ILC Cavity Qualifications- Americas

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Outline:

- Procedures for Cavity Qualification at JLab
  - Process Algorithm Used
  - Resulting Production Schedule
  - Limitations to production rate
- Cavity Performance
  - RF Test Data
  - Field Emission Data
  - Material Removal Data
- Production Issues to Address
- Technical Questions?


DANGER
HAZARDOUS
CHEMICALS
DANGER
HAZARDOUS
CHEMICALS

Process Algorithm Used:

- Chemistry for Vertical Qualification
  - **Degrease** - (1 hr) 150KHz ultrasonic with DI + 1 liter Micro-90 + DI rinse + Dry
  - **EP 20um** (1 hr) starting at 17V, 10 lpm fill, 1rpm rotation
    - Adjusting voltage to maintain acid temperature at exit below 35C
    - Followed by:
      - DI rinsing = 6 fill & dumps + 1 hr overfill
      - Horizontal removal of cathode
      - Flange cleaning
      - Transfer to chemroom
  - **Degrease** - (1 hr) 150KHz ultrasonic with DI + 1 liter Micro-90 + DI rinse + pass into Cleanroom

Process Algorithm Used:

- **HPR** (12 Hrs) – 1200-1300psi Pressure, 2 fan jet nozzles, LEWA pump, Top beamline flange blanked
  - Wand Cycle:
    - Move to top
    - Lower after full rotation 0.2 inches and repeat until reaches bottom
    - Drain 15 minutes
    - Repeat
    - Blank all flanges and transfer to Class 10 to dry
- **Dry** (8hrs)
  - All flange blanks removed
  - All flanges covered before any work in Class 10 area

Process Algorithm Used:

- **First Assembly** (4 Hrs)
  - All components nitrogen gun cleaned
  - Assembly of components from below – cavity positioned and rotated as necessary
  - Only minimal bolts added (2 typically) to seal flanges
    - Field probe transition
    - FPC transition
    - HOM blanks
    - Top Beamline flange
  - Bottom beamline flange blanked
- **Second HPR** (12hrs)
  - Bottom beamline blank removed
  - HPR same as first time

Process Algorithm Used:

- **Second Assembly** (4 hrs)
  - All components nitrogen gun cleaned
  - Assembly of components from below – cavity positioned and rotated as necessary
  - Only minimal bolts added (2 typically) to seal flanges
    - Field probe
    - Input Probe (FPC port, fixed coupling)
    - Valve flange assembly
- **Evacuation + Leaktest** (3-4 hrs)
  - 60 lps turbo backed by scroll pump
  - Cold trap – removed after reaching E-6 mBar
  - RGA leak test – gross spray of all components
  - Leak detected – letup, second HPR and assembly repeated
  - Pressure usually E-7 mBar

Process Algorithm Used:

- **Bake out** (52 hrs) – 110C forced hot nitrogen in bake-out box
  - 2 hr ramp up
  - 48 hr soak
  - 2 hr ramp down
  - Pressure usually mid E-9 mBar
  - Transfer into Dewar
- **RF Test** (2-8Hrs)
  - Cool-down, fill and pump to 2K
  - RF test
    - Pass-band measurements if necessary
    - Q-disease test at least once after bulk chemistry
    - Warmup
  - Transfer to cleanroom and disassemble

Process Algorithm Used:

- **Subcomponent Cleaning**
  - All Hardware, flanges and subcomponents completely disassembled
  - Ultrasonic degreasing with micro-90 and DI 30min
  - Di rinsing
  - Small Hardware
    - Nitrogen gun drying
    - Bagging
    - Transfer to cleanroom
  - Flanges and transitions
    - Pass-thru to cleanroom in DI water bath closed container
    - In cleanroom remove from water bath nitrogen gun blow dry
  - All hardware in cleanroom
    - Ionized nitrogen gun cleaned to particle count >10, 0.3um
    - Repeated at each assembly step

Resulting Production Schedule:

- Two process cycles every two weeks
  - **Mon** – C1 setup Ep
  - **Tues** – C1 Process/Degrease/HPR
  - **Wed** – C1 Assembly/HPR, C2 setup Ep
  - **Thurs** – C1 Assembly/Evac/Leaktest/Bake, C2 Process/Degrease/HPR
  - **Fri** – C1 Bake, C2 Assembly/HPR
  - **Mon** – C1 insert into dewar, C2 Assembly/Evac/Leaktest/Bake
  - **Tues** – C1 Rf test, C2 Bake
  - **Wed** – C1 transfer/Warmup, C2 Bake
  - **Thurs** – C1 disassembly, C2 insert into dewar
  - **Fri** – C2 Rf test, C1 setup Ep

