Accelerator Design and Integration Meeting at DESY

SCRF

May 28, 2009

Subjects to be discussed

1. **Cavity Field Gradient and the Re-baseline**
2. **HLRF: RF Distribution System**

PM "SB2009" Proposal

- A Main Linac length consistent with an optimal choice of average accelerating gradient
  - **currently 31.5 MV/m, to be re-evaluated**
- Single-tunnel solution for the Main Linacs and RTML,
  - **with two possible variants for the HLRF**
    - **Klystron cluster scheme**
    - **DRFS scheme**

- Undulator-based e+ source located at the end of the electron Main Linac (250 GeV)
- Reduced parameter set (with respect to the RDR) with n_b = 1312 and a 2ms RF pulse.
- ~3.2 km circumference damping rings at 5 GeV, 6 mm bunch length.
- Single-stage bunch compressor with a compression factor of 20.
- Integration of the e+ and e- sources into a common "central region beam tunnel", together with the BDS.

Global Plan for SCRF R&D

Calender Year	2007	2008	2009	2010	2011	2012
Technical Design Phase	TDP-1				TDP-2	
Cavity Gradient R&D to reach 35 MV/m		Process Yield > 50%			Production Yield >90%	
Cavity-string test: with 1 cryomodule			**Global collab.** **For <31.5 MV/m>**			
System Test with beam 1 RF-unit (3-modulce)		FLASH (DESY)			STF2 (KEK) NML (FNAL)	

R&D Mile Stone

- From TDP R&D Plan, Release 3, p8

3.1.2 SCRF Technical design and R&D Milestones

The milestones for the TD Phase 1 and 2 SCRF goals outlined in section 3.1.1 (notably the S0, S1 and S2 programs) are given in Table 3.1.

Table 3.1: Milestones for the SCRF R&D Program.

High-gradient cavity performance at 35 MV/m according to the specified chemical process with a process yield of 50% in TDP1, and with a production yield of 90% in TDP2 (S0, see section 3.1.3 for definition of process yield)	2010 2012
Plug-compatible Cryomodule internal and external interface specifications to be defined: - including considerations of tuneability and maintainability - thermal balance and cryogenics operation - beam dynamics (addressing issues such as orientation and alignment)	2009
Cavity-string performance in one cryomodule with the average gradient 31.5 MV based on a global effort (S1 and S1-global)	2010
Cryomodule-string performance achieving the average gradient 31.5 MV/m with full-beam loading and handling (S2)	2012

Definition of Yields to be updated

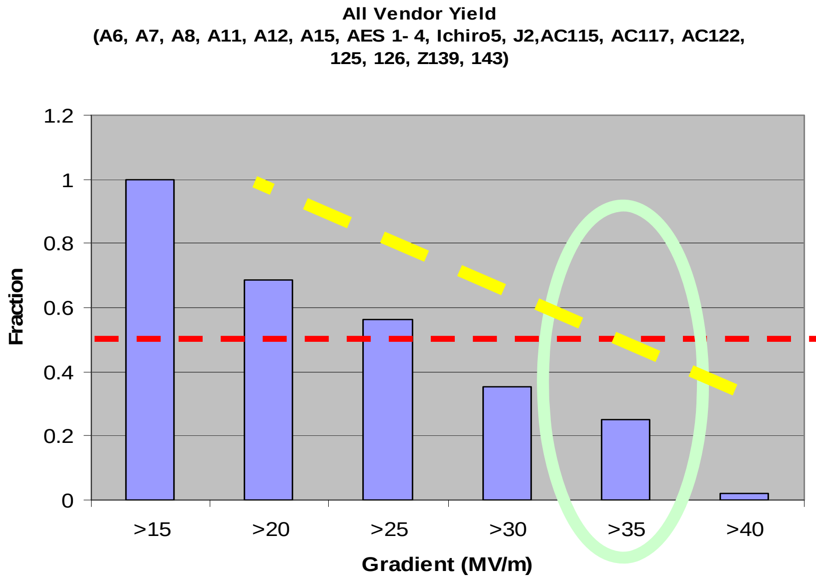
- We may need to
  - **update the Definition of "Process" and "Production" Yield given in R&D Plan (releae 3, page 9)**

For the purpose of evaluating progress towards producing cavities with a reproducible gradient near our goal, we have separated the concept of yield into two distinct definitions for the TD phases:

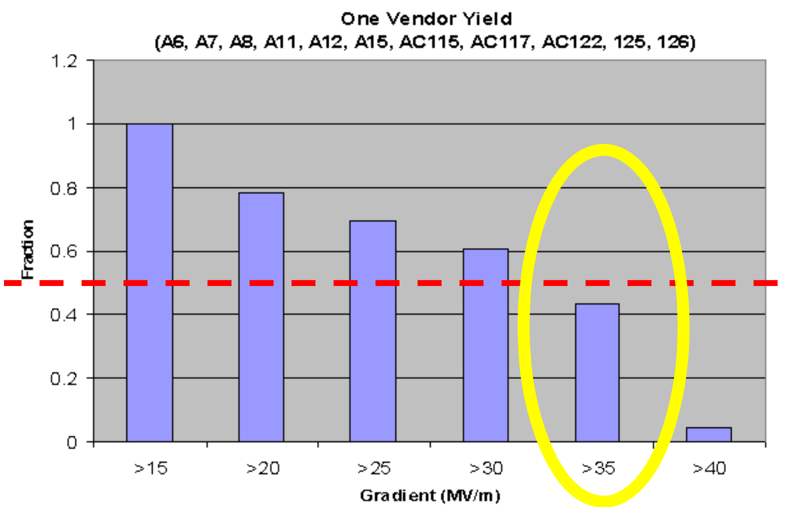
- For TD Phase 1, we define 'process yield' as the number of accepted cavities divided by the number of chemically processed cavities which fulfil some specified and justifiable criteria, such as those ordered from a qualified vendor or those passing specified mechanical test criteria. This allows us to separate fabrication-related defects, such as the pits or bumps in the vicinity of the electron-beam weld, from chemical surface treatment and cleaning-related problems. Final chemical treatment and rinsing is often done at an institution, rather than in industry, and is tightly coupled to the final assembly and testing procedure.
- For TD Phase 2, definition of 'production yield' is the number of accepted cavities divided by the number ordered. Production yield, as defined in the Reference Design, makes allowance for 20% of the cavities to be re-processed.

