Symposium in honour of prof. Brian Foster

Oxford, September 11, 2024

Jos Engelen,
Professor emeritus University of Amsterdam / Nikhef

1964: quarks

Volume 8, number 3 PHYSICS LETTERS 1 February 1964

A SCHEMATIC MODEL OF BARYONS AND MESONS *

M. GELL-MANN
California Institute of Technology, Pasadena, California

Received 4 January 1964

For more complete account (including role of Petermann; Serber) see:

Llewellyn Smith, C.

From concrete quarks to QCD:
a personal perspective. *EPJ H* **48**, 13 (2023).

https://doi.org/
10.1140/epjh/s13129-023-00061-4

AN SU_3 MODEL FOR STRONG INTERACTION SYMMETRY AND ITS BREAKING

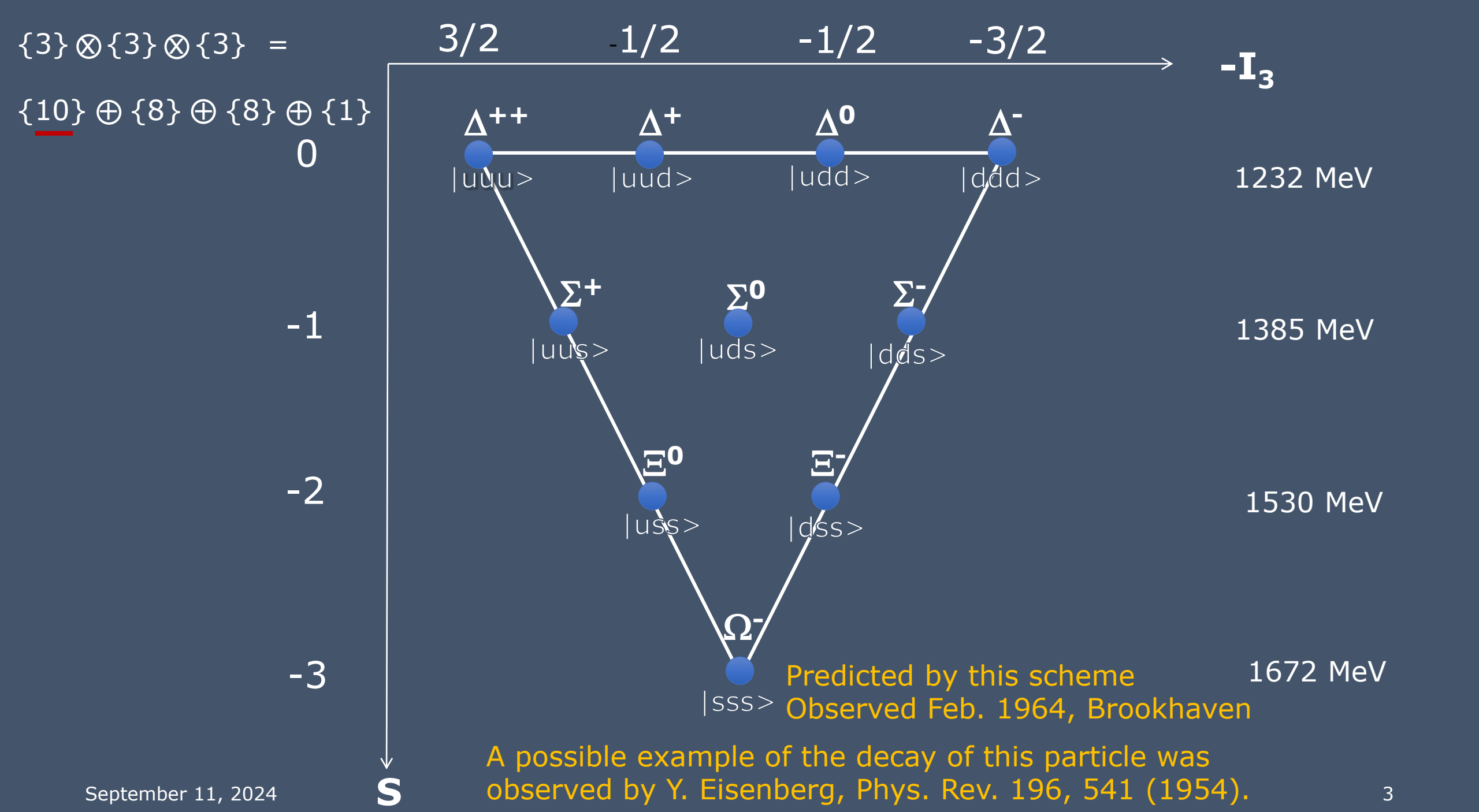
II *)

G. Zweig **)
CERN--Geneva

*) Version I is CERN preprint 8182/TH.401, Jan. 17, 1964.

