



# Open-source data acquisition: EPICS

*Experimental Physics and Industrial Control System*

Patrick Oppermann

[epics.mpg.de](http://epics.mpg.de)



# What is EPICS and where is it used?

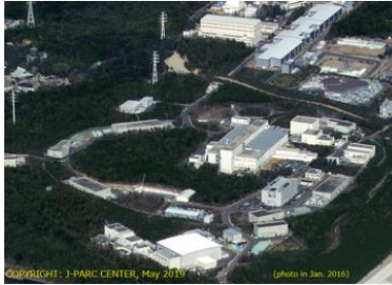
- EPICS offers a collection of software tools for the construction of distributed control systems for experimental projects
- EPICS includes a runtime database, robust network protocols, an extensive collection of **device drivers** for hardware connectivity, and a set of client tools for operator control and monitoring
- It also includes **data archiving** and **alarms**



# What is EPICS and where is it used?

- The modular design is extensible and can easily be used to meet the technical requirements of a variety of experimental projects
- The software is operating system and platform independent
- It is an open source product; you can make changes and improvements yourself at any time

# What is EPICS and where is it used?



## Japan Proton Accelerator Research Complex (J-PARC)

The Japan Proton Accelerator Research Complex (J-PARC) is an exciting accelerator research facility in Ibaraki, Japan,...

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## National Synchrotron Radiation Research Center (NSRRC)

The National Synchrotron Radiation Research Center (NSRRC) operates two synchrotron light sources, named Taiwan Light...

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## Experiments at GSI and FAIR

GSI Helmholtzzentrum für Schwerionenforschung (GSI Helmholtz Centre for Heavy Ion Research) operates a large-scale worldwide unique accelerator facility for...

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## China Spallation Neutron Source (CSNS)

The China Spallation Neutron Source (CSNS), operated by the Institute of High Energy Physics (IHEP),...

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# What is EPICS and where is it used?



## STAR Detector at RHIC

The STAR detector at Brookhaven National Lab specializes in tracking the thousands of particles produced by...

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## Beijing Electron Positron Collider (BEPC-II)

BEPC-II is the upgrade project of Beijing Electron Positron Collider (BEPC), located at the Institute...

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## Antarctic Bright Star Survey Telescope (BSST)

The Antarctic Bright Star Survey Telescope (BSST) is an optical telescope built by University of...

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## Kyoto University Fixed Field Alternating Gradient Accelerator Complex (KUFFA)

The Kyoto University Fixed Field Alternating Gradient Accelerator Complex (KUFFA) was developed as a proton driver...





# What is EPICS and where is it used?



**East Asian Observatory  
(JCMT, UKIRT)**

The EAO (East Asian Observatory) is formed by EACOA (East Asian Core Observatories Association)

**Brazilian Synchrotron Light  
Laboratory (LNLS)**

The Brazilian Synchrotron Light Laboratory (LNLS), located in Campinas, São Paulo state, operates the only...

**Spallation Neutron Source  
(SNS)**

SNS is a one-of-a-kind research facility that provides the most intense pulsed neutron beams in...

**Fritz Haber Institute Free-  
Electron Laser (FHI FEL)**

The free-electron laser (FEL) at the Fritz Haber Institute (FHI) generates intense pulses of infrared...





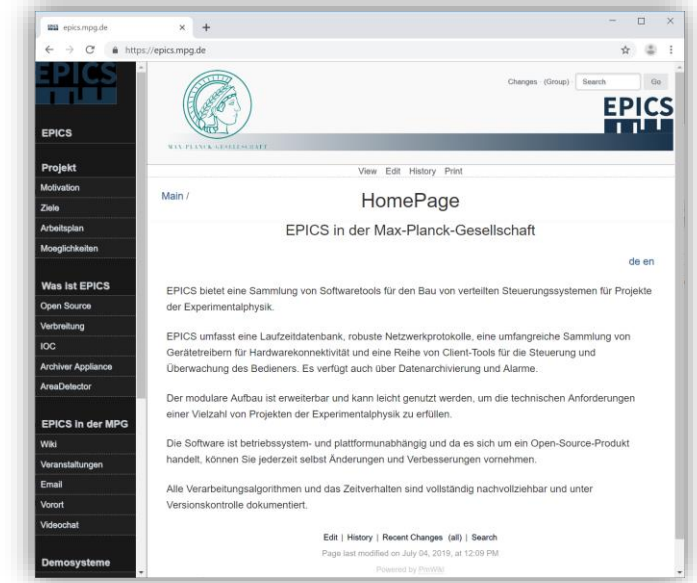
# What is EPICS and where is it used?





