

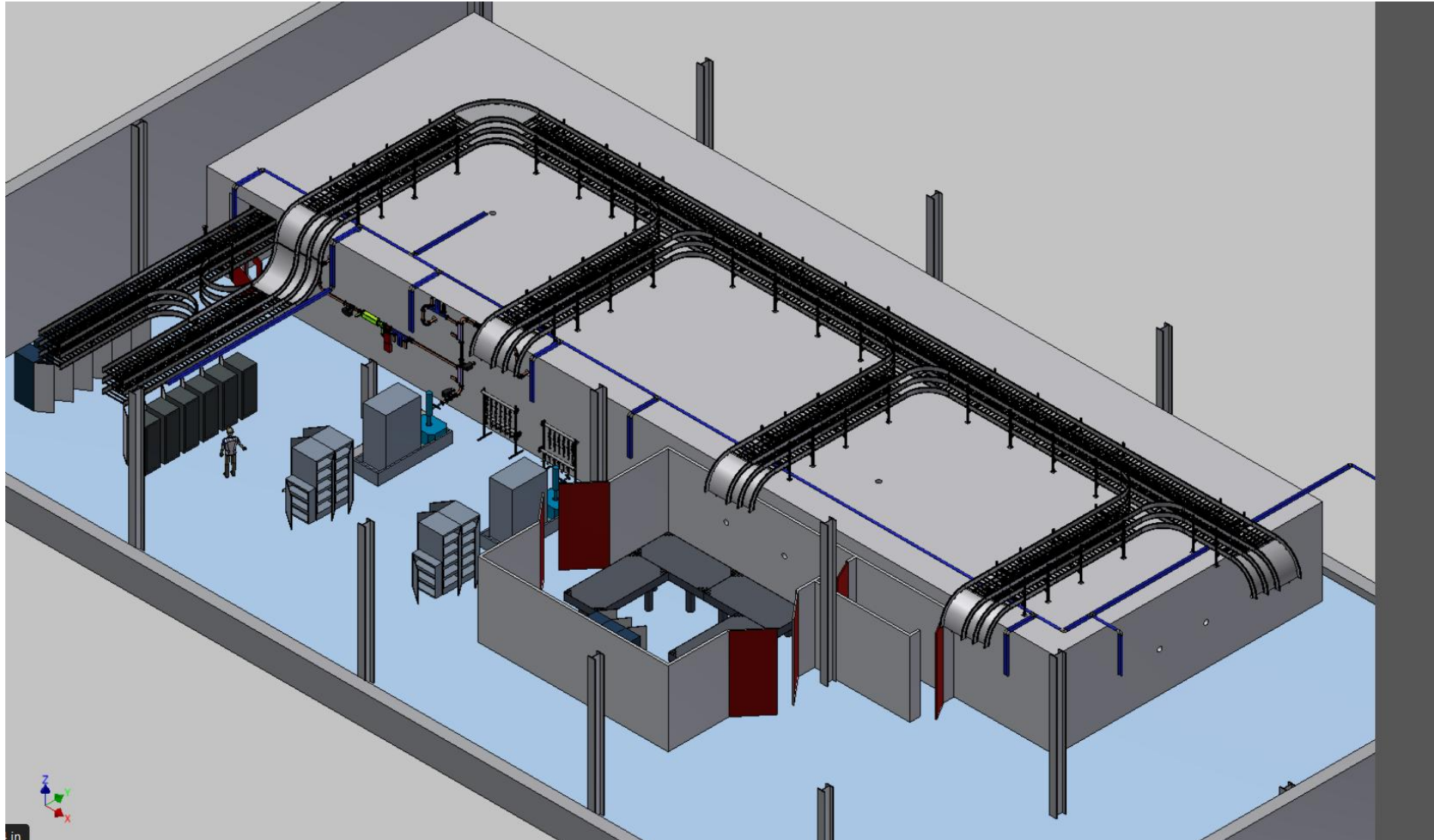
The STAR Project: Southern european Thomson source for Applied Research

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for the STAR Project Team
Channeling 2014
09 Oct 2014

Outline of Talk

- Introduction
- Beam Dynamics
- PC and IP Lasers
- Radio Frequency
- Beam Diagnostics
- Conventional Facility

STAR Hangar/Bunker Layout







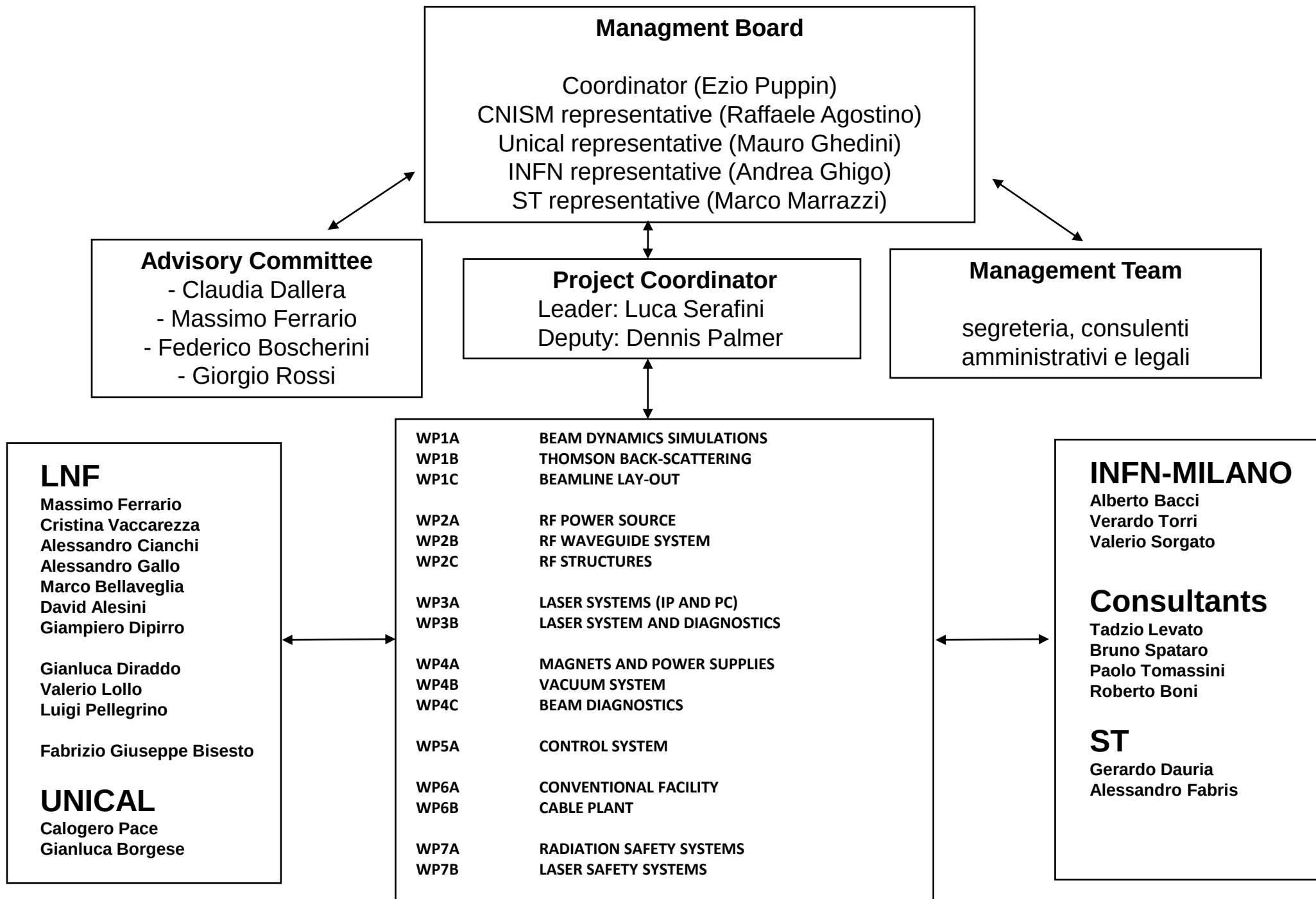


Table 2: Electron beam parameters

	Phase-1	Phase 2
Bunch charge (nC)	0.5	0.5
Energy (MeV)	20-60	20-85
Rms length (ps)	1-5	1-5
$\epsilon_{n-x,y}$ (mm-mrad)	1-3	<1.5
Energy spread (%)	0.1-2	0.05-0.5
Focal rms spot size (μm)	15-40	10-40

