

# beam stability issues and diagnostics developments :



The European Synchrotron



**Kees Scheidt**

ASD-day, Grenoble, January 24, 2023



**beam stability issues and  
diagnostics developments :**

**on behalf of the  
Diagnostics Group :**

**ASD-day, Grenoble  
January 24, 2023  
Kees Scheidt**

**Nicolas Benoist  
Elena Buratin  
Guillaume Denat  
Friederike Ewald  
Benoit Roche  
Kees Scheidt  
Fouhed Taoutaou**

# outline of this presentation

## the beam's positional stability

- 1 too much reliance on the 320 e-BPMs only → can NOT warrant a perfect stability ...
- 2 version-1 X-BPMs on two BM-sources : full results >1year, but (almost) only during MDT
- 3 version-2 X-BPMs on two BM-sources : now (Jan. 2023) installed → first results & perspectives
- 4 temperature stabilization in the cubicles of the BPM-electronics → in good progress
- 5 the upgrades of the (slow/fast) orbit control system

## Diagnostics Developments

- 6 two units of non-destructive vertical beam Halo monitors → excellent results
- 7 the measurement of ultra-low beam-current, down to the single electron
- 8 general upgrades, activities, corrections or improvements on numerous Diag. systems

# Beam's positional stability : How good is it really ??

“the EBS has very good stability ”

“the beam stability is excellent ”

“the stability is really perfect !! ”

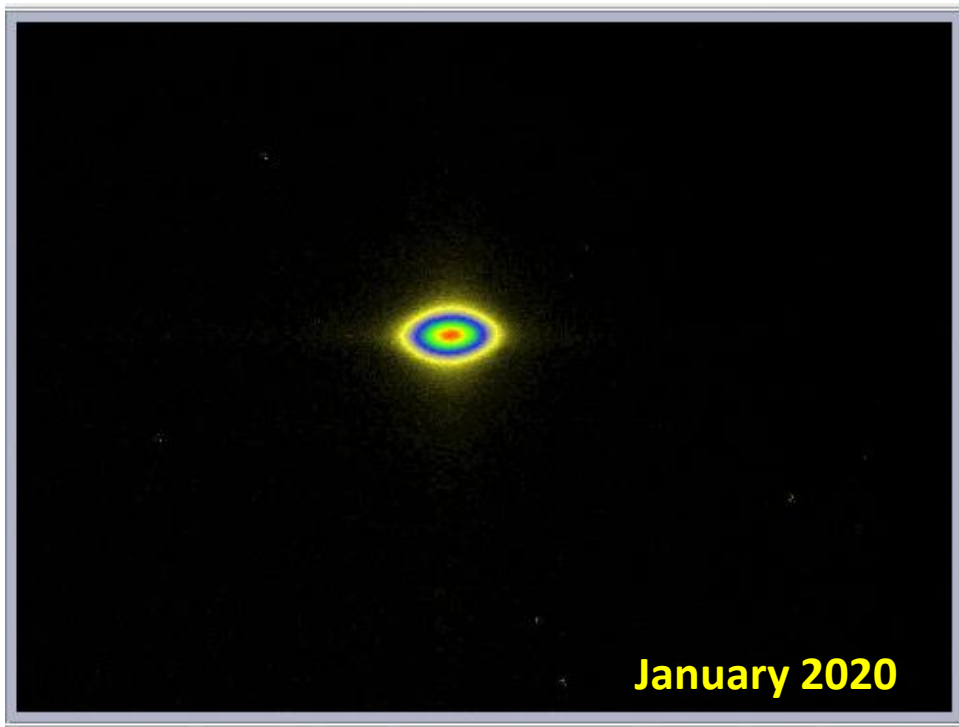


image from the  
X-ray pinhole camera

it is an image, NOT a movie ...

if I had put a movie  
you would NOT see the difference :  
the beam appears extremely stable !

this since the first days  
of commissioning of EBS  
i.e. 3 years ago

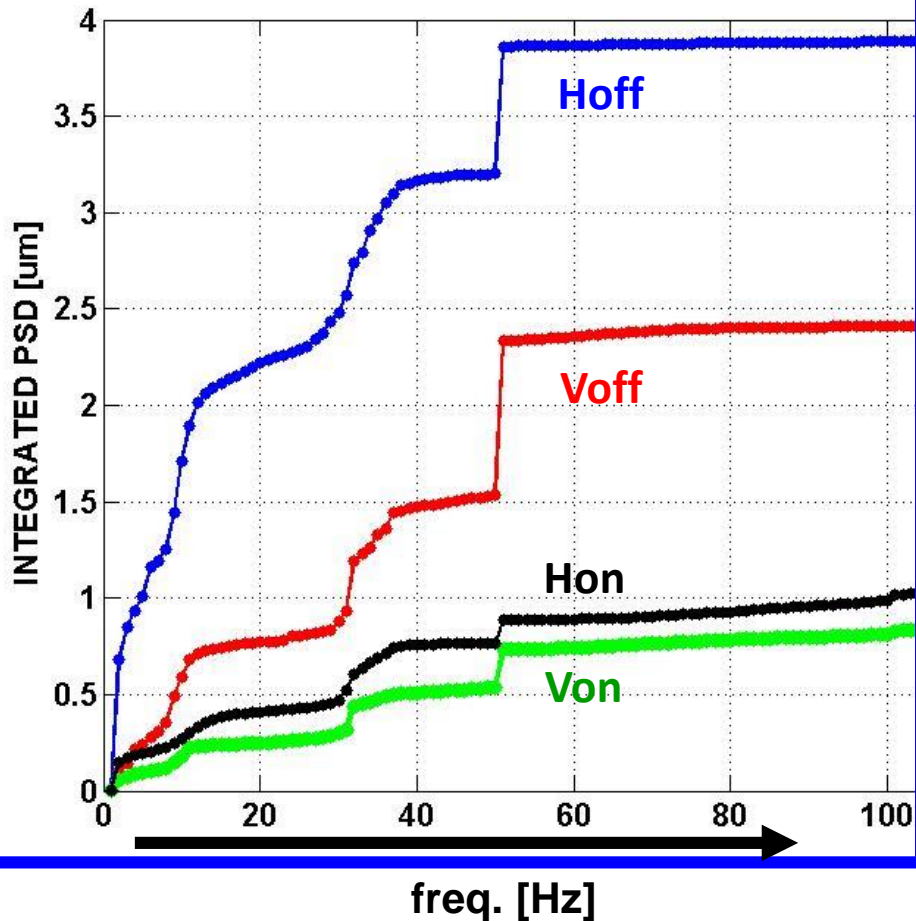
# AC domain stability is very good → thanks to girders etc.

from ASD-day 3 years ago, 2020

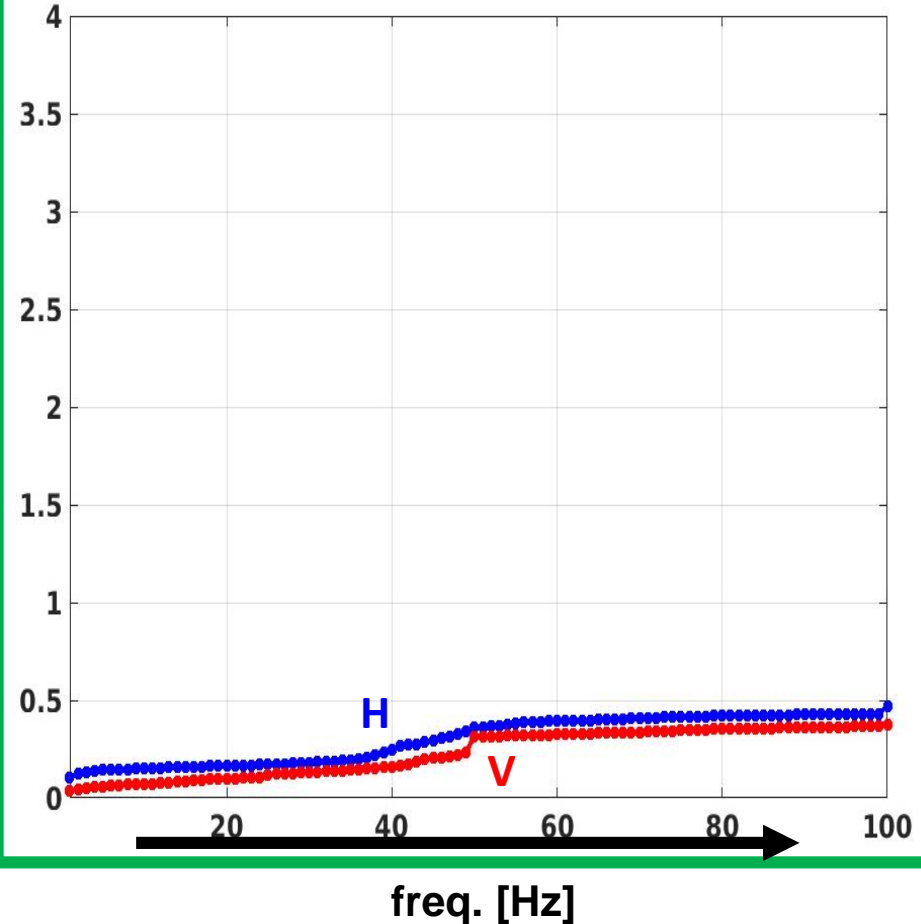
comparison between the old (data from 2010) and the new EBS ring :

Stability in the low-AC domain (1 – 100Hz)

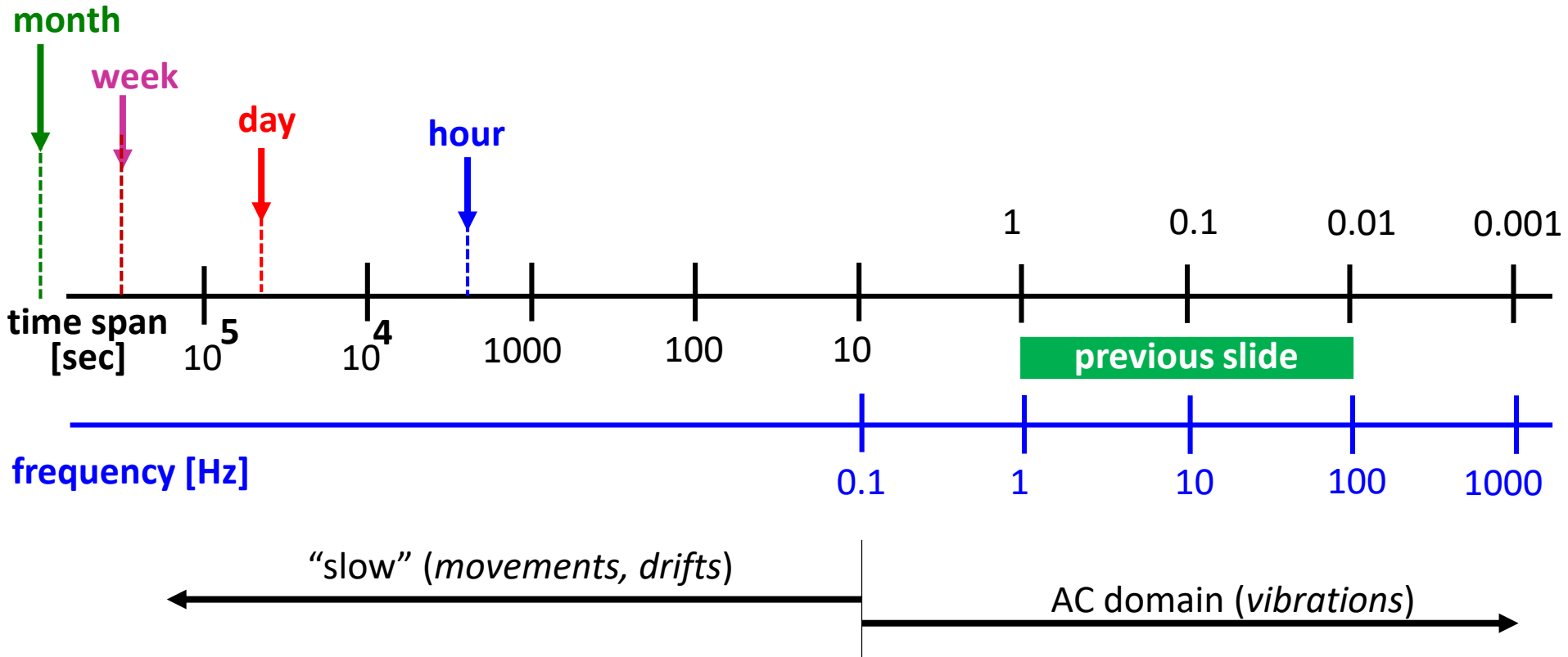
old ring 2010, FOC On & Off



new ring, no FOC (yet)



# stability needs assessment over a large time domain



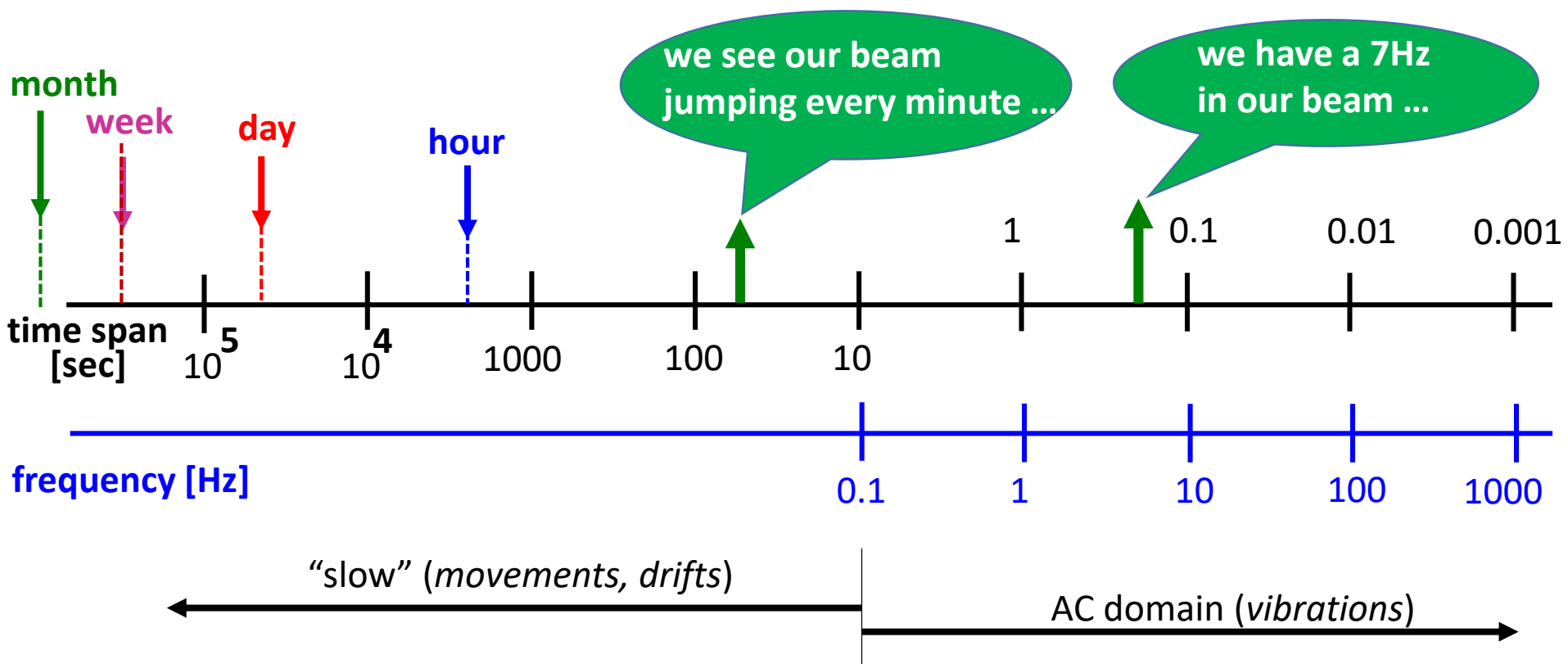
with our present e-BPM system we are :

un-certain

more difficult

excellent !!