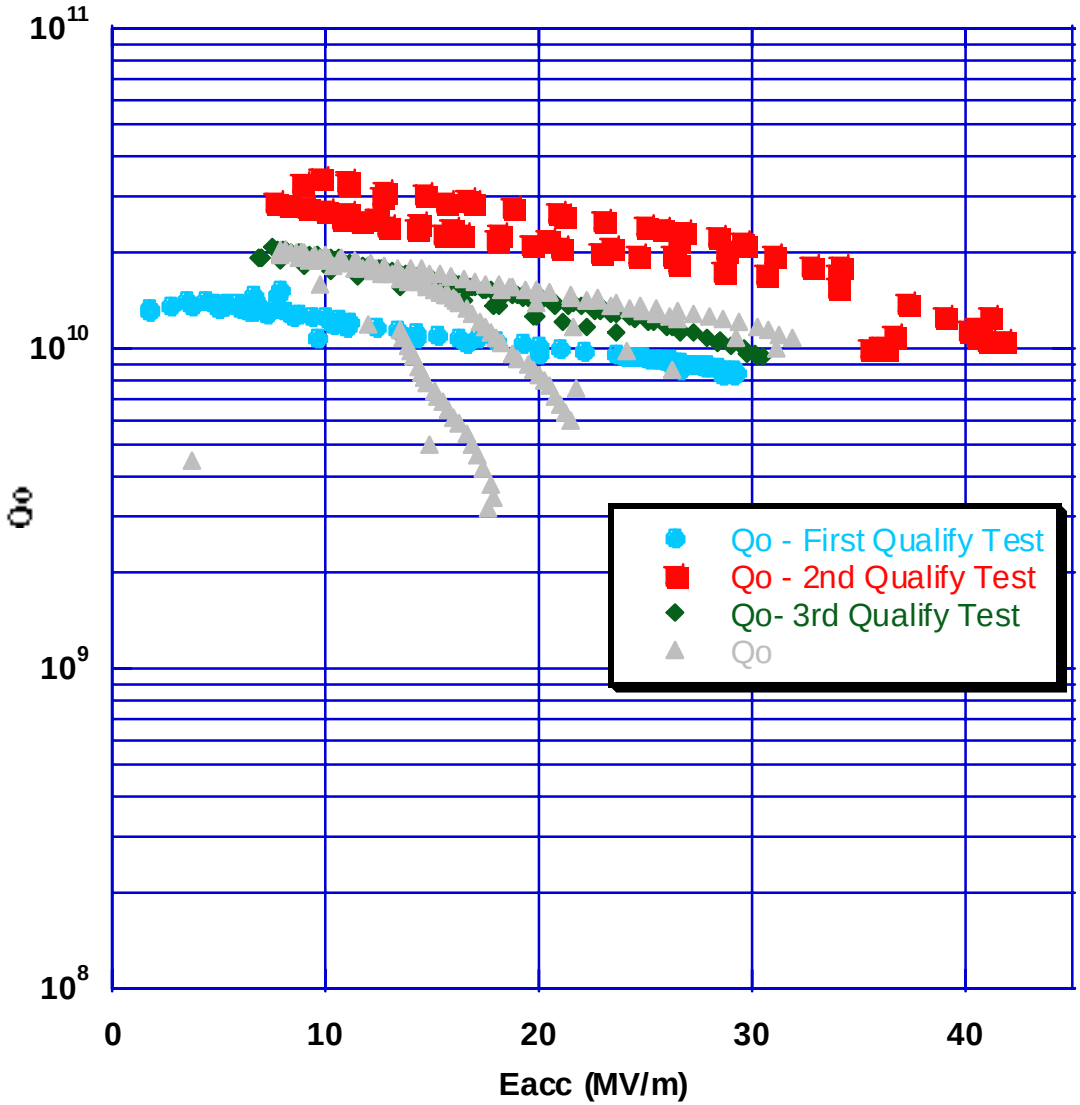
Resulting Production Schedule:

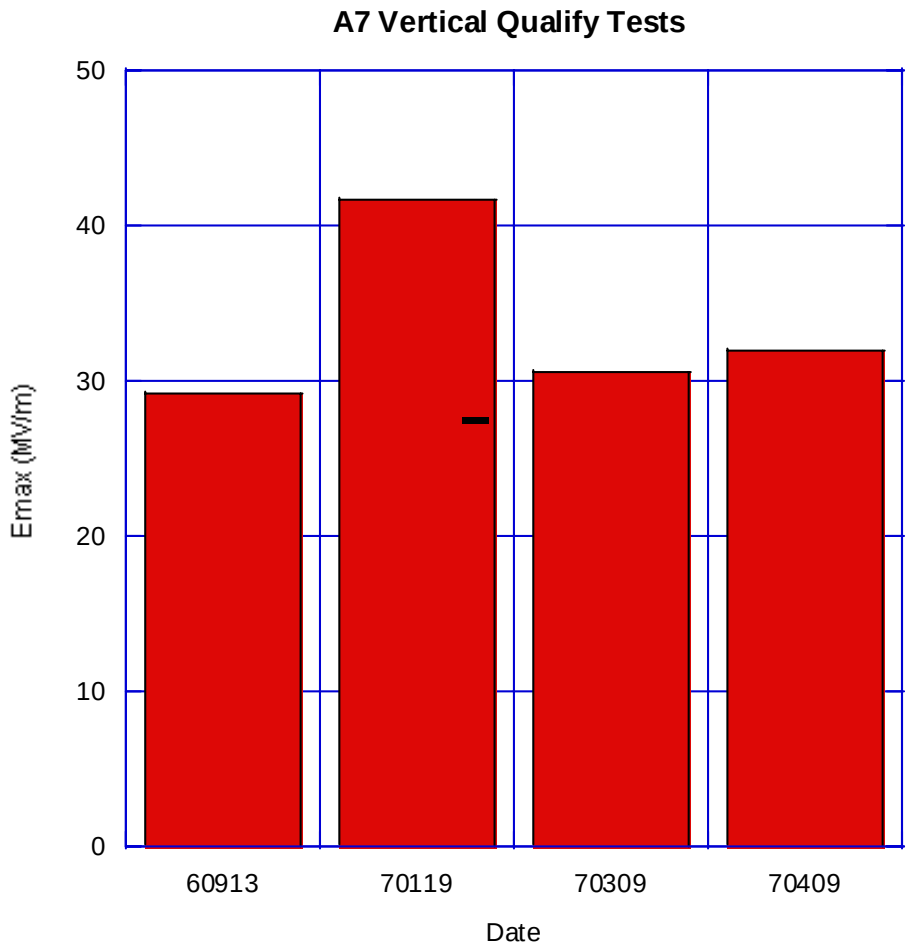
- We have successfully established a rate equivalent to 50 cycles per year with 3 FTE's and hardware for two cavities
- Limitations:
  - With only two cages we could not go any faster (third cage almost complete)
  - Facility availability
    - Improved communication
    - Established shift work to reduce facility conflicts
    - Delays encountered
      - Facility failures (Scrubber ect)

Results so far:

- 11 – ILC cavities tests performed
  - Easily reach the 30 scheduled test cycles this FY
- 1 - Single cell baseline test completed
  - Easily reach the 10 planned tests this FY

