Upgrade of RF Control system at SPring-8

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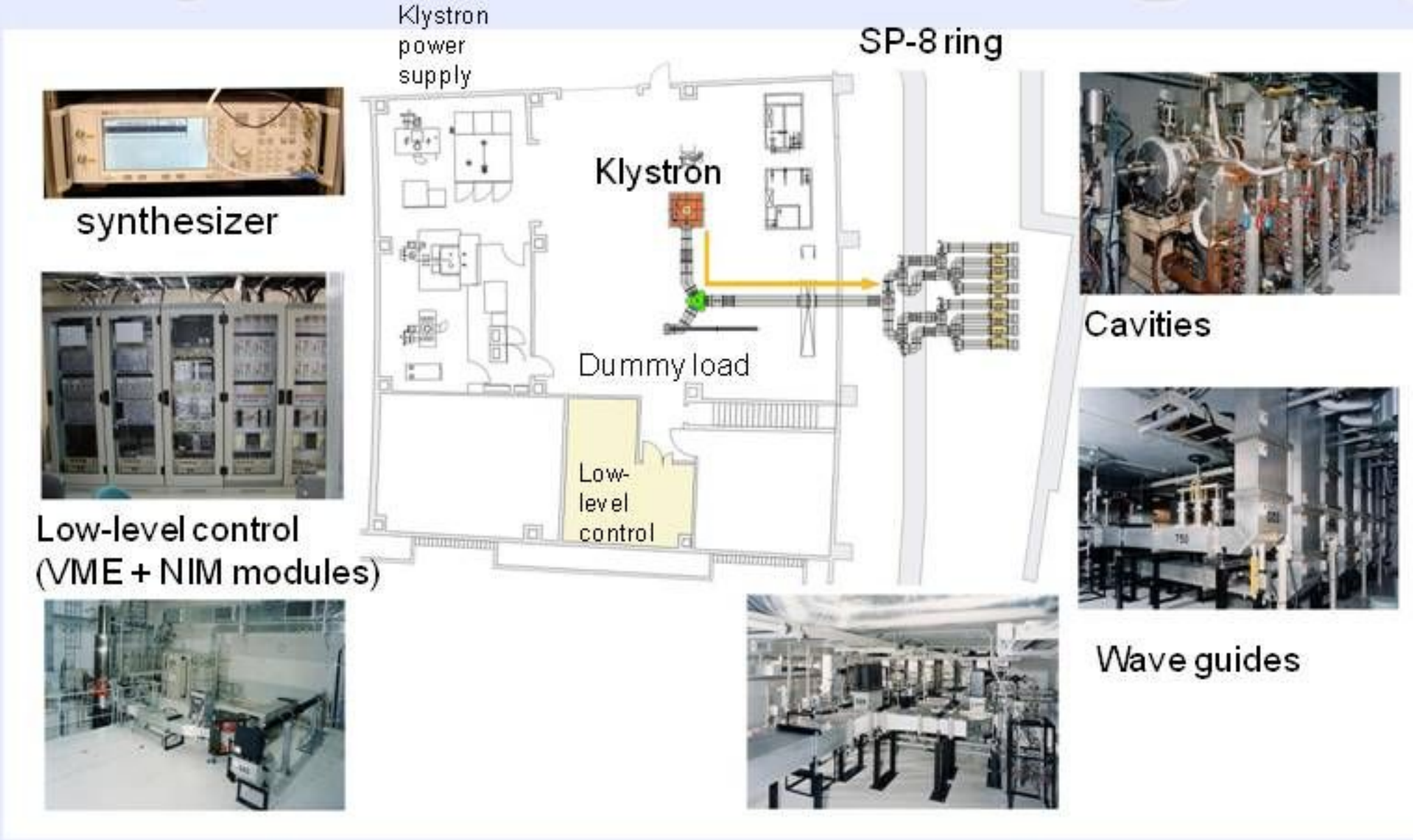
Outline

