

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 a Programmable Logic Controllers?



This a production line like example!



Figure: Example of a PLC controlled system

Definitions

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.”

Definitions

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Examples of an SCADAs

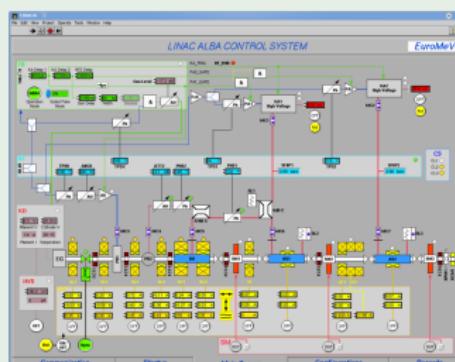


Figure: Labview as SCADA example

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.*

Definitions

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.

Definitions

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.*

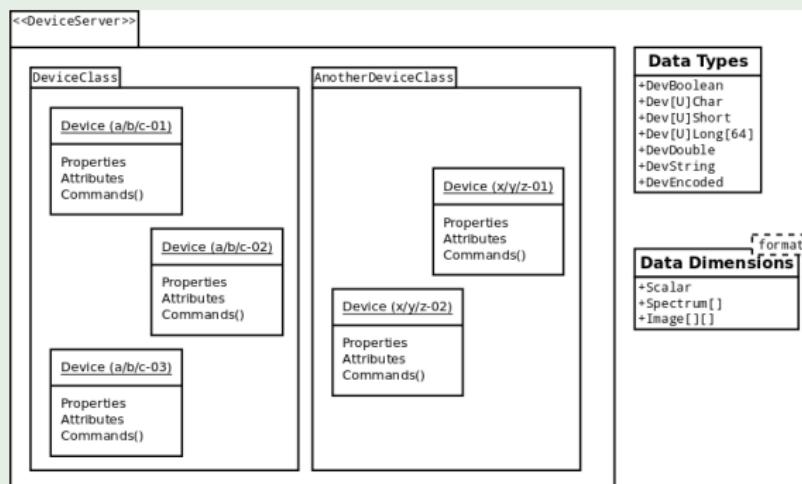
Definitions

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



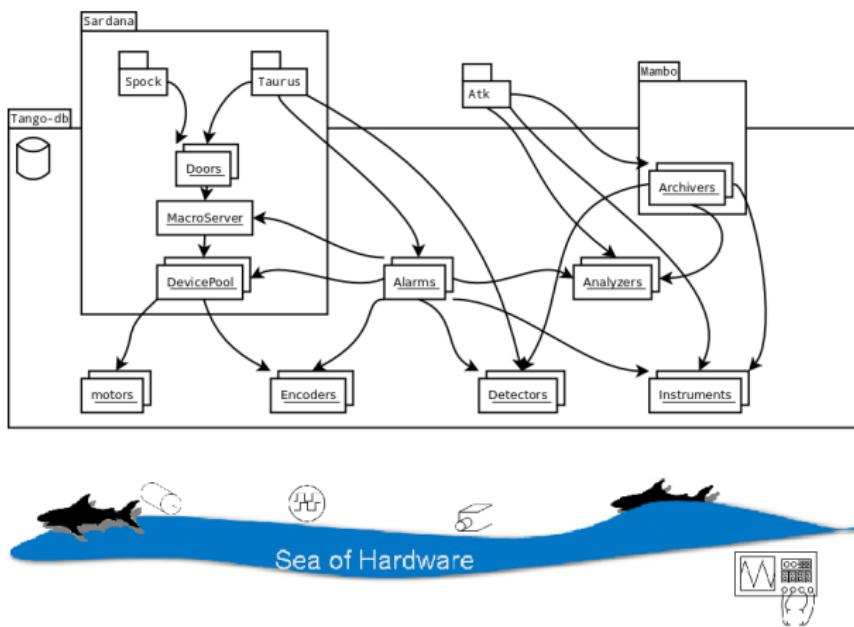
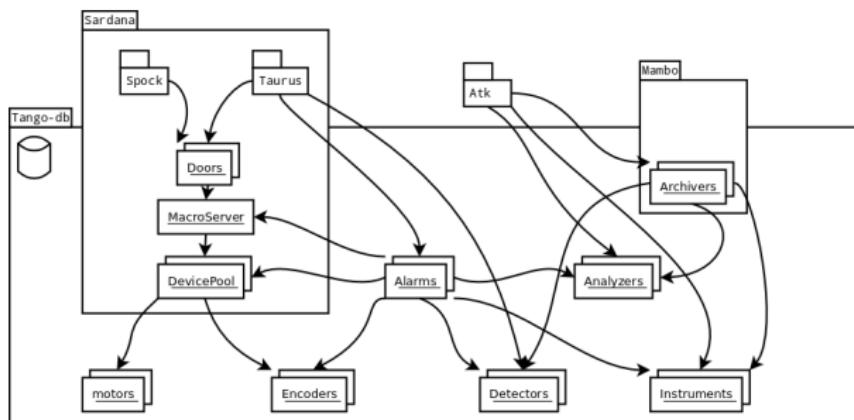


