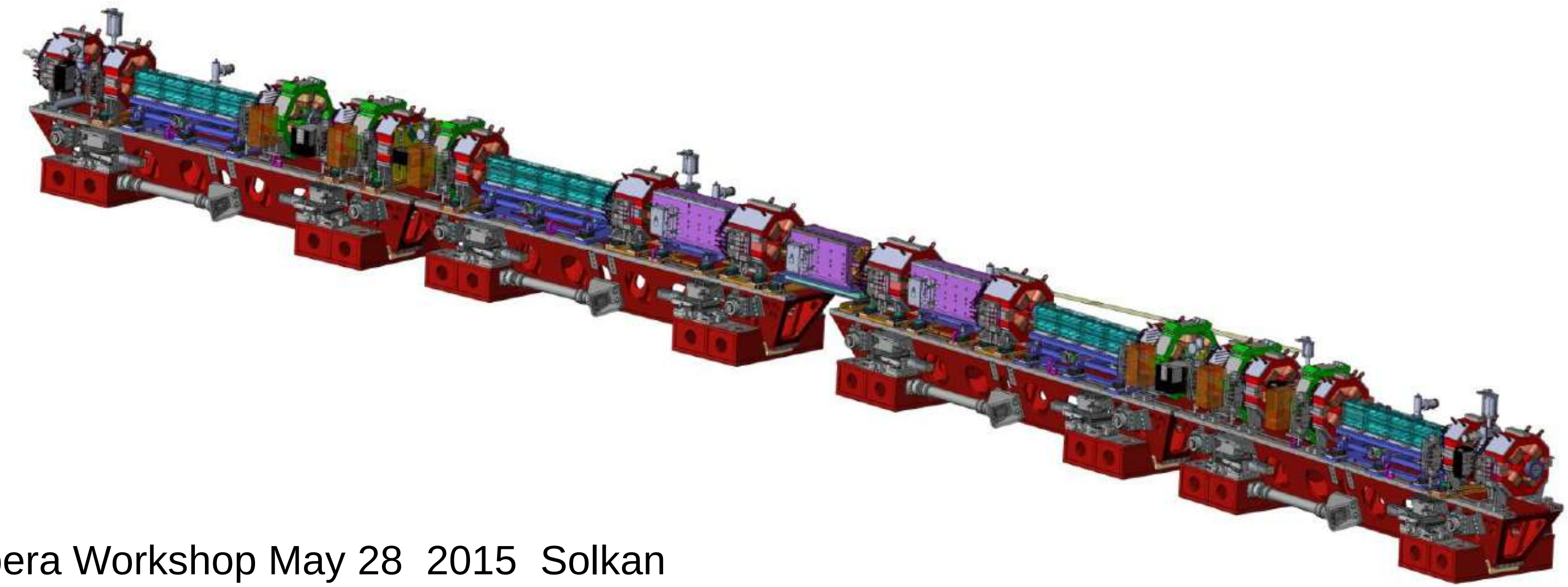
Kees Scheidt
Diagnostics Group
Accelerator & Source Division

the new ESRF low-emittance Storage Ring, its concept of both the BPM and the (Fast) Orbit Correction systems, with their consequences of implementation



Libera Workshop May 28 2015 Solkan

OUTLINE

The Low-Emittance Ring :
- motivation
- architecture & characteristics & constraints & time-schedule
- challenges & difficulties

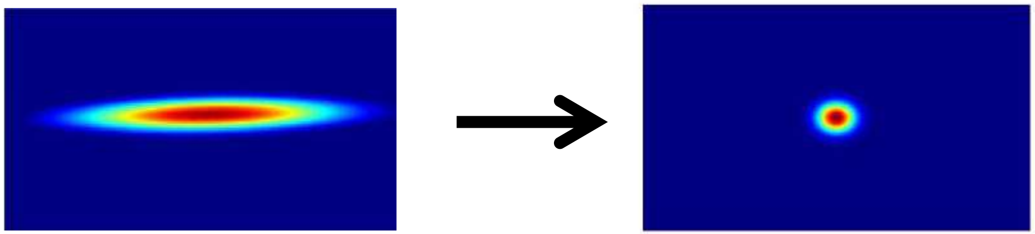
Diagnostics upgrade (?) :
- more BeamLoss Detectors → all (128) should be both fast & sensitive
- more BPMs (from 7 to 10 per cell) : but <u>NOT better</u> . . .
- emittance monitors (X-ray pinhole) : <u>LESS then today</u>, and <u>NOT better</u> . . .
- FOC and current monitors : "*copy-paste*" today's versions

BPMs in details :
- Buttons : C-f-T in process
- Blocks : 2 geometries
- RF connections & accessibility aspects
- Electronics :
  - recuperate the existing Liberas-Brillance (today >6years)
  - add a sufficiently good system . . . for the extra BPMs

Sufficiently good system :
- Spark ERXR :
  - some preliminary tests
  - specs & time-schedule
  - further ideas

Motivation :

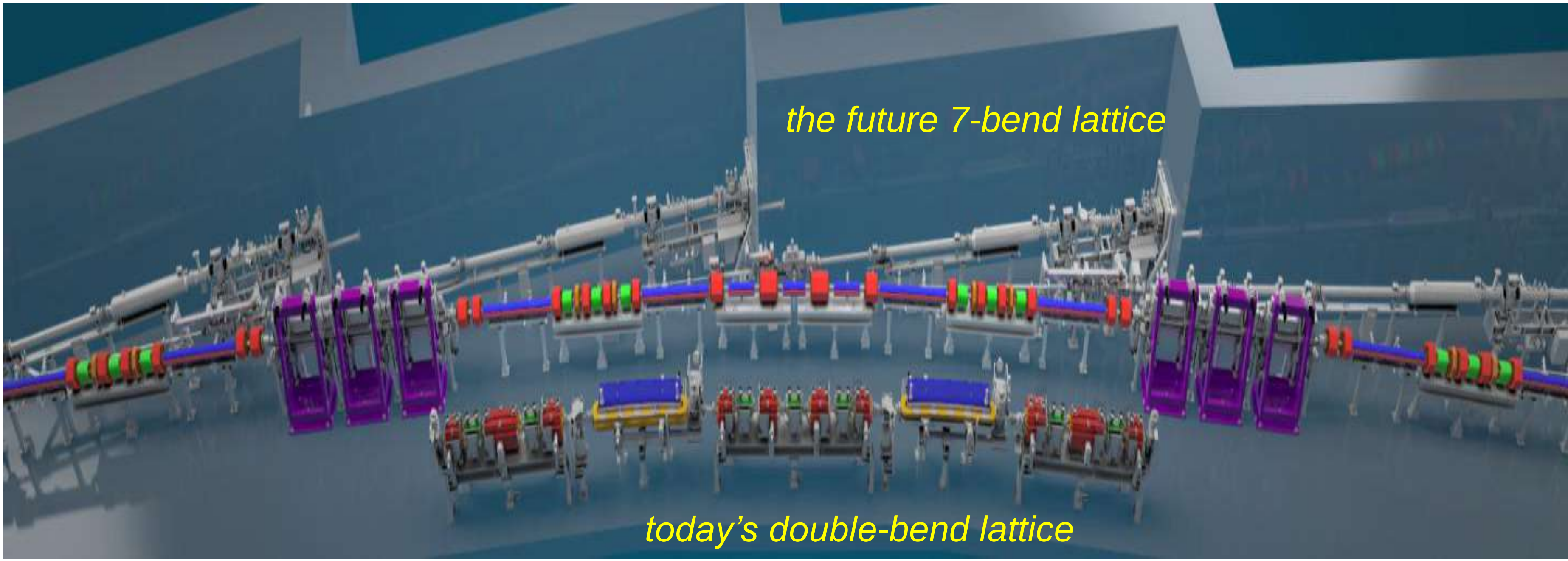
reduce the **horizontal** emittance from **4nm** to **0.15nm**



beam-line experiments can benefit from an increase in brilliance

Also, the coherence (the coherent fraction, in hor.plane) will increase

LOW-EMITTANCE RING AT THE ESRF



when : 2019 → the full year to <u>dismantle the old ring</u> and to <u>install the new</u>

major constraint : keep all X-ray beamlines at the same location

and : keep all Users happy until last day (19th dec 2018)

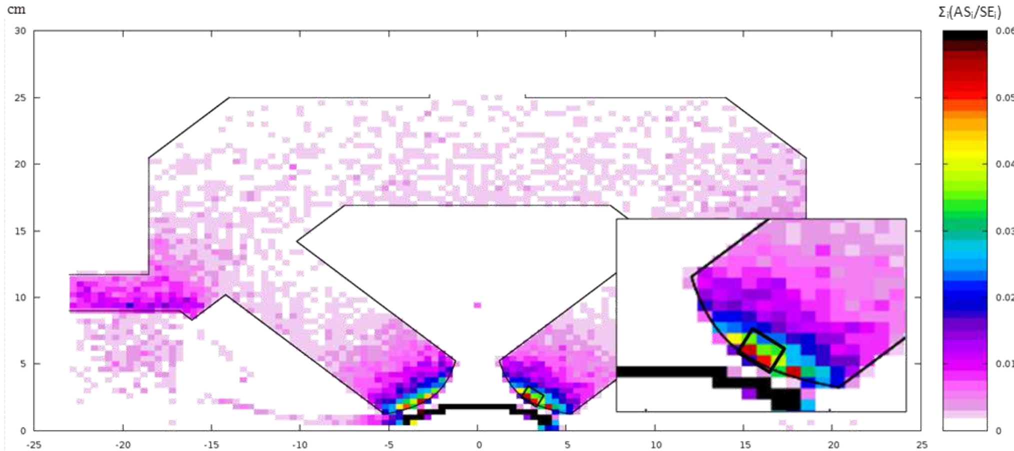
Proposed material release plan

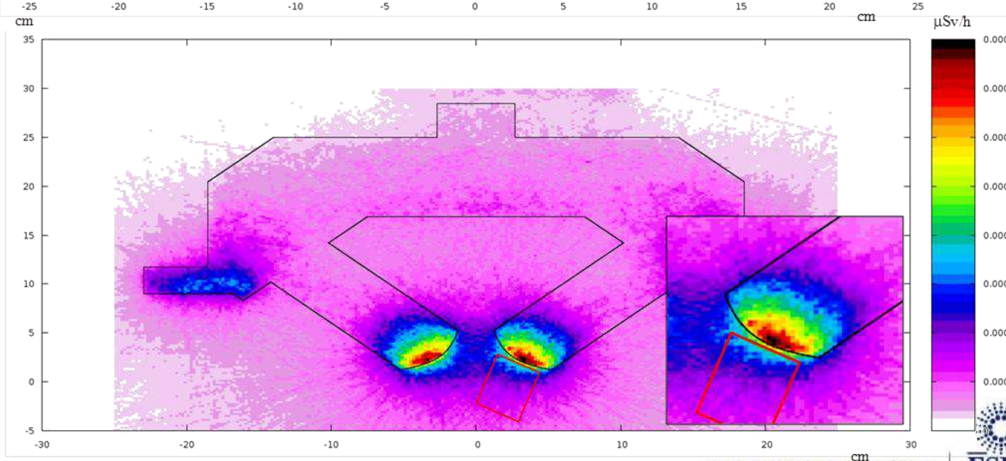
Compliance with the clearance levels defined in the Council Directive 2013/59/EURATOM

