RadSynch13 - BNL

The Gamma & Neutron Dose Rate Due to the Total Stored Beam Losses at the **ALBA** Synchrotron Light Facility

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Objective: answer this question

When an unexpected **total** electron beam **loss** occurs in the Storage Ring, what are the **equivalent dose** rate characteristics (**peak** value and space **distribution**) outside the ALBA **shielding** ?

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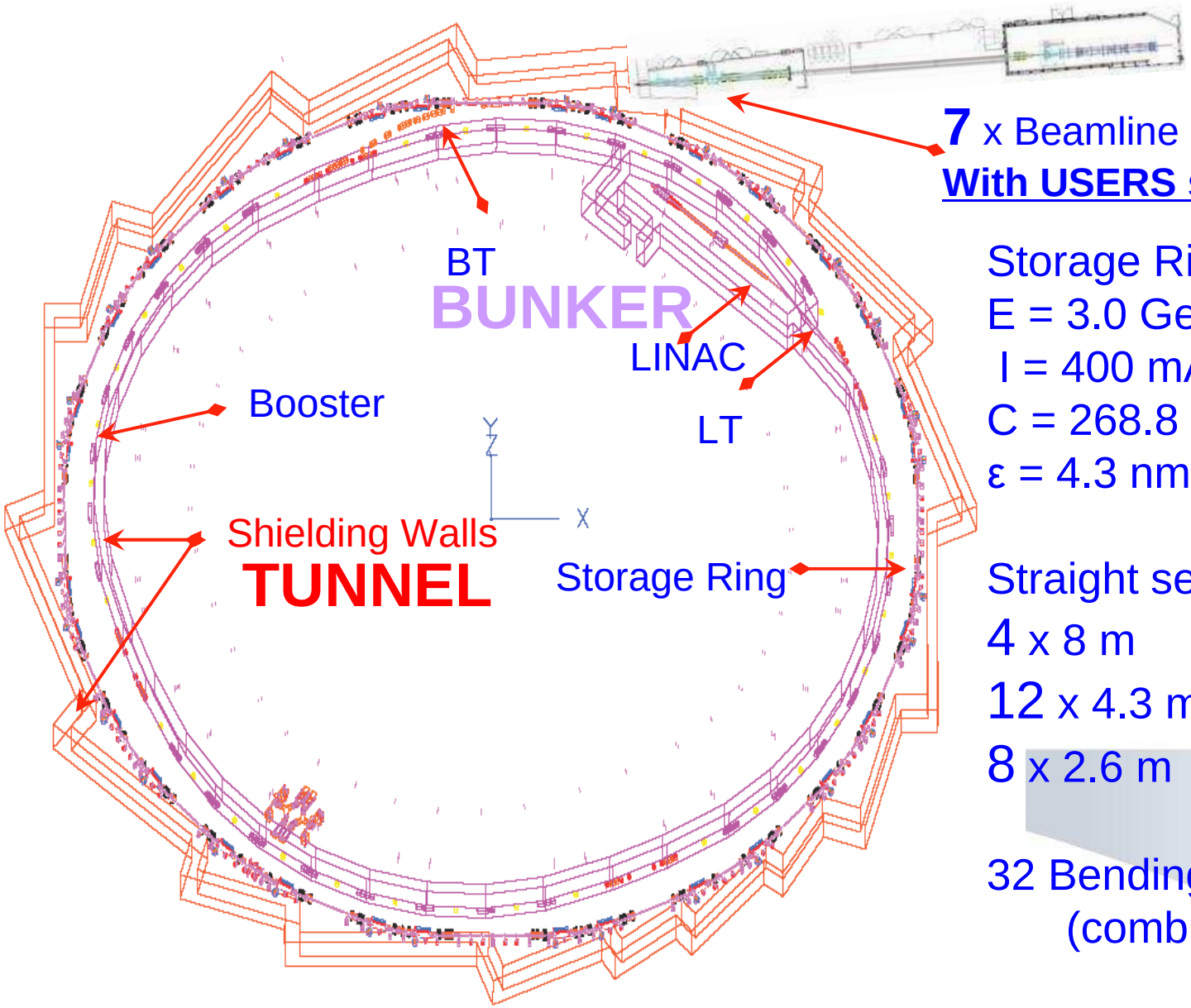
A. ALBA accelerators overview



7 x Beamline

With USERS since May'12

Storage Ring:
E = 3.0 GeV
I = 400 mA
C = 268.8 m
ε = 4.3 nm.rad

Straight sections:
4 x 8 m
12 x 4.3 m
8 x 2.6 m

32 Bending Magnets
(combined)

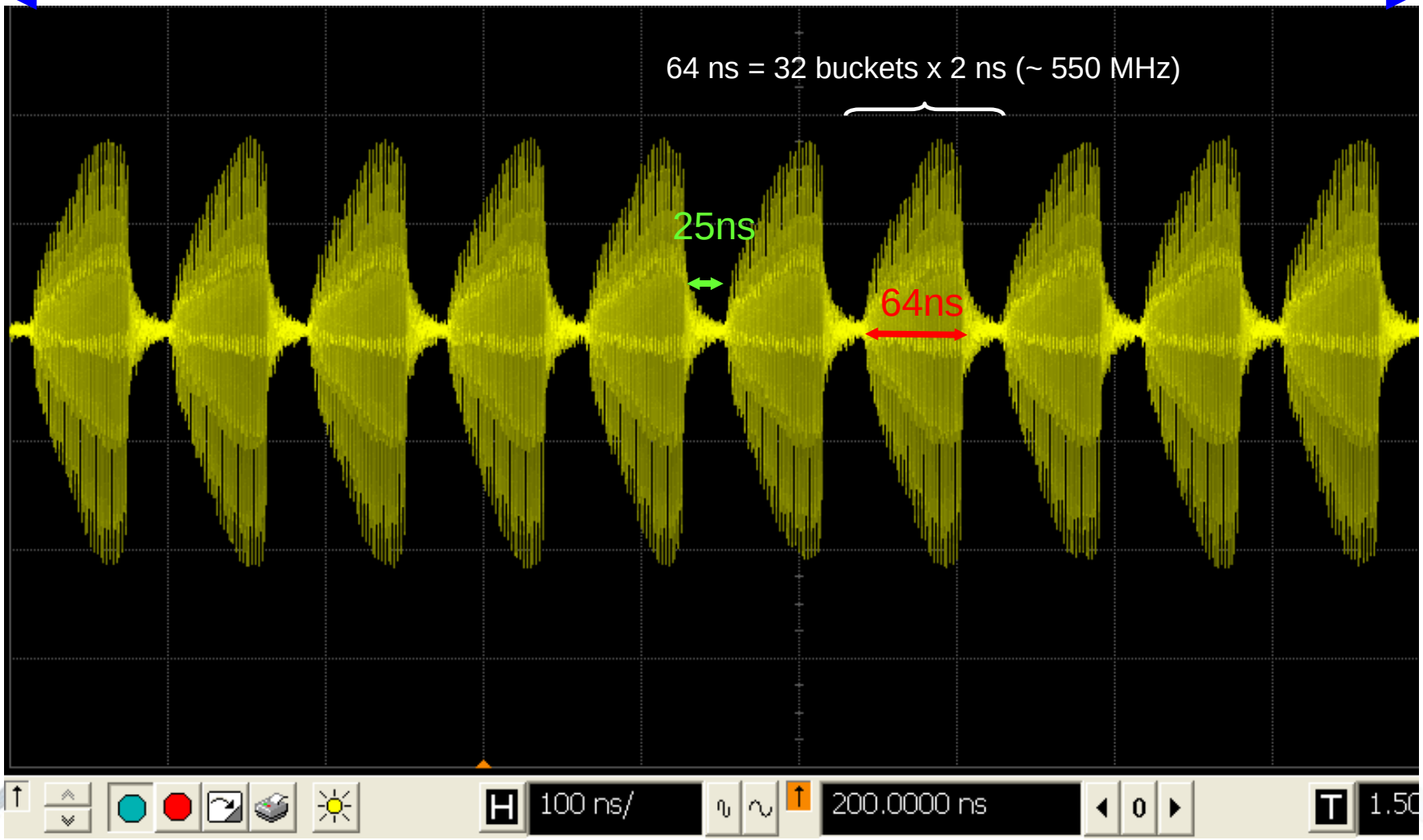
Accelerator parameters

Maximum LINAC energy	110 MeV
Charge per pulse	~ 4 nC
Booster energy	0.1 to 3.0 GeV
Stored beam energy	3 GeV
Booster circumference	249.6 m
Storage ring circumference	268.8 m
Maximum injection frequency	3 Hz
Stored current	120 mA
Stored charge	$6.8 \cdot 10^{11}$ e^-
Lifetime at 120 mA	~ 24 h
Pressure	10^{-9} mbar

Stored Beam Pattern

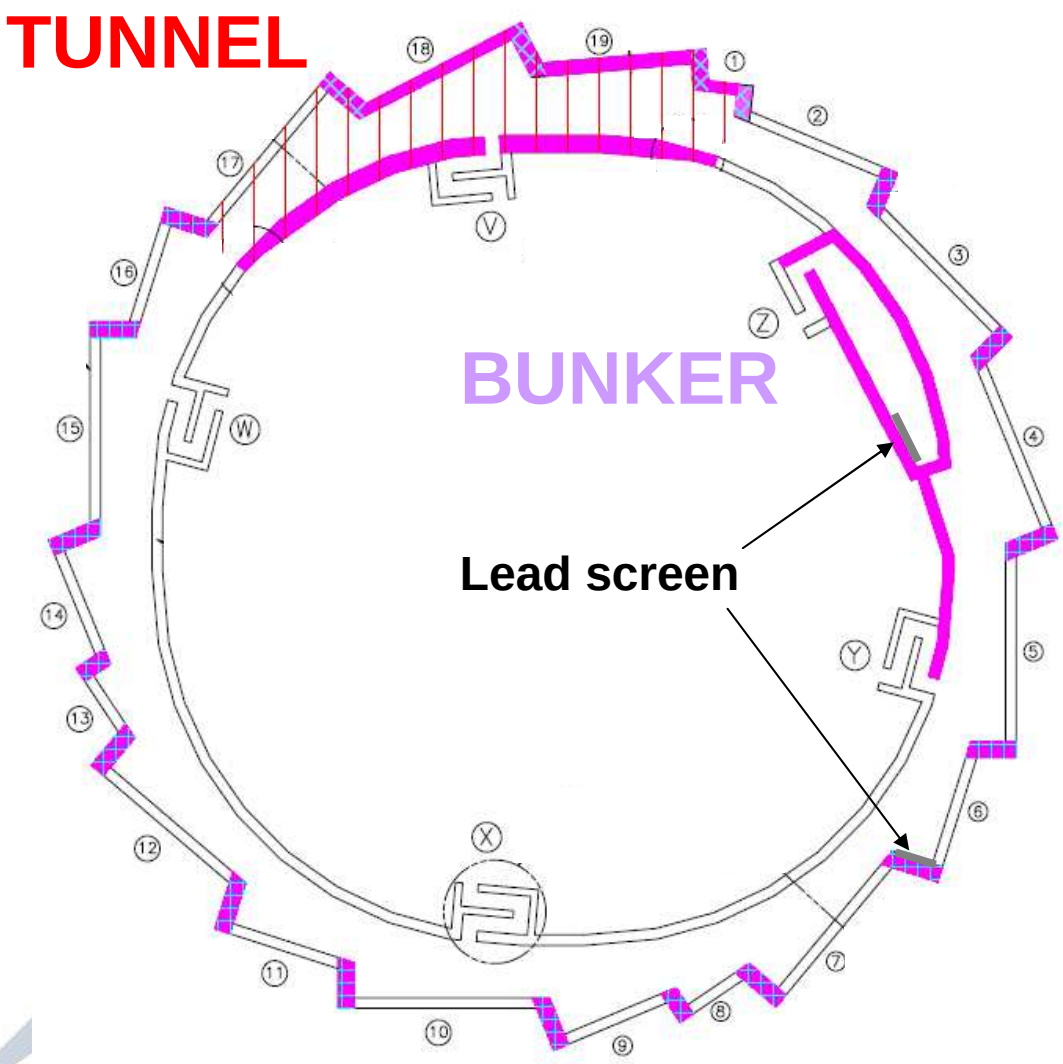
- From the FCT-Fast Current Transformer data:

