

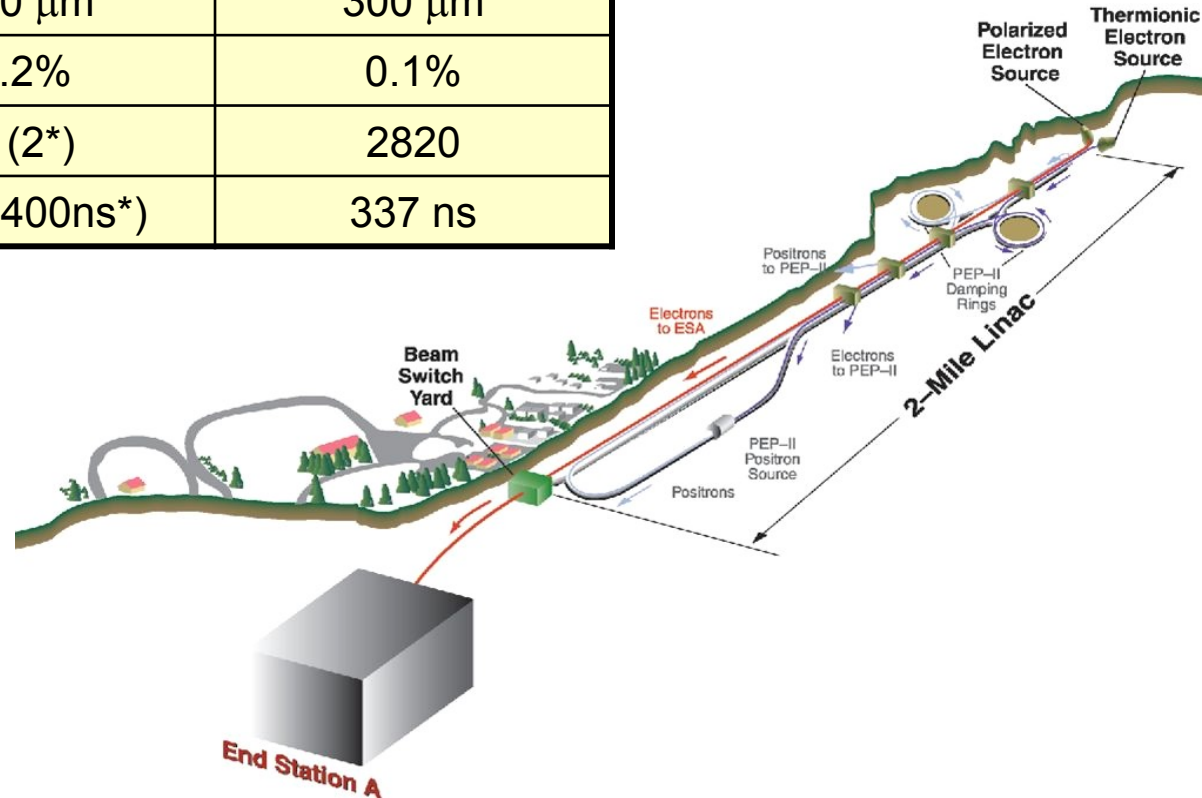
Plans for collimator survival and SLAC tests

