The present situation of DAQ in the RIKEN radioactive isotope beam line RIPS

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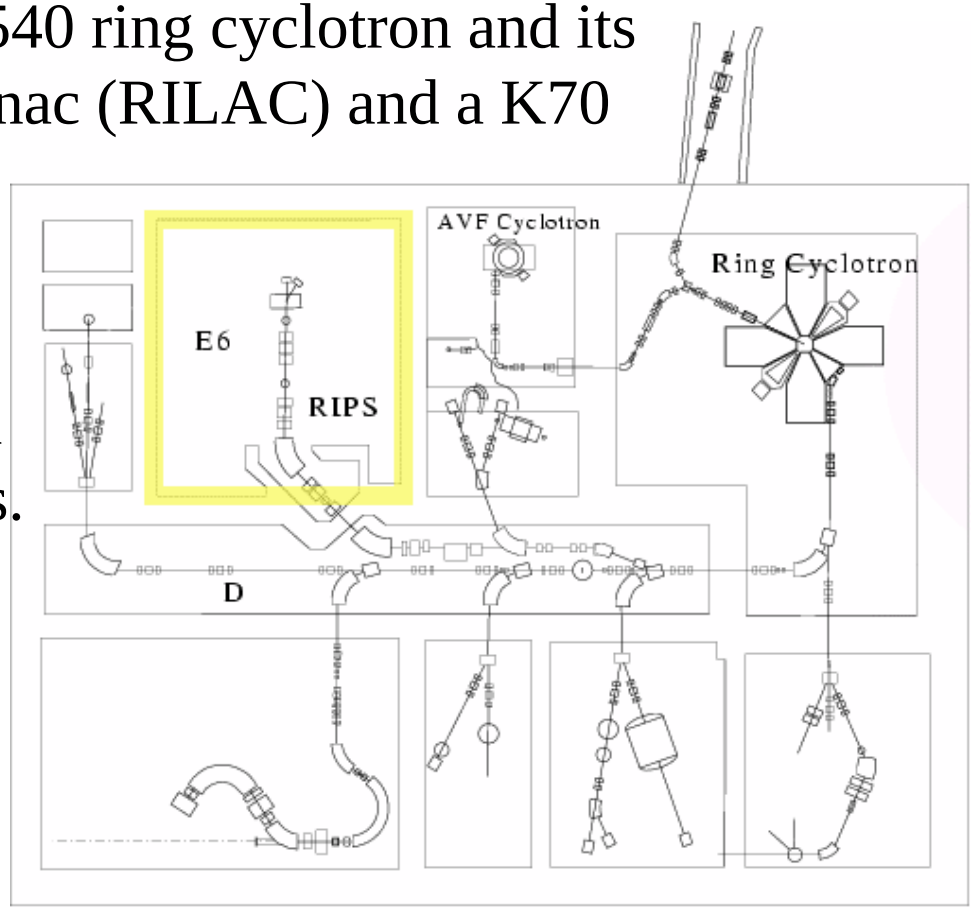
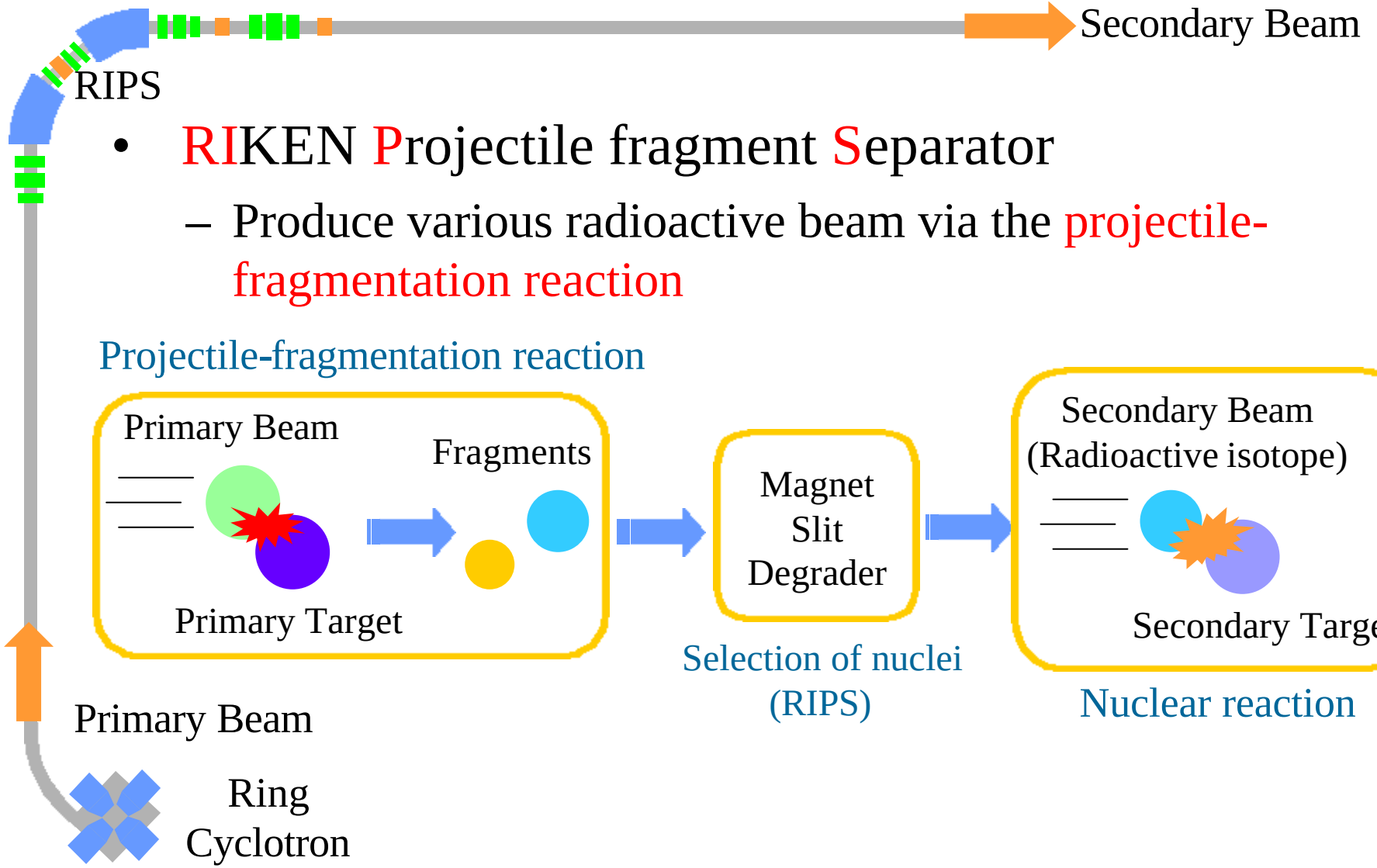
RIKEN Accelerator Research Facility (RARF)

- The RIKEN heavy-ion accelerator facility consists of a main accelerator of a K540 ring cyclotron and its injectors of a heavy-ion linac (RILAC) and a K70 AVF cyclotron.
- This system provides various beams from protons to bismuth ions in the wide range of energies.
- The RIPS is one of the course in the RARF.

