Francesco Forti

Curriculum Vitae

Univ di Pisa, Dip. di Fisica & INFN-Pisa
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Short biography

In my professional career I have been mainly working on instrumentation development, in particular silicon detectors, and their application to advancing flavor physics in the context of e^+e^- colliders. After graduating from Pisa University and Scuola Normale Superiore in 1985, I participated in the ALEPH experiment, in particular contributing to the development of double-sided silicon detectors, employed for the time in the ALEPH minivertex. In 1992 I spent a year at the Lawrence Berkeley Laboratory working on the development of pixel detectors for the SDC detector at SSC. After the cancellation of the SSC I joined the Babar experiment in 1993, taking on the responsibility for building the Silicon Vertex Tracker which was successfully installed in 1999 and operated until 2007. I contributed to several analyses in Babar, whose discovery of CP violation in the B mesons remains to the present day a cornerstone of flavor physics.
While continuing the development work on various aspect of silicon technology, I started to explore the case and feasibility of a high luminosity B-Factory. I was one of the initiators of the SuperB proposal, aiming at the construction of a Super B-factory in the Frascati area. In the course of several years I have been coordinating the international detector collaboration, leading to the publication of the technical design report in 2012. After the cancellation of the SuperB project, in 2013, I lead the Italian contingent joining the Belle II experiment at KEK, directly contributing to the construction of the Silicon Vertex Tracker that has started operation in 2019. The Belle II data sample will contribute enormously to our understanding of the Standard Model, and hopefully shed light on the various anomalies currently detected in flavor physics observables. I am currently Upgrade Coordinator of the Belle II experiment, exploring possible upgrade options on different timescales.
Throughout my career I have been teaching various courses at the Pisa University, as detailed below. I have also systematically engaged in outreach activities, in particular giving public lectures and lectures for high school students. I have received numerous appointments as reviewer both at the national and international level, culminating in the chairmanship of the CERN LHC Committee, from January 2015 to April 2019. In November 2019 I have been elected Secretary of the Italian association USPID, Union of Scientists for Disarmament.

Education

1985 – 1988 **Graduate school, Physics, Pisa**, *Scuola Normale Superiore*, Pisa, Italy
(note: never formally obtained a PhD title)

1981 – 1985 **"Laurea" (B.Sc.+M.Sc.) in Physics**, *University of Pisa and Scuola Normale Superiore*, Pisa, Italy, 110/110 e lode
Thesis title: "Riconoscimento dei flavour pesanti con l'esperimento Aleph a LEP", supervisor Prof. Marcello A. Giorgi.

Professional Appointments

Current

2016 – **Full Professor of Physics**, *University of Pisa*

Past

2005 – 2016 **Associate Professor of Physics**, *University of Pisa*

1996 – 2005 **Research faculty ("Primo ricercatore")**, *INFN-Pisa*

1992 – 1993 **Visiting Scientist**, *Lawrence Berkeley Laboratory*

1990 – 1996 **Staff researcher**, *INFN-Pisa*

1988 – 1990 **Postdoc**, *INFN-Pisa*

Summary of research activities

In this section I summarize my research activities and projects, citing some relevant papers. A more detailed description is available in the section "Research activities".

Current

2021 – Participation in the AIDAInnova European project

2019 – Development of physics case and detector project for Belle II upgrade [1]

2019 – Development of CMOS MAPS vertex detector for Belle II upgrade [2]

2020 – PI of the MSCA Individual fellow project TAULEPGAMMA [3]

2019 – Participation in the Jennifer2 European RISE Projects

2013 – Construction and operation of the Belle II Silicon Vertex Tracker [4]

2013 – Participation in the Belle II Experiment [5]

1993 – Participation in the Babar Experiment [6]

Past

2020 – 2022 Supervision of the analysis for the search for a $\tau^+\tau^-$ resonance in $\mu^+\mu^-\tau^+\tau^-$ events with the Belle II data

2018 – 2020 Supervision of the analysis for the search for an invisible Z' in Belle II events with $\mu^+\mu^-$ and invisible energy [7]

2015 – 2019 Participation in the Jennifer European RISE Project

2015 – 2019 Development of graphene-based silicon detectors [8]

2014 – 2016 Development of a focal plan for X-ray detection at FEL machines (PixFEL) [9, 10]

2007 – 2013 Coordinator of the SuperB Detector group and editor of the SuperB Detector Technical Design Report [11]

2011 – 2014 Participation in the FP7 Eurepean Project AIDA (Advanced European Infrastructure for Detectors and Accelerators)

2009 – 2012 Supervision of the analysis for the measurement of $D^0\overline{D^0}$ mixing and CP violation with the *BABAR* experiment [12]

2005 – 2013 Develop the physics case and detector design for the SuperB project [13]

2003 – 2014 Development of monolithic active pixel systems using commercial CMOS triple-well technology and vertical interconnect technologies [14, 15, 16]

2005 – 2008 Analysis of $\tau \to \ell K_S$ lepton flavour violating decays with the *BABAR* experiment [17]

2002 – 2005 Study of the physics reach of a very high luminosity B Factory

2002 – 2003 Development of a parametrized detector simulation code used for high luminosity B Factory Physics studies

2002 – 2003 Analysis of CPT symmetry limits using B decays into CP and flavor eigenstates with the Babar experiment [18]

2001 – 2002 Optimization and construction of the replacement resistive plate chambers for the *BABAR* forward endcap [19]

1994 – 1995 Development of double-sided silicon strip detectors with integrated coupling capacitors for the Babar Silicon Vertex Tracker [20]

1993 – 1999 Design and construction of the *BABAR* Silicon Vertex Tracker [21]

1992 – 1993 Development of pixel detectors for SDC experiment

1985 – 1990 Development of double-sided silicon strip detectors [22, 23]

1985 – 1996 Participation in the ALEPH Experiment [24]

Research appointments

In this sectoin I summarize the formal research appointments and responsibility roles.

Current

2021 – Member, ICFA Panel on Instrumentation Innovation&Development.

2021 – Member, Steering group for ILC-prelab WG3.

2018 – Coordinator, Upgrade group Belle-II experiment.

2014 – Member, Belle-II Executive Board.

2015 – Chair, Belle-II SVD Quality Control Group.

Past

2015 – 2019 Member, CERN Scientific Policy Committee (ex-officio as LHCC chair).

