

Securing TANGO Control System: A brainstorming

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Outline

- 1 Introduction
- 2 Identify scenarios
- 3 Cryptography engineering
- 4 Proposed solutions
- 5 Reference Papers
- 6 Journals & Conferences

What is an Industrial Control System? (ICS)

Wikipedia's definition (en)

“It is a general term that encompasses several types of control systems used in industrial production, including *supervisory control and data acquisition* (SCADA) systems, *distributed control systems* (DCS), and other smaller control system configurations such as *programmable logic controllers* (PLC) often found in the industrial sectors and critical infrastructures.”

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What is a Programmable Logic Controllers?



Figure: Example of a PLC controlled system

What is an SCADA?

Wikipedia's definition (es)

"Supervisory Control And Data Acquisition it is a computer software to control and supervise industrial process remotely."

Examples of an SCADAs

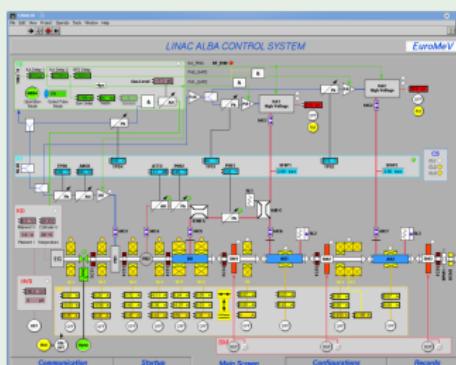


Figure: Labview as SCADA example

What is an Distributed Control System?

Wikipedia's definition (en)

a *Distributed Control System* is the computer software for a manufacturing system, process or any kind of dynamic system, in which the controller elements are not central in location (like the brain) but are distributed throughout the system with each component sub-system controlled by one or more controllers.

What is a distributed system?

Tanenbaum say [1]: *A distributed system is a collection of independent computers that appears to its users as a single coherent system.*

What is a TANGO? (I)

TANGO is an object oriented *Distributed Control System* with active collaborative development from:



Figure: Logos of the Tango Consortium Members

Together with tools like SARDANA, TAURUS, ATK and MAMBO there is a big *Industrial Control System*. They can act as an SCADA and/or DCS flexibly to the needs.

What is a TANGO? (II)

It's an Distributed Control System

using CORBA as a Middleware (OMNIORB),
with ØMQ in the event broadcasting.

What means middleware?

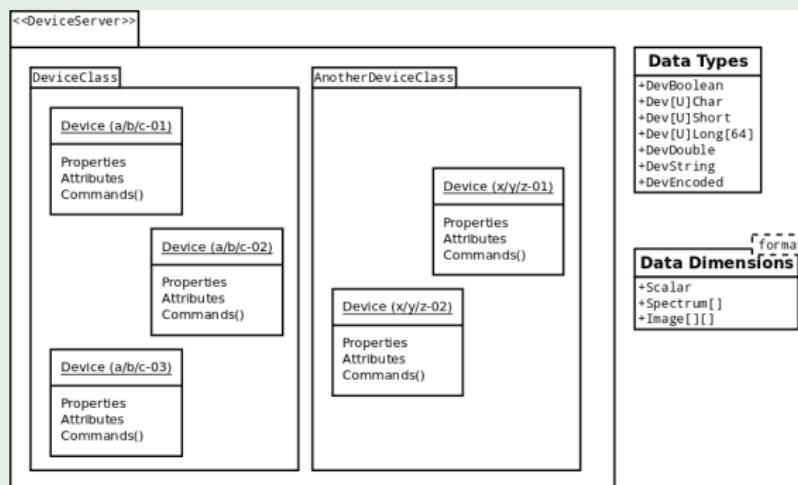
Tanenbaum say [1]: *It is what supports heterogeneous computers and networks while offering a single system view.*

What is a TANGO? (&III)

TANGO parts

- TANGO core ⇒ the Middleware
- TANGO Device Servers ⇒ the agents in the DCS

Device servers, device classes, and devices



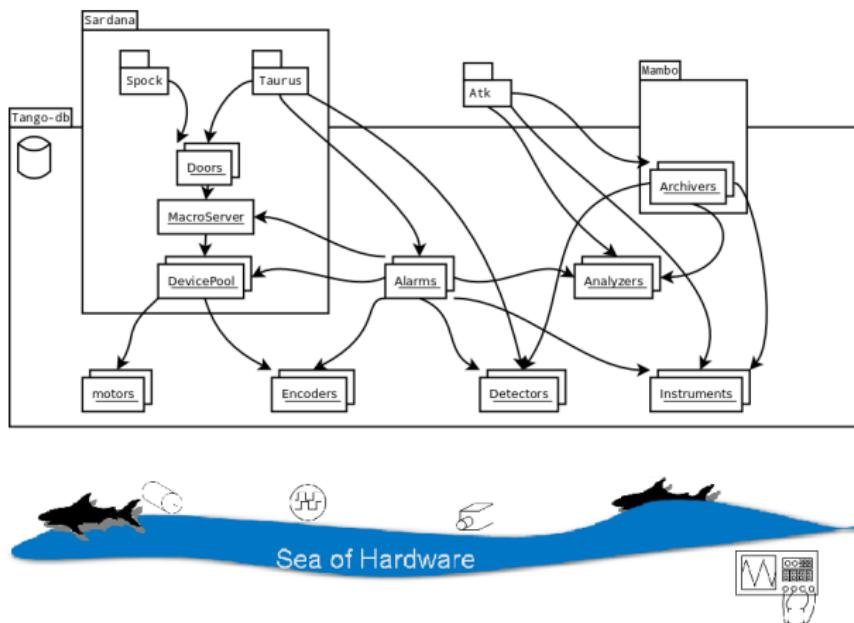
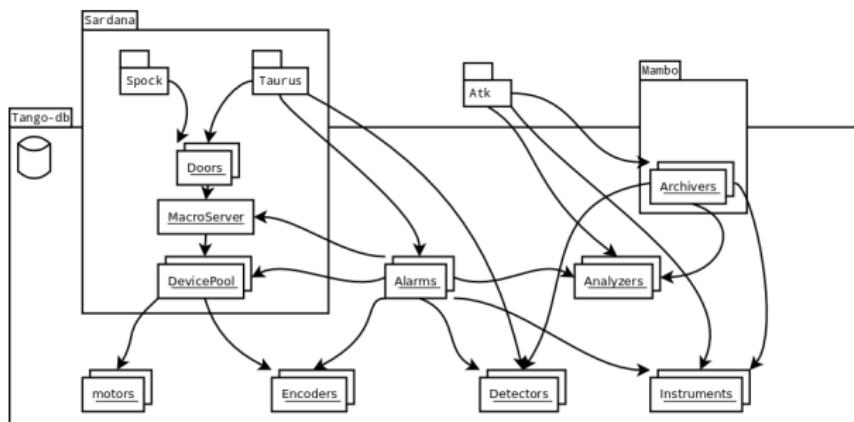