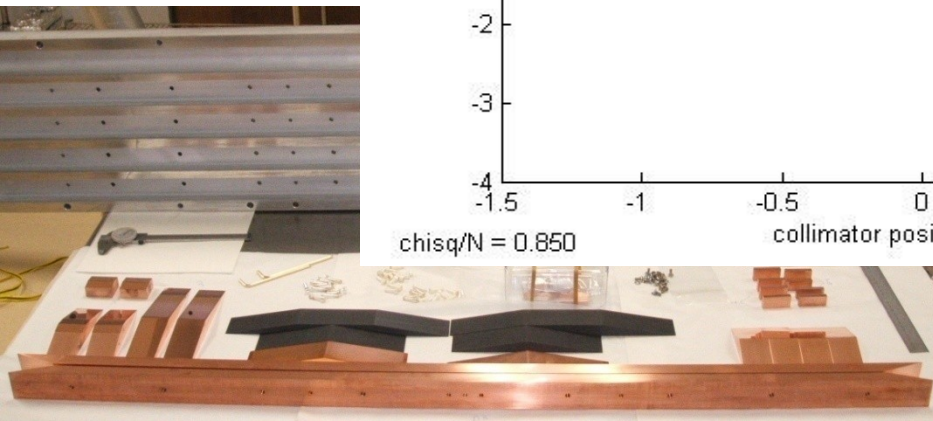
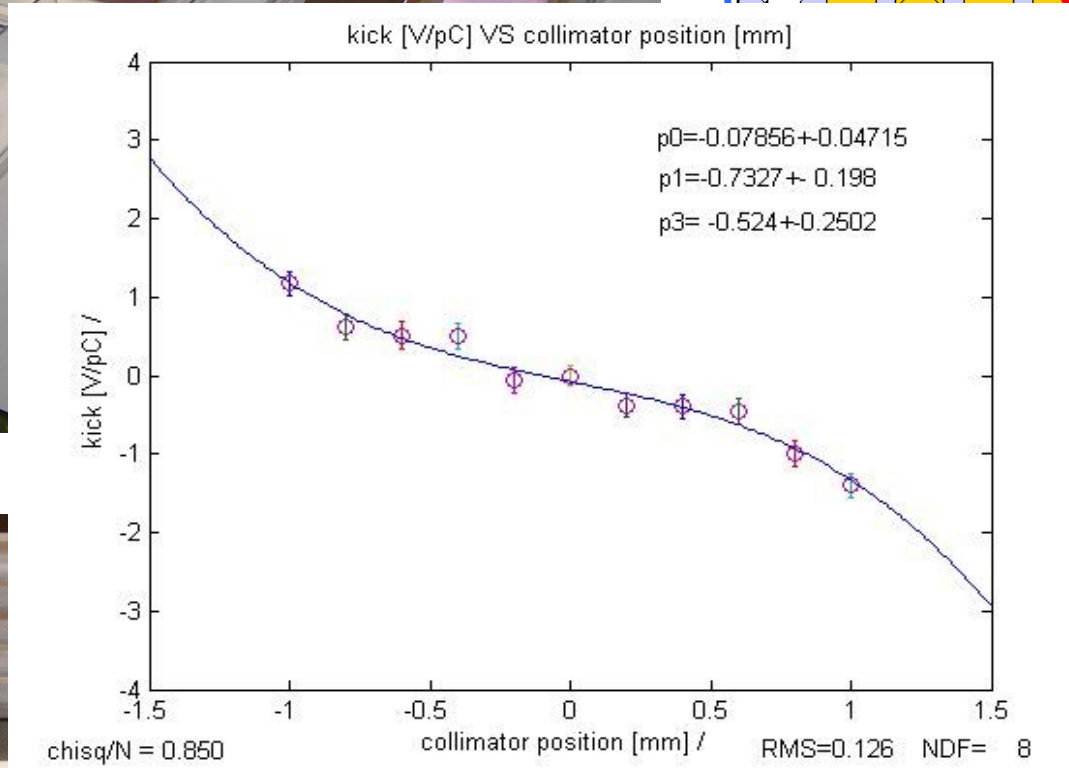
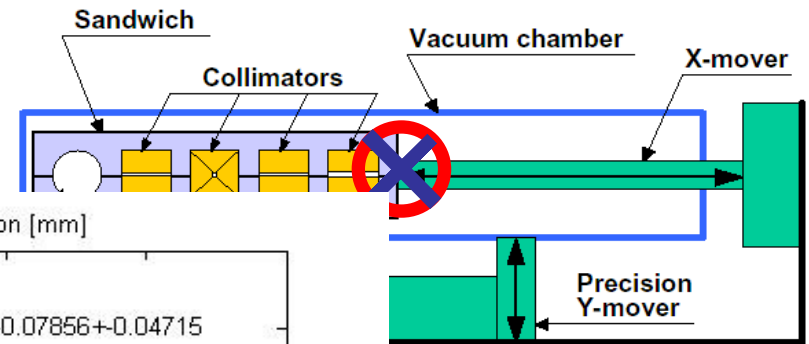
