Brazilian Center for Research in Energy and Materials

Brazilian Synchrotron Light Laboratory

MicroTCA.4 at Sirius and a closer look into the community

IBIC 2019 - Malmö

Daniel Tavares
LNLS Beam Diagnostics Group

September 11, 2019

MicroTCA.4 and MicroTCA.4.1

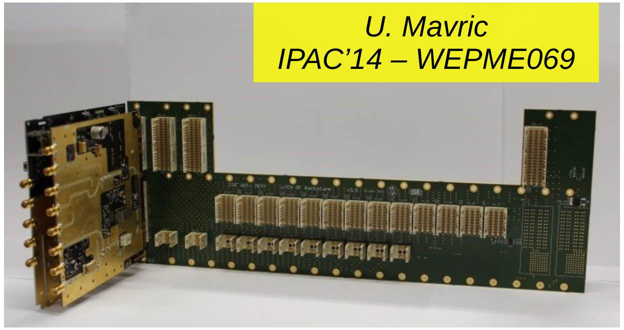
- **MicroTCA.4 (Jul/2011)**
  - Double-width AMC
  - Rear Transition Module
  - Triggers and clocks on the backplane
- **MicroTCA.4.1 (Nov/2016)**
  - Zone 3 connector (RTM) standardization
  - RF backplane
  - Protective covers
- **Software Guidelines (2017)**
- **Mature integration with several timing systems**
  - AMC modules for MRF, White Rabbit (WR), EuXFEL and SINAP event receivers
  - COTS White Rabbit tongue 2 for MCH
  - White Rabbit RF backplane LO distributor eRTM (Distributed DDS)

Vadatech Crate

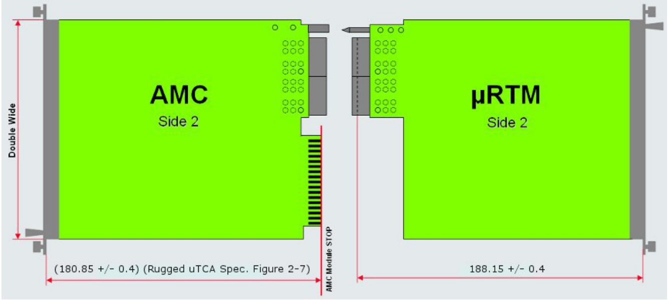
Pentair/Schroff Crate

ELMA Crate

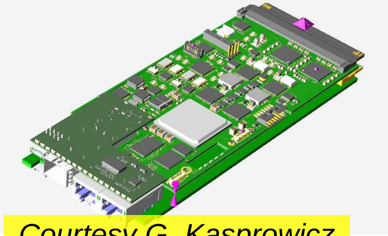
RF Backplane



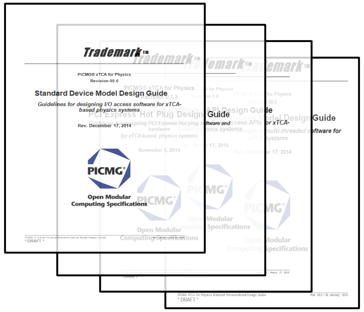
U. Mavric
IPAC'14 – WEPME069



White Rabbit
MCH Tongue 2 (clock)



Courtesy G. Kasprowicz



A bit of history...

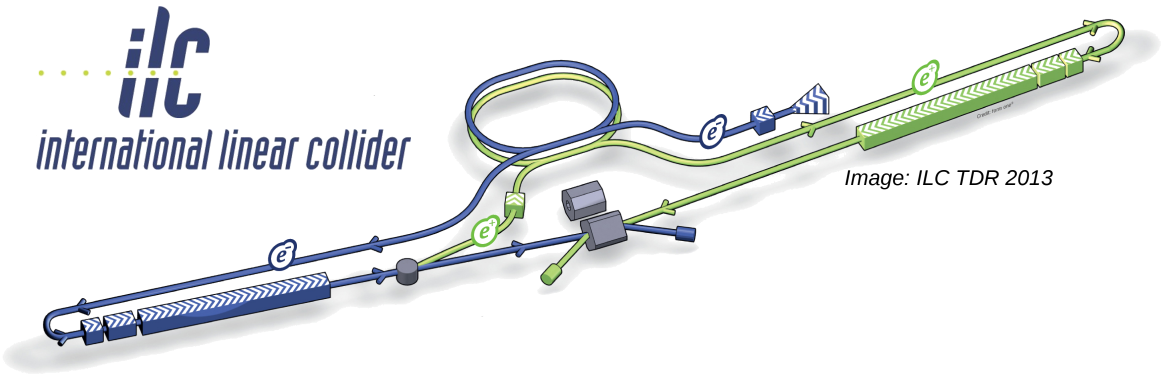


Image: ILC TDR 2013

2004: "Electronics Packaging Issues for Future Accelerators and Experiments", NSS-MIC paper, R. Larsen and R. W. Downing

2004-2009: several discussions, meetings, workshops, technology demonstrations for ATCA and MicroTCA (SLAC, DESY, FNAL, ANL, KEK – later on joined by CERN, ITER, IPFN, IHEP, IN2P3, ESS-Bilbao and others)

2009: "xTCA for Physics" PICMG Working Group

2011: MicroTCA.4 is officially released by PICMG

TESLA Test Facility

Image: DESY

FLASH

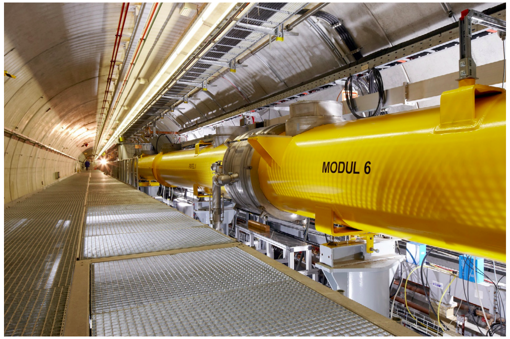


Image: DESY

European XFEL

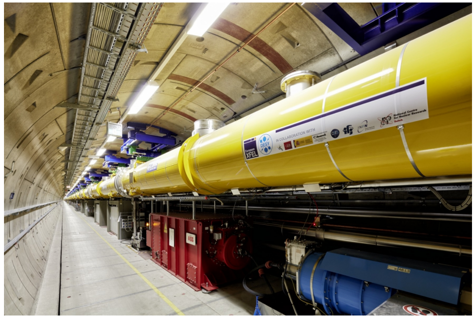
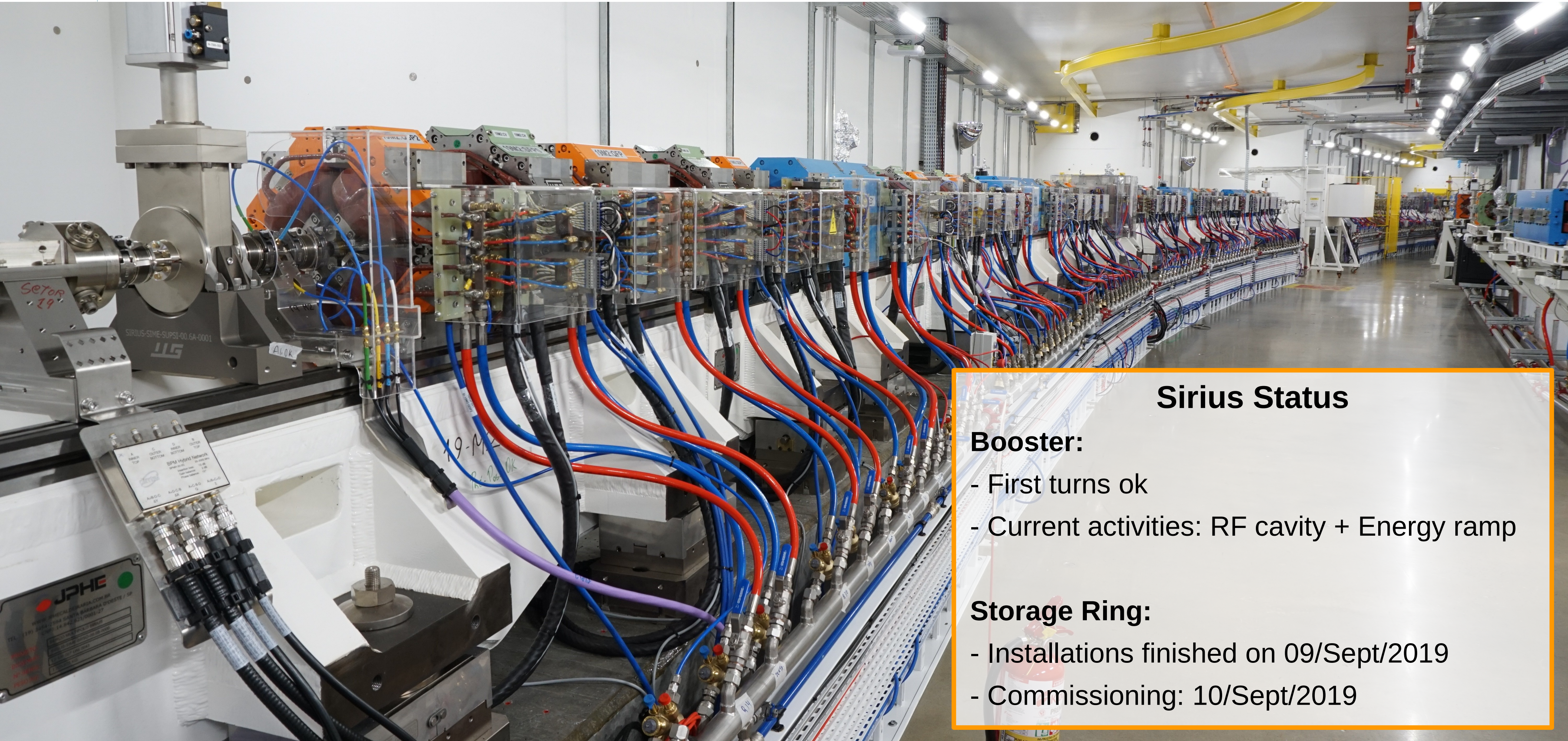