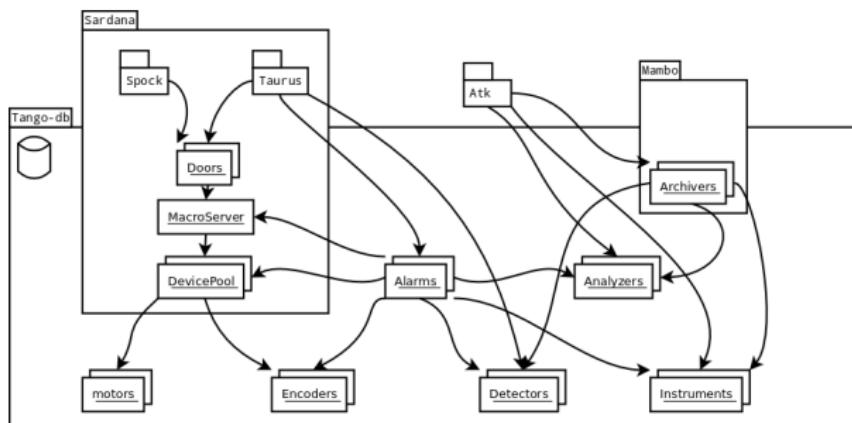
Figure: Tango schematic layout



Communication

- [a]synchronous ⇒ OMNIORB
- events ⇒ ØMQ

ematic layout



Communication

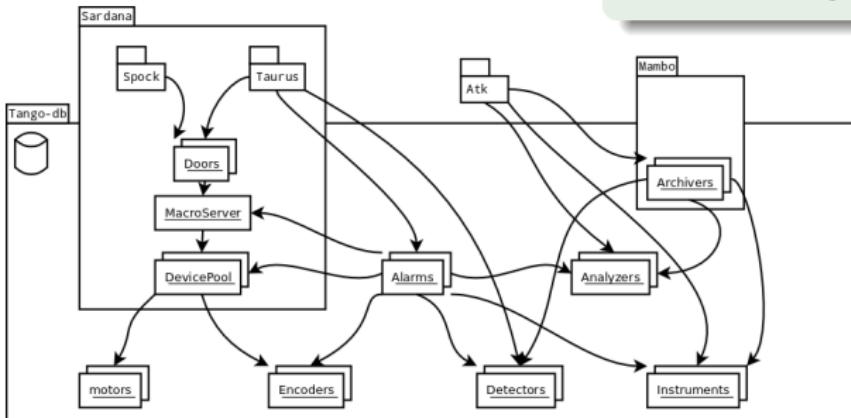
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Persistent config data

- tango-ds ⇒ MySQL

Archiving

- MAMBO⇒ MySQL



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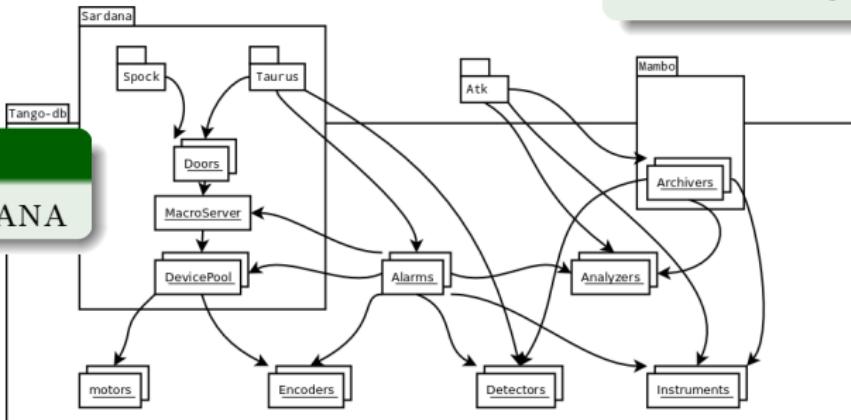
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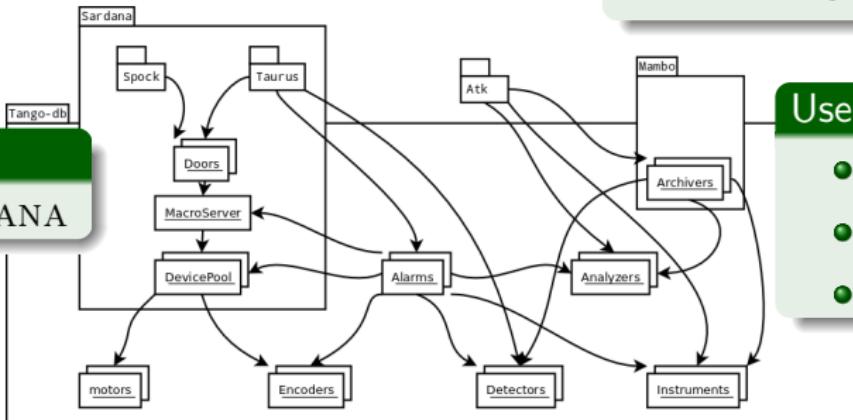
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User access

