CARE/JRA2: Annual Report 2006

Title: Charge production with Photo-injectors

PHIN **Coordinator: A. Ghigo (INFN-LNF)**
Deputy: R. Losito (CERN)

Participating Laboratories and Institutes:

Institute	Acronym	Country	Coordinator	PHIN Scientific Contact	Associated to
CCLRC Rutherford Appleton Lab. (20)	CCLRC-RAL	UK	P. Norton	G. Hirst	
CERN Geneva (17)	CERN	CH	G. Guignard	R.Losito	
CNRS-IN2P3 Orsay (3)	CNRS-LAL	F	T. Garvey	G. Bienvenu	CNRS
CNRS Lab. Optique Appl. Palaiseau (3)	CNRS-LOA	F	T. Garvey	V. Malka	CNRS
ForschungsZentrum ELBE (9)	FZR-ELBE	D	J. Teichert	J. Teichert	
INFN-Lab. Nazionali di Frascati (10)	INFN-LNF	I	S. Guiducci	A. Ghigo	INFN
INFN- Milan (10)	INFN-MI	I	C. Pagani	I. Boscolo	INFN
Twente University- Enschede (12)	TEU	NL	J.W.J. Verschuur	J.W.J. Verschuur	

Main Objectives: Perform Research and Development on charge-production by interaction of laser pulse with material within RF field and improve or extend the existing infrastructures in order to fulfil the objectives. Coordinate the efforts done at various Institutes on photo-injectors.

Cost:

Total Cost	Requested Cost
3.851 M€(FC) + 2.150 M€(AC) Total = 6.001 M€	**3.542 M€**

1. Management activities

1.1 Meeting:

SRF gun collaboration meeting on March 24, 2006 at FZR, Dresden

SRF gun collaboration meeting on July 24, 2006 at BESSY, Berlin

CERN – RAL Visit (technical discussions) 15 to 18/8/2006

CERN – LAL Meeting (technical discussions): 13/09/2006

INFN – LOA Meeting on "Future INFN-LOA collaboration on plasma acceleration: PHIN evolution" Frascati 18 May 2006

CARE Annual Collaboration Meeting Frascati, 15-17 November 2006

PHIN Collaboration Meeting Parallel section of CARE06 Frascati 15-17 November 2006

Annual Photo Injector Collaboration Meeting on December 15, 2006 at MBI, Berlin

2. Dissemination of Activity.

2.1 List of talks and conference contributions

1- Development of a Superconducting RF Photoelectron Injector
J. Teichert
DPG-Tagung, Vacuum Science and Technology, Dresden, Germany, March 27, 2006

2- Advantages of the superconducting 3 1/2 cell gun at Rossendorf
F.Staufenbiel, A. Arnold, H. Büttig, P. Evtushenko, D. Janssen, U. Lehnert, P. Michel, K. Möller, P. Murcek, Ch. Schneider, R. Schurig, J. Teichert, R.Xiang, J. Stephan, W.-D. Lehmann, T. Kamps, D. Lipka, I. Will, V. Volkov
37th ICFA workshop, Hamburg, Germany, May 15-18, 2006

3- 3-1/2 Cell Superconducting RF Gun Simulations
C.D. Beard, J.H.P. Rogers, F. Staufenbiel, J. Teichert,
EPAC 2006, Edinburgh, Scotland, June 26 – 30, 2006

4- Progress of the Rossendorf SRF Gun Project
D. Janssen, A. Arnold, H. Buettig, R. Hempel, U. Lehnert, P. Michel, K. Moeller, P. Murcek, Ch. Schneider, R. Schurig, F. Staufenbiel, J. Teichert, R. Xiang, T. Kamps, D. Lipka, F. Marhauser, W.-D. Lehmann, J. Stephan, V. Volkov, I. Will,
EPAC 2006, Edinburgh, Scotland, June 26 – 30, 2006

5- Photocathode Laser for the Superconducting Photo Injector at the Forschungszentrum Rossendorf
I. Will, G. Klemz, F. Staufenbiel, J. Teichert,
FEL 2006, Berlin, Germany, Aug. 27 – Sept. 01, 2006

6- Cryomodule and Tuning System of the Superconducting RF Photo-Injector
J. Teichert, A. Arnold, H. Buettig, R. Hempel, D. Janssen, U. Lehnert, P. Michel, K. Moeller, P. Murcek, Ch. Schneider, R. Schurig, F. Staufenbiel, R. Xiang, T. Kamps, D. Lipka, G. Klemz, W.-D. Lehmann, J. Stephan, I. Will,
FEL 2006, Berlin, Germany, Aug. 27 – Sept. 01, 2006

7- First RF-Measurements at the 3.5-Cell SRF-Photo-Gun Cavity in Rossendorf
A. Arnold, H. Buettig, D. Janssen, U. Lehnert, P. Michel, K. Moeller, P. Murcek, Ch. Schneider, R. Schurig, F. Staufenbiel, J. Teichert, R. Xiang, T. Kamps, D. Lipka, F. Marhauser, G. Klemz, W.-D. Lehmann, A. Matheisen, B. van der Horst, J. Stephan V. Volkov,
FEL 2006, Berlin, Germany, Aug. 27 – Sept. 01, 2006

8- Cs_2Te Photocathodes for CTF3 Photoinjectors, R. Losito Workshop on High QE Photocathodes for RF Guns, INFN-LASA, 4 to 6/10/2006

9- Laser plasma accelerators
V. Malka (plénière), Advanced Accelerators Concepts, July 10-14, Lake Geneva, Wisconsin (2006).

10- Desing, test and premise of laser plasma accelerators
V. Malka, (plénière) European Particle Acceleration Conference, June 26-30, Edimbrugh, UK (2006).

11- Compact laser plasma accelerators for science and society
V. Malka, “Many-Particle Dynamics and Precision Spectroscopy: Trends and Applications”, March 30-31, Heidelberg (2006).

12- Laser-plasma wakefield acceleration: concepts, tests and premises
V. Malka, J. Faure, Y. Glinec, A. Lifschitz, European Particle Accelerator Conference EPAC, Edimburgh, June 26-30 (2006)

13- Production and applications of quasi mono energetic electron bunches in Laser-plasma accelerator
Y. Glinec, V. Malka, J. Faure, A.F. Lifschitz, Superstrong Fields in Plasma, AIP Conf. Proceedings 827 (2006).

14- Simulations of pre-modulated e-beams at the photocathode of a high brightness rf-photoinjectors
M. Boscolo, M. Ferrario, C. Vaccarezza, I. Boscolo, F. Castelli, S. Cialdi, EPAC Conf. Edinburg UK, 2006 MOPCH025.

15- Production of flat top UV pulse for SPARC photoinjector
C. Vicario, A. Ghigo, G. Gatti, M. Petrarca, P. Musumeci, I. Boscolo, S. Cialdi; EPAC Conf. Edinburg UK, 2006.

16- Commissioning of the laser system for SPARC photoinjector
C. Vicario, A. Ghigo, G. Gatti *(INFN/LNF)*, M. Petrarca, P. Musumeci *(INFN-Roma1)*.
EPAC Conf. Edinburg UK, 2006

17- Cs_2Te Photocathode for the SRF Gun in Rossendorf, J. Teichert, R. Xiang *(FZD)*, Workshop on High QE Photocathodes for RF Guns, INFN-LASA, 4 to 6/10/2006

18- SRF Gun Cavity, A. Arnold *(FZD)*, CARE06 Annual Meeting, INFN-LNF Frascati, Italy,
15 – 17 November 2006.

19- Status of the Superconducting 3 ½ Cell Gun in Rossendorf, F. Staufenbiel *(FZD)*, CARE06 Annual Meeting, INFN-LNF Frascati, Italy,
15 – 17 November 2006.

20- Laser pulse shaping for high-brightness photoinjector
C. Vicario, CARE06, Frascati, Italy, 2006.

2.2 List of publications

1- Test of the photocathode cooling system of the 3 1/2 cell SRF gun
F. Staufenbiel, H. Büttig, P. Evtushenko, D. Janssen, U. Lehnert, P. Michel, K. Möller, Ch. Schneider, R. Schurig, J. Teichert, R. Xiang, J. Stephan, W.-D. Lehmann, T. Kamps, D. Lipka, I. Will, V.Volkov
Physica C 441 (2006) 216-219

2- Technology challenges for SRF guns as ERL sources in view of Rossendorf work
D. Janssen, H. Buettig, P. Evtushenko, U. Lehnert, P. Michel, K. Moeller, P. Murcek, Ch. Schneider, R. Schurig, F. Staufenbiel, J. Teichert, R. Xiang, J. Stephan, W.-D. Lehmann, T. Kamps, D. Lipka, V. Volkov, I. Will,
Nucl. Instrum. Meth. Phys. Res. A **557** (2006) 80

3- Laser-plasma wakefield acceleration: concepts, tests and premises
V. Malka, J. Faure, Y. Glinec, A. Lifschitz, to be published to PR -STA

4- Absolute calibration for a broadrange single shot electron spectrometer
Y. Glinec, J. Faure, A. Guemnie-Tafo, V. Malka, H. Monard, J.P. Larbre, V. De Waele, J.L. Marignier, M. Mostafavi, to be published in RSI.

5- Ultra short laser pulses and ultra short electron bunches generated in relativistic laser plasma interaction.
J. Faure, Y. Glinec, G. Gallot, and V. Malka, Phys. Plasmas 13, 056706 (2006).