- RF Control system at SPring-8
- Faced problems
- Replacement of manufacturing discontinued I/O boards
- Approach and some examples will be shown

RF system at SP-8 storage ring



- There are 4 RF stations (A, B, C, D) along the ring
- Control klystron, cavities, low-level equipments

RF control system

- Large numbers of signals to control klystron, cavities, low-level system
- Controlled by VME system
- MADOCA control framework

#Signals for each RF station

Type	#Signals
AI	~170
DI	~150
DO	~60
PTG	~30
GPIB	~170

- **PTG (Pulse Train Generator) board**
  - Used to control analog output voltage for low-level control (tuner control etc.)
- **GPIB control**
  - Control of RF cavities
    - flow and temperature of cooling water, vacuum

Faced problems

AI: AVME9325 (Acromag Inc.)
PTG: MP0351 (Micro Craft Inc.)

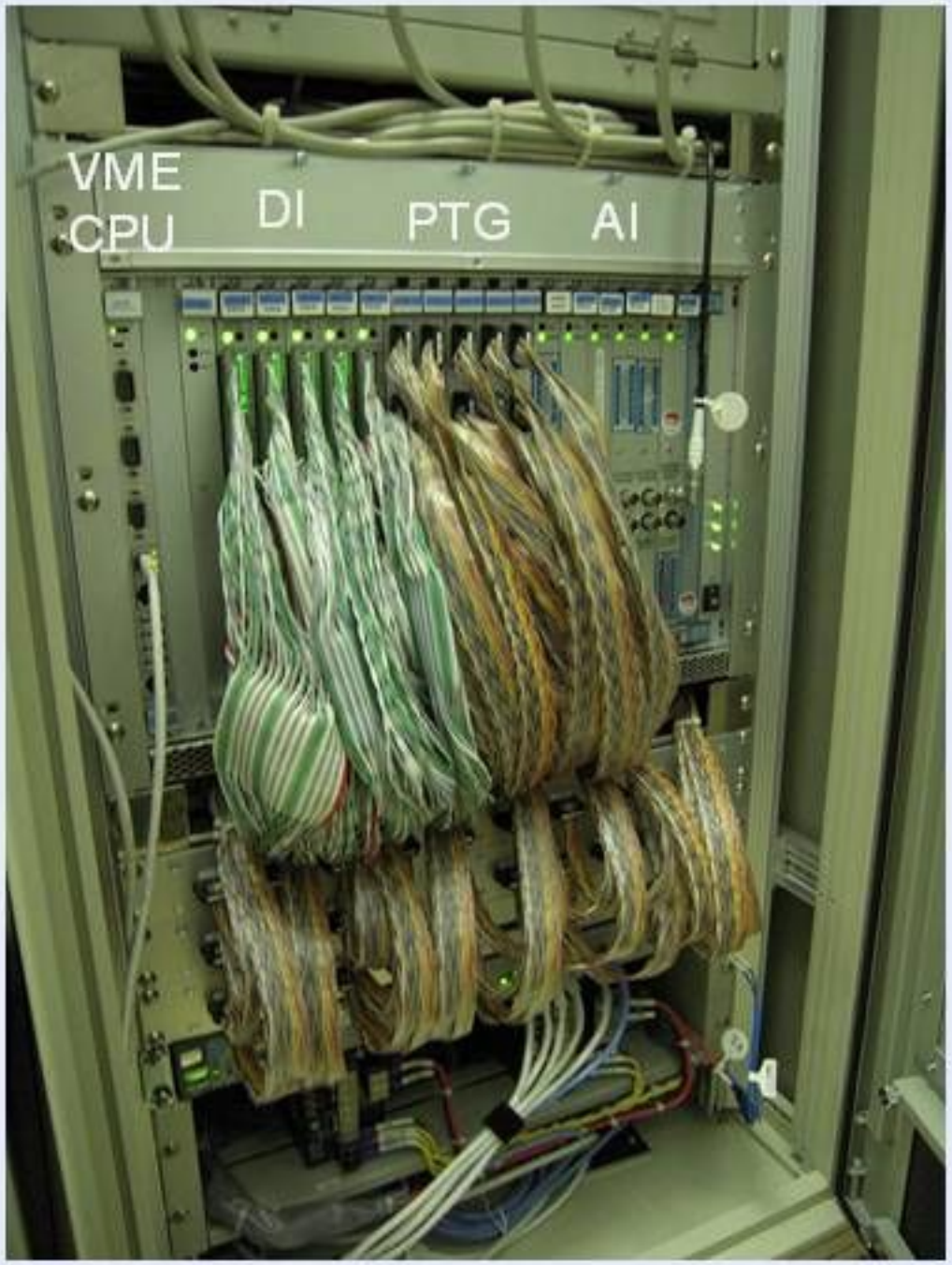
Two problems in the RF control system

- Manufacturing discontinuances in used VME I/O boards
  - VME I/O boards were implemented at the early stage of the construction (more than 10 years ago)
  - Need replacement to maintain the control system for a long time.
- Instabilities in GPIB control system*
  - For RF cavity, ~ 60 / 170 signals had RS-422 interface and controlled by GPIB with converters.
  - Communication errors occured in this complex part.

Showing how the replacement of I/O boards can be performed in SP-8 RF system

* Solved by introducing small embedded computer (Ref. Backup slide)

VME I/O boards



The replacement of VME I/O boards was difficult due to:

- Large number of signals, IO boards
- Restricted time
  - The replacement should be performed during short shutdown period of acc. operation

Approach to the replacement

- Introduction of commercial I/O boards

  Pros
  - We can select convinient boards from the market, with lower cost.

  Cons
  - Need cost, time to adjust peripheral environment (cabling, software etc.)

- Development of compatible I/O boards

  Pros
  - Smooth replacement of the I/O boards

  Cons
  - Need cost for the development

- We developed new I/O boards to facilitate the replacement.
- To reduce the cost, we aimed to unify used I/O boards at the same time.

Development of New I/O boards

- Same cabling scheme
  - A lot of cable are already wired in our VME rack.
  - We don't want to touch these as much as possible.
- Similar functions
  - We want to use new boards as same manner in the old one.
- Improvements, if possible
  - New technologies on hand can be utilized for better resolution, higher signal density etc.

Development of AI board (1)

Developed for replacement of two AI boards

- AVME9325 (Acromag Inc.)
  → SP-8 RF control
- VMIVME-3122 (VMIC Inc.)
  → SP-8 beam line control

AI (Compatible parts)

- Same signal cabling inputs
- Similar functions
  - Programmable input ranges
  - Data acquisition modes
  - Trigger modes
  - DRAM for data sampling

VME front-side

Compatible to VMIVME-3122

64 (64) ch Differential (single-ended)

VME bus-P2 side

Compatible to AVME9325

16 (32) ch Differential (single-ended)

Developed AI board, Advme2618 (Advanet Inc.)

