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The Crystal Ball Detector at DORIS–II

- Review of Achievements -

by

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The Crystal Ball Detector at DORIS-II – Review of Achievements –

J.K. Bienlein, DESY

Abstract

The Crystal Ball detector is specialized to measure electromagnetically showering particles. It has been operated at the DORIS-II e^+e^- storage ring at DESY in the years 1982-1986. Data have been taken on the $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(4S)$ resonances and nearby continua with an integrated luminosity of 254 pb^{-1}. The research topics have been bottonium spectroscopy, total cross section for $e^+e^- \rightarrow$ hadrons in the continuum, weak decays of $B-$ and $D-$mesons and $\tau-$leptons, and two-photon formation of resonances. The analyses resulted in 21 diploma, 27 Ph.D. and 4 habilitation theses, 4 physicists had been appointed to tenured professors. In an appendix some information is given on the LENA experiment which preceded the Crystal Ball at DORIS.

Updated report to the Crystal Ball plenary meeting on October 26, 1990

Contents

1 Motivation for the Project

The Crystal Ball detector had been designed for experiments at SLAC in 1974 (actually before the "November revolution"). It had been operated at the SPEAR e^+e^- storage ring at SLAC in the years 1978-1981 on the J/ψ, the ψ', the ψ'' resonances and the continuum up to 7.4 GeV c.m. energy. The highlights of the analyses have been charmonium spectroscopy and radiative $J/\psi-$decays where glueball candidates had been found. Besides other topics also two-photon formation of the $f_2(1270)$ and the η and $a_2(1320)$ resonances had been measured. After data samples of ~ 2 million $J/\psi-$ and $\psi'-$decays each had been collected the Crystal Ball collaboration had felt that further progress might be limited by systematics rather than by statistics.

At DESY the DORIS e^+e^- storage ring had been upgraded in 1977/78 to reach the energies of the $\Upsilon(1S)$ and $\Upsilon(2S)$ resonances. In 1978 the DASP-II, PLUTO, and DESY-Hamburg-Heidelberg-MPI München collaborations had first excited these resonances in e^+e^- collisions. The luminosities had been 20 and 10 nb^{-1}/d at the $\Upsilon(1S)$ and $\Upsilon(2S)$, respectively. A luminosity upgrade allowed 50 and 30 nb^{-1}/d, respectively, for the DASP-II and LENA collaborations in 1979 and 1980. Considering the importance of this field of high energy physics, DESY discussed another upgrade of DORIS in energy and luminosity.

At a workshop at DESY in January 1981 the plan came up to bring the Crystal Ball detector to the upgraded DORIS-II storage ring.

Appendix A lists the institutions and the personnel which operated the Crystal Ball experiment at DORIS-II.

2 Time Span of the Project

Table 1 summarizes the time span of the project. It needed about a year after the first idea to discuss within the old collaborations, to work out the proposal by the new, larger collaboration and to get approval from both, SLAC and DESY, and the funding agencies. The dismantling of the detector at SPEAR, its spectacular transport by a Galaxy aircraft, and its installation at DESY took altogether only seven months.

Table 1: **Time Span**

1981 Jan	DORIS workshop idea emerges	
1981	proposal, approval	$\sim$ 1.0 year
1982 winter $\rightarrow$ summer	dismantling at SLAC spectacular transport, installation at DESY	$\sim$ 0.7 years
1982 Aug 6 $\rightarrow$ 1986 Sept 22	data taking	$\sim$ 4.3 years
1987 summer	dismantling at DESY transport back to SLAC	
1986 $\rightarrow$ 1991 summer	analysis ongoing	$\sim$ 4.5 years
1981-1991	total time span	$\sim$ 10.5 years

Data were taken during four years and two months. Shift-taking was a considerable load. In some years the collaboration operated the detector during 200 days. In other words, 600 shifts had to be manned, or: 1200 shift assignments. During this time also various improvements to the detector had been made. Better radiation protection during the beam injection and new charged particle tracking chambers with one additional (double) layer and new pre-amplifiers were the more important changes.

I do not want to comment on the decision to stop data taking as I am not informed on the discussions which preceded it.

After the decision to stop data taking the detector had been dismantled at DESY and was transported back to SLAC in 1987.

The data analysis continued, after data taking had been stopped. Actually analysis gained full power only after 1986. Though the number of physicists active on the experiment decreased considerably, it turned out that the relief from shift-taking and from calibrations freed a lot of manpower which now finally could turn to data analysis.

A new push in data analysis was made in 1989. As will be seen later, interesting new results came out afterwards. Those who are still active in analysis feel that the topics which are unique for the Crystal Ball detector, and which can be done with the existing data samples, are coming to an end in 1991.

3 Data Taken

Data were first taken on the $\Upsilon(2S)$ resonance (and some on the continuum below) to measure the χ_b–states. During this time (1982 winter 1984) also some data on the $\Upsilon(1S)$ were recorded to check the algorithms for photon detection and measurement. In fall 1984 and in winter 1986 more data on $\Upsilon(1S)$ were taken. The measurements on the $\Upsilon(4S)$ were done on request of the ARGUS collaboration. Table 2 gives the luminosities recorded for the various data samples.

Table 2: **Data Taken**

energy range	luminosities
$ON\ \Upsilon(1S)$	46 pb^{-1}
$ON\ \Upsilon(2S)$	56 pb^{-1}
$ON\ \Upsilon(4S)$	89 pb^{-1}
$CONT$	42 pb^{-1}
$SCANS$ etc.	21 pb^{-1}
SUM	254 pb^{-1}

The next chapter will summarize the physics topics investigated with these data. As the physics anlaysis is now coming to an end one can look back and judge whether more data with the Crystal Ball detector (as it existed) would have been useful. It turns out that the

physics analyses were limited by statistics and not by systematics.

4 Achievements

The achievements of the Crystal Ball at DORIS-II will be described under three points:

1. Theses submitted by students and work by research associates,
2. Crystal Ball publications,
3. Physics topics.

One has to realize that the Crystal Ball is a highly specialized detector. Its strength is the observation and measurement (energy and direction) of photons, over a very large solid angle, in the NaI(Tl) calorimeter. It had been a deliberate decision not to worsen the strength of the detector for additional components which might allow a wider range of applicability. Detectors with better performance are available only since 1989 (CLEO-II at CESR and Crystal Barrel at LEAR). They use CsI instead of NaI for the calorimeter. The importance of the shorter radiation length of CsI is that the lateral shower size is smaller thus avoiding overlap of the energy depositions in an event. This had been the most serious limitation of the Crystal Ball detector at Υ−energies. The new detectors also combine the calorimeter for photon detection with charged-particle tracking in a magnetic field. They may also use vertex detectors (ARGUS). Furthermore, CESR has now, in 1991, a much higer luminosity than DORIS-II in, say, 1986.

