The Project ALBA

Contents
1.) General Information
2.) Linac
3.) Booster Synchrotron
4.) Storage Ring
Contents
1.) General Information
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The ALBA - Building

- Warehouse
- Parking
- Workshop
- SR and Boo Tunnel
- Offices
- Electricity
- Cooling, HVAC
- Size of the ground: 250m * 450m

Dieter Einfeld, CELLS-ALBA

ESP-RUS2011, 10th November 2011
Accelerator complex of ALBA: We followed the concept of the SLS to have the booster and the storage ring in the same tunnel. The preinjector is a 100 MeV Linac.
ALBA
17 ID beam ports
17 BM beam ports

Phase I
7 Beamlines (6 ID + 1 BM)
2 Diagnostic FEs
1 test FE (for future beamline)
Brilliances of ID’s

Light output at 400 mA of current in SR

- Bend
- SC-W31
- MPW-80
- IVU-21
- EU-62
- EU-71

On axis brilliance

Ph/s/mrad²/mm²/0.1%BW

Energy (eV)
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LINAC in the Tunnel

Accelerator Division

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- Pre-buncher
- Buncher
- Glaser Lens
- 1st Acc.-Str.
- 2nd Acc.-Str.
- E-Gun
$E = 110.087\text{ MeV}, \Delta E/E = 0.05\text{ MeV} = 0.046\%$

Energy jitter = 0.15 MeV = 0.14 %
Conditions at the exit of the Linac:

\[ \varepsilon(x) = 62.9 \text{ nm arad} \]
\[ \beta(x) = 10.88 \text{ m/rad} \]
\[ \alpha(x) = 2.01 \]
\[ \varepsilon(y) = 47.8 \text{ nm arad} \]
\[ \beta(y) = 9.14 \text{ m/rad} \]
\[ \alpha(y) = 1.98 \]
Linac

Booster Synchrotron

Injection Straight

Transfer Line

Diagnostic Line

Quad-triplet-system

Bending magnet

ε(x) = 62.9 nm/nd
β(x) = 10.88 m/rad, α(x) = 2.01
ε(y) = 47.8 nm/nd
β(y) = 9.14 m/rad, α(y) = 1.98

β(x) = 11.9 m/rad,
α(x) = 0.0
β(y) = 1.9 m/rad,
α(y) = 0.0
η(x) = 0.05
η'(x) = 0.0
**LTB-Machine-Functions**

**Accelerator Division**

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**Quads:**
- $G/I = 1.28 \text{ (T/m)/A}$
- $L_{eff} = 0.125 \text{ m}$

**Machine Functions:**
- $\epsilon(x) = 35 \text{ nmrd}$, $\epsilon(y) = 32.5 \text{ nmrd}$
- $\beta(x) = 11.57 \text{ m/rad}$, $\beta(y) = 8.36 \text{ m/rad}$
- $\alpha(x) = 1.93$, $\alpha(y) = 1.46$

**Dispersion Coefficients:**
- $Q(1) = 8.984$, $Q(2) = 0.4635$, $Q(3) = -3.343 \text{ m}^{-2}$
- $Q(4) = -6.519$, $Q(5) = 14.399$, $Q(6) = -8.498 \text{ m}^{-2}$
- $Q(7) = -5.227$, $Q(8) = 10.437$, $Q(9) = -8.019 \text{ m}^{-2}$

---

**Diagram Details:**
- **BetaX /m**
- **BetaY /m**
- **10 * DispX /m**
- **FSOTR-Station**
- **H,V-Correctors**
- **BPM-Station**

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**Credits:**
- *Dieter Einfeld, CELLS-ALBA*
- *ESP-RUS2011, 10th November 2011*
Project ALBA: Booster Synchrotron

Contents
1.) General Information
2.) Linac
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4.) Storage Ring
3 GeV Booster
gradient dip., with built-in sextupole. Circumference: 249.6 m

4 superperiods:
32 long dip. 2 m
8 short dip. 1 m
60 quads in 4 families

Emittance
10 nm·rad

Arc with 8 unit cells (10 degrees bending)

ALBA booster synchrotron with 4 fold symmetry

Matching section

Straigth section for injection and cavities
The characteristics of the machine are determined by the beta functions $\beta(x)$, $\beta(y)$ as well the dispersion function $\eta(x)$. 

