Cavity Gradient Discussion

Toward TDP-2 Goal

Rongli Geng

22th ILC Cavity Group Meeting, WebEx

What we heard at ILC10?

1	Cavity Gradient Session; Gradient R&D status and future strategy, plan for TDP2		
2	Conveners:	R. Geng, M. Champion, D. Reschke, H. Hayano	
3			
4	(Mar 28, 08:30 - 12:00)		
5	Time	Topics	Presenters
6	8:30 - 10:00		
7	20min	Summary of understanding of quench limit in 9-cell cavities using T-mapping and optical inspection	Yasuchika Yamamoto(KEK), Sebastian Aderhold(DESY
8	15min	Latest 9-cell cavity testing results from FNAL	Joe Ozelis(FNAL)
9	10min	Recent cavity test results from KEK	Eiji Kako(KEK)
10	5min	New results on field emission suppression	Rongli Geng(JLab)
11	10min	Comparison EP procesing parameters at KEK and JLAB	Takayuki Saeki(KEK)
12	10min	IHEP high gradient efforts on 1.3 GHz 9-cell cavity for ILC	Jie Gao(IHEP)
13	10min	Efforts on the R&D of SRF cavity at Peking University	Ke-Xin Liu(PKU)
14	10min	Replica-method and local grinding repair	Ken watanabe(KEK)
15			
16	10:00-10:30	Coffee break	
17	10:30 -12:00		
18	15min	Review of plans for upcoming cavity processing and testing	Camille Ginsburg(FNAL)
19	10min	Status report of Cornell activities	Zack Conway(Cornell)
20	15min	Status report of DESY activities	Eckhard Elsen(DESY)
21	20min	Update on global cavity database and yield evaluation	Camille Ginsburg(FNAL)
22	30min	discussion	

- Quench limit understanding
- FE suppression progress
- Test results of new cavities
- EP processing cross-checking
- Defect removal development
- Upcoming cavity proc. & test plan
- Yield curve update
- Lab status update

How are these talks related to our gradient goal?

ILC Research and Development Plan for the Technical Design Phase

Release 4

July 2009

ILC Global Design Effort

Director: Barry Barish

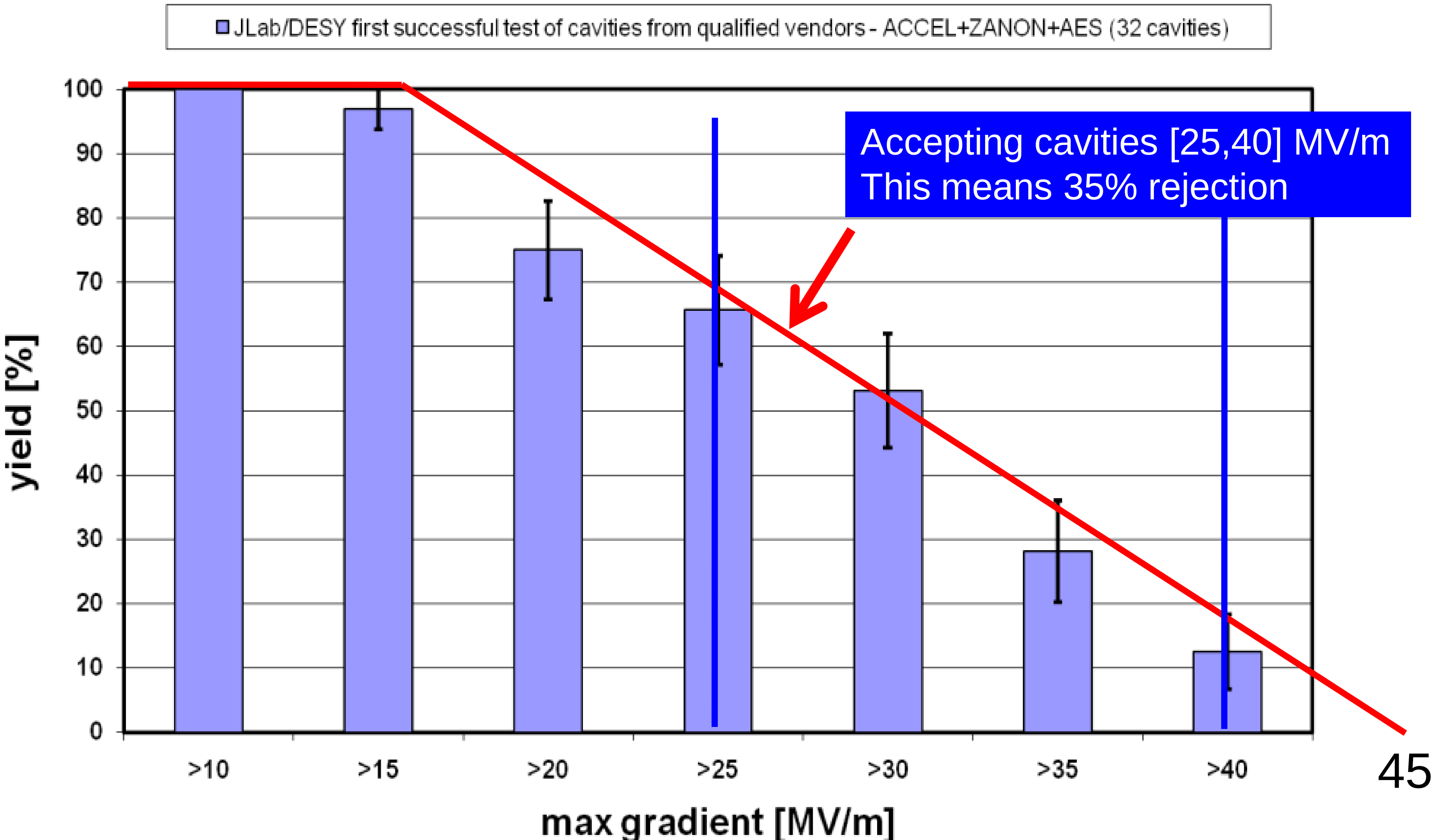
Prepared by the Technical Design Phase Project Management

