New ISU KLM meeting

Soeren Prell

ISU KLM group meeting

June 10, 2022

Coordinates

- 10 am Friday JST; 8 pm Thursday CDT

- Indico folder: https://indico.belle2.org/category/150/
  - Today's meeting: https://indico.belle2.org/event/7035/

- SpeakApp: https://indico.belle2.org/event/7035/ (passwd: KLM@ISU)
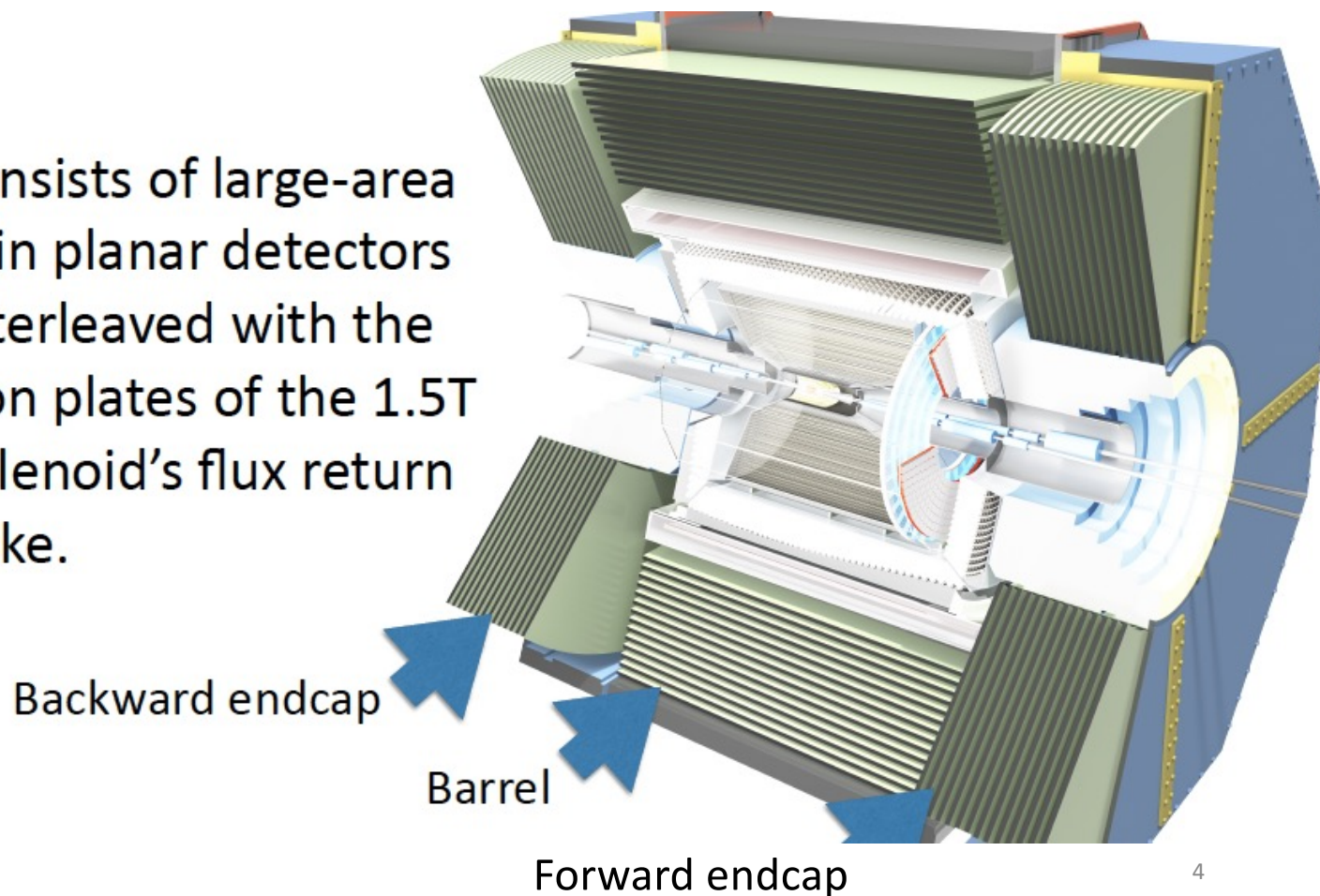 - Back-up: Zoom https://iastate.zoom.us/s/8868238362

Purpose

- We now have Seema and Michele involved in KLM operations at KEK, and the RPC bubbler board project, in addition to the KLM tasks

- Decided to split the weekly ISU meeting into 2 meetings. This one will focus only KLM-related topics

