http://www.cockcroft.ac.uk/events/cavity/

Workshop Summary

Peter McIntosh (STFC)

Outline

- Participation
- Programme
- Highlights Since Shanghai Mini-Workshop 2008
- Direction for Crabbing/Deflecting Cavity Applications
- The Next ICFA Mini-Workshop

Participation

STFC	9
ANL	5
Lancaster University	5
Shakespeare Engineering	3
CERN	2
JLAB	2
Manchester University	2
SLAC	2
Tech-X (UK)	2
BNL	1
FNAL	1
INR	1
JAI	1
JASRI	1
KEK	1
LBNL	1
Liverpool University	1
ODU	1
Total	**41**

- Original Mini-Workshop scheduled for 21 – 23 April 2010.
- Cancelled due to volcanic ash cloud disruption.
- Originally had 44 registrants for April event.
- Predominantly the same programme remained.

Programme (Wednesday)

Wednesday, September 1, 2010			
Plenary session I (Chair: Peter McIntosh)			
8:30 AM	Registration		
9:00 AM	Welcome	Swapan Chattophadhay	CI
9:15 AM	Program overview and local logistics	Peter McIntosh	DL
9:30 AM	New type of a bunch compressor and generation of a short wavelength coherent radiation	Vadim Sajeev	ANL
10:00 AM	Science of short pulse X-rays in Synchrotron Light Sources	Yuelin Li	ANL
10:30 AM	Coffee break		
Plenary session II (Chair: Ali Nassiri)			
11:00 AM	KEK-B Operational Experience with Crab Cavities	Yoshihiro Funakoshi	KEK
11:30 AM	Motivation and CERN Strategy for Crab Cavities	Ed Ciapala	CERN
12:00 PM	Beam Dynamics of Chirp Scheme in Storage Rings	Louis Emery	ANL
12:30 PM	EUCARD Collaboration Crab Cavity Research	Peter McIntosh	DL
1:00 PM	Lunch (with Tech-X Seminar)		
Working Group Session (Chair: Louis Emery)			
2:00 PM	Working Group Charges	Ali Nassiri	ANL
Working Group 1: Cavity-Beam Interactions			
2:15 PM	LHC Luminosity Upgrade Using Deflecting/Crabbing Cavities	Rama Calaga	BNL
2:45 PM	Deflecting rf cavity for emittance exchange experiment @ ANL	Jiaru Shi	CERN
3:15 PM	Coffee break		
3:45 PM	Emittance exchange experiement @FNAL and its applications	Yin-e Sun	FNAL
4:15 PM	Short Pulse X-ray (SPX) Project at APS	Ali Nasiri	ANL
5:30 PM	Shuttle to hotels		

Programme (Thursday)

Thursday, September 2, 2010			
Working Group 2: Cavity and coupler design studies (Convenor: Rama Calaga)			
9:00 AM	Dielectric Loaded Waveguide as a deflecting cavity	Bob Kustom	ANL
9:30 AM	X-band Deflectors	Valery Dolgashev	SLAC
10:00 AM	Experimental studies for ILC and CLIC crab systems	Amos Dexter	CI
10:30 AM	Coffee break		
Working Group 2: Cavity and coupler design studies (Convenor: Robert Rimmer)			
11:00 AM	Deflecting structures development for XFEL and PITZ TDS	Valentin Paramanov	BINP
11:30 AM	Compact half-wave resonator crab cavity for the LHC upgrade	Zenghai Li	SLAC
12:00 PM	Deflecting cavities @ SPring8	Toshiharu Nakazato	Spring-8
12:30 PM	CLIC Crab Cavities	Praveen Ambattu	CI
1:00 PM	Lunch		
Working Group 2: Cavity and coupler design studies (Convenor: Toshiharu Nakazato)			
2:00 PM	Particularities of normal conducting L-band deflecting cavities	Valentin Paramanov	BINP
2:30 PM	SRF 4-rod Deflecting Cavities	Graeme Burt	CI
3:00 PM	Deflecting Cavity Development for Project-X (Webex)	Nikolay Solyak	FNAL
3:30 PM	Coffee break		
4:00 PM			
4:30 PM	ALICE and SRF Infrastructure Tour		
5:00 PM			
5:30 PM	Shuttle to hotels		
7:30 PM	**Workshop Dinner (Peckforton Castle, Chester)**		

