LNF-CERN X-band test-stand collaboration programme

Alessandro Gallo *for*

the TEX (TEst stand X-band) LNF Team

RF engineers: David Alesini, Marco Bellaveglia, Bruno Buonomo, Fabio Cardelli, Claudio Di Giulio, Marco Diomede, Alessandro Gallo, Luca Piersanti

Conventional enegineers: Sergio Cantarella, Simona Incremona, Ruggero Ricci

Electronic engineers: Domenico Di Giovenale, Giovanni Franzini, Stefano Pioli, Angelo Stella

Mechanical engineers: David Alesini, Enrico Di Pasquale, Andrea Liedl

Management and coordination: Antonio Falone, Alessandro Gallo, Stefano Pioli

Technicians: Graziano Piermarini, Sergio Quaglia, Michele Scampati, Giorgio Scarselletta

INFN-CERN X-band collaboration Meeting

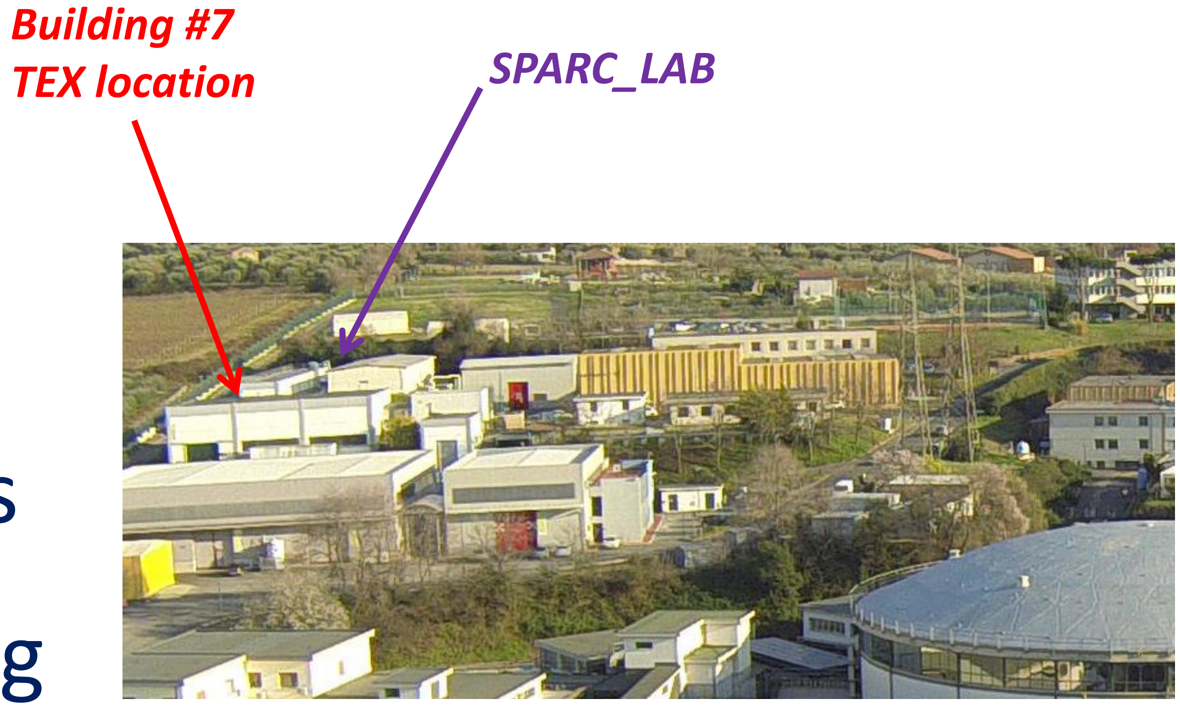
Nov. 26 - 2020

SUMMARY

- Status of TEX, the Frascati X-band test stand
- Short/medium term programme at TEX
- INFN/CERN collaboration/exchange programme

TEX (TEst stand for X-band) Status Report

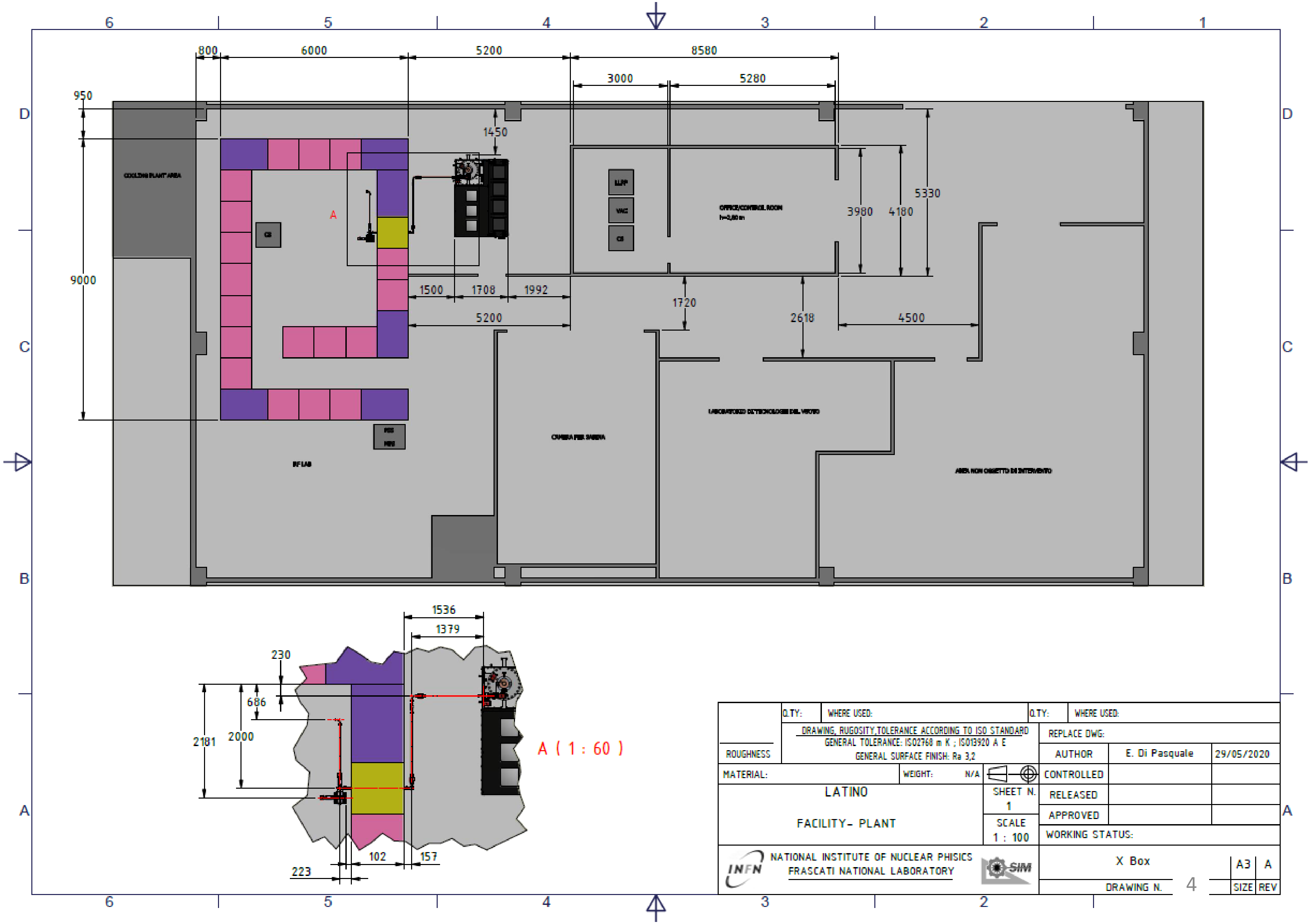
- The Infrastructure
- The RF power source
- RF Driver and LLRF
- Radiation safety evaluations
- Construction/commissioning schedule