2015 – 2019 Member, CERN Research Board (ex-officio as LHCC chair).

2015 – 2019 Chair, Belle-II Executive Board.

2014 – 2016 Chair, Belle-II SVD Institutional Board.

2013 – 2014 National Coordinator, Belle-II INFN Collaboration.

2011 – 2014 Local coordinator, FP7 Eurepean Project AIDA (Advanced European Infrastructure for Detectors and Accelerators).

2011 – 2013 Member, SuperB project Executive Board.

2011 – 2013 Co-chair, SuperB Detector Technical Board.

2006 – 2011 Co-convener, SuperB project detector R&D.

2008 – 2011 National coordinator, P-SuperB INFN Project.

2006 – 2008 Spokesperson, INFN SLIM5 R&D Project.

2003 – 2009 Member, BaBar Executive board.

2003 – 2004 Co-chair, Babar SVT Long term task force.

2002 – 2003 Co-chair, Babar 10^{36} Study group.

2002 Member, Babar Long term planning task force.

2001 – 2002 Member, Babar Instrumented Flux Return steering committee.

2000 – 2003 Italian representative, HEP Technical Advisory Subcommitte of HEP-CCC.

1998 – 2001 Member, INFN national computing committee.

1994 – 2000 Co-project manager, BaBar Silicon Vertex Tracker .

Institutional appointments

In this sectoin I summarize the formal institutional appointments from the Physics Department and INFN.

Current

2023 – Coordinator, of the UNIPI Physics Department "Excellent Derpartment" project.

2022 – Member, UNIPI Engineering School Didactic Paritetic Committee.

2020 – Coordinator, Physics Department Fundamental Interactions Group.

2020 – Representative, of the UNIPI Physics Deparment in the Engineering School.

2009 – Member, UNIPI Physics Graduate School Academic Board.

Past

2017 – 2020 Delegate, for research by UNIPI Physics Department.

2016 – 2020 Member, UNIPI Physics department Giunta.

2012 – 2013 Delegate, for Technology Transfer by INFN Pisa.

2007 – 2010 Member, UNIPI Physics department Giunta.

Organization of conferences and workshops

I have participated in the organization of several conferences and workshops, listed below.

2021 – Member, Steering Committee of TIPP conference series .

2016 – Member, International Advisory Committee of VERTEX workshop series.

2022 Chair, Pisa Meeting on Advanced Detectors.

2021, 2023 Member, International Advisory Committee of TIPP conference (Technology and Instrumentation in Particle Physics) .

2016 Chair, Internataional Workhop on Vertex Detectors.

2015 Member, International Advisory Committee of EDIT school (Excellence in Detector and Instrumentation Technologies).

2003, 2006, 2009, 2012 Member, Local Organizing Committee of Pisa Meeting on Advanced Detectors.

2007 Member, Local Organizing Committee of Hadron Collider Physics in 2007.

2003, 2005, 2008 Chair, Babar collaboration meeting.

2008 – 2012 Chair, Several SuperB Workshops.

Talks and seminars

In this section I list the talks at conferences and invited seminars since year 2000. .

Talks at conferences and workshops

11/11/2022 **"Belle II Upgrade Perspectives"**, *Invited talk*, Workshop on status and perspectives of physics at high intensity, Frascati

23/02/2022 **"The Belle II Upgrade Program"**, *Contributed talk*, Vienna Conference on Instrumentation, Vienna, Austria

16/07/2019 **"Belle II and flavor physics in e+e-"**, *Invited plenary talk*, EPS High Energy Physics Conference, Gent, Belgium

12/07/2019 **"Search for Low-Mass New Physics States at BABAR"**, *Contributed talk*, EPS High Energy Physics Conference, Gent, Belgium

13/05/2019 **"Technological challenges of particle physics experiments"**, *Invited plenary talk*, Open Symposium - Update of the European Strategy for Particle Physics, Granada, Spain

23/01/2019 **"Status and perspectives of the Belle II experiment"**, *Invited talk*, 57th International Winter Meeting on Nuclear Physics, Bormio

13/04/2015 **"Monolithic active pixels: status and perspectives"**, *Invited summary talk*, European Radiation Detection and Imaging Technology Platform Meeting, Pisa

26/09/2014 **"L'esperimento Belle-II a SuperKEKB"**, *Invited talk*, Società Italiana di Fisica Congress, Pisa

19/09/2014 **"Vertexing and Tracking: Summary and Outlook"**, *Invited summary talk*, VERTEX 2014 Workshop, Macha Lake, Czech Republic

22/05/2014 **"New Detector Technologies"**, *Invited plenary talk*, Workshop on long term strategy of INFN-CSN1, La Biodola, Isola d'Elba

23/07/2013 **"Trends in Detector Research and Development"**, *Invited plenary talk*, EPS High Energy Physics Conference, Stoccolma, Sweden [25]

18/01/2012 **"Status of the SuperB Project"**, *Invited talk*, Second Workshop on Physics in the LHC era, Valencia, Spain

24/08/2011 **"SuperB Project Status"**, *Invited talk*, 15th Lomonosov Conference on Elementary Particle Physics, Moscow, Russia

27/04/2011 **"Physics at the future B-Factories"**, *Invited talk*, Incontri Italiani sulla Fisica delle Alte Energie (IFAE), Perugia

23/09/2010 **"Il progetto SuperB: stato e prospettive"**, *Invited talk*, Società Italiana di Fisica Congress, Bologna

31/08/2009 **"The SuperB Silicon Tracker"**, *Invited talk*, 7th Hiroshima Symposium on the Development and Application of Semiconductor Tracking Detectors, Hiroshima, Japan

29/07/2008 **"Status of SuperB"**, *Invited talk*, VERTEX 2008 Workshop, Uto, Sweden

28/09/2007 **"The SuperB Project"**, *Invited talk*, Società Italiana di Fisica Congress, PIsa

28/09/2007 **"The SuperB Project"**, *Invited talk*, Hadron 07 Conference, Frascati

24/05/2007 **"The SuperB Project: Status and perspectives"**, *Invited contribution*, Round table of KAON Conference, Frascati

03/11/2006 **"Development of 130nm CMOS Monolithic Active Pixels with In-pixel Signal Processing"**, *Contributed talk*, 2006 IEEE Nuclear Science Symposium, San Diego, California

