Beam Loss Detectors at the ESRF

Overview of this presentation :

1) short Intro to the ESRF, its Upgrade and its crucial Vacuum system

2) The ESRF Storage Ring, the ASD division and the Diagnostics Group

3) The BeamLoss Detectors, their principle, distribution in the Ring, Results

4) Gass Bremstrahlung Detectors

5) Upgrade towards faster data acquisition for Beam Loss studies at Injection

The ESRF in brief

- Electron Energy **6 GeV**, Perimeter **844 m**
- DBA Lattice with 32 cells alternating high and low beta in IDs
- Ring current **200 mA**
- Emittances 4 nm (hor.) and <10 pm (vert.)
- First beam delivered in 1992
- ~ 70 ID segments serving 28 ID beam lines

- High beam availability : **98 to 99%**

- Lifetime ~ **60 h** at **200 mA**

- Many Filling modes (Uniform, 2/3, 7/8+1, 16 bunches, 4 bunches)

The ESRF in brief

- ~ 2000 Proposals each year
- > 6000 User Visits
- ~ 1500 Experimental Sessions
- ~ 43 Synchrotron Radiation Beam lines
- > 1500 Referenced Scientific Publications
- ~ 600 Staff
- ~ 80 M€ Annual Budget (55% Personnel, 25% Operation, 20% Investment)

ESRF: 19 Members and Associate Countries

Contribution to ESRF Budget (and share of beam time)

Members

• France	27.5%
• Germany	25.5%
• Italy	15%
• UK	14%
• BeNeSync (Belgium, The Netherlands)	6%
• NordSync (Denmark, Finland, Norway, Sweden)	4%
• Spain	4%
• Switzerland	4%
	100%

Scientific Associates

• Portugal	1%
• Israel	1%
• Austria	1%
• Poland	1%
• Central-Sync (Czech Republic, Slovakia, Hungary)	1.05%

a first part of an Upgrade Programme is going to be undertaken very soon (Dec. 2011 to April 2012)

The beam diagnostics group (7 colleagues) in the Accelerator & Source Division (~65 colleagues)

RF acceleration

Front-ends

Operation

Beam Dynamics (theory)

Power-Supplies

Insertion Devices

Diagnostics

Beam Diagnostics in the 844m Storage Ring :

Beam Position Monitors (224 units)

Global Orbit Stabilization system (224 BPMs & 96 Steerers)

Emittance monitors (~15 units)

BeamLoss monitors (64 units)

Tune monitors

Current monitors

Protective Interlock devices

Ultra-fast Feedback devices

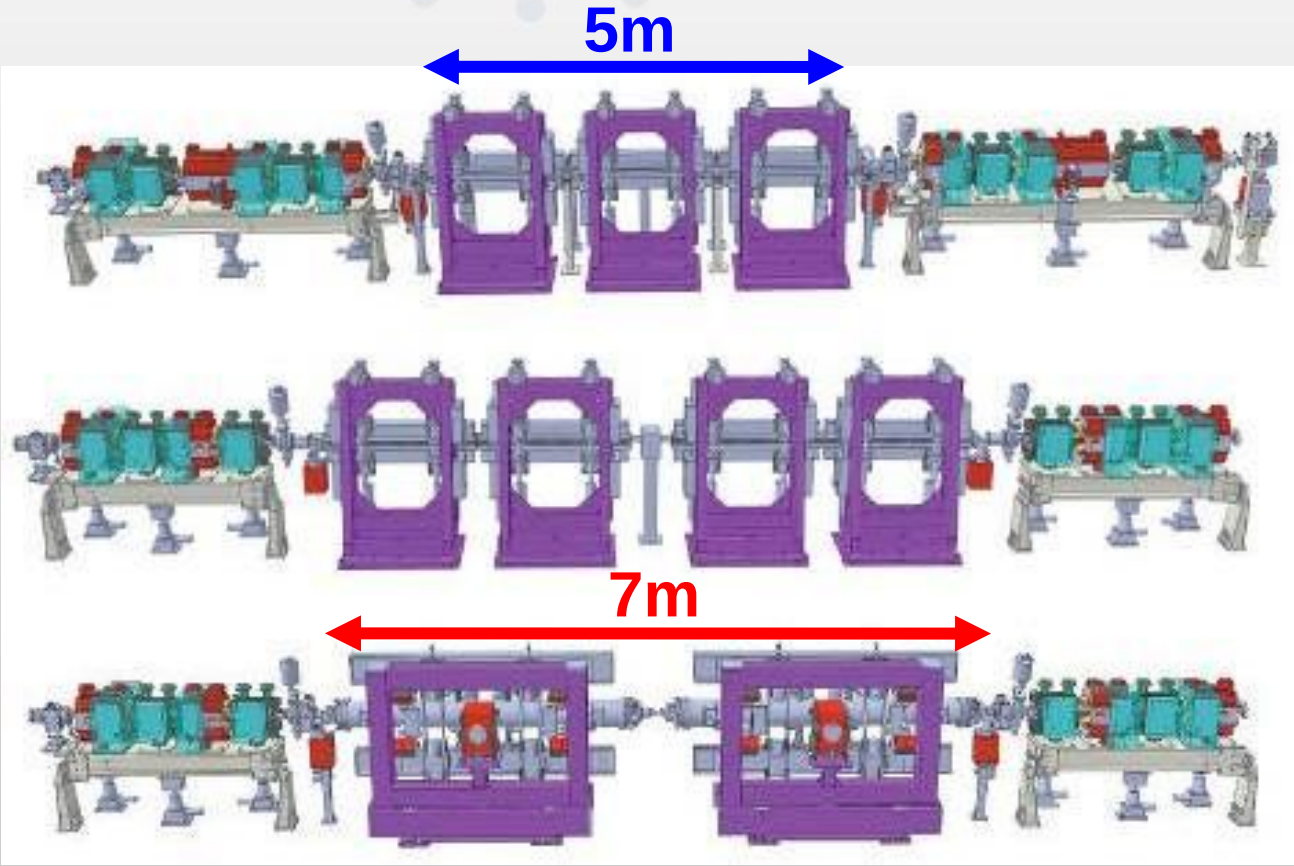
Visible & IR light extraction systems

Accelerator and Source Upgrade :

- Increased insertion device flexibility :
  - 7m straight sections
  - Wide-angle canting

now : 5m

from 2012 : 6 & 7m Strait or Canted IDs



Profile of the 6m long ID chamber
(10mm vert. !)

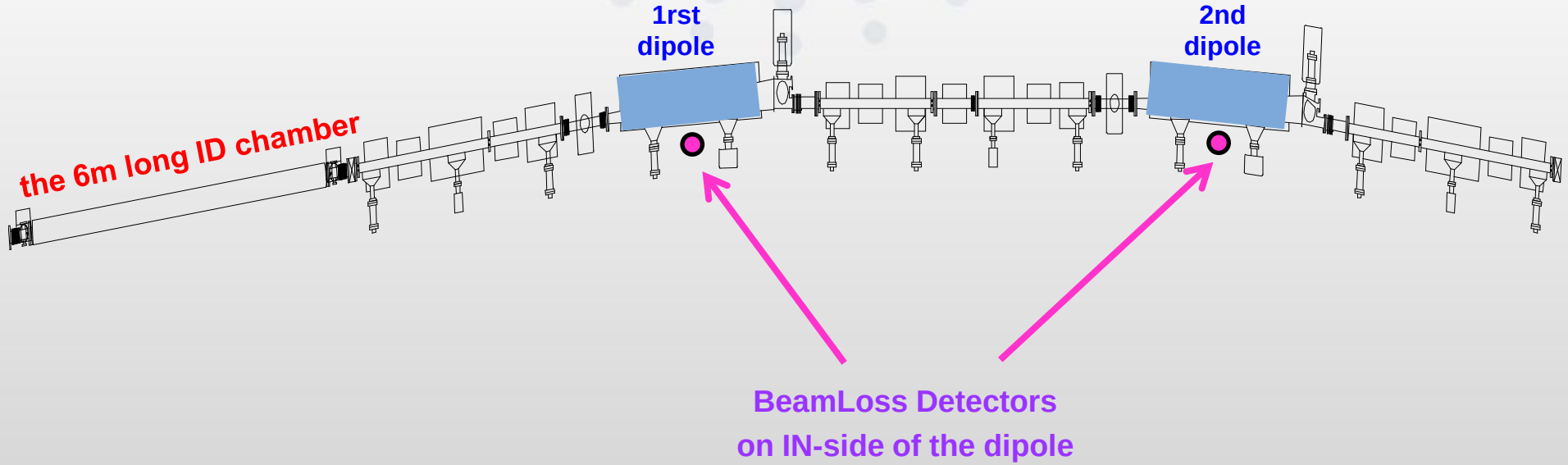
The vacuum lay-out of 1 cell (1 / 32 of the Ring) with :

