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The Elettra IKC to the ESS WS acquisition system

Mario Ferianis
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on behalf of the Elettra ESS WS Team

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Objective to provide the completely integrated operation of the Wire Scanners (WS) at the ESS

Who collaborative effort between **Elettra WS Team,** ESS **WS Diagnostics,** ESS **ICS Teams**...and CERN BD *

When it is a 3.5Y development effort;
kick off meeting held on OCT, 2015

What Elettra in-house developed boards and COTS items;
all FW development (from drivers up);
participation to the installation

** F. Roncarolo, G.J. Focker, U. Raich and E. Bravin*

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Two different schemes has been adopted to measure the particle number intercepted by wire:

- the **secondary emission** current (**SEM**) from the wire
- the flux of **high-energy secondary particles**, downstream the wire (**SCINT**)

The total number of items included in the WS Acquisition System is as follows:

- **11 WS stations** with a total number of:
  - 19 wire actuators
  - 22 SEM channels (4 inputs)
  - 20 SCINT channels (2 inputs)
  - 12 fast SCINT channels (4 inputs)

A **front-end module** acquires the **SEM** current generated in the wire as close as possible to the source;
the **SCINT** light will be propagated outside the tunnel by *Plastic Optical Fibre* (POF)

The following **interlock functions** have to be implemented in the WS Acquisition System:

- *Vacuum Interlock* and *Machine Protection Interlock* signals
- *Collision prevention* (for dual axis WS)

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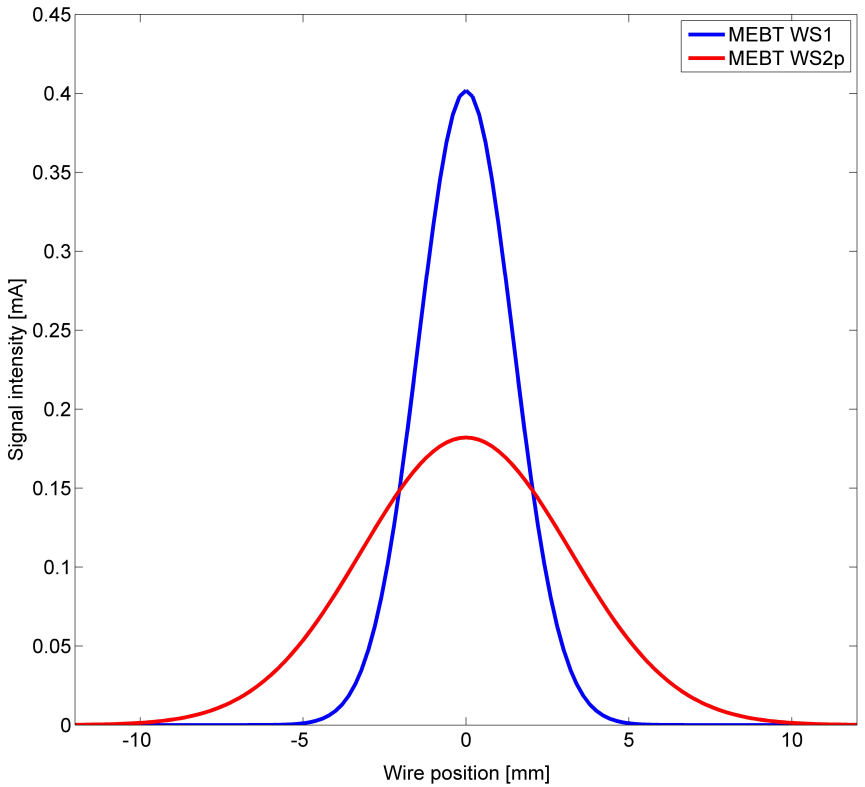
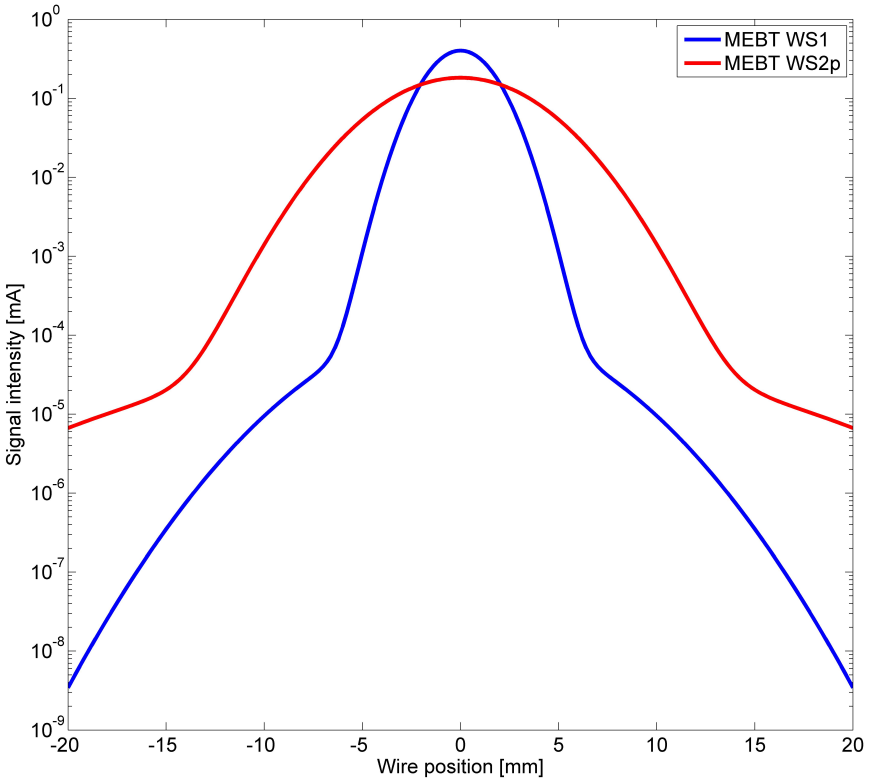
Specifications (ESS-0048680 by B. Chemyol)

Expected SEM signal in the MEBT for a highest focused beam (**blue line**) and smallest focused beam (**red line**)

linear



logarithmic



The **SEM peak current** varies **from 60 µA (SPK) to 400 µA (MEBT)**
The **sensitivity ranges from 60 nA** (DTL, SPK) **up to 200 nA** in the MEBT section, with a **dynamic range of 10^{-3}** for the measurement.

