HansMuller@cern.ch

SRS scalable readout system
Status and Outlook

Hans.Muller@cern.ch

HansMuller@cern.ch

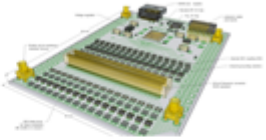
SRS corner stones

- **Complete RO system from detector to Online software**
- **Conceived independent of detector type**
- **scalable, very small to very large system with same HW and SW**
- **no buses, low cost, highly immune to single point failures**
- **cheap power from ATX standard**
- **data and trigger path within same HW architecture**
- **open system for both HW and SW**
- **Crate implementation 19" Eurochassis standard IEC 60297-3-101**
- **2012 SRS production and distribution via CERN store**
-

SRS User Status

CERN experiments

- ATLAS CSC upgrade MMegas (5kCH- APV -SRS systems for testbeams delivered, MMDAQ)
- ATLAS CSC upgrade Mmegas, (BNL chip readout via SRS, SRS Adapter by Arizona Univ under test)
- ALICE EMCaL , SRU-based readout backend (25 SRU for ALICE EMCaL upgrade, ongoing collaboration)
- NA62 ref. tracker with Micro-Megas (1kCH-SRS Minicrate delivered, MMDAQ)
- CMS high Eta, VFAT hybrid and VFAT SRS adapter design started, manpower needed



APV hybrid 128ch

HEP experiments

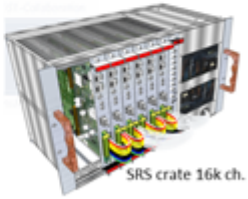
- NEXT Coll., dual Beta decay, SiPM, PM (Coll. on SRS hardware, FEC cards delivd, DATE)
- BUDKER,INP,Deuteron,triple-GEM (postponed, radhard embargo)
- BNL GEM detector readout (2kCH. APV Minicrate delvd. PHENIX DAQ port to SRS)
- Jeff. Lab Virginia Univ. GEM prototyping, 1kCh APV Minicrate delivered, DATE (Kondo)

Applications with Cosmic Tomography

- FIT Florida, Muon Tompography for homeland security, GEMs (16 kCh full SRS Crate delivered, DATE)
- Geoscienes CRNS- Waterquality, MMegas (5kCh SRS Crate delivered, DATE , Labview)

R&D with MPGD's (small systems)

- Tsinghua Univ, GEM Imaging (postponed radhard embargo)
- Bonn/Mainz Univ, Timepix readout (starting Nov. 2011 , 1 FEC /ADC combo)
- Helsinki HIP, GEM-MMega eval. (2kCh SRS Crate delivered)
- MEXICO UNAM, THGEM (500ch SRS Minicrate delivered , DATE)
- C.E. Saclay, Micromegas (2k Ch SRS Minicrate delivered, MMDAQ)



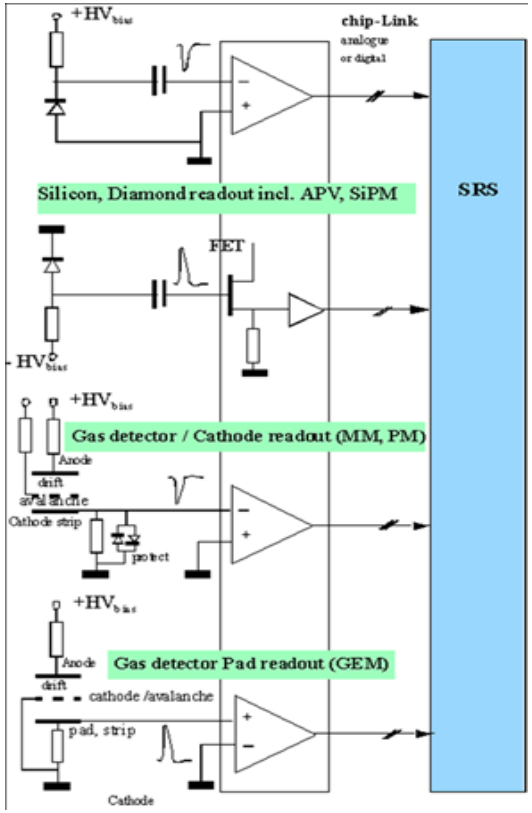
SRS crate 16k ch.

New orders (commercial SRS)*

- RD51 lab, WIS, USTC, SAHA, INFN Bari, INFN Napoli, Radcore, Stony Brook, UPV Valencia, ATLAs upgrade + more

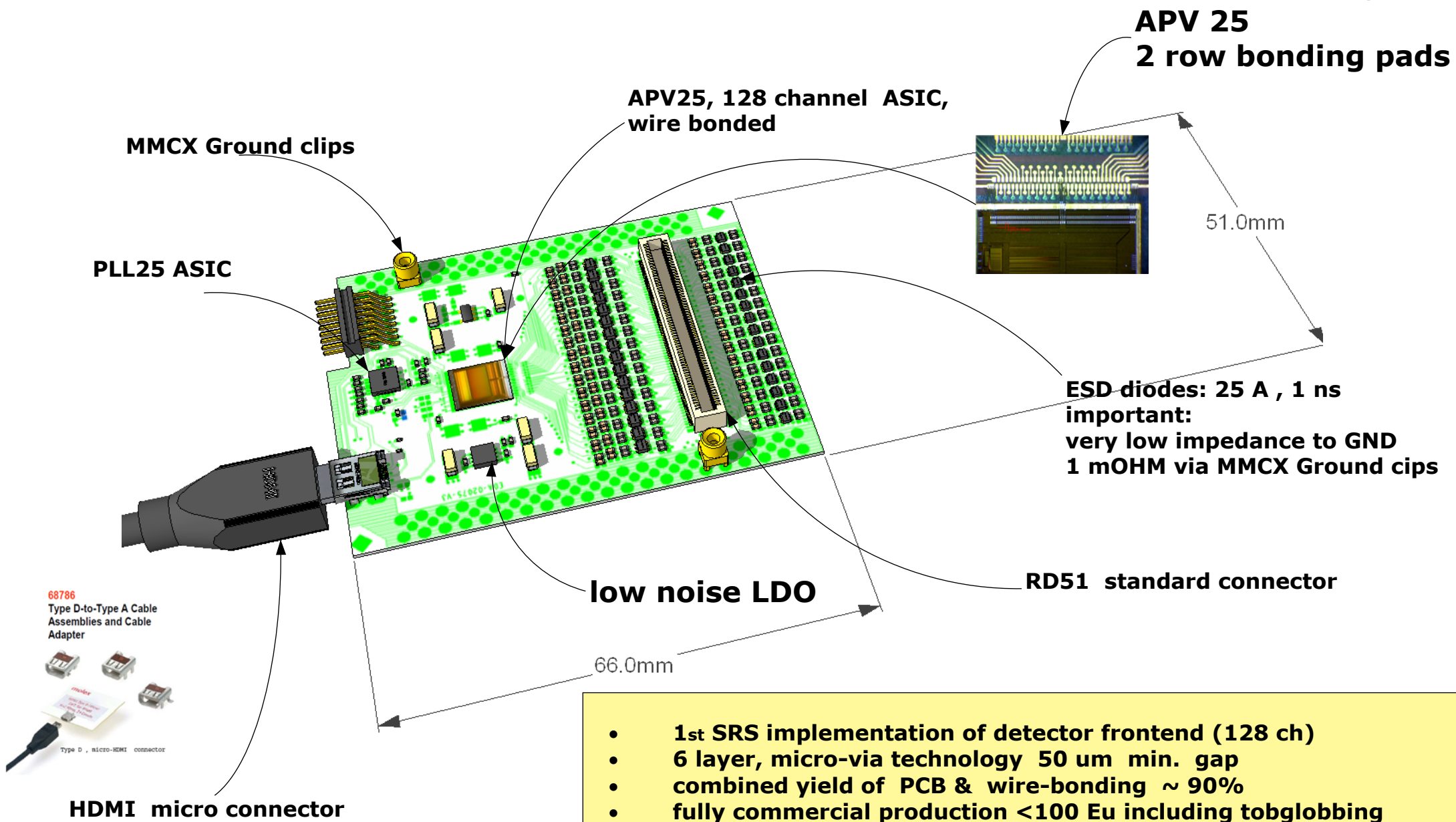
* **SRS Production 2012 (commercial):** PRISMA, Alexandoupulis Gr, sales via CERN store, CERN contract KTT in prep.
250 Ch SRS Minicrate delivd. as Ref. System, Labview*

Different detector types



HansMuller@cern.ch

APV -25 hybrid carrier for Gas detectors

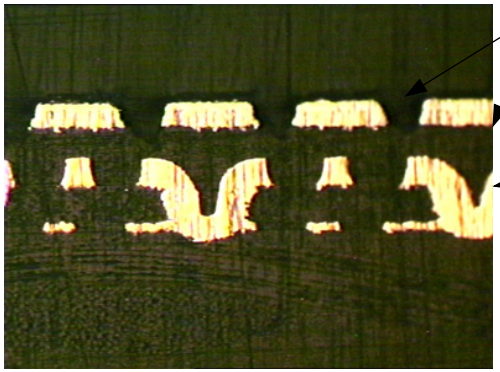


- 1st SRS implementation of detector frontend (128 ch)
- 6 layer, micro-via technology 50 um min. gap
- combined yield of PCB & wire-bonding ~ 90%
- fully commercial production <100 Eu including tobglobbing
- powered via HDMI cable (180 mA per hybrid)
- master-slave design for 256 ch over single HDMI cable

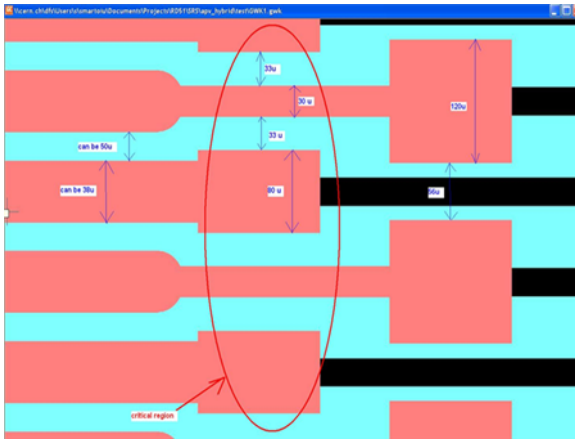
HansMuller@cern.ch

Hybrid technology by ELTOS

Cross section through layers



Bonding pads



Multi layer microvia- ENIG coating

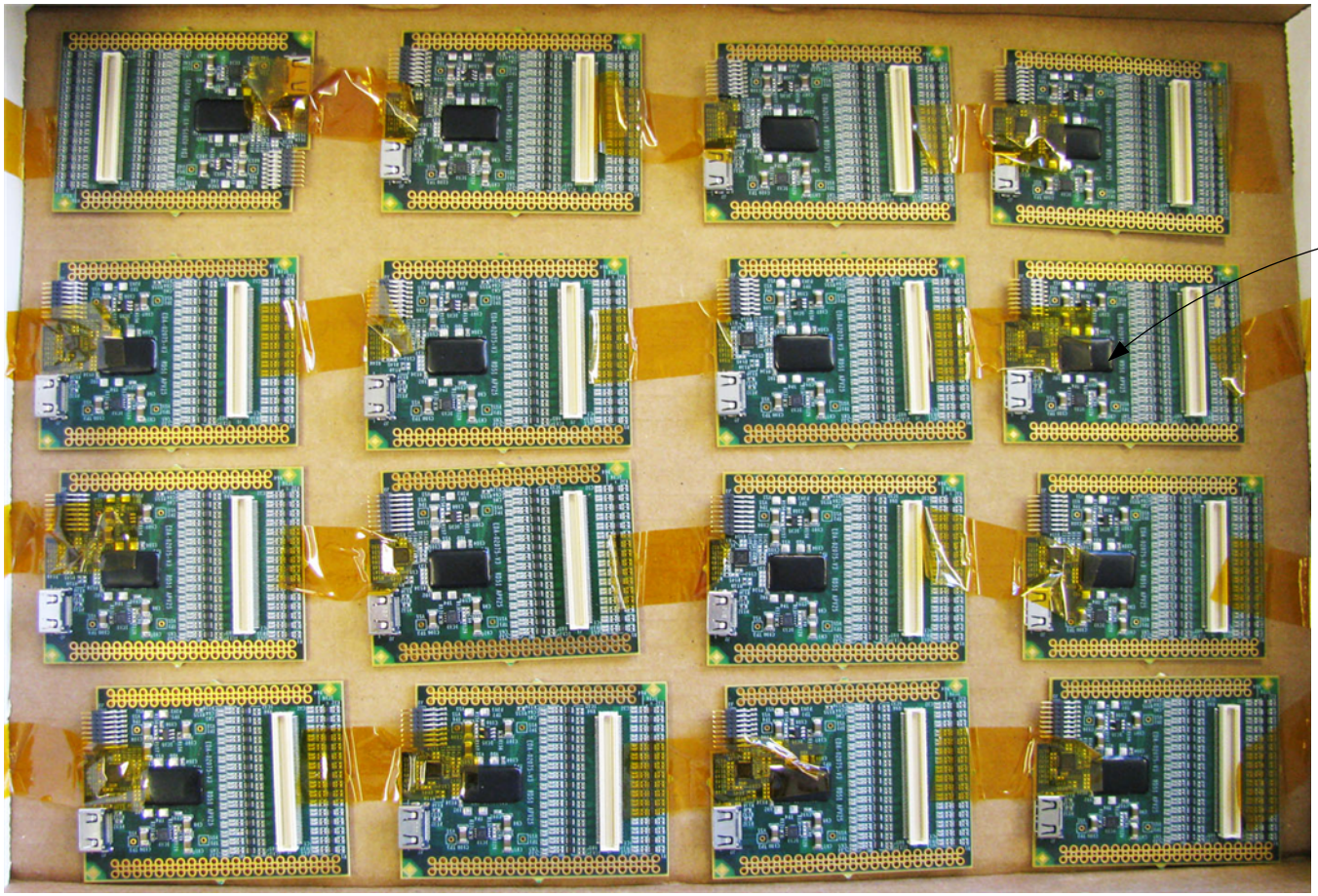
	W / S		Required		Build-up
A	60/45µ		Cu 12µ + plating		12
			50		1*106
2	60/45µ		Cu 12µ + plating		12
			50		1*106
3	60/45µ		Cu 12µ		12
			800µ		800
4			Cu 12µ		12
			50		1*106
5			Cu 12µ + plating		12
			50		1*106
P	90/100µ		Cu 12µ + plating		12
Final T			1,0 mm		