1. Theses submitted by students and work by research associates
   Table 3 lists the 21 students who have submitted a diploma thesis from work on the Crystal Ball experiment, Table 4 the Ph.D. students in the same way, while Table 5 gives the four habilitation theses.

   The number of research associates (RA's) working on the experiment had been considerably smaller than the number of students. Table 6 gives a summary of the number of RA's, also indicating when they had heavy duties outside of the experiment. The numbers apply for the running period. From 1987 on, the numbers of RA's still working on the experiment for analysis decreased considerably.

   Table 7 gives the names of the four physicists who had worked for some time on the Crystal Ball experiment and who got nominations to tenured professors. More people got permanent positions in research institutes, former students are now assistant professors. All other students who graduated with Crystal Ball work got jobs in industry which satisfy them.

2. Crystal Ball publications
   Appendix B lists the journal publications. Table 8 summarizes the number of publications, conference proceedings, and theses according to the year. It is split into work before August 1989 and afterwards. A plenary meeting in that month had started an effort to get existing results published and to concentrate for future analysis on topics for which the Crystal Ball detector is a unique tool.

   Published conference proceedings have been taken from the DESY Annual Reports. Appendix C lists the Ph.D. and diploma theses, as far as known to me. Appendix D gives the topics (and the name(s) of the physicist(s) who mainly work on it) of work

which has been finished and of which a draft exists, of work which is finished and is in process of being written up as a thesis and for publication, and, finally, of ongoing work. It has to be mentioned that for one topic into which an extensive effort had gone (among it two Ph.D. theses) no publication is foreseen at the moment.

Getting out publications by the Crystal Ball Collaboration has been an extremely painful process. People did not care about deadlines for comments. No procedure had been established to check the data analysis and to correct the write-up for physics and style in an effective way.

3. Physics topics
The physics topics investigated by the Crystal Ball at DORIS-II, in the Υ energy range, cover a wide range. They can be classified in the fields

quarkonium spectroscopy	using $\Upsilon(2S)$ and $\Upsilon(1S)$ data
QCD	using $\Upsilon(1S)$ and continuum data
weak interactions	of $B-$decays ($\Upsilon(4S)$ data)
	of $D-$decays (all data)
	of $\tau-$decays (all data)
hadron spectroscopy	by $\gamma\gamma-$formation of resonances (all data).

Also work on Monte Carlo simulation of particle interactions in the calorimeter was triggered by analysis needs. Table 9 lists these topics in detail.

The **highlights**, in my personal point of view, have been:

- $b\bar{b}$ system quarkonium spectroscopy,
  especially the measurement of Γ_{ee}, $B_{\mu\mu}$, and the $\gamma-$transitions to the χ_b-states, but this piece of work lacks $\Upsilon(3S)$ data.
- σ_{tot} in the continuum.
- Inclusive $\gamma-$spectra: $\Upsilon(1S) \rightarrow \gamma gg$ / $b \rightarrow s\gamma$
- $\gamma\gamma-$physics: a complete set of measurements of resonance formation by $\gamma\gamma-$collisions could be established. Among them is the first observation of the $\pi_2(1670)$ in $\gamma\gamma-$reactions and the first observation of a hitherto unknown, though not unexpected, hadron resonance, the $\eta_2(1870)$.

The Crystal Ball could not make a large impact on B-meson physics for two reasons: it did not have a magnetic field and there was a lack of a sufficiently large data sample.

Table 3: **Crystal Ball Diploma Theses**

Institution	Student	Year
DESY	Kloiber	1984
	Bartels	1986
	Meyer	1987
	Voigt	1987
	Brockmüller	1987
Hamburg	Maschmann	1984
	Sievers	1985
	Graaf	1987
	Heinsius	1987
	Krüger	1987
	Stock	1987
	Kiel	1988
Erlangen	Kobel	1986
	Schütte	1986
	Glaser	1986
Firenze	de Judicibus	1985
	Compagnucci	1986
	Papini	1990
Würzburg	Keh	1983
	Schmitt	1984
	Karch	1986
Sum :	21 diploma theses	

Table 4: **Crystal Ball Ph.D. Theses**

Institution	Student	Year
DESY	Wachs	1988
	Marsiske	1988
	Karch	1991
Hamburg	Nernst	1985
	Bieler	1989
	Maschmann	1989
	Sievers	1989
	Lekebusch	1991*
Erlangen	Folger	1986
	Lurz	1986
	Schütte	1989
	Kobel	1991*
Würzburg	Keh	1986
	Schmitt	1986
	Kilian	1991*
Nijmegen	Walk	1986
	Janssen	1990
Cracow	Skwarnicki	1986
	Jakubowski	1990
	Lesiak	1991*
Firenze	Bizzeti	1987
SLAC/Stanford	Gelphman	1985
	Leffler	1986
	Lowe	1986
Harvard	Williams	1987
CMU	Prindle	1985
	Renger	1987
CIT	-	
Princeton/ Santa Cruz	-	
Sum :	27 Ph.D. theses	

*Thesis not yet submitted in March 1991

Table 5: **Crystal Ball Habilitation Theses**

Institution	Name	Year
Erlangen	Volland	1986
Hamburg	Heimlich	1986
Würzburg	Königsmann	1986
Cracow	Muryn	1990
Sum :	4 habilitation theses	

Table 6: **Research Associates (=RA's)**
Definition: RA ≡ non-permanent contract
(research associates, assistant professors, and similar status)

Institution	
DESY	3 positions given at beginning of project, all 3 cancelled in 1983/84 ⇒ serious difficulties for experiment after stop of data taking: adequate support from DESY (i.e. we got what we had requested)
Erlangen	1 RA, but heavy teaching duty
Hamburg	1 RA, but heavy teaching duty
Würzburg	1 RA, but heavy teaching duty
Nijmegen	1 RA for 2 years, at DESY
Cracow	-
Firenze	1 RA for 1 year, at DESY
SLAC	2-3 RA's at any time, at least 1 at DESY
Harvard	1 RA, not at DESY
CMU	2–3 RA's, at least 1 at DESY
Princeton/ Santa Cruz	1 RA, at DESY
Stanford	2 RA's, not at DESY
Caltech	1 RA, not at DESY

Table 7: **Nominations of Crystal Ball Physicists to Tenured Professors (4)**

Name	Institution
F. Porter	at CIT
H. Vogel	at CMU
D. Marlow	at Princeton
G. Conforto	at Urbino

Table 8: **Summary of Crystal Ball Publications**

year	journal publications	conference proceedings	Ph.D. theses	diploma theses
1982	-	-	-	-
1983	1	3	-	-
1984	-	14	-	4
1985	2	10	3	2
1986	2	12	8	6
1987	3	15	3	7
1988	4	7	2	1
1989	2	-	4	-
$\sum(\leq Aug\ 89)$	14	61	20	20
1990	7	3	2	1
1991 ($\leq March$)	-	-	1	-
in press	2	-	-	-
submitted	-	-	-	-
drafts	5	1	1	-
expected	3	-	3	-
ongoing work	3	-	-	-
$\sum(\geq Aug\ 89)$	9+5+6	3+1+?	3+1+3	-
$\sum(total)$	23+5+6	64+1+?	23+1+3	21

