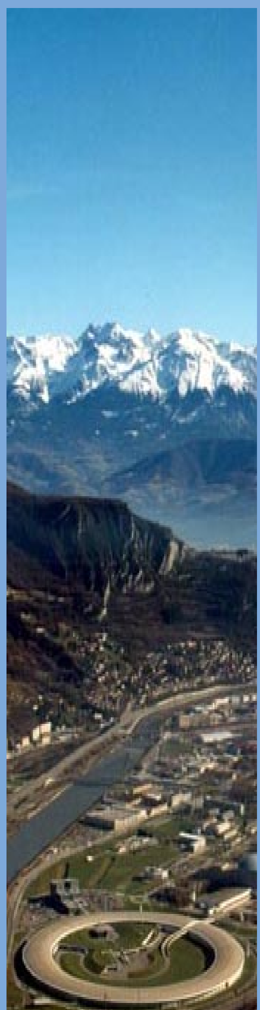
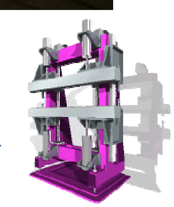
STATUS OF ESRF INSERTION DEVICES



1. **Installed IDs**
2. **Conventional IDs**
   - Vacuum chambers
   - Revolver undulators
   - Helical undulators
3. **In vacuum undulators**
   - Room temp. P.M IVUs
   - R&D cryogenic IVUs
4. **ESRF long term strategy**
   - ID straight section
   - Canted undulators



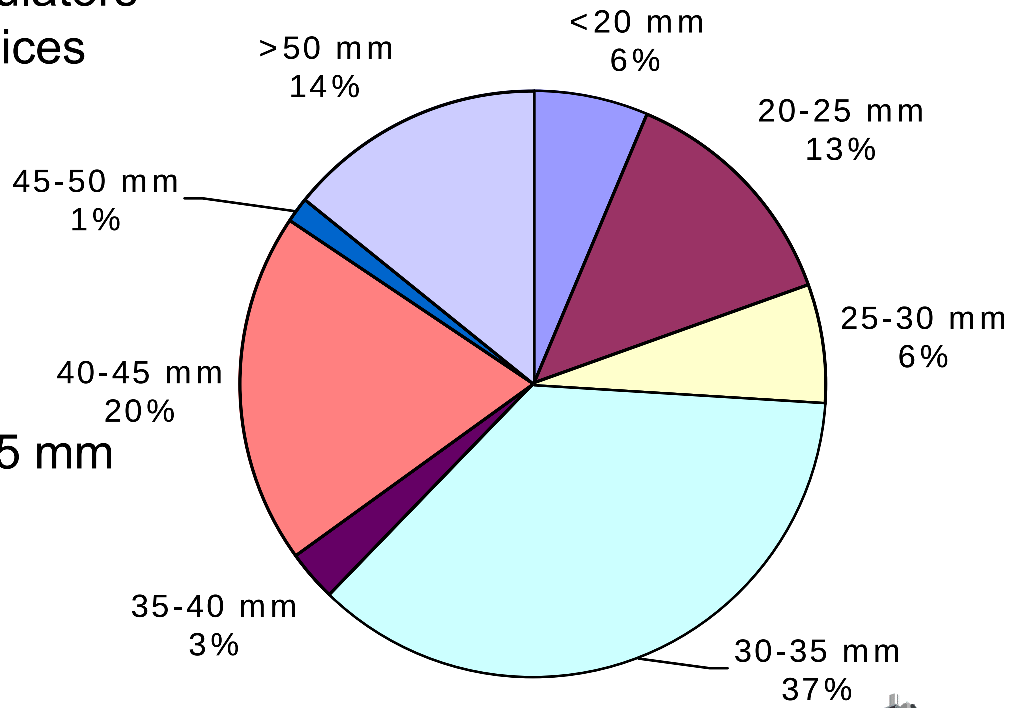
Installed Insertion Devices

November 2006: 73 devices in the storage ring

- 5 wigglers
- 6 helical undulators
- 62 undulators & in-vacuum undulators
- ~ 100% permanent magnet devices

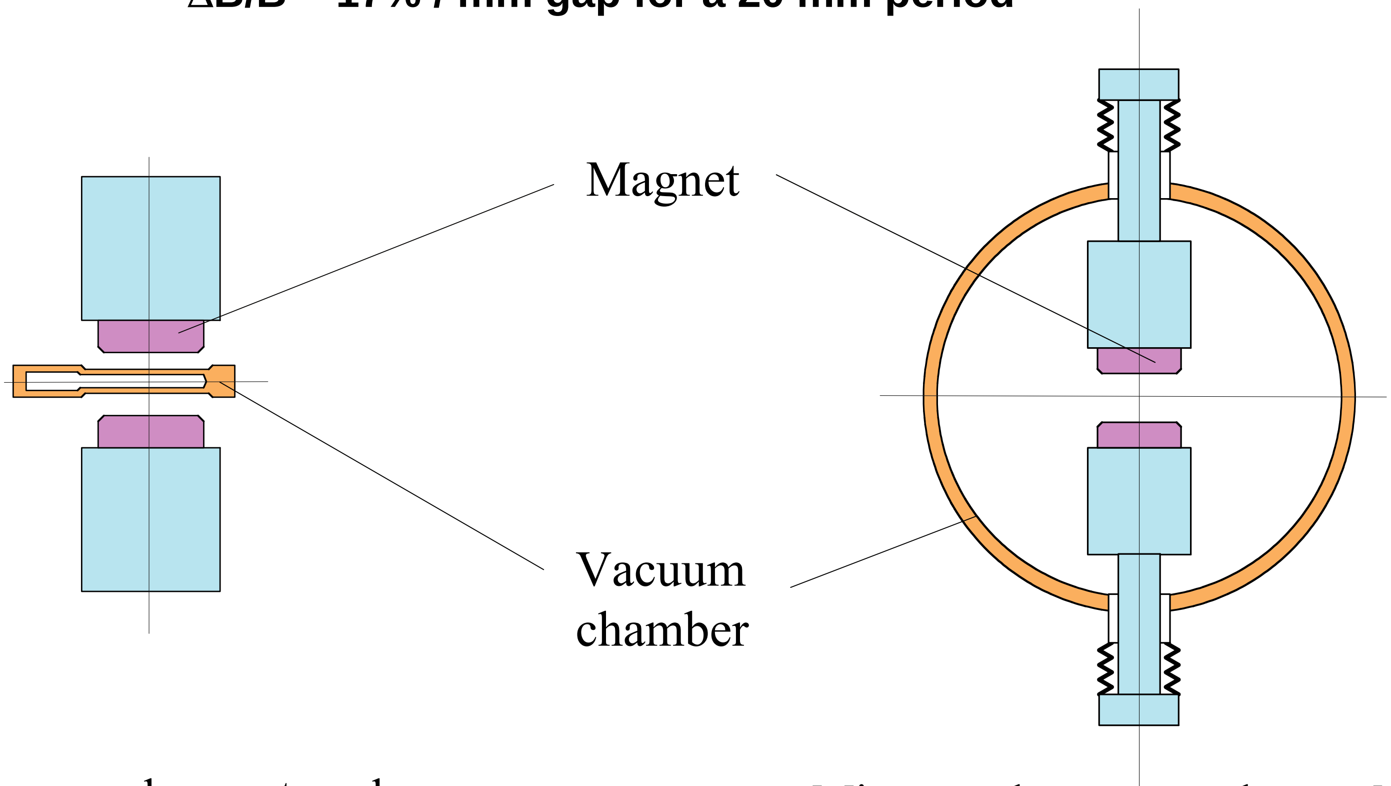
Major trend over the past years

- Gap & period reduction
- 62 % of devices with period ≤ 35 mm
    - Kmax < 2 (1- 1.5)