30/06/2005 **"CKM Parameters and Rare B Decays"**, *Rapporteur talk*, Lepton-Photon 2005, Uppsala, Sweden [26]

02/03/2005 **"Physics at a Super B Factory"**, *Invited talk*, Les Rencontres de Physique de la Vallée d'Aoste, La Thuile, Val d'Aosta

14/04/2004 **"To SuperB or not to SuperB ?"**, *Invited talk*, Incontri sulla fisica delle alte energie (IFAE), Torino

04/03/2002 **"Babar results on CP violation in the B sector"**, *Invited talk*, Les Rencontres de Physique de la Vallée d'Aoste, La Thuile, Val d'Aosta [27]

24/09/2001 **"La scoperta della violazione di CP con l'esperimento Babar"**, *Invited talk*, Società Italiana di Fisica Congress, Milano

Seminars

11/12/2018 **"Future of Flavour Physics Belle II @ SuperKEKB"**, *Seminar*, Babar Collaboration Meeting, SLAC

08/03/2018 **"Belle II at SuperKEKB"**, *Seminar*, LHCB Collaboration Meeting, CERN

05/10/2016 **" LHC & Co. Some opportunities for accelerator-based physics"**, *Seminar*, LPNHE Biennal Meeting, Tirrenia, Pisa

13/01/2013 **"Future of B Physics**, *Seminar*, SLAC, California

16/02/2012 **"Status of the SuperB Project"**, *Seminar*, Fondazione Bruno Kessler

19/11/2011 **"Status of the SuperB Project"**, *Seminar*, 10th Belle-II General Meeting, Tsukuba, Japan

11/04/2011 **"Il progetto SuperB: stato e prospettive"**, *Seminar*, INFN Bologna

11/03/2011 **"Il progetto SuperB: stato e prospettive"**, *Seminar*, INFN Roma3

21/02/2011 **"Il progetto SuperB: stato e prospettive"**, *Seminar*, INFN Bari

22/04/2009 **"The SuperB Project - Status and Perspectives"**, *Seminar*, INFN Torino

18/03/2009 **"The SuperB Project - Status and Perspectives"**, *Seminar*, INFN Bologna

03/07/2008 **"Dai test su Dafne a SuperB"**, *Seminar*, Giornate sul piano triennale dell'INFN

06/12/2007 **"The SuperB Project"**, *Seminar*, Lawrence Berkeley Laboratory, California

30/05/2007 **"The SuperB Project"**, *Colloquium*, Roma Tor Vergata University

26/04/2007 **"The SuperB Project: Stato e prospettive"**, *Seminar*, INFN Pisa

23/10/2006 **"The SuperB Project: Status and R&D"**, *Seminar*, Barcelona

28/04/2005 **"Active Silicon for Physics at a Super B Factory"**, *Seminar*, Valencia

27/04/2005 **"Active Silicon for Physics at a Super B Factory"**, *Seminar*, Barcelona

21/05/2004 **"Physics at Super B-Factories"**, *Seminar*, LNF spring school

Publications

I have published 857 papers. A full list of publication is available on `https://orcid.org/0000-0001-6535-7965`.

Unfortunately Scopus created two profiles for my publications, which I have not been able to merge yet: `https://www.scopus.com/authid/detail.uri?authorId=35227146800` and `https://www.scopus.com/authid/detail.uri?authorId=57204542985`. They can be combined using the advanced search term `'AU-ID ("Forti, Francesco" 35227146800) OR AU-ID ("Forti, Francesco" 57204542985)'`.
The bibliometric indices for the past *15 years* are indicated below, as obtained from Scopus:

Total number of papers:	421
Number of times cited:	17833
Average number of citations per paper:	42
h-index:	69

A list of the papers cited in this curriculum is included at the end of the CV.

Reviewing activities

I have been a member of numerous review and evaluation committees. I have chaired the LHC Committee from 2014 to 2019, during the challenging period of the approval of the Technical Design Reports for the Phase II upgrade of the LHC experiments. Since December 2021 I am chairing the INFN review committee for the Darkside experiment at LNGS.

Review committee appointments

2021 –	Member, FNAL Long Baseline Neutrino Committee.
2021 –	Chair, INFN Darkside Review Committee.
2020, 2022	Reviewer, Catalan Institution for Research and Advanced Studies.
2018, 2019, 2021, 2023	Reviewer, Swiss Science Foundation.
2015 – 2019	Chair, CERN Large Hadron Collider Committee.
2014	Reviewer, Italian Government SIR projects.
2013, 2015, 2021	Reviewer, French Research Agency, ANR.
2013, 2015, 2017	Member, ERC Consolidator PE2 Panel.
2009, 2011, 2015 – 2021	Reviewer, ERC projects.
2009	Member, U.S. NSF-DOE LHC Joint oversight group.
2004 – 2008	Member, CERN Large Hadron Collider Committee.
2004 – 2007	Chair, INFN Grid and LHC computing review committee.
2003 – 2006	Reviewer, Italian Government Research Department.
2001 – 2002	Member, Fermilab Technical Review Committee.
1996 – 2004	Member, INFN Atlas experiment review committee.

Review of journal papers

2008 – present	Reviewer for several journals: Journal of High Energy Physics, Journal of Instrumentation, Nuclear Instruments and Methods, IEEE Transactions on Nuclear Science.

Teaching experience

Since I graduated I was always involved in teaching activities, with lectures, course assistance, and eventually course responsibilities at the University of Pisa.

Course responsibilities

2021 – **Instrumentation for Fundamental Interaction Physics**, *Physics*, Master, 9 ECTS.

2019 – **Fundamental Interactions**, *Physics*, Master, 9 ECTS.

2018 – 2019 **Advanced Physics Laboratory 3**, *Physics*, Master, 6 ECTS.

2012 – 2019 **Physics Laboratory 3**, *Physics*, Bachelor, 12 ECTS.

2011 – 2014 **Physics II complements, Analytical Mechanics**, *Engineering (S.Anna)*, Bachelor, 2 ECTS.

2003, 2008 **Physics Laboratory V** , *Physics*, Master, 6 ECTS.

2007 **Physics Laboratory VI** , *Physics*, Master, 6 ECTS.

2007 **Modern Physics**, *Engineering School Excellence Path*, Bachelor, 3 ECTS.

2006 **Thermodynamics**, *Biomedical Engineering*, Bachelor, 3 ECTS.

