INFN Istituto Nazionale di Fisica Nucleare

Università degli Studi di Roma Tor Vergata

SuperB

CABIBBO LAB

Laboratorio Nicola Cabibbo

Accelerator status

M. Biagini, LNF

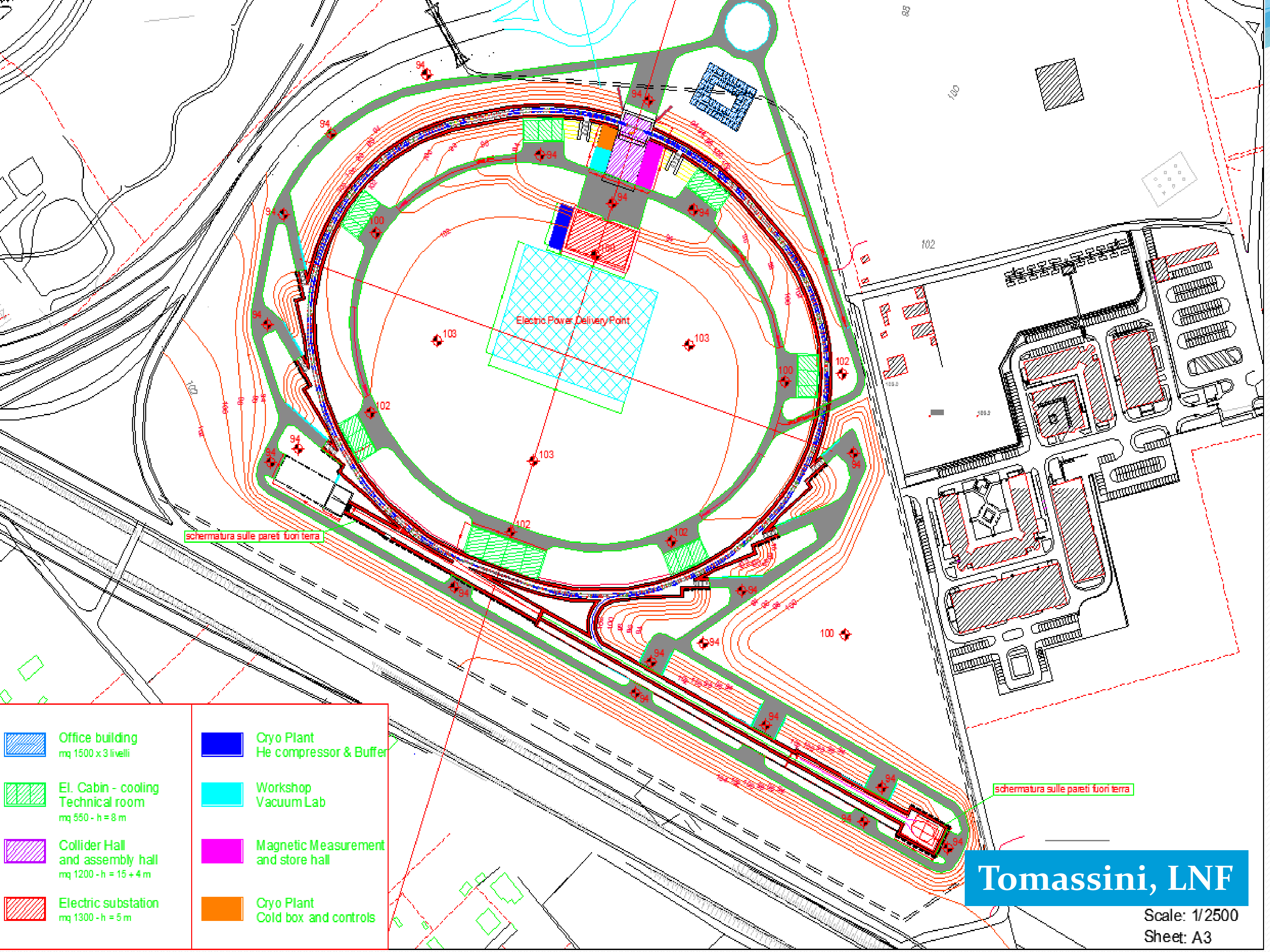
IV SuperB Meeting, Elba, June 4th 2012

Since last meeting…

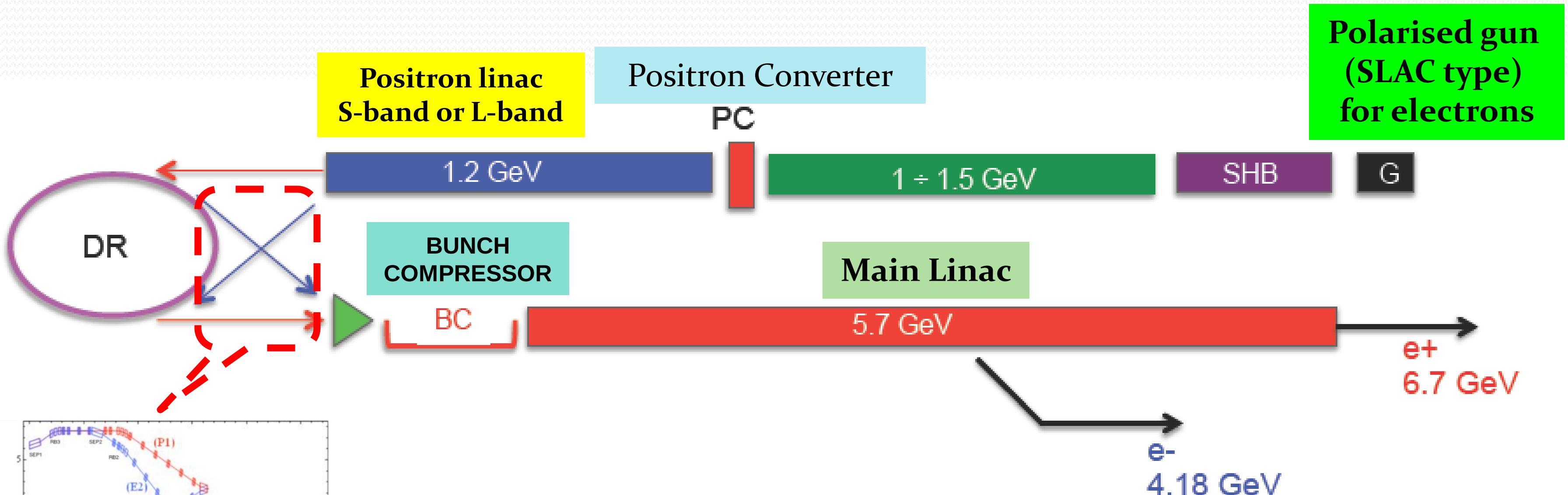
- Two «management» meetings (2-3 April, 16 May) for definition of Work Breakdown Structure (WBS), work organization, cost estimate, collaboration with JAI (Oxford)
- Studies on FEL option with SuperB Linac (see next talk)
- Cost estimate task force:
  - Produce a cost estimate for the baseline design by end of June
  - Leaders of some sub-systems have not yet been identified → educated guess
  - Very fast response and coordination, help from INFN-LNS

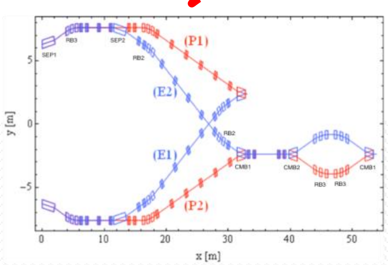
and…

- Layout of accelerator complex on Tor Vergata site
- Start-to-end simulation of beam from DR to end of Linac
- New tests on clearing electrodes
- Test of 14-bit bunch-by-bunch feedback at DAΦNE
- Mechanical layout of DR and MR elements
- MOU with John Adams Institute (Oxford) prepared for Final Focus work
- Published 18 job offers for CabibboLab → deadline June 6^{th}


Electric Power Delivery Point
schermatura sulle pareti fuori terra
schermatura sulle pareti fuori terra
Office building
mq 1500 x 3 livelli
El. Cabin - cooling
Technical room
mq 550 - h = 8 m
Collider Hall
and assembly hall
mq 1200 - h = 15 + 4 m
Electric substation
mq 1300 - h = 5 m
Cryo Plant
He compressor & Buffer
Workshop
Vacuum Lab
Magnetic Measurement
and store hall
Cryo Plant
Cold box and controls
Tomassini, LNF
Scale: 1/2500
Sheet: A3

New injection system layout





Transfer lines
Positron Source to Damping Ring (PSDR)
Damping Ring to Main Linac (PDRL)
Electron Source to Damping Ring (ESDR)
Damping Ring to Main Linac (EDRL)
Main Linac to HER (PLMR)
Main Linac to LER (ELMR)

Recent progresses:

- **Final design with DR for electrons too**
- **Start-to-end simulation**
- **Design of PSDR, ESDR and bunch compressor**
- **Options for e+ Linac still open (S-band or L-band)**
- **Design of Main Linac**
- **PLMR and ELMR to be modified**

Damping Ring specifications

TABLE 1 – Magnet system parameters

	Units	Value
Number of dipoles (rectangular)		16
Dipole length	m	0.75
Dipole field	T	1.745
Number of quadrupoles		50
Quadrupole length	m	0.3
Maximum gradient	T/m	23.3
Number of independent power supplies		8
Number of sextupoles		24
Maximum integrated gradient $\partial^2B/\partial x^2$	T/m	19.0
Number of independent power supplies		2

