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Preliminary Studies for the SOLEIL Upgrade BPM

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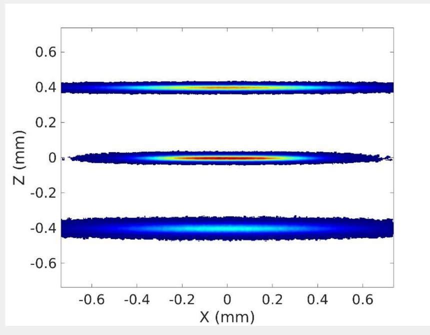
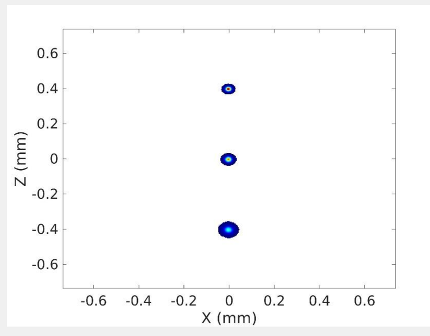
Synchrotron SOLEIL is currently preparing a machine upgrade based on multibend achromat lattice with a drastically reduced horizontal electron beam emittance (<100 pm•rad). Foreseen quadrupole and sextupole strengths will impose a small vacuum chamber diameter and the future Beam Position Monitors (BPM) will have a 16 mm inner diameter (circular shape). To minimise the BPM contribution to the longitudinal impedance, and induced heating on their mechanics, the feedthrough and button shapes must be optimised. This paper summarises the systematic electromagnetic simulations that have been carried on in order to distinguish the effect of single dimension changes (such as button thickness and shape, ceramic thickness and diameter) on the amplitudes and frequency position of the resonances. It also introduces the preliminary BPM design for the SOLEIL upgrade project

CONTEXT

Synchrotron SOLEIL has recently published the Conceptual Design Report (CDR) of the SOLEIL Upgrade. The specifications are challenging for the new beam parameters especially the beam size and emittance below 100 pm rad. The energy will remain the same as today (2.75 GeV). The project includes considerable modification of the accelerator and especially the replacement of the storage ring for a new multi bend achromat lattice. Natural bunch length will be 9 ps RMS, lengthened to 30 ps RMS by a harmonic cavity to preserve the transverse emittance and beam lifetime.

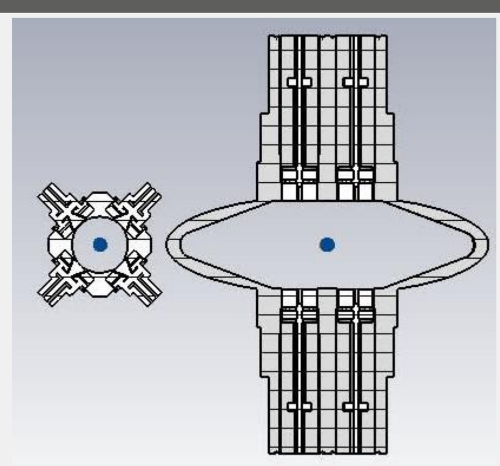
Comparison of the transverse beam profiles (x: horizontal, z: vertical plane) of the present SOLEIL (left) for 3 types of straight sections (short, medium and long / plots shifted for convenience) with 1% coupling and SOLEIL upgrade CDR reference lattice (right) with 50 pm.rad emittance.

	SOLEIL	*SOLEIL Upgrade*
Circumference (m)	354.097	353.74
Beam energy (GeV)	2.75	2.75
maximum beam current (mA)	500	500
Natural emittance (pm.rad)	3900	80
Bunch length rms (ps)	15	9
BPM vacuum chamber (mm)	70/25	16
Number of BPM	122	~200

