IMMW21

WELCOME

Joel Chavanne
Accelerator an Source Division, Insertion Devices and Magnets

ESRF | The European Synchrotron

OUTLINE

- ESRF EBS
  - Overview
  - Magnets & Photon Sources
  - Status
- IMMW21
  - Context & scope
  - practical information

3RD GENERATION LIGHT SOURCES

- **Many Dedicated straight section for undulators**
  - Low horizontal emittance ~ few nm
  - ESRF was the first facility constructed
    - SR commissioning completed in early 1992
    - First undulator installed in June 1992
    - Progressive ID installation & beamline construction

- **First facilities with high Electron Energy**

Beam current: 100 mA to 200 mA

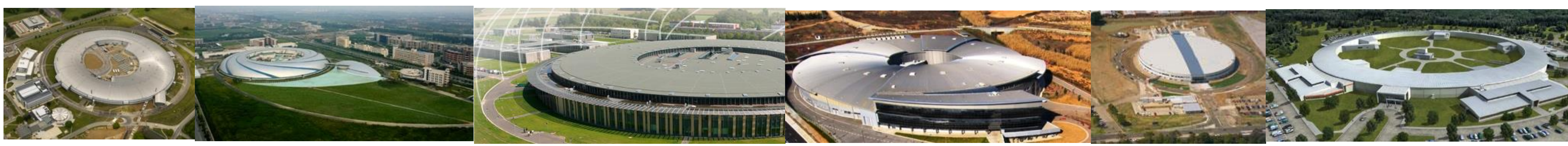
ESRF 6 Gev

APS 7 Gev

SPRING8 8 Gev

3RD GENERATION LIGHT SOURCES

- **From end of 90s : many medium Energy rings constructed from green field**
  - Energy: 2.0 to 3.5 Gev
  - Horizontal emittance ~ 0.5 nm – 5 nm
  - Beam current up to 500 mA with top up in most of cases



SOLEIL, DIAMOND, CLS, ALBA, SSRF, TPS ,Australian Synchrotron, NSLS II …

- **Transformation of existing old colliders to low emittance SR facility**

Ex: PETRA III

- Energy: 6Gev
- Horizontal emittance : 1 nm
- Beam current 100 mA

ESRF UPGRADE

2009
2015

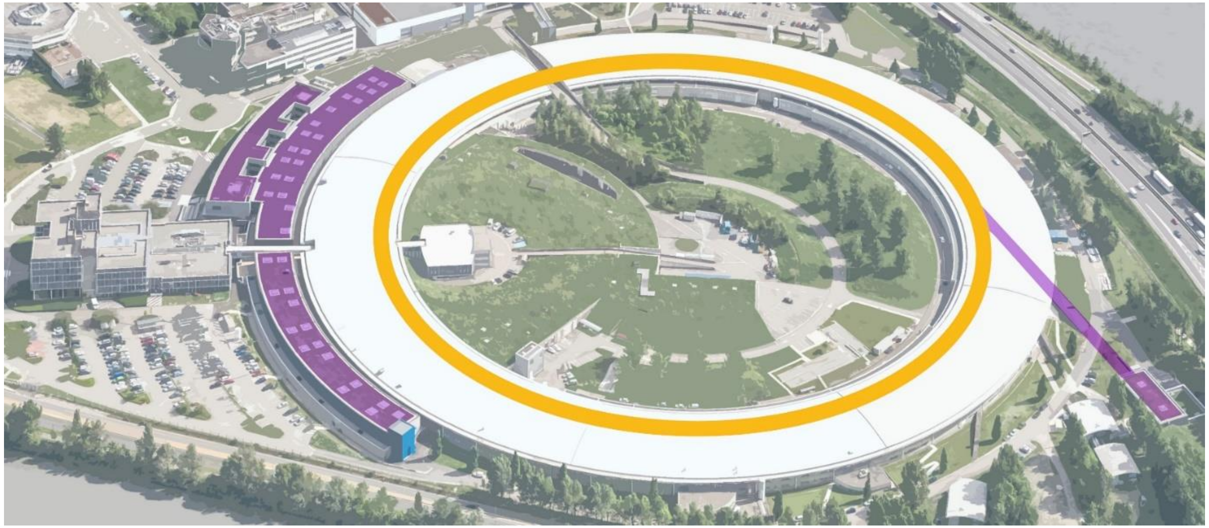
Upgrade PHASE I – 180 M€

- New beamlines (19 experimental stations)
- New ultra-stable experimental hall
- Improvement and refurbishment of most of the scientific equipment and accelerator infrastructure

