Head and tail dump

for the booster injection region

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EN/STI-TCD

Thanks to :

C. Maglioni ‹

R. Chamizo ‹

O. Aberle ‹

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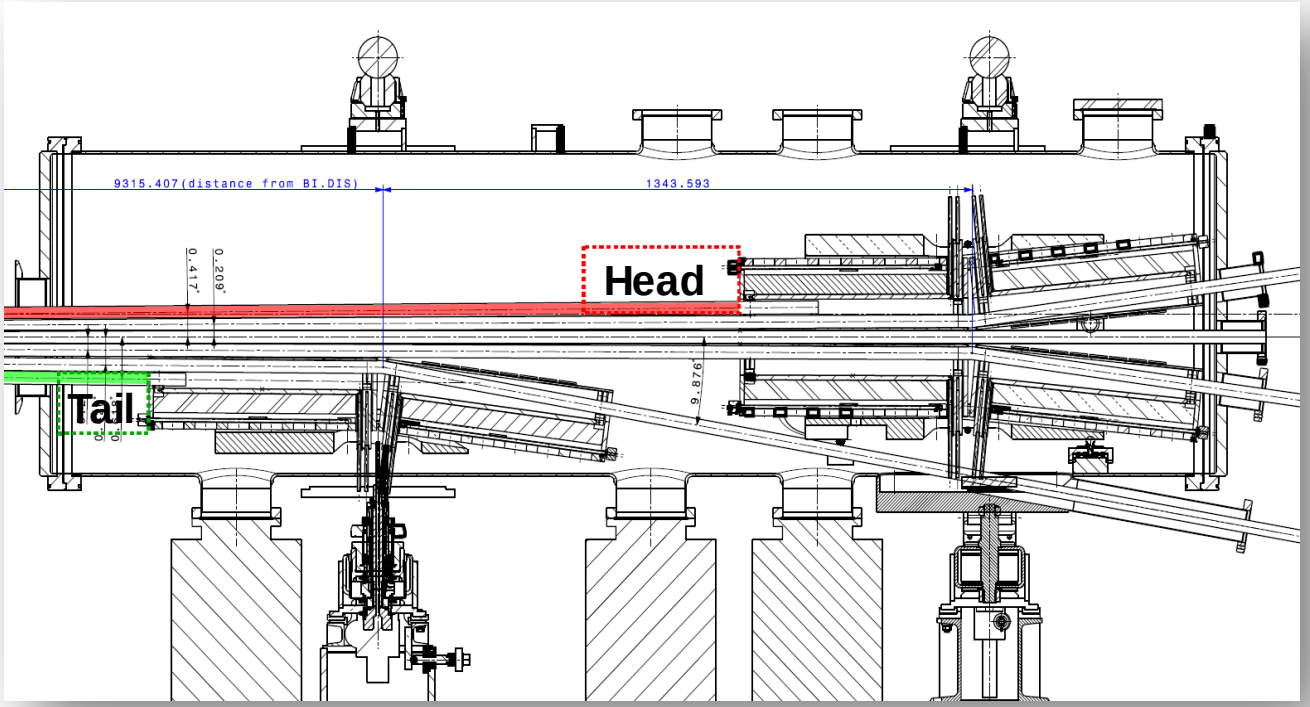
Outline

- Dump space & layout
- Loading cases
- Additional consideration
- Preliminary analyses :
  - Instantaneous ΔT
  - Steady operation
- Conclusions and open questions

