

EPICS⁽³⁺⁴⁼⁼⁷⁾ on RTEMS 4.12

(Within the scope of CRYVISIL)

May 16th, 2017

H. Junkes, M. Heyde, P. Marschalik
Fritz-Haber-Institute, Berlin, Germany

Why?

Scientific background

- ✦ Project CRYVISIL(*) (to resolve glass dynamics)
 - ✦ build up of a very high speed scanning tunneling microscope (VHS-STM)
 - ✦ High data rate (up to 100 MByte/s for ~5hrs)
 - ✦ EPICS Control System with VMEbus

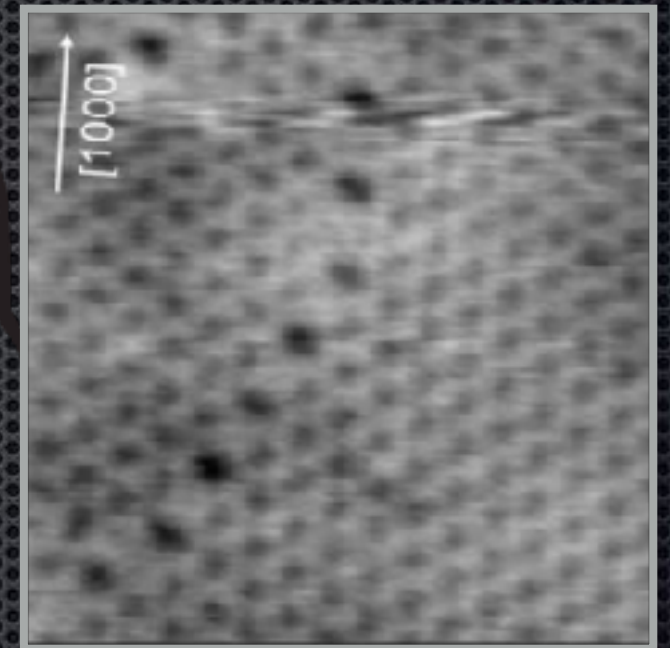
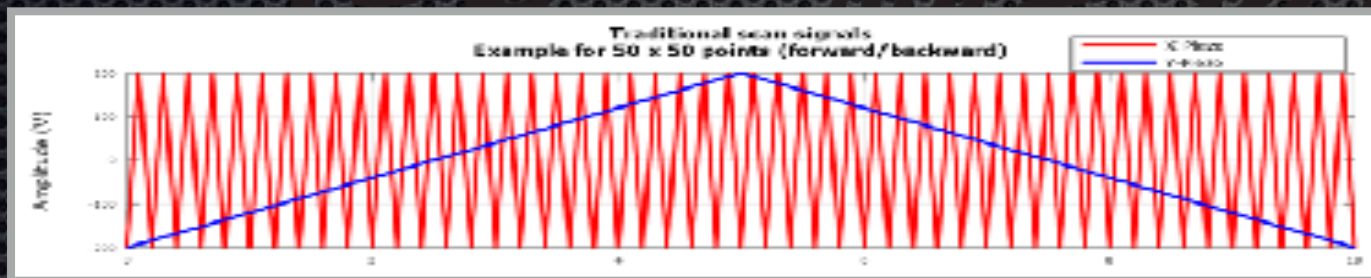
(*)This project has received funding from the European Research Council (ERC) under the European Union's Advanced Grant (AdG), 2014, ERC-2014-ADG



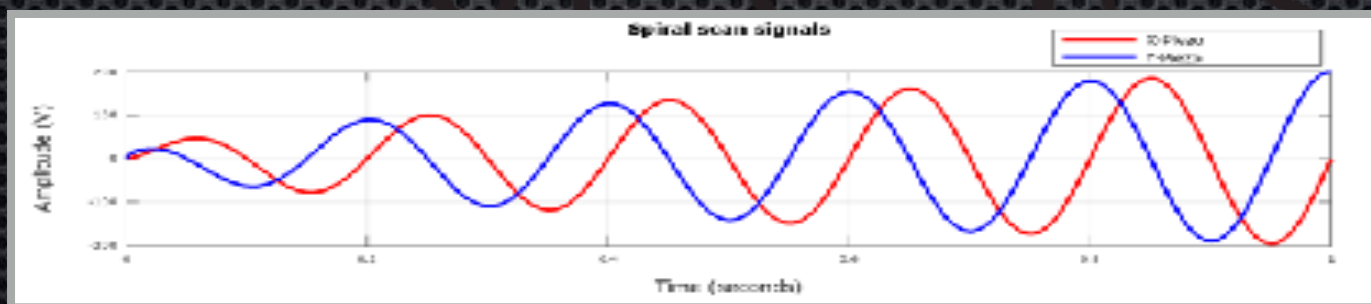
Why?

