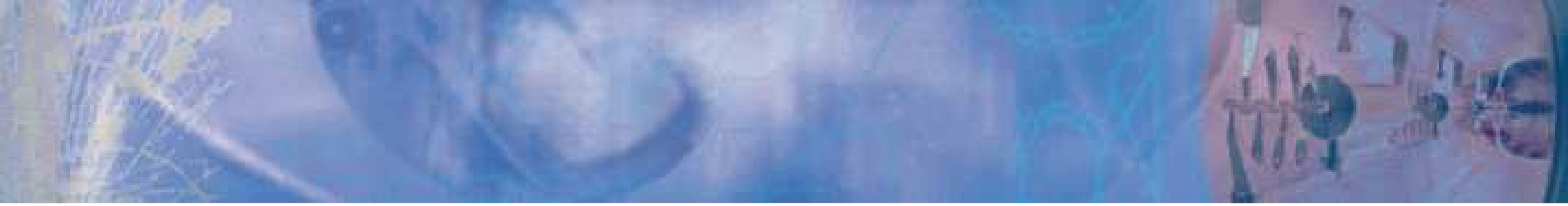


EPICS synergies and showcases

Peter Zumbruch

Experiment control systems group GSI

(KS/EE)

Outline

Synergies

- EPICS
  - Collaborative development
- Users @ FAIR (outlook)
  - HADES
    - ETRAX
    - Fully controlled
  - PANDA
    - MonAlisa
  - CBM
    - Virtex4/5
  - NUSTAR (HV)
    - Haik Simon

Showcases

- New mature developments
  - CSS
  - DAL (cosylab)
  - Java Client/Server (cosylab)
- Interfaces / Platforms
  - LabView
  - DIM
  - ETRAX
  - Virtex 4/5

Synergies

EPICS ...

What is EPICS?

… **short answer**:

*EPICS: **E**xperimental **P**hysics and **I**ndustrial **C**ontrol **S**ystem*

… **a bit more elaborate**:

EPICS is a set of Open Source software tools, libraries and applications developed collaboratively and used worldwide to create distributed soft real-time control systems for scientific instruments such as particle accelerators, telescopes and other large scientific experiments. (From the EPICS Home Page: http://www.aps.anl.gov/epics/)

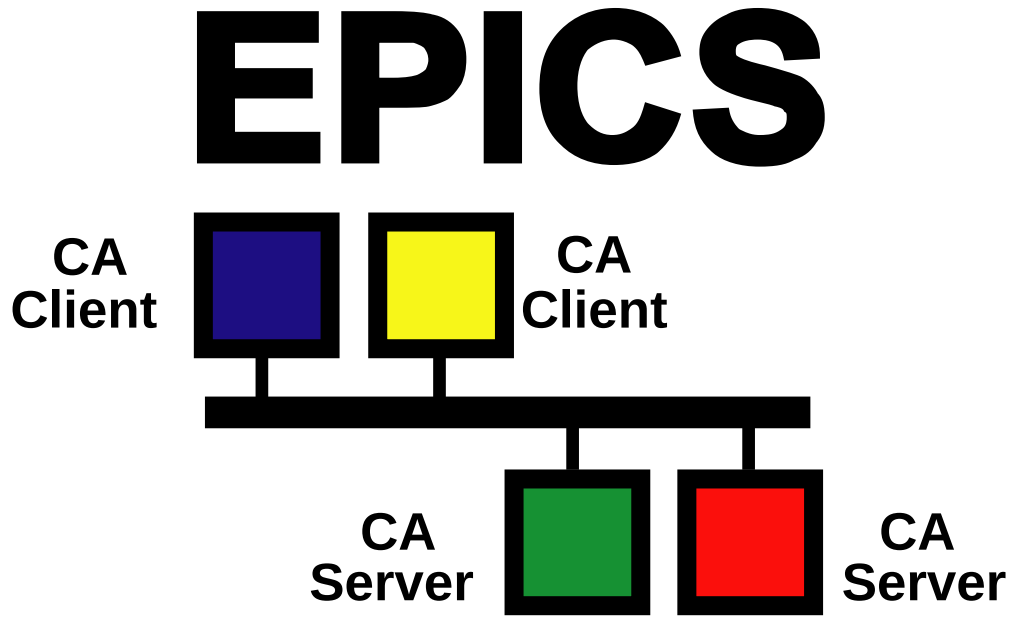
… ***striking*** - is three things at once:

- A ***collaboration*** of major scientific laboratories and industry (> 100)
  - A world wide collaboration that shares designs, software tools and expertise for implementing large-scale control systems
- An ***architecture*** for building scalable control systems
  - A client/server model with an efficient communication protocol (Channel Access) for passing data
  - The entire set of Process Variables establish a Distributed Real-time Database of machine status, information and control parameters
- A ***Software Toolkit*** of Open Source code and documentation
  - A collection of software tools collaboratively developed which can be integrated to provide a comprehensive and scalable control system

What is EPICS? *(Getting Started with EPICS: Introductory Session I)*

A Control System Architecture

Network-based "client/server" model (hence the EPICS logo)



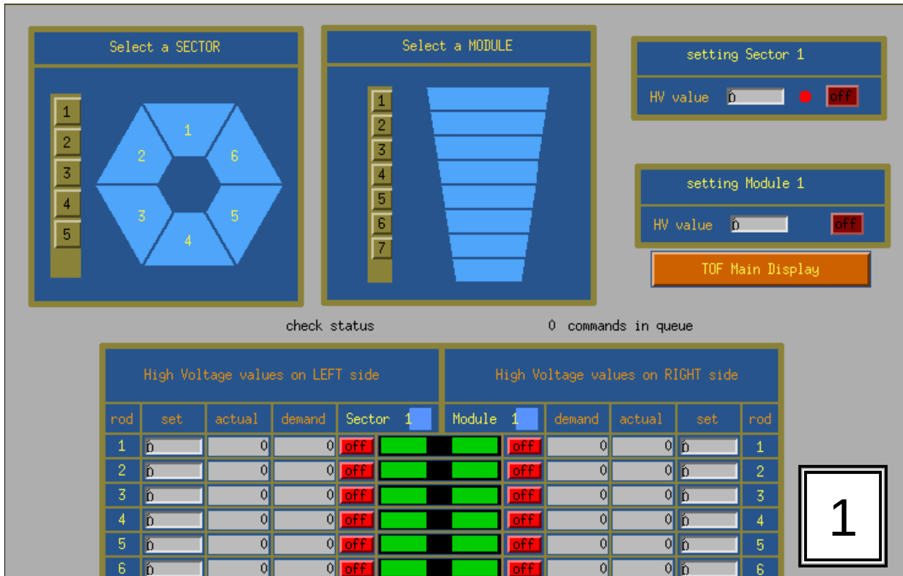
For EPICS, *client* and *server* speak of their Channel Access role

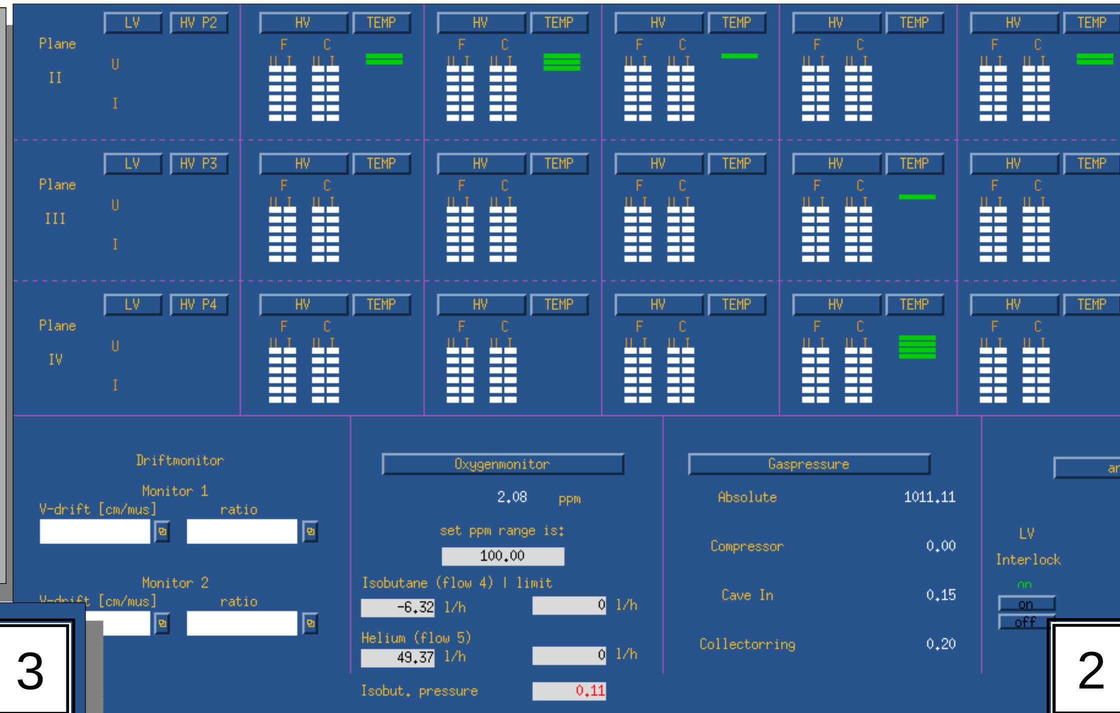
i.e. Channel Access Client & Channel Access Server

