

Developments and applications of DAQ framework DABC v2

<http://dabc.gsi.de>



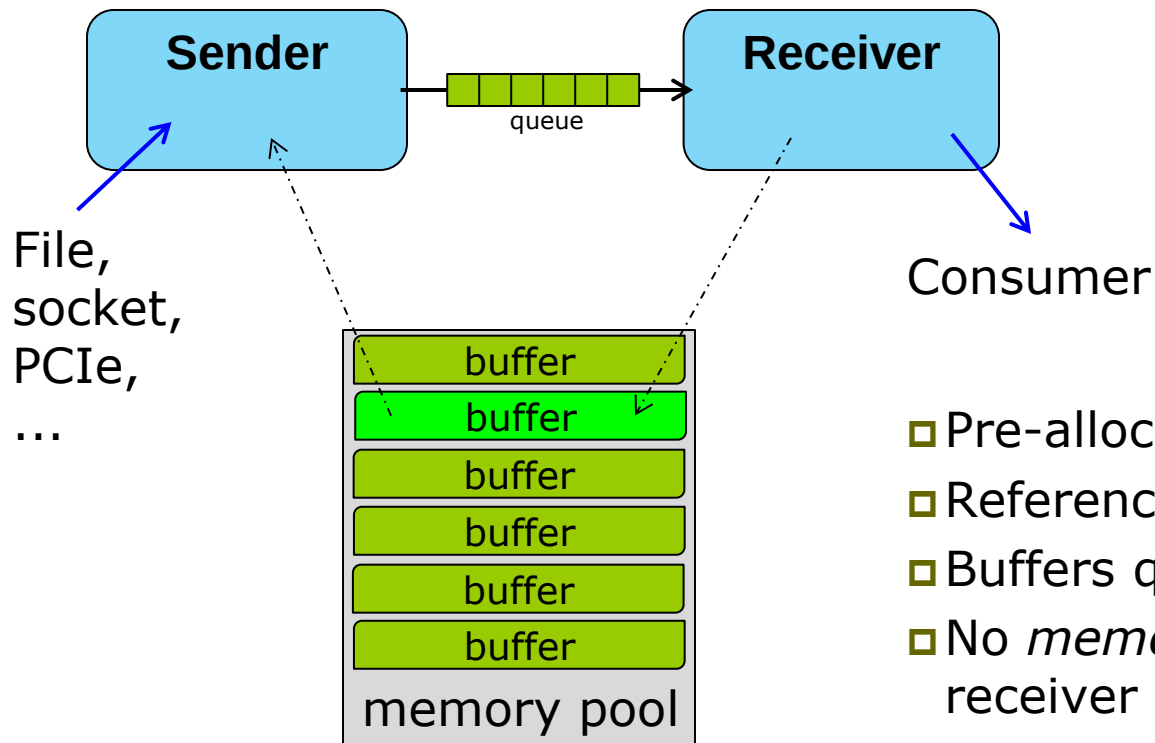
Jörn Adamczewski-Musch,
Nikolaus Kurz,
Sergey Linev

GSI / Experiment Electronic
CHEP 14.04.2015

DABC core functionality

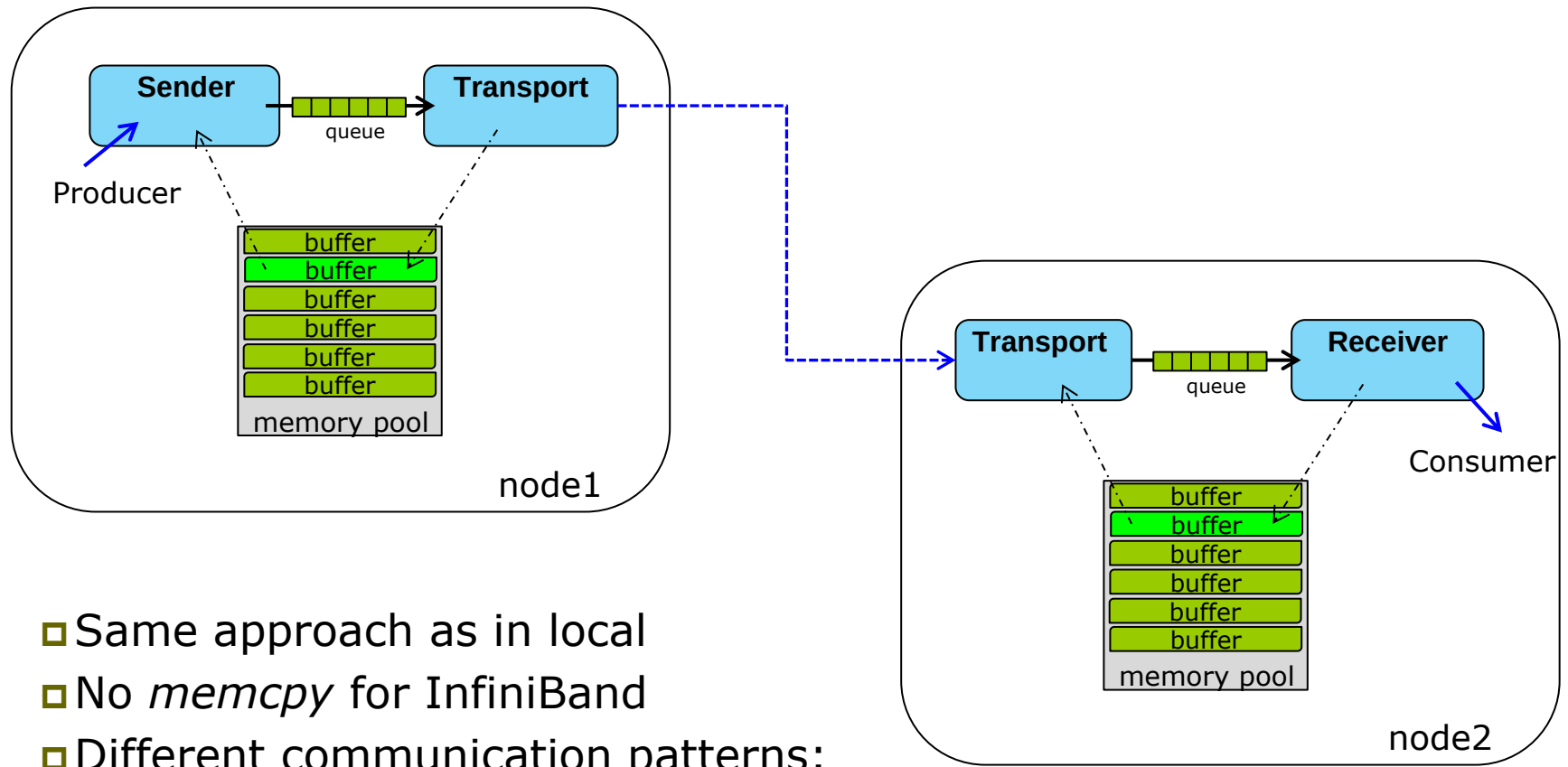
- ❑ Multi-thread, multi-node applications
- ❑ Zero-copy transport approach
 - full support for InfiniBand VERBS
 - advanced sockets treatment with *select()*
- ❑ Flexible plugin interface
 - MBS, HADAQ, ROOT, Go4, EPICS, DIM, FESA
- ❑ http for slow control
 - JavaScript ROOT as web GUI
- ❑ In development since 2007
 - v1.0 in 2009, now v2.7

