



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

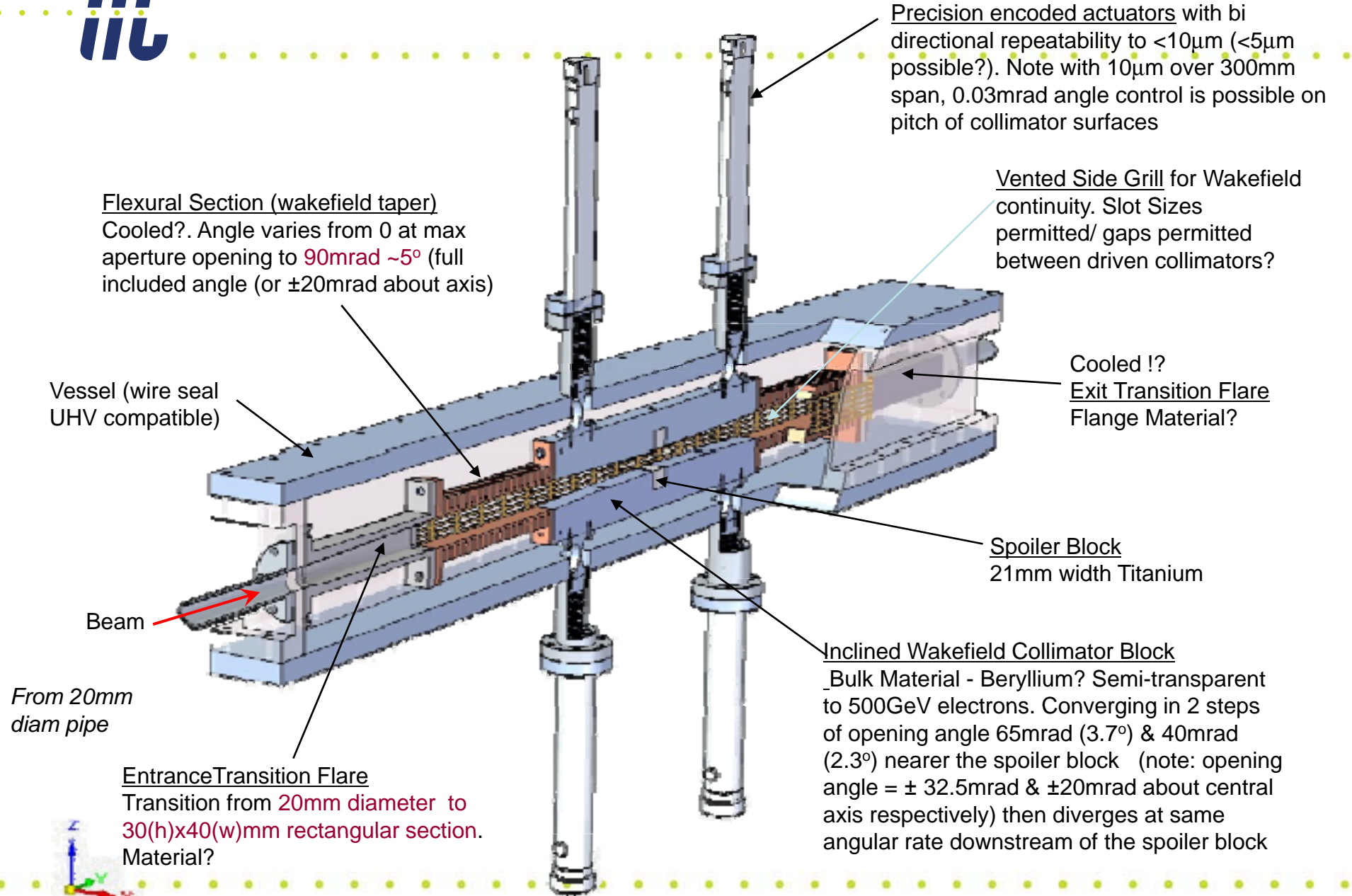


ILC-Collimator Initial Design Scheme

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

Nigel Watson, 15 Jan 2009

CLIC Collimation Meeting



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

Flexural Section (wakefield taper)
Cooled?. Angle varies from 0 at max aperture opening to 90mrad $\sim 5^\circ$ (full included angle (or $\pm 20\text{mrad}$ about axis)

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

Vessel (wire seal UHV compatible)

Cooled !?
Exit Transition Flare
Flange Material?

Beam

Spoiler Block
21mm width Titanium

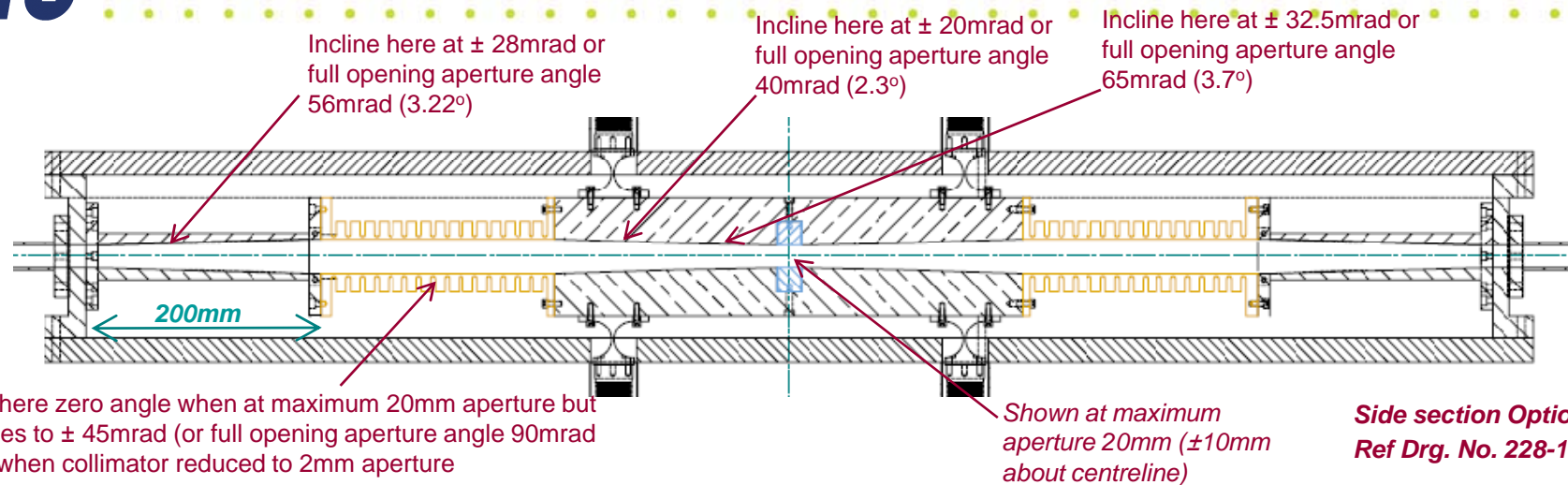
From 20mm diam pipe

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 = $\pm 32.5\text{mrad}$ & $\pm 20\text{mrad}$ about central axis respectively) then diverges at same angular rate downstream of the spoiler block

Entrance Transition Flare
Transition from 20mm diameter to $30(\text{h})\times 40(\text{w})\text{mm}$ rectangular section. Material?



Nigel Watson, 15 Jan 2009



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 $< 10\text{microns}$, 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.

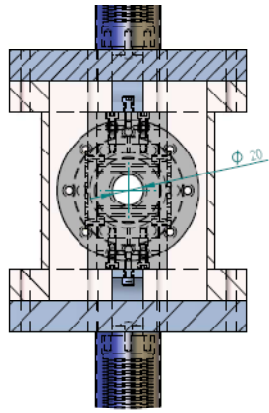
Advantages of this design are (1) encoders and motors can be placed well out of the plane of maximum radiation environment & can be further protected by shielding external to the vacuum environment & (2) are easily accessible for maintenance and/or replacement. An external linear encoder coupled to the 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 collimator 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)

