Heavy Ion Collisions in a historical Perspective 1960 - 1985

Rudolf Bock

The Cradle of Heavy Ion Physics in Germany:
MPI für Kernphysik in Heidelberg

My PhD Students at the MPI in the 60's

Research of my group at MPI-Heidelberg in two Areas:

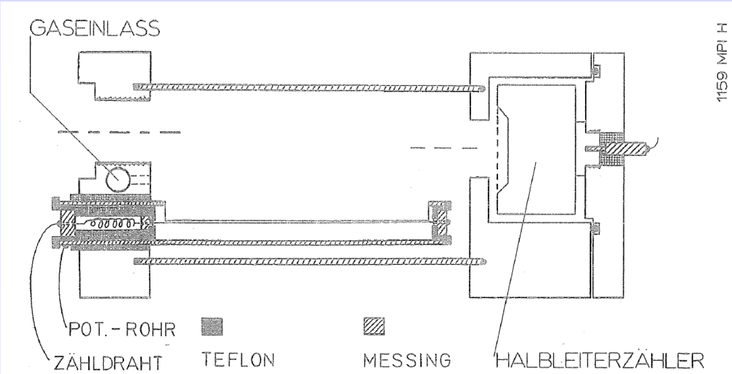
1. Nuclear Spectroscopy by Nuclear Reactions (with p, d, ^{3}He)
   Working horse: Browne-Buechner Spectrograph

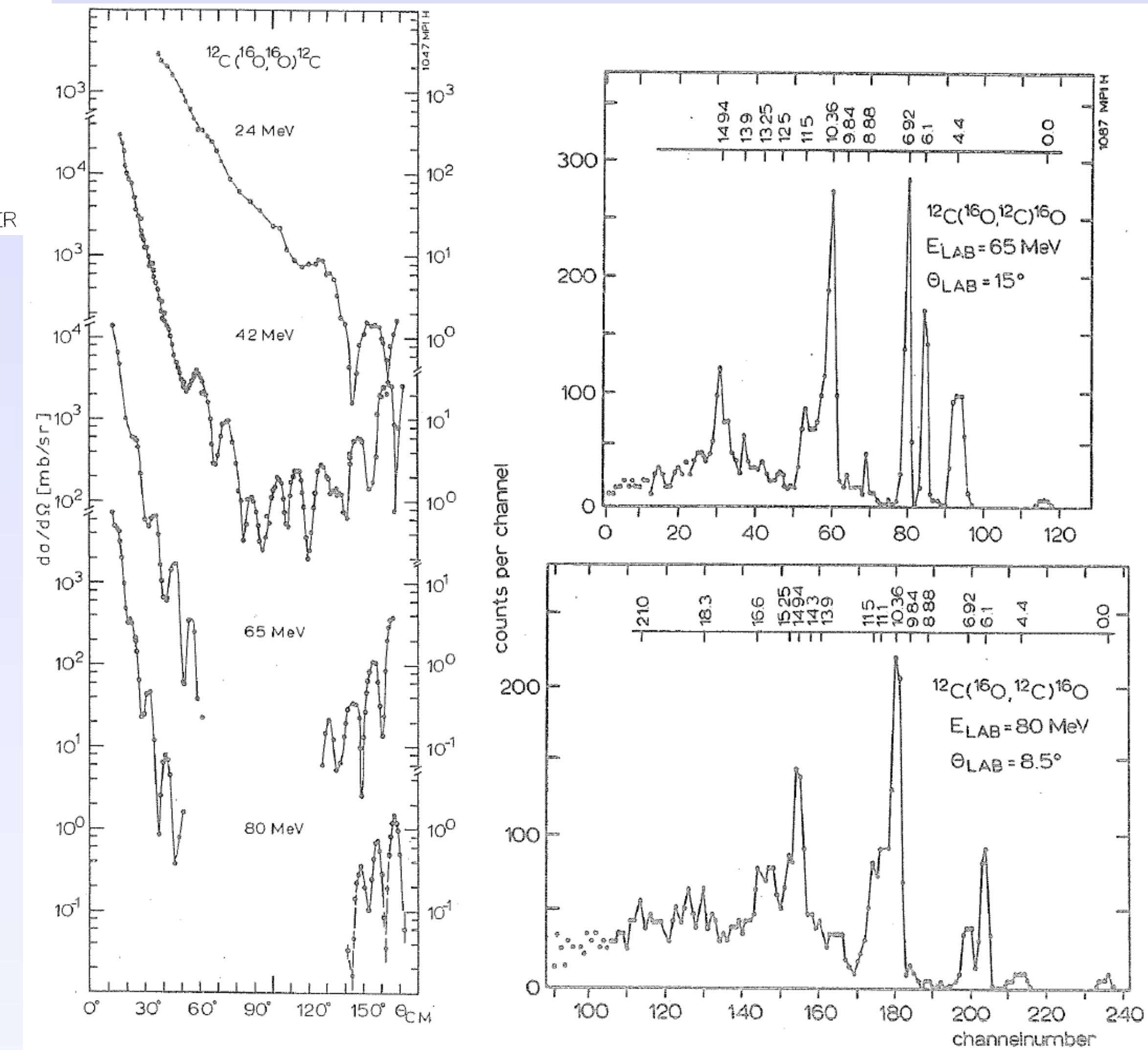
2. Nuclear Reactions with Heavy Ions (^{11}B, ^{12}C, ^{16}O, ^{19}F, ...)
   Working horse: ΔE/E-telescope

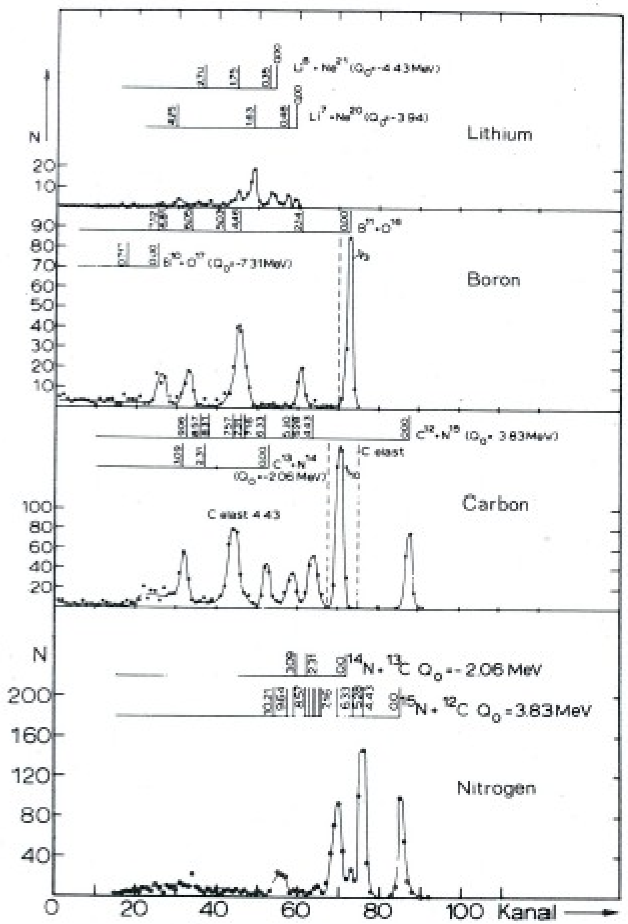
Some of my early Heidelberg PhD Students

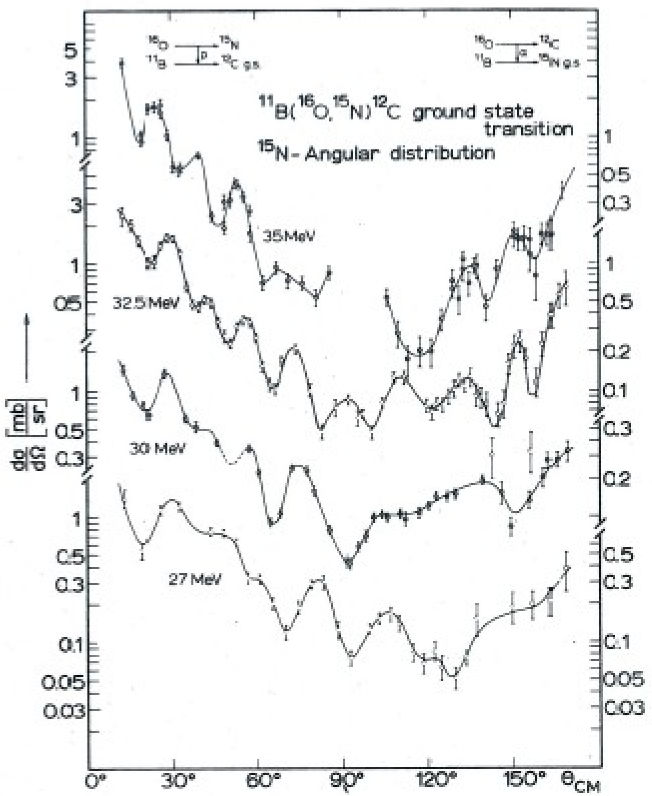
1962 – 67		1968 – 73	
Light Ions			
Hans H. Duhm	(1965)	Peter David	
Reinhard Stock	(1966)	Siegfried Martin	(1973)
Falk Pühlhofer	(1967)	Klaus Hildenbrand	(1973)
Uli Lynen	(1967)	S. Betigeri	
Heavy Ions			
Reinhardt Rüdel	(1965)	Hans Gutbrod	(1970)
Wolfr. v. Oertzen	(1967)	Ursula Voos	(1970)
M. Große-Schulte	(1967)	Konrad Gelbke	(1972)