6- Design of a compact GeV Laser Plasma Accelerator
V.Malka, A. F. Lifschitz, J. Faure, Y. Glinec, NIM A 561, p310-131 (2006)

7- Wakefield acceleration of low energy electron bunches in the weakly nonlinera regime
A. F. Lifschitz, J. Faure, Y. Glinec, V. Malka, NIM A 561, p314-319 (2006)

8- Proposed Scheme for Compact GeV Laser Plasma Accelerator
A. Lifschitz, J. Faure, Y. Glinec, P. Mora, and V. Malka, Laser and Particle Beams 24, 255-259 (2006)

9- Radiotherapy with laser-plasma accelerators: application of an experimental quasi-monoenergetic electron beam
Y. Glinec, J. Faure, T. Fuchs, H. Szymanowski, U. Oelfke, and V. Malka, Med. Phys. 33, (1) 155-162 (2006)

10- Laser-plasma accelerator: status and perspectives
V. Malka, J. Faure, Y. Glinec, A.F. Lifschitz, Royal Society Philosophical Transactions A, 364, 1840, 601-610 (2006)

11- High third harmonic flat pulse laser
S. Cialdi, M. Petrarca ,C. Vicario Generation Opt. Lett. 31, 19 (2006) 2885. (selected for the October 2006 issue of Virtual Journal Of Ultrafast Science)

12- Commissioning of the SPARC Photo-Injector
M. Bellaveglia et al., , Proceedings Fel Conference 2006, THPPH031, Berlin Germany.

13- Production Of Temporally Flat Top Uv Laser Pulses For Sparc Photoinjector
Petrarca, C. Vicario et al., , Proceeding EPAC Conference, p. 3152, Edinburgh, Scotland, 2006.

14 Commissioning of the Laser System for SPARC Photoinjector
C. Vicario, A. Gallo et al., Proceeding EPAC Conference, p. 3146, Edinburgh, Scotland, 2006.

15- -Laser Experience at SPARC
C. Vicario, *Drive*, LCLS Injector Commissioning Workshop, http://www-ssrl.slac.stanford.edu/lcls/workshops/lcls_icw_oct06/index.html , SLAC, USA, 2006.

16- Pulse Shaping for the SPARC Photoinjector,
M. Petrarca, C. Vicario et al., *Laser* Workshop on Laser Pulse Shaping http://www-zeuthen.desy.de/~haenel/WSLPS/index.html , DESY Zeuthen, Germany, 2006.

17- Laser Timing and Synchronization Measurements,
M. Bellaveglia, C. Vicario, et al., SPARC Technical Note LS-06/001, http://www.lnf.infn.it/ , 2006.

18- UV-IR Cross Correlator
M. Petrarca, C. Vicario et al., SPARC Technical Note LS-06/002, http://www.lnf.infn.it/, 2006

19 - An optical system developed for target laser pulse generation
S. Cialdi, I. Boscolo, A. Paleari, " Report INFN-BE-05-2

20- Rectangular pulse formation in a laser harmonic generation",
S. Cialdi, F. Castelli and I. Boscolo, Appl. Phys. B 82, 3 (2006) 383-389.

21- Train of micro-bunches for PWFA experiments produced by RF photoinjectors
M. Boscolo, M. Ferrario, C. Vaccarezza, I. Boscolo, F. Castelli,
S. Cialdi, "A " Int. J. Mod. Phys. B. (2006)

22- Laser comb: simulations of pre-modulated e-beams at the photocathode of a high brightness rf-photoinjector
M. Boscolo, M. Ferrario, C. Vaccarezza, I. Boscolo, F. Castelli,
S. Cialdi, "" EPAC Edinburg 2006

2.3 Thesis

1- Untersuchung zur Feldverteilung verschiedener Moden in mehrzelligen Beschleunigerresonatoren,
André Arnold,
Diploma Thesis, Technical University of Dresden, January 2006

3. Status of the work

WP 2, CHARGE PRODUCTION

CERN

In the first part of 2006 most of the work for refurbishing the installations of the photocathode laboratory has been completed. Only a few components (i.e. a wall current monitor) and some control software need to be finished.

The DC Gun, used to pre-qualify the photocathode performance was baked out till a pressure close to 10^{-10} mbar was reached. After that operation it was possible to condition the Gun up to its nominal field of 10 MV/m with a copper photocathode (without any photosensitive film). This process was repeated with a photocathode with a bulk quartz substrate to prove that no problems arise with such material, in view of the possible use of Secondary Emission Yield photocathodes. Fig. 1 shows the profile of vacuum level during conditioning.

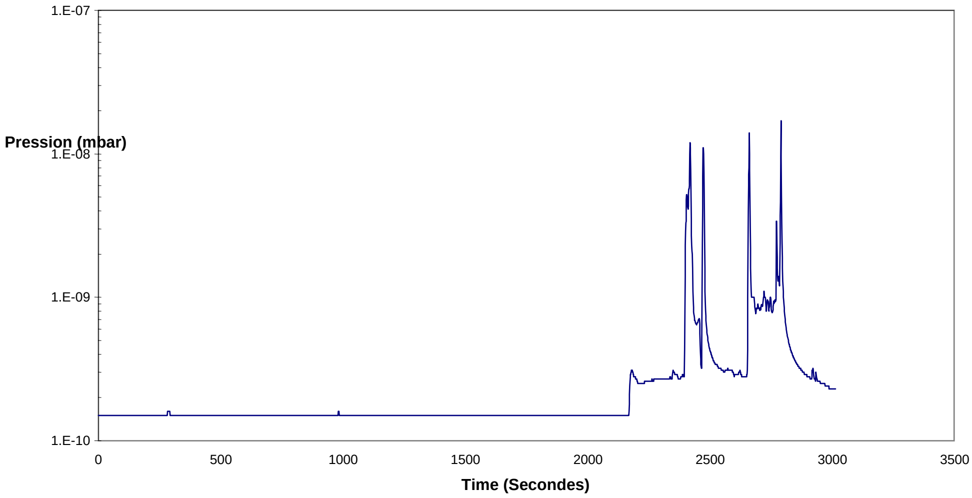


Fig. 1: Diagram of pressure inside the DC Gun during conditioning.

The integration of the RF Gun into the layout chosen for the off-line test has been fixed and drawn in 3D to check for interferences (see fig. 2). Several problems of incompatibility among the different parts of the photoinjector and measurement line have been solve thanks to detailed modelisation.

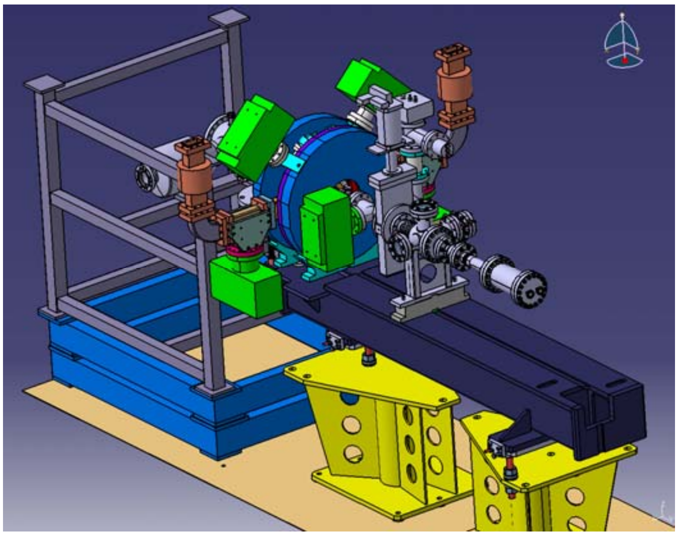


Fig. 2: Integration layout of the photoinjector.

With the deposition chamber fully refurbished, and intense campaign of calibration of the different sensors has started, In particular, to ensure a good reproducibility of the Quantum Efficiency of the photocathodes in Cs_2Te an intense campaign of calibration of the different sensors included in the chamber is on-going. The most significative technique in our installation is to read the thickness directly on two independent quartz microbalances positioned in the vicinity of the photocathode during deposition. A 3D study has been carried out to determine convenient masks to apply during the deposition process to protect the Te balance from Cs and viceversa. The masks have been simulated with CATIA and then realized, and according to our first measurements the rejection of the unwanted species is better than a factor 150. The masks are shown in fig. 3-6.

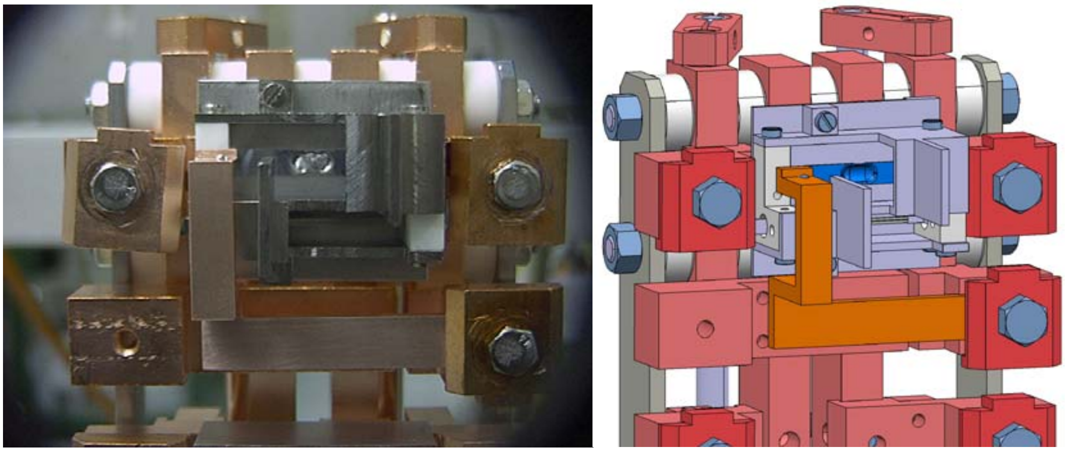


Fig. 3: A picture and the 3D drawing of the deposition ovens and the masks to protect the microbalances.