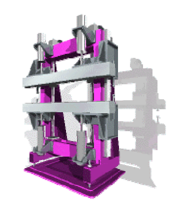
Permanent magnet undulators

ΔB/B ~ 17% / mm gap for a 20 mm period



Min gap = beam stay clear
+ Material thickness
+ alignment tolerances
≈ 10 mm

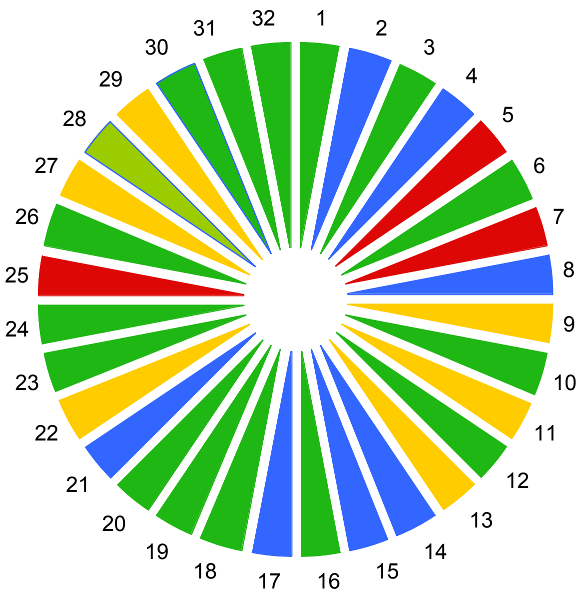
Min gap= beam stay clear + NiCu sheet
≈ 5 - 6 mm
Large International development
following success at Spring8



Conventional undulators

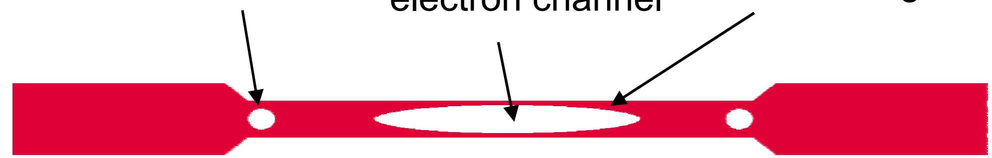
connected to the ongoing replacement of ID vacuum chambers

Gap 16 mm -> 11 mm



Present situation:

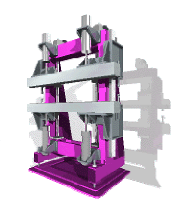
- 10mm Al NEG coated
- 10mm Stainless steel
- In-vacuum
- RF cavity
- Other



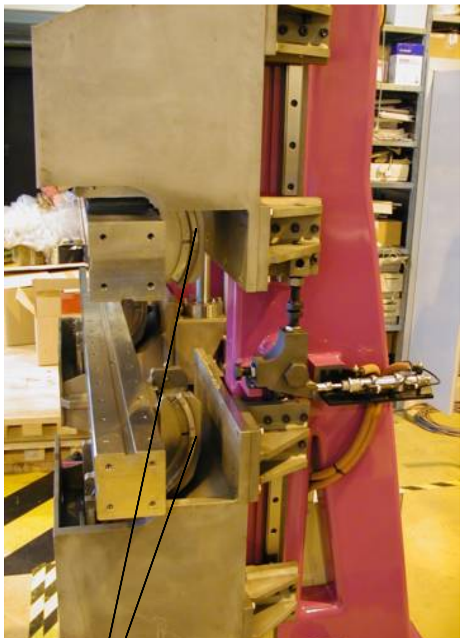
ESRF type Chamber

- •Cheap extruded Al profile
- •Int/ext gap = 8-10 mm , L=5 m
- •In house NEG Coating, Ti-Zr-V, 1 µm
- •Activation @ 200 °C.
- •R. Kersevan, EPAC 2002.
- •Low Photon Induced Desorption
- •Rapid Conditioning

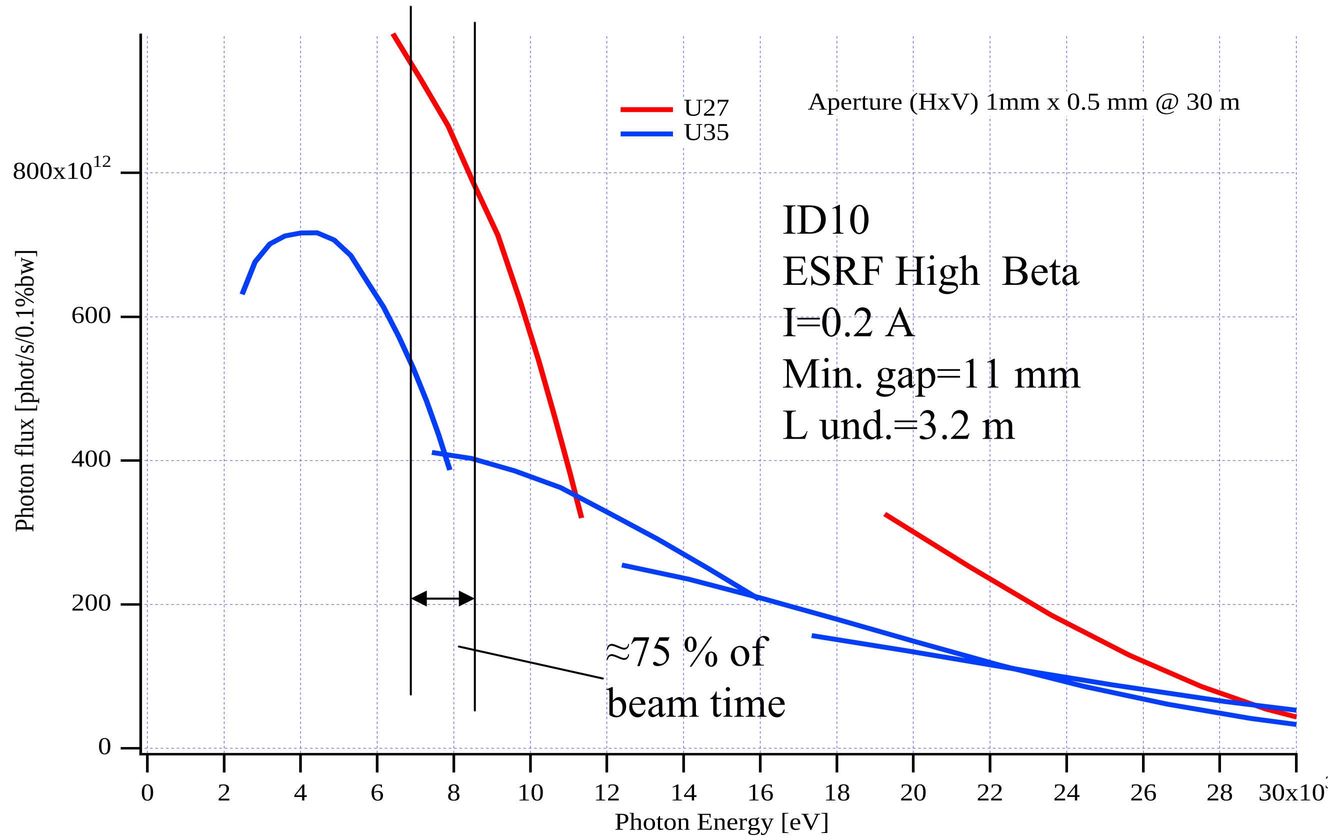
Applied at **ESRF**, ELETTRA, MAXLAB, SLS, SOLEIL (10 m) , DIAMOND,…