Project Managers: Marc Ross, Nick Walker, Akira Yamamoto

Table 3-1: Milestones for the SCRF R&D Program.

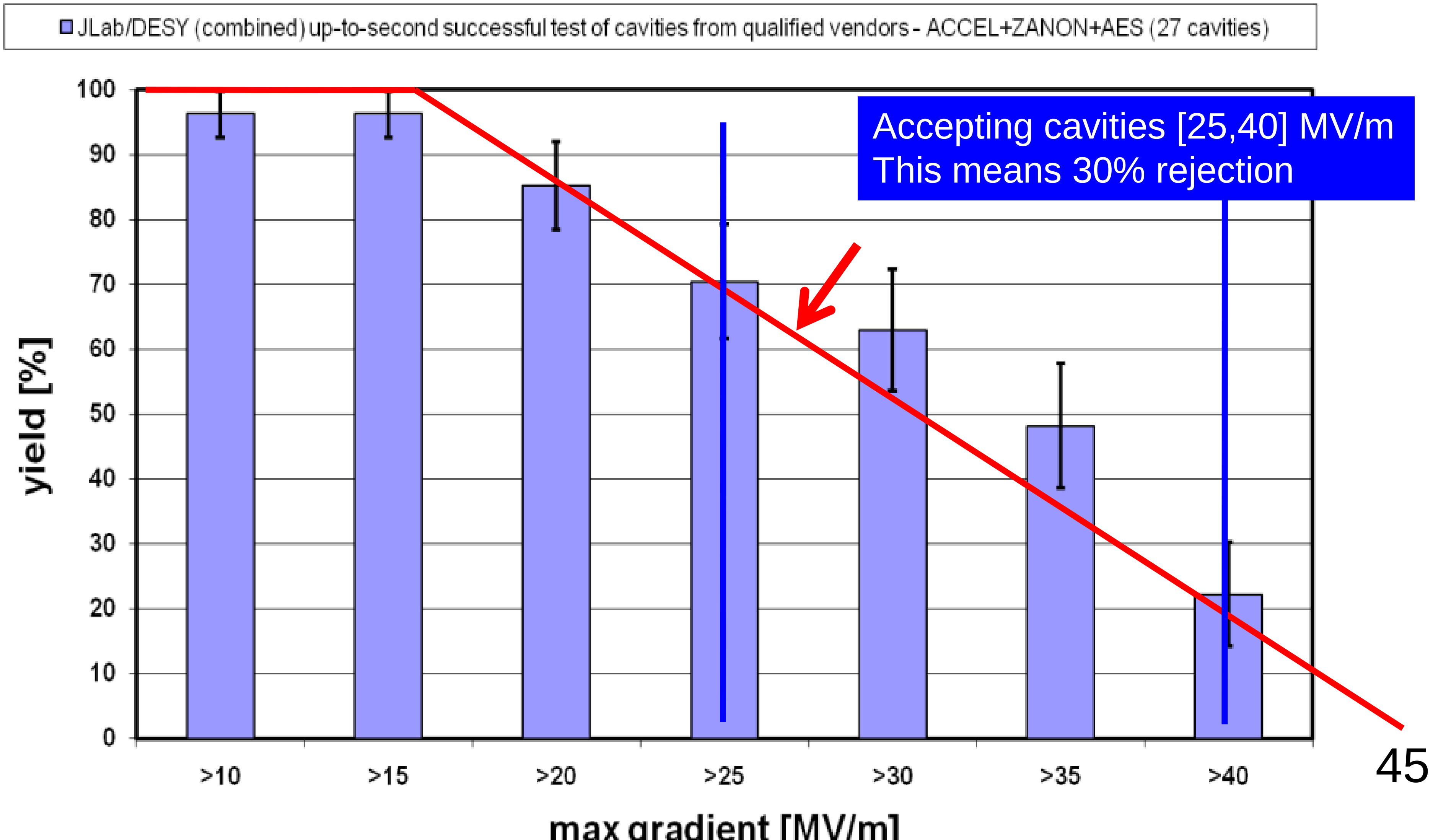
High-gradient cavity performance at 35 MV/m according to the specified chemical process with a process yield of 50% in TDP1, and with a production yield of 90% in TDP2 (S0, see section 3.1.3 for definition of process yield)	2010 2012