**) This work was supported by the U.S. Air Force Office of Scientific Research and the National Academy of Sciences - National Research Council.

8419/TH.412
21 February 1964


{3}⊗{3}⊗{3} =
{10}⊕{8}⊕{8}⊕{1}
3/2
-1/2
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-I3
0
-1
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S
Δ++
Δ+
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|uuu>
|uud>
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1232 MeV
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|uus>
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1385 MeV
Ξ0
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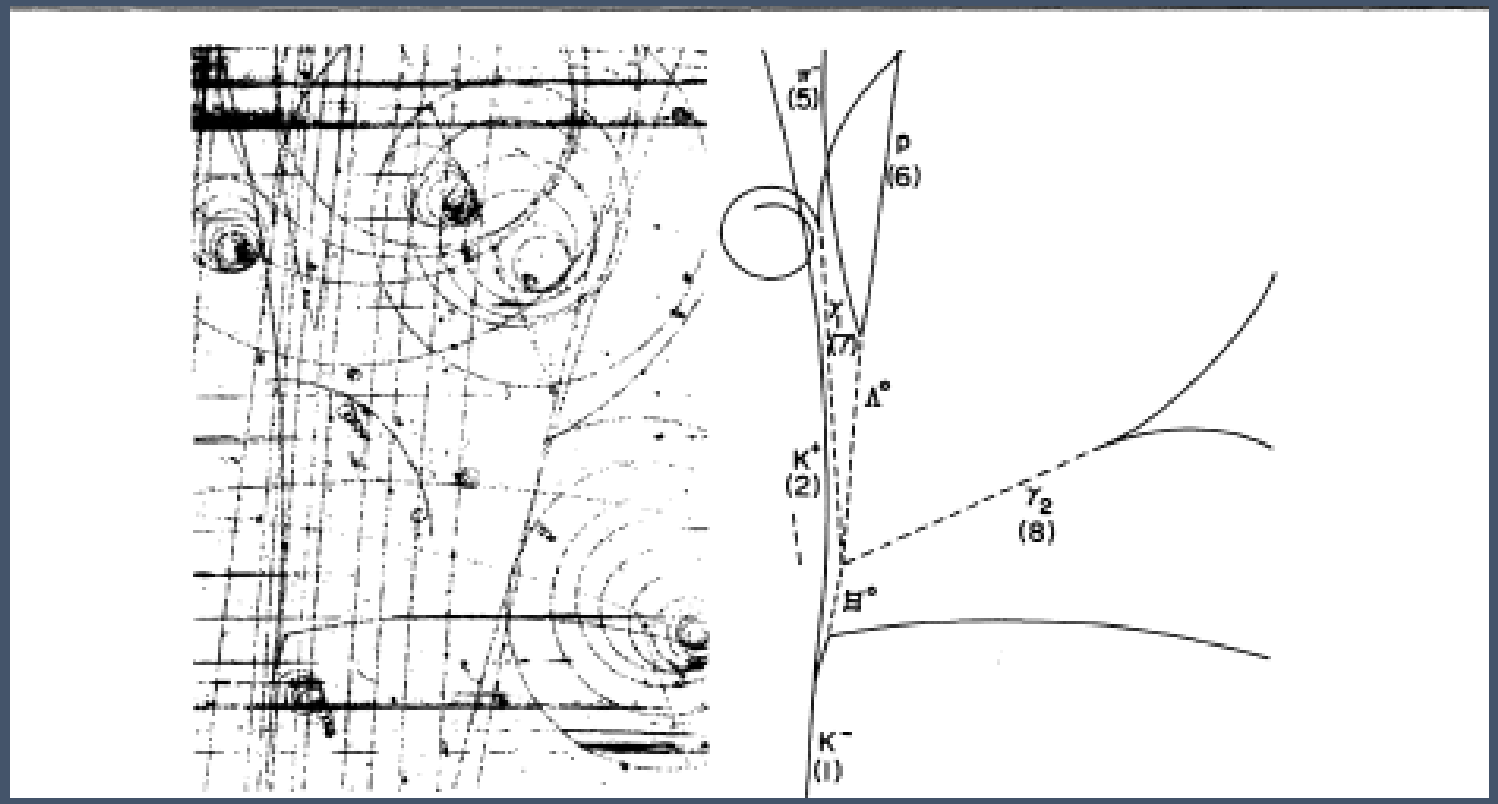
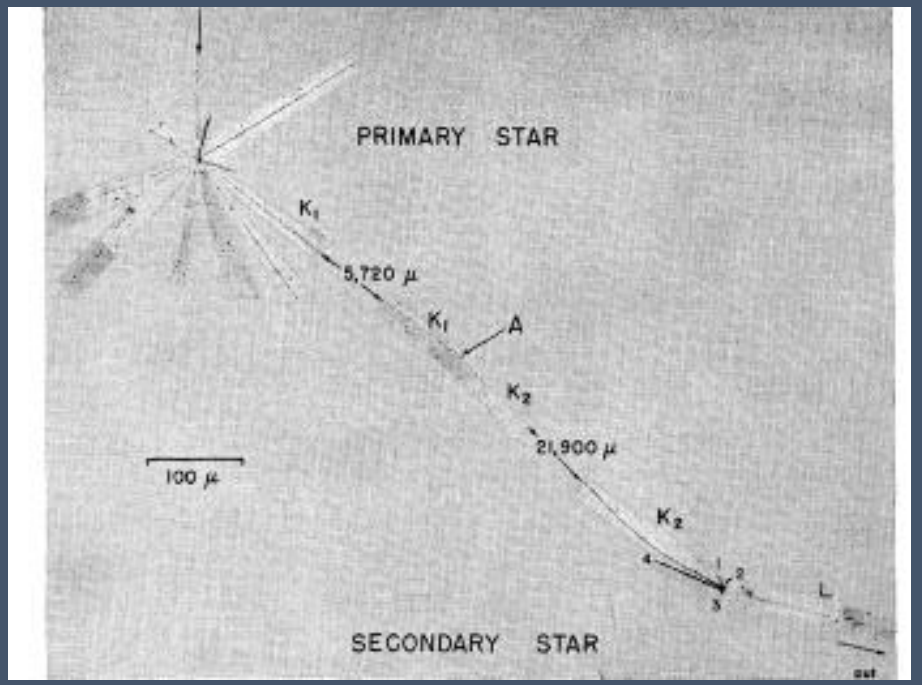
|uss>
|dss>
1530 MeV
Ω-
|sss>
1672 MeV
Predicted by this scheme
Observed Feb. 1964, Brookhaven
A possible example of the decay of this particle was observed by Y. Eisenberg, Phys. Rev. 196, 541 (1954).