893 ns (Total SR length is 896 ns)

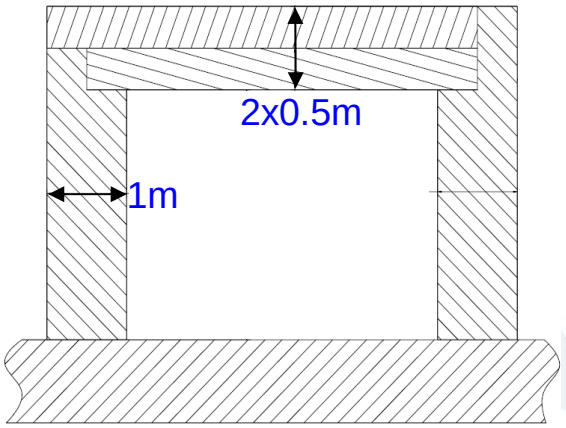


B. Shielding characteristics

- Wall & Roof structures:



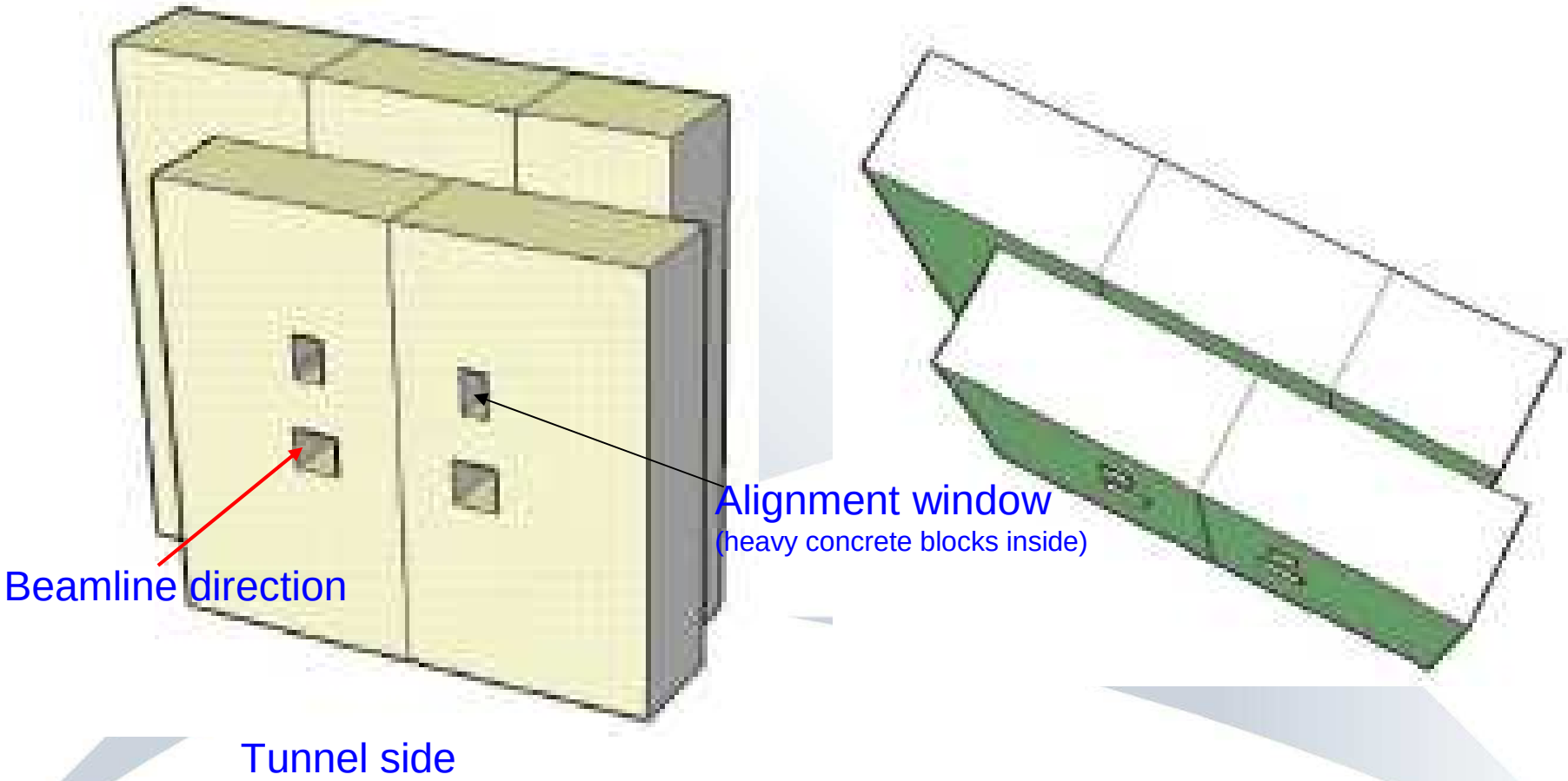
Inner and side walls thickness	1 m
Inner wall thickness at injection	1.65 m
Side wall thickness at injection	1.25 m
Roof thickness	1 m
Roof thickness at injection	1.4 m
Linac walls thickness	1 m
Labyrinths walls thickness	0.7 m
Front walls thickness	1.5 m
Number of side/front walls	19
Concrete density	2.4 g/cm^3
Heavy concrete density	3.2 g/cm^3



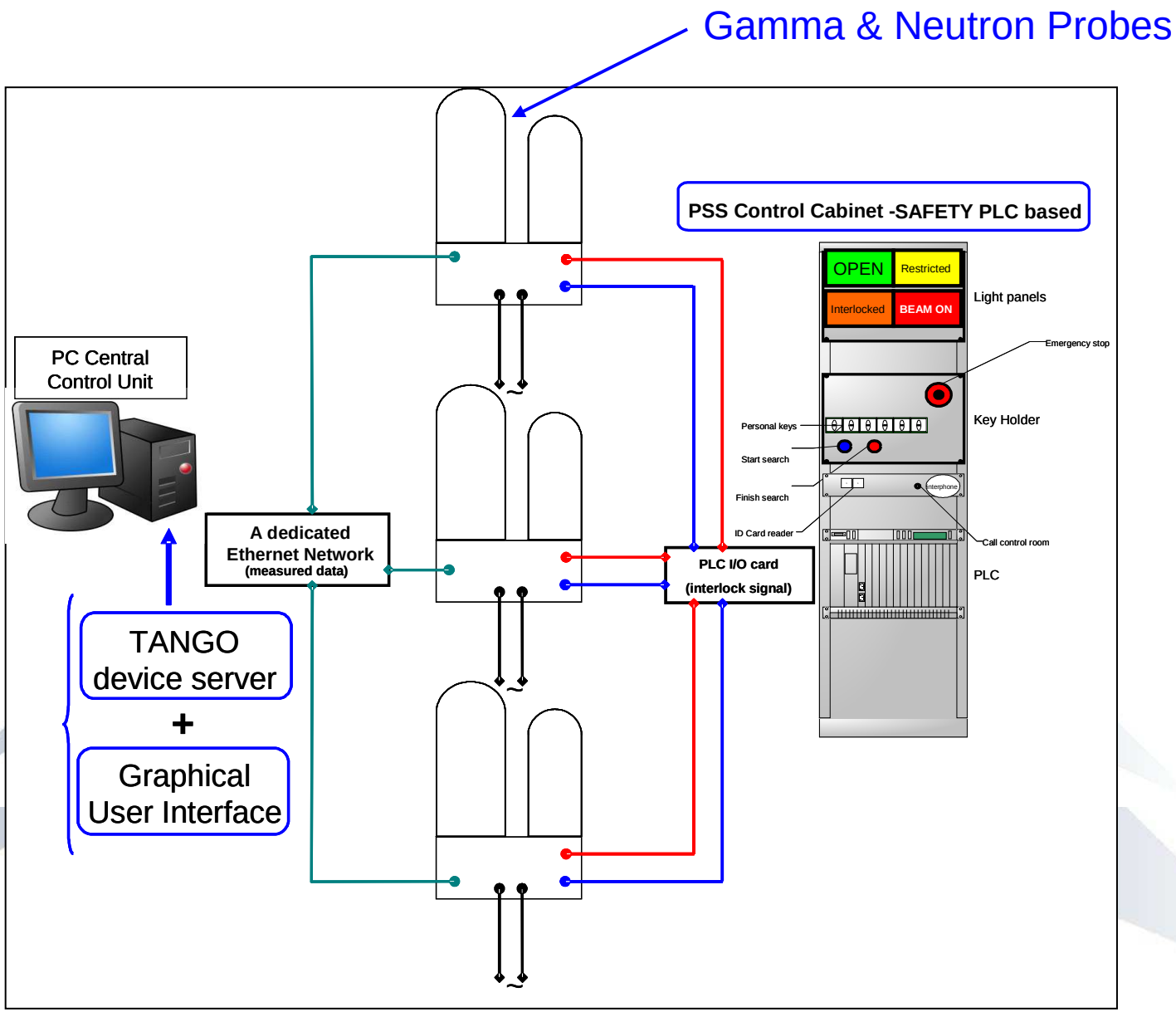
Tunnel cross section

Front wall geometry

- No direct line in e-beam direction (75 cm minimum)



