Lost particles in the IR and Issues for Beam Induced Backgrounds in Higgs Factories

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Introduction: Particle Losses

- First concern is beam loss per se -> beam loss implies beam degradation: luminosity loss, finite lifetime , frequency injection
- Second concern is the background that beam loss generates
- IR Particle losses shower into detectors may cause damages and may fake triggers
- Lepton machines: Halo may not be an issue as for hadron machines, but
  - Beam-Beam related Halo can be an issue, in particular in the low emittance (vertical) plane
  - Beamstrahlung generates significant off-momentum halo at IR

Background Sources

Two Main Classes:

- beam particles e+, e-, e+e- effects
  - Bhabha
  - Beamstrahlung
  - Touschek
  - beam-gas
  - …
- Synchrotron Radiation

Both aspects deeply studied for present/past machines

- beam particles effects (better) studied at Factories
- SR manageable extrapolation from LEP experience

- **Challenge for HF: maximize performance (integrated luminosity) for experiments for good or at least tolerable experimental (background, stability) conditions.**
- **The MDI group should work together with the IR design group to reach the goal.**

Machine Detector Interface

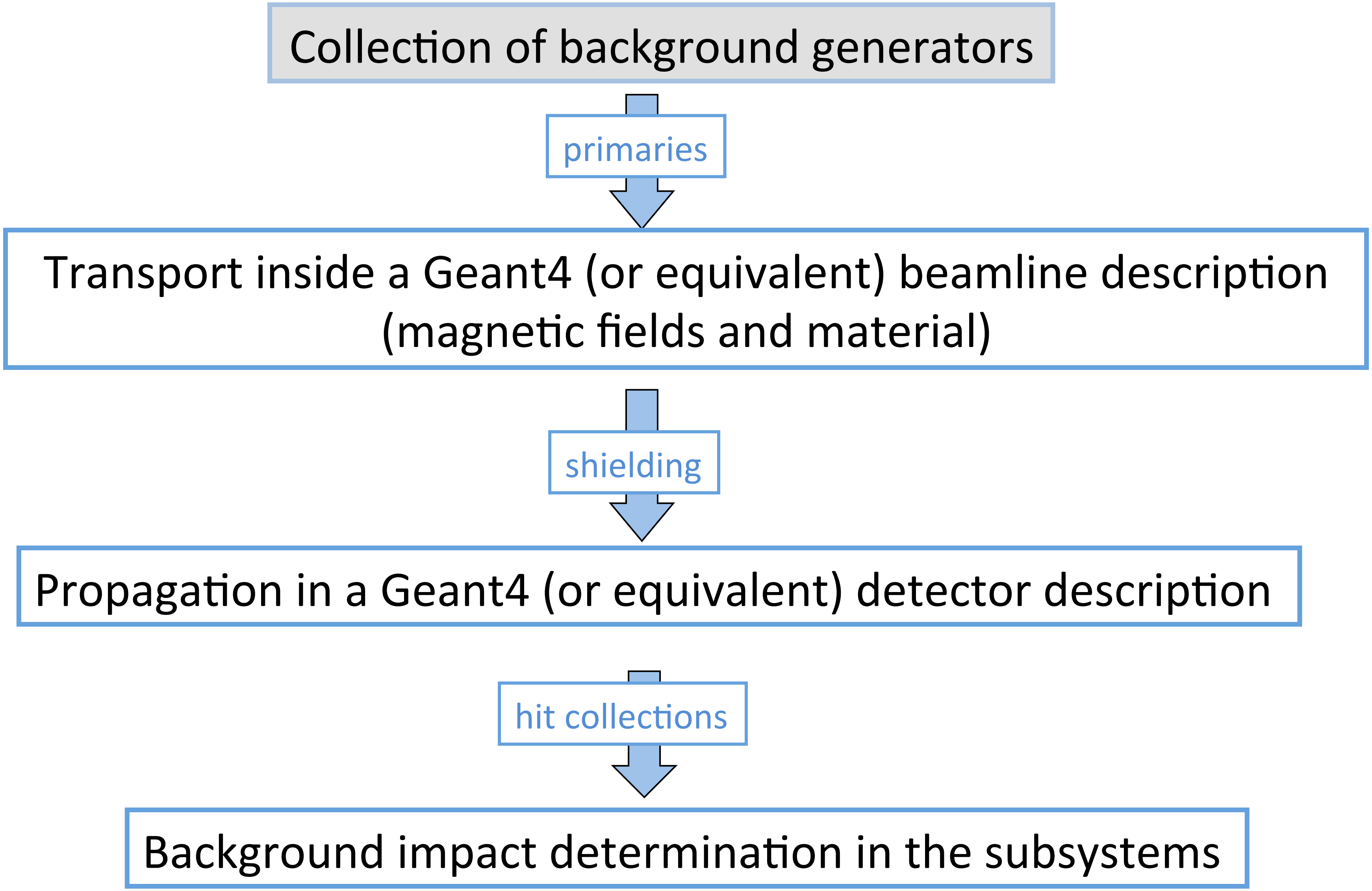
Provided estimates of Beam losses at IR,

- Follow MDI issues as

  shielding, masking, collimation system

- Follow Radiation Limits estimates:
  - Peak residual dose rate in the tunnel in non-controlled areas
  - Ground-water activation
  - Peak energy deposition and absorbed dose
  - Air activation

General Approach



Beam Particle Effects

- Beam-gas
- Touschek

Machine Induced Backgrounds
single beam effect, losses in the whole tunnel

- Radiative Bhabha
- Beamstrahlung

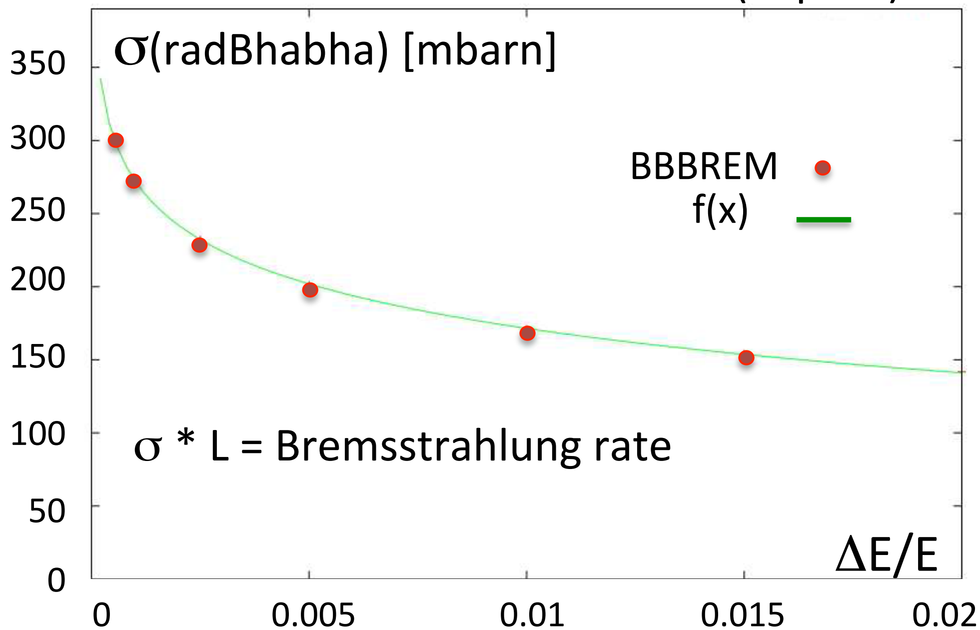
IP backgrounds, mainly losses at IP,
multiturn tracking needed for low-angle scatterings

strongly dependent on momentum acceptance

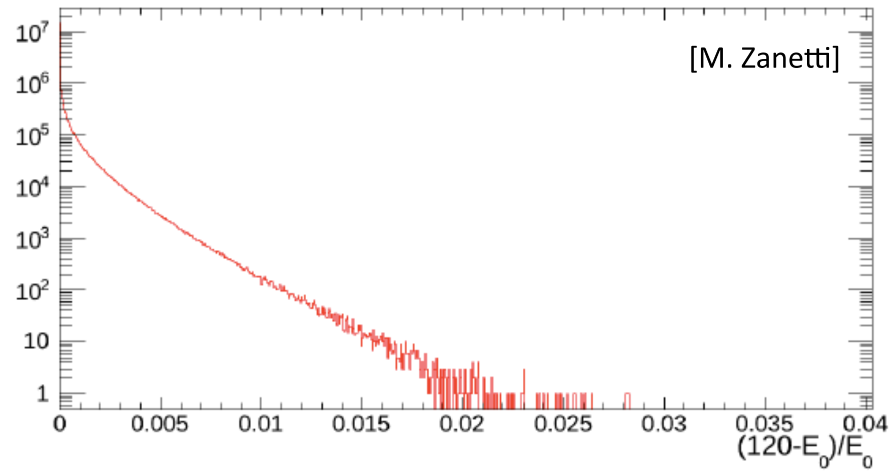
- e+e- pairs

Dependence on Energy Acceptance

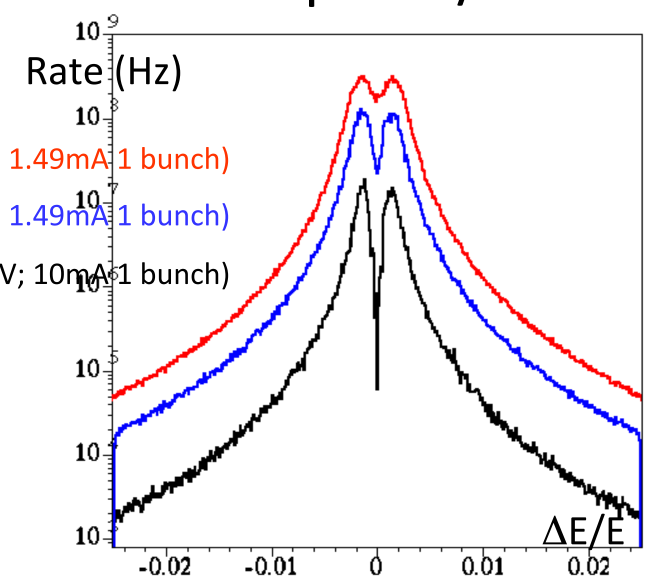
Radiative Bhabha Cross-section (SuperB)



Beamsstrahlung rate (FCC-ee)



Touschek particles/ second



Lifetime estimated for these effects usually assumes ring's energy acceptance

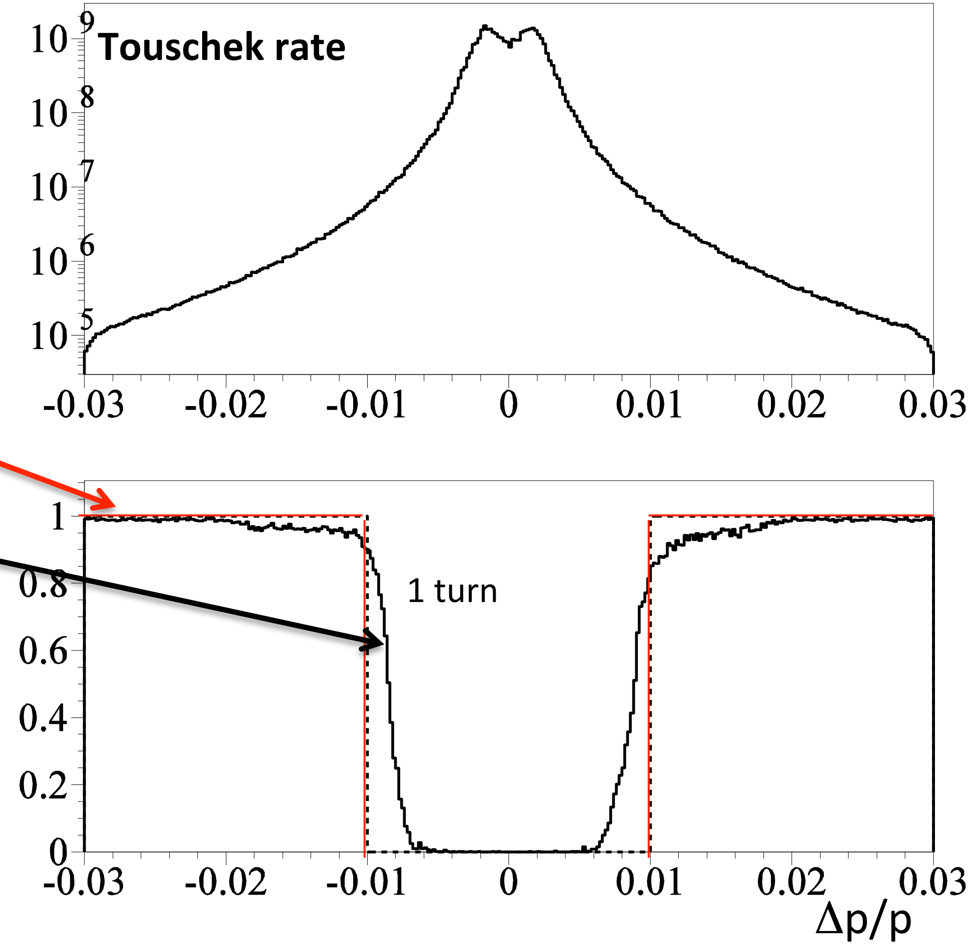
Lifetime estimate from formula/tracking

SuperB case

P(loss) step function when ΔE/E=1% is assumed

P(loss) when ΔE/E is calculated with numerical tracking (~0.6-0.8%)