Global Yield of Cavities Recently Tested at Jlab and DESY

48 Tests, 19 cavities	23 tests, 11 cavities
ACCEL, AES, Zanon, Ichiro, Jlab	One Vendor



50%

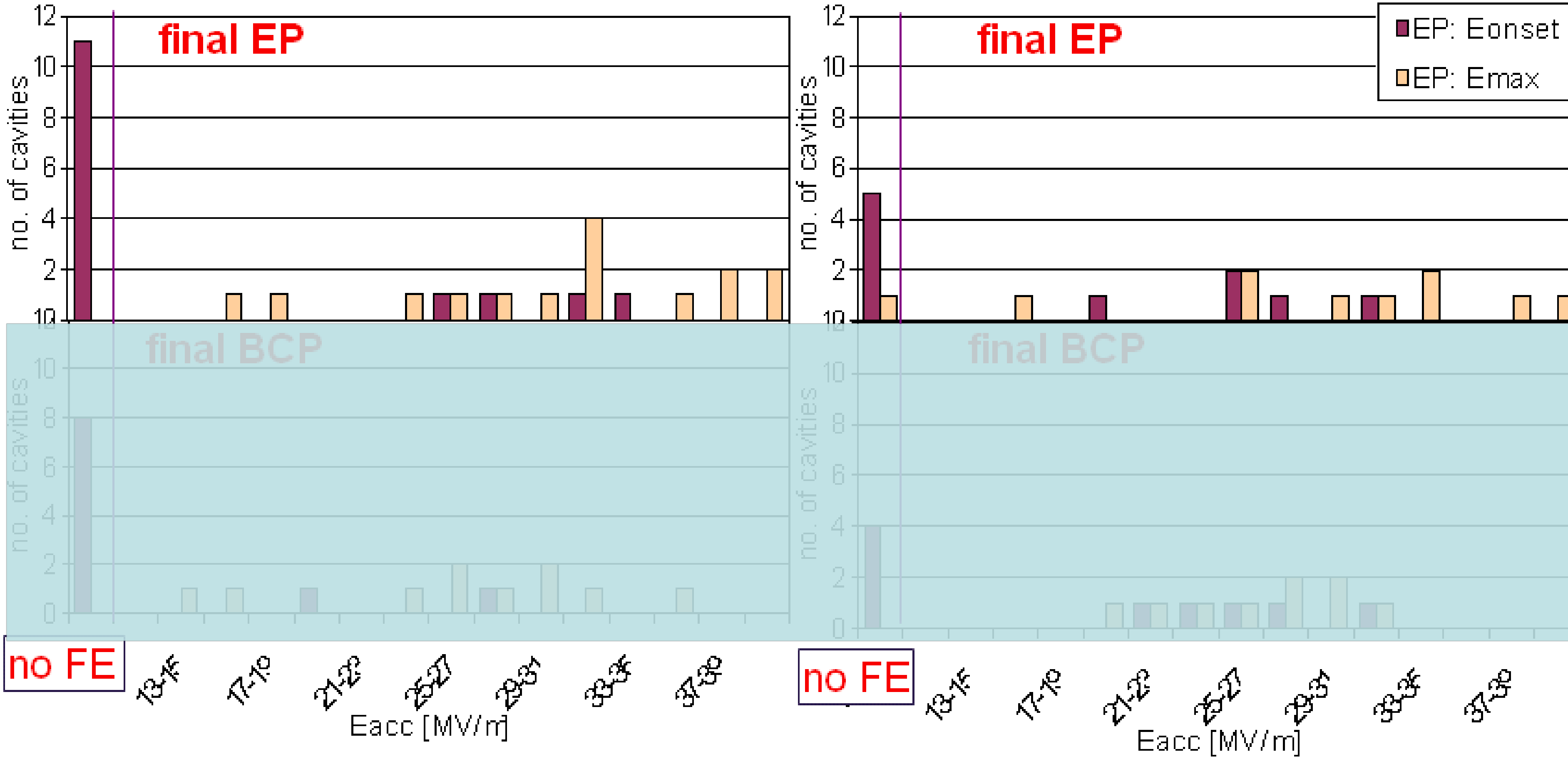


Yield 45 % at 35 MV/m being achieved by cavities with a qualified vendor !!

A Summary from TTC-08 (IUAC), ILC-08 (Chicago) by H. Padamsee

Final preparation: Analysis of final test

No He-tank !! With He-tank !!



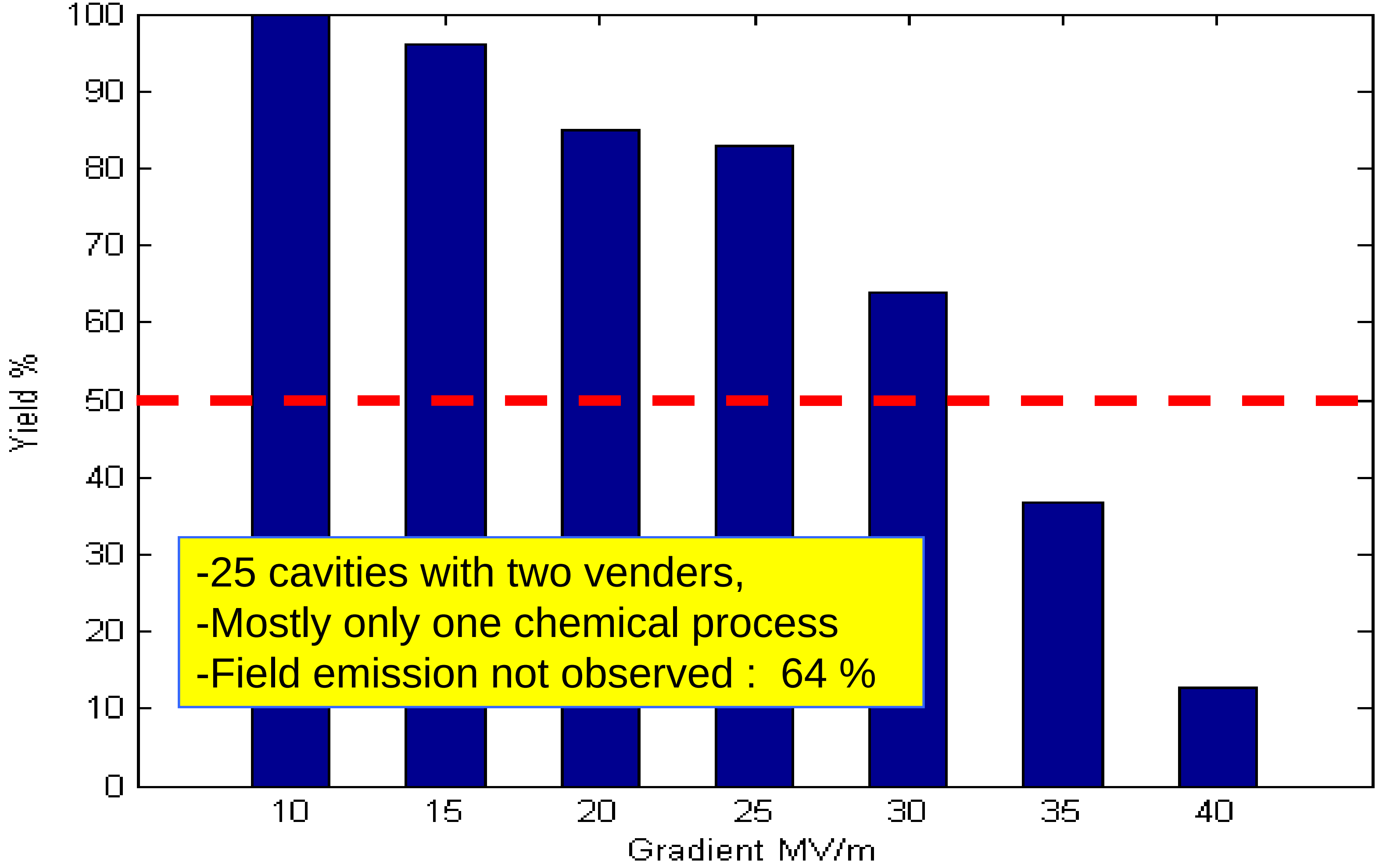
=> as expected: some improvement with respect to field emission

=> "final EP" gives higher E_{max} than "final BCP"

