



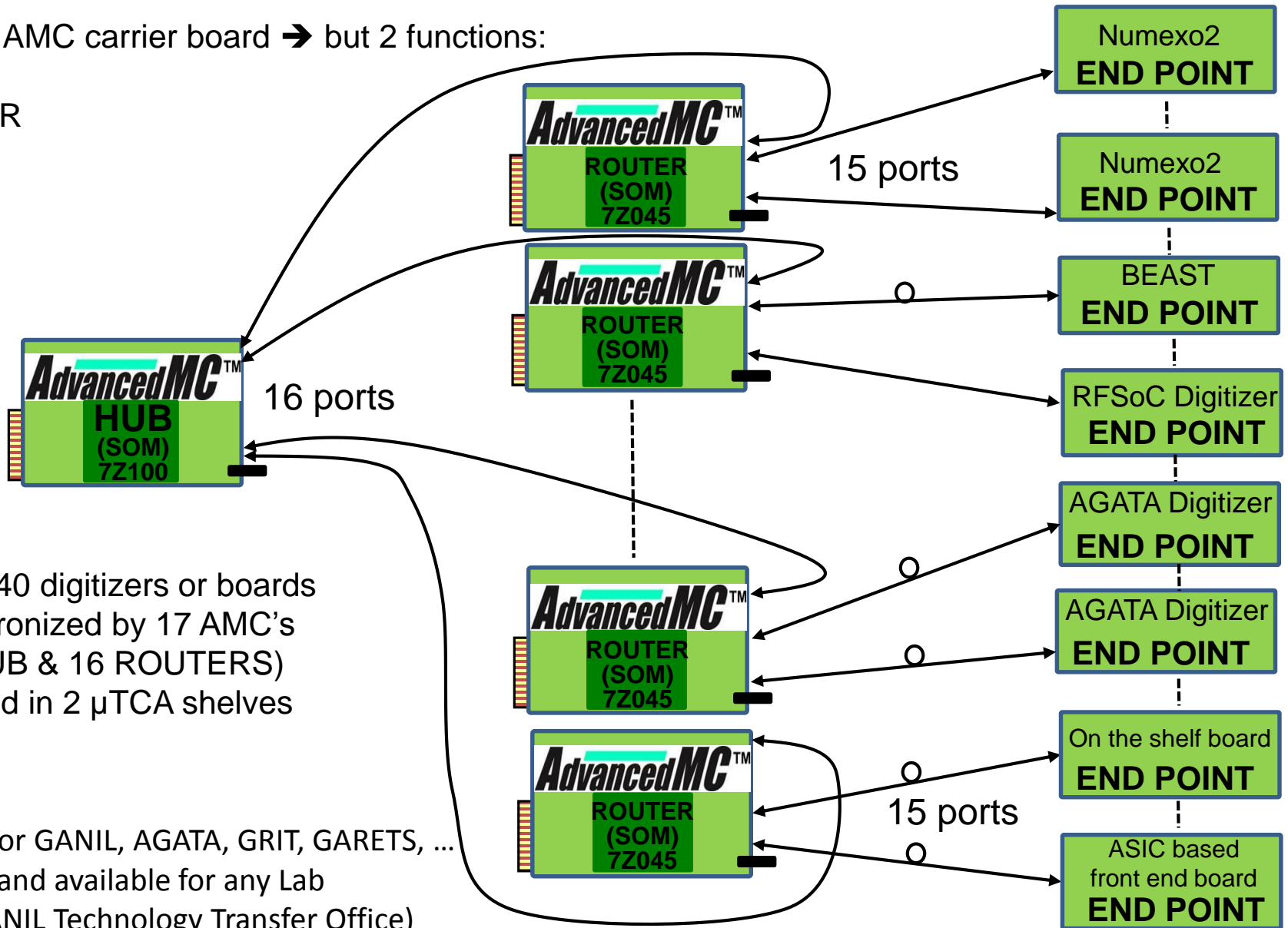
Sfp connectivity and **M**icrotca for **A**dvanced **R**emote **T**rigger

