CBN 09-7

LITHIUM LENS STUDIES

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Linear Collider Workshop of Americas

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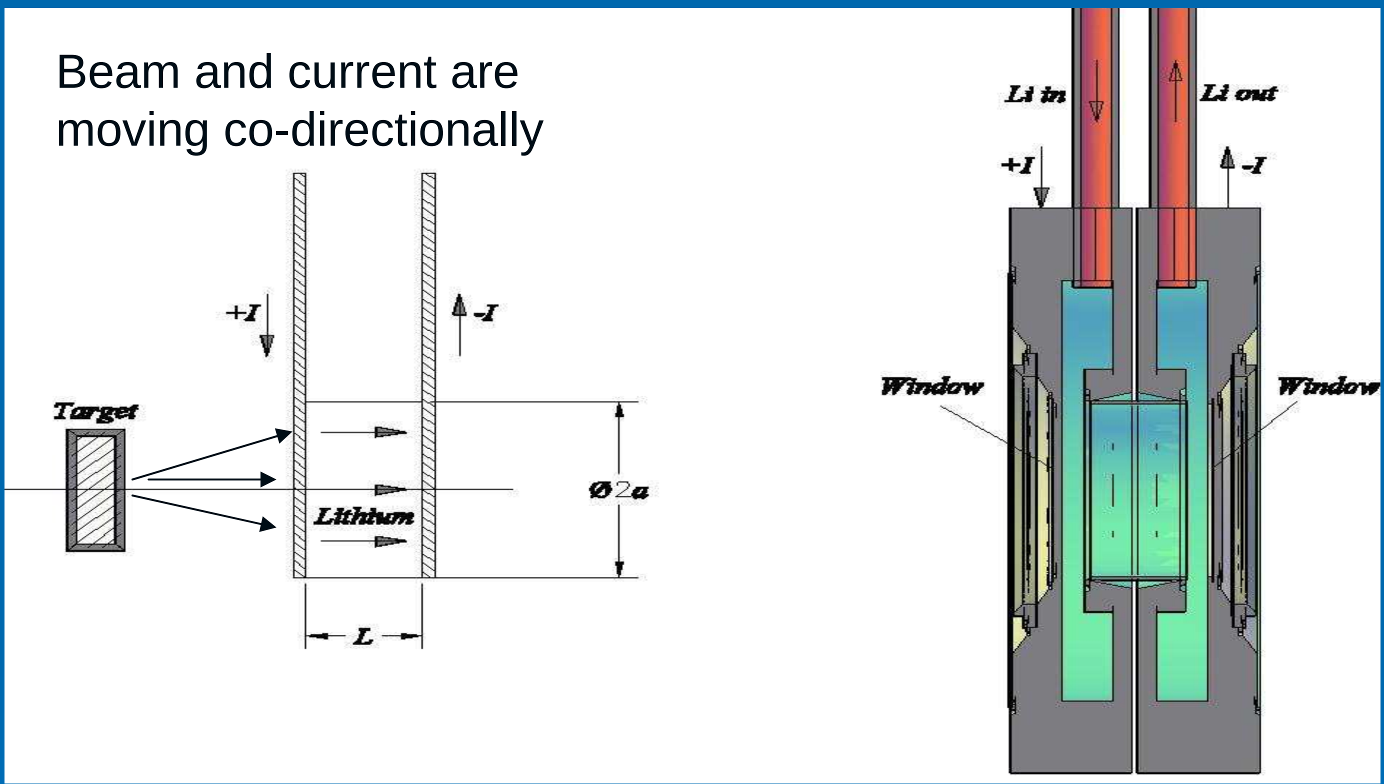
Albuquerque NM

Li LENS BASICS

Beam and current are moving co-directionally



Li also serves as a coolant for windows

Windows made from BN, BC or Be

W is also under consideration for entrance window

For given focal distance *F,* radius *a,* length *L,* the current required is

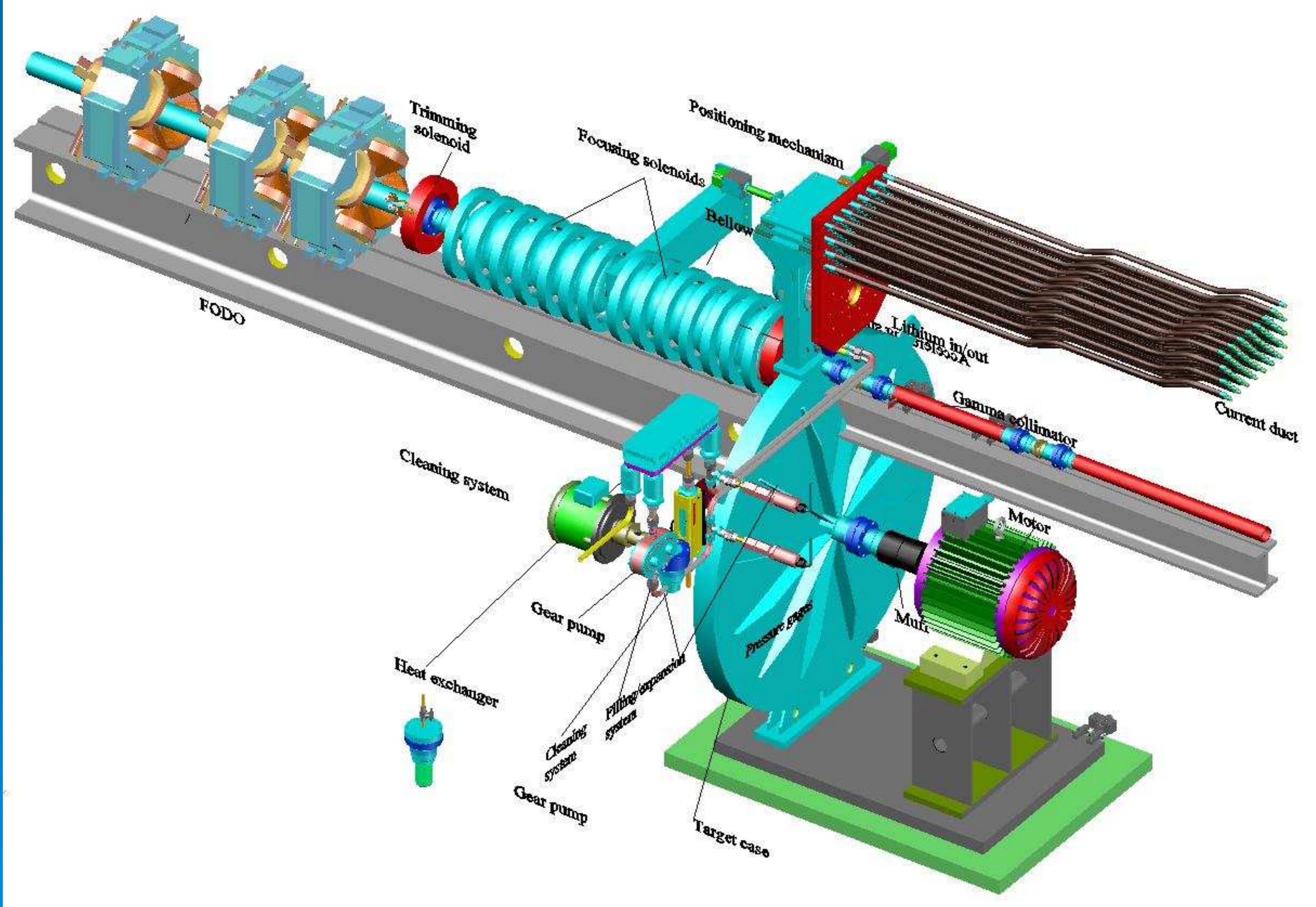
$$I \cong \frac{a^2 \cdot (HR)}{0.2FL}$$

For *F*~1cm, *a*~0.5cm, *L*~0.5cm, *E*~20MeV → *I*~166kA

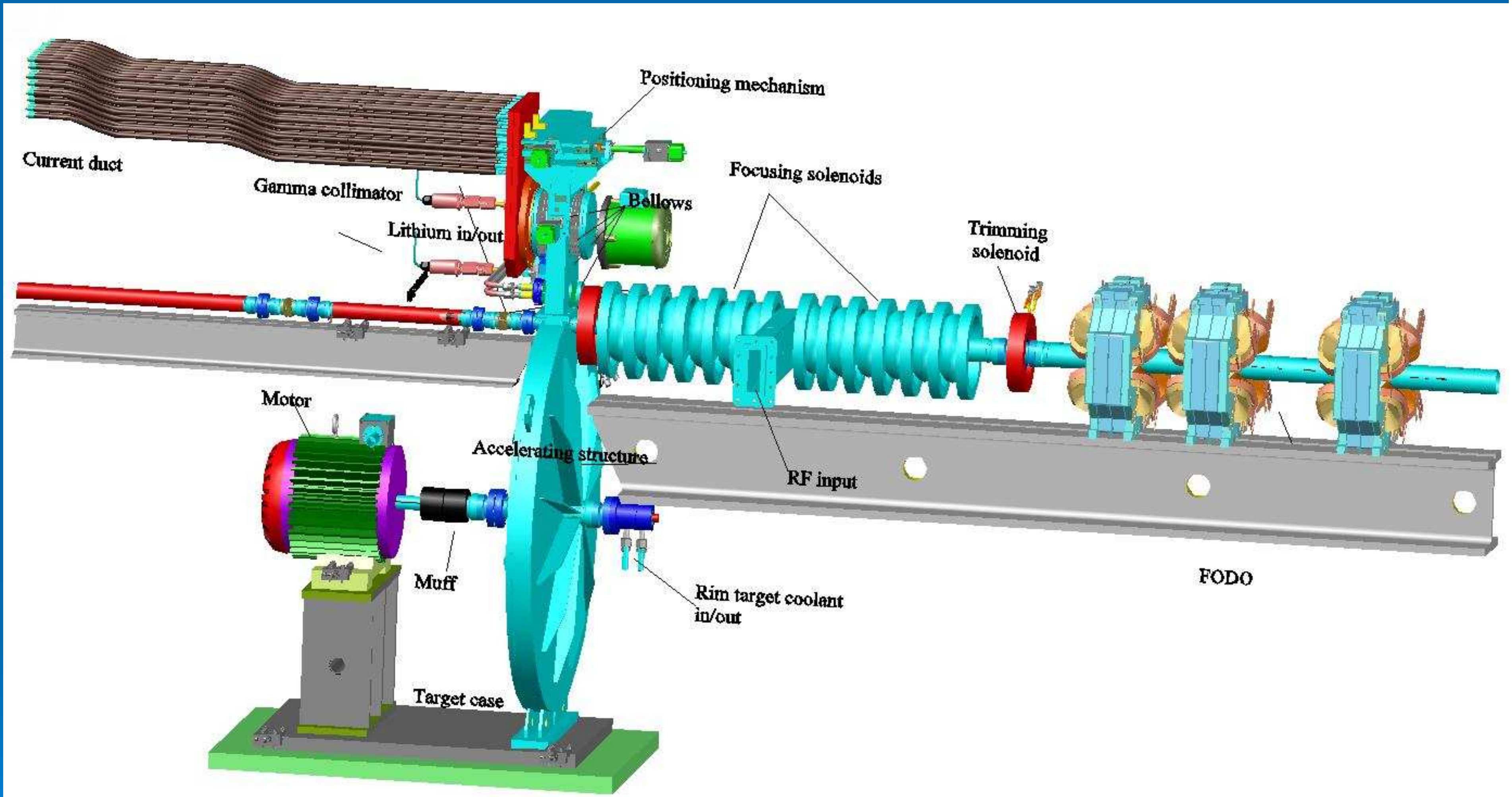
A.Mikhailichenko,” Lithium Lens (I)”, CBN -09-4, Aug 2009, 17pp.

