

SLS-Components

Accelerators

- Electron gun 90 keV
- LINAC 100 MeV
- Booster, 3 Hz 0.1-2.4 GeV
- Storage Ring, 288m 2.4 GeV

Beamlines

- Protein Cristallography
- Material Sciences
- Surface Microscopy
- Surface Spectroscopy
- environment sciences

SLS Strategy

Quality

- high brightness , small emittance,
→ large circumference with many magnets

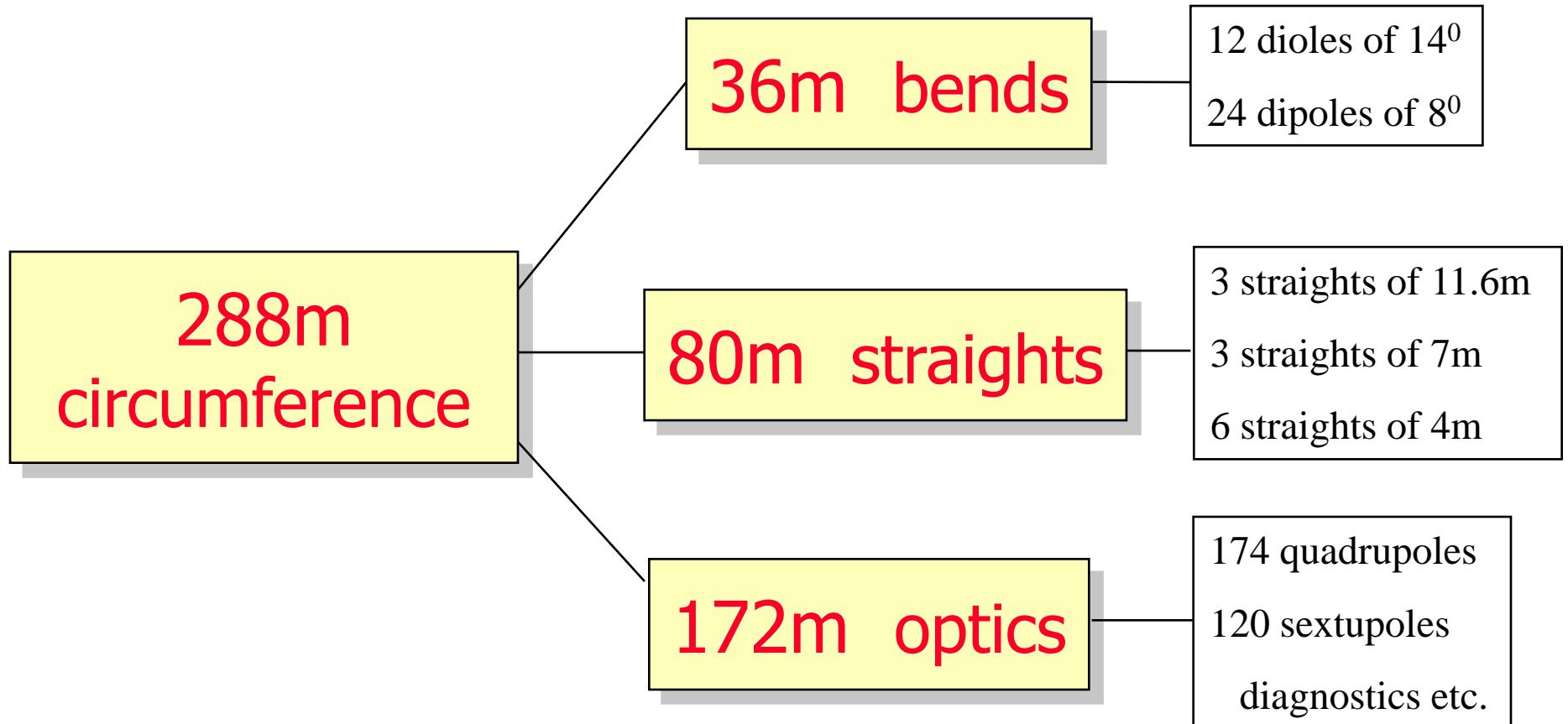
Flexibility

- large spectral range (VUV to hard x-rays)
- straights of 4 m, 7 m and 11 m => choice for undulators

Stability

- separation of building structure from floor
- stable temperature in tunnel and experimental hall
- positioning of the magnets on rigid girders
- fast orbit feedback (up to 100Hz)
with high accuracy (< 0.5 µm)
- constant beam current with **top-up injection** (every 3 min)
→ constant heatload on optical components

Allocation of space for Storage Ring



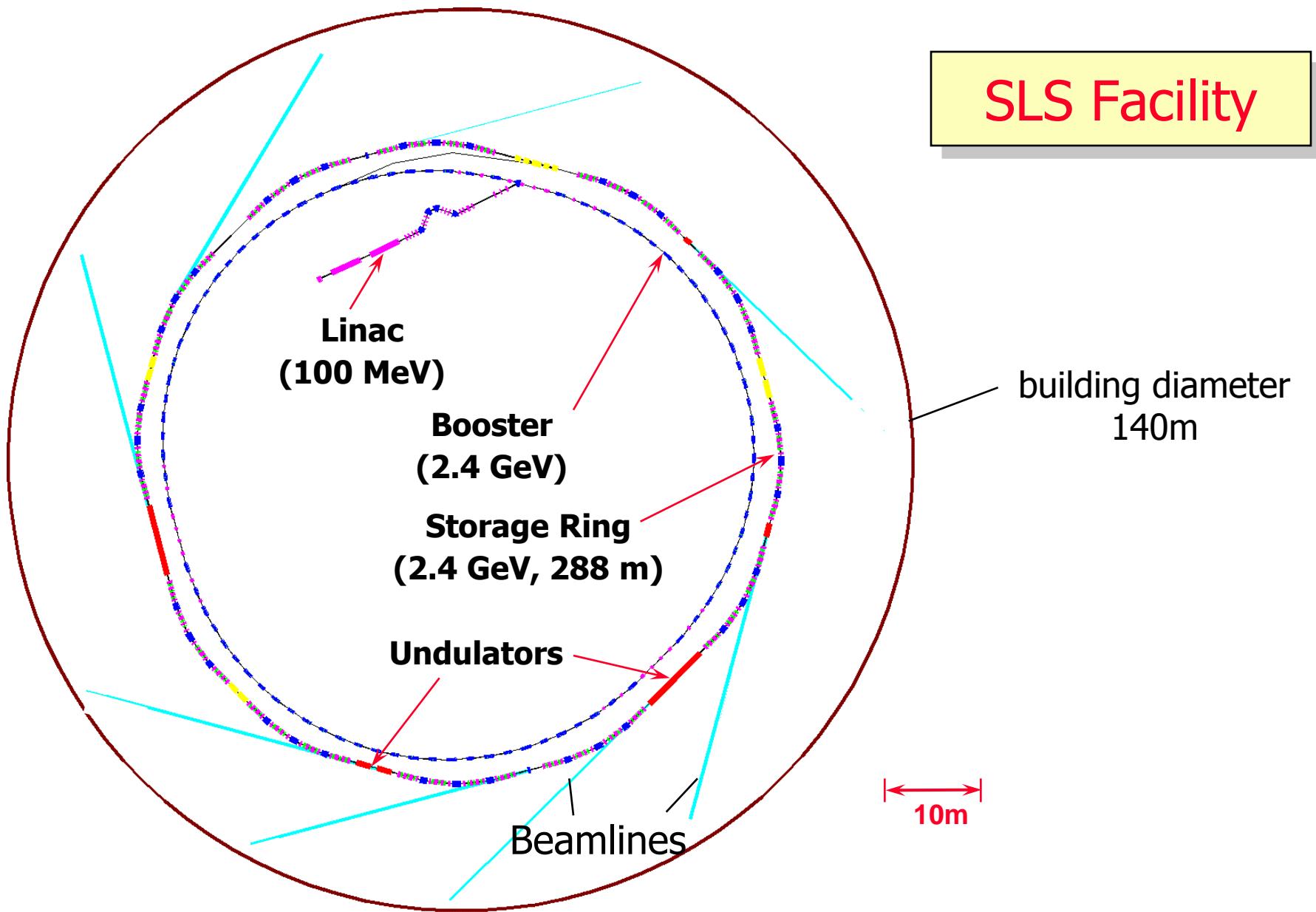
Research with Synchrotron Radiation

X-Ray Analysis

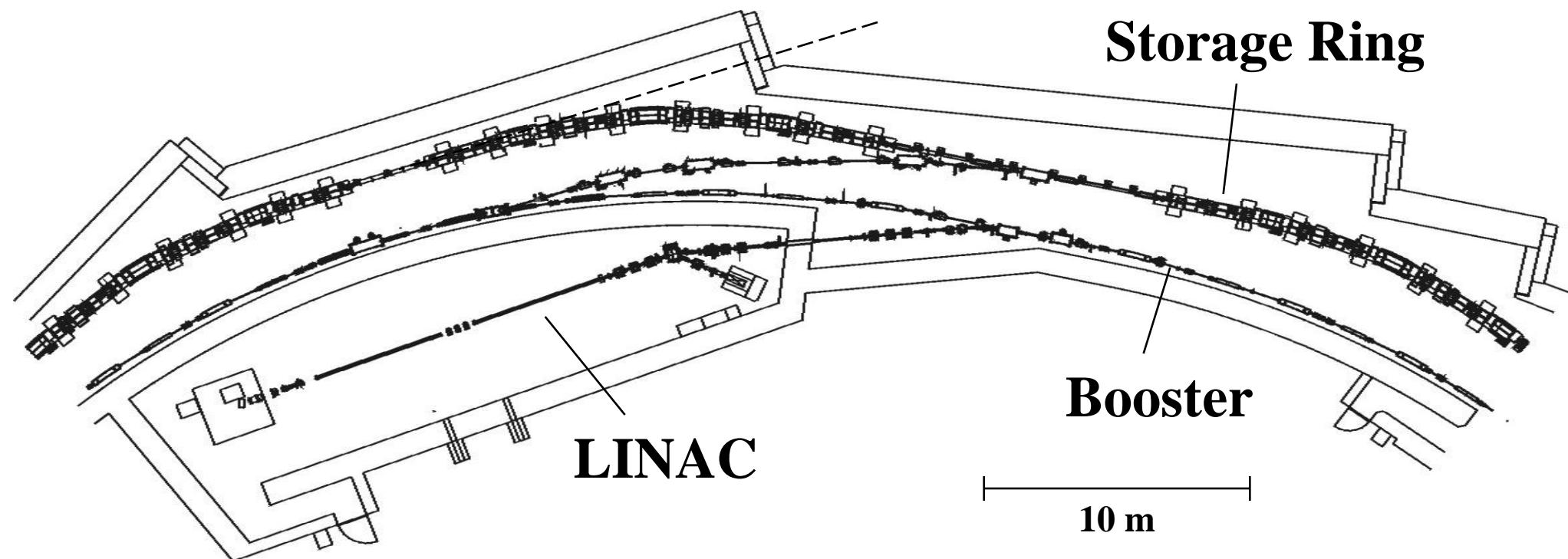
- Structure of Bio-Molecules (Proteins)
=> new drugs
- new Materials, Nano-Structures
- Micro-Tomography
(3-dim. Reconstruction
e.g. biological probes)
- high Temperature Superconductors

X-Ray Microscopy

- compact magnetic Structures
=> Data Storage
- Solar Cells
- special Surfaces
(Catalysts, minimal Friction etc.)
- Detection of Trace Elements on
Surfaces => Analysis of Impurities