A7 - Vertical Qualify Test Data

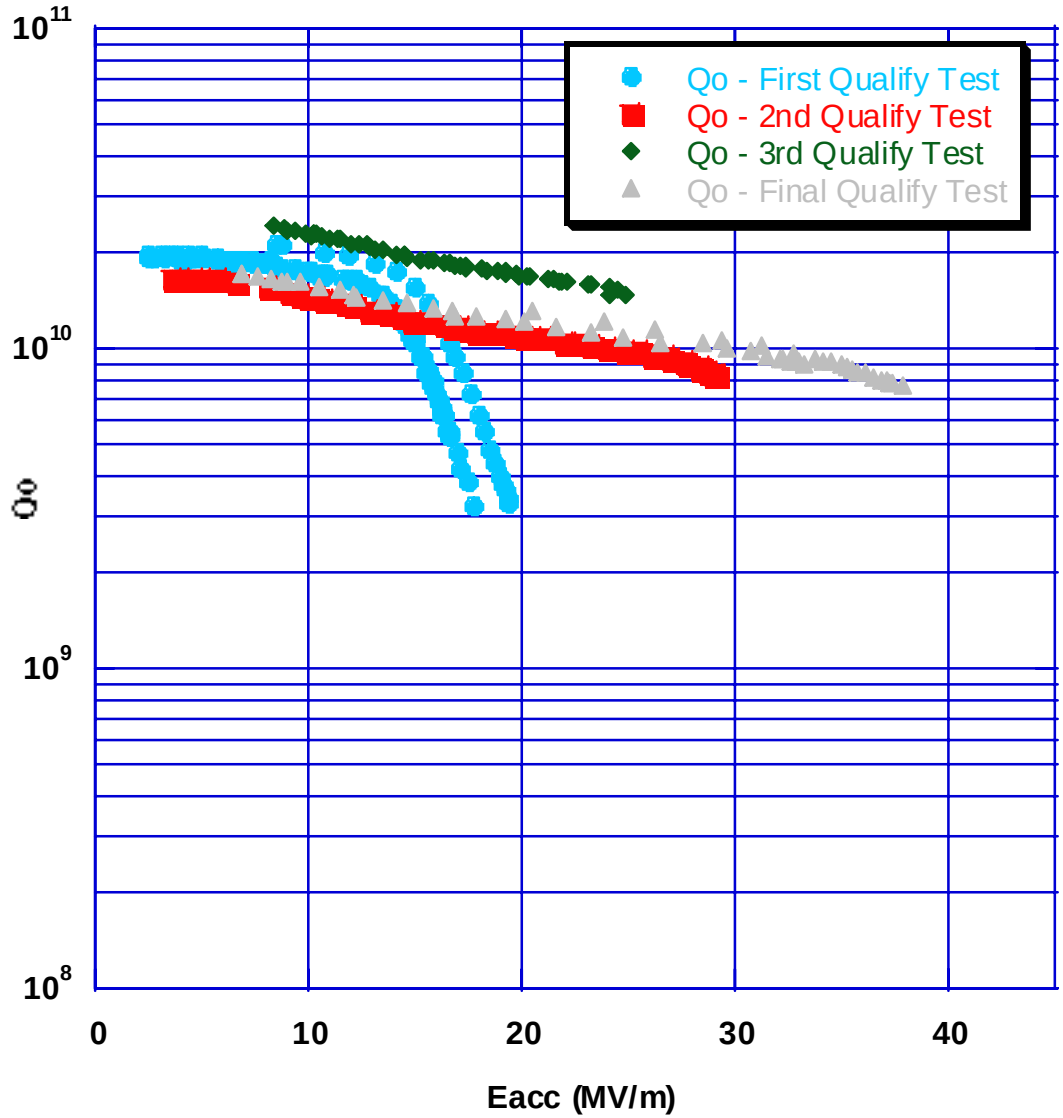


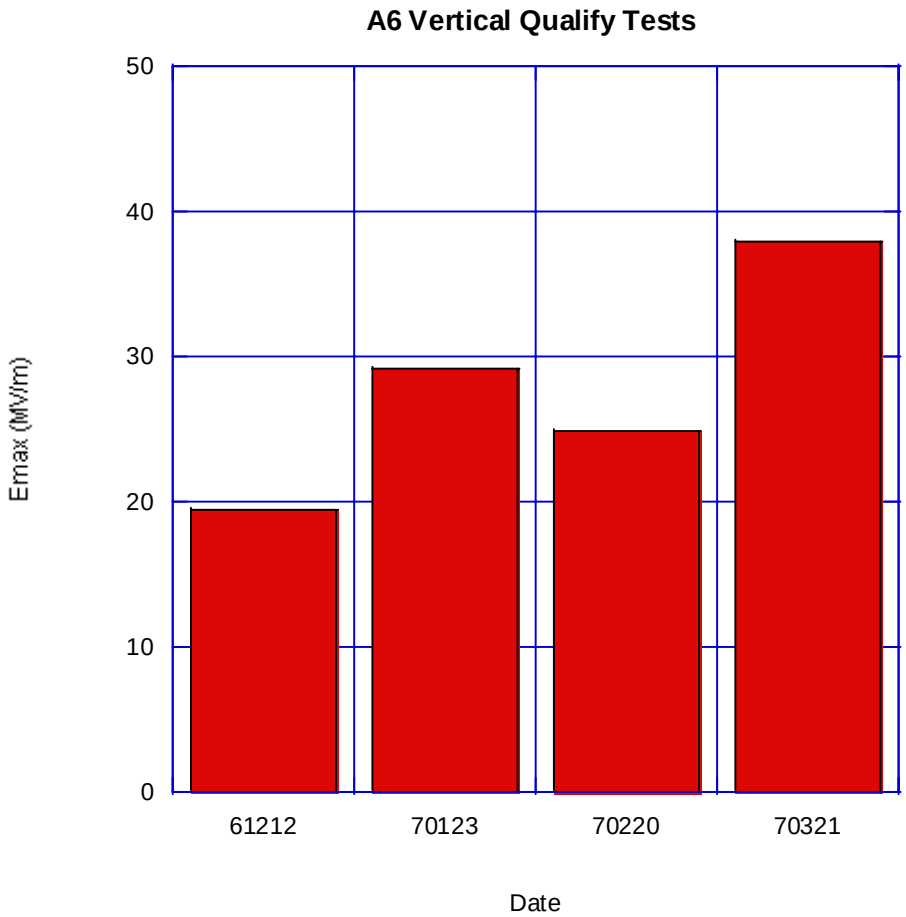

A7 Vertical Qualify Tests
50
40
30
20
10
0
Emax (MV/m)
60913
70119
70309
70409
Date

Material Removal Data: Equators

A7	FPC								Fp
	1	2	3	4	5	6	7	8	9
As received	3.007	2.952	2.976	3.016	2.963	2.913	2.938	2.977	2.975
After Bulk	2.836	2.789	2.813	2.853	2.782	2.734	2.761	2.813	2.798
	171	**163**	**163**	**163**	**181**	**179**	**177**	**164**	**177**
After 2nd	2.811	2.765	2.784	2.825	2.751	2.709	2.73	2.789	2.783
	196	**187**	**192**	**191**	**212**	**204**	**208**	**188**	**192**
After 4th	2.756	2.704	2.73	2.768	2.694	2.658	2.682	2.732	2.726
	251	**248**	**246**	**248**	**269**	**255**	**256**	**245**	**249**