http://www.lepp.cornell.edu/public/CBN/2009/CBN09-4/CBN%2009-04.pdf

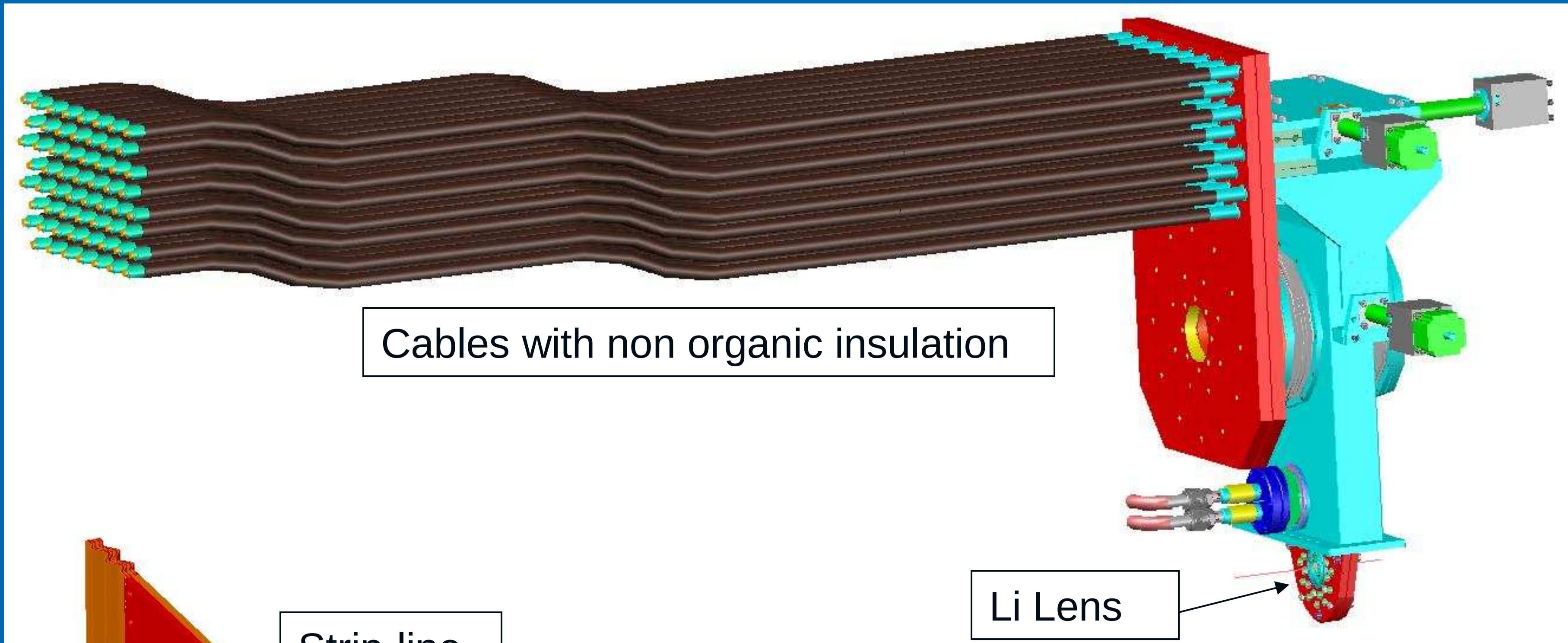
All references are there

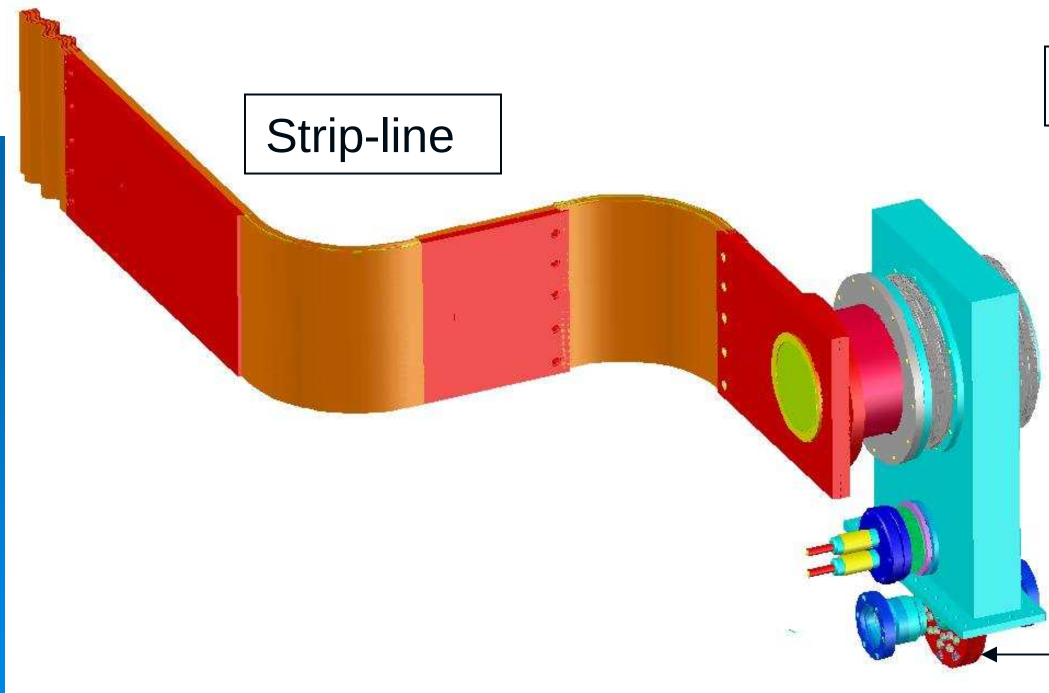


View from other side



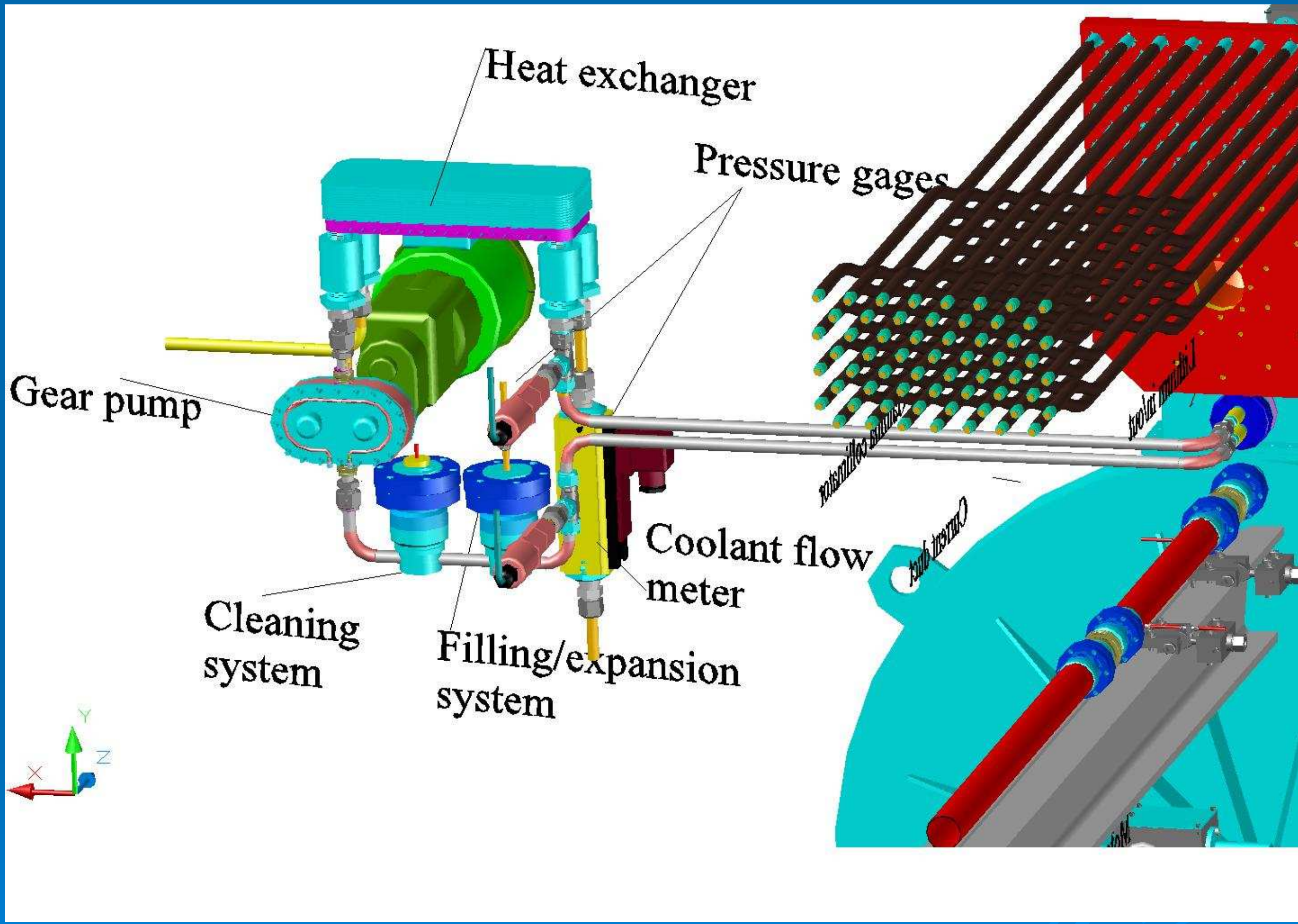
Variants of current duct