Scientific background

- ✦ STM tip driven by piezo actuators
- ✦ traditional scanning (sawtooth for x-y)

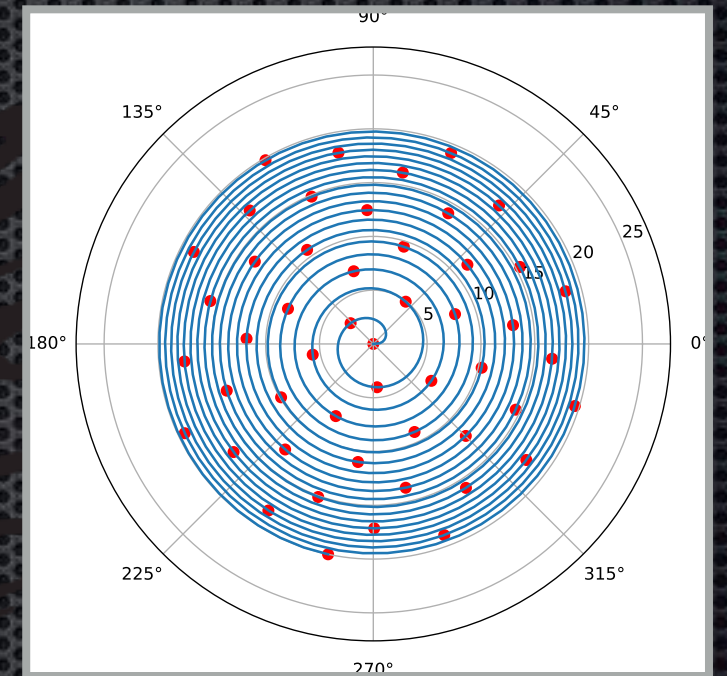
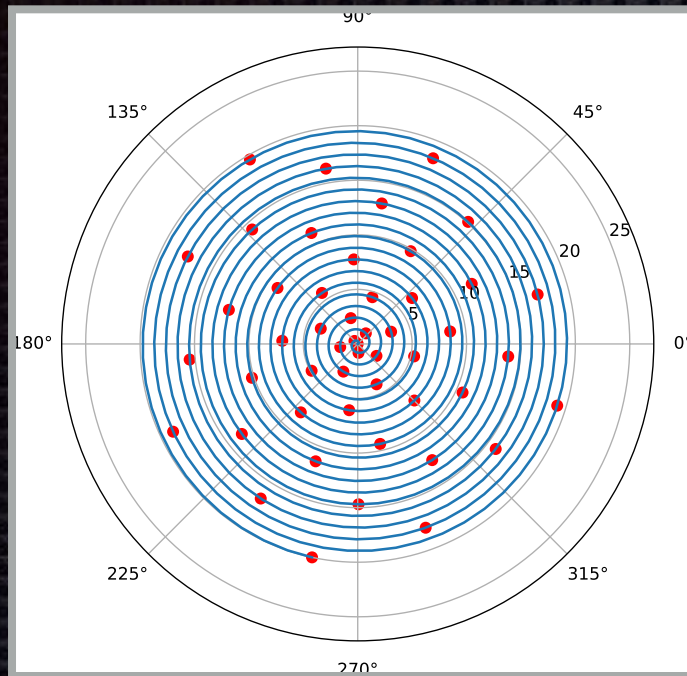


- ✦ reverse movement at high speed leads to distortion
- ✦ new scanning with spirals



Why?