- Will usually discuss contributions on the KLM bubbler project first, then other ISU KLM topics.
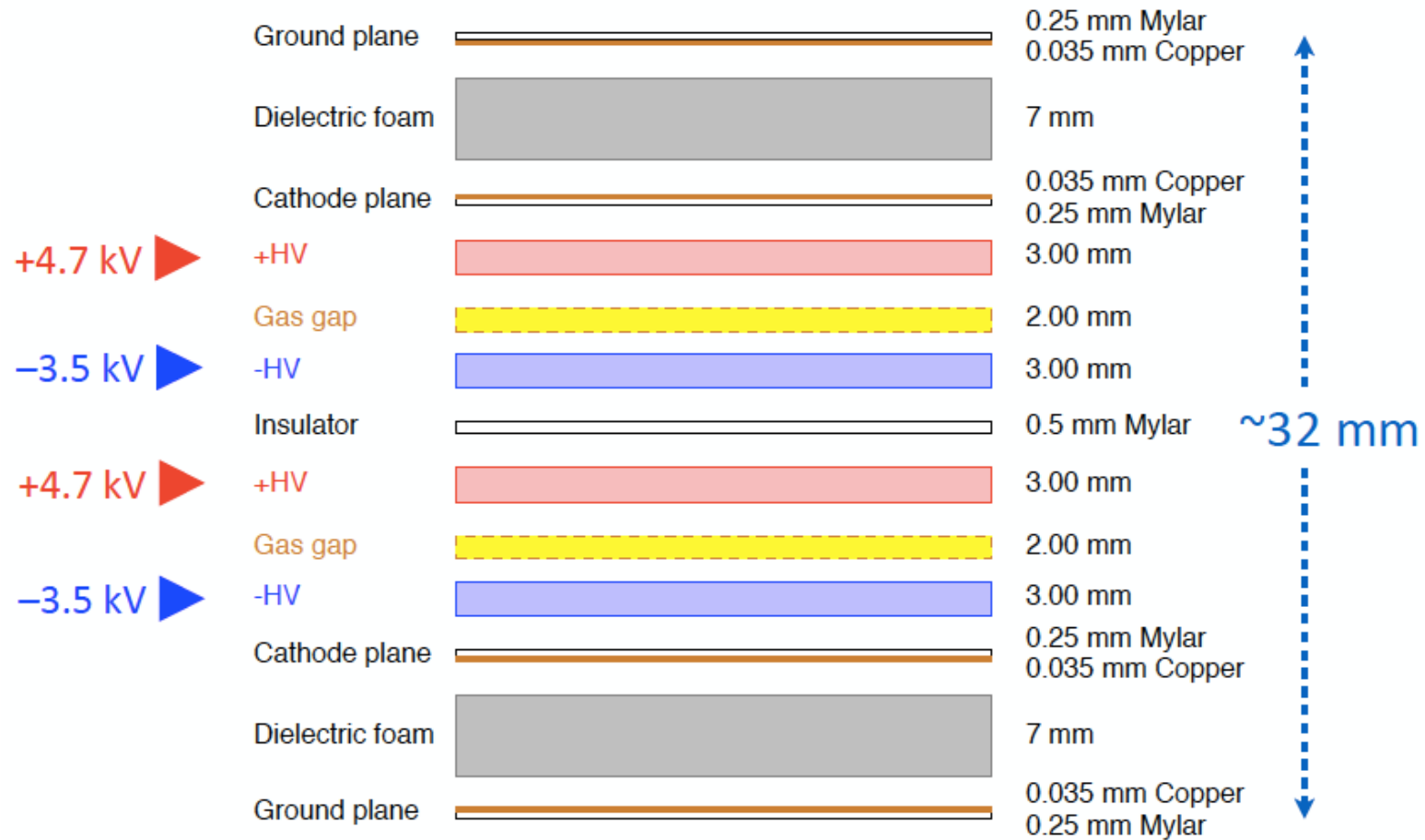
The KLM (K-Long and Muon detector)

- KLM is the outermost component of the Belle II detector

- Barrel layers 3-15 are gas-filled resistive plate chambers (RPCs)

