International Situation

➔

日本の研究者の
電子･陽電子衝突実験での国際協力
歴史的変遷

山田作衛

2013. 7. 23

第4回：ILC夏の学校@富山

加速器R&Dの国際協力

Linear collider R&D in three regions over 20 years

Asia: JLC/GLC at KEK

US: NLC at SLAC

Europe: TESLA at DESY

CLIC at CERN

2002: ICFA created
ILC Steering Committee

2003: Parameter Committee
Defined the baseline machine and various upgrade options

2004: **International Technology Recommendation Panel**

Cold Technology recommended and approved

2005: Global Design Effort

Parameters for the Linear Collider

September 30, 2003

Up-date November 20, 2006

Asia: Sachio Komamiya, Dongchul Son
Europe : Rolf Heuer (chair), Francois Richard
North America: Paul Grannis, Mark Oreglia

Baseline Machine

Total Energy: 200-500 GeV with energy-scan capability

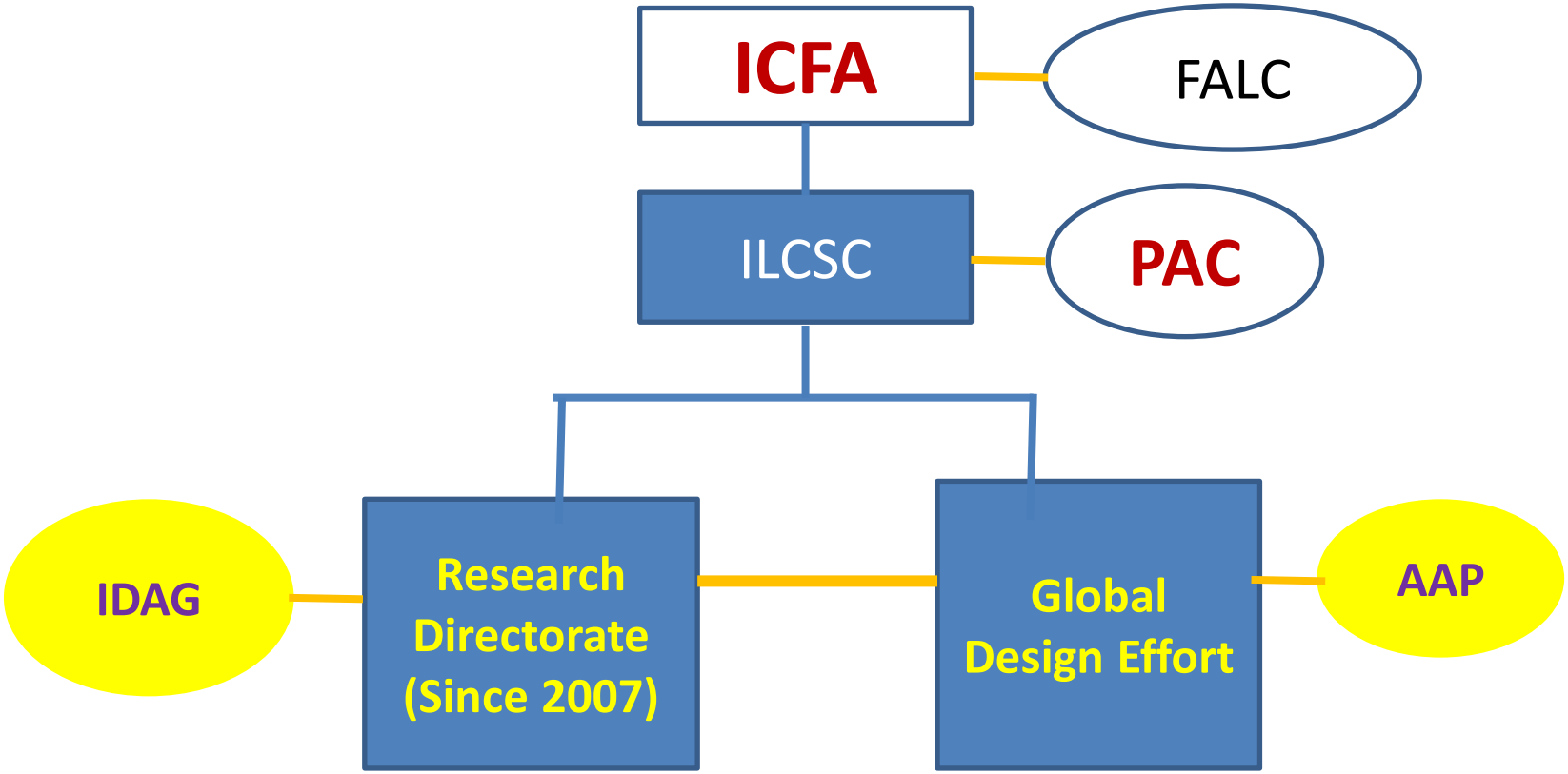
High Luminosity: 500/fb in 4 years.

Upgrade options

Energy upgrade to 1TeV with total luminosity 1/ab

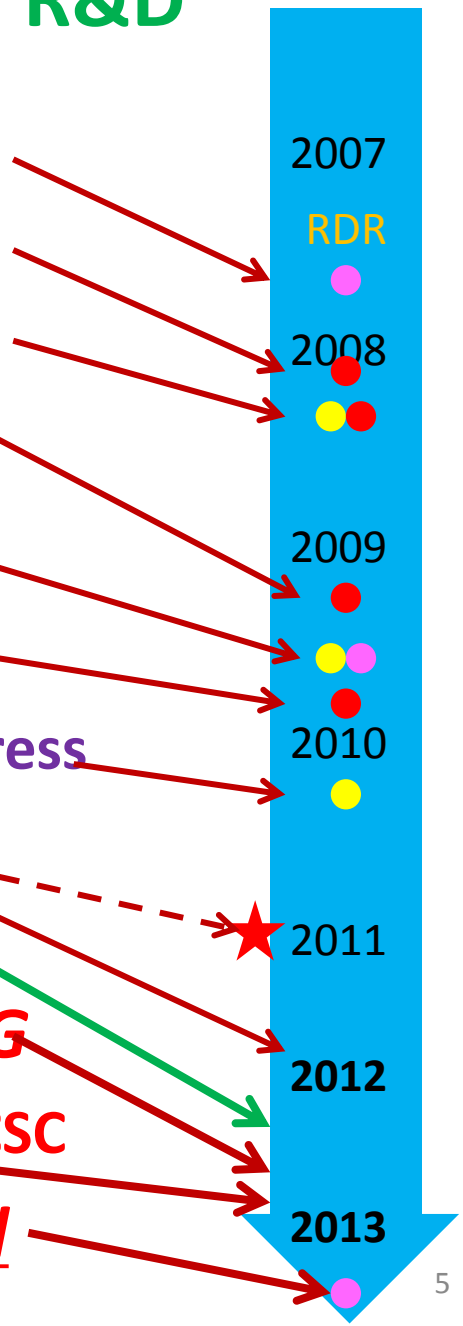
Possible e-e- or gamma-gamma collisions

Organization (2005-2013.6)

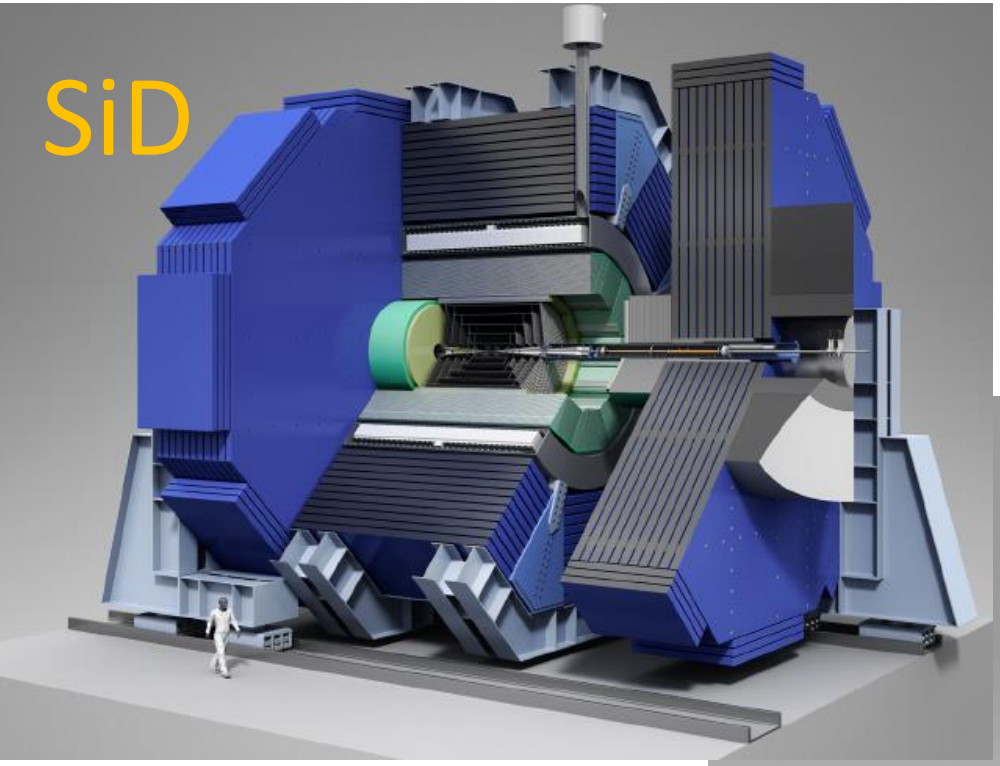


The time line of Physics/Detector R&D

- **Oct. 2007: Call for LOIs was made by ILCSC**
- Jan. 2008: Detector management was formed
- Mar.2008: IDAG formed, 3 LOI groups known
- ***Mar.2009: 3 LOIs submitted***
- Summer 09: **IDAG recommendation for validation and ILCSC's approval**
- Oct 2009: Work plan of the validated groups
- **Mar:2009: IDAG began monitoring the progress**
- *End 2011:* ***Interim report completed***
- **Apr.2012 DBD outline monitored by IDAG**
- ***Oct. 2012 DBD Draft Reviewed by IDAG***
- End 2012: **Review by PAC & submitted to ILCSC**
- ***June 12, 2013: The final TDR published***