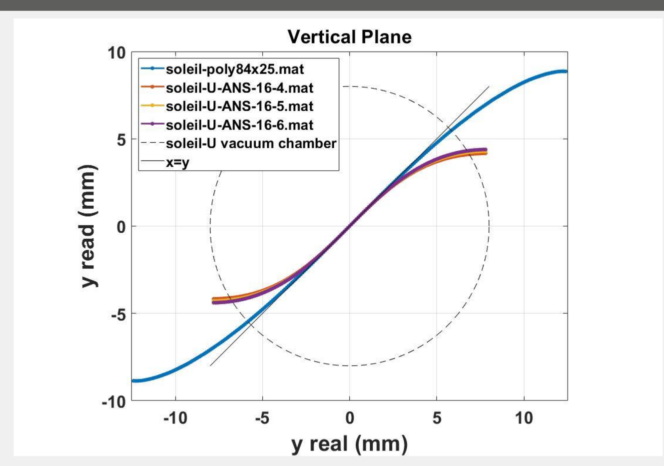
Main parameters of the present and CDR reference lattice

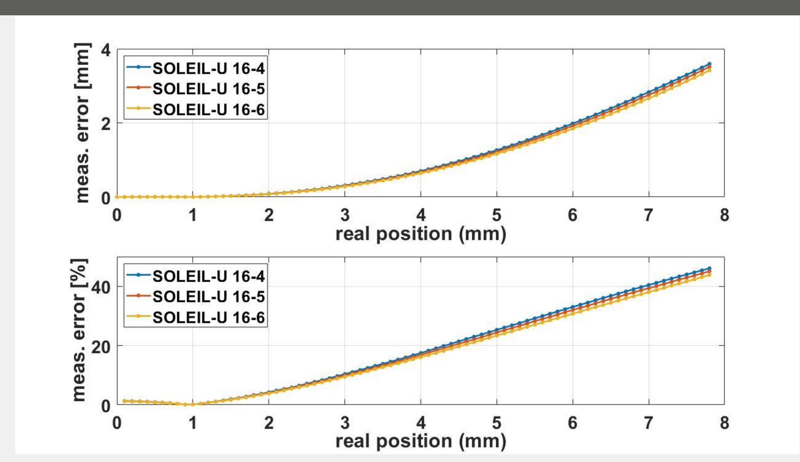
BPM CHALLENGES

The BPM sensors for the SOLEIL upgrade will be the usual RF button pickups installed at 45° on the vacuum chamber. 200 position measurement units are considered in the CDR reference lattice. In order to protect the BPM from possible heating due to synchrotron radiation, its internal diameter is enlarged to 16 mm. The challenge will be the manufacturing of a small dimension pickup and its positioning on the BPM body with respect to tight tolerances in order to maintain an absolute position.



Comparison between the current (right) and the future BPM sizes (left)

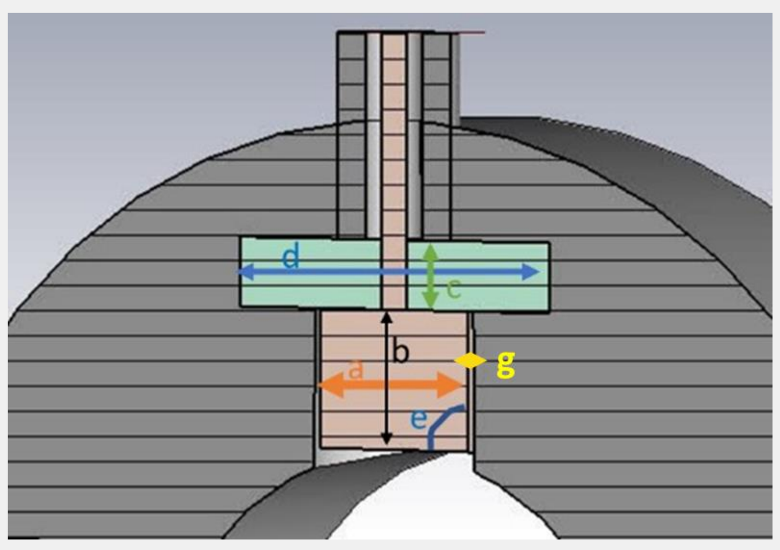




Linearity response (left) and Estimation of the error (right) for different button diameter (orange=4mm, yellow=5mm, purple=6mm) , the current BPM in blue