# Why we what to establish EPICS in the MPG

- Independence from commercial products
- More flexible in scientific questions
- Reduce the hurdle to using open source software and hardware
- Improve the documentation of EPICS and create training documents (English and German)
- Set up of Demo hardware

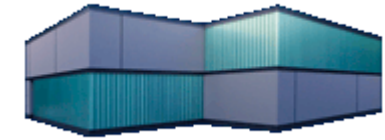






# EPICS base with modules and Archiver Appliance

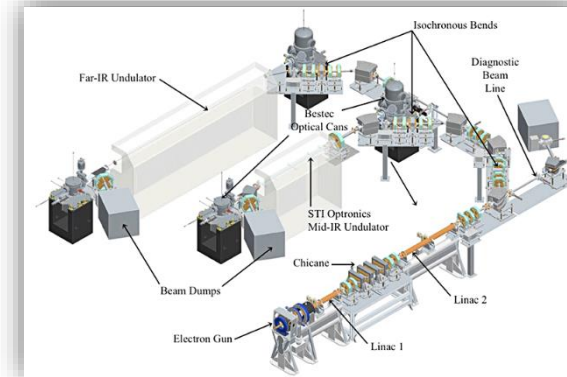
- EPICS base is the main core of EPICS, which includes the build system and tools, common and operating system interface libraries
  - Process value client and server libraries, static and database processing code and standard dataset, device and driver support
- EPICS Archiver Appliance is an implementation of an Archiver for EPICS control systems that aims to archive millions of PVs
  - Possibility of bundling and scaling appliances by adding appliances to the cluster
  - Multiple stages and an integrated method for data transfer between stages



# Machine Learning / Big Data

- FEL optimization by analysis of the FEL data of the last 10 years
- Time stamp and shot number and practically any profile of a shot with all "environmental parameters"
- EPICS Archiver Appliance saved data such as FEL-magnets, accelerator and even building management such as water temperature and flow through the magnets and modulators

## The FHI free-electron laser (FEL) facility





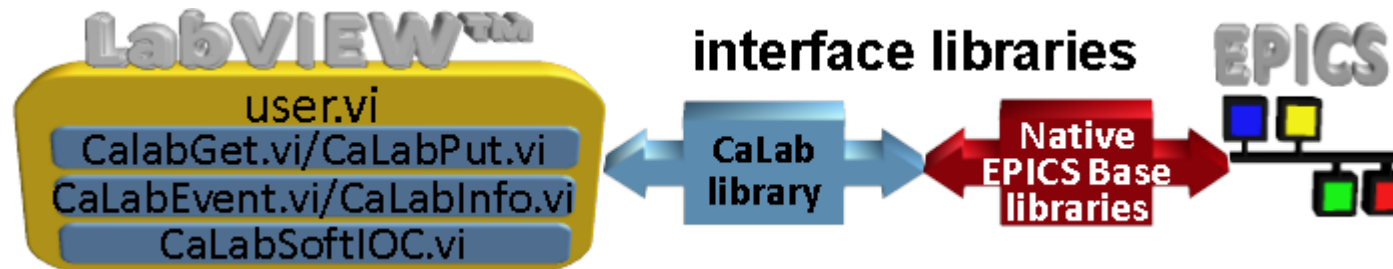


# LabVIEW™ and EPICS: CA Lab SoftIOC

- Researcher like LabVIEW™
- Requirements:
  - communication with LabVIEW
  - easy to integrate
  - data acquisition
  - long-term data storage
  - Hardware and therefore number of channels expandable
  - FAIR principles (research data should be searchable, accessible, interoperable and reusable)