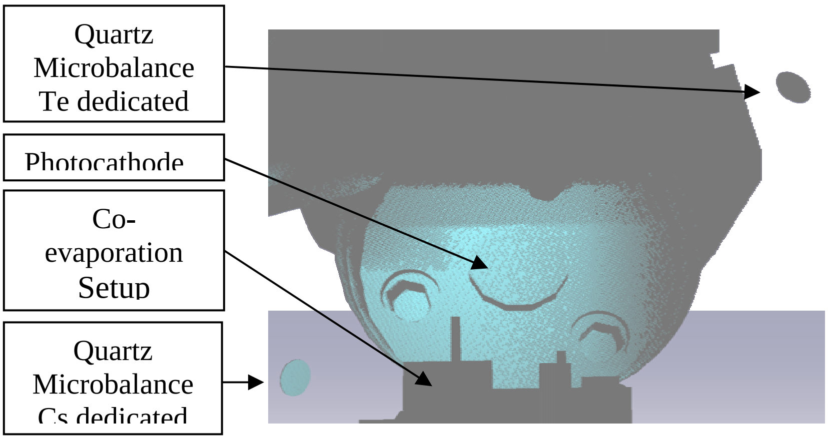


Fig. 4: the deposition set-up designed with CATIA in 3D to determine the deposition profile. It can be noticed that only one microbalance is illuminated by the active oven (the one containing Cesium).

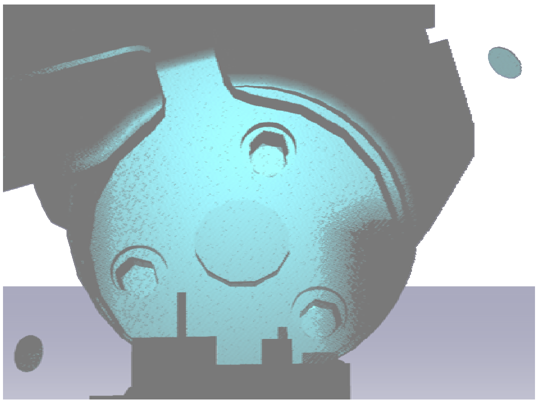


Fig. 5: Activating only the oven containing Tellurium, now it is the other microbalance that sees the deposition vapor.

After verification of the independence of the measurements from the unwanted element, the calibration of the measurements given by the microbalances has started. Several photocathodes were deposed with only one element, then the thickness of the thin film measured with different techniques:

1) special photocathodes made of quartz have been deposed to measure the optical transmission of the sample. Though this measurement does not give an absolute measurement of the thickness of the film, it allowed to optimise the shape of the mask to maximize the quantity of elements arriving to the photocathode. In fig. 6 and 7 measurements of Te deposition for two different masks are presented. In the second, the shape of the mask has been modified to increase the quantity of tellurium on the microbalance for a given measurement on the photocathode.

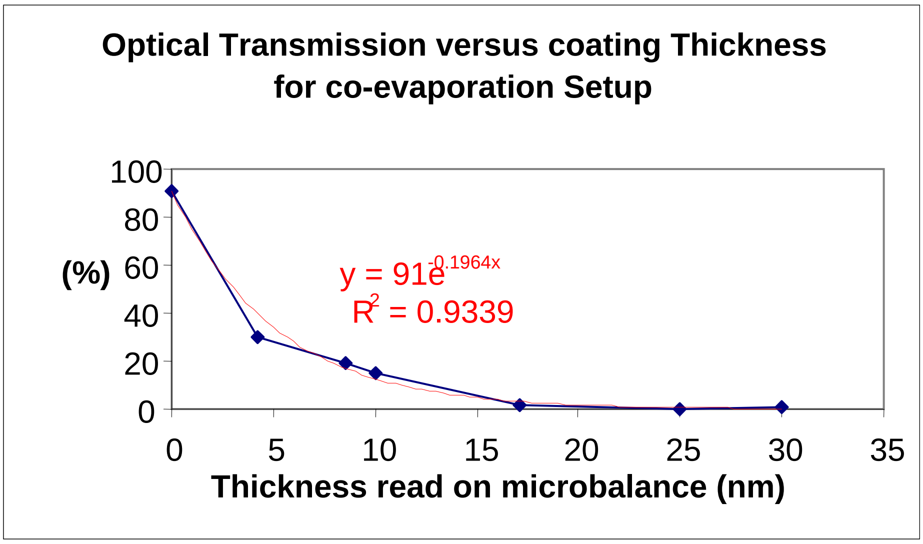


Fig. 6

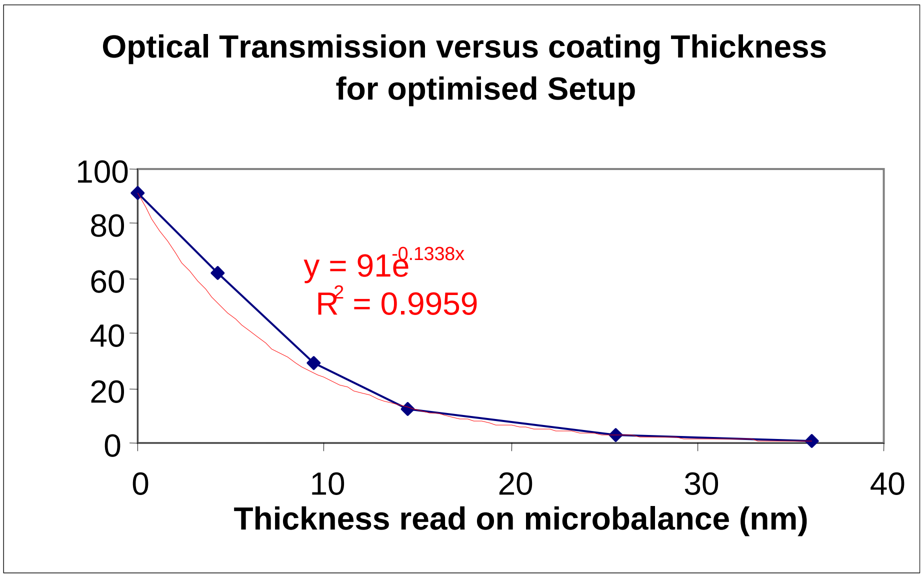


Fig. 7

2) Measurement of absolute thickness using a precision rugosimeter. A new rugosimeter has been installed in the CERN metrology department. The theoretical measurement accuracy is 0.1 nm. Some test measurements have already been performed, but several tricks need to be implemented to get a significative measurement with the desired accuracy. Intensive work of measurement will be performed during the second part of the year.

In the second part of 2006 CERN made progress in the understanding of the process of deposition of Cs_2Te photocathodes in the CERN photocathode laboratory. In order to get repeatable results the control of the stoichiometric ratio is fundamental. In CERN's laboratory this is pursued by the control of the thickness of the deposed elements on two quartzes whose change in resonant frequency is monitored and correlated with the film deposed on the photocathode, measured independently with special profilers. During the calibration of this method, we discovered that the quantity of Te deposed on the corresponding quartz was changing with time, and we correlated the integrated thickness deposed on the different samples with the actual measurement from the quartz. Instead of a straight line, as we get on

Quartz 1, we have an exponential decrease on Quartz 2. We explained that decrease with geometrical consideration. In Practice, as the boat containing the Te compound empties, the quartz is little by little masked by the boat geometry, therefore the quantity of Te seen by the quartz is changing with respect to the quantity deposed on the photocathode.

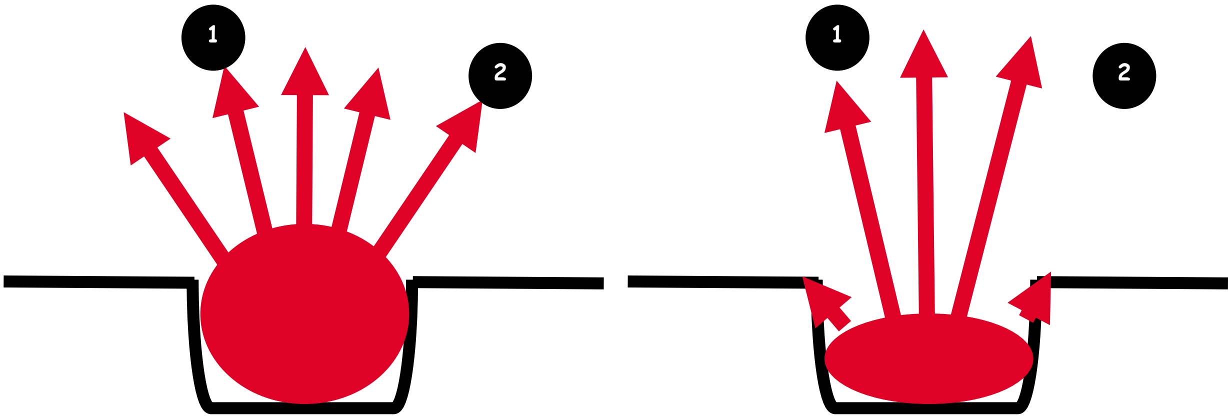


Fig. 1: The quantity of Te seen by Quartz 2 diminishes over time due to the geometry of the boat and to the relative position of the quartz with respect to the Photocathode.

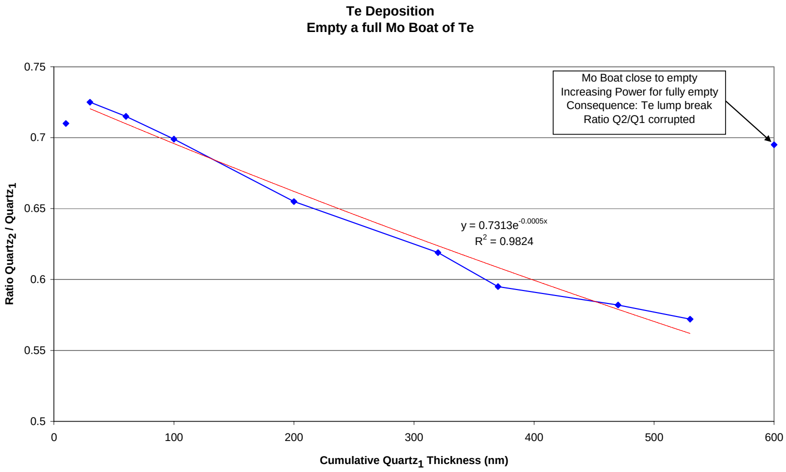


Fig. 2: Calibration of Quartz 2 vs Quartz 1. Ideally we should see a line parallel to the abscissa.