Surface dose measurements
(indistinguishable from background)

$$\sum_{all\ isotopes} \frac{AS_i}{SE_i} \leq 1$$

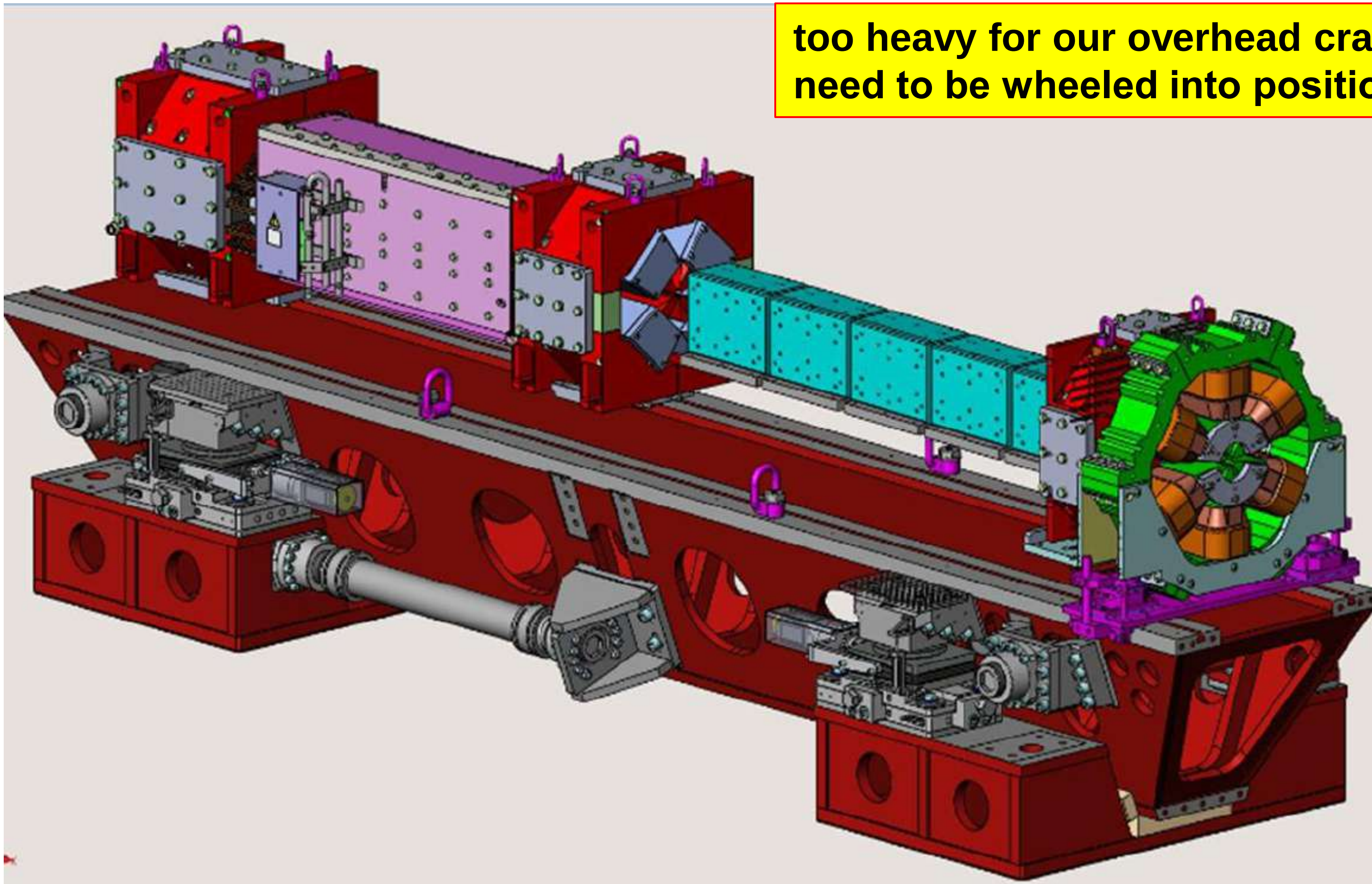
guaranteed for 1 cm^3 hotspots.



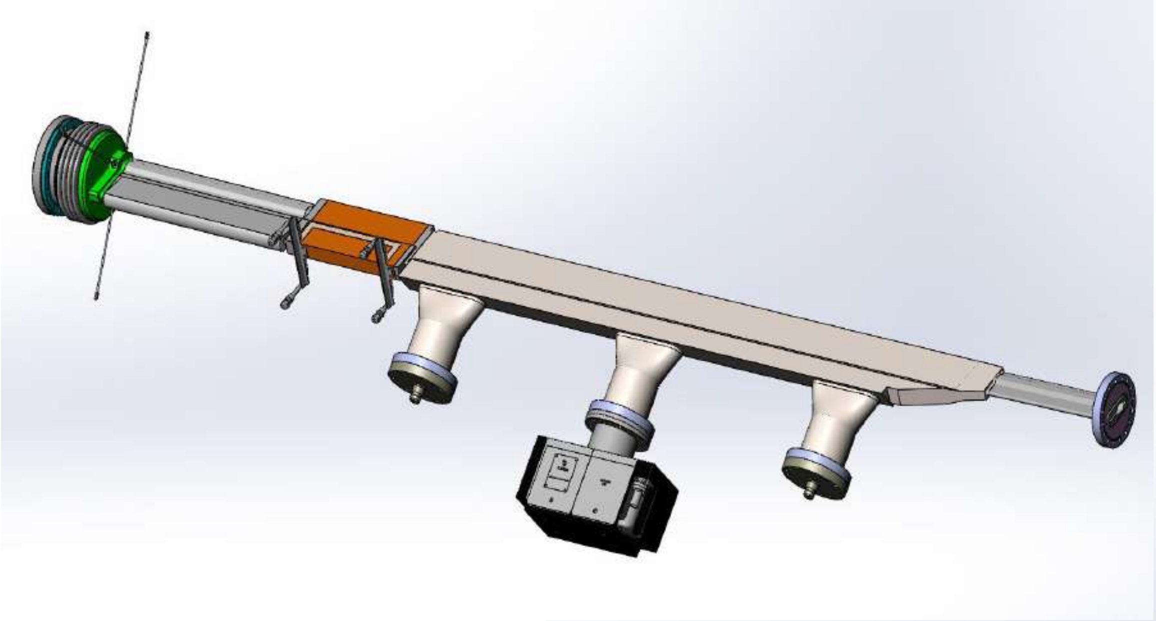


ESRF LOW-EMITTANCE RING : THE CHALLENGES : GIRDERS & TRANSPORT

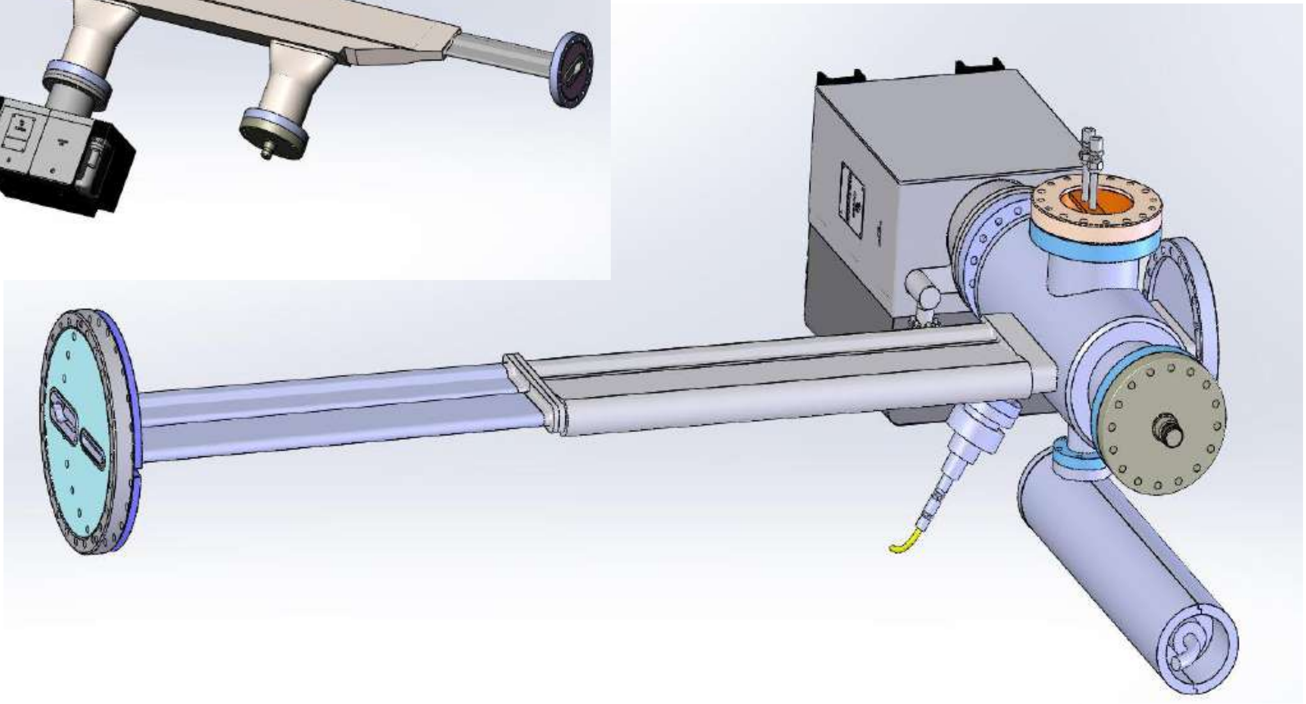
too heavy for our overhead cranes !
need to be wheeled into position …



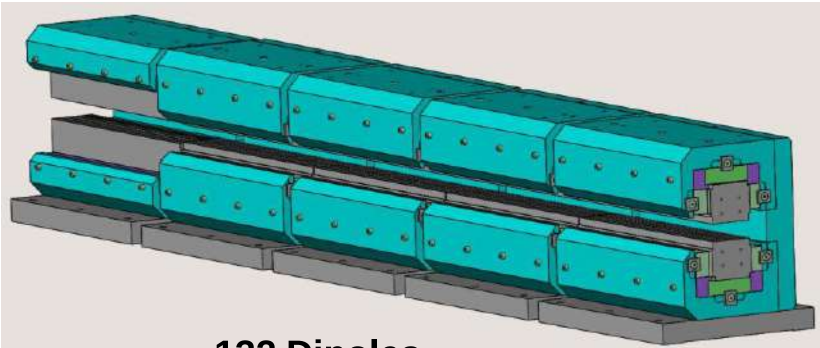
CHALLENGES : A TOTAL OF 14 *COMPLEX* VACUUM CHAMBERS PER CELL



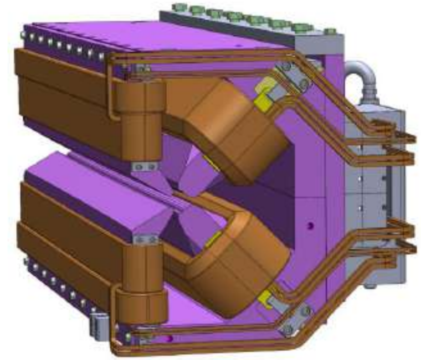
two examples shown



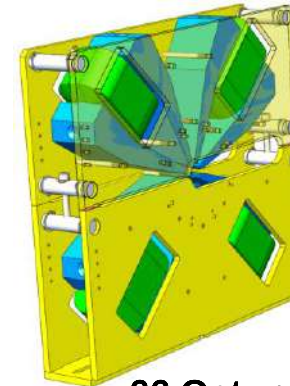
LOW-EMITTANCE RING : CHALLENGES : THE MAGNETS AND TOLERANCES



132 Dipoles

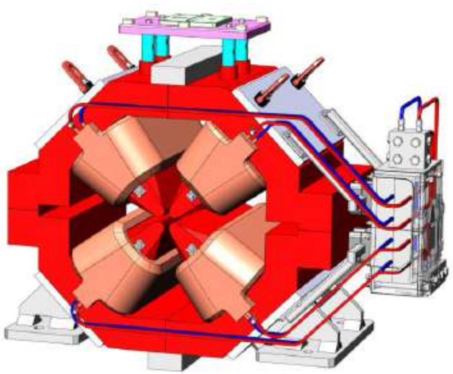


99 Dipole-quadrupoles

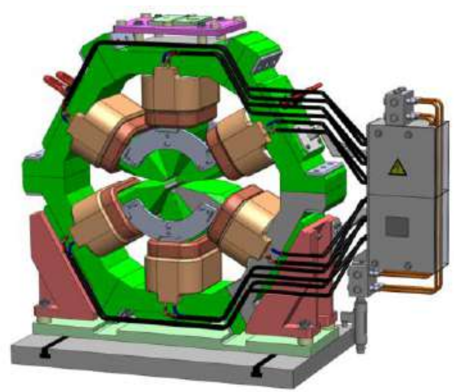


66 Octupoles

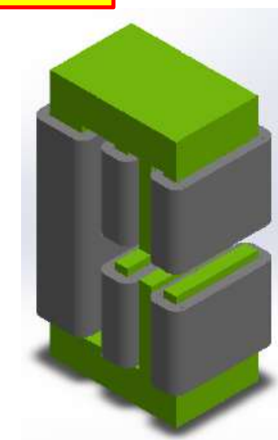
> 1000 Magnets to procure & handle in < 3 years



528 Quadrupoles



196 Sextupoles



100 Correctors

BPMS & FOC : COPY & PASTE + SOME NEW ELECTRONICS

Reminder of today's systems :

today's FOC :

7 BPMs (Liberas) per cell
3 Fast Steerers per cell

all in a dedicated 10KHz (Fast) network for the FOC with dedicated broadcasting protocols, FOC processors Tango-servers, timing network, additional nodes, etc.