Injection Region



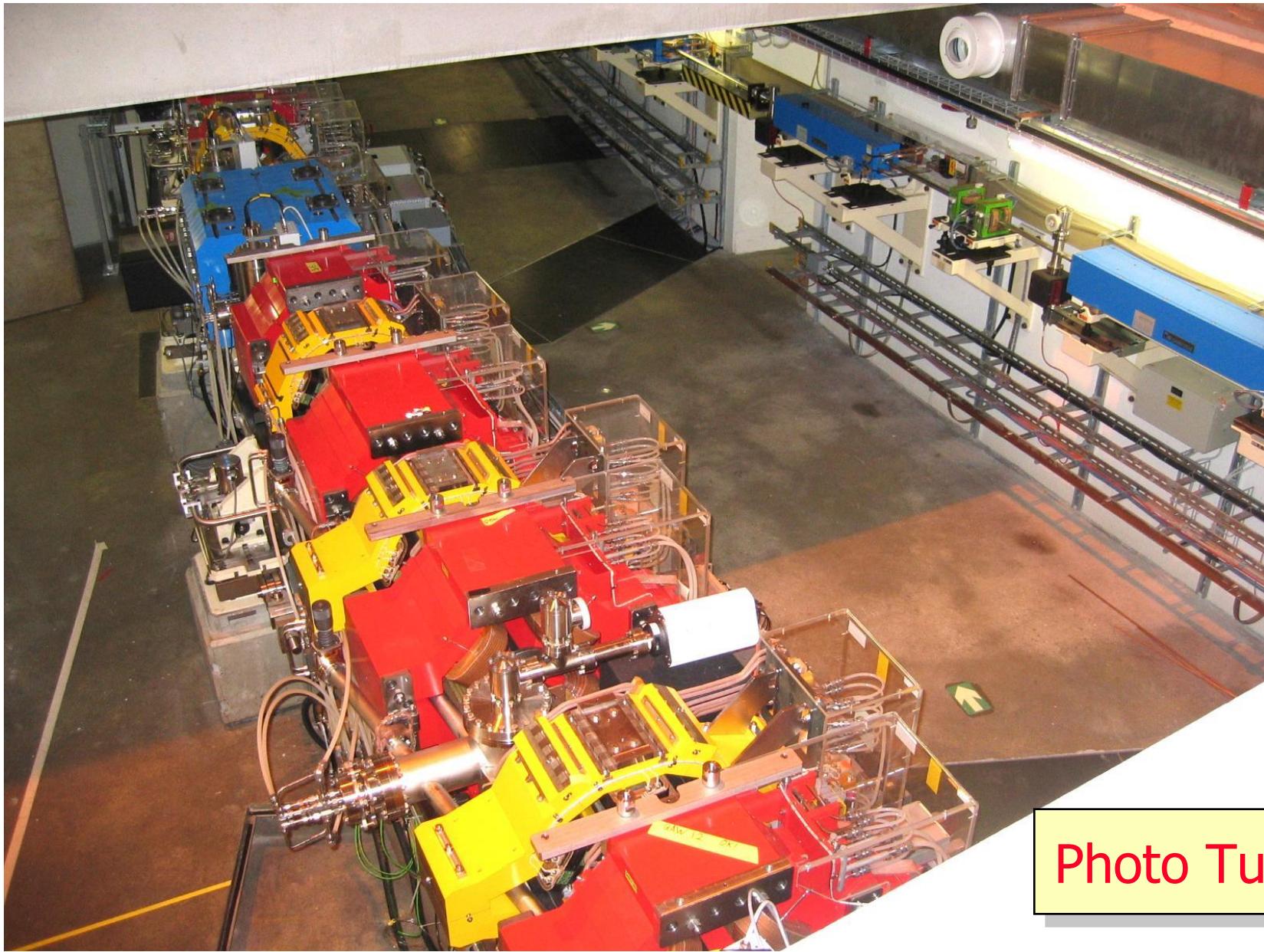


Photo Tunnel

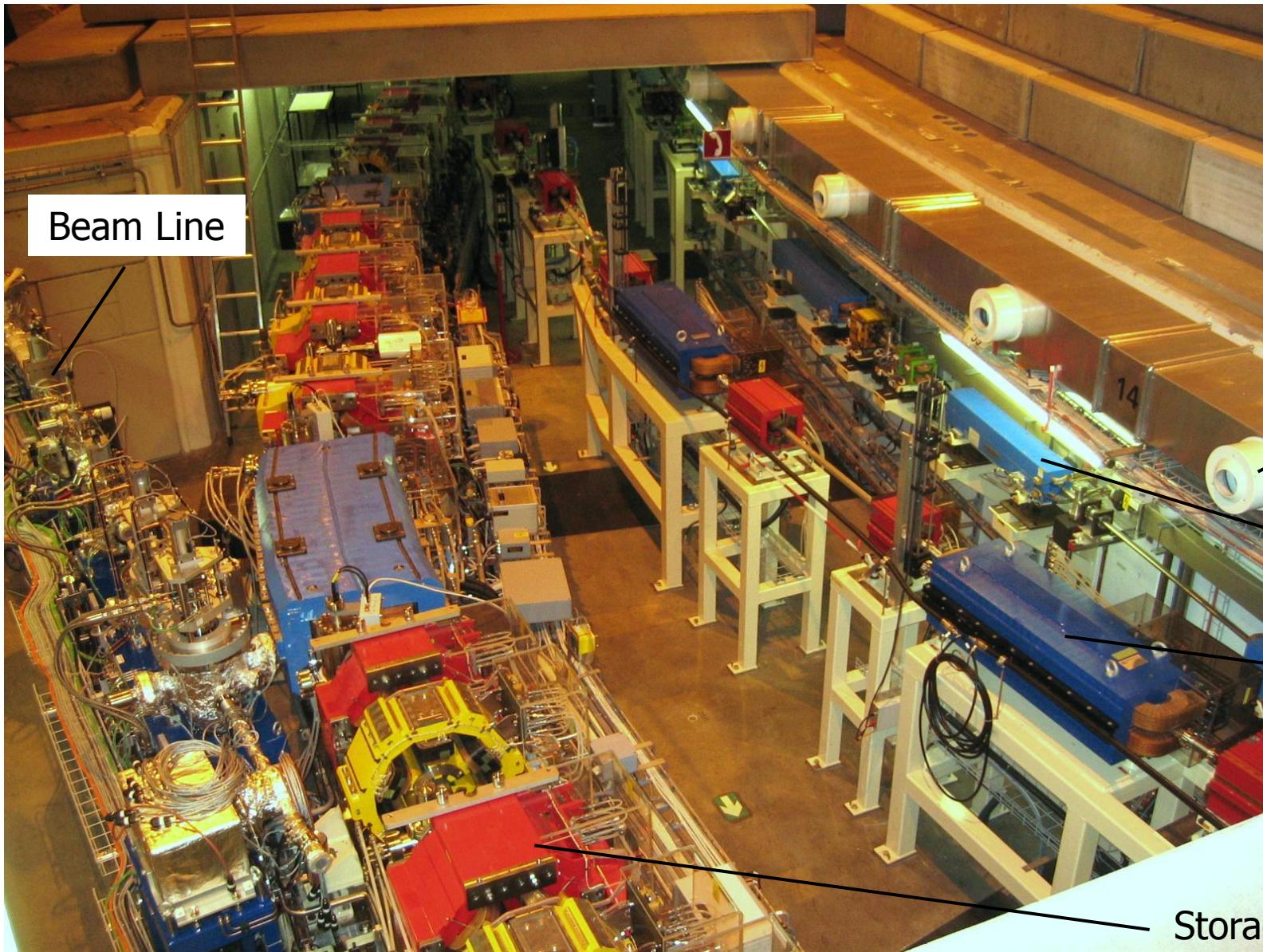


Photo
Tunnel

Beam Line

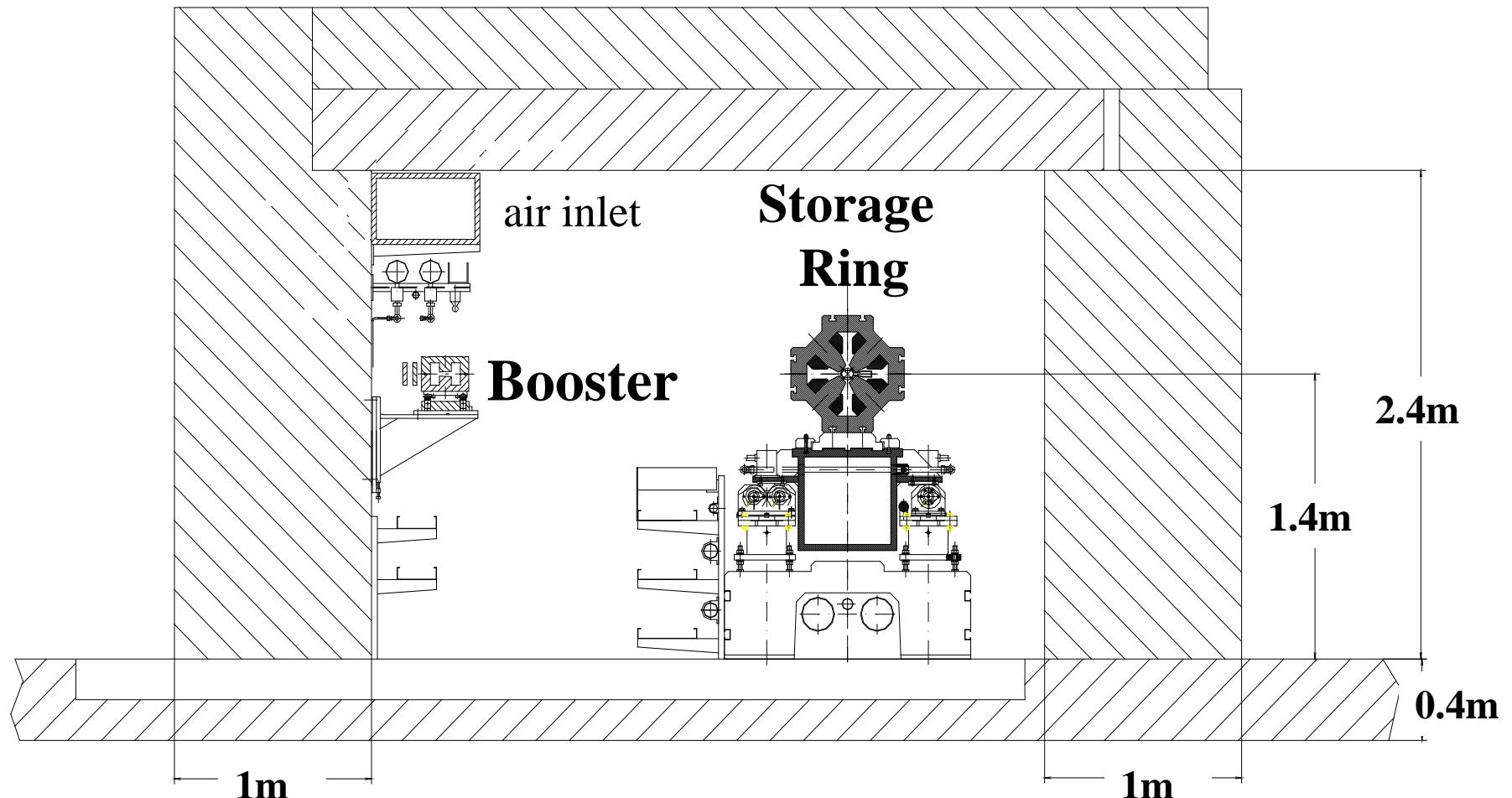
Air Jet

Booster

Transfer Line

Storage Ring

SLS Tunnel



Beamlines

2007:

11 Beamlines in Operation:

1D Infrared Spectroscopy

2D Tomography

3M Spectroscopy

4S Material Sciences

5L Environment/Materials

6S Protein Crystallography I

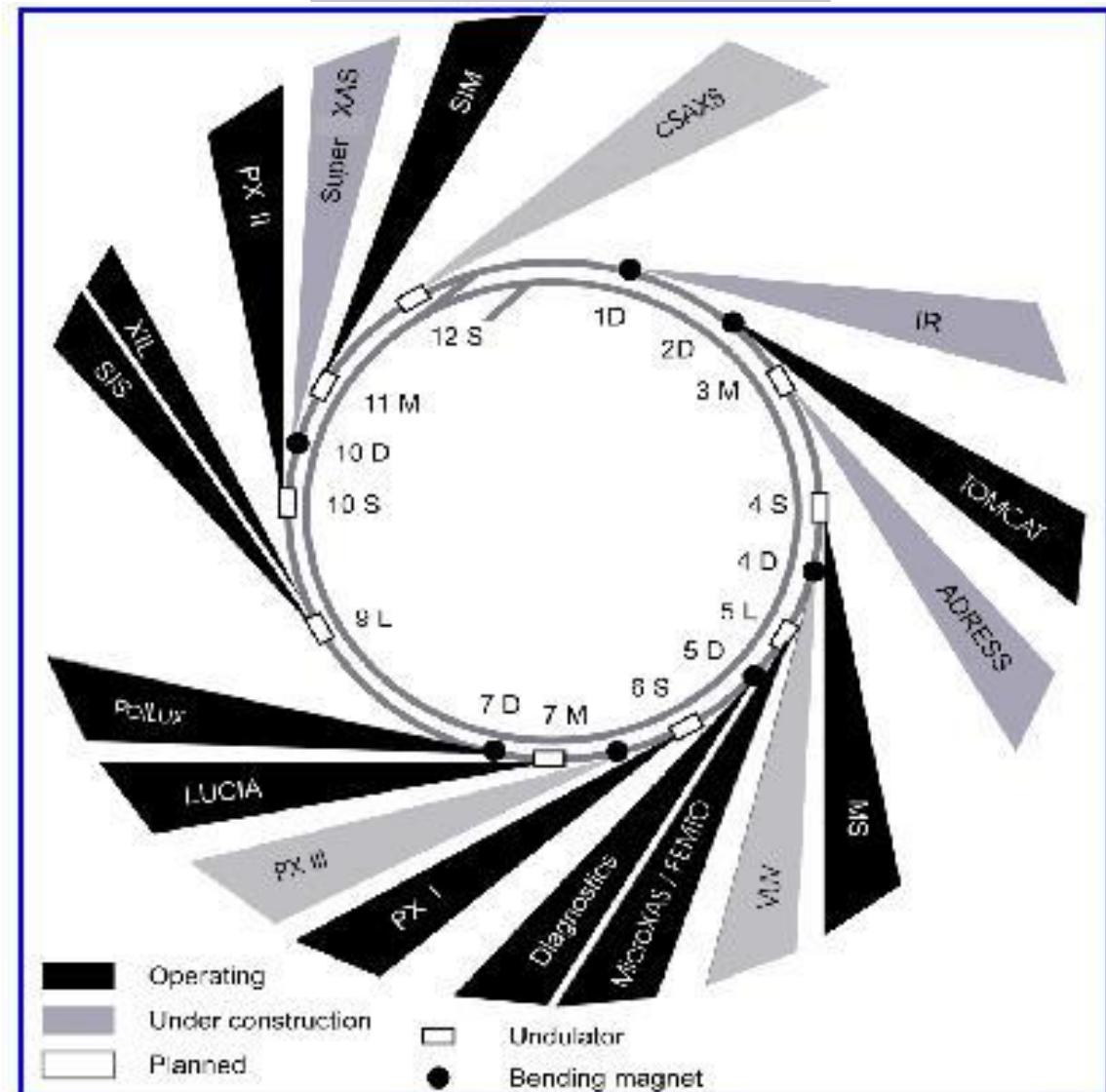
7M Environment/Materials

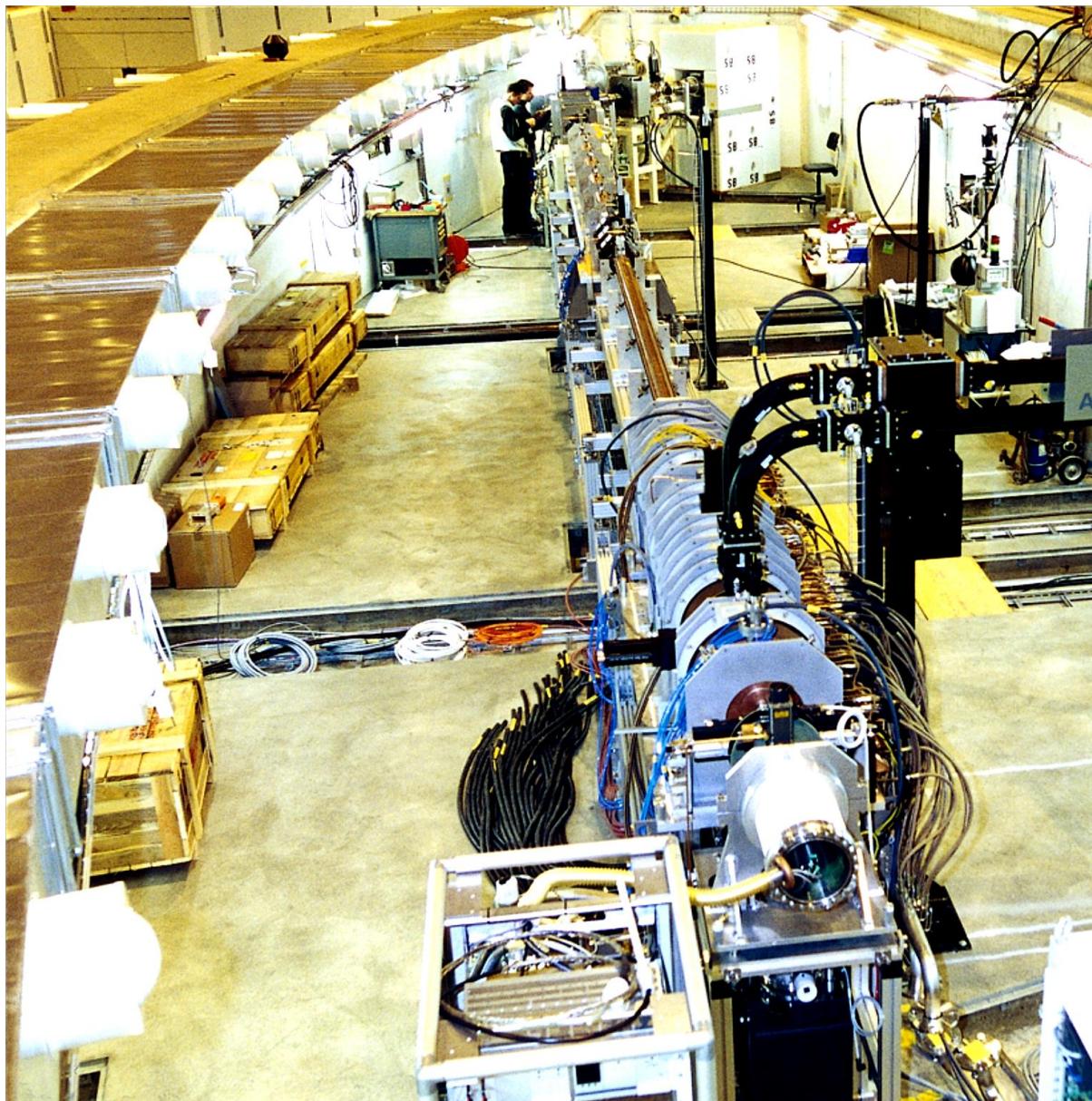
7D Microspectroscopy

9L Surfaces, Spectroscopy

10S Protein Crystallography II

11M Surfaces, Spectroscopy





Linac

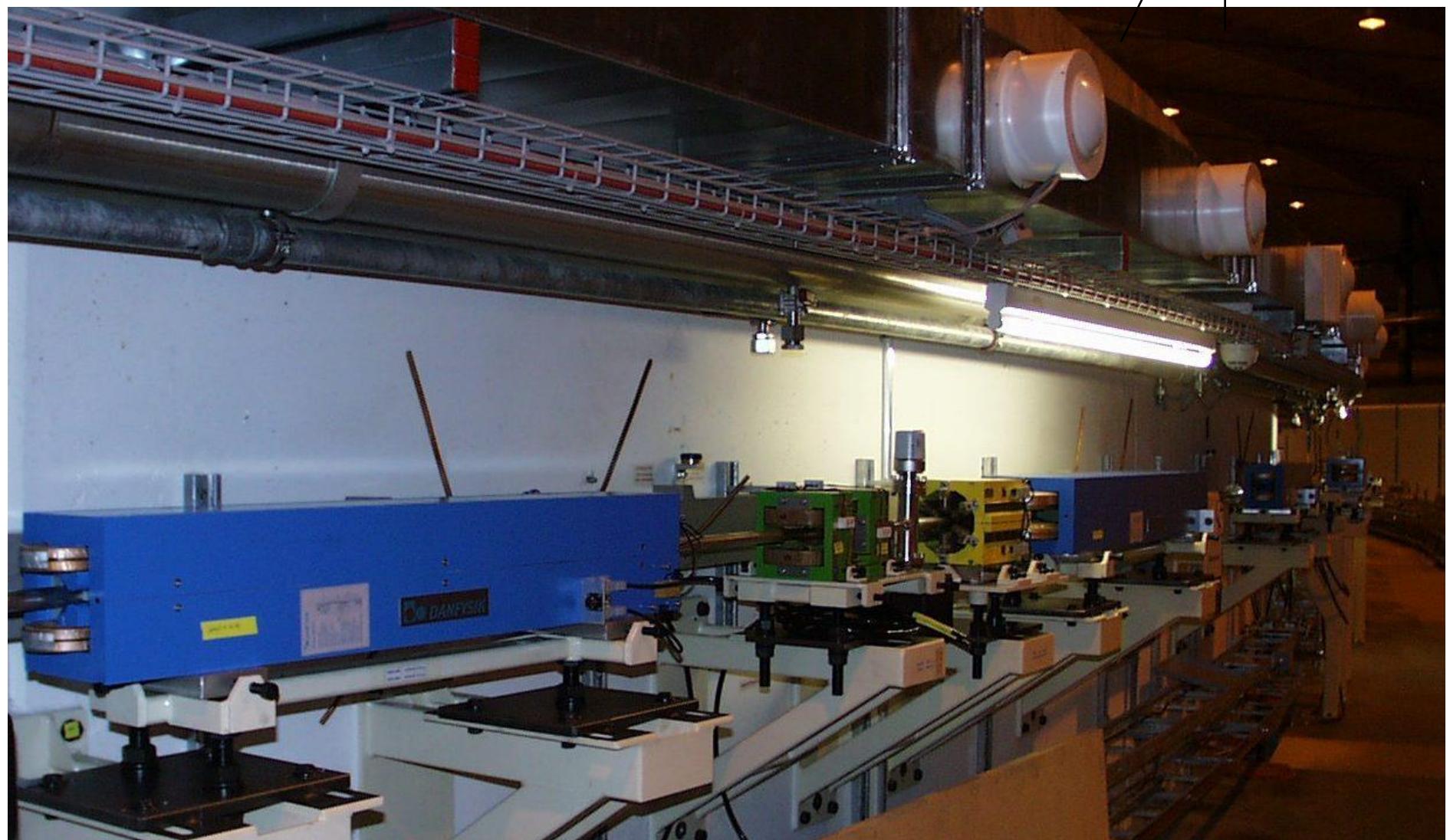
Electron Gun 90 keV

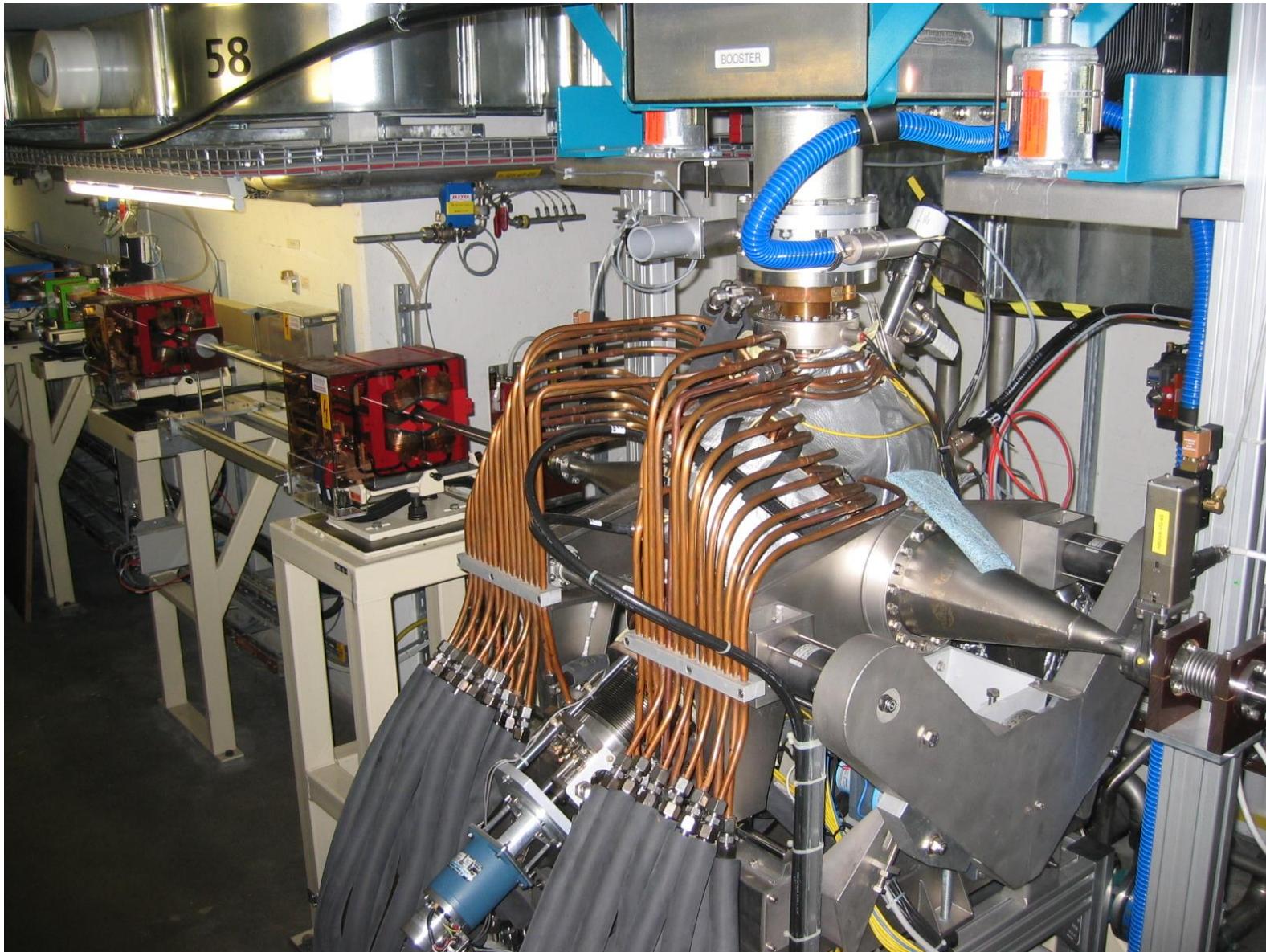
Linac (11m long) 100 MeV

Booster Specialty

- Booster in same Tunnel
as Storage Ring
 - Top-up Injection
- => large Circumference
=> small Emittance
 - short refill every 3 min.
=> constant Beam Current
- efficient Injection into Storage Ring,
filling in 6 min.
 - => stable Temperatures on
optical Components
- compact, economic Magnets
 - Energy Consumption < 20 kW
- simple Vacuum Chamber (30 x 20 mm)

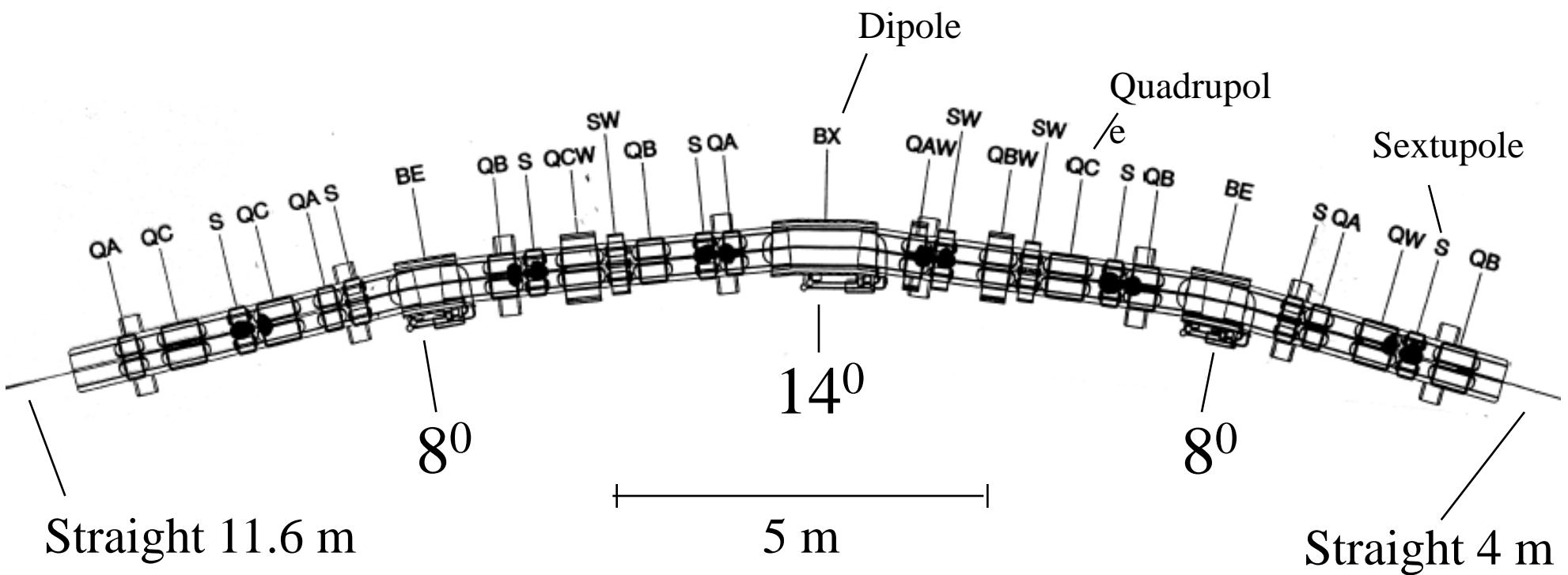
Booster





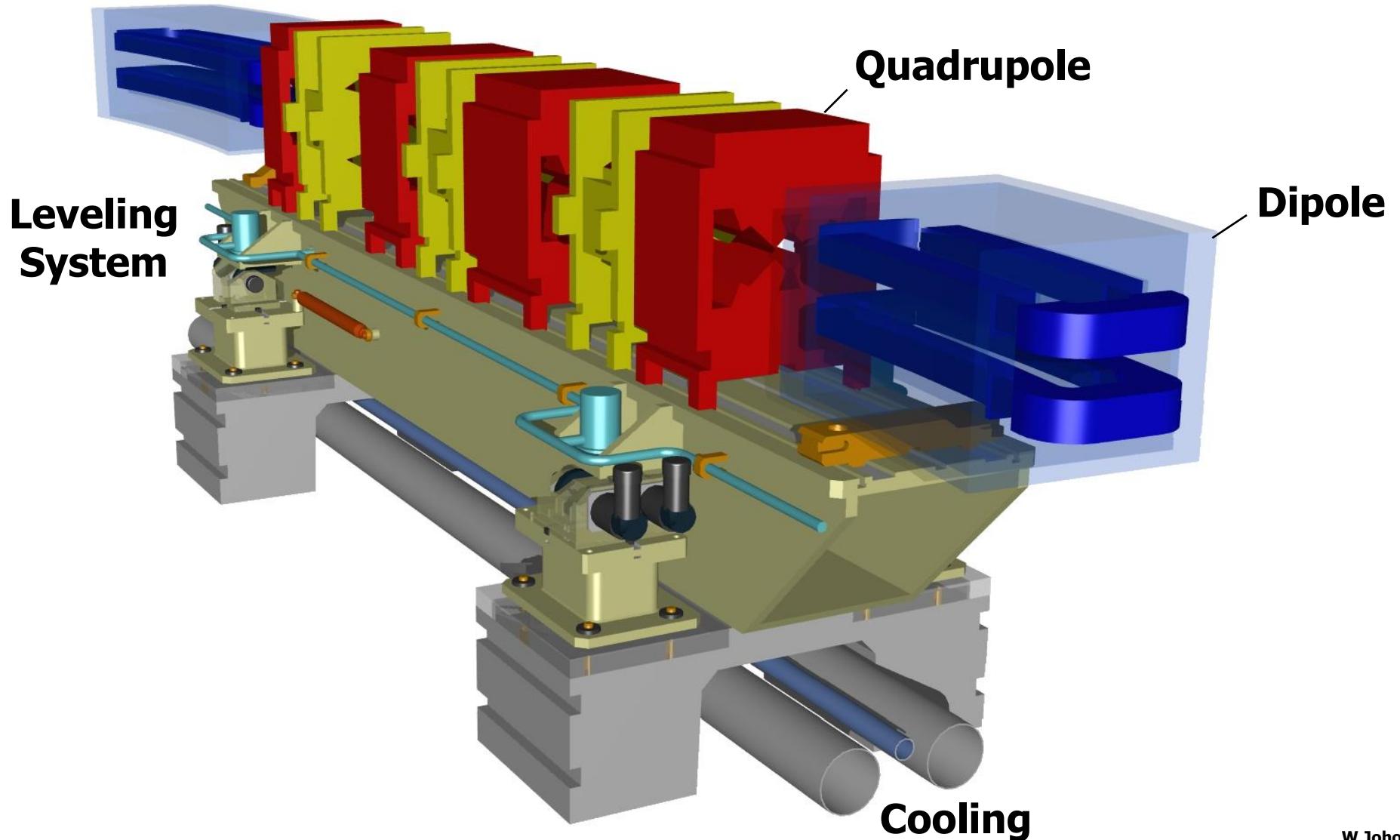
Booster
cavity

SLS 30° Arc

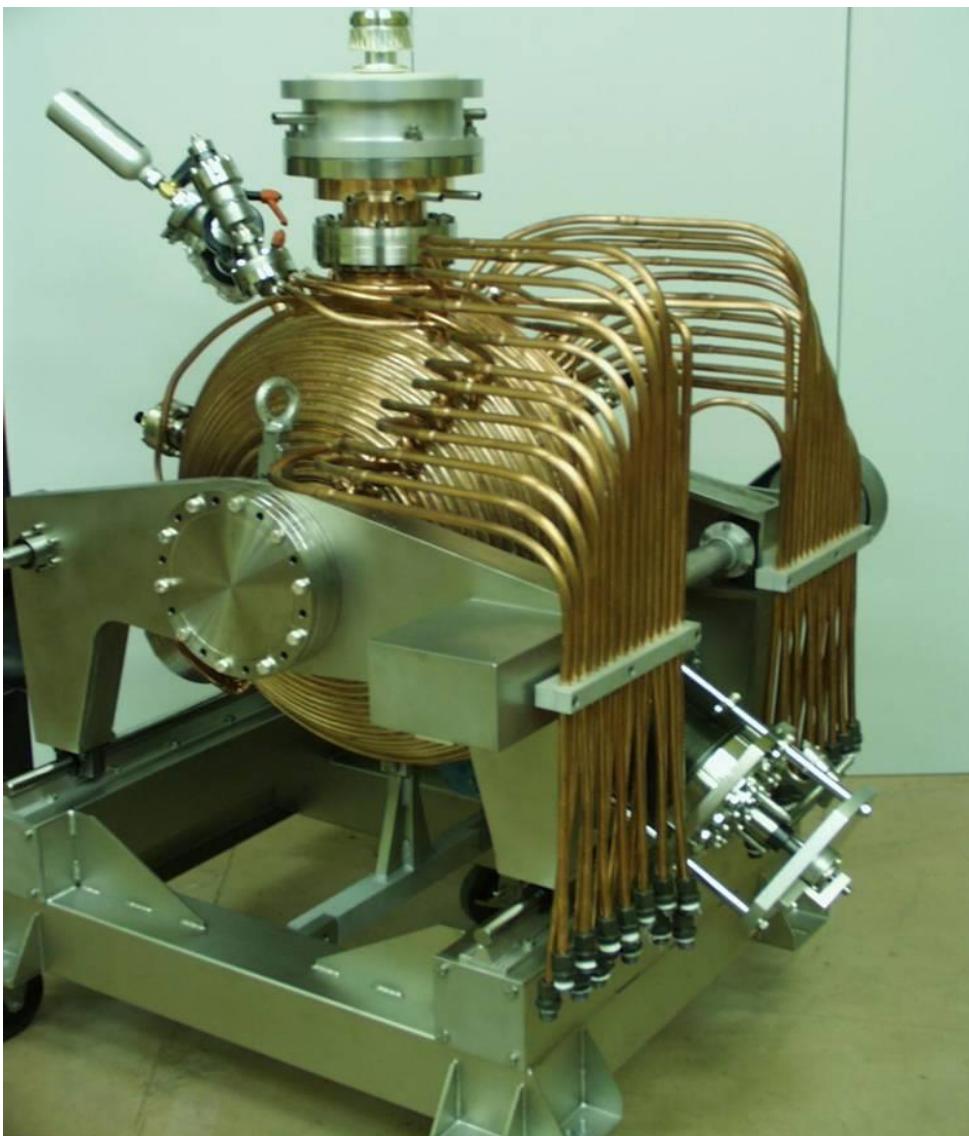


Magnet Configuration:

„TBA-lattice“ (Triple Bend Achromat)

SLS Girder

RF-Cavity



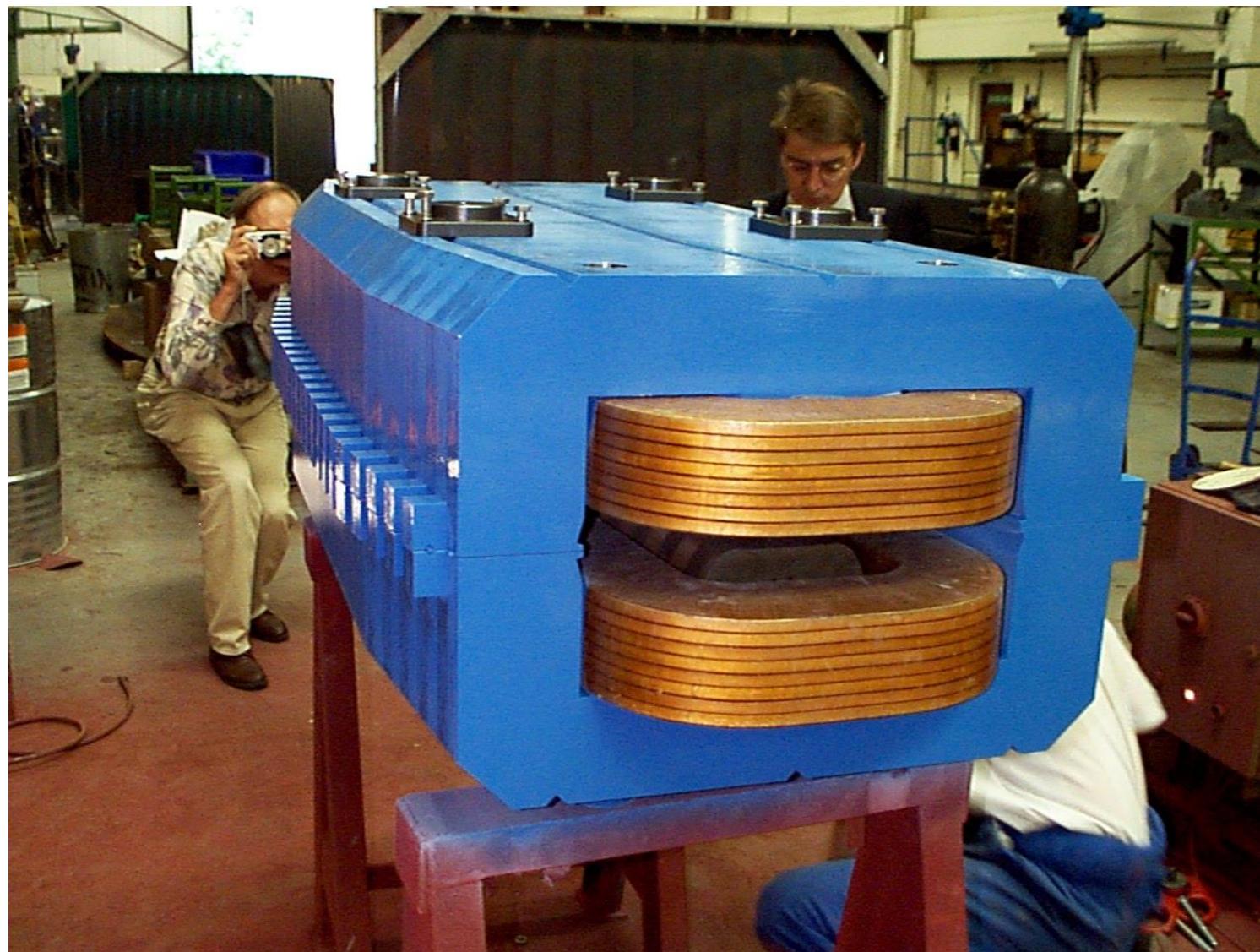
circulating Electrons generate
200 kW of X-Ray