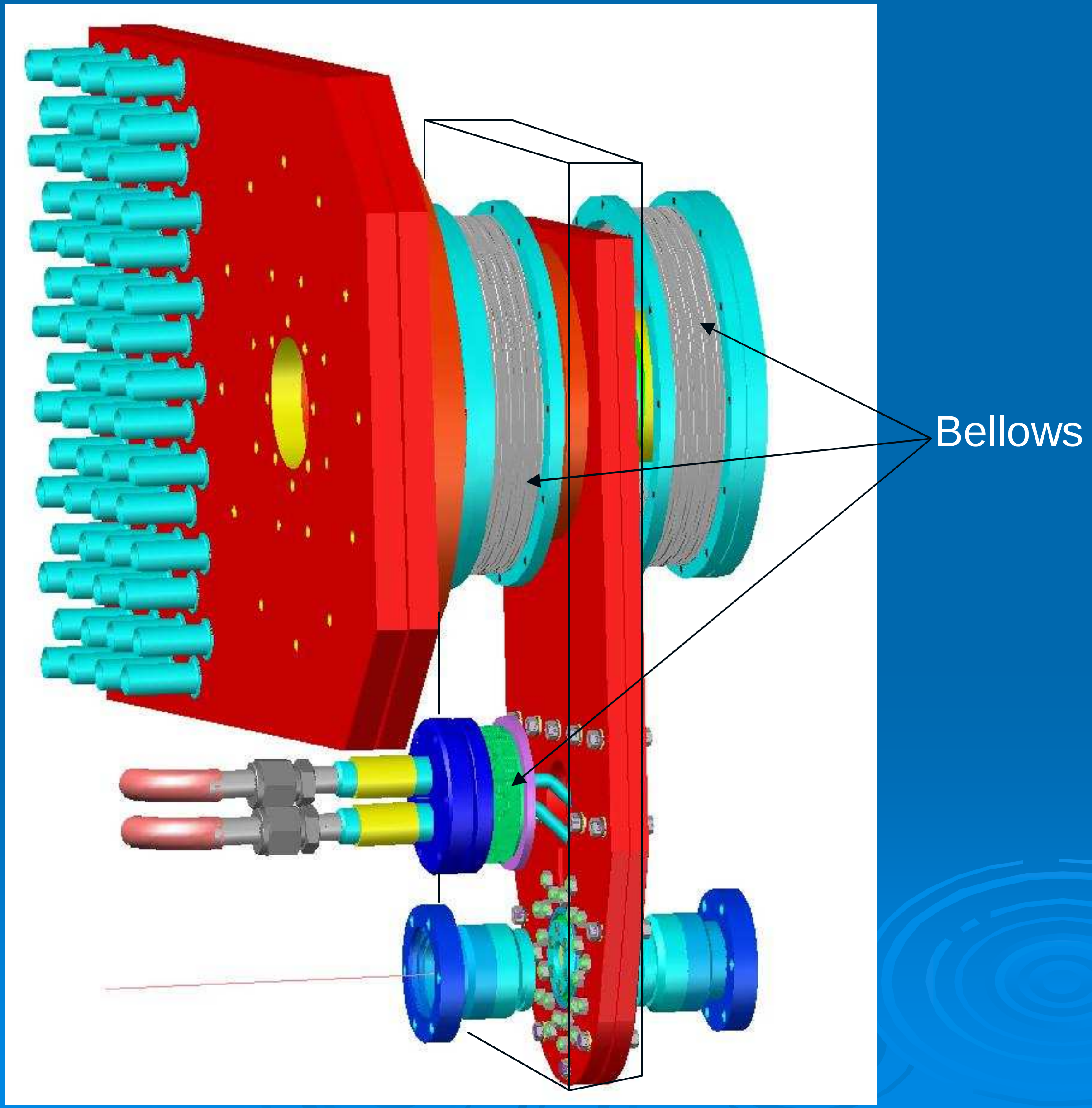


Current duct must be able to transfer ~ 150 kA in ~4 ms pulse with repetition rate up to 10 Hz

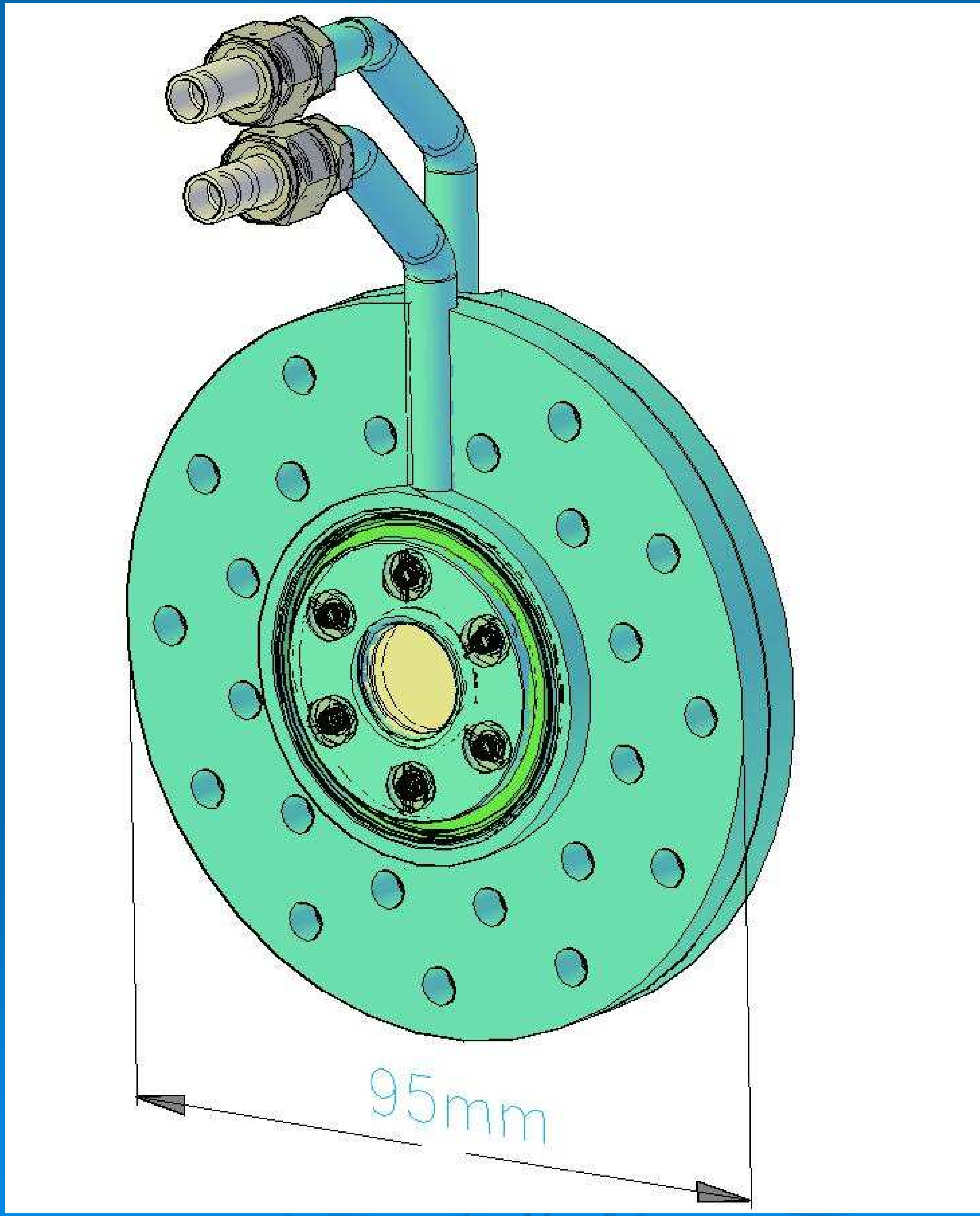
Lithium loop



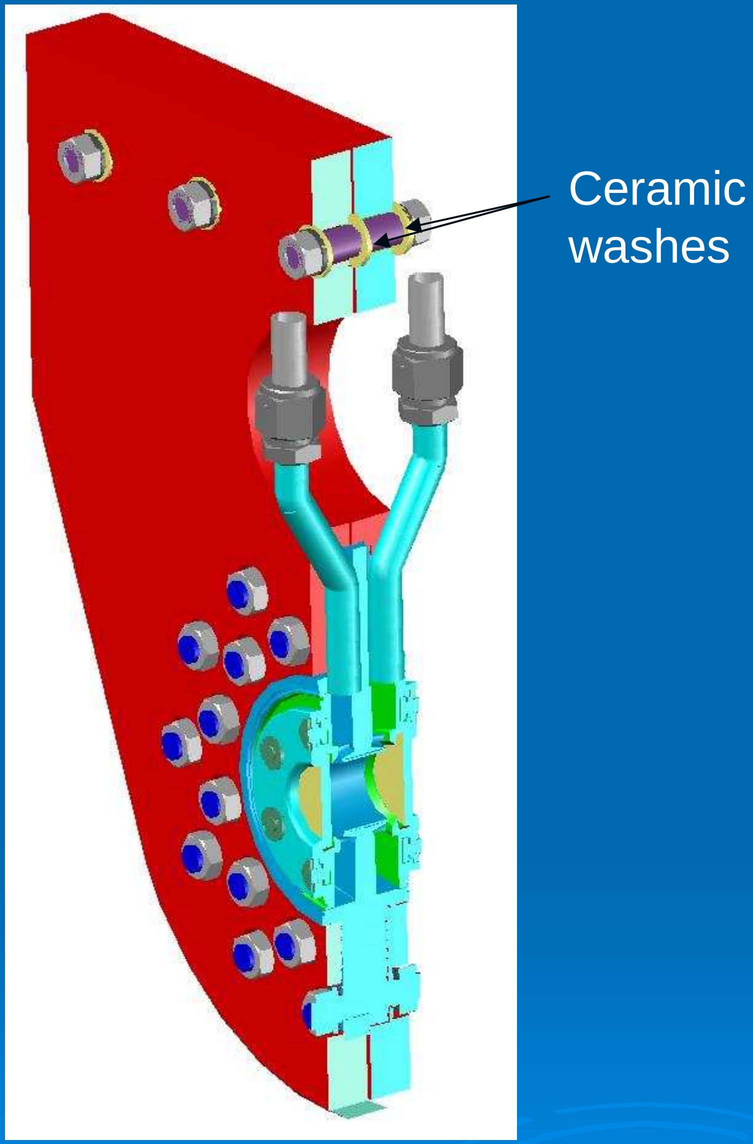
Scaled view on vacuumed feed through and lens; vacuum case not shown

