CERN North Area setup and DAQ for fixed target experiments with crystals

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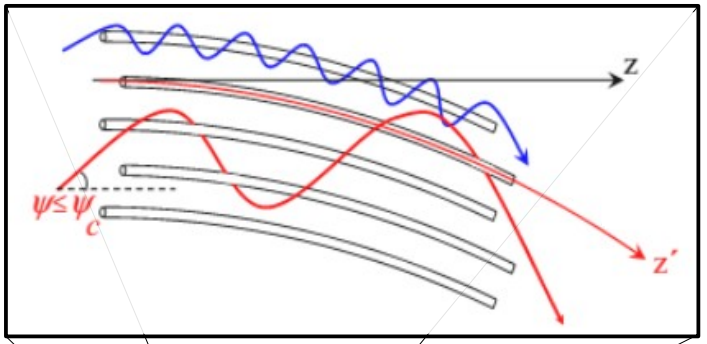
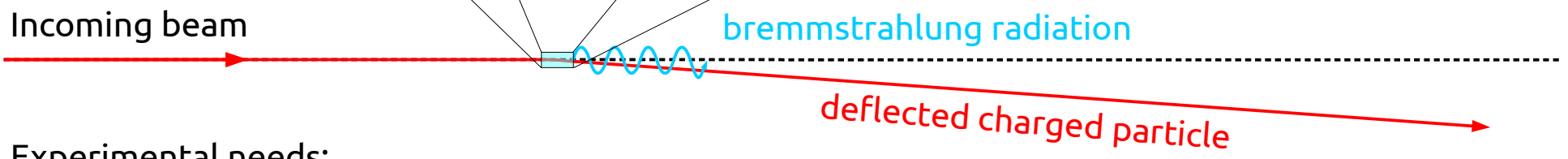
How to observe channeling*

* channeling-related processes



bent/orientated crystal



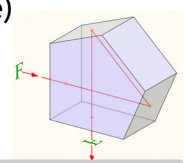
Experimental needs:

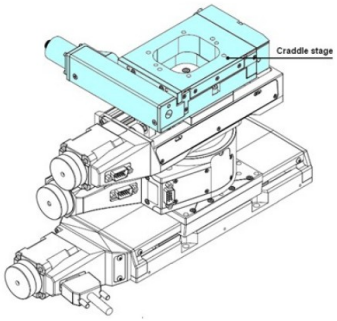
- beam purity (only electrons/positrons) → **particle selection/identification**
- crystal position (XYZ, orientation) → **alignment**, **goniometers**
- deflection angle → incoming particle direction before & after → **tracking**
- emitted photons energy → **gamma calorimetry**

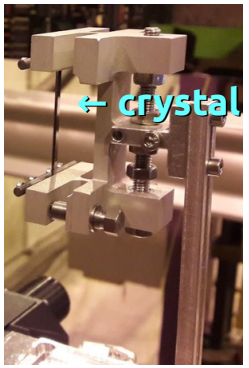
Many detectors/tools

CRYSTAL POSITION

- laser+pentaprism
- precision gonimeter (INFN-Fe)





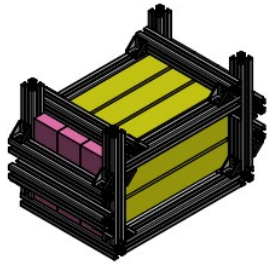


GAMMA CALORIMETRY

- 9 x Pb-glass crystals (2.8x2.8x22 cm^3): 17 X_0, each 1.3 Mol. radii

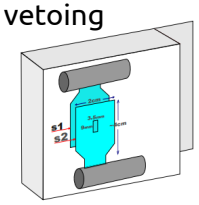
(full EM shower containement @80-100 GeV)
- each readout by 4 SiPMs (4x4mm2, cell size 50um) + 1 LED (online self-calibration)