Barnes et al, 1964



Y. Eisenberg, Phys. Rev. 196, 541 (1954).



$$K^- p \to \Omega^- K^+ K^0$$

$$\Omega^- \to \Xi^0 \pi^-$$

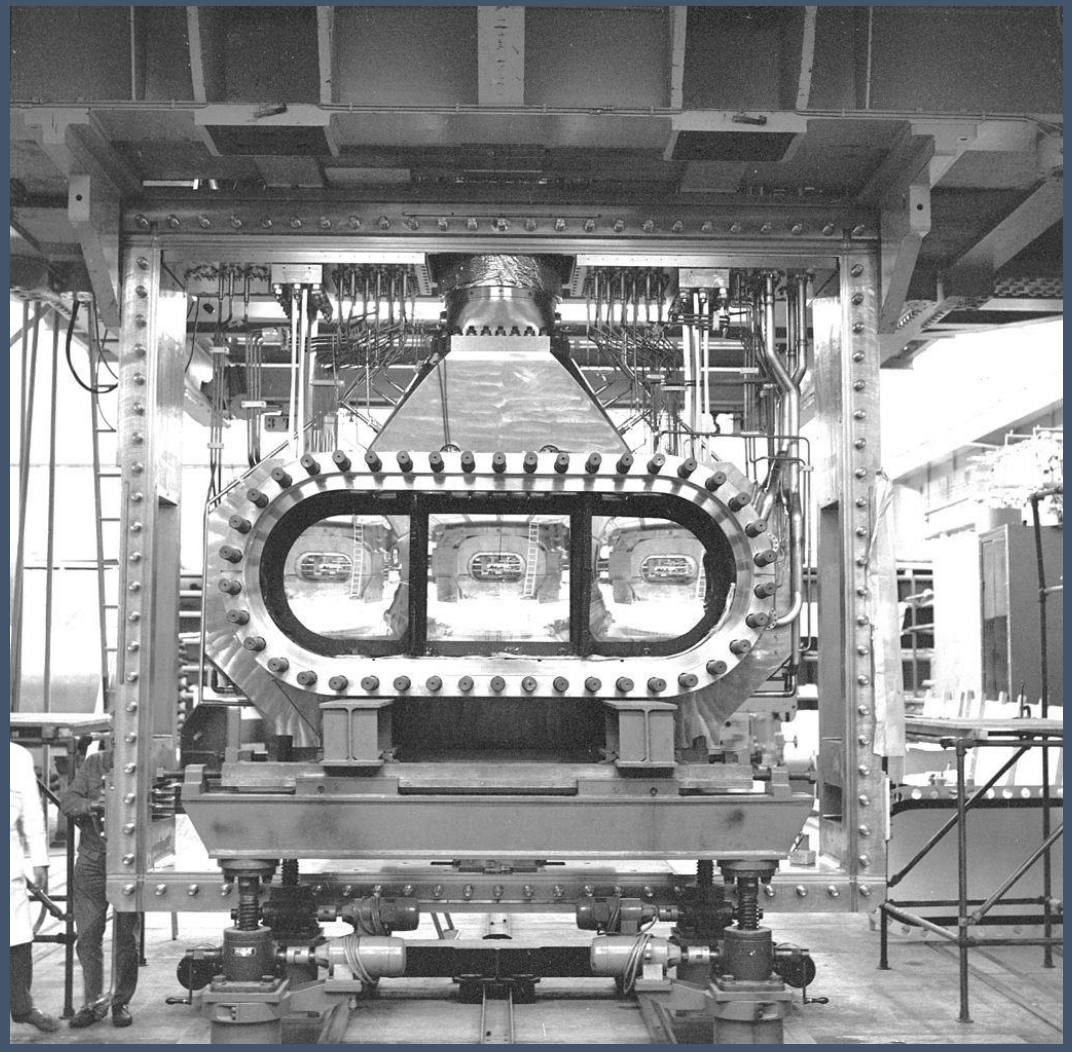
