This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

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European network
for developing new horizons for RIs

WP 4.1
Concepts of 4th generation synchrotron machines in Europe

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WP4.1 CONCEPTS OF 4TH GENERATION SYNCHROTRON MACHINES IN EUROPE

Beam dynamics:

Adapt/extend existing tools to provide a framework that may be used during design and commissioning phase of SR or to enhance performances of the existing storage rings.

- **Improve lattice modelling**
- **Perform lattice optimization and correction**
- **Simulate realistic operation conditions**

- **Apply tools to EBS and PETRAIV models**
- **improve either Inj.Eff., Lifetime or hor. Emittance.**
- **test on real beam during Machine dedicated time**

Diagnostics:

Control of vertical emittance

ESRF shares expertise to support DESY in :

- **choice of a shaker device**
- **practical design and implementation**
- **electronics for control and power driving**

See following presentation by ELENA BURATIN

ACHIEVEMENT OF FIRST MILESTONES: START COLLABORATION AND DEFINE SPECIFIC TOPICS

Beam dynamics:

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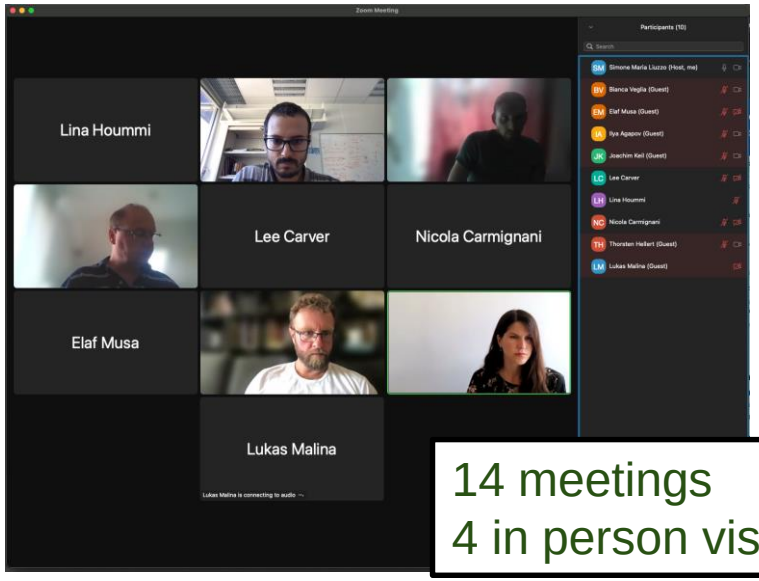


14 meetings
4 in person visits

3 topics

1) Lattice modelling including cross-talks:

For EBS this is a modelling enhancement to simulate realistic operation conditions
For PETRAIV it is a crucial step to be done before commissioning.
All future fourth generation storage rings will require lattice models including cross talks due to the small space among magnets.

2) Error and correction functions in pyAT for simulated commissioning.

pyAT presently lacks advanced methods to implement alignment errors. Also commissioning simulation sequences are missing. This is of interest for simulations of future light sources and to asses expected performances for existing ones.

3) Machine dedicate time for Optimization of Lifetime and Optics measurements based on Turn by turn data

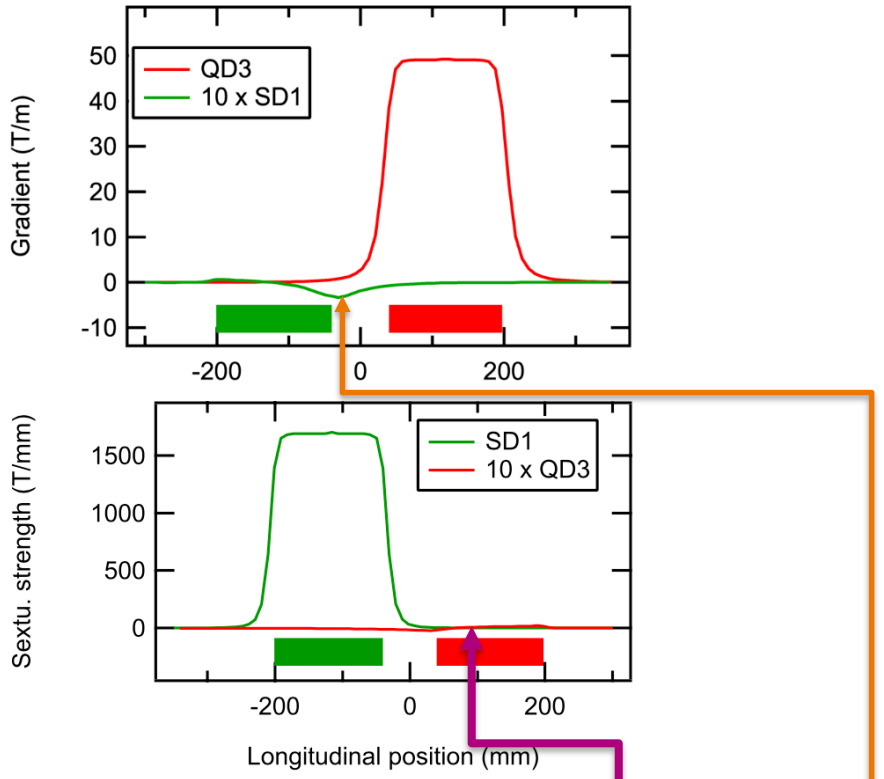
Existing tools are tested in simulations and on the electron beam at EBS and PETRAIII to prove their effectiveness for 4th generation light sources.