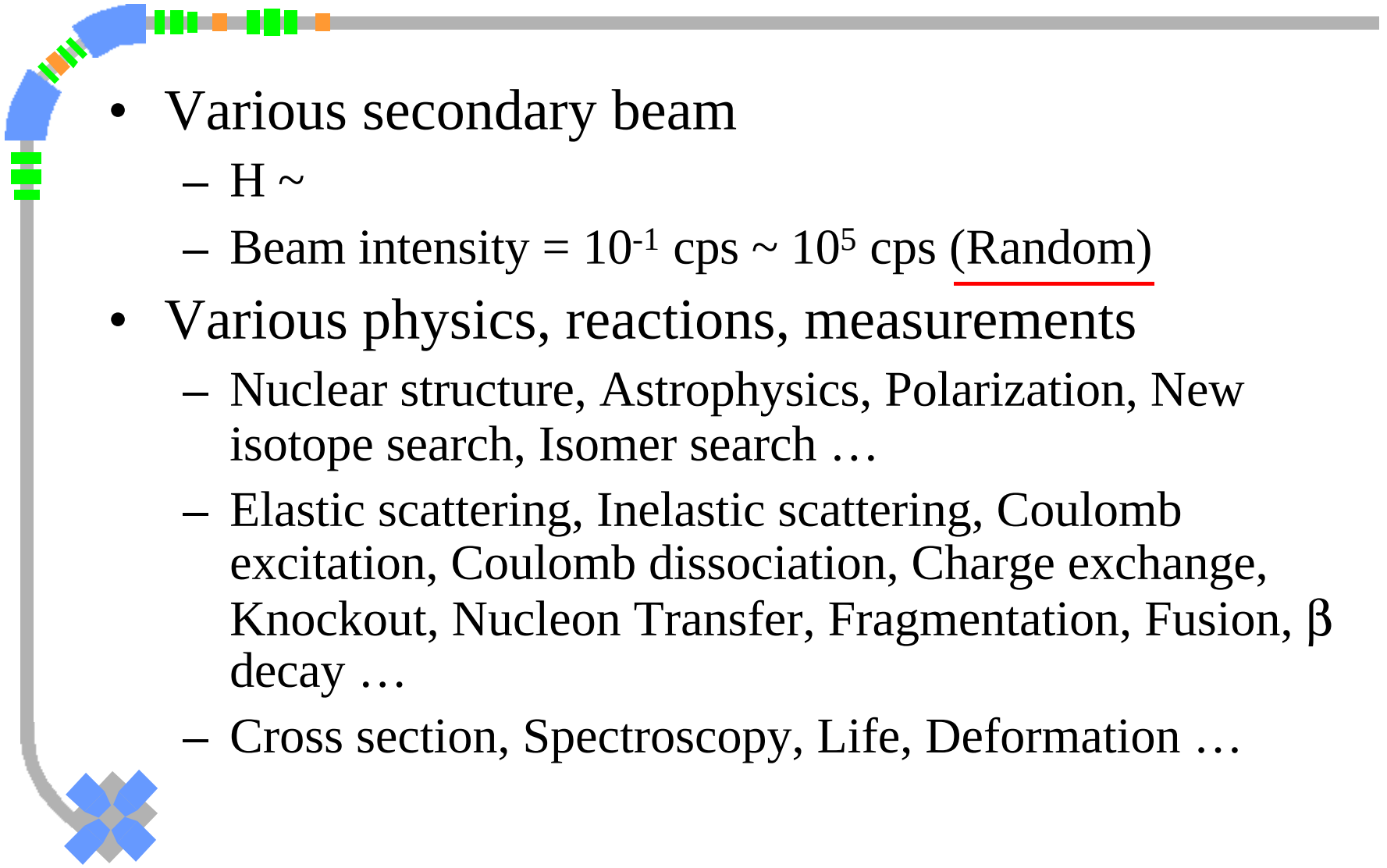


Brief introduction for the RIPS



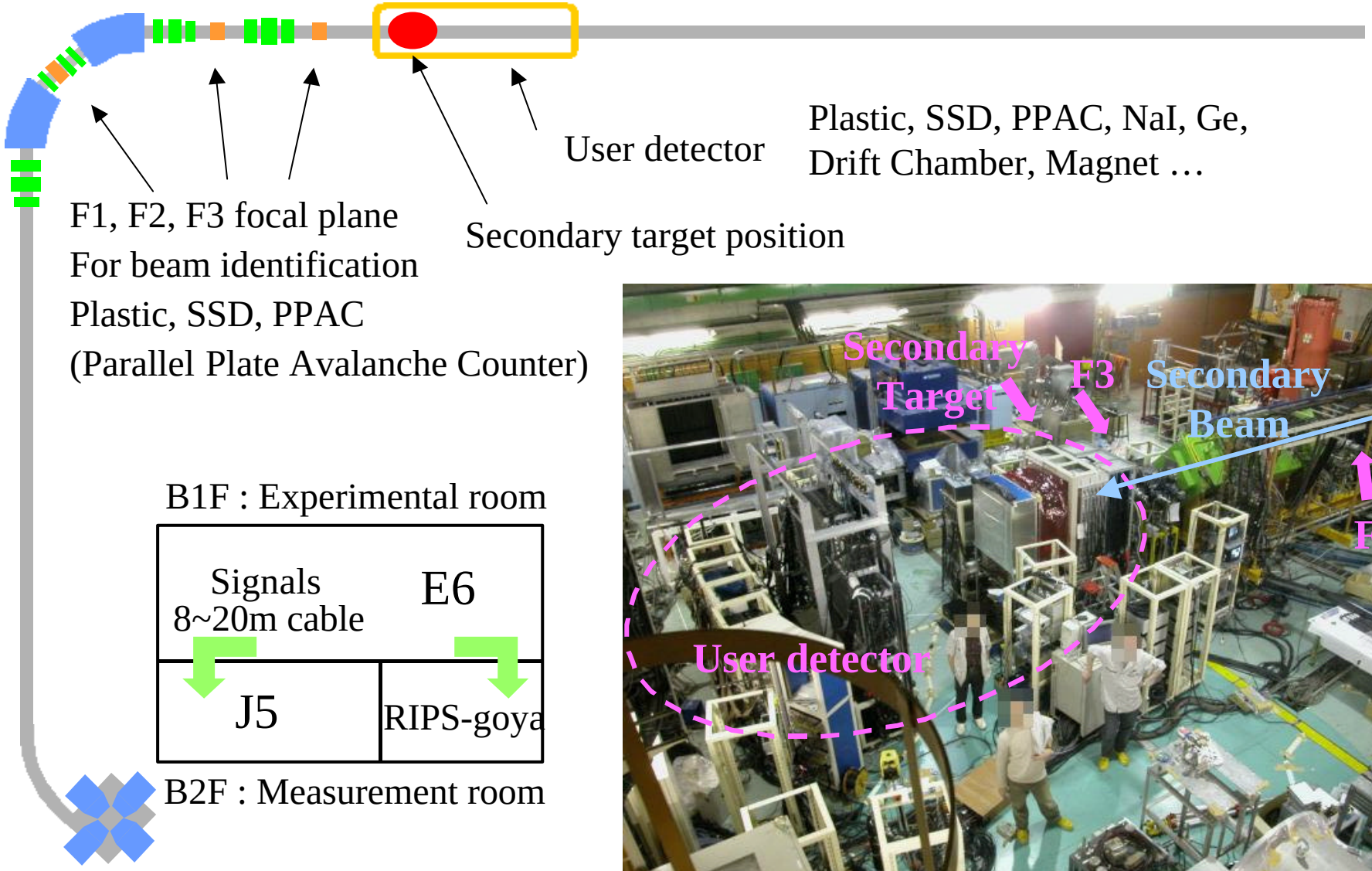
- RIKEN Projectile fragment Separator
  - Produce various radioactive beam via the projectile-fragmentation reaction

