CR
↓
31 linac SC

1932 e^+
n
d
Cockcroft - Walton Cyclotron

Cosmic Ray → Parcle physics not C.R.

e^+ γ
$\mu^\pm \to e^\pm + \nu + \nu$ η
$\pi^+ \to \mu + \nu$ π^0 η^0
$\pi^- + AZ \to$ star ρ ω
$K^\pm$ K^0 Σ^0
$\Sigma^\pm$ Λ^0

1948 Part. Phys. Cosmic rays → Accelerators
pion physics

1952 → BNL Cosmotron 3GeV
Strange Particles Berkeley Bevatron 6 GeV
K, Σ Λ $\bar{p}$ $\bar{n}$
Ξ

✡ visual (emulsion, Cl. chamber)
decay mode
θ $K_{2\pi}$
τ $K_{3\pi}$
κ $K_{3\ell}$
KY pair creation
Gell-Mann - Nishijima

$\theta - \tau$ Parity violation

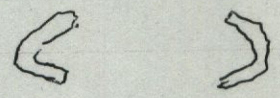
Target
(H target)
$C_n H_{2n} - C$
H target → 1960's
detectors + mag fd
space / time resol.

AG PS

1932 cyclotron

1945 synchrotron

1952 AG (Strong Focusing)



BM + Focus. Combined

BM + FM + A Sep. function

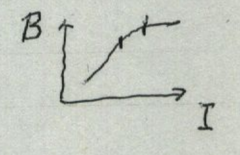
Cornell ES 2 GeV

INS ES

CERN PS 25/27 GeV 1959

BNL AGS 30/33 GeV 1960

mg fd.



exp. USA 圧勝

SU_3

ν exp.

B C.

1953 Glaser propane

Alvarez H liq H, liq D

1960 – 70's HBC DBC.

{ BEBC $30\ m^3$
{ BNL, ANL

(1970's pol H target
→ ヨコサワ スワ

Xe BC

Freon BC.

No.
Date

Lagarique

HBC dominate age

Sensitive

Heavy liquid B.C. (Gargamelle) γ, e

France (Orsay) + CERN (~~Acc~~ Exptl Apparatus Dept)

1972 ν-e scattering

N.C.

bkgd → N.C.

1972 ν-e, NC
1973 Renorm. gauge theory) WE complete, USA

1953 → CERN

1968 $\sum_{WE}$ (H.E. Phys Budget) > (USA)

~~1953 → CERN | dom. { Cosmic ray HEP / Accel. Collid HEP WE / USA~~

1980's Z, W, gluon 3:0 ~~U~~A

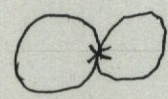
SSC

PLUS

collider colliding beam machine

MURA 大河 et al internal report early 1950's

Princeton O'Neil Richter e^-e^- collider



QED

Frascati  e^+e^- in the same ring

QED + hadron physics

$e^+e^- \rightarrow$ all charged pair, etc.

Frascati - Orsay e^+e^- 先行

---

e - machine 1960's SLAC 2mile e linac

1960's CEA 6 GeV ES $\rightarrow$ DESY 6 GeV ES

Jentcke

QED B.D. $\gamma \rightarrow e^+e^-$ S. Ting QED OK

1970's SLAC SPEAR J/ψ

e^+e physics USA (SLAC) dominance

1960's

CERN PS   BNL AGS   30 GeV

USA	
Berkely	BNL
1950's Bevatron	Cosmotron
1960's	AGS
200 GeV PS	800 GeV PS
	↓
	200 GeVp×200 GeVp ISA

plan
1960's

cost up.   Sup C. Magnet

{ Mass prod X
{ menegement Non Exist

Budget 1/4   Tunnel Reprog.
RHIC

B Wilson   200 GeV (Berkely) → 500 GeV PS

X Berkeley, BNL Acc. Expert

Fermilab 500 GeV PS

1970's

CERN ISR 30 GeV p x 30 GeV p

Fermilab 500 GeV PS ✗ 1st gen. exp ‖ γ

CERN 450 GeV SPS OK 〃

Next Projects in Fermilab

☆ { 500 GeV → 1000 GeV p S.C. Mag.

e - p → DESY

p - $\bar{p}$ → CERN (Rubbia)

C. Rubbia late 1970's

SPS → S$p\bar{p}$S 350 GeV p x $\bar{p}$

→ Z^0, W^+

early 1980's

---

early 1980's

Z, W CERN

gluon DESY (gluon jet)

WE : USA = 3 : 0

USA SSC Higgs?

