$e^+ e^-$ Factories

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Outline

- Factory Running
- KEKB
- PEP-II
- DAFNE
- CESR-c
- BEPCII
- Summary

Factory Running

- High luminosity is the "other physics discovery channel"
- The B factories, after having measured CP violation in the B meson system, are now looking for very rare decay channels that can have a signature for physics beyond the Standard Model
- All factories are looking for deviations from the Standard Model or are making precision measurements
- These kinds of searches need as much data as possible. The more data the rarer the decay channel that can be investigated.

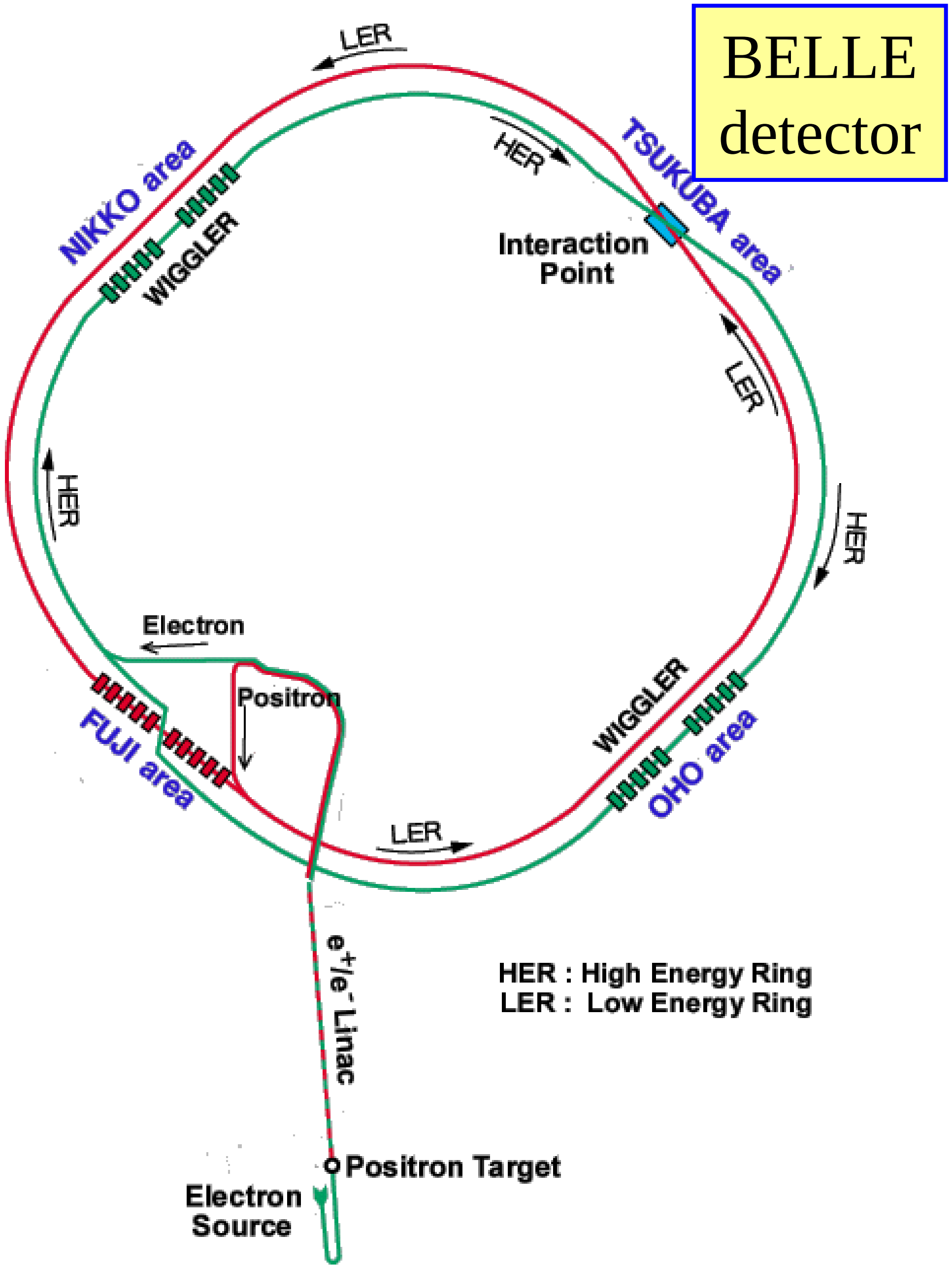
Factory Running (2)

- There are five e^+e^- factories
- The two asymmetric-energy B factories, KEKB and PEP-II – Looking at B meson decays
- DAFNE – a Φ factory looking at K meson decays
- CESR-c – A pioneering B factory that has moved down to the Tau-charm energy region – looking at D meson decays
- BEPC II – A new factory in the Tau-charm region as well

KEKB

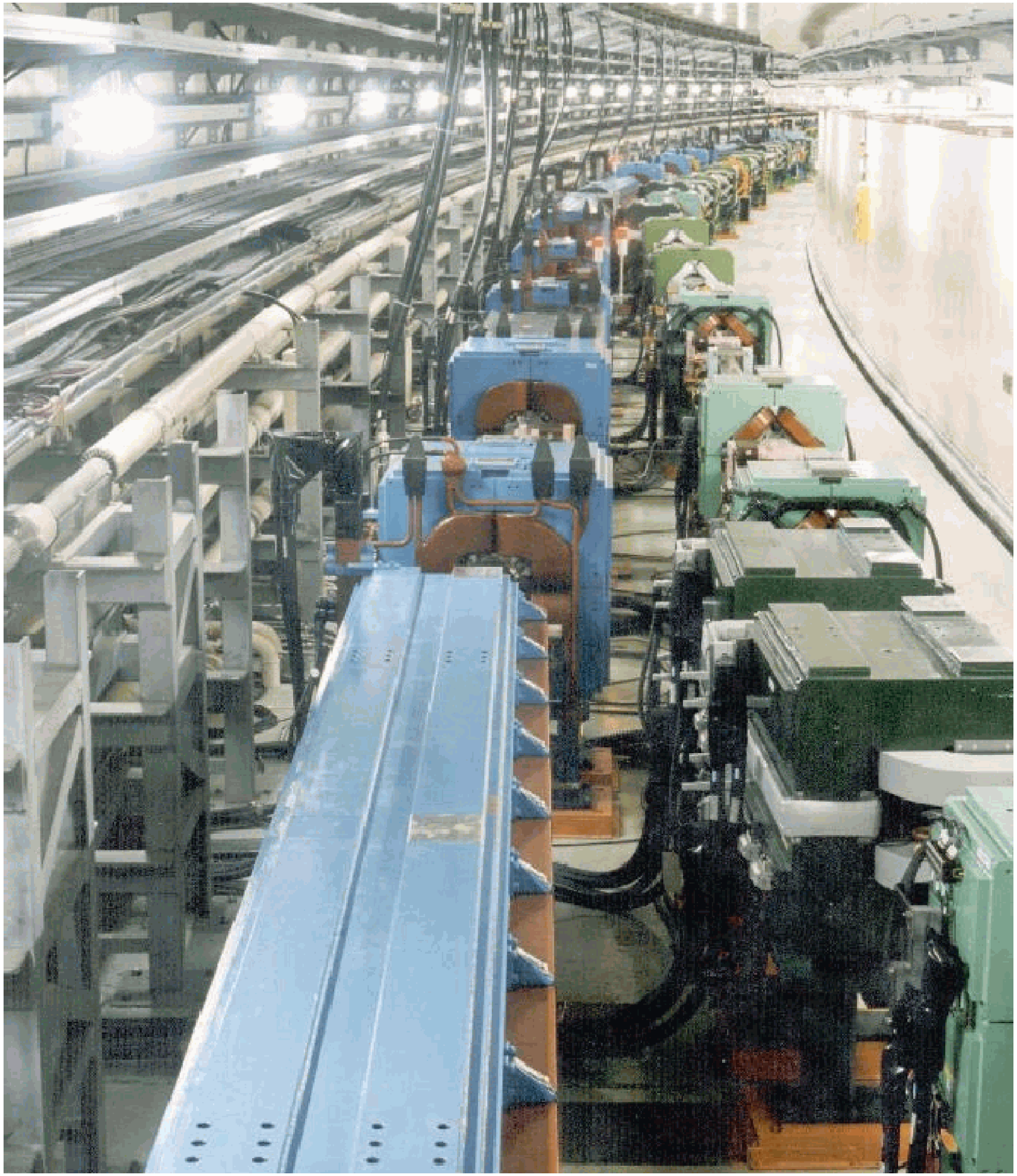
- KEKB has the highest luminosity of any e^+e^- collider (1.7×10^{34} cm^{-2} s^{-1})
- Ring circumference – 3000 m
- BELLE, the detector, has the largest data set of B meson decays
- KEKB has a ±11 mrad crossing angle collision
- They are commissioning crabbing cavities to convert the collision into a head-on type
- Hope for a factor of two increase in luminosity
- They also have a proposal to upgrade KEKB to a 4×10^{35} cm^{-2} s^{-1} luminosity machine

