402.2 B04 MaPSAs

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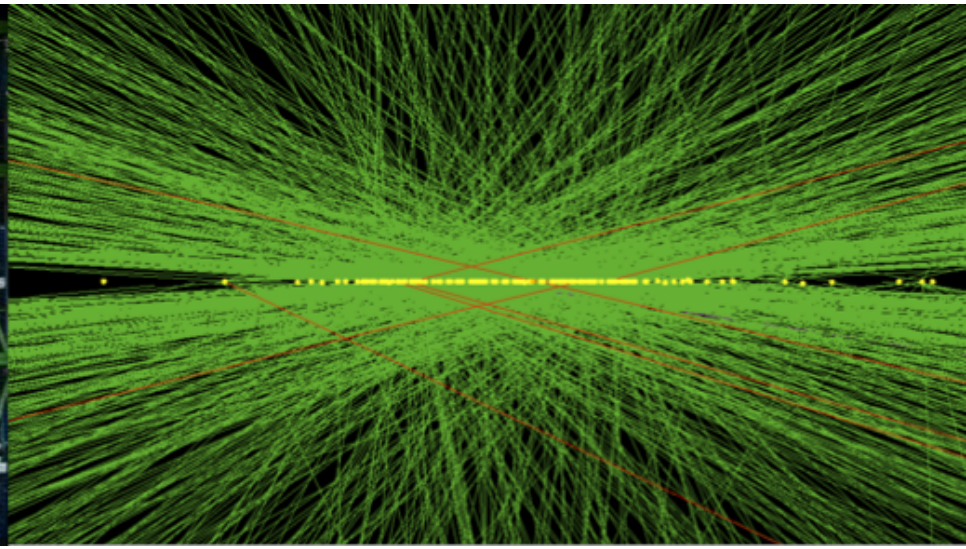
CD1 Director's Review

March 20, 2019



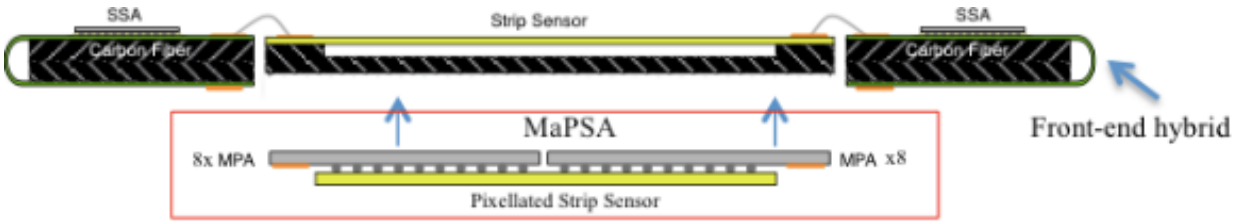
Outline

Overview of technical progress since the June 2018 IPR

- 402.2.4.1 MaPSA

MaPSA Introduction

- Since the 2018 review, USCMS continued to progress on qualifying bump-bonding vendors and to validate the assembly procedures
  - USCMS responsibility to OT