Figure: Tango schematic layout

Definitions

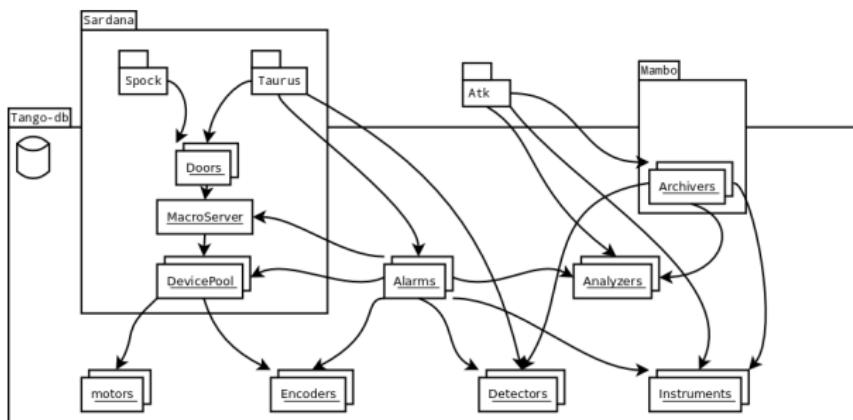


Communication

ematic layout

- [a]synchronous ⇒ OMNIORB
- events ⇒ ØMQ

Definitions



Communication

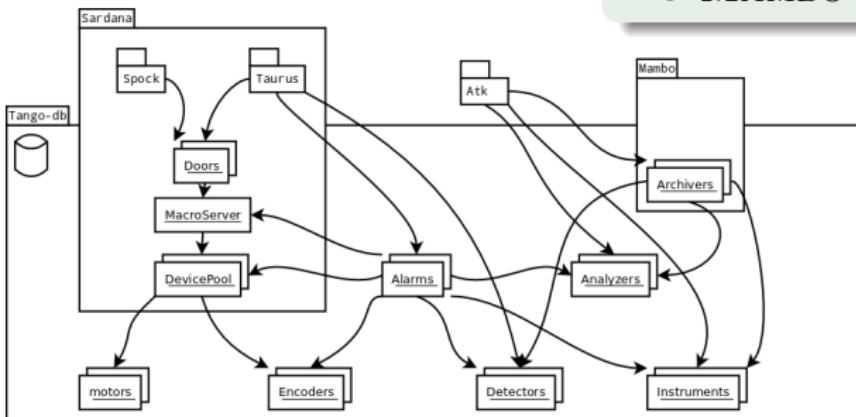
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Persistent config data

- tango-ds ⇒ MySQL

Archiving

- MAMBO \Rightarrow MySQL



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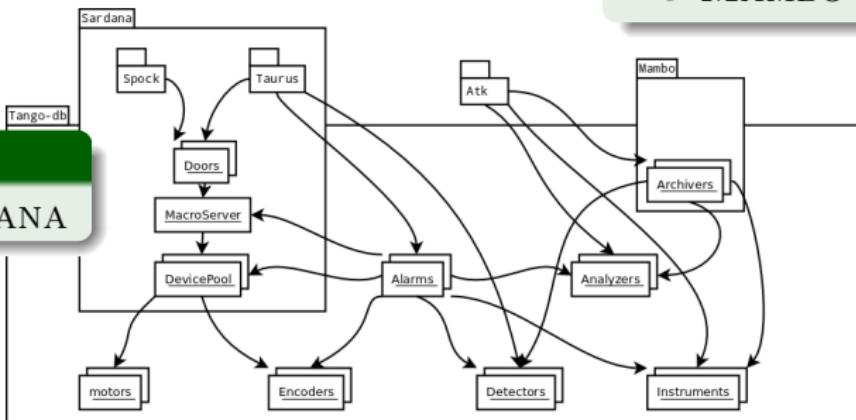
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Framework

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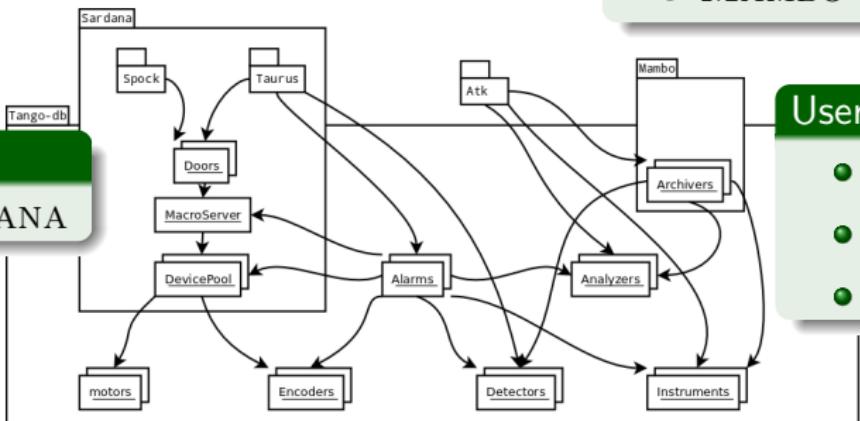
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User access

