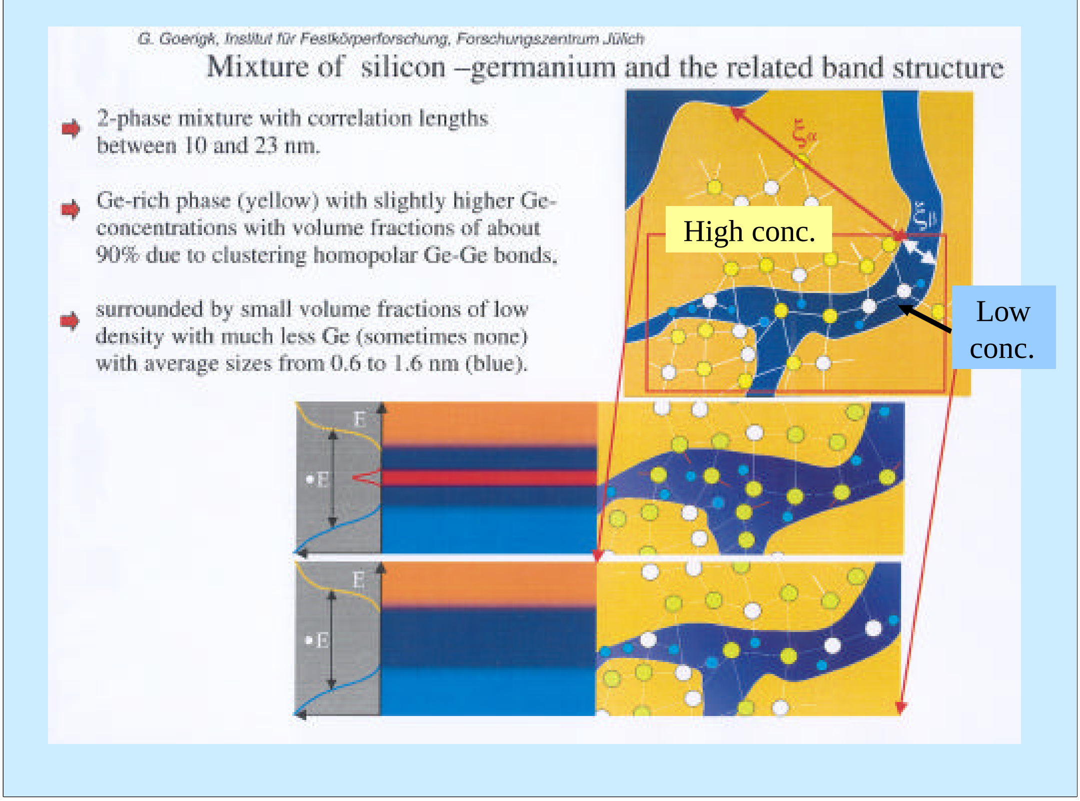


About 55% of the energy of sunlight cannot be used by most photovoltaic (PV) cells