$$\Xi^0 \to \Lambda\ \pi^0 \qquad \gamma \to e^+ e^-$$

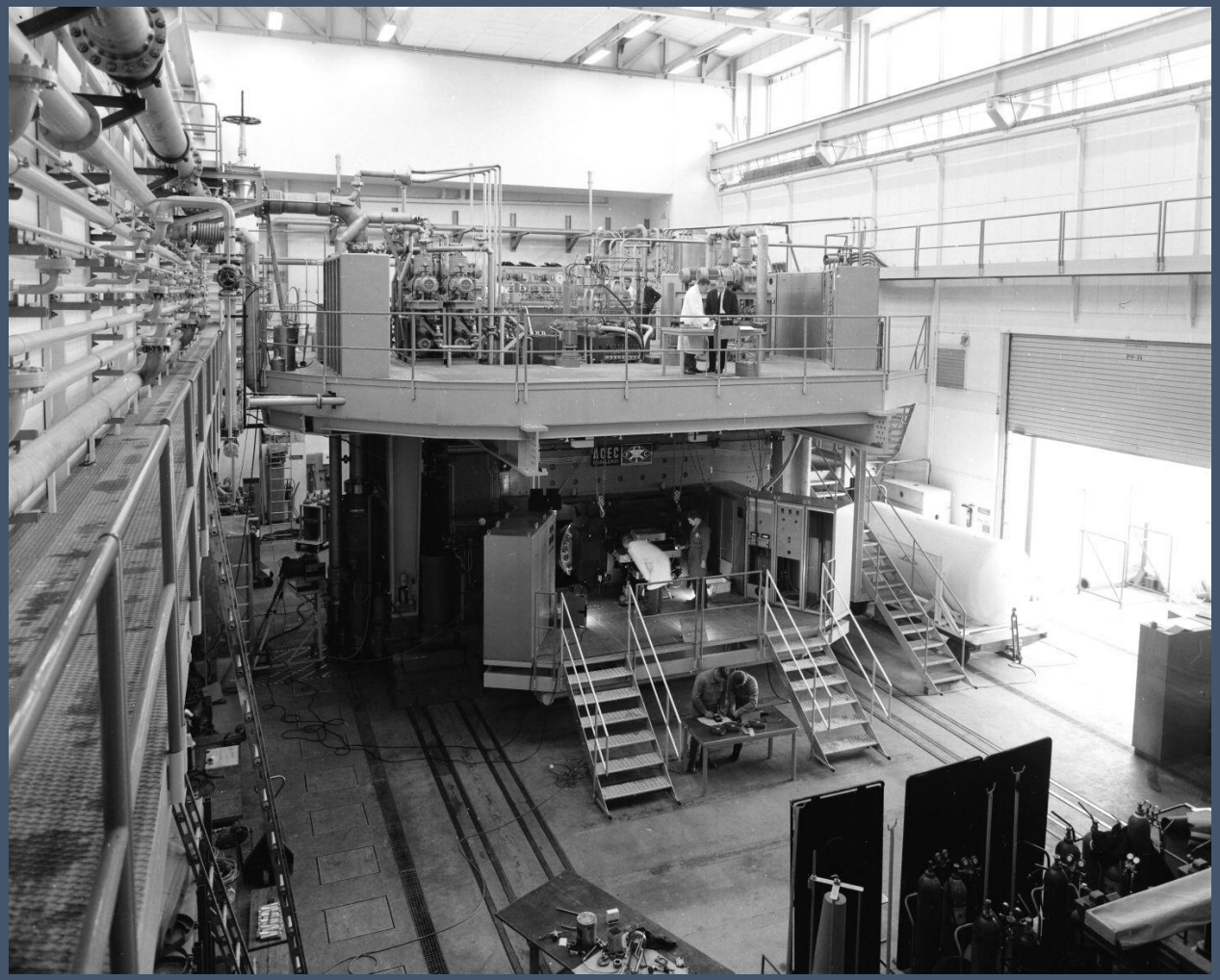
$$\pi^0 \to \gamma\gamma \quad \gamma \to e^+ e^-$$