# we are really good in the fast domains (faster than 1hr)



with our present e-BPM system we are :

un-certain

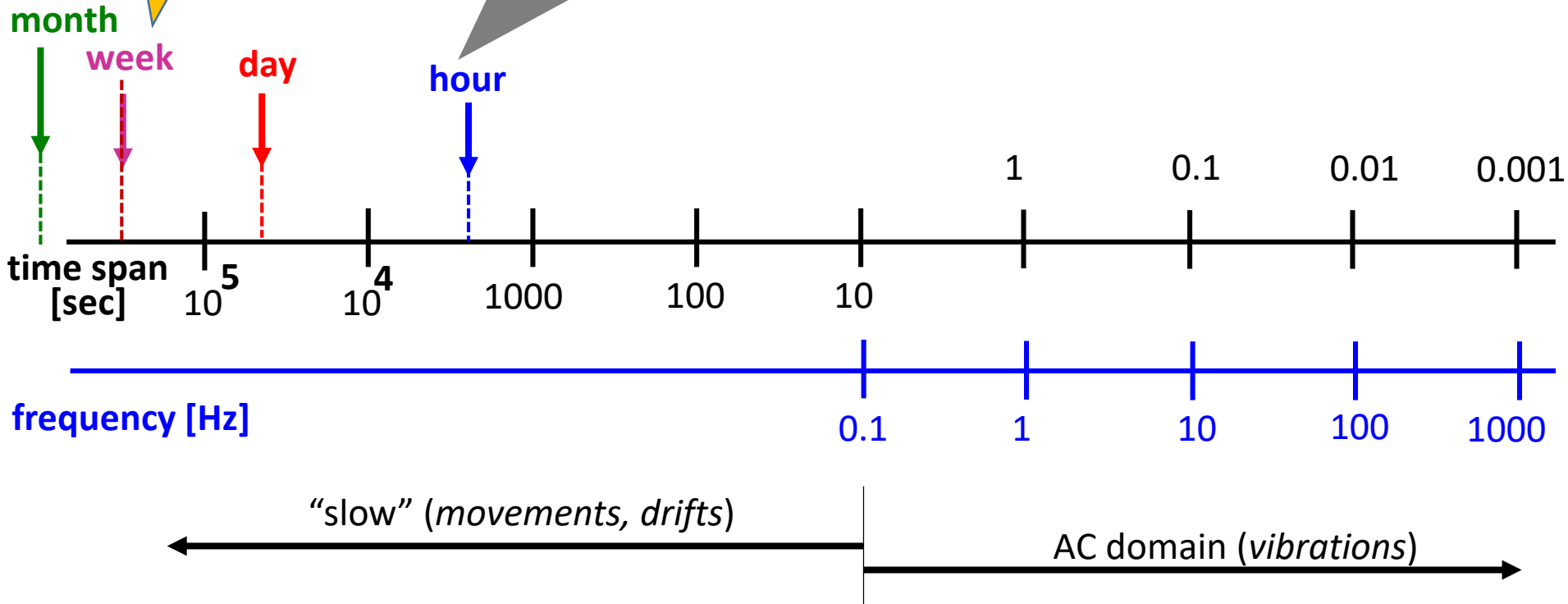
more difficult

excellent !!

# we need to **better** address (only) the **slow domains**

our beam is not where it was 5 days ago ...

there is 1hr periodic motion in our beam ...



with our present e-BPM system we are :

un-certain

more difficult

excellent !!



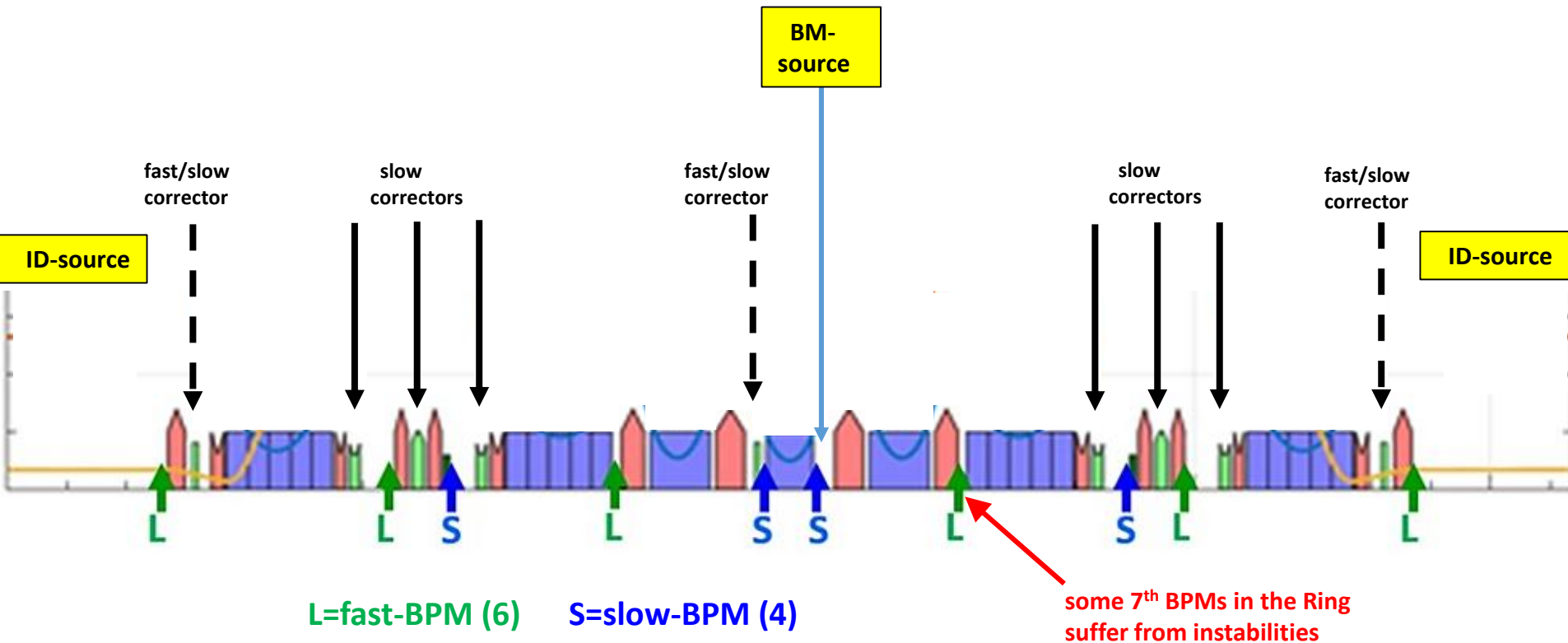
# layout of the e-BPMs and the Steerers

the EBS orbit stabilization has distinctive FAST & SLOW parts

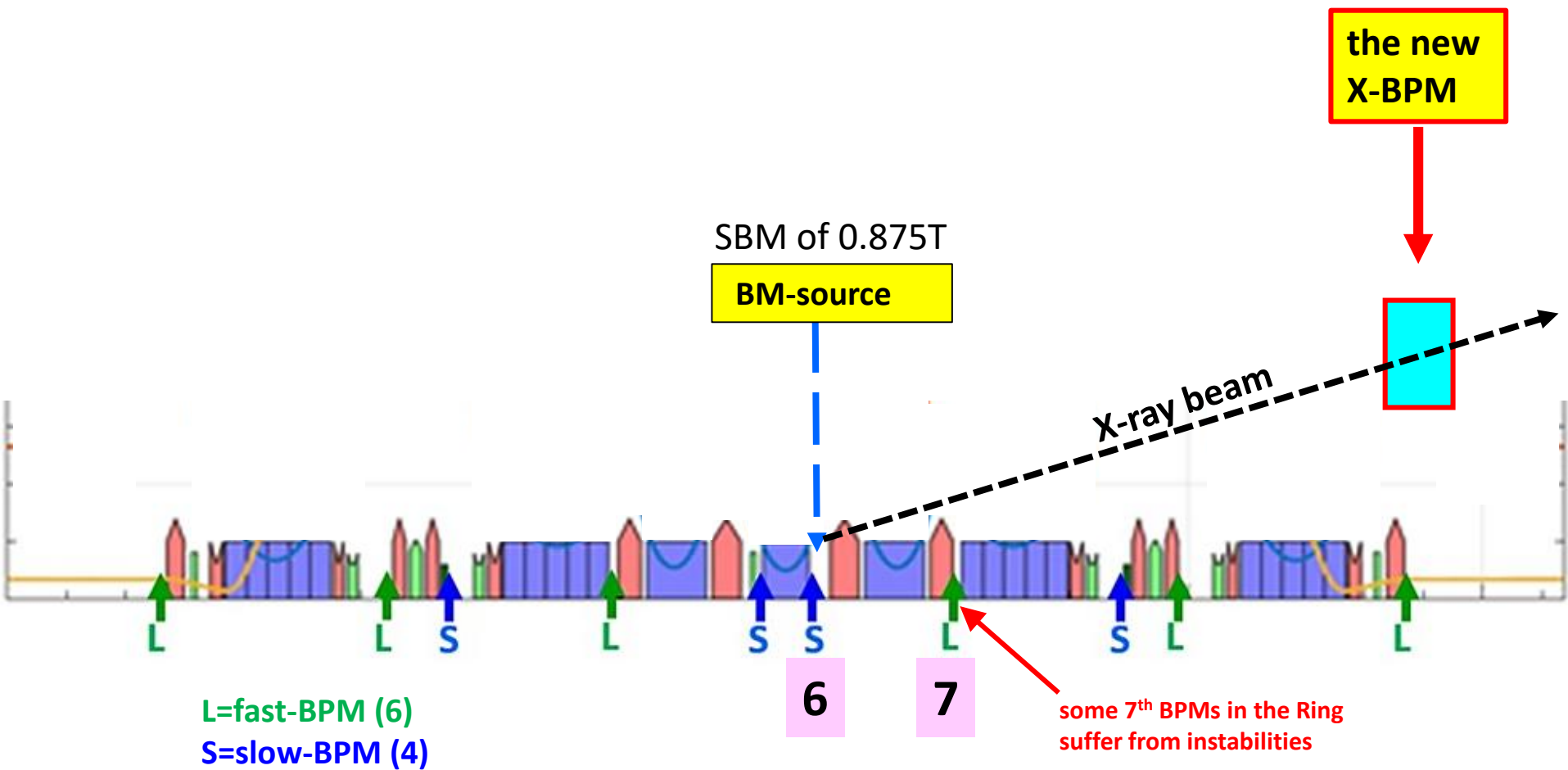
for the FAST part it uses 192 e-BPMs (later all 320) and 96 fast steerers , both H & V planes

for the SLOW part it uses 320 e-BPMs and 288 slow steerers, also both H & V planes

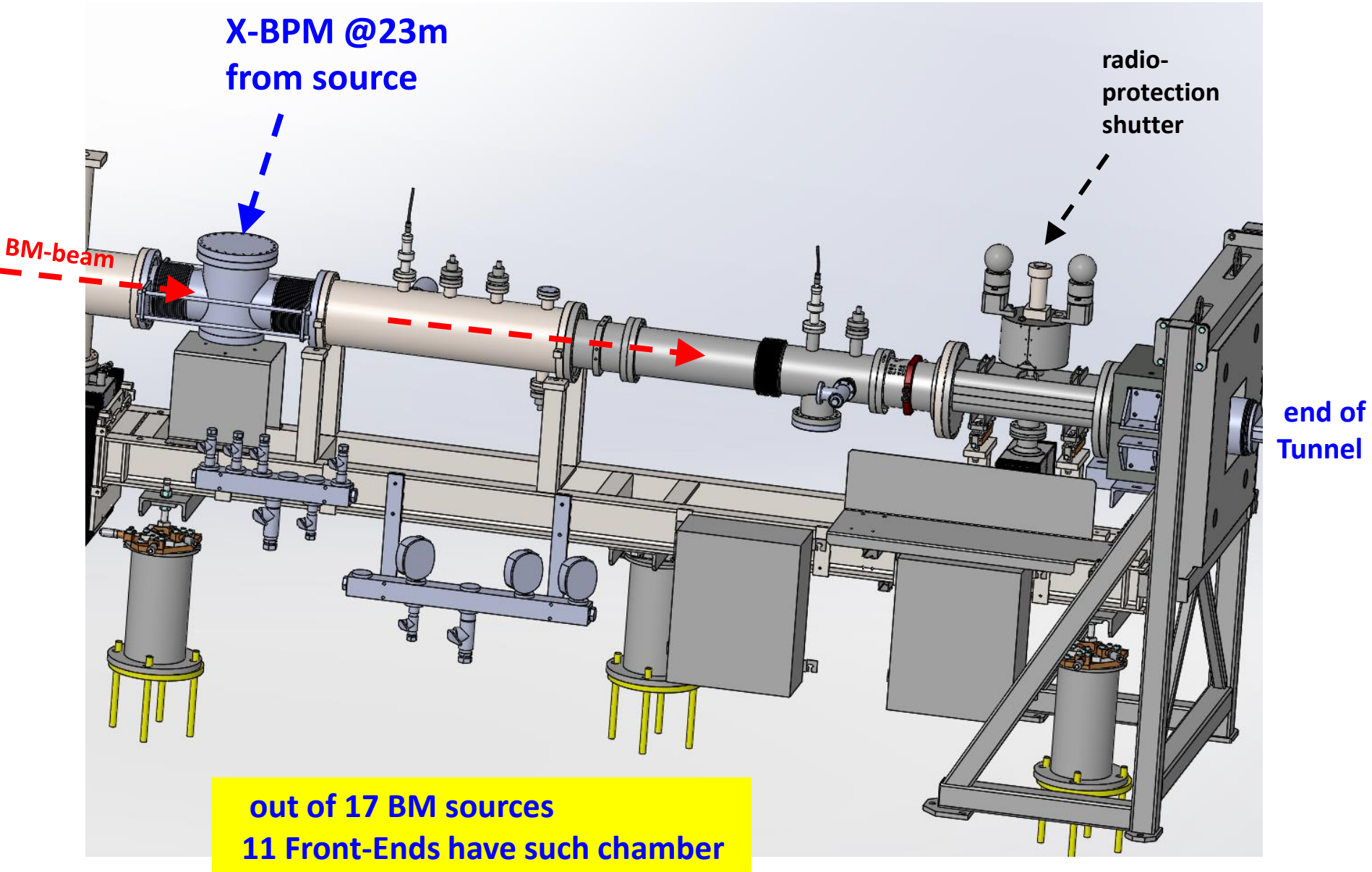
→ in EBS we had NOT foreseen X-BPMs → so our e-BPMs are both Judge & Party



