MTCA - a High Data Rate Solution for FAIR Beam Instrumentation

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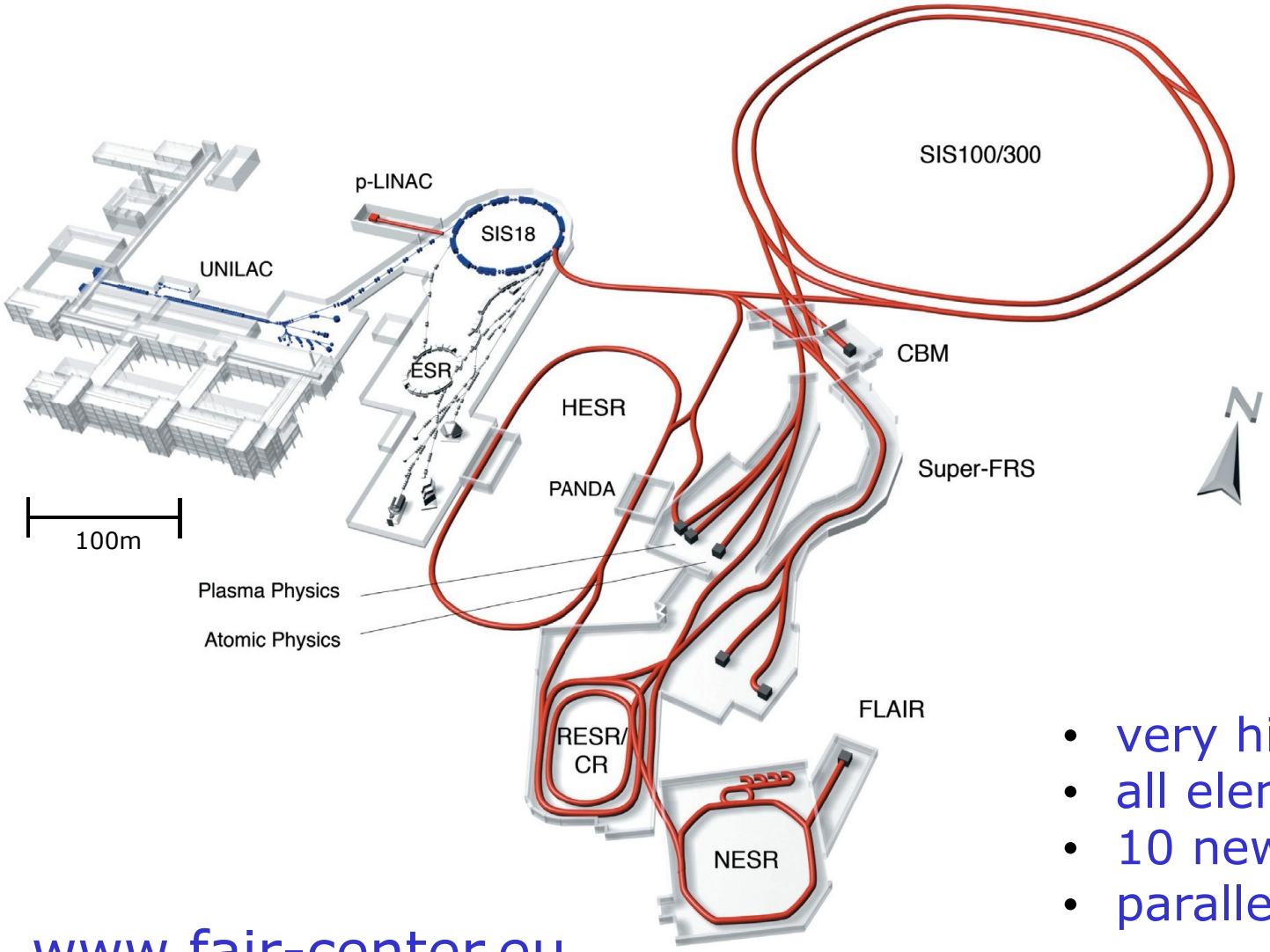
GSI and FAIR



primary beams:
up to 35 GeV/u Uranium
up to 90 GeV/u Protons

secondary beams:
- broad range of radioactive beams
- antiprotons 0 - 30 GeV

storage and cooler rings:
- radioactive beams
- 10^{11} stored and cooled 0.8 - 14.5 GeV antiprotons