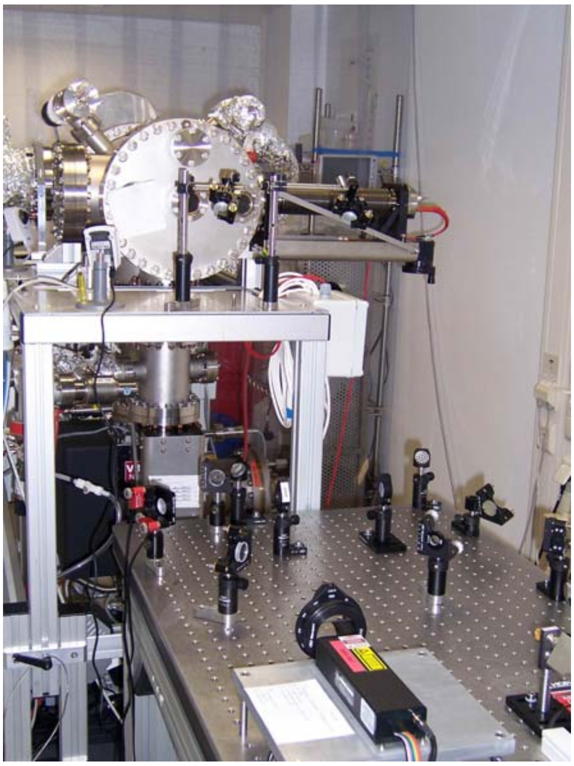
In order to further characterize the system and refine and speed –up the thickness measurements, a mechanical stylus profiler with nanometer resolution has been purchased and will be available for operation at the end of the year.

CERN has also extensively collaborated with LAL in order to finalize the integration of the RF Gun into the CTF2 environment. Several technical decisions have finally been taken concerning pumping of the gun and of the waveguides and installation procedures. CERN has also started simulations of the gun to verify the thermal stability of the gun for operation at 50 Hz.

Finally, an important milestone has been reached, with the delivery to CERN of all the components of the laser. Though not all the performances of the laser were proven at RAL, it was decided anyway to transfer the system to CERN (what was done of August 28th) and the assembly is now going on in the CTF2 laser room. An associate previously working on this laser at RAL has been hired for 6 months to complete the installation and commissioning of the laser.

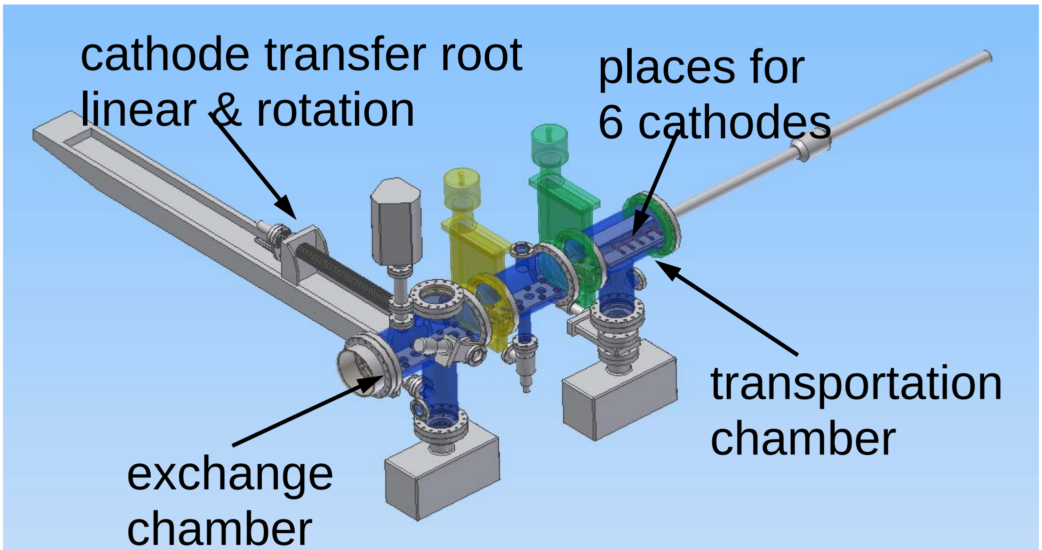
FZR

The photocathode preparation system has been installed in the new clean room. The equipment has been assembled without particle contamination. Photo cathodes can now be inserted with the cleanness required in the SRF gun. The preparation system is connected to control electronics and the control PC with National Instruments input-output cards. The software was written in Visual C++. Complete remote-controlled operation (cathode heating, Cs and Te evaporation, deposition rate monitoring, shutter, Q.E. measurement, vacuum) and parameter recording is realized. The preparation system was improved by means of a precise positioning system for the evaporators. Within test measurements the deposition rate sensors were calibrated and the tellurium heater design was optimized.

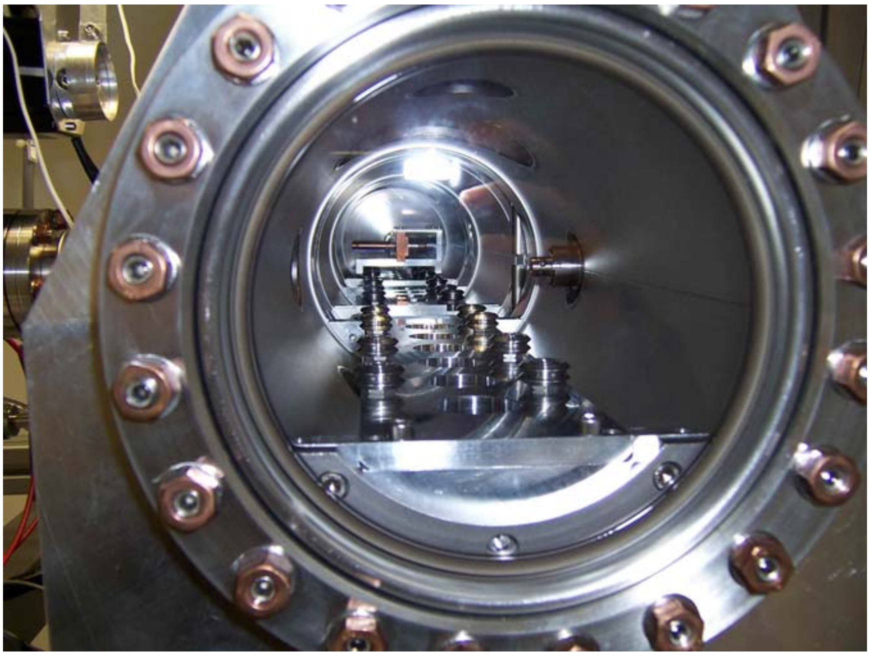


Photograph of the cathode preparation equipment in the clean room at FZD.

The transfer and storage systems for the photo cathodes were assembles, tested and installed in the clean room. As shown in the design figure, the transfer system consists of the exchange chamber with a linear-rotation precision manipulator, the transportation chamber with places for six photo cathodes, and a lock chamber in between. The photograph presents a view in the installed transfer system. In the foreground is the transfer chamber with the head of the transfer root on the right. In the background is the carrier with photo cathodes. A second transfer and storage system is fabricated and will later be installed at the SRF gun.
In spring a delay in photo cathode technology work was happened due to the pregnancy leave of the responsible co-worker. Since July, this work has been continued and the lost time will be regained.



Design of the photo cathode transfer system.



Photograph of photo cathode transfer system.

LOA

The prototype of the low energy electron spectrometer which has been designed last year, has been calibrated and tested during this year. The design and the view of the magnet are presented on Figure 1.

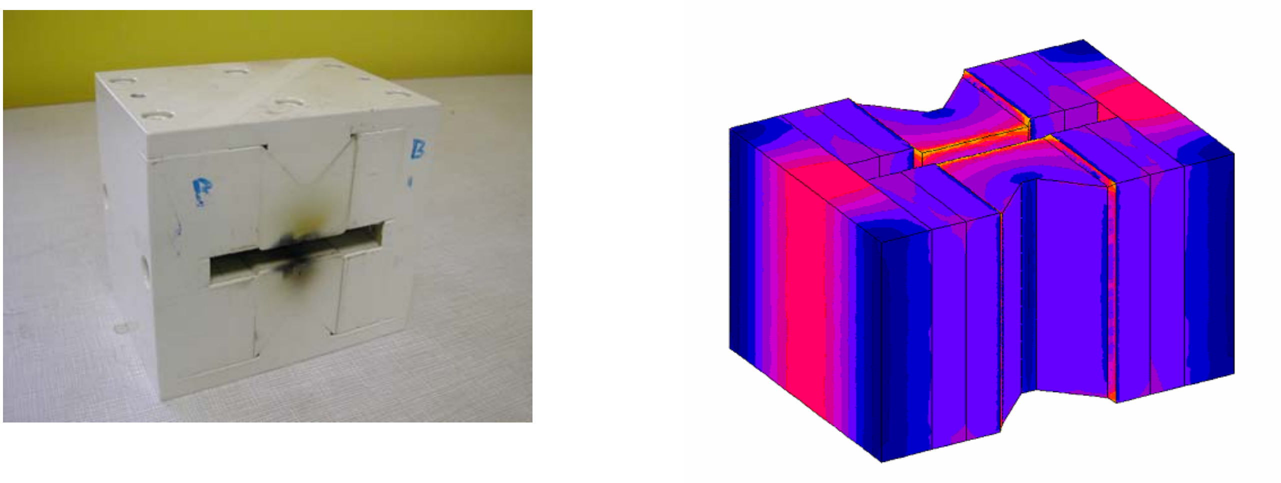


Figure 1 : View and design of the low energy electron magnet

The absolute calibration has been performed using the ELYSE accelerator, a laser-triggered radiofrequency (RF) picosecond electron accelerator, located at Orsay. The results are then extrapolated to our experimental conditions. The results of the calibration are represented on figure 2.