# LabVIEW™ and EPICS: CA Lab SoftIOC

- interface between LabVIEW™ and EPICS
- CA Lab works with Windows® and Linux
- Any VI can use caLabGet.vi to read or caLabPut.vi to write EPICS variables
- CaLabSoftIOC.vi

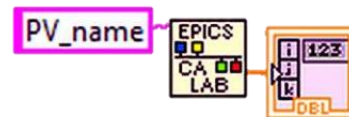




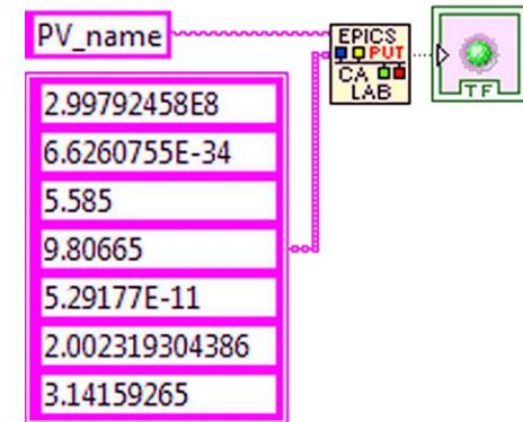
# LabVIEW™ and EPICS: CA Lab SoftIOC

- Practice

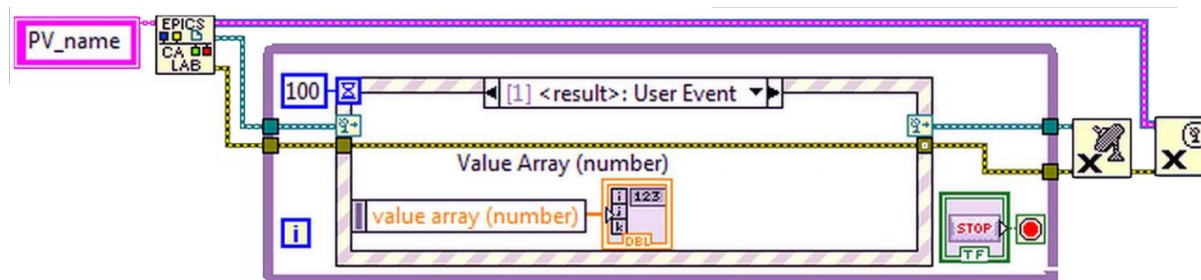
Read value



write value



Event



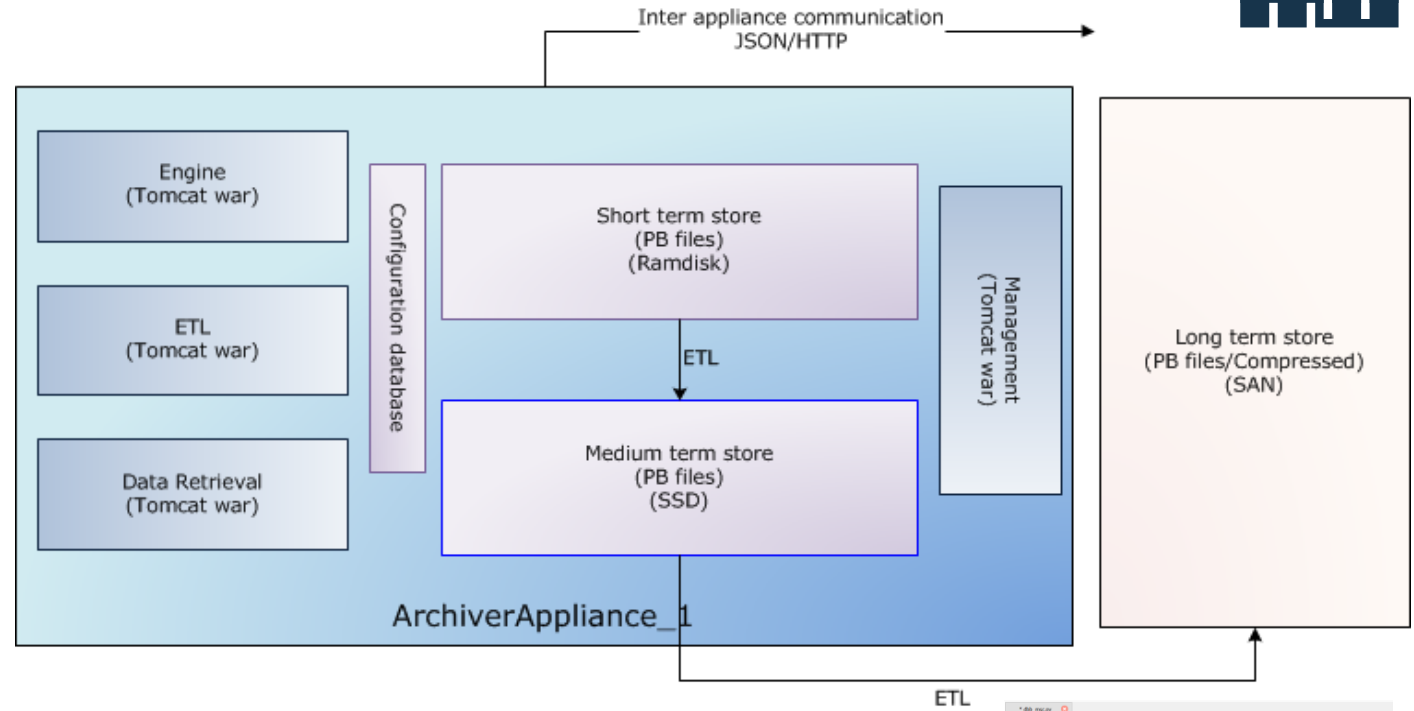
- Conclusion

- Very easy handling of EPICS variables in LabVIEW™

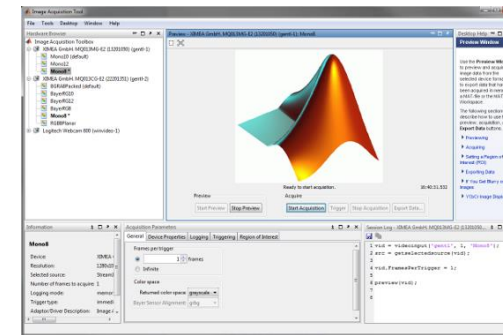
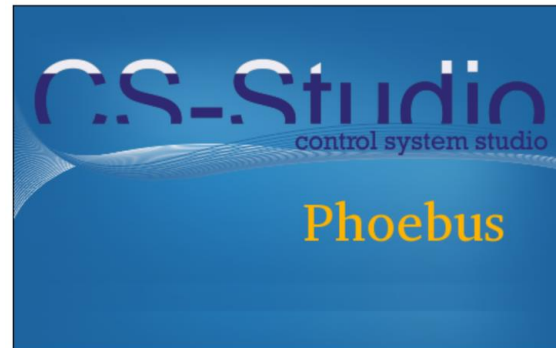


# Data evaluation

- EPICS Archiver Appliance
  - summarize different experiments in one data storage



- Data using
  - CS-Studio (Phoebus)
  - ArchiveViewer
  - Matlab
  - Script



```

*db.mech
#!/usr/bin/perl
use strict;
use warnings;
use DBI;
use DBD::ODBC;
use JSON;
use HTTP::Request;
use HTTP::Response;
use HTTP::Status;
use HTTP::Message;
use HTTP::Cookie;
use HTTP::Date;
use HTTP::Date::RFC822;
use HTTP::Date::RFC2822;
use HTTP::Date::RFC1123;
use HTTP::Date::RFC1950;
use HTTP::Date::RFC2616;
use HTTP::Date::RFC7540;
use HTTP::Date::RFC893;
use HTTP::Date::RFC9110;
use HTTP::Date::RFC9500;
use HTTP::Date::RFC9599;
use HTTP::Date::RFC9600;
use HTTP::Date::RFC9601;
use HTTP::Date::RFC9602;
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use HTTP::Date::RFC9698;
use HTTP::Date::RFC9699;
use HTTP::Date::RFC9700;
  
