Tau Charm flavor factory

- Accelerator
- Physics
- Detector
- International scenario

More information available in “la Biodola meeting” talks :
https://agenda.infn.it/conferenceDisplay.py?confId=6193

Accelerator

- Design parameters
- Project status
    - Physics
- Financial and human resources
- Primitive planning

Accelerator study group

LNF team

- M. Biagini
- M. Boscolo
- A. Chiarucci
- A. Clozza
- A. Drago
- S. Guiducci
- C. Ligi
- G. Mazzitelli
- R. Ricci
- C. Sanelli
- M. Serio
- A. Stella
- S. Tomassini

ESRF & Pisa team

- P. Raimondi
- S. Liuzzo
- E. Paoloni

LNS team

- G. Schillaci
- M. Sedita

CabibboLab team

- S. Bini
- F. Cioeta
- D. Cittadino
- M. D'Agostino
- M. Del Franco
- A. Delle Piane
- E. Di Pasquale
- G. Frascadore
- S. Gazzana
- R. Gargana
- S. Incremona
- A. Michelotti
- L. Sabbatini

Accelerator scheme superB inspired

- Energy tunable currently in the range **E_{cm} = 2-4.8 GeV**
- **$2*10^{35}$ cm^{-2} s^{-1} maximum** peak luminosity at the τ/charm threshold and upper
- Low currents and crab waist solution for the interaction region
  - Low power consumption
- Polarization available on one beam (65-70%)
- A symmetric machine
- Compact dimensions (about 340 Meters for the rings)
- Only positrons damping ring
- Competitive luminosity also at lower energy (currently 2 GeV)

Beam parameters

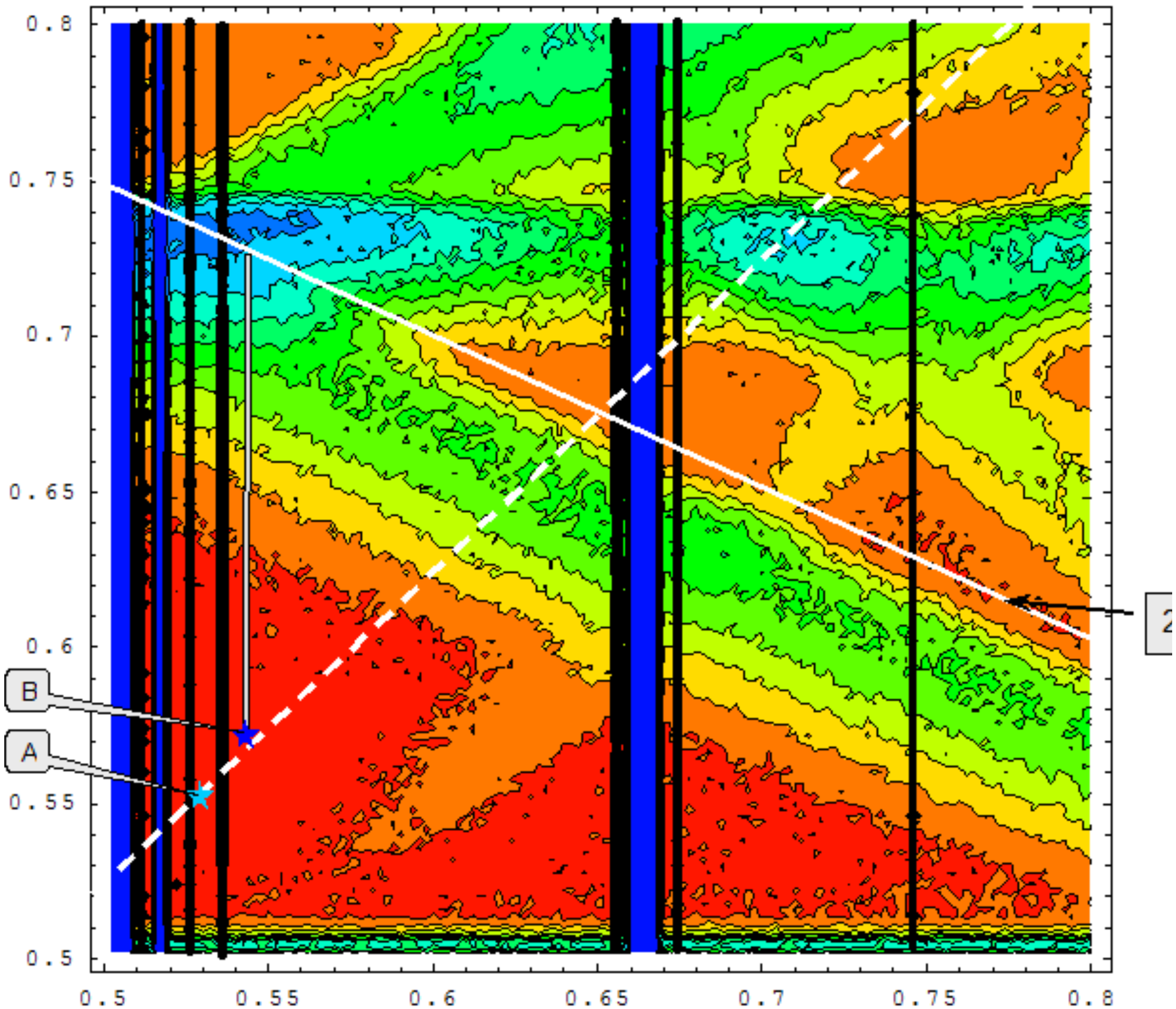
- Beam parameters to reach a **baseline luminosity of 10^{35} cm^{-2} s^{-1}** @ 2 GeV/beam have been chosen
- An upgrade to **2×10^{35} cm^{-2} s^{-1}** can be possible by increasing the beam current
- Design features are the same as for the SuperB design:
  - "Large Piwinski angle & crab waist sextupoles" collision scheme
  - Low H-emittance lattice
  - Small H-V coupling → ultra low V-emittance
  - Small IP β functions and beam sizes
  - Beam-beam tune shifts < 0.1
  - Same RF frequency as PEP-II (re-use of cavities)
  - Low beam power

Table of parameters @ 2 GeV/beam

- Baseline design $L=10^{35}$, with possibility to increase currents for $2x10^{35}$ cm^{-2} s^{-1}
- Intra Beam Scattering and hourglass factors included
- Beam power about 15 times less than the SuperB baseline one (4 MW (HER) and 2MW (LER) of RF power)

Parameter	Units		
LUMINOSITY	10^{35} cm^{-2} s^{-1}	1.0	2.0
cm Energy	GeV	4.0	4.0
Beam Energy	GeV	2.0	2.0
Circumference	m	340.7	340.7
X-Angle (full)	mrad	60	60
Piwinski angle	rad	10.84	10.80
Hourglass reduction factor		0.85	0.84
Tune shift x		0.004	0.006
Tune shift y		0.089	0.120
β_x @ IP	cm	7	7
β_y @ IP	cm	0.06	0.06
σ_x @ IP	microns	18.95	19.97
σ_y @ IP	microns	0.088	0.092
Coupling (full current)	%	0.25	0.25
IBS emittance growth factor		1.8	2
Emittance x (with IBS)	nm	5.13	5.70
Emittance y (with IBS)	pm	12.8	14.3
Bunch length (with IBS)	mm	6.9	7.2
Beam current	mA	1745	2600
Buckets distance	#	1	1
Ion gap	%	2	2
RF frequency	Hz	4.76E+08	4.76E+08
Number of bunches	#	530	530
N. Particle/bunch	#	2.34E+10	3.48E+10
Beam power	MW	0.16	0.24
Transverse damping times (x/y)	msec	35/49	35/49

Design robustness: the luminosity tune scan (BINP)



CW advantage:

- BB coupling resonances are suppressed

- Wide red area corresponds to 10^{35} $cm^{-2}s^{-1}$

Lumi vs Energy

Parameter	Units			
LUMINOSITY	10^{35} cm^{-2} s^{-1}	1.0	1.0	0.2
c.m. Energy	GeV	4.6	4.0	2.0
Beam Energy	GeV	2.3	2.0	1.0
Circumference	m	340.7	340.7	340.7
X-Angle (full)	mrad	60	60	60
Piwinski angle	rad	11.19	10.84	14.66
Hourglass reduction factor		0.86	0.85	0.83
Tune shift x		0.004	0.004	0.002
Tune shift y		0.078	0.089	0.064
β_x @ IP	cm	7	7	7
β_y @ IP	cm	0.06	0.06	0.06
σ_x @ IP	microns	18.50	18.95	20.67
σ_y @ IP	microns	0.086	0.088	0.096
Coupling (full current)	%	0.25	0.25	0.25
IBS emittance growth factor		1.3	1.8	4.3
Emittance x (with IBS)	nm	4.89	5.13	6.11
Emittance y (with IBS)	pm	12.2	12.8	15.3
Bunch length (with IBS)	mm	6.9	6.9	10.1
Beam current	mA	1720	1745	1000
Buckets distance	#	1	1	1
Ion gap	%	2	2	2
RF frequency	Hz	4.76E+08	4.76E+08	4.76E+08
Number of bunches	#	530	530	530
N. Particle/bunch	#	2.3E+10	2.3E+10	1.3E+10
Beam power	MW	0.28	0.16	0.05
Transverse damping times (x/y)	msec	23/33	35/49	35/49

Radiative gamma-gamma luminosity (e- e- mode)

2.0	2.3*10^32	9.2*10^31	5.2*10^31	3.7*10^31
1.5	3.3*10^32	1.3*10^32	7.4*10^31	5.2*10^31
1.0	5.8*10^32	2.3*10^32	1.3*10^32	9.2*10^31
0.5	1.4*10^33	5.8*10^32	3.3*10^32	2.3*10^32
E1 / E2	0.5	1.0	1.5	2.0

Project status

From Mini Mac superb 2009 detailed work needed on:

- lattice designs
- dynamic aperture
- beam-beam and crabbed waist
- electron cloud
- Touschek effect and beam-gas scattering
- Interaction region
- QD0
- Low emittance tuning, tolerances
- RF & Impedance
- Feedback
- Injection
- Site considerations
- Polarization
- Machine availability

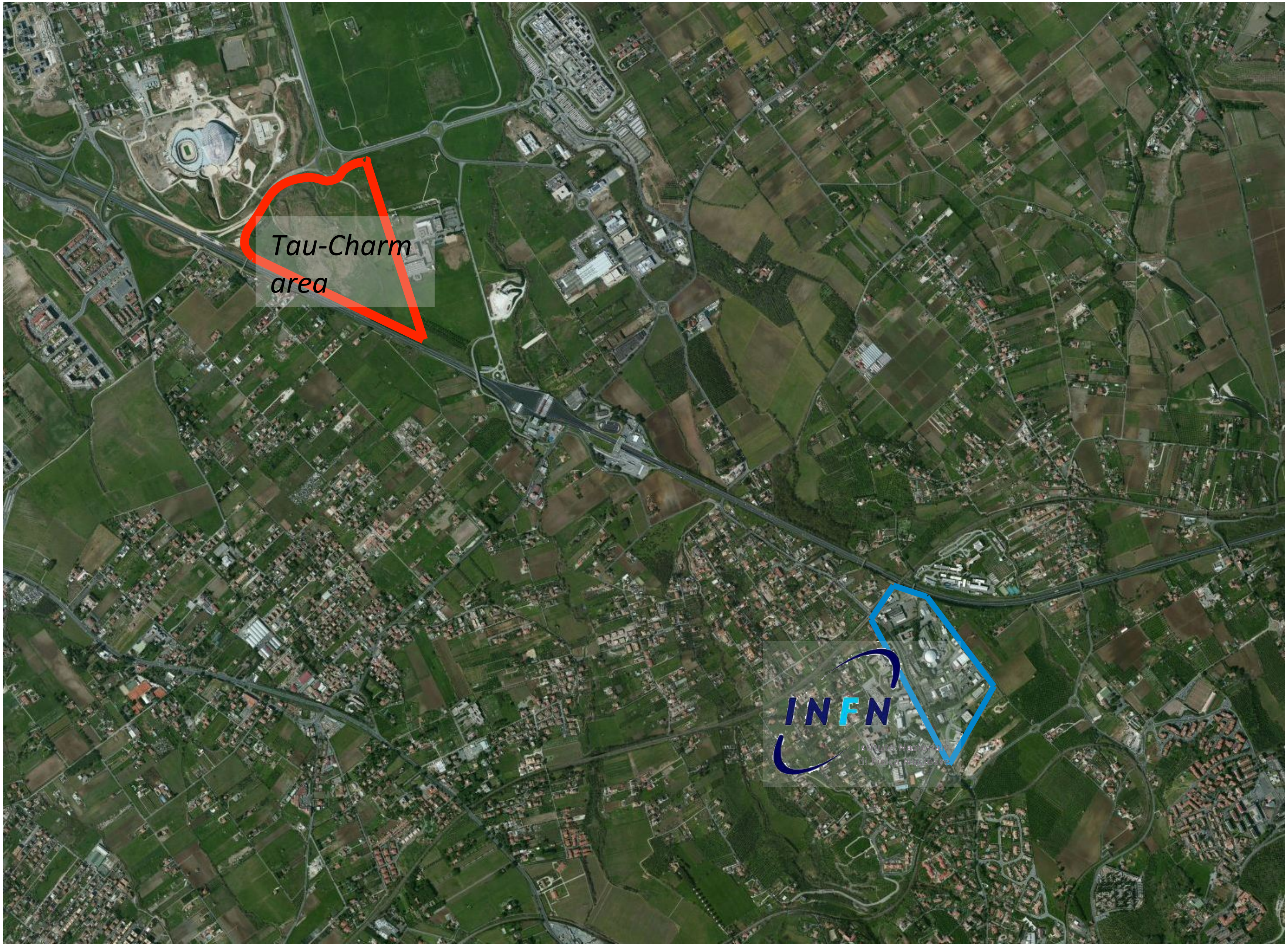
superB end 2012

- ✓ lattice design DONE
- dynamic aperture IN PROGRESS
- ✓ beam-beam and crabbed waist DONE
- ✓ electron cloud DONE
- ✓ Touschek effect and beam-gas scattering DONE
- ✓ Interaction region DONE
- QD0 IN PROGRESS
- ✓ Low emittance tuning, tolerances DONE
- RF & Impedance
- ✓ Feedback DONE
- ✓ Injection DONE
- ✓ Site considerations DONE
- ✓ Polarization DONE
- Machine availability ?

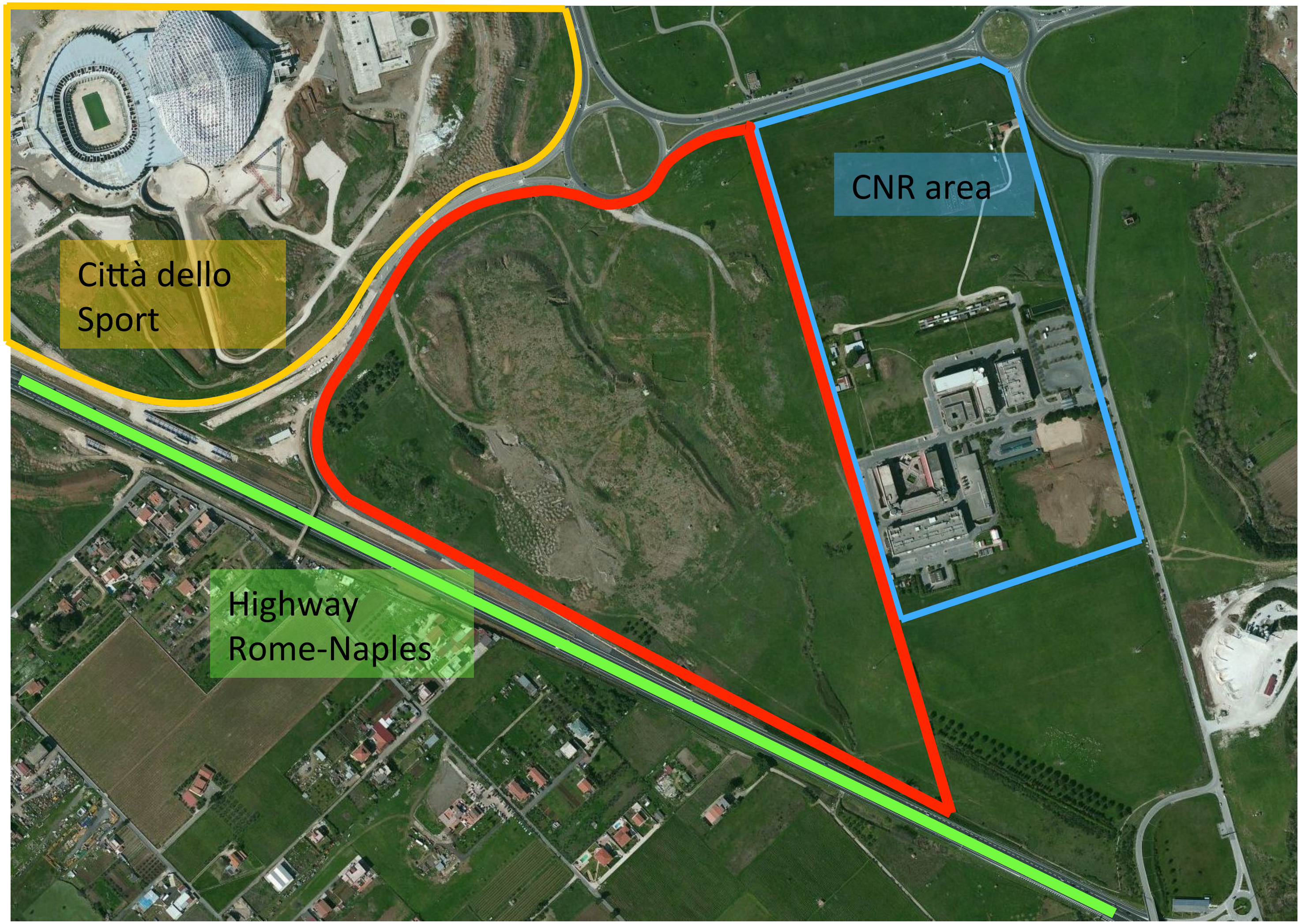
Tau charm middle 2013

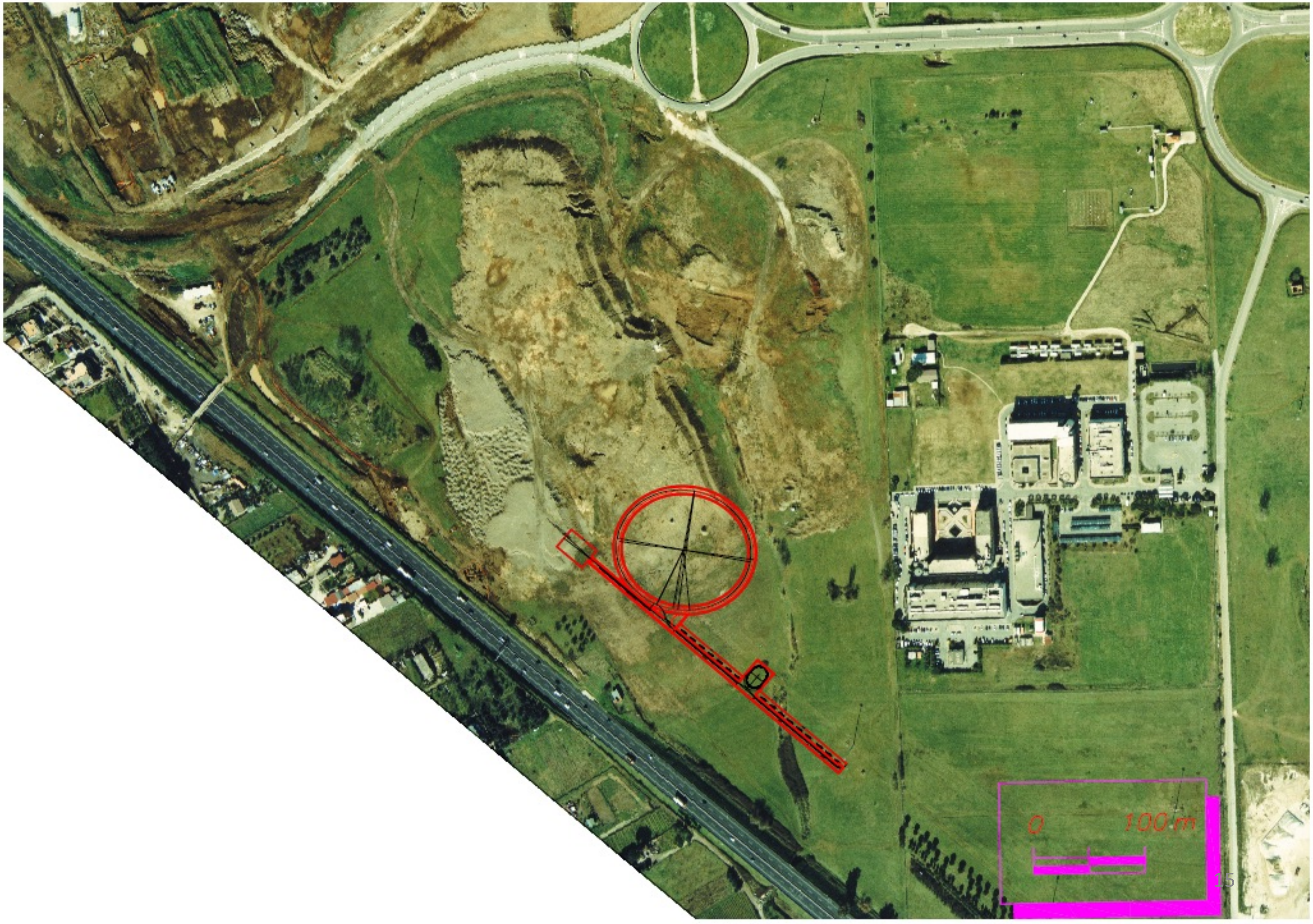
- ✓ lattice design DONE
- beam-beam and crabbed waist (assumed similar to SuperB)
- ✓ dynamic aperture DONE
- electron cloud IN PROGRESS
- ✓ Touschek effect and beam-gas scattering DONE
- Interaction region IN PROGRESS
- QD0 IN PROGRESS
- ✓ Low emittance tuning, tolerances DONE
- RF & Impedance
- ✓ Feedback DONE
- ✓ Injection DONE
- ✓ Site considerations DONE
- ✓ Polarization DONE
- Machine availability ?