KEKB storage ring layout



KEKB Parameters

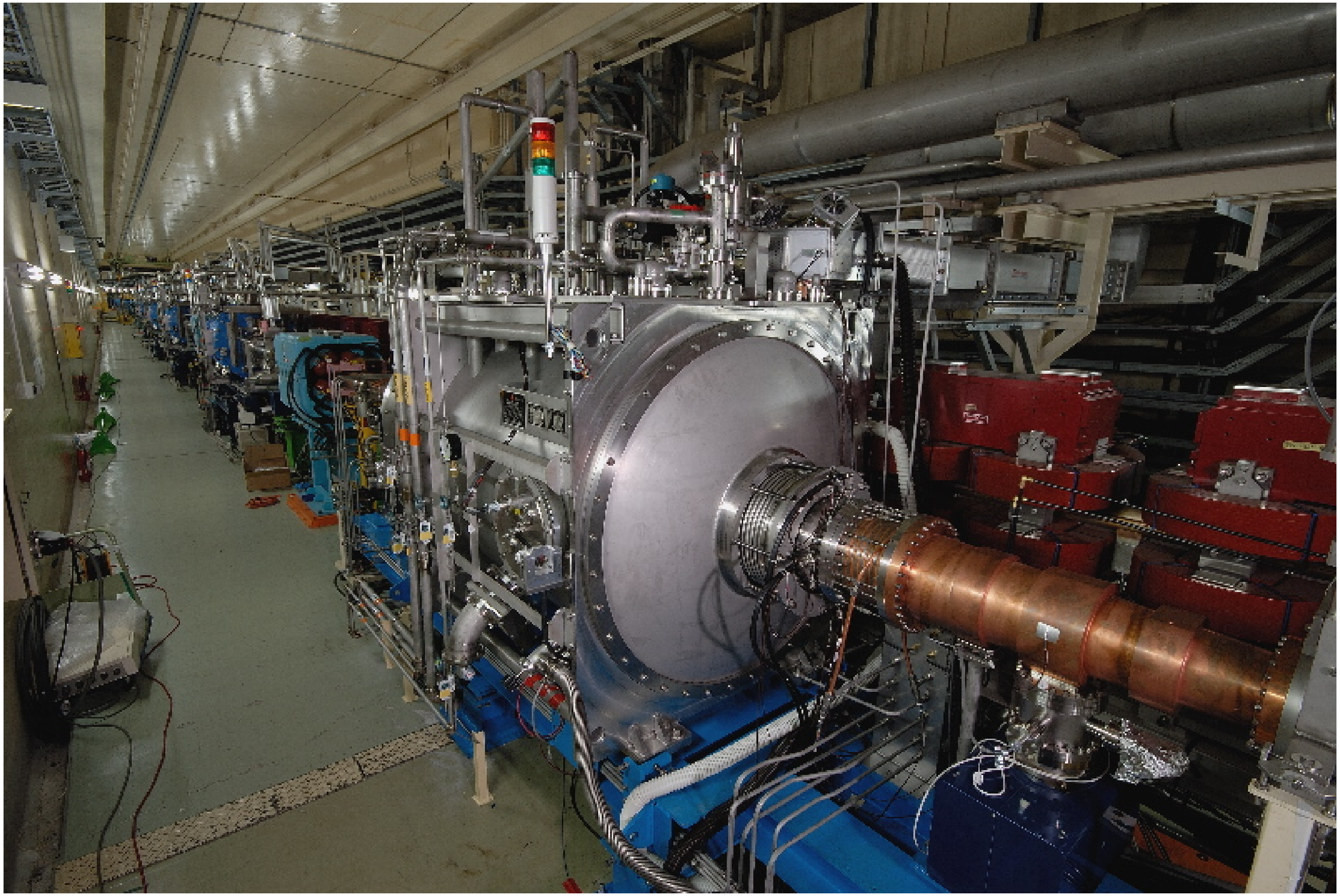
	Design		Achieved	
	e^-	e^+	e^-	e^+
•Beam energies (GeV)	8.0	3.5	E_{cm}=10.80	
•Currents (A)	1.1	2.6	1.34	1.66
•Number of bunches	5000		1388	
•Bunch spacing (m)	1.2		2.4	
•Bunch currents (mA)	0.22	0.52	0.97	1.20
•Beam stored energy (kJ)	90	92	110	59
•Luminosity ($\times 10^{33}$/cm^2/sec)	10.0		17.12	
•Integrated Luminosity (fb^{-1})			710	
•Data set (B mesons)			$1.4\text{x}10^9$	