→ resolution σ_E/E ~ 2-3%



TRIGGER

2 Plastic scintillators (~ cm x cm+hole) + 2 PMT tube for halo vetoing
→ beam size ~ mm^2

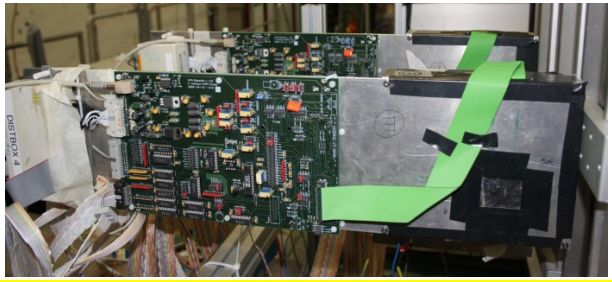


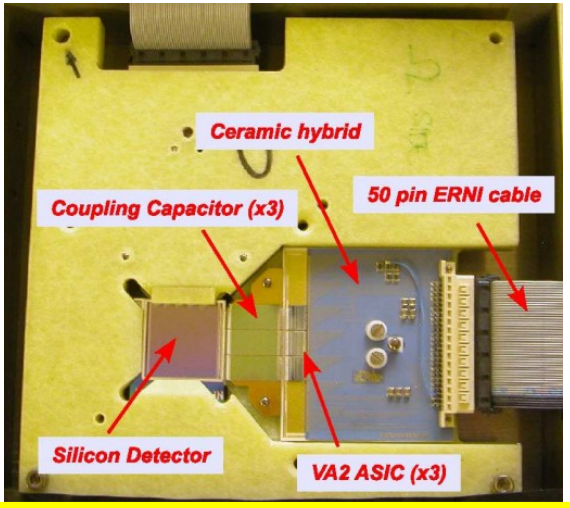
BENDING MAGNET

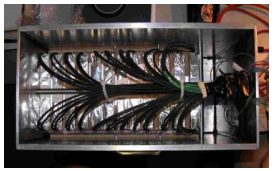
~ T · m → further charged/neutral separation
(@ 120GeV ~ 15 cm separation ~ 20 m)

TRACKING

- 2-side XY strips (384), thickness 300um
  phys pitch 25/50 um (p/n side), readout pitch 50um
  → SNR ~ 80, spatial resolution 4um
- 3 x VA2 ASIC: low power, shaping, sample&hold
- custom frontend electronic boards: FPGAs, ADCs, multiplexing @ 5MHz

