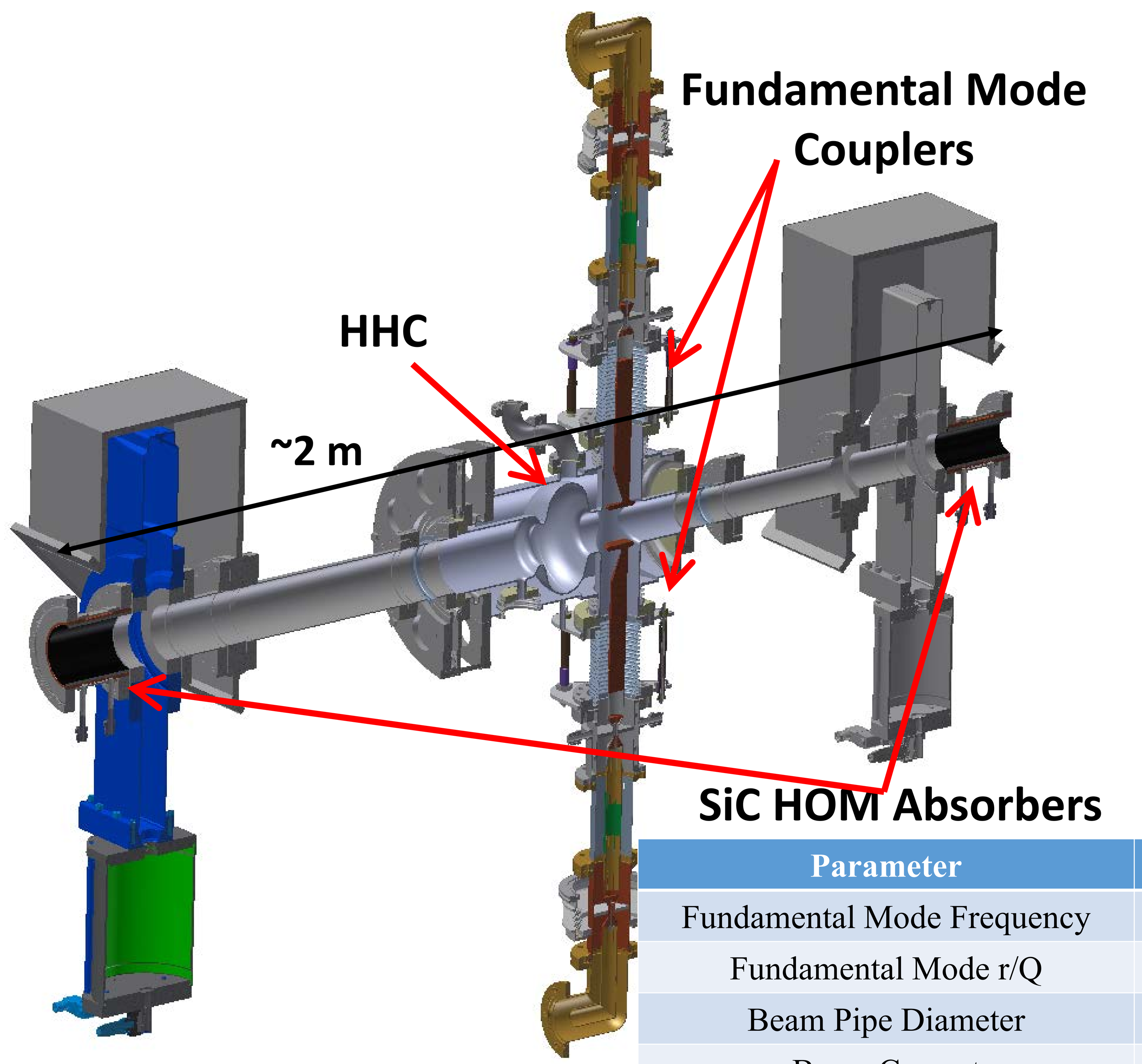
THPB072

HIGHER ORDER MODE DAMPING IN A HIGHER HARMONIC CAVITY FOR THE ADVANCED PHOTON SOURCE UPGRADE*

S.H. Kim#, M.P. Kelly, Z.A. Conway, B. Mustapha, G. Waldschmidt, P.N. Ostroumov, J. Carwardine, G. Decker
ANL, Argonne, IL 60439, USA

