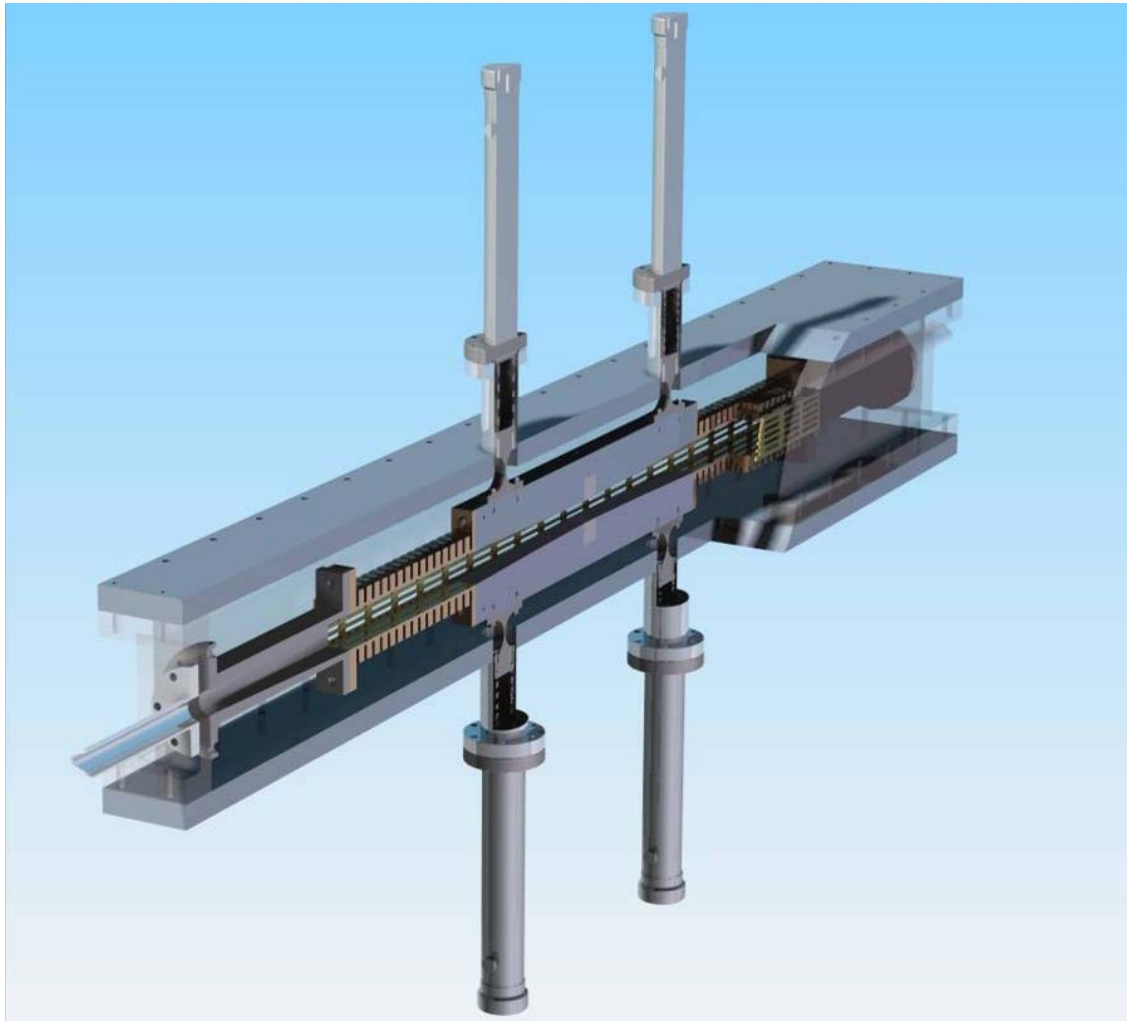
Spoiler designs and beam damage tests

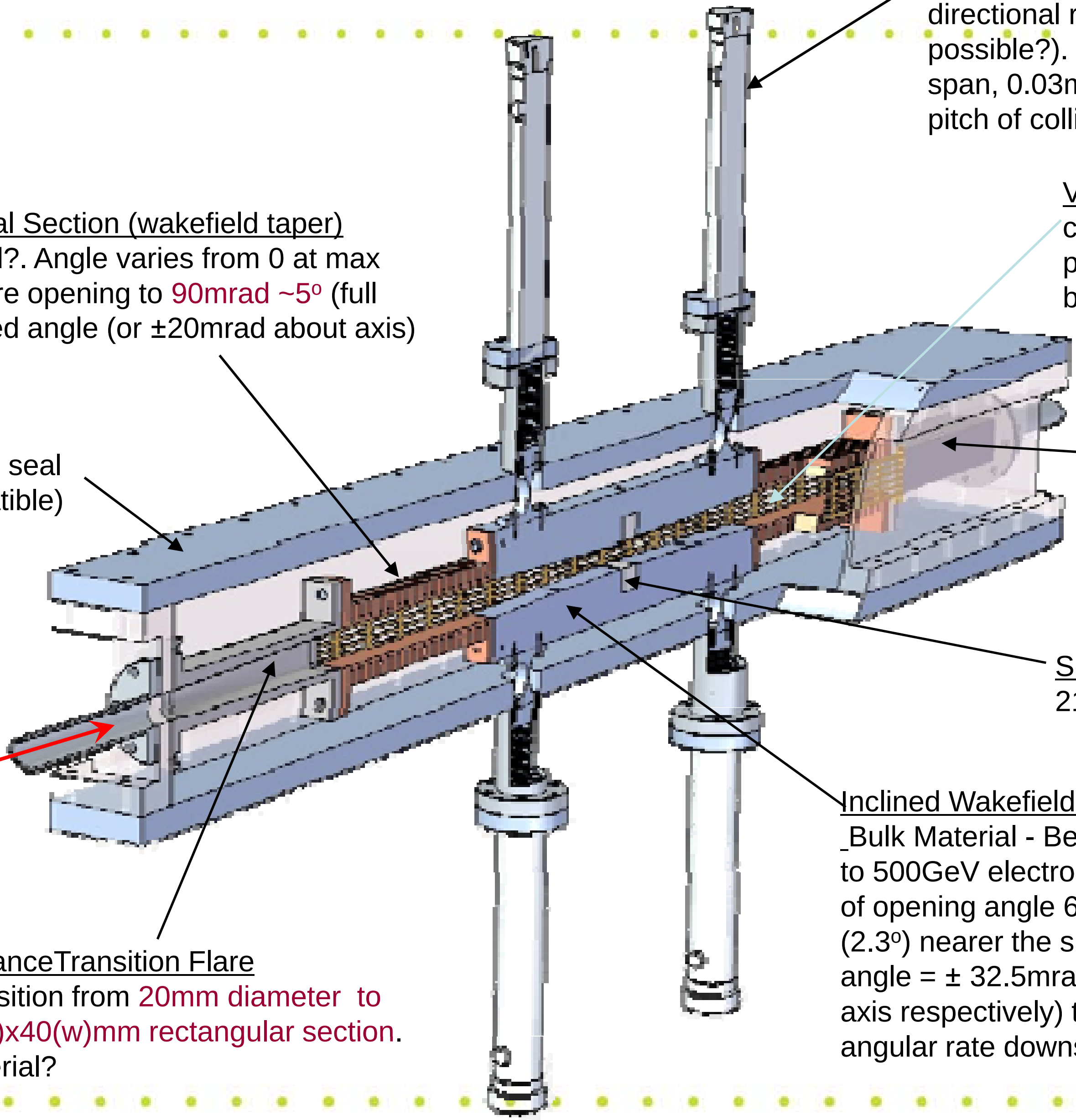
T480 calculations – see
https://twiki.cern.ch/twiki/bin/view/ILCBDSColl/T480Calcs

- Spoiler designs for ILC (details for info.)
- Damage tests at ATF/ATF2



ILC–Collimator Initial Design Scheme

Simon Appleton/Barry Fell et al., May 08 – See EPAC'08



Precision encoded actuators with bi directional repeatability to <10µm (<5µm possible?). Note with 10µm over 300mm span, 0.03mrad angle control is possible on pitch of collimator surfaces

Vented Side Grill for Wakefield continuity. Slot Sizes permitted/ gaps permitted between driven collimators?

Flexural Section (wakefield taper)
Cooled?. Angle varies from 0 at max aperture opening to 90mrad ~5° (full included angle (or ±20mrad about axis)

Vessel (wire seal UHV compatible)

Cooled !?
Exit Transition Flare
Flange Material?

Beam

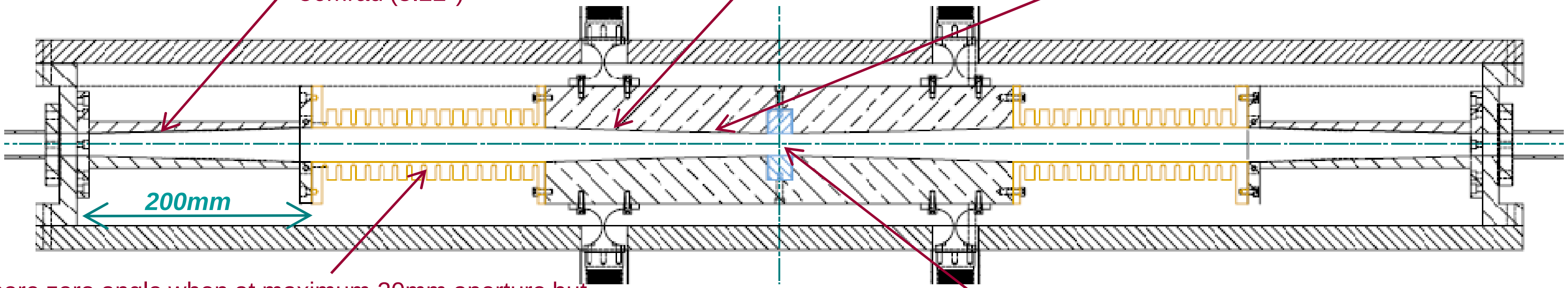
Spoiler Block
21mm width Titanium

Inclined Wakefield Collimator Block
Bulk Material - Beryllium? Semi-transparent to 500GeV electrons. Converging in 2 steps of opening angle 65mrad (3.7°) & 40mrad (2.3°) nearer the spoiler block (note: opening angle = ± 32.5mrad & ±20mrad about central axis respectively) then diverges at same angular rate downstream of the spoiler block

From 20mm diam pipe

EntranceTransition Flare
Transition from 20mm diameter to 30(h)x40(w)mm rectangular section. Material?