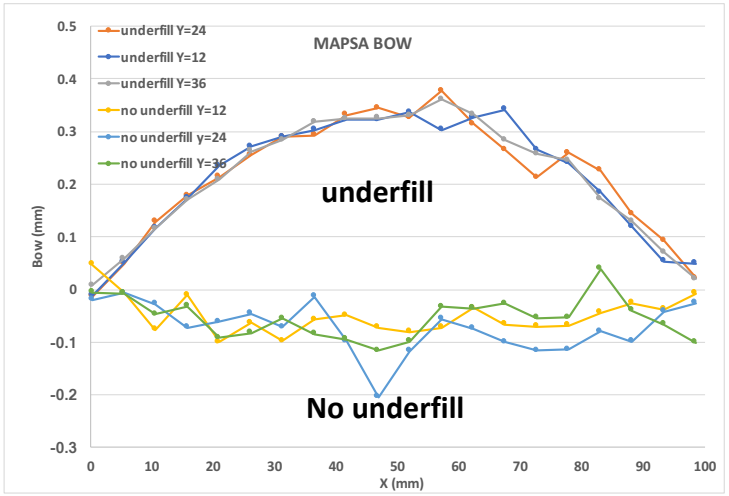


MaPSA assembly in RED box

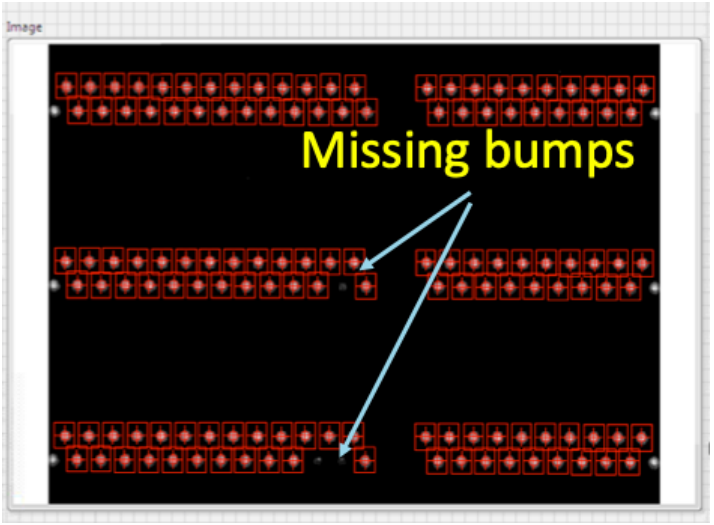
- The process included the following:
  - Fabrication and test of dummy assemblies (complete)
  - Fabrication of the 1st set of assemblies with functional MPAs (in progress)
  - Fabrication of a 2nd set of MaPSAs (pre-series).

MaPSA Dummy Fabrication

- 20 dummy parts from each of 2 vendors were received and tested.
- USCMS has also received two “free samples” from Hamamatsu
- Testing required:
  - The development of automated visual inspection and pattern recognition algorithms to select the best parts for dummies
  - The investigation of the observed bowing due to underfill CTE
- The testing of the dummies lead to vendor down-selection



Bump Inspection



MaPSA Prototyping

- 2 rounds of functional prototyping planned before preproduction
  - MaPSA dashboard for international colleagues

- Round 1 underway at two vendors
  - Expecting results early summer 2019 (test setup being assembled at Fermilab as reported in the 'Test Systems and QA plan' presentation)
- Round 2 includes setup of testing apparatus at vendor

MaPSA Prototyping Round 1: Status

- The production of functional MAPSAs is underway at Hamamatsu and AEMTec
  - 15 “setup” and 10 active devices at each of the 2 vendors
  - Room temperature cure of underfill with better CTE match to eliminate bowing
- Logistics:
  - Wafers and good die MPAs are sent from CERN to AEMTec for thinning and dicing
  - AEMTec sends ½ of diced parts to Hamamatsu (via CERN)
    - Diced, picked MPAs due mid-March
- Status:
  - Sensors have been sent to AEMTec from KIT
  - AEMTec MaPSAs will be available at the end of March
  - Hamamatsu MaPSAs should be available two months after receipt of MPAs

