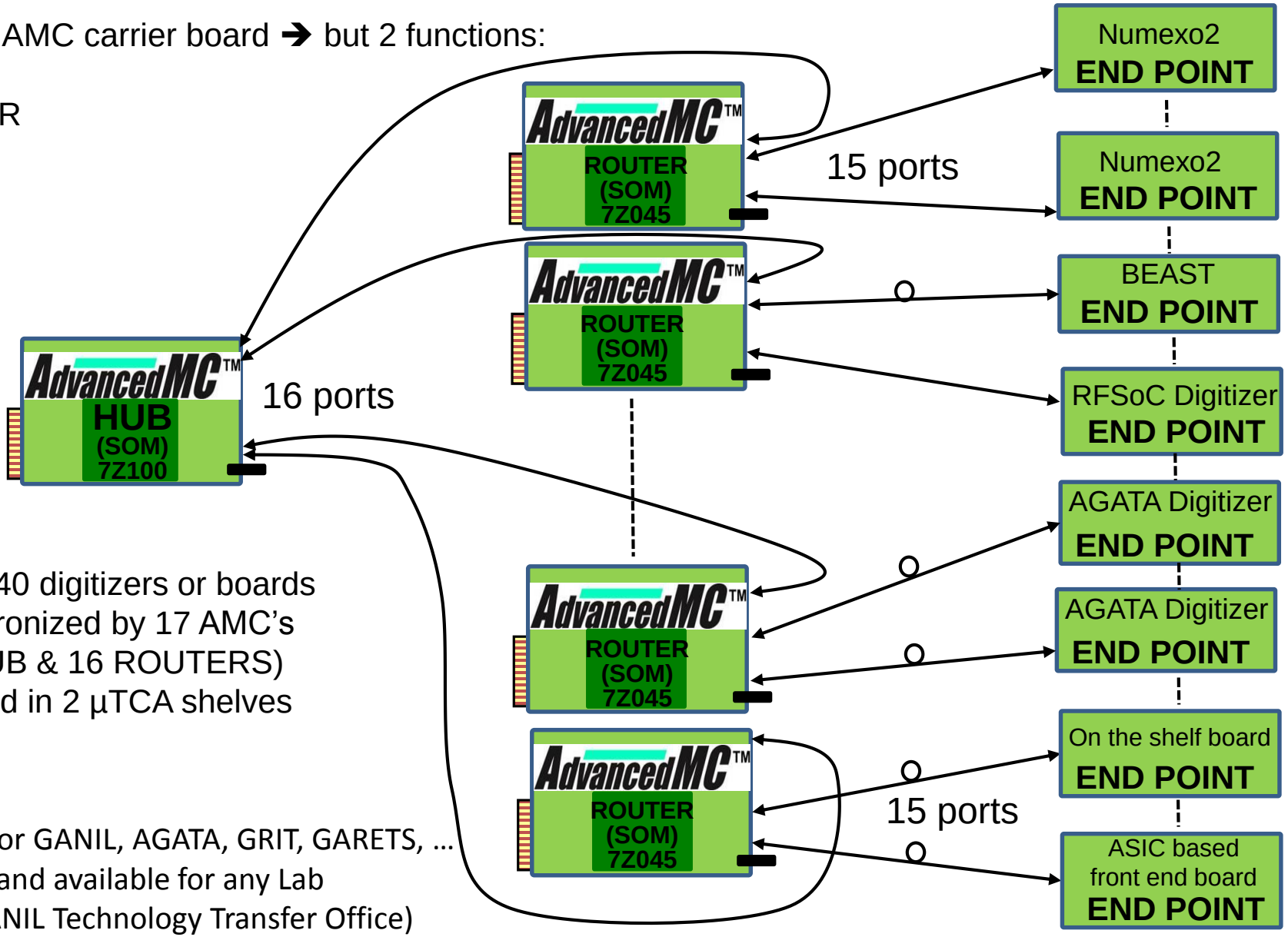
Sfp connectivity and **M**icrotca for **A**dvanced **R**emote **T**rigger

Project Status

Architecture (Phase 1) & terminology reminder

Only one AMC carrier board ➔ but 2 functions:
- HUB
- ROUTER



Up to 240 digitizers or boards synchronized by 17 AMC's (1 HUB & 16 ROUTERS) housed in 2 µTCA shelves

A project for GANIL, AGATA, GRIT, GARETS, … and available for any Lab (see GANIL Technology Transfer Office)

Main characteristics (Phase 1)

CLOCK & TIMESTAMPING

- **HUB to ROUTER (to EP's)** : 8B/10B encoding/decoding with Recovered Clock = 100 MHz;
  TS on 48 bits/10ns (more than 1 month of experiment)

COMMUNICATION RATES

- **HUB ↔ ROUTER**: Line Rate = 4 Gb/s; Payload Data Rate = 400 MB/s; Reference Clock = 100 MHz

- **ROUTER ↔ EP's**: Line Rate = 2 Gb/s; Payload Data Rate = 200 MB/s; Reference Clock = 100 MHz

COMMUNICATION MEDIA (Interoperability)

- **COPPER**: SFP to SFP or QSFP to 4xSFP; Up to 7 meters with passive Direct Attach Cables (DAC) characterized @ 10Gb/s