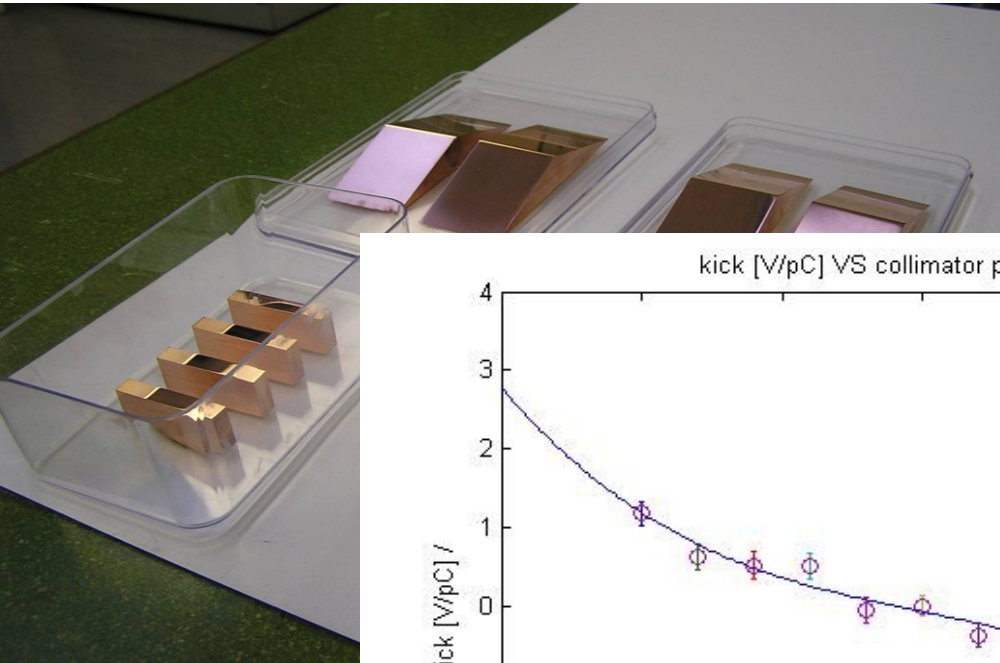
J. L. Fernandez-Hernando
STFC/ASTeC Daresbury Lab