Lifetime estimation is different with the two approaches. The more realistic calculation of energy acceptance gives a more realistic lifetime estimate.
The importance of this approach is more important if the distribution vs ΔE/E is very nonlinear (as for Touschek)



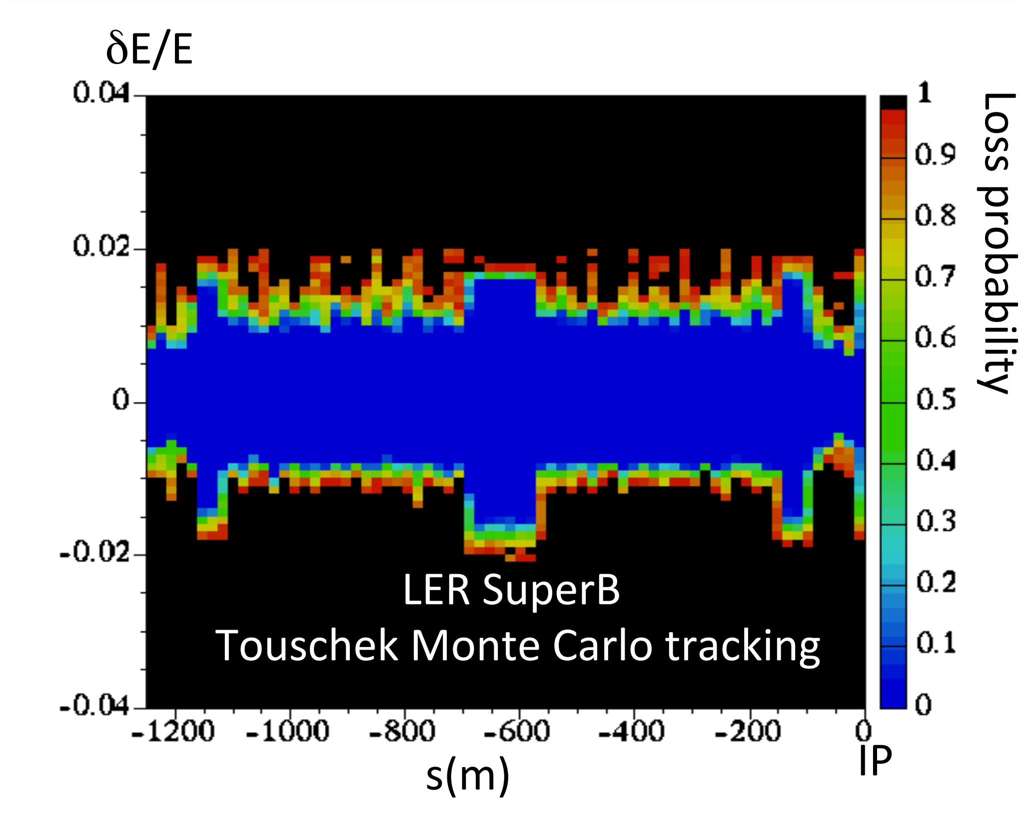
⇒ numerical tracking needed to estimate lifetime accurately and essential for beam losses around the ring (approach used for DAΦNE, SuperB, Italian Tau/C)

Momentum aperture

- Crucial for all sources inducing a δE/E

like Touschek, rad Bhabha, beamstralung (HE)

- Best determined with full tracking



Not simply an *s* dependent momentum aperture

A.Xiao,M.Borland, PAC07 p.3457

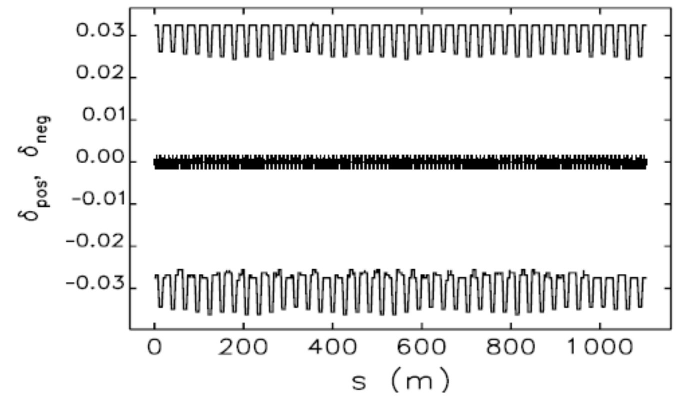
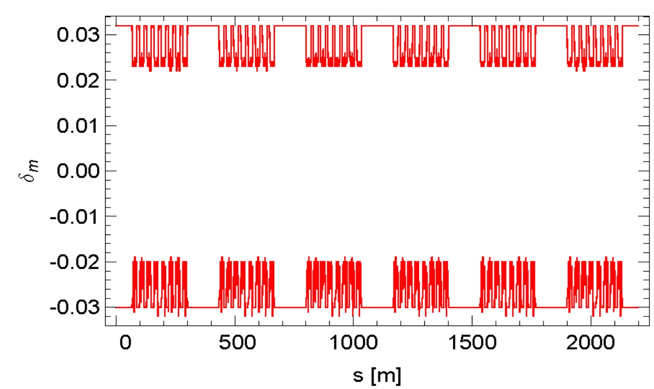


Figure 1: Momentum aperture of the APS.

momentum aperture



PEP-X Y. Cai, SLAC
FLS-2012, March 2012

Touschek Losses

- In low-ε **rings with no IR and relatively low energy (Synchrotron Light Sources)**

  Touschek effect is a big issue → it impacts **lifetime**

  -> cure: continuous injection, top-up

- In low-ε **colliders and relatively low energy**

  Touschek effect is a big issue both for **lifetime and IR losses**

  -> cure: top-up injection and collimation,

  IR physical aperture design

- In low-ε **rings and very high energy (Higgs Factories)**

  Touschek effect not a big issue, not dominant,

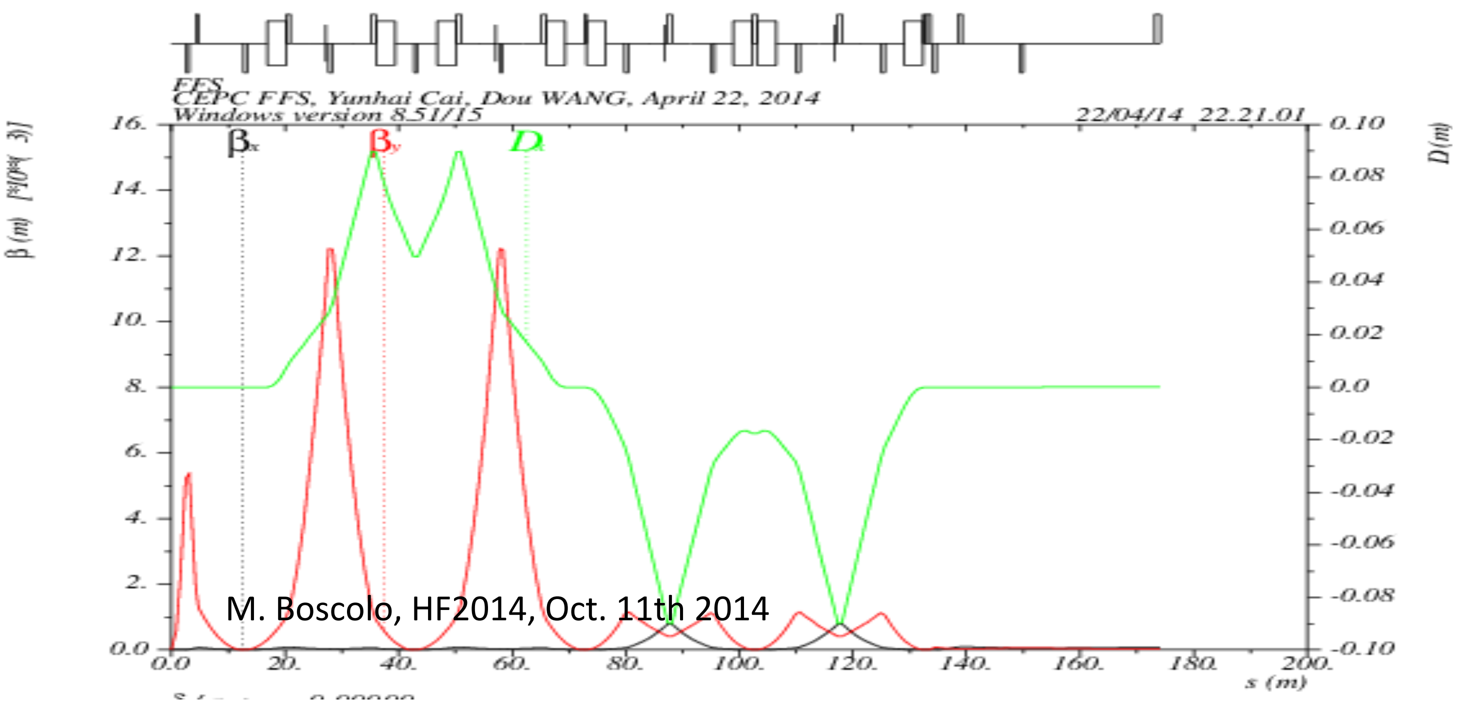
  but it needs to be checked

FFS in CEPC

- **Functions of Interaction Region (IR) optics**
  - **Provide very small beta function to achieve very small beam size: β_y^*=1.2mm, σ_y^*=0.16um, for CEPC**
  - **Correct large chromaticity due to small beta function: $W \sim L^* / \beta_y^*$**

Based on Yunhai's design

L*=2.5m
βx*=0.8m
βy*=1.2mm

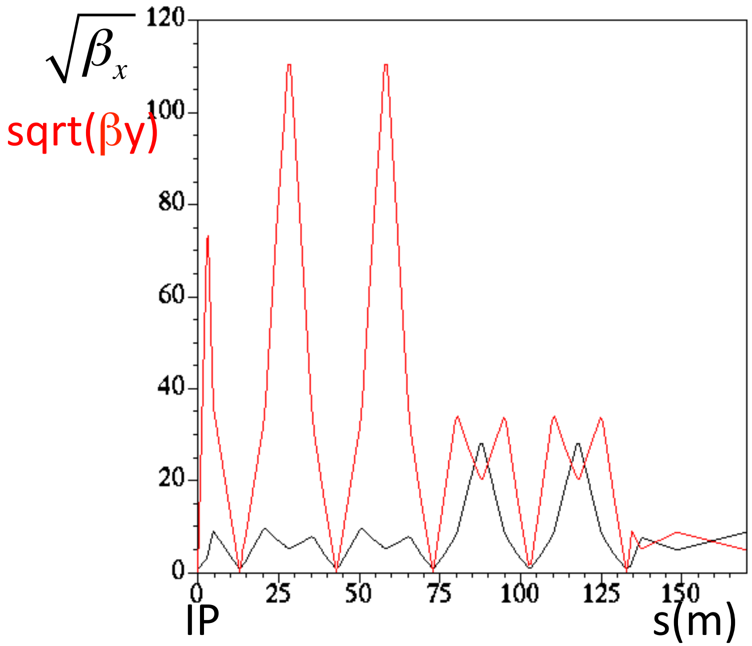


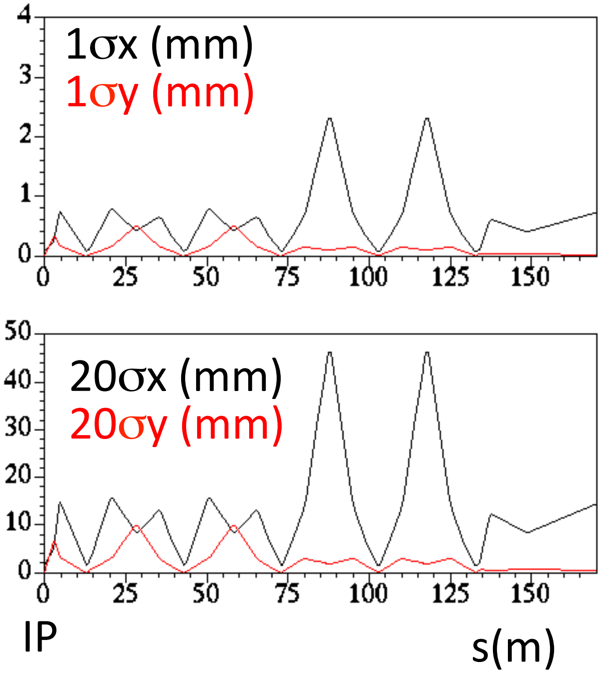
[Q.Qing]