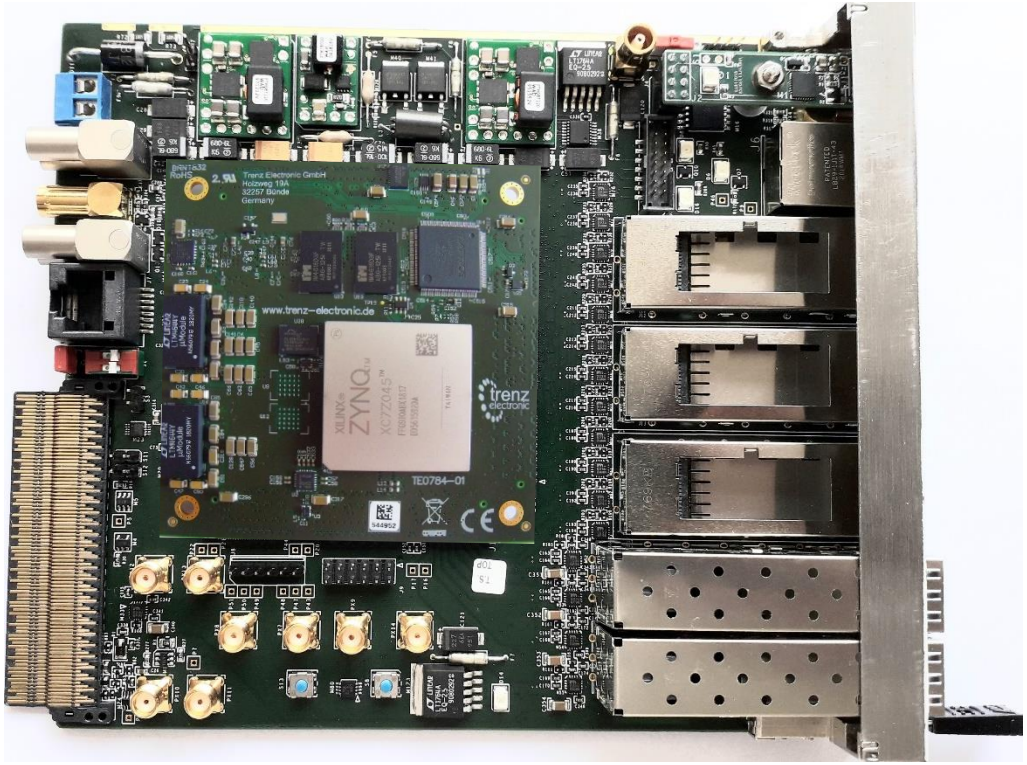
- **FIBER** : SFP transceiver (LC) to SFP transceiver (LC) or QSFP (MPO) to 4xSFP (LC) with optical patch cord; up to 150 meters with OM3/OM4 fibers

SOM and SOC USED on SMART AMC BOARD

- **HUB**: TE0784-01 from TRENZ Company with Xilinx XC7Z100-2FFG900I

- **ROUTER** : TE0784-01 from TRENZ Company with Xilinx XC7Z045-2FFG900I

SMART AMC status in terms of Hardware, Firmware and Software



- 3 PCBs and 3 front panels designed and delivered one year ago
- 6 x SOM TE0784-01 from TRENZ with Xilinx XC7Z100 and XC7Z045 purchased over the last 2 years
- 3 extra SMART AMC assembled, delivered before summer and tested
- Firmware's for ROUTER and HUB are ready (Clock distribution & TS version)
- Bare metal C programs are written (register init, PLL's setup, MGT init, alignment, TS broadcasting, …)
- Tests in progress in order to validate various configurations and system robustness
- Firmware for BEAST AMC End Point is written and is used in 3 modules to validate the full chain

New communication media qualified for SMART

(all them remotely identified by “SFP_QSFP_device_checker”

SFP+ to SFP+
(10Gb/s passive cables)

2 Finisar SFP transceivers
One 6.1 Gb/s and one 8.5 Gb/s
(more than 150 m with OM3 fiber)

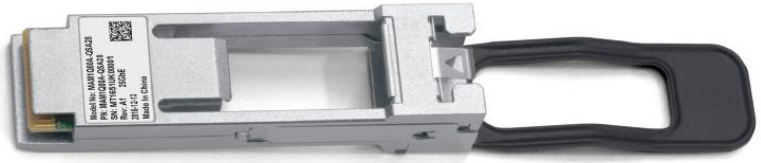
- Four-channel full-duplex transceiver module
- Hot Pluggable QSFP+ form factor
- Maximum link length of 100m on OM3 Multimode Fiber (MMF) and 150m on OM4 MMF
- Multirate capability: 1.06Gb/s to 10.5Gb/s per channel

QSFP to MPO
(Finisar FTL410 series)

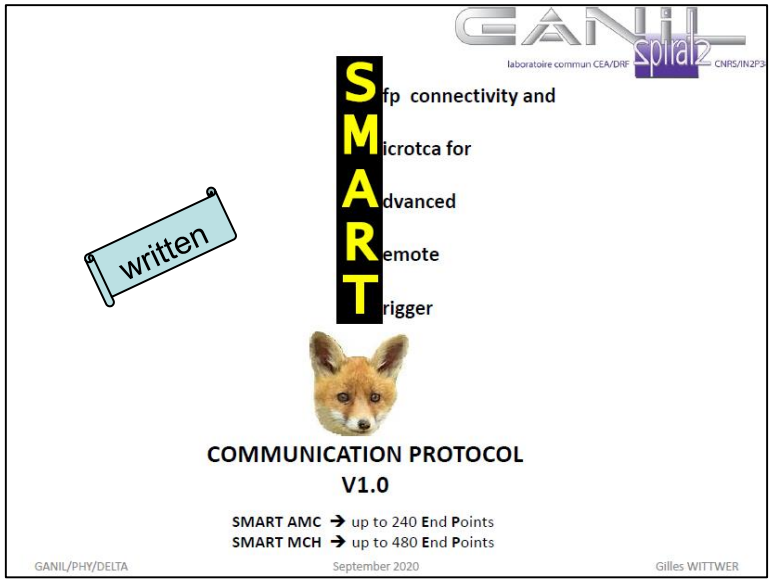
QSFP to 4xSFP+
(40G breakout passive cables)