Local communication



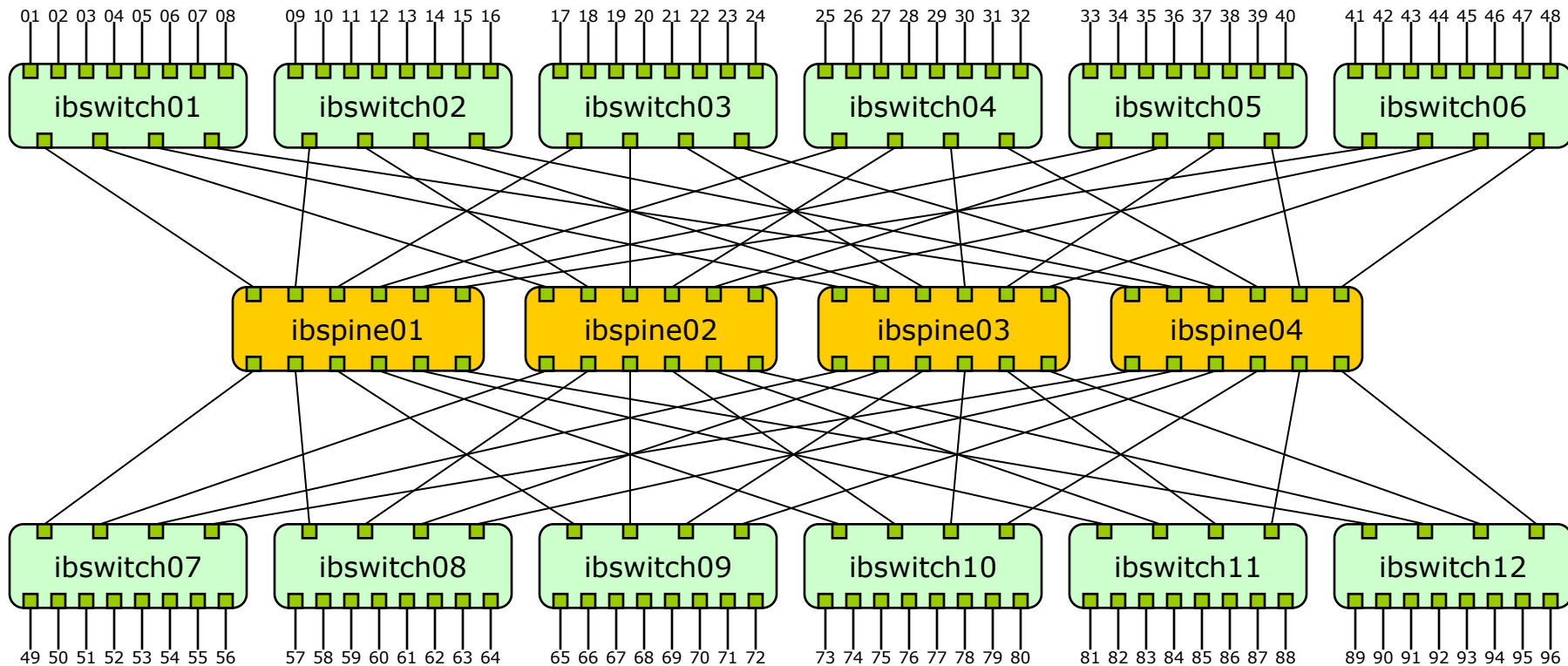
- Pre-allocated memory pool
- Reference counter for each buffer
- Buffers queue between modules
- No *memcpy* between sender and receiver