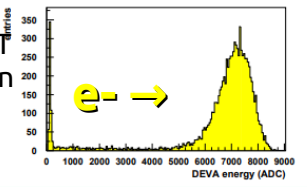




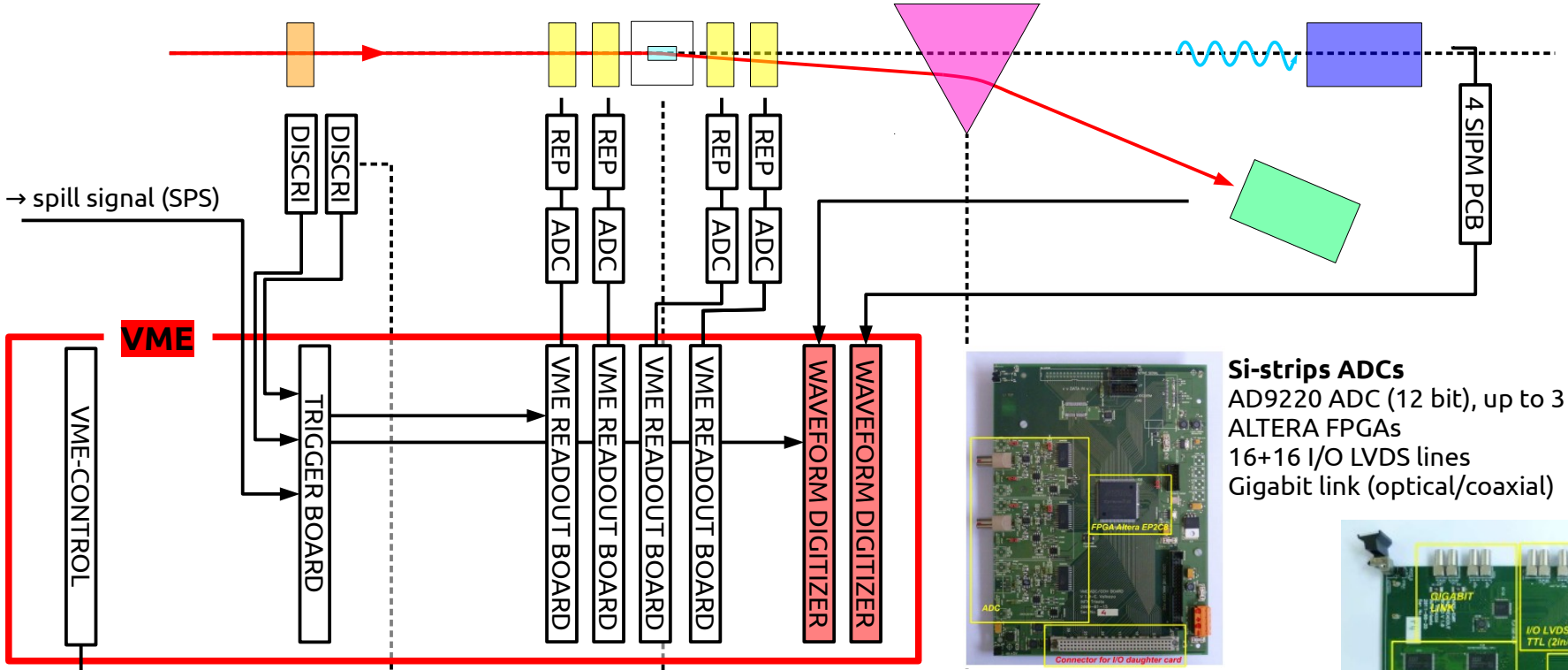


e+/- CALORIMETER

- sampling calorimeter: 12 x 15x15x2cm^3 tiles (plastic scintillator) interleaved with 11 Pb tiles (0.5-1cm) → 13 X_0
- readout by 16 channel PMT
- ~90% e-/MIP discrimination

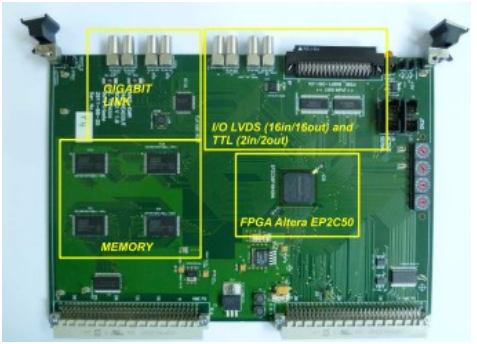


DAQ system

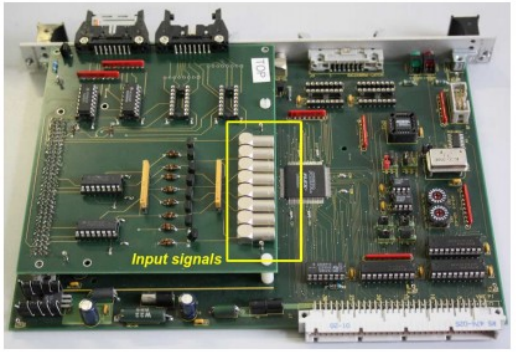


Si-strips ADCs
AD9220 ADC (12 bit), up to 3 channels
ALTERA FPGAs
16+16 I/O LVDS lines
Gigabit link (optical/coaxial)