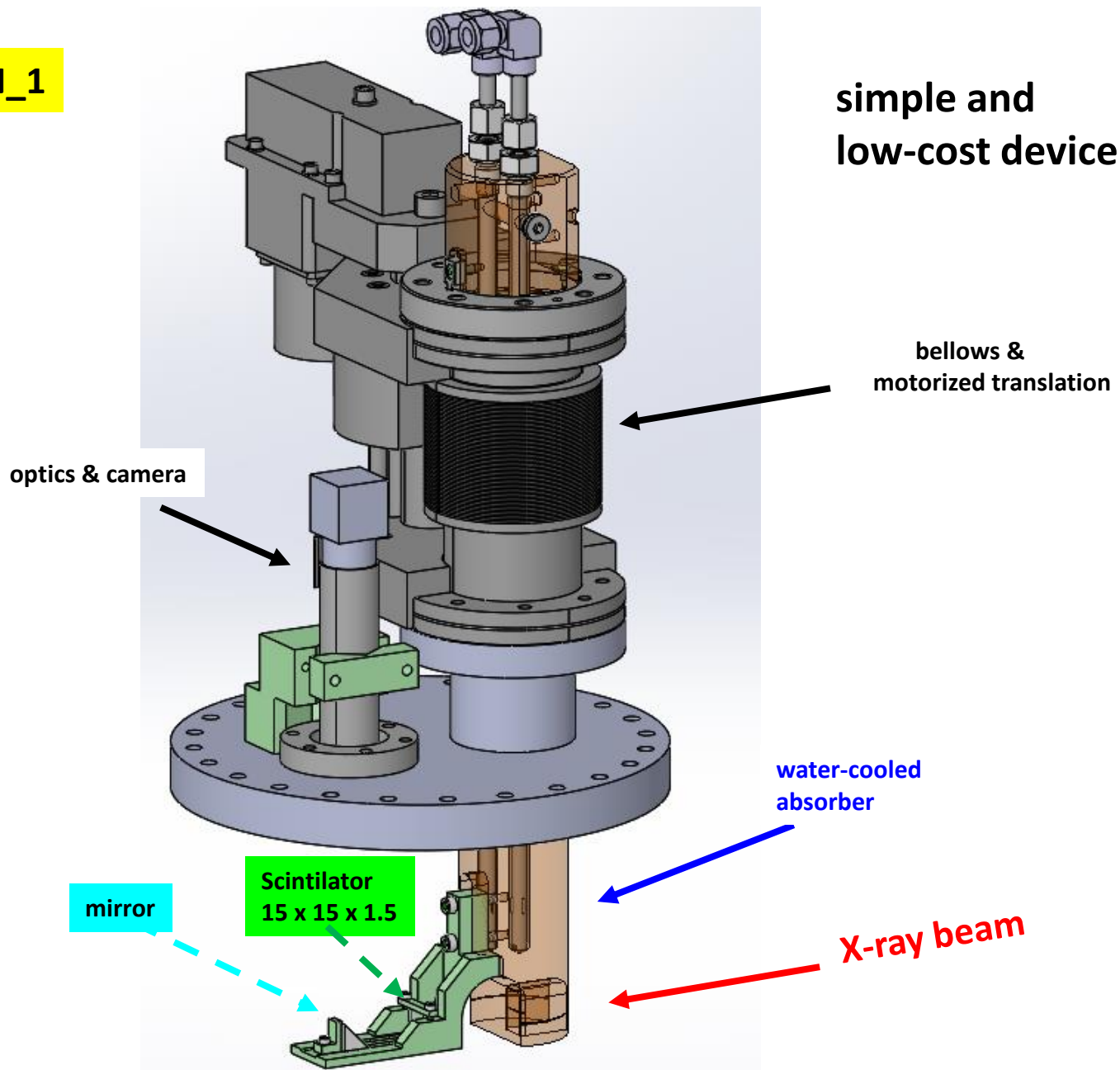
# X-BPMs on BM-8 and BM-16 added in Oct. 2021

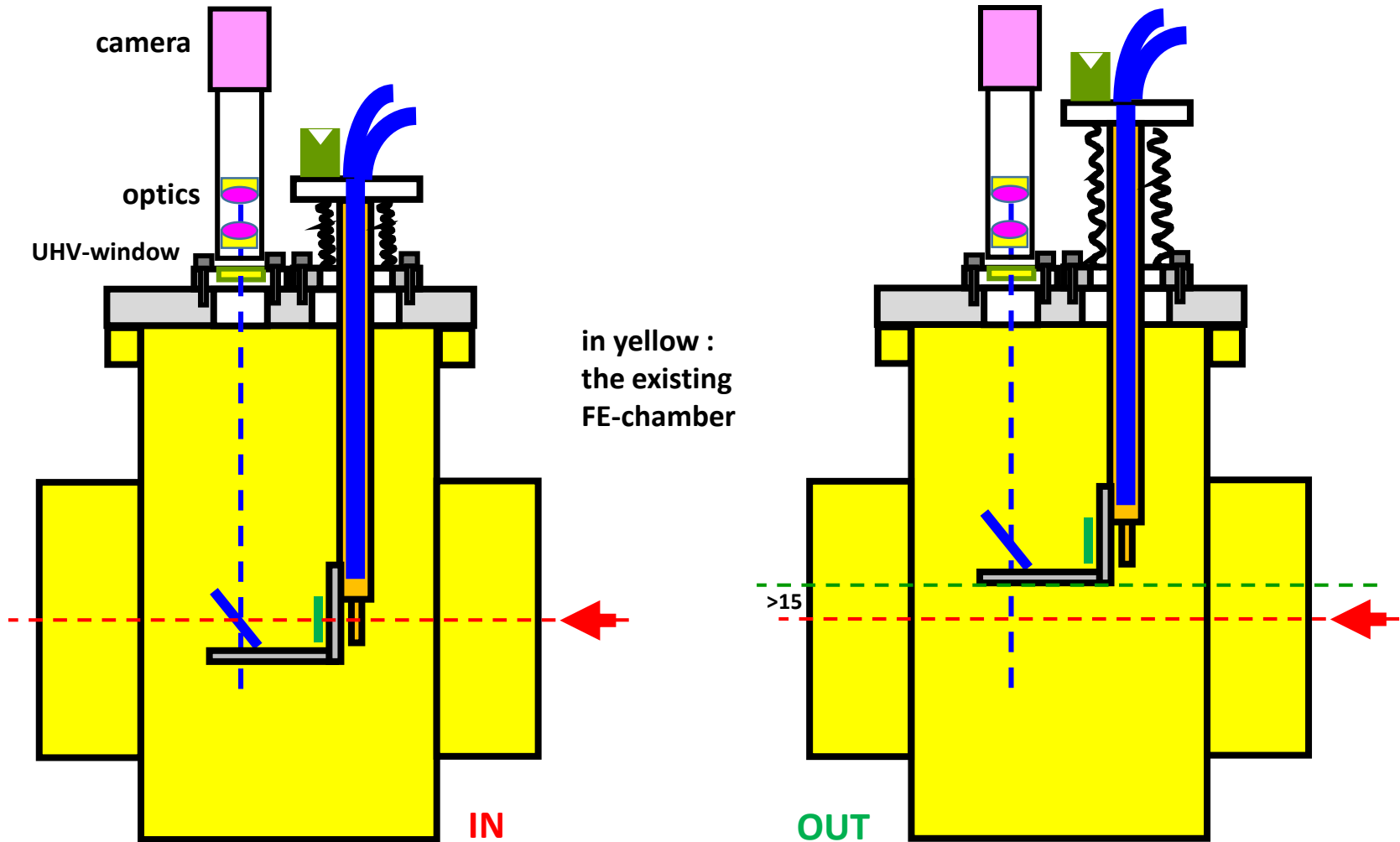


# available Front-End chambers at 23m from source



VERSION\_1





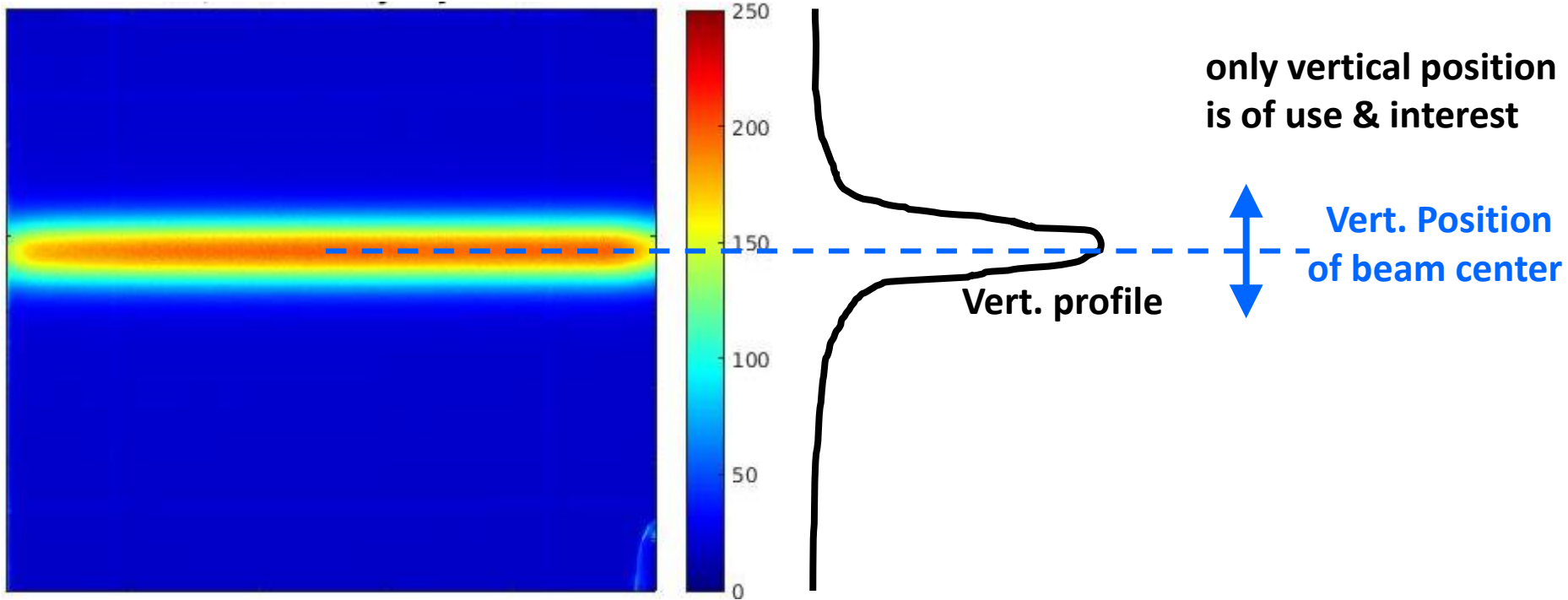
in yellow :  
the existing  
FE-chamber

an image of the X-ray beam is  
projected on the scintillator (green)  
the light emitted from that is captured/focused  
on to a camera via mirror (blue), window, lenses  
a water-cooled absorber is in front of the scintillator

so when the BM uses the beam then  
this X-BPM is OUT (>15mm)

**this X-BPM yields images**

**we use only vert. position**

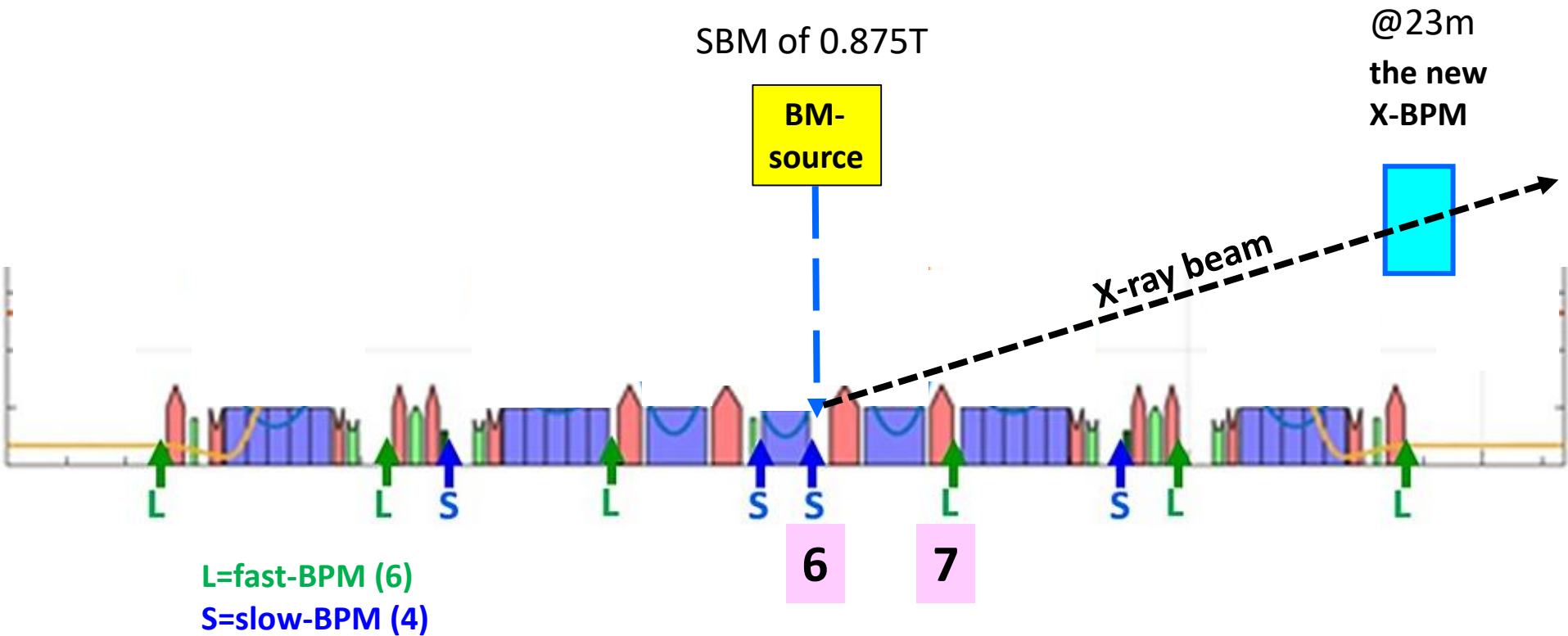


**this V1 X-BPM :**

- is interceptive → we can only use 1 day/week (MDT)
- only yields vertical position → is not such an issue
- is slow (few Hz data rate) → is not an issue