Remote communication



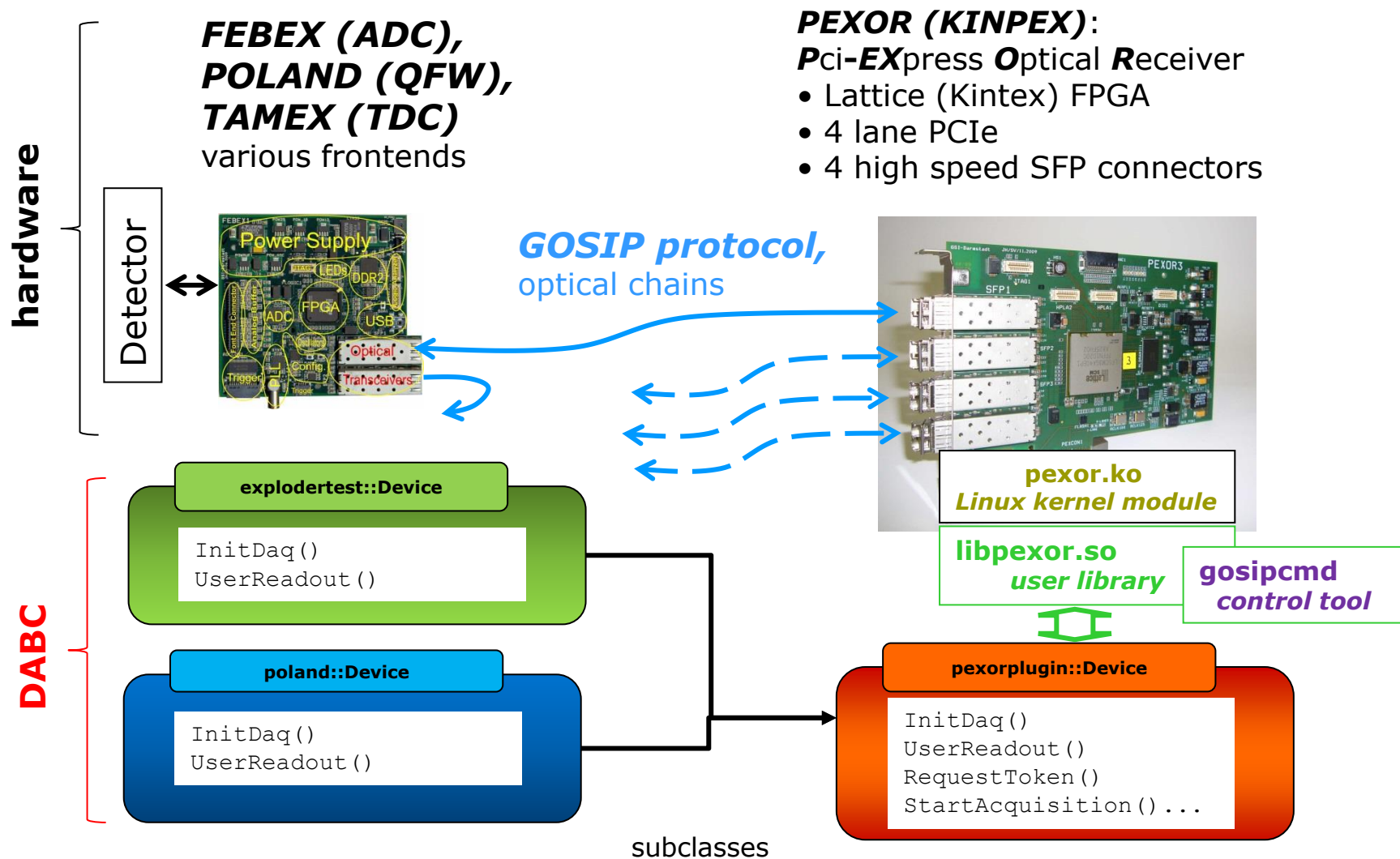
- Same approach as in local
- No *memcpy* for InfiniBand
- Different communication patterns:
 - $1 \rightarrow 1$, $1 \rightarrow N$, $N \rightarrow 1$, $N \times M$

InfiniBand tests with DABC



- ❑ 1/2 fat tree topology
- ❑ ~800 nodes with QDR IB
- ❑ 12 spine and 34 leaf switches
- ❑ all-to-all traffic pattern
- ❑ **1.25 TB/s** or 80% of available bandwidth

PEXOR/KINPEX plug-ins

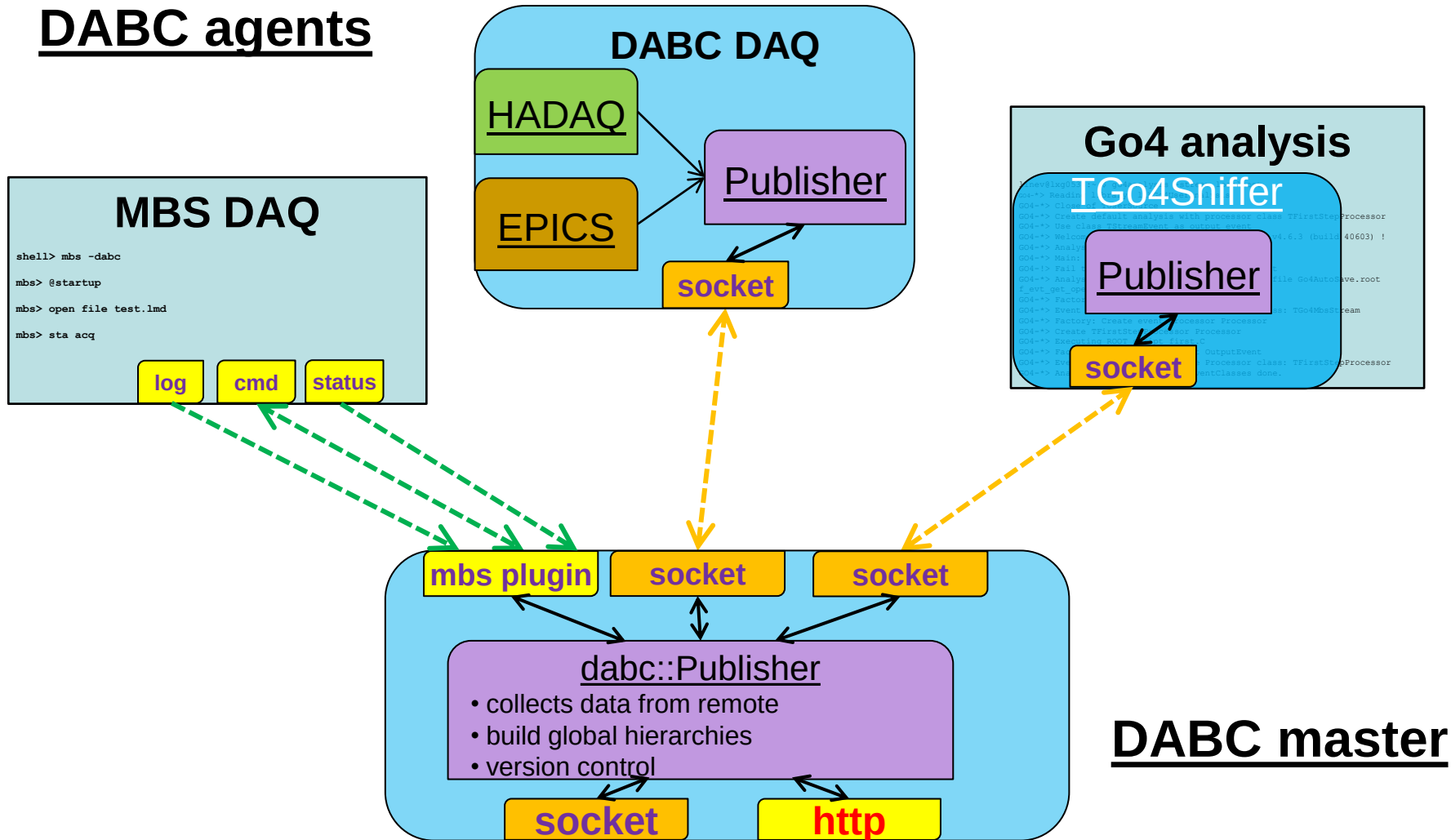


http::Server in DABC

- ❑ Access to different data in DAQ application
- ❑ JavaScript ROOT as user interface
- ❑ One could integrate and access data from different sources:
 - DABC, ROOT, Go4, MBS, EPICS, DIM, FESA, ...
- ❑ Same data could be accessed by Go4 and displayed using native ROOT graphics
- ❑ One also could use command-line tools to access DAQ/analysis data via http or socket