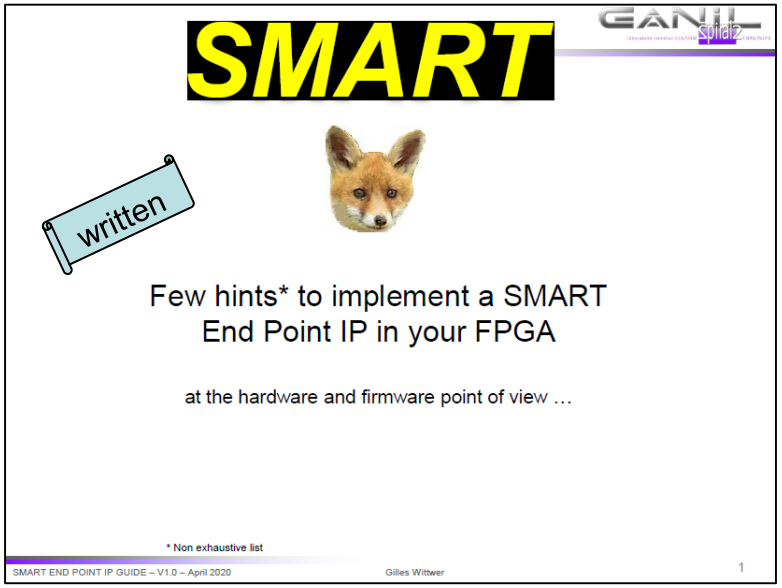
Fiber MPO to 4 x 2 Fiber MPO Duplex LCs

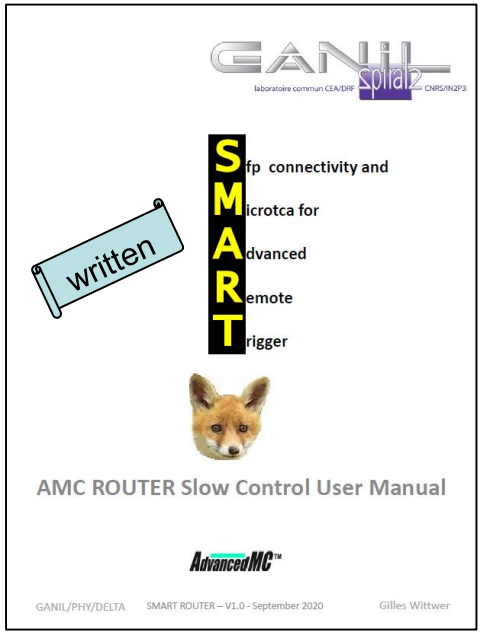
QSFP(ch.1) to SFP adapter
(Useful with passive cables
or transceivers)

