Istituto Nazionale di Fisica Nucleare

LNF – xx/xx
Xxx xx, 20xx

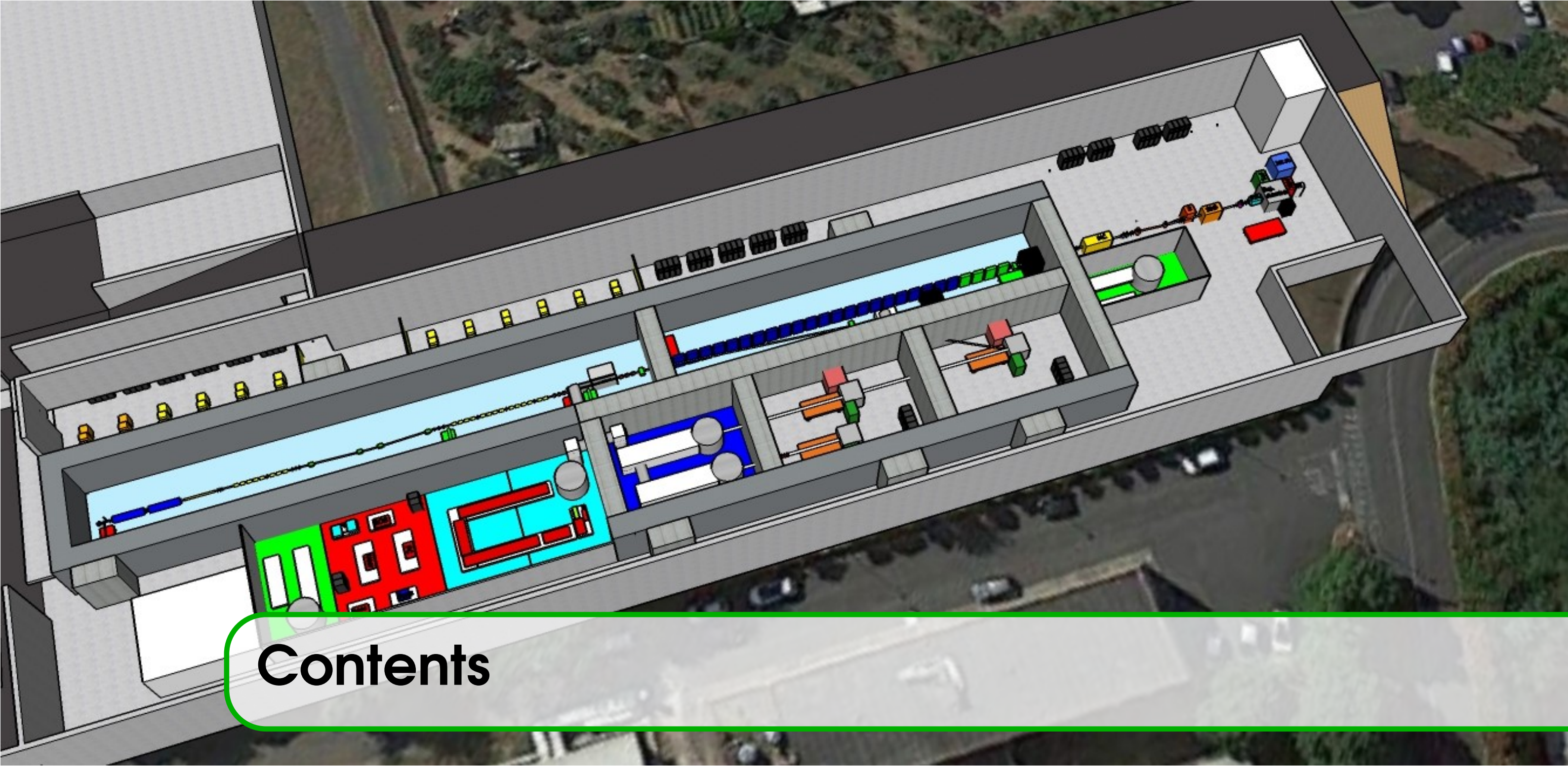
EuPRAXIA@SPARC_LAB

Technical Design Report

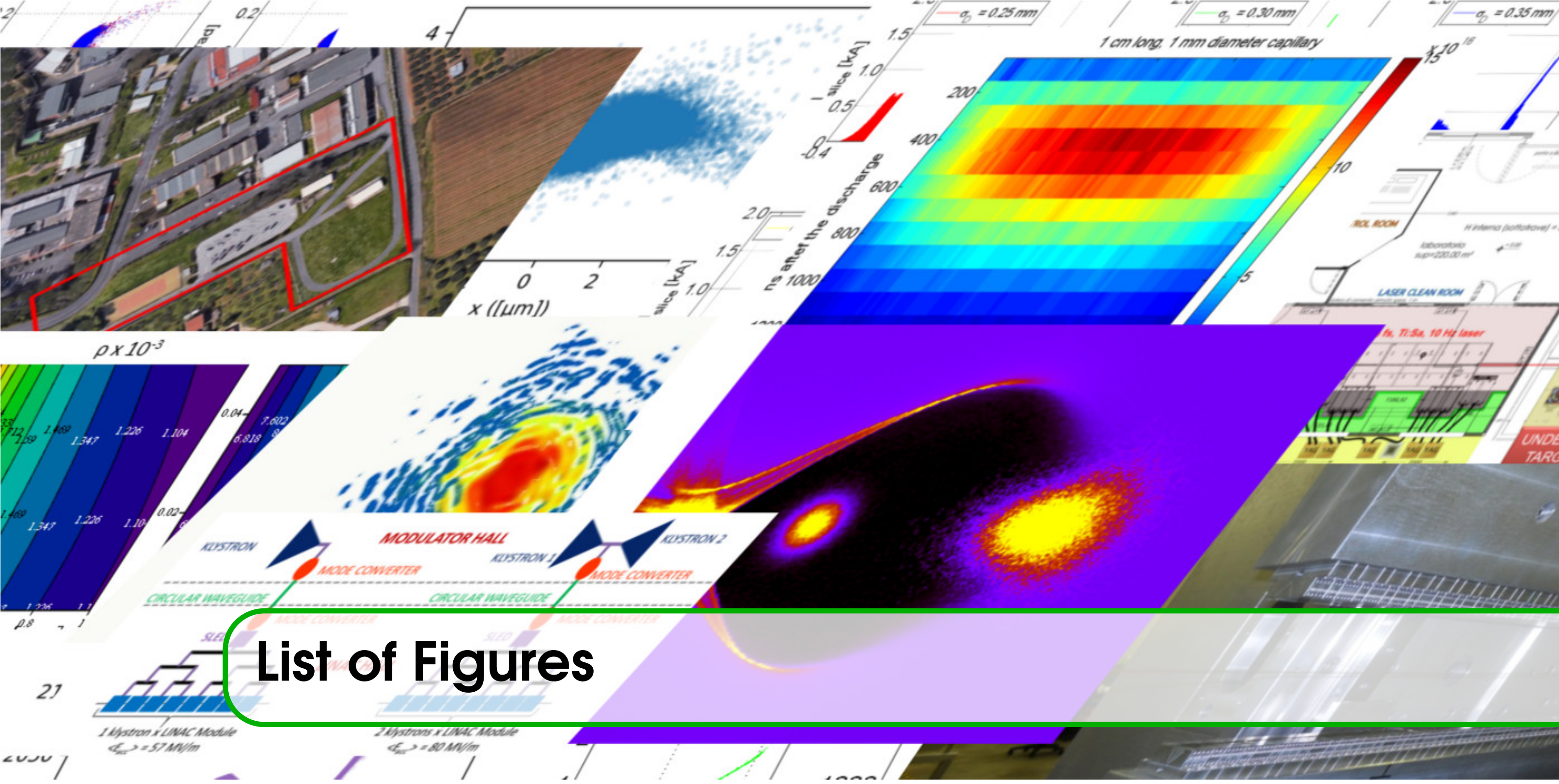
Authors

D. Alesini[a], M. P. Anania[a], M. Artioli[b], A. Bacci[c], S. Bartocci[d], R. Bedogni[a], M. Bellaveglia[a], A. Biagioni[a], F. Bisesto[a], F. Brandi[e], E. Brentegani[a], F. Broggi[c], B. Buonomo[a], P. Campana[a], G. Campogiani[a], C. Cannaos[d], S. Cantarella[a], F. Cardelli[a], M. Carpanese[f], M. Castellano[a], G. Castorina[g], N. Catalan Lasheras[h], E. Chiadroni[a], A. Cianchi[i], R. Cimino[a], F. Ciocci[f], D. Cirrincione[j], G. A. P. Cirrone[k], R. Clementi[a], M. Coreno[l], R. Corsini[h], M. Croia[a], A. Curcio[a], G. Costa[a], C. Curatolo[c], G. Cuttone[k], S. Dabagov[a], G. Dattoli[f], G. D'Auria[l], I. Debrot[c], M. Diomede[a,g], A. Drago[a], D. Di Giovenale[a], S. Di Mitri[l], G. Di Pirro[a], A. Esposito[a], M. Faiferri[d], M. Ferrario[a], L. Ficcadenti[g], F. Filippi[a], O. Frasciello[a], A. Gallo[a], A. Ghigo[a], L. Giannessi[f,l], A. Giribono[a