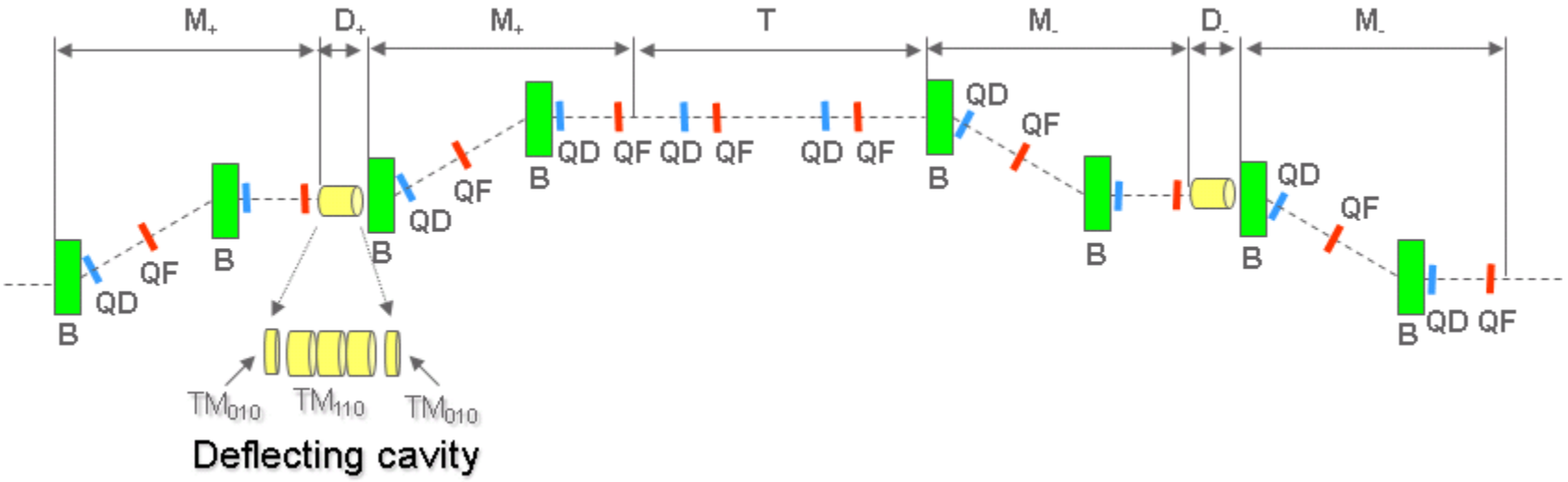
Programme (Friday)

Friday, September 3, 2010			
Working Group 1: Cavity-Beam Interactions (Convenor: Steven Jamison)			
9:00 AM	Vertical Emittance Blowup in APS storage ring with RF Deflection Scheme	Vadim Sajaev	ANL
9:30 AM	TEM-type cavities	Robert Rimmer	JLAB
10:00 AM	Multipactor simulations	Peter Stoltz	TECH-X
10:30 AM	Coffee break		
Working Group 1: Cavity-Beam Interactions (Convenor: Graeme Burt)			
11:00 AM	Deflecting cavity applications on ALICE and NLS	Steven Jamison	DL
11:30 AM	ANL Crab Cavity Development	Haipeng Wang	JLAB
12:00 PM	Transverse-to-longitudinal emittance exchange in FELs	Valery Dolgashev	SLAC
12:30 PM	Closing remarks (Announcing 2012 Workshop)	McIntosh/Nassiri	DL
12:45 PM	Lunch		
1:45 PM	Workshop Close		

Highlights Since Shanghai 2008

- New ‘deferred’ bunch compressor scheme
- Beam manipulation for short pulses in storage rings and linacs:
  - Emittance exchange
  - Beam diagnostics (~10fs resolution)
- New crab/deflecting cavity R&D identified:
  - CLIC
  - LHC
  - Project-X
  - Spring8
  - SPX @ ANL (conventional and dielectric loaded w/g)
  - XFEL
- High surface fields identified elevates importance of multipactor analysis
- Advances is computational design tools having significant impact

‘Deferred’ Bunch Compressor (Sajaev ANL)

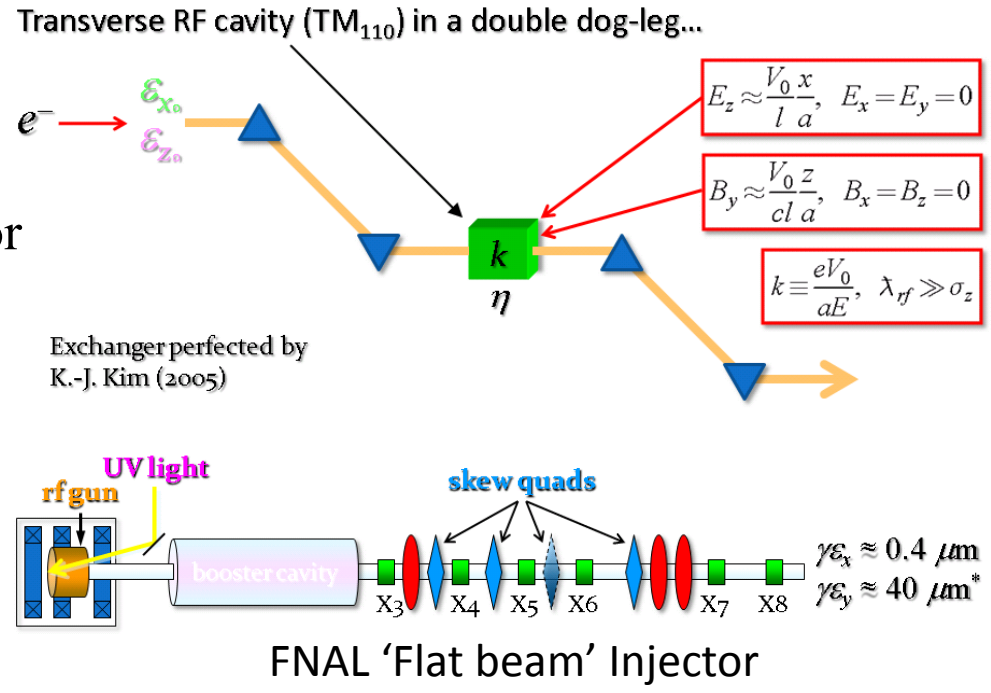


- Efficient electron bunch manipulation in the longitudinal phase space is accomplished by:
  - first exchanging longitudinal and transverse emittances,
  - manipulating electrons in the transverse phase space and
  - finally exchanging emittances back to their original state.