Electropolished 9-cell cavities



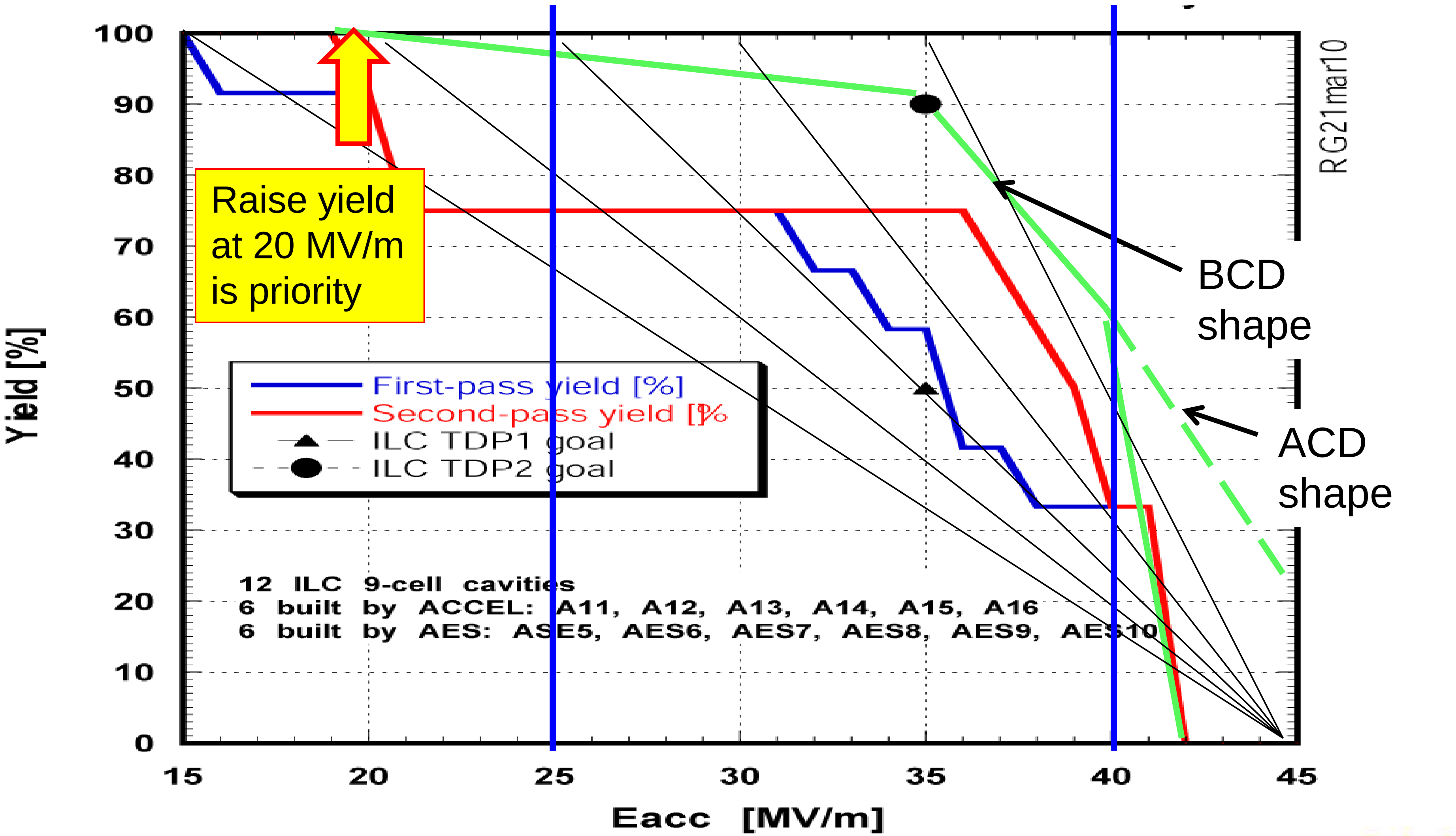
First-pass yield, updated March 2010 (ILC10)