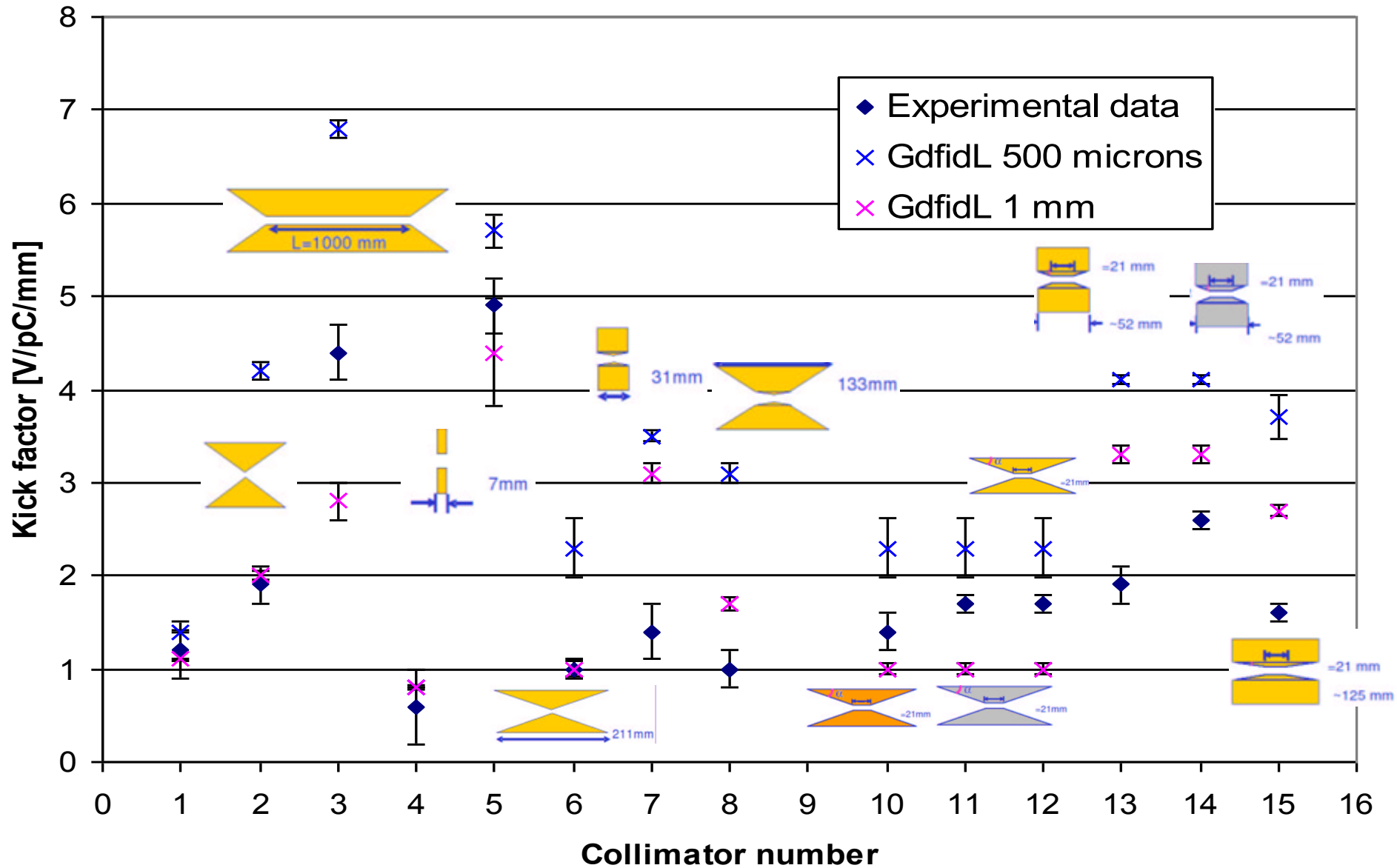
Beam Parameters at SLAC ESA and ILC

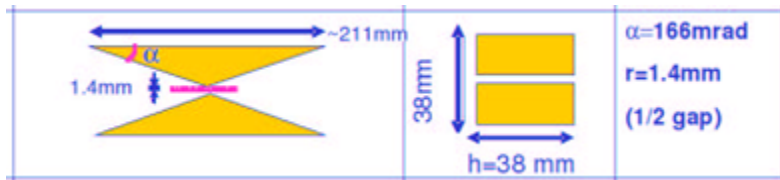
Parameter	SLAC ESA	ILC-500
Repetition Rate	10 Hz	5 Hz
Energy	28.5 GeV	250 GeV
Bunch Charge	2.0×10^{10}	2.0×10^{10}
Bunch Length	300 μm	300 μm
Energy Spread	0.2%	0.1%
Bunches per train	1 (2*)	2820
Microbunch spacing	- (20-400ns*)	337 ns