Nuclear Spectroscopy: Detector and Results






Lithium
Boron
Carbon
Nitrogen
C elast 4.43
C elast
Kanal
$^{14}N + ^{13}C$ $Q_0 = -2.06$ MeV
$^{15}N + ^{12}C$ $Q_0 = 3.83$ MeV


$^{11}B(^{16}O,^{15}N)^{12}C$ ground state transition
^{15}N- Angular distribution
35 MeV
32.5 MeV
30 MeV
27 MeV
$\frac{d\sigma}{d\Omega}\left[\frac{mb}{sr}\right]$
θ_{CM}

Exchange effects in H.I.transfer reactions: B on O

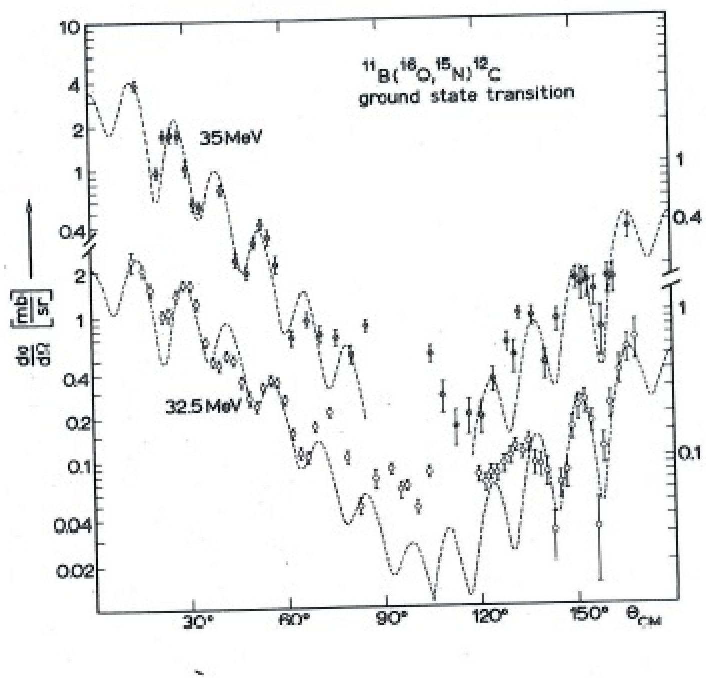


Fig. 4 Fits of the 35 and 32.5 MeV data by Dar's diffraction theory.

Vier Nukleonen-Transfer

An Kernen der p- und sd-Schale

INAUGURAL - DISSERTATION

zur

Erlangung der Doktorwürde

der

Naturwissenschaftlichen Gesamtfakultät

der

Ruprecht - Karl - Universität

Heidelberg

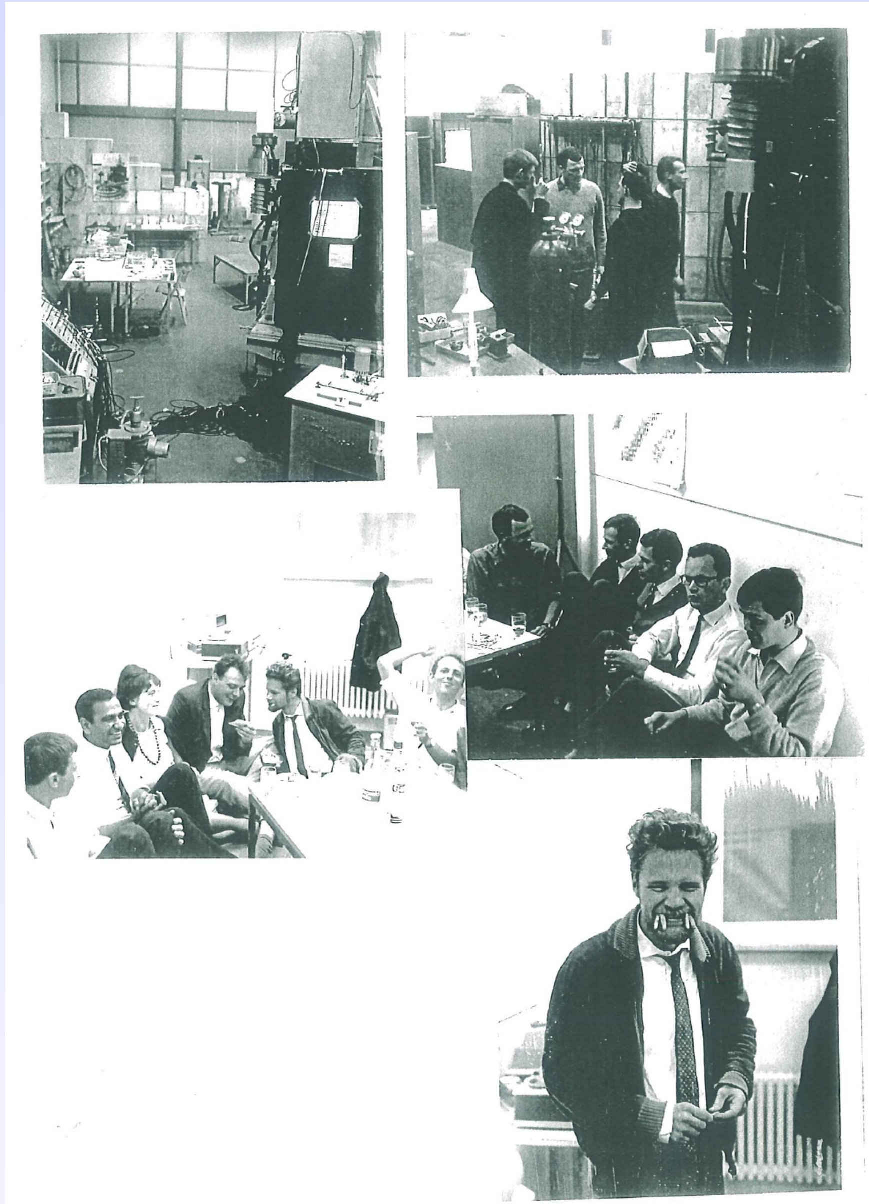
vorgelegt von

Diplom-Physiker Hans Herbert Gutbrod

Stuttgart

1970

Referent : Prof.Dr.Rudolf Bock
Korreferent : Prof.Dr.Wolfgang Gentner



International Heavy Ion Conference, MPI Heidelberg 1969

Initiative for a Center of Heavy Ion Research by the KAH in Hessen (1966 – 1969)

M E M O R A N D U M

zur Errichtung des Schwerionenbeschleunigers "UNILAC"

im Land Hessen

Kernphysikalische Arbeitsgemeinschaft Hessen

Juli 1968

Darmstädter Tageblatt vom 11.August 1969

Schwerionenbeschleuniger kostet 75 Millionen DM

Land hat Gelände erworben / Großprojekt für die Forschung / Voraussetzung für Arbeitsaufnahme

(lh) Die Vorbereitungsarbeiten für die Errichtung eines Schwerionenbeschleunigers durch den Bund und das Land will Hessen jetzt intensivieren, nachdem der Bund sich endgültig für einen Standort bei Darmstadt entschieden hat.

Wie das hessische Finanzministerium am Freitag in Wiesbaden mitteilte, hat das Land für einen Kaufpreis von 1,5 Millionen Mark ein bereits bebautes Industriegelände in unmittelbarer Nähe der künftigen Forschungsanlagen erworben und damit die Voraussetzung für die vorläufige Arbeitsaufnahme geschaffen.

Mit diesem Ankauf sei es gelungen, die sofortige Errichtung von Neubauten zu vermeiden und dadurch Einsparungen zu erzielen. Für vorbereitende Arbeiten seien zusätzlich zu den Kosten des Grunderwerbs weitere 100 000 Mark bereitgestellt worden.

Hessen hat nach Ansicht eines Sprechers des Ministeriums mit diesen Maßnahmen die ersten Schritte zur Verwirklichung eines Großprojektes der Forschung unternommen, das in Europa einzigartig sein wird. In den neuen Anlagen sollen Schwerionenstrahlen erzeugt werden, die für die Weiterentwicklung der Kernphysik und Kernchemie sowie der Festkörperforschung, Strahlenbiologie und Medizin außerordentlich wichtig sind. Die vom Bund und vom Land aufzubringenden Baukosten werden rund 75 Millionen Mark betragen, teilte das Finanzministerium mit.

Darmstadt

„Siehste, Bubche, so hoch naus macht es Auditorium Maximum von de Hochschul. Da komme fer die Studente ganz viel Hörsäl enei." — „Fer was brauche dann die so viel Klassezimmer, Oba, wo se doch alsfort demonstriern und streike?!"

