Detectors, DAQ and slow control issues at the SuperFRS

H.Simon

AIMS: detector system used for

1. initial beam steering → ACS/FESA
   → simple, reliable, slow control interface

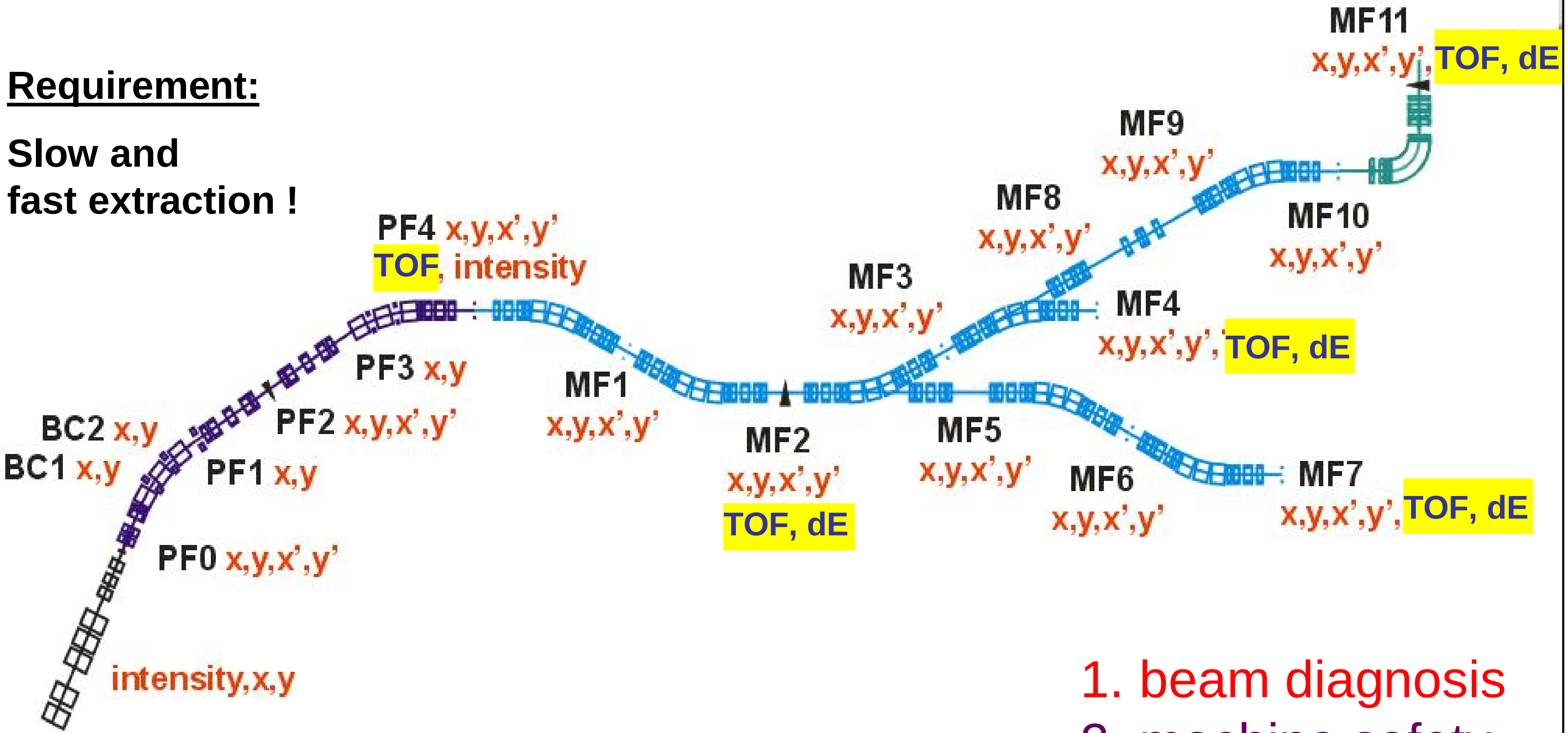
2. machine safety → ACS/FESA
   → slow control interface, interlocks

3. part of the experiments → MBS/DABC/EPICS
   → interface to DAQ system

Detector Instrumentation of the SuperFRS

Requirement:

Slow and fast extraction !



1. beam diagnosis
2. machine safety
3. experiments

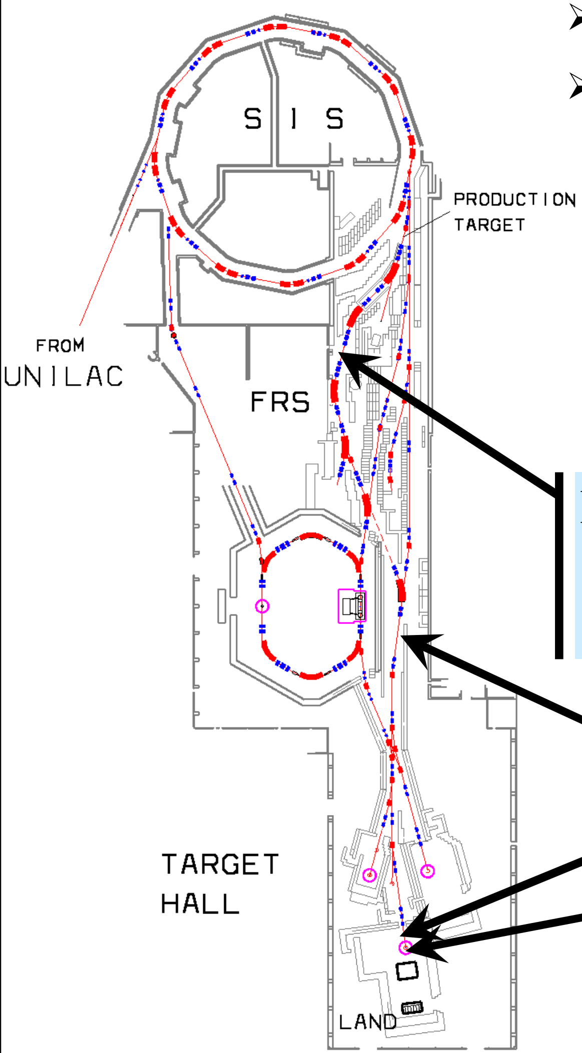
10^{12} /s <10^{10} /s <10^{9} /s <10^{7} /s <10^{5} /s

FAIR

Continous beam ID is integral part of experiments

Example: ^{132}Sn PDR studies

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

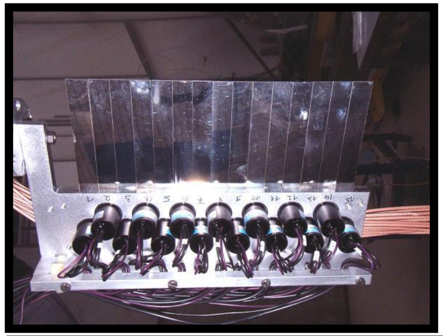


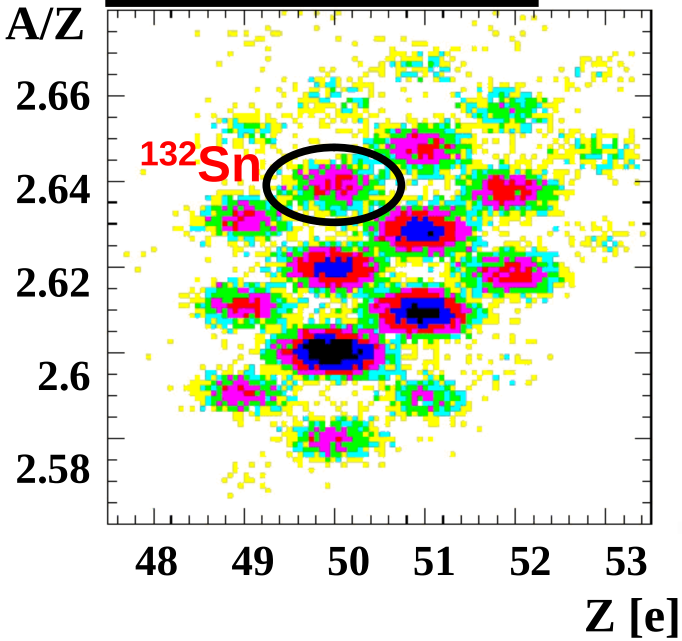
$$\frac{A}{Z}=\frac{m_u c}{e}\frac{B\rho}{\beta\gamma}$$

Bρ – from position at middle focal plane of the FRS

β – from TOF

Z – from ΔE





NO CHARGE STATES !

Bρ-ΔE-TOF method: Requirements

$B\rho = A/Z \cdot \beta \cdot \gamma$ → A/Z, P

$TOF = L/\beta$ ↗ ↘

$\Delta E \sim Z^2/\beta^2$ → Z

Pos res. $\sigma \leq 1$ mm

Timing res. σ: 50 ps

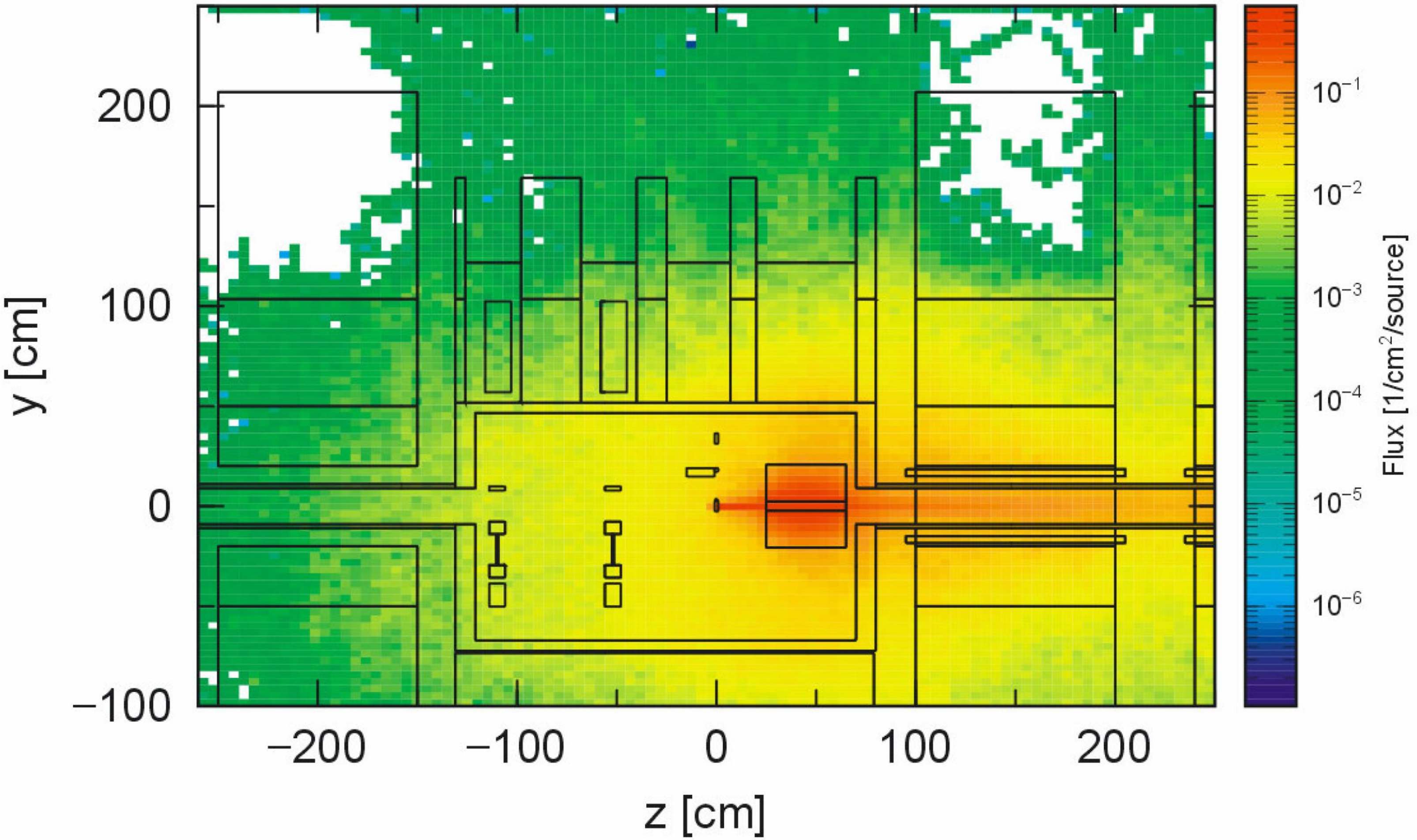
ΔE resolution σ: 1-2 %

- Position: Wirechambers (single event readout)/Diamond
- ΔE: MUSIC/TEGIC
- TOF: Plastic/Diamond

Standard detectors at the FRS

- Beam diagnostics : Current Grid (CG)
- Intensity : Secondary Electron Emission Transmission Monitor (SEETRAM)
- x,y : Multi Wire Proportional Chamber (MWPC)
  ΔE : Multi Sampling Ionization Chamber (MUSIC)
  Tof : Scintillators

Radiation environment target area



Detector Scheme for Super-FRS target area

available/possible systems

Fast extraction		Slow extraction
	Intensity	
Resonance Transformer		Cryogenic Current Comparator (SQUID)
Diamond (single crystal, current readout)		SEETRAM
		Diamond (poly crystal & particle)
	Position	
Pickups		
	Profile	
Beam induced fluorescence(BIF)		BIF
Rest Gas Monitor (RGM)		RGM
Current Grids		Current Grids/Wire chambers
	Monitoring	
Camera on target (IR)		Camera on target (IR)

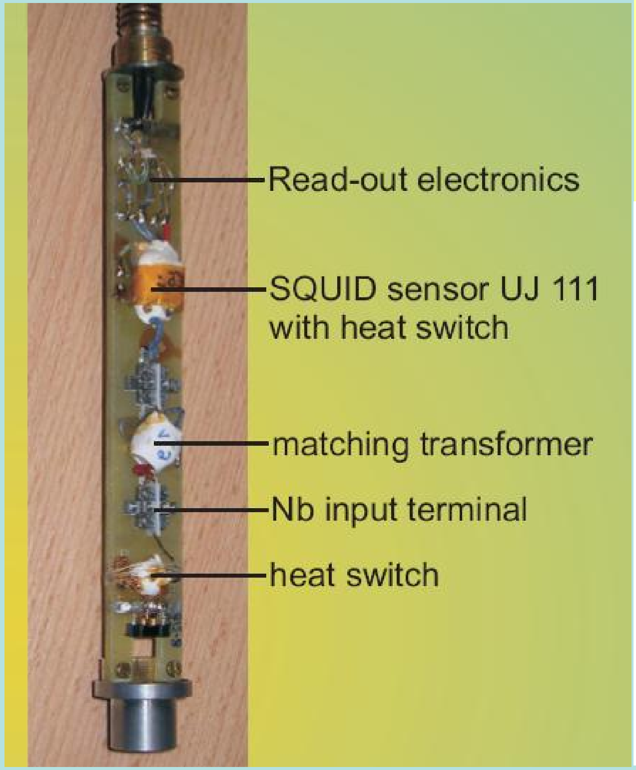
full intensity | *reduced intensity (< about 1 nA)*

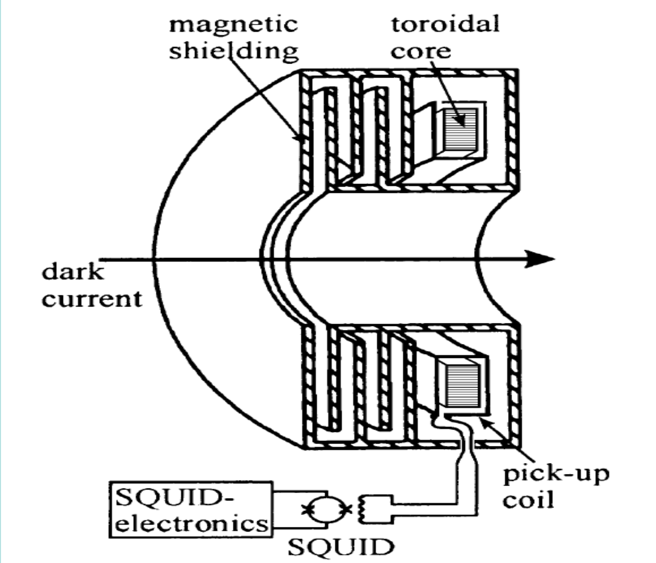
Cryogenic Current Comparator

W. Vodel , R. Neubert , S. Nietzsche , R. Nawrodt , K. Knaack , K. Wittenburg
A. Peters

- About 100 k€ / system
- > 1nA, pulse to DC

The design of the CCC is realized as co-operation of
DESY Hamburg, Jena University and
GSI Darmstadt.



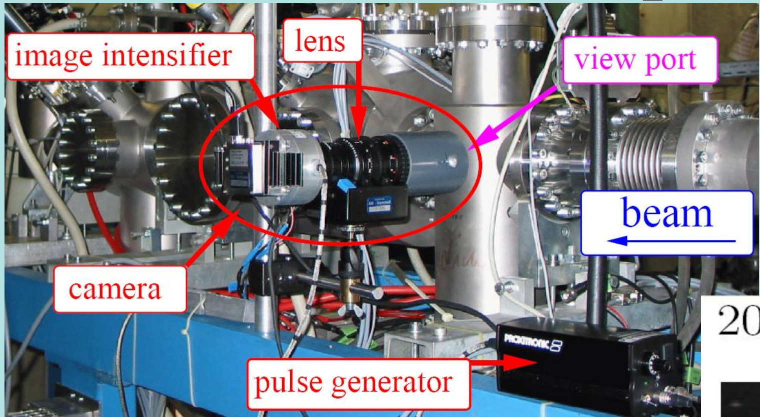


- R&D: Radiation Hardness/Shielding of SQUID

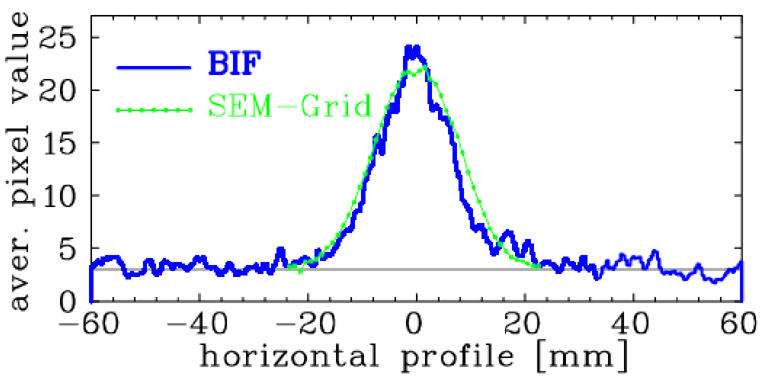
Beam Induced Fluorescence

P. Forck / GSI

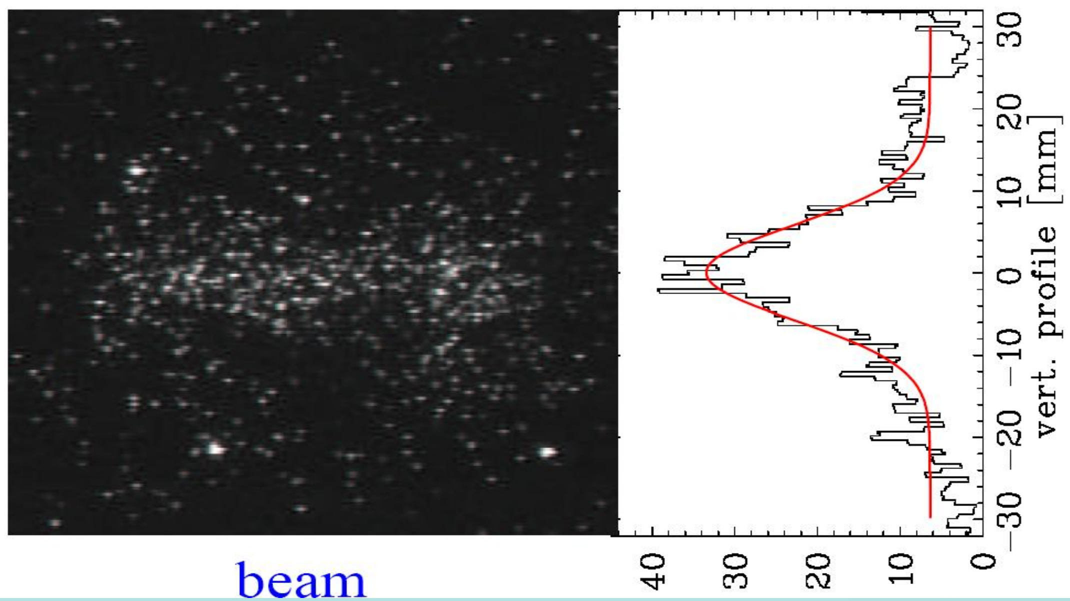
- about 100 k€ / system
- Optical imaging of a N_2-filled test volume (MCP + camera)



@UNILAC

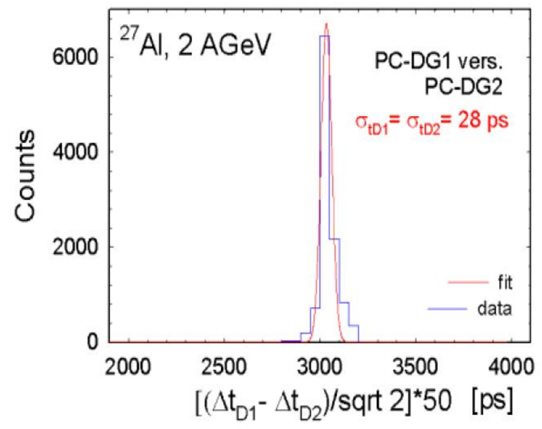


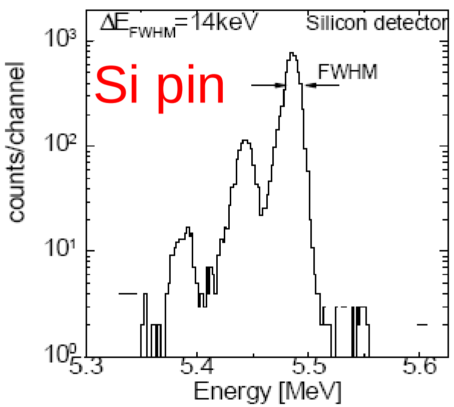
200 μs Ar^{11+} beam of $I = 700\ \mu$A with 6 MeV/u

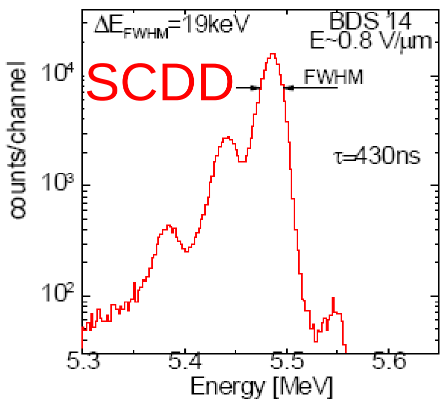


Throughout the separator:
Diamond Detectors

- current readout for single crystal (a few mm²)
- cheaper polycrystaline diamonds (a few cm²)
- very good homogenity and radiation hardness
- price from a few 100 €/cm² to 1000 €/cm²
- expertise inhouse



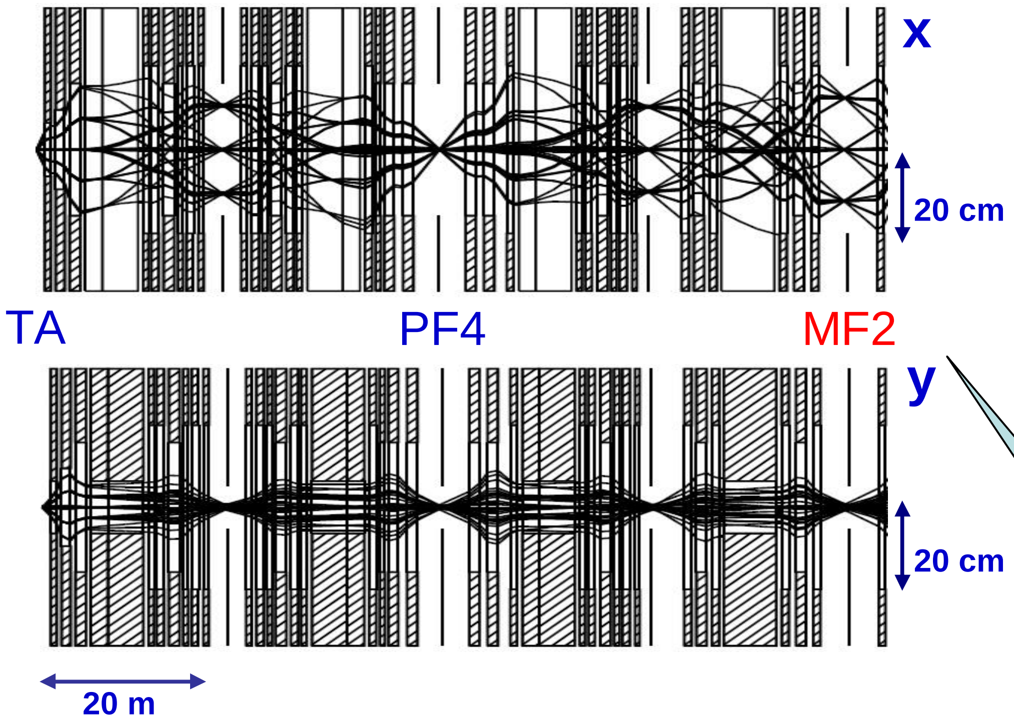




M. Pomorski,
E. Berdermann
et al. Nordhia, RD42

Detector sizes: Super-FRS

→ dipole gaps 140mm



TA
- (6x12)mm² slow extr.
- (12x72)mm² fast extr.

PF4
- (30x30)mm² slow extr.
- (60x60)mm² fast extr.

MF2
- Dispersive/full appert.
- (380x140)mm²
- slow/fast extr.

MF4
- (90x30)mm²
- slow extr.

MF7
- (120x30)mm²
- fast extr.

MF9
- (90x30)mm²
- slow extr.