Heterogeneous distributed applications

DABC agents



MBS/GOSIP web gui

MBS web GUI - Iceweasel <2>

File Edit View History Bookmarks Tools Help

MBS web GUI

depc418:8095/MBS/depc418/ControlGUI/

Google

GSi Web Linux HADES Go4 Programming

MBS

▶ ◻ ◻ ◻ ◻ ◻

mbs> [sho acq] [100] Log history

```

DEPC418:util collected: 33 KB/s, 1 Buffers/s, 1 Events/s
-DEPC418:util Rate : 33 KB/s, 1 Buffers/s, 1 Events/s
-DEPC418:util -----
-DEPC418:cmd_exe sho setup
-DEPC418:cmd_exe
-DEPC418:cmd_exe 140.181.84.148 connected
-DEPC418:stream_serv
-DEPC418:dispatch cmdrem: get command id:6 sto acq
-DEPC418:cmd_exe sto acq
-DEPC418:util stop acquisition
-DEPC418:collector acquisition NOT running
-DEPC418:read_web found trig type 15 == stop acquisition
-DEPC418:dispatch cmdrem: get command id:7 sta acq
-DEPC418:cmd_exe sta acq
-DEPC418:util start acquisition
-DEPC418:read_web found trig type 14 == start acquisition
-DEPC418:collector acquisition running
                    
```

GOSIP

gospicmd -h

```

\t\t -i : initialize sfp chain
\t\t -r : read from register
\t\t -w : write to register
\t\t -s : set bits of given mask in register
\t\t -u : unset bits of given mask in register
\t\t -b : broadcast io operations to all slaves in range (0-sfp)(0-slave)
\t\t -c FILE : configure registers with values from FILE.gos
\t\t -v FILE : verify register contents (compare with FILE.gos)
\t\t -n DEVICE : specify device number N (/dev/pexorN, default:0)
\t\t -d : debug mode (verbose output)
\t\t -x : numbers in hex format (defaults: decimal, or defined by prefix 0x)

\t Arguments:
\t\t sfp -sfp chain- -l to broadcast all registered chains
\t\t slave -slave id at chain, or total number of slaves. -l for internal broadcast
\t\t address -register on slave
\t\t value -value to write on slave
\t\t words -number of words to read/write/set incrementally

\t Examples:
\t\t gospicmd -z -n 1 : master gospic reset of board /dev/pexor1
\t\t gospicmd -i 0 24 : initialize chain at sfp 0 with 24 slave devices
\t\t gospicmd -r -x 1 0 0x1000 : read from sfp 1, slave 0, address 0x1000 and printout
\t\t gospicmd -r -x 3 0x1000 5 : read from sfp 0, slave 3, address 0x1000 next 5 words
\t\t gospicmd -b 1 3 0x1000 10 : broadcast read from sfp (0..1), slave (0..3), address 0x1000 next 10 words
\t\t gospicmd -r -x 1 -1 0x1000 10 : broadcast read from address 0x1000, next 10 words from sfp 1, slave 0
\t\t gospicmd -w -x 0 3 0x1000 0x2A : write value 0x2A to sfp 0, slave 3, address 0x1000
\t\t gospicmd -w -x 1 0 20000 0x2A : write value 0x2A to sfp 1, slave 0, address 0x20000
\t\t gospicmd -w -b 1 3 0x20004c 1 : broadcast write value 1 to address 0x20004c on sfp (0..3)
\t\t gospicmd -w -x 1 -1 0x20004c 1 : write value 1 to address 0x20004c on all registered sfp
\t\t gospicmd -s 0 0x200000 0x4 : set bit 100 on sfp0, slave 0, address 0x200000
\t\t gospicmd -u 0 0 0x200000 0x4 0xFF : unset bit 100 on sfp0, slave 0, address 0x200000-0x200004
\t\t gospicmd -x -c run42.gos : write configuration values from file run42.gos to slave
                    
```