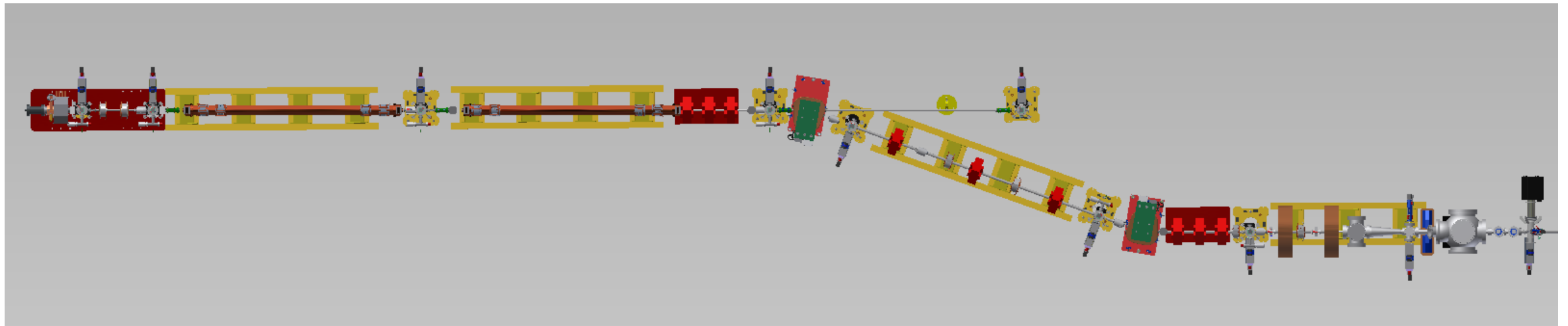
Table 3: Laser beam parameters

	Phase 1	Phase 2
Pulse energy (J)	0.8	0.8
Wavelength (eV)	1.2-2.4	1.2-2.4
FWHM pulse length (ps)	10-20	10-20
M^2	< 1.5	<1.5
Focal spot size w_0 (μm)	20-50	10-40

ACC1

ACC2

Diagnostics Section



RF Photoinjector

Dog Leg

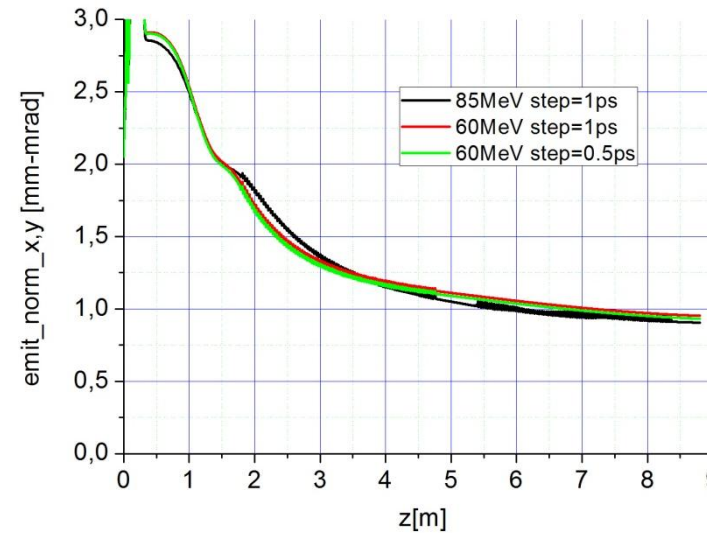
Interaction Point

Dump

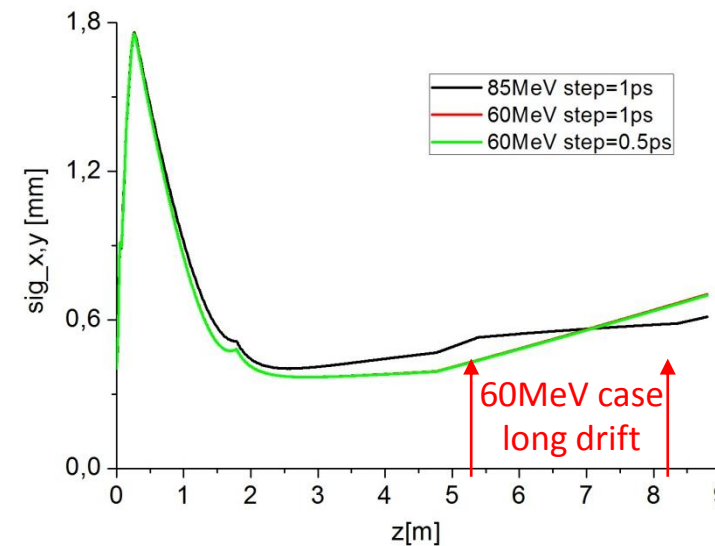
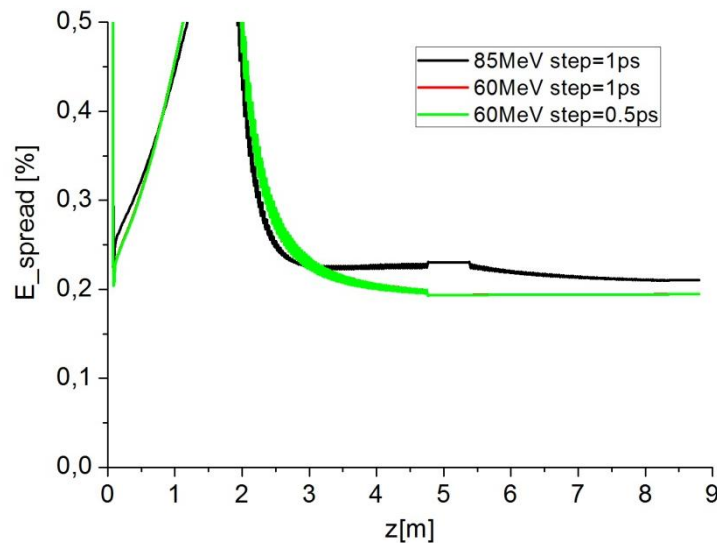
Injector Optimization (1-8.8m) for the two new referece cases: 85MeV and 60MeV