- TAURUS
- ATK
- SPOCK



Communication

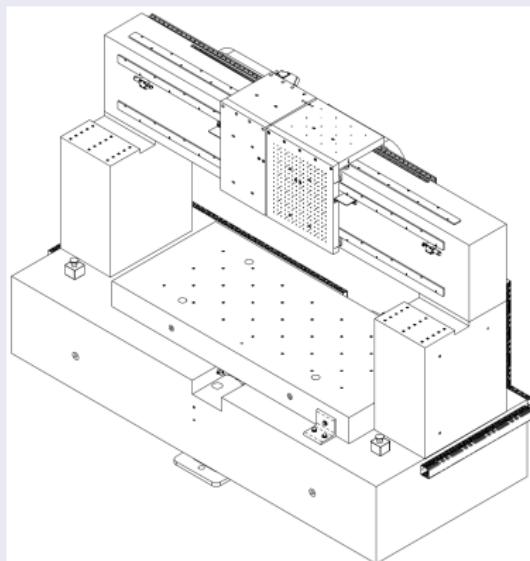
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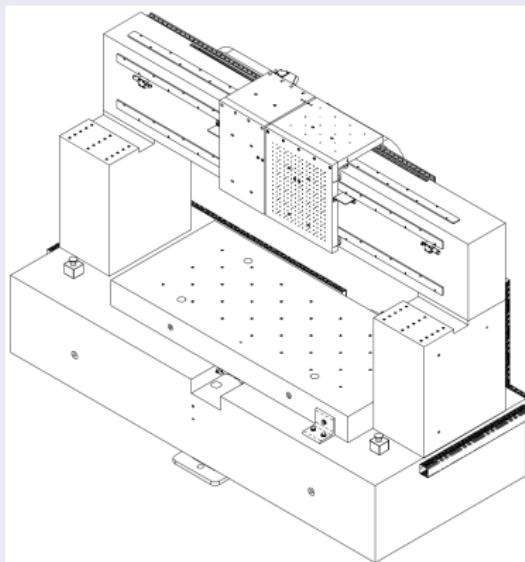
Optics Lab: Nanometer Optical Measuring

Drawing of the optics lab
NOM-Long Term Profiler



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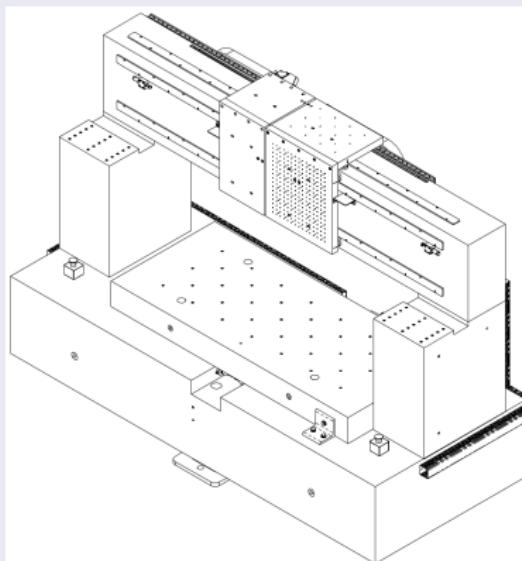
From the clean room



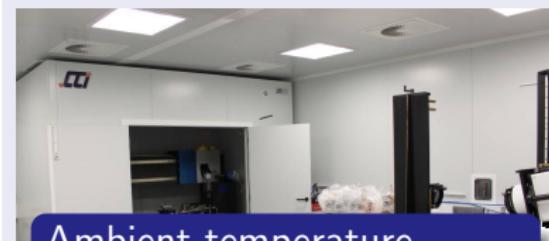
Use cases of TANGO

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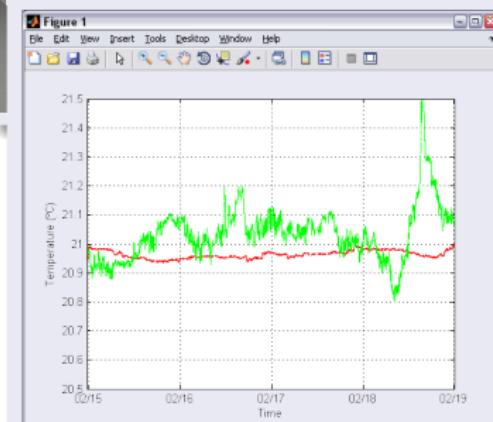
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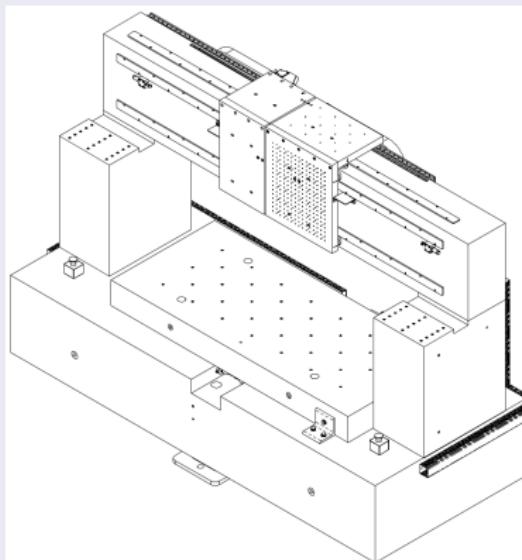


Ambient temperature



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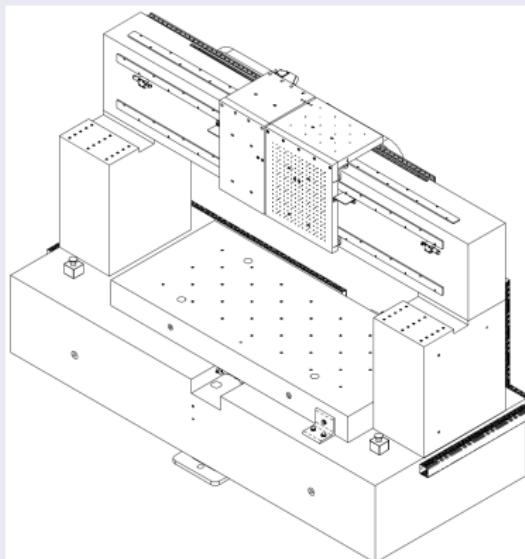