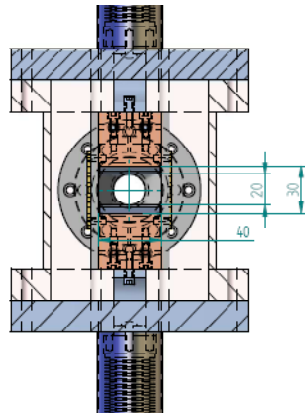
Operational Overview

Front Elevation (Along Beam) & Plan View



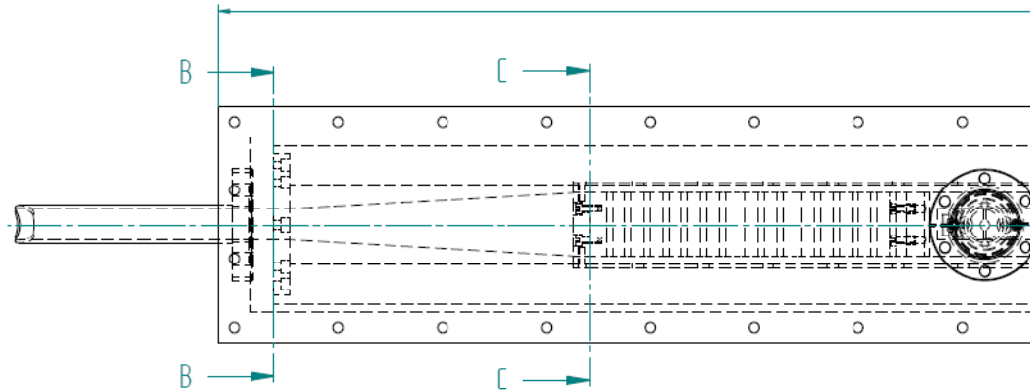
SECTION B-B

View at circular entrance
to flared transition

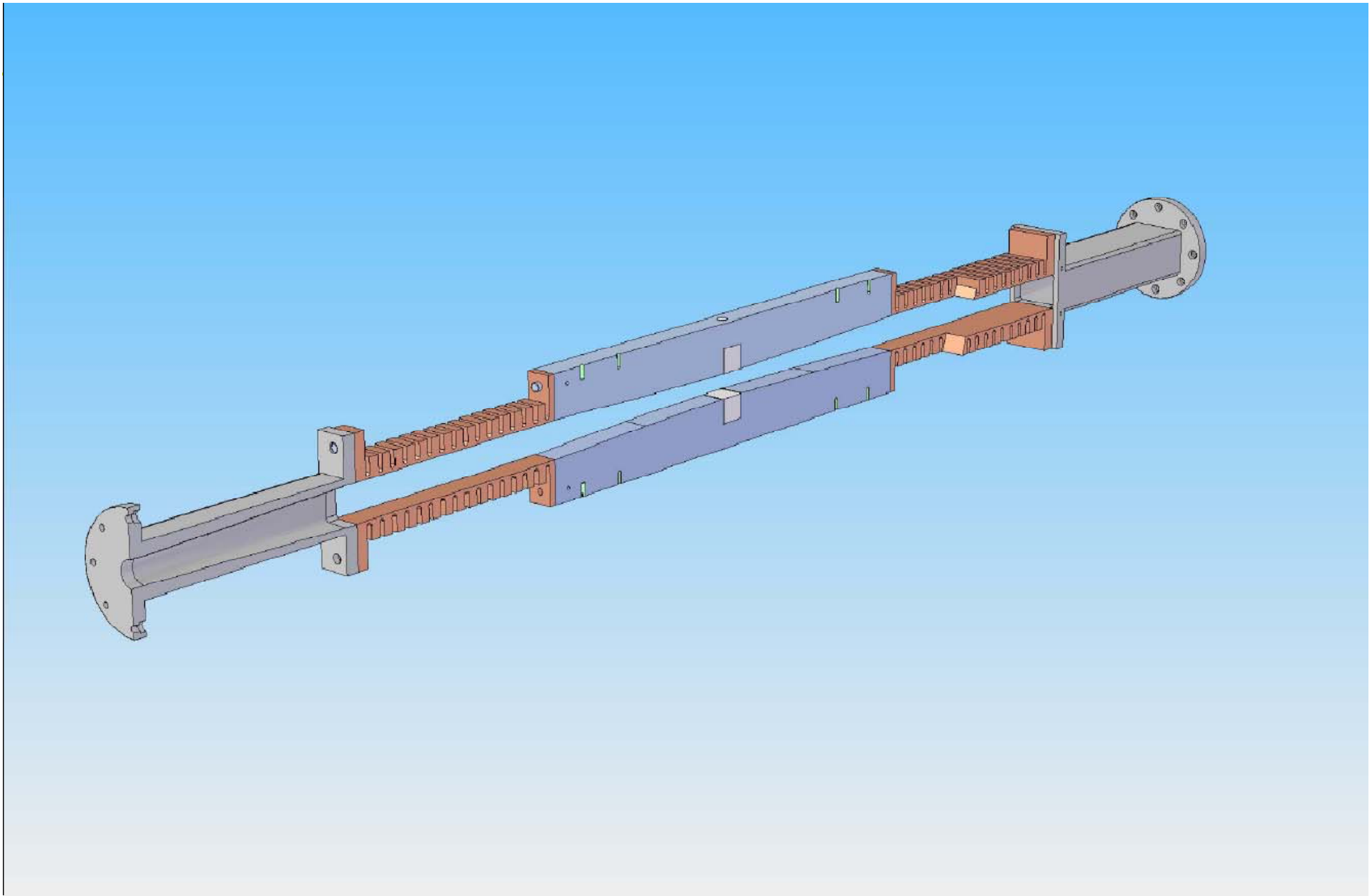


SECTION C-C

View at rectangular exit
from flared transition



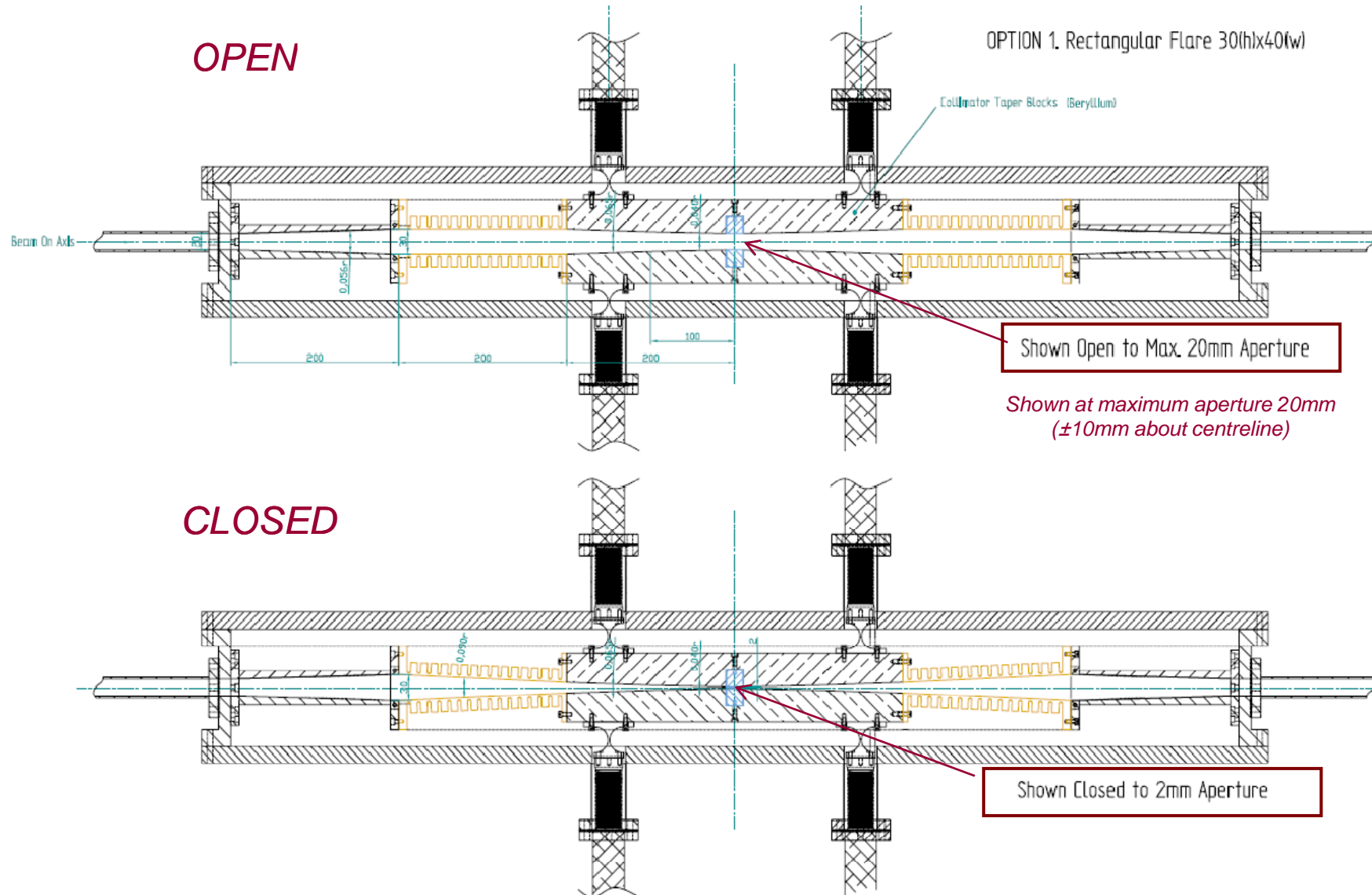
Plan View

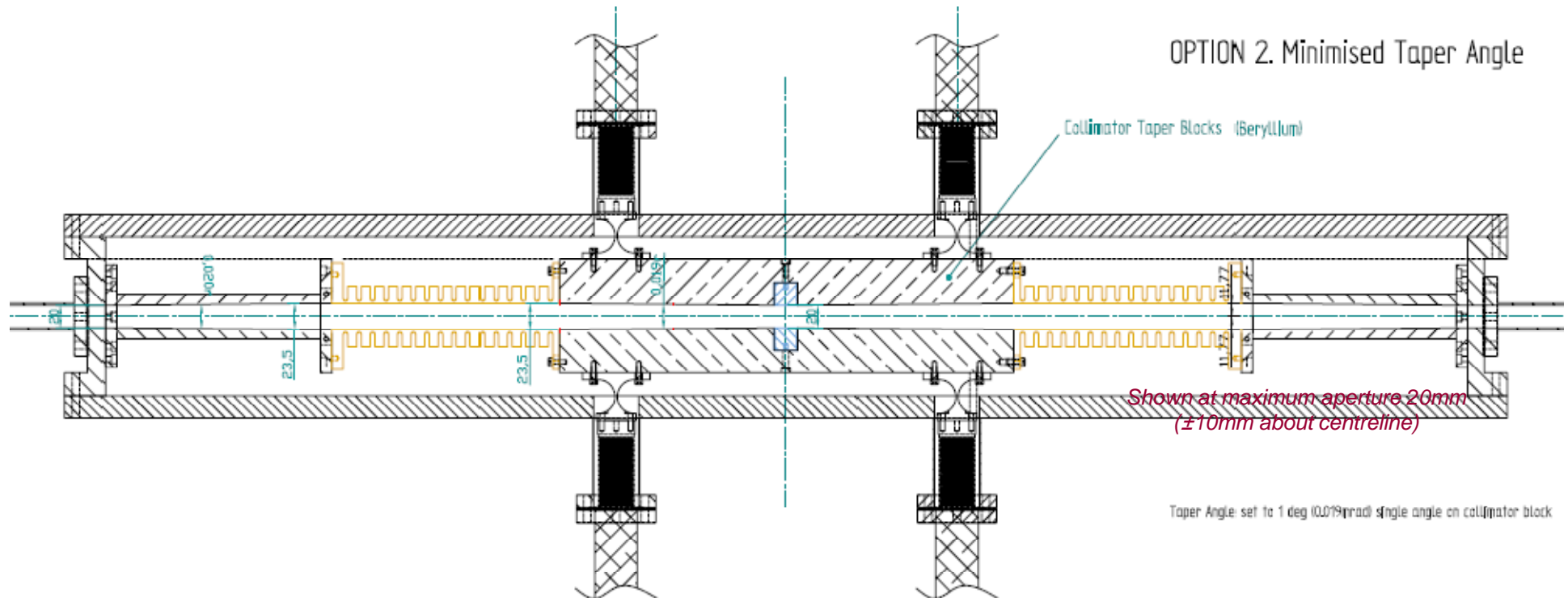




OPTION 1

Shown at maximum & closed apertures





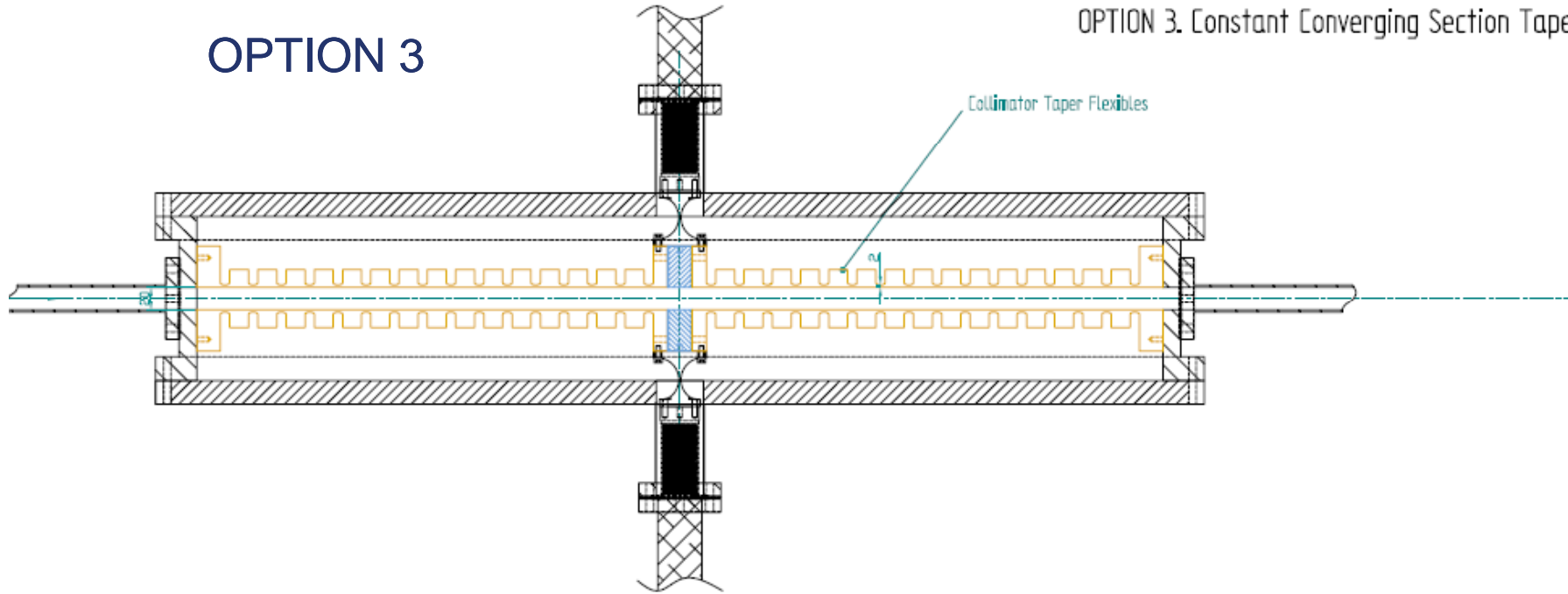