Sketch of LNF bld. #7

The building will host various activities including:

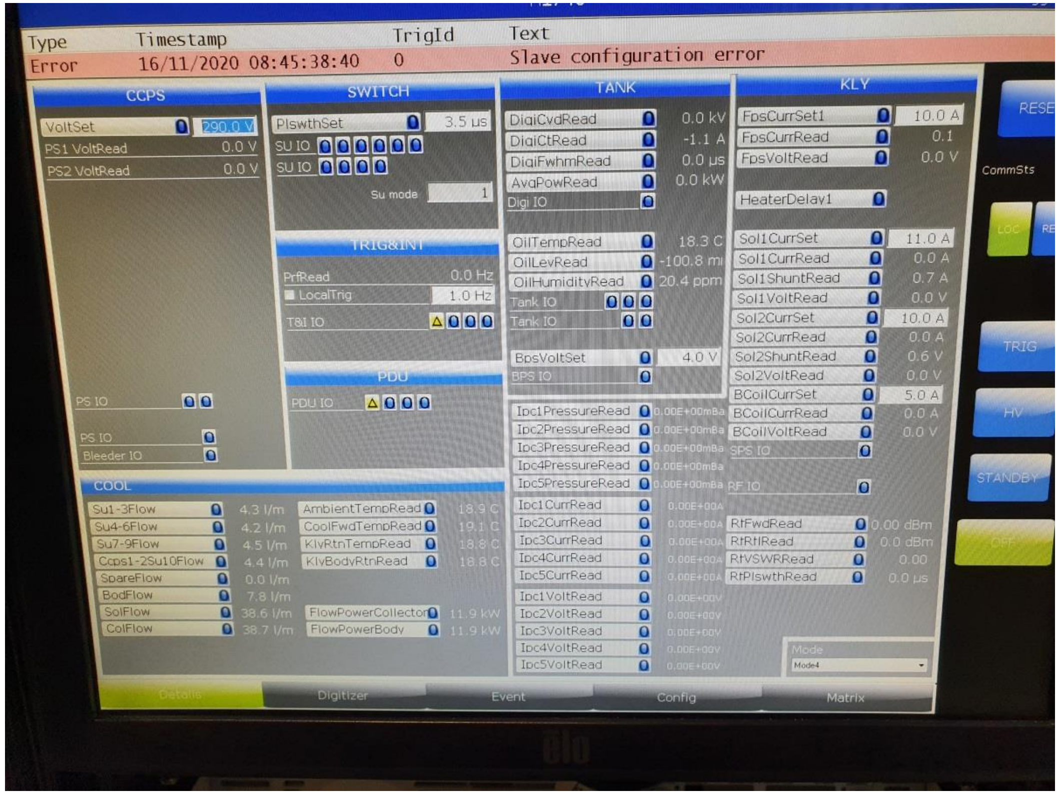
- ✓ X-box test stand;
- ✓ New oven for brazing;
- ✓ THz user end station;
- ✓ RF structure tuning and preparation area;
- ✓ Meeting area;
- ✓ Storage area



Modulator transported in place as for September 24, 2020

Courtesy of S.Pioli

MODULATOR SAT - PHASE 1



LNF technical staff with SCANDINOVA remote support

MODULATOR SAT SPLITTED IN TWO PHASES

Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI FRASCATI
Divisione Acceleratori
Il Responsabile

Frascati, 23 Novembre 2020

Scandinova K400 Modulator Site Acceptance Test (SAT) up to Standby Mode (INFN order 16075)

Scandinova modulator has been factory accepted at beginning of March 2020 then, due to COVID-19 emergency, we agreed to delay the shipment to Frascati to May 2020. At modulator arrival, all the shock detectors were ok.

Due to the unavailability of the klystron tube required for the full SAT of the modulator, INFN and Scandinova agreed to reschedule the test and the related payment of the remaining 70% of the full price.

In October 2020, CERN informed INFN that the klystron tube shipping has been scheduled for January 2021 so INFN proposed to Scandinova to have a partial SAT in OFF and Standby mode and proceed with payment of 50% of the full price (2658000,00 SEK). When klystron tube will be available in Frascati, we will proceed with the complete SAT in High Voltage e Trigger mode and pay the remaining 20% of the full price (1063200,00 SEK).

INFN and Scandinova schedule the partial SAT in November in remote and augmented reality mode, in order to reduce the risk for Scandinova and INFN personnel due to the COVID-19 emergency.

To perform the SAT up to Standby mode we planned these tests:

1. Connection of the modulator to mono-phase power line
2. Power up the modulator in OFF mode to run the control PLC
3. Connection of the modulator to cooling plant
4. Test of cooling system at nominal flow 108 l/min at 3bar
5. Test remote internet connection of the PLC
6. Connection of the modulator to the tri-phase power line
7. Power up the modulator in Standby mode to run Switching Units

The 11th of November, tests 1-2 have been performed. Initially tests passed then we had a fault with the power enabling safety relay. Scandinova provided the spare part and the instructions for the replacement to INFN people. After this early mortality failure, the modulator starts working properly in OFF mode.

The 13th of November, tests 3-4 have been successfully performed. Cooling system have been connected, air flushed out and flow increased over the nominal required threshold to 113 l/min (25 l/min for Switching Units circuit, 88 l/min for the klystron circuits). The forward and return pipes of the klystron and solenoid magnet have been short-circuited in order to perform the test as the klystron is not yet installed.

The 18th of November, test 5-6-7 have been performed. Scandinova successfully connected remotely to the modulator through embedded Teamviewer application. When the modulator switched in Standby mode a fault in the communication chains of the PLC and its sub-units happened. Scandinova detected an unplugged optical cable on the RF Digitizer unit probably due to shipping vibrations. INFN people re-plugged the connector and the interlock disappear. The modulator goes successfully in Standby mode initializing Switching Units and related CCPSs.