Goals of GSI Research

Investigation of nuclei at the borderline of their existence
with respect to
mass, proton/neutron ratio, excit.energy, angular momentum
[Super-heavy elements, nuclei far from stability, multiple Coulomb excitation]
Reaction mechanisms

Atomic physics of heavy systems, 1 electron systems

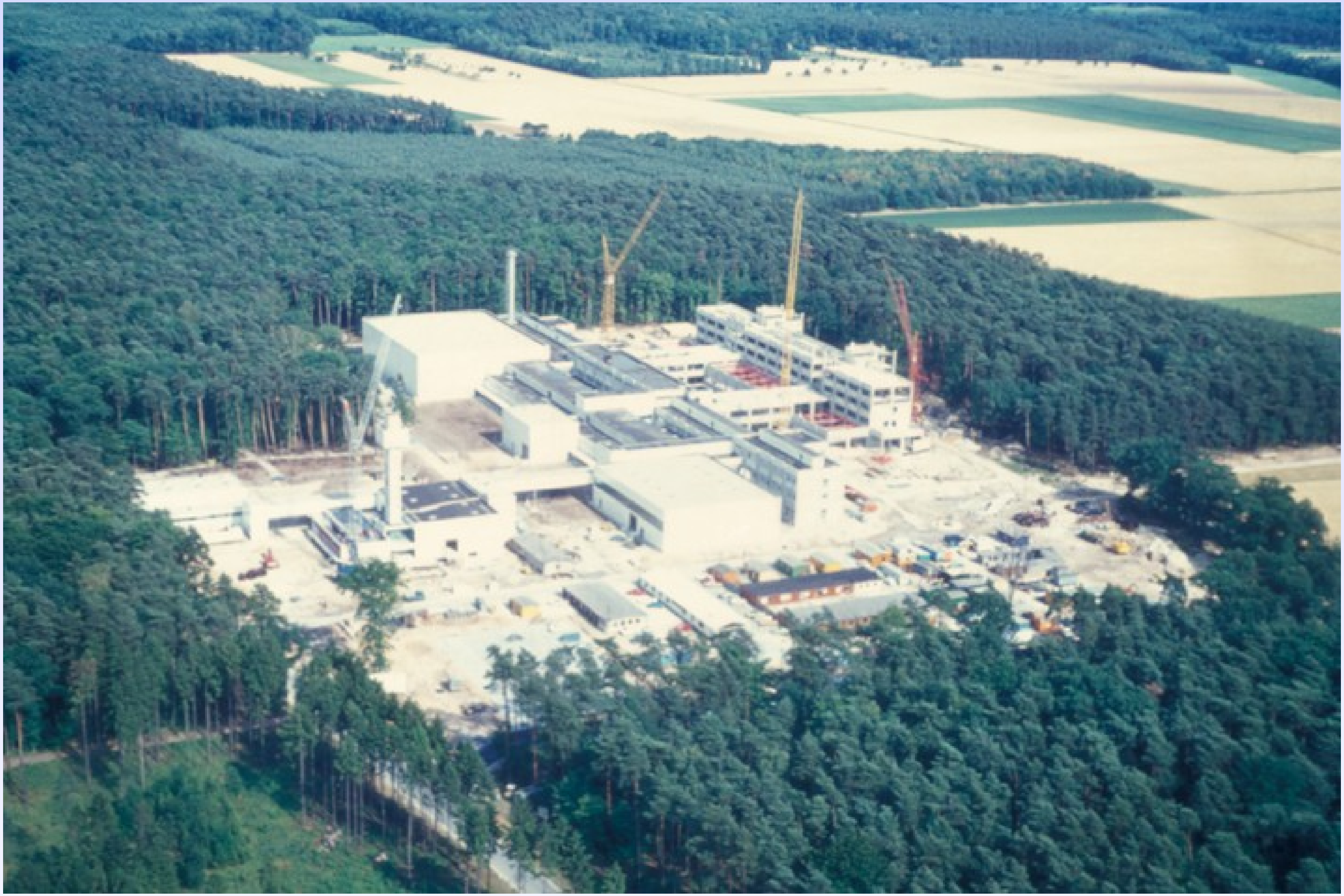
Medical and technological applications

Working Groups from Universities startet 1970
1. Arbeitstreffen at the GSI Barracks 1971

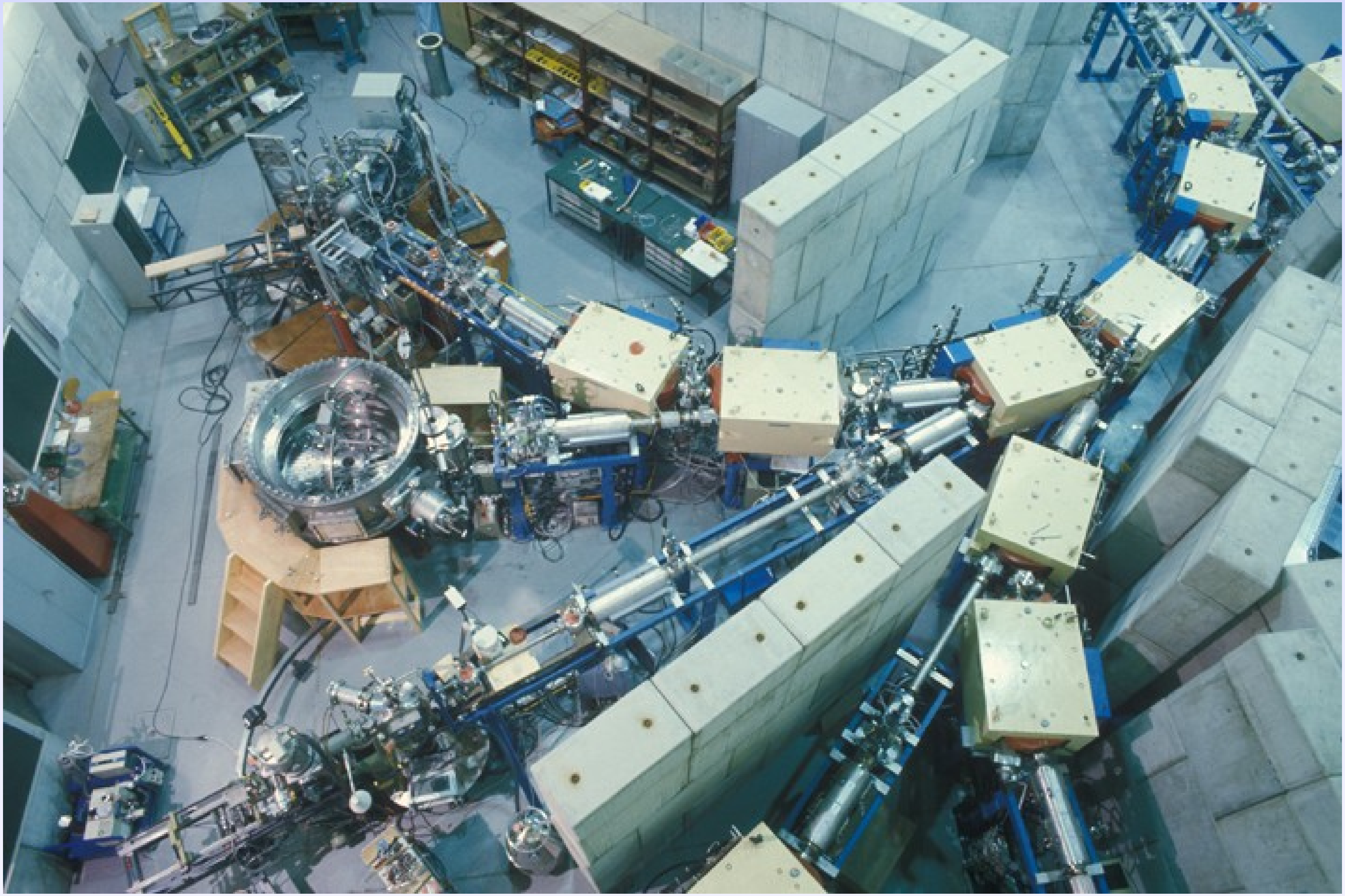
Bau-Besprechung 1971: Wiss. Direktorium mit Architekten