Touschek trajectories at CEPC

1 run on Touschek code STAR* used for DAFNE, SuperB, Tau-C

over-imposed betax from MAD/ STAR

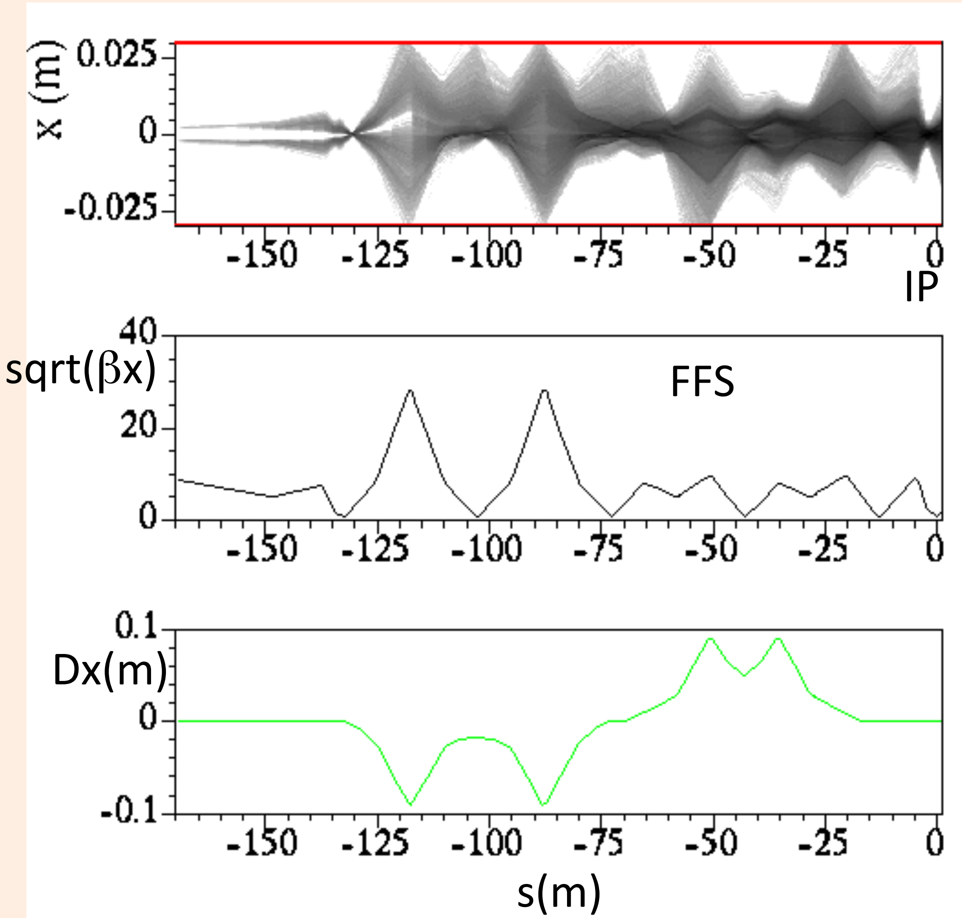




M.Boscolo and P. Raimondi, Phys.Rev.ST-AB 15 104201 (2012)

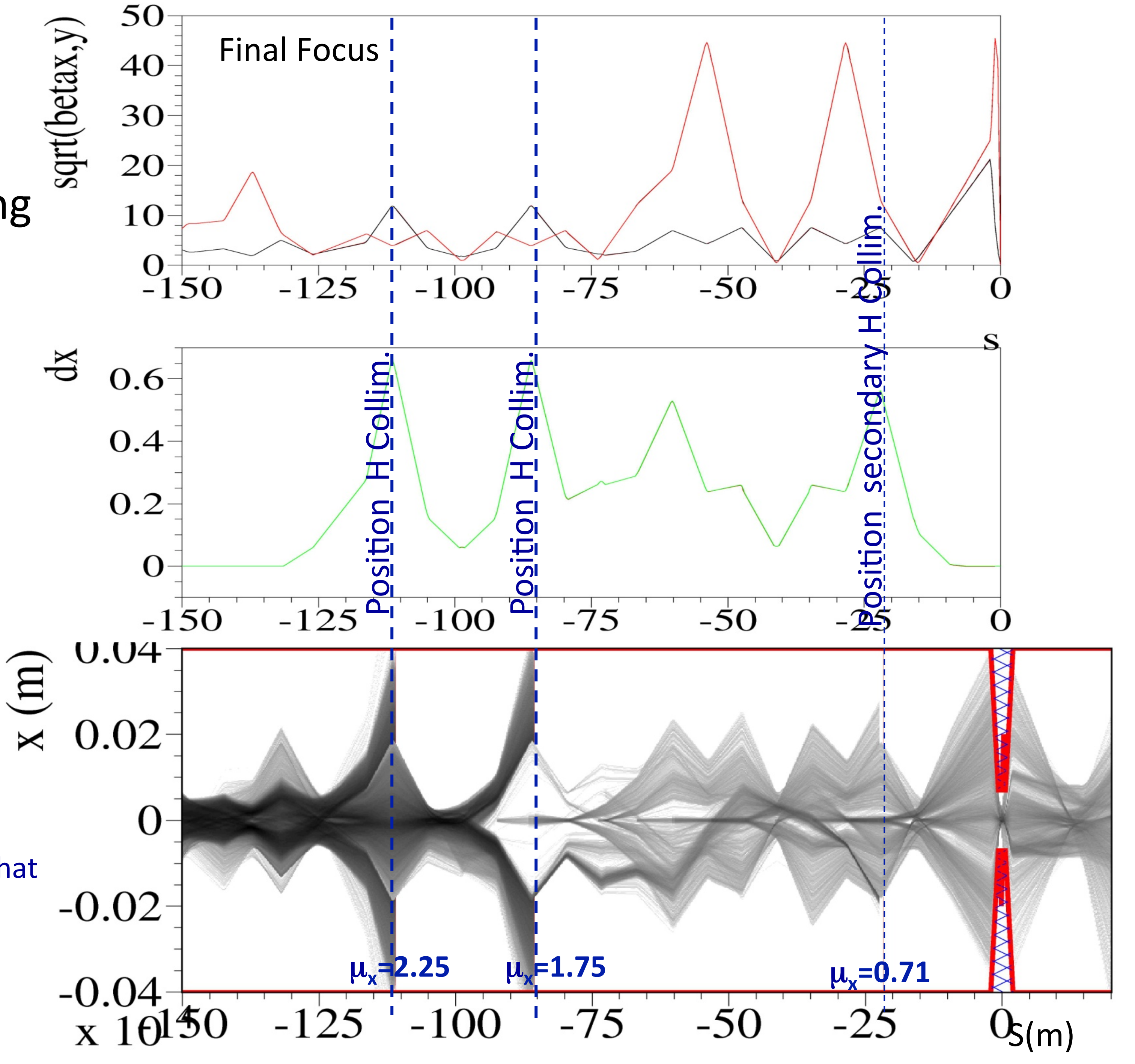
CEPC Touschek trajectories in FFS

1 run: Touschek trajectories starting upstream the IR in the FFS



- constant horizontal physical aperture 3 cm assumed everywhere
- losses consistent with high βx locations
- no Touschek lifetime estimate as simulation is not done for the whole ring, lattice needs to be closed

Example of Collimators optimization for intercepting Touschek particles in **HER SuperB**



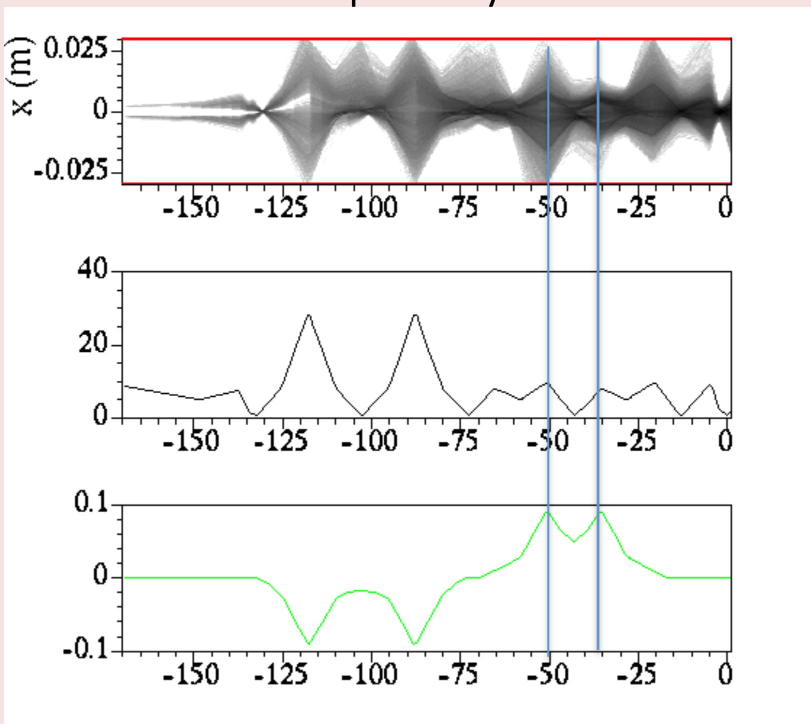
collimators at **n·π/2** upstream the IP to intercept particles that would be lost at IP

Next steps for Touschek simulations at CEPC

- evaluate Touschek rates
- Introduce `realistic' IR physical aperture and check IR losses
- Collimation IR losses

CEPC FFS: first attempt hor. collim?

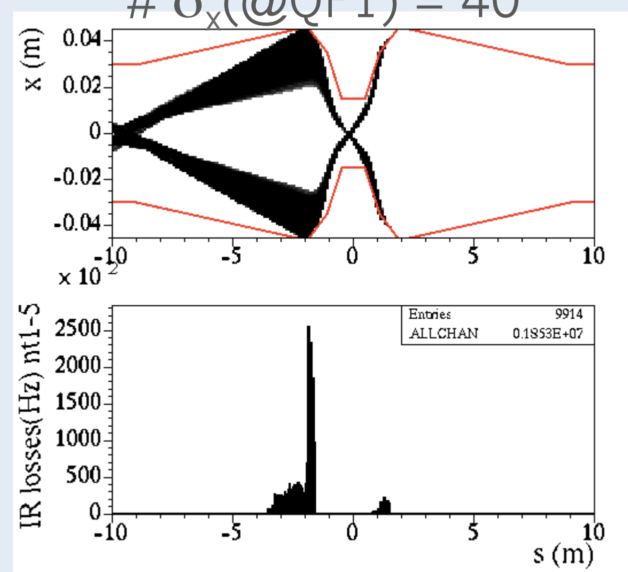
probably too close to IP



example

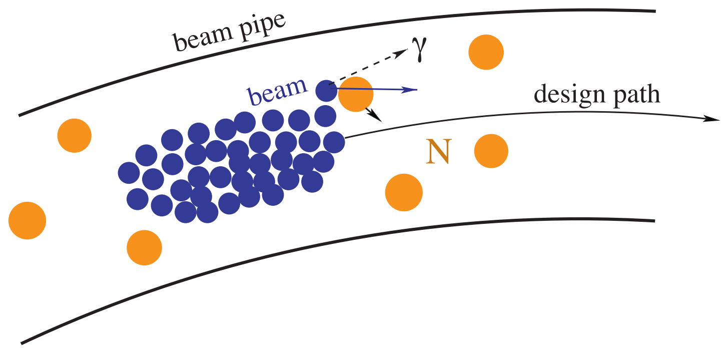
Italian Tau/charm Factory

σ_x(@QF1) = 40



0.9GHz/beam/10m

Beam-gas scattering



- Mainly Coulomb and Bremsstrahlung interactions with residual gas molecules in the beam pipe
- As a start: the estimate based on LEP2 rates and rescale for beam currents

- For a more quantitative and accurate estimate the lattice description is needed

  TOOLS:

  - PLACET, HTGEN (Helmut)
  - MCGAS Monte Carlo developed for SuperB and Italian τ-charm (Manuela)

Beam-Gas Interactions

- Products of beam-gas interactions in **straight sections and arcs upstream the experiments** (and not intercepted by collimation system) have a good chance to be **lost on limiting apertures in front of the collider detectors**
- The rate of beam-gas interaction is proportional to the beam intensity and residual gas pressure in the beam pipe