\[
H = \gamma_x \eta_x^2 + 2\alpha_x \eta_x \eta'_x + \beta_x \eta'_x^2
\]

\[
\alpha_x(s) = -\frac{1}{2} \beta'_x(s) \quad \gamma_x(s) = \frac{1 + \alpha_x^2(s)}{\beta_x(s)}
\]

\[
\varepsilon_x = C_q \frac{\gamma^2}{\rho J_x} \frac{1}{2\pi\rho_{\text{Dipoles}}} \int H ds \approx \gamma^2 \cdot \varphi^3
\]

\[
n_x = \frac{1}{2\pi} \int_0^C \frac{ds}{\beta_x(s)} = N + \Delta n
\]

\[
\alpha = \frac{\eta}{R_0} = \frac{2\pi\eta}{L_0} = \frac{1}{L_0} \int \frac{\eta \cdot ds}{\rho(s)}
\]
The lattice is a TME-structure
The ALBA synchrotron should have the smallest emittance in the world

Design working point: \( Q_x = 12.42, Q_y = 7.38 \)
Booster Components

Unit Cell

Bending Magnet

Sextupole

Quadrupole
Booster Components

- **Straight**
- **Matching Cell**
- **Booster Arc**
- **Injection**
- **Extraction**
Good agreement with the model
LOCO: Beta Functions (DC)

\[ \beta\text{-function (Tune} = 12.271 / 7.356) \]

\[ \beta_x, \beta_y \text{ [meters]} \]

Good agreement with the model.
Closed Orbit Movement

9th October 2011: 8 horiz. + 2 vertic
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Accelerator Division

25th October 2011
Movement of Working Point

Design value: $Q_x = 12.42$, $Q_y = 7.38$
Beam in the Booster Synchrotron

Accelerator Division

Bad shots

Increase transmission

LINAC  LT  BO  BT

70%  70-85%  100%

50% - 60%

110 MeV  3 GeV  200 MeV
Booster Injection Efficiency

9th October 2011

Each 14th shot is a “Bad Shot”
For the bad shots we loose everything during the first turns
Storage Ring

Injection Straight

Transfer Line

Accelerator Division

Beam size at injection (1σ)

\(\varepsilon_x = 9 \text{ nm.rad}\)

\(\sigma_{x,\text{max}} = 0.3 \text{ mm}\)

\(\sigma_{y,\text{max}} = 0.2 \text{ mm}\)
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Layout of BTS Transfer Line

\[ \beta(x) = 10.51 \]
\[ \alpha(x) = 0.034 \]
\[ \eta(x) = 0.442 \]
\[ \eta'(x) = 0.00 \]
\[ \beta(y) = 2.93 \]
\[ \alpha(y) = -0.002 \]

\[ \beta(x) = 11.21 \]
\[ \alpha(x) = -0.066 \]
\[ \eta(x) = 0.145 \]
\[ \eta'(x) = 0.00 \]
\[ \beta(y) = 6.005 \]
\[ \alpha(y) = -0.124 \]
The 1st extracted Beam from the Booster Synchrotron, 28th of October 2010

\[ \sigma(x) = 0.86 \text{ mm}, \quad \sigma(y) = 0.19 \text{ mm} \]

\[ \varepsilon(x) = 13 \text{ nmrad}, \quad \varepsilon(y) = 2.6 \text{ nmrad} \]

We are 30% off to the theoretical emittance and have a coupling factor of roughly 20%.
Contents

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Layout of ALBA Storage Ring

Symmetry = 4 fold
Circumference = 268.8 m

- 4 long straights (7.8 m)
- 12 medium straights (4.0 m)
- 8 short straights (2.3 m)
4 long: $\sigma(x) = 300\mu m$, $\sigma(y) = 16.2\mu m$

12 medium: $\sigma(x) = 147\mu m$, $\sigma(y) = 7.6\mu m$

8 short: $\sigma(x) = 362\mu m$, $\sigma(y) = 15.1\mu m$

Q(x) = 18.18
Q(y) = 8.37
$\epsilon(x) = 4.5$ nmrad
$\alpha = 8.83 \times 10^{-4}$
$\delta E/E = 1.05 \times 10^{-3}$
Storage Ring Components

