PHANGS workshop, Elettra, Trieste, Italy, 4-5 December 2017

The Photon Sources for The ESRF-EBS

Joel Chavanne, Gael Le Bec
European Synchrotron Radiation Facility

ESRF | The European Synchrotron

OUTLINE

ESRF-EBS

Insertion Devices in EBS context

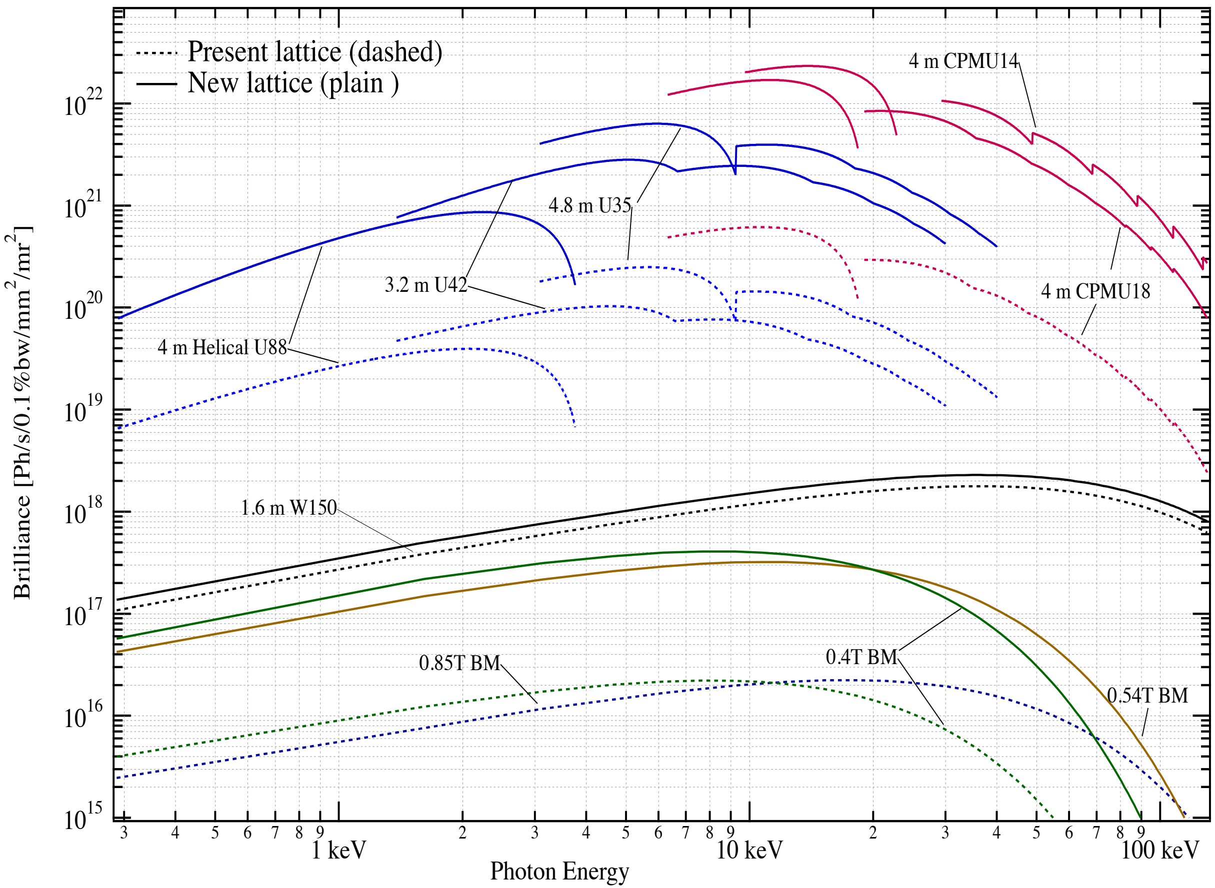
- Migration & adaptation
- Minimum ID gap
- IDs schemes

Bending Magnet beamlines

Summary

* EBS: Extremely Brilliant Source

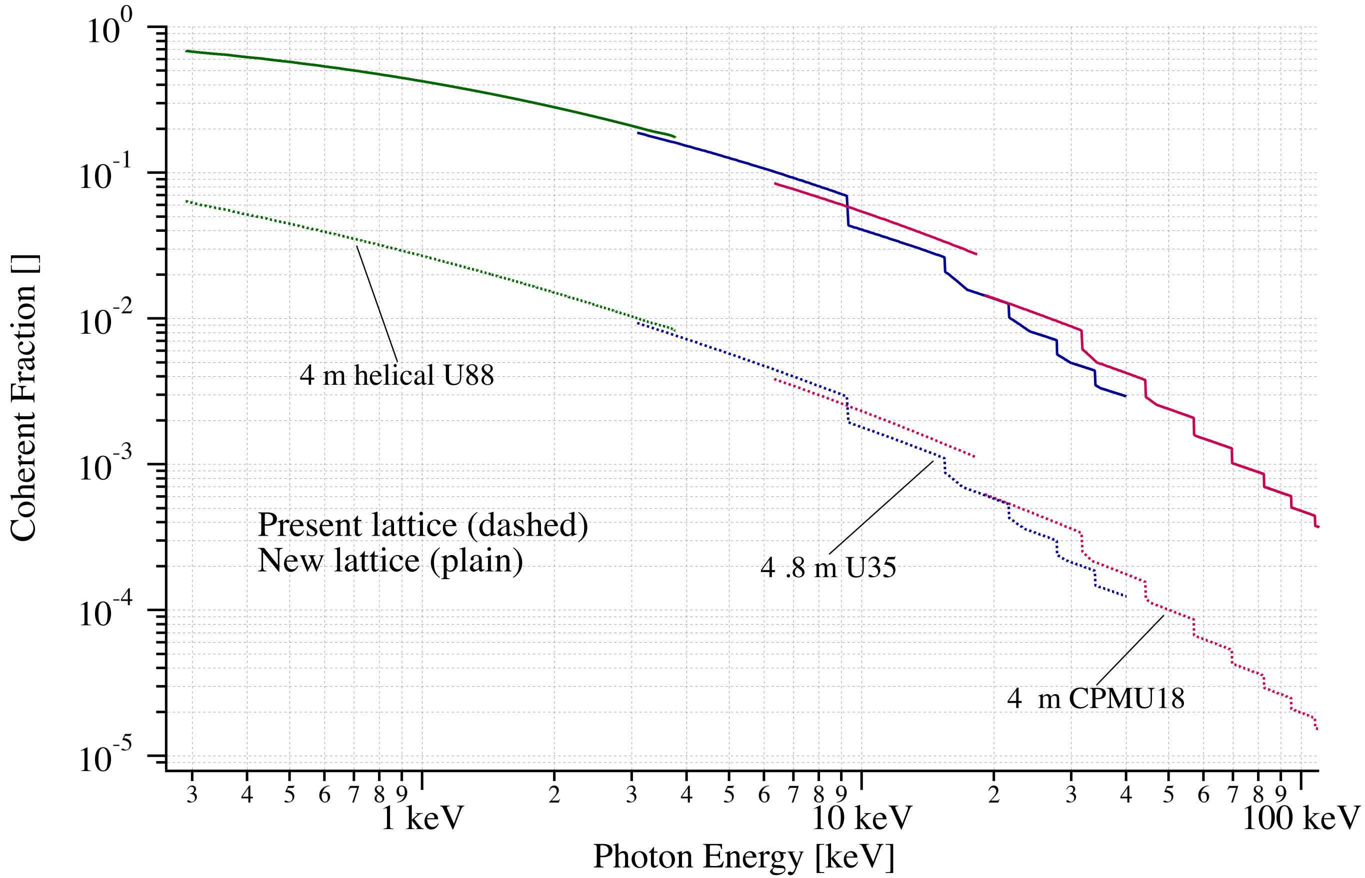
EBS: BRILLIANCE



ESRF Lattice	Present	EBS
Hor. Emittance [nm]	4	0.134*
Vert. Emittance [pm]	5	5
Energy spread [%]	0.1	0.095
$Beta_x$ / $Beta_z$ [m]	37/3	6.8/2.9
Beam current [mA]	200	200

* w/o IDs

EBS: TRANSVERSE COHERENCE



Coherence fraction (expressed in $\lambda/2\pi$)