Table 9: **Crystal Ball Physics Topics**

$\Upsilon(2S)$	mass
	Γ_{ee}
	$B_{\mu\mu}$
	χ_b states by inclusive γ's
	χ_b states by cascade γ's
	spin of χ_b states
	$\gamma\eta_b$
	$\pi\pi$ transitions
	π^0, η transitions (limits)
$\Upsilon(1S)$	Γ_{ee}
	$B_{\mu\mu}$ and spin of $\Upsilon(1S)$
	$(\pi^0, \eta)X$
	γgg
	decay into neutrals
	decay to 2 charged + neutrals
	decay topology
	axion search
CONT	σ_{tot}
	$(\pi^0, \eta)X$
$\Upsilon(4S)$	electron spectrum
	$B \rightarrow D^* e\nu$
	$B \rightarrow \pi^0 e\nu$
	$B \rightarrow J/\psi\ X$
	$B^0 \rightarrow \pi^0\pi^0$
	$b \rightarrow s\gamma$
D-decays	$D^0 \rightarrow \pi^0\pi^0$
τ- decays	rare decays ($\rightarrow e\pi^0$, $\rightarrow e\eta$)
	Michel-parameter
	$\rightarrow \rho\nu$, $a_1\nu \rightarrow \pi^0 X$, $\pi^0\pi^0 X$
	$\rightarrow \eta X$
$\gamma\gamma$	$\rightarrow 2\gamma \rightarrow \pi^0$, η, η'
	$\rightarrow 4\gamma \rightarrow \pi^0\pi^0$ (from threshold to $f_2(1270)$)
	$\rightarrow 4\gamma \rightarrow \pi^0\eta$
	$\rightarrow 4\gamma \rightarrow \pi^0\pi^0, \rightarrow \eta\pi^0$ (above 800 MeV)
	$\rightarrow 6\gamma \rightarrow \pi^0\pi^0\pi^0$ (η)
	$\rightarrow 6\gamma \rightarrow \eta\pi\pi$ (η')
	$\rightarrow 6\gamma \rightarrow \pi^0\pi^0\pi^0$ ($\pi_2(1670)$)
	$\rightarrow 6\gamma \rightarrow \eta\pi^0\pi^0$ ($\eta_2(1870)$)
	$\gamma\gamma^* \rightarrow \pi^0\pi^0$
techniques	Monte Carlo (particle interactions in calorimeter)

5 Conclusions

What was our experience in working for the Crystal Ball experiment? First of all we felt that the personnel situation had always been extremely critical. The load of shift-taking was already mentioned (running up to 200 days per year, i.e. 1'200 shift assignments). In addition, the calibrations and similar work had to be done: energy, tube chambers, time-of-flight counters, luminosity, radiation levels, detector-checks by hard- and software (BOL-job), light-flasher system, on-line computer, data transfer to the IBM. The time load for both duties had been checked in some cases and was found to amount to between four and four-and-a-half days per week and per active physicist. This left half-a-day per week for analysis, or one-and-a-half to two-and-a-half days, if also weekends are used for work (which had been usual). Work had also to be done for the software: off-line program maintainance and especially development, data production (for which during some time shifts had been assigned at SLAC) and, last but not least, shipping of raw data tapes from DESY to SLAC and of production tapes from SLAC to DESY. Also selected data samples had been produced. So the first experience had been: overload of work. Being one of the co-spokesmen of the DESY group I have to say that in 1983/84 the cancellation of all three RA positions (all which the group had) had been a severe blow. The DESY group had to start again with new diploma and Ph.D. students.

The next experience was that the composition of the US-groups was different from that of European institutions. European institutions worked essentially with the Ph.D. and diploma students and had only extremely few research associates (who also had heavy teaching duties). In contrast to this situation the US groups had comparatively few students but more research associates most of whom could spend all their time on the experiment. Table 10 shows this.

Table 10: **Effort from RA's and Ph.D. and Diploma Students**

	RA's	Ph.D. students		Diploma students
	man-years	number	publications	number
US groups	24	6	2	–
European groups	14	21	16 + 4	21

Remarks to Table 10: The man-years of work by RA's mainly refer to the years of running (1982-1986). Then it decreased rapidly. It is an estimate. On some published topics two Ph.D. students had worked. This check of the analysis had been a deliberate decision of the collaboration.

One may now count the total man-years spent by RA's and by students for the experiment. I take an average of three years for Ph.D. and two years for diploma students. Then I find a total of 160 man-years, out of these 120 by students. In addition, most of the analysis after closing the detector at the end of 1986 was done by students. So the final conclusion is:

The Crystal Ball experiment was run and analysed by students.
To observe this and to participate in it was fun.

Acknowledgements

As became clear in the preceding, students played an exceptionally important role in the Crystal Ball experiment. So my thanks go first to them. I hope they learned how to do physics. Anyhow, I learned a lot from them.

Next I have to thank all the people in the Crystal Ball collaboration. Hard and devoted effort manned the data taking shifts, let work on the detector and for calibrations be done in an intellegent way and has put forward clever ideas for analysis.

This experiment would not have been possible without the DORIS machine group who has built DORIS-II in 1981/82 in record time and operated it with high performance reaching considerably higher luminosity than with DORIS-I.

Installation of the detector and keeping up the infrastructure was done by the DESY experiments' support group. They have proven their competence many times.

One must not forget the friendly help which we always got from the administrative services, both at DESY and at SLAC, for traveling, housing, visa, and most important, for the transport of the Crystal Ball from California to Hamburg.

The SLAC and DESY directorates supported this untypical collaboration in high energy physics where a successful detector had been moved to a new storage ring. Our thanks also go to the funding agencies, they are listed in the publications.

Finally I have to excuse for omissions and wrong statements (if they slipped in). I knew a lot of what was going on in the collaboration, but certainly not everything – and thirteen years are a long time to remember everything. All complaints fall on my part.

For this write-up I got help from Karl-Heinz Karch and two students from Vienna (H. Jakob and M. Moser) and critical remarks from W. Koch. Special thanks to them. Ms. Rehder typed from my (hardly legible) notes and corrected the text.