BPM DESIGN OPTIMISATION

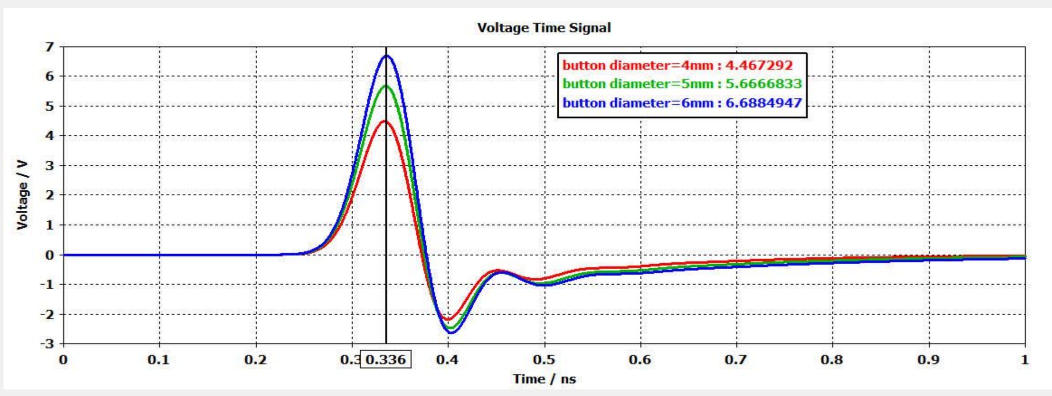
The power loss in the BPM block is one of the main parameters to be considered during its design. The BPM contribution to overall impedance budget has to be minimized and as well as the power deposited by the beam on the mechanics, the power loss depends on the beam currant , the bunch length and real part of longitudinal impedance.



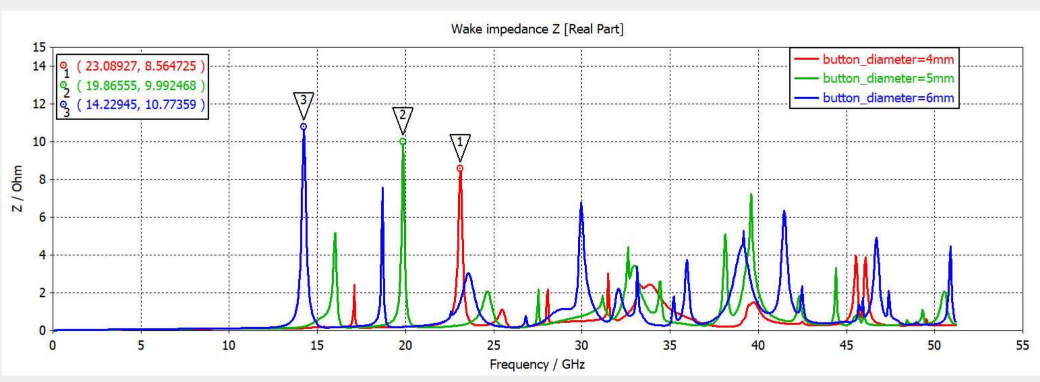
The real part of the longitudinal impedance depends directly on the geometry of the electrode. It can be optimized by varying the different parameters of this one, such as the shape of the button, the spacing of the case, the diameter and the thickness of the button and of the ceramic.

BUTTON DIAMETER EFFECT

Button diameters are studied in order to find the best compromise between high signal collection (i.e. largest button surface) and lowest contribution to the longitudinal impedance (i.e. smallest diameter)



voltage versus button diameter for bunch charge=1.44nC and σ=30ps.