DESIGN NOTES FOR OPTION 2- MINIMISED TAPER DESIGN

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’ occurring due to diverge/converge section from the entrance flare to the collimator section

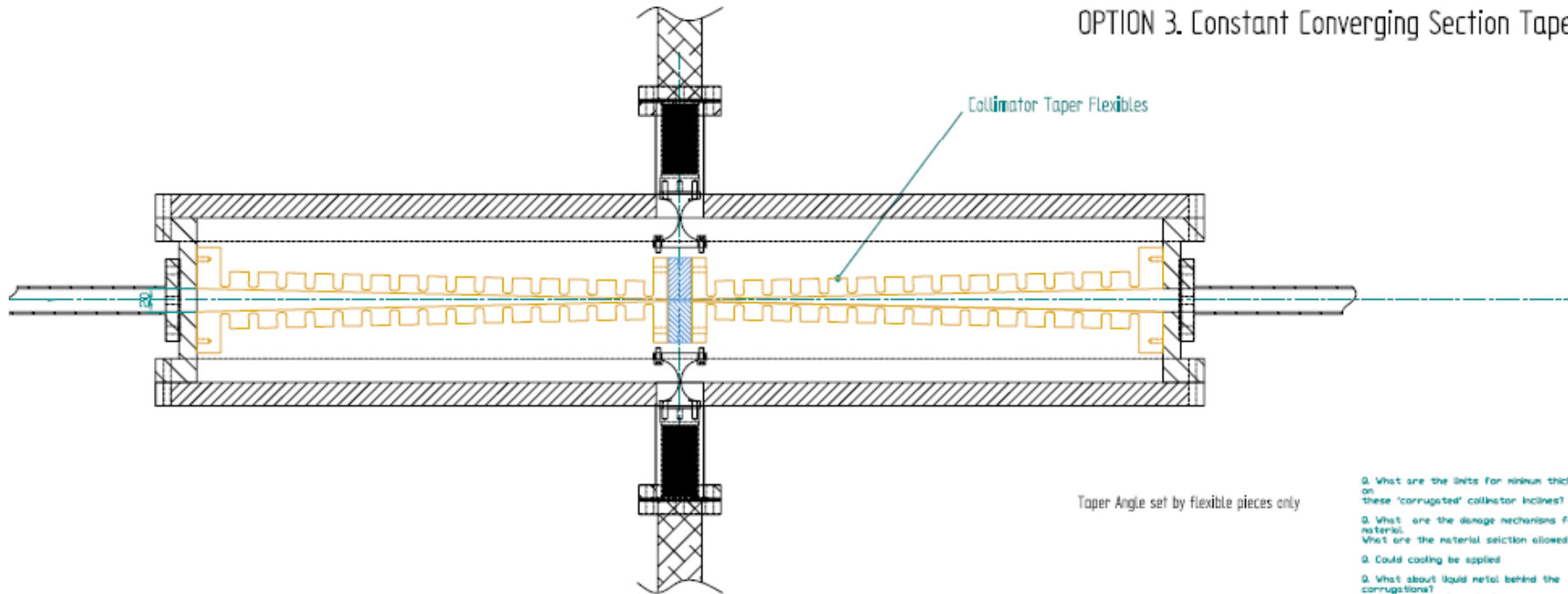
Furthermore, in an extension of this concept, if the maximum collimator aperture could be agreed as 16.5mm (reduced from current 20mm), then the diverging flare section could be removed with altogether in the vertical at least.