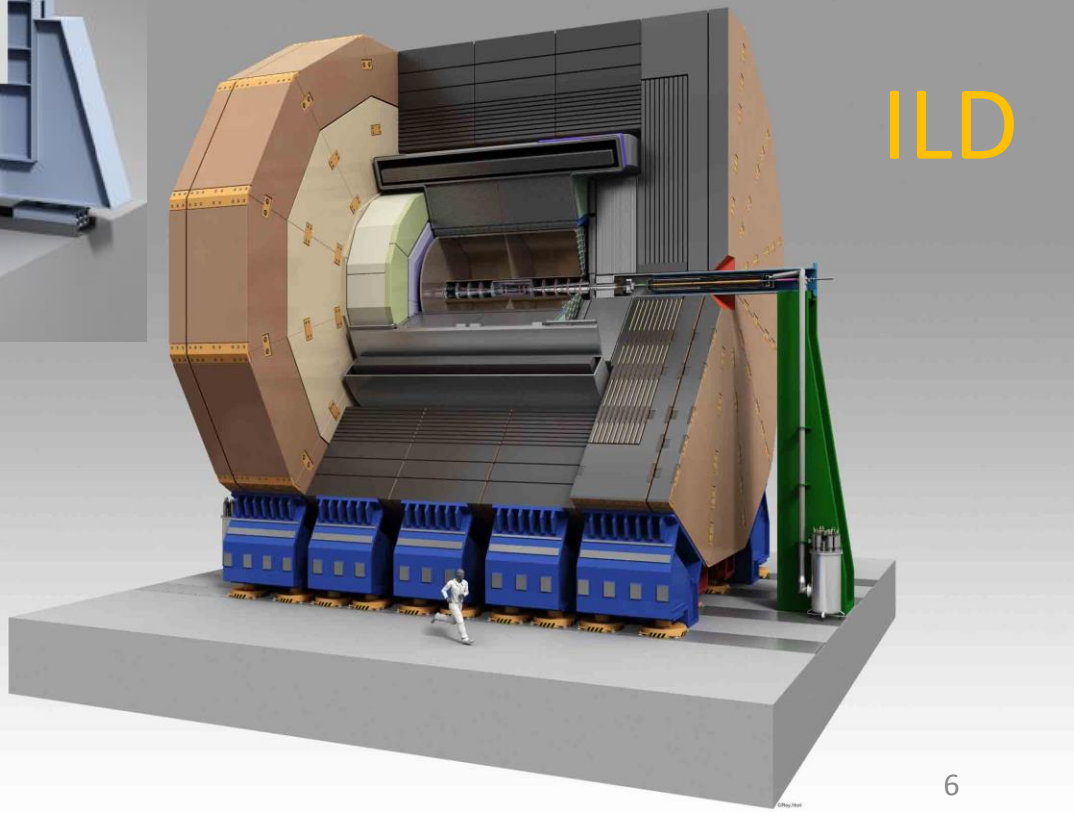


Detector chapters, SiD and ILD

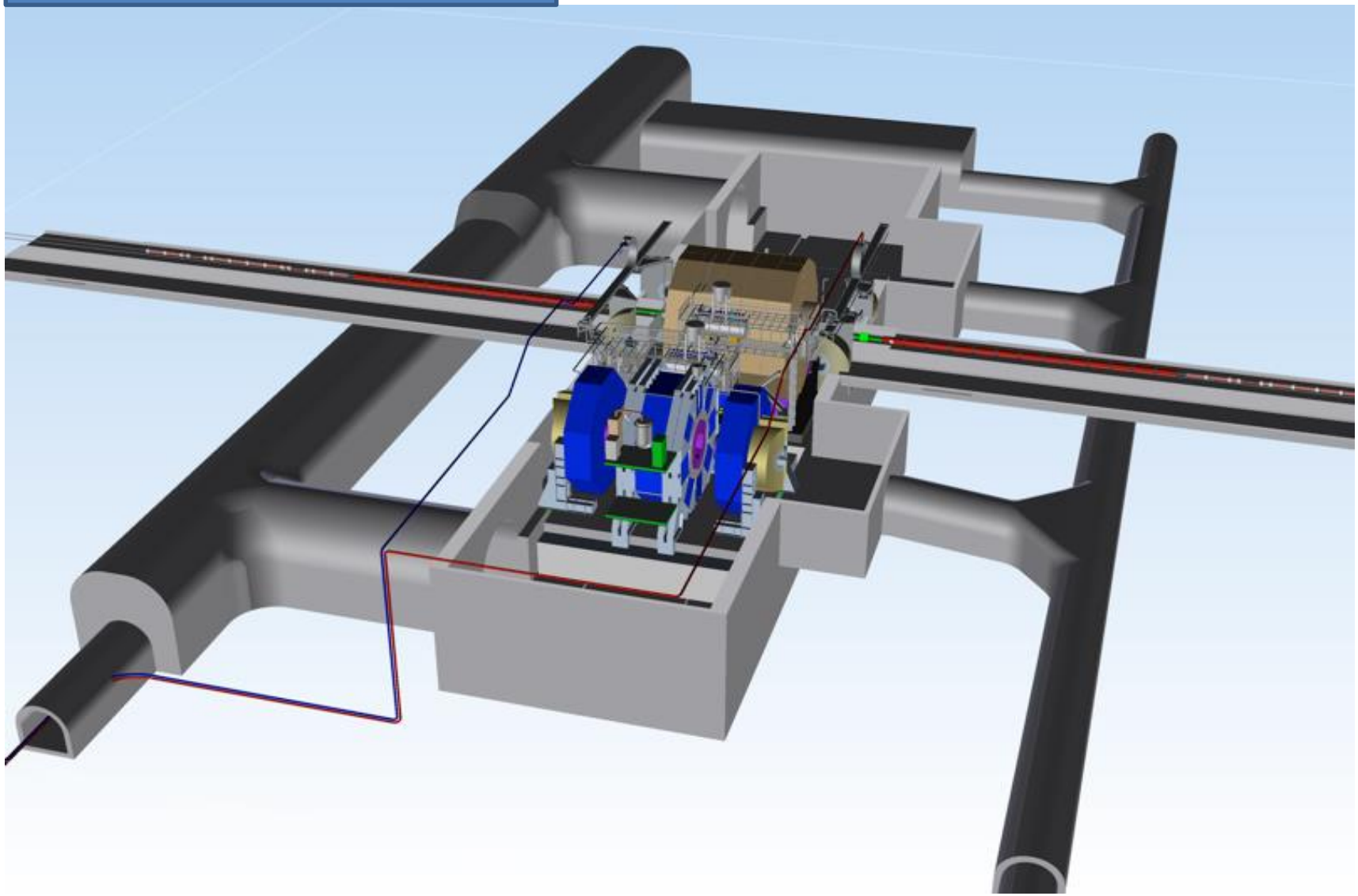


High magnetic field 5T
Compact tracker (Si)