DEMAG
SEHRING

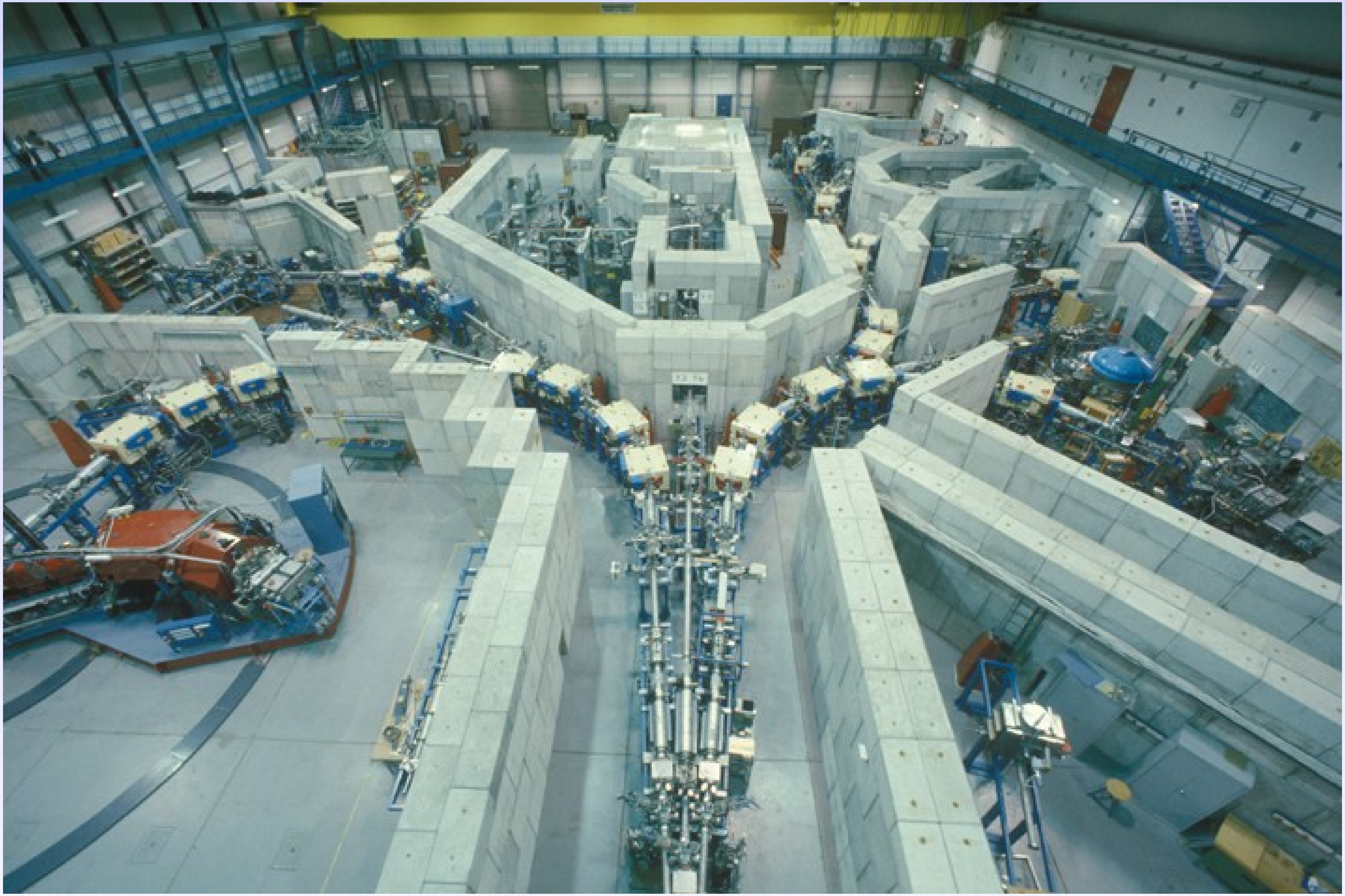

DEMAG
TC 140



UNILAC and Injection Area 1974



GSI Experimental Area 1977



Relativistic Heavy Ions

1974:Heavy Ion Acceleration up to relativistic energies

was achieved by a transfer line between the SuperHILAC and the Bevatron:
The BEVALAC was created in Berkeley (Hermann Grunder)

GSI decided for a participation in such experiments at Berkeley [that was already a year *before* the UNILAC had its first beam!]

Grunder Vortrag bei GSI
Herbst 1976

SUPER HILAC & BEVALAC
STRAHL STRÖME
OKTOBER 1976

ION	S-H (pnA)	BEVALAC (particles/sec)	maximal erwartet
^{12}C	2900	10^9	6×10^9
^{16}O ^{18}O	1700	3×10^8	2×10^9
^{20}Ne	2100	5×10^8	2×10^9
^{40}Ar	1700	2×10^8	5×10^8
^{48}Ca	250	—	
Fe	30	5×10^3	5×10^4
^{84}Kr ^{86}Kr	180	—	
^{132}Xe ^{136}Xe	38	—	

Reactions with Relativistic Heavy Ions (1974)

The official justification of the management of GSI for experiments in Berkeley was the ***future of GSI***, the extensions of our own accelerator facilities. The Berkeley activities were considered as kind of a 'pilot study' for getting experience in this new energy range.

For us, the experimenters, it was the road into a New Territory, a new scientific adventure in an exciting new field of research: the physics of nuclear matter at high density and temperature.
At that time, there were already preliminary experiments on nuclear shock waves (Schopper), at the Penn-Princeton accelerator and already many theoretical activities about the nuclear EoS (Bodmer, Chapline; in our community: Greiner, Müller, Stöcker, Scheid et al.)

Reinhard Stock had first contacts to this community at his stay in Philadelphia. He reported about these new possibilities enthusiasticly.

First Proposal for Experiments at the BEVALAC in Berkeley

PROPOSAL FOR BEVATRON EXPERIMENT
LAWRENCE BERKELEY LABORATORY

Twenty (20) copies required — a separate set for each experiment.

Group:	Date: March 7, 1975
Institution LBL - Marburg - GSI	Experimenters (complete list):
Person in Charge or Spokesman for Group: Poskanzer - Stock - Gutbrod	Poskanzer (LBL) Stock (Marburg) Sextro (LBL) Sandoval (Marburg) Zebelman (LBL) Gutbrod (GSI)

Title of Experiment:

Study of Large Momentum Transfer in Target Fragmentation

Summary of Experiment (for circulation):

We propose to measure energy spectra and angular distributions of high energy, non-evaporative nuclear target fragments with $2 \leq Z \leq 18$ resulting from bombardment of Al, Ag and U targets with ^{16}O beams at 0.4, 1.0, and 2.1 GeV per nucleon. The experiments focus on fragments in the energy range from 10 to about 100 MeV per nucleon that come from interactions in which a high total energy and high transverse momentum is deposited in the target. The detector will be a telescope of large area silicon and high purity germanium detectors which will identify the nuclear charge of the fragments by dE/dx - E techniques. The events will be tagged by a second detector system which will record the multiplicity of coincident cascade pions and protons that may be considered as a signature of non-peripheral, small impact parameter collisions. The spectra and angular distributions of nuclear fragments should provide information about the fast decay processes of the excited target nucleus and, in particular, look for emission phenomena that could elucidate the mechanism of large momentum and energy transfer, such as the predicted formation of nuclear shock waves.

The LBL-Marburg-GSI-Collaboration

Objectives
Nuclear EoS
Phase transitions
Quark matter

Experimental facilities
1) Streamer chamber (Stock et al.)
2) Plastic Ball (Gutbrod et al.)
(both 4π-detctors, visual and electronic)

Basic questions
Stopping power of nuclear matter
Identification of central collisions
Can equilibrium be achieved?
What are the observables?

Nuclear Equation of State

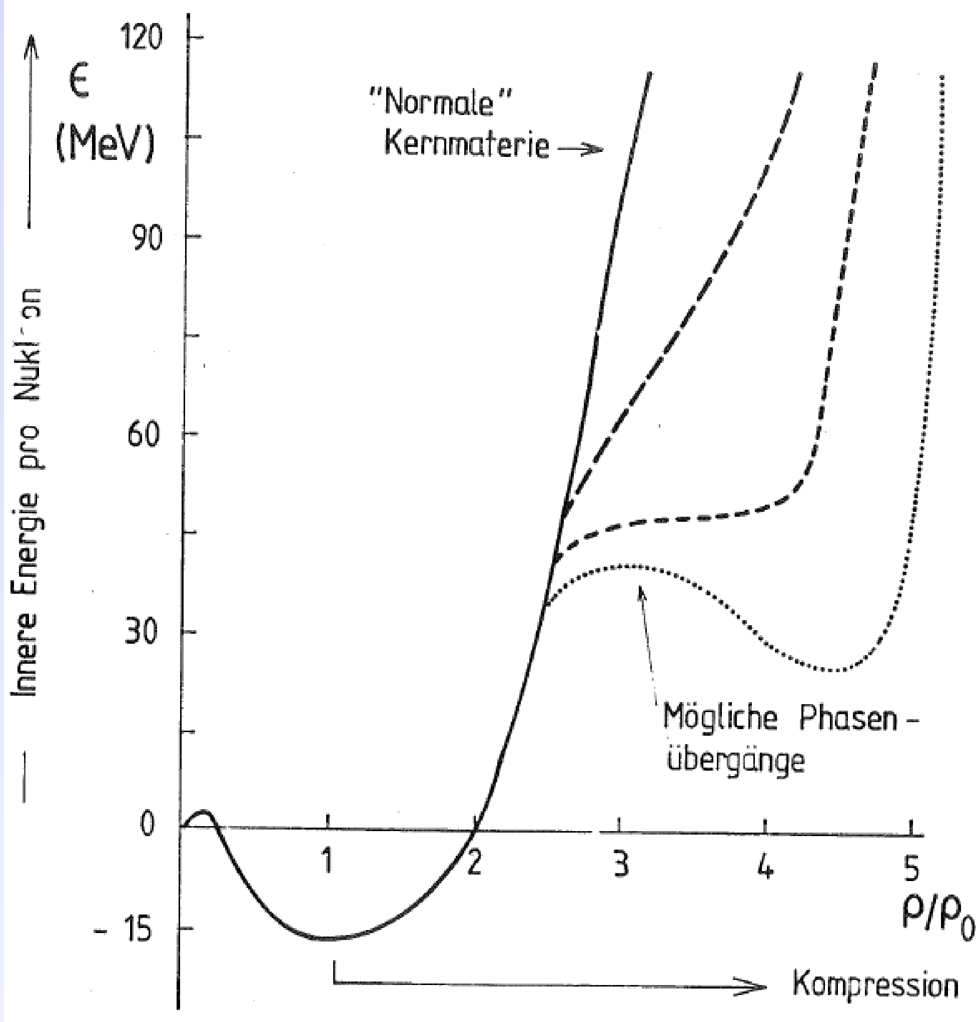


Abb. 2

Hans Gutbrod, Arthur Poskanzer et al. assembling the Plastic Ball

Dr. W. Schött (BMFT) and Reinhard Stock (at a GSI Workshop)

Bill Myers, Miklos Gyulassy and Horst Stöcker

January 1977: First Proposal for an
Extension to Relativistic Heavy Ions at GSI (SIS-18)

