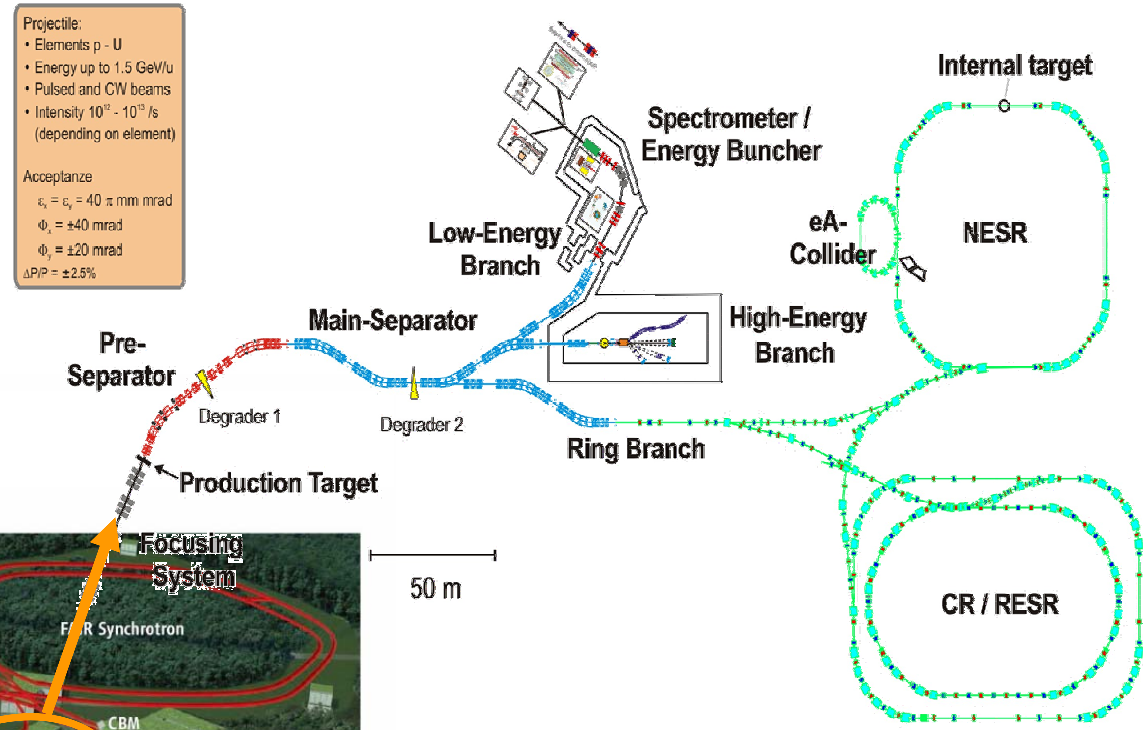
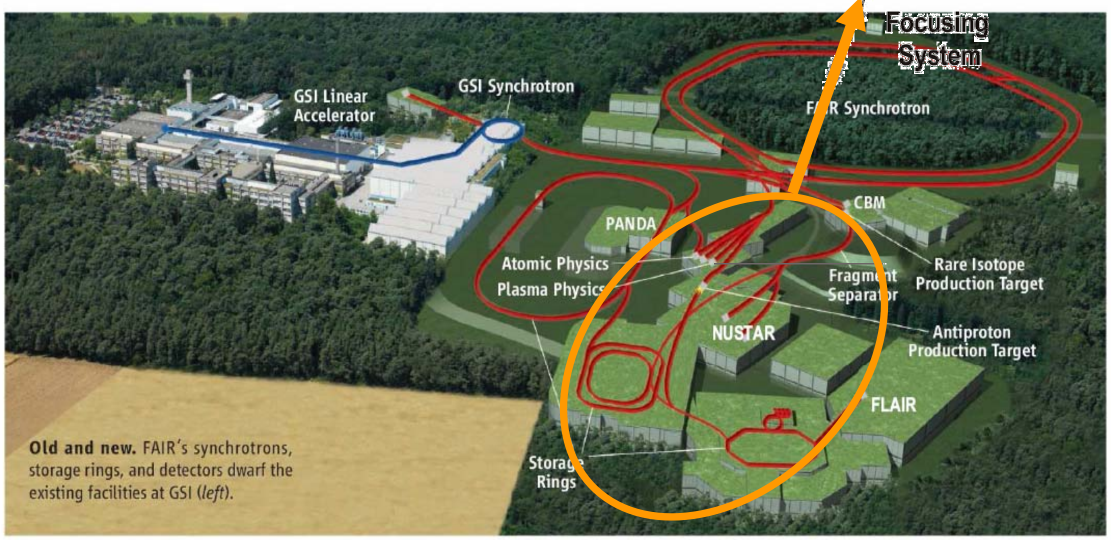
Time stamping and online data processing for **NUSTAR@FAIR.**

H.Wörtche - H.Simon
INCAS GSI

Exotic Nuclei
- Spectroscopy
- Reactions
- Mass/gs. prop.



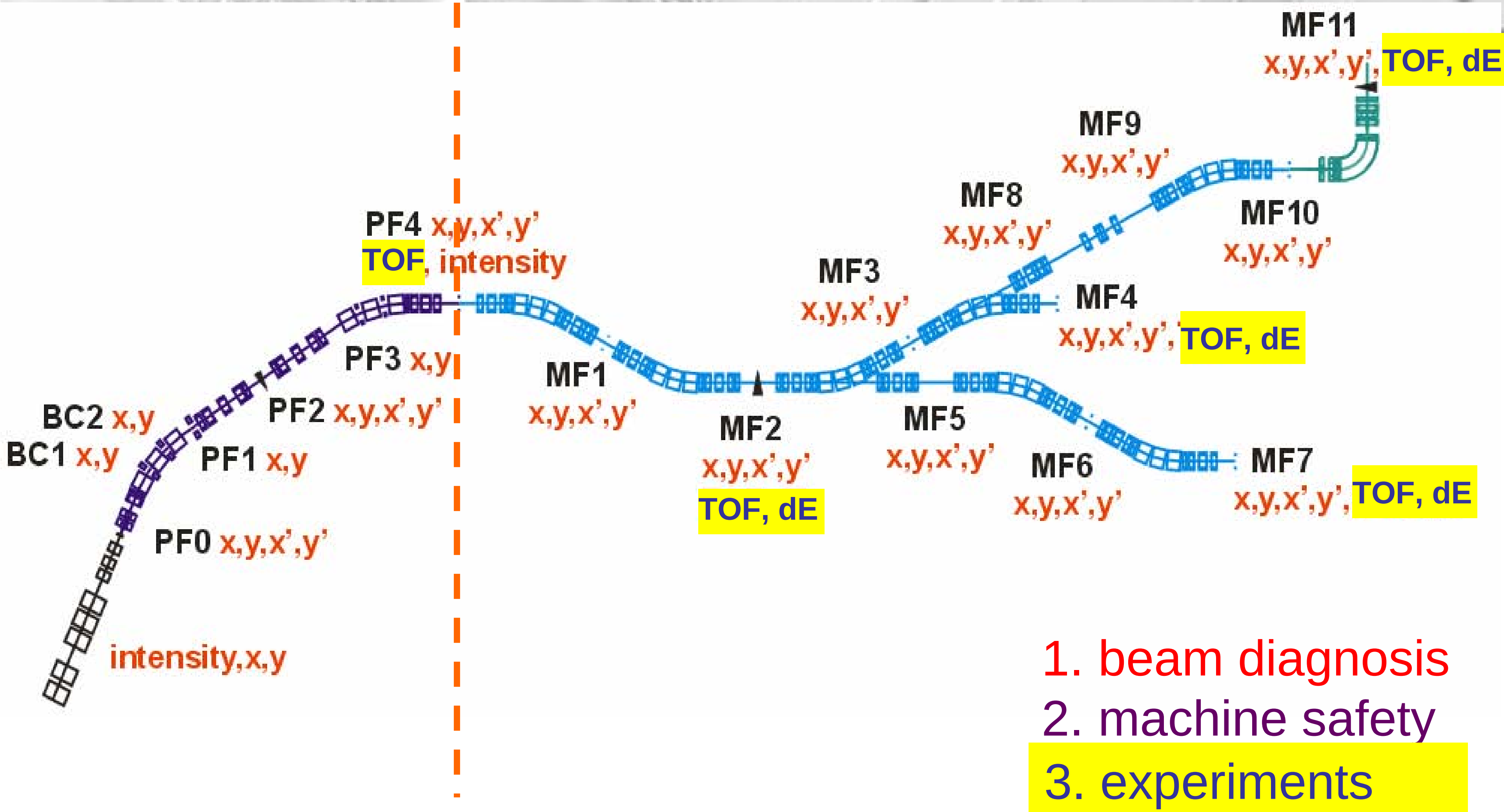
schematic



Old and new. FAIR's synchrotrons, storage rings, and detectors dwarf the existing facilities at GSI (*left*).

2 NOVEMBER 2007 VOL 318 **SCIENCE** www.sciencemag.org

Beam Tracking/ID for Experiments !