- very high diversity
- all elements from p to U
- 10 new large facilities
- parallel beam operation

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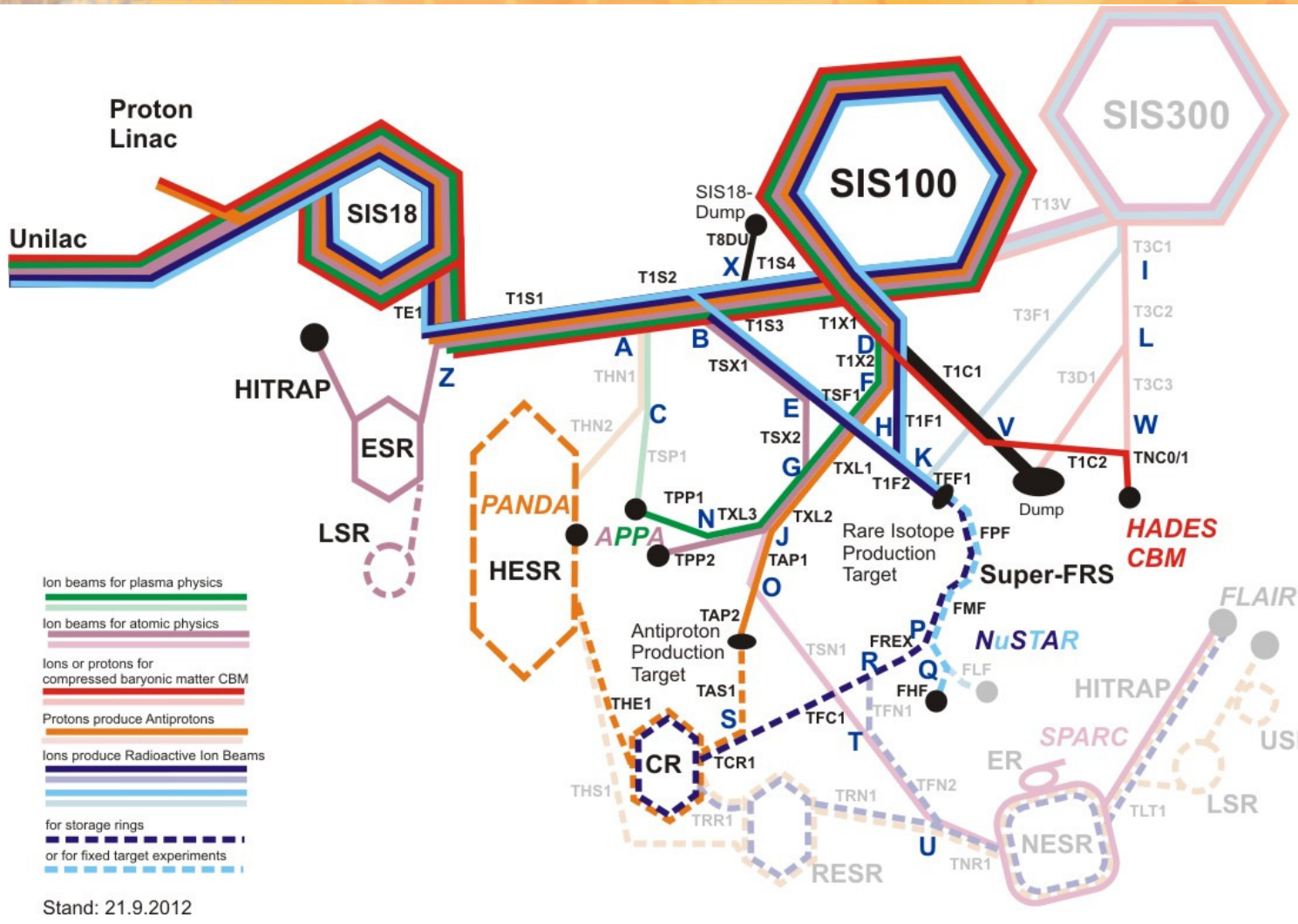
FAIR



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FAIR

Luftbild des Baufelds vom 12.08.2012 (Foto: Jan Schäfer für FAIR)