TABLE 2 – Vacuum system parameters

	Units	Value
Maximum Energy	GeV	1.2
Maximum beam current	mA	10
Circumference	m	67
Dipole field	T	1.745
Beam stay clear radius	cm	3
Operating pressure	nTorr	1

Guiducci, LNF

DR Transfer Lines specifications

Table 1 - Dipole Magnets for all lines E2, E1, P2, P1						
name	**N**	**l (m)**	**angle (rad)**	**B (T)**	**bsc H (mm)**	**bsc V (mm)**
Septum magnet	4	2.00	0.3366	0.5610	25	10
Rectangular bending RB3	8	1.35	0.3366	-0.8311	35	10
Rectangular bending RB2	4	1.35	0.2244	0.5541	25	10
Combiner magnet	4	1.35	0.3366	-0.8311	25	10

Table 2 - Quadrupole Magnets for all lines E2, E1, P2, P1				
Number of quadrupoles	44			
Quadrupole length (m)	0.43			
Beam stay-clear radius (mm)	25			
Maximum gradient (T/m)	7.3	maximum value + 10%		
Minimum gradient (T/m)	0.2			
Max integrated gradient (T)	3.1	maximum value + 10%		
Min integrated gradient (T)	0.2			

Table 3 - Corrector dipoles for all lines E2, E1, P2, P1			
Number of orizontal correctors		0	
Number of vertical correctors		18	
Max angle of vertical correctors (mrad)		0.5	
Max vertical integrated field (Tm)		1.67E-03	
Beam stay-clear radius (mm)		25	

Linac specifications

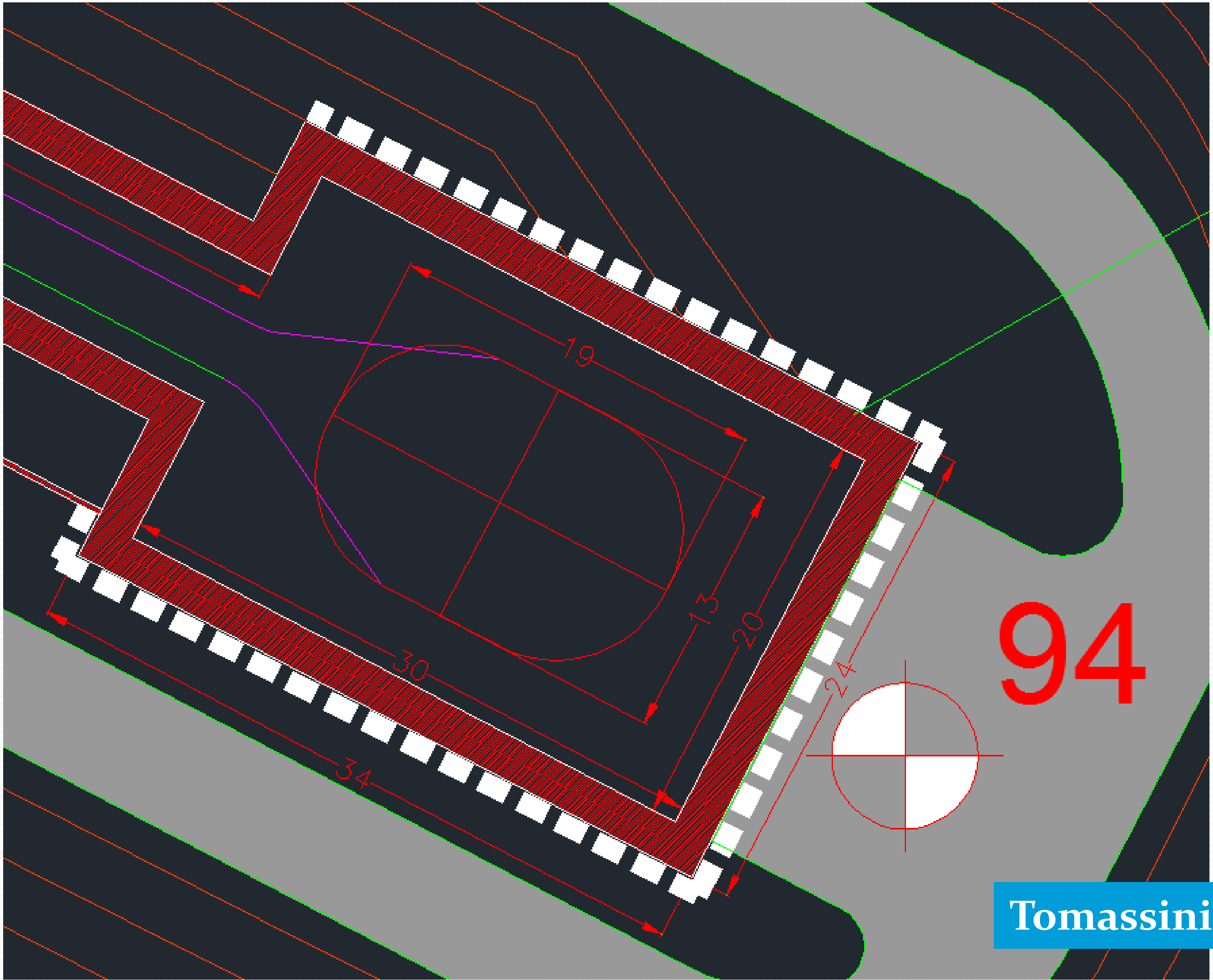
L1 from electron gun to positron production target, E= 1.5 GeV
L2 from positron target to damping ring, E= 1 GeV
L3 from damping ring up to E= 6.7 GeV.
All the linac, L1+L2+L3, is made of 120 S-band accelerating sections

Table 4 – Linac magnets

Quadrupoles	
Number of quadrupoles	60
Magnetic length (m)	0.086
Physical length (m)	0.102
Maximum gradient (T/m)	9
Aperture radius (mm)	25.5
Correctors	
Total number of correctors	120
Correctors at E≤1 GeV	36
Correctors at E>1 GeV	84
Maximum corrector angle (mrad)	0.5
Maximum corrector field integral at E≤1 GeV (Tm)	$1.1\ 10^{-2}$
Maximum corrector field integral at E>1 GeV (Tm)	$1.7\ 10^{-3}$
Aperture radius (mm)	25

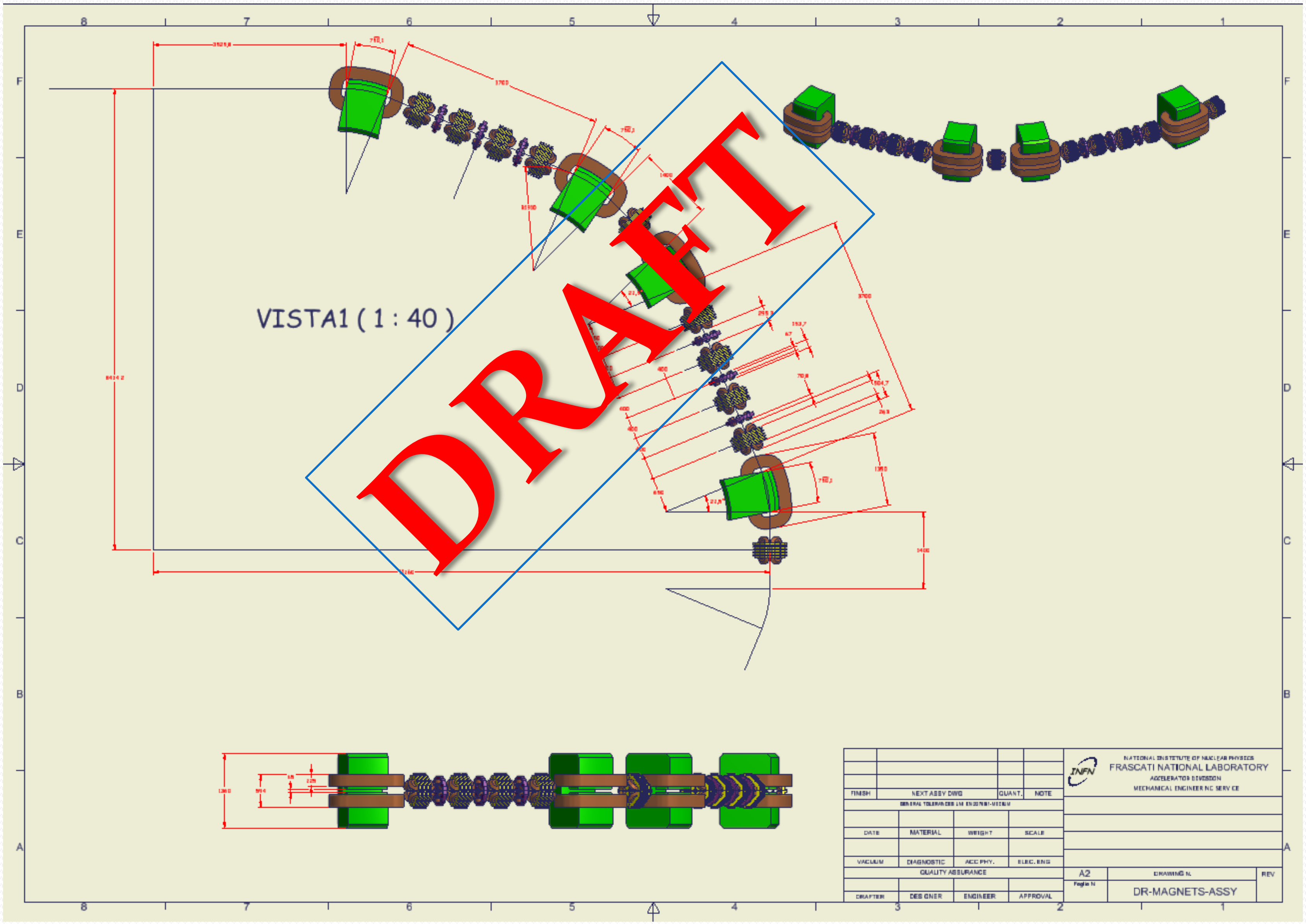
L2 has solenoids in the first ~4 sections and 2 quadrupoles/section in the following ~10 sections