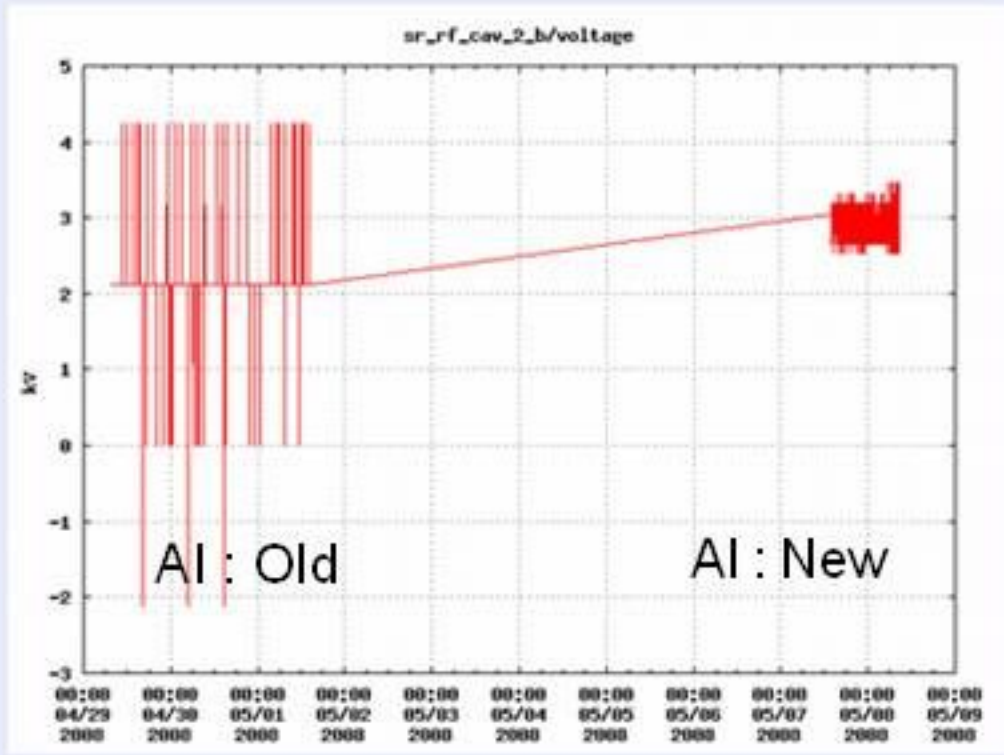
Development of AI board (2)

AI (Improved parts)

- Higher signal density
  - For AVME9325, signal density was increased by changing input from VME-bus P2 to VME-front side.
    - Conversion card was prepared for this.
    - Number of boards → reduced to ~1/2
- Higher A/D resolution
  - 12 bit → 16 bit

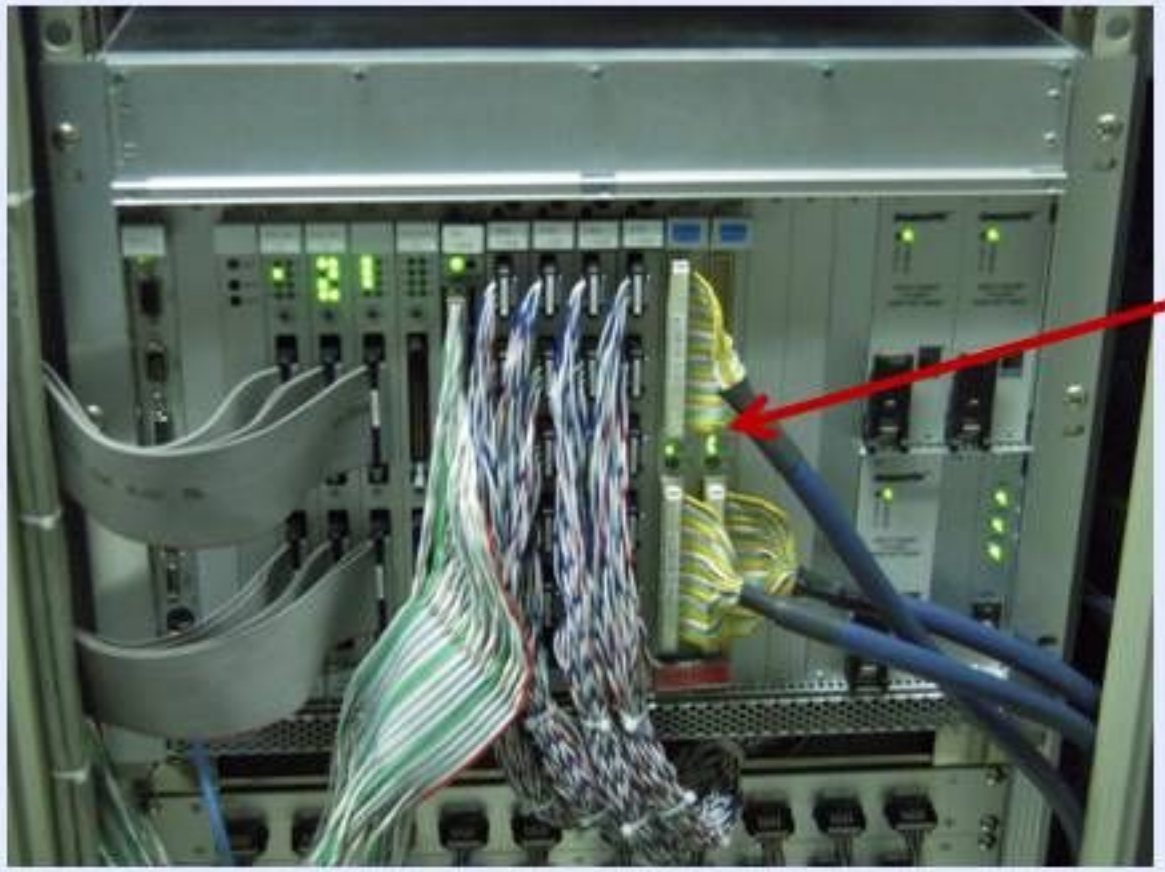
Replacement of AI boards (1)