Side Cross-Section Through Beam Centre Line



DESIGN NOTES & SPECIFICATION FOR CONCEPT COLLIMATOR DESIGN

1. Generic type motorised linear actuator shown which operates through vacuum bellows. Requires specification to permit bi-directional repeatability of < 10microns, with resolution 1 micron. The final design shall ensure that changes in air pressure of 5% should not produce motion more than the repeatability. The chamber lids should also be of appropriate thickness (or ribbed) to ensure mechanical stiffness greater than this.

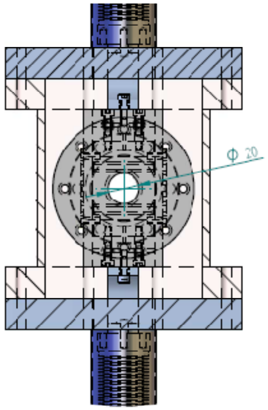
Advantages of this design are (1) encoders and motors can be placed well out of the plane of maximum radiation environment & can be further protected by shielding external to the vacuum environment & (2) are easily accessible for maintenance and/or replacement. An external linear encoder coupled to the direct motion of the drive should be fitted in addition to the motor encoder to produce absolute referenceable motion position. It is also possible that a radiation protected and/or hardened encoder device could be fitted inside the UHV environment to encode the motion closer to the actual spoiler position. This would also provide a redundancy check. Externally precision limit switches and possibly a laser level could also be fitted to monitor angular difference (as a function of differential motion between up and downstream actuators). Note that the design has flexural pivot points to allow a certain degree of differential motion between actuators so that the collimators can be changed in pitch angle w.r.t. beam axis.

2. Tapered angle shown in radians at various stages along the collimator. The collimator is shown in maximum aperture only. Drawing 228-10001 shows collimator cross sections at different openings.

3. No cooling routes are shown. It is envisaged that the spoiler will stop 10Watts of power but the colliator blocks, flexibles and flared aperture downstream of the spoiler could potentially absorb kilowatts of high energy particle and X-ray/Gamma ray power. Small bore stainless steel (or OFHC Cu) piping should be brazed to these components. The exact sizing, distribution and pattern of the cooling tubes should be assessed after (1) radiation deposition analysis (eg. FLUKA) has been undertaken, followed by (2) thermo-mechanical analysis (FEA)