85 MeV – two S-band TW SLAC cavities
Sig_t=3.7ps (gauss pulse)
Sig_x=320 micron
Charge=0.5 nC

60 MeV – one S-band TW SLAC cavity
Sig_t=3.4ps (gauss pulse)
Sig_x=340 micron
Charge=0.5 nC

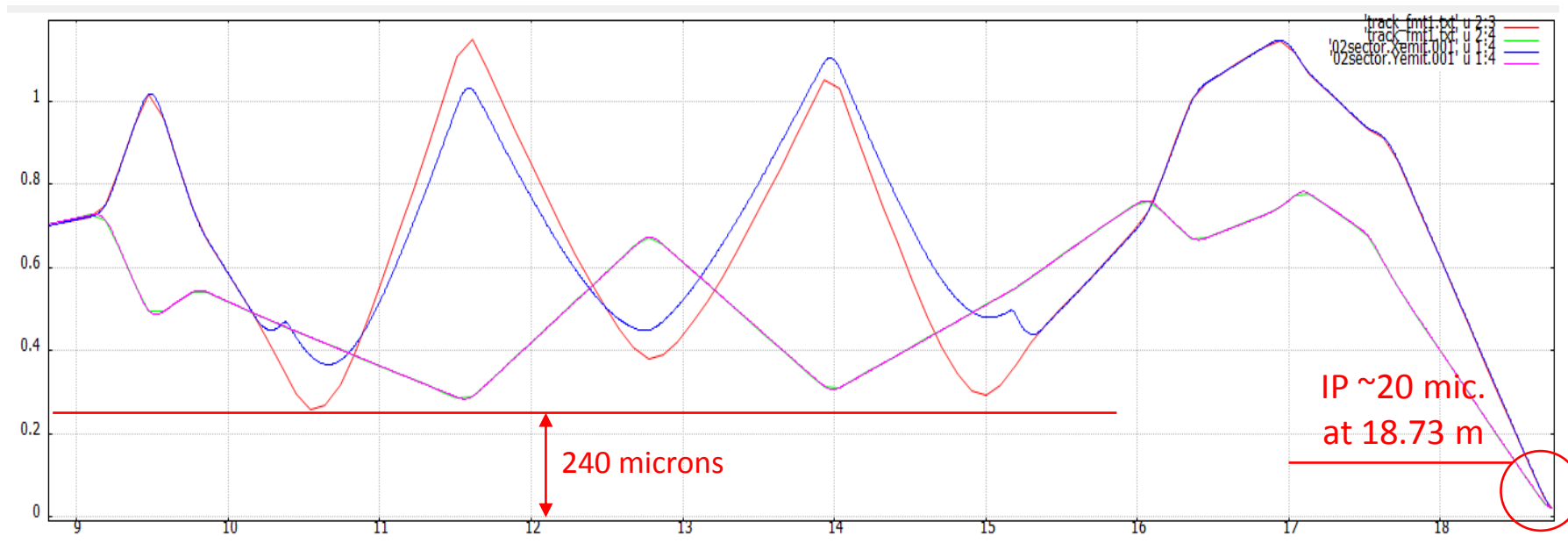


5000mp Astra simulations

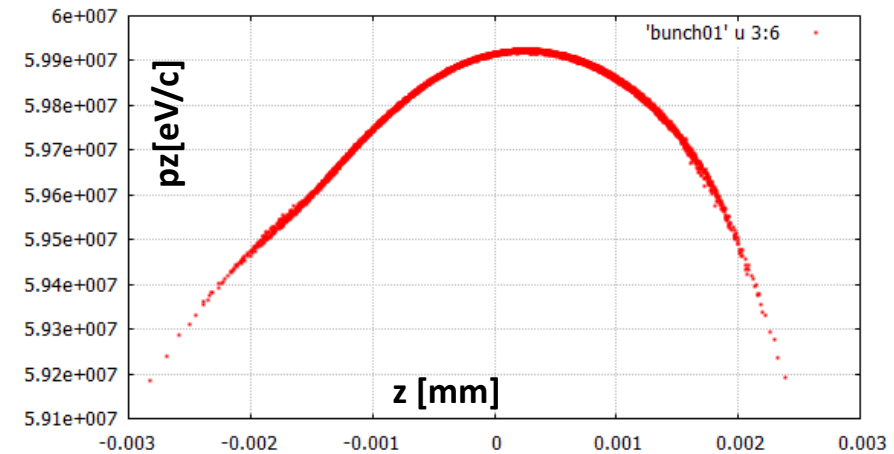
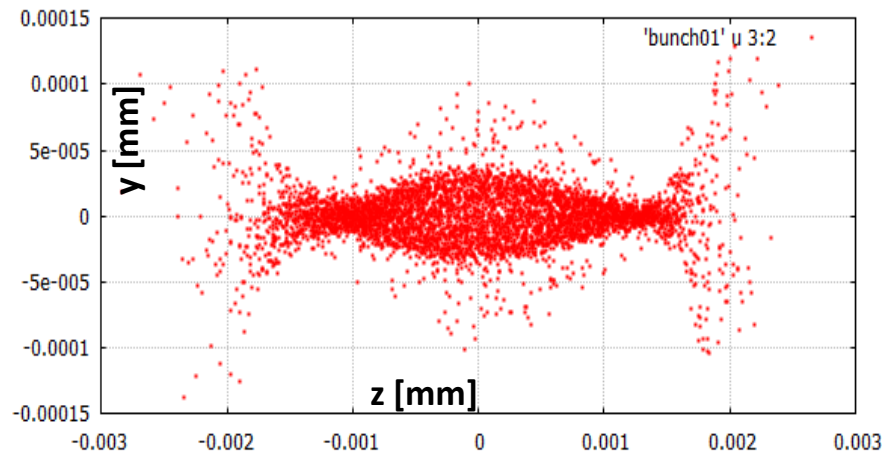
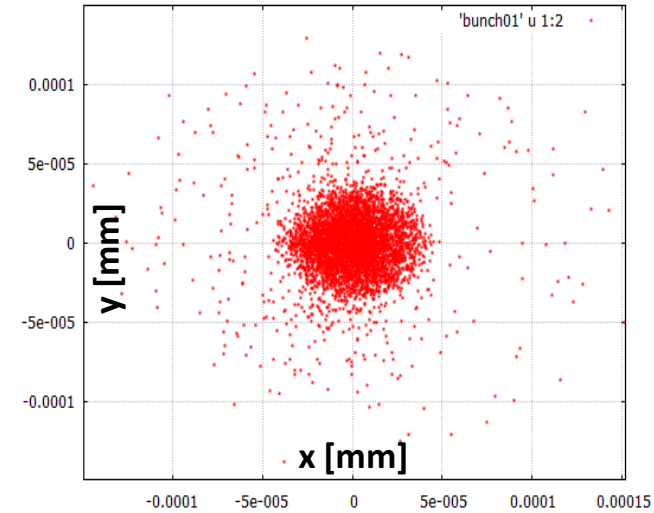
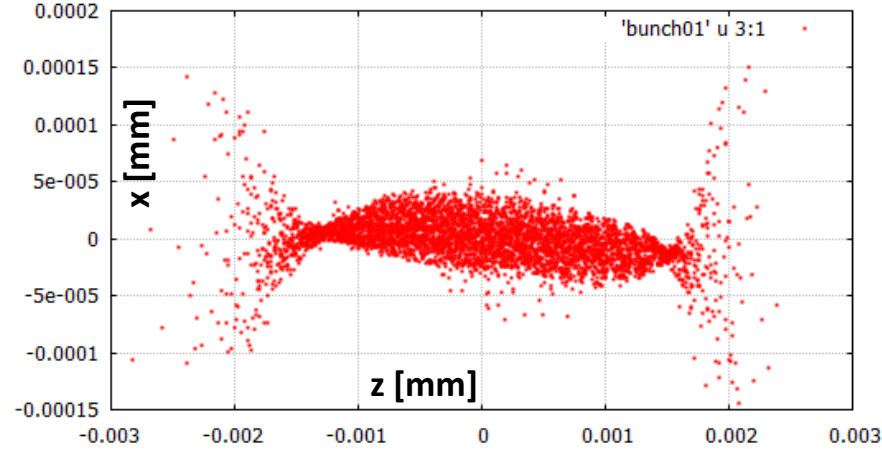


Dog Leg

Astra sc-on:
comparison between envelope computed by Astra and my post-processor with beam rotation



60MeV at IP (18.736m)



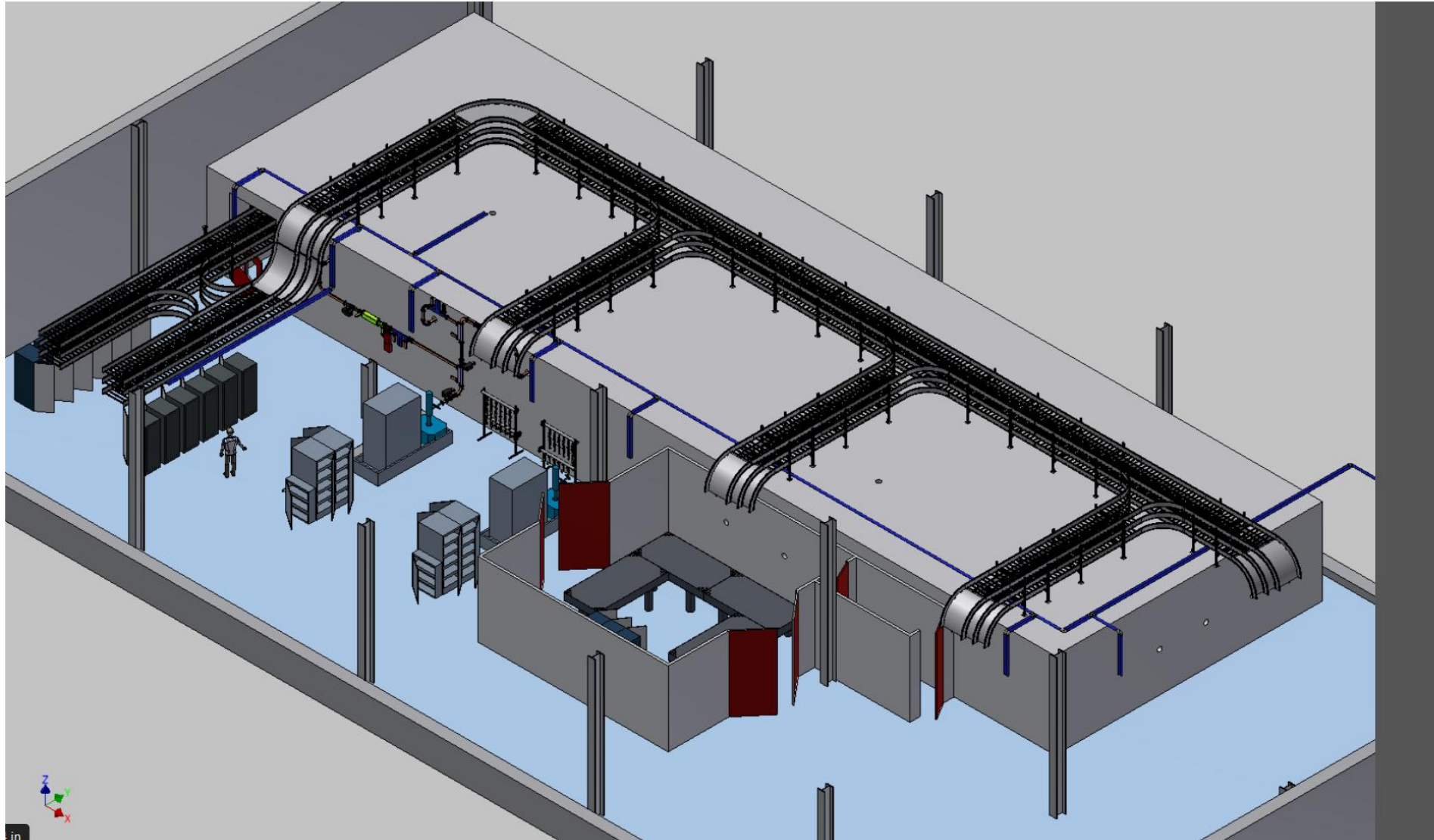
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n_partic sigpz/pz_med[%] sigg/g_med[%] pz_med[eV/c] x_max[mm] sig_x[mm] sig_y[mm] emit_x[mm*mrاد] emit_y[mm*mrاد] I_med[A] sig_z[mm]
5000(100%) 0.1953E+00 0.1954E+00 0.5982E+08 0.1508E+00 0.2175E-01 0.2248E-01 0.2143E+01 0.1419E+01 0.4598E+02 0.9405E+00

bunch average reference values: x_med[m]=-1.005862060310392E-015 y_med[m]=1.261232058461653E-022 p_med[eV/c]= 59816620.7754280
beam energy= 59.3077996904716
unorm. emit_x,y= 1.830771316194258E-002 , 1.212449323230308E-002
z_emit[deg-keV]= 354.408756902291
Courant-Snyder parameters:
beta_x,y [mm/mrad]= 2.584983162844841E-002 , 4.168309213526192E-002
alfa_x,y = 4.073654413237204E-002 , 3.367938163285845E-002
gamma_x = 38.7491679027223
beta_z = 2.935487766803476E-002 [deg/KeV]
alfa_z = -0.361049422291223