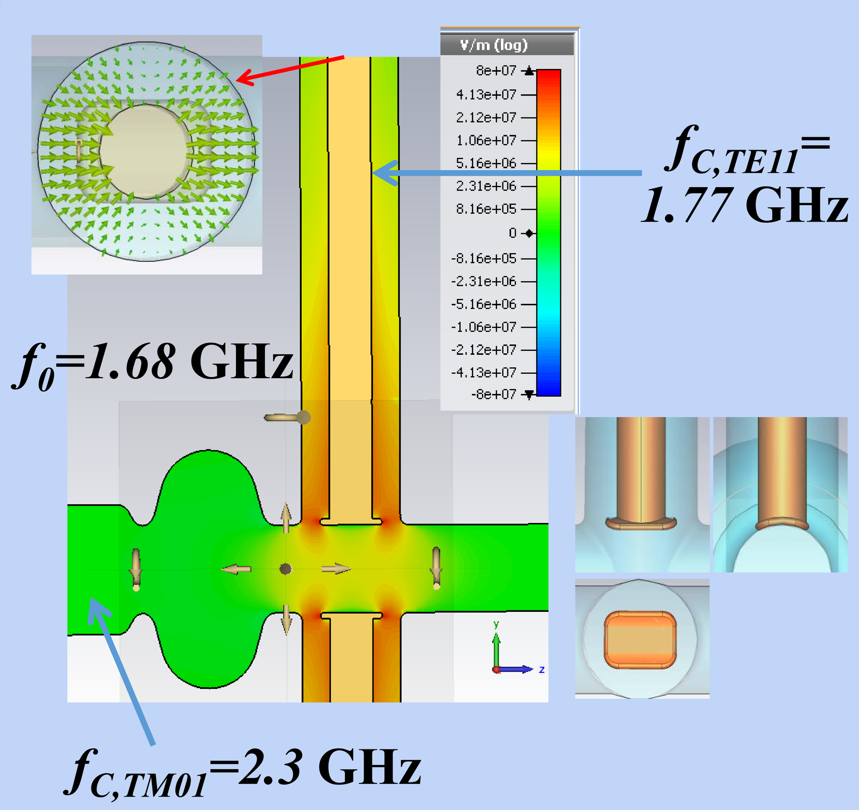
A superconducting higher-harmonic cavity (HHC) is under development for the Advanced Photon Source Upgrade based on a Multi-Bend Achromat lattice. This cavity will be used to improve the Touschek lifetime and the single bunch current limit by lengthening the beam. A single-cell 1.4 GHz (the 4th harmonic of the main RF) cavity is designed based on the TESLA shape. Two adjustable fundamental mode power couplers are included. The harmonic cavity voltage of 0.84 MV will be driven by the 200 mA beam. The RMS bunch length with the harmonic cavity will be >50 ps. Higher-order modes (HOM) must be extracted and damped. This will be done with two silicon carbide beamline HOM absorbers to minimize heating of RF structures such as the superconducting cavity and/or couplers and suppress possible beam instabilities. The HHC system is designed such that 1) most monopole and dipole HOMs are extracted along the beam pipes and damped in the 'beamline' silicon carbide absorbers and 2) a few HOMs, resulting from introduction of the couplers, are extracted through the coupler and dissipated in a room temperature water-cooled load. We will present time and frequency domain simulation results and discuss damping of HOMs.