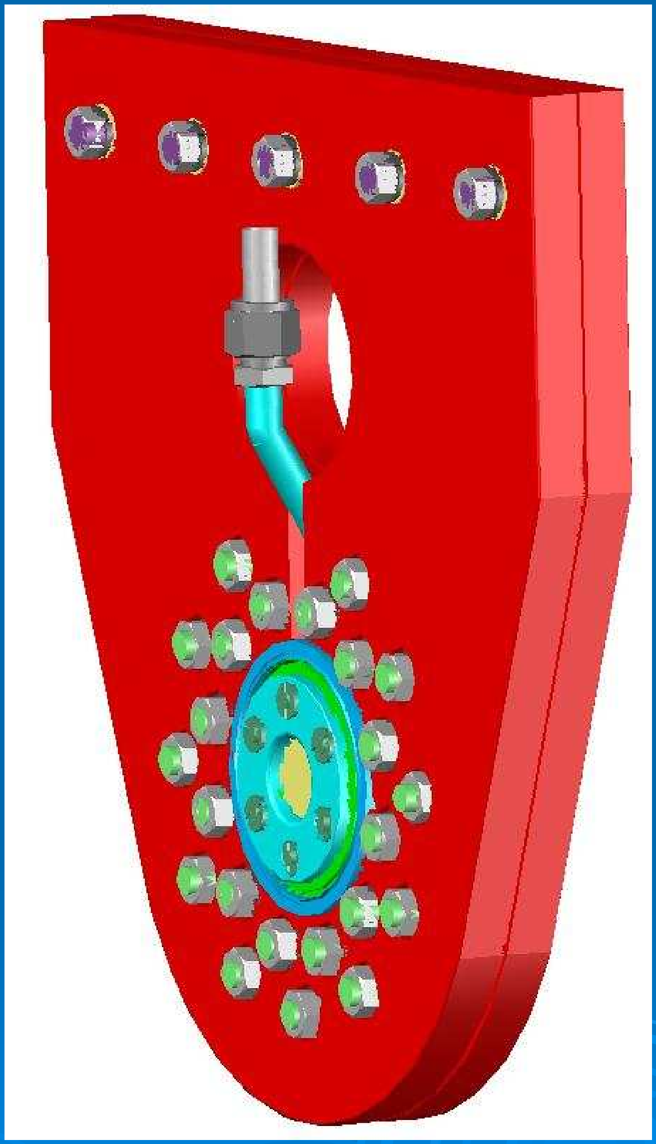


Lens itself

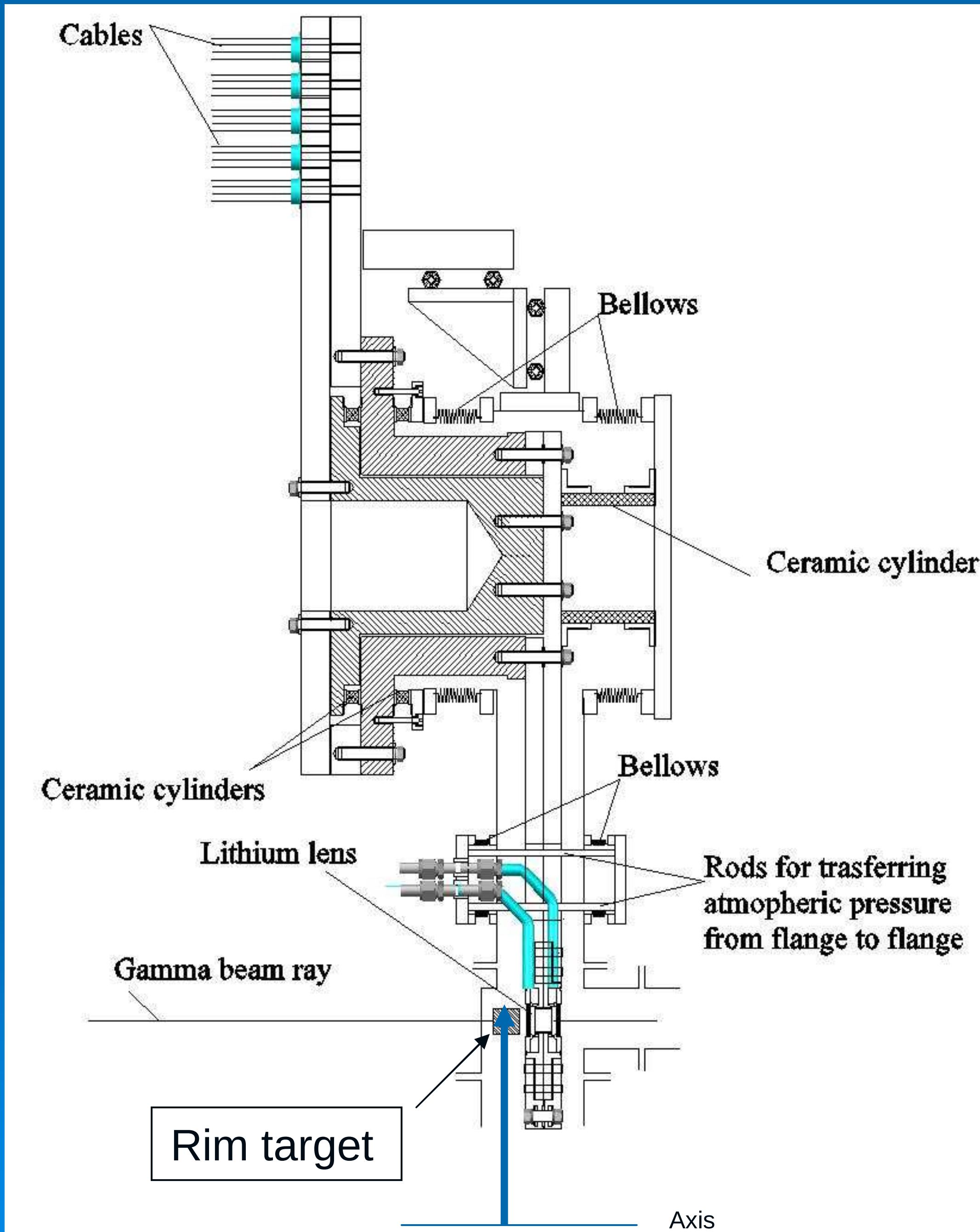


Li lens with current duct attached





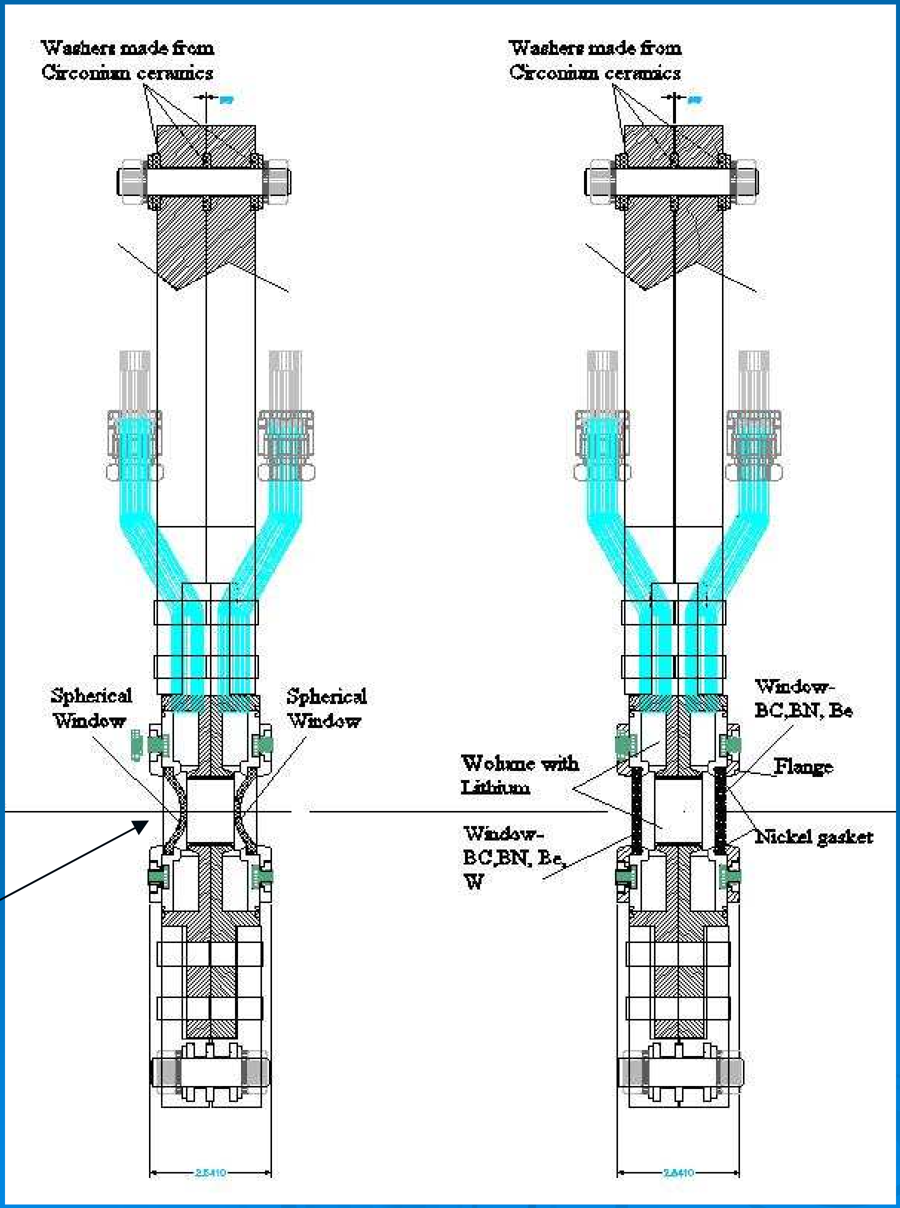
FEED THROUGH IN DETAIL

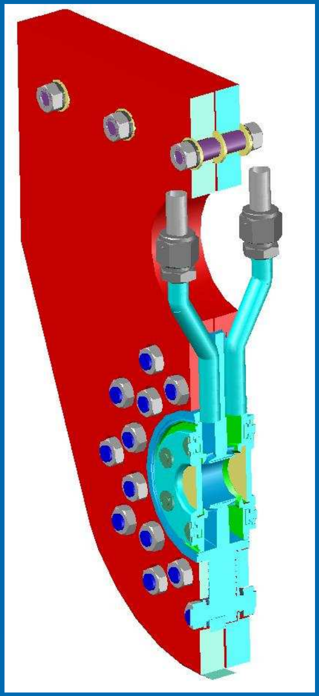


System with two bellows excludes net force from atmospheric pressure;

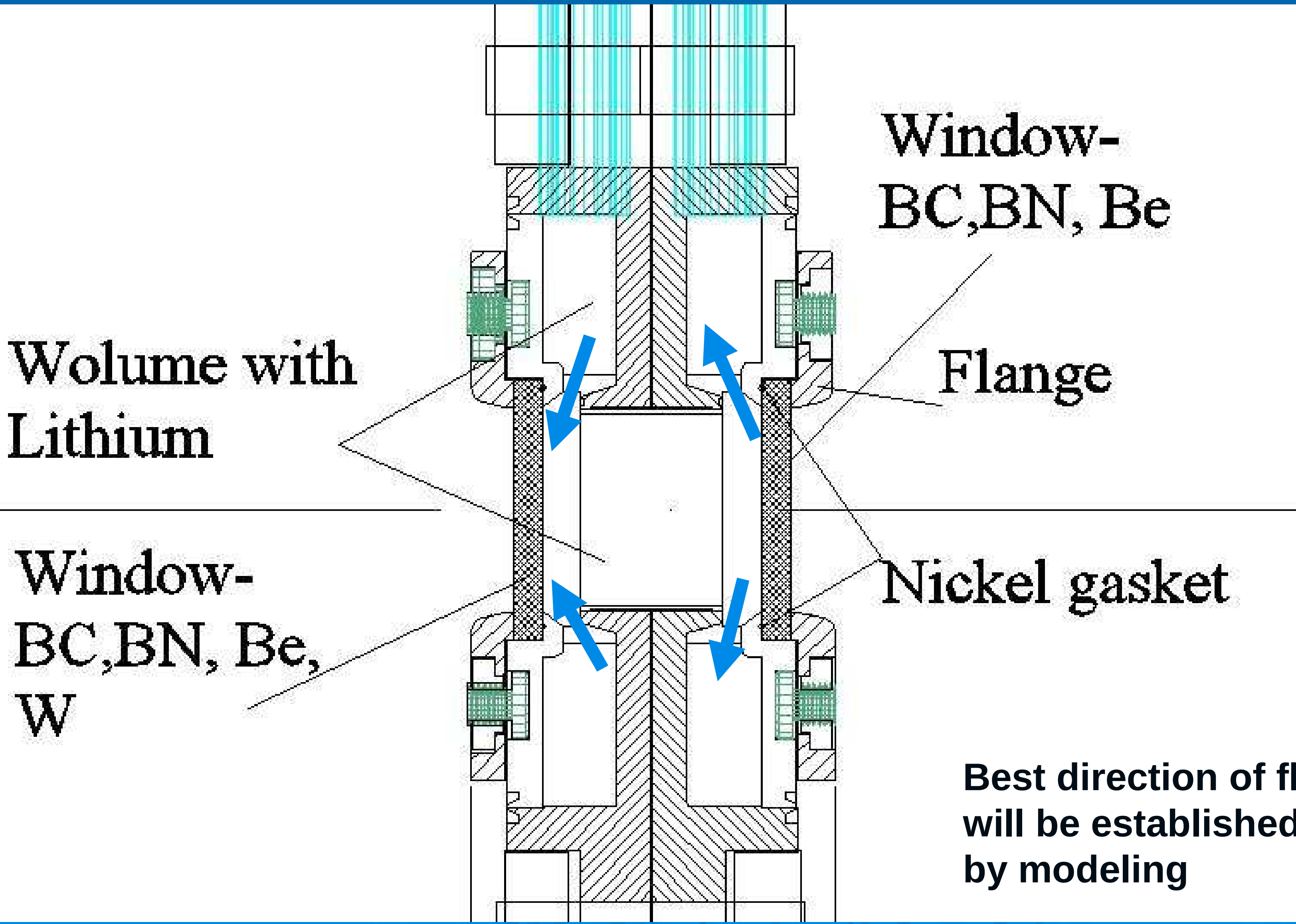
Positioning system serves for ajustment the distance between target and lens –what is required by optimization of yield/heating for the entrance window