EBS MAGNETS

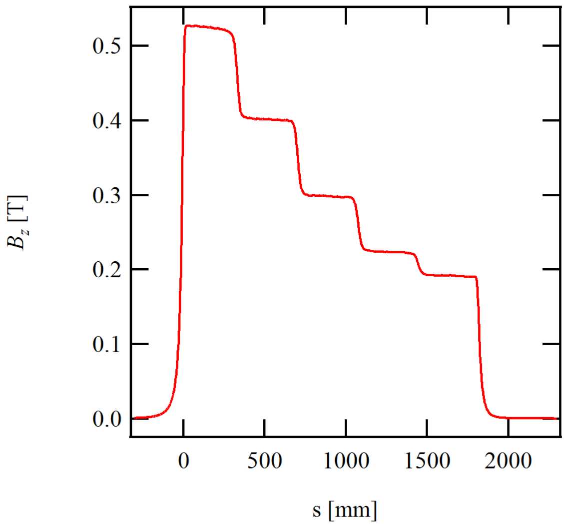
IDM* group task, except IDs

- Magnet design
- Procurement (about 1000 magnets)
- Measurements and fiducialization

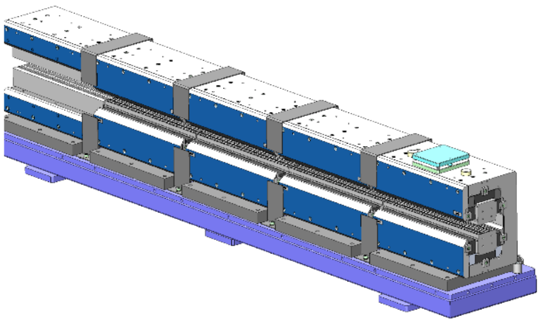
*IDM: Insertion Devices and Magnets

The EBS mock-up cell

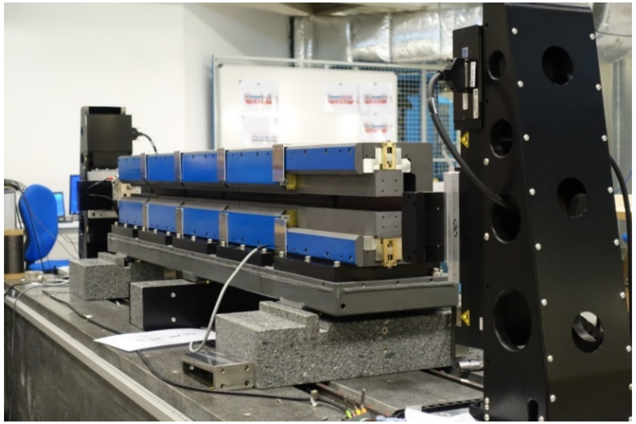
PM DIPOLES: FROM CONCEPT TO IN-HOUSE SERIAL PRODUCTION



Longitudinal field steps



Design view

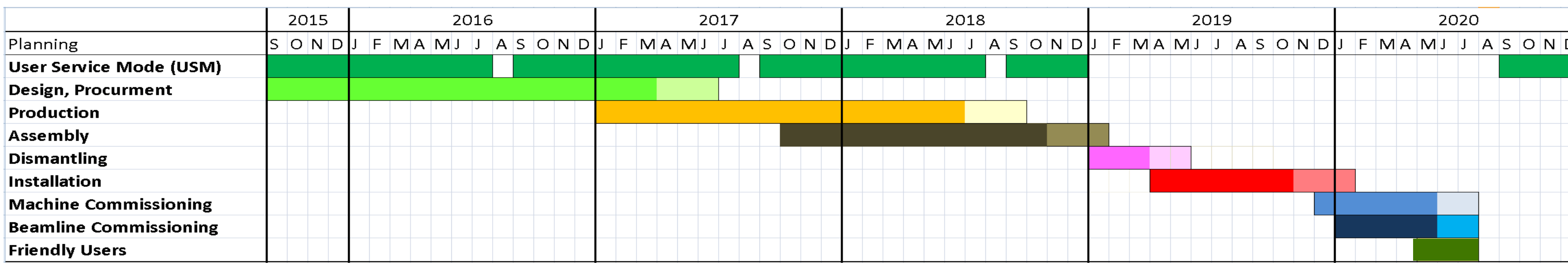


Assembly, measurement and alignment

In a few words…
132 dipoles, 1.8 m each
6 tons of Sm_2Co_{17}
Completed in October 2017

EBS MASTER PLAN (2015-2020)

Master Plan and Major Milestones



PHOTON SOURCES : INSERTION DEVICES

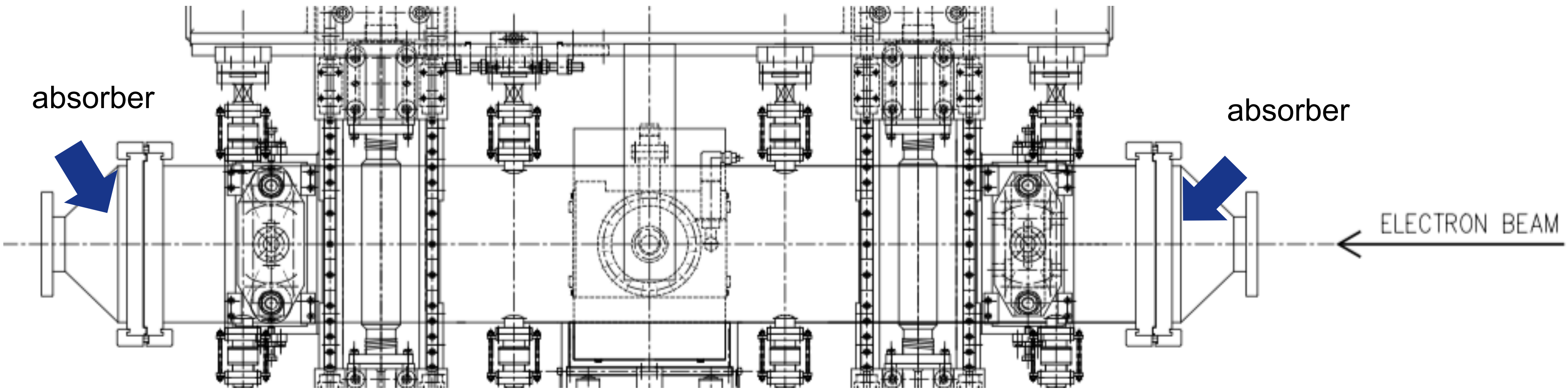
Situation at the restart (2020)

- Same energy: 6 GeV
- Most of the existing ID to be reused in the EBS
- About 90 magnetic assemblies installed
  - 33 standard in-air undulators
  - 18 revolver undulators
  - 13 IVUs and CPMUs
  - 8 other devices
- Length of the straight sections: 5 m
  - Same length for most of sections
  - Length reduced 6 m ➔ 5 m on a few sections
- Adaptation work on IVUs and CPMUs

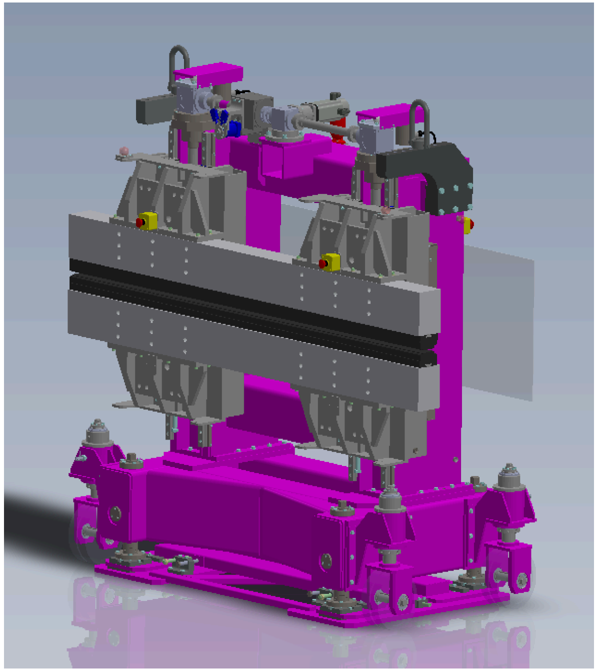
IVU AND CPMU COMPATIBILITY ISSUES

IVU adaptation

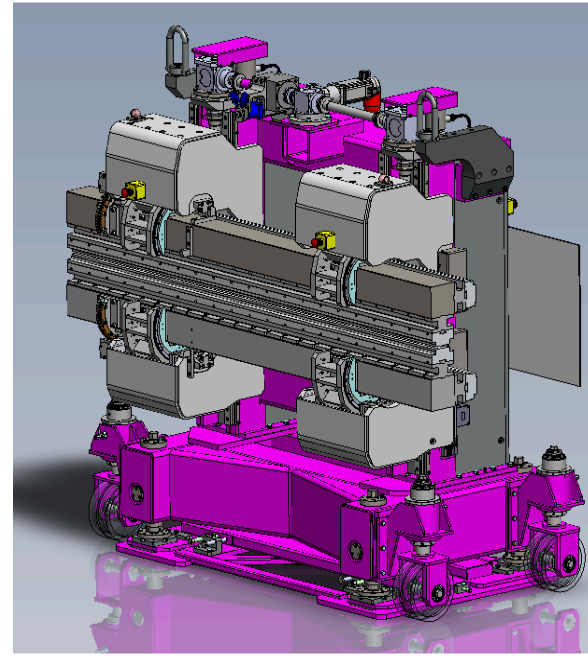
- Integration of photon absorbers on both sides
- Modification of water cooling circuit (IVUs) & flexible transitions
- New conical chambers at both ends
- Implementation before September 2019