Image: D Nölle/DESY

Sirius – new 4th generation light source in Brazil



Sirius Status

Booster:

- First turns ok
- Current activities: RF cavity + Energy ramp

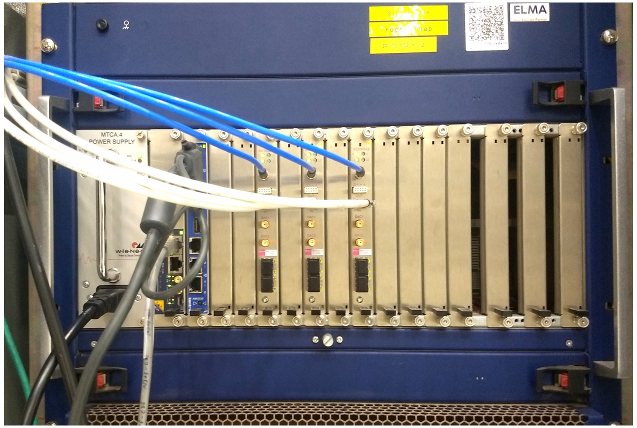
Storage Ring:

- Installations finished on 09/Sept/2019
- Commissioning: 10/Sept/2019

MicroTCA.4 at Sirius

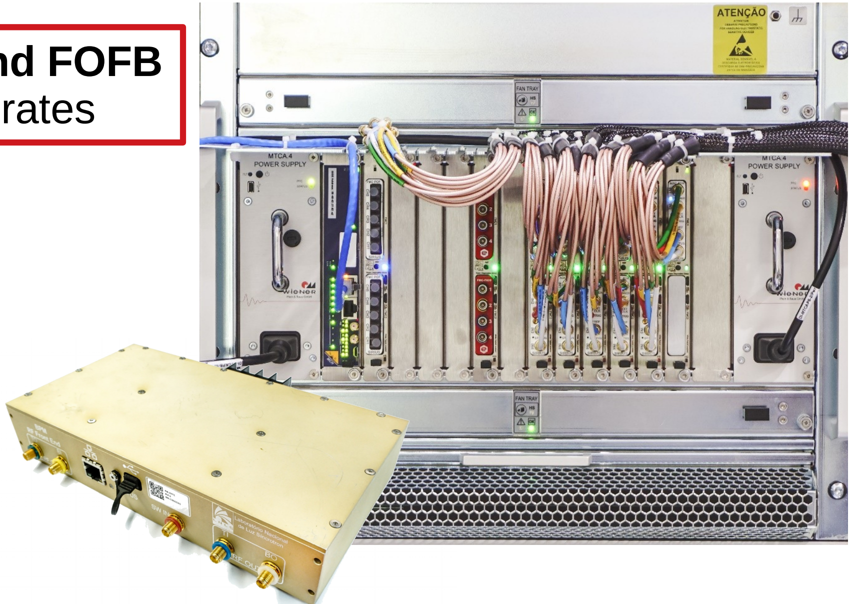
- **LINAC LLRF Crate – provided by SINAP**
  - 3x Struck SIS8300-L2
  - 3x Struck DRTM-DWC8VM1
  - FPGA gateware and software provided by SINAP

Linac LLRF
1 crate



- **BPM Electronics and Orbit Feedback Crate**
  - Pentair/Schroff 12-slot Crate with JSM
  - N.A.T. PHYS80 MCH + µRTM COMex CPU
  - Wiener Low Noise 1 kW Power Supply (redundant)
  - CAENels FMC-Pico-1M4
  - Faster Technology FMC SFP FM-S14
  - **Open Hardware AMC FMC Carrier (AFC)**
  - **Open Hardware FMC ADC 16-bit 250 MS/s**
  - **Open Hardware FMC POF (plastic optical fiber)**
  - **Open Hardware µRTM 8-SFP**
  - **Open Hardware RTM Fast Orbit Corrector Power Supply (coming soon!)**
  - **Open source MMC firmware (openMMC)**
  - **Open source gateware and software for controls and data acquisition**
  - **Standalone RF Front-End Electronics (not integrated to the crate)**

BPM and FOFB
21 crates



Our MTCA.4 successes

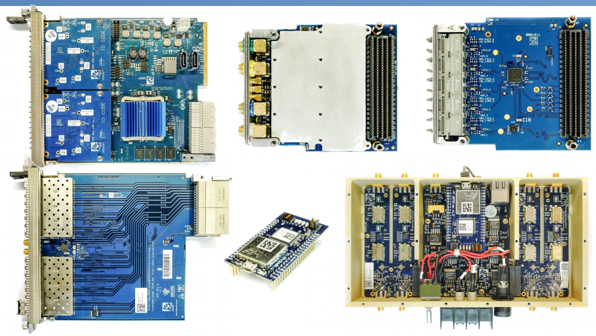
- **Designed and funded reusable hardware designs (e.g. AFC, FMC ADC 16 bit 250 MS/s)**

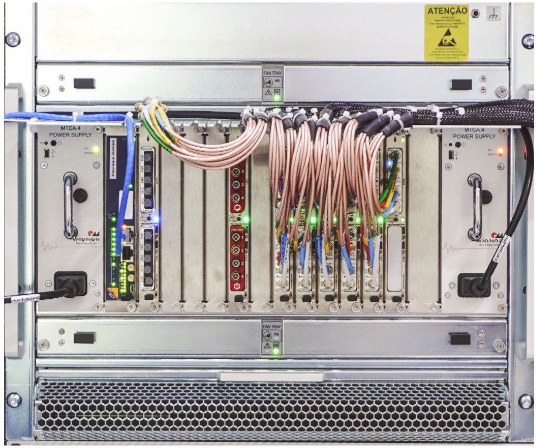
- **Cheap and versatile open hardware AMC FMC Carrier (AFC)**
  - Based on cheap FPGA device (< 200 USD): Xilinx Artix-7 200T
  - Gave us flexibility to accommodate system architecture changes along the project
  - Spin-off Kintex version (AFCK) – by WUT

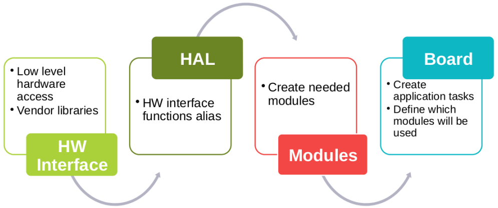
- **High integration in one single crate – one MTCA.4 crate per Sirius sector:**
  - 9 AMC slots: 4x X-Ray BPM + 14x RF BPM Electronics (Booster and Storage Ring)
  - 1 AMC slot: FOFB Controller
  - 1 AMC slot: Timing Receiver

- **openMMC has been adopted by other facilities**
  - openMMC is built on top of FreeRTOS
  - Adopted by LNLS and CERN – collaborative development
  - GPL code available at: https://github.com/lnls-dig/openMMC