- Bending
- Quadrupole
- Sextupole and correctors
- Matching Cell
There are: 8 foc. and 3 def. families of quadrupoles
4 foc. And 5 def. families of sextupoles
Girder of Unit Cell

Accelerator Division

SF-04  Qf-08  SD-05  Q-Bend  SD-04  SF-03  Qf-07  Qd-03

Beam-Direction

Vacuum pumps
Magnetic field: 1.42 T
Bending angle: 11.25 deg.
Gradient: 5.6 T/m
Bending radius: 7.047 m
Gap: 36 mm
Current: 520 A
Field accuracy: <3*10^{-3}
Grad. accuracy: <5*10^{-3}

The dipole is split in the middle of the magnet for machining of both pole faces with an accuracy of +/- 15 μm.
Bending Magnets: Individual Settings

Change of k-Values of the individual magnets.

Change of fringe field angle of the individual Magnets.

Change of Bending Gradient

Change of Bending Fringe Field Angle

Number of Magnet

Number of Magnet
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**ALBA-Lattice with nominal Settings**

**Accelerator Division**

\[ C = 268.8 \text{ m}, \quad Q_x = 18.182, \quad Q_y = 8.373, \quad \varepsilon = 4.42 \text{ nmrad} \]

\[ \text{Rho} = 7.0470423, \quad l = 1.383684 \text{ m}, \quad k = 0.565618, \quad \phi = 5.625, \]
C = 268.8 m, Qx = 18.183, Qy = 8.395, ε = 4.44 nmrad

Rho = 6.99718, l = 1.373893 m, k = 0.568103, phi = 5.9395,
ALBA-Lattice with individual Settings

\[ C = 268.8 \text{ m}, \quad Q_x = 18.183, \quad Q_y = 8.395, \quad \varepsilon = 4.44 \text{ nmrad} \]

\[ \text{Rho} = 6.99718, \quad l = 1.373893 \text{ m}, \quad k = \text{individual}, \quad \phi = \text{individual} \]
According to the individual characteristics of the bending magnet, the beta beating (deviation from the model) will be around +/- 3% and the settings of the power supplies will vary about +/- 0.6 % from the nominal ones. These are the guide lines for the real machine.
The unit cell ~ 13 m

- Antechamber design with lumped copper absorbers.
- Keyhole profile 28x72 mm.
- Stainless steel 316LN.
- Pumping mainly by ion and NEG pumps.

The matching cell ~ 11 m

Keyhole profile

- Cold cathode gauge
- Ion pumps
- RGA
- Lumped absorbers
- NEG pumps
- Bending magnet

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Vacuum System Layout

ESP-RUS2011, 10th November 2011
RF - System

Radiofrequency System (RF), $f = 500$ MHz

1. ACCELERATING CAVITIES
   - 160 kW / cav
   - 600 KV / cav

2. WAVEGUIDES

3. IOT (RF Amplifier)
   - 80 kW / amplifier

4. RF CIRCULATOR

5. CACO
   (Cavity Combiner)

6. RF LOADS

7. HVPS
   (High Voltage Power Supplies)

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ESP-RUS2011, 10th November 2011
DIAGNOSTIC SYSTEM

eBPM
Corrector
Fluorescent Screen
Fast Current Transformer
DC Current Transformer
Beam Loss Monitor
Pin Hole X-Ray
Scraper
Stripline

SR - Diagnostic
Accelerator Division
Apple II EU62, EU71 and MPW are installed.
Recabling Quads:

- Sectors 1&2
  - Quadrant 1
  - Quadrant 2
- Quadrants 3&4

19h35: 1st turn!
Maximum
SR FCT

Vacuum
Average
13-14 March: Firsts measurements

Lifetime

Synchrotron light at pin hole camera

Energy = 2.985 GeV

Qinteger = (18, 8)
16th of March 2011: a historical day of the ALBA – project: the first accumulated beam at ALBA.