This Power has to be
refurbished by an RF-System

Cavity = Resonator, made of Copper,
Frequency 500 MHz

4 Cavities in Storage Ring,
1 Cavity in Booster

600 kV Voltage
55 kW Power Loss/Cavity



Dipole-Magnet

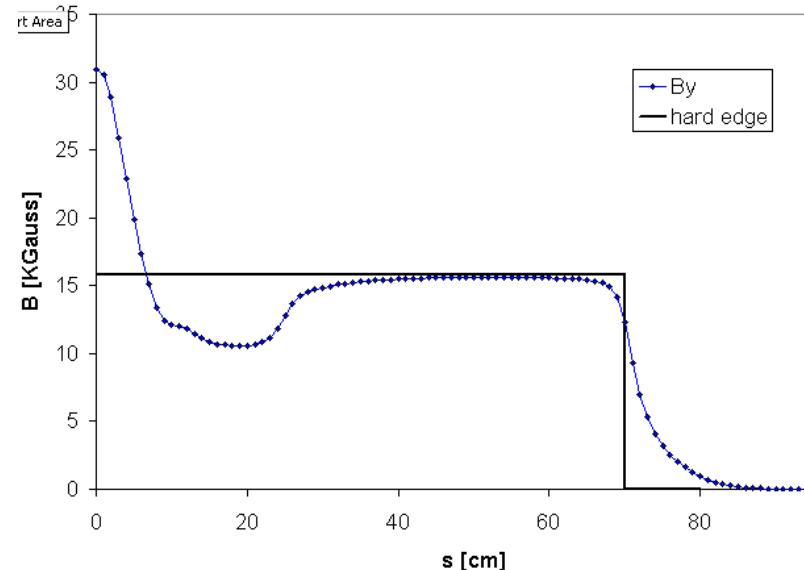
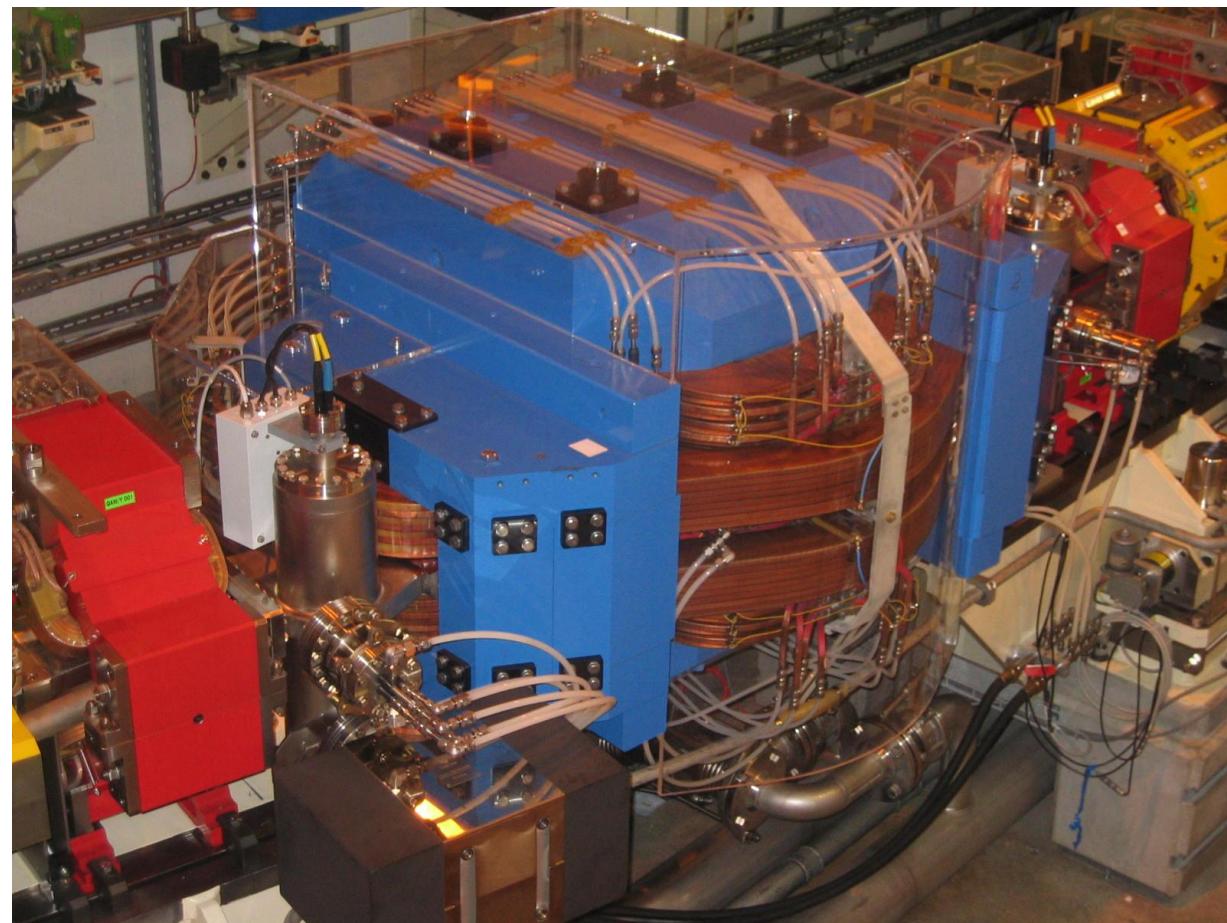
Deflection 14°

Field 1.4 T

Length 1.4m

Weight 3 Tons

Superbend



bending angle 14^0

center cone with 3 T

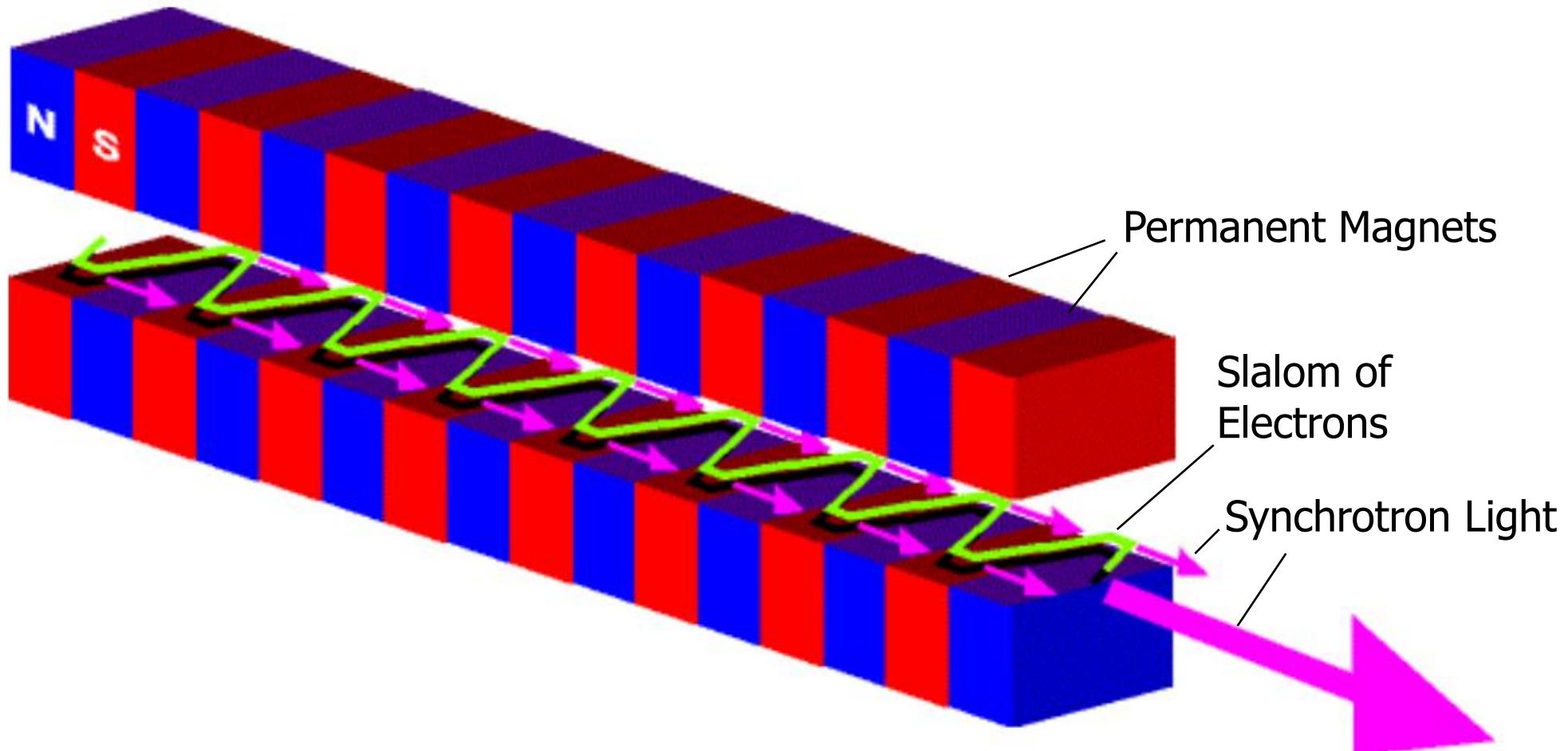
critical energy = 11.5 keV

end regions with 1.5 T

Accelerator Components

- 600 Magnets
- 300 Vacuum Pumps
- 150 Beam Monitors
- 5 RF Cavities
- 600 m Vacuum Tubes
- 50 km Power Cables
- 500 km Signal Cables
- 3 MW Power Consumption