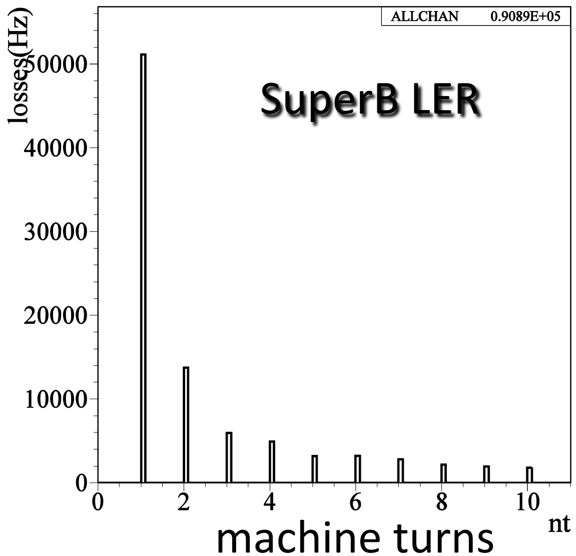
  scattering Rate $\propto$ P·I·<β>

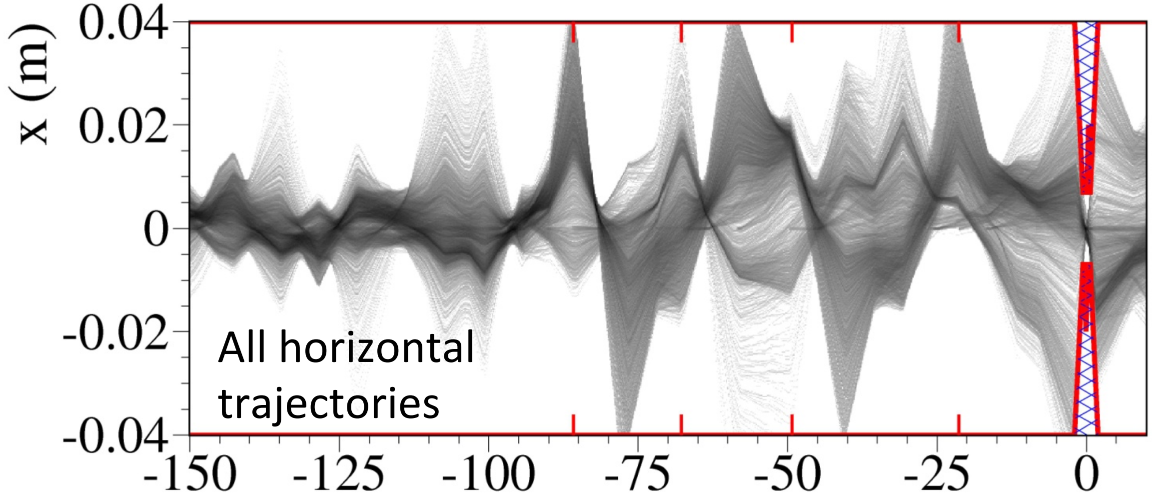
  So, rate longitudinally follows the pressure maps
- Not energy dependent (first order), but
- if **high gas pressure due to SR outgassing** (dynamic pressure) ->

  scattering Rate $\propto$ I^2

Beam-gas Bremsstrahlung

- At **LEP** off-energy particle background was largely dominated by beam-gas bremsstrahlung along the straight sections [τ_B= 430 hrs with P=10^{-10} Torr, NIM A 403 (1998) 205-246]
- From 45 GeV to 65GeV dynamic pressure increased by a factor 5
- -> Needs to be studied with particle tracking for HF
- General requirement: **P < 1.E-9 Torr**





Beam-gas Coulomb scattering

LER parameters	unit	KEKB	SuperKEKB	SuperB	LEP	CEPC
		B-Factories				
V beam pipe @QD0	mm	35	13.5	6		
β_y (max) @QD0	m	600	2900	1497	**150 m**	**12.1 km**
$<\beta_y>$ [m]	m	23	48	47		
Coulomb lifetime	hr/min	>10 hrs	35 min	24 min		

$$\frac{1}{\tau_{Coul}} = c n_G \langle \sigma_R \rangle = c n_G \frac{4\pi \sum Z^2 r_e^2}{\gamma^2} \left\langle \frac{1}{\theta_c^2} \right\rangle \Rightarrow \frac{1}{\tau_{Coul}} \propto \frac{1}{\gamma^2} \left\langle \frac{1}{\theta_c^2} \right\rangle$$

- Coulomb rate decreases quadratically with energy ⇒ beneficial for HF
- Coulomb rate increases linearly with β_{ave} ⇒ worse for HF
- Losses happen vertically at β_y**(max)** (i.e. at QD0) larger by 1 order of magnitude with respect to SuperB Factories, at LEP there was no high beta close to the IP ⇒ worse for HF should be found a trade off for this value

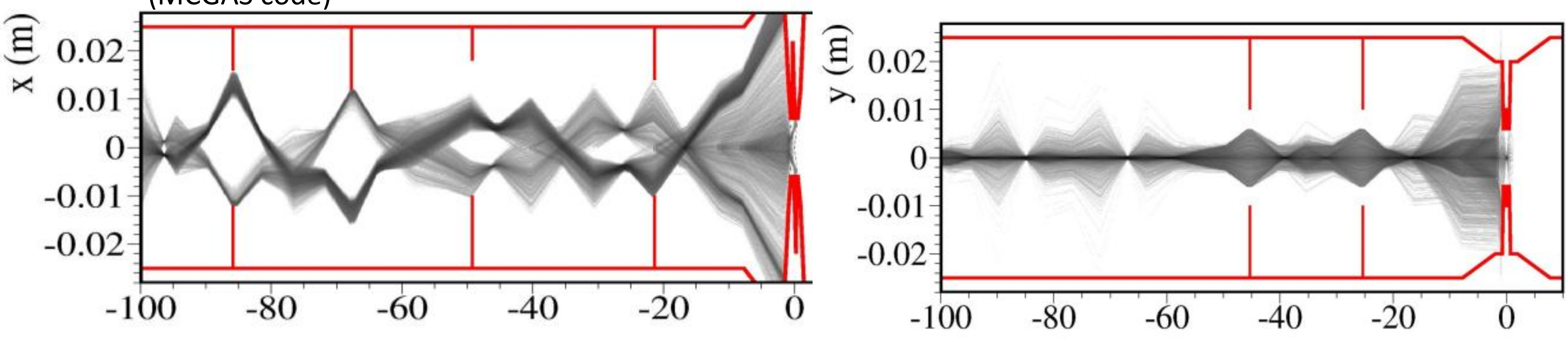
Beam-gas Coulomb scattering

B-Factories

LER parameters	unit	KEKB	SuperKEKB	SuperB	CEPC
V beam pipe @QD0	mm	35	13.5	6	
β_y (max) @QD0	m	600	2900	1497	**β_y(max) =12.1 km**
$<\beta_y>$ [m]	m	23	48	47	
Coulomb lifetime	hr/min	>10 hrs	35 min	24 min	

SuperB: Trajectories of Coulomb scattered particles eventually lost at IR

(MCGAS code)



Radiative Bhabha

- Bremsstrahlung process in the forward direction is dominated by BhaBha scattering: $e^+e^- \to e^+e^- \gamma$
- Radiative Bhabha is almost independent on sqrt(s)
- **Lifetime** depends essentially on energy acceptance at IP and on Luminosity
- **First turn IR particle losses** just depend on Luminosity
- Energy acceptance at IP calculated by tracking
- **Multi-turn particle losses** calculated by tracking:
  - interested in IR losses
  - interested in losses over the ring for collimation

Radiative Bhabha Process

It takes place only at IP, of course, with two possibilities:

- Bhabha final states particles with ***large* energy deviation** => lost almost immediately, closeby detectors
  - almost independent on machine lattice but the Final Focus
  - BBBREM generator [R. Kleiss, H.Burkhardt](collinear), BABAYAGA, BHWIDE(low angle) -> into detectors with GEANT4
- Bhabha final states particles have ***small* energy deviation** => may be lost after few machine turns
  - multi-turn tracking with a dedicated Monte Carlo simulation* (only first and second turn losses relevant for SuperB) with BBBREM generator for the weights of the tracking particles -> into detectors with GEANT4

At **SuperB** both possibilities investigated, 1-turn and multi-turn

* M.Boscolo unpublished, used for SuperB and Italian τ-Charm

Machine Induced Background (MIB) from Radiative Bhabha Process

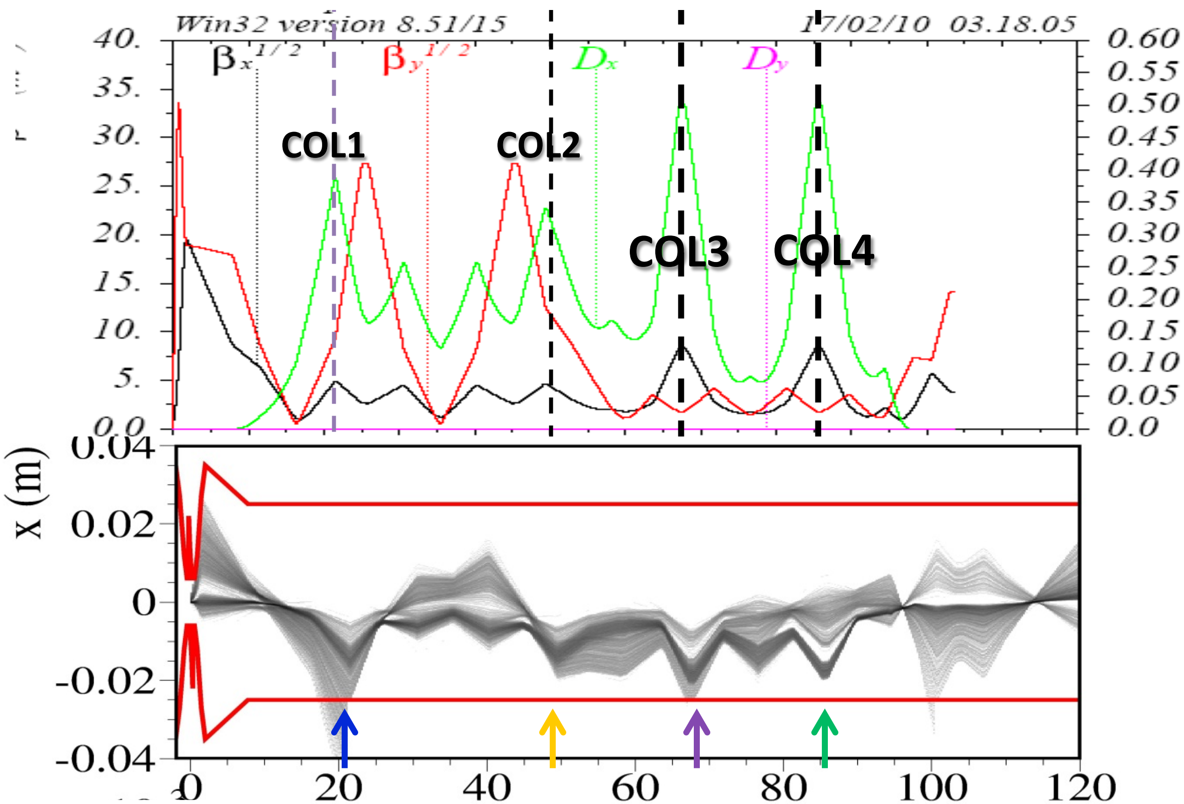
- The outgoing particles are not the direct responsible for detector backgrounds but they generate potentially dangerous showers and backscattered particles in the downstream beamline elements
- Beamline and shielding design is very important

Low angle Bhabhas also very important at such high luminosity (showers in various materials)

Carefully studied for Super-B Factories, dominant source of particles IR losses and it drives the lifetime

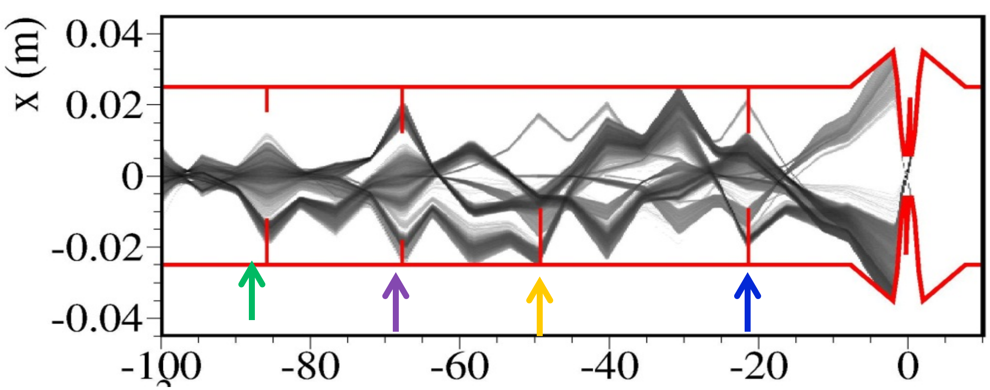
Multi-turn Tracking of Radiated Bhabha particles for **LER SuperB**

