XFEL CAVITY RESULTS AND EXTRAPOLATION TO ILC

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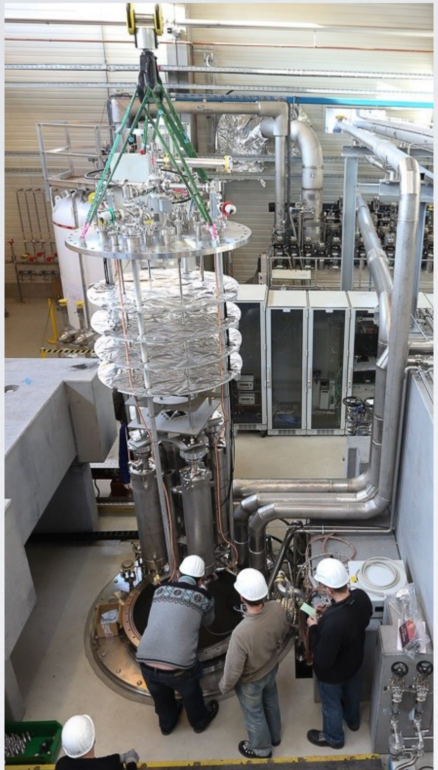
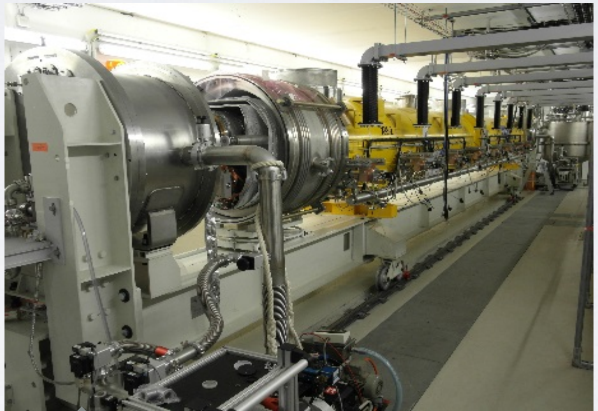
12.12.14 ILC@DESY project meeting

SRF CRYOMODULE PRODUCTION

Fabrication in Industry (EZ, RI)



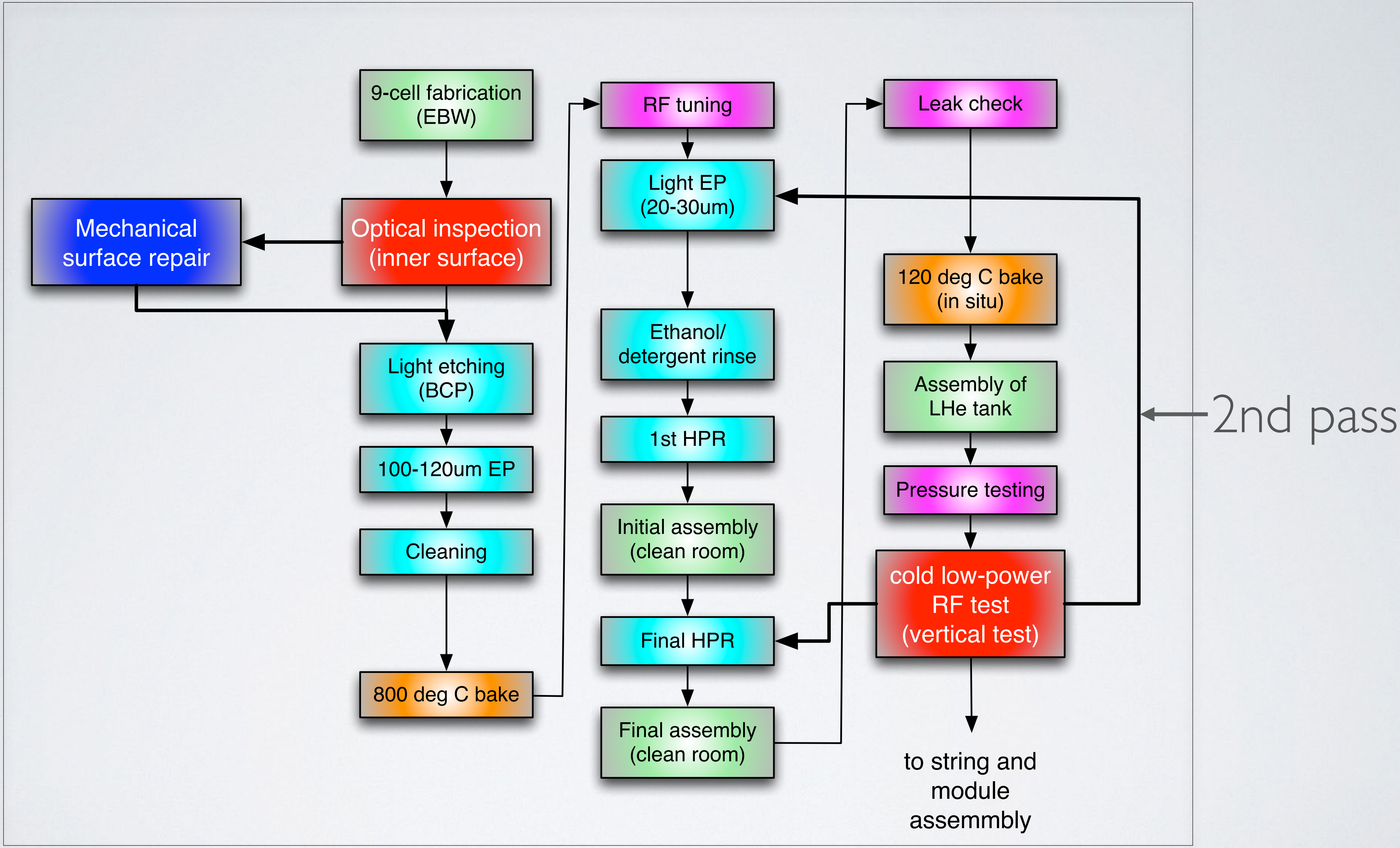
Vertical (accept.) Test (VT) at DESY AMTF