Slalom Race in Undulator



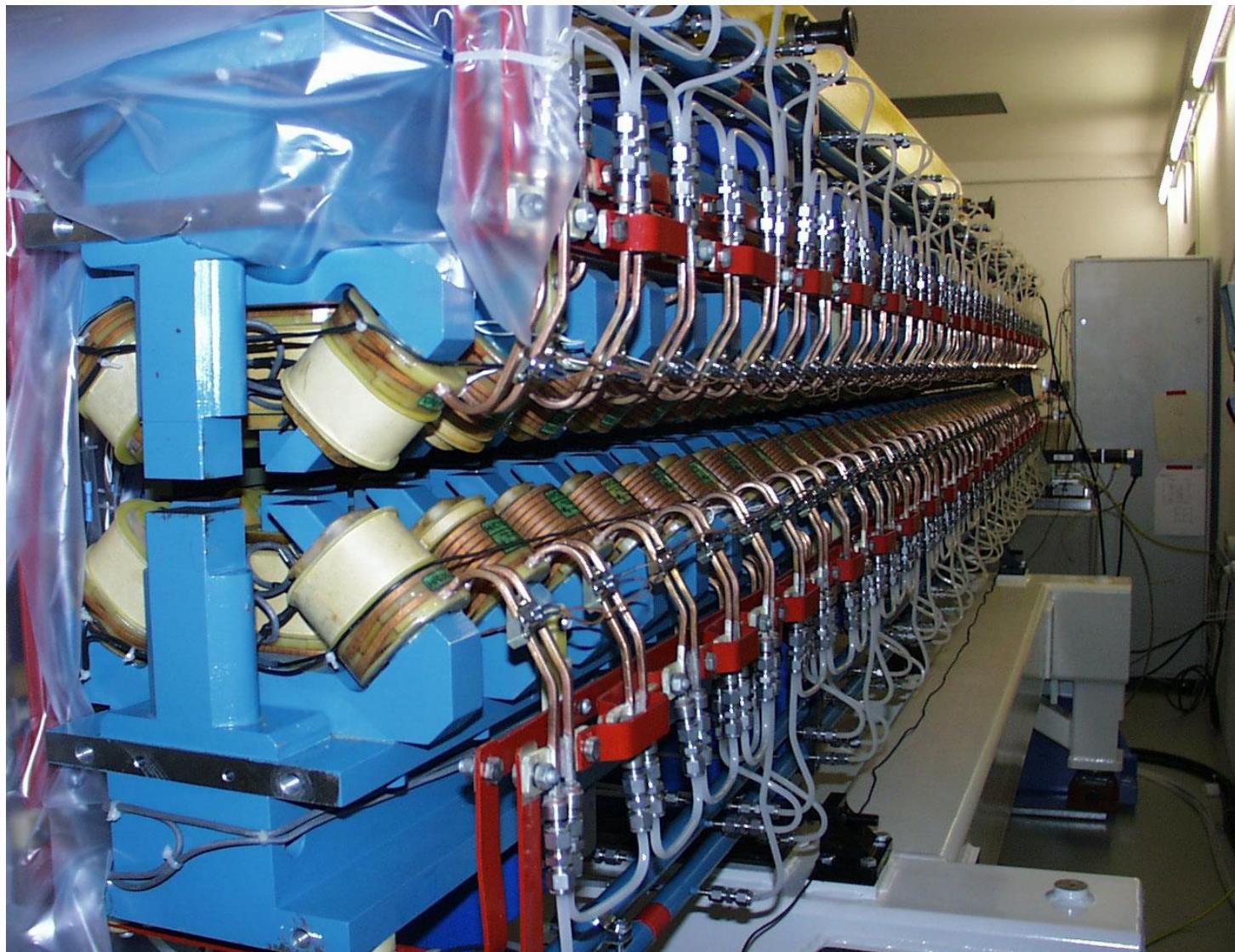
Undulator UE56



Permanent Magnets
62 Periods à 56mm

helical Fields give
circular and linear
Polarisation

Undulator UE212

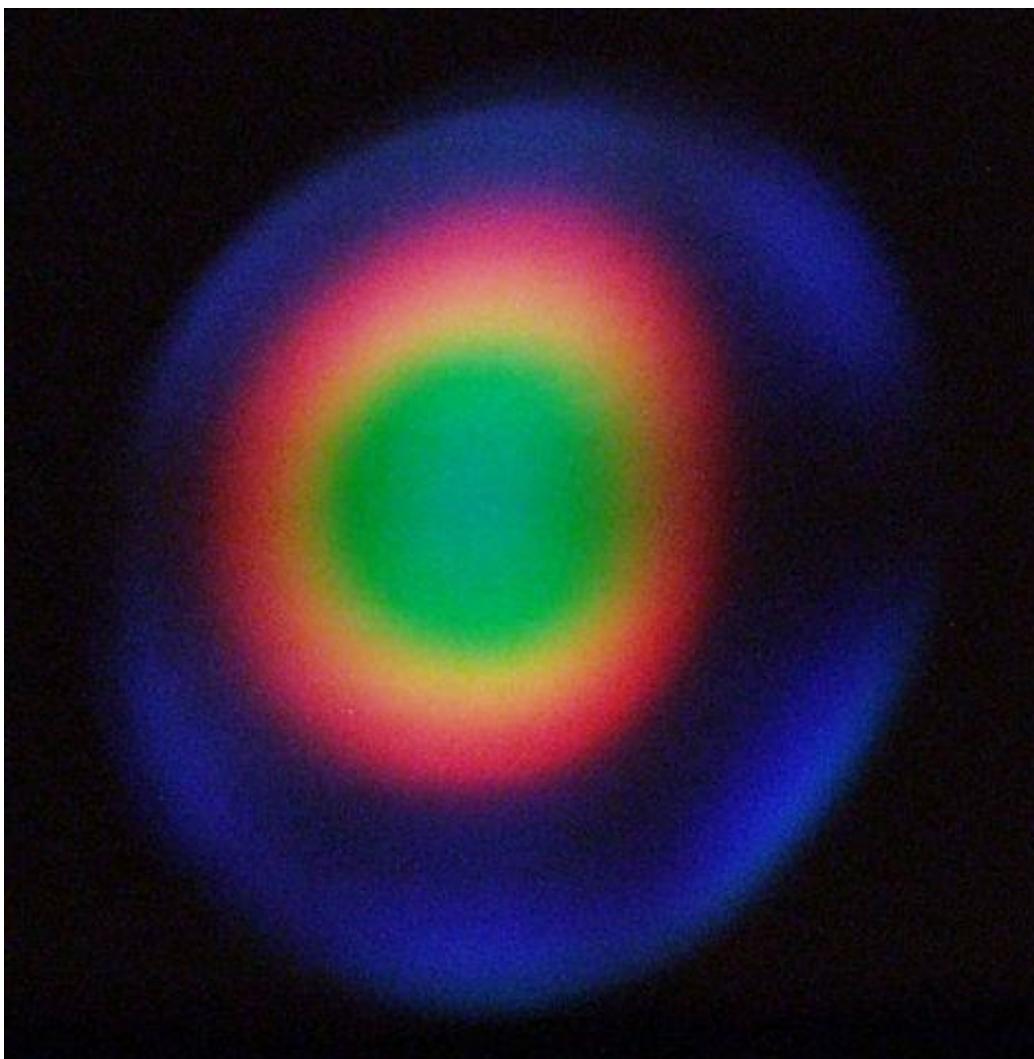


Electromagnets

2*21 Periods à
212mm

helical Fields give
circular and linear
Polarisation

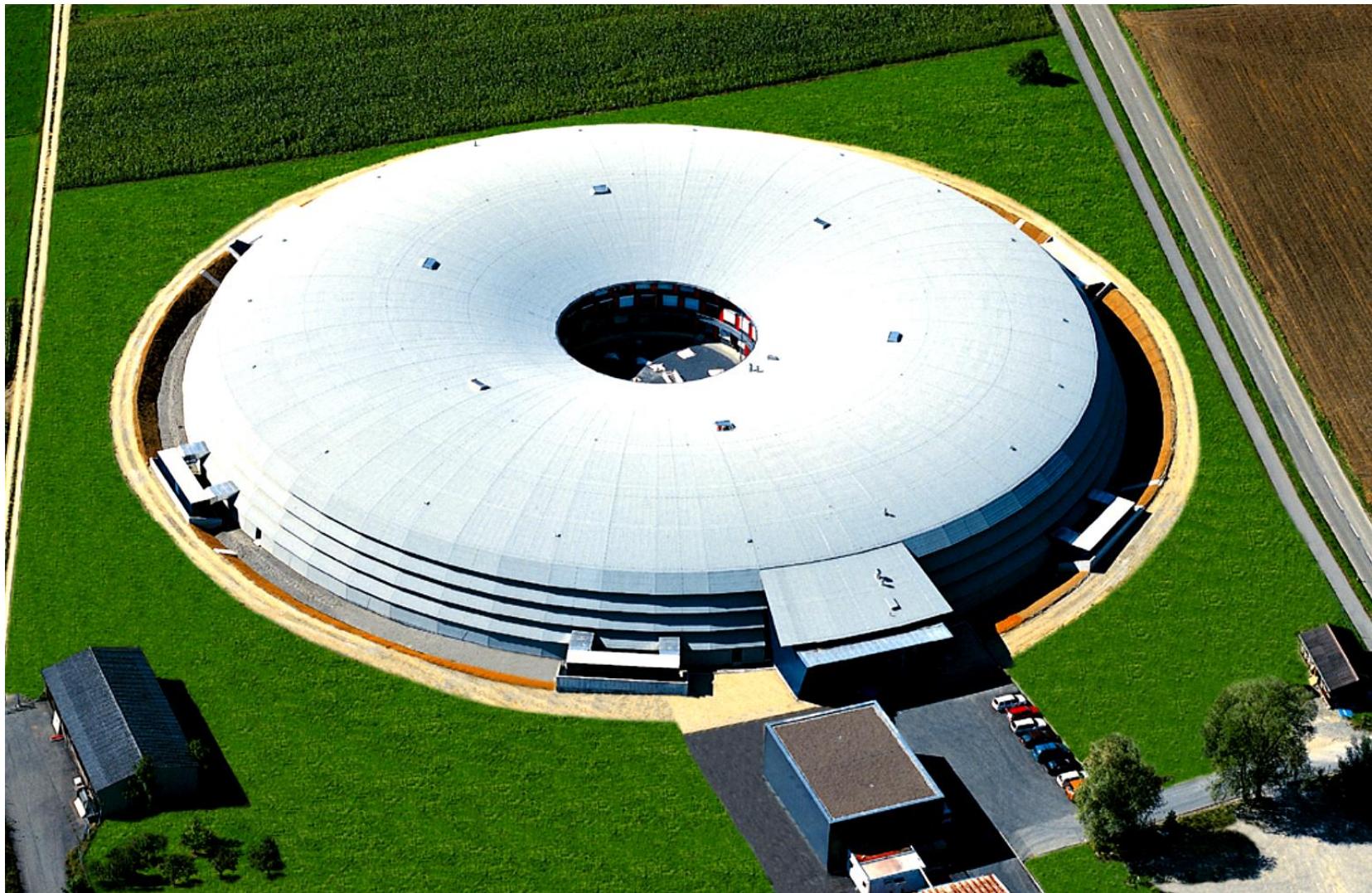
Light Cone



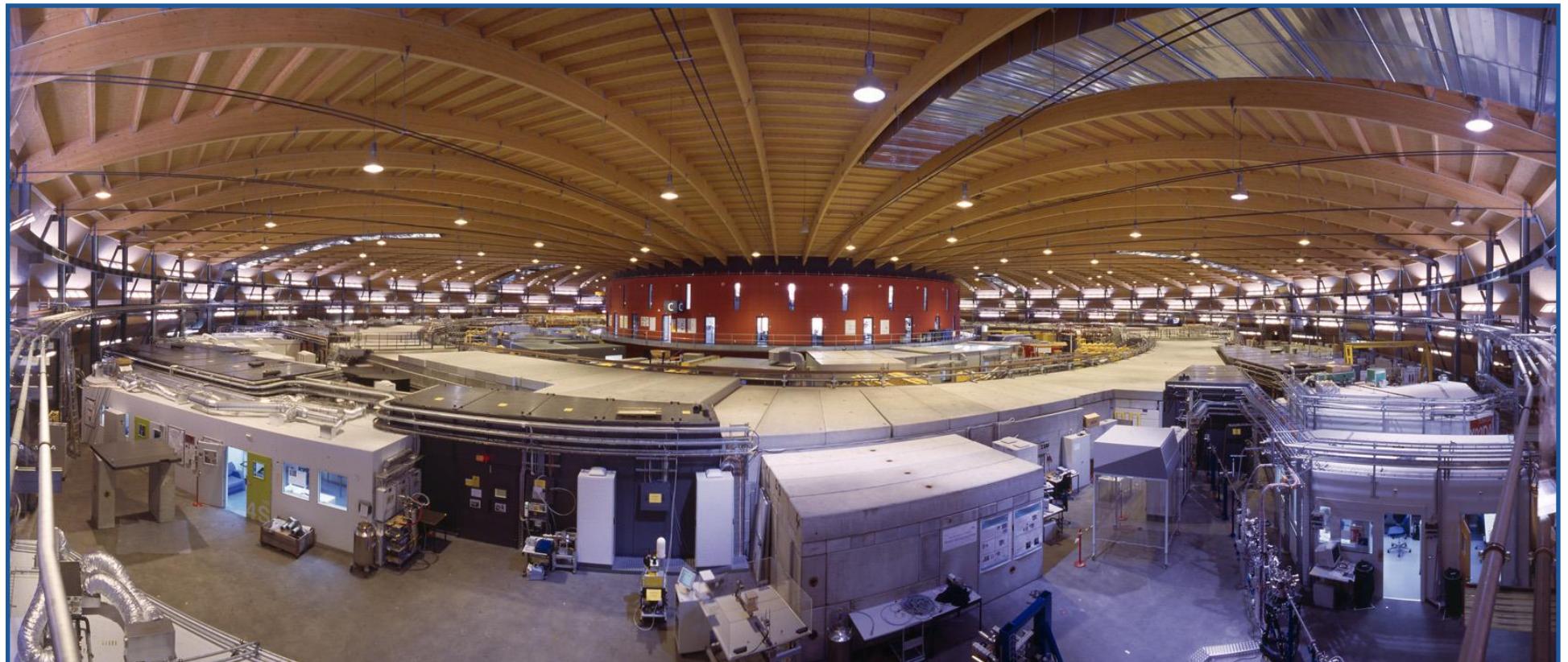
Light Cone from Wiggler W138

1. harmonic, $K=18$ ($B=1.4$ T)

SLS Photo



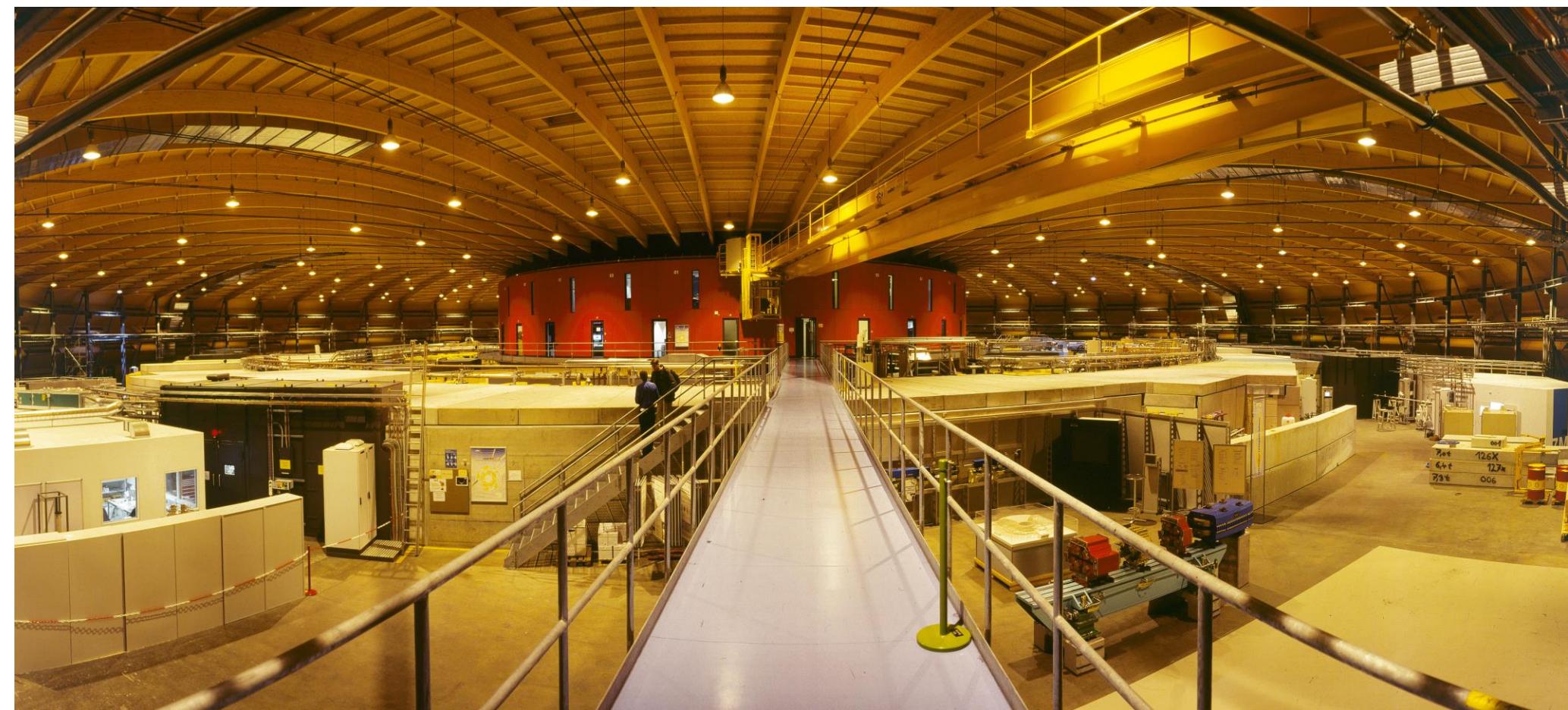
SLS Building

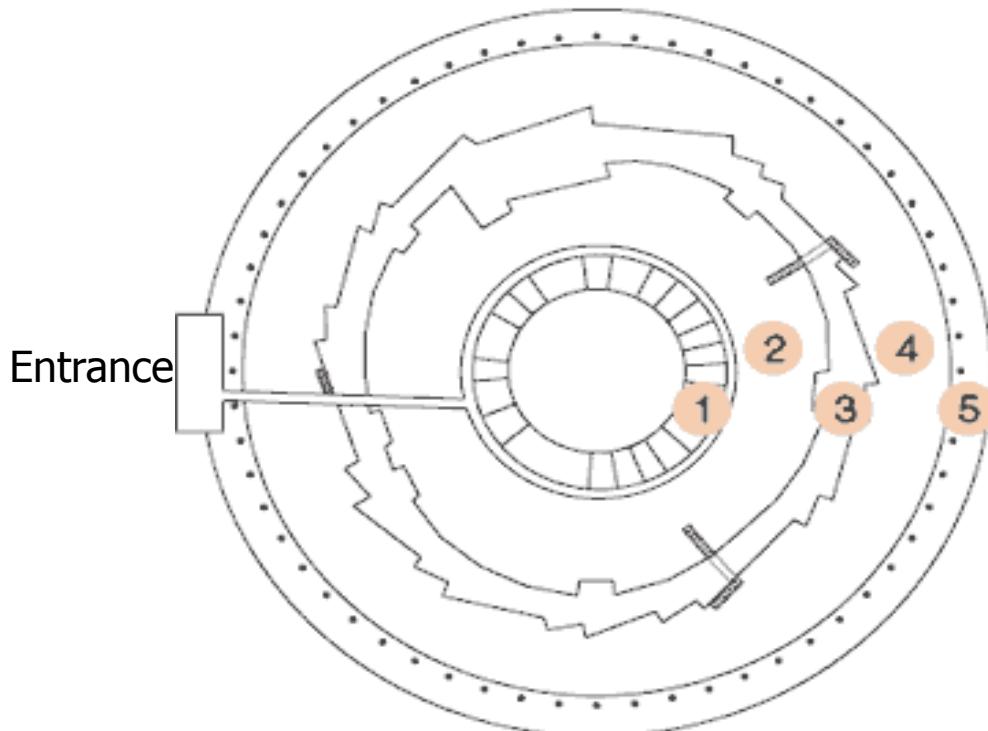


an architectural Juwel !

Team of Architects from Bern
(Gartenmann, Werren, Jöhri, Marchand)

SLS Panorama





Zones:

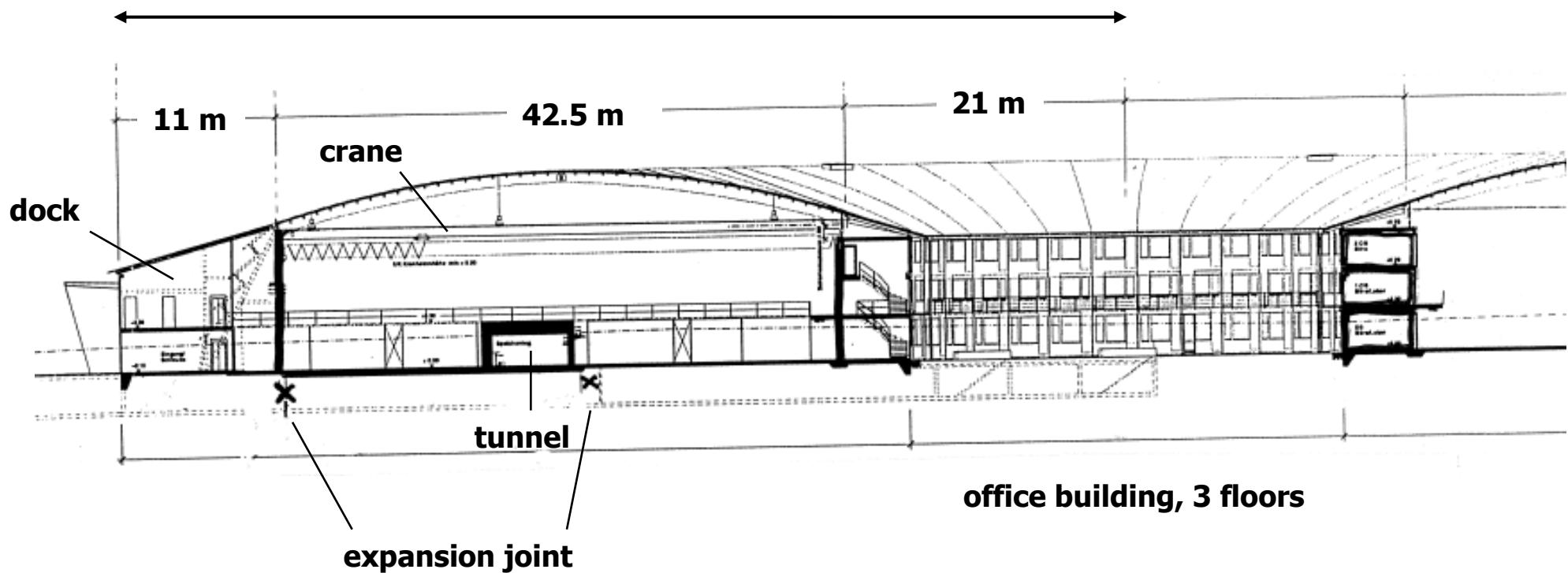
- 1 Office Building (3 Floors)
- 2 Technical Galery
- 3 Tunnel (Storage Ring, Linac and Booster)
- 4 Area for Beam Lines
- 5 Outer Ring (60 Columns, Air Inlet System)

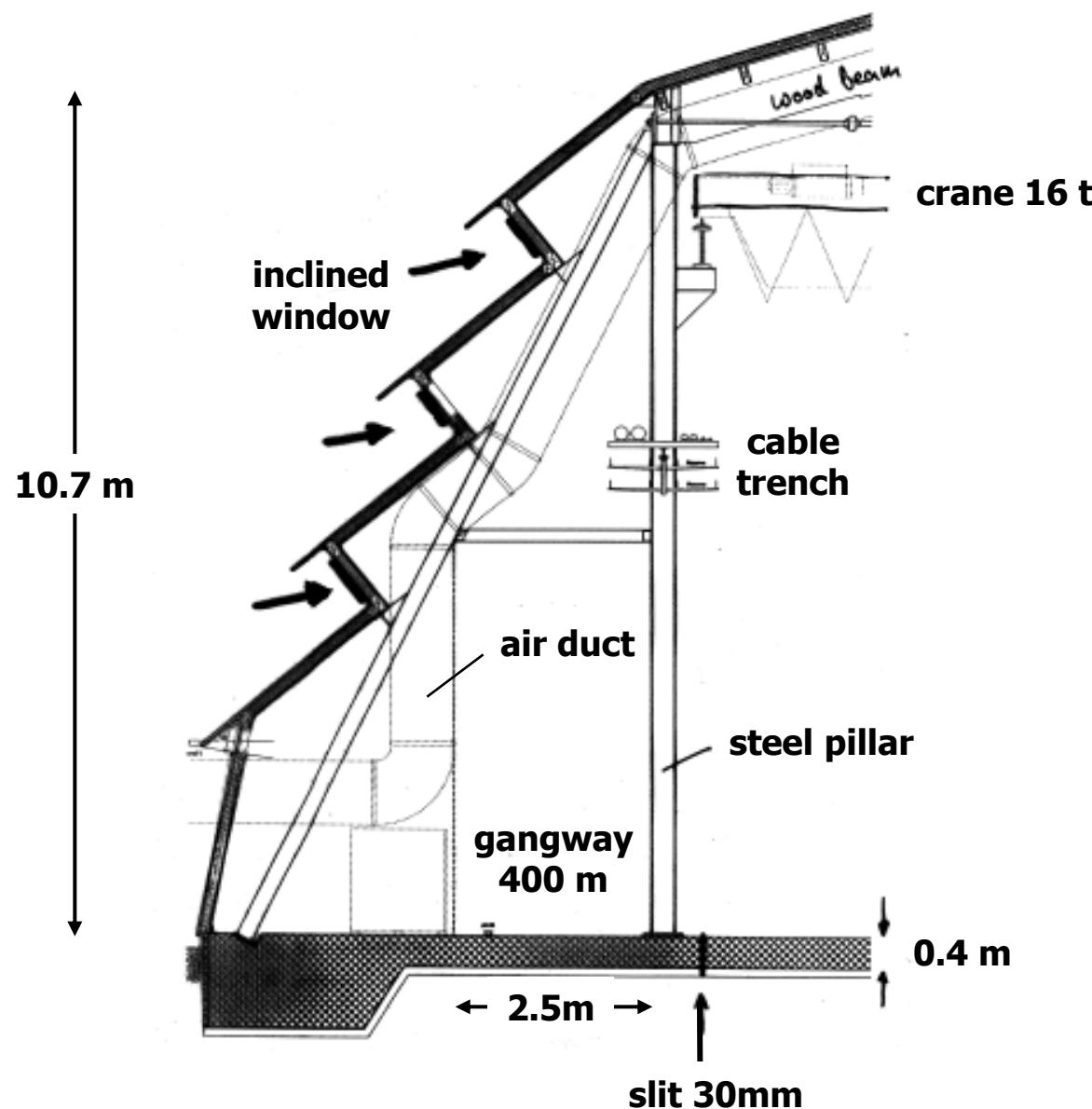
Building Concept

- separate annular Ring (40 cm) for Floor of Tunnel und Beam Lines (Zones 3, 4)
=> decouples Tunnel and Exp. Floor from Rest of Building
- very stable Temperatures in Tunnel und Hall