- Advantage is bunch compressor that does not need energy chirp:
  - Can also be used for compression of any features introduced to the electron bunch, like, for example energy modulation produced in interaction with the laser.
- Proposed techniques for a bunch compression allows *deferred compression* that might be useful to mitigate possible adverse effects caused by collective forces.

Emittance Exchange (P Emma SLAC)

- X-Ray FEL motivation for:
  - $\gamma\varepsilon_x < 1\ \mu m$
  - $\gamma\varepsilon_z < 100\ \mu m$
- Strategy to use 'flat beam' injector to produce:
  - $\gamma\varepsilon_x \sim 10\ \mu m$
  - $\gamma\varepsilon_z \sim 0.1\ \mu m$
- Use RF deflector and bends to exchange emittances:
  - $\gamma\varepsilon_x \Leftrightarrow \gamma\varepsilon_z$
- FEL saturation without micro-bunching instability.
- Transverse deflectors open potential for shorter wavelength FELs:
  - Smaller, lower cost accelerators



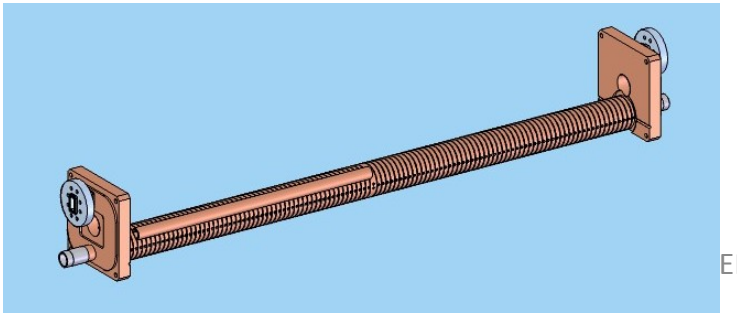
FNAL 'Flat beam' Injector

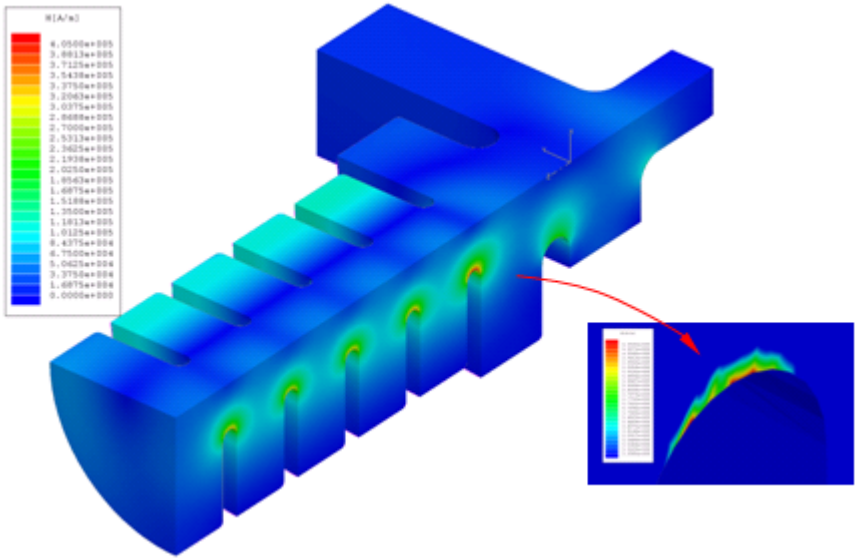
- Large z-emittance should damp micro-bunching instabilities.
- Jitter sensitivity may be the achilles heel.

Deflectors for Diagnostics (V Dolgashev SLAC)

- Development of X-band TW deflector for ~10fs beam diagnostic at 14 GeV for LCLS.