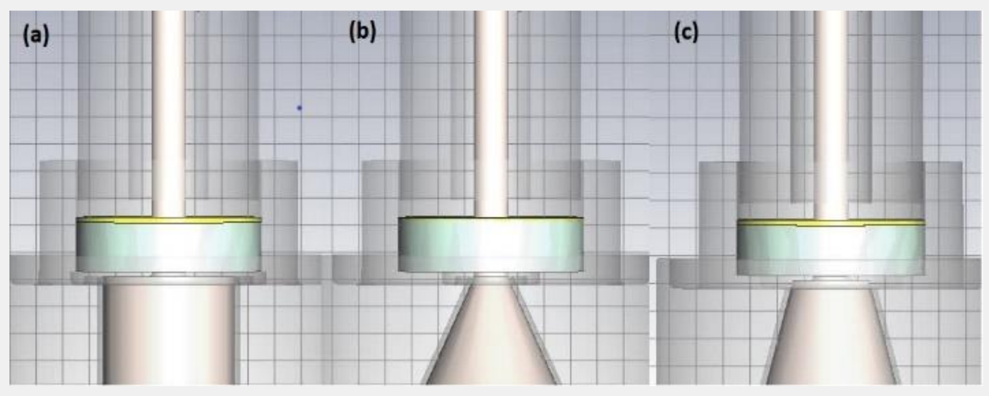


Real impedance against button diameter

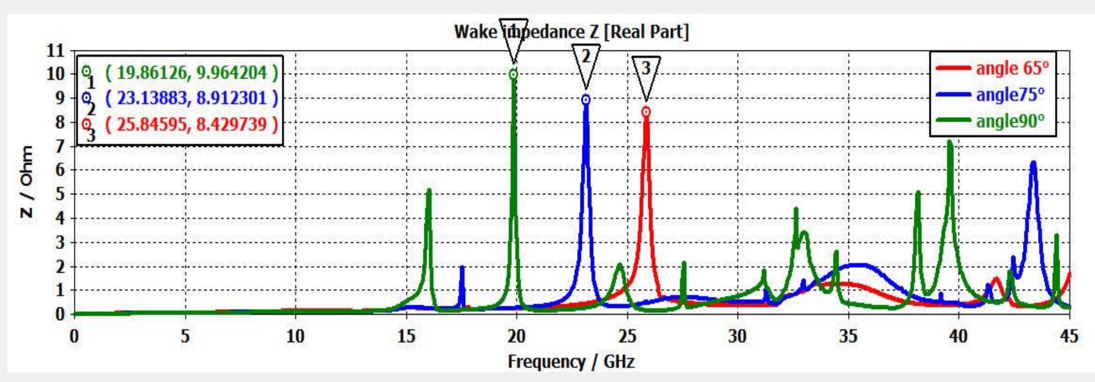
Button diameter (mm)	4	5	6
Analytical value (GHz)	22,72	18,35	15,39
Numerical computing (GHz)	23.14	19.85	14.24
Power loss (W)	2.99	4.91	7.73

analytic cut off frequency TE11, H11 mode frequency computing by CST Wakefield solver and the power loss versus button diameter

THE BUTTON SHAPE EFFECT



button angle shape simulates (a) Button 90° (b) 65° conical button. (c) 75° conical button.

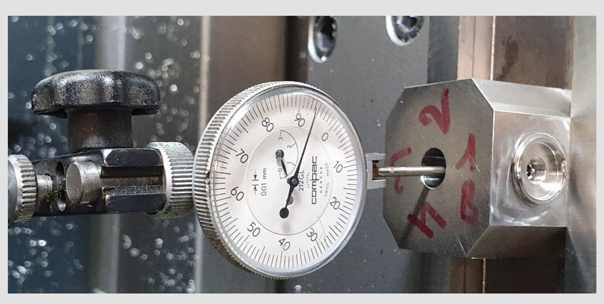


Real impedance for three button shape red 65°,blue 75° and green 90°

Button angle in degree	65	75	90
power loss (w)	3,93	4.25	4.91

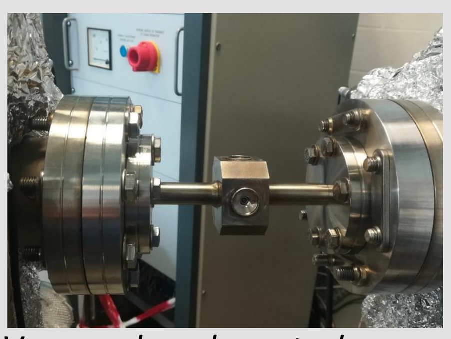
power loss versus button angle

PROTOTYPE



Electrode positioning metrology

In order to validate the mechanical integration of such a small design (initial internal diameter was even smaller at 10 mm) and BPM calibration procedure, we have realised a first prototype with commercially available feedthroughs (3 mm buttons)



Vacuum bunch control

CONCLUSION

A new button design is being validated, and a new prototype is being manufactured. Thermal simulation has still to be conducted to decide the materials for the BPM body and button, and if a cooling system will be required.