INFN and Scandinova agreed that the K400 Modulator is accepted up to Standby mode. INFN invite Scandinova administration to send the invoice for the 50% of the full price.

Scandinova INFN

Istituto Nazionale di Fisica Nucleare
codice fiscale 84001850589

INFN - Laboratori Nazionali di Frascati – Via Enrico Fermi 54 (già 40) - 00044 Frascati R (Italia)
tel. +39 06 9403 2639/8431 - fax +39 06 9403 2256 – http://da.lnf.infn.it/
PEC: divacc.lnf@pec.infn.it

SAT – PHASE1 REPORT

ScandiNova

Invoice - 4912

Order no.	Customer code	Page
M1740	1042	1 / 1

Your VAT no.	Your order no.	Order date	Printout date
		2019-02-18	2020-11-20

Your VAT no.	Your order no.	Our reference	Your reference
IT 04430461006	16075	Mikael Lindholm	Alessandro Gallo

Delivery address
INFN
Instituto Nazionale Di Fisica
Nucleare
Laboratori Nazional di Frascati
Via Enrico Fermi n. 40
00044 Frascati (Roma), Italy

Invoice address
INFN
Instituto Na
Nuclea
La ascati
40
(Roma), Italy

Terms of delivery
FCA
Delivery method
Road

ment
s net
ter due date 2020-12-20
late payment fee will be charget at 18 %
Goods label
ref: CIG 76516705D5
ScN doc-009928

Reverse charge, intra-Community supply of goods

Pos	Part no.	Name	Del. period	Qty	Price each	%	Amount
1		After split of SAT-invoice	2020-11-20				2 658 000,00

Order info:
024872 MODULATOR K400, INFN 1 pcs

Total rows excl. VAT **2 658 000,00**
Total amount due (SEK) **2 658 000,00**

Invoicing plan			Amount
Partial invoice	1	30% ARO	1 594 800,00
Partial invoice	2	At delivery	0,00
Partial invoice	3	After split of SAT-invoice	2 658 000,00
Partial invoice	4	After SAT with Klystron	1 063 200,00

Mailing address
ScandiNova Systems AB
Ultunaallén 2A
756 51 UPPSALA
SWEDEN
info@scandinovasystems.com

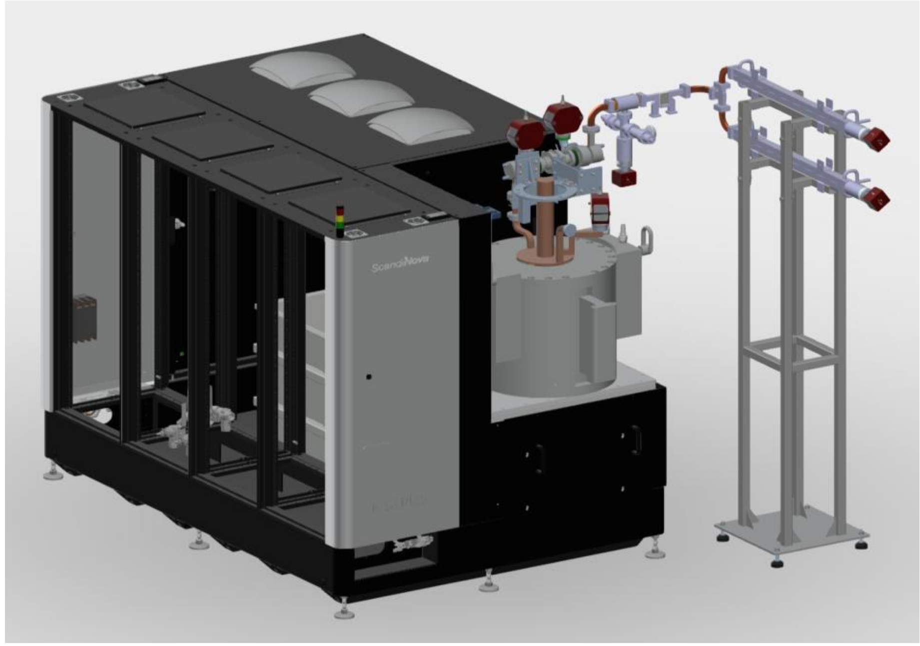
Street address
Ultunaallén 2A
756 51 UPPSALA
www.scandinovasystems.com

Phone 018-4805900
Fax 018-4805999
Corp. ID 556616-3605
VAT no. SE556616360501
Dom: Uppsala
F-tax sheet available

Bank giro 5366-5790
Plus giro 766714-0
SWIFT/BIC NDEASESS
IBAN
SE0295000099604207667140
Nordea

