

Belle II Detector: US contributions

James Fast – US Belle II Project manager
Pacific Northwest National Laboratory



Pacific Northwest
NATIONAL LABORATORY

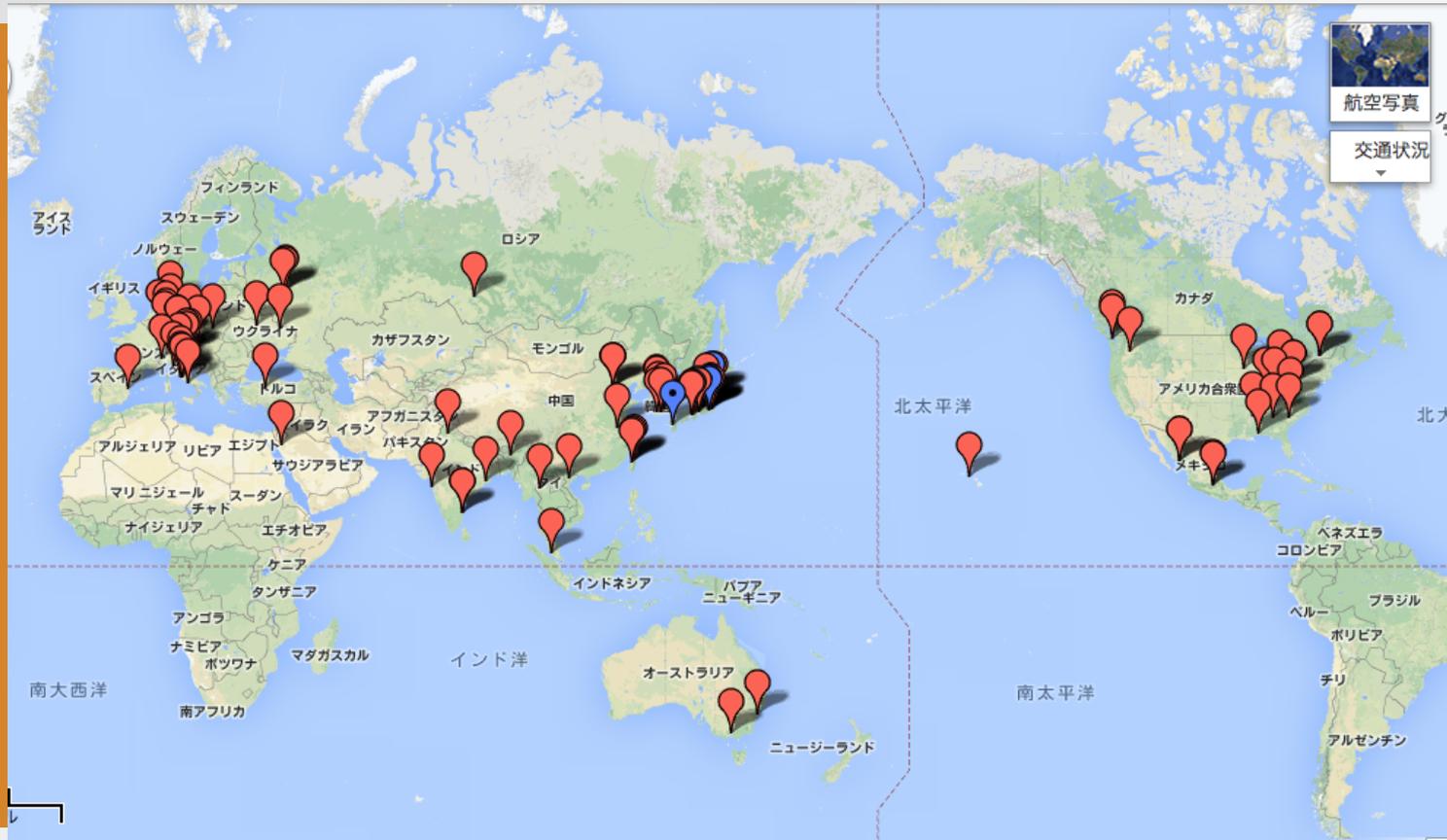
Proudly Operated by Battelle Since 1965

Collaboration growing internationally and in the US

- ▶ Belle-II is now a collaboration of ~560 physicists from 94 institutions in 23 countries.

US Groups:

PNNL
Carnegie Mellon
Cincinnati
Hawaii
Indiana
Kennesaw State
Luther College
U. Mississippi
U. Pittsburgh
South Alabama
U. South Carolina
VPI (Virginia Tech)
Wayne State

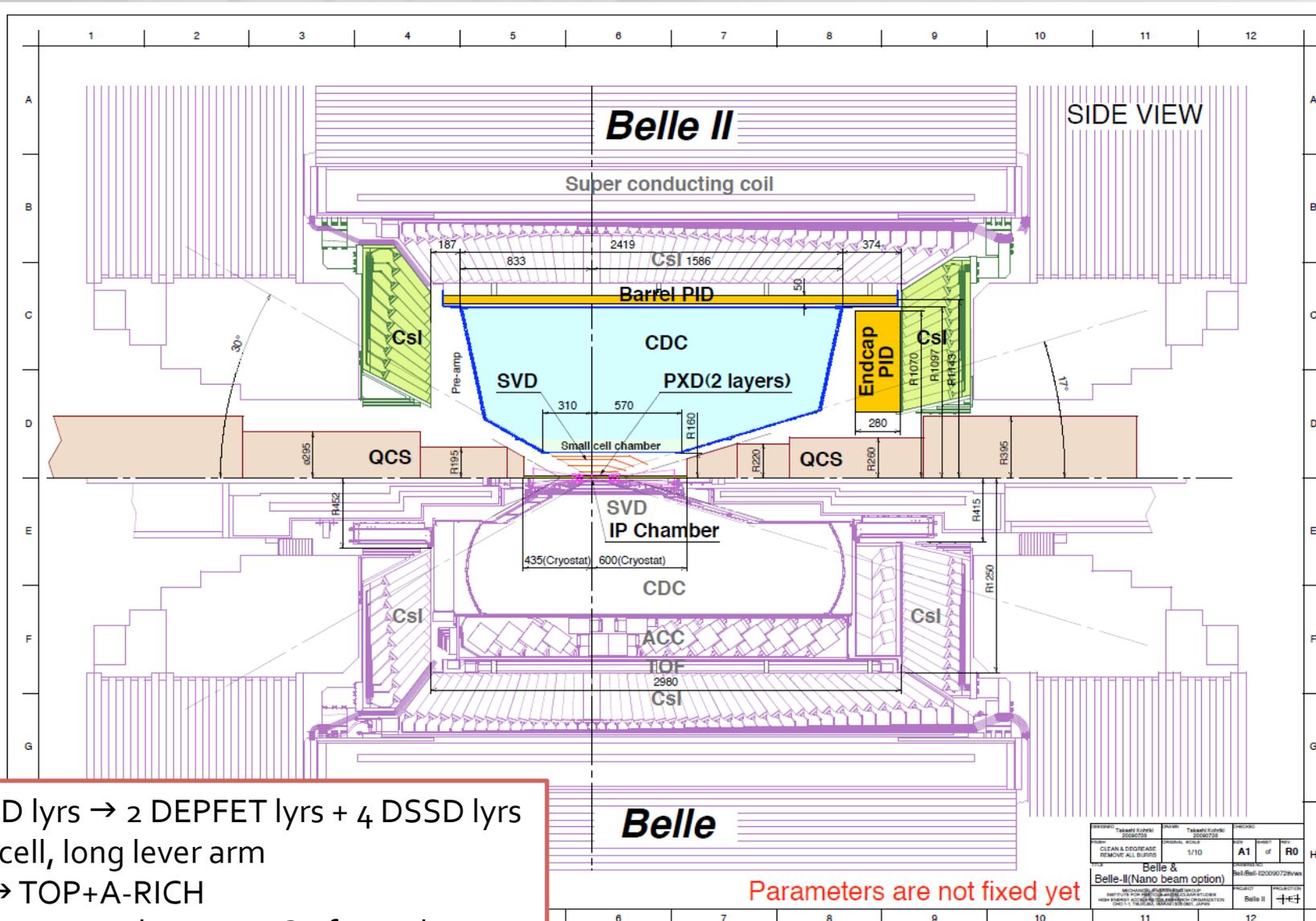


Belle-II detector

Belle-II



Belle



- SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
- CDC: small cell, long lever arm
- ACC+TOF → TOP+A-RICH
- ECL: waveform sampling, pure Csi for end-caps
- KLM: RPC → Scintillator + SiPM (end-caps)