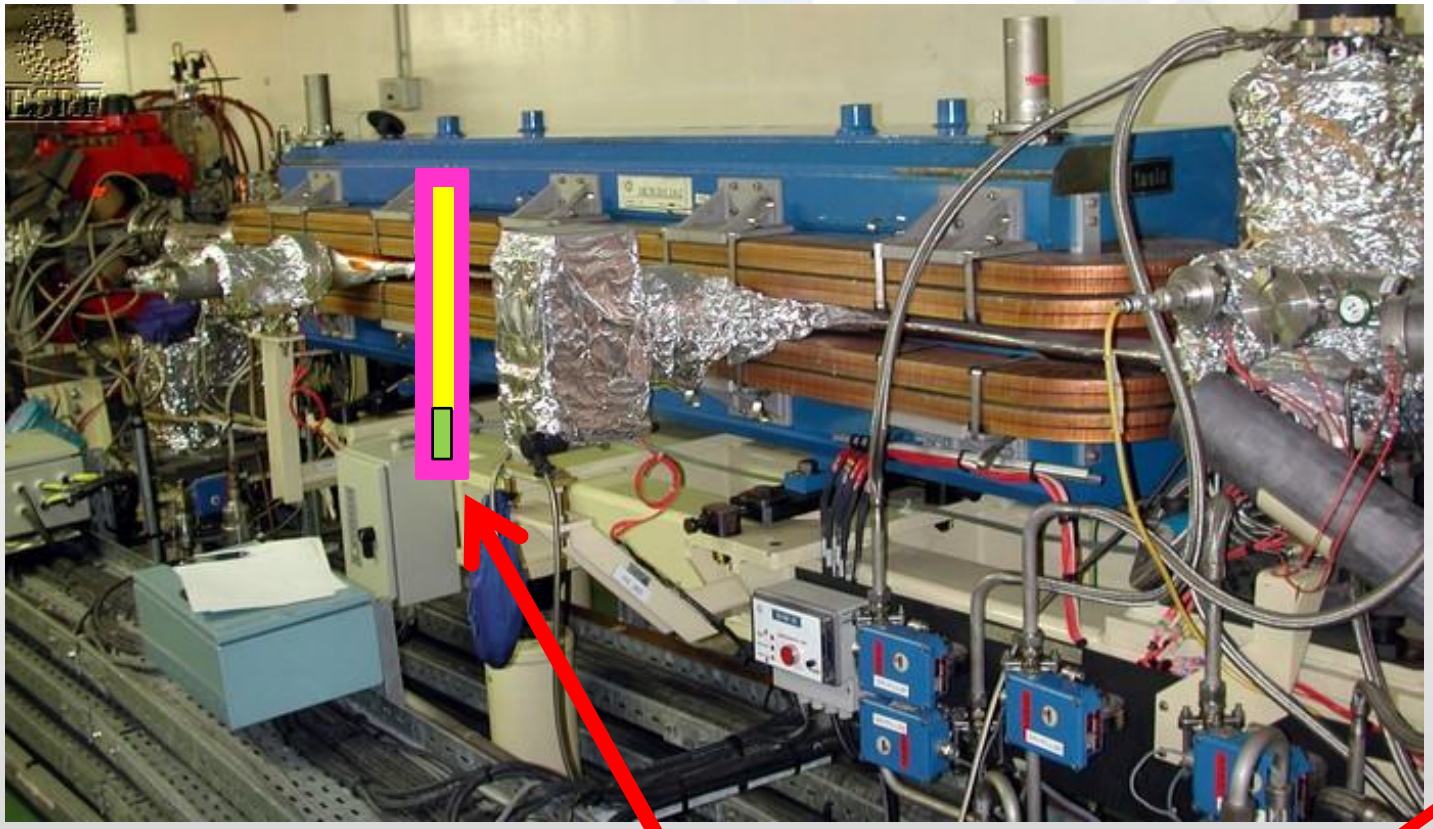
the 6m long ID chamber

the 2 dipoles

the 2 BeamLoss Detectors

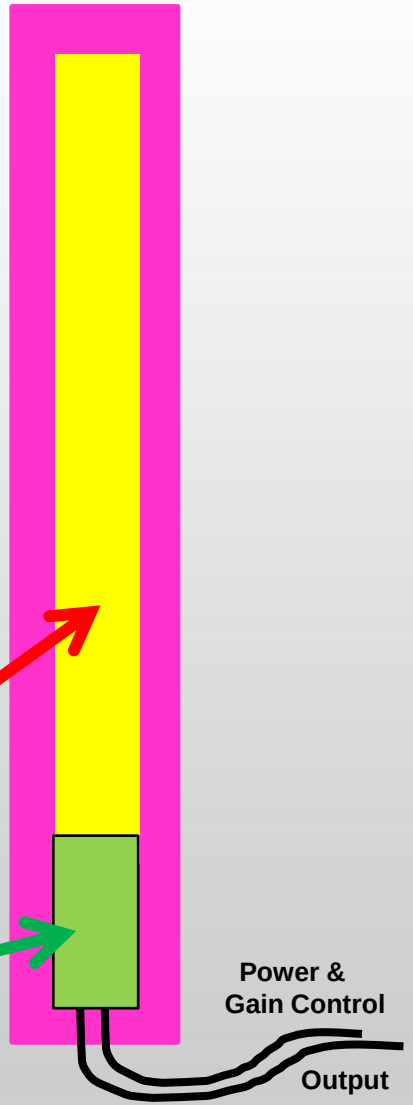
Top View



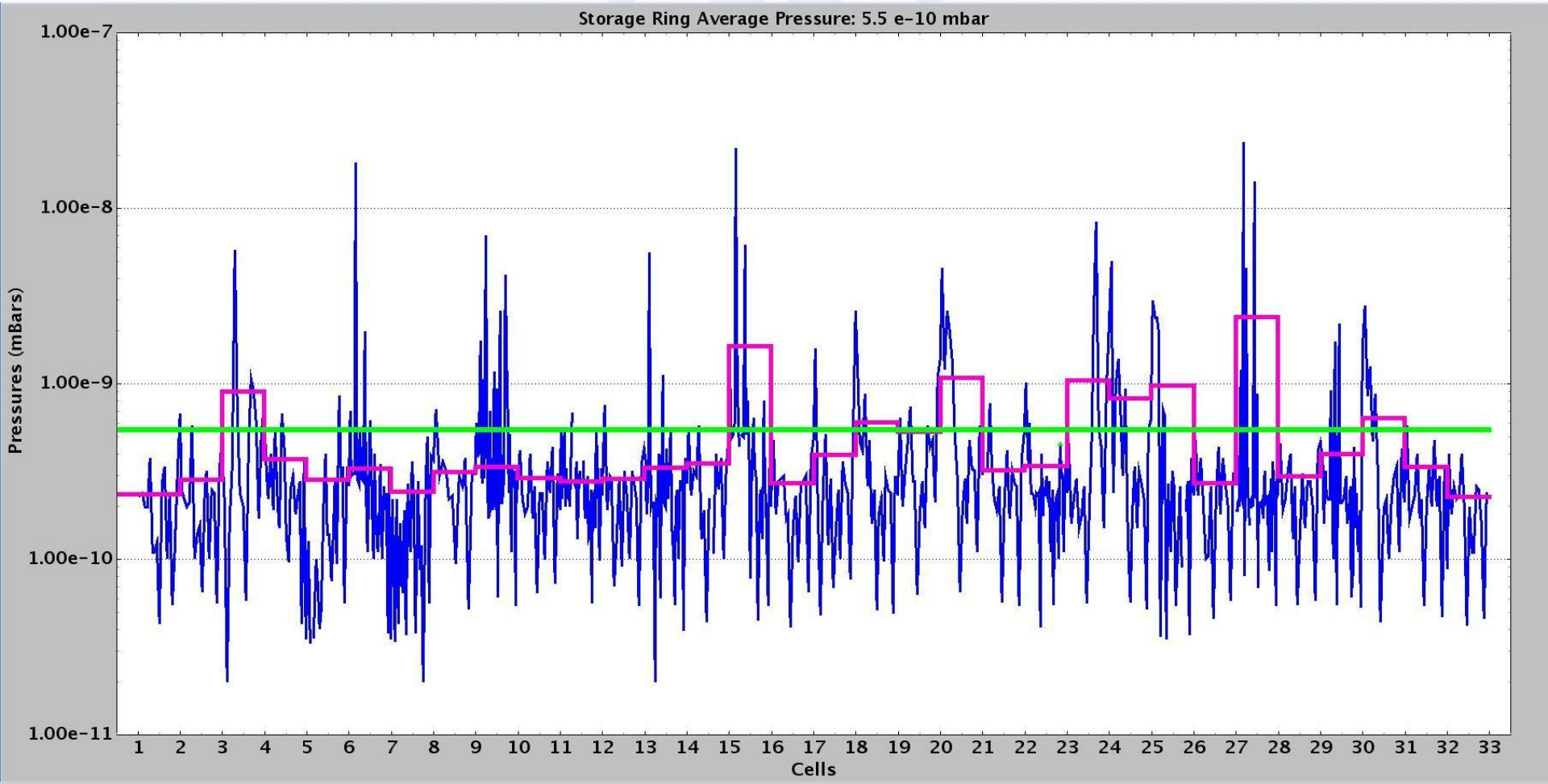


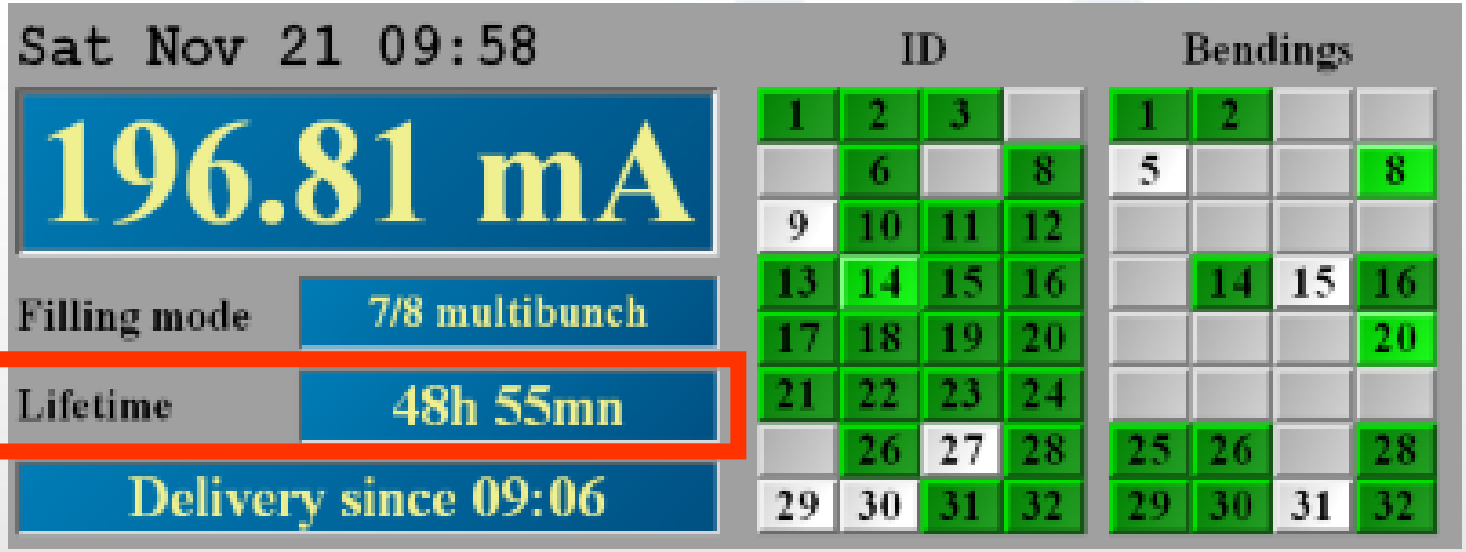
The ESRF **Beam Loss Detector** :

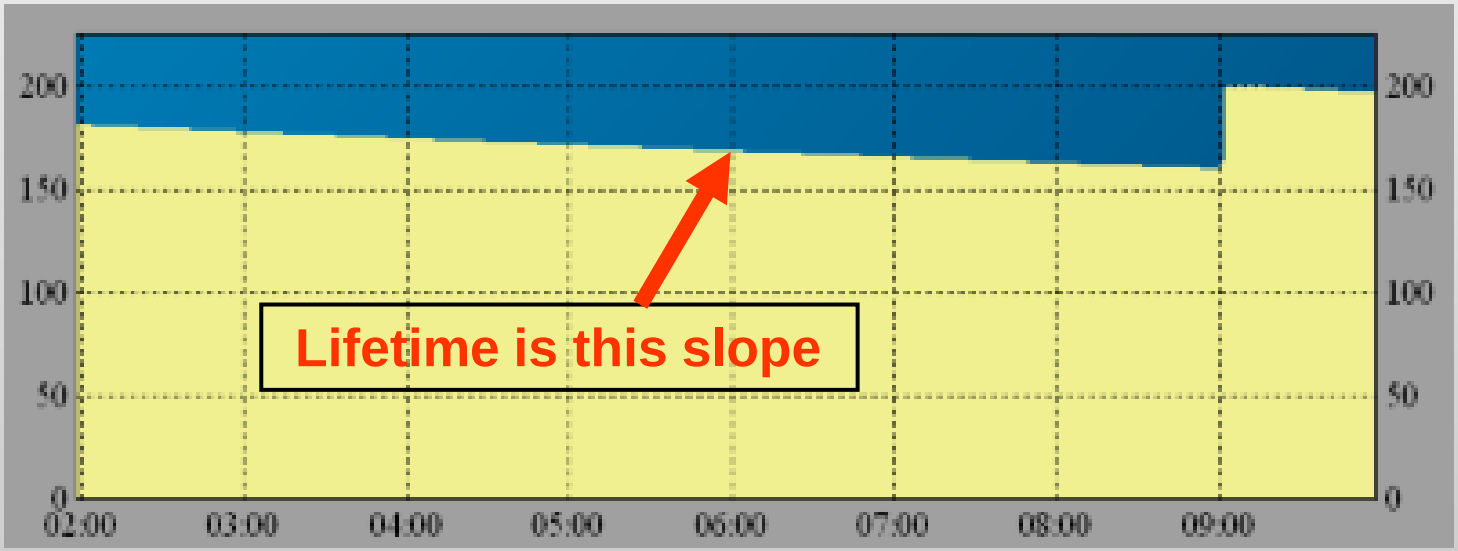
on the inside of each of the 64 Dipoles,
Perspex scintillator rod of 600mm x 25mm diam.
with a 10 mm tubular Lead shielding
and a Photomultiplier tube for light amplification



Excellent vacuum in the ESRF Storage Ring (5.5E-10 mBar)
needed to operate in 'decay-mode' with lifetimes of ~60hrs