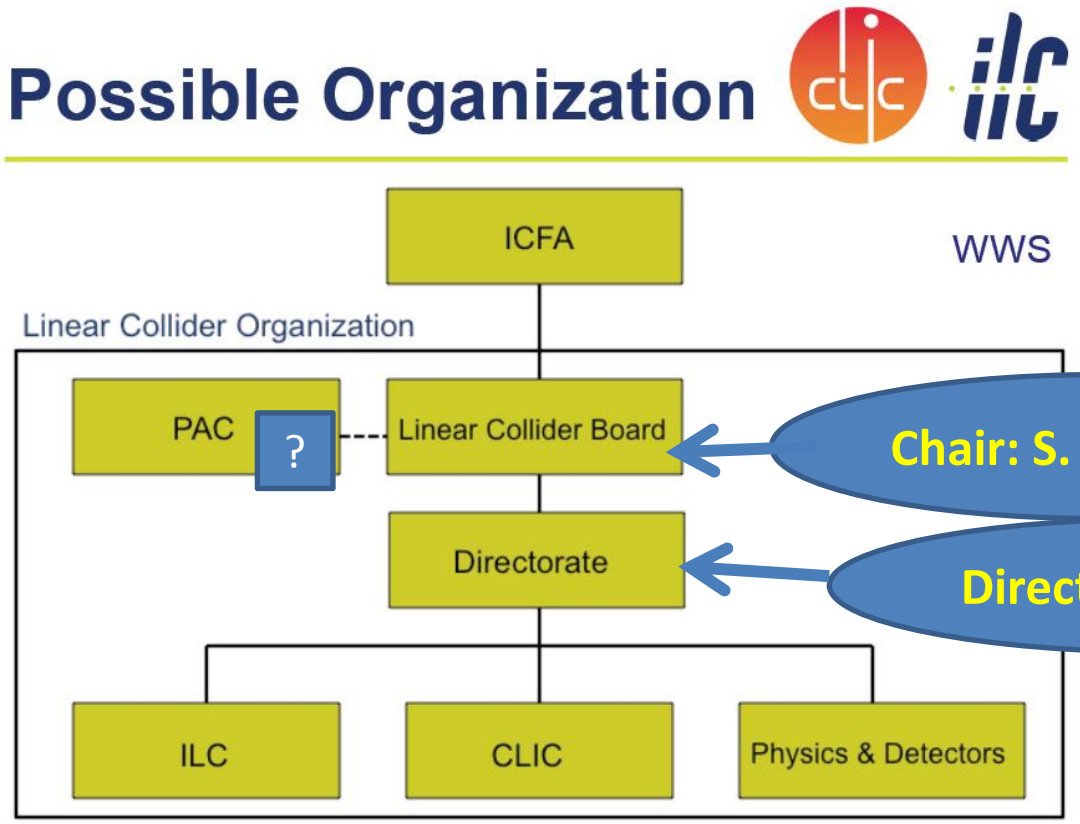
3.5T solenoid
Central tracker (TPC)
Larger calorimeters



Push-Pull scheme



The new organization since Feb.2013



Chair: S. Komamiya

Director: Lyn Evans

Associate Directors:
M.Harrison, S. Stapnes, H. Yamamoto

「日本がホスト」への期待

- 3局の一つとして、活躍、要の役割。
- 地道で周到な努力の継続
  (山下氏の講義参照)

自信を持って、努力を続けるべし。

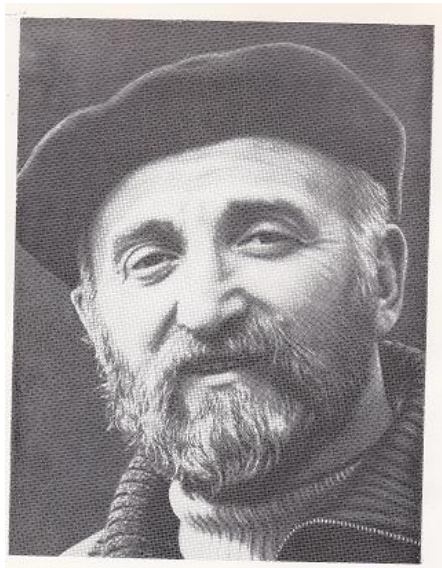
その下地となっているe+e-物理・加速器に関する国際協力の歴史

最初の試み

1968ー1972年:

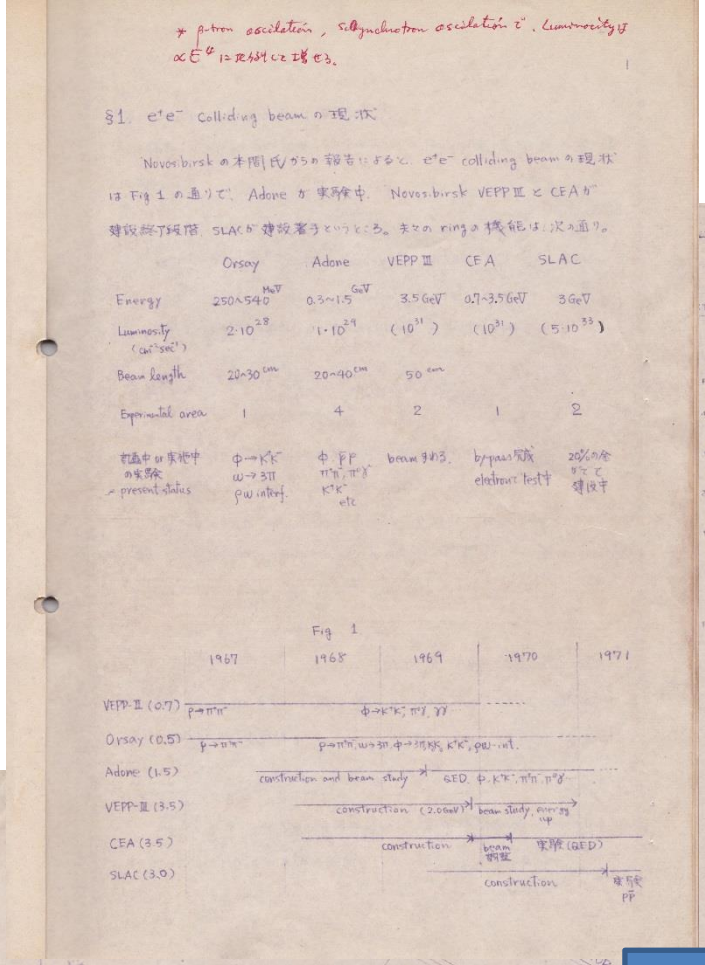
ノヴォシビルスク(Budker Inst)との共同研究
小柴ーBudker 連携
東大理を中心に: Budkerも来訪、
当時は、ハドロン物理が全盛で、
e+e-はマイナー分野

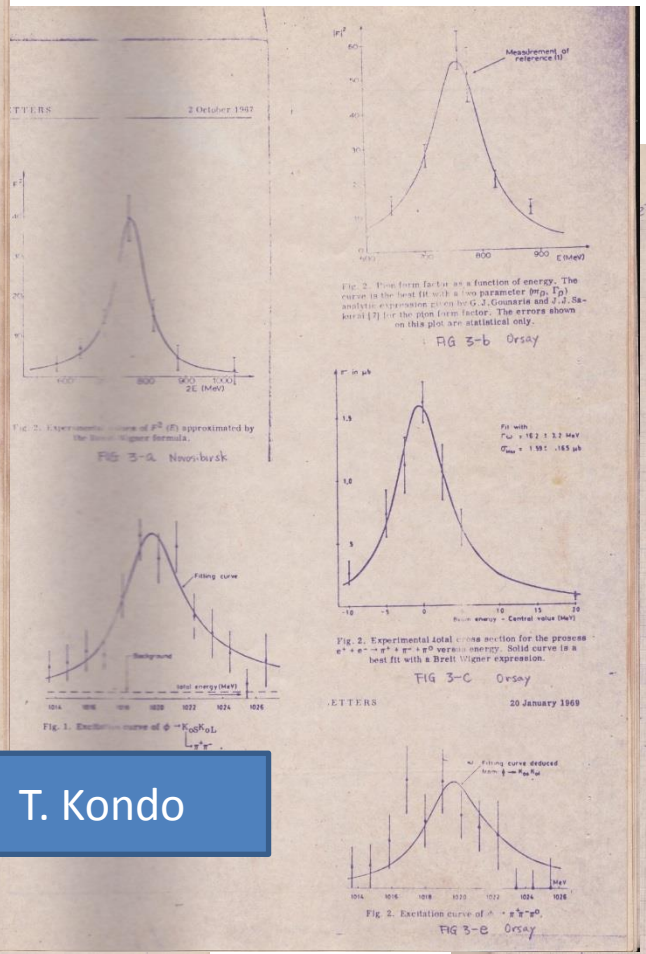
ビーム衝突装置の開発:**Stanford＆Novosibirsk**
高エネルギー反応実現への有効手段。
初めはe-e-で主にQED検証。
のちにFrascatti ,Orsayでe+e-: vector meson