- Barrel layers 1-2 and all endcap layers are plastic scintillators

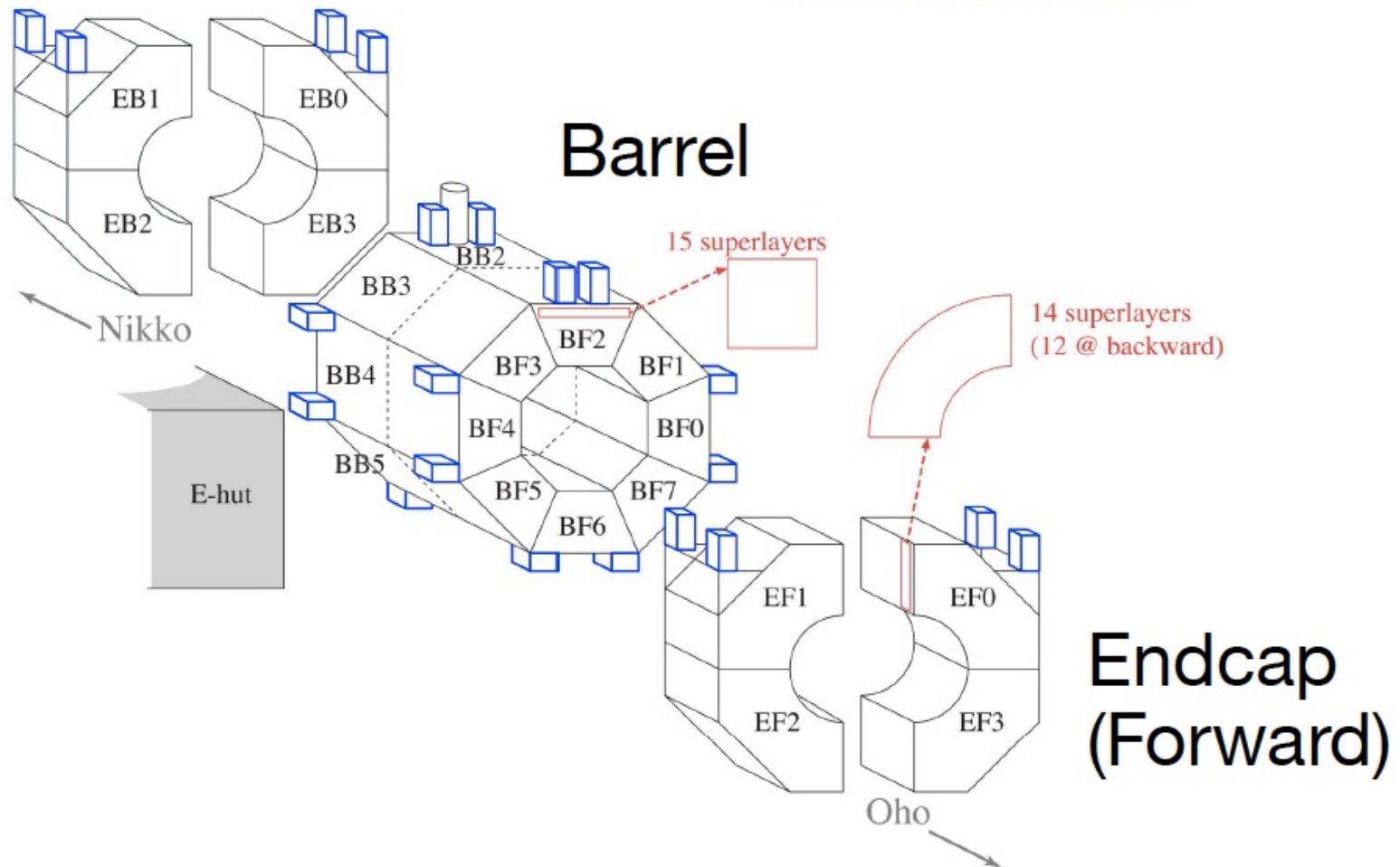consists of large-area thin planar detectors interleaved with the iron plates of the 1.5T solenoid's flux return yoke.

Backward endcap

Barrel

Forward endcap

4

Belle Resistive Plate Counter

	Ground plane	0.25 mm Mylar 0.035 mm Copper
	Dielectric foam	7 mm
	Cathode plane	0.035 mm Copper 0.25 mm Mylar
+4.7 kV ▶	+HV	3.00 mm
	Gas gap	2.00 mm
−3.5 kV ▶	-HV	3.00 mm
	Insulator	0.5 mm Mylar
+4.7 kV ▶	+HV	3.00 mm
	Gas gap	2.00 mm
−3.5 kV ▶	-HV	3.00 mm
	Cathode plane	0.25 mm Mylar 0.035 mm Copper
	Dielectric foam	7 mm
	Ground plane	0.035 mm Copper 0.25 mm Mylar

~32 mm

Endcap
(Backward)

DC crate

Barrel

EB1

EB0

EB2

EB3

Nikko

BB2

BB3

15 superlayers

BF2

BB4

BF3

BF1

14 superlayers
(12 @ backward)

BF4

BF0

E-hut

BB5

BF5

BF7

BF6

EF1

EF0

Endcap
(Forward)