Experiments at the RIPS



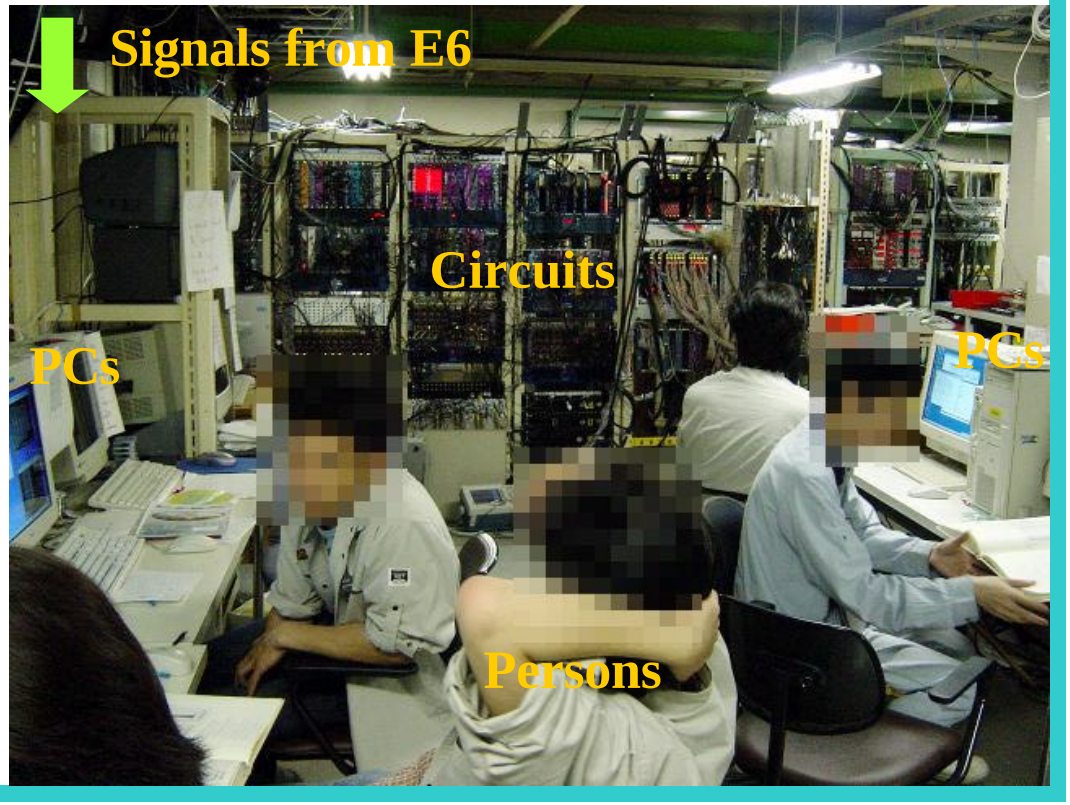
- Various secondary beam
  - H ~
  - Beam intensity = 10^{-1} cps ~ 10^{5} cps (Random)
- Various physics, reactions, measurements
  - Nuclear structure, Astrophysics, Polarization, New isotope search, Isomer search …
  - Elastic scattering, Inelastic scattering, Coulomb excitation, Coulomb dissociation, Charge exchange, Knockout, Nucleon Transfer, Fragmentation, Fusion, β decay …
  - Cross section, Spectroscopy, Life, Deformation …

Experimental room (E6)



Measurement room (J5)

- Data acquisition
  - Circuits (NIM, CAMAC and VME)
    - Pulse shaping, Coincidence, Trigger, ADCs …
  - PCs
- On-line analysis

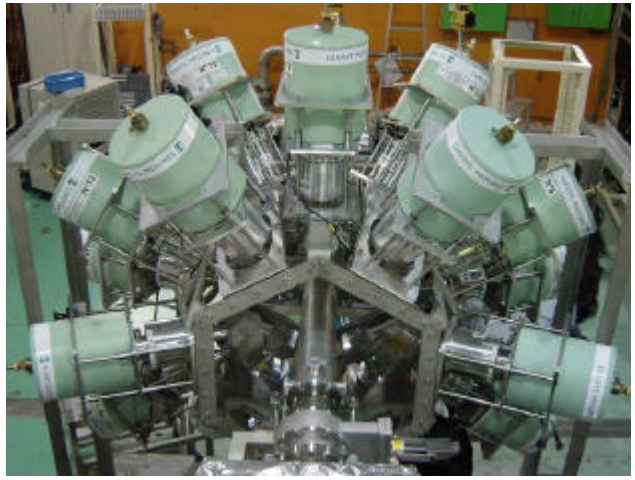


Condition of DAQ in the RIPS

- Typically, 1 week for preparation and 1 week for machine time
- Many experimental groups
  - Every group uses different DAQ system
    - VAX, Alpha, PC (Linux), PC98
    - CAMAC with ACC, PCI-CAMAC, PCI-VME …
  - Have to construct DAQ system within few days
  - Have to clean up DAQ system within few days after machine time
- In case of using large detector arrays, we have to connect more than few thousand of cables.
  - Number of signal is increasing year by year.