OPTION 3

OPTION 3. Constant Converging Section Taper



OPTION 3. Constant Converging Section Taper



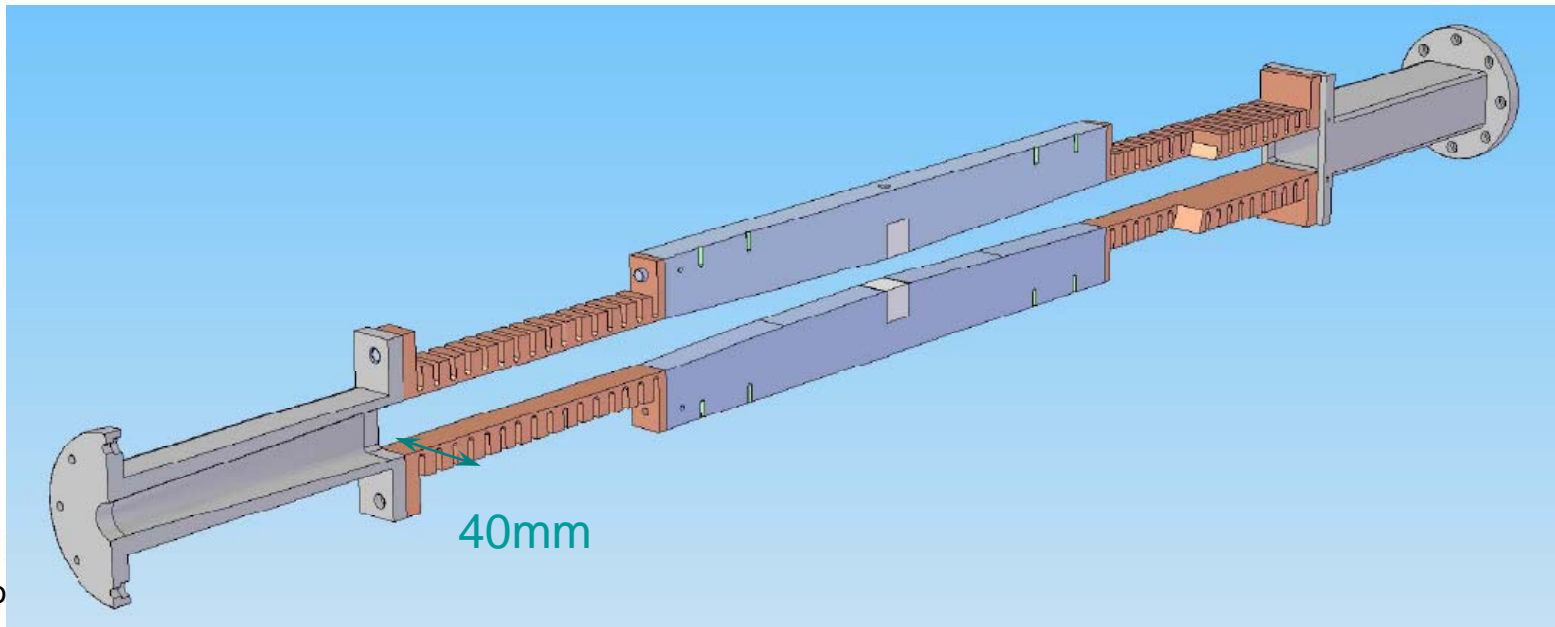
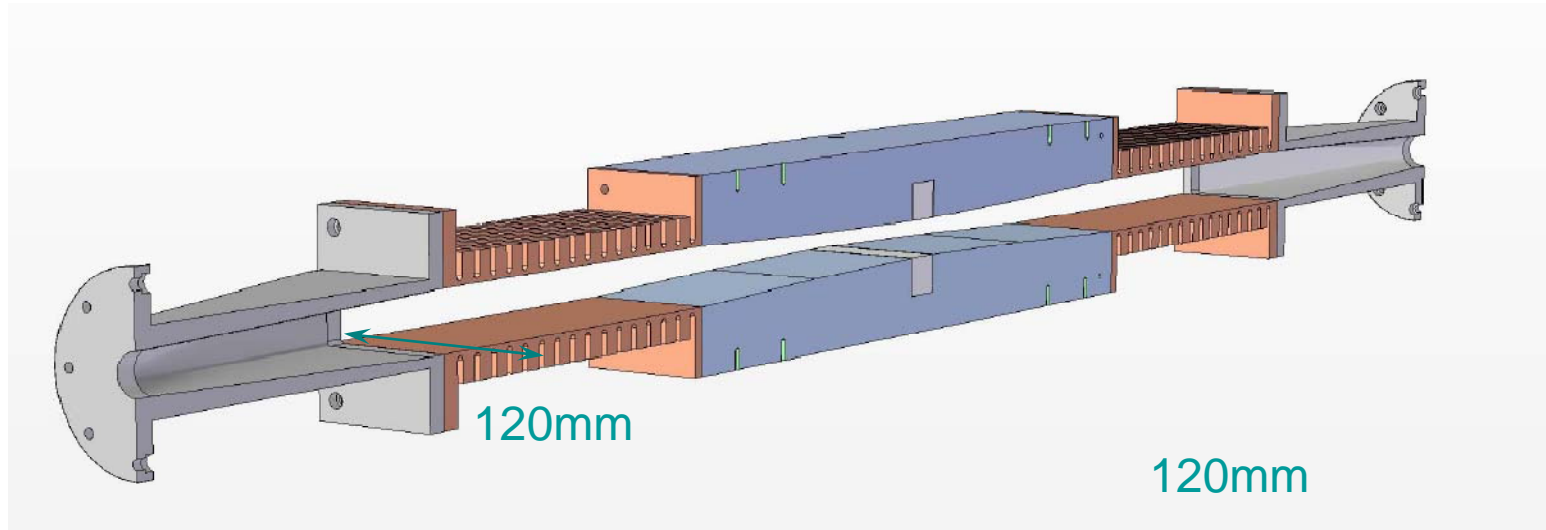
Taper Angle set by flexible pieces only

- Q. What are the limits for minimum thickness on these 'corrugated' collimator incises?
- Q. What are the damage mechanisms for thin material. What are the material selection allowed?
- Q. Could coating be applied?
- Q. What about liquid metal behind the corrugations? Stopping power + cooling?



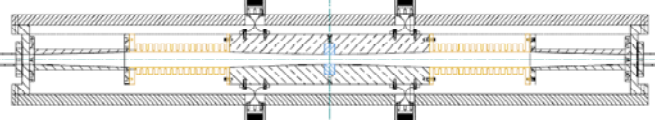
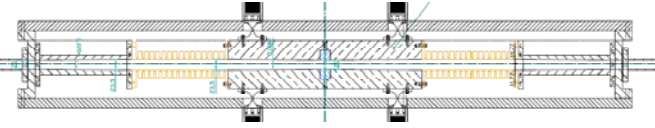
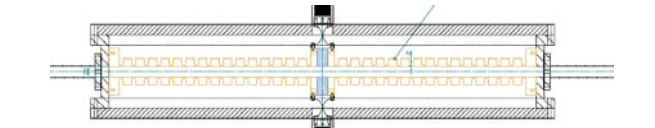
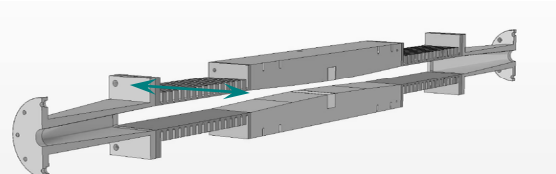