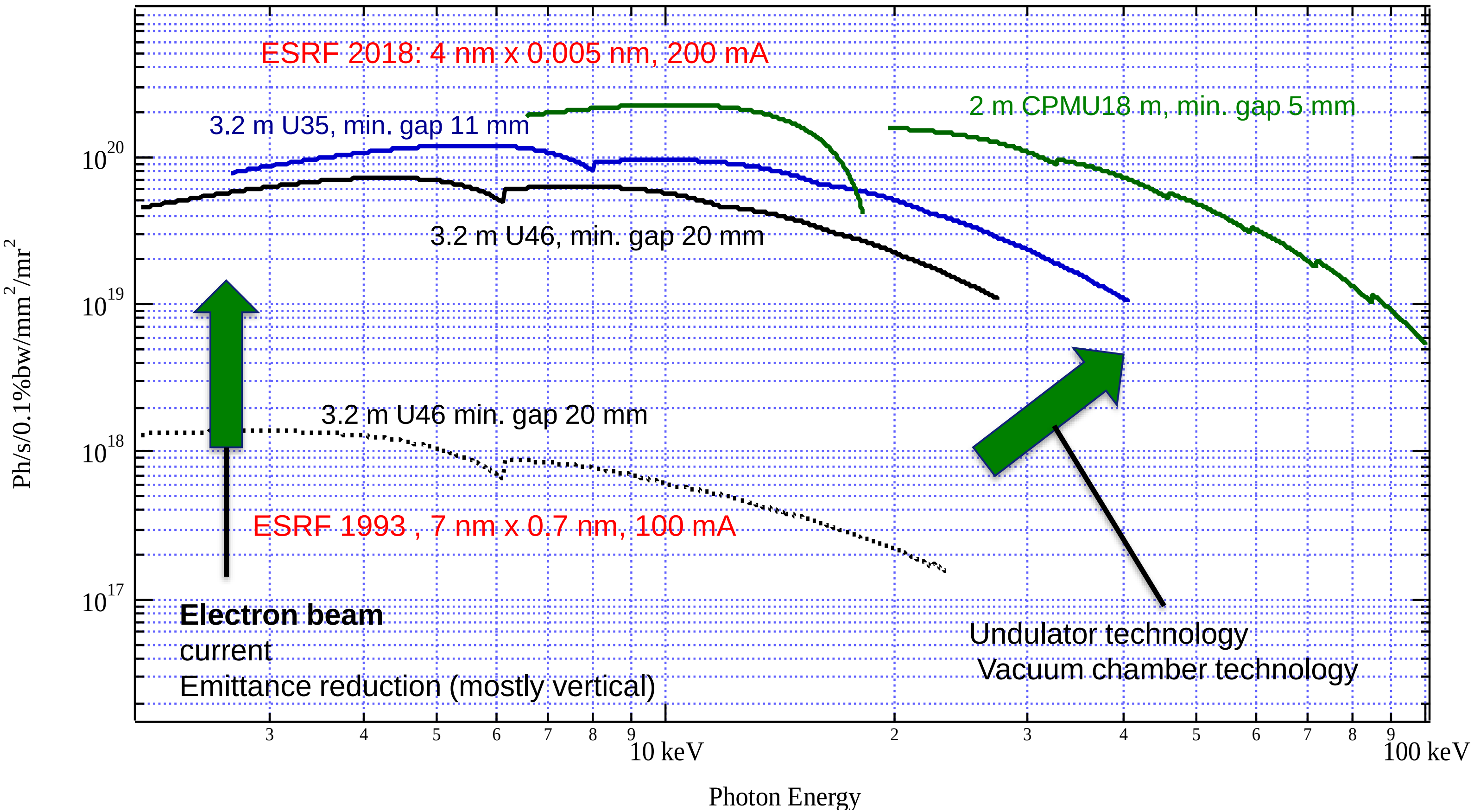
150 M€ – ESRF-EBS

2015
2022

- Construction of a new storage ring
- Construction of new beamlines
- Important instrumentation program
- Intensified big data strategy



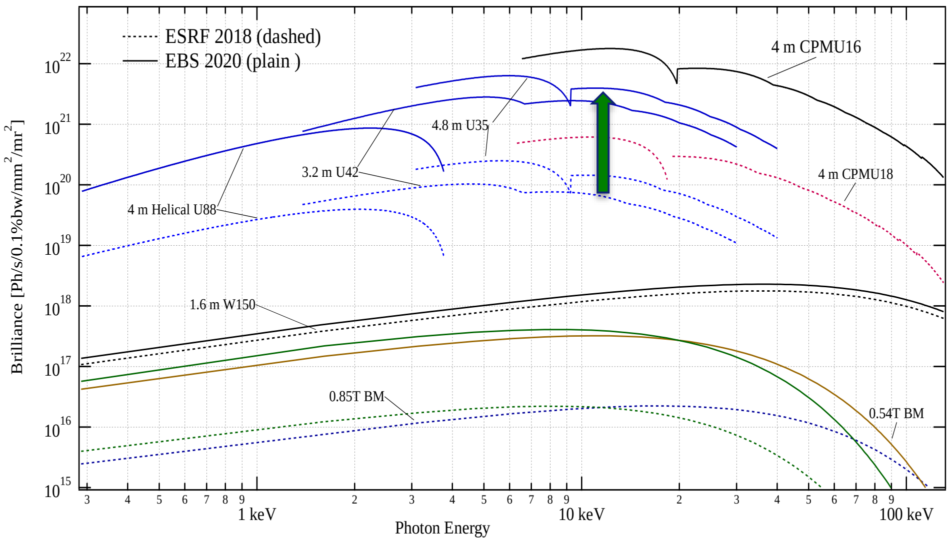
BRILLIANCE IMPROVEMENT AT ESRF UP TO 2018

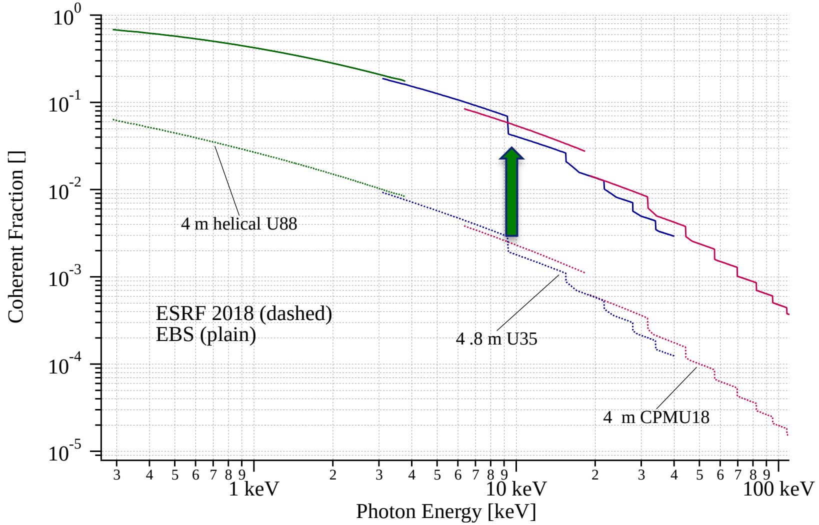


ESRF EBS: 4^{TH} GENERATION SR LIGHT SOURCES

The quest: Improving transverse coherence of x-ray photon sources

- decreasing the horizontal emittance of electron beam by at least one order of magnitude