2005 – 2012 **General Physics**, *Management Engineering*, Bachelor, 12 ECTS.

Course assistance

2022 – **Fundamental Interactions Laboratory**, *Physics*, Master, 40 hours.

2019 – **General Physics for undergraduate engineering students**, *Biomedical Engineering*, Bachelor, 25 hours.

2019 – 2022 **Physics Laboratory 3**, *Physics*, Bachelor, 40 hours.

1987 – 1992 **Physics Laboratory 3**, *Physics*, Bachelor, 40 hours.

1986 **System models**, *Physics (SNS)*, Bachelor, 10 hours.

Other Lectures

2021 **Semiconductor detectors**, *Belle II Physics Week*, Master / Graduate

2020 **Particle detectors**, *Jennifer Summer School*, Master

2002 – 2003 **Physics perspectives at B-Factories**, *Particle Physics* , Graduate School

2002 – 2003 e^+e^- **colliders: the luminosity frontiers**, *Particle Physics* , Graduate School

1998 – 1999 **Semiconductor detectors**, *Nuclear and Subnuclear Physics Laboratory*, Master

1990 , 1993 **Semiconductor device physics**, *Physics Laboratory 3*, Bachelor

1992 – 1997 **Solid state detectors and vertex detectors**, *High Energy Physics Detectors*, Graduate School

Thesis Supervision

I have supervised the thesis of several students in physics courses:

Bachelor 17 students completed

Master 16 students completed and 1 ongoing

Ph.D 3 students completed and 2 ongoing

Outreach activities

I have been involved in many outreach and science communication events, in particular with high school students. I have regularly participated in the "Pianeta Galileo" science communication program of the Regione Toscana.

2021 – 2023 **Il nucleare oggi: armamenti e fonti di energia. Quale futuro ?**, *Pianeta Galileo and Public seminar*, Livorno, Empoli, Colle Val d'Elsa, Torino, Castelfiorentino, Lucca, High school students and general public

2017 – 2019 **Che fine ha fatto l'antimateria ?**, *Public seminar*, Pisa, Livorno, General public

2015 **Un velo di particelle minutissime. La fisica delle particelle tra ricerca di base, nucleare, applicazioni**, *Pianeta Galileo*, Montepulciano, High school students

2013 – 2018 **Le simmetrie dall'estetica alla scienza**, *Pianeta Galileo and Public seminar*, Pisa, Massa, Arezzo, Figline Valdarno, Montevarchi, Firenze, Montepulciano, Piombino, Prato, Pescia, High school students and general public

2012 **SuperB: una nuova finestra sull'Universo a Roma**, *Public seminar*, Roma 3 University, General public

2009 – 2012 **Natura allo specchio: simmetria e leggi di conservazione in fisica**, *Pianeta Galileo*, Livorno, Pisa, Portoferraio, Firenze, High school students

Technology Transfer Activities

2004 **Patent registration TO2004A000901**, *Procedure for the realization of a ionizing radiation solid state detector*, Applicants: G.Batignani, F.Forti, M.Giorgi (INFN-UniPI), M.Boscardin, C.Piemonte (IRST/ITC), L.Bosisio (UniTS),G.F.Dalla Betta (UniTN)

Languages

Italian	Native Speaker
English	Fluent
French	Intermediate knowledge
German	Basic knowledge
Japanese	Basic knowledge

Research activities

In this section I describe in more detail my scientific activity, divided into the main lines of research, providing the most relevant references.

ALEPH experiment

ALEPH

Aleph [24] was a magnetic detector designed to reconstruct the e^+e^- annihilation events, produced in CERN's LEP collider at 90 GeV in the center of mass, as completely as possible with a large solid angle coverage. The physics program was vast and included measurements of the parameters of the standard model of electroweak interactions, search for new particles, τ, and heavy flavours physics.

I started my participation to the Aleph experiment in 1985, during my thesis, concentrating my interest in methods for identification and analysis of events containing heavy flavors (charm and beauty) or τ, that produce high transverse momentum particles with production vertices displaced from the primary event collision vertex (also known as secondary vertices). Identification is based both on kinematical methods (transverse impulse and distribution angle of the impulses in the event), and geometric quantities (secondary vertices and impact parameter) [28].

Double-sided strip detectors

From 1985 to 1990 I worked in the simulation, development, design, construction and the installation of the Aleph silicon vertex detector, called Mini-vertex [29] or VDET which, contributing with two precise space points ($12\,\mu$m resolution) to the reconstruction of charged tracks, drastically improved the impact parameter resolution and allowed the reconstruction of secondary vertices. This was the first application in a large scale experiment of double-sided silicon strip detectors, for which I significantly contributed to technological development [22].

I worked on various simulations to optimize the detector design, first using a parametrization of the detector response, and then, in the role of software coordinator offline of the Mini-vertex (1986), inserting a detailed description of the detector in the general simulation program of Aleph based on Geant.

VDET90

In building the first version VDET90[29], I worked both on the assembly and testing of hybrid reading circuits, both mechanical assembly and installation in Aleph in January 1990. During the 1990 run I participated in data taking activities, assuming the role of VDET coordinator in various periods. I developed the power supplies remote control software, allowing the reduction of the sensor polarization voltage during beam injection, thus minimizing the risk of radiation damage. I also worked onthe alignment software which, using the reconstructed tracks, determines the relative position of the sensors inside VDET, and the position of VDET w.r.t. Aleph with an accuracy appropriate to the high intrinsic resolution of detectors.

VDET91

The experience gained in the 1990 run on reliability problems, alignment and efficiency, was incorporated into the next version VDET91 which, used in the 1991 and 1992 runs[30], iproved to be an essential tool for precision measurements in the sector of heavy flavours. For example: systematic errors on the B and τ lifetimes have been improved by about a factor 2 [31, 32]; the measurement of the mass and lifetime of the B_s meson became possible [33]; the time dependence of $B^0_d - \bar{B}^0_d$ mixing [34].

DaΦne collider

Phebo

From 1990 to 1992 I participated in the study of an apparatus (called Phebo) for the exploration of CP violation at DaΦne, a newly proposed e^+e^- collider designed to provide high luminosity at $1020\,\text{MeV}$ in the center of mass, corresponding to the mass of the Φ. The measurement of ϵ'/ϵ in process $\Phi \to K_L K_S \to 4\pi$ requires an accurate reconstruction of low momentum charged particles and photons and a careful control of systematic errors coming from regeneration, physics backgrounds (such as the $K_{\mu 3}$ decay), and from the knowledge of the absolute spatial scale of the detector.