DR hall

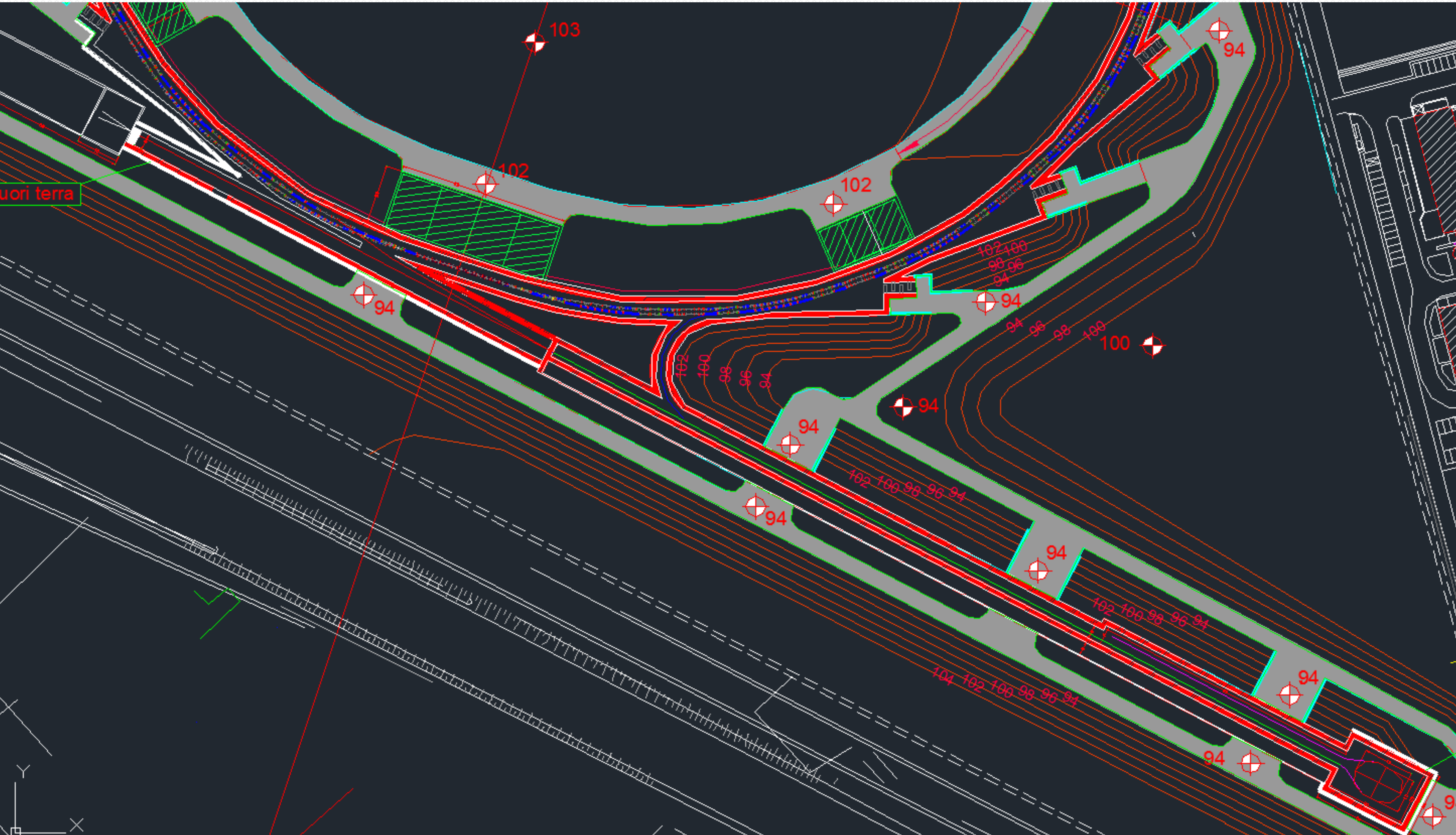


Tomassini, LNF

DR mechanical layout



MR injection



Cost estimate requirements

- Cost estimate is being done in a WBS, prepared by C. Sanelli
- Description of methodology required
- Definition of group structure and needed personnel, possibly with timeline, required
- Risk analisys required

- Some examples below (not showing costs)...

Magnets cost estimate

- Two independent first estimates by C. Sanelli and P. Fabbricatore (in fair agreement) since «Magnet» group leader has still to be appointed
- The «magnets commission» has studied the PEP-II available magnets, but potential savings are overcome by the cost of: substitution of Al coils, shipping & handling, QA and test
- List of MR, DR and TL magnets given to Power Supplies leader for cost estimate

Power supplies cost estimate

Total Converter and Power

Small Gap

	LER	HER
Bending	34	55
Power	1.401.300	1.668.370
Quadrupoles	362	353
Power	1.394.336	2.030.292
Sextupoles	102	104
Power	60.000	62.400
Correctors	300	300
Power	180.000	180.000
Total Power	3.035.636	3.941.062

Large Gap

	LER	HER
Bending	34	55
Power	2.244.000	2.805.120
Quadrupoles	362	353
Power	3.764.805	5.585.090
Sextupoles	102	104
Power	242.760	355.680
Correctors	300	300
Power	180.000	180.000
Total Power	6.431.565	8.925.890

Damping Ring	
Bending	4
Power	340.400
Quadrupoles	8
Power	164.000
Sextupoles	2
Power	11.500
Correctors	20
Power	21.600
Total Power	537.100

Total Converter	1644
Total Power (Small)	7.513.798
Total Power (Large)	15.894.557

Sedita, LNS

Cost estimate for power needs (1 example)

	Riepilogo apparecchiature cabine							
	Cabine MT/BT	Arrivi MT (IMS)	Partenze MT (Int)	Cong MT	Montanti TR 1,6 MVA	Partenze BT 400/630	Partenze BT 160/250	Rifasamento 600 kVA
1	RF-PS	4	20	2	4	25	10	2
2	ARC 1	2	3	0	3	16	10	1
3	ARC 2	2	3	0	3	16	10	1
4	ARC 3	2	3	0	3	16	10	1
5	ARC 4	2	3	0	3	16	10	1
6	ARC 5	2	3	0	3	16	10	1
7	ARC 6	2	3	0	3	16	10	1
8	LIN 1	2	4	0	4	20	15	4
9	LIN 2 (DR)	2	4	0	4	20	15	4
10	LIN (TL)	2	4	0	4	20	15	4
11	IR	2	2	0	2	10	10	1
12	Stazione e Crio (diretto da QMTG)	0	0	0	2	10	10	0
13	Building	2	2	0	2	15	10	2
	Tot apparecchiature per 13 cabine:	26	54	2	40	216	145	23

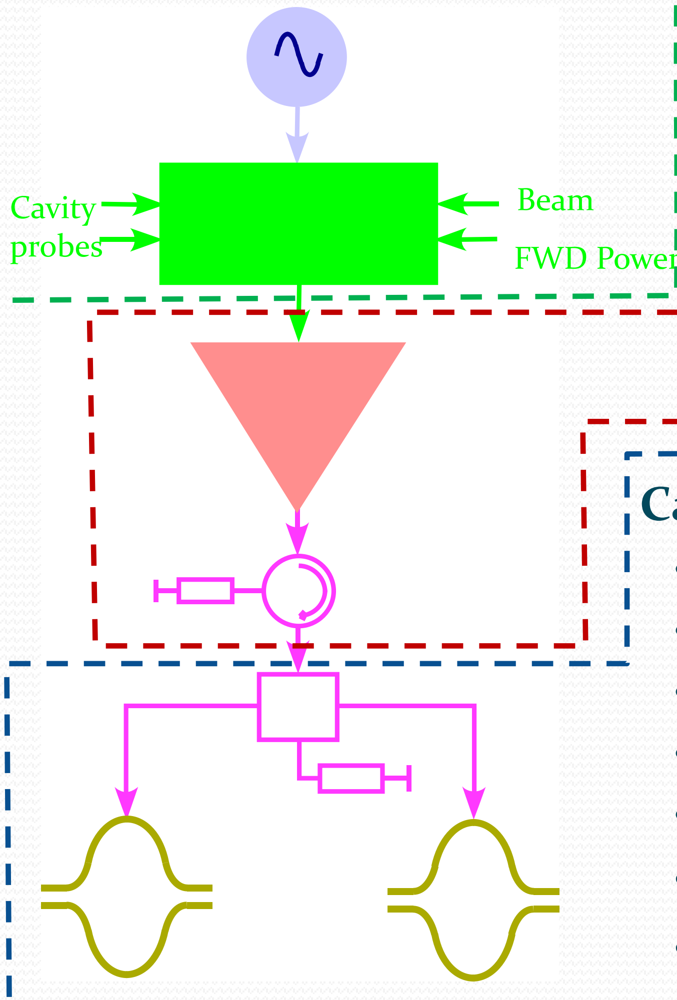
Ricci, LNF

RF cost estimate (PEP-II RF)

Basic breakdown structure of the RF system to be used for:
- Cost review (based on PEP-II RF system)
- Team organization and manpower effort estimate