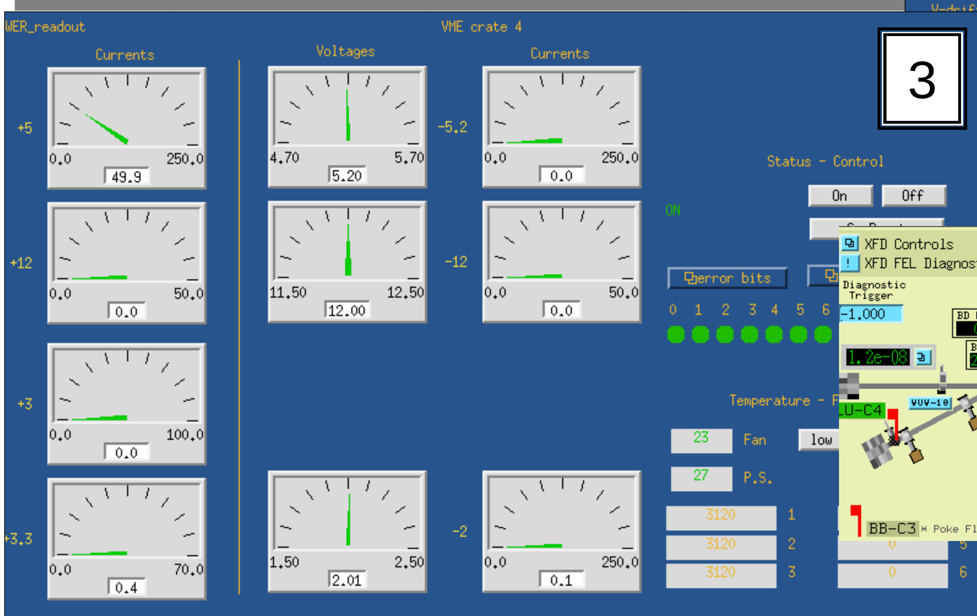
… basics

- Server: (soft) IOC
  - Provides Process Variables (PV), i.e. EPICS records to the network system
  - Using Channel Access as protocol
  - Connects to real or virtual devices
  - sources („driver“, application), EPICS Database and/or sequencer code
- Clients
  - GUIs and „other“ application which talk channel access and can therefore access PVs
- Each Server can also act as a client
- Knowledge / collaboration => Synergy

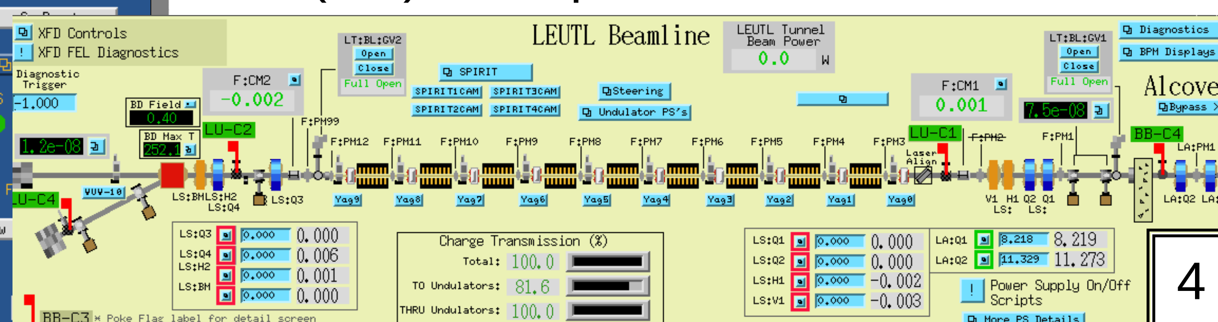
Displays and Controls





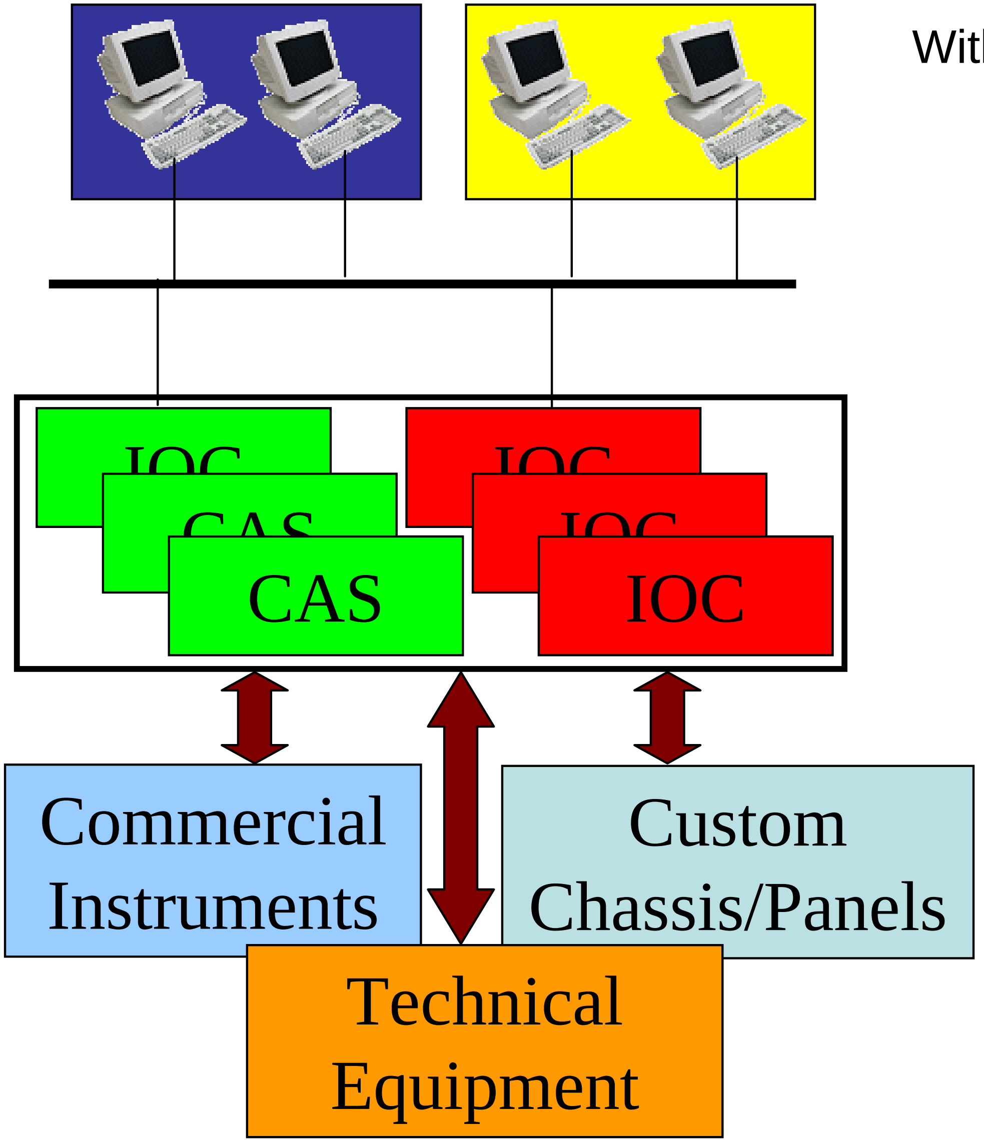


(1-3) Examples from HADES



Typical Realizations of an EPICS System

(Getting Started with EPICS: Introductory Session I)



With Release 3.14, the operating system limitations for iocCore have been removed.

So What Does it Do?

- EPICS tools are available to accomplish almost any typical Distributed Control System (DCS) functionality, such as:
  - Remote Control & Monitoring of Technical Equipment
  - Data Conversion/Filtering
  - Access Security
  - Equipment Operation Constraints
  - Alarm Detection/Reporting/Logging
  - Data Trending/Archiving/Retrieval/Plotting
  - Automatic Sequencing
  - Mode & Facility Configuration Control (save/restore)
  - Modeling/Simulation
  - Data Acquisition
  - Data Analysis

Ten really neat things about EPICS

(Getting Started with EPICS: Introductory Session I)

- It's free
- It's Open Source
- There are lots of users
- All a client needs to know to access data is a PV name
- You can pick the best tools out there …
- … or build your own
- The boring stuff is already done
- There is a lot of expertise available close by
- A good contribution becomes internationally known
- By following a few simple rules, you get a lot for free