Bookkeeping (i)

2.4. 6 Diagnostics

Fluorescent Screen		
Number of elements		1
Overall length	mm	50
Horizontal aperture	mm	100
Vertical aperture	mm	100

CVD-DD (diamond detectors, calibration)		
Number of elements		1
Overall length	mm	100
Horizontal aperture	mm	100
Vertical aperture	mm	100
Rate	Hz	$1 – 500 \cdot 10^6$

Luminosity Monitor (SEETRAM)		
Number of elements		2
Overall length	mm	200
Horizontal aperture	mm	100
Vertical aperture	mm	100
Intensity range	particles/spill	$<10^{11}$

Bookkeeping (ii)

Position Monitor (CG)		
Number of elements		32
Overall length	mm	300
Horizontal aperture	mm	400
Vertical aperture	mm	250
Intensity range (energy deposition)	mW/mm	<100

Tracking Detector (MW)		
Number of elements		32
Overall length	mm	300
Horizontal aperture	mm	400
Vertical aperture	mm	250
Rate	kHz	<100

Capacitive Pick-up		
Number of elements		2
Overall length	mm	300
Horizontal aperture	mm	150
Vertical aperture	mm	150
Intensity range	particles/spill	$<10^9$

MUSIC Detectors		
Number of elements		4
Overall length	mm	500
Horizontal aperture	mm	400
Vertical aperture	mm	80
Rate	kHz	200 ... 1000

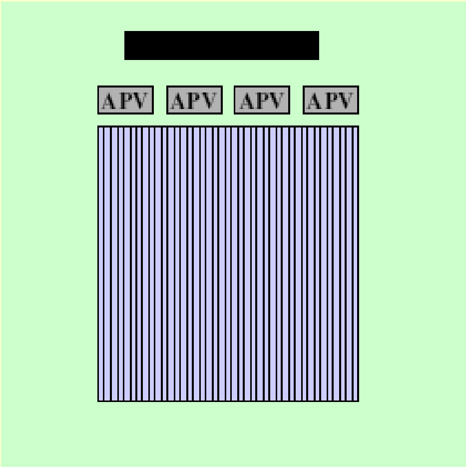
ToF (diamond detectors, PC-CVD-DD)		
Number of elements		4
Overall length	mm	200
Horizontal aperture	mm	400
Vertical aperture	mm	50
Pitch	mm	1
Time resolution	ps	<50

R^3B diamond detector layout:

→ MF2 SuperFRS: × 8(h)

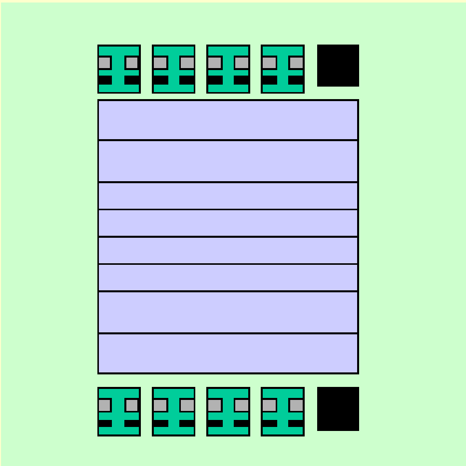
Test exp. 04/08

R. Gernhäuser (TU-München)



tracking layer:

- 50 x 50 mm, d = 100 μm, PC-CVDD
- 140 μm pitch (125μm strips, 15 μm gap)
- only digital position information
- multiplexed readout in vacuum



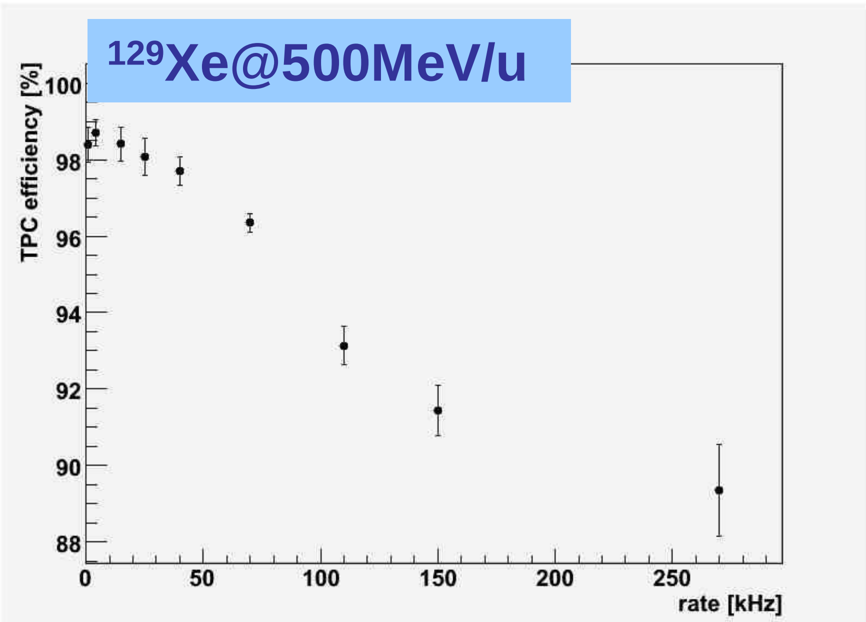
timing layer:

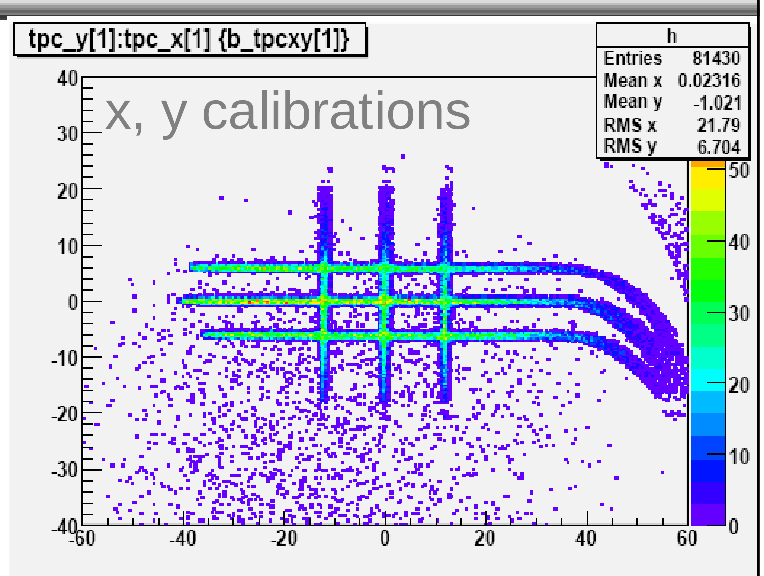
- 50 x 50 mm, d = 100 μm, PC-CVDD
- 8 rate matched strips, y information, trigger
- analog preamplification in vacuum
- discriminator @ 5 m distance

Time Projection Chamber

- CUB Bratislava

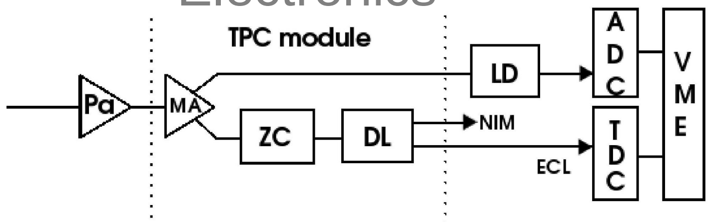
- (240x100) mm^2 active area
- Gas P10 at 1 atm
- Integrated delay lines (2x-pos, 4y-pos)
- σ_x ~ 0.1 mm, σ_y~ 0.05 mm





- VME standard electronics
- 90% efficency at ~100kHz

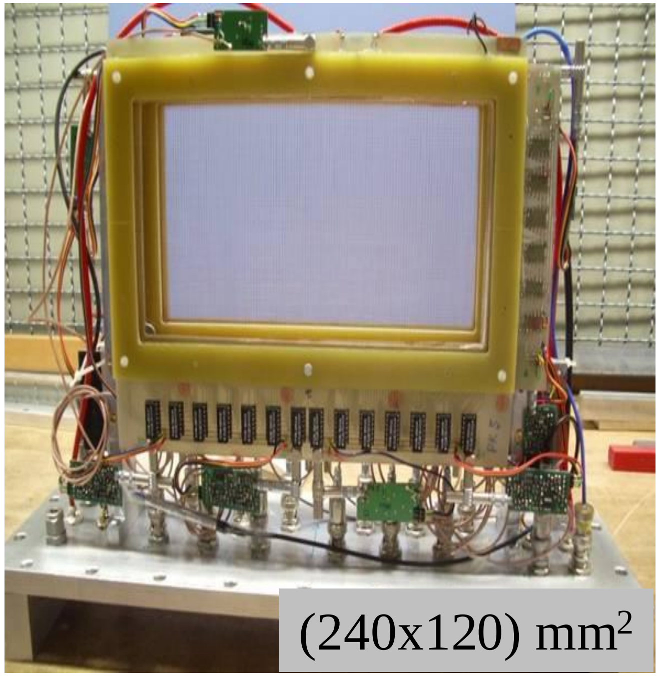
Electronics



Beam Profile Detector - CUB Bratislava

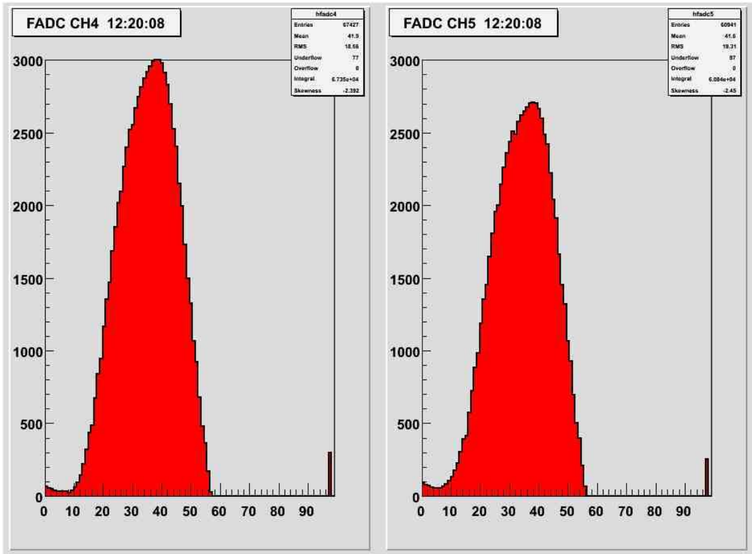
for intense fast extracted and slow extracted beams

- Basic module (120x120) mm^2
- 5mbar < gas Ar+(10%)CO_2 < 1bar
- Wires 2mm pitch directly connected to delay lines



(240x120) mm^2

Beam profile



^{12}C@200-400 MeV/u

10^4- $1.6\cdot10^9$ ions/spill

Spill length: 300 ns

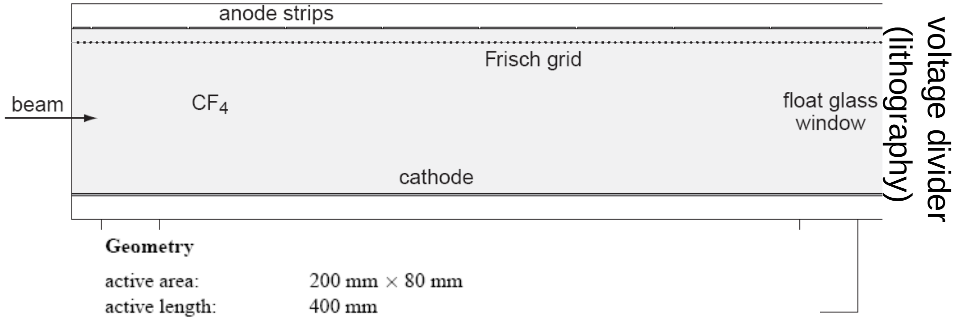
FADC SIS3301(100MHz)

A. Procházka, C. Nociforo *et al.*

Missing items:

FRS MUSIC

- Fast ΔE counter
  100 kHz – 1MHz, res. 1-2%,
  large dynamic range
  (no MIPS Z → ~100)
  - TEGIC (RIKEN, ca 1MHz)
  - Silicon stacks ?
  - sc-CVDD ?
- Fast Tracking detectors
  large dynamic range
  - PC-CVDD with continous readout
  - ?
- Fast TOF (currently SCI, ca. 10MHz)
  large dynamic range
  - PC CVDD
  - ?



Geometry

active area:	200 mm × 80 mm
active length:	400 mm
anode:	8 anode strips with 50 mm active length each
total gas length:	420 mm
entrance windows:	float glass D263 (DESAG), thickness 210 μm
distance anode – grid:	7 mm
grid wire diameter:	100 μm
grid wire spacing:	1 mm

Gas supply

counting gas:	CF_4 (tetrafluoromethane)
counting gas pressure:	atmospheric pressure (≈1 bar)
maximum differential pressure:	± 5 mbar to atmospheric pressure
total gas volume:	8.6 l
recommended gas flow:	4 – 6 l/h
typical drift velocity:	10–12 cm/μs @ 1kV/cm for electrons
gas supply connectors:	Swagelok tube fittings, 8 mm

High voltage supply

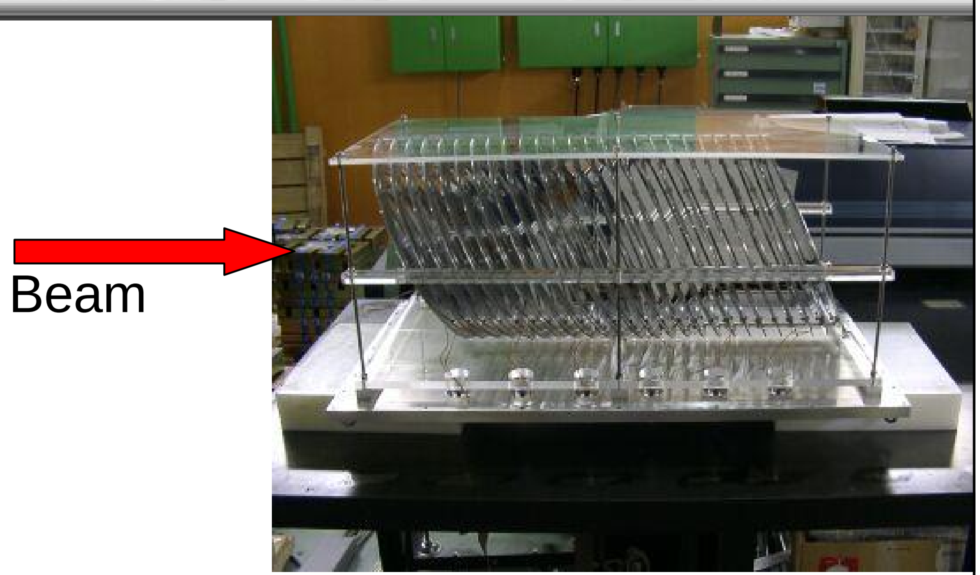
maximum input voltage:	-10 kV
operating input voltage:	-8 kV – -10 kV
field homogenization current:	32 μA @ 10 kV
high voltage connector:	SHV connector

~200 kHZ

Missing items:

TEGIC

- Fast ΔE counter
  100 kHz – 1MHz, res. 1-2%,
  large dynamic range
  (no MIPS Z → ~100)
  - TEGIC (RIKEN, ca 1MHz)
  - Silicon stacks ?
  - sc-CVDD ?
- Fast Tracking detectors
  large dynamic range
  - PC-CVDD with continous readout
  - ?
- Fast TOF (currently SCI, ca. 10MHz)
  large dynamic range
  - PC CVDD
  - ?



K. Kimura et al., Nucl. Instr. and Meth. A538(2005)608

P10 425mm normal pressure
Electrodes(anode/cathode) 4μm×25 Mylar
14 mg/cm^2
Distance(anode-cathode) 2cm
Detector Window 150μm Kapton

~1 MHZ

Readout using MBS

- Basic system (http://daq.gsi.de)
  - Trigger module + VME processor
    Modules (CAMAC, VME)
- Integrates foreign DAQ Systems
  (via Time Stamps)
- various FEE integrated

  via GTB/SAM (Bus / DSP&FPGA VME board)

lightweight, scalable, N x M, full VME speed
allows for staged transition !!!
SuperFRS, R³B, PRESPEC(High/Despec)

APV Frontend (triggered) - M. Böhmer, TUM

- APV25-S1 RAL
  → CMS (Si, …)

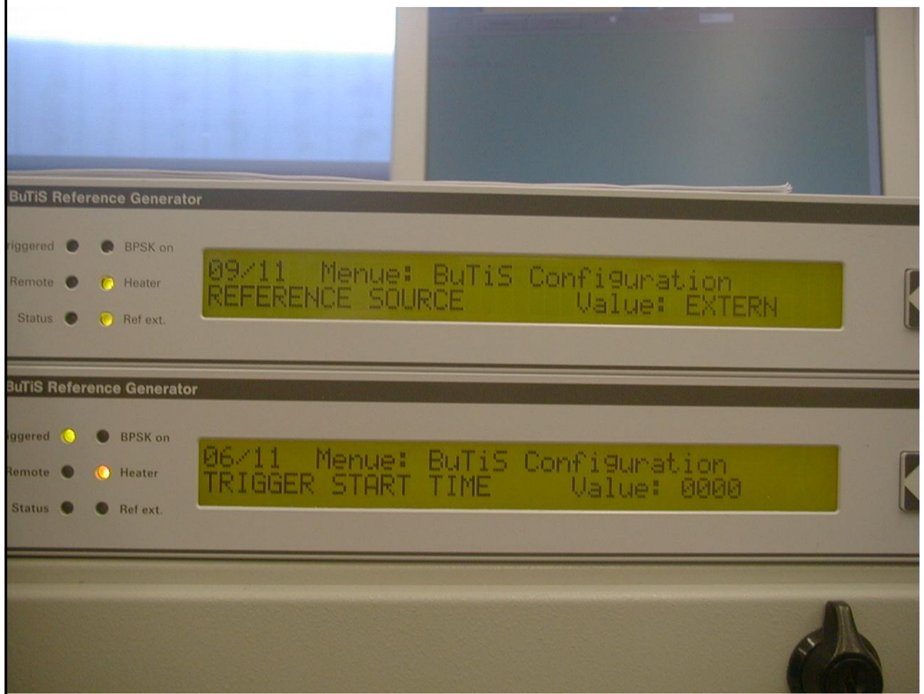
(128 channel analogue pipeline
192 columns analogue storage.
50 ns shaped pulses
100mV / 25,000 electrons
40MHz sample
Useful data marked
test pulser, pos/neg, …)

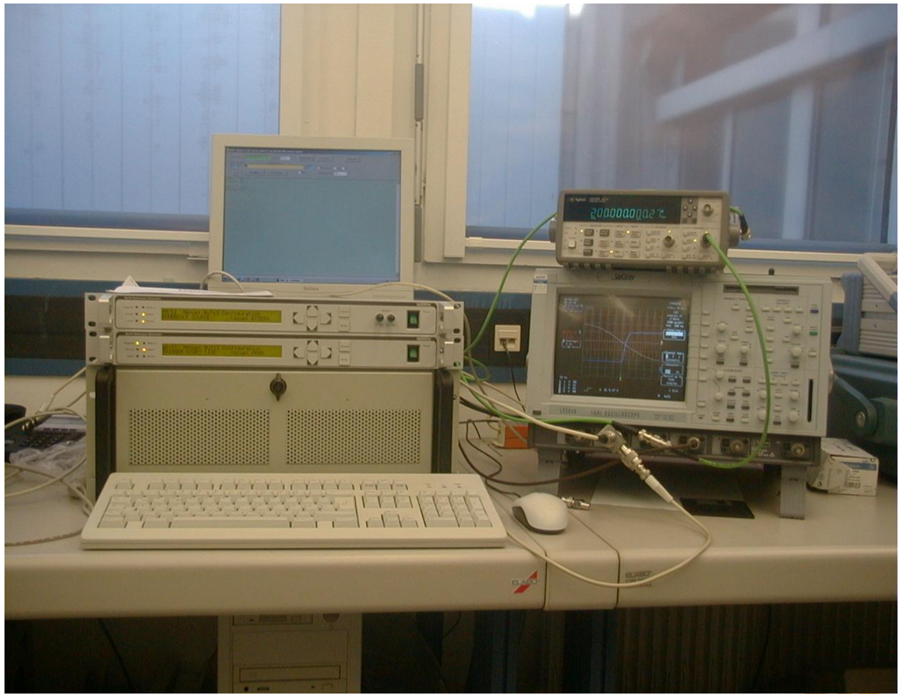
- I²C control
- Clck, Trg
- Low power consumption
- Readout to MBS (ADC/FPGA/DSP)

Extended Time distribution (BuTiS)

P.Moritz/GSI

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

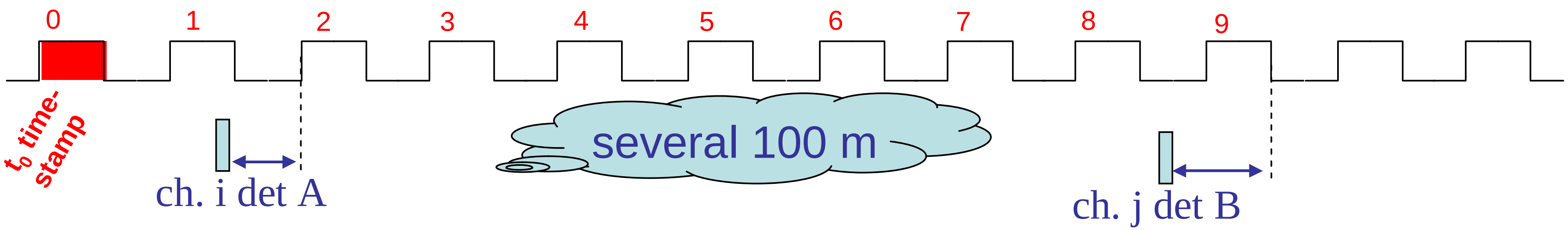


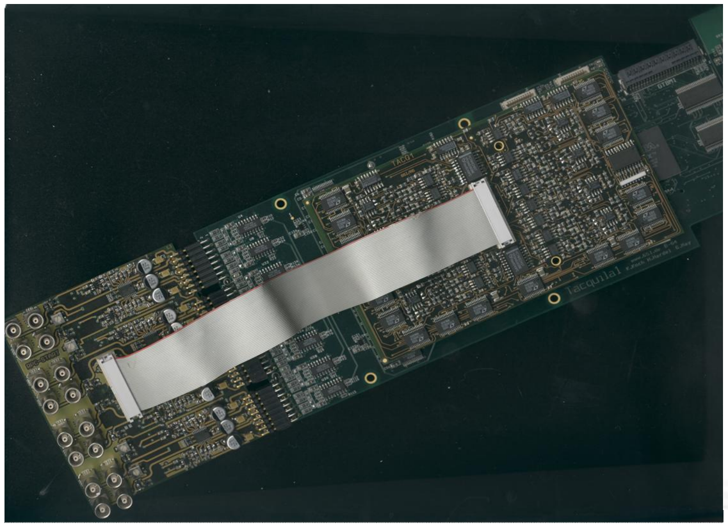


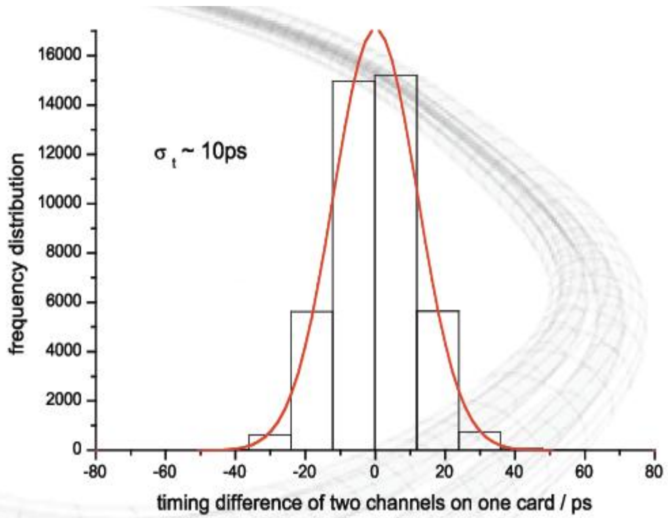
Precision timing (<50ps) vs. Campus Clock

- avoid extended cabling and dead time domains

➔ free running time stamped systems SuperFRS -- Caves







Timing FEEs:

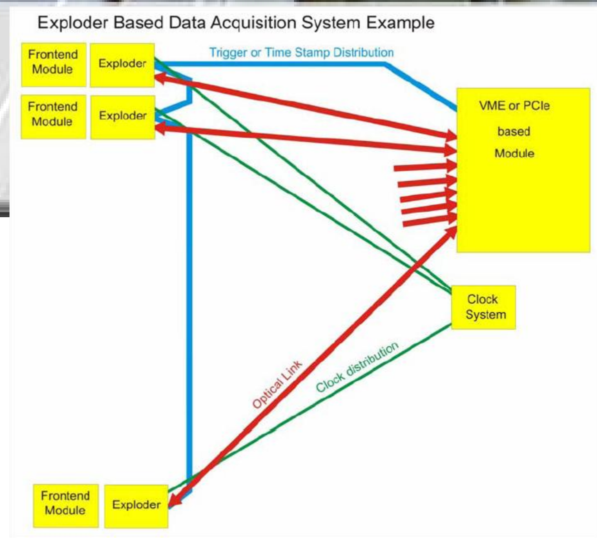
Tacquila system
(ASIC FhG/GSI)

New systems
(ASIC dev. GSI)

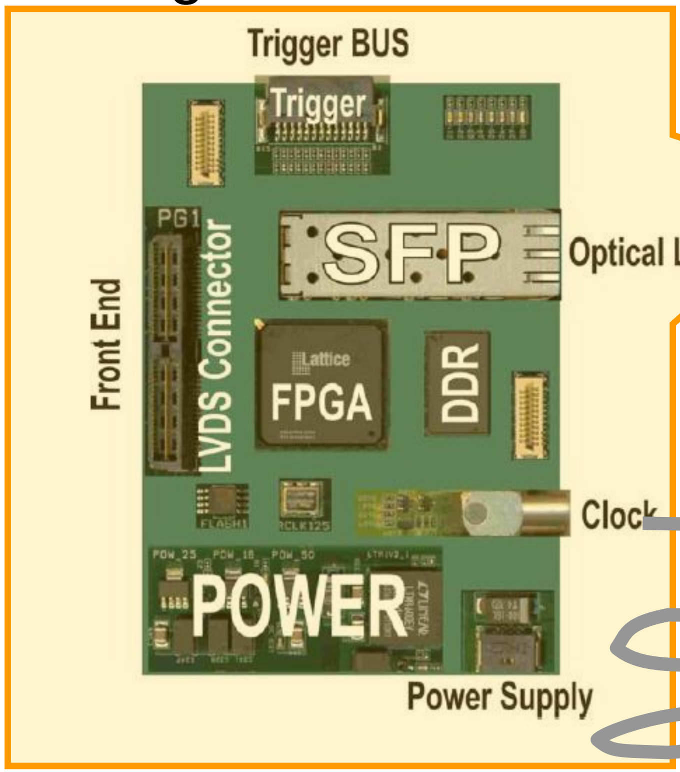
Readout Chain revisited …

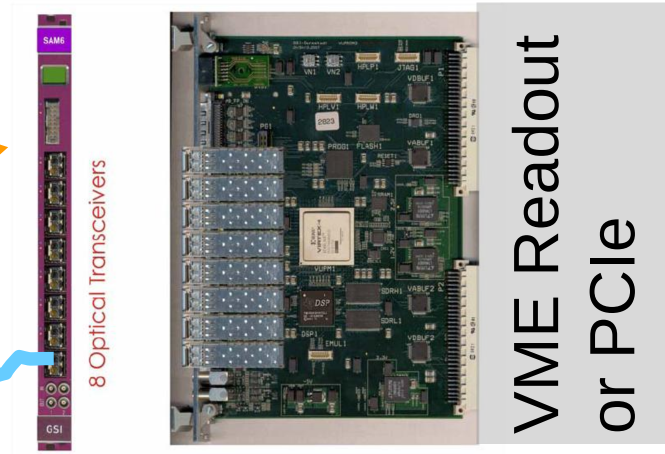
- NUSTAR uses MBS, a (in principle) triggered DAQ system …

➔ preprocessing



any LVDS input





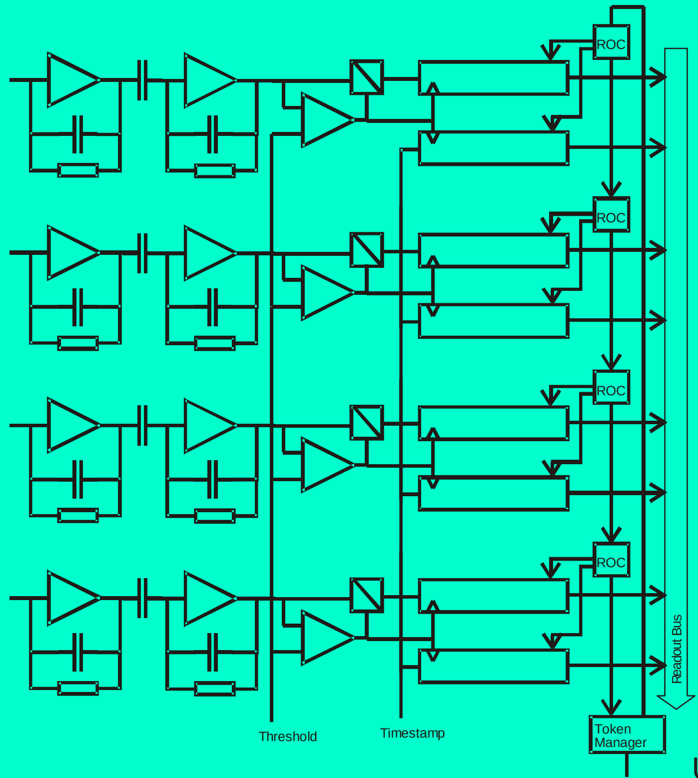
Token Ring Scheme (NXYTER)

➔ "deadtime free"

Ch. Schmidt (GSI)

ASIC Labor Heidelberg

Sparse & derandomized readout



Ulrich Trunk
Physikalisches Institut der Universität Heidelberg

- Periodic readout at 20MHz
- Token asynchronously passes from channel to channel in search of data
- Within one readout cycle token could pass through all channels
- If token encounters occupied channels, data readout is initiated.
- After readout the token passes to the next channel.

→20 MHz/128 Ch ≈ 160 kHz

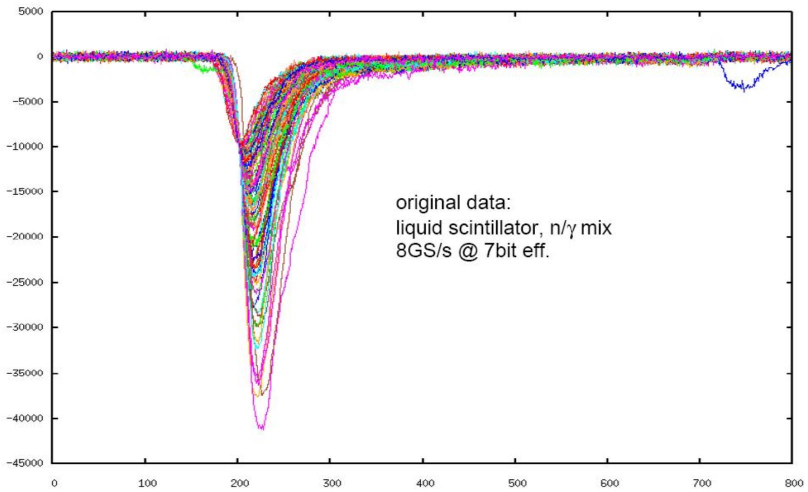
ENOB 10.4

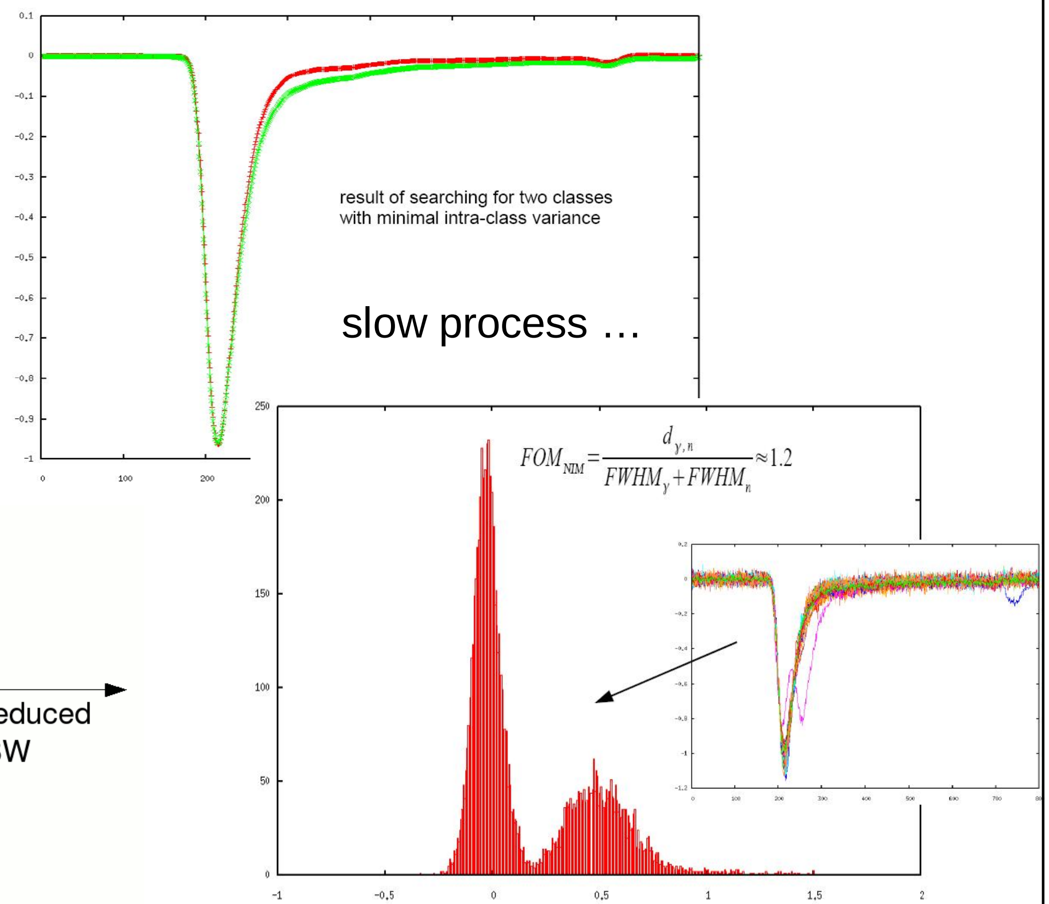
Variety of applications: Test with single wire readout foreseen !