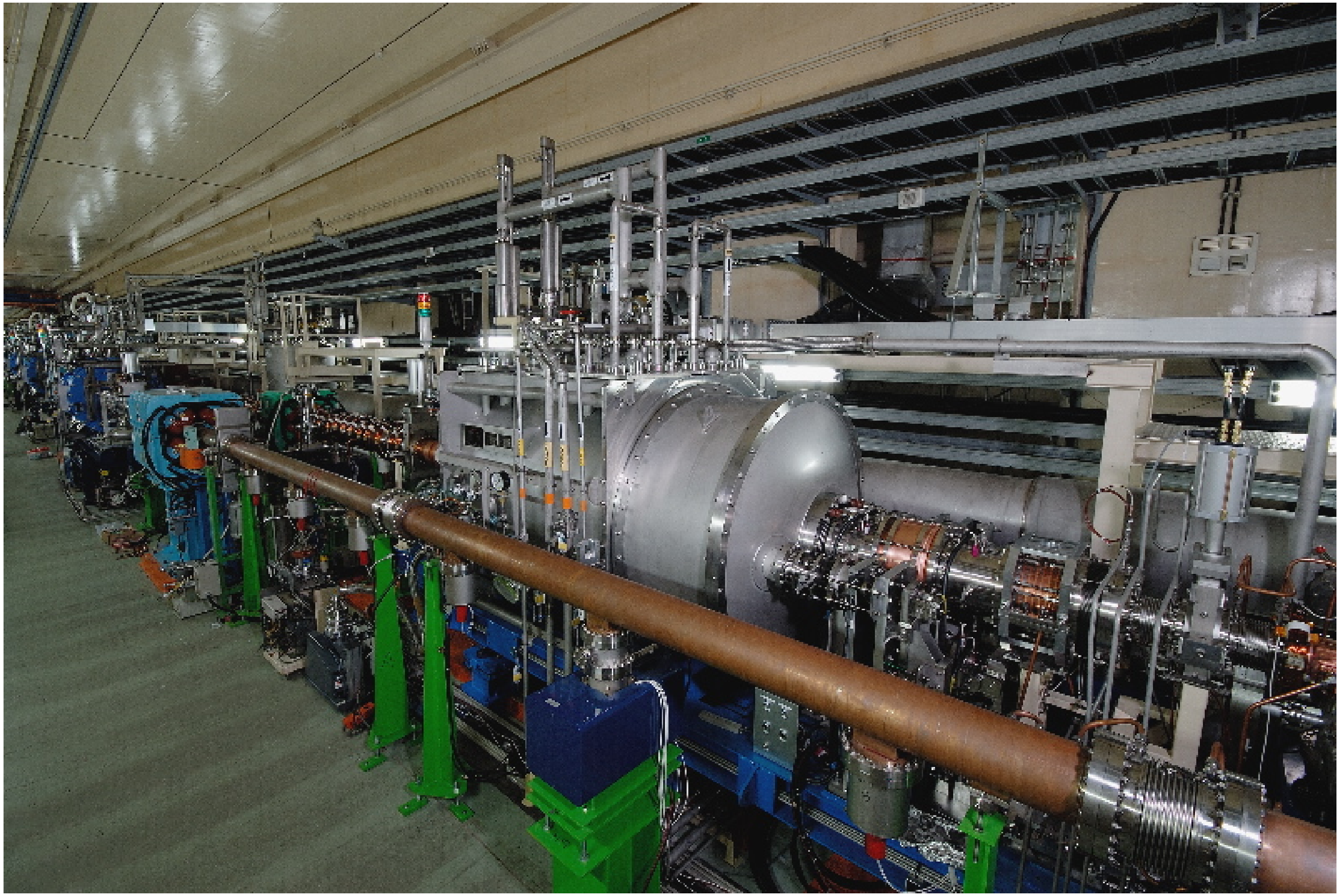
KEKB arc

KEKB
RF section

HER Crab Cavity



LER Crab cavity



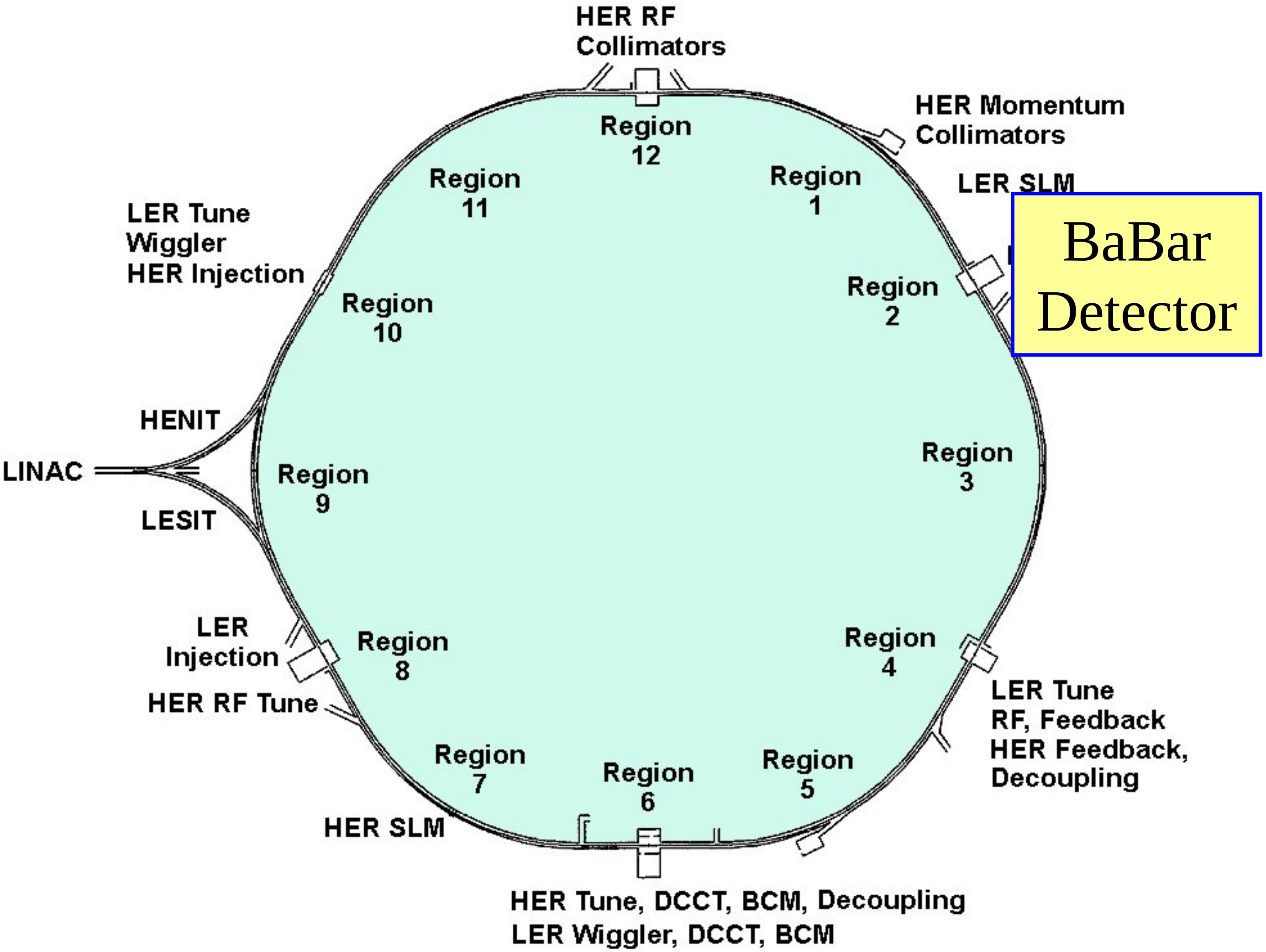
Selected KEKB Talks and Posters

- Talks
- MOZAKI02 Compensation of the Crossing Angle with Crab Cavities at KEKB
- TUODAB01 Variations of Betatron Tune Spectrum due to Electron Cloud Observed in KEKB
- THOBKI01 Development of a Movable Collimator with Low Beam Impedence
- Posters
- TUPAN041 Recent Progress of KEKB
- TUPAN042 Calibration Method for Synchrotron Radiation Monitor by Using a Vertical Bump in KEKB
- TUPAN045 Beam Operation with Crab Cavities at KEKB
- THPAN037 Beam-Beam Effects Observed at KEKB
- THPAN041 Optics Correction Using Orbit Displacement at Sextupole Magnet
- THPAN042 Recent Progress of Optics Correction at KEKB
- FRPMN035 Crabbing Angle Measurement by Streak Camera at KEKB
- FRPMN038 Simulation of Synchro-betatron Sideband due to Electron Cloud Instability
- FRPMN041 Study on the Longitudinal Impedance of BPM for KEKB and Super KEKB
- FRPMN042 Continued Study on the Photoelectron and Secondary Electron Yield of TiN Coating and NEG (Ti-Zr-V) Coating at the KEKB Positron Ring