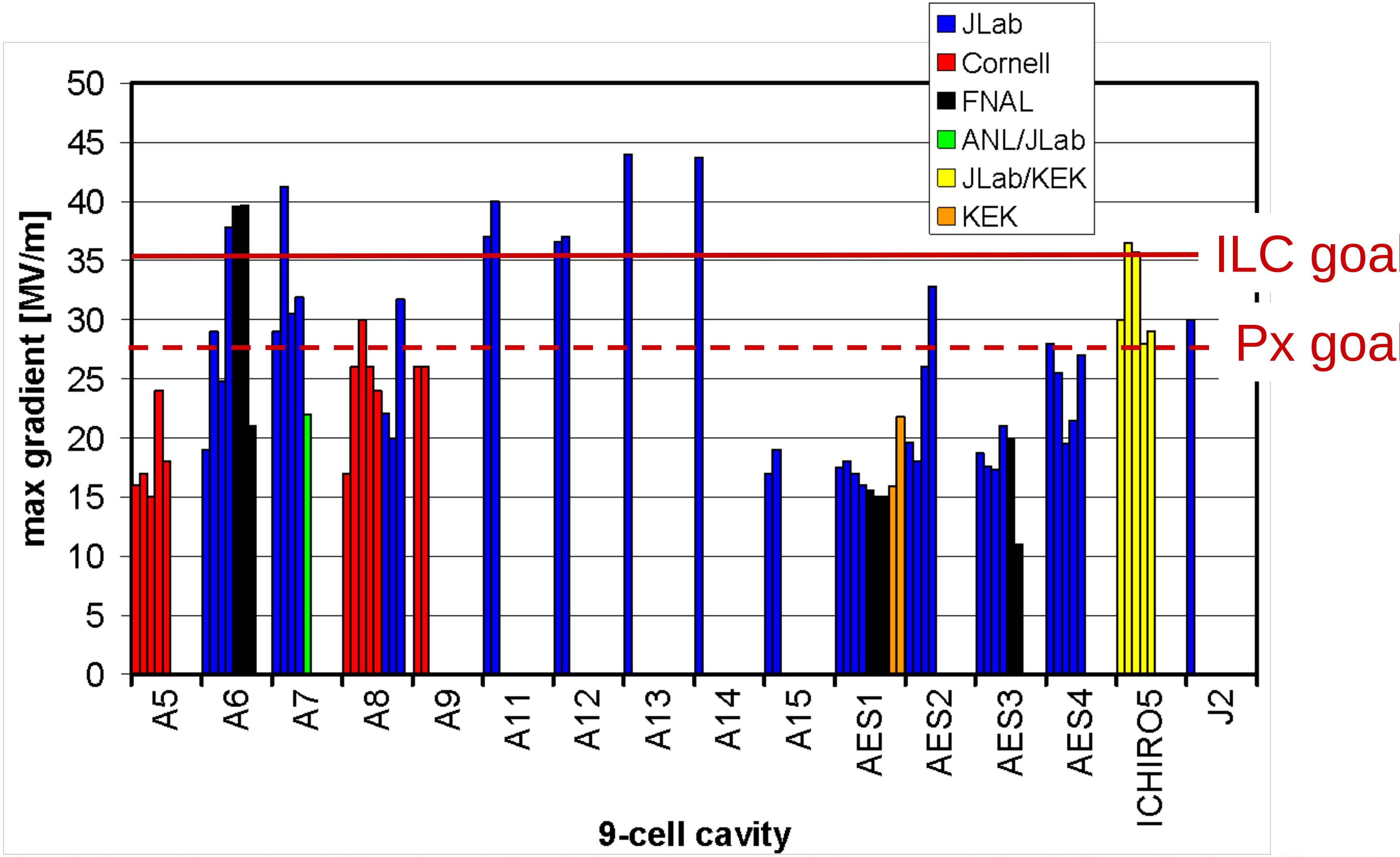
D. Reschke, to be published SRF 2009

Recent Progress in Yield at DESY

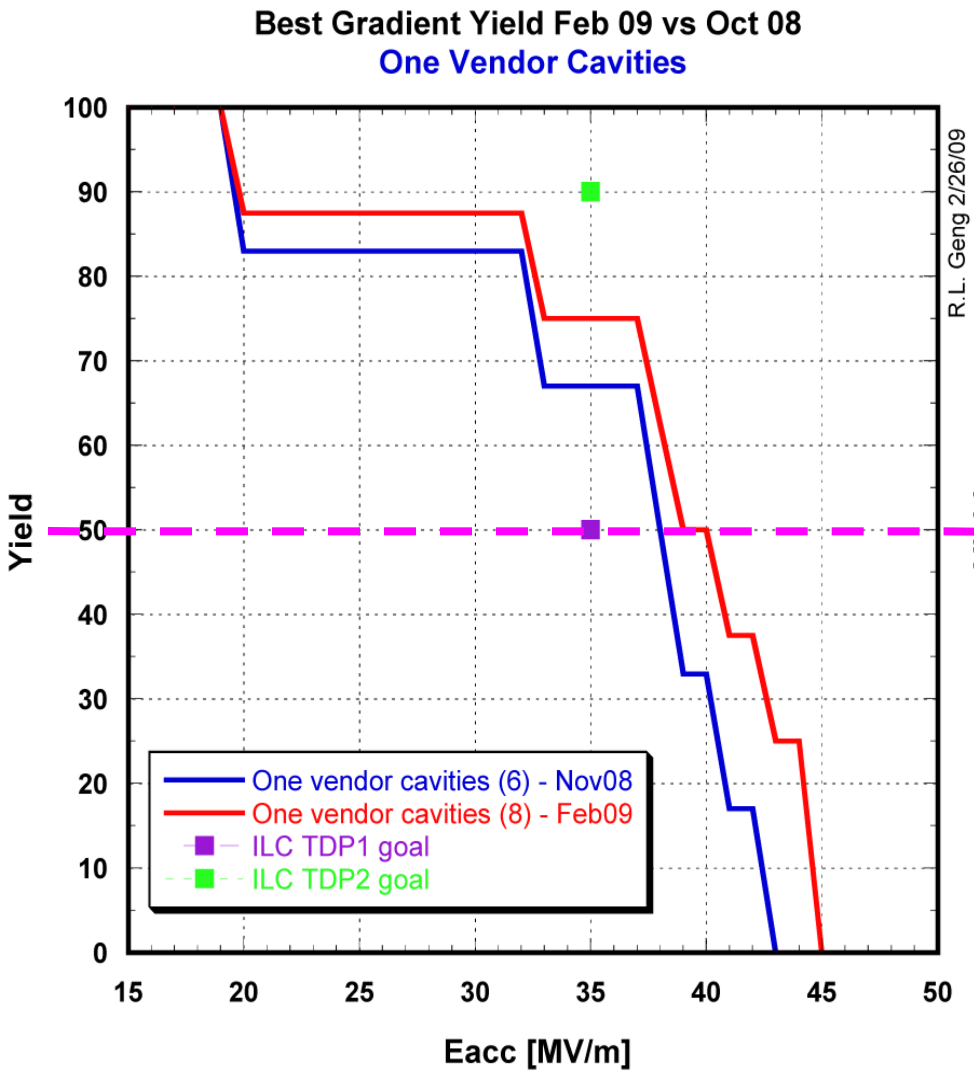
Data provided by D. Reschke, and reassembled by M. Ross