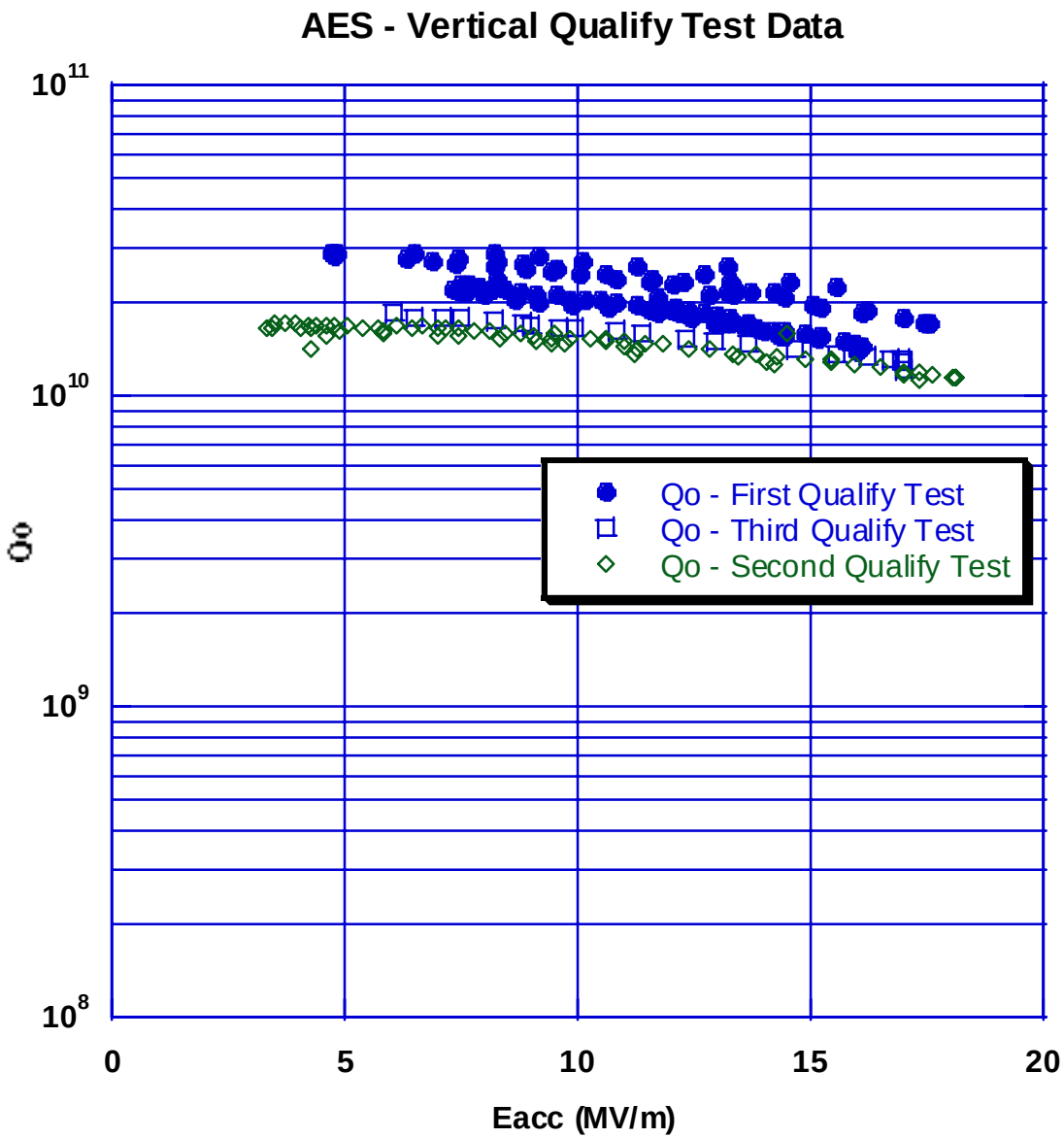
A6 - Vertical Qualify Test Data




A6 Vertical Qualify Tests
Emax (MV/m)
50
40
30
20
10
0
61212
70123
70220
70321
Date

Material Removal Data: Equators

A6	FPC								Fp
	1	2	3	4	5	6	7	8	9
As received	2.974	2.95	3.002	3.042	2.921	2.946	2.973	3.07	3.015
After 1st	2.792	2.789	2.818	2.852	2.73	2.748	2.78	2.871	2.824
	182	**161**	**184**	**190**	**191**	**198**	**193**	**199**	**191**
After 2nd	2.773	2.76	2.792	2.83	2.706	2.711	2.758	2.849	2.795
	201	**190**	**210**	**212**	**215**	**235**	**215**	**221**	**220**


