Dr. Paulo Gomes

on behalf of the team CERN — TE — CRG

with the precious contributions of the colleagues:

Project Associates (NTU-Athens, AGH-Krakow)
Industrial Support
Cryogenic Operation
AB — CO
energy per beam: 7 TeV
luminosity: $10^{34}$ cm$^{-2}$s$^{-1}$
main dipoles field: 8 T
current: 12 kA
main magnets superconducting: 1200 D + 400 Q
QRL feeds He to the superconducting magnets

- in all magnets +QRL: 10,000 cryogenic sensors & actuators
- super-fluid liquid He bath temperature: 1.9 K
- cryo distribution line feeding magnets every: 107 m
52 DFBs

5,000 instruments

support and cool

Current Leads that power the magnets
RF superconducting accelerator cavities @ 4.5 K

16 cavities grouped on 4 modules, on IP4
200 cryo instruments
tunnel - radiation
sector = 3.3 km

alcoves - radiation free

CERN Control Centre

CIET PVSS data server

surface - local control room

Ethernet Technical Network

2 PLC Siemens S7-400 500 ms cycle

CRYO-SCADA PVSS data server

CIET PVSS data server

8 FEC WorldFIP – Ethernet Gateway 500 ms cycle

point-to-point cables

4x Profibus 1.5 Mbit/s

180 cryogenic CV without electronics

100 FIP crates custom rad-tol electronics

sector = 3.3 km

“intelligent” CV positioners with electronics

4x WorldFIP 1 Mbit/s

FieldBuses → large distances

industrial electronics → protected areas

CVs → electronics moved into protected areas

front-end electronics → radTol custom made

8 FEC

100 m cycle

179 8 FEC

194 8 FEC

209 8 FEC

223 8 FEC

238 8 FEC

253 8 FEC

268 8 FEC

283 8 FEC

302 8 FEC

317 8 FEC

332 8 FEC

347 8 FEC

362 8 FEC

377 8 FEC

392 8 FEC

407 8 FEC

422 8 FEC

437 8 FEC

452 8 FEC

467 8 FEC

482 8 FEC

497 8 FEC

512 8 FEC

527 8 FEC

542 8 FEC

557 8 FEC

572 8 FEC

587 8 FEC

602 8 FEC

617 8 FEC

632 8 FEC

647 8 FEC

662 8 FEC

677 8 FEC

692 8 FEC

707 8 FEC

722 8 FEC

737 8 FEC

752 8 FEC

767 8 FEC

782 8 FEC

797 8 FEC

812 8 FEC

827 8 FEC

842 8 FEC

857 8 FEC

872 8 FEC

887 8 FEC

902 8 FEC

917 8 FEC

932 8 FEC
a few numbers

<table>
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<tr>
<th></th>
<th>TT</th>
<th>CV</th>
<th>PV</th>
<th>QV</th>
<th>PT</th>
<th>LT</th>
<th>EH</th>
<th>total</th>
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<tbody>
<tr>
<td>average / sector</td>
<td>1000</td>
<td>325</td>
<td>90</td>
<td>90</td>
<td>65</td>
<td>310</td>
<td>1880</td>
<td></td>
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<tr>
<td>total all-sectors</td>
<td>8000</td>
<td>2600</td>
<td>720</td>
<td>720</td>
<td>520</td>
<td>2480</td>
<td>15040</td>
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<table>
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<tr>
<th>FIP crates</th>
<th>FIP segments</th>
<th>Profibus segments</th>
<th>PLC</th>
<th>CCL</th>
<th>alarms/interlocks</th>
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<tbody>
<tr>
<td>average</td>
<td>100</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>2x250</td>
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<tr>
<td>all sectors</td>
<td>800</td>
<td>68</td>
<td>42</td>
<td>16</td>
<td>4000</td>
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</table>
Databases are intensively used - LHC Controls Layout DB

17,055 instrumentation channels
798 FIP crates
855 cards
1,738 Profibus components
5,000 cable numbers

LHC Layout Database

- Specification files for manufacturing FIP Crates
- Cabling files for connecting & inspecting cables
- XML files for Mobile Test Bench
- Specifications for control software PLC, FEC, SCADA
(existing) **UNICOS framework** (Unified Industrial Control System) provides methodology & baseline tools to program industrial control systems @ CERN

**(developed)** generator of process specifications extracts from DBs the list of all objects, parameters, logical relations

**(new)** checker of specifications

**(written)** logic templates similar code for objects of same family

**(new)** external function with common logic

**(existing)** **UNICOS source code generator for PLC & SCADA**

**(new)** generator for specificities not covered by UNICOS gen code compilation with UNICOS libraries

**(new)** run/check code on test PLC with simulated inputs

**project deployment on field machines**

**(new)** last 5 LHC sectors to be deployed at a rate of 1 new sector every 2 weeks

**In the end, the full sector code generation took only 2 days**
200 panels / sector
40 synoptics, 35 bar-graphs, 60 alarms & interlocks
Repetitive panels use parameterized templates
Parameters generator, directly from DB

CRYO-SCADA for operation

CIET for Instrumentation Experts
Conclusions

The control software production relies strongly on a set of databases and on a package of automatic generation tools, which have been developed to create code in several steps, according to a well established methodology.

The UNICOS automated generation & checking tools proved to be essential for flexible and robust PLC code generation.

Thanks to extensive automatic code generation, we achieved reduced software-production time and effort, increased code reliability, minimised risk of human mistakes, simplified long term maintenance.

We managed to reach a deployment rate of 1 new sector every 2 weeks, while in parallel giving support and modifications on other operating sectors.

And…
At 10:28, one beam of protons was steered around the machine for the 1st time.

Around 15:00 the other beam circulated in the second ring (anticlockwise)