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)

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

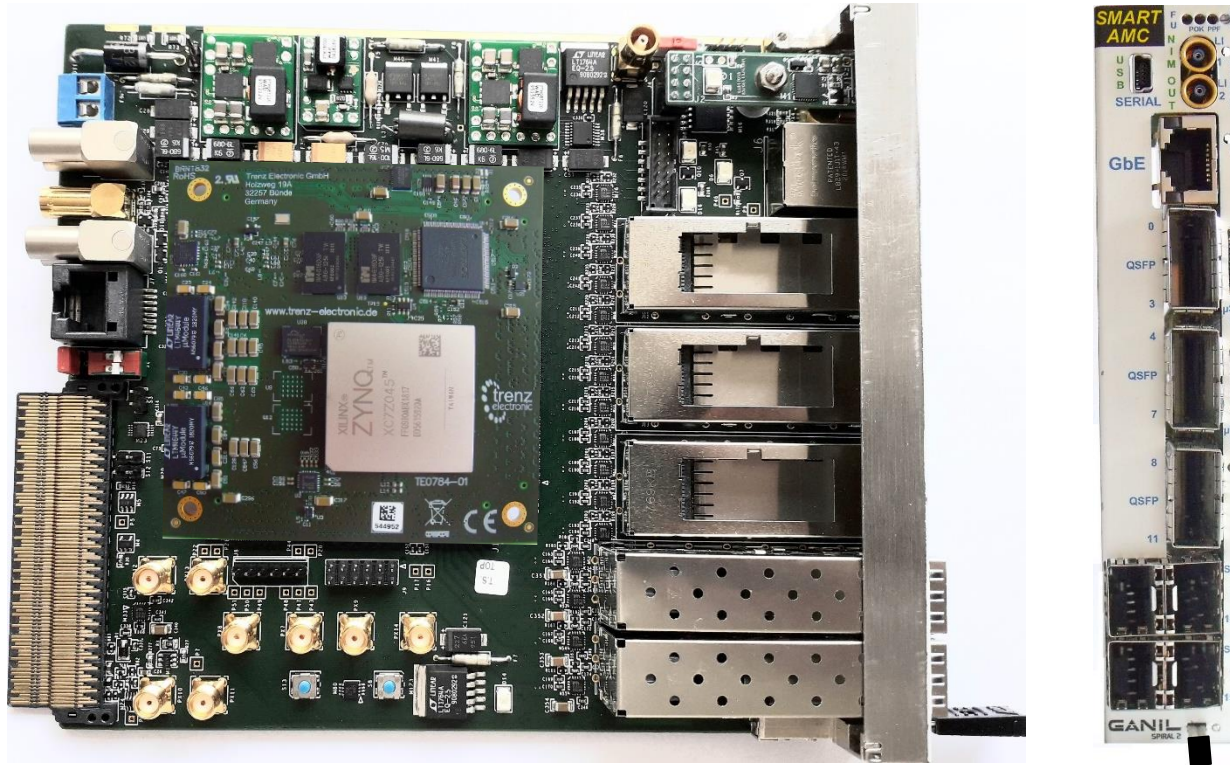
COMMUNICATION MEDIA (Interoperability)

- **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)



QSFP to MPO
(Finisar FTL410 series)

- 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 4xSFP+
(40G breakout passive cables)

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



Fiber MPO to 4 x 2 Fiber MPO Duplex LCs

GANIL logo: laboratoire commun CEA/DSM spiral2 CNRS/IN2P3

fp connectivity and
microtca for
advanced
remote
trigger

written

**COMMUNICATION PROTOCOL
V1.0**

SMART AMC → up to 240 End Points
SMART MCH → up to 480 End Points

GANIL/PHY/DELTA September 2020 Gilles WITTWER

GANIL logo: laboratoire commun CEA/DSM spiral2 CNRS/IN2P3

SMART

written

Few hints* to implement a SMART
End Point IP in your FPGA

at the hardware and firmware point of view ...