Module testing at DESY AMTF

Module assembly @ CEA Saclay

ILC CAVITY SURFACE PROCESS

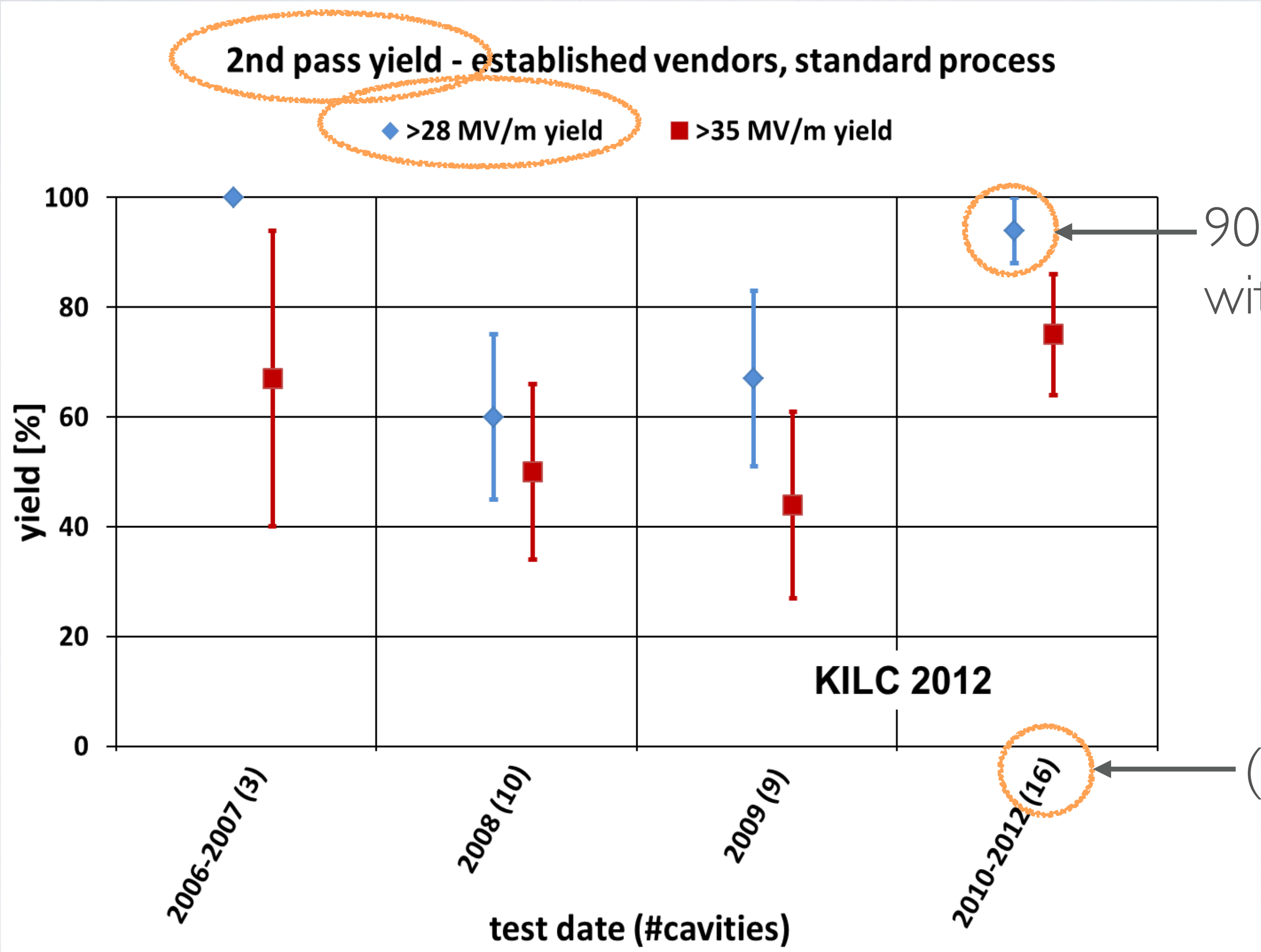


ILC TDR (based on XFEL)

TDR ASSUMPTIONS (COST)

- 1st pass yield: 75% with $G \geq 28$ MV/m and $\langle G \rangle = 35$ MV/m
- 25% undergo retreatment → ~90% yield (final)
- cost model included:
  - 10% over-production
  - 25% additional surface treatments (EP)
  - 1.25 vertical tests per cavity