Data taking

▶ test.lmd Filename 1000 Max size

Log modes

rate rash rast ratf 100 Log history

Event building	MB	Events	Kb/sec	Ev/sec	Server	File output	MB	Filled	Kb/sec	Filename
40	1233	32.8	1	720.9	0	-nan %	0.0	cl		
40	1234	32.8	1	720.8	0	-nan %	0.0	cl		
41	1235	32.8	1	720.9	0	-nan %	0.0	cl		
41	1236	32.8	1	720.8	0	-nan %	0.0	cl		
40	1237	32.8	1	720.9	0	-nan %	0.0	cl		
40	1238	32.8	1	720.9	0	-nan %	0.0	cl		
41	1239	32.8	1	720.9	0	-nan %	0.0	cl		
41	1240	32.8	1	720.8	0	-nan %	0.0	cl		
41	1241	32.8	1	720.9	0	-nan %	0.0	cl		
41	1242	32.8	1	720.9	0	-nan %	0.0	cl		
41	1243	32.8	1	720.9	0	-nan %	0.0	cl		
41	1244	32.8	1	721.0	0	-nan %	0.0	cl		
41	1245	32.8	1	720.9	0	-nan %	0.0	cl		
41	1246	32.8	1	720.9	0	-nan %	0.0	cl		
41	1247	32.8	1	720.9	0	-nan %	0.0	cl		
41	1248	32.8	1	720.9	0	-nan %	0.0	cl		
41	1249	32.8	1	720.9	0	-nan %	0.0	cl		
41	1250	32.8	1	720.9	0	-nan %	0.0	cl		
41	1251	32.8	1	720.9	0	-nan %	0.0	cl		
41	1252	32.8	1	720.9	0	-nan %	0.0	cl		
41	1253	32.8	1	720.9	0	-nan %	0.0	cl		
41	1254	32.8	1	720.9	0	-nan %	0.0	cl		
41	1255	32.8	1	720.9	0	-nan %	0.0	cl		
41	1256	32.8	1	721.0	0	-nan %	0.0	cl		
41	1257	32.8	1	720.9	0	-nan %	0.0	cl		
41	1258	32.8	1	720.9	0	-nan %	0.0	cl		
41	1259	32.8	1	720.8	0	-nan %	0.0	cl		
41	1260	32.8	1	720.9	0	-nan %	0.0	cl		
41	1261	32.8	1	720.9	0	-nan %	0.0	cl		
41	1262	32.8	1	720.8	0	-nan %	0.0	cl		
41	1263	32.8	1	721.0	0	-nan %	0.0	cl		
41	1264	32.8	1	720.8	0	-nan %	0.0	cl		
41	1265	32.8	1	720.5	0	-nan %	0.0	cl		
41	1266	32.8	1	721.1	0	-nan %	0.0	cl		
41	1267	32.8	1	720.9	0	-nan %	0.0	cl		
41	1268	32.8	1	720.9	0	-nan %	0.0	cl		
41	1269	32.8	1	720.8	0	-nan %	0.0	cl		
42	1270	32.8	1	720.8	0	-nan %	0.0	cl		
42	1271	32.8	1	720.8	0	-nan %	0.0	cl		
42	1273	32.8	2	720.6	0	-nan %	0.0	cl		
42	1273	32.8	0	721.2	0	-nan %	0.0	cl		
42	1274	32.8	1	720.8	0	-nan %	0.0	cl		
42	1276	32.8	2	720.8	0	-nan %	0.0	cl		
42	1277	32.7	1	720.2	0	-nan %	0.0	cl		
42	1278	32.8	1	721.4	0	-nan %	0.0	cl		
42	1279	32.8	1	720.9	0	-nan %	0.0	cl		
42	1280	32.8	1	720.8	0	-nan %	0.0	cl		
42	1281	32.8	1	720.9	0	-nan %	0.0	cl		
42	1282	32.8	1	720.7	0	-nan %	0.0	cl		
42	1283	32.8	1	721.0	0	-nan %	0.0	cl		

Display refresh

1 Refresh Interval [s]

Rates display

100 Trending history

/MBS/depc418/ControlGUI/./EventRate

1

/MBS/depc418/ControlGUI/./DataRate

32.8

/MBS/depc418/ControlGUI/./ServerRate

721

Di 27 Jan 2015 14:05:04 CET >Start Acquisition command sent.

DABC/PEXOR/GOSIP web gui

DABC **PEXOR** **Data taking** **Display refresh**

poland::Device::User_Read
poland::Device::User_Read
Initializing POLAND QWFS
Acquisition is stopped.
User_Readout finds stop trigger :15 !!
Acquisition is started.
poland::Device::User_Readout finds offset trigger :14 !!
Initializing POLAND QWFS done.
Acquisition is stopped.
User_Readout finds stop trigger :15 !!
Acquisition is started.
poland::Device::User_Readout finds offset trigger :14 !!
Initializing POLAND QWFS done.

GOSIP
gospicmd -d -r -x 0 0 0 0x180

test_0004.lmd	27.8 MB (2.8 %)	9346 ev
test_0004.lmd	28.8 MB (2.9 %)	9680 ev
test_0004.lmd	29.8 MB (3.0 %)	10014 ev
test_0004.lmd	30.8 MB (3.1 %)	10348 ev
test_0004.lmd	31.8 MB (3.2 %)	10682 ev
test_0004.lmd	32.8 MB (3.3 %)	11016 ev
test_0004.lmd	33.8 MB (3.4 %)	11349 ev
test_0004.lmd	34.8 MB (3.5 %)	11683 ev
test_0004.lmd	35.8 MB (3.6 %)	12017 ev
test_0004.lmd	36.7 MB (3.7 %)	12351 ev
test_0004.lmd	37.7 MB (3.8 %)	12685 ev
test_0004.lmd	38.7 MB (3.9 %)	13019 ev
test_0004.lmd	39.7 MB (4.0 %)	13353 ev
test_0004.lmd	40.7 MB (4.1 %)	13686 ev
test_0004.lmd	41.7 MB (4.2 %)	14020 ev
test_0004.lmd	42.7 MB (4.3 %)	14354 ev
test_0004.lmd	43.7 MB (4.4 %)	14688 ev
test_0004.lmd	44.7 MB (4.5 %)	15021 ev
test_0004.lmd	45.7 MB (4.6 %)	15355 ev
test_0004.lmd	46.7 MB (4.7 %)	15689 ev
test_0004.lmd	47.7 MB (4.8 %)	16023 ev
test_0004.lmd	48.7 MB (4.9 %)	16357 ev
test_0004.lmd	49.7 MB (5.0 %)	16690 ev
test_0004.lmd	50.7 MB (5.1 %)	17024 ev
test_0004.lmd	51.8 MB (5.2 %)	17358 ev
test_0004.lmd	52.6 MB (5.3 %)	17691 ev
test_0004.lmd	53.6 MB (5.4 %)	18025 ev
test_0004.lmd	54.6 MB (5.5 %)	18358 ev
test_0004.lmd	55.6 MB (5.6 %)	18692 ev
test_0004.lmd	56.6 MB (5.7 %)	19026 ev
test_0004.lmd	57.6 MB (5.8 %)	19360 ev
test_0004.lmd	58.6 MB (5.9 %)	19694 ev
test_0004.lmd	59.6 MB (6.0 %)	20028 ev
test_0004.lmd	60.6 MB (6.1 %)	20362 ev
test_0004.lmd	61.6 MB (6.2 %)	20695 ev
test_0004.lmd	62.6 MB (6.3 %)	21029 ev
test_0004.lmd	63.6 MB (6.4 %)	21363 ev
test_0004.lmd	64.6 MB (6.5 %)	21697 ev
test_0004.lmd	65.5 MB (6.6 %)	22030 ev
test_0004.lmd	66.5 MB (6.7 %)	22364 ev
test_0004.lmd	67.5 MB (6.8 %)	22698 ev
test_0004.lmd	68.5 MB (6.9 %)	23032 ev
test_0004.lmd	69.5 MB (7.0 %)	23366 ev
test_0004.lmd	70.5 MB (7.1 %)	23699 ev
test_0004.lmd	71.5 MB (7.2 %)	24033 ev
test_0004.lmd	72.5 MB (7.3 %)	24367 ev
test_0004.lmd	73.5 MB (7.3 %)	24701 ev
test_0004.lmd	74.5 MB (7.4 %)	25034 ev
test_0004.lmd	75.5 MB (7.5 %)	25368 ev
test_0004.lmd	76.5 MB (7.6 %)	25701 ev
test_0004.lmd	77.5 MB (7.7 %)	26035 ev
test_0004.lmd	78.5 MB (7.8 %)	26368 ev