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STAR Hangar/Bunker Layout

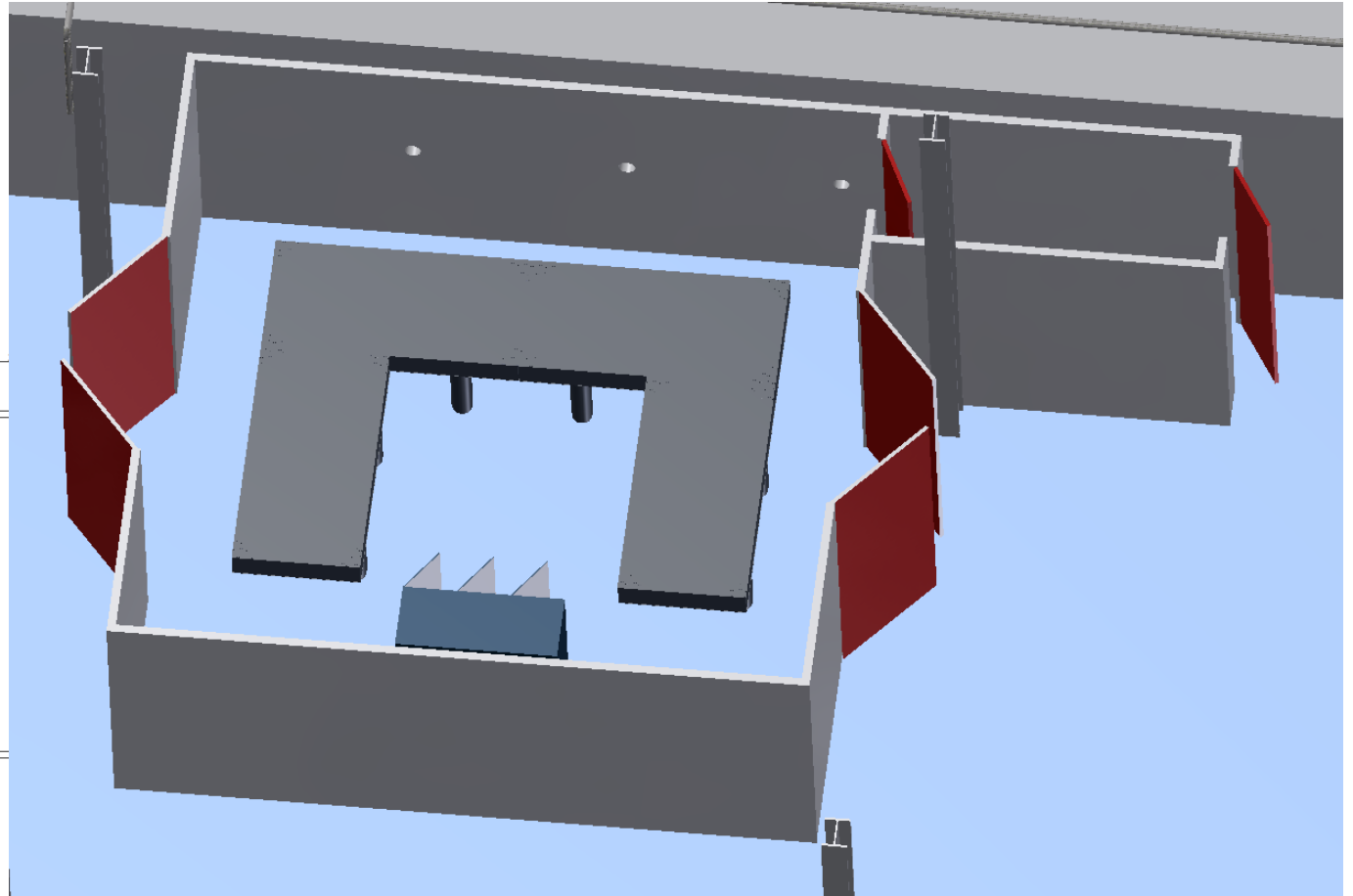
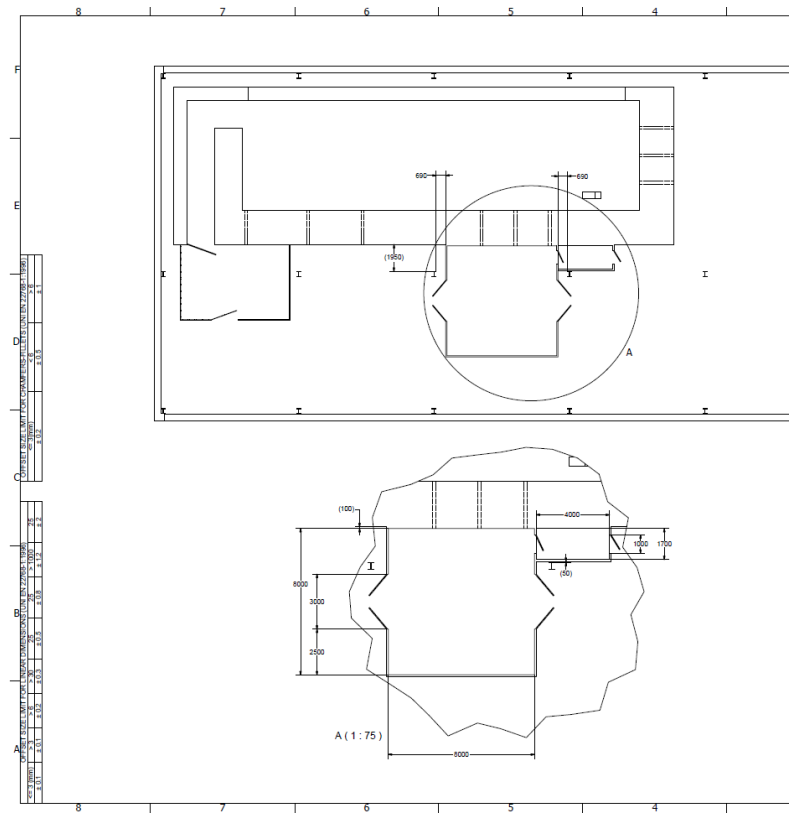


Laser System: IP and PC

Parameter	Interaction Laser	Photo-cathode Laser
Repetition rate (Hz)	100	100
Output Energy (mJ)	> 130 mJ (IR)	> 300 μ J (UV)
Short Term Energy Stability (rms)	3 %	1 %
Long Term Energy Stability (P2P)	< 5 %	< 2 %
Wavelength (nm)	1000 < λ < 1050	λ < 263
Jitter (rms) 10 – 10 KHz	< 1 ps	< 1 ps
Bandwidth	< 0.5 nm	< 1 nm
Pulse duration (ps FWHM)	5	5
Strehl Ratio	0.8	NA
M ²	NA	1.3