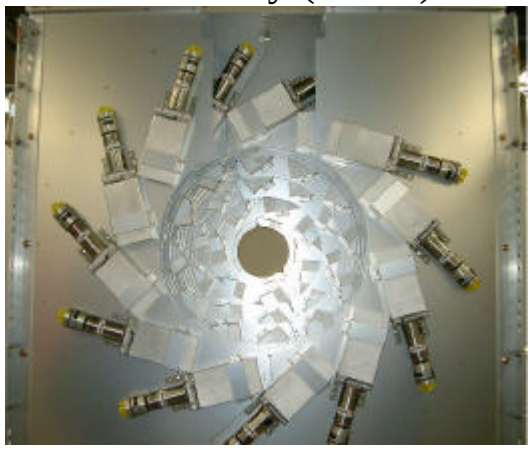
Detector arrays in recent years

Ge Array (720ch)

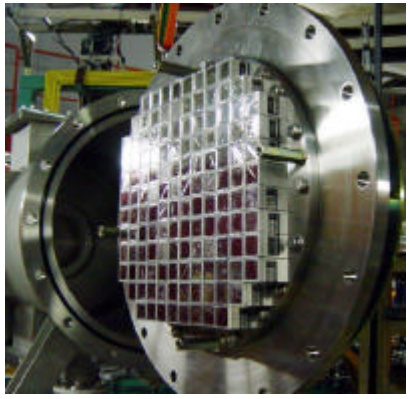


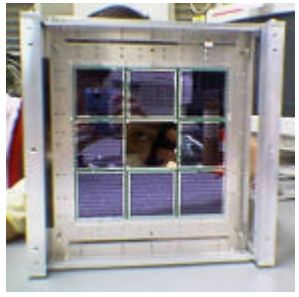
Neutron wall (~500ch)

NaI Array (320ch)



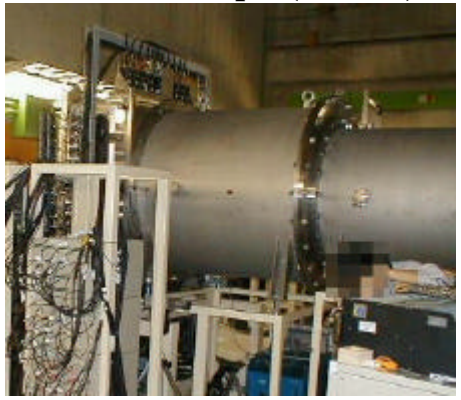
NaI Wall(264ch)





Stripped SSD
(120 → 300?ch)

HODO Scope (168ch)



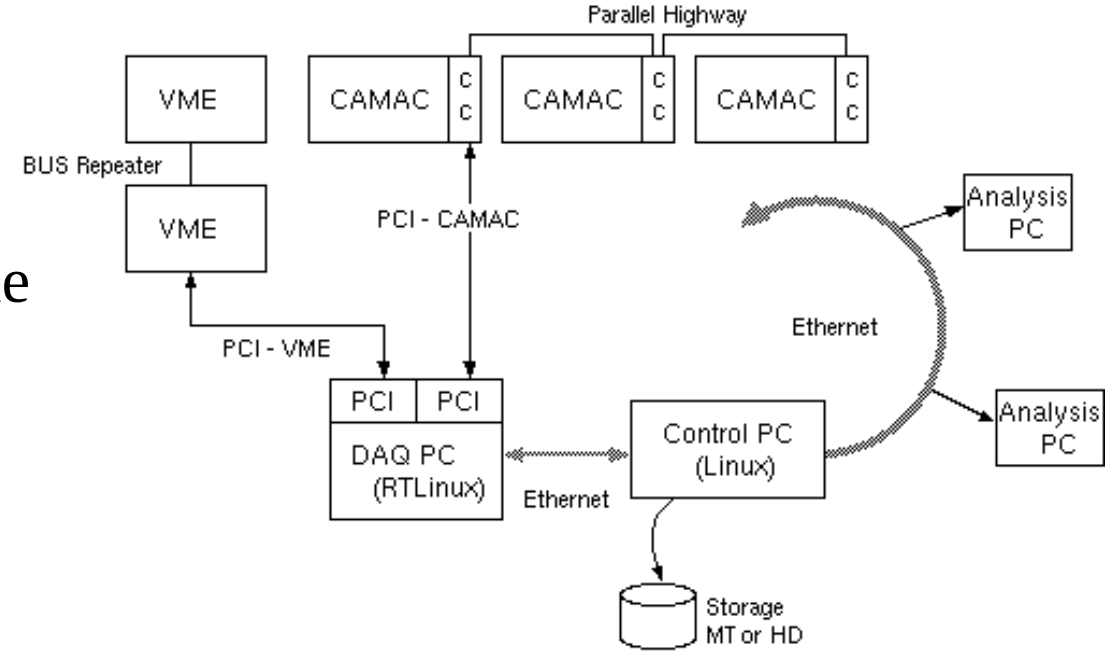
CsI ball (320ch?)

DAQ concept in the RIPS

- Trigger rate = 10 cps ~ 5 kcps (Random)
  - Simple trigger (Trigger is generated by NIM, CAMAC, and VME circuits.)
- 1 event size = 50 ~ 200 words
- Use NIM, CAMAC and VME modules
  - Started using VME modules 2002~
- Channel number = 10 ~ 1000
  - To deal with large number of channel in ADCs
    - Use Zero / Overflow Suppression mode in ADCs
    - Use LeCroy FERA with memory module (Out of production)
    - Use CAEN VME modules (V775, V785, V792, V767)
- Without event builder
  - Simple design (1CPU accumulate all data from every module)
  - Traditional data format in the RIPS (16kB = 1Block)

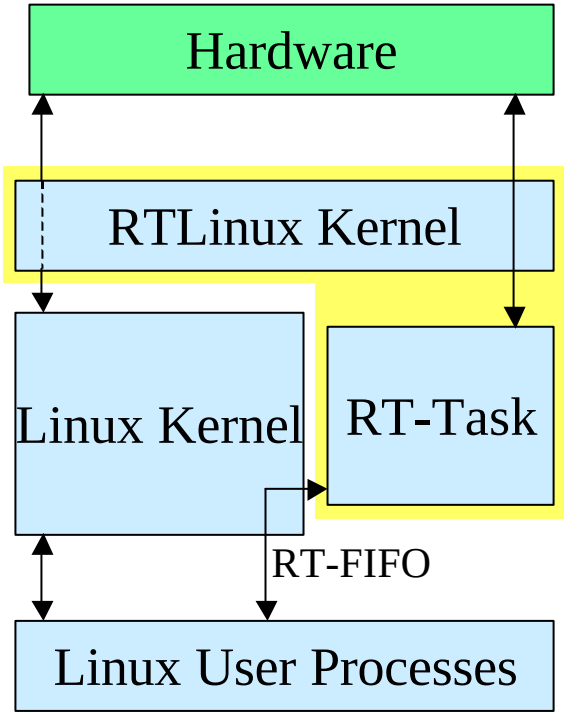
Overview the “babarlDAQ”

- Debut at year 2000 fall
- CAMAC & VME hybrid
- To handle CAMAC & VME, using RTLinux OS (RTOS)
  - Multi crate, Multi BUS, Single CPU (without Event Builder)
- Network distributed (data acquisition, control, analysis)
- Include On(Off)-Line analysis program
  - Compatible with previous system



