High Level RF (HLRF) EDR Planning

LCWS Meeting

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For the ILC HLRF Collaboration

HLRF Collaboration

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Outline

I. EDR Working Definition

II. Industrialization Assumptions

III. HLRF Factory Model Assumptions

IV. Proposed HLRF Work Packages

V. Example Work Package

VI. Conclusions

VII. Appendix: HLRF R&D Status Summary

I. EDR Working Definition

- EDR to be completed in two years, i.e. 2010.
- Detailed technical and cost plans considerably more mature than RDR.
- Schedule, new cost estimate, funding profile.
- Provide solid basis for international funding requests, implying
  - Technology down-selects recommendations in hand
  - Industry based cost estimates in hand to compare with estimates

EDR Tasks
R&D to Pre-Production, 2007-10

- *Management Level Tasks*
  1. *Develop Work Packages for R&D*
  2. *Develop specifications as basis for bid packages*
  3. *Identify industrial vendors for advanced prototypes (Design for Manufacture, DFM)*
  4. *Procure pre-production prototypes*
  5. *Complete EDR documentation*
  6. *Recommend technology down-selection*

EDR Tasks 2

R&D to Pre-Production, 2007-10

- *R&D Tasks (in parallel)*
  1. *Complete Alternate Conceptual Design prototypes*
  2. *Complete DFM designs, specifications, bid packages*
  3. *Evaluate industrial DFM prototypes*

II. HLRF Industrialization Assumptions

- All major system components will be provided by industry
- Industrialization has at least two meanings:
  - *1. Development & deployment of industry process for new designs of an exotic nature, e.g. SCRF structures, Sheet Beam Klystron*
  - *2. Identification & qualification of vendors for new designs of non-exotic nature, e.g. Modulator, Charging System, Controls & Interlock Protection System*

General Procurement Strategy

- ILC is developing and will *own* designs from ACD process
- Specifications will be developed for "Build to Spec" procurement
- Vendors may choose to offer any design that meets specifications including ACD designs
- Owning designs important for long term future:
  - *Modulators, Distribution have virtually no follow-on business so future procurements could be problematical*
  - *Klystrons have significant follow-on business but much smaller; owning a design is excellent insurance against future vendor ability to deliver (e.g. PEPII experience)*
- HLRF cost models assumed procurement split 50-50 between 2 vendors. (Actual ratios would vary.)

III. HLRF Factory Model Assumptions

- Factory Models developed for Modulators, Klystrons and Distribution for cost modeling in 2006:
  - *Factories to provide fully tested units essentially ready for final prep and installation to tunnels*
  - *Factories to be provided with necessary test equipment, support personnel*
  - *ILC inspectors at factory sign off on testing before shipment allowed*
  - *Delivery to on-site staging area for nominal inspection that no damage occurred in shipping, plus final prep before releasing to installation*

HLRF Factory Models 2

- Some Details:
  - *All components to be built to specifications (electrical power, cooling, mechanical form factor, drive requirements, test procedures)*
  - *Modulator factory to be provided with fully instrumented test stations, test loads*
  - *Klystron factory to be provided with klystron test stations, RF driver system, water loads*
  - *Integrated Distribution systems to be delivered packaged for quick final assembly, mounting on cryo-module in staging area for cold tuning prior to moving to tunnel*

IV. Proposed Work Packages (WP's)

- Prepare Separate WP's for *Modulator, Klystron, Distribution*
  - *Develop DFM design, build prototype, execute test program*
  - *Develop collaboration specifications for bid packages*
  - *Ideally each region lets bid for evaluation unit or units, shares costs, testing experience*
  - *Note: These could be different designs!*
  - *Procure, test, apply to L-Band test programs*
  - *Modify bid packages for pre-production quantity procurement*