1) CROSS TALKS MODELLING

https://journals.aps.org/prab/abstract/10.1103/PhysRevAccelBeams.24.072401

Done: Correctors cross talk for PETRAIV

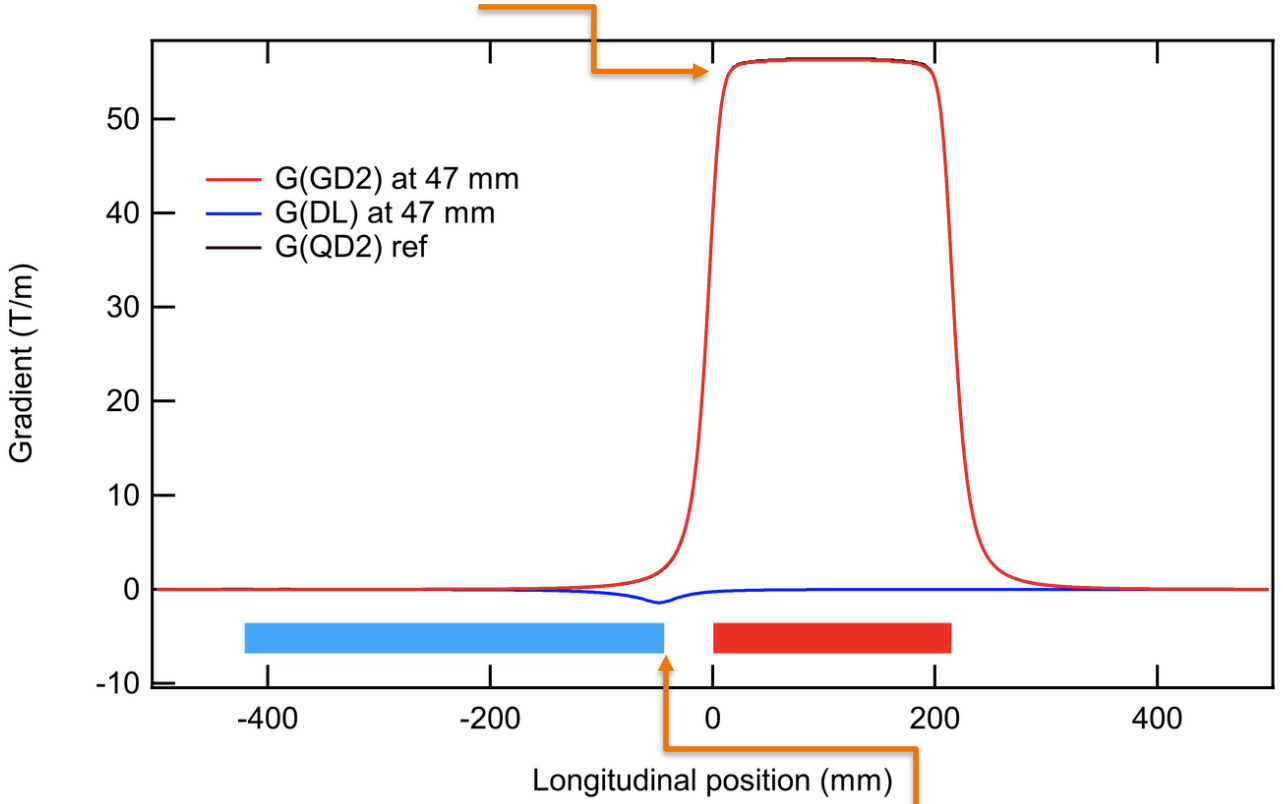
Status: **WAITING FOR MAGNET DESIGN DATA**



Additional sextupole gradient, modification of non-linear optics

To be included in EBS and PETRAIV lattice model

Reduced gradient, modification of calibration curves



Additional quadrupole gradient, modification of optics

To be included in PETRAIV lattice model

For EBS: contributes to **1.3** units of vertical tune

2) ERRORS AND CORRECTIONS SIMULATIONS IN PYAT

New software based on pyAT
(https://gitlab.esrf.fr/BeamDynamics/commissioningsimulations)

\+ **pyAT** error setting developments
(https://github.com/atcollab/at
https://accelconf.web.cern.ch/ipac2017/papers/thpab060.pdf).

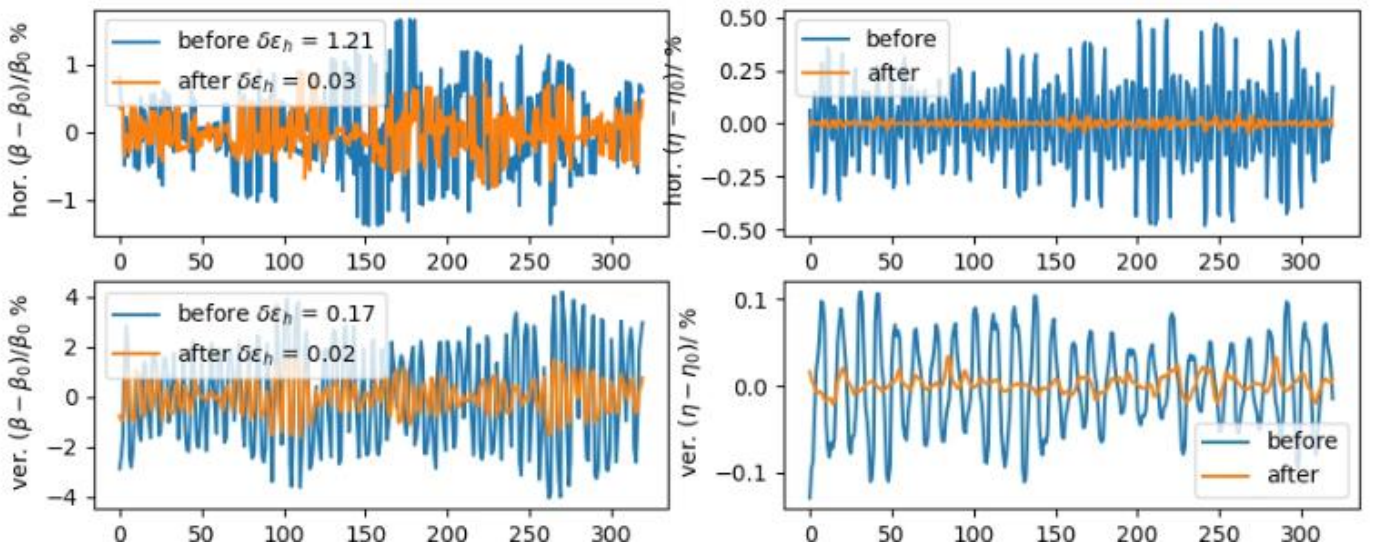
Features:

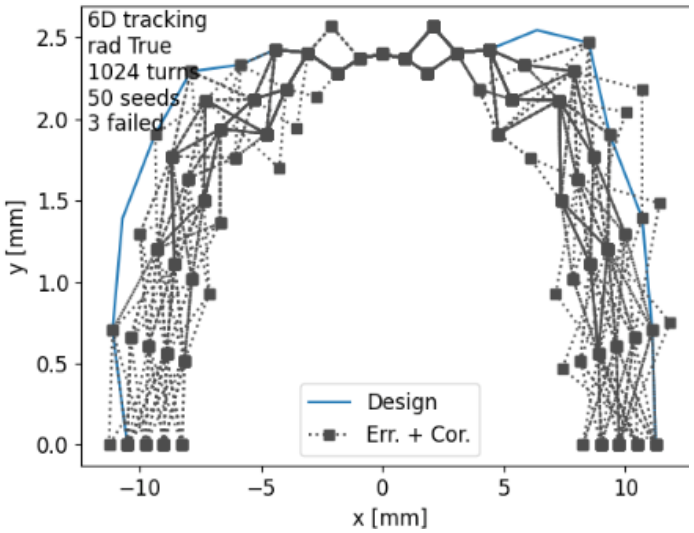
tunable commissioning sequence of corrections,

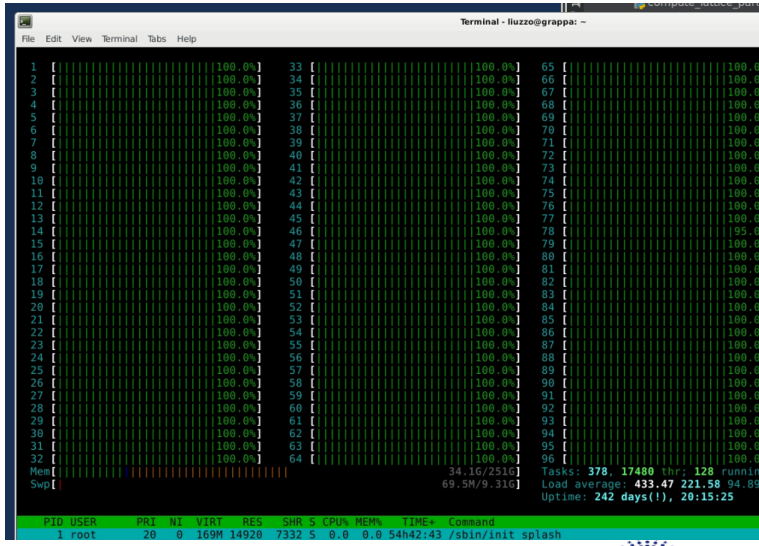
a single file for configuration of machine-dependent parameters
(tested on EBS, FCC and PETRA lattices),

distributed computation (local or cluster),

fully analytic formulas including corrections for thick elements.
https://arxiv.org/abs/1711.06589v2







TBT OPTICS MDT TIME @ EBS

OBJECTIVE: Use OMC3 https://github.com/lmalina/omc3 code to retrieve beta functions from TbT BPM data.

Use a smart filling patter to avoid change of BPM parameters (no use of MAF)

1 MDT done at EBS on 1st November 2022

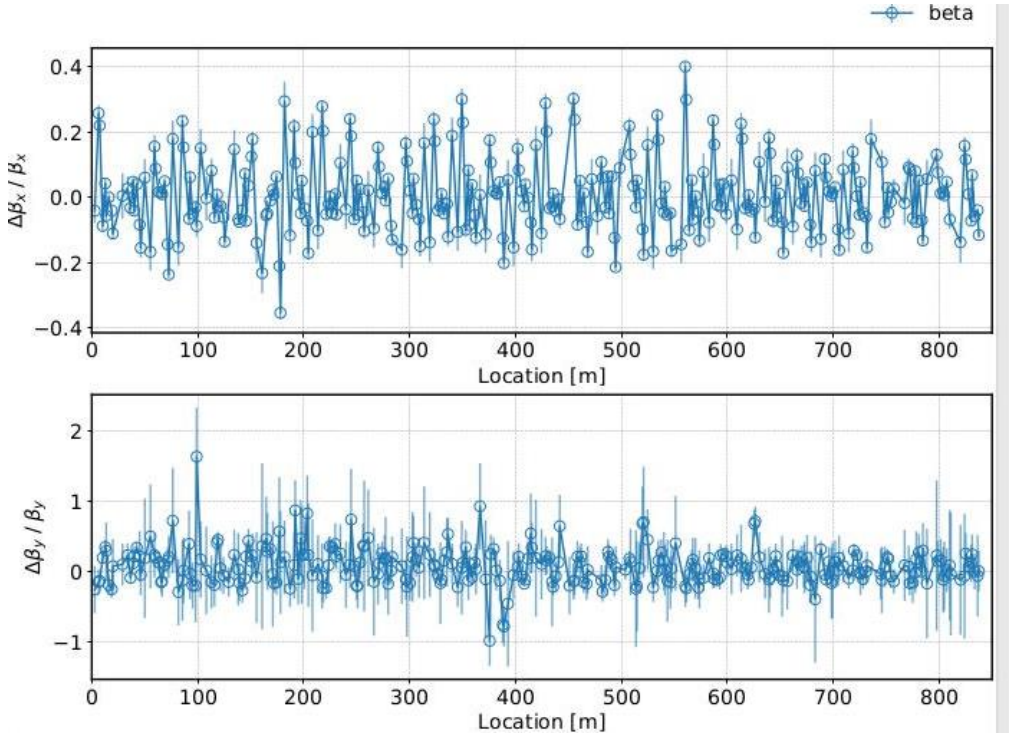
Set up of code for EBS

Tuning of TbT switch procedure

Tuning of measurement parameters with beam (shaker strengths, excitation frequency, etc…)

On-line data analysis

measurements



Simulations are being carried out in preparation of the next Machine Dedicated Time slot.

If time available and future MDT is successful, will convert the MADX part of the software to pyAT.

LIFETIME OPTIMIZATION MDT TIME @ EBS

OBJECTIVE: Use Extreemum Seeker to optimize Touschek lifetime. Compare to present optimization.