New Architecture : **10 BPMs per cell**

4 new electronics (but not Fast)

6 Liberas (from today)

3 Fast steerers
6 Slow steerers

new* FOC

*** new = old - 1 Lib./cell**

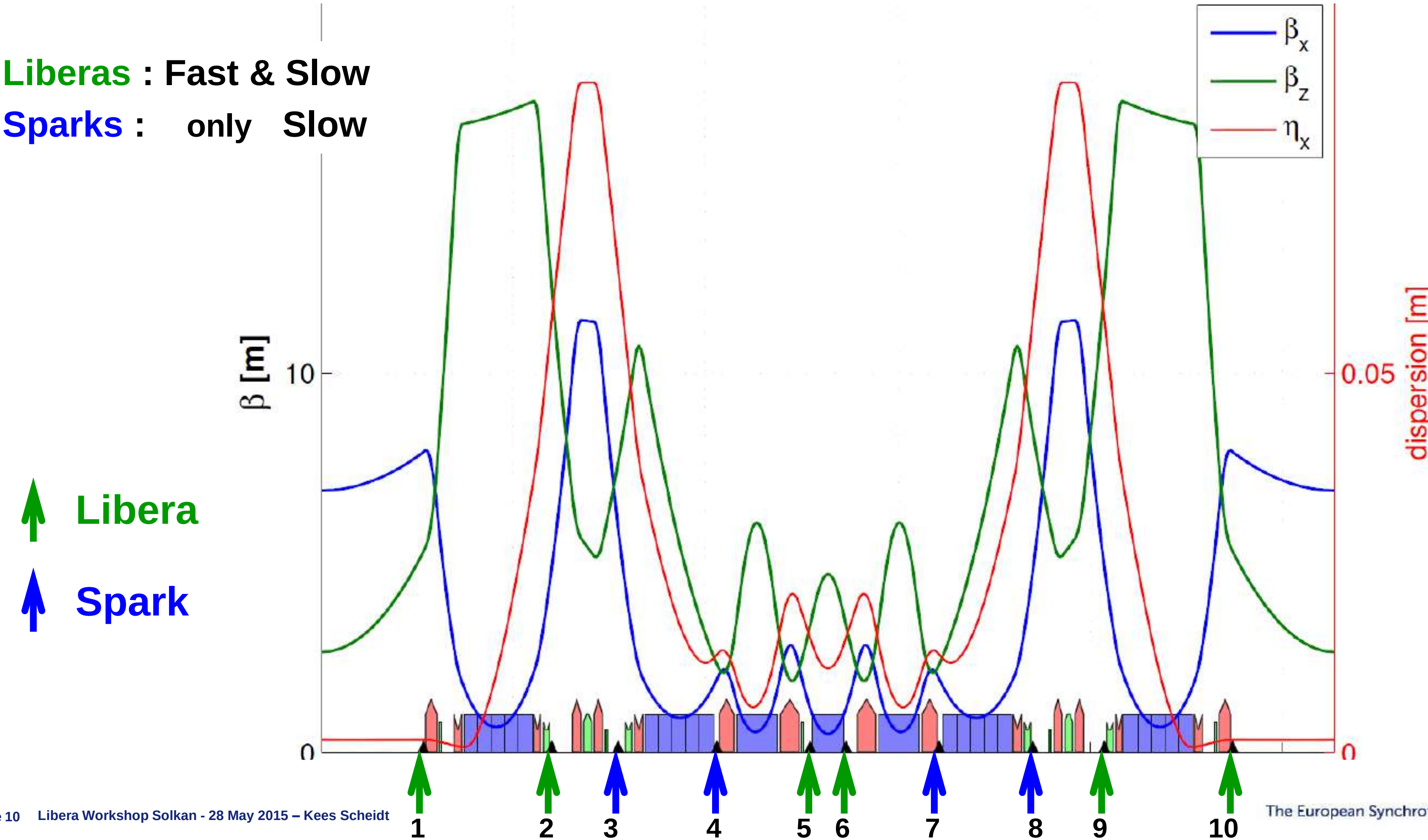
32 extra spares

FAST & SLOW ORBIT CORRECTION : 6 LIBERAS & 4 SPARKS PER CELL

X-ray beam stability for users will be identical to that of today

6 Liberas : Fast & Slow

4 Sparks : only Slow



WP-7 DIAGNOSTICS & FEEDBACKS : 6 LIBERAS & 4 SPARKS IN THE CELL

4 new electronics per cell = 128 units in the Ring :

a candidate : Spark ERXR is an upgrade from the 75 Sparks used in the new Booster BPM

- Variable RF attenuators
- PLL (software)

compared to Liberas these Sparks have NOT implemented :

- Fast-10KHz output,
- Interlock,
- Post-Mortem,
- Hi-stability / self-calibration mechanism (RF-mux + DSC)

yet, their natural stability / reproducibility (24hrs drift etc.) is expected within +/- 2 um [see measurements]

both have full functionality for Turn-by-Turn measurements (injection & lattice studies)
both have same sensitivity and noise characteristics [to be confirmed]

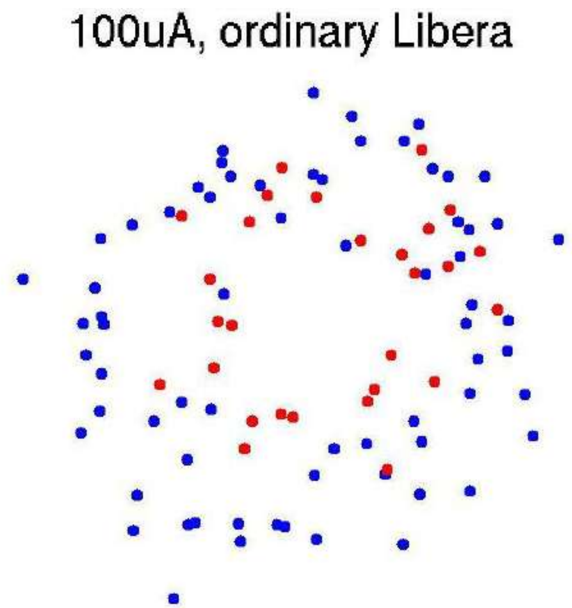
still to be added : nm output, 32bit DDC processing, offset-tune (Aug.2015)

Libera vs **Spark** :
how to compare what ?

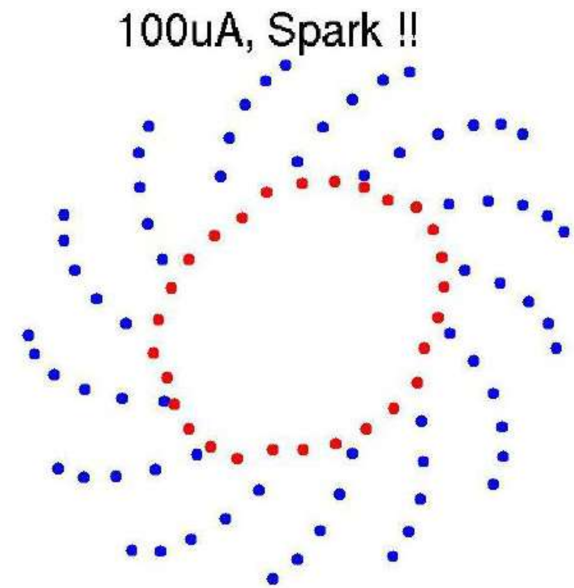
1) **T-b-T data (1MHz BW)**
   sensitivity (for ultra-low currents)
2) **~~FA-data (10KHz)~~** not available (Spark)
3) **Dec64 data (5KHz)**
4) **Short term stability (sec. - min.)**
5) **Longer term stability (e.g. 10hours)**

Libera vs **Spark** :

Phase/Space* plots from Turn-by-Turn data (at 0.1mA, **single-bunch**)



25m RF cable,
standard DDC



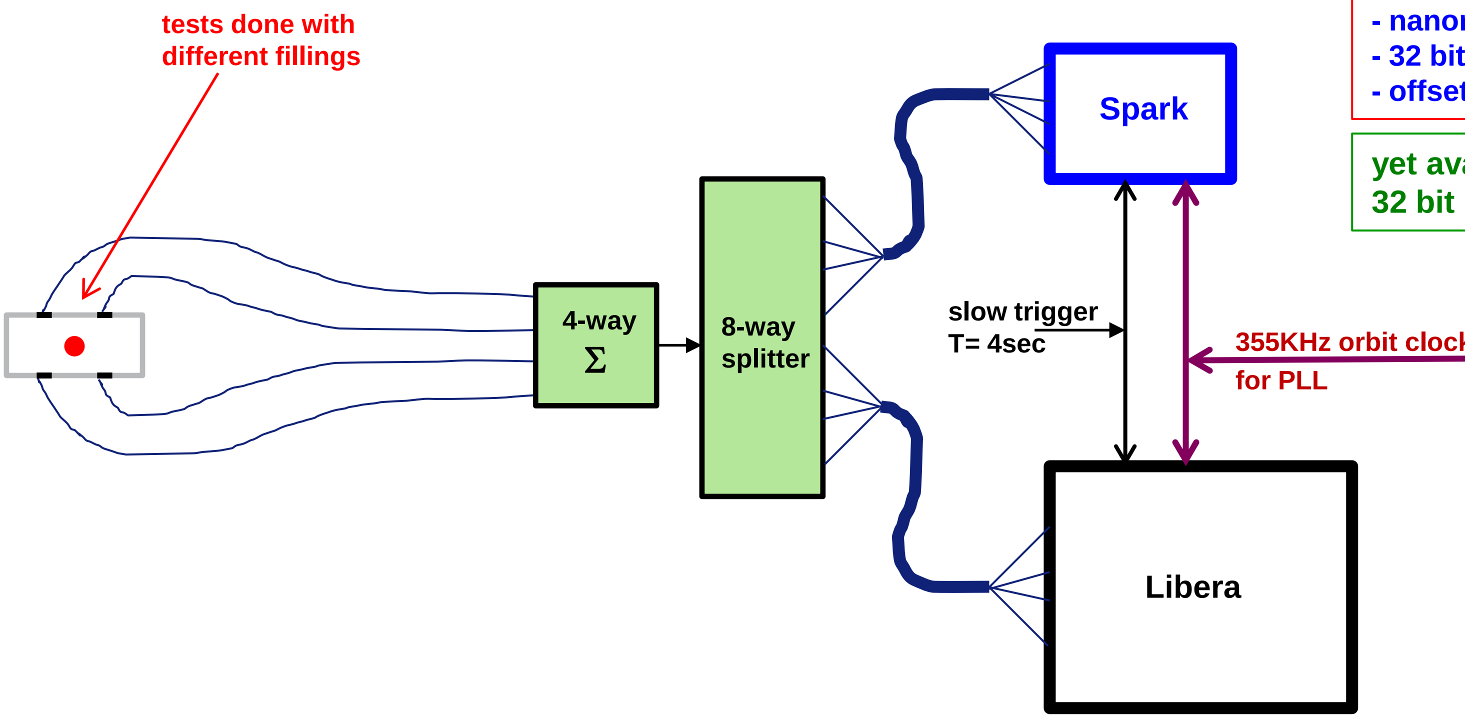
3m RF cable,
Time-Domain-Processing

*** poor man's**

SPARK VS LIBERA : NOISE, DRIFT, REPRODUCIBILITY

but NOT (yet) available :
- SA-output
- nanometer results
- 32 bit processing
- offset-tune