Scientific background



Archimedean spiral

Fermat's spiral

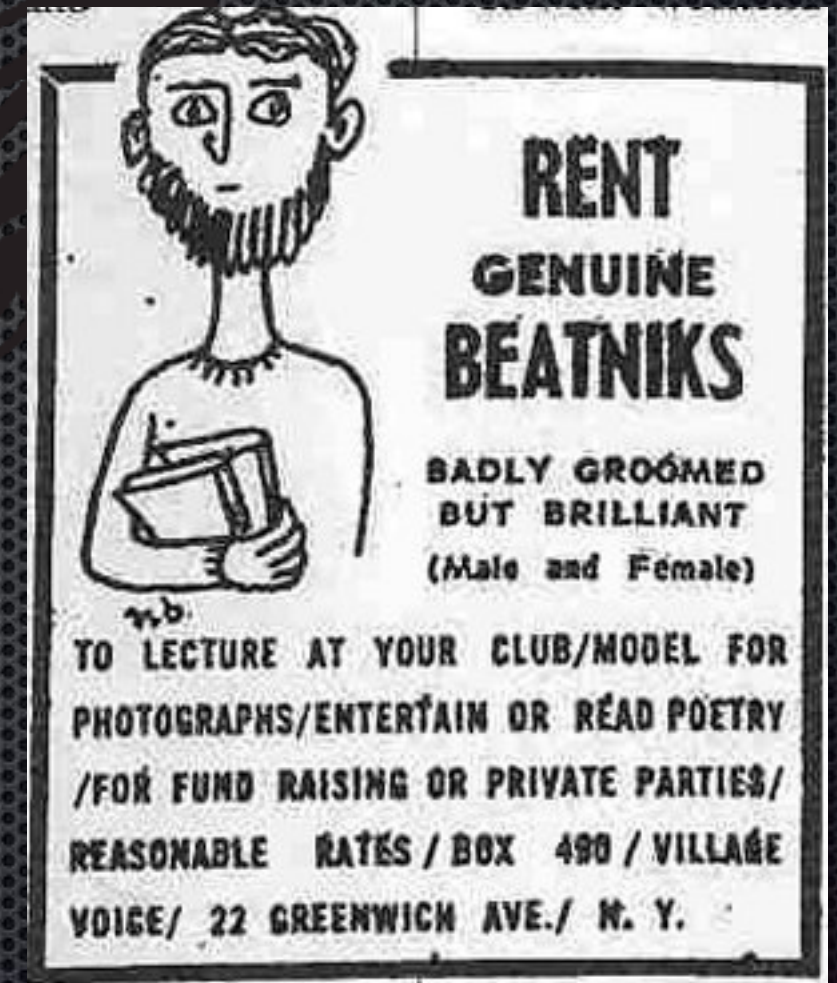


Decisions made

- ✦ EPICS framework, CSS as operator interface
- ✦ high density and/or fast I/O -> VMEbus, RTEMS
- ✦ all other systems should run Unix as OS
- ✦ integration of vendor locked Labview system (SPECS, Windows OS)
- ✦ must include archiver, snapshots, backup
- ✦ internetworking with Ethernet/IP, GigE-Cameras

Implementation

- EPICS R3.16.0.1-DEV,
CSS 4.x with BOY as operator interface
- MVME6100 CPU (beatnik),
VMEbus, rtems-4.11.99.0 (aka 4.12)
- Unix-Server (DELL) with Ubuntu OS
- LabView-CA-interface, archiver-appliance
- NetApp - Storage, TSM Backup
- development of own devices: HV - amplifier