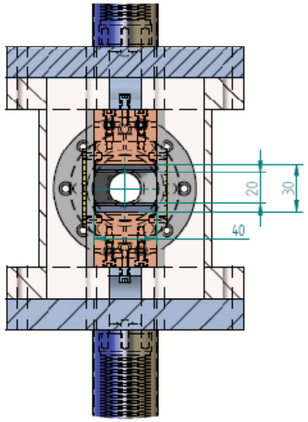
Operational Overview

Front Elevation (Along Beam) & Plan View



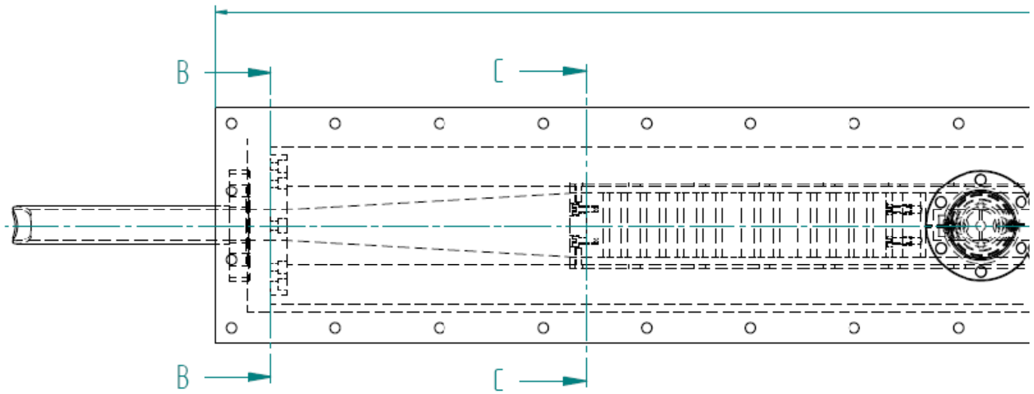
SECTION B-B

View at circular entrance to flared transition

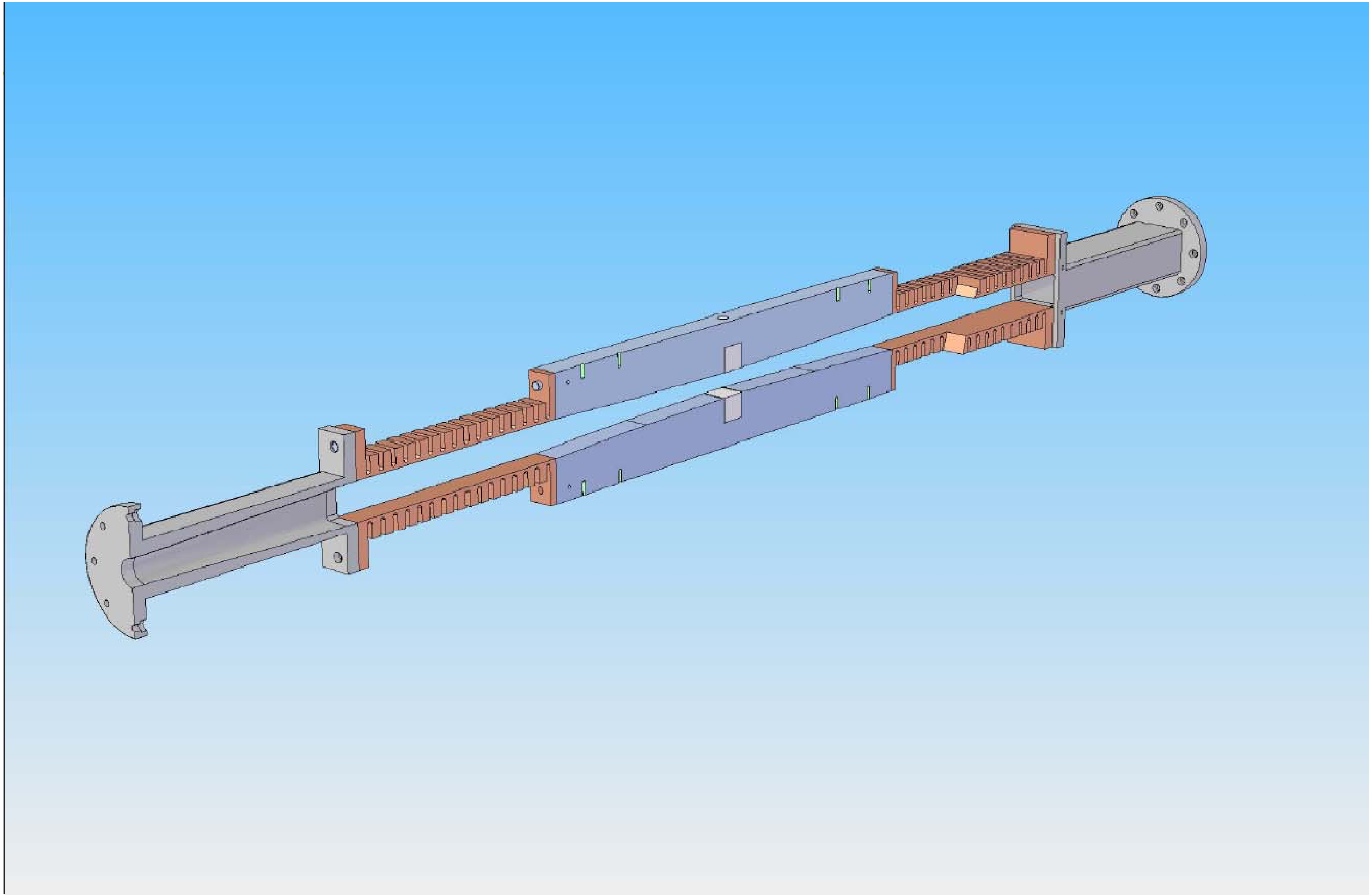


SECTION C-C

View at rectangular exit from flared transition



Plan View



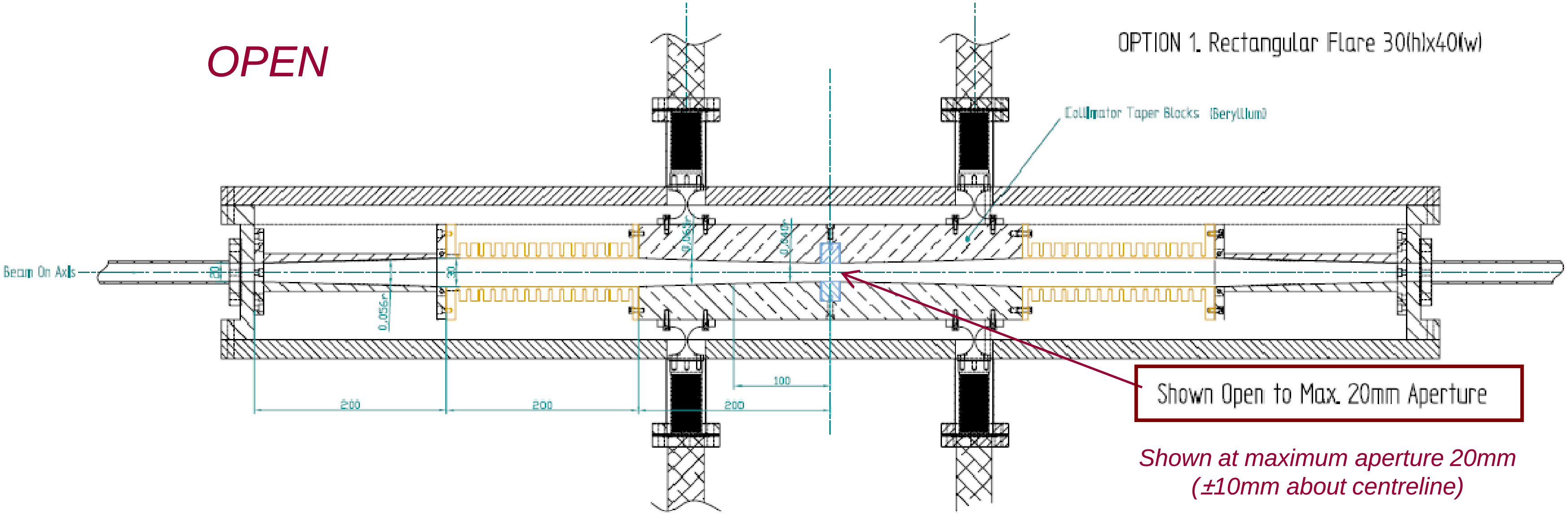
3D ‘Strip Down’ Views

Click to disassemble

OPTION 1

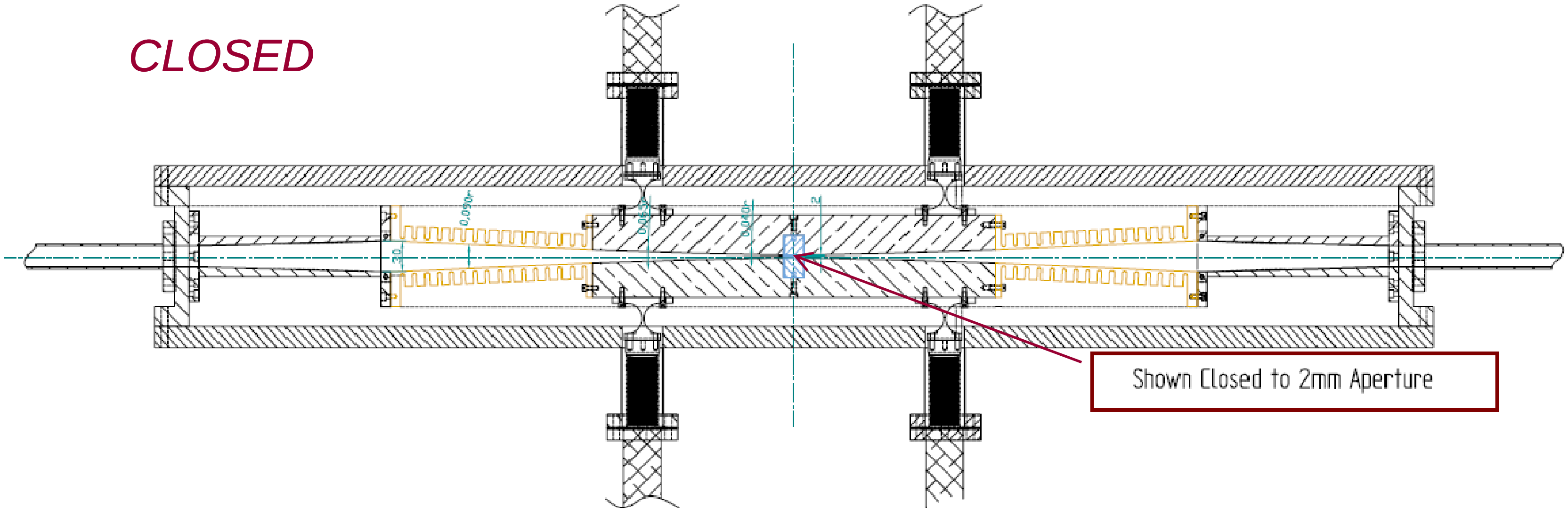
Shown at maximum & closed apertures

OPEN

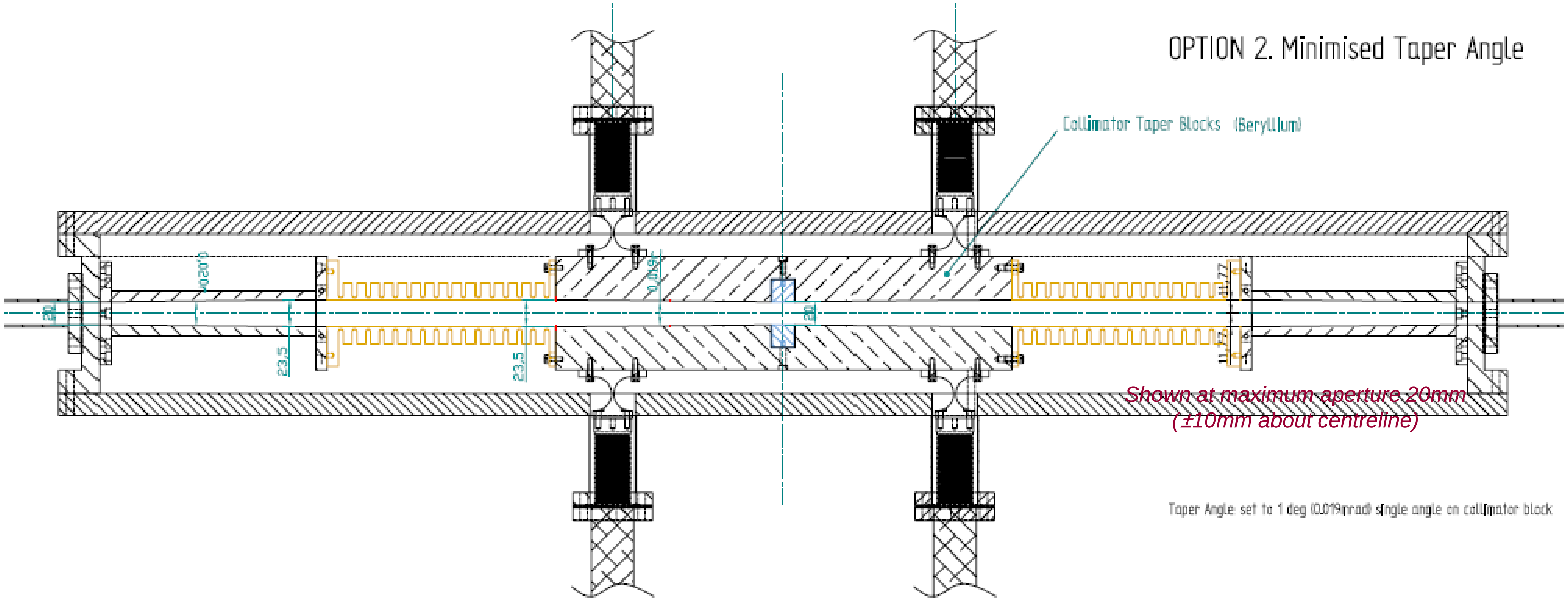


Shown at maximum aperture 20mm (±10mm about centreline)