LLRF + Interlock and PLC

- Amplitude and phase set of the accelerating fields
- Tuning control of the accelerating structures
- Beam loading compensation
- RF and beam feedback systems
- System Interlock and safety



RF Power Station

- Klystron
- Power supply
- RF driver
- Circulator
- Dummy load

Cavities and WG network

- Cavity body
- Input couplers
- Damping waveguides
- Tuners
- Vacuum
- Mechanics
- Cooling

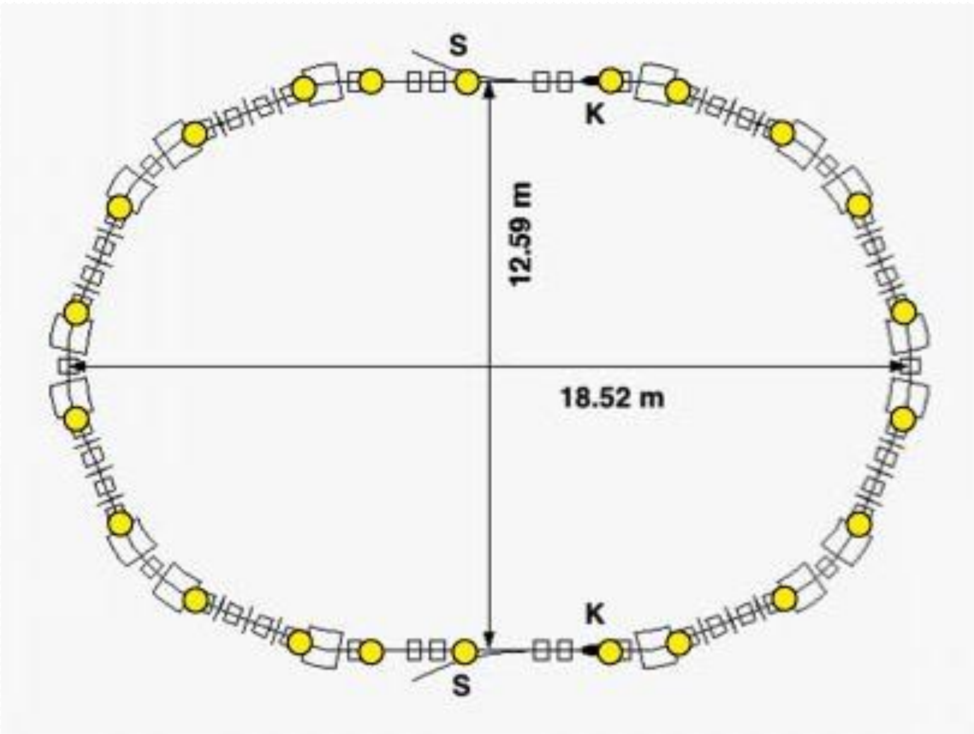
Gallo, LNF

Vacuum system

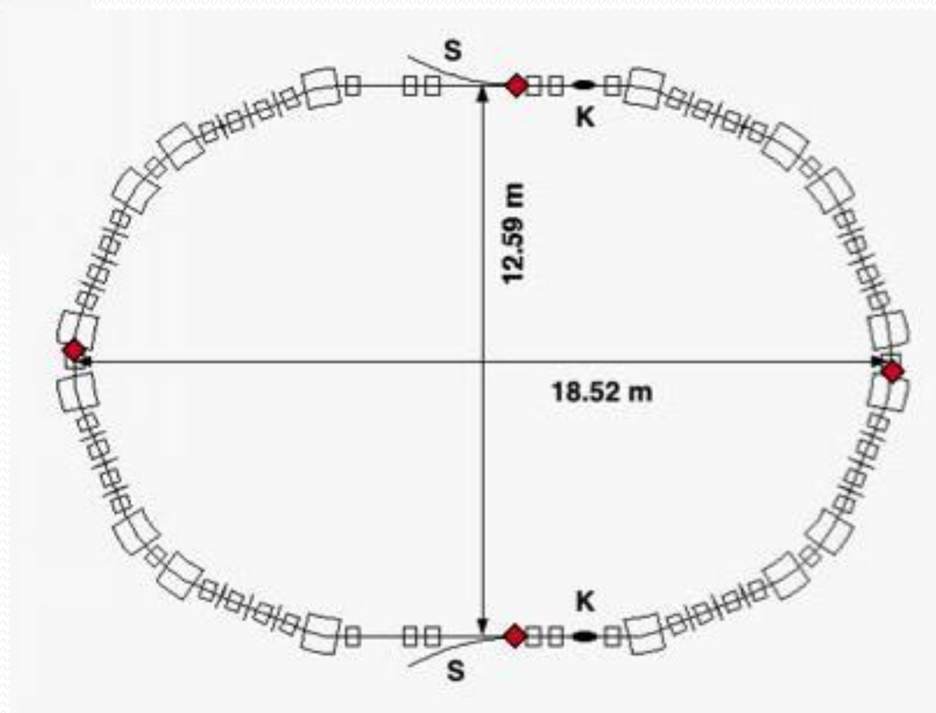
- Cost estimate ready for DR and Linac
- Waiting for definition of TL to the MR
- Discussion still open on MR beam pipe aperture → task force needed
- Needs interactions for definition of impedance budget (we are badly missing an impedance czar)

DR vacuum

Clozza, LNF



Ion Pumps



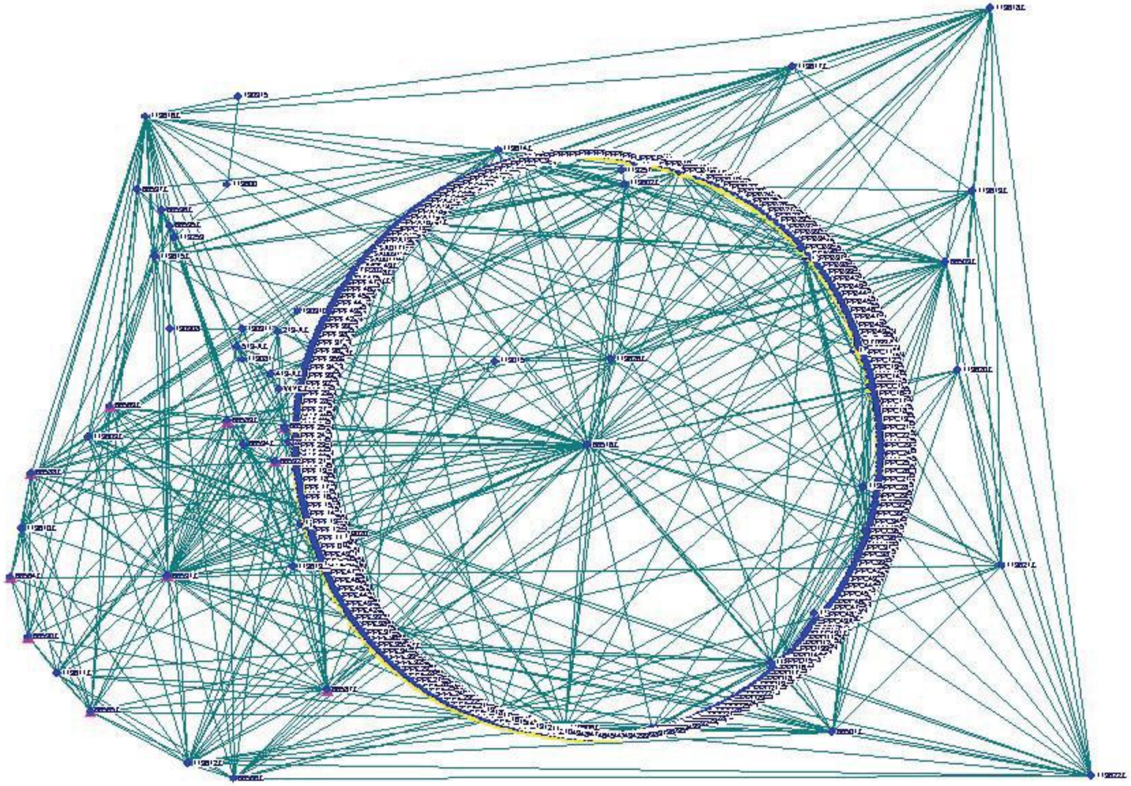
Gate Valves

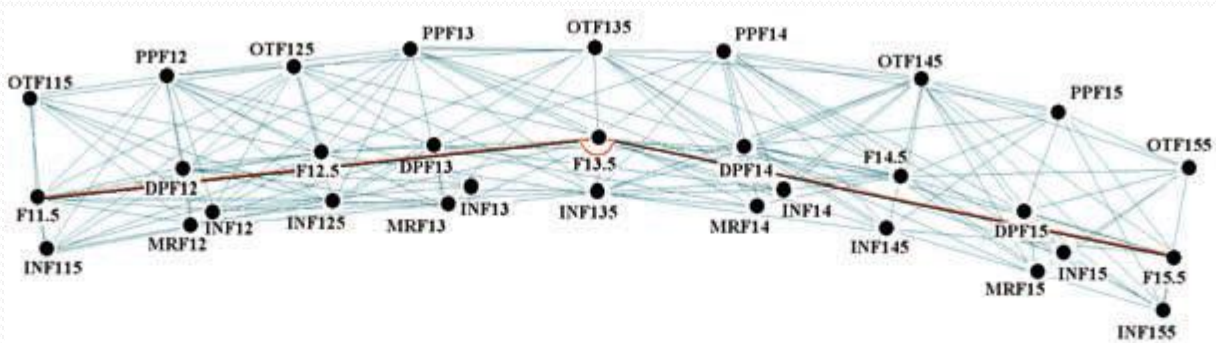
Mechanics & Alignment cost evaluation

- Magnet Supports (Girders) (**evaluated**)
- RF Cavity (Supports) (**not evaluated, from PEP-II**)
- Mechanical Installation (**evaluated**)
- Network survey and Alignment (**evaluated**)
- Final Focus (FF) Mechanical Stabilization (**not evaluated yet**)