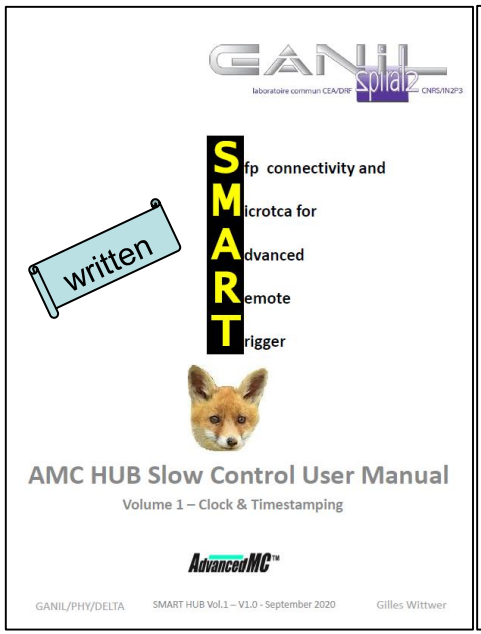


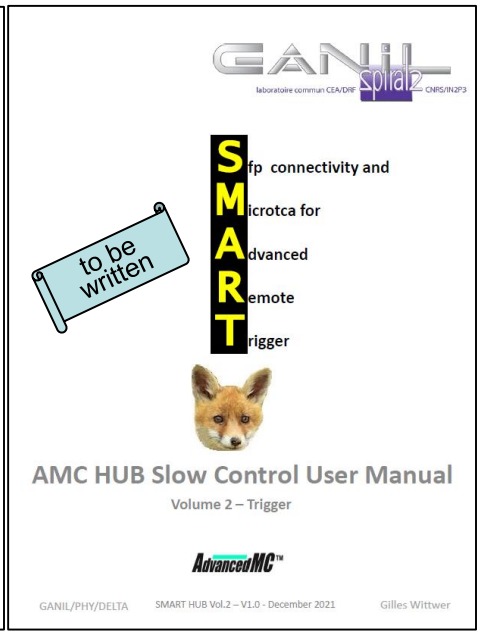
SMART - Phase 1 Documentation

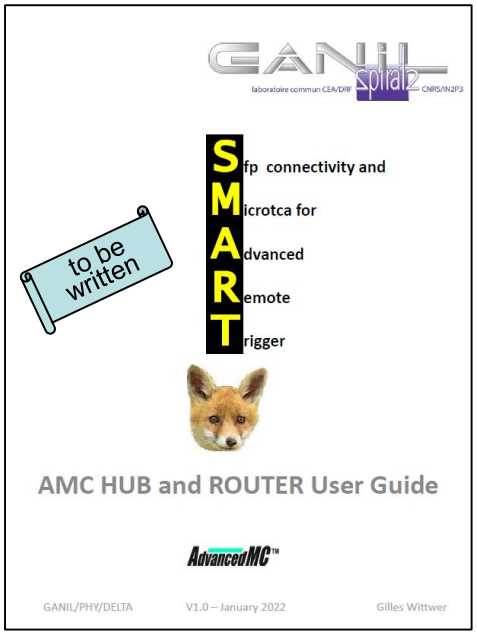












SMART AMC first results 1/3

SMART HUB - ttyUSB2

Fichier Éditer Affichage Terminal Onglets Aide

```
*** Delay results port by port for the current SMART HUB (delay in ps) ***


HUB port: 0 not connected ...

HUB port: 1 not connected ...

HUB port: 2
ROUTER port: 0 Min Delay:       0  Mean Delay:       0  Max Delay:       0  D=       0
ROUTER port: 1 Min Delay:       0  Mean Delay:       0  Max Delay:       0  D=       0
ROUTER port: 2 Min Delay:       0  Mean Delay:       0  Max Delay:       0  D=       0
ROUTER port: 3 Min Delay:       0  Mean Delay:       0  Max Delay:       0  D=       0
ROUTER port: 4 Min Delay:       0  Mean Delay:       0  Max Delay:       0  D=       0
ROUTER port: 5 Min Delay:       0  Mean D
ROUTER port: 6 Min Delay:       0  Mean D
ROUTER port: 7 Min Delay:       0  Mean D
ROUTER port: 8 Min Delay:       0  Mean D
ROUTER port: 9 Min Delay:       0  Mean D
ROUTER port:10 Min Delay:       0  Mean D
ROUTER port:11 Min Delay:       0  Mean D
ROUTER port:12 Min Delay:       0  Mean D
ROUTER port:13 Min Delay:  190080  Mean D
ROUTER port:14 Min Delay:       0  Mean D

HUB port: 3
ROUTER port: 0 Min Delay:       0  Mean D
ROUTER port: 1 Min Delay:  158166  Mean D
ROUTER port: 2 Min Delay:       0  Mean D
ROUTER port: 3 Min Delay:       0  Mean D
ROUTER port: 4 Min Delay:       0  Mean D
ROUTER port: 5 Min Delay:       0  Mean D
ROUTER port: 6 Min Delay:       0  Mean D
ROUTER port: 7 Min Delay:       0  Mean D
ROUTER port: 8 Min Delay: 1113102  Mean D
ROUTER port: 9 Min Delay:       0  Mean D
ROUTER port:10 Min Delay:       0  Mean D
ROUTER port:11 Min Delay:       0  Mean D
ROUTER port:12 Min Delay:       0  Mean D
ROUTER port:13 Min Delay:       0  Mean D
ROUTER port:14 Min Delay:       0  Mean D

HUB port: 4 not connected ...

HUB port: 5 not connected ...

HUB port: 6 not connected ...

HUB port: 7 not connected ...

HUB port: 8 not connected ...

HUB port: 9 not connected ...

HUB port:10 not connected ...

HUB port:11 not connected ...

HUB port:12 not connected ...

HUB port:13 not connected ...

HUB port:14 not connected ...

HUB port:15 not connected ...

For this SMART HUB, the most delayed port is EP: 53  HUB PORT: 3  ROUTER PORT: 8
              and the least delayed port is EP: 46  HUB PORT: 3  ROUTER PORT: 1
```

HUB CH.	ROUTER CHANNEL (fine delays are in ps)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X	X	X	X	X	95081	X	
3	X	79109	X	X	X	X	X	X	556669	X	X	X	X	X	X	
4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
11	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
15	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

A total of 3 end-point fine delay(s) have been measured (half loop)

SMART AMC first results 2/3

*** Coarse delay results port by port for the current SMART HUB (delay in ps) ***

HUB port: 0 not connected

HUB port: 1 not connected

HUB port: 2
ROUTER port: 0 Min Delay:
ROUTER port: 1 Min Delay:
ROUTER port: 2 Min Delay:
ROUTER port: 3 Min Delay:
ROUTER port: 4 Min Delay:
ROUTER port: 5 Min Delay:
ROUTER port: 6 Min Delay:
ROUTER port: 7 Min Delay:
ROUTER port: 8 Min Delay:
ROUTER port: 9 Min Delay:
ROUTER port:10 Min Delay:
ROUTER port:11 Min Delay:
ROUTER port:12 Min Delay:
ROUTER port:13 Min Delay:
ROUTER port:14 Min Delay:

HUB port: 3
ROUTER port: 0 Min Delay:
ROUTER port: 1 Min Delay:
ROUTER port: 2 Min Delay:
ROUTER port: 3 Min Delay:
ROUTER port: 4 Min Delay:
ROUTER port: 5 Min Delay:
ROUTER port: 6 Min Delay:
ROUTER port: 7 Min Delay:
ROUTER port: 8 Min Delay:
ROUTER port: 9 Min Delay:
ROUTER port:10 Min Delay:
ROUTER port:11 Min Delay:
ROUTER port:12 Min Delay:
ROUTER port:13 Min Delay:
ROUTER port:14 Min Delay:

HUB port: 4 not connected

HUB port: 5 not connected

HUB port: 6 not connected

HUB port: 7 not connected

HUB port: 8 not connected

HUB port: 9 not connected

HUB port:10 not connected ...