# comparing between two independent position results

comparing the vertical position of the new X-BPM  
with that from the e-BPMs in the Ring



$$\text{Pos } V = 0.8060 *V\_BPM\_6 + 0.0990 *V\_BPM\_7$$

$$\text{Ang } V = -0.9696 *V\_BPM\_6 + 0.49478 *V\_BPM\_7$$

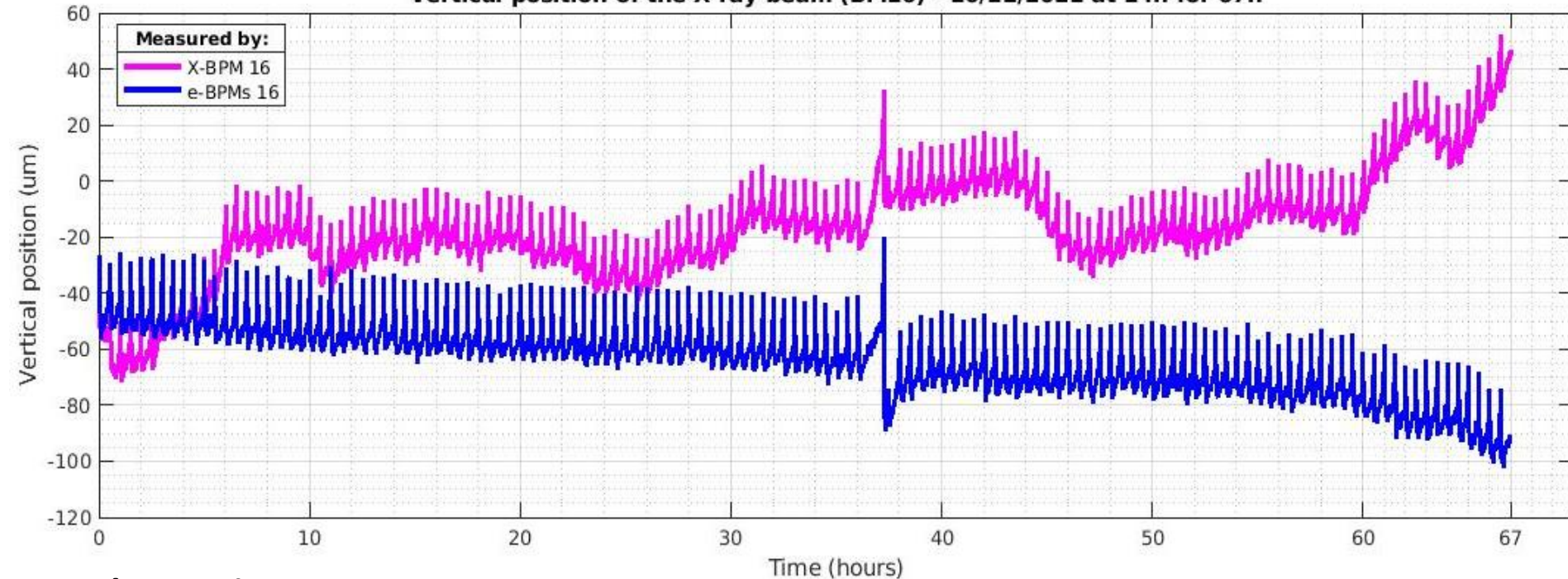


# discrepancy between two independent position results

67 continuous hours in 20mA, 10-12 December 2020

BM-16

Vertical position of the X-ray beam (BM16) - 10/12/2021 at 14h for 67h



## observation :

the X-BPM and e-BPM results drift in opposite direction, attaining 150um difference ...

in contradiction to what is so often said about EBS positional stability ( "very good", "excellent", "perfect" ) we now have clear indication/proof that it is NOT ...

1) what is the cause ? 2) what can we do about it ?

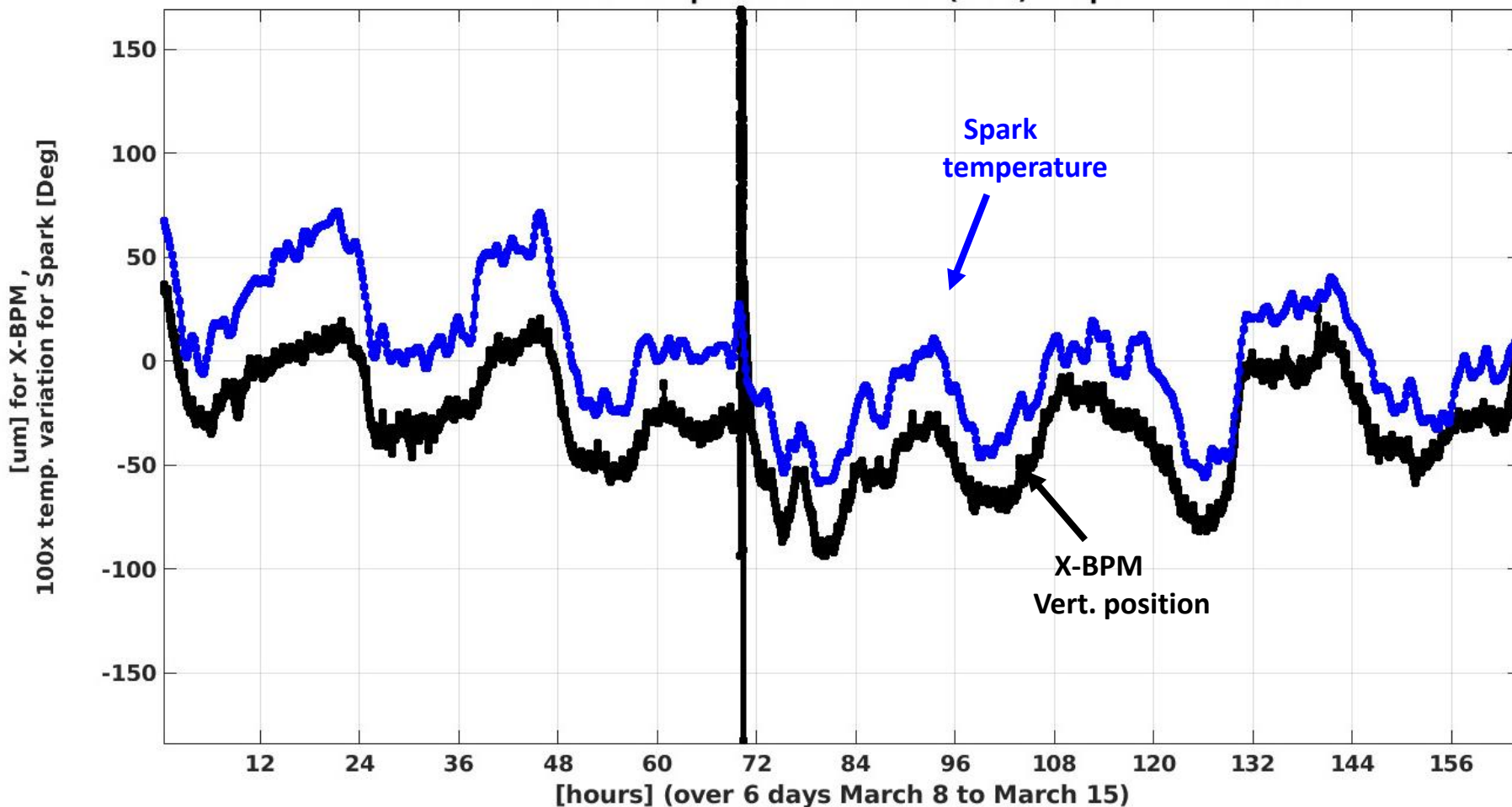


# the cause of the discrepancy : temperature of e-BPMs

strong correlation between BM-16 X-BPM and temperature of that C16-6 Spark

this measurement was only possible since BM-16 allowed us to keep the X-BPM inserted for a full 6 days

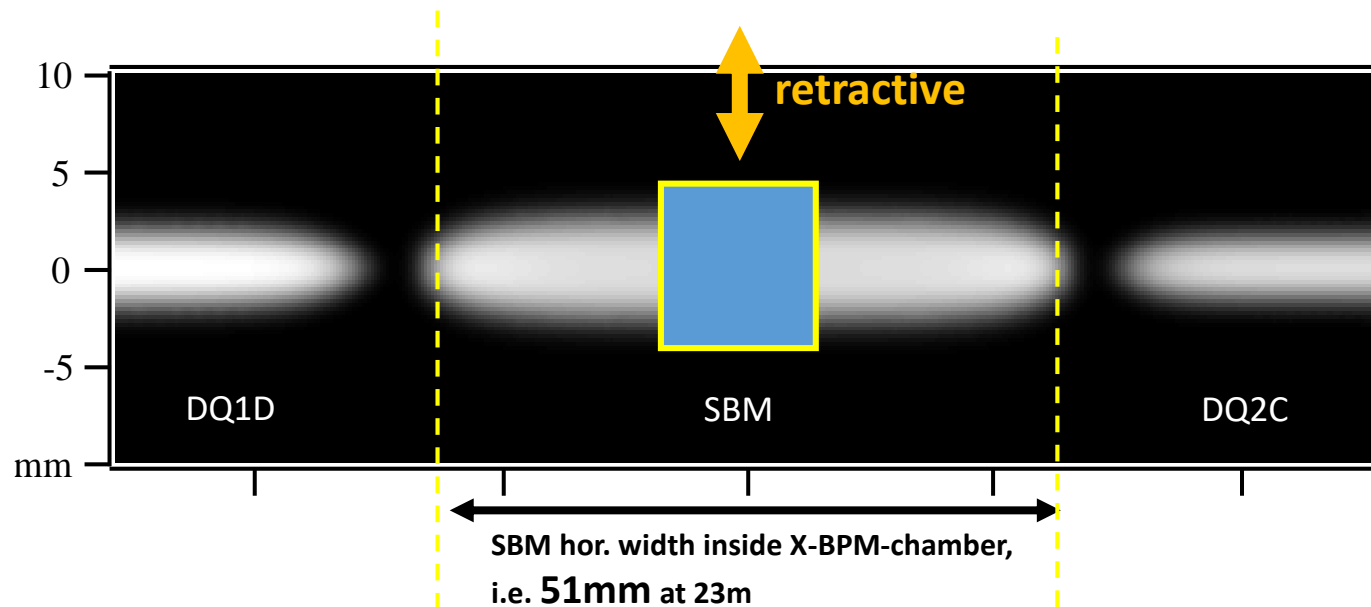
X-BPM-BM16 and temperature variation (blue) of Spark BPM C16-6



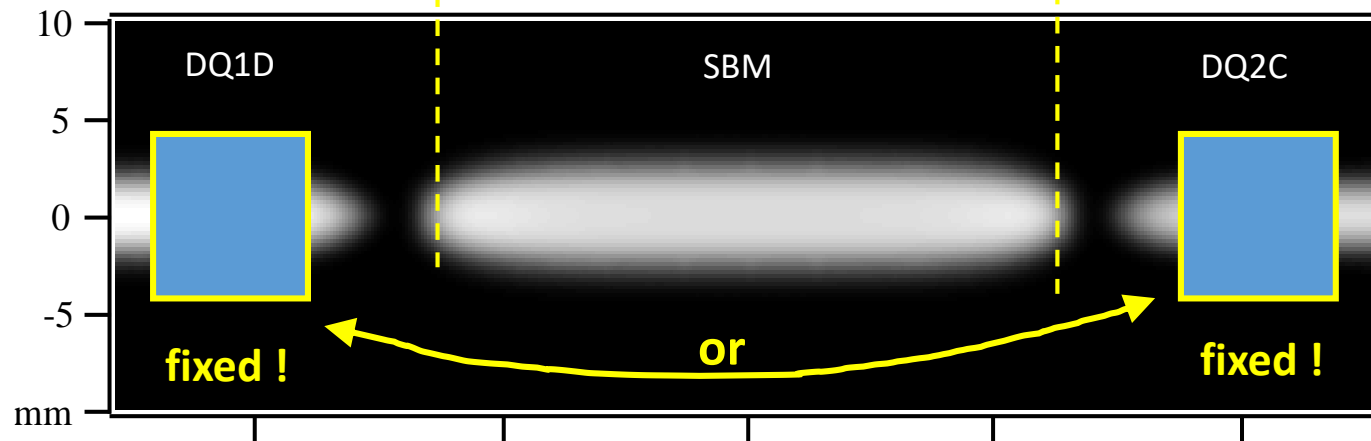
# from Version-1 to Version-2 → permanent monitoring