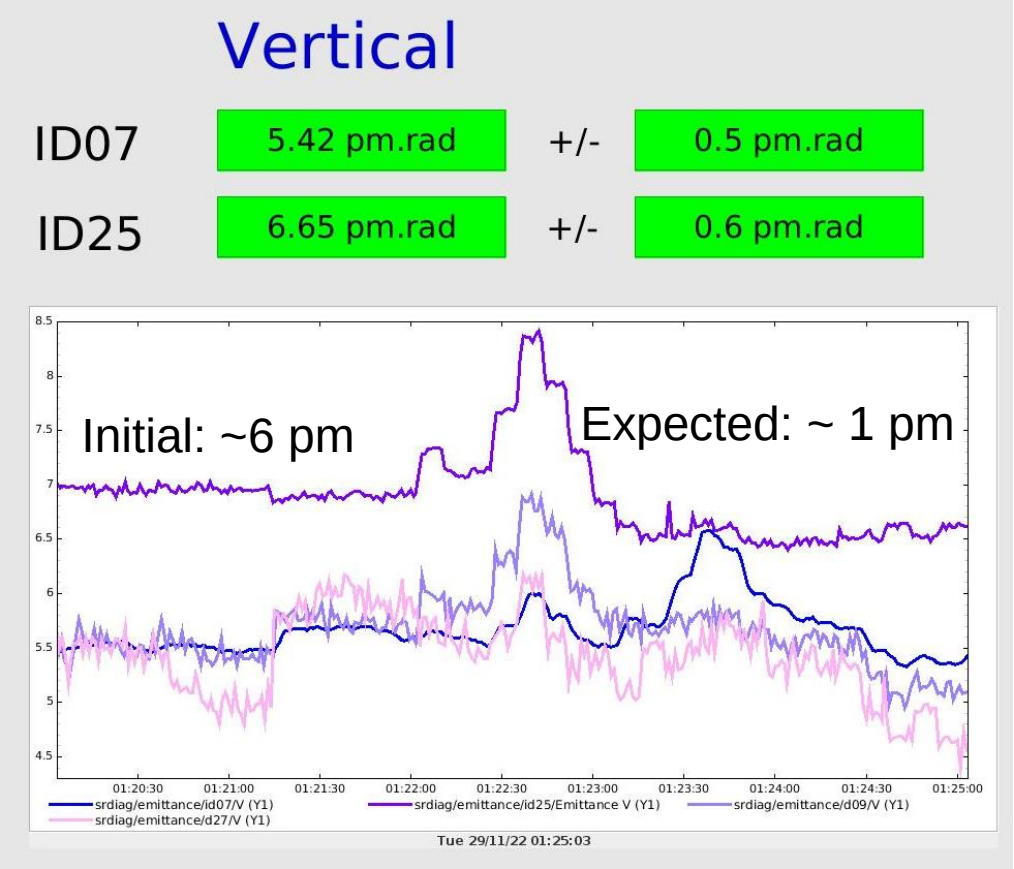
1 MDT done at EBS on 28th November 2022

Set up of code for EBS
(some esrf-jupyter issues consumed a good fraction of the MDT time)

Test on simple case: optimization of VERTICAL EMITTANCE. Vert. emittance increased in purpose and optimizer asked to recover with the same skew quadrupoles used to detune. Answer is known: artificially set skew quadrupoles should be cancelled.

Tuning of Optimizer parameters

For the moment the simple test case did not succeed.



Simulations are being carried out in preparation of the next Machine Dedicated Time slot.

If time available in a future MDT will try to use BADGER, giving way for test of several algorithms.

https://github.com/SLAC-ML/Badger

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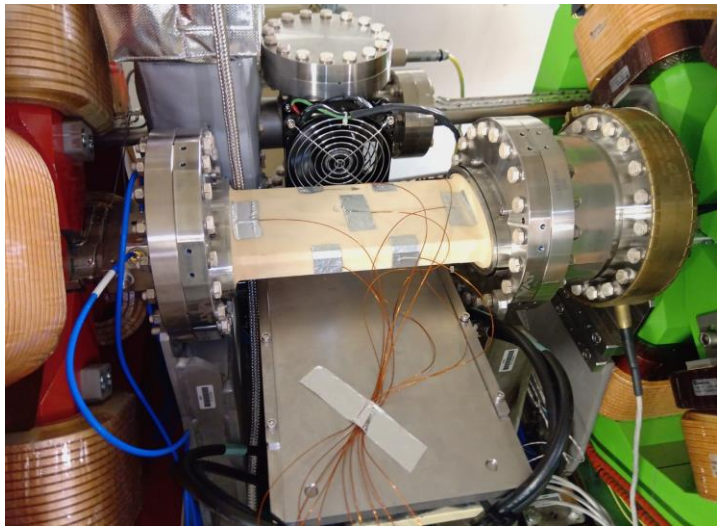
9th - 10th February 2023

Eurizon Task 4.1 on Diagnostics



Elena Buratin, on behalf of
Kees Scheidt, Friederike Ewald, Benoit Roche, Nicola Carmignani, Simone Liuzzo (ESRF),
Ilya Agapov, Sajjad Hussain Mirza, Szymon Jablonski, Holger Schlarb, Sven Pfeiffer and Gero Kube (DESY)

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EURIZON WP 4.1: DIAGNOSTICS SUB-TASKS

Several **sub-tasks** have been defined for the beam diagnostics (ESRF, DESY):

#	Task/Month	Jan. 2023	36	37	38	39	40	41	42	43	44	45	46	47	48	Jan. 2024
1	*Define the work organization (M54)*															✓
2	*Simulation task*															
3	*Emittance monitor selection*															
4	*Shaker evaluation / selection (M55)*															
5	*HW/FW/SW implementation aspects*															
6	*Summarize and write the report (D4.17)*															