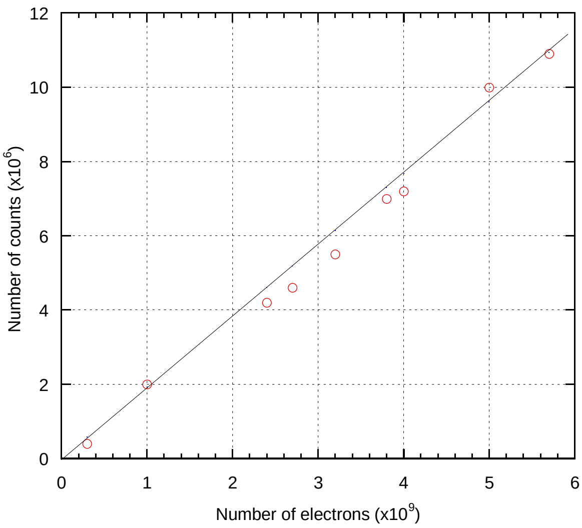


Figure 2 : Evolution of the signal intensity with the charge for 3.3 MeV electron energy

The spectrometer has been tested at LOA. On figure 3 and 4, one can see the spectrometer in the vacuum chamber. The spectrometer has been used to measure the electron beam produced in the new “colliding pulse” regime in a wide range of electron energy from 50 to 300 MeV.

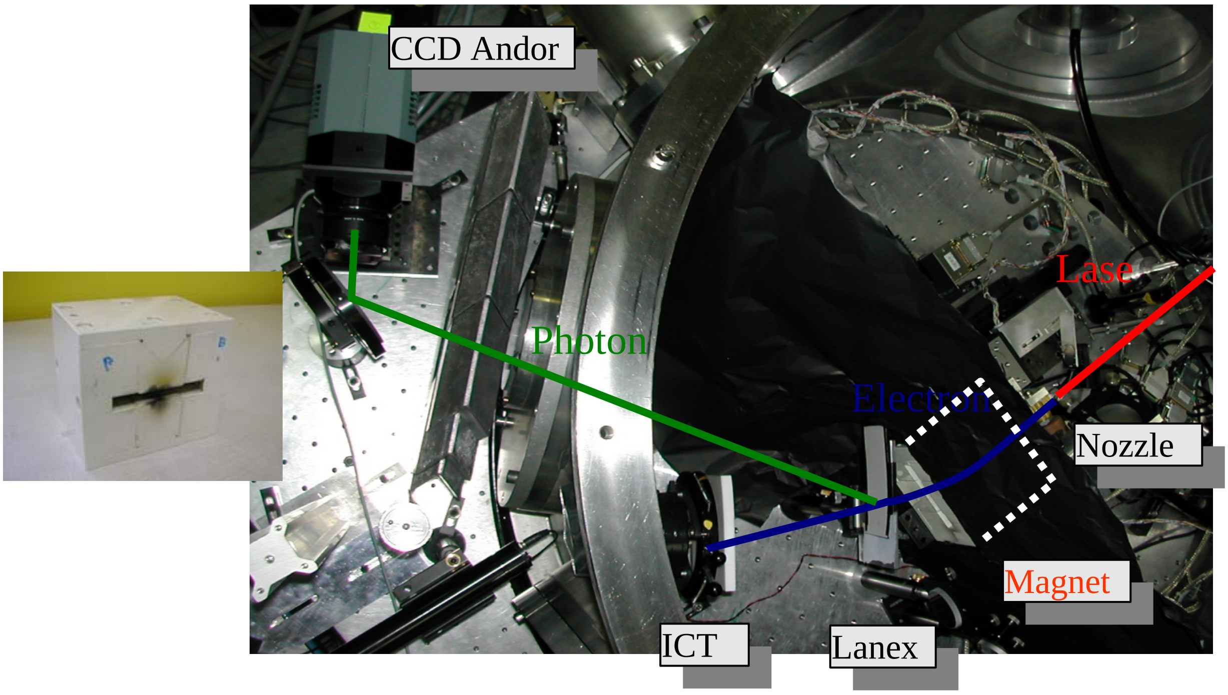


Figure 3: Picture of the experimental chamber. The back cloth is used to reduce the laser and visible light in the camera. A picture of the magnet is also shown on the following slide. Also indicated in the picture, the high dynamic CCD camera.

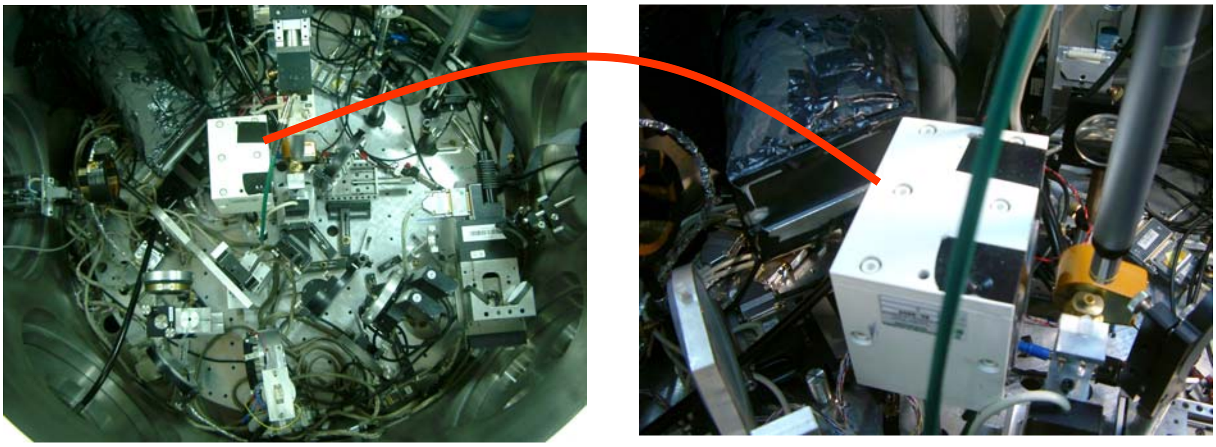


Figure 4 : View of the spectrometer used in the colliding pulses experiment

The spectrometer has been used to measure the electron beam produced in the new “colliding pulse” regime in a wide range of electron energy from 50 to 300 MeV. Results are indicated on figure 5.

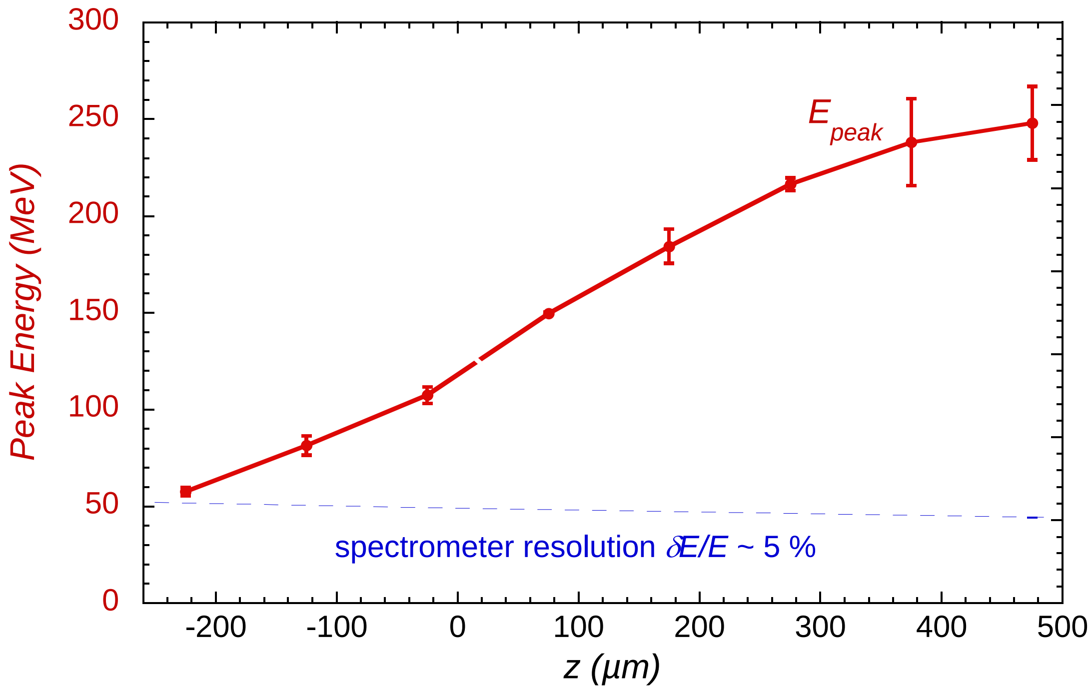


Figure 5 : Electron beam energy as a function of the delay of the two laser pulses

For future medical applications of the electron beam for cancer therapy, we have, in collaboration with DKFZ in Germany, calculated the dose deposition in a phantom.