Tuning a photovoltaic cell by modifying the band gap and the electronic states

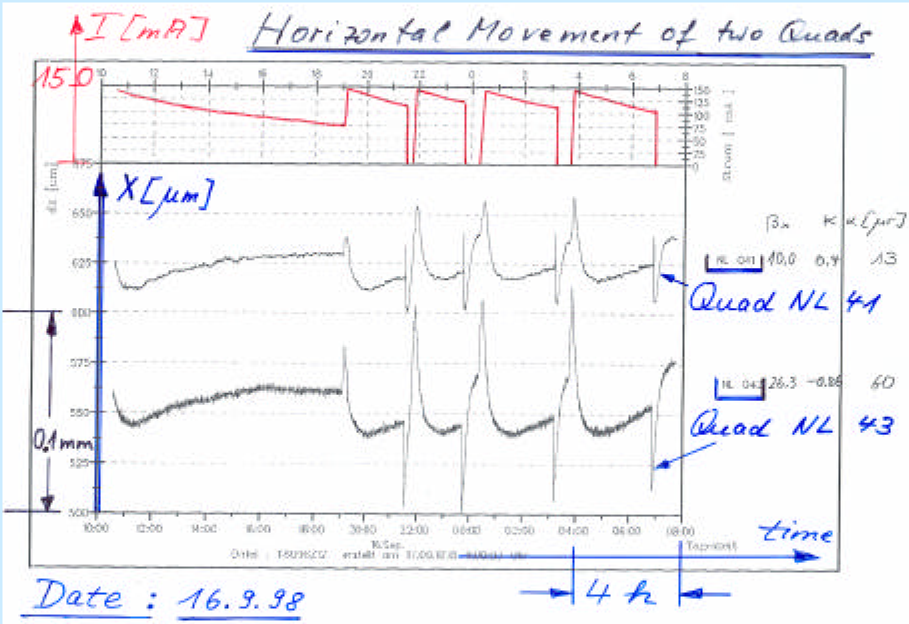
One application at such a beamline is the investigation of photovoltaic cells. Because of the poor efficiency of such cells based on amorphous silicon, one tries to improve the efficiency by doping the silicon for example with germanium. This changes the electronic band structure and may lead to a larger efficiency. To quantify the doping one can use the X-ray scattering technique to analyze the molecular structure. The next picture gives an example.



The electronic band structure strongly depends on the distribution of rich and poor concentrated germanium regions. The two different concentration arrangements as shown on both lower pictures are calculated using the small angle x-ray scattering technique. The two scetches on the left show the corresponding band-structures.

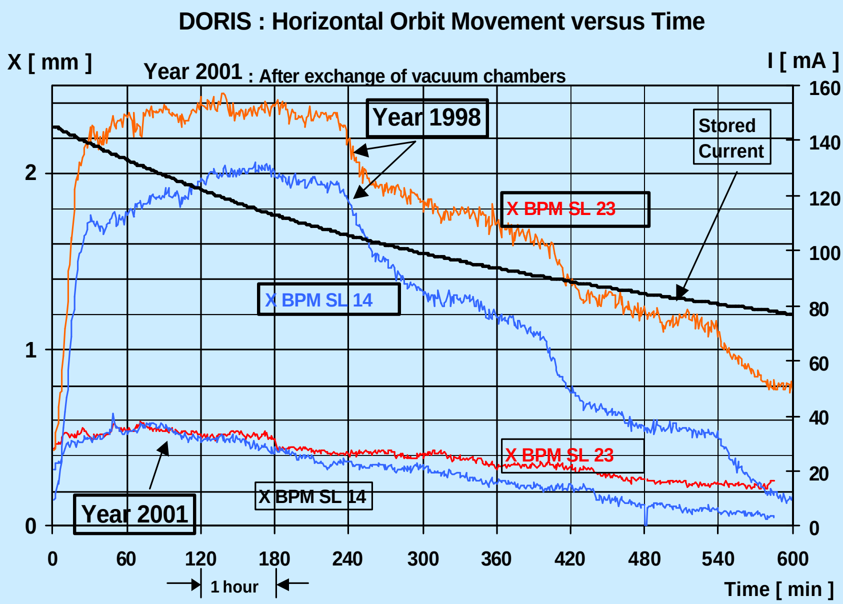
That's fine so far. But because the sample volume very often is smaller than 0.5mm in the vertical plane and is contained in a glas tube of the same diameter it is essential, that the vertical beam movement during a run period of 8 hours is much smaller. That is sometimes a problem because of orbit distortions, which are driven from quad displacements. The next picture illustrates this situation.

