ILC Cavity Gradient R&D Plan Proposal for Release 5

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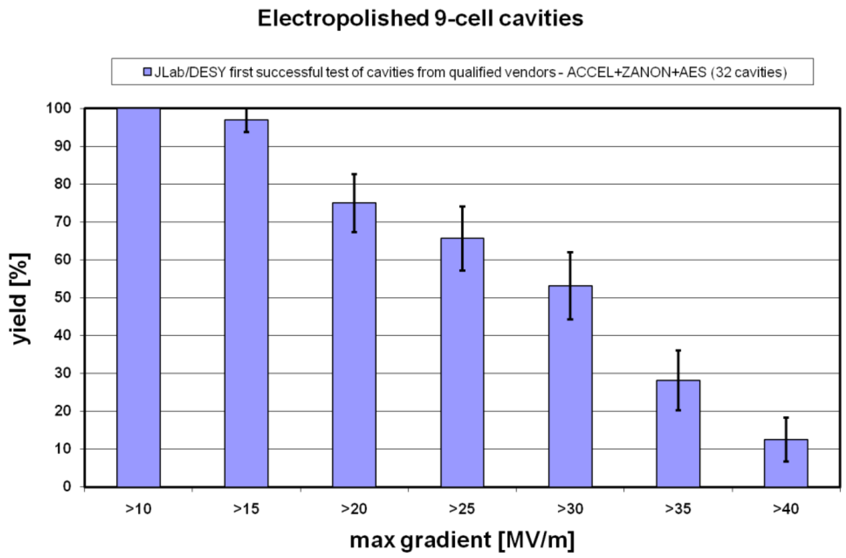
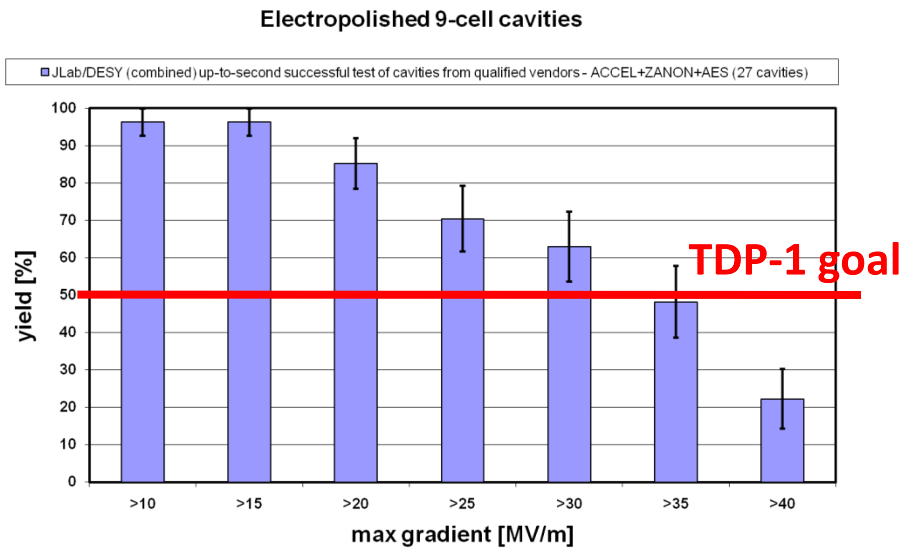
TDP-1 Cavity Gradient Goal Achieved