Mirror position



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Inverted configuration

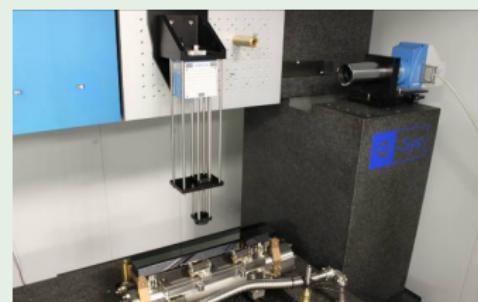


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Drawing of the optics lab NOM-Long Term Profiler Matlab GUI



Mirror position



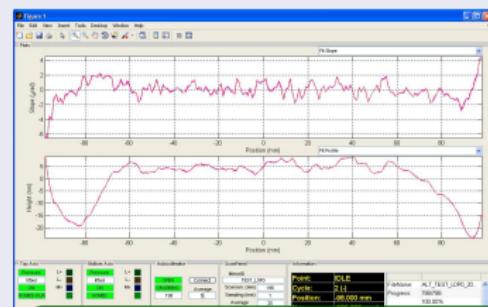
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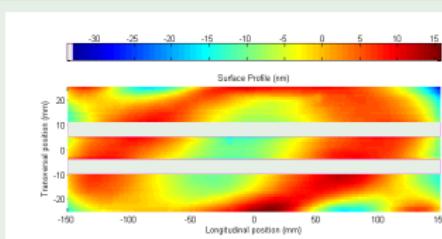
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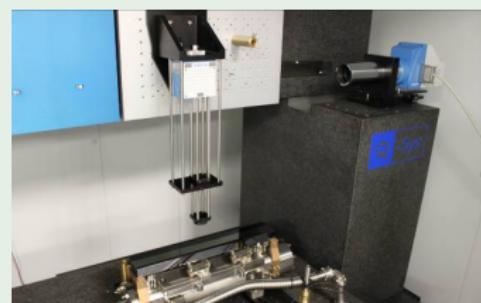
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NOM-Long Term Profiler
Matlab GUI



Surface example



Mirror position



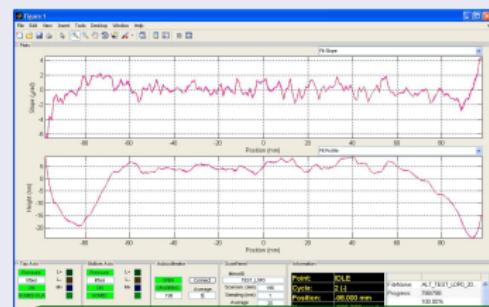
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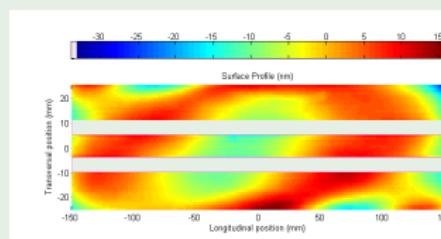
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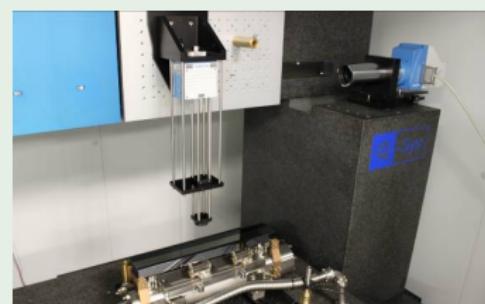
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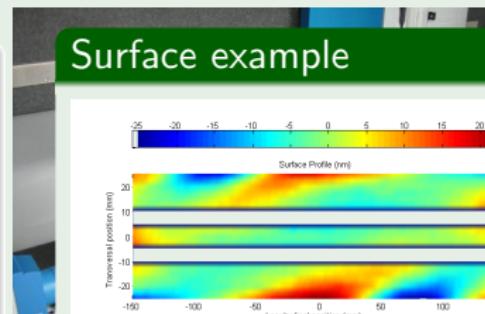
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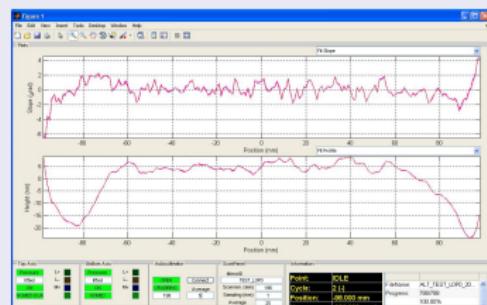
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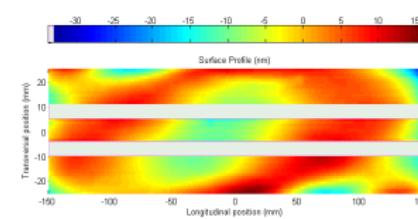
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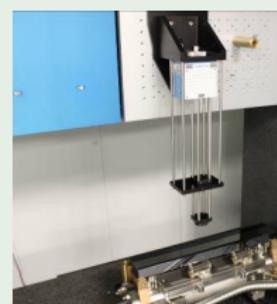
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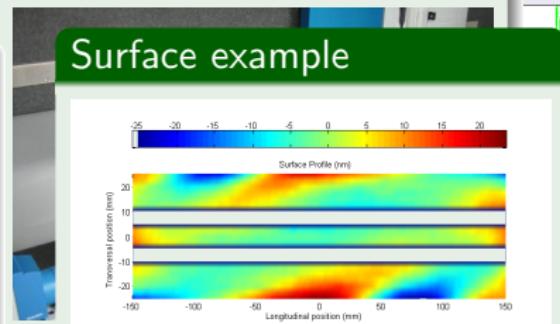
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TANGOinformation