NEW UNDULATOR SUPPORTS



2.3 m undulator



2.3 m revolver undulator

Can be used for any refurbishment and upgrade of ID straights after EBS initial operation
Two devices / ID straight, can be combined with an IVU/CPMU

CANTING IN EBS

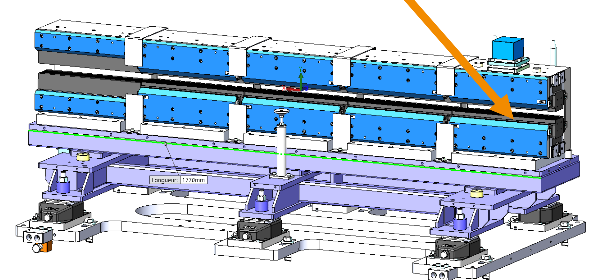
Adaptation of the canting sections

- PM canting magnets installed since 2012
- Entry and exit angles to be provided by the main dipoles
- Nearest dipole strength reduced by 2 to 2.7 mrad
- Middle canting magnet: same as present

Beam position at beamline location

- Same as present
- Max displacement: 0.2 mm

Strength reduction 2.7 mrad



ID MINIMUM GAPS

Top-up operation for the EBS

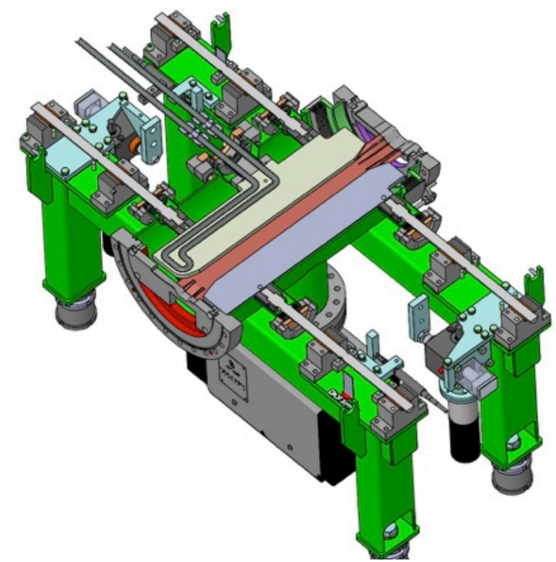
- Smaller beam lifetime (Touschek)
- Increased beam losses at small apertures (IVUs/CPMUs)

Beam losses must be localized on collimators

- Important studies with present SR (top-up, 16 bunch)
- Validation of the beam losses model

Two collimators to be installed on the EBS

- Important studies with present SR (top-up, 16 bunch)
- Cell 13 & 24
- 30 cm long tungsten blades
- Variable horizontal position
- Important shielding around collimators

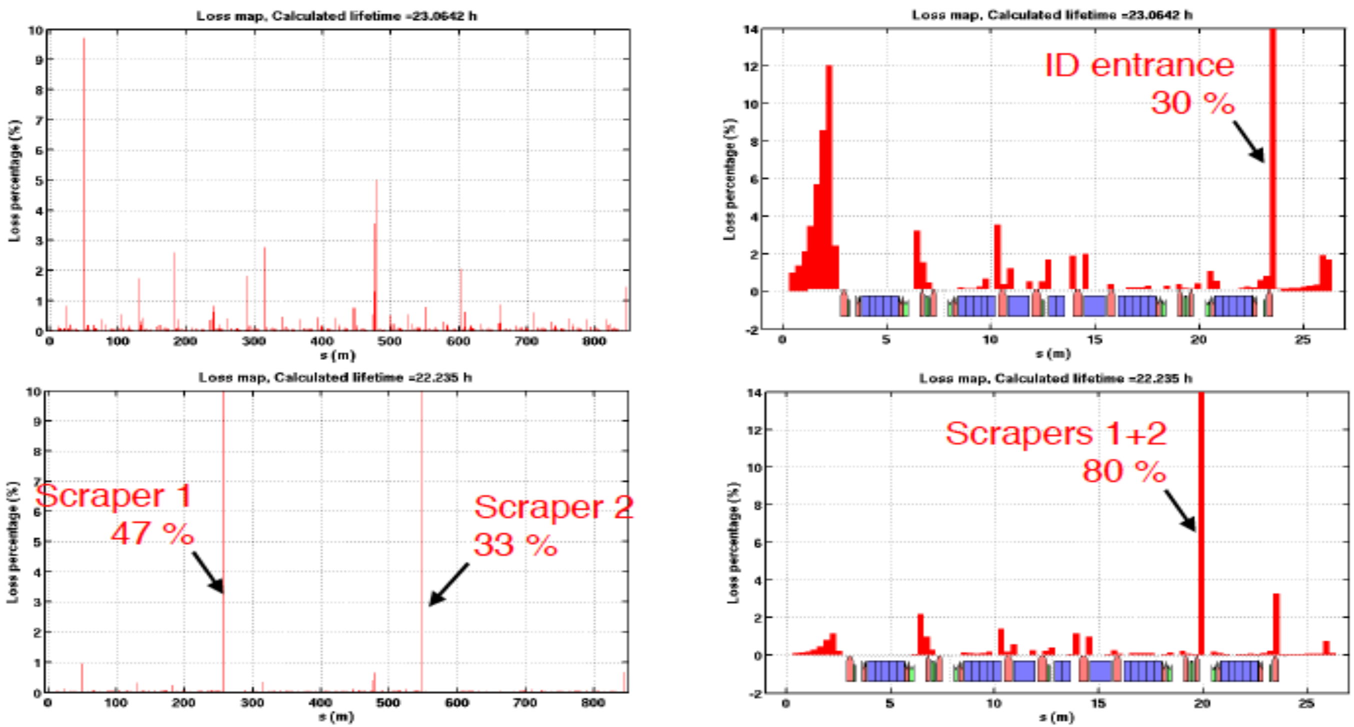


Collimator design view

COLLIMATION OPTIMIZATION

Scraper studies

- 80% of the losses relocated on the scrapers
- 4% lifetime reduction



No scrapers

Two scrapers in DR_37 of cells 13 and 24

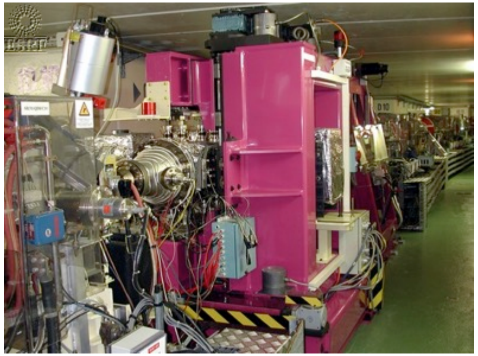
SHORT PERIOD CPMUS

CPMUs in operation

ID straight	Period [mm]	Length [m]	Gap [mm]	Peak Field [T]	PM	Instal. date
6	18	2	6	0.88	NdFeB	Jan. 2008
11	18	2	6	1	NdFeB	Jan. 2012
31	14.4	2	5	1	PrFeB	Jul. 2016