EF2

EF3

Oho
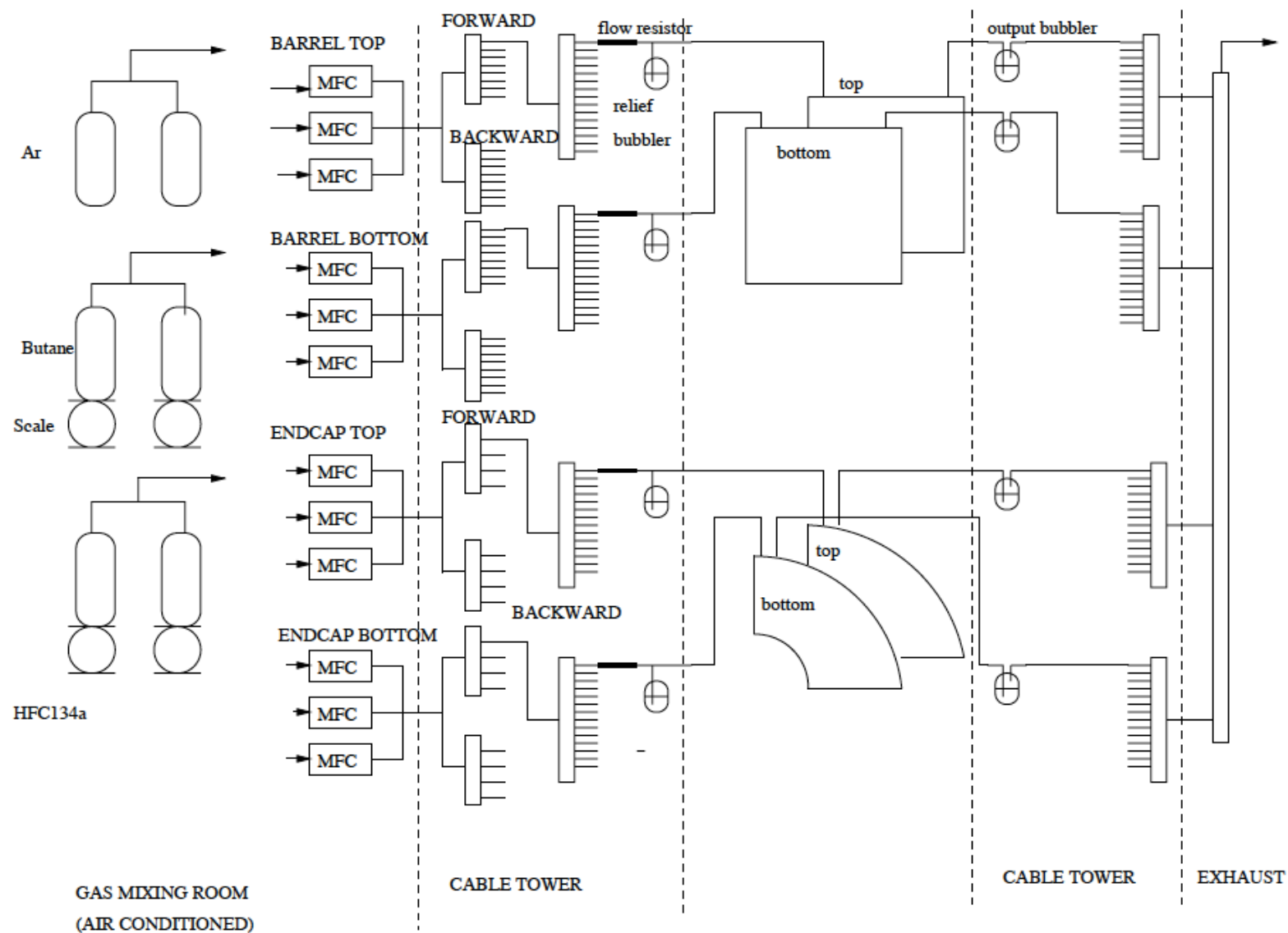
# 3 components of the KLM system

- Gas system (slow control)
  - See next slide

- HV system (slow control)
  - Controls and monitors the HVs for RPCs and scintillators
  - Turns HV off in case of over-current (trips) to protect the hardware

- Data and trigger system (fast read out)
  - Records hits (i.e. sparks in the RPCs and flashes of light in the scintillators) from traversing muons or K-long clusters
  - Hits are being stored for event reconstruction and separately analyzed for quick L0 trigger decisions

FORWARD
BARREL TOP
flow resistor
output bubbler
top
relief
BACKWARD
bubbler
bottom
BARREL BOTTOM
ENDCAP TOP
FORWARD
top
bottom
BACKWARD
ENDCAP BOTTOM

Ar

Butane

Scale

HFC134a

MFC

GAS MIXING ROOM
(AIR CONDITIONED)

CABLE TOWER

CABLE TOWER

EXHAUST

The RPC bubbler problem

- The gas flow to BB1, BB2, BF1 and BB2 RPCs was accidentally interrupted (for a long time) potentially allowing water vapor in BB2 to accumulate

- This was only noticed after the layer efficiency had significantly decreased, and irreversible damage may have been done to those RPCs

- This must not happen again.