A Crystal Ball Institutions and Personnel

1. California Institute of Technology, Pasadena, CA 91125, USA
   C. Edwards, C. Peck, F.C. Porter, P. Ratoff

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13. Stanford University, Department of Physics, HEPL, and Stanford Linear Accelerator Center, Stanford, CA 94309, USA
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14. Universität Würzburg, W-8700 Würzburg, Germany
K. Karch*, S. Keh, H. Kilian, K. Königsmann, M. Scheer, P. Schmitt

* Denotes physicists who changed the institution within the collaboration

B Crystal Ball Publications from work on DORIS-II

B.1 Publications in Journals

1. D.P. Barber et al.
   A precision Measurement of the Upsilon' Meson Mass
   Phys.Lett.B 135(1984)498, DESY 83-067

2. R. Nernst et al.
   Observation of three P States in the Radiative Decay of $\Upsilon(2S)$
   Phys.Rev.Lett. 54(1985)2195, DESY 85-018, SLAC-PUB-3571

3. W. Walk et al.
   The χ_b *States in Exclusive Radiative Decay of the* $\Upsilon(2S)$
   Phys.Rev.D 34(1986)2611. DESY 85-019, SLAC-PUB-3820

4. D. Gelphman, B. Lurz et al.
   Measurement of the Decay $\Upsilon(2S) \to \pi\pi\Upsilon(1S)$
   Phys.Rev.D 32(1985)2893, DESY 85-020, SLAC-PUB-3563

5. D. Antreasyan, K. Wacker et al.
   Formation of $\delta(980)$ *and* $A_2(1320)$ *in Photon-Photon Collisions*
   Phys.Rev.D 33(1986)1847, DESY 85-097, SLAC-PUB-3761

6. T. Skwarnicki et al.
   Spin Analysis of the χ_b *States*
   Phys.Rev.Lett. 58(1987)972, DESY 86-087, SLAC-PUB-4045

7. B. Lurz et al.
   Experimental Upper Limits for the Hadronic Transitions $\Upsilon(2S) \to \eta\Upsilon(1S)$ *and* $\Upsilon(2S) \to \pi^0\Upsilon(1S)$
   Z.Phys.C 36(1987)383, DESY 87-038, SLAC-PUB-4302

8. D. Antreasyan, R. Clare et al.
   Measurement of the η' *and Search for Other Resonances in* $\gamma\gamma \to \eta\pi^0\pi^0$
   Phys.Rev.D 36(1987)2633, DESY 87-054, SLAC-PUB-4305

9. P. Schmitt et al.
   Search for Radiative $\Upsilon(1S)$ *Decays into Light Mesons*
   Z.Phys.C 40(1988)199, DESY 88-031, SLAC-PUB-4568

10. Z. Jakubowski et al.
    Determination of Γ_{ee} *of the* $\Upsilon(1S)$ *and* $\Upsilon(2S)$ *Resonances and Measurement of R at* $W = 9.39$ GeV
    Z.Phys.C 40(1988)49, DESY 88-032, SLAC-PUB-4567

11. D. Williams et al.
    Formation of the Pseudoscalars π^0, η, *and* η' *in the reaction* $\gamma\gamma \to \gamma\gamma$
    Phys.Rev.D 38(1988)1365, DESY 88-033, SLAC-PUB-4573

12. S. Keh, H. Janssen et al.
Search for Exotic Tau Decays
Phys.Lett.B 212(1988)123, DESY 88-065, SLAC-PUB-4634, HEN-295

13. K. Wachs et al.
The Electron Spectrum from B Meson Decays
Z.Phys.C 42(1989)33, DESY 88-111, SLAC-PUB-4691

14. H. Janssen et al.
The Michel parameter for the decay $\tau \to e\nu\bar{\nu}$
Phys.Lett.B 228(1989)273, DESY 89-054, SLAC-PUB-4958, HEN-317

15. W. Maschmann et al.
Inclusive J/ψ *Production in Decays of B Mesons*
Z.Phys.C 46(1990)555, DESY 89-141, SLAC-PUB-4958

16. Z. Jakubowski, M. Kobel
A Verified Upgrade of the GEISHA 6/7 Simulation of Particle Interactions
Nucl. Instr. Meth. A297(1990)60, DESY 89-165

17. H. Marsiske et al.
Measurement of $\pi^0\pi^0$ *Production in Two-Photon Collisions*
Phys.Rev.D 41(1990)3324, DESY 90-002, SLAC-Pub-5163

18. D. Antreasyan, T. Skwarnicki, K. Wachs, T. Lesiak, W. Maschmann et al.
Observation of the Exclusive Decay $B \to e\nu D^*$ *and Search for* $B \to e\nu\pi^0$
Z.Phys.C 48(1990)553, DESY 90-038, SLAC-Pub-5250

19. D. Antreasyan, B. Muryn et al.
First Observation of the Reaction $\gamma\gamma \to \pi_2 \to \pi^0\pi^0\pi^0$
Z.Phys.C 48(1990)561, DESY 90-054, SLAC-PUB-5254

20. K. Karch et al.
Observation of a New $\eta\pi^0\pi^0$ *Resonance at 1900* MeV/c^2 *in Two-Photon Scattering*
Phys.Lett.B 249(1990)353, DESY 90-068, SLAC-PUB-5266

21. C. Bieler et al.
Measurement of π^0 *and* η *Production in* e^+e^- *Annihilation at* $\sqrt{s}$ *near 10* GeV
Z.Phys.C 49(1991)225, DESY 90-086, SLAC-PUB-5301

22. D. Antreasyan, K. Fairfield et al.
Limits on Axion and Light Higgs Boson Production in $\Upsilon(1S)$ *Decays*
Phys.Lett.B 251(1990)204, DESY 90-094, SLAC-PUB-5307

23. D. Antreasyan, H. Janssen et al.
Measurement of the Branching Ratios for the Decays $\tau \to$ *hadron* $\pi^0\nu$ *and* $\tau \to$ *hadron* $\pi^0\pi^0\nu$
Phys.Lett.B in press, DESY 91-001, SLAC-PUB-5403, HEN-334

B.2 Review Articles

1. K. Königsmann
   Radiative Decays in the ψ Family
   Physics Reports 139(1986)243
   DESY 86-009

2. W. Buchmüller, S. Cooper
   Υ Spectroscopy
   in *"High Energy Electron-Positron Physics"*, A. Ali und P. Soeding (Eds.),
   (World Scientific, Singapur, 1988), p. 412.
   MIT-LNS-159

3. S. Cooper
   Meson Production in Two-Photon Collisions
   Ann.Rev.Nucl.Part.Sci. 38(1988)705
   MIT-LNS-169

B.3 Published Conference Contributions

(Compiled from DESY annual reports 1982 - 1990)

1. G. Conforto
   Study of Υ' Radiative Decays with the Crystal Ball at DORIS-II
   Procs. Workshop on Search for Heavy Flavours, p.387
   Como, I, August 29-30, 1983
   INFN/G1 83/002

2. J.E. Gaiser
   Results from the Crystal Ball at DORIS-II
   Procs. 11th SLAC Summer Institute on Particle Physics, p.421
   Stanford, CA, USA, July 18-29, 1983
   SLAC-PUB 3232

3. A. Schwarz
   First Results from the Crystal Ball at DORIS-II
   Procs. Int. Europhysics Conference on High Energy Physics, p.376
   Brighton, GB, July 20-27, 1983
   DESY 83-108