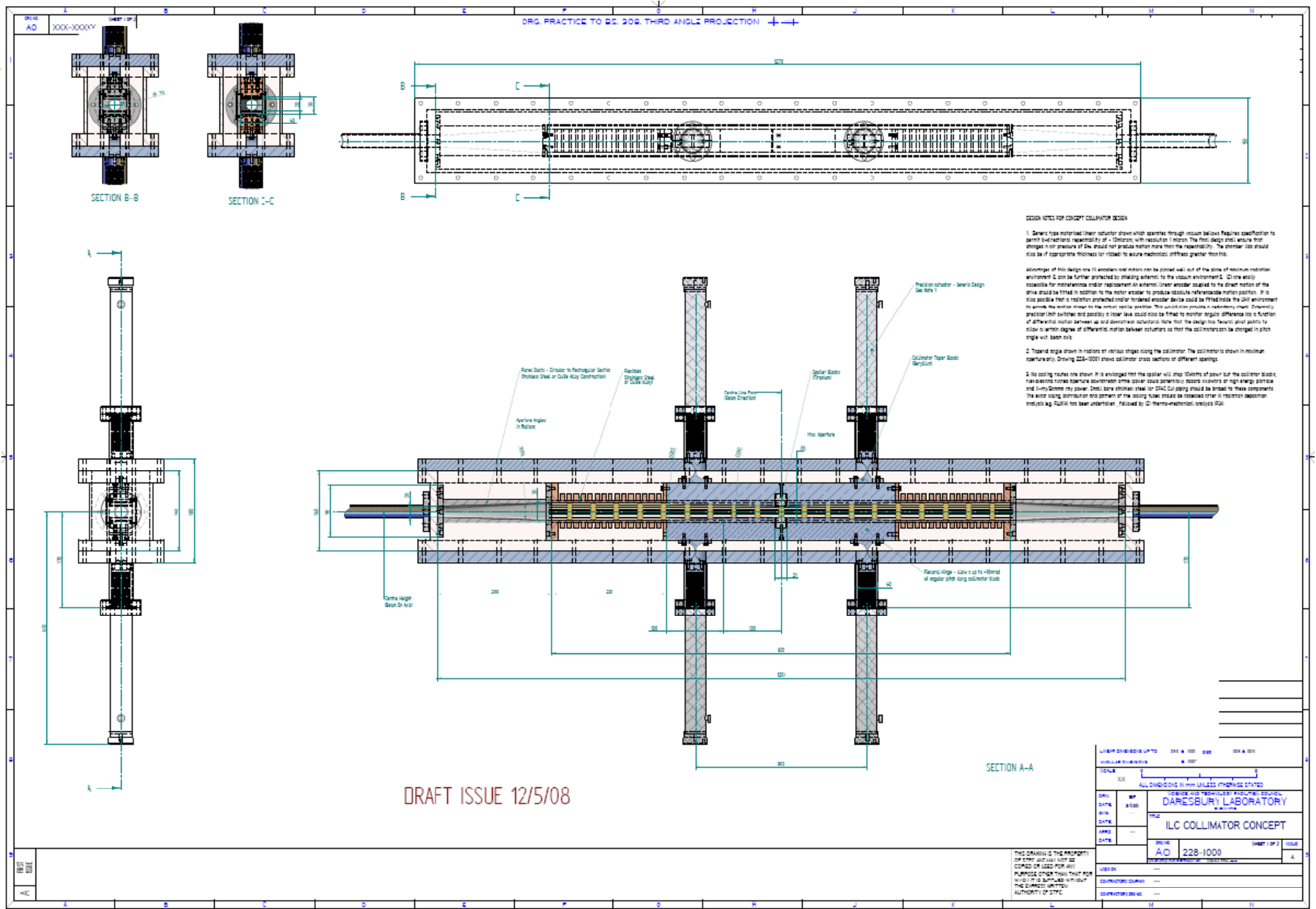
OPTION 4





OPTION & FILE ACCESS SUMMARY (15 May 08)

Option	Note	File Reference
	<p>1. 'Default' design proposal - 20mm diameter circular cross-section flares into 30x40mm rectangular section (over 200mm length) then tapered collimator (2 step angle with minimum)</p>	<p>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)</p>
	<p>2.</p>	<p>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)</p>
		<p>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)</p>
		<p>Project Drawing: ilc-coll-meng-dwg-0004 folder containing following STL files STL4 as per STL3 model but with aperture width 1290mm instead of 40mm (filename: 28-10000-STL4 [15-5-08].stl)</p>



Nigel Watson, 15 Jan 2009

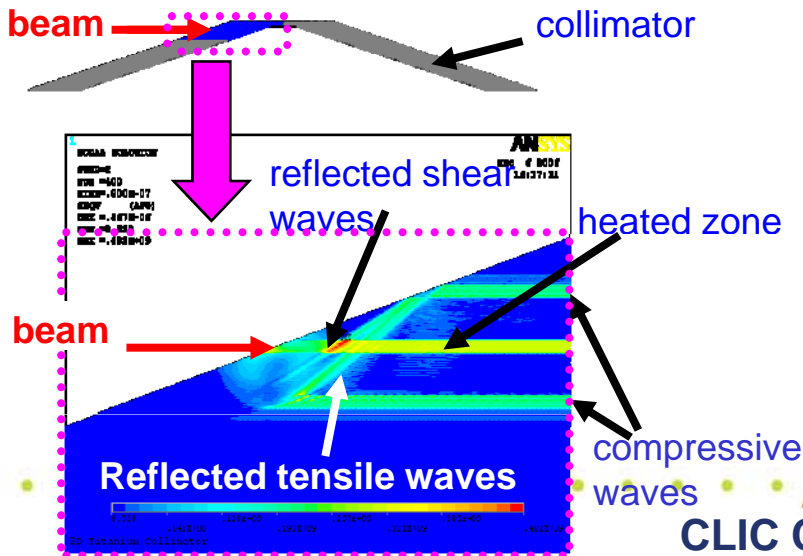
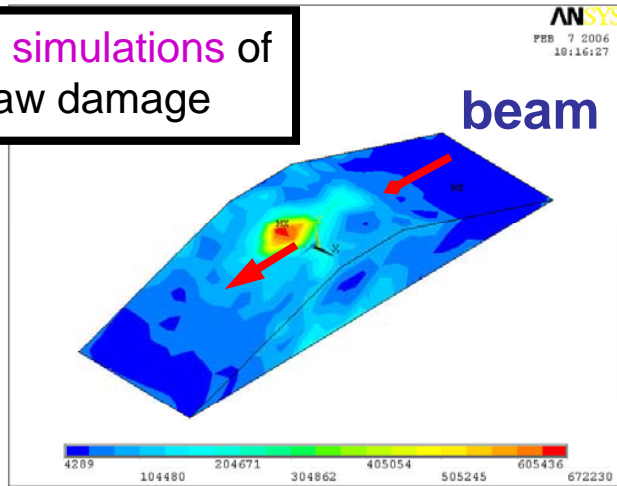
CLIC Collimation Meeting



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.

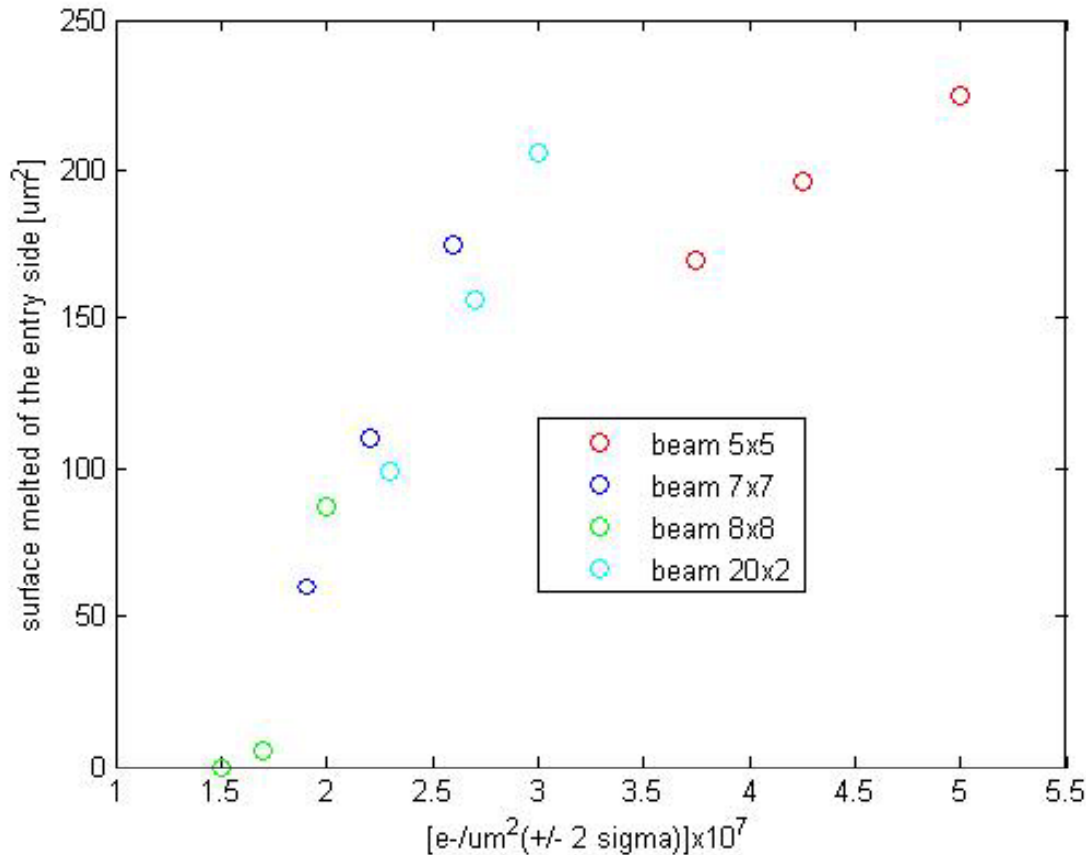
 Best candidate designs

	2mm depth		10mm depth	
	250GeV 111×9 μm ²	500 GeV 80×6 μm ²	250 GeV 111×9 μm ²	500 GeV 80×6 μm 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

CLIC Collimation Meeting



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**
- ...