- **Custom backplane with 11-slot full mesh on AMC ports 2-3, 8-15**



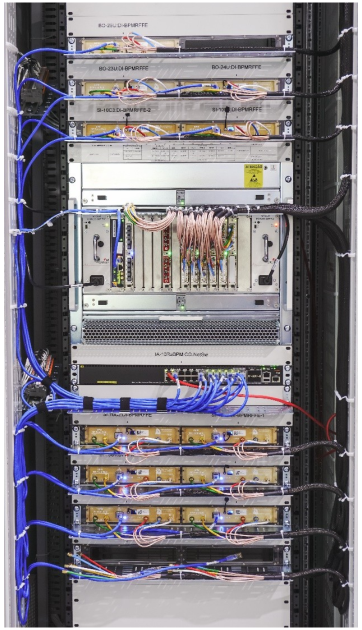




Our MTCA.4 mistakes and struggles

- **Mistakes**
  - Many RF cables entering in the frontral area / empty RTM slots
  - RF Front-End electronics do not benefit from MTCA.4 hardware management
- **Struggles**
  - Interoperability issues → tended towards typical crate setup to minimize risks
  - Recovery on system reset
  - FPGA gateware update via JSM
  - High dependency on MCH supplier for IPMI debugging
  - Mechanical insertion and removal of modules is painful (sometimes literally!), especially the MCH

Front View



Rear view

Outline

- **Mission:** picture the status and maturity of MicroTCA.4 in the accelerators community

- **Survey:** 27 participants

- **This talk:**
  - Part 1: status of MTCA.4 adoption in accelerator facilities
  - Part 2: maturity of MTCA.4 standard and its ecosystem
  - Part 3: topics for discussion and summary

Disclaimer

- **Declaring the biases of this talk:**
  - Accelerators (not Experiments, not Detectors)
  - Diagnostics and Beam-based Feedbacks (not LLRF, not Timing, not MPS)
  - Collaboration
- **Point-of-view:**
  - “Ordinary user”
  - Not member of any PICMG working group (yet)
- **We have made “MicroTCA.4 mistakes” in the past!**

Survey results

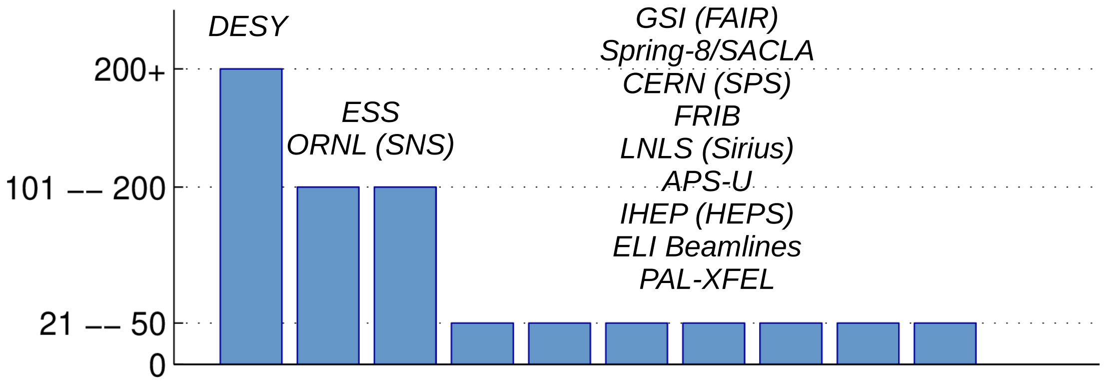
Table 1: MTCA.4 projects on accelerator facilities (non-exhaustive list). a) LLRF, b) BPM Electronics, c) BAM Electronics, d) Beam Diagnostics (other than BPM and BAM Electronics), e) Synchronization/Timing, f) Machine Protection, g) Feedback Control, h) Image Processing, i) Experiment Control, j) Massive Data Processing.

Facility	Location	a	b	c	d	e	f	g	h	i	j	Number of Crates
DESY (E-XFEL, FLASH) [39]	Germany	x	x	x	x	x	x	x	x	x	x	200+
ESS [40, 41]	Sweden	x	x	-	x	x	x	-	-	-	-	101-200
ORNL (SNS) [42]	USA	x	-	-	-	-	x	x	-	-	x	101-200
GSI (FAIR) [43]	Germany	x	x	-	x	x	-	x	x	x	-	51-100
Spring-8/SACLA [44, 45]	Japan	x	x	-	x	x	-	x	-	-	-	51-100
CERN (SPS) [46]	Switzerland	x	-	-	-	x	-	x	-	x	-	21-50
FRIB [47]	USA	-	x	-	x	x	x	-	-	-	-	21-50
LNLS (Sirius) [20]	Brazil	x	x	-	-	x	-	x	-	-	-	21-50
APS-U [48]	USA	x	-	-	x	-	-	x	-	-	-	21-50
IHEP (HEPS)	China	x	-	-	-	x	x	-	-	-	-	21-50
ELI Beamlines [49]	Czech Republic	-	-	-	-	x	-	-	-	x	-	21-50
PAL (PAL-XFEL)	South Korea	-	x	-	-	-	-	-	-	-	-	21-50
CSNS (IHEP)	China	x	-	-	-	-	-	-	-	-	-	11-20
Diamond [50]	UK	x	-	-	x	-	-	x	-	-	-	6-10
KEK (SuperKEKB, STF-2) [51]	Japan	x	x	-	-	-	-	-	-	-	-	6-10
SINAP (SXFEL, SHINE) [52]	China	x	-	-	-	-	-	-	-	-	-	6-10
KIT (FLUTE) [53]	Germany	x	x	-	x	x	-	x	-	x	-	1-5
CANDLE [54]	Armenia	x	-	-	x	x	-	-	-	-	-	1-5
Soleil	France	x	-	-	-	-	-	-	x	x	-	1-5
USTC (HLS-II)	China	x	x	-	-	-	-	-	-	-	-	1-5
HZDR (ELBE) [55]	Germany	x	-	-	-	x	-	-	-	-	-	1-5
ANSTO (AS) [56]	Australia	-	-	-	-	-	x	-	-	-	-	1-5
Elettra	Italy	-	-	-	-	-	-	x	-	-	-	1-5
ESRF	France	-	-	-	-	-	-	x	-	-	-	1-5
IMP/CAS (ADS) [57]	China	x	-	-	-	-	-	-	-	-	-	1-5
J-PARC [58]	Japan	x	-	-	-	-	-	-	-	-	-	1-5
JGU (MESA [59])	Germany	x	-	-	-	-	-	-	-	-	-	1-5

Size

Table 1: MTCA.4 projects on accelerator facilities (non-exhaustive list). a) LLRF, b) BPM Electronics, c) BAM Electronics, d) Beam Diagnostics (other than BPM and BAM Electronics), e) Synchronization/Timing, f) Machine Protection, g) Feedback Control, h) Image Processing, i) Experiment Control, j) Massive Data Processing.

Facility	Location	a	b	c	d	e	f	g	h	i	j	Number of Crates
DESY (E-XFEL, FLASH) [39]	Germany	x	x	x	x	x	x	x	x	x	x	200+
ESS [40, 41]	Sweden	x	x	-	x	x	x	-	-	-	-	101-200
ORNL (SNS) [42]	USA	x	-	-	-	-	x	x	-	-	x	101-200
GSI (FAIR) [43]	Germany	x	x	-	x	x	-	x	x	x	-	51-100
Spring-8/SACLA [44, 45]	Japan	x	x	-	x	x	-	x	-	-	-	51-100
CERN (SPS) [46]	Switzerland	x	-	-	-	x	-	x	-	x	-	21-50
FRIB [47]	USA	-	x	-	x	x	x	-	-	-	-	21-50
LNLS (Sirius) [20]	Brazil	x	x	-	-	x	-	x	-	-	-	21-50
APS-U [48]	USA	x	-	-	x	-	-	x	-	-	-	21-50
IHEP (HEPS)	China	x	-	-	-	x	x	-	-	-	-	21-50
ELI Beamlines [49]	Czech Republic	-	-	-	-	x	-	-	-	x	-	21-50
PAL (PAL-XFEL)	South Korea	-	x	-	-	-	-	-	-	-	-	21-50

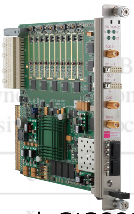


- **12 facilities** having more than 20 crates deployed or to be deployed
- Most common applications:
  - LLRF (9)
  - Timing/Synchronization (9)
  - BPMs (7)
  - Feedbacks (7)
- Still rare applications:
  - Image Processing (2)
  - BAM (1)

LLRF

Table 1: MTCA.4 projects on accelerator facilities (non-exhaustive list). ... BPM Electronics, ... onics, d) Beam Diagnostics (other than BPM and BAM Electronics), e) Syn... n/Timing, f) Mach... on, g) Feedback Control, h) Image Processing, i) Experiment Control, j) Massi... cessing.