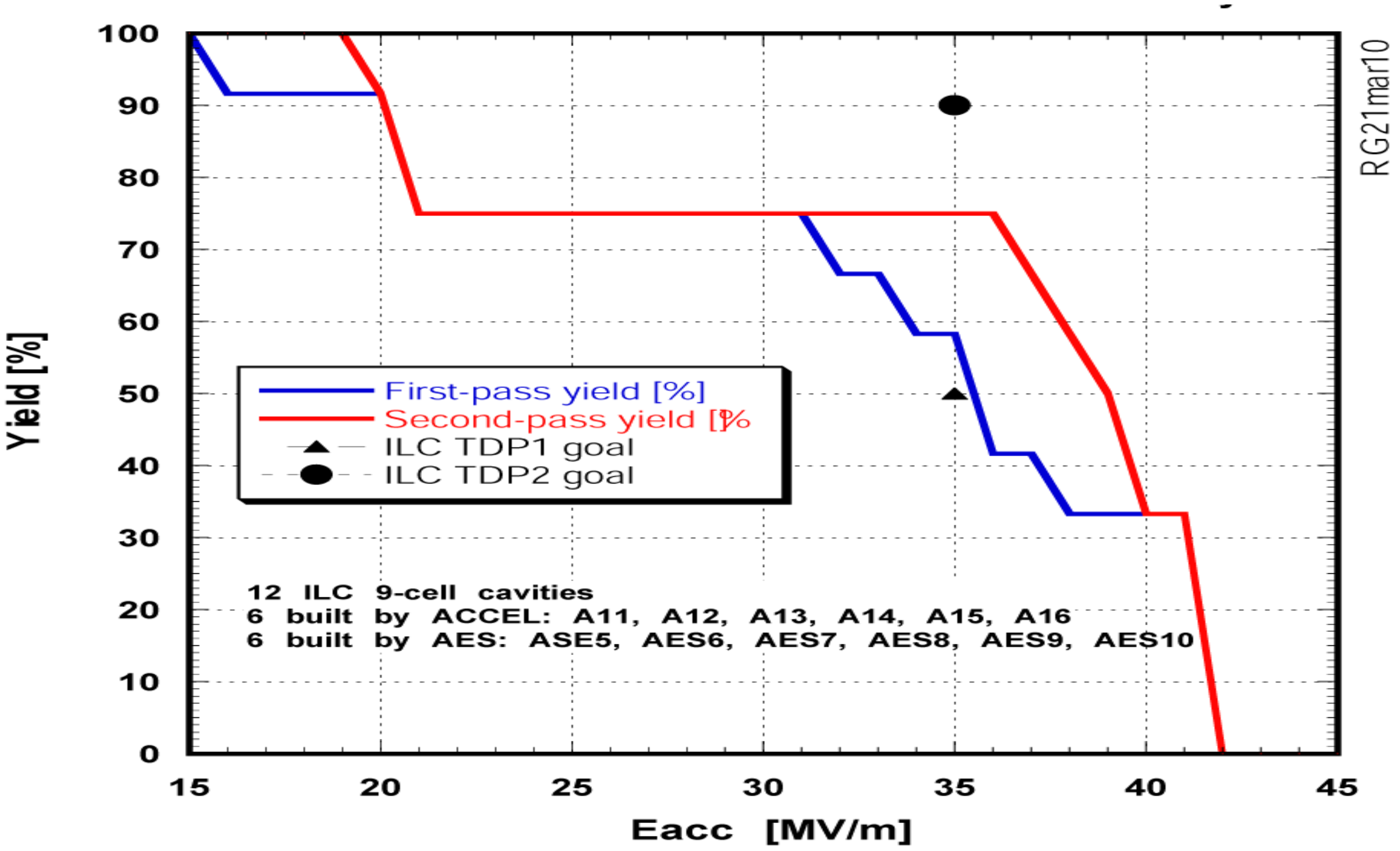
- 50% yield at 35MV/m with Q0>=8E9 for vertical acceptance test with up to 2nd-pass processing.
  - "global" data
  - 32/27 cavities built by 3 vendors (Zanon, ACCEL, AES)
  - Processed and tested in 2 labs (DESY, JLab)
- FY09-FY10 subset data demonstrated 75% yield at 35 MV/m with Q0>=8E9 up to 2nd-pass processing.
  - 12 cavities built by 2 vendors (ACCEL, AES)
  - Processed and tested in 1 lab (JLab)