Beam within the storage ring

Beam within the booster
16th of March 2011: A historical day of the ALBA – project, The Accelerator Division is celebrating this success.
Once the MPS was operational…

**CURRENT** 100.299 mA

**Life Time** 0h 06m

**Filling Mode** 56

**Avg. Pressure (mbar)** 7.34e-09

Friday 01-Apr-2011 18:25:28

SR commissioning. Max current 90.0 mA
7th of June: 170 mA at ALBA

CURRENT 170.010 mA

Life Time 0h 09m  Curr/LifeT 29.8
Filling Mode 56 b.  Avg. Pressure (mbar) 6.10e-09

Tuesday 07-Jun-2011 20:32:38

SR Commissioning. Max Current 1
Orbit Correction

Raw orbit without correctors

Offsets of BBA included and RF frequency adjusted

Storage Ring Orbit (Difference from the Offset Orbit)

Horizontal orbit < 3mm
Vertical orbit < 2 mm

Good alignment
Injection Efficiency

SR DCCT

Injection efficiency \(\sim 95\%\)

Booster DCCT

\[
\langle I \rangle = 0.55 \text{ mA}
\]

\[
I = 21 \text{ mA}
\]

\[
t = 40 \text{ s}
\]
Summary of Measurements

- Tune
- Chromaticity
- Beam Based Alignment
- Orbit correction, including frequency adjustment
- LOCO measurements: Beta functions, dispersion and beating correction
- Beam size, emittance
- Bunch length
- Vacuum performance
- Closing IDs
- Slow orbit correction system

(Most of these measurements were done with 10~20 mA)
SCW and IVU’s are installed
The agreement between the LOCO results and the matched solution with BAD are pretty good. There are small differences in the short and in the middle medium straight.
The agreement between the LOCO results and the matched solution with BAD are pretty good.
The agreement between the LOCO results and the matched lattice with BAD are pretty good.
## Settings of QH08 and QH09

<table>
<thead>
<tr>
<th>Location (m)</th>
<th>S (m)</th>
<th>β(x), Aver. (m/rad)</th>
<th>β(y), Aver. (m/rad)</th>
<th>η(x), Aver. (m/rad)</th>
<th>β(x), BAD (m)</th>
<th>β(y), BAD (m/rad)</th>
<th>η(x), BAD (m)</th>
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</thead>
<tbody>
<tr>
<td>Start</td>
<td>0.0000</td>
<td>11.2928</td>
<td>6.7918</td>
<td>0.1212</td>
<td>11.2910</td>
<td>6.7265</td>
<td>0.1207</td>
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<tr>
<td>1st med.</td>
<td>16.4200</td>
<td>2.0046</td>
<td>1.2144</td>
<td>0.0790</td>
<td>2.0036</td>
<td>1.2195</td>
<td>0.0791</td>
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<tr>
<td>1st short</td>
<td>24.9960</td>
<td>9.3919</td>
<td>5.2120</td>
<td>0.2471</td>
<td>9.5210</td>
<td>5.1589</td>
<td>0.2449</td>
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<tr>
<td>2nd med.</td>
<td>33.5650</td>
<td>2.0049</td>
<td>1.2111</td>
<td>0.0791</td>
<td>1.6300</td>
<td>1.2793</td>
<td>0.0767</td>
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<tr>
<td>2nd short</td>
<td>42.1300</td>
<td>9.3713</td>
<td>5.1685</td>
<td>0.2468</td>
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<td>0.2449</td>
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<td>3rd med.</td>
<td>50.7000</td>
<td>1.9966</td>
<td>1.2317</td>
<td>0.0788</td>
<td>2.0036</td>
<td>1.2195</td>
<td>0.0791</td>
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<tr>
<td>End</td>
<td>67.2000</td>
<td>11.2983</td>
<td>6.8392</td>
<td>0.1209</td>
<td>11.2910</td>
<td>6.7265</td>
<td>0.1207</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Location (m)</th>
<th>S (m)</th>
<th>β(x), Beat (%)</th>
<th>β(y), Beat (%)</th>
<th>η(x), Beat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>0.0000</td>
<td>0.0162</td>
<td>0.9700</td>
<td>0.3728</td>
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<tr>
<td>1st med.</td>
<td>16.4200</td>
<td>0.0474</td>
<td>-0.4203</td>
<td>-0.1896</td>
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<td>1st short</td>
<td>24.9960</td>
<td>-1.3565</td>
<td>1.0288</td>
<td>0.8983</td>
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<tr>
<td>2nd med.</td>
<td>33.5650</td>
<td>23.0000</td>
<td>-5.3310</td>
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<td>2nd short</td>
<td>42.1300</td>
<td>-1.5721</td>
<td>0.1856</td>
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<td>3rd med.</td>
<td>50.7000</td>
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<td>End</td>
<td>67.2000</td>
<td>0.0649</td>
<td>1.6755</td>
<td>0.1450</td>
</tr>
</tbody>
</table>