C. The on-line detectors network: RADMON



RADMON: Gamma & Neutron Probes Characteristics

	FHT192	FHT 762 Wendi-2
Manufacturer	Thermo Electron GmbH	Thermo Electron GmbH
Particle	Photons	Neutrons
Energy range	30 keV – 7 MeV	25 meV – 5 GeV
Measuring range	100 nSv/h – 1 Sv/h	1 nSv/h – 100 mSv/h
Calibration Factor	Related with Cs-137 For low dose rate: 0.01 - 0.02 (µSv/h)/cps For high dose rate: 1.9 - 2.2 (µSv/h)/cps	1.14 (µSv/h)/cps
Unit measure	Hp(10)	Hp(10)
Type	Active Ionization chamber	Active Proportional counter
Sensitive material	Inert gas (7 bar)	He-3 (2 bar) + polyethylene moderator + Tungsten
Dead Time	For high dose rate: 6-7 µs	1.8 µs
Amplifier	FHT 6020 (v1.21): 2 channels	

RADMON: Quantity, Type & Distribution

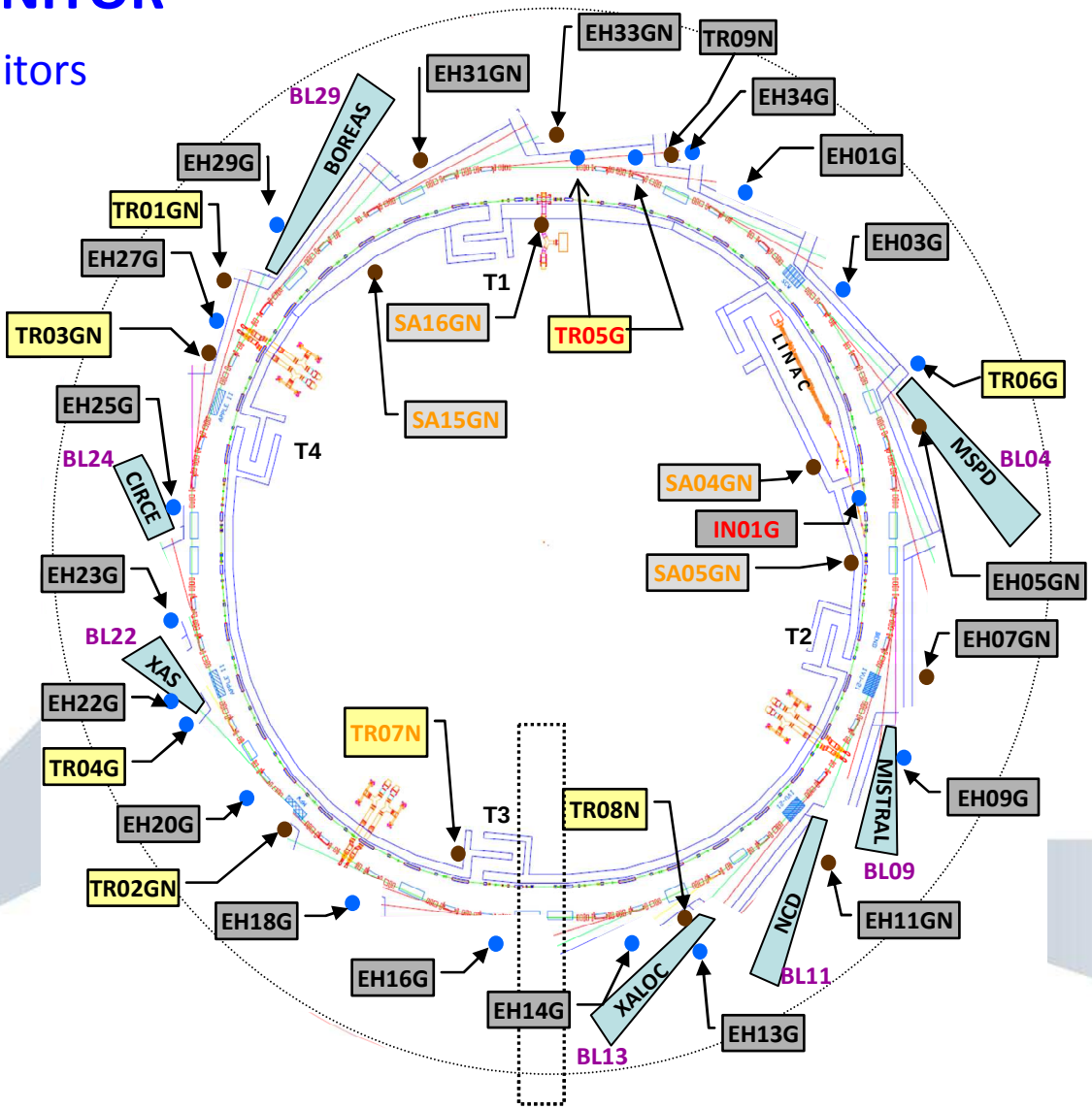
- **33** RADMON units:
  - **19** fixed at the *Experimental Hall* →
    - 14 gamma
    - 5 gamma + neutron
  - **4** fixed at the *Service Area* →
    - 4 gamma + neutron
  - **1** fixed inside the *Tunnel* →
    - 1 gamma
  - **9** movables (on trolleys): →
    - 3 gamma
    - 3 neutron
    - 3 gamma + neutron