Dedicated electronics

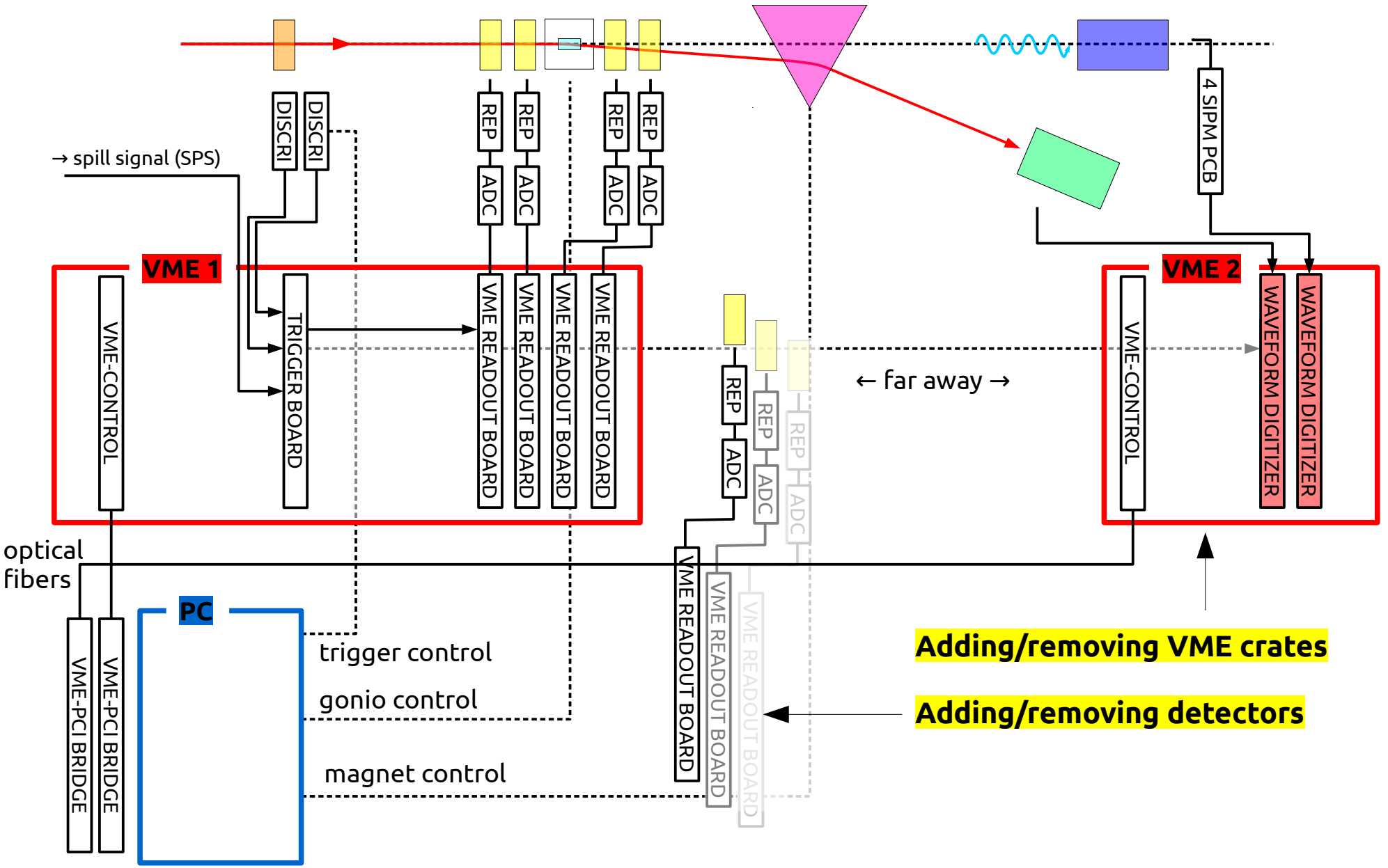


VRB
ALTERA FPGAs, local RAM, Gigabit link
→ clock generation,
digitized/multiplexed signal handling