Showcases

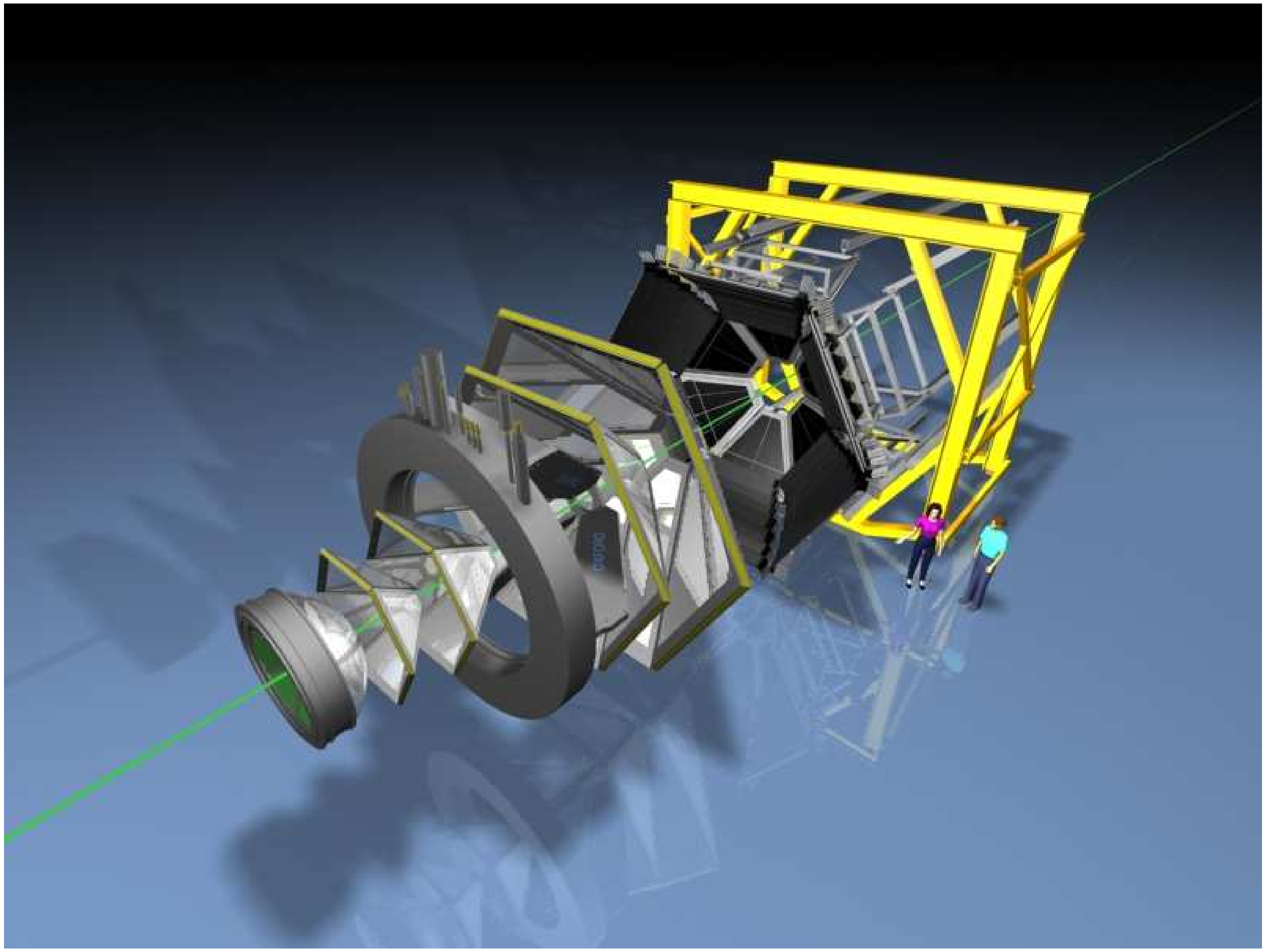
HADES

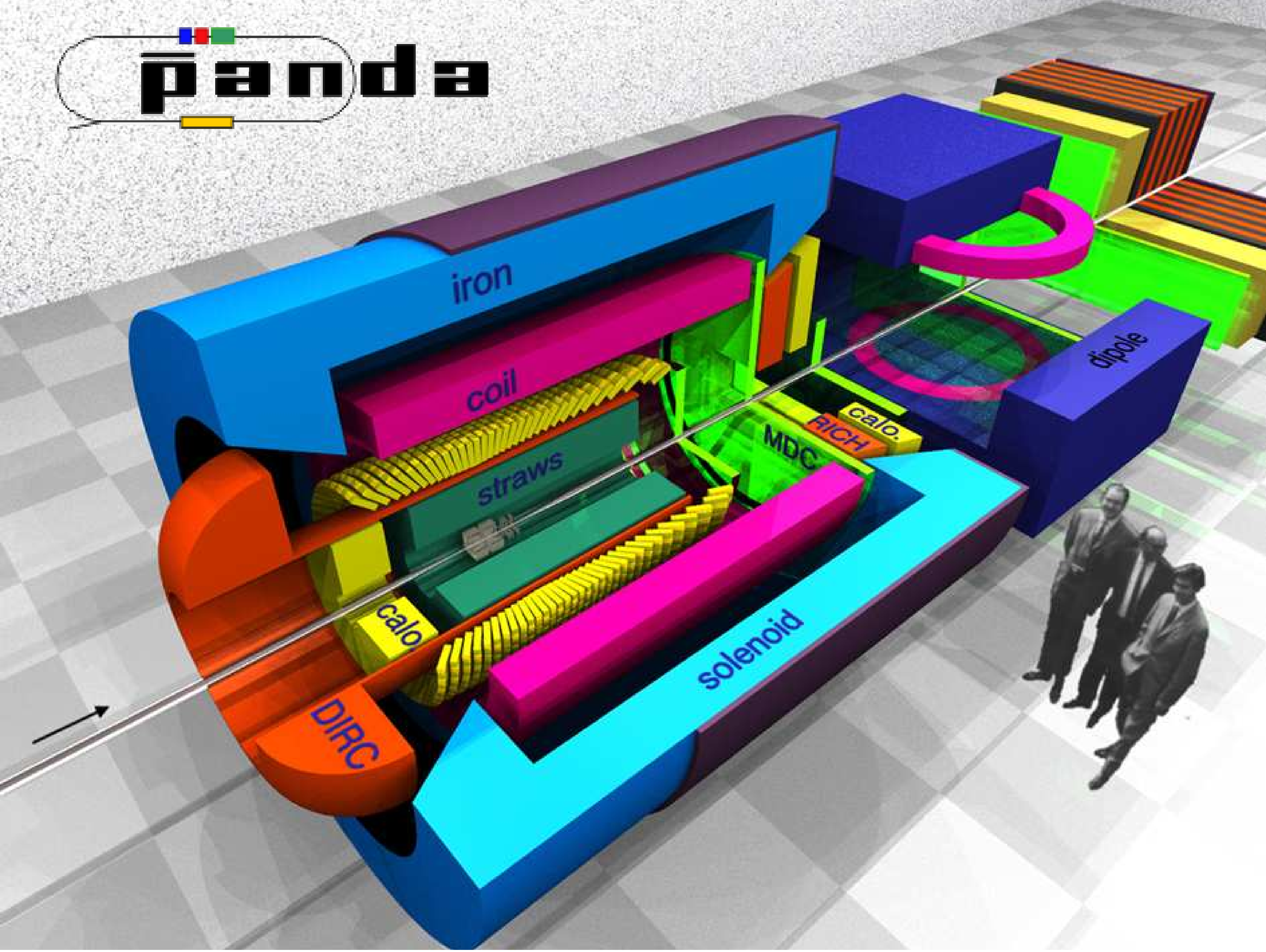
High **A**cceptance
Di**E**lectron
Spectrometer

fully EPICS controlled (B.Kolb), running experiment

~ 80,000
physical channels

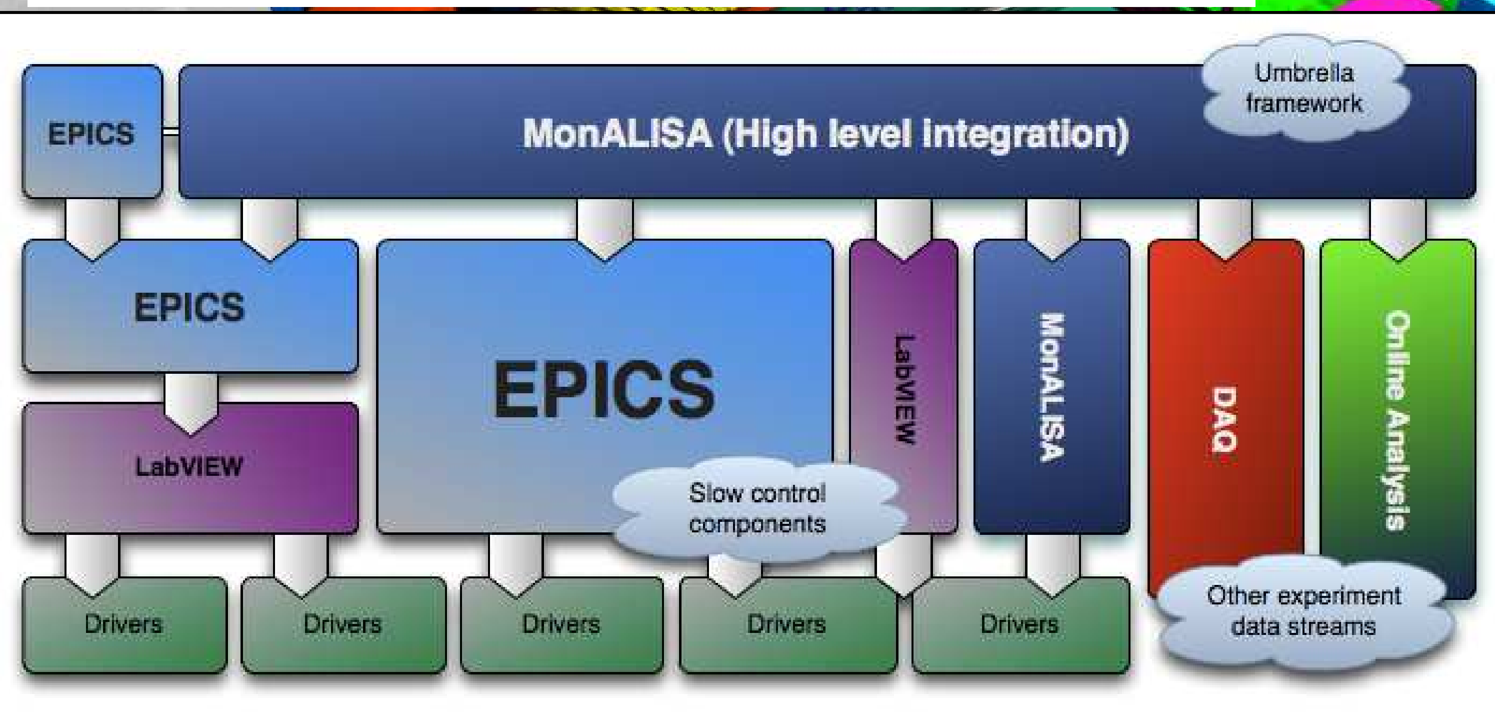
~ 10,000 PV
HV, LV, Temp, Gasquality, SPS, Thresholds, Scaler