- 3 Hosts
- 28 Devices
- 12 DServers
- 19 DClasses

Inverted configuration

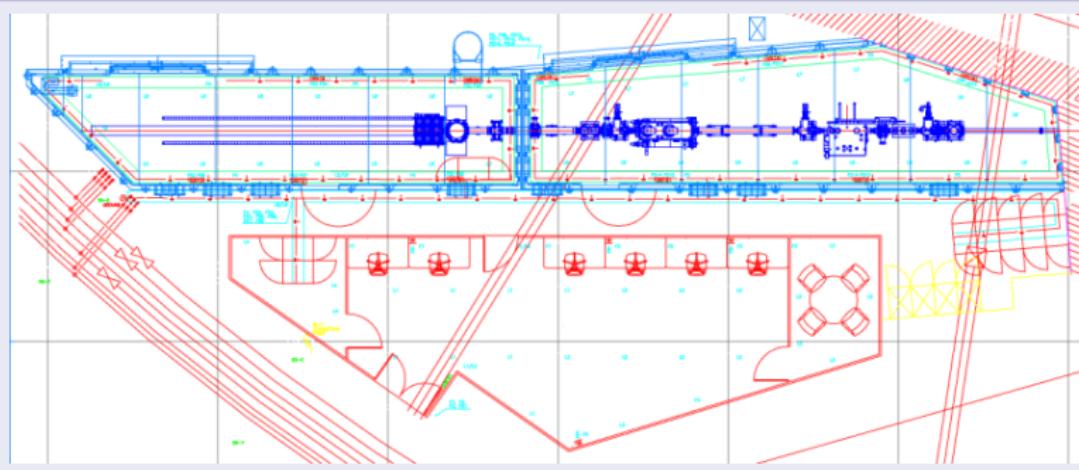


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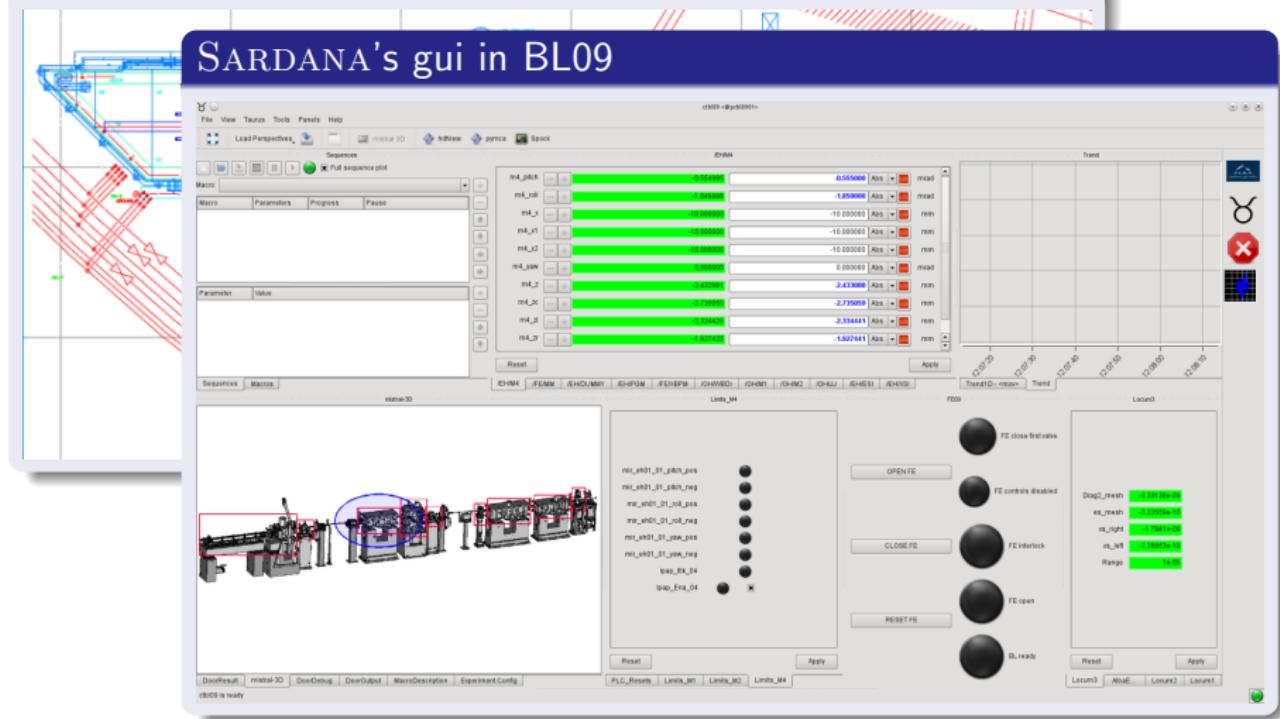
A beamline

layout of BL11



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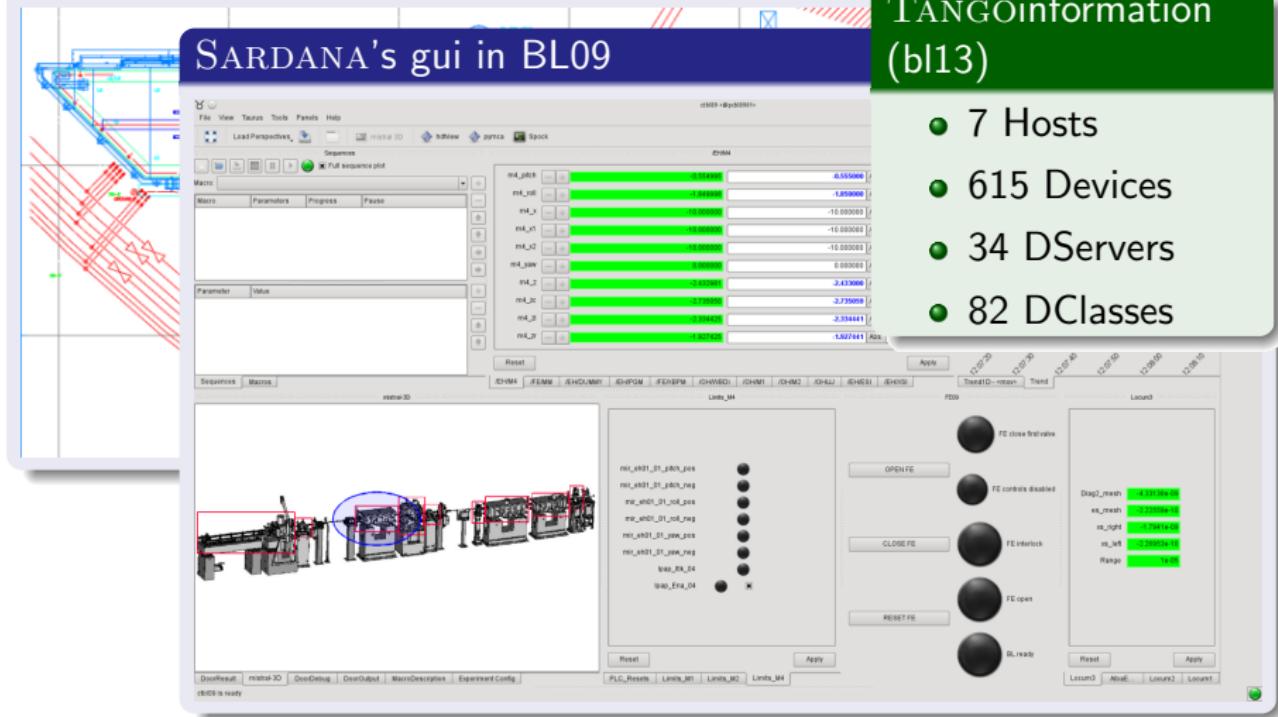


