RHIC Permit System

- ✓ further development of FERMILAB.
- ✓ VME platform (running *VxWorks* OS) using a module called "PERMIT module" able to break 3 loops operating with 10 MHz signals:
  - Permit loop (common for the 2 beams),
  - Quench loop for the yellow ring and Quench loop for the blue ring.
- ✓ modules linked by optical fibre:
  - multimode (1300 nm) fibres are used only in single mode.
  - where high beam losses are expected an "easier" replacement (splice) of the fibre is planned in case of degradation.
  - so far, no problems with fibres were experienced.
  - Conversions light-to-current & current-to-light in a separate 3U crate.
- ✓ 35 modules installed in 27 different buildings:

  6 insertions and 18 alcoves (3 per sextant) plus others...

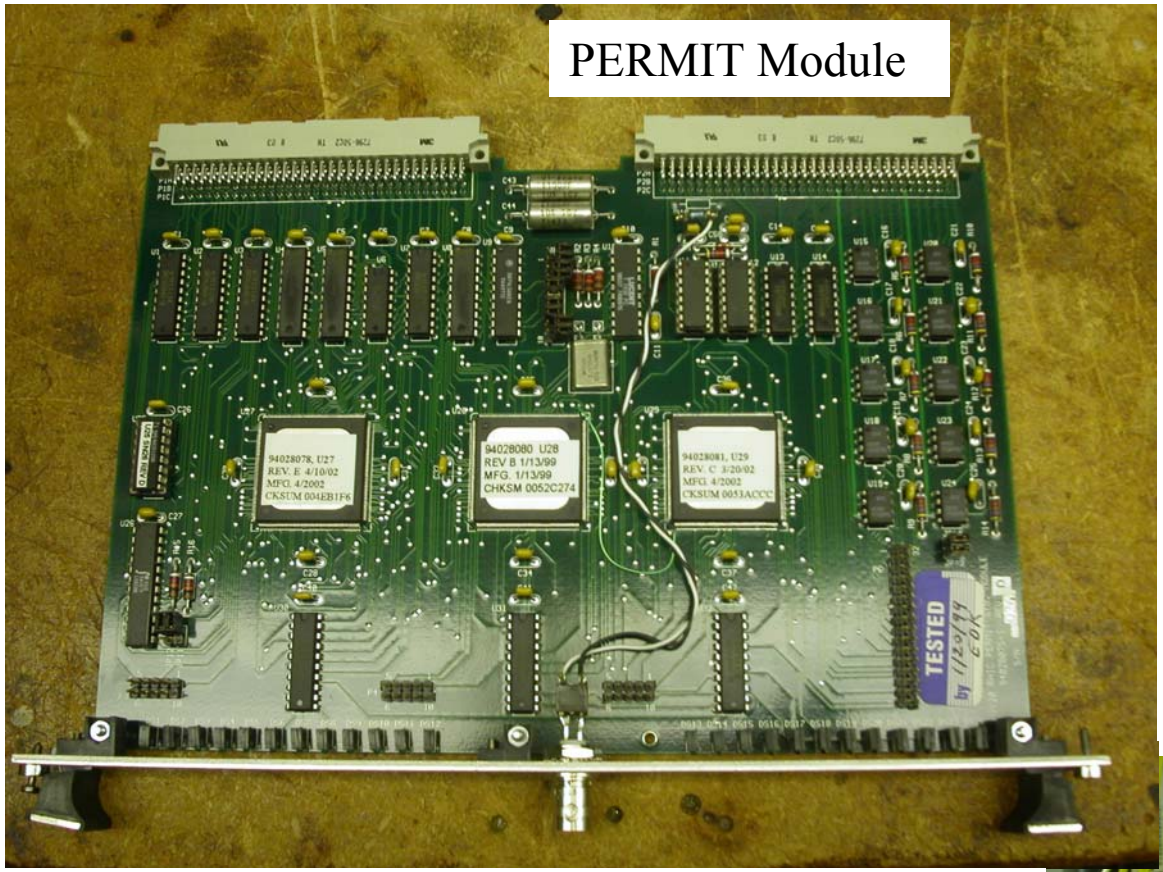
RHIC Permit System: the Permit module (1/2)