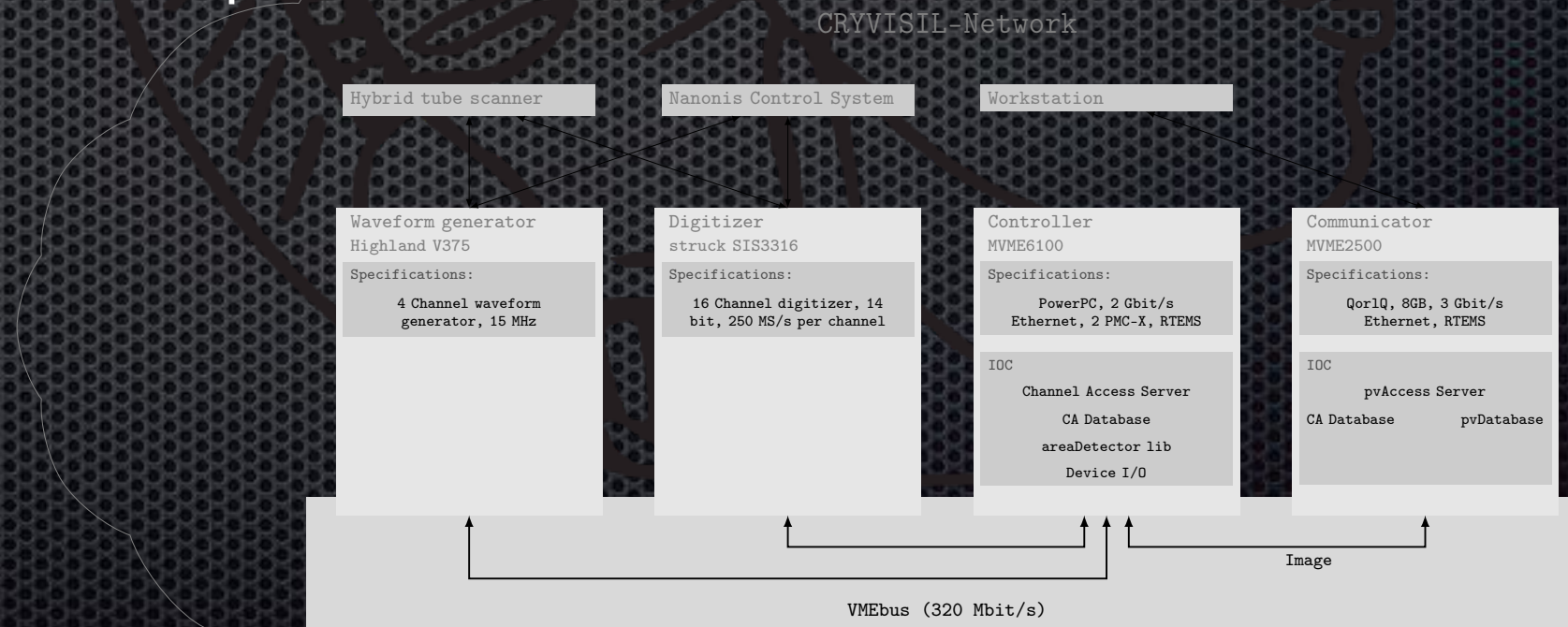


VMEbus based control system

- ✦ MVME6100 (MPC7457) as main cpu, rtems-4.11.99.0 (will become 4.12)
- ✦ MVME2500 (QorIQ P2020) as communication cpu, rtems-4.11.99.0 (will become 4.12)
- ✦ Highland V375 arbitrary waveform generator
- ✦ SIS3316 Digitizer, 14bit, 16 channel, 250 MSample/s
- ✦ Wiener Crate 6U VME 395 Mini with CML Shelf Manager

EPICS v3 + v4

- ✦ EPICSv3 with channelAccess does not meet the requirements e.g. data rate
- ✦ EPICSv4 (bundleCPP 4.6.x) must be used
- ✦ Strong use of e.g. C11 smart pointers
- ✦ Modern compilers needed



RTEMS why new Version

- ✦ To meet the requirements high network data rate necessary
- ✦ Multiple 1 Gbit/s Ethernet interfaces must be controlled simultaneously
- ✦ Multiple CPU's with multiple cores must be handled
- ✦ Need SMP support

EPICS for RTEMS 4.12

- MVME6100 (beatnik), bsp included in rtems build (*)
`../rtems/configure --enable-maintainer-mode --prefix=/home/rtems/RTEMS/rtems-4.12 --target=powerpc-rtems4.12 --enable-rtemsbsp="beatnik" --enable-posix --enable-cxx --enable-networking`
- MVME2500 (QorIQ P2020), bsp included in rtems build (*)
`--enable-rtemsbsp="QorIQ"`
- RTEMS closely corresponds to POSIX Profile 52 (single process, threads, filesystem)
- includes a port of the FreeBSD TCP/IP stack, NFS
- SMP (Symmetric Multiprocessing) extension in 4.12 available

(*) Thanks to Sebastian Huber, embedded brains

EPICS for RTEMS 4.12

- ✦ Beginning with rtems $\geq 4.11.99$ we will use as much as possible from the posix path in `src/libCom/osi/os`
 - ✦ mainly added `osdMessageQueue.[h cpp]`
 - ✦ some changes to existing `posix/osdPosix.cpp`
 - ✦ using `_Thread_local` as a replacement for `posix_key`'s as thread local data storage

EPICS for RTEMS 4.12

- ✦ Build system supports “extended” OS_CLASS’s

```
#-----  
# operating system class (include/os/<os_class>)  
OS_CLASS = RTEMS  
#-----  
# operating system API (src/os/<os_class>-<os_api>)  
OS_API_4.7 = kernel  
OS_API_4.8 = kernel  
OS_API_4.9 = kernel  
OS_API_4.10 = kernel  
OS_API_4.11 = $(error RTEMS-4.11 is not currently supported)  
# Later RTEMS versions will use posix, no need to specify  
OS_API = $(firstword $(OS_API_$(RTEMS_SERIES)) posix)
```


EPICS for RTEMS 4.12

- ✦ open issues
 - ✦ intensive tests so far only for powerPC (beatnik bsp)
 - ✦ C11 threads support is not yet common
 - ✦ can't test it on i386, C++ atomics on i386 is broken or fragile
 - ✦ binding to loopback and multicast addresses
 - ✦ need more test on other platforms
 - ✦ registers in exception frame
- ✦ not yet merged into base