- TAURUS
- ATK
- SPOCK



Communication

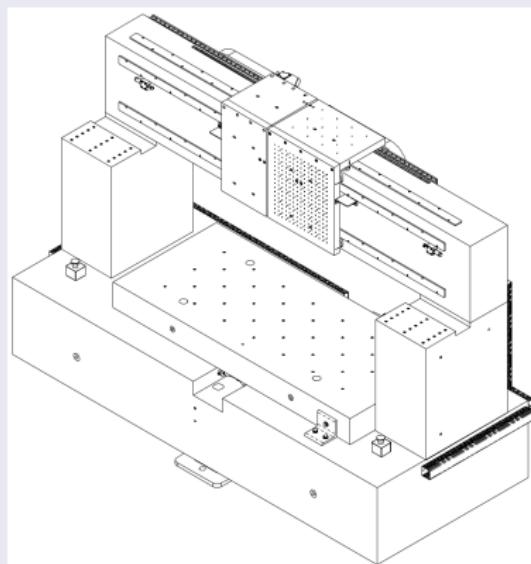
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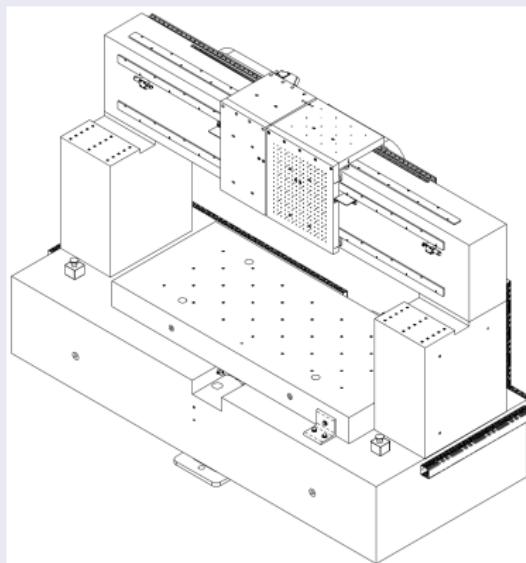
Optics Lab: Nanometer Optical Measuring

Drawing of the optics lab
NOM-Long Term Profiler



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Drawing of the optics lab NOM-Long Term Profiler



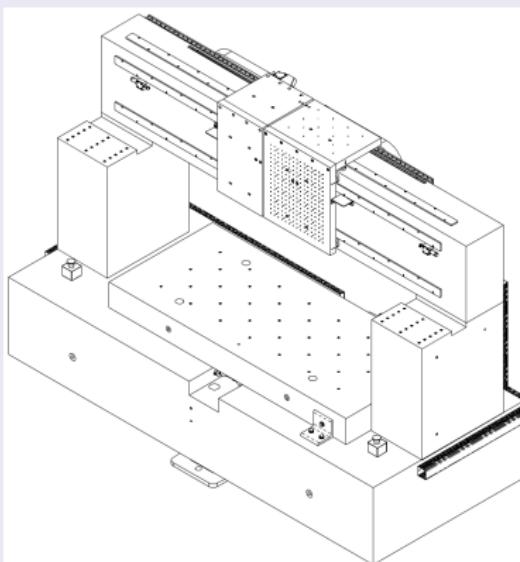
From the clean room



Use cases of TANGO

Optics Lab: Nanometer Optical Measuring

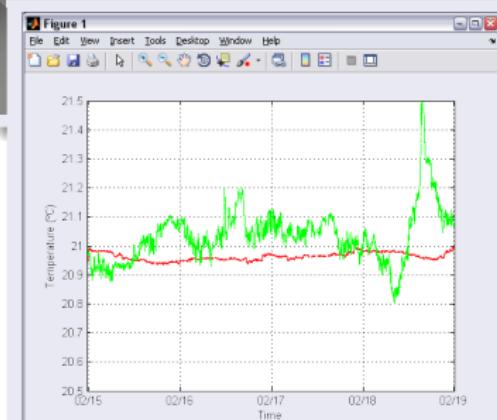
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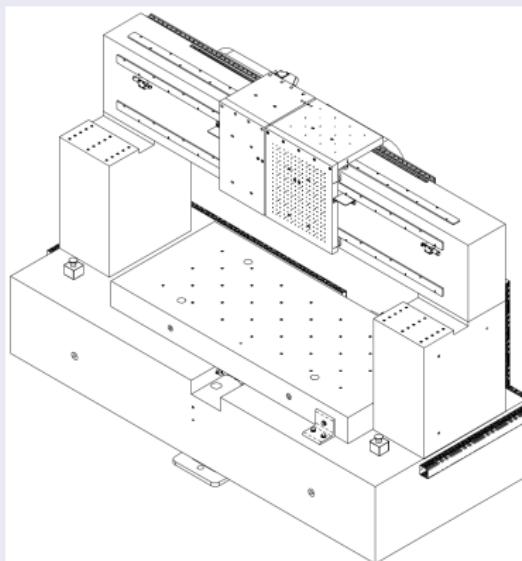
Ambient temperature