Beta beating between the LOCO results and the values of the matched lattice. There are differences only in the middle medium straight. This means there is a good agreement. The emittance of the matched lattice is 4.67 nmrad.
\[ \frac{\Delta \sigma(l)}{\Delta(1/fs)} = \frac{(46.115-29.5)}{(0.24-0.12)} = \frac{16.615}{0.12} = 138.46 \times 10^{-9} \]

\[ \sigma(l) = \frac{1}{2 \pi} \alpha \left( \frac{1}{fs} \right) \sigma(E)/E \]

\[ \sigma(E)/E = \frac{\Delta \sigma(l)}{\Delta(1/fs)} \times 2 \pi / \alpha \]

\[ \sigma(E)/E = 138.46 \times 10^{-9} \times 2 \pi / (8.681 \times 10^{-4}) \]

\[ \sigma(E)/E = 10.02 \times 10^{-4} \]

From the matched lattice we have a value of:

\[ \sigma(E)/E = 10.547 \times 10^{-4} \]

Which is an excellent agreement.
Relations of the Synchrotron Integrals

\[ \left( \frac{\sigma(E)}{E} \right)^2 = C \cdot \frac{I_3}{2 \cdot I_2 + I_4} \]
\[ = C \cdot \frac{I_3}{I_2} \cdot \left( \frac{1}{2 + (I_4/I_2)} \right) \]
\[ = C \cdot \frac{I_3}{I_2 \cdot J_s} \]
\[ \varepsilon = C \cdot \frac{I_5}{I_2 - I_4} \]
\[ = C \cdot \frac{I_5}{I_2} \cdot \left( \frac{1}{1 - (I_4/I_2)} \right) \]
\[ = C \cdot \frac{I_5}{I_2 \cdot J_x} \]
\[ \frac{\left( \frac{\sigma(E)}{E} \right)^2}{\varepsilon} = \frac{I_3}{I_5} \cdot \frac{J_x}{J_s} \]
\[ = \frac{0.128}{4.11 \times 10^{-4}} \cdot \frac{1.3}{1.70} \]
\[ = 238.2 \]

With \( \sigma(E)/E = 10.02 \times 10^{-4} \) it follows an emittance of
\[ \varepsilon = 4.67 \times 10^{-9} = 4.67 \text{ nmrad} \]

From the matched lattice we have a value of:
\[ \varepsilon = 4.62 \text{ nmrad} \]
Which is an excellent agreement
Summary:
All the evaluations from: LOCO, energy spread and pinhole agree very well. The emittance of the Storage ring is 4.6 nmrad.

Table 1: Horizontal and Vertical parameters used for the emittance calculation, and associated error bars.

<table>
<thead>
<tr>
<th></th>
<th>$\sigma$, $\mu$m</th>
<th>$\beta$, m</th>
<th>$D$, m</th>
<th>$\epsilon$, nmrad</th>
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<tbody>
<tr>
<td>Hor Value</td>
<td>59.15</td>
<td>0.489</td>
<td>0.0355</td>
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<tr>
<td>Hor Error</td>
<td>3%</td>
<td>1%</td>
<td>1%</td>
<td>10</td>
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<tr>
<td>Ver Value</td>
<td>27.79</td>
<td>24.465</td>
<td>0.0</td>
<td>0.031</td>
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<tr>
<td>Ver Error</td>
<td>3%</td>
<td>1%</td>
<td>0.0</td>
<td>7</td>
</tr>
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</table>
## Settings of QH01 and QH04