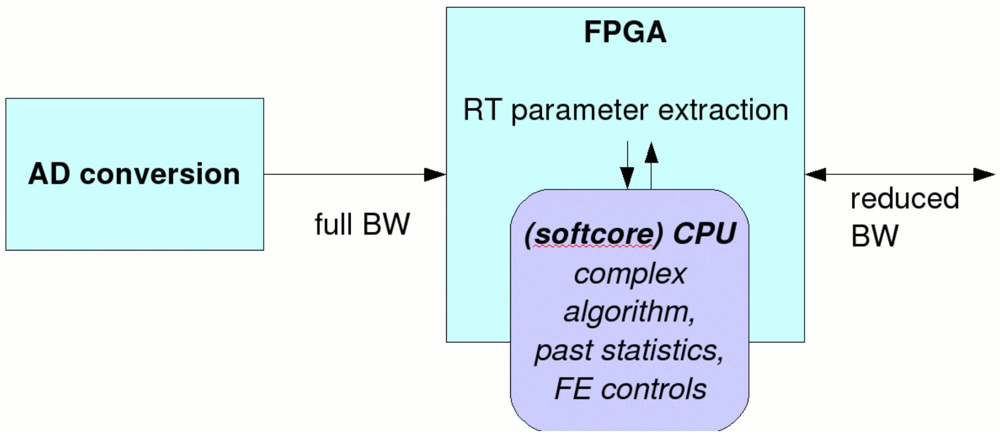
FAIR

Digital Signal Processing (PULSE SHAPE)

M. Vencelj et al. (JSI)



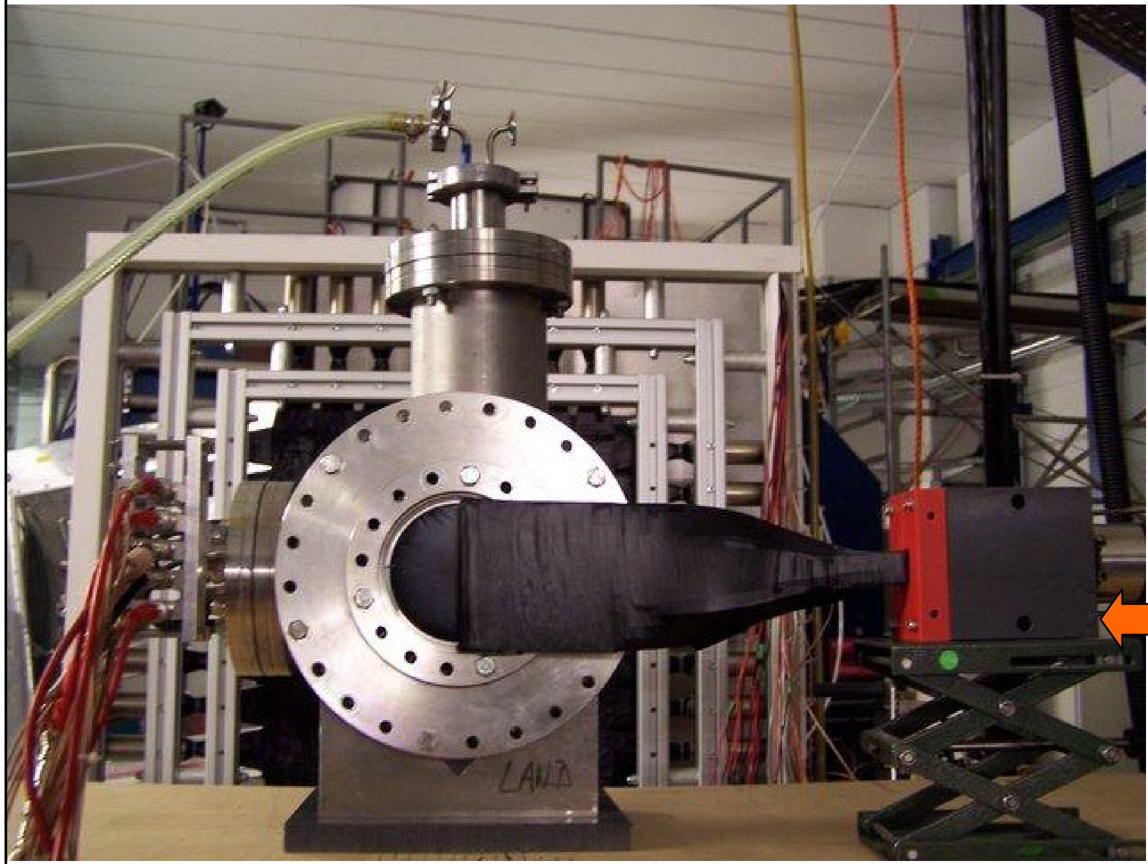


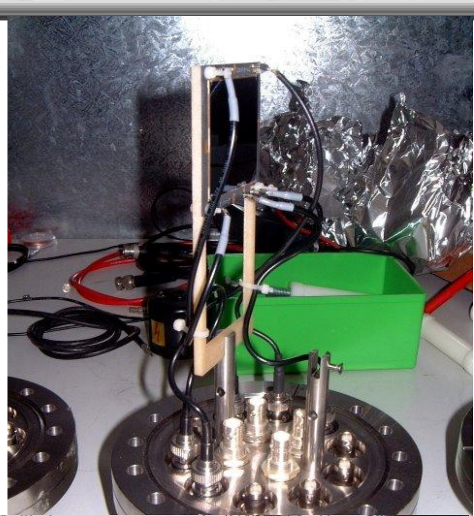


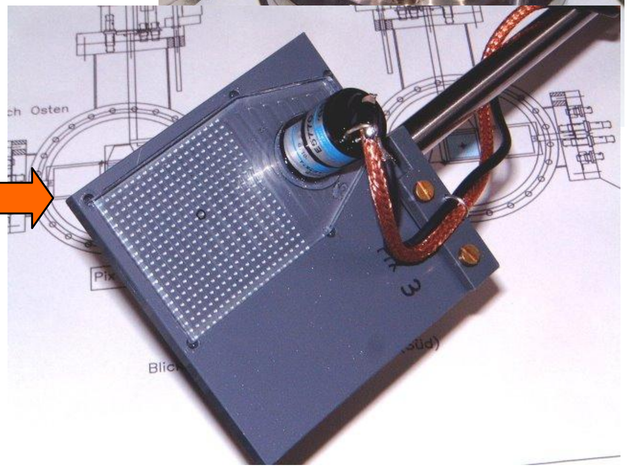
similar: energy loss/position

→ fast pos. sens. PIN tracker project (P. Lubberdink, H. Wörtche, H. Simon)

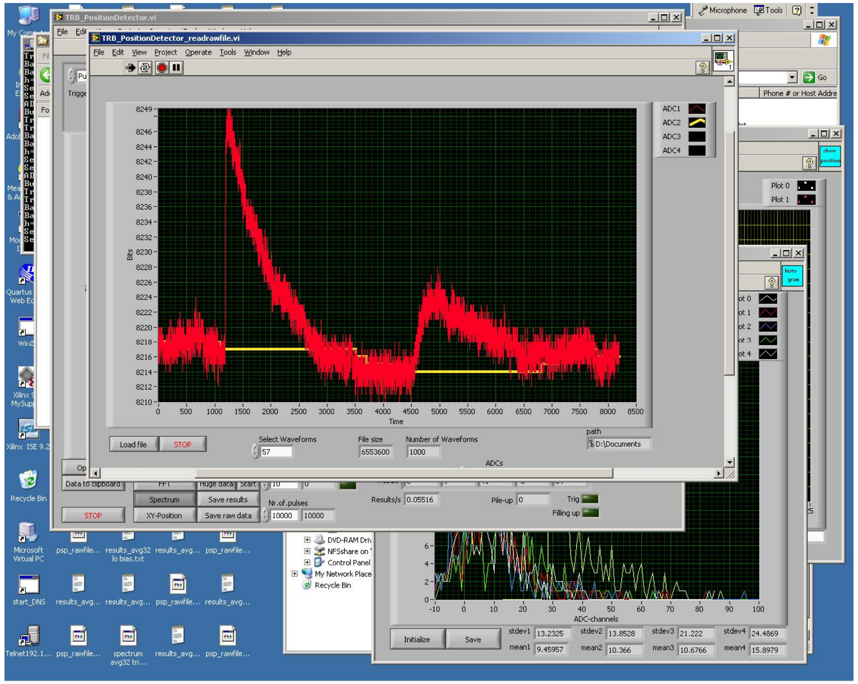
Test experiment S327 (16.-18.4.2008)
^{12}C: 550-700 MeV/u ; 2-50 kEv/s

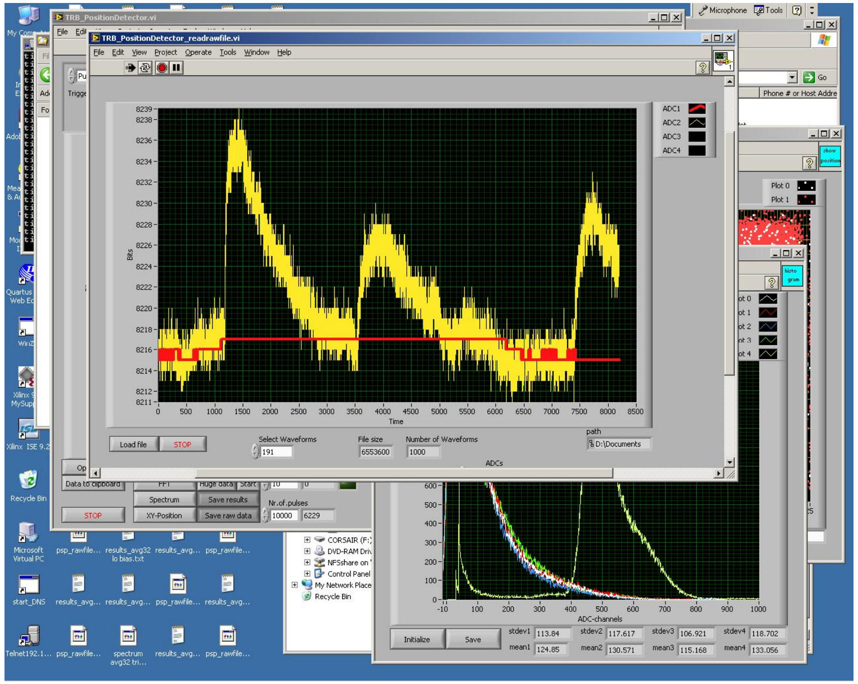






First Results: Baseline

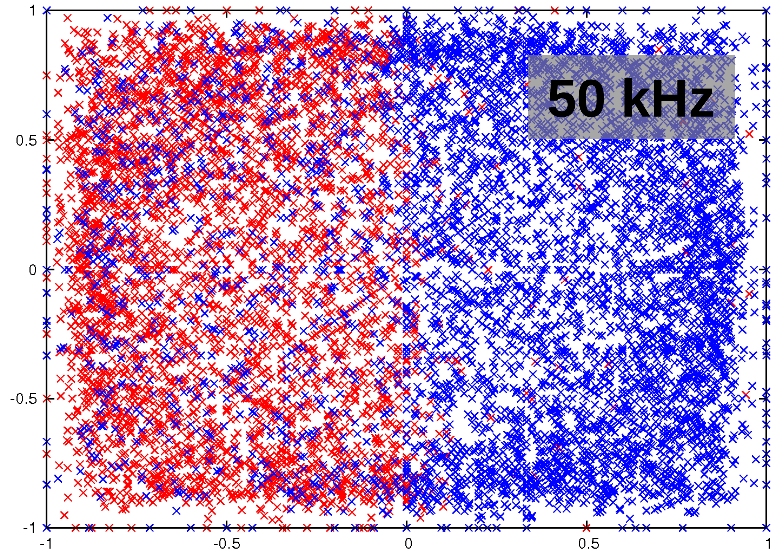


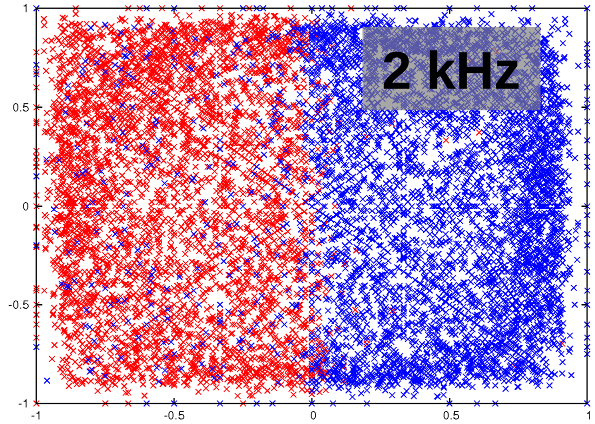


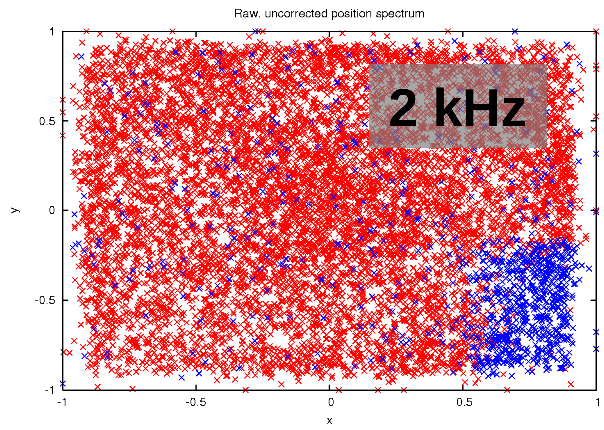
Baseline follower works !
(Bimodal Kalman Filter)

Treatment of double hits !

Results: Position







minimal distortions

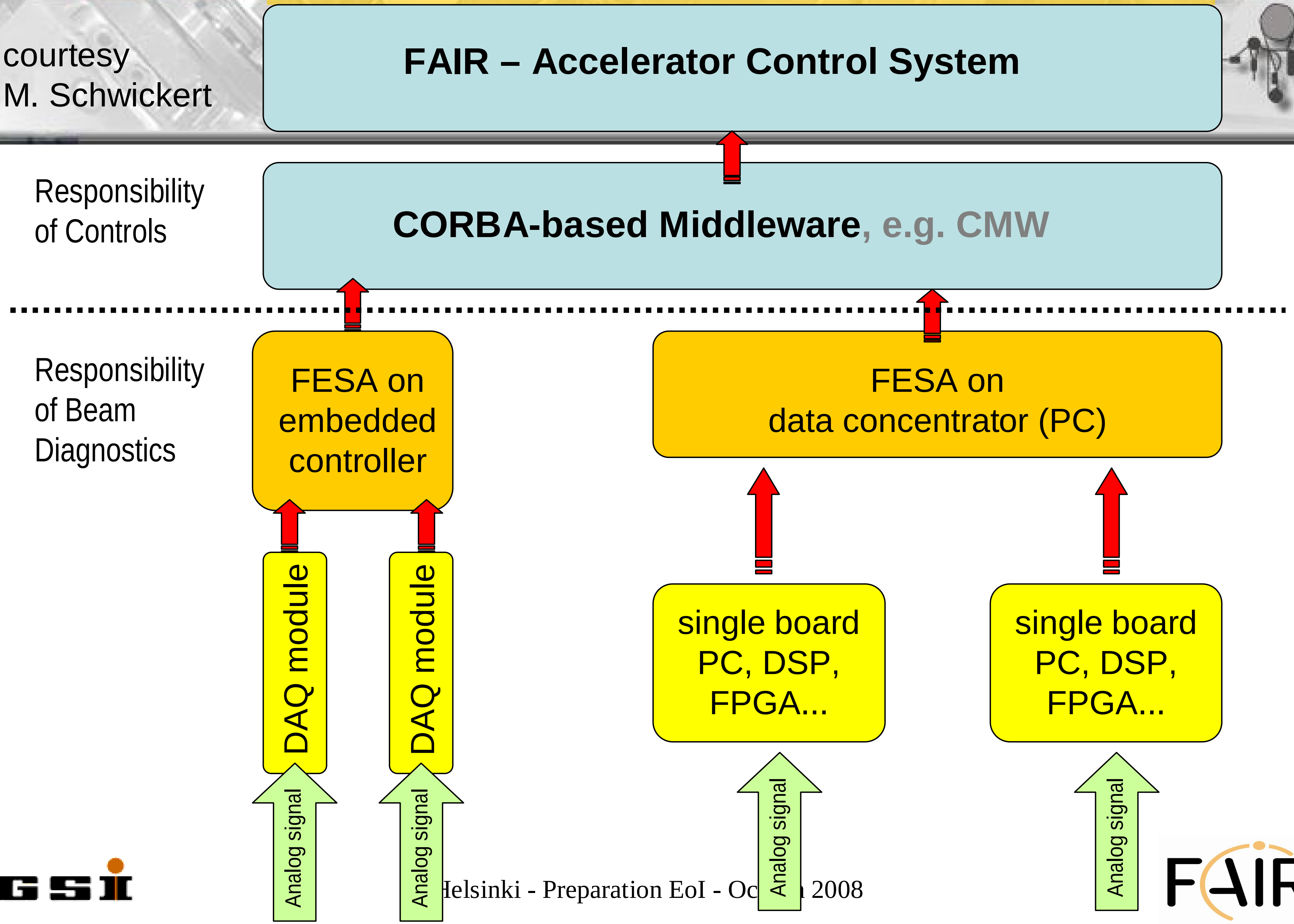
Online reconstruction of positions:

i. @ full rate (i.e. 50+ kHz, theoretical limit: ADC speed !)
ii. no correction yet

→ development of a "slow process"

DAQ Concept for Beam Diagnostics @ FAIR

courtesy
M. Schwickert



Summary

- fast tracking & ID for experiments
  - clean beams required
- most detector systems available (in principle)
  → but better performance would be welcome !
- adaption to Super-FRS needs
- staged implementation
- readout concept → share between
  ACC readout FESA/ACS &
  EXP readout MBS
- interfaces/Procedures for machine safety develop
- fast sampling and PSA (pile up treatment)

Collaborators

- CU Bratislava - B. Sitar et al. (MWs)
- TU Munich - R. Gernhäuser et al. (Diamond)
- JSI Ljubljana - M. Vencelj et al. (PSA)
- KVI Groningen - H. Wörtche et al. (FE-Controls)

GSI

- Detector Laboratory - Ch. Schmidt et al.
- Experimental Electronics - E. Badura et al.
- Accelerator Group - R. Bär, P. Forck, et al.

EoI: Helsinki University (Rad-hard Si/GEM)

ID Detectors at the Super-FRS

beam optics ➔ { size (400x60) mm^2
position resolution ~ 1mm

Fluorescent Screen		
Number of elements		1
Overall length	mm	50
Horizontal aperture	mm	100
Vertical aperture	mm	100

CVD-DD (diamond detectors, calibration)		
Number of elemsents		1
Overall length	mm	100
Horizontal aperture	mm	100
Vertical aperture	mm	100
Rate	Hz	$1 – 500 \cdot 10^6$

Specs ff

Luminosity Monitor (SEETRAM)		
Number of elements		2
Overall length	mm	200
Horizontal aperture	mm	100
Vertical aperture	mm	100
Intensity range	particles/spill	$<10^{11}$

Position Monitor (CG)		
Number of elements		32
Overall length	mm	300
Horizontal aperture	mm	400
Vertical aperture	mm	250
Intensity range (energy deposition)	mW/mm	<100

Specs ff

Tracking Detector (MW)		
Number of elements		32
Overall length	mm	300
Horizontal aperture	mm	400
Vertical aperture	mm	250
Rate	kHz	<100

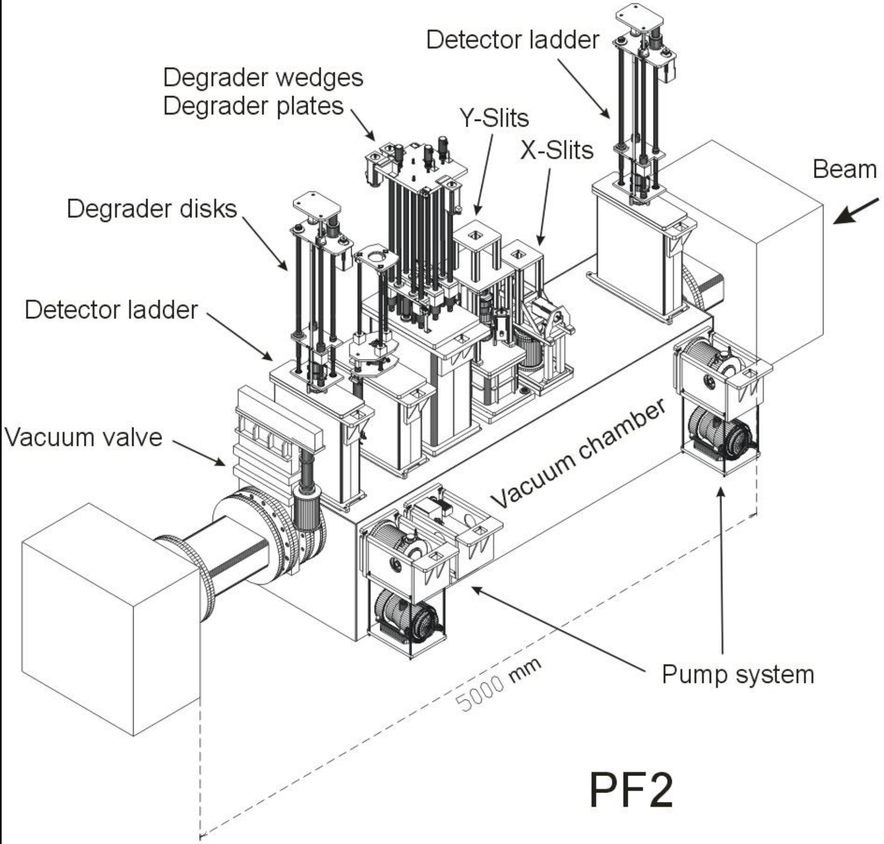
Capacitive Pick-up		
Number of elements		2
Overall length	mm	300
Horizontal aperture	mm	150
Vertical aperture	mm	150
Intensity range	particles/spill	$<10^9$

Specs ff.

MUSIC Detectors		
Number of elements		4
Overall length	mm	500
Horizontal aperture	mm	400
Vertical aperture	mm	80
Rate	kHz	200 ... 1000

ToF (diamond detectors, PC-CVD-DD)		
Number of elements		4
Overall length	mm	200
Horizontal aperture	mm	400
Vertical aperture	mm	50
Pitch	mm	1
Time resolution	ps	<50

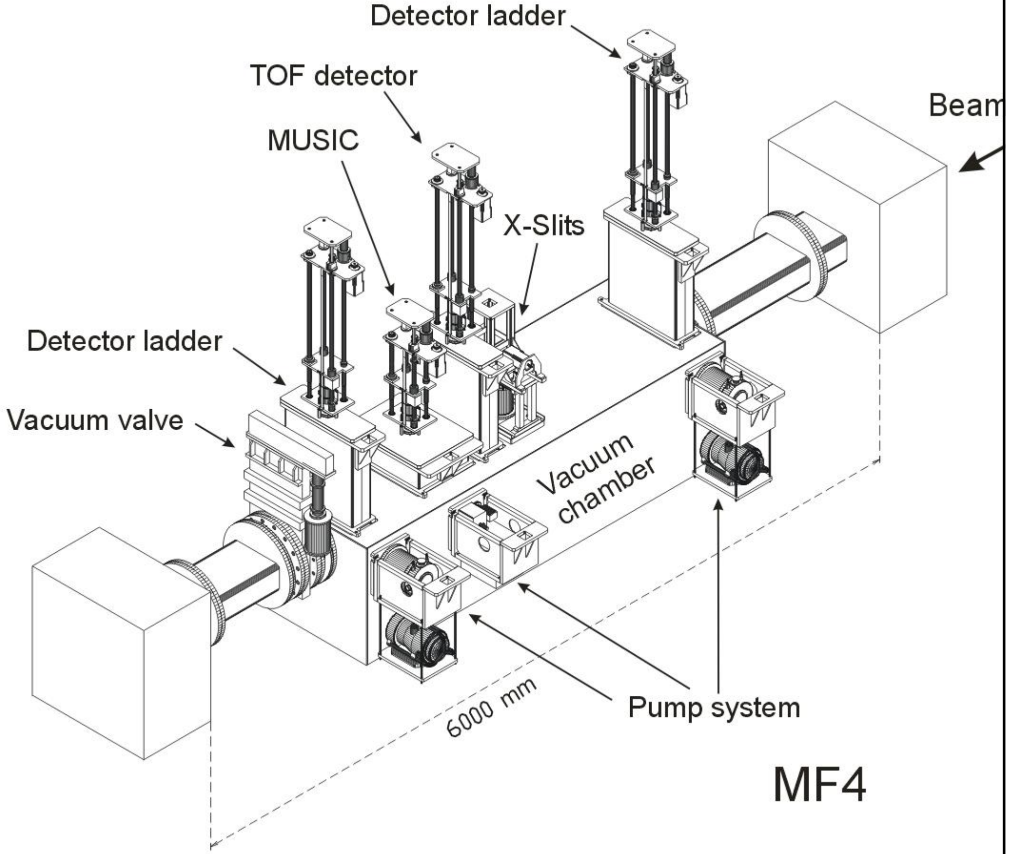
Diagnostic boxes designs



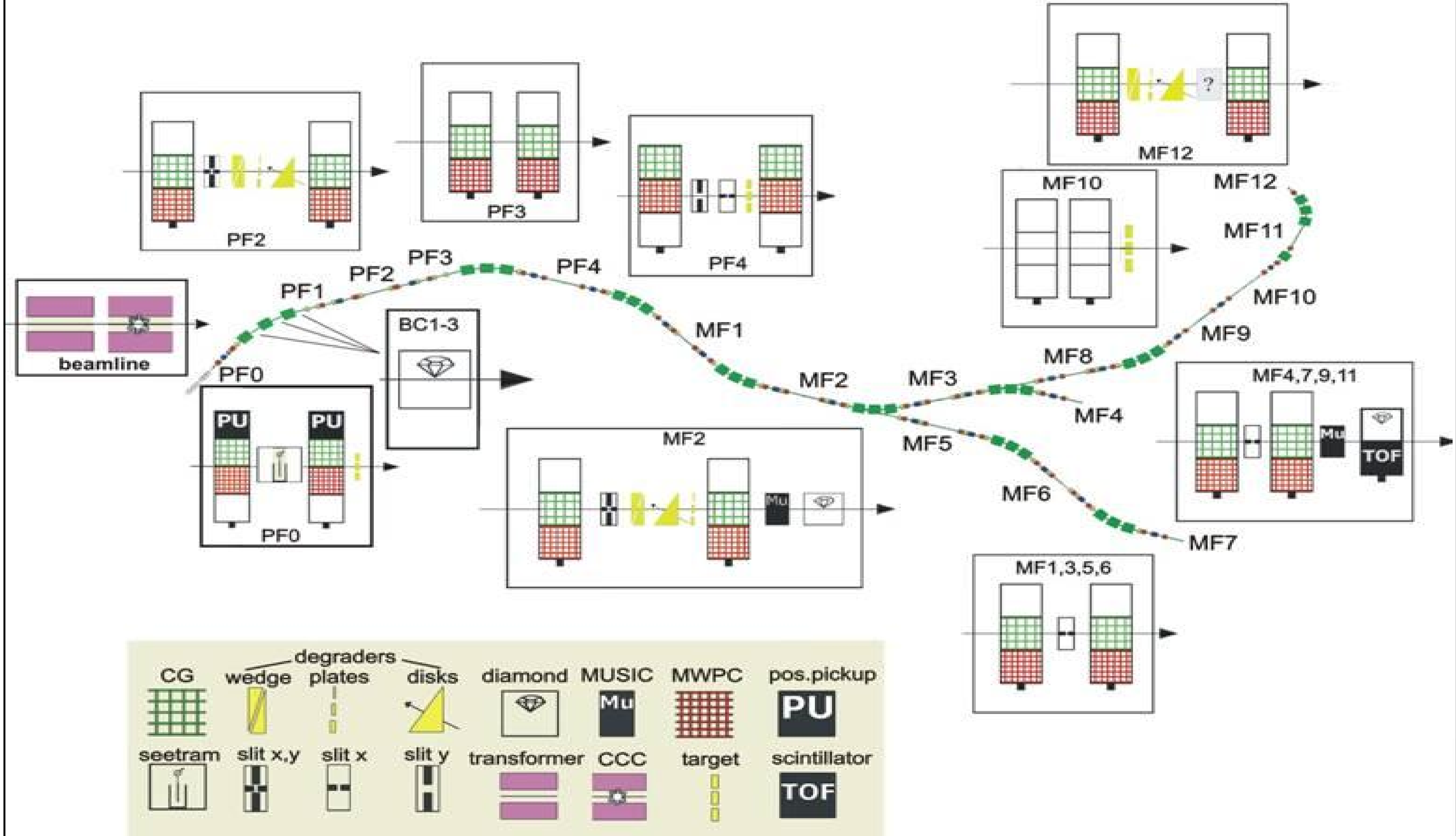
PF2

Beam diagnosis

Beam diagnosis
& experiments



MF4

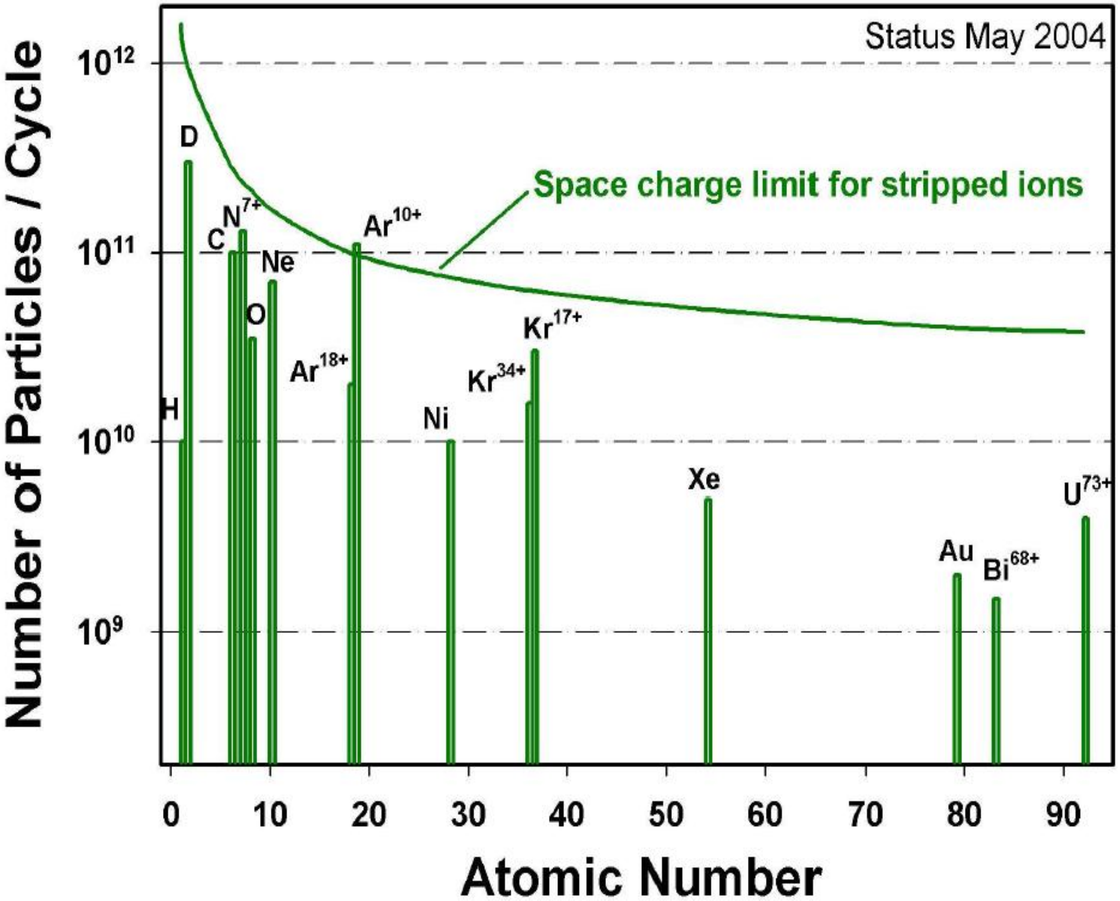


PF2
PF3
PF4
MF12
MF10
MF12
MF11
MF10
MF9
MF8
MF3
MF4
MF2
MF1
PF4
PF3
PF2
PF1
PF0
beamline
BC1-3
PU
PU
PF0
MF2
Mu
MF5
MF6
MF7
MF4,7,9,11
Mu
TOF
MF1,3,5,6
degraders
CG
wedge
plates
disks
diamond
MUSIC
MWPC
pos.pickup
Mu
PU
seetram
slit x,y
slit x
slit y
transformer
CCC
target
scintillator
TOF