the un-used X-rays of close-by EBS dipoles can be used with the same purpose

courtesy of J.Chavanne



**V1 :**  
the interceptive  
X-BPM  
served in 2022



**V2 :**  
the fixed & NON-  
interceptive X-BPM  
results since January



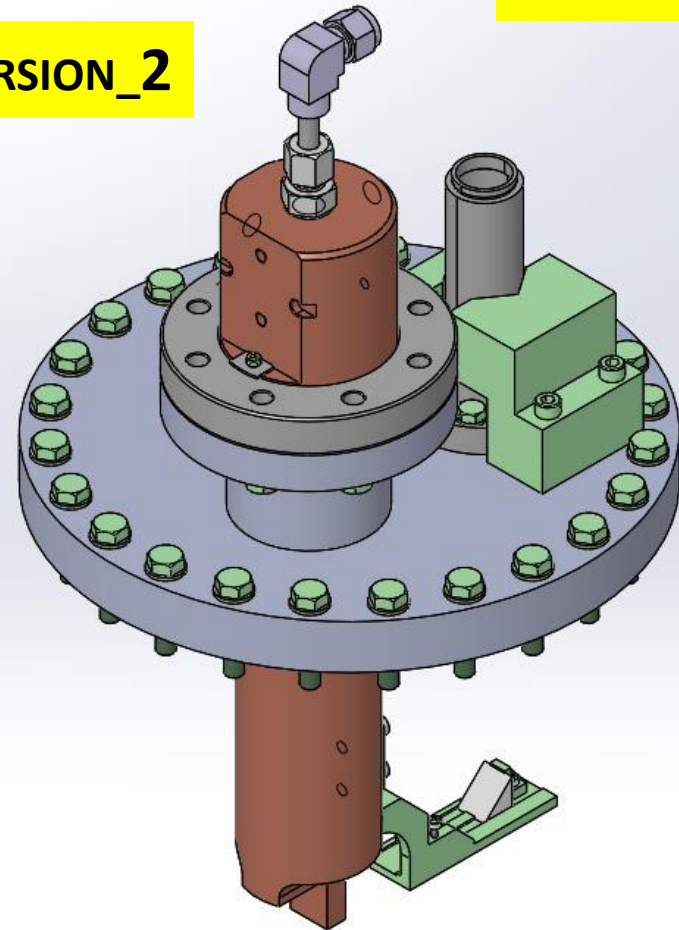
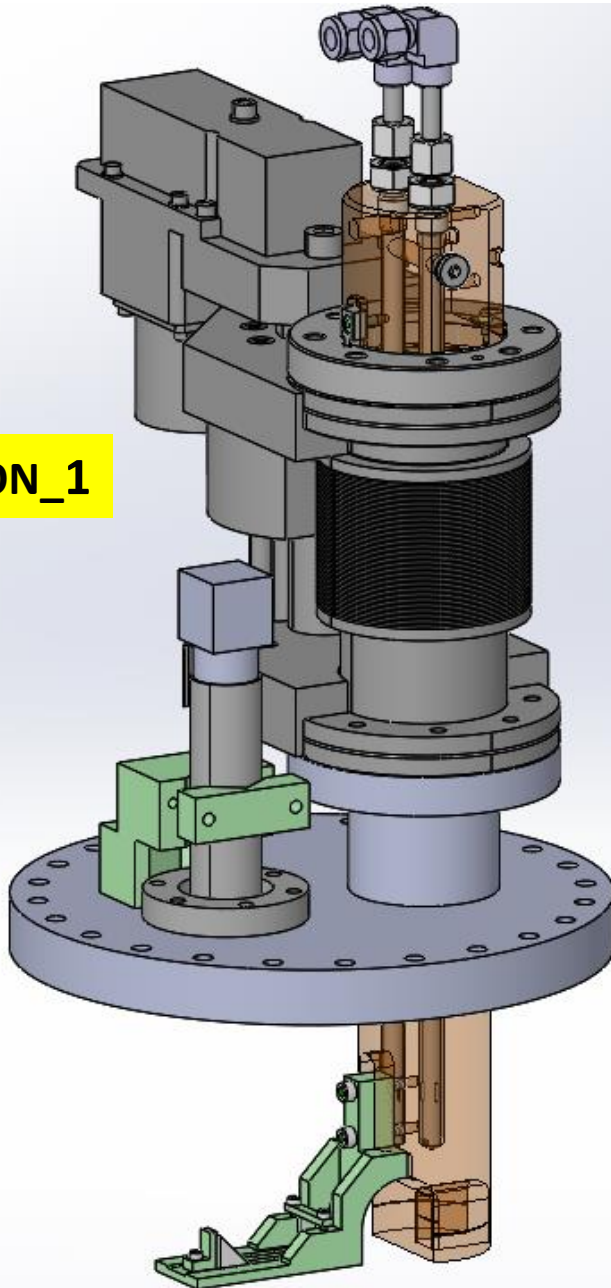
# replacing the V1 with the V2 X-BPM for BMs

simpler, cheaper  
more efficient !

installed this  
January on  
both BM-8  
and BM-16

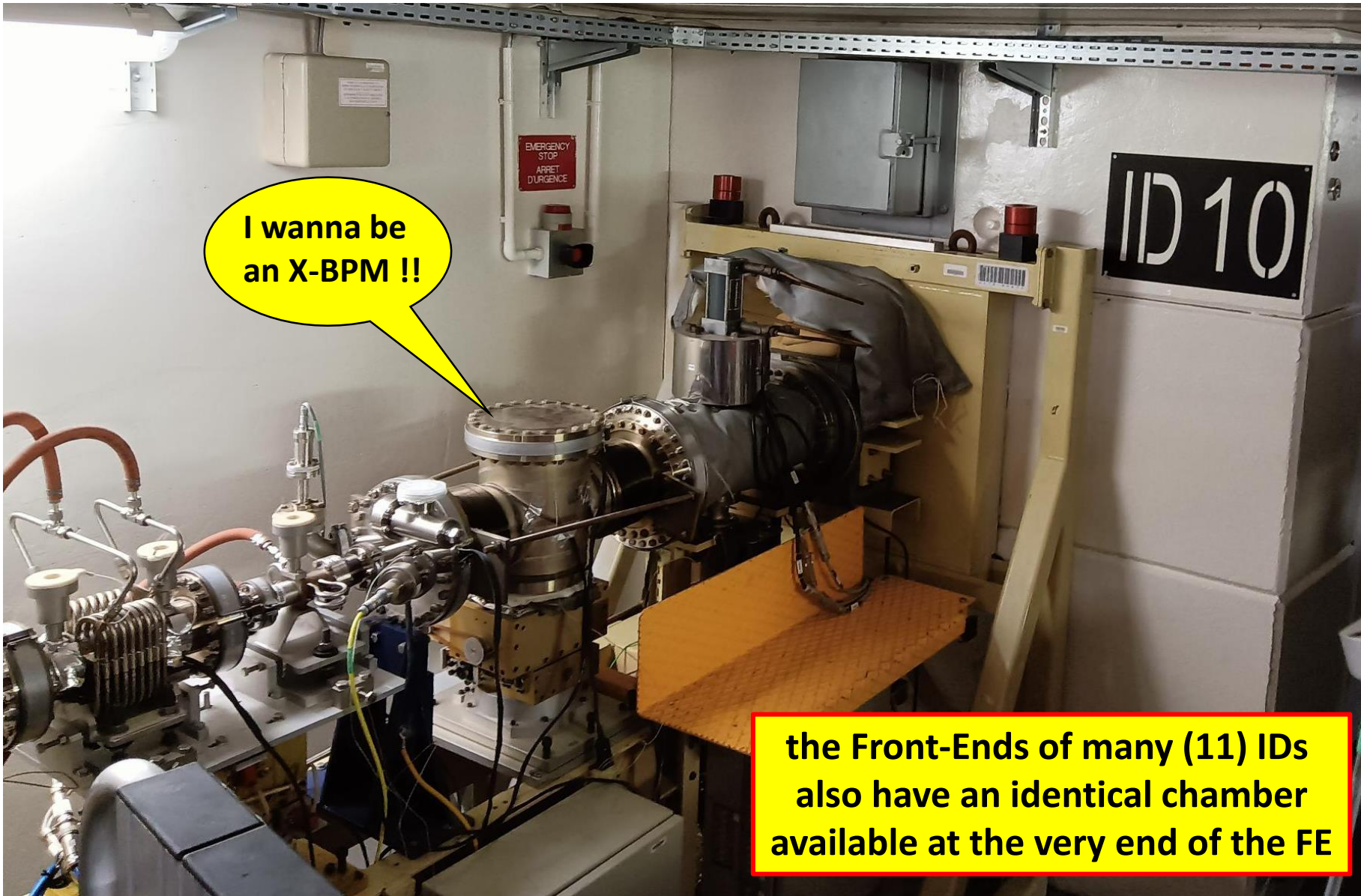
VERSION\_2

VERSION\_1



see results next slides !

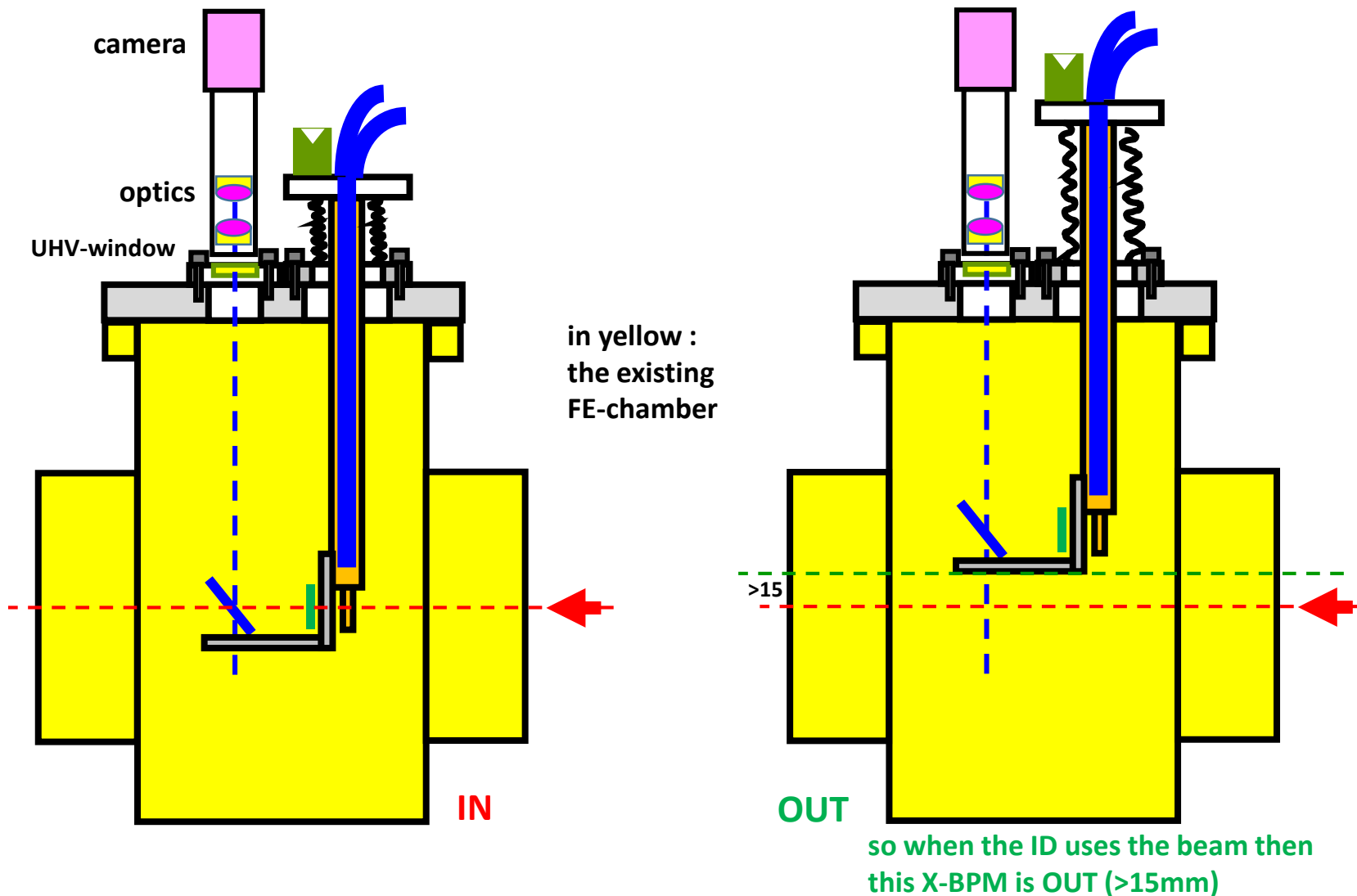
# What about Insertion Device X-BPMs ?



I wanna be  
an X-BPM !!

the Front-Ends of many (11) IDs  
also have an identical chamber  
available at the very end of the FE

# the X-BPM for IDs would be interceptive & retractable





# What use for an Insertion Device X-BPMs ?

1) very regularly different beamlines ask for (and get) an angular bump (on the e-beam) so to bring their X-ray beam back to where they want it

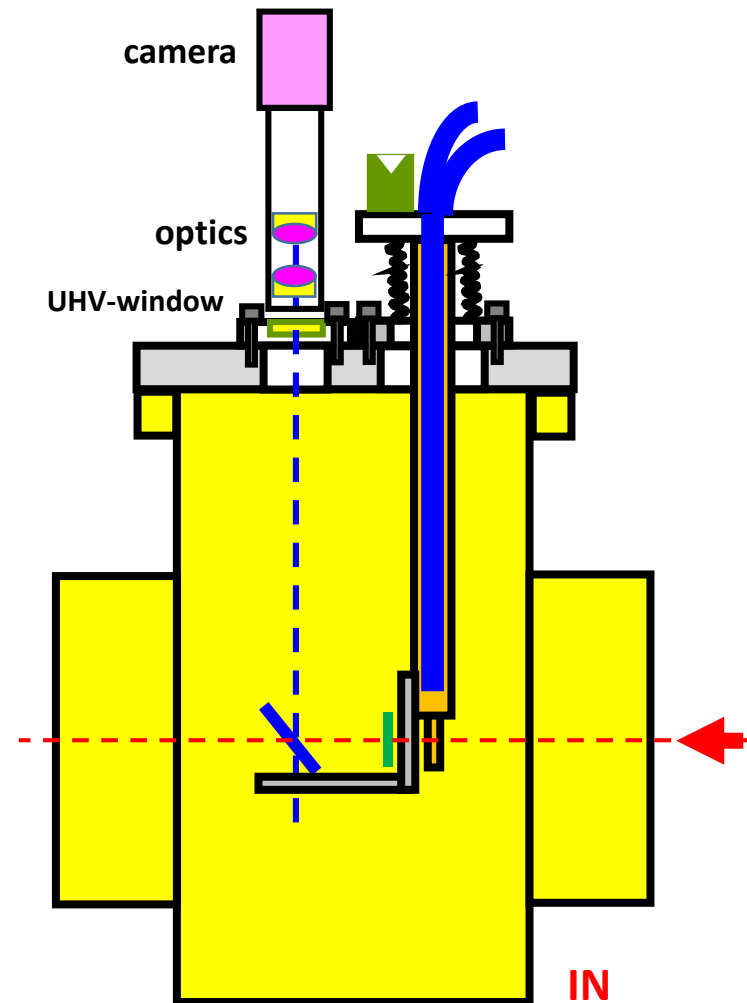
we have no way to know if such X-ray beam-shift was caused by the EBS e-beam or by the beamline itself