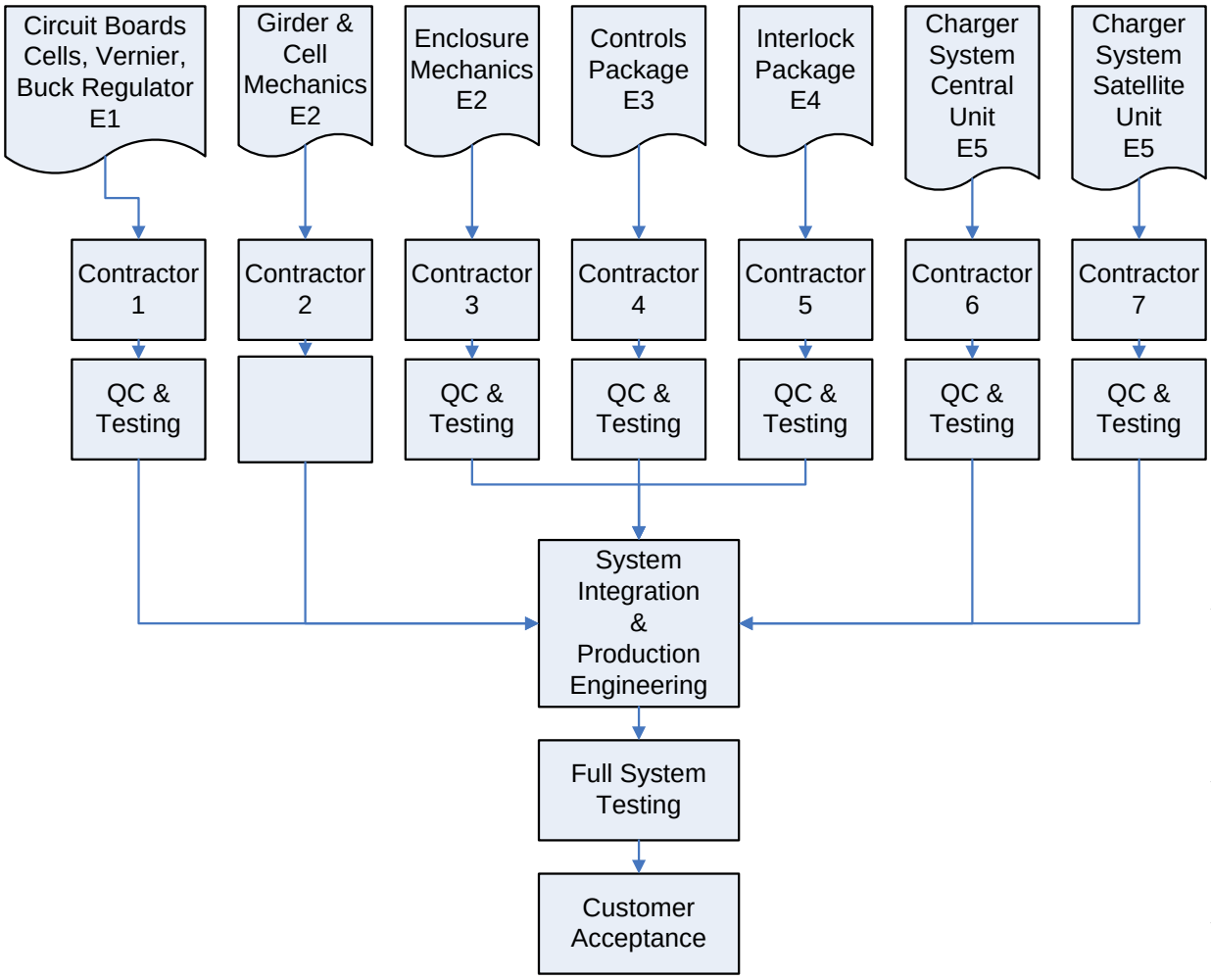
Proposed WP's 2

- Charger system, Controls-Interlock system also WP candidates for delivery of pre-tested integrated systems
  - *Could also be part of modulator, klystron systems respectively*

V. Example Work Package: Marx

	High Level RF Work Packages	2006	2007	2008	2009	2010	2011	2012	2013	2019
		RDR	EDR			Approval		Construction		Commiss.
1	**EDR Work Packages**									
	Marx Modulator									
	Complete 08-09 Work Packages		♦							
	Down-select technology			♦						
	Prepare bid packages for 3 Regions				♦					
	Place factory orders in 3 Regions				♦					
	Receive units in 3 Regions					♦				
	Implement Test Stands 3 Regions					♦				
	Test Stand operation 3 Regions					------				
2	**R&D Work packages**									
	Marx Modulator									
	Complete prototype power test			♦						
	Complete DFM design			♦						
	Complete DFM Prototype				♦					
	Implement DFM Prototpe on Test Stand				♦-----					

WP for Marx DFM Prototypes



LAB ENGRG. TEAM

- **Generate Bid Packages**
- **Oversee Vendor Production**
- **Oversee Vendor-Based QC, Testing**
- **Oversee Vendor-Based Integration, Production Engineering.**
- **Oversee Vendor based Full System Test**
- **Customer Acceptance**

VI. Conclusions

- EDR is window of opportunity for strong inter-regional growth in ILC HLRF
  - *HLRF has strong Alternate R&D program to improve costs, availability*
  - *Strong inter-region contributions can be advanced through shared Work Packages*
  - *WP's for major HLRF components R&D, industrialization proposed for discussion*
  - *Early collaboration agreements & commitments necessary for EDR success*

END OF SLIDES

VII. Appendix: HLRF R&D Status Summary

- SLAC ACD Modulator, Klystron, Distribution R&D Progress
- KEK Latest Progress HLRF System
- FNAL Improved Baseline Modulator for SRF Test Facility