4. C. Peck et al.
   Evidence for a Narrow Massive State in the Radiative Decays of the Υ
   Contributed Paper submitted to the XXII Int. Conference on High Energy Physics
   Leipzig, D, July 19-25, 1984
   DESY 84-064, SLAC-PUB-3380

5. H.J. Trost
   Evidence for a Narrow Massive State in the Radiative Decays of the Υ
   Procs. XXII Int. Conference on High Energy Physics, p.201
   Leipzig, D, July 19-25, 1984

6. H.J. Trost
   Evidence for a Narrow Massive State in the Radiative Decays of the Υ
   Procs. NATO Advanced Study Institue on Supersymmetry, p.679
   Bonn, D, Aug. 20-31, 1984

7. B. Niczyporuk
   Evidence for a Narrow Massive State in the Radiative Decays of the Υ
   Procs. SLAC Summer Institute on Particle Physics, p.513
   Stanford, CA, USA, July 23 - Aug. 3, 1984

8. S. Cooper
   Testing the Potential Model in the Υ System
   Procs. SLAC Summer Institute on Particle Physics, p.388
   Stanford, CA, USA, July 23 - Aug. 3, 1984

9. U. Volland
   Crystal Ball Results on $\Upsilon(2S)$ Radiative Decays

Procs. XXII Int. Conference on High Energy Physics, p.186
Leipzig, D, July 19–25, 1984

10. D. Coyne
Υ Family Decays
Procs. IVth Int. Conf. on Physics in Collision, p.163
Santa Cruz, CA, USA, Aug. 22–24, 1984

11. D. Antreasyan
Radiative Decays from the $\Upsilon(2S)$
Procs. VIIth Int. Conf. on Elementary Particle Physics, p.398
Nashville, TN, USA, 1984

12. J. Irion
Radiative Decays of the $\Upsilon(2S)$ Resonance
Procs. XIXth Rencontre de Moriond, p.211
La Plagne, F, 1984

13. I.C. Brock
Latest Results from the Crystal Ball
Procs. Santa Fee Meeting DPF/APS, p.214
Santa Fe, NM, USA, Oct. 31 – Nov. 3, 1984

14. A. Fridman
Results form the Crystal Ball Experiment
Procs. 6th Int. Symp. on High Energy Spin Physics
Marseille, F, Sep. 12–19, 1984
J. de Physique 46, C2, Suppl.2(1985)157

15. G. Conforto
Quarkonium Spectroscopy
Procs. EPS General Conference, p.309
Prag, CSR, Aug. 27–31, 1984

16. K. Wacker
$\pi^0\eta$ Production in Photon-Photon Collisions
Procs. VIth Int. Workshop on Photon-Photon Collisions, p.453
Granlibakken, CA, USA, Sept. 10–13, 1984

17. D. Williams
Observation of Photon-Photon Production of π^0
Procs. VIth Int. Workshop on Photon-Photon Collisions, p.454
Granlibakken, CA, USA, Sept. 10–13, 1984

18. E.D. Bloom
The Search for New Effects in e^+e^- Interactions
Procs. VIth Topical Workshop on Proton Antiproton Collider Physics, p.722
St. Vincent, I, 1985
SLAC-PUB-3686

19. S. Cooper
Hadron Spectroscopy
Procs. Int. Europhysics Conf. on High Energy Physics, p.945
Bari, I, July 18-24, 1985
SLAC-PUB-3619

20. F.H. Heimlich
Results from the Crystal Ball
Procs. Topical Europhysics Meeting "The Quark Structure of Matter", p.365
Strasbourg/Karlsruhe, Sept. 26 - Oct. 1,1985

21. J. Irion
Spectroscopy of the $\Upsilon(2S)$ with the Crystal Ball
Procs. AIP Int. Conf. on Hadron Spectroscopy, p.351
College Park, MD, USA, April 20-22, 1985
SLAC-PUB-3643

22. W. Koch
Crystal Ball Results on Bottomonium Spectroscopy
Procs. Topical Seminar on Few and Many Quark Systems, p.35
San Miniato, I, March 25–29, 1985

23. K. Königsmann
Υ Spectroscopy
Procs. Int. Conf. on Physics in Collision, p.161
Autun, F, July 3–5, 1985
DESY 85-089

24. S.T. Lowe
Status of the $\zeta(8.3)$
Procs. XXth Rencontre de Moriond, p.299
Les Arcs, F, March 10–17, 1985
SLAC-PUB-3683

25. T. Skwarnicki
Spin Analysis of the χ_b States
Procs. XXth Rencontre de Moriond, p.291
Les Arcs, F, March 10-17, 1985
DESY 85-042

26. K. Wacker
Meson Formation by Photon-Photon Collisions Observed in the Crystal Ball Detector at DORIS-II
Procs. Int. Europhysics Conf. on High Energy Physics, p.323
Bari, I, July 18–24, 1985

27. W. Walk
The χ_b States

Procs. Int. Europhysics Conf. on High Energy Physics, p.287
Bari, I, July 18–24, 1985

28. R. Clare
A Measurement of $\Gamma_{\gamma\gamma}(\eta')$ using the Crystal Ball Detector
Procs. XXIth Rencontre de Moriond, p.451
Les Arcs, F, March 9–16, 1986

29. S. Cooper
Spectroscopy of Light and Heavy Quarks
Procs. XXIIIrd Int. Conf. on High Energy Physics, p.67
Berkeley, CA, USA, July 16–23, July 1986
SLAC-PUB-4139

30. F.H. Heimlich
Gluon and Quark Fragmentation in the Υ Region
Procs. Int. Sym. on The Production and Decay of Heavy Hadrons, p.76
Heidelberg, D, May 20-23, 1986

31. F.H. Heimlich
Crystal Ball Results on $\Upsilon(1S)$ Decays
Procs. XVIIth Int. Sym. on Multiparticle Dynamics, p.341
Seewinkel, A, June 16–20, 1986

32. K. Königsmann
Production, Spectroscopy and Decays of Heavy Bound Quark States
Procs. Int. Conf. on Physics in Collision, p.147
Chicago, Il, USA, Sep. 3–5, 1986
DESY 86-136

33. S.T. Lowe
Recent Results from the Crystal Ball Experiment
Procs. XIVth SLAC Summer Institute on Particle Physics, p.525
Stanford, CA, USA, July 28 – Aug. 8, 1986
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34. P. Schmitt
Search for Radiative $\Upsilon(1S)$ Decays to All-Neutral Final States
Procs. Int. Sym. on The Production and Decay of Heavy Hadrons, p.36
Heidelberg, D, May 20-23, 1986

35. T. Skwarnicki
Electron Endpoint Spectrum in $\Upsilon(4S)$ Decays
Procs. Int. Sym.on The Production and Decay of Heavy Hadrons, p.146
Heidelberg, D, May 20-23, 1986