Revolving undulators



Circular motion

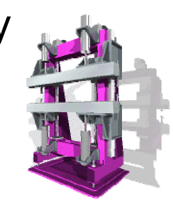


Typical Revolver Undulator :

- K=2.2, Continuously Tunable
  Period ~ 35 mm @ 11 mm

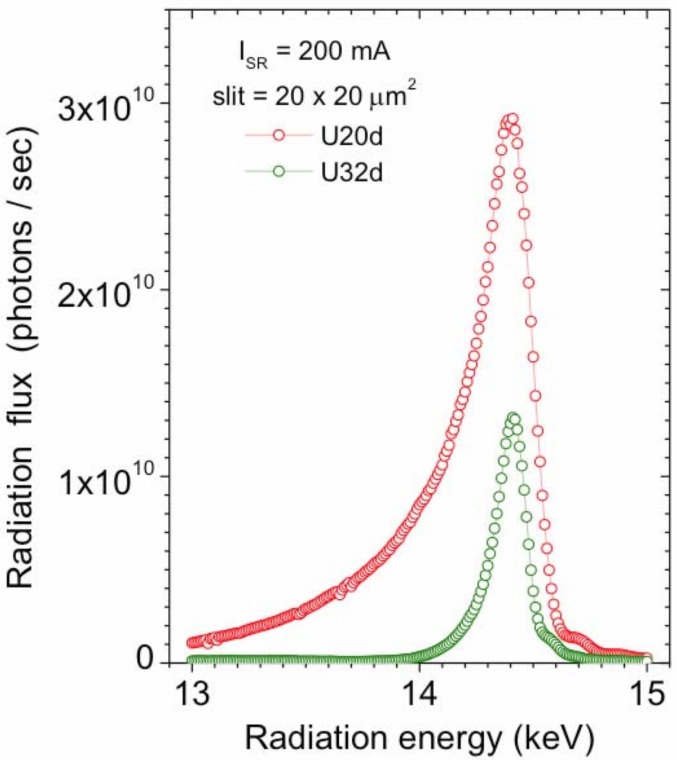
+

K=1-1.5 High Brilliance but limited tunability
Period ~ 18-27 mm @ 11 mm



Revolving undulators

Measured photon flux on ID18
(A. Chumakov, R. Rueffer)



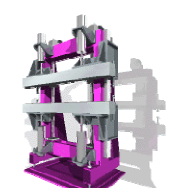
ID18 ESRF
20.02.2004.

2 different undulators on the same support:

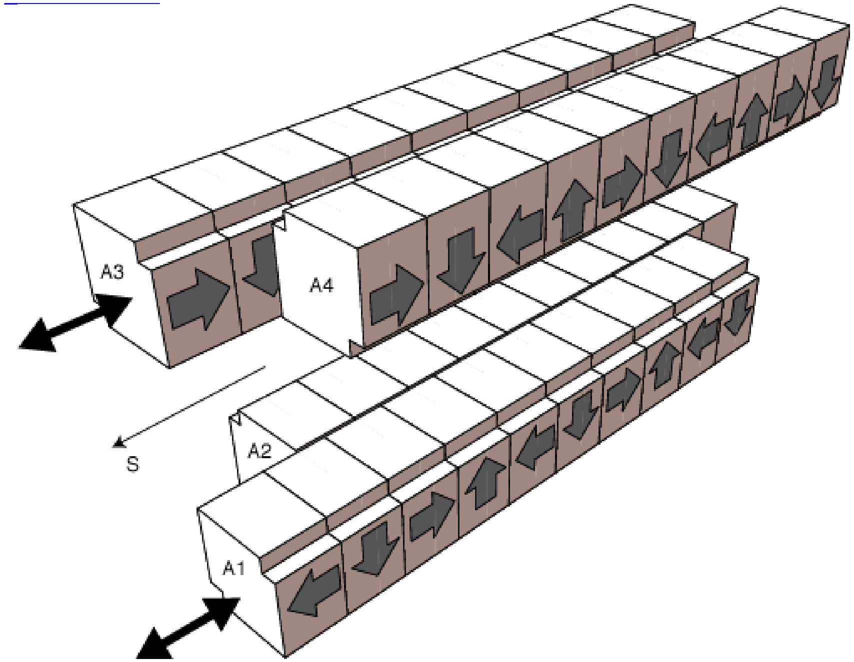
Key points:
-Length: 1.6 m
-Interchangeable with standard IDs
-Compatible with all vacuum chambers

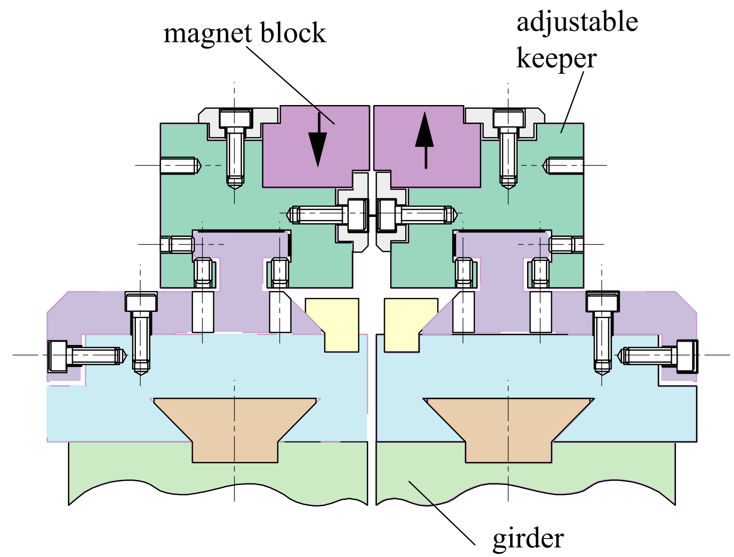
4 devices installed
4 devices in construction