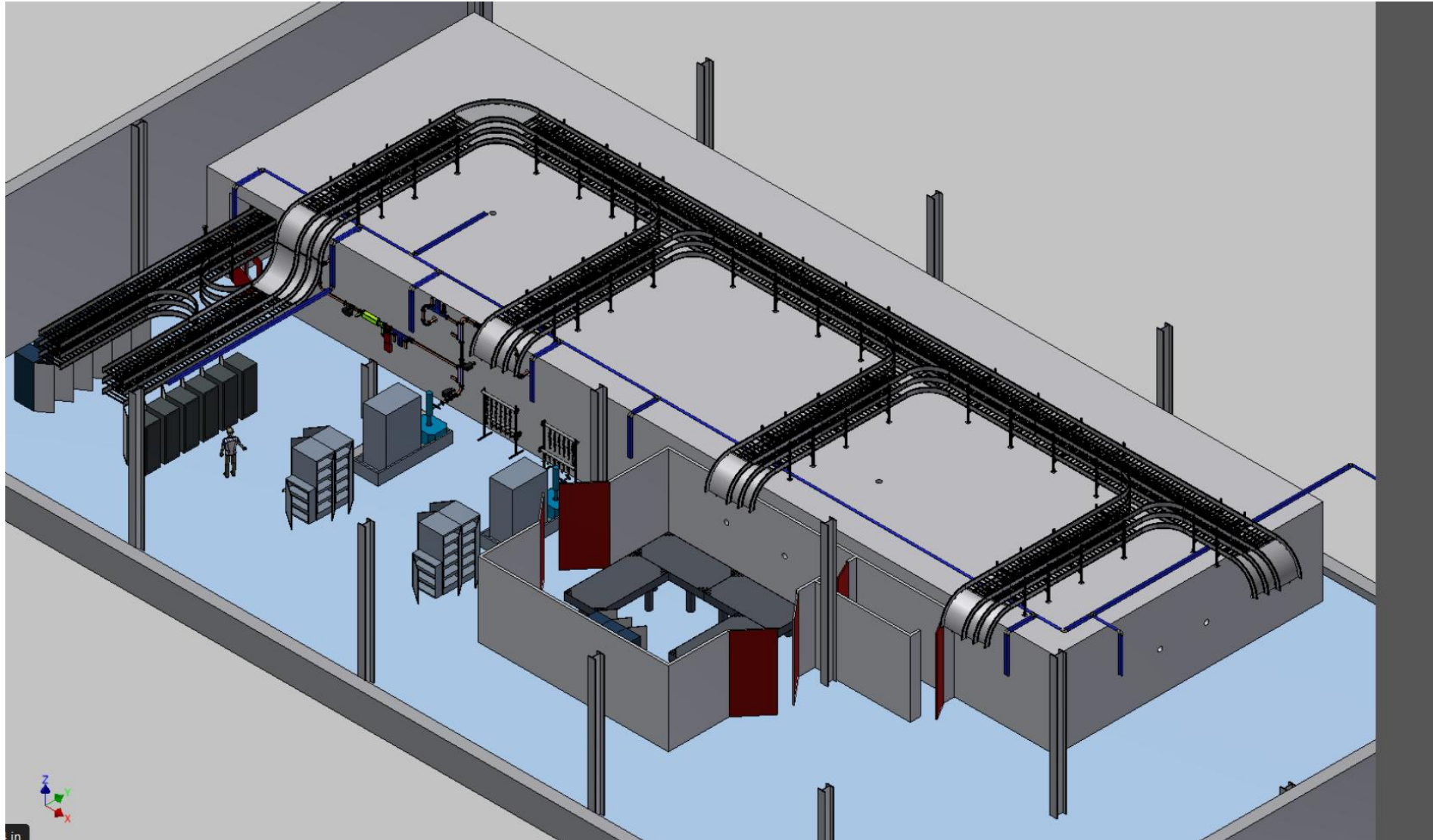
Laser Room

- 1) $20^{\circ}\text{C} \pm 0,5^{\circ}\text{C}$
- 2) 50% RH
- 3) Faraday Shield



PROJECT	STAR	ASSEMBLY	STAR-01-00	SUB-ASSEMBLY	
DATE		DATE		DATE	
DESIGNED		DATE		DATE	
CHECKED		DATE		DATE	
APPROVED		DATE		DATE	
RELEASED		DATE		DATE	
INFN - LNF National Institute of Nuclear Physics INFN - Laboratori Nazionali di Frascati GENERAL GENERAL DESCRIPTION STAR-LASER ROOM DIMENSION SCALE SCALE 1:100 DATE DATE 01/11/2000 REV REV 00					

STAR Hangar/Bunker Layout

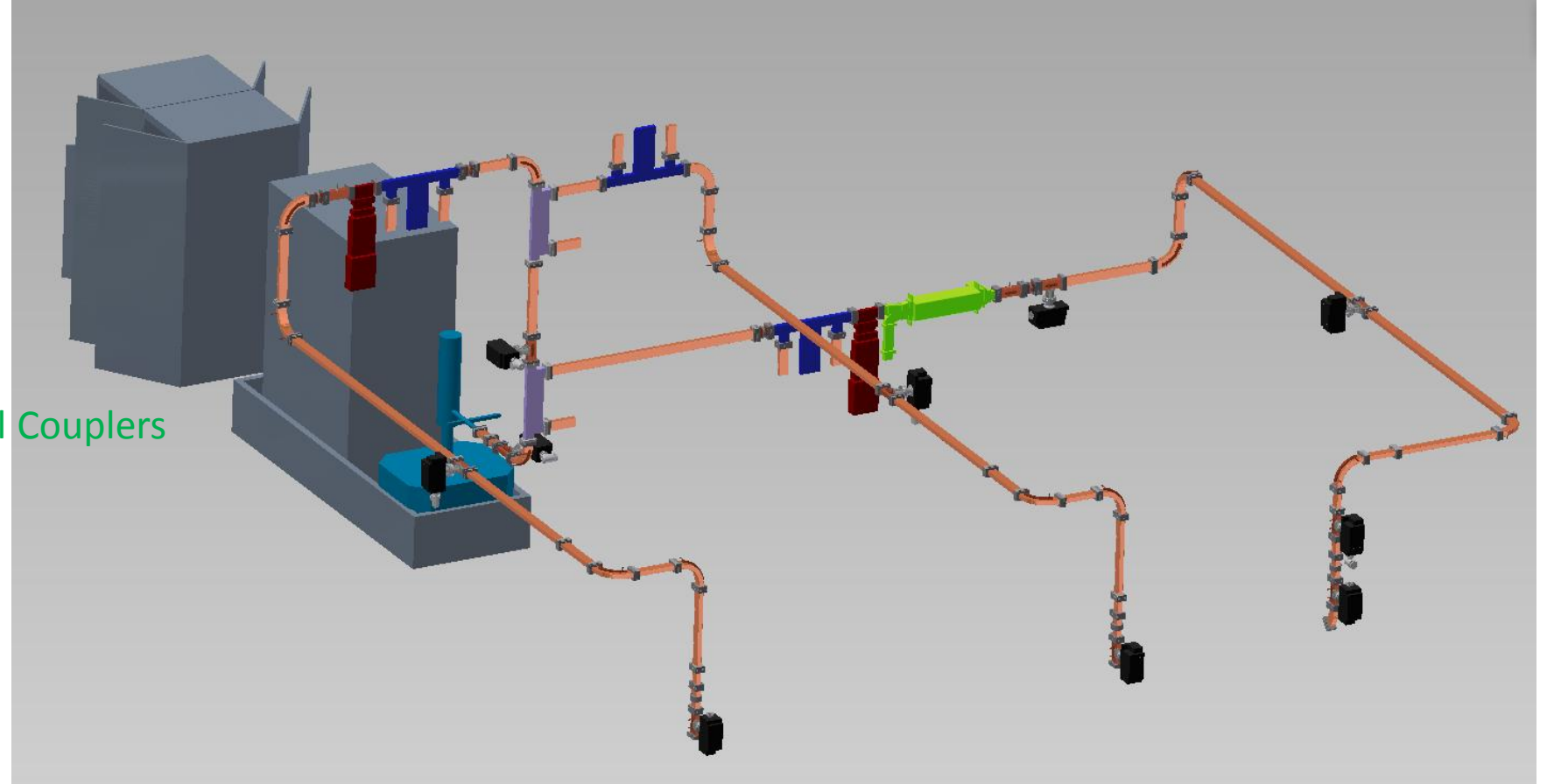


RF Waveguide Network Layout

RF Power Station

- Mode 1: 45 MW 4.5 μ s
- Mode 2: 55 MW 2.5 μ s
- 100 Hz

- Adapter
- E-Bends
- H-Bends
- RF Windows
- High Power Hybrid Directional Couplers
- Vacuum Pumping Stations
- Beta Hole Couplers
- SF6 Fill Stations
- HP Phase Shifters
- HP Attuneators
- RF Isolator/Circulator
- Straight Sections
- Loads