“Global” Data
first-pass and second-pass yield





FY09-FY10 Subset Data

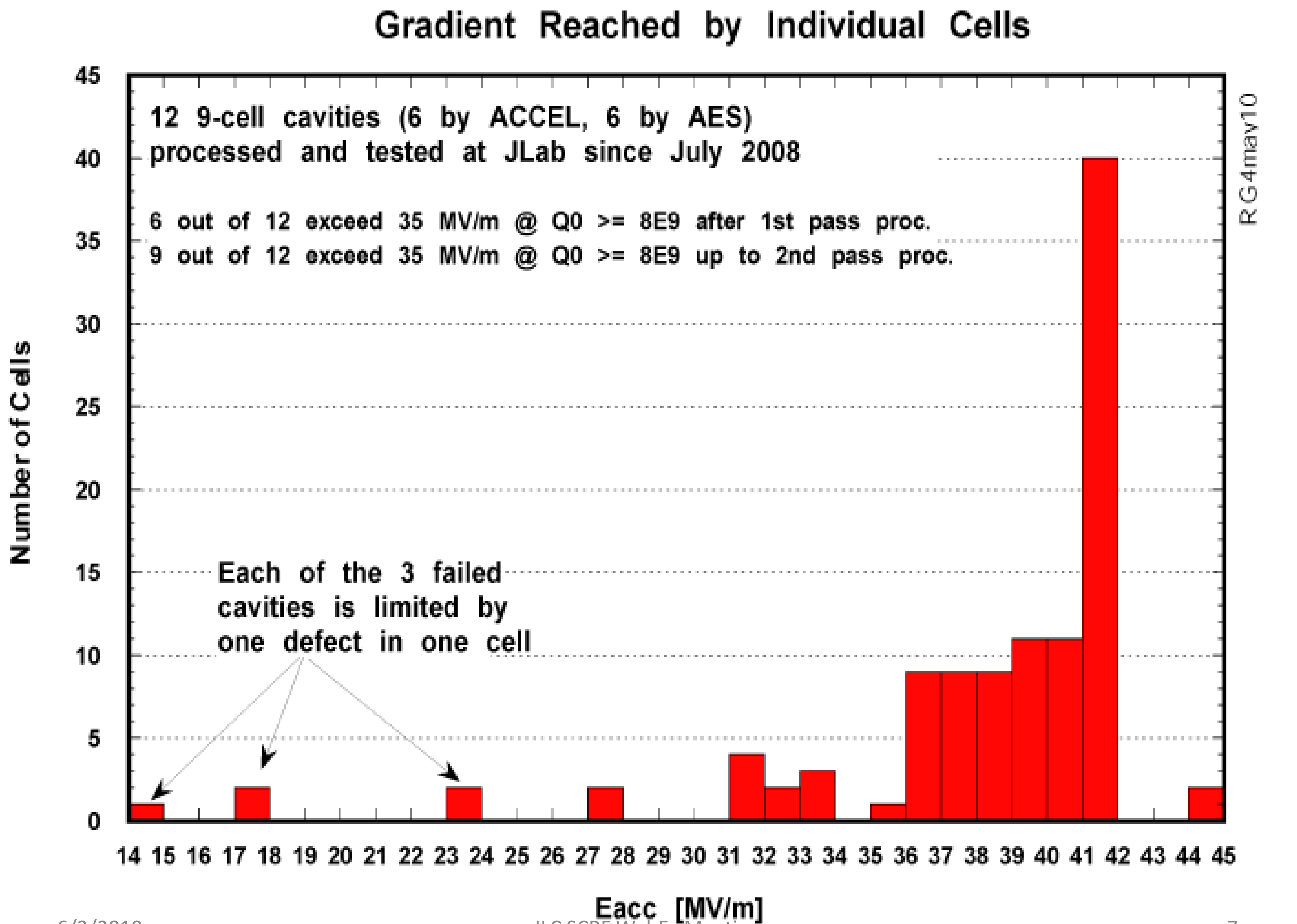


Globally Coordinated S0 Effort a Success

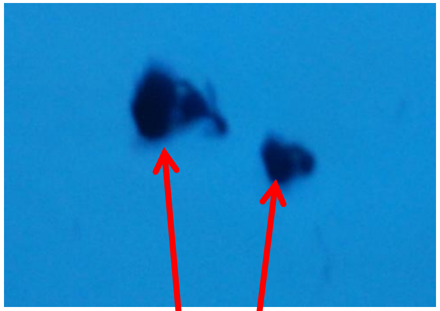
- Gradient limit by field emission much reduced.
  - Post-EP rinsing
  - Optimal EP
  - Streamlined assembly procedure
- Key sources of FE on EP'ed surface understood.
  - Sulfur
  - Nb_xO_y granulus
- Optimal EP.
  - Simplicity demonstrated
  - Repeatability demonstrated
  - Transferability across facilities demonstration in progress