Dumps space & layout

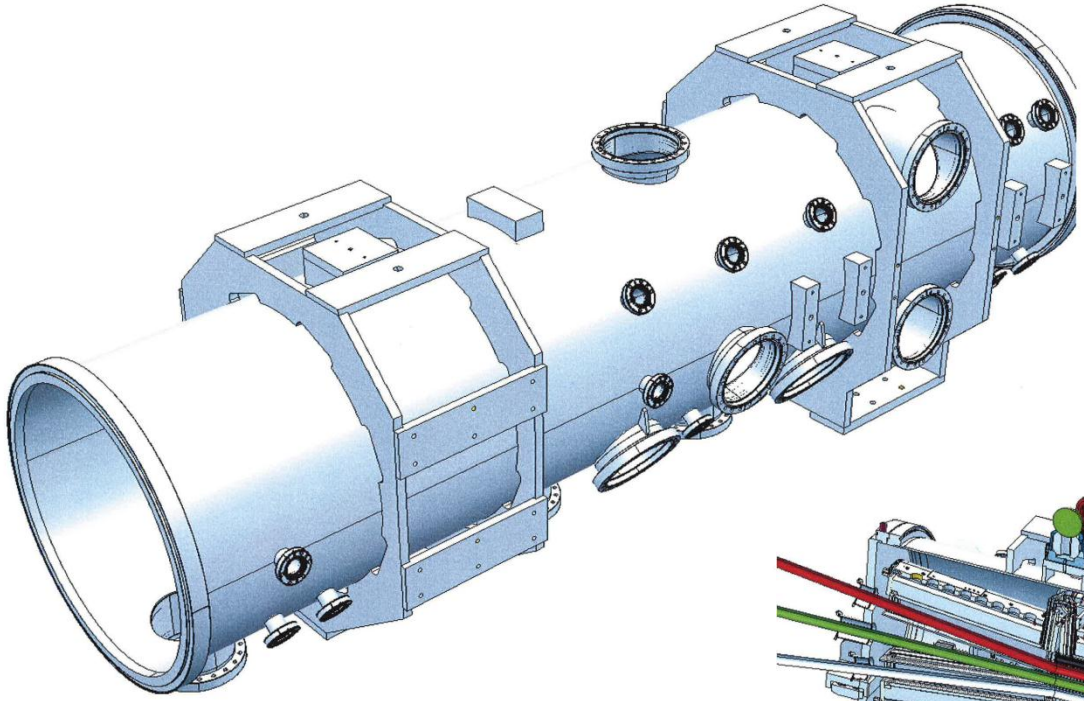


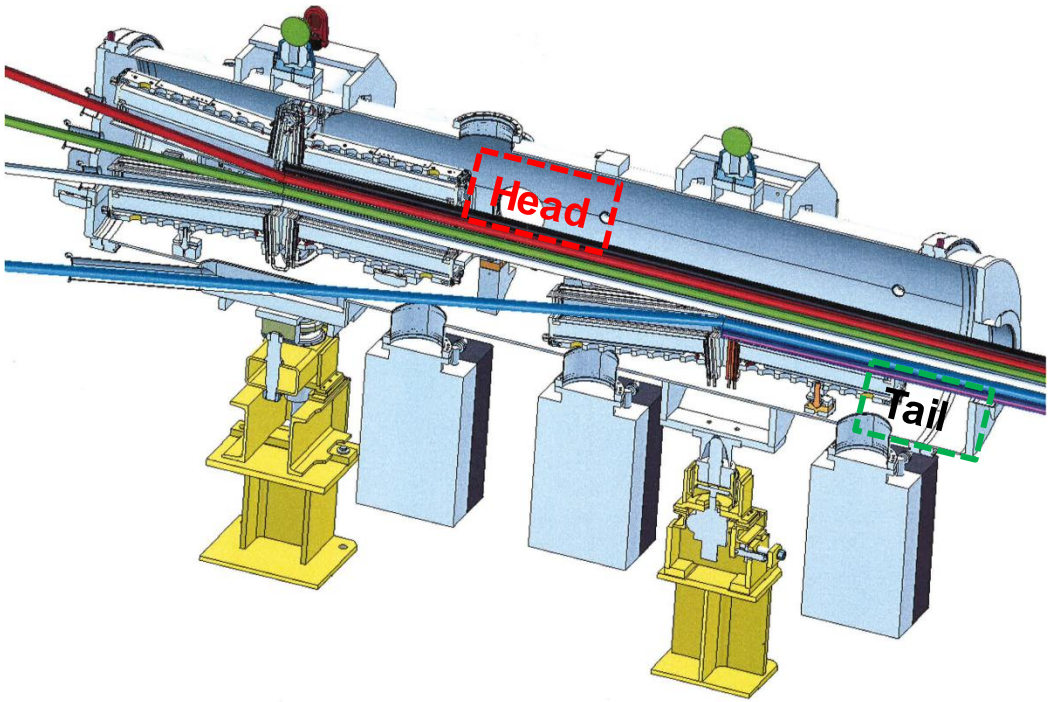
EDMS 963395

- **Head dump located into BI.SMV3 magnet**
- **Tail dump located into BI.SMV1 magnet**

Minimum Dimensions	*Head dump*	*Tail dump*
Width *W* [mm] – x	40	40
Height *H* [mm] – y	40	40
Length *L* [mm] – z	200	200