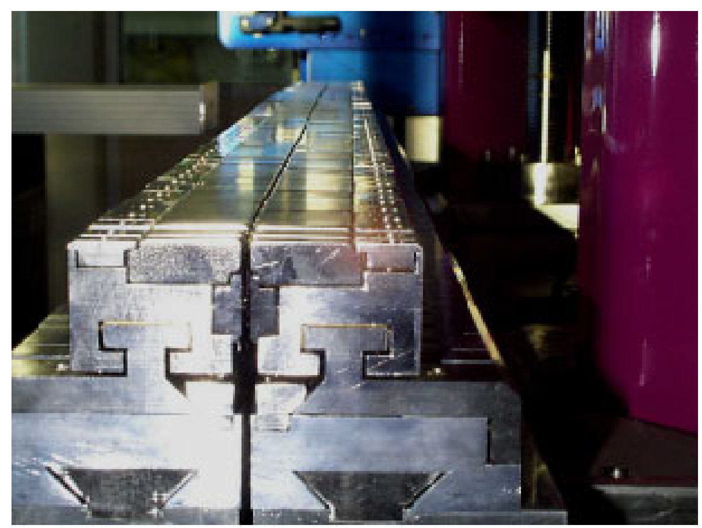
Switching time between the 2 undulators ~ 1 mn



Circular Polarization: APPLE II undulators







Why so popular ? :
- High linear/helical magnetic field
- Generating any polarization (linear,elliptical,..)

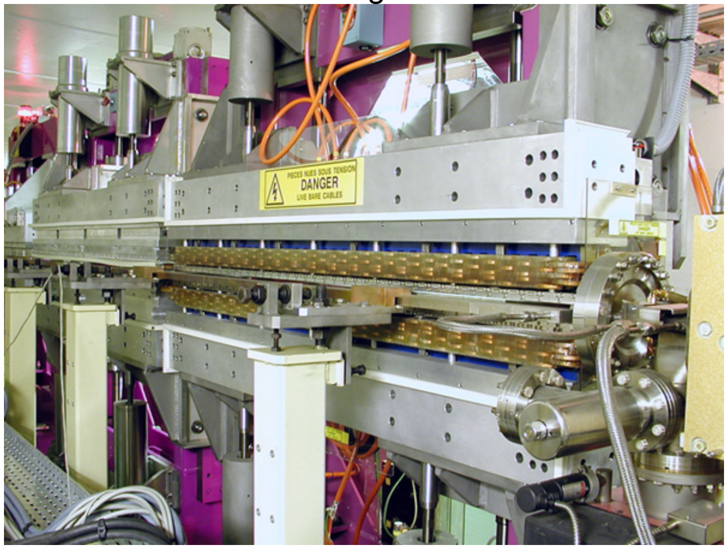
Several Devices in the last years
- Maxlab, Soleil, Diamond,…

Variable polarization at ESRF

ESRF

2 dedicated beamlines

ID12 straight section

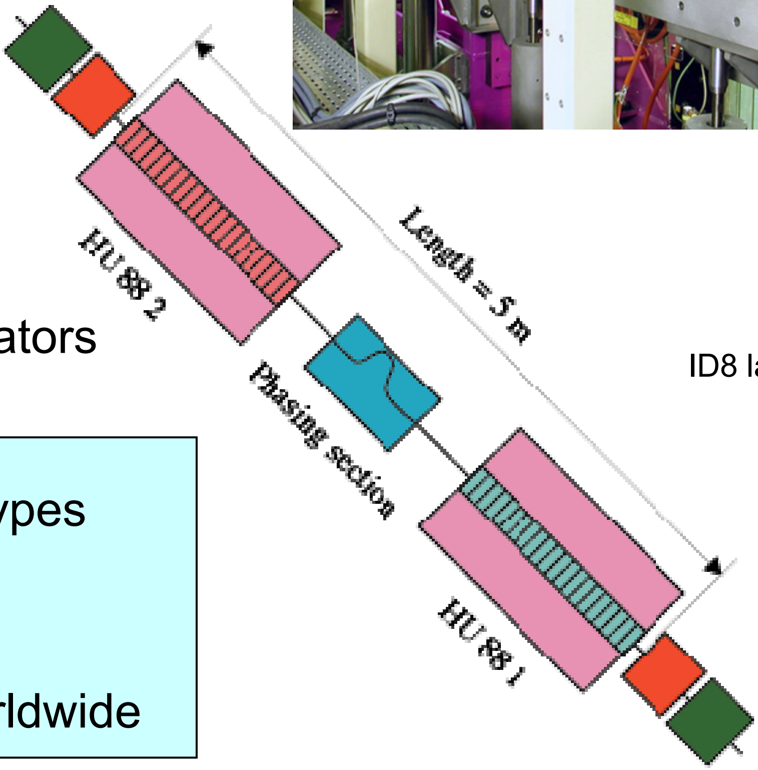


ID12 (2-10 keV) 3 segments of 1.6 m

- ESRF helios type (HU52)
- APPLE II HU38
- Electromagnet/permanent magnet device (HU80)
  - 2 Hz, switching time 150 ms

ID8 (0.3-2 keV) 2 segments of 1.6 m

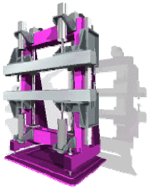
. 2 Apple II (HU88)
. Phasing section between undulators



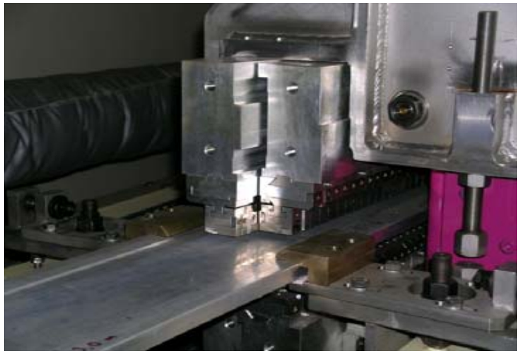
ID8 layout

APPLE II + Electromagnet types

>90 % of helical devices
recently constructed worldwide



Experience with helical IDs at ESRF



APPLE II undulators

Machine & ID side:

- complicated field shimming but workable
- tune shift vs phase as predicted -> corrected with “L” shims
- Some effects on vertical emittance (non reproducible)

Beamline side:

- Transient heat load at zero phase when switching between left and right circular polarization is problematic (ID12) ---> New Helios device under design
- APPLE II Ok in ID8, but still photon flux limited

Electromagnet/permanent magnet device:

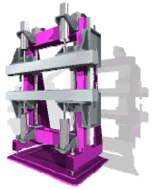
Machine & ID side:

stable and transparent until replacement of vacuum chamber

- Stainless steel -> aluminium (higher consductivity)
- New correction scheme --> ok since then

Beamline side:

- Left & right x-ray spectra exactly the same
- Very low level circular dichroism (1.0e-4)
- higher photon flux would be welcome



In -Vacuum undulators

High photon energy: > 40 keV at ESRF

ID11, ID15,ID27 high energy beamlines

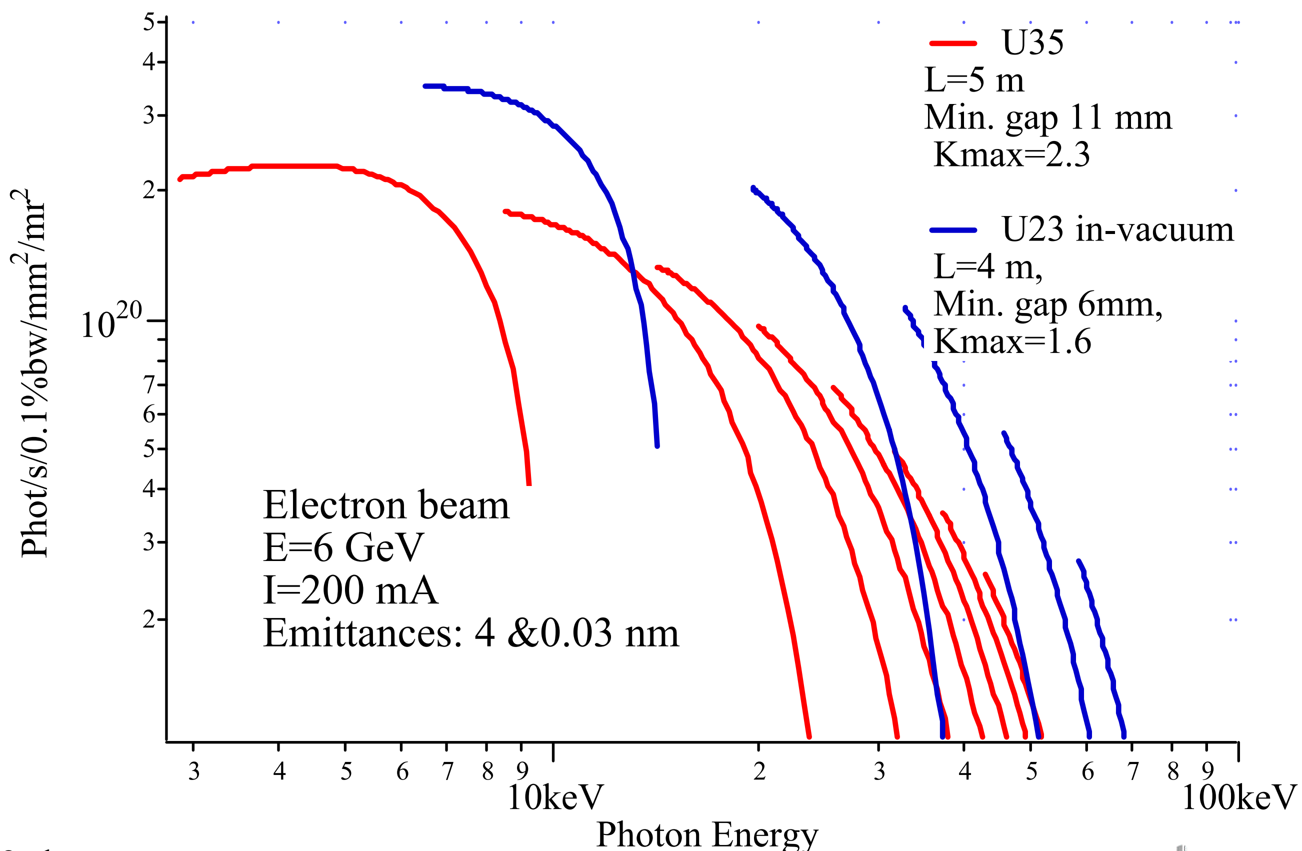
Initially covered with wigglers (W70,W125,W150)

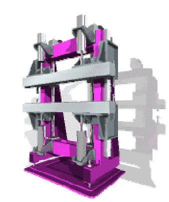
Conventional "in air" undulators not well adapted