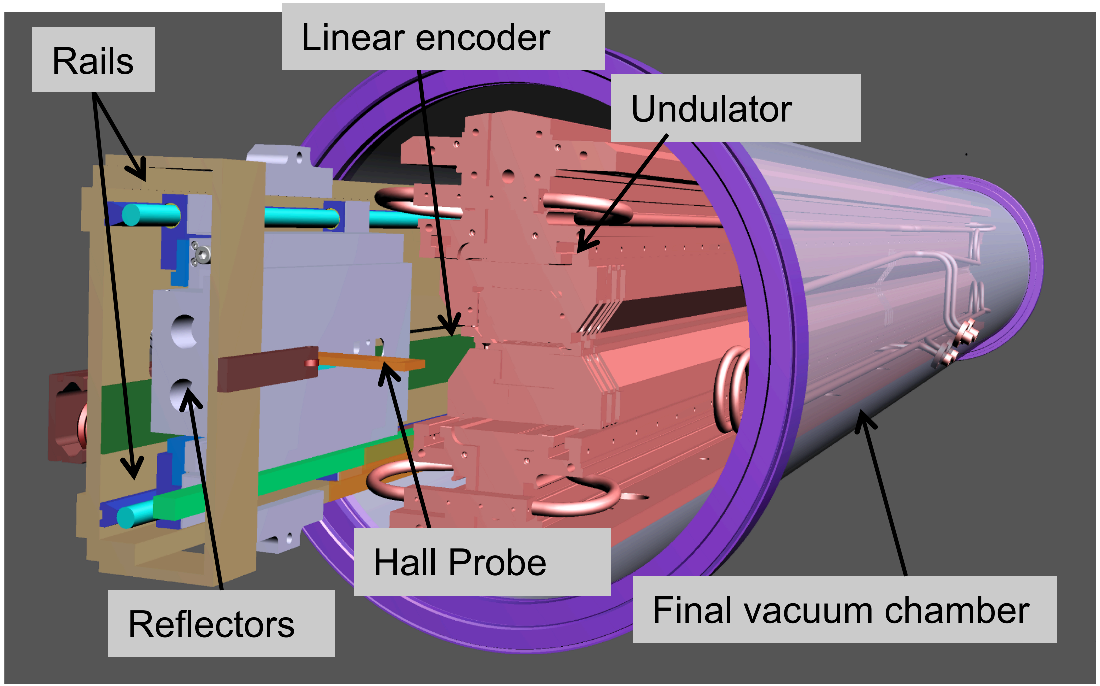
Plans

- Large demand from beamlines
- One lab fully dedicated to CPMU/IVU construction (2020)

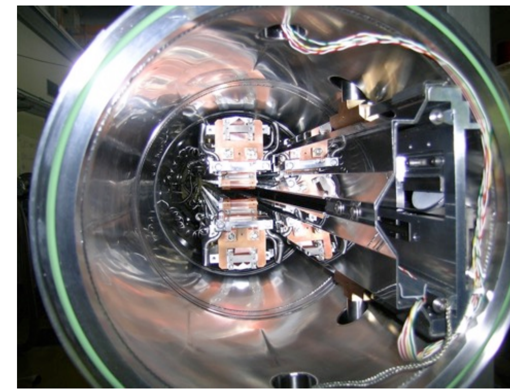


ID6 CPMU

IN-SITU HALL PROBE MEASUREMENTS OF CPMUS



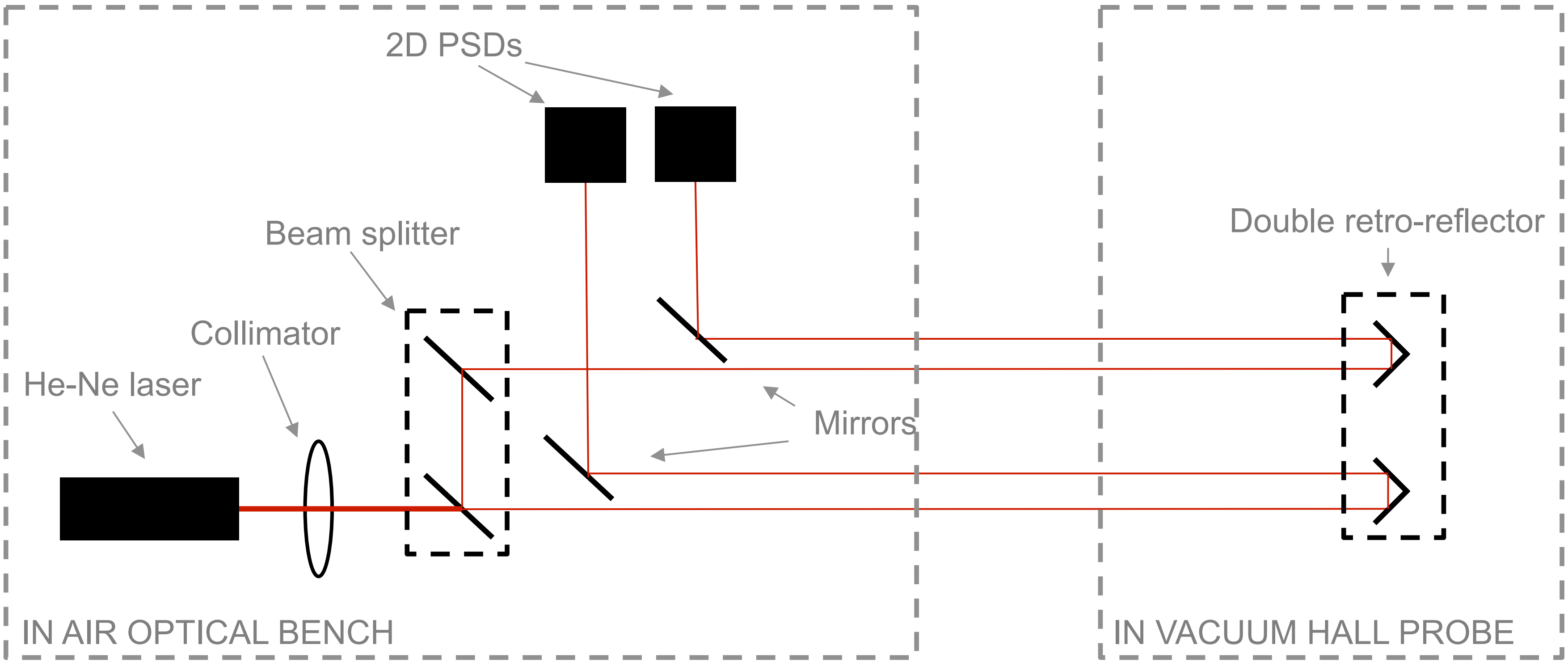
Design view of the *in situ* Hall probe bench (stretched wire system not shown)



Inside the bench

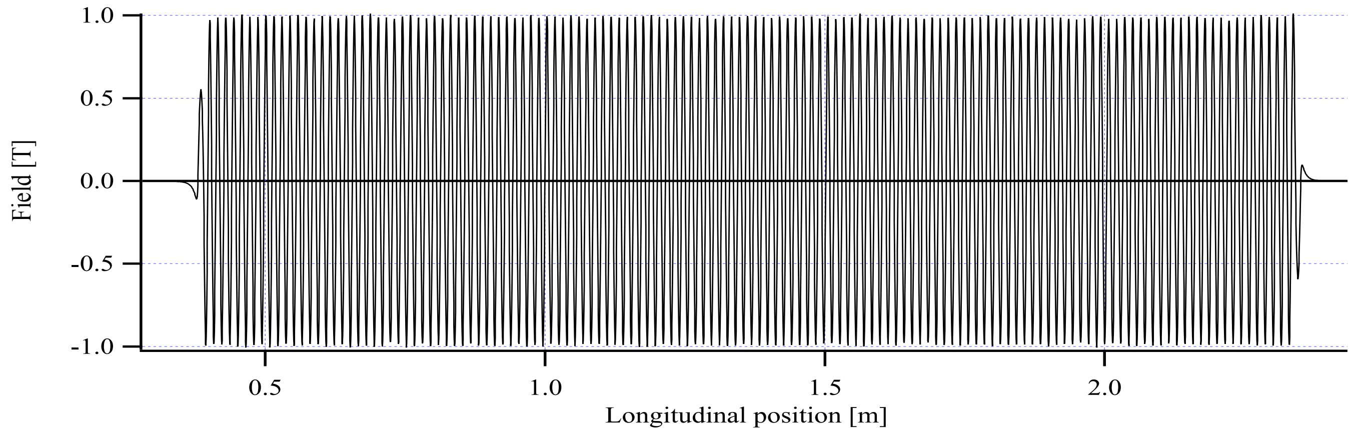
(Design in collaboration with ProActive Engineering, Spain)