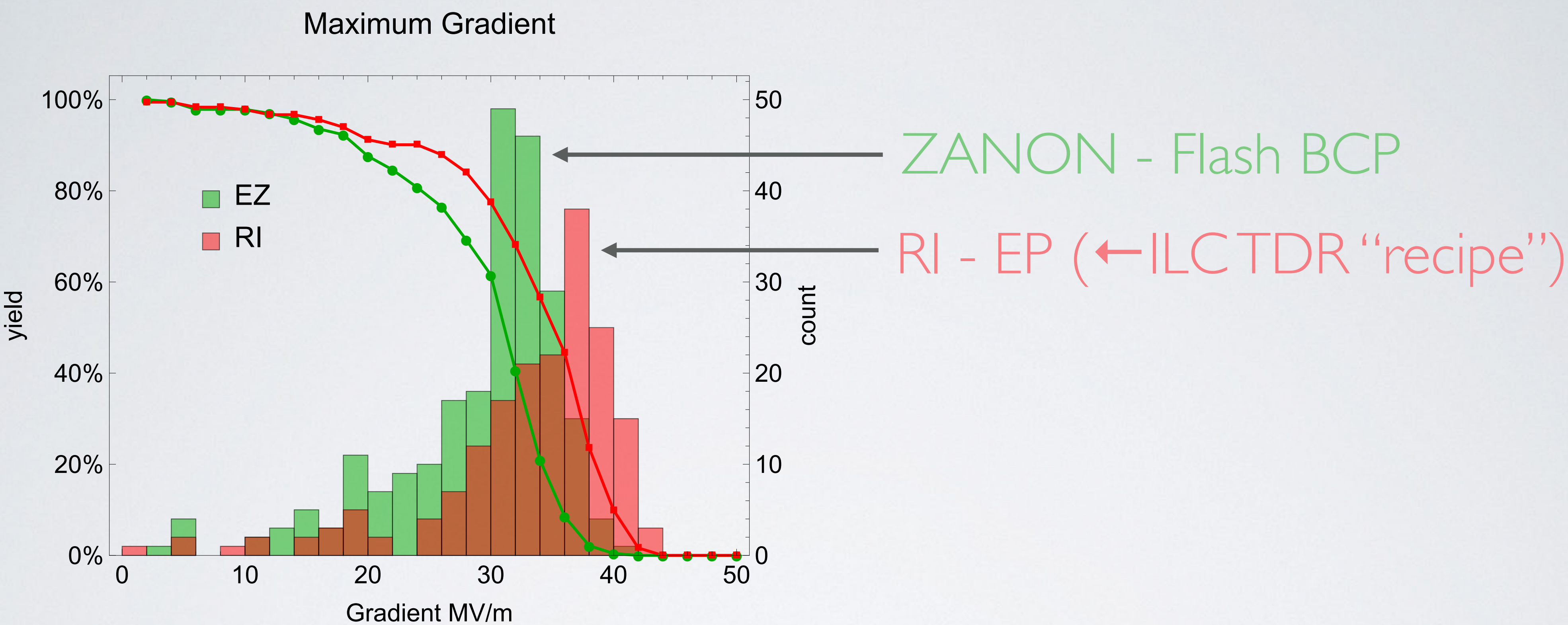
TDR HIGH-GRADIENT R&D



90% second pass yield with G≥28 MV/m

(based on 16 cavities)

XFEL CAVITY PRODUCTION

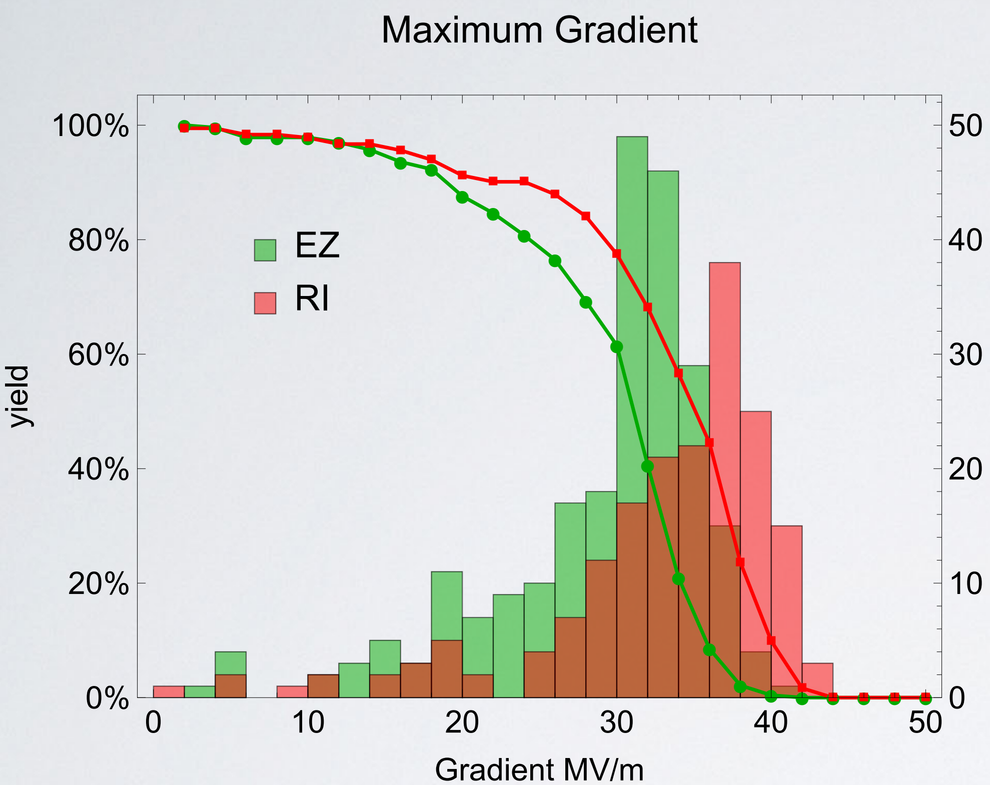


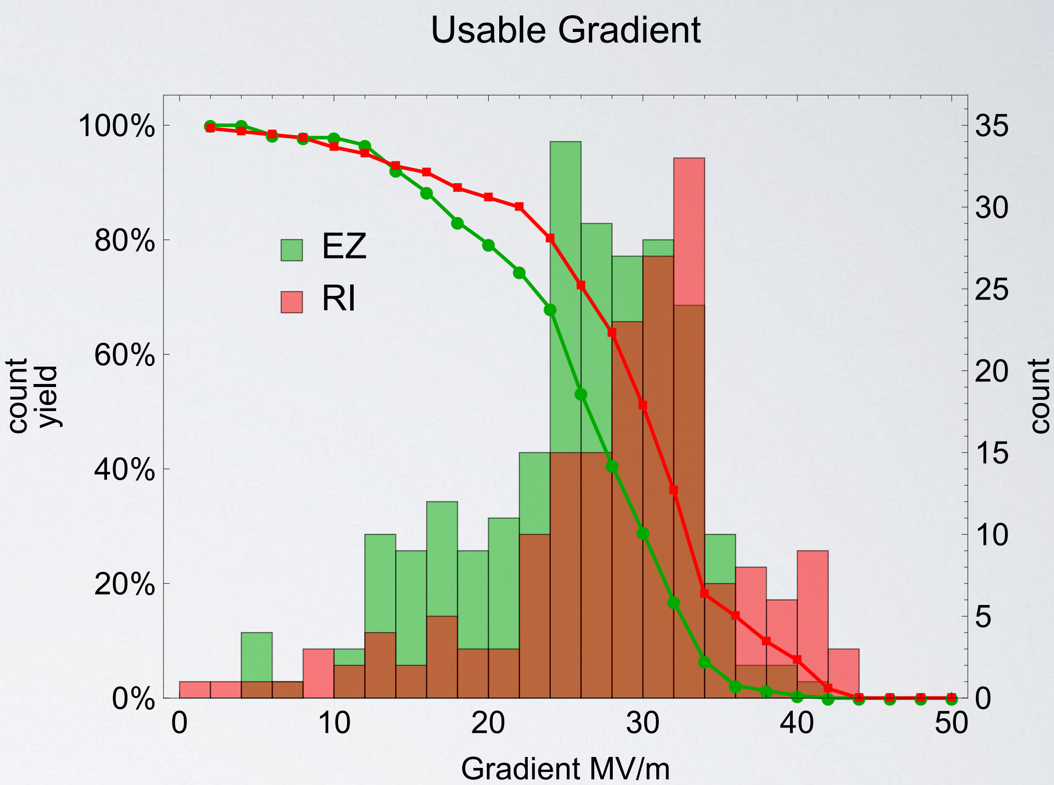
	RI	EZ	Total
Tests	182	234	416
G_{AVG} (MV/m)	33.1	29.1	30.8
G_{RMS} (MV/m)	7.5	7.	7.5
yield @ 20MV/m	91%	88%	89%
yield @ 26MV/m	88%	76%	81%
yield @ 28MV/m	84%	69%	76%