LEP (Z^0) → SM test LHC dirty like Nucl. Target

20th century Energy ×10 per 7 yrs

21st century

accel. $\frac{約 10 MV}{m} \rightarrow \frac{約 10 GV}{m}$

laser ?

dectetors space/time resolution

like emulsion → 10^{-15} sec

---

small but efficient accelerators/colliders

detectors

↓

(ILC) → ?

ILC etc

study of dark matter particles and their exc. states

New Sym.

SUSY, ...

~~E x 10 / myas~~

Galaxy rotational ~~velocity~~ velocity Dark Matter

$1/3\ GeV/cm^3$

Gal. 500 km/sec escape velocity

Star 50 km/sec "

Dark Matter Ideal gas

$\sqrt{\langle v^2 \rangle} \sim 400$ km/sec

ILC. ~~SR~~ SUSY particles

Dark matter — No container

---

laser accel.

Space resolution — detector

(emulsion)

Antimatter Factory $\bar{p}$ $\bar{d}$ $\bar{p} + \bar{p} \to \bar{d} + \pi$

$\bar{p} + \bar{d} \to$ light nuclei

New heavy nuclei $Z \gg 100$

2nd World War

Govmt → Funds to (Nucl.) Physicists

冷戦；原爆づくりへの褒彰

20c　政府，軍 → Scientists
(AEC)　とくに ㊜
H.E. Phys

かげり　ISA, SSC

20c末　科学の花形

(HEP)素 → Space science
Inform. 〃
Life 〃

↓

21c　Space research
との joint mission

	WF	SF (AG)
	JINR	CERN
	Synchrophasotron	CPS
const. started		1955
1st beam	1957	24 Nov. 1959
Magnet units	W.F. 48	S.F. 100
Straight Sections	4	20 (3m)
Field at injection	150 G	147 G
Field at max	13 kG	14 kG
Rise Time	3.3 sec	1.2 sec
Magnet Weight	Fe 36 000 tons; Cu 2 700 tons	Fe 3000 tons; Al 130 tons
Power Input Av	4 MW	1.6 MW
Power Input peak	140 MW	32 MW
Mag. Sec.	5.3 x 7.5 m	1.16 x 1.94 m
gap	40 x 200 cm	10.0 x 15.0 cm
Ring Diameter	72 m	200 m
Energy	10 GeV	28/24 GeV
Repetition Rate	0.08 sec^{-1}	0.2/0.33 sec^{-1}
Internal Beam	1967 (1980)	1967 (1980)
	10^{10} (10^{12}) p/pulse	10^{12} (1.8×10^{13})
	10^{9} (10^{11}) p/s	$(1 \sim \frac{1}{4}) \times 10^{12}$ (0.5×10^{13})
cost accel. only		120 MSF (1954-59)

Longitudinal polarization can be obtained by additional magnetic devices making spin rotate or by injecting longitudinally polarized beams, P_L being not affected during motion along the orbit.

$e^{\pm}$ Storage Rings in the World

e^-e^- :	Vepp -1 (Novosibirsk, USSR)	2 x 0.17 GeV	1963-1966
	Princeton-Stanford (USA)	2 x 0.55 GeV	1961-1966
e^+e^- :	Ada (Frascati, Italy; Orsay, France)	2 x 0.2 GeV	1961-1965
	Vepp -2 (Novosibirsk, USSR)	2 x 0.7 GeV	1967-1974
	Vepp -2 M (Novosibirsk, USSR)	2 x 0.7 GeV	1974-
	ACO (Orsay, France)	2 x 0.55 GeV	1967-1976
	Adone (Frascati, Italy)	2 x 1.5 GeV	1970-
	By-Pass (Cambridge, USA)	2 x 2.5 GeV	1973-1974
	Spear (Stanford, USA)	2 x 4.2 GeV	1973-
	Doris (Hamburg, Germany)	2 x 5 GeV	1974-
	Petra (Hamburg, Germany)	2 x 19 GeV	1978-
	CESR (Cornell, USA)	2 x 8 GeV	1979-
	PEP (Stanford, USA)	2 x 15 GeV	1980-
	Vepp -4 (Novosibirsk, USSR)	2 x 7 GeV	1980(?)-
$e^{\pm}e^{\pm}$:	DCI (Orsay, France)	2 x 1.9 GeV	1976-

1.3 Detectors and Measurements

During an experiment one has to identify the nature of the particle produced, their kinematical characteristics and the rate of the reactions.

The intersection regions of the storage rings are surrounded by detectors whose accuracy is defined by:

– their solid angle Ω as close as possible to 4π in order that no particle escapes detection,

– their ability to identify particles, charged ones, neutral ones and unstable ones. Charged particles are easily detected by various kinds of chambers using ionisation effects; their identification is done using secondary reactions in various materials (showers for electrons, nuclear interactions for hadrons) and dE/dx informations (energy loss by ionisation). Neutral particles (photons or