yet available :
32 bit on the TDP a,b,c,d

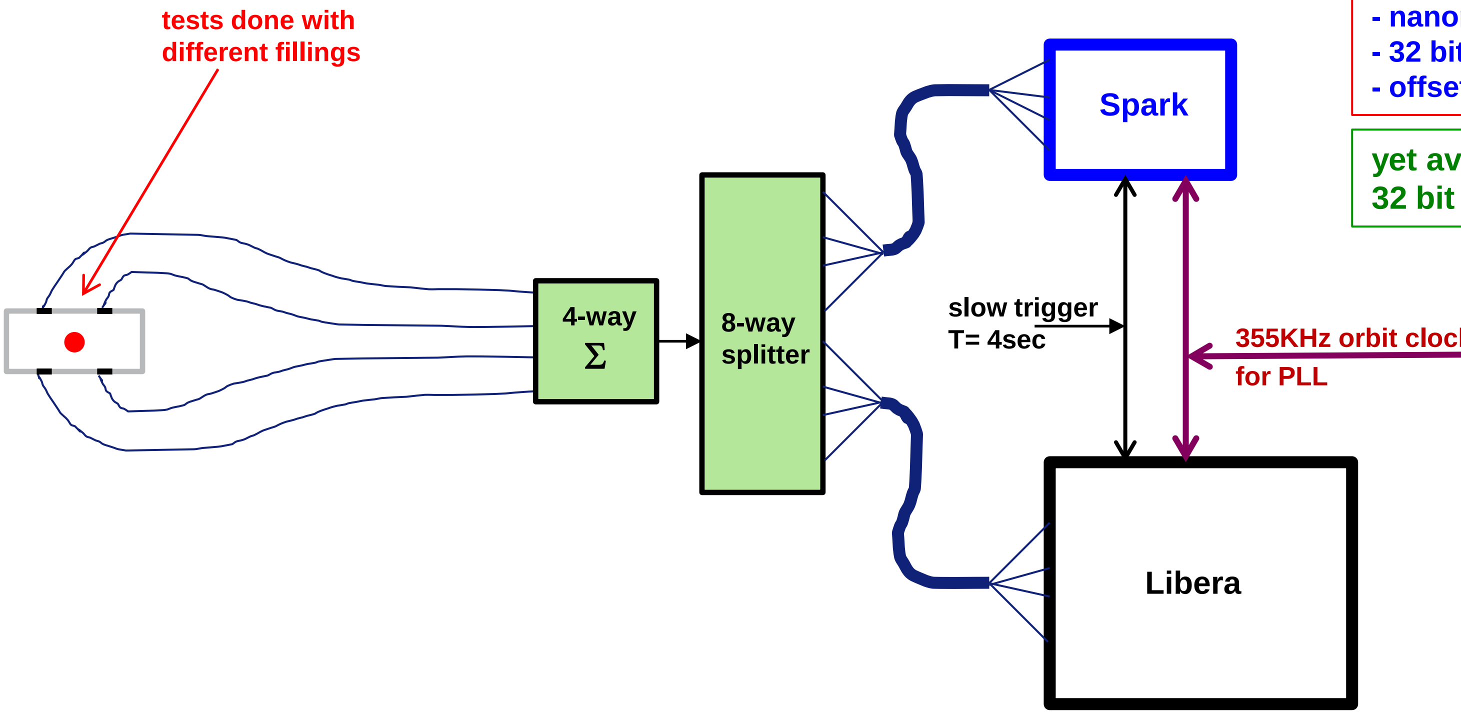


read-out on both :

the 30ms DD64 buffers (a,b,c,d),
at 4 sec interval,
over many hours,

then calculate noise & drift (K=10)

SPARK VS LIBERA : NOISE, DRIFT, REPRODUCIBILITY



but <u>NOT</u> (yet) available :
- SA-output
- nanometer results
- 32 bit processing
- offset-tune

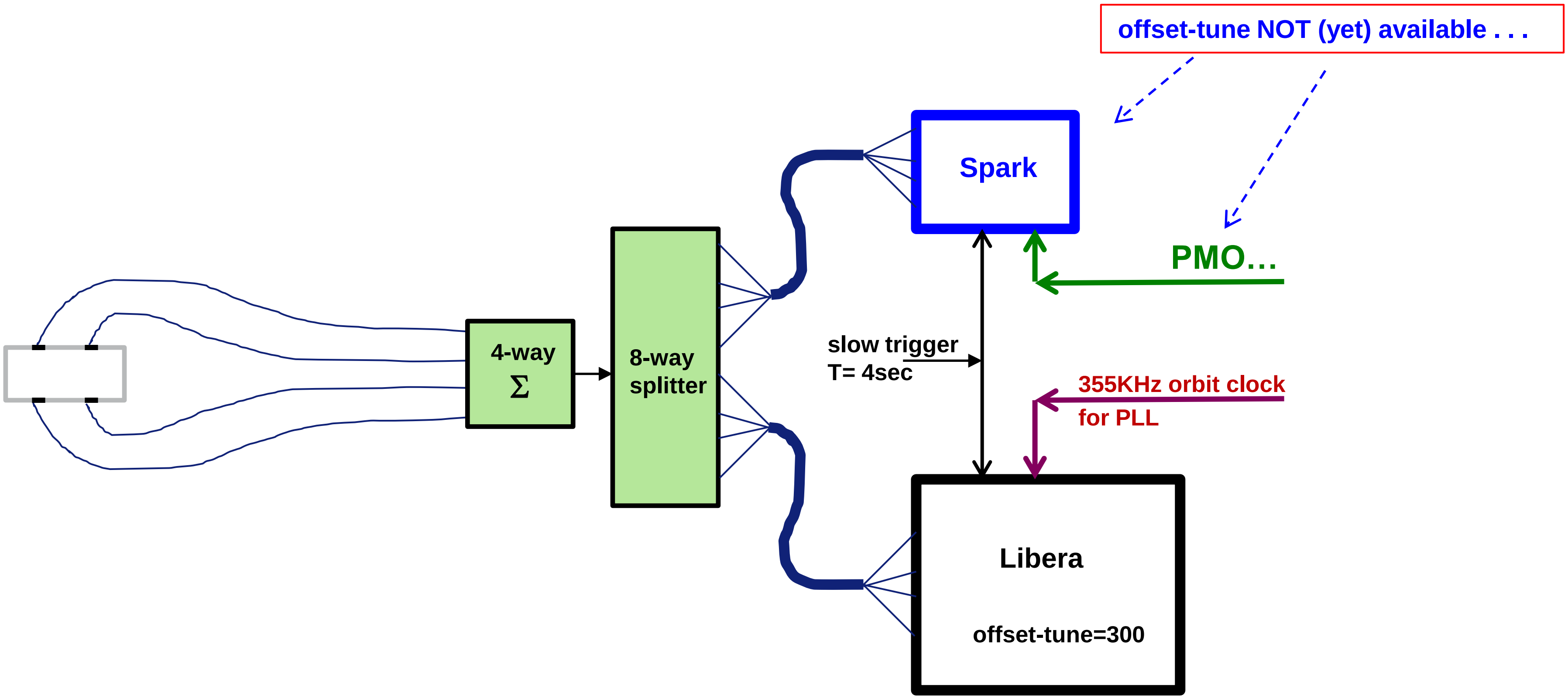
yet available :
32 bit on the TDP a,b,c,d

read-out on both :

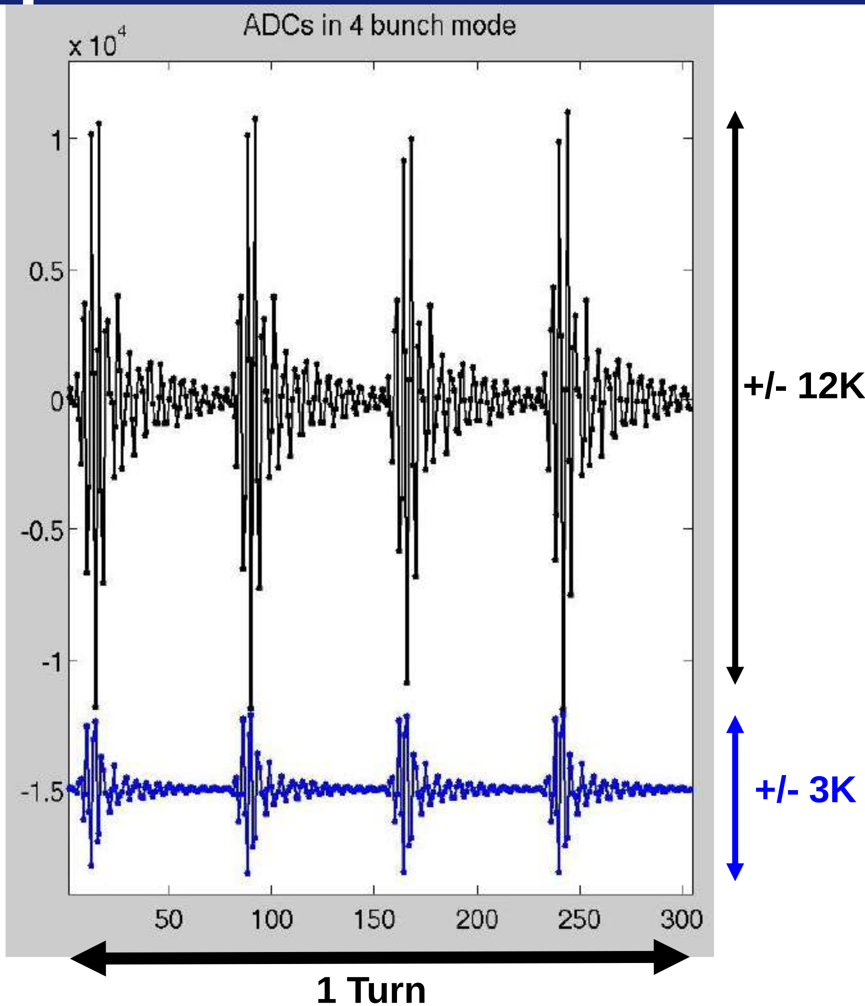
the 30ms DD64 buffers (a,b,c,d),
at 4 sec interval,
over many hours,

then calculate noise & drift (K=10)

SPARK : NO OFFSET TUNE YET,   BUT …. POOR MAN'S OFFSET-TUNING



SPARK & LIBERA : ADC IN 4 BUNCH MODE



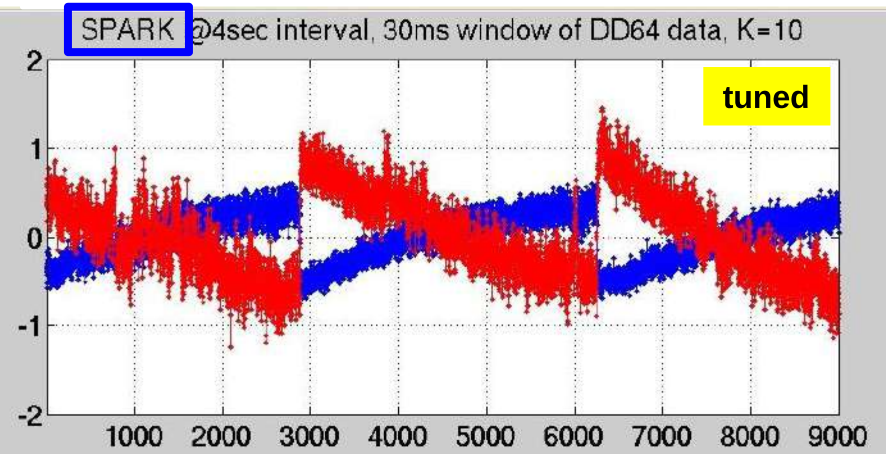
data from Libera
with standard DDC

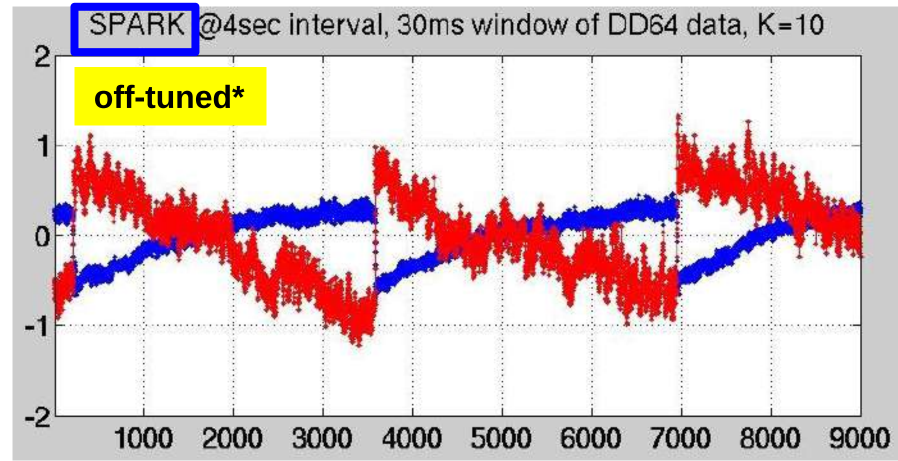
data from Spark
with TDP, but filter
fully open (304)