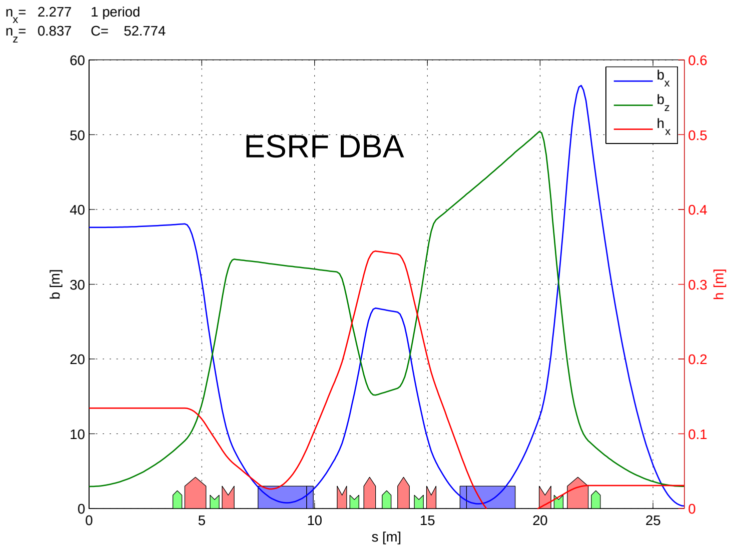
Electron beam	H emittance [nm]	V emittance [pm]	Rel. energy spread[%]
ESRF 2018	4	5	0.1
EBS 2020	0.132	5	0.094

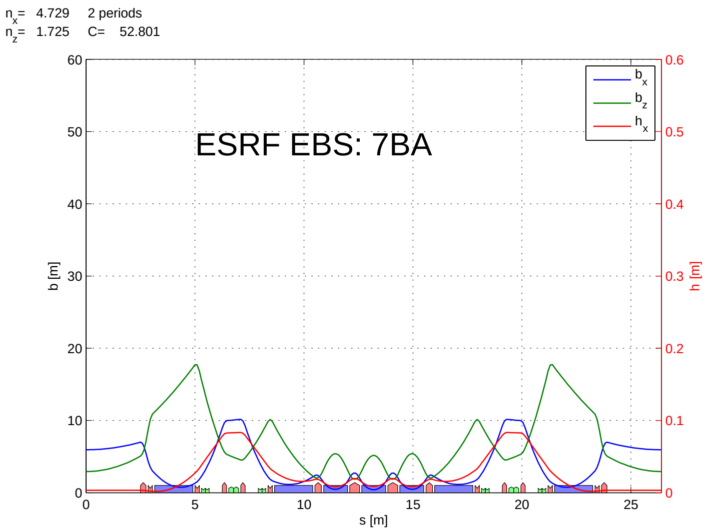
6 GeV, 0.2 A

NEW GENERATION OF MAGNET LATTICE FOR LIGHT SOURCES

Achieving lower horizontal emittance requires new magnet lattice

- Based on Multiple Bent Achromats: 7BA @ ESRF (32 cells)
- Upgrade context and associated constraints (SR tunnel, beamlines,… etc)





~ all 3rd generation SR light sources

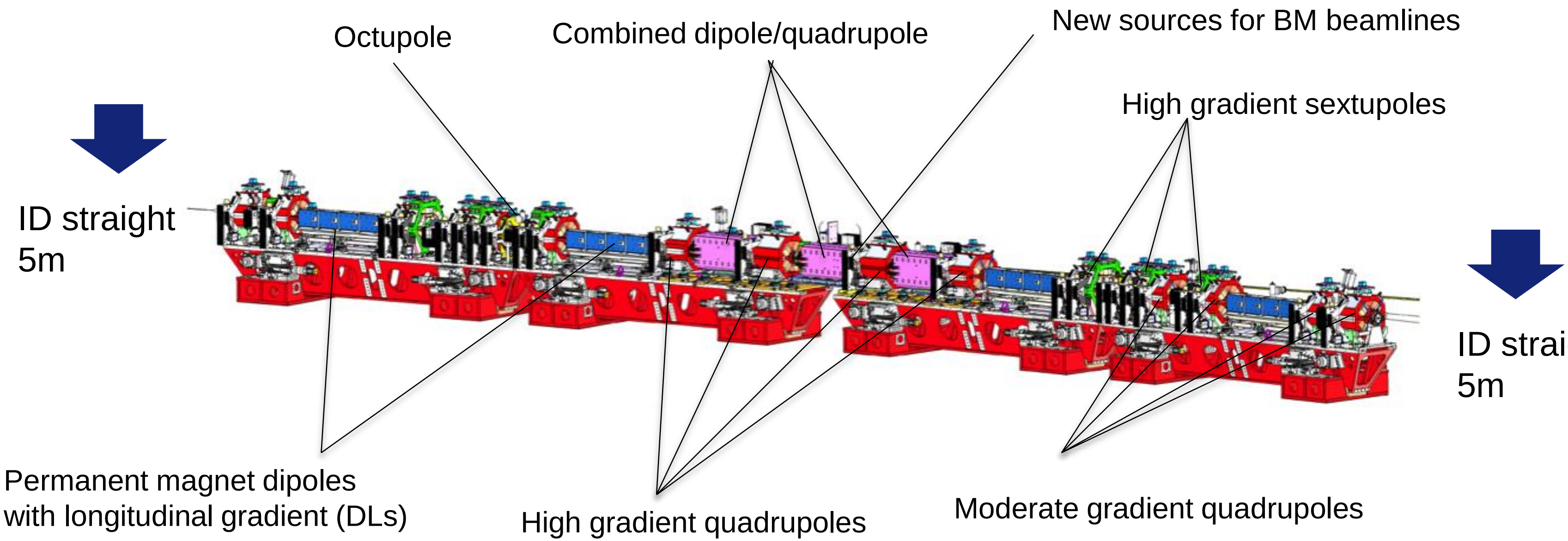
Cell packed with magnets

- Stronger focusing:
- Smaller beta functions
- Smaller dispersion

MAGNETS

- Important design effort, new types of magnets (~ 1000 magnets in total)
- Compact magnet lattice
- Small aperture vacuum chamber technology
- Reduce wall plug power as much as possible
- 4 supporting girders/cell