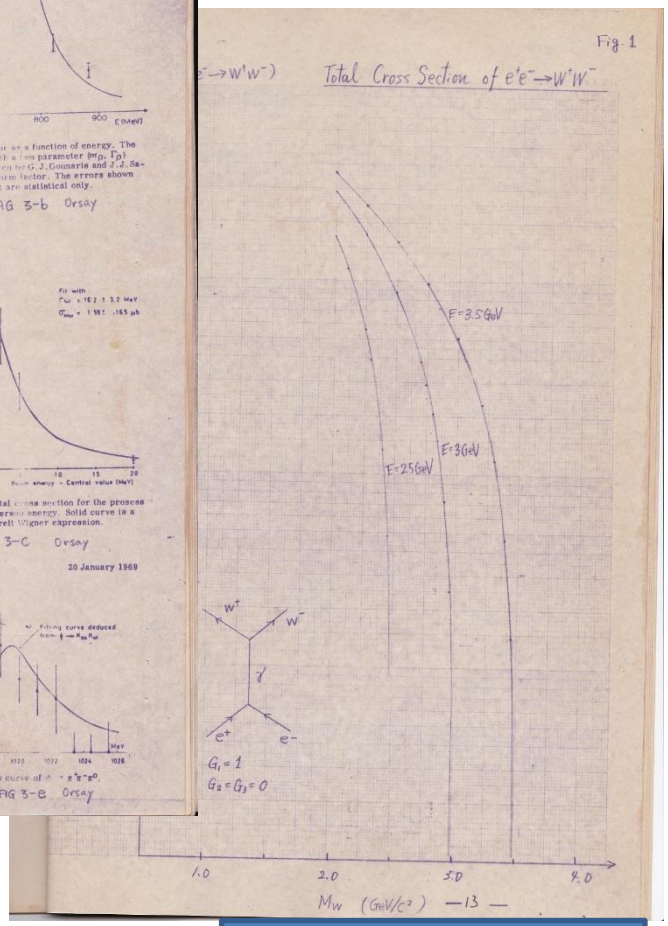


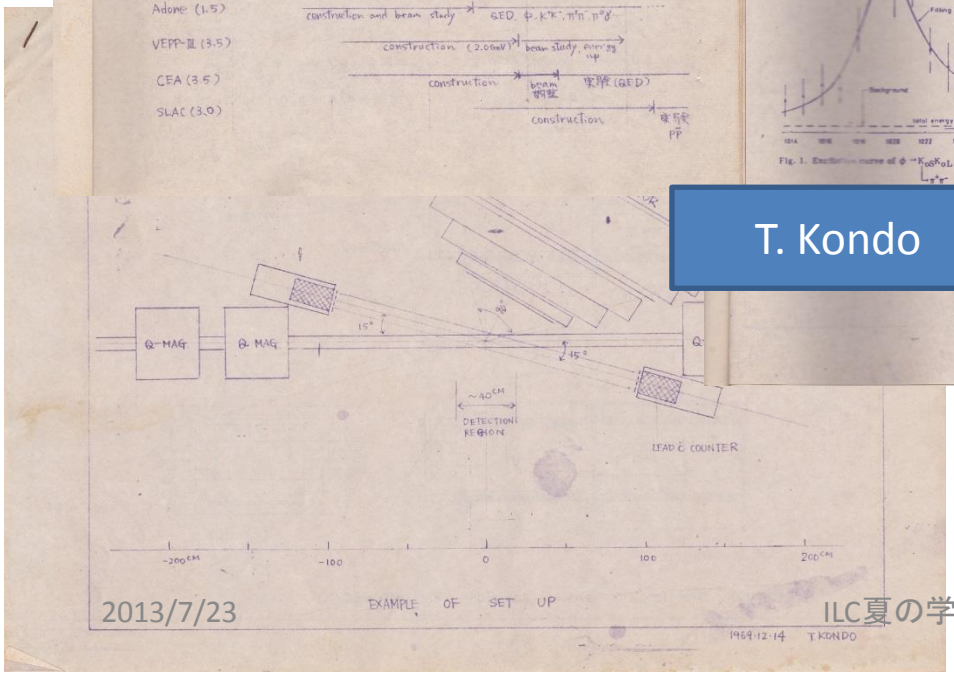
4年間の準備研究で5名がシベリアへ
(本間 / 富家&藤井 / 梶浦 / 山田)
ソ連政府の許可が出ず、Budkerの健康も問題
→ 断念。

当時の勉強の資料





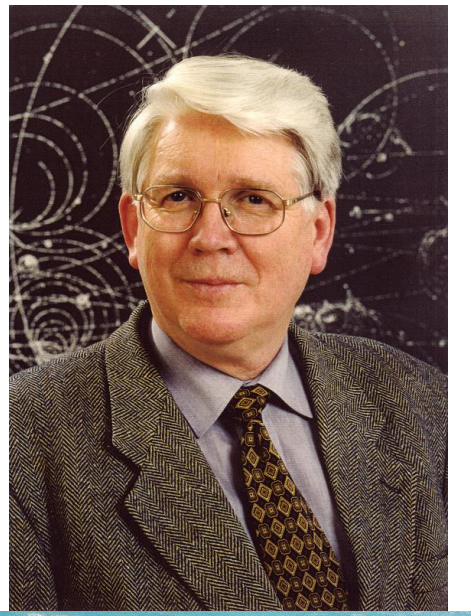




T. Kondo

T.Kondo & T.Nozaki

DESY- DORISでの共同研究



1972ー1976年：DASP実験

小柴-Lohrmann (Research Dir.)

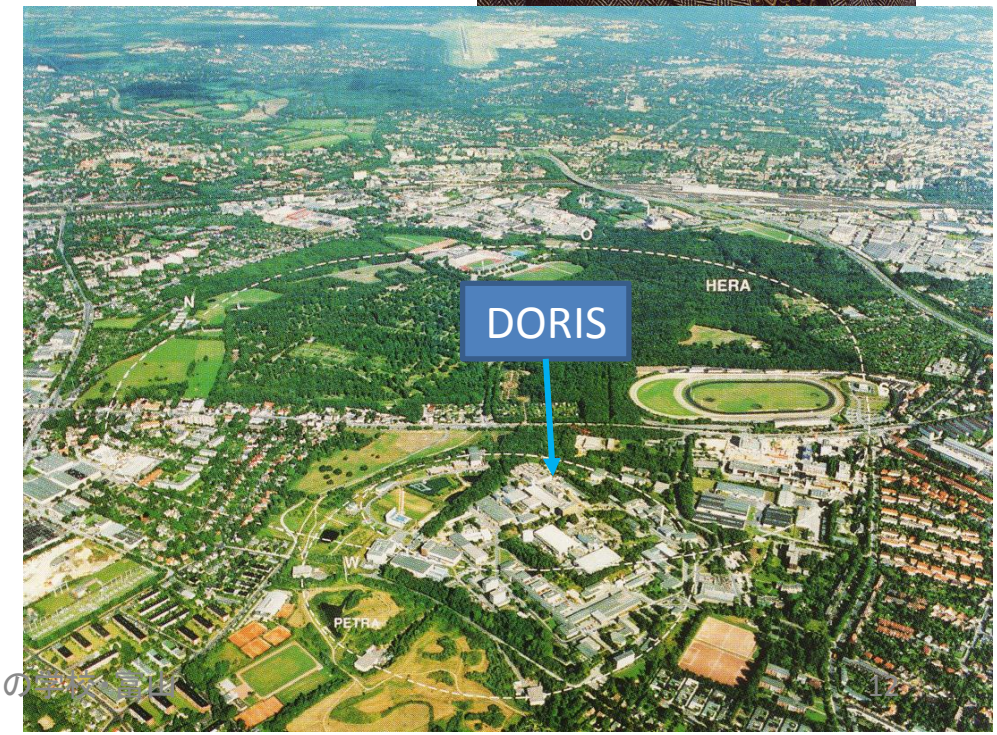
小柴ーW. Paul (chair dir.)

B. Wiik＆G. Wolf の受け入れ

戸塚、山田、須田、折戸　参加

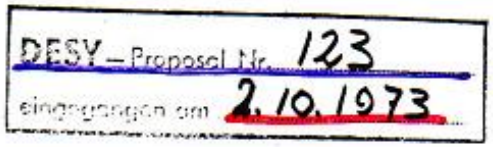
（まったくの無名グループ、

～未経験）



DASP Experiment @DORIS

実験プロポーザル



Vorschlag für ein erstes Experiment mit dem Doppelarmspektrometer: QED-Prozesse und inklusive Hadronerzeugung

W. Braunschweig, Ch. Jordan, D. Schmitz, Sturm, W. Walraff,
I. Physikalisches Institut der RWTH Aachen

Aachen

D. Cords, R. Felst, G. Grindhammer, P. Joos, W. Koch, U. Kötz, H. Krehbiel, D. Kreinick, J. Ludwig, K.-H. Meß, D. Notz, P. Schmüser, G. Vogel, B.H. Wiik, G. Wolf,
Deutsches Elektronen-Synchrotron DESY, Hamburg und II. Institut für Experimentalphysik der Universität Hamburg, Hamburg

DESY+Hamburg II

G. Buschhorn, H. Lierl, R. Kotthaus, H. Oberlack, S. Orito, K. Pretzl, M. Schliwa,
Max-Planck-Institut für Physik und Astrophysik, München

MPI(Muenchen)