DESIGNED T. Takahashi 02/08/07	DRAWN T. Takahashi 02/08/07	CHECKED R. Oishi 02/08/07	DATE 1/10	REV A1	BY R0
CLEAN & DEGREASE REMOVE ALL BURRS					
BELLE & BELLE-II(Nano beam option)					
PROJECT BELLE II					

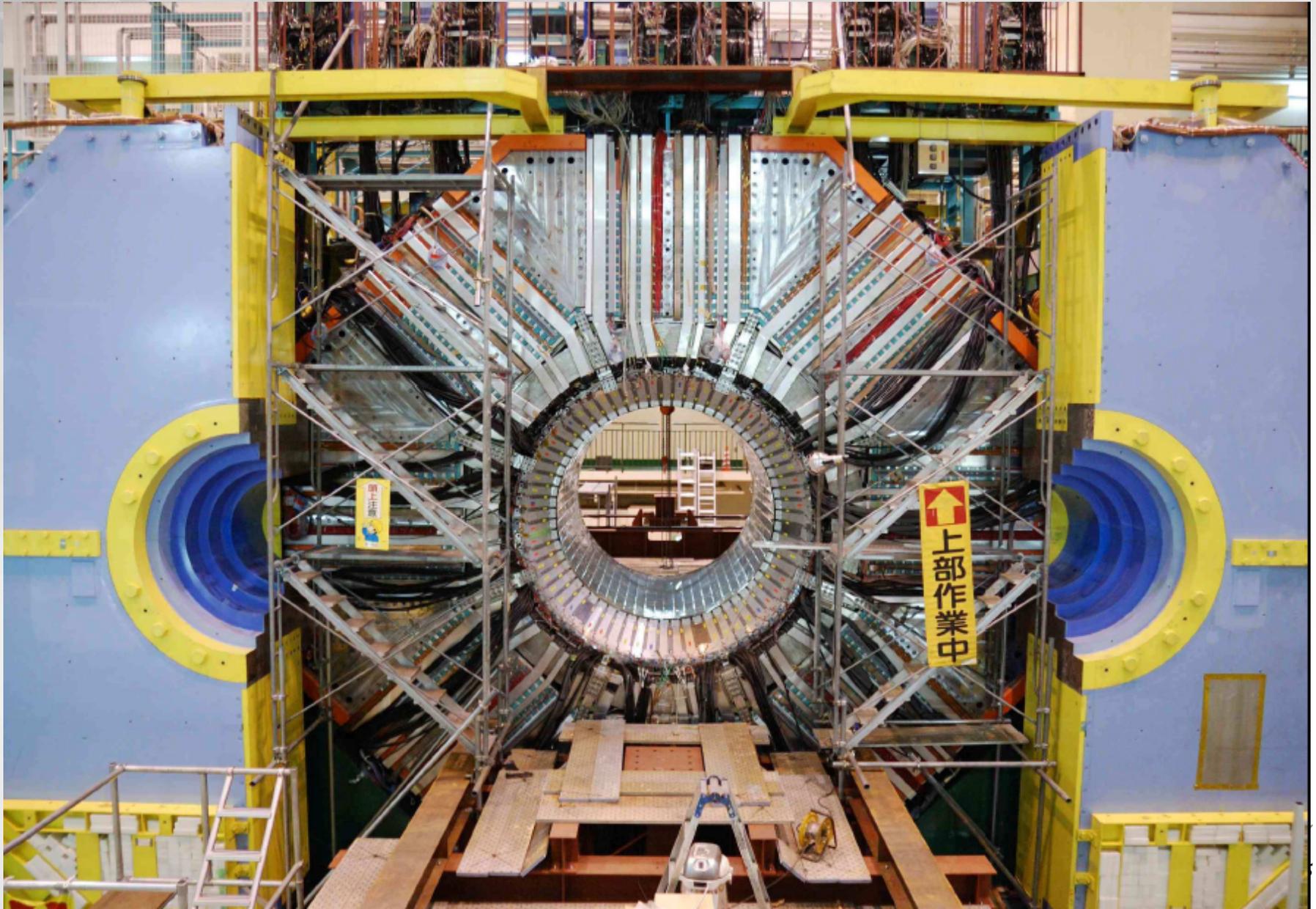
Parameters are not fixed yet

Belle detector today – ready for upgrade



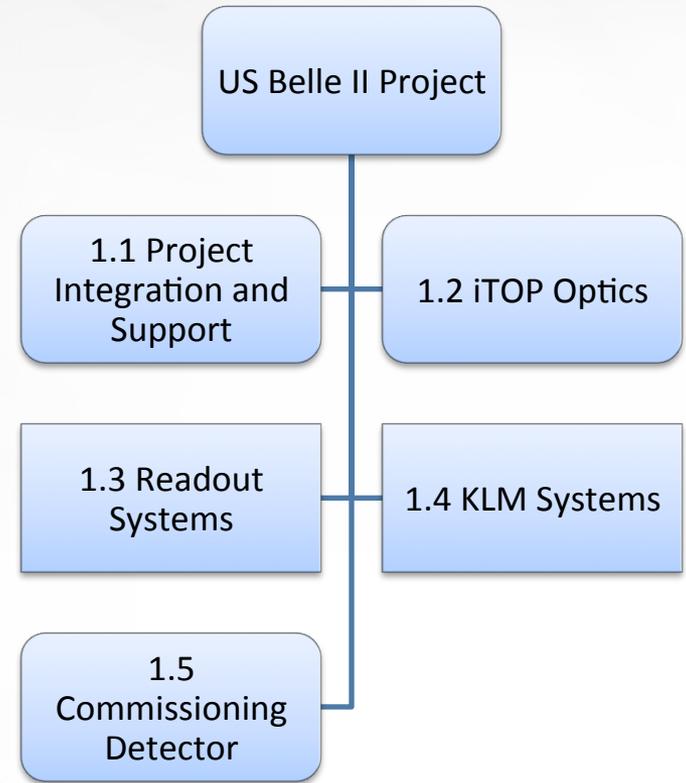
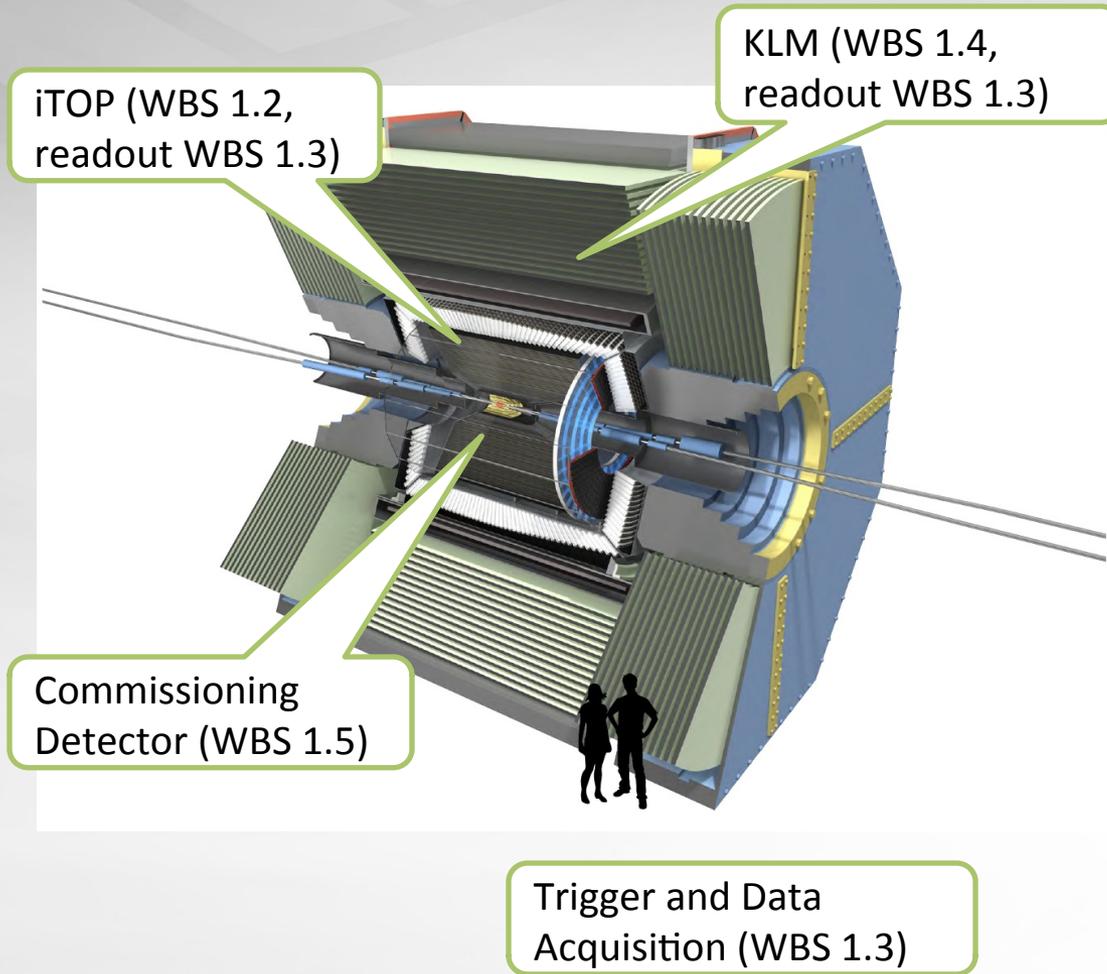
Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** Since 1965