Magnet layout in one cell



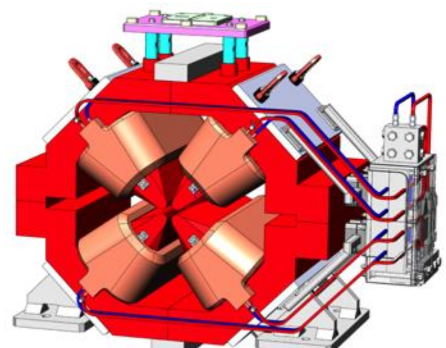
QUADRUPOLES

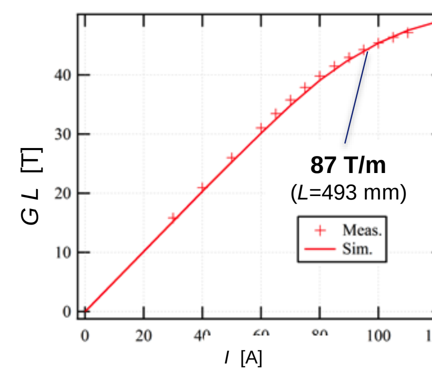
Moderate gradients (MG)

Parameter	Value	Unit
Nominal strength	Up to 54	T/m
Mech. length	162 - 295	mm
Bore radius	16.4	mm
Nominal current	95 - 91	A
Power	0.7 – 1.1	kW
# pre-series	8	
# of series	384	
GFR (HxV)	13x9	mm
$\Delta G/G$ in GFR	$<10^{-3}$	

High gradients (HG)

Parameter	Value	Unit
Nominal strength	89 - 87	T/m
Mech. length	388 - 484	mm
Bore radius	12.7	mm
Nominal current	95 - 91	A
Power	1.9 – 1.7	kW
# pre-series	2 - 2	
# of series	64 - 64	
GFR (H x V)	7x5	mm
$\Delta G/G$ in GFR	$<10^{-3}$	





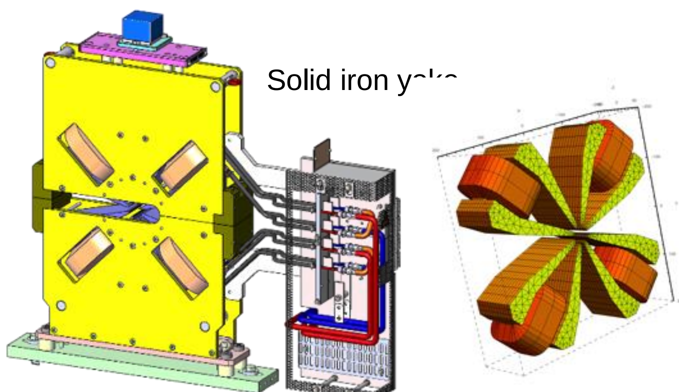
SEXTUPOLES & OCTUPOLES

Sextupole Magnets

Parameter	Value	Unit
Nominal strength	1700	T/m^2
Mechanical length	166 - 200	mm
Bore radius	19.2	mm
Nominal current	62	A
Power consumption	0.5	kW
# of pre-series	2 - 2	
#of series	128 - 64	
GFR	13x9	mm
ΔH/H	10 %	

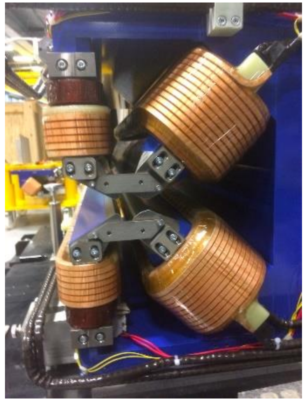
Octupole Magnets

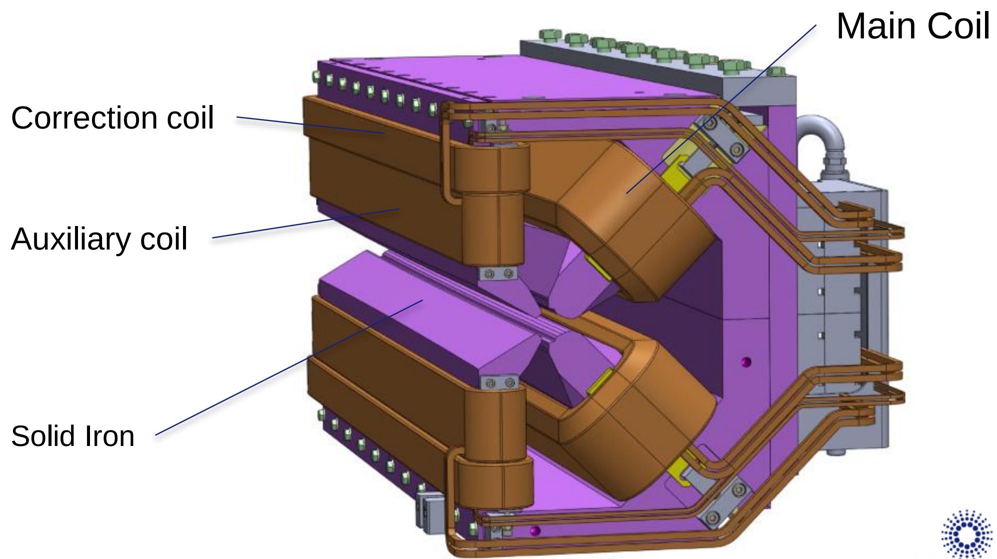
Parameter	Value	Unit
Nominal strength	36900	T/m^3
Mechanical length	90	mm
Bore radius	18.6	mm
Nominal current	54	A
Power consumption	0.1	kW
# of pre-series	1 - 1	
# of series	33 - 31	
GFR (HxV)	13x9	mm
ΔO/O	10%	



COMBINED FUNCTIONS DIPOLE-QUADRUPOLE (DQ)