Y. Totsuka, S. Yamada,
Universität Tokyo

Tokyo

Sprecher: B.H. Wiik

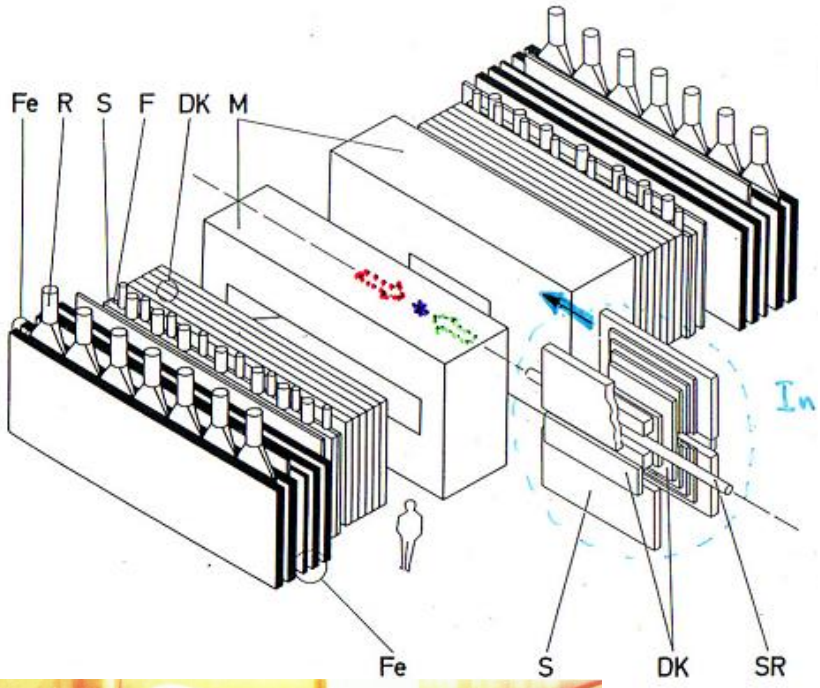
Zusammenfassung

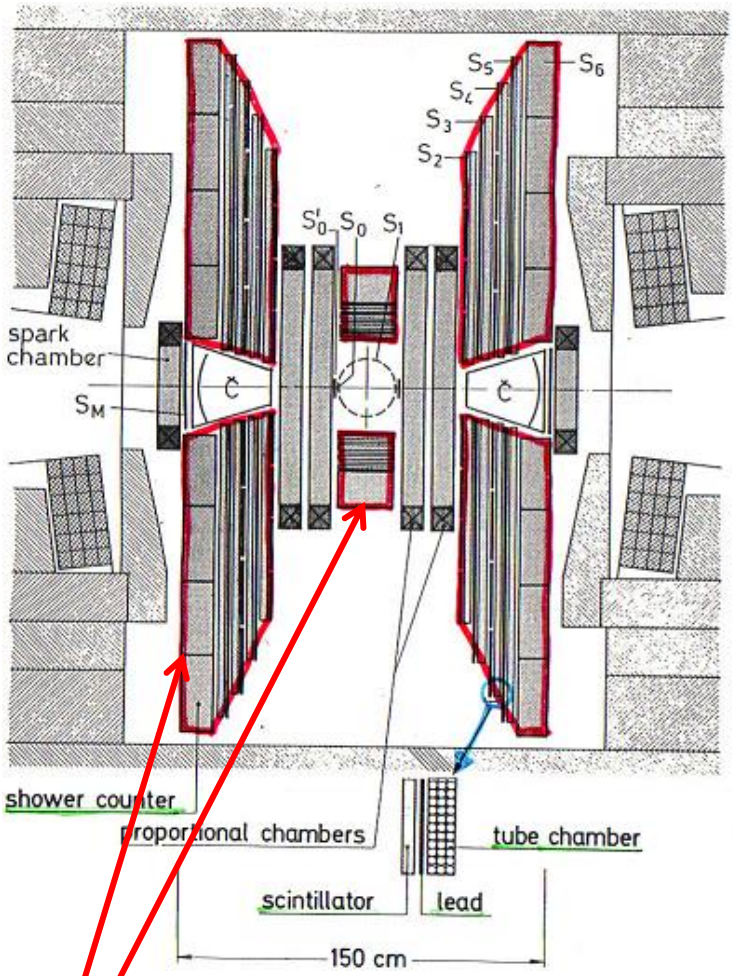
Als erstes Experiment mit DASP wird die Messung der QED-Reaktion $e^+e^- \to e^+e^-$ und $e^+e^- \to \mu^+\mu^-$ bei E = 2 GeV, der inklusiven π und k Erzeugung und des totalen Wirkungsquerschnitts für Hadronerzeugung zwischen 1.5 GeV und der erreichbaren Maximalenergie vorgeschlagen. Hadronischer Untergrund aus Zwei-Photonprozessen soll in einer Kontrollmessung mit e^-e^--Streuung bestimmt werden. Bei einer integrierten Luminosität von $\mathcal{L} = 3 \cdot 10^{37}$ cm^{-2} können etwa $5 \cdot 10^4$ Pionen und einige Tausend geladene Kaonen beobachtet werden. Für Erprobung und Meßzeit werden 9 Monate veranschlagt.

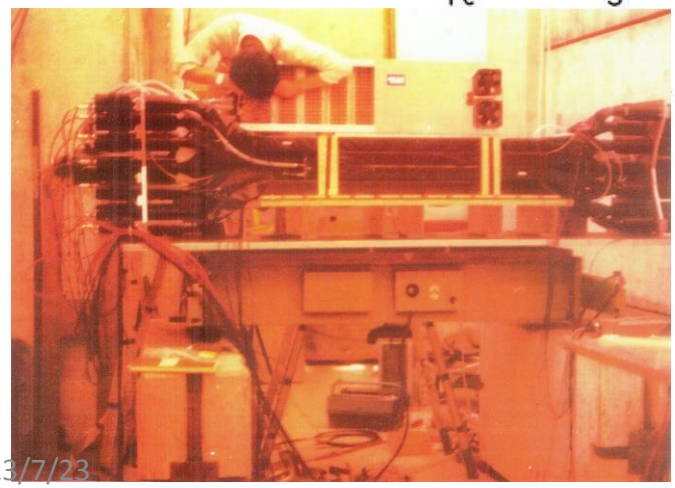
日本の大学が参加した最初の海外での加速器実験。

国際共同実験と言っても、実情は「ドイツのグループに入れてもらった。」と言う方が正確。

DASP detector

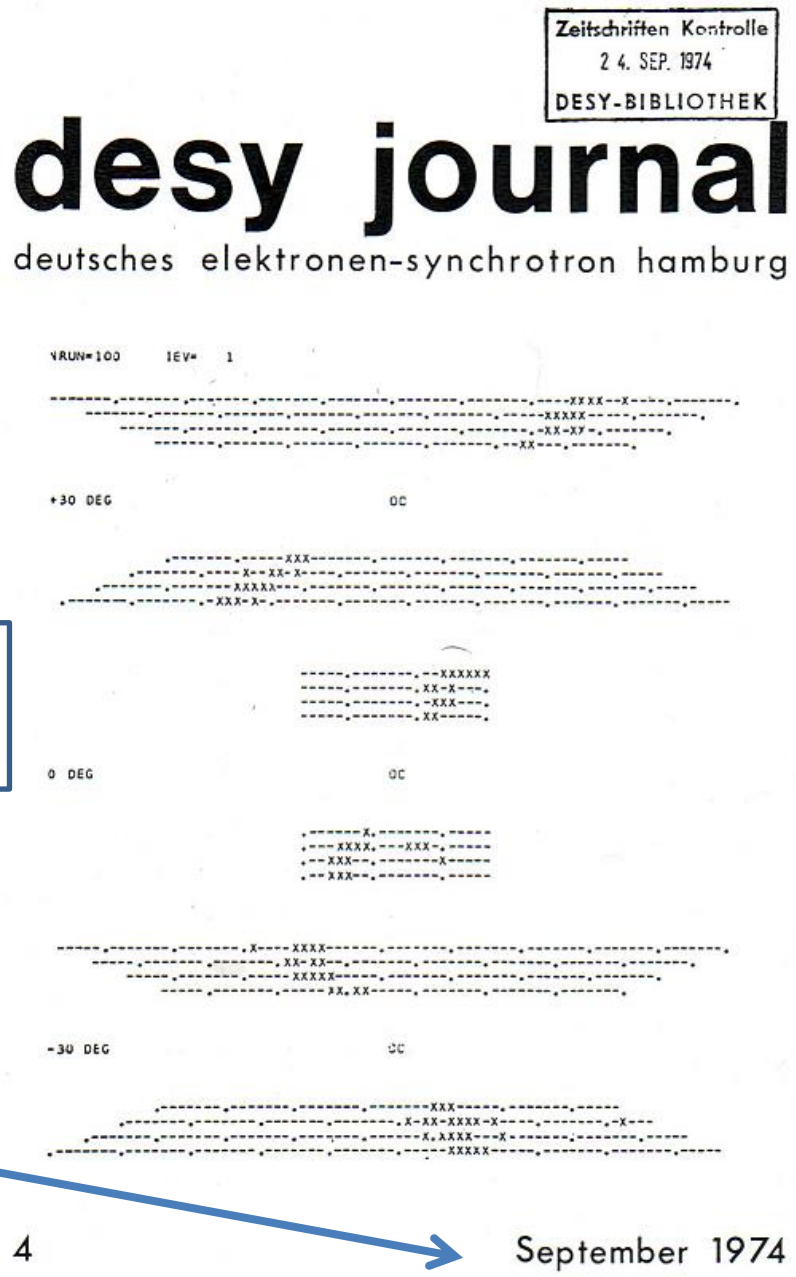






Tokyo members worked on the inner detector: (P. Schmueser, J. Ludwig) (scintillater hodoscope +shower counter+ prop.tube chamber)

The first Bhabha scattering observed at DORIS (W=4GeV) made a cover-picture of DESY journal September 1974.



event display
PDP8のテレタイプで印刷した

The U/O detector became ready for data.

11 or 12. Nov. 1974

Experimentierschichten

√s 4 → 3.1 GeV

Mittwoch 13.11. 23^{00} - Freitag 15.11. 15^{00}
Samstag 16.11. 15^{00} - Dienstag 19.11. 7^{00}

In den ersten 5 Schichten soll der Detektor überprüft und ein guter Außentrigger aufgestellt werden. Während des Shutdowns sollen Tests mit der kosmischen Strahlung durchgeführt werden. In den letzten 8 Schichten soll nach dem Teilchen ϕ_c bei 2E = 3.1 GeV gesucht werden. Das Programm hierfür soll am Samstag aufgestellt werden.