*possible, using undamped beam





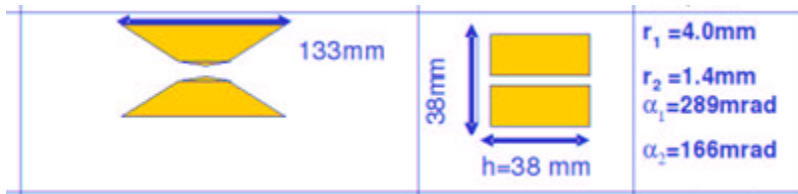




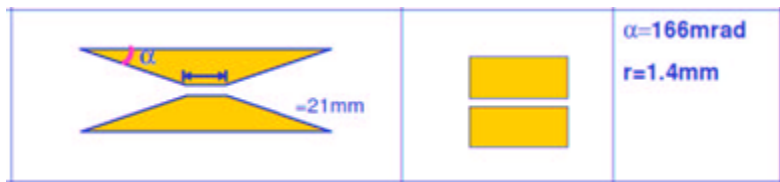
$$1 \pm 0.1 \text{ V/pC/mm}$$



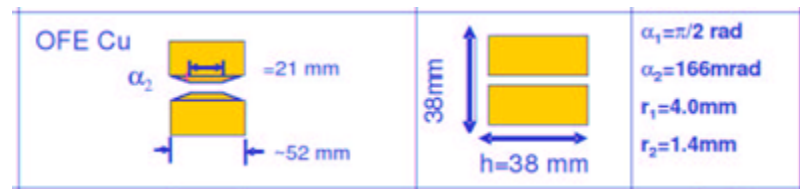
$$1.4 \pm 0.3 \text{ V/pC/mm}$$



$$1 \pm 0.2 \text{ V/pC/mm}$$



$$1.7 \pm 0.1 \text{ V/pC/mm}$$



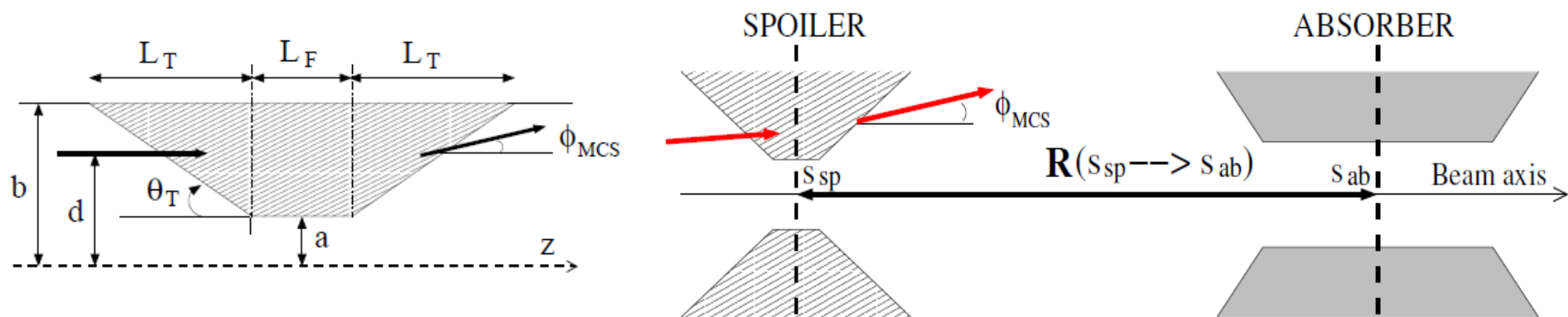
$$1.9 \pm 0.2 \text{ V/pC/mm}$$



$$1.7 \pm 0.1 \text{ V/pC/mm}$$



$$2.6 \pm 0.1 \text{ V/pC/mm}$$



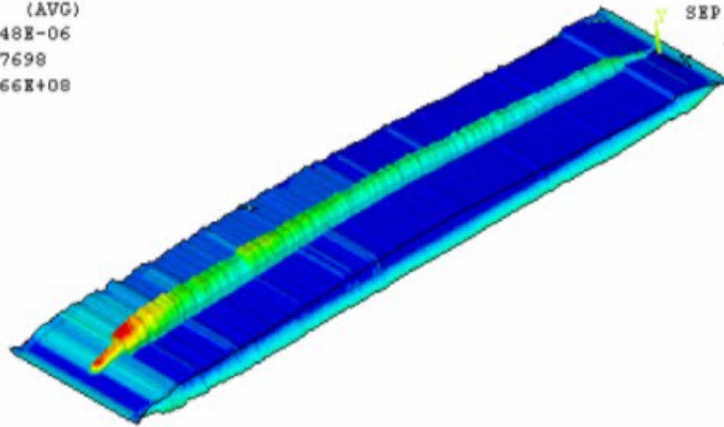
Parameter	ENGYSP (spoiler)	ENGYAB (absorber)
Geometry	Rectangular	Rectangular
Hor. half-gap a_x [mm]	3.51	5.41
Vert. half-gap a_y [mm]	8.0	8.0
Tapered part radius b [mm]	8.0	8.0
Tapered part length L_T [mm]	90.0	27.0
Taper angle θ_T [mrad]	50.0	100.0
Flat part length L_F [radiation length]	0.05	18.0
Material	Be	Ti alloy–Cu coating