Stopped file
Close file test_0004.lmd

Rates display
100 Trending history

/PEXOR/PexReadout/PexorEvents

/PEXOR/PexReadout/PexorData

Di 31 Mär 2015 12:32:41 CEST > Stop DABC command sent.

POLAND frontend web gui

The screenshot shows the POLAND web GUI interface. At the top, there's a menu bar with File, Edit, View, History, Bookmarks, Tools, and Help. Below it is a browser address bar showing the URL 'dep418:8095/GOSIP/Test/UI/'. The main interface is divided into several sections:

- Top Control Panel:** Includes buttons for SFP (set to 0), DEV (set to 0), All Devs, ScanOffset, InitChain, Reset, and Reset PEX.
- Right Panel:** Features a green 'Trigger ON' button, a 'Trigger...' button, and a 'QFW Counters' section showing 'Trigger' as '0x15' and 'Errors' as a list of hex values (0x8, 0x1, 0x1, 0x1, 0x1, 0x1, 0x0). There's also a 'Hexmode' button.
- Main Content Area:** Displays 'SFP:0 DEV:0 - Di 27 Jan 2015 14:12:51 CET >Dump data OK'. It has tabs for 'QFW' and 'DAC'. Under 'QFW', there are checkboxes for 'Trigger Master' (checked), 'Internal Trigger' (checked), and 'FESA Mode' (unchecked). A dropdown menu shows '(+) [2.5pF & 0.25pC]'. Below this is a table with columns 'Step' and 'Time per Step [mus]':

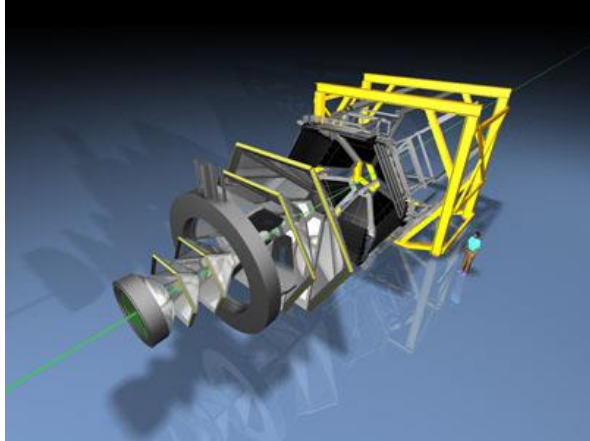
	Step	Time per Step [mus]
Time slice 1	0x3	56.08
Time slice 2	0x5	56.08
Time slice 3	0x2	56.08

Below the table is a list of SFP data entries:

```
SFP: 0x0 Module: 0x0 Address: 0x5bc Data: 0xd
SFP: 0x0 Module: 0x0 Address: 0x5c0 Data: 0xaa
SFP: 0x0 Module: 0x0 Address: 0x5c4 Data: 0xbb
SFP: 0x0 Module: 0x0 Address: 0x5c8 Data: 0xcc
SFP: 0x0 Module: 0x0 Address: 0x5cc Data: 0xdd
SFP: 0x0 Module: 0x0 Address: 0x5d0 Data: 0xaaa
SFP: 0x0 Module: 0x0 Address: 0x5d4 Data: 0xbbb
SFP: 0x0 Module: 0x0 Address: 0x5d8 Data: 0xccc
SFP: 0x0 Module: 0x0 Address: 0x5dc Data: 0xddd
SFP: 0x0 Module: 0x0 Address: 0x5e0 Data: 0xaaaa
SFP: 0x0 Module: 0x0 Address: 0x5e4 Data: 0xbbbb
SFP: 0x0 Module: 0x0 Address: 0x5e8 Data: 0xcccc
SFP: 0x0 Module: 0x0 Address: 0x5ec Data: 0xdddd
SFP: 0x0 Module: 0x0 Address: 0x5f0 Data: 0xaaaaa
SFP: 0x0 Module: 0x0 Address: 0x5f4 Data: 0x8badbad8
SFP: 0x0 Module: 0x0 Address: 0x5f8 Data: 0xaaffaaff
SFP: 0x0 Module: 0x0 Address: 0x5fc Data: 0x27
```

At the bottom, there are buttons for Show, Apply, Configure, DataDump, and Clear. A tooltip over the DataDump button reads 'Dump main register contents of selected device'.