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global figures

The Elettra SoW for the IKC of the WS Acquisition System includes:

- the analog front-end and back ends (SEM and SCINT)
- the wire and photo detector biasing power supplies (±100V)
- the digitizer cards, according to ESS specifications (COTS)
- the electronic crates (COTS)
- the motion controllers (COTS)
- the EPICS integration with the **control software** for the **computation of the beam profile** and the **engineering screen** of the WS system

The **kick-off meeting** has been held at Elettra, on October, 28th 2015

The **preliminary design report** (PDR) of the front-ends is expected by June / December 2016 for the SEM and scintillator, respectively

A test session of the WS system on a **real beam** is foreseen at a partner laboratory (to be jointly identified) in the **2nd half of 2017**

A total effort of **108 man-month** has been allocated at Elettra over **3,5 / 4 years**
The **total budget including HW and FW development** is less than **1MEUR** (VAT excluded)

The *support during installation* of the WS system at the final location in the ESS linac tunnel and in the klystron gallery is also *under consideration*

Block Diagram of the WS Acquisition System

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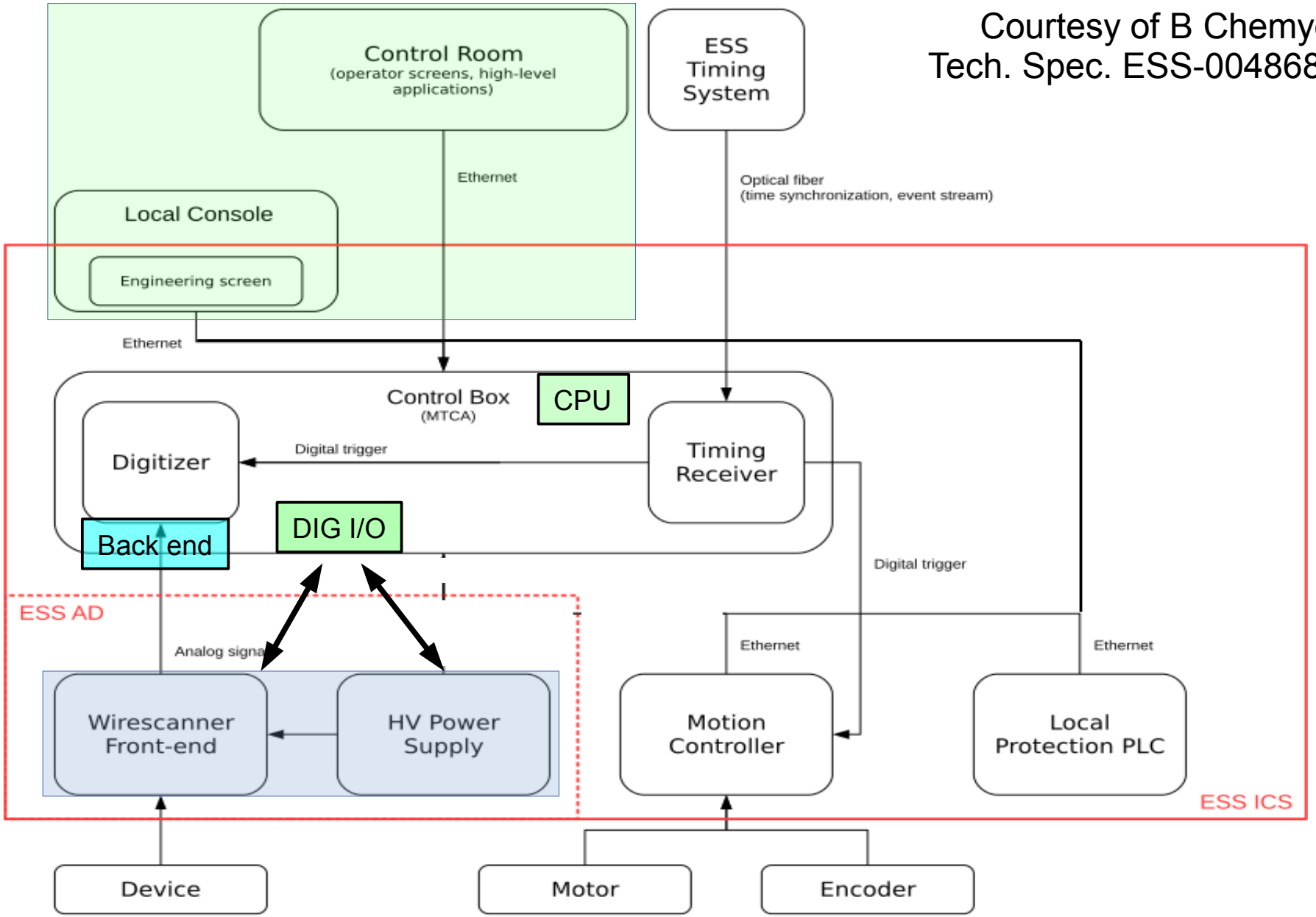
Courtesy of B Chemyol
Tech. Spec. ESS-0048680