US Belle II project scope: delivering key systems to KEK



US Contributions to Belle II

- ▶ US contributions to critical particle identification systems
 - iTOP system (barrel PID)
 - Providing quartz optical elements
 - KLM (muon system upgrade, endcap and barrel)
 - Providing replacement of inner layers of barrel KLM
 - ASICs and front end electronics
 - Hawaii-designed “oscilloscope on a chip” ASIC
 - Front end electronics for iTOP, KLM
- ▶ US leading commissioning detector effort
 - Critical to avoid damage to new inner detector elements at start-up
 - Si diode array and micro-TPCs for fast neutron “imaging”
- ▶ Belle II Computing plans includes Tier 0 at PNNL
 - 10% demonstration system brought on line for Belle
 - Part of US response to Fukushima disaster
 - PNNL is lead lab that coordinated DOE response efforts



US Belle II project schedule is driven by KEK Belle II/SuperKEKB schedule

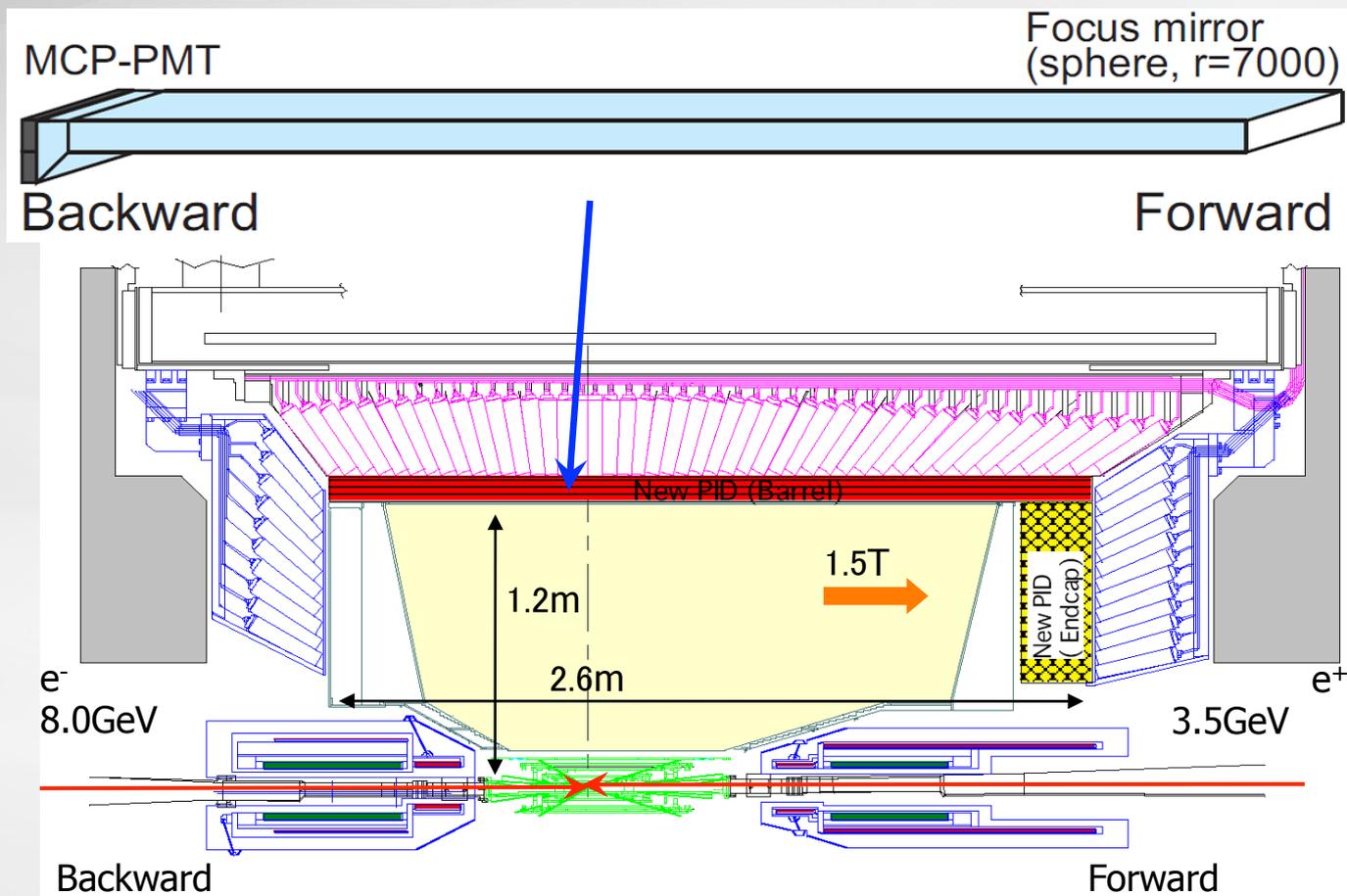
- KLM module installation June-August 2013
- iTOP module installation Mar-May 2015; Optics production 22 months

Milestone	MNS Schedule	Project Schedule
CD-0 Approve Mission Need	FY 2011	Aug 2011 (actual)
CD-1 Approve Alternative Selection and Cost Range	FY 2012	Aug 2012 (actual)
CD-3A Approve Long-lead Procurements (KLM modules)		Aug 2012 (actual)
CD-2/3 Approve Performance Baseline, Start of Construction	FY 2013	Dec 2013?
CD-4 Approve Project Completion	FY 2015	Jun 2016