$$\Lambda \to p\pi^-$$

1967-1974: 3 M pictures 2m CERN HBC; 133 events/microbarn

1978: Ph.D. Thesis Brian





Nuclear Physics B187 (1981) 231–253

PARTIAL-WAVE ANALYSIS OF BACKWARDLY PRODUCED THREE-PION SYSTEMS IN K^-p INTERACTIONS AT 4.2 GeV/c

ACNO Collaboration

B. FOSTER[1], P. GROSSMANN, P.R. LAMB, W.L. McDOWELL and J. WELLS

Nuclear Physics Laboratory, University of Oxford, UK

We report on the results of a partial-wave analysis of the 3π system produced by baryon exchange in the reaction

$$K^-p \to \Sigma^-\pi^+\pi^+\pi^-$$

at 4.2 GeV/c. We confirm the existence of an enhancement in the $1^+S(\rho\pi)$ wave as previously established from a Dalitz plot analysis of the same data. The phase variation of this wave is found to be consistent with that expected for a resonance and thus the enhancement is identified with A_1 production. No clear signal for this state is found in either the reaction

$$K^-p \to \Sigma^+\pi^+\pi^-\pi^- \quad \text{or} \quad K^-p \to \Lambda\pi^+\pi^-\pi^0.$$

We also find production via baryon exchange of the A_2 in all three reactions and the ω and $\omega^*(1675)$ in the third reaction.

Foster:

Cashmore [32] points out that complicated multi-Regge effects may be present in the backward exchange processes; however, the phase variation of the 1^+S wave and the observation of other 1^+S resonances via baryon exchange in our experiment make this seem unlikely. It would also seem implausible that such a multi-Regge

R.HEMINGWAY (Carleton) - I don't agree with the flippancy with which you dismissed the 3π 1^+ data from backward production and τ-decay.

R.J.CASHMORE - I expected somebody not to agree with my evaluation of the backward 1^+ 3π system from K^-p and the τ decay 3π systems. Let me first make the comment that I don't dispute the measurements but I certainly feel the analyses are, in general, of the naive variety.

Generalized isobar model formalism*

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Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720

Roger J. Cashmore
Stanford Linear Accelerator Center, Stanford, California 94305
(Received 16 January 1974)

I would say, Brian and Roger, today is the day to finally settle this dispute once and for all!