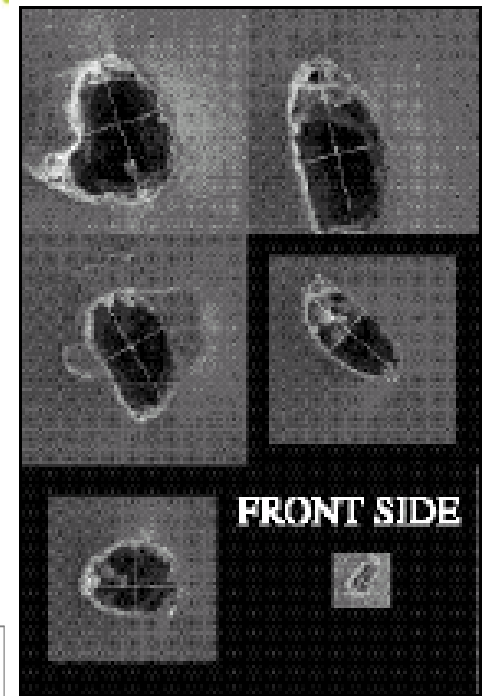
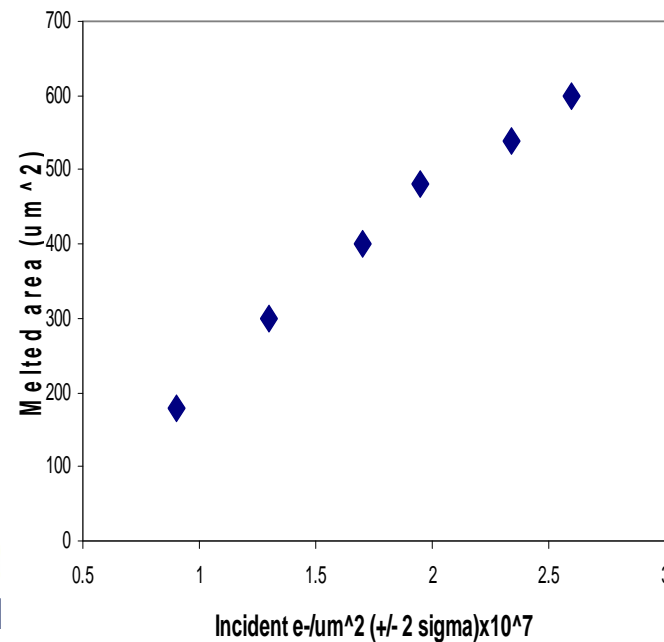
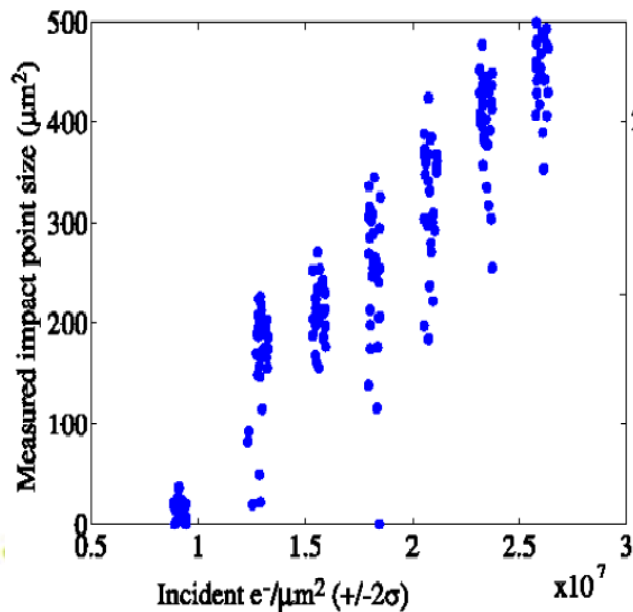


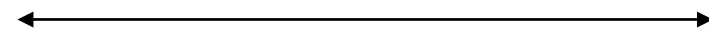
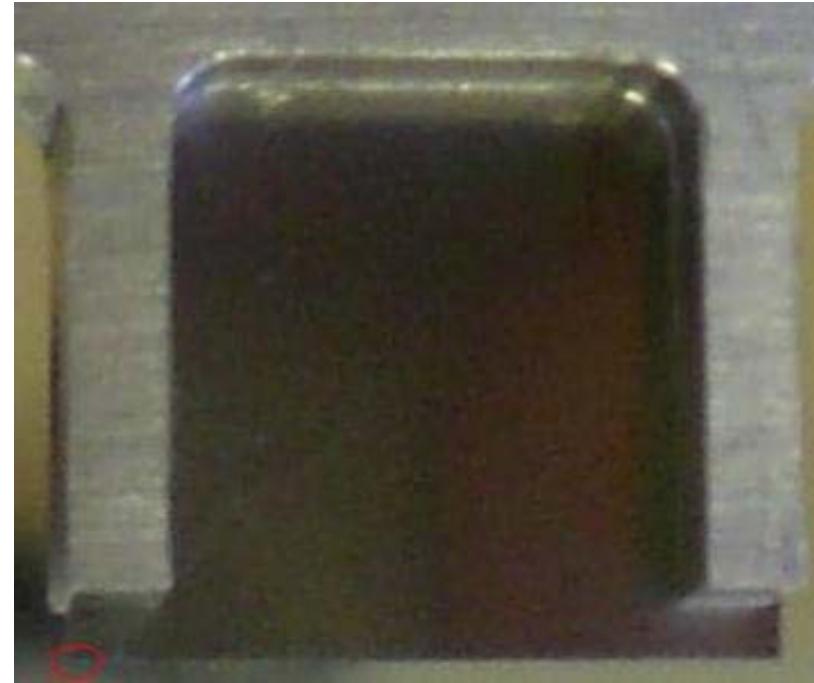
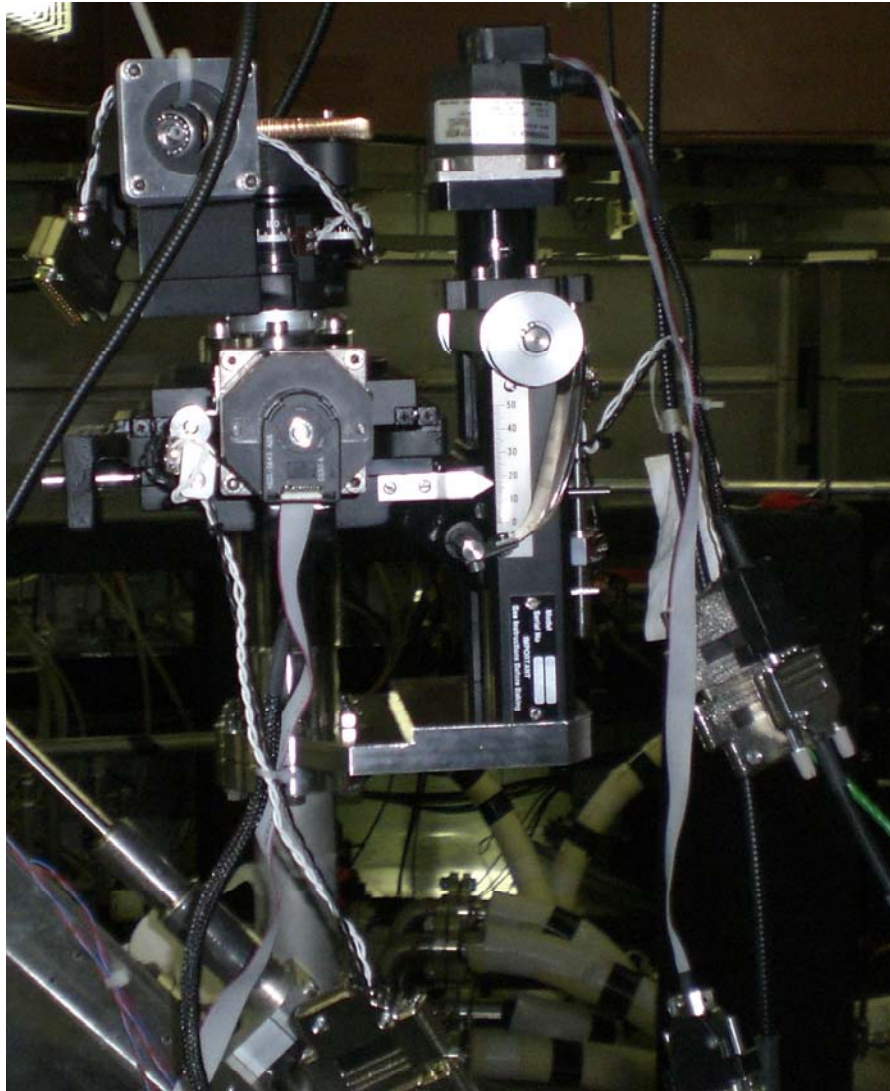
A similar test done in SLAC FFTB gave the results that can be seen in the bottom left plot of this section.

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 $\sim 100 \mu\text{m}^2$ but both plots agree in the slope.