- ✓ module is using 3 *ALTERA* FPGAs to:
  - manage the inputs and to set the appropriate masks,
  - process the time stamps using internal 32-bit counters,
  - dialog with the VME-bus master.
- ✓ "classic" TTL 50ohms as input signal and 20/30 mA to activate the internal opto-couplers:
  - After ~ 3 years of operation, no opto degradation has been observed
  - galvanic insulation, and good immunity from noise.
  - failsafe if the cable is off or if the current source is down
- ✓ Each module has only 8 inputs

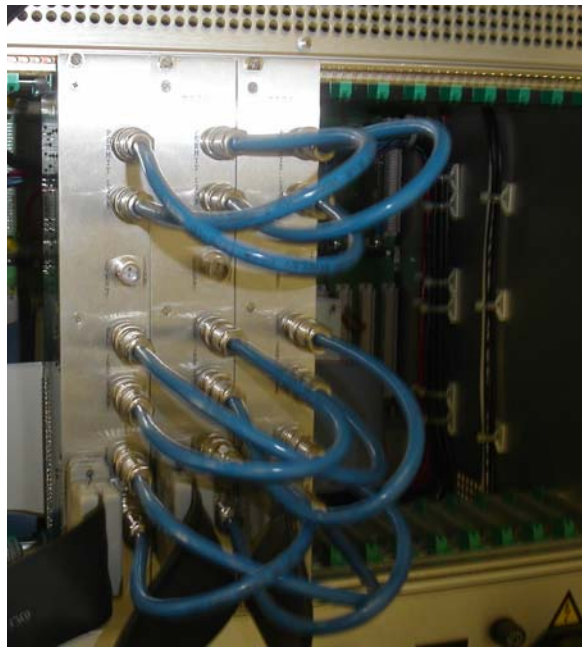
  (6 for the Permit loop, 1 for Quench Yellow and 1 for Quench Blue).
- ✓ The response time inside a module is some 10 ns.

RHIC Permit System: the Permit module (2/2)

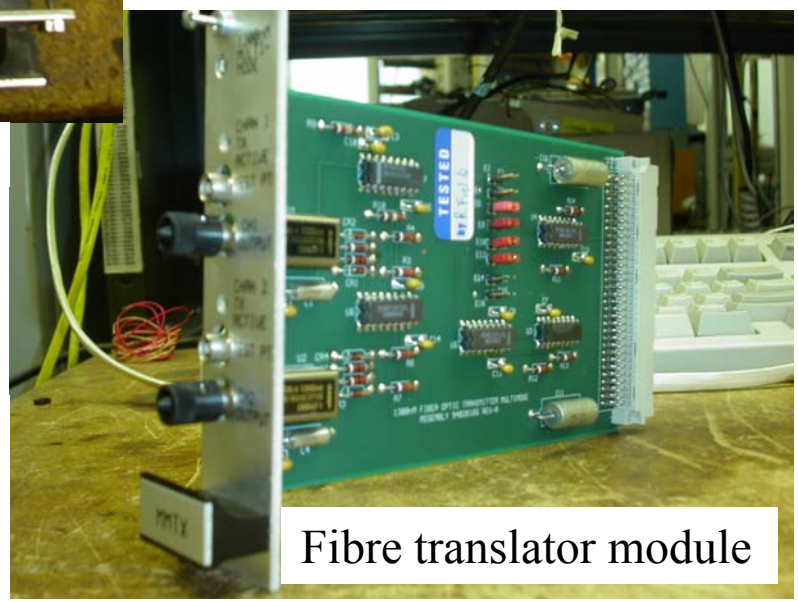
- ✓ "Local" output to indicate if the Permit Loop is closed or open.
  - "TTL 50 ohms signal"
  - used to cascade the different Interlock systems from the RHIC to its transfer lines and its injector: (RHIC -> Arcs -> uvw -> AGS).
- ✓ When Slave breaks the loop, it generates an Interrupt to the VME-bus master to activate an ALARM process.