Beam Instrumentation

What is Beam Instrumentation:

- BI creates and operates small (particle) detectors, within or attached to the accelerators, to observe and optimize the ion beams on their way to a target
- Department of approx. 40 persons

Responsible for:

- FAIR Beam Instrumentation
- Data Acquisition for FAIR Beam Instrumentation

Challenges for FAIR-Beam Instrumentation

HEBT, Super FRS, CR, p-Linac, SIS100, pBar Target, HESR (later: NESR, SIS300, RESR)

- 24 different types of BI systems, 17 electronic rooms, total sum of approx. 1000 channels of diverse signal types
- Development of all systems at the same time!
- Full integration of **all** devices into control system (no exceptions)
- Long distances
  (How to bring data together? SIS100 circ. 1.1km)
- High radiation
  best: no digital electronics near the beam pipe

Front-End Software

Requirements and decisions:

- FESA (Front-End Software Architecture) from CERN
- OS for Intel CPUs (32/64Bit): Scientific Linux, PXEBoot
- RT functionality (Linux RT-Patch)
- Drivers and test software in **source code** for long term maintenance
- Access of standard low level communication (TCP/IP, LXI, SCPI, SNMP, GPIB, RS232 etc.) foreseen
- Field-bus system (Profinet, Siemens), Step7 and IEPLC/FESA

Front-End Hardware

Requirements and decisions:

- Various hardware platforms (VME, PCI/PCIe, µTCA)
- Distributed timing (White Rabbit Project)

  Defined form factors: VME, PCIe, AMC, PMC, Stand-alone
- Redesign or review of all existing electronics (Ratio (price/effort))
- Favored: COTS (Commercial off the shelf) and 2nd source
- Full remote control (reset and terminal control, crate and CPU)
- Ethernet, Fieldbus

Front-End Hardware Platforms

VME

- Good for multi channel applications e.g. counter systems
- Well known
- Many different acquisition boards available Scaler, ADC, TDC, QDC, Discriminator a.o.

PCI/PCIe (Industry PC)

- Good for cost-efficient solutions with low amount of channels
- Simple technology

µTCA

- Good for high bandwidth applications e.g. video imaging, ADCs
- Upcoming technology in High Energy Physics community
- Good remote control features and redundancy

Possible DAQ systems with µTCA

Scaler applications:

- readout of particle detectors (e.g. SIS18: 6x32 Ch.)

Video imaging:

- readout of several GigE cameras with FPGA based online analysis

  Scintillating screens, Beam induced fluorescence

ADC applications:

- Flash ADCs with online FPGA processing for:

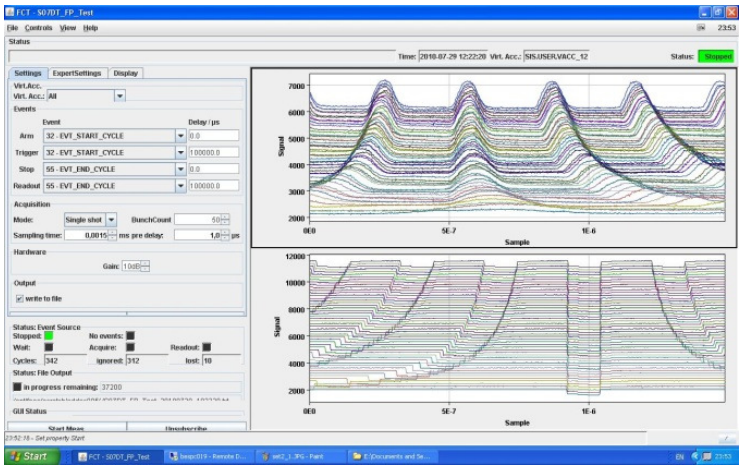
  Beam position monitoring, Closed Orbit Feedback,

  Tune Measurements

- Fast Current Transformers:

  SIS3350: 500MSa/s, 1GB RAM onboard

  at the limit of VME



µTCA Road Map at GSI

Next: Evaluation of

- Crates (MTCA.4): Schroff, Elma, others?
- MCH: Module or on backplane? PCIe or 10GB?
- CPU: State of the art in 2015/16, Intel X86 based
- Availability of suitable DAQ AMCs
- Determination of suitable BI systems for µTCA DAQ
- Experience at other Labs

Our MTCA hardware wishlist

ADCs:

- few channels, high end (>Gs/s, triggered or free running with dual port RAM)
- multi-channel, 1-100MSa/s

Specialities:

- Scalers, TDC, QDC, Multi-NIC, FPGA/FMC Carrier, I/O

Support electronics like NIM modules:

- I/f, U/f, Clock, Gate, Fan In/out, Discriminator etc.