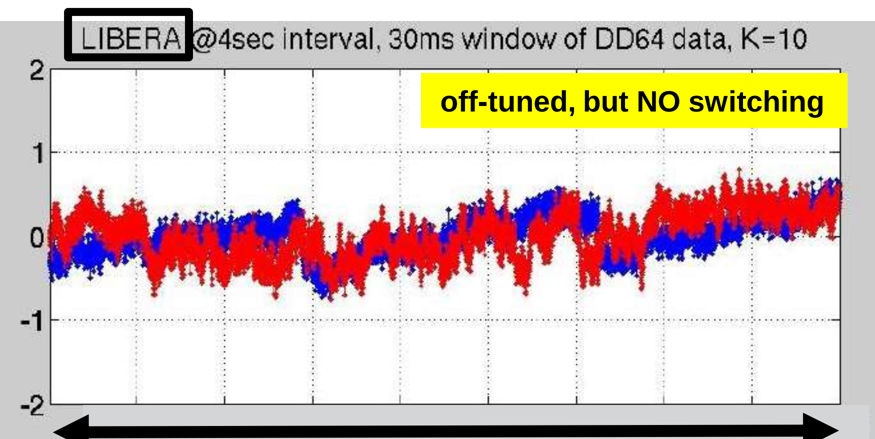
Libera
16 bit (65K)
13dB attenuator

Spark
14 bit (16K)
26dB attenuator

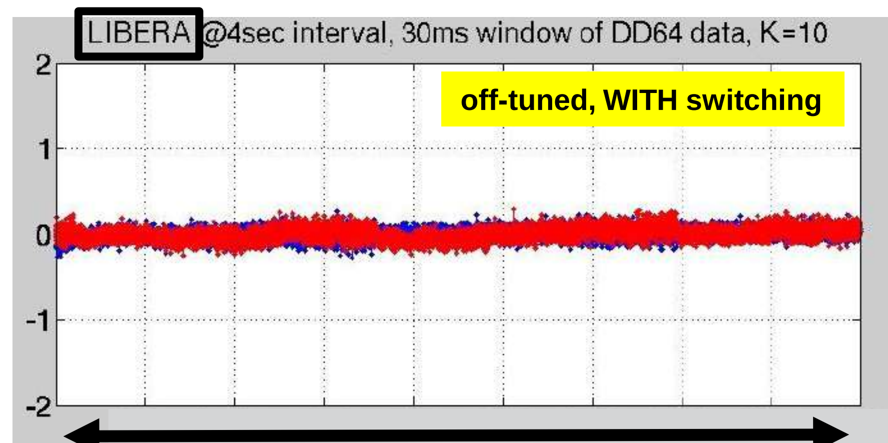
SPARK & LIBERA : DRIFT OVER 10 HRS (4 BUNCH FILLING MAY 2015)







10hrs

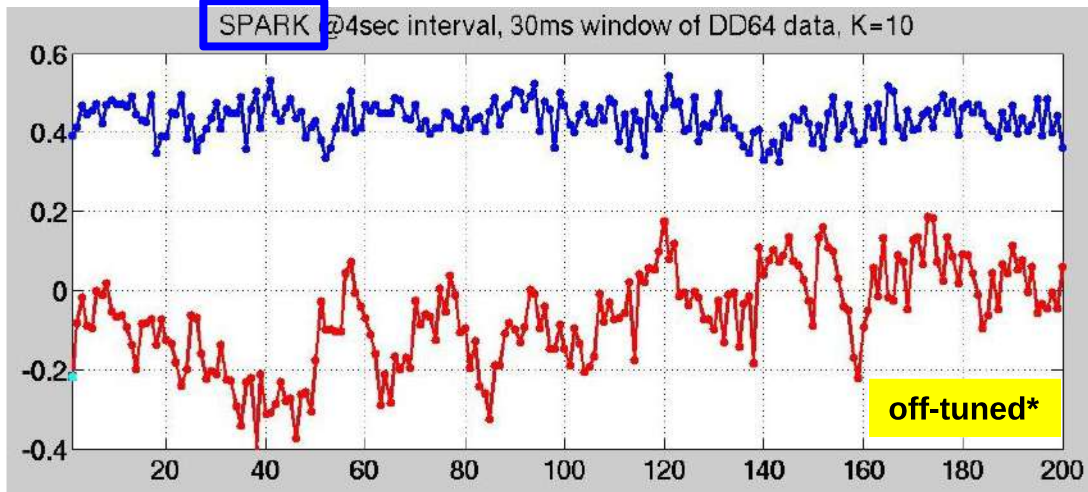


10hrs

Current variation : 43 to 27mA, decay of 37%

SPARK : DRIFT IN 13 MINS (4 BUNCH FILLING MAY 2015)

1um



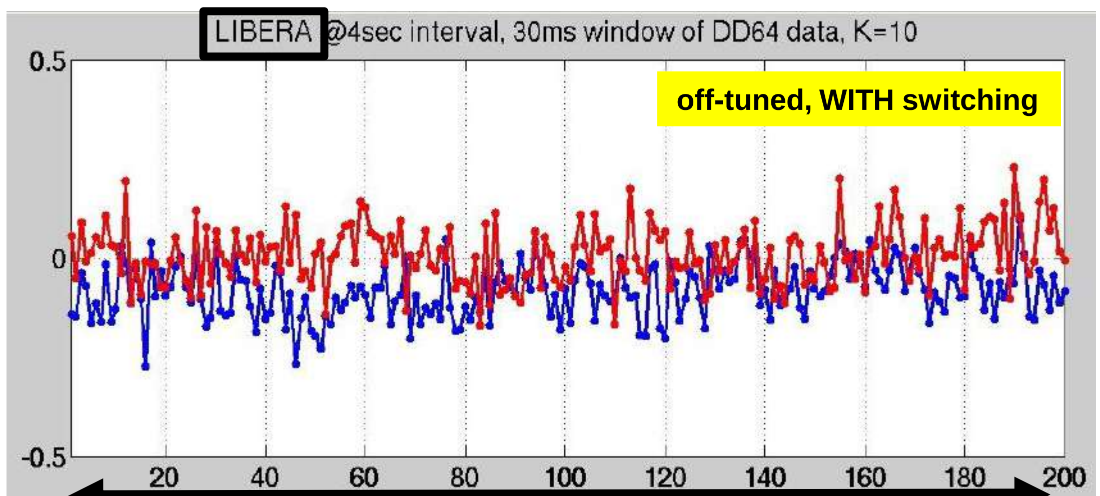
Spark :

rms X = 43 nm

rms Z = 123 nm

?

1um



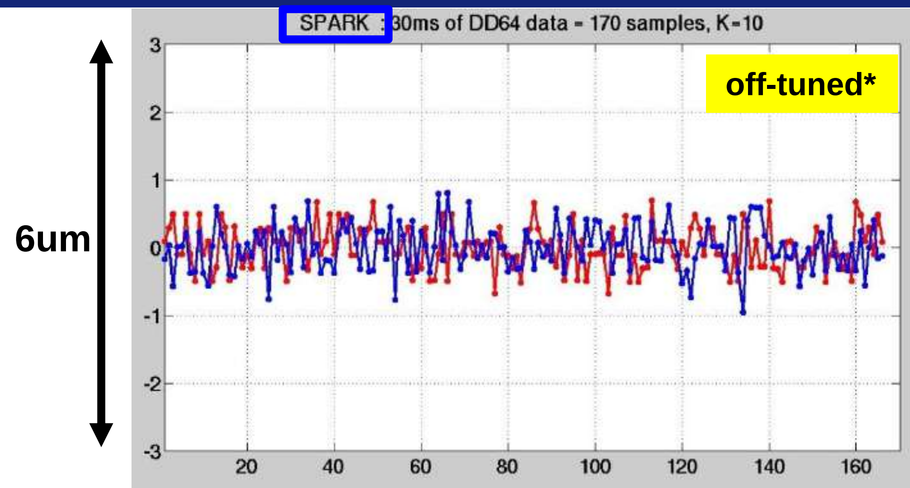
13 min

Libera :

rms X = 67 nm

rms Z = 73 nm

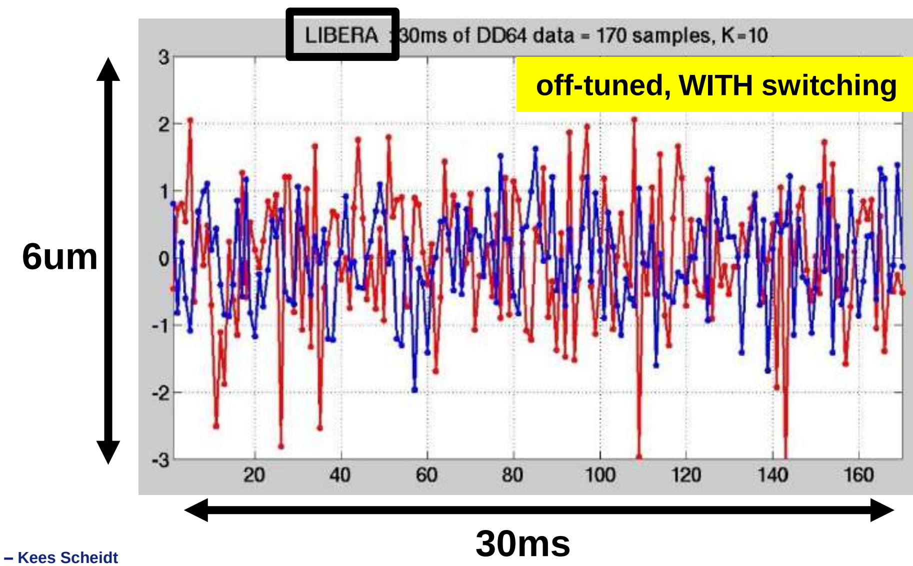
SPARK : NOISE IN 30 MILLISEC (4 BUNCH FILLING MAY 2015)



Spark :

rms X = 334 nm

rms Z = 315 nm



Libera :

rms X = 723 nm

rms Z = 1000 nm

Libera vs **Spark** :

how to compare what ?

1) **T-b-T data (1MHz BW) sensitivity (for ultra-low currents)** → **Spark** at least as good, probably better (depending on use)

2) ~~**FA-data (10KHz)**~~

3) **Dec64 data (5KHz)** → **Spark** at least as good

4) **Short term stability (sec. - min.)** → **Spark** at least as good

5) **Longer term stability (e.g. 10hours)** → **Spark** drifts with beam-current but +/- 1um for 37% decay

very long time-drifts or non-reproducibility not (yet ?) observed

when injecting from 0 to full nominal current (e.g. 200mA) then Liberas take care of attenuation changes & calibration, with Sparks you have to calibrate yourself . . .