Staged implementation

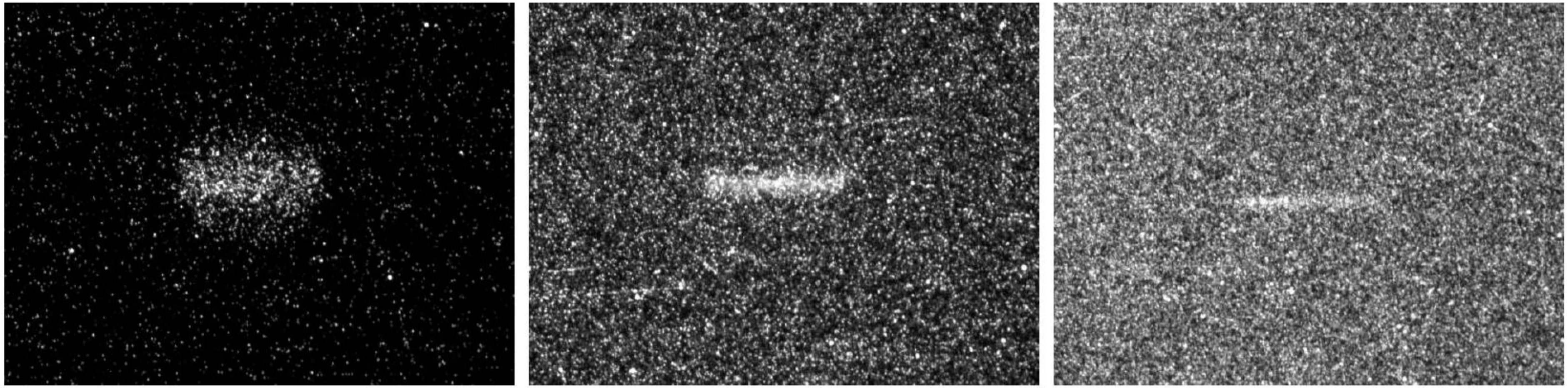
R&D high current admissible for some years!

Fair Stage	today	0 (Existing Facility)
Ion Species	U^{73+}	U^{73+}
Maximum Energy	1 GeV/u	1 GeV/u
Maximum Intensity	$3x10^9$	$2x10^{10}$
Repetition Rate	0.3 Hz	1 Hz
Approx. Year		2008/2009



Applications to beam transport line

P. Forck F. Becker

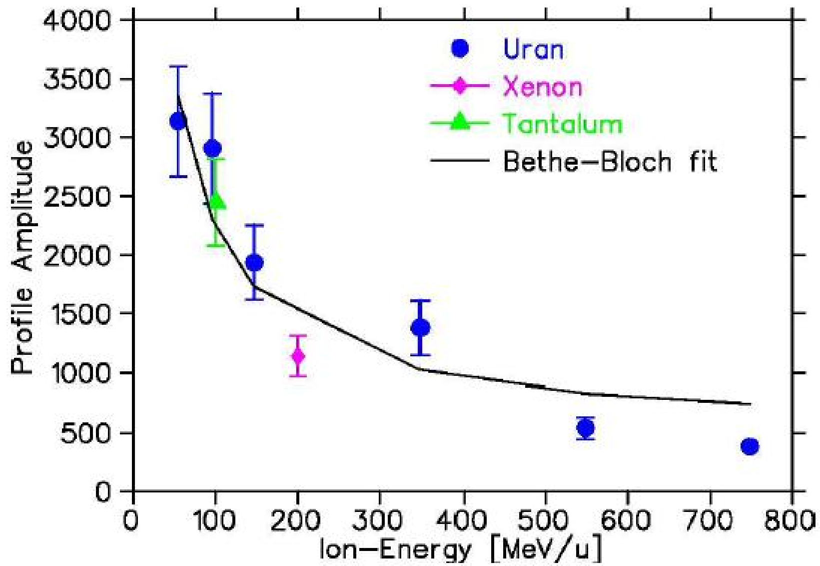


(a) $4 \cdot 10^8$ U @ 60 MeV/u (b) $1,2 \cdot 10^8$ U @ 350 MeV/u (c) $1 \cdot 10^9$U @ 750 MeV/u

S/N gets worse

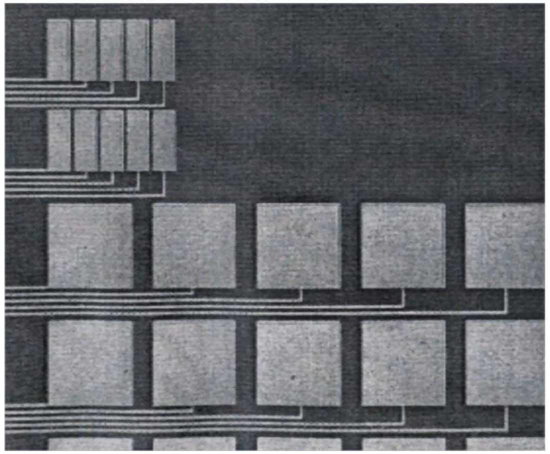
- energy loss
- neutron background in the imaging system

→ R&D fiber/mirror optics UV ~390nm



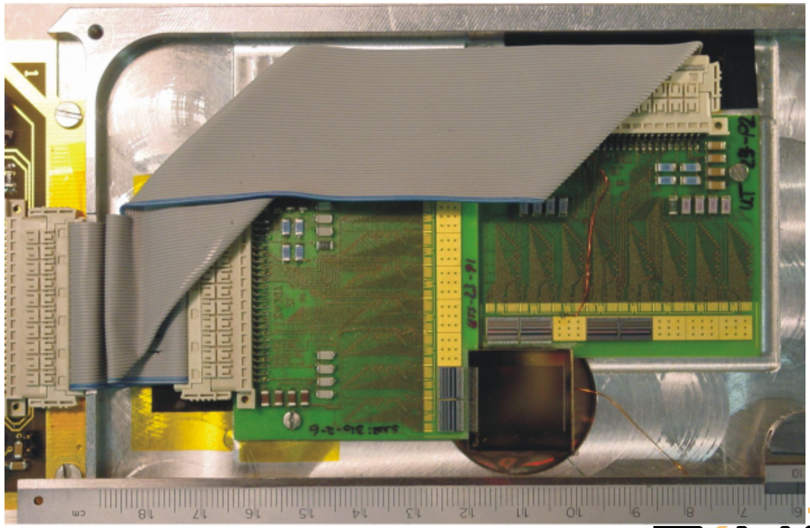
Segmented CVDD detectors

RD42 collaboration



Pixel readout by Si_3N_4 - isolated micro tracks.

Pixels (110 x 290) μm^2 , (400 x 400) μm^2.
Tracks 15 µm / pitch 30 µm

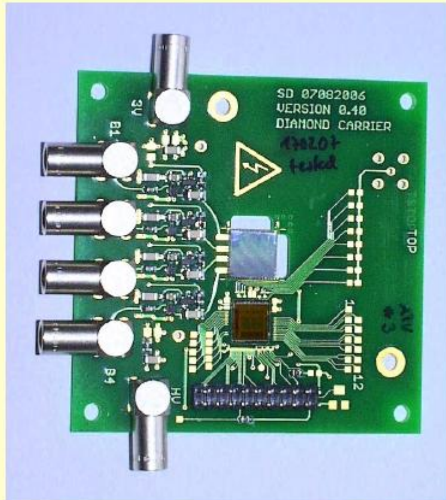


CVDD micro strip 50 µm

APV-25 CERN/CMS ASIC
shaping time: 25 ns
analogue daisy chains
128 channels per chip

Diamond detector test

PC CVDD (10x10) mm^2



Check readout scheme, crosstalk, range
Different readout on both sides

Radiation Hardness:

some samples show persistent photo current (PPC) after irradiation limit

^{16}O@112MeV 10^{13} cm^{-2}

Efficiency: **98% for ^{16}O@120MeV**

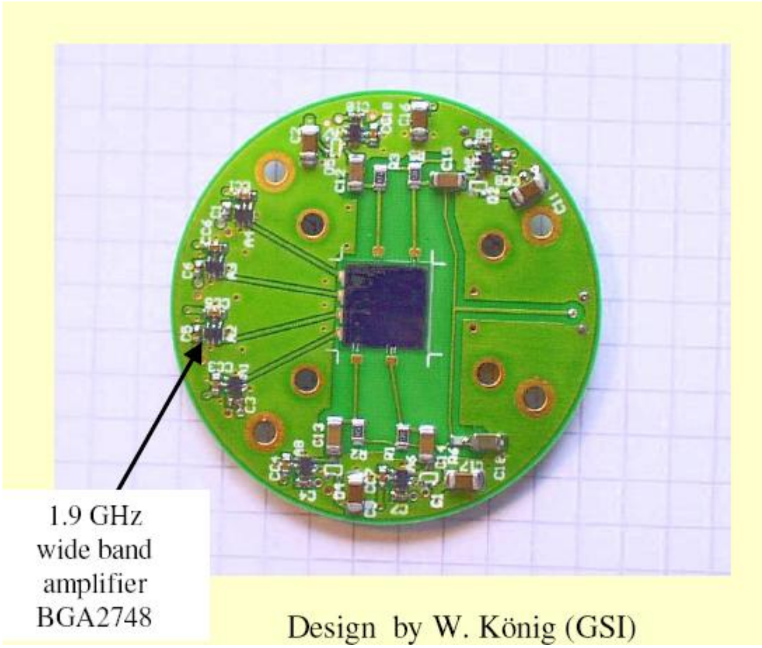
Signal Properties:

new frontend electronics based on the APV25 chip (CMS tracker chip) produced and in use

R. Gernhäuser (TU-München) et al.

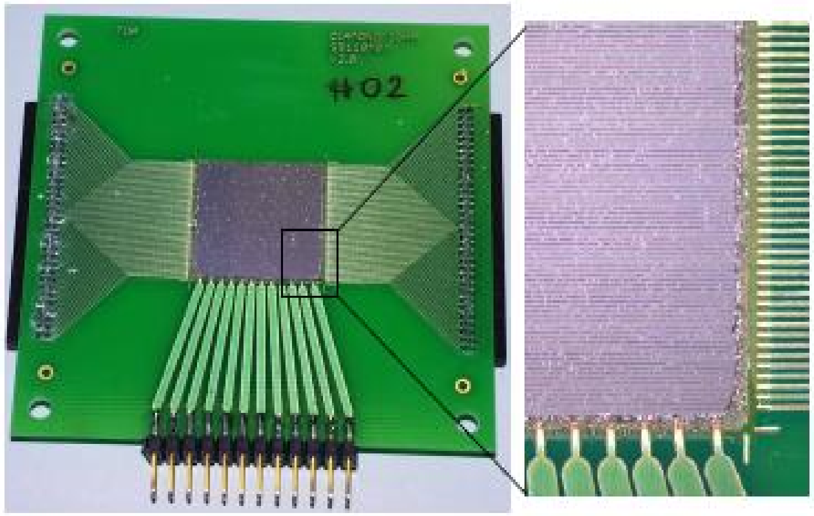
Fast pre-amplifiers

- New low power pre-amplifier from HADES Start detector



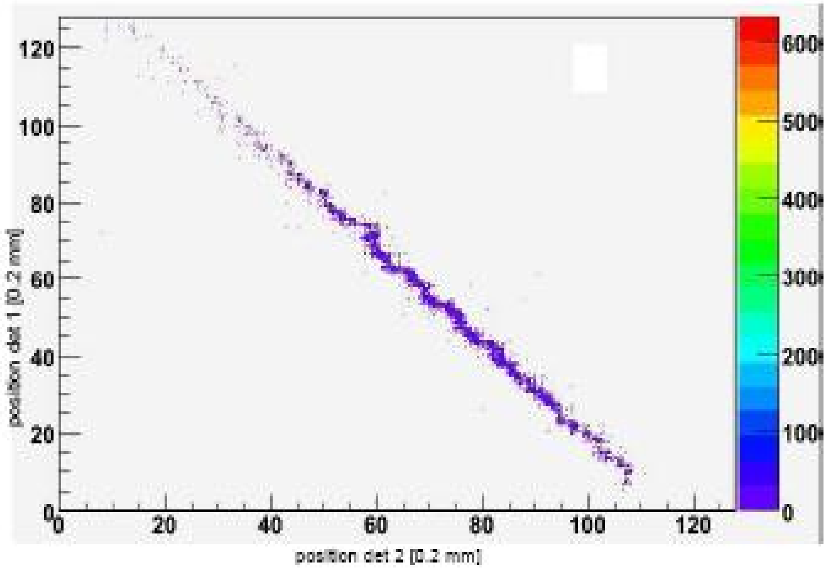
- New pre-amplifiers for HISPEC/DESPEC –LYCCA designed by R. Schneider (Mesytec)

Diamond Detector for R^3B



- 2.54x2.54 cm^2
- 200 µm pitch, 20 µm gap
- Back side divided in 16 Al strips each with a gap of 50 µm
- excessive cost

^{129}Xe @600 MeV/u, 10^5 pps

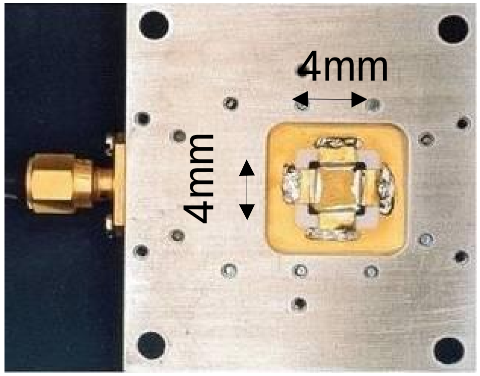


Tested with ^{12}C beam

R. Gernhäuser (TU-München) *et al.*

Diamond Detector test

Tested at CNA-Sevillle



SC CVDD , 110-500 μm
(GSI Detector Laboratory)

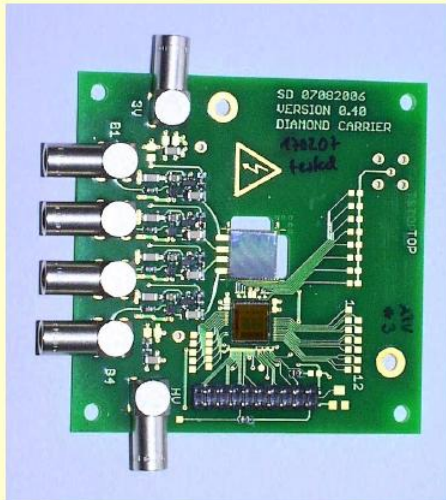
SC CVDD
p, α, ^{7}Li low energy beams

- Energy resolution ~1% (similar to Si)
- $\Delta t < 100$ps
- Estimated efficiency > 70%
- Samples irradiated up to 10^{9} ions/s cm^{2}

P. Bednarczyk, E. Berdermann *et al.*, Act. Phys. Pol. B38(2007)1293

Diamond detector test

PC CVDD (10x10) mm^2



Check readout scheme, crosstalk, range
Different readout on both sides

Radiation Hardness:

some samples show persistent photo current (PPC) after irradiation limit

^{16}O@112MeV 10^{13} cm^{-2}

Efficiency: **98% for ^{16}O@120MeV**

Signal Properties:

new frontend electronics based on the APV25 chip (CMS tracker chip) produced and in use

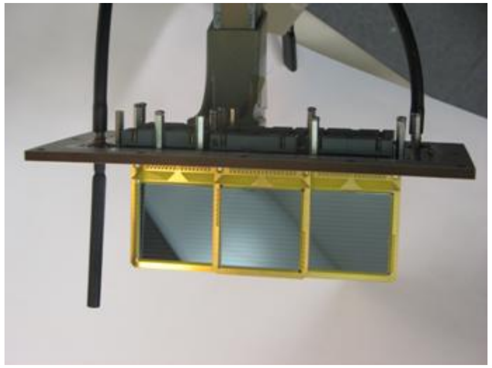
R. Gernhäuser (TU-München) *et al.*

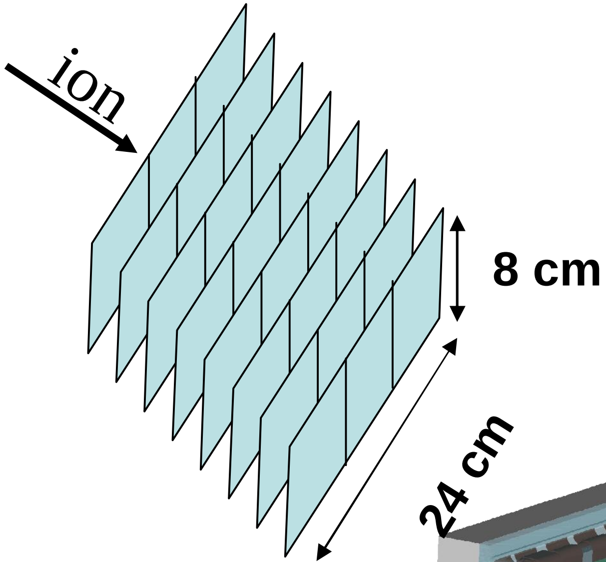
HISPEC/DESPEC

Advanced Implantation Detector Array (*AIDA*)

Up to 10 planes of

RISING active stopper

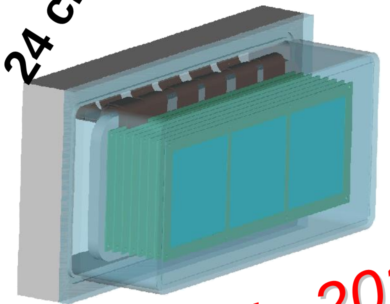


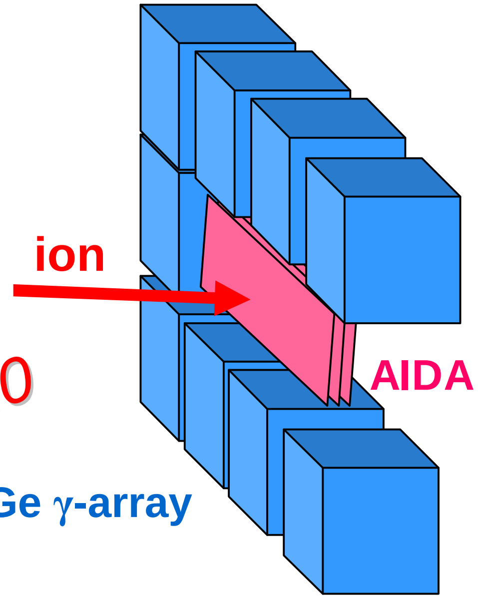


- DSSSD, 8 x 8cm, d=1 mm
- pitch 625μm, 128 x 128 strips
- ΔE(FWHM)~ 10 keV
- Δt(FWHM)~1 ns
- threshold < 50 keV

Observe:

p, 2p, α, β, γ, βp, βn … decays





Ready in 2010

Edinburgh

T. Davinson, P. Woods *et al.*

Liverpool:
R. Page *et al.*

STFC DL & RAL:
J. Simpson *et al.*

T. Davinson (Edinburgh)

Test detector for slow down beams

Degrader

TOF,X,Y

RIB from FRS

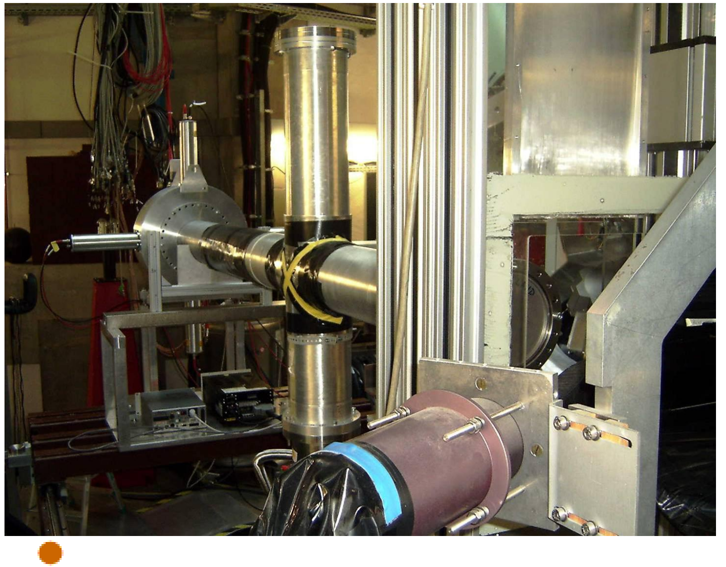
Super FRS

ID the fragment

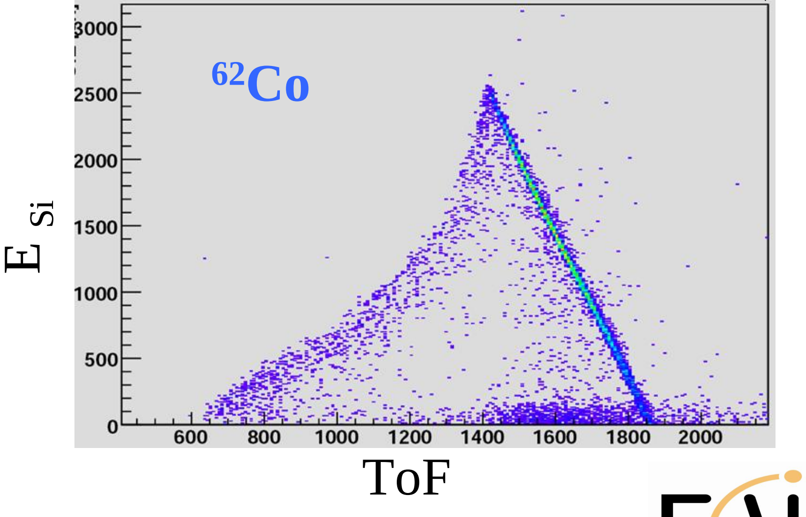
determine E by TOF, and ID fragment by energy loss if needed

Secondary Target

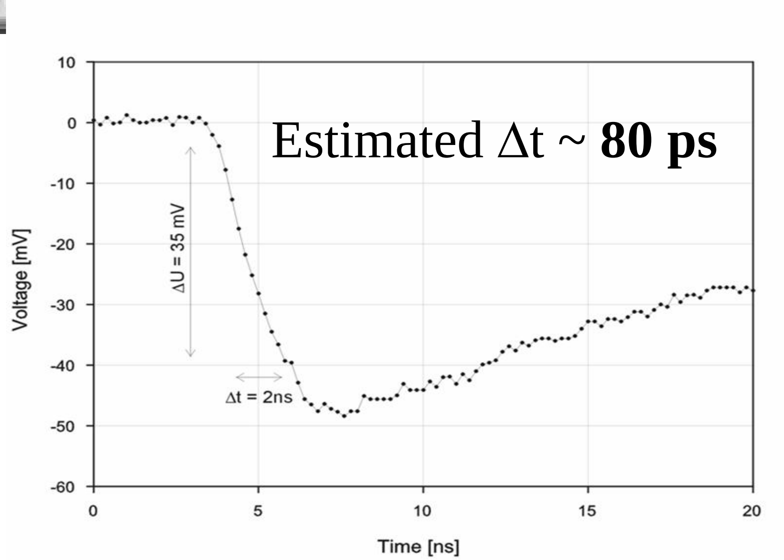
Tof: $\Delta t<150$ps, rate: 10^7 pps



P. Boutachkov (GSI)



Test detector for slow down beams



<u>GSI group</u>:
P. Boutachkov, M.Górska, J.Gerl, H.Geissel, W.Koenig, I.Kojouharov, C.Nociforo, W.Prokopowicz, H.Schaffner, H.Weick

<u>LNL group</u>:
J.J.Valiente, A.Gadea

<u>JINR Dubna</u>:
N.Kondratiev

Large Area Secondary Electron Detection

$1.5x1.0x1.0\ m^3$

<u>Sevilla group</u>:
J.Gomez Camacho, M.Alvarez, J.M.Espino, I.Mukha, J.M.Quesada

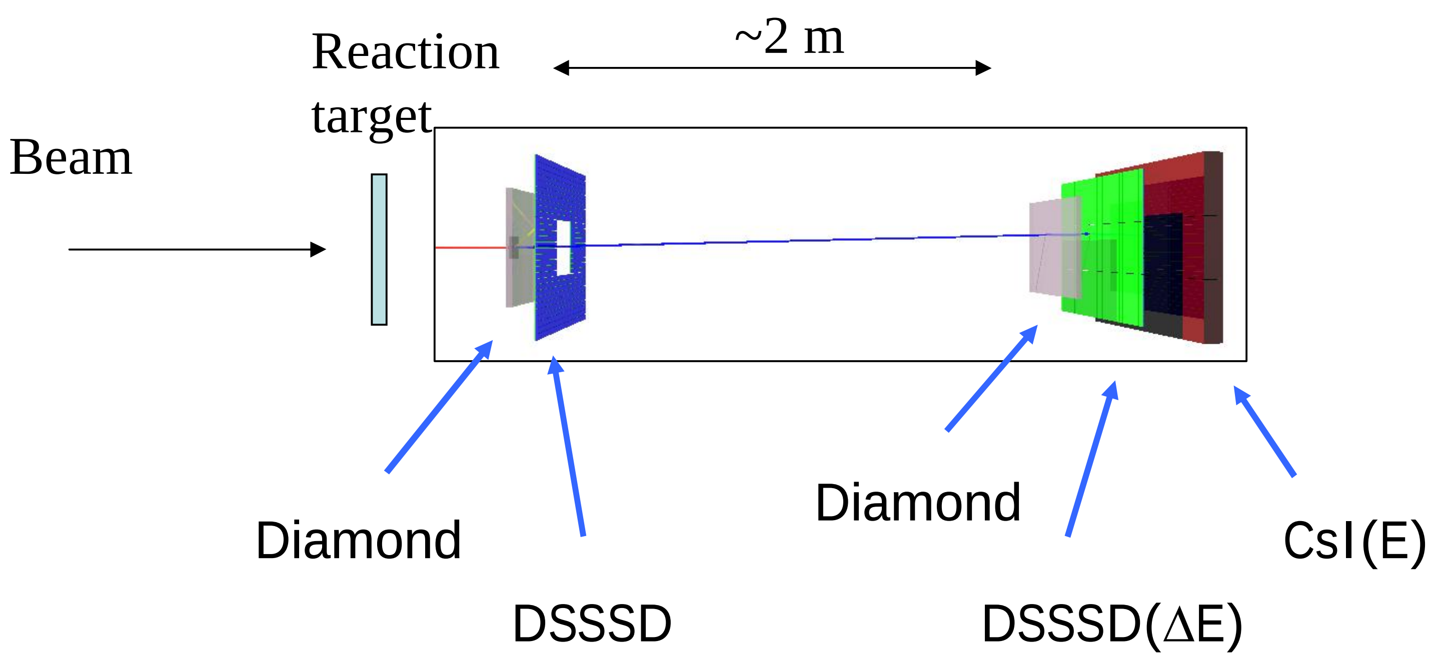
Development with MCP, MICROMEGAS technology