Can be used for compensation of spherical aberrations





Windows attachment technique



Best direction of flow will be established by modeling

To the choice of material for windows

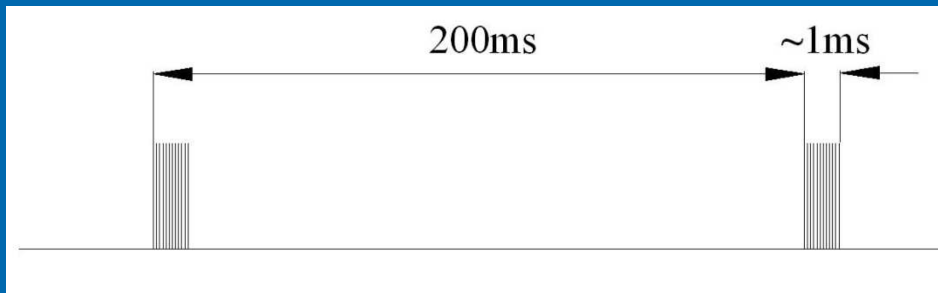
Table 1: properties of Lithium, Li[1], Be, BC, BN, W

	Units	Li	Be	BN	B_4C	W
Atomic number, Z	-	3	4	5/7	5/6	74
Yong modulus	*GPa*	4.9	287	350-400	450	400
Density, ρ	$[g/cm^3]$	0.533	1.846	3.487	2.52	19.254
Specific resistance	*Ohm-cm*	$1.44 x10^{-5}$	$1.9 x10^{-5}$	$>10^{14}$	$7.14 x10^{-3}$	$5.5 x10^{-6}$
Length of *Xo*, *lXo*	*cm*	152.1	34.739	27.026	19.88	0.35
Boil temperature	°C	1347	2469	Sublim. at melt	3500	5660
Melt temperature	°C	180.54	1287	2973	2350	3410
Compressibility	cm^2/kg	$8.7 x10^{-6}$	$9.27 x10^{-7}$			$2.93 x10^{-7}$
Grüneisen coeff.	-					2.4
Speed of sound (long)	*m/sec*	6000	12890	16400	14920	5460
Specific heat	*J/g°K*	3.6	1.82	1.47	0.95	0.134
Heat conductivity	*W/cm/°C*	0.848	2	7.4	0.3-0.4	1.67
Thermal expansion	1/°C	$4.6x10^{-6}$	$11x10^{-6}$	$2.7x10^{-6}$	$5x10^{-6}$	$4.3x10^{-6}$

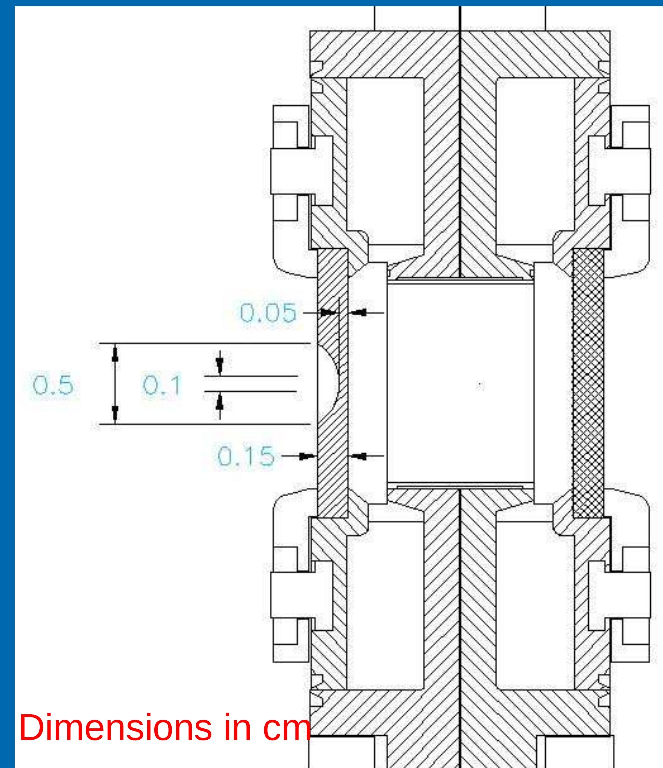
[1] Total mass of Lithium in ~70*kg* human body is ~7*mg*.

Heat capacity, Heat conductivity – functions of temperature; this need to be taken into account

Beam pattern



Flange with recession has faster relaxation time



Equation for thermal diffusion

$$\nabla(k\nabla T)+\dot{Q}=\rho c_V\dot{T}$$

defines time of relaxation from its characteristic

$$\frac{dx^2}{k}=\frac{dt}{\rho c_V}\rightarrow\quad \delta^2=\frac{k}{\rho c_V}\tau\rightarrow\ \tau=\frac{\rho c_V}{k}\delta^2$$

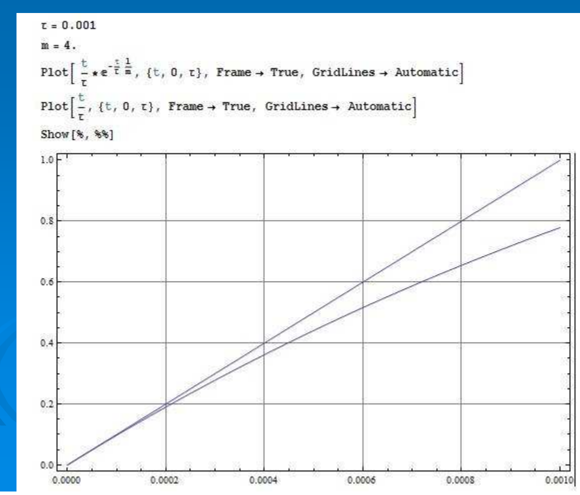
For Be: k=2 $W/cm/^oK$, ρ=1.84g/cm^3 , c_V =1.82 $J/g/^oK$

If δ=0.05cm $\qquad \tau=\frac{1.84\cdot1.82}{2}2.5\cdot10^{-3}\cong4.2ms$

This gives ~20% temperature drop within train for Be

For Li thermal skin-layer for 1 *msec* time goes to

$$\delta=\sqrt{\frac{k}{\rho c_V}\tau}=\sqrt{\frac{0.848}{0.533\text{x}3.6}0.001}=0.021cm$$



LOSSES FOR DIFFERENT MATERIAL OF TARGET

If energy Q deposited in mass m, then the temperature rise is

$$\Delta T = \frac{Q}{mc_V},$$

where c_V stands for the heat capacity. In its turn, for the $1cm^2$ cross section

$$Q \cong l[cm] \times 1[cm^2] \times 2[MeV/g/cm^2] \times \rho[g/cm^3].$$

For the gamma target, the length l is a fraction of radiation length, $l \cong \frac{1}{2} X_0/\rho$,

$$Q \cong X_0 \times 1[MeV]$$

From the other hand $m = \rho \times 1[cm^2] \times \frac{X_0}{2\rho} = \frac{1}{2} X_0 \times 1[g],$

so the temperature gain goes to be

$$\Delta T \cong \frac{2}{c_V[J/g/^oK]}[^oK] \quad \left(\cong \frac{2A}{25[Mol/g/^oK] \cong const : (D-P\ law)} \right)$$

For Ti c_V=0.5 $J/g/^oK$; for W c_V=0.134 $J/g/^oK$; for Pb c_V=0.13 $J/g/^oK$,
So ratio of temperatures comes to

$$\Delta T_{Ti} : \Delta T_W : \Delta T_{Pb} \cong 1 : 3.7 : 3.8; \qquad (A_{Ti} : A_W : A_{Pb} \cong 47 : 183 : 207)$$

The ratio difference in temperature gain is not so drastic; however it is important if the temperature approaching the melting threshold.

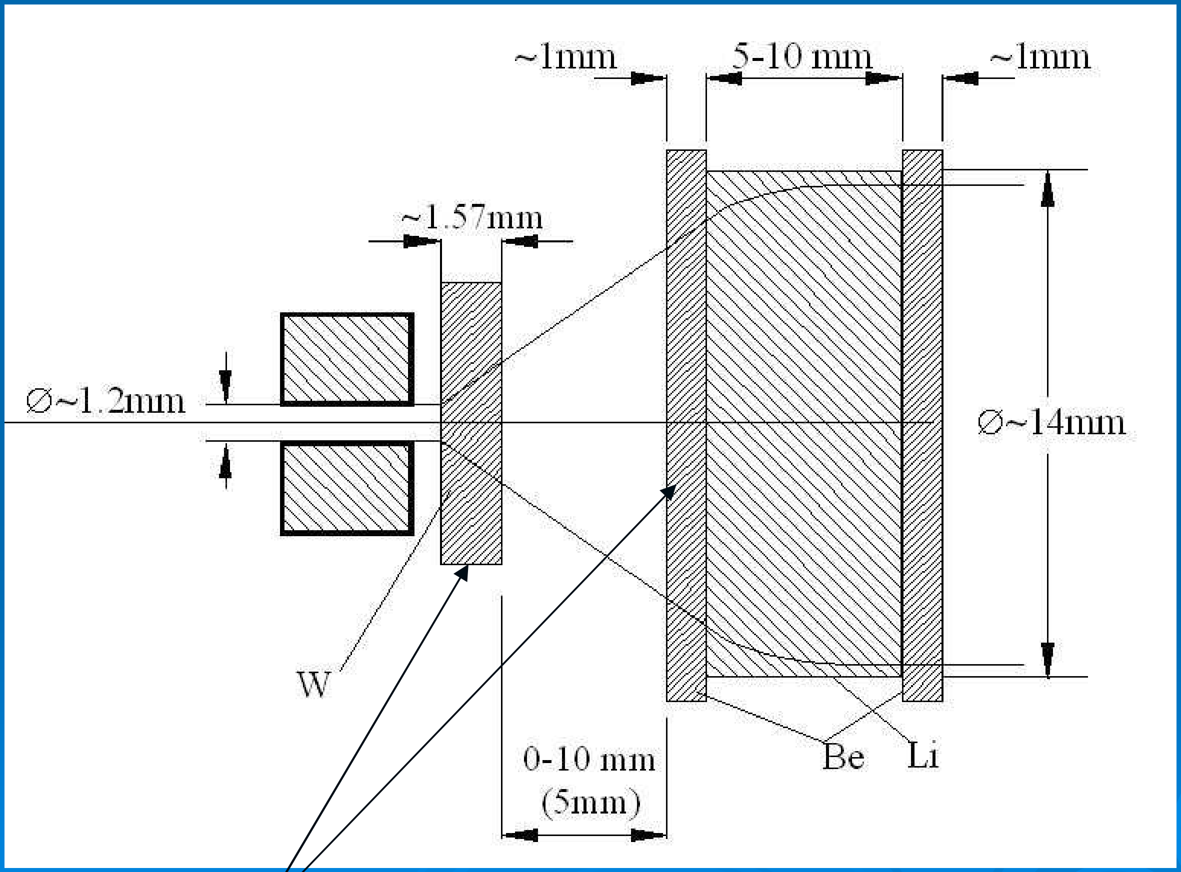
Usage of heavier targets desirable from the point of lowering of focal depth (~10 times) needed to be serviced by capturing optics, however. Also, the positron production efficiency is higher for heavier materials. All together this gives ~50% higher yield for W compared with Ti.

E-166 REJECTED Ti TARGET

KONN –Monte-Carlo code for positron production starting from undulator

KONN can calculate now the energy deposition and temperature rise in target and in Li lens at any point.

Distance between target and lens serves for enlargement the spot size on the entrance window



←Typical parameters

Target could be combined with entrance flange

Losses calculated with KONN compared with systematic calculations done with GEANT 3.21 by A.Dubrovin

M.Dubrovin," Energy Deposition in the Li Lens", Note on Nov 18, 2007,17pp.