Electropolished 9-cell cavities



Second-pass yield, updated March 2010 (ILC10)

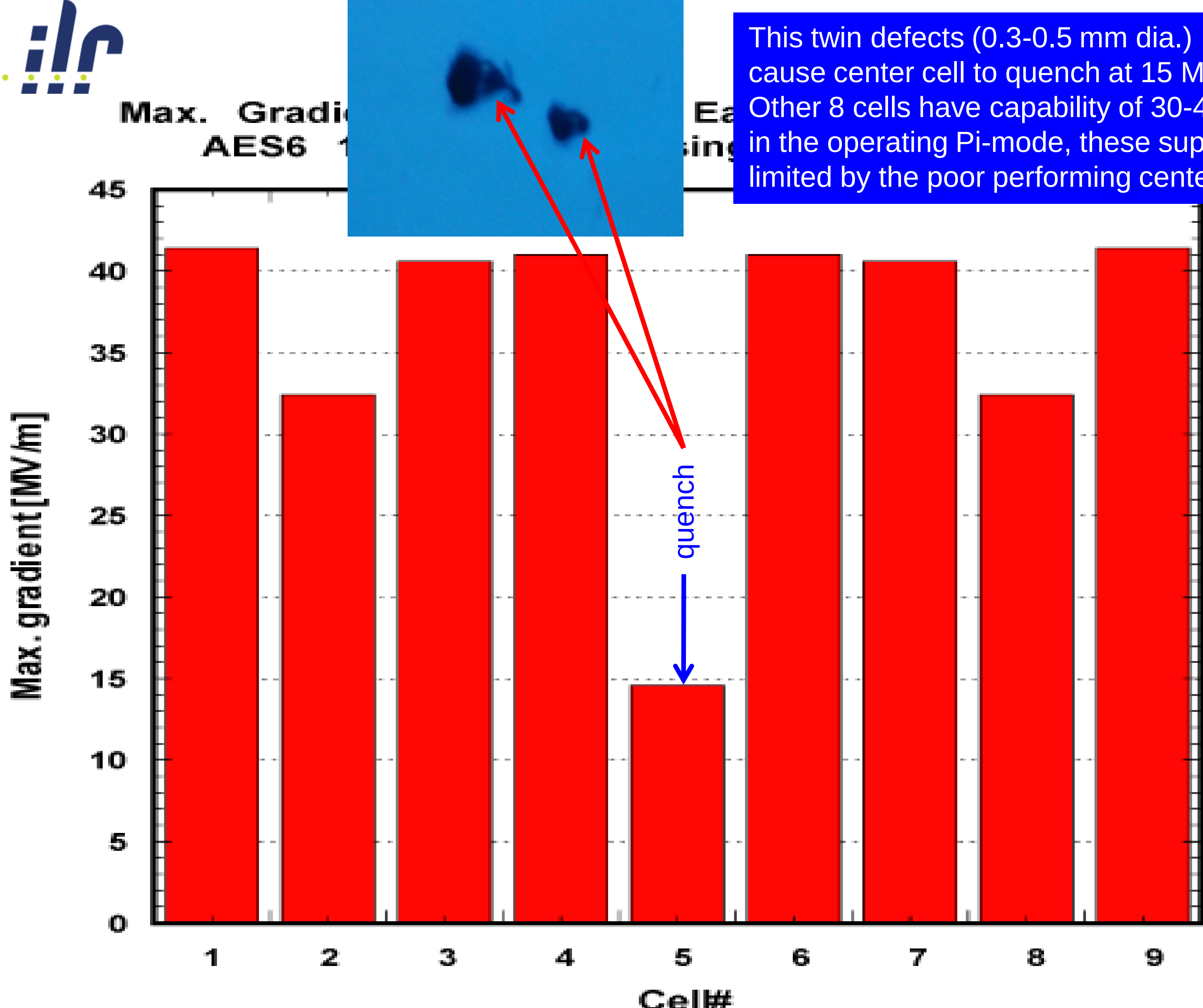
An Optimistic Expectation at end of TDP-2
Based on 12 cavity gradient yield of latest JLab results
<Eacc> scenarios to be evaluated