Final design of V4 hybrid on EDMS:

https://edms.cern.ch/nav/P:EDA-02075:V0/I:EDA-02075-V4-0:V0/TAB4

SRS Hybrid Production fully commercial

HansMuller@cern.ch

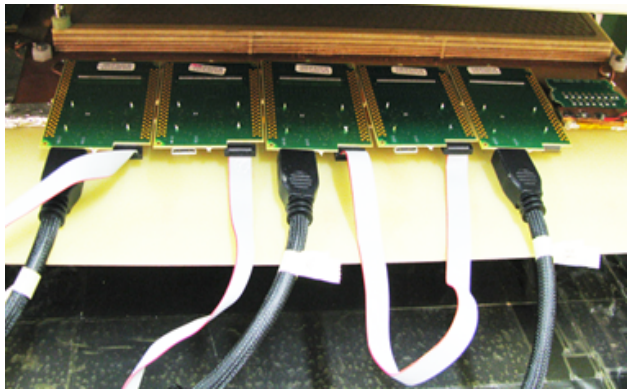


Hybrid S.A production

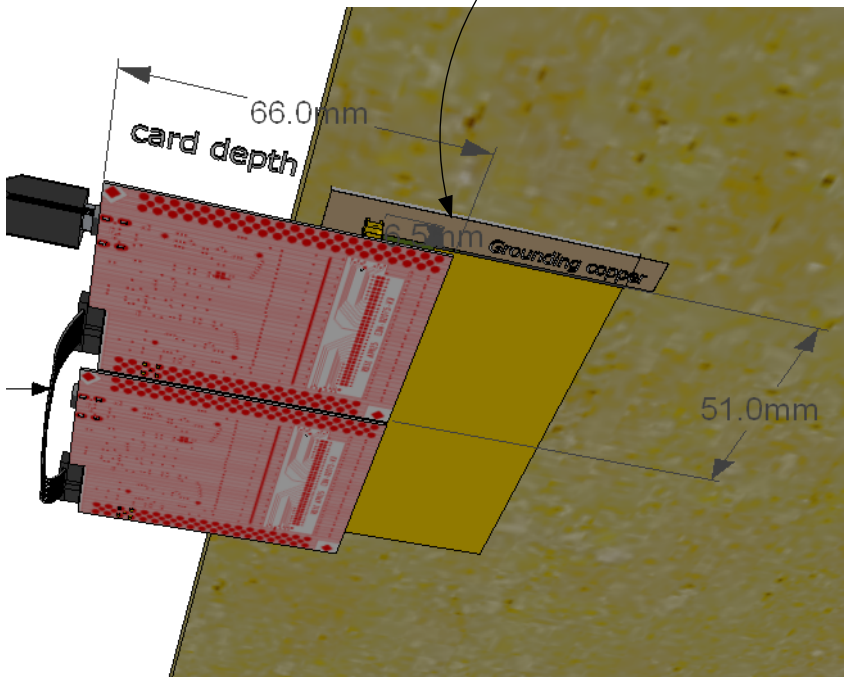
- **Proto Versions 1&2 produced at CERN, PCB & wire bonding, several iterations**
- **very few replies to international call for high-tech PCB**
- **Hybrid V3: 100% produced by industry : ELTOS (IT) and HYBRID S.A. (CH)**
- **Material & chips for 320 hybrids, 280 working ones received**
- **~ 90 % production yield**
- **Hybrid V4: production (500)started in Nov 2011 by CERN store**

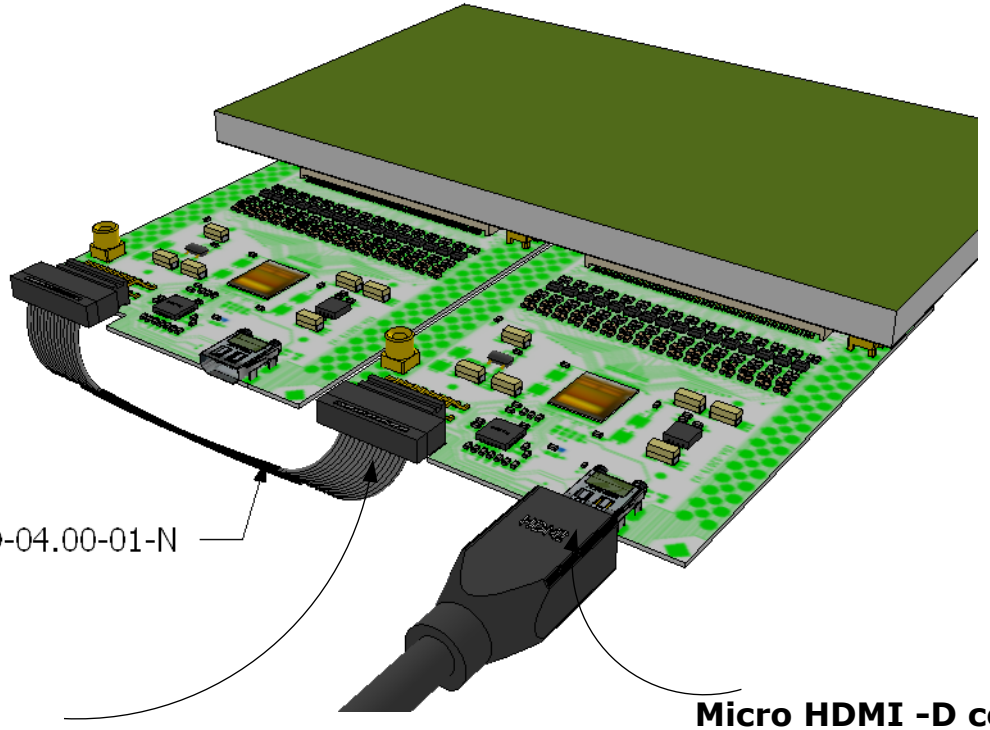
HansMuller@cern.ch

Detector Geometry



Detector bottom side



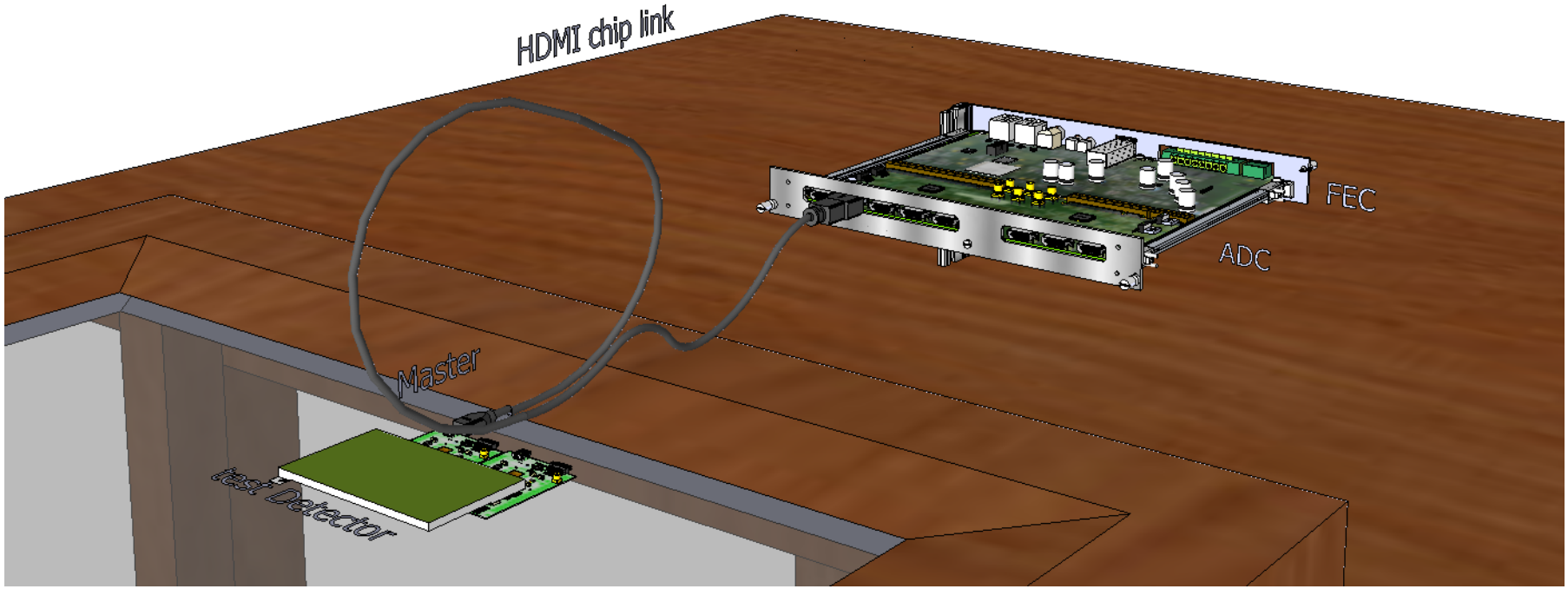


Master-Slave cable

Micro HDMI -D connector

HansMuller@cern.ch

Minimal table-top SRS electronics

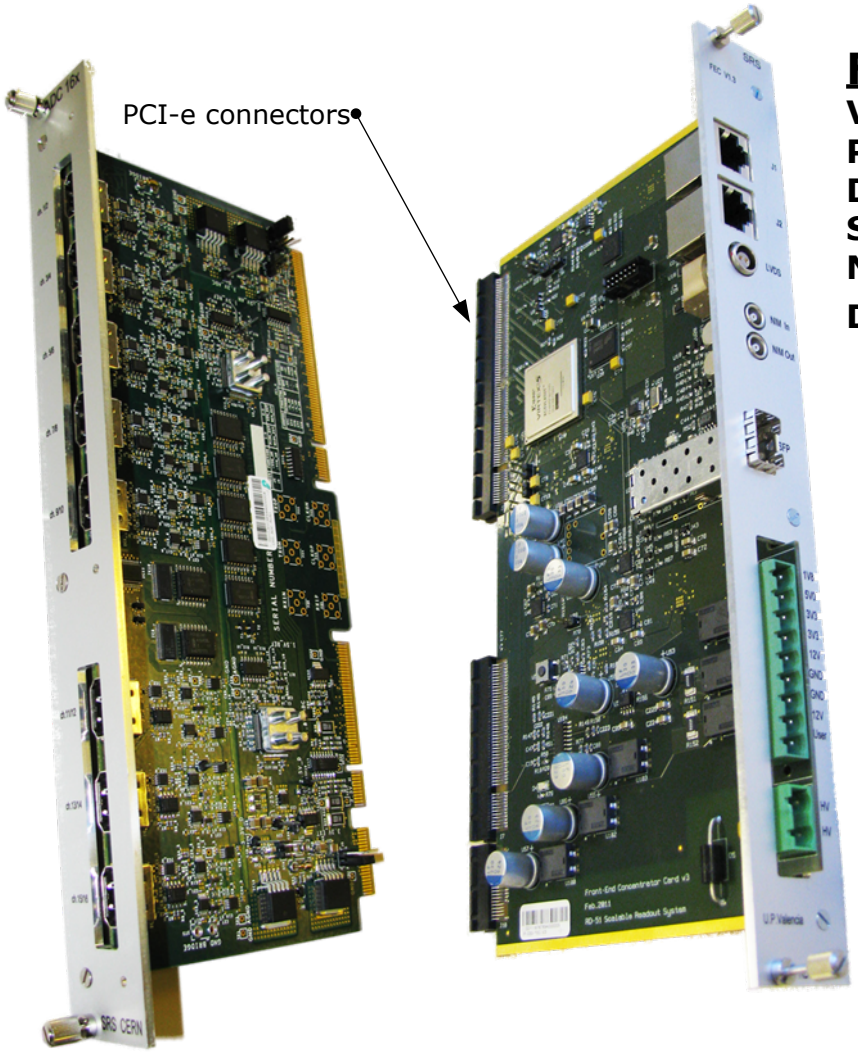


- Entry system for 128 channels upgradable to 2048 ch
- 1 FEC / ADC combo directly read out via Ethernet to Laptop
- up to 8 HDMI links / card
- one HDMI link for one or two detector hybrids
- Hybrid powered via HDMI cable

FEC and ADC Combo

standard for APV or Beetle frontend

HansMuller@cern.ch



FEC card :