Dumps space & layout





Loading cases

EDMS 963395

Operating Conditions	*Location*	*Load*	*Pulse [μs]*	*Energy [kJ]*
Nominal	Head	-	-	0
Accidental distributor failure	Head	1E14 p+	400	2
Nominal	Tail	-	-	0
Accidental distributor failure	Tail	2.5E13 p+	100	0.5

* *Following discussion with C. Carli, K. Hanke and M. Vretenar about possible LLRF incident.*

Worst case scenario: accident on the **Head dump**
BUT
Interception are possible during normal beam operation * → 2 more cases were considered and studied for the Head dump

Three loading case:

- (1) accident
- (2) constant beam
- (3) prolonged accident

Operation:

- -- › 1 full Linac 4 pulse → Transient
- -- › Before every beam pulse → Steady-state
- -- › At the beginning of every beam pulse, **one week** duration once per year → Steady-state

Loading cases

Parameter	Symbols	*Case 1:* ***Accident***	*Case 2:* ***Constant beam***	*Case 3:* ***Prolonged Accident***
Current (mA)	*I*	40	0.5	20
Pulse length (μs)	*tp*	400	50	20
Cycle frequency (Hz)	*f*	1.11	1.11	1.11
Max. pulse intensity	*Np*	1.10^{14}	$1{,}56.10^{11}$	$2{,}5.10^{12}$
Power deposited (W)	*P*	**2841**	**4.4**	**71**

In Steady-state operation, low power:

⇨ No active cooling is foreseen to be necessary

Passive cooling by radiation only.

Additional consideration

Several aspects must be considered

- Space constraint
- Induced temperature and stresses
- Vacuum
- Activation
- Fire risk
- Electrical risk

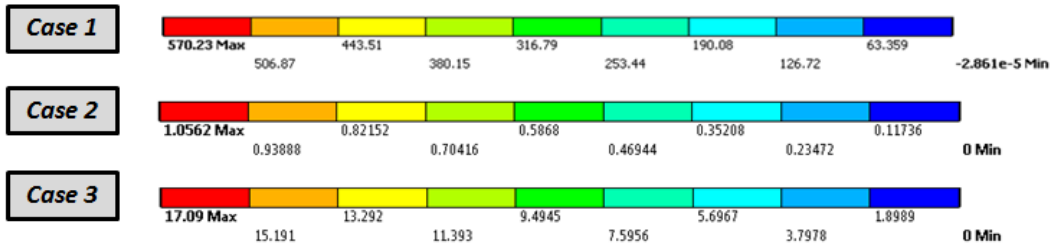
Graphite R4550

Property	*Unit*	*Value*
Average srain size	µm	10
Density	g/cm3	1.83
Open porosity	Vol.-%	10
Average pore size	µm	1.5
Permeability	cm2/sec	0.04
Rockwell Hardness	HR 5/100	95
Specific electrical resistivity	µΩm	13
Flexural Strength	MPa	60
Compressive Strength	MPa	125
Young's modulus	GPa	11.5
Poisson ratio	-	0.1
Thermal conductivity	W/mK	100
Thermal expansion coefficient 20-200 °C	10^{-6} K^{-1}	4.00
Ash value	ppm	20