    1 inside the *Tunnel* / 1 *Service Area* / 7 *Experimental Hall*

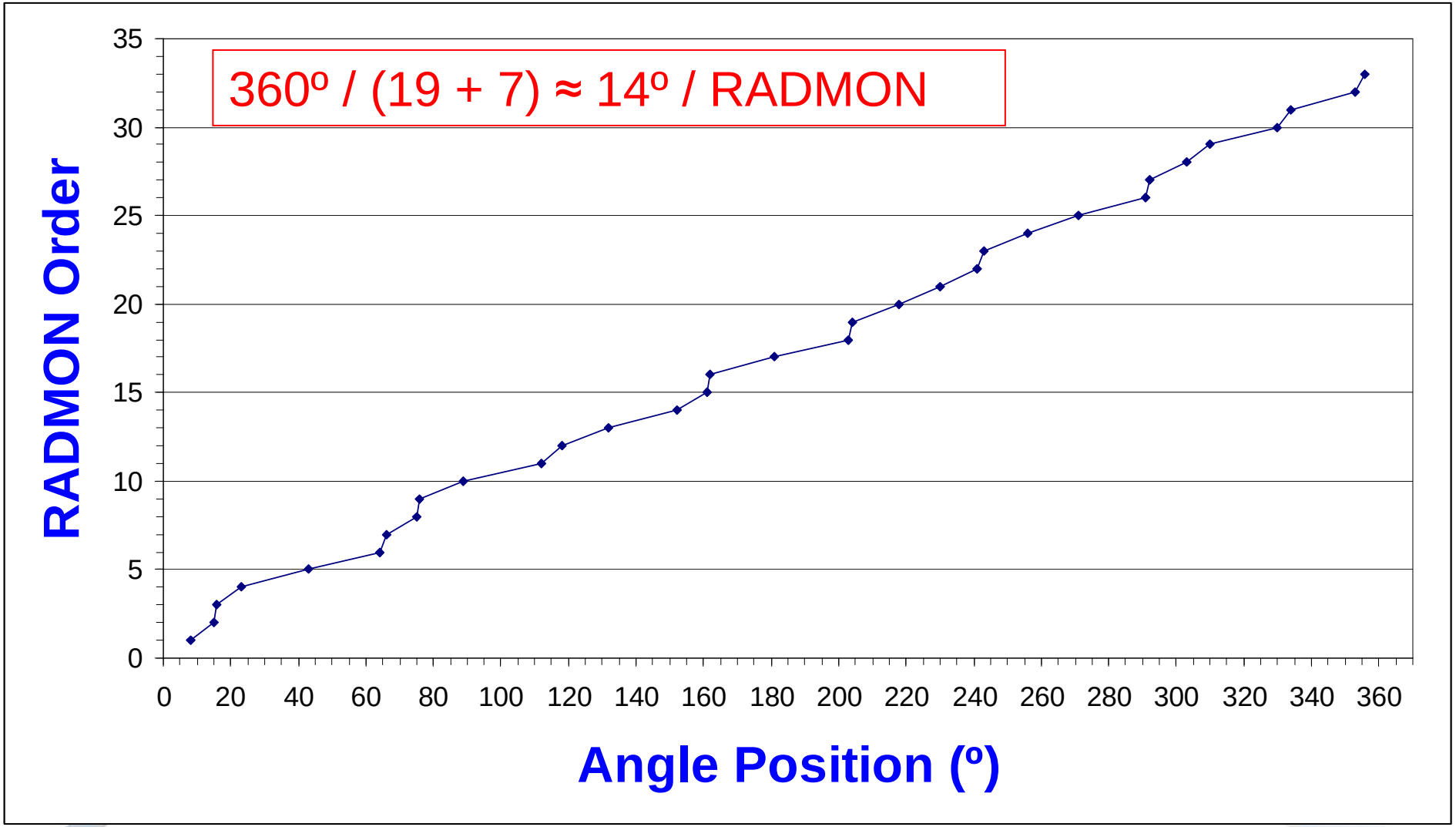
RADMON: their position

TYPE OF MONITOR

- Fixed monitors
- Trolleys



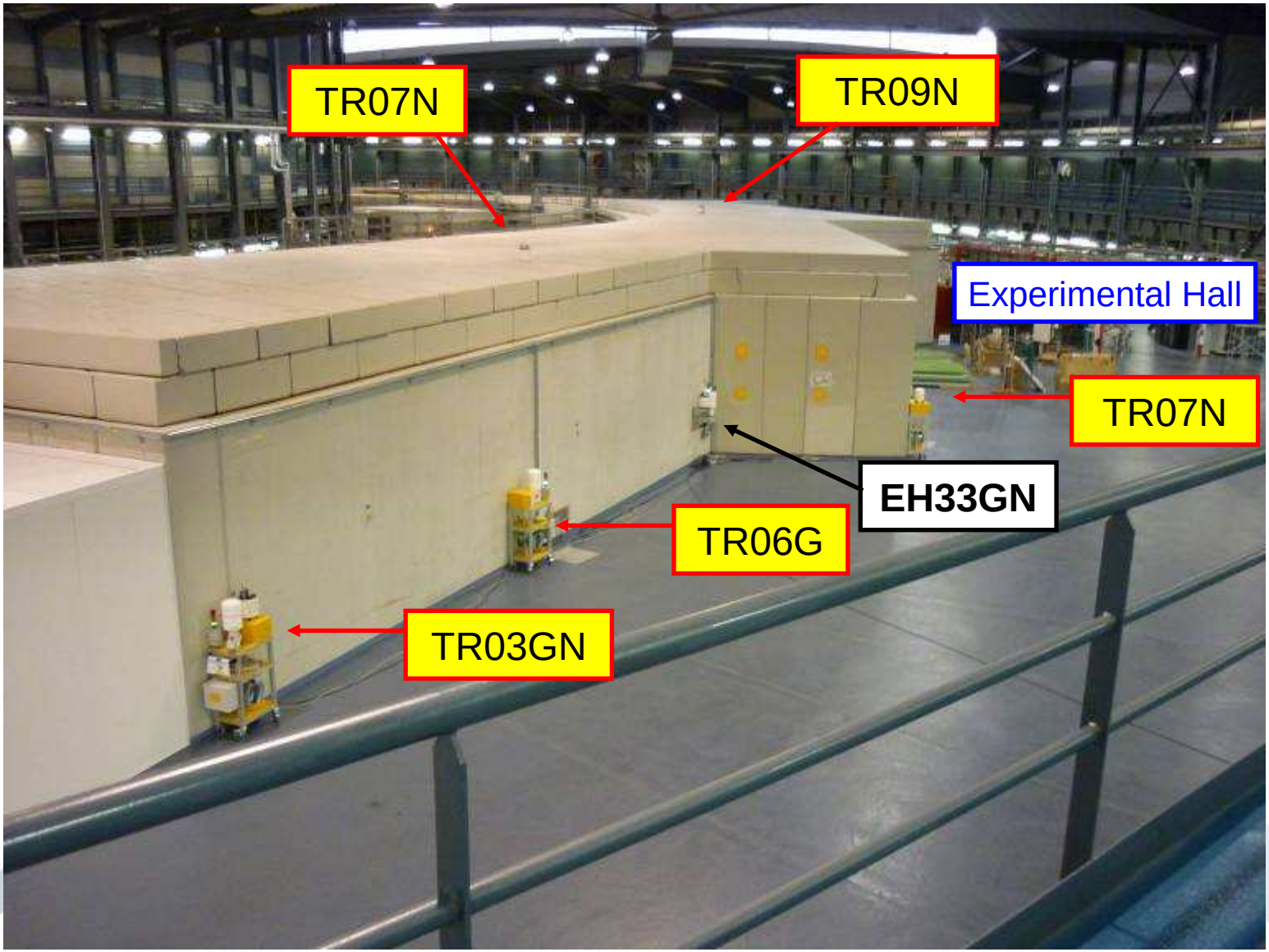
RADMON: their position



RADMON: their position

RADMON	Angle (º)	Component	RADMON	Angle (º)	Component	RADMON	Angle (º)	Component
1 TR05	8		**12** EH07	118	RF Plant-1	**23** EH22	243	ID-BL24
2 TR09	15		**13** EH11	132	ID-BL13	**24** EH23	256	
3 EH34	16		**14** EH13	152		**25** EH25	271	
4 EH01	23	RF Plant-2	**15** TR08	161		**26** TR03	291	ID-BL29
5 EH03	43	ID-BL04	**16** EH14	162		**27** EH27	292	RF Plant-3
6 EH05	64		**17** EH16	181		**28** TR01	303	
7 TR06	66		**18** EH18	203		**29** EH29	310	
8 SA04	75	BM-LT	**19** TR07	204		**30** SA15	330	Septum-E Bo
9 IN01	76		**20** TR02	218		**31** EH31	334	Septum-E Bo
10 SA05	89	Septum-I Bo	**21** EH20	230	ID-BL22	**32** SA16	353	Septum SR
11 EH09	112		**22** TR04	241		**33** EH33	356	Septum SR

RADMON: An Example



D. eBeam losses: characterization

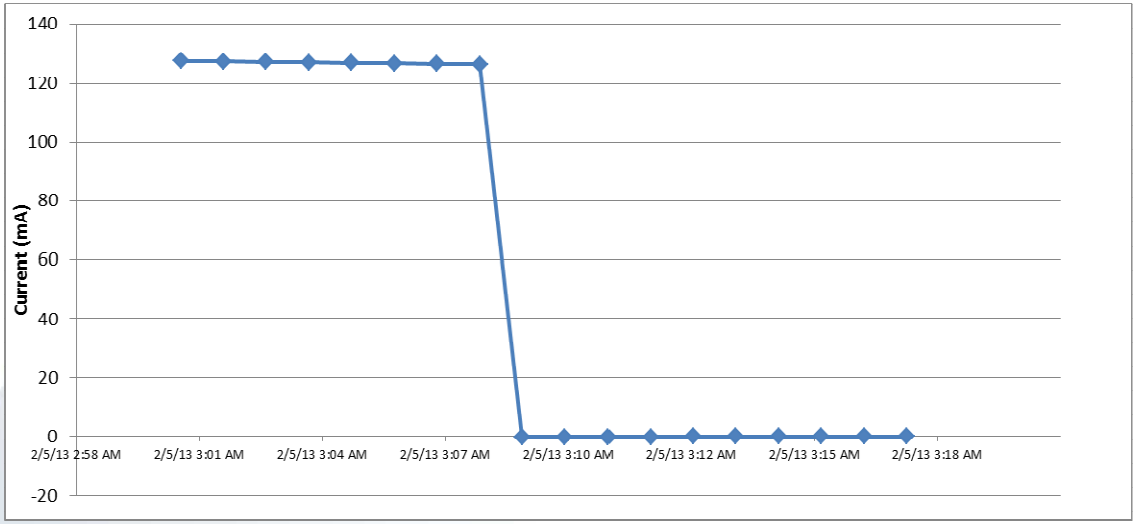
- 10 events of total ebeam losses:

Event #	Current loss (mA)	Cause Type	Angle Losses (º)
1	126.4	RF Plant-1 trip	118
2	19.1	RF Plant-1 trip	118
3	80.3	Fluorence Screen trip	163
4	129.5	RF Plant-2 trip	209
5	126.8	RF Plant-3 trip	298
6	129.5	RF Plant-3 trip	298
7	129.6	RF Plant-3 trip	298
8	128.9	RF Plant-3 trip	298
9	117.8	RF Plant-3 trip	298
10	118.1	RF Plant-3 trip	298

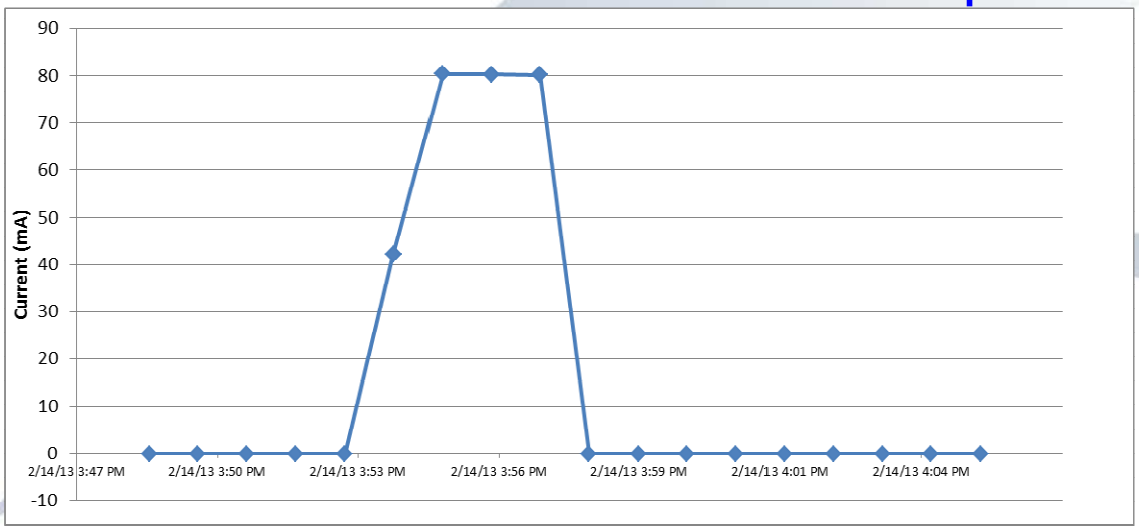
D. eBeam losses: sudden lost

- From the DC Current Transformer-DCCT data:

Event #1: RF Plant-1 trip

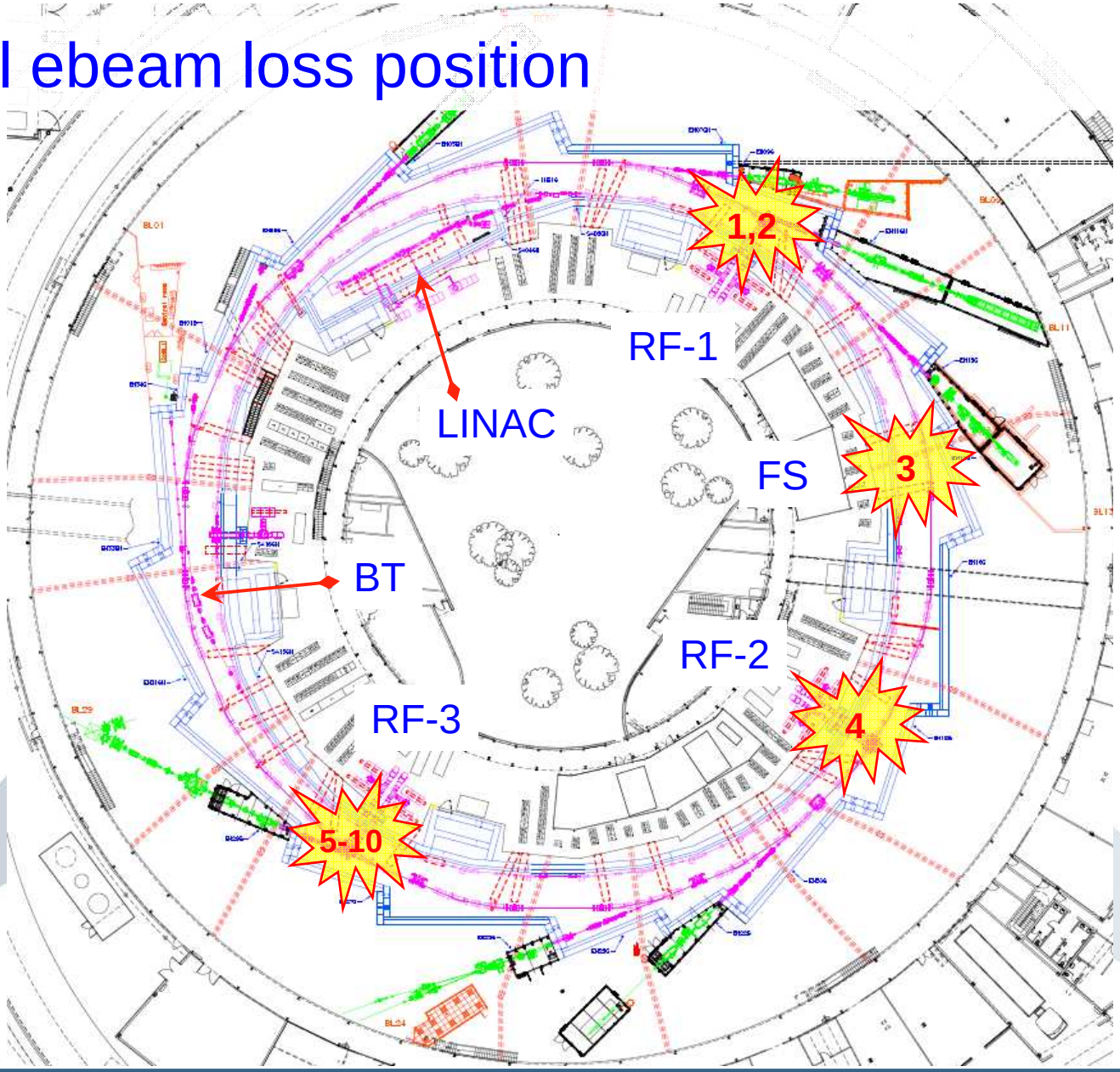


Event #3: Fluorescence Screen trip



D. eBeam losses: loss point

: total ebeam loss position



E. Dose rate data: peak values & distribution

- The data (Angle, Peak) corresponds to the maximum peak value
- The Peak ratio is the (2nd Peak / 1st Peak) %