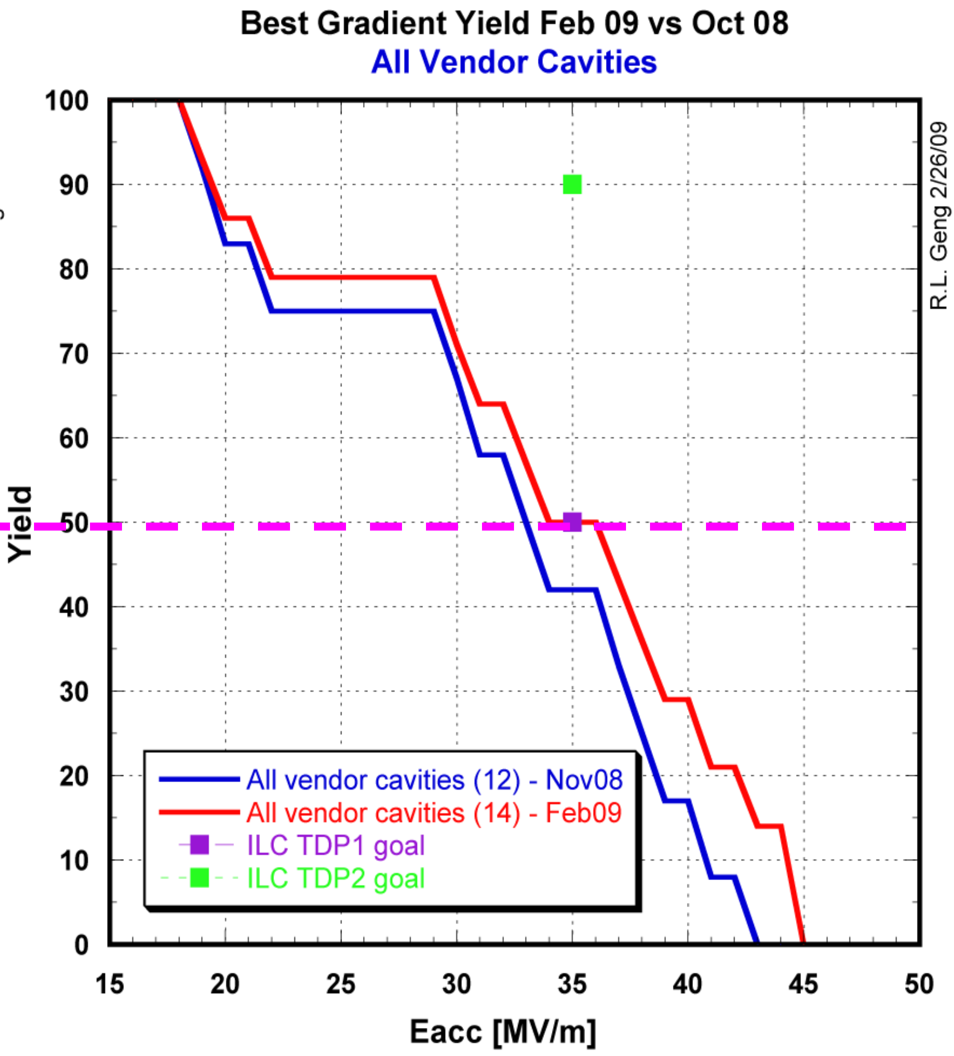


Summary of 9-cell Vertical Tests in U.S. as of Feb., 2009

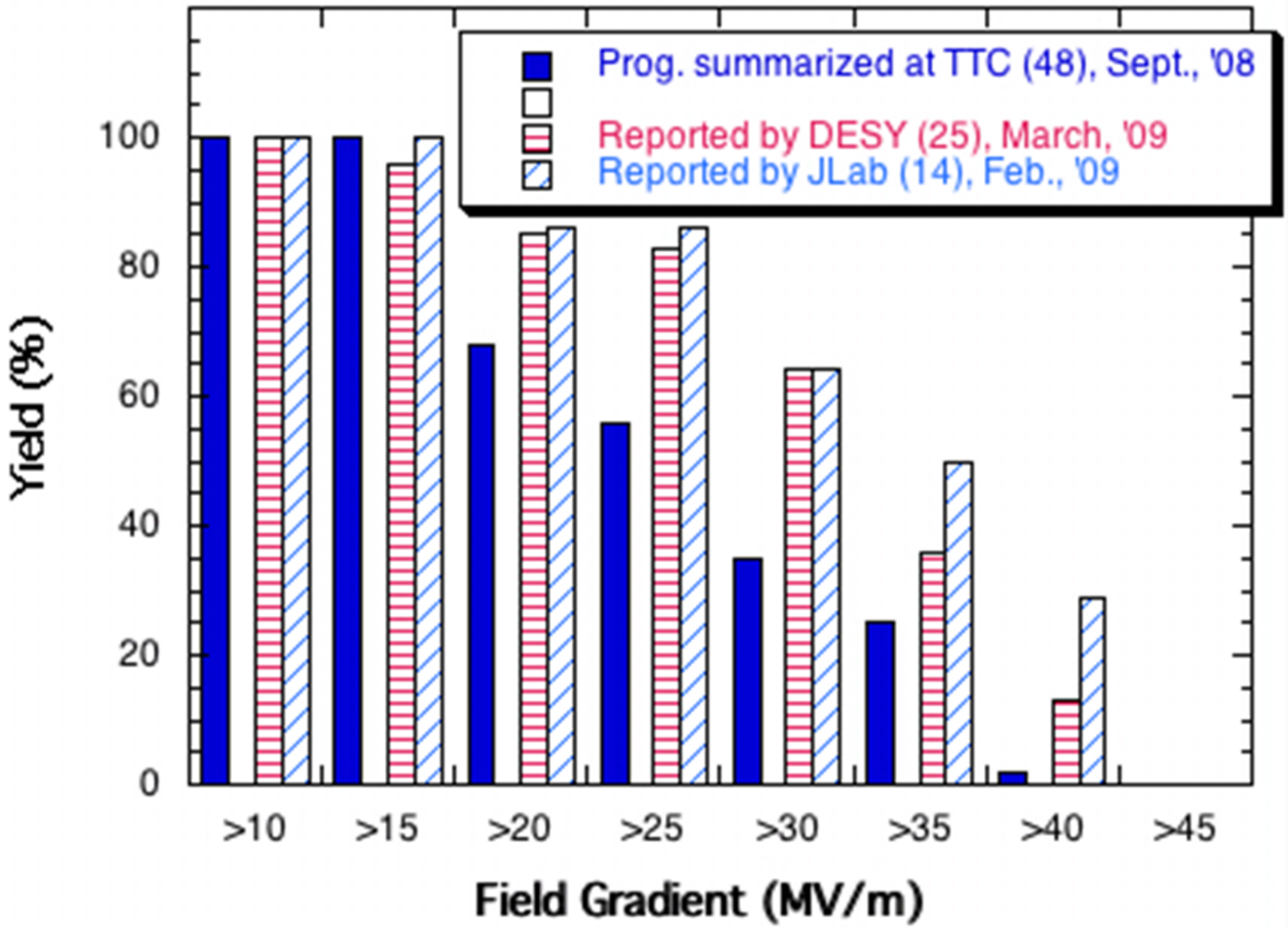


Recent Gradient Yield Progress at JLab

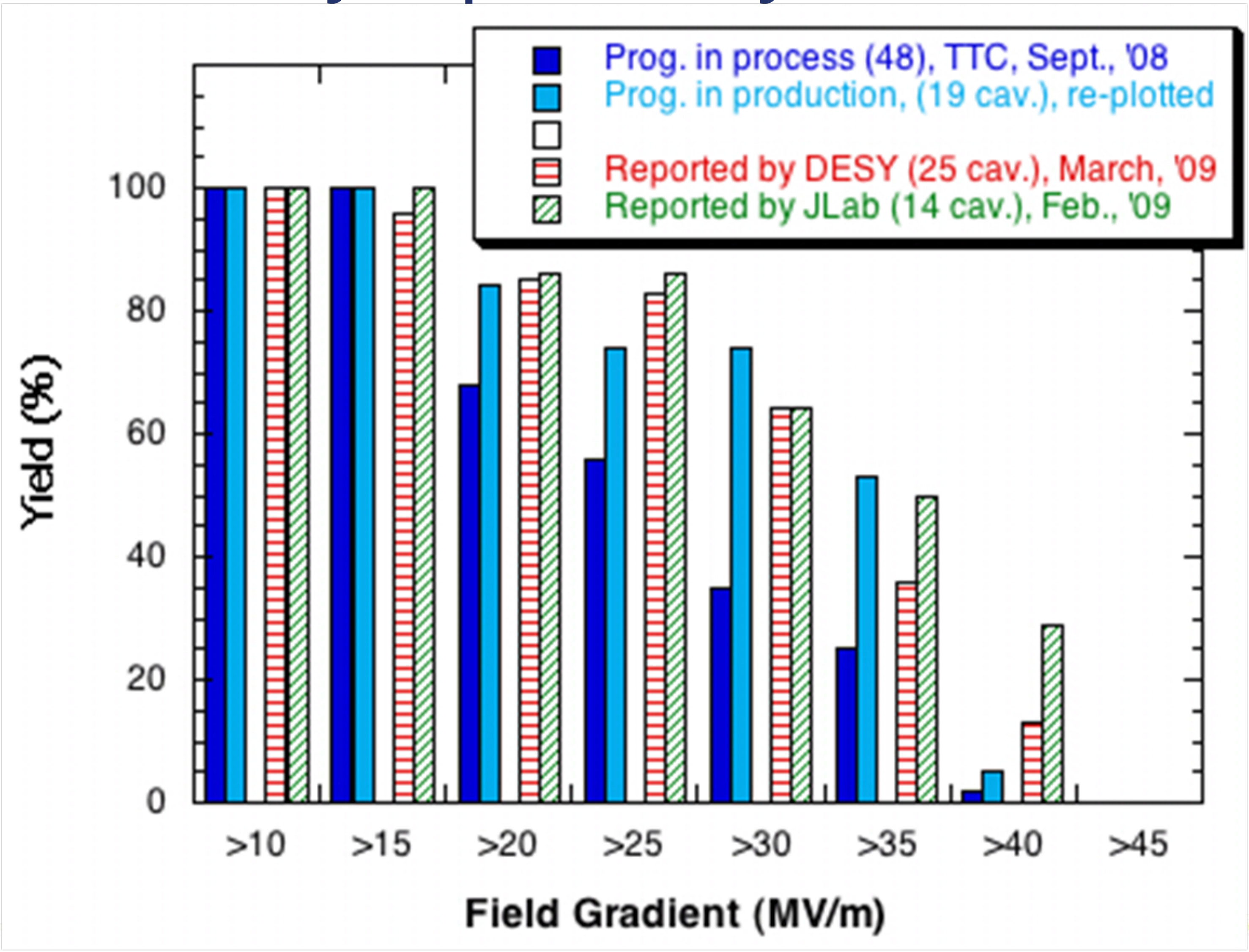




Progress summarized at TTC and recently reported by DESY/Jlab ('09)