Exhaust tank pressure regulator

K. Haruki @ TB meeting 5/20/22

The power cable is disconnected.
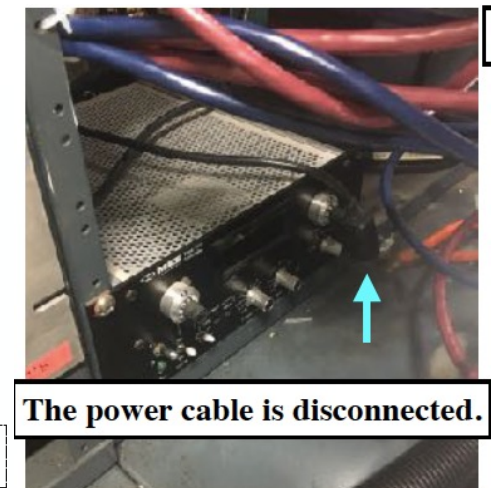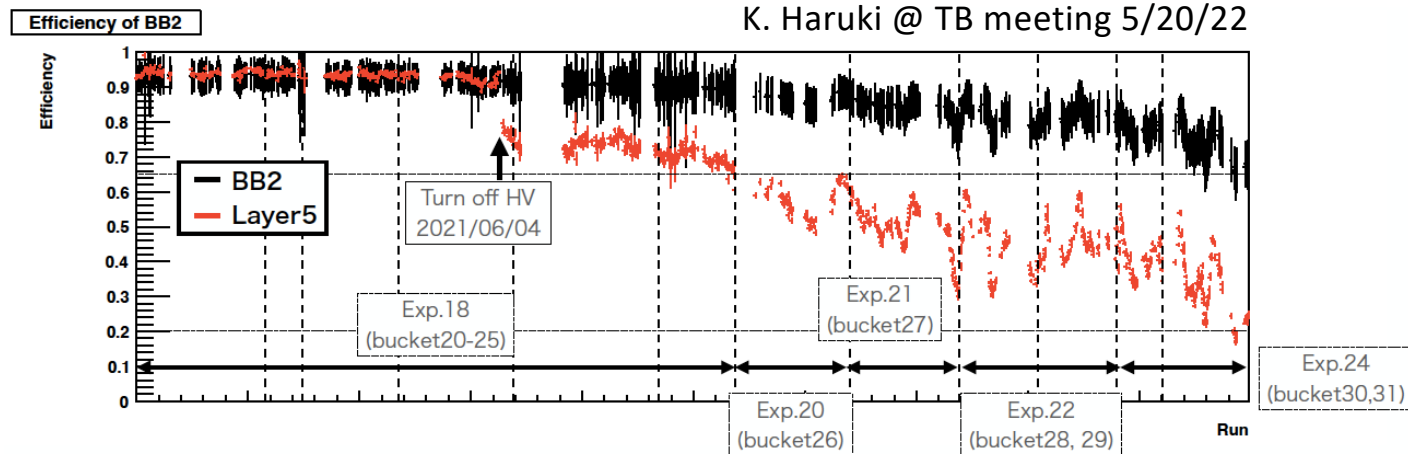
The Fix

- Revive (and maybe extend) the RPC bubbler monitoring readout of the Belle era
  - Bubblers, sensors, and cables to VME crates are still on the detector
  - VME boards do not exist anymore and need to be designed and produced
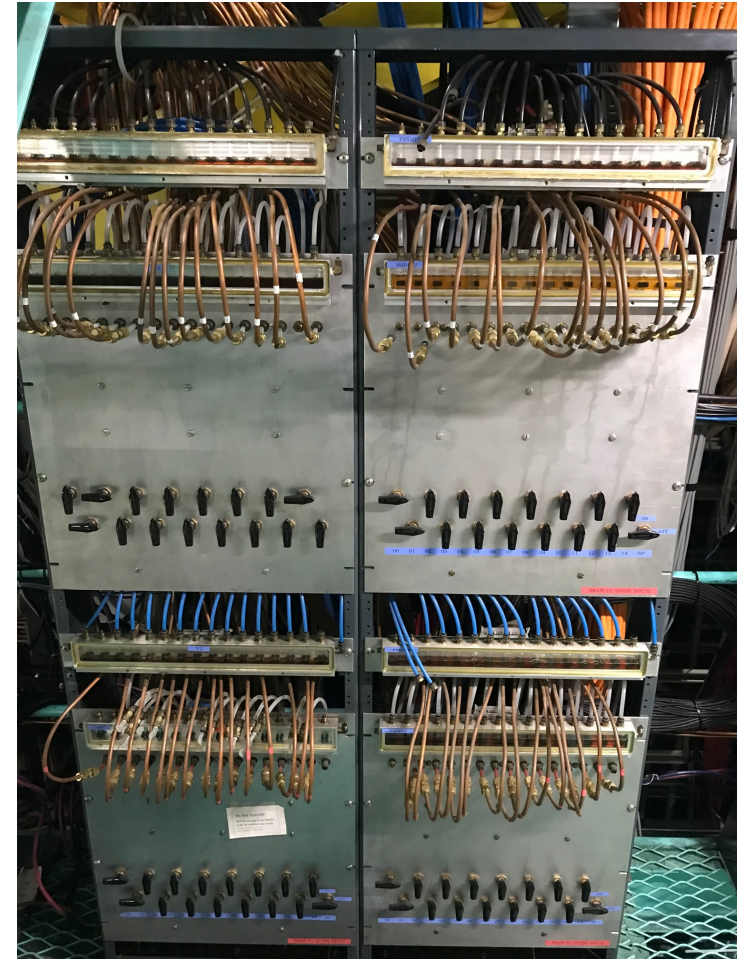 - Interface for slow-control readout needs to be established