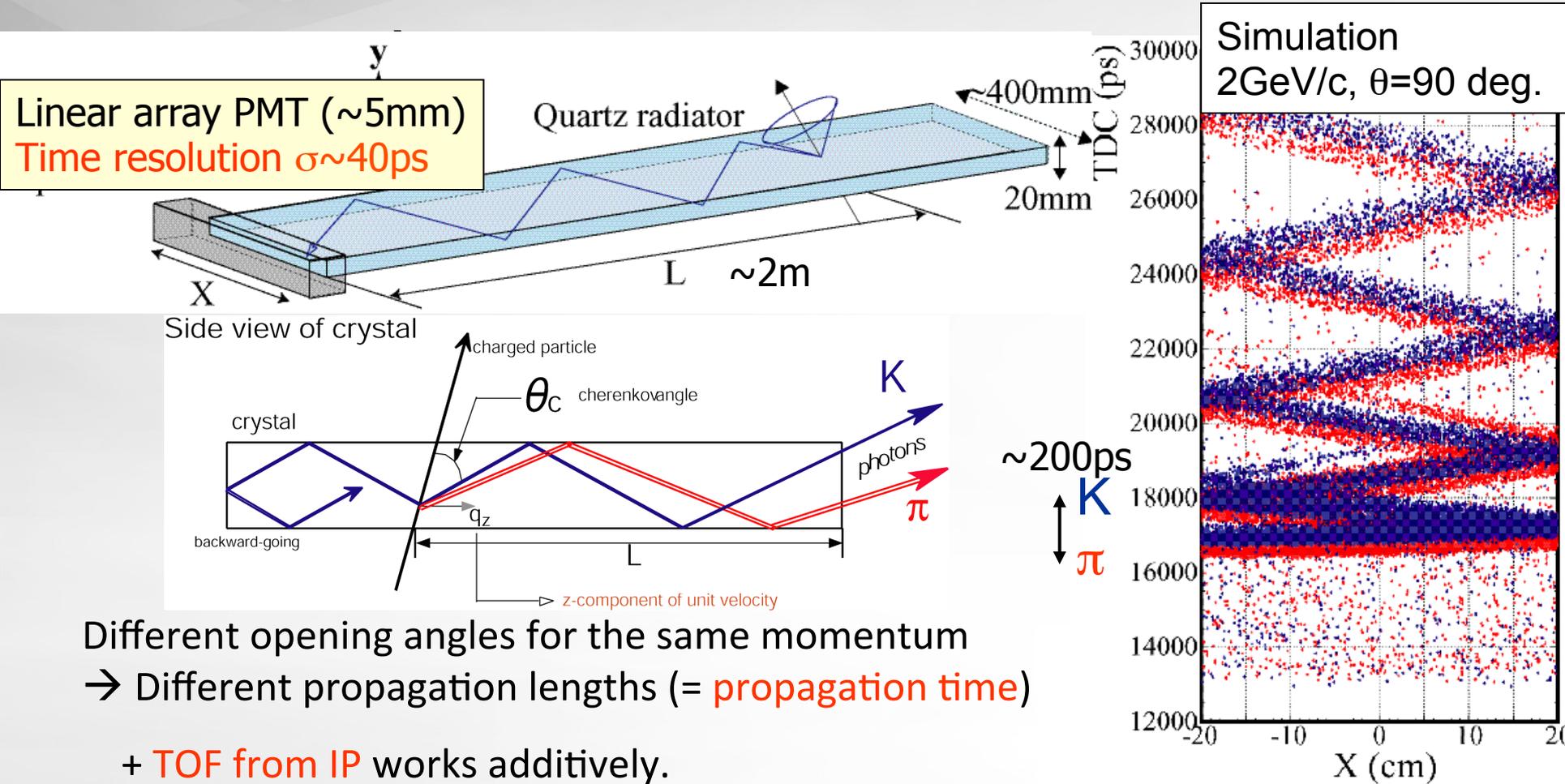
imaging time-of-propagation detector

Space constrained by existing calorimeters

Quartz radiator + mirror + expansion block + MCP-PMT



iTOP counter



Overview of Quartz Optics for iTOP

- ▶ Each module has 2 bars, 1 mirror and 1 prism

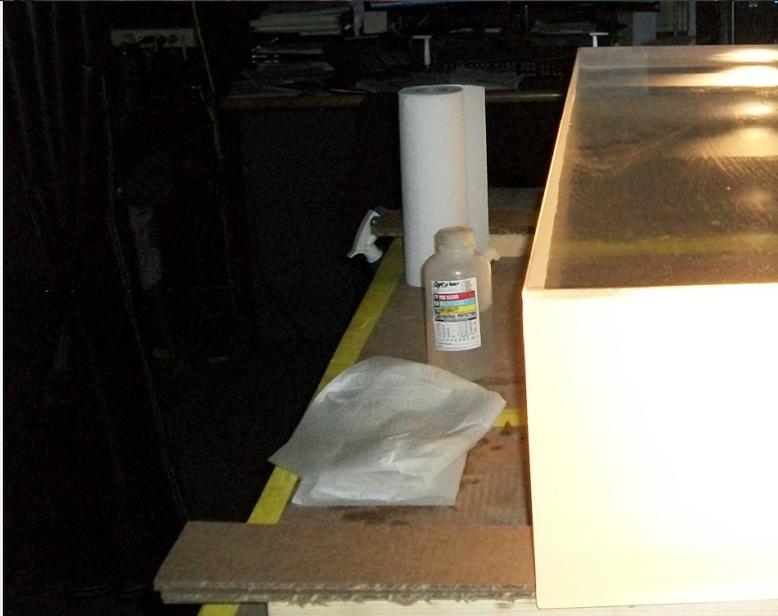


First AOS/OOW bar undergoing metrology to evaluate material quality (homogeneity).