Instantaneous T

Half dump LEFT view

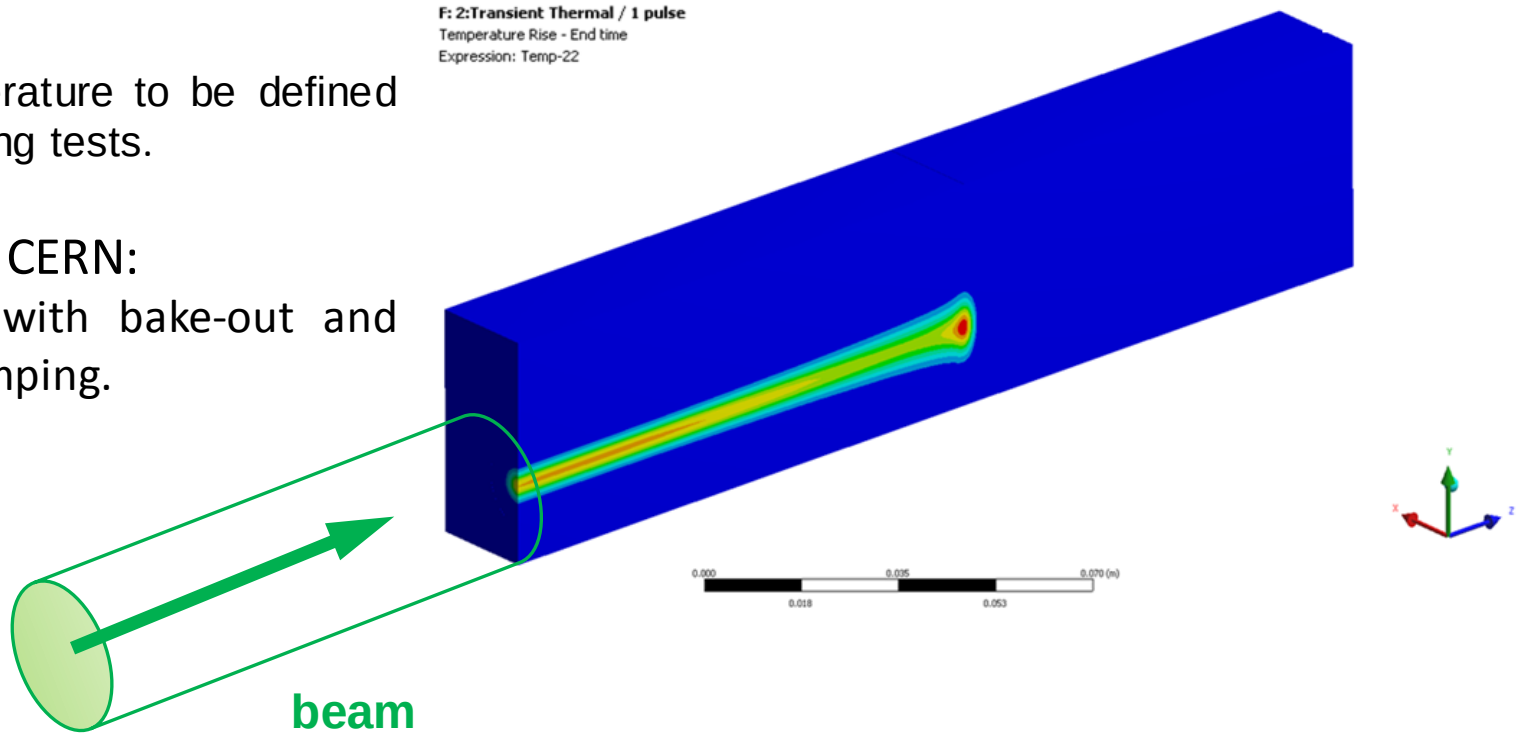
Loading case	*ΔT analytical (K)*	*ΔT ANSYS (K)*	*Error %*
Case 1	576	570	1
Case 2	1.17	1.06	9.4
Case 3	18.6	17.09	8.1



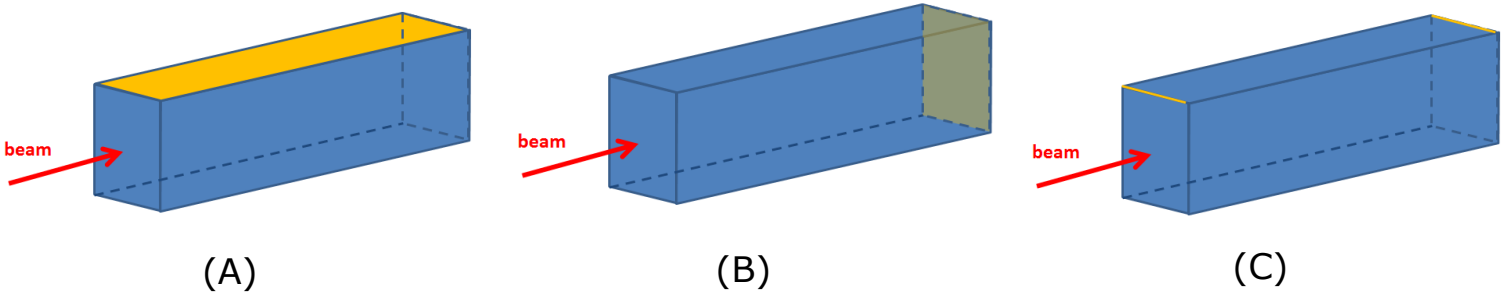
Maxi serv. Temperature to be defined based on degassing tests.

Standard use at CERN:

22 to 1 000°C with bake-out and appropriated pumping.