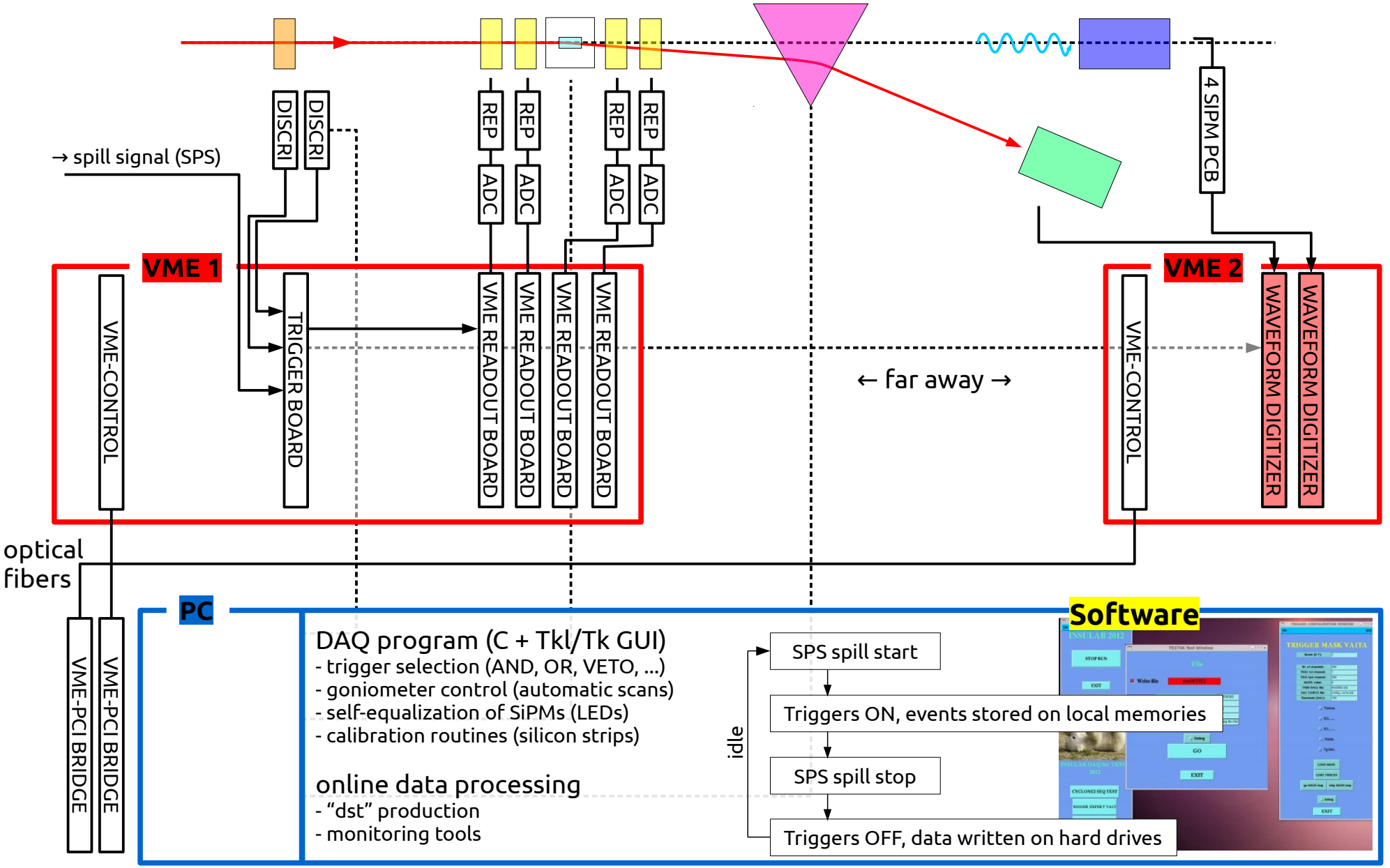


Trigger boardstrips)
Receiving spill signal from SPS
Receiving scintillator signals
→ Trigger generation to VRB boards