CLOSED



OPTION 2

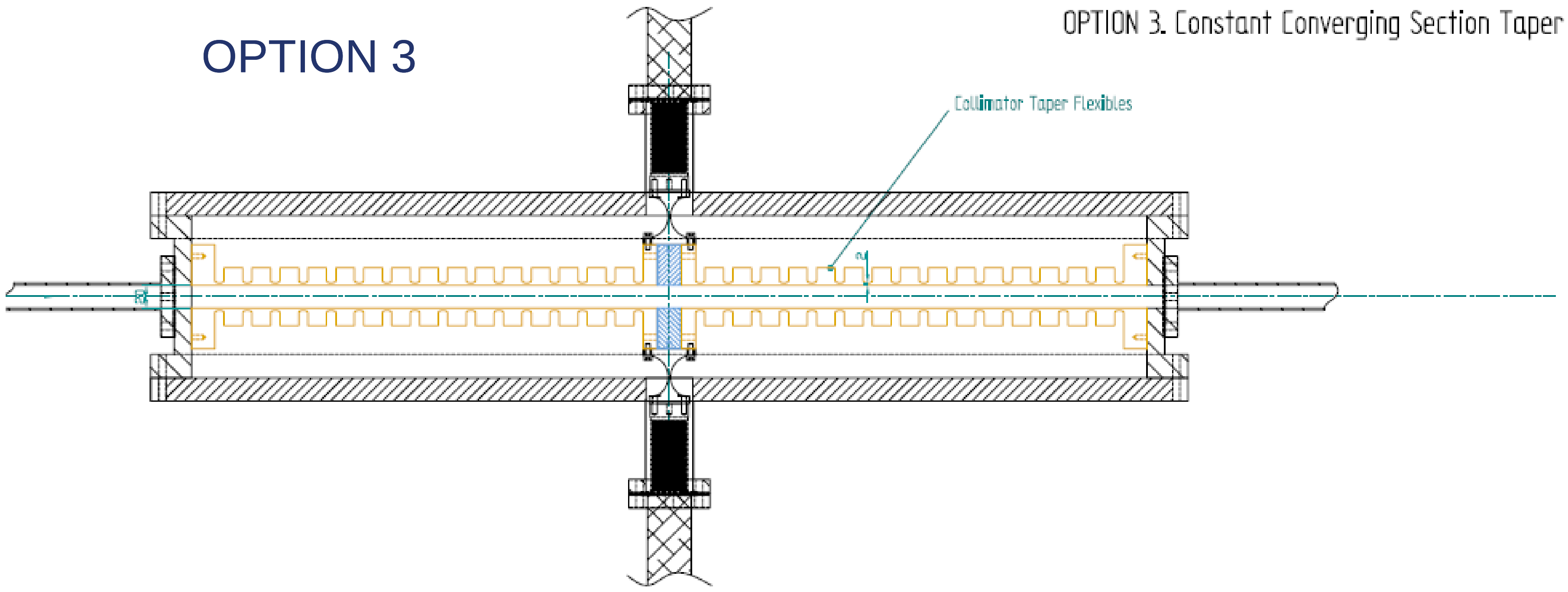


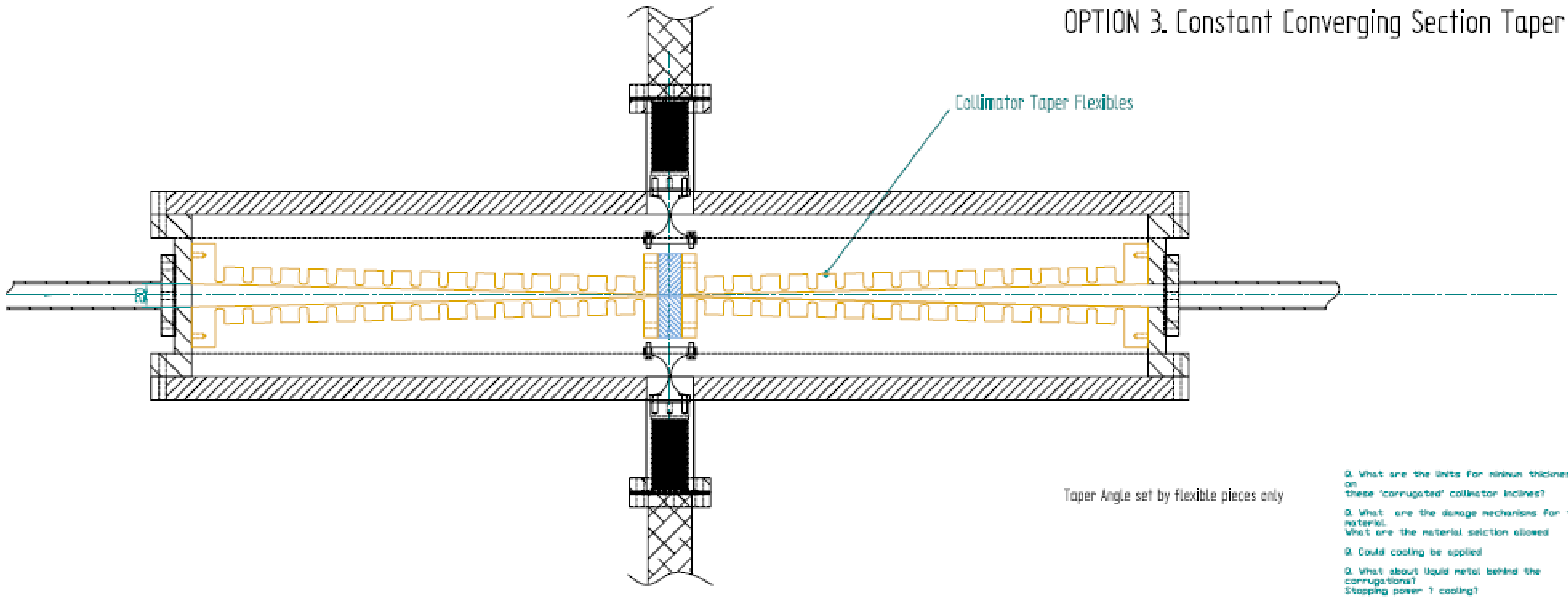
DESIGN NOTES FOR OPTION 2- MINIMISED TAPER DESIGN

If a single (i.e. not 2 step) and shallower opening angle on the collimator blocks of only 19mrad (~1°) is employed, the opening at the entrance of the block is now only 23.5mm – just 3.5mm larger than the maximum aperture. This may be useful in reducing further possibility of disruptive 'cavity modes' occuring due to diverge/converge section from the entrance flare to the collimator section

Furthermore, in an extension of this concept, if the maximum collimator aperture could be agreed as 16.5mm (reduced from current 20mm), then the diverging flare section could be removed with altogether in the vertical at least.

OPTION 3





Taper Angle set by flexible pieces only

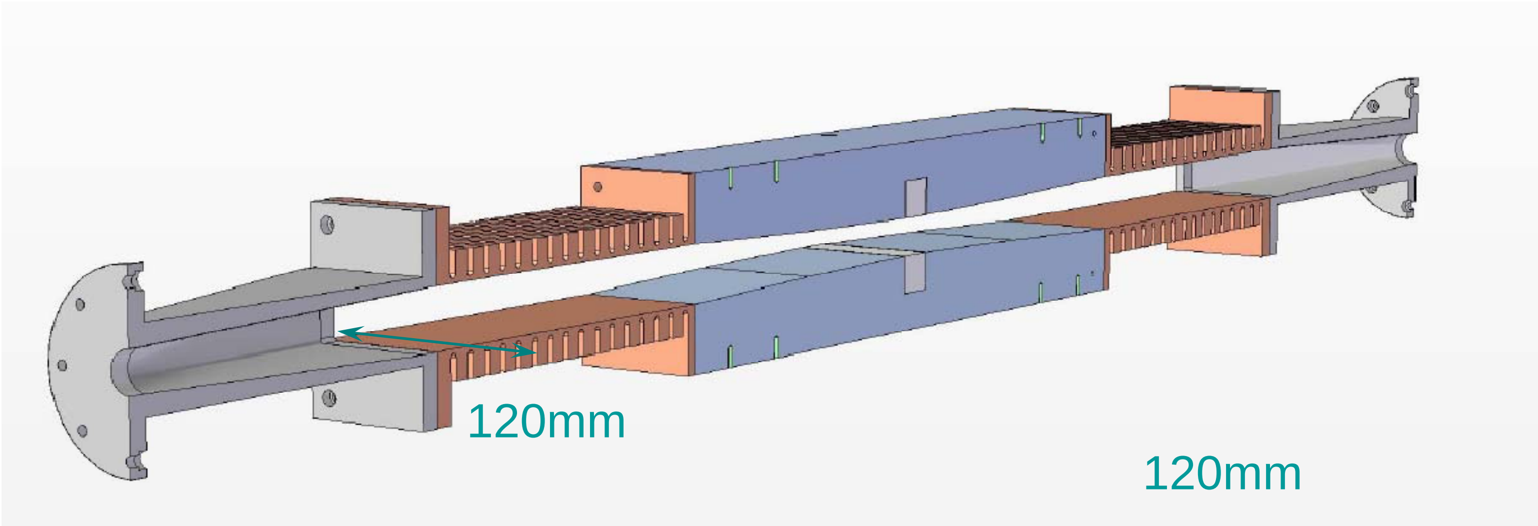
Q. What are the limits for minimum thickness on
these 'corrugated' collimator inclines?

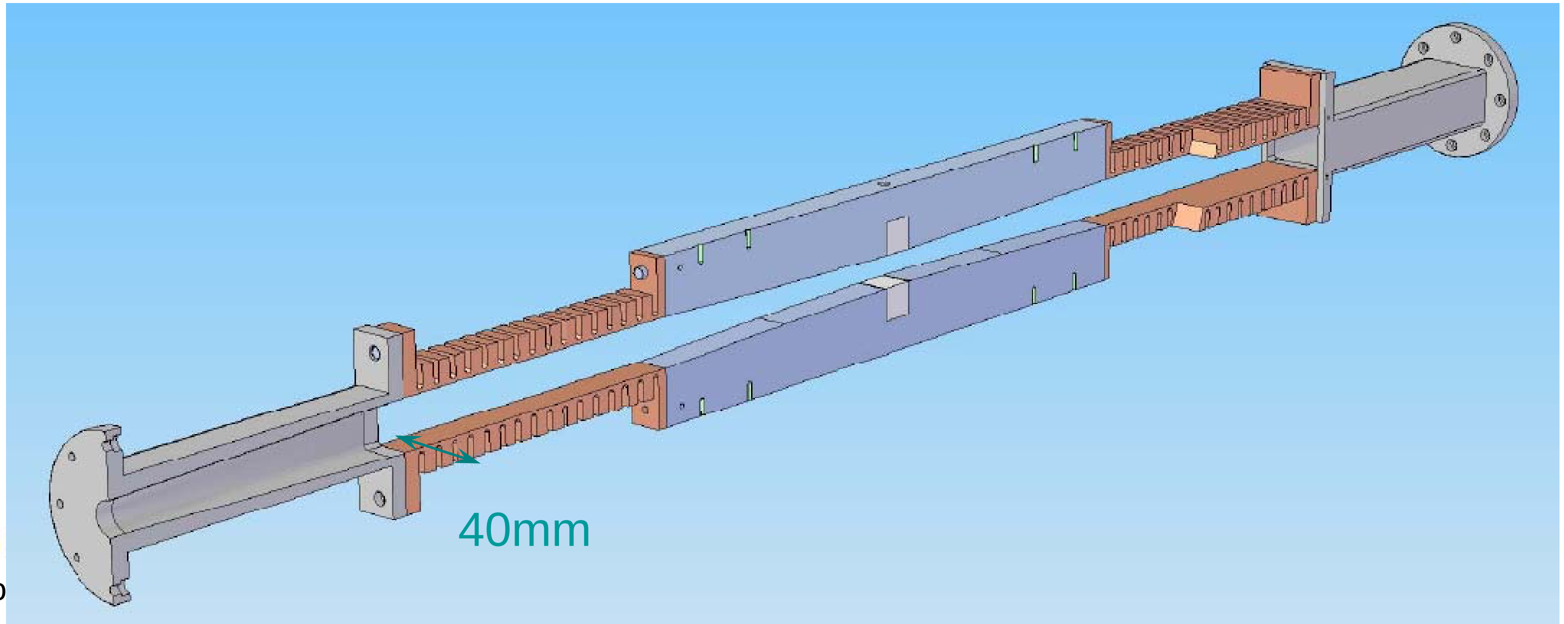
Q. What are the damage mechanisms for thin material.
What are the material selection allowed

Q. Could cooling be applied

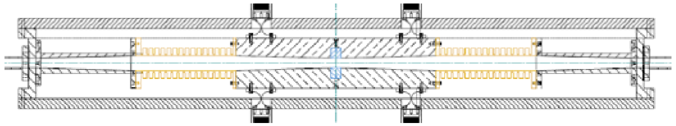
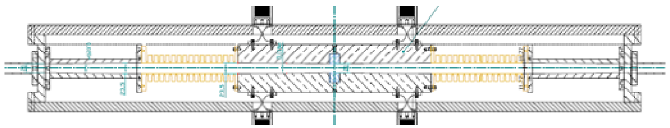
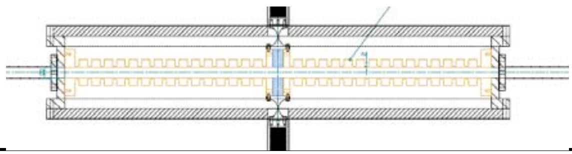
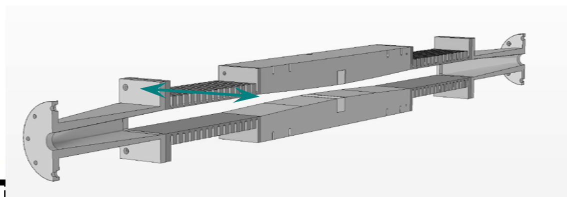
Q. What about liquid metal behind the corrugations?
Stopping power ? cooling?