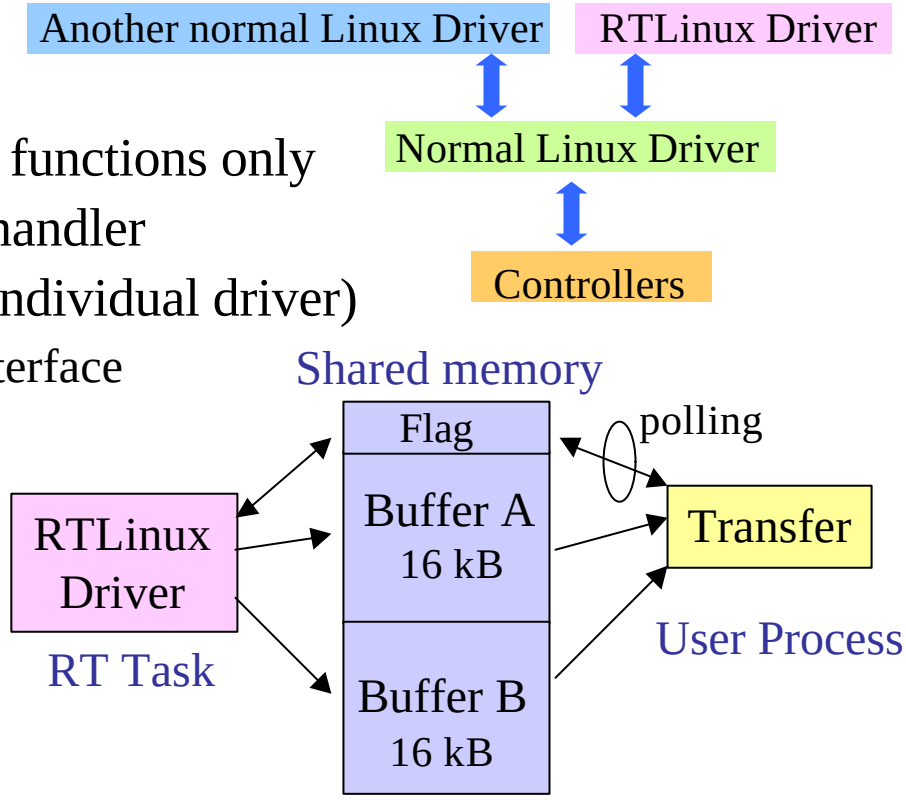
What is RTLinux ?

- Real-time extension of Linux OS
- License GPL (RTLinux/Free)
- U.S. Patent No. 5,995,745
- Linux Kernel is a lowest priority task in RTLinux
- RT-Task is implemented as a Linux loadable module.
- ~5 μs interrupt latency
- 30 ~ μs periodic scheduled task
- Support CPU
  - x86, PPC, Fujitsu FR-V, ARM, MIPS, Alpha

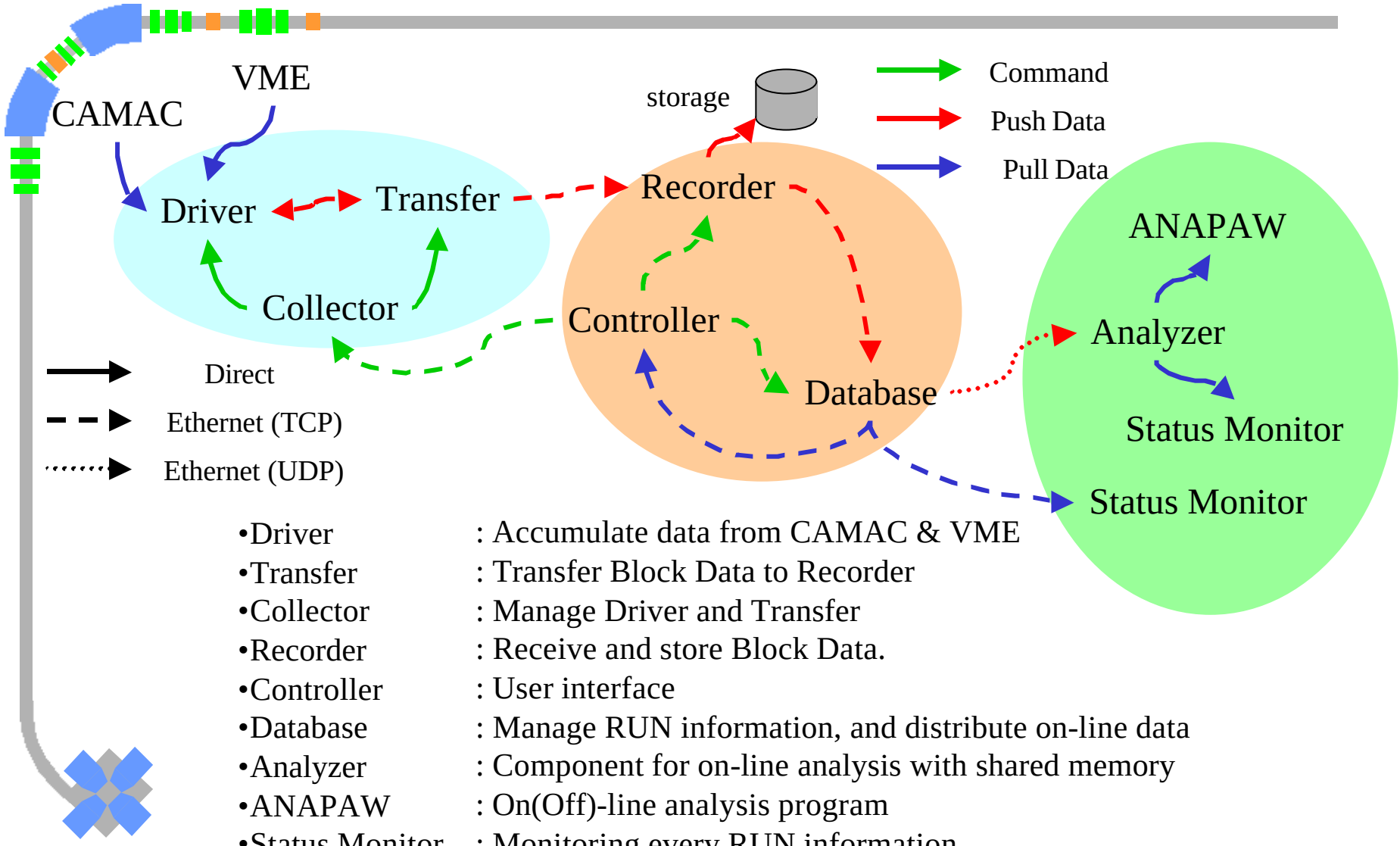


Drivers in the “babarlDAQ”

- Normal Linux type
  - Read, write and some control functions only
  - Without any scheduling and handler
  - Support various controllers (Individual driver)
    - Kinetic 3922 + 2915 PCI Interface
    - TOYO CC/7700 + CC/PCI
    - SBS 620 PCI-VME
    - Wiener PCI-VME
    - Advanet Advme8001
- RTLinux type
  - Scheduling only
  - To detect ADCs have finished conversion, driver checks CAMAC LAM or VME IRQ every 40 μs (polling).
  - To access CAMAC and VME, driver calls external functions in a above normal linux device driver.