```

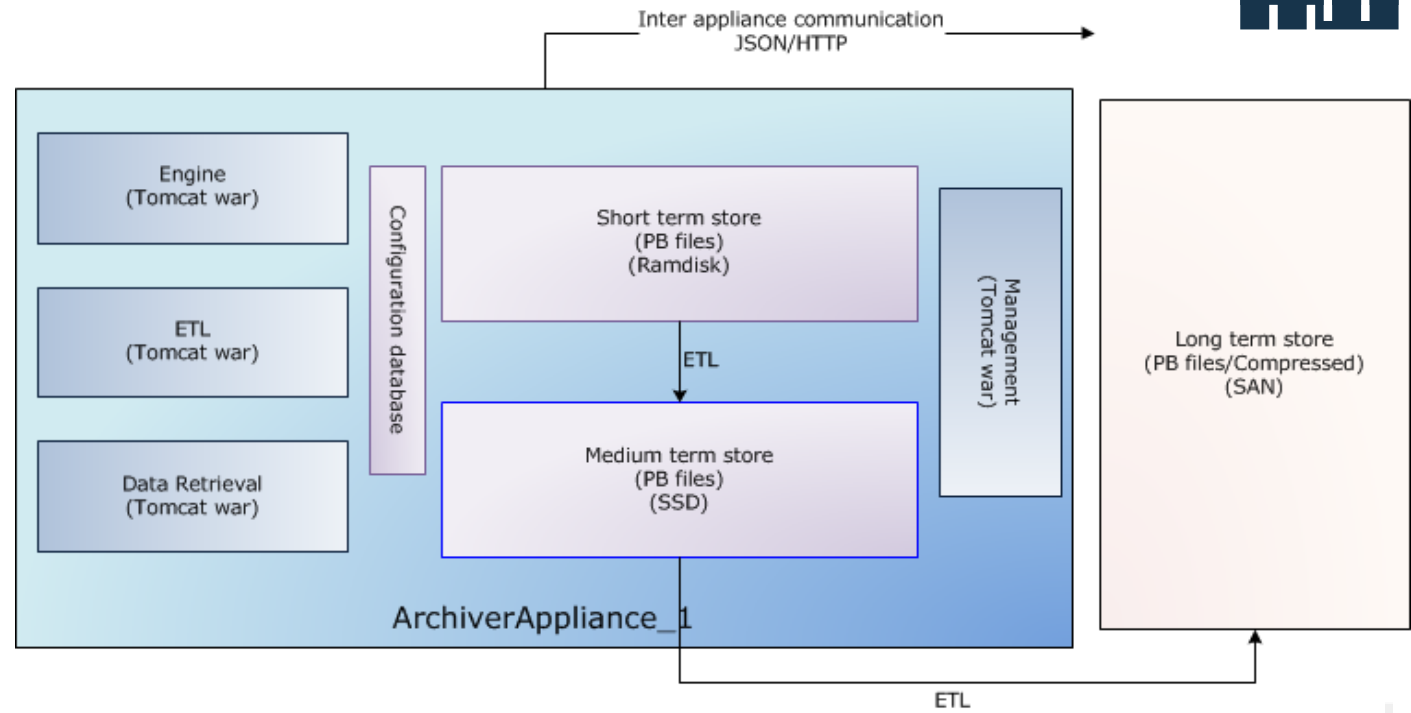




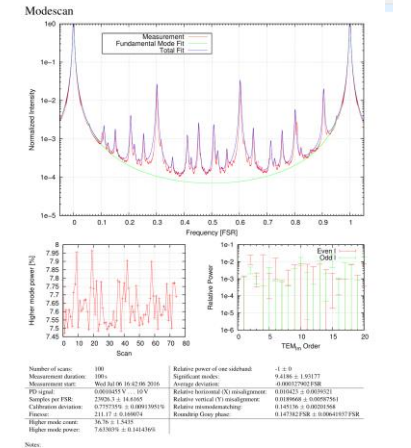
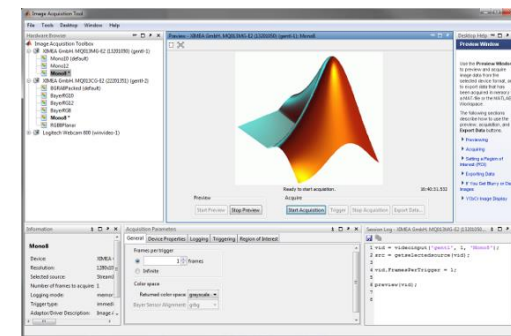
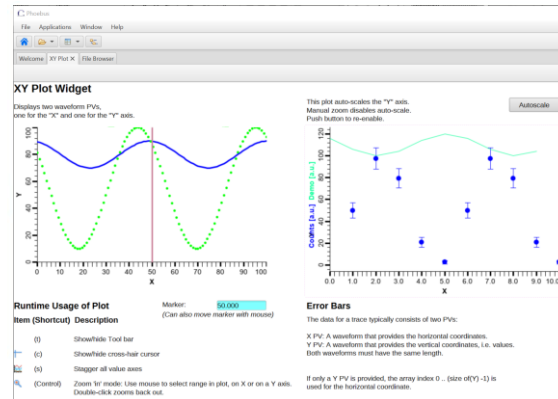