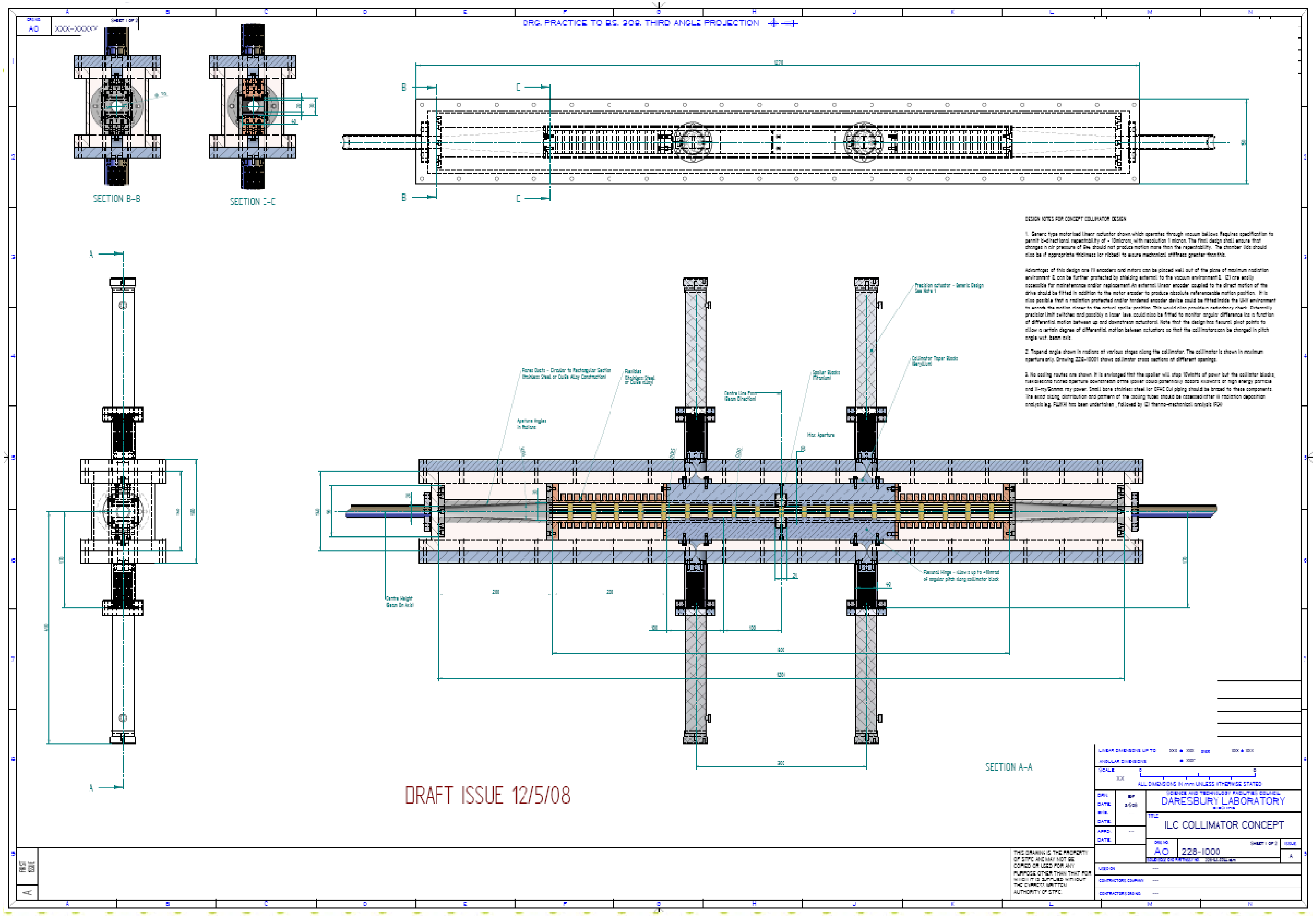
OPTION 4





OPTION & FILE ACCESS SUMMARY
(15 May 08)

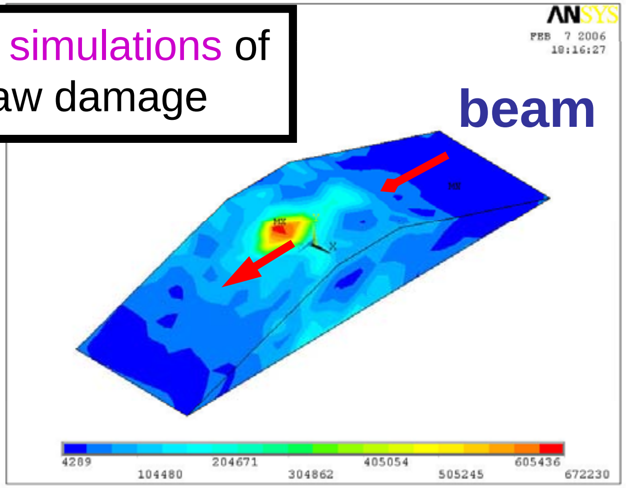
Option	Note	File Reference
	1. ‘Default’ design proposal - 20mm diamter circular croos-section flares into 30x40mm rectangular section (over 200mm length) thentapered collimator (2 step angle with minimum)	***Drawing:* 228-10000** ***Project Drawing:* ilc-coll-meng-dwg-0003** folder containing following STL files ***STL1*** *option 1 model with grill in place (filename:* ***228-10000-STL1 [15-5-08].stl)*** ***STL2*** *as above model with grill holes removed (filename:* ***228-10000-STL2 [15-5-08].stl****)* ***STL3*** *as above with no grill plate (filename:* ***228-10000-STL3 [15-5-08].stl****)*
	2.	***Project Drawing:* ilc-coll-meng-dwg-0002v1** contains 2D view of this concept No 3D CAD model or STL file generated (as of 15 May 08)
		***Project Drawing:* ilc-coll-meng-dwg-0002v1** contains 2D view of this concept No 3D CAD model or STL file generated (as of 15 May 08)
		***Project Drawing:* ilc-coll-meng-dwg-0004** folder containing following STL files ***STL4*** *as per STL3 model but with aperture wdith 1290mm instead of 40mm (filename:* ***28-10000-STL4 [15-5-08].stl****)*

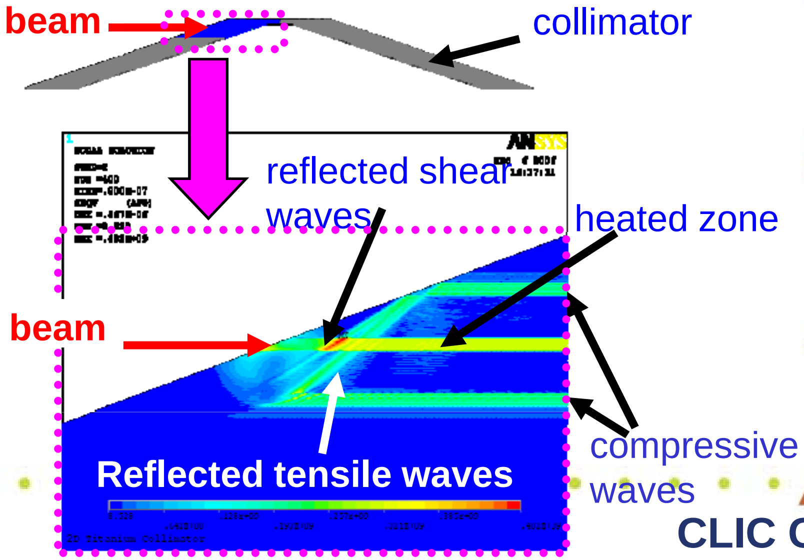

DRG. PRACTICE TO BS. 308. THIRD ANGLE PROJECTION
SECTION B-B
SECTION C-C
SECTION A-A
DRAFT ISSUE 12/5/08
DARESBURY LABORATORY
ILC COLLIMATOR CONCEPT
A0
228-1000

Summary of motivating simulations

Wakefields, **survivability**. Strong collaboration between SLAC and EUROTeV groups.

Detailed simulations of spoiler jaw damage

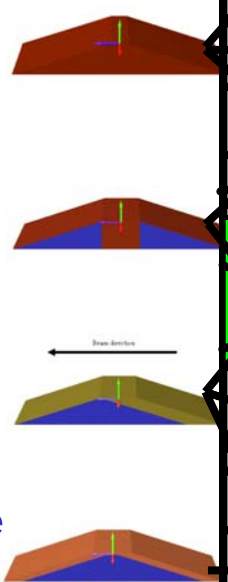




Temperature increase from 1 bunch impact

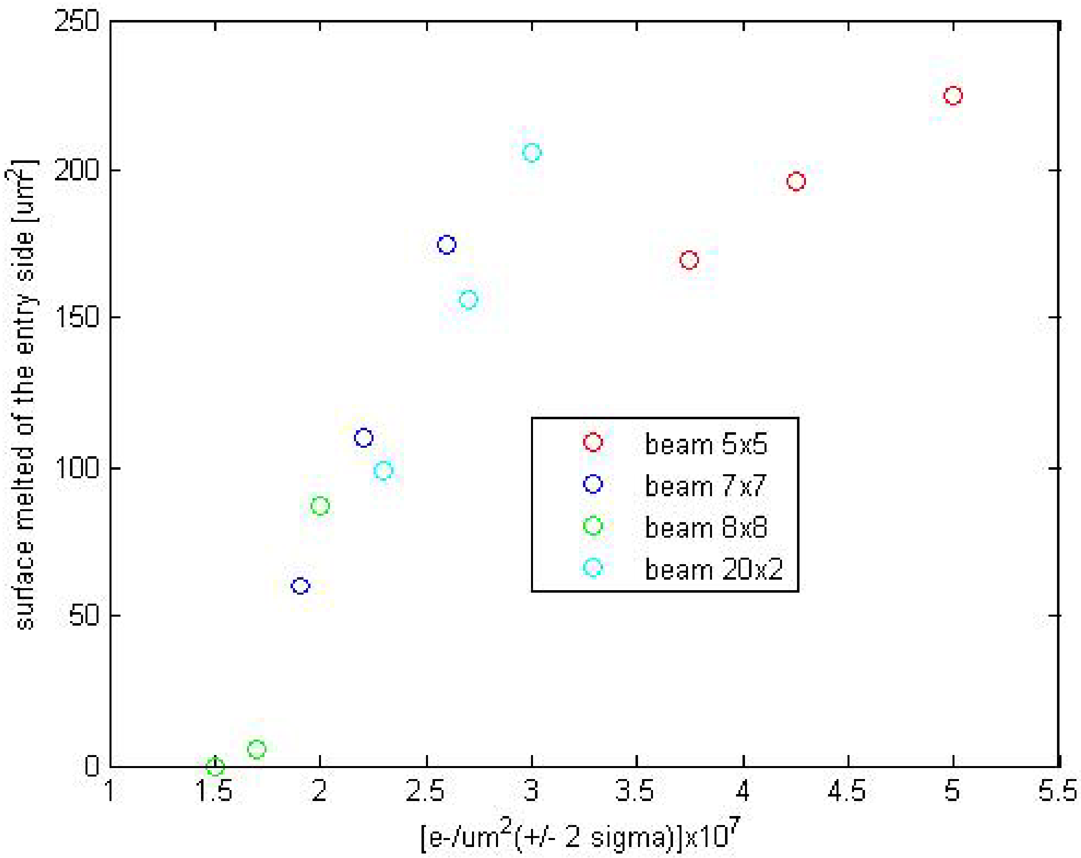
Exceeds: fracture temp. melting temp.