**with such an X-BPM we would know**

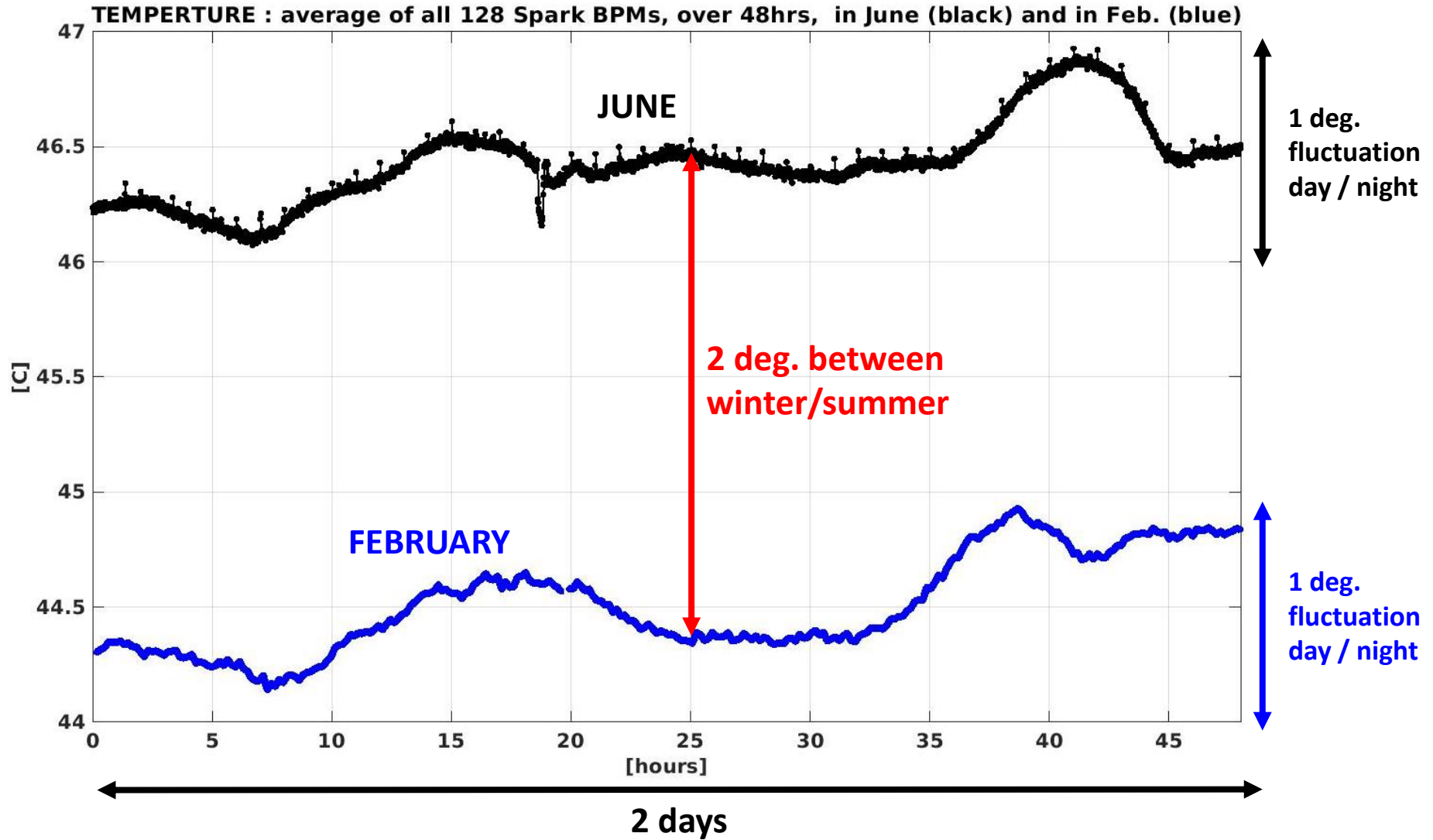
2) the electronics of e-BPMs have excellent reliability but can have a rare failure. Replacing them during USM is sometimes unavoidable.

this can be a problem for those e-BPMs that are around the IDs : this replacement can introduce a small but very disturbing angular shift of the e-beam, and thus ID X-ray beam.

**the X-BPM would be used to compare new position values with those taken every week (during MDT) and can thus serve to correct such shift.**



# situation of temperature fluctuations on e-BPMs (Sparks)



these are averages of all 128 Spark units, the worst ones are a few times worse !

# solution to dampen the temperature fluctuations of BPM



**home-made  
solution**

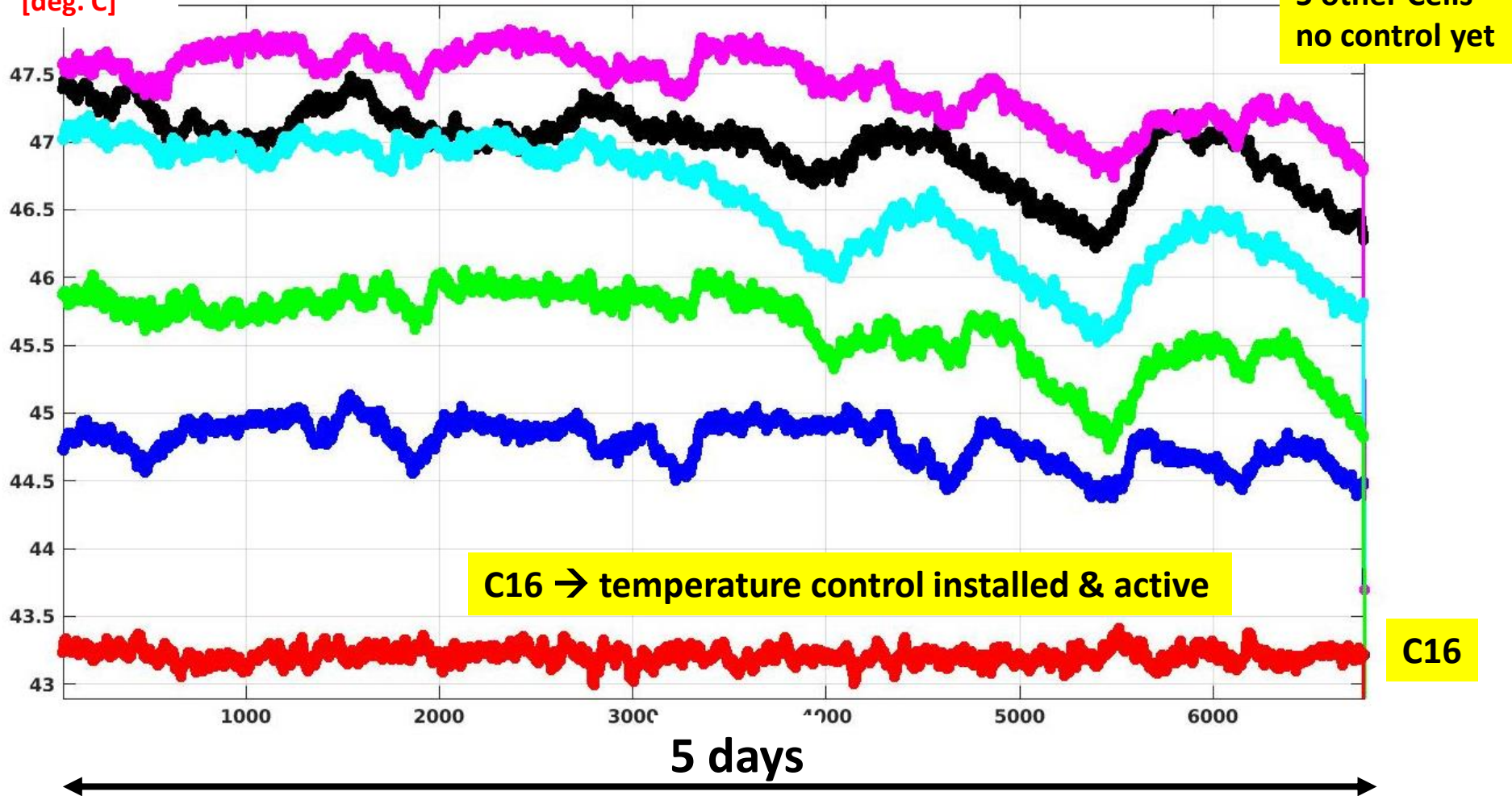
**Costs : 500 Euros  
per unit (cubicle)**

**in total 17 units to be done,  
5 units partly done in 2022  
all 17 will be completely done by summer 2023**



# installation in good progress, will be finished summer 2023 (17 units)

Spark  
Temperature  
[deg. C]

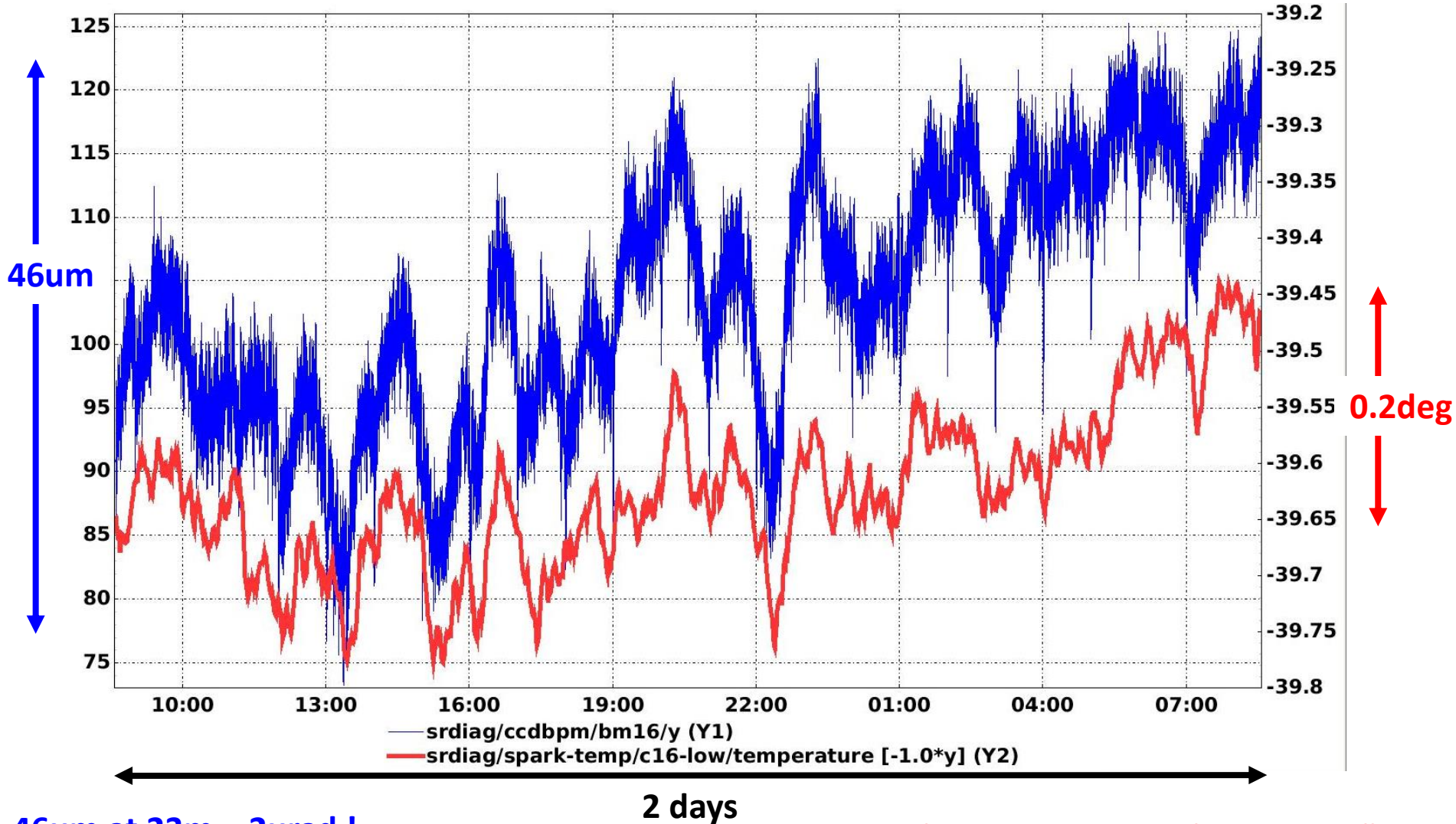


ACU has delivered an efficient device-server for the temp. control

# first results with permanent V2 X-BPM on BM-16

blue=X-BPM-vert. position

red=temperature

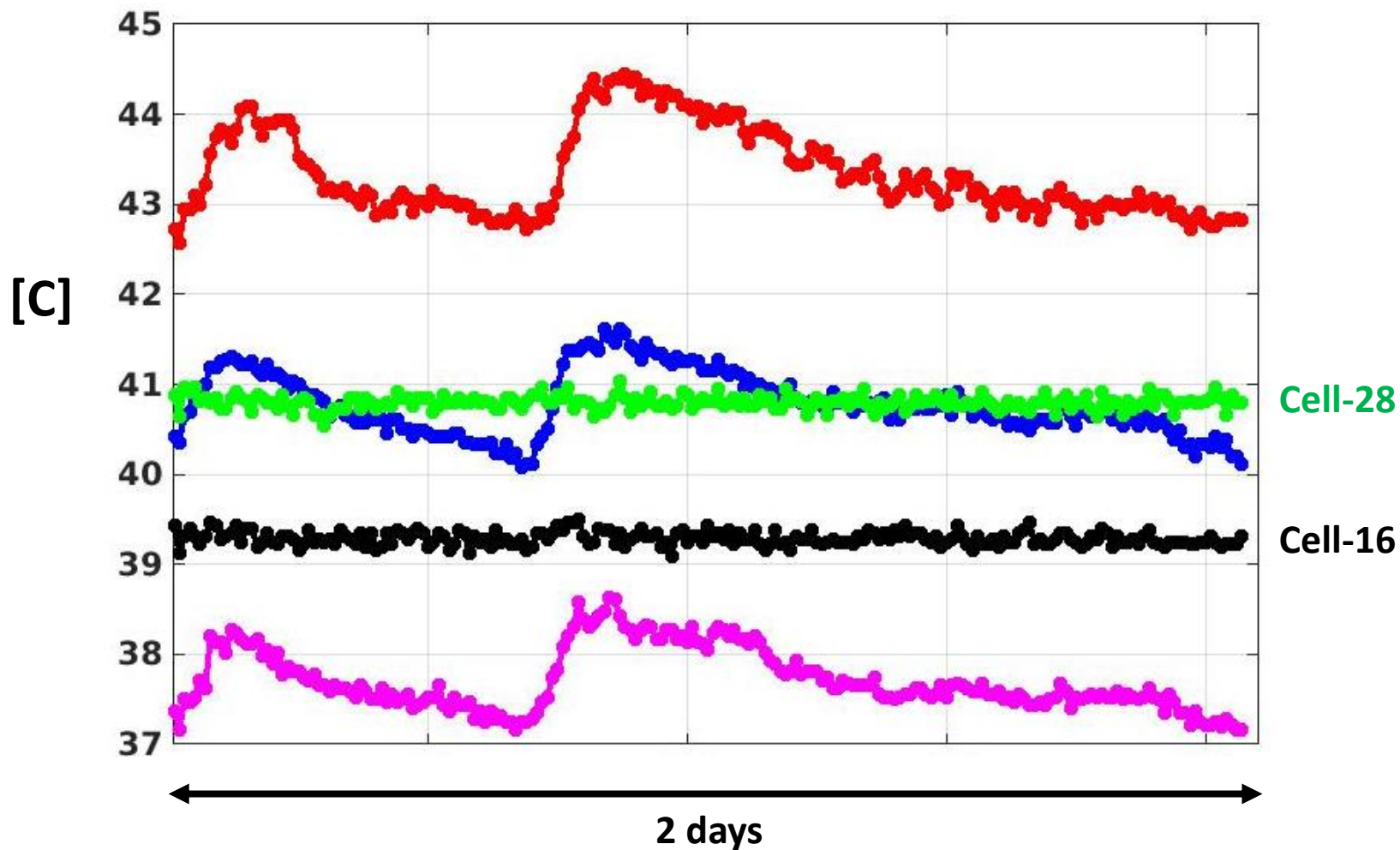


46 $\mu$ m at 23m = 2urad !  
Jean-Louis Hazemann of  
BM-16 asks for 1urad stability ...