RPC bubbler panel for BKLM forward sectors 1 and 2, inlet and outlet, inner and outer RPCs (8 x 13 layers = 104 bubblers); **in total 832 individual RPC bubblers on Belle II**

KLM readout crate for 1 sector/ section (inner + outer RPCs)

Ribbon cables from bubbler sensor circuit to VME r/o board

The bubbler sensor circuit
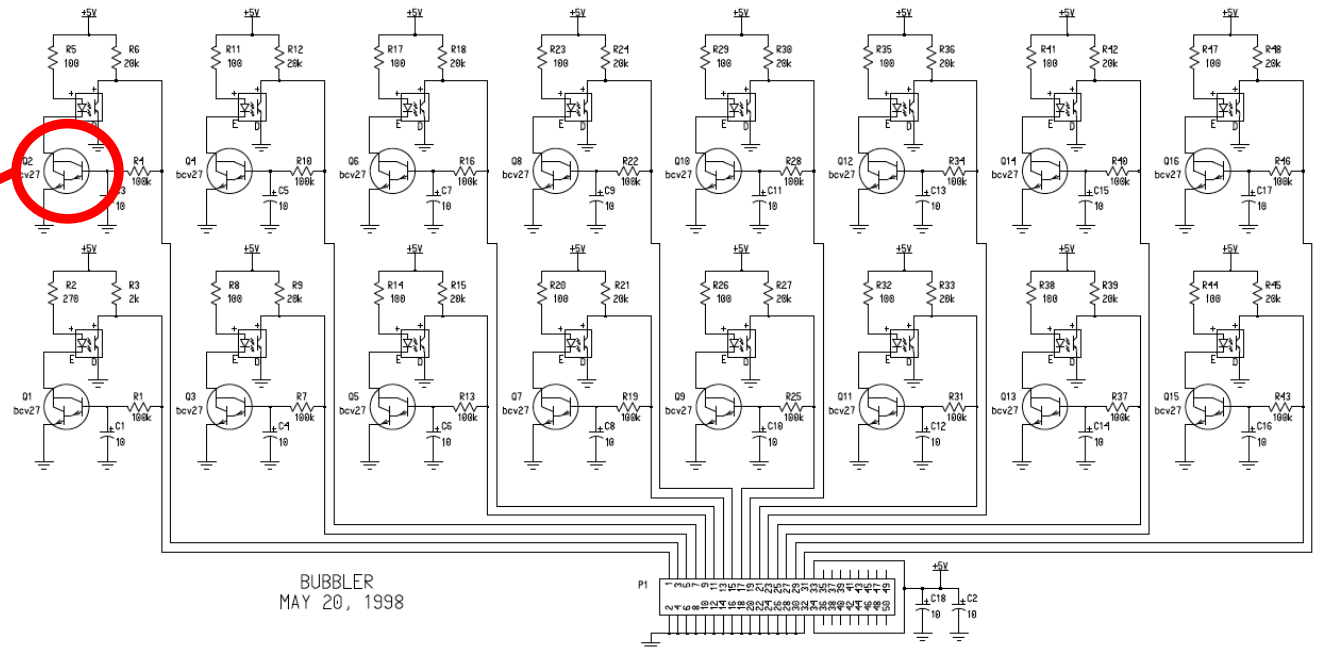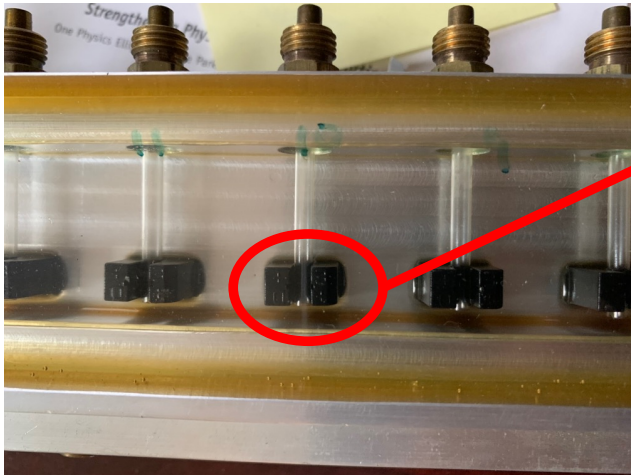
- Each bubbler has an LED + photo sensor gizmo attached, circuit boards are located on the backside of the bubbler panel
- 1 circuit board servers 13 bubblers
- Connector: +5V power, 16 (analog) outputs (only 13 used)