=> **stable Conditions for
Electron Beam and Beam Lines**

SLS Cross Section





cross section
periphery

Building Parameter

| | |
|----------------------------|-----------------------|
| outer Diameter | 138 m |
| Height | 14.3 m |
| Area | 14'000 m ² |
| Columns, Roof Beams | 60 |
| Length of Roof Beams | 43 m |
| Crane | 16 t |
| Circumference Storage Ring | 288 m |
| Tunnel, inner Height | 2.4 m |

Office Building:

3 Floors with Offices for 80 Persons, Control Room, Labs

Building Specifications

- Base Ground: Glacial Gravel and Sand,
only removal of ground for leveling!
- separate annular Concrete Ring Floor (Cast in one Piece)
for Tunnel and Beam Lines
- differential Settlement: < 0.2 mm/year over 10 m
- Tolerance on Vibrations: < 0.5 μm (up to 50 Hz)
- recessed Windows in Building Walls
=> no direct Sun Light on Floor

Wooden Roof



Aufnahmedatum
18. November 1998
PSI / SLS

Radiation Dose

natural Background

- Villigen : $\approx 800 \mu\text{Sv/year}$
(Davos , Locarno : $\approx 1'500 \mu\text{Sv/year}$)
- human, internal (K^{40} etc.) $\approx 200 \mu\text{Sv/year}$
- medical Applications: $\approx 1'000 \mu\text{Sv/year}$
- 8 h Flight: $\approx 200 \mu\text{Sv}$

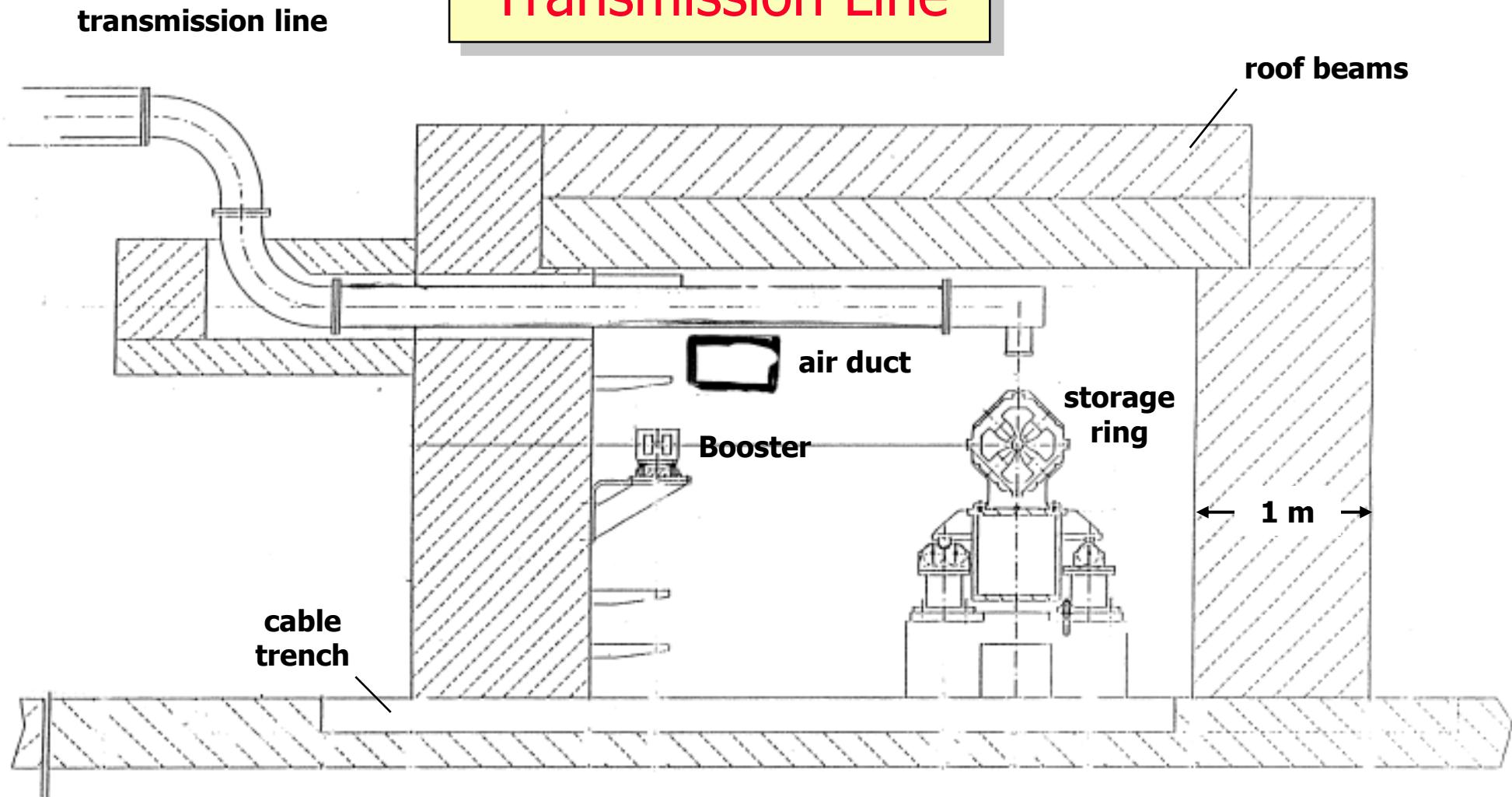
Tolerance for SLS

- outside PSI : $< 50 \mu\text{Sv/year}$
- in SLS Building: $< 1000 \mu\text{Sv/year}$

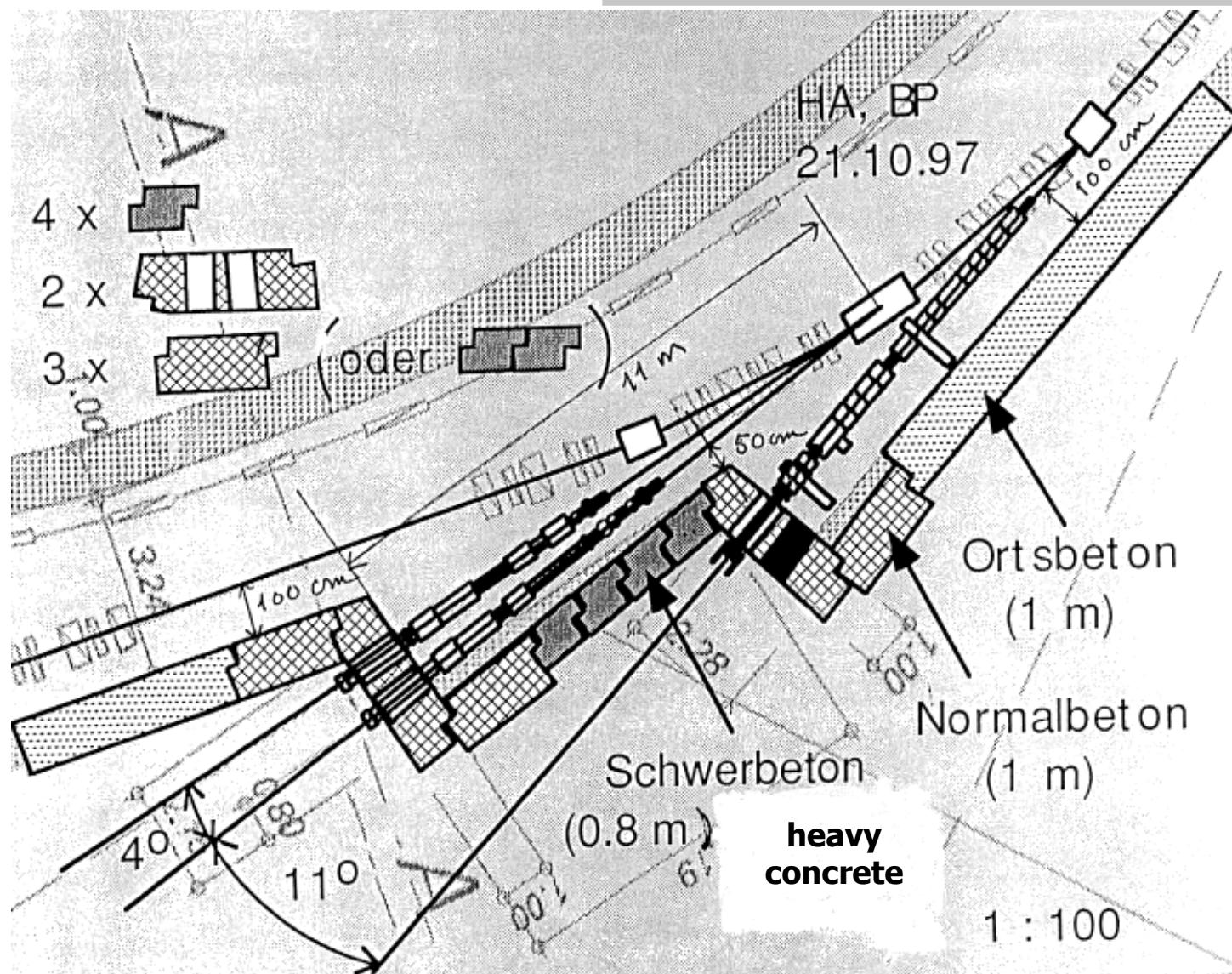
Shielding of Accelerators

- Tunnel Walls : 1.0 - 1.3 m
- Tunnel Roof : 2 Concrete Layers of 0.4 m

Tunnel with RF Transmission Line



concrete shielding



Temperature Stability

=> vital for stable Beams !

Tunnel

$25^{\circ} \pm 0.03^{\circ}$

- Air Conditioning: 5 Units à $6'000\text{m}^3/\text{h}$
- 150 Jets for stable Air Circulation
- 40kW Cooling, 90kW Heating (Shutdown)

Hall

$24^{\circ} \pm 0.2^{\circ}$ (Summer and Winter)

- Air Conditioning: 6 Units à $50'000\text{m}^3/\text{h}$
- 800kW Cooling Power
- gentle Air Inlet on 55% of outer Circumference

Temperature Control in Experimental Hall

Cooling: 6 aircondition units à 50'000 m³/h
air inlet grids on 230m (=55% of the building periphery)
cooling capacity ca. 800 kW (120 kW / °C)
temperature control: $\Delta T \approx \pm 0.2^{\circ}\text{C}$

Heat transfer to air : standby, storage ring „off“ : 250 kW
storage ring „on“ : 700 kW

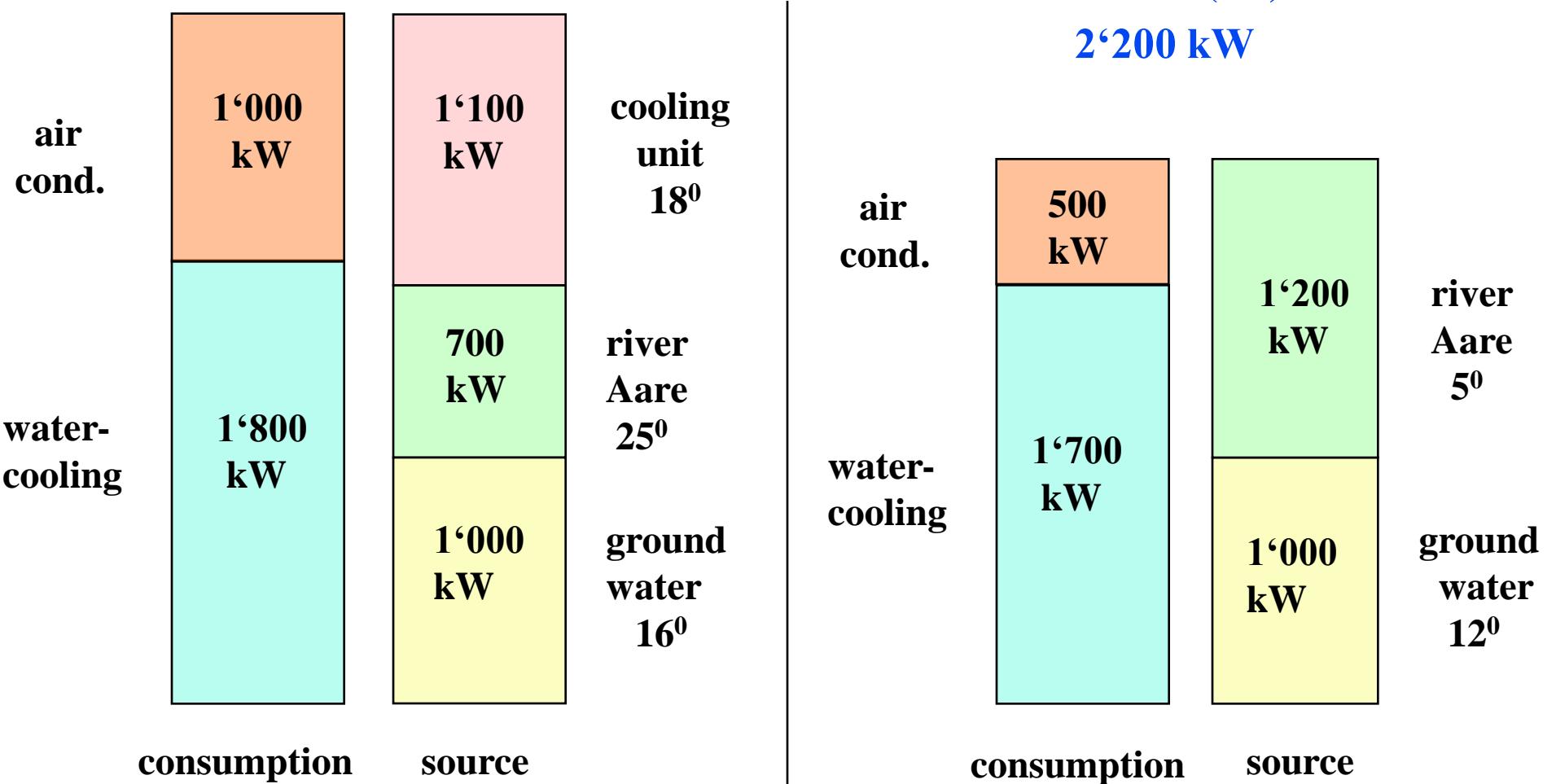
Heat loss in winter (-10° outside, +24° inside) :
 roof, walls and floor : 200 kW
 windows, doors : 30 kW
 minimum fresh air exchange : 10 kW
 Total 240 kW

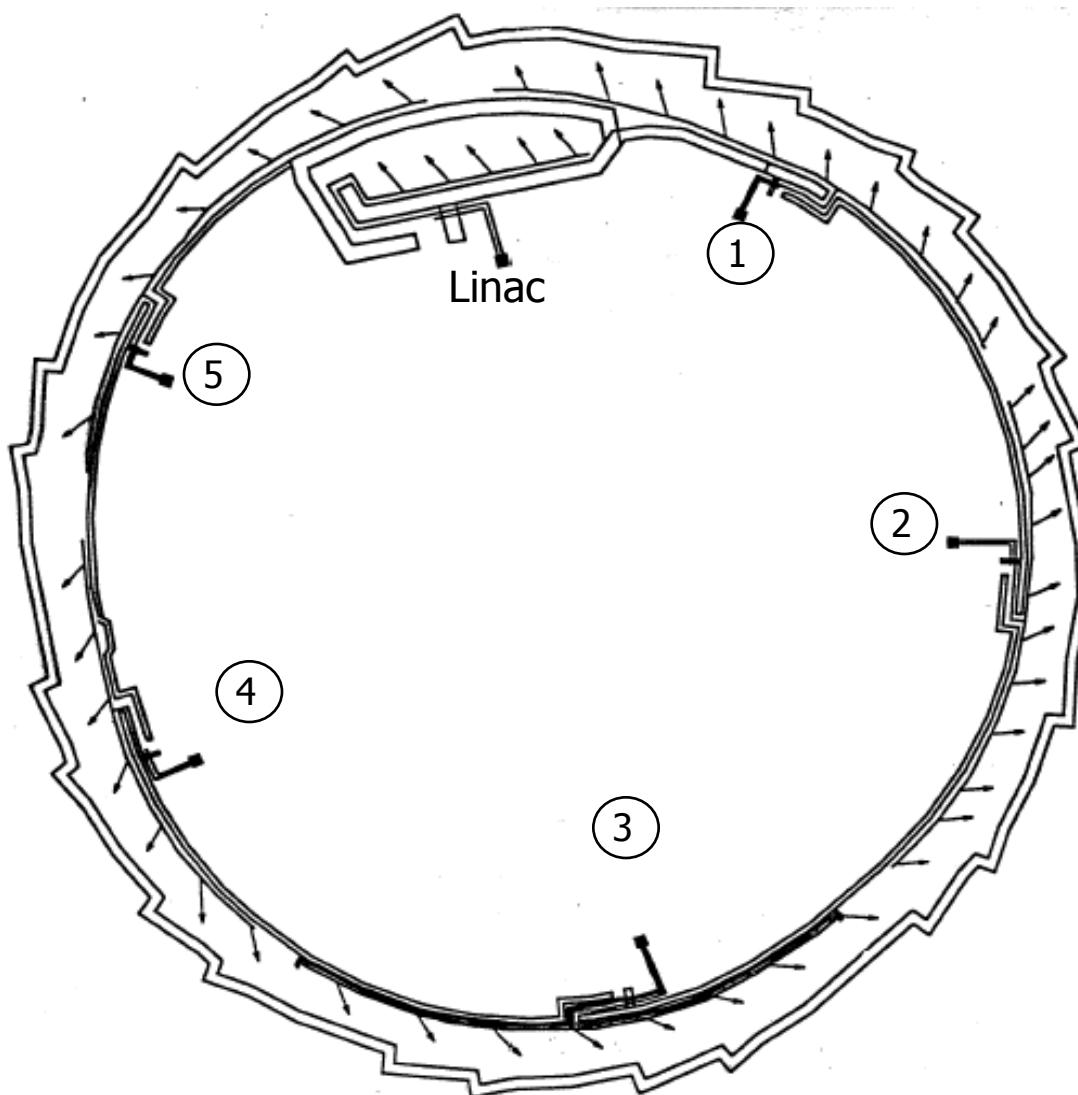
=> in Winter no need for heating even during „shutdown“!