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some critical issues

WS Acquisition System Front End design **critical issues**:

- Ultra low charge detection capability
- Very large dynamic range
- Operation in a radiative and EM noisy envvironment
- Large distance from signal source to the acquisition system

Proposed solutions, currently under investigation at Elettra:

- Ultra low charge detection and high dynamic range are achieved by using 2 charge detectors, eachone connected at one wire end
- High dynamic range is achieved by using remotely programmable 2 (or 4) steps gain
- Reliable operation in radioactive environment is achieved by minimizing electronic components in machine tunnel available in “aereospace package”; no P-S in tunnel
- EM noise immunity is achieved by using a ground isolation, triaxial lines & connectors for the source and with an adeguate EMI shielding for the electronics
- The high distance from source to the acquisition system is achieved using low impedance shielded twisted pair cable

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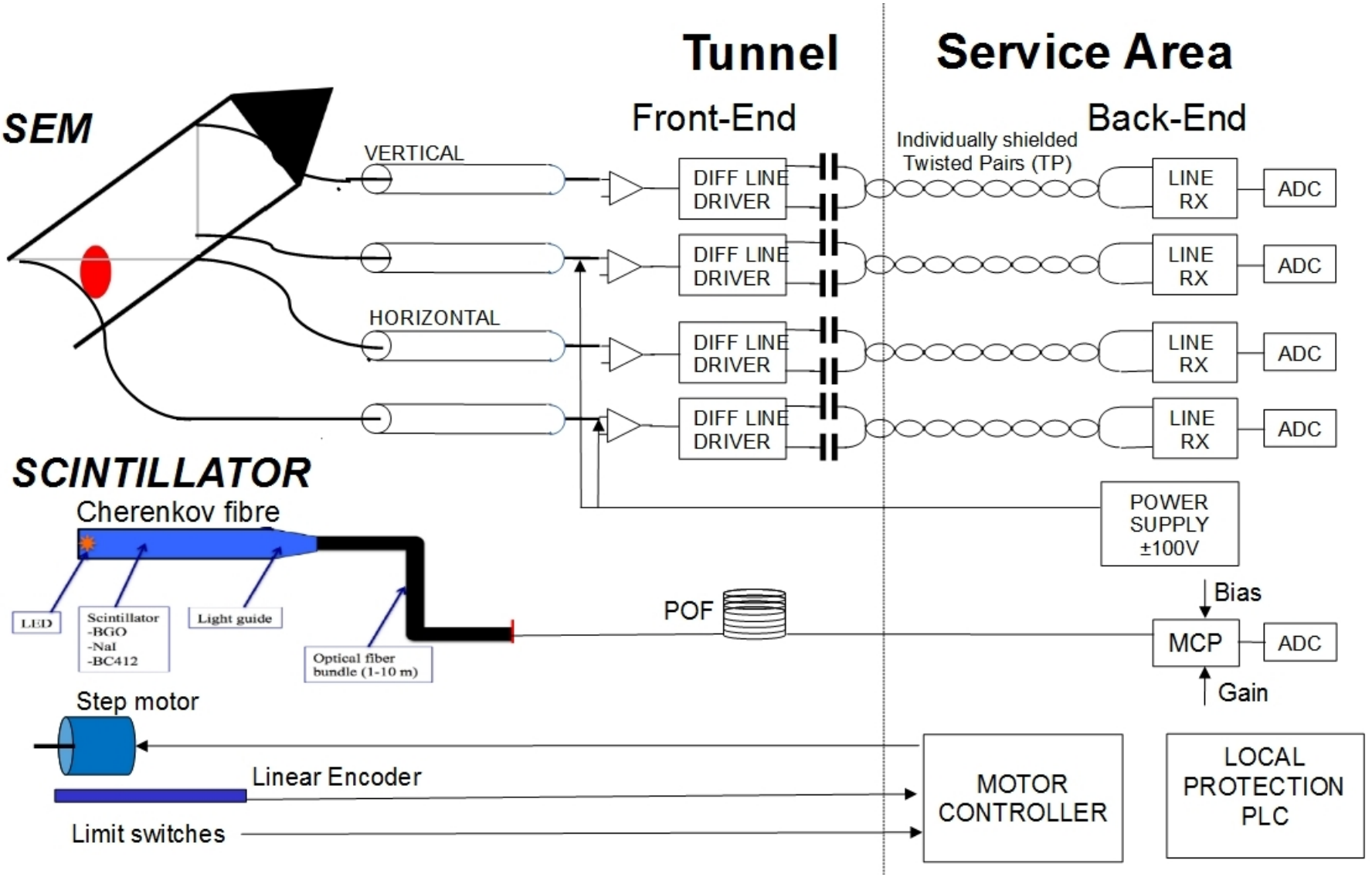
system layout



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Front-End / Back-End block diagram

