TOP
Readiness for DOE Reviews
25-JUL-2012
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University of Hawai’i
For the TOP group

• Quartz procurement status/plan
• Beam test and CRT status and plan (incl. Fuji-B4 status)
• Electronics status and plan
• Strategy for CD-3b review (CRT, LEPS test)
US Requests to DOE

*WBS = Work Breakdown Structure
Department of Energy Support for US Belle II Groups Managed through the **Critical Decision process**

<table>
<thead>
<tr>
<th>Milestone</th>
<th>MNS Schedule</th>
<th>Project Schedule</th>
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</thead>
<tbody>
<tr>
<td>CD-0 Approve Mission Need</td>
<td>FY 2011</td>
<td>Aug 2011 (actual)</td>
</tr>
<tr>
<td>CD-1 Approve Alternative Selection and Cost Range</td>
<td>FY 2012</td>
<td>Jul 2012</td>
</tr>
<tr>
<td>CD-3A Approve Long-lead Procurements (KLM modules)</td>
<td></td>
<td>Aug 2012</td>
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<tr>
<td>CD-3B Approve Long-lead Procurements (iTOP quartz)</td>
<td></td>
<td>Dec 2012</td>
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<tr>
<td>CD-2/3 Approve Performance Baseline, Start of Construction</td>
<td>FY 2013</td>
<td>Jul 2013</td>
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<tr>
<td>CD-4 Approve Project Completion</td>
<td>FY 2015</td>
<td>Dec 2015</td>
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- US Gov’t standard process; specific set of gates/reviews need to be passed to proceed
US Belle II has been thoroughly reviewed

• CD-1 Review 26 June 2012
• Peer Review 29-30 March 2012 (PNNL)
• Conceptual Design Review 15-16 March 2012 (KEK)
• 6th BPAC 26-27 February 2012
• Director’s Review 15-16 December 2011 (PNNL)
• Focused BPAC 11-12 November 2011
• 5th BPAC 14-15 February 2011
• (OHEP) Intensity Frontier Review 10-11 August 2010
Basis of technical Review: TOP Testing History

• 2010 CERN Beam Test ("simple" focusing TOP)
  – < 2 m bar, focusing mirror, no expansion block
  – 4-channel SL10s
  – Constant fraction discriminators and CAMAC ADC/TDC

• 2011 Fermilab Beam Test ("imaging" TOP)
  – ~2.5 m bar, "block" expansion volume
  – 16-channel SL10s
  – Highly integrated, waveform sampling electronics

• 2011 – 2012 Bench/Electronics Tests
  – Tests with pulser inputs
  – Tests with 16-channel SL10 and laser scan
CD-1 Passed, requiring...

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Documentation</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Approve Acquisition Strategy</td>
<td>Belle-II Acquisition Strategy</td>
<td>✔</td>
</tr>
<tr>
<td>Approve Preliminary Project Execution Plan (PEP)</td>
<td>Belle-II Preliminary Project Execution Plan</td>
<td>✔</td>
</tr>
<tr>
<td>Appointment of the Federal Project Director (FPD)</td>
<td>Belle-II Preliminary Project Execution Plan, Section 7</td>
<td>✔</td>
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<tr>
<td>Establish and Charter Integrated Project Team (IPT)</td>
<td>Belle-II Preliminary Project Execution Plan, Appendix A</td>
<td>✔</td>
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<tr>
<td>Develop a Risk Management Plan</td>
<td>Belle-II Preliminary Project Execution Plan, Section 8.1</td>
<td>✔</td>
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<tr>
<td>Comply with the One-for-One Replacement</td>
<td>NA</td>
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<tr>
<td>Complete a Conceptual Design</td>
<td>Belle-II Conceptual Design Report</td>
<td>✔</td>
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<tr>
<td>Document High Perf. &amp; Sustainable Bldg. &amp; Sustainable Env. Stewardship considerations</td>
<td>NA</td>
<td></td>
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<tr>
<td>Conduct a Conceptual Design Review</td>
<td>Held 15-16 March 2012 at KEK</td>
<td>✔</td>
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<tr>
<td>Complete a Conceptual Design Report</td>
<td>Belle-II Conceptual Design Report</td>
<td>✔</td>
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<tr>
<th>Requirement</th>
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<tbody>
<tr>
<td>Prepare a Preliminary Hazard Analysis Report</td>
<td>Belle-II Preliminary Hazards Analysis Report</td>
<td>✔</td>
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<tr>
<td>Develop and Implement an Integrated Safety Management Plan</td>
<td>Belle-II Preliminary Project Execution Plan, Section 8.7</td>
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<tr>
<td>Establish Preliminary Quality Assurance Program</td>
<td>Belle-II Project-Specific Quality Assurance Program</td>
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<tr>
<td>Identify general Safeguards and Security requirements for the recommended alternative</td>
<td>Belle-II Preliminary Project Execution Plan, Section 8.8</td>
<td>✔</td>
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<tr>
<td>Complete National Environmental Policy Act Strategy by issuing a determination (i.e., EA).</td>
<td>Categorical Exclusion (B3.6) for the US Belle-II Project</td>
<td>✔</td>
</tr>
<tr>
<td>Conduct Independent Project Review</td>
<td>Office of Project Assessment (SC-28)</td>
<td>This Review</td>
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<tr>
<td>Update PDS, or other funding documents for MIE and OE projects, and OMB 300s, if applicable.</td>
<td>Field Work Proposal</td>
<td>✔</td>
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• However....
CD-1 Passed, with caveats...