* Non exhaustive list

SMART END POINT IP GUIDE - V1.0 - April 2020 Gilles Wittwer 1

GANIL logo: laboratoire commun CEA/DSM spiral2 CNRS/IN2P3

fp connectivity and
microtca for
advanced
remote
trigger

written

AMC ROUTER Slow Control User Manual

AdvancedMC™

GANIL/PHY/DELTA SMART ROUTER - V1.0 - September 2020 Gilles Wittwer

GANIL logo: laboratoire commun CEA/DSM spiral2 CNRS/IN2P3

fp connectivity and
microtca for
advanced
remote
trigger

written

AMC HUB Slow Control User Manual
Volume 1 - Clock & Timestamping

AdvancedMC™

GANIL/PHY/DELTA SMART HUB Vol.1 - V1.0 - September 2020 Gilles Wittwer

GANIL logo: laboratoire commun CEA/DSM spiral2 CNRS/IN2P3

fp connectivity and
microtca for
advanced
remote
trigger

to be written

AMC HUB Slow Control User Manual
Volume 2 - Trigger

AdvancedMC™

GANIL/PHY/DELTA SMART HUB Vol.2 - V1.0 - December 2021 Gilles Wittwer

GANIL logo: laboratoire commun CEA/DSM spiral2 CNRS/IN2P3

fp connectivity and
microtca for
advanced
remote
trigger

to be written

AMC HUB and ROUTER User Guide

AdvancedMC™

GANIL/PHY/DELTA V1.0 - January 2022 Gilles Wittwer

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 Delay: 0 Max Delay: 0 D= 0
```

		ROUTER CHANNEL (fine delays are in ps)															
		HUB CH.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ROUTER port: 6 Min Delay:	0 Mean Delay:	0															
ROUTER port: 7 Min Delay:	0 Mean Delay:	0															
ROUTER port: 8 Min Delay:	0 Mean Delay:	0															
ROUTER port: 9 Min Delay:	0 Mean Delay:	0															