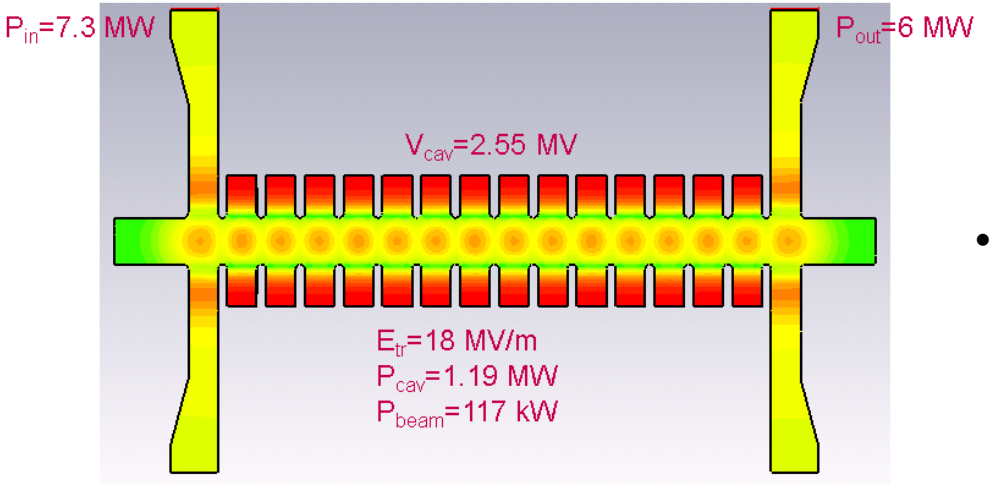
Frequency	11.424 GHz
Beam pipe diameter	10 mm
Phase advance per cell	2π/3
Kick per meter	31 MeV/m/Sqrt(20 MW)
102 cell structure kick	21.3 MeV/Sqrt(20 MV)
Maximum Electric field (input coupler)	100 MV/m / Sqrt(20 MW)
Maximum Magnetic field (input coupler)	400 kA/m / Sqrt(20 MW)
Group velocity/ speed of light	3.2 %
Structure length (with beam pipes)	~94 cm





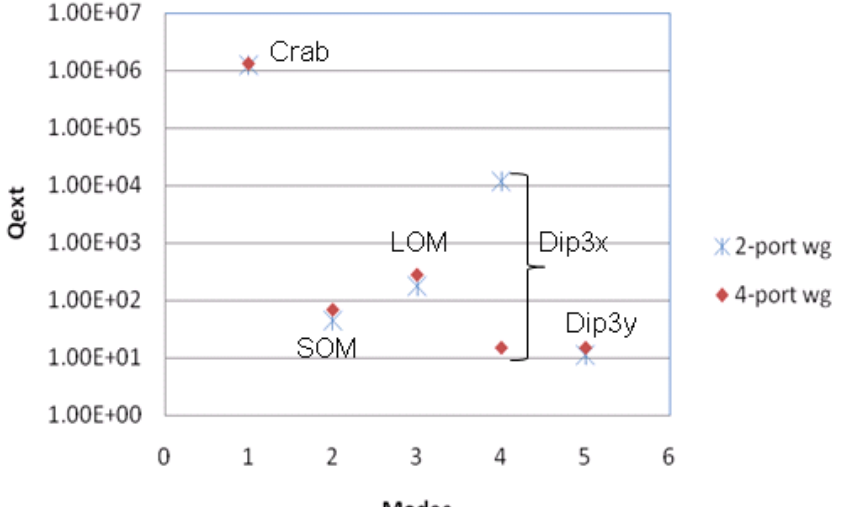
- Maximum surface magnetic fields ~400 kA/m,
- Pulse heating 22 deg. C for 100 ns pulse.

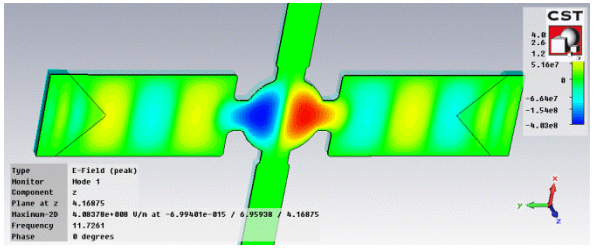
New Crab R&D – CLIC (Ambattu ULAN-CI)



- For CLIC-CC phase synchronization (~0.020°) highly stable matched cavities driven from the same klystron proposed
- For adequate amplitude stability (~1.5%), a high energy flow through the cavity is needed so that beamloading becomes a temporary transient as energy quickly propagate out of the structure.
- 12 GHz, TW structure proposed.

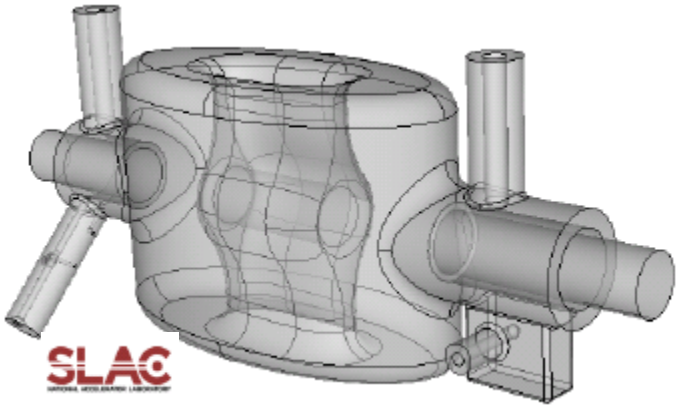
- Wakefields managed by using large iris apertures, minimum number of cells, strong damping for transverse modes (Q_{ext}~40) and moderate damping for longitudinal modes (Q_{ext}~1400).
- Various damping schemes have been investigated, with a preference for waveguide damping.