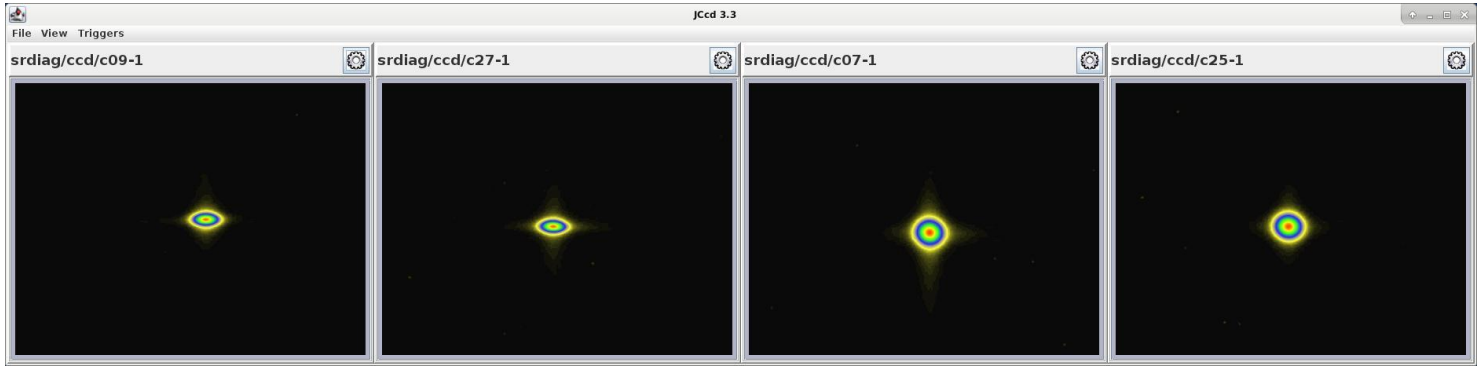
A **3-day ESRF visit** was made by Sven Pfeiffer and Gero Kube from DESY (11th -13th January 2023):

- to inspect the storage ring
- to have a practical demonstration of the use of the vertical emittance feedback
- to discuss about the best excitation noise to be used for emittance blow-up

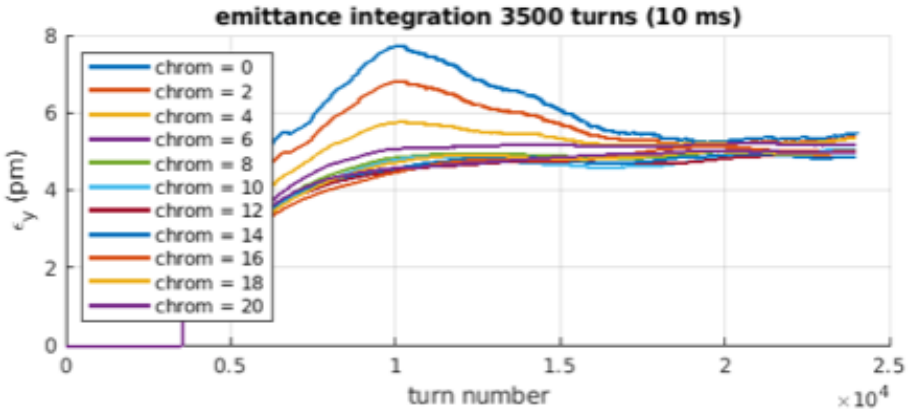
EBS EMITTANCE MONITORS AND SIMULATIONS

Several **pinhole systems** (slits + camera) takes light from two different source types to allow energy spread measurements.

- Vertical emittance: ~1 pm with no blow-up, **10 pm** with blow-up
- Horizontal emittance: **120÷130 pm**



Vertical emittance simulation as a function of **chromaticity** and **number of turns**
[courtesy of N. Carmignani]



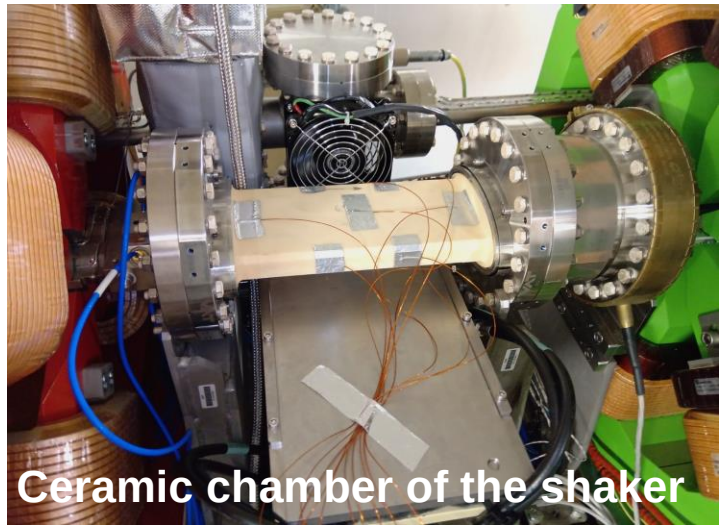
EBS SHAKERS

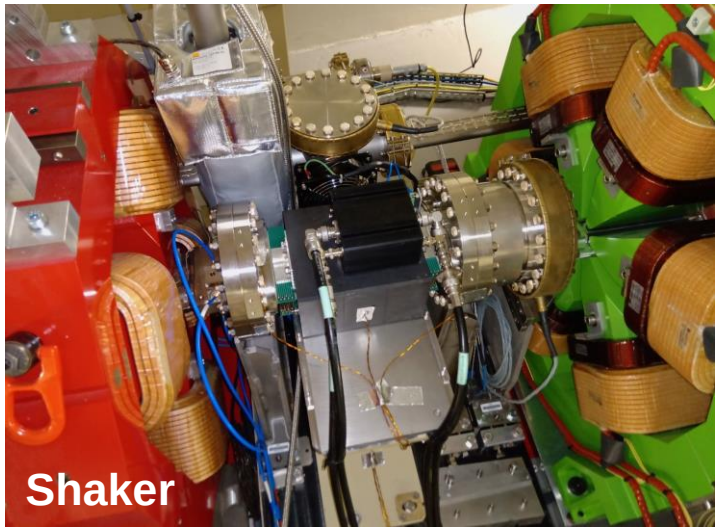
2 **shakers** installed in the storage ring:

- a Ti-coated **ceramic chamber**
- a regular **PCB** glass/epoxy substrate for the **windings** inserted in the **ferrite material**
- **RF amplifier** to drive the windings, **impedance of 50 Ohms** in installed in cell 1 and cell 26

- the thinner the coating is, the higher the bandwidth is
- **limited bandwidth of 1.5 MHz, but much more powerful than a ESRF-EBS stripline**

- used also for killing the beam (blow-up for collimator protection), compensation of kickers (injection perturbations) and aperture measurements during Machine Dedicated Time