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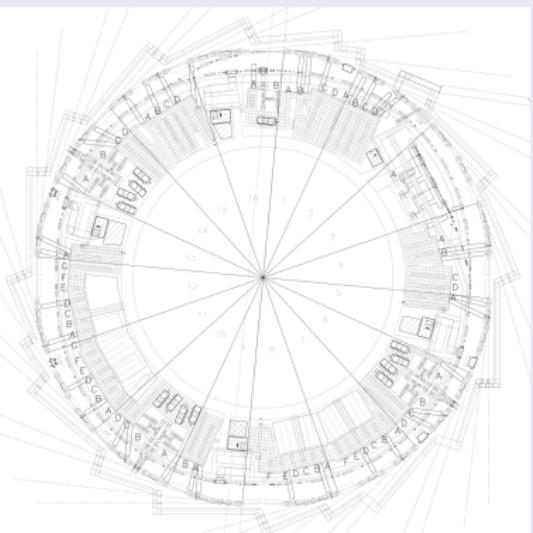
layout of BL11

SARDANA's gui in BL09



Control a synchrotron accelerator

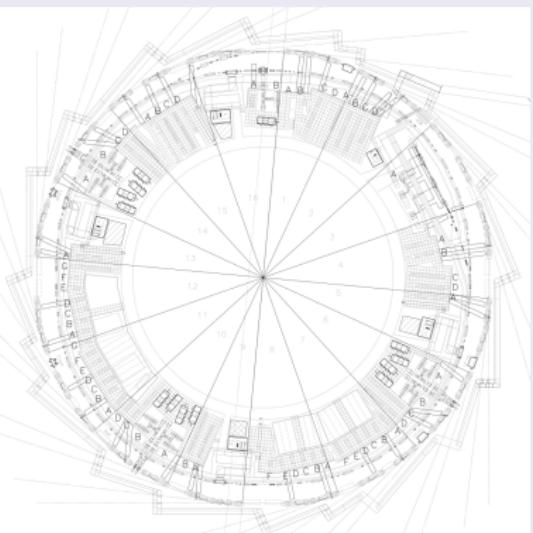
Alba's overview



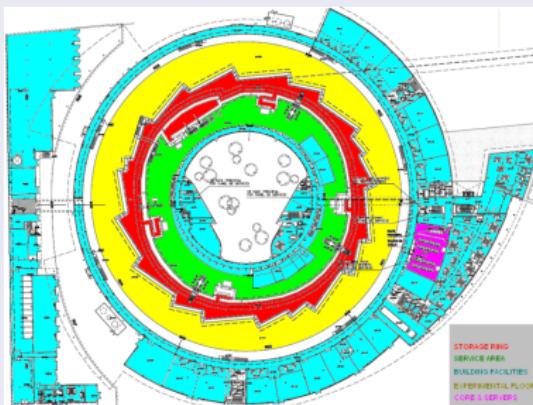
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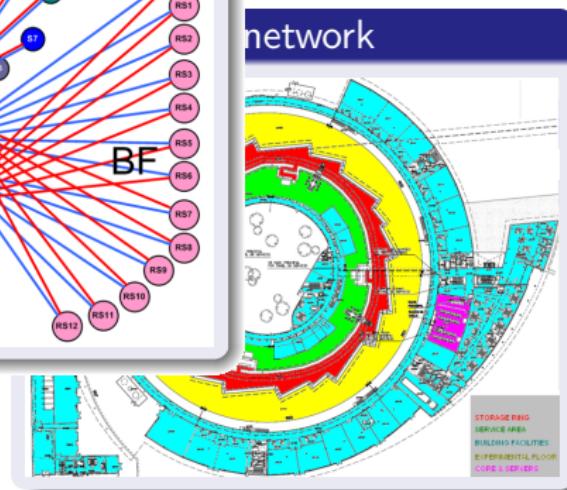
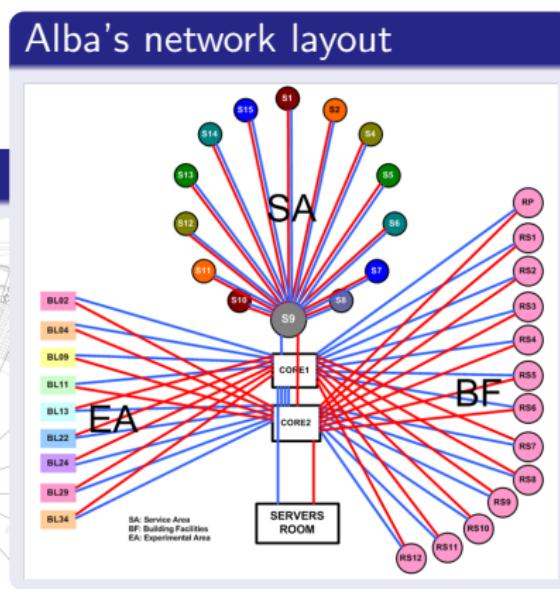
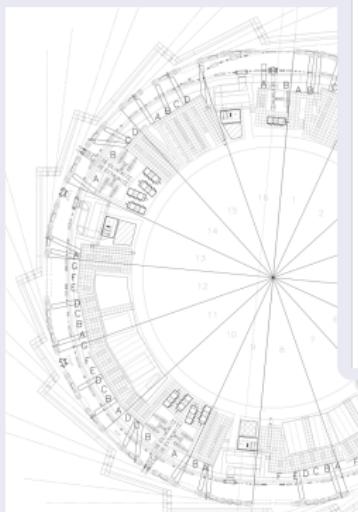
Alba's main network