1. beam diagnosis
2. machine safety
3. experiments

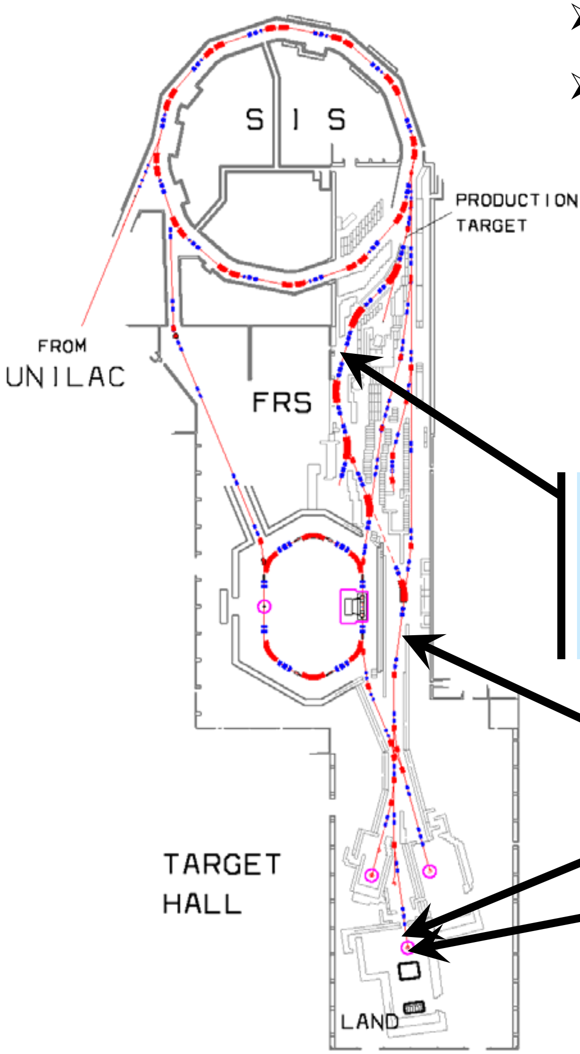
10^{12} /s $<10^{10}$ /s $<10^{9}$ /s $<10^{7}$ /s $<10^{5}$ /s

FAIR

Continous beam ID is integral part of experiments

Example: ^{132}Sn PDR studies (reaction study @ CaveB)

- Primary: 3*10^{8} ^{238}U/spill @550Mev/u
- Secondary (mixed): 50 ions ^{132}Sn/spill

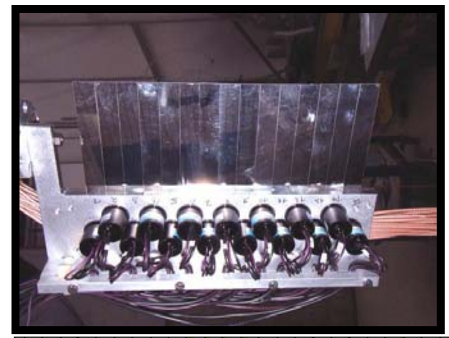


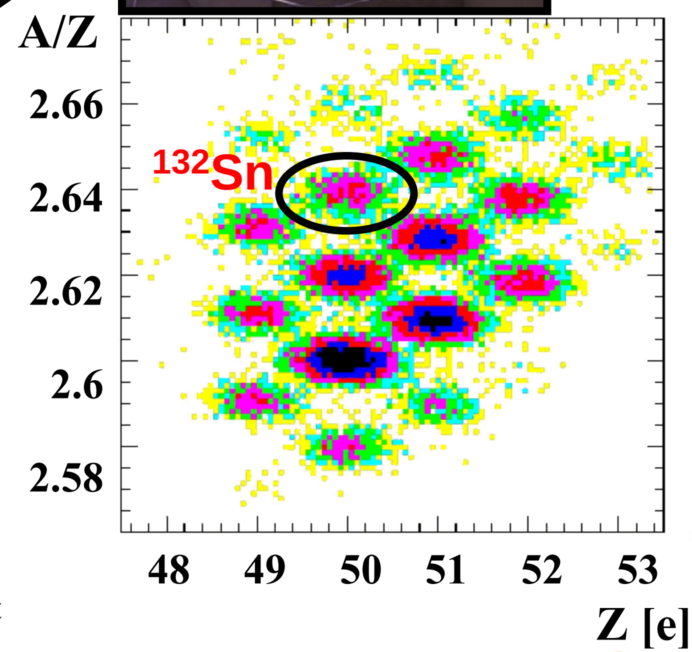
$$\frac{A}{Z} = \frac{m_u c}{e} \frac{B\rho}{\beta\gamma}$$

Bρ – from position at middle focal plane of the FRS

β – from TOF

Z – from ΔE





NO CHARGE STATES !

$B\rho - \Delta E$-TOF method: Requirements

$B\rho = A/Z\ \beta\ \gamma$ ➡ A/Z, P

TOF=L/β

$\Delta E \sim Z^2/\beta^2$ ➡ Z

Pos res. $\sigma \leq 1$ mm

Timing res. σ : 50 ps

ΔE resolution σ : 1-2 %

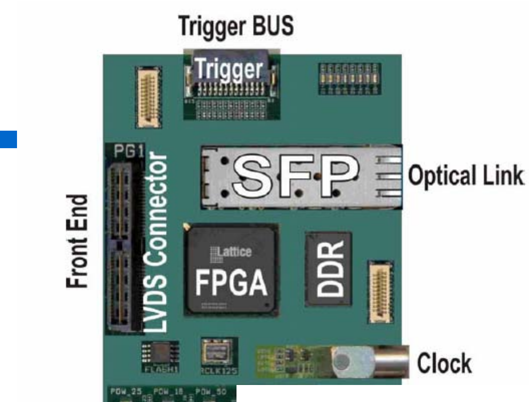
- Position: Wirechambers (single event readout)/Diamond
- Δ E: MUSIC/TEGIC ➔ limit about 1MHz
- TOF: Plastic/Diamond

Integration/Controls

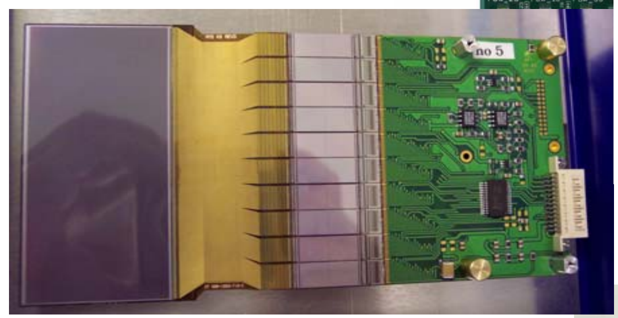
- Challenge:
  - Increasing complexity of setups.
  - Typically few 100 channels ➔ up to several 100'000 channels.
  - Prohibitive setup times.

- Solution:
  - Integrated (frontend) electronics.
  - Modularity (distributed DAQ systems).
  - Scalable Controls (e.g. EPICS + various frontends).

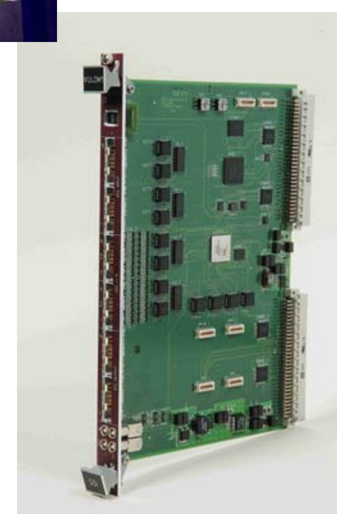
- FEE projects: Tacquila, NXYTER, ASDQ, APV25 → integration into running setups (MBS).
- FPGA trigger implementations & diagnostics.
- EPICS implementation studies (also used for ITER).



"Exploder" MBS FEE combiner



VA64.hdr Si readout



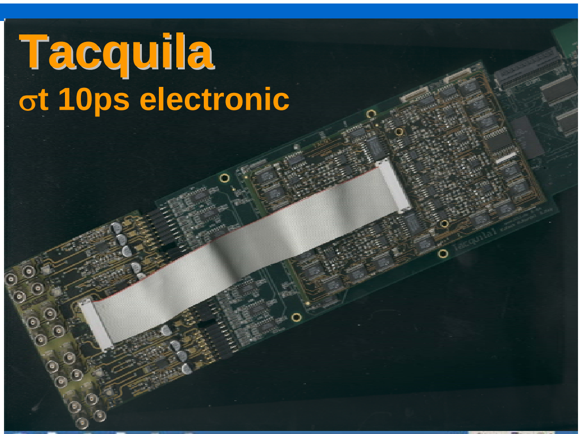
Logic Module & softscope

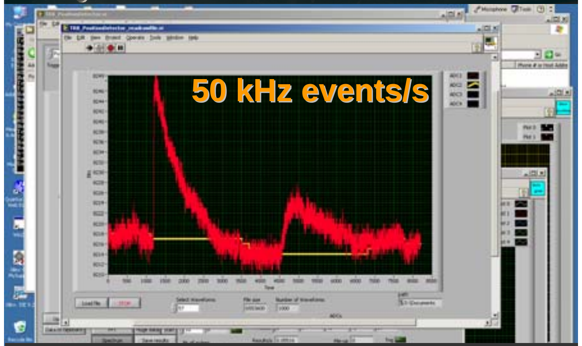
Fast sampling & timing techniques

- Challenge:
  - Beam identification at rates up to 1MHz.
  - ToF over km distance with sub-ns resolution.
  - ΔE resolution 2-3%

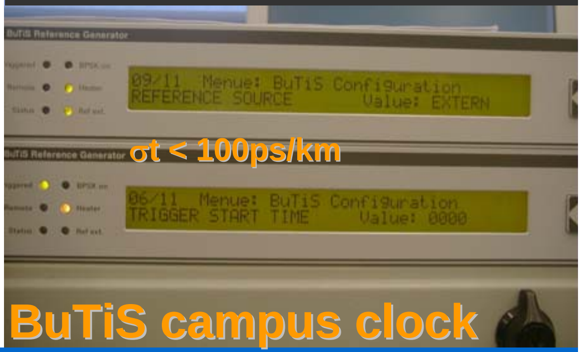
- Solution:
  - Fast sampling and FPGA based digital signal processing & pulse shape analysis.
  - Campus wide Time Distribution System based on FAIR BuTiS timing system.
  - TAC or DLL based Frontends.