XFEL USABLE FIELD

- Usable field for XFEL is defined as the lowest of
  - MAX FIELD (i.e. vertical test max achieved)
  - $Q_0 < 10^{10}$ (Q-limited)
  - X-RAY monitors (F.E. limited)
    - top sensor ≤0.01 mGy/min (historical from TTF measurements)
    - bottom sensor ≤0.12 mGy/min (calibrated wrt top)

XFEL CAVITY PRODUCTION





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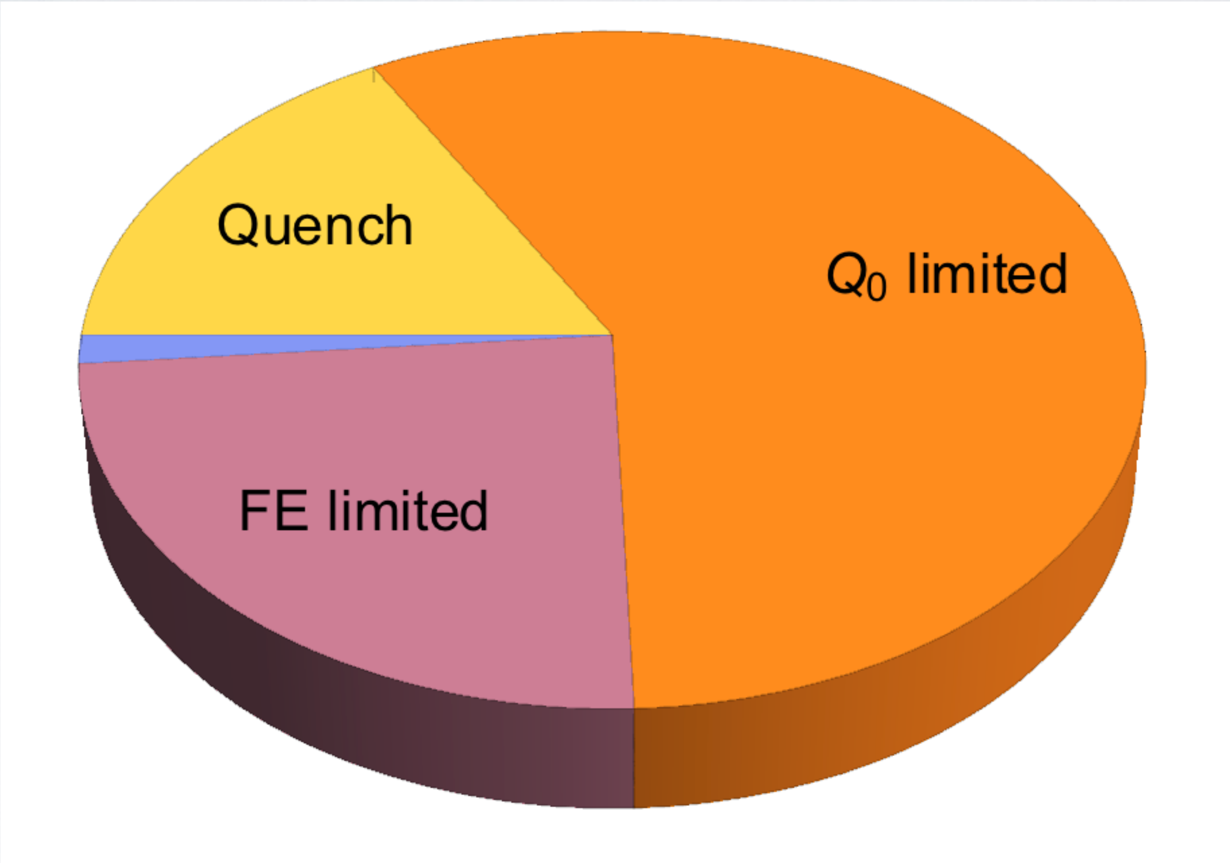
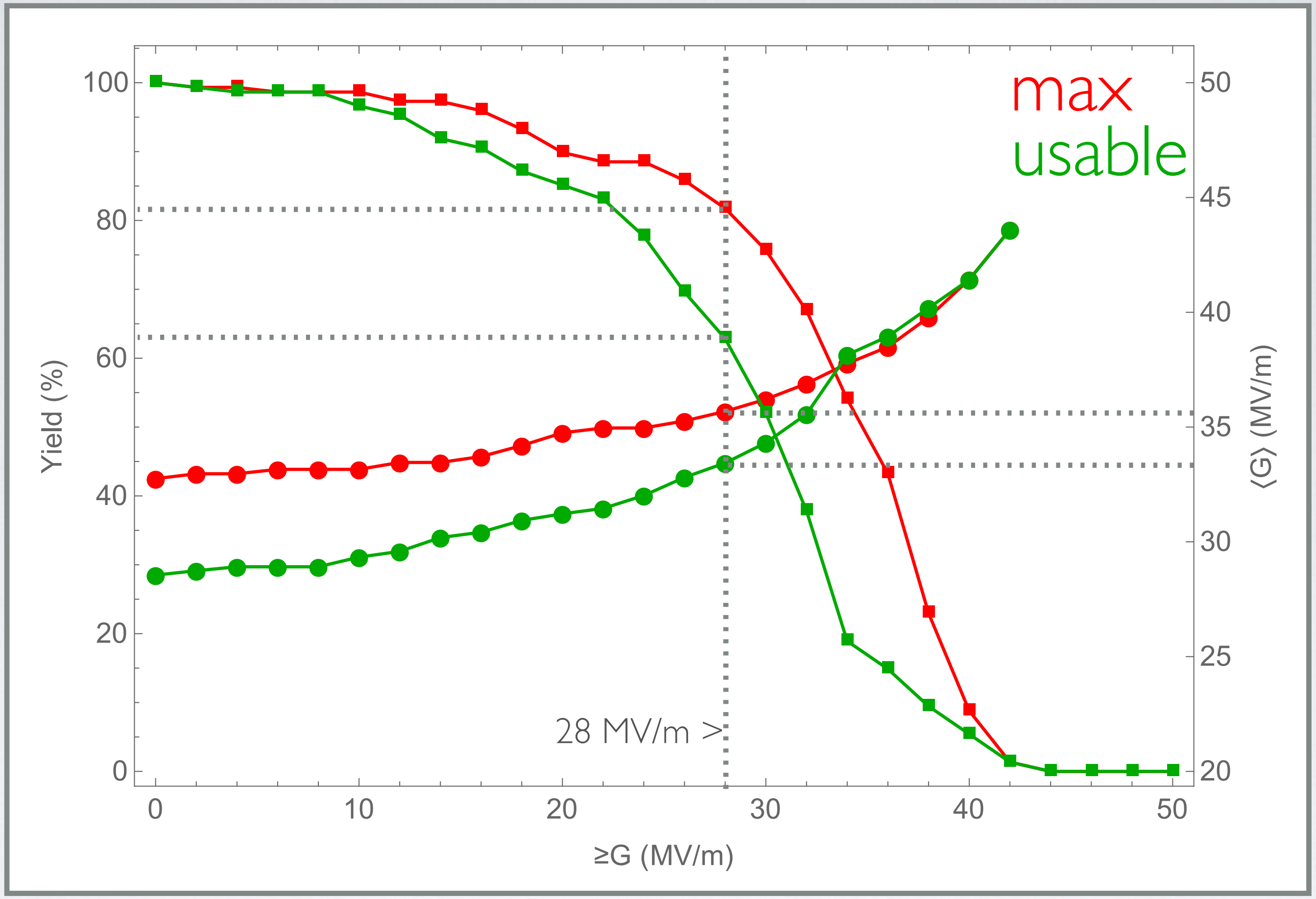
	RI	EZ	Total
Tests	182	231	413
G_{AVG} (MV/m)	28.8	25.5	26.9
G_{RMS} (MV/m)	7.9	6.9	7.5
yield @ 20MV/m	87%	79%	83%
yield @ 26MV/m	72%	53%	62%
yield @ 28MV/m	64%	41%	51%