No collimators



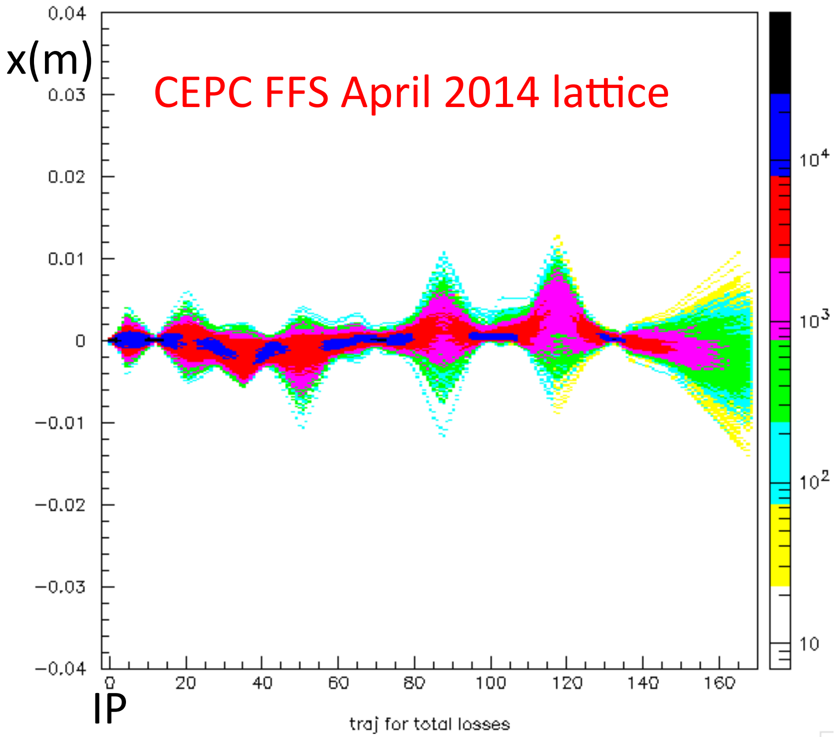
Trajectories final state radiative Bhabha particles from IP

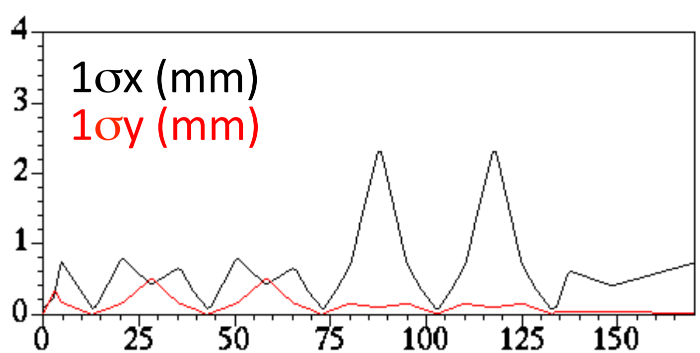
Same phase advance as Touschek particles!



Trajectories of particles after Touschek scattering upstream IP

CEPC Radiative Bhabha Trajectories

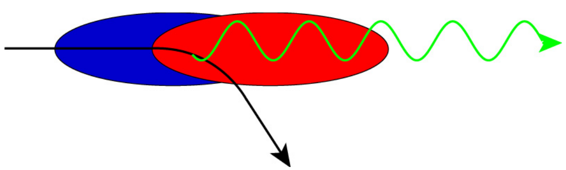


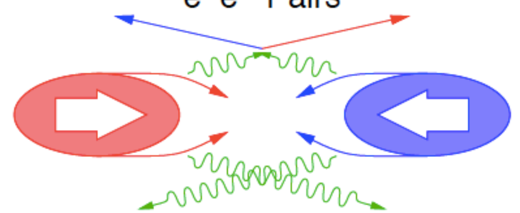


- constant physical aperture 3 cm assumed everywhere
- losses consistent with high βx locations
- dedicated particle tracking needed, this is just the starting point

Beamstrahlung

- Beamstrahlung is synchrotron radiation in the field of the opposing beam
- When two charged bunches collide, the EM field of each bunch bends the trajectories of the opposite bunch particles
  - ➔ energetic photons are emitted
  - ➔ –(ΔE/E) bunch particles get lost in the IR





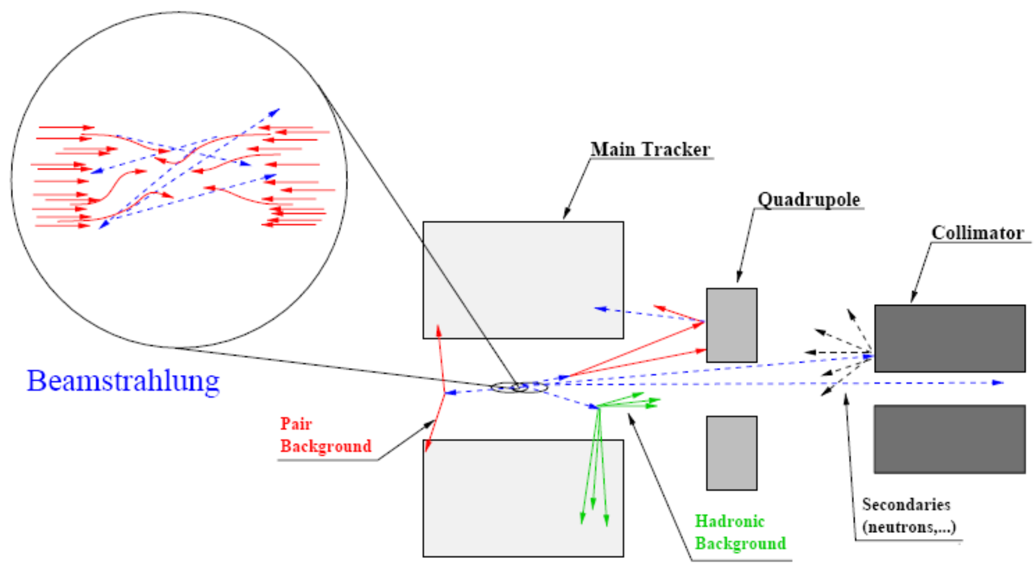
BS parameter $\Upsilon \propto \dfrac{N\gamma}{\sigma_z(\sigma_x + \sigma_y)}$ measure of the field seen by a beam particle in its rest frame

For a given bunch length, horizontal size and particles per bunch drive the BS effects

Same dependencies for the BS photon energy

Beamstrahlung

- Beamstrahlung is synchrotron radiation in the field of the opposing beam
- When two charged bunches collide, the EM field of each bunch bends the trajectories of the opposite bunch particles
  - ➔ energetic photons are emitted -> produce background
  - ➔ –(ΔE/E) bunch particles get lost in the IR
    - -> Backgrounds from debris
    - -> Luminosity drops
    - -> beam energy spread



Beamstrahlung dominant for HF

- Many analogies (dependence on energy acceptance at IP, direct losses) with Radiative Bhabha but Beamstrahlung is the dominant effect at the high energies of HF, in fact :

$$P(Beamstrahlung) \propto \gamma \cdot \frac{N^2}{\sigma_x \sigma_y}$$

$$P(Bremstrahlung) \propto \ln\left(\sqrt{s}\right) \cdot L \propto \ln\left(\sqrt{s}\right) \cdot \frac{N^2}{\sigma_x \sigma_y}$$

$$P(Touschek) \propto \frac{1}{\gamma^3} \frac{N}{\sigma_x \sigma_y \sigma_z}$$

- The aim is to increase the energy acceptance as high as possible

Beamstrahlung Simulation

- Mainly studies for lifetime estimation (Guinea-pig, D. Schulte's code)
- Effect on luminosity studied by K. Ohmi
- It is the dominant lifetime/machine induced background source in Higgs Factories => full simulation needed
  - Beam particles lost in the IR need to be tracked into detector
  - multi-turn tracking needed

Pair production: e^+e^- (and $\mu^+\mu^-$)

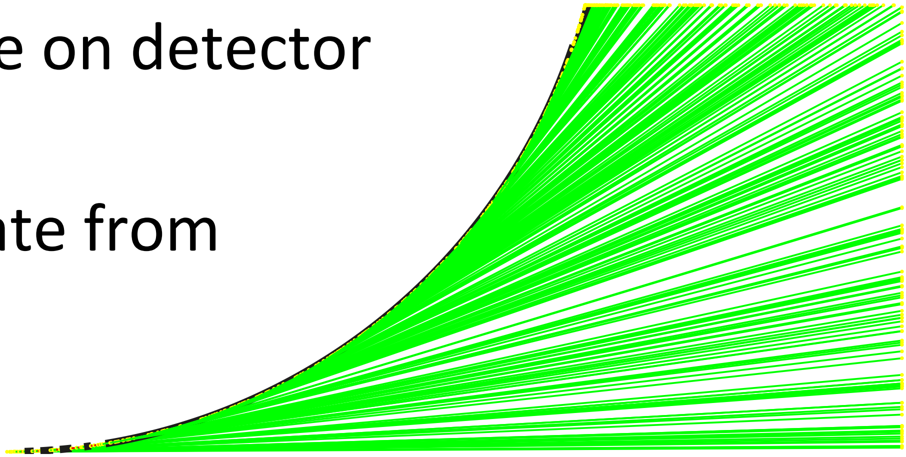
- $e^+e^- \to e^+e^-\ e^+e^-$
- It can be studied with GUINEA-PIG generator
- can be high production rate but particles have low energy and loop in the solenoid field
- relevant for which sub-system?
  - typically low energy curling e^+e^- relevant for vertex detector and first layers of tracking devices
- first guess at generator level (with magnetic fields)
- full simulation with Geant4 needed for detailed study
- Same statements are valid for $\mu^+\mu^-$ production ($e^+e^- \to e^+e^-\ \mu^+\mu^-$) to be checked at these energies

Synchrotron Radiation in the IR

Issues to be addressed:

Big Issue

- SR Power (dipoles, quads, ..)
- calculate the rate of photons through the detector beam pipe
- add in calculation the compensating solenoids and detector field
- calculation of backscattered photons
- scattering rate and incidence on detector beam pipe
- forward scattered photon rate from upstream bend magnets



Geant4 bend example

SR scaling

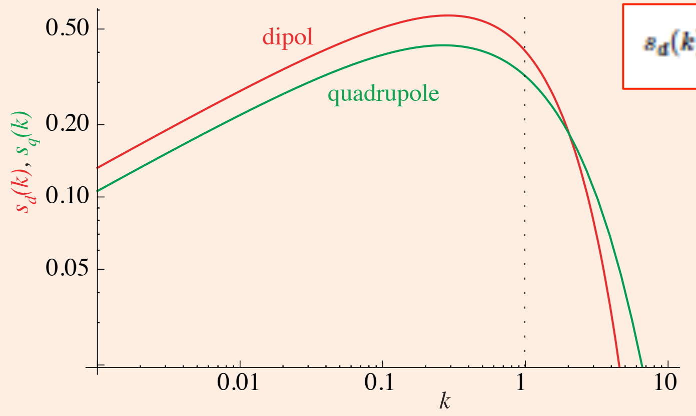
- Power
- Critical energy
- spectrum

Normalized power spectra for SR

$$s_q(k) = \frac{9\sqrt{3}}{8\pi} k \int_0^\infty \left(1 - \mathrm{erf}(k/\sqrt{2}s)\right) K_{5/3}(s)\, ds\,, \quad k = \frac{E}{E_{cr,1\sigma}}\,,$$

$$s_d(k) = \frac{9\sqrt{3}}{8\pi} k \int_k^\infty K_{5/3}(s)\, ds$$

$$k = \frac{E}{E_{cr}}\,.$$



- The IR has to be designed to reduce:
  - the bending of incoming beam trajectories
  - the offset in quadrupoles

- **The MDI group should work together with the IR design group**

Synchrotron Radiation

Concerns:

- compatibility of stay-clear apertures with effective masking of incoming SR
- edge scattering from upstream SR masks
- backscattering from downstream aperture limitations

Next slides:

- Recall the LEP experience (1 slide)
- approach for FCC

Typical Fields

	LEP	FCC-ee (tt)
Energy	100 GeV	175 GeV
Bending fields	0.1 T	0.06 T
Mean γ energy	0.2 MeV	0.4 MeV

LEP e+e- and LHC (pp and ion)