IN-SITU HALL PROBE MEASUREMENTS OF CPMUS

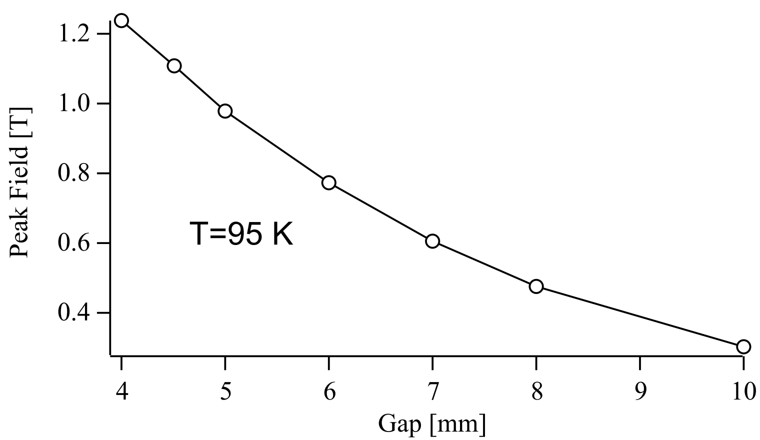


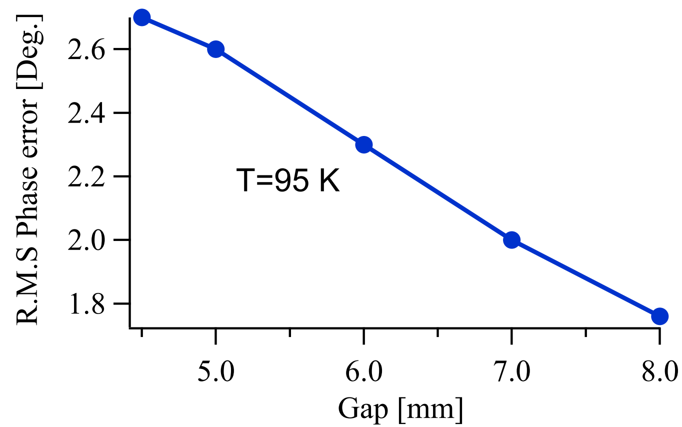
Laser setup for the measurement of the transverse positions and roll angle of the Hall probe.

MAGNETIC MEASUREMENTS: CPMU14

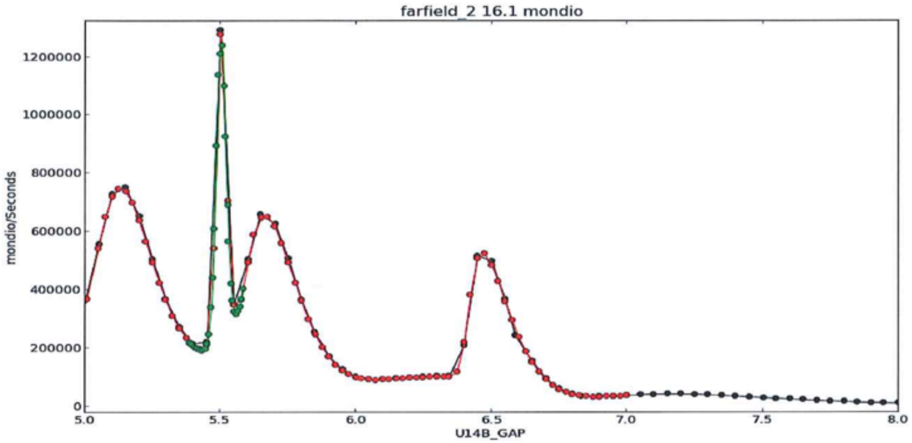


Gap 5 mm
97 K

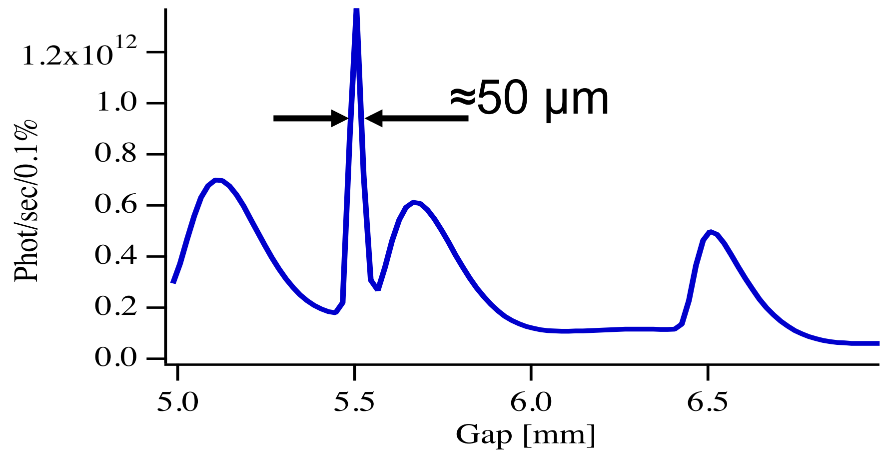




CPMU14:MEASURED PHOTON BEAM SPECTRUM

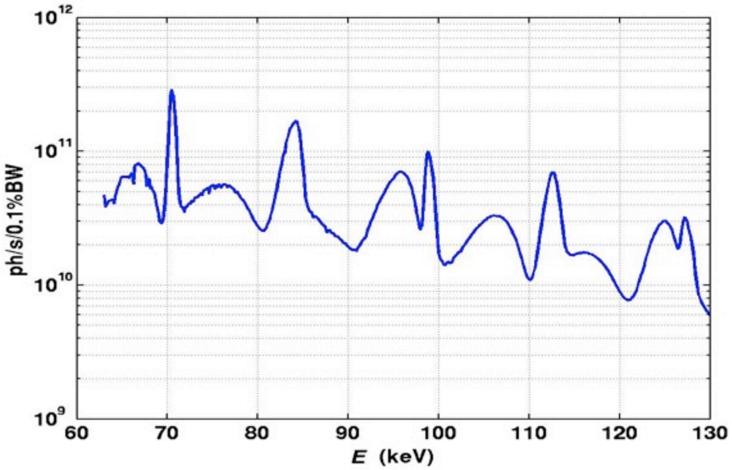


Gap scan around harmonic 7 (100.75 keV) (Courtesy V. Honkinaki)



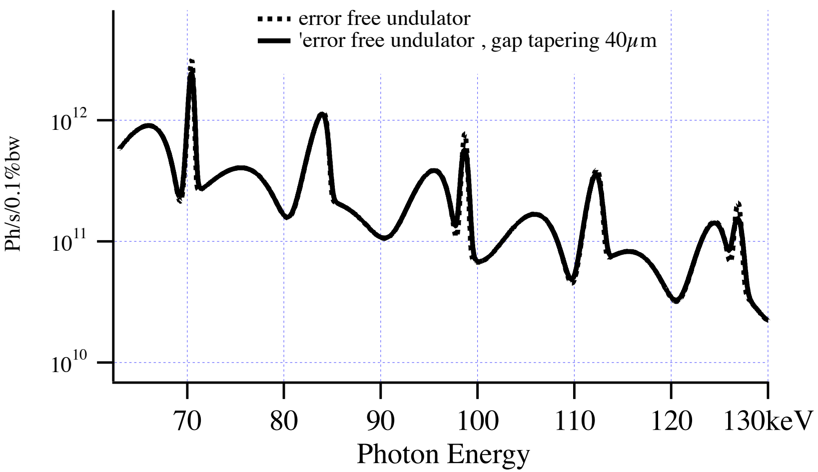
Computed gap scan with error free undulator

MEASURED PHOTON BEAM SPECTRUM (CONT'D)



Energy scan from beamline
63 keV-130 keV
Undulator gap 5.4 mm

(V. Honkinaki)



Computed Energy scan
63-130 keV
Undulator gap 5.35 mm
Ideal undulator with measured peak field
0.04 mm gap tapering
Aperture: 300µm x300µm @ 30 m

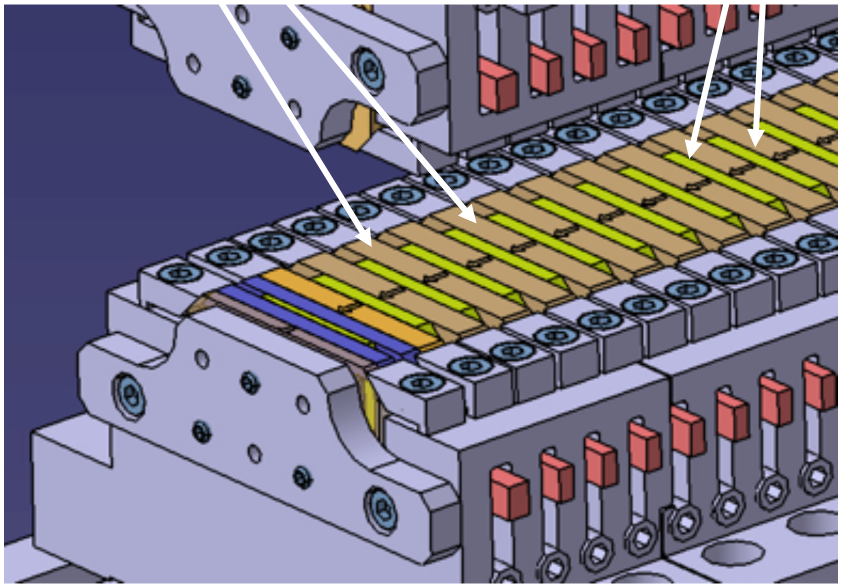
CPMUS MAGNETIC ASSEMBLIES

Magnet holders

- Based on the last CPMU (14.5 mm period)
- Efficient phase error correction
- Fine tuning of individual poles