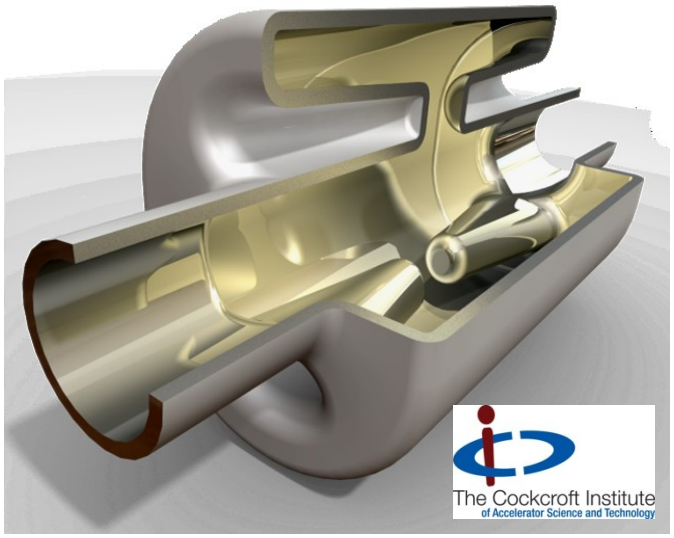


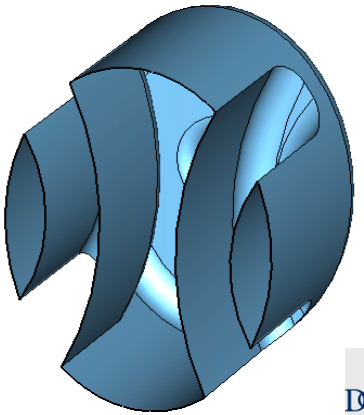


New Crab R&D - LHC

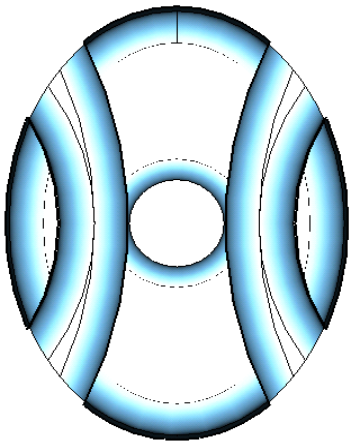
- 5 specific talks on LHC requirements for Crab Cavities and associated compact solutions:
  - LHC crab motivation
  - LHC crab planning and implementation
  - ODU elliptical parallel bar
  - CI cylindrical 4-rod
  - SLAC HWSR





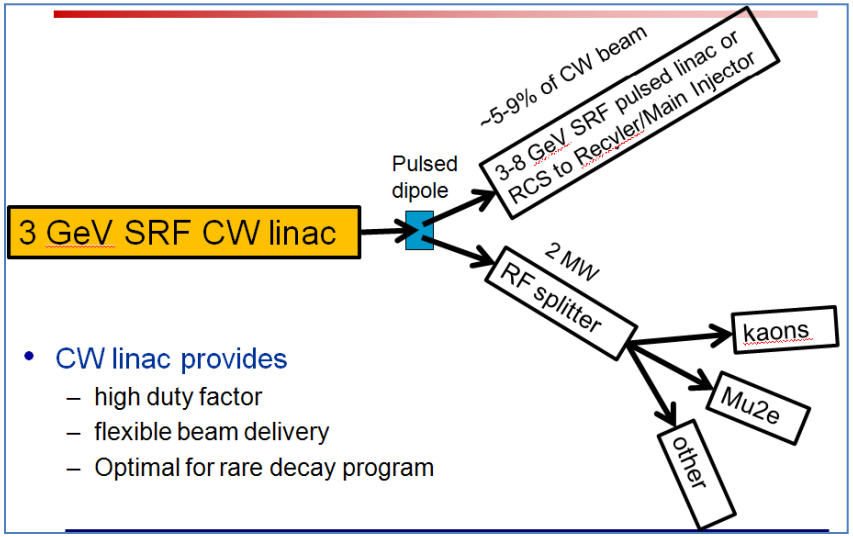


Old Dominion University

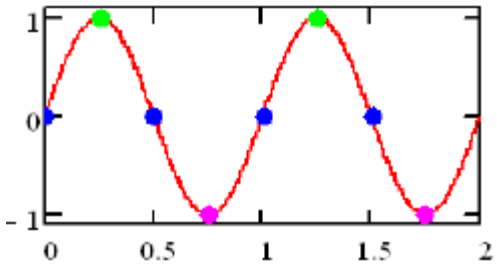


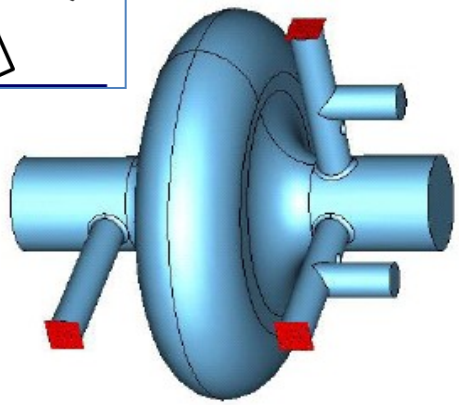
New Crab R&D – Project-X (Solyak FNAL)

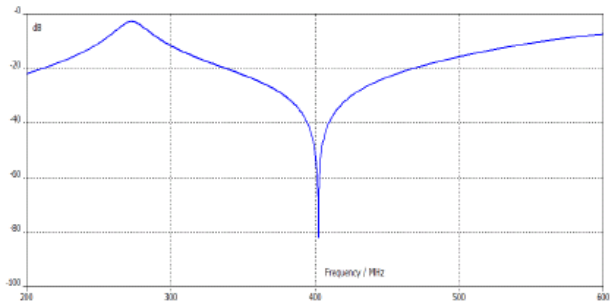
- ICD-2 uses a 3 GeV, 1 mA CW linac to accelerate H- or P's:
  - Provides an additional 2 - 3 MW to the high intensity program.
  - High duty factor & flexible beam manipulation via RF separators.