<u>Saclay</u>:
A.Drouart, A.Polacco

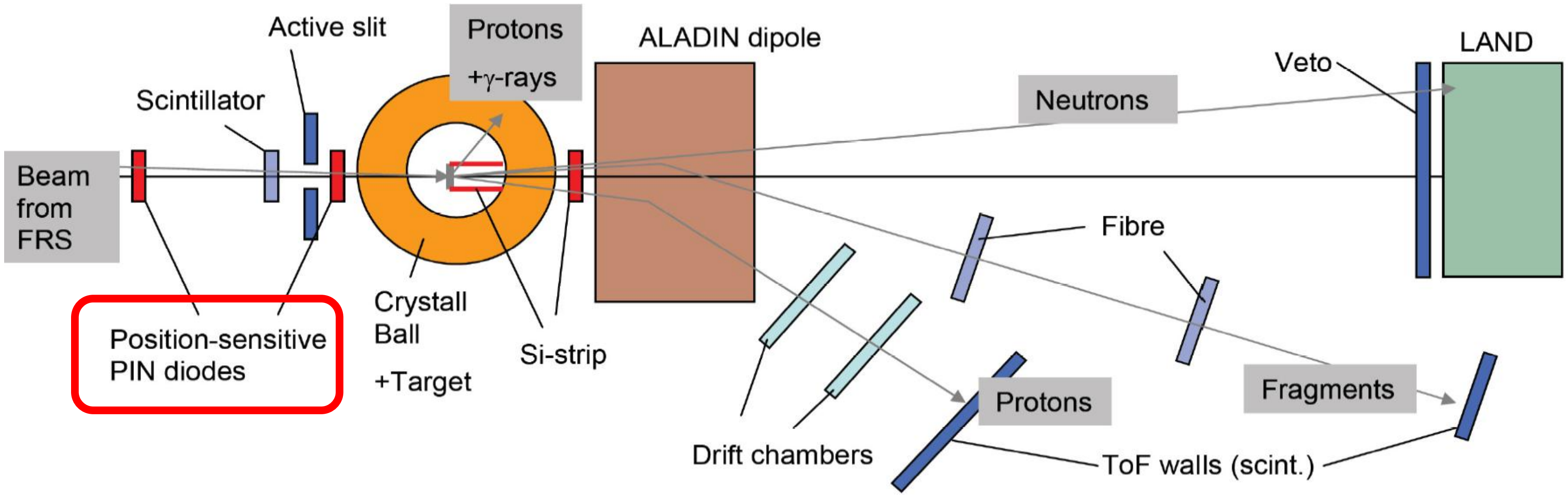
<u>Koln</u>:
J.Jolie, F.Naqvi, C.Pascovici

HISPEC/DESPEC

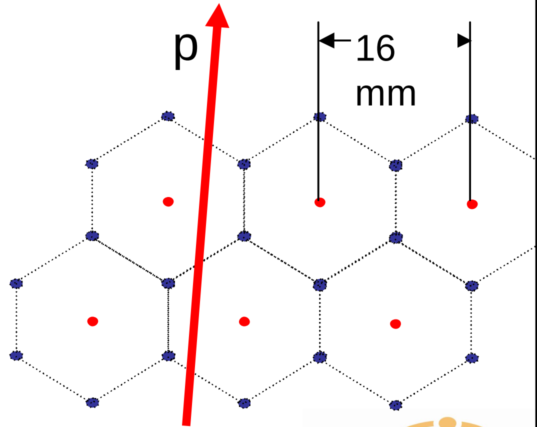
Lund-York-Cologne CAlorimeter (*LYCCA*)



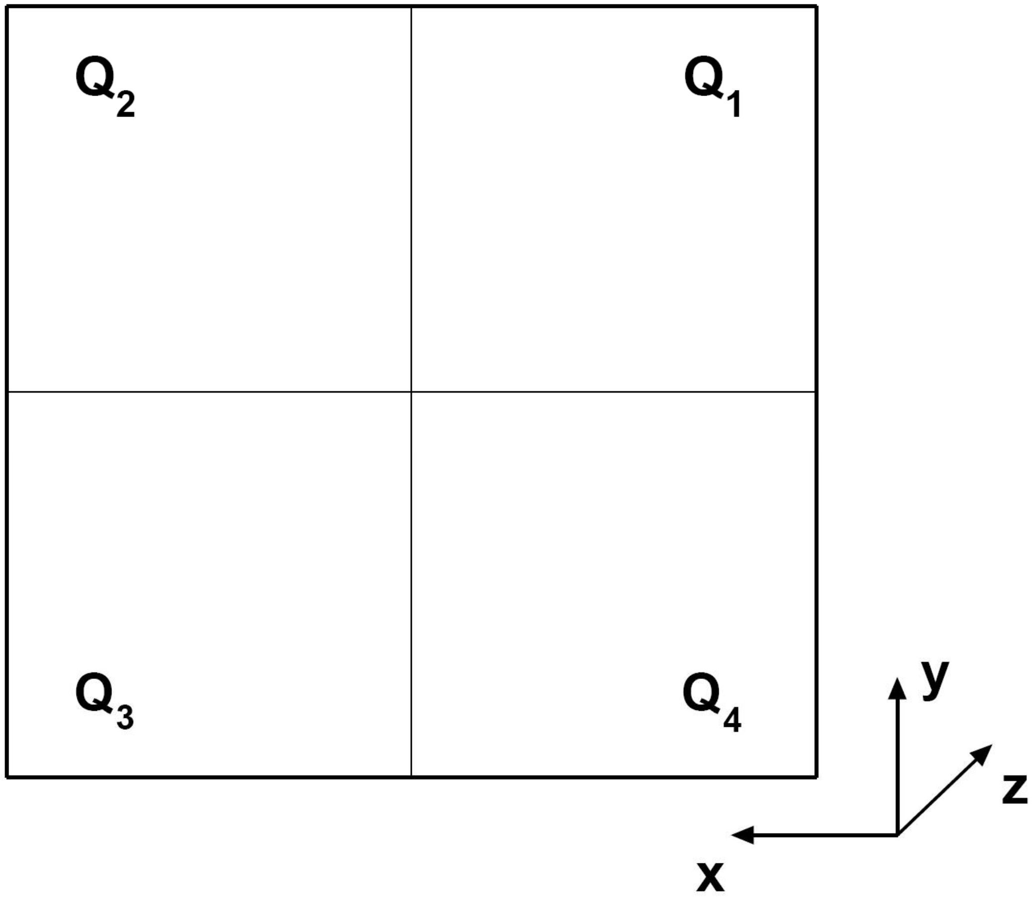
Prologue: Extended experimental Setup at Cave C



300 µm high n-type Si
4,5 x 4,5 cm²
B doped → p-side



PSP



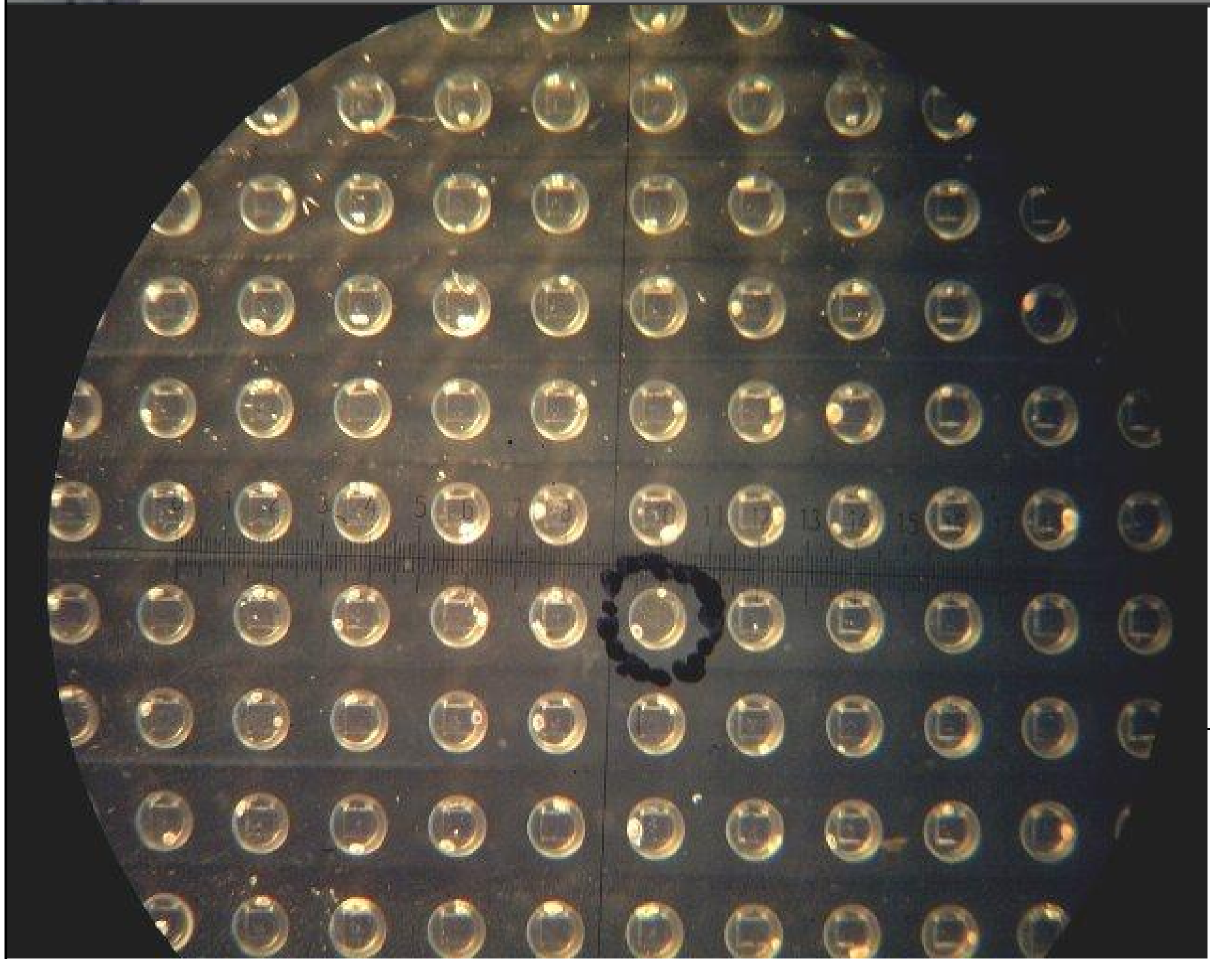
- Cathode : Sum energy
- 4 Anodes → position

u = (Q2 + Q3) – (Q1 + Q4) / Q
v = (Q1 + Q2) – (Q3 + Q4) / Q

Q= Q1+Q2+Q3+Q4

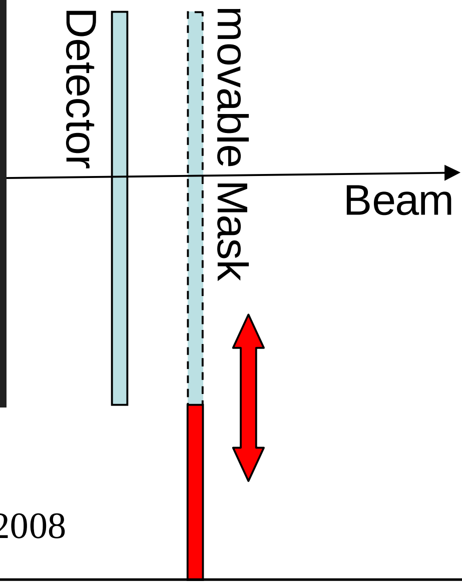
→ x(u,v) ; y (u,v)

PSP

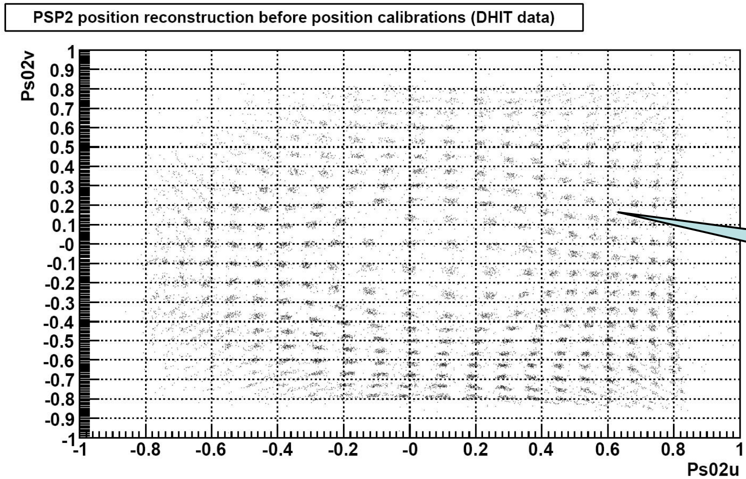


Calibration via active mask

i.e. Scintillator dots glued into PMT read out light guide

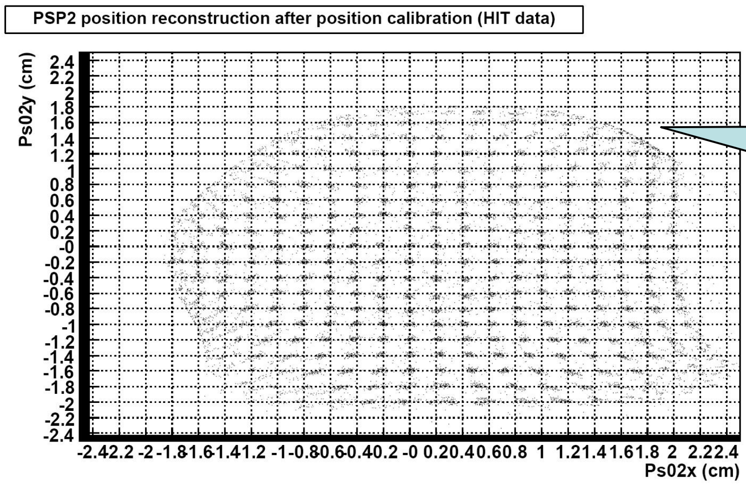


PSP



∃ **Semi automized**
Off- or Near line calibration

Distortions
Gain Matching
Automatic pedestals from DAQ system

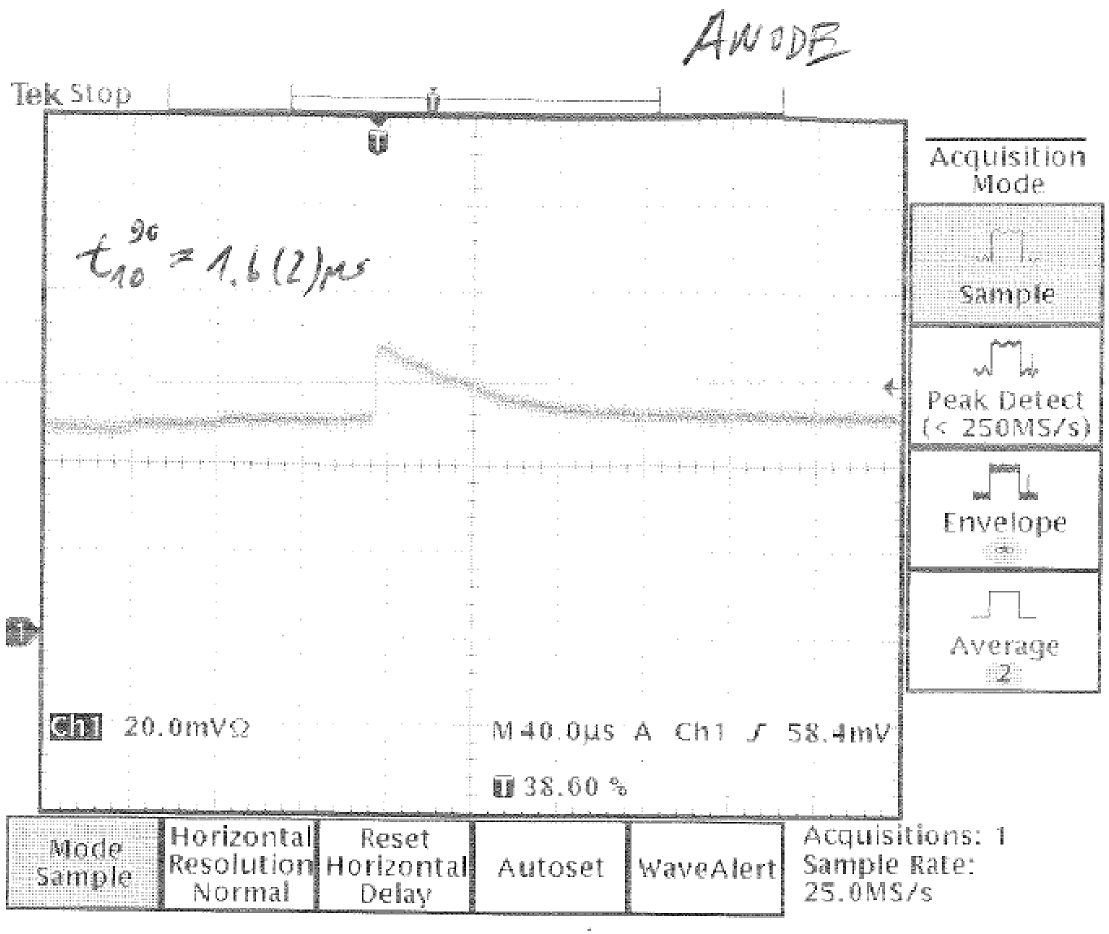


Treshold effect

Rate limit to few kHz
(conv. readout chain)

Need:
intelligent fast sensor !

PSP



Signal characteristics:

- few mV
- preamp decay time ~few 10µs
- riding on noise and ripple

➔ pile up treatment
➔ good thresholds

Idea: Use ADC coupled to Hades TRB2 of KVI: Peter Schakel / Pim Lubberdink

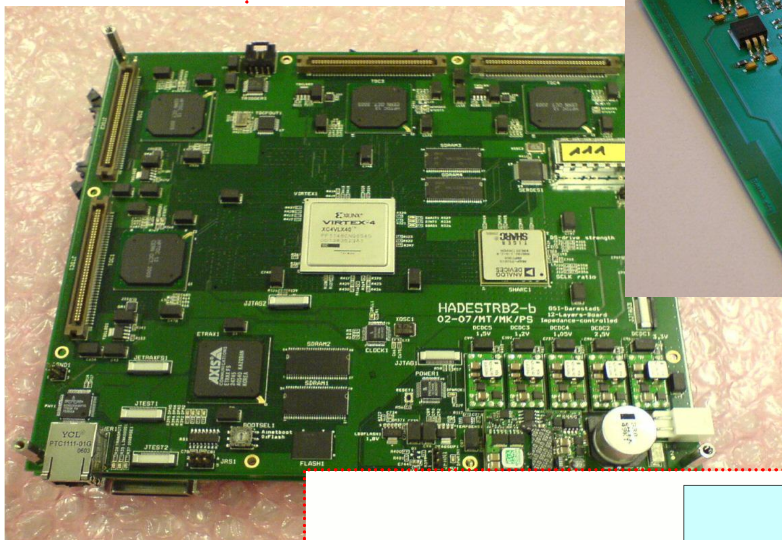
- Available hard/software environment:

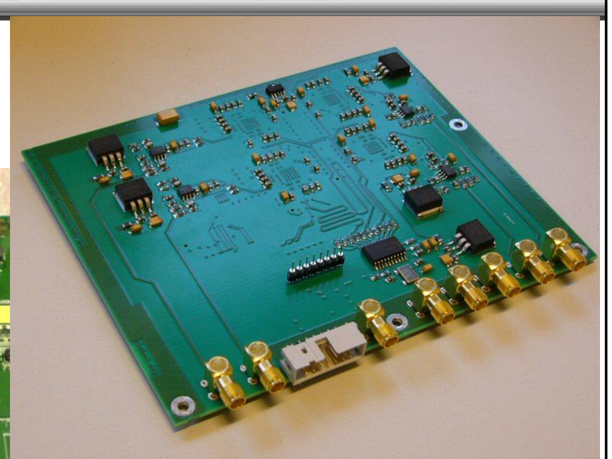
  (1) ADC Piggy back / KVI
  100MS/14Bit
  50MHZ BW

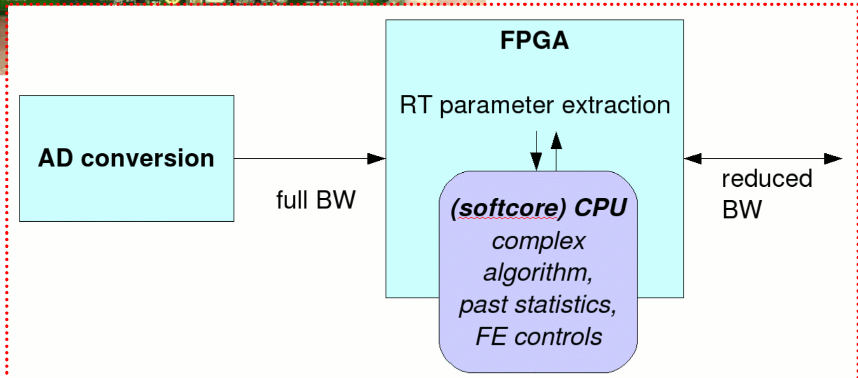
  (2) Xilinx based board
  HADES TRB2

  (3) Base line follower/
  kσ trigger
  (J. Jungmann / M. Vencelj)

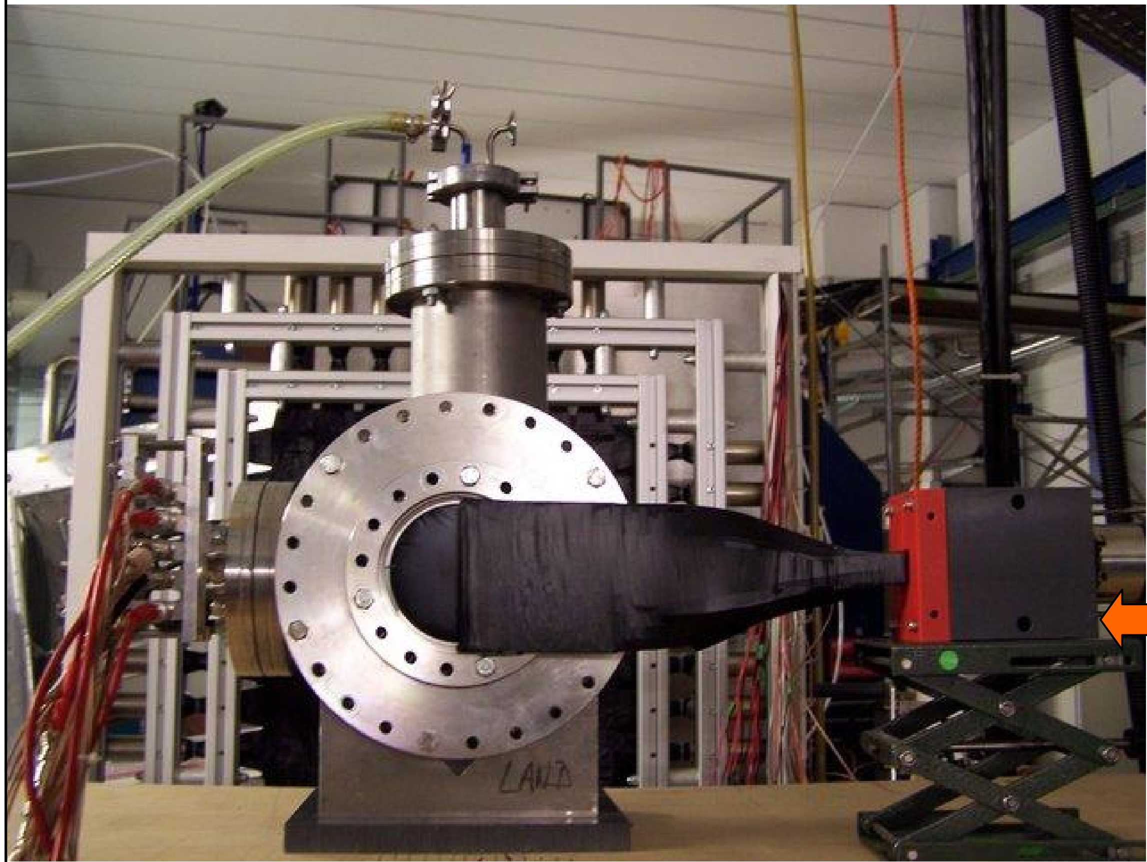
  Labview based readout system

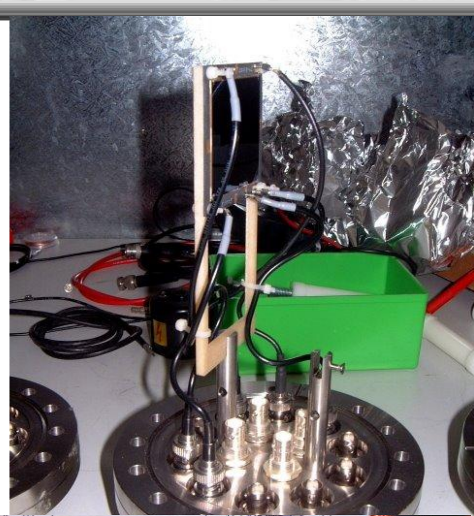


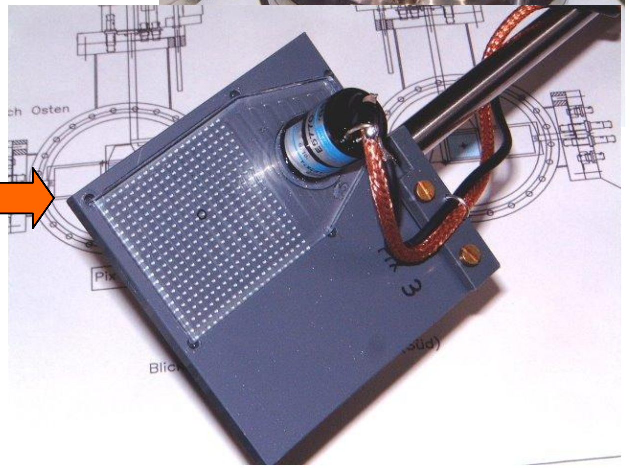




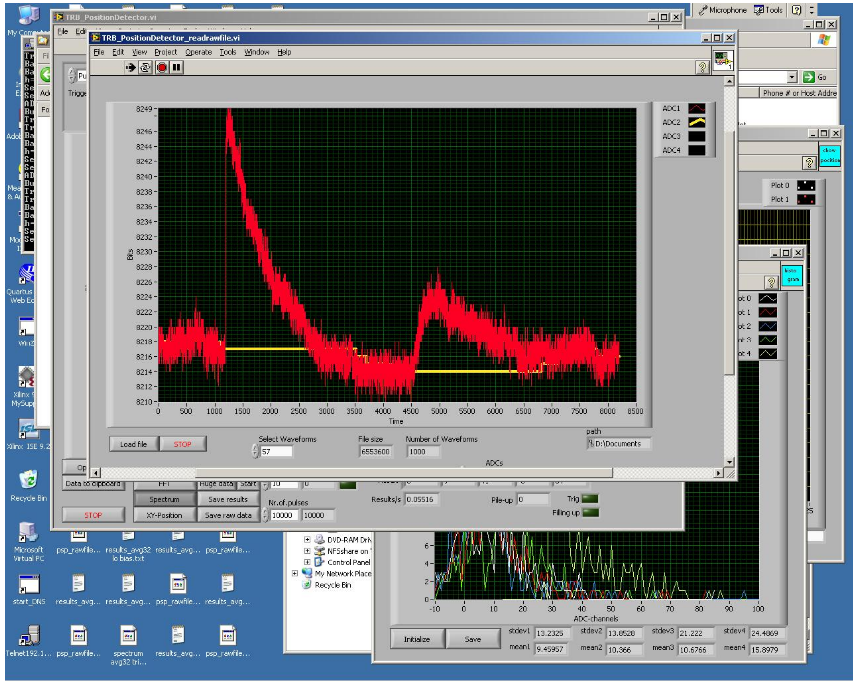
Test experiment S327 (16.-18.4.2008)
^{12}C: 550-700 MeV/u ; 2-50 kEv/s

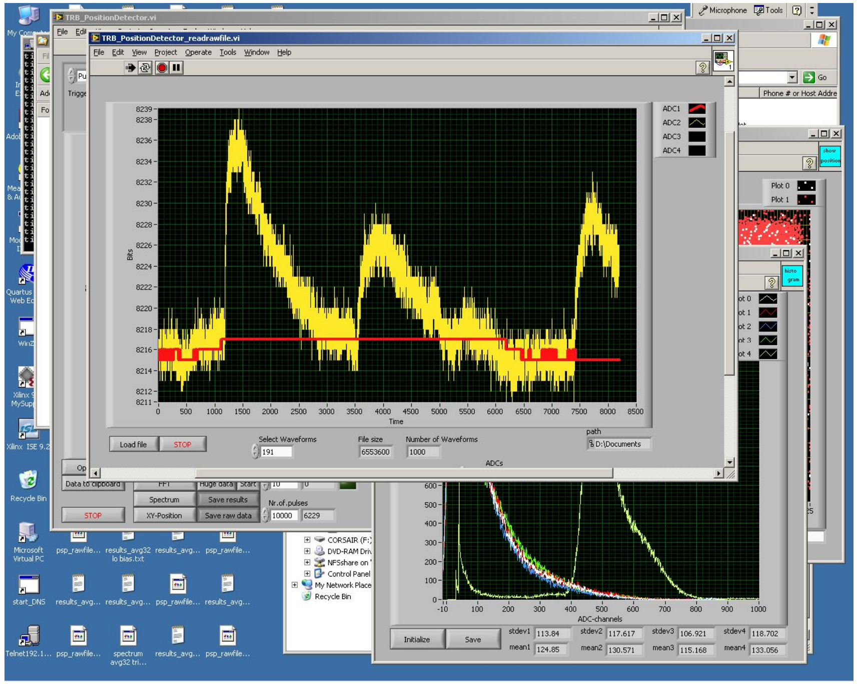






Results: Baseline

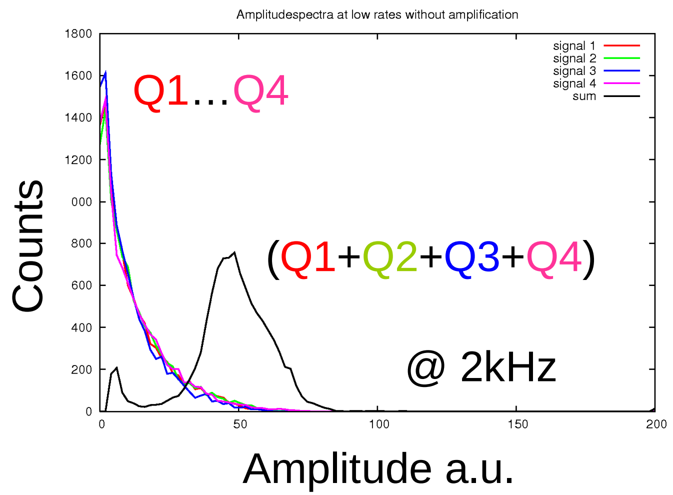


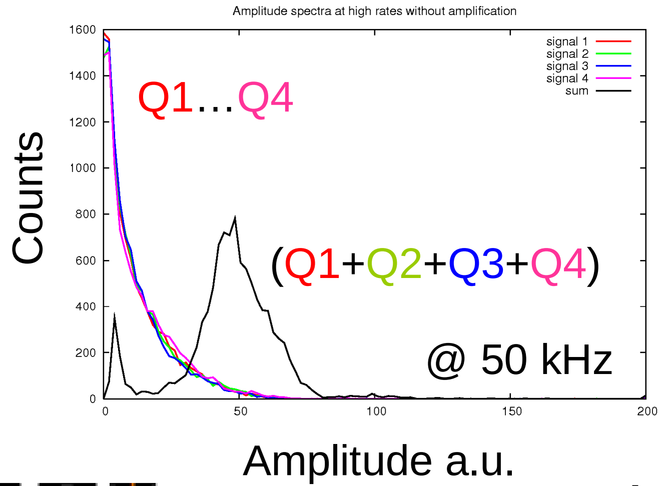


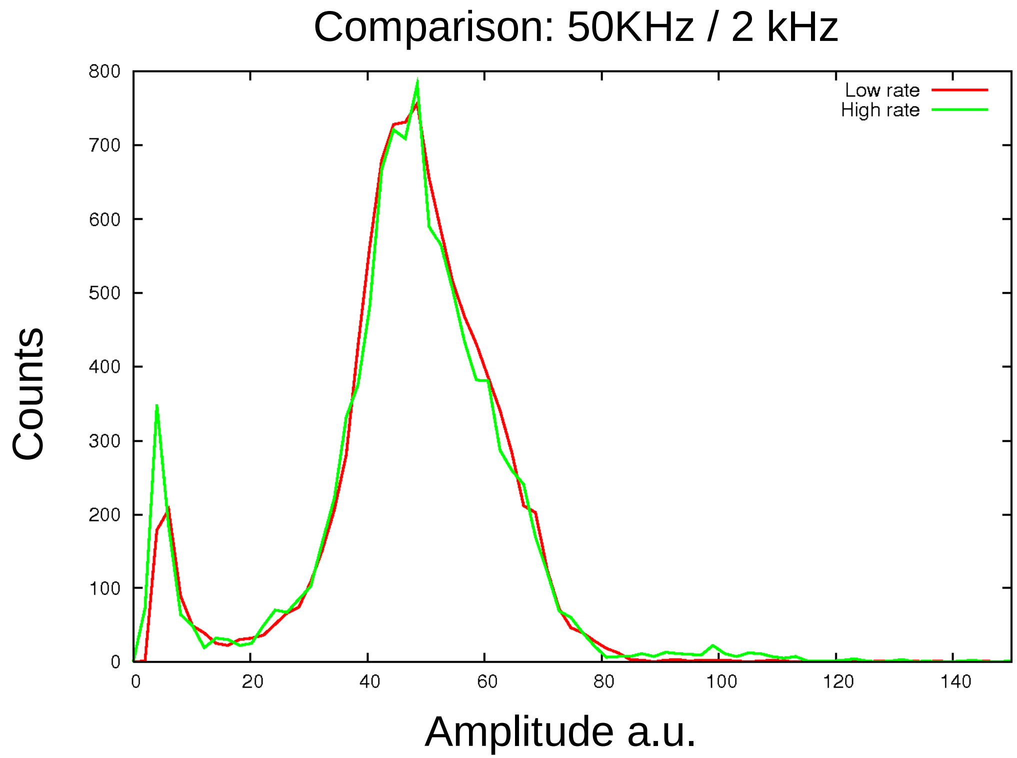
Baseline follower works !
(Bimodal Kalman Filter)

Treatment of double hits !