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



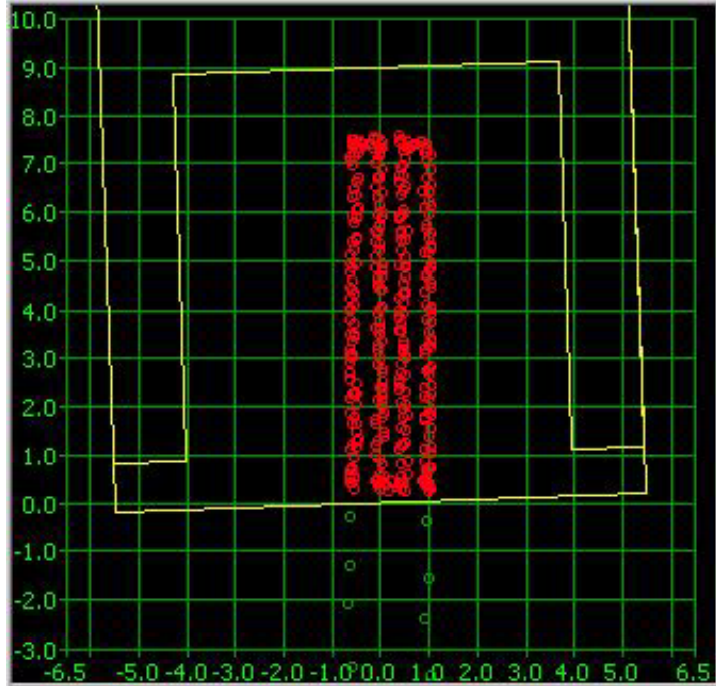
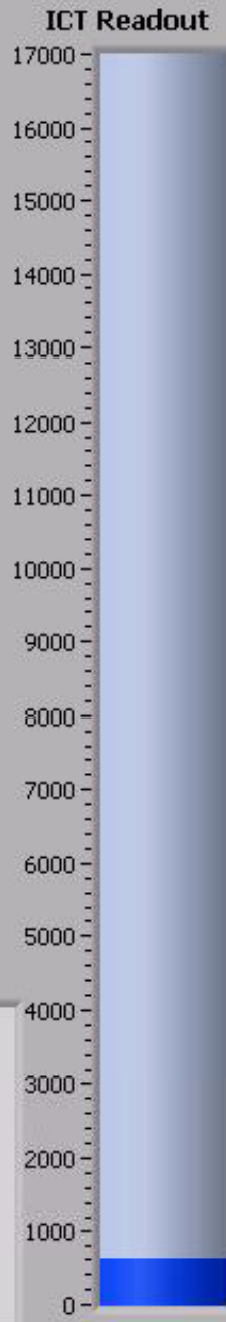


11 mm

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

Collimation Damage DAQ

EXIT



Controller Info

Controller link ● Connection Error ●

Simple moves
Relative move

Axis
Vertical

Dist. / Pos. (mm) Speed (mm/s)

Move by 100um

Horiz. motion ● Vert. motion ●

Horiz. (mm) Vert. (mm)

ATF Info

Connected to ATF ● ATF Alive ●

Remote Address	Port	Charge	X Pos	Y Pos
<input type="text" value="20.10.71.44"/>	<input type="text" value="50101"/>	<input type="text" value="0.97145"/>	<input type="text" value="-0.7388E"/>	<input type="text" value="-0.40954"/>

Offset Y Offset Rotation

Current Log File
 Restart Log

Mint Terminal Output

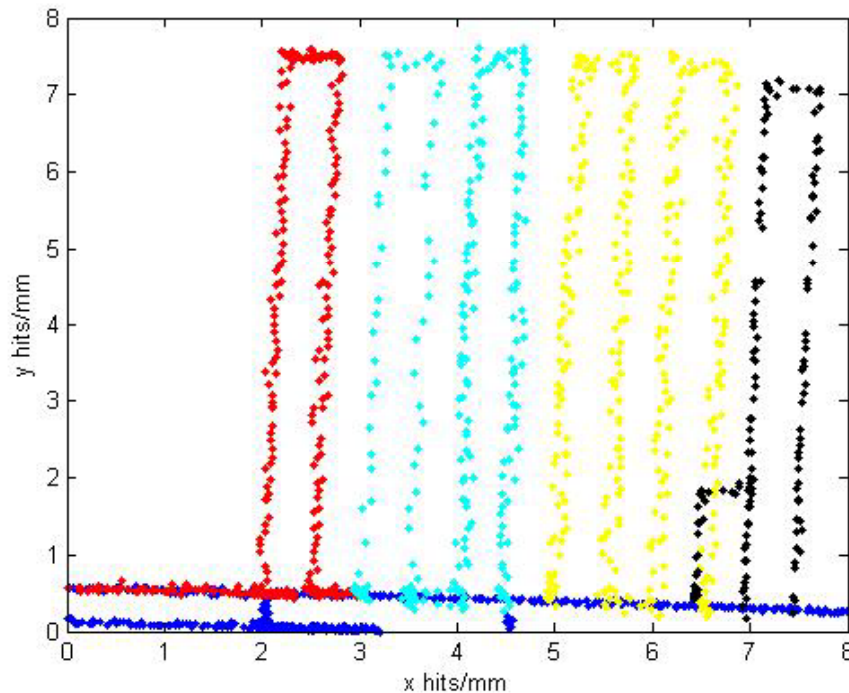
```
[1] encoder.2 = -35.3010 residual = 0.0020  
move finished in 1 iterations, residual : 0.0020  
one.  
moving axis 2 over 5.0000 mm, speed 0.5000 mm/s.  
moving axis 2 from -35.3010 to -30.3010  
[1] encoder.2 = -30.3005 residual = 0.0005  
move finished in 1 iterations, residual : 0.0000  
one.
```

Error Message
No Error

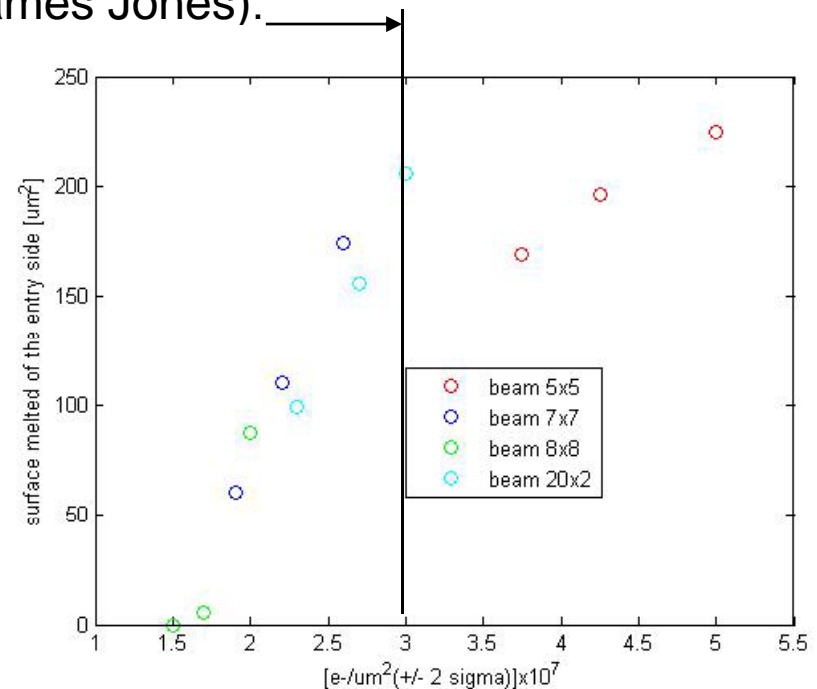


Phase 1 of Damage Test Beams at ATF-KEK

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.

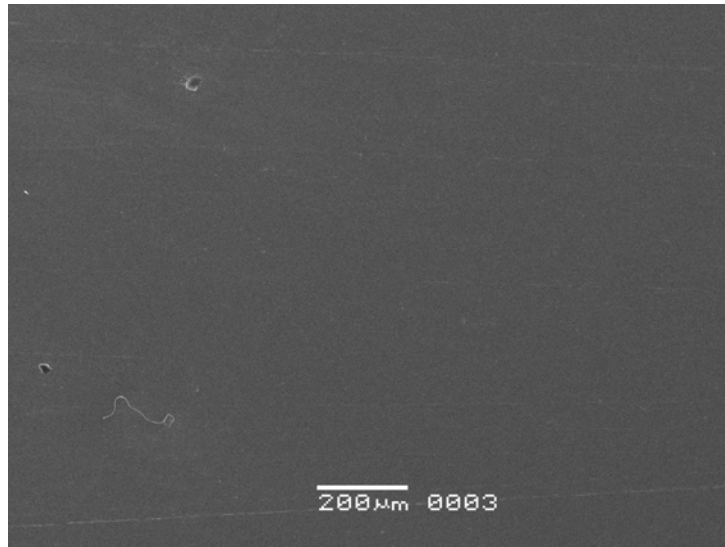


Hits with different beam charges, from 0.8×10^{10} to triple bunch hits with a total charge of 3.6×10^{10} . Calculated beam sizes of 15×2 to 15×5 microns square (James Jones).