The site

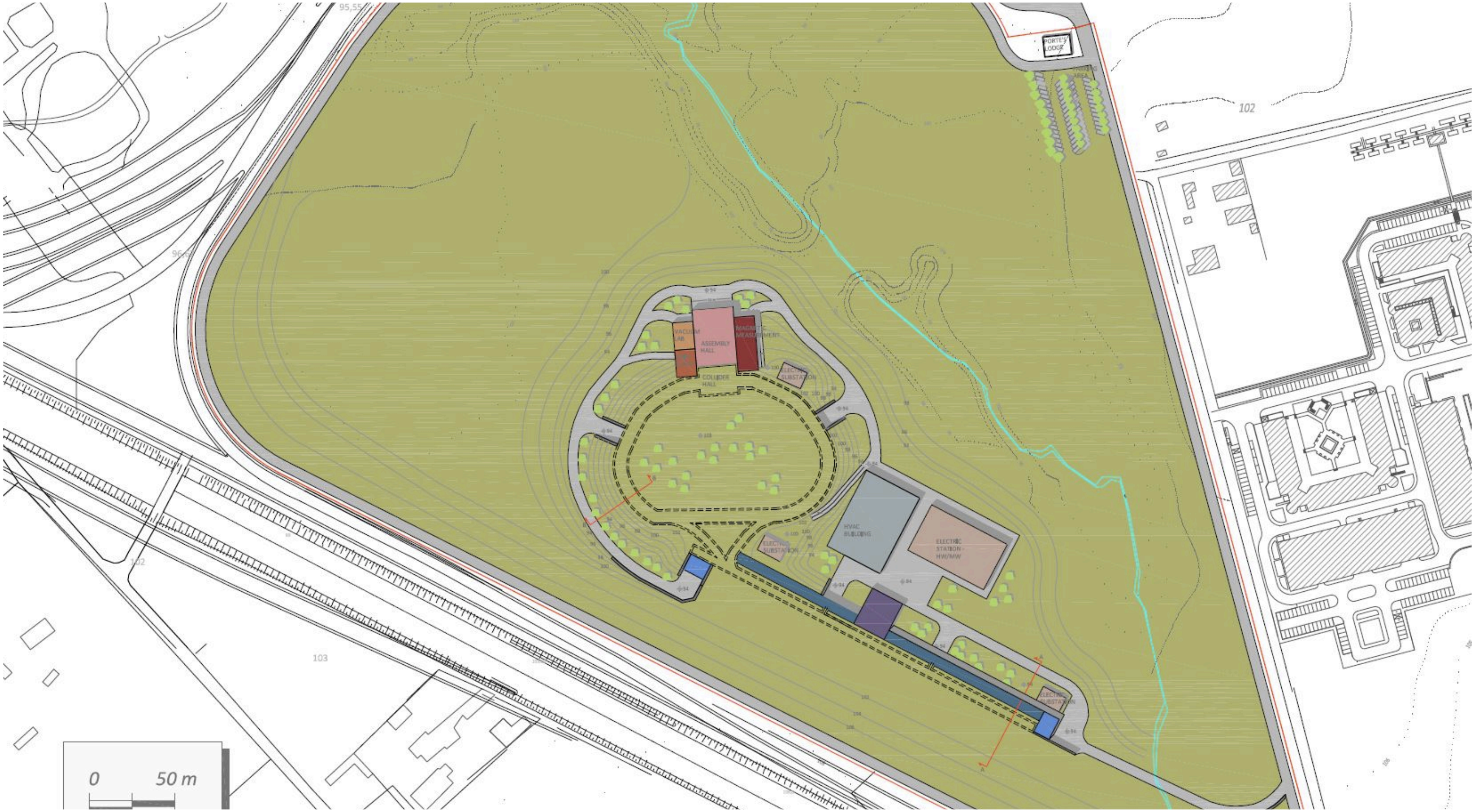


The site

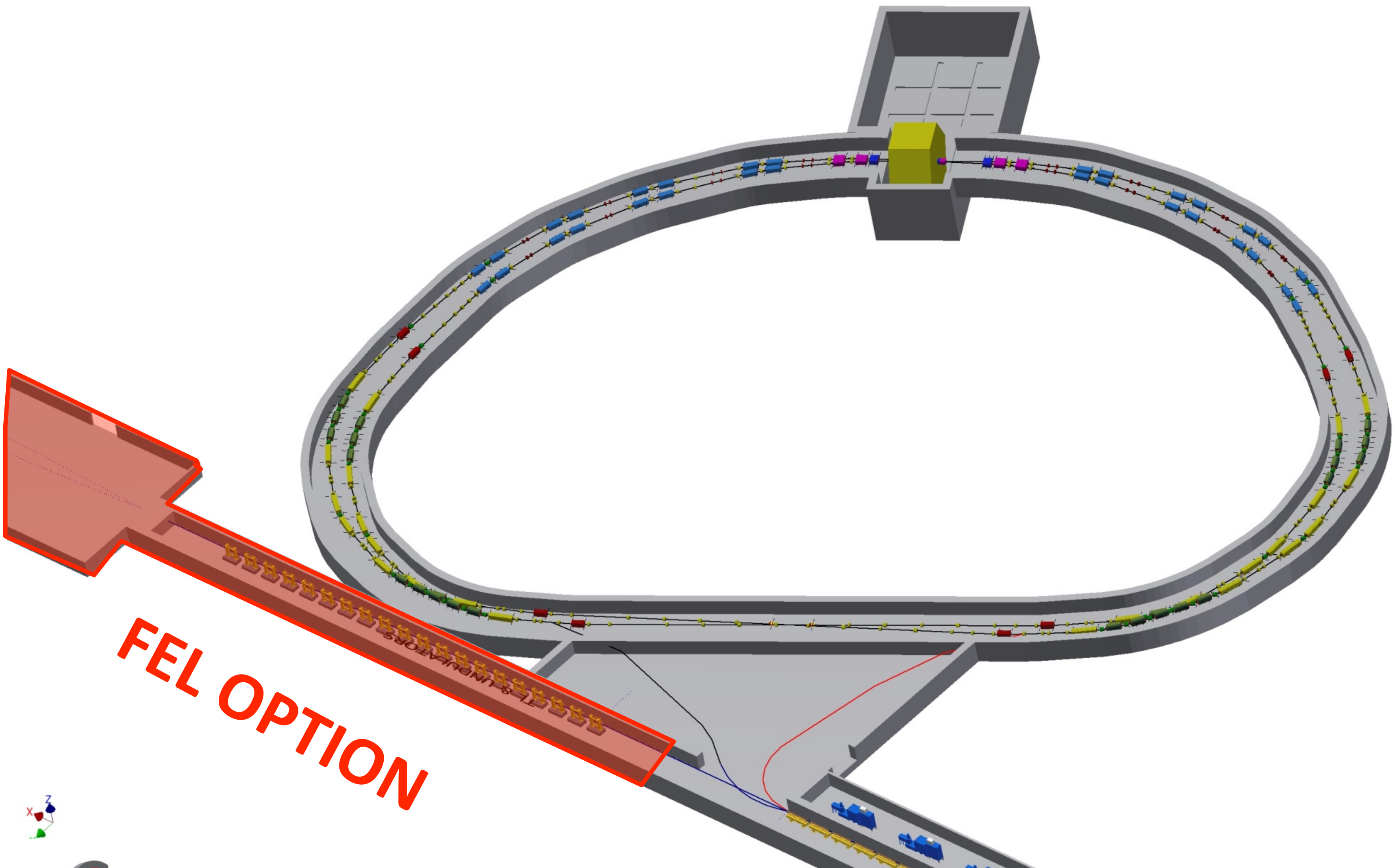



0
100 m

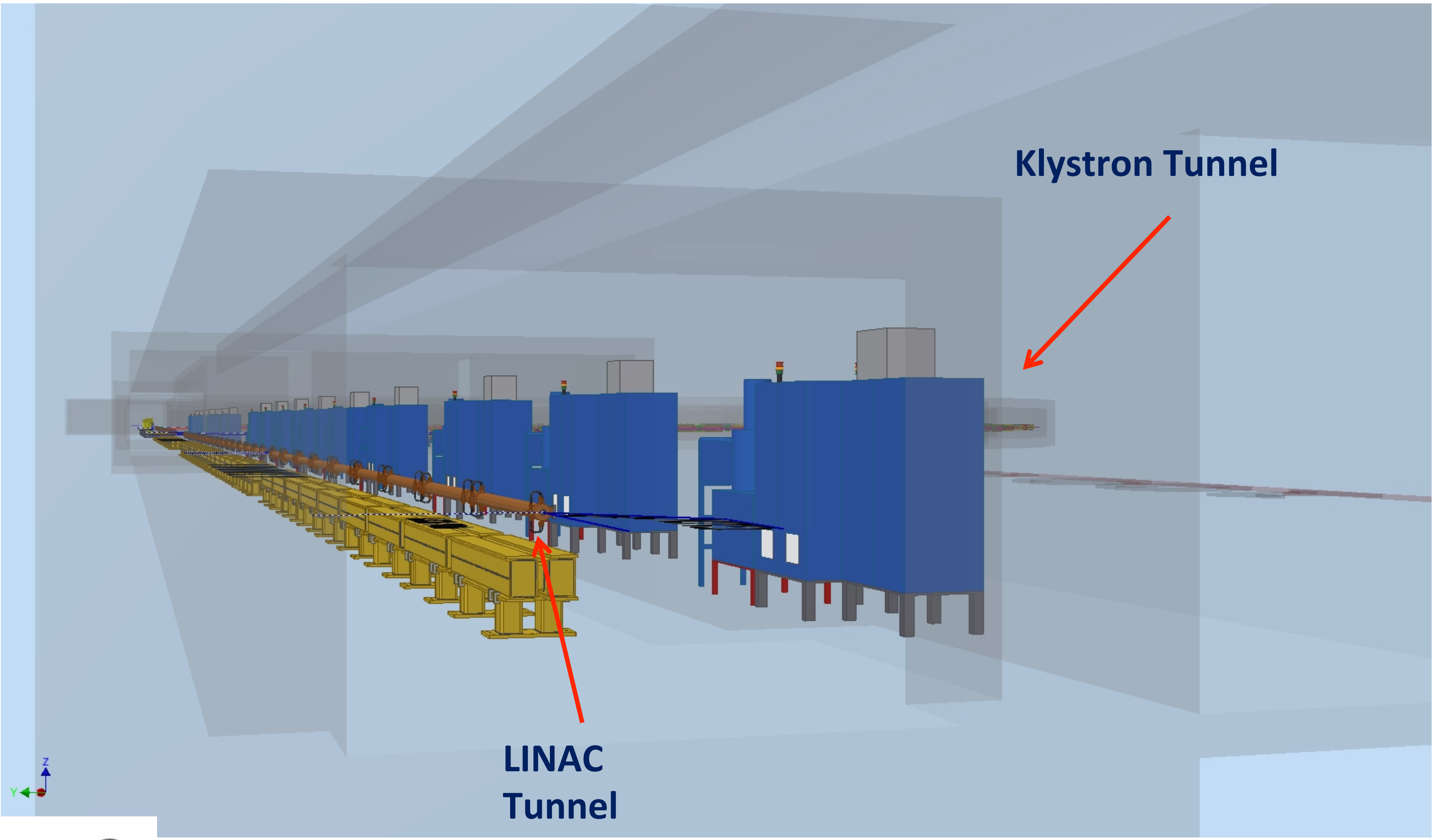
A closer view



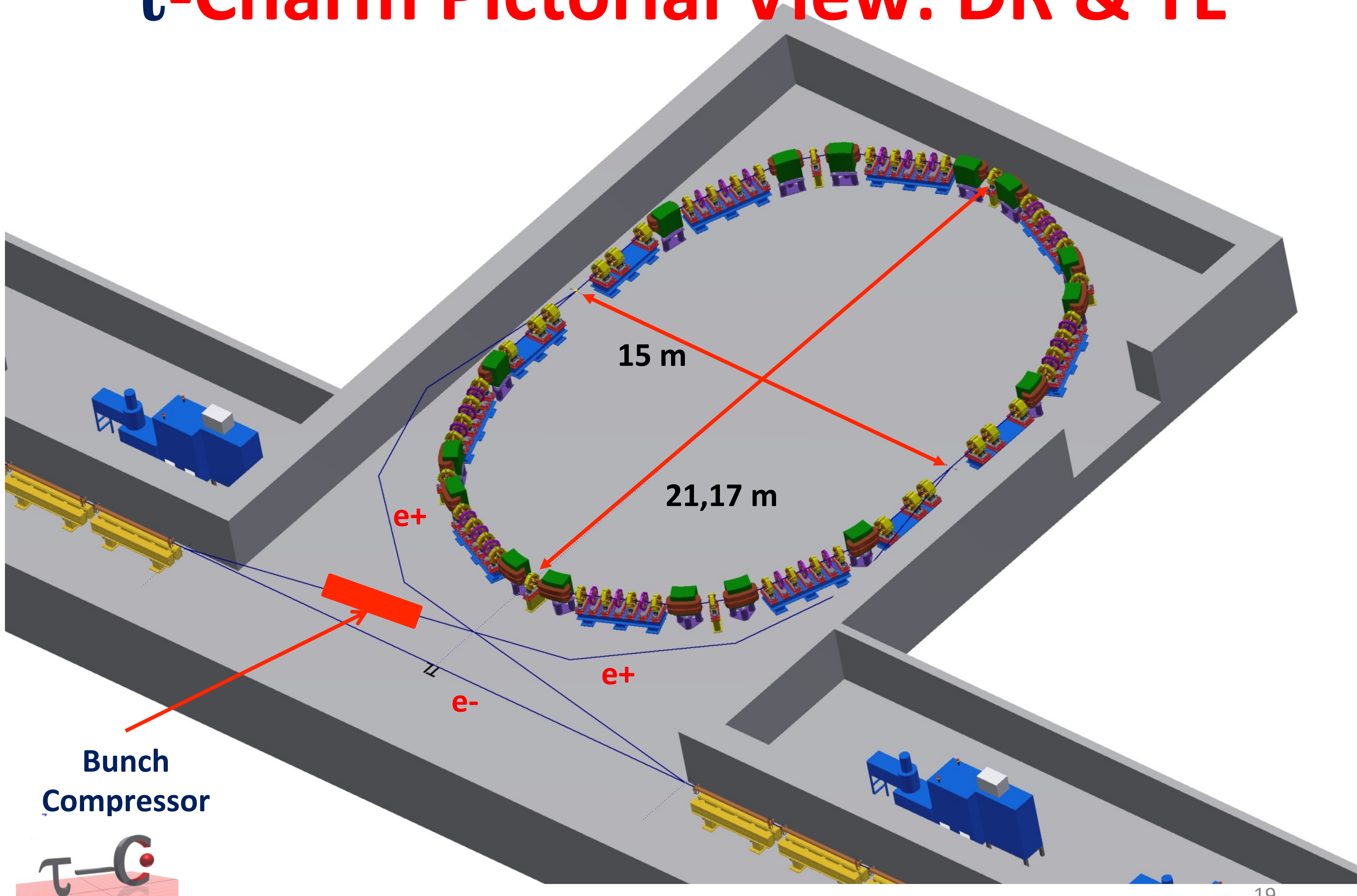
τ-Charm Pictorial View: FEL option



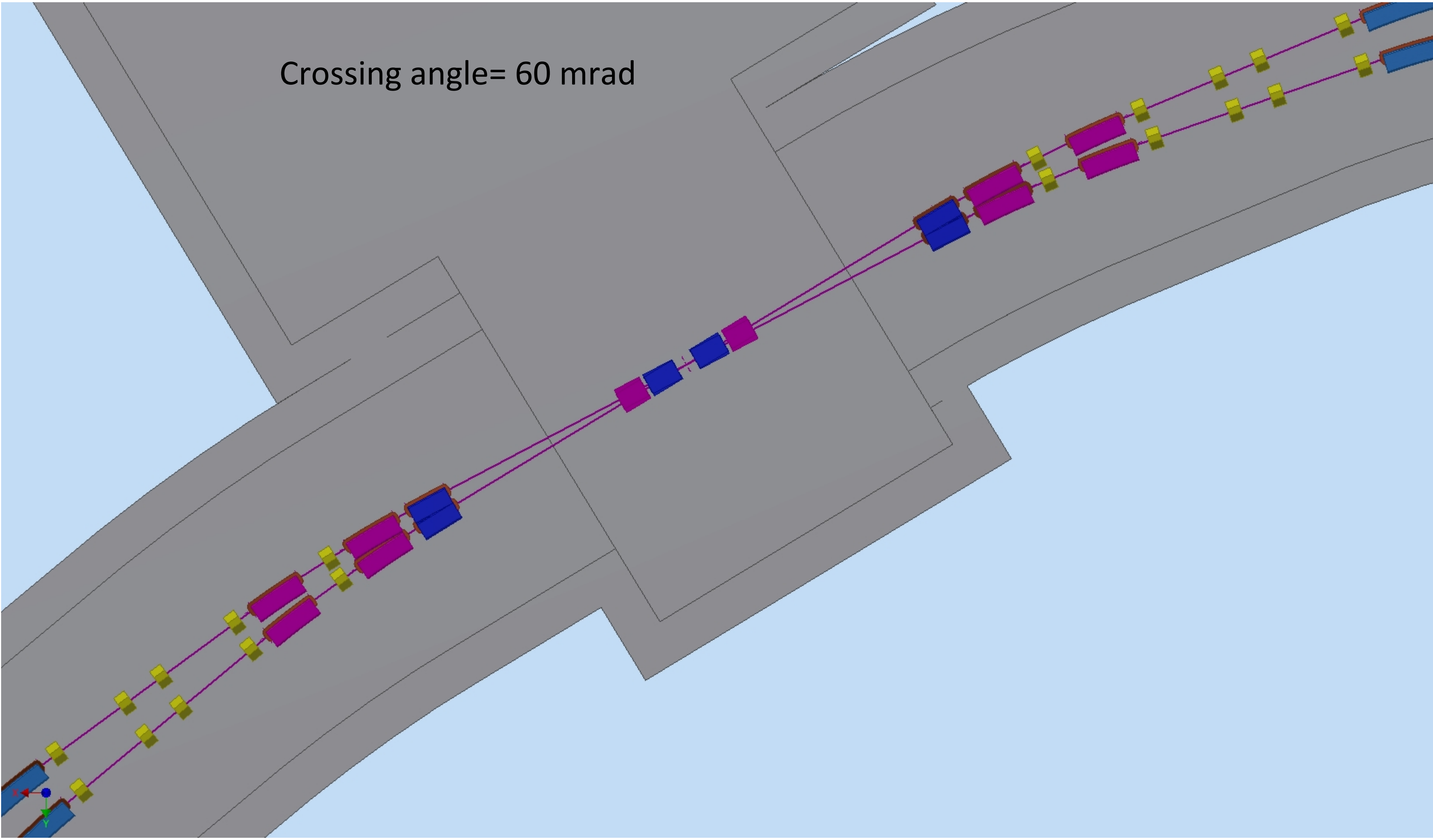
τ-Charm Pictorial View: LINACs



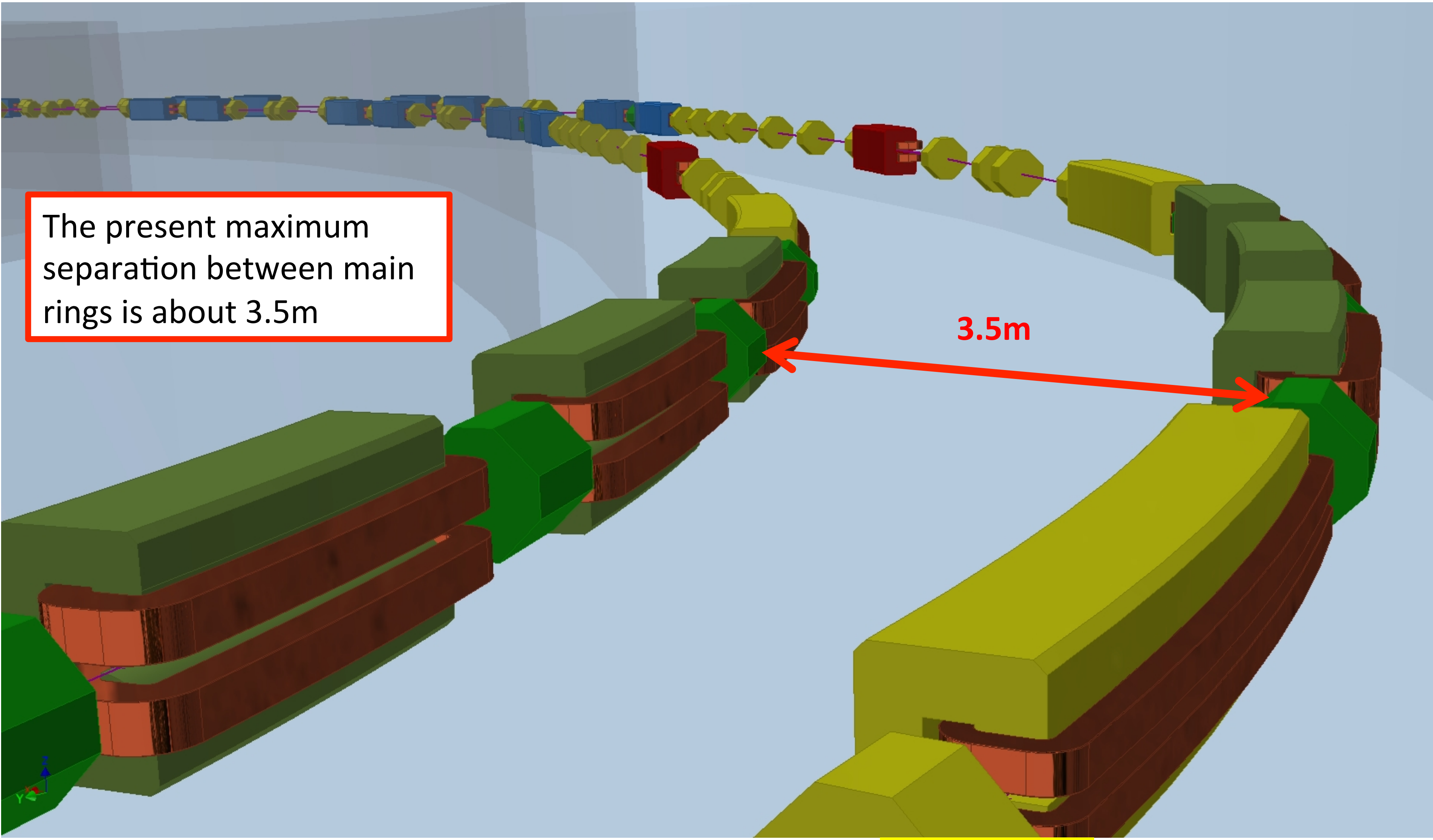
τ-Charm Pictorial View: DR & TL



Interaction Point

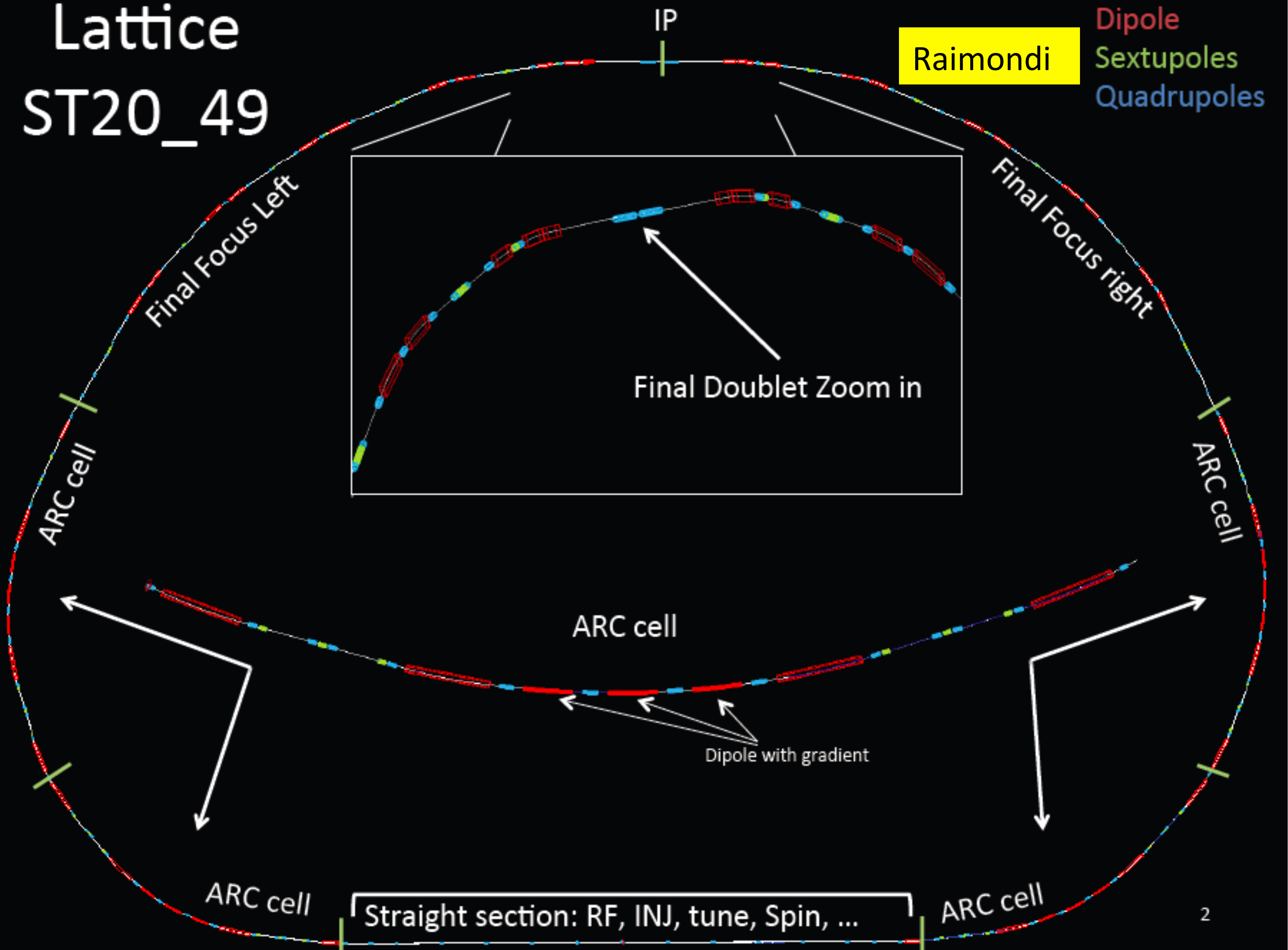


Main Rings side by side

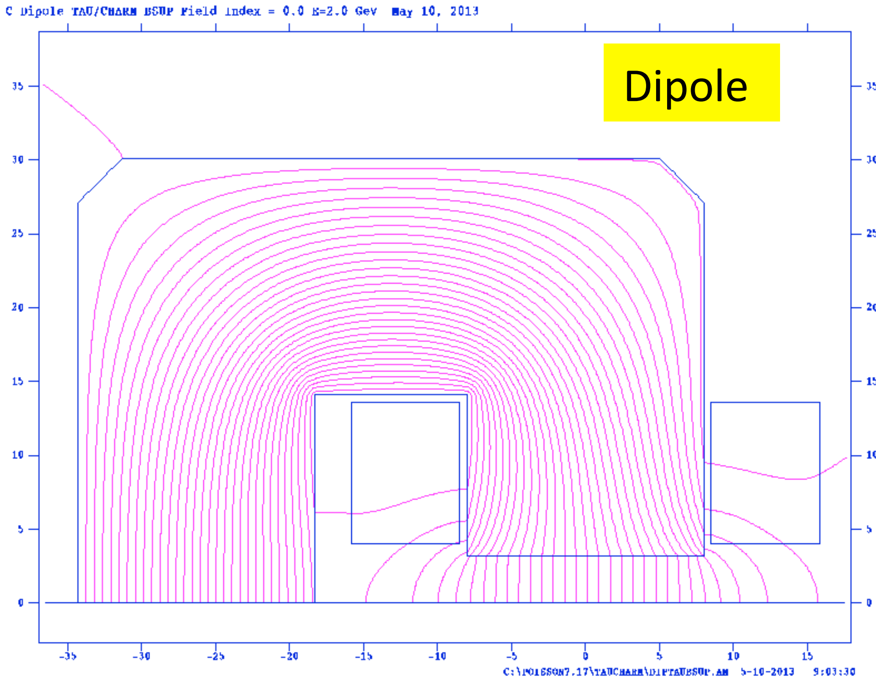


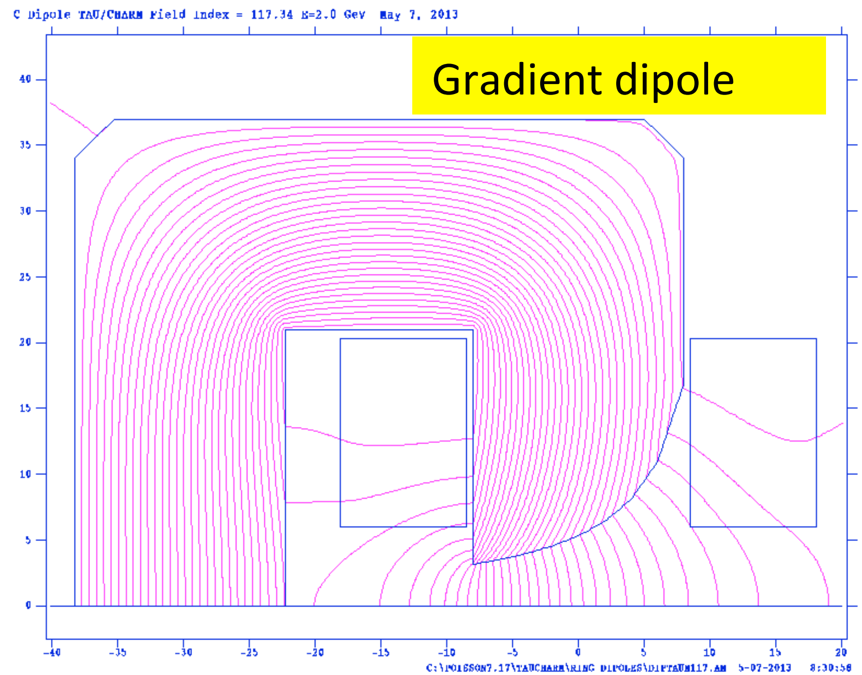
Di Pasquale

Lattice ST20_49



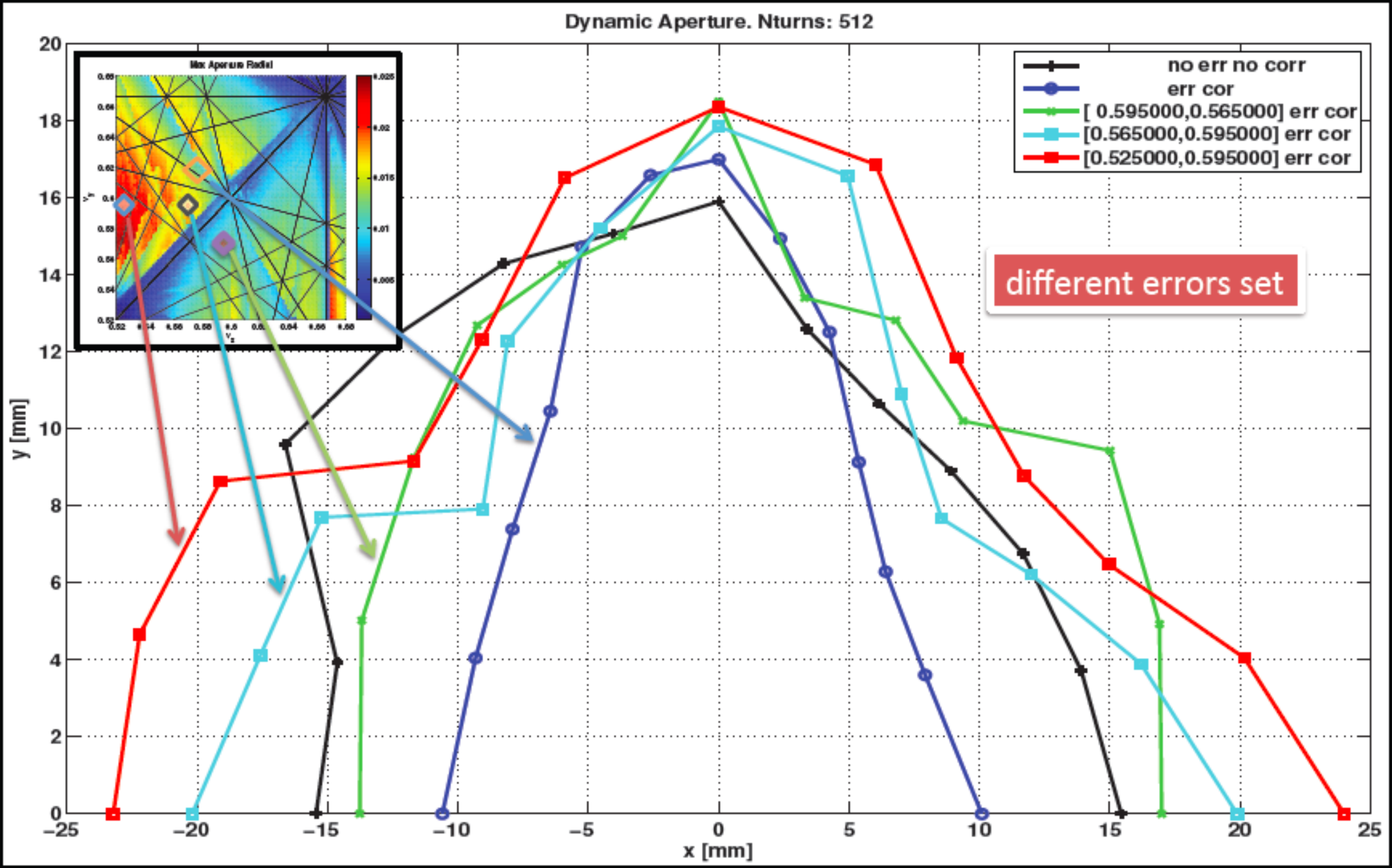
First design of MR magnets





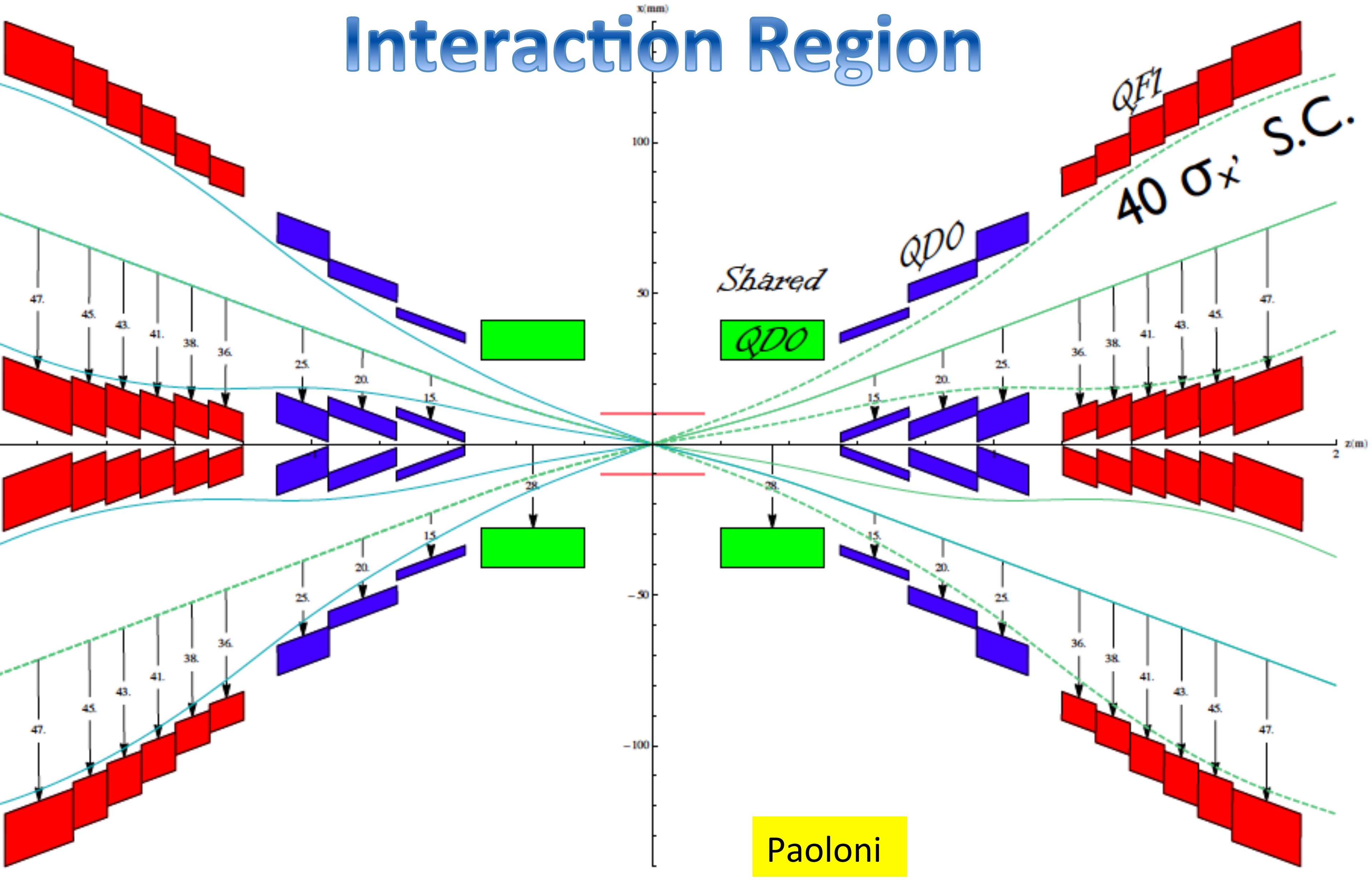
C. Sanelli

Dynamic Aperture at Best Points



Liuzzo