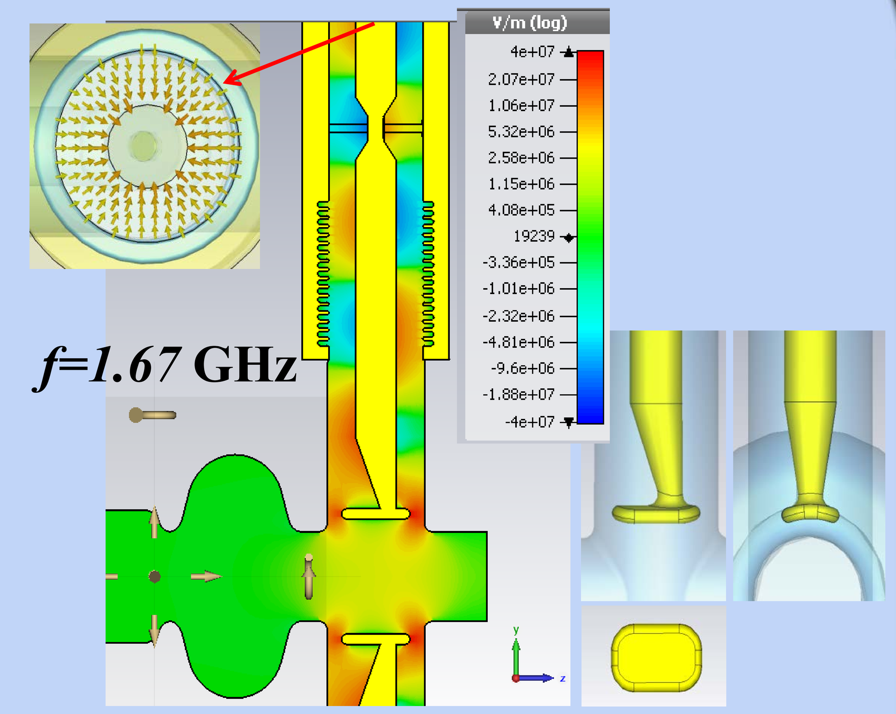
Parameter	Value
Fundamental Mode Frequency	1.408 GHz
Fundamental Mode r/Q	109 Ohm
Beam Pipe Diameter	104/70 mm
Beam Current	200 mA
Number of Bunches	48/324
Bunch Charge	15.3/2.2 nC
Bunch Repetition Rate	13/88 MHz
Bunch Length	>50 ps