The old VME readout board

- 2 100-pin connectors for 4x16 analog inputs and +5V power

- 4 analog multiplexers

- 1 12-bit ADC

- 1 XC4005PC84 Xilinx FPGA

- One board can serve 4 bubbler sensor circuits, or 52 bubblers

- 16 boards would have been necessary to read out all 832 bubblers

- The board was read out via VME bus; this is not possible in Belle II

BUBBLER READOUT BOARD
Rev 2.1
14 OCTOBER 1998

VME interface
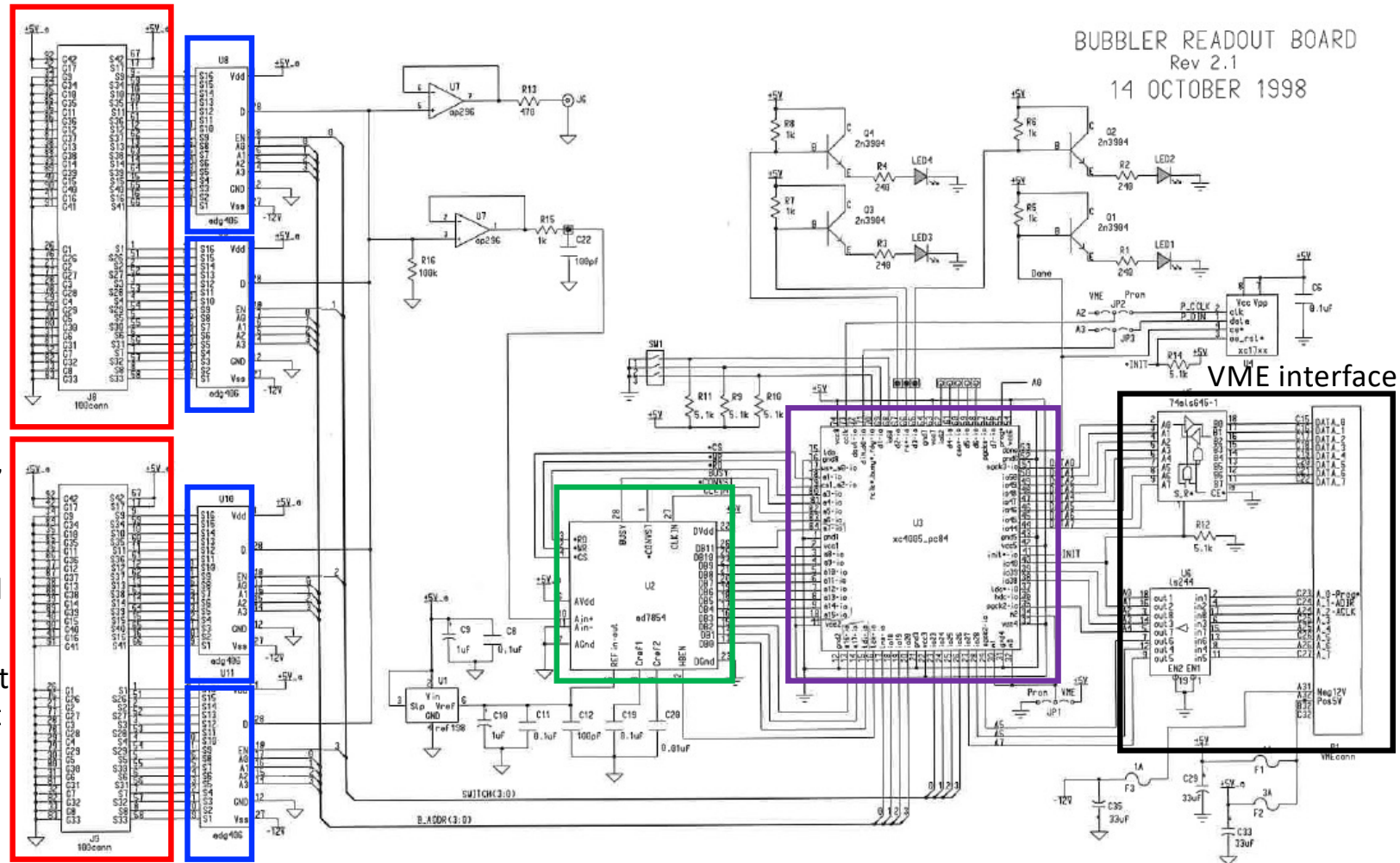
Ideas for the new readout

- Use a single-board computer, instead of an FPGA
  - Will integrate bubble flow into a gas volume flow rate
  - Can be (re)programmed (e.g. in C), no need for firmware experience
  - Communicate with backend via built-in Ethernet
  - Could even have the ADCs on board