- First studies using Tacquila@R^3B/Cave-C.
- Digital Signal Processing (for PSP, MUSIC) in collaboration with KVI Groningen/JSI Lubljana





Online PSA @ 100MHz



NUSTAR DAQ/controls architecture
(MBS[/DABC] & EPICS)

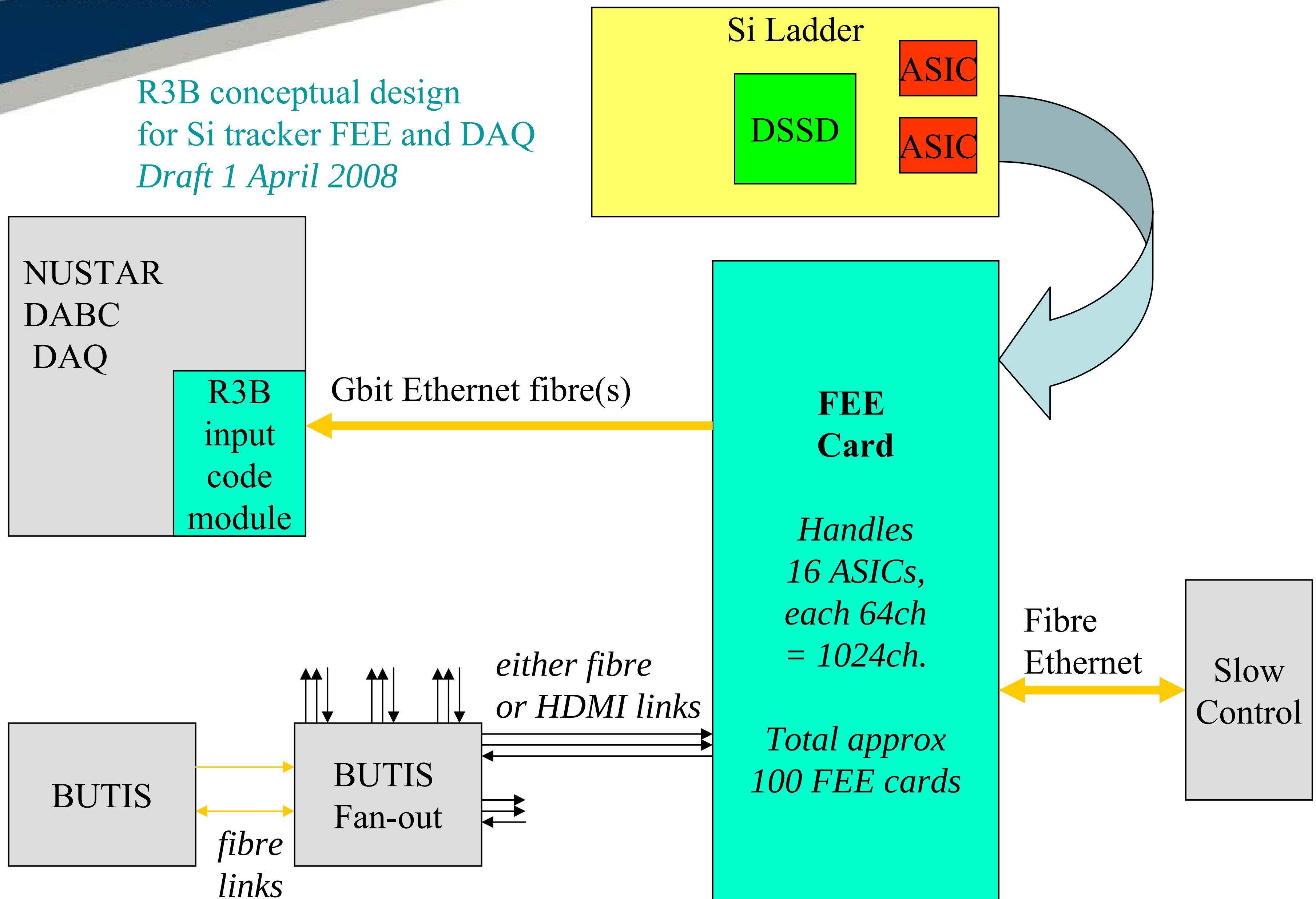
- smooth transition from existing systems
- triggered systems will be replaced whenever they cause excessive dead time or
- … are difficult to handle

Examples: (1) incoming tracker (deadtime)
(2) calorimeter (100’000 channel or ;o)
(3) delayed coincidences

… so don’t forcefully leave out trigger capabilities
and don’t force triggers to be there ➔ Building blocks

Ian Lazarus

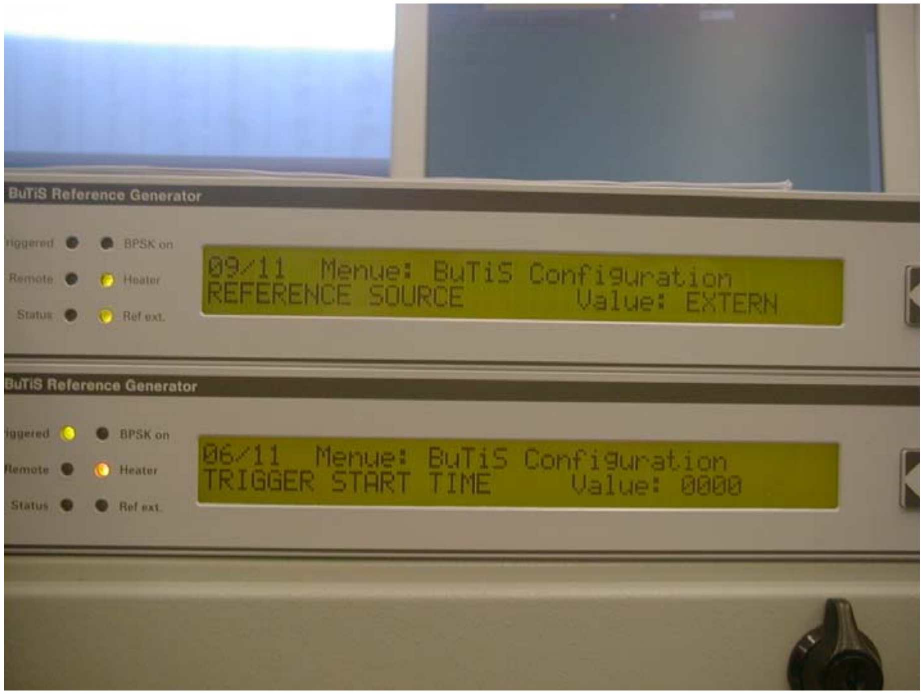
R3B conceptual design
for Si tracker FEE and DAQ
Draft 1 April 2008

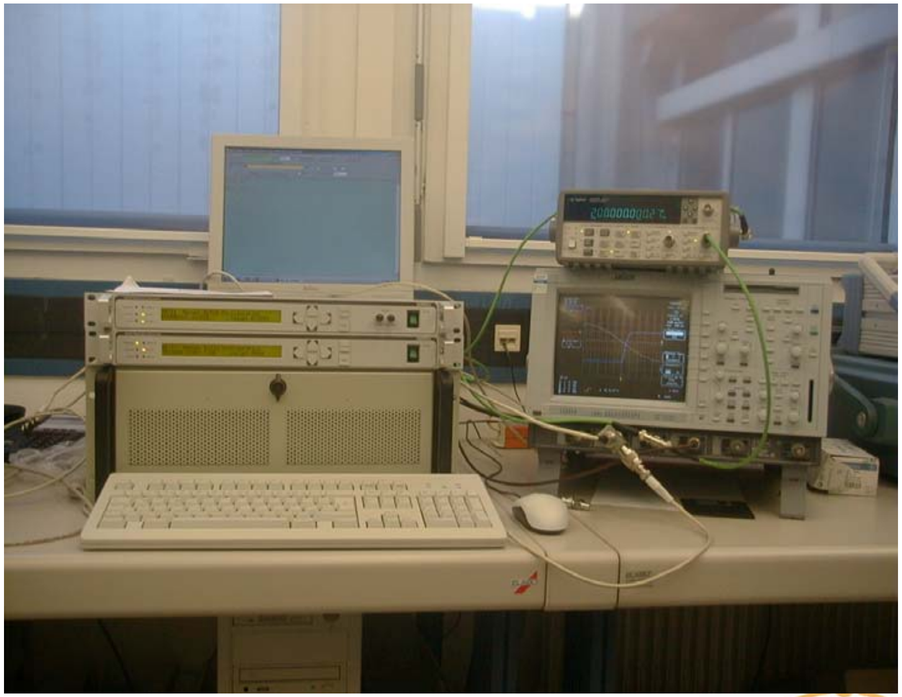


Campus wide time distribution (BuTiS)

P.Moritz/GSI

- Campus wide time distribution via fibre optics / local TDS(s)
- Synchronized local oscillators (100kHz, 10Mhz, and e.g. 200, 155 or 76 Mhz) with +/-100ps/km absolute uncertainty and << 10ps oscillator jitter



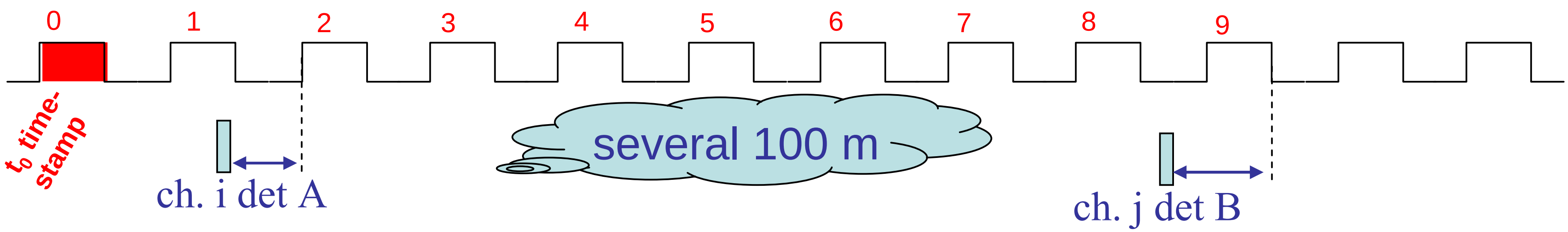


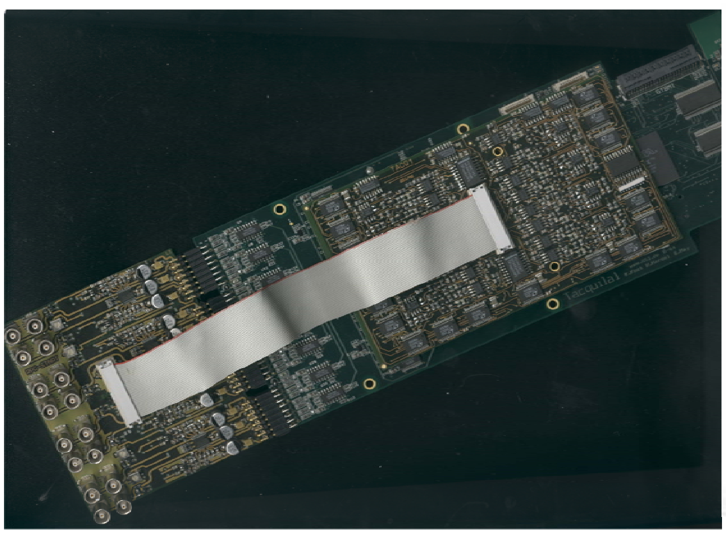
Precision timing (<50ps) vs. Campus Clock