AES - Vertical Qualify Test Data
10^11
10^10
10^9
10^8
Qo
0
5
10
15
20
Eacc (MV/m)
Qo - First Qualify Test
Qo - Third Qualify Test
Qo - Second Qualify Test

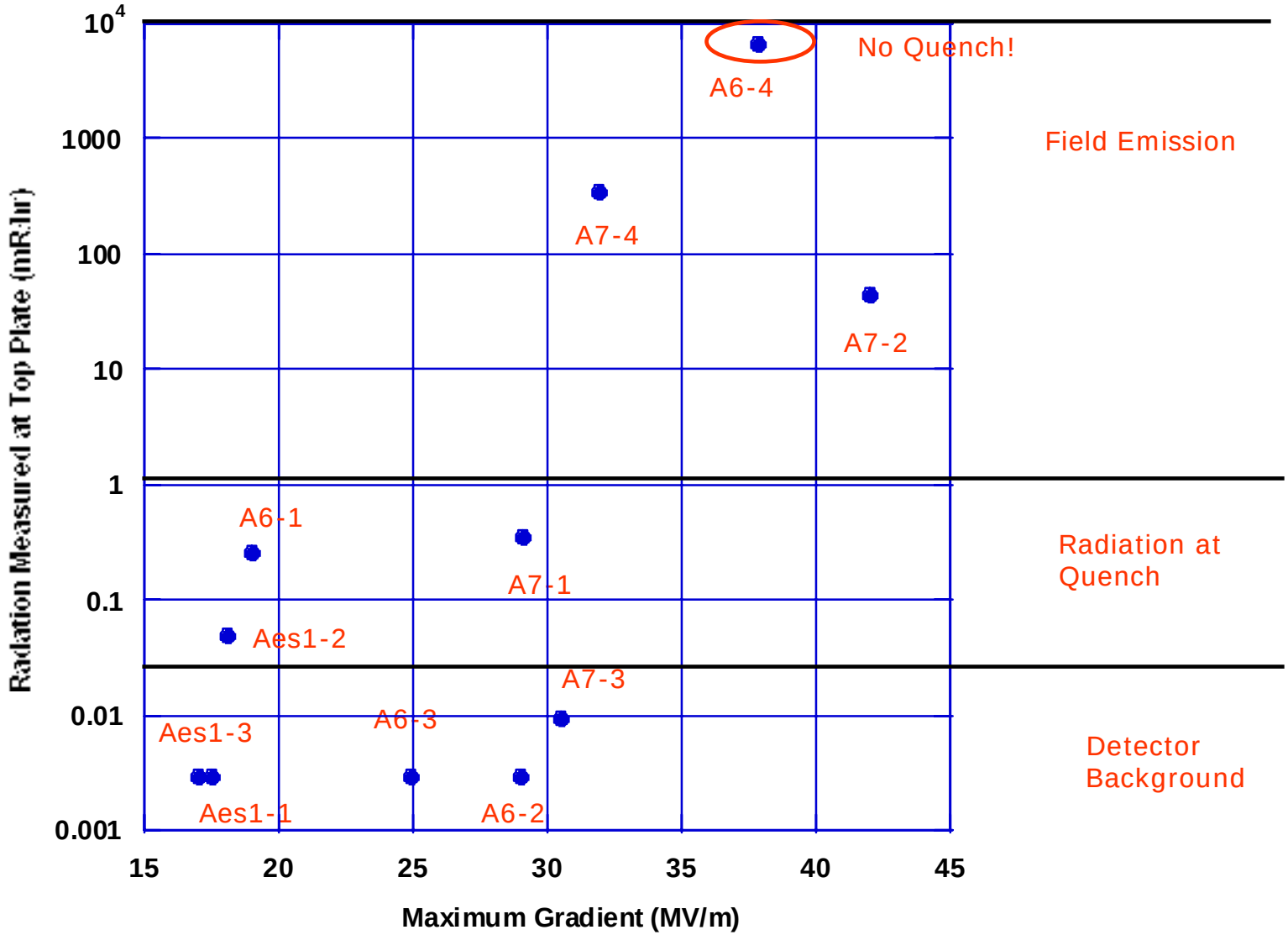
Analysis of Stored Energy Sqrt(P*Q) for AES1 Test #2