HUB port:11 not connected ...

HUB port:12 not connected ...

HUB port:13 not connected ...

HUB port:14 not connected ...

HUB port:15 not connected ...

ROUTER CHANNEL (coarse + fine) delays are in ps)

HUB CH.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X	X	X	X	X	594688	X
3	X	760442	X	X	X	X	X	X	1061963	X	X	X	X	X	X
4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

A total of 3 end-point coarse delay(s) have been measured most del. Hport 3, Rport 8, - least del. Hport 2, Rport 13

SMART AMC first results 3/3

-- True End Point coarse/fine delays are the following ...

HUB CH.	ROUTER CHANNEL (delays to set in registers)														
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X	X	X	X	X	0/
3	X	10/23F	X	X	X	X	X	X	2E/2D7	X	X	X	X	X
4	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15	X	X	X	X	X	X	X	X	X	X	X	X	X	X

3 Sets of HEXADECIMAL end-point delay values are now available for correction ...

Terminal

Fichier Éditer Affichage Terminal

gwittwer@ganp156:~/bin gwit

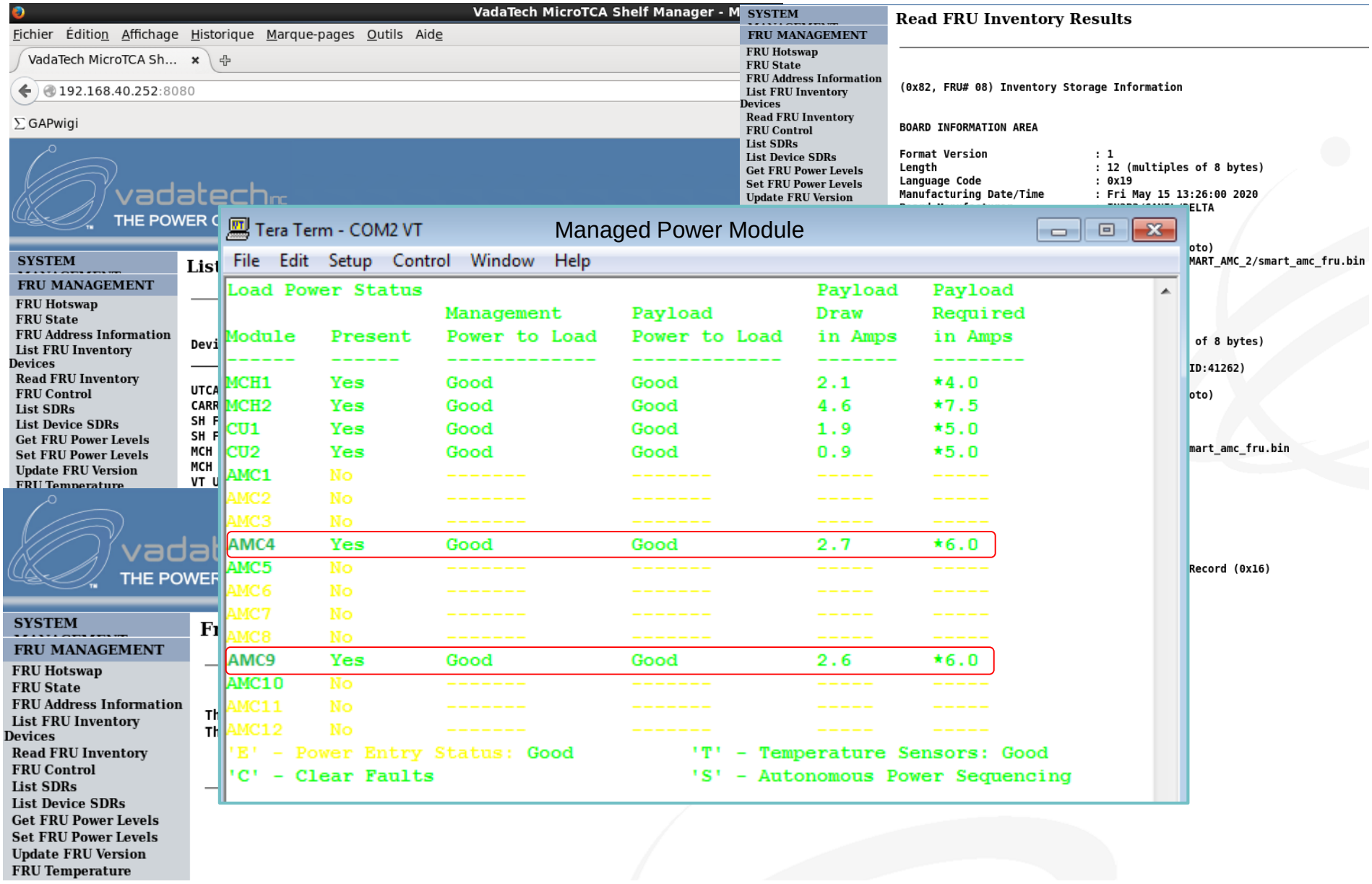
```
beast-1: 0xa8937cd20638
beast-2: 0xa8937cd20638
beast-3: 0xa8937cd20638
diffs: 0 0 0
current out of limits=2
pulse counter = 147560

connected BEASTs are: 1 2 3.
pulse on beast-1
beast-1: 0xa893990afb5d
beast-2: 0xa893990afb5d
beast-3: 0xa893990afb5d
diffs: 0 0 0
current out of limits=2
pulse counter = 147561

connected BEASTs are: 1 2 3.
pulse on beast-1
beast-1: 0xa893b5144e09
beast-2: 0xa893b5144e08
beast-3: 0xa893b5144e08
diffs: 1 1 0
current out of limits=2
pulse counter = 147562

connected BEASTs are: 1 2 3.
pulse on beast-1
beast-1: 0xa893d08bb285
beast-2: 0xa893d08bb284
beast-3: 0xa893d08bb284
diffs: 1 1 0
current out of limits=2
pulse counter = 147563
```