“babalDAQ” Components

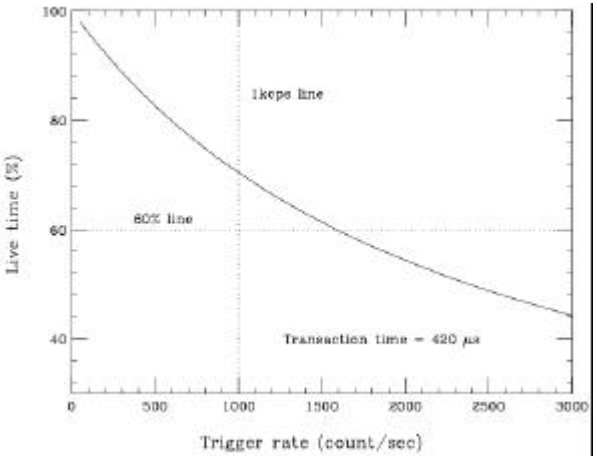


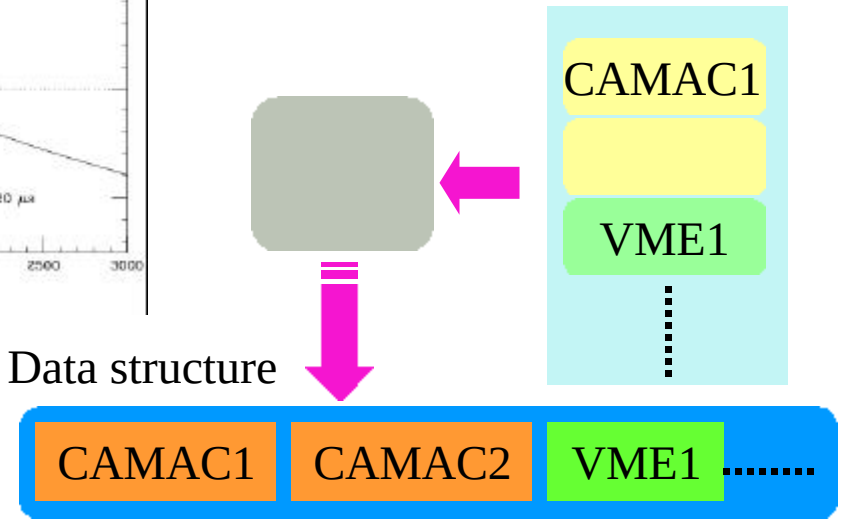
- Driver : Accumulate data from CAMAC & VME
- Transfer : Transfer Block Data to Recorder
- Collector : Manage Driver and Transfer
- Recorder : Receive and store Block Data.
- Controller : User interface
- Database : Manage RUN information, and distribute on-line data
- Analyzer : Component for on-line analysis with shared memory
- ANAPAW : On(Off)-line analysis program
- Status Monitor : Monitoring every RUN information

Multi crate, Multi BUS, Single CPU

- Adapt PCI-CAMAC, PCI-VME type controllers.
  - They can be used from same PC, and it is easy to construct simple data structure.
- Dead time is increased in proportion to channel number.

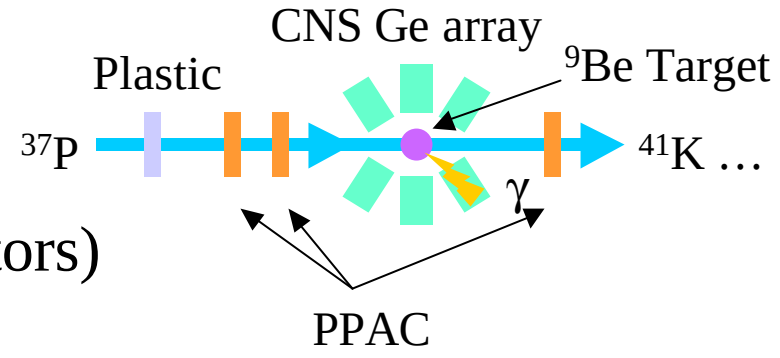
R337n-2
January, 2003
1 event ~ 150 words
Trigger rate 500cps
CAMAC + VME

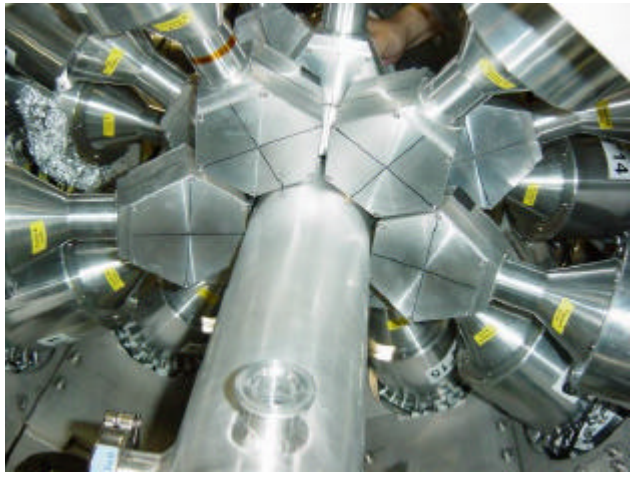




In case of July 2003 (R355n)

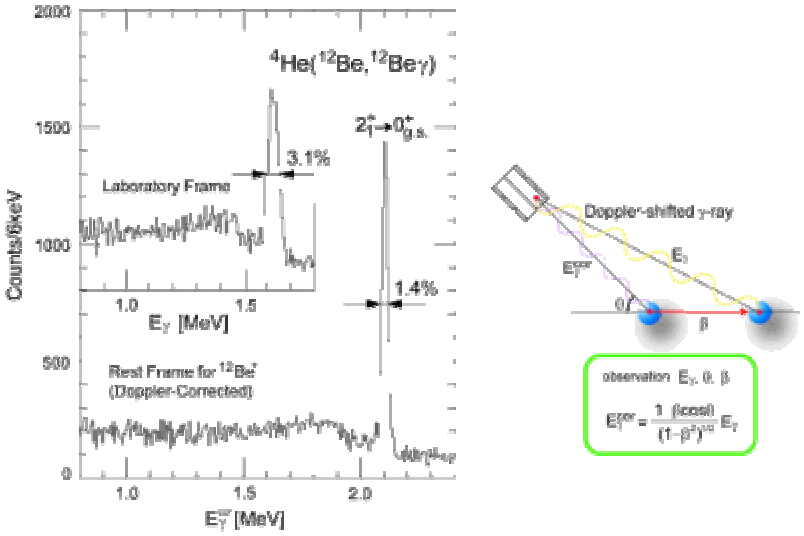
- High-spin states in ^{41}K …
- ^{9}Be(^{37}P,xn)$^{46-x}$K
- Use CNS Ge array (16 Ge detectors)
  - Segmented Ge detector
  - Doppler shifted γ, Multiple coincidence
- 1 week preparation, 2.5 days machine time