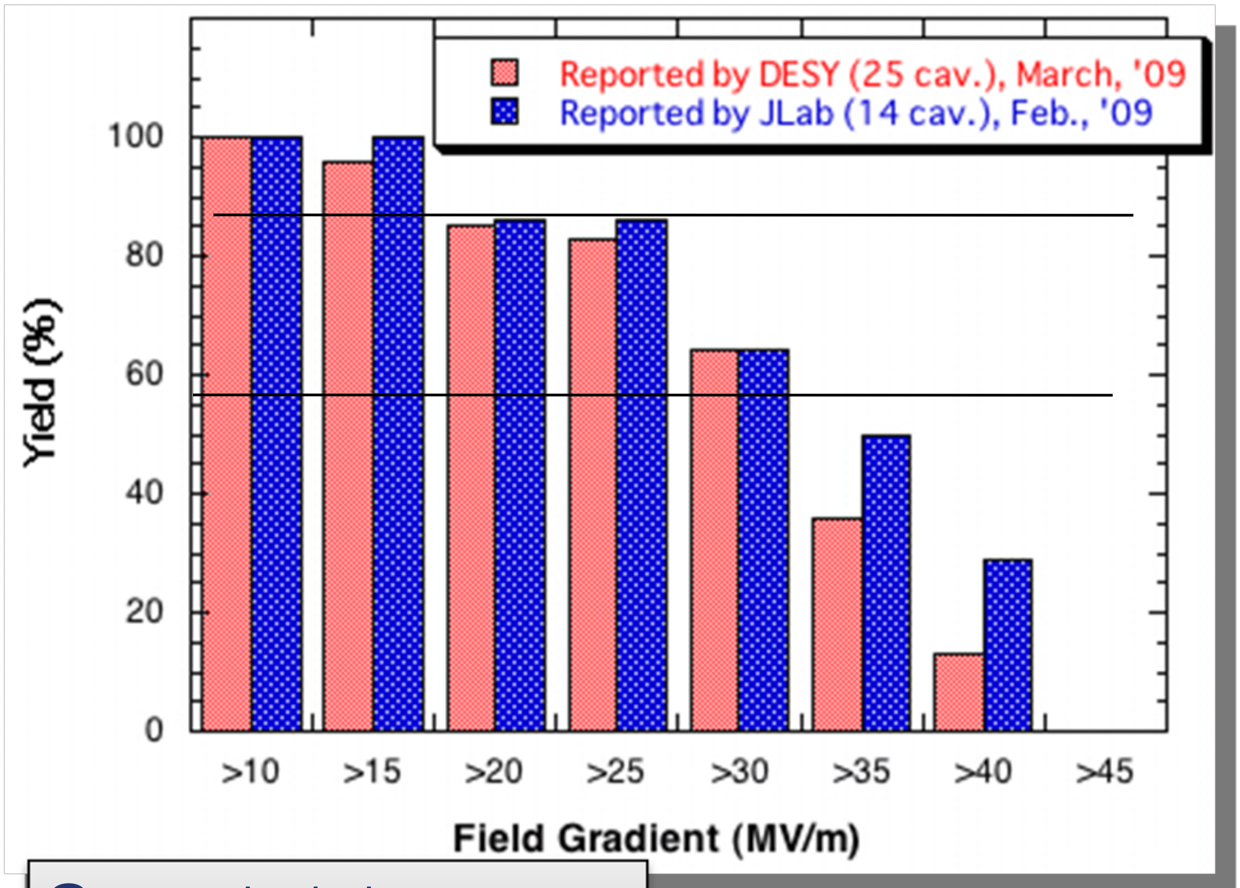


Progress summarized at TTC and recently reported by DESY/Jlab ('09)



Progress Towards High-Gradient Yield

Reported at ILC-PAC, by N. Walker



Current status:
50% yield at ~ 33 MV/m;
(80% >25MV/m)

Recent DESY/JLab "production" series.