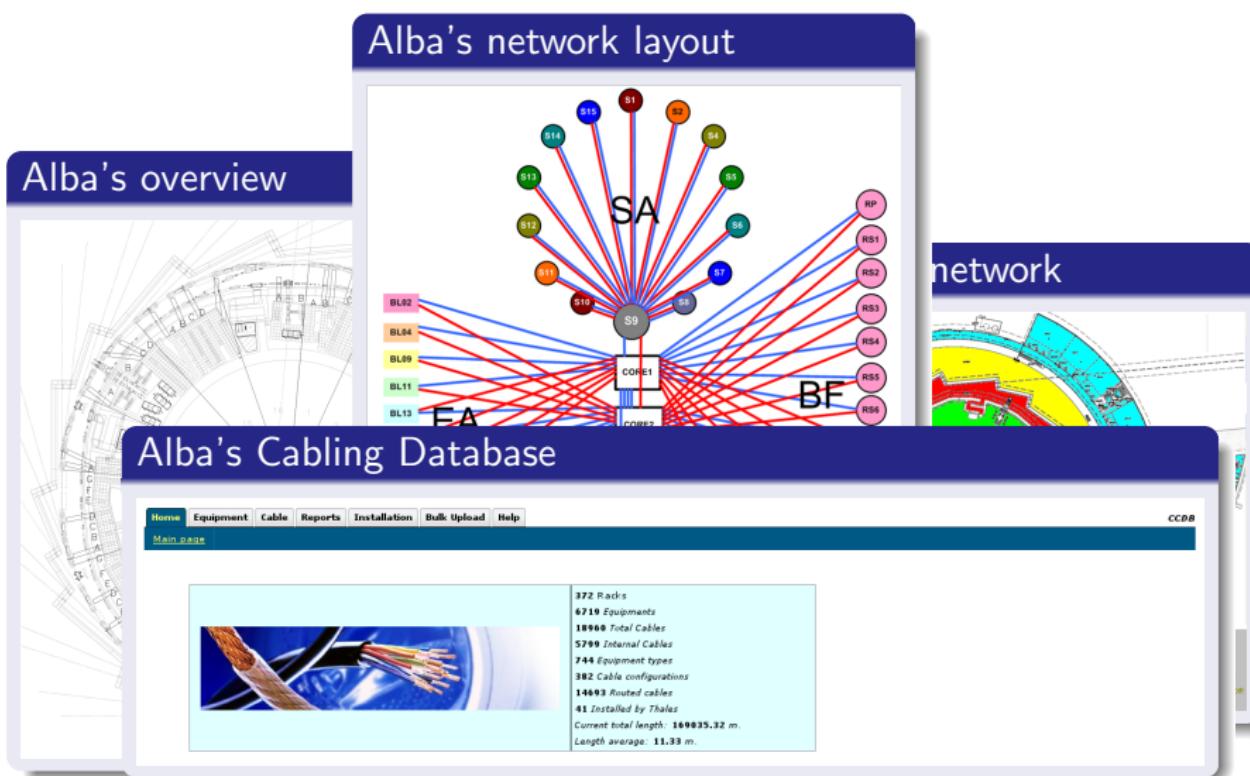
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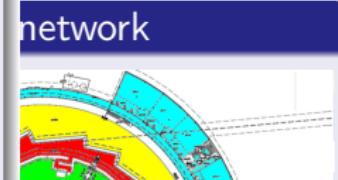
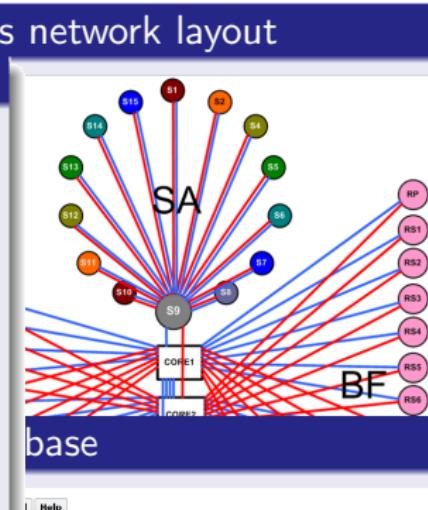


Control a synchrotron accelerator

Alba's network layout

Alba's subsystems

- Timing
- Vacuum
- Power supplies
- Radio frequency
- Diagnostics
- EPS and PSS
- Fronted and IDs



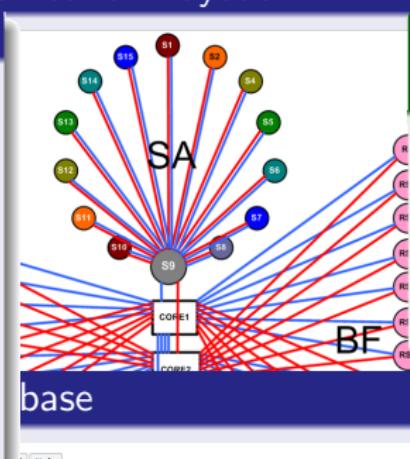
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6719 Equipments
18966 Total Cables
5799 Internal Cables
744 Equipment types
382 Cable configurations
14693 Routed cables
41 Installed by Thales
Current total length: **160035.32 m.**
Length average: **11.33 m.**

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In distributed system

Against the transparencies

Access	Hide differences in data representation and how a resource is accessed
Location	Hide where a resource is located
Migration	Hide that a resource may move to another location
Relocation	Hide that a resource may be moved to another location while in use
Replication	Hide that a resource is replicated
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Security threads

All those transparencies shows at least one security issue

Basics on *information security*

- ① Confidentiality
- ② Integrity
- ③ Availability
- ④ Authenticity
- ⑤ Non-repudiation

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Those first 5 are the basics of the **Information Security**

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⑥ Auditory

- trace who access where
(extremely useful for a security breach analysis).