Problem for FAIR: low quantities, no money for development → COTS

µTCA test systems

MTCA.4 ELMA Chassis
Kontron AM5010 CPU
NAT MCH
SIS8300 ADC
-> e.g. BPM system

MTCA.4 Schroff Chassis
Adlink AMC-1000 CPU
NAT MCH
TAMC260 PMC Carrier
Kontron AM4301 4xNIC
-> e.g Scintillating screens

Recommendations to the MTCA working group

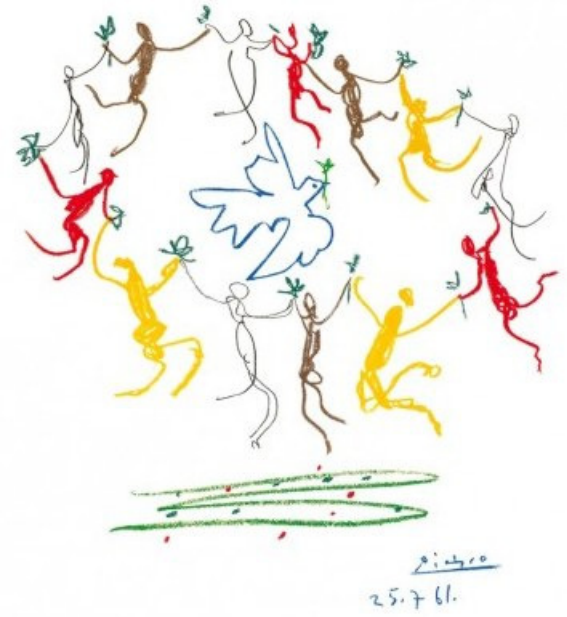
Documentation: at least for beginners

- Backplane
- Configurations
- Bus types
- Pit-falls

What´s an Upstream transparent slot number (cluster1) e.g. root complex ?

Website:

- probably mtca.desy.de ?
- White Papers
- Wishlist
- Forum

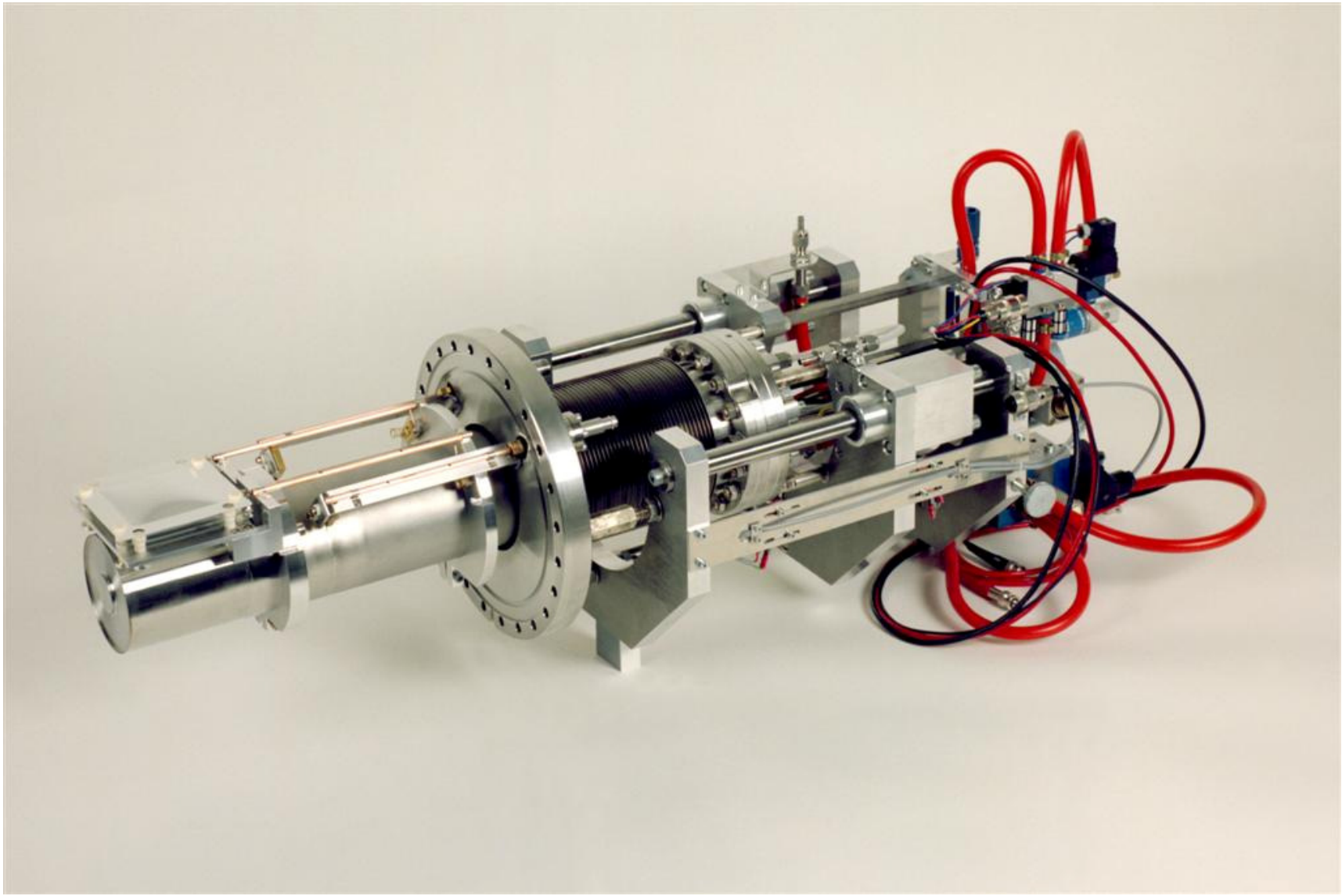