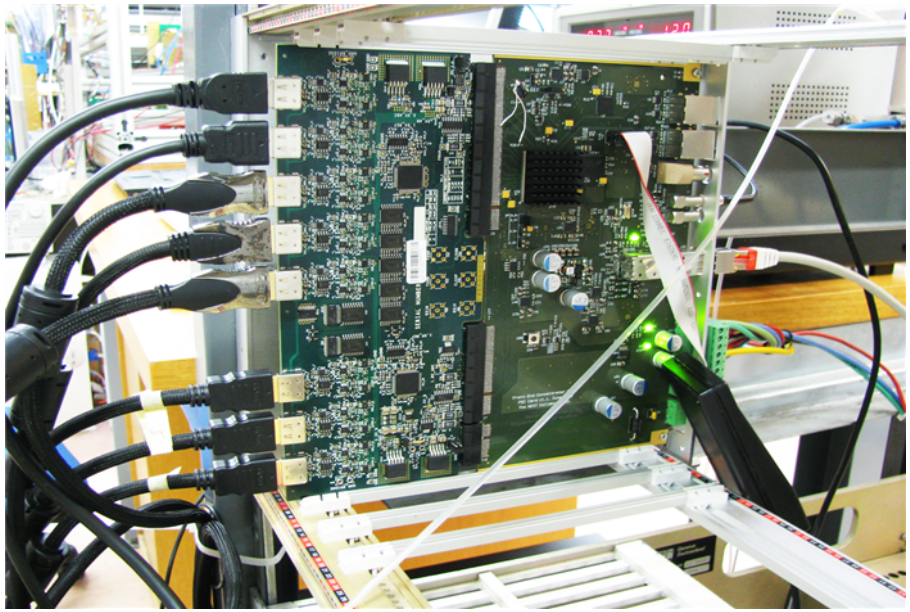
V5 FPGA
PCIe I/O to adapter cards
DDR2 buffer
SFP output
NIM and LVDS pulse I/O
DTC link (SRU)

32 Combos produced 2010/11
all in use in different fields

ADC card:

8 HDMI -A connectors
can power/readout 16 APV hybrids
16 ADC channels 40 MHz

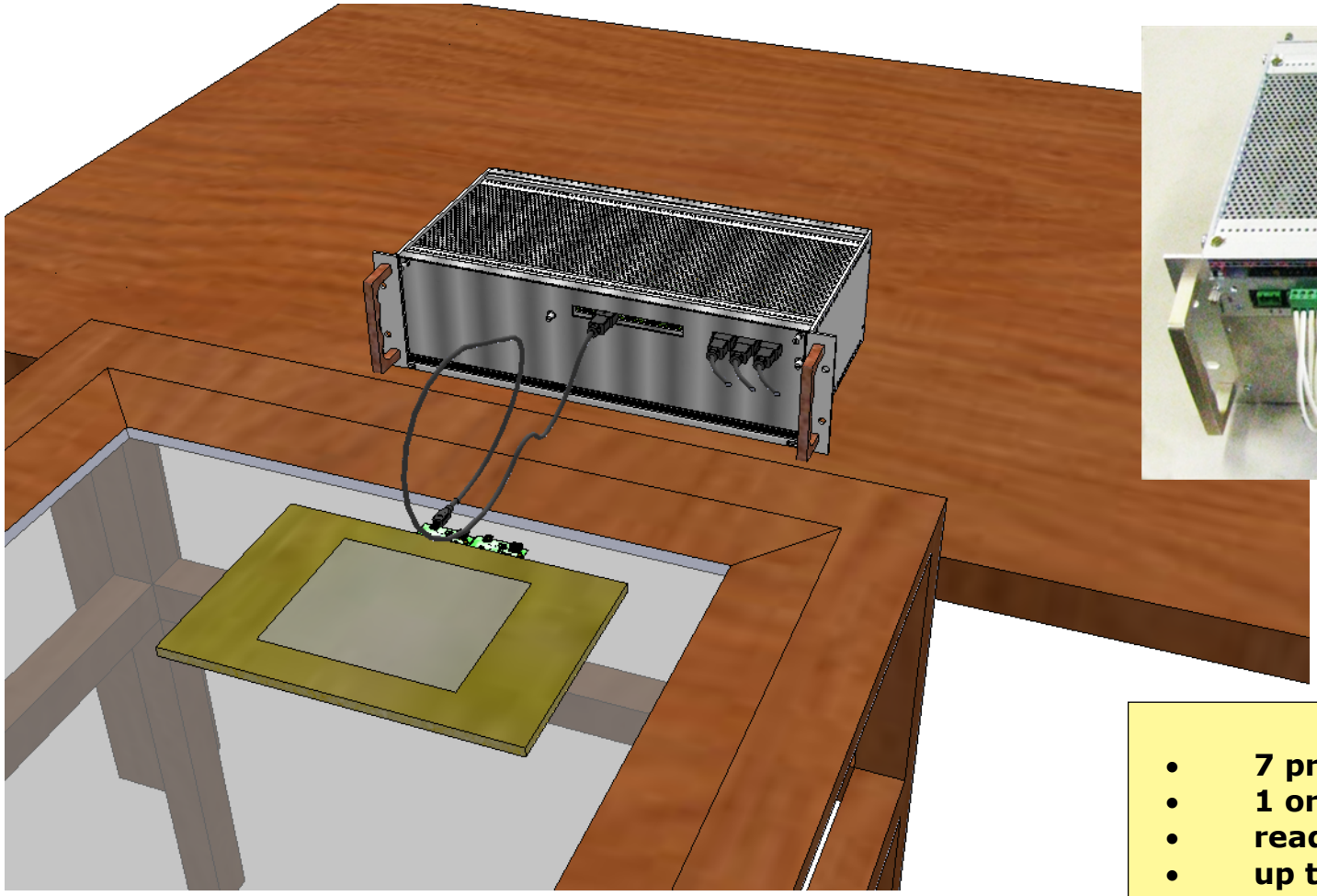
Photo of FEC/ADC combo with 8 connected HDMI links to 16 hybrids



SRS Minicrate, a Portable (5kg) table top:

powered 3U-Crate for up 4096 channels

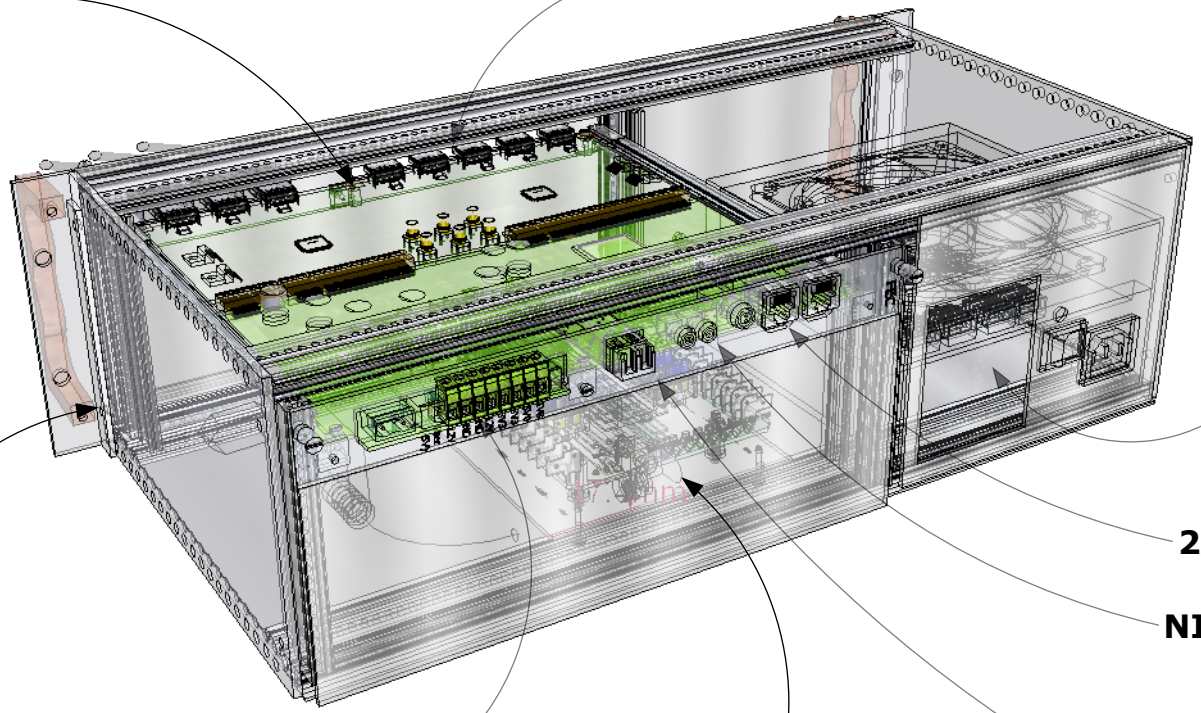
HansMuller@cern.ch



- 7 produced and distributed in 2011
- 1 or 2 powered FEC / ADC combos
- readout via Ethernet to Laptop
- up to 32 hybrids (4096 channels)

HansMuller@cern.ch

X-Ray view of Minicrate



FEC / ADC card combo

Chiplink (HDMI -A connectors)

ATX power supply 500W

2x RJ45, DTC and STF link

NIM trigger interface

SFP plug (Ethernet)