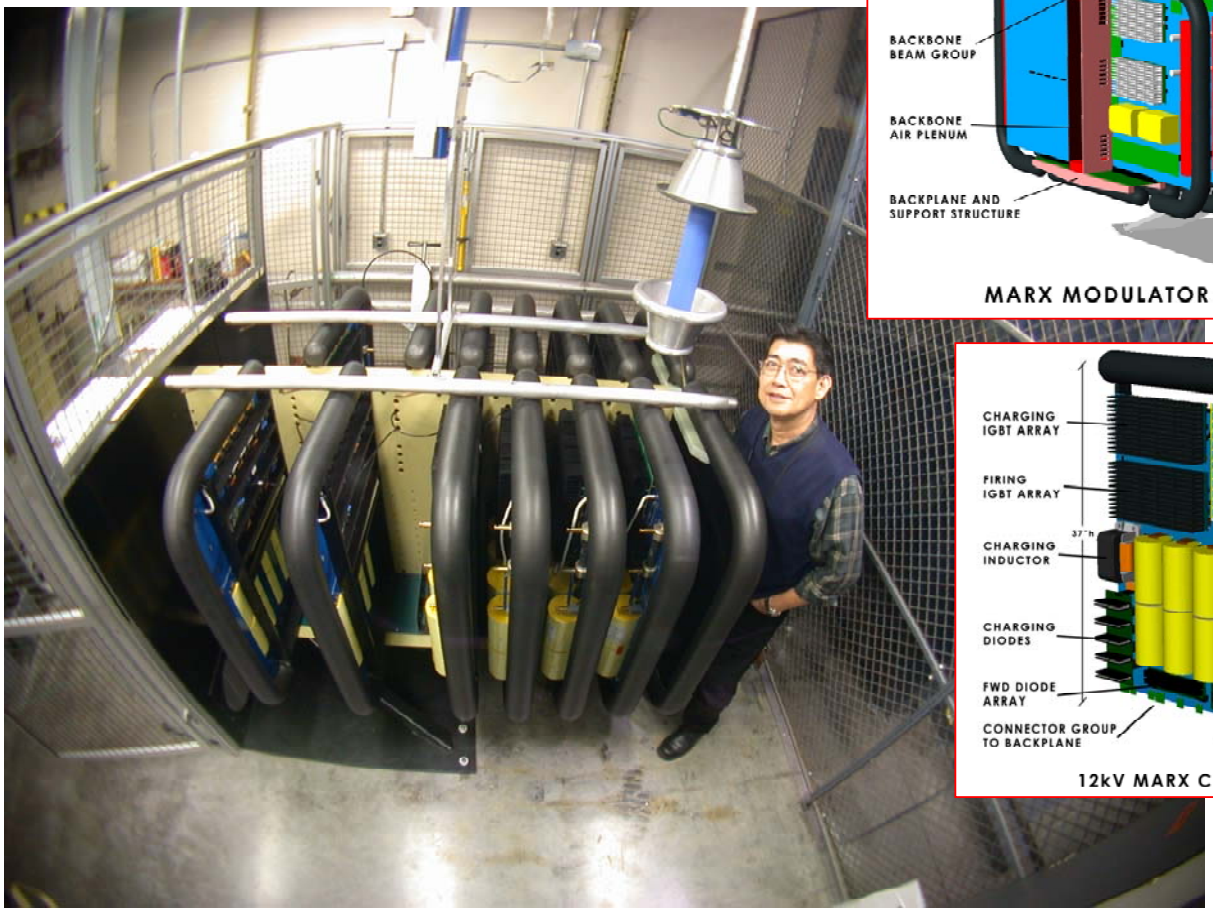
HLRF ACD R&D Status Summary

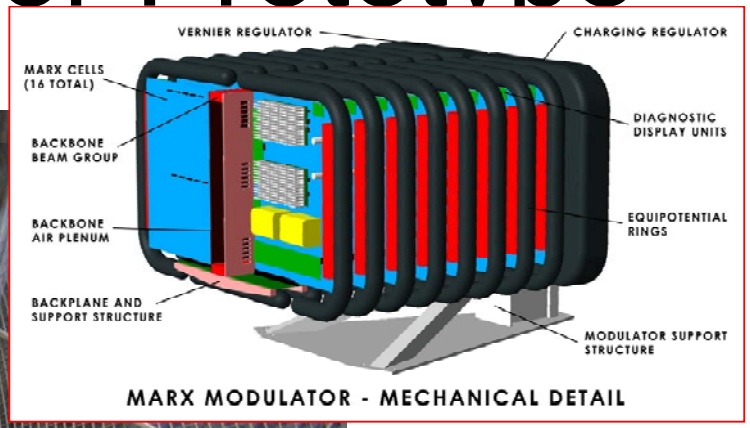
- R&D program on Alternate Conceptual Designs underway for three major components to improve reliability, cut costs by ~40-50%
  - *Marx Modulator*
  - *Sheet Beam Klystron*
  - *Integrated Waveguide Distribution*
- Prototype designs also planned for:
  - *High Availability Modulator Charger*
  - *Klystron Interlocks and Controls*