SMART Phase 1 – with the help of µTCA IPMI for inventory, monitoring …



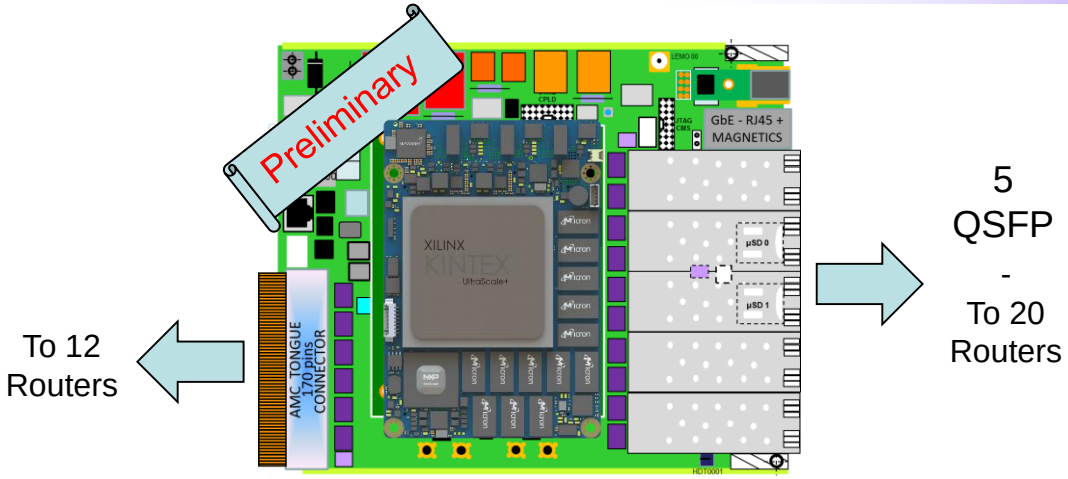
Involved manpower and Updated project schedule (Phase 1)

A minimum of 6 people involved in the project:

- Project leader, global architecture, firmware, software, CAD:……Gilles Wittwer
- PCB Routing, component ordering, manufacturing follow-up: ……Maria Blaizot
- Embedded software (Linux OS, slow control): ……Sébastien Coudert
- CPLD firmware and AMC board tests: ……Patrice Bourgault
- SMART IP in NUMEXO2, Tests and Trigger firmware:……(*recruitment in progress*)
- SMART GUI: ……Blandine Duclos

Main tasks	Updated key dates
• 3 PCBs purchased, boards assembled and populated with SOM	• June 2021
• SMART AMC prototypes tested and SMART concept validated	• June 2022
• Embedded Linux with SMART C applications included	• *June 2023*
• SMART AMC production launching (SOM purchasing, active components purchasing, FP mechanics, …)	• *2023*
• SMART Trigger 1st version test (NUMEXO2-SMART EP FW req.)	• *Summer 2023*
• Specifications ready for “French public market” production and subcontractors selected	• *December 2023*
• Production (PCB’s, Board Assembly, tests …)	• *Spring 2024*
• Delivery of SMART AMC production (first batch)	• *Summer 2024*

Few words about SMART MCH (Phase 2)

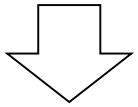


A total of 32 transceivers will be used

Main tasks	Estimated date/time (from now)
• Architecture design of SMART MCH	• Completed
• SOM selected and ordered (Iwave - Kintex KU19P + Arm)	• Completed
• Xilinx UltraSCALE+ SOM + baseboard delivery	• 4 months
• SMART MCH Schematics	• 2 month
• PCB routing	• 3 months
• PCB manufacturing and SMART MCH assembly	• 3 months
• Porting SMART AMC HUB FW/SW to SMART MCH	• 6 months
• Integration and tests in existing SMART phase 1	• 6 months
	= 2 YEARS