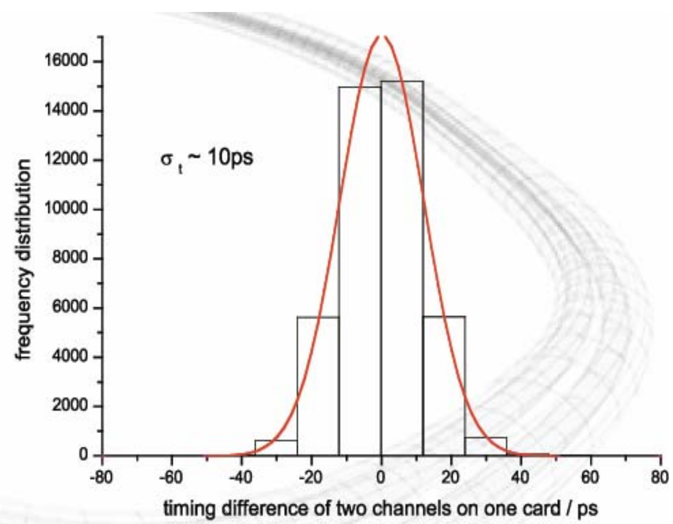
K. Koch/GSI

- avoid extended cabling and dead time domains

➔ free running time stamped systems SuperFRS -- Caves







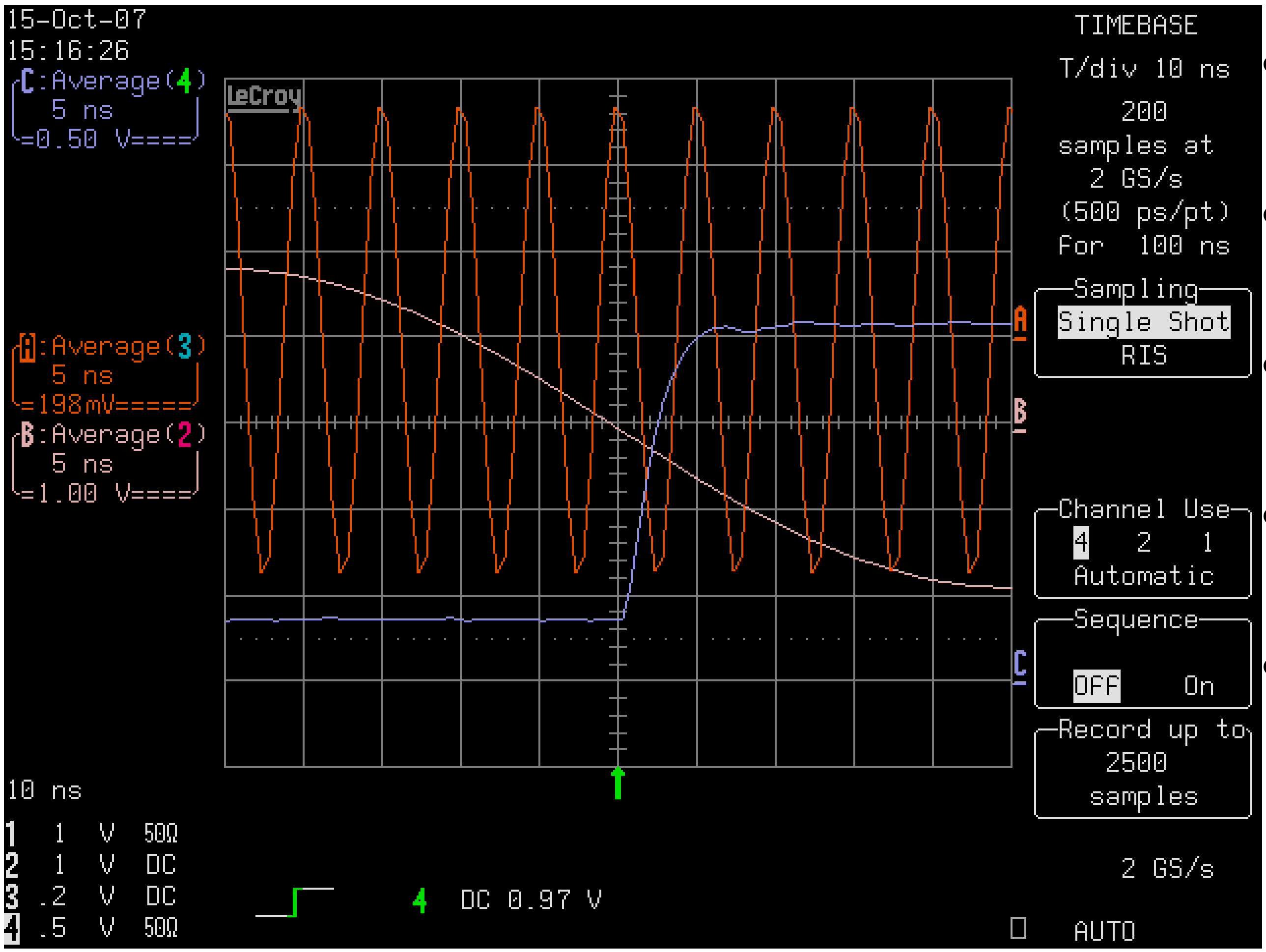
Timing FEEs:

Tacquila system (ASIC FhG/GSI) all existing chips in house

New systems (ASIC dev. GSI FPGA based TDC)

BuTiS at work (20071015)

P.Moritz/GSI



- 10, 200 MHz sine waves (adj. phase)
- T0 pulse for sync. every 100µs
- very good phase stability
- BuTiS oscillator can run standalone
- about 10k€/system