- min. gap 11 mm
- use harmonics ≥9

Reduce gap with in-vacuum Undulator technology

- use harmonics ≥3
- K≥ 1.5 (U23 @ gap 6 mm)
- small residual phase error <3 deg



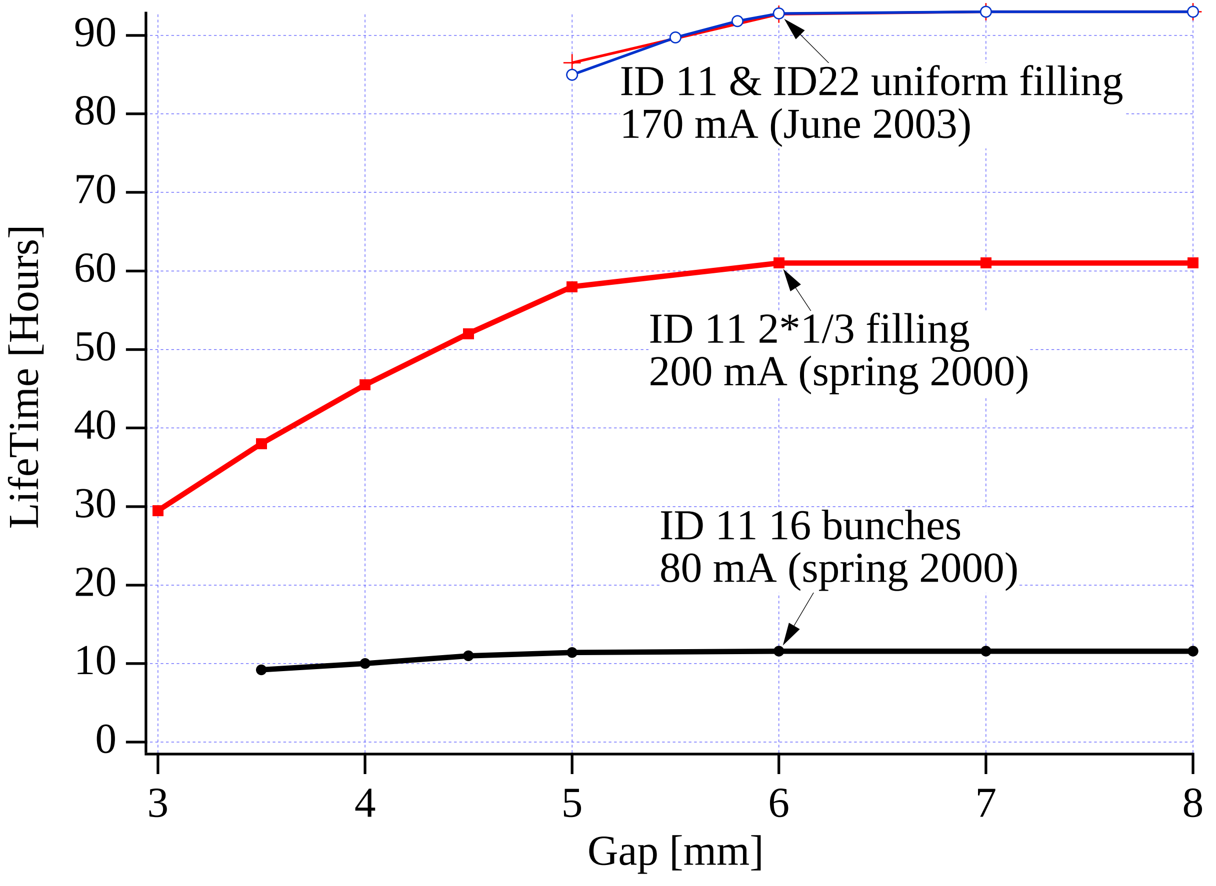


Minimum gap for IVUs

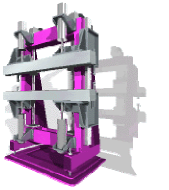
1 : Beam lifetime versus gap

ID11:
λ0= 23 mm
L=1.6 m
(hybrid)

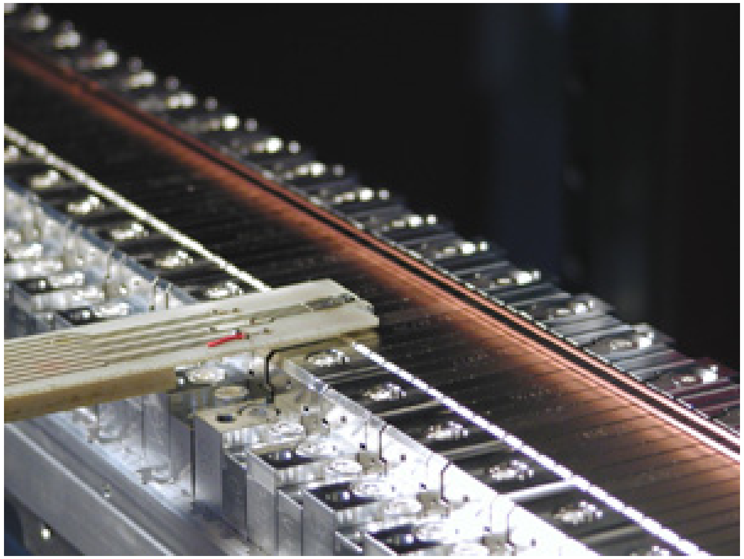
ID22:
λ0= 23 mm
L=2 m
(p.p.m)



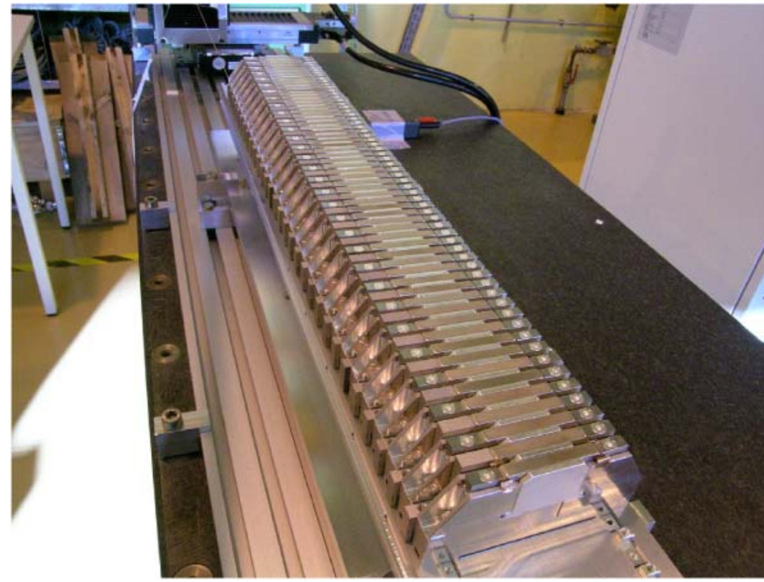
-> minimum gap 6 mm for ESRF IVUs



Magnetic structures



Pure Permanent magnet

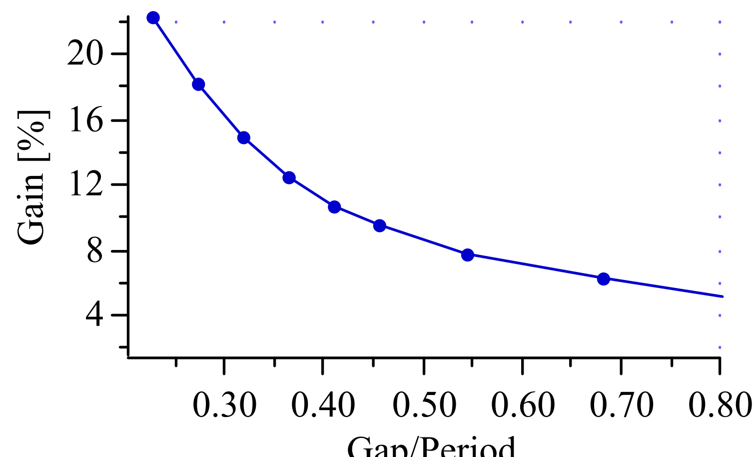


Hybrid

Higher field with hybrid structure:

≈ 20 % (U22 @ gap 6 mm)