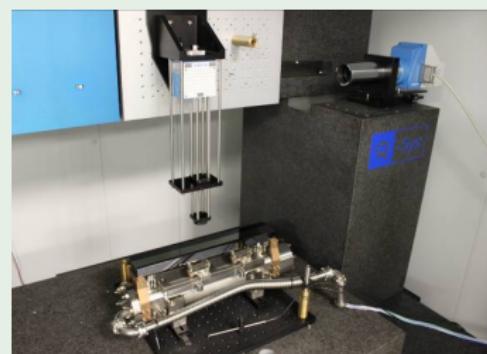
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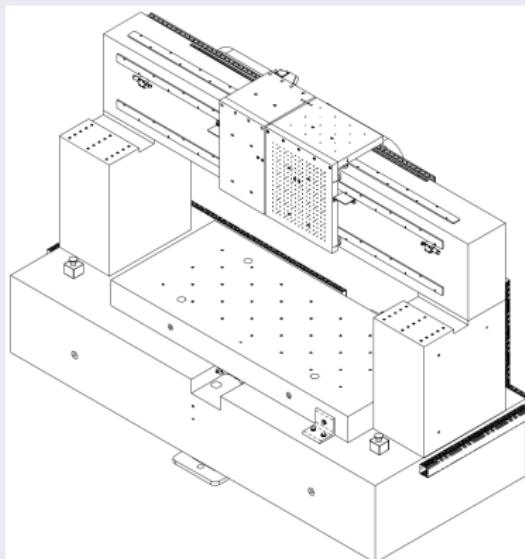
Mirror position



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Mirror position



Inverted configuration



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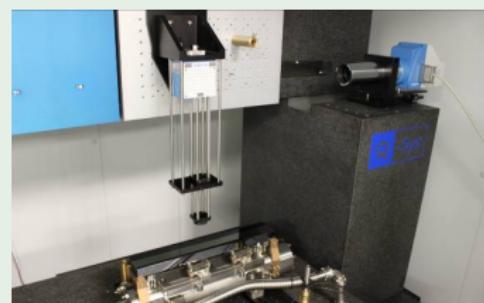
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Matlab GUI



Mirror position



Inverted configuration



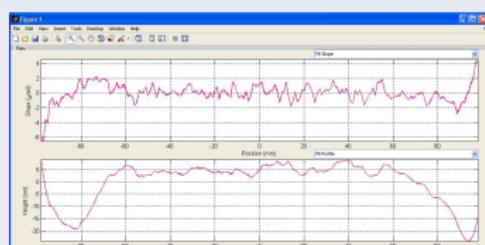
02/19

Use cases of TANGO

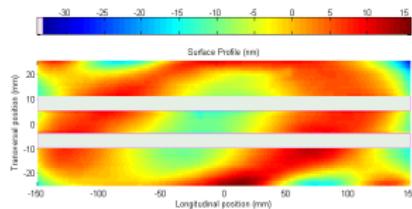
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Matlab GUI



Surface example



Mirror position



Inverted configuration

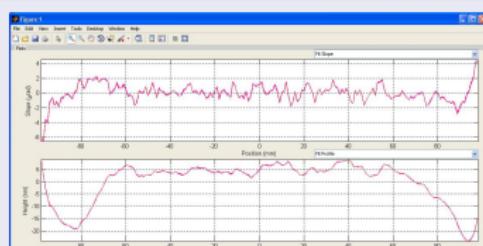


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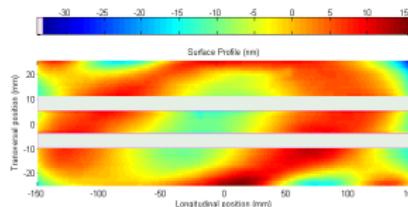
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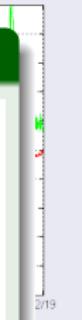
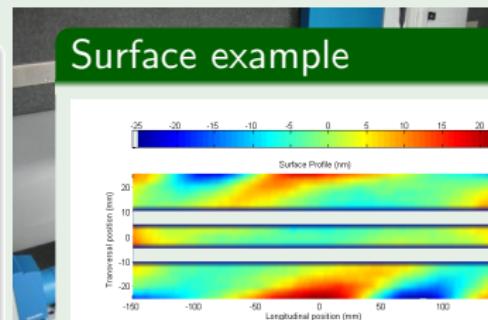
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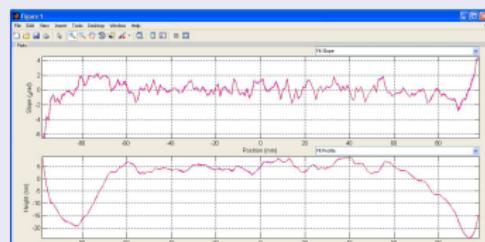