GSI-P-2-77
JANUAR 1977

ÜBERLEGUNGEN
ZUR PHYSIK DER KERNMATERIE
UNTER EXTREMEN BEDINGUNGEN
UND
ZU EINEM BESCHLEUNIGER
FÜR RELATIVISTISCHE SCHWERE IONEN

GSI - BERICHT P-2-77

GESELLSCHAFT FÜR SCHWERIONENFORSCHUNG MBH, DARMSTADT

An dieser Studie wirkten mit:
K. Blasche, R. Bock, B. Franzke, W. Greiner,
H.H. Gutbrod, B. Povh, Ch. Schmelzer und R. Stock

Change of paradigms:
New accelerator proposal: SIS 100 (10 GeV/A)

SIS

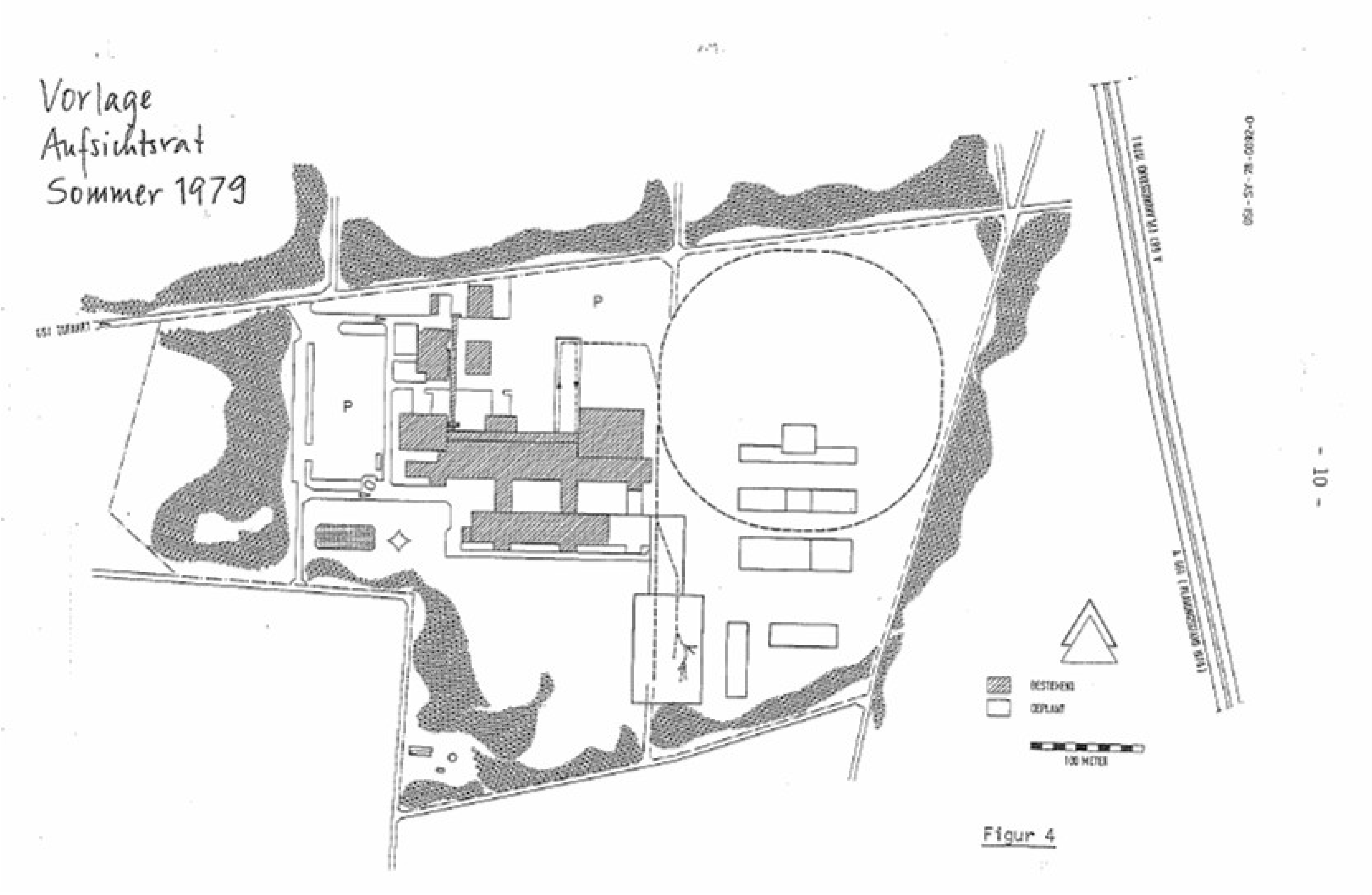
SIS 100
10 GeV/u

EINE BESCHLEUNIGERANLAGE
FÜR
SCHWERE IONEN HOHER ENERGIE

NOVEMBER 1981

GESELLSCHAFT FÜR SCHWERIONENFORSCHUNG MBH DARMSTADT

1979: GSI and SIS-100



1981: SIS-12 + SIS-100

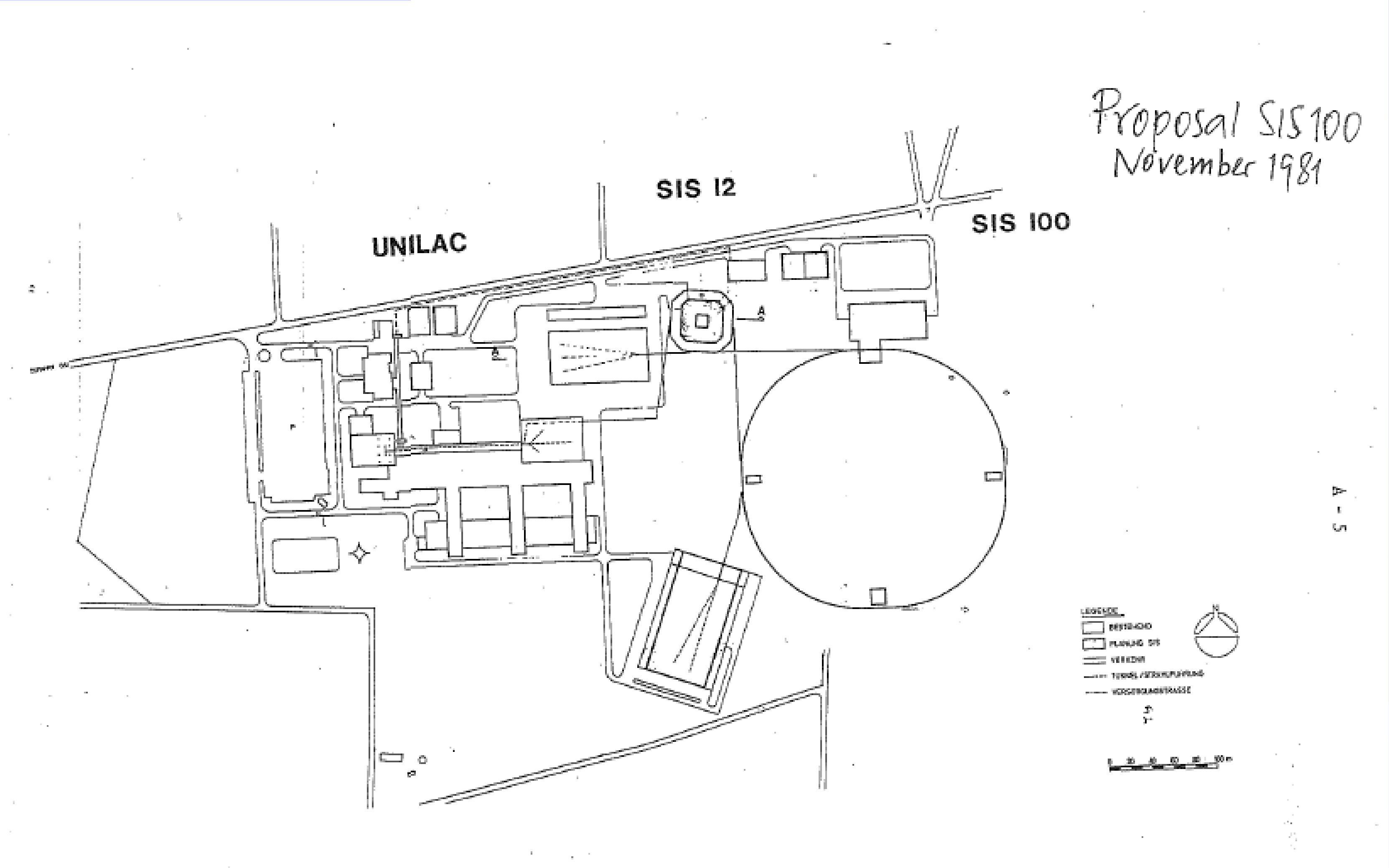


Abb. 2.1: Anordnung der geplanten Beschleunigeranlage.