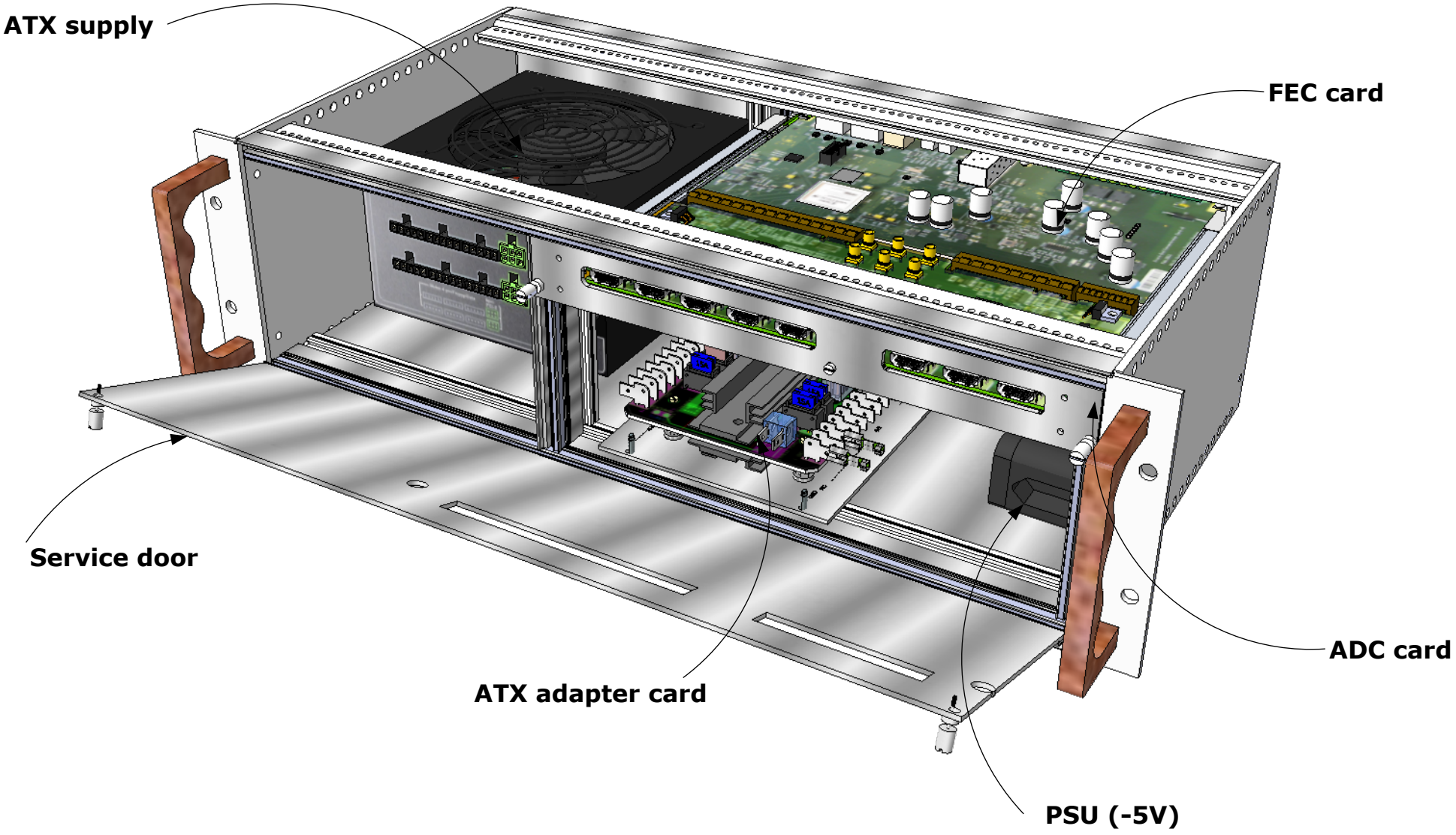
Adapter electronics card for SRS

9-way power connector

3U x 220 Minicrate

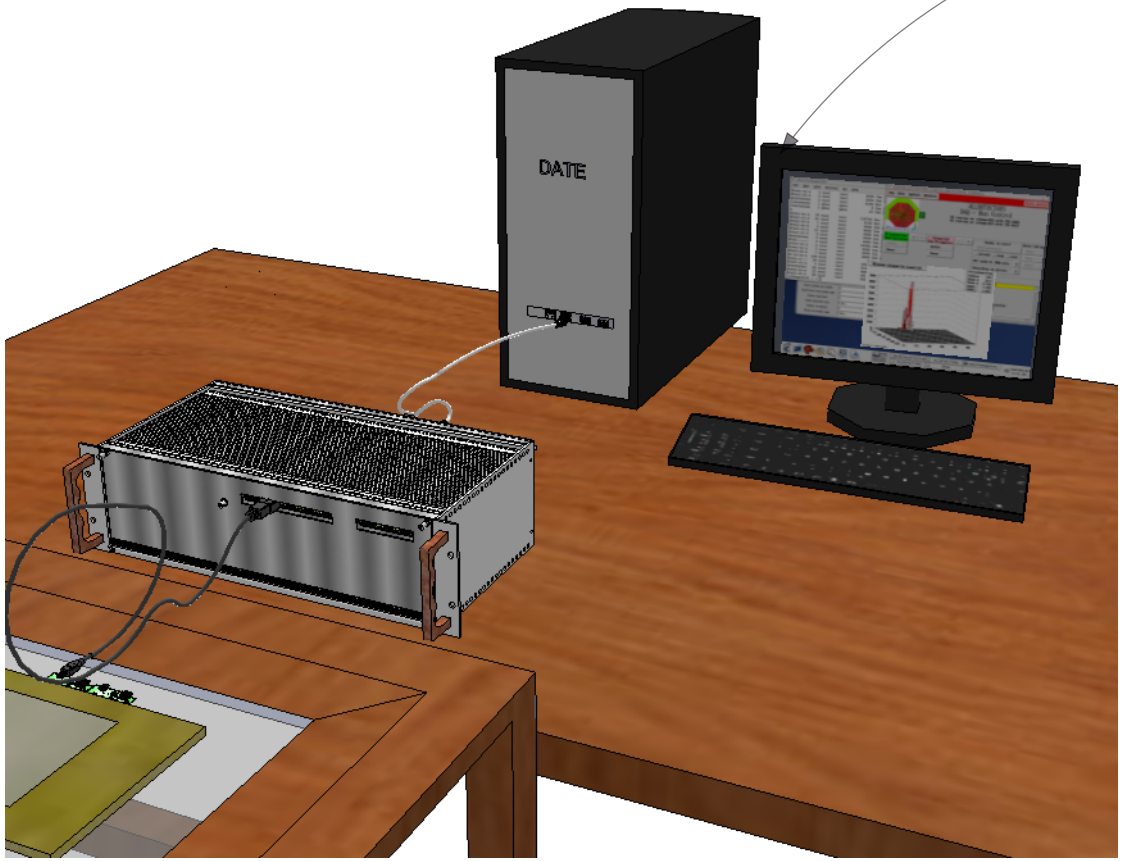
HansMuller@cern.ch

Service door Minicrate



SRS tabletop readout system*

HansMuller@cern.ch



Online HW can be PC or Laptop

1 GBit network card with 9kB Jumno packet support needed

Online Software options

- **DATE (Linux SCL5) +Root/Amore**
- **MMDAQ (Linux SCL5) + Root**
- **Labview (Windows 7)**
- **more coming**

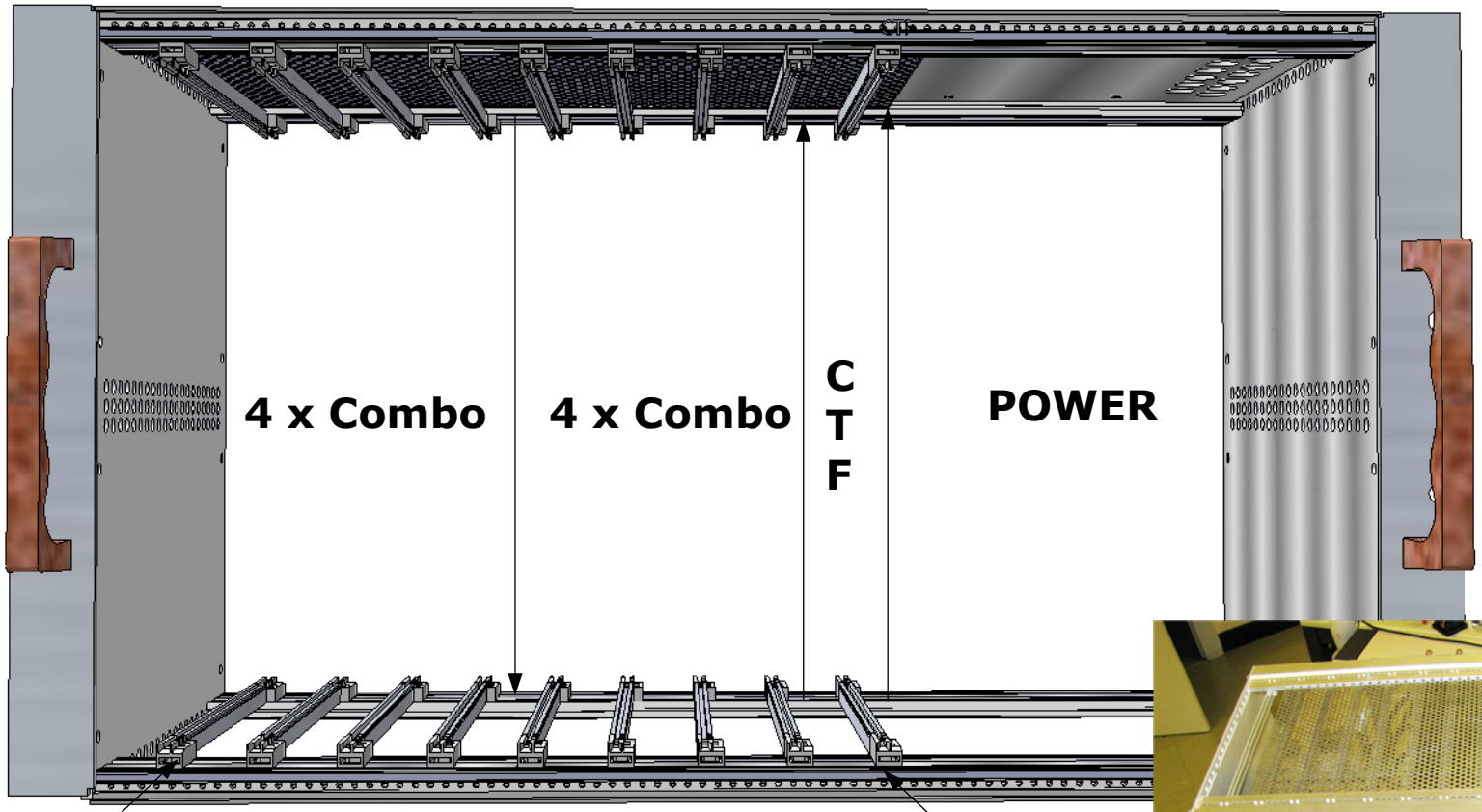
Slow controls (via ethernet):

- **SDC scalable detector controls**

*** Entry cost without PC - O(4 kEu) for 512 ch system**

HansMuller@cern.ch

Eurocrate 6U x 220



SRS power requirement

HansMuller@cern.ch

1.1 SRS Voltages for the 9-way FEC connector

SRS Combos, and optionally also the detector-resident hybrids get powered via SRS ATX adapter though a horizontal, 9-way power bus cable. The power cable bus consists of nine 2.5mm^2 flexible wires which are chained -connected by 9-way 12A connectors[3] that plug to the frontside of the FEC cards.

Figure 2
Color-coded power bus cable for 4 Combos , daisy chain connected to 9way Phoenix TMSTB power connectors All cables have 2.5mm^2 crossection.

The SRS voltage 1V8 is derived from the ATX 3V3 using 2 cooled power diodes on the ATX adapter[4]. The negative -5V (SRS User Voltage) is provided by a separate PSU supply.

The SRS supply voltages for up to 4 SRS Combos from top to bottom on the 9-way TMST connector:

- 1V8 generated by 2 cooled power diodes on ATX adapter from the 3V3 ATX, fused 15 A
- 5V0 directly from the 5V0 ATX, fused 15A
- 3V3 directly from the 3V3 ATX, fused 15 A
- 3V3 ‘ ‘ ‘ ‘
- +12V directly from +12V ATX, fused 2 A
- GND-A
- GND-B
- -12V directly from ATX, fused 2 A
- -5V0 (USER) directly from PSU, fused by PSU

Power figures SRS Crates based on case study with FEC_V3 + ADC_1.1 + APV_hybrid V3

Table 3 ATX Power supply current for 4 FEC/ADC Combos and a total of 64 hybrids

ATX PS output	current [A] of 4 Combos/hybrids	Power [W]
3V3 (includes 1V8)	**18 A**	60
5V0	**6 A**	30
+12	**0.08 A**	2.4
-12	**0.12 A**	3

- A single APV hybrid consumes 0.18 A from the supply line (3V3)
- The resistance of a typical HDMI 3m cable is of Order (0.6 OHM) [see chapt 1.7] combined for GND and VCC, hence a cable which powers two hybrids (master and slave) dissipates 0.1 Watt.
- One 2048 channel FEC/ADC Combo with all 16 APC hybrid consumes ~24.4 W of which 9 W are consumed by 16 APV hybrids and ~1 Watt by 8 HDMI cables .
- The equivalent power consumption per APV channel is 4.9 mW or 0.63W per hybrid (128 channels).
- The return Ground per fully loaded Combo is 6.5 A , adding up to 26 A on 4 Units in a Eurocrate (13 A per GND wire).
- Four fully loaded Combos units consume a total of 95 W from the combined 5V0 and 3V3 ATX power lines. The maximum combined power for “450Watt supplies” is 100-120 Watt.

We conclude a general rule:

One 450 W ATX supply is sufficient to power 4 fully loaded SRS Combo units and their frontend chips

Eight fully loaded Combos require two ATX supplies of 450 W min. each

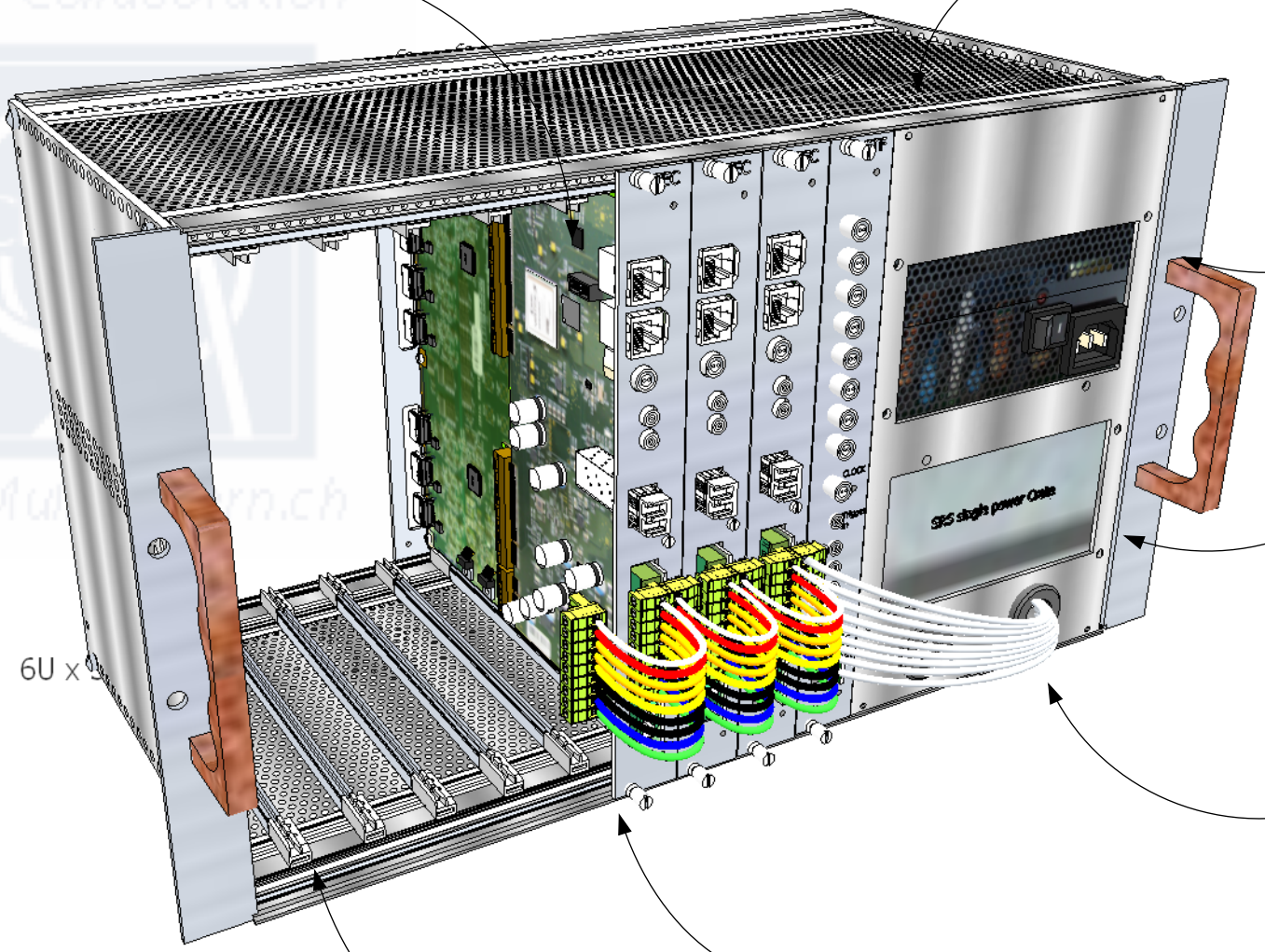
These two rules have led to the decision to classify and design SRS Eurocrates in two different flavors, half power with 1 ATX supply and and full power with 2 ATX supplies.

a.) half-power Eurocrates for up to 4 fully loaded Combos with 64 hybrids (128 ch each) powered via 32 HDMI cables. Hence half-power Eurocrate system covers up to 8192 channels.

b.) full power Eurocrates for up to 8 fully loaded Combos with 128 hybrids powered via 64 HDMI cables