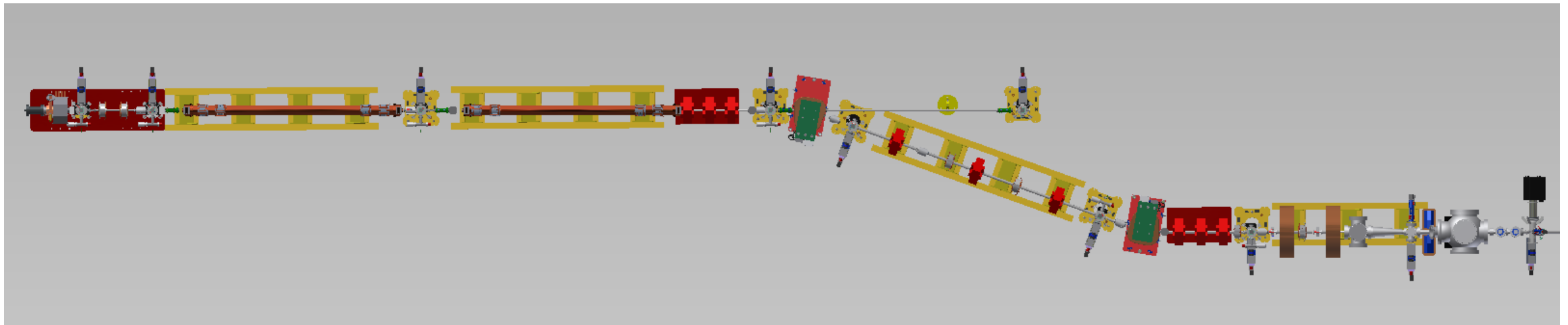


Vendors: AmpegCML, TSC, Ferrite

ACC1

ACC2

Diagnostics Section



RF Photoinjector

Dog Leg

Interaction Point

Photoinjector Layout

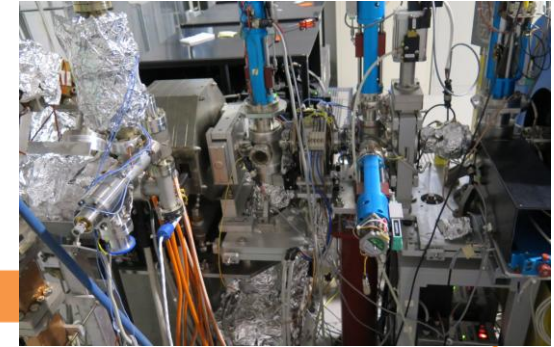
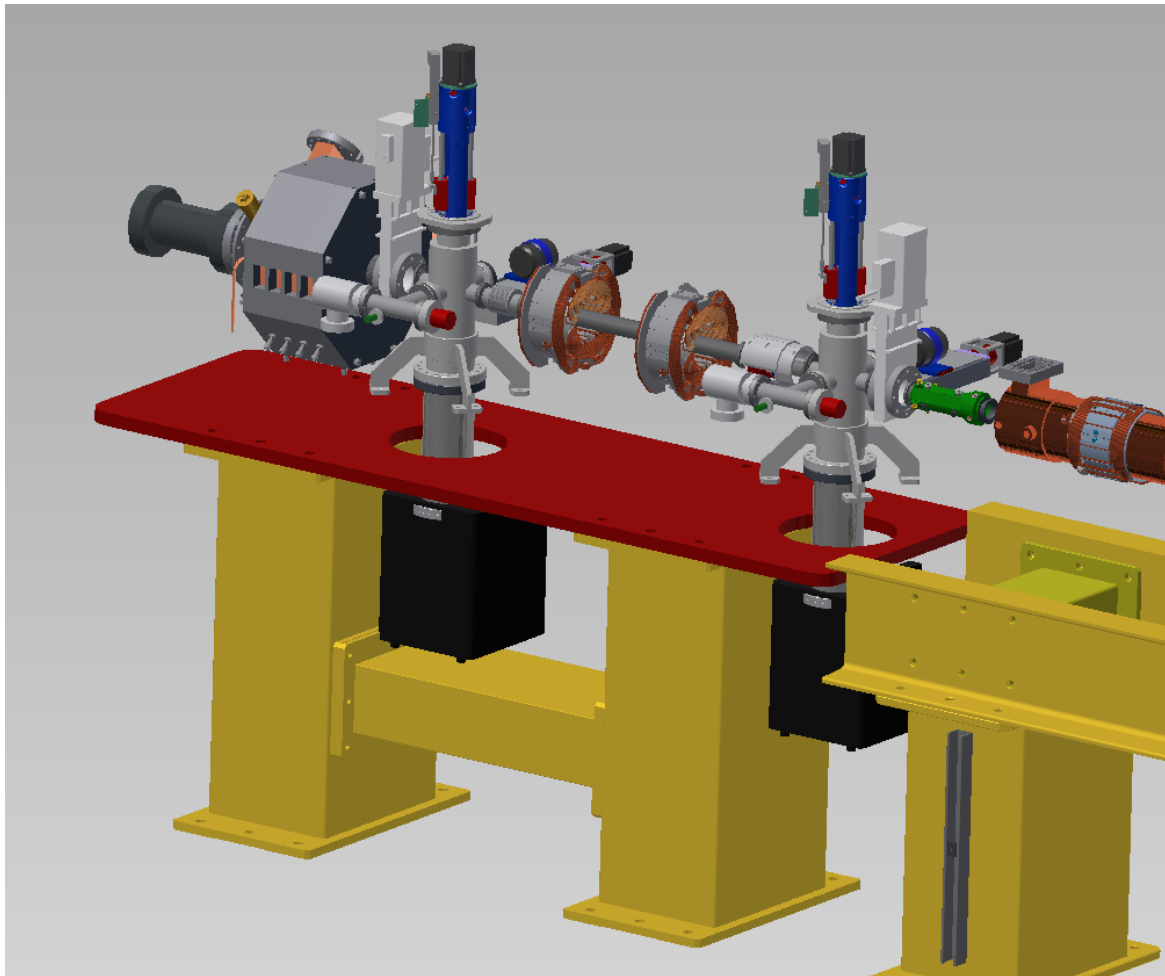
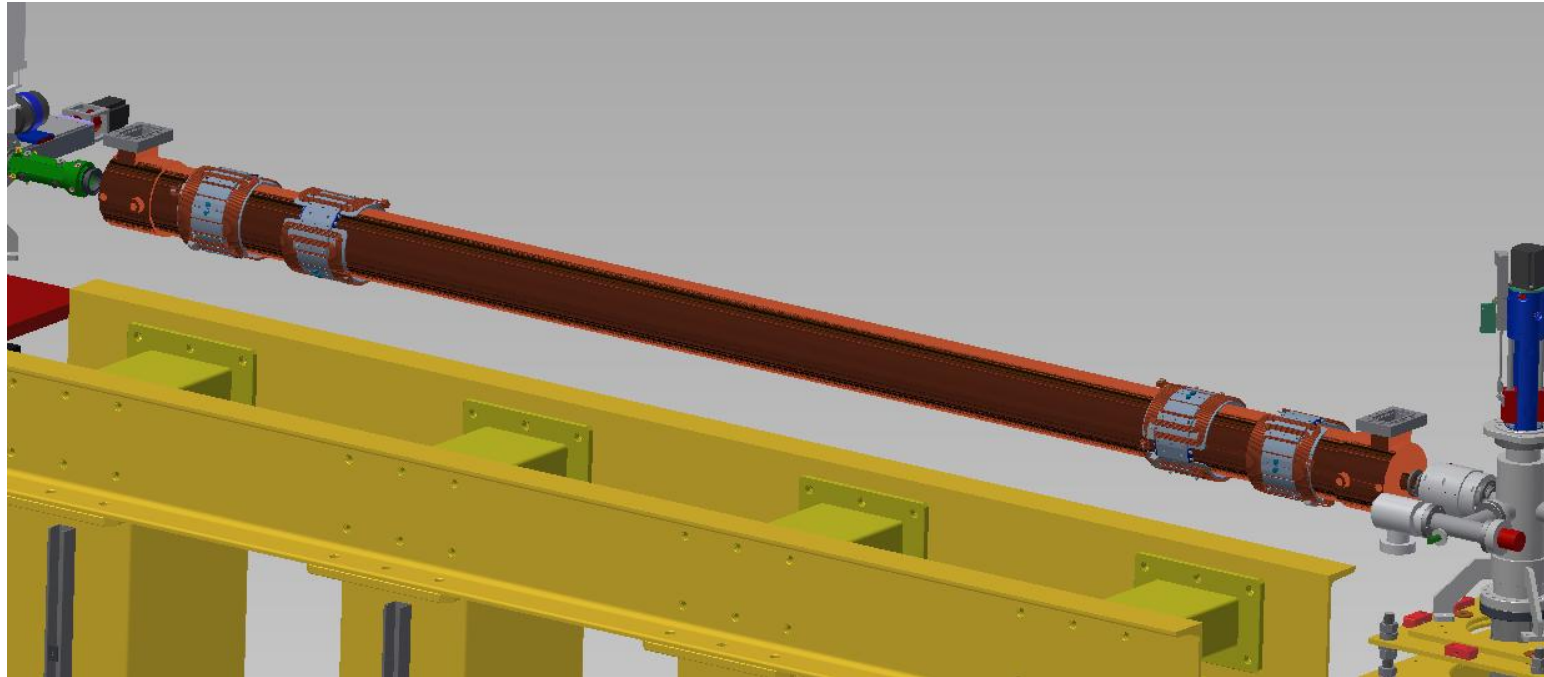


Table 1: Specifications of the RF Photoinjector System

Parameter	Value
Input power	9.5 MW
Output Energy	5 MeV
Operating Frequency	2.856 GHz
Normalized emittance*	≤ 1.0 micron at 500 pC
Repetition rate	Up to 100 Hz
Quality factor Q_0	13,800
Shunt impedance R'_{shunt}	60 M Ω /m
Peak surface field	102 MV/m
Peak cathode field	120 MV/m
External coupling factor (β)	2.0
Operating temperature	40° C
Materials	OFHC grade 1 copper, cross-forged 316L SST flanges, Aluminum stands
Magnetic permeability of flange material	< 1.05
RF flange type	LIL
Braze materials/steps	3-steps: 25/75, 35/65, 50/50 Au/Cu
Material certs	To be delivered to customer
Fasteners	All metric
Warranty	1 year from delivery