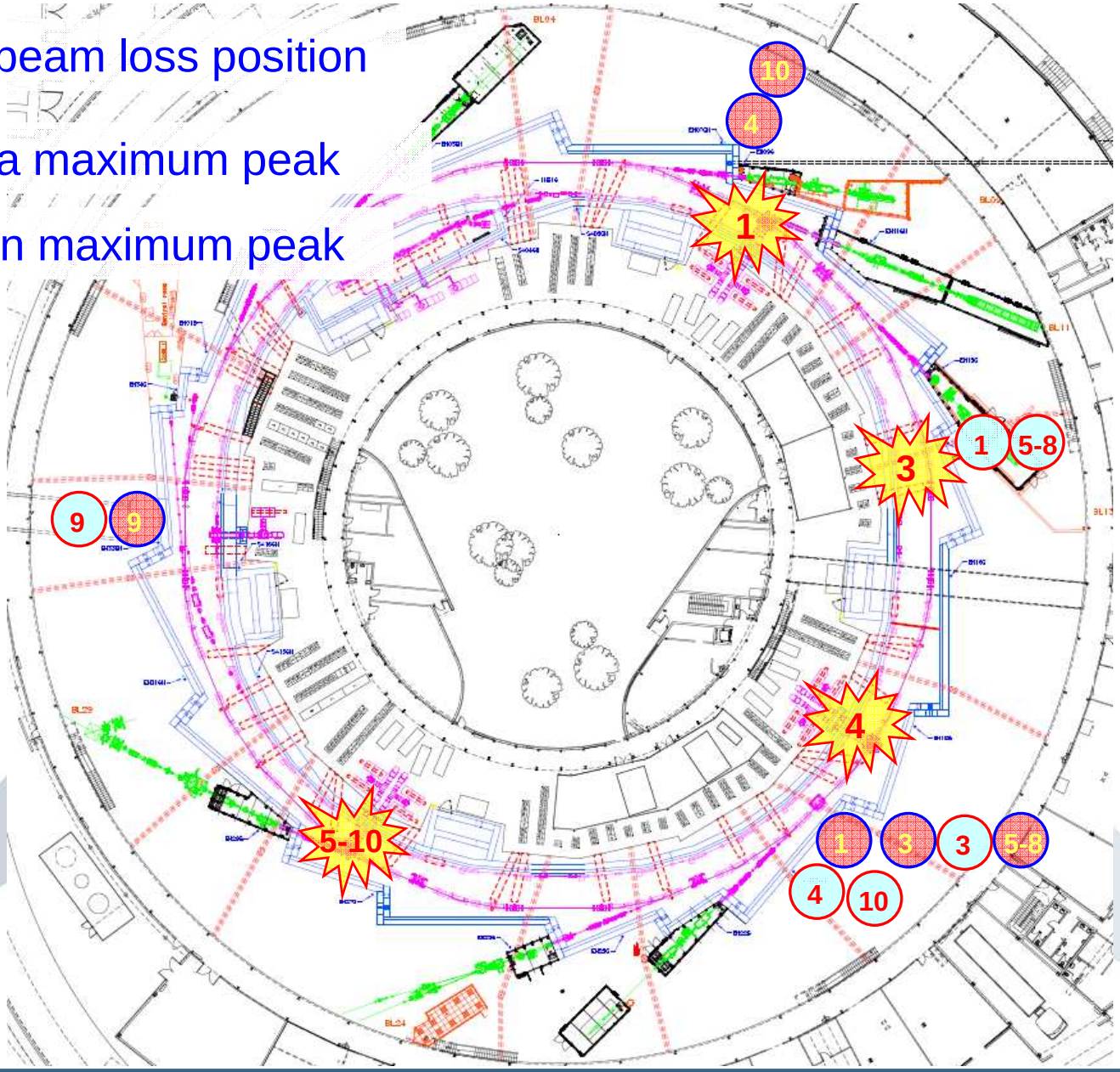
		GAMMA PROBE				NEUTRON PROBE			
Event #	Current loss (mA)	Angle (º)	Peak (µSv/h)	Peak ratio	Detectors involved	Angle (º)	Peak (µSv/h)	Peak ratio	Detectors involved
1	126.4	161	759.2	27.1%	9	218	110.4	74.8%	3
2	19.1	48	0.7	-	14	70	0.0	-	4
3	80.3	218	919.3	43.3%	7	218	190.3	36.3%	3
4	129.5	222	50.0	20.3%	9	104	34.4	64.3%	2
5	126.8	161	679.3	30.0%	10	218	114.4	87.1%	3
6	129.5	161	788.2	30.0%	10	218	86.6	87.1%	4
7	129.6	161	784.7	29.1%	10	218	83.0	92.6%	4
8	128.9	161	616.5	28.6%	11	218	126.2	59.3%	4
9	117.8	355	7.8	94.9%	5	355	95.8	49.6%	4
10	118.1	222	49.2	13.2%	10	104	36.5	50.7%	2