PEP-II

- Second highest factory for luminosity (1.2×10^{34} cm^{-2} s^{-1}) 4x over design
- Highest beam currents and largest amount of stored positrons
- Ring circumference – 2200 m
- Upgrade plans include lower emittance for both rings
- Also plan to raise beam currents to 2.2 A for the HER and 4 A for the LER
- Hope to get to 2×10^{34} cm^{-2} s^{-1}
- HOM power

PEP-II Rings

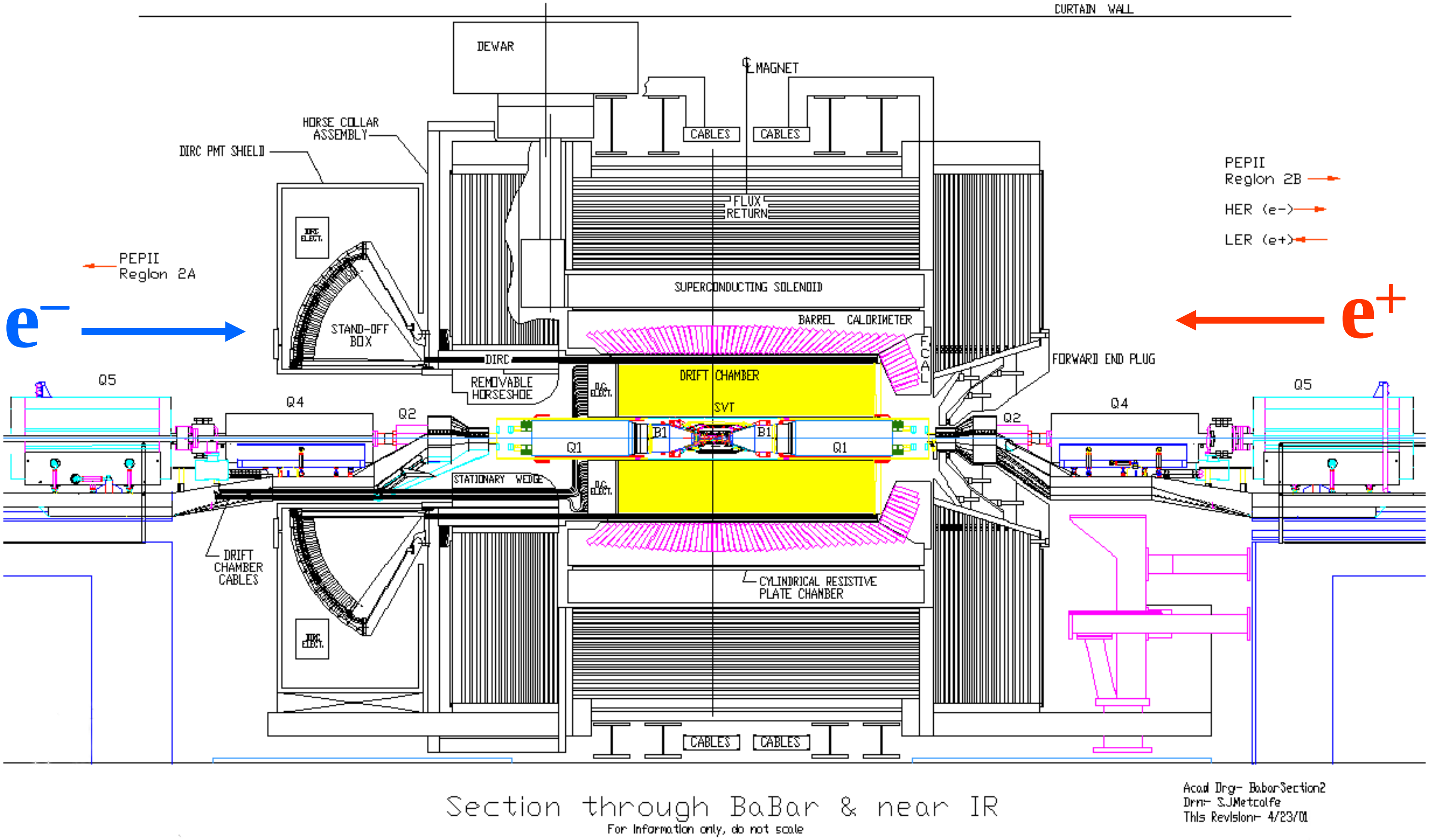

HER RF
Collimators
HER Momentum
Collimators
LER SLM
BaBar
Detector
Region
12
Region
11
Region
1
Region
2
Region
10
Region
3
Region
9
Region
8
Region
4
Region
7
Region
6
Region
5
LER Tune
Wiggler
HER Injection
HENIT
LINAC
LESIT
LER
Injection
HER RF Tune
HER SLM
LER Tune
RF, Feedback
HER Feedback,
Decoupling
HER Tune, DCCT, BCM, Decoupling
LER Wiggler, DCCT, BCM