- In all, 43 AI boards were successfully replaced
  - Smoothly replaced in summer and winter shut down period last year without problems.
  - Required time is ~ 3 days with 1 person.
  - New AI boards are working fine as expected.
- We also had additional improvements at the same time
  - Better A/D resolution



Replacement of AI boards (2)

- For RF station A, #boards reduced : 10 → 6
  by increasing signal channel density
  → Will be applied for other RF stations in near future



Development of PTG board

- Function of PTG is simple
  - CW/CCW pulses from PTG just increase/decrease the analog voltage

→ We chose logic-reconfigurable VME, Axvme4900 for New PTG

* Several applications at SPring-8
(PID feedback system, Beam shutter control etc.)

See TUP061

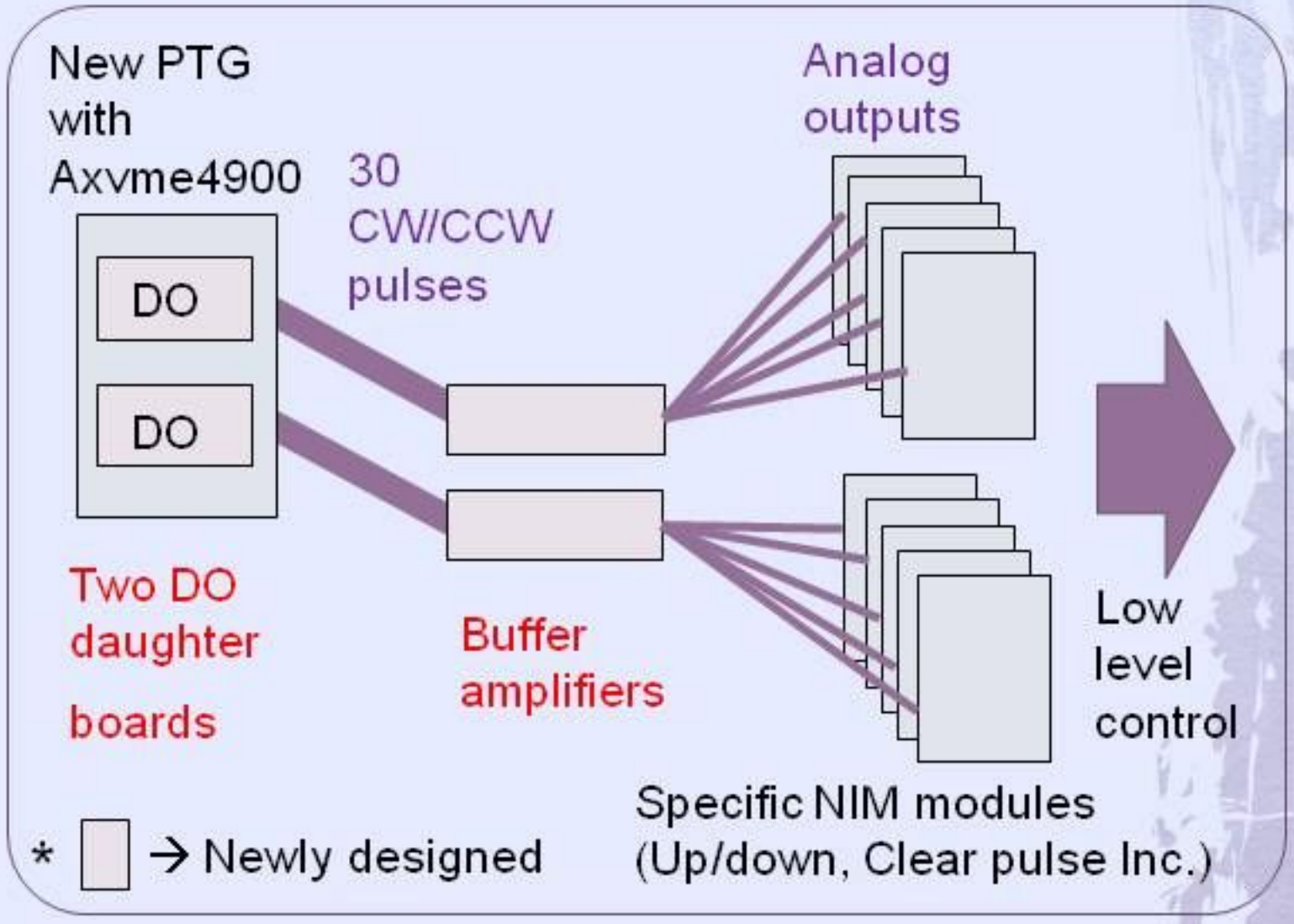
- Selectable daughter boards
  → Flexible I/O for each purpose
- Logic can be flexibly programmed with FPGA on the board

Can be applied to New PTG

Axvme4900 (ARKUS Inc.)

New PTG design

- We designed DO daughter boards, and buffer amplifiers
  → Easier hardware development, using existing Axvme4900
- Same cabling scheme can be applied
  after buffer amplifiers
  → Possible for smooth replacement
- Higher channel density
  5 CW/CCW pulses for 1 PTG board (Now)
  → 30 CW/CCW pulses (New)
  → #PTG/RF station can be reduced from 6 (Now) to 1(New)



Summary

- The replacement of manufacturing discontinued I/O boards was needed to maintain SP-8 RF control system for long time period.
- The replacement of the boards was not so easy due to:
  - Large number of signals, I/O boards
  - Restricted time during short shutdown period
- To facilitate the replacement, it was effective to develop new boards, having compatibilities.
  - ~40 AI boards were smoothly replaced with new boards.
  - Additional improvements were possible at the same time. (Higher signal densities, better A/D resolution)
- It was possible to unify several I/O boards at the same time.
- PTG boards will be replaced in the same manner.

Backup

Replacement of GPIB control system

- Data taking on RF cavities for long time, was impossible due to communication errors on GPIB control.
  - RS-232C control had been done with GPIB-VME boards with conversion boards.
  - Troubled due to bad compatibility between RS-232C-GPIB converter and GPIB-VME.
- For RS-232C, we chose small embedded computer, Armadillo-220.
  - Compact, Running Linux OS, Reliable, Powered by PoE
  - Control system by embedding MADOCA is also possible.
  - Several applications at SPring-8 (Linac modulator PLC control, voice talker system etc.)
- Replaced with Armadillo-220 last year. Stably operated so far.