36. T. Skwarnicki
Crystal Ball Results on Semileptonic B-meson Decays
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37. R.T. van de Walle
Search for Rare $b\bar{b}$ Decays
Procs. XXIIIrd Int. Conf. on High Energy Physics, p.677
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38. D.A. Williams
Recent Results from the Crystal Ball on Photon-Photon Collisions
Procs. XXIIIrd Int. Conf. on High Energy Physics, p.1223
Berkeley, CA, USA, July 16–23, July 1986

39. D.A. Williams
Studies of Resonance Production in $\gamma\gamma$ Collisions by the Crystal Ball
Procs. VIIth Int. Workshop on Photon-Photon Collisions, p.404
Paris, F, April 1–5, 1986

40. J.K. Bienlein
Semileptonic B-meson Decays (Crystal Ball Results)
Procs. Topical Seminar on Heavy Flavours
San Miniato, I, May 25-29, 1987
Nucl.Phys.B(Proc. Suppl.)1B(1987)67

41. E.D. Bloom
J/ψ and Υ Radiative and Hadronic Decays
Procs. Rencontre de Physique , p.439
La Thuile, I, March 1–7, 1987
SLAC-PUB-4361

42. S. Cooper
Two Photon Physics with the Crystal Ball
Procs. 2nd Int. Conf. on Hadron Spectroscopy, p.98
Tsukuba, J, April 16–18, 1987

43. K.H. Fairfield
Search for Axion Production in $\Upsilon(1S)$ Decays
Procs. Int. Sym. on The Production and Decay of Heavy Flavours
Stanford, CA, USA, Sep. 1–5, 1987

44. S. Keh
Rare Decays of the Tau Lepton
Procs. XXIInd Rencontre de Moriond, p.549
Les Arcs, F, March 15–21, 1987

45. K. Königsmann
Leptonic Widths of ψ and Υ Resonances
Procs. XXIInd Rencontre de Moriond
Les Arcs, F, March 15–21, 1987
DESY 87-046

46. K. Königsmann
Two-Photon Production of Pseudoscalar Particles
Procs. Int. Europhysics Conf. on High Energy Physics
Uppsala, S, June 25-July 1, 1987

47. K. Königsmann
Heavy Quarkonia
Procs. Int. Sym. on The Production and Decay of Heay Flavours
Stanford, CA, USA, Sep. 1–5, 1987
DESY 87-151

48. S.T. Lowe
Crystal Ball Results on Tau Decays
Procs. Int. Sym. on The Production and Decay of Heavy Flavours
Stanford, CA, USA, Sep. 1–5, 1987
SLAC-PUB-4449

49. H. Marsiske
Exclusive Production of $\pi^0\pi^0$ and $\pi^0\pi^0\pi^0$ in Photon-Photon Collisions
Procs. XXIInd Rencontre de Moriond, p.697
Les Arcs, F, March 15-21, 1987

50. M. Reidenbach
Determination of Γ_{ee} of the $\Upsilon(1S)$ and $\Upsilon(2S)$ resonances, and Measurement of R at $W = 9.46$ GeV
Procs. Topical Seminar on Heavy Flavours
San Miniato, I, May 25-29, 1987
Nucl.Phys.B(Proc. Suppl.)1B(1987)383

51. T. Skwarnicki
Search for Tau Decays to the η Meson
Contributed Paper to the Int. Europhysics Conf. on High Energy Physics
Uppsala, S, June 25-July 1, 1987
DESY 87-166

52. T. Skwarnicki
Tau Lepton Decays
Procs. Int. Europhysics Conf. on High Energy Physics, p.334
Uppsala, S, June 25-July 1, 1987

53. T. Skwarnicki
B Meson Physics with the Crystal Ball Detector
Procs. Int. Sym. on The Production and Decay of Heavy Flavours
Stanford, CA, USA, Sep. 1–5, 1987

54. K. Wachs
Semileptonic Decays of B Mesons
Procs. XXIInd Rencontre de Moriond, p.303

Les Arcs, F, March 8–15, 1987
DESY 87-084

55. J.K. Bienlein
Observed and Unobserved States – Crystal Ball Results on Two-Photon Physics –
Procs. Workshop on Glueballs, Hybrids and Exotic Hadrons
Brookhaven, NY, USA, Aug. 29 – Sep. 1, 1988,
AIP Conference Procs. Vol. 185, p.486
DESY 88-165

56. A. Bizzeti
Determination of α_s from Υ Decays
Procs. XXIVth Int. Conf. on High Energy Physics, p.909
München, D, Aug. 4–10, 1988

57. K. Königsmann
Heavy Flavours
Procs. Workshop on Glueballs, Hybrids and Exotic Hadrons
Brookhaven, NY, USA, Aug. 29 – Sep. 1, 1988,
AIP Conference Procs. Vol. 185, p.36

58. H. Marsiske
Two-Photon Physics with the Crystal Ball
Procs. VIIIth Int. Workshop on Photon-Photon-Collisions, p.15
Shoresh, Israel, April 24–28, 1988

59. B. Muryn
First Observation of the $\pi_2(1680)$ Resonance in Photon-Photon Reactions
Procs. VIIIth Int. Workshop on Photon-Photon-Collisions, p.102
Shoresh, Israel, April 24–28, 1988

60. D. Sievers
Recent Crystal Ball Results on Photon-Photon Physics
Procs. XXIIIrd Rencontre de Moriond
Les Arcs, F, 1988

61. J. Schütte
Measurement of the Direct Photon Spectrum from the $\Upsilon(1S)$
Procs. Workshop on Glueballs, Hybrids and Exotic Hadrons
Brookhaven, NY, USA, Aug. 29 – Sep. 1, 1988,
AIP Conference Procs. Vol. 185, p.551
DESY 89-007

62. J.K. Bienlein
Recent Crystal Ball Results on Resonance Formation in $\gamma\gamma$ – Reactions
QCD90 Workshop, Montpellier 1990, France
DESY 90-133. Nucl.Phys.B(Proc.Suppl.), to be published

63. K. Karch
Two-Photon Production of $\eta\pi\pi$ Final States
Rheinfels Workshop on Hadron Mass Spectrum, St. Goar 1990
DESY 90-117, Nucl.Phys.B(Proc.Suppl.), to be published

64. U. Volland
ARGUS and Crystal Ball Results on Meson and Baryon Production in e^+e^- Annihilation at $\sqrt{s}$ Near 10 GeV
Proc. of 25th Int. Conf. on High Energy Physics, Singapore (1990), to be published

65. K. Karch
Two-Photon Production of $\pi^\circ\pi^\circ, \pi^\circ\pi^\circ\pi^\circ, \eta\pi^\circ\pi^\circ, 4\pi^\circ$ and $5\pi^\circ$ final states Procs. XXVIth Rencontre de Moriond,
Les Arcs, F, March 17–23, 1991, to be published