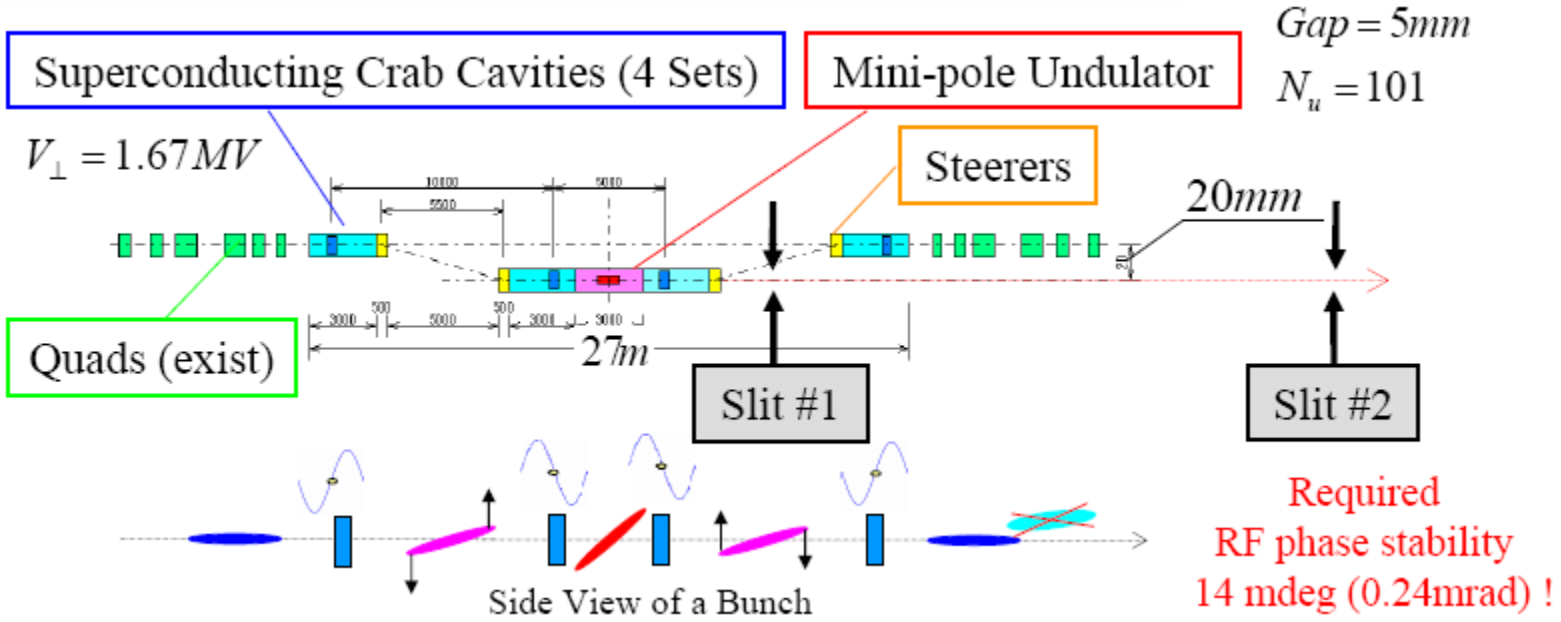
Frequency, [MHz]	406.25
V_{kick}, (MeV)	3.3
E_{sp}/V_{kick}, [(MV/m)/MeV]	7.8
B_{sp}/V_{kick}, [mT/MeV]	19.2**
R/Q* [Ohm]	27
Longitudinal size [mm]	440
Vert/Horiz. size (mm)	865/962

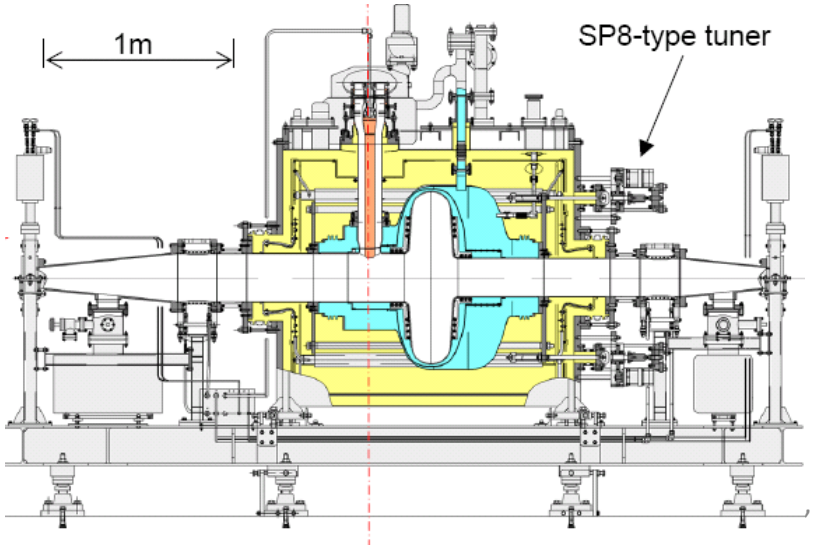






New Crab R&D – SPring-8 (Nakazato JASRI)