- Serious concerns raised by technical reviewers
  - Detector performance with final optics not convincing demonstrated
  - Data verification for mirror/corners
  - Performance with multi-track/realistic backgrounds
  - Demonstrate works with final PMTs/electronics

- Next preparation steps critical
  - Quartz procurement
  - Beam test/cosmic ray test status/plans
  - Electronics status/plans

- Will come back to CD-3a schedule/strategy
Quartz Procurement items

• Bars
  – Contract in place for full production
  – 10 blanks already produced and “delivered” (US-J funded)
    • Up to 8 more will be ordered with US-J FY12 funds
  – 2 polished bars ordered – delivery ~December (DOE $$)

• Mirrors
  – Specifications settled – tilted mirror(?), 100 mm long
  – Nagoya has ordered prototype – due any day
  – PNNL issuing RFP for another prototype now (DOE $$)

• Prisms
  – Specifications less settled, but time to prototype
  – PNNL issuing RFP for prototype “option 5” design (DOE $$)
Outstanding Optics R&D

• Finalize mechanical design for quartz bar box to set final specifications for quartz prism
  – Many details in and around the prism/readout interface region that need to be finalized and tested before prism production

• Outstanding issues for the mirror
  – Tilted mirror marginally better, but *some concerns remain*
    • Mechanics of applying spring load in –Z direction on tilted surface
    • Reconstruction algorithms for continuum of impact positions, momenta and angles has not been demonstrated and may be more difficult for the tilted mirror design

• Analyzed data with final optics will be needed for DOE approval for production
  – Earliest reasonable date for building prototype with final optics is around December

• DOE is working with us to relieve “CD approval” pressure on the production of the optics
  – Schedule is still tight, but we have some relief in early U.S. FY13
TOP (Quartz-driven) Schedule

- Key drivers/constraints
  - CD-3b and **passing of FY13 Energy and Water bill** required to start production
  - Delivery of iTOP System to support KEK installation date – Feb 2015
- Increasing preproduction prototyping (time and quantities of optics)

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<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<tbody>
<tr>
<td>Beam &amp; Cosmic Tests</td>
<td>B</td>
<td>CR</td>
<td>B</td>
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<td>CR</td>
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<tr>
<td>Preproduction Optics</td>
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<tr>
<td>Production Optics</td>
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<tr>
<td>Module Assembly</td>
<td></td>
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<tr>
<td>Install &amp; Commission</td>
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*Periods shown are calendar years*
Cosmic Ray and Beam Campaigns

- Need to address serious concerns of referees
- 3-prong strategy:

1. Beam tests at LEPS
   - Demonstrate available optics, new PMT, different conditions/angles

2. Cosmic Ray tests in Fuji Hall
   - Commissioning platform for readout electronics
   - Will use to confirm/first cal constants assembled production modules

3. Final confirming beam-test
   - Demonstrate iTOP concept/TOP detector performance

➤ Optics has evolved
➤ Electronics (firmware) needs development/manpower
LEPS option