I implemented from scratch the Geant-based simulation program for Phebo, based on a gas tracking and a liquid argon tracking calorimeter. The simulation was used to optimize the geometry of the apparatus and to estimate the sensitivity [35]. This proposal, which was meant to occupy the second interaction point of DaΦne, was not approved.

BABAR experiment at the PEP-II collider

BABAR

I have been a member of the *BABAR* collaboration since its formation in November 1993. The *BABAR* detector [36, 37] was designed primarily to study CP violation in the B meson system at the PEP-II collider at SLAC, Stanford, California. PEP-II is an asymmetric e^+e^- collider with an energy in the center of mass equal to the mass of the $\Upsilon(4S)$, which decays into a pair of mesons $B^0\overline{B}^0$ with a probability of 50%. The asymmetry of the beam energy ($9\,\text{GeV}$ on $3.1\,\text{GeV}$) corresponds to a center-of-mass boost $\beta\gamma = 0.56$, which allows the separation of the B decay vertices along the beam axis.

CP violation

For the measurement of CP violation, events in which one of the B decays into a CP eigenstate f_{CP} (e.g. $J/\psi K_S$, D^+D^-, $\pi^+\pi^-$), while the other B can be tagged as a B^0 or a $\overline{B}^0$ (e.g. from the sign of the lepton in a semileptonic decay $B \to \ell X$ or by the sign of the K in $B \to D \to K$) are selected [38]. The time difference between the two decays allows the measurement of the time-dependent asymmetry between $B^0 \to f_{CP}$ and $\overline{B}^0 \to f_{CP}$. Since the time-integrated asymmetry vanishes, the accurate determination of the position of the two decay vertices is crucial for the CP-violation measurement. Such determination was performed, in BABAR, with a five-layer silicon vertex detector called "Silicon Vertex Tracker" (SVT).

Letter of Intent

I have been involved in all aspects of the SVT development, from the initial optimization studies, to the detailed design, to the construction, installation, operation, and data analysis. Starting in November 1993 I was co-convener of the SVT working group, coordinating the activities and acting as editor of the SVT chapter in the Letter of Intent published in 1994 [39].

Silicon Vertex Tracker

From November 1994 to June 2000 I was co-system manager of the SVT group, with the responsibility for the design, construction and installation of the detector, and performing coordination functions of work in the various participating institutions: Pisa, Milan, Turin, Pavia, Trieste, Berkeley, Santa Barbara, Stanford, Santa Cruz.

Technical Design Report

In the first phase we optimized the detector design through simulations and tests, arriving at a five-layer structure of AC-coupled double-sided silicon strip detectors, organized in 3 inner barrels and 2 outer arches, which make use of an innovative bent module technology developed by the Pisa group with my strong contribution and leadership. The arch structure reduces the crossing angle of the particles, thus improving the tracking performance. The five layers allow a standalone SVT reconstruction of the low p_T tracks, such as the π from the $D^* \to D\pi$ decay, that do not reach the central drift chamber DCH. Machine backgrounds cause a moderate irradiation of the SVT (estimated around 200 kRad/year), requiring the use of a "radiation-tolerant" technology for electronics and detectors [40]. The project of the detector was described in the Technical Design Report [41], published in 1995, for which I was the editor of the SVT chapter.

SVT Construction

In the following period, 1995–1999, I coordinated the construction phase of the SVT. Besides the managerial responsibilities, such as the budget and schedule, I was directly involved in many technical aspects, such as production and testing of silicon detectors [20]; the procedures for module assembly, wire-bonding, and testing; the production of high-density hybrid readout circuits; the production database system. Despite many difficulties the SVT construction was completed on schedule, in February 1999. I subsequently participated in the installation and commissioning of the detector, leading to the first data taking in June 1999.

Radiation damage

The SVT complied with the design specifications during the entire *BABAR* data taking, which ended (abruptly) in April 2008. I participated in various studies to characterize the effects of radiation damage on detectors and electronics of the SVT [42, 43]. In particular we studied the effects on charge collection efficiency of a non-uniform radiation, concentrated in the horizontal plane [44]. In 2003–2004 I was the chair of the "Long Term Task Force" of the SVT subsystem, in charge of studying the resistance to radiation of the detector and possible upgrades to improve its performance, leading to the conclusion that detector performance were satisfactory, even with a level radiation higher than expected [21].

Instrumented Flux Return

In 2000, after about one year of data taking, the RPC (Resistive Plate Chambers) used in the Instrumented Flux Return (IFR) of the *BABAR* magnet for the μ and K_L^0 identification showed a significant drop in efficiency, which in some cases reached 1% per month[45]. I was part of the task force organized by the *BABAR* collaboration to understand the efficiency problem of the RPCs and possibly improve their performance, since the μ identification efficiency was crucial for the success of *BABAR*'s physics program.

Resistive Plate Chambers

Numerous studies proved that the drop in efficiency was due to a set of contributing causes such as poor linseed oil polymerization and a high leakage current due in part to the high summer temperature, with a consequent evaporation of the graphite deposited on the outside of the bakelite plates. The absence of graphite made it impossible to ensure an adequate electric field in the gap, resulting in an efficiency drop [46].

New RPCs

It was decided to replace the Forward Endcap chambers with a new RPC production where greater controls on room cleaning and linseed oil polymerization were applied. From January 2001 to December 2002 I was part of the IFR subsystem steering committee. In particular I contributed to the preparation of the quality control protocol for the manufacturing company and participated in the installation of the new chambers. They worked stably until the end of the data taking [19].

BABAR results

The *BABAR* experiment accumulated a total luminosity of about $531\,\text{fb}^{-1}$, which allowed the first measurement of CP violation in the B meson system [47], the precision measurement of the sides and angles of the triangle of unitarity, such as the angle γ [48], as well as the measurement of many rare B decays. The extreme cleanliness of the e^+e^- events and the coherence of the initial state from the $\Upsilon(4S)$ decay allowed to study $B^0\overline{B}^0$ oscillations asymmetries also in channels with "penguin" diagrams, such as $B^0 \to \phi K^0$ [49], which are sensitive to the insertion of new physics particles in the loops. *BABAR* measured also the direct CP violation in the $B^0 \to K\pi$ channel [50]. I have presented the most significant *BABAR* results in a plenary talk at the Congress of the Società Italiana di Fisica in 2001 and at the La Thuile conference "Les Rencontres de Physique de la Vallée d'Aoste" in 2002 [27]. I was subsequently invited to the 2005 Lepton-Photon conference in Uppsala to present a review talk on "CKM parameters and rare decays of the B", with results obtained by *BABAR* and the competitor experiment Belle [26].