Quench limit in EP 9-cell Cavities

- What we know from latest experience
  - Local
  - Near equator EBW
  - Sub-mm defect in size (with exceptions)
  - One defect in one cell
  - All other cells reach already higher gradient
  - This is ~1ppm probability considering total RF surface area

  - Quench limit 15-20 MV/m insensitive to re-EP
  - Quench limit > 25 MV/m improvement by re-EP



This twin defects (0.3-0.5 mm dia.)
cause center cell to quench at 15 MV/m.
Other 8 cells have capability of 30-40 MV/m – but in the operating Pi-mode, these superior cells are limited by the poor performing center cell.

AES6 first-pass processing and testing

- Understand defect
- Prevent defect
- Remove defect
- Suppress field emission
- Improve/stabilize EP processing
- Develop enabling alternative
- Develop low-cost alternative
- And don't forget to…
- Share experience
- Help each other

Where are We Going?

- Major issue is yield drop at 20 MV/m due to geometrical defect
- A set of inspection criteria for acceptance of as-built cavity is needed
  - **Presently we have some tantalizing correlation between quench limit and the profile and size of operating defect**
- But it may take a long time for final answers with confidence and it will also takes time for vendor to learn "build in quality" instead of "inspect out problem"
- We have only 2-3 years for TDP-2

Are we stuck?

- Probably not
- What can/should we do?
  - **Early defect prevention**
    - Talk to your vendor and let them know what you have found on cavity surface, including "obvious" features
    - In fact you will find many features that do matter when you order cavities from new vendor
    - Send experienced cavity researcher (if you have one) to vendor and give advices and guidance
  - **Post-fab/VT complete surface re-setting**
    - Barrel polishing, tumbling before EP
    - Re-EP after first test
  - **Post-VT local defect treatment**
    - Local grinding
    - Local re-melting (e-beam or laser)

But we have limited resources (manpower, equipment, expertise and available cavities)

We need to balance and some level of optimization

Early Defect Prevention

- Pros
  - **Benefit mass production**
- Cons
  - **May take longer time for results**
  - **Require lab industry collaboration (intellectual property, proprietary information, how should we transfer the knowledge? how much information will be shared?)**
- Actions

Post-fab Surface Re-setting (before bulk surface removal)

- Pros
  - **Increase tolerance for fabrication variability**
- Cons
  - **Cost**
  - **Added steps increases chance of damage**
- How to select cavities?
  - **New vendor cavities?**
- Where is proven equipment and expertise?
  - **CBP at KEK**
  - **Tumbling at Cornell**
  - **New machine at FNAL & JLab? When for 9-cell?**

Post-VT Surface Re-EP

- Pros
  - Technology and equipment available globally
  - Seems effective in raising gradient for "featureless" defect (i.e. locally suppressed superconducting spots)
- Cons
  - **Re-EP not effective for defects limiting gradient 15-20 MV/m**
- How to select cavities?
  - Rapid quench location identification with Cornell OST, then rapid inspection of quench region. Move on to re-EP if no defect obvious
- This should be done in all labs with a EP machine. A reliable EP processing is imperative.

Post-VT Defect Treatment

- Three options: Local grinding, local e-beam re-melting, local laser re-melting
- Pros
  - Effective in removing geometrical defects
  - local grinding of 9-cell demonstrated at KEK
  - Local e-beam re-melting of 1-cell demonstrated at JLab
  - Local laser re-melting of 1-cell demonstrated at FNAL
- Cons
  - **Developments needed**
  - **Insertion devices risk damaging non-defective area**
- How to select cavities?
  - **T-mapping and optical inspection**
- Where/when equipment and expertise for 9-cell?

But don't forget

- It is imperative that your EP process is stable and reproducible
- You must keep field emission at bay up to 40 MV/m