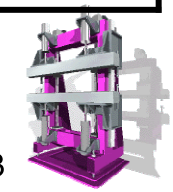
But more complicated field correction



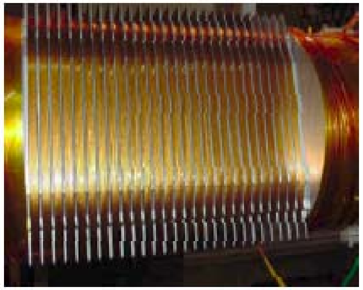
Status of In-vacuum undulators

ID	Period [mm]	Type	Peak field @ 6 mm [T]	p.m material	Rms Phase Error [deg] @ 6 mm	Installation date
ID11u	23	Hybrid	0.96	Sm_2Co_{17}	?	Jan 99
ID22d	23	PPM	0.76	Sm_2Co_{17}	1.9	July 01
ID9d	17	PPM	0.57	Sm_2Co_{17}	< 5	July 01
ID29d	21	PPM	0.7	Sm_2Co_{17}	2.3	Dec 02
ID13d	18	PPM	0.6	Sm_2Co_{17}	<5	July 02
ID11d	22	Hybrid	0.93	Sm_2Co_{17}	< 2.5	Dec 2003
ID27u	23	PPM	0.76	Sm_2Co_{17}	2.1	Dec 2003
ID27d	23	PPM	0.76	Sm_2Co_{17}	< 2	Dec 2003
ID9u	20	Hybrid	0.92	NdFeB	<3.5	Jul 2006
ID15u	22	Hybrid	0.93	Sm_2Co_{17}		Jul 2007

Nominal length: 2m



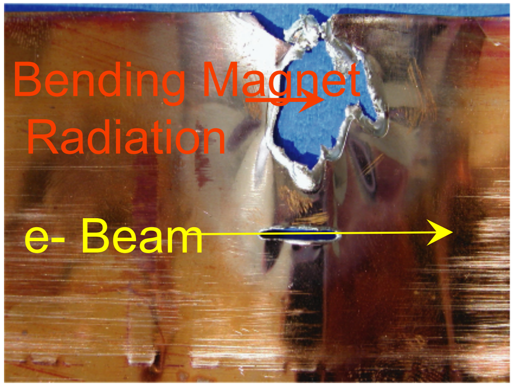
Cryogenic IVUs (R&D)



Superconducting devices:

- •New attractive SCU concept proposed at ANKA (Rossmanith et al.)
  - •10 period prototype build by ACCEL
  - •Dry cooling based on cryocooler
- •Workshop on superconducting IDs at ESRF (2003)
  - •Worldwide interest
- •January 2004, contract between ACCEL and ESRF
  - •SCU, period 15 mm, Lmag=1.35 m, K=1.5, NbTi conductor
- •January 2005, project cancelled at end of design phase
  - •Too high risk of damaging an insulated Cu foil in case of large vertical mis-steering of e- beam

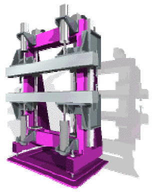
Experience with a CuNi sheet locally not in thermal contact with permanent magnet assembly



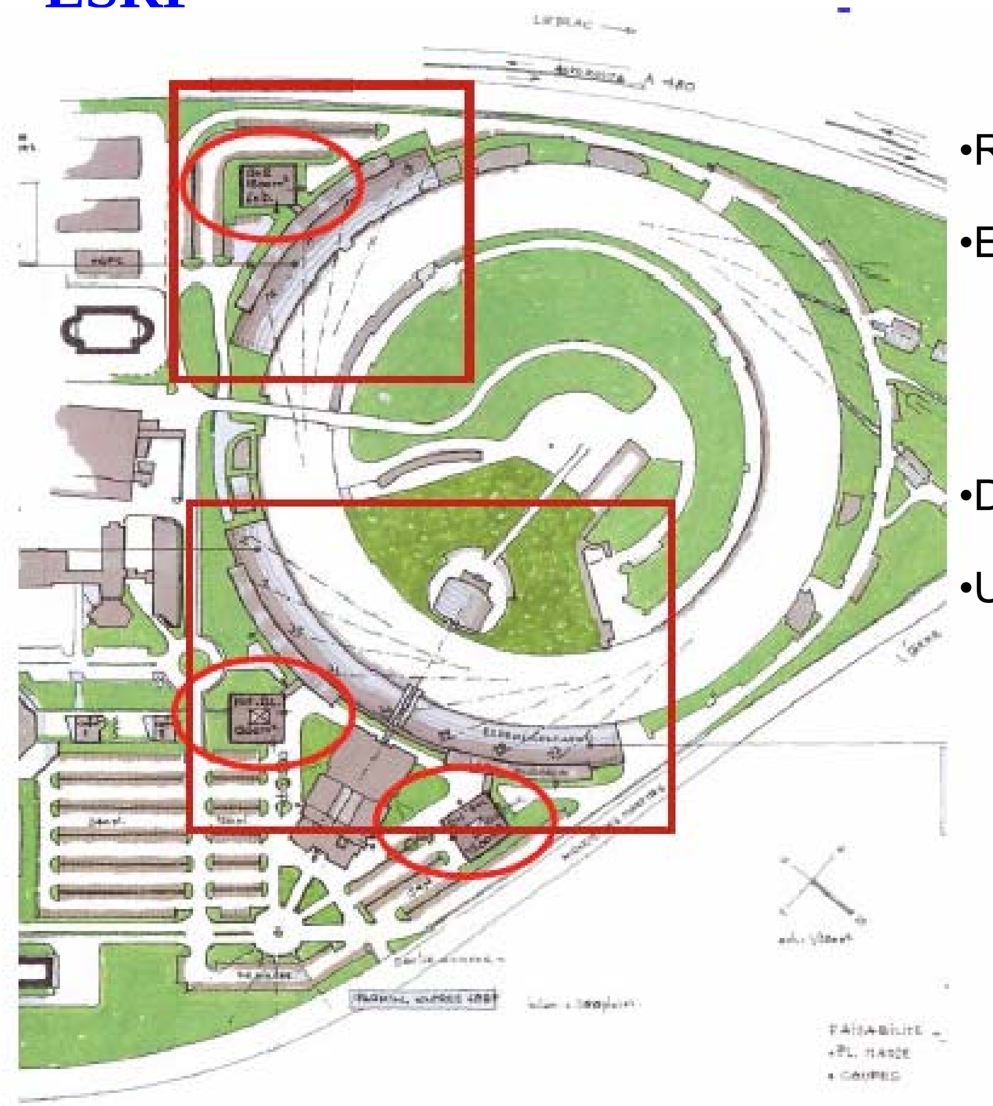
Damaged Cu-Ni sheet on ID9 p.m IVU

Cryogenic permanent magnet IVUs:

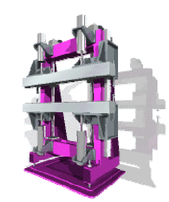
- R&D is going on
- more details in tomorrow's talk