- LEP, LHC built in the same tunnel, 26658.9 m circumference

8 straight sections, ± 284 m around IPs, 4 used as interaction regions

distance IP 1st superconducting Quadrupole

$L^* =$ 3.7 m for LEP

23 m for LHC

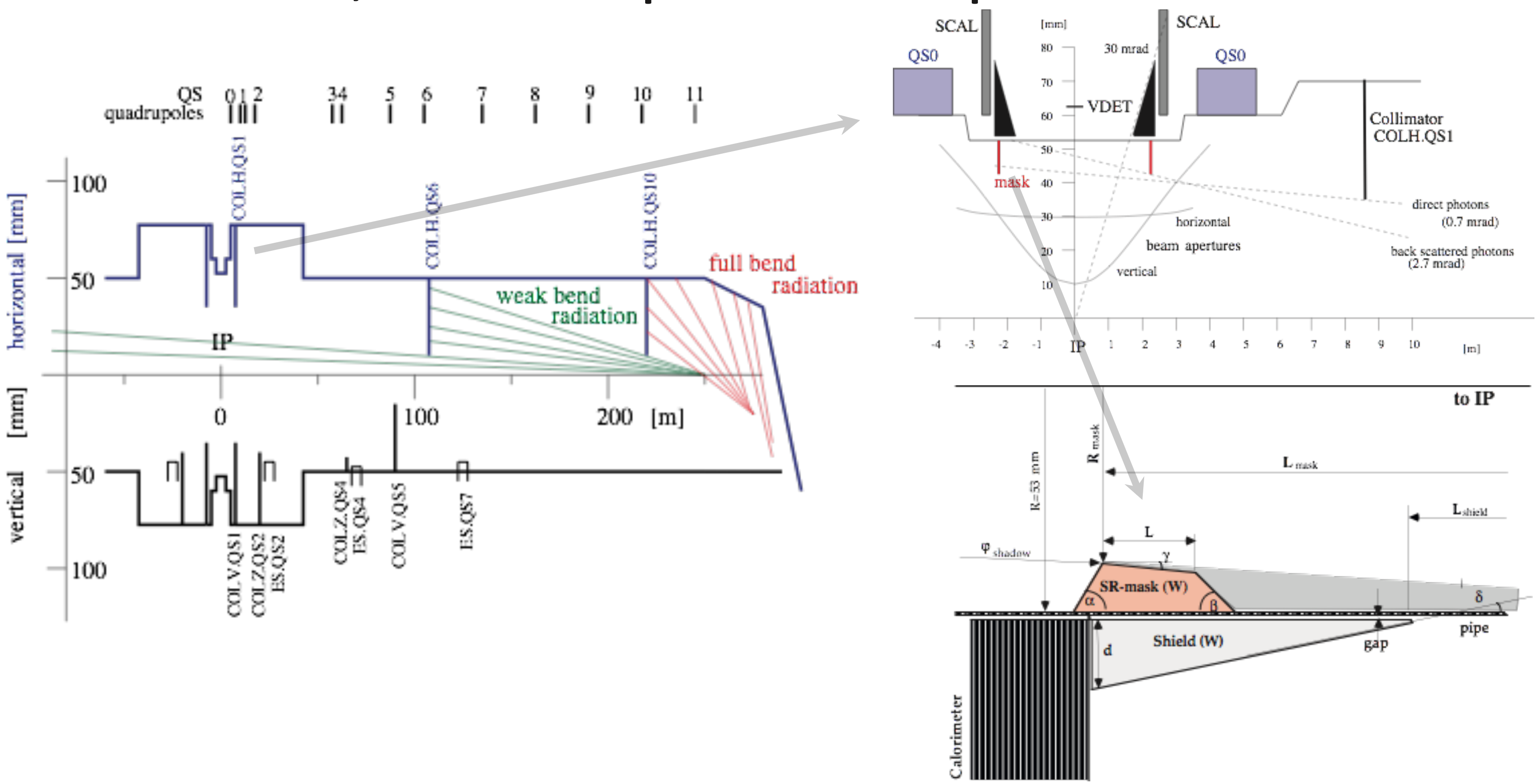
LEP : (tunnel) construction started in 9/1983, operated 1989 - 2000

beam energy 45 GeV to 104.5 GeV, bending radius = 3026 m

Maximum power in synchrotron radiation : 18 MW

Maximum energy loss per turn in synchrotron radiation : 3.5 GeV

LEP, as example of an optimized IR



E_b= 45 GeV to 105 GeV the closest we got to FCC-ee

Machine induced backgrounds, MIB in LEP ~ 100 collimators to reduce MIB

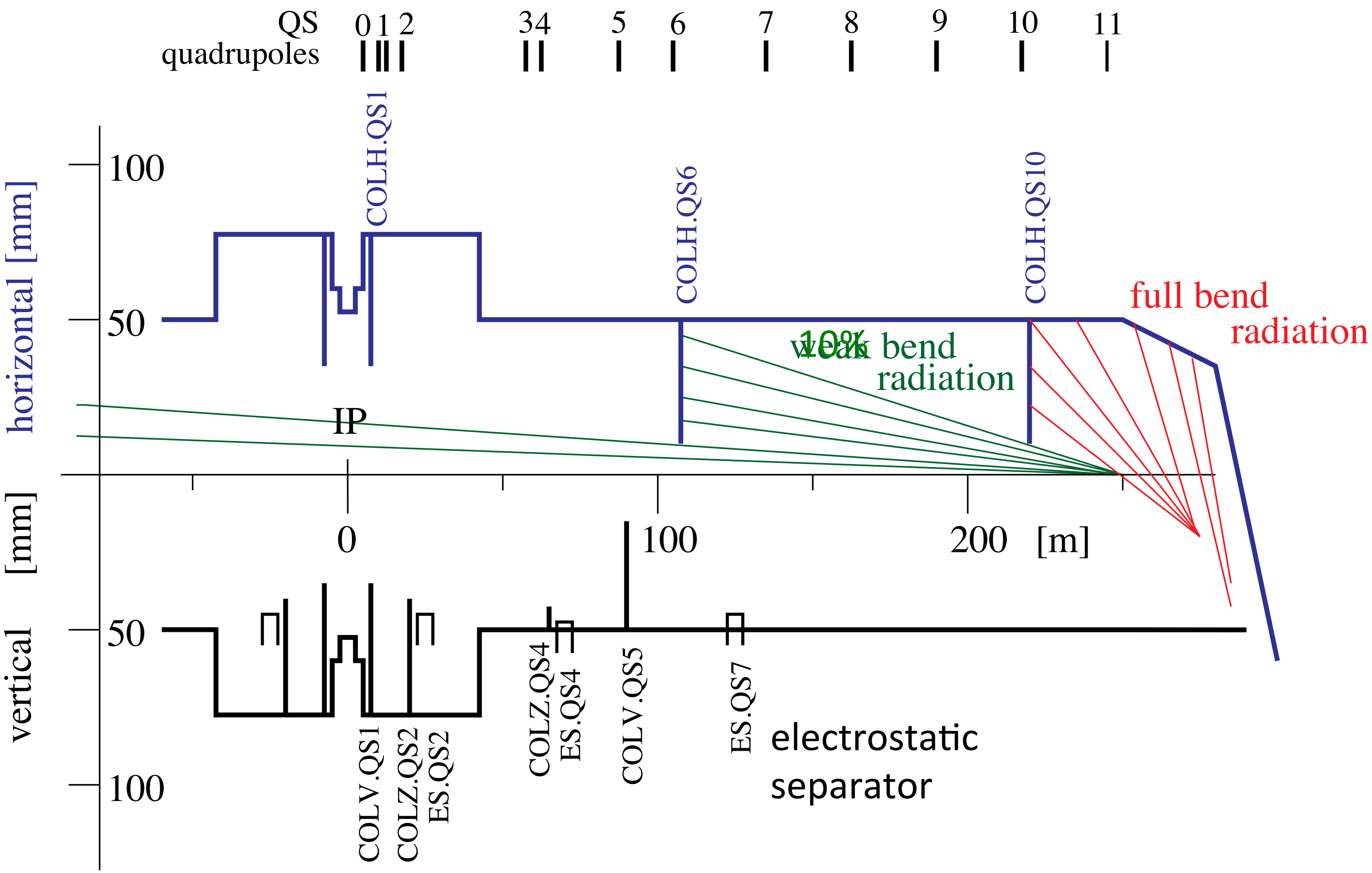
flat, symmetric machine, no crossing angle, few (4-12) bunches

Synchrotron radiation - no direct and single reflected radiation to experiments in IP region

Off-momentum beam-gas and thermal photon

G. von Holtey at al., Nucl.Instrum.Meth.A403:205-246, 1998

LEP IR

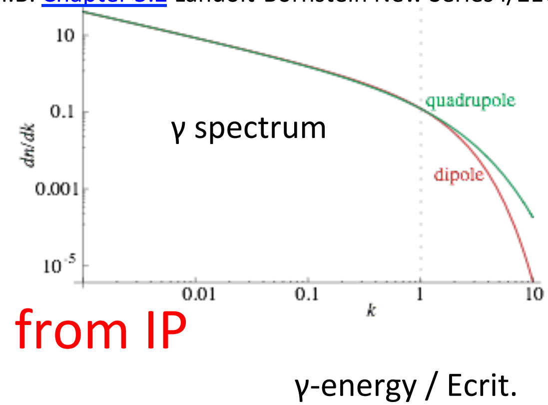


Straight section upstream IP in the horizontal (top) and vertical (bottom) planes.

Approach for FCC-ee IR challenges

Challenge: maximize performance (integrated luminosity) for experiments **for good** or at least tolerable **experimental (background, stability) conditions.**

H.B. Chapter 5.2 Landolt-Börnstein New Series I/21C



Some key points :

Minimize synchrotron radiation in the IR region =>

- **Bends** as weak as possible and as far as possible from IP
- **Quads** have to be strong and close to IP,
  Minimize offset from quad axis
  Careful with vertical halo/tails

SR Monte Carlo : H.B. CERN-OPEN-2007-018 integrated in G4

- **For FCC the approach has been to start developing the software tools**

Generic tool for FCC IR studies (1/3)

```
Welcome to ROOT 6.00/00
From heads/master@v5-99-06-967-gdd4636e, Jun 13 2014, 17:02:00
MAD-X tfs interface and C++11 on
```

Basis: MAD-X lattice and survey (geometry) description, if available with apertures

ROOT as main geometry and interface tool

With extra library to read MAD-X tfs files and calculate derived machine parameters (SynRad)

Step 1: Construct tables (ntuples) with detailed information element by element with transformation of Courant-Snyder machine coordinates to Euclidian detector coordinates

optionally scale up transverse dimensions

```
NtupleRoot* nt_b1 = ReadAndMerge(~/mad/tlep_175_twiss.tfs, ~/mad/tlep_175_survey.tfs); // example, optics TLEP V9, calc Euclid coord
Ering* ering_b1 = new Ering(~/mad/tlep_175_twiss.tfs); // get Energy and Synchr. Integrals from tfs header + body
double nsig=1; // quad radiation from sawtooth + beam size.  0 is sawtooth only, 1 is at 1 sigma; LEP had tails to ~ 50 sigmay
double emitx=ering_b1->emitx(),emity=0.001*emitx;  // emitx=1.41008e-09 emity=1.41008e-12 m
CalcBeamSizeDivergence(nt_b1,emitx,emity,verbose); // calculate beam sizes and divergences and add to ntuple
CalcSynrad(nt_b1,ering_b1->Get_Eb(),emitx,emity,verbose,nsig); // calc bend synrad and quad synrad for nsig
Part e+  E=      175 GeV m=0.000510999 GeV gamma= 342466
```

Bends

iele	NAME	KEYWORD	S	L	Angle	Emean	ngamBend	rho	B	BETX	SIGX	divx
			m	m		MeV		m	T	m	mm	mrad
22	BD07	SBEND	99.5500	21.3000	0.00107	0.18415	3.86499	19878.962	0.029365	41.5836	0.2421	0.0092
26	BD07	SBEND	124.5500	21.3000	0.00107	0.18415	3.86499	19878.962	0.029365	36.2368	0.2260	0.0087
30	BD07	SBEND	149.5500	21.3000	0.00107	0.18415	3.86499	19878.962	0.029365	33.4915	0.2173	0.0093

Quads

iele	Element	s	betx	sigx	divx	K1L	k0	L	x	Angle	Emean	ngam
		m	m	mm	mrad	m-2	m-1	m	mm		MeV	
2	QD1IR	4.375	21.154	0.1727	0.0082	-0.32151	0.00005	0.75000	-0.01078	0.000039	0.190583	0.140844
4	QF2IR	12.625	601.200	0.9207	0.0015	0.15726	0.00014	0.75000	-0.05818	0.000102	0.496561	0.366967
6	QD3IR	28.050	15.864	0.1496	0.0094	-0.35858	0.00005	0.10000	-0.00952	0.000005	0.183835	0.018114