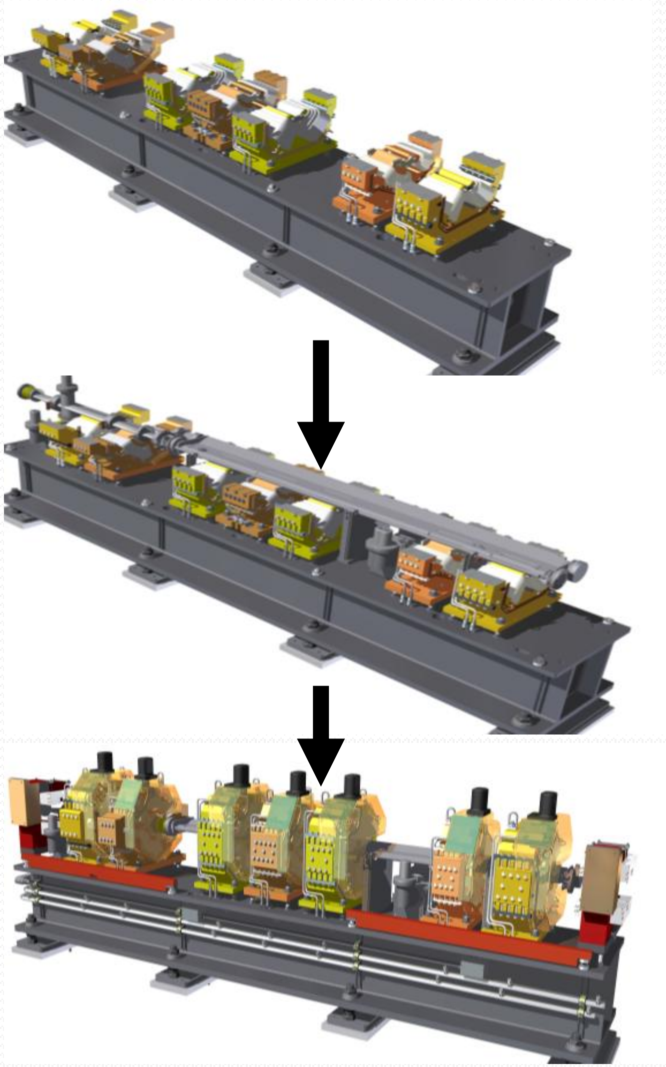
Tomassini, LNF

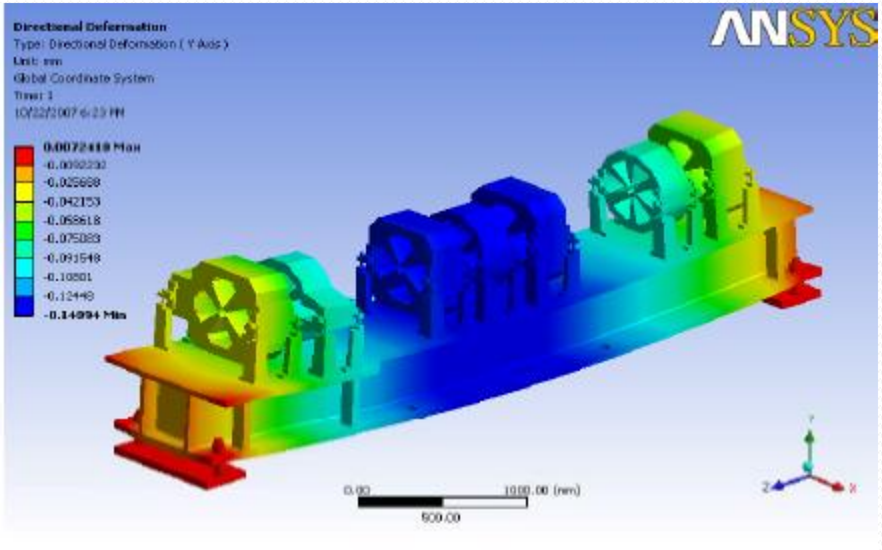
Survey Network Strategy (example Tevatron)





Girders Philosophy





- **Fundamental frequency > 30 Hz**
- **Low strain-High flexural rigidity**
- **Mechanical assembly**

Feedbacks & Timing cost estimate

- 1.6.6 BEAM CONTROL FEEDBACK
  - 1.6.6.1 HORIZONTAL FEEDBACK (ler + her)
  - 1.6.6.2 VERTICAL FEEDBACK (ler + her)
  - 1.6.6.3 LONGITUDINAL FEEDBACK (ler + her)
  - 1.6.6.4 IP (Interaction Point) FEEDBACK
    - 1.6.6.4.1 FAST IP FEEDBACK
    - 1.6.6.4.2 DITHER FEEDBACK
    - 1.6.6.4.3 IP FEEDFORWARD
  - 1.6.6.5 SYNCHRONIZATION (2PS RMS JITTER)

Drago, LNF

- **Cost estimate** are mostly based on real quotations (single piece) without taking in account discount that can be foreseen for big order (20-30 %)

- For several items cost estimate is based on reasonable considerations.

- For items that need R&D the list could be changed in the future both in terms of what is necessary and how much it costs

- Great part of the necessary instrumentation is explicitly included in the cost evaluation list: for example an oscilloscope at 1GHz , 4 channels is part of two transverse bunch-by-bunch feedbacks (hor+ver, 1 single main ring) because it will be located in the same rack of the feedback to monitor the correct behavior

- in general the accessories are included (racks, trays, crates), nevertheless the costs are roughly estimated

Diagnostics cost estimate

Serio, LNF

- WORK BREAKDOWN STRUCTURE WBS

  Reference Document (Dynamic)
- COST ESTIMATE BASED ON
  - Budgetary Offer for the most expensive systems (BPM)
  - Offer from Cable/Connectors Manufacturer
  - Pricelists of Commercial Diagnostic Instruments
  - Pricelist of UHV components
  - Past and Recent Experience of Similar Systems
  - Educated Guess