ROUTER port:10 Min Delay:	0 Mean Delay:	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ROUTER port:11 Min Delay:	0 Mean Delay:	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ROUTER port:12 Min Delay:	0 Mean Delay:	0	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ROUTER port:13 Min Delay:	190080 Mean Delay:	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ROUTER port:14 Min Delay:	0 Mean Delay:	0															
HUB port: 3			2	X	X	X	X	X	X	X	X	X	X	X	X	95081	X
ROUTER port: 0 Min Delay:	0 Mean Delay:	0															
ROUTER port: 1 Min Delay:	158166 Mean Delay:	3	X	79109	X	X	X	X	X	X	556669	X	X	X	X	X	X
ROUTER port: 2 Min Delay:	0 Mean Delay:	0															
ROUTER port: 3 Min Delay:	0 Mean Delay:	0															
ROUTER port: 4 Min Delay:	0 Mean Delay:	0															
ROUTER port: 5 Min Delay:	0 Mean Delay:	0															
ROUTER port: 6 Min Delay:	0 Mean Delay:	0															
ROUTER port: 7 Min Delay:	0 Mean Delay:	0															
ROUTER port: 8 Min Delay:	1113102 Mean Delay:	6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ROUTER port: 9 Min Delay:	0 Mean Delay:	0															
ROUTER port:10 Min Delay:	0 Mean Delay:	0															
ROUTER port:11 Min Delay:	0 Mean Delay:	0															
ROUTER port:12 Min Delay:	0 Mean Delay:	0															
ROUTER port:13 Min Delay:	0 Mean Delay:	0															
ROUTER port:14 Min Delay:	0 Mean Delay:	0															
HUB port: 4 not connected ...			9	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HUB port: 5 not connected ...			10	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HUB port: 6 not connected ...			11	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HUB port: 7 not connected ...			12	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HUB port: 8 not connected ...			13	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HUB port: 9 not connected ...			14	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HUB port:10 not connected ...			15	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)															