EPICS for RTEMS 4.12

- ✧ works in our environment ...
 - ✧ asyn, autosave
 - ✧ Control System Studio
 - ✧ archiver appliance
 - ✧ python
- ✧ stable and reliable so far

IOCCryvisil> epicsThreadShowAll

NAME	EPICS ID	PTHREAD ID	OSIPRI	OSSPRI	STATE	STACKSIZE
main	0x36aff0	0x0B010001	91	191	OK	16384
errlog	0xa7af98	0x0B010003	10	110	OK	16384
timerQueue	0xa87038	0x0B010004	60	160	OK	32768
timerQueue	0xa87598	0x0B010005	60	160	OK	32768
awgport update	0xa88f00	0x0B010007	51	151	OK	16384
timerQueue	0xe11620	0x0B010009	70	170	OK	32768
cbLow	0xe11840	0x0B01000A	59	159	OK	65536
cbMedium	0xe11a80	0x0B01000B	64	164	OK	65536
cbHigh	0xe11cc0	0x0B01000C	71	171	OK	65536
dbCaLink	0xe0cce8	0x0B01000D	50	150	OK	65536
taskwd	0xe0d180	0x0B010008	10	110	OK	16384
scanOnce	0xe77100	0x0B01000E	67	167	OK	65536
scan-10	0xe87548	0x0B01000F	60	160	OK	65536
scan-5	0xe97748	0x0B010010	61	161	OK	65536
scan-2	0xea7948	0x0B010011	62	162	OK	65536
scan-1	0xeb7b48	0x0B010012	63	163	OK	65536
scan-0.5	0xec7d48	0x0B010013	64	164	OK	65536
scan-0.2	0xed7f48	0x0B010014	65	165	OK	65536
scan-0.1	0xee8148	0x0B010015	66	166	OK	65536
CAS-TCP	0xefce50	0x0B010016	18	118	OK	32768
CAS-UDP	0xf05038	0x0B010017	16	116	OK	32768
CAS-UDP2	0xf1dd90	0x0B010018	16	116	OK	32768
CAS-beacon	0xf36528	0x0B010019	17	117	OK	16384

gonzo> epicsThreadShowAll

NAME	EPICS ID	PTHREAD ID	OSIPRI	OSSPRI	STATE	STACKSIZE
main	0x4e8c40	0x0B010001	91	191	OK	16384
errlog	0xbfcf28	0x0B010003	10	110	OK	16384
timerQueue	0xc68b60	0x0B010005	70	170	OK	32768
cbLow	0xc68d80	0x0B010006	59	159	OK	65536
cbMedium	0xc68fc0	0x0B010007	64	164	OK	65536
cbHigh	0xc69200	0x0B010008	71	171	OK	65536
dbCaLink	0xc69c88	0x0B010009	50	150	OK	65536
scanOnce	0xc6bae8	0x0B01000A	67	167	OK	65536
scan-10	0xc6bdd0	0x0B01000B	60	160	OK	65536
scan-5	0xc6bfc8	0x0B01000C	61	161	OK	65536
scan-2	0xc0be68	0x0B01000D	62	162	OK	65536
scan-1	0xc0c028	0x0B01000E	63	163	OK	65536
scan-0.5	0xc0c208	0x0B01000F	64	164	OK	65536
scan-0.2	0xc0c3e8	0x0B010010	65	165	OK	65536
scan-0.1	0xc0c5e0	0x0B010011	66	166	OK	65536
taskwd	0xc68648	0x0B010004	10	110	OK	16384
CAS-TCP	0xd435f0	0x0B010012	18	118	OK	32768
CAS-UDP	0xd4b7d8	0x0B010013	16	116	OK	32768
CAS-UDP2	0xd64530	0x0B010014	16	116	OK	32768
CAS-beacon	0xd7ccc8	0x0B010015	17	117	OK	16384
ntndarrayServer	0xdc0590	0x0B010016	90	190	OK	16384
ntndarrayServer	0xe03590	0x0B010017	90	190	OK	16384
TCP-acceptor	0xe151b0	0x0B010019	50	150	OK	32768
pvAccess-server	0xe106a0	0x0B010018	25	125	OK	16384
UDP-rx 0.0.0.0:0	0xe3dc18	0x0B01001A	50	150	OK	16384
UDP-rx 0.0.0.0:5	0xe865a8	0x0B01001B	50	150	OK	16384
UDP-rx 0.0.0.0:5	0xe8a838	0x0B01001C	50	150	OK	16384
UDP-rx 224.0.0.1	0xeb2ee8	0x0B01001D	50	150	OK	16384
startPVAServer	0xf32890	0x0B01001E	50	150	OK	65536