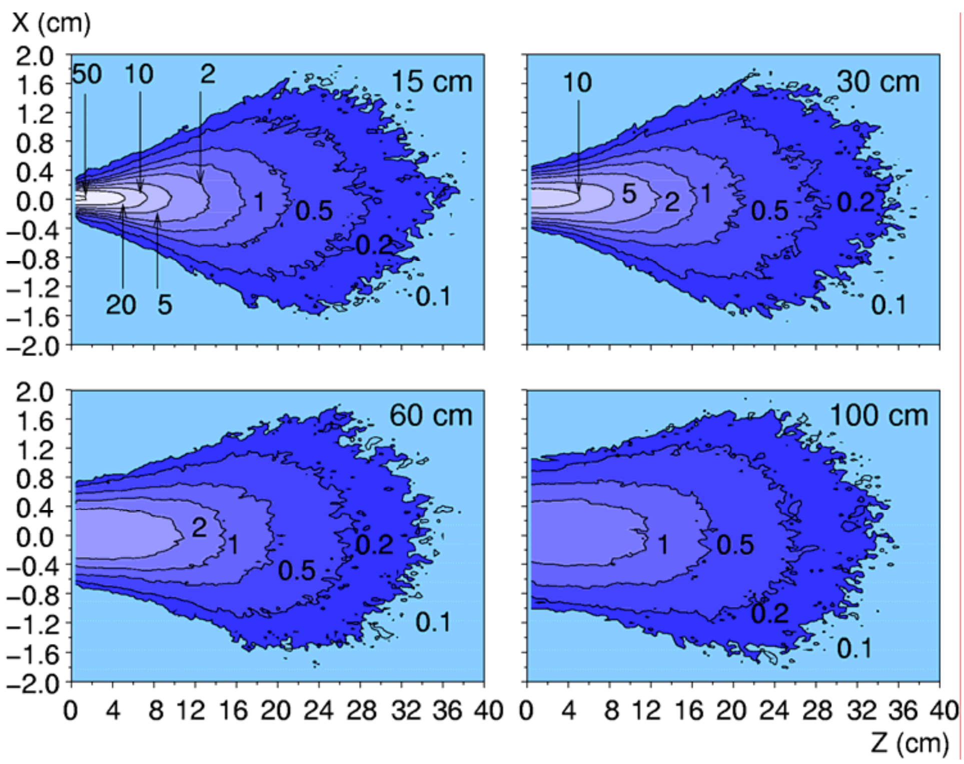
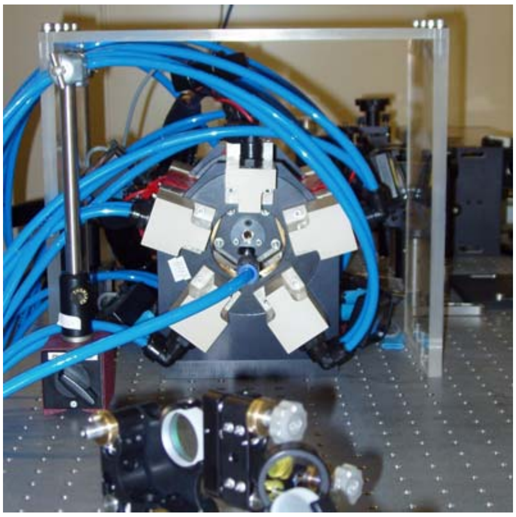


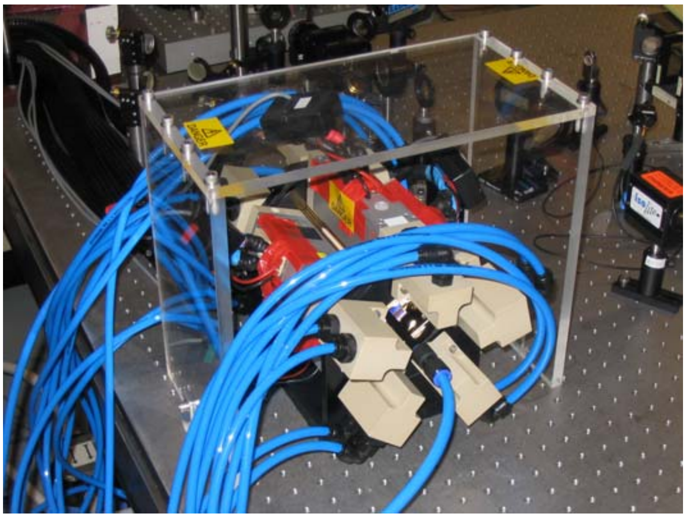
Figure 6: Contour of dose produced in one laser shot
with the parameter of the 170 MeV electron beam..

WP3, LASER

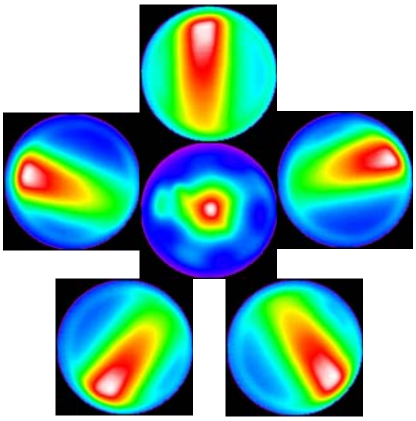
RAL

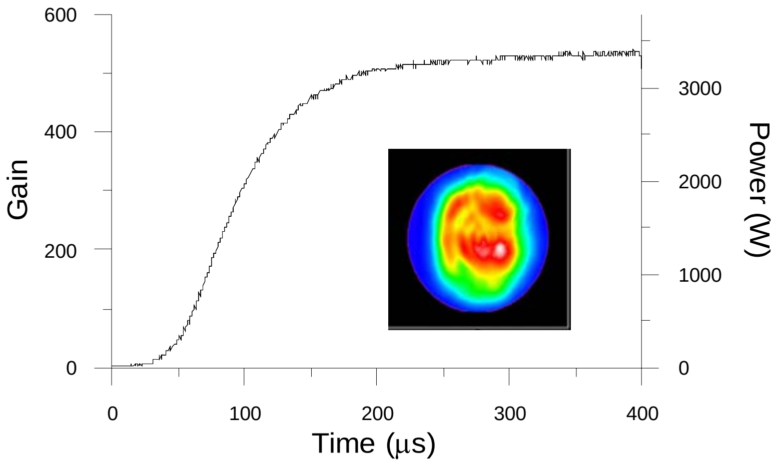
All the laser system components have been tested in the final conditions and shipped to CERN for the installation and final test. The two multi-pass amplifiers almost achieved the final energy per pulse and the amplitude stability along the pulse trains.



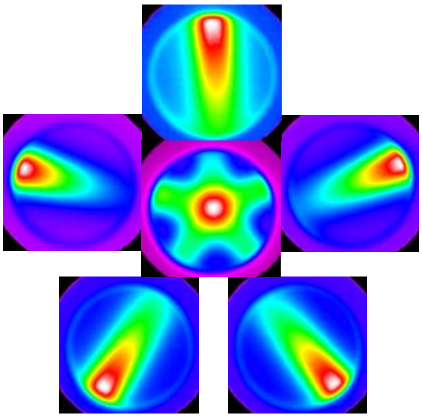


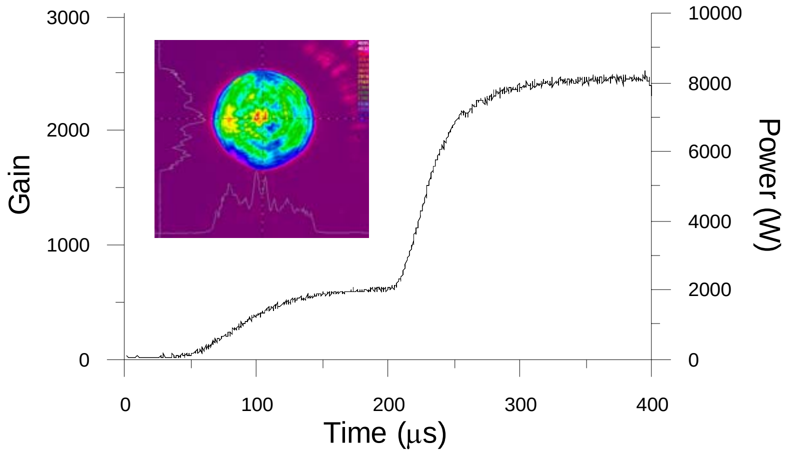
The test of the first amplifier has been performed at 10 and 50 Hz repetition rate and the measured output exceeds target power (3 kW from 3 passes). Output saturates in agreement with model and as shown below the pumping arrangement delivers good uniformity across the rod. Near-field profile is flattened by saturation but shows some effects of rod inhomogeneities





Second amplifier has been tested up to more than 8kW: 10kW from Amp 2 corresponds to 6.7mJ/pulse. Uniformity is good but the rod is underfilled

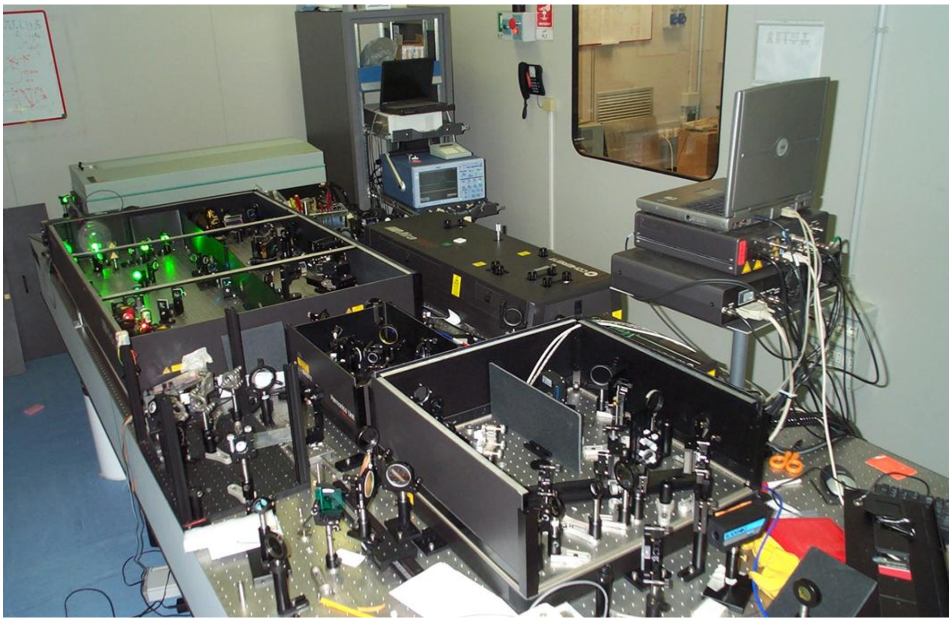




The pulse coding system has been also developed; fibre modulation, based on telecommunication technology, is fast but lossy and limited in average power.
Measurements on the High Q system suggest 10dB loss before the preamp results in <3dB output reduction. Delay can be adjusted by varying the fibre temperature (~0.5ps/°C) Attenuation can be controlled by varying the fibre bending losses Preliminary assembly and tests of temperature tuning were carried out at RAL

INFN – LNF

In the frame of the CARE collaboration, strong efforts have been devoted to study the techniques to shape the temporal profile of the drive-laser pulse for the SPARC photoinjector. We recall here that to minimize the emittance in a photocathode RF-gun an uniform UV pulse of 10 ps, with less than 1 ps rise time and with limited ripple (<30% ptp). Beside, other requests are placed on the spot mode, the laser energy and stability.