Facility	Location	a
DESY (E-XFEL, FLASH) [39]	Germany	x
ESS [40, 41]	Sweden	x
ORNL (SNS) [42]	USA	x
GSI (FAIR) [43]	Germany	x
Spring-8/SACLA [44, 45]	Japan	x
CERN (SPS) [46]	Switzerland	x
FRIB [47]	USA	-
LNLS (Sirius) [20]	Brazil	x
APS-U [48]	USA	x
IHEP (HEPS)	China	x
ELI Beamlines [49]	Czech Republic	-
PAL (PAL-XFEL)	South Korea	-
CSNS (IHEP)	China	x
Diamond [50]	UK	x
KEK (SuperKEKB, STF-2) [51]	Japan	x
SINAP (SXFEL, SHINE) [52]	China	x
KIT (FLUTE) [53]	Germany	x
CANDLE [54]	Armenia	x
Soleil	France	x
USTC (HLS-II)	China	x
HZDR (ELBE) [55]	Germany	x
ANSTO (AS) [56]	Australia	-
Elettra	Italy	-
ESRF	France	-
IMP/CAS (ADS) [57]	China	x
J-PARC [58]	Japan	x
JGU (MESA [59])	Germany	x



Struck SIS8300 (L, L2, KU, etc.)

Struck DWC8VM1 DWC8300, etc.

Soleil

Vadatech AMC580

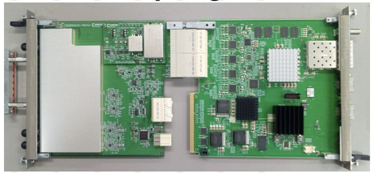
ORNL (SNS Linac)

Vadatech AMC523

ORNL (SNS Ring)

Vadatech AMC502

Spring-8



T. Ohshima IPAC'14 – THPAB117

KEK (ILC)

Mitsubishi Electric TOKKI

- LLRF systems based on E-XFEL/FLASH design:
  - Widespread:
    - E-XFEL, FLASH, ESS, GSI, CERN-SPS, Sirius, CANDLE, SXFEL, SHINE, FLUTE, CANDLE, ELBE, AS, ADS, MESA – not shown in the Table: bERLinPRO, TARLA, NICA and others
  - Mature hardware market
    - Digitizers and Frequency converters
    - RF Backplane and eRTM 14-15 (uLOG and WR)
- Other LLRF architectures
  - KEK
  - Spring-8
  - J-PARC
  - ORNL (SNS)
  - APS-U
  - FRIB
  - Diamond (mostly MicroTCA.0)
  - Soleil (evaluating)

BPM Electronics

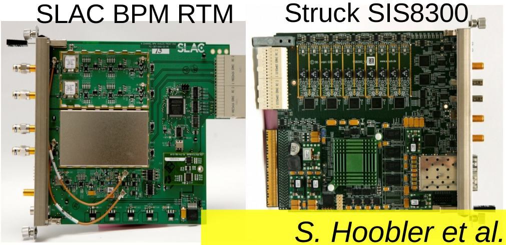
Table 1: MTCA.4 projects on accelerator facilities (non-exhaustive list
d) Beam Diagnostics (other than BPM and BAM Electronics), e)
Feedback Control, h) Image Processing, i) Experiment Control, j) Ma

Facility	Location	a	b
DESY (E-XFEL, FLASH) [39]	Germany	x	x
ESS [40, 41]	Sweden	x	x
ORNL (SNS) [42]	USA	x	-
GSI (FAIR) [43]	Germany	x	x
Spring-8/SACLA [44, 45]	Japan	x	x
CERN (SPS) [46]	Switzerland	x	-
FRIB [47]	USA	-	x
LNLS (Sirius) [20]	Brazil	x	x
APS-U [48]	USA	x	-
IHEP (HEPS)	China	x	-
ELI Beamlines [49]	Czech Republic	-	-
PAL (PAL-XFEL)	South Korea	-	x
CSNS (IHEP)	China	x	-
Diamond [50]	UK	x	-
KEK (SuperKEKB, STF-2) [51]	Japan	x	x
SINAP (SXFEL, SHINE) [52]	China	x	-
KIT (FLUTE) [53]	Germany	x	x
CANDLE [54]	Armenia	x	-
Soleil	France	x	-
USTC (HLS-II)	China	x	x
HZDR (ELBE) [55]	Germany	x	-
ANSTO (AS) [56]	Australia	-	-
Elettra	Italy	-	-
ESRF	France	-	-
IMP/CAS (ADS) [57]	China	x	-
J-PARC [58]	Japan	x	-
JGU (MESA [59])	Germany	x	-

ESS BPM

R. Baron et al.
IBIC'19 – WEPP015

PAL-XFEL BPM

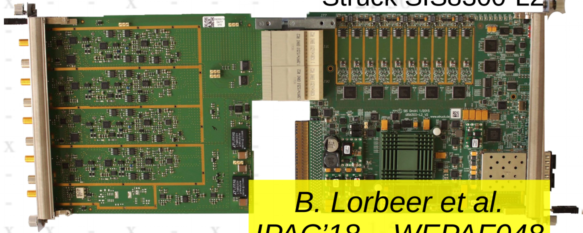


S. Hoobler et al.
ICALEPCS'15 - MOPGF038

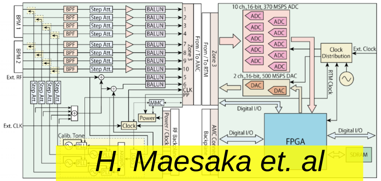
CRYRING BPM (GSI)

T. Hoffmann
MTCAWS'18

FLASH LCBPM



B. Lorbeer et al.
IPAC'18 – WEPAF048

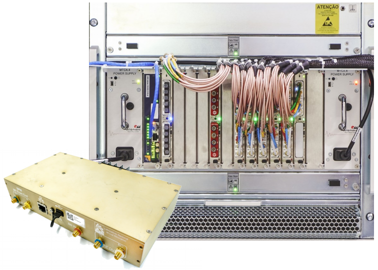


H. Maesaka et. al
IBIC'19 – WEBO03
(next talk!)

FRIB BPM

S. Cogan et al.
IBIC'16 – WEAL03

Sirius BPM



I-tech Libera Brilliance+*

*MicroTCA.0

Feedback Control

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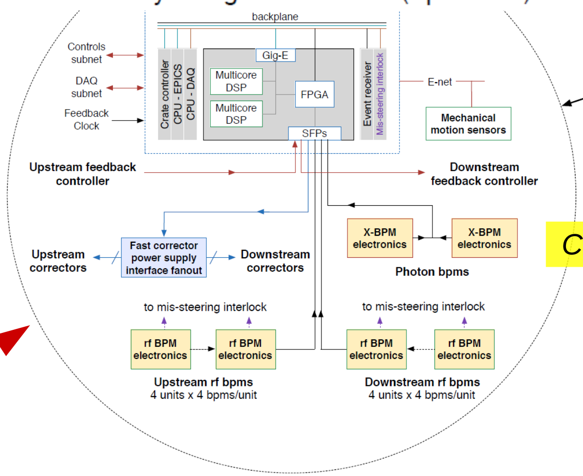
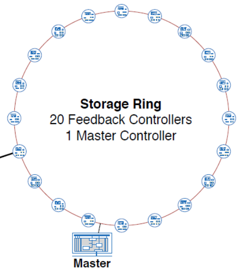
d) Beam Diagnostics (other than BPM and BAM Electronics), e) Synchronization/Timing,
Feedback Control, h) Image Processing, i) Experiment Control, j) Massive Data Processing.

Facility	Location	a	b	c	d	e	f	g	h	i
DESY (E-XFEL, FLASH) [39]	Germany	x	x	x	x	x	x	x	x	x
ESS [40, 41]	Sweden	x	x	-	x	x	x	-	-	-
ORNL (SNS) [42]	USA	x	-	-	-	-	x	x	-	-
GSI (FAIR) [43]	Germany	x	x	-	x	x	-	x	x	x
Spring-8/SACLA [44, 45]	Japan	x	x	-	x	x	-	x	-	-
CERN (SPS) [46]	Switzerland	x	-	-	-	x	-	x	-	x
FRIB [47]	USA	-	x	-	x	x	x	-	-	-
LNLS (Sirius) [20]	Brazil	x	x	-	-	x	-	x		-
APS-U [48]	USA	x	-	-	x	-	-	x	-	-
IHEP (HEPS)	China	x	-	-	-	x	x	-	-	-
ELI Beamlines [49]	Czech Republic	-	-	-	-	x	-	-	-	x
PAL (PAL-XFEL)	South Korea	-	x	-	-	-	-	-	-	-
CSNS (IHEP)	China	x	-	-	-	-	-	-	-	-
Diamond [50]	UK	x	-	-	x	-	-	x	-	-
KEK (SuperKEKB, STF-2) [51]	Japan	x	x	-	-	-	-	-	-	-
SINAP (SXFEL, SHINE) [52]	China	x	-	-	-	-	-	-	-	-
KIT (FLUTE) [53]	Germany	x	x	-	x	x	-	x	-	x
CANDLE [54]	Armenia	x	-	-	x	x	-	-	-	-
Soleil	France	x	-	-	-	-	-	-	x	x
USTC (HLS-II)	China	x	x	-	-	-	-	-	-	-
HZDR (ELBE) [55]	Germany	x	-	-	-	x	-	-	-	-
ANSTO (AS) [56]	Australia	-	-	-	-	-	x	-	-	-
Elettra	Italy	-	-	-	-	-	-	x	-	-
ESRF	France	-	-	-	-	-	-	x	-	-
IMP/CAS (ADS) [57]	China	x	-	-	-	-	-	-	-	-
J-PARC [58]	Japan	x	-	-	-	-	-	-	-	-
JGU (MESA [59])	Germany	x	-	-	-	-	-	-	-	-