➔ labeling of T0

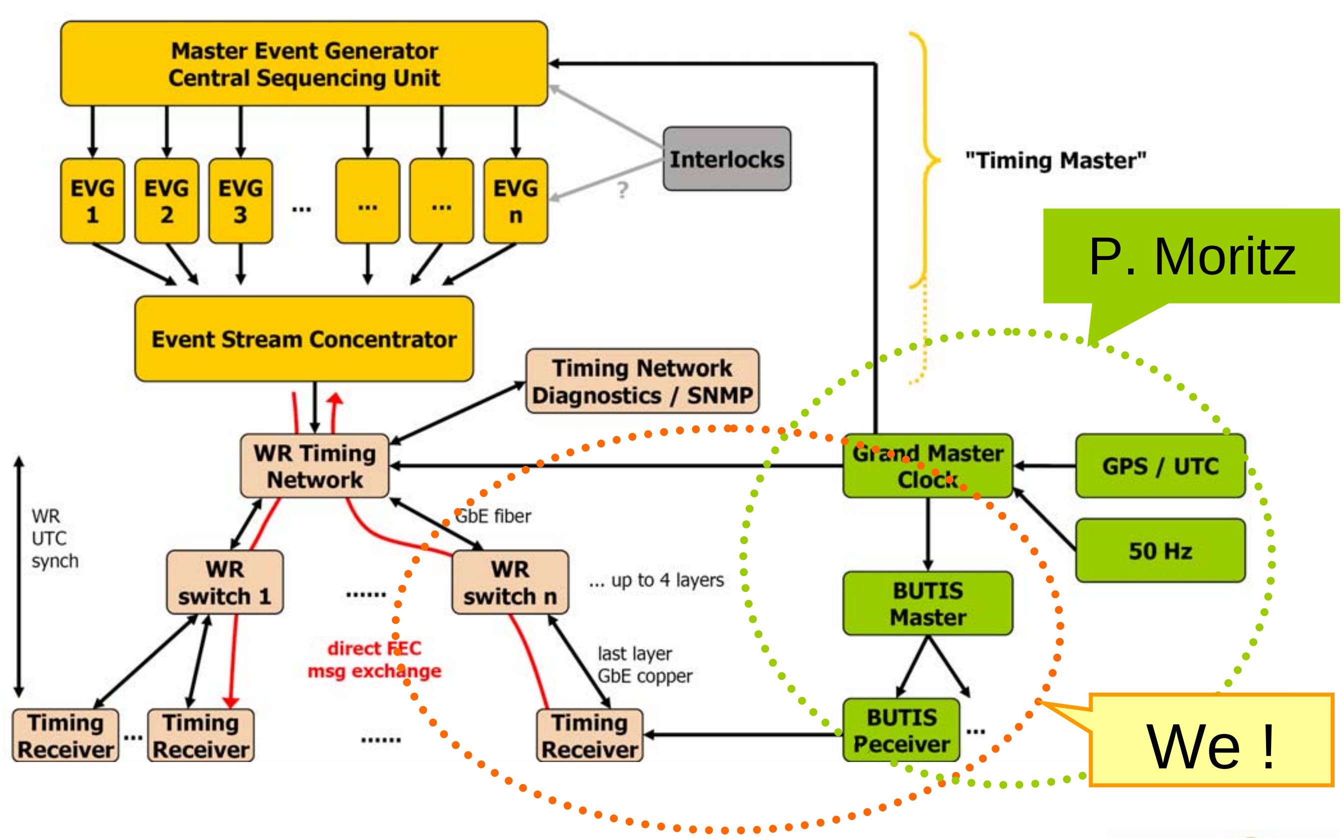
White Rabbit Event- & TDS
CERN/FAIR

T. Fleck/GSI

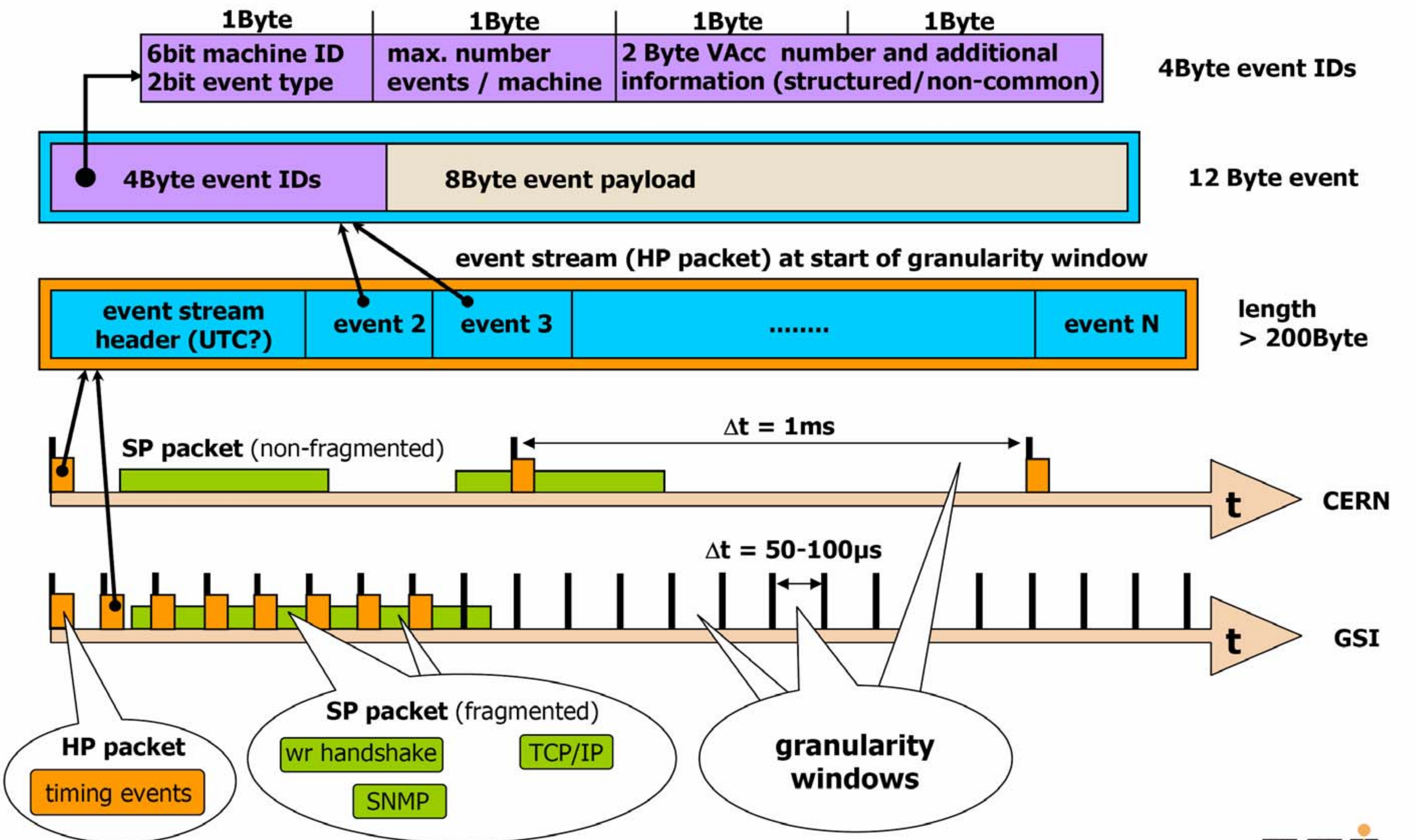
- Event and timing distribution with priorities

Form factors:

- GB copper/fibre
- Piggy back
  → VME
  → COTS
  e.g. PC



timing event messages / content granularity windows

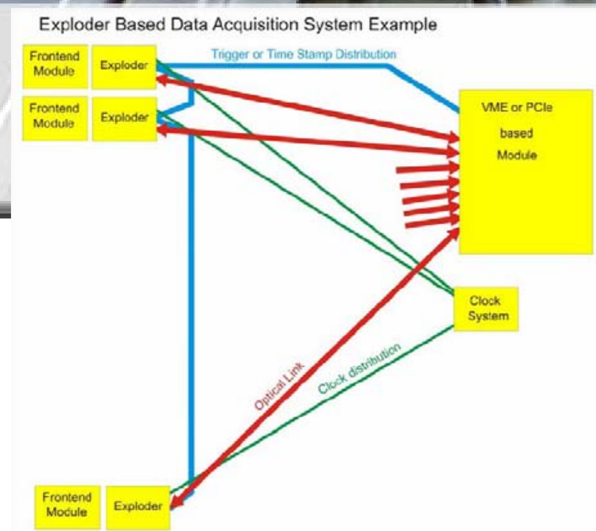


“Intelligent sensors”

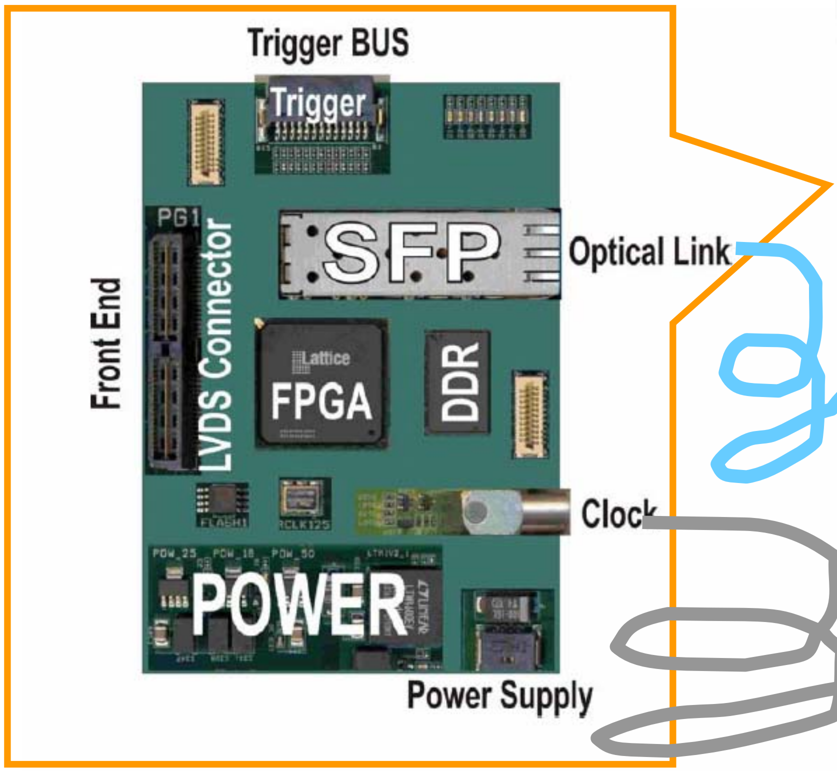
N.Kurz, J.Hoffmann, W.Ott/GSI

- NUSTAR uses MBS, a (in principle) triggered DAQ system …

➔ preproc./region of interest stored



any LVDS input



VME Readout or PCIe

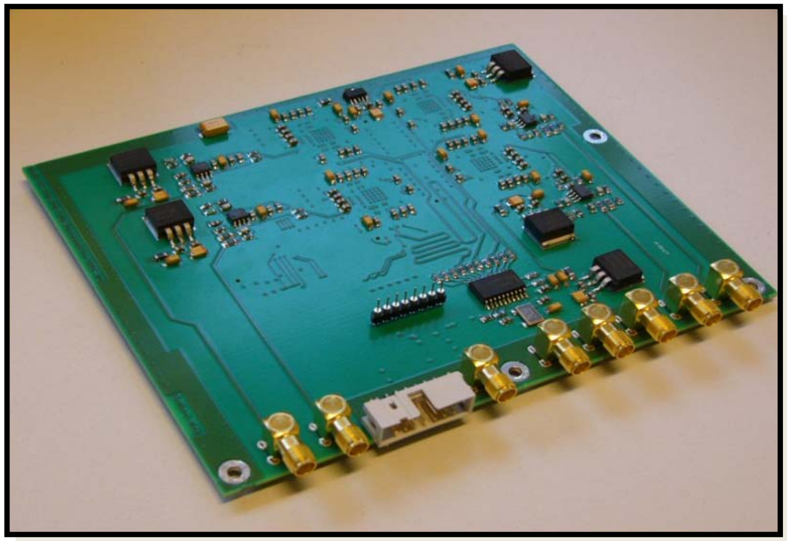
ng

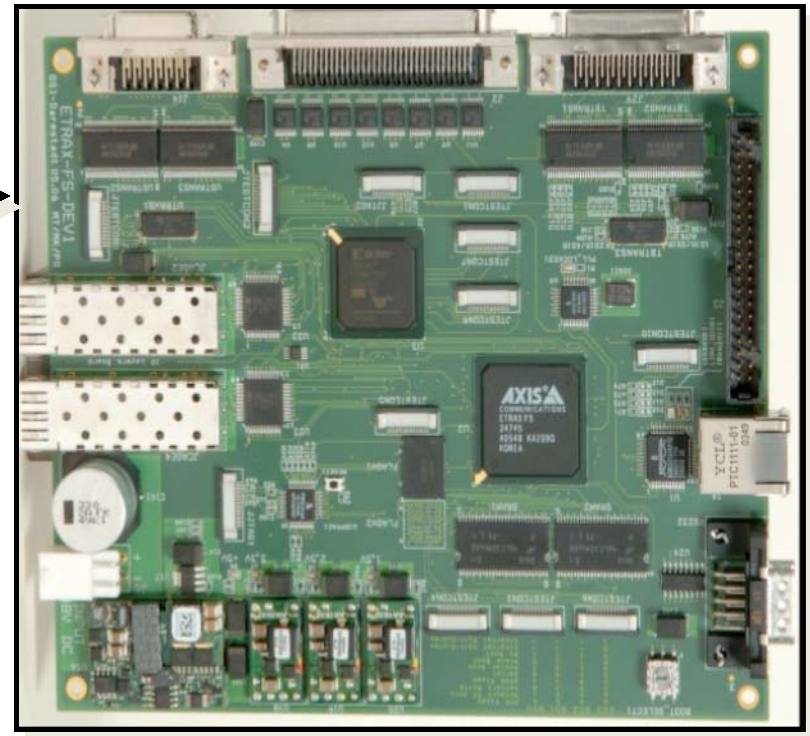
GSI/JSI/KVI collaboration:

Present working areas digital signal analysis:

1.base-line follower
2.noise level monitoring
3.dynamic signal trigger level in σ noise units
4.amplitude/timing
5.real time pile-up correction
6.Virtex 4 LX40 FPGA (4 x 14 bit) & Xilinx XC3S500E FPGA implementation (2 x 8 bit)