Results: Amplitude → ΔE

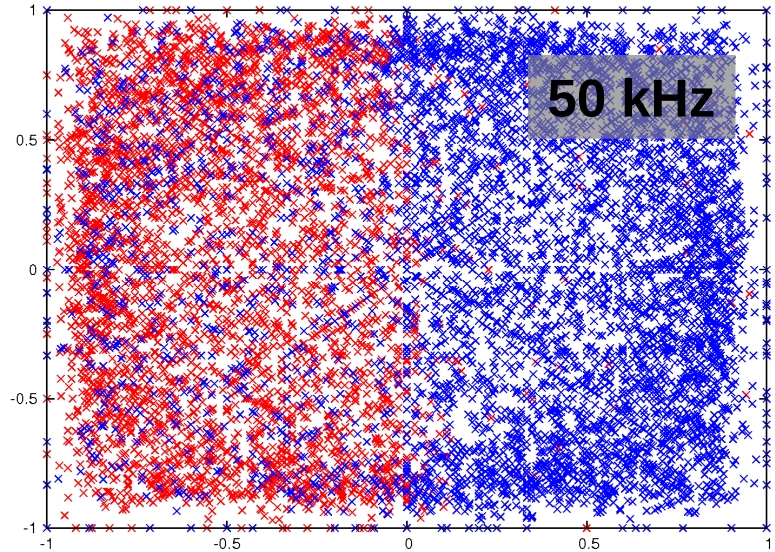


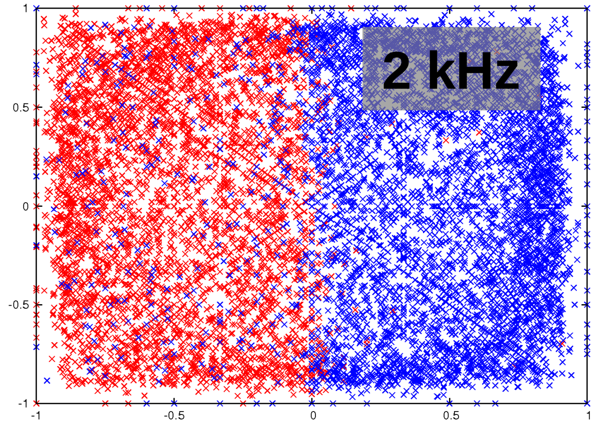


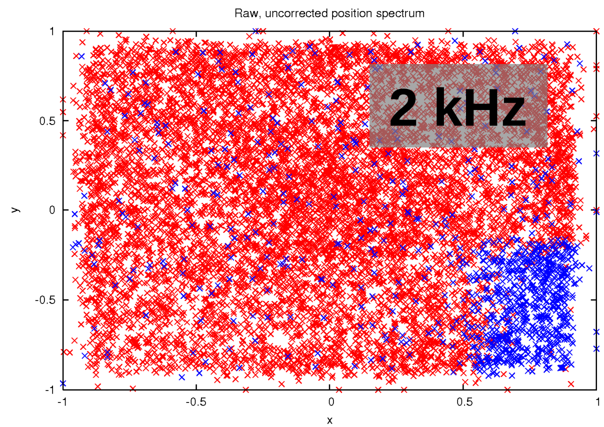


Gain matched amplitude spectra
No degradation with rate !

Results: Position







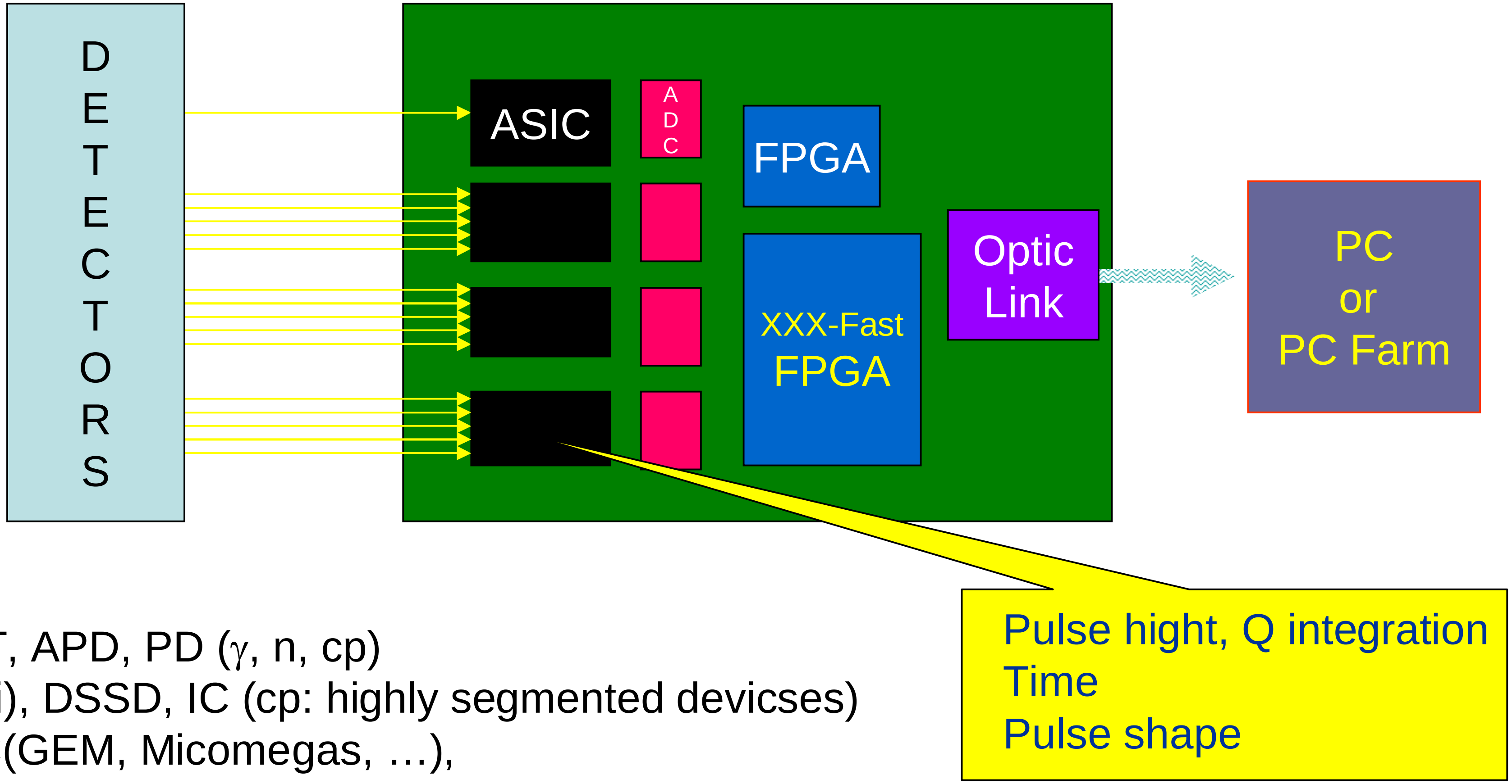
minimal distortions

Online reconstruction of positions:

i. @ full rate (i.e. 50+ kHz, theoretical limit: ADC speed !)
ii. no correction yet

→ development of a “slow process”

… so what do we really want (c.f. FREEDAQ proposal)



PMT, APD, PD (γ, n, cp)
Si(Li), DSSD, IC (cp: highly segmented devicses)
TPC(GEM, Micomegas, …),

Collaboration

KVI

H. Wörtche, J. Jungmann,

P. Lubberdink, P. Schakel,

V. Stoica

TU Darmstadt

D. Savran, B. Löher

JSI Ljubljana

M. Vencelj

GSI

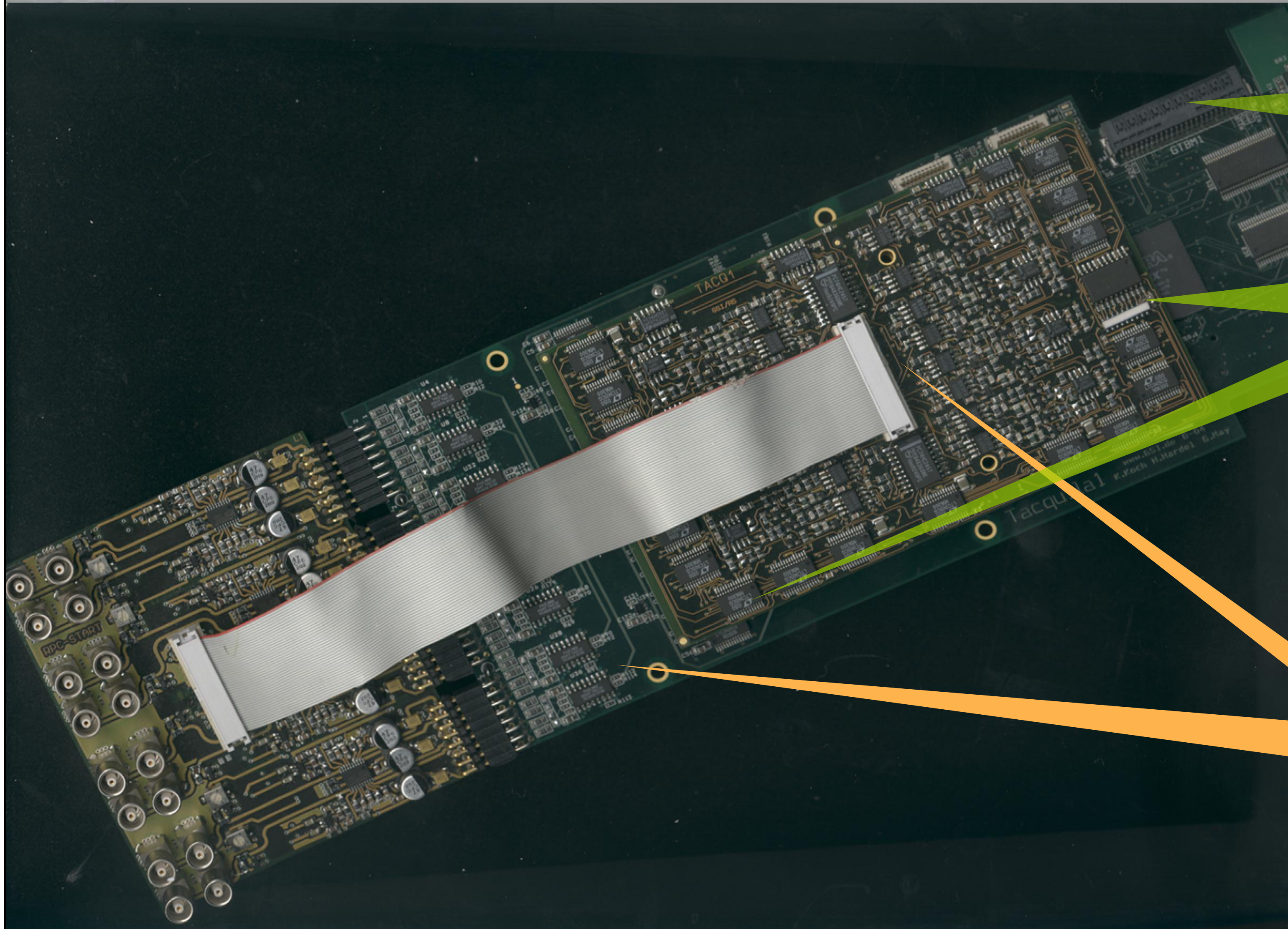
H. Simon, T. Aumann, Y. Aksyutina,

K. Boretzky, O. Ershova, M. Heil, A. Klimkiewicz,

T. Le Bleis, A. Kelic, R. Plag, R. Reifarth,

D. Rossi, K. Sümmerer, F. Wamers

Example: Precision timing
Tacquila System (R³B, FE prototype) - GSI



GTB interface

12 Bit ADCs
10 Bit read ...

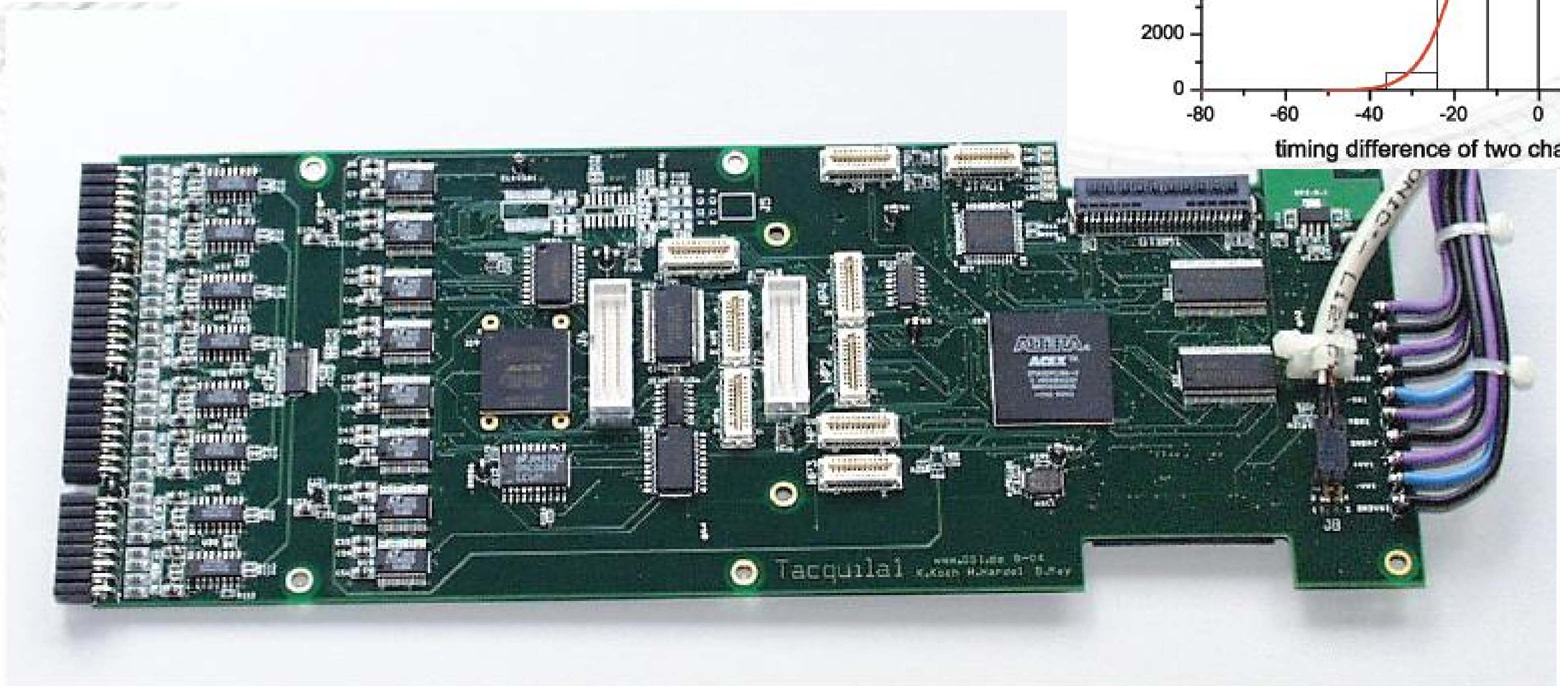
TAC Q uila

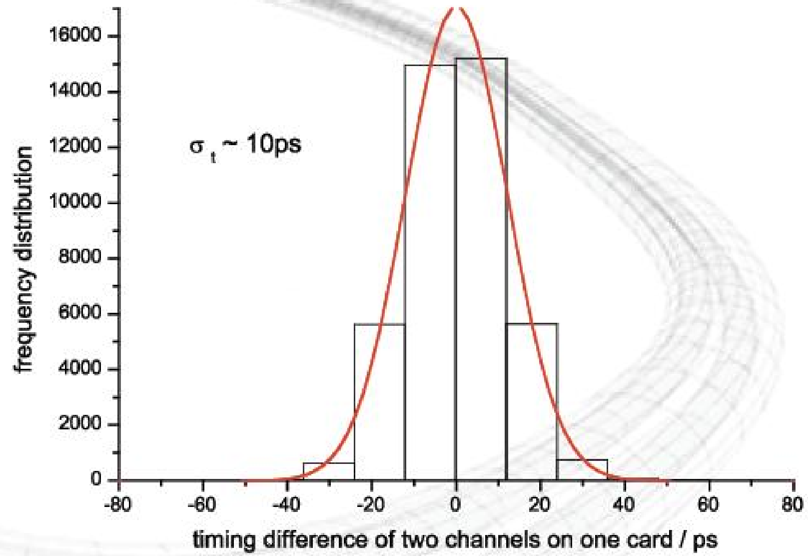
Tacquila

- **triggered system**

For our application:

- **PM signals (LAND, TOF-wall, …)**
- **+ slow control + monitoring → dedicated front end card**





Diamond Detectors

- Super-FRS: $(400x60)mm^2$, pitch 1mm, thickness <0.2mm, ΔTof<100ps, rate 10^8 pps

- R^3B: $(20x20)\ mm^2$, pitch 0.5mm, thickness <0.1mm, ΔTof<50ps, rate 10^6 pps

- HISPEC/DESPEC- LYCCA: $(60x60)\ mm^2$, thickness <0.2mm, ΔTof<50ps, rate 10^6 pps

BuTiS fibre distribution test bench

BuTiS Master

0.01, 10, e.g. 200 MHz copper

LASER +
AM modulator

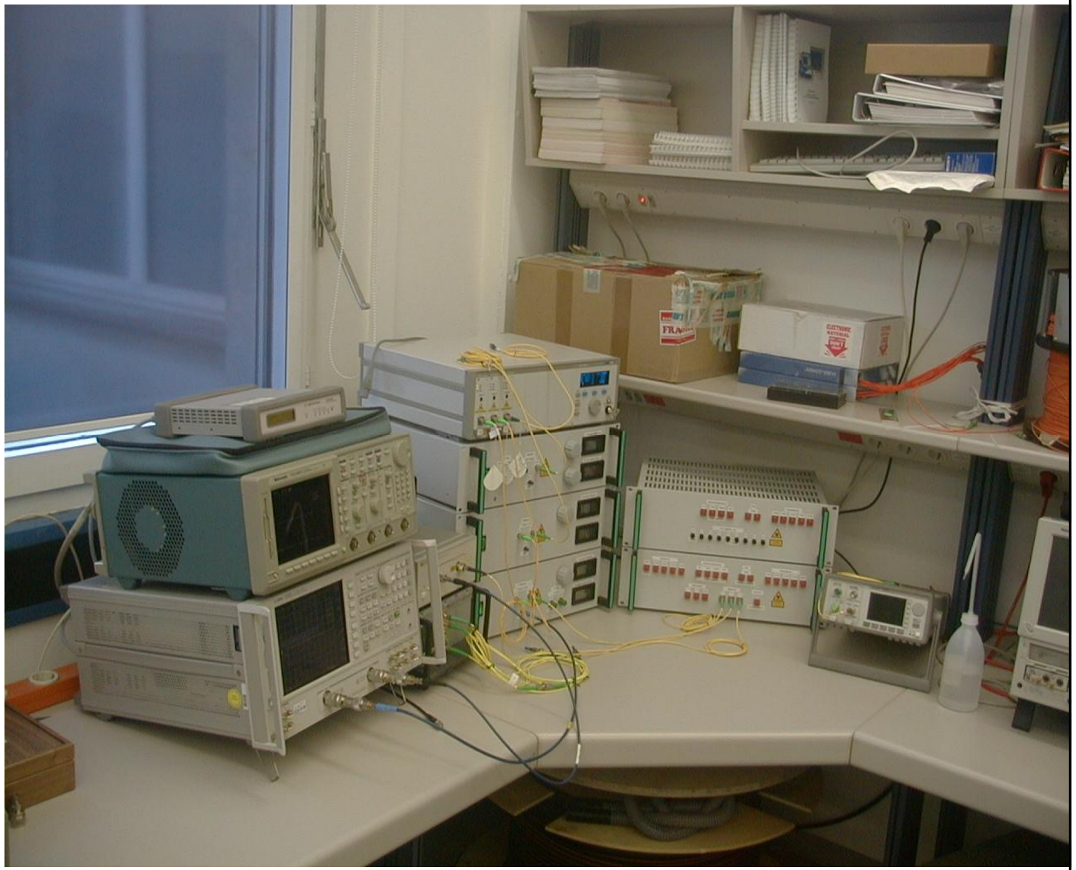
opt. fibre (4 * 200GHz bands)

passive splitter
distribution 1..2 km

Demodulator + reflector (4th ch)

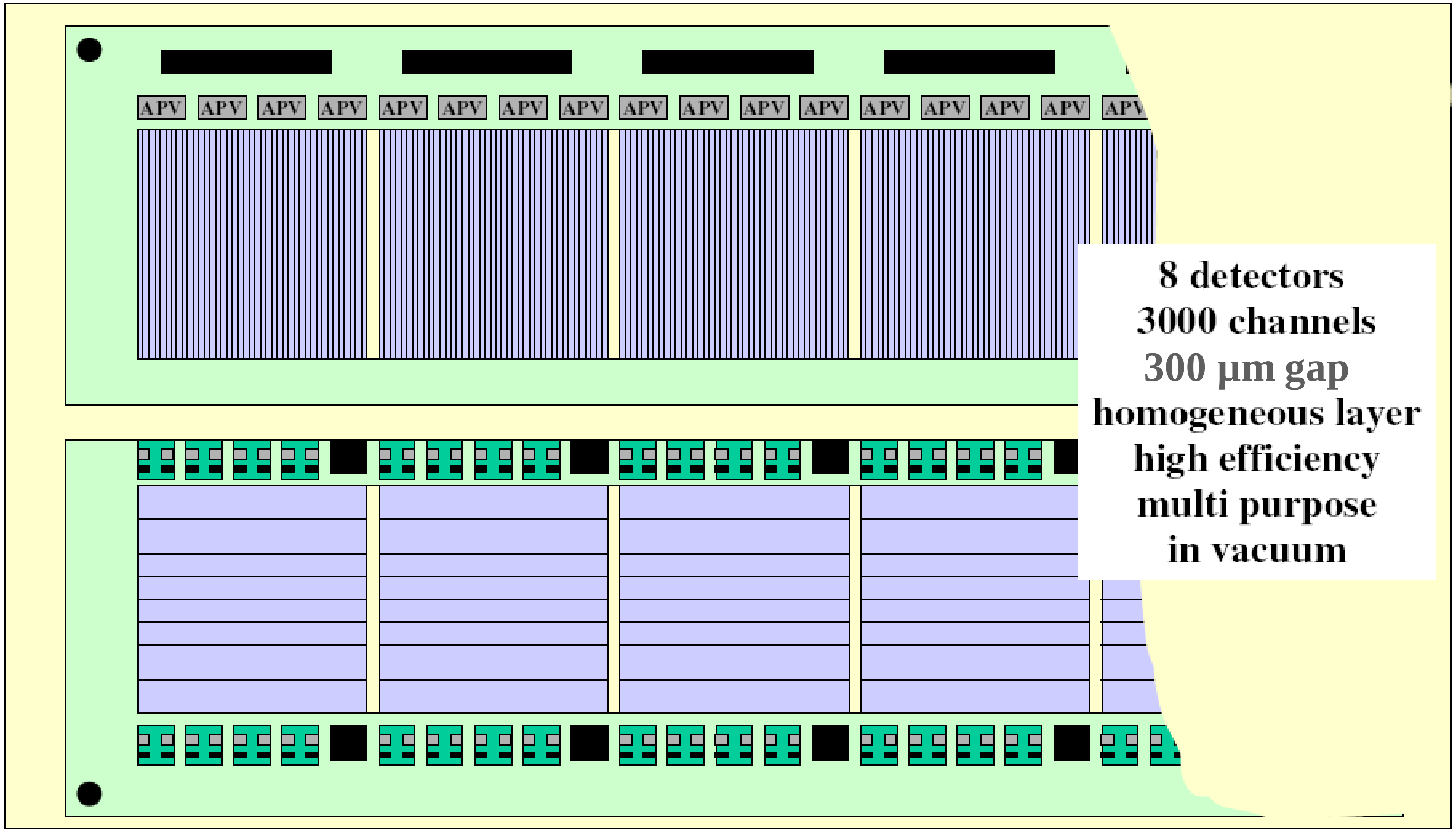
0.01, 10 MHz copper

BuTiS Slave osc.



0.01, 10, e.g. 200 MHz copper ➔ **(local TDS) ?**

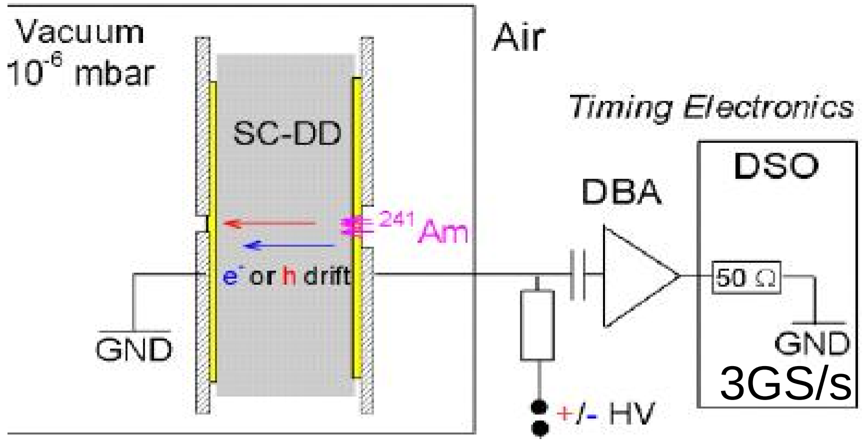
Super-FRS detector layout

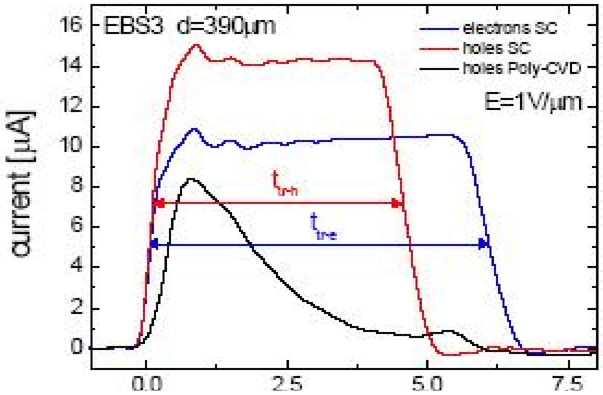


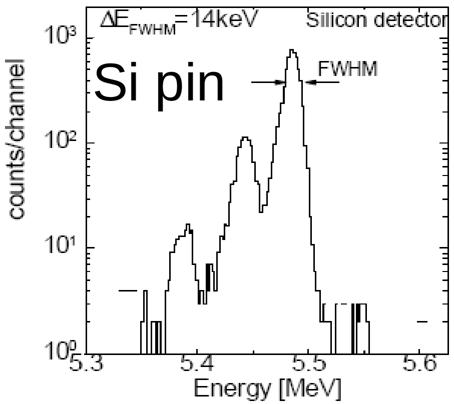
8 detectors
3000 channels
300 μm gap
homogeneous layer
high efficiency
multi purpose
in vacuum

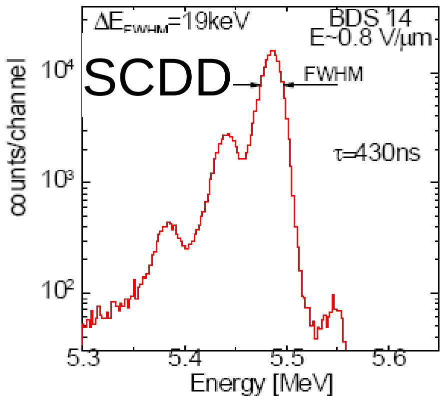
Diamond Detectors

ΔE ...