### Currents QH01

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<th>Magnet Number</th>
<th>AVER.</th>
<th>STEDV</th>
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<tbody>
<tr>
<td>1</td>
<td>128.4</td>
<td>0.08</td>
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<tr>
<td>2</td>
<td>128.5</td>
<td>0.08</td>
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<td>3</td>
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<td>4</td>
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<td>5</td>
<td>128.8</td>
<td>0.08</td>
</tr>
<tr>
<td>6</td>
<td>128.9</td>
<td>0.08</td>
</tr>
<tr>
<td>7</td>
<td>129</td>
<td>0.08</td>
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<tr>
<td>8</td>
<td>129.1</td>
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### Currents QH02

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<td>0.1</td>
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<tr>
<td>2</td>
<td>153.9</td>
<td>0.1</td>
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<td>3</td>
<td>154</td>
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<td>4</td>
<td>154.1</td>
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<td>154.2</td>
<td>0.1</td>
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<td>6</td>
<td>154.3</td>
<td>0.1</td>
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<tr>
<td>7</td>
<td>154.4</td>
<td>0.1</td>
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<tr>
<td>8</td>
<td>154.5</td>
<td>0.1</td>
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### Currents QH03

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<th>STEDV</th>
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<td>2</td>
<td>130.9</td>
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<td>4</td>
<td>131.1</td>
<td>0.17</td>
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<td>5</td>
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<td>0.17</td>
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<tr>
<td>6</td>
<td>131.3</td>
<td>0.17</td>
</tr>
<tr>
<td>7</td>
<td>131.4</td>
<td>0.17</td>
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<tr>
<td>8</td>
<td>131.5</td>
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</tbody>
</table>

### Currents QH04

<table>
<thead>
<tr>
<th>Magnet Number</th>
<th>AVER.</th>
<th>STEDV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>120.8</td>
<td>0.08</td>
</tr>
<tr>
<td>2</td>
<td>120.9</td>
<td>0.08</td>
</tr>
<tr>
<td>3</td>
<td>121</td>
<td>0.08</td>
</tr>
<tr>
<td>4</td>
<td>121.1</td>
<td>0.08</td>
</tr>
<tr>
<td>5</td>
<td>121.2</td>
<td>0.08</td>
</tr>
<tr>
<td>6</td>
<td>121.3</td>
<td>0.08</td>
</tr>
<tr>
<td>7</td>
<td>121.4</td>
<td>0.08</td>
</tr>
<tr>
<td>8</td>
<td>121.5</td>
<td>0.08</td>
</tr>
</tbody>
</table>
For the horizontal focusing quadrupoles there are standard deviations up to 0.42 %, this is in a good agreement with the expected values. For the vertical focusing quadrupoles the values are going up to roughly 1 %. This is okay, but it could be a bit better. The difference between the horizontal and vertical direction is given by the variation of the gradient from magnet to magnet.
ID’s: Change of Tune

Theoretical IDs effect (at min gap)

$10^3 \Delta Q_{x, \text{theor}}$
$10^3 \Delta Q_{x, \text{meas}}$
$10^3 \Delta Q_{y, \text{theor}}$
$10^3 \Delta Q_{y, \text{meas}}$

Dieter Einfeld, CELLS-ALBA
Stability of the Beam

**FE11**
- Stability: +/- 2.6 μm
- Drift: 0.4 μm / hour

**FE13**
- Stability: +/- 2.8 μm
- Drift: 0.5 μm / hour

Dieter Einfeld, CELLS-ALBA

ESP-RUS2011, 10th November 2011
Stability of the Beam

Change of the BPMs when closing the MPW with FeedForward table

\[ \Delta x \text{ [\mu m]} \]

\[ \Delta y \text{ [\mu m]} \]

\[ t \text{ [s]} \]
Average pressure without beam = $4 \times 10^{-10}$ mbar.

With 4.5 A.h. dose, the average pressure was $3.2 \times 10^{-9}$ mbar with 80 mA of beam current (multi-bunch filling mode).

Vacuum Clean-up rate estimated 0.68.
Thank you very much

This was not only a success from the commissioning team, it was a success of the whole CELLS staff.

The machine is ready to serve as a source for the experiments.
Thank you very much

gap=16.5mm — ANTIPARALLEL mode

Thank you very much
Thank you very much

This was not only a success from the commissioning team, it was a success of the whole CELLS staff.