], L. A. Gizzi[e], A. Grudiev[h], S. Guiducci[a], P. Koester[e], S. Incremona[a], F. Iungo[a], L. Labate[e], A. Latina[h], S. Licciardi[f], V. Lollo[a], S. Lupi[g], R. Manca[d], A. Marcelli[a,m,n], M. Marini[d], A. Marocchino[a], M. Marongiu[g], V. Martinelli[a], C. Masciovecchio[l], C. Mastino[d], A. Michelotti[a], C. Milardi[a], M. Migliorati[g], V. Minicozzi[i], F. Mira[g], S. Morante[i], A. Mostacci[g], F. Nguyen[f], S. Pagnutti[f], L. Palumbo[g], L. Pellegrino[a], A. Petralia[f], V. Petrillo[o], L. Piersanti[a], S. Pioli[a], D. Polese[d], R. Pompili[a], F. Pusceddu[d], A. Ricci[m], R. Ricci[a], R. Rochow[l], S. Romeo[a], J. B. Rosenzweig[p], M. Rossetti Conti[o], A. R. Rossi[c], U. Rotundo[a], L. Sabbatini[a], E. Sabia[f], O. Sans Plannell[a], D. Schulte[h], J. Scifo[a], V. Scuderi[k], L. Serafini[c], B. Spataro[a], A. Stecchi[a], A. Stella[a], V. Shpakov[a], F. Stellato[i], P. Tomassini[e], E. Turco[d], C. Vaccarezza[a], A. Vacchi[j], A. Vannozzi[a], G. Vantaggiato[e], A. Variola[a], S. Vescovi[a], F. Villa[a], W. Wuensch[h], A. Zigler[q], M. Zobov[a]