Ω^- PRODUCED IN K^-p REACTIONS AT 4.2 GeV/c

Amsterdam-CERN-Nijmegen-Oxford Collaboration

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Nuclear Physics B142 (1978) 205–219

$K^- p \rightarrow \Omega^- K^+ K^0$

Cross section 0.5 +/- 0.1 μb

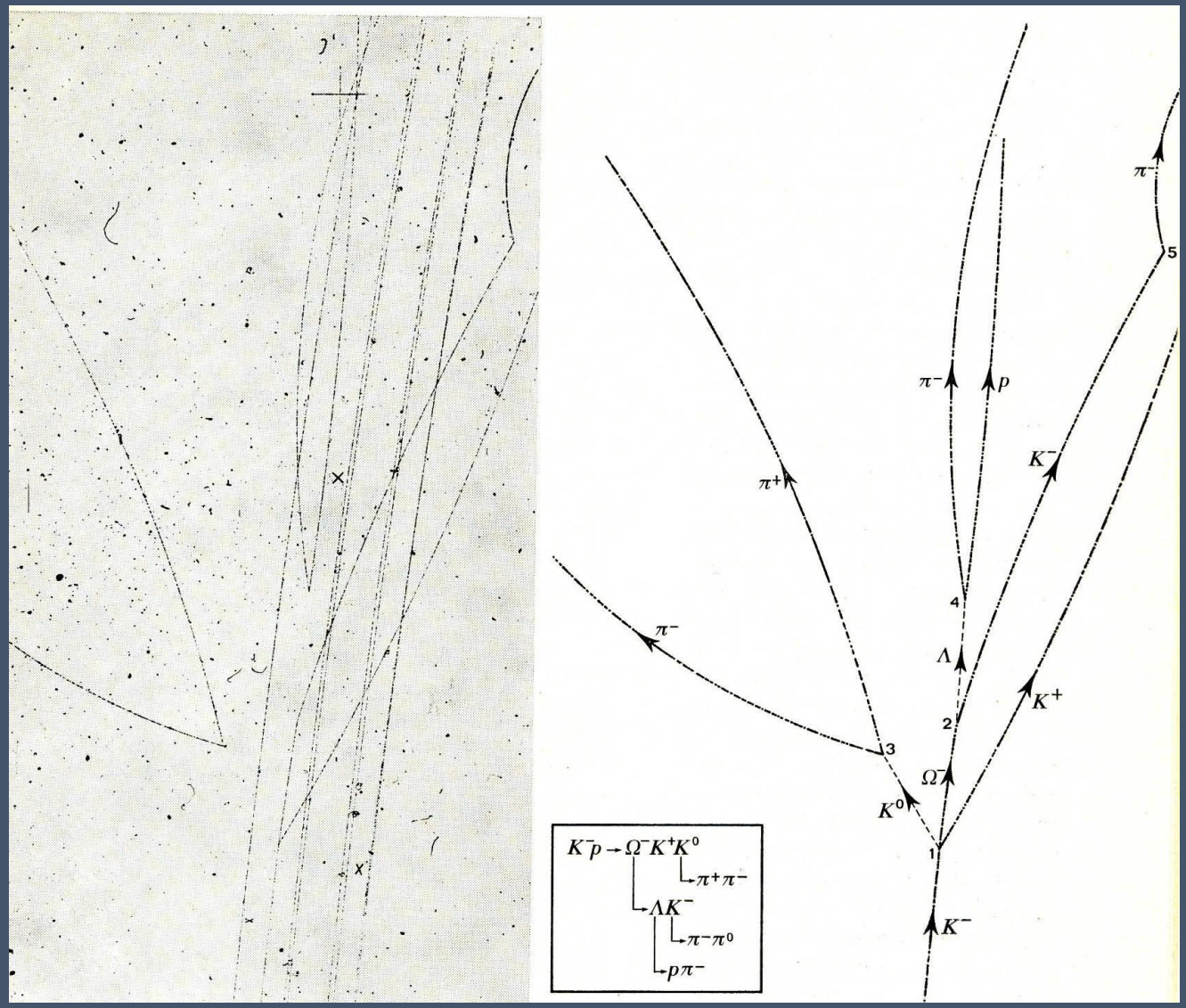
Forty Ω^- events have been observed in a large (133 events/μb) experiment at 4.2 GeV/c incident K^- momentum. Thirty nine of the events come from the three-body reaction $K^-p \rightarrow \Omega^- K^+ K^0$. The Ω^- is mainly produced in the forward hemisphere (direction of the incident K^-). The lifetime is measured to be $\tau = (0.75^{+0.14}_{-0.11}) \times 10^{-10}$ sec., substantially less than the Particle Data Group value of $(1.3^{+0.3}_{-0.2}) \times 10^{-10}$ sec. The