Gradient Scatter Remains

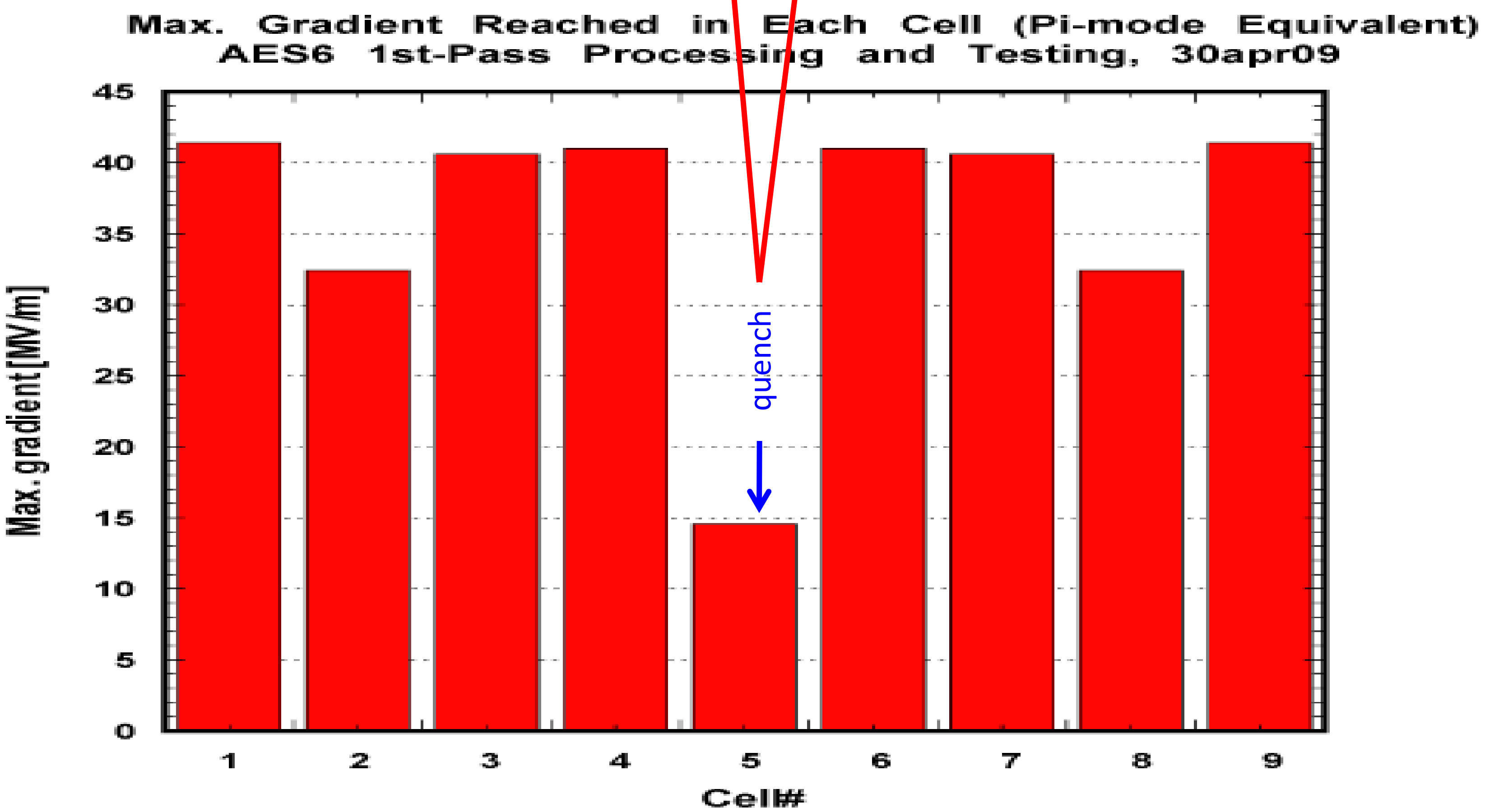
- Yield drop at 15-20 MV/m a major issue.
  - 30% rejection up to 2nd–pass processing, even if all cavities passing 25 MV/m will be used.
    - It means 43% overproduction needed.
    - This is unlikely acceptable for mass production.
- Source of problem is local defect near (within a few cm from seam) equator EBW.
  - One small defective area (<1mm dia.) limits entire cavity.
  - Superior surface area outside defect reaches very high surface field already.