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** Since 1965

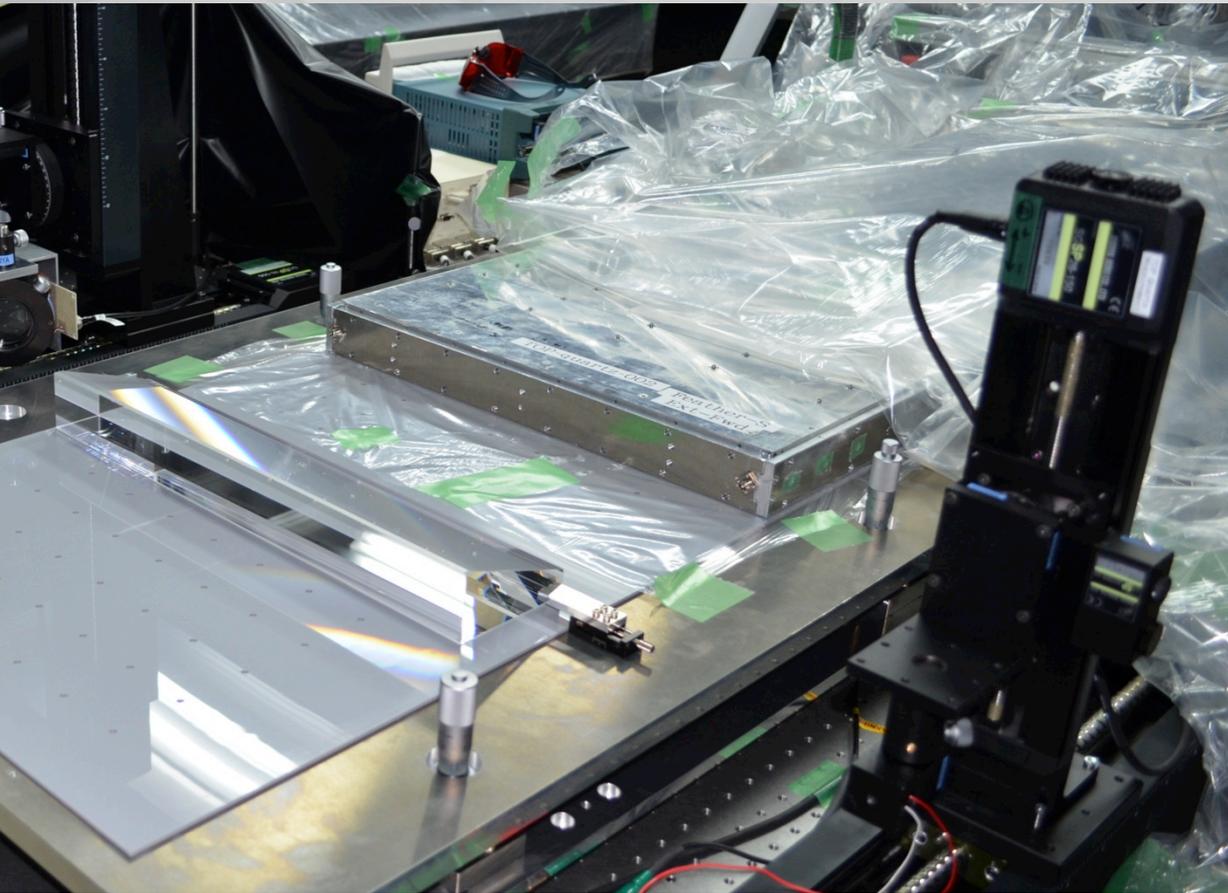


Cosmo Optics Prism



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** Since 1965



July 30, 2013

Mirror undergoing final metrology at ITT



Pacific Northwest
NATIONAL LABORATORY

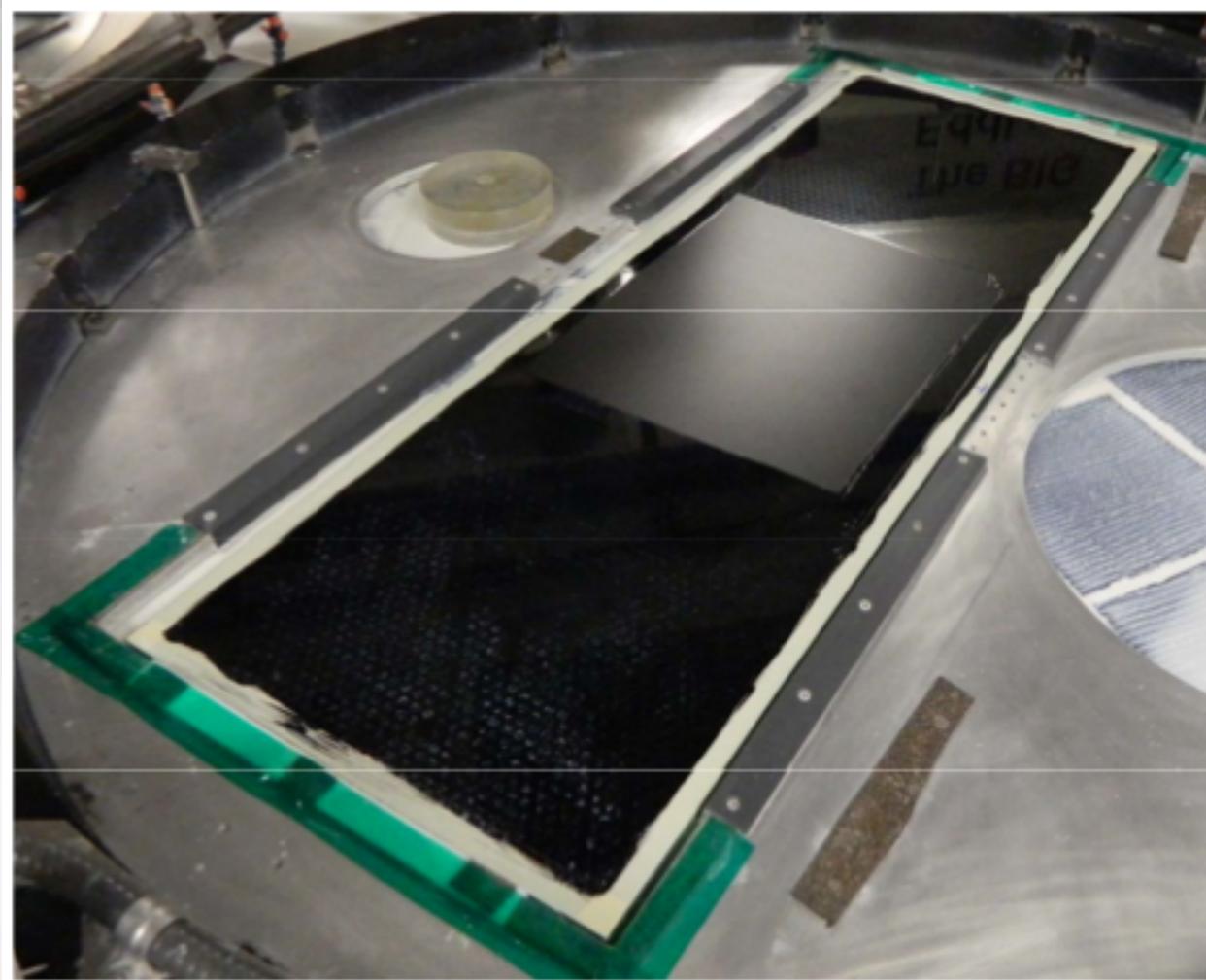
Proudly Operated by **Battelle** Since 1965

Quality Improvement Institute



July 30, 2013

First bar in process at Zygo

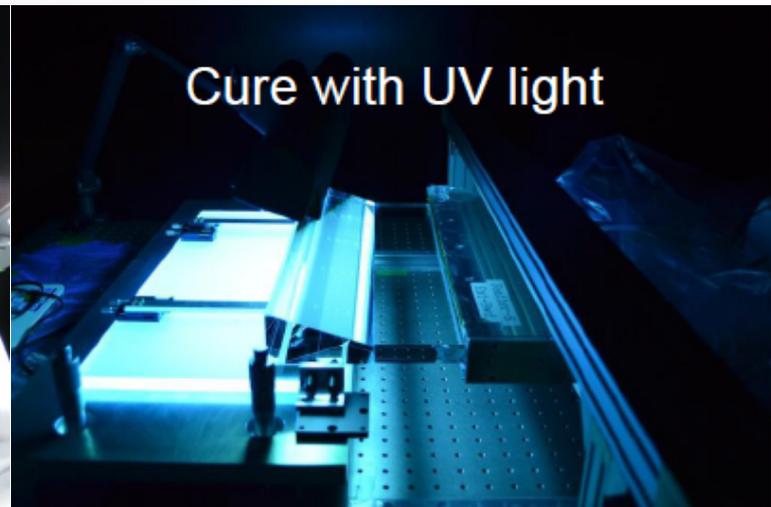
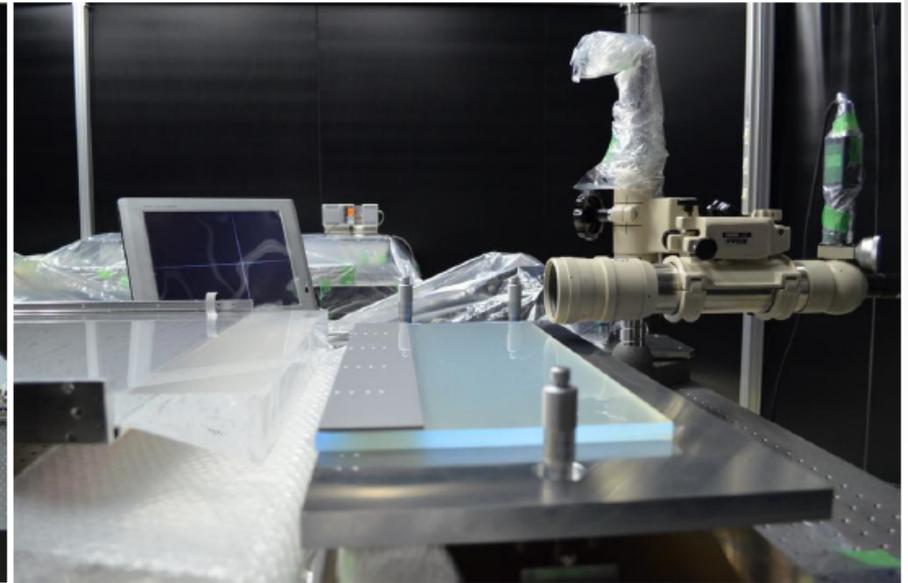
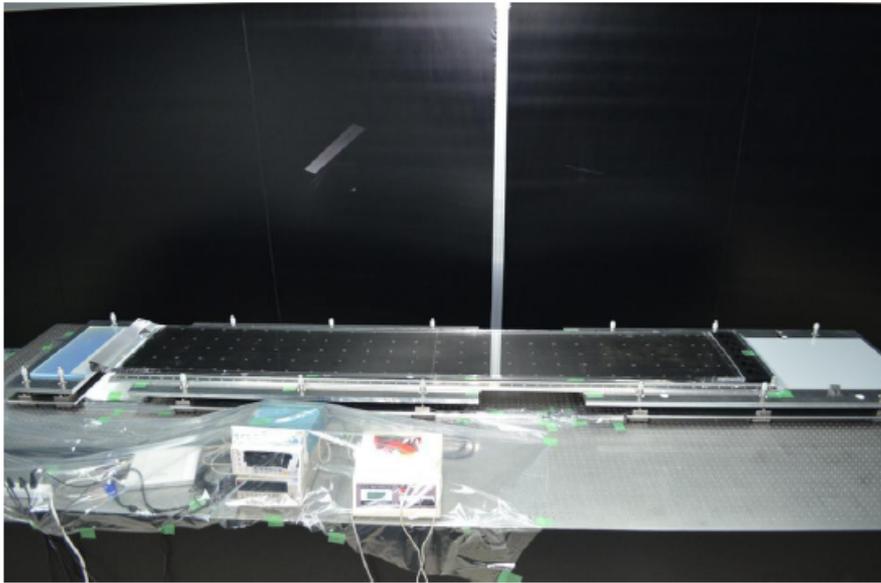