Total 39 cavities (08/09)

Mostly result of **first cold-test** (few cases second-test)

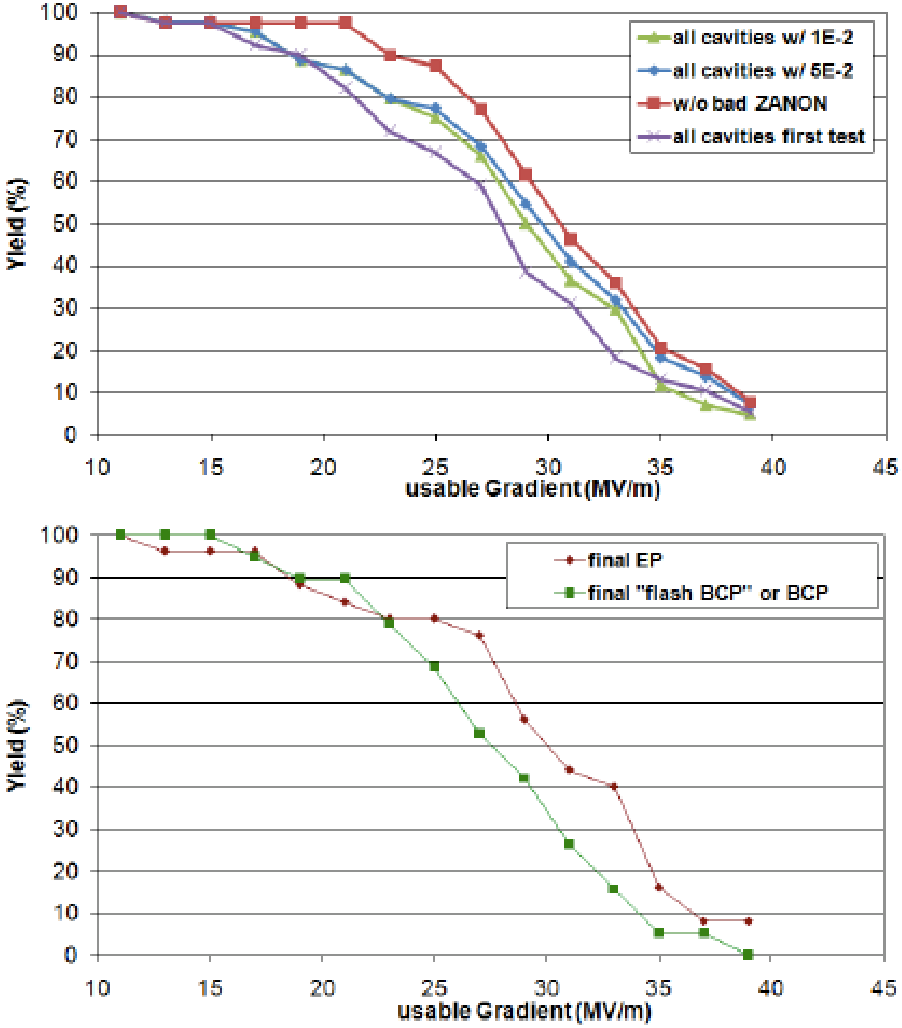
Field Emission greatly reduced (rinses)
→ identified RDR barrier

Baseline gradient re-evaluation (TDP1) expected to be based on sample of >60 cavities

European XFEL

Progress Integrated at DESY

- cavity progress can be evaluated on the basis of **44 measured cavities**
  - 23 cavities w/o He tank
  - **21 cavities with He tank,** i.e. XFEL configuration
  - Approx. **60%** of the cavities with final **electro-polishing** (EP)
  - Approx. **25% with additional High Pressure Rinsing (HPR)** due to field emission (FE)
  - **Difference between first and last test** dominated by FE reduction
  - **Definition of radiation limit** at XFEL gradients not too critical
  - choice of final surface treatment impacts yield at higher gradients
- yield seems to depend on **steps after the final chemical treatment;** further improvement expected for series production



What we need to make clear?

Reported by	Date of Rep.	# of cavities ordered	# of cavities accepted & meas.	# of cavities w/ EP processed	# of meas. after EP	Yield at 35 MV/m	Note/ Understanding
TTC H. Padamsee	08/10	?	19	19	(48)	~50% ~25 %	Process Y.
DESY: D. Reschke W. Singer, L. Lilje,	09/03	?	25	25	25 +?	~40 %	Accepted Product. Y.
Jlab R. Geng	09/02	14	14	14	14+?	~50 %	Product. Y.
DESY H. Weise	09/05	44+?	44	44x~0.6	44x0.6+ ?	15 %	Accepted Produc. Y.