Quad Movement

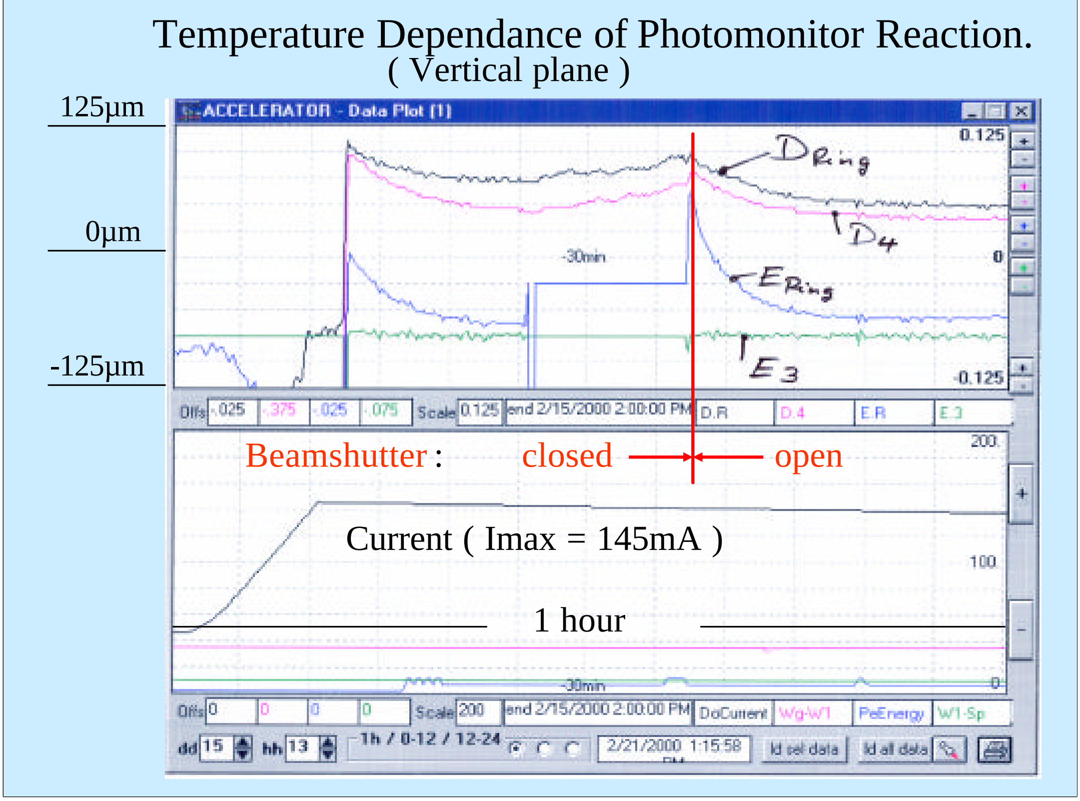


This measurement was done in 1998. At that time most of the quads underwent rather large displacements of up to +-100µm corresponding to currents between 0 and 150mA. The vacuum chambers touched the iron polfaces of the quads. The asymmetric heating of the chambers by the synchrotron radiation light induced a change of the curvature of the chambers and therefore a displacement of the quads. As a consequence of these displacements the horizontal orbit was disturbed.The successful measure was the exchange of these chambers around the machine. The next picture shows the result.

Orbit Movement

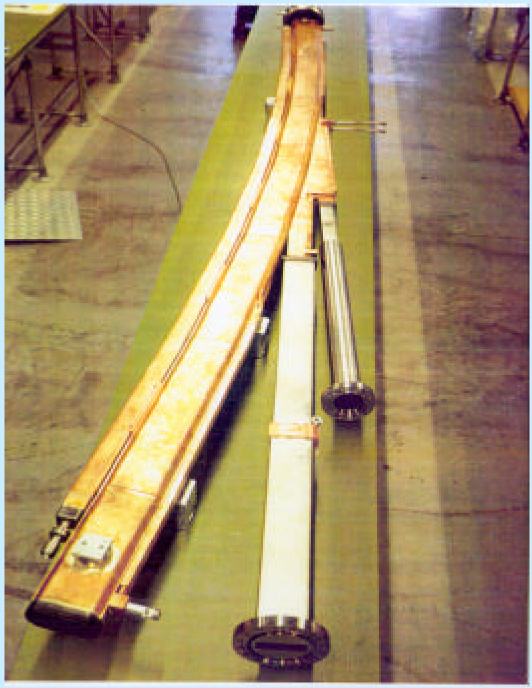


Shown are two different runs of 10 hours duration, one before the excange of the chambers in 1998 and the other in the year 2001. To illustrate the difference the horizontal measurements of two XBPM`s are drawn. The improvement is significant. The orbit distortion is reduced by a factor of about 4. The remaining movement is mainly caused by the kicker vacuum chambers, which we could not replace at that time, because of some technical problems. They have been solved in the meantime, so that we could install the three new injection-kickers just in the actual shutdown.