Parameter	Value	Unit
Nominal dipole	0.55 – 0.39	T
Nominal strength	36 - 31	T/m
Mechanical length	1028 - 800	mm
Nominal current	85.5 - 90	A
Power consumption	1.6 – 1.2	kW
Number of pre-series	2 - 2	
Number of series	64 - 32	
GFR (HxV)	7x5	mm
$\Delta G/G$ in GFR	$< 5.10^{-3}$	

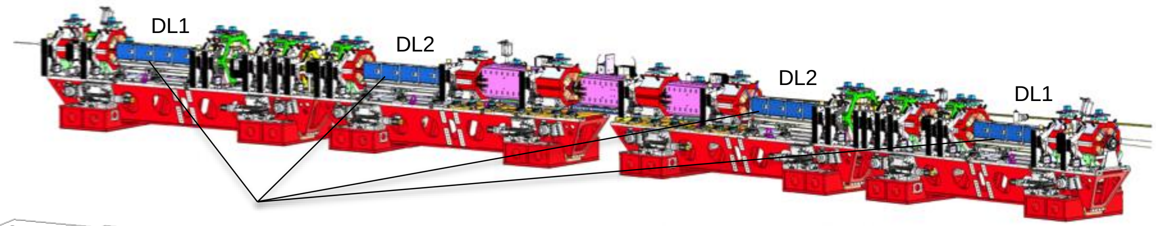


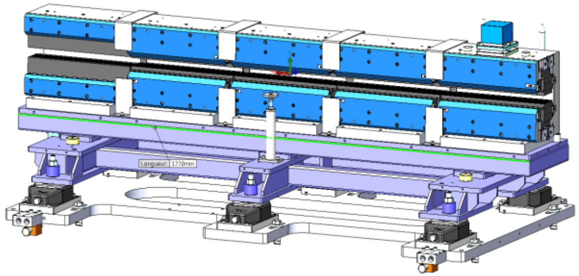


- Independent tuning of *B* and *G*
- ±2.5 % at fixed *B* and ±2 A in correction coils

DIPOLES WITH LONGITUDINAL GRADIENT (DL)

In-House development





Permanent magnet structure

- 5 modules/DL: 5 field steps
- Length: 1.8 m
- 128 units (64 DL1, 64 DL2)
- PM material: Sm_2Co_{17} ~ 12000 blocks
- Construction completed in September 2017

PHOTON SOURCES IN EBS: FIRST STAGE

- re-use existing undulators (6 GeV -> 6 GeV)
- Build 6 undulators
- 2 CPMUs

Important refurbishment & adaptation:

- In-Vaccum undulators & CPMUs
    - New flexible transitions
    - Integration of photon absorbers
    - cooling modification
    - … etc

ESRF01

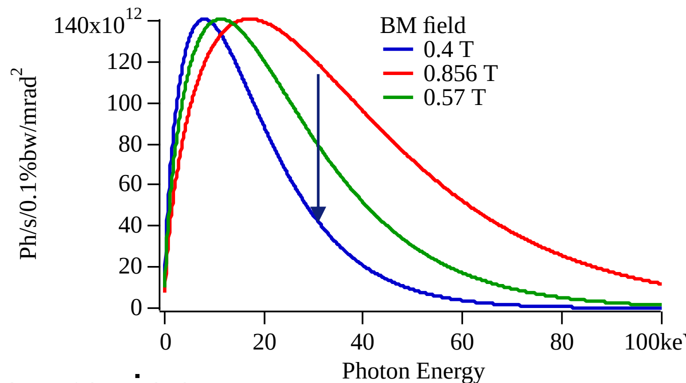
IVU/CPMU adaptation

BENDING MAGNETS SOURCES

Upgrade context:

The trend is to reduce the dipole field in storage rings (0.86 T -> ~ 0.5 T@ ESRF)

- higher number of dipoles
- Lower horizontal emittance
- Critical photon energy : $E_c =\propto B$



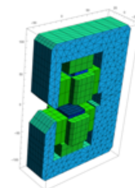
Consequence: loss of performance in hard X-ray region

➡ Needs fo alternative BM type sources

BM SOURCE TYPES

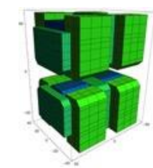
Permanent Magnet structures

- Short Bending Magnet (SBM)
  - 2 mrad X-ray fan
  - 8 units



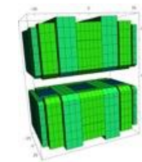
0.86 T

- 2 Pole Wiggler (2PW)
  - 1.7 mrad x-ray fan
  - 2 possible configurations
  - 8 units



0.86 T

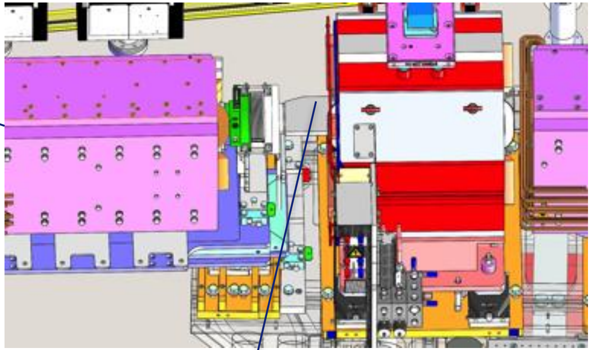
- 3 Pole Wiggler (3PW)
  - 2 mrad fan
  - 1 unit (BM18)