D. eBeam losses: dose rate peak

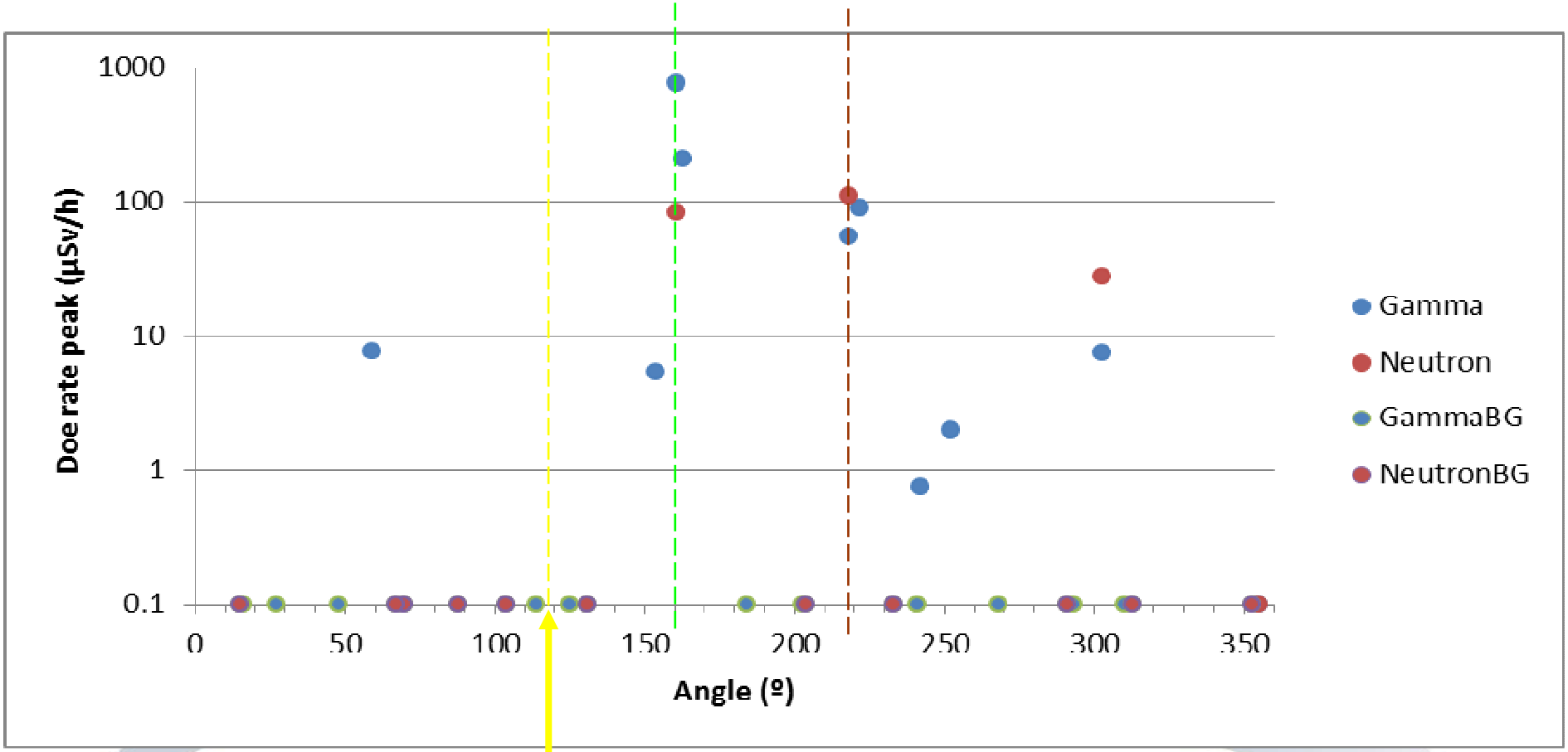
: total ebeam loss position

: gamma maximum peak

: neutron maximum peak

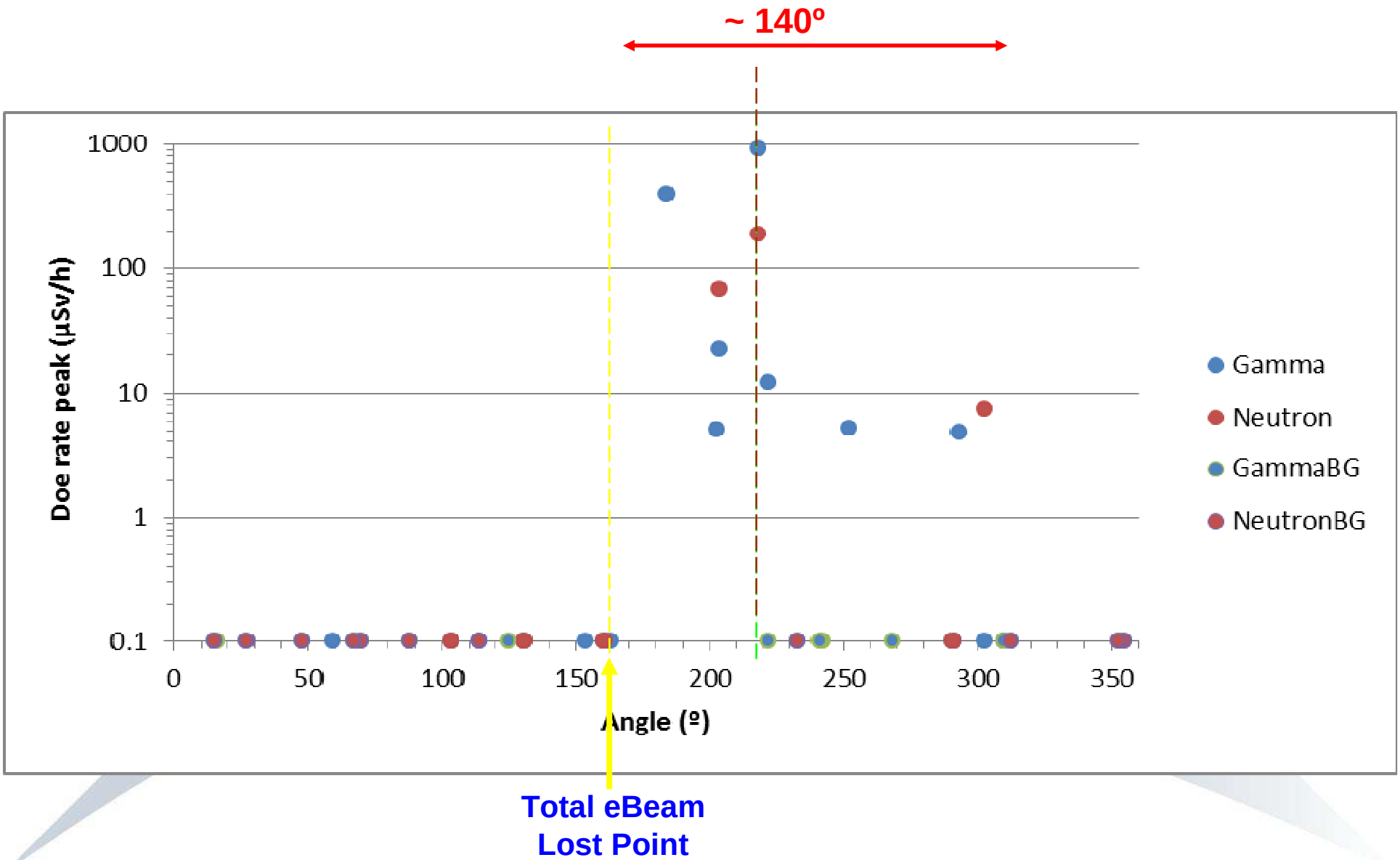


Event #1: RF Plant-1 trip

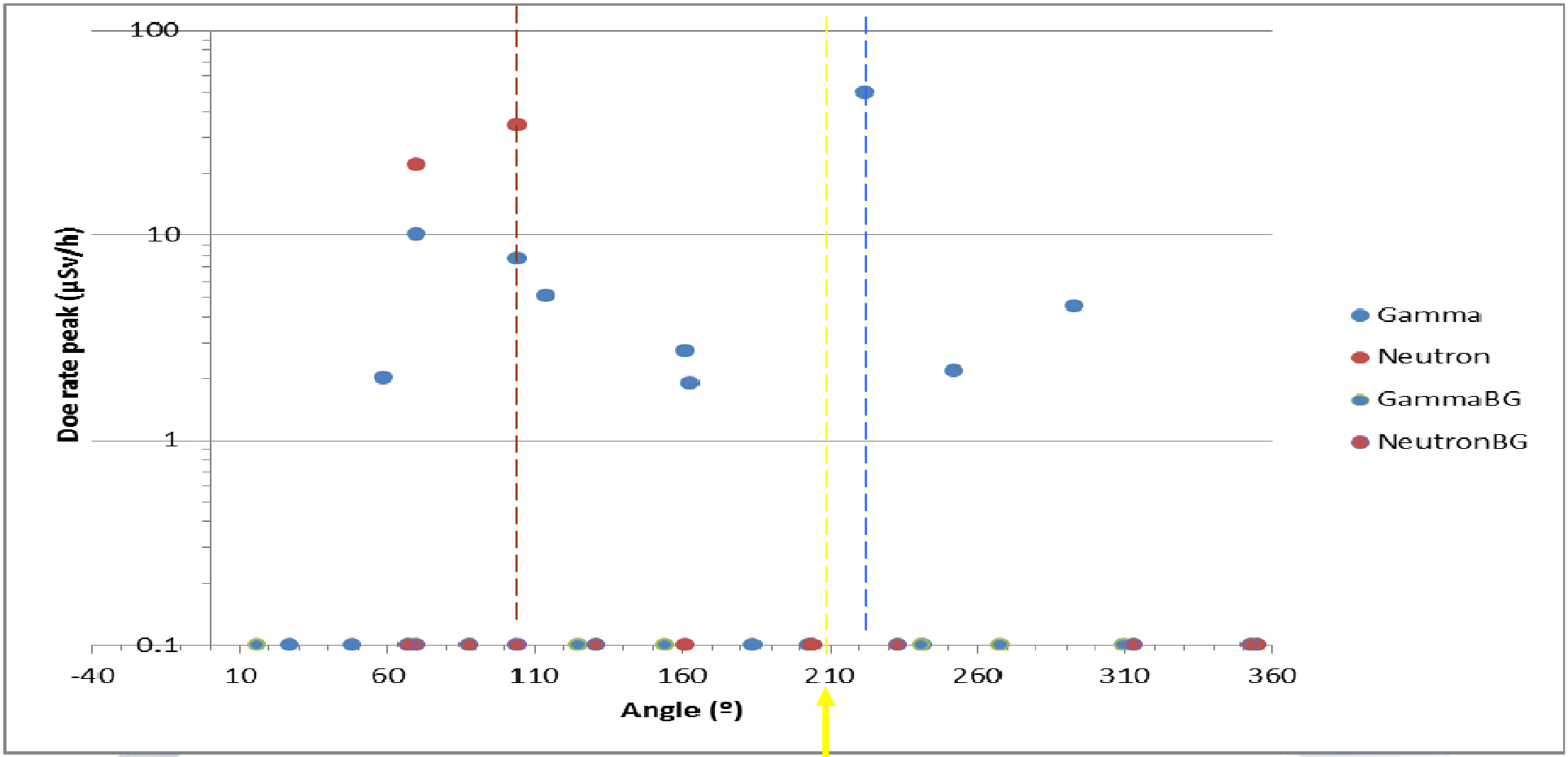


Total eBeam Lost Point

Event #3: Fluorescence Screen trip

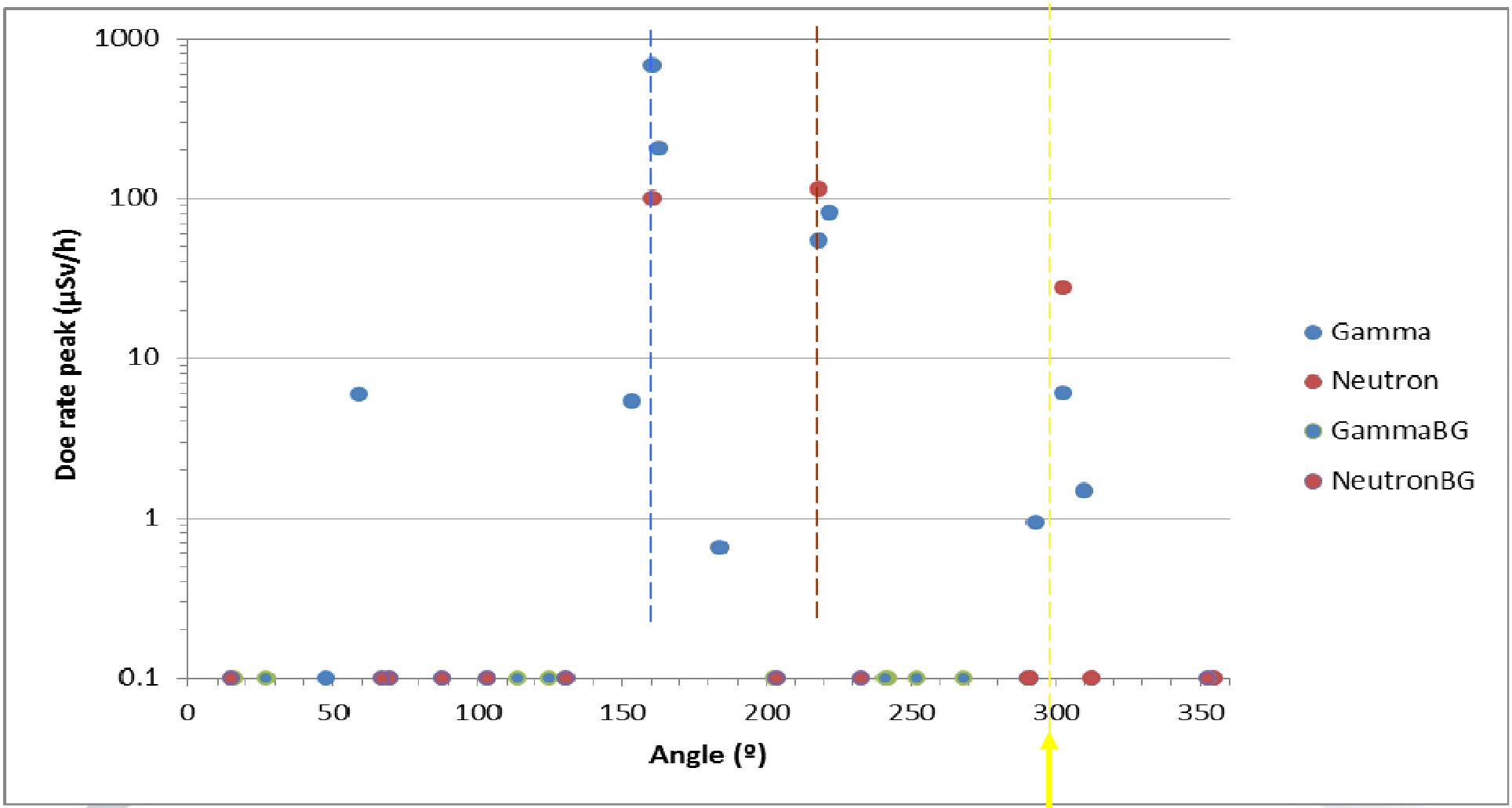