Ceramic chamber of the shaker

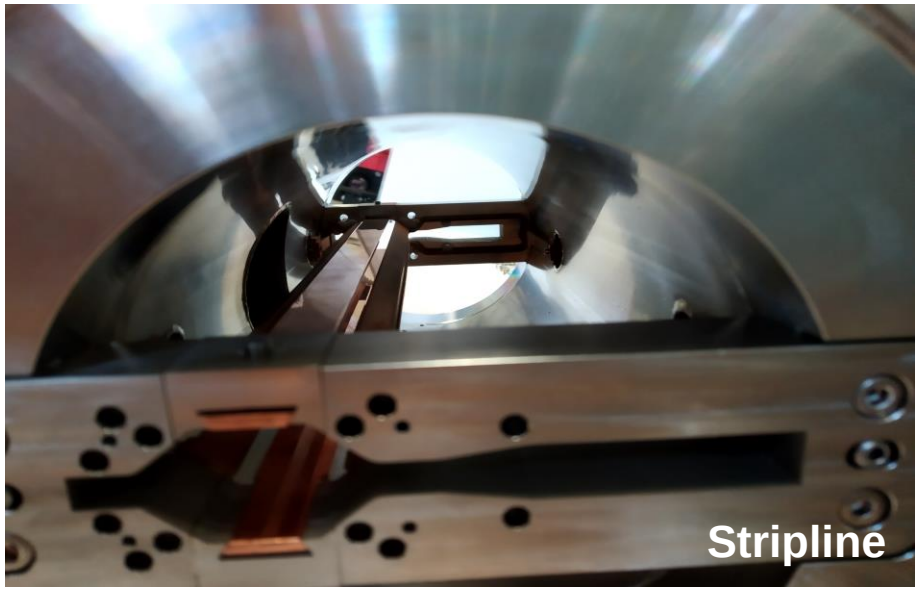

Shaker

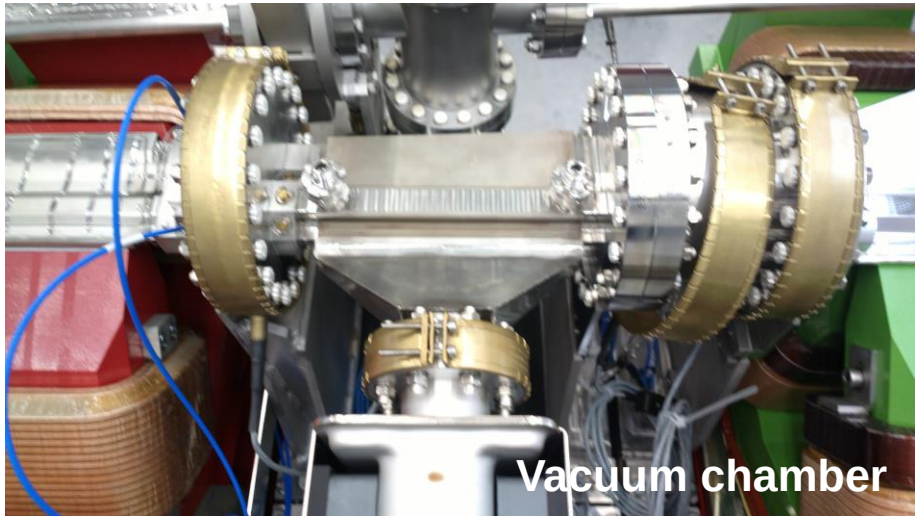
EBS STRIPLINES

3 in-vacuum **striplines** in the storage ring:

- 3 horizontal striplines + 2 vertical ones
- composed of **copper strips** for electrical continuity and signal
- Installed from cell 27 to cell 31

- used as pick-up or to act on the beam
- but less powerful than EBS shakers





NEXT STEPS

With help of future **simulations** and the definition of the **beam parameters** (chromaticity, etc.), we will be able to chose the **emittance monitor** for PETRA IV and **the best excitation noise method** for emittance blow-up**.**

Email exchange and discussions continue between the diagnostics groups of ESRF and DESY.

A **visit to DESY** is planned for June 2023.

BACK-UP SLIDES

EBS SHAKER

2 shakers are installed in the SR (cell 1 and cell 26)

The shaker has to be installed around a **ceramic chamber** with **Ti coating**.

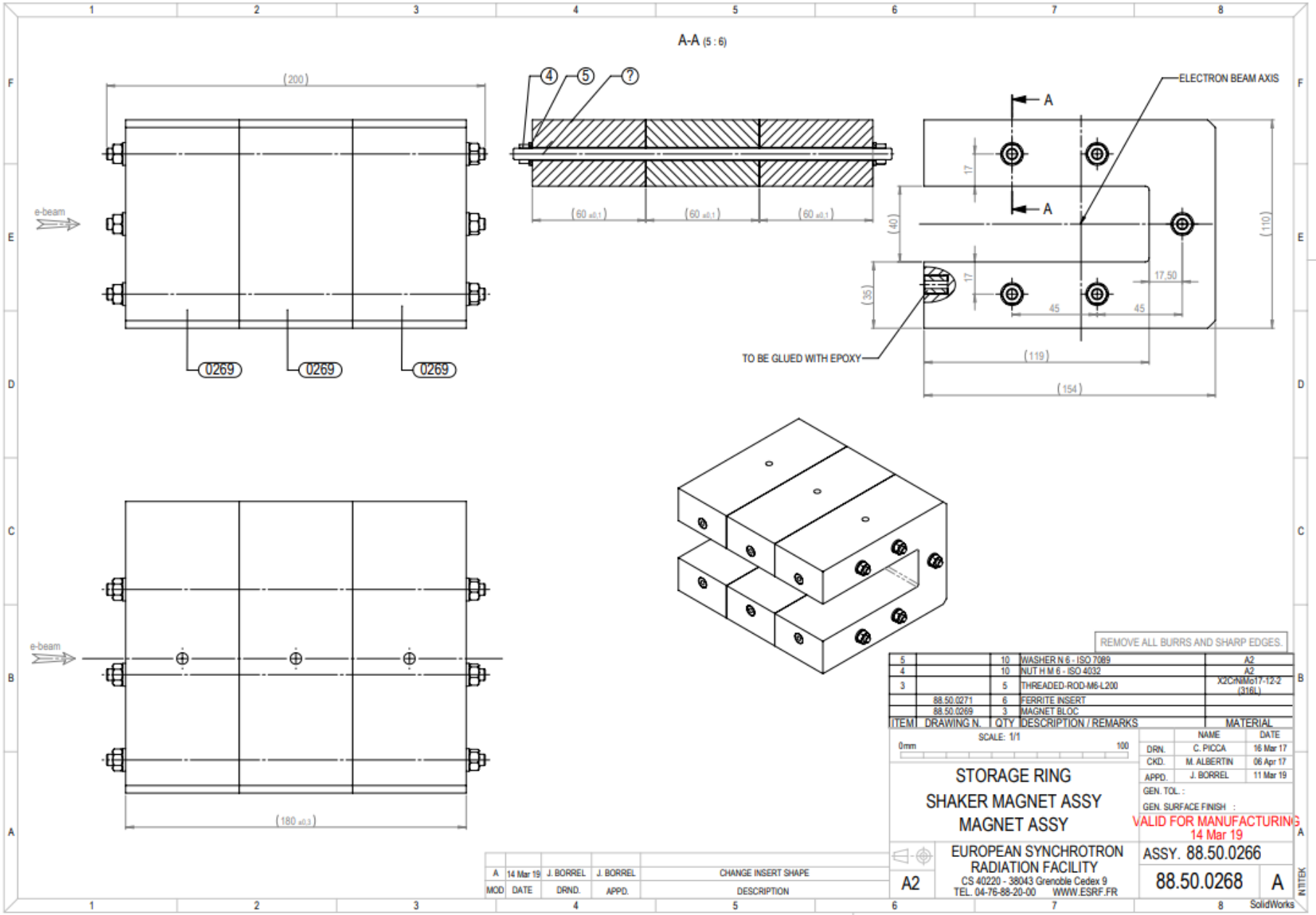
Ferrite Material: 8c11 (NiZn, μ_r=1200)