Programm

Mittwoch - Freitag

I. Außentrigger zum Laufen bringen. Mi 23^{00} - Do 3^{00}
II. Propkammem testen. Do 3^{00} - Do 12^{00}
III. Untergrund studieren mit dem Außendetektor. Do 12^{00} - Do 20^{00}
IV. Innendetektor überprüfen) Do 20^{00} - Fr 15^{00}
V. Außentrigger und Innentrigger aufbauen)
Soviel wie möglich von der Torseite in Betrieb nehmen.

I. Magnet auf 300 Amp. E = 1.55 GeV $I_{e^-} \approx$ 20m Amp.
Timing zwischen OS1 · OSS · OSM mit Lichtdioden setzen.
OS1 · OSS · OSM gegen ΣFH · ΣSH timen. Dann versuchen, die Schwelle für minimal ionisierende Teilchen in OSS_k zu bestimmen.

i.e. $\frac{OS1 \cdot OSS_k \cdot OSM \cdot \Sigma FH \Sigma SH}{OS1\ OSM \cdot \Sigma FH\ \Sigma SH}$ als Funktion der H.V.

bei vorgegebener Diskriminatorschwelle.
Das gleiche für OS1 und OSM wiederholen.
Nachdem die Verstärkung gut ist, scharfes Timing zwischen OSS, OS1 und OSM verlangen. ≈ 10 nsec.
Timing zwischen Innen- und Außenzähler überprüfen mit einer Delaykurve.
Breite der Koinzidenz etwa 50 nsec.

November 11, 1974

- **The discovery of a new sharp resonance at 3.1 GeV changed the entire experiment program.**

New shift plan following the news (DASP group note on 11 or 12, November, 1974)

This was the start of very exciting and productive time.

これで歴史が変わった！
物理の歴史、東京グループの歴史も。

The first paper from DASP

Volume 53B, number 4 PHYSICS LETTERS 23 December 1974

A MEASUREMENT OF LARGE ANGLE e^+e^- SCATTERING AT THE 3100 MeV RESONANCE

DASP – Collaboration

W. BRAUNSCHWEIG, C.L. JORDAN, U. MARTYN, H.G. SANDER
D. SCHMITZ, W. STURM, W. WALLRAFF
I. Physikalisches Institut der RWTH Aachen

K. BERKELMAN*, D. CORDS, R. FELST, E. GADERMANN, G. GRINDHAMMER,
H. HULTSCHIG, P. JOOS, W. KOCH, U. KÖTZ, H. KREHBIEL, D. KREINICK, J. LUDWIG,
K.-H. MESS, K.C. MOFFEITT, D. NOTZ**, G. POELZ, K. SAUERBERG, P. SCHMÜSER,
G. VOGEL, B.H. WIIK, G. WOLF
Deutsches Elektronen-Synchrotron DESY and II. Institut für Experimentalphysik der Universität Hamburg, Hamburg

G. BUSCHHORN, R. KOTTHAUS, U.E. KRUSE**, H. LIERL, H. OBERLACK,
S. ORITO, K. PRETZL, M. SCHLIWA
Max-Planck-Institut für Physik und Astrophysik, München

T. SUDA, Y. TOTSUKA and S. YAMADA
University of Tokyo, Tokyo

Received 19 December 1974

Elastic e^+e^- scattering has been measured at total energies covering the newly found resonance at 3100 MeV. The angular distribution is consistent with spin-parity 1^-, and the cross section integrated over energy yields $\Gamma_{ee}^2/\Gamma_{tot} = 0.23 \pm 0.05$ keV for the resonance.

The new 3100 MeV resonances [1] has been studied in the reaction $e^+e^- \to e^+e^-$ at the DESY colliding beam facility DORIS using a non-magnetic spectrometer. The rings were normally filled every 6 hours, and the luminosity averaged over one fill was about $2 \times 10^{29} cm^{-2}$. The luminosity was monitored by observing the rate of small angle Bhabha scattering using a set of four counter telescopes located in the horizontal plane symmetrically with respect to the interaction point. Each telescope consists of three scintillation counters and one shower counter. The scintillation counters define the direction of the scattered electron or positron, and the shower counter measures its energy. A Bhabha event is defined as a coincidence between two such telescopes located on opposite sides of the beam pipe at a mean scattering angle of 8°. With the threshold of the shower counter set at 500 MeV the accidental rate is negligible. For this experiment the luminosity monitor was used as a relative monitor only.

The apparatus shown in fig. 1 is a part of the Double Arm Spectrometer (DASP) and consists of two identical detectors mounted above and below the beams. Events were accepted for θ between 40° and 140° in a total solid angle of 1.2 sterad. The basic unit of this detector is made of a scintillation counter hodoscope, a sheet of lead 5 mm thick, and a proportional tube chamber [2]. Each chamber (see insert of fig. 1) has three layers of brass tubes, 10 mm in diameter and with 0.25 mm wall thickness, oriented at 0° and ±30° with respect to the beam axis. The efficiency for detecting one charged particle is 95% per plane, a value consistent with the geometric efficiency. Each of the scattered particles passes through a layer of scintillation counters surrounding the beam pipe, then through four of the units just described and finally

* On leave from Cornell University, Ithaca, N.Y.
** Now at CERN, Geneva.
*** On leave from the University of Illinois, Urbana, Illinois.

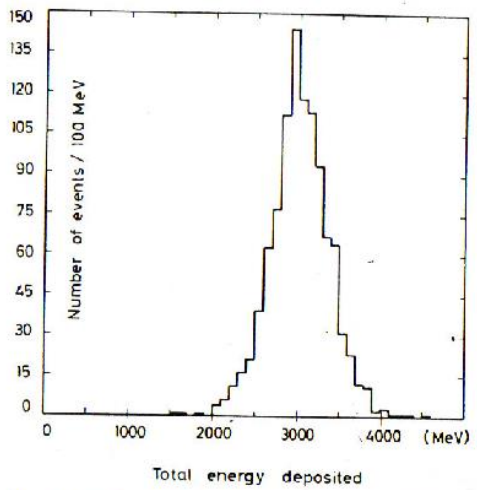


Fig. 2. Spectrum of total shower pulse height for accepted events. The minimum pulse height required was 1400 MeV.

5 weeks to submit from the data taking

フラスカッチより先！

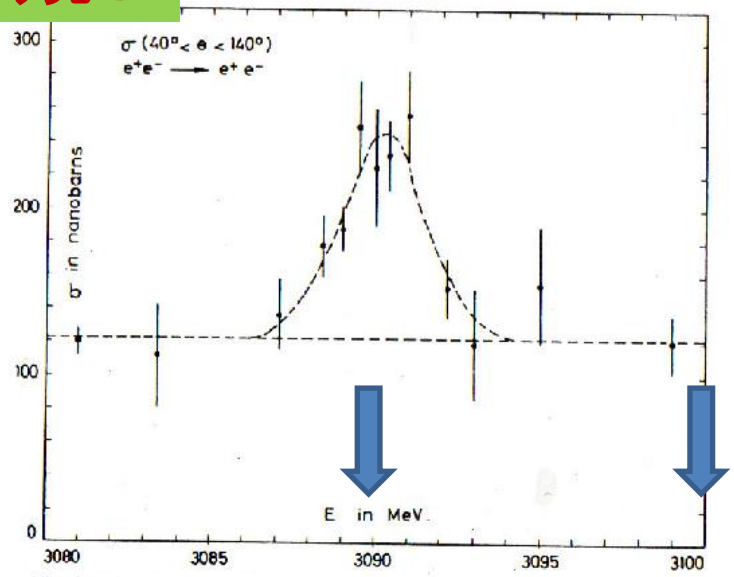


Fig. 3. The observed e^+e^- scattering cross section for $40° < \theta < 140°$ plotted against the total energy. The dashed lines show the best fit Gaussian plus nonresonant background.

新らしい物理の展開
SPEAR ＆ DORIS

- “クォーク”の確立：

  ４番目のcが、予言通りにあった。

  それまでに知られていたu，d，sも、同様に存在。

  R：クォーク模型と整合

  チャームの弱崩壊　Cabibbo結合

  (電子へのセミレプトニック崩壊）

- Sphericityの減少：
- Tauの発見

電子・陽電子衝突実験の有効性が世界に浸透

JADE experiment

1976

DORIS の後DESY は PETRAを建設.

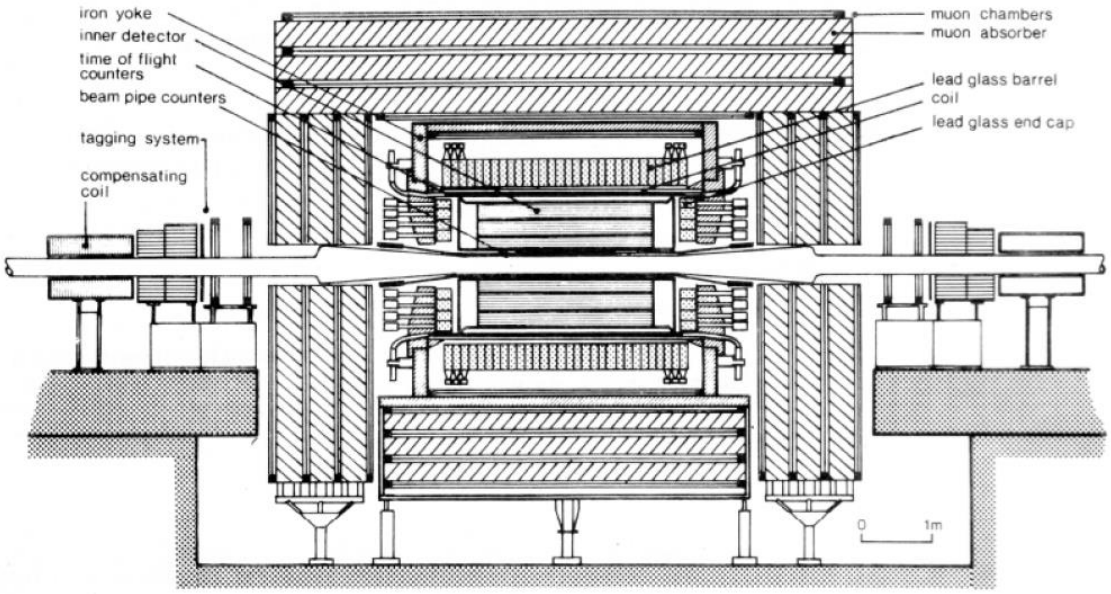
日本チームはJADEグループ発足の核に。

大学院生も参加。

(旅費の問題：助手、DAAD etc.)