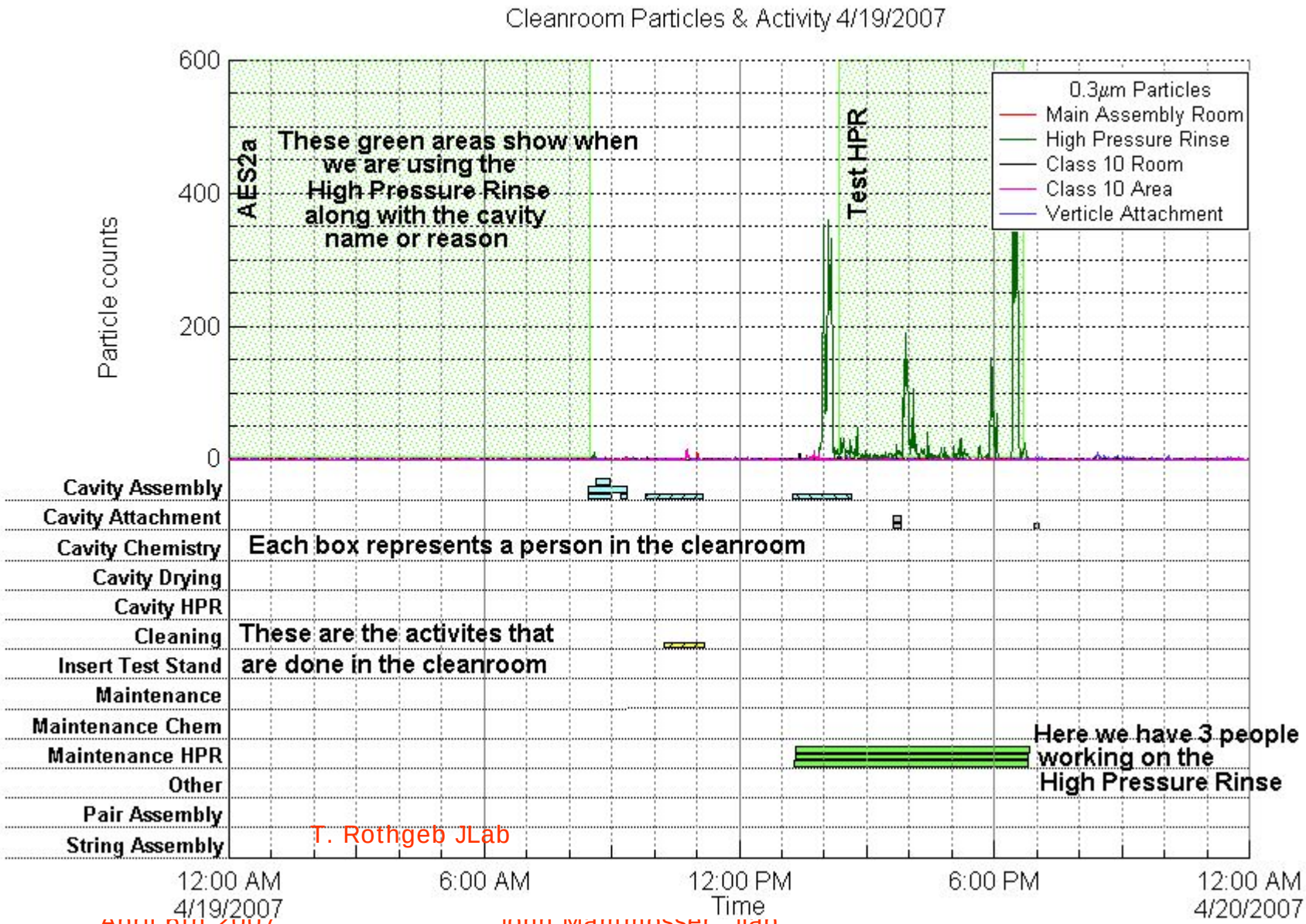
Mode	FPC Cell1	Cell2	Cell3	Cell4	Cell5	Cell6	Cell7	Cell8	Cell9
9	34.3	-34.3	34.3	-34.3	34.3	-34.3	34.3	-34.3	34.3
8	**43.0**	-37.8	28.1	-14.9	0.0	14.9	-28.1	37.8	**-43.0**
7	**38.5**	-20.5	-7.1	31.4	**-40.9**	31.4	-7.1	-20.5	**38.5**
6	32.6	0.0	-32.6	32.6	0.0	-32.6	32.6	0.0	-32.6
5	31.6	20.6	-38.7	-7.2	41.2	-7.2	-38.7	20.6	31.6
4	37.7	**50.8**	-20.1	**-57.8**	0.0	**57.8**	20.1	**-50.8**	-37.7
3	21.4	**42.9**	21.4	-21.4	**-42.9**	-21.4	21.4	**42.9**	21.4
2	12.2	30.9	35.2	23.0	0.0	-23.0	-35.2	-30.9	-12.2
1	7.8	22.3	34.2	**42.0**	**44.6**	**42.0**	34.2	22.3	7.8