The machine is ready to serve as a source for the experiments.
Problems and Next Steps

- RF problems
  LLRF deregulation, water leaks, vacuum leaks, trips ...

- Vacuum problems
  Water configuration, chamber overheating, leaks ...

- Diagnostics problems
  Streak camera, Libera electronics, stack FS ...

- PS problems
  Wrong cabling, correctors and quadrupoles PS ...

- Control system problems
  Applications froze, motors, CCD camera, cycling, MPS, PSS, timing ...

Next Steps

- Commissioning with ID’s
- Slow orbit feedback
- Vacuum cleaning
- Better control filling pattern
- Fast orbit feedback
- Multibunch feedback
- Topping up
- …
For the families QV01 to QV02 the standard deviation of the different settings goes up to 0.64%. For the families QV03 and QV04 they are going up to 0.81%. This is a pretty good agreement.
Stability of the Beam

Change of the BPMs when closing the MPW with FeedForward table

\[ \Delta x [\mu m] \]

\[ \Delta y [\mu m] \]

\[ t [s] \]
History of the Project

- 1997: Finishing the conceptual design report
- 2003: Approval of the project by the Spanish- and the Catalanian Government. Site selected in the Valles area, close to Barcelona.
- 2003-05: Users meeting and workshops to establish the scientific program. 7 beam lines approved.
- 2004: Location of CELLS at the UAB
- 2004-05: Redesign of the machine, Staff recruiting (13 different nationalities)
- 2005-08: Building.
- 27th July 2006: ground breaking
- 2008-10: Mechanical installation.
- 2008: Linac installation and commissioning
- Eastern 2009: Movement from UAB to the new Building
- 2009-10: Booster commissioning
- 22nd March 2010: Official Inauguration
- 2011: SR commissioning
**Milestones for the Linac**

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.) First beam out of the Linac:</td>
<td>July 2008</td>
</tr>
<tr>
<td>3.) Phase 1 Commissioning of Linac:</td>
<td>October 2008</td>
</tr>
<tr>
<td>4.) Acceptance of Linac:</td>
<td>October 2008</td>
</tr>
<tr>
<td>5.) Phase 2 Commissioning of Linac:</td>
<td>October 2009</td>
</tr>
<tr>
<td>7.) Reparation of Linac structure 1:</td>
<td>April 2010</td>
</tr>
<tr>
<td>8.) Restart of Linac:</td>
<td>May 2010</td>
</tr>
<tr>
<td>9.) Optimisation of Linac:</td>
<td>June – July 2010</td>
</tr>
<tr>
<td>10.) Normal operation of Linac:</td>
<td>since July 2010</td>
</tr>
</tbody>
</table>

**Summary:** Some specifications of the Linac are much better as given by the specifications (for example the emittance is by a factor 1.5 smaller). The Linac operation is very reliable for the different modes: long bunch, small bunch, single bunch, large charge (4 nC), small charge (0.5 nC), etc.
Milestones for the Installation, Commissioning, and Operation of the Booster Synchrotron

1.) Mechanical installation of booster: Jan. 2009 to March 2009
2.) Installation of RF-System: Febr. 2009
3.) Installation of secondary piping: July to Sept. 2009
4.) Cooling available: September 2009
5.) Personal safety system finished: November 2009
6.) Alignment of booster synchrotron: Nov. to Dec. 2009
7.) Control system finished: December 2009
8.) Pre-commissioning of booster components: Nov. to Dec. 2009
9.) CSN- certificate for booster commissioning: December 2009
10.) First beam in the booster synchrotron: 21st December 2009
11.) Phase 1 of booster commissioning: 10th to 24th Jan. 2010
12.) Phase 2 of booster commissioning: July 2010
13.) Phase 3 of booster commissioning: Sept.- Octob. 2010
14.) Reaching 3 GeV: 4th October 2010
14.) Extraction of 3 GeV beam out of booster: 28th October 2010
15.) Normal operation of booster synchrotron: since Nov. 2010

Summary: The booster synchrotron runs reliable. The behaviour of the booster is pretty well understood. It is ready, working as an injector for the storage ring, but we have to make some optimisation.
## Storage Ring Milestones