C Crystal Ball Ph.D. and Diploma Theses

1. S. Keh
   Decays of Heavy Quarkonia via Hadronic Cascades
   Diploma Thesis - Würzburg, 1983

2. T. Kloiber
   Bestimmung der Luminosität aus der Bhabha-Streuung
   DESY F31-84-01
   Diploma Thesis - Erlangen-Nürnberg 1984

3. P. Schmitt
   Measurements of the Radiation Backgrounds
   at the Crystal Ball Experiment at DORIS
   Diploma Thesis - Würzburg, 1984

4. W. Maschmann
   Energieeichung des Crystal Ball-Detektors unter Benutzung
   eines van de Graaff-Generators
   Diploma Thesis - Hamburg, 1984

5. R. Nernst
   Inclusive Photon Spectrum of $\Upsilon(2S)$*-Decays*
   DESY F31-85-01
   Ph.D. Thesis - Hamburg 1985

6. D. Gelphman
   Measurement of the Decay $\Upsilon(2S) \rightarrow \pi^0\pi^0\Upsilon(1S)$
   SLAC-286
   Ph.D. Thesis - Stanford, CA 1985

7. D. Prindle
   Meaurement of the Resonance Parameters of the Υ *and* Υ' *Mesons*
   Ph.D. Thesis - Pittsburgh, PA, 1985

8. D. Sievers
   Energieeichung des Crystal Ball mit radioaktiven Quellen
   Diploma Thesis - Hamburg, 1985

9. D. De Judicibus
   Analisi spettroscopica dei decadimenti radiativi della Υ'
   Diploma Thesis - Firenze, 1985

10. A. Bizzeti
    Studio dello spettro dei fotoni di alta energia nei decadimenti della $\Upsilon(1S)$
    Ph.D. Thesis - Firenze, 1985-86

11. H.W. Bartels
    Jet-Achsen beim $\Upsilon(1S)$*-Zerfall*

DESY F31-86-01
Diploma Thesis – Hamburg 1986

12. S. Leffler
A Search for primarily non-interacting Decay Modes on the Upsilon
SLAC-0293
Ph.D. Thesis – Stanford, CA 1986

13. T. Skwarnicki
A Study of the Radiative Cascade Transitions between the Upsilon-Prime and Upsilon Resonances
DESY F31-86-02
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14. M. Kobel
A Study of the Process $\Upsilon(1S) \to \mu^+\mu^-$ *using the Crystal Ball Detector*
DESY F31-86-03
Diploma Thesis – Erlangen 1986

15. B. Lurz
Messung von neutralen hadronischen Übergängen der $\Upsilon(2S)$ *in die* $\Upsilon(1S)$ *Resonanz mit dem Crystal Ball Detector bei DESY*
DESY F31-86-04
Ph.D. Thesis – Würzburg 1986

16. G. Folger
Suche nach monochromatischen Linien im Energiespektrum inklusiver Photonen in hadronischen Zerfällen der $\Upsilon(1S)$*–Resonanz mit dem Crystal Ball Detektor bei DORIS*
DESY F31-86-05
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17. S. Keh
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Ph.D. Thesis – Würzburg 1986

18. S. Lowe
A Search for Narrow States in Radiative Upsilon Decays
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Ph.D. Thesis – Stanford, CA 1986

19. J. Schütte
Suche nach radiativen Zerfällen der $\Upsilon(4S)$*–Resonanz*
DESY F31-87-01
Diploma Thesis – Erlangen-Nürnberg 1986

20. H. Meyer
Das Crystal Ball Mikroprozessor-System

DESY F31-87-02
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21. P. Schmitt
All-Neutral Exclusive Decays of the Υ
Ph.D. Thesis - Würzburg, 1986

22. W. Walk
A Study of the χ_b *States in Exclusive Radiative Decay of the* $\Upsilon(2S)$
Ph.D. Thesis - Nijmegen, 1986

23. K. Karch
A Study of the Crystal Ball Charged Particle Identification System
Diploma Thesis - Würzburg, 1986

24. Gabriele Glaser
Energieeichung des Crystal Balls bei DORIS-II mit QED 3-Teilchen Ereignissen
Diploma Thesis - Erlangen-Nürnberg, 1986

25. A. Compagnucci
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Diploma Thesis - Firenze, 1986

26. Silja Krüger
Untersuchungen an CsJ(Tl)-Kristallen mit Photomultiplier- und Photodiodenauslese
DESY F31-87-03
Diploma Thesis - Hamburg 1987

27. V. Stock
Untersuchung der Energieauflösung einer CsJ(Tl)-Szintillationszählermatrix
DESY F31-87-04
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28. K. Brockmüller
Messung der π^0*-Energiespektren im Energiebereich der* $\Upsilon(1S)$*-Resonanz mit dem Crystal Detektor*
DESY F31-87-05
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29. A. Voigt
Messung der Energie-Spektren neutraler Pionen ($E_{\pi^0} > 600$ *MeV*) *in der Reaktion* $e^+e^- \rightarrow$ *Hadronen im Energiebereich der* $\Upsilon(1S)$*-Resonanz mit dem Crystal Ball Detektor*
DESY F31-87-06
Diploma Thesis - Hamburg 1987

30. B. Renger
Study of Low-Multiplicity Exclusive Hadronic Decays of the $\Upsilon(9460)$
Ph.D. Thesis - Pittsburgh, PA, 1987

31. D.A. Williams
Resonance Production in Elastic Scattering of Quasi-Real Photons
Ph.D. Thesis – Cambridge, MA, 1987

32. K. Graaf
Bestimmung der partiellen Zerfallsbreiten Γ_{ee} für die Bottoniumzustände $\Upsilon(1S)$ und $\Upsilon(2S)$
Diploma Thesis – Hamburg, 1987

33. F.-H. Heinsius
Untersuchungen zur Selektion elektromagnetisch schauernder Teilchen an einem segmentierten Kalorimeter
Diploma Thesis – Hamburg, 1987

34. K. Wachs
The Electron Spectrum from B Meson Decays
DESY F31-88-01
Ph.D. Thesis – Hamburg 1988

35. H. Marsiske
$\pi^0\pi^0$ Produktion in Photon-Photon Reaktionen
DESY F31-88-02
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36. T. Kiel
Überwachung des Crystal-Ball-Detektors mit einem Lichtpulsersystem
Diploma Thesis – Hamburg, 1988

37. C. Bieler
Messung der inklusiven Energiespektren und Multiplizitäten von π^0- und $\eta-$Mesonen im Energiebereich der $\Upsilon(1S)-$Resonanz
DESY F31-89-01
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38. W. Maschmann
Inklusive Charmoniumproduktion in Zerfällen der $\Upsilon-$Resonanzen
DESY F31-89-02
Ph.D. Thesis – Hamburg 1989