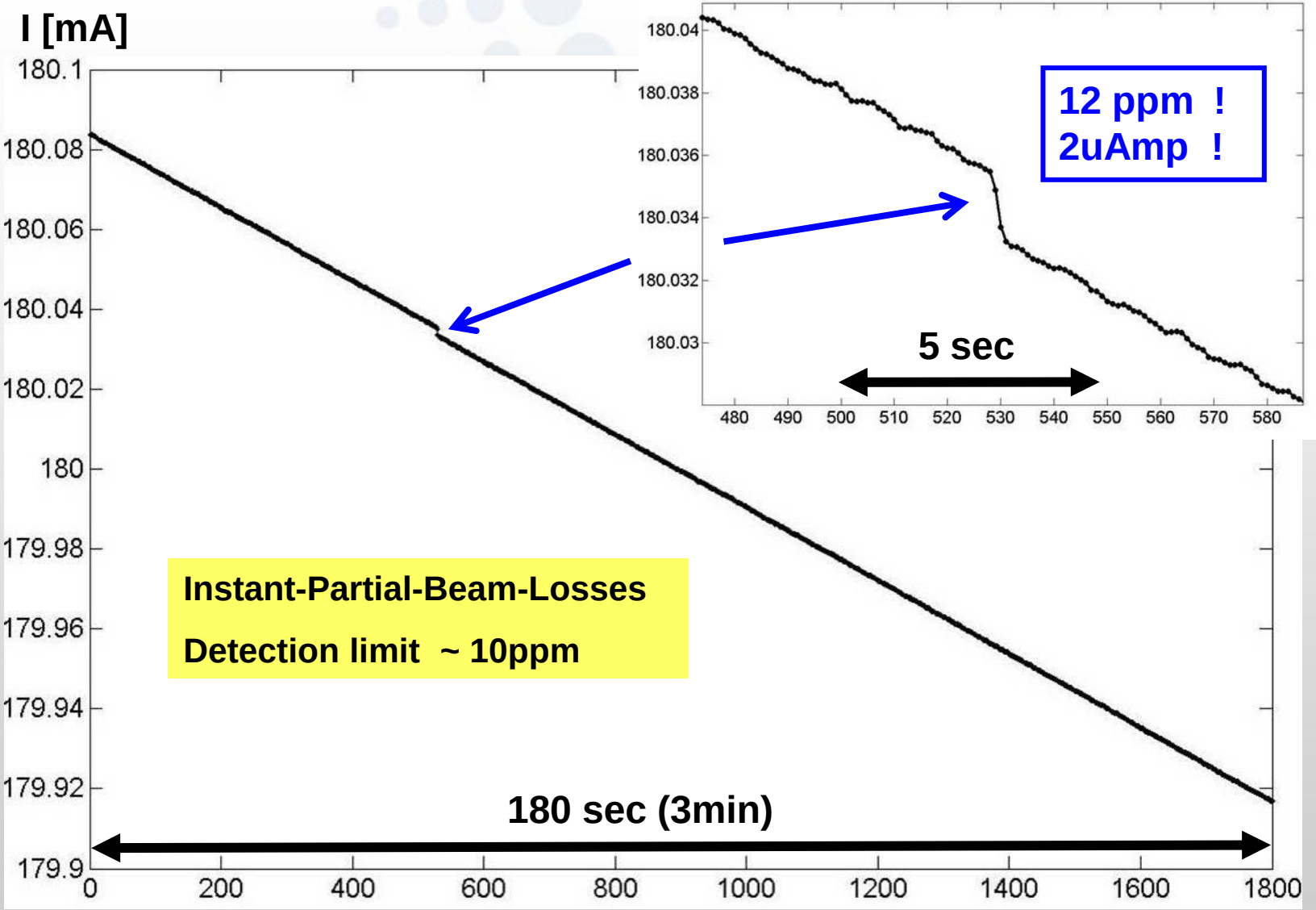


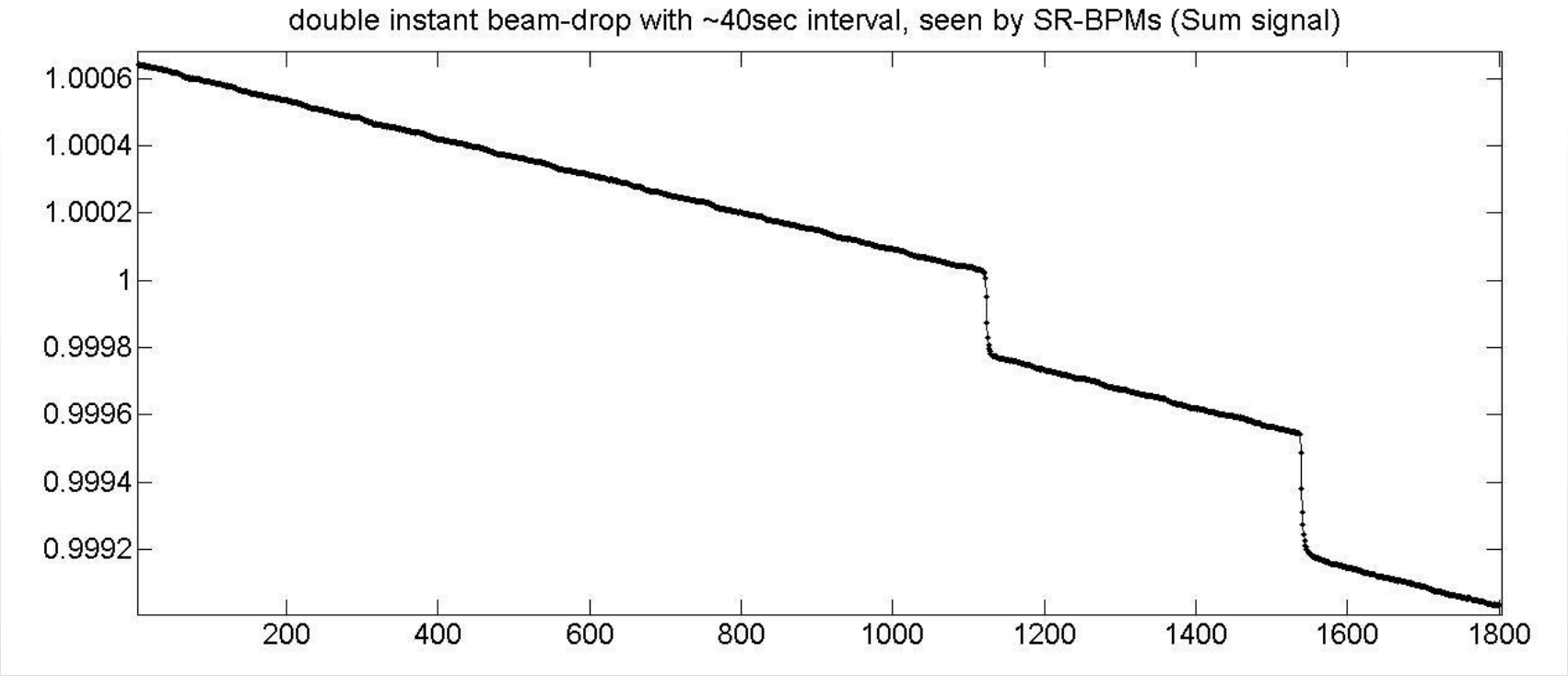




at 200mA
(3.5 E12 electrons)
and a lifetime ~60hrs

the losses are
~ E7 electrons /sec


I [mA]
180.1
180.08
180.06
180.04
180.02
180
179.98
179.96
179.94
179.92
179.9
0
200
400
600
800
1000
1200
1400
1600
1800
180 sec (3min)
Instant-Partial-Beam-Losses
Detection limit ~ 10ppm
180.04
180.038
180.036
180.034
180.032
180.03
480
490
500
510
520
530
540
550
560
570
580
5 sec
12 ppm !
2uAmp !


double instant beam-drop with ~40sec interval, seen by SR-BPMs (Sum signal)
1.0006
1.0004
1.0002
1
0.9998
0.9996
0.9994
0.9992
200
400
600
800
1000
1200
1400
1600
1800

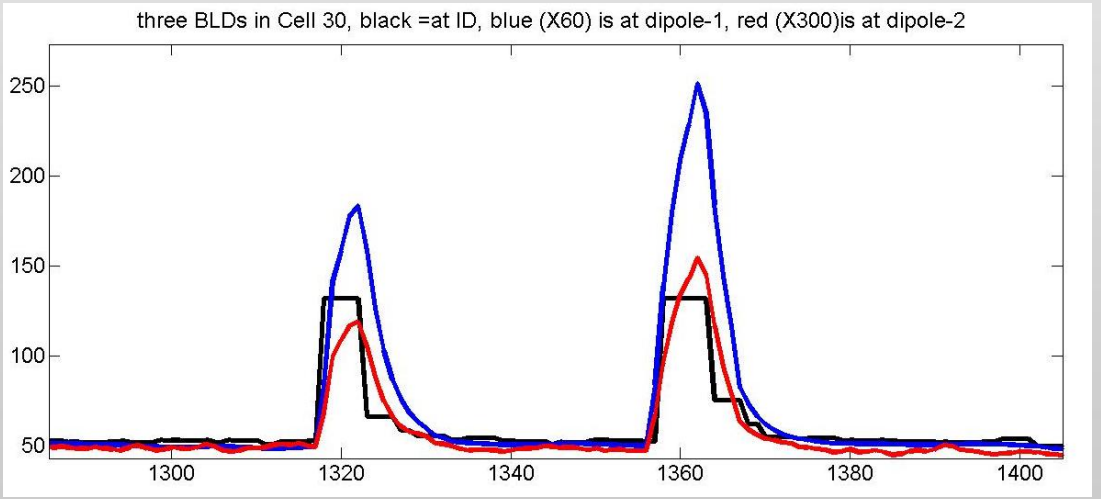

three BLDs in Cell 30, black =at ID, blue (X60) is at dipole-1, red (X300)is at dipole-2
250
200
150
100
50
1300
1320
1340
1360
1380
1400

Image of all 64 BLDs (vertically) during 30 minutes (horizontally) at the time of Injection