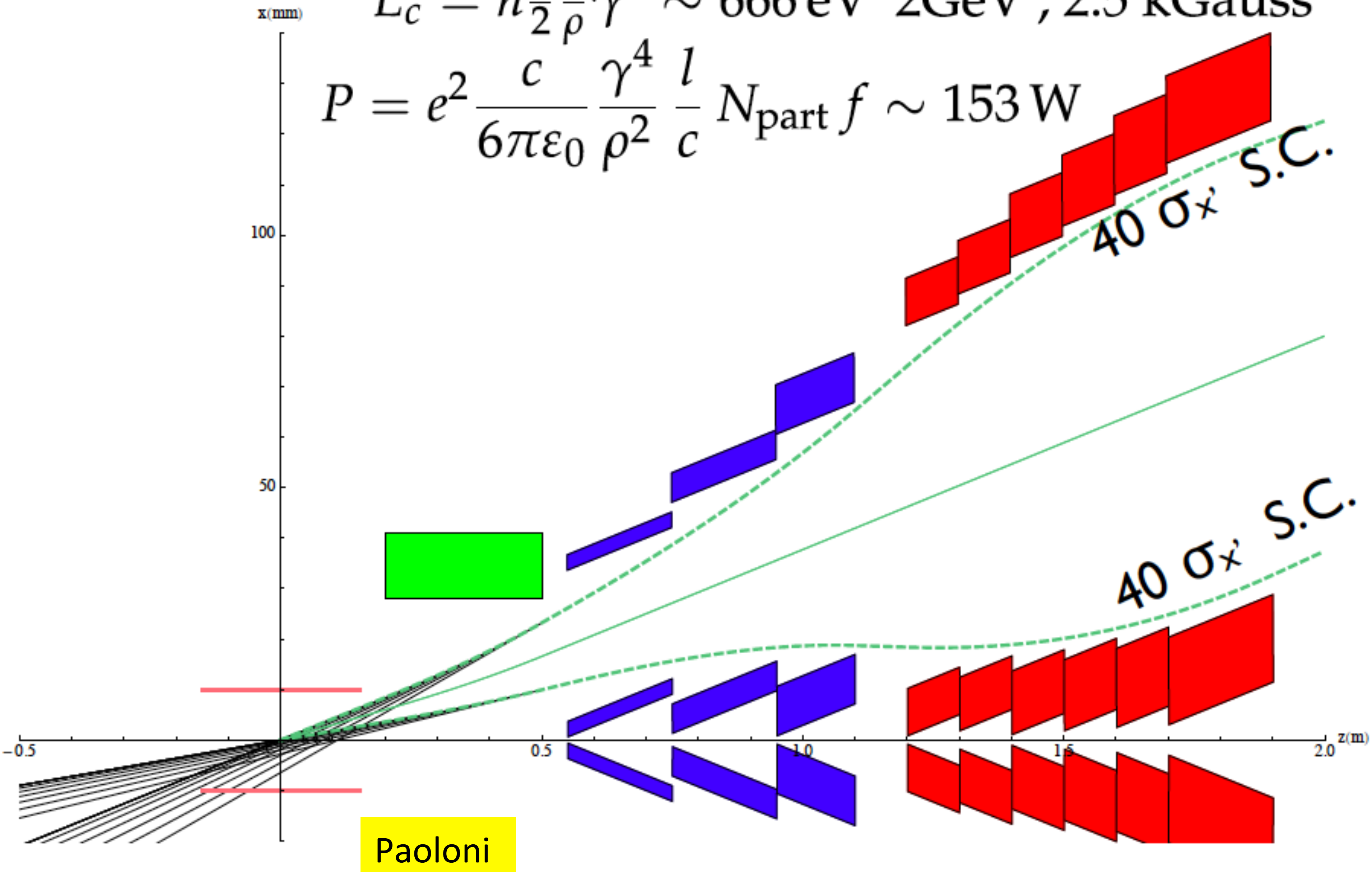
Stay Clear & Layout (Mike style)



Radiation fans from the common QDO

$$E_c = \hbar \frac{3}{2}\frac{c}{\rho}\gamma^3 \sim 666\,\mathrm{eV} \;\; 2\mathrm{GeV}\;,\, 2.5\;\mathrm{kGauss}$$

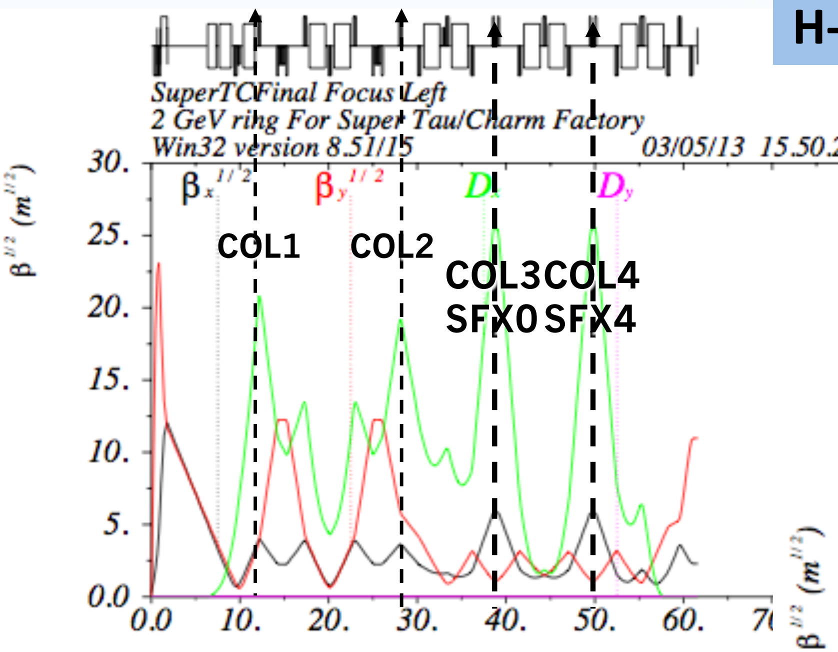
$$P = e^2 \frac{c}{6\pi\varepsilon_0}\frac{\gamma^4}{\rho^2}\frac{l}{c} N_{\mathrm{part}}\, f \sim 153\,\mathrm{W}$$



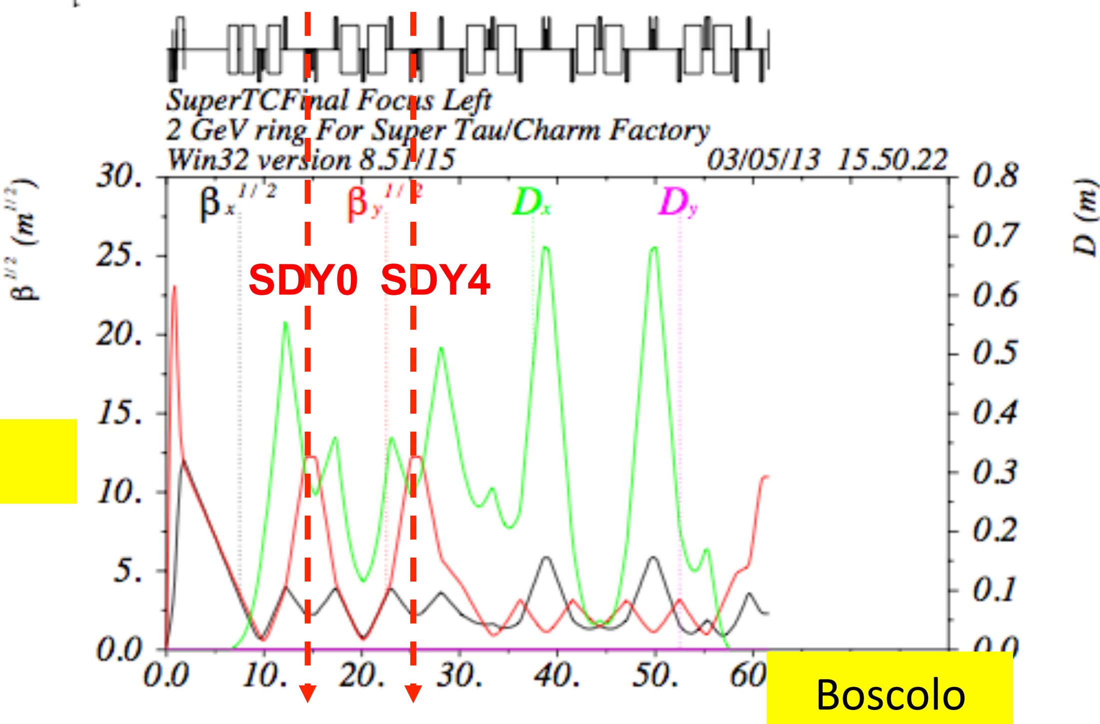
Final Focus collimation system

SECONDARY **PRIMARY**

H-collimators



V-collimators



M. Boscolo

Touschek lifetime-with tracking

# σX (@QF1)	Machine set	Lifetime (s) with IBS	Lifetime (minutes)
30	R(QD0)=1.5cm; R(QF1)=2cm; R(10m-)=3cm	**376** (162 s NO IBS)	**6.3**
40 +kinterm	R(QD0)=2.0cm; R(QF1)=3.5-4.6cm; R(10m-)=3cm with kinematic term	**484**	**8.0**