FM Coupler Antenna

(a) Initial Design

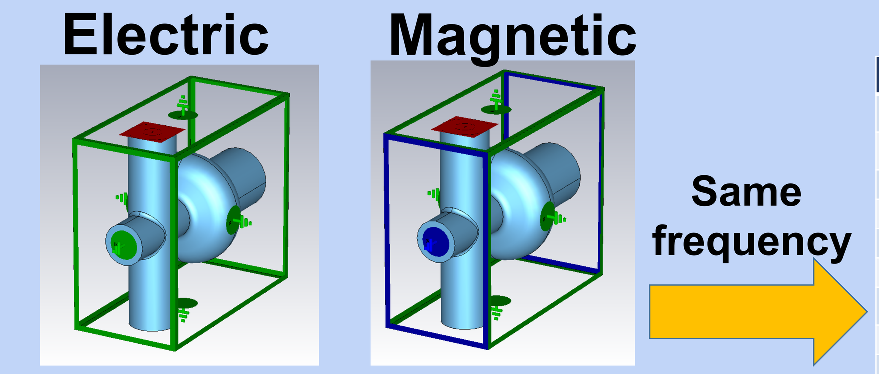


(b) Modified Design

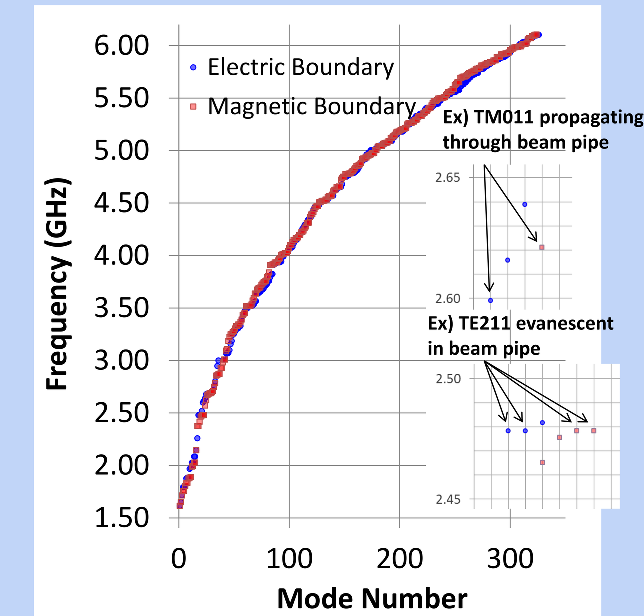


- Fundamental mode coupler: OD 3-1/8", 50 Ω
- The first TE11-like mode in the coaxial coupler is trapped around the coupler tip as shown in the initial design (a)
- A new antenna (b) is invented. The asymmetric conical transition allows this mode to be converted to the TEM mode such that it propagates along the rest of the coupler and be damped in the coaxial load.

Search for Trapped Mode



f (GHz)	Mode	f (GHz)	Mode
1.72	**C/BP TE111x-like**	4.52	CAV TM510
2.03	**C/BP TE111y-like**	4.53	CAV TE611
2.14	C/BP TE011-like	4.75	CAV TM411
2.48	CAV TE211	**4.78**	**CAV TE131**
2.69	CAV TM210	5.00	CAV TE412
2.70	CAV TE011	5.04	CAV TE711
2.71	**C/BP TE111y-like**	5.09	CAV TM610
2.75	C/BP TE011-like	5.18	CAV TE421
2.86	**C/BP TE121x-like**	5.33	CAV TM511
3.01	CAV TE311	5.41	CAV TM420
3.28	**C/BP TM011-like**	5.48	CAV TE231
3.33	CAV TM310	5.50	CAV TM512
3.52	CAV TE411	5.56	CAV TE811
3.64	**CAV TM120**	5.65	CAV TM710
3.93	CAV TE221	**5.86**	**CAV TE132**
3.93	CAV TM410	5.89	CAV TM611
4.02	CAV TE511	5.99	CAV TE612
4.15	CAV TM311	6.01	CAV TM520
4.47	CAV TE312	6.07	CAV TE911
4.51	C/BP TE013x-like	6.10	CAV TM421