Proposed simplified attached system



(A) (B) (C)

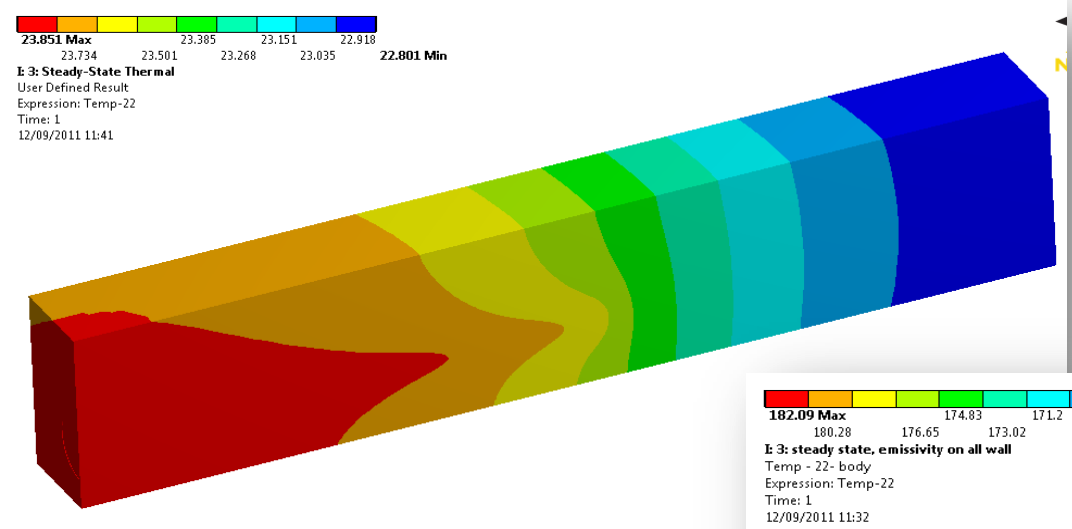
1 pulse

Support configuration	*Top (A)*	*Back (B)*	*Top edges (C)*
Case 1: complete failure			
Maximum vertical deflection [μm]	3.96	4.44	13.09
Maximum Thermal Stress [MPa]	31	31	31
Max Stassi Eq Compressive σ_{SC}^{max} [MPa]	-47.3	-47.2	-47.1
Case 2: continuous			
Maximum vertical deflection [μm]	0.00611	0.0063	0.0063
Maximum Thermal Stress [MPa]	0.05	0.05	0.05
Max Stassi Eq Compressive σ_{SC}^{max} [MPa]	-0.075	-0.074	-0.074
Case 3: prolonged accident			
Maximum vertical deflection [μm]	0.1	0.1	0.1
Maximum Thermal Stress [MPa]	0.81	0.81	0.81
Max Stassi Eq Compressive σ_{SC}^{max} [MPa]	-1.22	-1.2	-1.2

Limit in compression: **125 MPa**

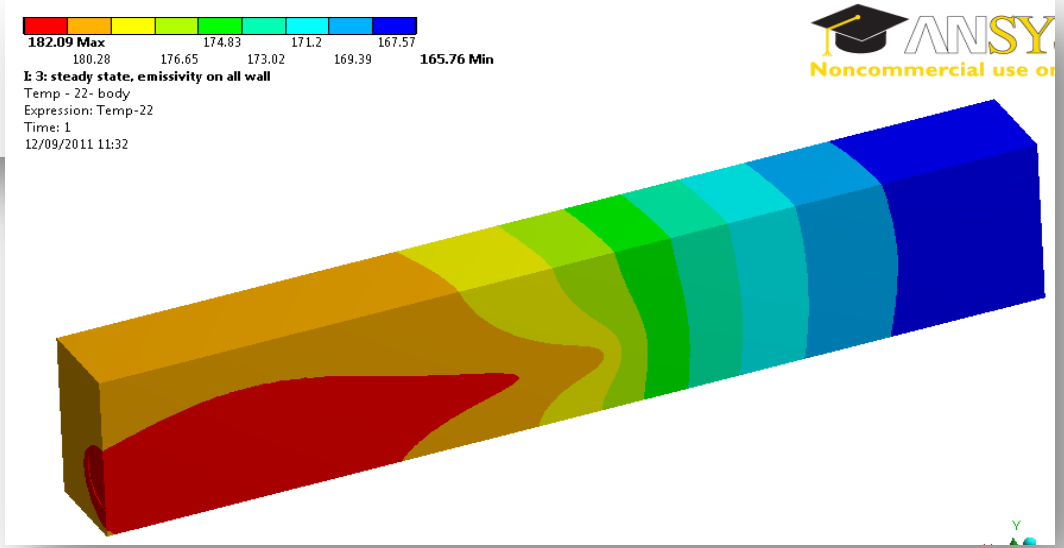
Maxi deflection allowed: **0.5 mm** (guess)