USABLE GRADIENT - LIMITING EFFECTS

RI cavities only



YIELD (RI)

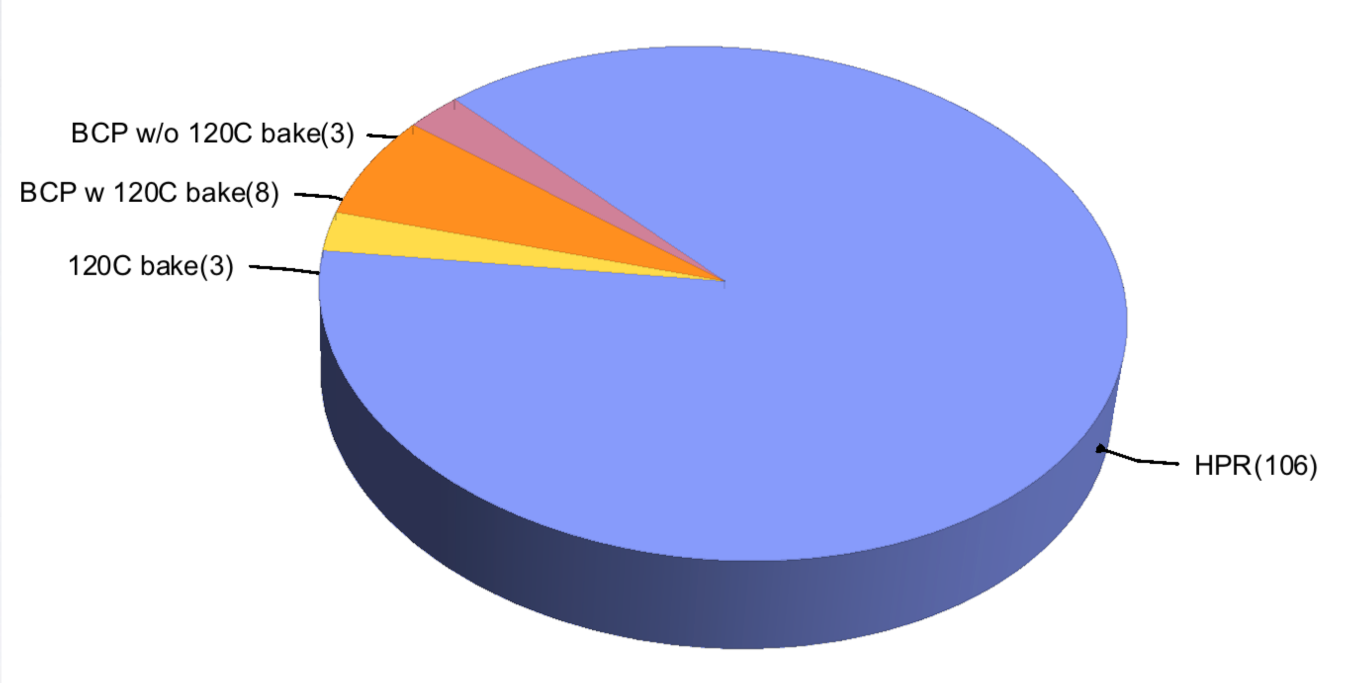


	Yield @ 28 MV/m	Average above 28 MV/m
Max gradient	82%	35.7 MV/m
Usable gradient	64%	33.4 MV/m