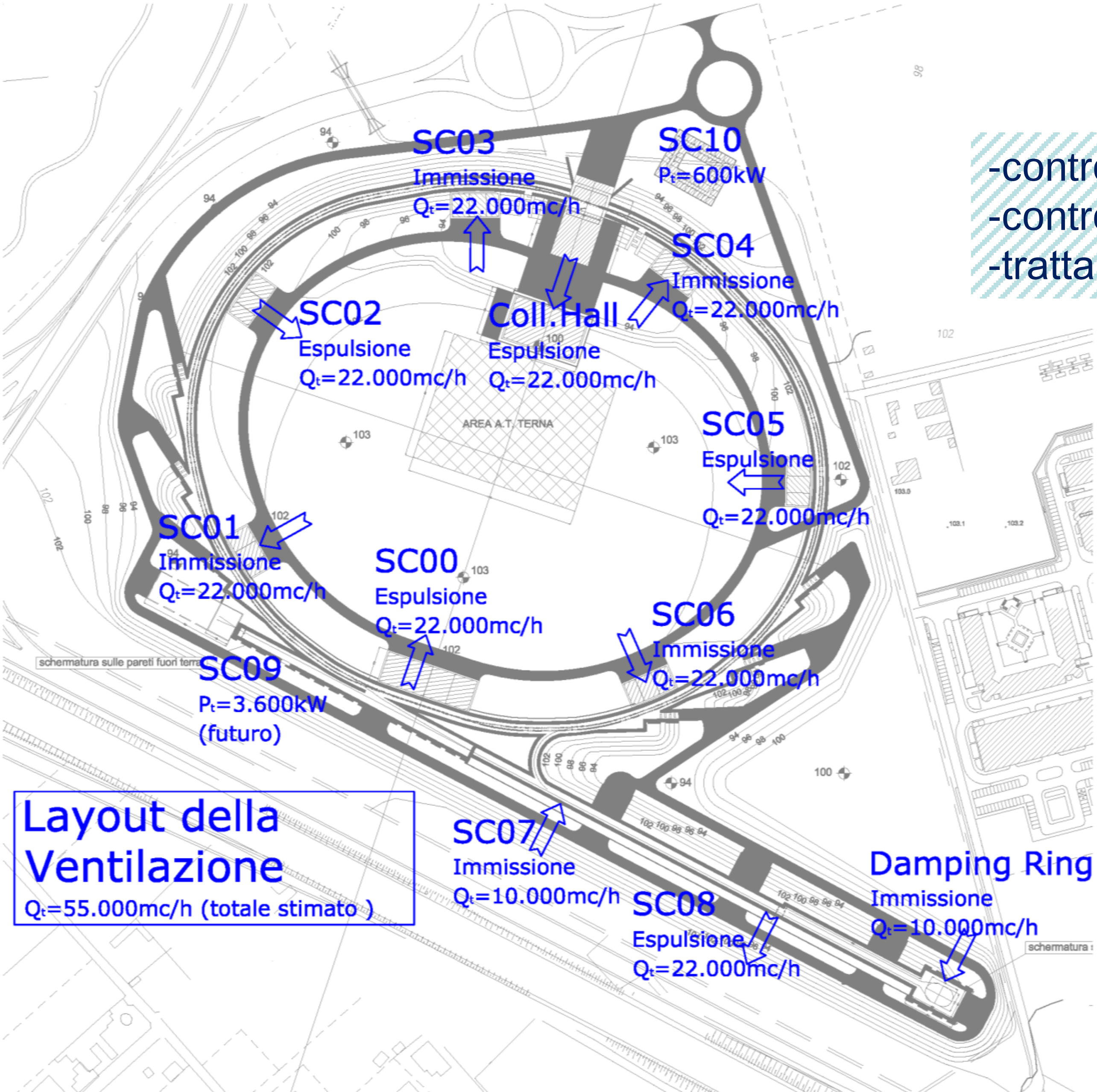
Diagnostics needed

	LINAC	Transfer Lines	Damping Ring	Storage Rings	IP
Beam passage/Presence	Screen				
Position/Closed orbit	Striplines		Button BPM		
Emittance		Screen	SR Monitor (Visible/X-Ray Pinhole)		
Energy/Energy Spread	Magnet + SEM Hodoscope				
Charge/Current	Faraday Cup/WCM/TCM		DCCT		
Bunch by bunch current			WCM/Fast Photodiode/BbB Feedback		
Bunch length		Streak Camera			
Beam size	Screen		SR Monitor (Visible/X-Ray Pinhole)		
Coherent Beam Response			Tune Monitor/BbB Feedback		
Incoherent Beam Response			SR Monitor		
Polarization		TBD	TBD	TBD	
Luminosity					TBD
Fast Loss	Long Ionization Chamber/Cherenkov Fiber				
Slow Losses			Coincidence PIN Diode + Counter		

SuperB SR - Operative Conditions

Type	First Turn	Run-in	Machine Studies	Luminosity Run
Dynamic range > 66 dB	< 1 mA	10-200 mA	200-2000 mA	2000 mA
Screen	x			
BPM-Single pass	Coarse	Coarse	Fine	
BPM-Turn by Turn		Coarse	x	
BPM-Stored beam		Coarse	Hi-res	Hi-res + FBK
Beam Profile (visible light)		Coarse	Fine	Fine
Beam Size			Hi-res	Hi-res
Tune Monitor		Coarse	Fine	Fine
Tune kick (H&V)		x	x	
Current		Coarse	Fine	Fine
Bunch by bunch Current		Coarse	Fine	Fine
Polarization			?	?
Fast Beam Loss	x	x	x	x
Slow Beam Loss			x	x
Luminosity			x	x

HVAC cost estimate



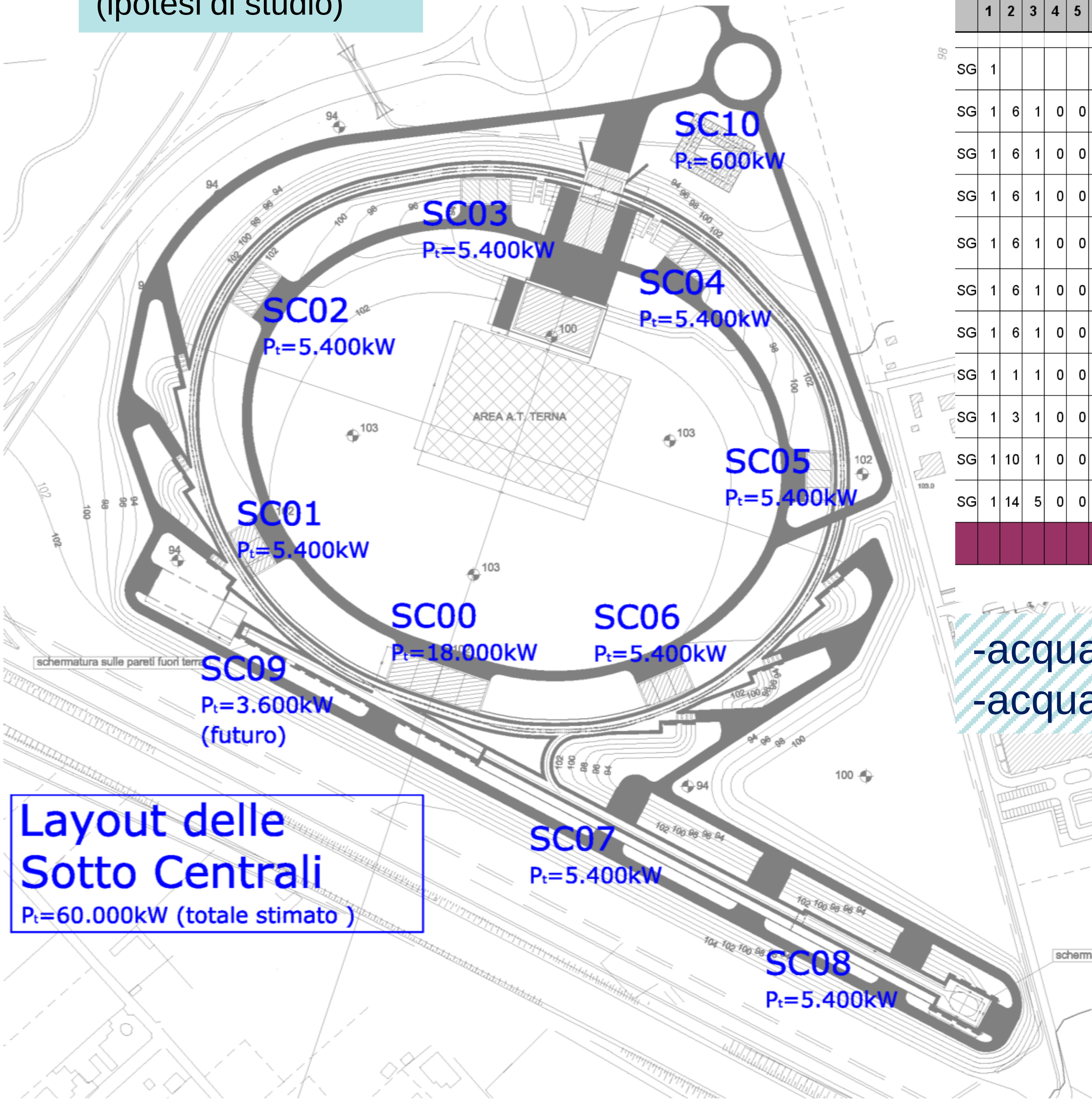
Air Ventilation System

- -controllo aria in ambiente
- -controllo pressurizzazione
- -trattamento dell'aria di rinnovo

La prima <u>**ipotesi**</u> di dimensionamento di ciascuna Sottocentrale di Ventilazione, prevede l'alternanza di stazioni di immissione aria e di espulsione aria.

Schillaci, LNS

Carichi Termici e Sottocentrali
(ipotesi di studio)



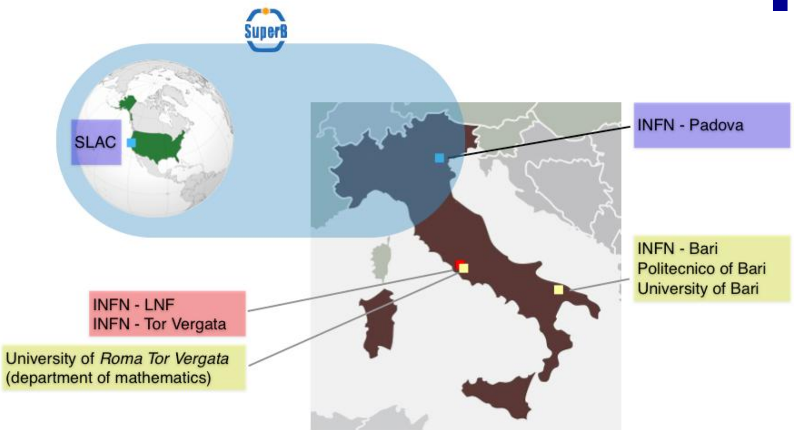
LOAD IDENTIFICATION												
Resp.	WBS NUMBER								-Equipment -Device -Label	Sottocentrale	Quantity	COOLING SYSTEM <kW>
	1	2	3	4	5	6	7	8				[Kw t]
SG	1								LINAC TRANSFER LINES R.F.C.	S.C.00	1	18.000
SG	1	6	1	0	0	0	0		STORAGE RING	S.C.01	1	5.400
SG	1	6	1	0	0	0	0		STORAGE RING	S.C.02	1	5.400
SG	1	6	1	0	0	0	0		STORAGE RING CRIOGENICS	S.C.03	1	5.400
SG	1	6	1	0	0	0	0		STORAGE RING COLLIDER HALL SALA CONTROLLO	S.C.04	1	5.400
SG	1	6	1	0	0	0	0		STORAGE RING	S.C.05	1	5.400
SG	1	6	1	0	0	0	0		STORAGE RING	S.C.06	1	5.400
SG	1	1	1	0	0	0	0		LINAC SYSTEM TUNNEL	S.C.07	1	5.400
SG	1	3	1	0	0	0	0		LINAC SYSTEM TUNNEL DAMPING RING	S.C.08	1	5.400
SG	1	10	1	0	0	0	0		LABORATORIO LINAC LINAC PHOTON LINE TUNNEL	S.C.09	1	3.600
SG	1	14	5	0	0	0	0		Palazzina Uffici	S.C.10	1	504
											SOMMANO	65304,0