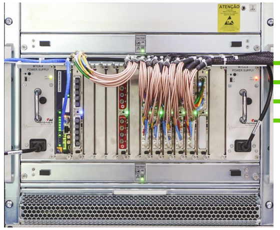
APS-U Orbit Feedback Controller (FBC)
Preliminary Design Architecture (April 2016)

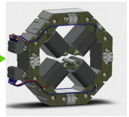


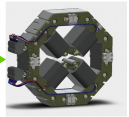


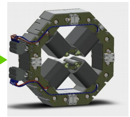
Courtesy J. Carwadine

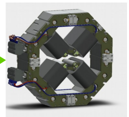
Sirius FOFB
RTM Corrector PS
(~3 W/ch)



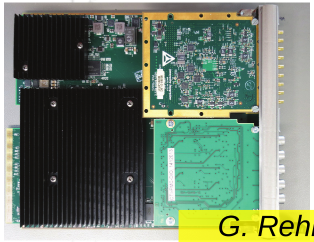








Diamond Multibunch Feedback
Diamond, ESRF, Elettra, BESSY II



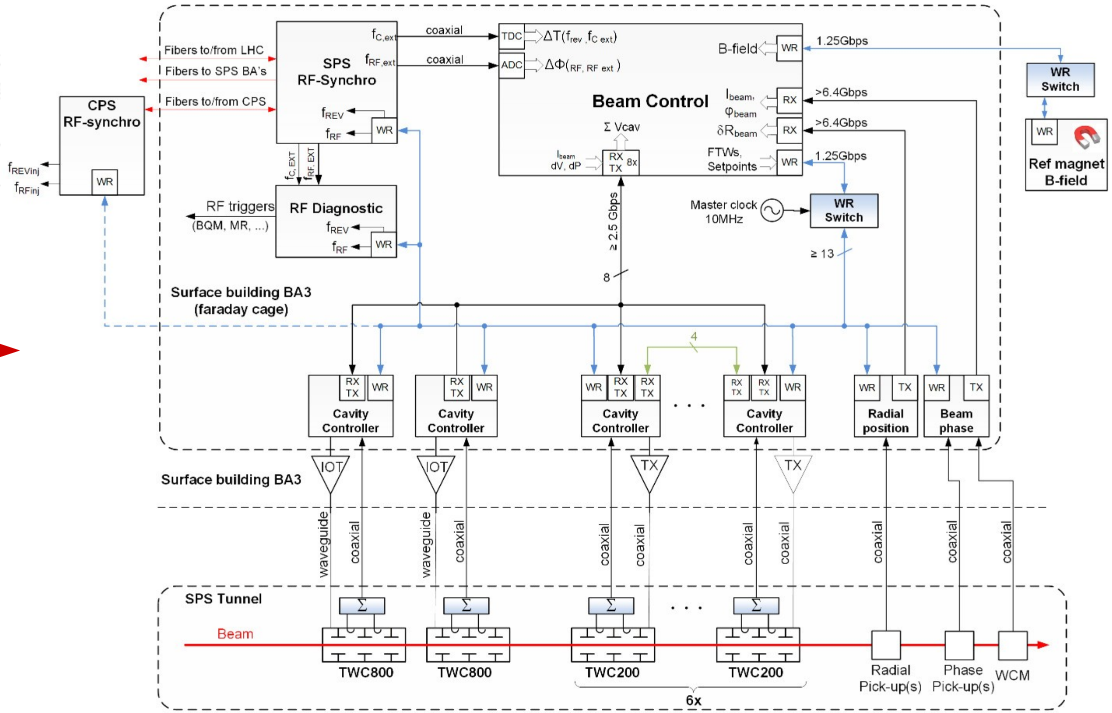
G. Rehm et al.
IBIC'16 – TUCL03

Vadatech AMC525
Innovative Integration FMC-500
Open Hardware FMC-DIO-5chttl

Feedback Control

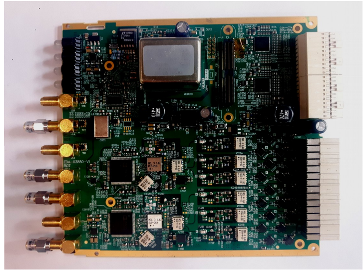
Table 1: MTCA.4 projects on accelerator facilities (non-exhaustive list). a) LLRF, b) BPM Elec… d) Beam Diagnostics (other than BPM and BAM Electronics), e) Synchronization/Timing… Feedback Control, h) Image Processing, i) Experiment Control, j) Massive Data Processing.

Facility	Location	a	b	c	d	e	f	g	h	i
DESY (E-XFEL, FLASH) [39]	Germany	x	x	x	x	x	x	x	x	x
ESS [40, 41]	Sweden	x	x	-	x	x	x	-	-	-
ORNL (SNS) [42]	USA	x	-	-	-	-	x	x	-	-
GSI (FAIR) [43]	Germany	x	x	-	x	x	-	x	x	x
Spring-8/SACLA [44, 45]	Japan	x	x	-	x	x	-	x	-	-
CERN (SPS) [46]	Switzerland	x	-	-	-	x	-	x	[illegible]	[illegible]
FRIB [47]	USA	-	x	-	x	x	x	-	-	-
LNLS (Sirius) [20]	Brazil	x	x	-	-	x	-	x	-	-
APS-U [48]	USA	x	-	-	x	-	-	x	-	-
IHEP (HEPS)	China	x	-	-	-	x	x	-	-	-
ELI Beamlines [49]	Czech Republic	-	-	-	-	x	-	-	-	x
PAL (PAL-XFEL)	South Korea	-	x	-	-	-	-	-	-	-
CSNS (IHEP)	China	x	-	-	-	-	-	-	-	-
Diamond [50]	UK	x	-	-	x	-	-	x	-	-
KEK (SuperKEKB, STF-2) [51]	Japan	x	x	-	-	-	-	-	-	-
SINAP (SXFEL, SHINE) [52]	China	x	-	-	-	-	-	-	-	-
KIT (FLUTE) [53]	Germany	x	x	-	x	x	-	x	-	x
CANDLE [54]	Armenia	x	-	-	x	x	-	-	-	-
Soleil	France	x	-	-	-	-	-	-	x	x
USTC (HLS-II)	China	x	x	-	-	-	-	-	-	-
HZDR (ELBE) [55]	Germany	x	-	-	-	x	-	-	-	-
ANSTO (AS) [56]	Australia	-	-	-	-	-	x	-	-	-
Elettra	Italy	-	-	-	-	-	-	x	-	-
ESRF	France	-	-	-	-	-	-	x	-	-
IMP/CAS (ADS) [57]	China	x	-	-	-	-	-	-	-	-
J-PARC [58]	Japan	x	-	-	-	-	-	-	-	-
JGU (MESA [59])	Germany	x	-	-	-	-	-	-	-	-



G. Hagmann et al.
IPAC'19 – THPRB082
"The CERN SPS Low Level RF upgrade Project"

White Rabbit eRTM 15
LO and ref. clocks distributed over RF Backplane
https://ohwr.org/project/ertm15-llrf-wr/wikis/home



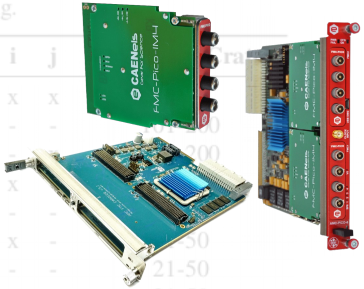
Other Diagnostics

Table 1: MTCA.4 projects on accelerator facilities (non-exhaustive list). a) LLRF, b) BPM Electronics, c) BAM Electronics, d) Beam Diagnostics (other than BPM and BAM Electronics), e) Synchronization/Timing, f) Machine Protection, g) Feedback Control, h) Image Processing, i) Experiment Control, j) Massive Data Processing.