Vendor: RadiaBeam Europe

SLAC 3M Section

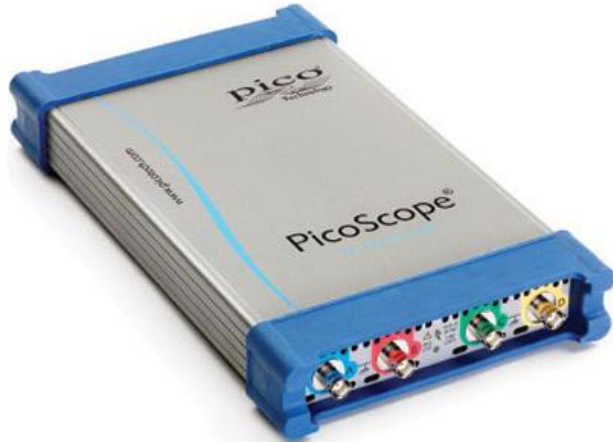


Main Specifications of the Accelerating Sections

Type	Constant-Gradient, Travelling-Wave
Structure	Disk-loaded
Mode	$2\pi/3$
Working Frequency	2856.00 MHz
Phase velocity	velocity of light in vacuum
Period	3.499 cm
Number of cavities	86 (including in/out couplers)
Attenuation constant	0.57 neper
Normalized group velocity (v_g/c)	0.0202 to 0.0065
Shunt impedance	53 to 60 M Ω /m
Input RF pulse length	2.5 μ sec
Max RF pulse frequency	100 Hz
Average accelerating electric field	> 25 MV/m
Input VSWR	≤ 1.1
Q of the structure	> 13,000
Phase error	$\Sigma \theta_i < \pm 2$ deg
Operating temperature	35°C $\pm$ 0.05°C
Max vacuum leak rate	< 2×10^{-10} mbar x liters x sec ⁻¹
Operating internal pressure	< 10^{-8} mbar
Accelerating structure body material	OFHC-Cu (> Cu 99.99% ASTM F68 class1)
RF flanges	LIL
Beam line flanges	fast-demountable type (*)