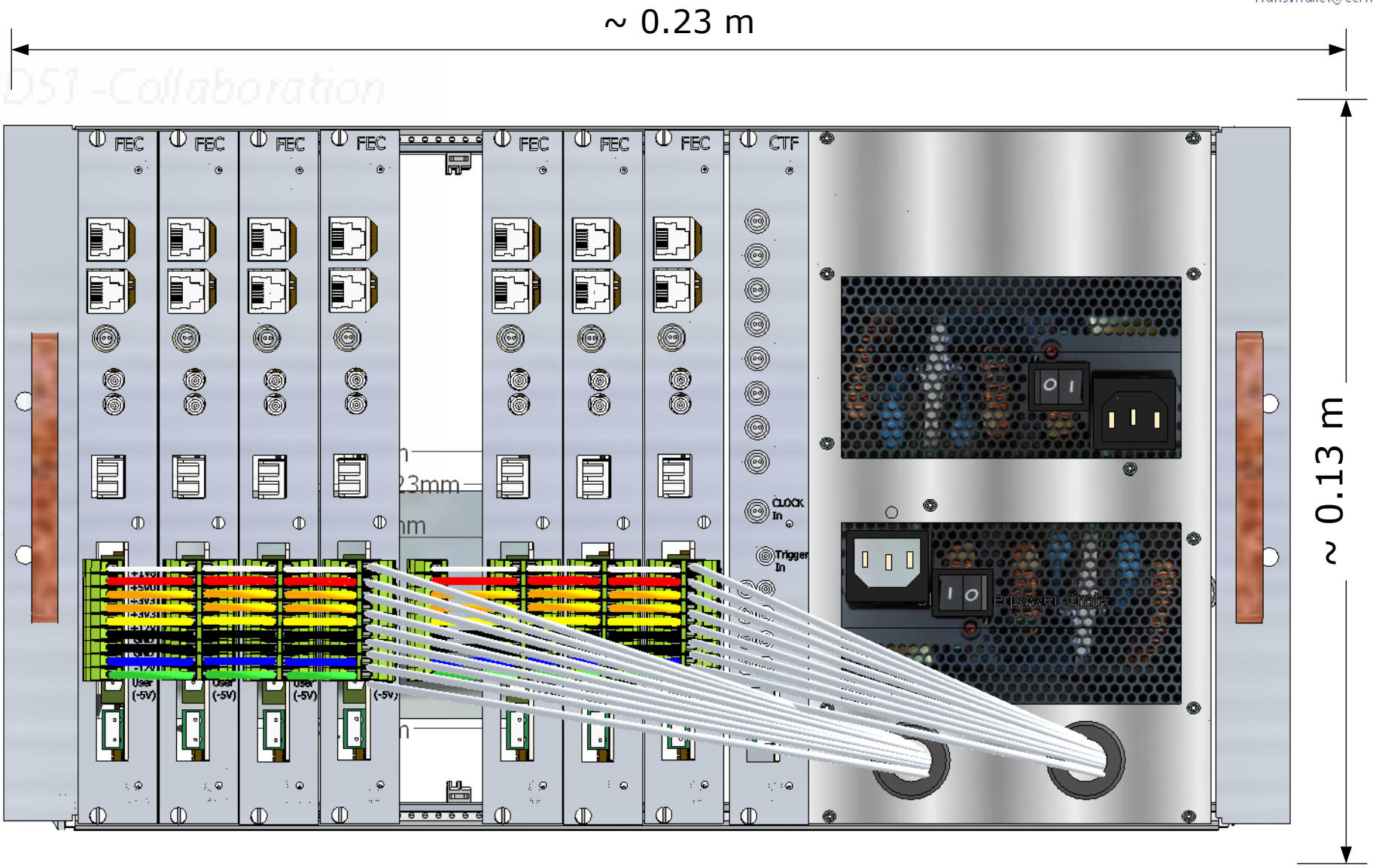
Single-Power Eurocrate

RD51 -Collaboration
HansMuller@cern.ch



Full power SRS Eurocrate, 6U x 220

RD51-Collaboration
HansMuller@cern.ch



Slot 1 .... Slot 4
put additioal 4 FEC combos

Slot 5 ..... Slot 8
put 1st four FEC combos

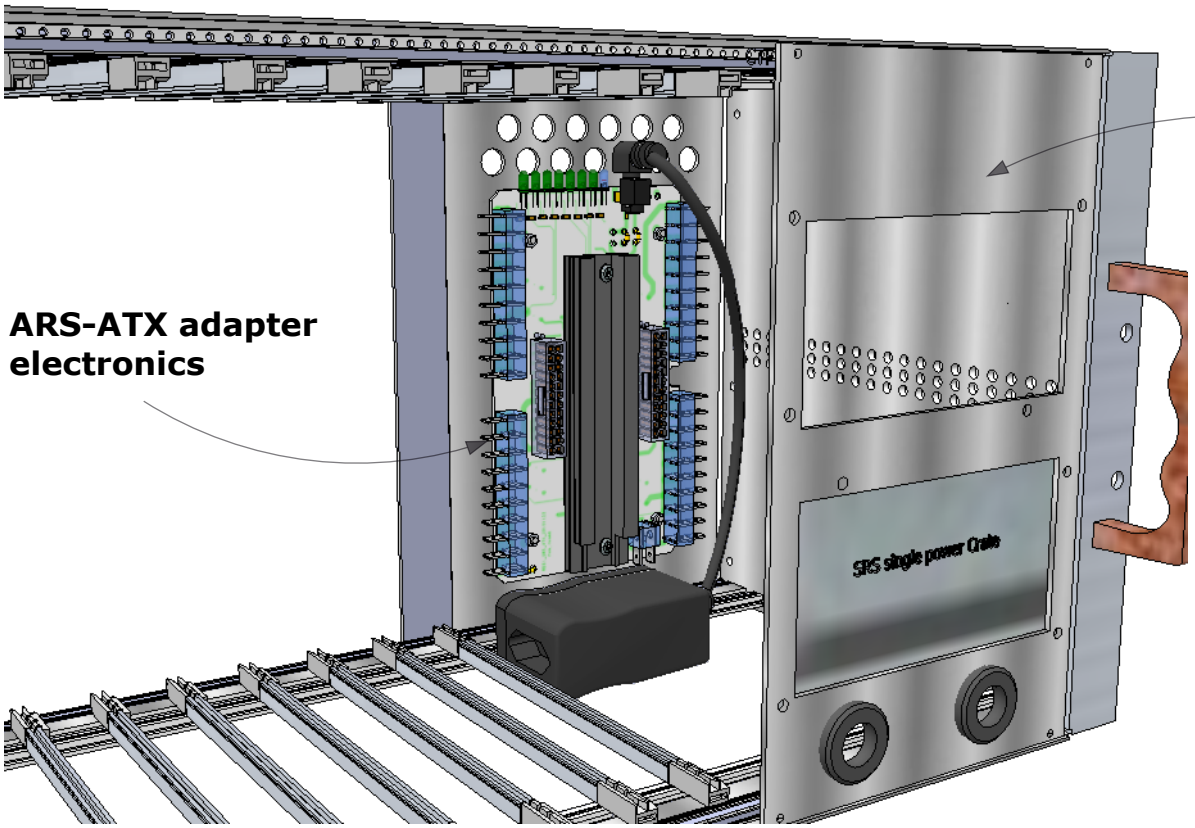
Slot 9
CTF card

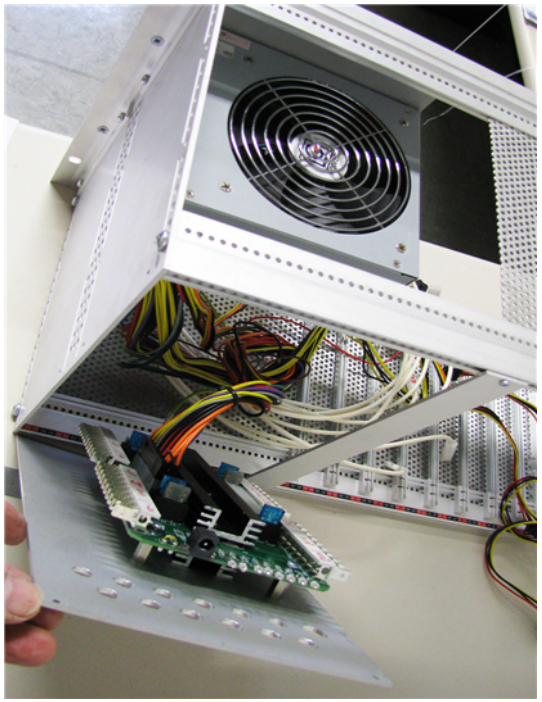
Slots 10 ... 14
used by Power Supplies

HansMuller@cern.ch

Power department Eurocrate

one or two ATX supplies & adapters



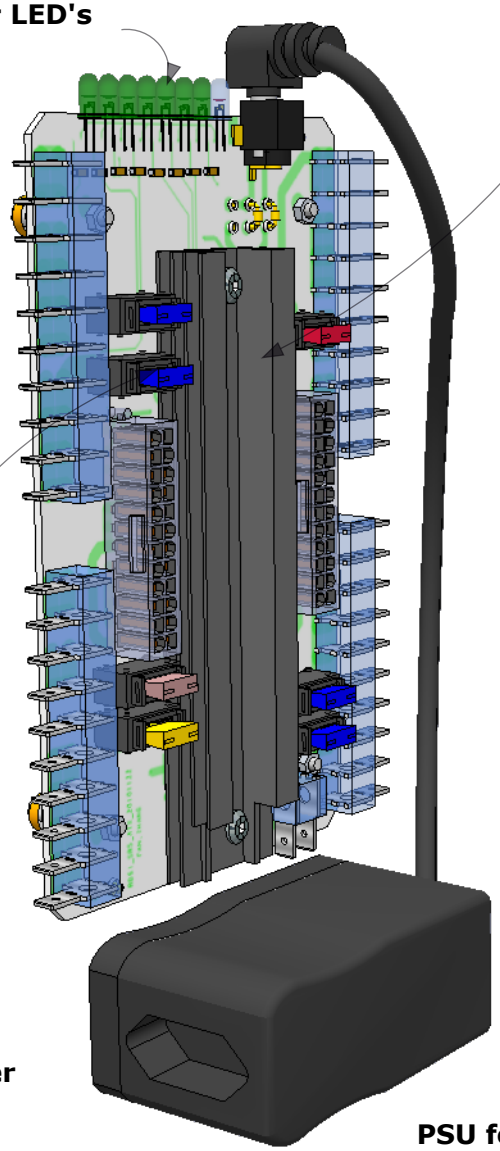


SRS - ATX adapter electronics

HansMuller@cern.ch

Indicator LED's

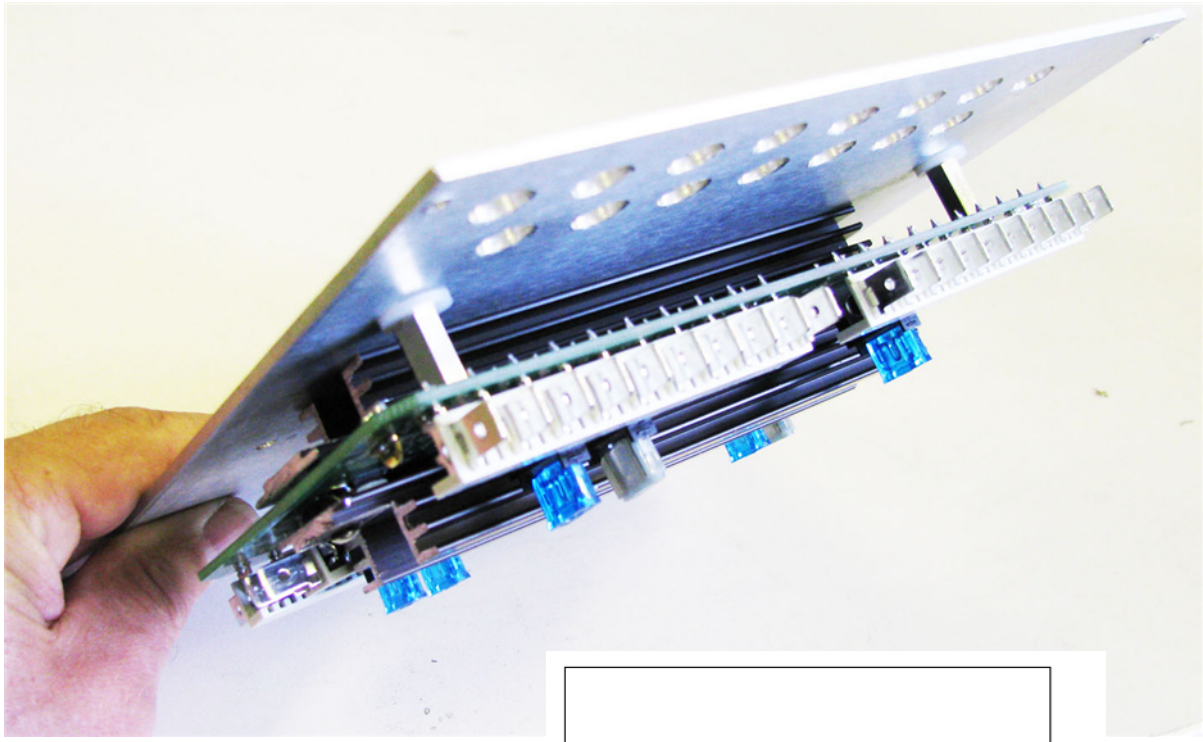
Cooler for 1.8 and 4.2 V generation

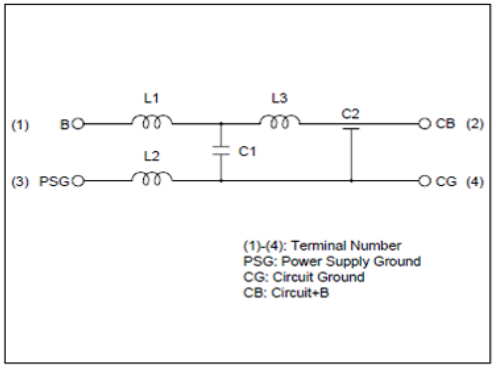


Mini fuses
15 A, 2A

PCB layout V2
by Volkan.Gezer

PSU for -5V
(not provided by ATX)