小林、駒宮、佐藤、柳沢、野崎、川越、神崎、尾高、真下

スタッフ強化： 井森、武田、蓑輪、川本、竹下



J A D E

Proposal for a Compact Magnetic Detector at PETRA

D.P. Barber, J. Dainton, and R. Marshall
Daresbury Laboratory

W. Bartel, Th. Canzler, D. Cords, P. Dittmann, R. Felst, E. Gadermann*, M. Helm*, H. Krehbiel, J. Olsson, L.H. O'Neill, A. Petersen*, D. Pandoulas, M. Schädlich*, and P. Steffen
DESY, Hamburg

P. Brauel*, G. Grindhammer, W.D. Kollmann, and K. Sauerberg*
II. Institut für Experimentalphysik der Universität Hamburg

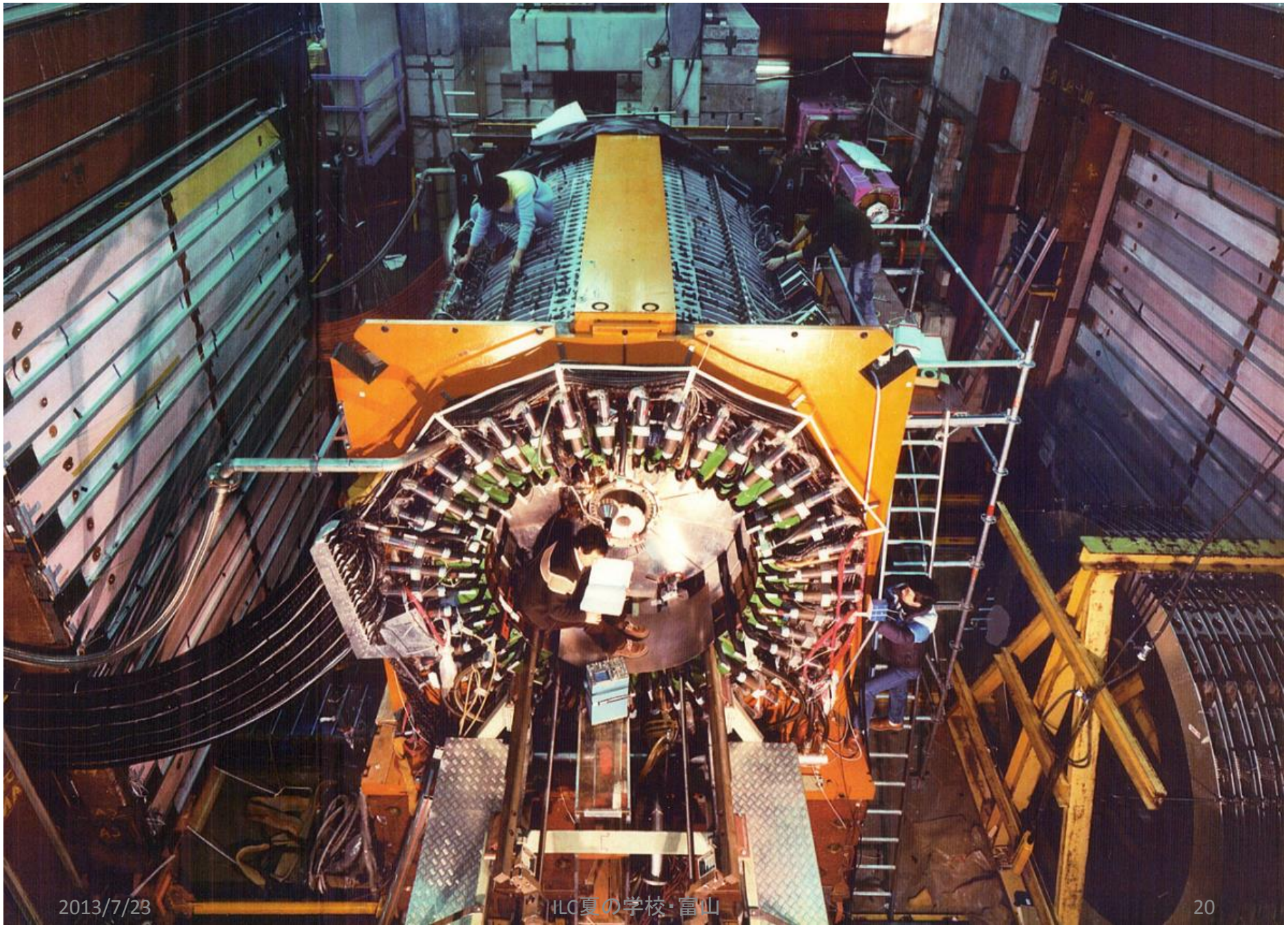
W. Farr, B. Granz, J. Heintze, G. Heinzelmann, R.D. Heuer*, P. Lennert, H. Rieseberg, A. Wagner, and A.H. Walenta
Physikalisches Institut der Universität Heidelberg

D. Darvill, F. Foster, and G. Hughes
Physics Department, University of Lancaster

J. Allison, B. Dickinson, F.K. Loebinger, P.G. Murphy, and K. Stephens
Physics Department, University of Manchester

N. Imori, T. Kobayashi*, S. Komamiya*, M. Koshiba, S. Orito, A. Sato*, T. Suda, Y. Totsuka, S. Yamada, and C. Yanagisawa*
High Energy Physics Laboratory and Department of Physics, University of Tokyo

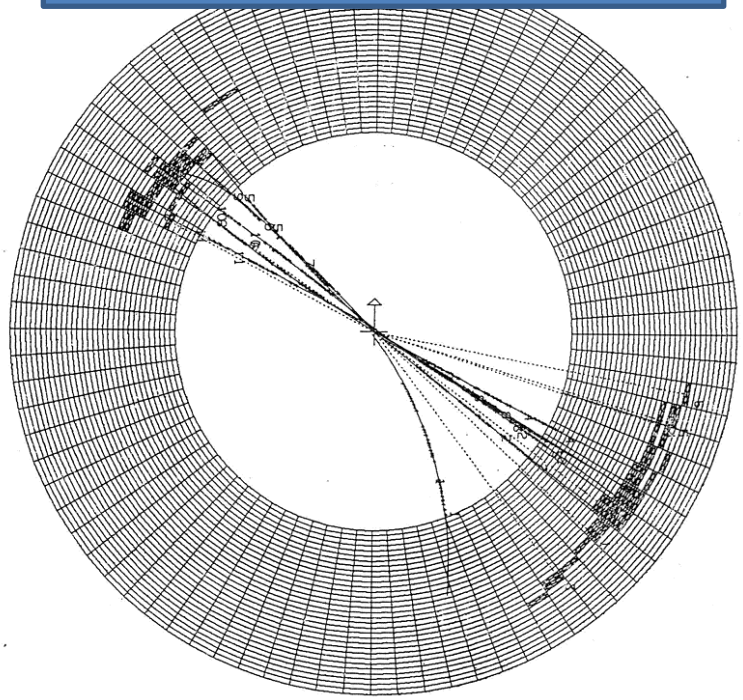
*graduate student



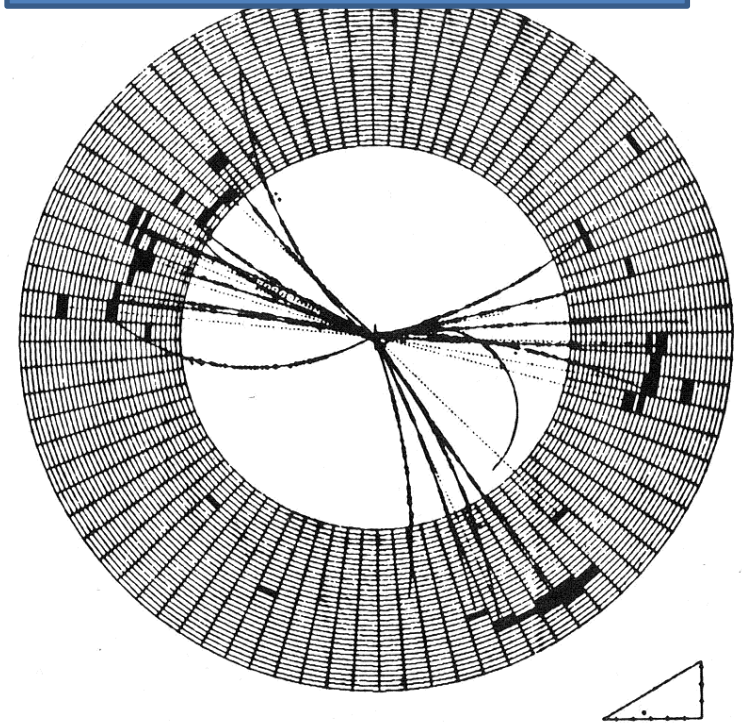
Observation of clear hadron jets and gluon get