Gradient Reached by Individual Cells
12 9-cell cavities (6 by ACCEL, 6 by AES)
processed and tested at JLab since July 2008
6 out of 12 exceed 35 MV/m @ Q0 >= 8E9 after 1st pass proc.
9 out of 12 exceed 35 MV/m @ Q0 >= 8E9 up to 2nd pass proc.
Each of the 3 failed
cavities is limited by
one defect in one cell
RG4may10
Number of Cells
Eacc [MV/m]
0
5
10
15
20
25
30
35
40
45
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45



Twin defects 300-500μm dia.
8mm from equator EBW seam



Local Defects Responsible for Quench Limit at 15-20 MV/m

- Strong evidence to show these defects have origin from fabrication and/or material.
  - Re-EP ineffective in curing defective cell for raised quench limit.
  - Local treatment (grinding) found effective in raising quench field from ~ 20 MV/m to > 30 MV/m without losing performance of healthy cells.
- Abating these defects with cavity mass production in context requires improvements/changes in fabrication and material.

Strategy for TDP-2

centered on BCD and oriented for impact in TDR

- Fabrication QA/QC
  - Improve tools for QC
    - DESY: Cavities for XFEL and ILC-HiGrade, mass production aspect
- Fabrication improvement/optimization
  - Forming/Machining
    - FNAL/PAVAC: smart cups
    - KEK: Forming optimization with pilot plant
  - EBW
    - KEK: EBW optimization with pilot plant
    - FNAL/JLAB/Cornell/Industry: build and test “destructible” bare 9-cell cavities
    - JLAB: EBW optimization by build bare 9-cell cavities with in-house welder
- Mechanical polishing prior to heavy EP
  - Eliminates weld irregularities
  - Reduce (or may even eliminate the need of ?) surface removal by heavy EP
    - FNAL: raw 9-cell mechanical polishing before main chemistry
    - Cornell: 9-cell tumbling for cavity recover
- Large-grain material (directly sliced from ingot)
  - Eliminates rolling in standard sheet material
    - KEK: large-grain cavities and multi-wire slicing
    - DESY: processing and evaluation of 8 existing 9-cell large grain cavities
    - JLab: in-house fabrication and test 2 9-cell large grain cavities
- Seamless cavity
  - Eliminates weld prep machining and EBW
    - DESY in collaboration with JLab: hydrofrom and test multi-cell cavities
    - FNAL/industry: hydroform and test multi-cell cavities
- Material improvement/optimization
  - For example Nb with low Ta concentration
    - FNAL: material characterization and 1-cell cavity testing
    - JLab: material characterization and 1-cell testing
- Post heavy EP heat treatment optimization
  - Engineering thermal and metallurgical properties
    - JLab: 1-cell, 9-cell experimenting with associated material characterization
- Post vertical test local treatment
  - Rapid quench limit improvement with small incremental cost
    - KEK: local grinding
    - FNAL: local re-meting with laser beam
    - JLab: local treatment/re-melting with electron beam

Strategy beyond TDP-2

- ACD shape cavity
  - Extends 1-cell cavity success to 9-cell cavity
- Nb-Cu clad material cavity
  - Yield improvement potential due to increased thermal stabilization
  - Cost reduction
- Thin film cavity
  - Significant cost reduction potential
  - Very high gradient breakthrough potential by using unconventional material