MaPSA Prototyping Round 2: Plans

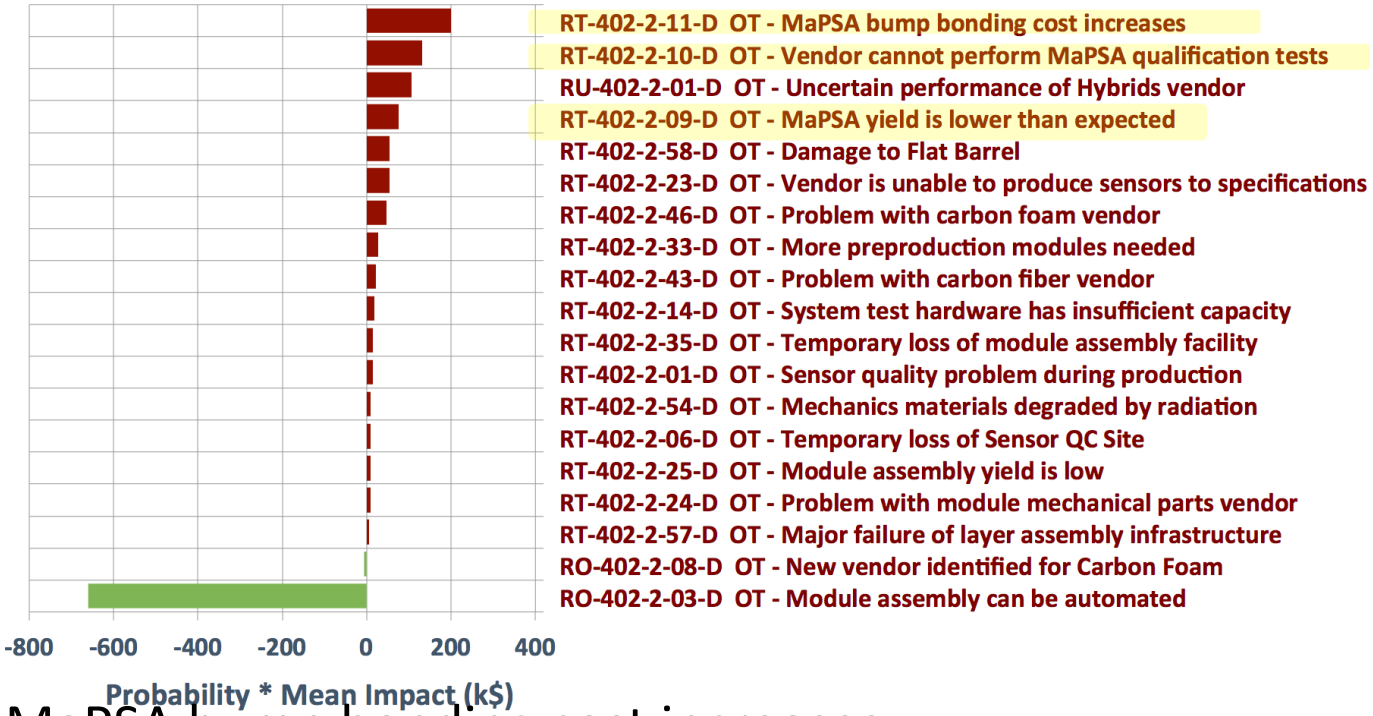
- Round 2: ~ 80 prototype MaPSAs for PS Module building
- Start procurement in May 2019
  - Look at options for including full production as part of contract
  - Actual fabrication is dependent on availability of parts
    - MPAs mid-summer at earliest
    - PS-p with a 4 month delay from order
- Round 2 MaPSAs should be available for Module Assembly by early 2020

MaPSA Production Cost Estimate

- We received initial quotes for bump bonding from several companies
- There is a large spread between these quotes
- R&D and prototyping phase to vet less expensive, but less known companies vs. well known, but more expensive ones
- Until final vendor selection has been made and final quotes, we assume $2M for planning purposes

Vendor	Preliminary full order quote
Hamamatsu	$1,721,250
AEMtec	$472,037
Quik-Pak	$3,129,840
Micross	$3,501,000
I3	$799,509

Risks



- MaPSA bump bonding cost increases
  - Variance in quotes is 0.5-3.5M$, we assume 2M$ for planning for entire order
  - Bump bonding production cost could increase beyond 2M$
- MaPSA vendor cannot perform QC tests
  - In that case we will perform QC for all MaPSAs at Fermilab (additional labor)
- MaPSA yield is lower than expected
  - Will have to assemble additional parts; might have to purchase additional PS-p sensors and MPA chips

- P=20%
- 0.5-1.0-1.5 M$
- No delay
- Impact = 200 k$

- P=33%
- 0.2-0.4-0.6 M$
- No delay
- Impact = 132 k$

- P=15%
- 0.37-0.51-0.64 M$
- No delay
- Impact = 76 k$

Summary

Technical progress has been made since the June 2018 IPR

- Dummy MaPSAs have been received and tested
  - This resulted in an improvement of the bump bonding process and the down selection of vendors
- Functional MaPSAs round 1 are being produced by AEMTec and HPK
  - MaPSAs are expected in late Spring 2019
  - Test setup is being assembled at FNAL
- Procurement of Functional MaPSAs round 2 will start in May 2019
  - Test setups with be installed at vendors
  - Options for including full production as part of contract will be considered
  - Round 2 MaPSAs should be available for Module Assembly by early 2020