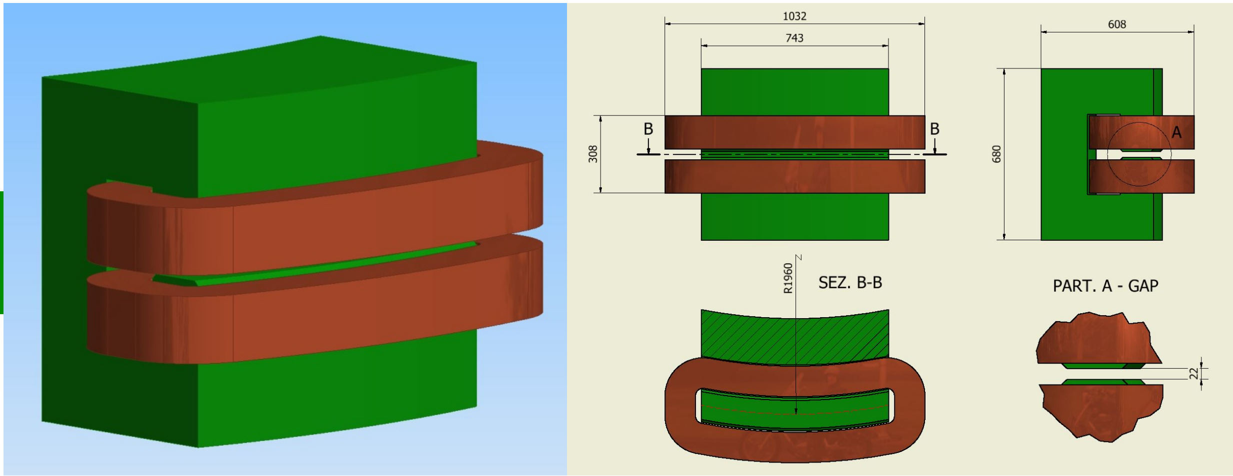
Lifetime Summary

	minutes
Touschek	7.8
Coulomb beam-gas	1.5hrs*60
Bremsstrahlung with residual gas	80hrs*60
Radiative Bhabha	11.3

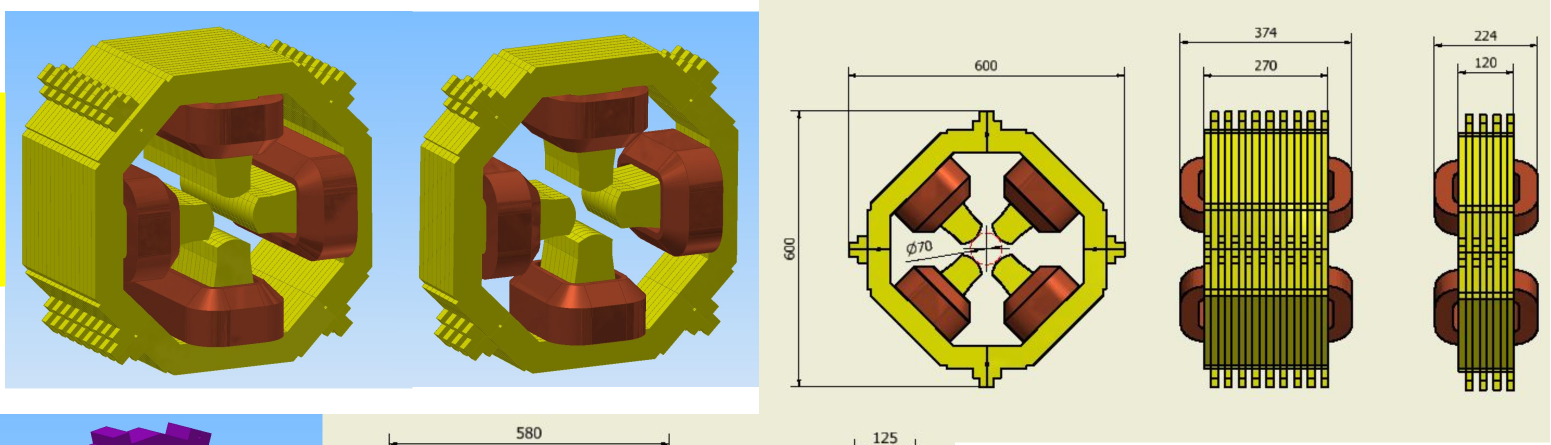
Boscolo

DR magnets design

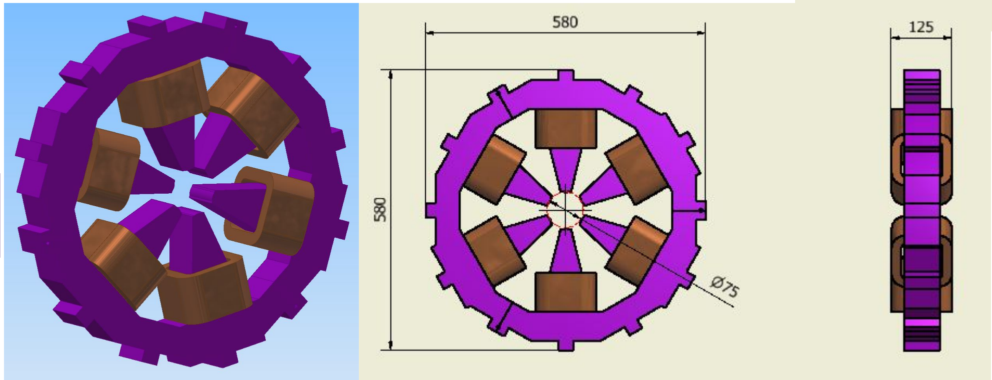
Dipoles



Long
And short
Quadrupoles



Sextupoles



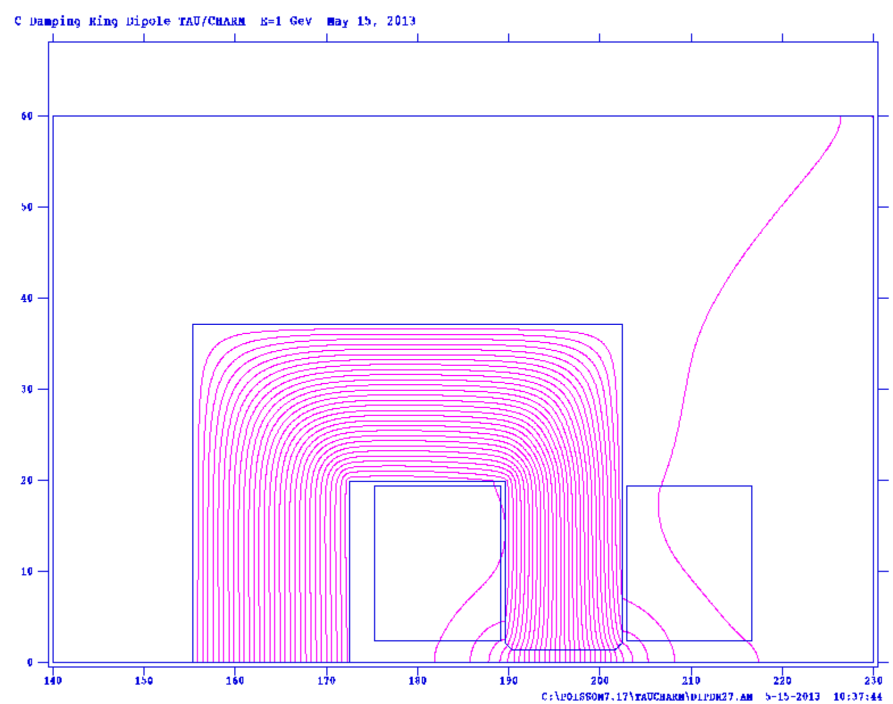
C. Sanelli

Damping Ring Magnetic System

- ❖ Bending Dipole Magnet ok
- ❖ Quadrupole Magnet ok
- ❖ Sextupole Magnet ok
- ❖ Horizontal and Vertical Steering Magnet to be done

Bending Dipole:		
Nominal Energy	GeV	1.0
Nominal Mag. Field (@ pole center)	T	1.7
Bending Radius	m	1,96
Dipole number		16
Gap (@ pole center)	m	0.027
Magnetic Length	m	0.77
Deflection angle	rad	0.3927
Ideal orbit sagitta	m	0.03766

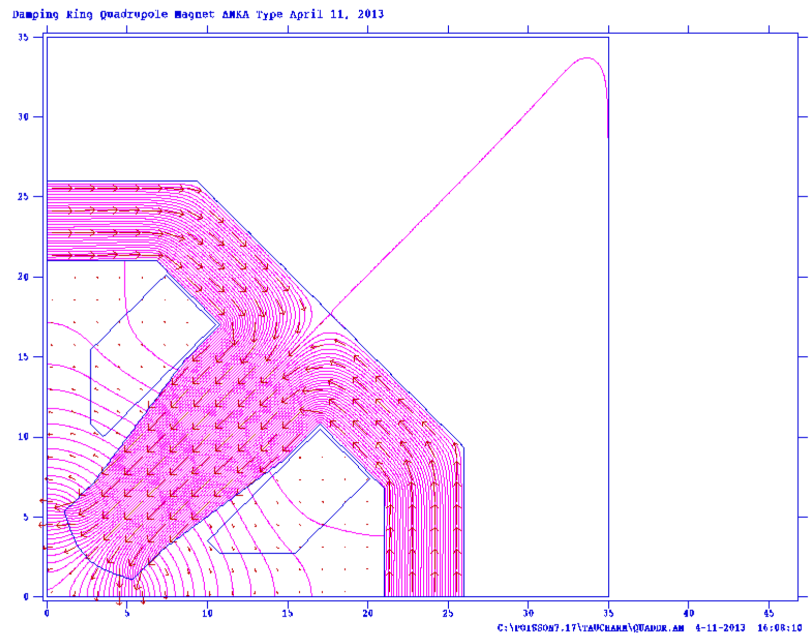
Type of magnet: Curved, C shape, parallel ends, laminated (1-1.5 mm)-massive (t.b.c.)

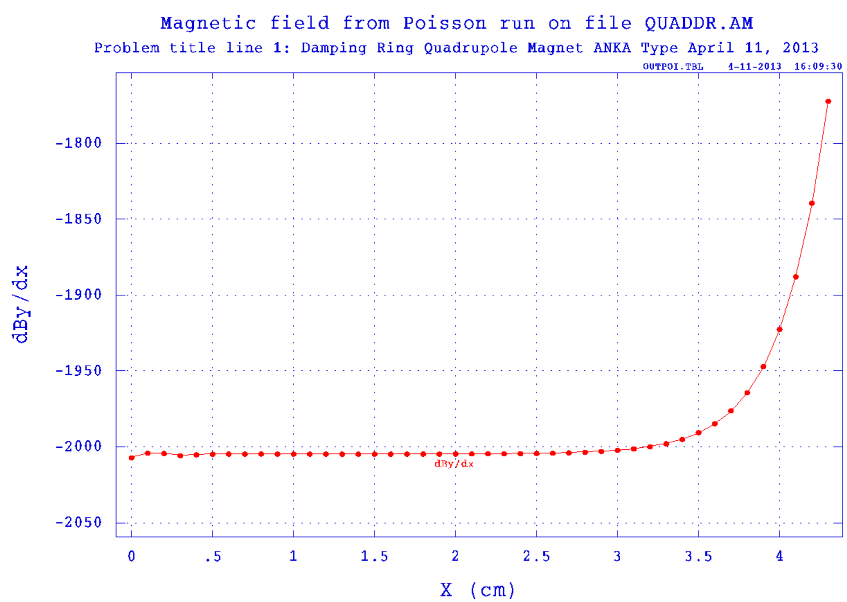


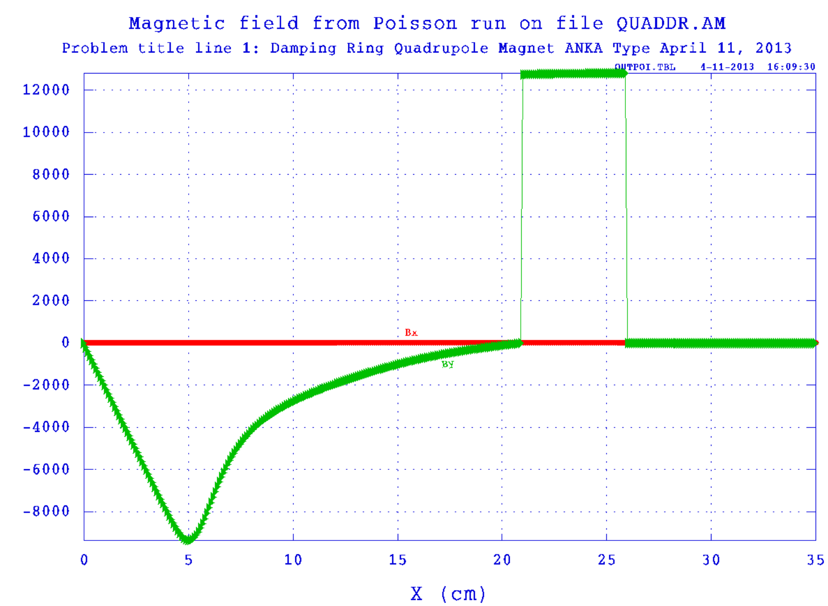
C. Sanelli

Quadrupole Magnet:

Nominal Energy GeV 1.0
Nominal Gradient T/m 20
Quadrupole number 12+38
Bore Radius m 0.035
Magnetic Length m 0.30/0.15
Type of magnet: Four Fold Symmetry
laminated (1-1.5 mm)
Max. Iron Induction T 1.6
Pole width m 0.06/0.08
Amper*turns/pole A 10120
(@ 20.0 T/m)







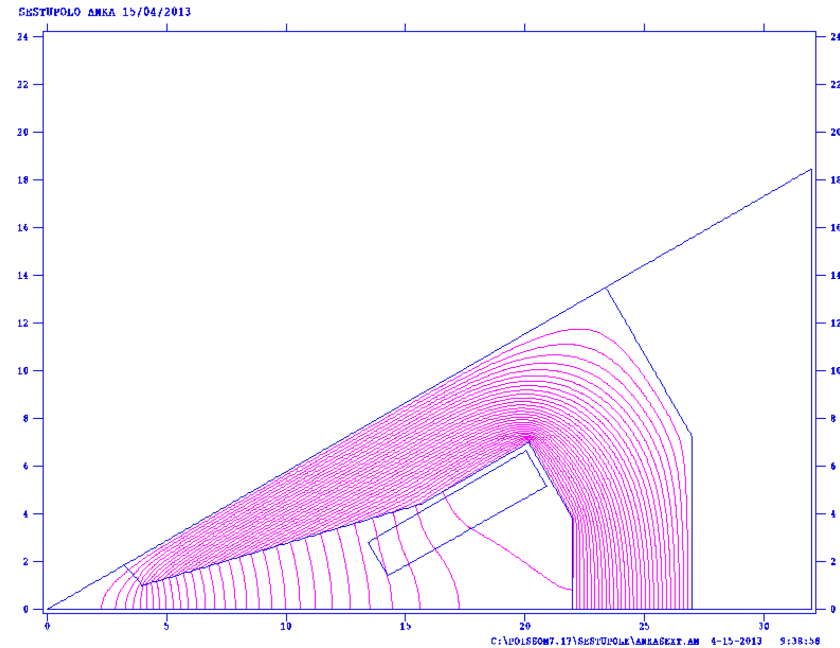
C. Sanelli

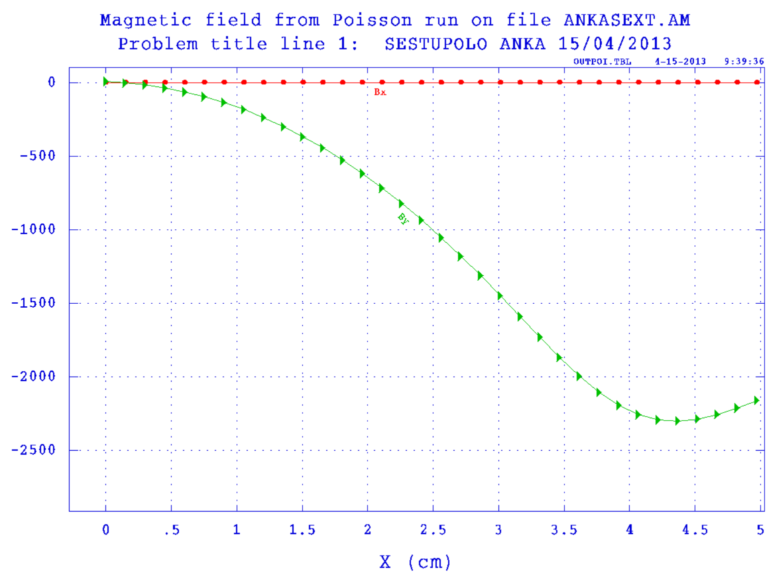
Sextupole Magnet:

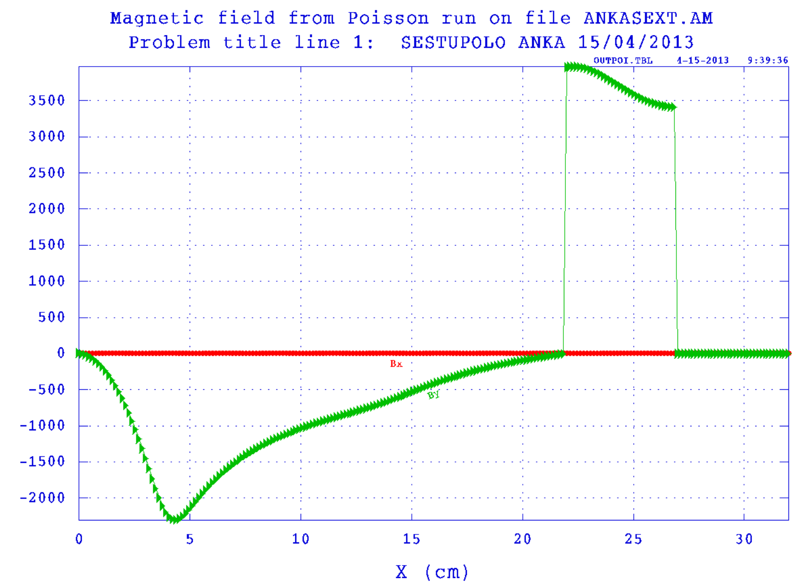
Nominal Energy	GeV	1.0
Nominal Gradient	T/m^2	154
Sextupole number		24
Bore Radius	m	0.035
Magnetic Length	m	0.1

Type of magnet: Six Fold Symmetry laminated (1-1.5 mm)

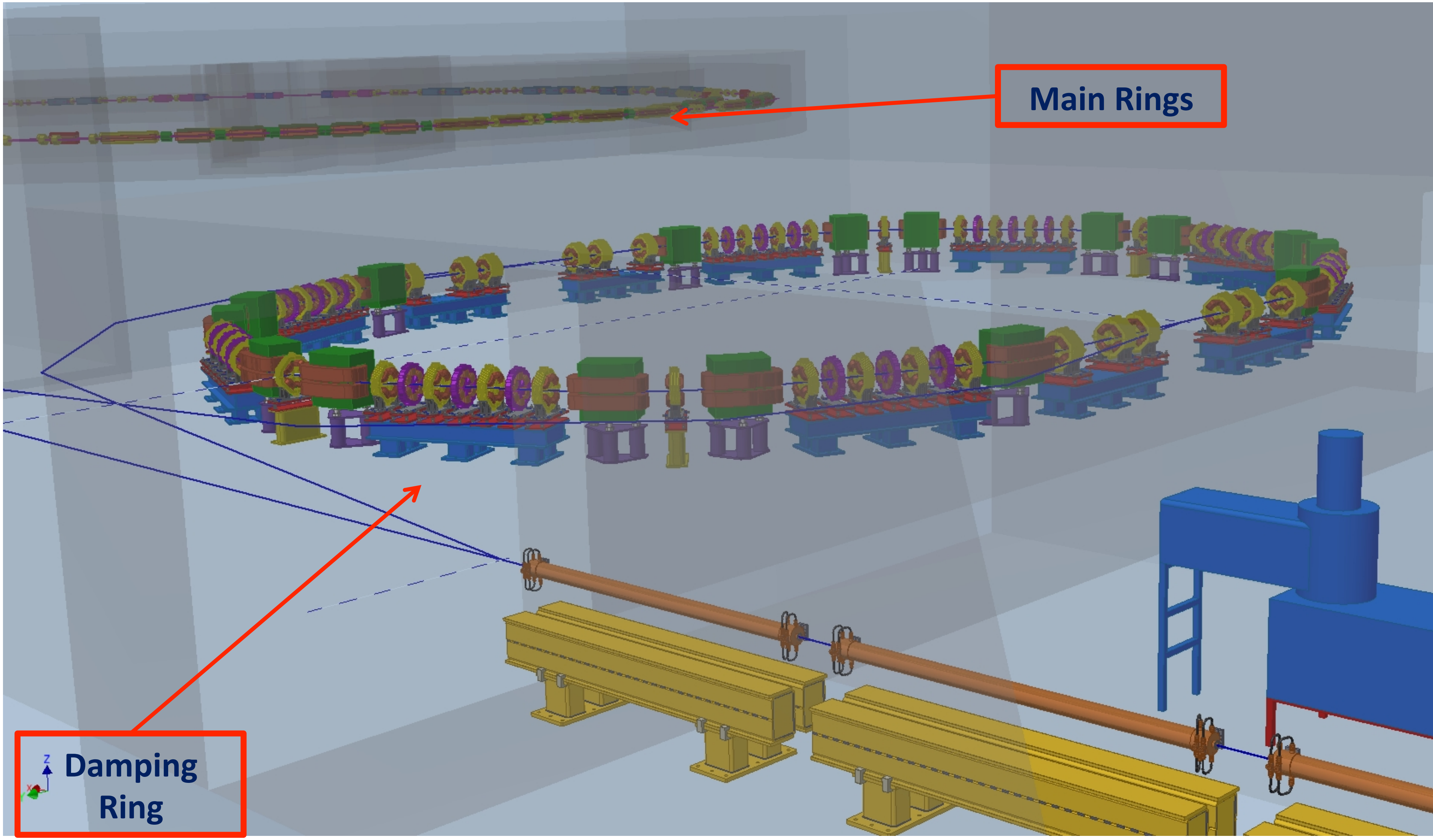
Max. Iron Induction	T	0.5
Pole width	m	0.08
Nominal A*turns/pole (@ 154 T/m^2)	A	2260