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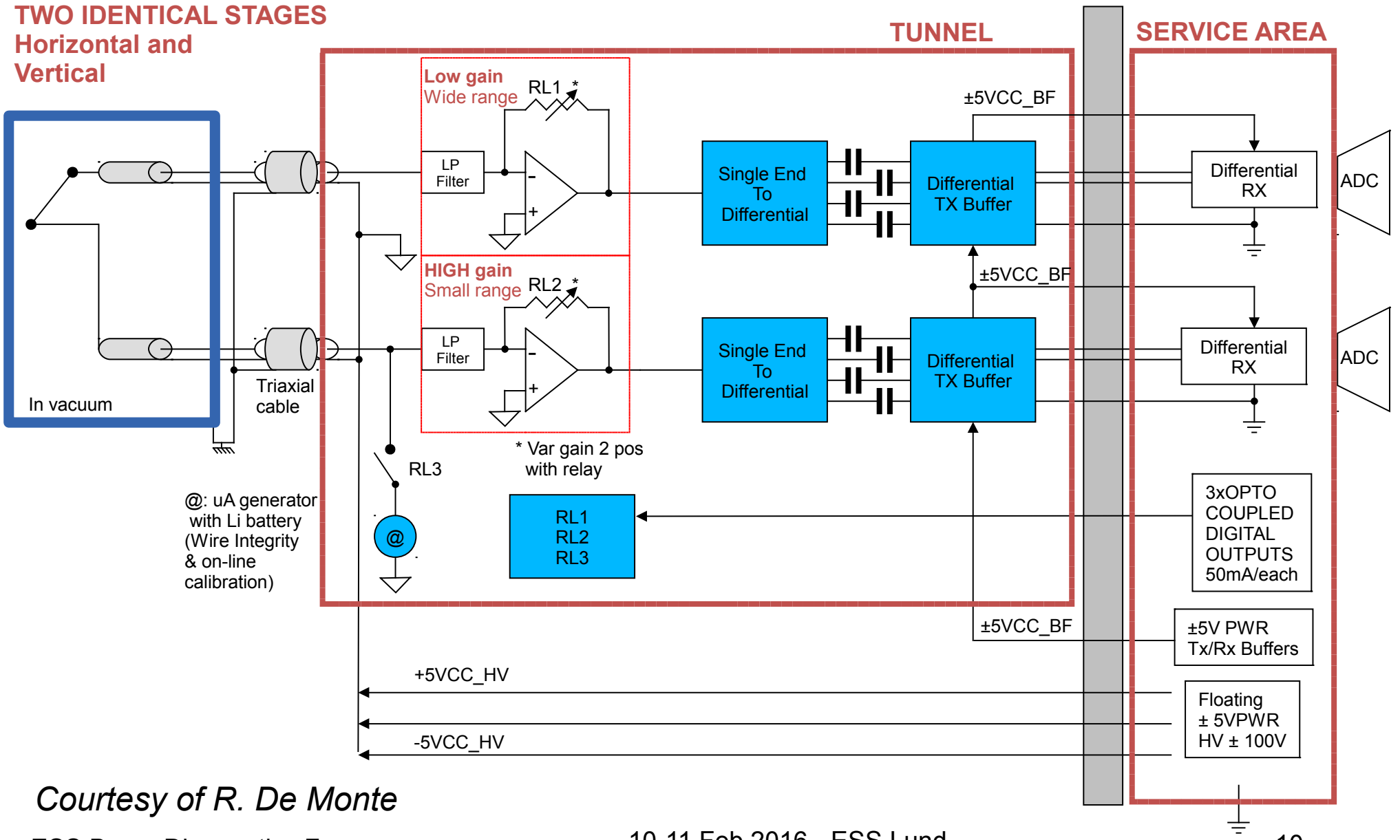

Courtesy of R. De Monte

The Elettra IKC to the ESS WS acquisition system

Picoammeter developed at Elettra

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INSTRUMENTATION

AH501B Picoammeter

For applications with multi-channel fast acquisition

24 bit, 40 k sample/sec, 4-channel, low noise and wide dynamic range digital picoammeter

HIGHLIGHTS

FEATURE	BENEFIT
Especially suited for applications where multi-channel fast acquisition is a concern, i.e. feedback systems	
This device performs current measurement from ±2.5 nA (with a resolution of 298 aA) up to ±11 mA (resolution of 1.35 nA) with sampling frequencies of up to 26 kHz (for 1 channel and a 16-bit resolution) and 6.5 kHz (4 channels, 16 bit/sample)	Extremely low current measurements Bipolar current measurements
Housed in a light and extremely compact box	Can be placed close to the signal sources in order to reduce cable lengths and minimize possible noise pick-up
Low temperature drifts, good linearity and very low noise	High-precision current measurements
Straightforward remote control via communication interface	Integration time, range, data format, type of acquisition, baud rate and several other parameters can be instantly set and checked
Modular communication capability	Allows the user to freely select the type of communication interface, allowing control of the instrument with different types of programming languages and/or operating systems
Buffered voltage monitors that are proportional to the measured input current	Allows direct analogue monitoring on the oscilloscope
High voltage (30 V) output	Detector biasing

APPLICATIONS

- Ultra-low current measurements
- Beam position monitoring
- Diamond detectors readout
- Ion chamber readout

HOW DOES IT WORK?

A compact user friendly AH501B Picoammeter covers the whole acquisition, counting and digitization chain. To a great extent this simplifies and streamlines the read out at high speed and with extremely low noise X-ray detectors.
It is composed of a particular transimpedance input stage for current sensing combined with several analogue signal conditioning and filtering stages with state-of-the-art electronics.

Acquisition of samples from the AH501B may be performed using either "continuous" or "on demand" transmission modes:
- "Continuous" mode: data are continuously sampled and transmitted, without external intervention, to the host device, allowing for real time data acquisition
- "On demand" mode: data are sampled and transmitted only on a specific remote command request.

The external TRIGGER/GATE input signal is available for the purpose of synchronizing the acquisition of the picoammeter with external events (i.e. laser triggering). Furthermore, digital samples can be transferred using either the ASCII format or the RAW binary data format for fast data transmission.
The AH501B is available in different configurations: analogue cut-off frequency (the standard value is 1 kHz but it has been successfully tested up to 10 kHz), communication interface (xPiggy) and input connectors (SMA or BNC).
The availability of trigger input and output signals on an RJ11 connector allows for the synchronization of the acquisition to external events.