Best candidate designs



	2mm depth		10mm depth	
	250GeV $111\times9\ \mu m^2$	500 GeV $80\times6\ \mu m^2$	250 GeV $111\times9\ \mu m^2$	500 GeV $80\times6\ \mu m^2$
Ti	420 K	870 K	850 K	2000 K
Al	200 K	210 K	265 K	595 K
Cu	1300 K	2700 K	2800 K	7000 K
C+Ti	325 K	640 K	380 K	760 K
Be+Ti	-	-	-	675 K
C+Ti	290 K	575 K	295 K	580 K
C+Al	170 K	350 K	175 K	370 K
C+Cu	465 K	860 K	440 K	870 K
C+Ti	300 K	580 K	370 K	760 K

Summary of tests at ATF/ATF2

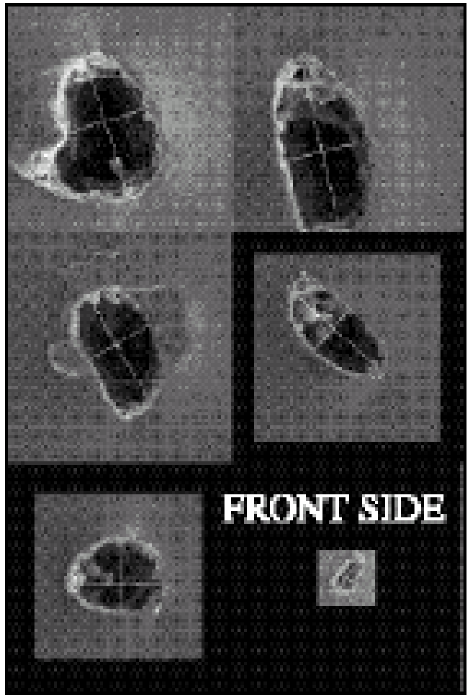


- 1st run at ATF, March 2008
- Measure size of the damage region after individual beam impacts on the collimator test piece.
- Commission the proposed test system of vacuum vessel, multi-axis mover, beam position and size monitoring.
- Validate single bunch mode of operation required for ATF
- Ensure that the radiation protection requirements can be satisfied
- Validation of FLUKA/ANSYS simulations of properties of the materials under test, assuming ATF beam parameters achieved
- 2nd phase:Measure the shock waves within the sample using surface motion via laser-based system, such as VISAR (or LDV), for single bunch, multiple bunches at approximate ILC bunch spacing.
  - **Useful for CLIC given timing?**
  - **1 CLIC train ~ ILC bunch**
- …

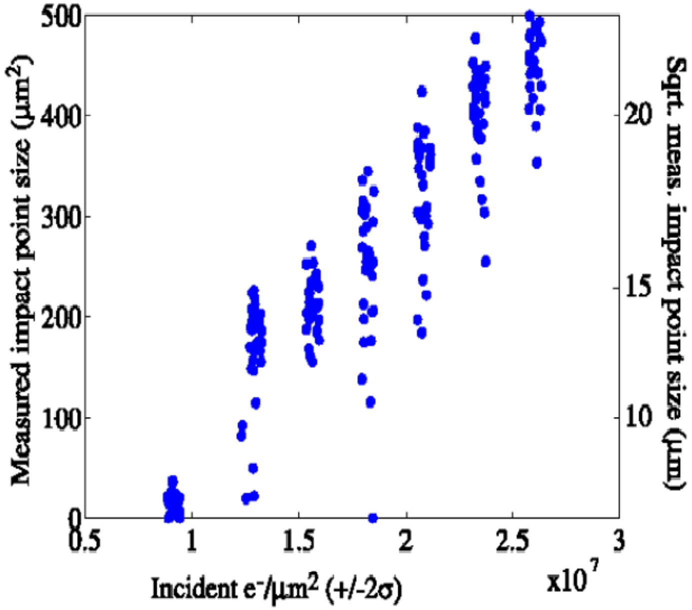
A similar test done in SLAC FFTB gave the results that can be seen in the bottom left plot of this section.

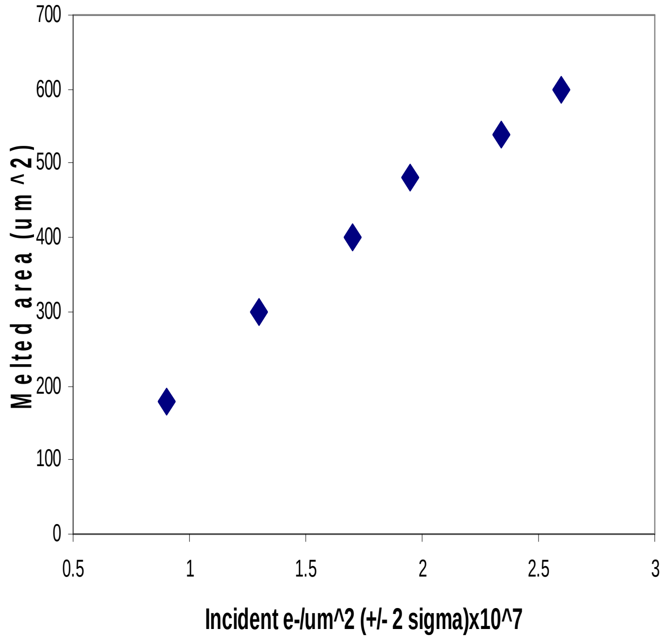
Results of a FLUKA simulation using same beam and target specification can be seen in the bottom right plot of this section.

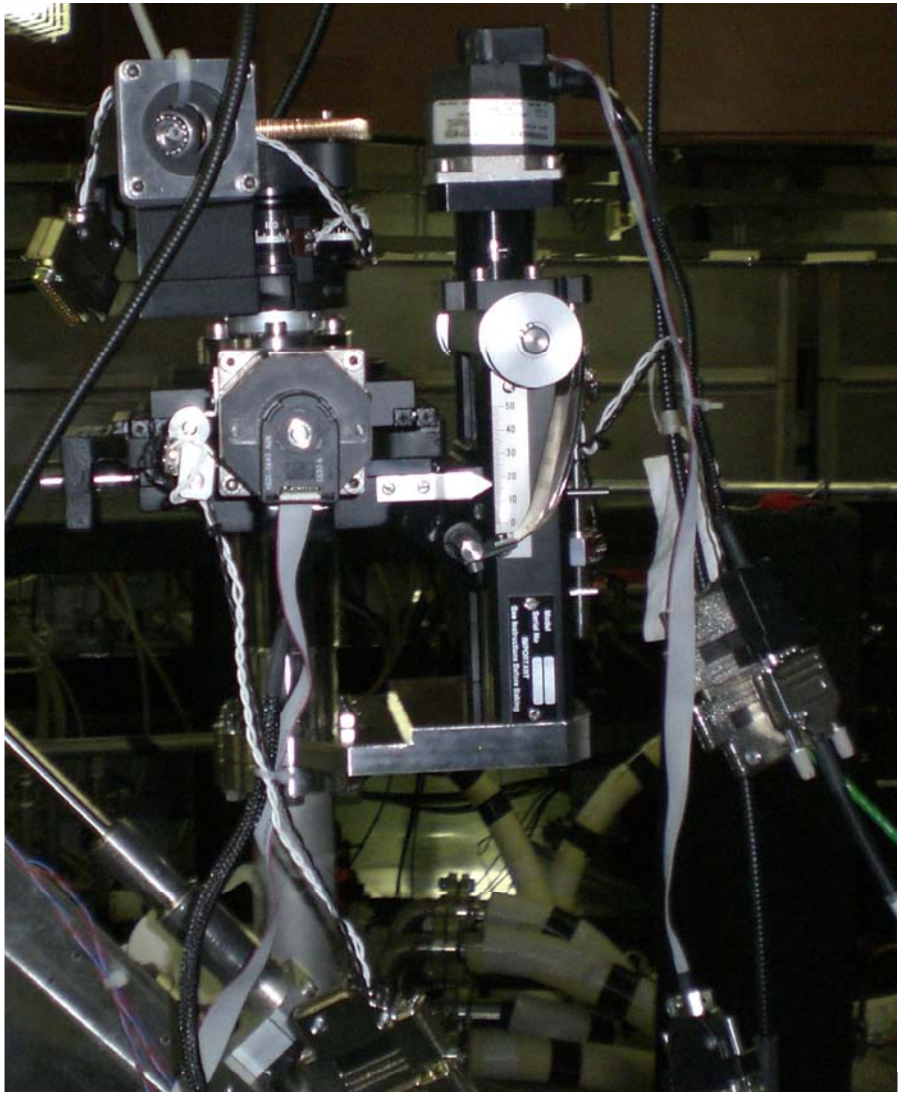
There is a systematic divergence of ~100 μm^2 but both plots agree in the slope.