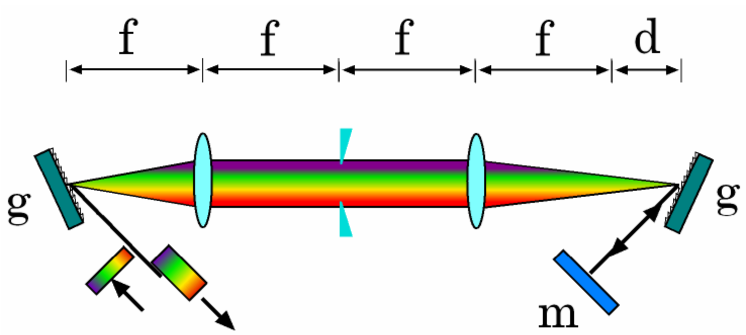
SPARC photoinjector laser system

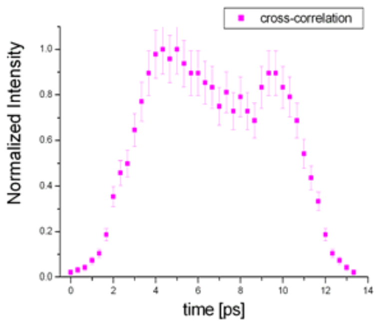
During this year, the SPARC Ti:SA laser system has been integrated with an active temporal pulse shaper based on a commercial acousto-optic filter, named Dazzler. The filter can modify the spectral amplitude and phase in order to modify the natural Gaussian profile of the laser into the wanted one. The pulse shaper has been installed between the oscillator and the amplification stage. Several measurements have been performed to demonstrate the capabilities and the major limits of the filter. In particular, the alterations on the pulse spectrum, due to the chirped pulse amplification (CPA), have been investigated. It came out that the usual distortions associated with the laser amplifiers, such as the frequency red-shift and the gain saturation, can be effectively pre-compensated by the Dazzler. On the other hand, we observed that the filter can not counterbalance the smoothing of at the spectrum edges introduced by the CPA process.

Also the distortions due to the third harmonic generation (THG) downstream the CPA have been extensively characterized. The spectral intensity in the third harmonic, obviously, influences the temporal profile. In particular we demonstrated that when a large chirp is applied at the UV pulse, as in our system configuration, the intensity time profile reproduces directly the spectral distribution. Therefore the square-like spectrum is necessary to produce a flat top time profile. The correlation between spectrum and time intensity has been studied and experimentally confirmed using two home-built diagnostic tools: a spectrometer and an UV cross-correlator.

To characterize the distortions introduced by the harmonic generation we performed a series of measurements changing the input spectral phase and intensity with the Dazzler. It turned out that the harmonic spectra shape is strongly influenced by different input chirp. A key result is that the harmonic spectra tend to reproduce the IR only for large input chirp and a pulse longer than 600 fs rms. Approaching the transform-limited condition, the harmonic spectral shape becomes triangular with narrow bandwidth and the temporal profile develops into a Gaussian distribution. These distortions cannot be effectively compensated by the acousto-optics pulse shaper. To overcome this problem, we demonstrated that a proper chirp allows UV square-like spectra with enough TGH efficiency.

The shaped spectrum and time profile obtained is reported in the fig. 1. As shown there is a direct correlation between the spectral and the time shape. The rise time results to be less than 2.5 ps, and the ripple is about 20 % ptp. The rise time is worse than the required one. Optical simulations show that better profile can be achieved by using a spectral filter within the UV stretcher. This solution is going to be implemented.





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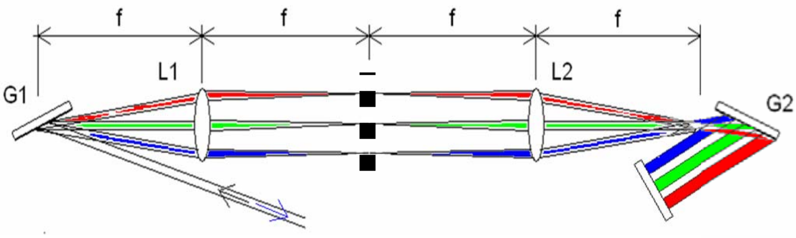
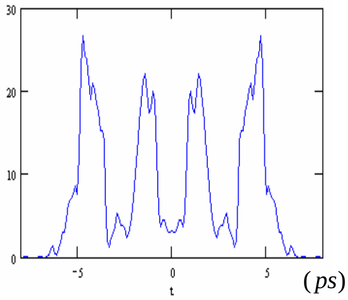
In parallel with the AO filter a pulse shaper, based on a liquid crystal mask in the 4-f configuration, has been installed. The 4-f optical system has been designed and mounted. In the next future the two pulse shaping techniques are going to be compared.

Besides, experimental work is in progress to measure the jitter between the rf clock and the UV laser pulse. The actual results demonstrate a good laser stability within the SPARC specs (0.65 ps rms). This value take into account also the jitter of the measurement equipment and unwanted electrical noise. Further experimental activities are foreseen to quantify the real jitter between the laser and the rf master clock.

INFN - MI

INFN- Milano worked mostly at the SPARC-Frascati experiment in setting the 4f-system for the generation of the rectangular laser pulse within the laser system of the SPARC project and for comparison with DAZZLER system. The shaping system within the entire laser system has been designed and assembled according the proper spectral configuration and the successive longitudinal modulation via the stretcher for the rectangular pulse generation at the third harmonic of the Ti:Sa laser. The result is quite satisfactory. Within this program we have operated the SPARC rf-gun together with the SPARC team.
The investigation of the spatial shaping of the laser pulse by means of the 4f-system, that is transforming the mask as special movable mirror has been finished.



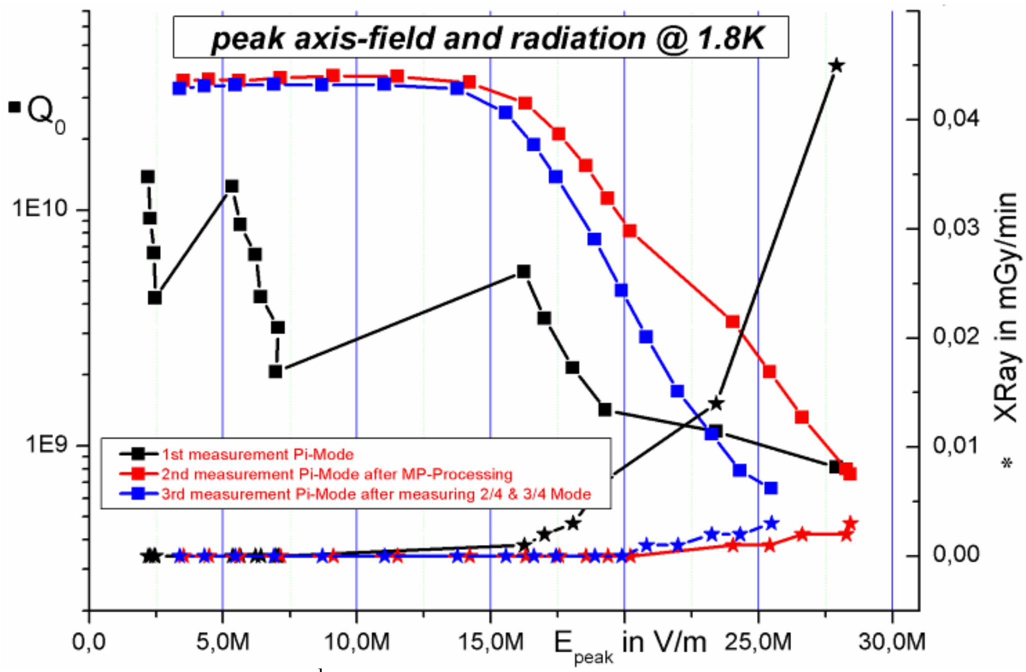


As third item the problem of the generation of a laser comb beam aiming to produce electron beam trains of THz frequency has been tackled: simulated temporal pulse shape is shown in the picture.
The 4f-asymmetric system with an iris at the Fourier plane has been tested in the Milano laser Lab and afterwards it was implemented in the SPARC Frascati experiment where it operates quite successfully.

WP 4, RF GUN AND BEAM DYNAMICS

FZR

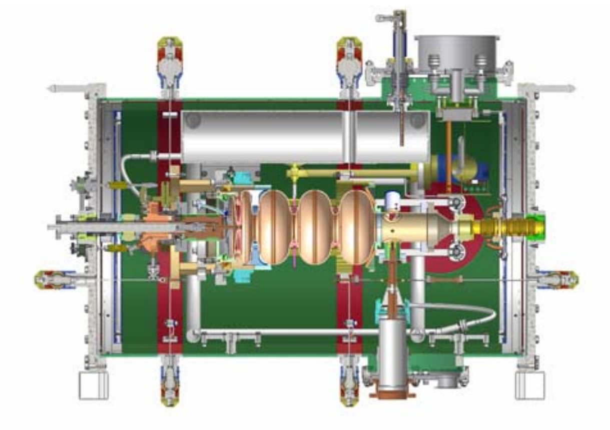
In January 2006, a new helium transfer line was installed which allow the connection of the srf gun to the ELBE helium refrigerator. The transfer line consists of a new He line from the main distribution box in the accelerator hall to cryomodule 1, a valve box above the cryomodule and an additional He line to the srf gun. Later in 2006 the liquid nitrogen pipeline was installed.
In the summer shut-down 2006, the currently used thermoionic injector of ELBE was modified and components moved in order to obtain the space for the installation of the new SRF photo injector. In the driver laser room the clean room installation is finished. For the RF power connection the waveguide has been installed. One of the 10 kW spare klystrons of the ELBE accelerator can be used. The laser room was reconstructed and clean room techniques were installed. A new hutch for the streak camera of the bunch length measurement system was built.
The warm tuning of the two cavities was finished and they were sent to DESY for treatment (buffered chemical polishing, backing, cleaning). The RRR300 cavity was measured in the vertical test stand at DESY two times. The results of these measurements and of warm rf measurements performed at FZR were published at the FEL 2006 conference. Unfortunately, a failure happened during high pressure rinsing. Thus the cavity had to be sent to ACCEL for mechanical treatment. At ACCEL the cavity was BCP etched and HPR cleaned. A third test in the vertical test stand was carried out with insufficient results due to strong field emission. As presented in the picture, a maximum peak field of about 15 – 20 MV/m was obtained whereas the goal is 50 MV/m.