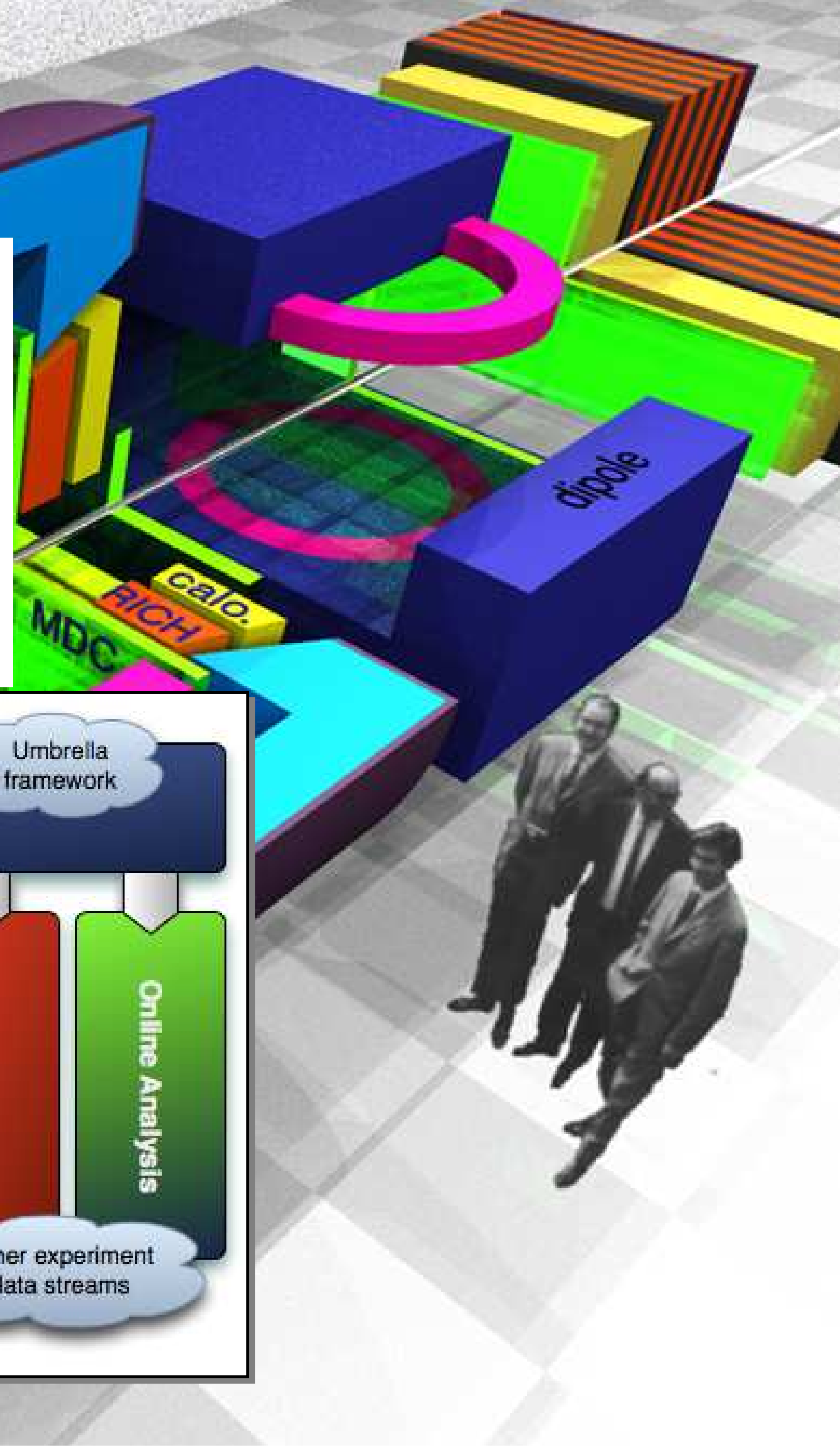



iron
coil
straws
calo
DIRC
solenoid
MDC
RICH
calo.
dipole

DCS framework structure

It is very likely that the PANDA DCS will be a combination of various specialized systems integrated via a high-level framework. MonALISA would be the umbrella system that would aggregate the data streams from slow controls, DAQ and online analysis.





MonALISA

MONitoring Agents using a Large Integrated Services Architecture

MonALISA, which stands for Monitoring Agents using a Large Integrated Services Architecture, has been developed over the last four years by Caltech and its partners with the support of the U.S. CMS software and computing program.

The framework is based on Dynamic Distributed Service Architecture and is able to provide complete monitoring, control and global optimization services for complex systems.

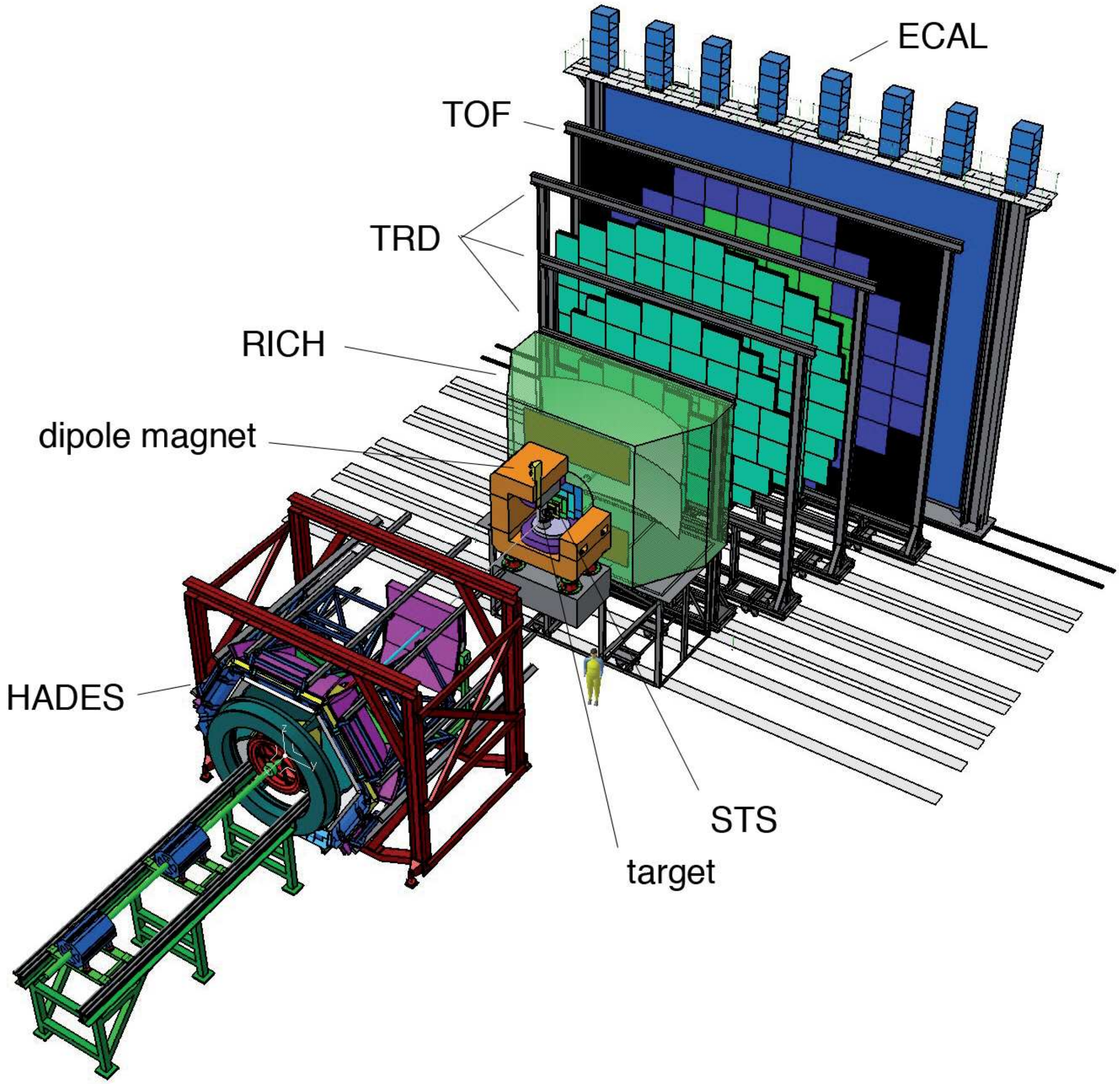
The MonALISA system is designed as an ensemble of autonomous multi-threaded, self-describing agent-based subsystems which are registered as dynamic services, and are able to collaborate and cooperate in performing a wide range of information gathering and processing tasks. These agents can analyze and process the information, in a distributed way, to provide optimization decisions in large scale distributed applications. An agent-based architecture provides the ability to invest the system with increasing degrees of intelligence, to reduce complexity and make global systems manageable in real time. The scalability of the system derives from the use of multithreaded execution engine to host a variety of loosely coupled self-describing dynamic services or agents and the ability of each service to register itself and then to be discovered and used by any other services, or clients that require such information. The system is designed to easily integrate existing monitoring tools and procedures and to provide this information in a dynamic, customized, self describing way to any other services or clients.