CPT symmetry tests

In 2002 and 2003 I worked with a postdoc (F. Martinez Vidal) on an analysis aimed at verifying the CPT symmetry and measuring the difference of width between the mass eigenstates of the mesons B. The analysis exploited both the decays of B into CP eigenstates (such as $B^0 \to J/\psi\, K^0_S$ and $B^0 \to J/\psi\, K^0_L$), and the decays into flavor eigenstates (such as $B^0 \to D^{(*)-}\pi^+(\rho^+, a_1^+)$) to perform a global fit to the time-dependent asymmetry without imposing the CPT symmetry. The power of the method lies in the fact that the detector reconstruction asymmetries are determined simultaneously from the data, exploiting the information present in the events where the flavor is determined. The results of the analysis [18], while not revealing any CPT violation, significantly improved the previous measurements both on the violation parameter z and on the width difference $\Delta\Gamma$.

Lepton Flavor Violation

In addition to the B mesons, an equivalent number of τ leptons and charmed hadrons are produced at PEP-II. Lepton flavor violation (LFV) is expected to be very small in the standard model, and if measured would be an unmistakable sign of new physics. It can be searched for in many channels, such as the decay $\tau \to \mu\gamma$ [51] or $\tau \to \ell hh$ [52]. I supervised a PhD student (R. Cenci) who completed the analysis for the search of lepton number violation in the $\tau \to \ell K_S$ decay [17].

$D^0\overline{D^0}$ mixing and CP violation

The abundant production of charmed mesons allowed *BABAR* to measure the first evidence of the $D^0\overline{D^0}$ mixing [53]. I supervised PhD student (G.Casarosa) who completed an analysis to measure the mixing and CP violation parameters of the D mesons system in two body decays [12].

BABAR legacy

Overall the *BABAR* experiment produced an impressive amount of physics results collected, together with those of the competitor Belle, in the review volume [6]. As part of the experiment I played a leading role in the construction and management of the detector, in various physics analyses, as well as in the management of the experiment and of the collaboration, as member of the Executive Board collaboration and numerous internal committees. The scientific conviction that flavor physics has the potential to open windows on discovering physics beyond the standard model prompted me to work on the possibility of realizing high-luminosity B-Factories.

SuperB Project

BABAR 10^{36} Study Group

Since 2002 I participated in various groups set up within *BABAR* to study the long-term prospects of the experiment, the upgrade opportunities, and the physics interest of a high luminosity B-factory. I developed a method for inserting a parameterized detector in the *BABAR* simulation and reconstruction programs, allowing to easily simulate the effects of possible detector upgrades on existing physics analyses. I was part of the "Long term planning task force" and of the "Roadmap Committee" of the experiment. I have also been the co-chair of the "10^{36} Study Group". The conclusions of these studies indicated that a factor 100 larger luminosity (50-100 ab^{-1} compared to the 531 fb^{-1} collected by *BABAR*) would open up the possibility of detecting new physics particles through precision measurements of the unitarity triangle and through searches for forbidden or very rare decays, such as lepton flavor violating decay of the τ lepton.

SuperB

Such a large data sample is only achievable with a Super B-Factory with luminosity of the order of $10^{36}\,\text{cm}^{-2}\text{s}^{-1}$. Simply increasing the currents in the existing B-Factories (PEP-II and KEKB) would not allow to achieve this peak luminosity, because of the large increase both in the machine background and in the power necessary to operate the RF cavities. In 2005 it was presented an innovative idea opening the possibility of designing a very high luminosity Super Flavor Factory with currents and backgrounds only moderately larger than those of current machines, but drastically reducing the beam size. This project was named SuperB [13] and attracted the interest of a large international community.

SuperB Detector

I was among the founders of the SuperB project, working both on physics studies and detector design. The detector for SuperB was based on the *BABAR* project and reuses some important components, such as the superconducting magnet, the barrel of the electromagnetic calorimeter and the quartz bar used for particle identification. However, R&D was still needed of to finalize the SuperB detector design. One of the main changes was the reduction of the asymmetry of the beams (from $9/3.1\,\text{GeV}$ to $7/4\,\text{GeV}$) which required a reduction in radius and thickness of the first detection layer, for which the CMOS MAPS technology would be an ideal solution [54].

Conceptual Design Report

In 2006, I assumed the responsibility for coordinating the R&D developments for the SuperB detector. Such developments included all subsystems: the vertex detector, the drift chamber, the particle identification system, the electromagnetic calorimeter, the instrumentation of the return iron of the magnet, with about 25 institutions involved in the activities. In April 2007 the Conceptual Design Report[55] was published, a 400-page volume detailing the physics case, the machine concept, and the detector design. I was the editor of the detector chapter. INFN included SuperB in its roadmap, proposing a possible site for the accelerator at the University of Rome Tor Vergata, very close to the Frascati National Laboratories.

SuperB cancellation

In the period 2007-2012 I devoted myself to the development of the SuperB project and to the establishment of the international collaboration necessary for the detector construction. I coordinated the drafting of the Technical Design Report meant to form the basis for the start of construction activities [11]. At the end of 2012 it became clear that the cost of the SuperB project was not sustainable in the political and financial situation of the moment, and the project was cancelled.

Belle II experiment at SuperKEKB collider

Belle II

Following the cancellation of the SuperB project at the end of 2012, my interest for the physics of flavor it led me to open a line of collaboration with the Belle II experiment on the SuperKEKB accelerator, under construction in the KEK laboratory, Tsukuba, Japan. This experiment aimed to reach a peak luminosity of $8 \times 10^{35}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$, opening new horizons in the search for new physics in rare decays and in interference phenomena of B, D, τ particles.