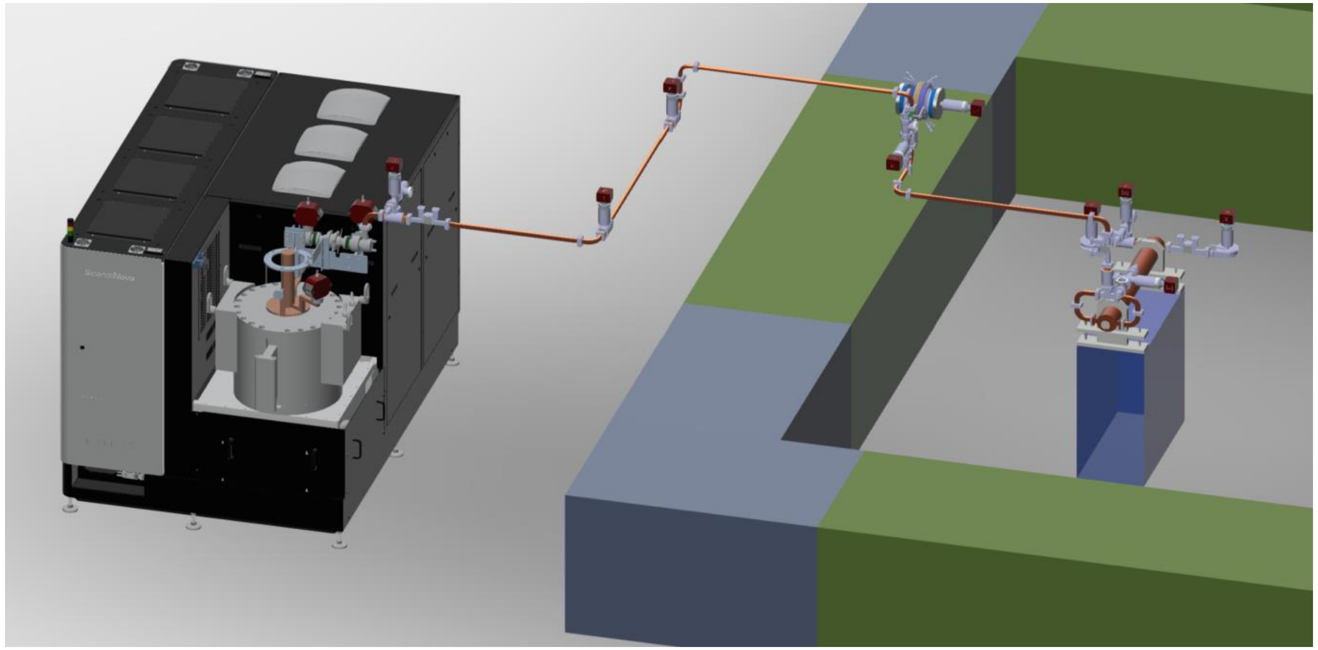
ISSUED INVOICE

TEX (TEst stand for X-band) Status Report



ScandiNova K400 SAT setup

XBox EuPraxia/CLIC setup



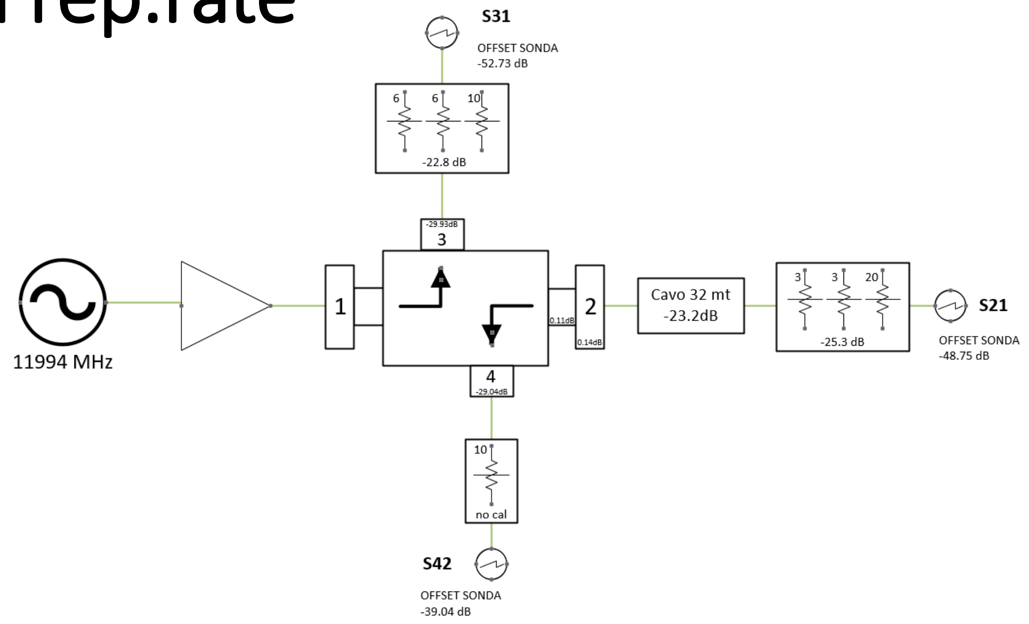
Courtesy of S.Pioli and E. Di Pasquale

RF DRIVER TEST

Gain curves for different pulse length and rep.rate

- 1 μs, 10 Hz (first attempt)
- 1.5 μs, 50 Hz (realistic pulse length with pulse compressor)
- 5 μs, 100 Hz (datasheet reference)
- 100 ns, 50 Hz
- 200 ns, 50 Hz

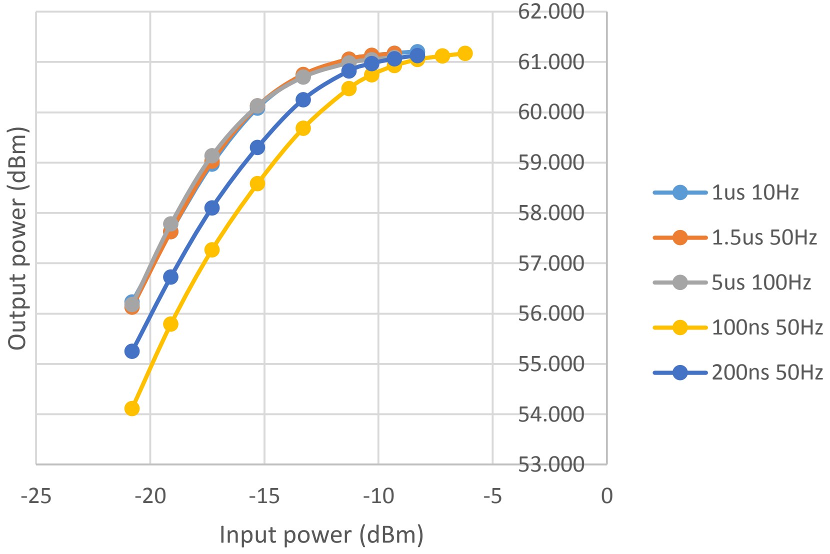
realistic pulse length (w/o pulse compressor)



Measurement setup

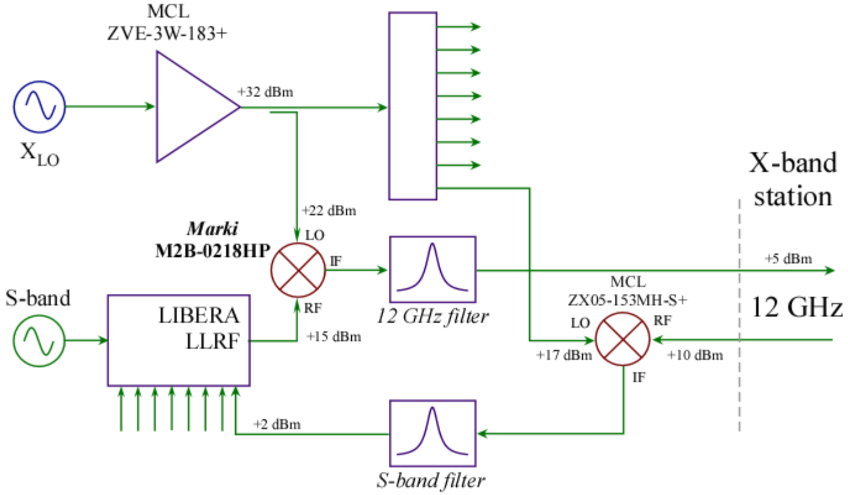
- 3 power meter calibrated probes (S21, S31, S42)
- 200 ns – calibrated RF diode on S31 to cross-check measurements with power meter
- Front panel power indicator
- Internal power meter voltage output