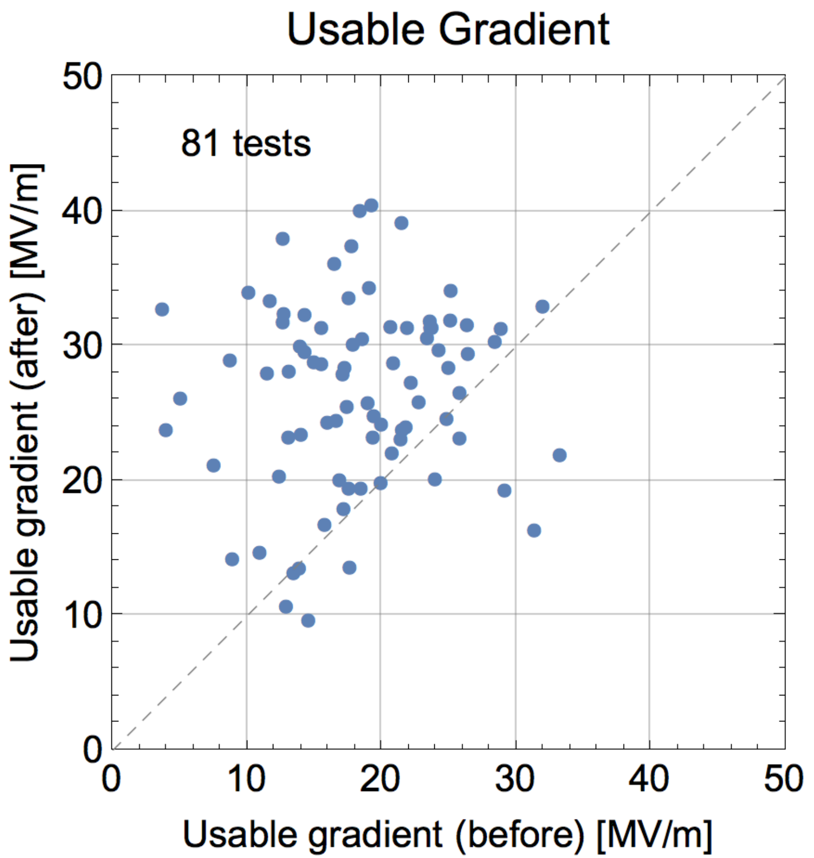
TDR: 75% with 35 MV/m

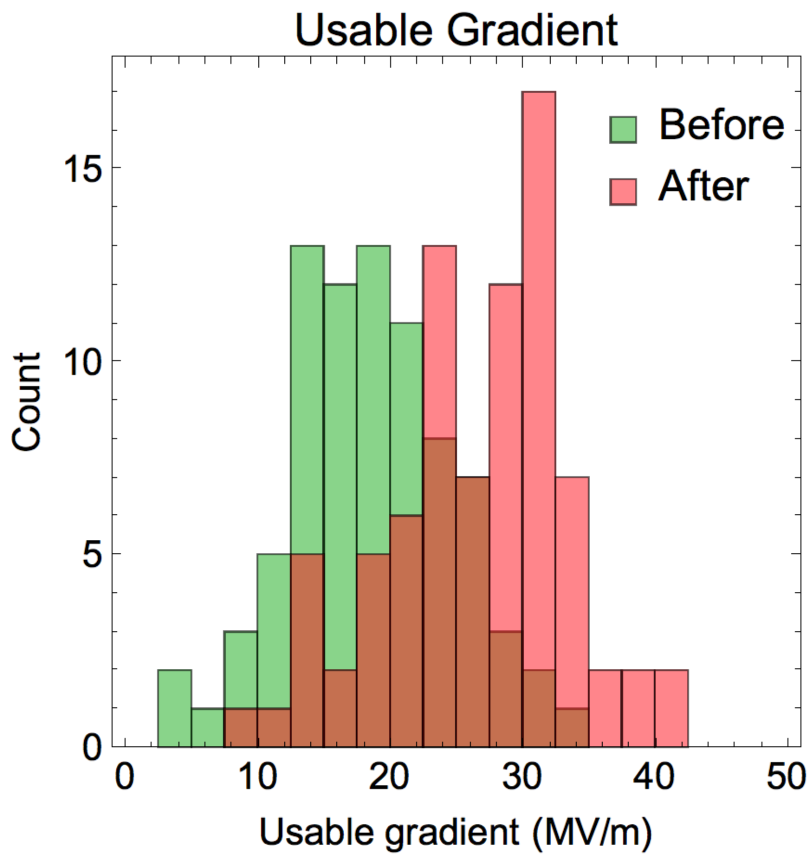
XFEL RETREATMENT

- Original retreatment criteria was <26 MV/m
  - ~40% of cavities
- Now <20 MV/m
  - ~20% of cavities
- FE dominated
  - mostly HPR



XFEL RETREATMENT (HPR)



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retreatment, low Q      6
retreatment, quench     7
retreatment, FE         61
retreatment, other      6
retreatment, leak       2
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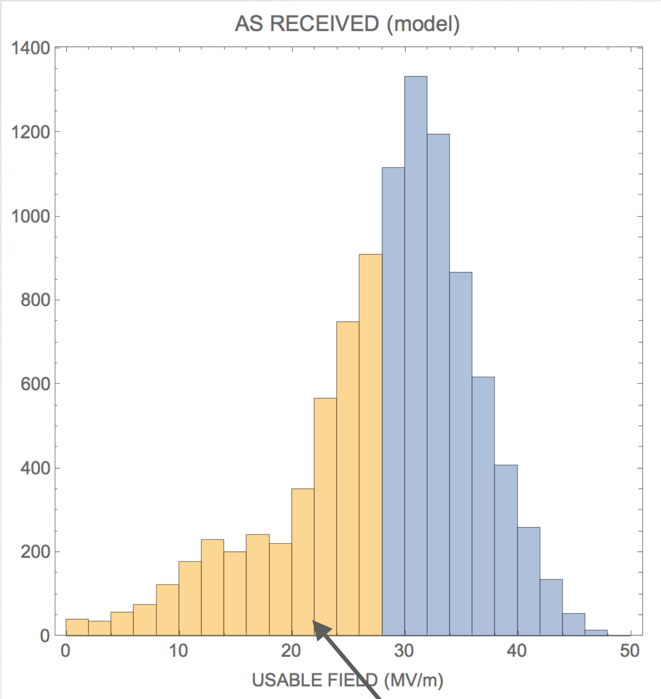
	Before	After
Tests	81	82
G_{AVG} (MV/m)	18.5	26.6
G_{RMS} (MV/m)	6.3	6.8
yield @ 20MV/m	40%	83%
yield @ 26MV/m	10%	56%
yield @ 28MV/m	7%	50%