Facility	Location	a	b	c	d
DESY (E-XFEL, FLASH) [39]	Germany	x	x	x	x
ESS [40, 41]	Sweden	x	x	-	x
ORNL (SNS) [42]	USA	x	-	-	-
GSI (FAIR) [43]	Germany	x	x	-	x
Spring-8/SACLA [44, 45]	Japan	x	x	-	x
CERN (SPS) [46]	Switzerland	x	-	-	-
FRIB [47]	USA	-	x	-	x
LNLS (Sirius) [20]	Brazil	x	x	-	-
APS-U [48]	USA	x	-	-	x
IHEP (HEPS)	China	x	-	-	-
ELI Beamlines [49]	Czech Republic	-	-	-	-
PAL (PAL-XFEL)	South Korea	-	x	-	-
CSNS (IHEP)	China	x	-	-	-
Diamond [50]	UK	x	-	-	x
KEK (SuperKEKB, STF-2) [51]	Japan	x	x	-	-
SINAP (SXFEL, SHINE) [52]	China	x	-	-	-
KIT (FLUTE) [53]	Germany	x	x	-	x
CANDLE [54]	Armenia	x	-	-	x
Soleil	France	x	-	-	-
USTC (HLS-II)	China	x	x	-	-
HZDR (ELBE) [55]	Germany	x	-	-	-
ANSTO (AS) [56]	Australia	-	-	-	-
Elettra	Italy	-	-	-	-
ESRF	France	-	-	-	-
IMP/CAS (ADS) [57]	China	x	-	-	-
J-PARC [58]	Japan	x	-	-	-
JGU (MESA [59])	Germany	x	-	-	-

Sirius, FRIB, ESS

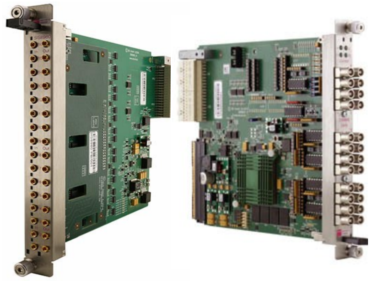
(XBPM, ion chamber, profile monitor, icBLM, GRID)



CAENels FMC-Pico-1M4
CAENels DAMC-FMC25 (FRIB, ESS)
Open Hardware AMC FMC Carrier (Sirius)

GSI

Particle Detectors - Discriminator+Scaler



Struck SIS8800 Struck SIS8980

Possible applications on Diagnostics

- RF Diagnostics
- XBPM
- Ion chambers
- DCCT / ACCT / ICT / FCT
- Filling Pattern Monitor
- Screen Monitors
- Wire-scanners
- Slits / Scrapers / Collimators (Motor-based)
- Laser Synch./Modulation (Piezo-based)
- Faraday Cup
- Bunch Purity Monitor
- Particle Detectors

ELI-Beamlines

Fast Digitizer (10 GS/s – 14-bit)

Teledyne SP Devices
ADQ7-DC-F10-MTCA

Image Processing

Table 1: MTCA.4 projects on accelerator facilities (non-exhaustive list). a) LLRF, b) BPM Electronics, c) BAM Electronics, d) Beam Diagnostics (other than BPM and BAM Electronics), e) Synchronization/Timing, f) Machine Protection, g) Feedback Control, h) Image Processing, i) Experiment Control, j) Massive Data Processing.

Facility	Location	a	b	c	d	e	f	g	h	i	j	Number of Crates
DESY (E-XFEL, FLASH) [39]	Germany	x	x	x	x	x	x	x	x	x	x	200+
ESS [40, 41]	Sweden	x	x	-	x	x	x	-	-	-	-	101-200
ORNL (SNS) [42]	USA	x	-	-	-	-	x	x	-	-	x	101-200
GSI (FAIR) [43]	Germany	x	x	-	x	x	-	x	x	x	-	51-100
Spring-8/SACLA [44, 45]	Japan	x	x	-	x	x	-	x	-	-	-	51-100
CERN (SPS) [46]	Switzerland	x	-	-	-	x	-	x	-	x	-	21-50
FRIB [47]	USA	-	x	-	x	x	x	-	-	-	-	21-50
LNLS (Sirius) [20]	Brazil	x	x	-	-	x	-	x	-	-	-	21-50
APS-U [48]	USA	x	-	-	x	-	-	x	-	-	-	21-50
IHEP (HEPS)	China	x	-	-	-	x	x	-	-	-	-	21-50
ELI Beamlines [49]	Czech Republic	-	-	-	-	x	-	-	-	x	-	21-50
PAL (PAL-XFEL)	South Korea	-	x	-	-	-	-	-	-	-	-	21-50
CSNS (IHEP)	China	x	-	-	-	-	-	-	-	-	-	11-20
Diamond [50]	UK	x	-	-	x	-	-	x	-	-	-	6-10
KEK (SuperKEKB, STF-2) [51]	Japan	x	x	-	-	-	-	-	-	-	-	6-10
SINAP (SXFEL, SHINE) [52]	China	x	-	-	-	-	-	-	-	-	-	6-10
KIT (FLUTE) [53]	Germany	x	x	-	x	x	-	x	-	x	-	1-5
CANDLE [54]	Armenia	x	-	-	x	x	-	-	-	-	-	1-5
Soleil	France	x	-	-	-	-	-	-	x	x	-	1-5
USTC (HLS-II)	China	x	x	-	-	-	-	-	-	-	-	1-5
HZDR (ELBE) [55]	Germany	x	-	-	-	x	-	-	-	-	-	1-5
ANSTO (AS) [56]	Australia	-	-	-	-	-	x	-	-	-	-	1-5
Elettra	Italy	-	-	-	-	-	-	x	-	-	-	1-5
ESRF	France	-	-	-	-	-	-	x	-	-	-	1-5
IMP/CAS (ADS) [57]	China	x	-	-	-	-	-	-	-	-	-	1-5
J-PARC [58]	Japan	x	-	-	-	-	-	-	-	-	-	1-5
JGU (MESA [59])	Germany	x	-	-	-	-	-	-	-	-	-	1-5

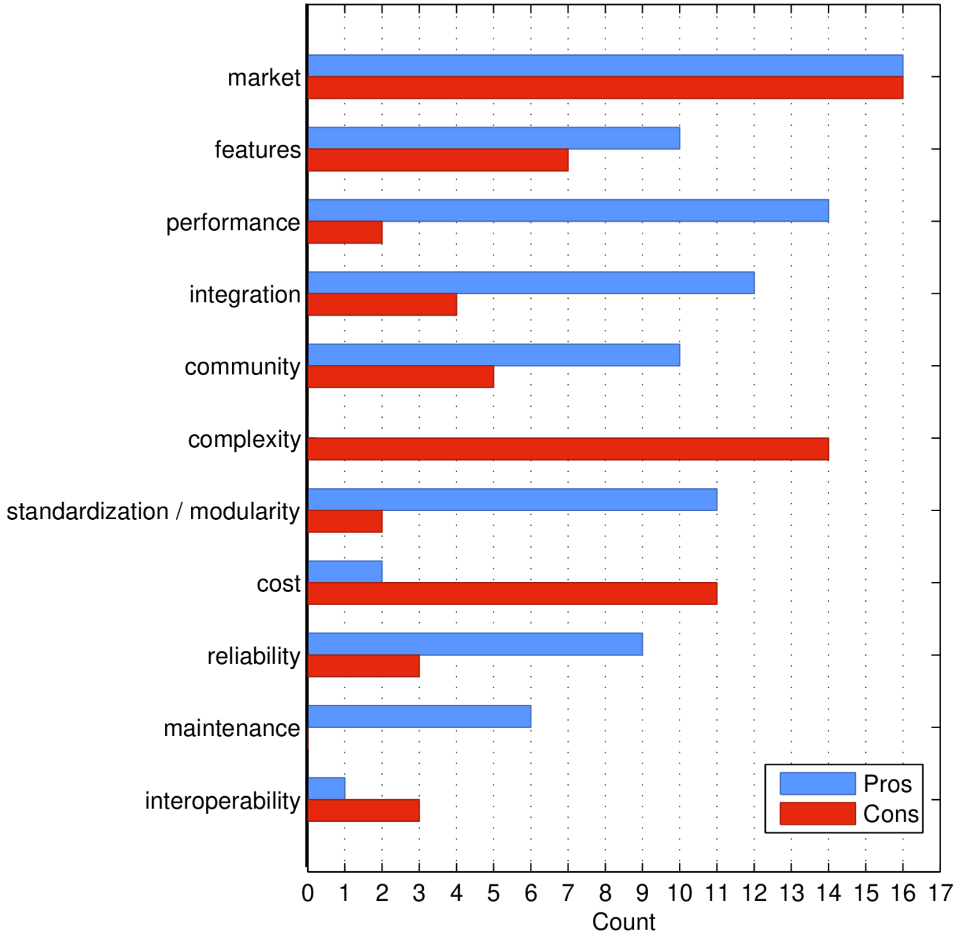
- **Today:**
  - **Processing on CPUs**
    - DESY (E-XFEL)
    - GSI (FAIR)
    - Spring-8 – MicroTCA.0
    - Soleil (planning)
  - MTCA TechLab (DESY) R&D on GigE Vision
- **Future:**
  - Image processing on AMC FPGA
  - Process at >100 fps
  - Opens up possibilities for fast coupling and beam size control