1980-84 Discussion about various accelerator concepts

	SIS 10	SIS 18	SIS 40	SIS 100 SL	SIS 100	SIS 18 SIS 100 SL	SIS 40 SIS 100 SL
Kosten/MDM	31	36	67	84	110	120	140
Beschleuniger	22	25	46	60	70	85	106
Beschl.-Gebäude	4	5	11	12	22	17	12
Techn. Inst. Beschl.	5	6	10	12	18	18	22
Bauzeit/J	3-4	3-4	4	4-5	5-6 J	8 J	8-9 J
Personalbedarf	36	40	45	45	64	85	90

Tab. 4: Vorläufige grobe Zusammenstellung von Kosten, Zeit- und Personalbedarf für die untersuchten Synchrotrons

von Bö im WD verteilt
24.2.83

-1-

	SIS18	SIS30	SIS40
Durchmesser (m)	62	100	130
Energie (GeV/u)			
Ne^{10+}	1.9	3.6	5.1
U^{72+}	0.95	1.9	2.8
Kosten (MDM)			
Maschine + Gebäude	58	78	95
EH + Strahltransport	34	38	42
	92	116	137

Δ= 45

	SIS 54SL	SIS 80SL	SIS 100SL
Energie (GeV/u)			
Ne^{10+}	7.2	11	14
U^{92+}	5.4	8.3	10.5
Kosten			
Maschine	45	62.5	75
Gebäude			
techn. Inst.	5	7.5	10
	50	70	85

Kosten der Doppelringanlage	142	186	220

The German Physics Community was invited to GSI for a discussion of the SIS project (zu Putlitz, 1979)

Diskussion über ein Projekt zur Beschleunigung schwerer Ionen auf relativistische Energien*

GSI Darmstadt 2. Februar 1979, 10.00 - 16.00 Uhr

Zusammenfassung der Diskussion

Herr zu Putlitz weist einleitend darauf hin, daß die GSI Überlegungen zu einem Ringbeschleuniger mit 240 m Durchmesser anstellt, um schwere Ionen bis auf ca. 10 GeV pro Nukleon zu beschleunigen. Bei Verwirklichung dieses Projekts kann die GSI völlig neuartige Forschungsmöglichkeiten zur Verfügung stellen. Diese müßten dann von deutschen Universitäten genützt werden, wie das bereits bisher für Unilac der Fall ist. Die heutige Diskussion sollte daher auch Grundlage für die Eckwerte eines solchen Konzepts ergeben. Ein detailliertes Konzept des Beschleunigers soll dann aufgrund der heutigen Diskussion erarbeitet werden. Zu Vorschlägen und Kritik wurden insbesondere die Teilnehmer von auswärts aufgefordert.

Discussion meeting at GSI (July 1979)

Supporters and Opponents

Heavy Ions at CERN

The community could not agree on the higher energy.
Recommendations were for SIS-18 and for the higher energies to convince CERN for relativistic heavy ions.

G.zu Putlitz ask me to take over the negotiation for GSI and LBL with CERN. In the beginning, CERN was very reluctant, but finally a solution could be found. The contract between LBL, GSI and CERN was signed in July 1984.

Unfortunately zu Putlitz' term as GF ended in Dezember 1984.

HEAVY NUCLEAR BEAMS AT CERN

R. STOCK , FACHBEREICH PHYSIK , UNIV. FRANKFURT
R. BOCK , GSI DARMSTADT.

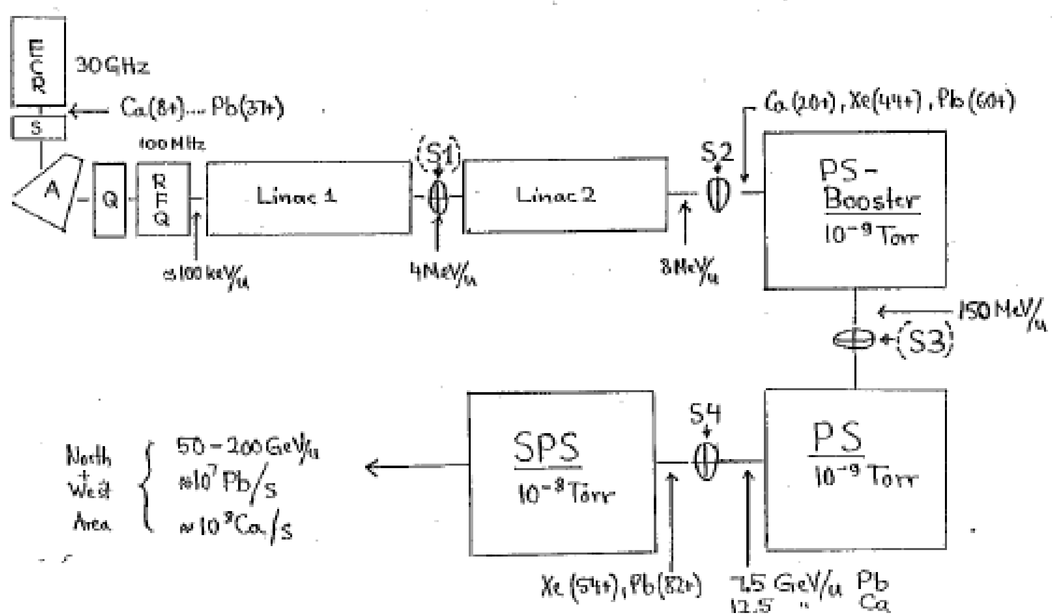


FIG.2

Agreement CERN/LBL/GSI, signed July/August 1983

Aug. 25, 1983 to Schopper and Klapisch (CERN)

Letzte Version 19.8.83 (3 Expl. an H.S.)

A G R E E M E N T

BETWEEN *EUROPEAN ORGANIZATION FOR NUCLEAR* RESEARCH (CERN)
AND GESELLSCHAFT FOR SCHWERIONENFORSCHUNG MBH (GSI)
LAWRENCE BERKELEY LABORATORY (LBL)

unterschrieben
GSI: G. zu Putlitz
LBL: Pappas
CERN Schopper

INTRODUCTION

Considering that:

A collaboration between GSI and LBL (hereafter referred to as "the Collaboration") has proposed to CERN an experimental programme based on acceleration of ^{16}O ions at PS energies.

The Collaboration has agreed to procure, construct and install an ion source and pre-injector.

The CERN Research Board, taking into account the scientific interest and the general constraints on resources and schedule of the CERN accelerator complex, has accepted the proposal subject to a written agreement on sharing of responsibilities between CERN and the Collaboration.

ORGANISATION OF THE COLLABORATION

3. Each party nominates a person responsible for carrying out the programme as defined *in paragraphs 1 and 2* above. These are:

For the Collaboration:	LBL:	H. Grunder
		R. Gough
	GSI:	R. Bock
		N. Angert -- Accelerator part
For CERN	:	H. Haseroth -- PS Division part
		M. Reinharz -- SPS and West Area part

The end of the story

It was the merit of G. zu Putlitz that he had successfully pushed the 'Heavy Ions at CERN'. At GSI he had achieved the upgrade of UNILAC to higher energy, which was important for the injection into SIS.

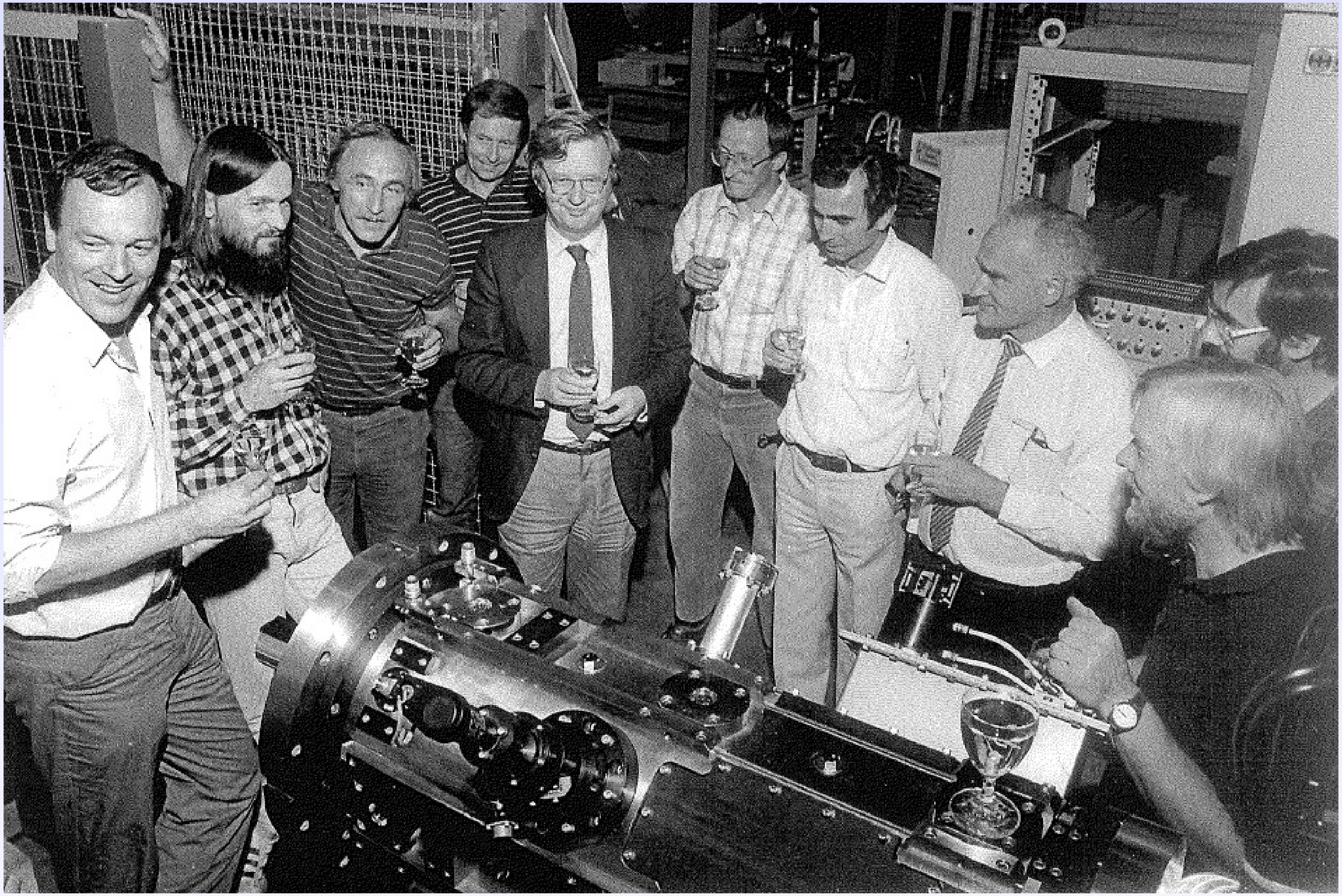
When Paul Kienle came as successor of zu Putlitz in January 1985, he wanted to change or at least reduce the CERN activities – in vain. The contract was already settled.
In his suitcase he had another problem: SUSE, which was supposed to replace SIS. The discussion 'SUSE contra SIS' was, fortunately, only a short intermezzo.
We, at GSI, had already a better solution: The combination of SIS with a storage ring. In fact, two rings were already conceived: SITAR (designed by Ingo Hofmann for Inertial fusion research) and ESR (Franzke et al.). A storage ring combined with SIS-12 had a lot of