A MODEL FOR ILC

RI USABLE FIELD distribution used to generated 1st pass VT results

XFEL HPR results used to generate model for (HPR) retreatment



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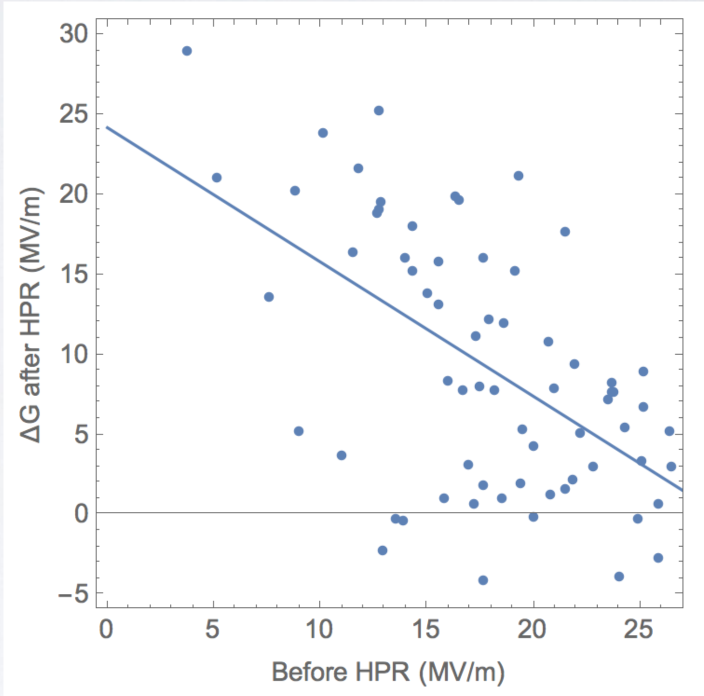
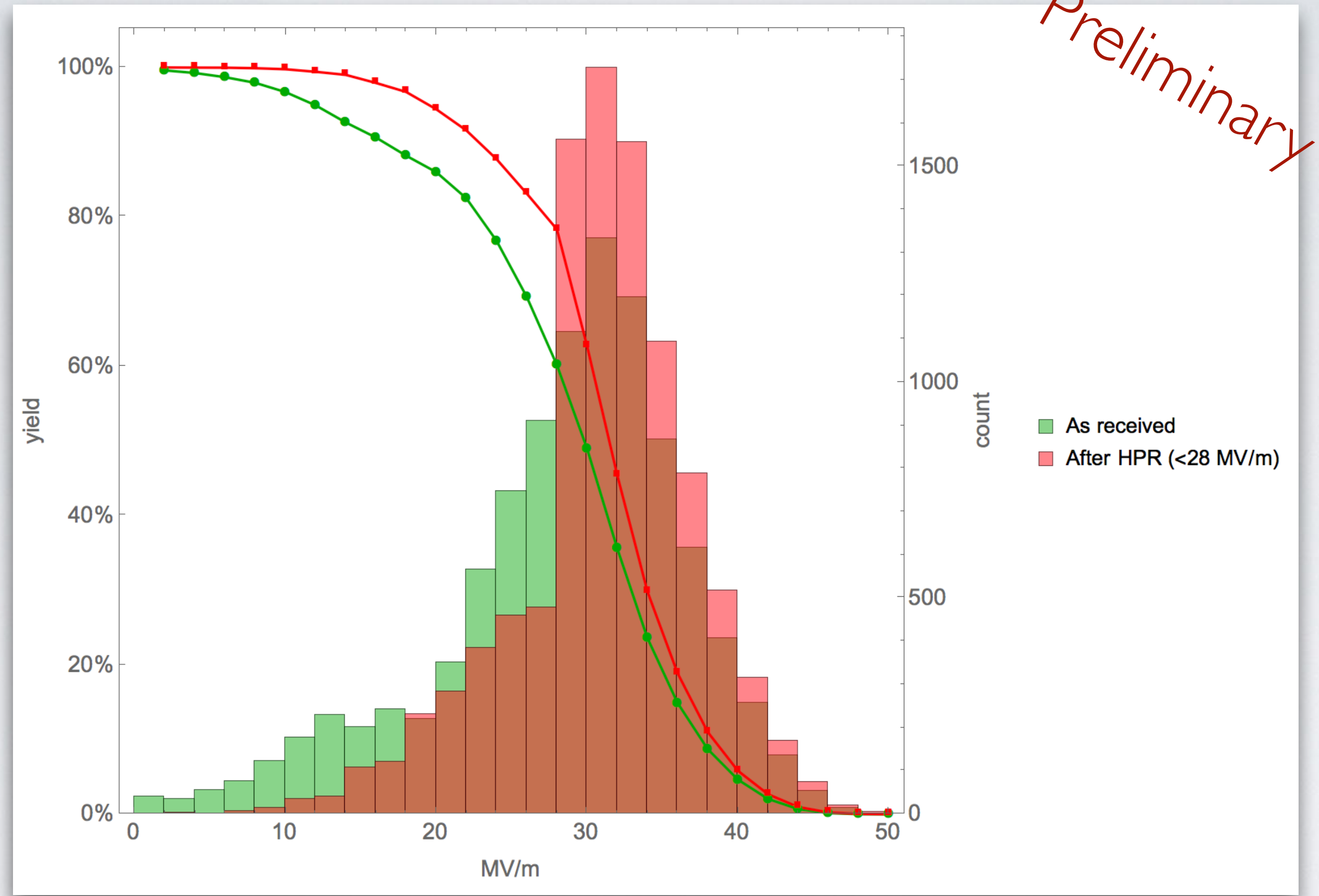


Retreatment model applied to cavities with *G*<28 MV/m

ILC MODEL - RESULT

Preliminary result!!



	Tests	Average	rms	Yield@28	Yield@31.5	Yield@35
As received	10 000	28.4	8.3	61%	40%	19%
Second Pass	10 000	30.9	6.4	77%	49%	24%

SOME INITIAL CONCLUSIONS

- RI (ILC recipe) results close to TDR assumptions
  - MAX FIELD 82% yield, <G>~35.7 MV/m
  - USABLE FIELD (XFEL) 61% yield <G>~33.4 MV/m
  - ILC TDR: 75% with <G> = 35 MV/m
- XFEL dominated by FE at low gradients for which simple HPR proves quite effective
- ILC projection of HPR retreatment increases UF yield 61% to 77%
  - 23% of cavities would still require further retreatment
  - projected tests per cavity = 1 + 0.4 (1st pass) + ~0.2 (2nd pass) + ~0.1 (other) ~ 1.7

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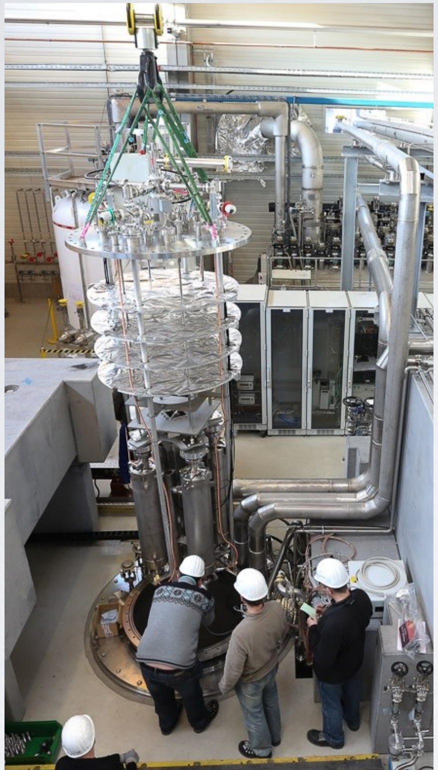