GOOD AGREEMENT

Also with calculations with FLUKA:

S.Riemann, A.Schälicke, A.Ushakov, D.Andrienko, "Activation and Capture simulation", ILC Positron Source Collaboration Meeting", October 29, 2008, 16 pp.

Deposited Energy per Photon

Part	E [keV/ph]
Target	803.2
Be window (left)	11.6
Li	37.9
Be window (right)	6.5

$\langle E_{ph} \rangle$ = 10.4 MeV

Undulator Length = 131.6 m

Our numbers: $N\gamma tot$ =101

1.55 MeV/e (W)

1.44 MeV/e

1.61 MeV/e

1.05 MeV/e

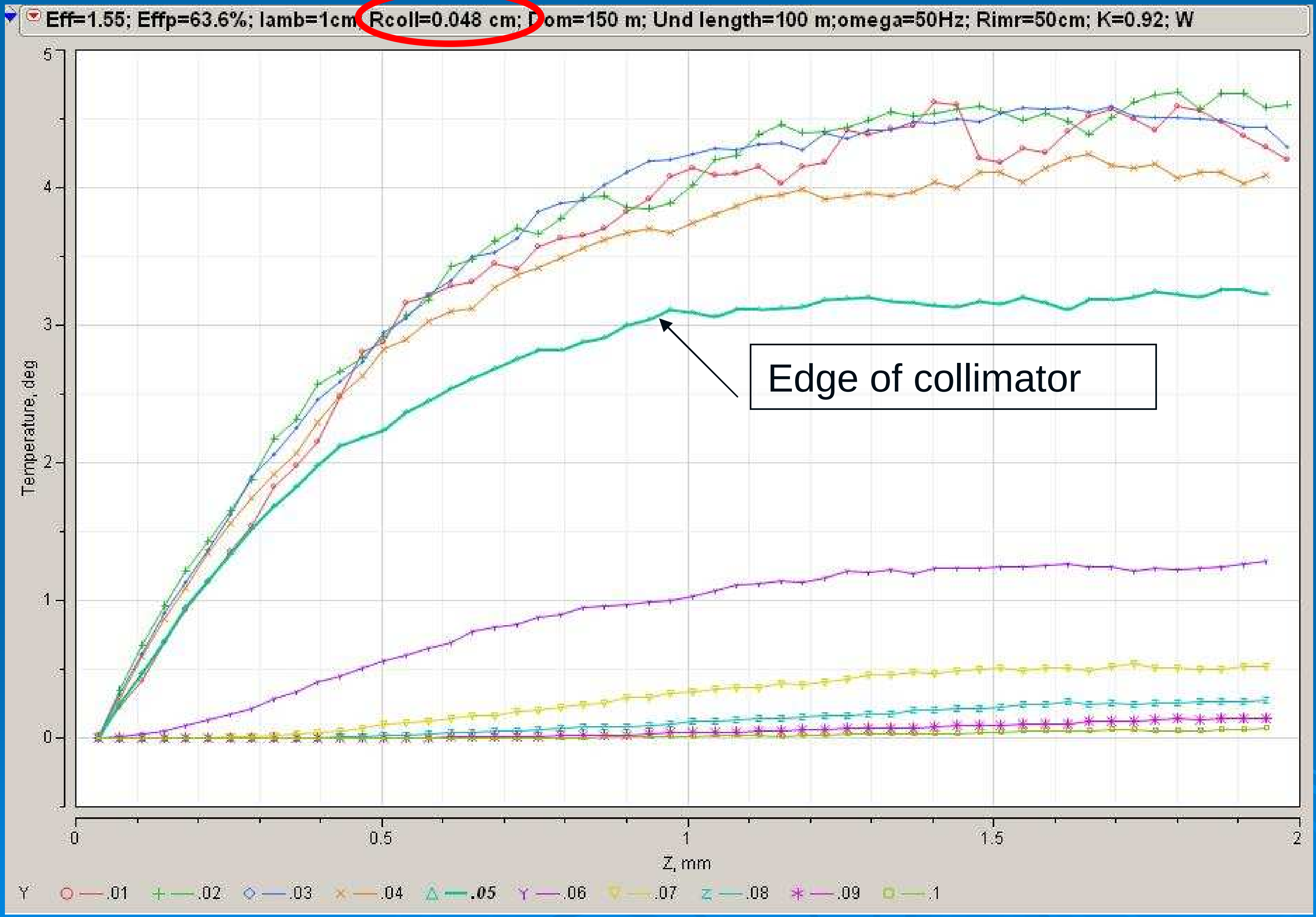
Also considering calculations with GEANT4:

W.Liu, W.Gai ,"Update on Be Window Thermal Issues", HEP, ANL, May 16,2007

In this publication the gamma beam only was considered; no cooling; Be survives ~20sec

TEMPERATURE ALONG THE **W** TARGET FOR DIFFERENT RADIUSES

per 10^{13} initial electrons



Each particle radiates 2.76 GeV in undulator

Rim W target;

R=50 cm

f=50 Hz

K=0.92

Eff=1.6

Effp=32%

Lund=35m

λ_u=1.15cm

Dis=300 m

G=45kG/cm

I=110kA

Rcoll=0.5cm

DISTRIBUTION OF TEMPERATURE IN TARGET T(R,Z) DEG PER 10^13 INITIAL ELECTRONS

DELTA R = .100 cm, DELTA Z = .003 cm

Collimator

R→

.008	.005	.002	.001	.000	.000	.000	.000	.000	.000
.300	.113	.030	.004	.000	.000	.000	.000	.000	.000
.581	.219	.051	.008	.000	.000	.000	.000	.000	.000
.840	.317	.068	.011	.001	.000	.000	.000	.000	.000
1.106	.416	.083	.010	.001	.000	.000	.000	.000	.000
1.408	.504	.097	.011	.001	.000	.000	.000	.000	.000
1.654	.579	.113	.013	.001	.000	.000	.000	.000	.000
1.858	.662	.122	.013	.001	.000	.000	.000	.000	.000
2.060	.749	.135	.014	.001	.000	.000	.000	.000	.000
2.276	.816	.143	.013	.002	.000	.000	.000	.000	.000
2.432	.886	.156	.014	.002	.000	.000	.000	.000	.000
2.616	.946	.158	.015	.002	.000	.000	.000	.000	.000
2.797	.997	.165	.015	.001	.000	.000	.000	.000	.000
2.874	1.051	.175	.016	.001	.000	.000	.000	.000	.000
3.001	1.118	.181	.016	.001	.000	.000	.000	.000	.000
3.053	1.167	.188	.018	.001	.000	.000	.000	.000	.000
3.240	1.220	.203	.019	.001	.000	.000	.000	.000	.000
3.322	1.276	.202	.018	.002	.000	.000	.000	.000	.000
3.428	1.303	.213	.019	.001	.000	.000	.000	.000	.000
3.532	1.385	.221	.018	.002	.000	.000	.000	.000	.000
3.581	1.416	.225	.018	.001	.000	.000	.000	.000	.000
3.649	1.431	.227	.019	.001	.000	.000	.000	.000	.000
3.732	1.483	.232	.018	.002	.000	.000	.000	.000	.000
3.807	1.479	.239	.019	.001	.000	.000	.000	.000	.000
3.788	1.511	.249	.022	.002	.000	.000	.000	.000	.000
3.845	1.534	.246	.021	.002	.000	.000	.000	.000	.000
3.901	1.562	.248	.020	.002	.000	.000	.000	.000	.000
3.984	1.590	.253	.021	.001	.000	.000	.000	.000	.000
3.966	1.643	.254	.020	.001	.000	.000	.000	.000	.000
4.029	1.636	.257	.019	.002	.000	.000	.000	.000	.000
4.089	1.699	.260	.019	.001	.000	.000	.000	.000	.000
4.131	1.712	.266	.021	.001	.000	.000	.000	.000	.000
4.220	1.738	.257	.021	.001	.000	.000	.000	.000	.000
4.261	1.731	.268	.021	.001	.000	.000	.000	.000	.000
4.267	1.743	.268	.021	.001	.000	.000	.000	.000	.000
4.219	1.748	.270	.020	.001	.000	.000	.000	.000	.000
4.278	1.750	.270	.024	.001	.000	.000	.000	.000	.000
4.308	1.769	.274	.022	.001	.000	.000	.000	.000	.000
4.334	1.773	.279	.021	.001	.000	.000	.000	.000	.000
4.315	1.808	.274	.024	.001	.000	.000	.000	.000	.000
4.342	1.824	.275	.025	.001	.000	.000	.000	.000	.000
4.307	1.830	.282	.024	.001	.000	.000	.000	.000	.000
4.440	1.850	.277	.025	.001	.000	.000	.000	.000	.000
4.406	1.847	.281	.024	.001	.000	.000	.000	.000	.000
4.435	1.864	.275	.024	.001	.000	.000	.000	.000	.000
4.421	1.865	.270	.024	.001	.000	.000	.000	.000	.000
4.424	1.893	.277	.023	.001	.000	.000	.000	.000	.000
4.394	1.912	.284	.022	.001	.000	.000	.000	.000	.000
4.452	1.929	.276	.023	.001	.000	.000	.000	.000	.000

Now the target is not spinning

DISTRIBUTION OF TEMPERATURE IN TARGET T(R,Z) DEG PER 10^13 INITIAL ELECTRONS

DELTA R = .100 cm, DELTA Z = .003 cm

Collimator

R→

.178	.111	.052	.012	.001	.001	.000	.000	.000	.000
6.306	2.380	.628	.076	.004	.001	.000	.000	.000	.000
12.211	4.606	1.062	.160	.009	.002	.000	.000	.000	.000
17.650	6.666	1.420	.233	.020	.001	.002	.000	.000	.000
23.229	8.744	1.735	.215	.022	.001	.001	.000	.000	.000
29.563	10.592	2.031	.237	.023	.000	.000	.000	.000	.000
34.737	12.165	2.363	.272	.025	.001	.000	.000	.000	.000
39.023	13.906	2.565	.268	.026	.001	.000	.000	.000	.000
43.268	15.722	2.833	.297	.025	.000	.000	.000	.000	.000
47.793	17.145	3.002	.270	.032	.000	.000	.000	.000	.000
51.077	18.602	3.274	.302	.033	.000	.000	.000	.000	.000
54.937	19.866	3.320	.311	.042	.000	.000	.000	.000	.000
58.733	20.944	3.455	.312	.028	.000	.000	.000	.000	.000
60.357	22.063	3.681	.329	.025	.000	.000	.000	.000	.000
63.027	23.468	3.808	.333	.029	.000	.000	.000	.000	.000
64.106	24.499	3.939	.378	.030	.000	.000	.000	.000	.000
68.045	25.610	4.259	.396	.025	.001	.000	.000	.000	.000
69.764	26.800	4.235	.379	.032	.000	.000	.000	.000	.000
71.979	27.366	4.476	.399	.026	.000	.000	.000	.000	.000
74.173	29.083	4.638	.378	.038	.000	.000	.000	.000	.000
75.208	29.744	4.727	.378	.022	.001	.000	.000	.000	.000
76.633	30.043	4.762	.397	.030	.000	.000	.000	.000	.000
78.364	31.152	4.869	.378	.032	.000	.000	.000	.000	.000
79.947	31.063	5.025	.399	.031	.000	.000	.000	.000	.000
79.545	31.740	5.219	.456	.038	.000	.000	.000	.000	.000
80.736	32.216	5.176	.448	.032	.000	.000	.000	.000	.000
81.911	32.812	5.205	.423	.033	.001	.000	.001	.000	.000
83.666	33.400	5.312	.440	.029	.000	.000	.000	.000	.000
83.296	34.506	5.341	.428	.030	.001	.000	.000	.000	.000
84.613	34.365	5.394	.392	.041	.000	.000	.000	.000	.000
85.876	35.674	5.450	.400	.030	.001	.000	.000	.000	.000
86.751	35.954	5.579	.432	.027	.000	.000	.000	.000	.000
88.622	36.495	5.402	.434	.025	.000	.000	.000	.000	.000
89.485	36.344	5.629	.440	.026	.001	.000	.000	.000	.000
89.609	36.608	5.621	.433	.022	.000	.000	.000	.000	.000
88.595	36.706	5.672	.429	.030	.001	.000	.000	.000	.000
89.832	36.755	5.675	.494	.026	.000	.000	.000	.000	.000
90.468	37.159	5.757	.472	.029	.001	.000	.000	.000	.000
91.011	37.239	5.867	.449	.026	.000	.000	.000	.000	.000
90.623	37.963	5.753	.507	.022	.000	.000	.000	.000	.000
91.176	38.300	5.777	.515	.026	.001	.000	.000	.000	.000
90.441	38.423	5.921	.494	.026	.000	.000	.000	.000	.000
93.246	38.856	5.822	.534	.028	.000	.000	.000	.000	.000
92.526	38.793	5.903	.513	.026	.000	.000	.000	.000	.000
93.128	39.141	5.767	.496	.018	.001	.000	.000	.000	.000
92.849	39.155	5.677	.498	.025	.000	.000	.000	.000	.000
92.913	39.756	5.822	.493	.018	.000	.000	.000	.000	.000
92.267	40.144	5.969	.467	.017	.001	.000	.000	.000	.000
93.494	40.505	5.786	.490	.020	.000	.000	.001	.000	.000