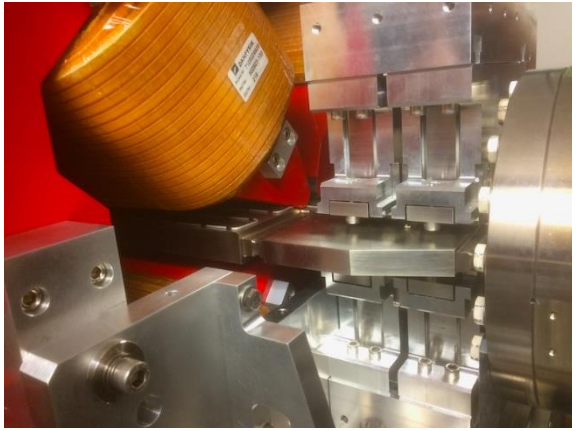


1.5 T

BM SOURCES

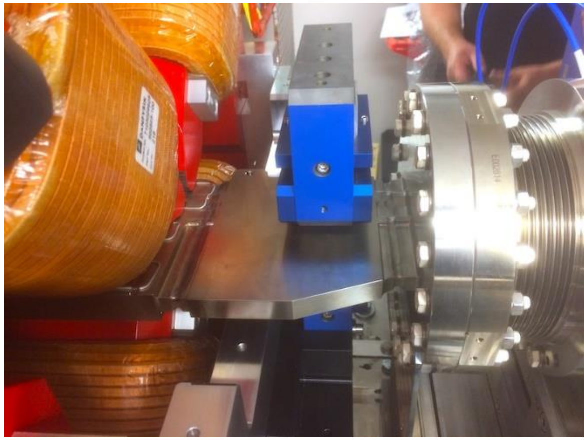
17 Sources to be commissioned
Feb 2020- July 2010