DAQ system


→ spill signal (SPS)
DISCRI
DISCRI
REP
ADC
4 SIPM PCB
VME 1
VME-CONTROL
TRIGGER BOARD
VME READOUT BOARD
← far away →
VME 2
VME-CONTROL
WAVEFORM DIGITIZER
optical fibers
PC
VME-PCI BRIDGE
trigger control
gonio control
magnet control
Adding/removing VME crates
Adding/removing detectors

DAQ system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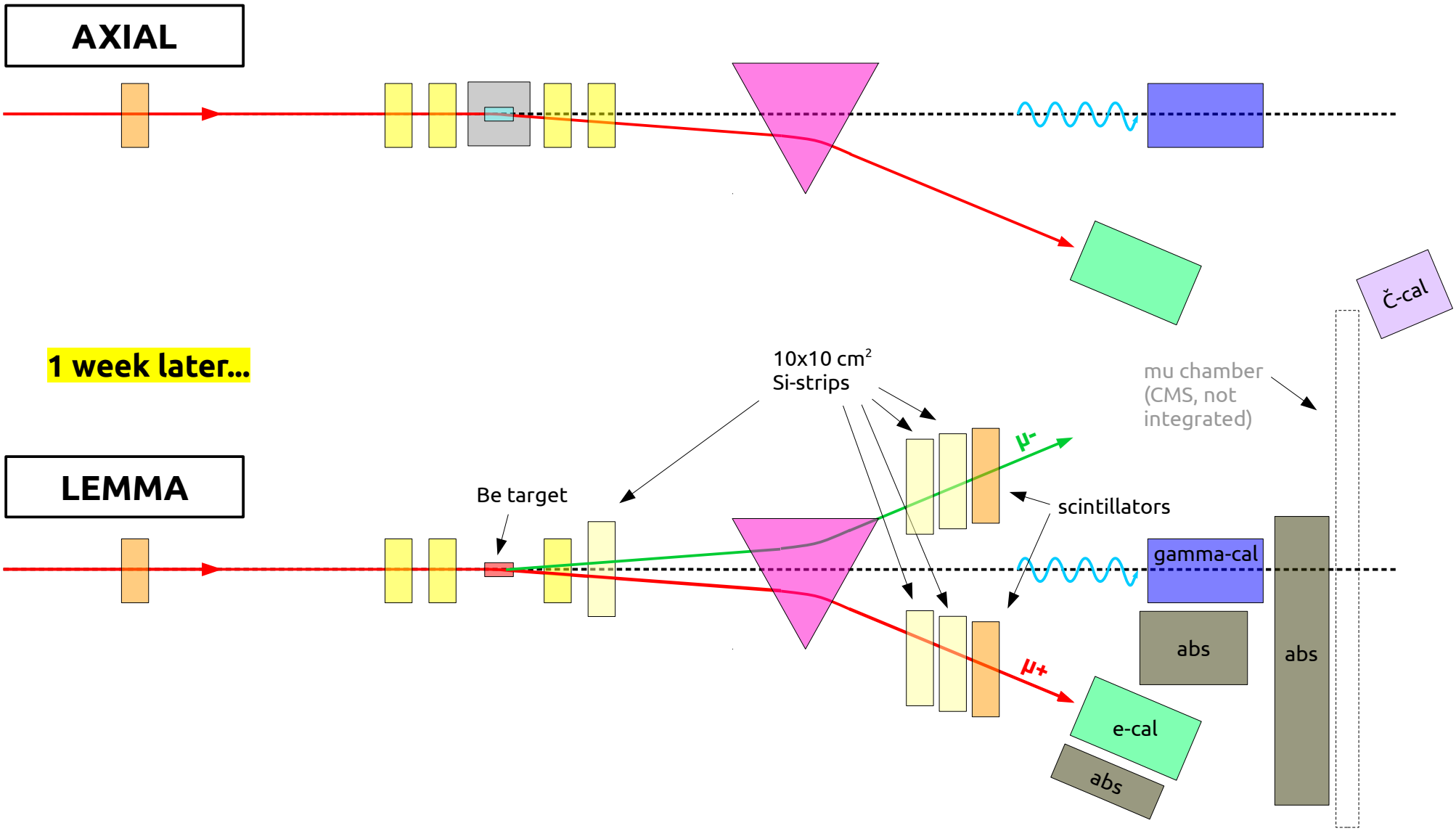
VME READOUT BOARD
VME READOUT BOARD
← far away →
VME 2
VME-CONTROL
WAVEFORM DIGITIZER
WAVEFORM DIGITIZER
optical fibers
PC
VME-PCI BRIDGE
VME-PCI BRIDGE
DAQ program (C + Tkl/Tk GUI)
- trigger selection (AND, OR, VETO, ...)
- goniometer control (automatic scans)
- self-equalization of SiPMs (LEDs)
- calibration routines (silicon strips)
online data processing
- "dst" production
- monitoring tools
idle
SPS spill start
Triggers ON, events stored on local memories
SPS spill stop
Triggers OFF, data written on hard drives
Software