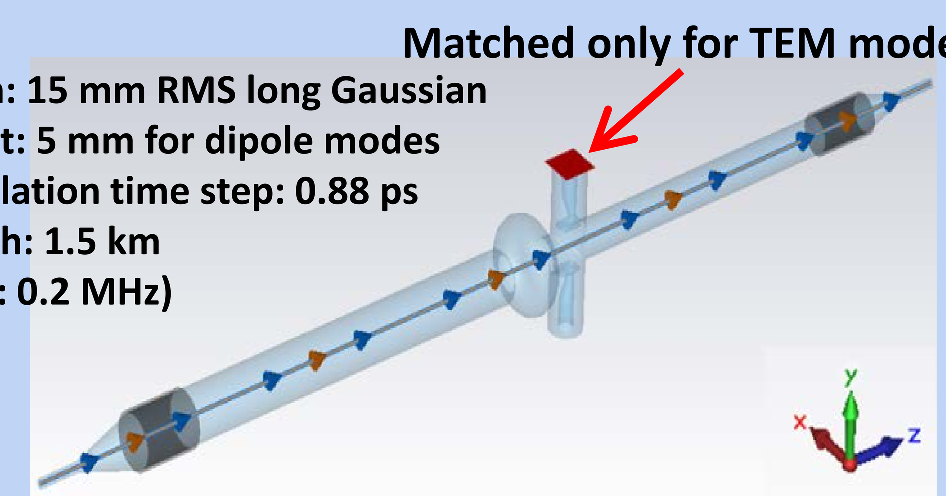
Checked with the full model

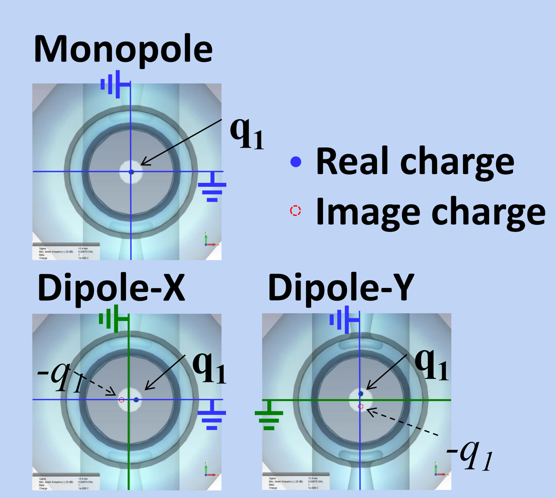
f (GHz)	Q_L	Z_{0L} (Ohm), Z_{1T} (Ohm/m),	Remark
3.284	3.0E+02	6.3E+00	C/BP TM011-like
1.736	5.6E+03	1.3E+05	C/BP TE111-like
2.162	3.4E+03	1.6E+03	C/BP TE111-like
2.71			C/BP TE111y-like, strongly damped
2.86			C/BP TE121x-like, strongly damped
3.636	1.3E+03	3.2E+03	CAV TM120
4.782	5.5E+03	5.8E+03	CAV TE131
5.172	5.6E+02	3.2E+03	CAV TE132+BP
5.186	3.8E+02	4.6E+02	CAV TE132+BP

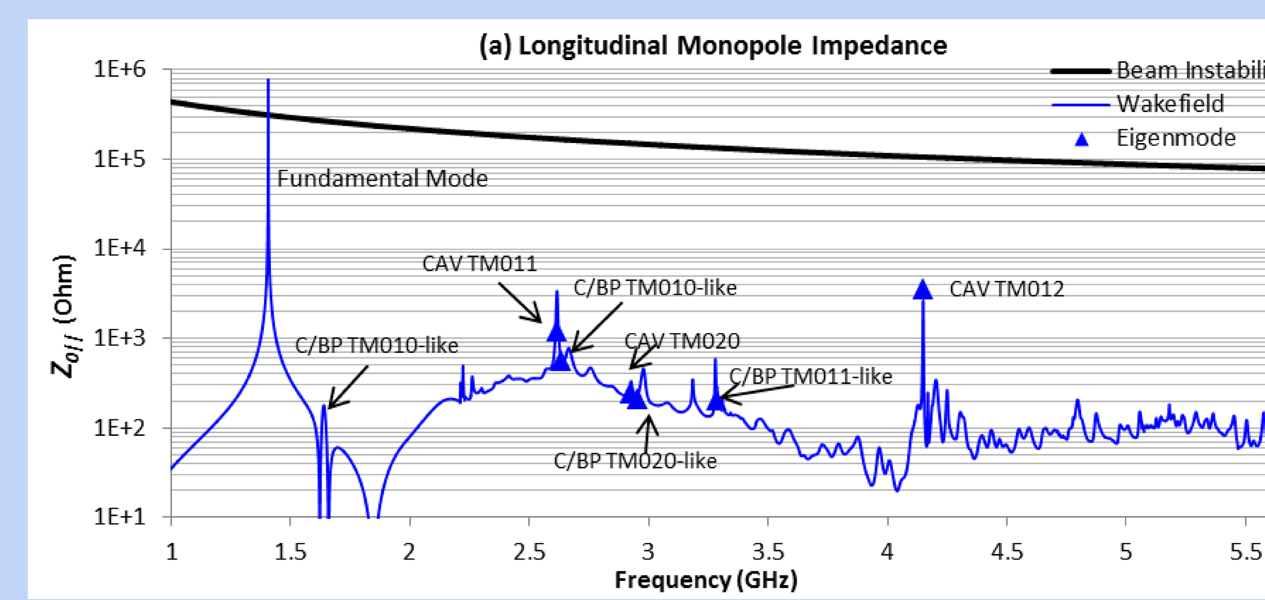
- No trapped modes were found with the new antenna