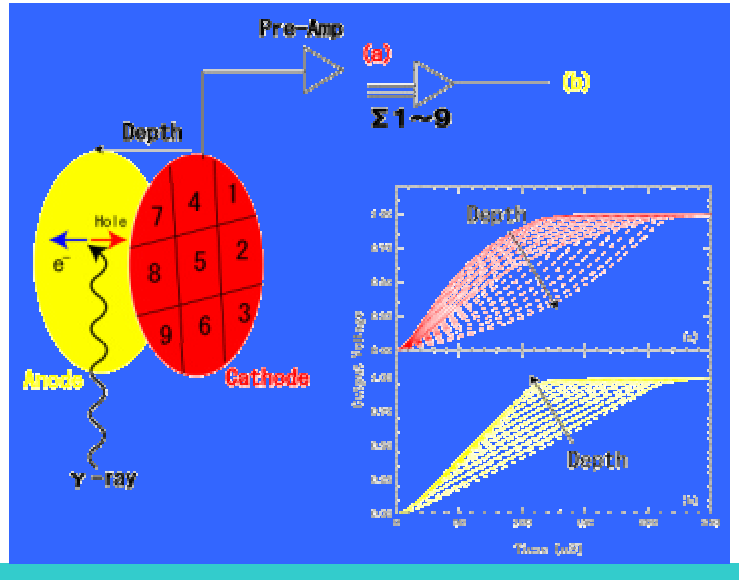




Pulse shaping in the CNS Ge Array

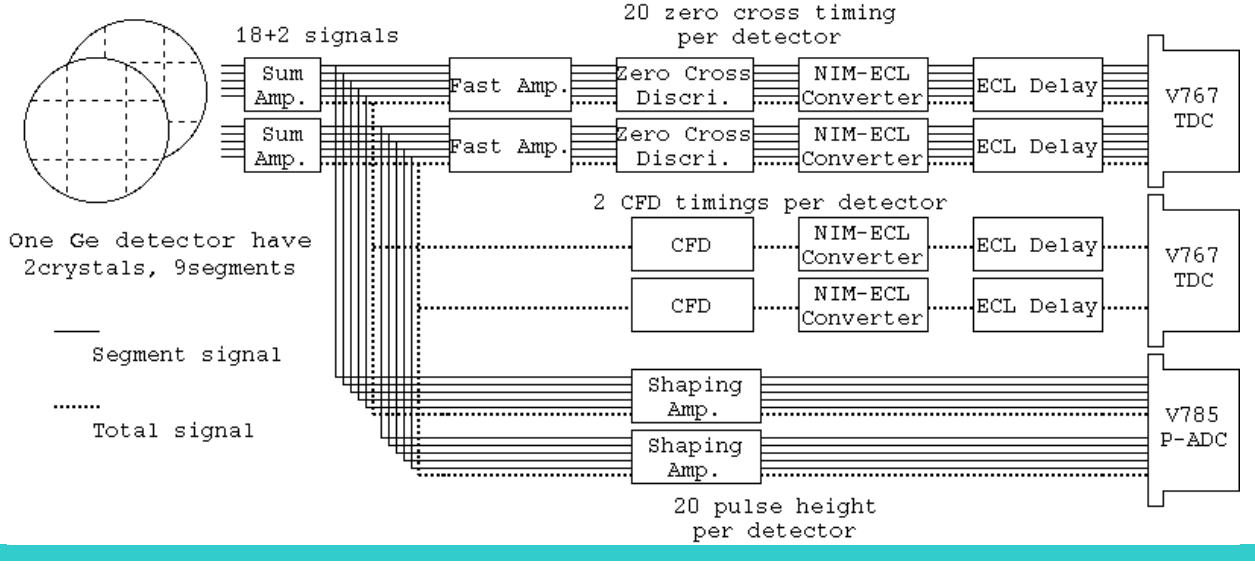
- To perform accurate correction of the energy for Doppler-shifted γ rays, emitted polar angle must be measured.
  - One Ge detector have 2 crystals that is divided into 9 segments.
  - We can obtain hit position of γ–ray by comparison between segmented signal and total signal.





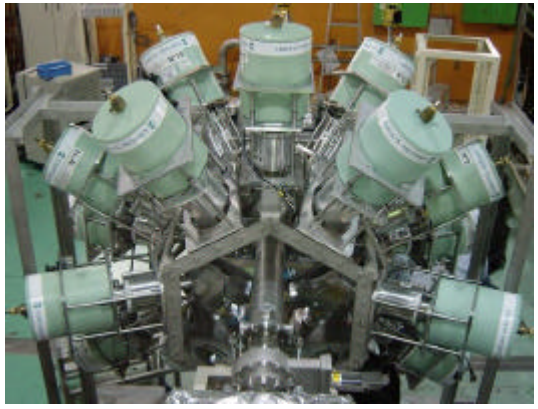
Circuits in the CNS Ge Array (R355n)

- Signals
  - 20 Zero cross timing (TDC)
  - 2 CFD timing (TDC)
  - 20 Pulse height (ADC)
  - Total = 672 ch
  - About 3000 Cables (LEMO & BNC)
- Adjustments
  - Sum Amp.
  - Fast Amp.
  - Discriminator
  - Shaping Amp.



Next experiment plan

- One particle state in near N=20 neutron drip-line nucleus
- More than 3000 cables (BNS and LEMO)
- More than 1500 ADC channels

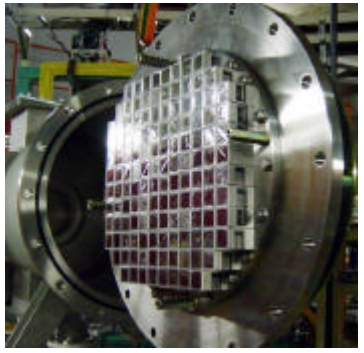


Ge Array (720ch)

In-flight γ-ray

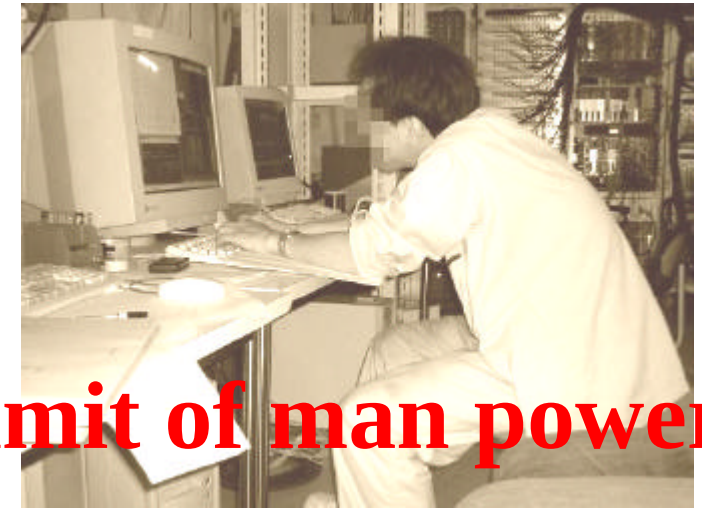
PID (ΔE)