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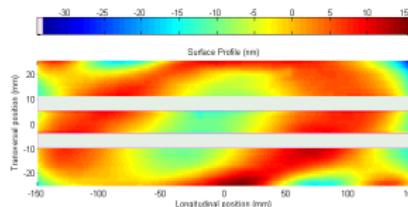
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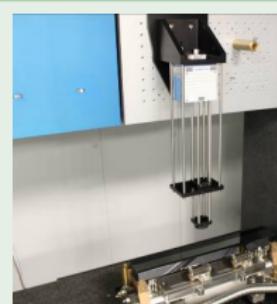
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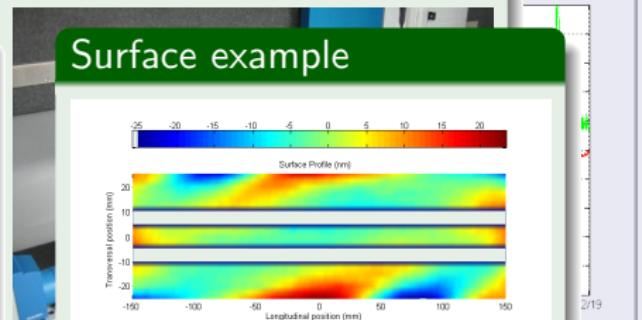
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TANGOinformation

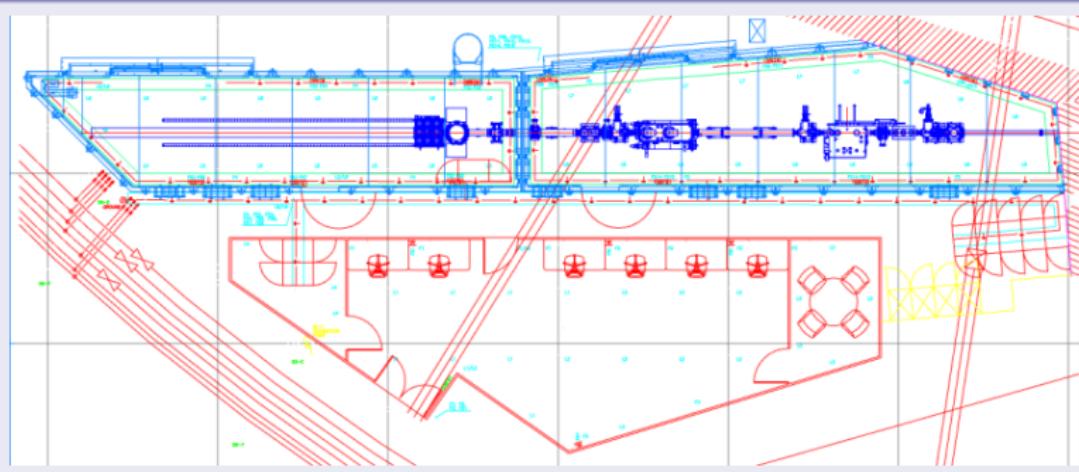
- 3 Hosts
- 28 Devices
- 12 DServers
- 19 DClasses