1. **Mechanical installation of storage ring:** April to Nov. 2009  
2. **Storage ring under vacuum:** November 2009  
3. **SAT of power supplies:** Oct. 2009 to June 2010  
4. **Radio frequency installation:** Dec. 2009 to April 2010  
5. **Installation of injection straight:** May to June 2010  
6. **Cabling of magnets and power supplies:** Dec. 2009 to March 2010  
7. **Cabling of signals, EPS, and MPS:** Jan. to Sept. 2010  
8. **Magnetic measurements of W80 and EPU’s:** Jan. to Sept. 2010  
9. **SAT of superconducting wiggler:** October 2010  
10. **BTS installation finished:** September 2010  
11. **Pre-commissioning of subsystems:** July to Octob. 2010  
12. **Ready for storage ring commissioning:** 22nd of Nov. 2010  
13. **Installation of 3 insertion devices:** Jan. to Febr, 2011  
14. **Weekend for storage ring commissioning:** 12th / 13th Febr. 2011  
15. **License for storage ring commissioning:** 8th of March 2010  
16. **Bake out of in-vacuum undulators:** March to May 2011  
17. **Phase 1 of storage ring commissioning:** 8th to 26th of March  
18. **Phase 2 of storage ring commissioning:** 1st of April to 14th of May  
19. **Phase 3 of storage ring commissioning:** 25th of May to 10th of June  
20. **Installation of in-vacuum undulators and SCW:** 10th of June to 22nd of August  
21. **Restart of the machine:** 29th of September
The commissioning of the ALBA storage ring started at Monday the 8th of March in the afternoon with the following steps:

1.) Optimization of the booster and injection to SR 8th of March
2.) The first turn was reached in the evening of the 9th of March with on axis injection (adjustment of energy)
3.) 10th of March: 20 turns with off axis injection
4.) 13th of March: 1 sec stored beam.
5.) 16th of March: first accumulated beam in ALBA (20 mA)
6.) 1st of April: stored beam of 100 mA
7.) 7th of June: stored beam 170 mA
8.) At the beginning of June the 1st phase of commissioning has been finished. (Reminder: The specifications of ALBA are to deliver a beam of 250 mA to the user)
9.) June to August: installation of SCW and 2 IVU’s.
10.) 12th of September: restarting the machine again
11.) 19th to 30th September: optimization of SR - components
12.) 3rd of October: start of 2nd phase of commissioning with ID’s
13.) 22nd of October: start of beam line commissioning
### Quadrupole magnets:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field at pole tip</td>
<td>0.715 T</td>
</tr>
<tr>
<td>Gradient</td>
<td>23.43 T/m</td>
</tr>
<tr>
<td>Aperture</td>
<td>61 mm</td>
</tr>
<tr>
<td>Current</td>
<td>190 A</td>
</tr>
<tr>
<td>Field accuracy</td>
<td>&lt;3*10^{-3}</td>
</tr>
<tr>
<td>Grad. accuracy</td>
<td>&lt;2*10^{-3}</td>
</tr>
<tr>
<td>Length (mm)</td>
<td>200, 260, 310, 530</td>
</tr>
</tbody>
</table>

Results of measurements done at SOLEIL

**Q500OC at SOLEIL @ 25 mm**
Sextupole Magnets

Field at pole tip: 0.450 T
Diff. Gradient: 700 T/m²
Aperture: 72 mm
Current: 200 A
Field accuracy: <3*10⁻³
Grad. accuracy: <2*10⁻³
Length (mm): 150, 220

Higher Multipoles S220 (NSLS-Measurements)
Accelerator Division

RF System

- Normal conducting HOM damped cavities.
- Watrax, transition from WG to Coaxial
- CaCo, cavity combiner of 2x80 kW IOTs
- Digital LLRF

RF Voltage: 3600 kV, beam current: 400 mA, losses: 1.3 MeV/turn, beam power: 520 kW
the vacuum layout of the unit cell of the booster synchrotron
Storage Ring Commissioning
Storage Ring Commissioning

Accelerator Division

Dieter Einfeld, CELLS-ALBA
Thank you very much

gap=16.5mm — ANTIPARALLEL mode

Thank you very much