Survey

What are the perceived ***strengths*** *of MicroTCA.4 for your use cases?* (pros)

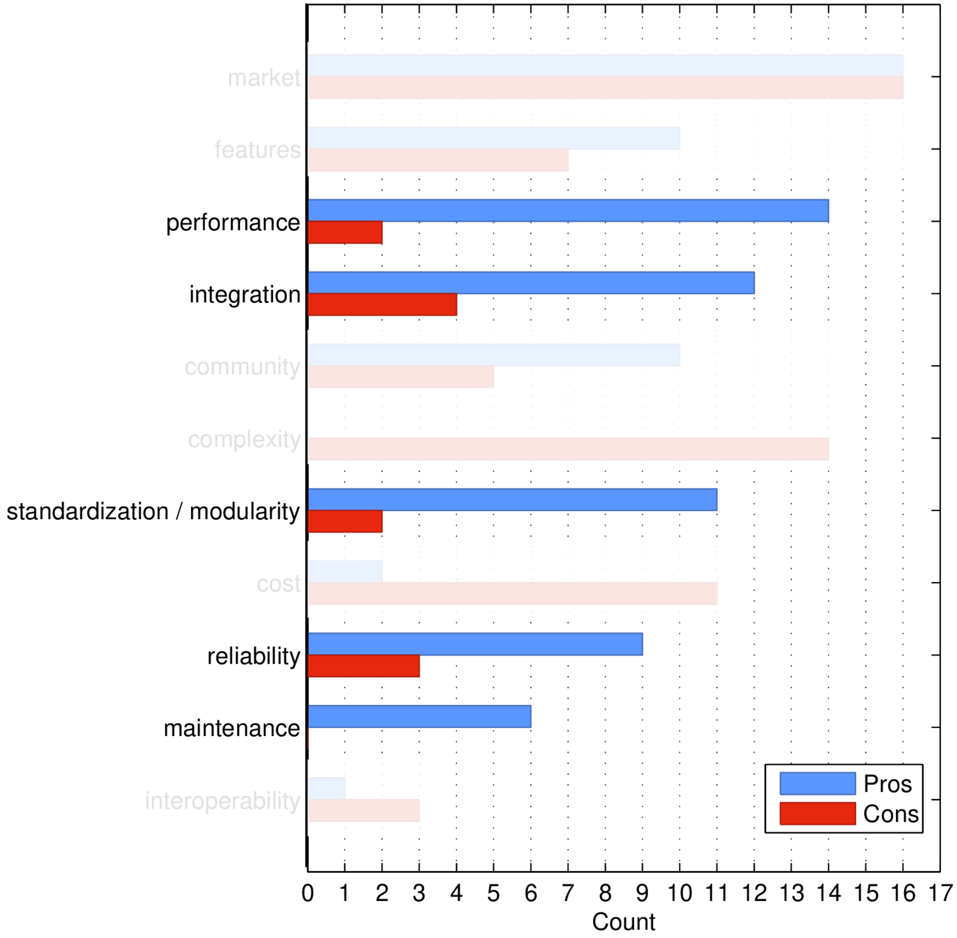
What are the perceived ***downsides*** *and* ***flaws*** *of the MicroTCA.4 standard and "ecosystem"?* (cons)

Survey results – pros and cons



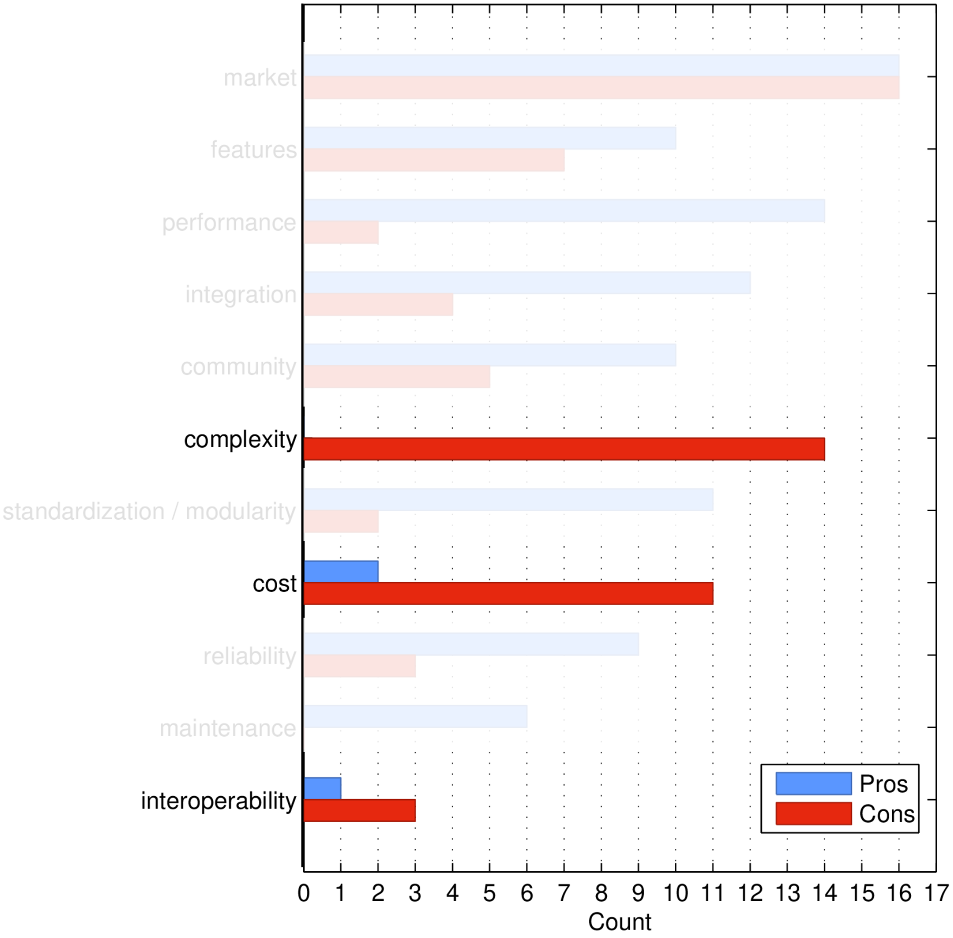
- **27** facilities have replied (including Sirius)
- **159** mentions of strengths, downsides or flaws of MicroTCA.4
  - **92** pros
  - **67** cons
- **3** respondents: no downsides or flaws at all

Survey results – mostly pros



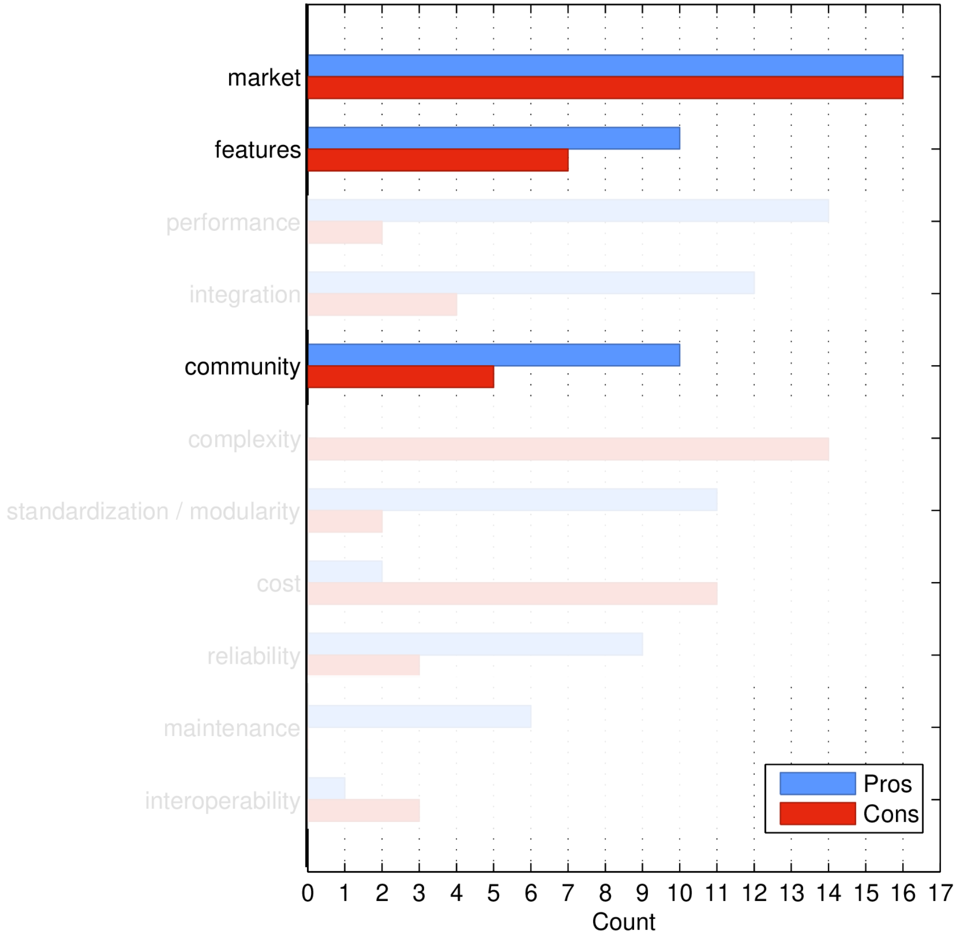
- **Performance**
  - high data bandwidth
  - high processing power
  - good analog signal quality
  - **Bad:** PCIe bandwidth (for high density camera aggregation), JSM
- **Integration**
  - High channel density, high compactness, useful services in the crate (CPU, timing, analog I/O, network, RF infrastructure)
  - **Bad:** lack of unified gateware/software frameworks
- **Standardization**
  - Well defined standard, good modularity choices
  - **Bad:** standard still in evolution
- **Reliability**
  - In general users report high MTBF
  - **Bad:** some has problems on system reset and failover
- **Maintenance**
  - Remote hardware management capabilities, hot swap and serviceability are great