PEP-II Parameters

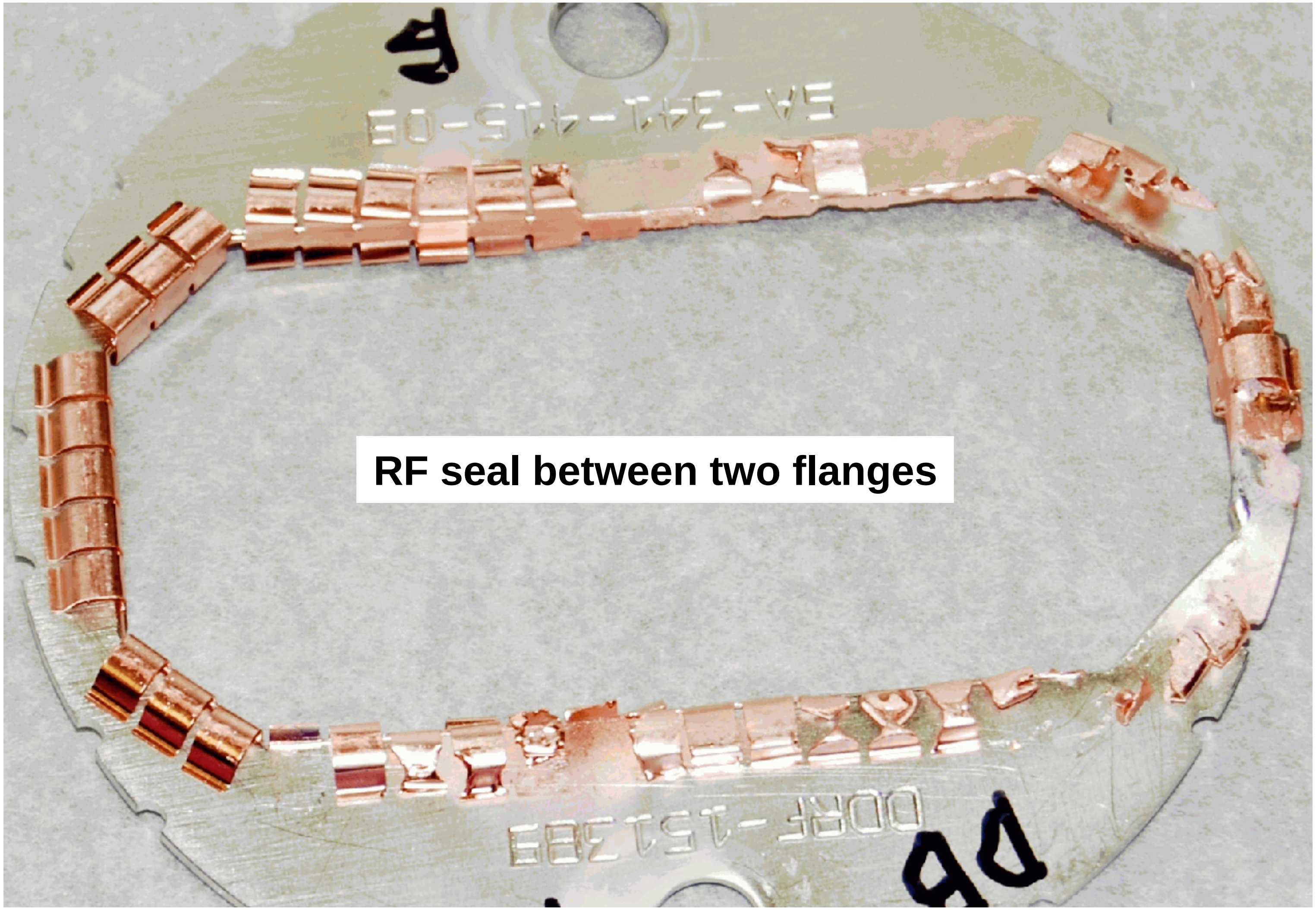
	Design		Achieved	
	e^-	e^+	e^-	e^+
•Beam energies (GeV)	9.0	3.1	E_{cm}=10.80	
•Currents (A)	0.75	2.14	1.85	2.99
•Number of bunches	1658		1722	
•Bunch spacing (m)	1.26		1.26	
•Bunch currents (mA)	0.45	1.29	1.07	1.73
•Beam stored energy (kJ)	49	49	118	68
•Luminosity ($\times 10^{33}$/cm^2/sec)	3.0		12.07	
•Integrated luminosity (fb^{-1})			450	
•Data set (B mesons)			9×10^8	