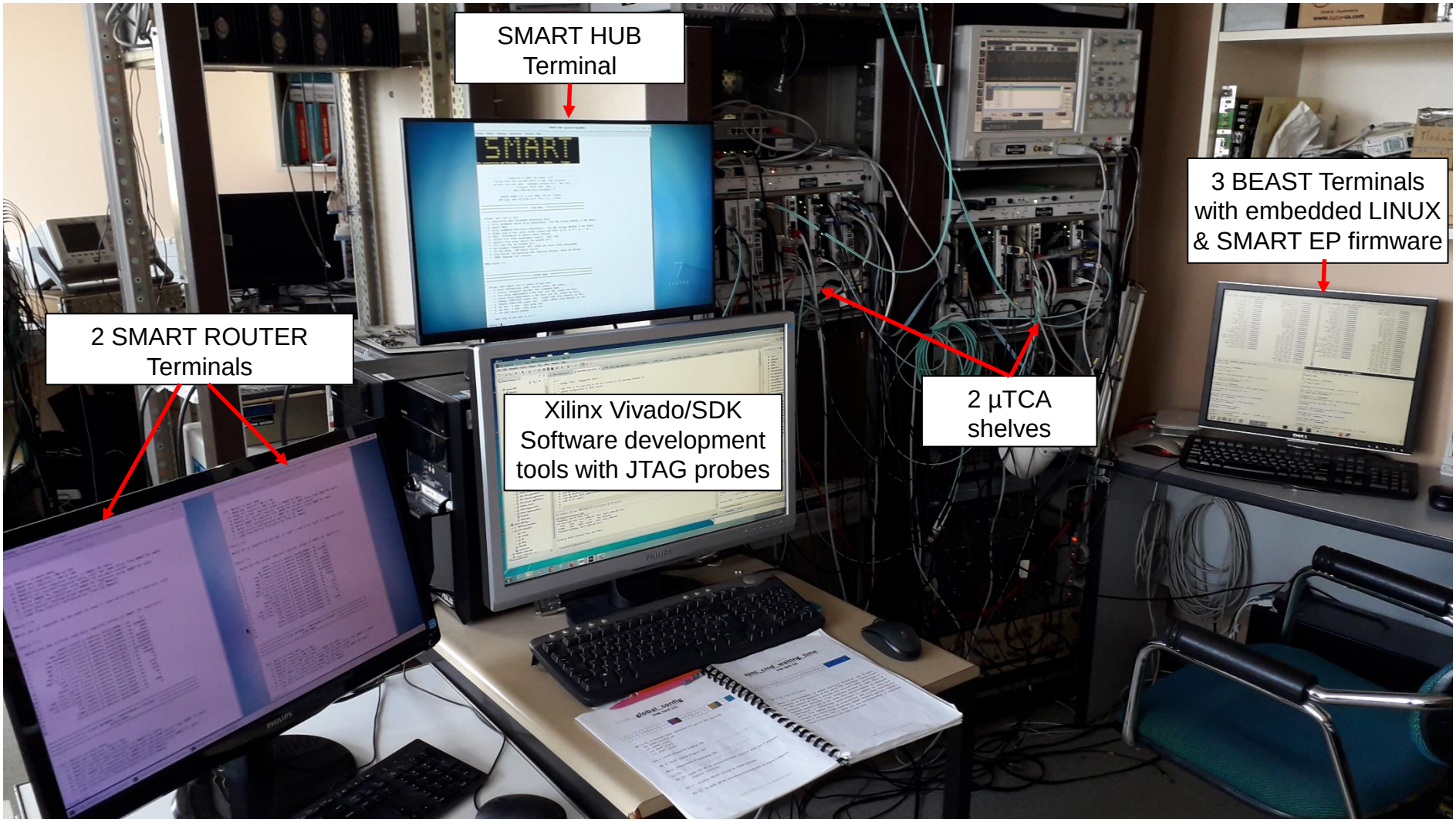
SMART modules in terms of cost

Production série Phase 1	SMART AMC ROUTER	SMART AMC HUB
Price/Unit (€)	3700	4300

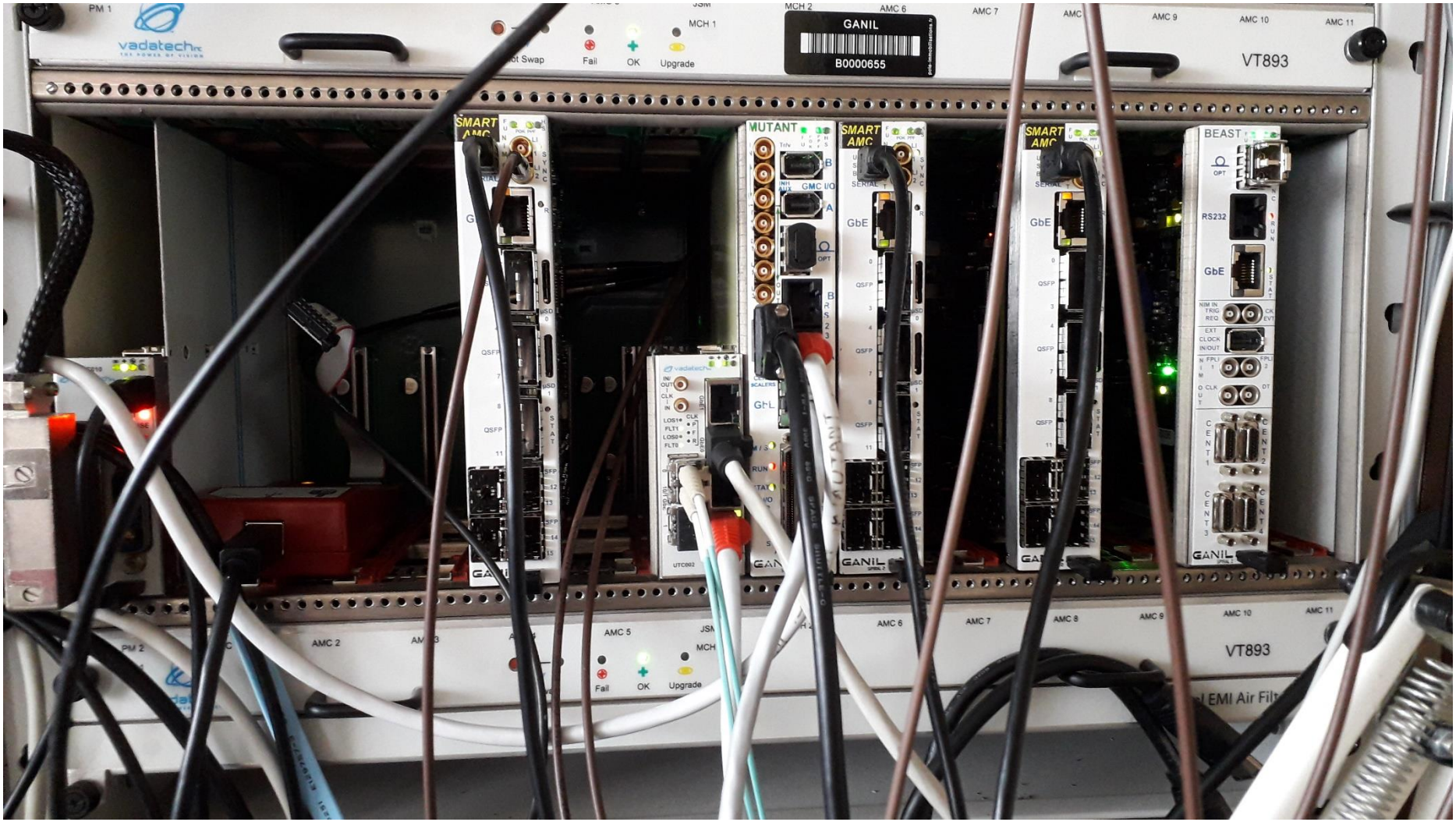