the temperature control in SR-BPM cell 16  
was ON but not well configured  
due to suddenly cold weather of last week

# limitations of temperature control on e-BPMs (Sparks)

3 cells NO temp. control versus 2 cells WITH control

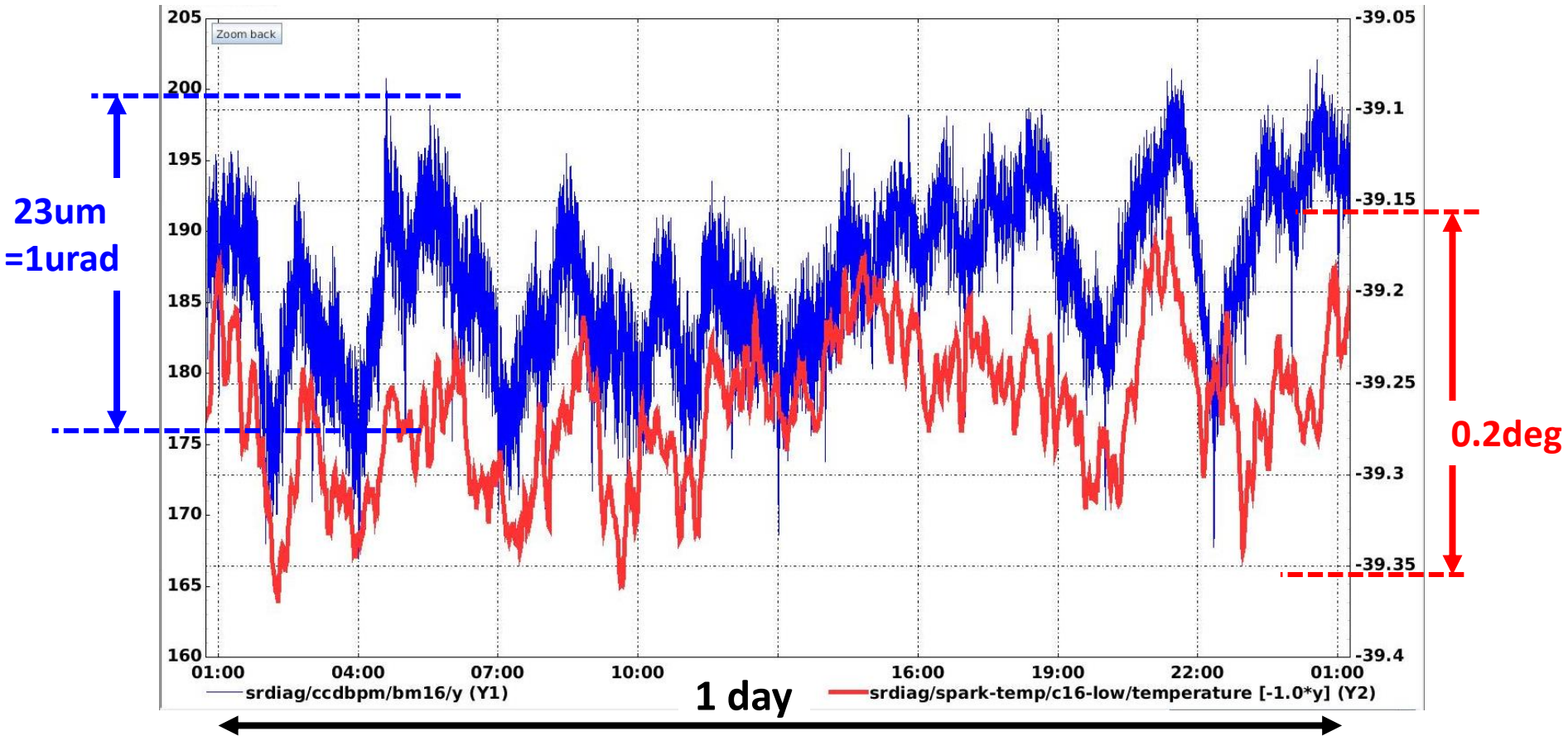




# situation of temperature fluctuations on e-BPMs (Sparks)

blue=X-BPM-vert. position

red=temperature



+/- 0.1 deg temperature control is the best we can do ! if not good enough then we could use the X-BPM to further stabilize the BMs beam position

# conclusion and prospects for X-BPMs

## BM

out of 17 BM sources 11 Front-Ends have such available chamber :  
7 x SBMs (Single-Bending-Magnet)  
4 x 2PWs (2-Pole-Wiggler)

the costs per unit is about 8 KEuros

this year (2023) we expect to install about 4 SBMs

and the next year(s) the 7 others

## ID

out of all 17 ID sources 11 Front-Ends have such available chamber :

the costs per unit is about 12 KEuros

this year (2023) we intend to install one prototype (May, or August)  
perhaps one more in 2<sup>nd</sup> part of 2023

and if prototype experience is successful then  
the others in the next year(s)

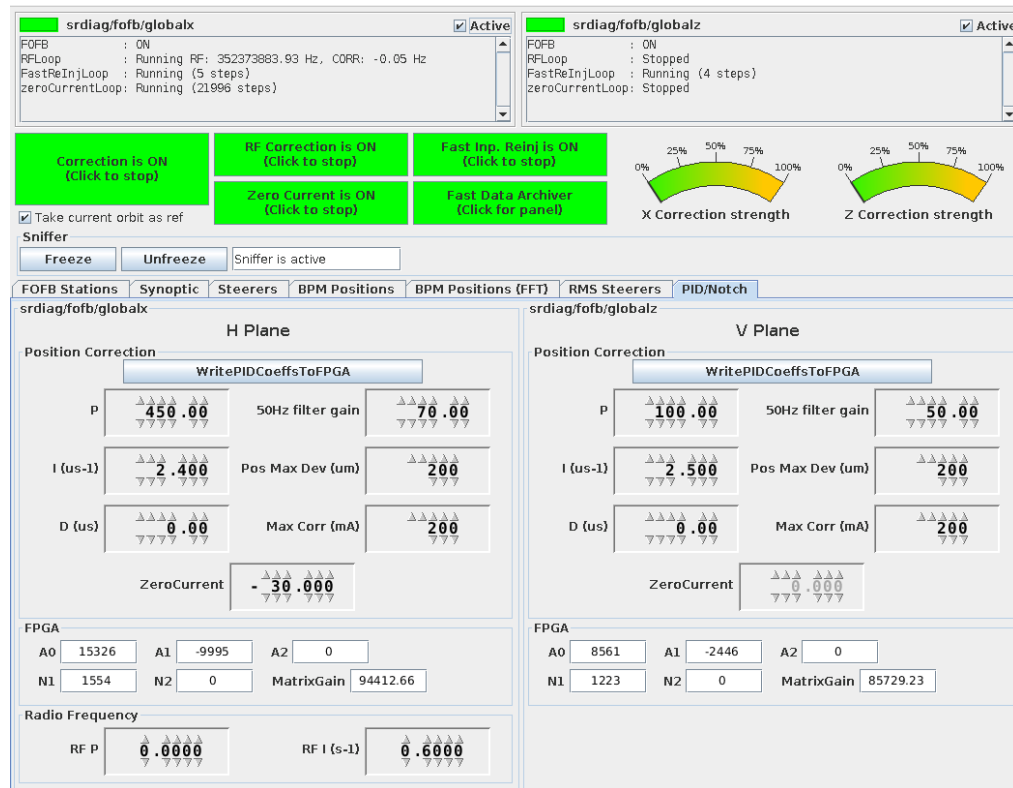
# the upgrades on the fast orbit correction system

1) Adding the 10KHz data-stream on all 128 Spark-BPM-electronics for optimized Fast Orbit Feedback (FOFB) and specific & dedicated applications

2) Optimization of the PID parameters for more flexibility & performance

the old system for setting/controlling these parameters has been fully and drastically modernized

this allows a strongly increased efficiency during MDT studies in assessing and optimizing the performance and behavior of the FOFB

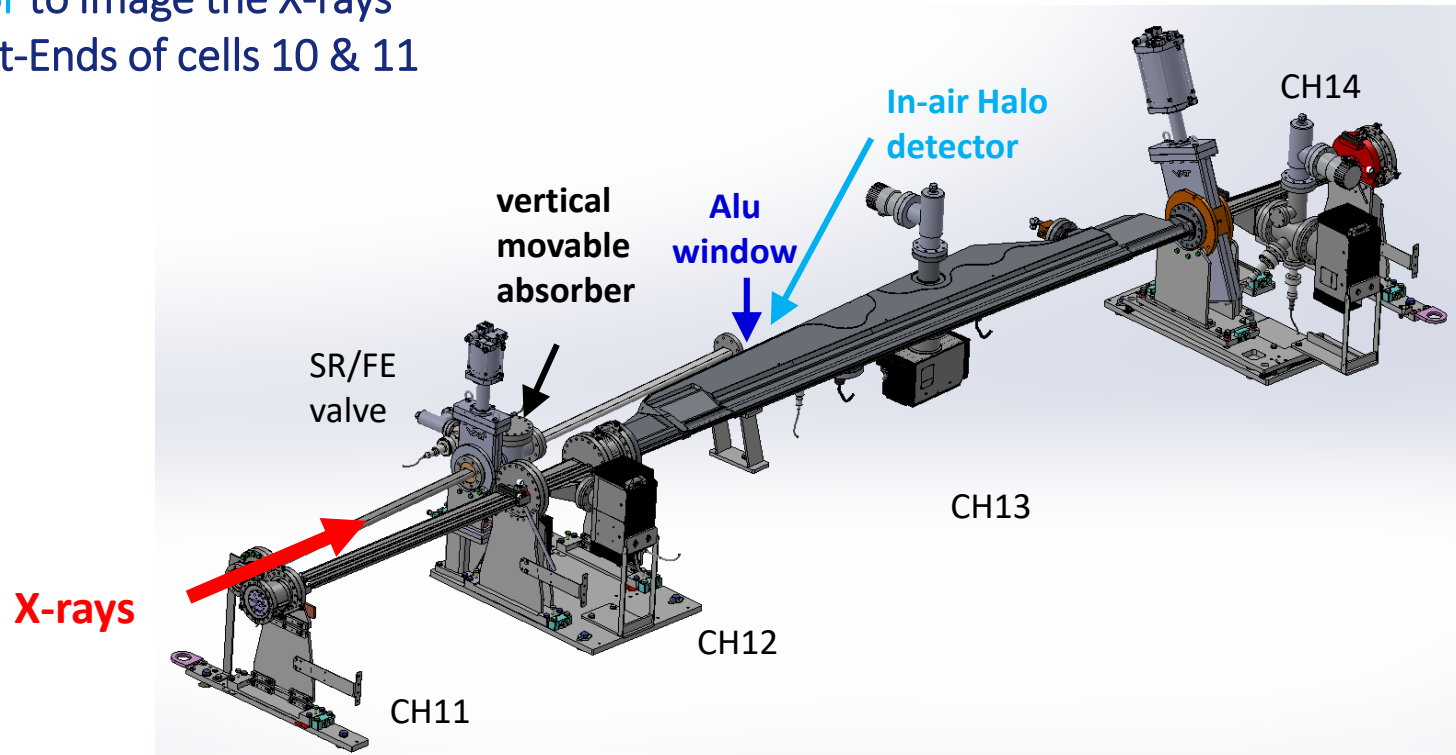


application window

# two units of vertical non-destructive HALO-monitors

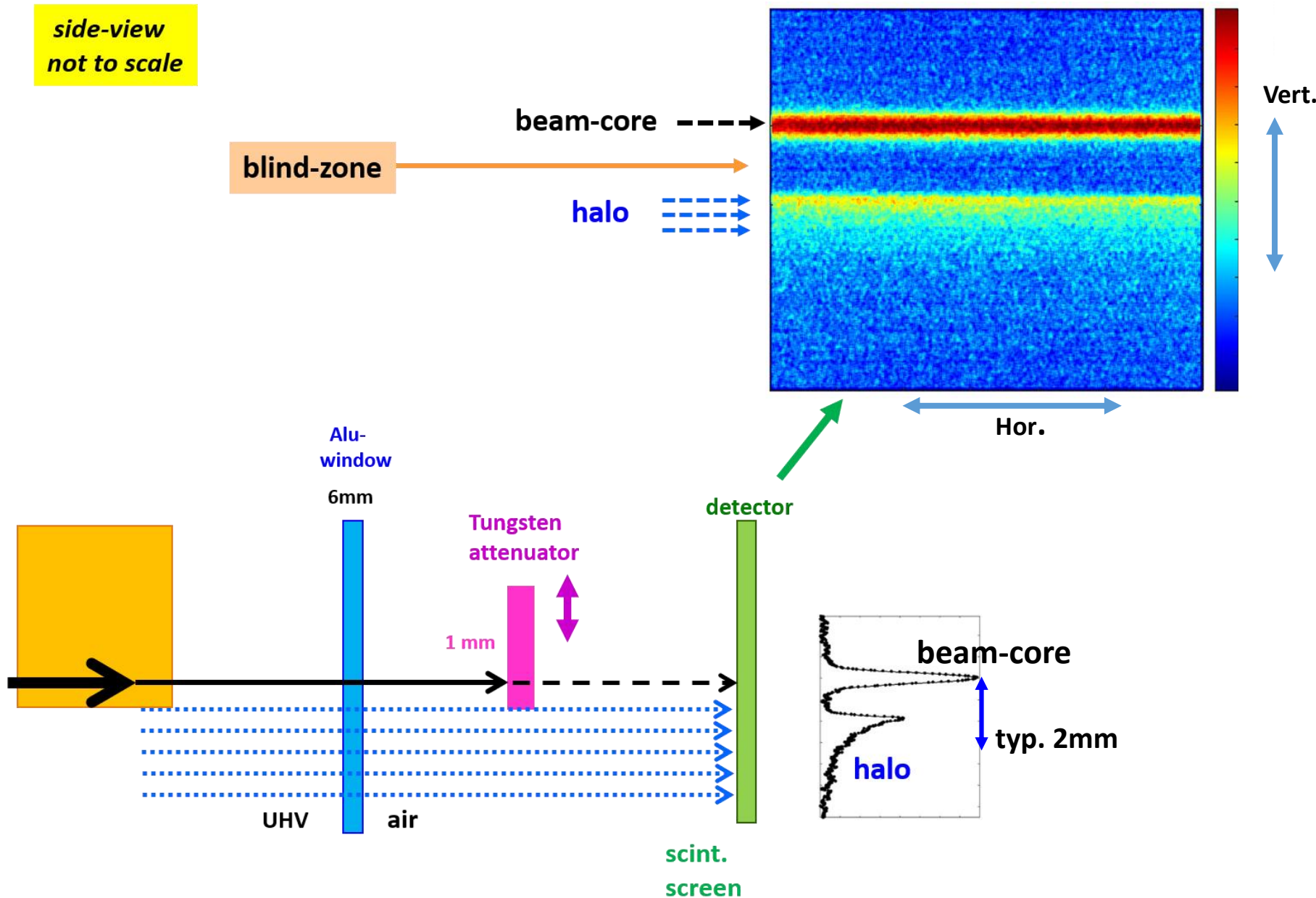
Components:

- dipole **source** (DQ1D, 0.57T)
- free beamport
- vertically adjustable X-ray Absorber to shadow the intense beam-core
- **Aluminium window** to let the X-rays from UHV to air
- sensitive **Detector** to image the X-rays
- in the (free) Front-Ends of cells 10 & 11



# two units of vertical non-destructive HALO-monitors

side-view  
not to scale



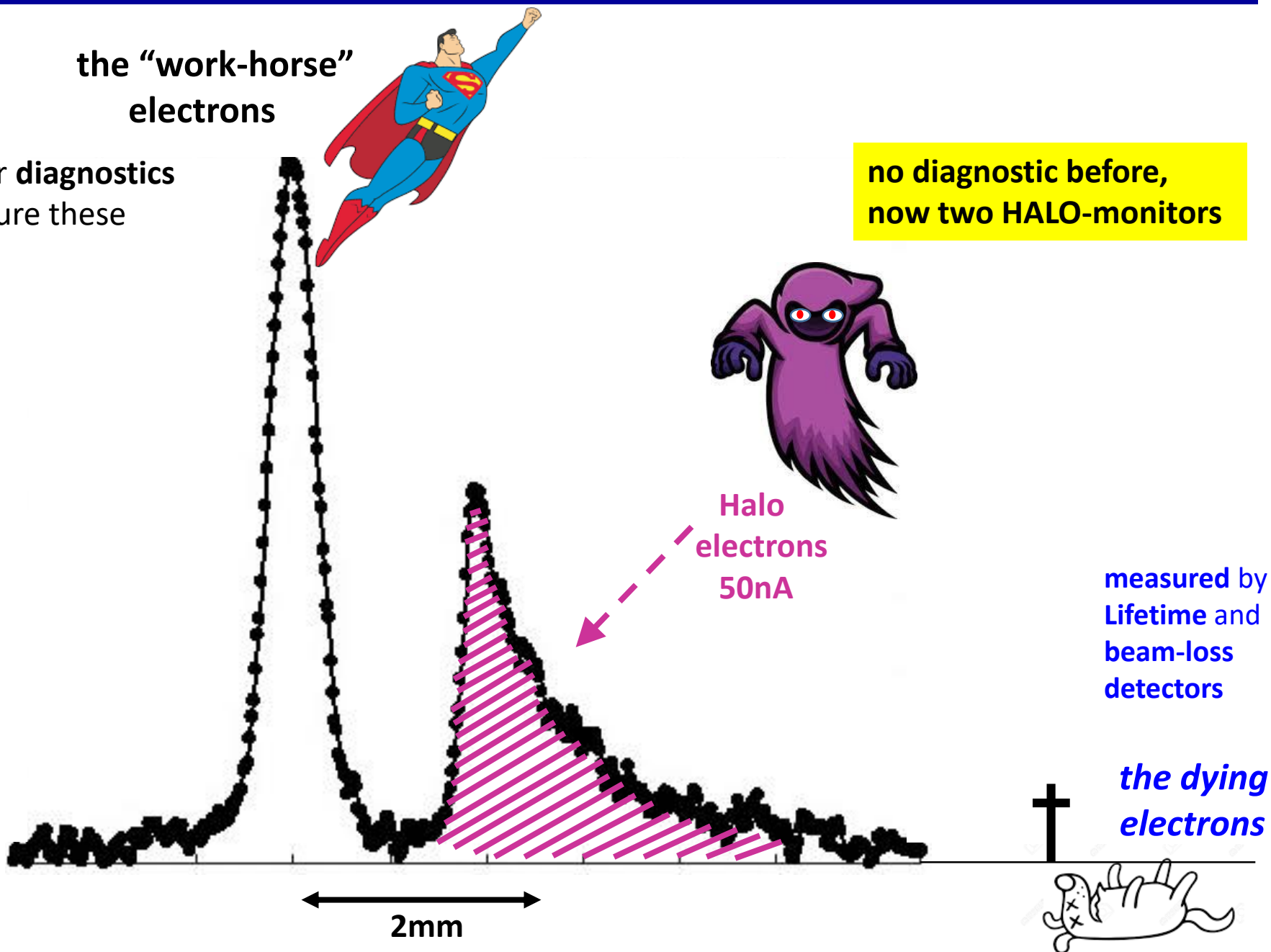


# our Diagnostics now measure all kind of electrons

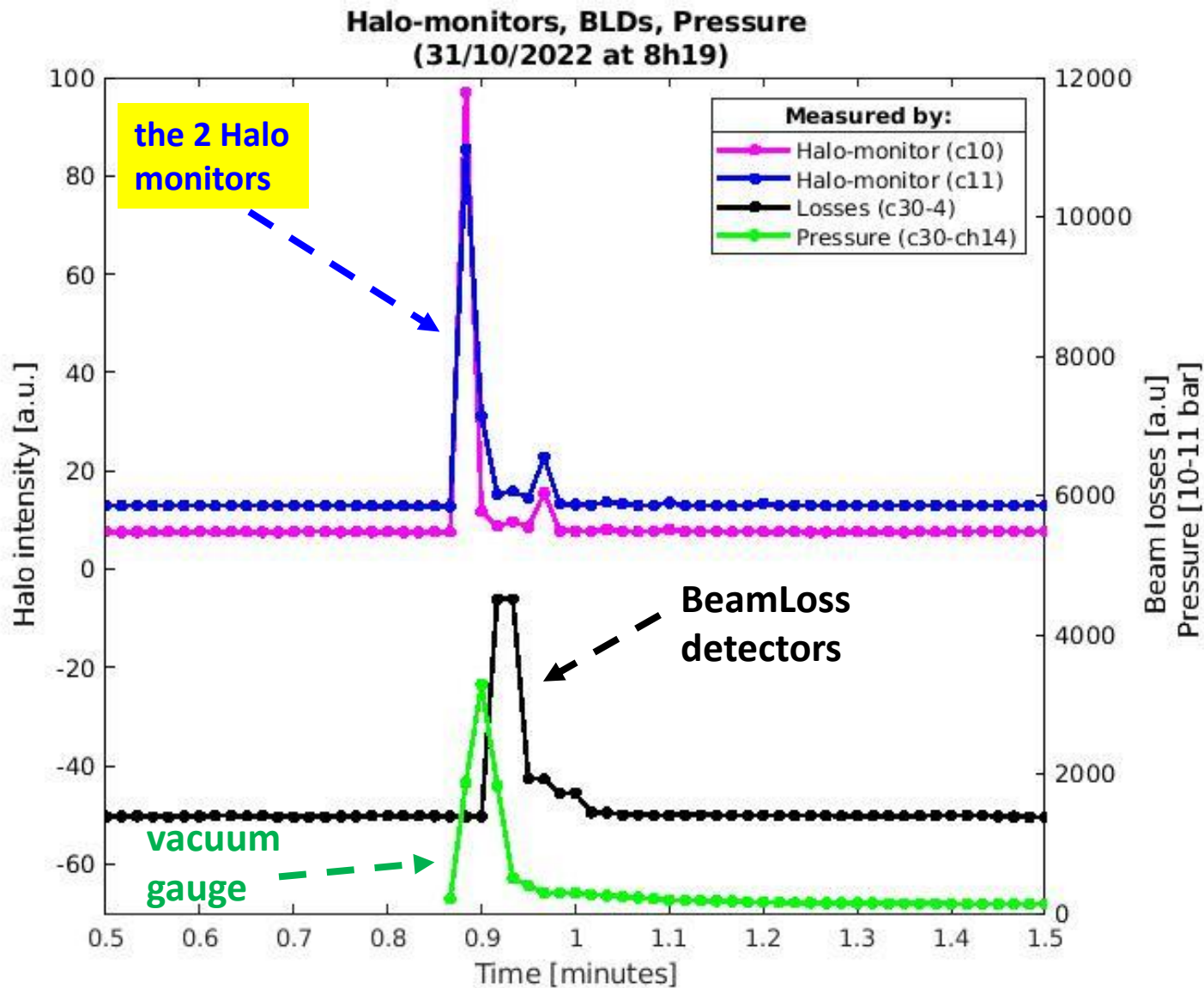
the "work-horse"  
electrons

all our diagnostics  
measure these

no diagnostic before,  
now two HALO-monitors



# the HALO-monitors are an excellent watch-dog on Vacuum

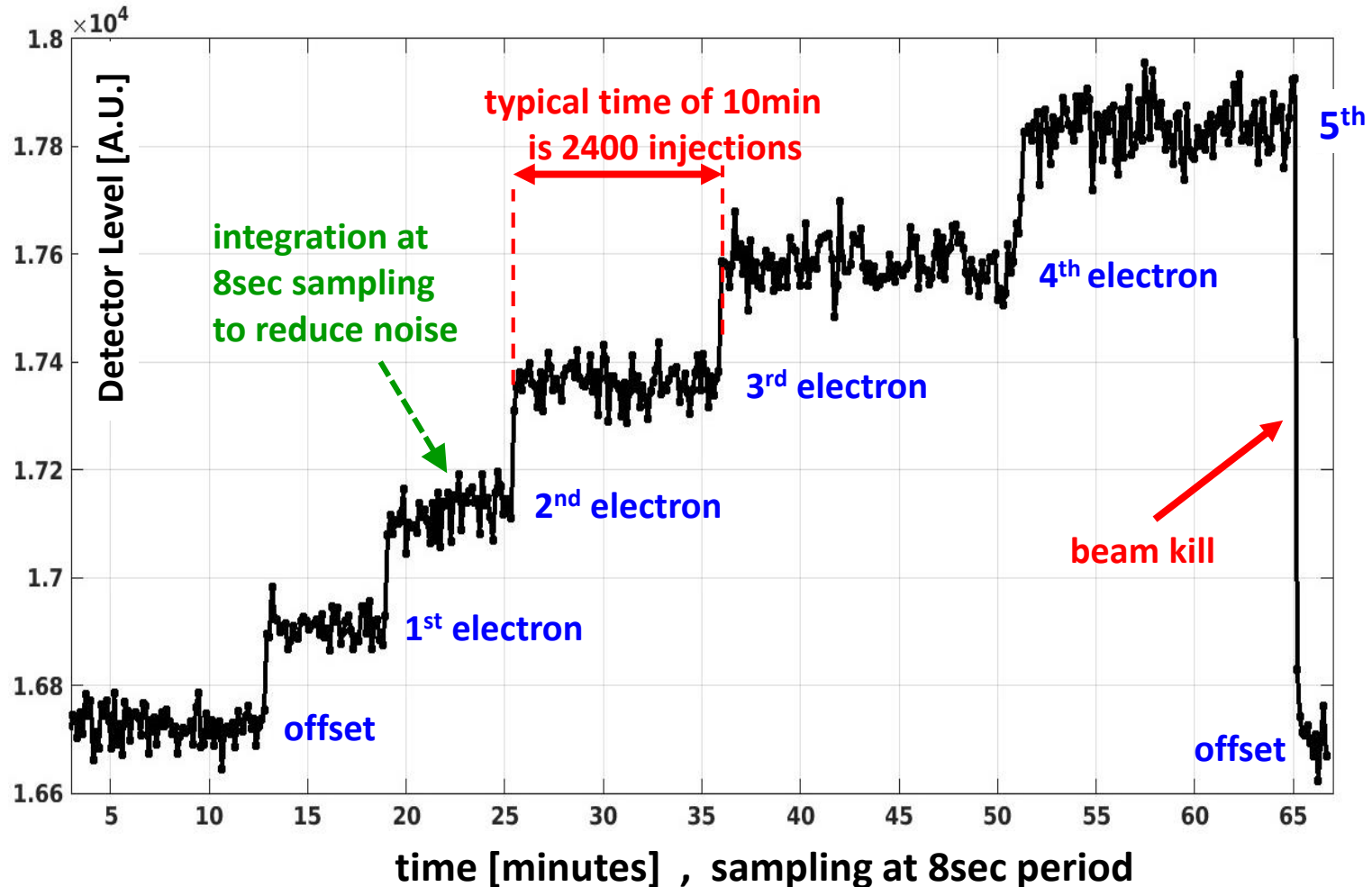


# single electron(s) in the EBS

at 200mA there are : 3 500 000 000 000 electrons

can we put & measure only

1 electron ?



# other developments & activities

## 1) improvements on the damping of injection perturbation

**this is a FeedForward system that often needs fine-tuning & optimization  
the precise calculation of the FF parameters is now semi-automized**

**→ see presentation Simon White**

## 2) all emittance-monitors now have Injection-synchronized gating added

**this allows to much better assess the effect of injection perturbations  
and also the effect of its damping system**

# KEEP OUR DIAG. STAFF !!

we have lots of essential systems to look after  
and projects that will yield benefits to the ASD

we just need to keep our staff !!



ASD-day, Grenoble  
January 24, 2023  
Kees Scheidt

## The Diagnostics Group :

Nicolas Benoist

Elena Buratin

Guillaume Denat

Friederike Ewald

Benoit Roche

Kees Scheidt

Fouhed Taoutaou



ASD-day, Grenoble  
January 24, 2023  
Kees Scheidt



The European Synchrotron

on behalf of the  
Diagnostics Group :

a big **thank-you** for help & support  
from colleagues in :

Vacuum , RF , Beam-Dynamics , ACU ,  
FE , Operation , ALGE , TID  
Radio-Protect. , Mech. Engineering