Steady operation



Passive cooling by radiation only

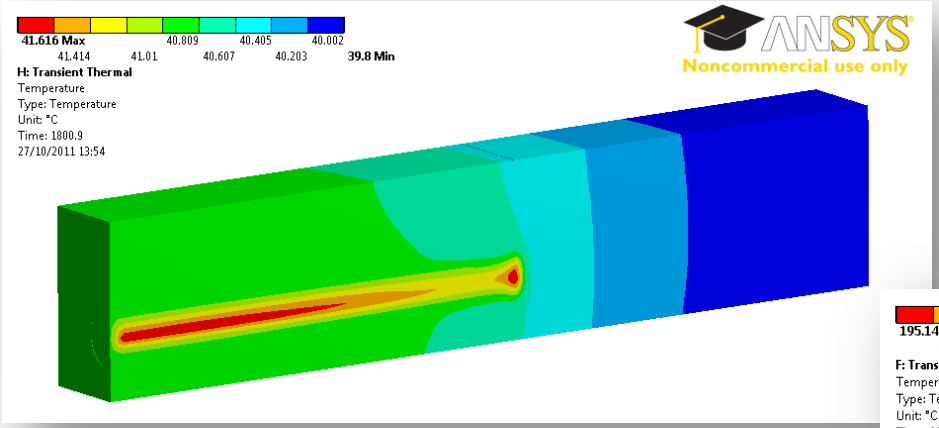
Case 2: *After 1 h 50 min*



Case 3: *After 40 min*

Loading case	*ΔT ss analytical (K)*	*ΔT ss ANSYS (K)*	*Error %*
Case 2	23.98	23.82	0.7
Case 3	182.81	180.94	1.0

steady operation + ΔT



Passive cooling by radiation only

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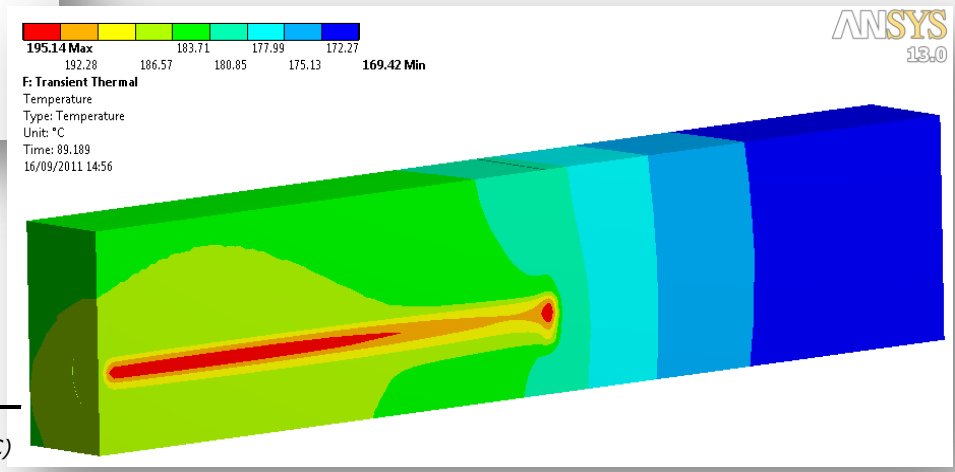

Case 3: *After 40 min*

Support configuration	*Top (A)*	*Back (B)*	*Top edges (C)*
Case 2: continuous			
Maximum vertical deflection [µm]	3.65	1.63	13.75
Maximum Thermal Stress [MPa]	0.94	0.94	0.94
Max Stassi Eq Compressive σ_{SC}^{max} [MPa]	-6.98	-5.18	-9.86
Case 3: prolonged accident			
Maximum vertical deflection [µm]	32.5	13.1	134
Maximum Thermal Stress [MPa]	8.56	8.56	8.56
Max Stassi Eq Compressive σ_{SC}^{max} [MPa]	-39.4	-22.8	-70.5

Limit in compression: **125 MPa**

Maxi deflection allowed: **0.5 mm**

Advised to used support type (A) or (B)

Conclusions and open questions

- The analyses have been done based on up-to-date specs : temperatures and stresses are not an issue
- Support type A or B are preferred
- Detailed study can be done ONLY when the support is defined

Open questions:

- Support?
- Bake-out?
- Name of the device?