PDG: 0.821±0.011 10^{-10} sec

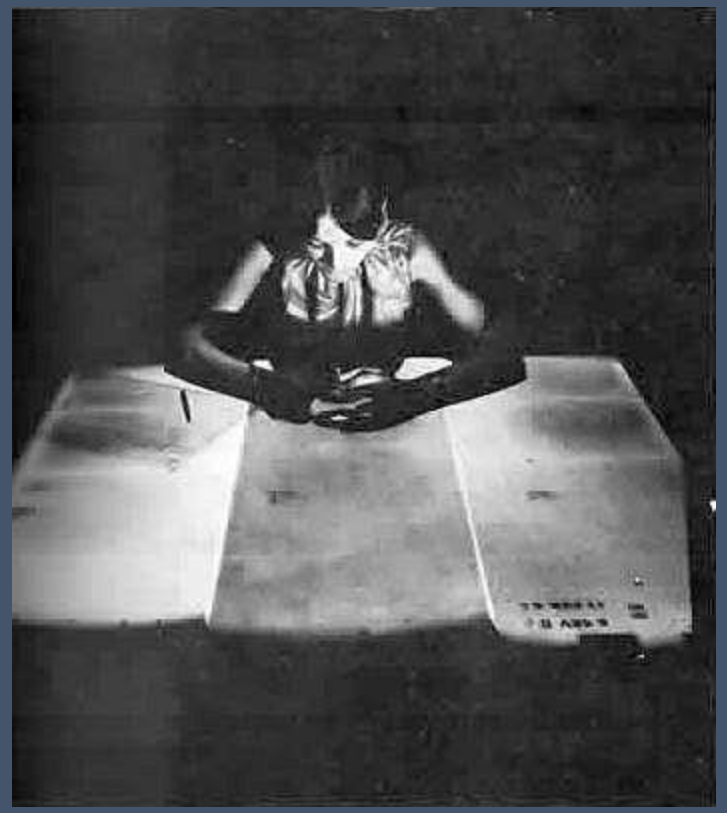
1672.43±0.32 MeV/c^2

mass 1671.7 -+ 0.6 MeV/c^2

One of 40 Ω-minus events observed in X42



Scanning X42 film (Nijmegen)



The 4.2 GeV/c K^-p experiment was an inspiring start of an exciting journey to new territories.

1954 Local gauge invariance (Yang-Mills)
1964 Quarks
1964 Spontaneous symmetry breaking
1968 Invention Multiwire Proportional Chambers
1969 Electroweak unification
1969 Deep inelastic scattering
1971 Renormalisation massive gauge fields
1973 QCD
1973 Neutral currents
1974 Discovery charm (beauty 1977, top 1995)
1974 – 1977 Tau-lepton
1983 Discovery W, Z bosons
1988 Nobel Prize mu neutrino (1962)
2000 Tau neutrino
2012 Discovery Higgs boson