-acqua refrigerata per gli apparati
-acqua refrigerata per gli ambienti

Schillaci, LNS

Controls, Computing a
!CHAOS developing

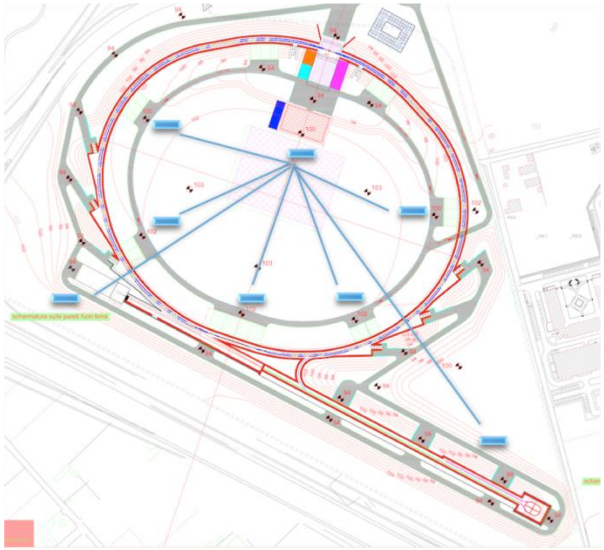
Mazzitelli, LNF



The !CHAOS collaboration continues the development of the **control system core**, integrating the expected functionality.
A **first Open Source release** is available on the INFN web site http://chaos.infn.it/

*University of Cagliari and computer science department of Tor Vergata recently **joint** the collaboration with **thesis** and **PhD positions***

The **cost estimation** is going on taking into account also the networking and computing infrastructure needed to Controls and Accelerator project development and maintenance (EMDS, PMDS, etc).
Integration of standard I/O device (GPIB, LIBERA BPM) is started in order to check real performances.
Commercial partners collaborations are under study

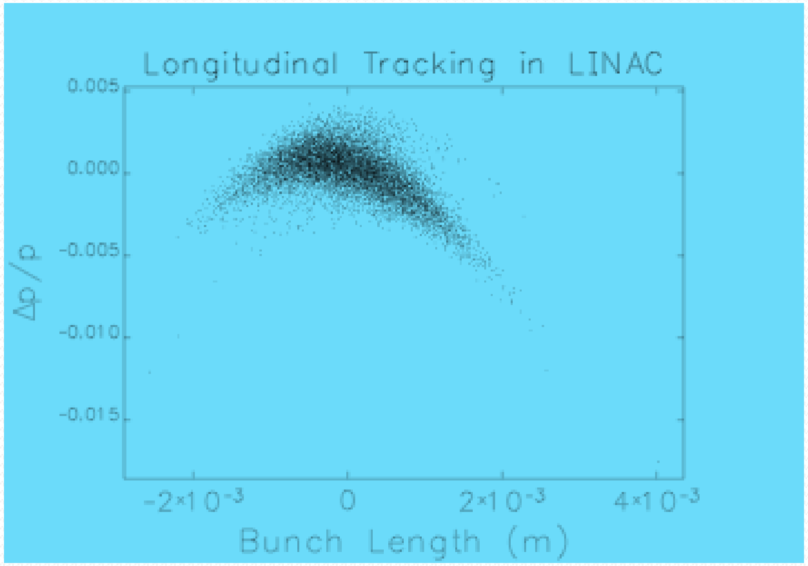


L2/L3 Network layout
more than 2000 network device have been estimated up to now

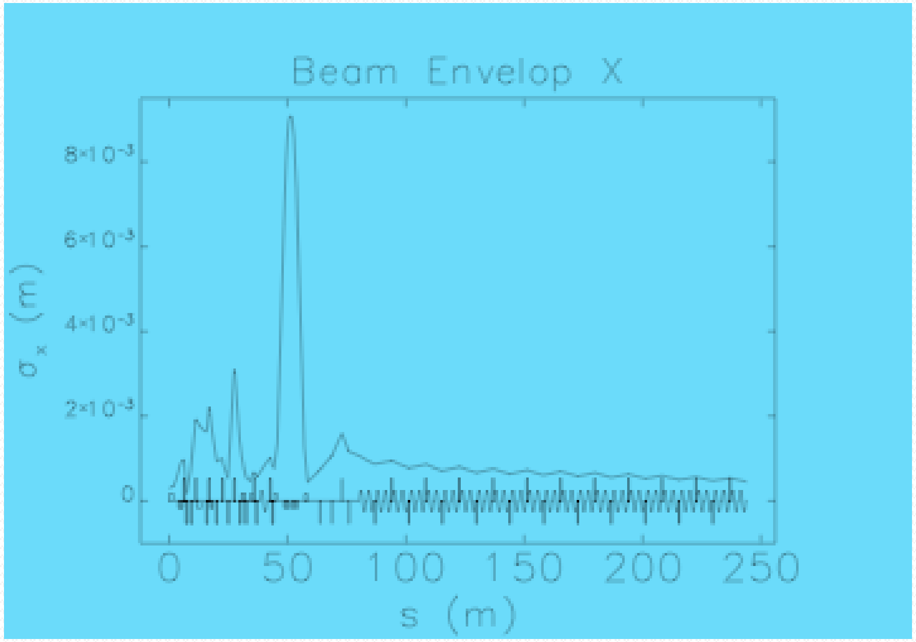
Not just

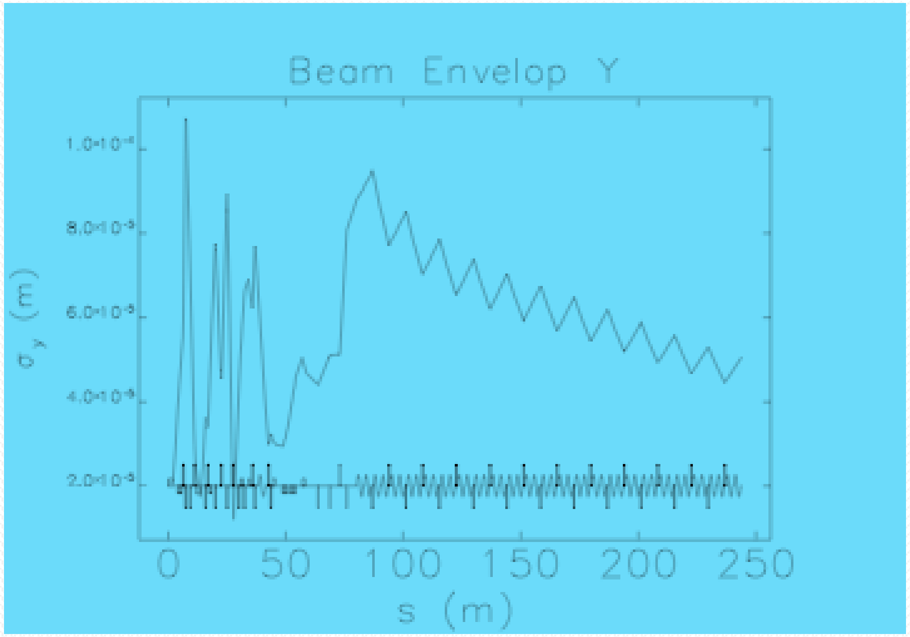
Beam simulation from DR to Linac end

Pellegrini, Pd-LNF



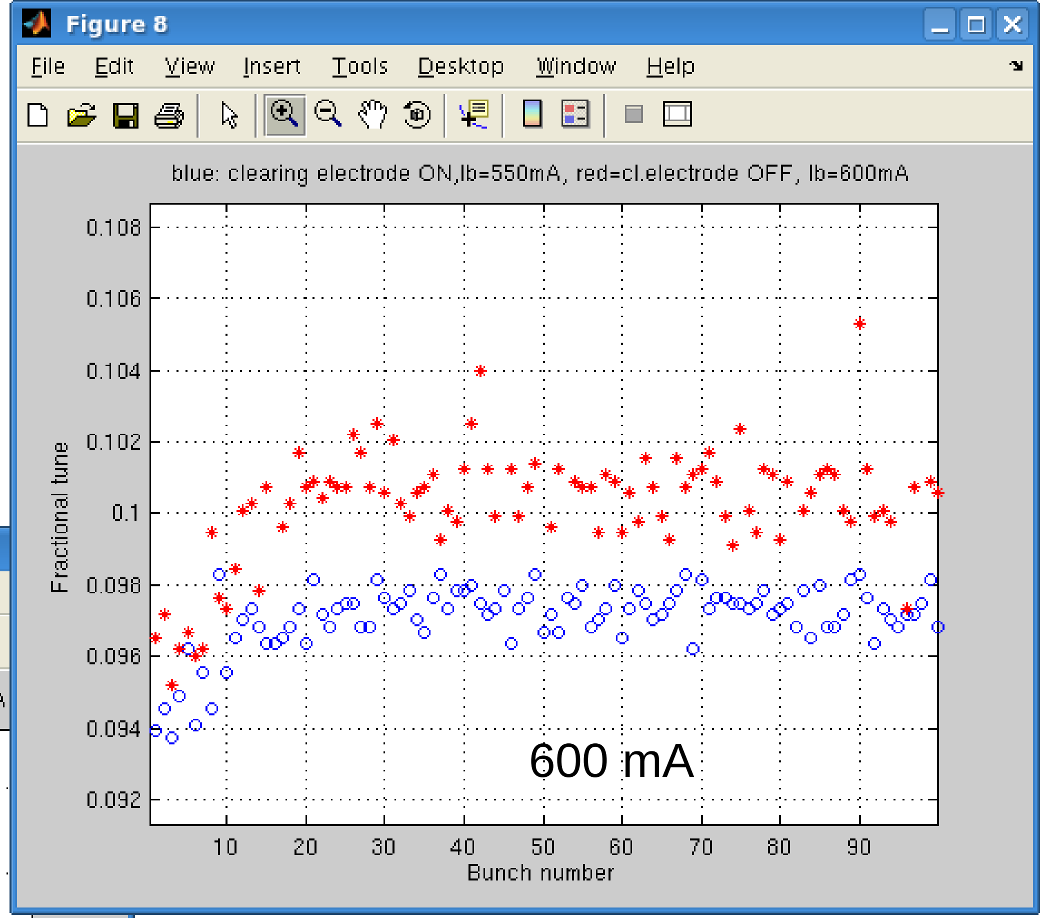
	DR exit	Linac end
ELECTRONS		
Energy (GeV)	1.0	4.18
Bunch charge (pC)	300	
Emittance ε_x (nm)	23	5.5
Emittance ε_y (nm)	0.20	0.047
Bunch length (mm)	4.8	0.67
Energy spread Δp/p rms	6.2e-4	1.6e-3
Energy spread Δp/p 99%	±1.9e-3	±4.3e-3
POSITRONS		
Energy (GeV)	1.0	6.7
Bunch charge (pC)	300	
Emittance ε_x (nm)	28	4.2
Emittance ε_y (nm)	5	.075
Bunch length (mm)	4.8	0.67
Energy spread Δp/p rms	6.2e-4	1.3e-3
Energy spread Δp/p 99%	±1.9e-3	±3.6e-3