from http://monalisa.cern.ch/monalisa.html

<u>Workshop Glasgow with MonALISA developers January 2008</u>

- Basic tests for communication between EPICS and ML (perl based)
- Future: EPICS device support ?

CBM



CBM Slow control

“Heir“ of HADES (B.Kolb, responsible for control)
therefore EPICS foreseen.

Plans to have EPICS running on FPGAs (Virtex4) on FEE cards

- To reload parts FPGA data
- Status and monitoring

⇒ FPGA project by EE/KS (me) (Thanks to Vic maybe soon advancing “my own synergy“

⇒ Planned channels ~10^7-10^8

⇒ Expected PVs ~10^6

Experiments @ FAIR

Experi-ment	Scientific Area	Research Program	Technical Facility	Mem-bers	Insti-tutes
R3B	NUSTAR	Nuclear reactions in inverse kinematics reaction studies with relativistic radioactive ion beams	Large reaction set-up allowing complete kinematics reaction experiments	178	54
HISPEC / DESPEC	NUSTAR	High resolution, high efficiency particle and gamma spectroscopy of nuclei far off stability	State-of-the-art γ detectors (AGATA) plus set-ups for charged particle and neutron detection	89 / 62	52 / 34
LASPEC	NUSTAR	Laser spectroscopy of radioactive ion species	Multi-purpose laser spectroscopy station	33	15
MATS	NUSTAR	High precision, high efficiency mass and life-time measurements on radioactive nuclei	Combined set-up of an electron beam ion trap (for charge breeding), ion traps (for beam preparation) and a precision Penning trap system.	64	22
ILIMA	NUSTAR	Mass and lifetime measurements of stored and cooled radioactive ion beams	Devices for Schottky mass and isochronous mass spectroscopy at CR/NESR	73	23
EXL	NUSTAR	Inverse kinematics light ion reactions on radioactive nuclei	In-ring reaction set-up to be installed at the NESR	134	39
AIC	NUSTAR	Measurements of mass radii of nuclei far off stability	Antiproton (radioactive) ion collider	25	8
ELISe	NUSTAR	Measurements of elastic, inelastic and quasi-free electron scattering of nuclei far off stability	Electron-ion collision device including a high resolution electron spectrometer at the NESR	96	29
NCAP	NUSTAR	Production of specific radio-nuclides for (off-site) neutron capture studies	None	20	14
EXO-pbar	NUSTAR	Measurements of proton-neutron abundance at the nuclear surface of nuclei far off stability	Reaction experiment of very low-energy radio-active ions with antiprotons stored in a Penning trap	20	5

Experiments @ FAIR

Experiment	Scientific Area	Research Program	Technical Facility	Members	Institutes
R3B	NUSTAR	Nuclear reactions in inverse kinematics reaction studies with relativistic radioactive ion beams	Large reaction set-up allowing complete kinematics reaction experiments	178	54
HIS DE					
LA					
MA					
ILI					
EX					
AIC					
EL					
NC		site) neutron capture studies			
EXO-pbar	NUSTAR	Measurements of proton-neutron abundance at the nuclear surface of nuclei far off stability	Reaction experiment of very low-energy radioactive ions with antiprotons stored in a Penning trap	20	5

PANDA	QCD	QCD and hadron physics studies with cooled high energy antiproton beams at the HESR	Large state-of-the-art internal target detector system covering almost the full solid angle	344	70
CBM	QCD	Studies of the QCD phase diagram in high-energy nucleus-nucleus collisions	Large state-of-the-art fixed target detector system covering almost the full solid angle	357	63
PAX / ASSIA	QCD	QCD and hadron physics studies with polarized antiproton beams	State-of-the-art collider detector system covering a large solid angle	170/ 85	33 / 12
HEDgeHOB/ WDM	APPA	Investigations of warm and dense bulk matter produced by intense ion and/or laser pulses	Various plasma physics experimental stations	162 / 55	50 / 19
FLAIR	APPA	(Precision) studies with low energy or stopped antiproton ion beams	Various stations including an ultra-low energy electrostatic storage ring, a Penning trap, low energy antiproton target stations	142	54
SPARC	APPA	Atomic physics spectroscopy and collision studies with (stored) high energy ion beams	Various fixed target and in-ring experiments	218	108
BIOMAT	APPA	Applications of ion and antiproton beams in biophysics, biology, materials research and other disciplines	Various multi-purpose target stations	49	28

Experiments @ FAIR

Collaborations showing interest in EPICS

- NuSTAR
- PANDA
- CBM

Experiment	Scientific Area	Research Program	Technical Facility	Members	Institutes
R3B	NUSTAR	Nuclear reactions in inverse kinematics reaction studies with relativistic radioactive ion beams	Large reaction set-up allowing complete kinematics reaction experiments	178	54
NO[illegible]		[illegible] site) neutron capture studies			
EXO-pbar	NUSTAR	Measurements of proton-neutron abundance at the nuclear surface of nuclei far off stability	Reaction experiment of very low-energy radioactive ions with antiprotons stored in a Penning trap	20	5

PANDA	QCD	QCD and hadron physics studies with cooled high energy antiproton beams at the HESR	Large state-of-the-art internal target detector system covering almost the full solid angle	344	70
CBM	QCD	Studies of the QCD phase diagram in high-energy nucleus-nucleus collisions	Large state-of-the-art fixed target detector system covering almost the full solid angle	357	63
PAX / ASSIA	QCD	QCD and hadron physics studies with polarized antiproton beams	State-of-the-art collider detector system covering a large solid angle	170/ 85	33 / 12
HEDgeHOB/ WDM	APPA	Investigations of warm and dense bulk matter produced by intense ion and/or laser pulses	Various plasma physics experimental stations	162 / 55	50 / 19
FLAIR	APPA	(Precision) studies with low energy or stopped antiproton ion beams	Various stations including an ultra-low energy electrostatic storage ring, a Penning trap, low energy antiproton target stations	142	54
SPARC	APPA	Atomic physics spectroscopy and collision studies with (stored) high energy ion beams	Various fixed target and in-ring experiments	218	108
BIOMAT	APPA	Applications of ion and antiproton beams in biophysics, biology, materials research and other disciplines	Various multi-purpose target stations	49	28