Doris
Petra
HERA

(S)**PS**
SppS
LEP
LHC
……
FCC …

SPEAR
PEP (II)
SLC

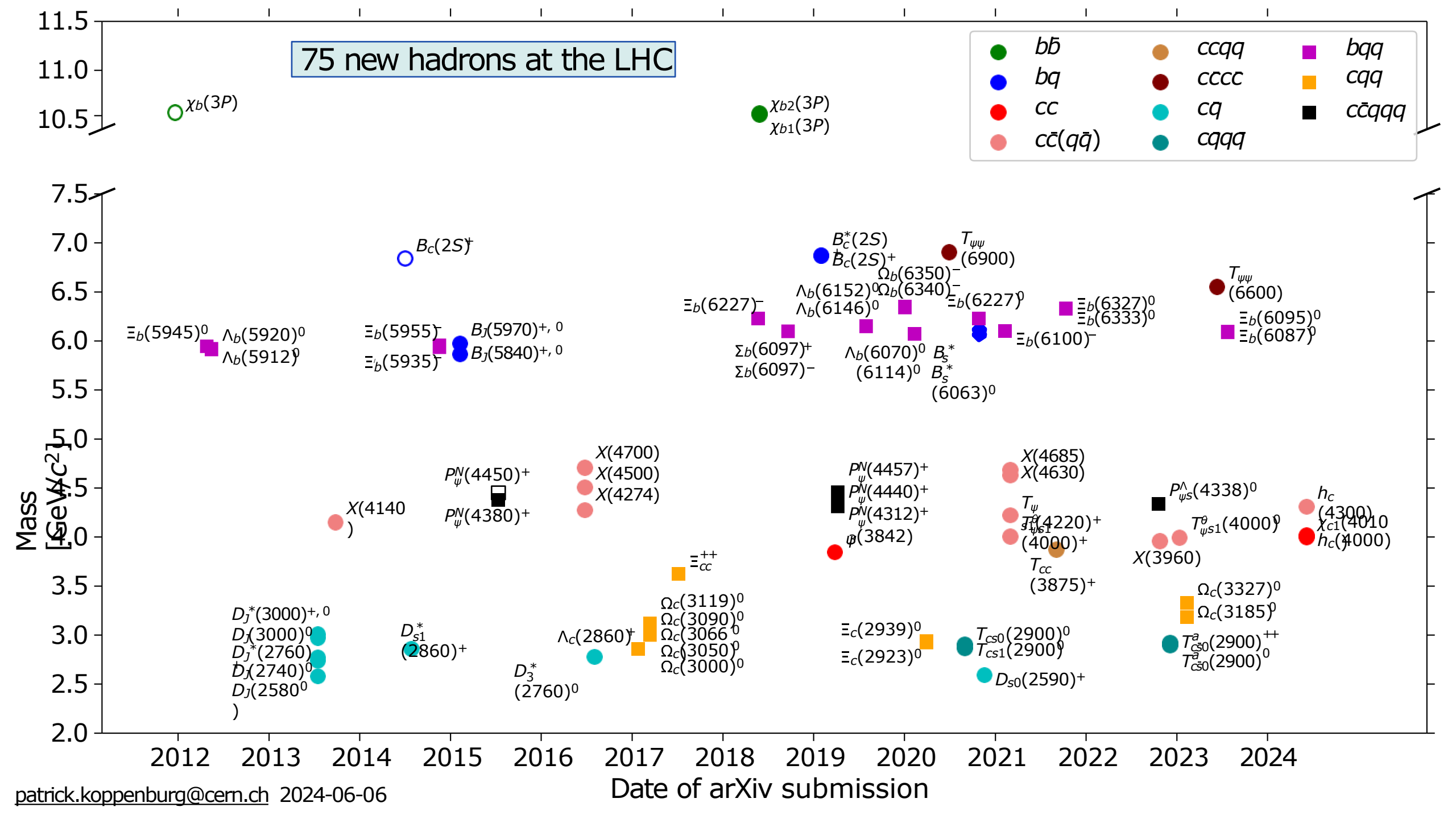
Tevatron

Tristan
KEK-B

RHIC

Future Accelerators

Novel Acceleration Technologies


75 new hadrons at the LHC
bb̄
bq
cc
cc̄(qq̄)
ccqq
cccc
cq
cqqq
bqq
cqq
cc̄qqq
χb(3P)
χb2(3P)
χb1(3P)
Bc(2S)+
B*c(2S)+
Bc(2S)+
Tψψ (6900)
Ωb(6350)−
Ωb(6340)−
Λb(6152)0
Λb(6146)0
Ξb(6227)−
Ξb(6227)0
Ξb(6327)0
Ξb(6333)0
Ξb(6100)−
Tψψ (6600)
Ξb(6095)0
Ξb(6087)0
Ξb(5945)0
Λb(5920)0
Λb(5912)0
Ξb(5955)−
Ξb(5935)−
BJ(5970)+, 0
BJ(5840)+, 0
Σb(6097)+
Σb(6097)−
Λb(6070)0
Λb(6114)0
B*s
B*s
(6063)0
X(4700)
X(4500)
X(4274)
PNψ(4450)+
PNψ(4380)+
X(4140
)
PNψ(4457)+
PNψ(4440)+
PNψ(4312)+
ψ(3842)
X(4685)
X(4630)
Tψ
Tψs1(4220)+
(4000)+
Tcc
(3875)+
PΛψs(4338)0
Tθψs1(4000)0
X(3960)
hc
(4300)
χc1(4010
hc(4000)
Ξcc++
Ωc(3119)0
Ωc(3090)0
Ωc(3066)0
Ωc(3050)0
Ωc(3000)0
Λc(2860)+
D*3
(2760)0
D*s1
(2860)+
DJ*(3000)+, 0
DJ(3000)0
DJ*(2760)+
DJ(2740)0
DJ(2580)0
)
Ξc(2939)0
Ξc(2923)0
Tcs0(2900)0
Tcs1(2900)0
Ds0(2590)+
Ωc(3327)0
Ωc(3185)0
Ta c̄s0(2900)++
Ta c̄s0(2900)0
Mass [GeV/c2]
11.5
11.0
10.5
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
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Date of arXiv submission
patrick.koppenburg@cern.ch 2024-06-06