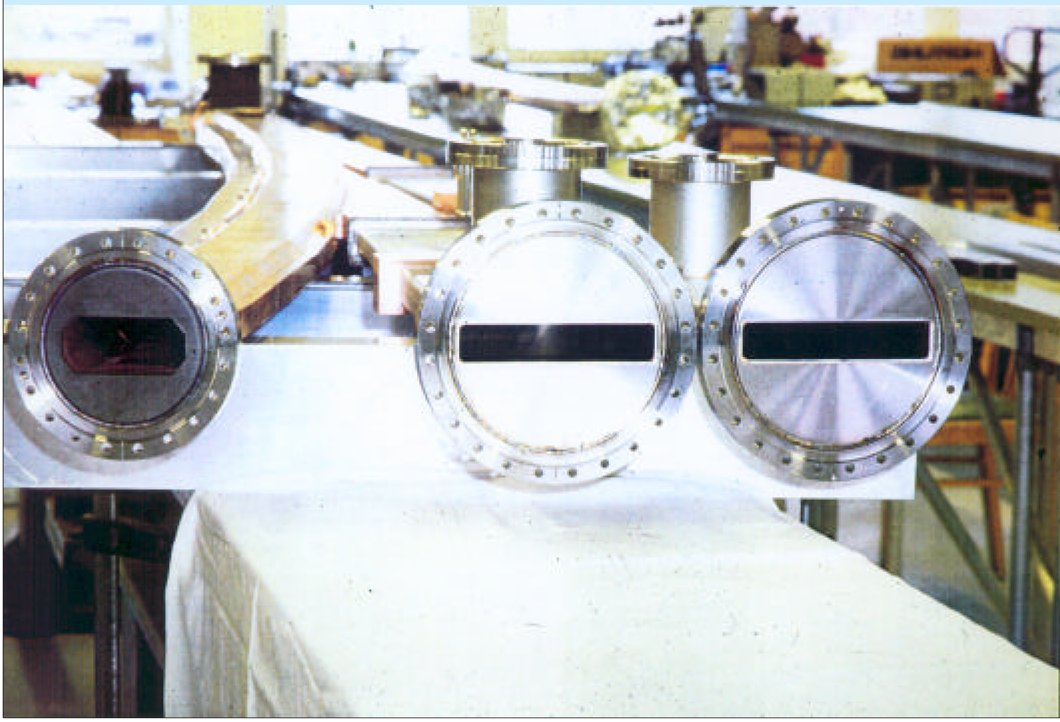
Using photomonitors other problems may occur. Sometimes the construction gives room to a mechanic movement which scales with the stored current. To analyse this behaviour the beam shutters are closed to allow the monitor housings to cool down. After the following opening the reaction should be stable as it is for the E3 monitor, but for example the E-ring monitor shows a strange behaviour. This is not acceptable. As a consequence of this wrong performance the mechanic construction of such monitors has been revised.