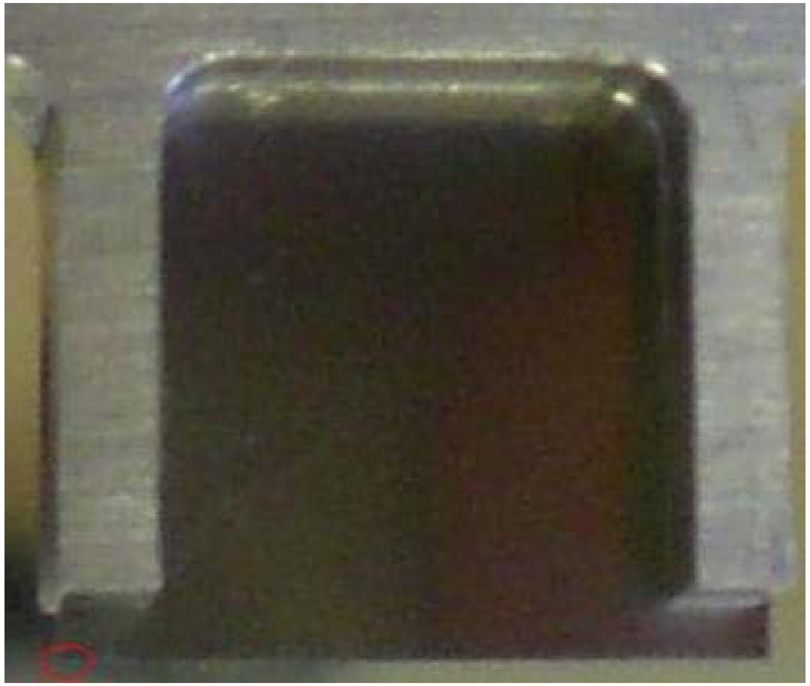


[Measurements c/o Marc Ross et al., Linac’00]





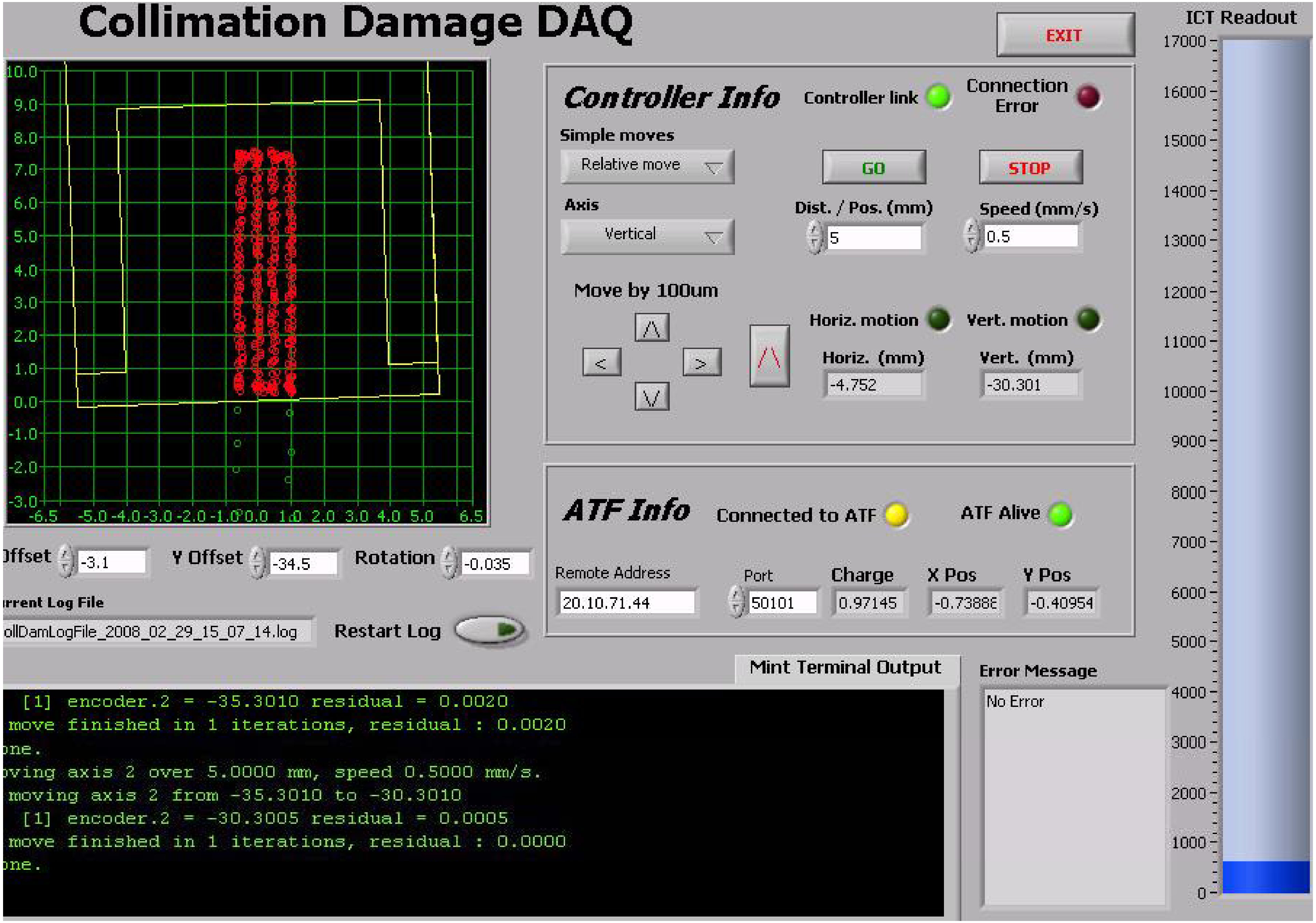




11 mm

ATF experience and commissioning the mover system, beam control and instrumentation.

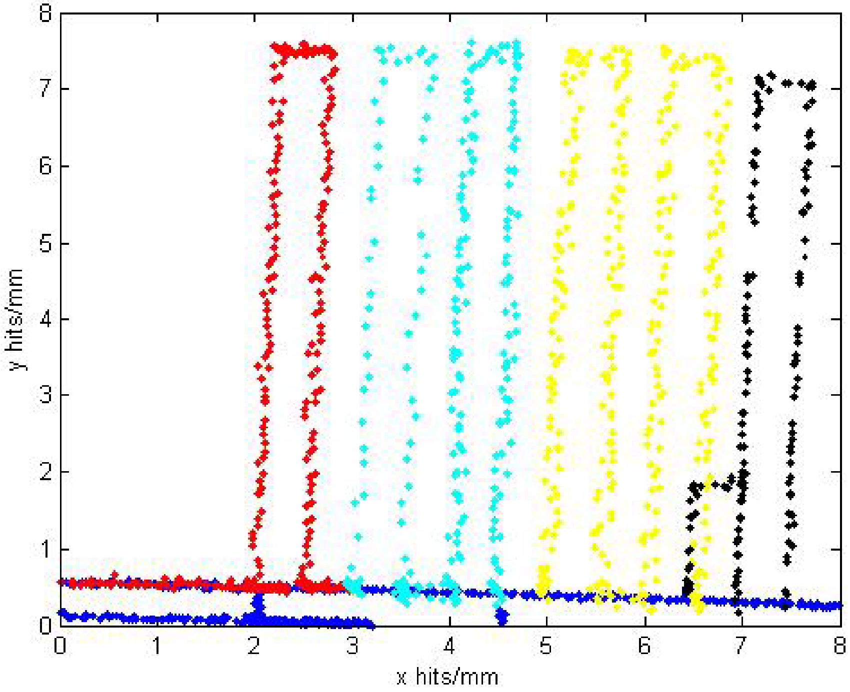
(George Ellwood)



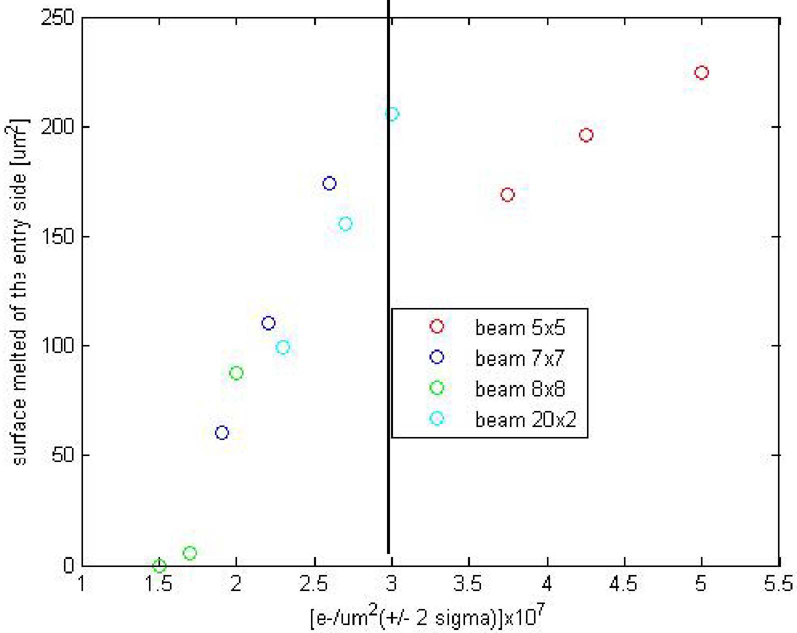
(Bino Maiheu, Mark Slater)

Phase 1 of Damage Test Beams at ATF-KEK

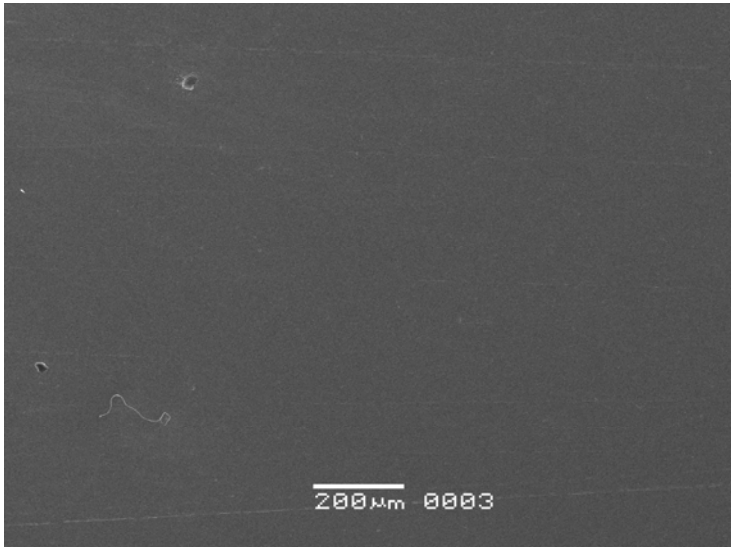
A **Ti alloy target**, same material as spoiler preliminary design, was hit by the **ATF electron beam**, at KEK, the amount of damage (melted surface) will be measured with the help of a SEM and compared to what FLUKA simulations predict.