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

SMART AMC first results 2/3

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

HUB port:	HUB CH.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
HUB port: 0 not connected																	
HUB port: 1 not connected																	
HUB port: 2																	
ROUTER port: 0 Min Delay:	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 1 Min Delay:																	
ROUTER port: 2 Min Delay:	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 3 Min Delay:																	
ROUTER port: 4 Min Delay:	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 5 Min Delay:																	
ROUTER port: 6 Min Delay:	2	X	X	X	X	X	X	X	X	X	X	X	X	X	594688	X	
ROUTER port: 7 Min Delay:																	
ROUTER port: 8 Min Delay:	2	X	X	X	X	X	X	X	X	X	X	X	X	X	594688	X	
ROUTER port: 9 Min Delay:																	
ROUTER port: 10 Min Delay:	3	X	760442	X	X	X	X	X	X	1061963	X	X	X	X	X	X	
ROUTER port: 11 Min Delay:																	
ROUTER port: 12 Min Delay:	4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 13 Min Delay:																	
ROUTER port: 14 Min Delay:	5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
HUB port: 3																	
ROUTER port: 0 Min Delay:	6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 1 Min Delay:																	
ROUTER port: 2 Min Delay:																	
ROUTER port: 3 Min Delay:	7	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 4 Min Delay:																	