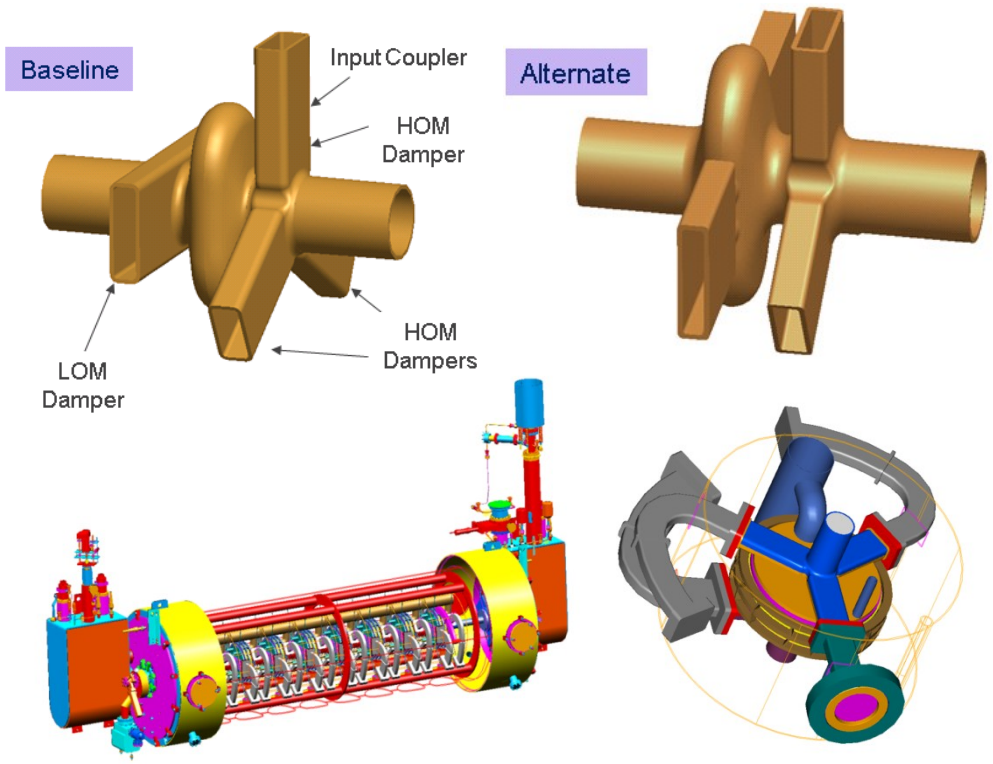




•Cavity Type	Superconducting Crab Cav.
•Number of Cavities	4 or 2
•Deflecting Frequency	508.58 MHz
•Deflecting Mode	TM110
•R/Q	46.7 Ω
•Loaded Q (Q_L)	1×10^5
•RF power	150 kW/Cavity
•Length of Drift Space	10 m
•Deflecting Voltage	1.67 MV
•Bunch Tilting $\tan\theta_{tilt}$	0.044 at 4GeV 0.022 at 8GeV

New Crab R&D – SPX@APS (Nassiri ANL)

- Collaboration with JLab on cavity and CM designs.
- Alternative cavity design provides more margin to instability threshold:
  - Being investigated in parallel to baseline cavity design
  - Encouraging initial results from prototype
- Down selection in R&D phase.
- Design of damper and tuner will commence soon
- Design modifications for improved cavity-to-cavity alignment or adjustments to be investigated
- Formal collaboration with LBNL on LLRF controller and timing/synchronization system.
- Overall technical solution looks feasible but challenging in key parameters:
  - Phase stability
  - HOM damping
  - Alignment
  - Impact on the APS storage ring reliability
- Comprehensive 3 yr R&D program initiated.



System Parameters	
Slow Tuner Range	+/-200kHz
Number of Cavities per Cryomodule	4 (8)
Total Number of Cryomodules	2
Cavity Offset Alignment Tolerance	0.3 mm
Beam Offset Tolerance	0.05 mm
Klystron Power per Cavity	5 kW

New Crab R&D – XFEL (Paramonov INR)

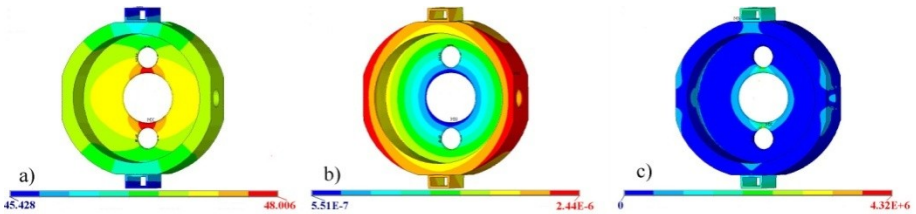
1. Single bunch operation with bunch repetition rate 4.5 MHz (Injector) – short filling time.
2. The remaining bunches in the bunch train must not be affected by RF field of the TDS.
3. A conservative, proven design is favored compared to a technically challenging design which requires substantial R&D. Also powerful RF hardware for deflecting system (DS) must be commercially available.
4. The impact of the TDS installation on regular beam operation must be minimized.
5. The structures have to be designed to balance performance and wakefields, both longitudinal and transversal effects, as well as short range and long range (multi-bunch) effects.