Phase 2	SMART MCH (estimation)
Price/Unit (€)	10 k€

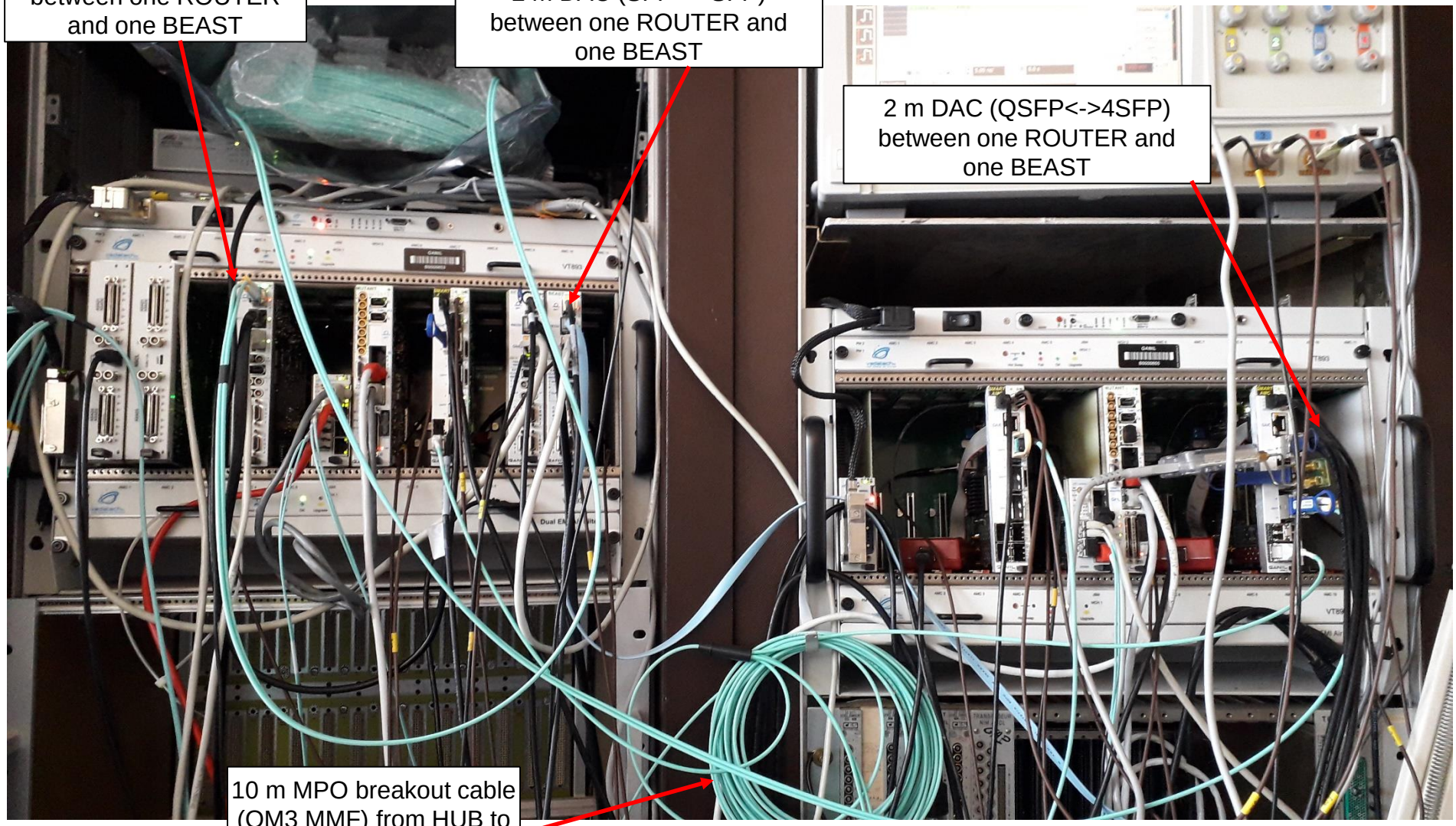
SMART tests - Full test bench overview



First tests of SMART AMC in one µTCA



Few pictures of SMART AMC test bench



questions