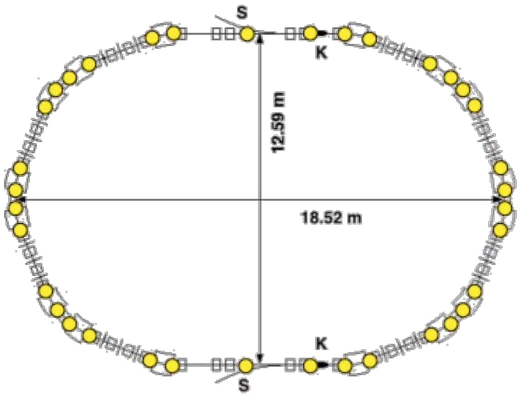


Damping Ring mechanical layout

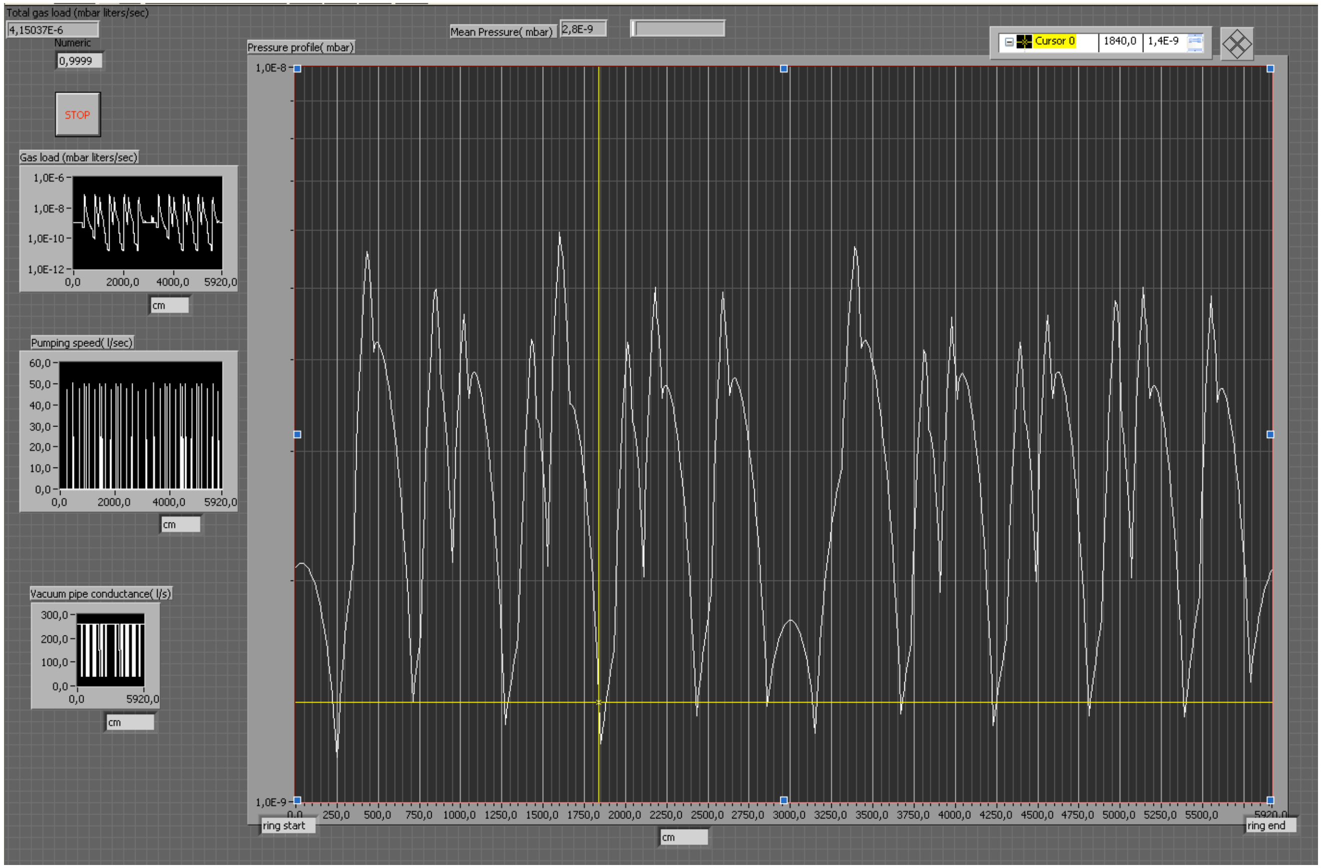


Di Pasquale

DR Results Vacuum profile



Simulations show that a mean pressure of about 3×10^{-9}mbar expected.



The Pressure profile for Damping ring has been simulated for nitrogen gas at 293K, taking into account thermal gas load too.

The SIP are assumed to be StarCell 120 l/s, connected to vacuum chamber by means of RF screened ports.

!CHAOS Control System

Another way to see !Chaos

Chaos can be view as a distributed computer

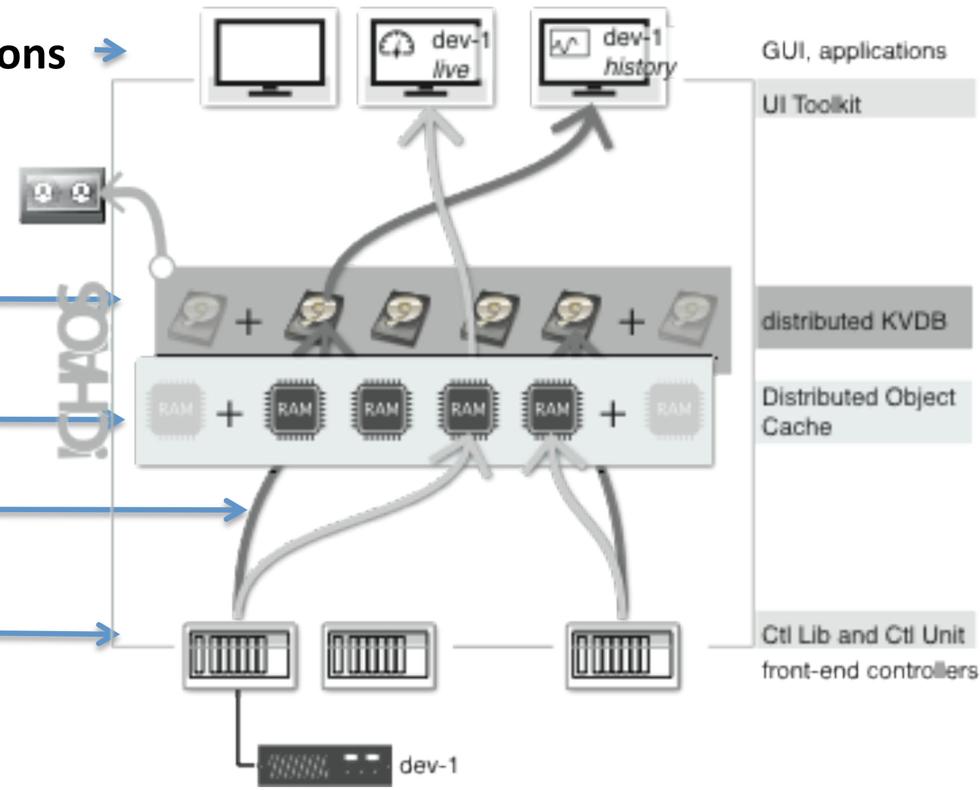
UI,EU are the CPUs running user applications

KVDB is the HardDisk

DOC is the RAM

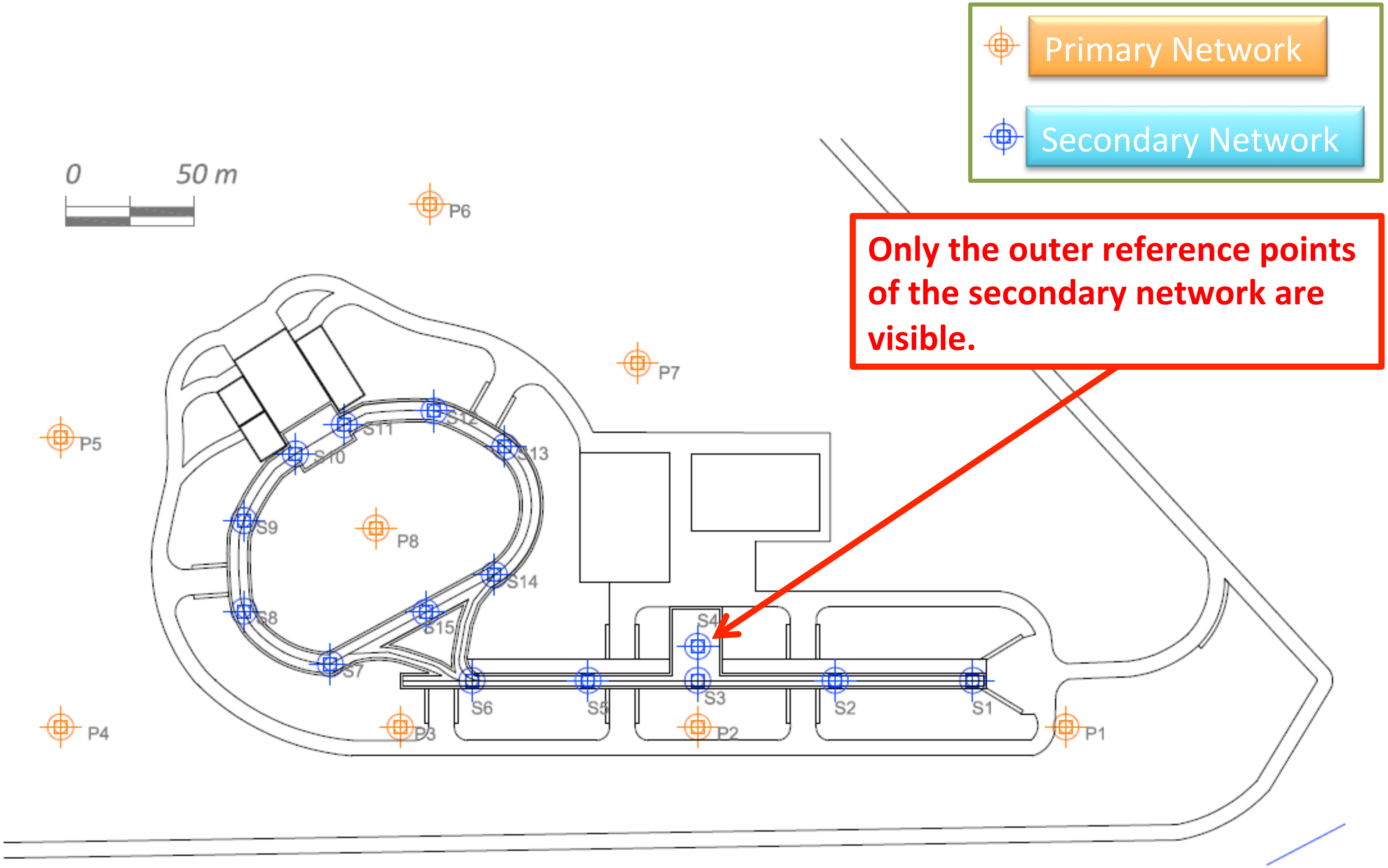
BSON is the BUS

CUs are the drivers attached to devices



Mazzitelli. Andrea Michelotti for the Control Team

τ-charm alignment case study



Feedbacks

Research activities that are common to DAFNE and Tau-Charm feedback systems

- Transverse feedback

The upgrade of the feedback systems designed for the SuperB is absolutely valid also for the Tau-Charm Factory.

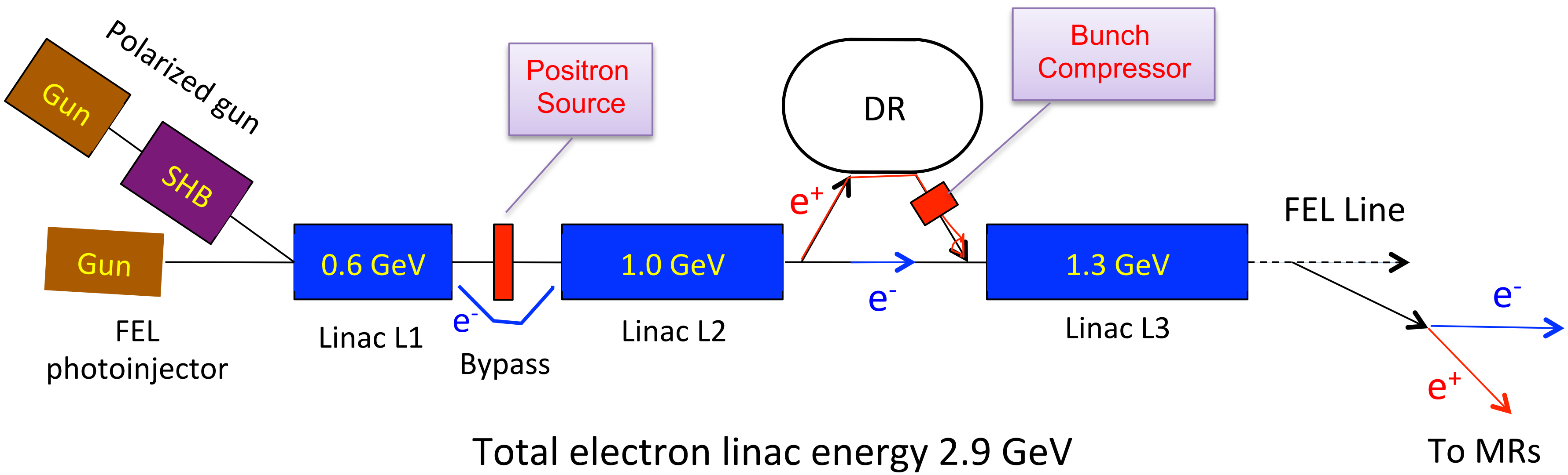
It is not even foreseen a scaled version respect to SuperB feedback design in terms of power or digital processing hardware, although Tau-Charm harmonic number should be smaller than Superb one, so, it asks for less computing but this variation is basically negligible.

- Longitudinal feedback

- Simplified analog longitudinal back end without QPSK modulation (only with amplitude modulation)
- 8-bit FPGA processing units tests during DAFNE runs

Drago

Tau-Charm Injection System



Total electron linac energy 2.9 GeV
Total positron linac energy 2.3 GeV

	Linac L1	Linac L2	Linac L3
N. of klystrons	3	6	7
N. of cavities	9	18	21
Max. Energy (GeV)	0.62	1.24	1.45

The number of klystrons and cavities allows to reach the maximum positron energy of 2.3 GeV also with one klystron off

index of the accelerator white paper

- Introduction
- Collider Main Rings
  - Beam parameters
  - Lattice
  - Interaction Region
  - Dynamic Aperture
  - Tolerance to errors
  - Backgrounds and lifetimes
  - E-cloud instability
  - Intra Beam Scattering
- Injection Complex
  - General layout
  - Sources (e+, e-)
  - Damping Ring
  - Linacs
  - Transfer Lines
- Accelerator Systems
  - Diagnostics
  - Feedbacks
  - RF
  - Controls
  - Vacuum requirements
  - Magnets
  - Mechanics
  - Survey and alignment
  - Health Safety and Environment
- Conventional Facilities
  - Layout & site
  - Infrastructures
  - Civil engineering
  - Power electronics
  - Fluids
  - Cryogenics
- Costs and schedule

physics

- Is there a strong physics case?
  - Discovery physics
  - Progress physics

Discovery: general considerations

- The success of the standard model and the "no show" of new physics (so far) at LHC impose a systematic and unbiased research program
- The general model independent parametrisation of SU2xU1 symmetric effective interactions include about 18 operators
- The four lepton sector involves three operators
- The two lepton sector five

Gauge Invariant dim-6 operators in the SM

- $[\bar{L}^i_p \gamma_\mu L_{q\;i}]\,[\bar{L}^j_r \gamma^\mu L_{s\;j}]$
- $[\bar{E}_p \gamma_\mu E_q]\,[\bar{E}_r \gamma^\mu E_s]$
- $[\bar{L}_p \gamma_\mu L_q]\,[\bar{E}_r \gamma^\mu E_s]$

4 Leptons

Gauge invariant with two fermions

- $[\bar{L}_p \sigma_{\mu\nu} E_q H]\ B^{\mu\nu}$
- $[\bar{L}_p \sigma_{\mu\nu} E_q \sigma^I H]\ W^{I\ \mu\nu}$
- $[\bar{L}_p \gamma_\mu L_q]\ [H^\dagger D^\mu H]$
- $[\bar{L}_p \sigma^I \gamma_\mu L_q]\ [H^\dagger \sigma^I D^\mu H]$
- $[\bar{E}_p \gamma_\mu E_q]\ [H^\dagger D^\mu H]$

2 Leptons + Gauge bosons

A “Fermi” type Lagrangian

$$\sum_i \frac{c_i}{\Lambda_i^2}\,\mathcal{O}_i$$

with conventional $C_i = 4\pi$

The case of the four leptons sector

- Two probes
  - Production (e+ e- incoming)
  - Decay (tau)

The case of the four leptons sector

PRODUCTION $\quad \dfrac{4\pi\alpha^2}{3s} \quad .vs. \quad \dfrac{4\pi\alpha}{3}\,\dfrac{4\pi}{\Lambda^2}\,\dfrac{s}{\Lambda^2}$

the ratio $\quad \sim \quad \dfrac{s}{\alpha\Lambda^2}\,\dfrac{4\pi s}{\Lambda^2} \quad \sim \quad \boxed{\dfrac{4\pi}{\alpha}\left(\dfrac{s}{\Lambda^2}\right)^2}$

The case of the four leptons sector

DECAY $\Gamma_{rare} \sim \left(\frac{4\pi}{\Lambda^2}\right)^2 M^5$

$\Gamma_{weak} \sim G_F^2 M^5$

$$\frac{\Gamma_{rare}}{\Gamma_{weak}} \equiv BR \simeq \boxed{\frac{(4\pi)^2}{G_F^2 \Lambda^4}}$$

The case of the four leptons sector

$$G_F \sim M_F^{-2} \quad \text{where} \quad M_F \sim 300\ \text{GeV}$$

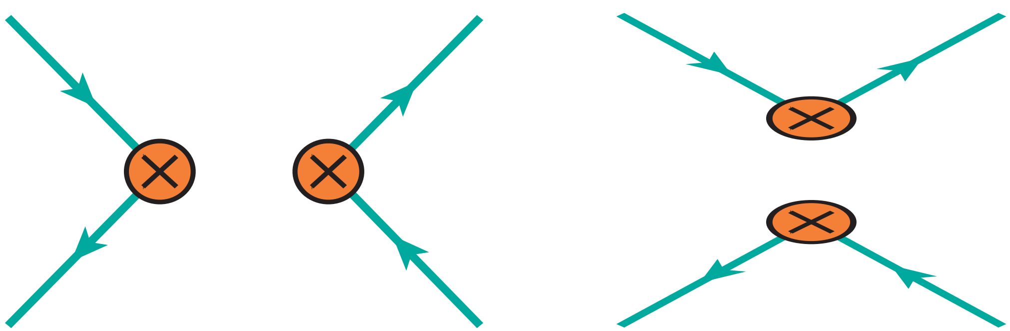
$$\Longrightarrow \boxed{BR \simeq \left(\frac{M_F^2}{\Lambda^2}\right)^2 (4\pi)^2}$$

The case of the four leptons sector

- Decay much more powerful
  - If BR ≈ 10^-9 are accessible → Λ ≈ 200 TeV

the interference case

- New physics may occur via "Flavor violation" and/or via "Dirac violation"
  - novel Dirac structures for contact interactions
  - LxL
  - RxR
  - LxR
  - RxL



- In this case NP can interfere with ordinary physics

INTERFERENCE

1.production $\sim \frac{4\pi}{\Lambda^2}\frac{\alpha}{3}$

the ratio $\sim \frac{s}{\Lambda^2}\frac{1}{\alpha}$

2.decay $\sim \frac{M_F^2}{\Lambda^2}(4\pi)$ ⇒ Λ≈10^4TeV

interference in production

- Production interference can be detected from forward backward asymmetries (both signs)
- Polarization is an essential asset
- FB asymmetries of the order 10^-6 can be sensitive to $\Lambda \approx$ 10–20 TeV

Tau charm and LEP limits

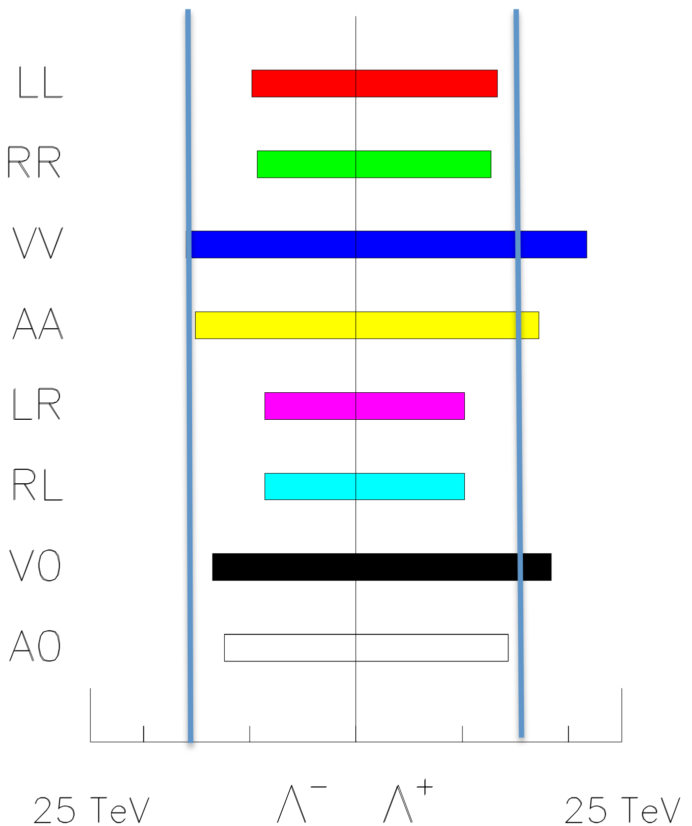


Fig. 2. Limits on the scale of CI in $e^+e^- \to \mu^+\mu^- + \tau^+\tau^-$ using LEP combined measurements from 130 to 209 GeV