The windings inserted in the ferrite to produce the H and V magnetic fields are printed on a regular PCB glass/epoxy substrate.

Length	l	180 mm
Kick H	$l*B_H/R$	~ 2.5 µrad/A
Kick V	$l*B_V/R$	~ 2.5 µrad/A
Inductance H	L_H	18.5 µH
Inductance V	L_V	17,6 µH

EBS SHAKER

Assembly



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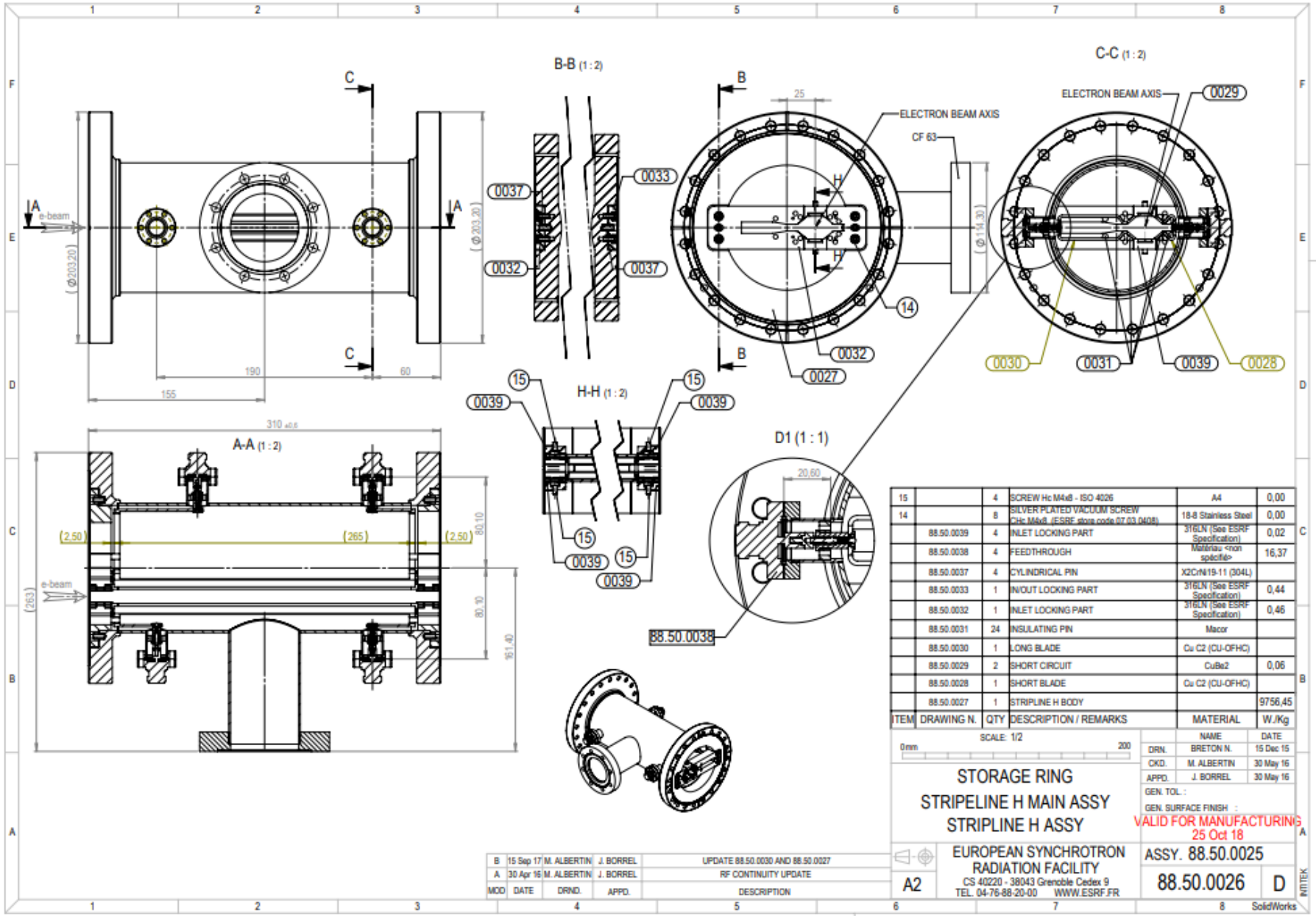
EBS HORIZONTAL STRIPLINE