Italian groups

In July 2013, 9 INFN sections (LNF, Rome1, Rome3, Naples, Turin, Perugia, Padua, Pisa and Trieste), with about 60 physicists, officially joined the Belle-II collaboration. I was elected national coordinator and member of the Financial Board of the experiment. I contributed directly to the drafting of the agreements between the KEK laboratory and INFN defining the collaboration and commitments of INFN and the laboratory, subsequently approved and signed by the INFN President and the General Director of KEK. I contributed in a decisive way to organize the Italian group and create the opportunity for INFN to participate in this world leading experiment at the intensity frontier.

Belle II Executive Board

In June 2014 I became the Italian member in the Belle II Executive Board, that has the charge of assisting the spokesperson in managing the experiment activities and to provide international support for management decisions. I attended meetings with the directorate of KEK and with the Japanese research ministry aimed at applying international pressure to avoid funding delays or cuts for the experiment program. In the period June 2015-June 2019 I was appointed chair of the Executive Board.

SVD

During the construction phase my scientific activity has focused on the Belle II Silicon Vertex Detector, based on double-sided silicon strip detector technology. I contributed significantly to the finalization of the detector design and to the organization of the detector construction activities, as well as to the definition of the quality control procedures of the components. Starting in 2014 I created a Quality Control and Quality Assurance group, of which I am the chair, with the task to standardize and verify the assembly procedures carried out in the various construction sites (Vienna, Pisa, Melbourne, Tokyo) [56]. The importance of the work of this group has been also recognized in the various reviews of the Belle Advisory Committee. I have also been elected chair of the Institutional Board of the SVD for the period 2014–2106. The SVD was successfully completed and installed in Belle II in 2018. I was the editor of an extended paper with detailed technical description of all SVD aspects [4].

Belle II data taking

Belle II data taking started in 2018 without the vertex detector (called Phase II) to measure the background levels and ensure they were not dangerous for the detector. Data taking with the full detector started in 2019, reaching a record peak luminosity of $2.2 \times 10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$ with a total integrated luminosity of $427\,\mathrm{fb}^{-1}$, which opens the door to the development of many physics analyses. The overall perspective on Belle II analyses has been documented in the Belle II Physics Book [5]

Long Shutdown 1

Machine operation was suspended in summer 2022 until the end of 2023 for the Long Shutdown 1 (LS1), to perform accelerator and detector maintenance and improvements. In particular it is planned to complete the installation of the two-layer Pixel Detector (PXD) of which the second layer is only partially equipped. This requires a complex de-installation and re-installation of the central part of the detector, including the SVD. I am currently chairing the internal review committee for the quality control and verification on the installation procedures, to ensure the risks for the existing components is minimized.

Belle II upgrades

In 2019 Belle II set up an Upgrade Working Group, of which I am the coordinator, with the purpose of exploring the possibilities of upgrading the detector to cope with higher machine luminosity and backgrounds and to adapt to a different geometry of the interaction region. The group has been developing a full menu of upgrade options for various time scales, documented in a document submitted to the Snowmass process [1]. The Conceptual Design Report for the upgrade is in preparation and is schedule to be completed by June 2023.

Marie Curie Action

In 2020, together with Francesco Tenchini (then at DESY), I developed a proposal for an MSCA Individual Fellowship Action, called TAULEPGAMMA. The project focused on possible improvements on the search for lepton flavour violation in τ decays by exploiting three-prong tagging and improved kinematical selection. The project was approved and I am supervising Francesco Tenchini as a MSCA postdoc. A first paper on the search for $\tau \to \ell\alpha$ has been accepted by PRL [3].

Belle II physics analysis

The initial Phase II data set taken in 2018 (only $0.5\,\text{fb}^{-1}$) could be effectively exploited for dark sector searches, exploring new processes and domains. I supervised a PhD student (Laura Zani) who carried out the search for an invisible Z' in events with $\mu^+\mu^-$ and invisible energy. The search improved significantly existing limits and brought to the first physics paper published by Belle II [7]. With the larger data set of the initial running, it was possible to search also for more complicated topologies. Another PhD student (Luigi Corona) that I supervised developed the first search for a $\tau^+\tau^-$ resonance in $\mu^+\mu^-\tau^+\tau^-$ events. The paper is almost ready for publication. The accuracy of the tracking devices, and in particular of the SVD, allows precision measurements of lifetimes. I supervised a master student (Gaetano De Marino) who developed the analysis to measure the D^0 lifetime, leading to the most precise measurement [57].

Research and development

My research activity has always been characterized by a strong technology development component of semiconductor detectors for applications in high-energy physics and other fields. Initially I worked on the development of double-sided silicon strip detectors, and subsequently I explored various avenues with the goal of improving the performance of tracking detectors: pixel detectors; the integration of a part of the electronics on the high resistivity substrate of the detector; the use of commercial processes CMOS for the creation of active monolithic pixel systems.

Double-sided silicon strip detectors

I contributed to develop the technology of silicon microstrip detectors with readout on both faces[22], used for the first time in the Aleph microvertex. In these detectors the charge produced by a charged particle is simultaneously read on the two faces with a reduction of material compared to single sided detectors. The realization of the double-sided detectors requires numerous changes compared to standard production processes, such as: the insulation of the readout electrodes on the n side with p-type impant; special wafer handling care to avoid damage on the back side. I designed the the first series of detectors in collaboration with the manufacturer, with very positive results[58]. Subsequently I participated in the production phase of the detectors for the Aleph mini-vertex, realizing the semi-automatic system used in mass testing of sensors.

AC Coupling

In the first prototypes, the readout strips of the detectors (with pitch of $100\,\mu\text{m}$) were connected directly to the low noise integrated preamplifiers. In the DC connection the detector leakage current must be absorbed by the preamplifier, with possible saturation effects, while non-uniformities in the input voltage of the preamplifiers affect directly the strip polarization. To avoid these negative effects, in 1989 I designed a decoupling integrated circuit containing an RC circuit for each strip to be inserted between the detector and the electronics [59]. A further development of the technology, to which I contributed, allowed the integration of the decoupling capacitor and the bias resistor directly on the detector, thus realizing in 1995 AC-coupled double-sided detectors [60, 40].

Pixel detectors

In pixel detectors, the extreme segmentation of readout electrodes (of the order of $100 \times 100\,\mu\mathrm{m}^{\,2}$) totally eliminates spatial ambiguities, while the very small input capacity (50–100 fF) allows high signal-to-noise ratios even with very fast preamps. To draw advantage of the potential of a pixel system, each element of reading must be connected to a low noise preamplifier. The technological problem was to develop amplifiers in the limited space available and to connect them to the active element, or alternatively to integrate the preamplifiers directly on the same high resistivity substrate as the detector.