K=0.44; Eff=1.58; Effp=67%; Rcoll=0.06; Lamb=1cm;Lund=170m; 150 GeV
Each particle radiates 1.07 GeV in undulator

DISTRIBUTION OF TEMPERATURE IN TARGET T(R,Z) DEG PER 10^13 INITIAL ELECTRONS

DELTA R = .012 cm, DELTA Z = .003 cm

R→

.000	.002	.005	.005	.002	.001	.000	.000	.001	.000
.365	.276	.205	.168	.110	.003	.000	.002	.000	.000
.630	.589	.400	.335	.208	.009	.000	.000	.000	.000
.804	.866	.643	.526	.347	.015	.000	.000	.000	.000
.996	1.144	.844	.708	.439	.023	.000	.000	.000	.000
1.350	1.308	1.092	.853	.550	.041	.000	.000	.000	.000
1.756	1.601	1.381	1.003	.631	.059	.000	.000	.000	.000
2.041	1.888	1.566	1.090	.720	.083	.001	.000	.000	.000
2.200	2.169	1.756	1.234	.826	.100	.002	.000	.000	.000
2.539	2.410	1.884	1.418	.882	.131	.004	.000	.000	.000
2.765	2.504	2.116	1.522	.970	.164	.006	.000	.000	.000
2.889	2.745	2.174	1.598	1.046	.184	.011	.000	.000	.000
3.405	2.935	2.336	1.676	1.141	.215	.014	.001	.000	.000
3.445	3.031	2.486	1.734	1.180	.221	.019	.003	.000	.000
3.630	3.099	2.709	1.879	1.282	.255	.024	.003	.000	.000
3.804	3.366	2.830	2.012	1.255	.304	.036	.001	.001	.000
3.820	3.389	2.844	2.121	1.300	.313	.042	.002	.001	.000
3.997	3.618	2.998	2.189	1.402	.311	.060	.005	.001	.000
3.872	3.878	3.013	2.248	1.475	.331	.075	.008	.001	.001
4.001	4.074	3.173	2.340	1.531	.363	.068	.012	.000	.000
4.115	4.137	3.271	2.485	1.543	.398	.076	.016	.001	.000
4.245	4.110	3.366	2.621	1.583	.453	.078	.024	.003	.000
4.678	4.128	3.461	2.563	1.694	.481	.086	.023	.005	.000
4.814	4.149	3.584	2.633	1.698	.524	.097	.018	.007	.000
4.803	4.301	3.690	2.614	1.685	.543	.117	.026	.006	.000
5.067	4.599	3.619	2.682	1.803	.547	.138	.026	.007	.001
4.838	4.644	3.660	2.743	1.800	.569	.141	.039	.005	.003
4.777	4.696	3.764	2.846	1.845	.586	.164	.045	.008	.003
4.601	4.571	3.884	2.951	1.909	.586	.174	.046	.010	.004
4.773	4.570	3.850	2.987	1.909	.587	.209	.050	.012	.004
4.615	4.601	3.955	2.980	1.953	.589	.199	.048	.017	.006
4.778	4.607	3.991	3.097	1.988	.620	.206	.060	.023	.005
4.536	4.546	4.049	3.020	1.992	.649	.197	.071	.022	.008
4.564	4.695	3.976	3.130	1.944	.660	.216	.072	.021	.010
4.549	4.763	3.918	3.164	2.030	.673	.210	.075	.025	.009
4.406	4.773	3.948	3.052	2.070	.699	.220	.089	.027	.008
4.793	4.688	3.979	3.063	2.068	.706	.237	.082	.026	.009
4.798	4.726	3.949	3.037	2.084	.711	.239	.086	.033	.008
4.836	4.790	4.093	3.101	2.086	.749	.245	.096	.038	.011
4.715	4.577	4.049	3.134	2.072	.750	.252	.093	.037	.009
4.563	4.692	4.043	3.169	2.004	.749	.286	.097	.034	.013
4.610	4.854	4.076	3.145	2.051	.787	.286	.107	.037	.017
4.703	4.731	4.053	3.276	2.035	.765	.277	.117	.044	.011
4.918	4.692	4.151	3.213	2.095	.777	.282	.130	.043	.012
5.080	4.635	4.091	3.223	2.105	.809	.307	.135	.043	.015
4.997	4.797	4.176	3.189	2.117	.798	.326	.140	.041	.017
4.898	4.821	4.066	3.165	2.101	.792	.296	.133	.046	.021
4.679	4.969	4.171	3.156	2.094	.762	.319	.132	.053	.021
4.523	5.009	4.138	3.187	2.137	.782	.319	.123	.063	.020
4.538	4.797	4.185	3.277	2.138	.764	.316	.131	.064	.024
4.531	5.012	4.166	3.228	2.116	.781	.319	.142	.062	.022
4.705	4.771	4.190	3.206	2.133	.786	.308	.146	.058	.023
5.104	4.749	4.259	3.182	2.099	.788	.312	.134	.059	.024
5.189	4.636	4.317	3.128	2.129	.817	.313	.134	.063	.023
5.185	4.620	4.330	3.140	2.153	.825	.303	.138	.057	.028
5.079	4.663	4.286	3.128	2.091	.823	.322	.134	.061	.029

Moving target

DISTRIBUTION OF TEMPERATURE IN TARGET T(R,Z) DEG PER 10^13 INITIAL ELECTRONS

DELTA R = .012 cm, DELTA Z = .003 cm

R→

.000	.366	.891	.766	.294	.231	.000	.000	.110	.000
61.159	46.252	34.342	28.174	18.390	.567	.000	.275	.000	.000
105.617	98.783	67.078	56.238	34.923	1.450	.000	.000	.000	.000
134.738	145.274	107.852	88.149	58.141	2.573	.025	.000	.000	.050
166.932	191.743	141.460	118.791	73.655	3.934	.000	.000	.000	.000
226.272	219.360	183.026	143.001	92.135	6.916	.000	.070	.000	.000
294.366	268.408	231.499	168.095	105.857	9.946	.000	.000	.000	.000
342.125	316.534	262.530	182.721	120.720	13.948	.231	.000	.000	.000
368.868	363.671	294.349	206.862	138.410	16.831	.295	.000	.000	.000
425.653	404.083	315.942	237.827	147.805	22.008	.662	.000	.046	.000
463.673	419.850	354.846	255.157	162.570	27.548	1.023	.000	.000	.000
484.464	460.318	364.562	267.948	175.372	30.790	1.784	.000	.000	.000
570.879	492.064	391.750	280.971	191.264	36.087	2.275	.246	.000	.000
577.650	508.118	416.767	290.663	197.778	37.072	3.208	.565	.000	.000
608.652	519.617	454.206	314.976	214.973	42.696	4.064	.570	.000	.000
637.811	564.410	474.500	337.353	210.375	50.997	6.041	.131	.123	.000
640.545	568.291	476.761	355.608	218.024	52.550	7.114	.349	.242	.000
670.182	606.625	502.650	367.037	235.150	52.199	10.080	.839	.119	.000
649.275	650.198	505.209	376.906	247.331	55.479	12.514	1.405	.182	.105
670.760	683.094	532.002	392.349	256.708	60.871	11.425	2.056	.054	.000
689.872	693.557	548.392	416.580	258.708	66.692	12.724	2.675	.251	.000
711.817	689.077	564.338	439.400	265.416	75.893	13.020	4.029	.506	.000
784.330	692.138	580.342	429.650	284.009	80.706	14.401	3.933	.756	.000
807.120	695.661	600.961	441.406	284.761	87.820	16.322	3.081	1.119	.000
805.369	721.066	618.735	438.359	282.589	91.042	19.697	4.382	1.046	.000
849.548	771.024	606.704	449.717	302.273	91.773	23.204	4.288	1.116	.221
811.220	778.575	613.700	459.937	301.816	95.389	23.658	6.522	.875	.459
800.987	787.428	631.179	477.260	309.269	98.307	27.423	7.545	1.324	.502
771.494	766.389	651.142	494.839	320.040	98.310	29.215	7.787	1.658	.727
800.309	766.280	645.544	500.830	320.038	98.435	35.071	8.403	2.057	.715
773.733	771.435	663.186	499.719	327.486	98.805	33.397	8.063	2.785	.939
801.143	772.357	669.241	519.308	333.390	103.875	34.529	10.058	3.871	.858
760.605	762.134	678.826	506.274	333.931	108.824	33.058	11.834	3.699	1.287
765.209	787.192	666.652	524.772	325.880	110.589	36.224	12.129	3.596	1.695
762.684	798.661	656.898	530.469	340.428	112.829	35.192	12.593	4.199	1.521
738.784	800.192	661.873	511.769	347.102	117.257	36.807	14.967	4.447	1.385
803.648	786.068	667.198	513.551	346.693	118.341	39.750	13.728	4.368	1.527
804.455	792.443	662.102	509.171	349.473	119.208	40.148	14.402	5.610	1.337
810.827	803.191	686.244	520.007	349.774	125.541	41.145	16.020	6.394	1.836
790.541	767.371	678.829	525.540	347.476	125.695	42.285	15.628	6.230	1.579
765.124	786.768	677.815	531.287	335.965	125.630	48.003	16.346	5.715	2.203
772.885	813.800	683.430	527.345	343.876	132.009	47.986	17.887	6.214	2.796
788.617	793.229	679.595	549.286	341.152	128.322	46.447	19.619	7.306	1.768
824.523	786.624	695.988	538.730	351.329	130.290	47.276	21.816	7.198	1.981
851.787	777.160	685.842	540.311	352.949	135.594	51.520	22.700	7.206	2.435
837.876	804.250	700.175	534.671	354.944	133.738	54.654	23.493	6.908	2.825
821.201	808.332	681.701	530.736	352.325	132.775	49.629	22.237	7.706	3.438
784.468	833.114	699.302	529.240	351.133	127.829	53.541	22.193	8.837	3.468
758.353	839.836	693.726	534.303	358.301	131.182	53.518	20.638	10.598	3.311
760.916	804.293	701.618	549.469	358.503	128.069	53.013	21.894	10.654	4.053
759.666	840.416	698.492	541.247	354.832	130.926	53.415	23.809	10.373	3.694
788.896	799.929	702.600	537.479	357.705	131.744	51.558	24.539	9.651	3.926
855.792	796.170	714.141	533.448	351.962	132.154	52.366	22.490	9.896	3.961
869.960	777.358	723.870	524.532	356.965	137.057	52.398	22.537	10.522	3.891
869.400	774.687	725.933	526.515	361.019	138.362	50.765	23.213	9.591	4.755
851.572	781.763	718.550	524.466	350.632	137.991	53.952	22.394	10.235	4.802