Dipole Outlet-Chamber



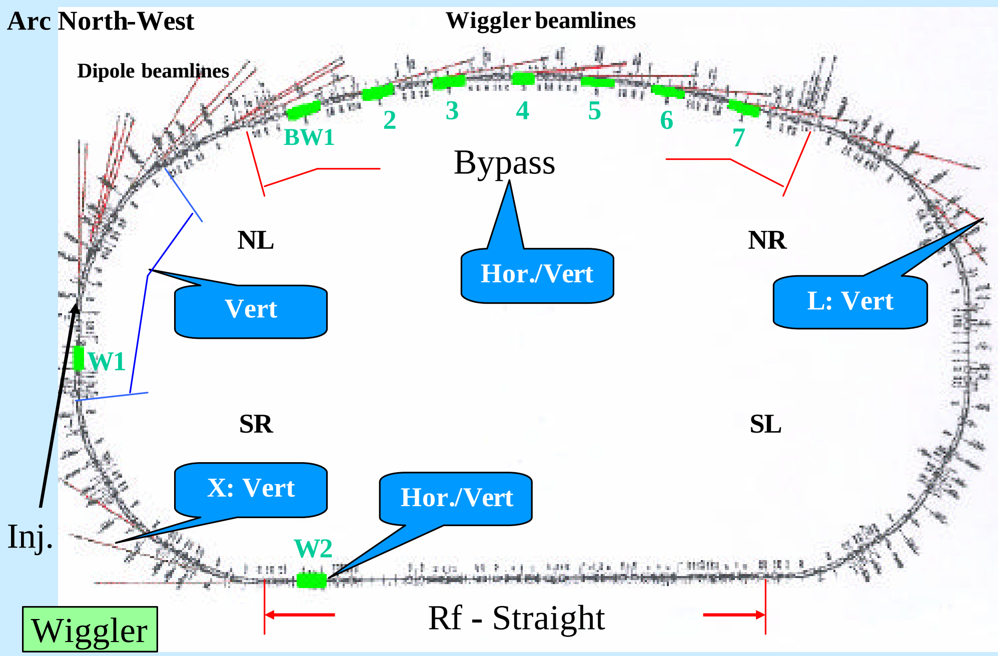
A dipole outlet-chamber serving two beamlines. These chambers are also hit asymmetrically by the synchrotron radiation, which changes their curvature. And because these chambers are fixed at the dipoles, they are moved about 20µm in the horizontal plane, which leads to a corresponding vertical orbit distortion. We can solve this problem by installing an additional cooling pipe of appropiate diameter on the inner side of the vacuum chamber, but that is a major investment.

Dipole Outlet-Chamber



A cross-section of a dipole outlet-chamber, with the particle chamber on the left side.

DORIS Beam Pos. Control

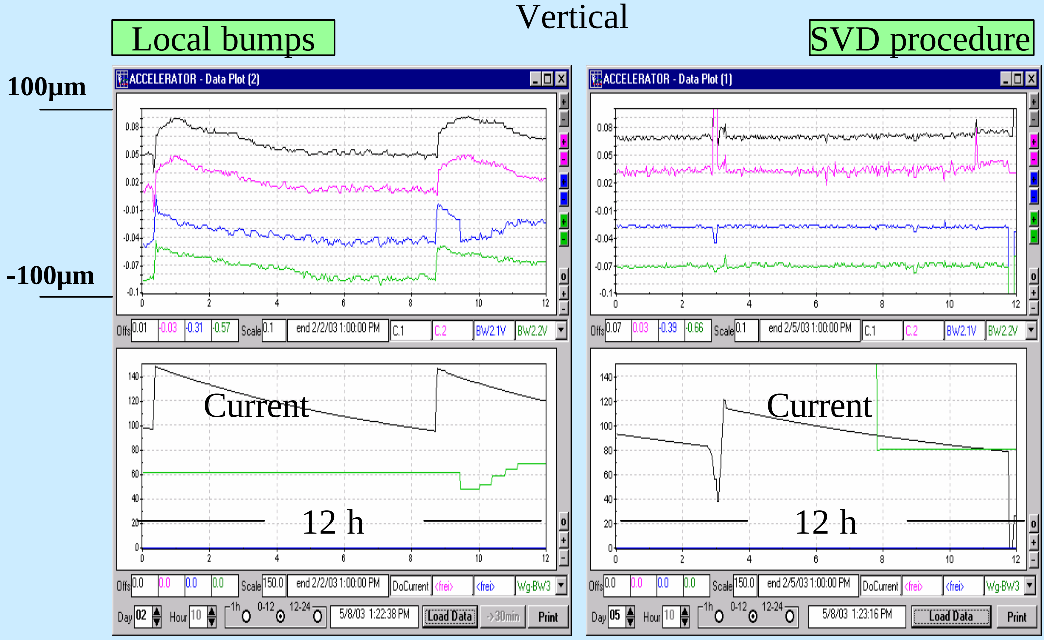


Apart from of a high availability the most important goal is an excellent beam position stability. This picture is used to explain the beam position control policy. At present we use up to 9 independent local beam bumps. The position information comes from photo-emission monitors which are installed in nearly all beamlines. In the near future we will introduce a global correction scheme like **SVD** (**S**ingular **V**alue **D**ecomposition)

Let us start with the bypass. Just two monitors are used to stabilize all wiggler beamlines in the horizontal as well as in the vertical plane. That applies for the HARWI (W2) beamlime too. At all other beamlines (just dipole beamlines), only the vertical plane is controlled. The result is shown on the next picture.