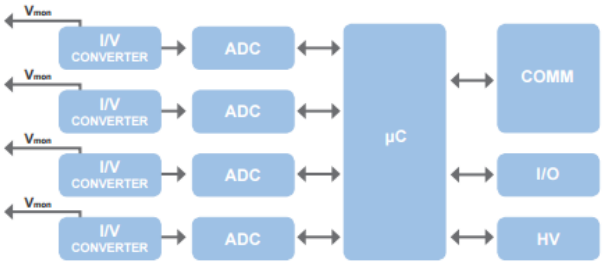
SPECIFICATIONS

Input channels	4
Input connectors type	SMA or BNC
Effective current measuring range	From ± 2.5 nA to ± 11 mA
Resolution bits	16 or 24
Data transfer	Up to 26 ksamples/sec (1 ch. 16 bit)
Analogue cut-off	Configurable (tested up to 10 kHz)
Polarity	Bipolar
Communication modules	Ethernet TCP-IP and UDP, USB 2.0, R-S232
Supply voltage	From ± 6 V to ± 9 V
Supply current	From 270 to 410 mA depending on comm. module
Dimensions	160 x 108 x 45 mm
Weight	500 g
Weight	420 g

DELIVERABLES

- AH501B Picoammeter
- Preinstalled Ethernet communication module
  Other compatible modules are: RS232, RS422/485, USB and Ethernet (TCP/IP and UDP)
- Power supply integration PS-2209
- Oscilloscope LabView Software

AH501B BLOCK DIAGRAM



Contact us!

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Courtesy of D. Giuressi

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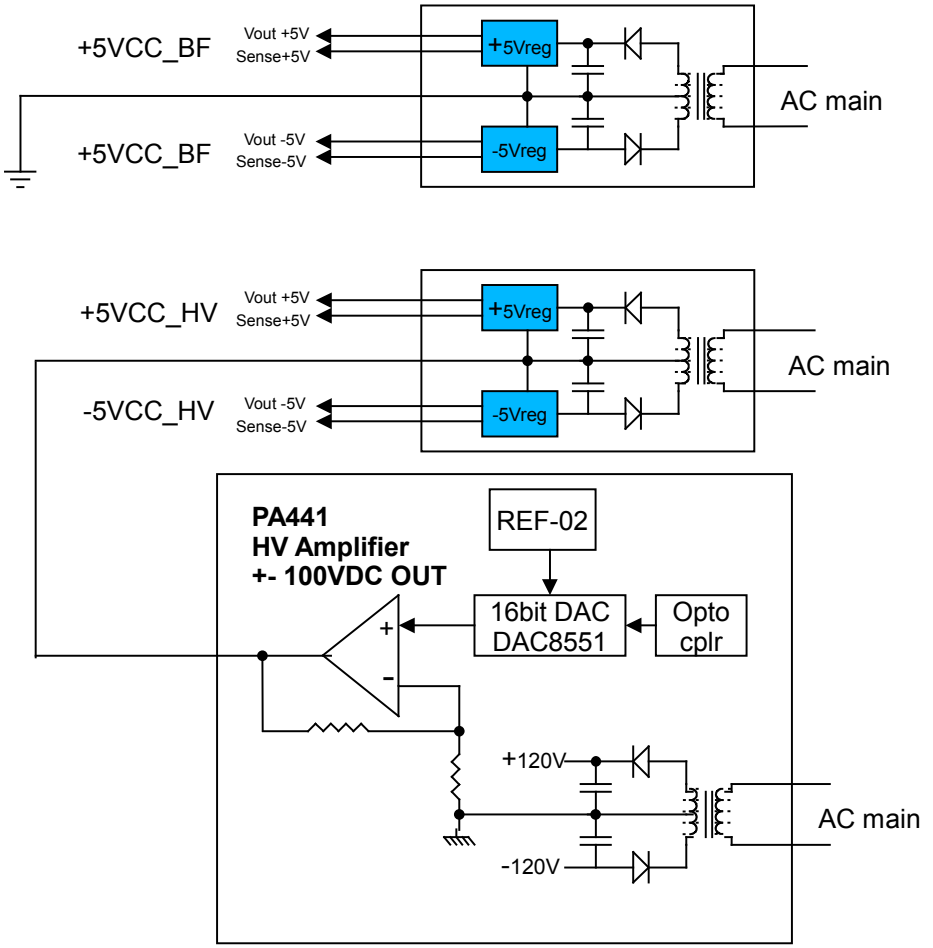
floating ±5V / ±100V power supply