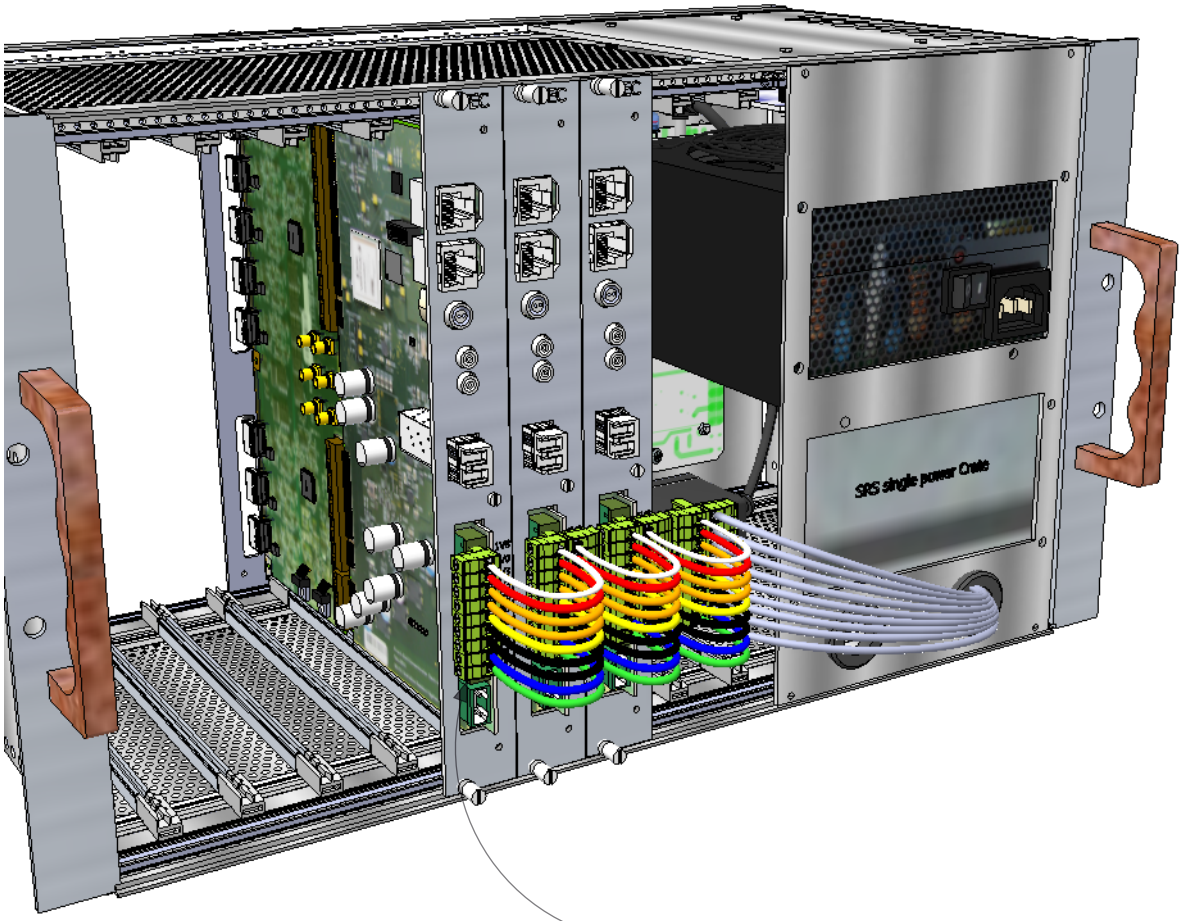


EMI filters on all SRS voltages

HansMuller@cern.ch

Eurocrate

half power version = max 4 FEC/ADC combos, 64 hybrids



Power cable bus for 4 Combos

SRS power cable bus

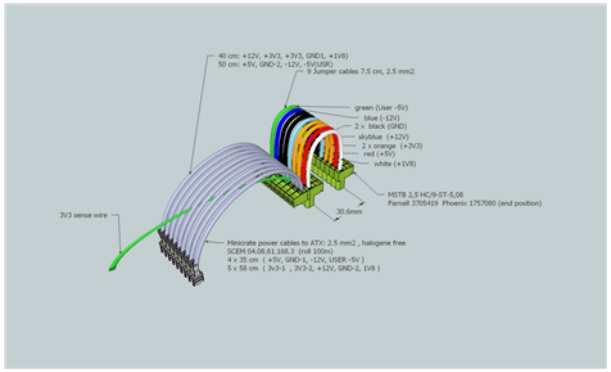


Photo SRS half power Eurocrate

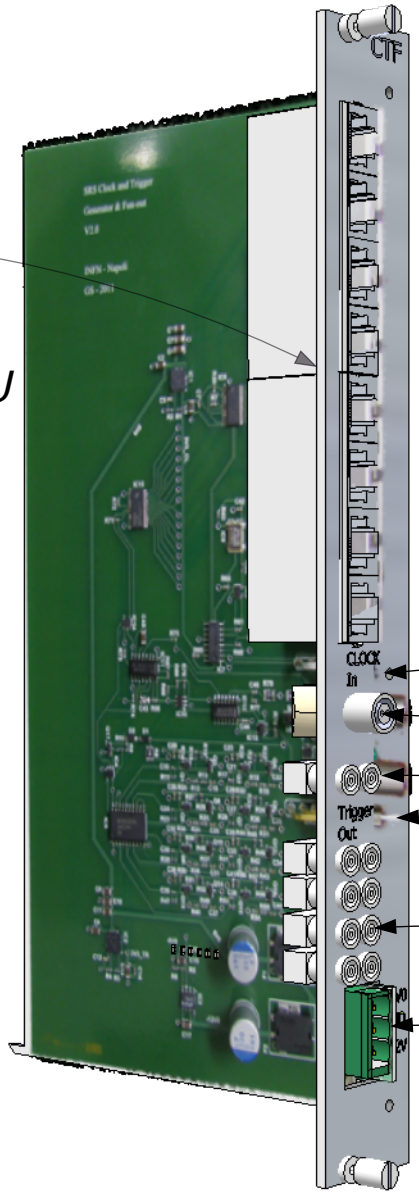
Clock-Trigger-Fanout (CTF)*:

synchronize clock and triggers for up to 8 FECs

RD51-Collaboration
HansMuller@cern.ch

CTF links:
subset of DTC links
(no SRU)

8x CAT5 cables to FEC
same pinout as DTC link to SRU



Features:

8 x RJ45
CFT-links to 8 FECs

Clock Selector switch:
internal 40 MHz / external

External clock input LVDS

Trigger input
NIM and TTL

Trigger selection switch
Manual, 10 Hz, External

8 x NIM Trigger
output

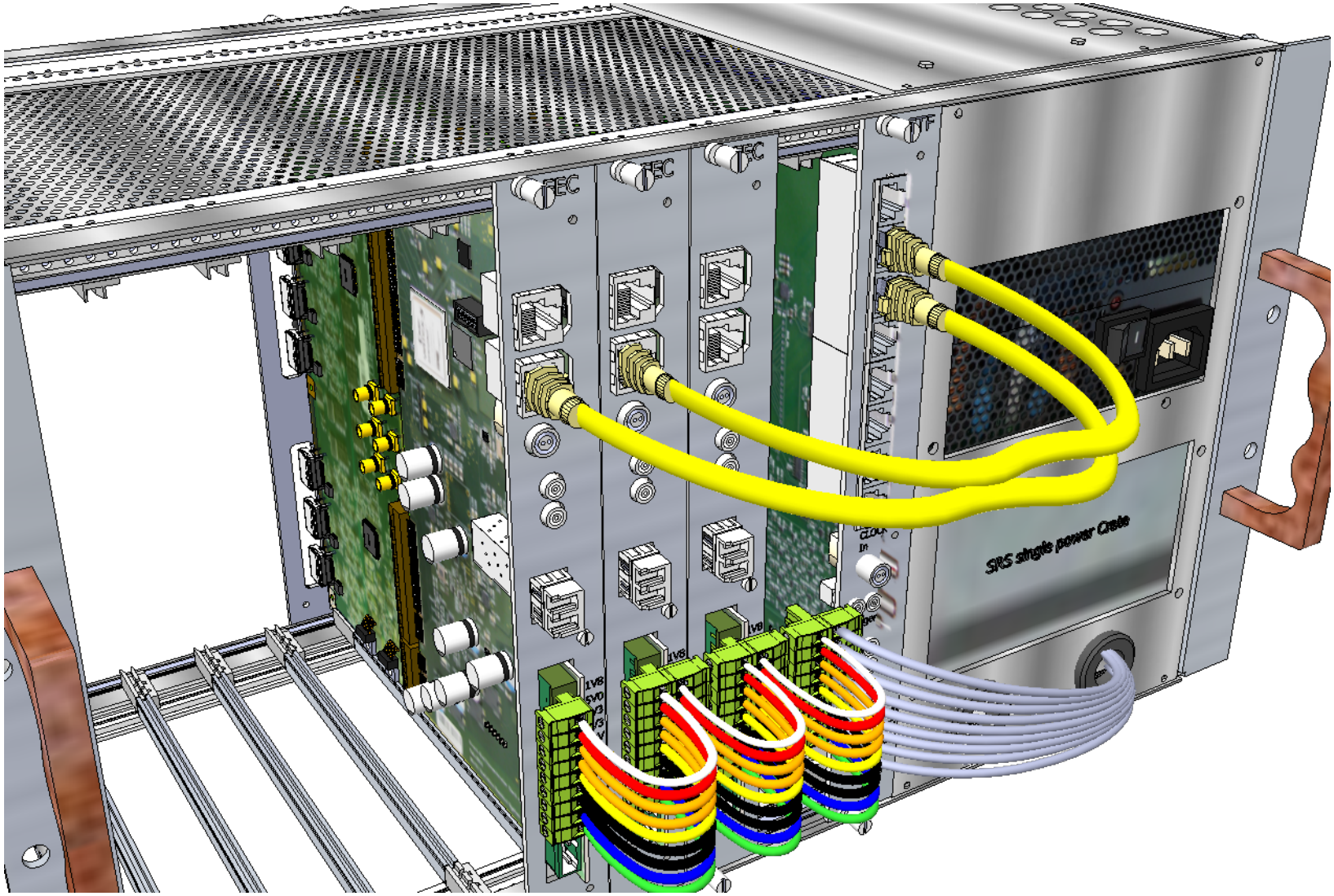
Power (cable from ATX)