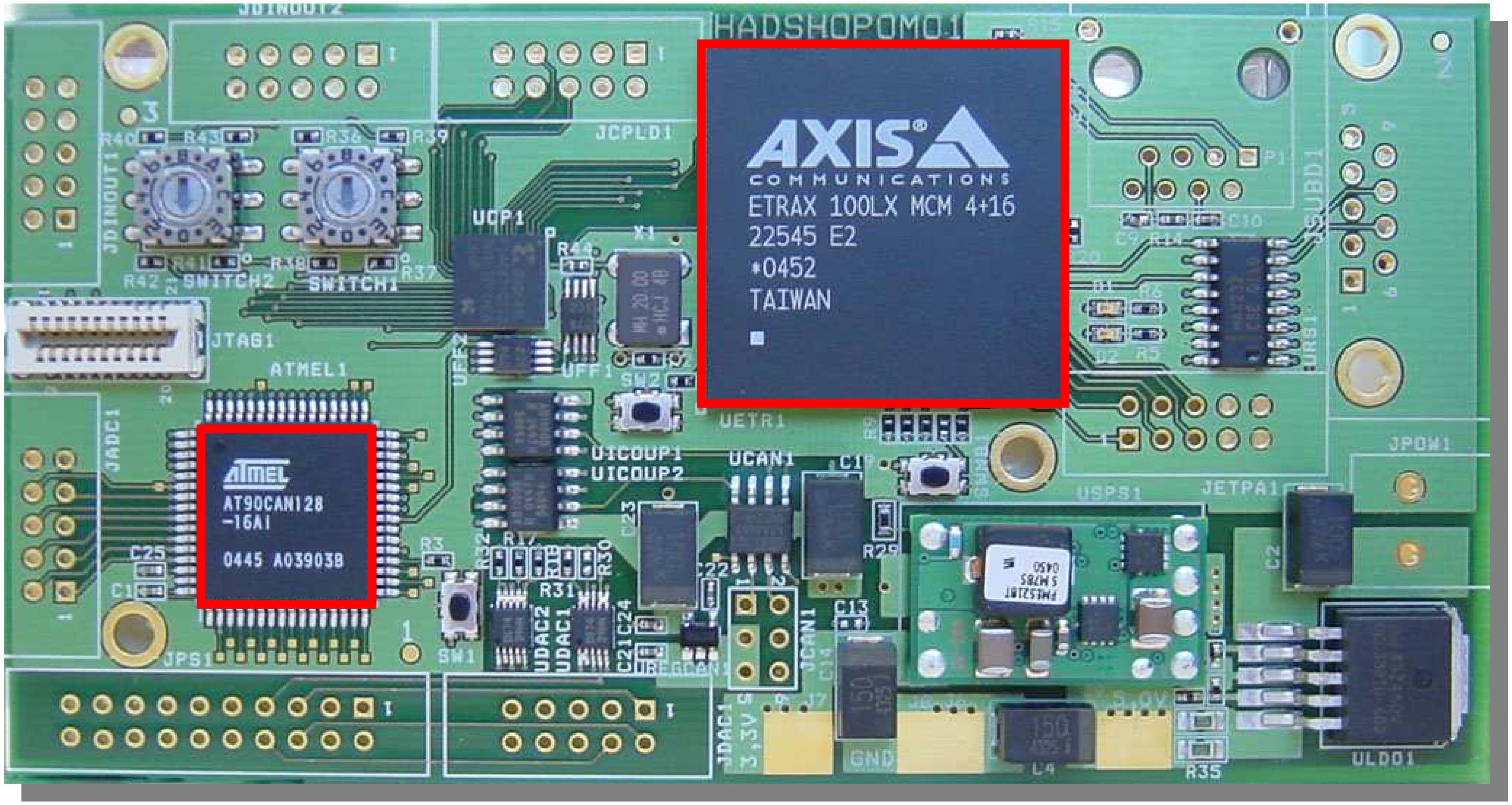
EPICS embedded

- EE/KS (GSI) Aiming at two architectures
  - ETRAX based CRIS architecture
    - HADControl (aka: HADSHOPOMO)
    - TRBv2
    - Experiments: HADES, CBM, Panda, …
  - Xilinx FGPA: Virtex 4 (5)
    - SysCore based Boards
    - Experiment(s): CBM, …

HADControl based on ETRAX 100LX MCM by AXIS

Development of GSI's Experimental Digital Electronic group (M.Traxler)

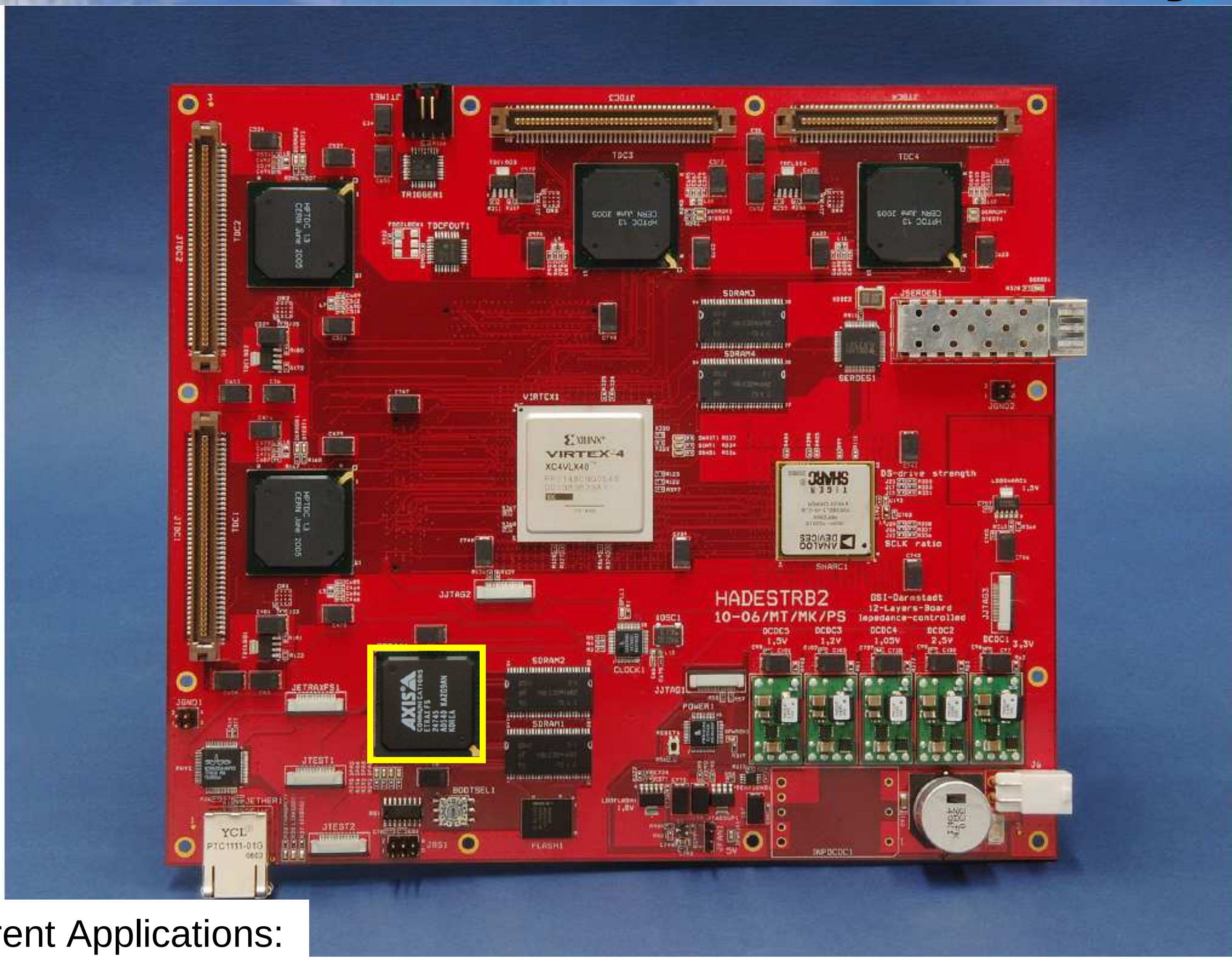
HADControl (aka HADSHOPOMO (HADES SHOWER POWER MONITOR))



"Multi-purpose control/monitor device developed for HADES […] is based on the ETRAX 100LX MCM4+16 and runs the "Experimental Physics and Industrial Control System, EPICS".

http://developer.axis.com/showroom

TRBv2 (multi purpose DAQ board) based on ETRAX FS by AXIS



- successor of TRBv1, which is used in the experiment
- larger FPGA
- faster CPU (x3)
- Tiger-Sharc DSP
- 2 GBit/s optical link for trigger and data
- Add-on connector
- TRBv1 functionality given

Current Applications:

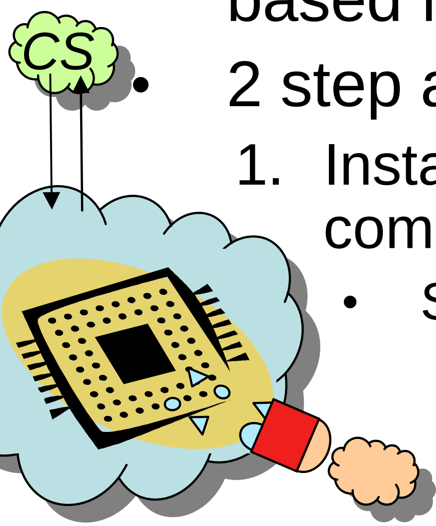
HADES complete DAQ upgrade, PET Readout Coimbra, PANDA, KVI,…

2007-06-04 Michael Traxler, GSI

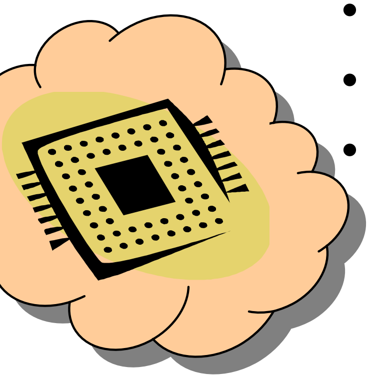
http://www-linux.gsi.de/~traxler/GSIScientificReport2006_TRB/TRBv2_2006.pdf

Embedded EPICS on ETRAX

- install embedded Linux on ETRAX chip CPU (axis.com) based front-end systems



- 2 step approach:
  1. Install DIM on ETRAX and use EPICS-DIM Interface to communicate via network with external EPICS clients or IOCs
     - Suitable for development:
       - DIM protocol also accessible via other controls software, i.e. LabVIEW, or *CS*, etc.
       - But locally no (EPICS) logic (database, (fast) sequencing, alarming) provided
  2. Install EPICS Embedded on ETRAX
     - Provides all features of EPICS
     - Local fast EPICS based logic, network independent
     - By „turning the direction of the interface“ users may still see a DIM device, mimicked by EPICS using the EPICS – DIM interface



ETRAX Applications

- HADControl Board
  (ETRAX 100LX MCM – *linux-cris_v10*)
  - Temperature Sensor 1-Wire Bus
  - Drift chamber HV-Interlock Control
  - development: CAN-Bus Controller

- TRB
  (ETRAX FS – *linux-cris_v32*)
  - Resistive Plate Counter – Threshold settings via SPI protocol
  - Development: DAQ monitoring, FEE controls

CSS

Control System Studio

Eclipse and Java based

Integrated Development Environment

Developed at DESY

From the first principle independent of EPICS

… but via DAL (cosylab: DATA Access Layer) access too many different control systems

- EPICS, TINE, GSI beam controls, TANGO, …
- replaces (soon) the Motif based, old EPICS GUIs
- good collaboration with developers
- css.desy.de

EPICS – C/C++ based?