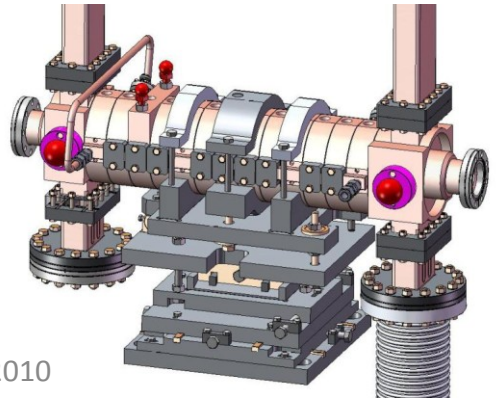
S-band TW option preferred for XFEL:

- Tolerable filling time, mode impedances and fabrication tolerances.

Resonant pulsed heating:

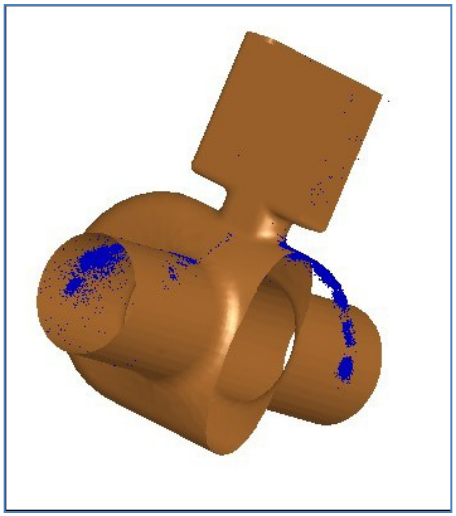
- Maximal fields are in BC1 input cells.
- E_{smax} ~ 58 MV/m (1.1 Ek)
- H_{smax} ~ 220 kA/m
- Visible RF pulsed heating with Ts ~ 17 C^{o} for 3.1 μs pulse.
- Average heating is small, BC1 df ~ 48 kHz

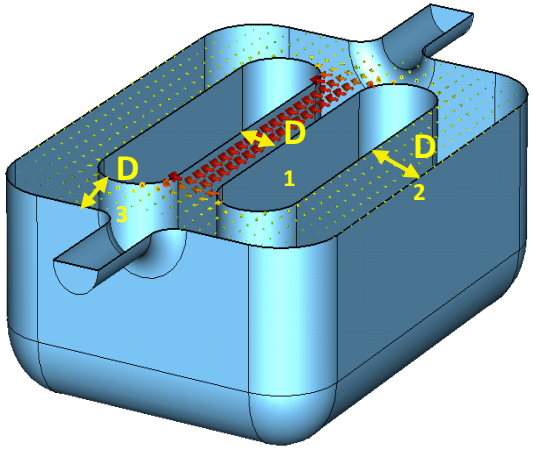


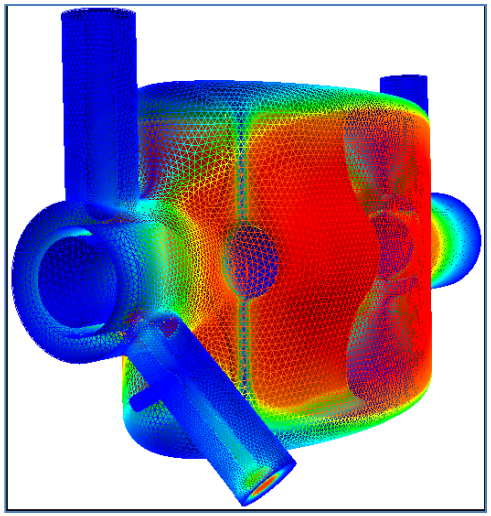


Multipactor Analysis

- Complex and compact crab and deflecting structure geometry designs elevate surface e-m fields ⇒ multipactor issues!
- Coaxial input couplers and mode dampers magnify such problems when coupling in/out RF power.
- Several multipactor analysis examples identified.







Direction for Crabbing/Deflecting Cavities

- Electron beam manipulation to generate short pulse X-rays in both storage rings and FELs is becoming more prominent.
- Many new applications identified:
  - ALICE
  - FNAL
  - LCLS
  - NLS
  - Project-X
  - SPring8
  - SPX@APS
  - XFEL

Next Crab/Deflecting Cavity Mini-Workshop

- To be hosted by ANL in April 2012.
- Chaired by Ali Nassiri

- Hope to hear more about:
  - SPX@ANL hardware testing
  - LHC-CC down selection and hardware testing
  - CLIC-CC high power testing
  - Emittance exchange demonstration at LCLS