** CTF Design: Givi.Sekhniaidze@na.infn.it*

HansMuller@cern.ch

CTF -links

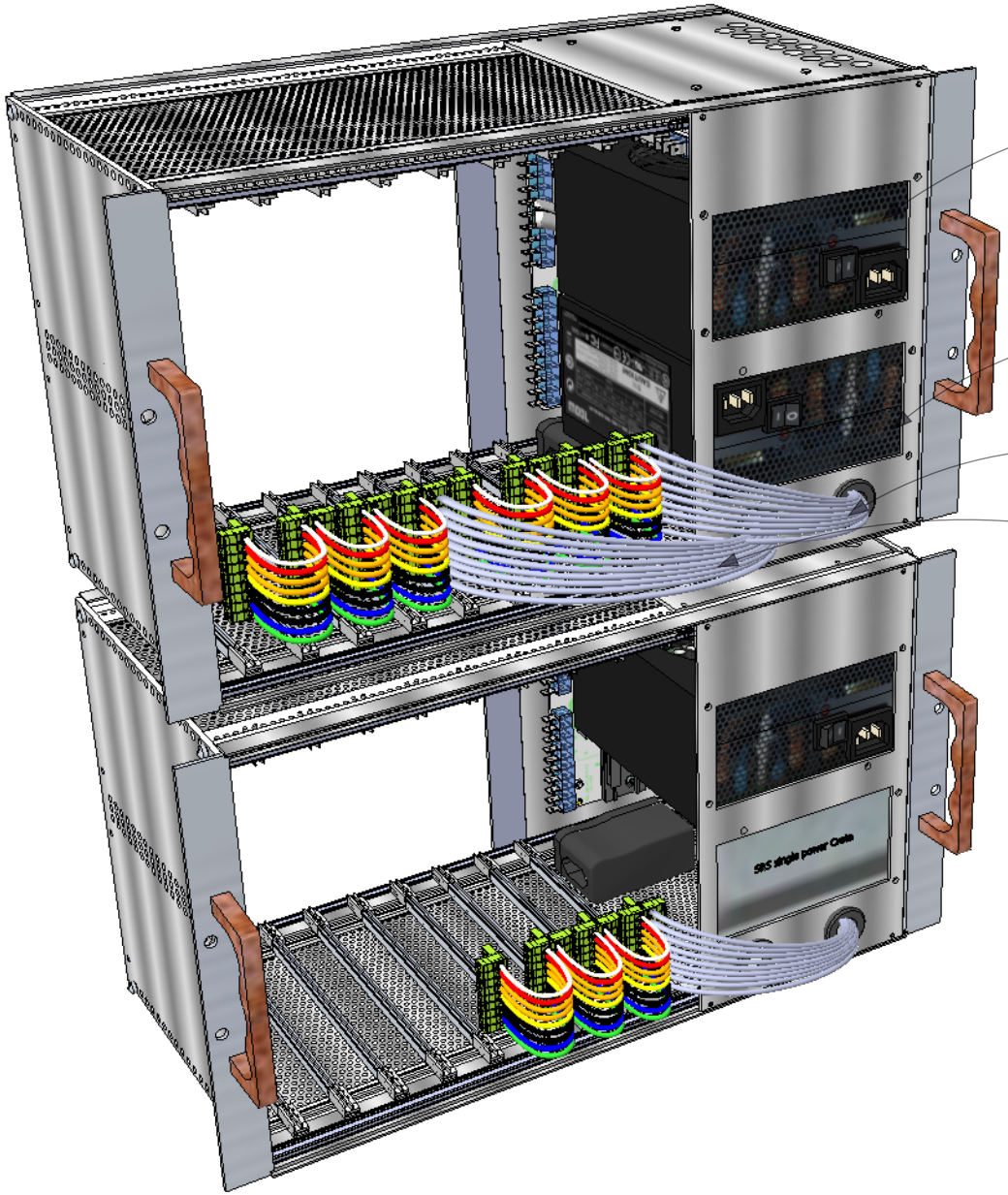
for synchronous clock and trigger



Crate options Full power - Half power

HansMuller@cern.ch

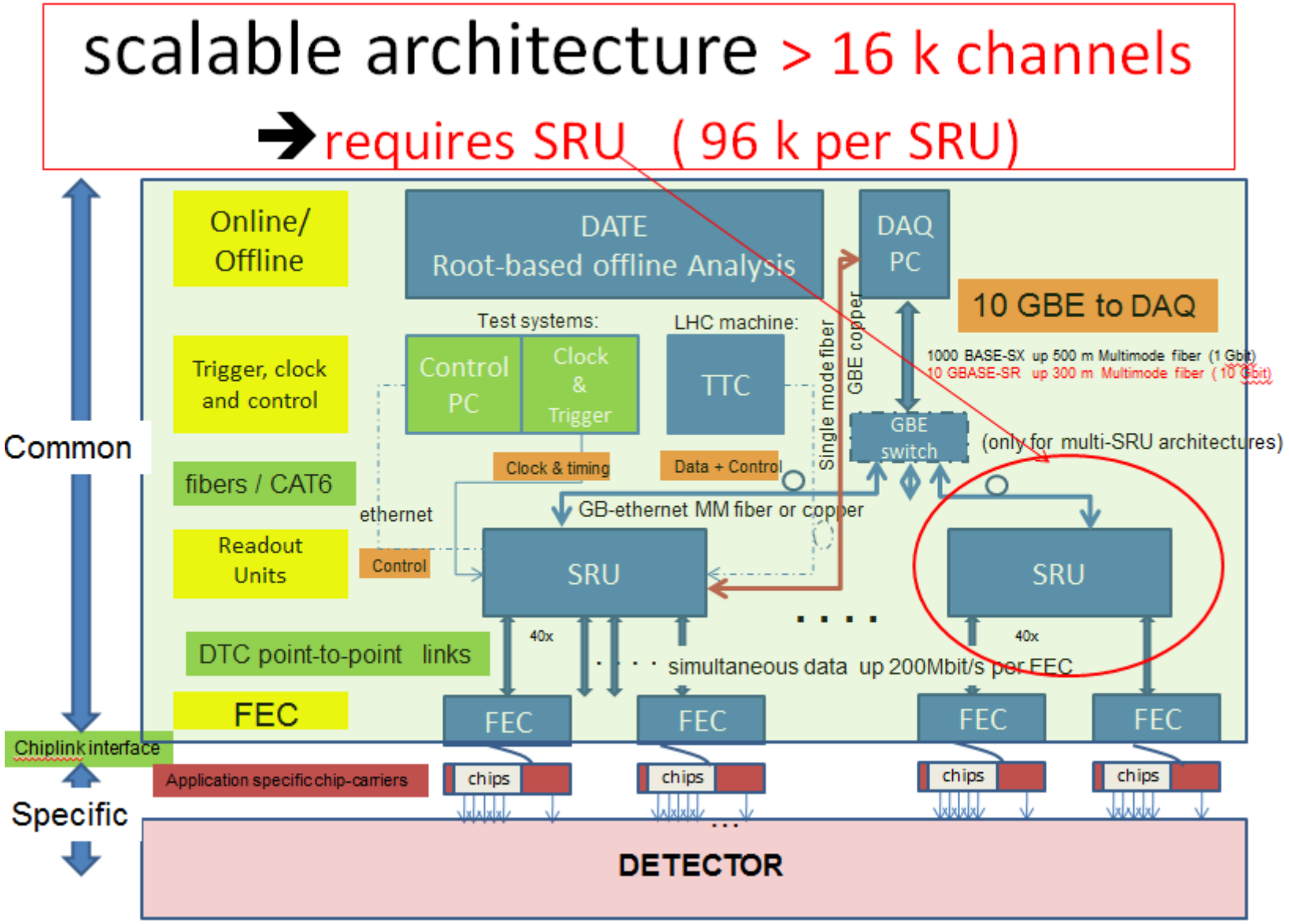
Full power
8 FEC + 1 CTF
128 hybrids



Half power
4 FEC and 1 CTF
64 hybrids

Scalable Readout Architecture

HansMuller@cern.ch



1 ethernet cable

Smallest Unit:
128 - 2048 ch

1-2 ethernet cables

Mini-Crate:
128-4096 ch

1 network switch
Eurocrate:
2048-16384 ch

1 SRU
>1 Eurocrate
16k - 82 k ch

n x SRU
n Racks a 5 Eurocrates
82k - n x 82 kch

HansMuller@cern.ch

Scalable readout Unit (SRU)

DTC links to FEC cards

LVDS trigger interface

TTCrx

NIM pulse interface

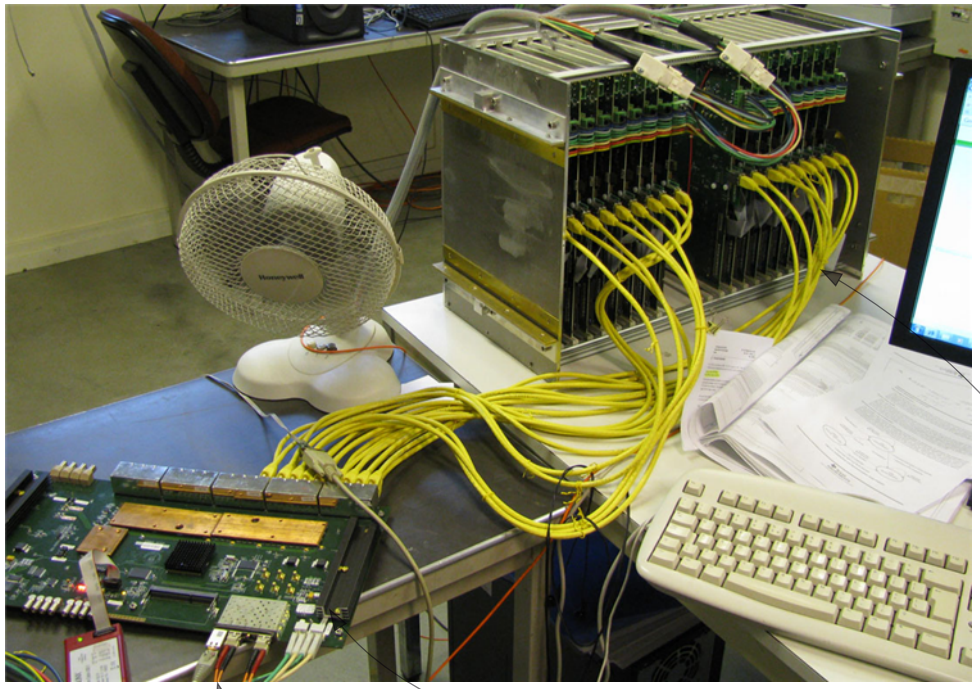
4 x SFP+ ports

SRU - based readout

HansMuller@cern.ch

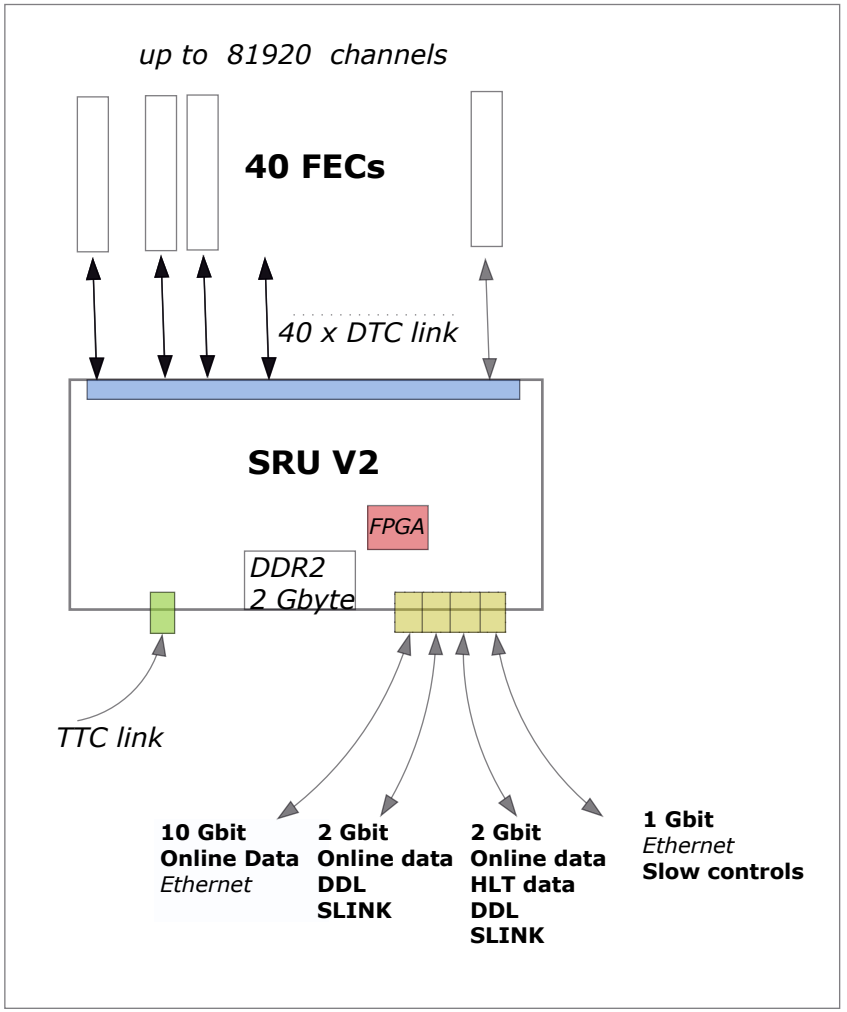
SRU readout of ALICE EMCal
(non -SRS frontend)

SRU firmware for ALTRO chip readout via DTC links and output to DATE via 2 Gbit/s DDL link
by Fan Zhang



SRU V1

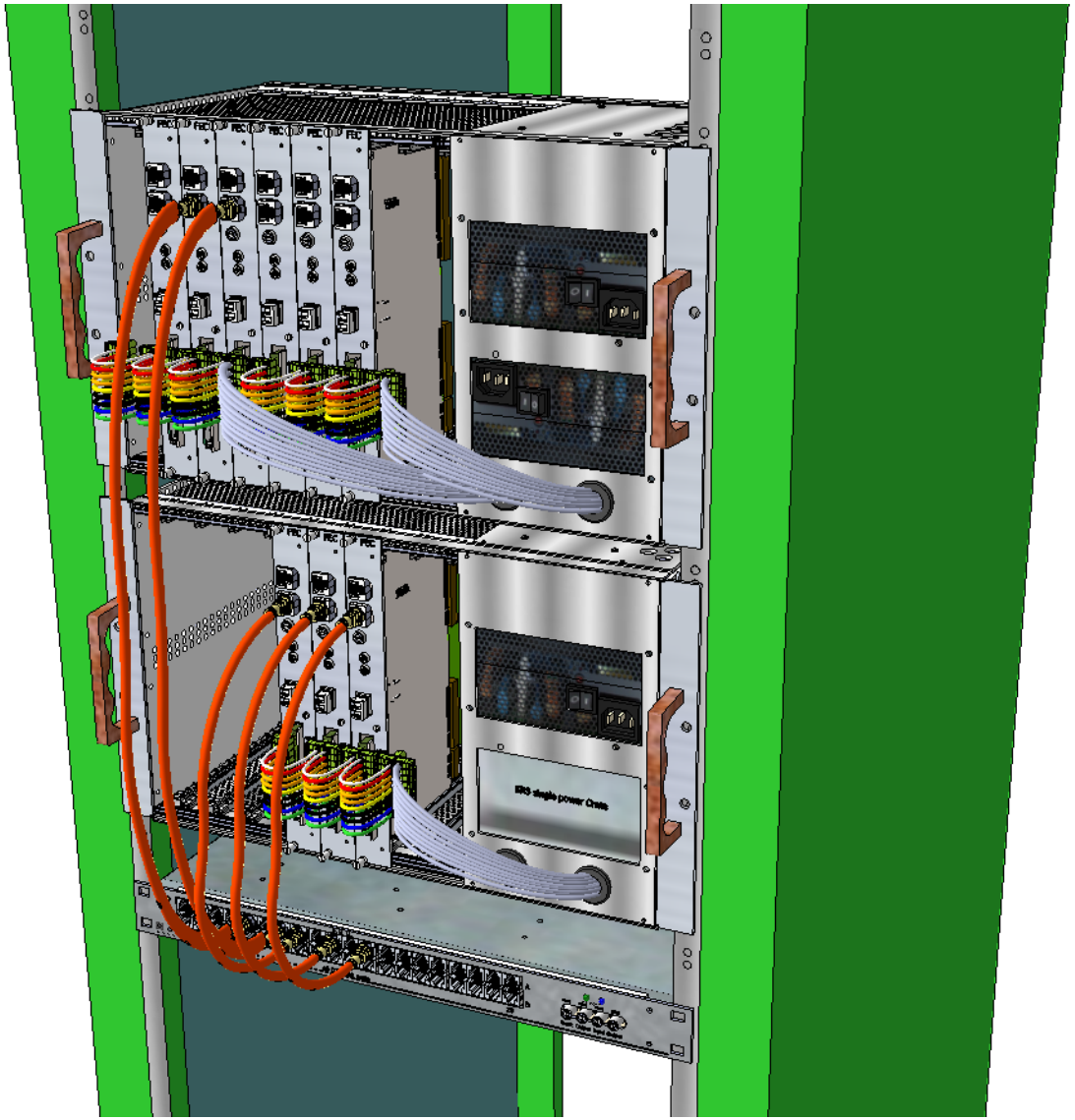
2 x DDL link



DTC links (CAT6)