The vertical blue lines are the Tau charm new limits

Discovery: two fashionable benchmarks

- CPV in D mixing (or decay)
- Tau $\rightarrow$ mu gamma

Ciuchini, Silvestrini

CPV IN D MIXING

- In the SM, M_{12} and Γ_{12} dominated by long-distance, non-calculable but real with excellent accuracy ($O(1°)$)
- Goal: search for NP manifesting itself in $\arg(M_{12}/\Gamma_{12}) \geq$ few degrees
- Present status:
  $-39° < \arg(M_{12}/\Gamma_{12}) < 35°$ @95% probability

- How do we get there?
  - define $|D_{S,L}\rangle = p|D^0\rangle \pm q|\bar{D}^0\rangle$
  - measure $x \approx |M_{12}|/\Gamma$, $y \approx |\Gamma_{12}|/2\Gamma$, $|q/p|-1 \mu \arg(M_{12})-\arg(\Gamma_{12})$ and $\phi_f \approx \phi = \arg(y+i(1-|q/p|)x)-\arg(\Gamma_{12})$
  - extract $|M_{12}|$, $|\Gamma_{12}|$, $\arg(M_{12}/\Gamma_{12})$
  - accuracy on $|q/p|-1$ and on ϕ crucial to measure $\arg(M_{12}/\Gamma_{12})$ and to disentangle $\arg(M_{12})$ from $\arg(\Gamma_{12})$ (relative to a CP-conserving amplitude such as a CF decay)

D MIXING @ SYMMETRIC e+e-

- Time-integrated decays of quantum-correlated D-anti D pairs, with Dbar decaying in a flavour-specific final state g:

  $|\langle f,g|(D\bar{D})_{\eta c}\rangle|^2 = |A_f\bar{A}_g|^2\,(1 - r_f\cos(\delta_f+\phi)(1+\eta_c)y + r_f\sin(\delta_f+\phi)\,(1+\eta_c)\,x + O(x^2,y^2))$, with $r_f=\bar{A}_f/A_f$, δ_f strong phase

- At the $\psi(4040)$ produce DD^* pairs, obtain $\eta_c=-1$ for $D^*\to D\pi$ and $\eta_c=1$ for $D^*\to D\gamma$, exploit the linear terms for $\eta_c=1$ to measure x, y, ϕ_3

Bondar, Poluektov & Vorobiev

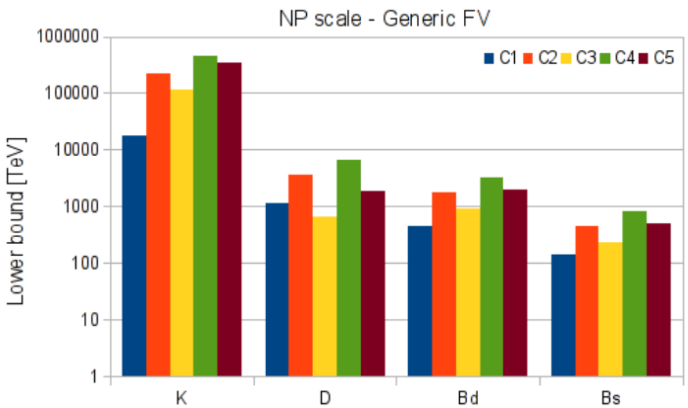
D MIXING CPV REACH

	Belle-II (50 ab^{-1})	LHCb upgr. (50 fb^{-1})	Tau-charm (9 ab^{-1})
x (10^{-4})	8	1.5	1.7
y (10^{-4})	4	1	1.7
$\|q/p\|$-1 (10^{-2})	5	1	0.5
ϕ (°)	2.6	--	0.5

- Belle-II does not include strong phases from BES-III or Tau-charm
- LHCb upgrade x, y & ϕ should be revised as measurement from $K_s\pi\pi$ should allow for CPV
- Tau-charm extrapolated from Bondar et al
- Only Tau-charm allows for sub-degree determination of $\arg(M_{12})$ and $\arg(\Gamma_{12})$

IMPLICATIONS FOR NP SCALE

- The upper bound on $\arg(M_{12})$ can be turned into a bound on the coefficients of the relevant effective Hamiltonian:
  - $H_{eff}=\Sigma_i(c_i/\Lambda^2)\,O_i^6$
- A lower bound of the NP scale Λ can be obtained for fixed couplings c_i, or an upper bound on the couplings c_i can be obtained for fixed NP scale Λ



Generic Flavor Violation

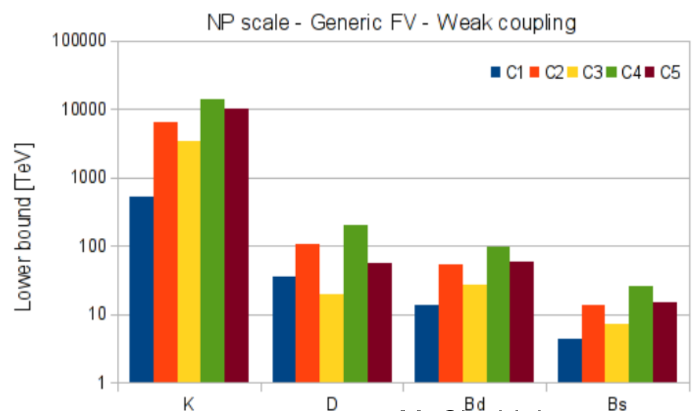
Non-perturbative NP

$\Lambda > 4.6\ 10^5$ TeV

NP in α_W loops

$\Lambda > 1.4\ 10^4$ TeV

preliminary results



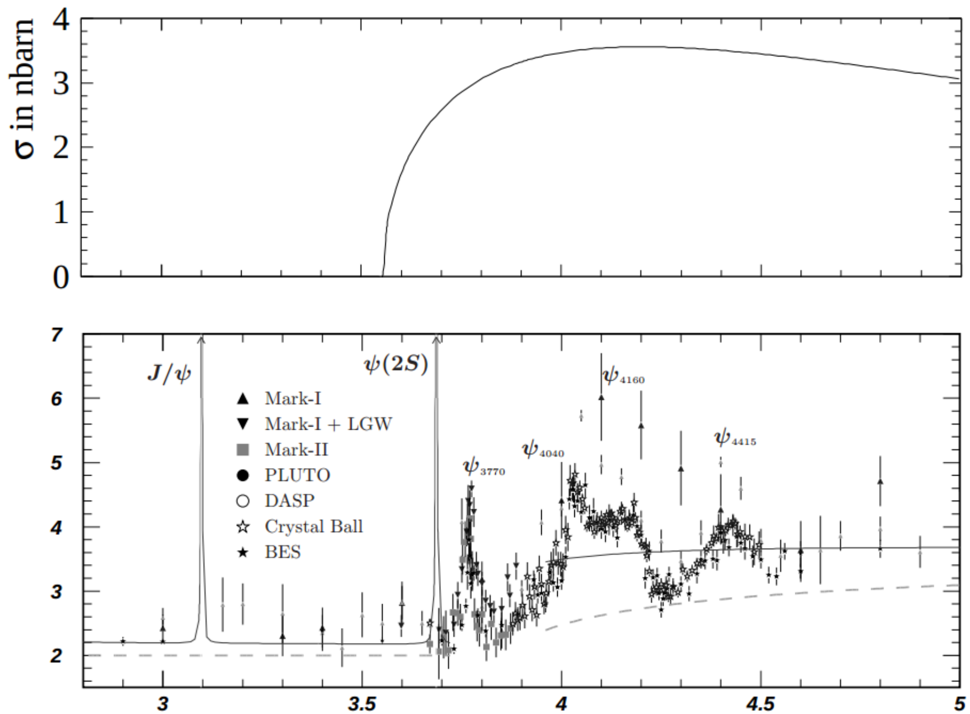
M. Ciuchini

Tau → mu gamma

Tau pairs production rates

at √s = 4.04 GeV $\sigma_{ee \to \tau\tau} \cong 3.4$ nb
at √s = 10.58 GeV $\sigma_{ee \to \tau\tau} \cong 1.0$ nb

Tau-Charm ($L = 2 \times 10^{35}$ $cm^{-2}s^{-1}$) ≅ **7 x 10^9** τ τ events per year
BELLE II ($L = 8 \times 10^{35}$ $cm^{-2}s^{-1}$) ≅ **8 x 10^9** τ τ events per year
[Snowmass year = 10^7 s]



$\tau \rightarrow \mu\,\gamma$

Eγ for ISR ττγ background is lower than Eγ for τ → μγ
when the machine is operated at √s = 4.2 GeV

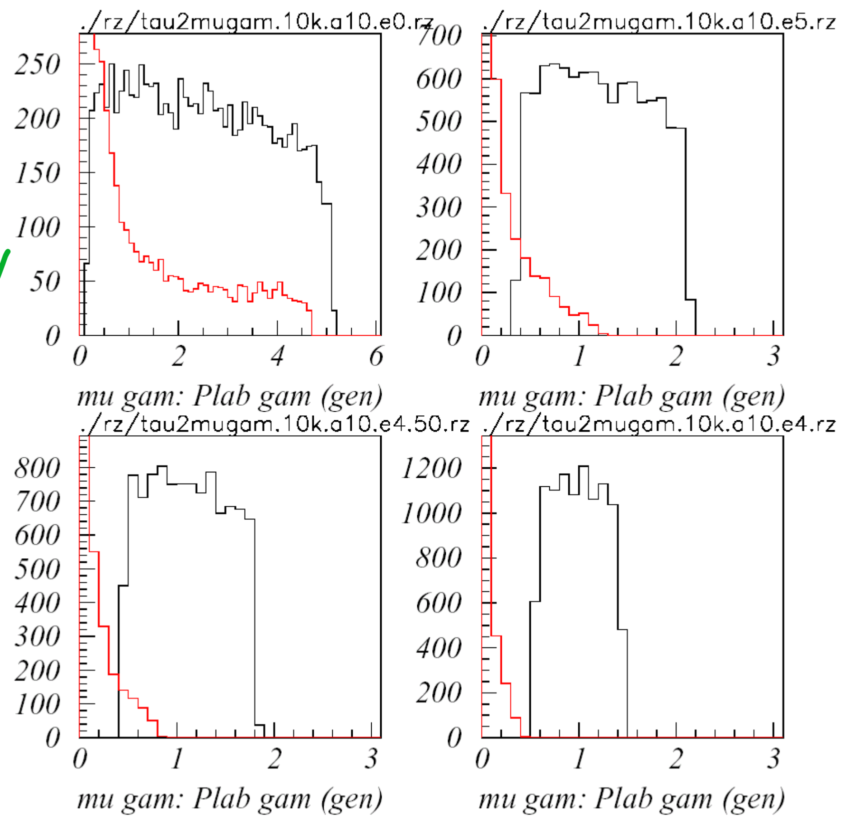
Eγ (CMS) from τ → μγ and ISR(ττγ)

Υ(4s)

$\sqrt{s} = 10.58GeV$

maximum σ=3.6nb

$\sqrt{s} = 4.25GeV$



$\sqrt{s} = 5.0GeV$

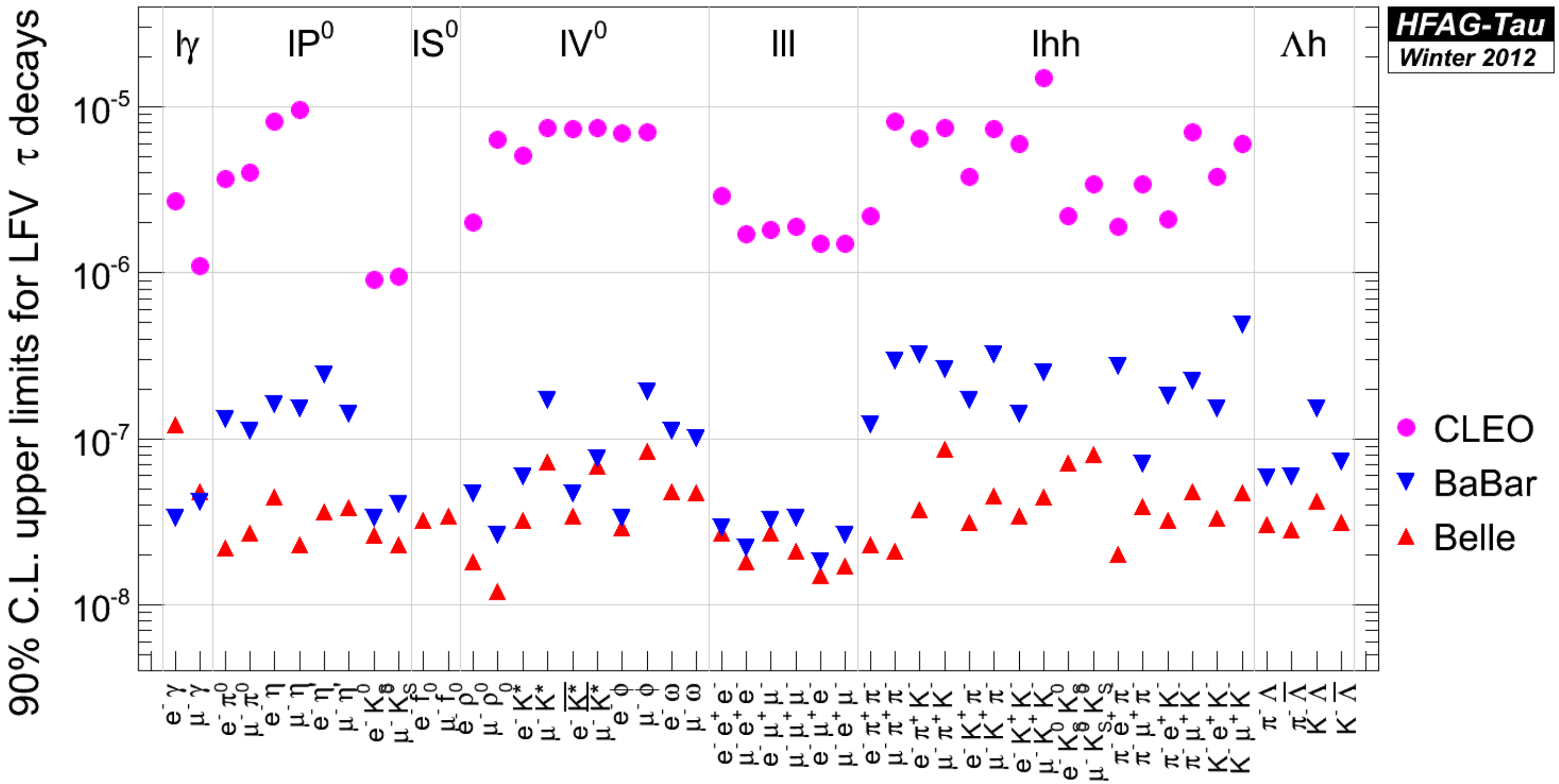
$\sqrt{s} = 4.0GeV$

Background suppression BINP simulations

Based on good calorimetry (Cesium Iodide ensure that) and good pion muon identification .

Novosibisk proposes Farich, we think that time of flight is better (as in PANDA) in this energy range. Goal is factor 30 suppression of pion contamination.

τFV



- BELLE-II [50ab^{-1}]: B($\tau \rightarrow \mu\gamma$) < 5 x 10^{-9}, systematically limited
- tau-charm: B($\tau \rightarrow \mu\gamma$) < 5 x 10^{-10}, statistically limited

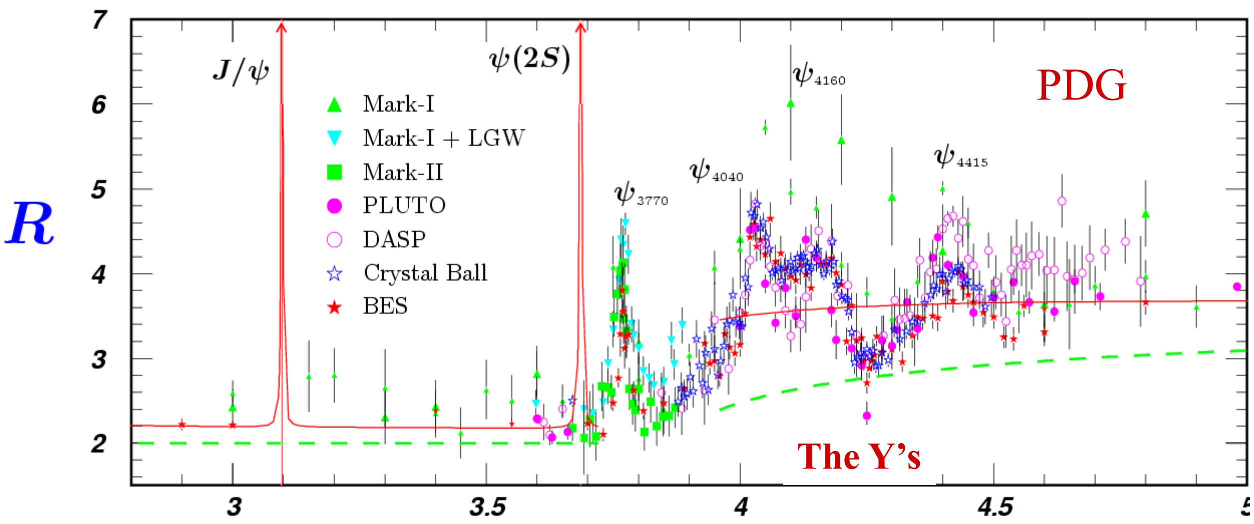
Also CP violation in τ decays

- Number of tau events at tau-charm and belle-II is comparable
- Final states in CP-violating observables involve multi-h (K or pi) + neutrino. More studies are needed to make a sensible comparison between the efficiency of tau-charm and Belle-II on these modes
- Polarization increases the number/improves the sensitivity of CP-violating observables and provides a better control on systematics

Progress physics

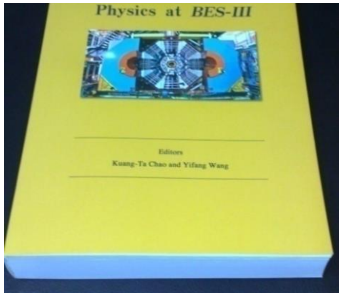
- Perturbative QCD
  - R and g-2
  - Tau hadronic decays
  - Fragmentation functions (pt dependent??)
  - Meson and baryon form factors
- Charm spectroscopy
- Precise determination of sin_theta_W
- Gamma gamma collisions (e- e- mode)

spectroscopy



Example: the BesIII physics case

- Study of hadron spectroscopy
  - search for non-$q\bar{q}$ or non-qqq states
  - meson spectroscopy
  - baryon spectroscopy



arXiv: 0809.1869

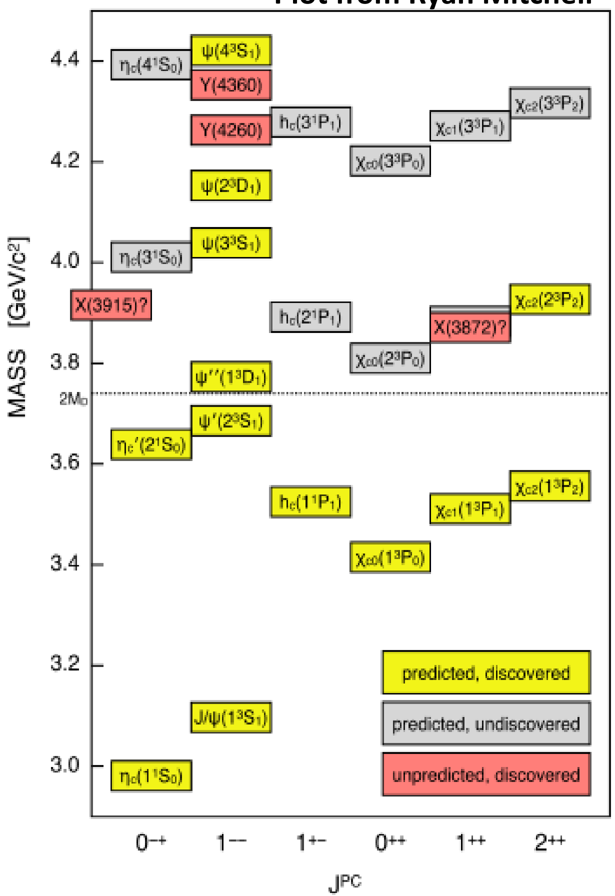
- Study of the production and decay mechanisms of charmonium states: J/ψ, $\psi(2S)$, $\eta_c(1S)$, $\chi_{C\{0,1,2\}}$, $\eta_c(2S)$, $h_c(^1P_1)$, $\psi(3770)$, etc.

New Charmonium states above open charm threshold.

- Precise measurement of R values, τ mass, ...
- Precise measurement of CKM matrix
- Search for DDbar mixing, CP violation, etc.