… not only:

since pure Java Client and Server (cosylab) available

Controls what is it?

Controls

- typically *"Slow" Controls:*
  - *monitoring and control of "slow" changing parameters of a system and providing this information to a human user*
  - *Alarm handling and Logging*
  - *Sequencing / state machines*
  - *Timing*
  - *BPM (Beam Profile Montioring) Video streams*

- *"New"*
  - *Online calibration*
  - *Online recalibration (e.g. baseline follower)*
  - *Code change of FPGAs (CBM)*
  - *Code distribution*
  - *Feedback-loops without human intervention*

http://wiki.gsi.de/Epics

Thank you for your attention.

For more information …

Have a look at the extra slides.

Extra slides

Vocabulary

(Getting Started with EPICS: Introductory Session I)

- EPICS
  - Experimental Physics and Industrial Control System
- Channel Access
  - The communication protocol used by EPICS
- Process Variable
  - A piece of named data referred to by its PV name
  - The primary object of the Channel Access Protocol
- Channel
  - A synonym for Process Variable
- Channel Access Server
  - Software that provides access to a Process Variable using the Channel Access Protocol
- Channel Access Client
  - Software that requests access to a Process Variable using the Channel Access Protocol

Vocabulary

(Getting Started with EPICS: Introductory Session I)

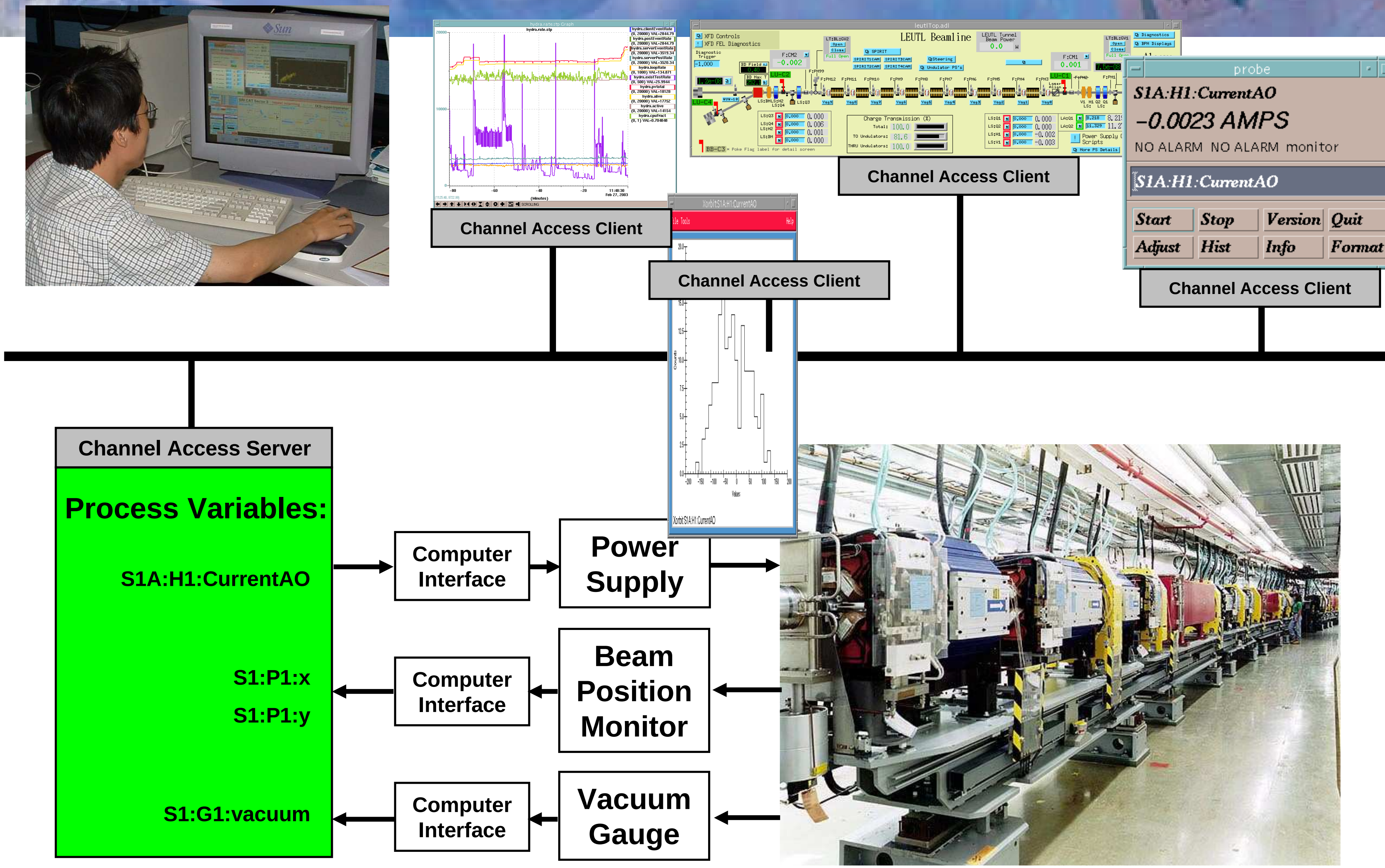
- IOC – Input Output Controller
  - A computer running *iocCore,* a set of EPICS routines used to define process variables and implement real-time control algorithms
  - *iocCore* uses database records to define process variables and their behavior
- Soft IOC
  - An instance of *iocCore* running as a process on a "non-dedicated" computer (i.e. a computer that is performing other functions as well)
- Record
  - The mechanism by which a Process Variable is defined in an IOC (using *iocCore*)
  - Dozens of record types exist, each with it's own attributes and processing routine that describe its functionality

What is EPICS?

- Process Variable
  - A ***Process Variable*** is a named piece of data with a set of attributes
  - Examples of Attributes:
    - Alarm Severity (e.g. NO_ALARM, MINOR, MAJOR, INVALID)
    - Alarm Status (e.g. LOW, HI, LOLO, HIHI, READ_error)
    - Timestamp
    - Number of elements (array)
    - Normal Operating Range
    - Control Limits
    - Engineering Unit Designation (e.g. degrees, mm, MW)