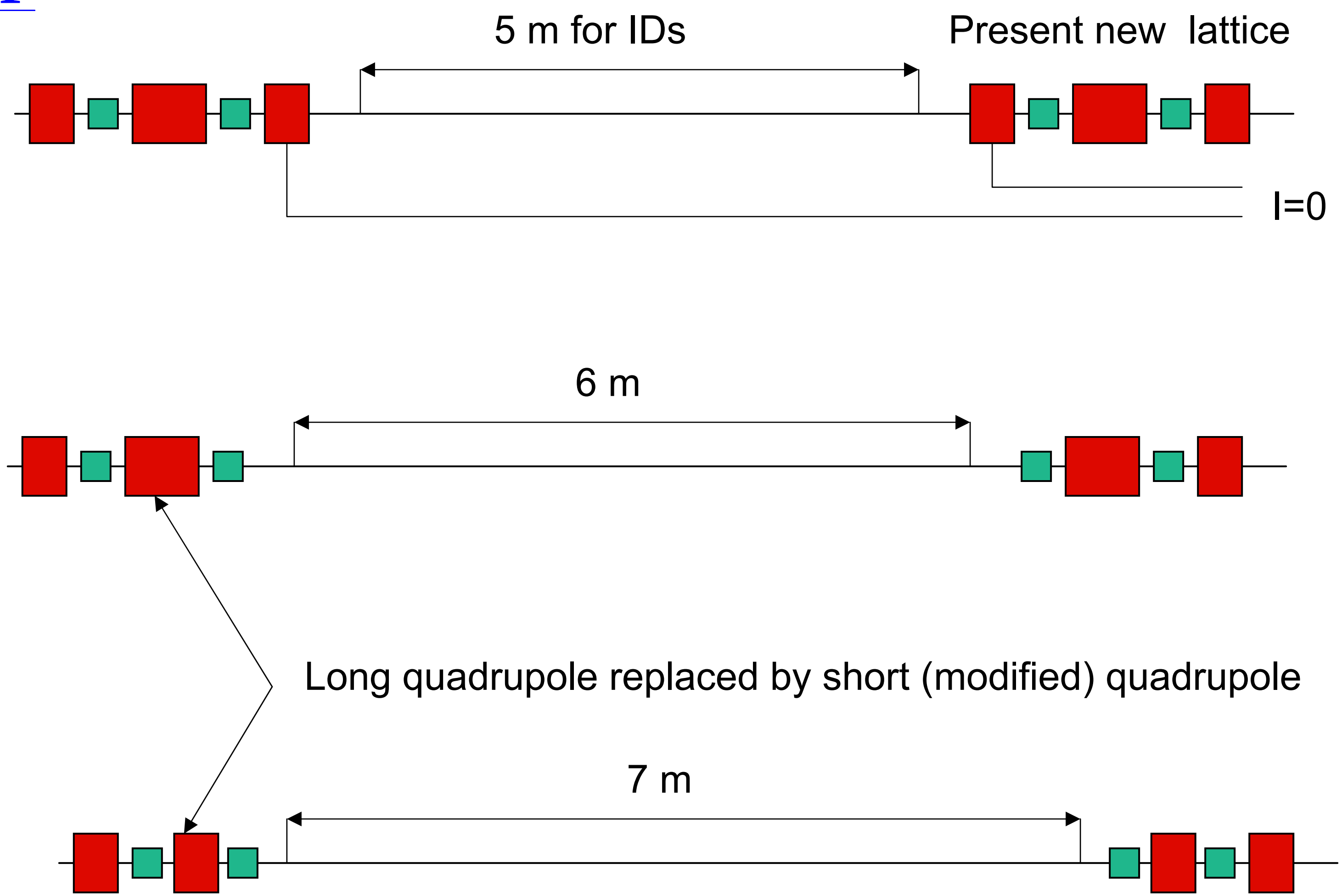
Long Term Strategy (LTS)



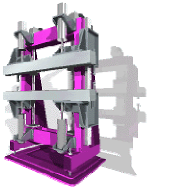
- Reconstruction of ~ 1/3 of beamlines
- Extension of ~ 1/3 of Experimental Hall
  - 120 m long beamlines for nano-meter and nano-radian beams
- Development of new SR instrumentation
- Upgrade of accelerator complex
  - Higher beam current ≥ 300 mA
  - Longer ID straight
  - Canted undulator capacity (more beamlines)



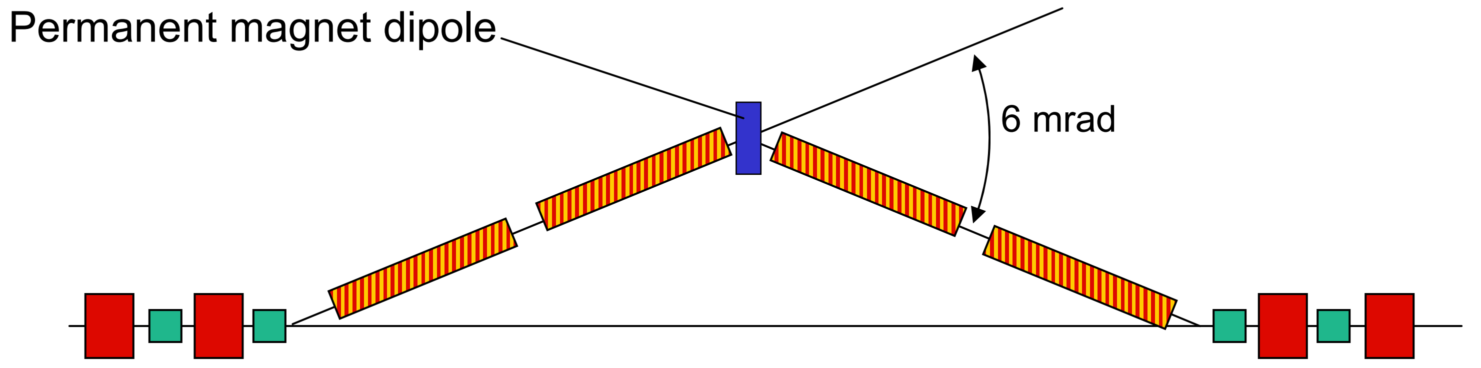
ID straight sections in LTS



Feasible for high beta straights but will need new short quads for low beta straights



Canted undulators



An option for the ESRF beamlines

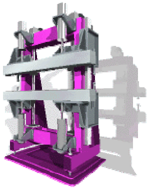
- included in the machine upgrade study
- More beamlines
- ~ 11 beamlines concerned (1st round)

Entry & exit angle (+3 mrad)

- quadrupole with hor. offset
- steerer integrated in sextupole

Permanent magnet dipole (-6 mrad)

- iron free device under design
- minimum longitudinal size



Concluding remarks

In air devices conventional IDs

- Refurbishment almost completed (2 ID straights remaining)
- Existing designs fit well the 7 m ID straights foreseen in LTS
  - 3 segments in 5 m -> 4 segments in 7 m (2x2 in canted option)
- growing demand for revolver type devices

In vacuum undulators:

- The installed devices operate with excellent reliability
- The existing design (2m long) is not well adapted for 7 m ID straights (LTS)
  - -new design(s) will be required
- R&D presently focuses on CPMU

Helical undulators:

- New devices will be needed within LTS
  - ID12 will be completely revisited
  - Additional devices for ID8