Charmonia

Plot from Ryan Mitchell



Charmonium spectroscopy

- Charmonium states below open charm threshold are all observed

Above open charm threshold:

- many expected states not observed
- many unexpected observed

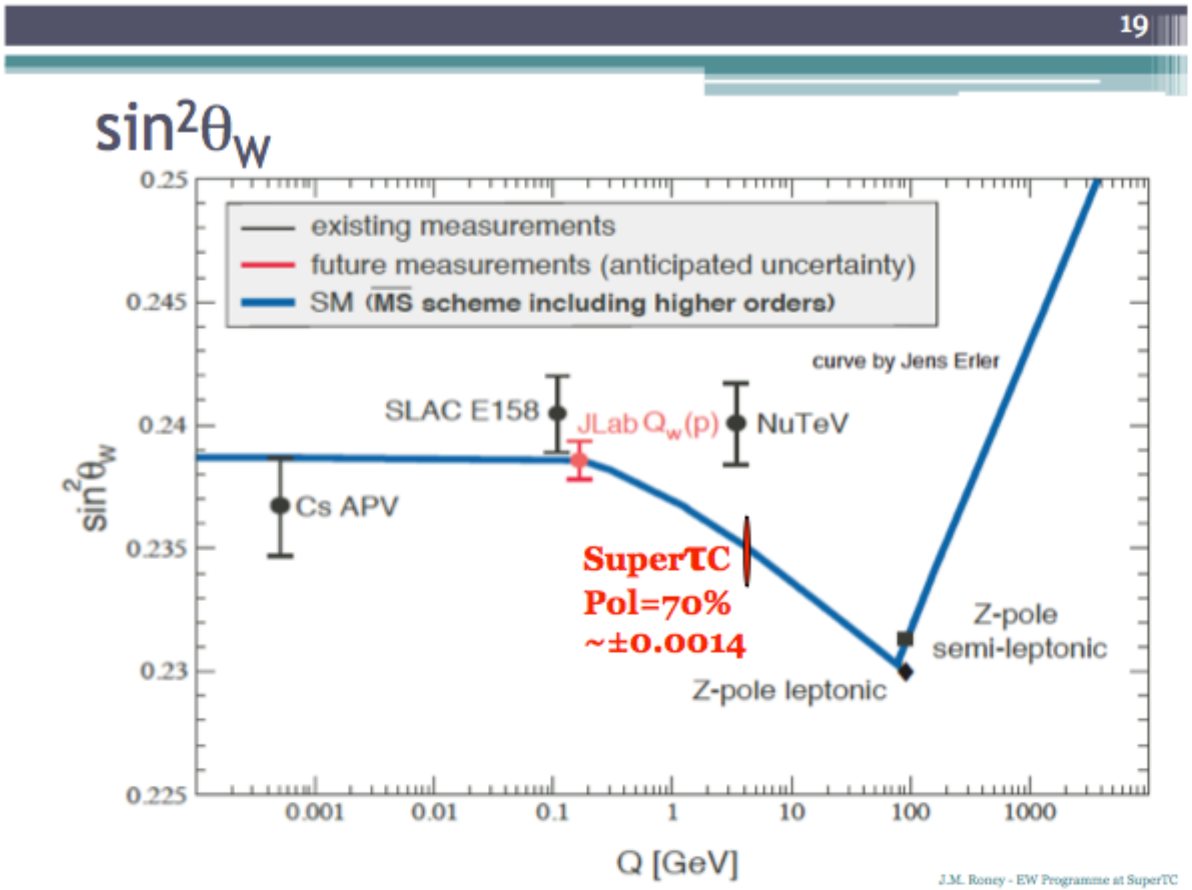
Z(4430)
Z(4250)
Z(4050)
Z(3900)

X(3872)

XYZ(3940)

X(3915)
X(4160)
Y(4008)
Y(4140)
Y(4260)
Y(4360)
X(4350)
Y(4660)

Precision EW tests



Back to accelerator

- If you now wonder about cost and planning
  - Financial and human resources
  - Primitive planning

Cost projection

- Training from SuperB costing review
- A tau charm projected WBS based on, item specific, scaling factors from SuperB WBS
- More than 30 firms quotations entries

Sanelli

WBS Contributors:

- Linac (*R. Boni*)
- Diagnostics (M. Serio)
- Superconducting Magnets (*P. Fabbricatore*)
- Vacuum (A. Clozza)
- Cryogenics (C. Ligi)
- Radioprotection (A. Esposito)
- Feedbacks (A. Drago)
- RF (*A. Gallo*)
- Controls (G. Mazzitelli)
- Mechanics and Alignment (S. Tomassini)
- Conventional Safety (A: Chiarucci)
- Electric Services (Ricci R.)
- Fluids (G. Schillaci)
- Power Supplies (M. Sedita)

In addition evaluations by *A. Variola* on injector and C. Sanelli on magnets

The superB effort

- 26 systems have been analysed in detail
- More than 1000 pages of documentation have been collected (available on web repository)
- In many cases three or more companies have been inquired for the best price
- Very preliminary layouts have been used to consider power distribution, cabling, cooling piping, etc., on the base of the past experience

Tau charm Factory case
(work in progress)

- Linac for **2.9** GeV e^- and **2.3** GeV e^+;
- Linac Length around **200** m;
- Two **Symmetric** rings;
- Storage Ring Length -> **600** -> **362** -> **326** m.

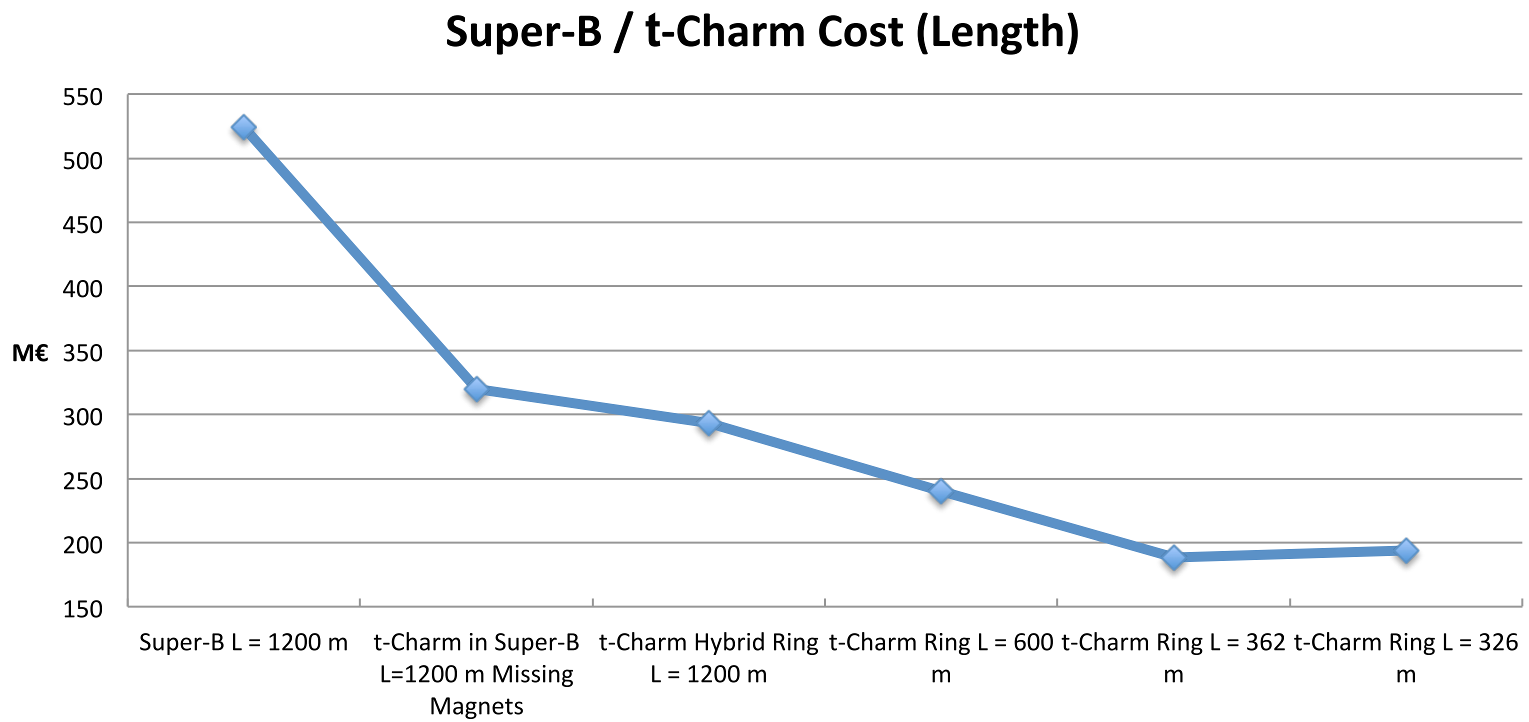
SuperB Final cost estimates

- The rough final cost partition (Meuros)
  - 530 the “bare” accelerator
  - 100 VAT
  - 100 Personnel
  - 80 SLAC donation (maximum reuse)
  - 140 ML risks and spares
- Unavoidable sum at least of the order of 650

Preliminary tau charm bare and "plus tax" cost summary

COST EVALUATION SUMMARY (VAT Excluded)			VAT (21%/10%)	TOTAL
		k€	k€	k€
LINAC SYSTEM		29614,54	6219,05	35833,59
LINAC - DAMPING RING TRANSFER LINE		4285,40	899,93	5185,34
DAMPING RING		12150,00	2551,50	14701,50
ELECTRON BEAM TRANSFER LINE		4428,17	929,92	5358,09
POSITRON BEAM TRANSFER LINE		4428,17	929,92	5358,09
STORAGE RINGS		58756,23	12338,81	71095,04
POLARIZATION		1991,00	418,11	2409,11
INTERACTION REGION		8187,06	1719,28	9906,34
SYNCHROTRON LIGHT SOURCES		0,00	0,00	0,00
PHOTON LINES		0,00	0,00	0,00
GENERAL FACILITIES		4816,42	1011,45	5827,86
ELECTRIC SERVICES		4992,19	1048,36	6040,55
CRYOGENICS		4018,00	843,78	4861,78
CIVIL ENGINEERING		35551,88	3555,19	39107,07
ARCHEOLOGICAL DIGGING AND VERIFICATION		2000,00	420,00	2420,00
GEOLOGICAL PROSPECTION		89,22	18,74	107,96
GAS PIPELINE CONNECTION		200,00	42,00	242,00
WATER DUCT CONNECTION		200,00	42,00	242,00
ELECTRIC DISTRIBUTOR CONNECTION		10200,00	2142,00	12342,00
FIRE DETECTION SYSTEM		227,69	47,81	275,50
FIRE EXTINGUISHING		736,86	154,74	891,61
CRANE & LIFTING SYSTEMS		995,32	209,02	1204,34
RADIATION PROTECTION		1083,35	227,50	1310,85
CONVENTIONAL SAFETY SYSTEM		252,00	52,92	304,92
PRELIMINARY EXTERNAL AREA MAKE-UP		3559,37	747,47	4306,84
FINAL EXTERNAL AREA MAKE-UP		1000,00	210,00	1210,00
TAU-CHARM COMPLEX COST		**193762,88**	**36779,50**	**230542,38**

Super-B -> Tau-Charm Cost



For Tau-Charm only:

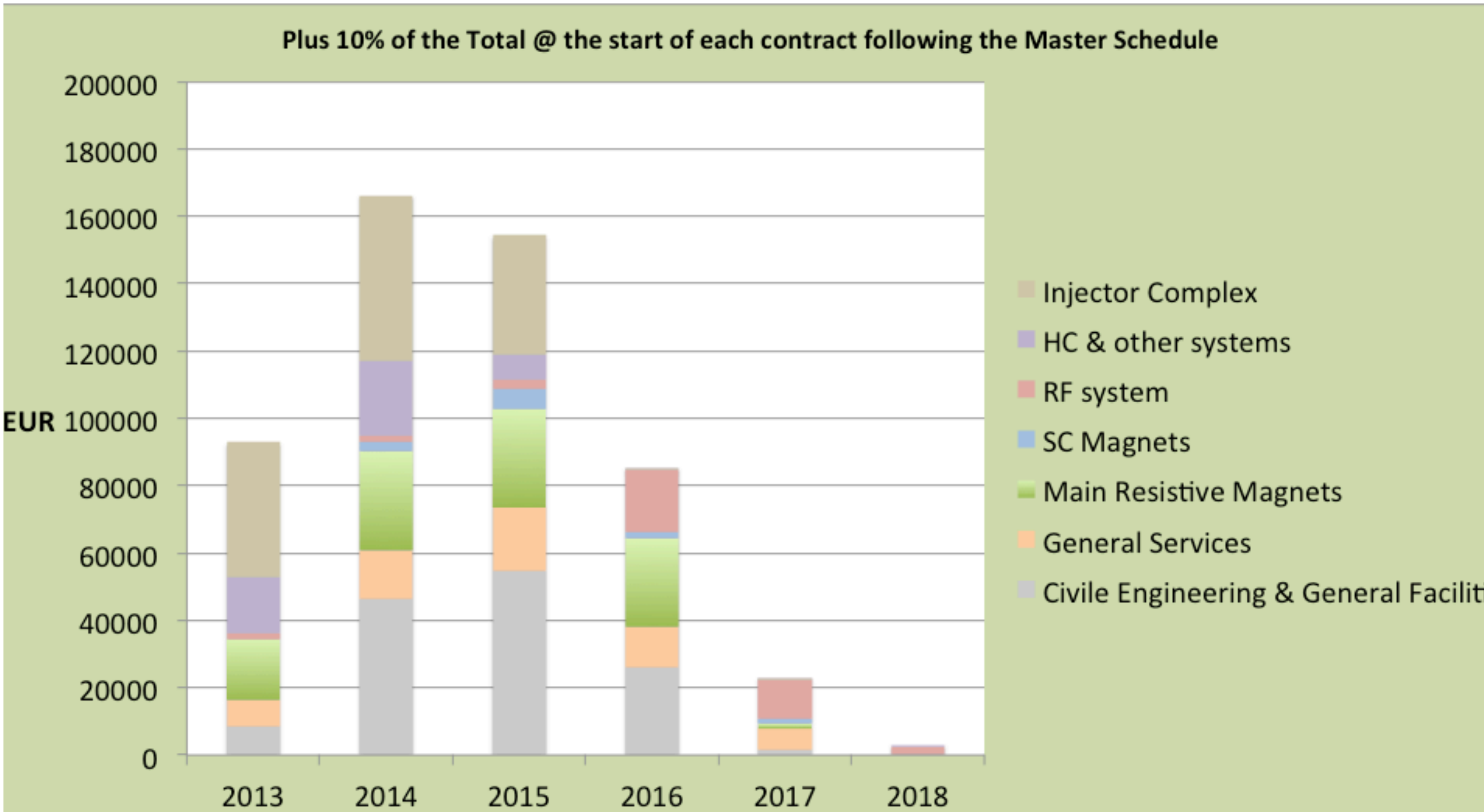
$$C(M€) \approx 149.5 + 0.132 * L(m)$$

$$300 < L(m) < 1200$$

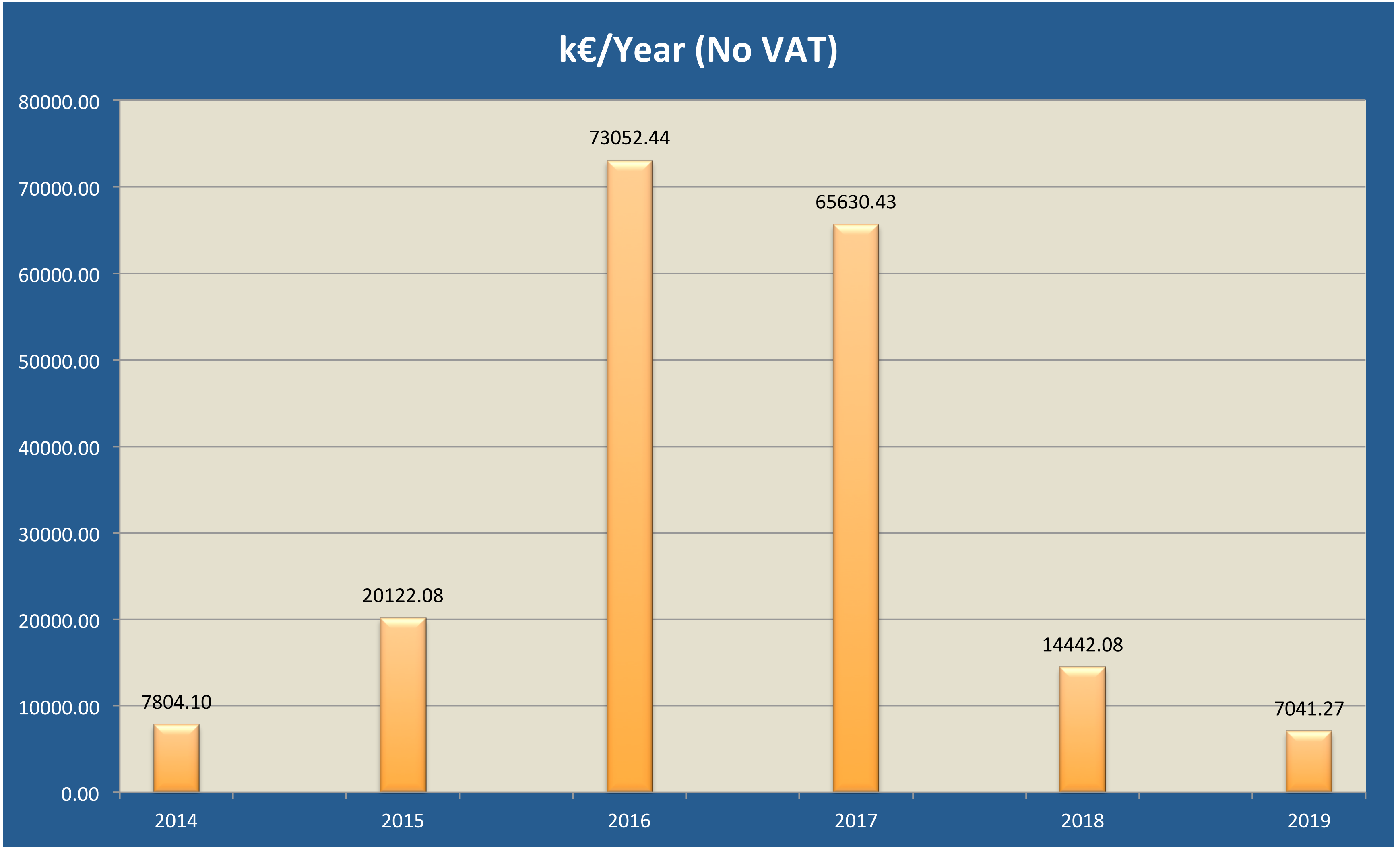
Operating cost

- Around 15Meuros/year

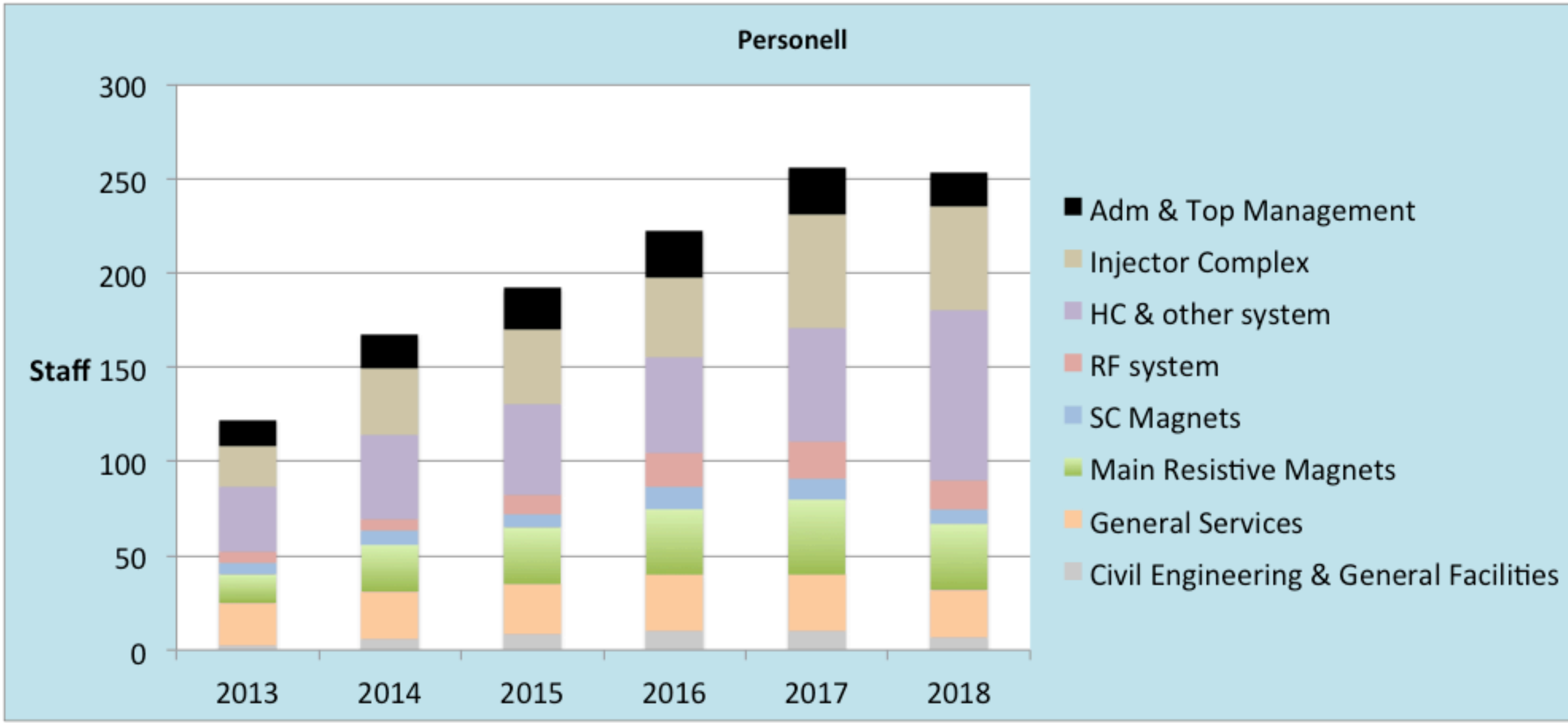
superB spending profile (bare cost)