Inverted configuration



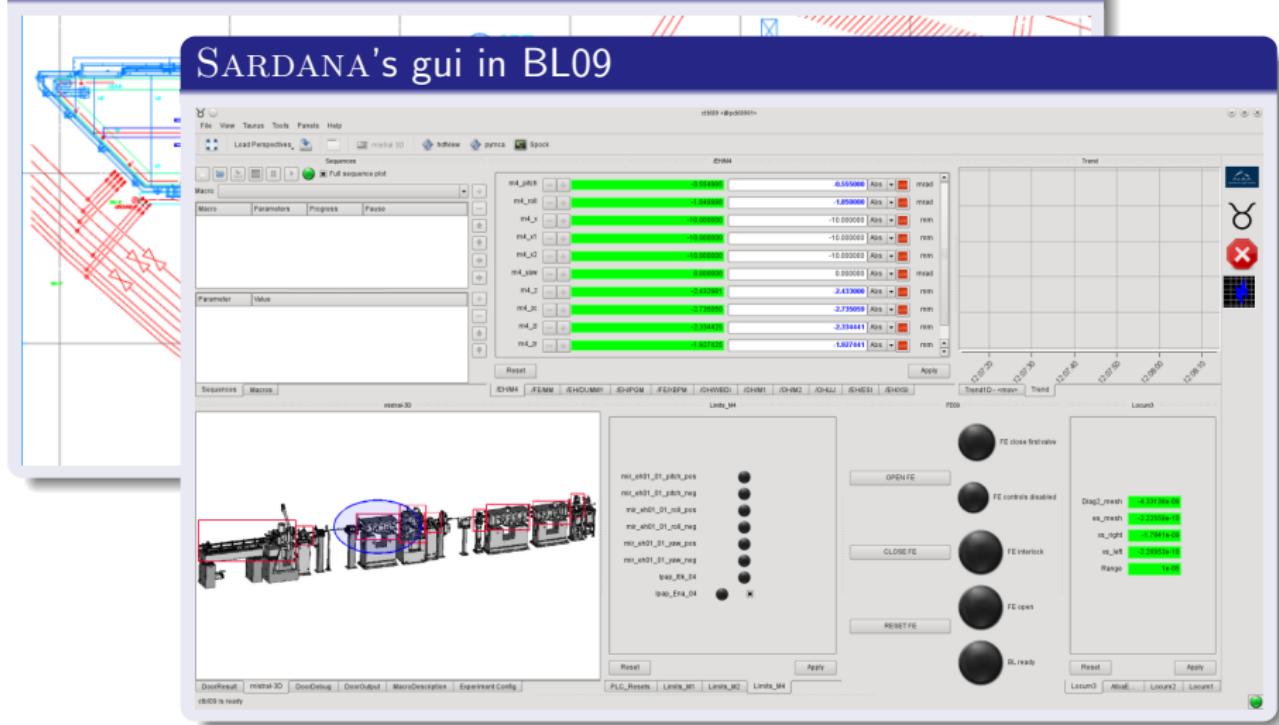
A beamline

layout of BL11



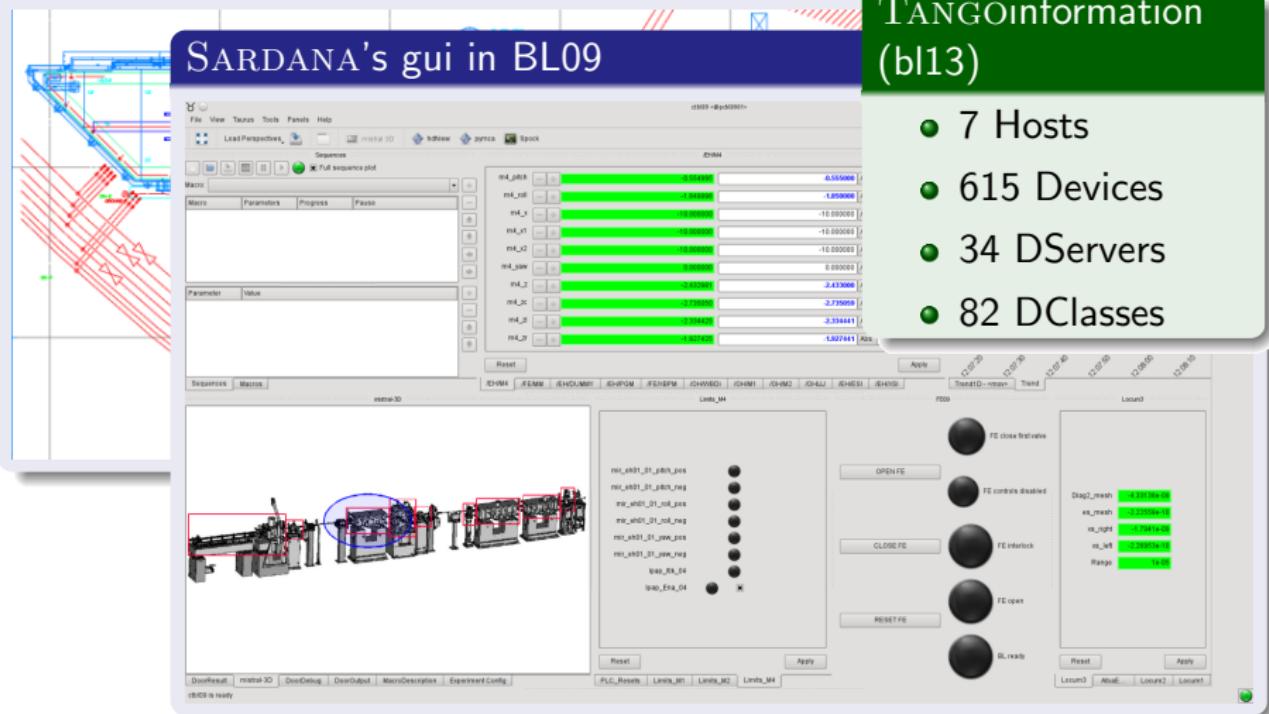
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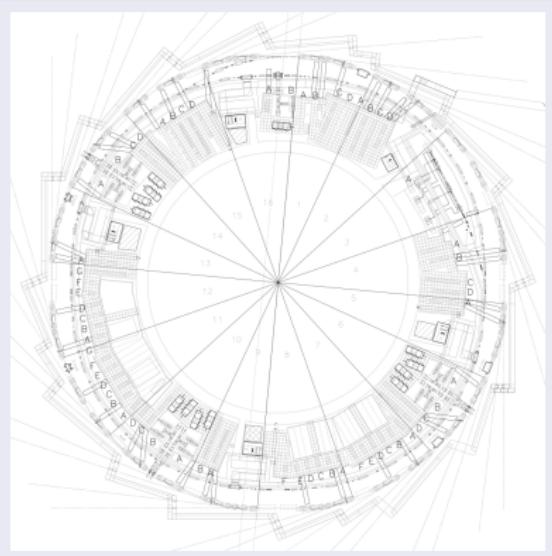
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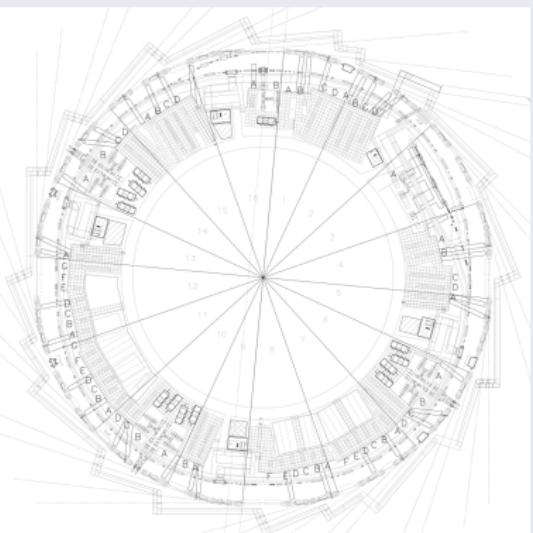
Control a synchrotron accelerator