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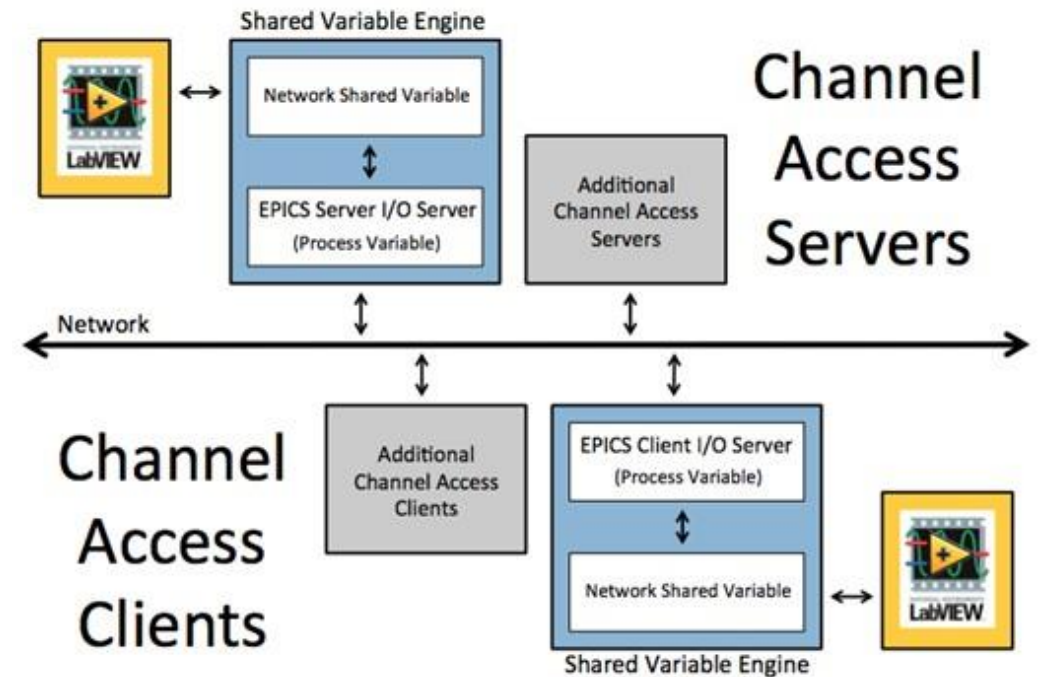
- Data using
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  - ArchiveViewer
  - Matlab
  - Script





# Take one more step: EPICS Device Support for cRIO and FlexRIO

- EPICS Device Support for cRIO and FlexRIO FPGA
- IRIO software tools
  - Templates with the description of the EPICS records, organized by functionality
  - IRIO EPICS device driver uses records connected with asyn-layer using the standard device support





# Thank you for your attention!

## epics.mpg.de

The screenshot shows a web browser window displaying the EPICS website. The address bar shows 'epics.mpg.de'. The page has a dark sidebar on the left with a menu. The main content area has a header with the EPICS logo and 'MAX-PLANCK-GESELLSCHAFT'. Below the header, the title is 'EPICS in der Max-Planck-Gesellschaft'. The text describes EPICS as a collection of software tools for distributed control systems, a database, network protocols, and hardware drivers. It also mentions that the software is open-source and modifiable. The footer indicates the page was last modified on July 22, 2019.