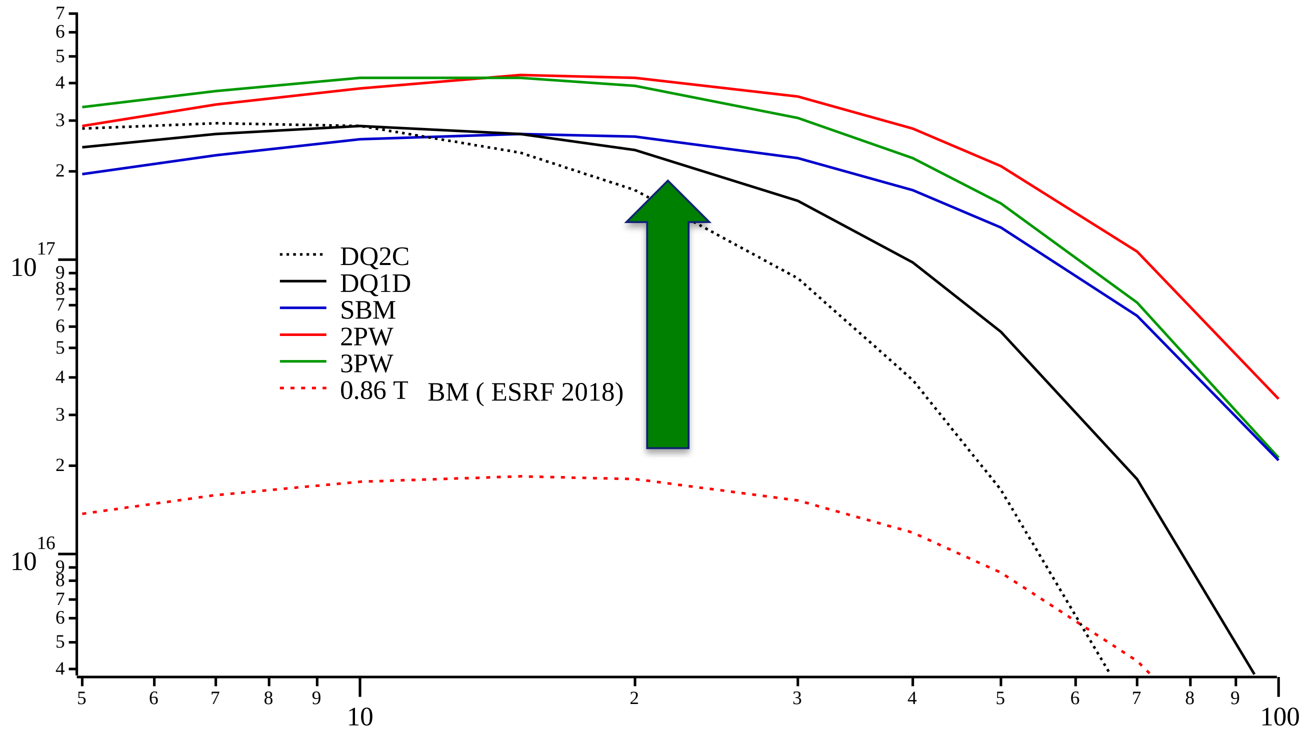
2PW/3PW

SBM



~ 120 mm drift space for new additional source

BM SOURCES: BRILLIANCE



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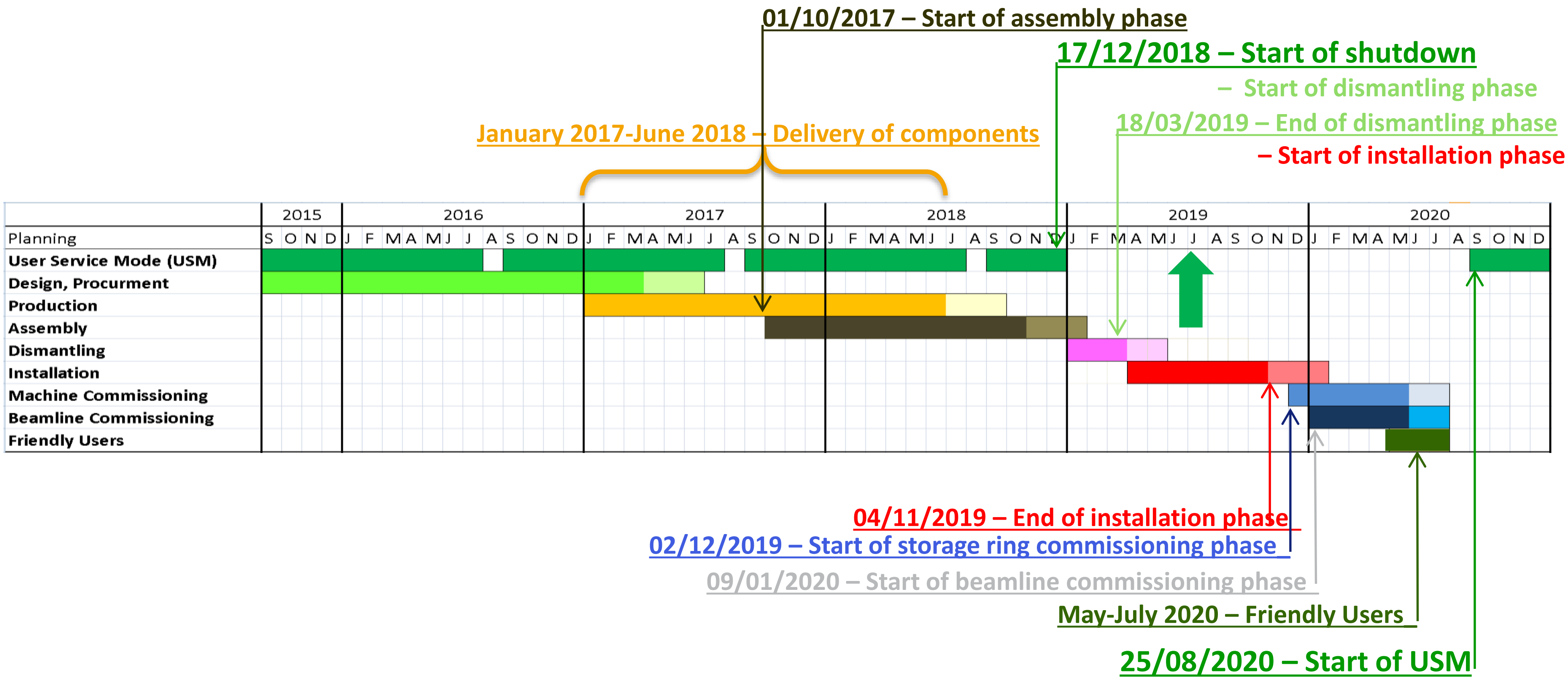
EBS MASTER PLAN (2015-2020)

Master Plan and Major Milestones



EBS: STATUS

24 June 2019

- All magnet girders in the SR tunnel
- RF cavities & waveguides installed
- Front ends installed
- Cabling and piping in progress
- Transfer line Booster/SR in progress

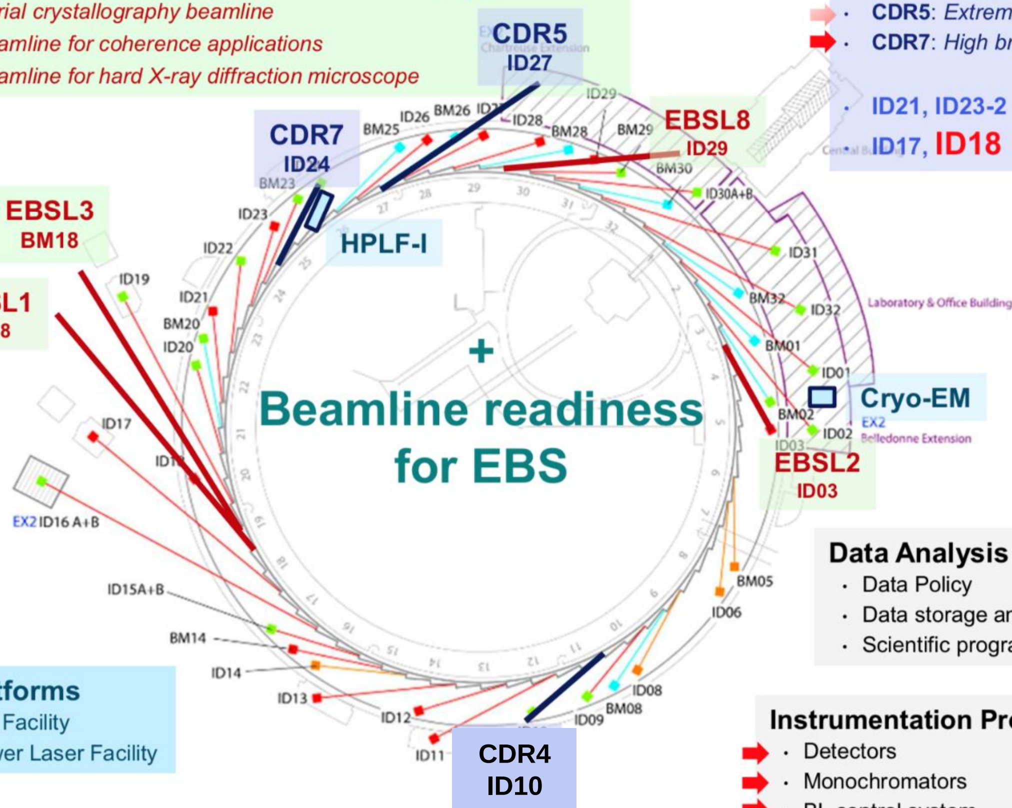
- From 15 July to end of October: straight sections
  - Vacuum chambers
  - Insertion device installation
    - 70 undulators including 10 IVUs/CPMUs

PHOTON SOURCES: NEXT STEP

Main focus : use of transverse coherence

EBS Beamlines
- **EBSL3**: *High throughput large field phase-contrast tomography beamline*
- **EBSL8**: *Serial crystallography beamline*
- **EBSL1**: *Beamline for coherence applications*
- **EBSL2**: *Beamline for hard X-ray diffraction microscope*

Refurbishment Programme
- **CDR4**: *Surface science*
- **CDR5**: *Extreme conditions*
- **CDR7**: *High brilliance XAS*
- ID21, ID23-2
- ID17, ID18 → ID14



Insertions devices from 2020:

intensive construction of CPMUs

- CPMU16
- Min gap 4 mm
- 2 m long segments

Data Analysis as a Service
- Data Policy
- Data storage and archiving
- Scientific programming