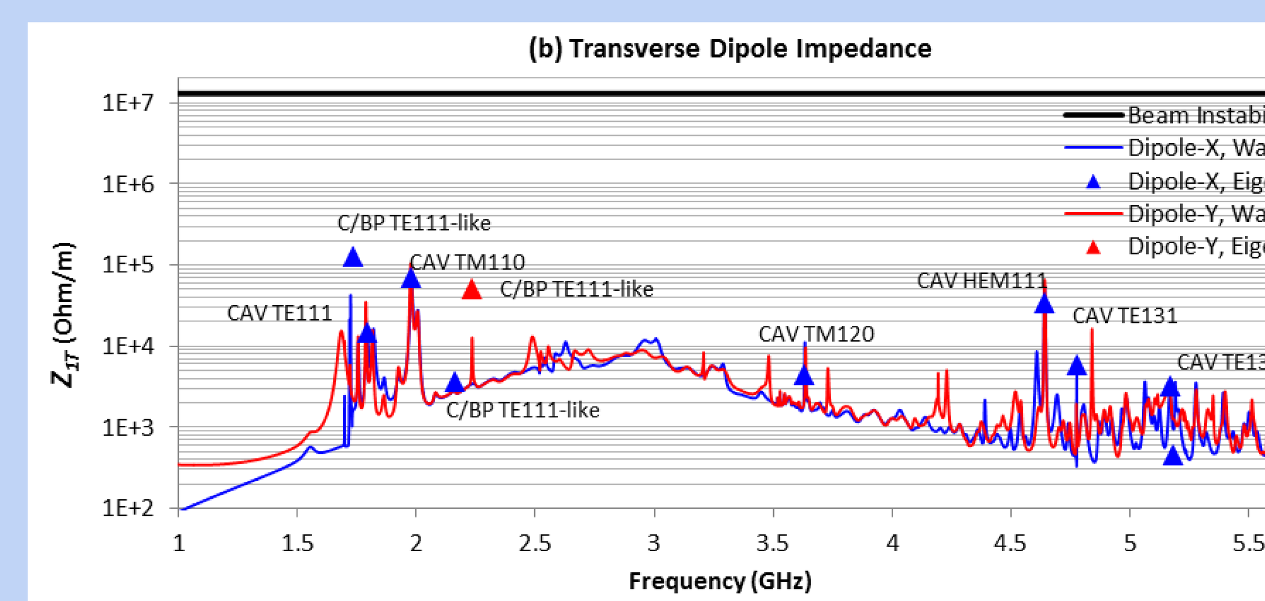
Wake Impedance and Power Loss

Drive beam: 15 mm RMS long Gaussian
Beam offset: 5 mm for dipole modes
Wake calculation time step: 0.88 ps
Wake length: 1.5 km
(resolution: 0.2 MHz)









- Monopole and dipole modes including coupler modes are well damped such that peak impedances are ~2 orders of magnitude lower than the beam instability limit.
- The broadband resonance between 2 and 4 GHz due to the silicon carbide ring helps stronger damping in this range.
- Loss power is estimated to be 1.7 kW. ~35% is due to the cavity and coupler HOMs; the rest is due to direct interaction between the beam and HOM absorbers.

- Results in this report are derived from work performed at Argonne National Laboratory. Argonne is operated by UChicago Argonne, LLC, for the U.S. Department of Energy under contract DE-AC02-06CH11357.
shkim121@anl.gov

Argonne NATIONAL LABORATORY
U.S. DEPARTMENT OF ENERGY