Flexible/modular

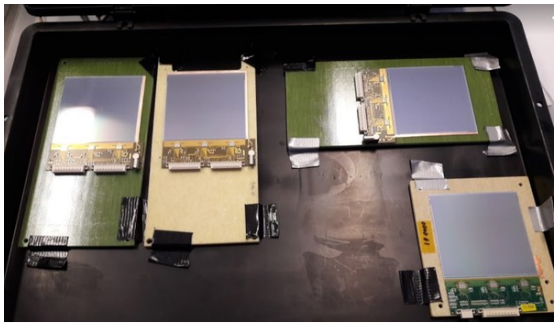
SPS, H4, July 2017



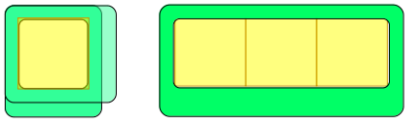
Ever-growing family

Work in progress (if $$$)

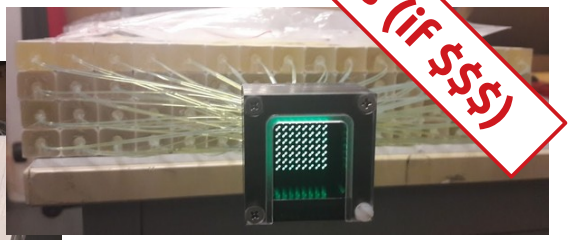
Silicon strip detectors



Several 10x10 cm2 strip detector available
→ covering of **larger areas**

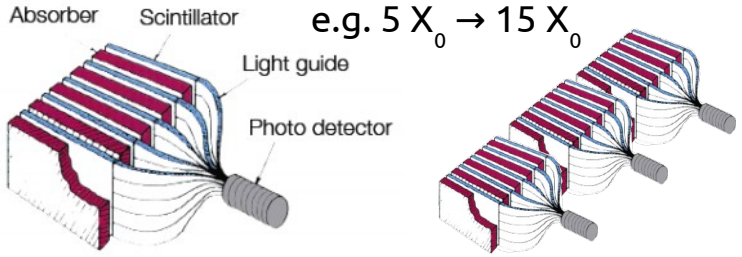


Scintillators



Scintillating bars readout by WLS and PMTs/SiPMs (fast readout, custom geometry)
→ **triggers&vetos**

Calorimeters



Assembly of lead-scintillator tiles for a new **modular sampling calorimeter**

DAQ improvements

Modular architecture consolidation → integration of **new detectors**

Integration of power, low/high voltages → **full remote operability**

Upgrade of the frontend electronic for the Si-strips (compression of the multiplexed data) → **faster readout**

Upgrade of the gigabit links (ADC ↔ VME readout boards, moving to optical) → **faster readout + easier setup** (less cables)

Conclusions

- Channeling (and channeling-related) experiments on a high energy beam require a non trivial recipe made of different detectors, tools, and a reliable integration.
- We developed a modular DAQ system able to operate different detector types, frontend control systems and trigger rate.
- The DAQ can be adapted in terms of experimental setup, number of detectors, physics goal.
- We are building new detectors and improving the DAQ