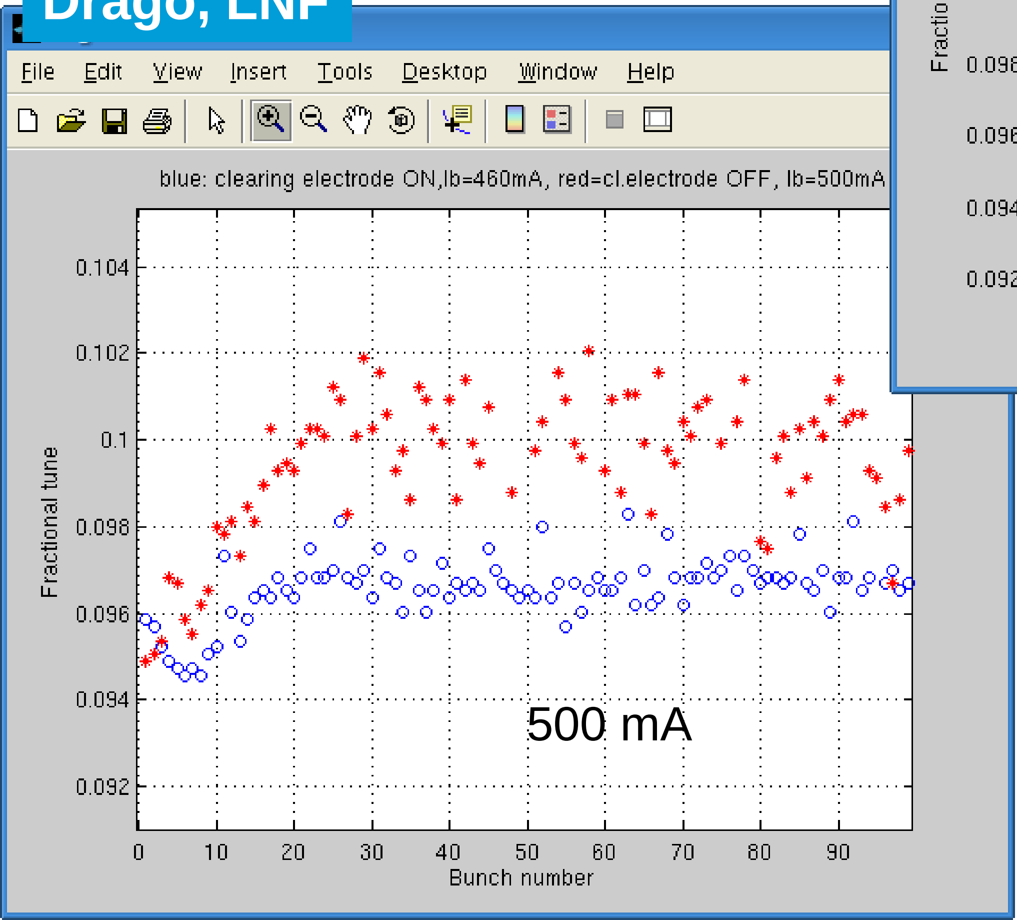




Horizontal bunch-by-bunch fractional tune measured by the feedback system (April 2012)

Drago, LNF



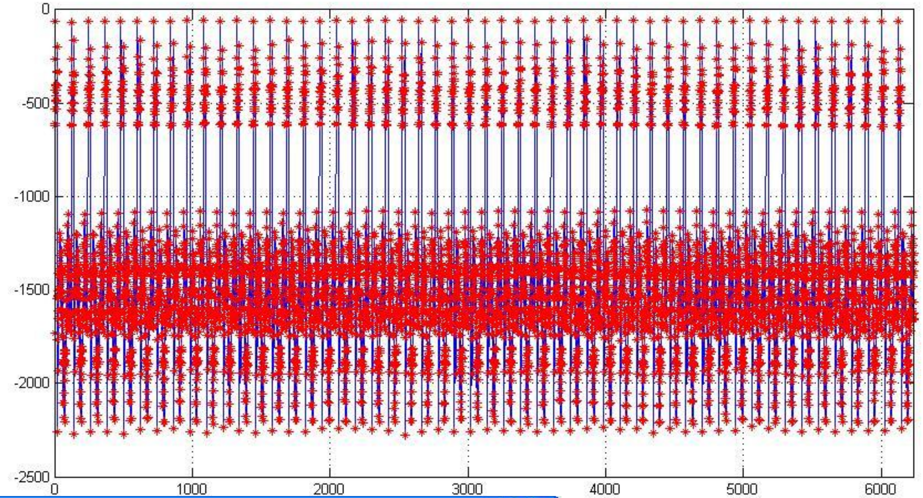


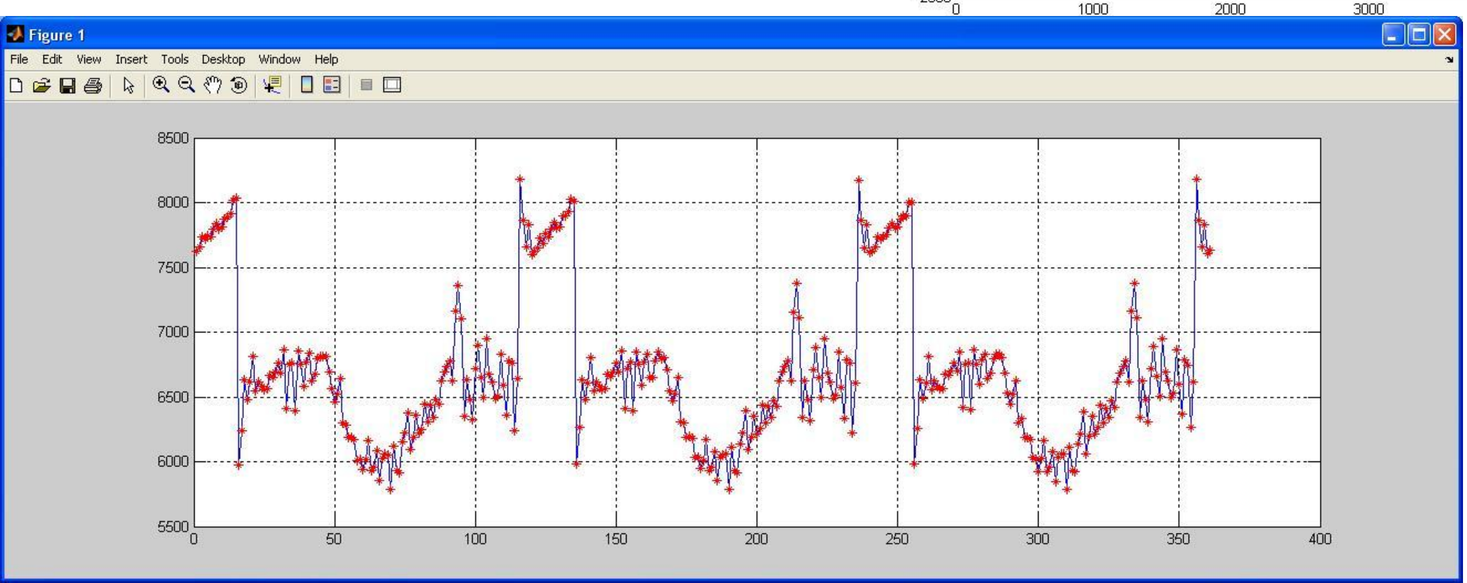
DAFNE e+ beam,
100 bunches, spaced by 2.7ns with 20 buckets gap

Turning off the electrodes in 4 wigglers and 2 dipoles, the horizontal tune goes up

FEEDBACK developments:

To start an R&D activity for the IP feedback: in May a new 14-bit hardware based on ready-made low cost board has been used to acquire long tracks of DAΦNE e+ bunch-by-bunch data. The output signal was also used to time the front end clock





Drago, LNF

Conclusions

- The cost estimate is expected to be ready by early July
- In the meantime we have prepared (see Variola's talk) a list of work packages for MR and Injection to be able to freeze the accelerator footprint before October (!)
- Each work package includes
  - a mandate
  - a coordinator
  - a list of key topics to be addressed
  - needed manpower