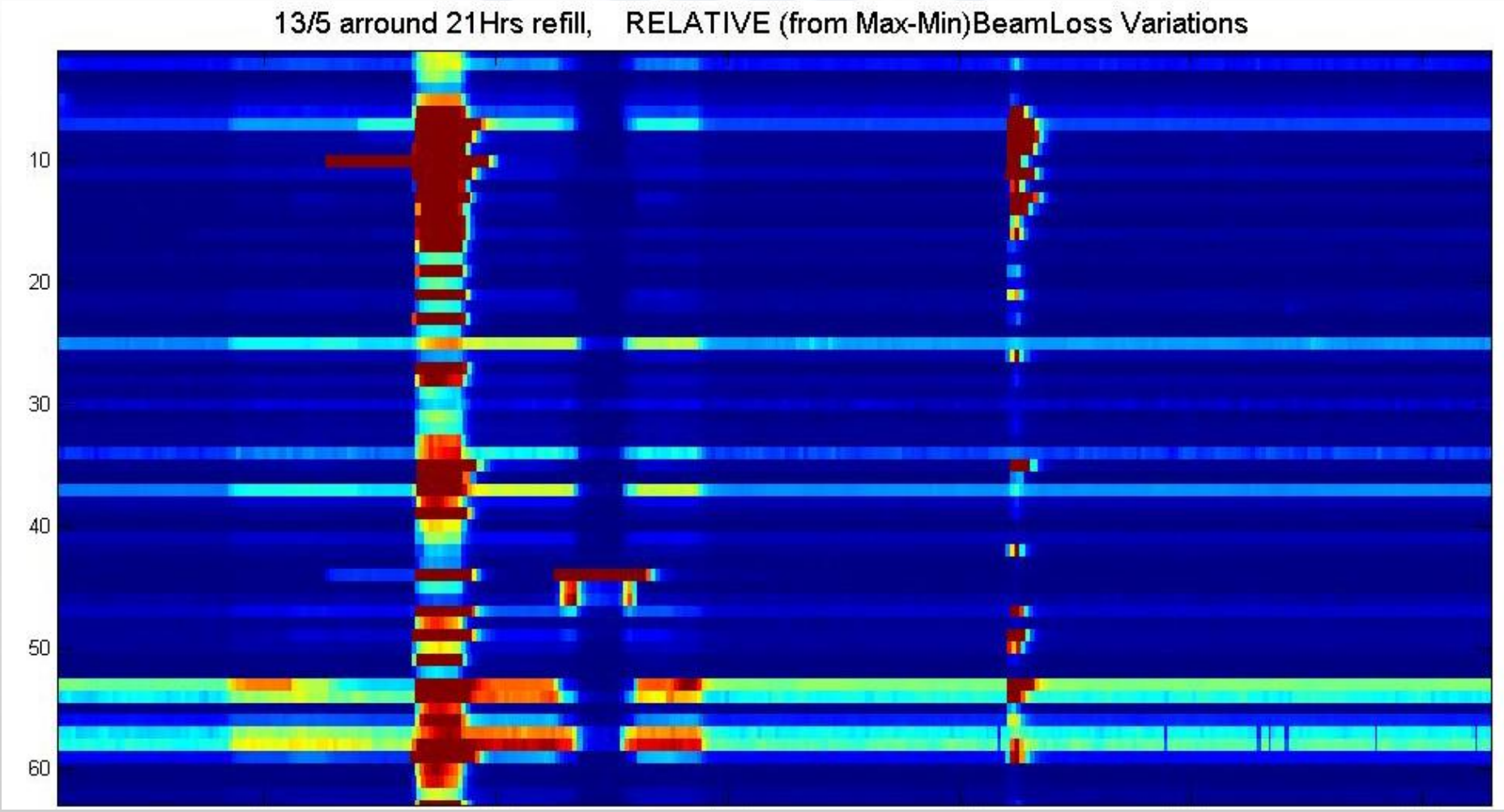
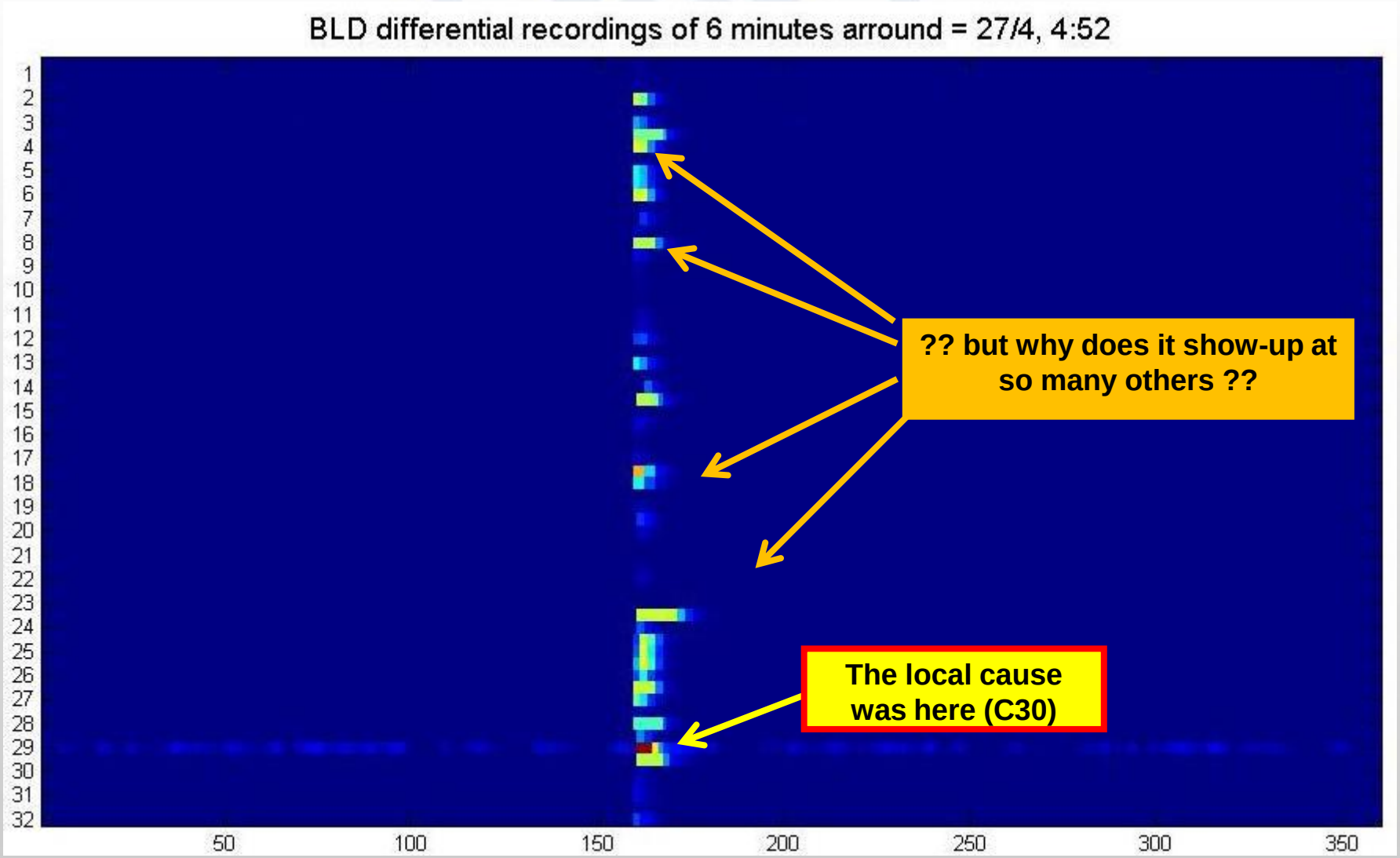
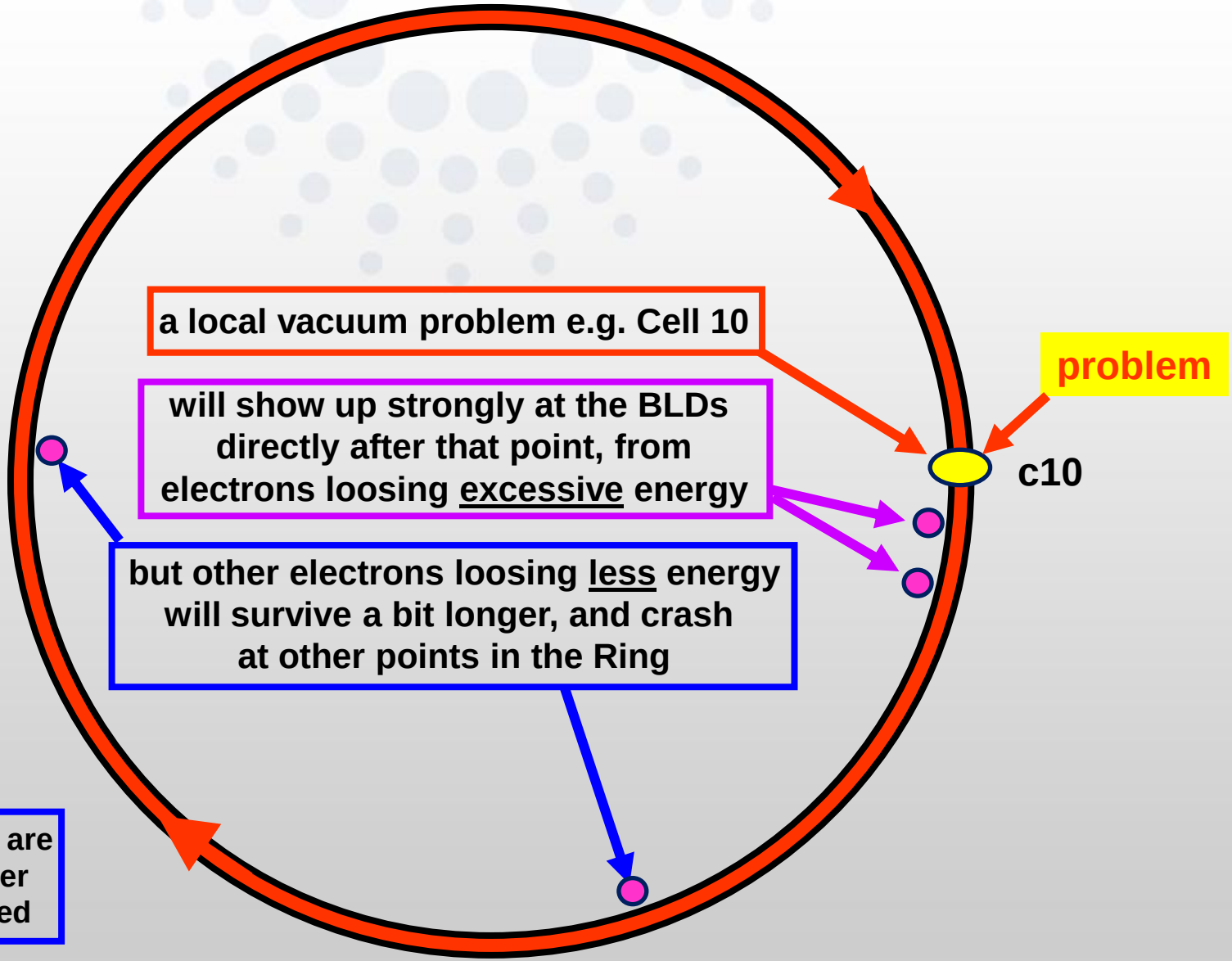


Image of all 64 BLDs (vertically) during 6 minutes (horizontally) around the time of a vacuum problem