Material Removal Data: Equators

AES1	FPC							Fp	
	1	2	3	4	5	6	7	8	9
As received	3.403	3.317	3.305	3.295	3.306	3.321	3.33	3.309	3.304
After bulk	3.262	3.155	3.163	3.143	3.163	3.183	3.199	3.165	3.163
	141	**162**	**142**	**152**	**143**	**138**	**131**	**144**	**141**
After 1st	3.212	3.13	3.129	3.12	3.122	3.136	3.147	3.132	3.117
	191	**187**	**176**	**175**	**184**	**185**	**183**	**177**	**187**
After 2nd	3.17	3.091	3.077	3.051	3.053	3.066	3.094	3.072	3.068
	233	**226**	**228**	**244**	**253**	**255**	**236**	**237**	**236**

Radiation Summary for All Qualifying Tests




Cleanroom Particles & Activity 4/19/2007
Particle counts
600
400
200
0
AES2a
Test HPR
0.3μm Particles
Main Assembly Room
High Pressure Rinse
Class 10 Room
Class 10 Area
Verticle Attachment
These green areas show when we are using the High Pressure Rinse along with the cavity name or reason
Each box represents a person in the cleanroom
These are the activites that are done in the cleanroom
Here we have 3 people working on the High Pressure Rinse
Cavity Assembly
Cavity Attachment
Cavity Chemistry
Cavity Drying
Cavity HPR
Cleaning
Insert Test Stand
Maintenance
Maintenance Chem
Maintenance HPR
Other
Pair Assembly
String Assembly
12:00 AM 4/19/2007
6:00 AM
12:00 PM
Time
6:00 PM
12:00 AM 4/20/2007

30 Elements in UPW by ICP-MS

		HPR ON 1/25/2007	FINAL FILTER 1/25/2007
Units: ppt (ng/L)			
Aluminum (Al)	3	*	*
Antimony (Sb)	2	*	*
Arsenic (As)	5	*	*
Barium (Ba)	1	*	*
Bismuth (Bi)	1	*	*
Boron (B)	50	73	73
Cadmium (Cd)	3	*	*
Calcium (Ca)	200	*	*
Chromium (Cr)	4	*	*
Cobalt (Co)	1	*	*
Copper (Cu)	3	*	*
Gallium (Ga)	2	*	*
Germanium (Ge)	3	*	*
Iron (Fe)	20	*	*
Lead (Pb)	3	*	*
Lithium (Li)	2	*	*
Magnesium (Mg)	2	*	*
Manganese (Mn)	2	*	*
Mercury (Hg)	20	*	*
Molybdenum (Mo)	4	*	*
Nickel (Ni)	4	*	*
Potassium (K)	100	*	*
Silver (Ag)	1	*	*
Sodium (Na)	7	*	*
Strontium (Sr)	1	*	*
Tin (Sn)	5	*	*
Titanium (Ti)	2	*	*
Tungsten (W)	5	*	*
Vanadium (V)	3	*	*
Zinc (Zn)	5	*	*

* = Analysis revealed that the analyte was not found at or above the reporting limit. RL = Reporting Limit

Low-level Dissolved Silica

			FINAL FILTER 1/25/2007
		HPR ON 1/25/2007	
Units: ppb (ug/L)			
Silica, LL dissolved	0.1	0.2	0.2

Total Silica

			FINAL FILTER 1/25/2007
		HPR ON 1/25/2007	
Units: ppb (ug/L)			
Silica, Total	0.5	*	0.6

Anions by IC (UltraPure)

			FINAL FILTER 1/25/2007
		HPR ON 1/25/2007	
Units: ppb (ug/L)			
Fluoride (F-)	0.03	*	*
Chloride (Cl-)	0.02	*	*
Nitrite (NO2-)	0.02	*	*
Bromide (Br-)	0.02	*	*
Nitrate (NO3-)	0.02	*	*
Phosphate (HPO4=)	0.02	*	*
Sulfate (SO4=)	0.05	*	*

Monovalent & Divalent Cations by IC (UltraPure)

			FINAL FILTER 1/25/2007
		HPR ON 1/25/2007	
Units: ppb (ug/L)			
Lithium (Li+)	0.01	*	*
Sodium (Na+)	0.01	*	*
Ammonium (NH4+)	0.02	*	*
Potassium (K+)	0.02	*	*
Magnesium (Mg++)	0.02	*	*
Calcium (Ca++)	0.02	*	*

Production Improvements Needed:

- Hands free assembly tooling needed for reduction of assembly errors
- Variable coupler for RF testing
- Documentation of procedures and development of working travelers

Questions:

- With the large distribution in performance due to quenches
  1. Are these quenches driven by field emission or MP?

  - Or is the limitation a product of each chemistry cycle a real surface feature or texture?

  - Can we characterize the surface each run?

  - Or is the quench caused by contamination on the surface due to improper cleaning?

- Clearly we need more production supportive studies to further improve our understanding and cavity performance!