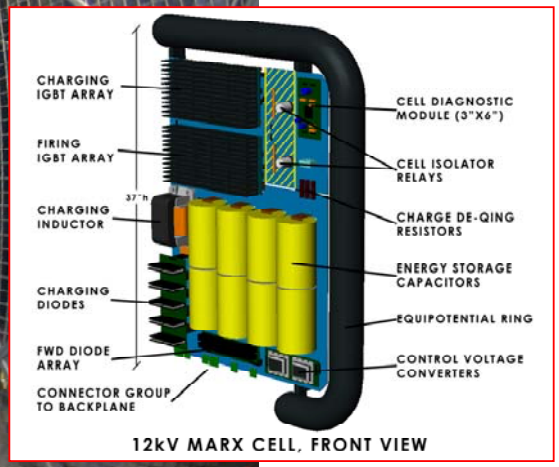
Modulator R&D

- Motivation:
  - *Reduce costs, size, weight*
  - *Improve Availability via N+1 redundancy*
- Approach:
  - *Marx generator using solid state switches, modular structure, on-board diagnostics for "intelligent platform management" of maintenance and repair*

Marx Modulator Prototype





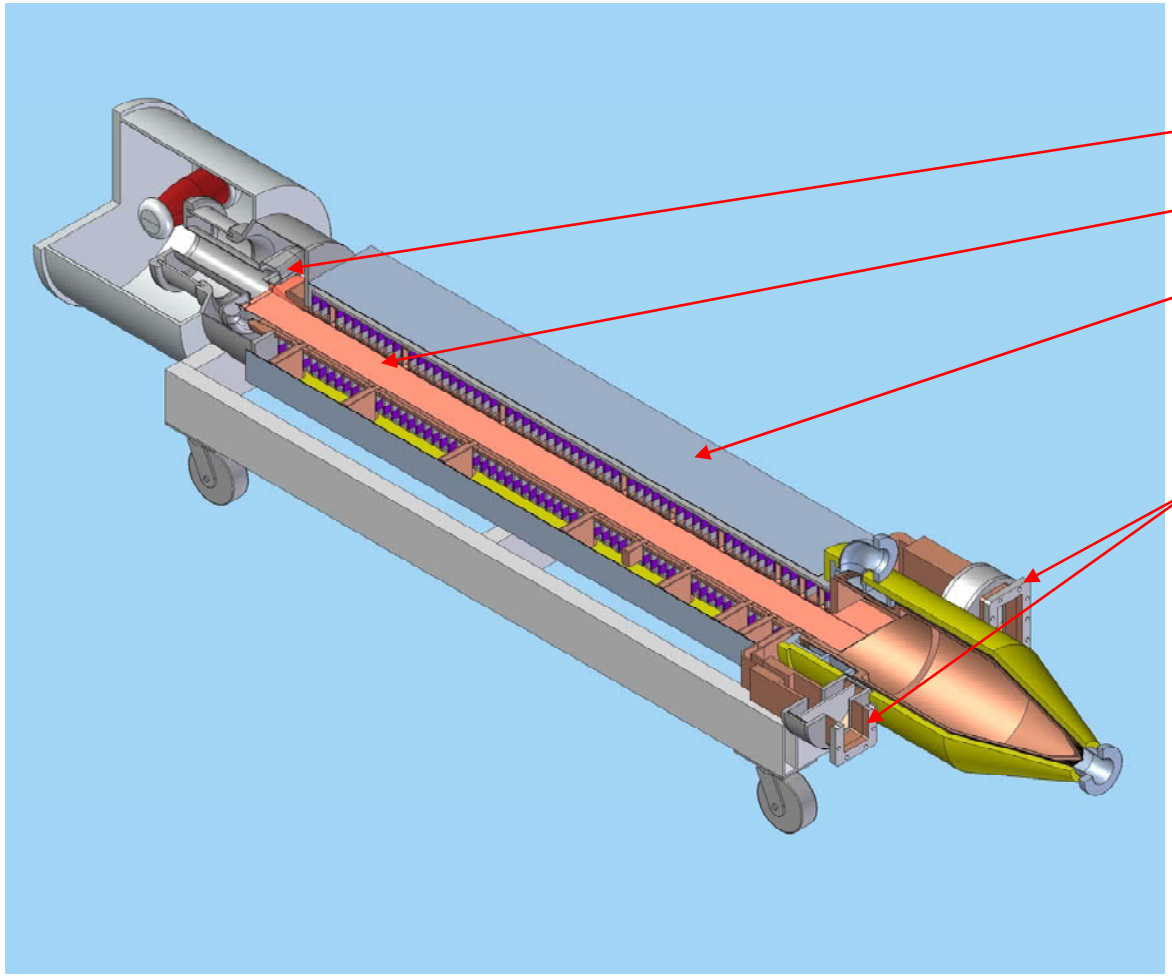


Courtesy G. Leyh

Klystron R&D

- Motivation:
  - *10MW MBK Klystrons new, complex to build, likely to be less reliable than single beams due to many more parts, braze joints, single points of failure*
  - *Several potential suppliers but costs likely to remain high.*
- Approach:
  - *Sheet Beam Klystron (SBK) has worked at W-Band but not a refined, efficient design. Goal is to design drop-in replacement 10 MW SBK. On paper, smaller size, lower weight, lower cost*