NODAL SOLUTION

STEP=1
SUB =1
TIME=.520E-07
SEQV (AVG)
DMX =.148E-06
SMN =397698
SMX =.966E+08



SEP 3 2010
11:28:49



A deviation from normal orbit of $10\sigma_x$ would have these effects on this particular spoiler design made of Be and of 0.05 radiation lengths of flat part.

950MPa, and tensile, which is way above tensile strength limit.

$$\sigma_{eq} = \frac{1}{\sqrt{2}} \sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}$$

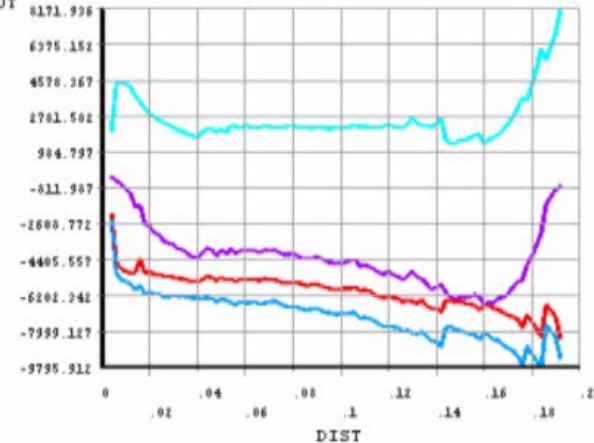
T_{melt} [K]	1560
Y [10^5 MPa]	2.87
α_T [10^{-6} K $^{-1}$]	11.3
σ_{UTS} [MPa]	370
ΔT_{fr} [K]	228
Yield Tensile Strength [MPa]	240
Yield Compressive Strength [MPa]	270
Specific Heat Capacity [J/g $^\circ$ C]	1.925
Density [g/cm 3]	1.844

POST1

STEP=1
SUB =1
TIME=.520E-07($\times 10^{+4}$)