Cooling of SLS

Summer (35°)

2'800 kW





Airconditioning in SLS Tunnel

Air Jets produce a helical
Air Flow

Tunnel ($3'100 \text{ m}^3$):

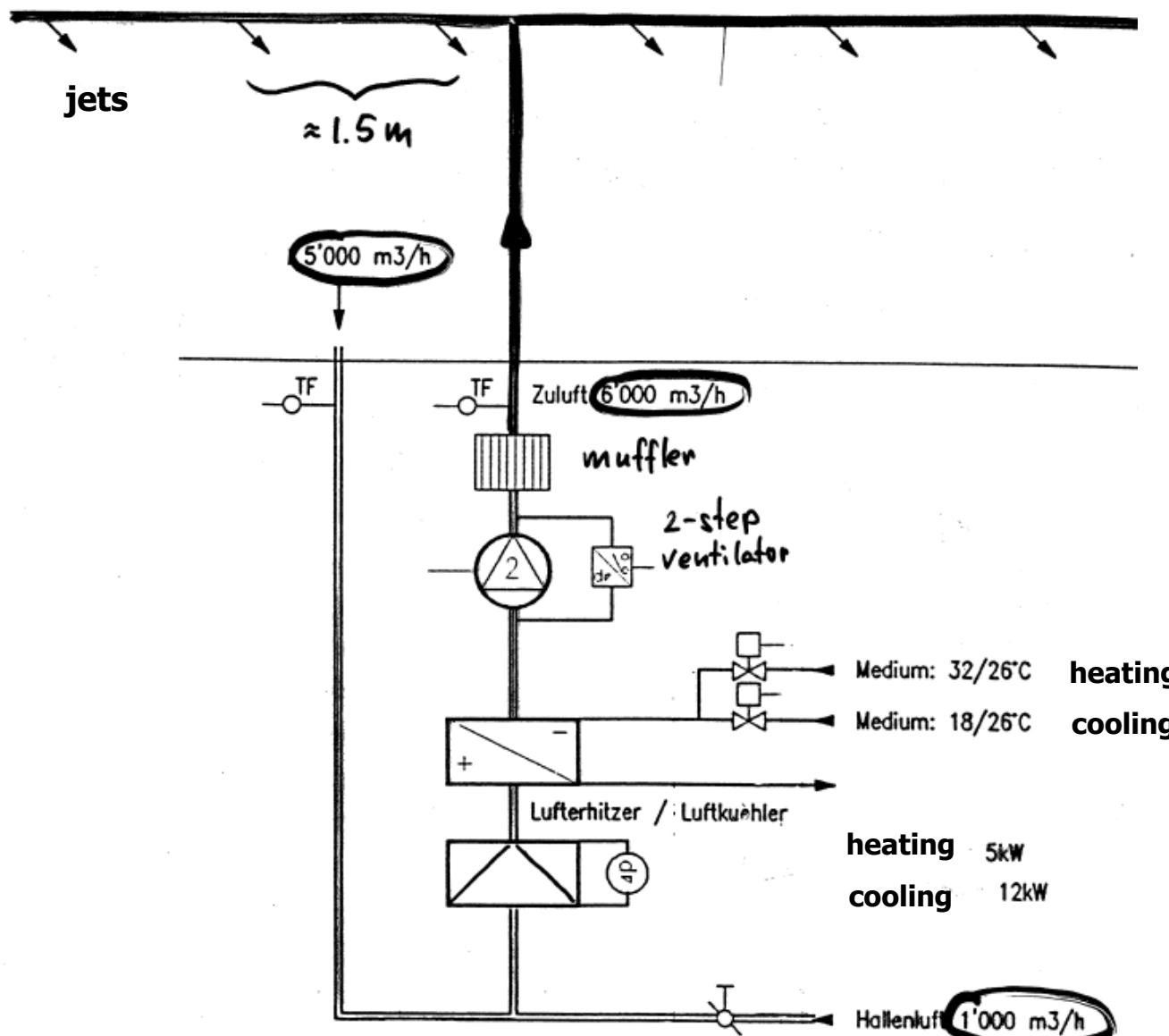
5 Cooling Units, 150 Jets

total: $30'000 \text{ m}^3/\text{h}$

40 kW Cooling, 90 kW Heating

$T=25^\circ \pm 0.03^\circ$

Linac: 1 Cooling Unit,
20 Jets

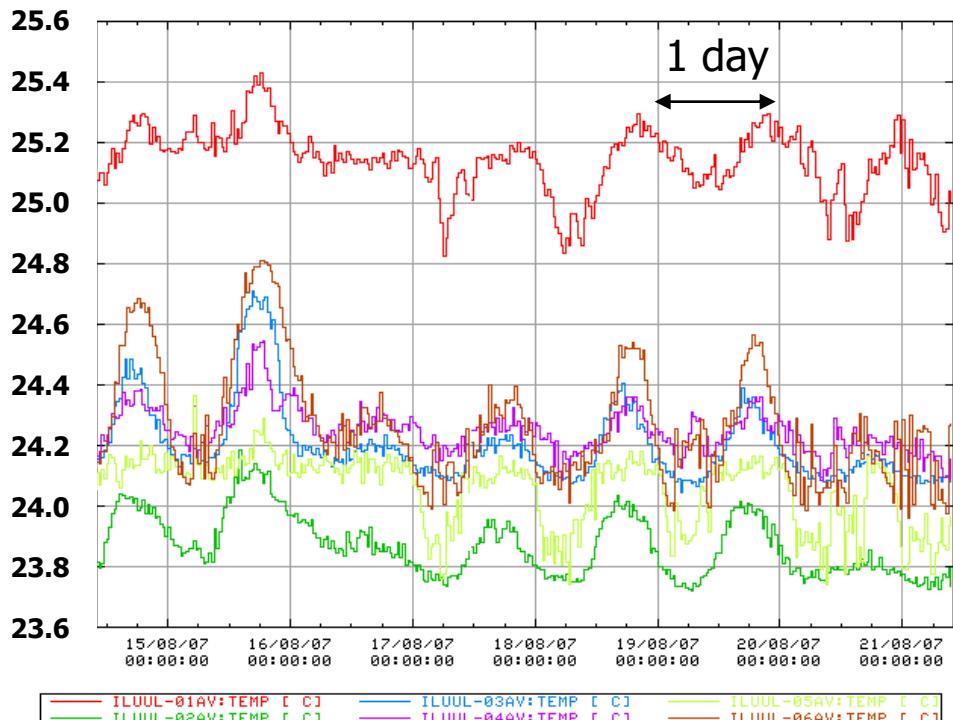


Airconditioning Tunnel

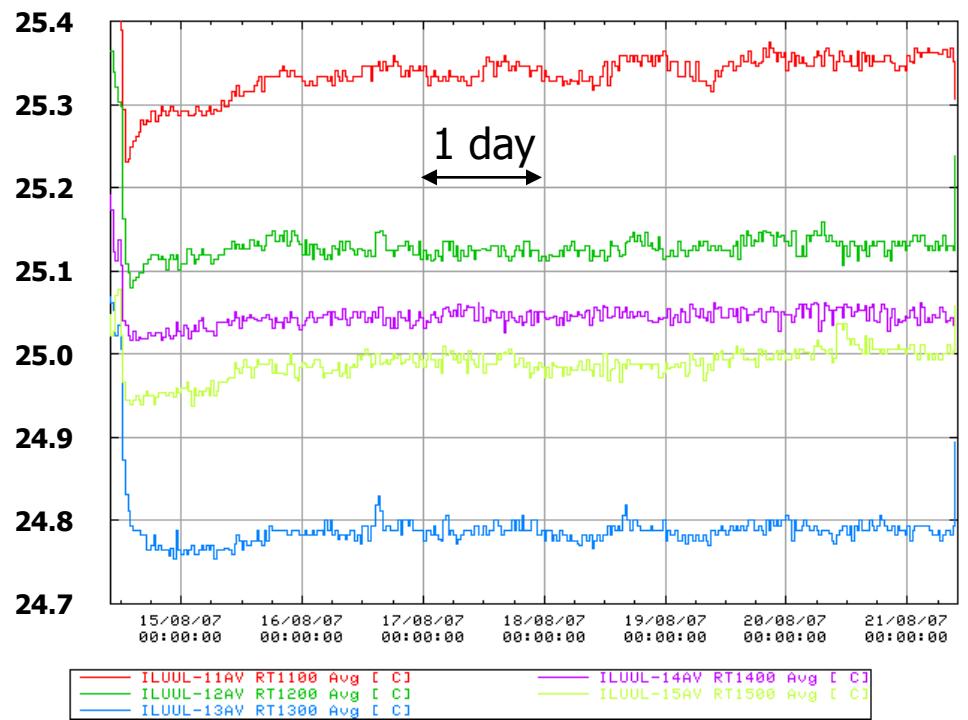
Temperature Stability Exp. Hall and Beam Tunnel

7 days in August 2007

Hall Temperature [$^{\circ}\text{C}$] of 6 Sectors



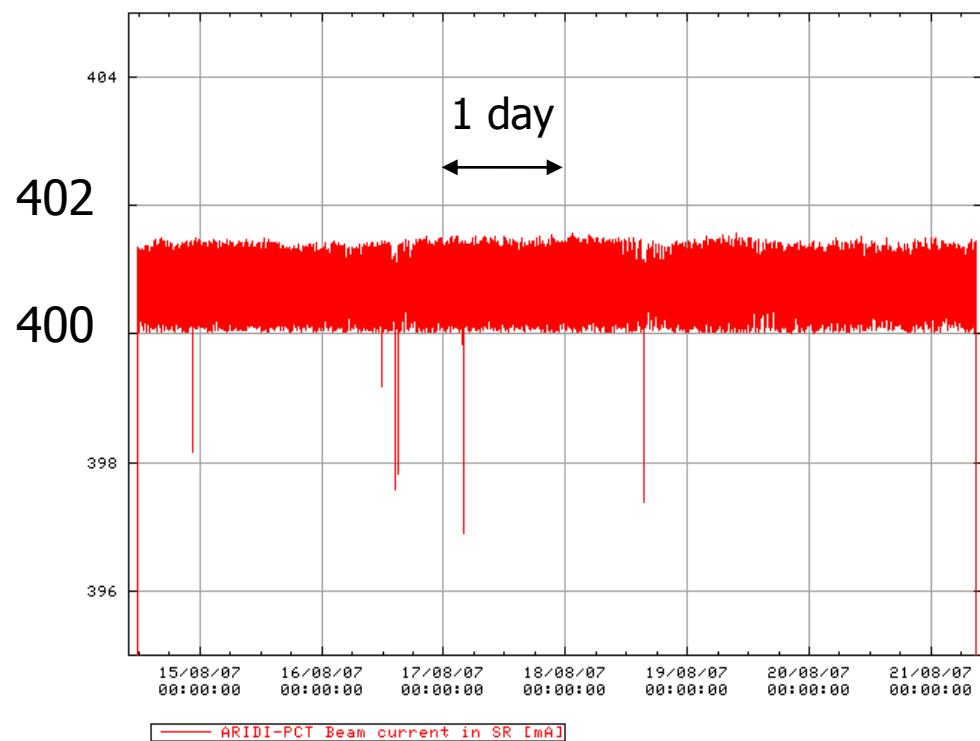
Tunnel Temperature [$^{\circ}\text{C}$] of 5 Sectors



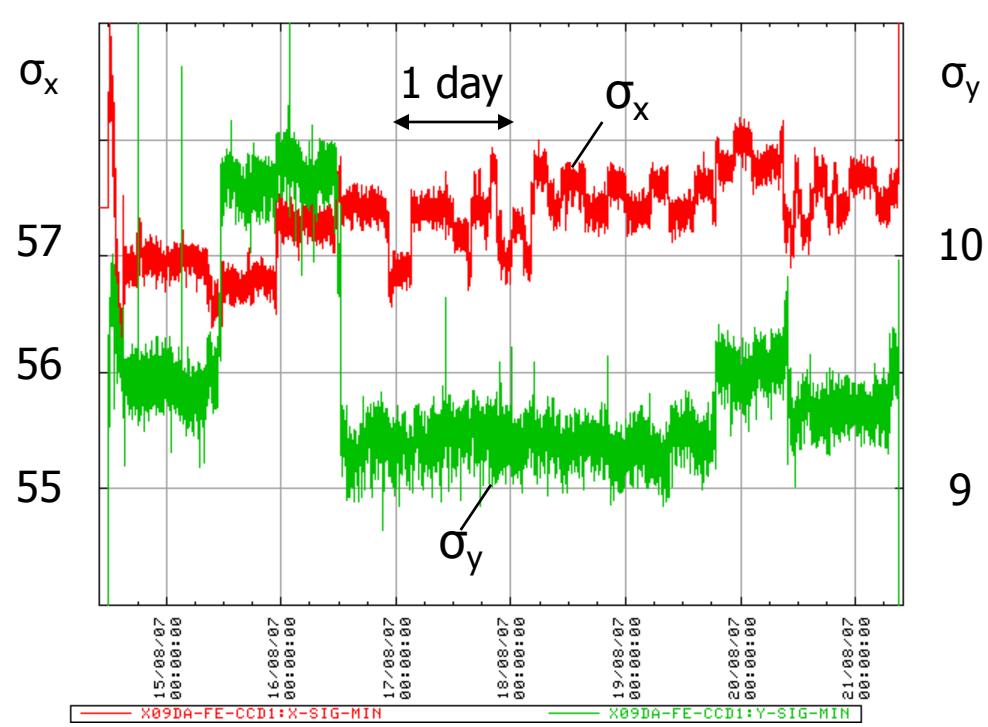
Beam Stability (top-up)

7 days in August 2007

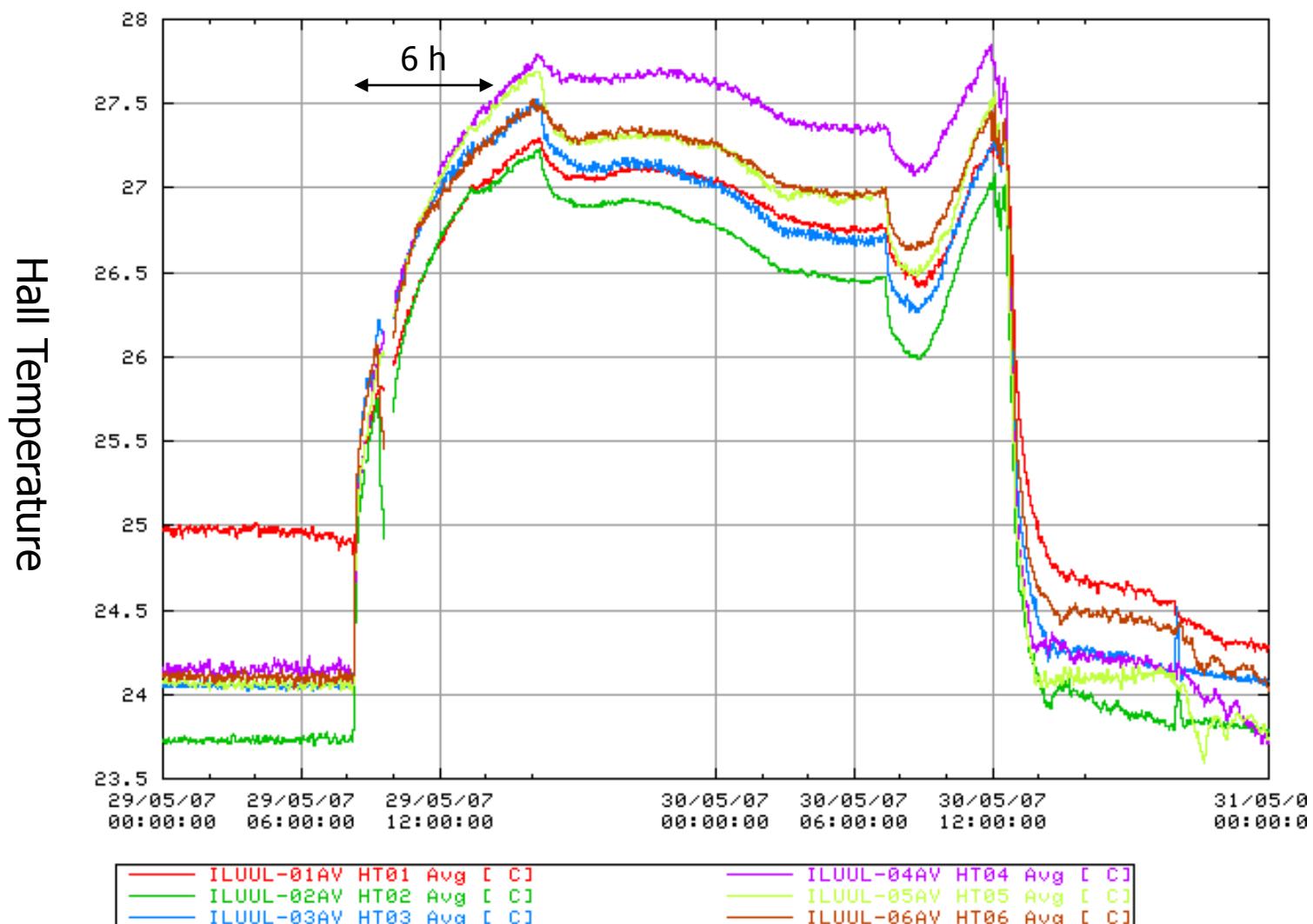
Beam current, top-up 400-401.5 mA



Beam size $\sigma_x \sigma_y$ [μm]