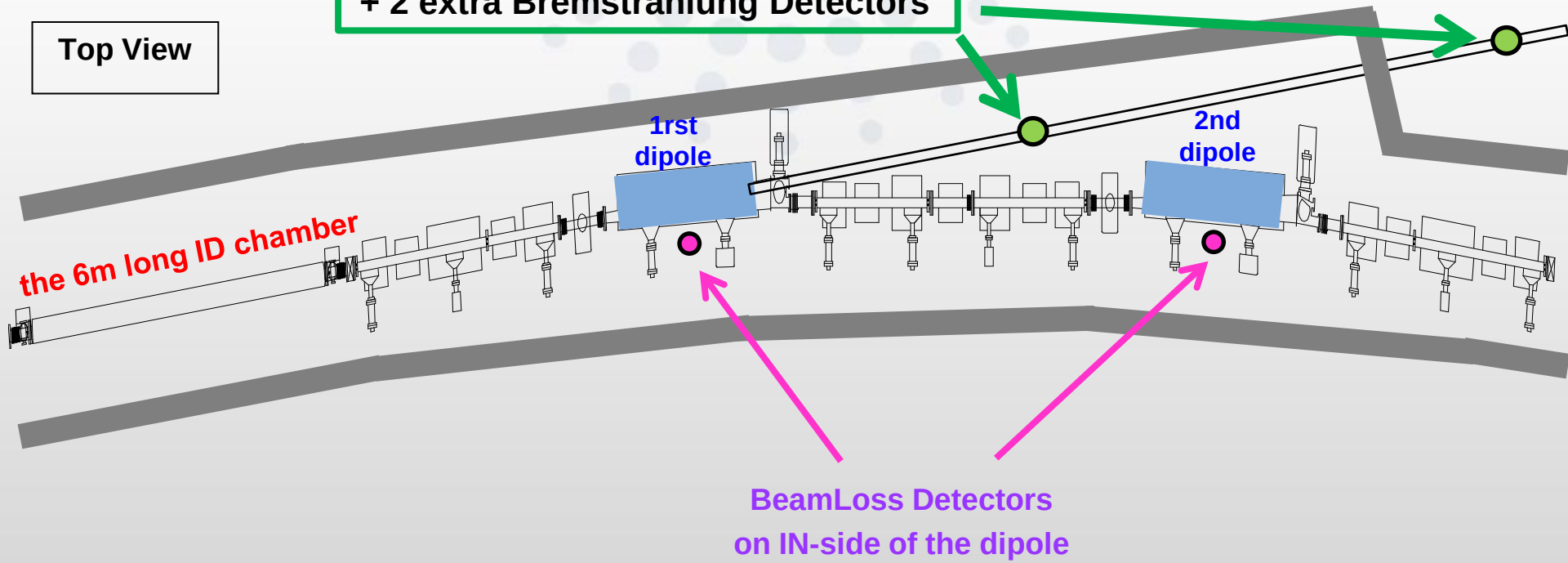



a local vacuum problem e.g. Cell 10
problem
c10
will show up strongly at the BLDs directly after that point, from electrons loosing excessive energy
but other electrons loosing less energy will survive a bit longer, and crash at other points in the Ring
These other points are where the chamber aperture is reduced

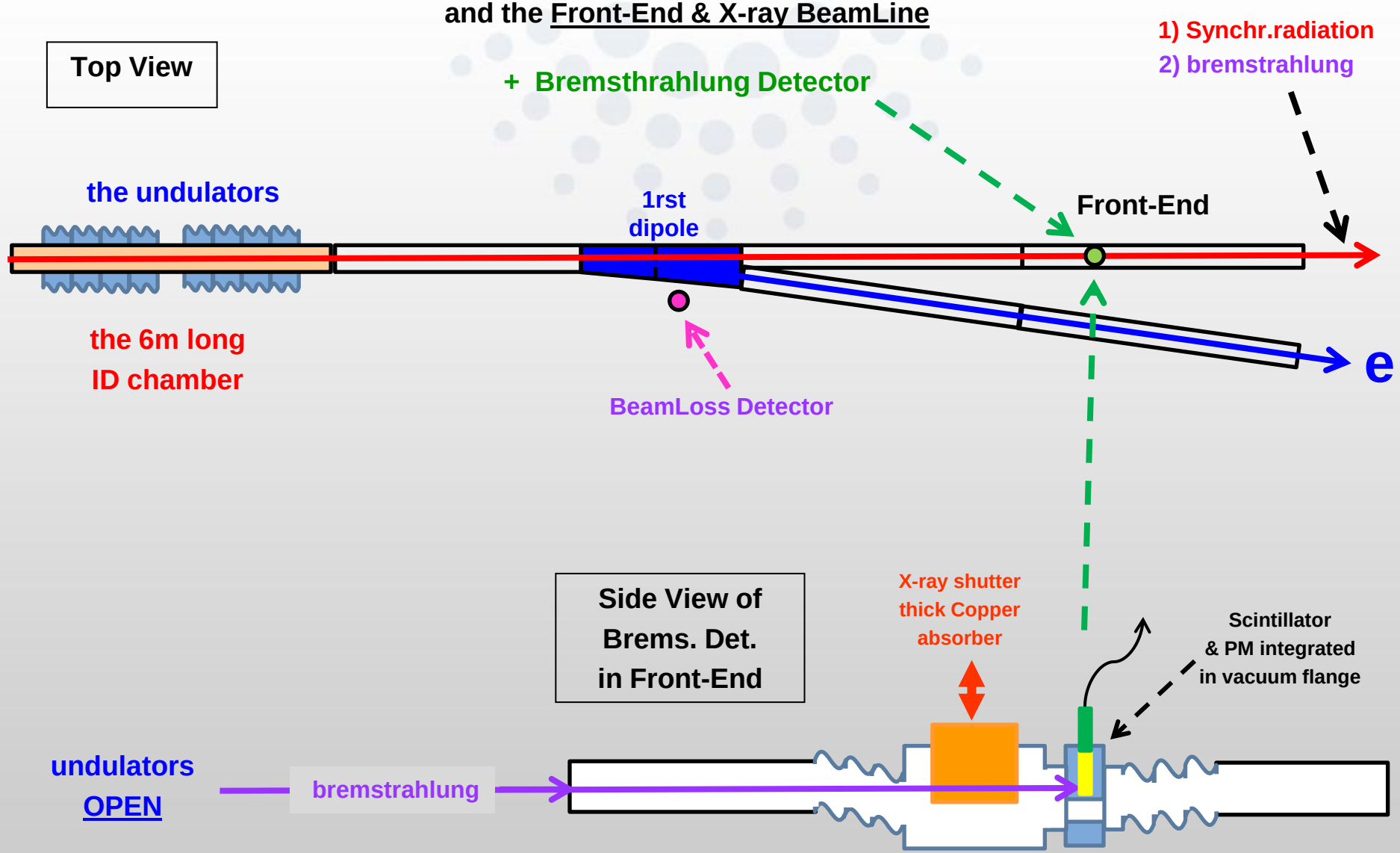
The vacuum lay-out of 1 cell (1 / 32 of the Ring) and the Front-End & X-ray BeamLine