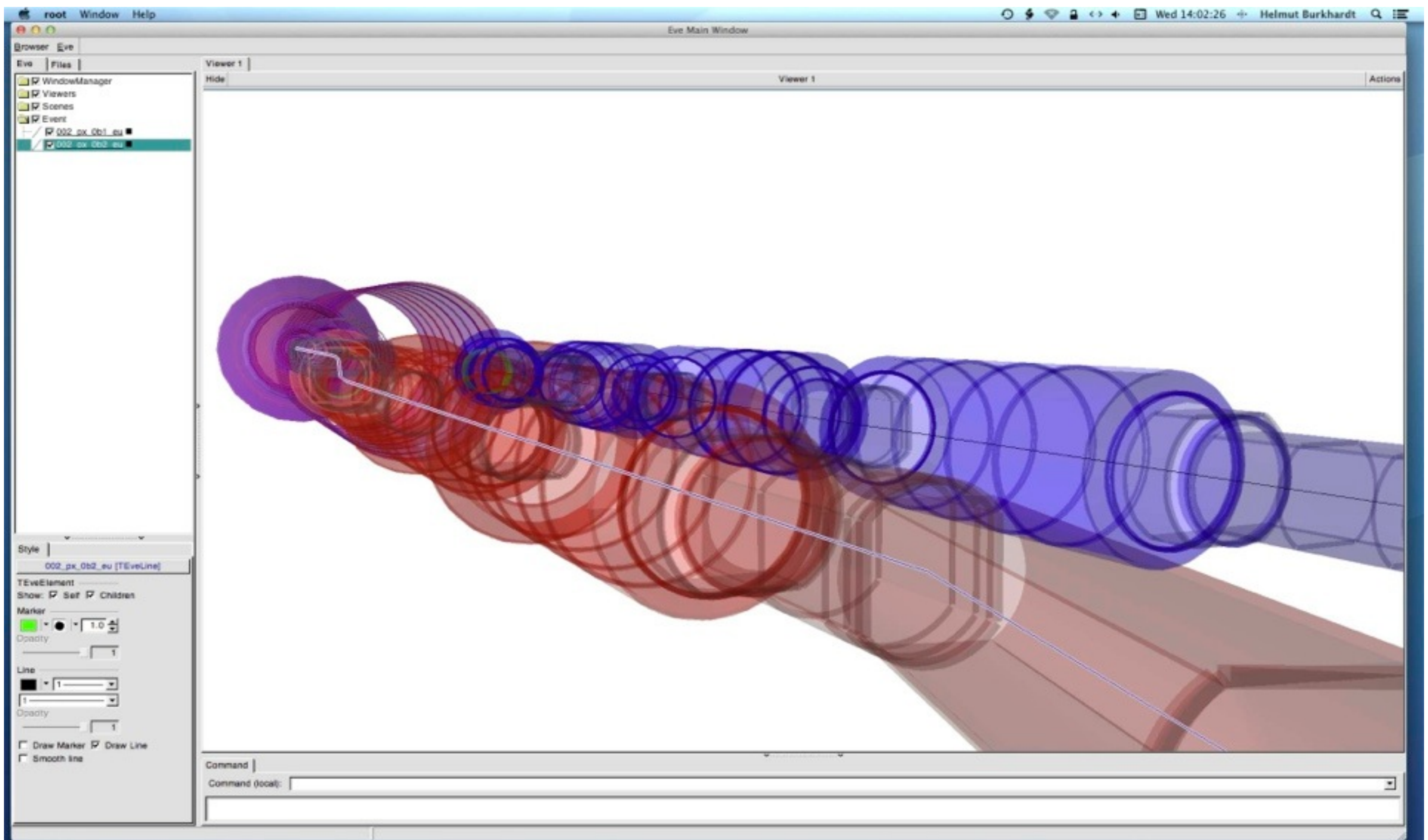
Generic tool for FCC IR studies (2/3)

Step 2: **Geometry display based on MAD-X aperture information using the**

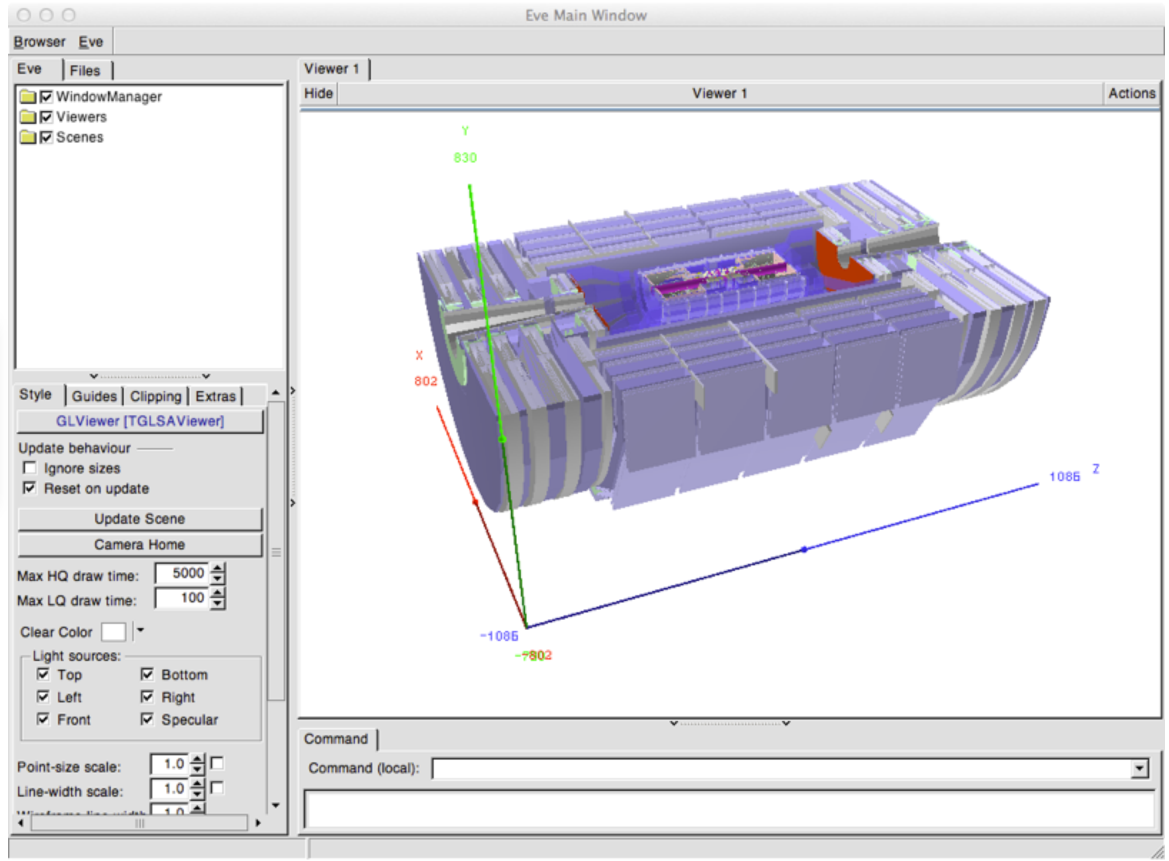
EVE the Event Visualization Environment

in ROOT with OPenGL

Step 3: **accelerator tracking (several options, example here is MAD-X, LHC IR geometry)**



Generic tool for FCC IR studies (3/3)



Detector example

```
cd $ROOTSYS/tutorials/eve/
root
.x geom_cms_playback.C
```

Next :

- **draw SR fans and estimate energy flows --- feedback into IR design**
- combine machine tracking and detector model
- **ROOT-VMC** geometry + with several possible shower codes **Geant4, FLUKA, MARS**

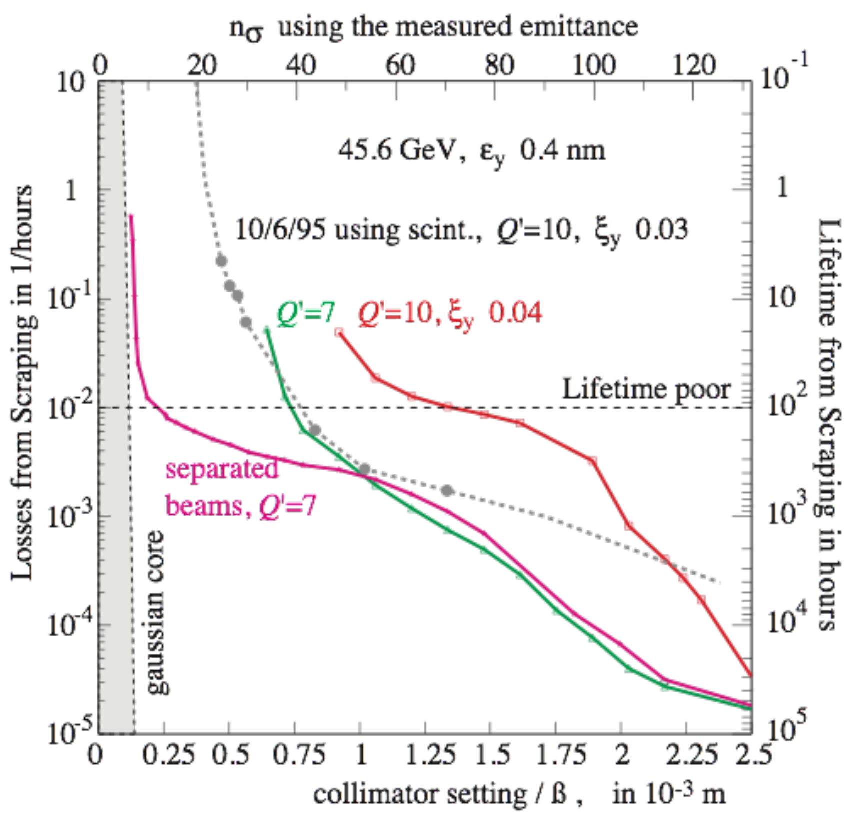
Comparisons with experimental data

important: significant can be the ones for LEP

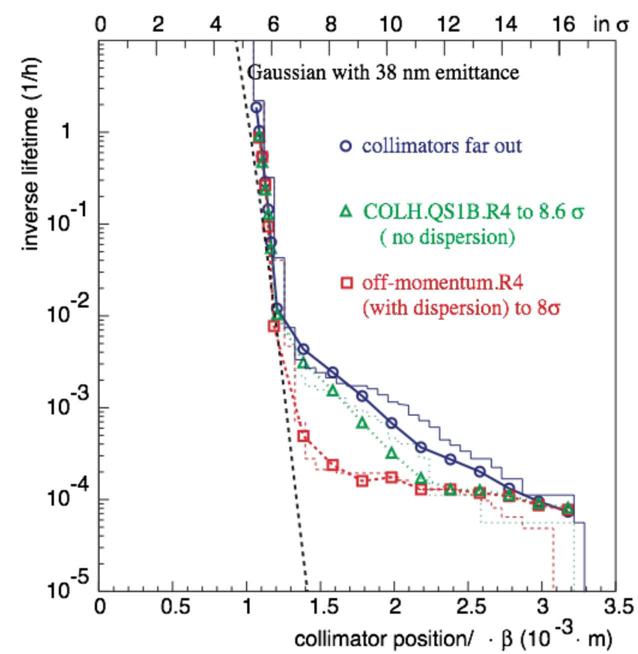
Non-Gaussian tails at LEP

measured by scraping with loss monitors

vertical plane, colliding beams



horizontal plane
reproduced by simulation



Tails from : beam-beam, high chromaticity, particle scattering

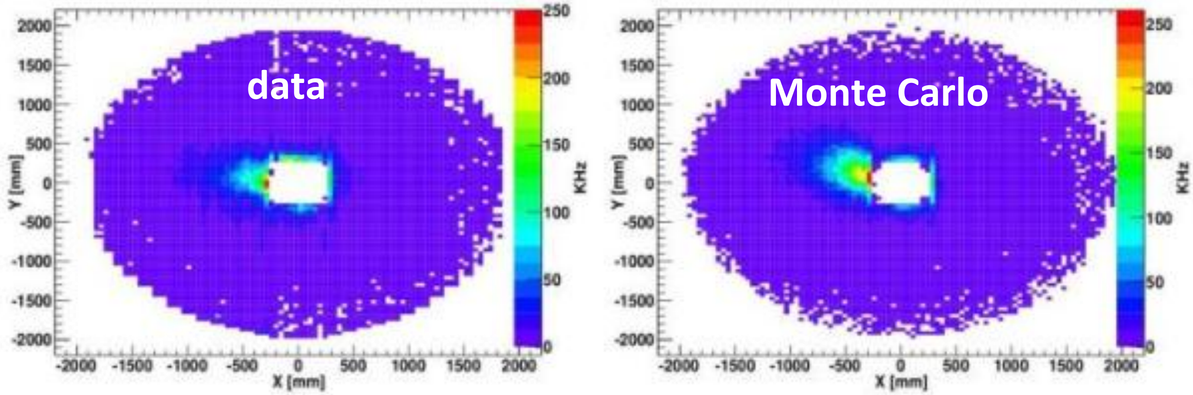
Background spikes, enhanced synchrotron radiation from quadruples