Prototype quartz assembly for beam test



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

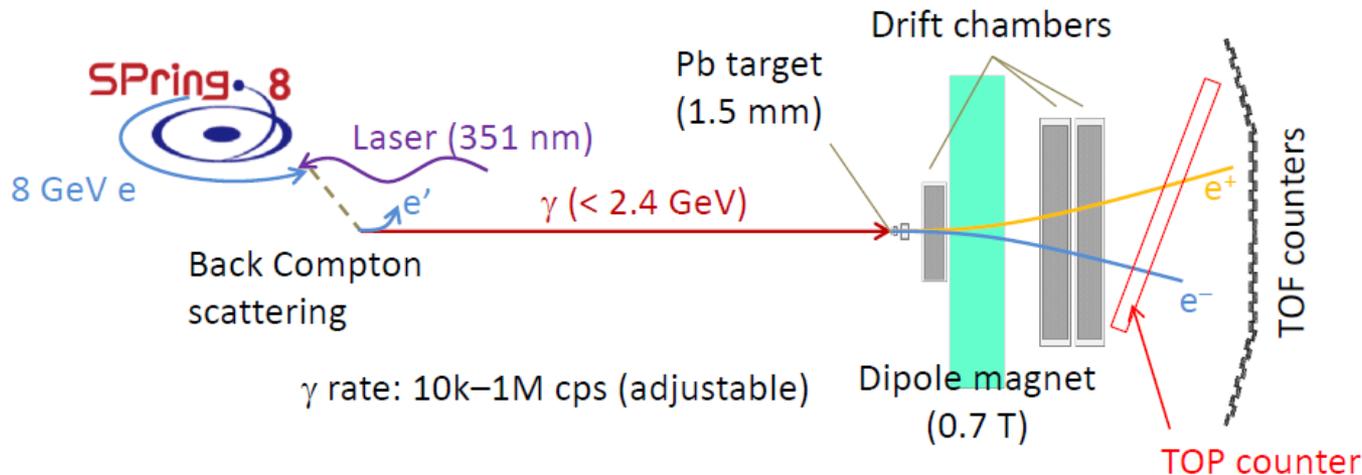


hwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

LEPS Beam Test – June 4-20, 2013

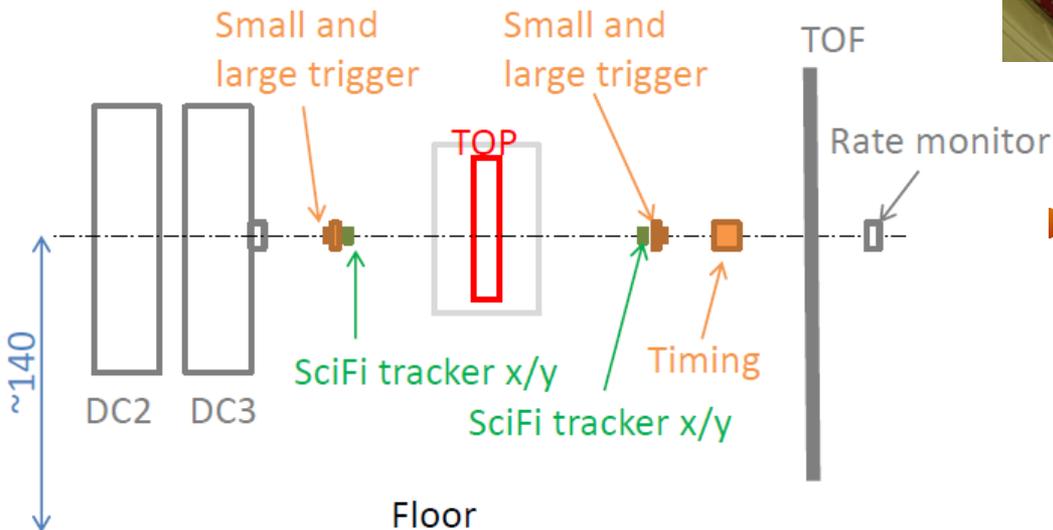
- ▶ Goal: end-to-end test with
 - Full quartz bar including mirror and prism
 - Full bar of PMTs and ASIC-based electronics
 - Belle II DAQ-based readout (COPPER)



- ▶ Facility: LEPS beamline at SPring-8
 - 2 GeV photon beams generated by backward Compton scattering of UV laser photons off 8 GeV synchrotron ring electrons
 - Photons strike Pb target, produce e^+/e^- pairs that pass through detector

LEPS Configuration

- ▶ e^+ beam trigger from four counters
 - γ rate: 30 kHz
 - Trigger rate: 10 Hz
 - DAQ rate: 8 Hz
- ▶ Timing available from accelerator timing signals: ~ 24.3 ps

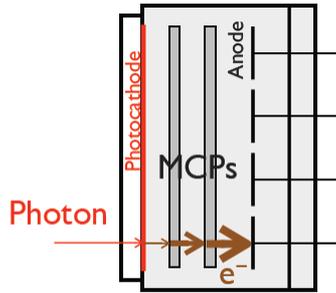


- ▶ Data taken at multiple angles of incidence and locations:
 - $\text{Cos } \theta = 0$ (normal to bar)
 - $\text{Cos } \theta = 0.39$, $x = 0\text{cm}$
 - $\text{Cos } \theta = 0.37$, $x = 20\text{cm}$

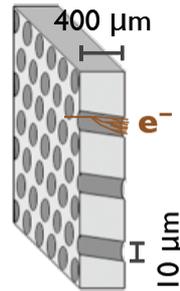
iTOP Electronics Overview



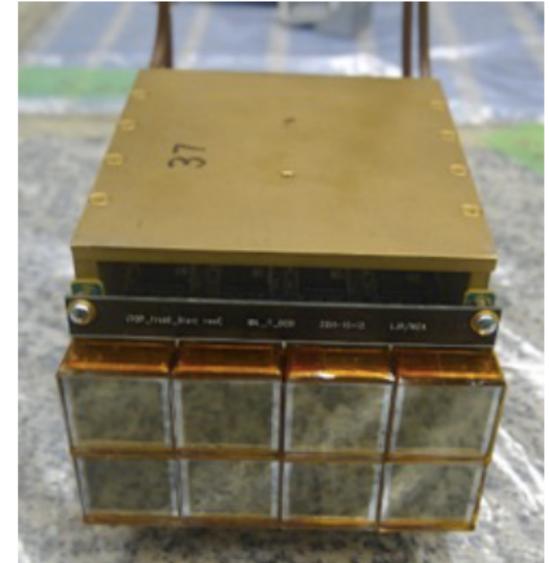
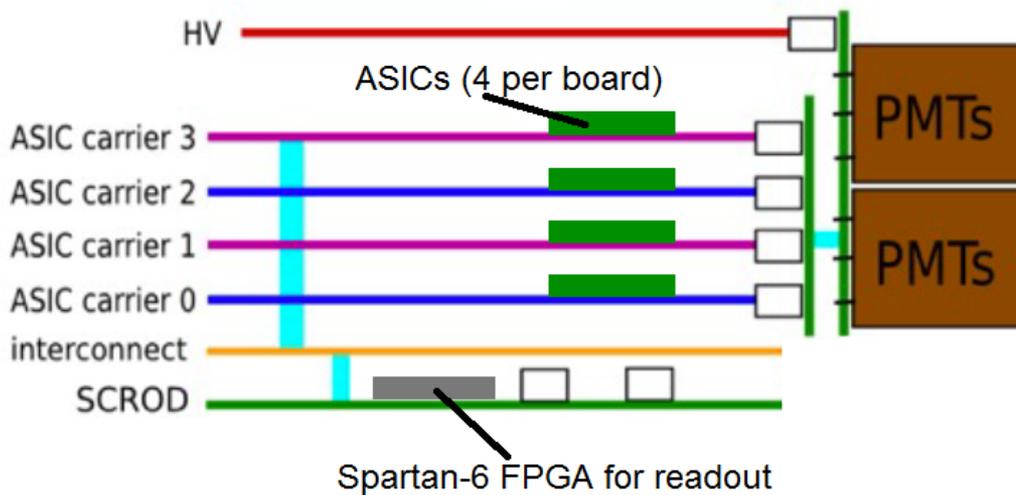
square shape