Stripped or matrix SSD (~300?ch)



PID (E)

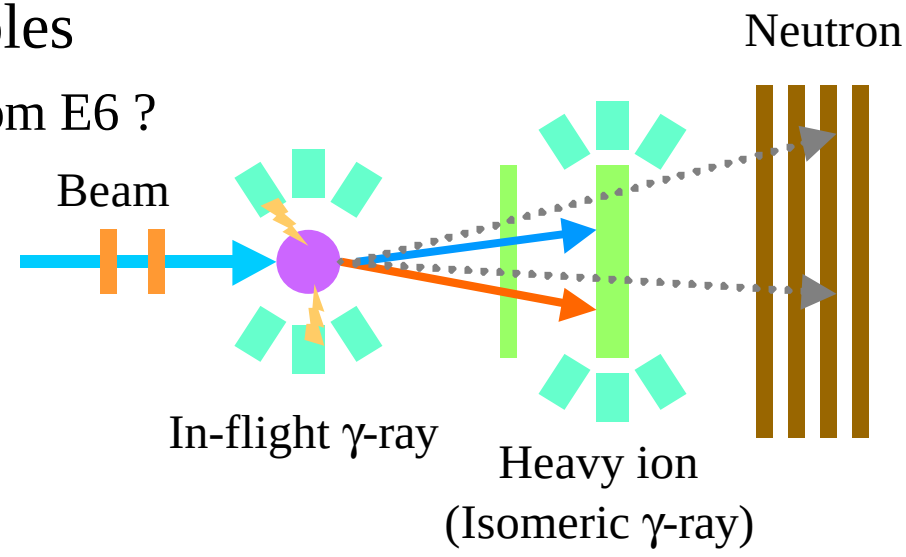
NaI Wall(264ch)



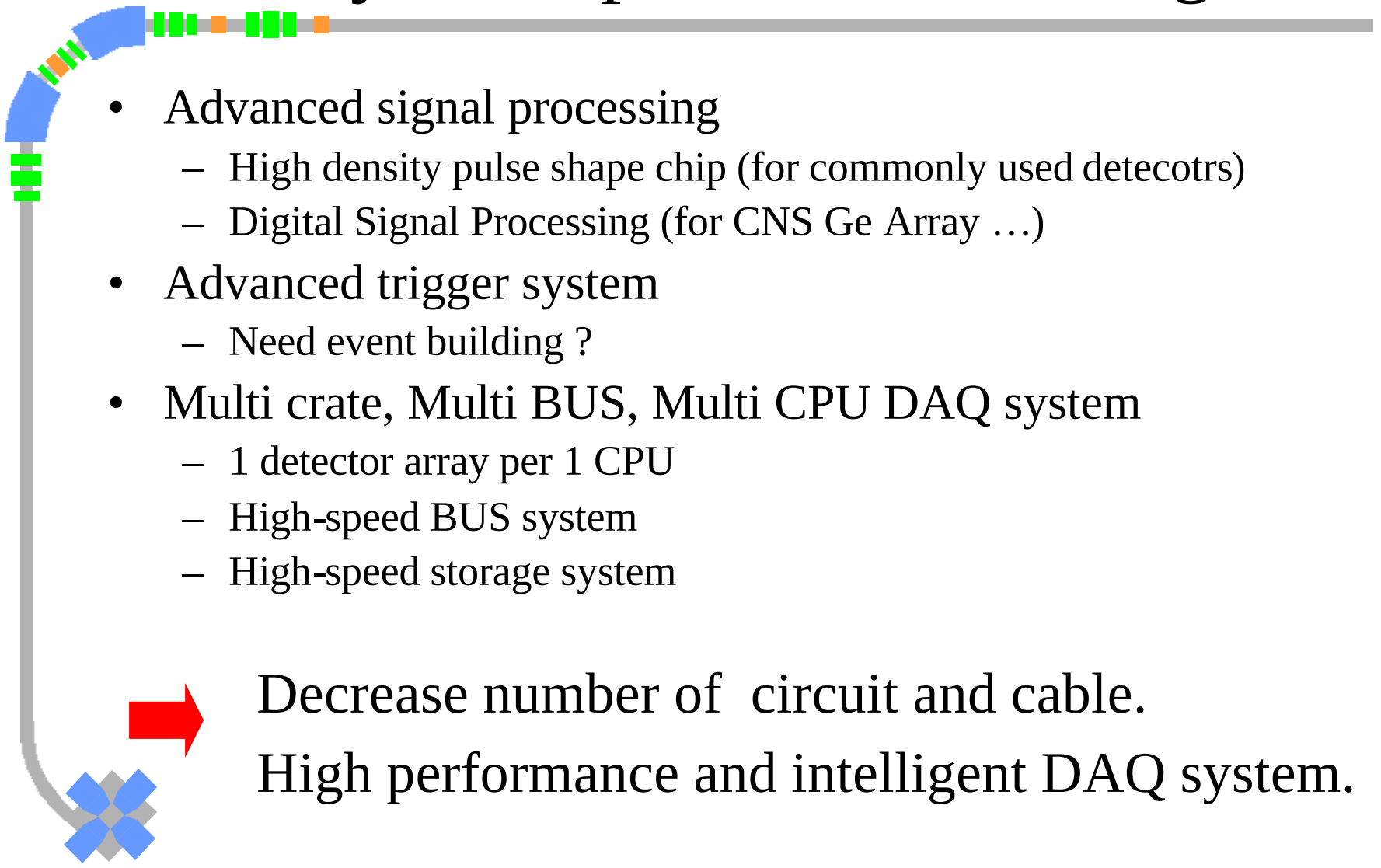
Limit of man power ?

Near future experiment in RIPS ?

- Research for higher excited state in neutron drip-line nucleus via the invariant-math method
  - Measure all reaction products (Charged particle, neutron, γ-ray)
  - Multiple coincidence
    - Use large solid angle and segmented / stripped detector arrays
  - As possible as high intensity beam
- As possible as decrease cables
  - Install circuits (ADCs) in room E6 ?
- High performance DAQ
  - Multi CPU ?
  - Event building ?



Wanted !!
Easy-to-implement following



- Advanced signal processing
  - High density pulse shape chip (for commonly used detecotrs)
  - Digital Signal Processing (for CNS Ge Array …)
- Advanced trigger system
  - Need event building ?
- Multi crate, Multi BUS, Multi CPU DAQ system
  - 1 detector array per 1 CPU
  - High-speed BUS system
  - High-speed storage system

Decrease number of circuit and cable.

High performance and intelligent DAQ system.