The End

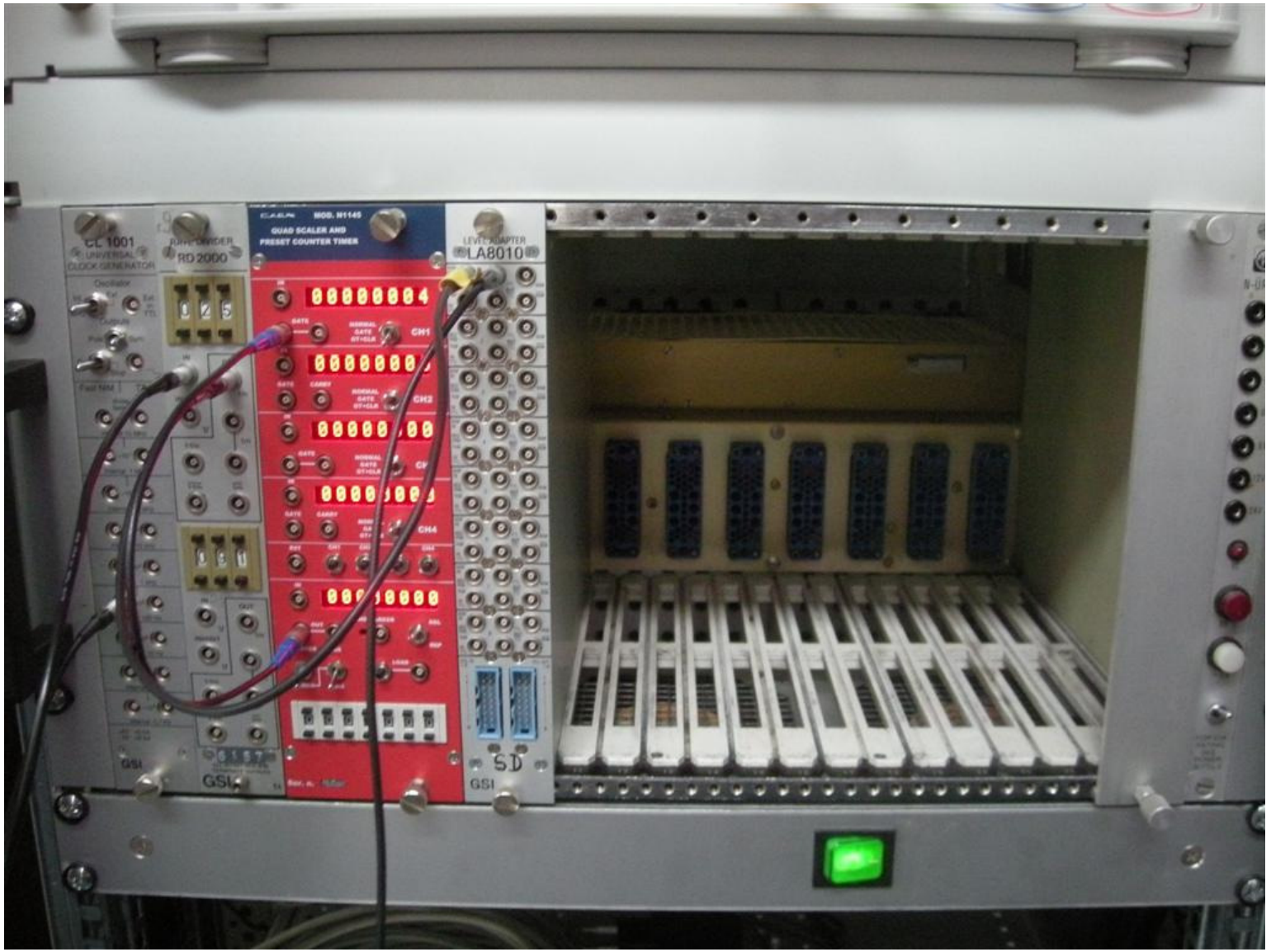
Thank you for your attention !