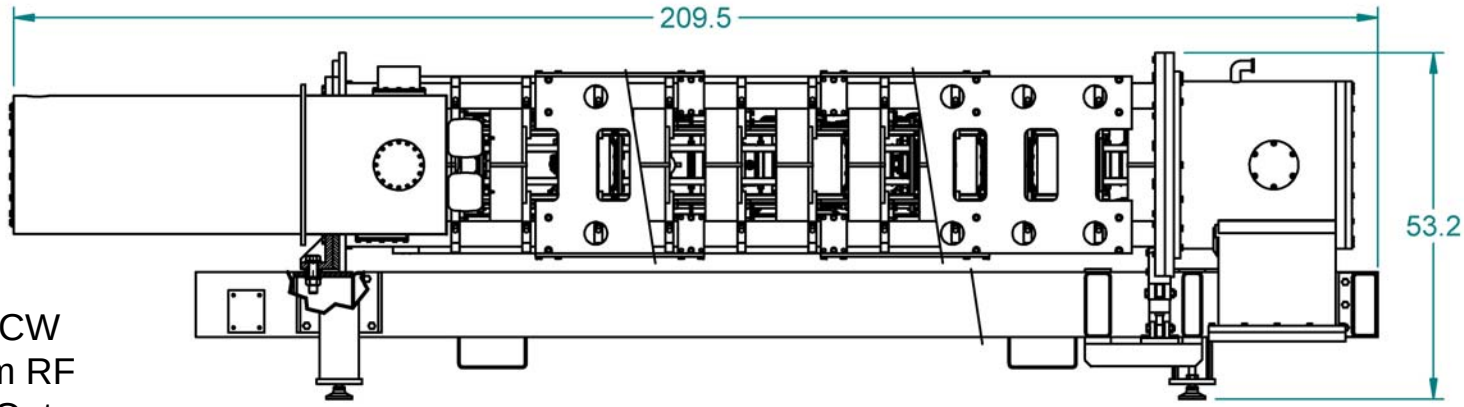
10 MW Sheet Beam Klystron Model



- Cathode
- Sheet beam
- Permanent magnet focusing
- Dual outputs

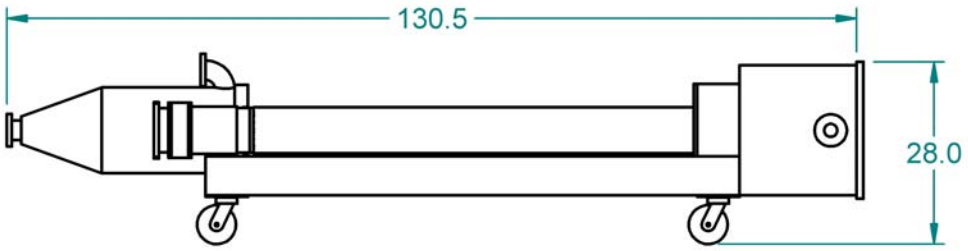
SBK Klystron Size Compare

1.2 MW CW
Maximum RF
Power Out



B-FACTORY KLYSTRON

10MW Peak
85kW Average
RF Power Out

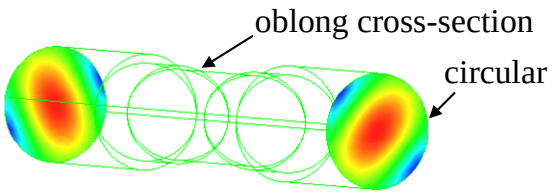


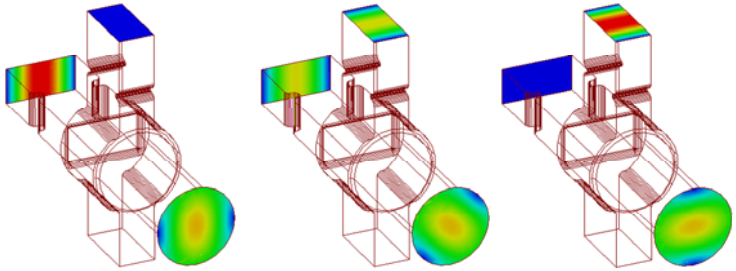
ILC SHEET BEAM KLYSTRON

Waveguide Distribution R&D

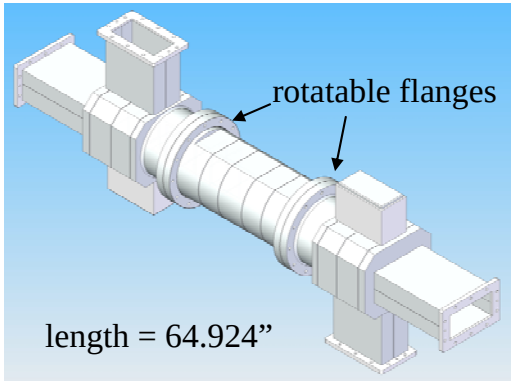
- Motivation:
  - *Reduce costs by integrated design to eliminate expensive components, reduce flanges, simplify final assembly and lower installation costs*
- Approach:
  - *Develop system to feed cavities in pairs via novel Variable Tap-Off (VTO) mode rotation coupler; eliminate expensive circulators & tuners*

Variable Tap-Off (VTO)*



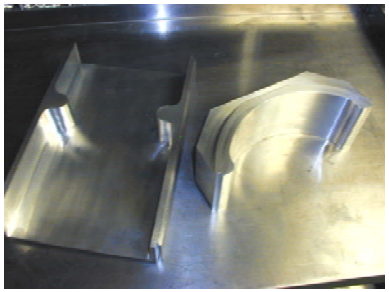


Full 4-Port Assembly:



Coupling as Function of Center Rotation:

$C = P_c / P_i$	$\alpha = 1/2 \sin^{-1}\sqrt{C}$
0	0.00°
1/4	15.00°
1/3	17.63°
1/2	22.50°
1	45.00°