Tender has started

Electron Beam Diagnostics: Beam Current Monitor



Beam Current Monitors (BCM): Bergoz ICT

Beam Position Monitors (BPM): Strip Line and Cavity

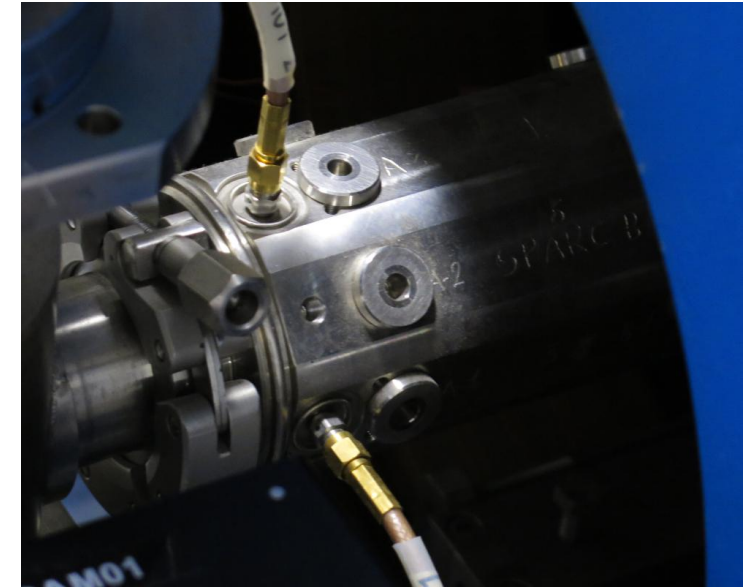
Beam Profile Monitors (BPM): CCD + YAG

Dipole Magnets: Energy + Energy Spread

Electron Beam Diagnostics: BPM Strip Line and Cavity



PSI

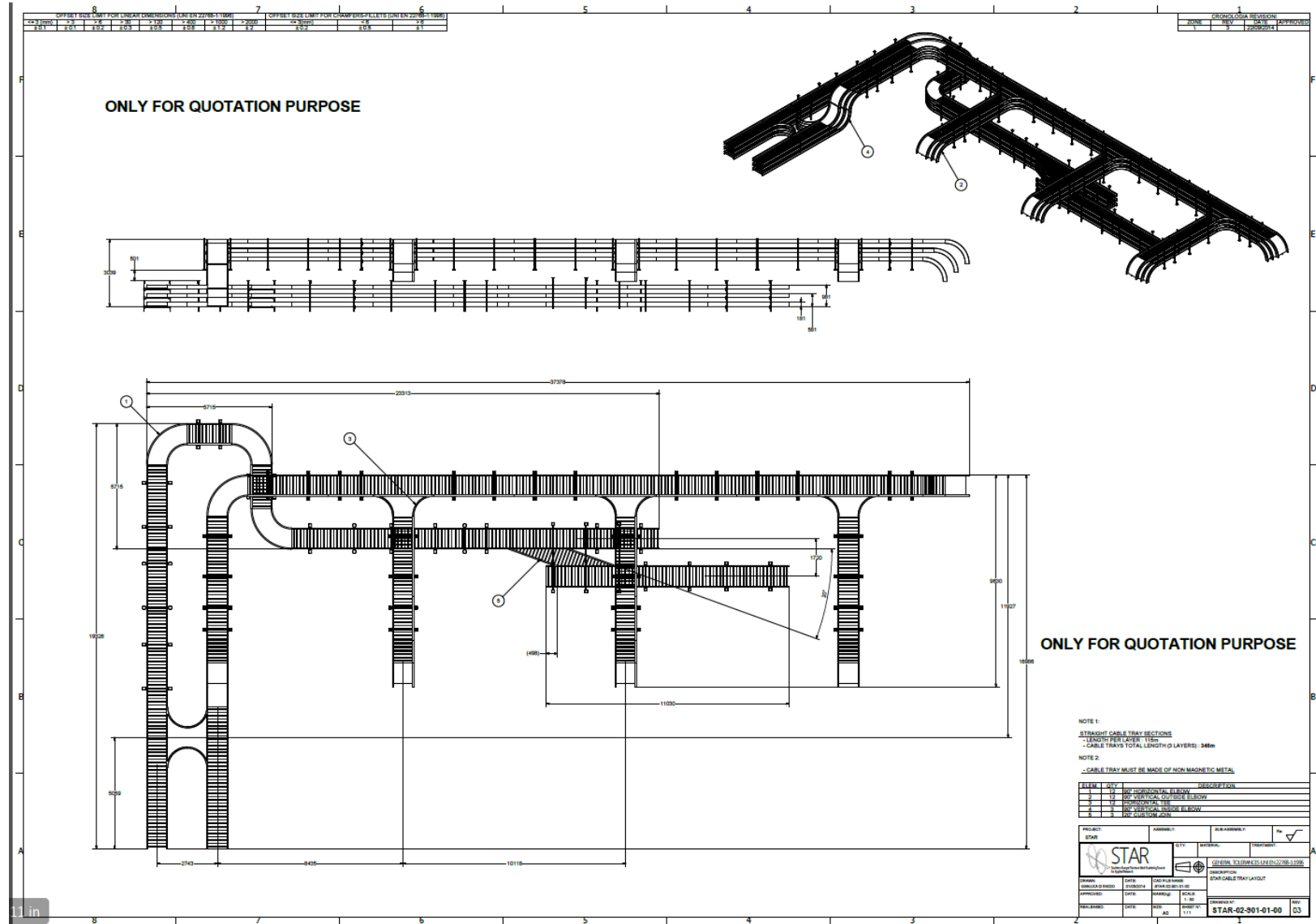


SPARC LAB

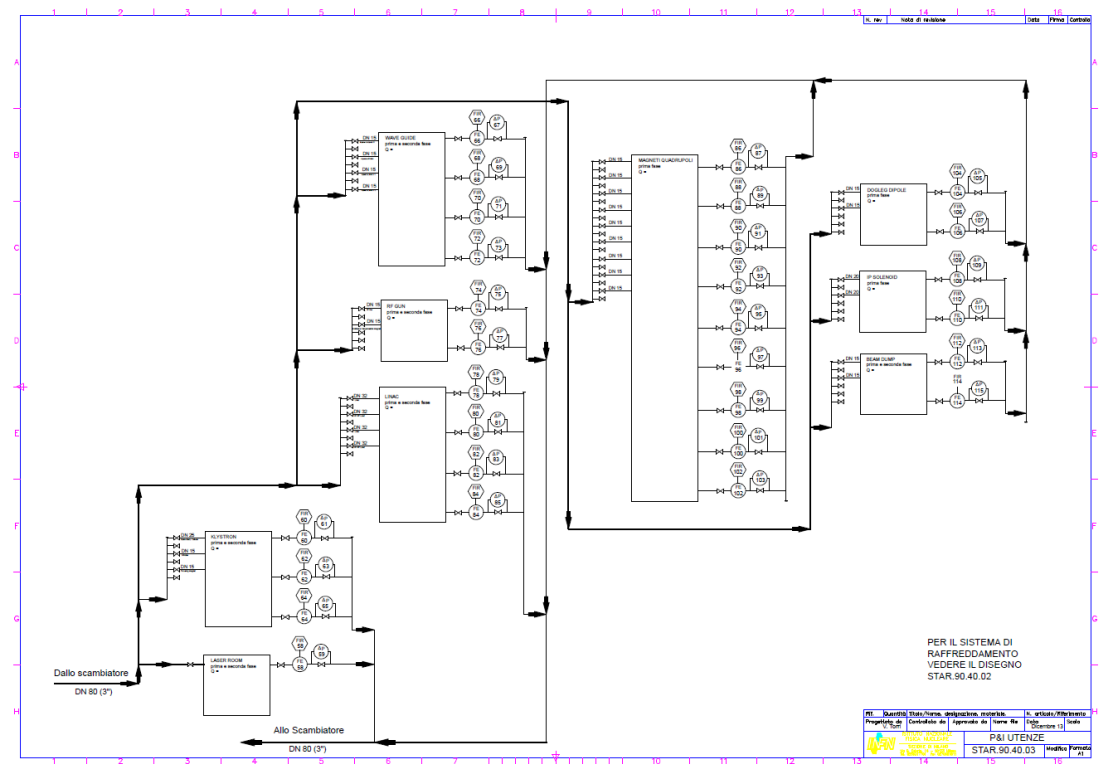
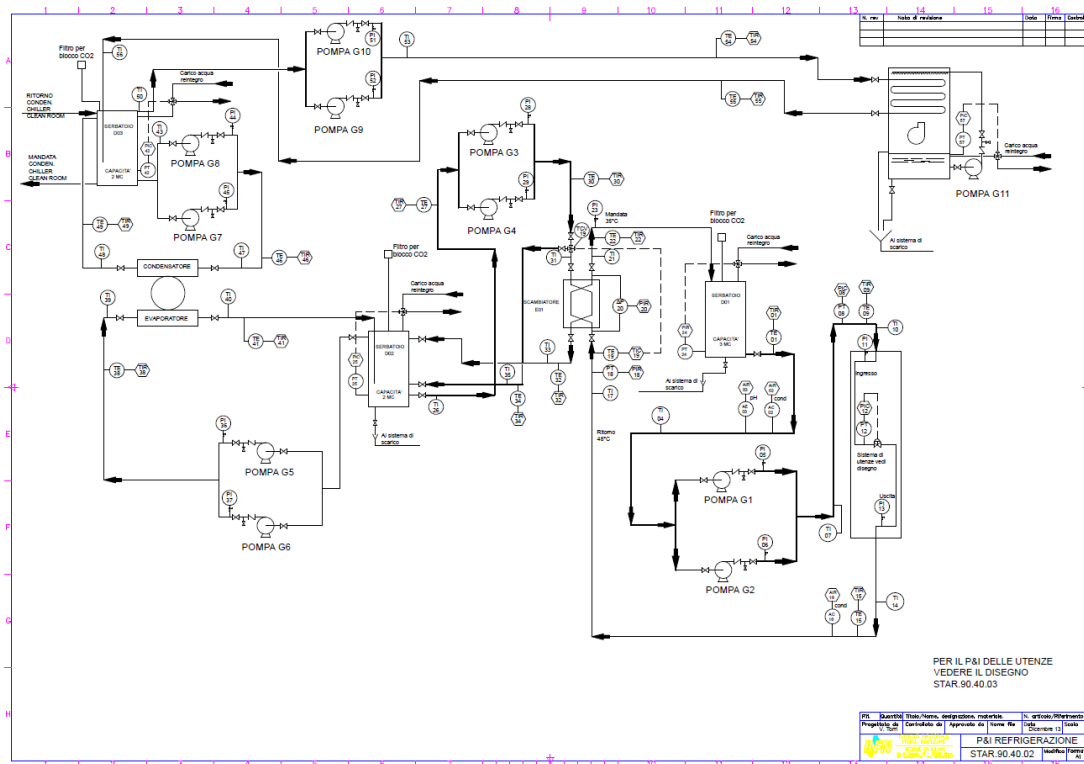


CONVENTIONAL FACILITY

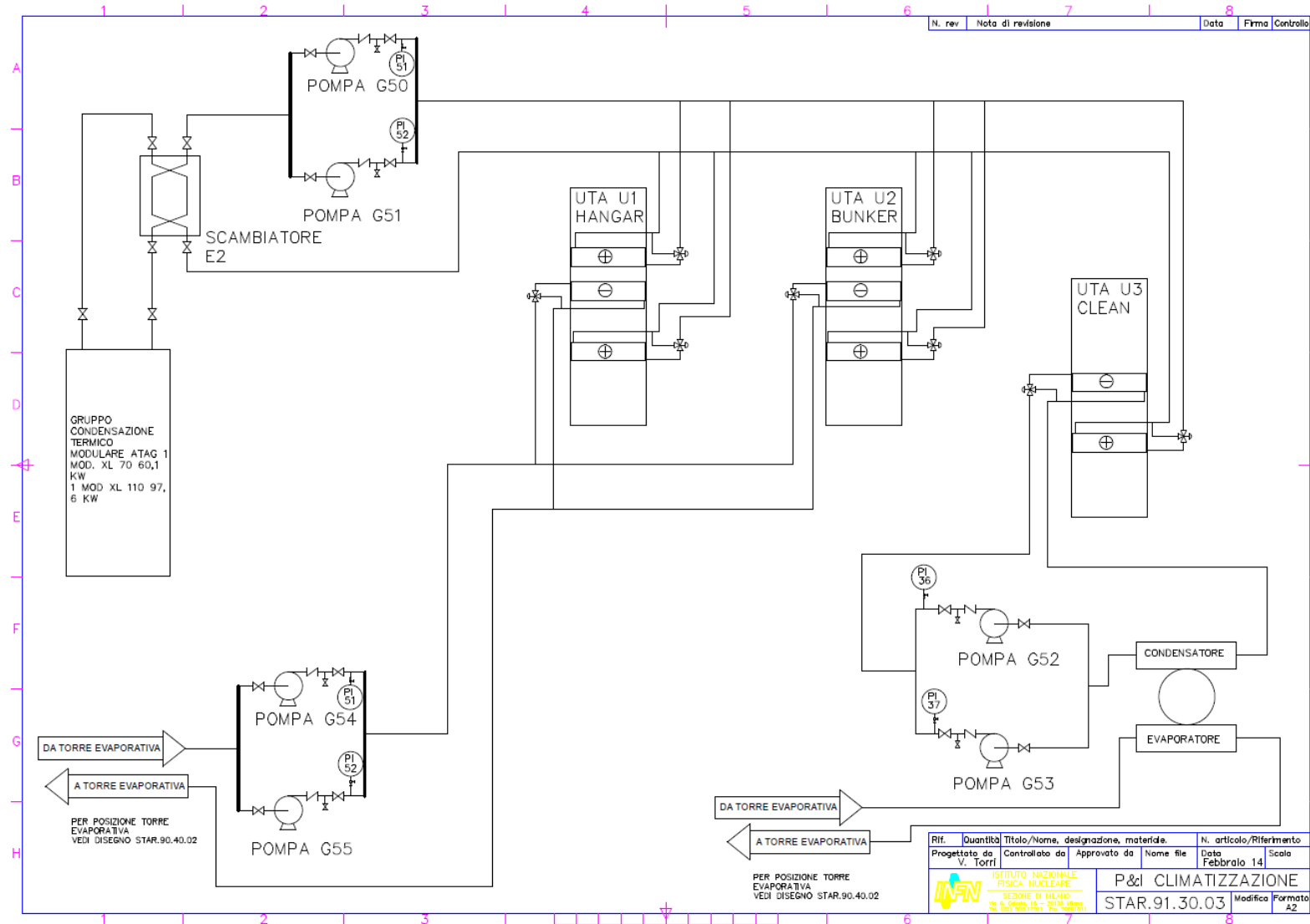
Cable Trays



DI Water System



AC Temperature Control System



MANPOWER REQUIREMENTS FOR OPERATIONS

Role	#
Accelerator Physicist	1
Electrical Engineer	1
Mechanical Engineer	1
Laser Physicist	1
Technician/Operators	3
Control System Engineer	1
Operations Manager	1

Machine COST

RF Power Station	1043700,00
Waveguide	396533,74
RF Structures	565750,94
Vacuum	326990,00
Diagnostics	545200,00
Stands	31815,00
Magnets and Power	
Supplies	698500,00
Laser	1868760,00
Laser Transport System	
PC	69924,60
IP	82568,89
Control System Software and Implementation	100000,00

STAR COST	5729743,17
VAT 22%	1260543,50
Total	6990286,67

Facility Cost not included in the Machine Cost

Equipment Racks	
Cable TRAYS/SUPPORTS/	
DI Water Cooling	€ 408.000,00
Water Treatment	€ 117.200,00
Ventilation	€ 263.275,00
Laser Room	€ 300.661,00
Control Room Hardware (100 k€)	
PPS (Personal Safety System)	
RF/ELECTRONIC LAB	
VACUUM LAB	
Machine Shop	
PART/STOCK ROOM	
Experimental Hutch	