Courtesy of R. De Monte

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scintillator Back-End

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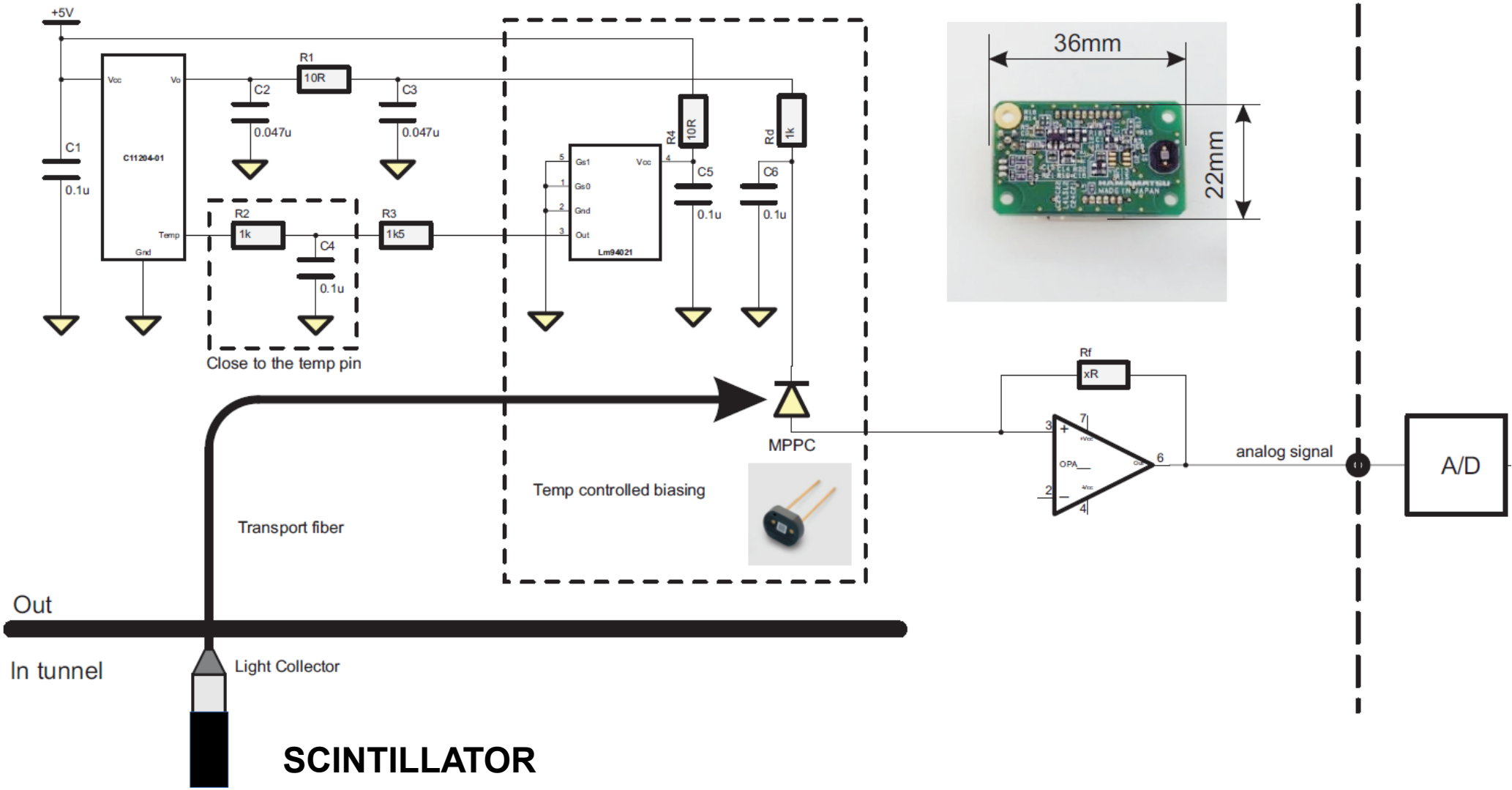

Courtesy of S. Grulja

The Elettra IKC to the ESS WS acquisition system cabling (draft)

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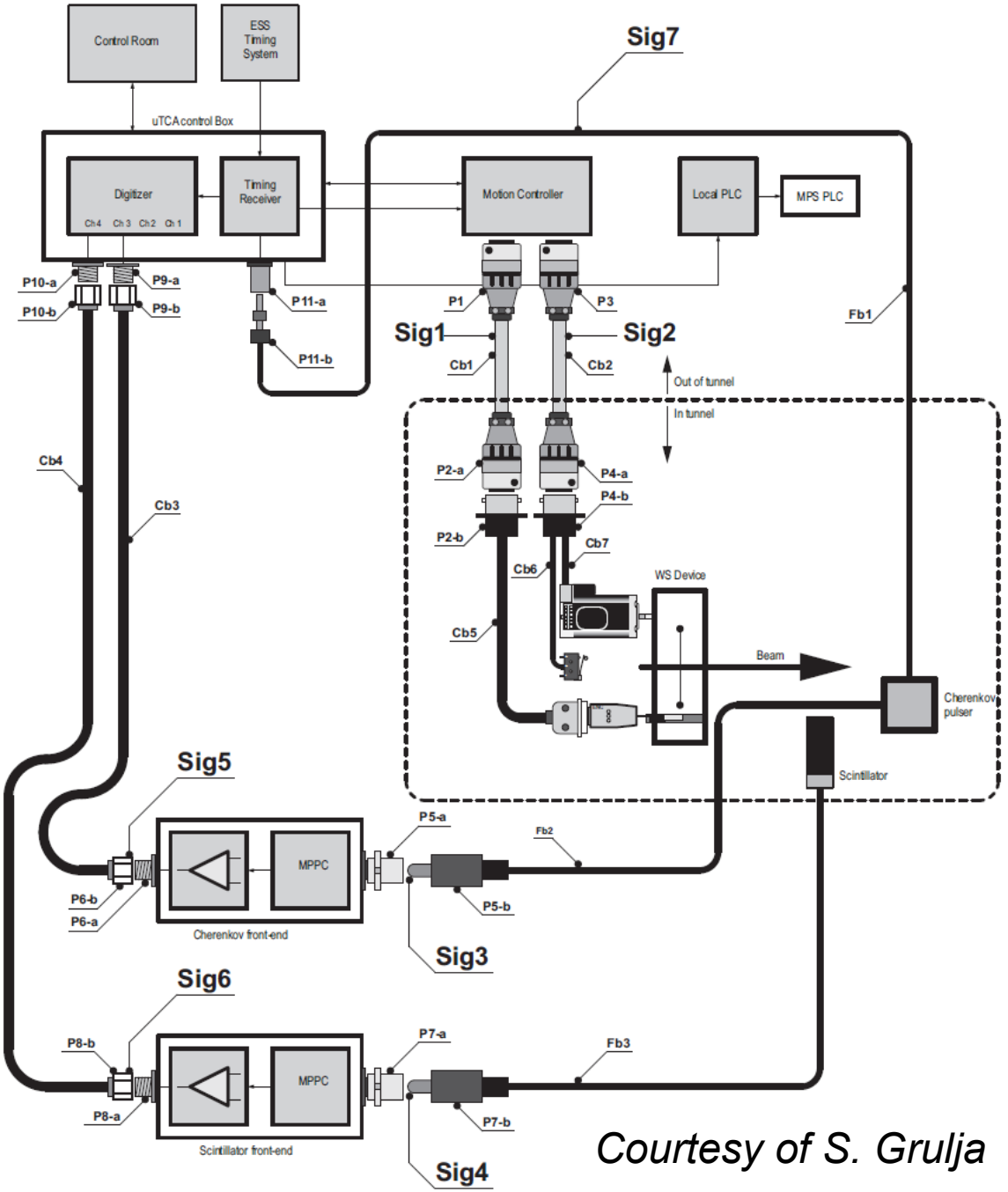
P1-connector type as on Motion Cotroller
P3-connector type as on Motion Cotroller
P2a-Trident 12 pin male cable
P2b-Trident 12 pin female pannel
P4a-Trident 19 pin male cable
P4b-Trident 19 pin female pannel
P5a-FC/APC fiber female
P5b-FC/APC fiber male
P6a-SMA female pannel
P6b- SMA male cable
P7a-FC/APC fiber female
P7b-FC/APC fiber male
P8a-SMA female pannel
P8b-SMA male cable
P9a-SMA female pannel
P9b-SMA male cable
P10a-SMA female pannel
P10b-SMA male cable
P11a-POF fiber connector
P11b-POF fiber connector