PEP-II Tunnel

BaBar Detector



HOM power



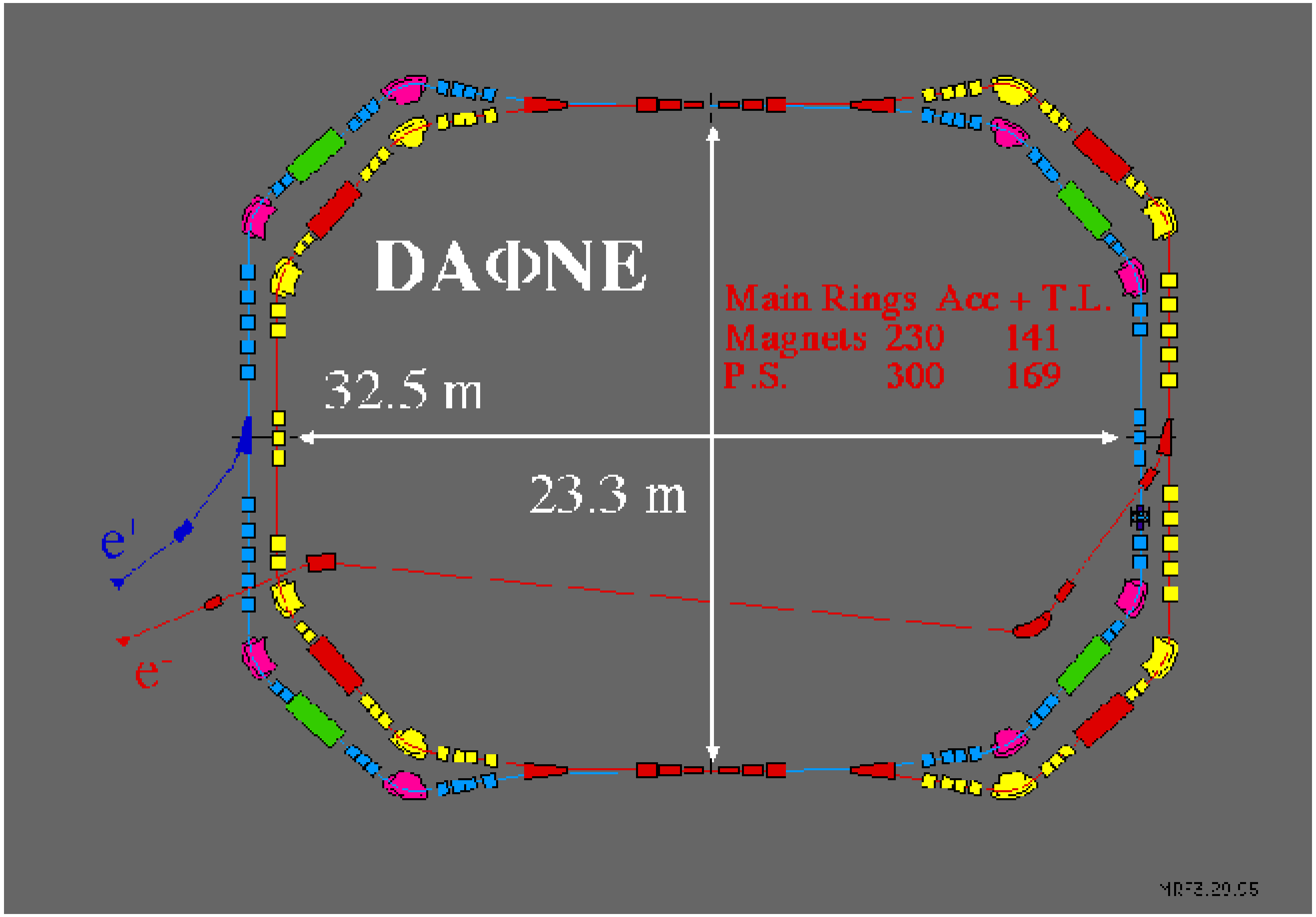
Selected PEP-II Talks and Posters

- Talks
  - MOZAKI03 — PEP-II Operation over a Luminosity of 10^{34}
  - MOOAKI02 — Overall HOM Measurement at High Beam currents in the PEP-II SLAC B-Factory
- Posters
  - MOPAS058 — Analysis of the Longitudinal Low-order Mode Beam Dynamics in PEP-II Rings at High Current
  - MOPAS063 — Longitudinal Low-order Mode Beam Dynamics at PEP-II: Models, Stability, and Limits
  - TUPAS065 — How to Reach Much High Beam-Beam Parameters in PEP-II?
  - TUPAS068 — A Beam Instability in the PEP-II HER Induced by Discharges in the Vacuum System
  - TUPAS069 — Commissioning the 90 Degree Lattice for the PEP-II High Energy Ring
  - TUPAS070 — Optimization of Chromatic Optics Near the Half Integer in PEP-II
  - WEPMS047 — Selecting RF Amplifiers for Impedance Controlled LLRF Systems – Nonlinear Effects and System Implications
  - THPAS056 — Perturbation of a Closed Orbit in Coupled Lattice
  - THPAS057 — Significant Lifetime and Background Improvements in PEP-II by Reducing the 3rd Order Chromaticity in LER with Orbit Bumps
  - THPAS058 — Lowering the Vertical Emittance of the LER Ring of PEP-II
  - THPAS068 — Calculating IP Tuning Knobs for the PEP-II High Energy Ring Using Singular Value Decomposition Response Matrices and an Adapted Moore Penrose Method
  - THPAS070 — Validation of PEP-II Resonantly Excited Turn-by-Turn BPM Data
  - FRPMS066 — Commissioning the Fast Luminosity Dither for PEP-II
  - FRPMS075 — Modeling of the Sparks in Q2-bellows of the PEP-II SLAC B-Factory
  - FRPMS076 — A New Q2-Bellows Absorber for the PEP-II SLAC B-Factory
  - FRPMS077 — High Current Effects in the PEP-II SLAC B-Factory

DAFNE

- The only Φ factory studying K meson decays
- K meson decay rates contributed to the prediction of the mass of the charmed quark – before it was discovered
- Ring circumference – 100 m
- Upgrade plans include an implementation of a "crabbed waist" collision similar to the ILC and proposed for a new Super B factory design

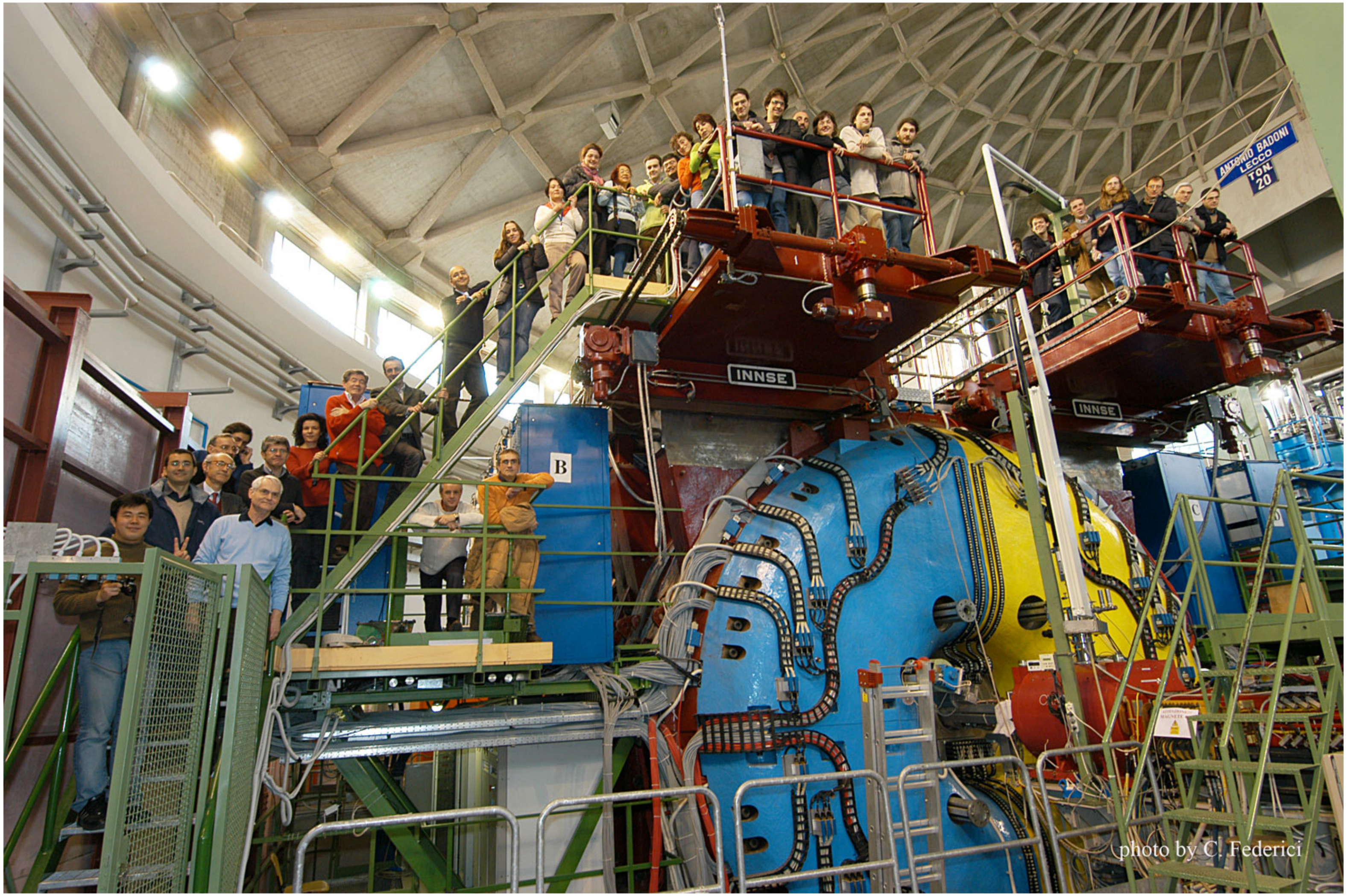
Accelerator Layout



DAFNE Parameters

	Design e^- and e^+	Achieved e^-	Achieved e^+
•Beam energies (GeV)	0.51	E_{cm}=1.02	
•Currents (A)	5.2	1.5	1.1
•Number of bunches	120	111	
•Bunch spacing (m)	0.8	0.8	
•Bunch currents (mA)	43	13.5	10.
•Beam stored energy (kJ)	0.85	0.24	0.18
•Luminosity ($\times 10^{32}$/cm^2/sec)	5.3	1.6	
•Integrated Luminosity (fb^{-1})		0.8	