+ 2 extra Bremstrahlung Detectors

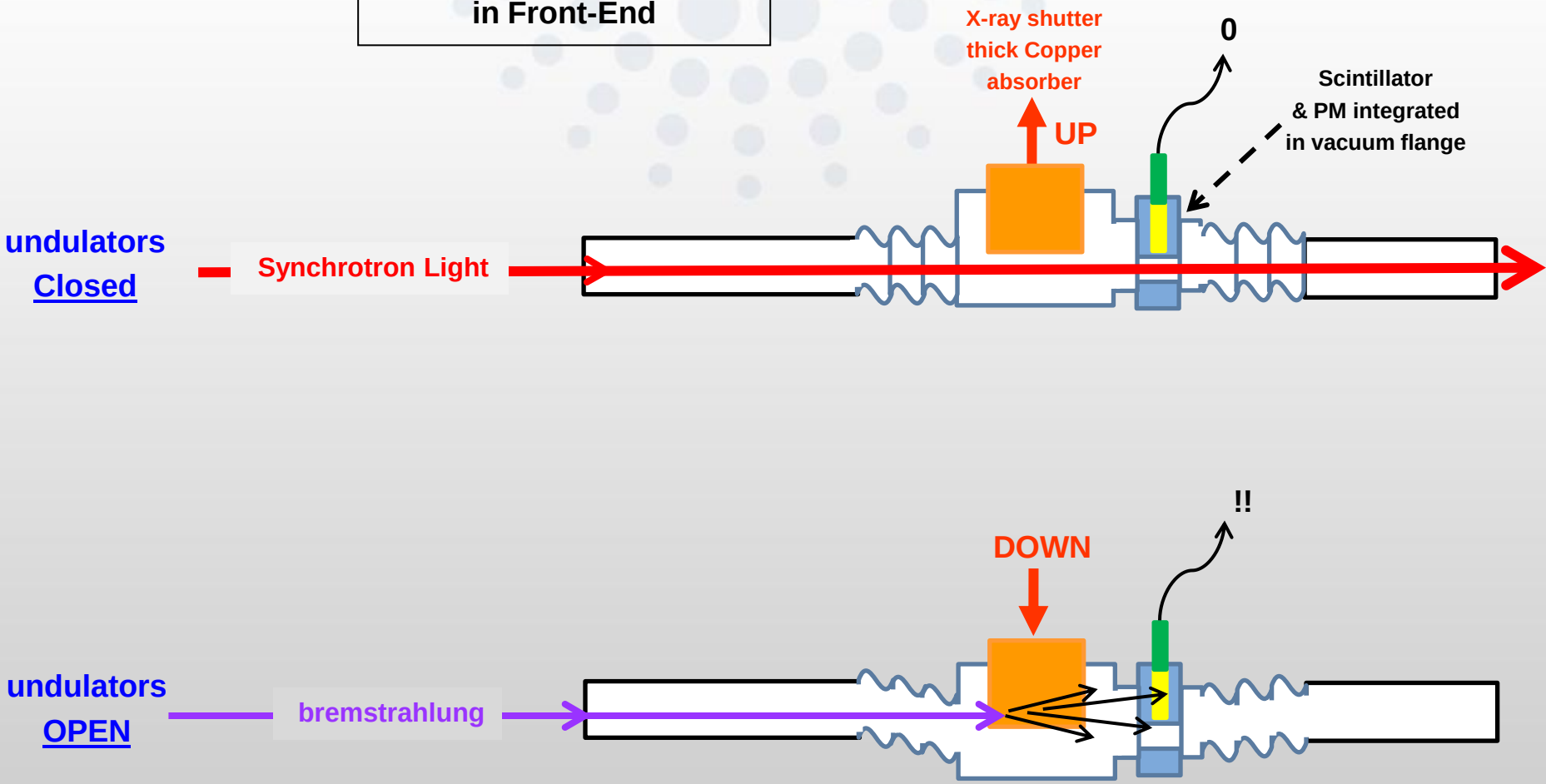
Top View



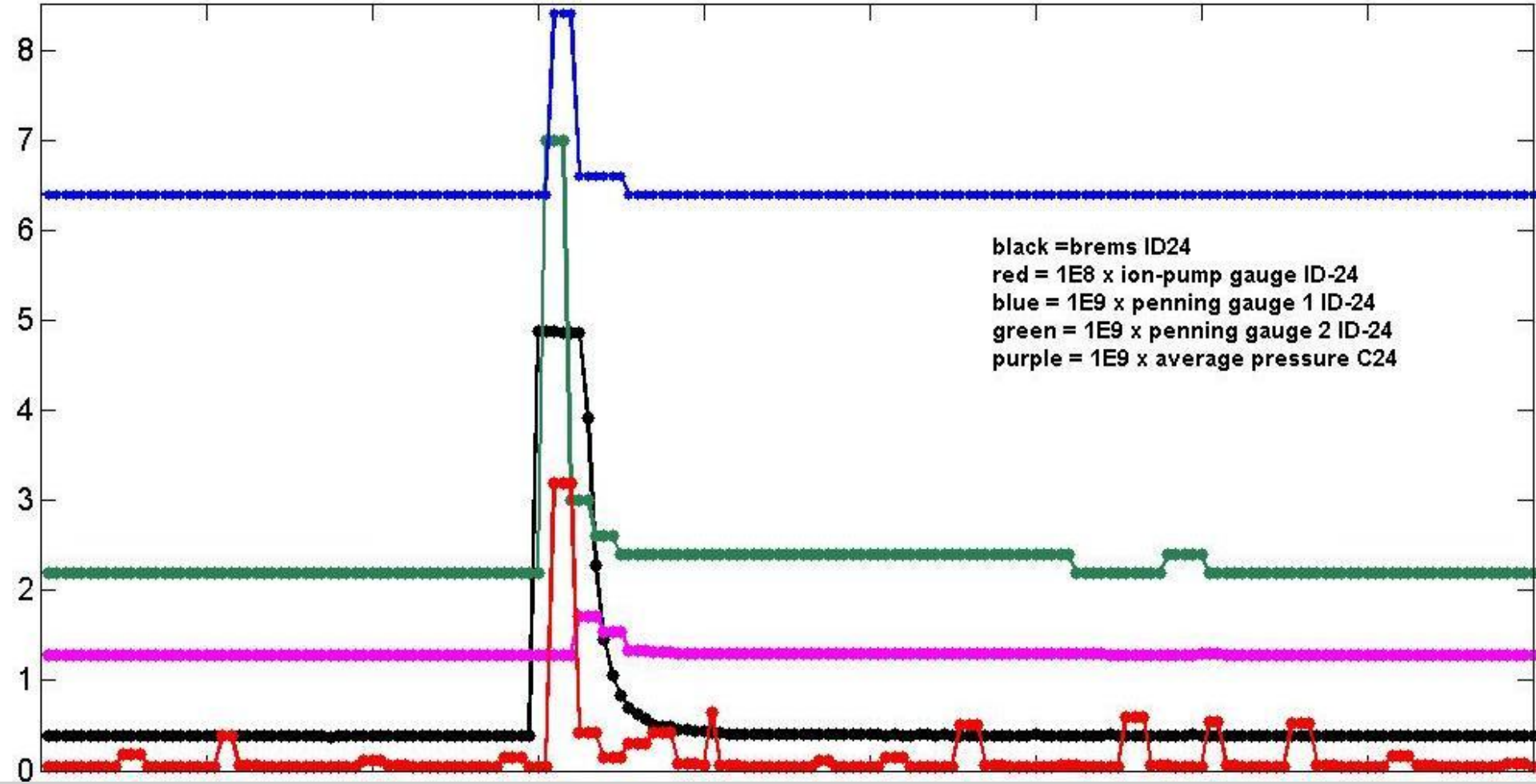
The vacuum lay-out of 1 cell (1 / 32 Ring) and the Front-End & X-ray BeamLine



Side View of Bremstrahlung Detector in Front-End



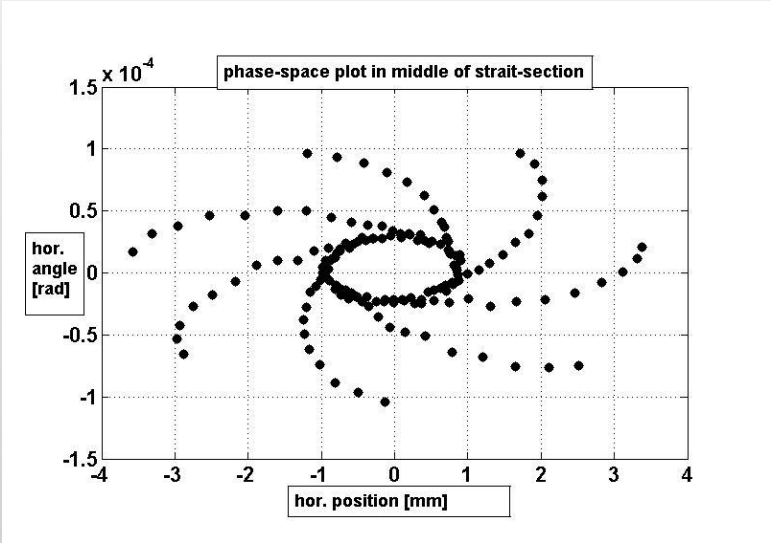
3min recording of c24 pressures & id-24 brems-detector around 04:52hrs 27 April



The results sofar shown are 'slow' output (typically 1 sec & 1Hz), this limitation comes from : signal treatment electrons (amplifiers) & the data acquisition system

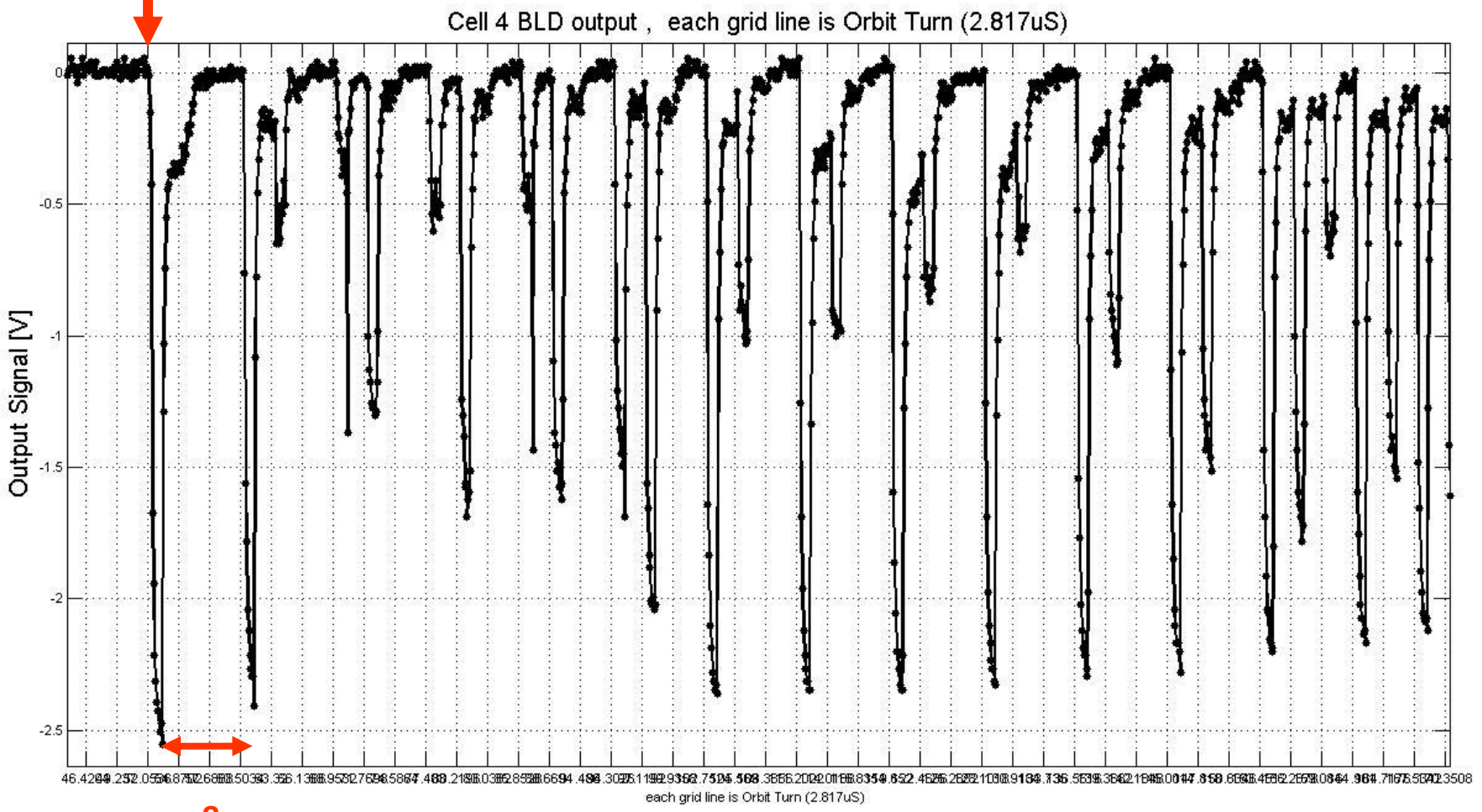
but the BLD & Brems Detectors (i.e. the PhotoMultiplier) has a much faster response-time & larger bandwidth

in the future we will try to exploit this for detailed Injection LossStudies with data acquisition at Turn-by-Turn frequency (355KHz), and correlate this with our 224 BPM T-b-T system