Interface module (back of VME crate)



Patch-Panel for Permit Inputs & local Outputs



Fibre translator module

RHIC Permit System: Initialisation

- ✓ There is one Beam Permit module defined by an on-board jumper to be the MASTER, the other ones are SLAVES.
- ✓ At the reception of a "dedicated event" (through the *Event-Link* input):
  - generated by an operator by pushing a "button" linked with the Event-Link Generator system.
  - Slaves reset theirs inputs' latches, and clear time stamping information.
  - If all enabled inputs activated => Slave lets carrier pass to the next one.
  - MASTER has initialised the loop by sending the 10 MHz carrier
  - MASTER waits for a certain time to get back this information
- ✓ Expected time for one loop is ~43 μs

  (i.e. Master sends, Slaves listen and respond one after the others, and the Master gets back the carrier)

RHIC Permit System: the Timing(s)

- ✓ Three different Timing links:
  - ✓ Event-Link system
  - ✓ Beam Sync Links (one for each collider ring)
  - ✓ Real Time Data Link system (RTDL)
- ✓ Event-Link system (~ identical to the CERN **G**eneral **M**achine **T**iming)
  - 8-bit frame @10Mhz, Manchester encoded
  - general purpose periodic events: 720Hz, 60Hz, 10Hz, 1Hz, 0.25Hz
  - this dedicated Event (every 4 seconds) synchronizes the Permit modules
  - dedicated Events to initialise the Permit & Quench loops
  - dedicated Events to enable or to disable Masks
- ✓ Real Time Data Link system:
  - broadcasts various information on every REL 720Hz event
  - Machine parameters, Magnet current, …
  - UNIX time, the number of 720 ticks,…

RHIC Permit System: the DUMP module

- A “special module” is inserted in the loop.
- This module detects the carrier loss and generates a signal (“TTL type” again) for the control of the beam dump kickers.
- Counts 10 periods (of 10 MHz) before firing the Dump.

  (parameter is hard coded in one of the ALTERA chips)
- has a ”Beam Synchronous” input to be synchronised with the Beam Abort gap.
- Time stamping is done with the *Event Link* of 10 MHz.
- In addition, the module provokes the generation of an “Abort Event” used to activate the Post-Mortem procedure.
- For redundancy, two modules are connected to the control of the beam dump kickers => in total 4 are installed for the 2 beams.

RHIC Permit System: Supervision

- ✓ The VME system is seen from the controls system as ADO (Accelerator Device Object).
- ✓ On the screen, an operator sees the status of every module:
  - Current state of the inputs,
  - ENB/DIS states
  - Mask/Unmask states
  - Time stamp of the last trigger.
- ✓ Supervision software in the Control Room must disable inputs that are not used in order to avoid permanent fault conditions.
- ✓ Authorization signature is needed to change the ENB/DIS state and the masks
- ✓ During injection, a Loss monitor (near injection Kicker) may be masked for a short-time (if losses may exceed the normal operating threshold)

RHIC Permit System: Reliability

- The modules are operating all year long, 24 hours/day.
- One module had to be replaced in three years.
- MTBF is in the order of 500000 hours.
- VME power supply an MTBF of about 100000 hours is quoted.
- In case of a broken power supply, the VME chassis had to be changed. (new chassis with power supplies that can be unplugged are introduced)
- VME chassis can be remotely restarted
  (development by BNL, now commercially available).
- All beam loss monitors (400 for RHIC) are used for the beam interlock system. The thresholds are driven by events. The electronics for eight monitors is installed on-board. The VME crates are connected via Ethernet.
- SNS uses the same interlock system, but with many more inputs.