Beam Position Control

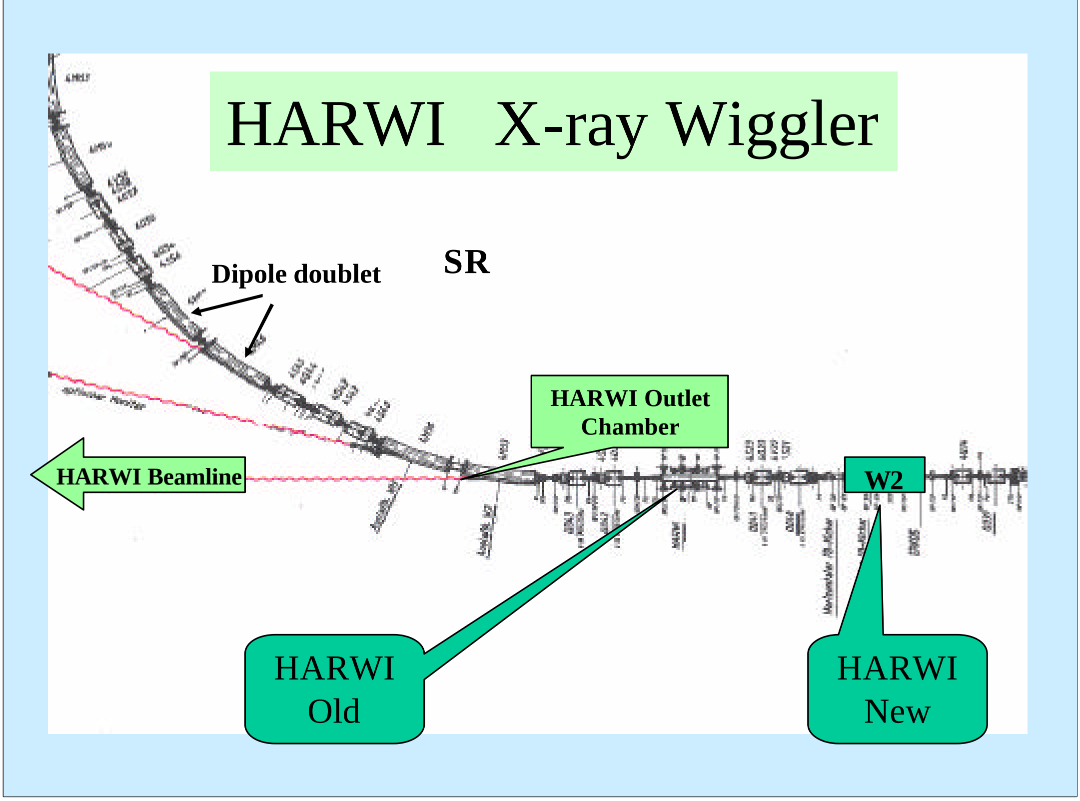
Vertical



Beam position measurement with photomonitors

The left diagram displays the vertical beam position at four photoemission monitors, two localized at the bypass and the others at the North-West arc. The actual beam position control is working. There are remaining movements in the range of 50µm within one run period of 8 hours.