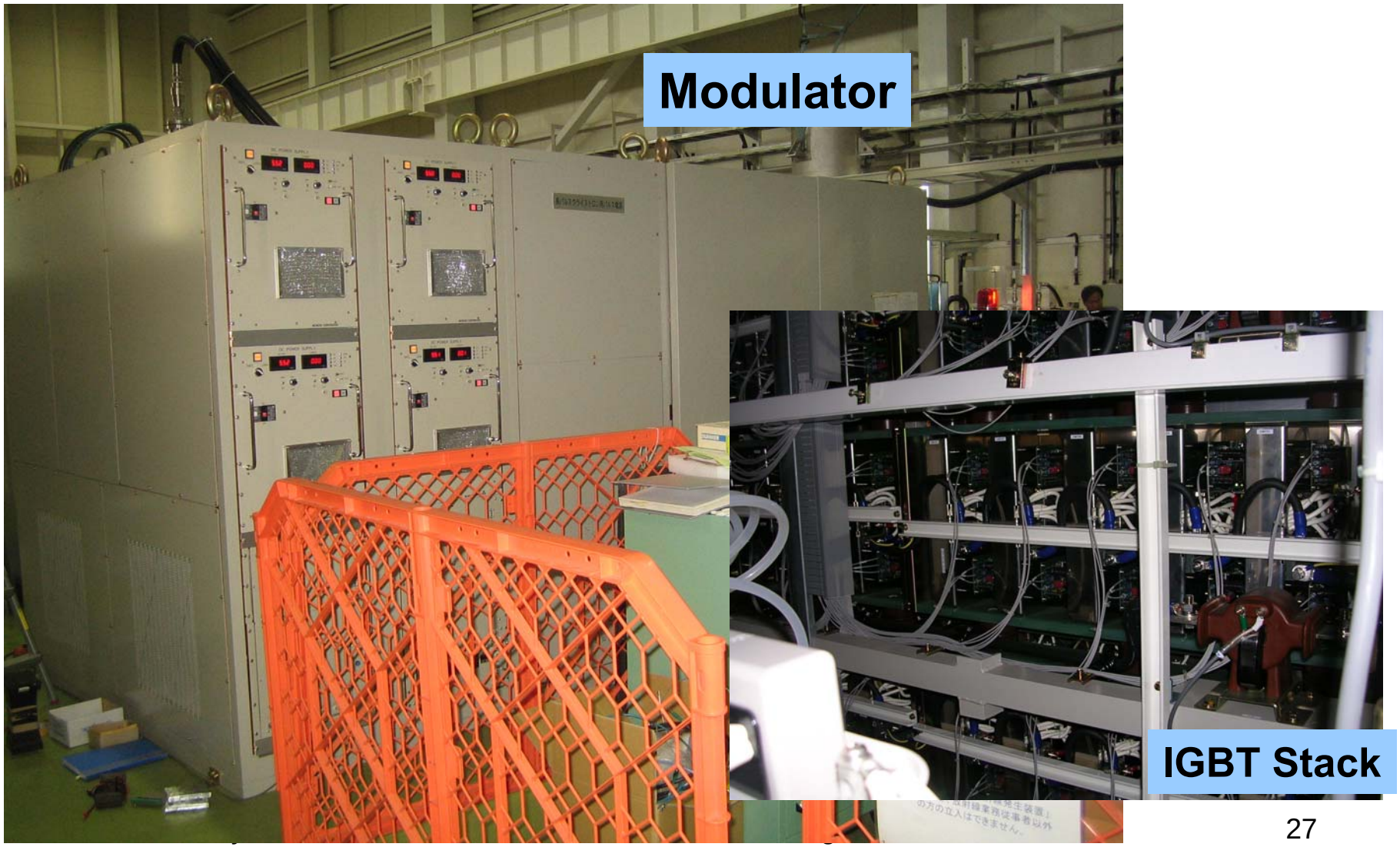


* Hybrids are similarly constructed SLAC design.

Charger, Interlocks & Controls

- HA Modulator Charger:
  - *High Availability architecture with central unit delivering 80% voltage to 6 satellites with 20% top-off switching supplies; 50% capacity in central unit for failover redundancy, cost optimized*
- HA Klystron Interlocks & Controls:
  - *Integrated package with local programmable protection controller; RF, temperature, vacuum, water flow interlocks; modular electronics package with diagnostics & redundancy, cost optimized*