1300 W = 61.14 dBm



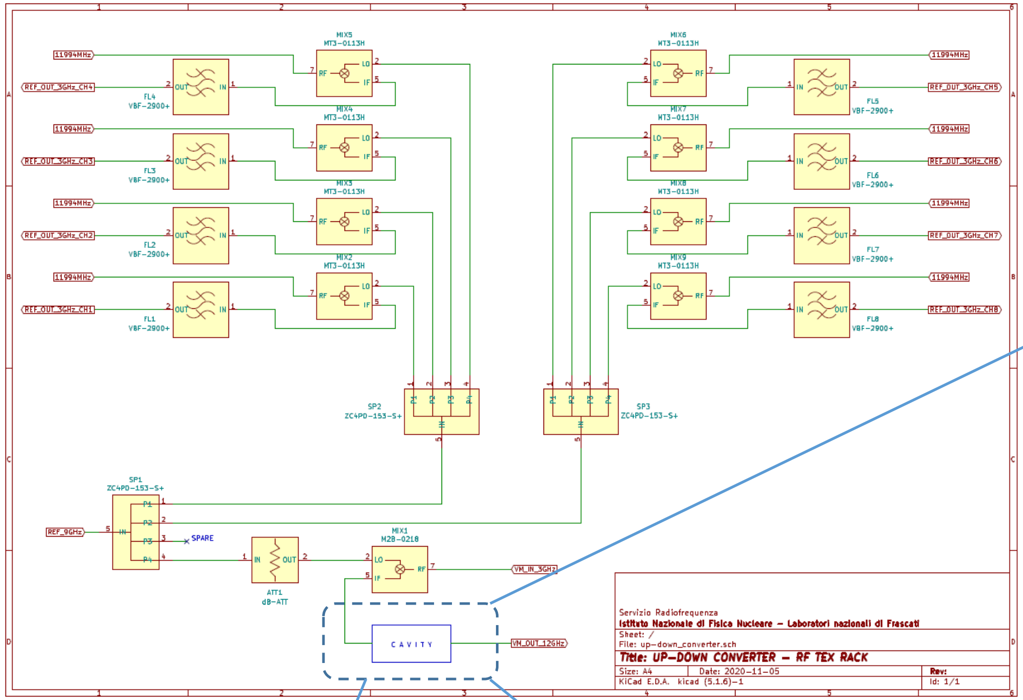
LLRF system based on S-band LIBERA-LLRF by Instrumentation Tecnlogy

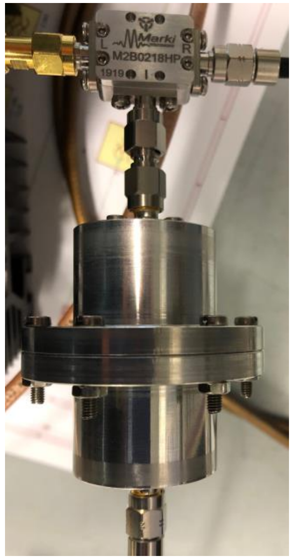
S to X band up/down converter

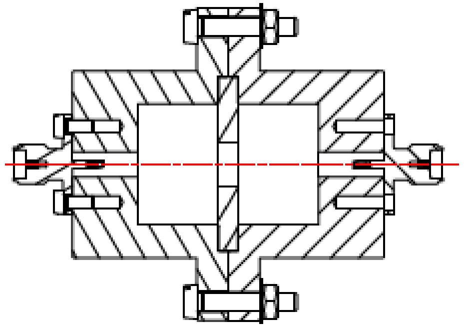


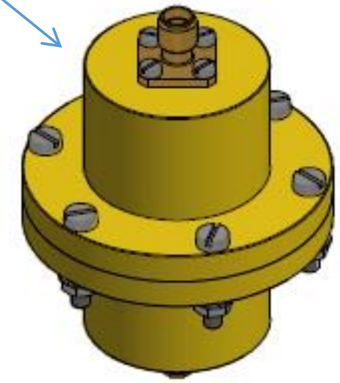
- Exploits experience acquired for ELI-NP project
- Possible option for Eupraxia@SPARC_Lab
- Development of the X-band board too expensive and time consuming
- Based on a home-made up/down converter board
- US S-band chosen to be aligned with other in-house applications