KLOE detector



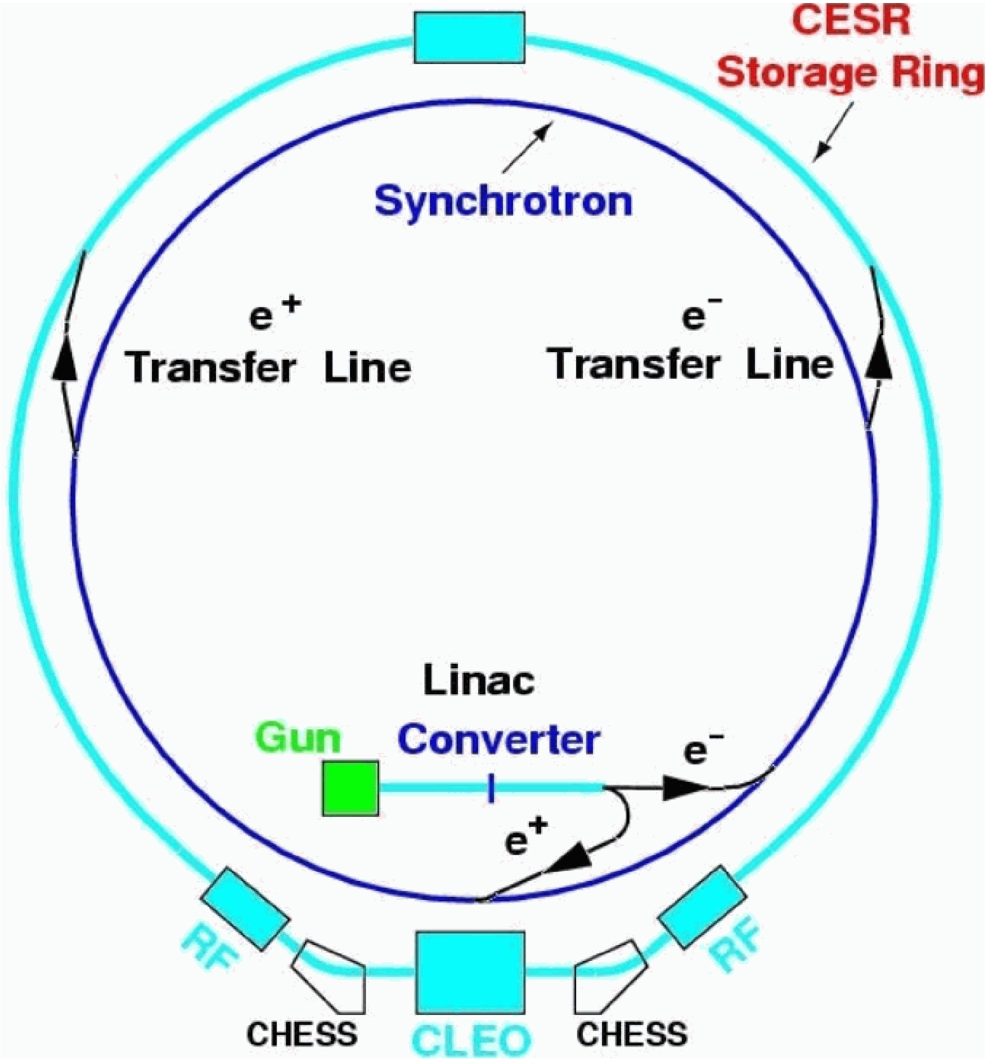
Selected DAFNE Talks and Posters

- Talks
  - MOOBKI02 DAPHNE Phi-Factory Upgrade for Siddharta Run
- Posters
  - TUPAN031 Touschek Background and Beam Lifetime Studies for the DAFNE Upgrade
  - TUPAN033 DAFNE Setup and Performances During the Second FINUDA Run
  - TUPAN035 DAPHNE Wiggler Modification
  - TUPAN036 DAPHNE Upgrade: A New Magnetic and Mechanical Layout
  - TUPAN037 Beam-Beam Simulation for Particle Factories with Crabbed Waist Scheme
  - FRPMN028 Design and E.M. Analysis of the New DAFNE Interaction Region
  - FRPMN029 Dynamic Aperture Optimization for the DAPHNE Upgrade

CESR-c

- Relative newcomer (running for 3 yrs)
- Ring circumference – 768 m
- Has achieved half of design luminosity
- Uses 12 large super-conducting wiggler magnets to improve damping times at the Tau-charm energy region
- These damping wigglers are being studied by the ILC

Layout


CESR
Storage Ring
Synchrotron
e+
Transfer Line
e−
Transfer Line
Linac
Gun
Converter
e−
e+
RF
RF
CHESS
CLEO
CHESS

CESR-c Parameters

	Design	Achieved	
	e^- and e^+	e^- and e^+	
•Beam energies (GeV)	1.5-2.5	E_{cm}=3-5	
•Currents (A)	0.23	0.06	0.07
•Number of bunches	45	24	
•Bunch spacing (m)	17	17	
•Bunch currents (mA)	3-5	2.5	2.9
•Beam stored energy (kJ)	1-1.5	0.26	0.30
•Luminosity ($\times 10^{33}$/cm^2/sec)	0.15-0.5	0.07	
•Integrated Luminosity (fb^{-1})	7	0.7	

Selected CESR-c Talks and Posters

- Talks

- MOZBKI02 CESR-c: A Wiggler-dominated Collider
- MOOAKI01 Plans for Utilizing the Cornell Electron Storage Ring as a Test Accelerator for ILC Damping Ring Research and Development