Thank You

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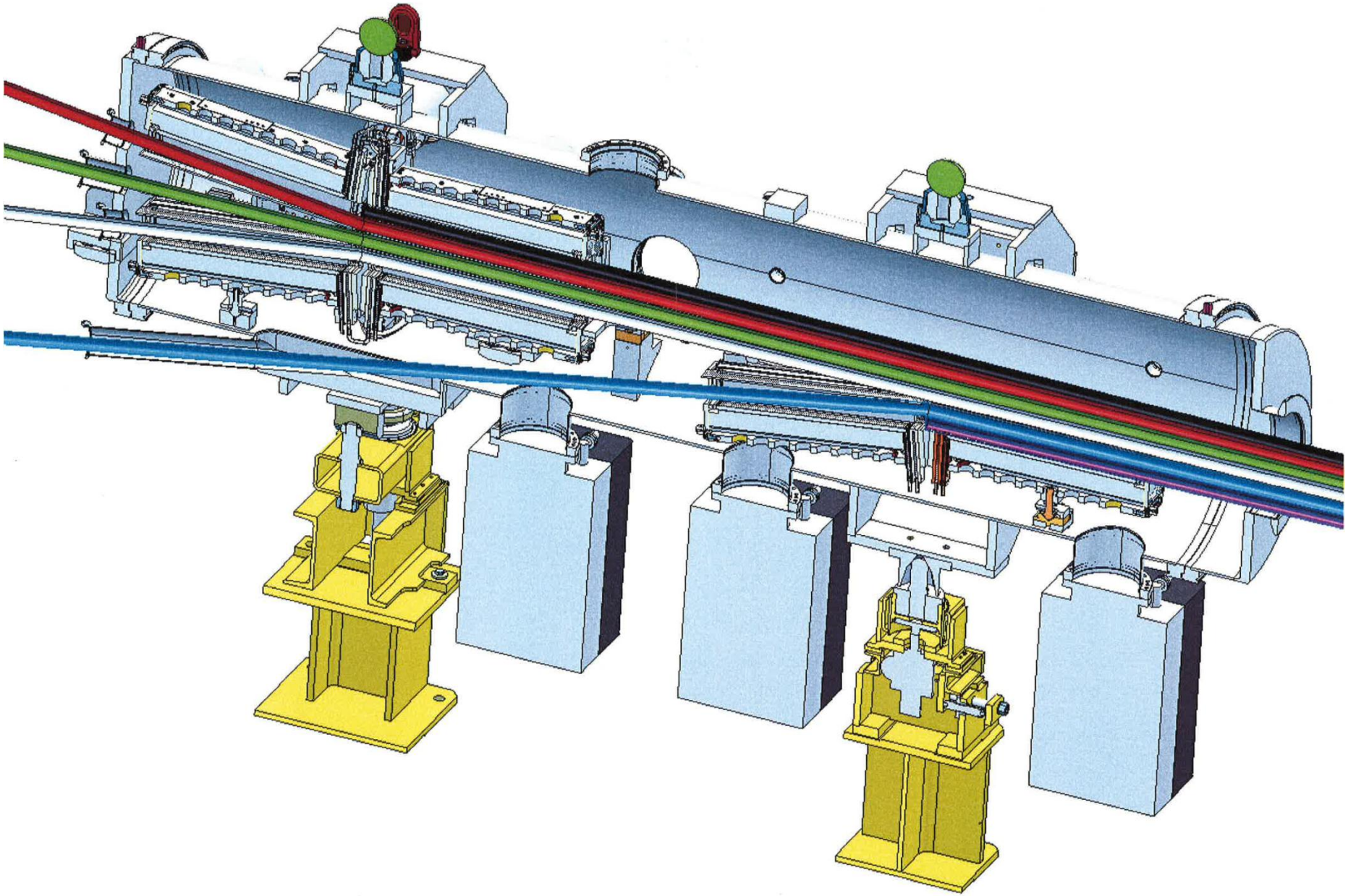