ROUTER port: 5 Min Delay:	8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 6 Min Delay:																	
ROUTER port: 7 Min Delay:																	
ROUTER port: 8 Min Delay:	9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 9 Min Delay:																	
ROUTER port: 10 Min Delay:	10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 11 Min Delay:																	
ROUTER port: 12 Min Delay:	11	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ROUTER port: 13 Min Delay:																	
ROUTER port: 14 Min Delay:																	
HUB port: 4 not connected	12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
HUB port: 5 not connected	13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
HUB port: 6 not connected	14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
HUB port: 7 not connected	14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
HUB port: 8 not connected	15	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
HUB port: 9 not connected	A total of 3 end-point coarse delay(s) have been measured most del. Hport 3, Rport 8, - least del. Hport 2, Rport 13																
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 ...																	

SMART AMC first results 3/3

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

HUB CH.	0	1	2	3	4	ROUTER CHANNEL (delays to set in registers)									
						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
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 μ TCA IPMI for inventory, monitoring ...

VadaTech MicroTCA Shelf Manager - M

Fichier Édition Affichage Historique Marque-pages Outils Aide

VadaTech MicroTCA Sh... * +

192.168.40.252:8080

GAPwigi

SYSTEM

FRU MANAGEMENT

FRU Hotswap
FRU State
FRU Address Information
List FRU Inventory
Devices
Read FRU Inventory
FRU Control
List SDRs
List Device SDRs
Get FRU Power Levels
Set FRU Power Levels
Update FRU Version
FRU Temperature

Read FRU Inventory Results

(0x82, FRU# 08) Inventory Storage Information

BOARD INFORMATION AREA

Format Version : 1
Length : 12 (multiples of 8 bytes)
Language Code : 0x19
Manufacturing Date/Time : Fri May 15 13:26:00 2020

SYSTEM

FRU MANAGEMENT

FRU Hotswap
FRU State
FRU Address Information
List FRU Inventory
Devices
Read FRU Inventory
FRU Control
List SDRs
List Device SDRs
Get FRU Power Levels
Set FRU Power Levels
Update FRU Version
FRU Temperature

Tera Term - COM2 VT

Managed Power Module

File Edit Setup Control Window Help

Load Power Status

Module	Present	Management	Payload	Payload Draw	Payload Required
		Power to Load	Power to Load	in Amps	in Amps
MCH1	Yes	Good	Good	2.1	*4.0
MCH2	Yes	Good	Good	4.6	*7.5
CU1	Yes	Good	Good	1.9	*5.0
CU2	Yes	Good	Good	0.9	*5.0
AMC1	No	-----	-----	-----	-----
AMC2	No	-----	-----	-----	-----
AMC3	No	-----	-----	-----	-----
AMC4	Yes	Good	Good	2.7	*6.0
AMC5	No	-----	-----	-----	-----
AMC6	No	-----	-----	-----	-----
AMC7	No	-----	-----	-----	-----
AMC8	No	-----	-----	-----	-----
AMC9	Yes	Good	Good	2.6	*6.0
AMC10	No	-----	-----	-----	-----
AMC11	No	-----	-----	-----	-----
AMC12	No	-----	-----	-----	-----

'E' - Power Entry Status: Good 'T' - Temperature Sensors: Good
'C' - Clear Faults 'S' - Autonomous Power Sequencing

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

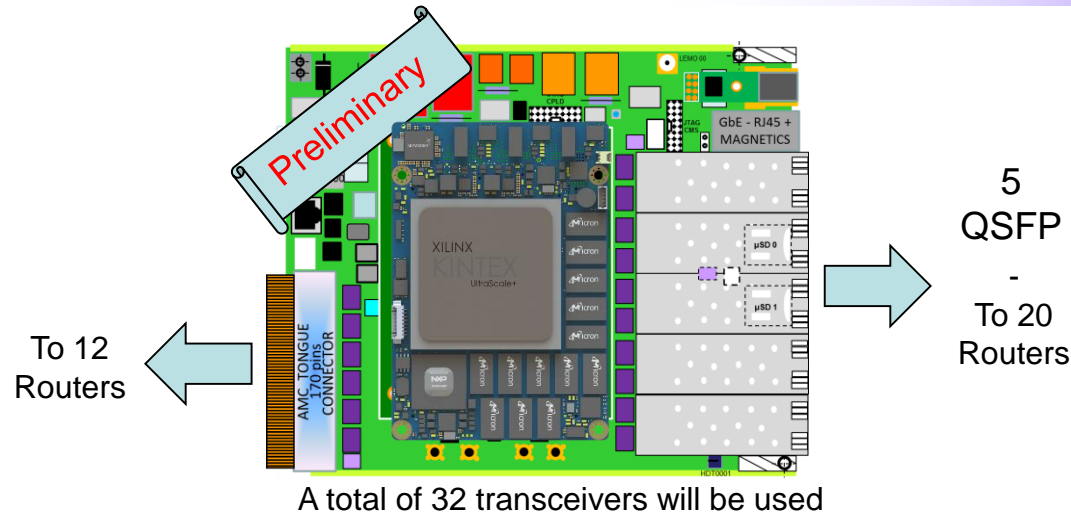
Main tasks

- 3 PCBs purchased, boards assembled and populated with SOM
- SMART AMC prototypes tested and SMART concept validated