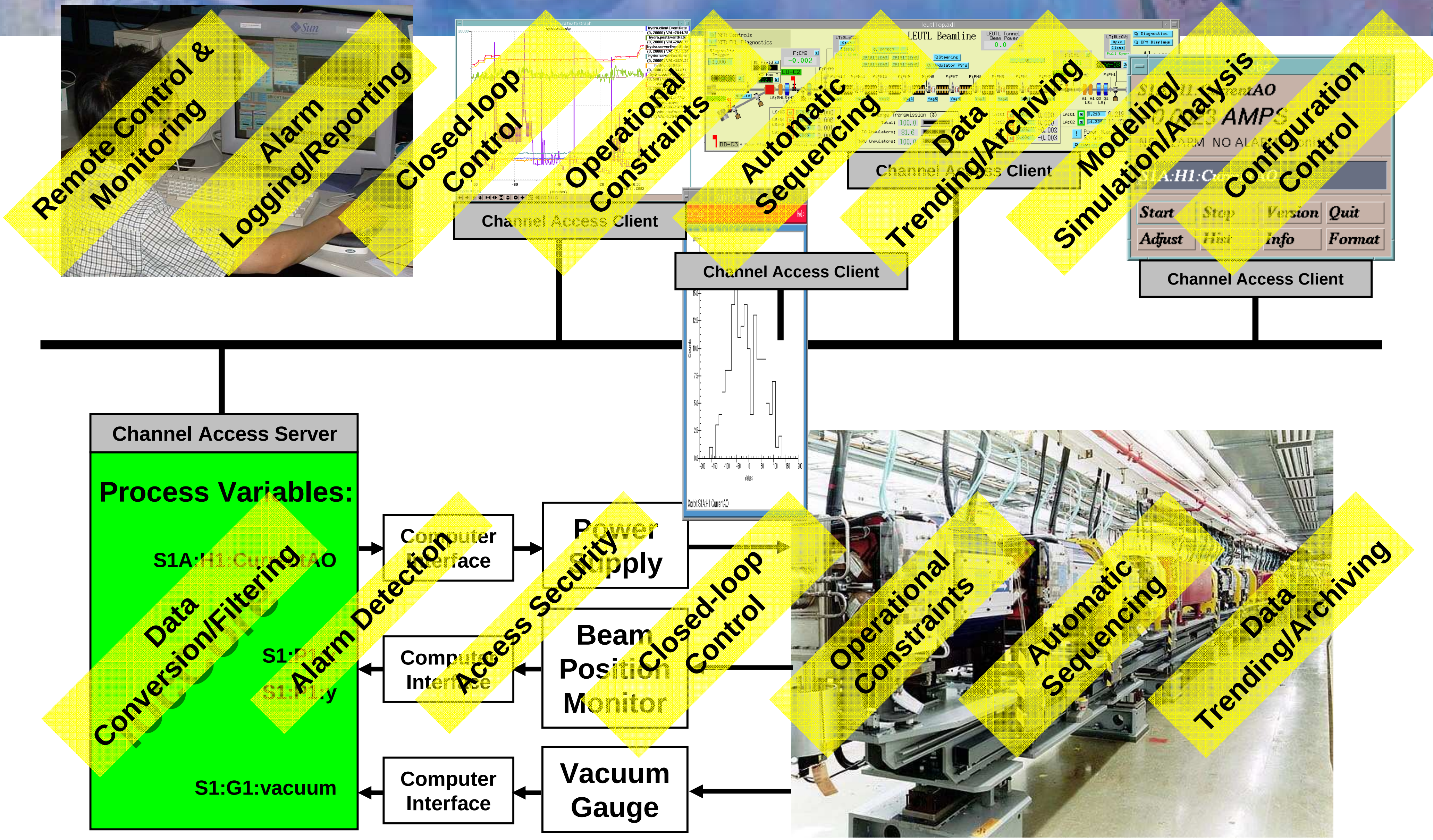
How does it do it?

(Getting Started with EPICS: Introductory Session I)



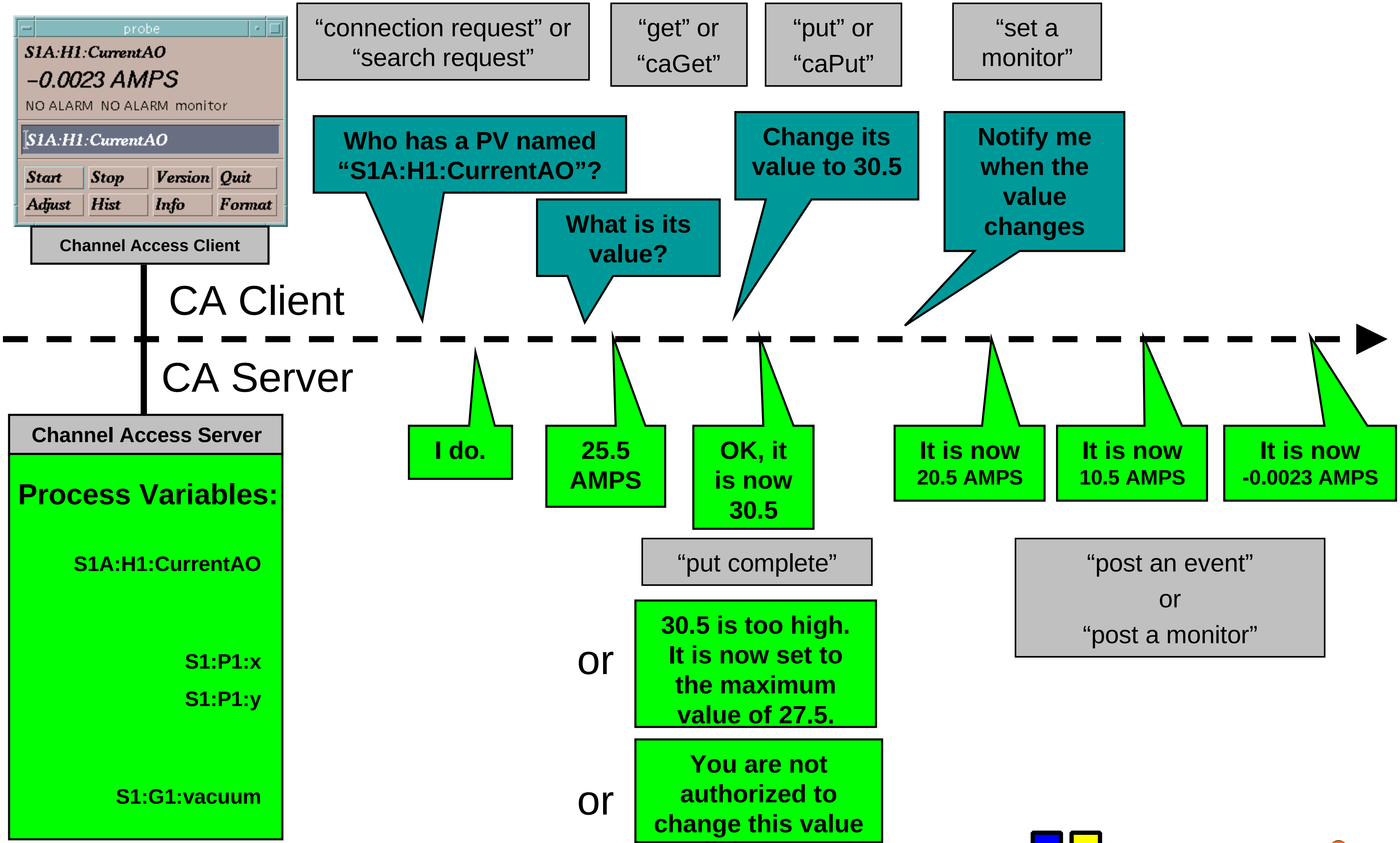
Where does it do it?

(Getting Started with EPICS: Introductory Session I)



Channel Access in One Slide

(Getting Started with EPICS: Introductory Session I)

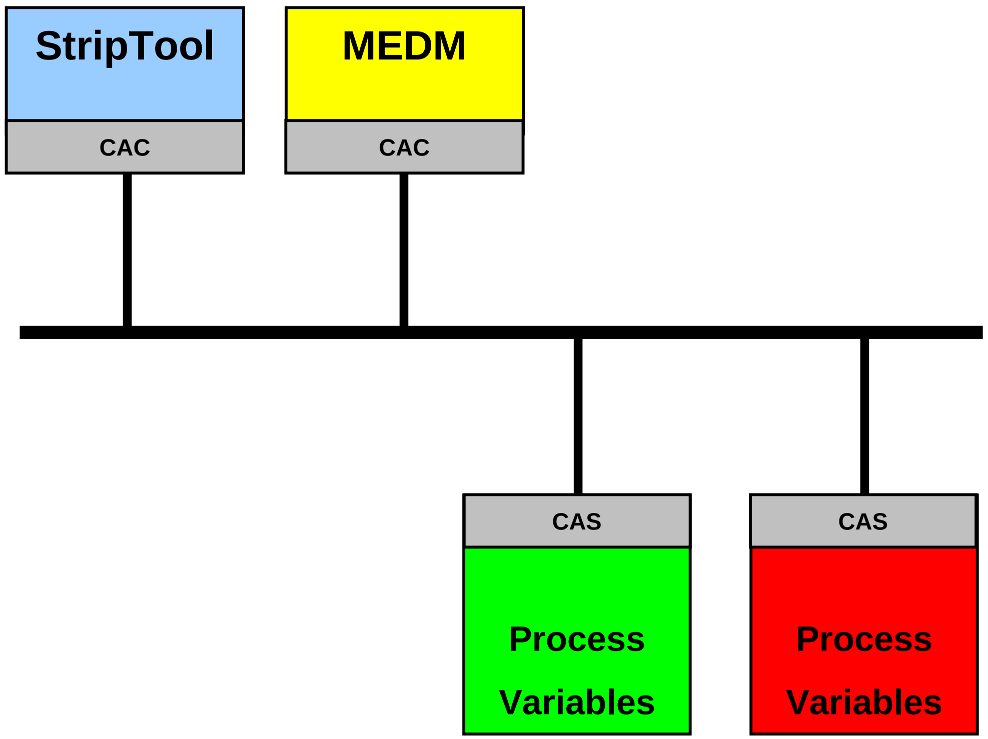


What is EPICS?

(Getting Started with EPICS: Introductory Session I)

Channel Access *clients* are programs that require access to ***Process Variables*** to carry out their purpose

The "service" that a Channel Access *server* provides is access to a ***Process Variable****



*** A *Process Variable* (PV) is a named piece of data.**

What is EPICS?

(Getting Started with EPICS: Introductory Session I)

Any tool/program/application that abides by the Channel Access protocol could be described as "EPICS Compliant".

EPICS can be viewed as a "toolkit" of EPICS compliant programs. One can select the appropriate tool for their need or develop their own.