Standard design

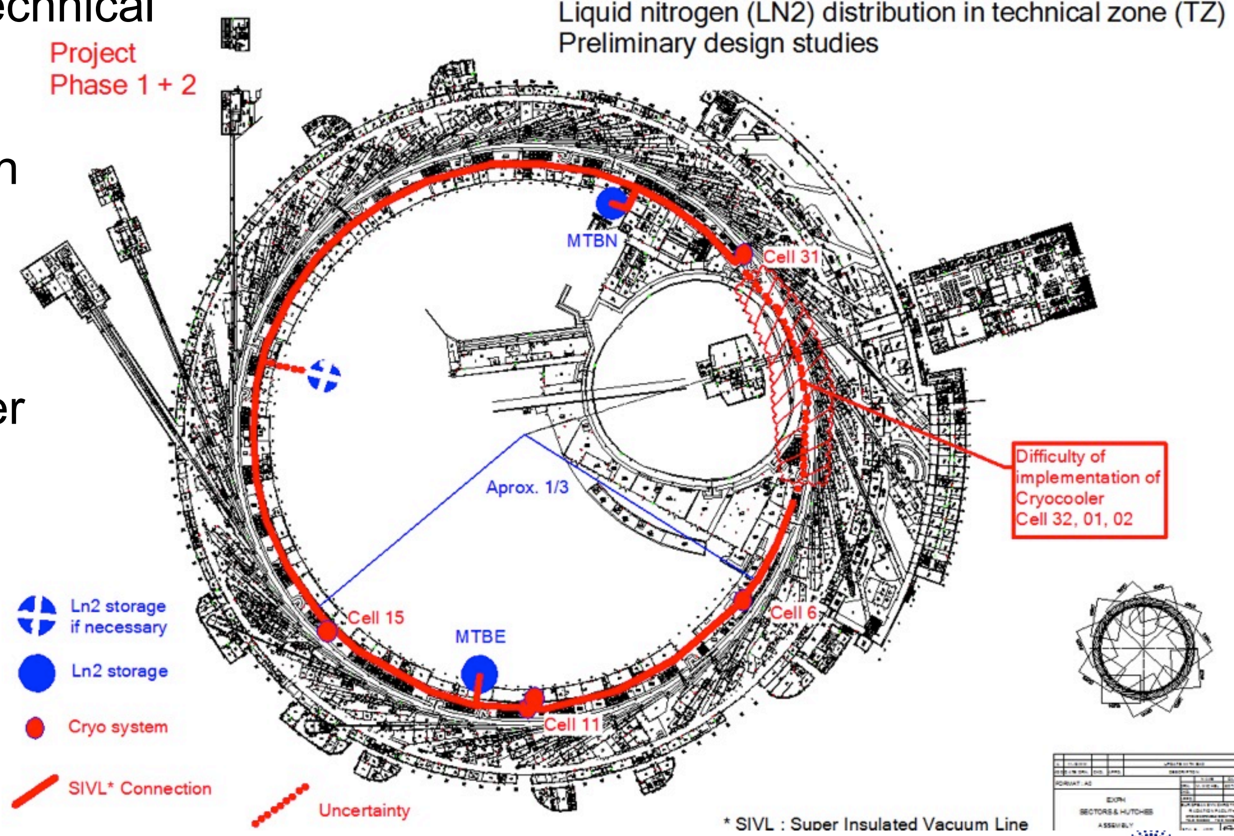
- Now fully parameterized
- 10 mm to 21 mm period
- Adaptable to any length
- End field structure included



LN2 COOLING INFRASTRUCTURE IN EBS

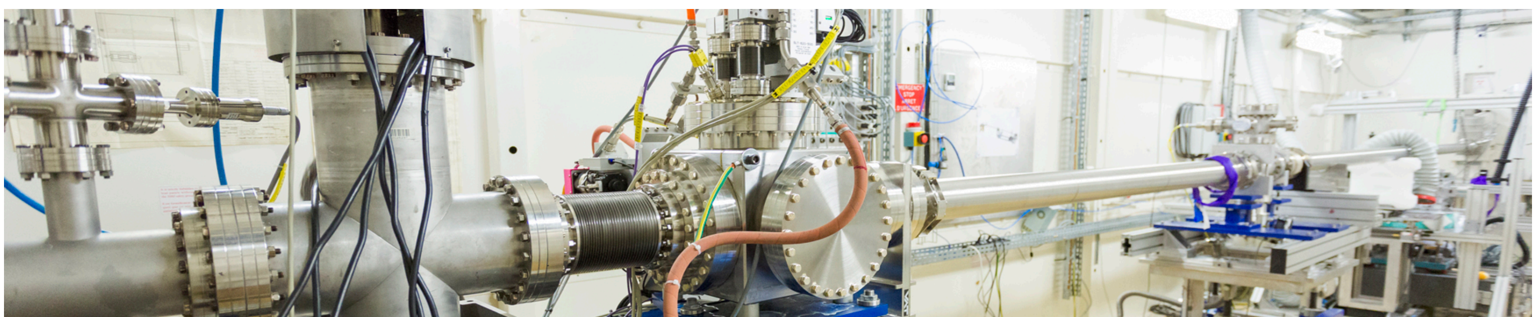
LN2 cooling loop

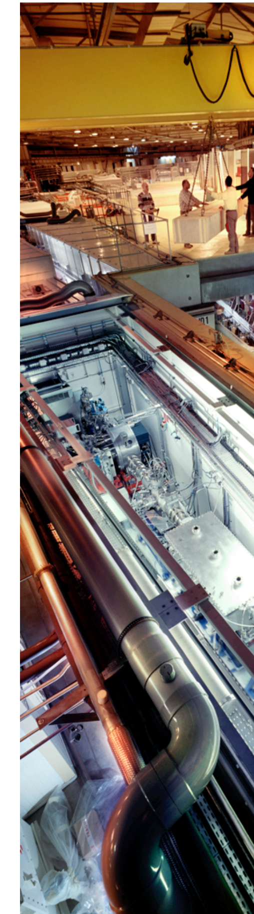
- To be implemented in the technical gallery
- For future CPMU installation
- LN2 outlet in each cell
- Available at restart of EBS
- Cell 32, 1 and 2 need further studies



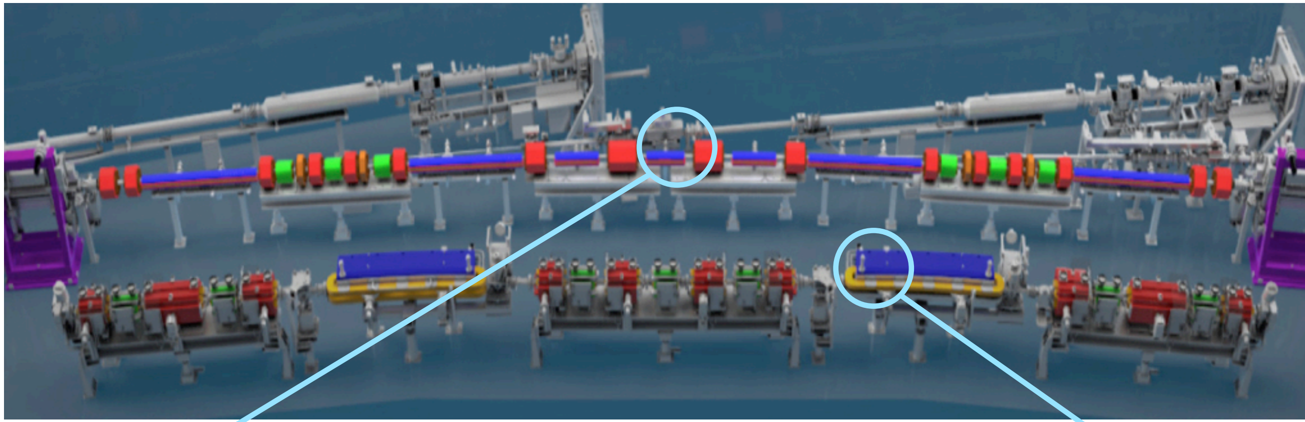
ID CONSTRUCTION FROM 2020

CDR #	Application	BL	Source
1	Coherence applications	ID10	2 x CPMU18
2	Hard X-ray diffraction microscopy	ID08	CPMU14, CPMU18
3	Large phase-contrast tomography	BM18	3 pole wiggler
4	Surface science	ID03	U27/U35
5	Extreme conditions	ID27	2 x CPMU18
6	Dynamic compression studies	ID23-ID24	CPMU18, CPMU12