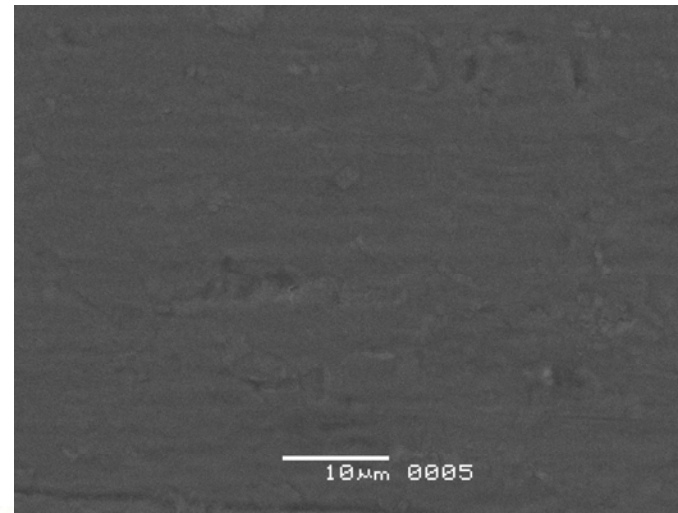
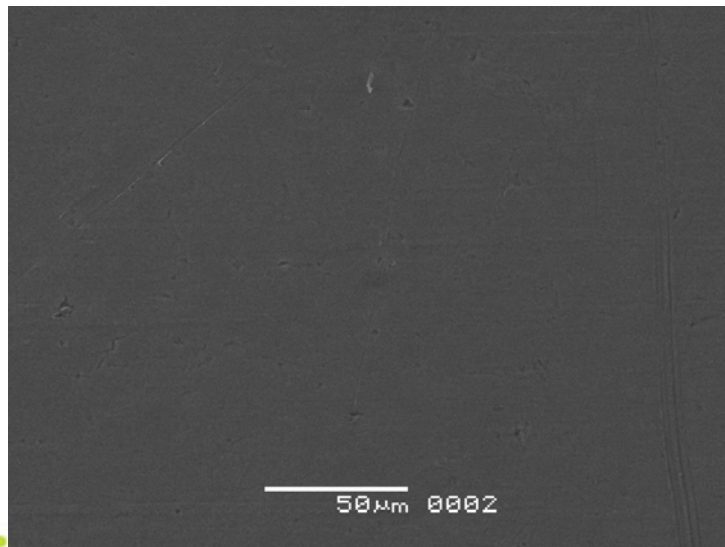




No damage - parameters

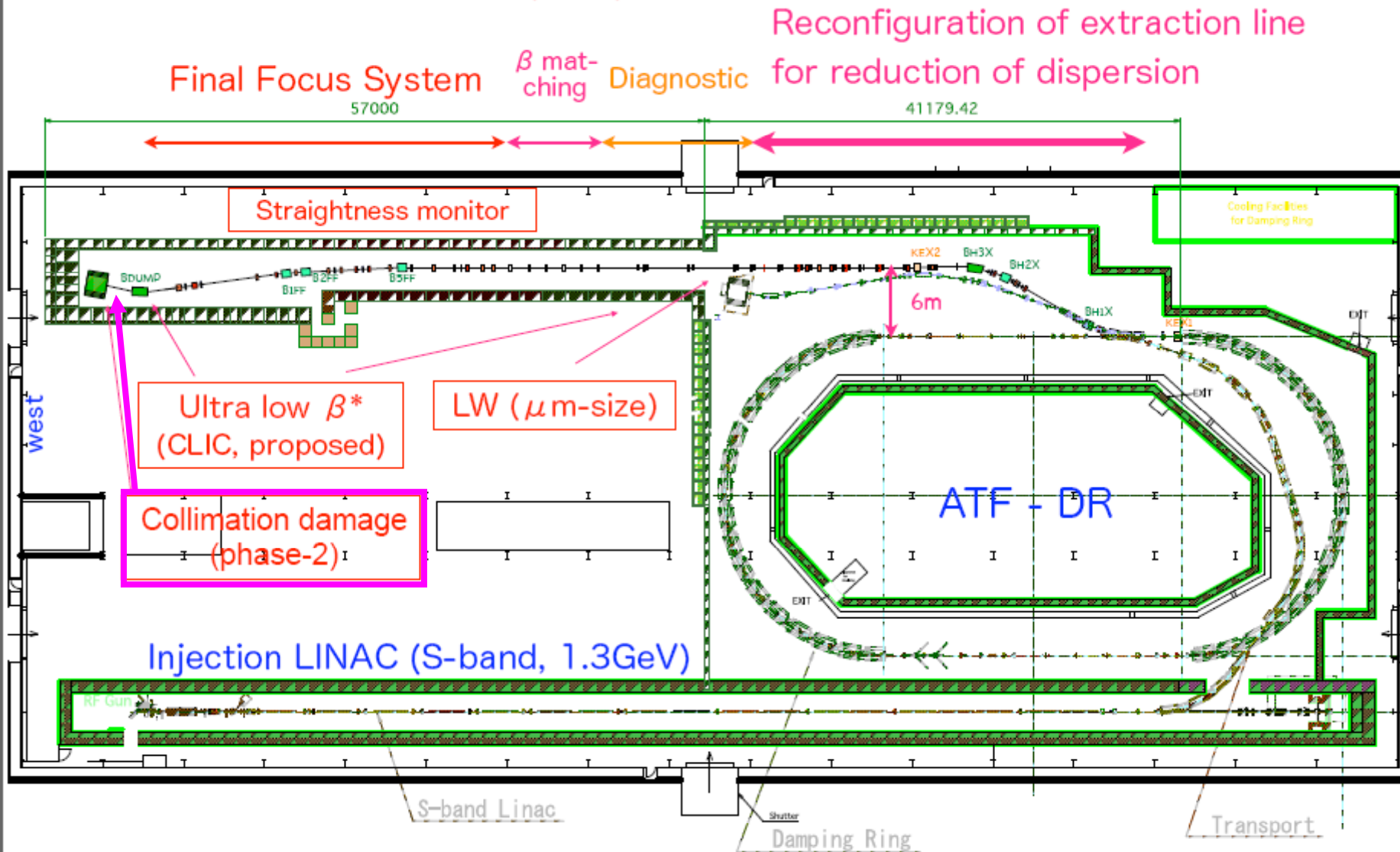


- After looking closely, nothing clearly like damage found
- Parameters of beam achieved not such that we could have expected damage...





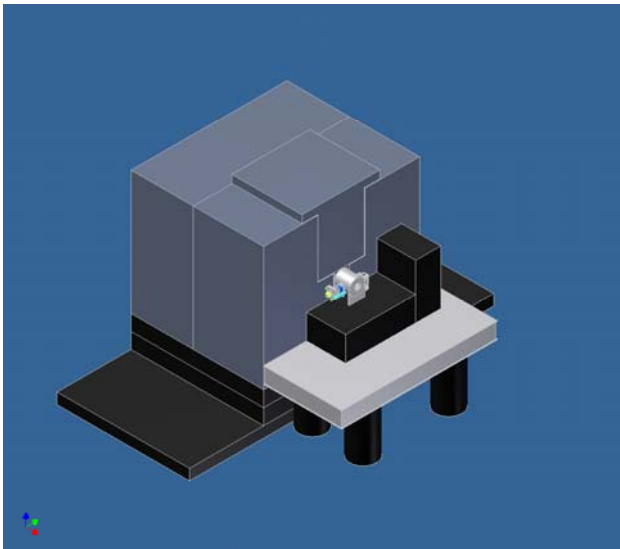
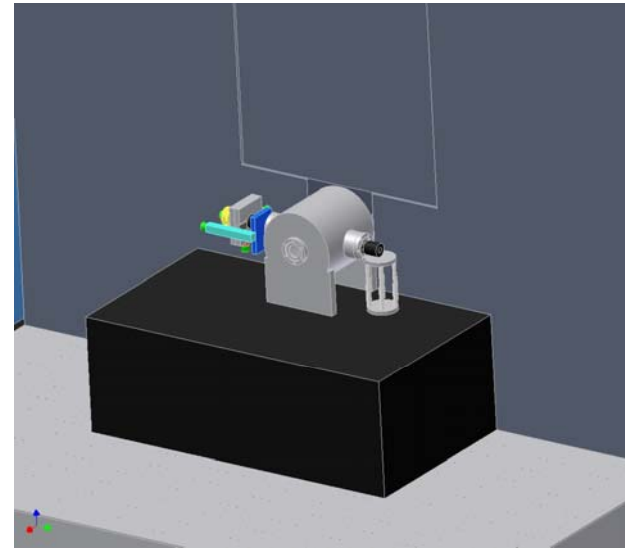
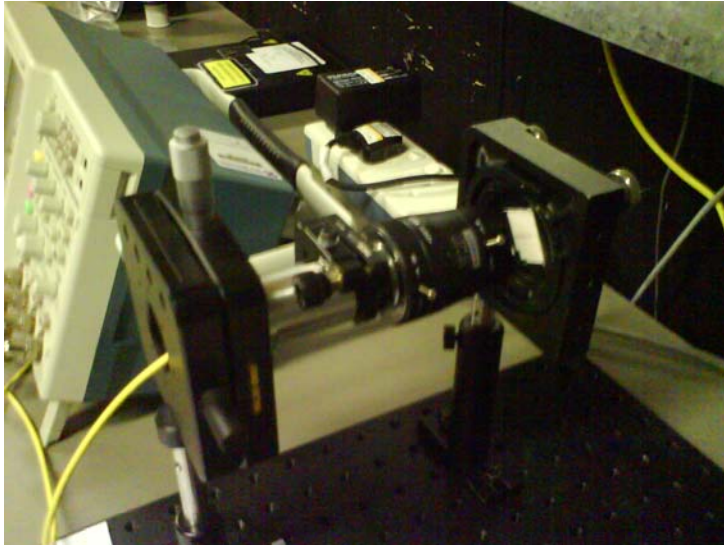
ATF2 beam line



Slide taken from ATF2 status talk by Tauchi

2007/Mar/02 N.Terunuma, KEK

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 ...