Passive

- Eavesdropping

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Active

- Men-in-the-middle
- Spoofing: mask and falsify data
- Noise-Interruption-poisoning: Block transmissions
 - Includes [D]DoS
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Counter-measures

- Intrusion detection and recovery

Security threads, policies and mechanisms

TANGO needs the 's', like https, stmpS, imaps, telnet (**ssh**)...

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Do not left all your security in ISO/IEC 27000-series!

Security levels

European commission *fiche 17*

“Exchange of EU classified information” [5]

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- Confidential
- Secret
- Top-Secret

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Sub-classifications

Elements in a group can have internal subsets. Agents with “Top-secret” access only under one subsystem, but “Confidential” under another.

Authentication (I)

- Agent authentication
- User authentication (PAM in Unix)

In TLS what is authenticated is the server, almost never the client.

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Who have rights to do any read/write action

Access Control Levels: would be similar than linux permissions

But multilevel and both directions.

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Tools

- Elliptic curve cryptosystem for TLS (RFC4492 [6])
- This one allow any curve (prime&char2) in WRF^a, unlike RFC6637 [7]

^aWeierstrass Reduced Form

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- Stream ciphers



ECC authentication & encryption

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Using different curves

- Each security level requires its curve size (\mathbb{F}_p)

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Collateral help

This would help to avoid to share same curve between too many.
Thread that the X9.62 [9] advice.

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Tools

- Homomorphic encryption/Ordered cryptography

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Reference Papers

- Zero-knowledge proof
- Session key exchange
- Symmetric and stream ciphers
- Homomorphic encryption

(free) Paper sources

- International Association for Cryptologic Research (e-print & archiver)
- arxiv (open access e-print archiver)
- vixra (alternative open e-print archiver)
- citeseer (scientific search engine)
- scholar (Google's indexer)
- dblp (bib reference)

Zero-knowledge proof for authentication

- S.Martínez, “*Protocolos de seguridad para sistemas de identificación por radiofrecuencia*”. PhD Thesis UdL, march 2011. Directed by: Concepció Roig and Magda Valls.[10]
- BSI TR-03110: “*Advanced security mechanisms for machine readable travel documents.*” .[11]

key exchange

- R. Tomàs, “*Volcans d’isogenies de corbes el·líptiques: Aplicacions criptogràfiques en targetes intel·ligents*”. PhD Thesis UdL, march 2011. Directed by: Josep M. Miret and Daniel Sadornil.[12]
- BSI TR-03111: “*Elliptic curve cryptography, version 2.0*”.[13]
- S. Blake-Wilson, N. Bolyard, V. Gupta, C. Hawk, and B. Moeller, “*Elliptic curve cryptography (ecc) cipher suites for transport layer security (tls)*” May 2006. RFC4492. [6]

Symmetric ciphers

- “*Specification for the advanced encryption standard (aes).*” Federal Information Processing Standards Publication 197, 2001.[14]
- J. Daemen and V. Rijmen, “*The Design of Rijndael*”. Secaucus, NJ, USA: Springer-Verlag New York, Inc., 2002. [15]
- J. Schaad and R. Housley, “*Advanced Encryption Standard (AES) Key Wrap Algorithm.*” Sept. 2002. RFC3394 [16]

Stream ciphers

- **TODO:** “*More information required!*”
- Key Derivation Functions
- Wikipedia (en)
 - Rabbit (RFC4503)
 - VEST
- Chacha20

Private database query system

- D. B. nad Craig Bentry, S. Halevi, F. Wang, and D. J. Wu,
“Private database queries using somewhat homomorphic encryption,” International Association for Cryptologic Research, June 2013.

Reference journals

- **TODO:** “*More information required!*”

Reference conferences & workshops

- **Icalepcs**: International Conference on Accelerator and Large Experimental Physics Control Systems
- **No-bugs**: New Opportunities for Better User Group Software
- **CHES**: Cryptographic Hardware and Embedded Systems
- **SAC**: Selected Areas in Cryptography
- Crypto, **Eurocrypt**, & Asiacrypt
- Tango Meeting

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-  A. S. Tanenbaum and M. van Steen, *Distributed systems, Principles and Paradigms*. Prentice Hall, 2002. International Edition.
-  R. J. Anderson, *Security engineering - a guide to building dependable distributed systems (2. ed.)*. Wiley, 2008.
-  N. Ferguson, B. Schneier, and T. Kohno, *Cryptography Engineering: Design, principles and practical applications*. Wiley, 2010.
-  N. Ferguson and B. Schneier, *Practical Cryptography*. New York, NY, USA: John Wiley & Sons, Inc., 2003.
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-  S. Blake-Wilson, N. Bolyard, V. Gupta, C. Hawk, and B. Moeller, "Elliptic Curve Cryptography (ECC) Cipher Suites for Transport Layer Security (TLS)." RFC 4492 (Informational), May 2006.
Updated by RFC 5246.
-  A. Jivsov, "Elliptic Curve Cryptography (ECC) in OpenPGP." RFC 6637 (Proposed Standard), June 2012.
-  "Sec 2. standards for efficient cryptography group:
Recommended elliptic curve domain parameters."
-  "Ans x9.62, public key cryptography for the financial services industry: The elliptic curve digital signature algorithm (ecdsa)."

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-  S. Martínez, *Protocolos de seguridad para sistemas de identificación por radiofrecuencia.*
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-  J. Schaad and R. Housley, "Advanced Encryption Standard (AES) Key Wrap Algorithm." RFC 3394 (Informational), Sept. 2002.