1.VME implementation (GSI MBS system)
2.scintillator & PSPD applications



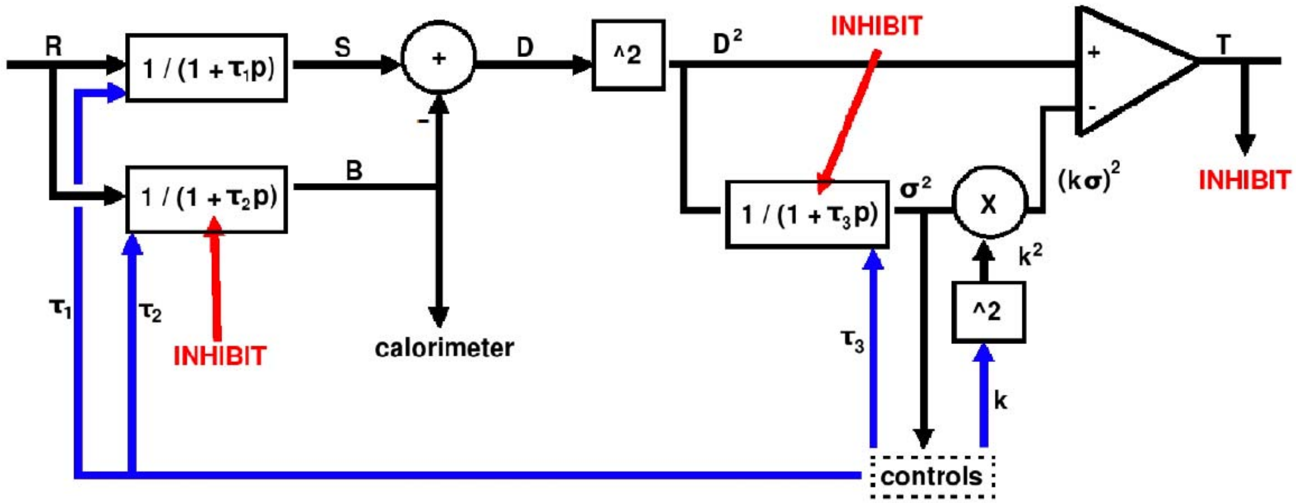


KVI Quad ADC's card

- Resolution : 14 bits (ADS5541)
- Speed : 100 MSamples/s
- Bandwidth : 50 MHz
- Input range : -4 to 4 Volt
- Input connector : SMA
- Input impedance : 50 Ohm
- External trigger inputs : 4*SMA
- External trigger input impedance : 50 Ω
- Power supply : 5Volt from TRB

GSI/HADES General Purpose Trigger and Readout Board (TRB)

- FPGA (Xilinx Virtex4 LX40) for online patternrecognition,
- Etrax-FS processor (AXIS) 128 MB memory, linux kernel
- TigerSharc DSP (600MHz, 128Bit)
- 10 GBit/s general purpose IO for ADC readout

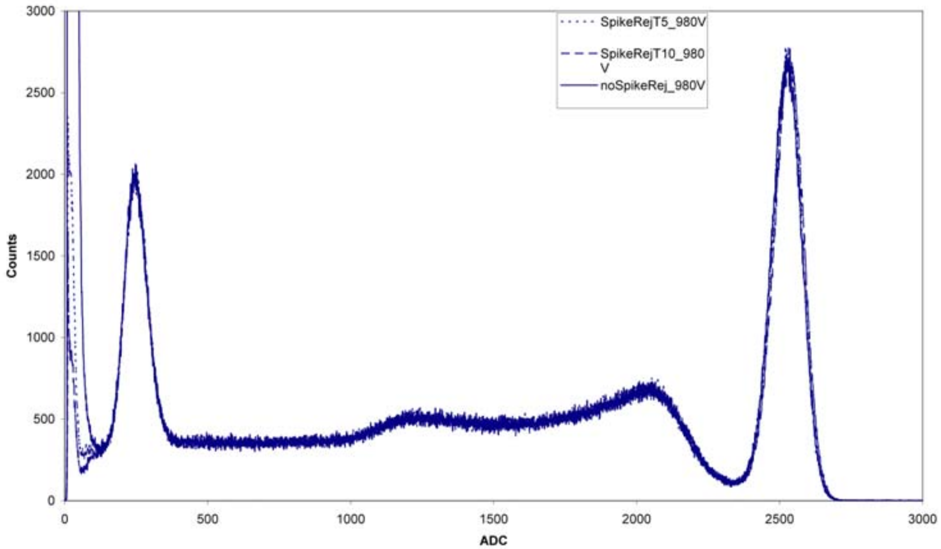


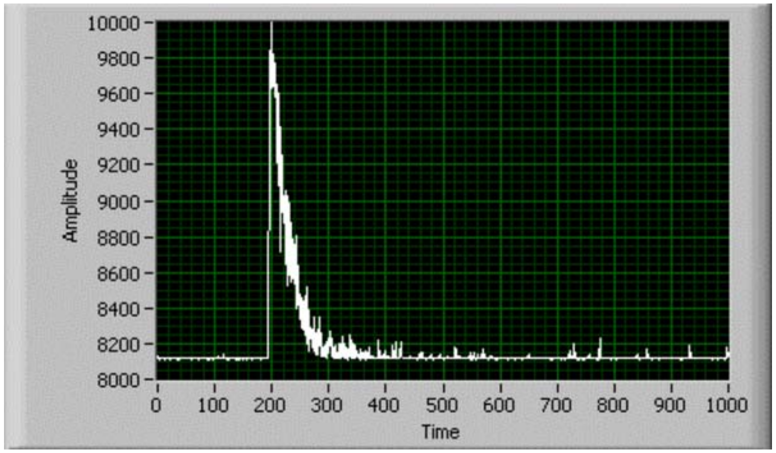
Baseline follower based on 3 fold low-pass filter

- **R**aw, **S**ignal, **B**aseline → **D**ifference → **D²** (Energy)
- **calorimeter,** σ² → histograming ➔ controls
- Inhibit → **Bimodal** filter

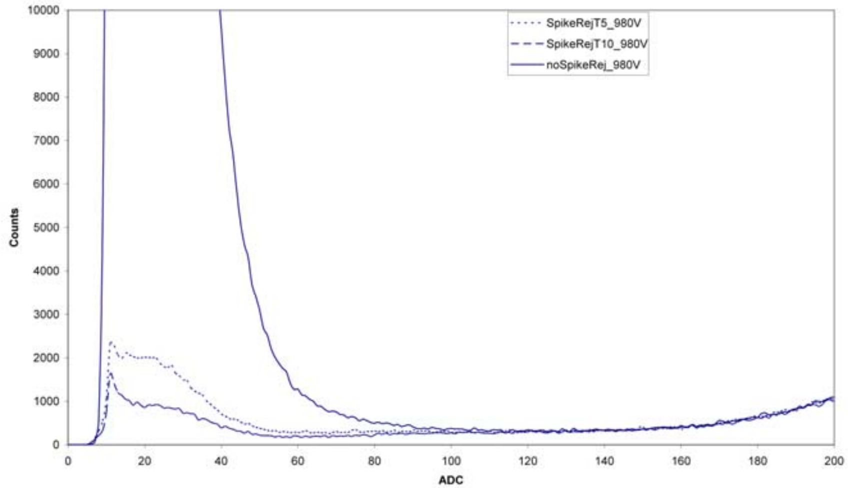
- controls ➔ filter parameters

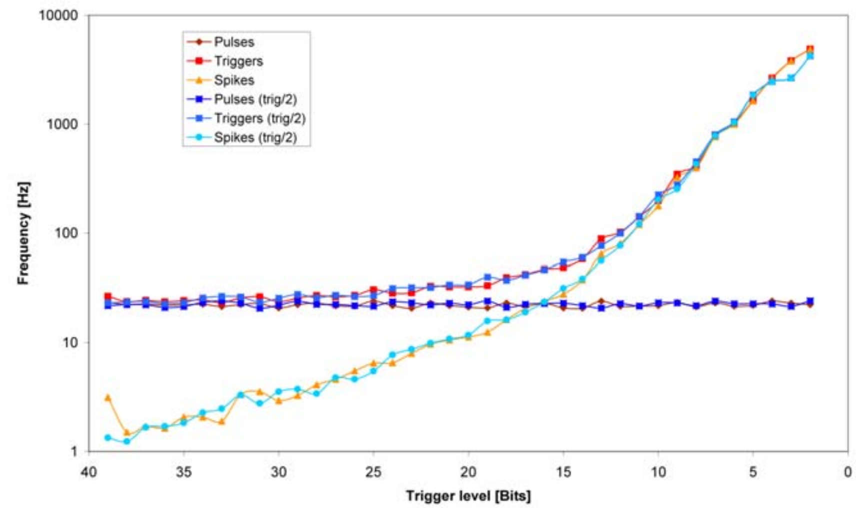
Benefit: kσ Trigger i.e. most precise & "quantitative" treshold
➔ Potential problem: Spikes