- Max. 2.4 GeV γ on 1.5 mm thick Pb to produce an e⁻e⁺ pair
- Trigger by scintillators (5 x 5 mm²)
  - Trigger rate: ~80 Hz
- Tracking by the LEPS DCs
- EM shower cut by the LEPS TOF array

(time??-timing00)/1e3 {timing.adc[0]>140}
Cosmic Ray Telescope (Fuji Hall, KEK)

- Tracking Layers
- Mirror, laser-feed, gas-feed end
- 4x TOP modules

Side View

- ~1mm resolution
- Sci Fi tracker over ~2 meters < ~1mrad

- 60ps/\sqrt{4}
- ~30ps

Steel/concrete shielding block
>1m Fe (1.5m better)

- 4x shortened TOF counters (start timing, dE/dx)
- 4x full TOF counters (range stack trigger/select)

Graph: Beam negative 2.0 [GeV/c]
Tent already ready

• Preparation / Test area
  • Cosmic-Ray Test (CRT), HV test, QBB, FrontEnd,…

• A highly utilized space:
  • CRT stand: 400cmx490cmx500cm(H)
  • CRT DAQ, HV test, ...: 300cmx300cmx250cm(H)
  • Electronics & PMT, ...: 250cmx200cmx250cm(H)
  • Mechanics: 240cmx490cmx500cm(H)
Cosmic Ray Telescope (optimizing)

Performance and FEA simulations

Considering sag, natural modes (earthquake resistance), optimizing location of tracking/timing detectors, range-stack and/or Cherenkov detector
Beam test options

- FNAL off-line
- LEPS, SLAC, DESY...
- Cost, shipping issues
TOP Readout Architecture

- Waveform sampling ASIC
- 8k channels
- 1k 8-ch. ASICs
- 64 SRM
- 64 DAQ fiber transceivers
- 32 FINESSE
- 8 COPPER
- 9 TRGmod
- 16 COPPER
- 16 FTSW

Subdetector Readout Module

- ASICS
- FPGA
- Clock jitter cleaners
- FTSW clock, trigger, programming

Clock/Event Timing Distribution

Global Decision Logic

Giga-bit Fiber Transceiver Links

FPGA firmware consists of 3 parts:
1) ASIC/ADC driver (common)
2) Trigger, feature extract (subdet. specific)
3) Unified DAQ transport protocol

Gary Varner, TOP Readiness for DOE Reviews, July 2012 B2GM
Lessons Learned (first proto readout)

1. Sample pointer dephasing fix → IRS3B ASIC
2. Timebase servo-loop
   1. Firmware needs to be re-written
   2. Possible hardware change (phase detector)
3. SCROD v2 ("final" form factor)
4. Better thermal management (85C redline ops)
5. HV divider redesign; packaging SL-10 into module by HPK/Nagoya
6. Demonstrate DSP (real time) data reduction
7. In-situ (on demand) calibration
2nd generation “board stack” status

new PCB designs

SCROD revA2

IRS2_DC revB2

carrier0 revB

new heatsink concept

bench testing

still too hot!
Readout Summary

• IRS3B “pre-production prototype” ASIC in fab, due back 10-SEP

• Next generation control firmware in development (fDIRC CRT)

• Redesign, fab of next generation board stack
  – Improved HV, cooling
  – Feedback control, in-situ calibration
  – Evaluate amplifier options

• Experience with pre-production prototypes by end of 2012

• Production in 2013-2014
Current TOP Strategy

Beam availability:
- Need check SLAC, FNAL, CERN, + others

“Airway”
- If IRS3B ready:
  - FNAL quartz + IRS3B 2 layer @ LEPS
  - * 1st quartz delivery & tests

“Jeep way”
- If IRS3B not ready:
  - FNAL quartz + CFD 1 layer @ LEPS

Verification of LEPS beam (multiple scattering ?)

FNAL or new quartz + IRS3B 2 layer @ LEPS or Somewhere (SLAC, CERN,...)
DOE Readiness Summary

• Software, MCP-PMTs, Assy/clean-room, bar box covered separately (next)
• We have clear homework we must complete before we will be ready for review
• Key items to demonstrate
  – Confirm performance with final optics
  – Robustness of performance
  – Demonstrate Belle II readout compatible electronics
• Cosmic ray and Test Beam Campaign
• Passing CD3-b is crucial to keep on schedule