BENDING MAGNET SOURCES: CONTEXT



ESRF EBS

7BA 6 GeV lattice

BM sources

Combined low field dipole-quads (DQ)

➔ 0.39 T DQ, $E_C = 9.3$ keV

➔ 0.57 T DQ, $E_C = 13.6$ keV

➔ 2 mrad max

Present ESRF

DBA 6 GeV lattice

Very productive BM beamlines

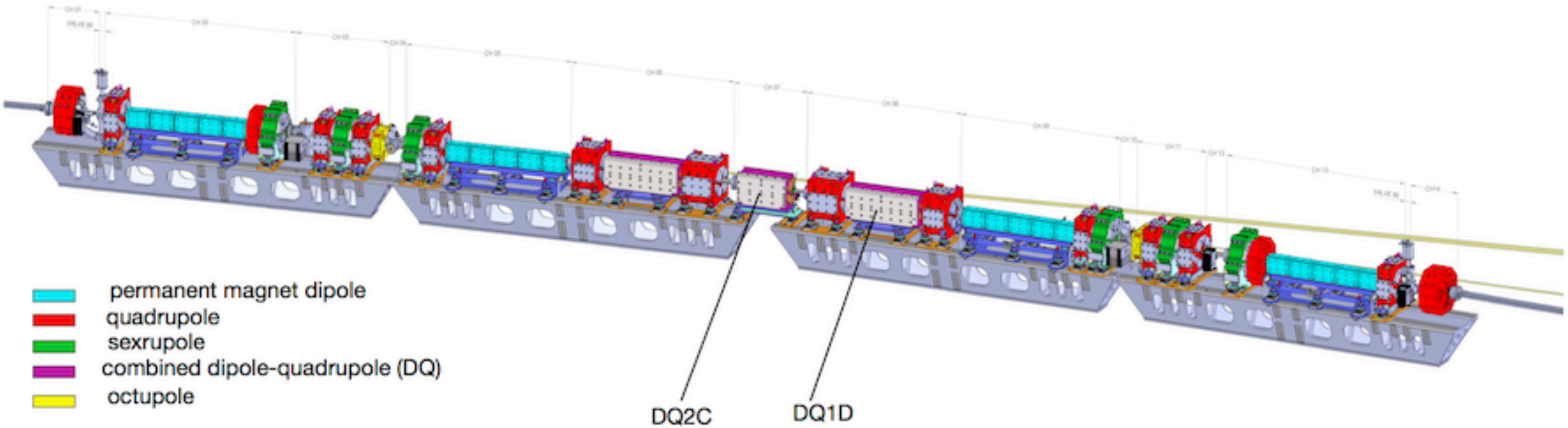
BM sources

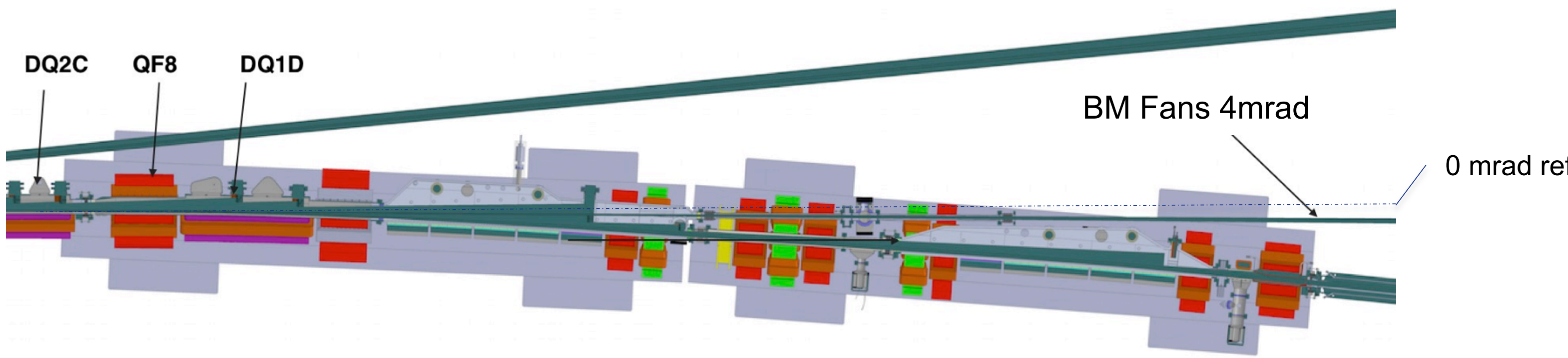
➔ 0.856 T bending magnet, $E_C = 20.5$ keV

➔ 0.4 T soft end, $E_C = 9.5$ keV

➔ 6 mrad max

GEOMETRICAL CONSIDERATIONS

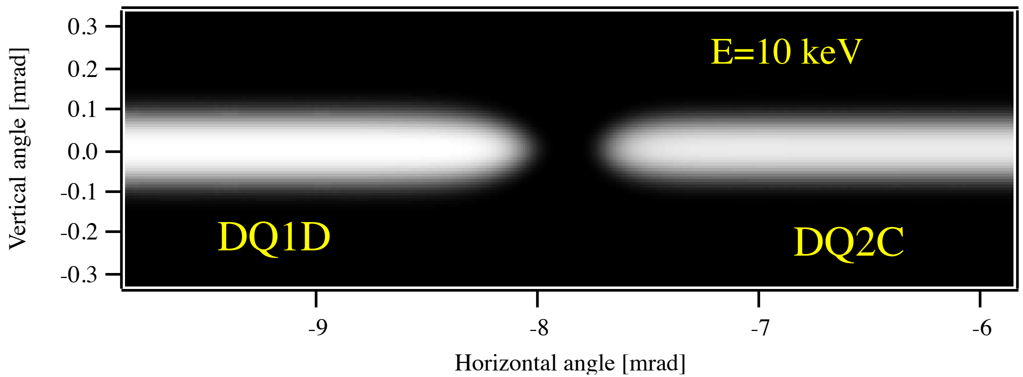


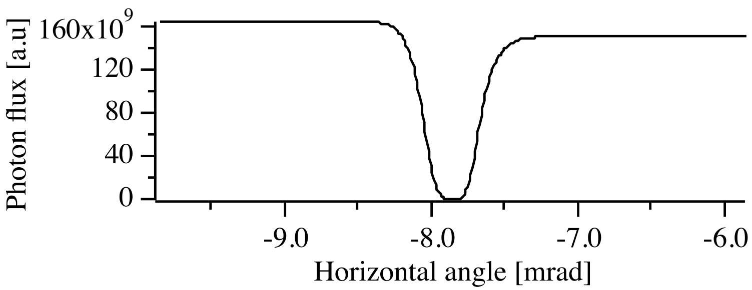


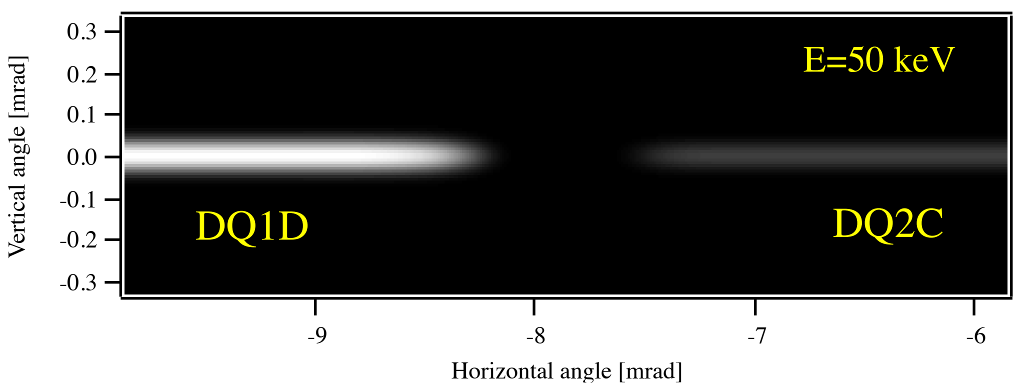
BM X-Ray fans limited to 4 mrad due to limitations imposed on photon beam path in magnets