1'x1' NaI, Photonis PMT, ^{137}Cs

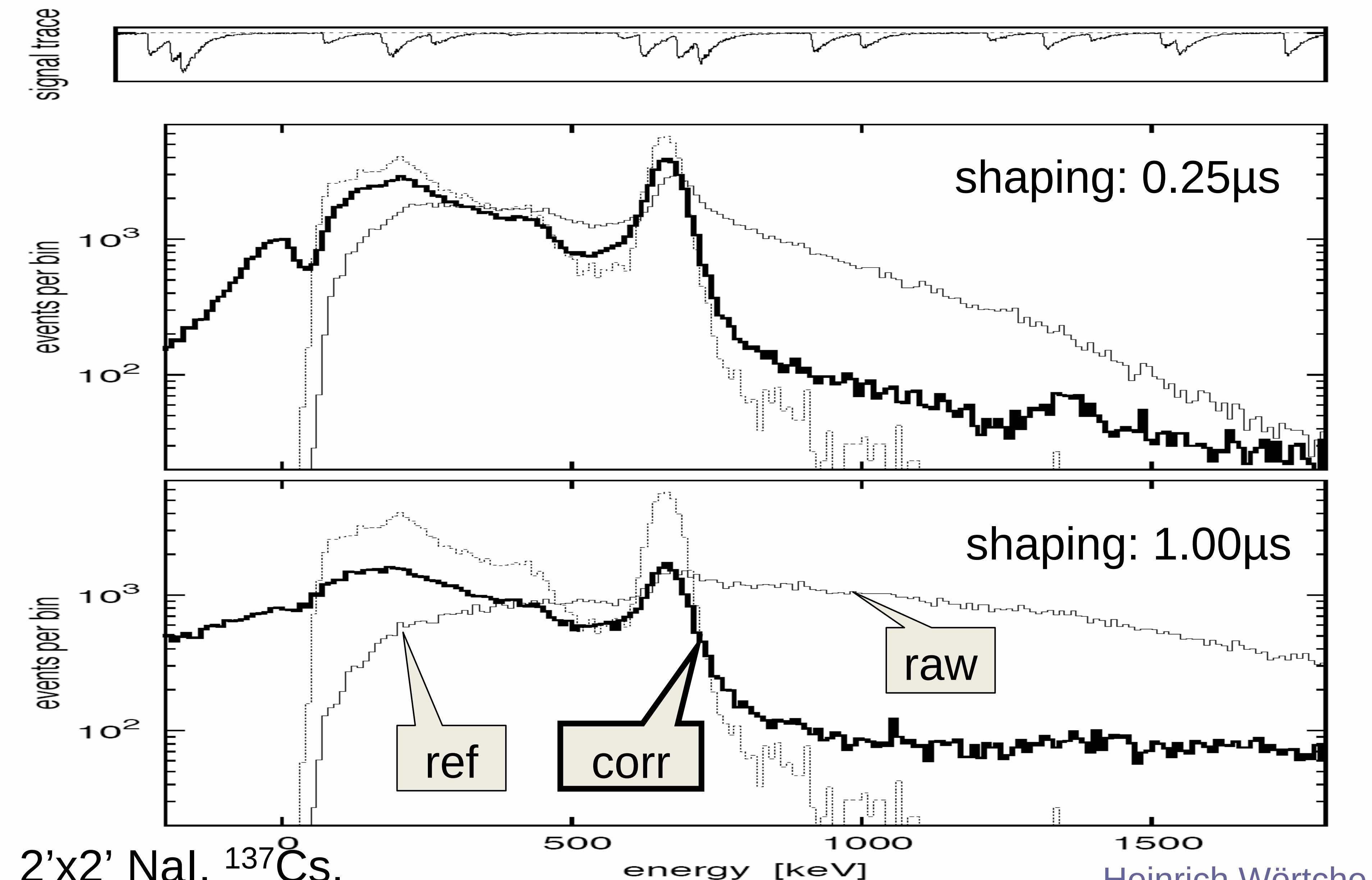




Spike rejection

Heinrich Wörtche

Pile up treatment (2)-1-x-1-(2): M. Vencelj

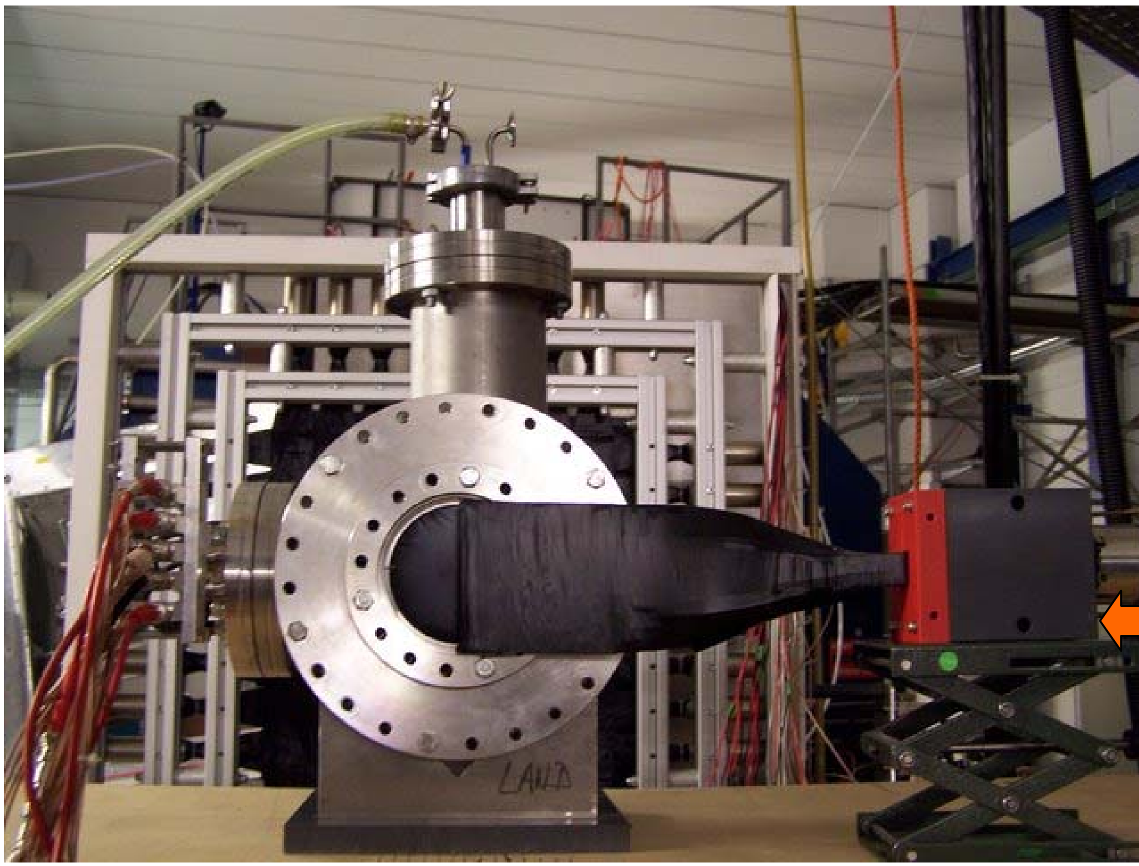


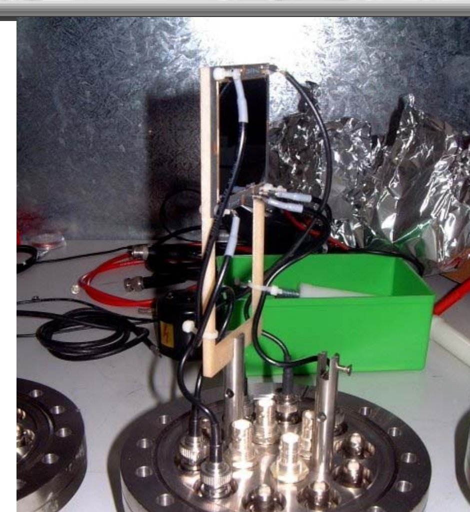
2’x2’ NaI, ^{137}Cs,

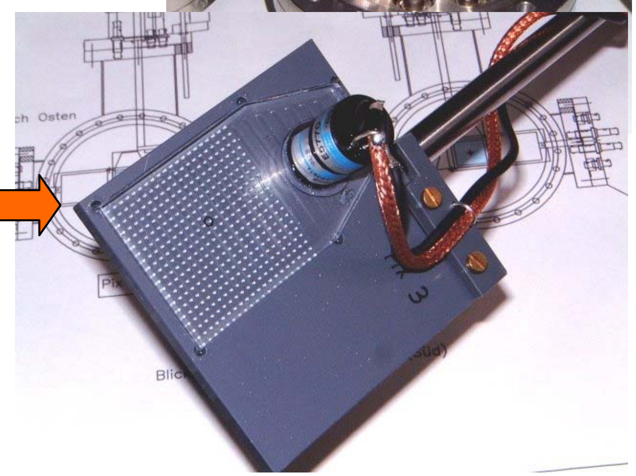
Heinrich Wörtche

Test experiment S327 (16.-18.4.2008)