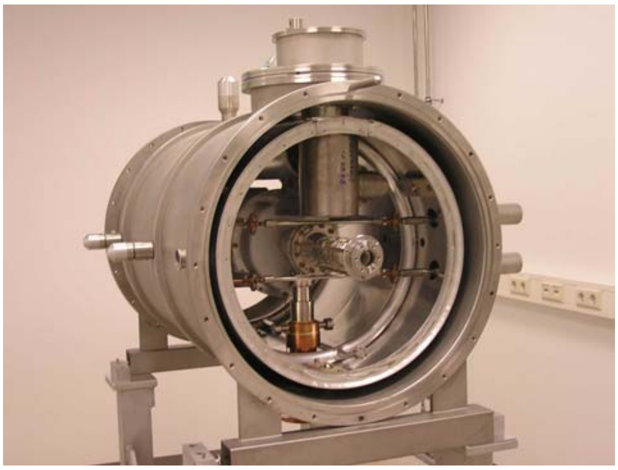
Results of the 3rd vertical test at DESY, November 2006.

It turned out that the envisaged acceleration gradient will only be obtained if the high pressure rinsing system is modified according to the needs of the geometry of the 3 ½ cell cavity. Therefore a contract with the company ACCEL was placed for modification of their HPR system. This modification will be finished till end 2006. In January the next treatment (BCP and HPR with the modified system) and the measurement in the vertical test stand will be performed. Then the helium tank welding can be finished in February 2007 and the cavity will be at Rossendorf for assembly in the cryostat begin March 2007.

In 2006 the assembly of the SRF gun cryomodule has been carried out in the workshop. This work includes the vacuum vessel, the liquid nitrogen thermal shield, magnetic shield, tuning systems, rf power coupler, cathode support and cooling system and cavity support. The standard vacuum components like pumps and gauges, and the diagnostic components (temperature sensors, He level meters) were delivered. All the subsystems were tested. In November tests of the isolation vacuum of the cryostat and of liquid nitrogen cooling system were performed. A second photo cathode transfer system was fabricated and assembled. The tuning system was tested and its parameters measured in a test bench.



Cut drawing of the SRF gun cryostat.



Assembly of the SRF gun cryomodule at FZD

MBI Berlin developed the driver laser and FZD is responsible for the laser beam line set-up which transports the laser beam from the laser room to the photo cathode of the SRF gun in the ELBE accelerator hall. The design of the laser beam line is finished. The mechanical components are delivered and fabricated. Most of the mechanical components are already installed. The remaining work will be carried out in winter shut-down of ELBE.

LAL

Status of the RF gun: the last copper pieces of the RF cells have been received just in half September instead of the end of July as it was foreseen. Yet, at this date, the two couples of end-caps (water box) have not still received. But, fortunately it is not necessary for the RF adjustment of cells. RF measurements started in September, 25th. We need at least one month to achieve a good adjustment of the cavities. From a point of view of the RF physics, a big step of cell dimensions occurred between the prototype and the definitive gun, one had to correct the resonant frequency by more 30 MHz. From the measurements on the definitive gun, it appeared that these corrections were reasonable for the coupler and central cavities. But, in the half cell, it seems that the "local resonant frequency" is too low. One possible way to overcome this difficulty that we are studying is to machine another cathode holder. According to the previous planning, LAL was supposed to deliver the cavities to CERN in the end of September for a brazing at the end of the year. Now, it seems the planning will be shifted by at least one month.

About the tapered waveguides, technical drawings are finished and approved by the CERN brazing specialist in early September. A selection of a tender is under way, a first quotation gives 2 weeks of machining. So, theses pieces should be fabricated by the end of the year and brazed at CERN. The last operation should take place before the brazing of the gun cells. Moreover the waveguides one brazed must come back at LAL for adjusting the RF flanges.

Vacuum pumping ports connected to the waveguides are in fabrication in the LAL workshop and should be finished also by the end of the year.

Thermal/vacuum model:

Big troubles occurred during the brazing of the model. Due to some defects of the oven, there was a leak which polluted the oven preventing the brazing process during summer. Once the problem fixed, the model was brazed but the solder between the model and the waveguide did not catch and the model showed a big leak. The latter has been fixed using a UHV high temperature glue. At room temperature, vacuum tests showed a pressure limit down to 10^{-8} mbar. To reach UHV, one had to bake out and, unfortunately during the process, around 100 °C a new leak has been detected. One thinks it is probably due to the difference in thermal expansion coefficient between copper and the resin. Alternative solutions are being studied. For the definitive brazing a "bell" has been designed to test a possible leak before the TIG soldering of the NEG envelop. The construction of this device is now under way.

Integration drawings

Drawings of the gun have been updated as shown in figure 1. Support of the gun is designed and will be machined in the LAL workshop. We had a meeting in September, 13th with E. Chevallay from CERN about the integration of the gun into the beamline. He asked the help of LAL to install the gun as it is not possible to put it directly with its girder into the tunnel because of the smallness of the chicane aperture. Moreover, CERN discovered that the gun must be pumped from two points: at the output and on the NEG chamber. E. Chevallay told us he did not know and therefore it was not foreseen. Recently, CERN people asked to us to bring several changes to the pumping system in order to reduce the need of primary pumping. It represents a new effort for LAL and can eventually lead to further delay.

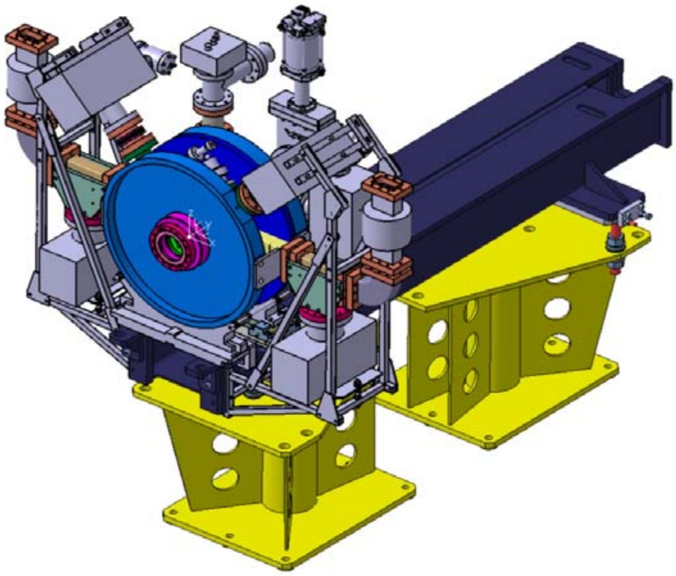


Fig. 1: 3D CATIA drawing of the gun.

Nepal station

Civil engineering begun in September, pillars are drilled into the floor (see figure2). Then, it must be left to dry for one month. After, a concrete floor is coated at the top of the pillars and again left to dry one month. Finally, walls made of concrete blocks are mounted. Before to set up the roof, all heavy elements of the machine will be installed with the crane. The end of civil engineering is foreseen for the end of January

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Fig.2: view of NEPAL room with a machine which drills a hole into the floor.

The laser came back from the manufacturer, HighQ, in September. It has been installed in the laser hutch close to the Nepal room. Our specialist checked its performances. For instance, the energy of the pulse exceeded the specifications; the external synchronization of the laser with the RF pilot generator is operating but the external trigger was forgotten by the manufacturer. Measurements of the laser pulse duration have been performed with a streak camera. One typical example is shown in figure3.

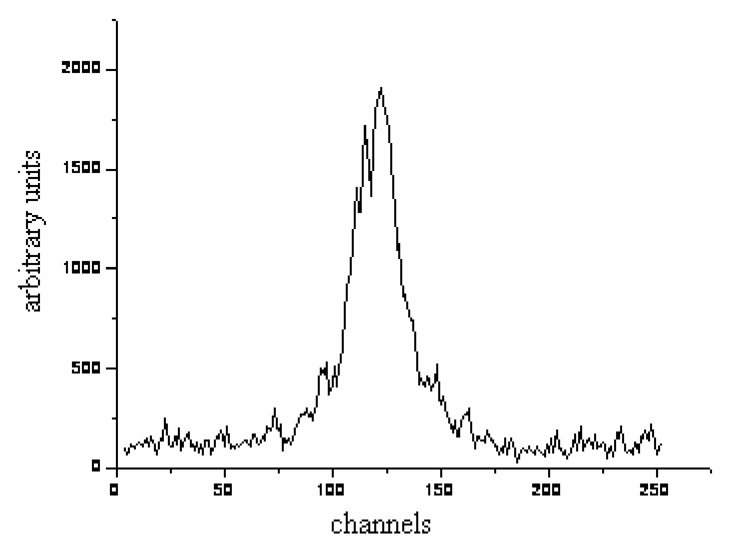

Figure 3: streak camera measurement of the laser after the frequency quadrupling, the abscissa axis stands for the picosecond time scale, i.e. 250 channels = 90 ps.

In this example, the width (FWHM) is 14.4 ps which is roughly the average value. Unfortunately it is 40 % bigger than the specified limit. As a consequence, the laser has again been sent back to the manufacturer to fix this problem. The latter gave one month for a new delivery.