PATH PLOT

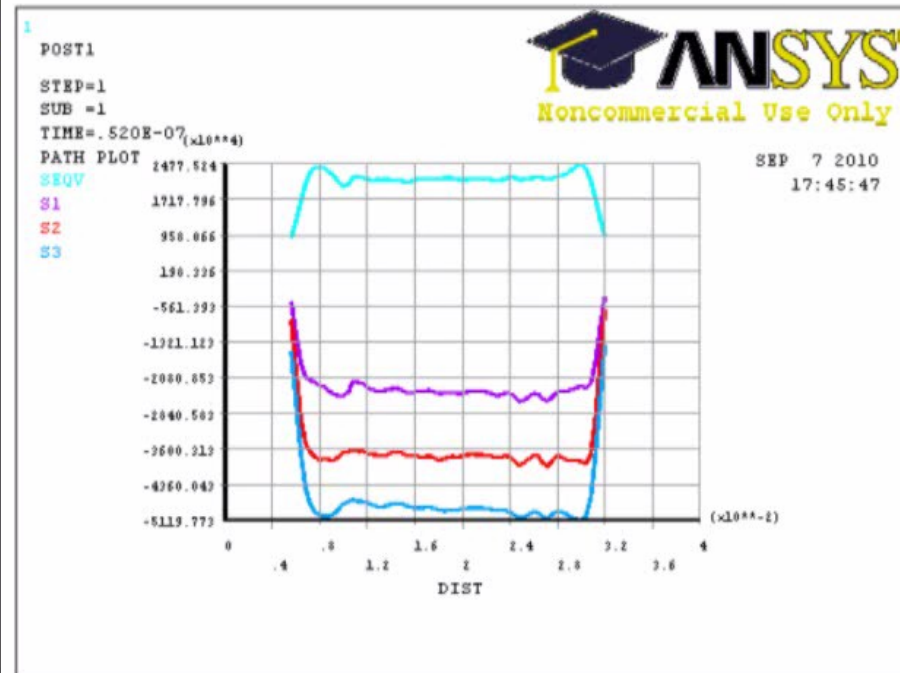
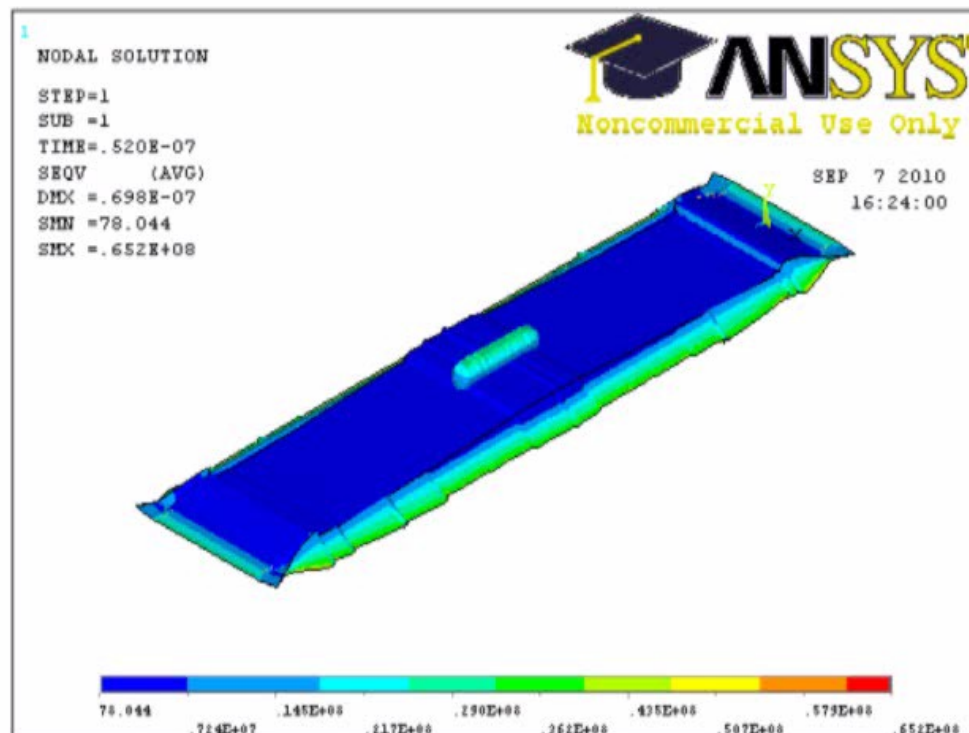
SEQV
S1
S2
S3



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15:32:03

I have also calculated the stresses when the bunch train hits at a deviation of “just” $4.75\sigma_x$. Which means that the beam “sees” 0.073 Xo of material.