Alba's overview

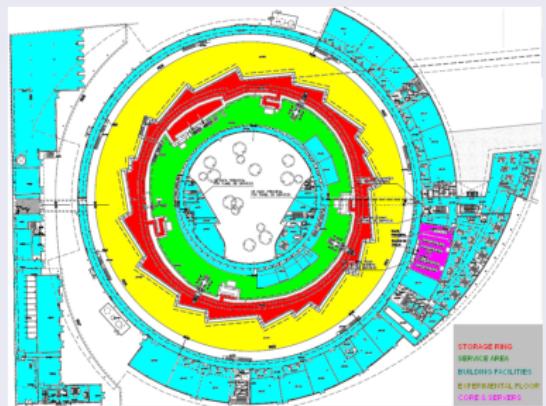


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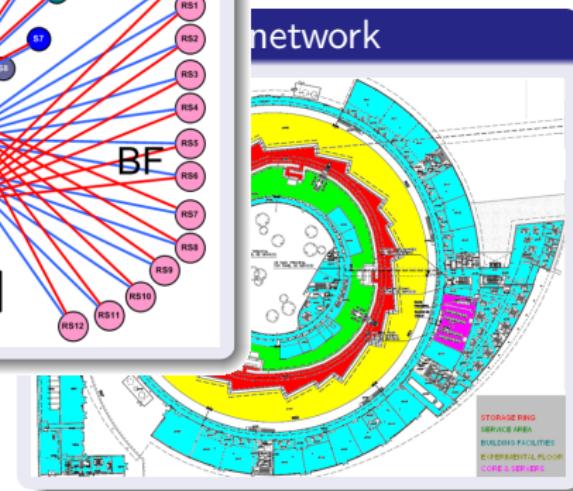
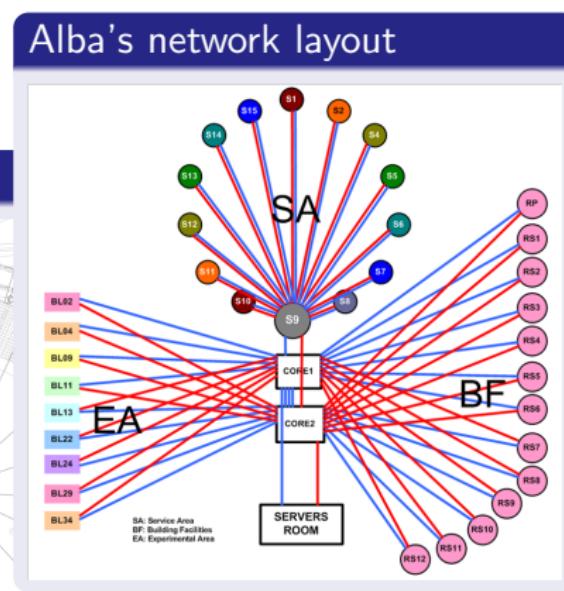
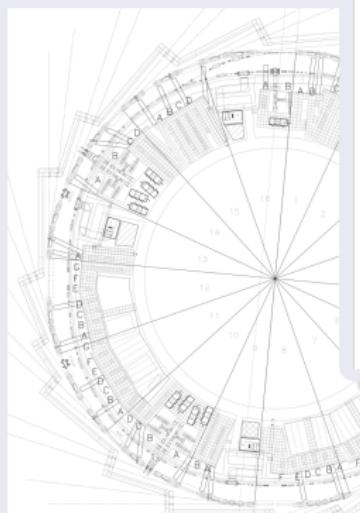


Alba's main network



Control a synchrotron accelerator

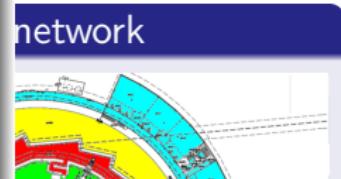
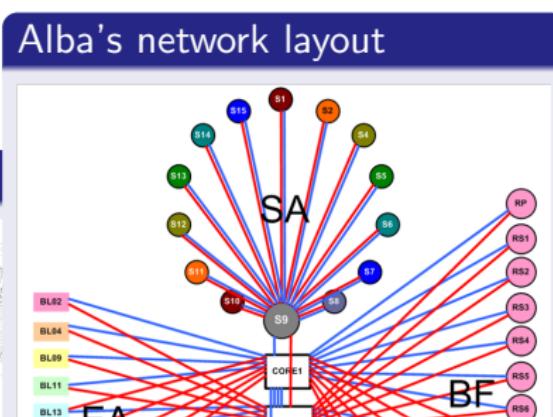
Alba's overview