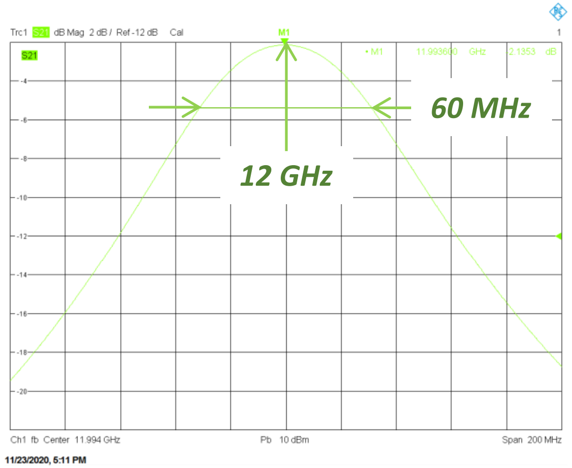
up-converter custom cavity filter

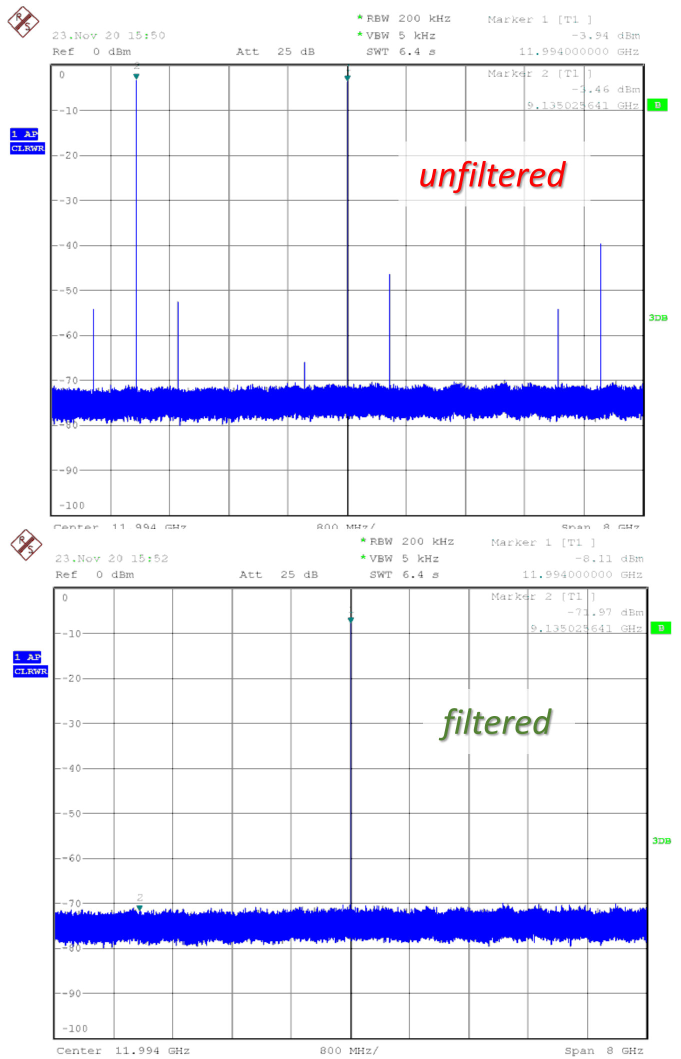






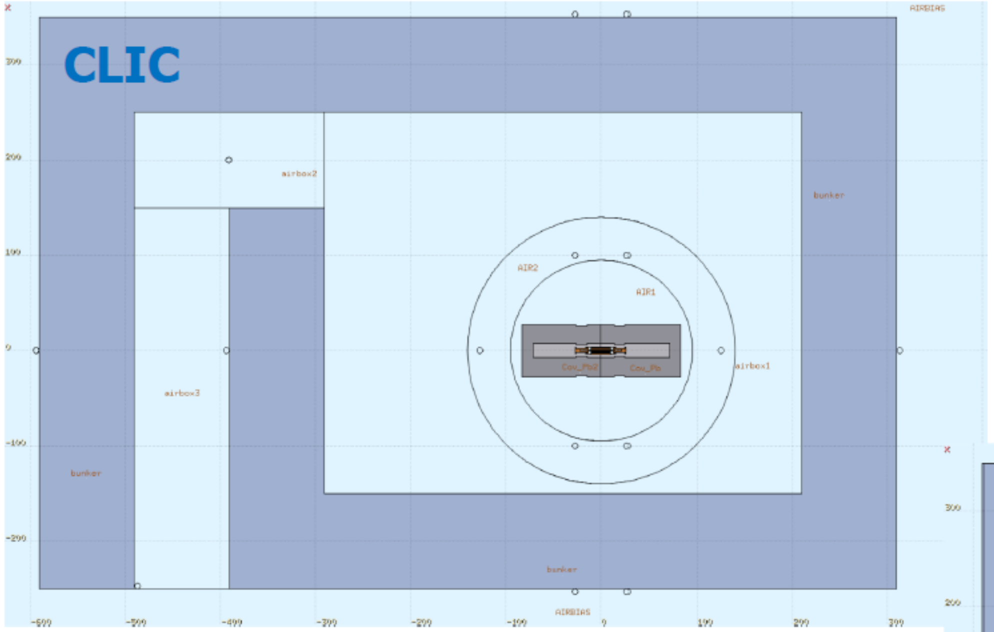






RADIATION SAFETY EVALUATION

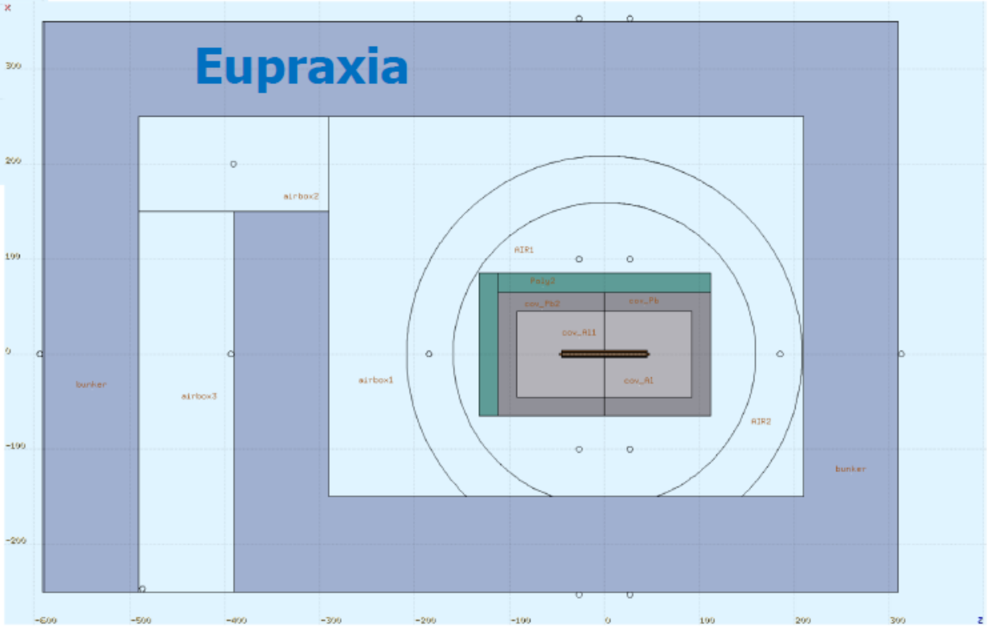
Parameters	CLIC	EUPRAXIA
Current [mA]	0.75	1
Frequency [Hz]	50	50
Period [ns]	250	150
Energy [MeV]	20	59
Power [W]	0.1875	0.4425
Electron per second	$5.8593 \cdot 10^{10}$	$4.6875 \cdot 10^{10}$