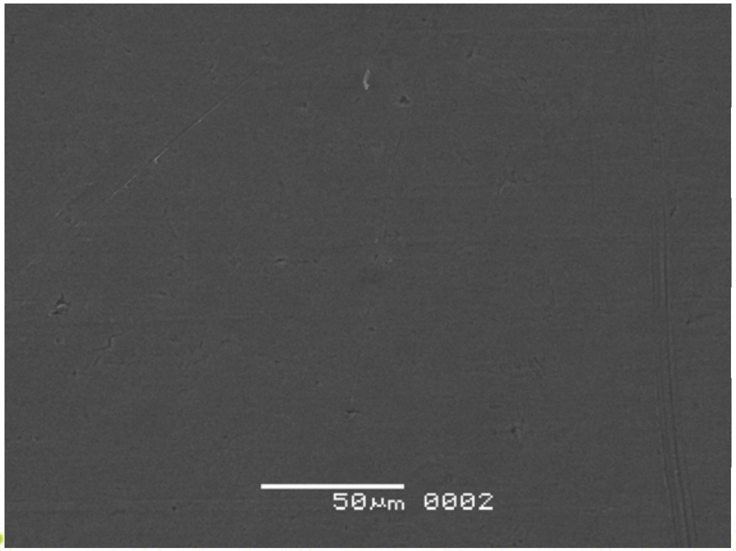


Hits with different beam charges, from 0.8x10^10 to triple bunch hits with a total charge of 3.6x10^10. Calculated beam sizes of 15x2 to 15x5 microns square (James Jones).

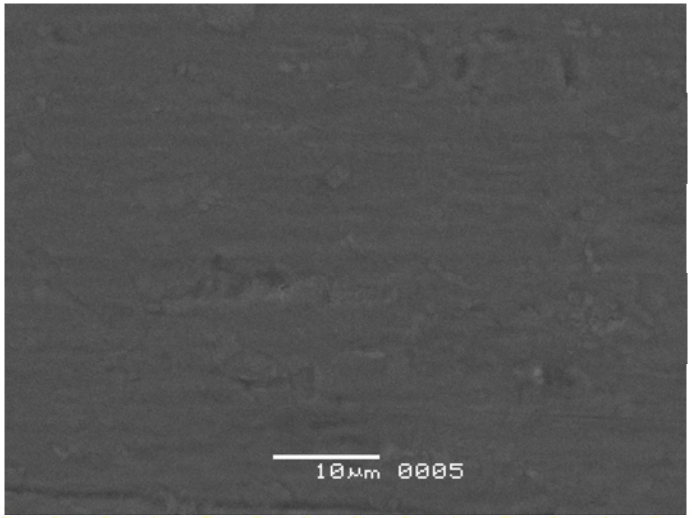


No damage - parameters

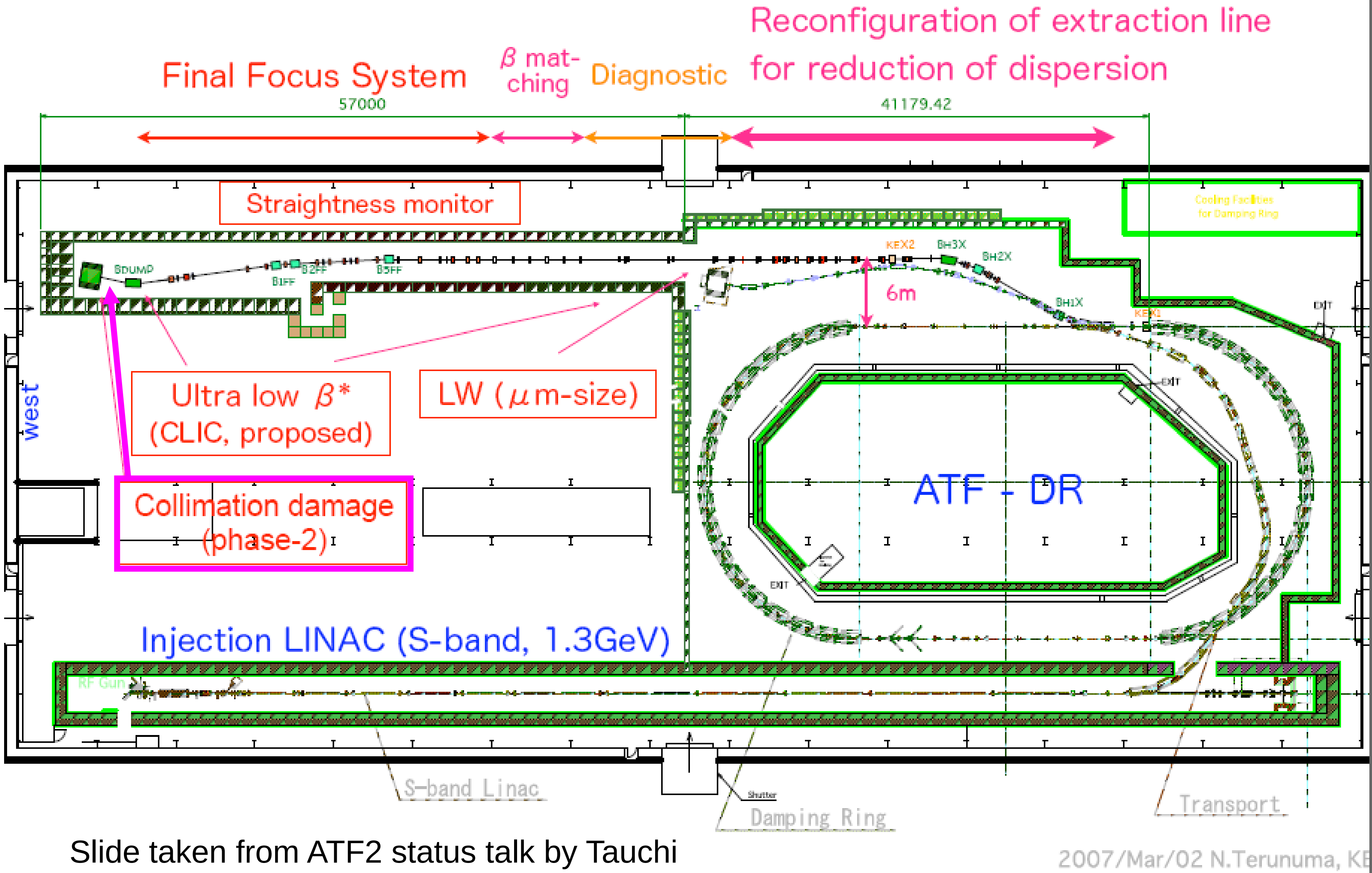




- After looking closely, nothing clearly like damage found
- Parameters of beam achieved not such that we could have expected damage…

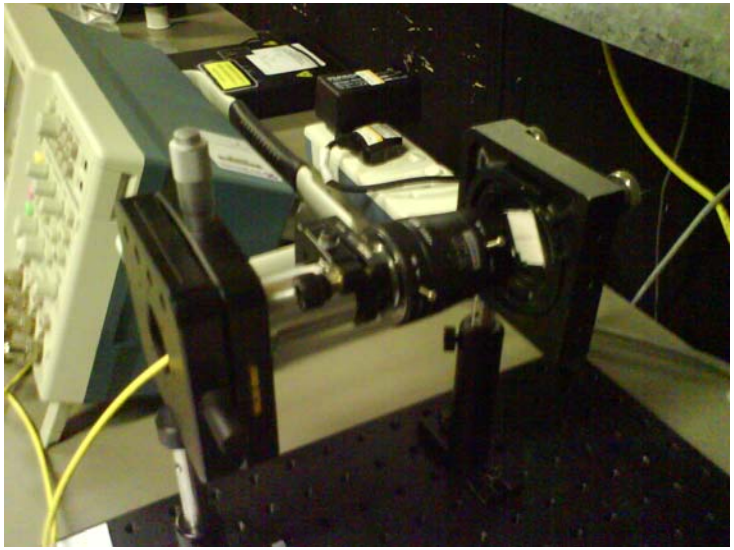


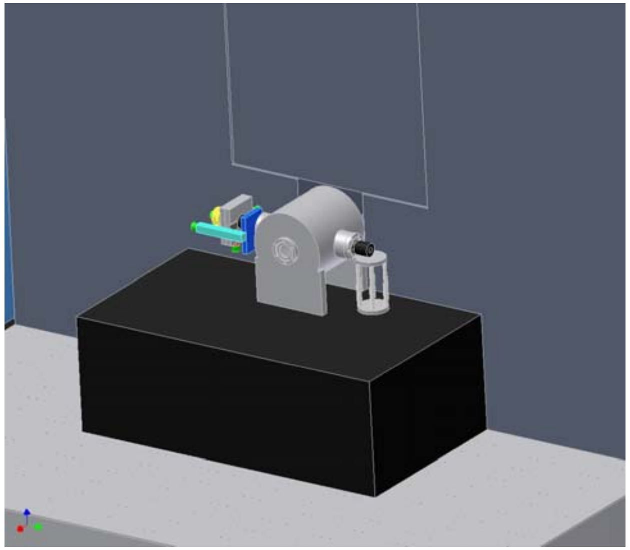
ATF2 beam line

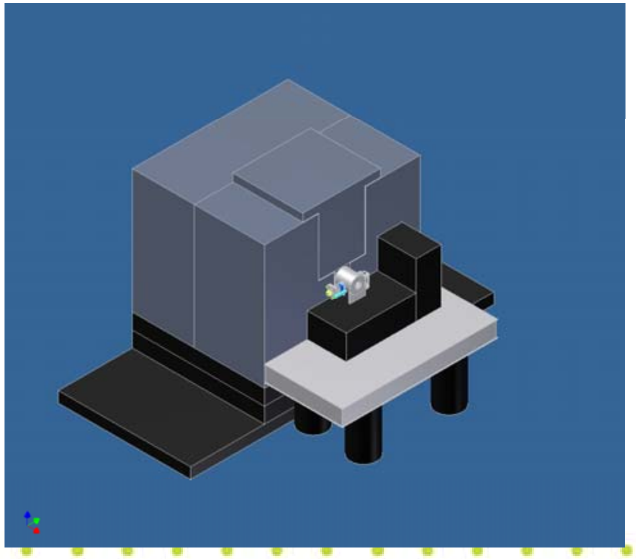


Slide taken from ATF2 status talk by Tauchi

VISAR







Next

- Phase 1 tests: see https://twiki.cern.ch/twiki/bin/view/ILCBDSColl/WebHome
- Assemble test system at RAL
- Feedback of sample movement/laser scan
- Induce small amplitude/high frequency vibrations on sample

- Verify measurement precision/biases
- Investigate impact of surface quality

- Validate ATF2 optics at assigned position in ATF2
- Move experiment to KEK and …