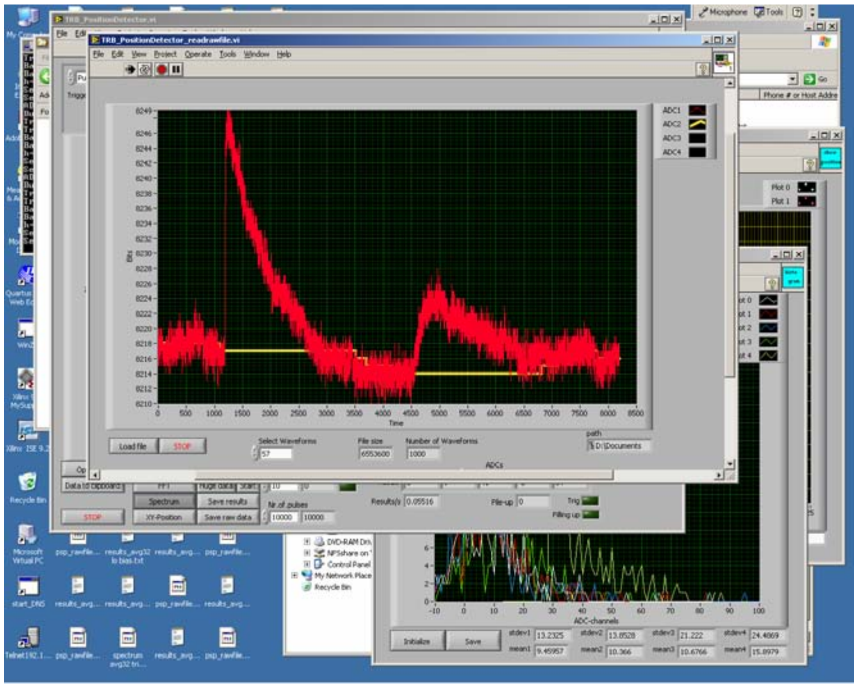
^{12}C: 550-700 MeV/u ; 2-50 kEv/s

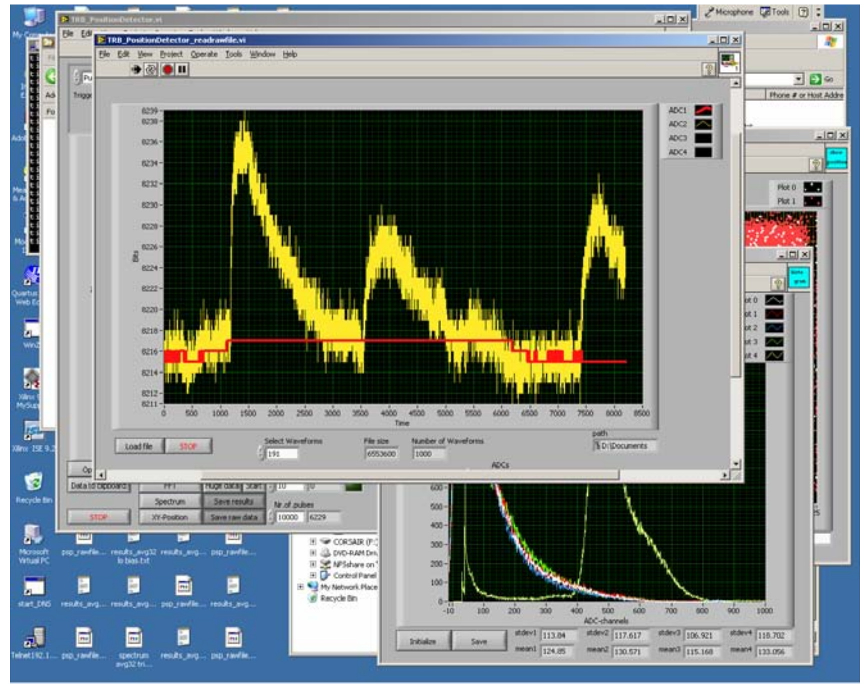






Results: Baseline

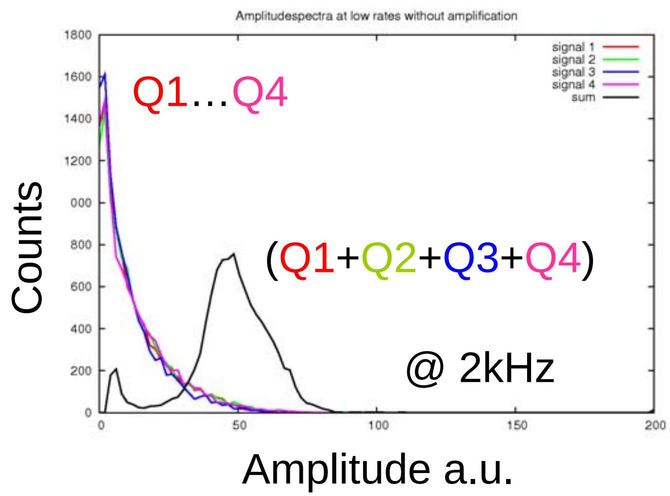


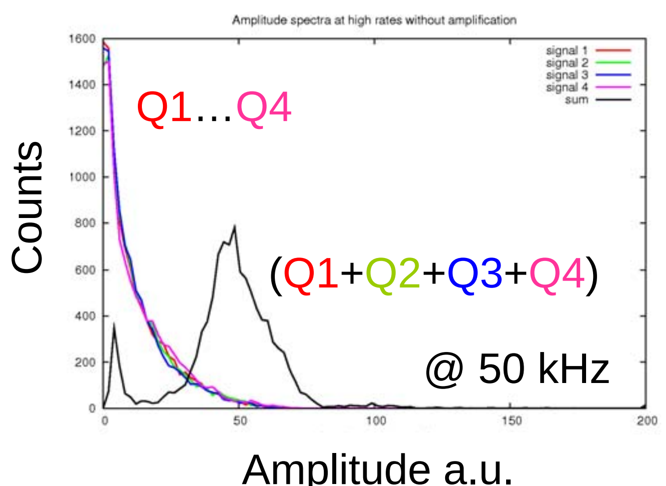


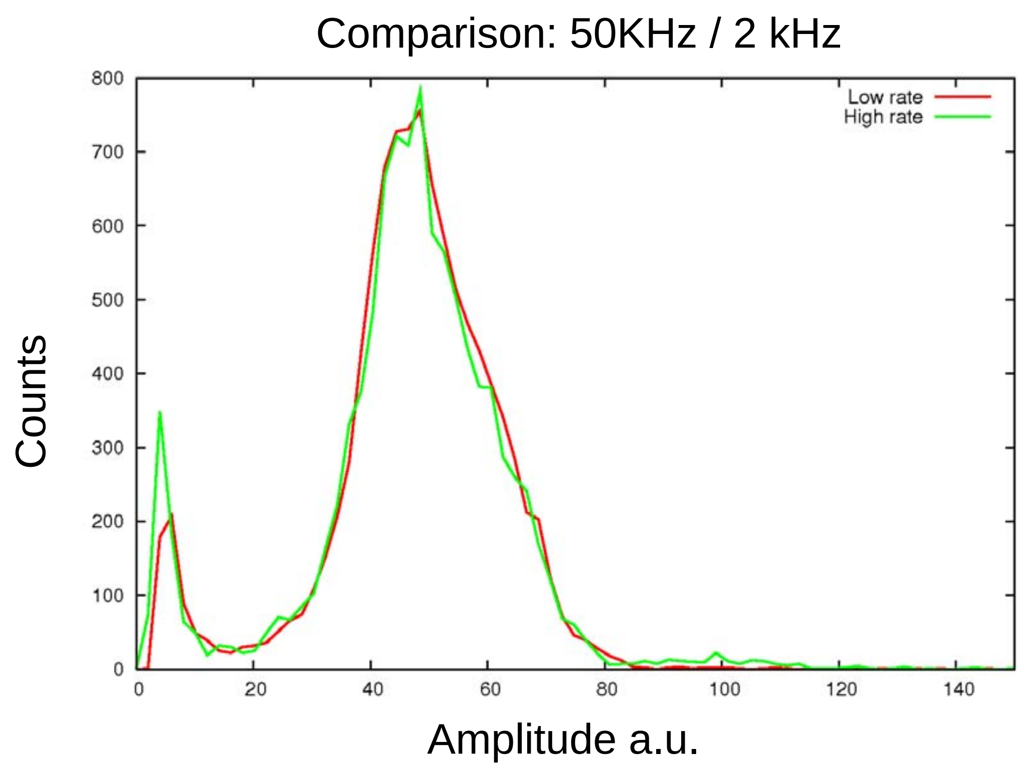
Baseline follower works !
(Bimodal Filter)

Treatment of double hits !

Results: Amplitude → ΔE

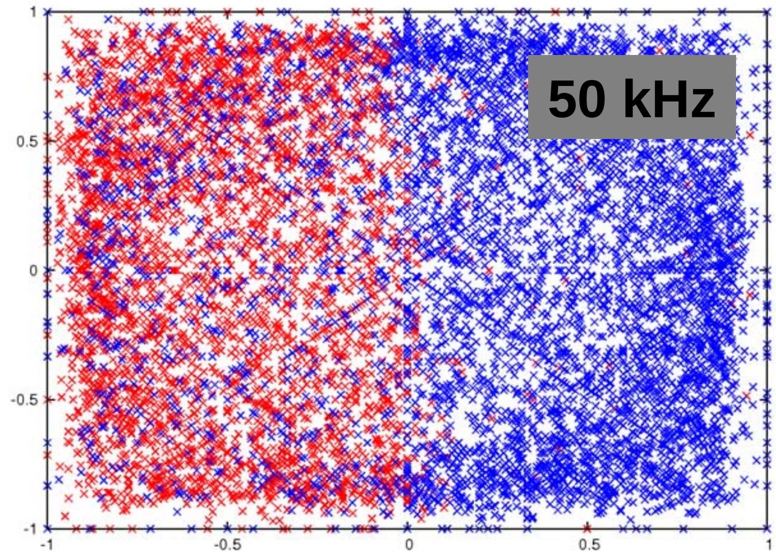


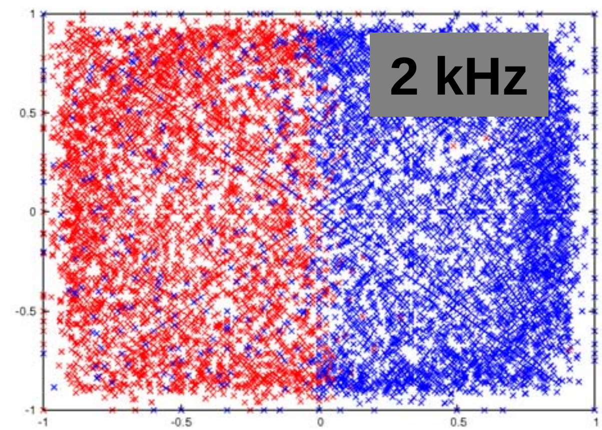


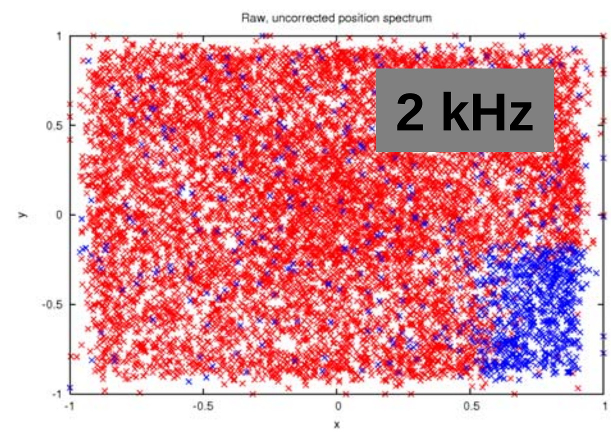


Gain matched amplitude spectra
No degradation with rate !

Results: Position







minimal distortions

Online reconstruction of positions:

i. @ full rate (i.e. 50+ kHz, theoretical limit: ADC speed !)

ii. no correction yet

→ development of a "slow process"

Summary / GET@R³B

- Current DAQ versatily system:
  - delayed coincidences via complex time stamps
  - triggered (digitally preprocessed) data
  - …
- GET inclusion → Mutant: external BuTiS clock
  & White Rabbit Labeling
- L0 trigger (trigger types)
- L1 trigger
  (latency: max ~ t_{drift} + transfer via CoBo toMutant ?)
- SYNC, PHYS, DIAG triggers ?