Stationary target

Temperature in lens

K=0.92; λ=1.15; Eff=1.6; Effp=32%; Undulator length=35m; Distance to target=300m

DISTRIBUTION OF TEMPERATURE IN LENS T(R,Z) DEG PER 10^13 INITIAL ELECTRONS

DELTA R = .070 cm, DELTA Z = .050 cm, PHOTONS GENERATED = 76991

→ R

Be entr.	39.396	23.757	16.011	11.015	6.154	3.953	2.325	1.351	.861	.275
	38.128	22.818	15.563	10.848	6.569	4.287	2.792	1.669	1.254	.433
Li	15.000	9.208	6.263	4.499	2.633	1.745	1.173	.689	.425	.162
	14.017	8.512	6.076	4.383	2.648	1.802	1.217	.795	.492	.197
	13.356	7.904	5.805	4.219	2.664	1.849	1.276	.875	.568	.198
	12.685	7.414	5.488	4.143	2.651	1.842	1.333	.948	.609	.205
	12.128	6.922	5.273	4.042	2.591	1.882	1.314	.968	.652	.221
	11.566	6.518	5.049	3.814	2.604	1.856	1.315	.959	.663	.221
	11.103	6.203	4.873	3.616	2.603	1.802	1.297	.904	.709	.213
	10.406	6.081	4.592	3.504	2.588	1.751	1.305	.913	.663	.226
	9.889	5.853	4.370	3.399	2.467	1.774	1.240	.915	.659	.224
	9.733	5.852	4.353	3.523	2.629	1.944	1.376	1.030	.738	.238
Be exit	19.89	12.03	9.07	6.89	4.98	3.58	2.46	1.72	1.25	.40
	20.17	12.17	9.15	6.93	5.04	3.76	2.65	1.84	1.42	.48

NEW TYPE OF COMMUTATORS FOR HIGH CURRENT

Fig.2. Reverse – switched dinistors for peak current from 200 kA to 500 kA and blocking voltage of 2400 V, encapsullated in hermetic metal – ceramic housing and without housing (RSD sizes of 64, 76, and 100 mm)

S.A. Belyaev, V.G.Bezuglov, V.V.Chibirikin, G.D.CHumakov, I.V.Galakhov, S.G.Garanin, S.V.Grigorovich, M.I.Kinzibaev, A.A.Khapugin, E.A.Kopelovich, F.A.Flar, O.V.Frolov, S.L.Logutenko, V.A.Martynenko, V.M.Murugov, V.A.Osin, I.N.Pegoev, V.I.Zolotovski, "*New Generation of High-Power Semiconductor Closing Switches for Puled Power Applications*", 28 ICPIG, July 15-20, 2007, Prague, Czech Republic, Topic#17, pp.1525-1528.

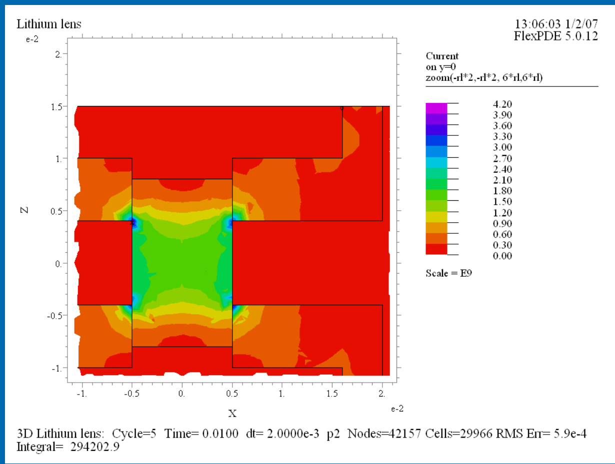
General parameters	
Energy of primary beam	~150 GeV-350GeV
Undulator period λ	10-12 mm
K factor, $K = eH\lambda / 2\pi / mc^2$	0.4-1
Undulator length	$\leq$ 200 m
Efficiency , e^+ / e^-	$\geq$ 1.5
Polarization	$\geq$ 65%
Target W/Ti	1.75 mm/14.8 mm
Energy of quanta	~9-20 MeV
Distance to the target	100-300 m
Lens	
Feeding current, *I*	<150 kA
Field at surface, H_m	43 kG
Gradient	$\leq$ 62kG/cm
Pulsed power	~200kW
Average power	~4kW
Pulsed duty , τ	<4msec
Lens diameter, 2*a*	1 cm
Length, *L*	0.5-1 cm**
Axial pressure, P_0	74atm (for *L*=0.5cm)
Temperature gain per train	$\leq$ 170°C at 150kA

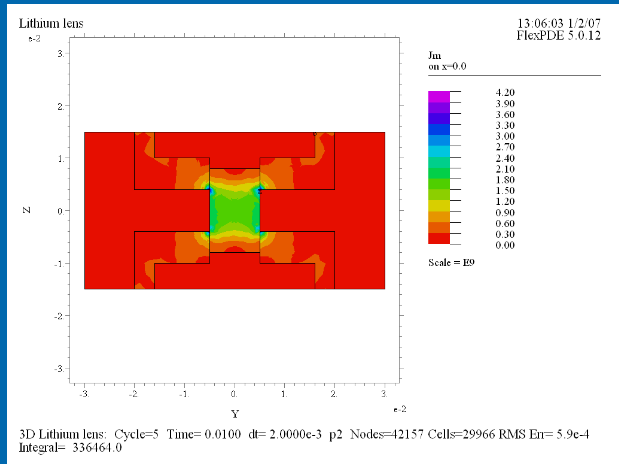
SUMMARY

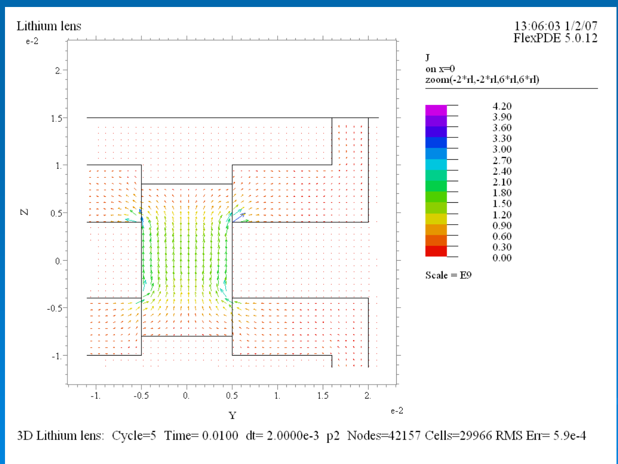
- In KONN, to efficiency calculations, added the possibility to calculate losses and temperature gain normalized to initial electron beam population.
- With KONN there were calculated conversion scenarios at 150, 250, 350 GeV with K=0.29–0.92 including thermal effects; at every energy, efficiency ≥1.5, Pol >65% obtained.
- General conclusion is that spinning Tungsten target survives irradiation in all scenarios including K=0.92 .
- Finished design of Li lens;
  it allows easy exchange of windows,
  lens position in housing could be adjusted with respect to the target and acceleration structure .
- Tungsten target could be combined with the entrance window of Lithium lens.
- All necessary preparations done for further modeling of dynamic heating processes such as shock waves, cyclic expansions, Li flow etc.
- New round of optimizations with thermal effects will be done
- Solenoidal lens will be implemented in KONN also

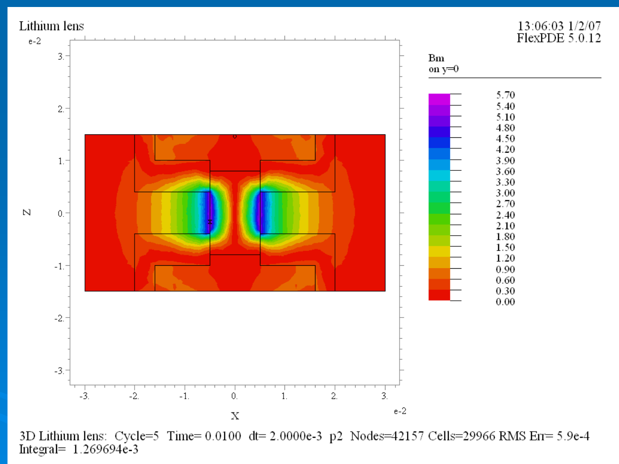
Backup slides

Recent calculation of Lithium lens done with FlexPDE© code at Cornell



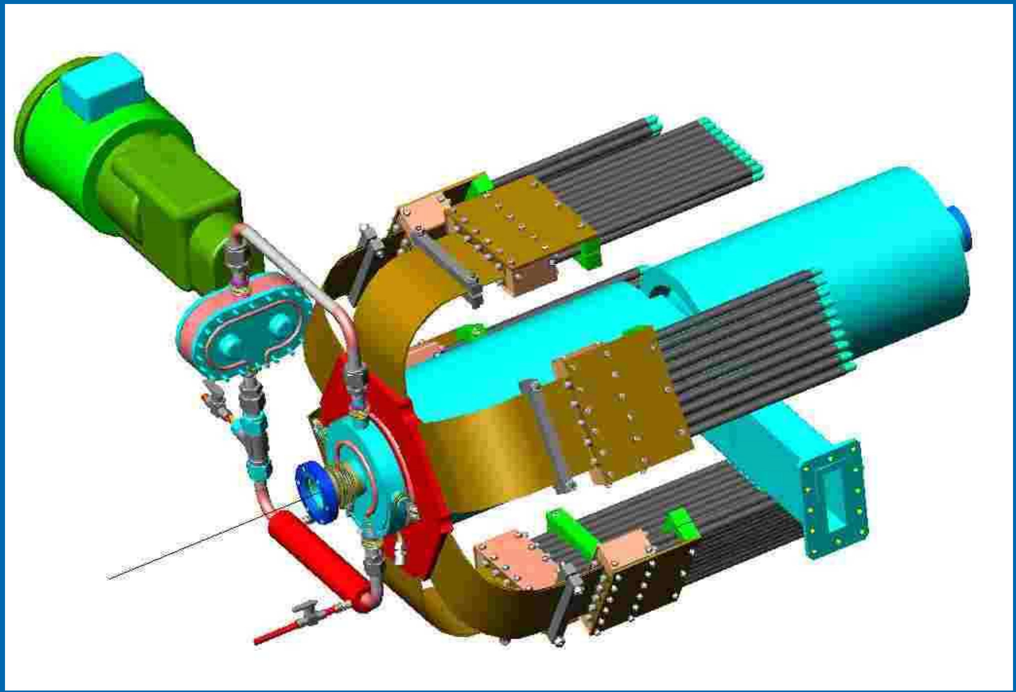






Time dependent 3D calculations

Li lens can be used with any target: liquid metal (Pb-Bi, Hg) or Ti rim



Right after the target located Aluminum made accelerating structure immersed in solenoidal magnetic field.

Sectioned solenoid wound with Al conductor. Sections supplied with reversed polarities