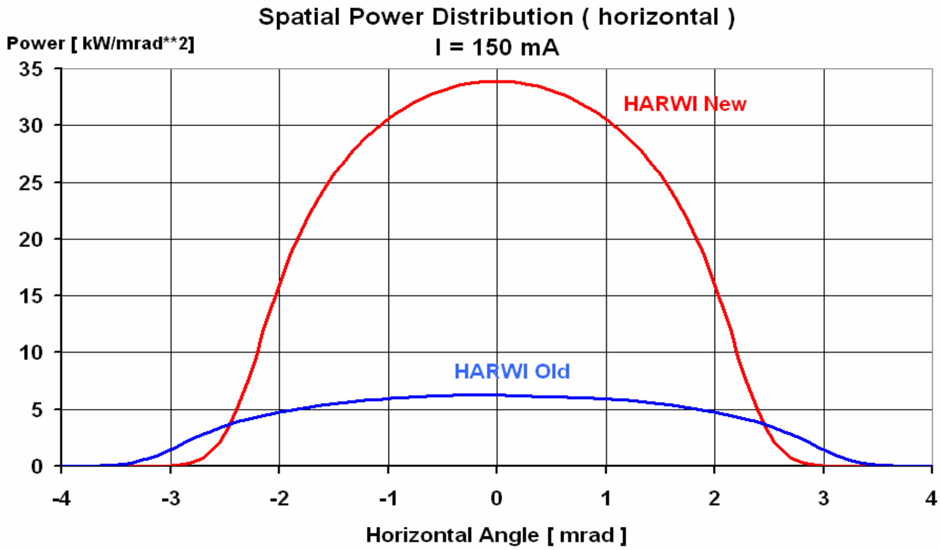
The picture on the right side demonstrates in a convincing manner the advantage of the global position control with the SVD procedure. The completion of the software is under way.



An actual challenge is the installation of a new very powerful wiggler in the next year. This will replace the old HARWI (W2) wiggler. We will operate this wiggler with a magnetic gap of 14mm. This corresponds to a vertical beam-stay-clear in the vacuumchamber of 10 to 11mm, that`s the reason why moving it to a more upstream position, because of the optical functions. The next picture shows the horizontal power distribution.