sex appeal and was finally accepted by the community and by the various GSI boards.

ECR-Heavy Ion Source developed by Gellert (Grenoble)

payed by GSI (3 MDM)

tested and adapted at GSI for the CERN injector (1984).
All participants seem to be satisfied and happy



Hard working physicists at CERN

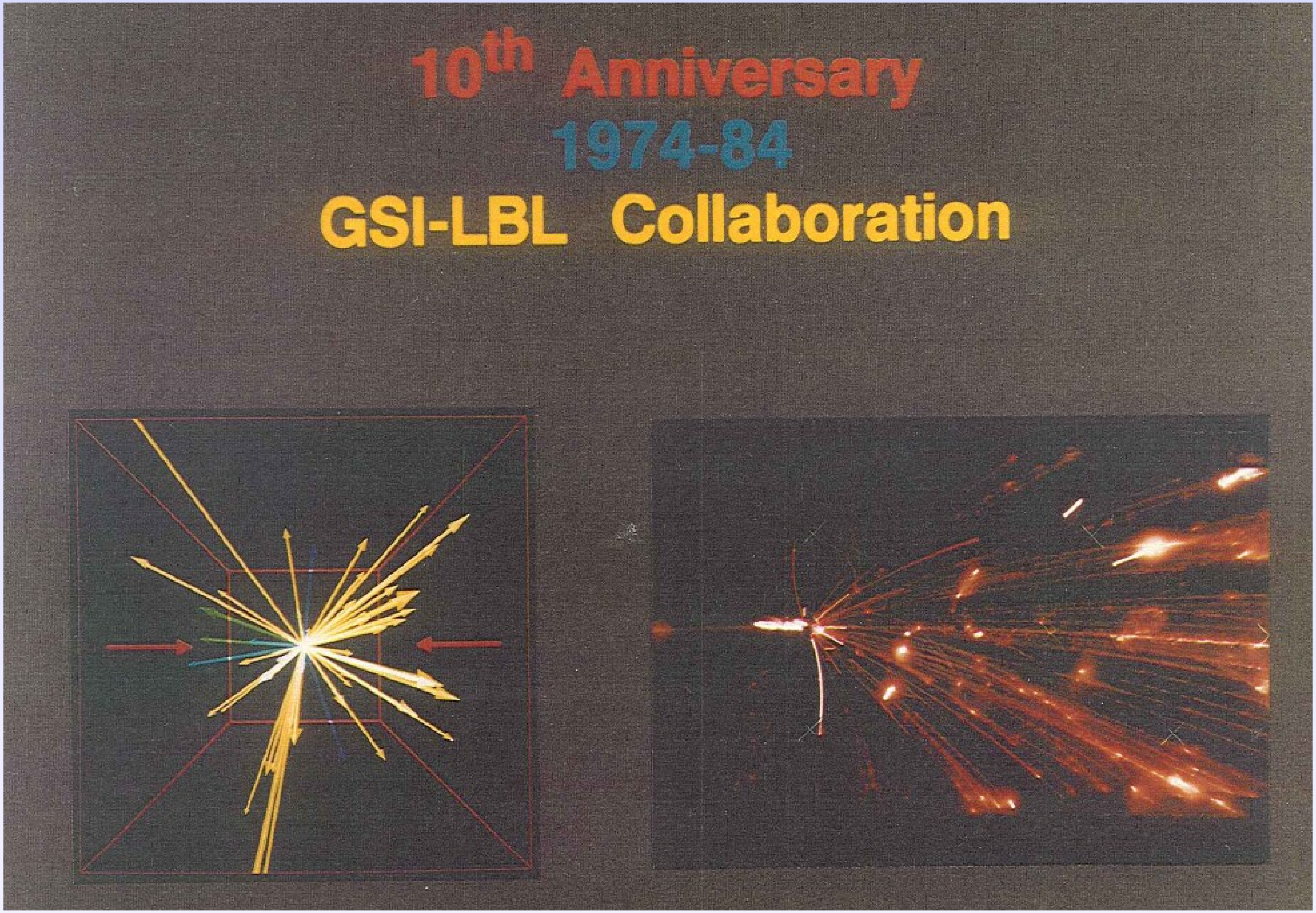
The Plastic Ball crew

Thanks for your attention

Wo damals die Grenzen der Wissenschaft waren,
das ist jetzt die Mitte

Georg Christoph Lichtenberg
Sudelbücher, Heft H (1784-88)

After 10 years in Berkeley: End of the "Fremdenlegion"
Negotiations with CERN since 1980 for Heavy Ions in the PS



July 1974: First discussion with Arthur Poskanzer about first experiments and collaboration

A HISTORY OF CENTRAL COLLISIONS AT THE BEVALAC

Arthur M. Poskanzer

Lawrence Berkeley Laboratory
Berkeley, CA 94720

THE GSI-LBL COLLABORATION

In July 1974 Reinhard Stock and Rudolf Bock came to visit me to talk about starting a collaboration. We spent three hours in my office calculating what would be the best experiment to do with the upcoming heavier ion beams. Because of the expected low beam intensities, time of flight techniques with small solid angle were ruled out and we decided on a large area dE/dx-E telescope made of an array of silicon and germanium detectors. The plan was to continue the study of the fragmentation products with the heavier beams. We decided to go ahead with this GSI-LBL collaboration and in the fall of 1974 Hans Gutbrod and Andres Sandoval arrived.

In 1974 the transfer line was completed connecting the SuperHILAC to the Bevatron, creating the Bevalac which could produce 2 GeV/nucleon heavy ions, an energy more than 100 times higher than previously available. Initially the heaviest beam was oxygen, but the mass increased later to neon. In this new energy regime it was hard to imagine what to expect. Because this field of relativistic heavy ion physics was completely new to all of us, group meetings were very exciting, as everybody contributed on an equal basis. Nobody had any experience and the young people, as you will see, participated equally with the more senior people.

SHOCK WAVES?

While the large area silicon-germanium telescope was being planned and built, Prof. Schopper reported his shock wave peaks in AgCl track detectors irradiated by 0.9 GeV/nucleon oxygen ions.[3] In his angular distributions he observed a broad peak with small narrower peaks superimposed. We decided to proceed quickly to verify this. We took a 5 cm thick piece of plastic scintillator, slapped it on a phototube, put a 1 mm thick Li drift silicon detector in front of it, and placed it in my existing scattering chamber (see Fig. 2). This silicon-plastic telescope was designed to look for ^{3}He and ^{4}He fragments. We used a 1 GeV/nucleon oxygen beam to irradiate a silver target in order to approximate the conditions of the silver chloride track detectors. Our results[4] in 1975 when plotted (see Fig. 3 top) as $d\sigma/d\theta$ showed a nice broad peak at about 60 degrees in the laboratory, similar to the data of Prof. Schopper. However,

INTERNATIONAL
Herald Tribune
Published With The New York Times and The Washington Post
THE HAGUE, THURSDAY, NOVEMBER 6, 1986

LATE NEWS

Dutch Support U.K. on Syria

New Shuttle Director

INSIDE TODAY

GENERAL NEWS

SCIENCE

Physicists Will Try to Glimpse the Universe at Birth

By Walter Sullivan
New York Times Service

GENEVA — Using the most powerful collisions of subatomic particles ever produced in a laboratory, physicists hope to recreate conditions they believe existed briefly after the explosive birth of the universe, before the formation of matter as it exists today.

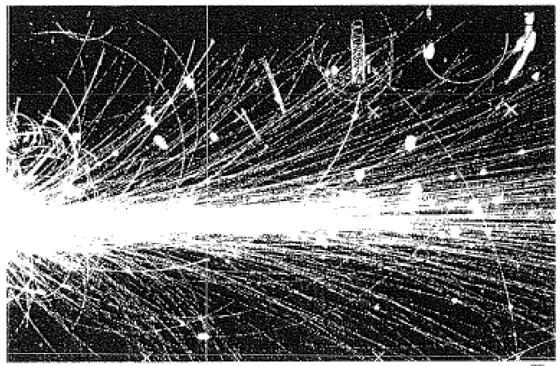
If they succeed, they may be able to observe how primordial material evolved to matter in its present form. The process would constitute a replay of the critical transition that took place during the first fraction of a second after the Big Bang, the gigantic explosion most scientists believe created the universe 10 billion to 18 billion years ago.