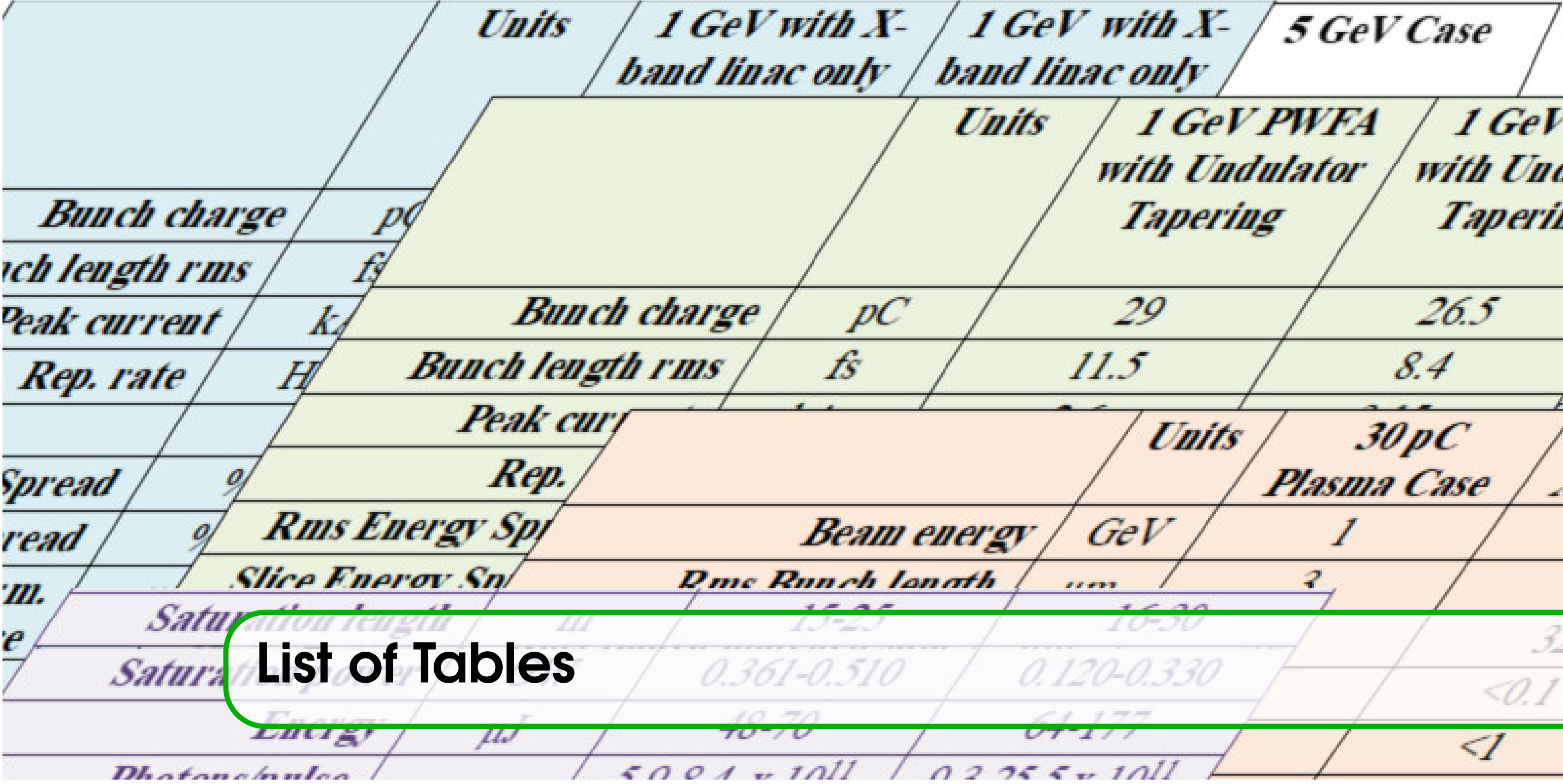
[a] *INFN - Laboratori Nazionali di Frascati, via E. Fermi 40, 00044 Frascati, Italy*
[b] *ENEA - Centro Ricerche Bologna, Via Martiri Monte Sole 4, 40129 Bologna, Italy*
[c] *INFN - Milano section, Via Celoria 16, 20133 Milan, Italy*
[d] *Universitá degli Studi di Sassari, Dip. di Architettura, Design e Urbanistica ad Alghero, Palazzo del Pou Salit - Piazza Duomo 6, 07041 Alghero, Italy*
[e] *Intense Laser Irradiation Laboratory (ILIL), Istituto Nazionale di Ottica (INO), Consiglio Nazionale delle Ricerche (CNR), Via G. Moruzzi 1, 56124 Pisa, Italy and INFN Pisa section, Pisa, Largo Pontecorvo 3, 56127 Pisa, Italy*
[f] *ENEA - Centro Ricerche Frascati, Via E. Fermi 45, 00044 Frascati, Italy*
[g] *Sapienza University of Roma and INFN, P.le Aldo Moro 2, 00185 Rome, Italy*
[h] *CERN, CH-1211 Geneva 23, Switzerland*
[i] *Universitá degli Studi di Roma Tor Vergata and INFN, Via della Ricerca Scientifica 1, 00133 Rome, Italy*
[j] *INFN - Trieste section, Via Valerio 2, 34127 Trieste, Italy*
[k] *INFN - Laboratori Nazionali del Sud, via S.Sofia 62, 95123 Catania, Italy*
[l] *Elettra-Sincrotrone Trieste, Area Science Park, 34149 Trieste, Italy*
[m] *RICMASS, Rome International Center for Materials Science Superstripes, 00185 Rome, Italy*
[n] *ISM-CNR, Basovizza Area Science Park, Elettra Lab, 34149 Trieste - Italy*
[o] *Universitá degli Studi di Milano and INFN, Via Celoria 16, 20133 Milan, Italy*
[p] *Department of Physics and Astronomy, University of California Los Angeles, Los Angeles, California 90095, USA*
[q] *Racah Institute of Physics, The Hebrew University of Jerusalem, 91904 Jerusalem, Israel*



Contents



List of Figures



List of Tables

1. Timing and Synchronisation

1.1 Timing system

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

1.1.1 Overview

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

1.1.2 System architecture and features

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

1.2 Synchronization system

1.2.1 Overview

The synchronization system is in charge of generating and distributing the high frequency reference signal towards the accelerator subsystems (lasers, LLRF, diagnostics). It is composed by the reference master oscillator of the facility and by stabilized links that bring its signal to the clients. The requested long-term performance for the signal generation is a long-term absolute jitter below 10 fs RMS (measured from 10Hz to 10 MHz from the carrier). The request for the signal distribution is an added jitter at each link end below 10 fs RMS. To achieve the expected performances an optical architecture for the synchronization system has been chosen. This can guarantee a stabilization of the links, a client locking and longitudinal diagnostics based on optical methods that intrinsically have a much better phase (time) detection resolution respect to electronic microwave devices. In the next paragraphs we will go into details.