Assembly



ITEM	DRAWING N.	QTY	DESCRIPTION / REMARKS	MATERIAL	W./Kg
15		4	SCREW Hc M4x8 - ISO 4026	A4	0,00
14		8	SILVER PLATED VACUUM SCREW CHc M4x8 (ESRF store code 07.03.0408)	18-8 Stainless Steel	0,00
	88.50.0039	4	INLET LOCKING PART	316LN (See ESRF Specification)	0,02
	88.50.0038	4	FEEDTHROUGH	Matériau <non spécifié>	16,37
	88.50.0037	4	CYLINDRICAL PIN	X2CrNi19-11 (304L)	
	88.50.0033	1	IN/OUT LOCKING PART	316LN (See ESRF Specification)	0,44
	88.50.0032	1	INLET LOCKING PART	316LN (See ESRF Specification)	0,46
	88.50.0031	24	INSULATING PIN	Macor	
	88.50.0030	1	LONG BLADE	Cu C2 (CU-OFHC)	
	88.50.0029	2	SHORT CIRCUIT	CuBe2	0,06
	88.50.0028	1	SHORT BLADE	Cu C2 (CU-OFHC)	
	88.50.0027	1	STRIPLINE H BODY		9756,45

	NAME	DATE
DRN.	BRETON N.	15 Dec 15
CKD.	M. ALBERTIN	30 May 16
APPD.	J. BORREL	30 May 16

MOD	DATE	DRND.	APPD.	DESCRIPTION
B	15 Sep 17	M. ALBERTIN	J. BORREL	UPDATE 88.50.0030 AND 88.50.0027
A	30 Apr 15	M. ALBERTIN	J. BORREL	RF CONTINUITY UPDATE

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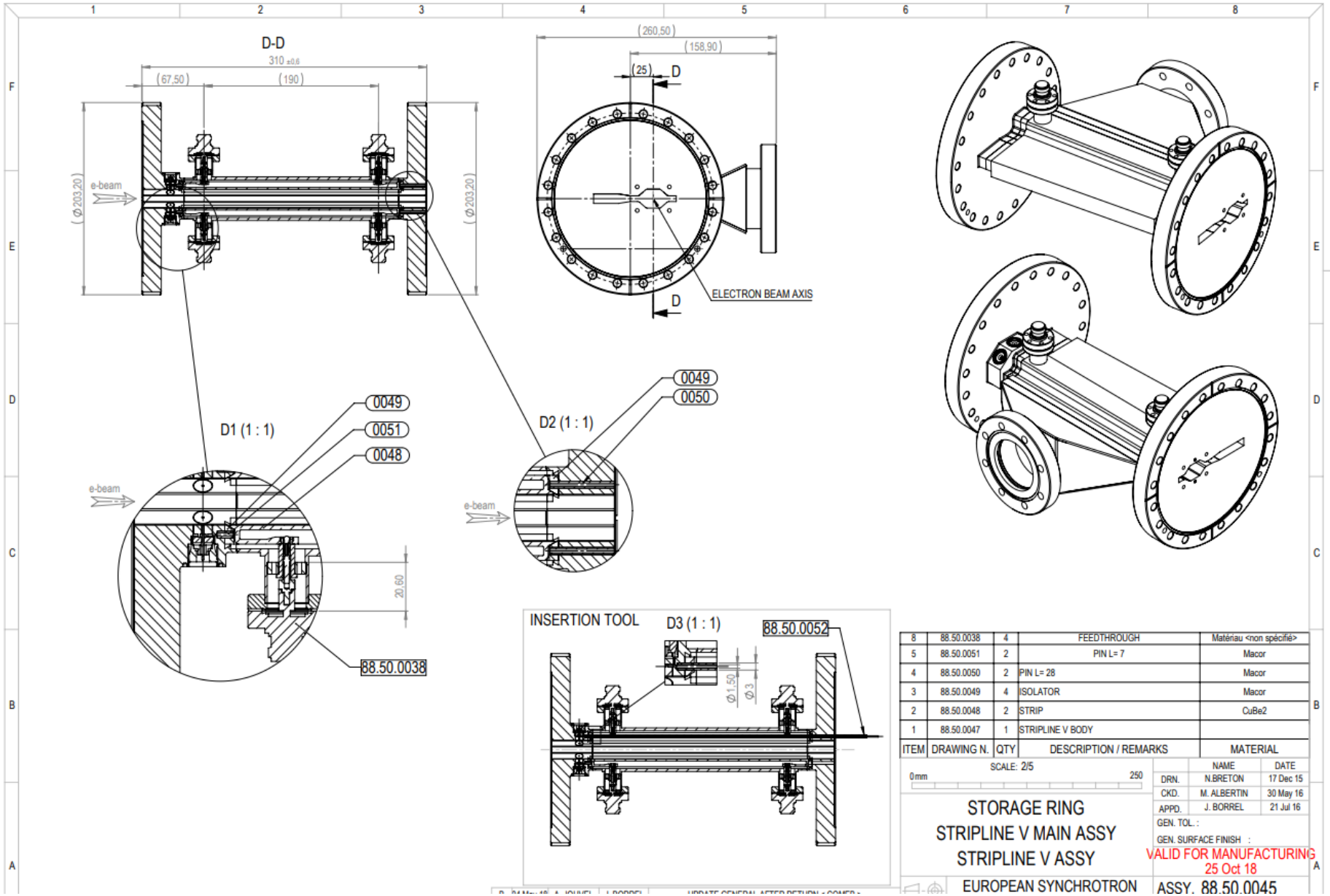
EBS VERTICAL STRIPLINE

Assembly



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8	88.50.0038	4	FEEDTHROUGH	Matériau <non spécifié>
5	88.50.0051	2	PIN L= 7	Macor
4	88.50.0050	2	PIN L= 28	Macor
3	88.50.0049	4	ISOLATOR	Macor
2	88.50.0048	2	STRIP	CuBe2
1	88.50.0047	1	STRIPLINE V BODY	

SCALE: 2/5

	NAME	DATE
DRN.	N.BRETON	17 Dec 15
CKD.	M. ALBERTIN	30 May 16
APPD.	J. BORREL	21 Jul 16

STORAGE RING
STRIPLINE V MAIN ASSY
STRIPLINE V ASSY

GEN. TOL. :
GEN. SURFACE FINISH :
VALID FOR MANUFACTURING
25 Oct 18

EUROPEAN SYNCHROTRON

ASSY. 88.50.0045

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