The experiments, among the most ambitious and complex ever undertaken, are to be conducted this month at CERN, the European high-energy physics research center in Geneva. The prospects for success were enhanced in September when scientists at CERN produced by far the highest-energy collisions achieved anywhere so far.

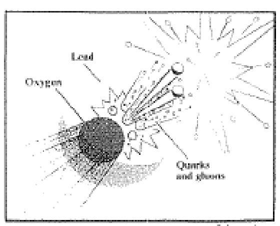
More than 300 physicists from countries are taking part, ignoring political differences between their countries. There are large contingents from the United States, West Germany and the Soviet Union, as well as scientists from Israel, India, Poland, Yugoslavia and almost all West European countries.

They seek to smash together atomic nuclei, formed of multiple protons and neutrons, with sufficient energy to break them up into their hypothetical constituent parts — quarks and gluons.

The resulting soup of freely moving quarks and gluons would briefly mimic the primordial state of the universe, the theorists believe. Then, as effects of the collision wore off, they would recombine into the particles of which the universe is made today and, perhaps, combinations never before observed.



Scientists at CERN produced this shower of subatomic particles in the most violent collision achieved so far.



How scientists hope quarks and gluons will be liberated.

In today's universe, particles forming the nuclei of all atoms are believed to be composed of quarks bound together by gluons. The latter not only form the glue that holds quarks inescapably within the nuclear particles but, it is believed, also bind together the nuclear particles themselves.

Normally neither quarks nor gluons can have an independent life. No laboratory experiment has produced free quarks or gluons. Yet quarks seem able to move about freely inside a nuclear particle.

This has led to speculation that, if many nuclear particles could be squeezed together until their accumulated density equaled that inside a nucleus, all their quarks and gluons might become free.

It is believed that under the extraordinary pressure and temperature that existed for a fraction of a second after the Big Bang, the universe was entirely formed of freely moving quarks and gluons.

They then presumably combined to produce the protons, neutrons and other constituents of today's universe, leading to the formation of planets, stars, and galaxies.

Some physicists call the hypothetical quark-gluon plasma a "quagma." Theorists believe conditions inside neutron stars — burned out stars collapsed to great density — may be so extreme that the quarks and gluons there have regained their freedom, the condition the researchers are hoping to achieve at CERN.

The experiments being prepared at CERN consist of accelerating the nuclei of relatively massive atoms to very high energy levels, then slamming them into a target also formed of atoms with large nuclei.

This contrasts with the experiments for which CERN has long been known in which beams of single particles, such as protons or electrons, are accelerated around a large ring and then either collide head on with particles circling in the opposite direction or are aimed at a fixed target.

The record-breaking energy achieved here, beginning last September, is extremely high because atomic nuclei consisting of many particles are accelerated.

So far, it is oxygen that has been accelerated to high energy. Its nuclei are formed of eight protons and eight neutrons. The nuclei are boosted until the energy of each particle is 200 billion electron volts. The total energy of the nucleus is therefore 16 times 200, or 3,200 billion electron volts.

It is as though 16 marbles were put in a bag and accelerated together instead of one by one. Each of those "marbles" is believed to be composed of three quarks.

The beam of nuclei is then fired at a target of lead, whose nuclei contain more than 200 particles, or other material.

If the collisions are sufficiently violent, they are expected to demolish very briefly the nuclear particles of both the oxygen and the target and form a quark-gluon plasma. The quarks and gluons are expected to join almost immediately to form particles.

While there is general agreement that forming a quark-gluon plasma is a reasonable expectation, there is less unanimity on how violent a collision will be needed.

The experiments at CERN will use energies as much as four times those in the most powerful such tests so far, conducted at the Lawrence Berkeley Laboratory of the University of California. Even if no quark-gluon plasma is achieved, it is expected that the tests will break new ground and provide new insight into the internal workings of the atomic nucleus which, despite probing by generations of physicists, is still imperfectly understood.

Among other nuclear mysteries, they may explain a discovery made at CERN earlier. It was found that the quark structure inside a nuclear particle, such as a proton, when the proton is embedded within a nucleus, differs from that when the proton is at liberty.

The experiments at CERN will use a series of accelerators originally designed for boosting protons. The machines have been modified to carry entire nuclei, stripped of all their electrons.

The primary challenge is to find out whether the hypothetical plasma has been formed and what are its properties.

Eight experiments are planned, all involving a beam of highly accelerated oxygen nuclei fired at targets of different composition: aluminum, silver and tungsten. Each experiment directs part of the beam to its own target and chain of detectors.

CERN has allocated 17 days in November for experiments using an oxygen beam and 17 days next May with a beam of sulfur nuclei, containing 32 particles, or possibly calcium nuclei, containing 40 particles.

Designing the experiments has been a formidable challenge. Test runs have demonstrated that each collision or near-collision produces a deluge of hundreds, if not thousands, of particles. For several years physicists have been debating how to analyze them.

The quark-gluon plasma itself is expected to remain hidden behind an impenetrable barrier akin to that which forbids direct observation of many phenomena on the atomic level. But if the plasma itself is not observable, its effects could be.

Since analyzing the properties of each piece of collision debris is impractical, they must be studied collectively. For example, banks of calorimeters have been set up ahead of and around the targets to measure temperatures and thus record the energies of particles flying off in various directions.

Detectors in the various experimental assemblies are designed to record effects anticipated under a variety of theories.

Only as a full-force collision appears to be occurring will all the detectors be turned on.

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Prof. Dr. H. Schopper
Prof. Dr. R. Klapisch
C.E.R.N.
1211 GENEVA 23

September 1st, 1986

Dear Professor Schopper and Professor Klapisch,

Enclosed please find a draft paper with thoughts on a possible future extension of the heavy ion SPS program to the acceleration of all nuclei up to lead. It briefly discusses the physics arguments in favour of heavy nuclear projectiles as part of a long-term CERN nuclear beam program. It also outlines the required accelerator construction, chiefly a new ECR source, an RFQ and a Linac at the site of the old Linac 1.

A preliminary version of the paper has been widely discussed among accelerator groups at CERN, GSI and Grenoble. The conclusion is that the proposed scheme should be close enough to any final solution in order to serve as a trigger and guideline for an initial discussion. A first presentation within the CERN "heavy ion community", convened on 1 August 1986 by N. McCubbin and G. London at the initiative of the SPSC, has received enthusiastic support of such plans by all experimental groups. It was decided to further discuss future experiments and to work out a more detailed accelerator design. This is expected to lead to a more formal proposal early next year, to be submitted by a wider and more international group. The experiences made in the first heavy ion runs will, of course, also guide the further approach. However, we consider it justified already now to point out to CERN the possibilities to further develop this attractive field of basic research.

The purpose of this letter is to bring these thoughts to your attention at the occasion of the first internal CERN discussion, taking place on September 2 in the joint SPSC/PSCC meeting. We would very much appreciate if you could support this idea, introduce it into the discussion and decision-making process, and, if possible, give an early indication of CERN's basic backing and support for an extended nuclear beam program.

Yours sincerely,

R. Bock (GSI)
W. Geist (LBL)
H.H. Gutbrod (GSI)
L. Kluberg (Ec.Poly.Palaiseau)
F. Pühlhofer (U. Marburg)
R. Santo (U. Münster)
N. Schmitz (MPI München)
H.J. Specht (U. Heidelberg)
R. Stock (U. Frankfurt)

c.c Prof. L. Foà,
Prof. G. Brianti,
Dr. N. McCubbin,
Dr. G. W. London

- finished

Berkeley Results

1975: Erster Antrag an das BMFT für Bevalac-Experimente (Reinhard Stock/W.Walcher, Universität Marburg)

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Thema:
Untersuchung von Schwerionenreaktionen bei relativistischen Energien

	Investitionsmittel (TDM)	Personalmittel (BAT-Gruppen)
1977	185.000 DM	1xBAT I, 1xBAT Ib, 1/2xBAT IIa
1978	noch offen	"
1979	"	1xBAT I, 1xBAT Ib

Kurzfassung der Aufgabenstellung

Am Bevalac-Beschleuniger des LBL,Berkeley, soll der Reaktionsmechanismus bei Stößen schwerer Ionen im Energiebereich von 0.2 bis 2.1 GeV pro Nukleon untersucht werden. Dabei interessiert vor allem eine detaillierte Analyse der in "Star-Explosionen" bei zentralen Stößen produzierten Multiplizität von Fragmenten des Compoundsystems. Hierbei handelt es sich sowohl um schnelle Pionen und Protonen als um komplexe Kernfragmente mit $4 \leq A < 20$ und $20 \leq E/\text{Nukl.} \leq 250$ MeV. Die hohe Multiplizität solcher Fragmente deutet einen neuartigen, kollektiven Mechanismus der Wechselwirkung an, bei dem sehr hohe Beträge von primärer Energie und Impuls in Kompression und Heizung von Kernmaterie übergehen. Solche Kernmaterie weitab vom Gleichgewicht soll auf ihre Zustandsgleichung, Phasenübergänge und Zerfallseigenschaften untersucht werden.