- Embedded Linux with SMART C applications included
- SMART AMC production launching (SOM purchasing, active components purchasing, FP mechanics, ...)
- SMART Trigger 1st version test (NUMEXO2-SMART EP FW req.)
- Specifications ready for “French public market” production and subcontractors selected
- Production (PCB’s, Board Assembly, tests ...)
- Delivery of SMART AMC production (first batch)

Updated key dates

- June 2021
- June 2022
- *June 2023*
- *2023*
- *Summer 2023*
- *December 2023*
- *Spring 2024*
- *Summer 2024*

Few words about SMART MCH (Phase 2)



Main tasks

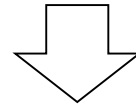
- Architecture design of SMART MCH
- SOM selected and ordered (Iwave - Kintex KU19P + Arm)
- Xilinx UltraSCALE+ SOM + baseboard delivery
- SMART MCH Schematics
- PCB routing
- PCB manufacturing and SMART MCH assembly
- Porting SMART AMC HUB FW/SW to SMART MCH
- Integration and tests in existing SMART phase 1

Estimated date/time (from now)

- Completed
- Completed
- 4 months
- 2 month
- 3 months
- 3 months
- 6 months
- 6 months
- = 2 YEARS

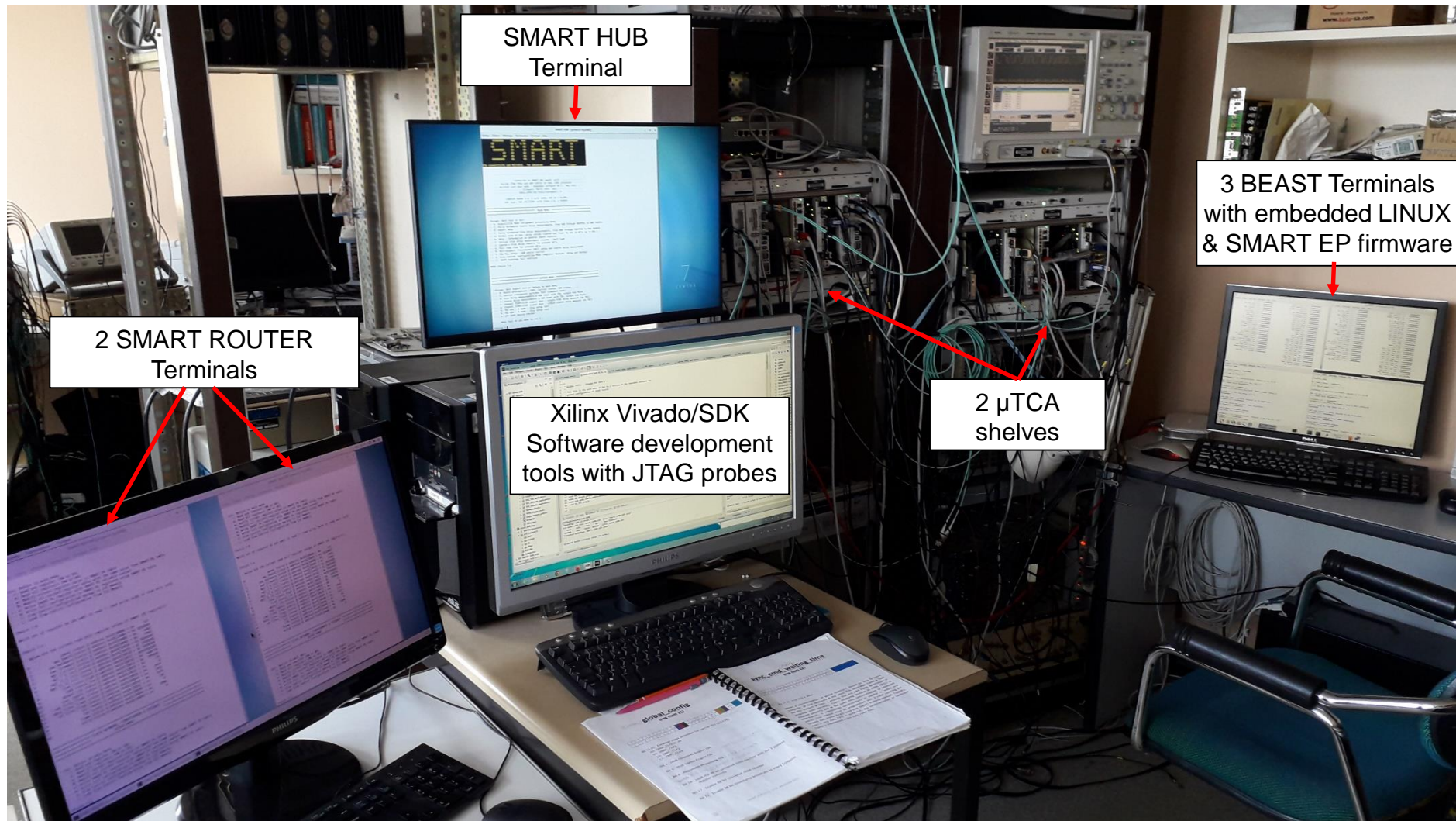
SMART modules in terms of cost

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

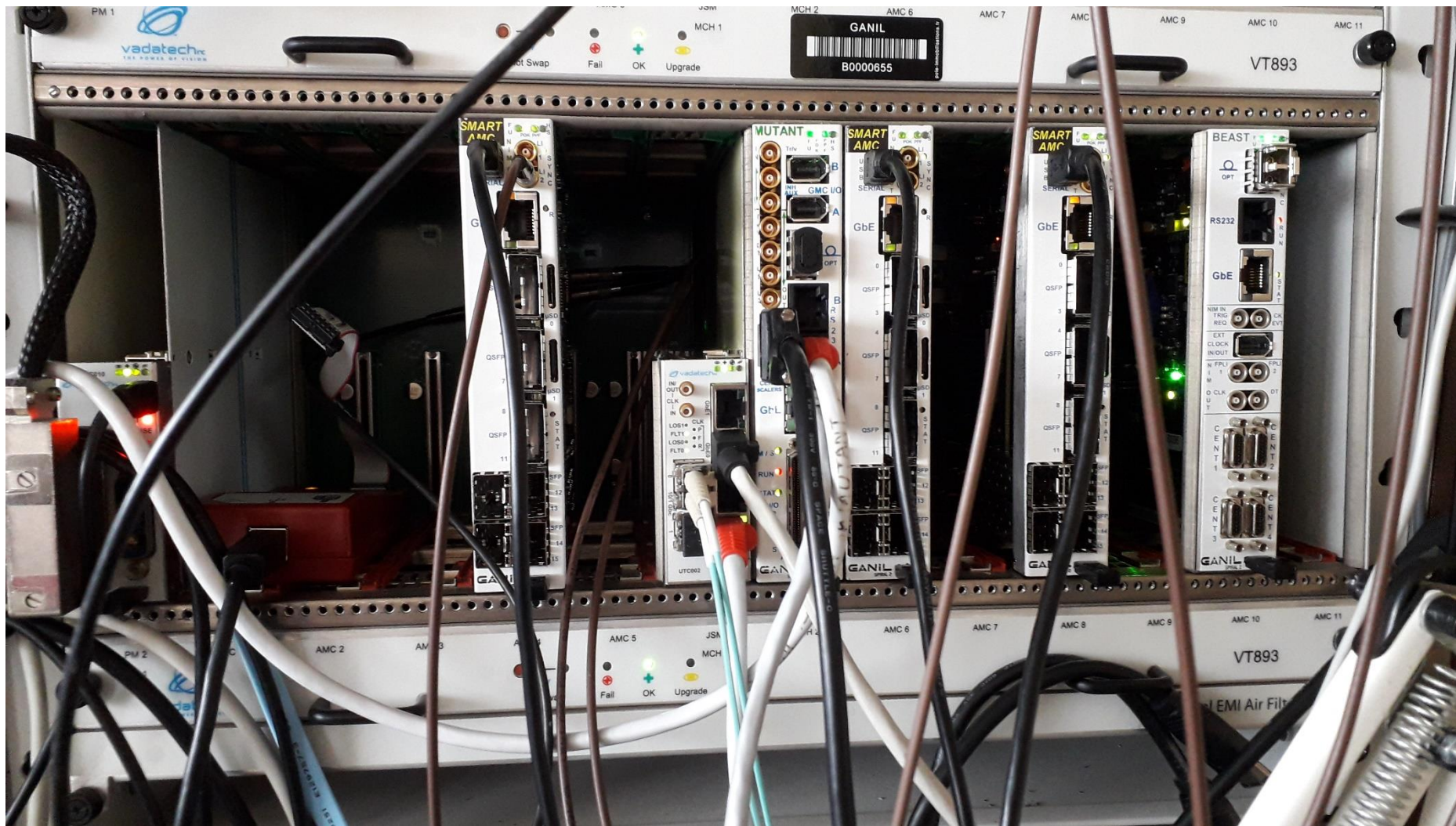


Phase 2	SMART MCH (estimation)
Price/Unit (€)	10 k€

SMART tests - Full test bench overview



First tests of SMART AMC in one μ TCA



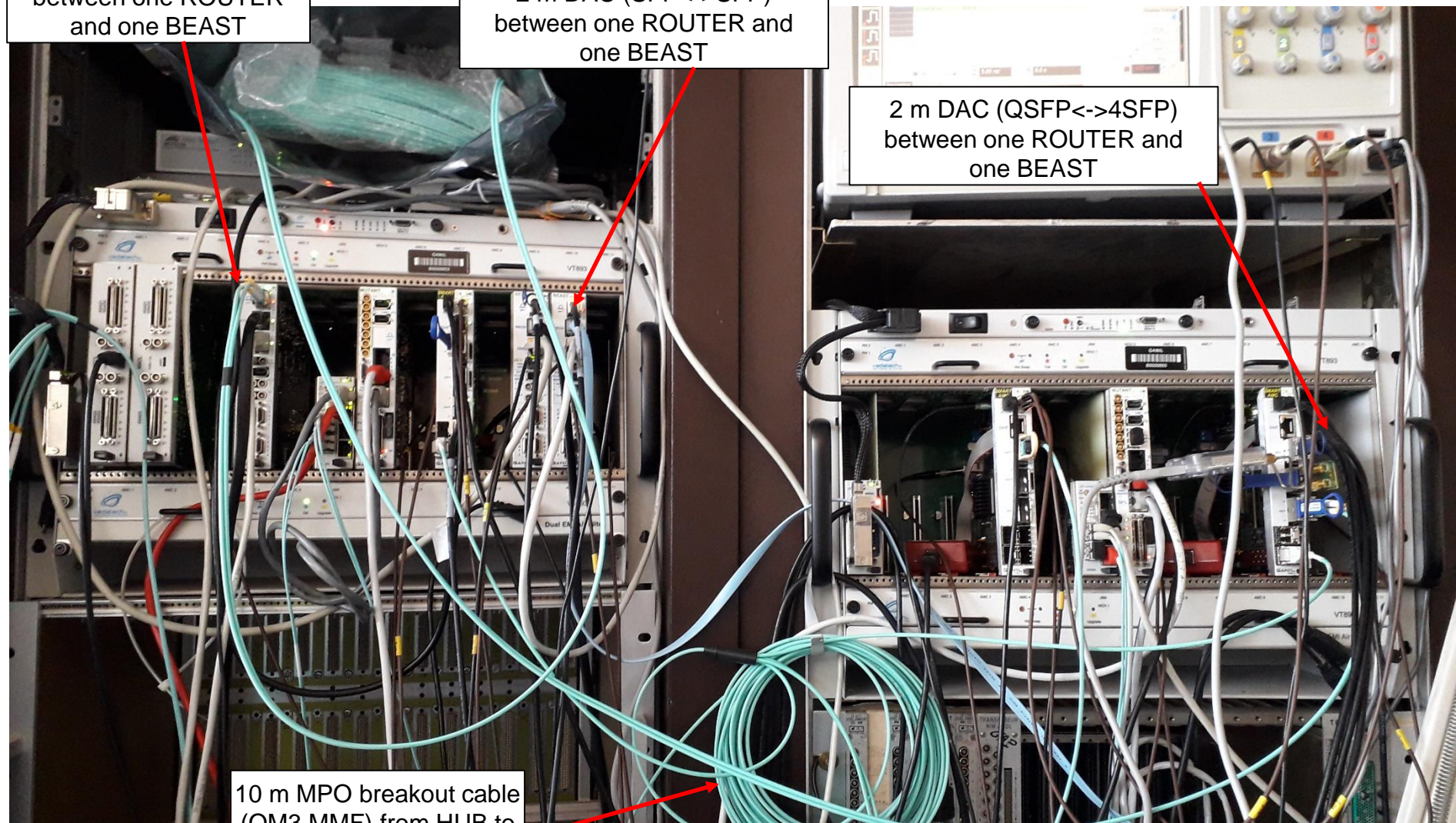
Few pictures of SMART AMC test bench

100m OM3 fiber
between one ROUTER
and one BEAST

2 m DAC (SFP<->SFP)
between one ROUTER and
one BEAST

2 m DAC (QSFP<->4SFP)
between one ROUTER and
one BEAST

10 m MPO breakout cable
(OM3 MMF) from HUB to
2 ROUTERS





questions