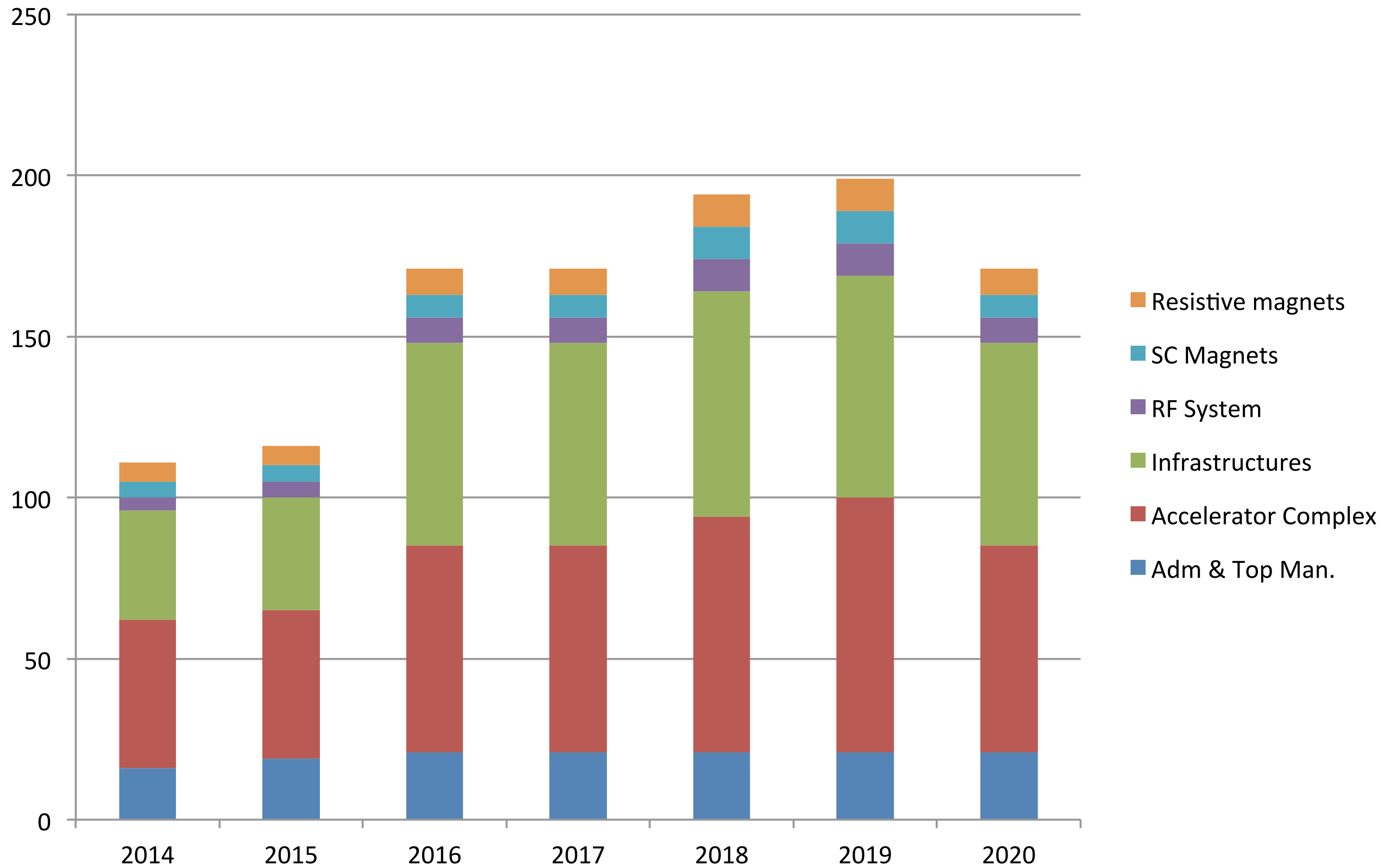
Tau charm spending profile (bare cost) (very preliminary)



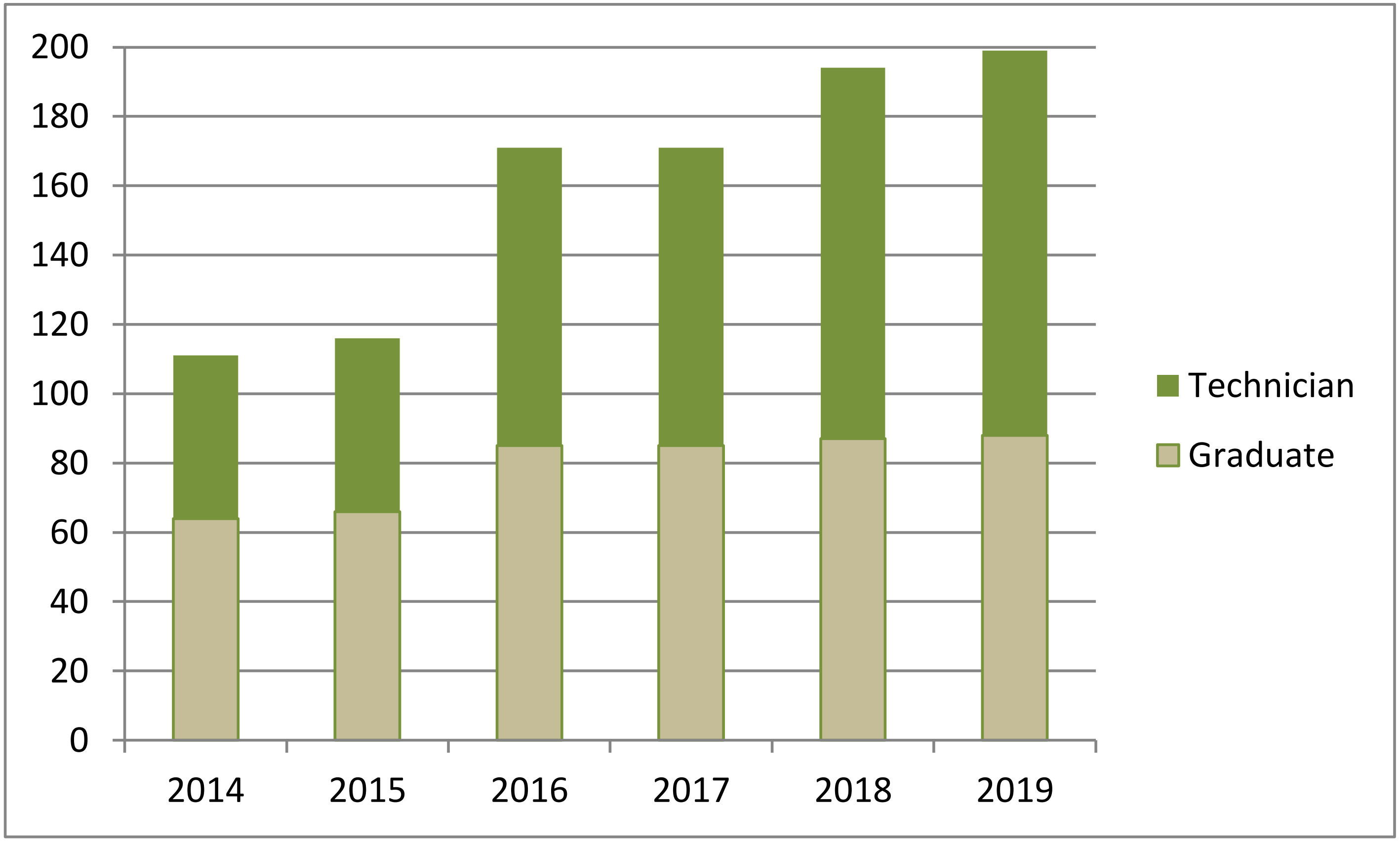
superB personnel (macrosystems)



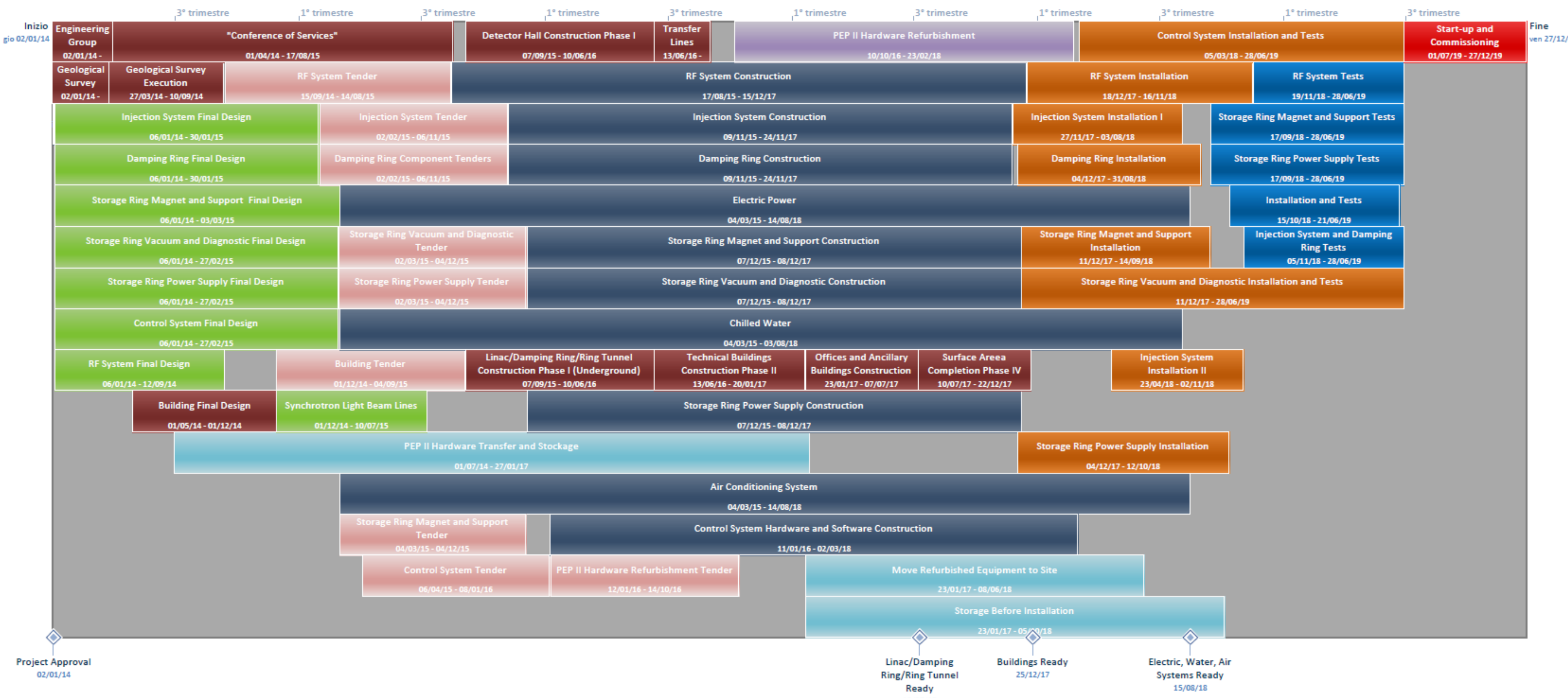
Tau charm personnel (macrosystems)



Tau charm personnel (qualification)



Tau charm master planning (very preliminary)



A consistent evaluation

– Italian tau charm points to a bare cost around 190 MEuros
– BINP layout is valued similarly

Compact BINP tau charm: very preliminary cost

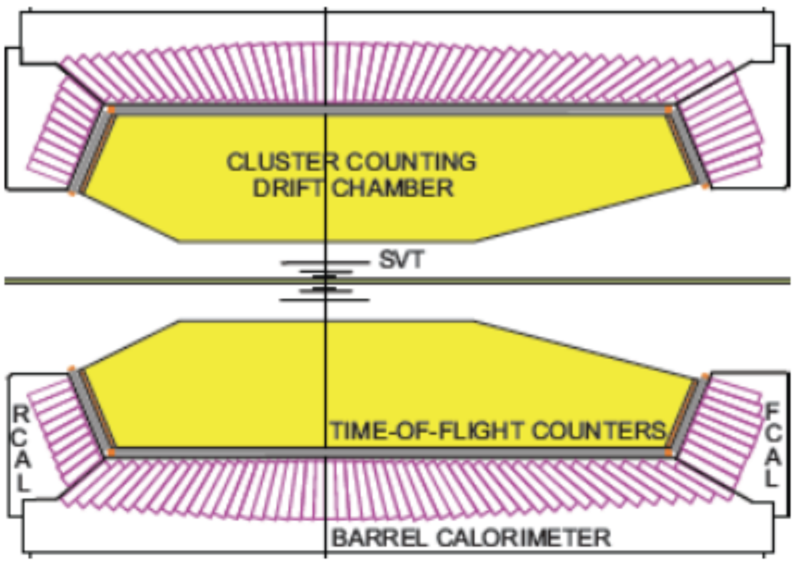
Item	800 m 2.5 GeV M€	400 m 2.1 GeV M€
•Detector	100	100
•Collider	250	100 (1/2, less spin rot. and damping wig.)
•Linac	40	30
•Pol.e source	1	1
•Building, tunnels, engineering, etc.	50	10 (renovation of equipment)
Civil engineering (IT)		35
•TOTAL	441	241 (141 + 35)

detector

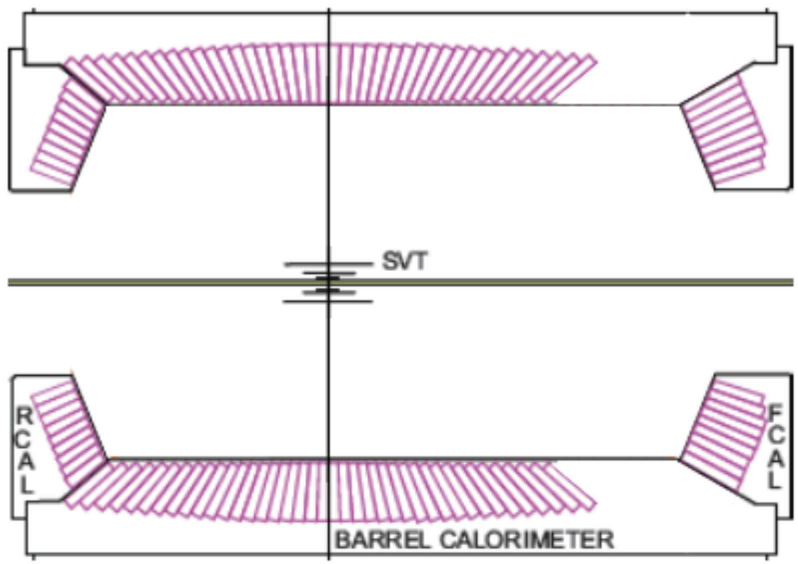
- The main point is the Babar detector’s reuse
- Specific work about
  - PID (pion rejection..)
  - Symmetric machine

The Babar metamorphosis

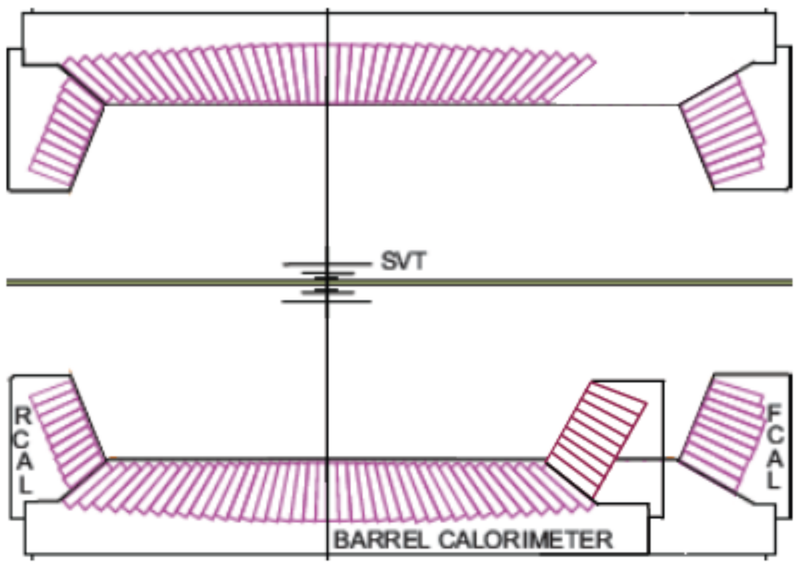
(F. Grancagnolo)



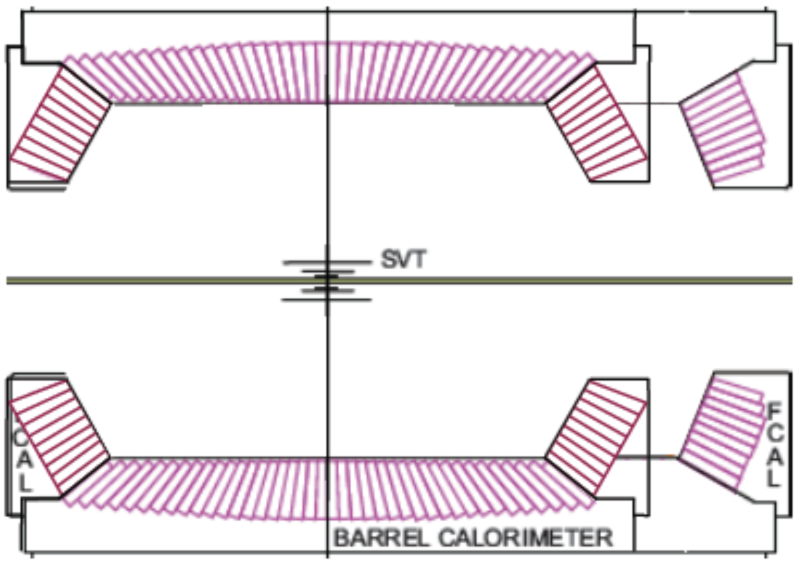
Consider only:
- Drift Chamber
- Calorimeter
- Time of Flight



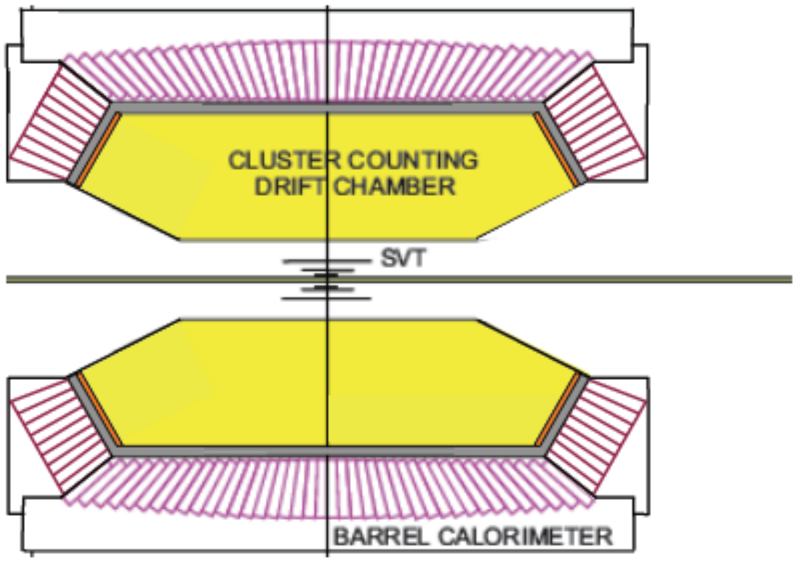
Remove the last 8 rows
of crystals in z in the
forward region
(can be used in the rear)



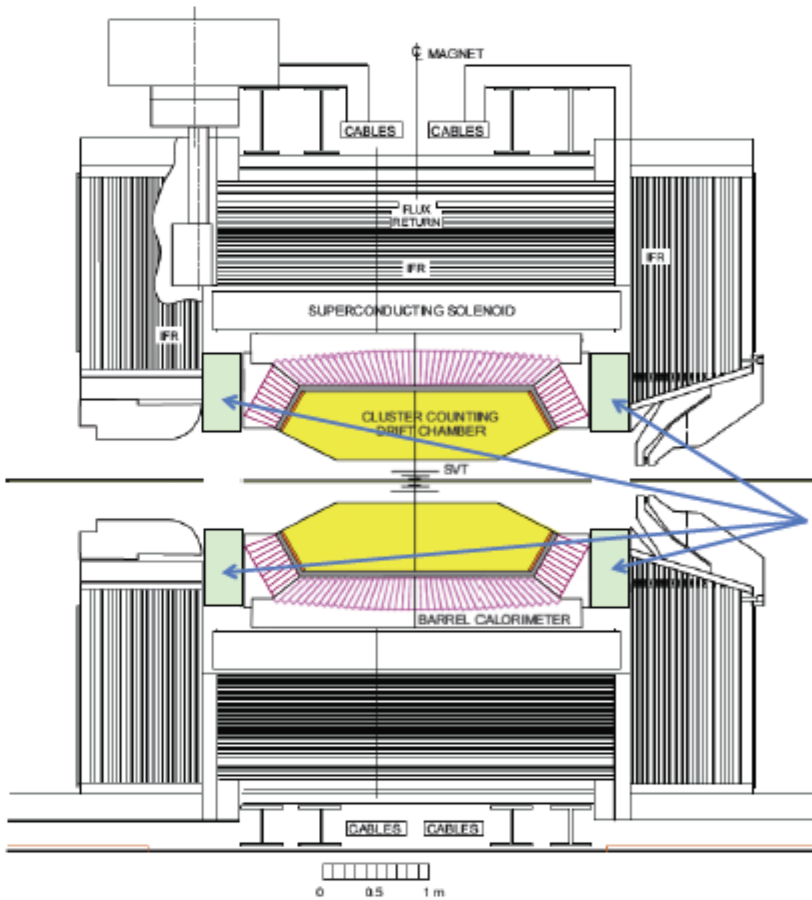
Rotate slightly the FCAL
(to point it to the beam
xing) and move it inward



Now that one has a symmetric calorimeter fit in a symmetric Drift chamber



Now that one has a
symmetric calorimeter
fit inside a symmetric
Drift Chamber
(> 2.5 m long)



Place the symmetric detector in the CL of the magnet (+ 37 cm)
Need to add extra supports

detector

- Active discussions ongoing
- An LOI-type paper by the summer

Today's international scenario

- Competing machines/experiments:
  - Belle II, LHCb
  - Possible relay races
- Cultural affinity
  - MEG, MUtoE, Kloe, Panda, Jlab QCD, Hadron Physics,…LC
- Similar future projects
  - BINP (also compact), the Turkish project, Bess X??
- Opportunities for collaboration
  - Active: BINP, Poland
  - Sleeping: Cern (SuperB agreement ready and quotes a "superflavor factory"), Spain
  - To be rescued: France, Canada, Caltech, Brasil

interdisciplinary

1 May 2012

A POSSIBLE HARD X-RAY FEL WITH THE SUPERB 6 GeV ELECTRON LINAC

D. Alesini[1], M. P. Anania[1], P. Antici[2], A. Bacci[3], R. Bartolini[5], M. Bellaveglia[1], M. Benfatto[1], R. Boni[1], R. Bonifacio[8], M. Castellano[1], L. Catani[4], A. Cianchi[4], R. Cimino[1], E. Chiadroni[1], S. Dabagov[1], A. Gallo[1], D. Di Gioacchino[1], D. Di Giovenale[1], G. Di Pirro[1], A. Drago[1], M. Ferrario[1], F. Ferroni[2], G. Gatti[1], S. Guiducci[1], R. Gunnella[9], S. Lupi[2], A. Marcelli[1], M. Mattioli[2], A. Mostacci[2], M. Migliorati[2], E. Pace[1], A. Perrone[10], V. Petrillo[3], R. Pompili[4], C. Ronsivalle[6], A. R. Rossi[3], W. Scandale[7], L. Serafini[3], B. Spataro[1], C. Vaccarezza[1], A. Variola[7], G. Venanzoni[1], F. Villa[1].

interdisciplinary

- Room to increase Linac Energy
- Possible use of the “Electron linac” (no e- DR)
- Room for long beamlines
- BTF in the 3 Gev range
- Laser-beam interactions
- Inverse Compton
- ….

conclusions

- The luminosity goal is supported by a consolidated lattice layout
- Fast progress strongly based on SuperB work
- Sound cost and planning estimates exist: more work needed to append an error bar
- A discovery machine and a powerful QCD and EW laboratory: on specific channels can challenge and overcome best actors in the next decade
- Interdisciplinary option concurrent with high energy mode viable on the Linac. On the main ring only compromising high luminosity.