HADES detector



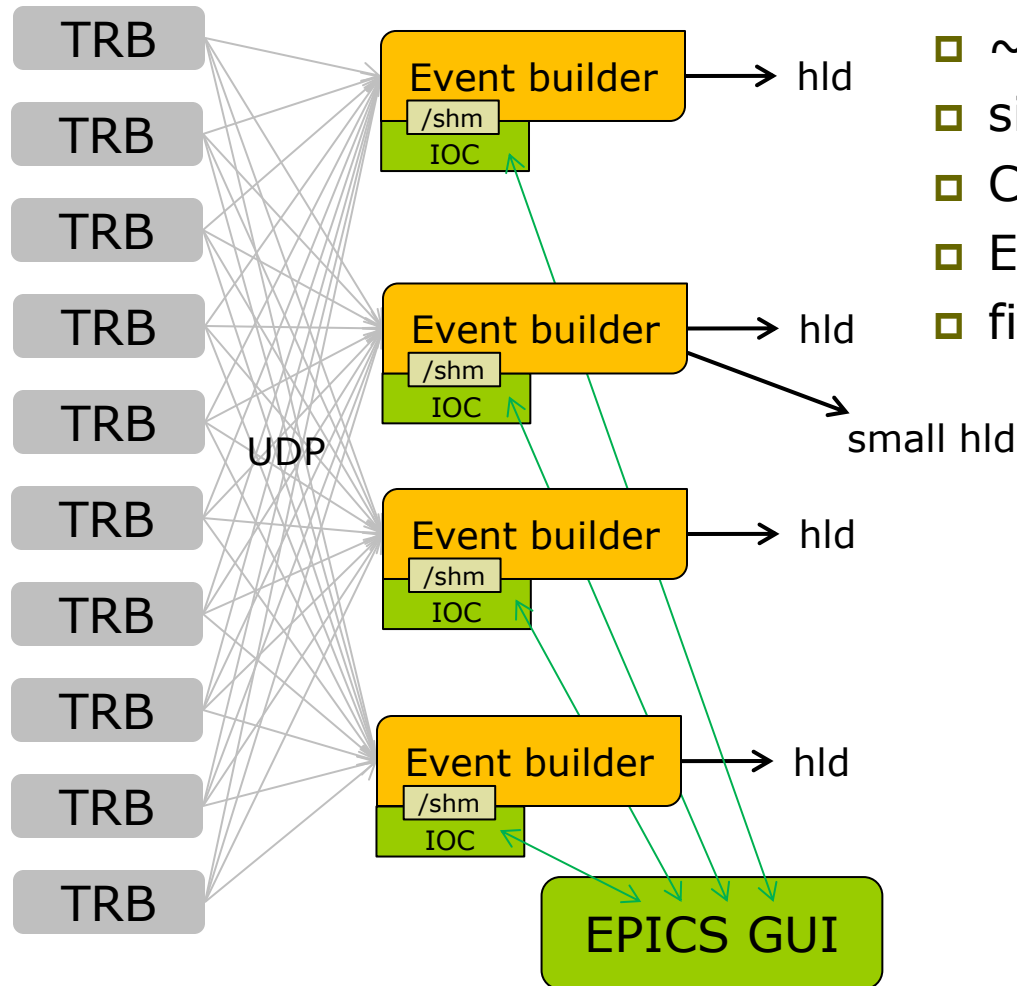
<http://www-hades.gsi.de>



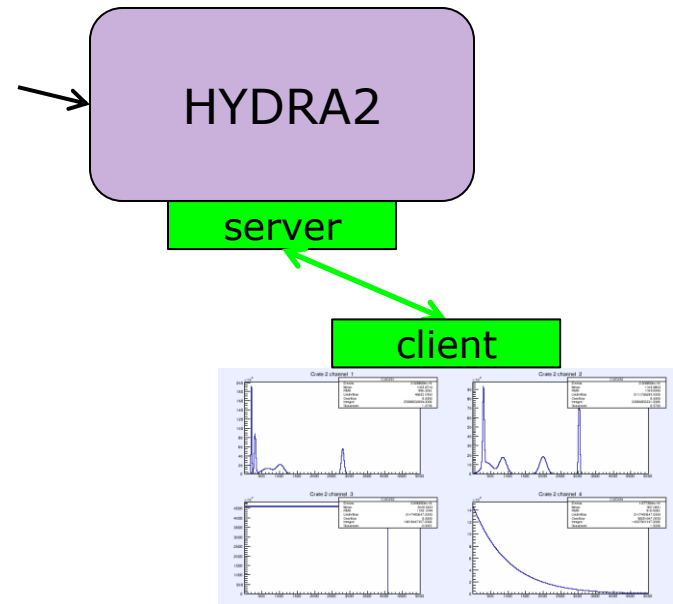
<http://blogs.helmholtz.de>

HADES is a versatile detector for a precise spectroscopy of e^+e^- pairs (di-electrons) and charged hadrons produced in proton, pion and heavy ion induced reactions in a $1 \div 3.5$ GeV kinetic beam energy region