BPM BUTTONS

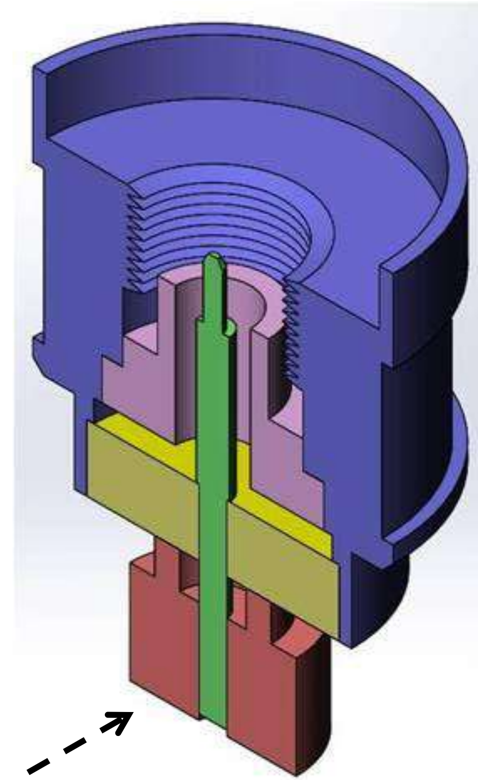
prototype tests fully satisfactory

C-f-T document is written

soon to be launched

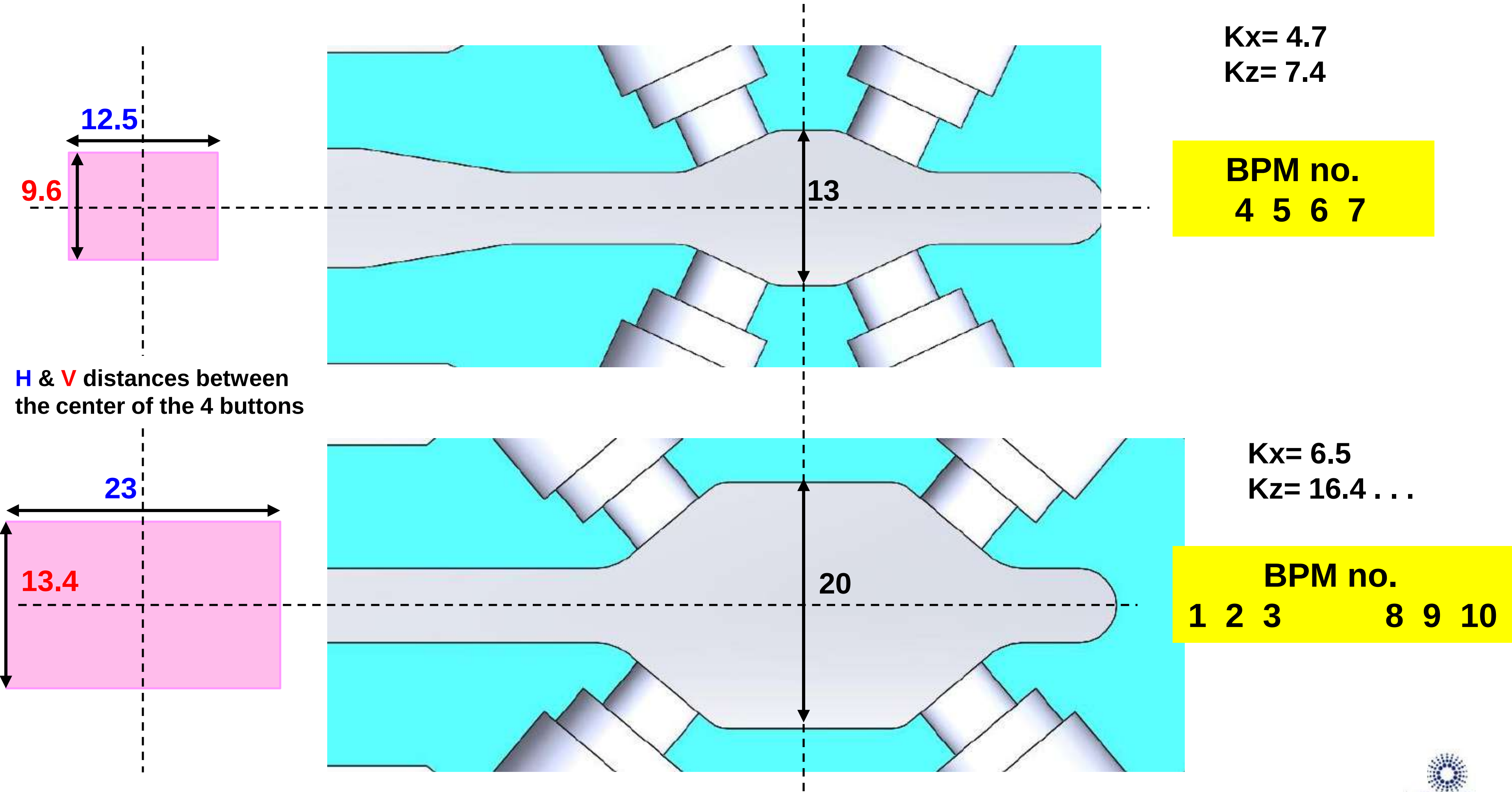
delivery (1500 units) expected by end 2015

total costs < 400 KEuros



1500 { 600 with 6mm
900 with 8mm

BPM BLOCKS



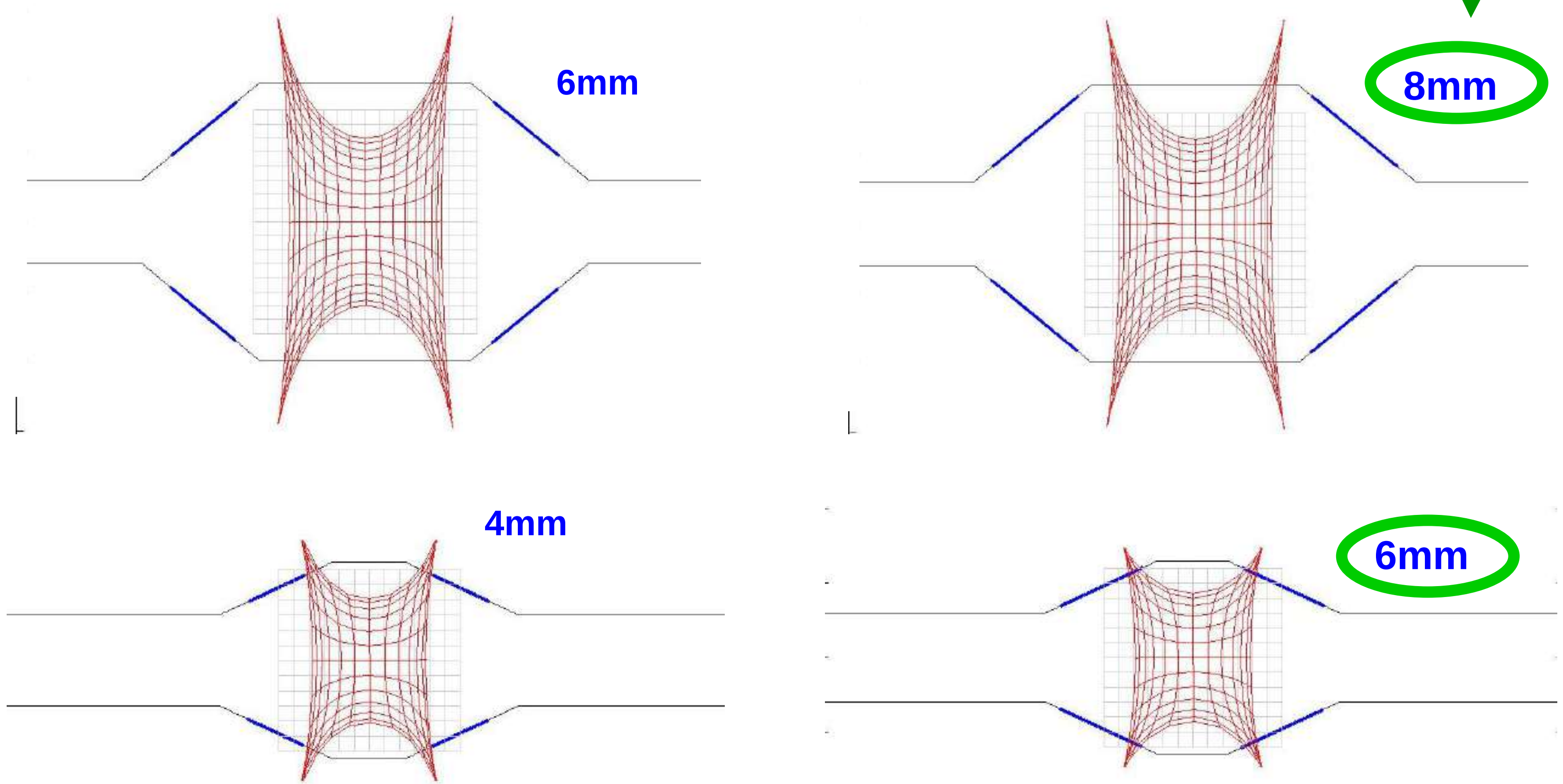
12.5
9.6
13
Kx= 4.7
Kz= 7.4
BPM no.
4 5 6 7
H & V distances between the center of the 4 buttons
23
13.4
20
Kx= 6.5
Kz= 16.4 . . .
BPM no.
1 2 3 8 9 10

BPM GEOMETRY , MAPPING, BUTTON DIAMETER

mapping is done, optimization of button diameters (for RF signal strength)