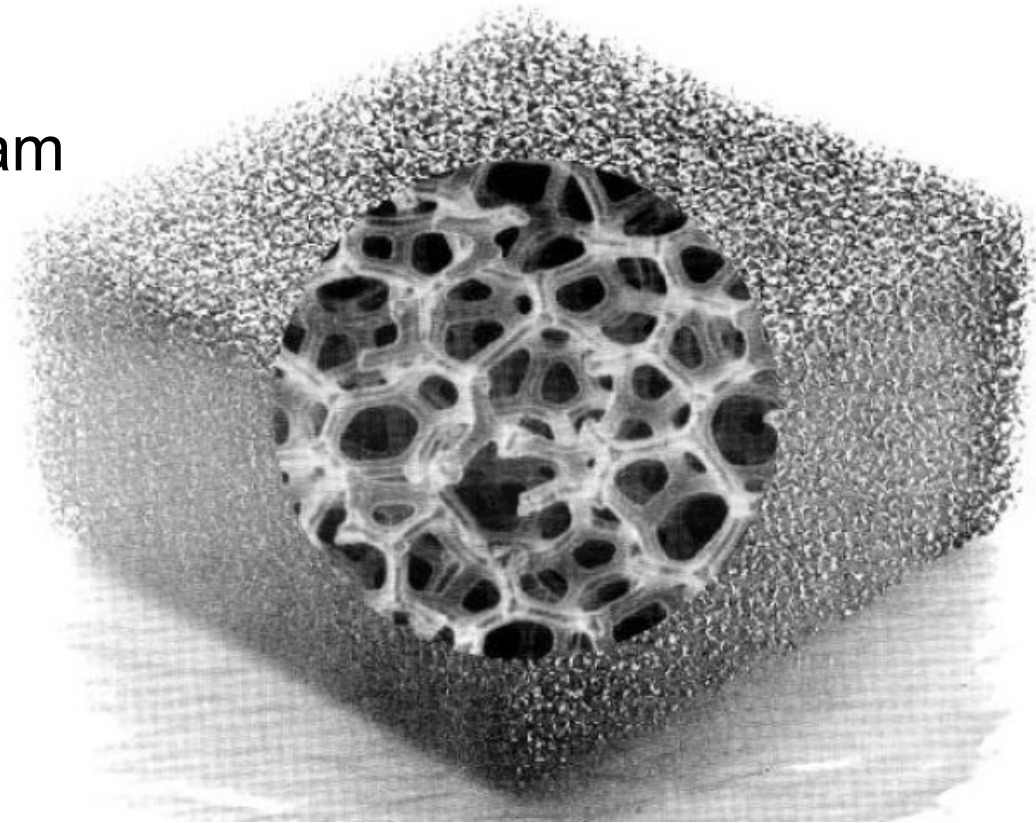
The top value of stress is $\sim 340\text{MPa}$ and compressive. Meaning that **there will not be fracture** but **there will be a permanent deformation**, and in this case it is a vertical deformation of $5\ \mu\text{m}$, which represents a **0.1% of the half gap**.



Silicon carbide (SiC) foam

SiC is a material with good thermomechanical properties. Used for LHC collimation phase 2, in F1 brakes, and aerospace applications.

It can be used as core material for CLIC spoilers, coated with metal (Be, Cu...)



Material	Radiation length X_0 [cm]
Copper	1.44
Ti alloy	3.56
Beryllium	35.3
SiC (solid)	8.1
SiC (foam 8%)	337

Very long radiation length of the foam at 8% of nominal density allows for low energy deposition of the particle beam.

Pros and cons for using SiC foam as core material in CLIC energy spoilers covered by $0.05X_0$ (in the z direction) of beryllium:

Pros:

- It will not matter the depth the beam hits as it will always see $0.05X_0$ of beryllium (the contribution of the SiC foam can be negligible).
- Save some beryllium.

Cons:

- The junction of two different materials is a complicated thing, mechanically speaking. The different thermal properties can lead to dislocation or fracture of the junction when the bunch train hits. A single material spoiler is more “whole” in that aspect.

Conclusions:

It would be very important to identify the failure modes and accident scenarios to know by how much the bunch train can be deviated from orbit as the energy spoiler design could perfectly withstand the worse case scenario... or not.

Studies on how to attach the spoiler to its mount are required to avoid concentration of tensions in the attached points.

Studies of using a SiC foam core would give us the maximum stress in the material junction and therefore tell us if it would survive a bunch train hit at any depth position.

We have seen that $0.05 X_0$ of material are not enough. Therefore SiC body solution covered with Beryllium would be the only option that occurs to me. Nevertheless, if the material needed to spoil the beam so it is safe for the absorber exceeds by far the $0.1X_0$, then other options should be looked at.