M. Pomorski, E. Berdermann et al. Nordhia, RD42

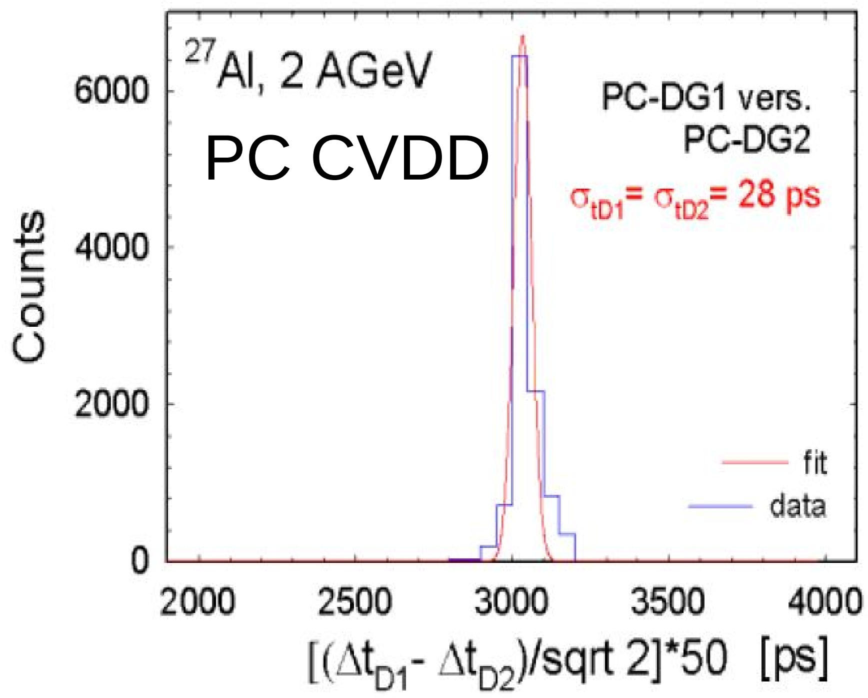
- R&D: usage as dE detector, FE electronics !

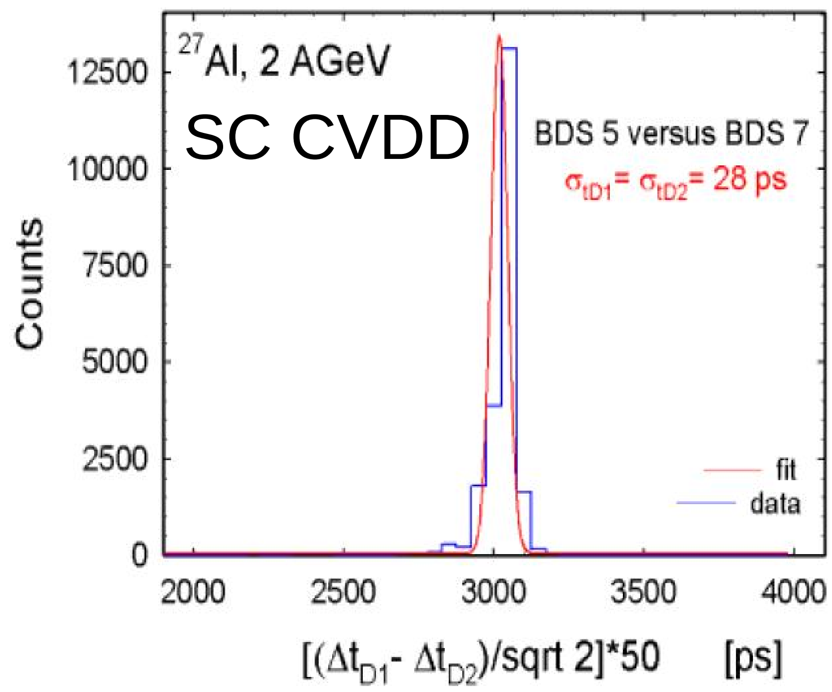
GSI

FAIR

Diamond Detectors

TOF

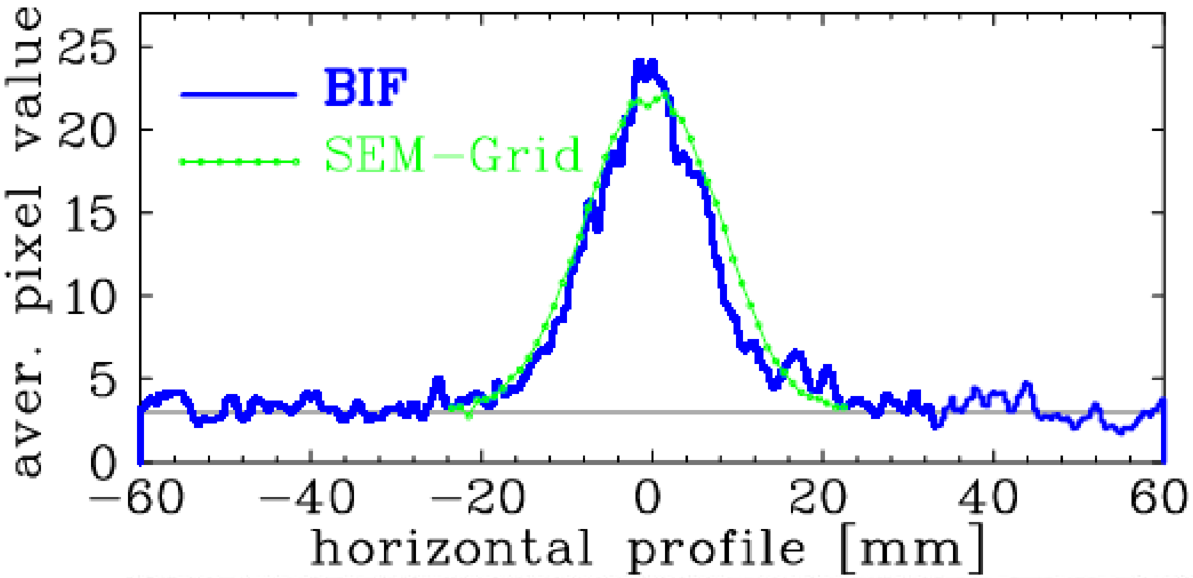




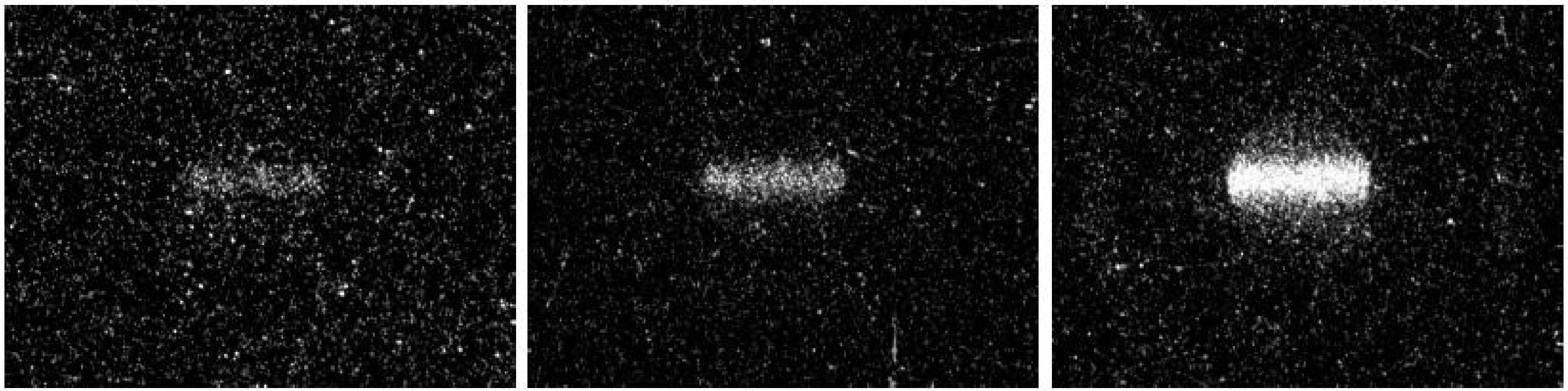
- good timing (eg. R3B req. σ_t~50ps)
- R&D: detector geometry strips or pxl / readout electronics (in about 1m distance)

Applications to beam transport line

P. Forck / GSI

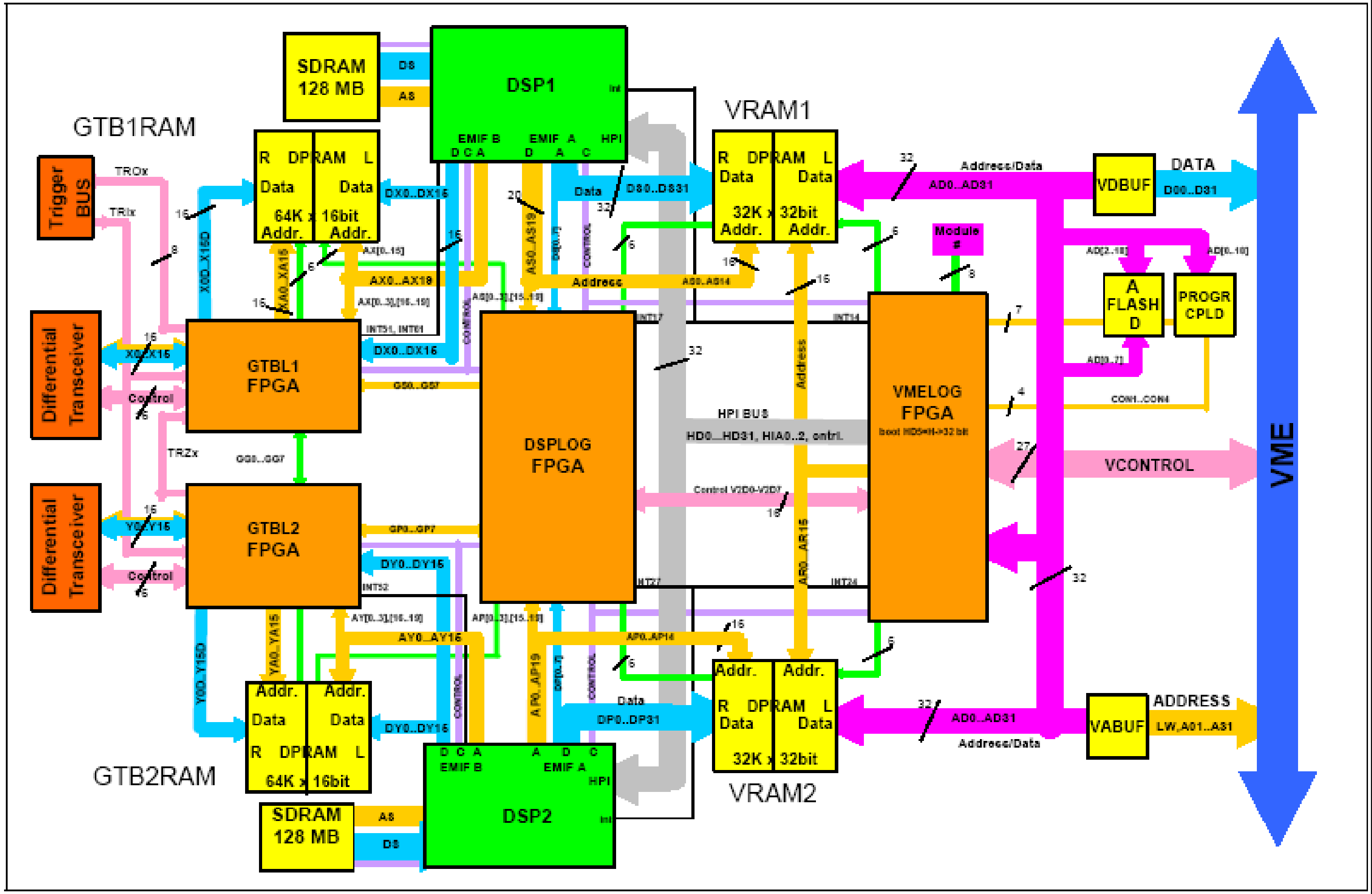


Xe^{48+}
200MeV/u



(a) Setup ($5 \cdot 10^{-4}$mbar) (b) Setup ($1,5 \cdot 10^{-3}$mbar) (c) Setup ($7 \cdot 10^{-2}$mbar)

SAM Readout → VME



Digital data processing
not yet in use !

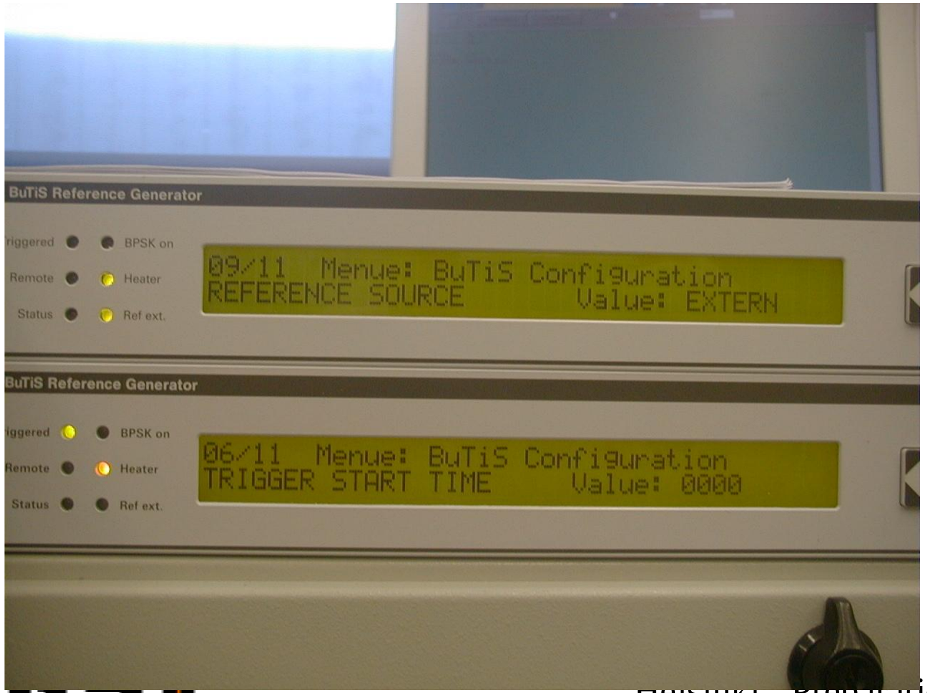
FAIR

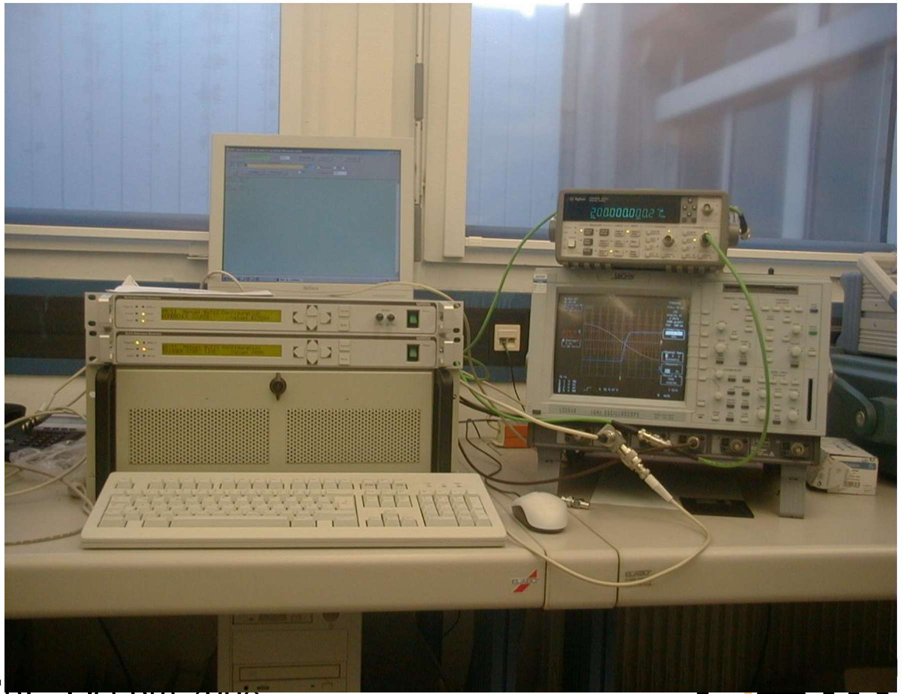
Large Scale → Time distribution system

P.Moritz (GSI) in collaboration with Works μ-wave GmbH

J. Agramunt, M. Bellato, P. Coleman-Smith, N. Kurz, H. Schaffner, H.Simon

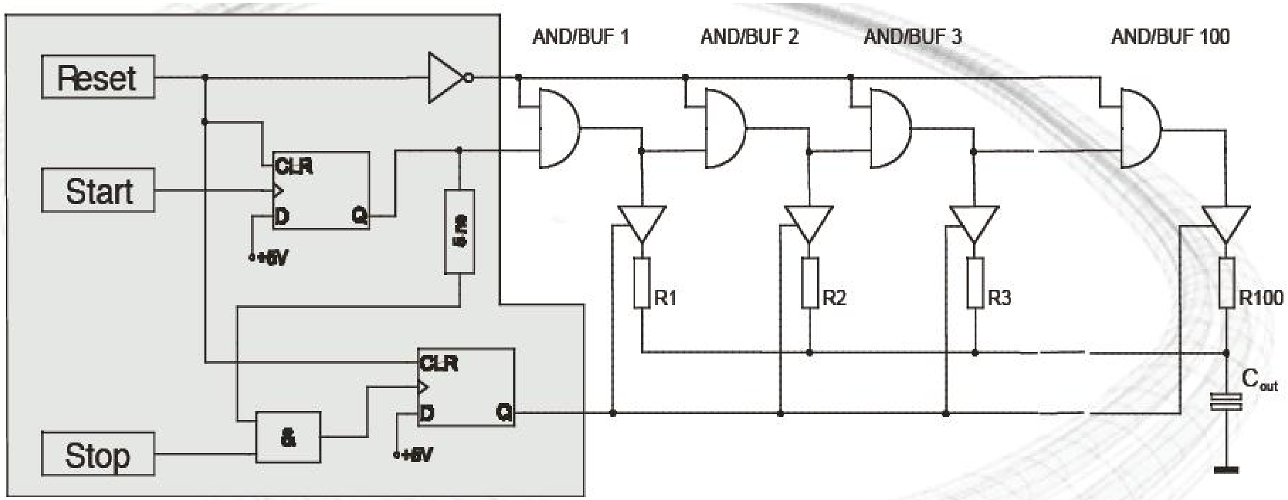
- Campus wide time distribution system (TDS)
  Bunch timing accelerator (BuTiS)
- Exp.: Time of flight between caves / DAQ synchronisation via local TDS
- Synchronous local oscillators (100kHz, 10Mhz, and e.g. 200, 155 or 76 Mhz)
  +-100ps/km absolute uncertainty few ps oscillator jitter





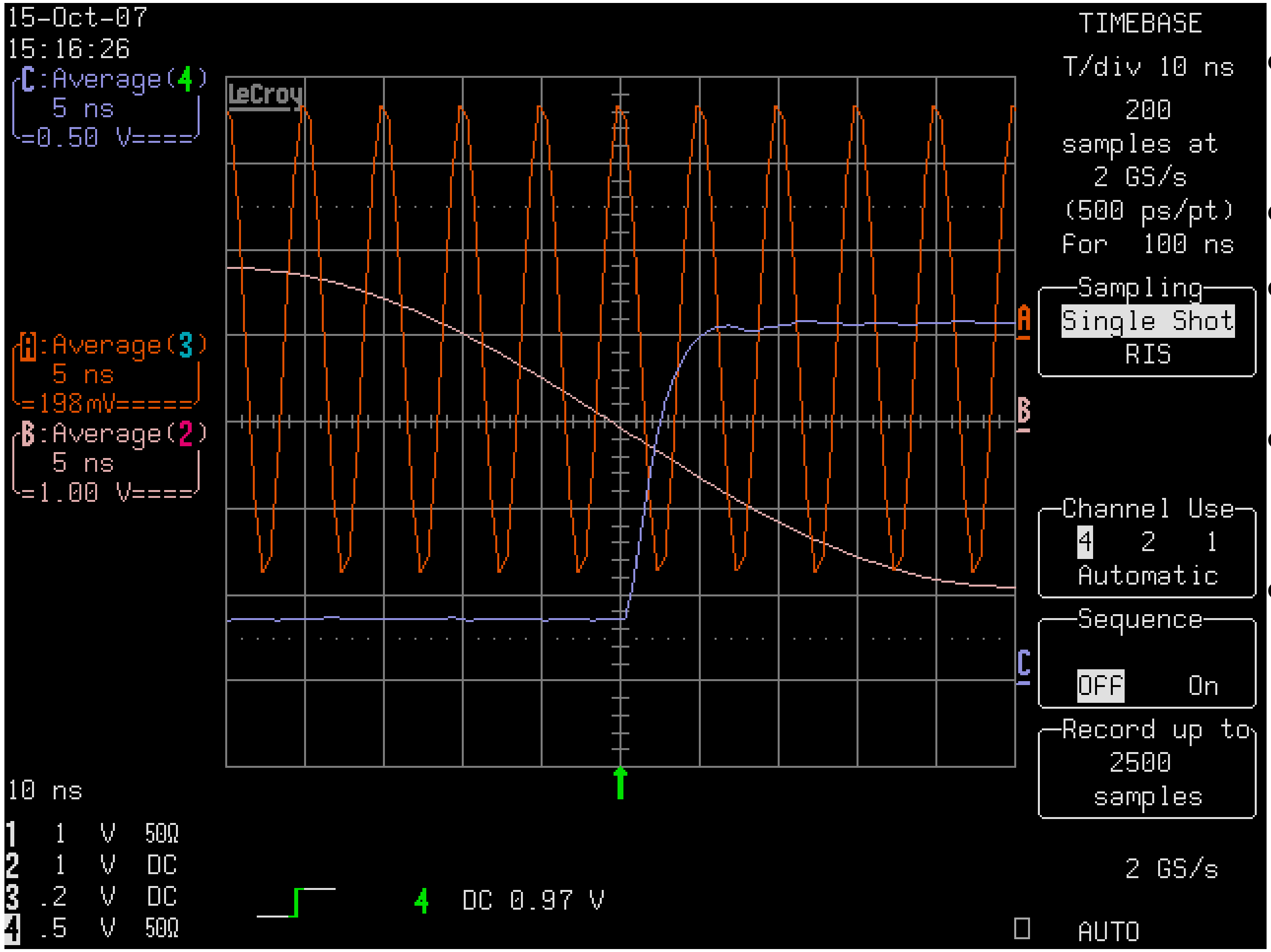
FEE „standard module“ Tacquila

Tac chips
ASIC: FHG Dresden
Concept: GSI



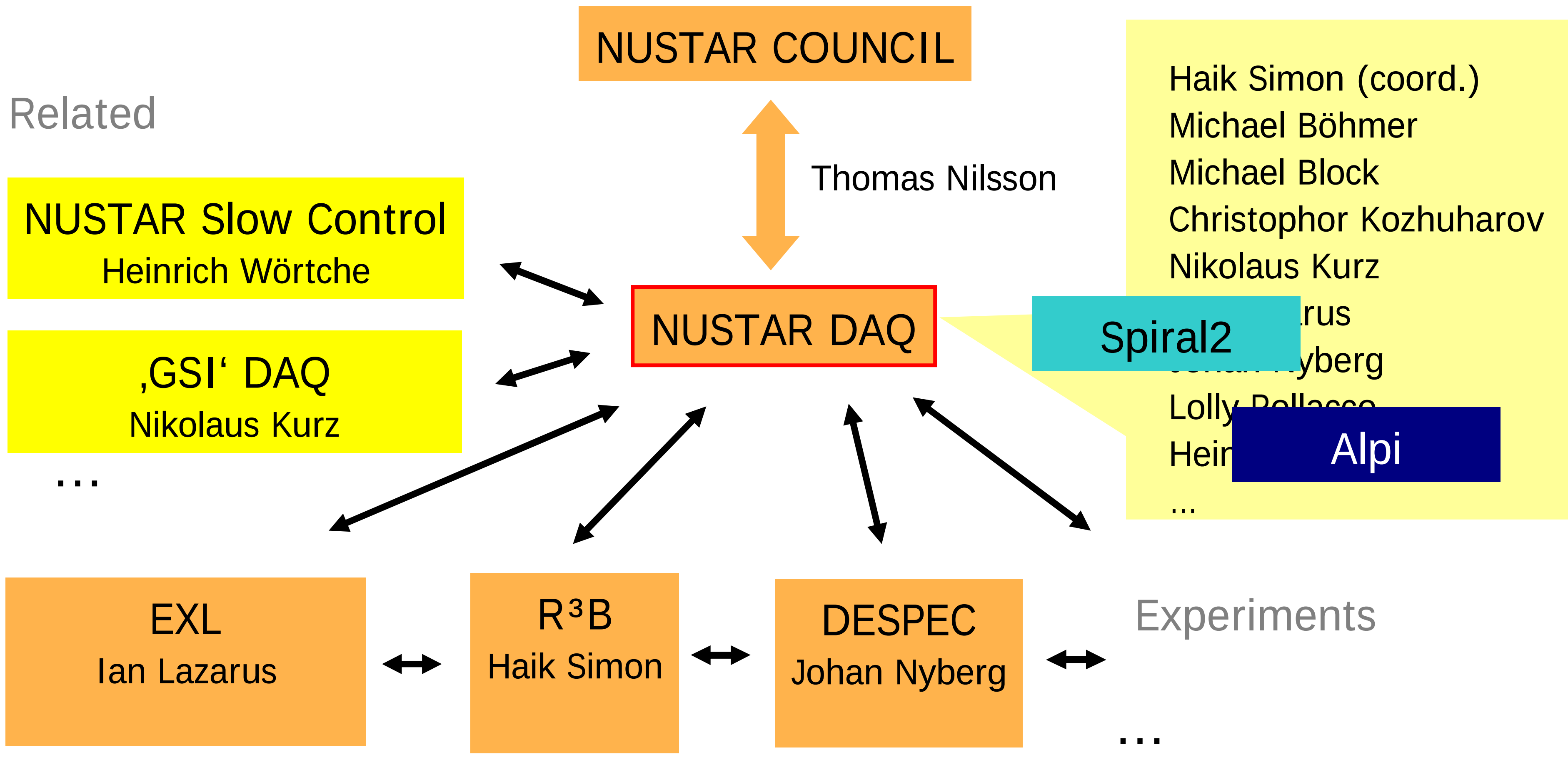
- 1241 chips are availble @GSI (9 €/chip)
- 40,000 could be produced from existing wavers and bought (price to be negotiated, one shot)
  - new company for packaging
  - testing about 0.5 €/chip
  - 2800 chips/wafer 2000 €/wafer

BuTiS at work (20071015)