cross-sectional view

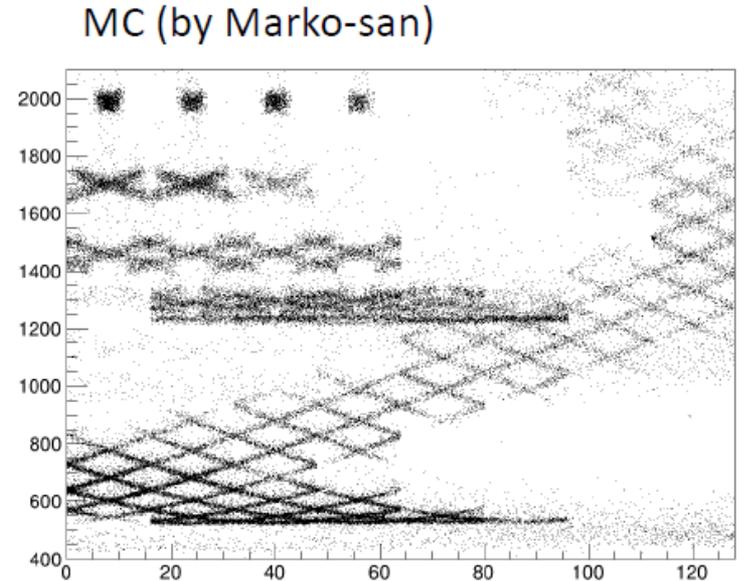
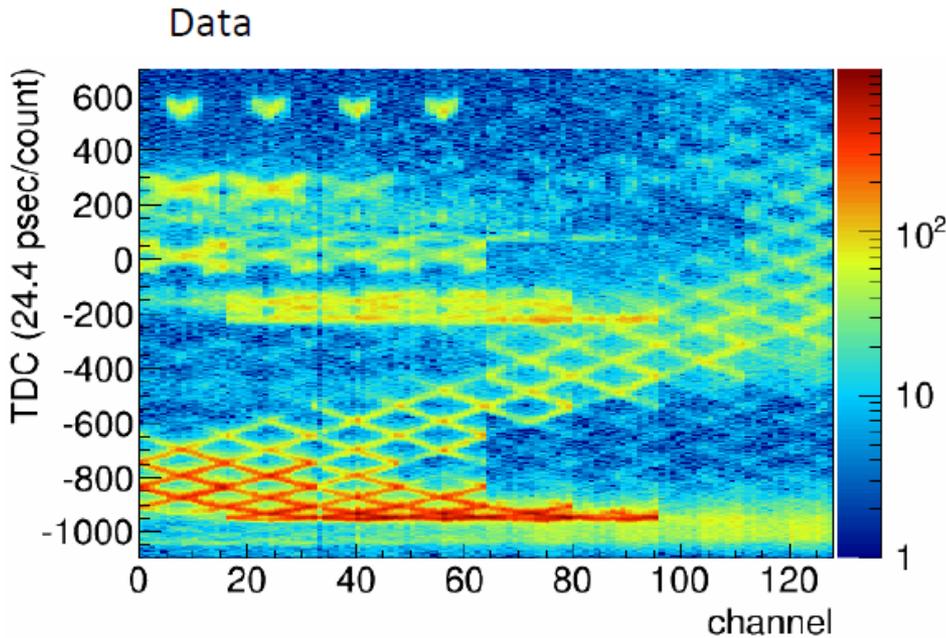


MCP



June 2013 Test Beam

CFD Readout – tests optics only (good for data – Monte Carlo comparison)



View from the electronics

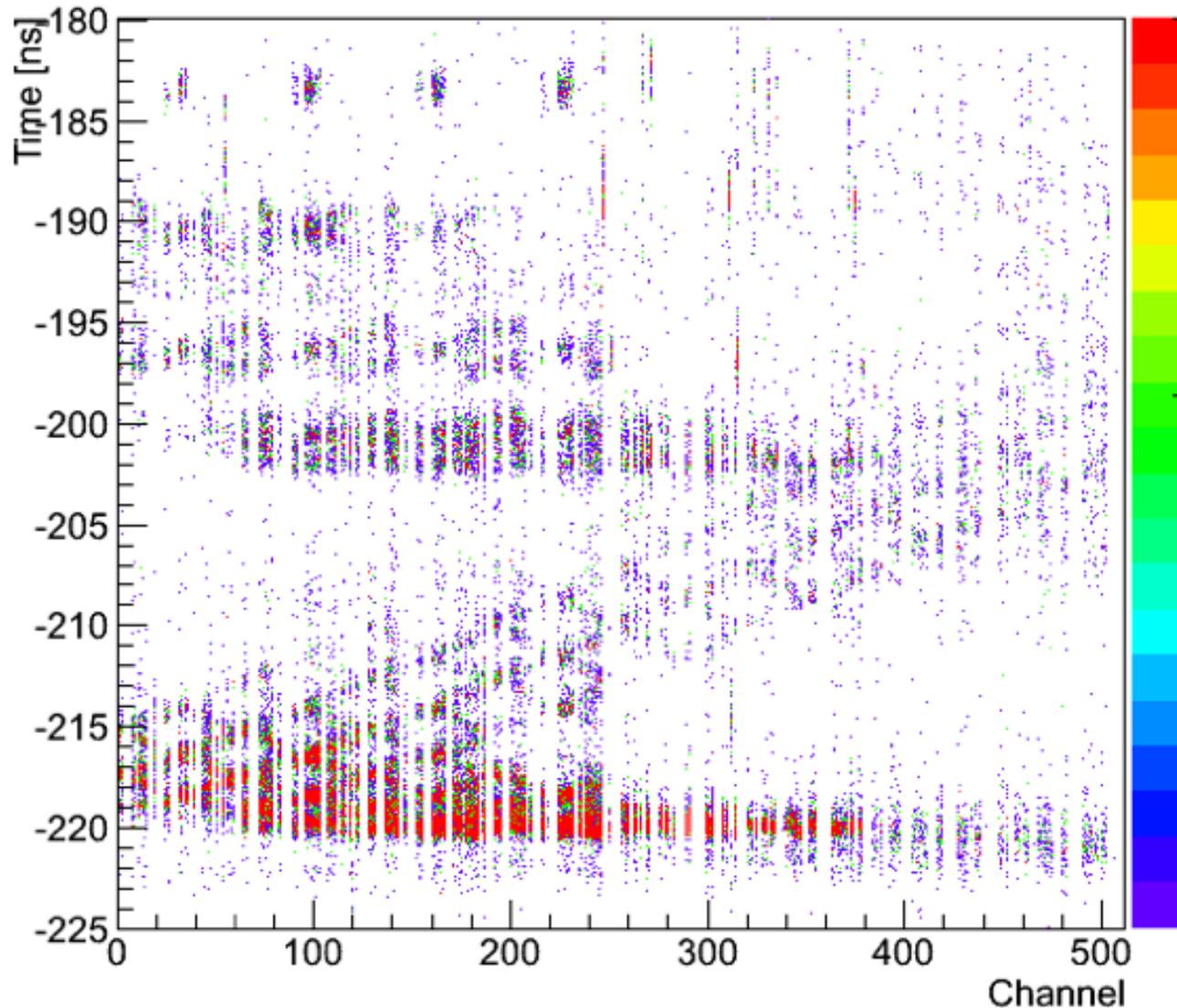
↓ Beam

Lower side

127																	112
31	14	13	12	11	10	9	8	7	6	5	4	3	2	1	ch0	16	
15																	

Upper side

Ring Image from Waveform Digitizing Electronics



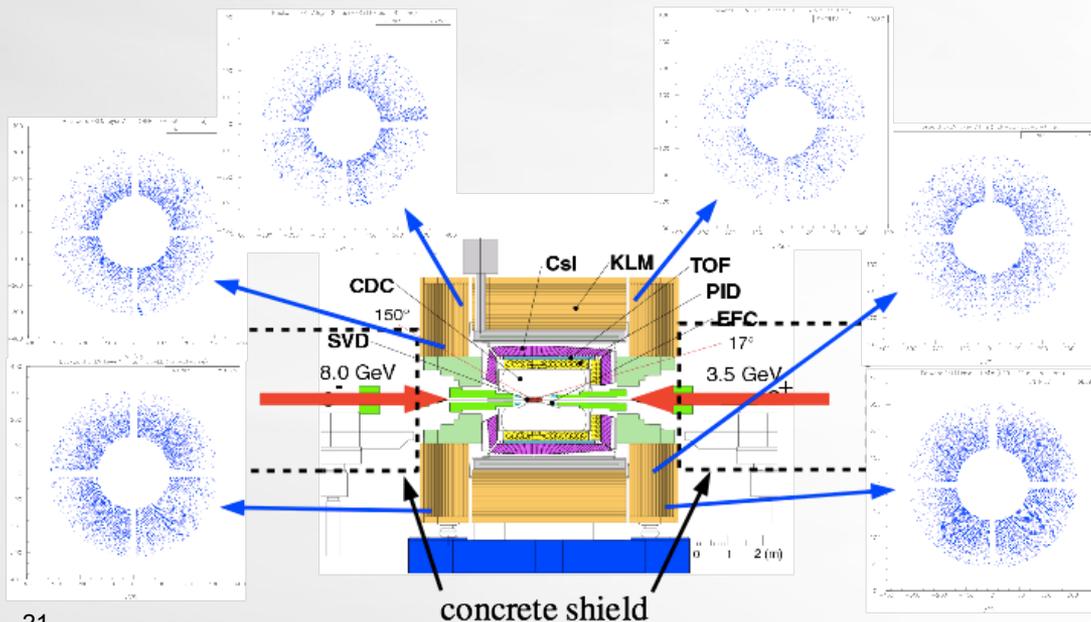
Work remains to improve timing resolution