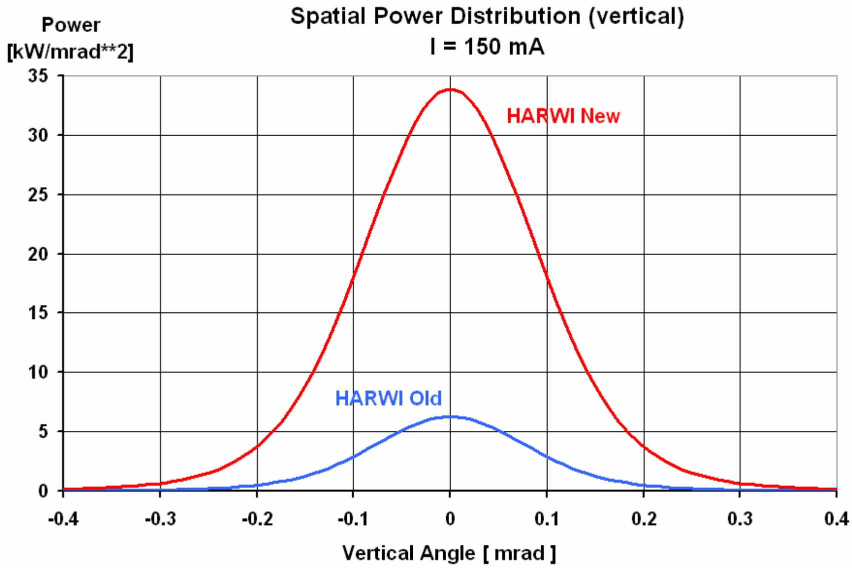
Power in X

Ptot = 30kW at 150mA



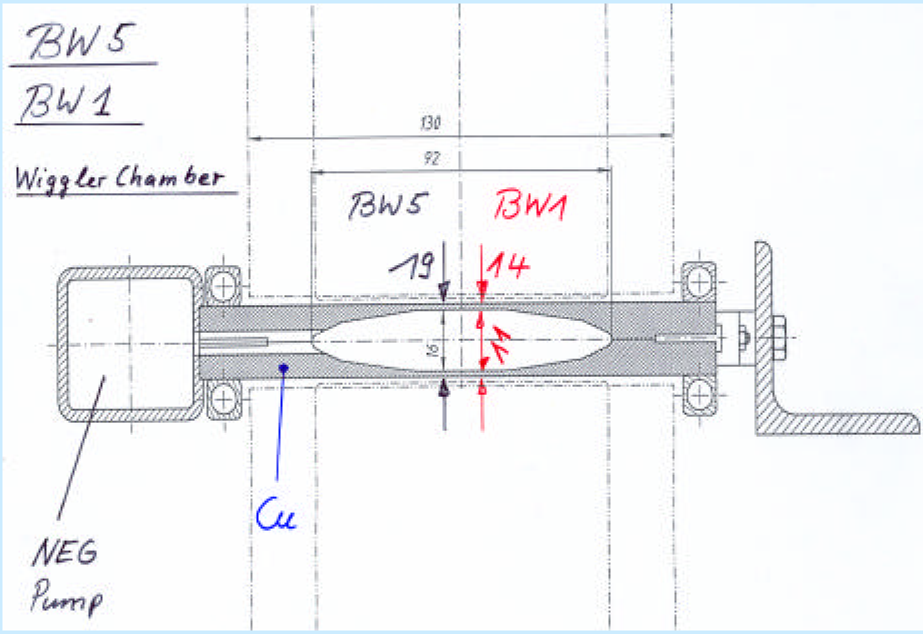
The total power amounts to 30kW at 150mA compared to the 6kW for the old HARWI. The opening angle is 2.3mrad respectively 3.6mrad and the associated k-values are 20 and 26.

Power in Z



The vertical angles are nearly the same, but because of the farther position of the new wiggler we have to protect the outlet-chamber by a synchrotron light absorber which we will install just before the dipole. The construction of the new wiggler chamber itself is also a challenge. One idea is to copy the BW1 chamber approximately.

BW5/1 Cross-Section

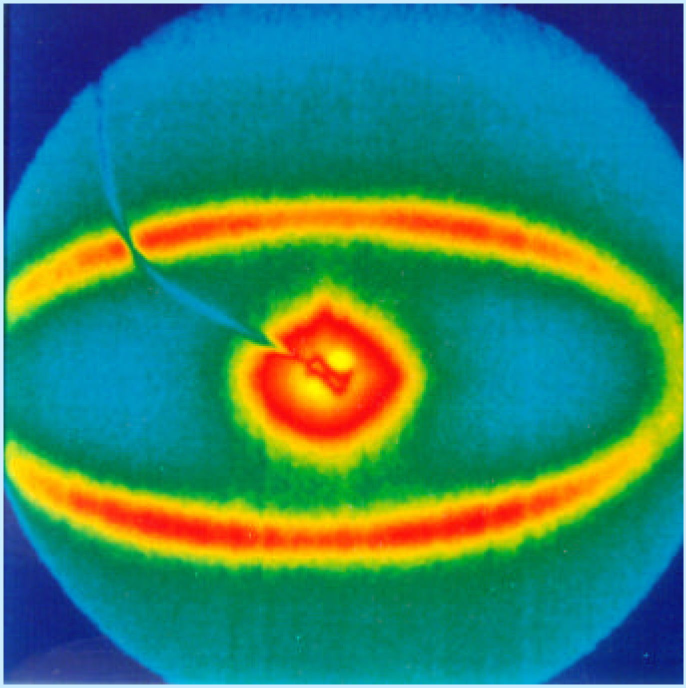


These chambers are made out of two copper halves, which are soldered together. To obtain a smaller wall thickness, stainless steel could be an appropriate material, perhaps with a coated NEG-pump. Such chambers had been manufactored at the **ESRF** laboratory.

Future Developments

- **Substitution of the HARWI Wiggler by a stronger one. (2004)**
- **Further improvement of the beam position control.**
  This includes a new orbit measurement electronic (in preparation)
- **Reduction of the vertical coupling (at present 3%)**
  (Reactivation of the pinhole-camera)
- **In the long term replacement of the main power supplies.**
  (25 years old)
- **New dipole-beamline outlet-chambers (source of vertical orbit oscillations)**

X-ray Scattering from a Plastics Molecule



The asymmetry comes from a lengthening of the material.