Survey results – mostly cons



- **Complexity**
  - Steep learning curve
  - Low-level FPGA programming as entry point
  - IPMI implementations (MMC and MCMC)
- **Cost**
  - Too high (11 replies)
    - Remark: too high for sparsely populated crates (1 reply)
  - **Good:** cost per channel is good (2 replies)
- **Interoperability**
  - Interoperability among different vendors
  - **Good:** interoperability is good (1 reply)

Survey results – mixed opinions



- **Market**
  - Good and Bad:
    - Market size / number of suppliers
    - Products quality and diversity
    - Technical support and documentation
    - Long-term market (sustainability)
- **Features**
  - **Good:**
    - RTM, Fat pipes, RF backplane, Point-to-point links, e-keying
  - **Bad:**
    - Mechanical insertion and removal of modules
    - Lack of star or mesh backplane topologies
    - PCB sizes
- **Community**
  - **Good:**
    - Satisfied with the fact that many laboratories adopting MicroTCA.4
    - Expectations of collaboration and design reuse
  - **Bad:**
    - Lack of open source solutions (4 replies)
    - High and harmful diversity of MMC projects (1 reply)

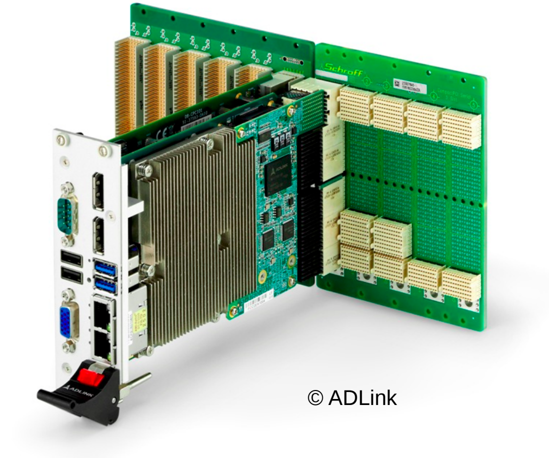
“Competitor” standards

- **ATCA**
  - Acceleratos: SLAC
  - Fusion: ITER, IPFN
  - Several HEP Experiments
  - CMS (LHC) moved from MTCA to ATCA for more real estate on the PCB and more power.

- **Out of scope:** VME, openVPX, cPCI, PXIe, NI cRIO and Single Board Computers (SBC), etc.

ATCA

CompactPCI



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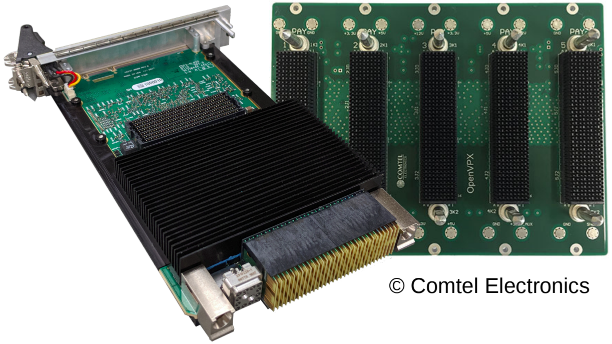
OpenVPX



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PXIe

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“Competitor” paradigm

- **Network-attached devices (NAD)** (or standalone or “pizza box”)
- Standards (e.g. Ethernet, FMC, mechanics)

BNL zDFE

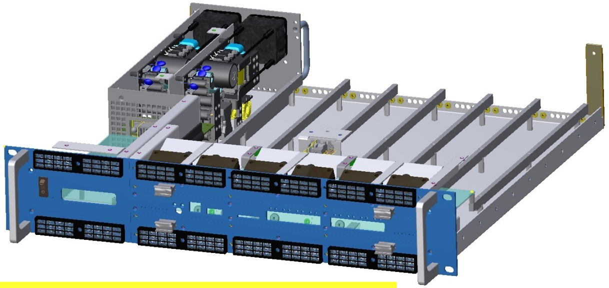
D. Padrazo et al. FLS’18

Elettra BPM Platform
Dual FMC carrier (HPC, LPC)

G. Brajnik et al. IBIC’19 – TUPP003

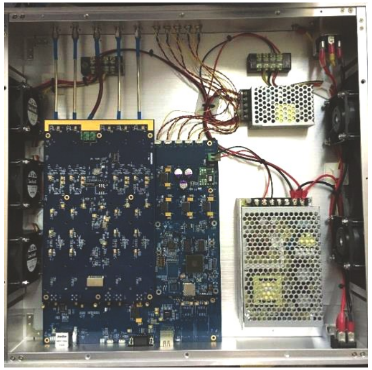
Non-exhaustive listing:

PSI DBPM3 Platform



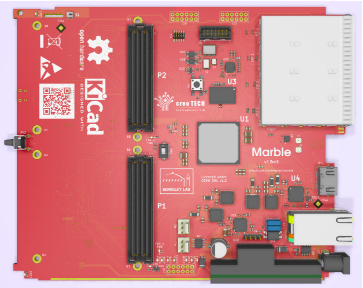
B. Keil ARIES workshop – Nov/2018

SINAP DBPM Platform



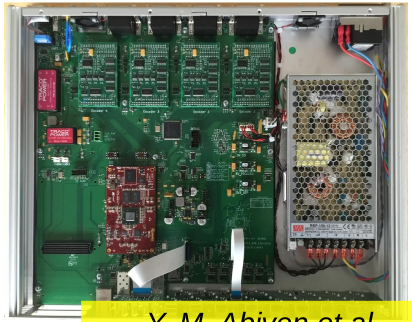
Y. Leng et al. FLS’18

LBNL Marble
may be mounted as an AMC dual FMC carrier



L. Doolittle et al.
https://github.com/BerkeleyLab/Marble

Soleil / Diamond PandaBox
FMC carrier / targets experiment control



Y. M. Abiven et al. ICALEPCS’17 - TUAPL05

Topics for discussion

- The community is mostly happy with:
  - Performance
  - Integration
  - Maintenance capabilities
  - Standard quality
  - Reliability

- The main MicroTCA.4 issues, as seen by the community, are:
  - **Complexity**
  - **Cost**
  - **Market of COTS products**
  - **Community**
  - **Interoperability**

- How to solve the issues?

Topics for discussion

- **Cost and Market**
  - Some few classes of modules have a great diversity of designs (AMC FMC carriers, AMC CPUs, AMC Timing Receivers), all others have often only 1 or 2 suppliers → high price risk
  - At LNLS we support the open hardware approach
    - Designs owned by the lab – manufacturing and support by the companies with no exclusivity
    - Mixing of open and non-open hardware modules

- **Community**
  - *“This community should organize a forum/wiki/documentation website”* – Tobias Hoffmann (GSI)

- **Interoperability**
  - *“I think the MMC part is the key. MTCA realizes the complicated functions (redundancy, hot-swap, etc) with the MMC. If MMC design becomes common, more companies in Japan will produce AMCs.”* – Fumihiko Tamura (J-PARC)
  - There are many MMC implementations around – couldn’t we converge to an open source solution?

- **Complexity**
  - Need more “starting kits” for getting boards working out of the box, e.g.: Diamond MBF documentation

Acknowledgment

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- Zeran Zhou and Gongfa Liu (USTC)
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- Yuhui Guo (IMP/CAS)
- Scott Cogan (FRIB)
- Hirokazu Maesaka (Spring-8)
- Tetsuya Kobayashi (KEK)
- Eric Breeding, Doug Curry and Karen White (ORNL)
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Thank you!

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Brazilian Center for Research in Energy and Materials

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