We need more clear definitions and rules to plot the yield

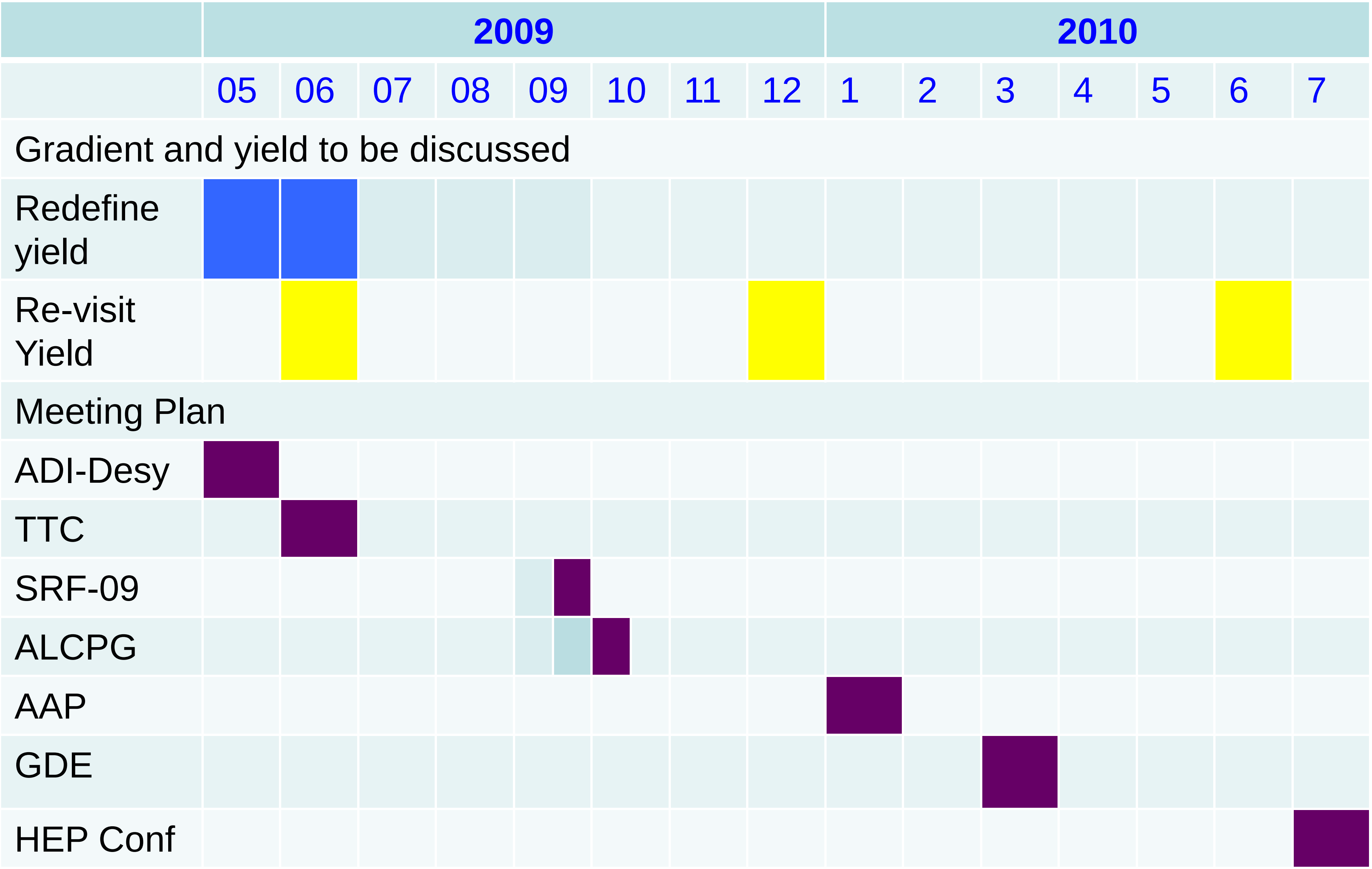
For Discussions

- What is our current understanding?
  - **Original S0 concept assumed:**
    - Surface can be reset according to the EP process, and
    - Multiple processes may be integrated for statistics.
  - **Several years of experience shows,**
    - Repeat processing may cause degradation
      - Possibly because of other reasons,
  - **Processing and Test recipe has changed**
    - Complete the process and test only with the first cycle, and
    - Not to process more, if the result acceptable.
- How can we update the definition of yield evaluation?
  - **We need to discuss it, and task force group with persons in charge**
    - to monitor and accumulate the data base in an agreed evaluation approach.

Further Discussions

- Led by Rongli (Geng) with his presentations and discussions, and
- Followed by Camille (Ginzburg) with her presentation and discussions on the current status on the data base and further international data accumulation
- In the end, we may briefly discuss
  - **how we may consider re-base line for the field gradient?**

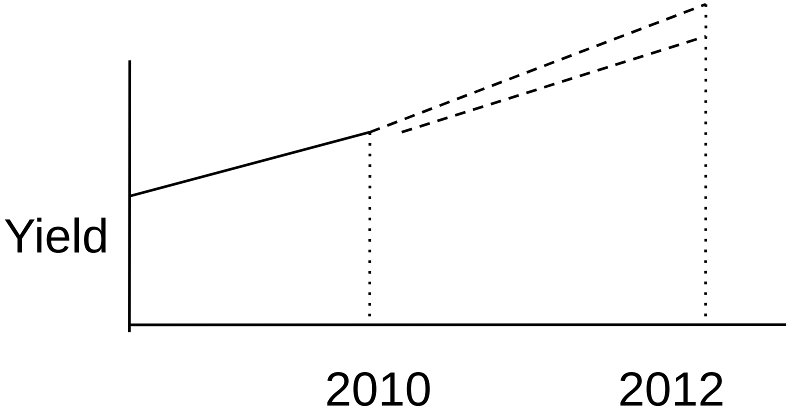
Some milestone



How we may settle Re-baseline

- Re-establish yield definition
- Provide progress of the yield, periodicallyk
- Figure out possible improvement, in future

- Set Rebaseline value:
  - **Field Gradient and Yield**



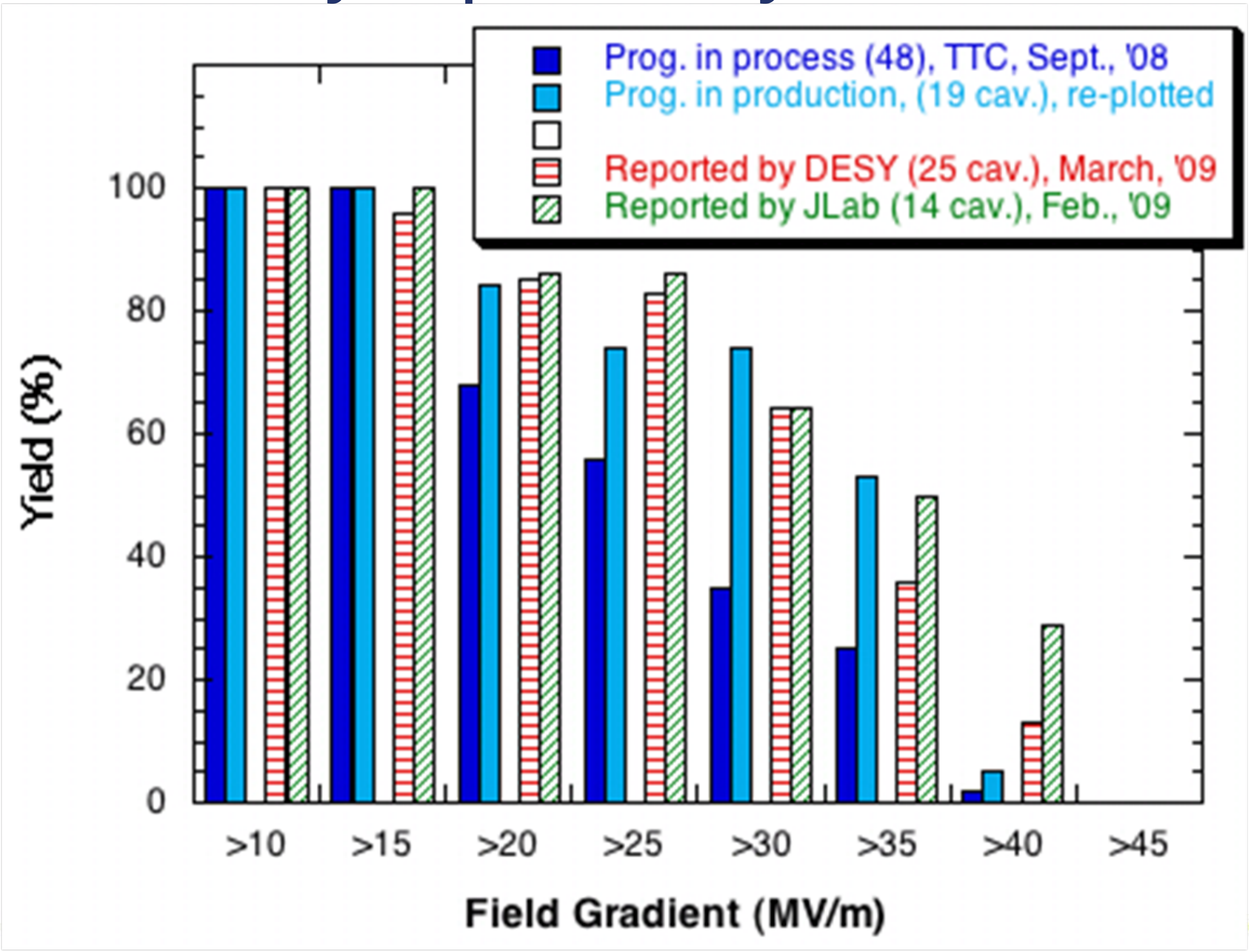
Re-baselining the Field Gradient:
A Possible Scenario

In early 2010 (possibly in January) we will review the status:

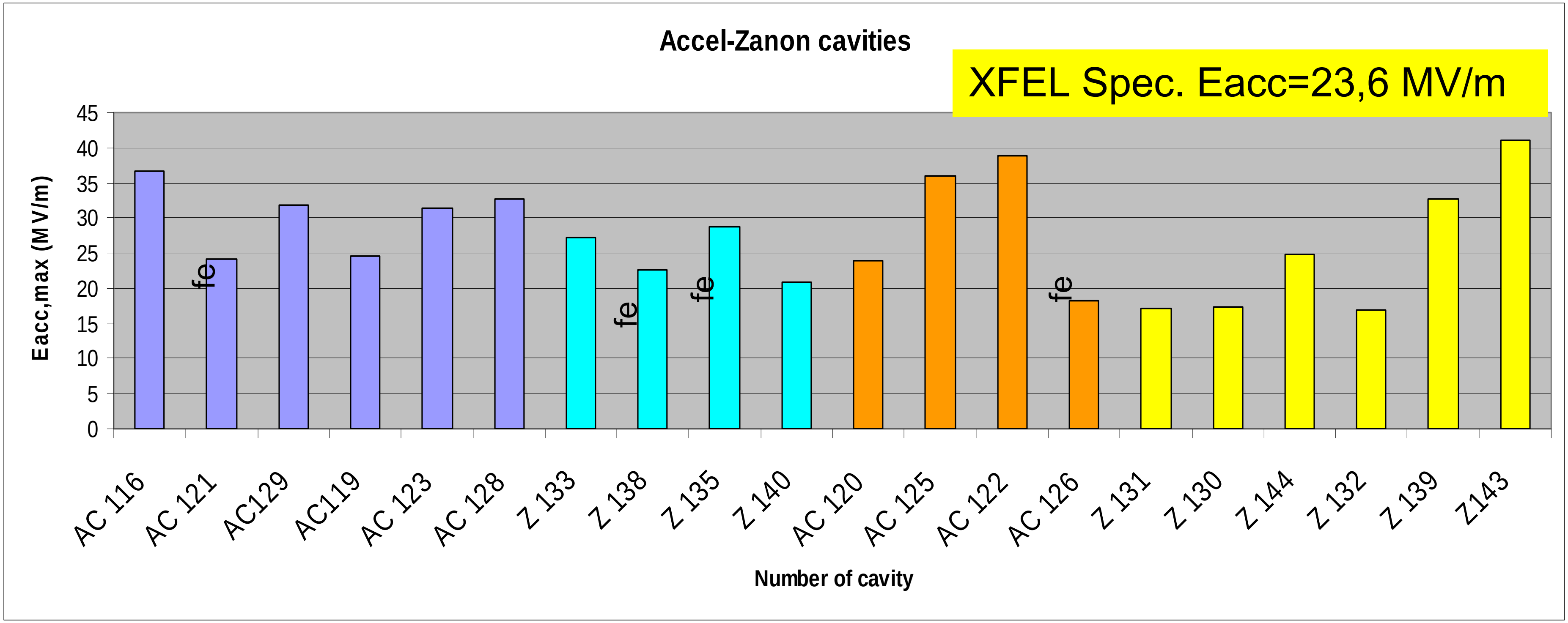
- Understand the field gradient / process yield
- Scope the 2012 gradient/yield milestones achievable
  - **based on understanding and extrapolation of available results,**
  - **Need consensus to cut in the data might be required due to, for instance, vendors, process modifications, experience, one-off errors….**
- The 2012 target should be not just yield but on a larger scale economic minimum
- The statistics may not be as large as we originally desired…
  - **our interpretation of the results may have to wait or we may be forced to be more conservative**
- The TDP-2 period may allow for further refinement of component technologies

Backup

Progress summarized at TTC and recently reported by DESY/Jlab ('09)



Preliminary RF statistic of 6th cavity fabrication at DESY



AC BCP Flash	Z BCP Flash	AC EP	Z EP
E_{acc}=30,2 +/- 4,9	E_{acc}=24,9 +/- 3,8	E_{acc}=29,3+/- 9,7	E_{acc}=24,9+/-4,4

- Max gradient, FE marked, if starts below 20 MV/m
- With He-vessel
- Without HOM pick up

Remark: some Z-Cavities might have suffered from fabrication problems so that the shown result could be independent of the final surface preparation process, i.e. wait for final analysis

Information provided by W. Singer

Guideline: Standard Procedure and Feedback Loop

	Standard Fabrication/Process	(Optional action)	Acceptance Test/Inspection
Fabrication	Nb-sheet purchasing		Chemical component analysis
	Component (Shape) Fabrication		Optical inspect., Eddy current
	Cavity assembly with EBW	(tumbling	Optical inspection
Process	EP-1 (Bulk: ~150um)		
	Ultrasonic degreasing (detergent) or ethanol rinse		
	High-pressure pure-water rinsing		Optical inspection
	Hydrogen degassing at 600 C (?)	750 C	
	Field flatness tuning		
	EP-2 (~20um)		
	Ultrasonic degreasing or ethanol	(Flash/Fresh EP) (~5um))	
	High-pressure pure-water rinsing		
	General assembly		
	Baking at 120 C		
Cold Test (vertical test)	Performance Test with temperature and mode measurement	Temp. mapping	If cavity not meet specification Optical inspection

Numbers of R&D Cavities for ILC
partly from the TDP R&D Plan (release 3)

Order	Bef TDP	2008	2009	2010	Sum 2010	~ 2012
Ams (FY)	34	20	40	15	109	TBD
AS (FY)	15	3	13+1*	17+2	48+3	TBD
EU (CY)	68		26 (+808)**		94 (+808)	TBD
Sum	117	23	48 (+808)	34	222 (+808)	

•Japan + China
•** 26 specific for ILC-R&D, 808 for XFEL mass production
- Order in 2010 and later is to be subject to budget available

Tests			2009	2010	2011	2012
Ams (FY)			45	70	TBD	TBD
AS (FY)			12	14	TBD	TBD
EU (CY)			15	10	20	TBD
Sum			72	94	TBD	TBD

Toward Industrialization

- Global status of Industries
  - **Research Instruments and Zanon in Europe**
  - **AES, Niowave, PAVAC in Americas**
  - **MHI in Asia**

Project Scope			
Euro XFEL	~800	2 years	~1 cavity / day
Project X	~400	3 years	~2 cavities/ week
ILC	~15,500	4 years	~20 cavities / day
(÷ 3 regions			~7 cavities / day)

- Industrial Capacity: status and scope
  - **No company currently has required ILC capacity**
  - **Understand what is needed (and cost) by 2012**

Industrialization and cost reduction

- Re-visit previous effort, and update the cost-estimate for production
  - **Review the RDR cost estimate (based on TESLA)**
  - **Include recent R&D experience (industry/lab)**
- Encourage R&D Facilities for industrialization
  - **Develop cost-effective manufacturing, quality control and cost-reduction in cooperation with industry**
- Reflect the R&D progress for cost-reduction
  - **Baseline $\Rightarrow$ Forming, EBW, assembly work…**

A Plan for R&D facilities and Preparation for Industrialization

- Bench-mark R&D facility (pilot plant) to study cost-effective manufacturing,
  - **Forming and preparation machining,**
  - **Pre-surface treatment and preparation,**
  - **EBW process with efficient automation,**
  - **In-line Inspection during fabrication process for quick-feedback,**
- R&D facilities to be sited at Laboratories
  - **Effort to seek for the most cost-efficient manufacturing with keeping information to be open,**
  - **Development to seek for a bench-mark, manufacturing facilities (design and/or itself can be applicable for the real production.**
  - **It is important for industries to participate to the program since Day-1. for planning.**
- We may discuss a possibility
  - An industrial meeting to be held as a satellite meeting at the 1st IPAC, Kyoto, May, 2010.
-

Global Plan for SCRF R&D
A Summary

Calender Year	2007	2008	2009	2010	2011	2012
Technical Design Phase	TDP-1				TDP-2	
Cavity Gradient R&D to reach 35 MV/m		Process Yield > 50%			Production Yield >90%	
Cavity-string test: with 1 cryomodule			**Global collab.** **For <31.5 MV/m>**			
System Test with beam 1 RF-unit (3-modulce)		FLASH (DESY)			STF2 (KEK) NML (FNAL)	

R&D/prepare for Indusrialization