CLIC-type structure

L = 20 cm

E = 100 MV/m

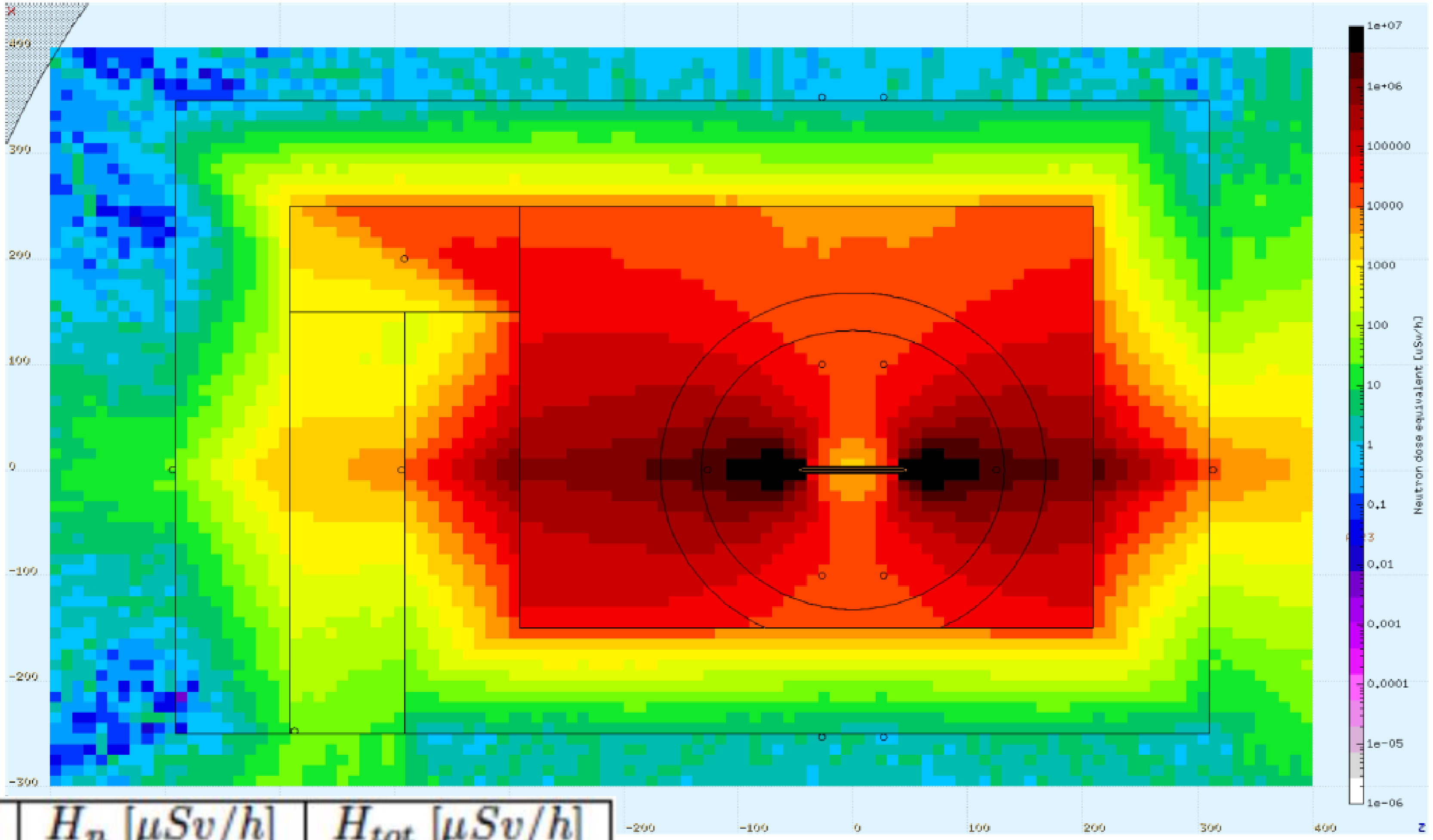


EUPRAXIA-type structure

L = 90 cm

E = 65 MV/m

EUPRAXIA STRUCTURE
no extra shielding



Detector	H_γ $[\mu Sv/h]$	H_n $[\mu Sv/h]$	H_{tot} $[\mu Sv/h]$
Frontale	$8.33 \cdot 10^3$	123	$8.49 \cdot 10^3$
Laterale	1.36 – 3.13	0.06 – 0.11	1.46 – 3.2
Sul tetto	2.13 – 3.73	0.20 – 0.22	2.36 – 3.94
Ingresso sala	3486	370	3857
Ingresso labirinto	36.7	6.74	44

many mSv/h !!!

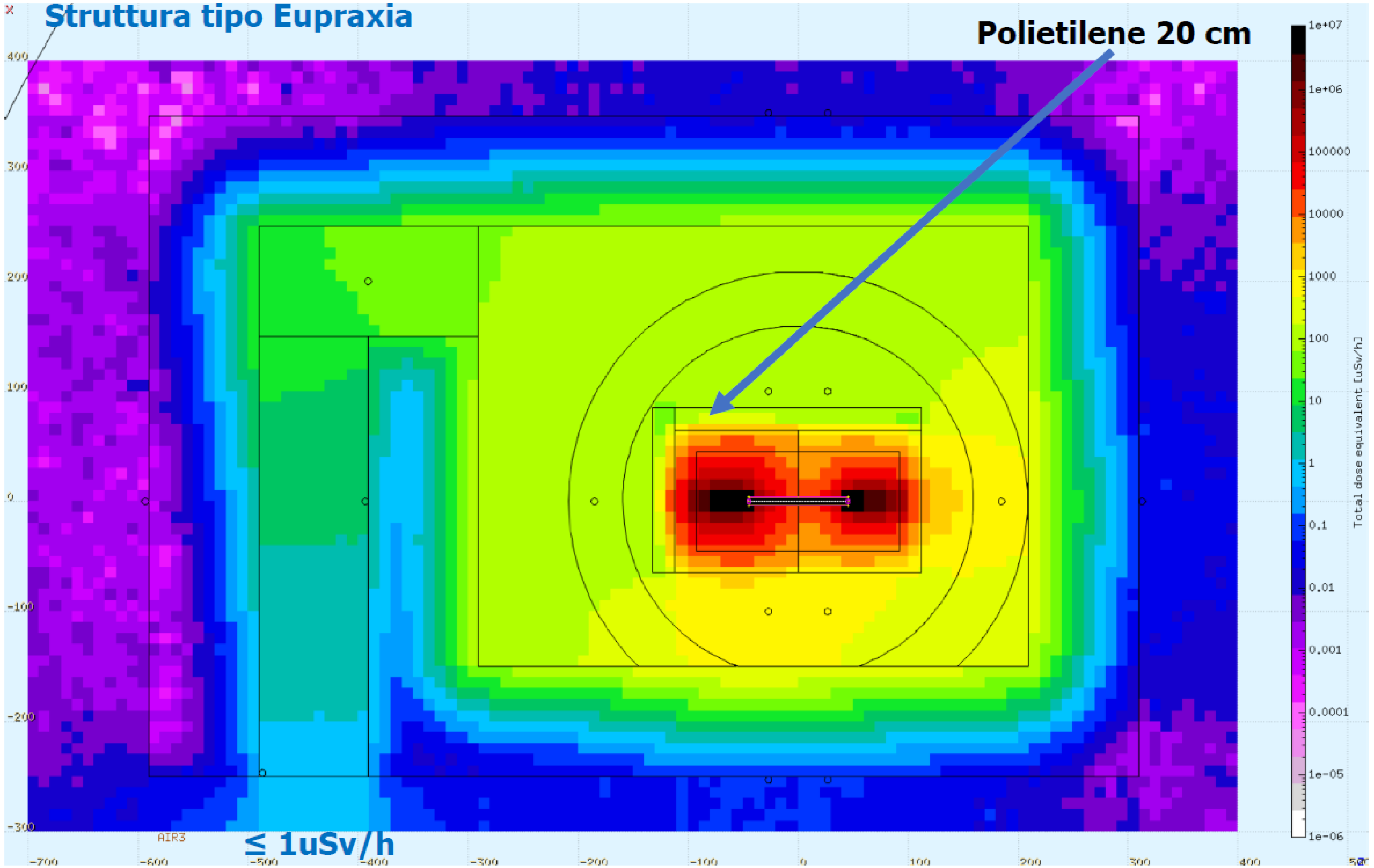
EUPRAXIA STRUCTURE with extra shielding:

Pb = 20 cm

Al = 5 x Rad Lengths

Polyethylene = 20 cm

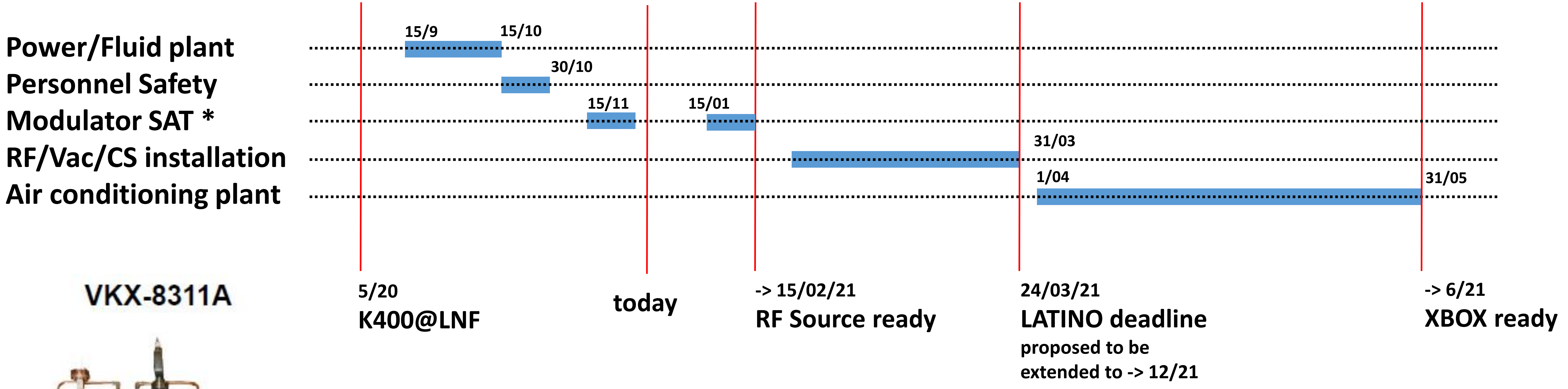
< 1 μSv/h



Already acceptable. Simulation needs to be refined, the source has to be better modelled

X-band Test Stand completion schedule

(based on the tentative assumption of having the klystron available by Jan 1st 2021)



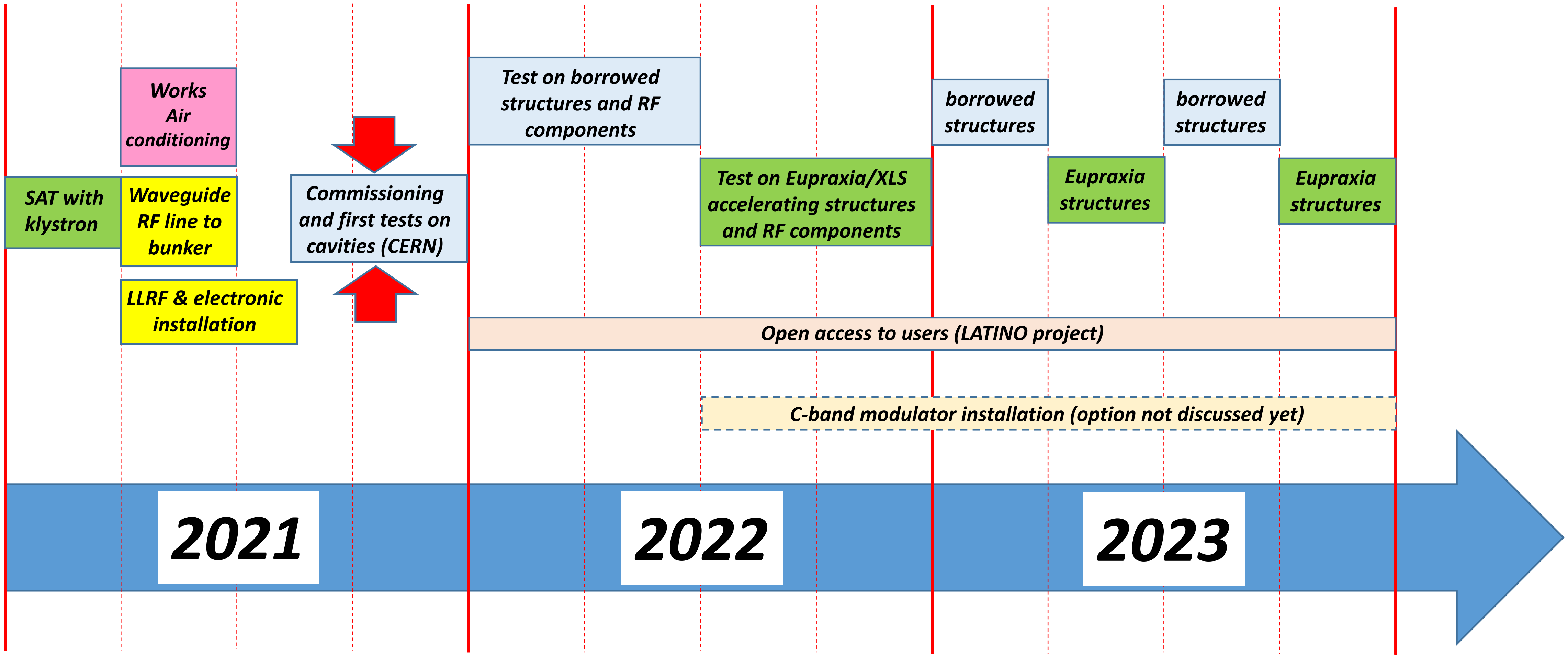
VKX-8311A

CPI klystron delivery @LNF originally expected early November 2020
CERN (repaired, tested in diode-mode, RF conditioning on going)

TEX: main items checklist

- Bunker: built and ready
- Bunker authorization: formal request submission by February 2021, answer expected in 90 days
- Cooling and mains: available
- Modulator: positioned, SAT phase 1 successfully done
- Klystron: to be delivered (in ≈ 4 weeks?)
- RF driver: available and tested
- LLRF: S-band module available and tested
- LLRF: up/down converter under construction, all components available
- Control room: completed and available
- Control room equipment: available, to be installed
- Radioprotection shields: under design
- Radioprotection monitor stations: available, in place
- Machine protection and safety system: ready
- RF components for SAT: available in house
- RF components for cavity test: mostly available, few under delivery (flanged waveguides, vacuum pumps, …)
- Building #7 air conditioning system installation: works planned for spring 2021

TEX: short/medium term programme



Strategic areas of collaboration

- RF expertise, components and accelerating structures
  - ✓ LNF has built a consistent RF group, but still need guidance especially in fabrication and test issues
  - ✓ Continuation of the CERN support for procurement of special RF parts is extremely important
  - ✓ Testing some CLIC structures and special components at TEX would be of mutual benefit
  - ✓ LNF RF engineers can support development and design of new or upgraded devices in a collaboration framework
- Conditioning strategy and algorithms developing
  - ✓ A porting of the CERN-developed automated conditioning tools into the LNF system is crucial
- Test stand operation
  - ✓ The size of the LNF TEX team is adequate, but personnel need to be trained. CERN expert guest are obviously very welcome especially in the initial phase of operation, but training of LNF personnel at CERN X-box is certainly the most effective way
- Data and experience sharing
  - ✓ X band is still a territory under exploration. Sharing of the accumulated technical information on devices and high power components, especially those of the power station is essential in view of the construction of a user facility based on this technology.