Cb1-Cu multiwire shilded cable AWG24
Cb2-Cu multiwire shilded cable AWG20
Cb3-Cu coaxial cable RG
Cb4-Cu coaxila cable RG
Cb5-Cu multiwire shilded cable AWG24
Cb6-Cu multiwire shilded cable AWG24
Cb7-Cu multiwire shilded cable AWG20

Fb1-POF fiber for timing
Fb2-Cherenkov fiber
Fb3-POF fiber for light transport from Scint

Sig1-Encoder TTL level analog signal
Sig2-Analog signal for stepper and power s
Sig3-Cherenkov light
Sig4-Light from scintillator
Sig5-Analog signal Voltage output
Sig6-Analog signal Voltage output
Sig7-Light pulses for timing



Courtesy of S. Grulja

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protection PLC Flow Chart (draft)

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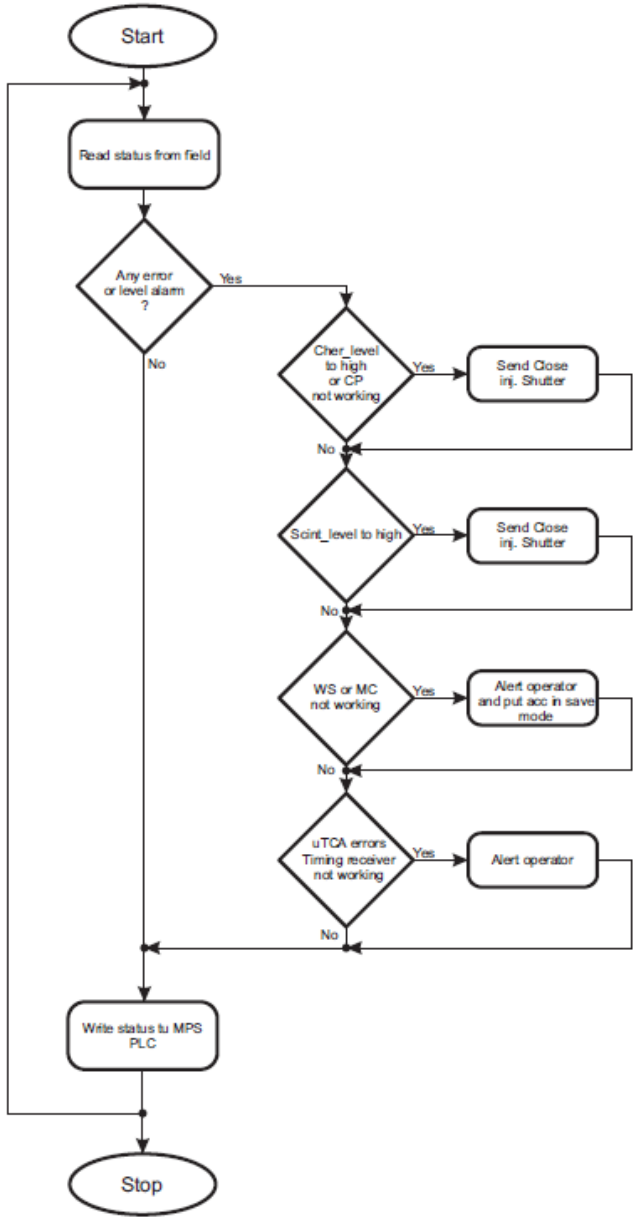