BIG 6/10

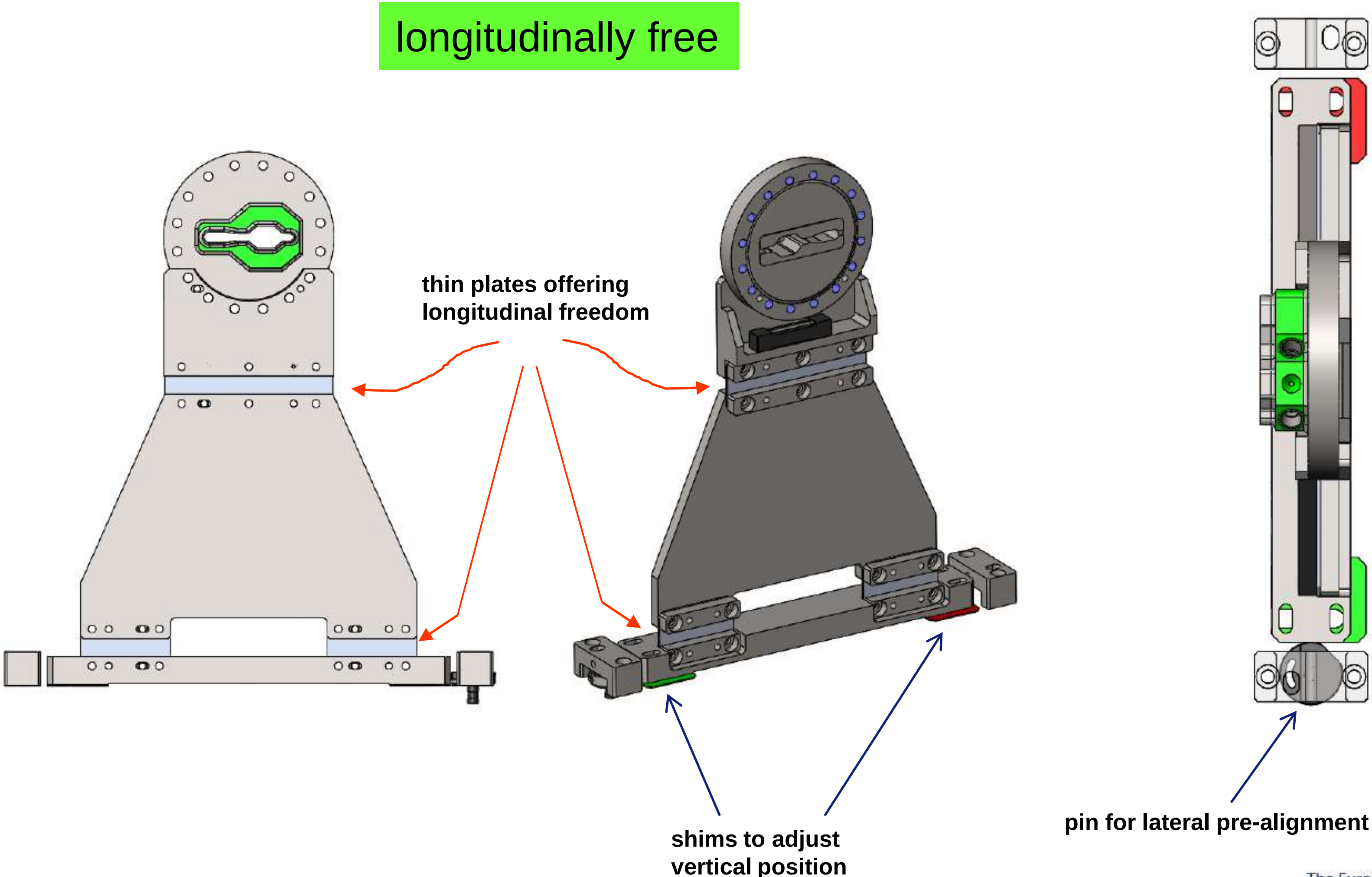
small 4/10



with courtesy to G.Rehm, DLS

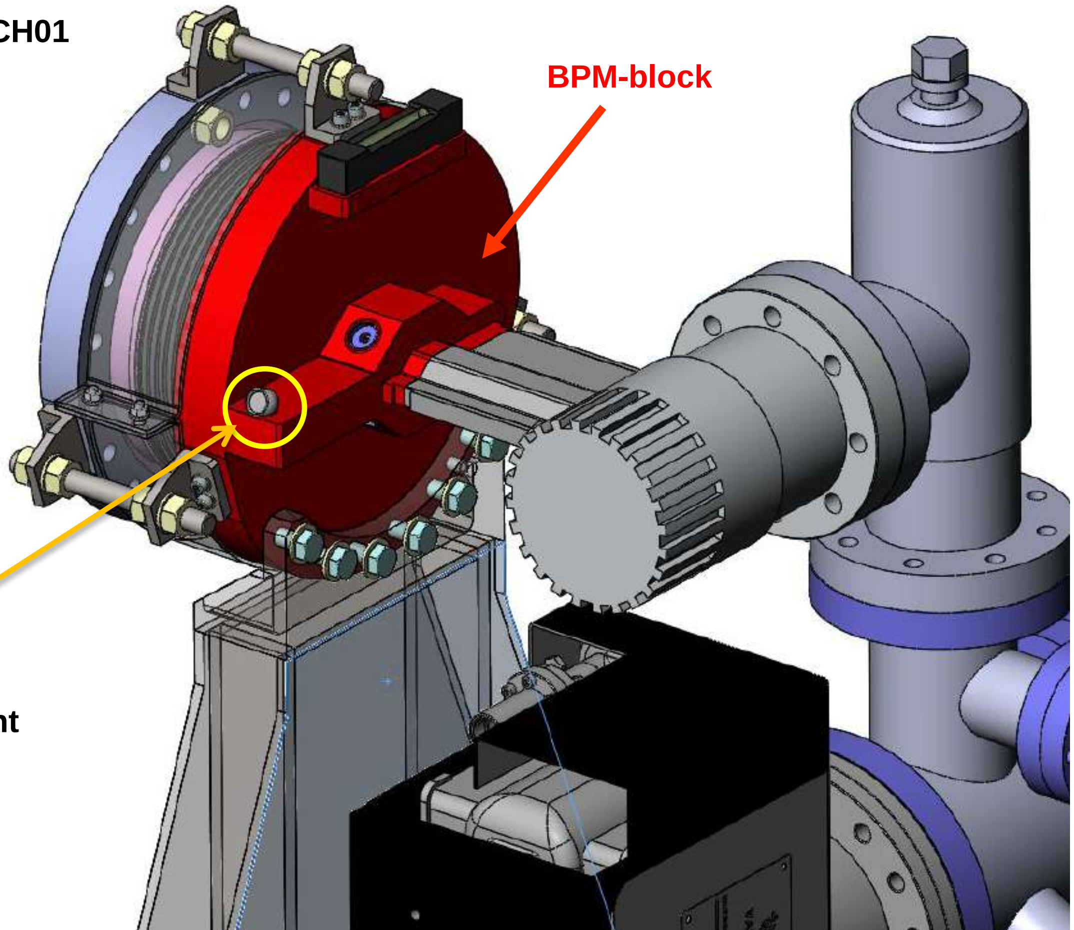
BPM BLOCKS , SUPPORT & FIXATION

longitudinally free



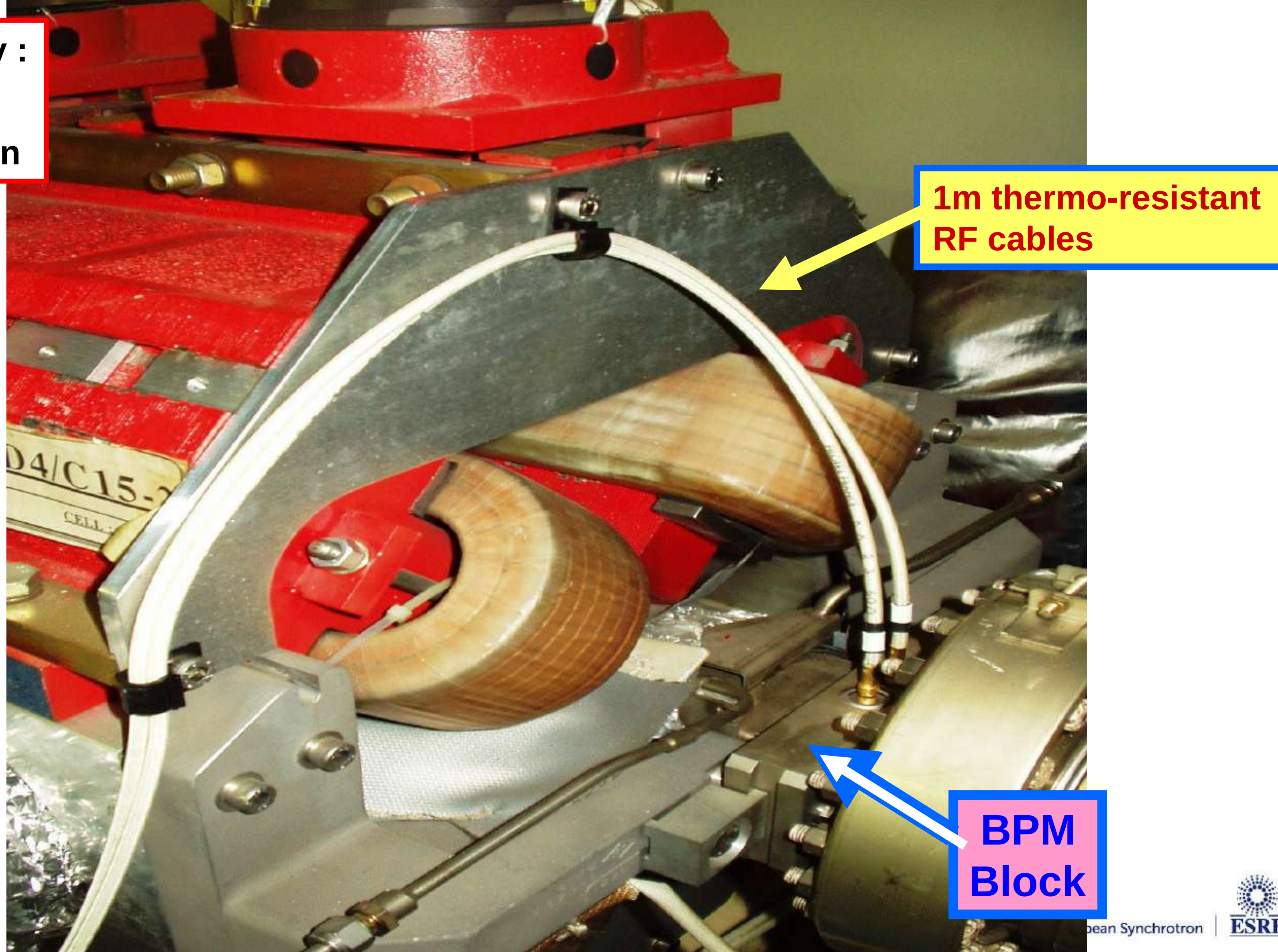
BPM BLOCKS , SUPPORT & FIXATION

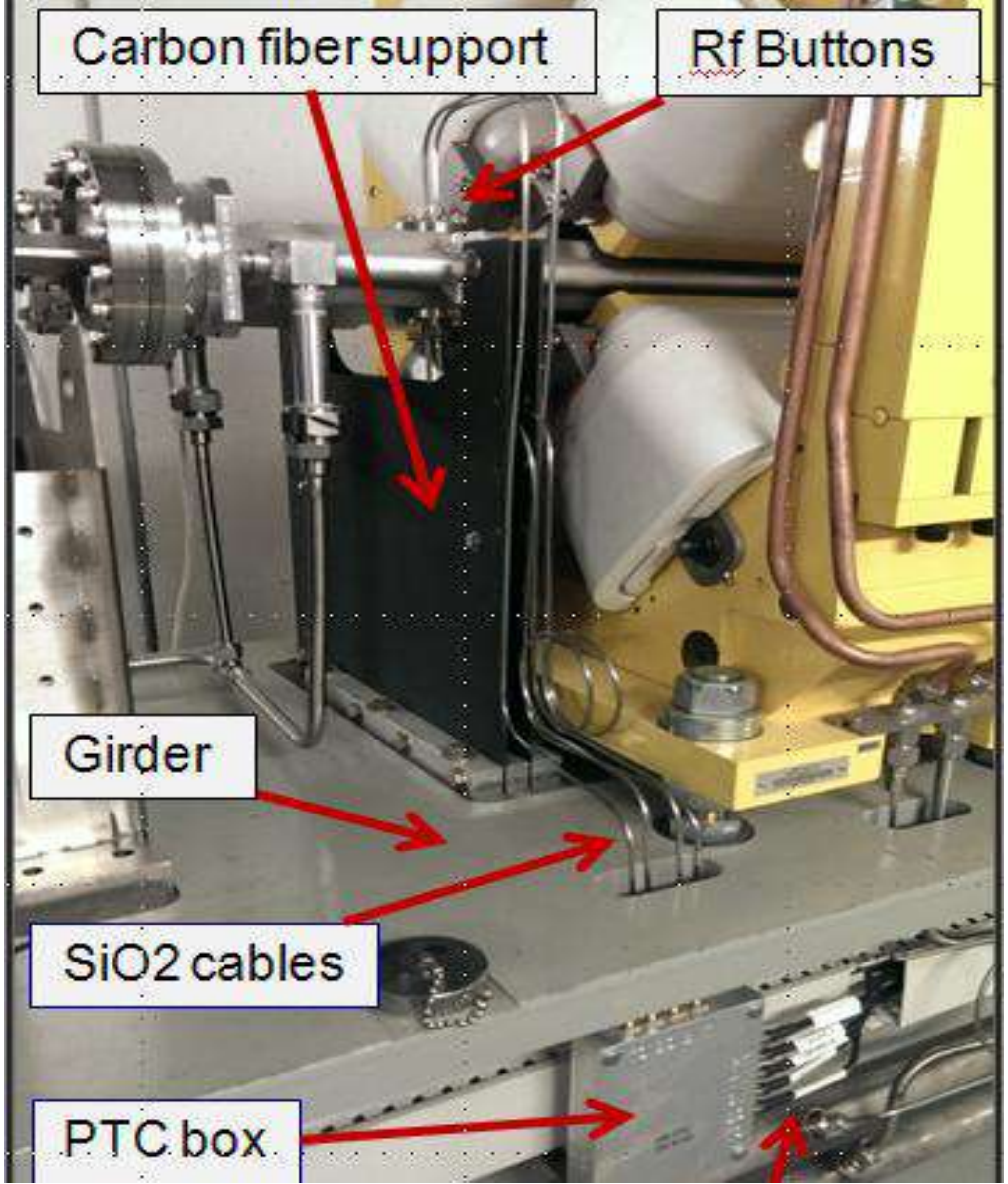
fully fixed



ESRF today :