1.2.2 System architecture and features

Reference generation

The core of the synchronization system is the master reference oscillator. In the case of optical architecture it is typically implemented by a mode-locked Er-doped fiber laser oscillator (Optical Master Oscillator, OMO). For the EuPRAXIA@SPARC_LAB project we decided to use a commercial device that fits the requirement. Today, more than one manufacturer is able to provide such a device, so we should avoid risk of vendor monopoly. Since such lasers show a good phase noise performance above $\approx 1kHz$ from the carrier, for frequency below this value (i.e. for compensating slow drifts of the pulse repetition rate) it is convenient to lock the OMO to an electronic oscillaotr (Reference Master Oscillator, RMO) by means of a phase locked loop (PLL). A RMO with very good performance in the requested range of frequency is available on the market. To give an idea of the jitter performance of such devices, we report in figure 1.1 the single side band phase noise power spectral density (SSB PSD) of the oscillators presently used in the SPARC_LAB facility at LNF, measured by a signal noise analyzer. In the figure is also reported the absolute jitter of the single sources, calculated from the numeric integration of the PSD data.

The repetition rate of the pulses of the OMO has to be a sub-harmonic of both the american S-band and european X-band RF frequency that are respectively defined as 2856 MHz and 11994.2 MHz . To select the OMO central frequency, since the two RF frequencies do not have an integer common sub-harmonic, we decided to choose a sub-harmonic of the X-band and approximate the american S-band to 2855.76 MHz . Thus, we selected an OMO rep. rate of 71.394 , that is the 168th sub-harmonic of the X-band frequency. Table 1.1 shows the relationships between the various frequencies involved in the facility. Concerning the other laser oscillators present in the facility, such as photo-cathode or interaction lasers, they have to be the same central oscillating frequency of the OMO to guarantee subsequent pulses superposition in time and take advantage of optical phase detection (cross-correlators) to lock their rep. rate at the state-of-the-art performance.

Reference distribution

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus

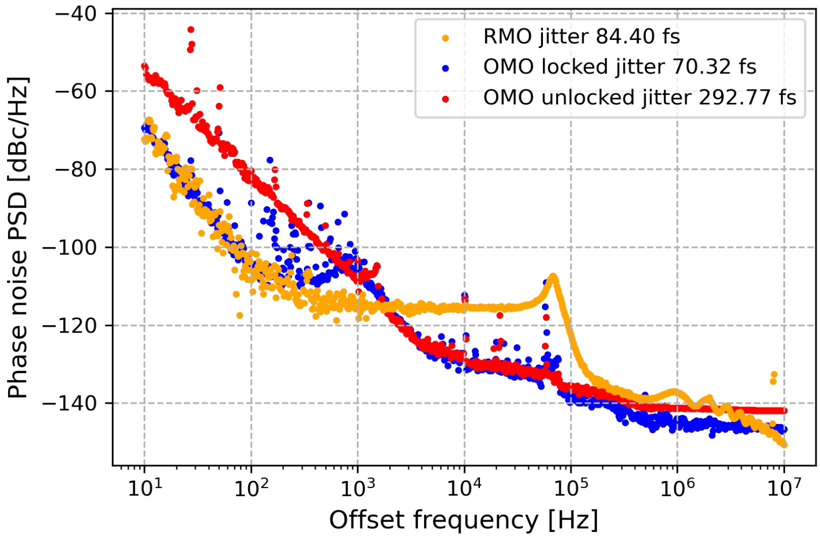


Figure 1.1: The figure reports the SSB PSD of the present SPARC_LAB OMO and RMO in the range 10 Hz - 10 MHz from the carrier (2856 MHz in this case). Integrated absolute jitters are shown in the plot legend

In \ Out	OMO 71.394 MHz	S-band 2855.76 MHz	X-band 11994.2 MHz
OMO 71.394 MHz	1	40	168
S-band 2855.76 MHz	1/40	1	21/5
X-band 11994.2 MHz	1/168	5/21	1

Table 1.1: Relationships between OMO and RF frequencies

rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Estimated performance

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Bibliography