α_s measurement

$e^+e^- \rightarrow q^+q^- \rightarrow 2$ jets



$e^+e^- \rightarrow q^+q^-g \rightarrow 3$ jets



Gamma-Z interference in mu+mu- F/B asymmetry
New particle searches

HEP日米協力がスタート　1979年

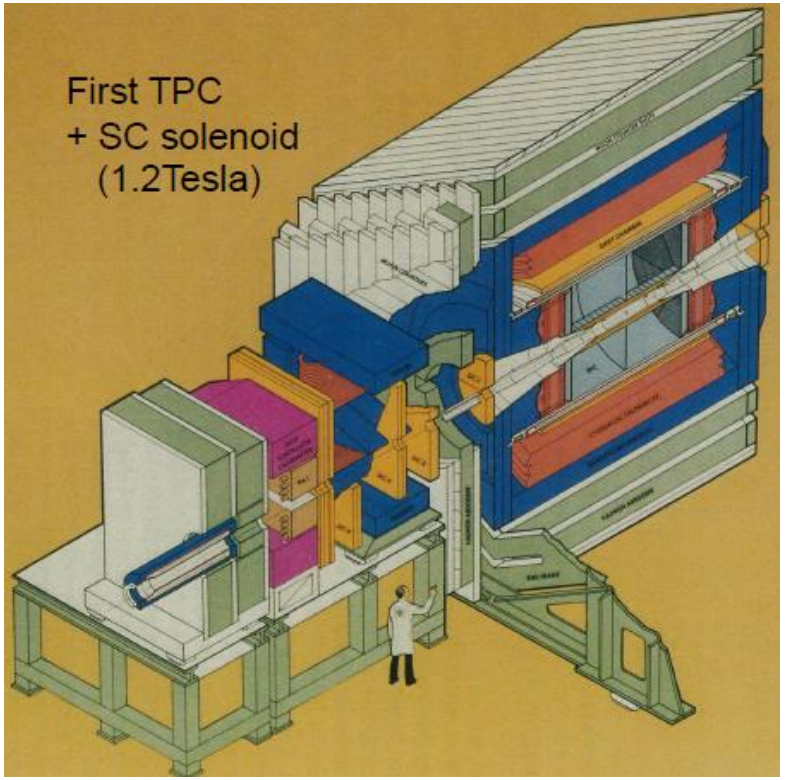
SLACのPEPのPEP4-TPC実験に東大藤井・釜江研＋核研が参加

（1976～、ほぼJADEに並行）

スタッフ（千葉、藤井啓）のほか

大学院生の参加

相原、峠、山内、丸山、高橋、榎本



個人レベルで、電子・陽電子実験にポスドクとして参加した人も多い。

岩崎、野崎（忠）、川端、窪田、片山、松井、福島、福永、・・・

我が国でのTRISTAN建設（1981～6）

- 1986年稼働
  一時期は世界の最高エネルギー　63GeV
- AMY, TOPAZ, VENUS の3実験
  このうちAMYは国際共同実験
    海外からアメリカ、中国、韓国、台湾の
    チーム　（KEKはhost経験）

経験者の参加と、加速器を含む多くの人材の育成
  衝突型加速器とさまざまの測定器技術の体得。
  (ex: 超伝導加速空洞, ビームダイナミクス）

TRISTAN　2期計画としてのKEKーB　(ep計画は破棄）
  世界最高Luminosity

並行して、JLCのR＆Dを進めた。
  JLC（x-band），ATF(当初は日米協力）、測定器開発

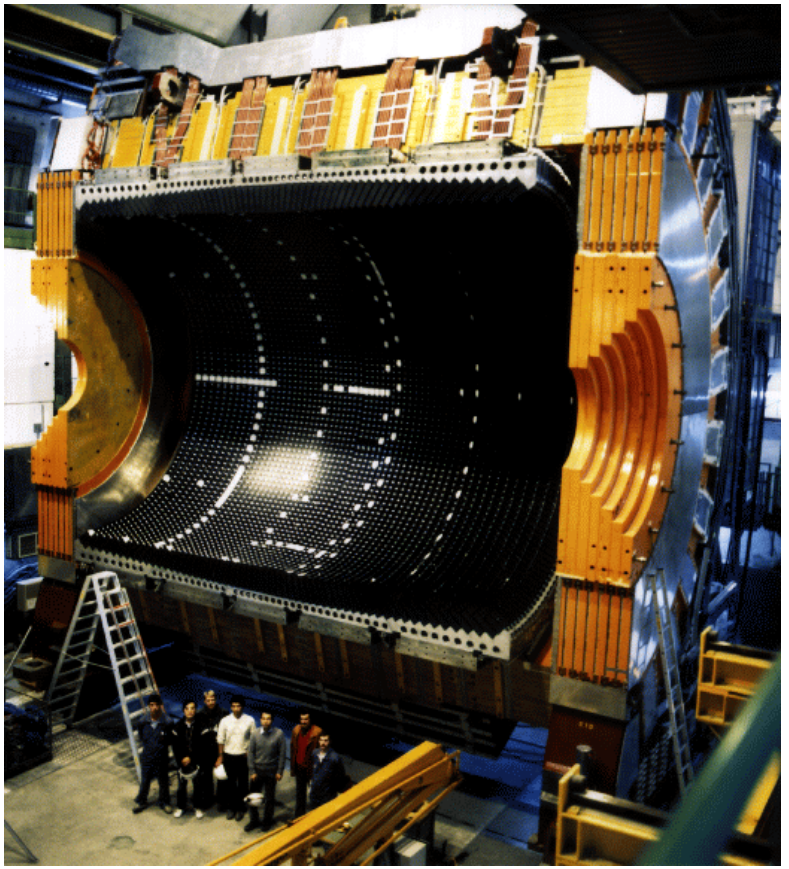
その後、国外では

- LEP、LEP-II　@CERN

OPAL実験に
JADEの経験者が多数と院生

- SLC @SLAC

posdocとしての参加者



EW　&　QCD　の精密測定、
Higgs 粒子の質量予測

まとめ

- 日本にも
  e+e-研究に40年余の実績
- 多くは国際共同研究の場でなされた。
- TRISTANは一時最高エネルギー
- KEK-Bは最高luminosity
- こうした実績に沿って、ILCに大きな役割を果たすのは自然の動向、意義もある。

個人的感想：
e+e-に深くかかわって良かった。

- *本当の素粒子研究*
- *国際的な研究環境*
- *ILCへの関与も*

Synchrotron proposals spark high-energy debate in Japan

Tokyo. A proposal by Tokyo University's Institute for Nuclear Study (INS) to build a powerful 50-GeV proton synchrotron has split Japan's high-energy physics community. While some leading high-energy physicists support the proposed facility, others fear that it could undermine their plans to build the world's next giant linear collider.

The synchrotron would be a key facility at a planned new complex of three national research institutes in Tsukuba science city, north-east of Tokyo. The three institutes — for high-energy physics, nuclear studies and synchrotron research — are expected to be set up in 1997 through reorganization of the National Laboratory for High Energy Physics (KEK) in Tsukuba, and the relocation of INS and its conversion to a national research institute, like KEK.

The proposed Japan Linear Collider (JLC) would consist of two linear accelerators (linacs), with a combined length of 25 km, for colliding beams of electrons and positrons, each with energies of 150–250 GeV (see *Nature* **370**, 169; 1994). Considerable research and development on the JLC has already been carried out at KEK.

The synchrotron proposal caught the high-energy physics community by surprise when it was announced by INS about two months ago, setting off a surge of protest by electronic mail. The idea was not entirely

it is "all the same tax" that pays for such facilities and the public "will probably ask why scientists need two such machines". But Yamada points out that, compared to high-energy physics, both nuclear and solid-state physics have received little government funding in recent years. He points out that the proposed synchrotron facility could be used by solid-state physicists and biologists as well as nuclear and high-energy physicists.

Apart from competition for funding within the physics community, a long-standing rivalry between the Ministry of Education, Science and Culture (Monbusho), which funds both INS and KEK, and the Science and Technology Agency (STA), has helped to launch the INS proposal. Ten years ago, the STA upset both Monbusho and the ministry's synchrotron researchers by deciding to build the world's largest electron synchrotron, the 8-GeV SPring-8, which will be completed in a few years time in Nishi Harima, west of Osaka. In the process the STA "took some power away" from Monbusho, says one physicist at Tokyo University, and the education ministry is now seeking to regain its position with the INS proposal.

The STA is planning to build a very high-powered 1.5-GeV proton linac as a neutron source and has the ultimate goal of using the proton beam to dispose of nuclear waste. Some efforts were made by researchers to

Nature (Vol 376): August 10, 1995