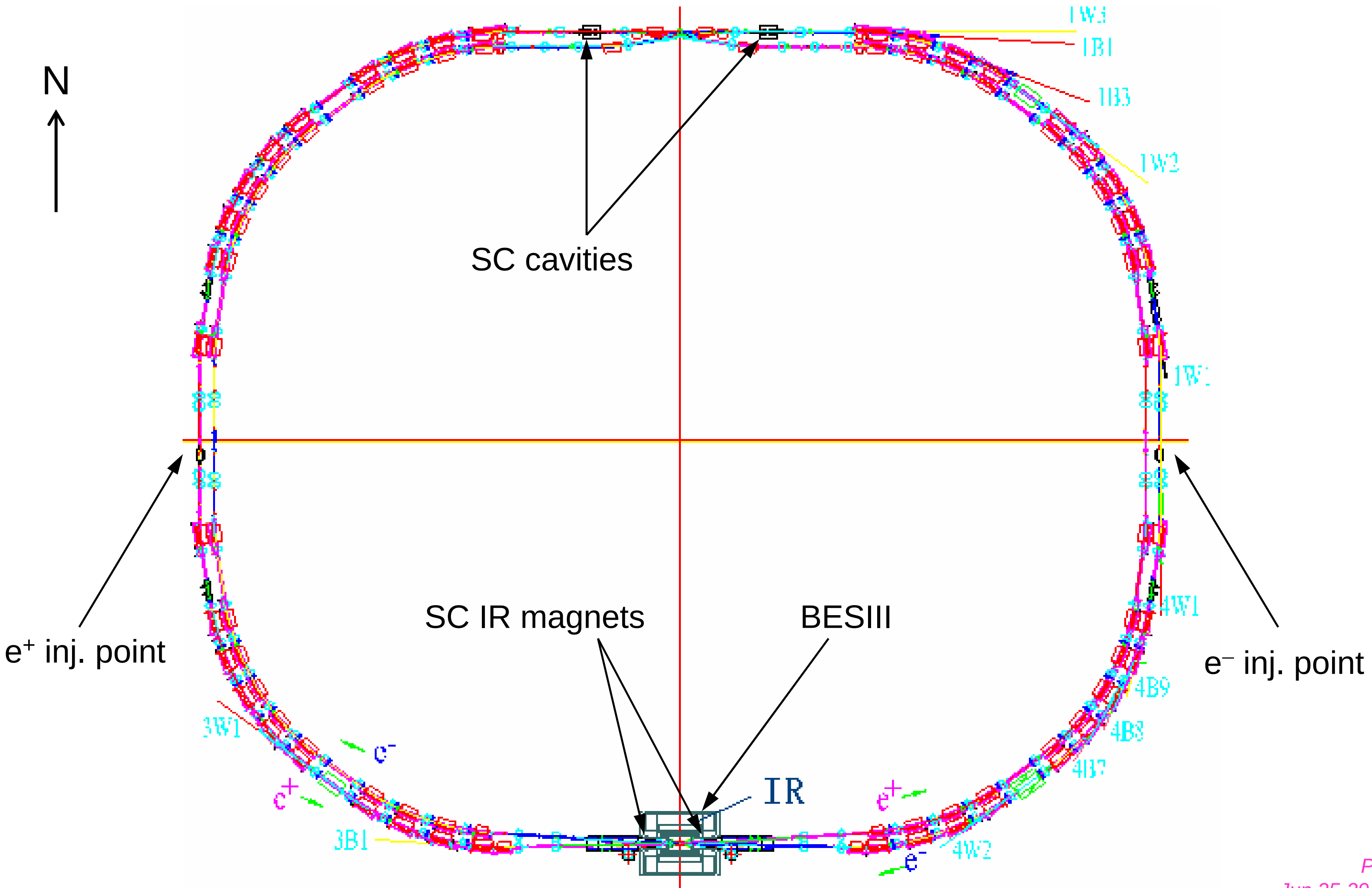
- Posters

- TUPAS056 Compensation Strategy for Optical Distortions Arising from the Beam-Beam Interaction at CESR
- THPAN087 Study of Turn-by-turn Vertical Beam Dynamics at Low and High Energy CESR Operation
- FRPMS047 Design and Implementation of an Electron and Positron Multi-bunchTurn-by-Turn Vertical Beam Profile Monitor in CESR

BEPCII

- Latest factory – just coming online
- Ring circumference – 238 m
- They have stored 500 mA e- and 610 mA of e+
- Collisions have been seen
- Interaction region has to accommodate colliding beams as well as an electron beam that travels out through the positron beam line when in light source mode

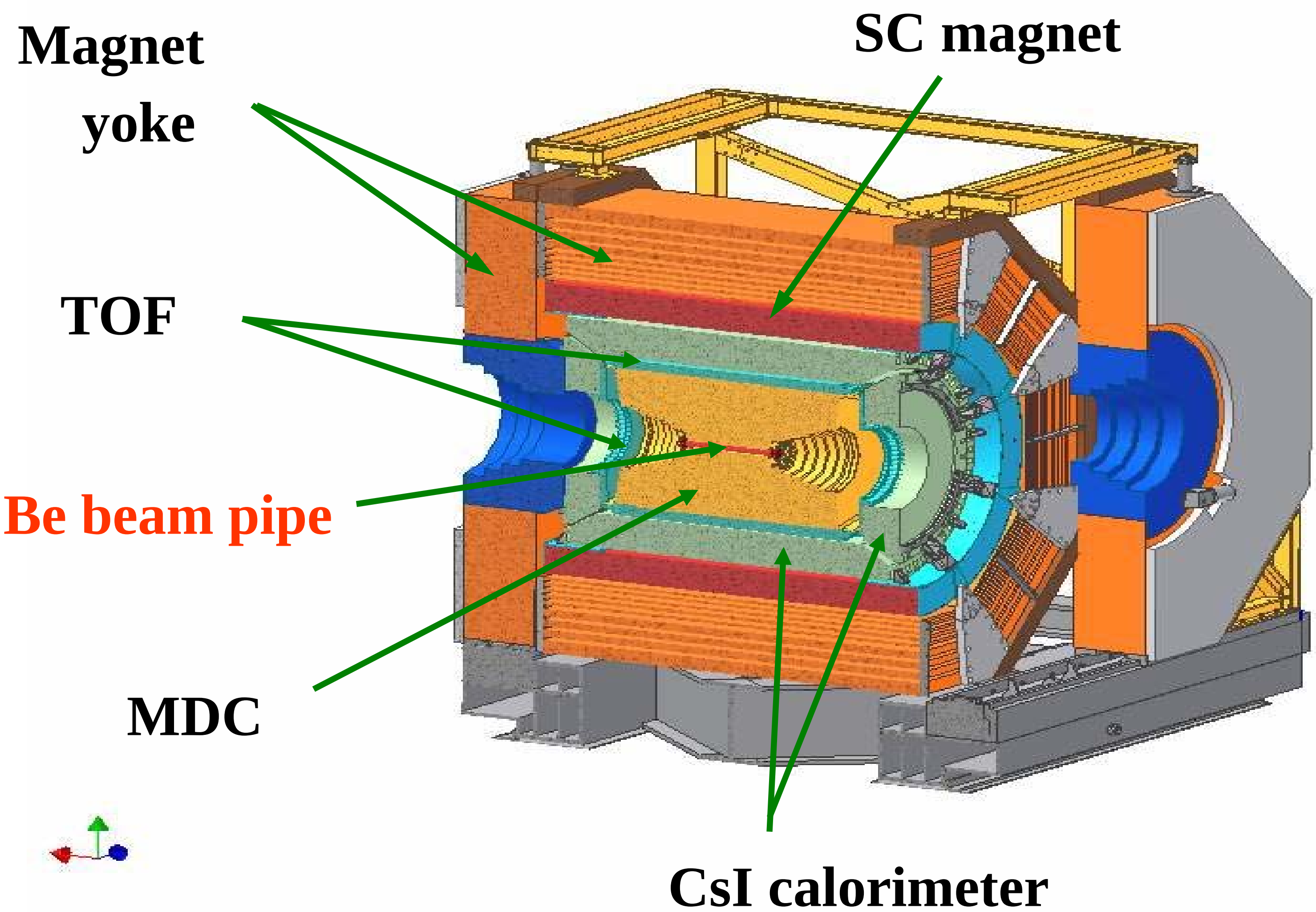
BEPCII Layout



BEPCII Parameters

	Design e^- and e^+	Achieved e^- and e^+
•Beam energies (GeV)	1.89	E_{cm}=3.78
•Currents (A)	0.91	0.15 0.2
•Number of bunches	93	~100
•Bunch spacing (m)	2.4	2.4
•Bunch currents (mA)	10	1.5 2.0
•Beam stored energy (kJ)	0.3	0.05 0.06
•Luminosity ($\times 10^{33}$/cm^2/sec)	1	
•Integrated Luminosity (fb^{-1})	Commissioning	

The BESIII Detector



Selected BEPC II Talks and Posters

- Talks
- MOZBKI02 BEPC II: Status and Early Commissioning
- Posters
- TUPAN068 The Progress of the BEPCII Injection Kicker Systems
- TUPAN069 Beam Trajectory Correction for BEPCII Linac
- TUPAN071 Commissioning and the First Stage Operation of BEPC-II
- TUPAN072 The Optics Measurement and Correction of BEPCII Storage Ring
- TUPAN074 BEPCII Interaction Region
- THPAN050 Studies of Two-bunch Acceleration for BEPCII Injector Linac

Summary

- e+e- Factories strive for higher luminosity by shrinking the collision spot size, shortening the bunch length, increasing the beam currents and by increasing the number of bunches
- These efforts have led to many insights about high-current machines: Ion instabilities, ECI, fast bunch-by-bunch feedback, HOM power, SR power, crossing angle collisions, ring impedances …

Summary (cont.)

- As the factories already running push these parameters farther and as new factories come online with even higher luminosity goals we will continue to learn more about running and operating these demanding high-current accelerators