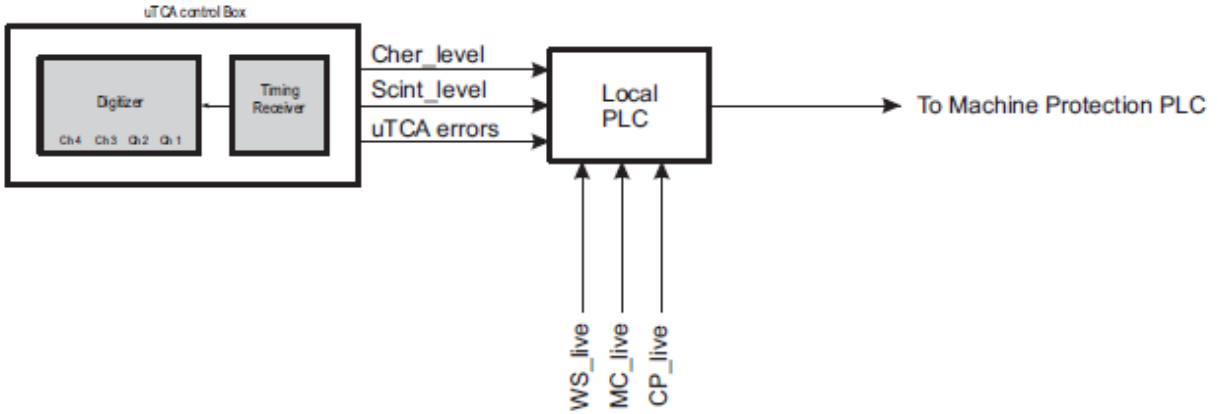

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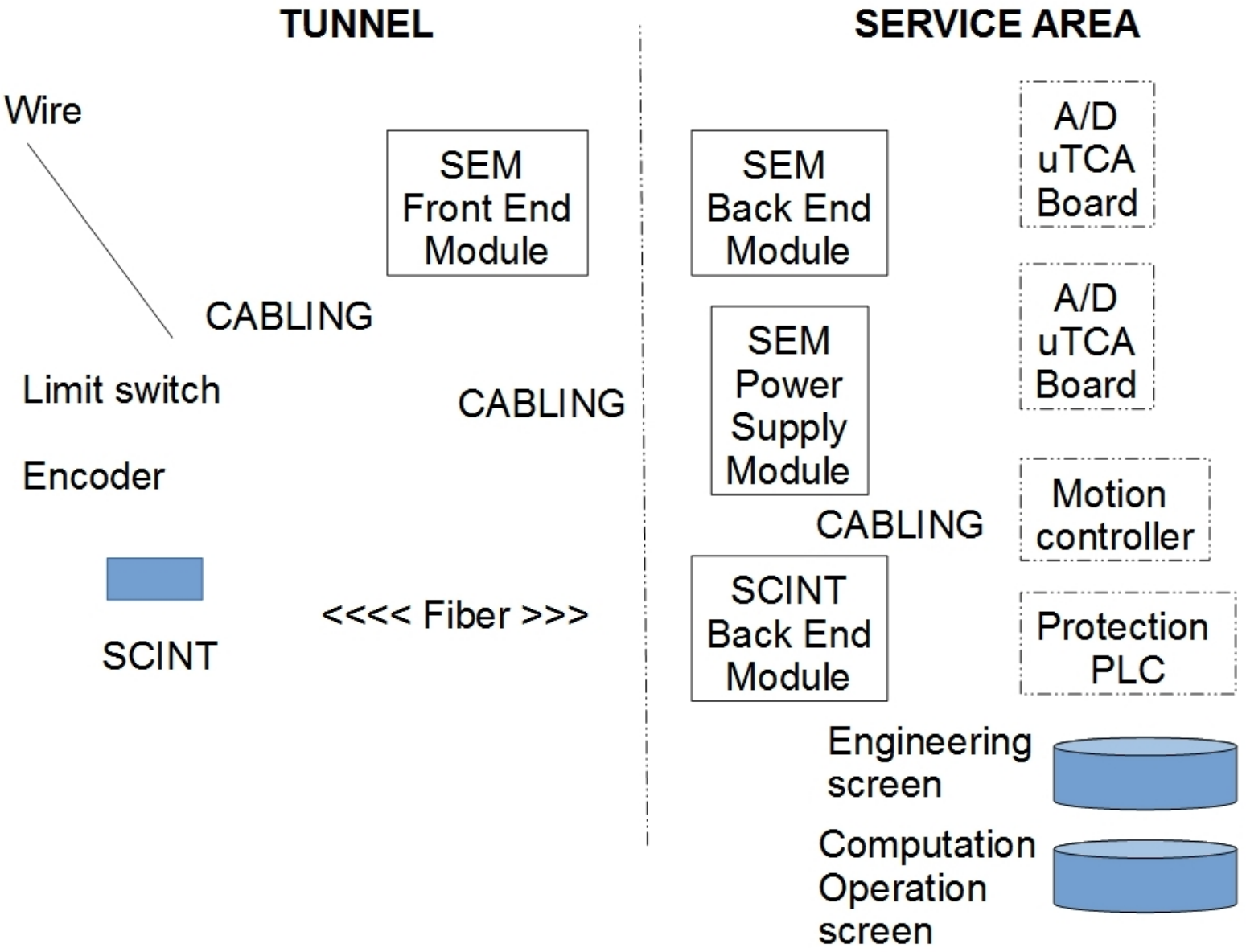
in summary...



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The Elettra IKC to the ESS WS acquisition system

the ESS WS Team @ Elettra

Mario Ferianis	Elettra IKC ESS WS co-ordinator and interface to ESS / WS
Raffaele De Monte	senior electronic designer and FW integrator
Sandi Grulja	senior electronic designer
Stefano Cleva	SW analist and programmer / FW integrator
Dario Giuressi	senior electronic designer
Gabriele Brajnik	electronic designer

Task assignments in the Elettra ESS WS acquisition system implementation:

- **Mario** overview: specification, budget and timeline control
- **Raffaele** SEM acquisition system & Front end principal design
- **Sandi** SCINTILLATOR acquisition system & PLC & Cable management
- **Stefano** SW development and FW integration
- **Dario** Front end design
- **Gabriele** Front end design

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Thank you for your attention