Questions?

Particle Detector Combination



NIM Crate and Modules



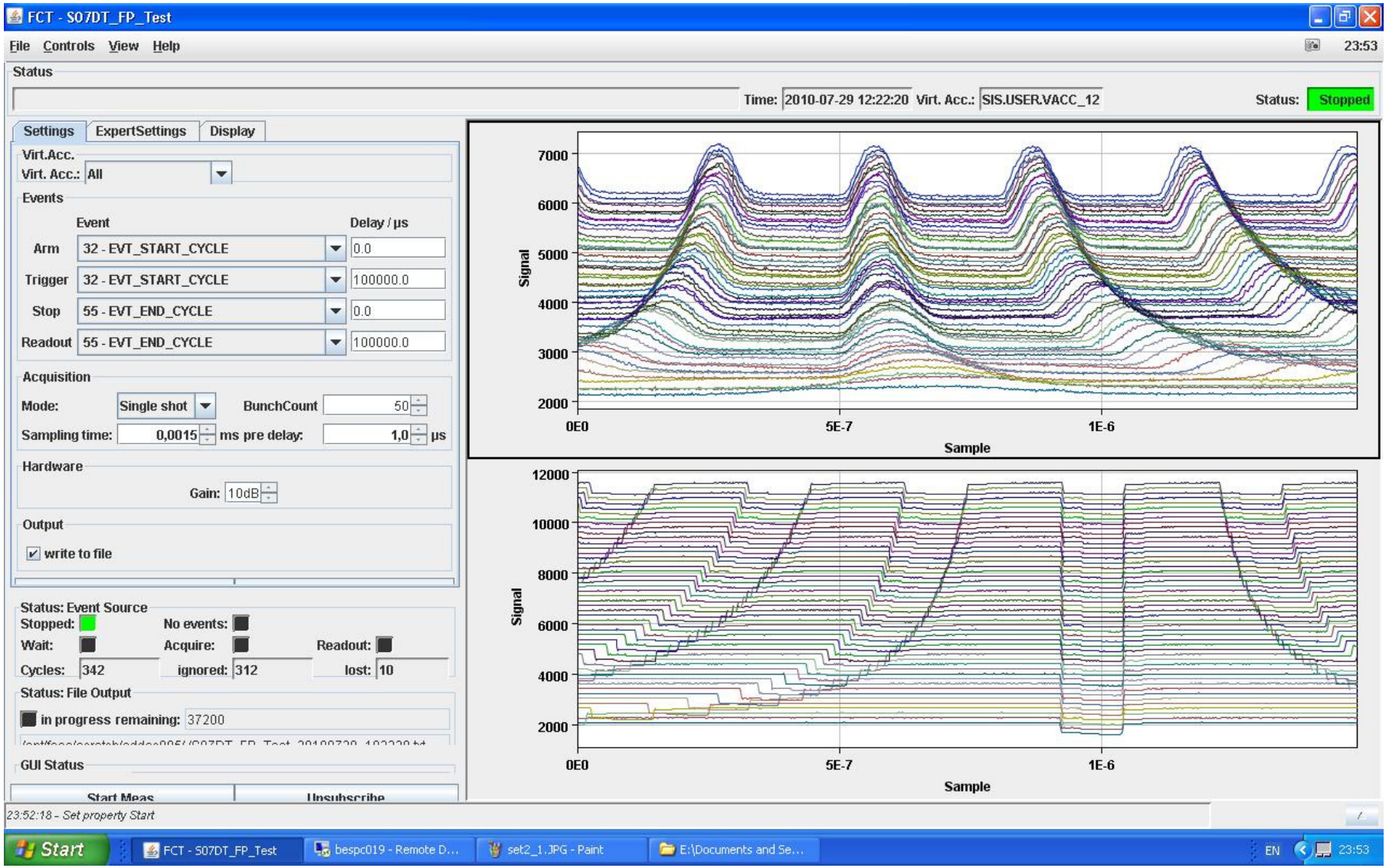
DAQ for FAIR-Beam Instrumentation

Device	pLinac	HEBT	SIS100	SFRS	pBar	HESR	CR	Sum:
AC Transformer	9						1	10
Beam Induced Fluorescence		18??						0
Beam Loss Monitor		50	50		4	118	8	230
Beam Position Monitor	14	60	84		4	80	18	260
Bunch Structure Monitor	1							1
Collimator			60					60
Cryogenic Current Comparator		6		1			1	8
DC Transformer			1			2	1	4
DC Transformer Novel Type			1					1
Faraday Cup / Beam Stopper	3		6				2	11
Fast Current Transformer		18	2		1		1	22
Ionization Chamber		21						21
Ionization Profile Monitor		18	1			2	1	22
Multi Wire Proportional Chamber		46		30		1		77
Plastic Scintillator		21						21
Profile Grid/SEM Grid	4	75	6		3		2	90
Quadrupolar Pick-Up			1			1		2
Resonant Transformer		36		1	1			38
Schottky Diagnosis			1			1	1	3
Scintillating Screen		31	2		3	4	2	42
Secondary Electron Monitor		21		4	3			28
Slit Pair / Scraper / Iris	4					2	12	18
Tune Measurement			1			1	1	3
Wall Current Monitor						1		1
Sum:	35	403	216	36	19	213	51	**973**

Modules 0-3:
no SIS300, NESR, RESR, FLAIR

24 DAQ-systems with approx. 1000 channels in 17 electronic rooms

Fast Current Transformer



DAQ for FAIR-Beam Instrumentation

FAIR financing concept is based on so-called:

- Expression of Interest (EoI) packages
- BI at GSI responsible for DAQ for FAIR-BI

BI partners within the EoI concept so far:

- Slovenia, France, Russia

Actual work:

- Writing of detailed specifications and contracting
- Discussions and preparation of test systems

FAIR

Some Details:

- FAIR GmbH was incorporated in October 2010
- Building permit granted in 2012, construction works have started
- FAIR project duration: The facility shall be set up by the year 2018.
- FAIR budget: 1,027 M€ in 2005 price levels.
- On top a Manpower equivalent to 1,550 person-years
- FAIR contracting parties:
  Spain, Finland, France, Germany, India, Poland, Romania, Russia, Slovenia, Sweden
- Partner institutions: More than 250 research institutions from 44 countries

Large Experiments:

APPA – Atomic, Plasma Physics and Applications

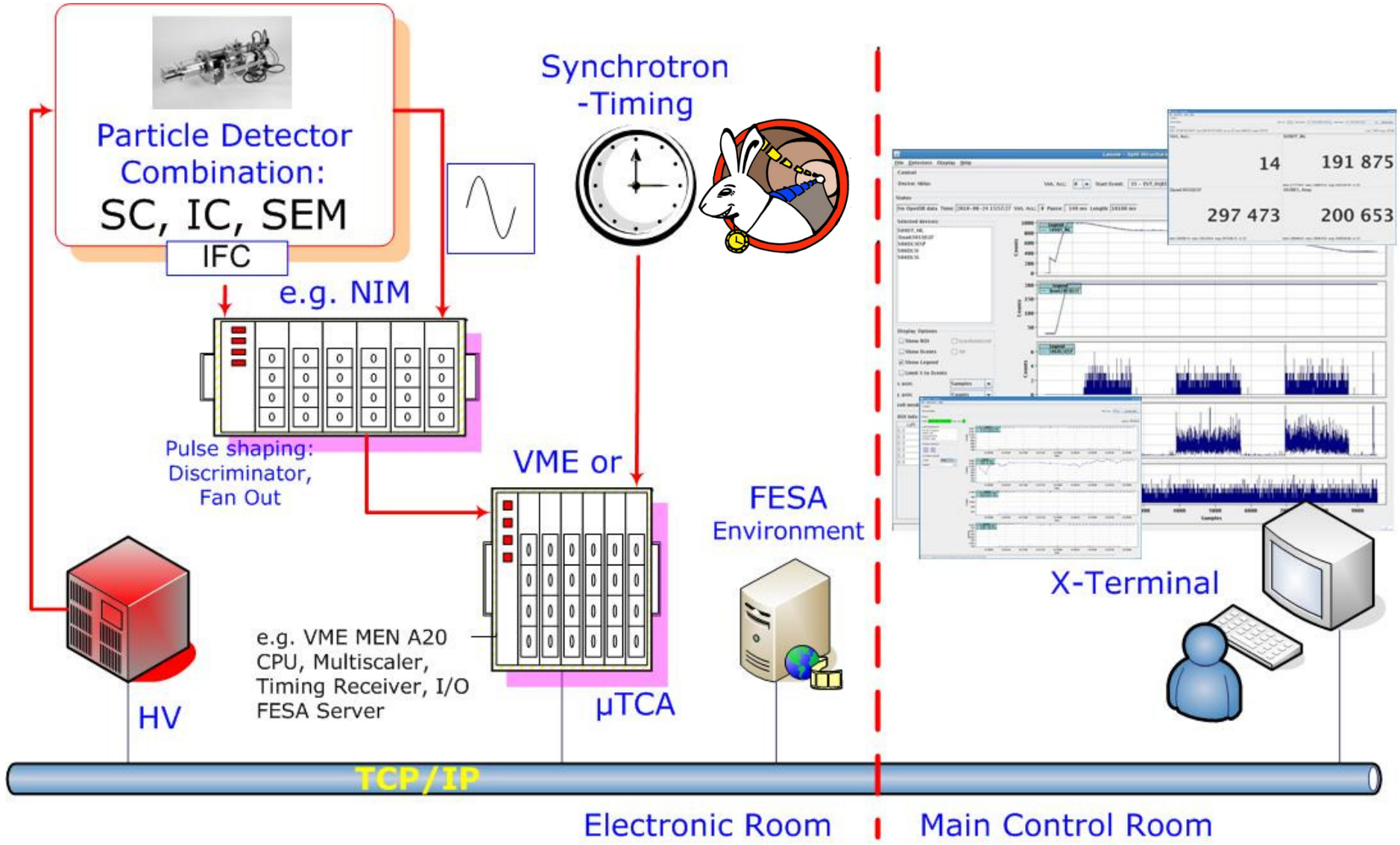
CBM – Condensed Baryonic Matter

NUSTAR – Nuclear Structure, Astrophysics and Reactions

PANDA – Antiproton Annihilation at Darmstadt

in collaborations with approx. 3000 scientists worldwide

Example of a typical DAQ system LASSIE



Time planning

Hardware specifications, estimation of quantities for all pieces and purchase test systems **2013**

Preparation of tenders, where required **2014/15**

Site acceptance tests **2016**

Installation into tunnel **2016/17**

Remark: Purchase of CPU based systems as late as possible