250 ps in beam
<100 ps for laser

Significant contributions remain from beam timing

K_L and muon (KLM) System Upgrades

- ▶ Virginia Tech was responsible for RPC system in Belle
 - Natural to take leadership role on upgrade to KLM
- ▶ Belle II background rates are too high for some elements
- ▶ Solution: Replace RPCs with plastic scintillators
 - Also update electronics throughout system

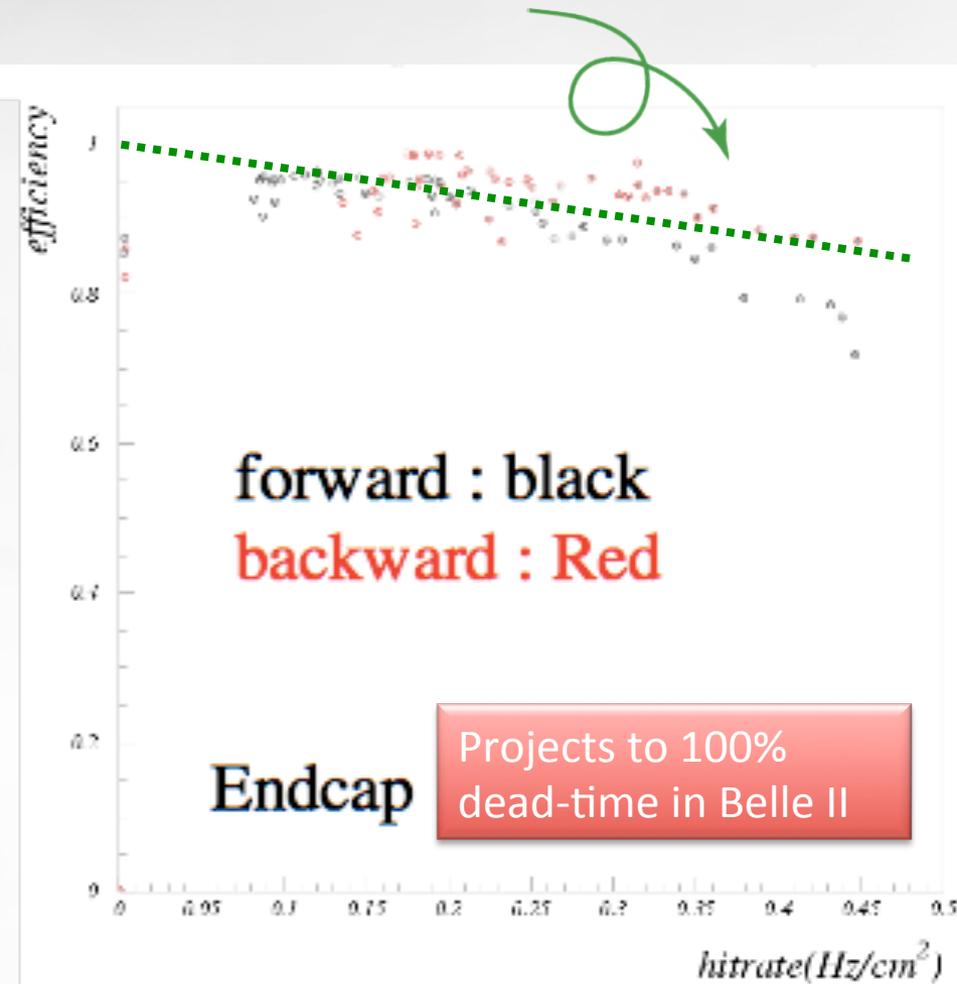
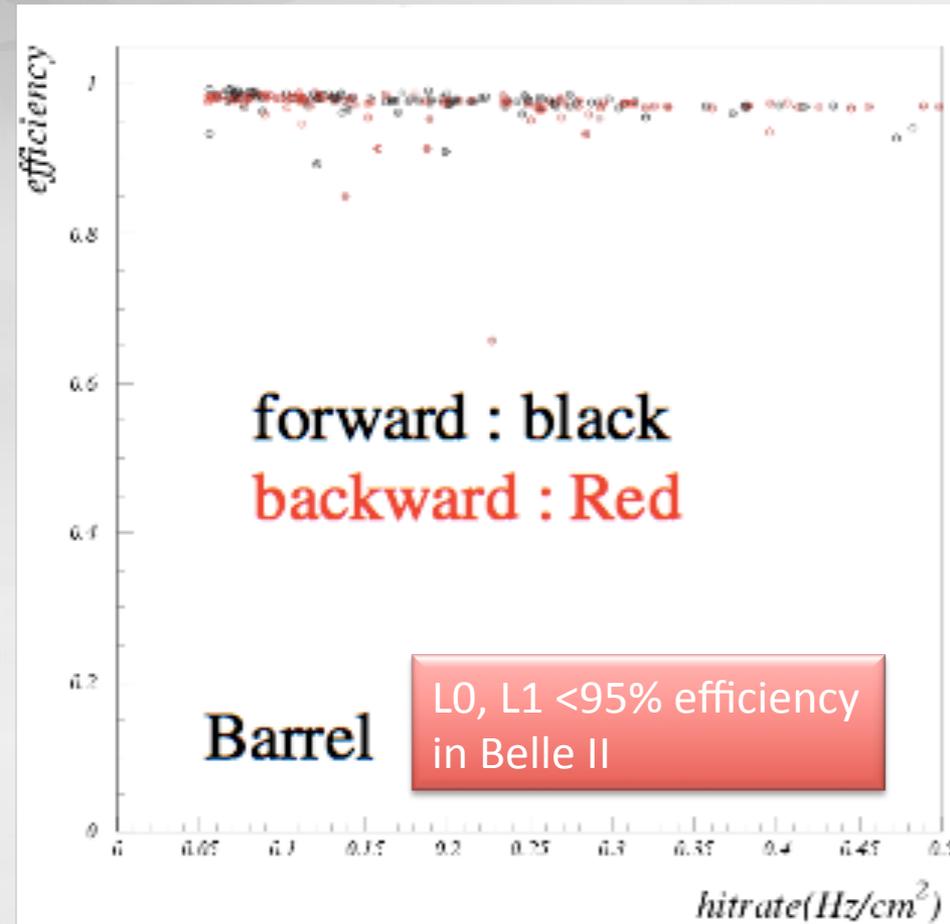


Belle's endcap KLM is bombarded by beam-induced soft neutrons ... *not enough exterior shielding*



Endcap needs complete replacement

High-resistivity glass electrodes in existing RPCs cause efficiency to drop with increasing ambient neutron rate



Scintillator-fiber-MPPC assemblies after cosmic ray testing – ready for installation



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** Since 1965



Layer-1 module during assembly



Shipping crate during filling



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** Since 1965



Belle II is vibrant and growing

- ▶ Opportunities for new US groups to join and make significant contributions to the Belle II upgrade
- ▶ KLM modules nearly complete and will be installed soon
 - Much remains to be done on electronics, testing, commissioning, alignment, software etc.
 - RPC readout system currently un(der)-funded within DOE project
- ▶ Commissioning detector system will be needed in 2015
 - Small effort at Hawaii and Wayne State currently
 - Plenty of opportunities to contribute to development and operations during SuperKEKB commissioning
- ▶ iTOP transitioning from research to production
 - Many opportunities to contribute to beam and cosmic ray test campaigns and analysis
 - Electronics effort would benefit from additional expert-level support