we can get our hands in

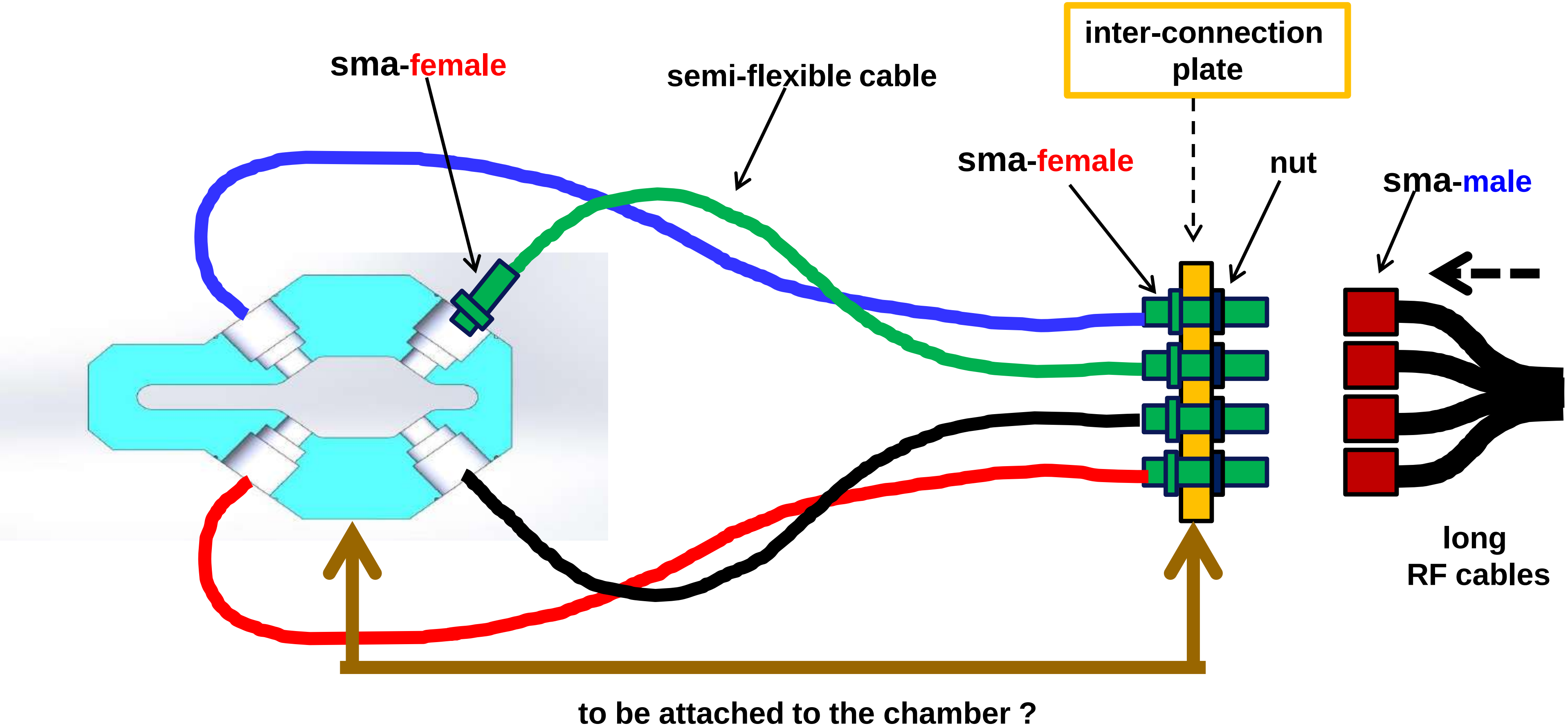




NSLS-2


ALBA

MAX-4

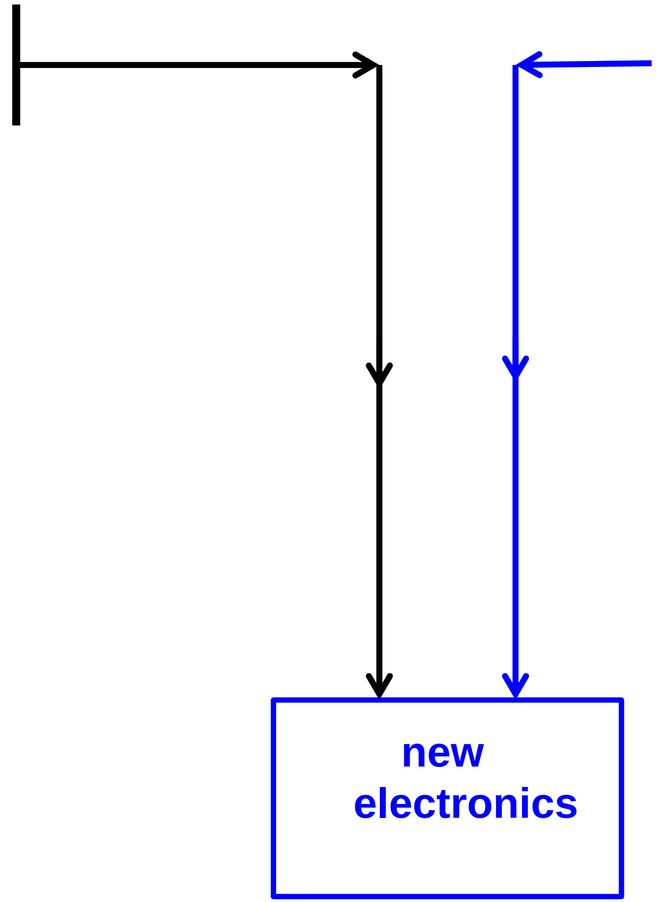


this cable installation will be done BEFORE installation of the vacuum chamber into the magnets and can, in principle, NOT be manipulated after that

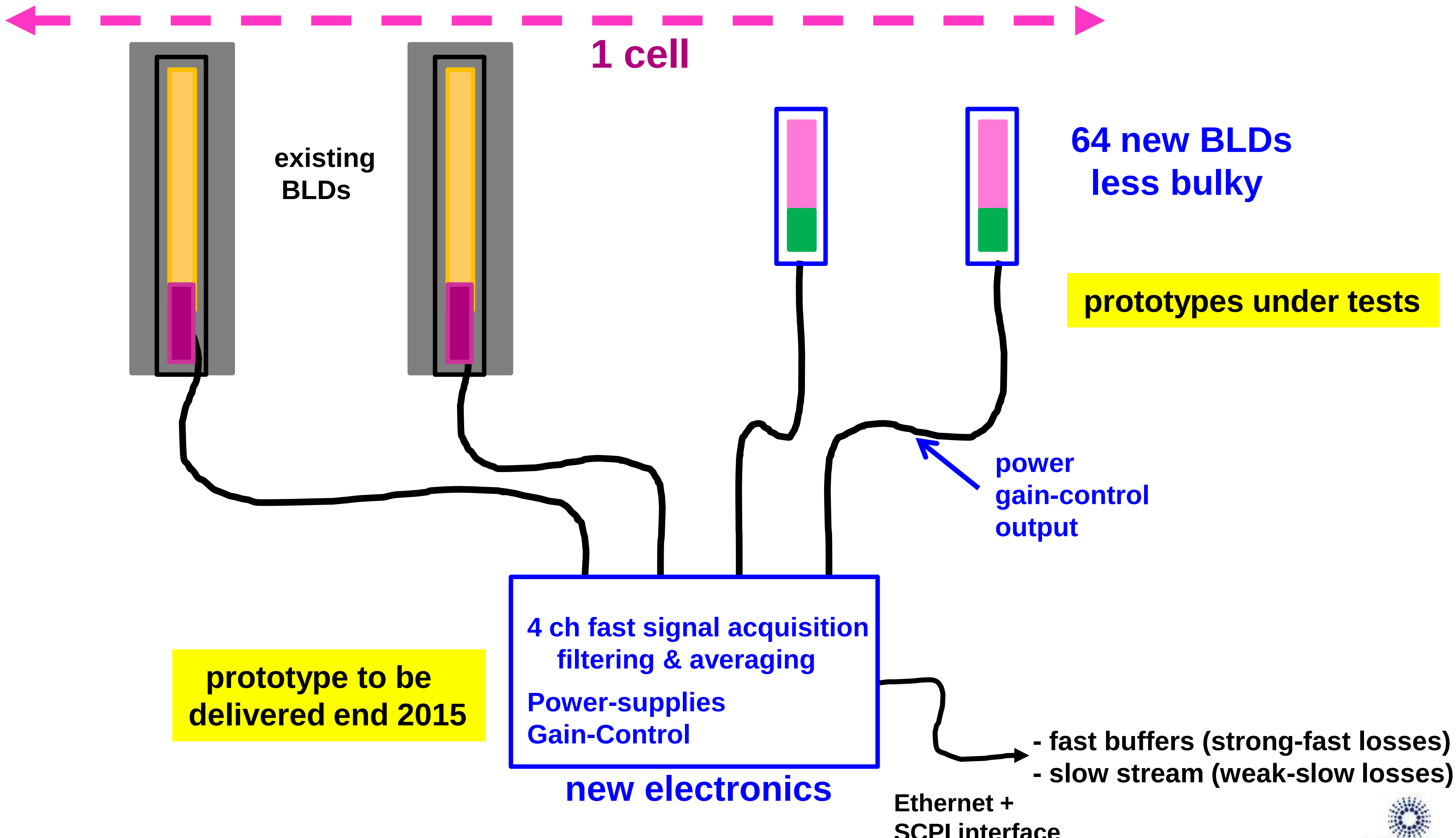
BEAM LOSS MONITORS

64 old “home-made” BLDs :
scintillator + PMT +
slow-electronics

64 new BLDs :
scintillator + PMT
<u>less bulky</u>



BEAM LOSS MONITORS



SPARK : FURTHER IDEAS

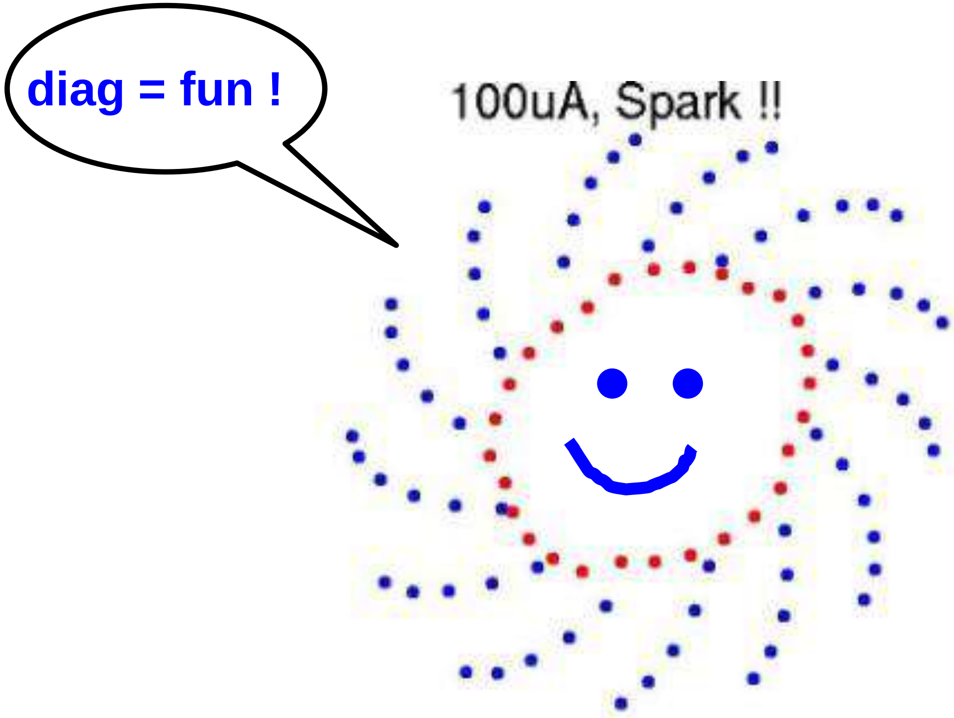
our experience with Spark in our Booster :

- **PoE works well :** **allowed installation inside the tunnel, thus avoiding much & costly RF cabling and enhancing sensitivity & resolution (at low currents)**

- **PLL not needed for T-b-T :** **the slow trigger re-synchronises all BPMs up to at least thousands of Turns**

Spark ERXR : - **installation <u>inside</u> the Storage Ring Tunnel or <u>outside</u> (accessible cabinets) ?**

My Idea : - **the PLL could be driven from RF signals this would avoid this separate Master-Clock (and cabling)**



thank you for your attention !