Event #4: RF Plant-2 trip



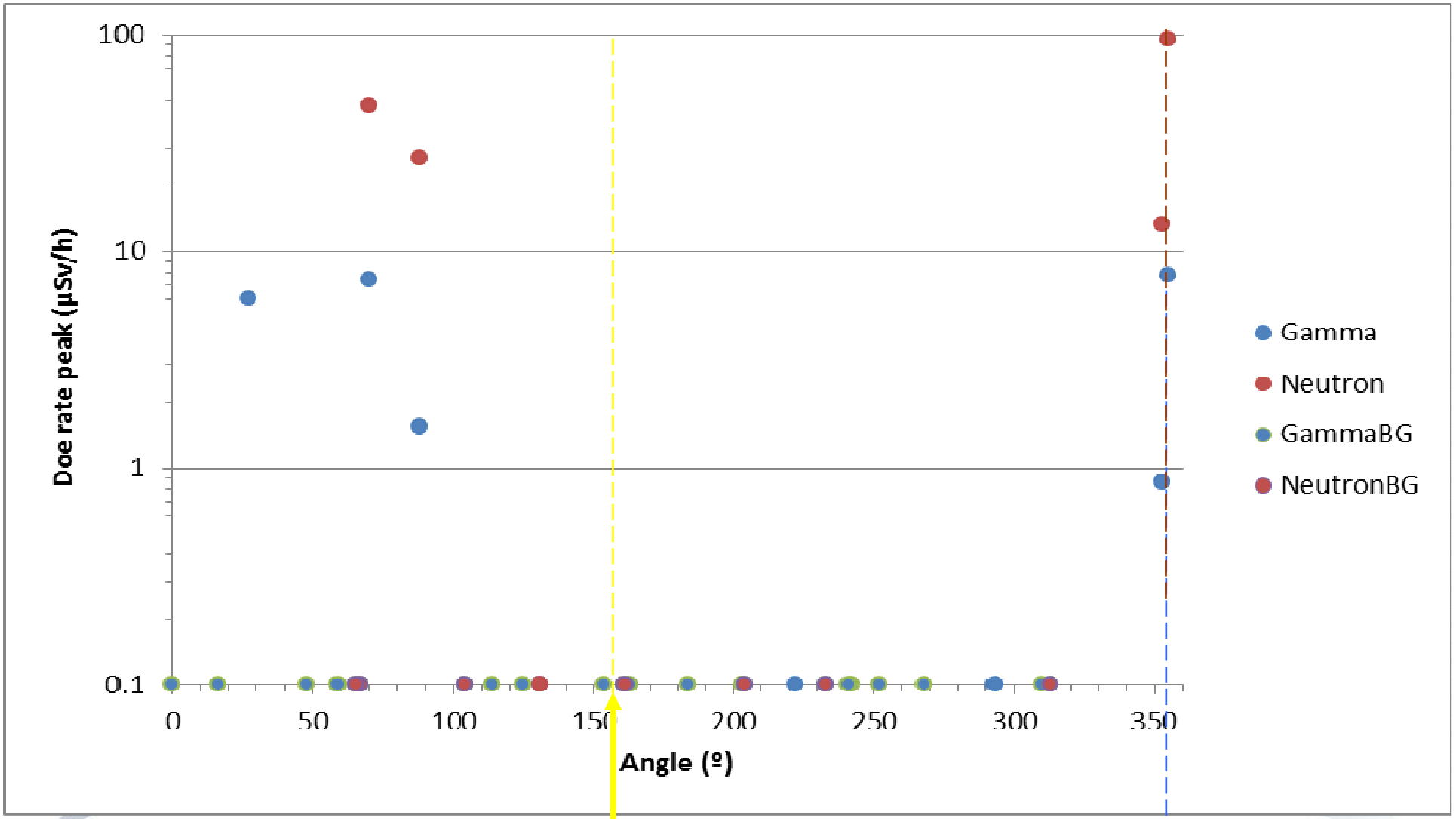
Total eBeam Lost Point

Event #5: RF Plant-3 trip (A)



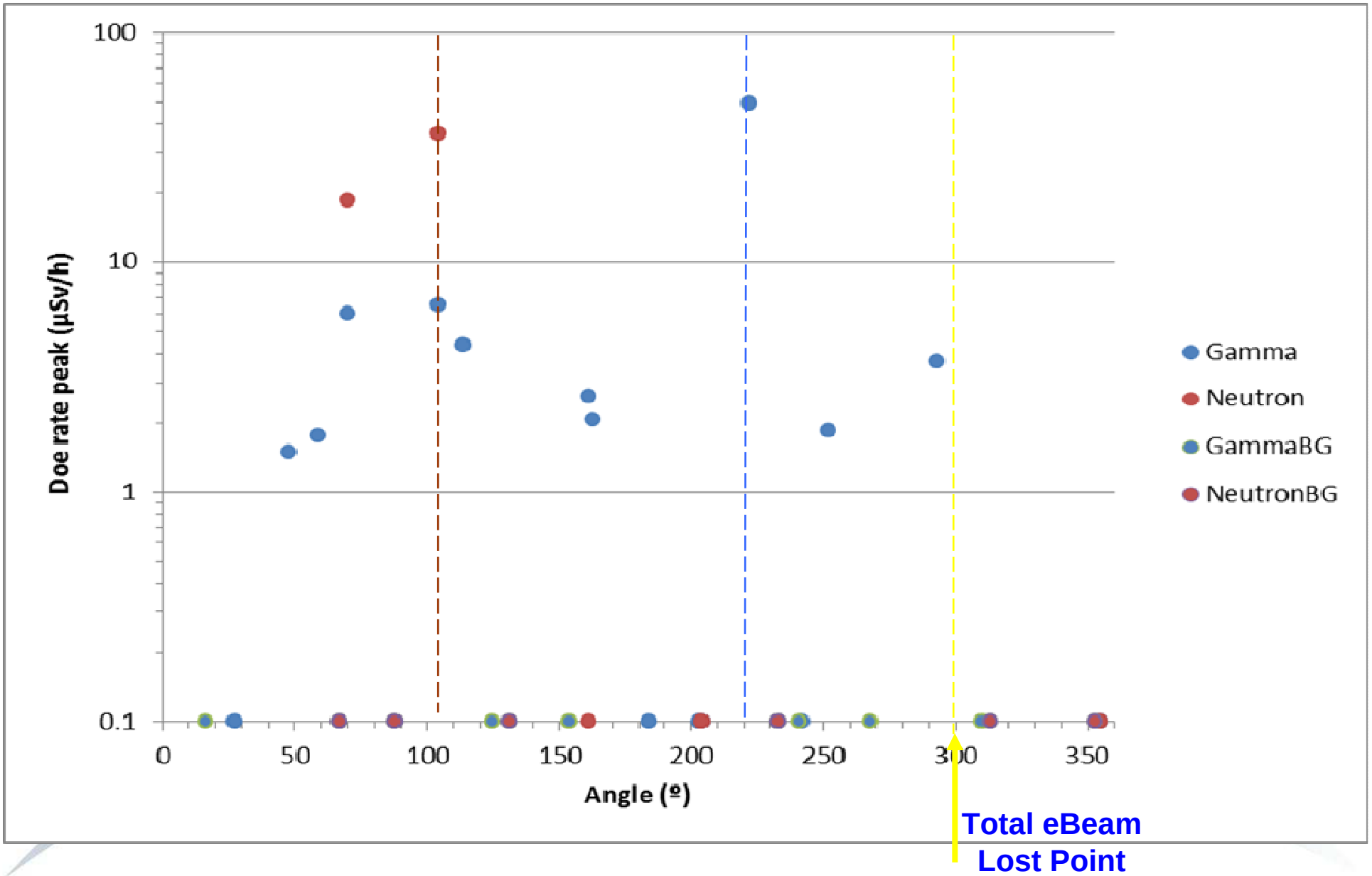
Total eBeam Lost Point

Event #9: RF Plant-3 trip (B)



Total eBeam Lost Point

Event #10: RF Plant-3 trip (C)



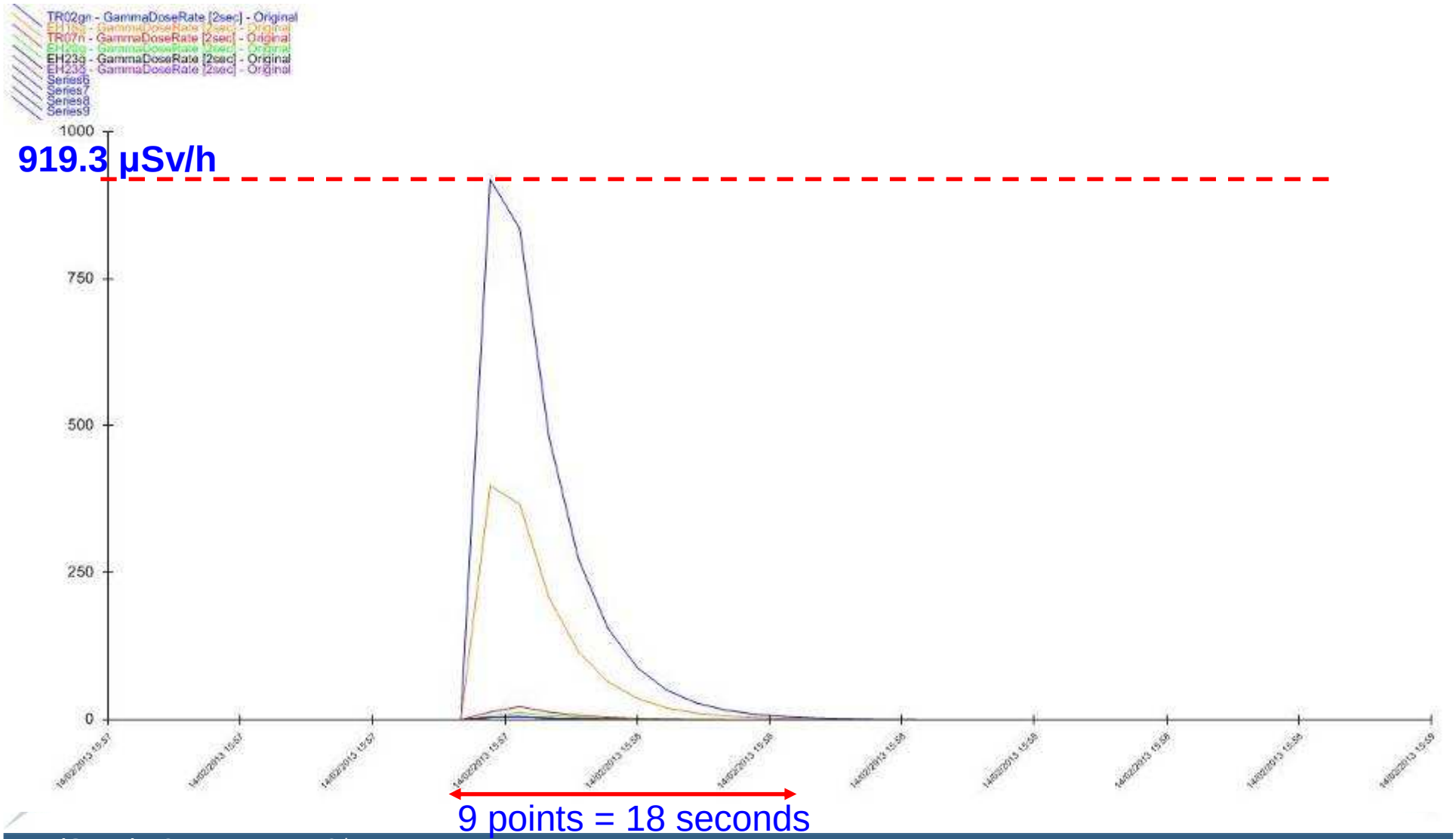
A possible correlation

❖ The e-loss point VS the detector position:

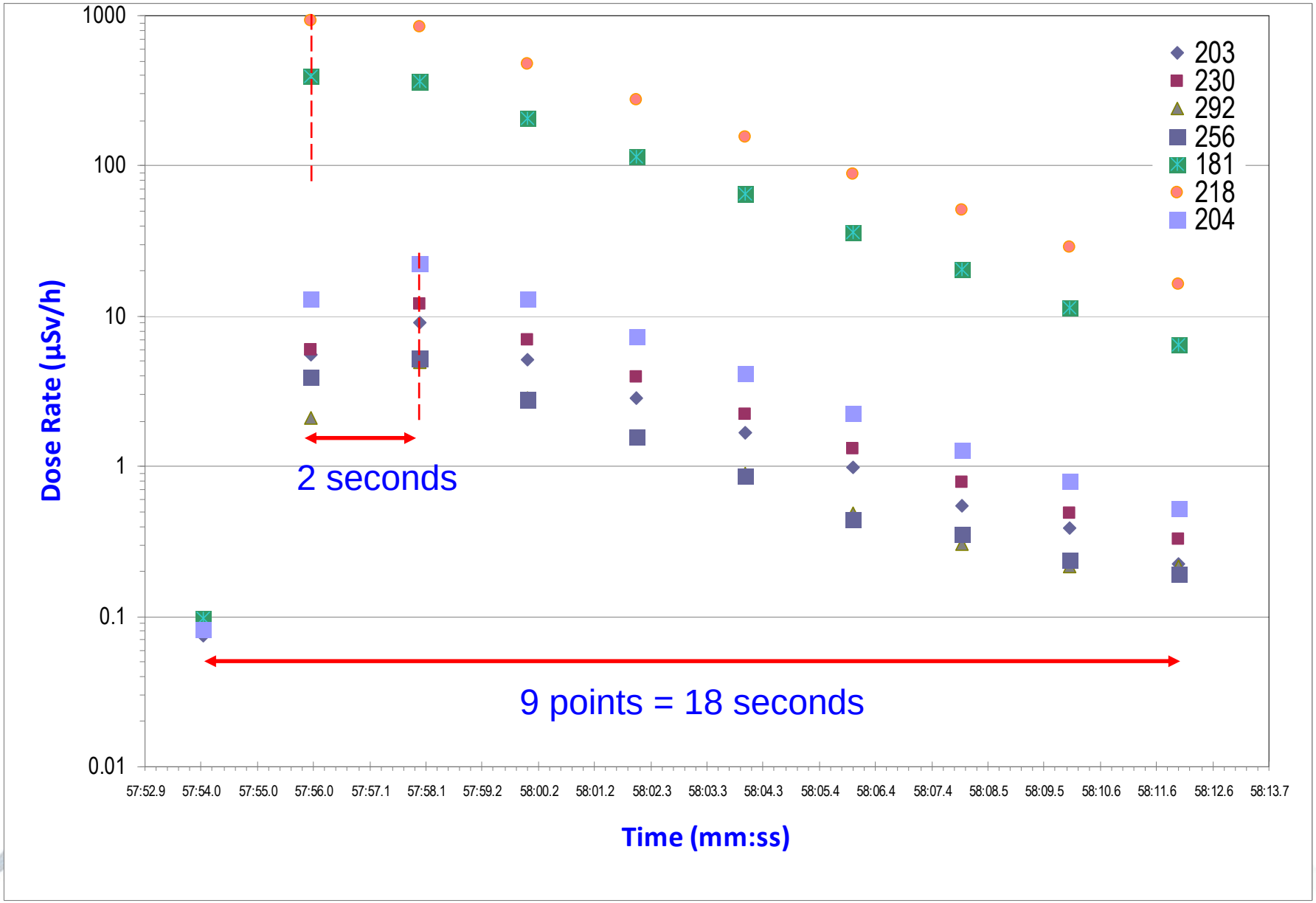
Event #	Loss Point Angle (º)	GAMMA PROBE Angle (º)	NEUTRON PROBE Angle (º)	γ-Step Angle (º)	n-Step Angle (º)	γ-n Angle (º)	
1	118	161	218	43	100	57	A
2	118	48	70	290	312	22	⊗
3	163	218	218	55	55	0	B
4	209	222	104	13	255	242	C
5	298	161	218	223	280	57	A
6	298	161	218	223	280	57	
7	298	161	218	223	280	57	
8	298	161	218	223	280	57	
9	298	355	355	57	57	0	B
10	298	222	104	284	166	242	C

Gamma peaks profile

❖Event #3: Fluorescence Screen trip

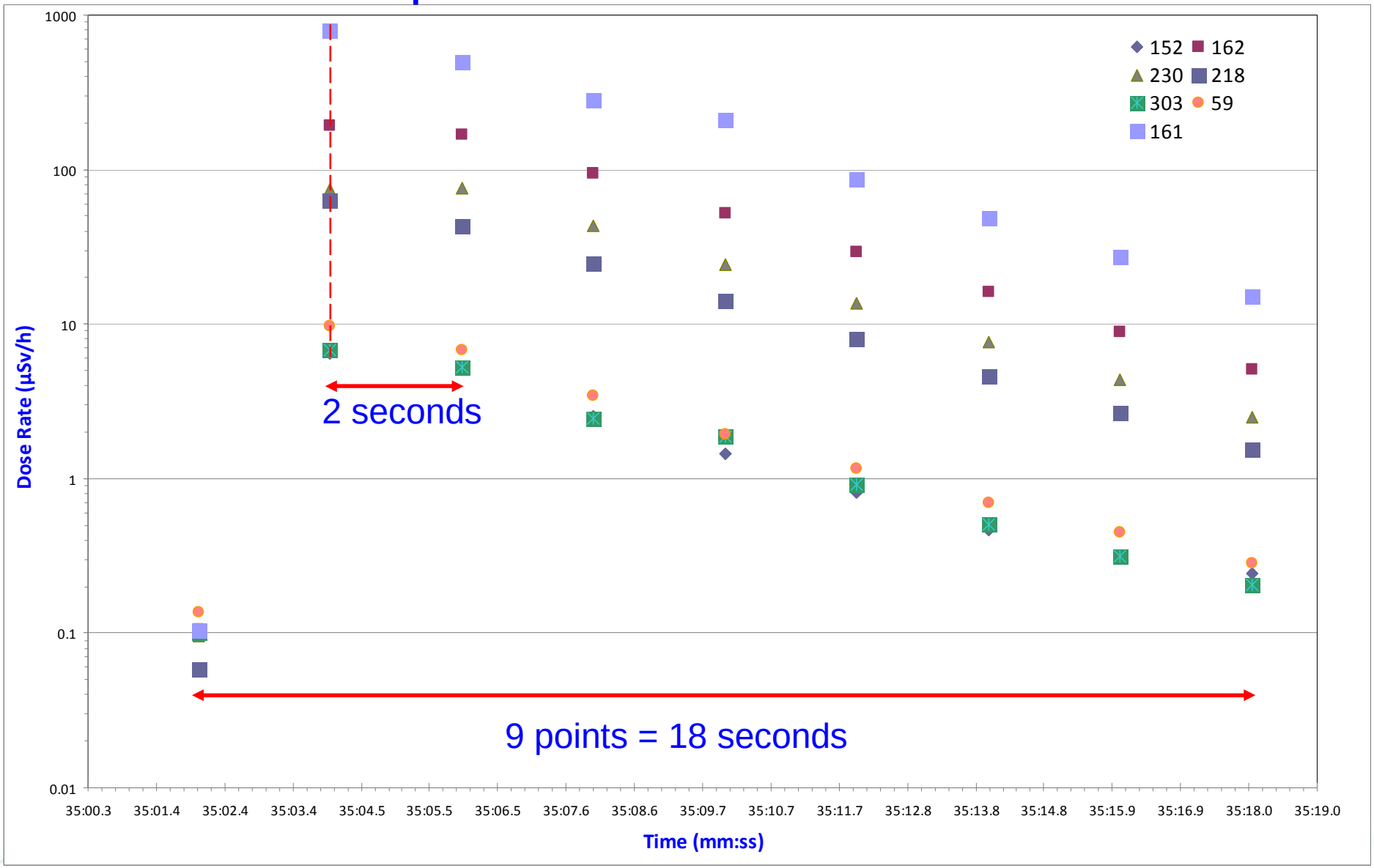


Gamma peaks profile: Event #3



Event #6: gamma peaks

❖RF Plant-3 trip



Conclusions

- The RADMON network records any single **total eBeam loss** event: in average by ~ 9 gamma detectors and ~ 3 neutron detectors.

- The concrete shielding **is not ENOUGH** to reduce the instant dose rate coming from a total loss event.

- In a **prompt event** (FS) the radiation is detected almost over a half turn.

- In a **distributed event** (RF) the radiation could be detected over a whole turn (at least).

Conclusions: Next steps…

- Propose specific machine runs to make studies like:
  1. Analyzing different types of beam loss causes: better records of the beam losses, different fluorescence screens, control how the RF plants work,…
  2. To compare 2 different scenarios: Front End shutters OPEN/CLOSED
  3. Making Monte Carlo simulations for the most significant losses
  4. To study the Storage Ring limit apertures

Many Thanks to…

- ✓ The BNL Organizing Committee
- ✓ The Scientific Program Committee
- ✓ Mrs. Tabatha Leighley
- ✓ All of you!