Rack-based SRU readout cluster

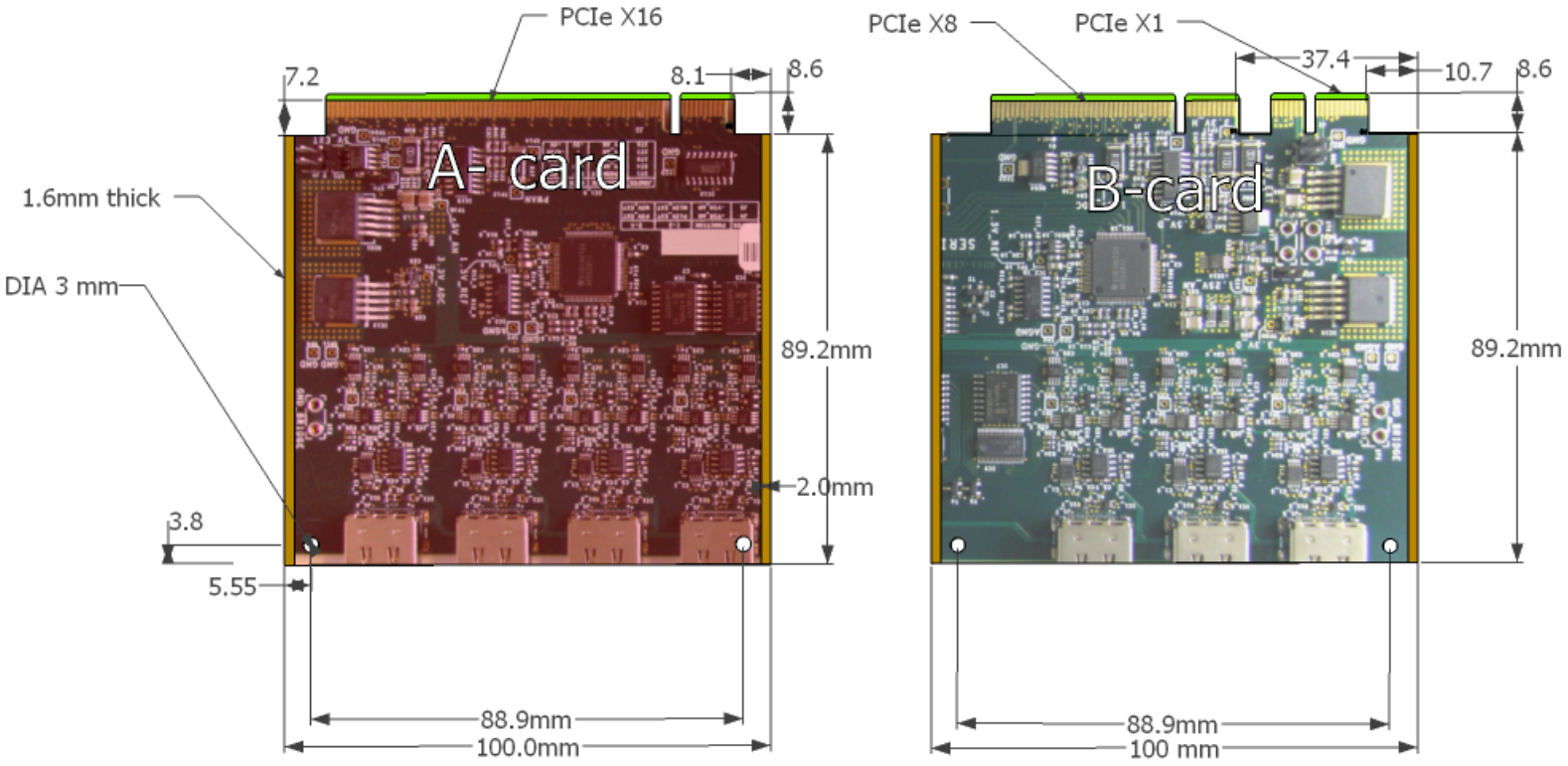
HansMuller@cern.ch



1 RACK = 5 Eurocrates + 1 SRU
40 DTC links = 40 FECs =
81 920 APV channels

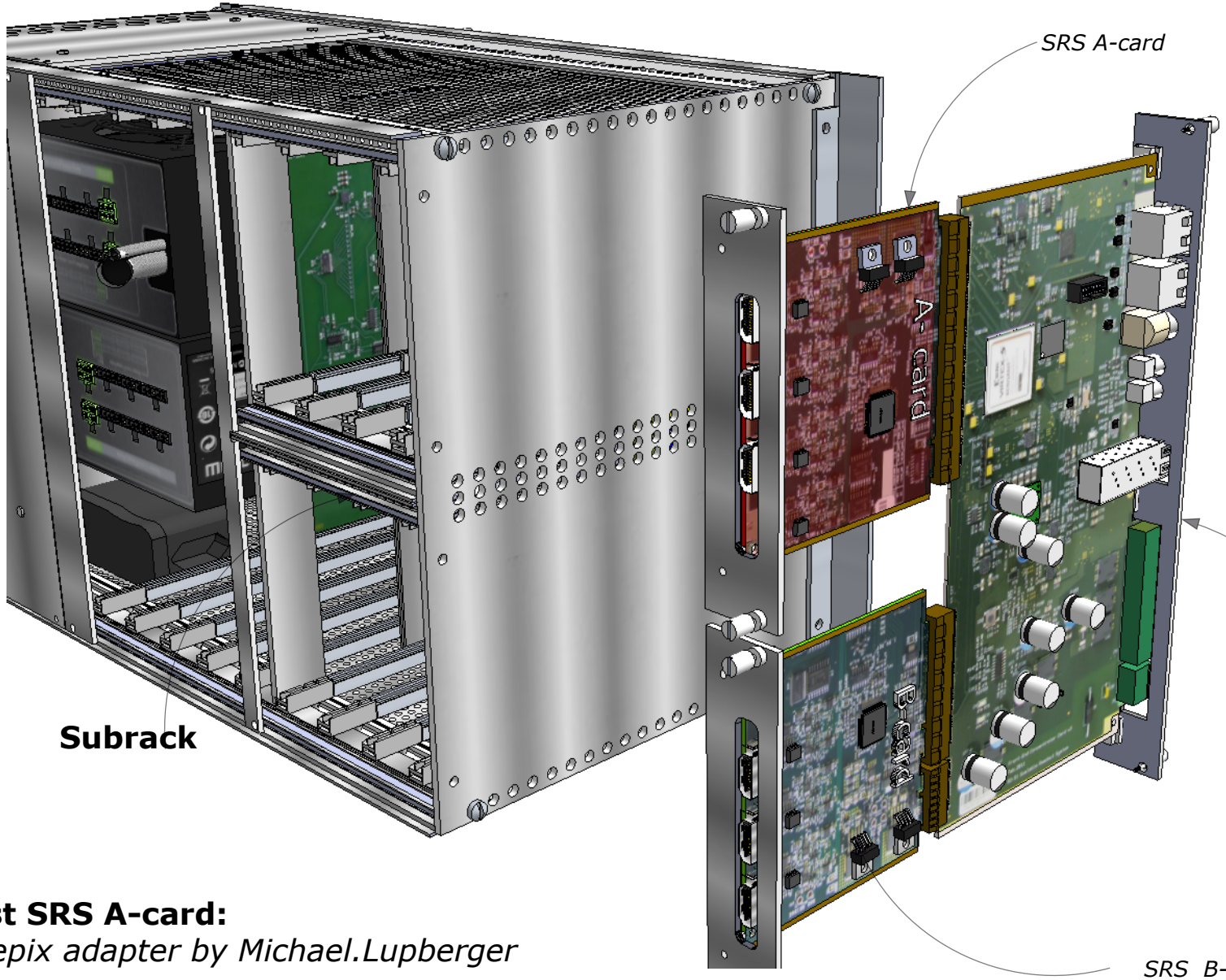
HansMuller@cern.ch

A-B card dimensions



3U-subsystem adapter / subrack option

RD51 -Collaboration
HansMuller@cern.ch



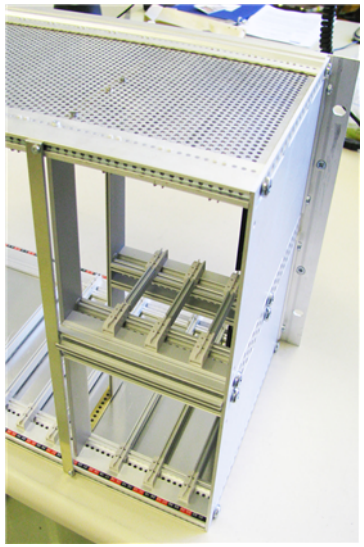


photo subrack for A-B cards

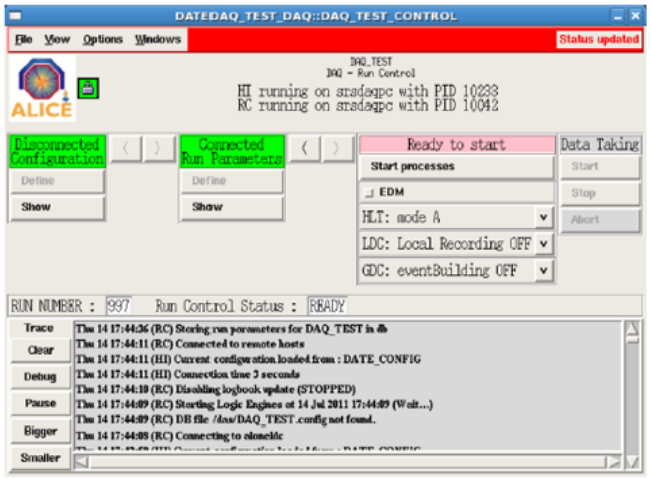
First SRS A-card:
timepix adapter by Michael.Lupberger

HansMuller@cern.ch

SRS Documentation

DATE for SRS

Getting Started Manual



v1.1

Notice: PRE-RELEASE for comments

Volkan Gezer

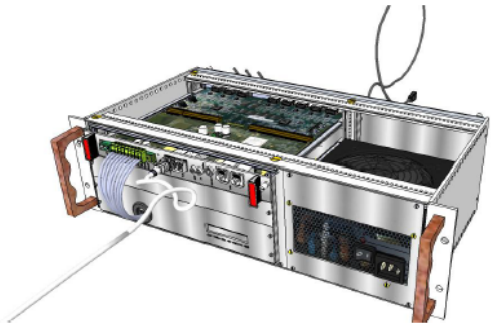
volkangezer@gmail.com

29 October 2011

http://dl.dropbox.com/u/31352454/Volkan-DATE-V1.1.pdf

Connecting, Programming and Testing

FEC and ADC



v1.1

Notice: PRE-RELEASE for comments

Volkan Gezer

volkangezer@gmail.com

25 October 2011

http://dl.dropbox.com/u/31352454/Volkan-HW-V1.1.pdf

In preparation ...

SRS Scalable Readout System
RD51 Note
Authors: Hans Muller, CERN PH Department, CH-1211 Geneva 23, Switzerland

Ref: RD51 2011-xxx
Issue: 1.0 Revision: 1
Date: 23 July 2011

CERN RD51 Note 2011-xx

SRS Scalable Readout System

draft for revision

RD51 Note

Issue: 1.0
Revision: 0

Reference: RD51 2011-xxx
Created: 23 July 2011
Last modified: 23 July 2011

Authors: Hans Muller, CERN PH Department, CH-1211 Geneva 23, Switzerland

to be announced

HansMuller@cern.ch

conclusions and outlook

- in 2010/11 a dozend small and medium sized SRS systems have been deployed
- Minicrates (table top) and Eurocrates (rack -based)
- Power, Filter and connectivity issues for SRS crates have been consolidated
- SRS is continuing its way into large systems
- 3 flavours of online software for SRS, more expected
- First SRUs for large systems (> 16k ch) in use by developers, more imminent
- feedback from SRS users is helping to eliminate SRS infancy problems
- 1st user manuals and publications
- Openness was very much liked und encouarged many SRS developers to contribute
- more C-cards have been designed
- upgrade of FEC to V6 version with more FPGA resources under way
- first proto A-card for timepix readout
- CFT will eliminate synchronization issues and provide basic test environment
- zero suppression firmware to increase of trigger rates under test
- new SRS hybrid frontends under design (Beetle, VFAT)
- 500 new APV hybrids with HDMI-D (micro) connector on order
- radhard export issue so far the only scale breaking limit
- CERN agreement for SRS -as-is production by PRISMA Electronics
- 2012 SRS distribution via CERN store

thanks to all SRS supporters and developers !
thanks to all patient users and their very valuable feedback !