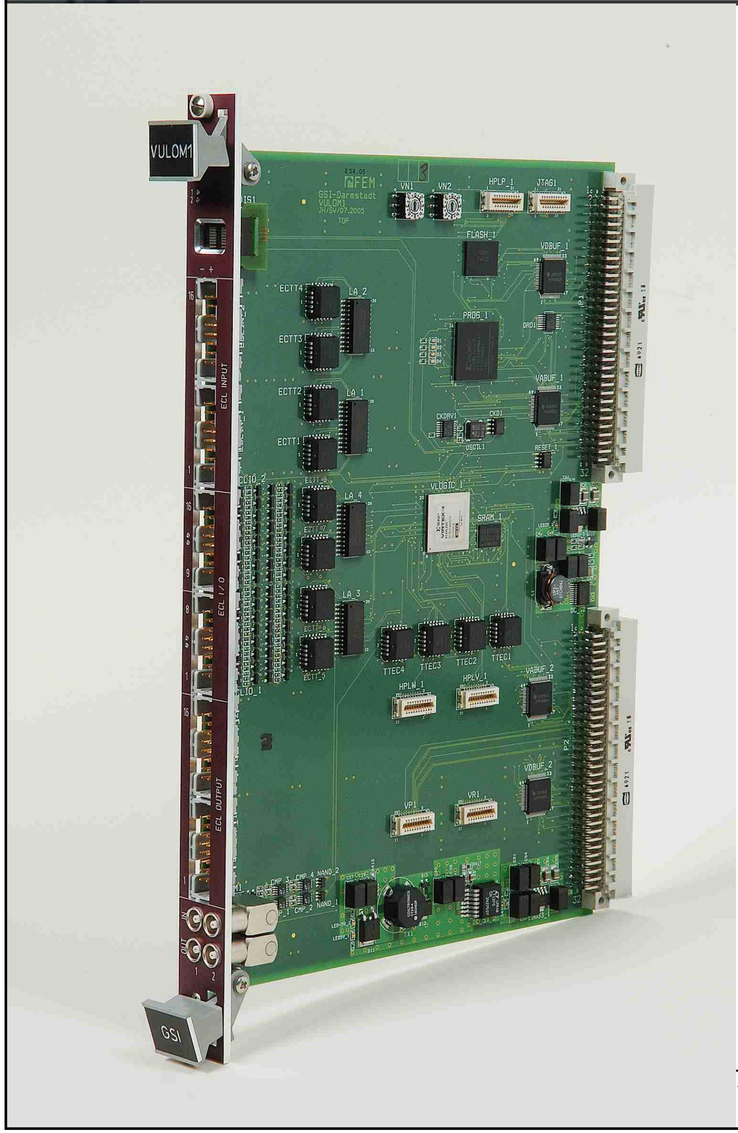


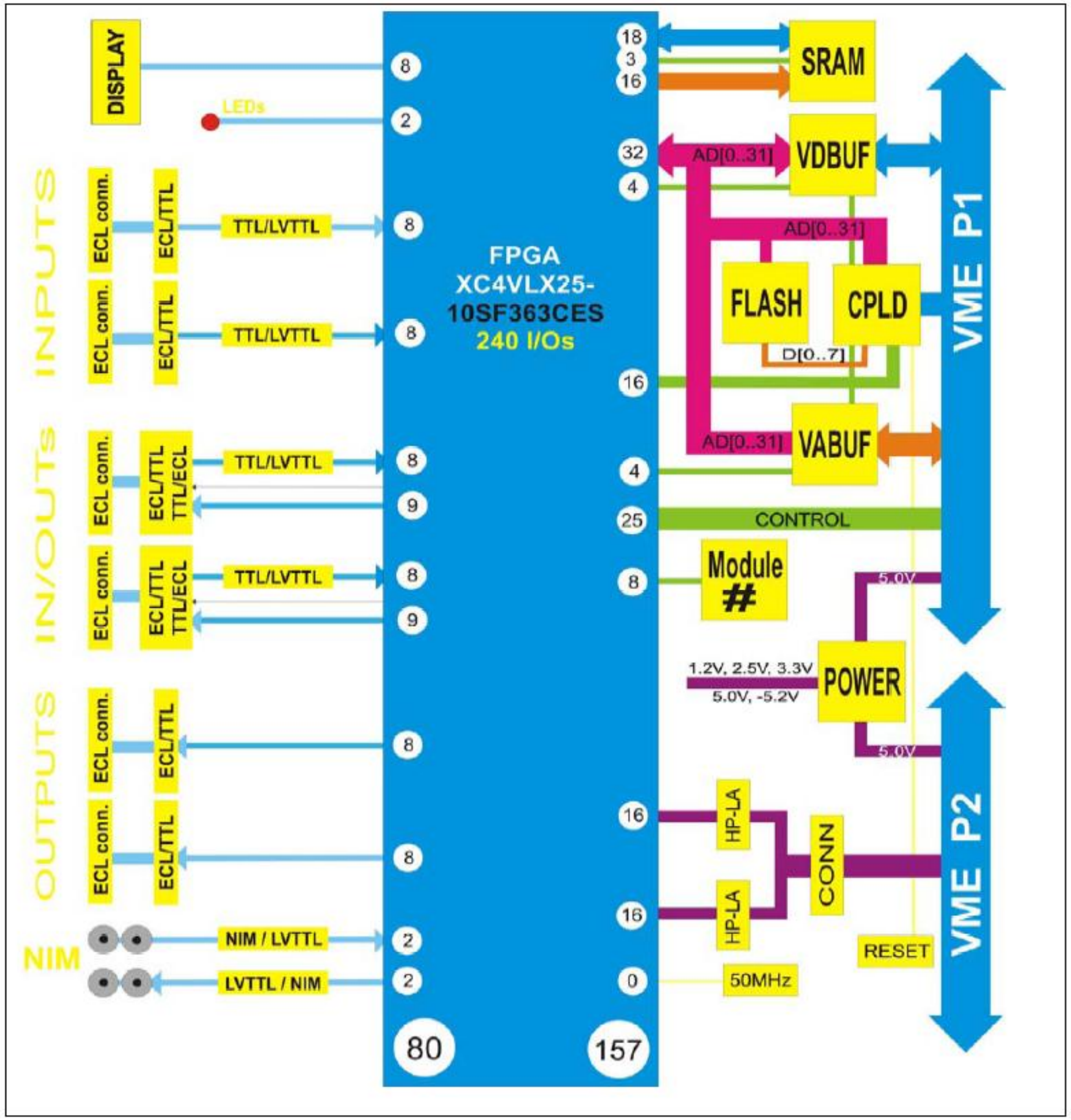
- 10, 200 MHz sine waves (adj. phase)
- T0 pulse for sync.
- very good phase stability
- BuTiS oscillator can run standalone
- about 10k€/system

NUSTAR DAQ organisation

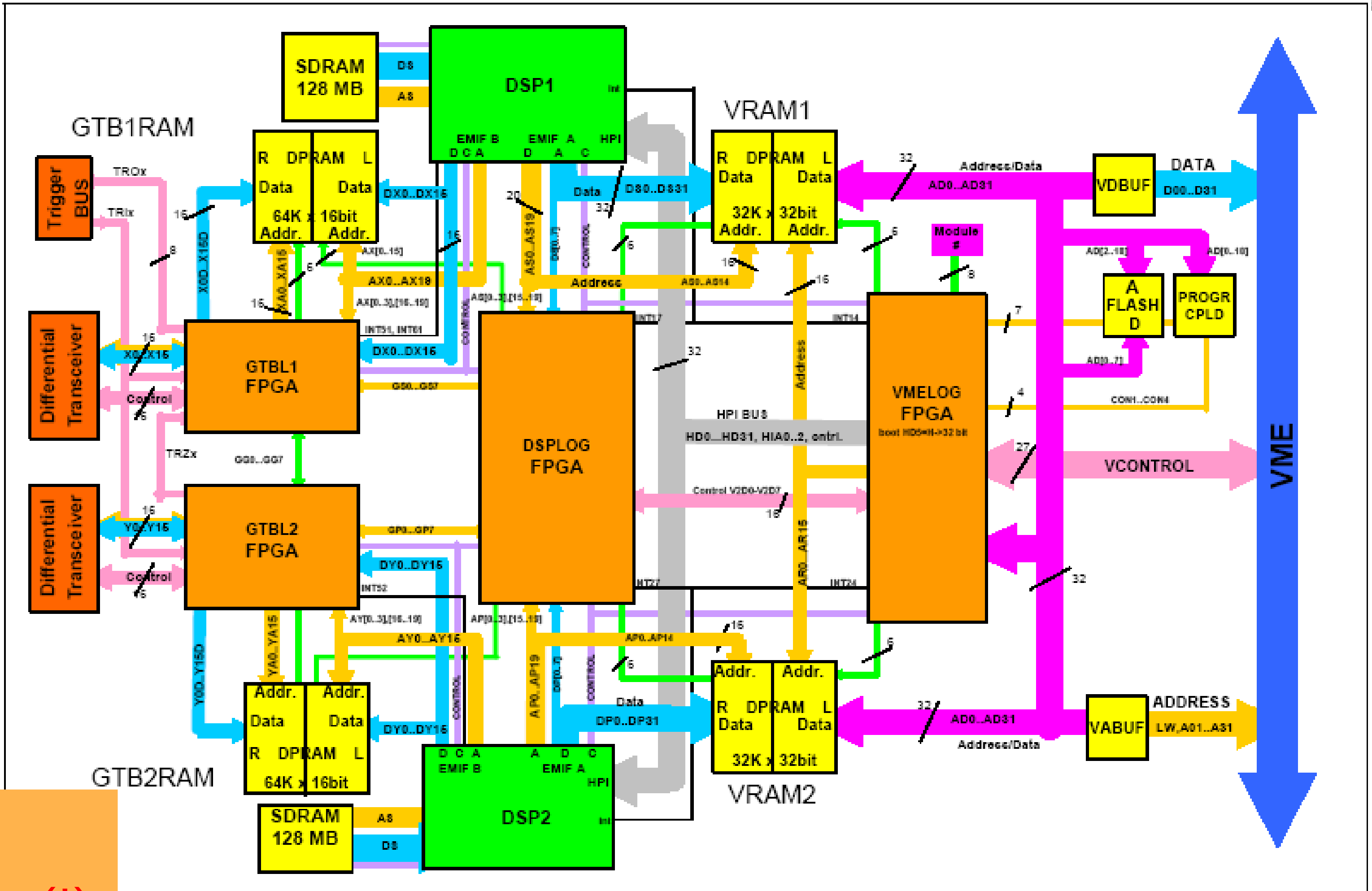


Logic Module





SAM Readout → VME → MBS (readout trigger)



FE Trigger != MBS trigger (!)

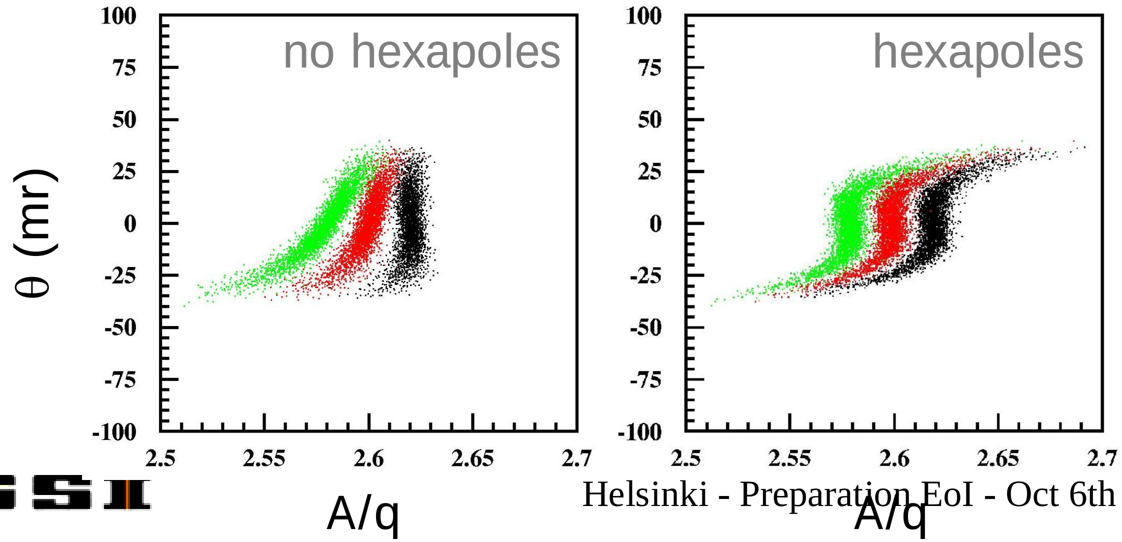
Constraints on detecting system

- Tracking detectors in front of and behind the target (x, y, θ, ϕ)
- Start detector (t_{start})
- Focal plane detector (x, y, θ, t_{stop}, ΔE, E_{res})

Δx, Δy ~ 1 mm

Δθ, Δϕ ~ 2 mr

ΔTof ~ 150 ps



$^{132-n}Sn$ knocked out fragments

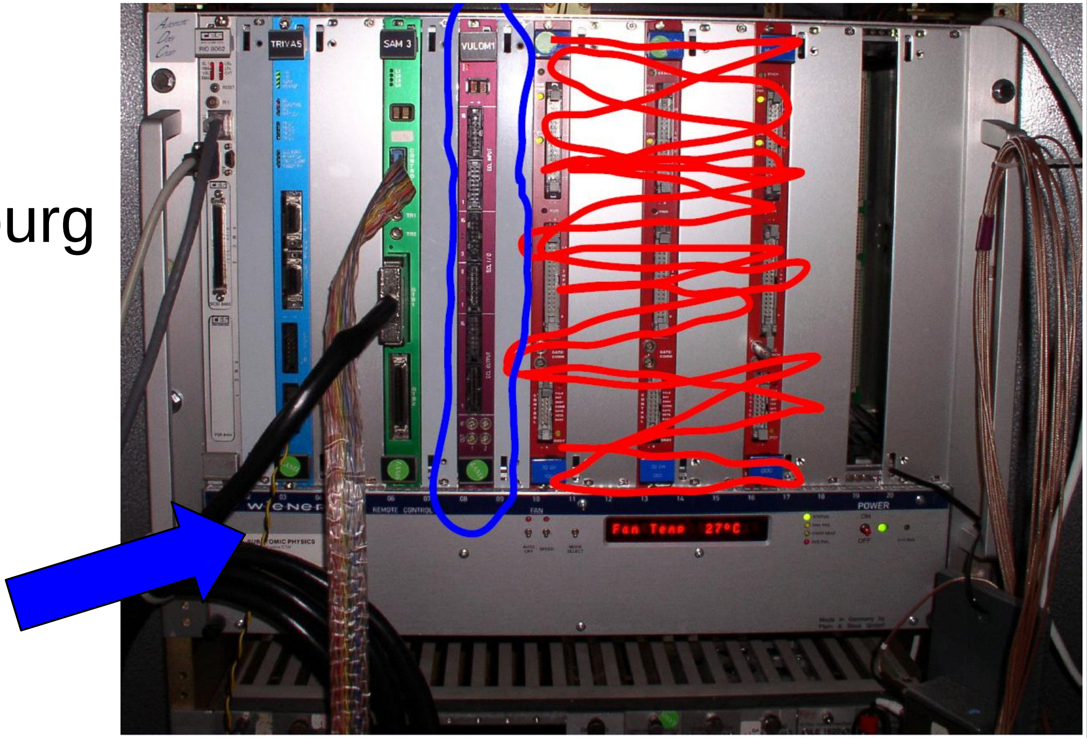
Monitoring integrated electronics (example: Vulom Trigger Electr.)

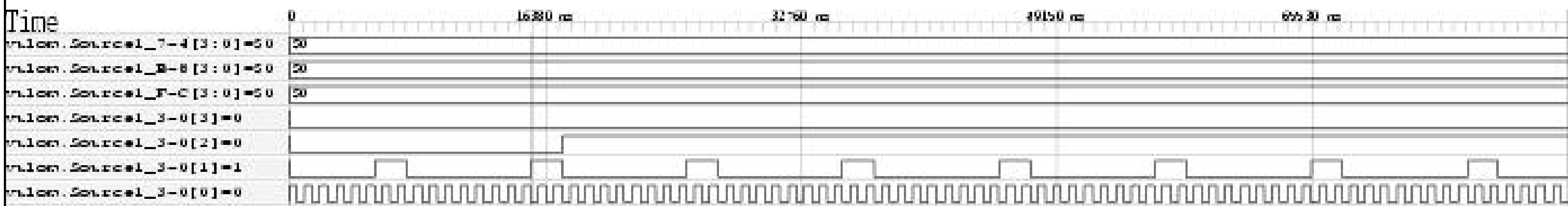
M.Fuhrmann, H.Simon

Logic Module (FPGA)
Master Thesis: Softscope
Univ of Applied Science Coburg

→GTKwave output
→programming
via DAQ channel

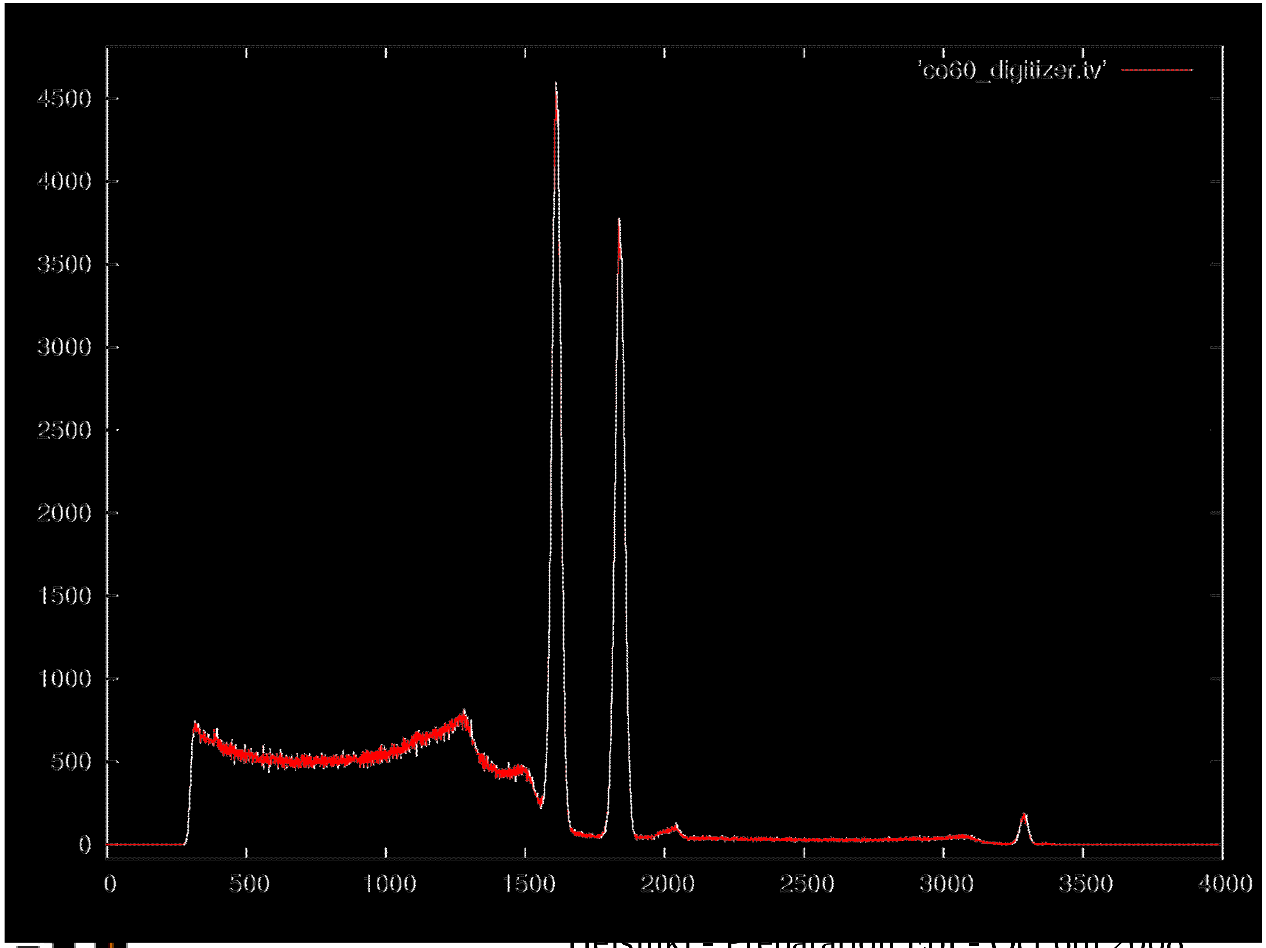
Test: Summer student
P. Lubberdink (KVI)





Digital Signal Processing (ENERGY)

H. Wörtche et al. (KVI)



- oversampling 2GS, intelligent averaging
- comparable resolution to conventional spectroscopy setup …

ASIC: System Design

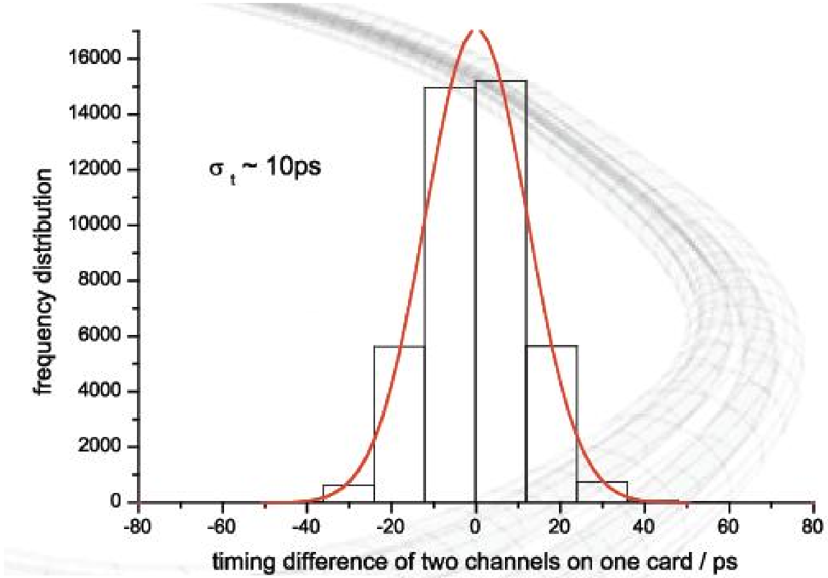
fast timing

G. May, H.Simon (GSI)

Application (100 - 1000 ch.)

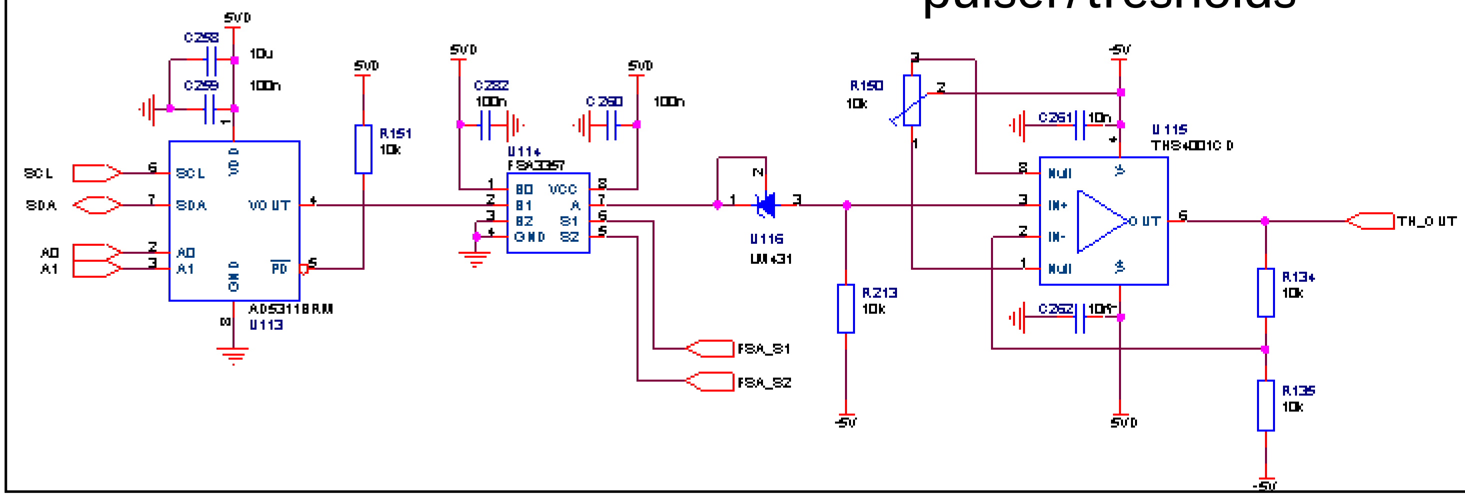
- PMT signals (TOF, LAND …)
- + slow control + monitoring → dedicated front end card
- Triggering facilities (OR/Mult./Anal. Sum)

→ TAC ASIC to be replaced with New CBM DLL chip



H. Deppe (GSI)

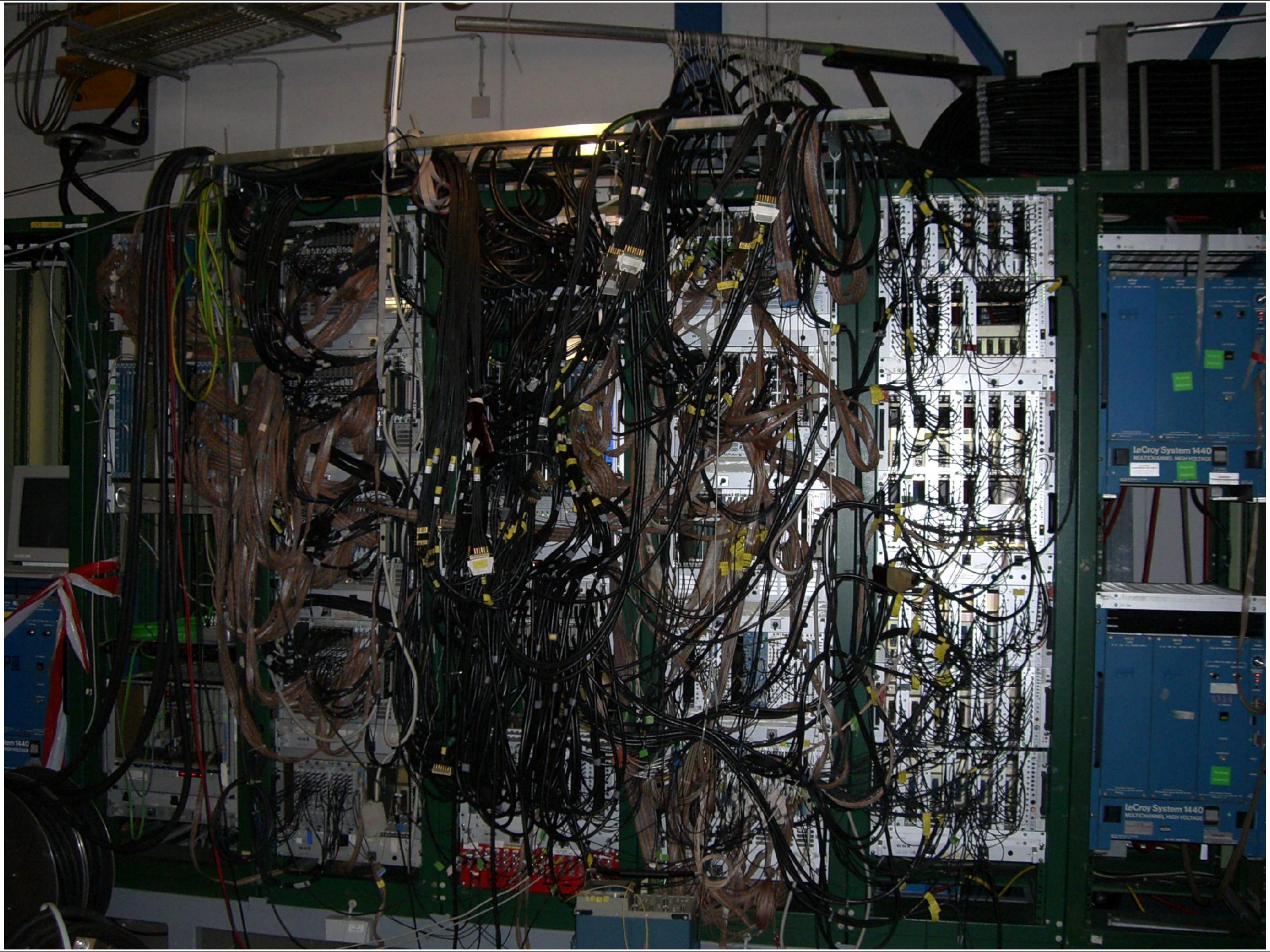
pulser/tresholds



E.g.
I2C controlled
discriminators

Example: Current LAND electronics ~ 600 ch

G. May, K. Koch, H.Simon (GSI)



New design

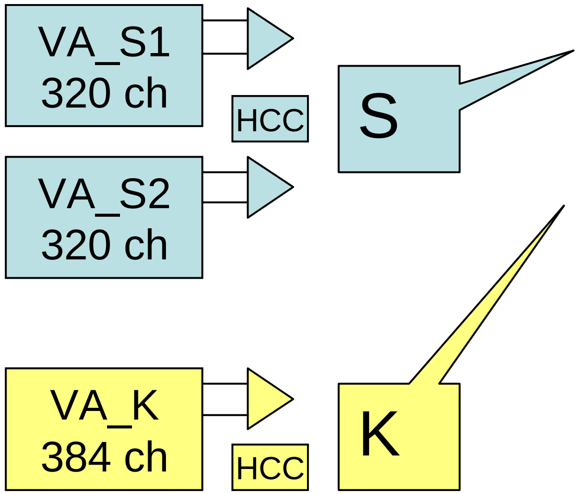
= 30 Tacquila cards with LAND FEE + 2 VME helper modules + 1 VME CPU
+ 10 VME QDCs
+ 3 HV bins

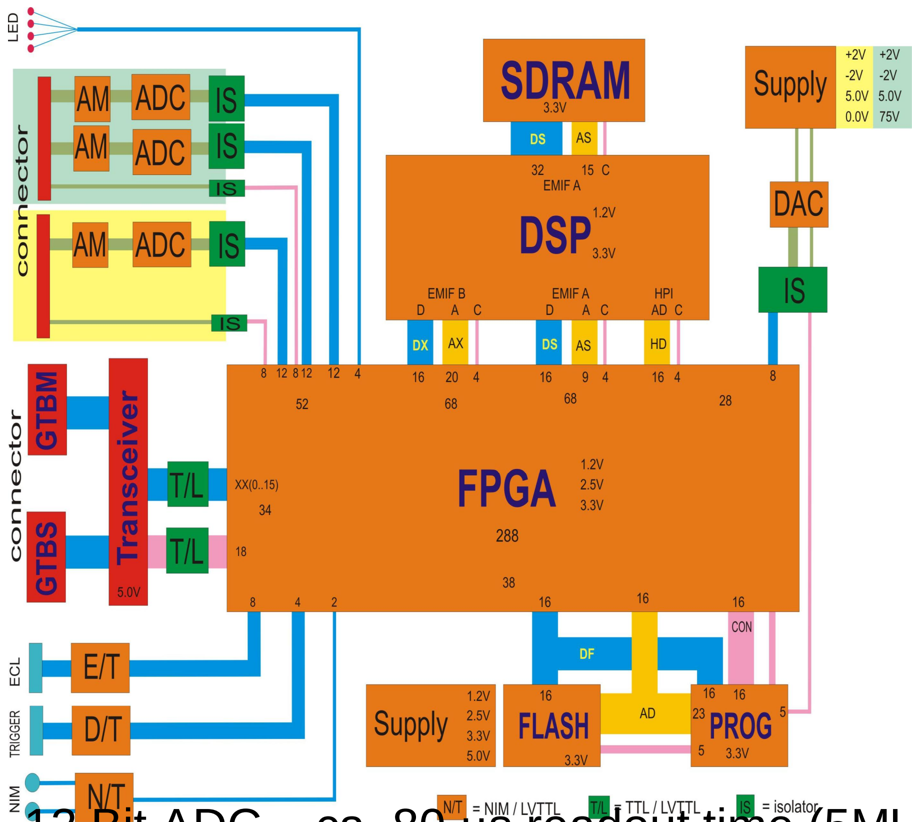
Boils down to
1 + ε crates !

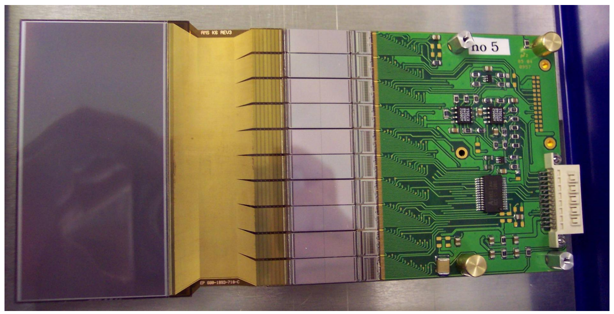
FAIR

SIlicon Strip DEtector REadout Module (SIDEREM)

J. Hofmann, W. Ott, N.Kurz (GSI)







12 Bit ADC ca. 80 µs readout time (5MHz)

DSP TMS320VC6414 (TI)

FPGA Virtex-4 LX25 (Xilinx)