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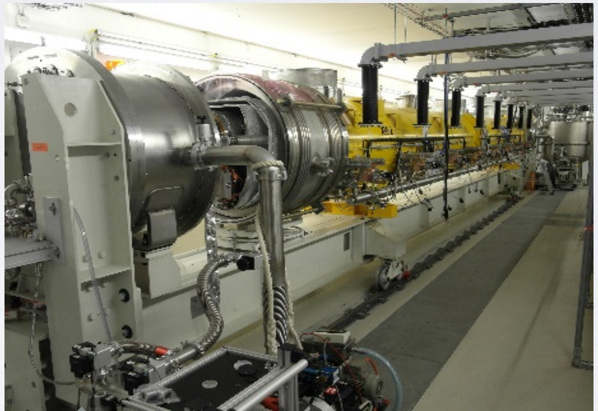
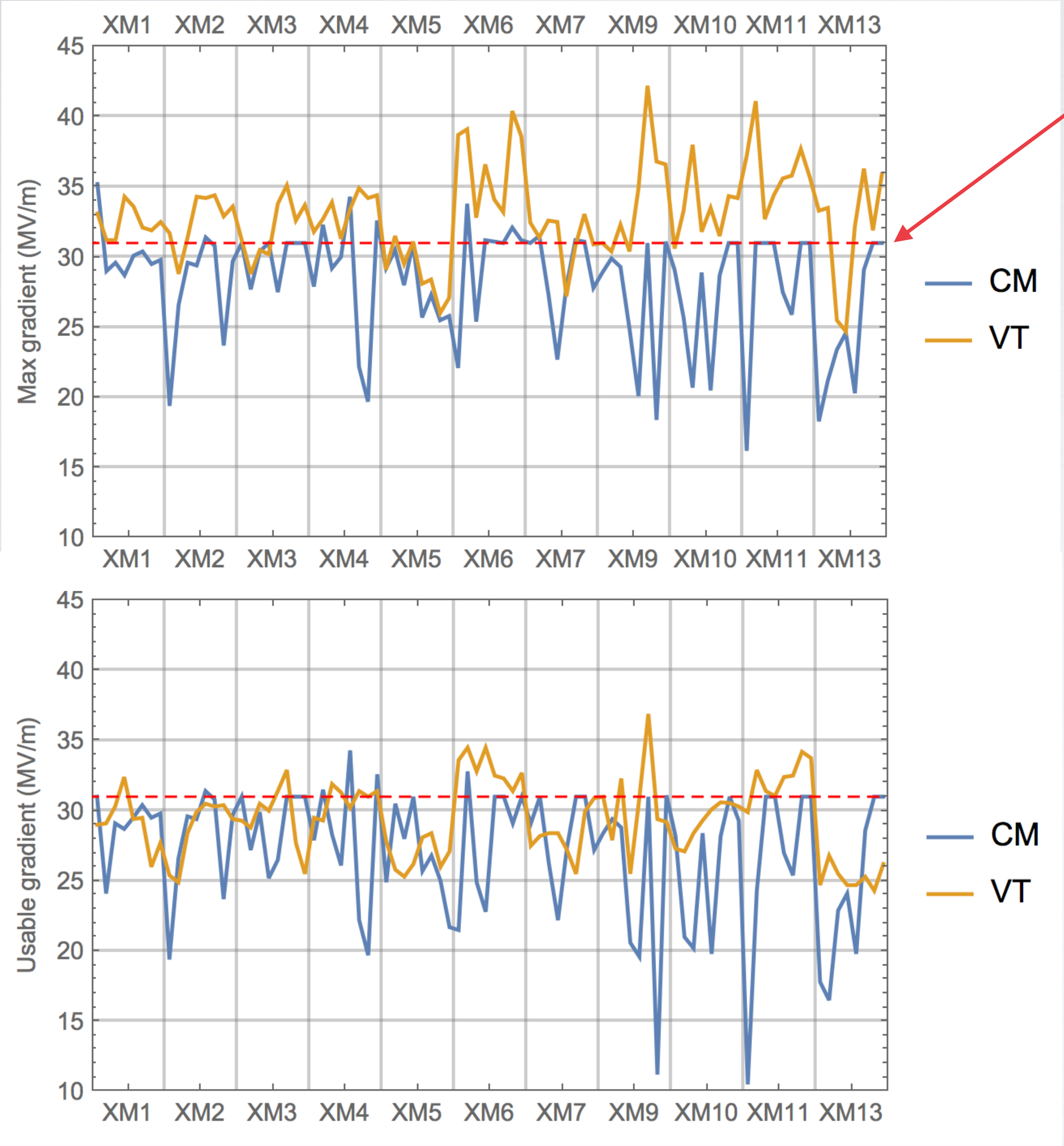


Module testing at DESY AMTF

XFEL MODULE RESULTS



31 MV/m max in AMTF

	max	usable*
VT	33.0 ±3.2	29.4 ±2.7
CM	28.1 ±4.1	27.0 ±4.7
Diff.	-14% ±14%	-8% ±17%

* no Q_0 constraint in CM test

FINAL COMMENTS (FOR NOW)

- XFEL looking OK for design gradient (23.6 MV/m)
  - 11 modules show ⟨G⟩ ~ 27 MV/m
- RI production (VT) close ILC specification
  - max gradient (quench) OK (82% yield >28 MV/m, with ⟨G⟩ ~35.7)
  - usable gradient (XFEL def) yield still a little low (64%, 33 MV/M)

cost increase
- required over-production
- VT per cavity

- For ILC production need to:
  - Reduce FE dominated low gradient tail and increase overall yield
  - Reduce "degradation" in module assembly to ~5% (and not just the average!)
- Watch this space!
  - Only 10% module production
  - 320 cavities to come (and RI showing improving trend over last three months)
- However, 31.5 MV/m join average remains a challenging goal (for mass production)
  - More margin in ILC design probably worth considering (tunnel length!)