Courtesy D. Biswas

- Backend for shifter monitoring and archival can be similar to RPC gas supply monitoring system
  - Monitoring software needs to be developed and/or adapted
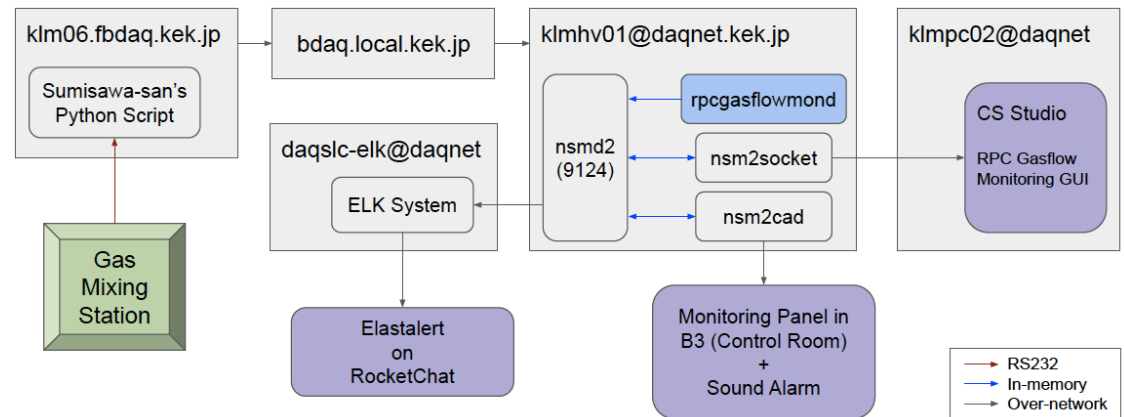
Development and testing at ISU

- Lab space that was previously used for ATLAS Inner Tracker upgrade QC development
  - Has dry air and nitrogen blow-off lines with pressure regulators installed
- Readout PC and test equipment (gas flow meter, pulse generator, scope, etc.) are available
- VPI has shipped a spare RPC bubbler panel to ISU
  - Develop bubble recognition and rate flow calibration (bubbles come in burst)

Courtesy L. Piilonen
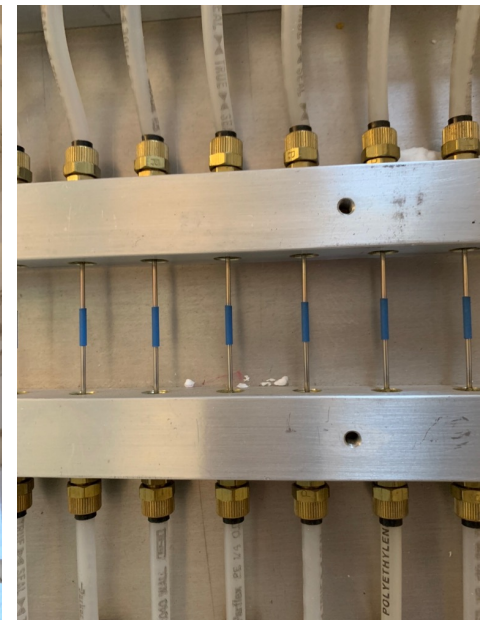
Timeline (rough – to be revised)

- 06-07/22   Measure output signals for all bubblers on Belle II
- 06-10/22   Commission bubbler panel in lab and measure output signal
- 06-10/22   Develop board and built 1st prototype
- 07/22-03/23 Develop SBC software (first with standalone SBC, then with prototype board when available)
- 07/22-03/23 Develop monitoring and archival software and interface to SBC
- 10-11/22   Test 1st prototype & ship 1 board to KEK for testing
- 12/22-02/23 Built 2nd prototype (if necessary)
- 03-04/23   Test 2nd prototype (if necessary) & ship 1 board to KEK for testing
- 05-06/23   Produce boards and ship to KEK
- 07-08/23   Install boards on Belle II and commission with backend

AOB

- Bubbler panel with readout circuit arrived at ISU from VPI on Tuesday
- Checked of bubbler sensors for F1, B1, F2, B2 yesterday
  - not all bubbler panels have sensor circuits and/or ribbon cables attached
  - Ribbon cable measurements: checked that B2 cables are ok, unfortunately F1 are cables are missing !
- Received an old readout board yesterday
- Mailing list requested (isu-klm@iastate.edu)
- Collaboration
  - Duke University (potentially 2 grad students)