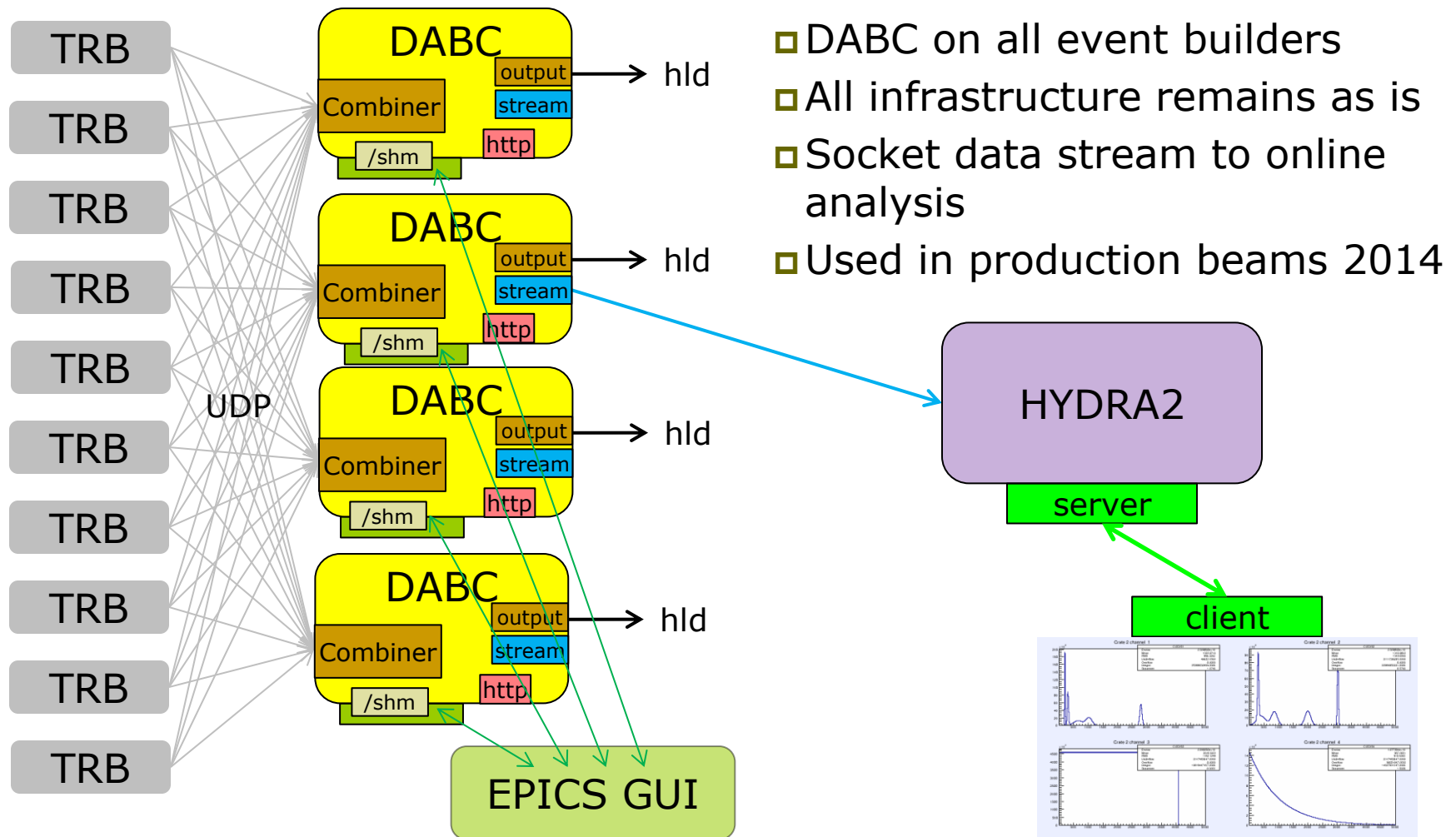
HADES DAQ before



- ~30 TRB frontend boards
- ~10 KHz, max 300 MB/s
- simple round-robin approach
- C-based, single thread code
- EPICS IOCs for DAQ slow control
- file-based quality monitoring



HADES DAQ now

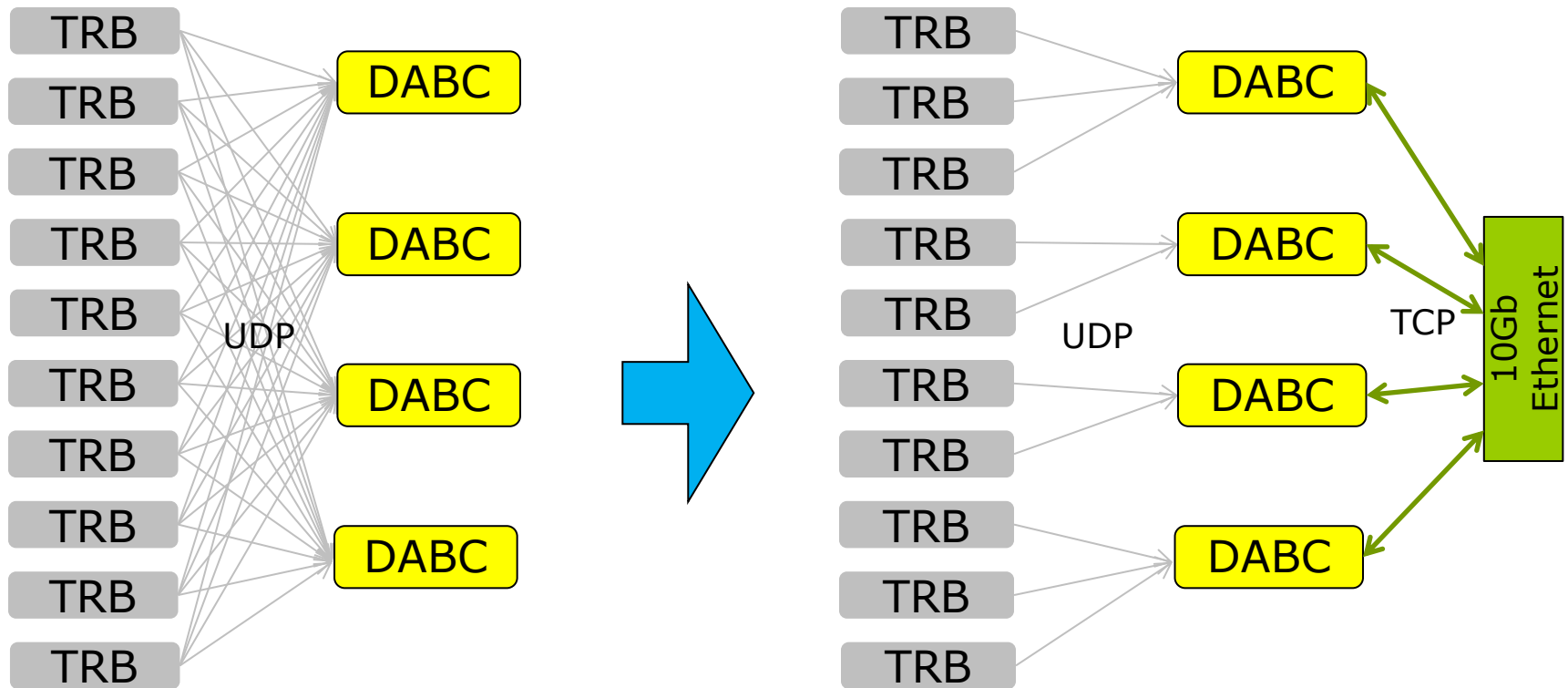


HADES DAQ upgrade

- ❑ New RICH and ECAL electronic
 - more than 100 TRBs (30 up to now)
- ❑ Use in many places FPGA TDCs
 - need for special calibration procedure
- ❑ Potentially free-running readout for RICH
 - need to produce subevents afterwards

- ❑ HLD data format should be preserved

Change networking topology



- All data from single TRB always send to same DAQ node
- Every DAQ node can perform TDC calibration and event selection immediately
- Event building done afterwards with TCP/IP or IB

Next plans

- ❑ FPGA TDCs calibrations in DABC
 - already done, including web control GUI
- ❑ Event building network (BNet) for HADES
 - planned as v3 release, end of 2015
- ❑ Accommodate C++11 features
 - native threads, references
 - probably as v4 in ~2017

Conclusion

- ❑ Flexible framework for different DAQ tasks
- ❑ Web and JSROOT as user interface
- ❑ Used in different test beams
- ❑ Production DAQ for HADES experiment