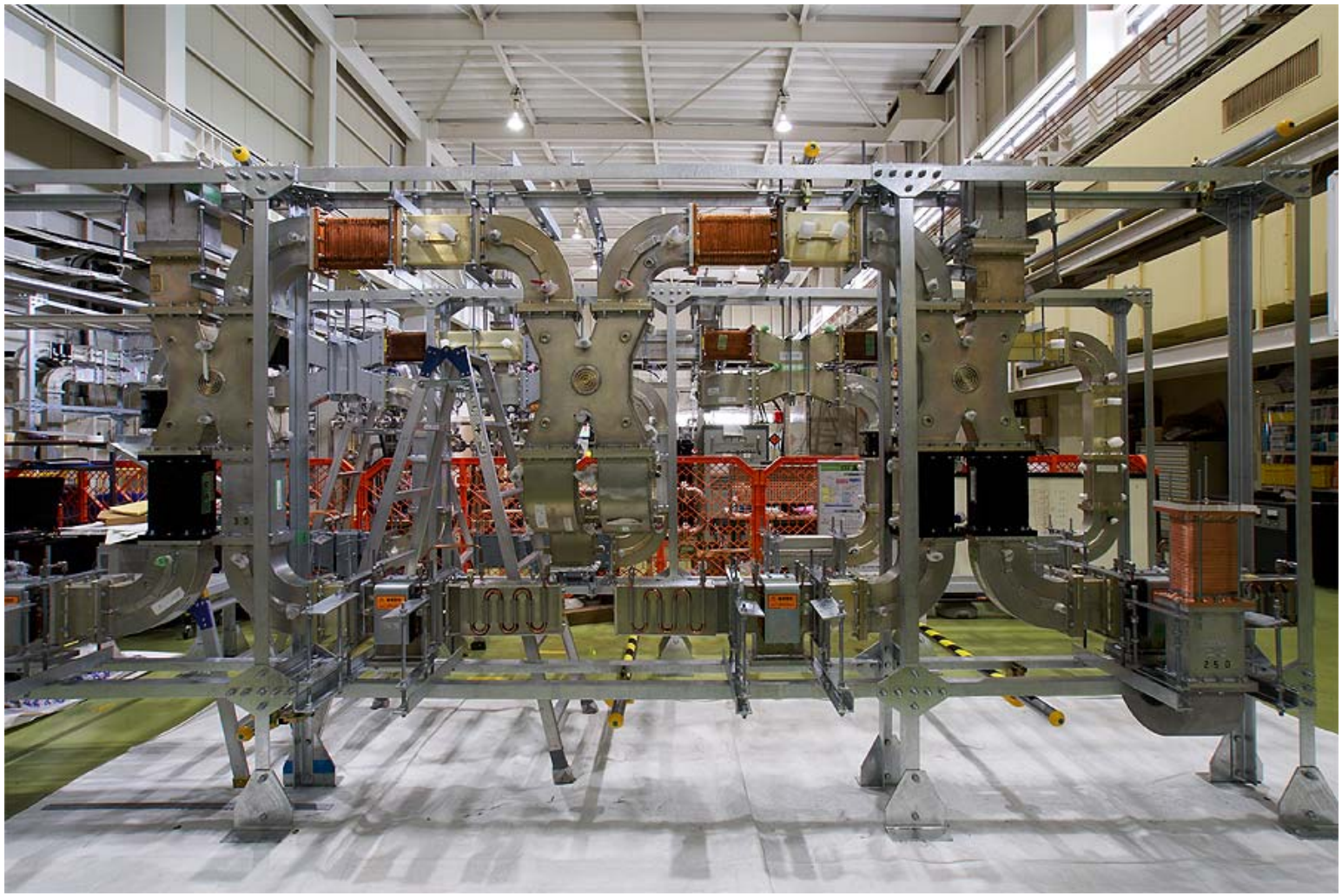
KEK New Bouncer Modulator



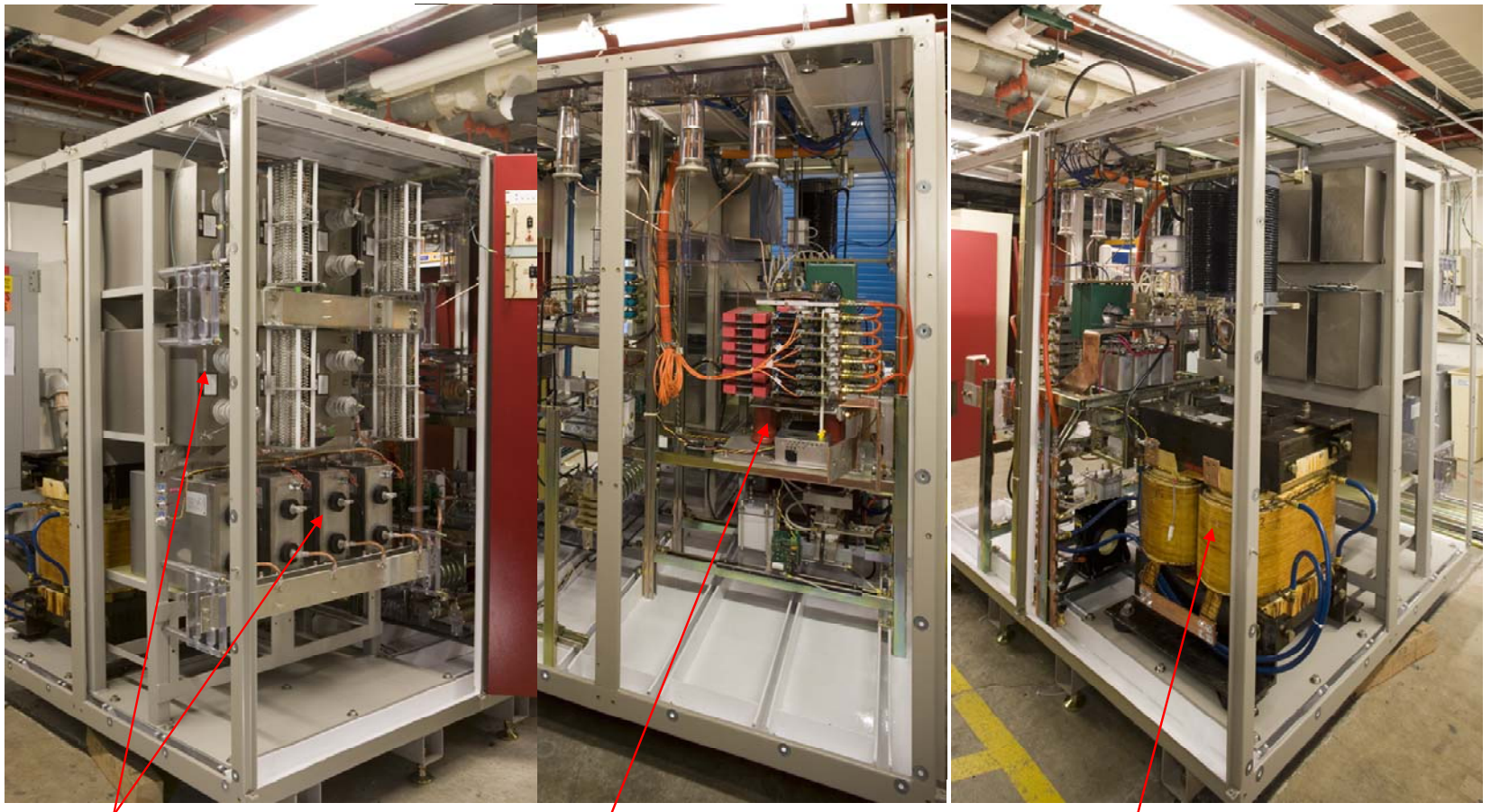
KEK Bouncer Modulator Sta.2

ACD Hybrid Distribution (KEK)
(Circulators Eliminated)

KEK Distribution 2



Improved Bouncer Modulator (FNAL)



Capacitor Banks

IGBT Redundant Switch

Bouncer Choke