User Platforms
- Cryo-EM Facility
- High Power Laser Facility

Instrumentation Programme
- Detectors
- Monochromators
- BL control system

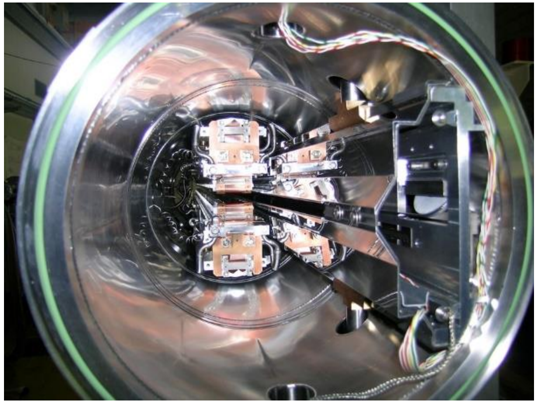
EBS: MAGNETIC MEASUREMENT ACTIVITIES

Accelerator magnets:

- Stretched Wire (SW) measurements
  - SW benches built by ESRF (see ESRF talks @ IMMW20)
    - 5 units at manufacturer/s premises
    - 3 units at ESRF
- SW benches sold after magnet construction (6 units)
- ESRF can provide turn key systems

Insertion Devices:

- Stretched wire for Field integral measurements
- Hall probe mapping
- Dedicated system for CPMU measurements
  - Integrable in vacuum chamber
  - Field integral measurements
  - Local field mapping



- ESRF talks this week
- Lab visits on Thursday

INDUSTRY INVOLVED IN EBS MAGNETS

Electro-magnets

- BINP (Russia)
- DANFYSIK (Denmark)
- SEF (France)
- SIGMAPHY (France)
- TESLA Engineering (UK)

Permanent- magnets

- Raw Iron material: Dillinger (Germany)
- Iron machining CECOM (It), AMF (UK)
- Permanent magnet material: MAGSOUND (China)

The European Synchrotron | ESRF

4^{TH} GENERATION SR LIGHT SOURCES: FEW COMMENTS

The path to lower emittance in SR based light sources has been opened with new MBA lattices

- Green field facilities
  - MAX IV, SIRIUS, HEPS

- Feasible Upgrades
  - ESRF, APS, ALS, SLS,SPRING8, SOLEIL, DIAMOND, …..,~ every 3^{rd} generation light sources
  - Use or permanent magnets due to high compactness & energy saving
  - Increasing magnet activities in comings years

What next ?

- Limiting factor in 4^{th} GLS will be longitudinal: energy-time
  - Undulator radiation dominated by energy spread of electron beam
  - Time structure for longitudinal coherence in electron bunches : peak brilliance
  - Example: EEHG @ SLS2

Probably a central topic for 5^{th} generation SR light sources

IMMW21

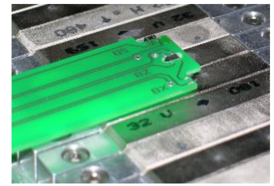
ESRF

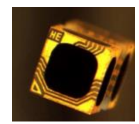
EPN Science Campus
- EMBL
- ESRF
- IBS
- ILL
- PSB
- PSCM

IMMW21 @ Hotel Mercure Grenoble Centre Président

IMMW21: SCOPE & CONTEXT

- **Scope**: mix together developers and users in magnetic measurements
  - Sensors
  - Methods
  - Ideas





- **Context**
  - 4th generation SR light sources
    - Magnetic measurements of new types of accelerator magnets
    - New generation of Insertion Devices (shorter period, smaller gap)
    - Transfer of know how to industry

IMMW21: PARTICIPATION& ORGANIZATION

- 75 participants
  - 17 countries
  - 8 colleagues from IHEP (China) could not get the visa on time

International Scientific Organizing Committee

Name	Affiliation
Marco Buzio	CERN
Josep Campmany	CELLS
Joel Chavanne	ESRF
Hwang Ching-Shiang	NSRRC
Joseph DiMarco	FNAL
Animesh Jain	APS
Gael Le Bec	ESRF
Ed Rial	BESSY
Stéphane Sanfilippo	PSI
Zach Wolf	SLAC

Local Organizing Committee

Name	Affiliation
Chamseddine Benabderrahmane	ESRF
Sandra Cardot	ESRF
Joël Chavanne - Workshop Chair	ESRF
Gaël Le Bec - Workshop Co-Chair	ESRF
Philippa Lean	ESRF
Loïc Lefebvre	ESRF
Reine Versteegen	ESRF

PROGRAMME & INFORMATION

IMMW21: url

https://www.esrf.eu/home/events/conferences/2019/immw21-1.html

	23/06/2019	24/06/2019	25/06/2019	26/06/2019	27/06/2019	28/06/2019
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
AM 08.30-12.00		Overview	Overview	Methods	Methods	Meas. reports
			Meas. reports		Sensors	Summary
Lunch						
PM 13.30-17.00		Sensors	Instruments	Instruments	Visit	
				Fidu. and alignment		
Evening	Welcome			Dinner		

Weather

Date	Matin	Aprèm	Matin	Aprèm
dim 23			14	32
lun 24			18	36
mar 25			20	38
mer 26			22	39
jeu 27			23	40
ven 28			23	40

Expected heat wave

27/06
Workshop is
at ESRF

TRANSFER TO/FROM ESRF AND RESTAURANT

Tram tickets (4) given to participants

- To be validated at tram station before entering the tram
- Validity is 1 hour

- Wednesday to go to the cable car for the restaurant
- Thursday to go to ESRF

See information in provided documents

Do not hesitate to contact the members of the local organizing committee for any question

INDUSTRY @ IMMW21

Industrial exhibitors: June 24 to June 26

tesla ENGINEERING LTD

DANFYSIK

SENIS magnetic & current measurement

KYMA

CAYLAR INSTRUMENTATION SCIENTIFIQUE

Metrolab Magnetic precision has a name

Sponsors

Metrolab Magnetic precision has a name

SENIS magnetic & current measurement

ESRF The European Synchrotron

THANK YOU

ENJOY IMMW21