39. J. Schütte
Messung des Spektrums direkter Photonen aus Zerfällen der $\Upsilon(1S)-$Resonanz
DESY F31-89-03
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40. D. Sievers
Bestimmung der $\gamma\gamma-$Partialbreite des $\eta-$Mesons und Suche nach anderen Zuständen in $\gamma\gamma \to \pi^0\pi^0\pi^0$
DESY F31-89-04
Ph.D. Thesis – Hamburg 1989

41. Z. Jakubowski
Measurement of Total Hadronic Cross Section $\sigma(e^+e^- \rightarrow \text{Hadrons})$ *in the Continuum at the C.M. Energy* $W = 9.39$ *GeV and Determination of* Γ_{ee} *of the* $\Upsilon(1S)$ *and* $\Upsilon(2S)$ *Resonances*
DESY F31-90-01
Ph.D. Thesis - Krakow 1990

42. H. Janssen
Leptonic Decay Modes of the τ *Lepton*
Ph.D. Thesis - Nijmegen, 1990

43. P. Papini
Ricerca della particella di Higgs con il rivelatore Crystal Ball
Diploma Thesis - Firenze, 1990

44. K. Karch
Beobachtung einer neuen $\eta\pi^0\pi^0$*-Resonanz bei 1900 MeV*$/c^2$ *in Zwei-Photon-Reaktionen*
DESY F31-91-01
Ph.D. Thesis - Hamburg 1991

D Topics which are still in work

1. Publications ready to be sent off

1. D. Sievers	$\gamma\gamma \to \eta \to 3\pi^0$
2. A. Bizzeti, J. Schütte	$\Upsilon \to \gamma gg$
3. T. Lesiak	$b \to s\gamma$
4. G. Nowak	$D^0, B^0 \to \pi^0\pi^0$
5. M. Kobel	$\Upsilon \to \mu\mu$

2. Work in good progress

1. R. Lekebusch	$\Upsilon \to \gamma\eta_b$
2. H. Kilian	$\Upsilon \to \gamma + 2$ *charged*
3. K. Karch	$\gamma\gamma \to \eta\pi^0\pi^0$, long paper

3. Work going on

1. K. Karch	$\gamma\gamma \to \pi^0\pi^0, \to \pi^0\eta \to \eta\pi^0, \to \eta\eta$
2. Z. Jakubowski, A. Compagnucci, M. Wolter	$\Upsilon \to 3g$ *topology, sphericity axis with polarization jet multiplicity*
3. B. Muryn, M. Korbel	$\gamma\gamma^* \to \pi^0\pi^0$

4. Missing draft (though considerable work had gone in)

1. ???	*Search for monoenergetic* γ*'s from* Υ *– decays*

E The LENA and the DESY-Hamburg-Heidelberg-MPI München Experiments

E.1 The LENA experiment

a) Runs

1979 fall	$\Upsilon(1S) + CONT$	$\int Ldt \simeq 600\text{nb}^{-1}$	ON
		$\int Ldt \simeq 600\text{nb}^{-1}$	CONT
1980 winter	$\Upsilon(2S) + CONT$	$\int Ldt \simeq 600\text{nb}^{-1}$	ON
		$\int Ldt \simeq 600\text{nb}^{-1}$	CONT
1980 summer	$CONT(7.4 - 9.4)$ GeV	$\int Ldt \simeq 1200\text{nb}^{-1}$	
		$\int Ldt \simeq 3.6\text{pb}^{-1}$	

b) LENA Publications

1. LENA Collaboration, B. Niczyporuk et al.
   Total Width and Leptonic Branching Ratio of the $\Upsilon(9.46)$
   Phys.Rev.Lett. 46(1981)92, DESY 80-53

2. LENA Collaboration, B. Niczyporuk et al.
   $\Upsilon'(10.01)$ *Resonance Parameters*
   Phys.Lett. 99B(1981)169, DESY 80-81

3. LENA Collaboration, B. Niczyporuk et al.
   Measurement of the Decay $\Upsilon' \to \Upsilon\pi^+\pi^-$
   Phys.Lett 100B(1981)95, DESY 80-125

4. LENA Collaboration, B. Niczyporuk et al.
   Charged Hadron Production in e^+e^- *Annihilation in the* Υ *and* Υ' *Region*
   Z.Phys.C 9(1981)1, DESY 81-008

5. LENA Collaboration, B. Niczyporuk et al.
   Measurement of R in e^+e^- *Annihilation for* $\sqrt{s}$ *between 7.4 and 9.4 GeV*
   Z.Phys.C 15(1982)299, DESY 82-052

6. LENA Collaboration, B. Niczyporuk et al.
   Experimental Upper Limits for Hadronic and Axion Decays of the $\Upsilon(1S)$
   Z.Phys.C 17(1983)197, DESY 82-068

c) List of Physics topics

$\Upsilon(1S)$	$B_{\mu\mu}$
	Γ_{ee}
	decay topology
	search for exclusive decays
$\Upsilon(2S)$	$B_{\mu\mu}$
	Γ_{ee}
	$\rightarrow \pi^+\pi^- l^+ l^-$
	$\rightarrow \pi^+\pi^- \Upsilon(1S)$ by multiplicity
	decay topology
$CONT$	topology (jets)
	σ_{tot}

d) Highlights

- $B_{\mu\mu}$ for $\Upsilon(1S)$,$\Upsilon(2S)$
- $\Upsilon(2S) \rightarrow \pi^+\pi^- l^+ l^- \quad (l = \mu, e)$
- σ_{tot}

e) Institutions

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E.2 The DESY-Hamburg-Heidelberg-MPI München Collaboration

a) Runs

1978 June	$\Upsilon(1S)$ scan	~ 20 nb $^{1}/d$
1978 August	$\Upsilon(2S)$ scan	~ 10 nb$^{-1}/d$

b) Publications

1. J.K. Bienlein et al.
   Observation of a Narrow Resonance at 10.02 GeV in e^+e^- Annihilations
   Phys.Lett. 78B(1978)360, DESY 78-45

2. F.H. Heimlich et al.
   Hadronic Jets from e^+e^- – Annihilation in the $\Upsilon-$ and $\Upsilon'-$Region
   Phys.Lett. 86B(1979)399, DESY 79-39

3. P. Bock et al.
   Total Cross Section for Hadron Production by e^+e^- Annihilation between 9.4 and 9.5 GeV
   Z.Phys.C(1980)125, DESY 80-58

c) List of Physics topics

$\Upsilon(2S)$	discovery at e^+e^-
	M
	Γ_{ee}
$\Upsilon(1S)$	Γ_{ee}
	M
	decay topology
	$B_{\mu\mu}$
$CONT$	σ_{tot}

d) Highlights

- Find $\Upsilon(2S)$
- M for $\Upsilon(1S)$ and $\Upsilon(2S)$
- Γ_{ee} for $\Upsilon(1S)$ and $\Upsilon(2S)$

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