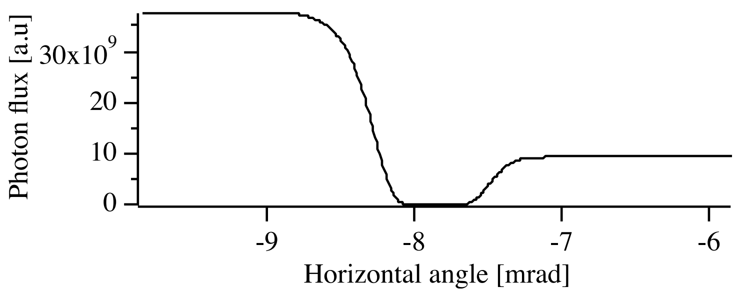
INCOMING BEAM(S) AT BEAMLINE (DQ2C & DQ1D ONLY)

Storage ring tunnel ← 2 separated beams → Experimental hall









PROPOSED ALTERNATIVE SOURCES

Options available

Short Bending Magnet (SBM)

- 2 mrad X-ray fan
- 7 SBM to be installed

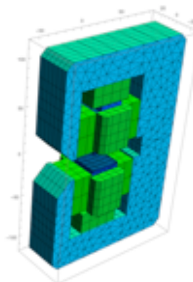
2-poles wiggler (2PW)

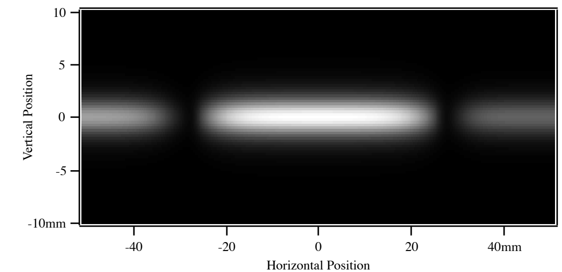
- 1.7 mrad fan
- 2 configurations
- 6 2PW to be installed

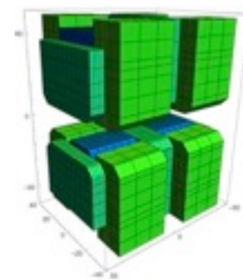
3-pole wiggler

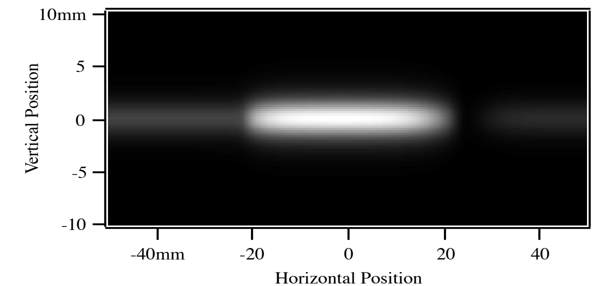
- 1.6 mrad fan
- 2 3PW to be installed

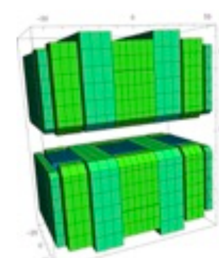
Peak field: 0.86 T for all sources

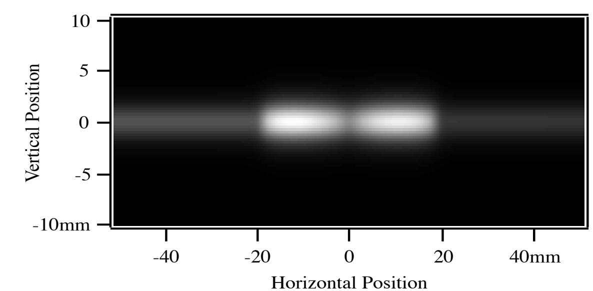








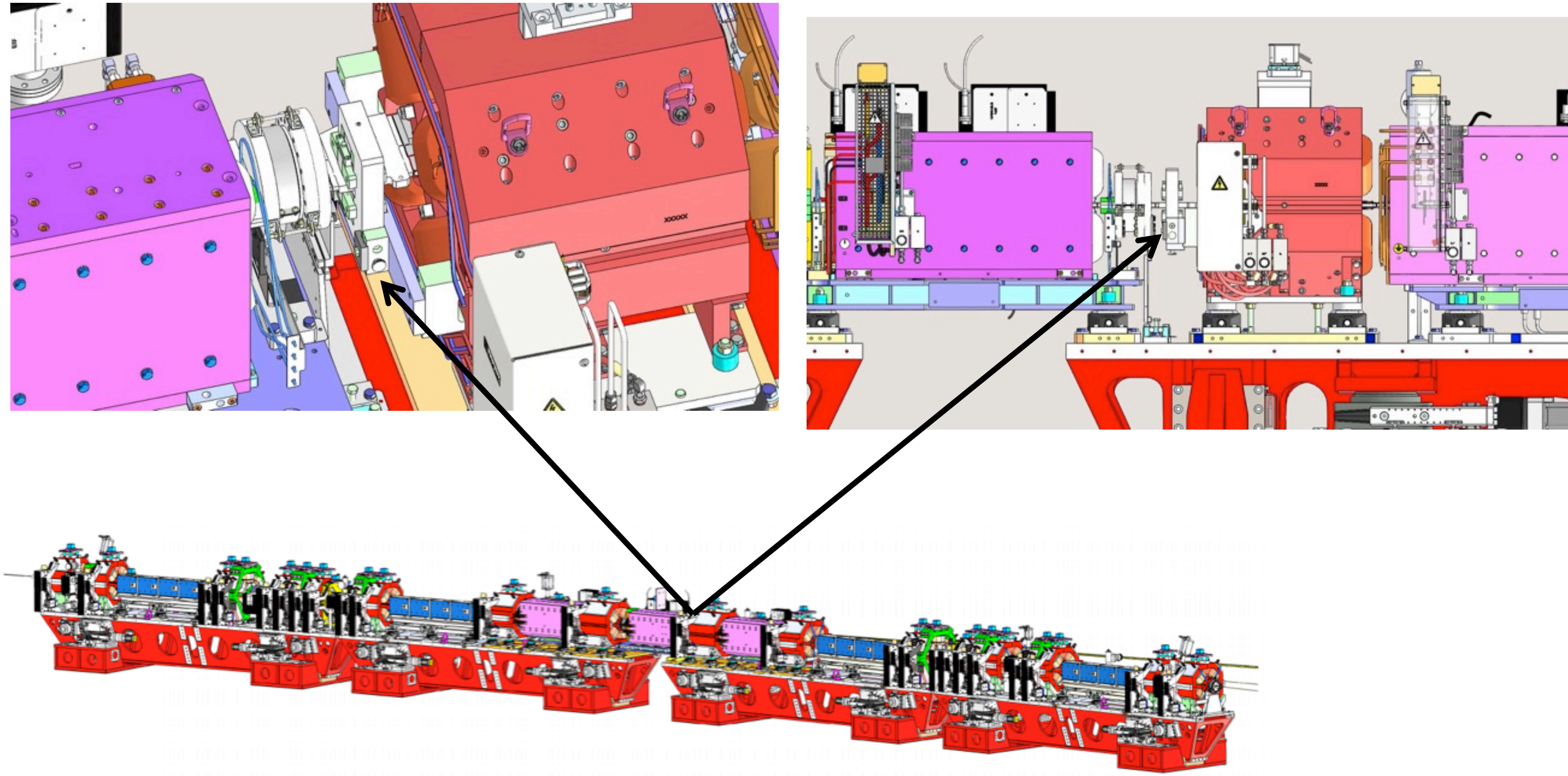




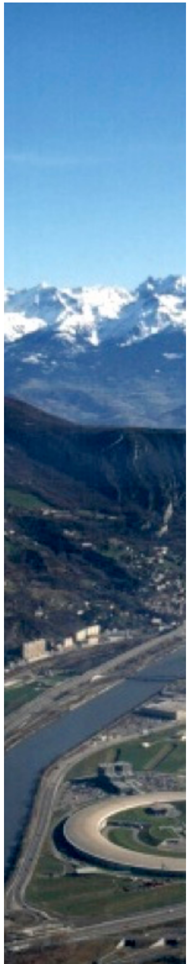
White beam at 25 m

SHORT WIGGLERS & SBM INTEGRATION

SBM insertion



SUMMARY



ESRF EBS

Procurement in progress, assembly started

Insertion devices

- Initial operation with present ID segments
- Operational experience very positive with CPMUs
- Large demand for CPMUs/ IVUs to anticipate
- Dedicated lab for construction of CPMUs

Bending Magnet beamlines

- New sources: SBM,2PWs,3PWs