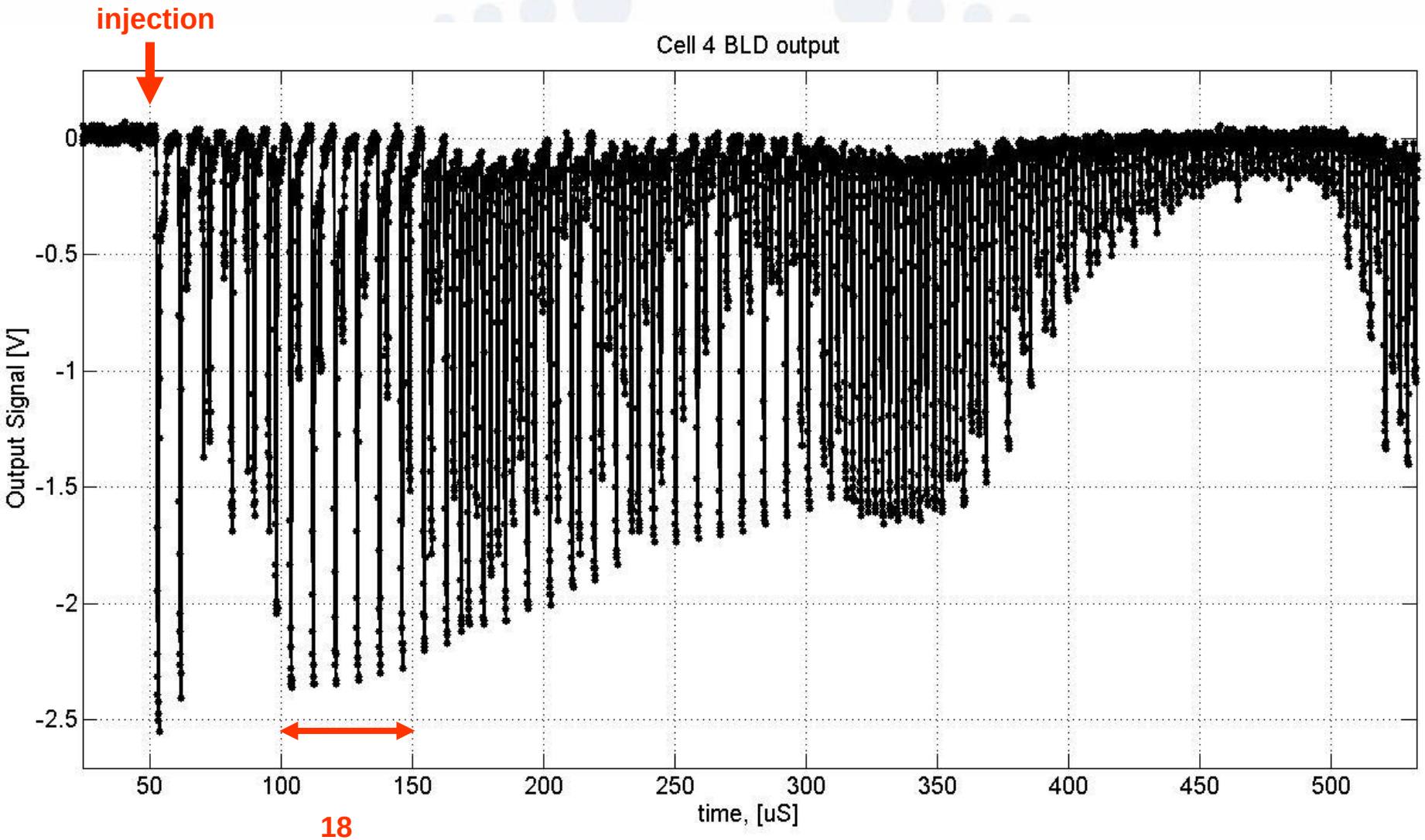


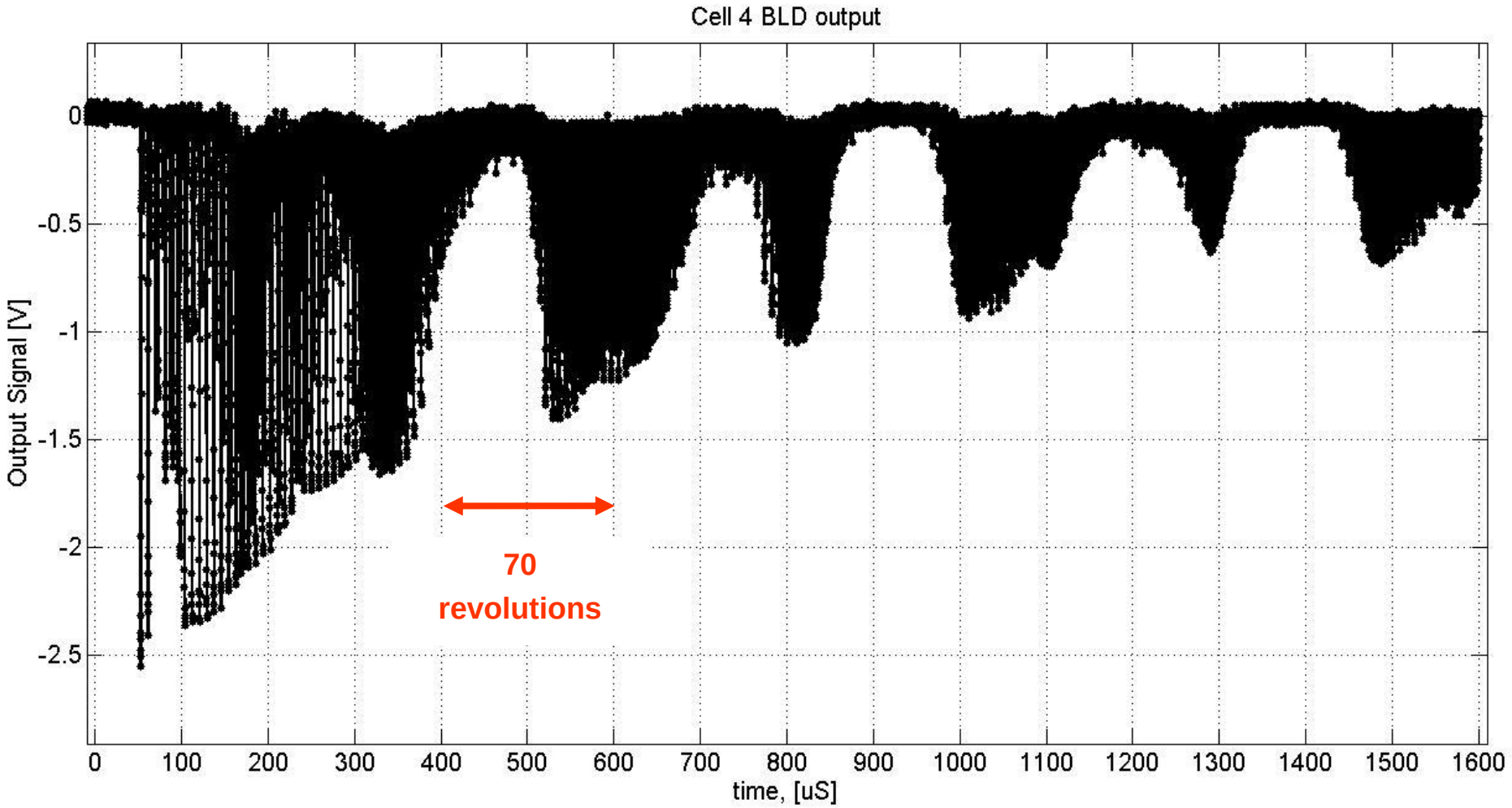
the following 3 graphs show results of a single BLD only at Injection of the beam into the Storage Ring

injection



3 revolutions


injection
Cell 4 BLD output
Output Signal [V]
0
-0.5
-1
-1.5
-2
-2.5
50
100
150
200
250
300
350
400
450
500
time, [uS]
18
revolutions


Cell 4 BLD output
Output Signal [V]
0
-0.5
-1
-1.5
-2
-2.5
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
time, [uS]
70
revolutions

conclusion :

1) The BeamLoss Detectors are very helpful to roughly localize & assess the amplitude of beamlosses, mostly linked with vacuum problems, during normal User-mode operation

2) the Gass Bremstrahlung Detectors are more sensitive and associated with the particular long ID chambers, but only available if the beamline user does not use the undulator

3) The speed & bandwidth of these Detectors makes it possible to use them for the Beam Loss studies at Injection, but needs a adapted data-acquistion system (in progress)