H. Burkhardt, "BEAM LIFETIME AND BEAM TAILS IN LEP." CERN-SL-99-061-AP and Proc. e+ e+ Factories 1999, KEK, Tsukuba 1999
Transverse beam tails due to inelastic scattering, Phys. Rev. ST Accel. Beams 3, 091001 (2000)

DAΦNE real data

Improved simulations (matching measurements) -> reliable predictions

[IPAC11]

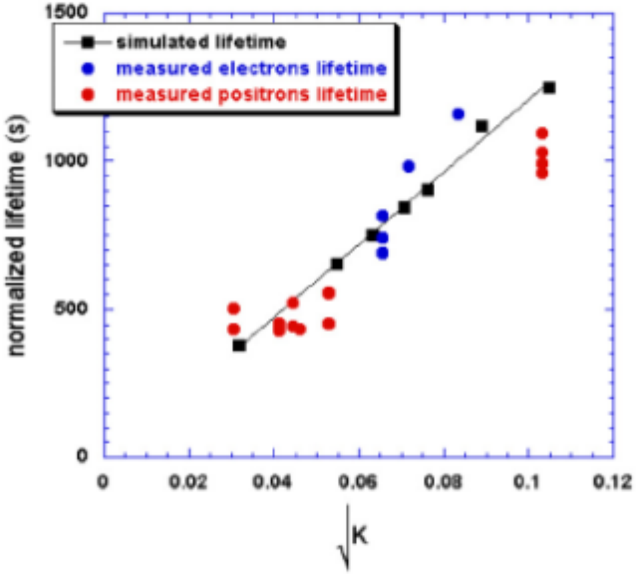


Transverse profile of the background (z<0) EmC rates

N_{part}/bunch	$2\cdot10^{10}$
I_{bunch} (mA)	10
ε_x (μm)	0.26
Coupling (%)	0.1- 0. 4
σ_z (cm)	1.4
β_x*(m)	0.25
β_y*(mm)	9

M. Boscolo et al. PAC01 P.2032
M. Boscolo, M. Antonelli and S. Guiducci, EPAC02 p.1238

M. Boscolo et al. / Nuclear Instruments and Methods in Physics Research A 621 (2010) 121–129



MONTE CARLO SIMULATION FOR THE ... Phys. Rev. ST Accel. Beams **15**, 104201 (2012)

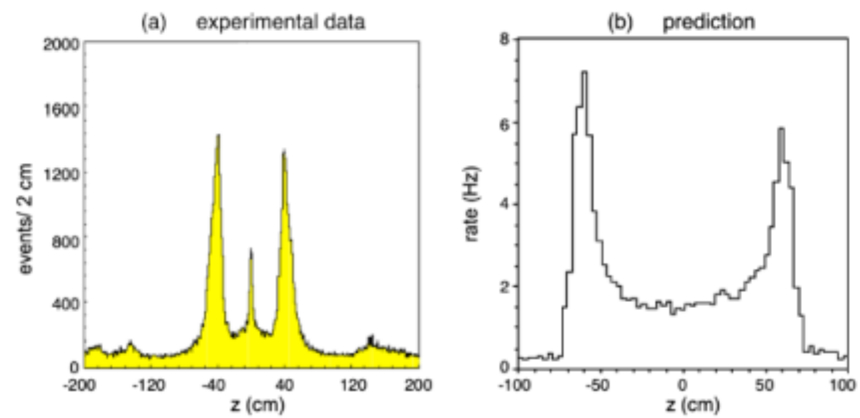
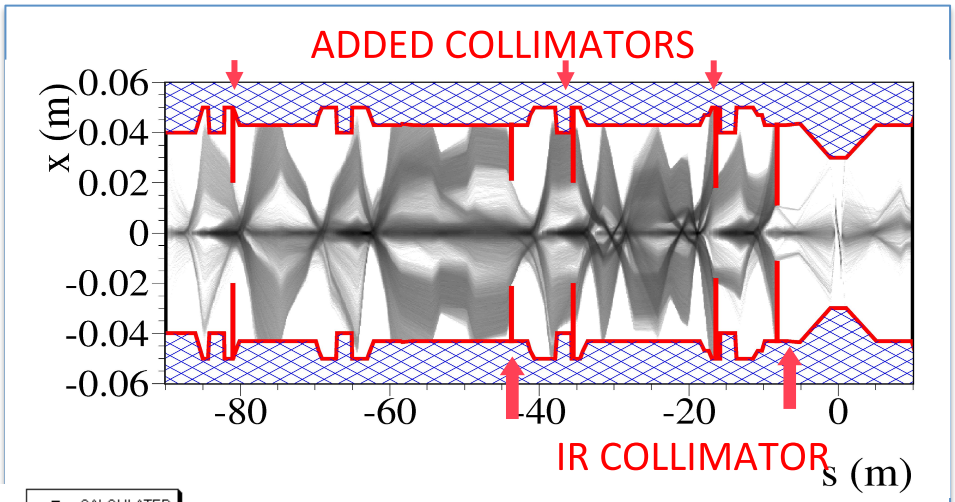
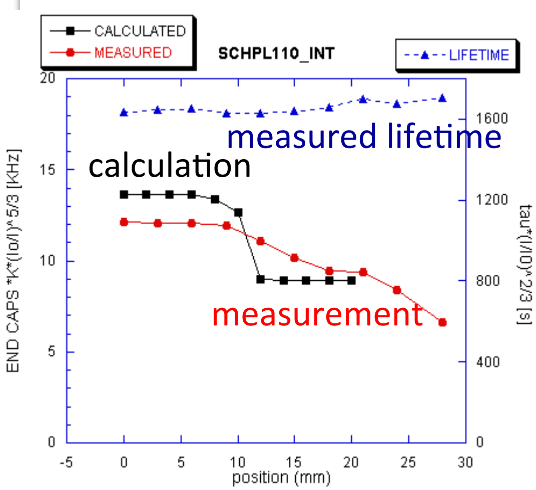


FIG. 12. (a) High rate of localized monotracks (protons) in KLOE until 2001 understood as photo-production $e\,p(n) \rightarrow \Lambda e \rightarrow p\pi^0(\pi^-)e$, induced by Touschek particles hitting the beam pipe support; (b) prediction from full simulation of Touschek particles into detector.

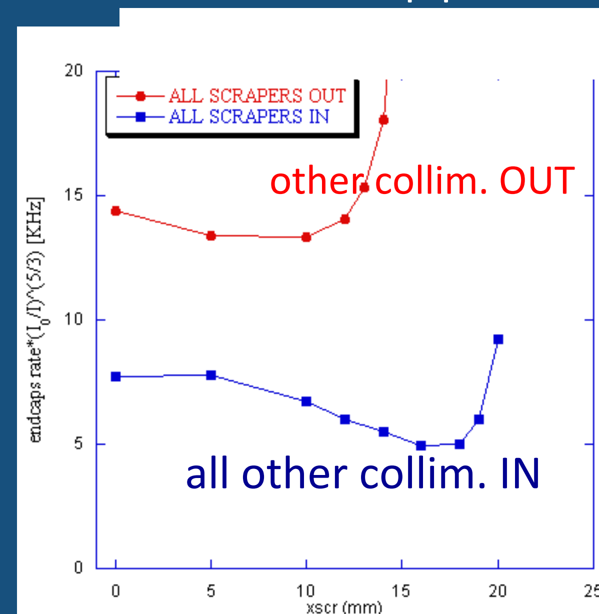
Additional Collimators in high β_x & D_x regions

- Direct background reduction
- They helped in making the IR collimator more effective, by stopping particles that would be just deviated by the IR collimator and eventually lost at the experiment.





A factor 1.6 is gained due to the fact that it can be inserted closer to the center of the pipe.



Scan of the normalized background rate in the KLOE forward calorimeter vs external jaw position of the e+ beam KLOE collimator.

Conclusions

- The design of the IR is a critical issue for the success of a collider
- Careful trade-off machine / detector constraints

detector constraints:

- Physics acceptance from the nominal beam axis
- Smallest possible beam pipe radius
- Thinnest possible beam pipe wall
- Solenoidal detector
- Separation scheme
- L* key parameter

- In this frame simulations of all the effects that induce machine backgrounds –as realistic as possible- are essential

spares

Typical values of beam parameters at the IP

		LEP (45.6 GeV)	FCC-ee (120 GeV)	CEPC (120 GeV)
$\varepsilon_x / \varepsilon_y$	nm	35 / 0.7	0.94 / 1.9E-3	6.8 / 20E-3
β_x^*/β_x^*	m	2.5 / 5.E-2	0.5 / 1.E-3	0.8 / 1.2E-3
σ_x^*/σ_y^*	μm	296 / 5.9	22 / 0.044	73.7 / 0.156

Main parameters (for our interest here)

Super-B factories vs B factories

Param	unit	PEP-II		KEKB		SuperKEKB		SuperB	
		LER(e-)	HER(e+)	LER(e-)	HER(e+)	LER(e-)	HER(e+)	LER(e+)	HER(e-)
L * 10^{34}	$cm^{-2}s^{-1}$	1.2		2.11		80		100	
Circumf.	m	2200		3014		3014		1200	
Energy	GeV	3.12	8.97	3.5	8.0	4	7.007	4.18	6.7
I(beam)	A	2.99	1.875	1.64	1.2	3.6	2.6	2.44	1.9
I (bunch)	mA	7.9	5.0	1.0	0.75	1.4	1.04	2.5	1.9
$\varepsilon_x/\varepsilon_y$	nm /pm	36 / 1000	73/ 1000	18 / 180	24 / 240	3.2/8.64	4.6/11.5	2.5 / 6.1	2 / 5
σ_x/σ_y(IP)	mm /nm	147/5000		150 / 940	150 / 940	10 / 48	11 / 62	8.9 / 36	7.2 / 36

full crossing angle
SuperKEKB = 83 mrad
SuperB (and tau-c) = 60 mrad

Denser beams → higher L

also : higher backgrounds
& lower lifetimes

SuperKEKB / TLEP

parameters	unit	TLEP t	TLEP Z	SUPERKEKB LER	SUPERKEKB HER
L/IP	10^{34} cm^{-2}s^{-1}	1.3	56	80	
E_{beam}	GeV	175	45	4	7
β_x*	m	1	0.5	0.032	0.025
β_y*	cm	0.1	0.1	2.7	3.0
ε_x	nm	10	30.8	3.2	4.6
ε_y	pm	10	0.07	8.6	12.9
I_{beam}	A	0.0054	1.18	3.6	2.6
$\kappa = \varepsilon_y / \varepsilon_x$	%	0.1	4.4	0.27	0.28
I_{bunch}	mA	0.45	0.27	1.44	1.04
N_{part}/beam	10^{12}	9	1960		
N_{part}/bunch	10^{11}	7.5	4.45		
n bunches	#	12	4400	2500	
σ_x*	μm	100	124	10	11
σ_y*	μm	0.1	0.27	0.048	0.062
beam lifetime	min	20	67	5	

Background Sources- / Rates to be evaluated

- **Luminosity sources**
  - Beamstrahlung
  - Bhabha (Radiative)
  - Pair production $e^+e^- \rightarrow e^+e^- \; e^+e^-$
  - Muon production $e^+e^- \rightarrow e^+e^- \mu^+\mu^-$
  - beam-beam (Halo)
- **Linear with Currents**
  - Synchrotron radiation
  - Beam-gas Coulomb/ Bremsstrahlung
- **Other sources**
  - thermal outgassing due to HOM losses
  - injection background
  - High order modes
  - Compton thermal photons
  - ion or electron cloud
  - intrabeam scattering

Lifetime/ IR loss summary

SuperKEKB

Life time	Touschek	Beam-gas Coulomb	Rad. Bhabha
LER	10 min	25 min	28 min+
HER	10 min	46 min	20 min+

IR loss |s|<4m	Touschek	Beam-gas Coulomb	Rad. Bhabha
LER	250 MHz	90 MHz	0.6GHz*
HER	30 MHz	<10 MHz	0.5GHz*

*Effective rate

calculated by scaling with beam energy to compare with almost on-energy Touschek and beam-gas losses

SuperB

Life time	Touschek	Beam-gas Coulomb	Rad. Bhabha
LER	7 min	24 min	6.3min+
HER	22 min	51 min	4.9 min+

IR loss |s|<2m	Touschek	Beam-gas Coulomb	Rad. Bhabha
LER	72 MHz	20 MHz	O(GHz)
HER	<7 MHz	<4 MHz	O(GHz)

+ 1% energy acceptance