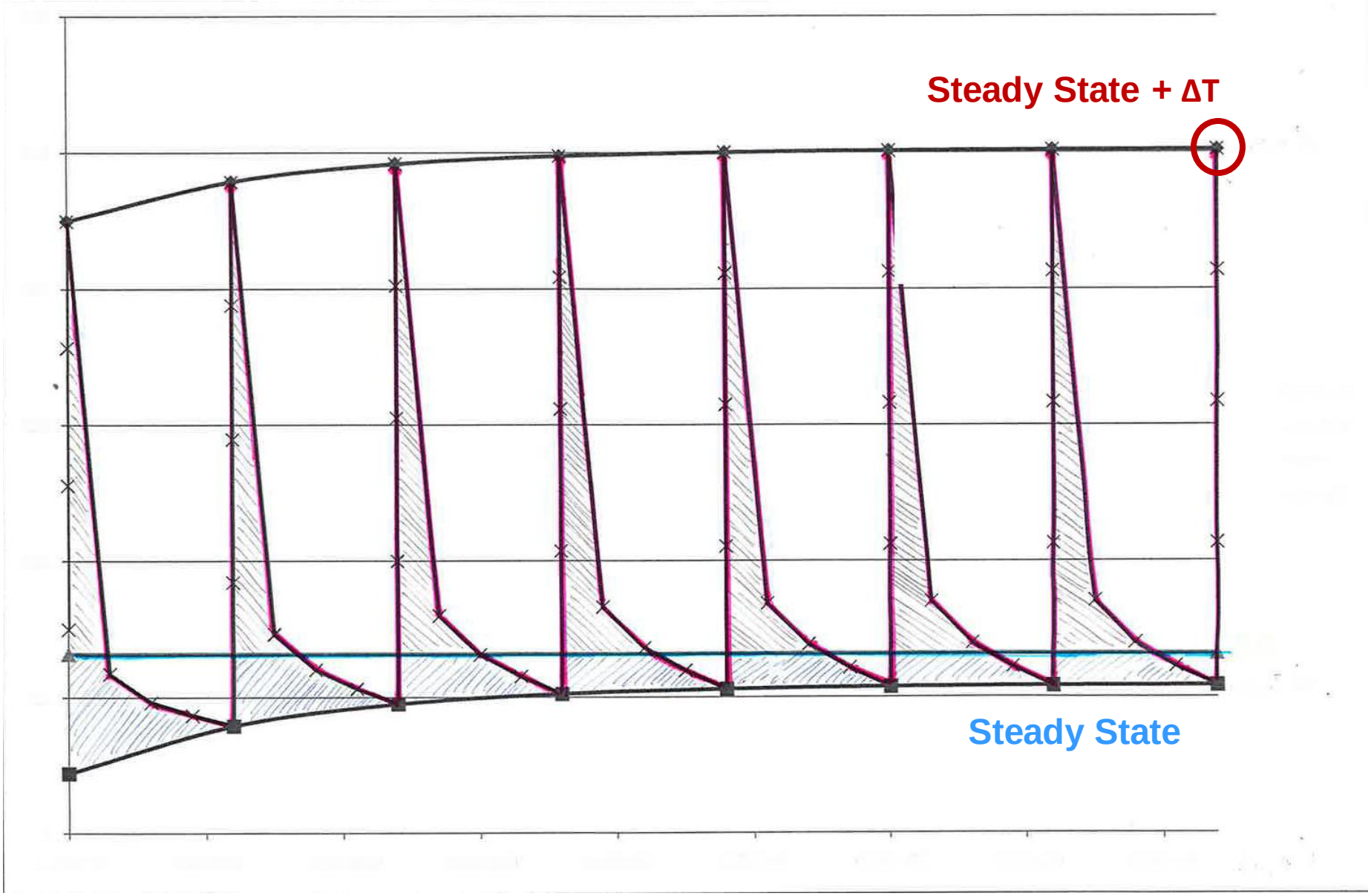
Dear all,

After discussion at the Linac4 core meeting this morning I propose the following specifications for the head dump.
Beam hitting the head dump is divided in 2 contributions, a "constant" beam (data from Alessandra) and an "occasional accident" beam (corresponding to our discussions).

1. constant beam: 0.5 mA during 50 us before every beam pulse, max. repetition frequency 1.11 Hz.
2. occasional accident: 20 mA during 20 us at the beginning of every beam pulse, max. 1.11 Hz, "from time to time".

After the discussion, I would propose to take "from time to time" = "one week duration once per year". To be revised if we see that the activation is too high.
I draw your attention to the fact that the beam current for the occasional accident is only 20 mA; we would be crazy to send the full current to the booster if we have a LLRF accident.

Cheers,
Maurizio


Steady State + ΔT
Steady State