Use cases of TANGO

Control a synchrotron accelerator

Alba's overview



Alba's Cabling Database

Home Equipment Cable Reports Installation Bulk Upload Help
Main page CCDB



372 Racks
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.**

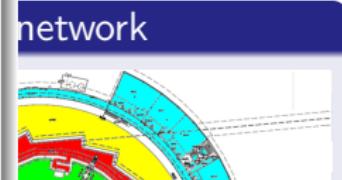
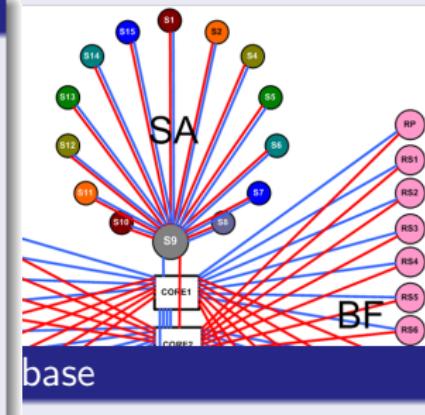
Use cases of TANGO

Control a synchrotron accelerator

Alba's network layout

Alba's subsystems

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



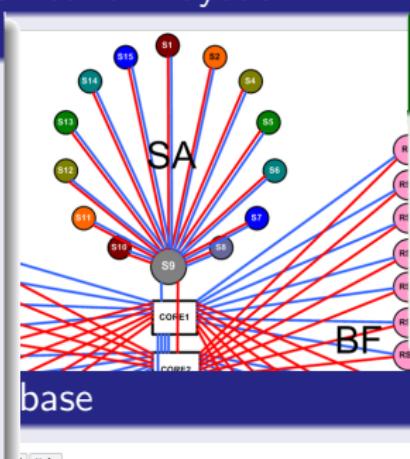
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TANGOinformation (bl13)

- 139 Hosts
- 4259 Devices
- 85 DServers
- 1551 DClasses

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Use cases of TANGO

Other possibilities

Use cases of TANGO

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- Factory production lines

Production lines



Use cases of TANGO

Other possibilities

- Factory production lines
- Critical factories

Production lines



Use cases of TANGO

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- Factory production lines
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- **Electronic traffic lights and tools**

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Use cases of TANGO

Other possibilities

- Factory production lines
- Critical factories
- Electronic traffic lights and tools
- **Energy industry**

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
- Modification/Fabrication: agent impersonate

Vulnerable attacks

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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)`,...

Security threads, policies and mechanisms

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

Labelling

Security levels

European commission *fiche 17*

“Exchange of EU classified information” [5]

- Open or Unclassified
- Confidential
- Secret
- Top-Secret

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European commission *fiche 17*

“Exchange of EU classified information” [5]

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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.

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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

Encryption

Encryption

- Encrypt *what has send* to an agent and its *answer*
- Encrypt events emitted

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- Stream ciphers

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Auditable EC generation algorithm.

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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

5

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

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]

Session key exchange

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]

Elliptic curves

- J. Valera, “Volcales de ℓ -isogenias de curvas elípticas,” Sistemas Informáticos. Escola Politècnica Superior. Universidad de Lleida, Sept 2011. Directed by: Josep M. Miret. [14]
- A. Rostovtsev and E. Rostovtsev and A. Stolbunov “Public-Key Cryptosystem Based On”. 2006 [15]
- R. Moreno, Subgrupos de Sylow de las curva ellípticas definidas sobre cuerpos finitos. PhD thesis, Universitat Politècnica de Catalunya, 2005. Directed by: Anna Rio and Josep M. Miret. [16]

Ongoing:

- S. Blanch-Torné and R. Moreno and F. Sebé and J. Varela “Security risk associated with multiple users sharing the same elliptic curve”. Draft [17]

Symmetric ciphers

- “Specification for the advanced encryption standard (aes).” Federal Information Processing Standards Publication 197, 2001.[18]
- J. Daemen and V. Rijmen, “The Design of Rijndael”. Secaucus, NJ, USA: Springer-Verlag New York, Inc., 2002. [19]
- J. Schaad and R. Housley, “Advanced Encryption Standard (AES) Key Wrap Algorithm.” Sept. 2002. RFC3394 [20]

Ongoing:

- S. Blanch-Torné and R. Moreno and F. Sebé and M. Valls “Generalised Rijndael”. Draft [21]

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.

Journals

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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-  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.
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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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-  J. Schaad and R. Housley, "Advanced Encryption Standard (AES) Key Wrap Algorithm." RFC 3394 (Informational), Sept. 2002.
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Alba's duties

- Diagnostics
 - CCDs
 - Instrumentation
 - Tune excitation
 - Filling Pattern
 - FCT
- Linac
- Power Supplies
 - Magnet cycling
 - StateCode interpreter
 - Fast orbit feedback
- Radio Frequency
 - Digital Low Level RF
 - Fast Data Logger
 - Facade
- Optics lab
 - Autocollimator
- Sardana controllers
 - IBACtrl
 - ElComatCtrl
 - AttenIOR (group)
 - MirrorPM & MonoPM
- Tango naming convention (and DNS)
- “Interfaces to the Alba Control System”
- “Controls coding standard and packaging convention”