SOI Pixel Detectors

Within the framework of the RD19 collaboration at CERN, I contributed with test programs and laboratory measurements to the feasability studies related to the realization of pixel detectors in an SOI (Silicon-On-Insulator) type substrate and the integration of electronics on high resistivity substrate [61].

LBL Pixel Detectors

From April 1992 to April 1993, I worked at Lawrence Berkeley Laboratory as visiting scientist in the "Pixel Detector Development Collaboration" for the development of a pixel system for experiments at the Superconducting Super Collider (SSC). Working closely with electronic designers, I developed electrical measurements needed to optimize the amplifier design, such as the matching parameters of the MOS transistors in the weak inversion zone [62]. I also started and completed a simulation and measurement program of the capacitance of pixel detectors, one of the essential parameters needed for the system design.

Electronics on high resistivity substrate

Since 1994, within the INFN R&D experiment named "LAST" and various PRIN projects (PRIN-Giorgi 1999,2001), I worked of the integration of active electronic devices on high resistivity substrate, developing in close connection with FBK-IRST of Trento processes compatible with the production of double-sided detectors [63, 64]. The integration of active devices on the same substrate as the detector allows reducing the material and the noise of the amplification chain. However, the quality of the devices that can be made with this technology in terms of intrinsic noise, speed and power dissipation is modest. The results obtained [65] indicate that even if these devices they are not suitable for for applications in high energy physics detectors, there are possible applications in space detectors or environmental monitoring. In particular we developed a floating base BJT junction bipolar transistors on high resistivity substrate, for which patent was registered, which can be used for environmental radon monitoring [66].

Monolithic Active Pixels

Since 2003, within the PRIN-Giorgi 2003 and 2005 projects, for which I had the scientific coordination responsibility, we developed monolithic active pixel detectors (MAPS) based on a commercial deep submicron triple well technology. In the monolithic active pixel systems, detector and readout electronics are realized on the same substrate, allowing a strong reduction of material and interconnections compared to hybrid pixels. In this technology the material of detection consists of the low resistivity epitaxial layer of the commercial CMOS process, with a signal of only about $1000e^-$. This can be converted to voltage exploiting a very small electrode capacitance, but this method has severe limitations of speed and leads to a very large number of readout channels. In the technology we developed [14] the charge is collected by a deep n-well which also contains part of the readout electronics. In this way it is possible to realize at the pixel level the full electronics readout chain, increasing speed and reducing the number of readout channels.

SLIM5

The positive results obtained, which I presented at the "IEEE 2006 Nuclear Science Symposium" in San Diego [67], prompted us to develop the SLIM5 research project within the framework of the National Scientific Commission V of the INFN. The SLIM5 project, which included the sections of Bologna, Bergamo, Pavia, Pisa, Trento and Trieste, and of which I was national coordinator, aimed to develop a demonstrator for a thin tracker based on triple well MAPS CMOS technology for high performance machine applications luminosity as SuperB. The project was developed from 2006 to 2009, ending with a test of the demonstrator made on the T9 beam at CERN [15].

VIPIX

In the development of MAPS CMOS devices the main difficulty we encountered, and which is still haunting many recent circuits, is the interference between the digital and analog parts of the readout electronics. To remedy this problem we explored vertical integration technology, in which two or more electronic chips are interconnected through vertical paths. This technology would allow to separate the digital part from the analog part reducing interference problems. Thanks to the availability of affordable vertical integration technology, we presented the VIPIX research project to the INFN CSN V, which approved it for the period 2009-2013. At VIPIX we have used vertical integration technologies to develop fine pixel detectors for applications to future accelerator machines such as high luminosity B Factories and ILC.[16]

PixFEL

The technological developments of vertically integrated pixels have possible applications in areas other than high-energy physics. In particular they lend themselves to be used to make a focal plane to detect X-rays diffracted from samples under illumination in a Free Electron Laser. The development of a sensor for this type of application poses new technological challenges for the high dynamic range and the high bandwidth. In the PixFEL project, approved by the INFN CSN V for the period 2014–2018, we developed sensors and electronics suitable for this application, with innovative solutions for both the sensors can support a dynamic range of 10^4, both for integrated electronics with compression of the dynamics, and for the analog-digital conversion in the pixel [9, 10].

Graphene In 2015 I started an activity in collaboration with the Department of Information Engineering aimed at studying the feasibility of radiation detectors using graphene or others two-dimensional materials (such as MoS2) as a reading or amplifying element. The remarkable electron transport properties of graphene make it particularly attractive and potentially useful for making fast detectors [8]. Simulations have identified the type of usable structures and samples were made in collaboration with the Garfield project of CSN V of INFN in Frascati. Measurements showed an extreme sensitivity to quality of the substrate surface, making it very hard to realize usable devices.

International recognition My results in the field of instrumentation are well recognized in the community, as testified the plenary talk that was entrusted to me at the EPS-HEP conference in 2013 [25] and the role of convener of the new technologies group in the "What Next ?" process organized in 2013–2015 by INFN [68]. In 2019, I was asked to present the talk "Technological challenges of particle physics experiments" at the Granada Open Symposium for the Update of the European Strategy for Particle Physics and participated in the preparation of the Instrumentation and Computing section of the Phyiscs Briefing Book, the Input for the European Strategy for Particle Physics Update 2020 [69]. Since 2019 I am a member of the ICFA Instrumentation Innovation & Development Panel, charged with supporting the instrumentation community enhancing innovation and development, for instance with the organization of instrumentation schools. One of the achievement of this panel, to which I significantly contributed, was the creation of the ICFA Instrumentation Award and the ICFA Early Career Instrumentation Award, for recognition of outstanding work in the field of instrumentation. The first edition of these prizes was awarded during the Pisa Meeting on Advanced Detectors, that I was chairing.

Department of Excellence In 2022 I contributed to the preparation of the Department of Excellence project, coordinating the Fundamental Interaction area of the Pisa Physics Department. They main strength of the project, that has been approved with the maximum rating, is the interdisciplinary research focused on instrumentation, with applications to Particle and Astro-particle Physics, Condensed Matter, Astrophysics, and Medical Physics. The project, starting in 2023, will allow a powerful development of the department research infrastructures and student attractiveness.

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