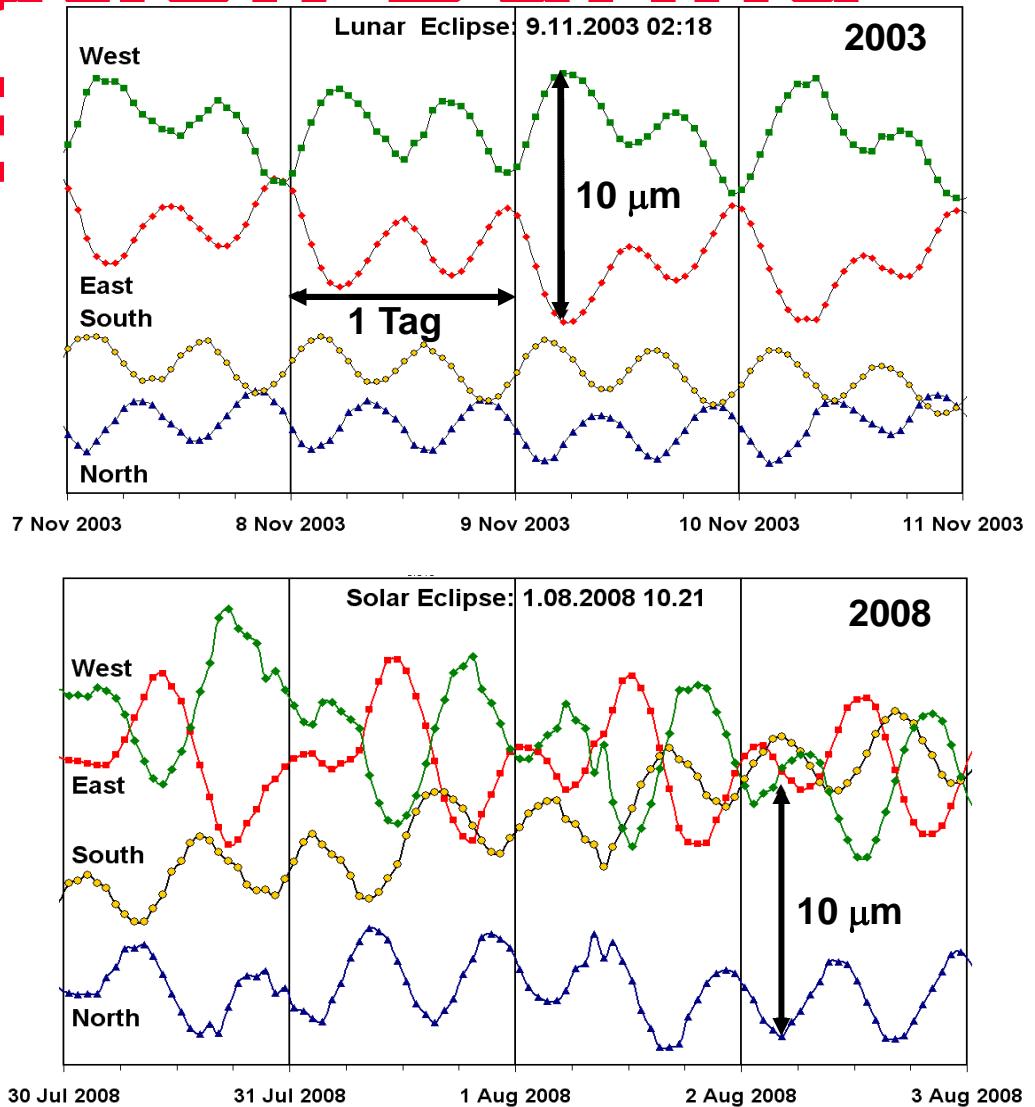
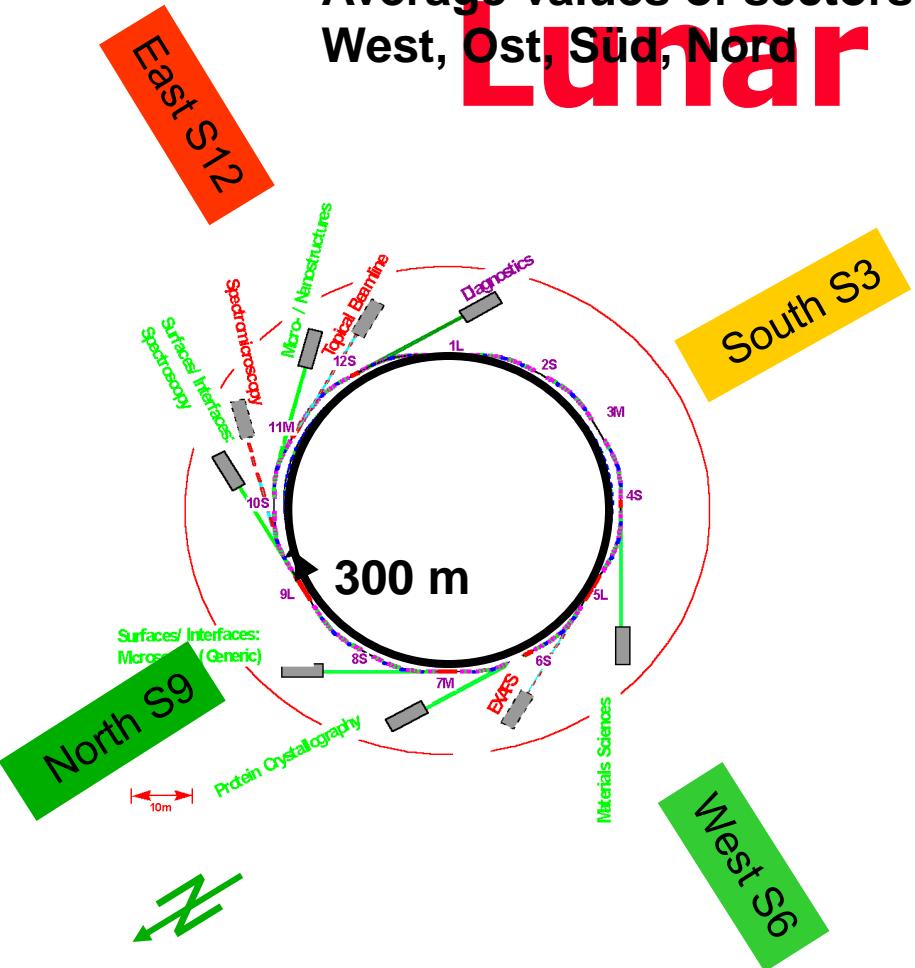
Temperature Exp. Hall during Revision of Pumps



SLS: Deformation During

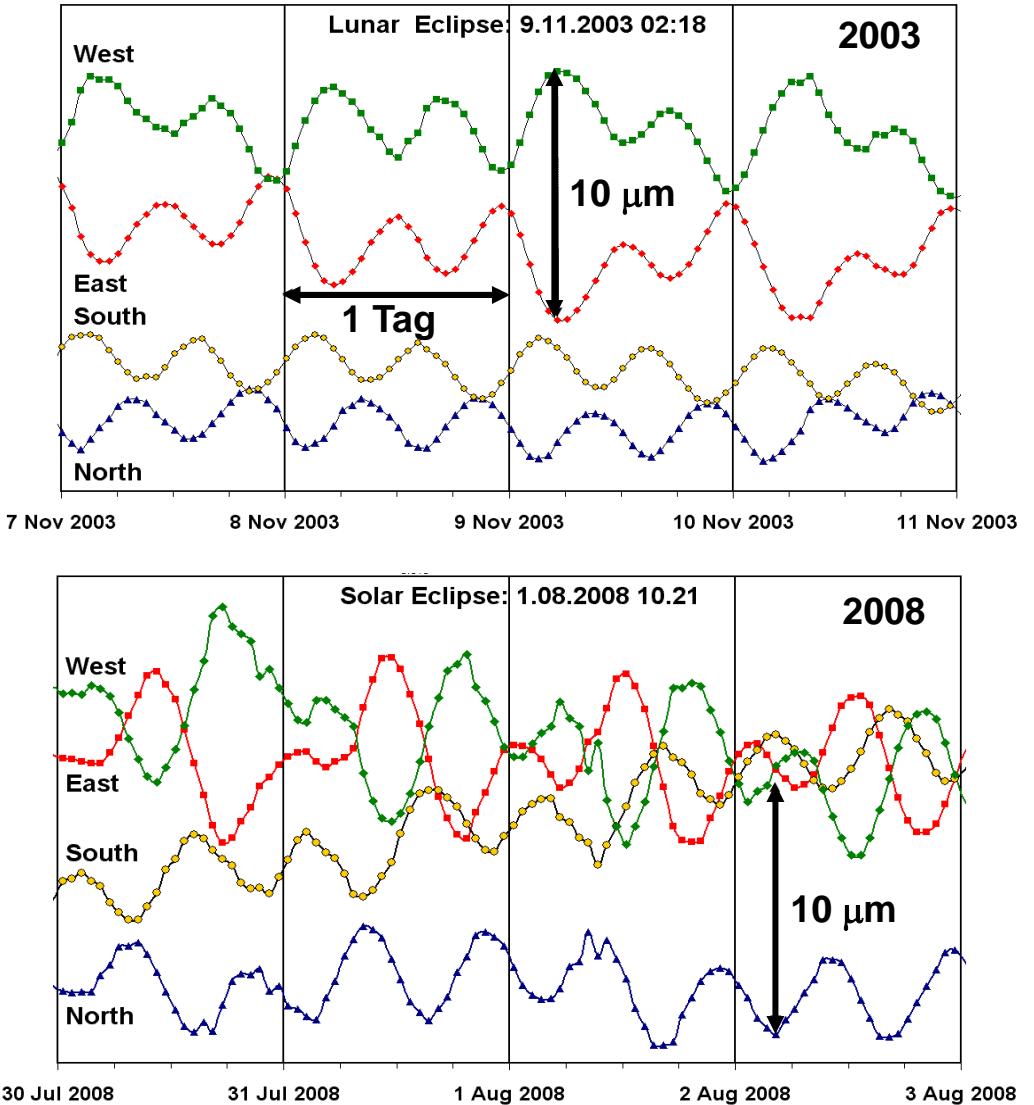
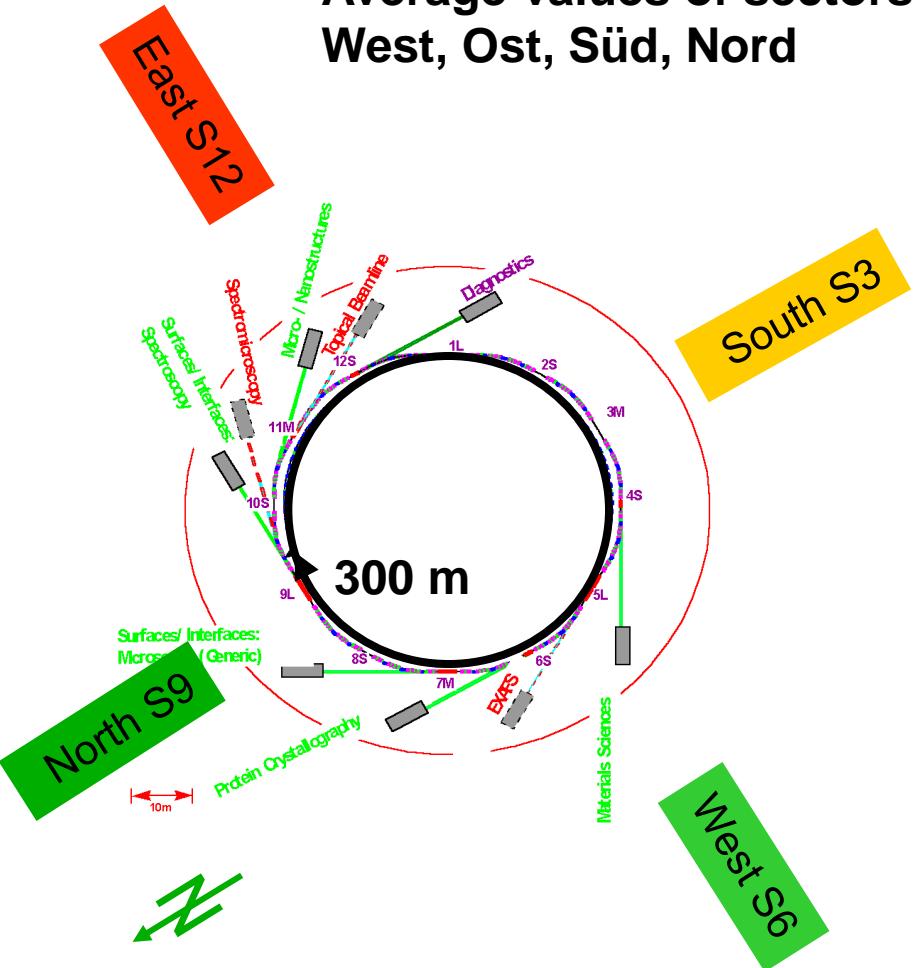
Lunar E

Average values of sectors
West, Ost, Süd, Nord

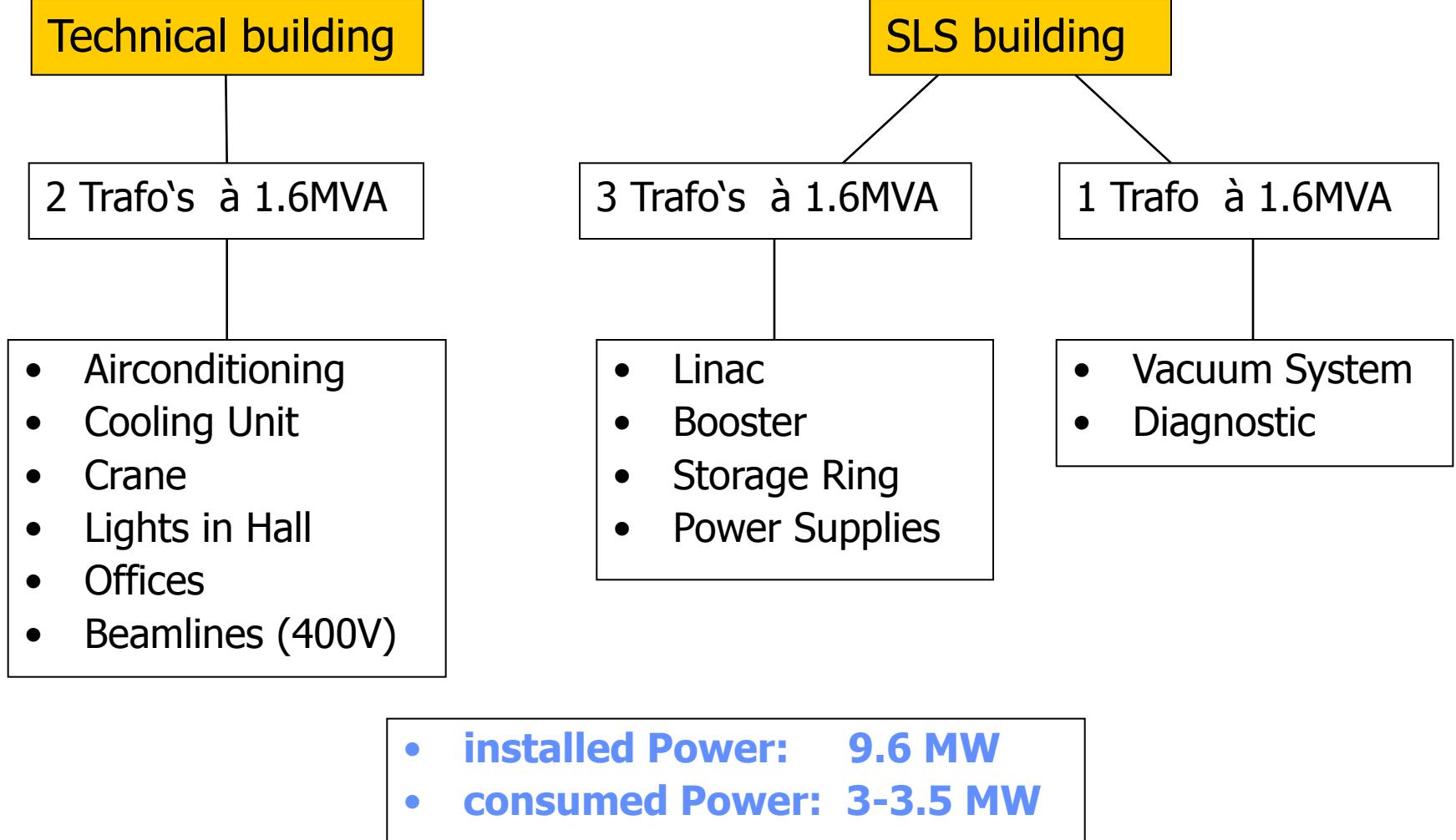


SLS: Deformation During Lunar Eclipse

Average values of sectors
West, Ost, Süd, Nord



SLS Electro Concept



Electro Installations for Tunnel

- all 174 quadrupoles and all 120 sextupolemagnets of the storage ring have individual powersupplies
- all powersupplies are placed in technical gallery
- access to tunnel through cabletrenches in floor
- powercables and diagnostic cables grouped together
- all control units outside tunnel (except pulsed magnets)

Electro Installations for Beam Lines

- 6 electro-stations at periphery of building
- distribution boxes (<63A) directly at each beamline hutch
- 8-15 km cable length for each beamline

SLS Users

Institutes

Industry

- ETH Zürich, ETH Lausanne
- Universities
(CH und abroad)
- PSI
- Research Labs
(IBM Rüschlikon, Max Planck Institute Munich,...)
- Novartis
- Hoffmann-LaRoche

Milestones

| | | | |
|--|---------------------|------------------------------|---------------------|
| First Ideas | 1991 | Start of Building: | 2.June 1998 |
| „Giessbach-Meeting“ (Users support SLS) | Oct. 1994 | Building finished: | 1.July 1999 |
| ETH-council approves SLS | Sept. 1995 | Beam from Linac: | 23.March 2000 |
| Parliament approves SLS | 18.June 1997 | Beam in Booster: | 11.July 2000 |
| | | Extracted Beam from Booster: | 8.Aug. 2000 |
| | | Beam in Storage Ring | 13.Dec. 2000 |
| | | goal of 400 mA reached | 5.June 2001 |
| | | => Begin Experiments: | 2.Aug. 2001 |

Budget SLS (1997)

Building + Land 38 MFr.

Infrastructure, Labs, Ringtunnel 25 MFr.

Storage Ring, Booster, Linac 68 MFr.

4 Beam Lines (2007: 8+3) 28 MFr.

Total Costs for SLS 159 MFr.

plus 400 man years

Thanks !