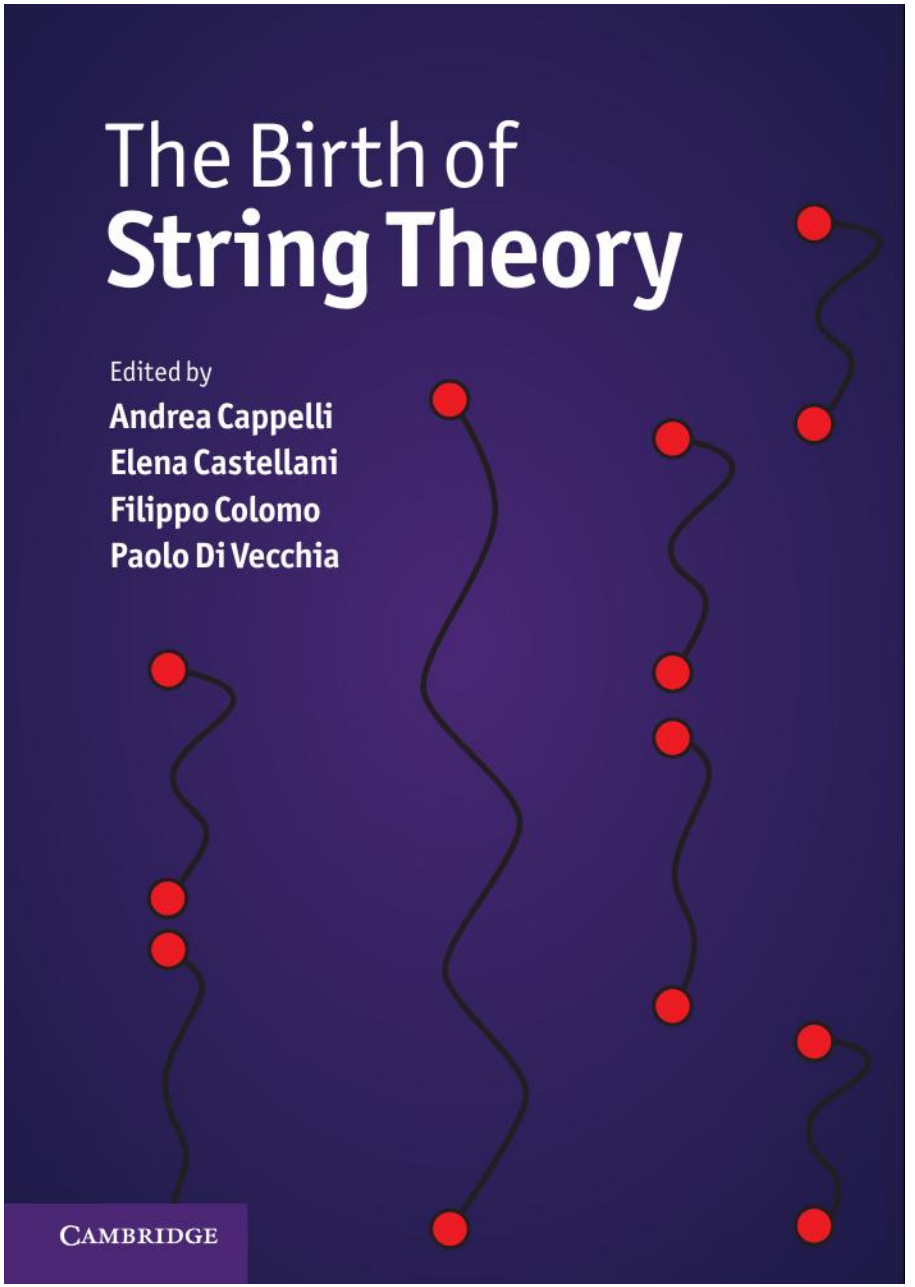
Outline

- book content
- motivations
- storyline



Content

- history from 1968 (Veneziano amplitude) to 1984 (first string revolution)
- 7 parts with introductions, 35 contributors and 5 appendices:

I. Overview	*(Veneziano, Schwarz, E. Castellani)*
II. The prehistory: the analytic S-matrix	*(Ademollo, Rubinstein, Freund, Gell-Mann)*
III. The Dual Resonance Model	*(Di Vecchia, Shapiro, Amati, Clavelli, Lovelace, Musto, Nicodemi, Sciuto)*
IV. The string	*(Goddard, Susskind, Nielsen, Nambu, Fairlie, Mandelstam, Brower)*
V. Beyond the bosonic string	*(Olive, Ramond, Neveu, Corrigan, Bardakci & Halpern, Gervais, Montonen)*
VI. The superstring	*(Gliozzi, Yoneya, Brink, Di Vecchia, Cremmer, Schwarz)*
VII. Preparing the string renaissance	*(Green, Polyakov, Cappelli & Colomo)*

Motivations

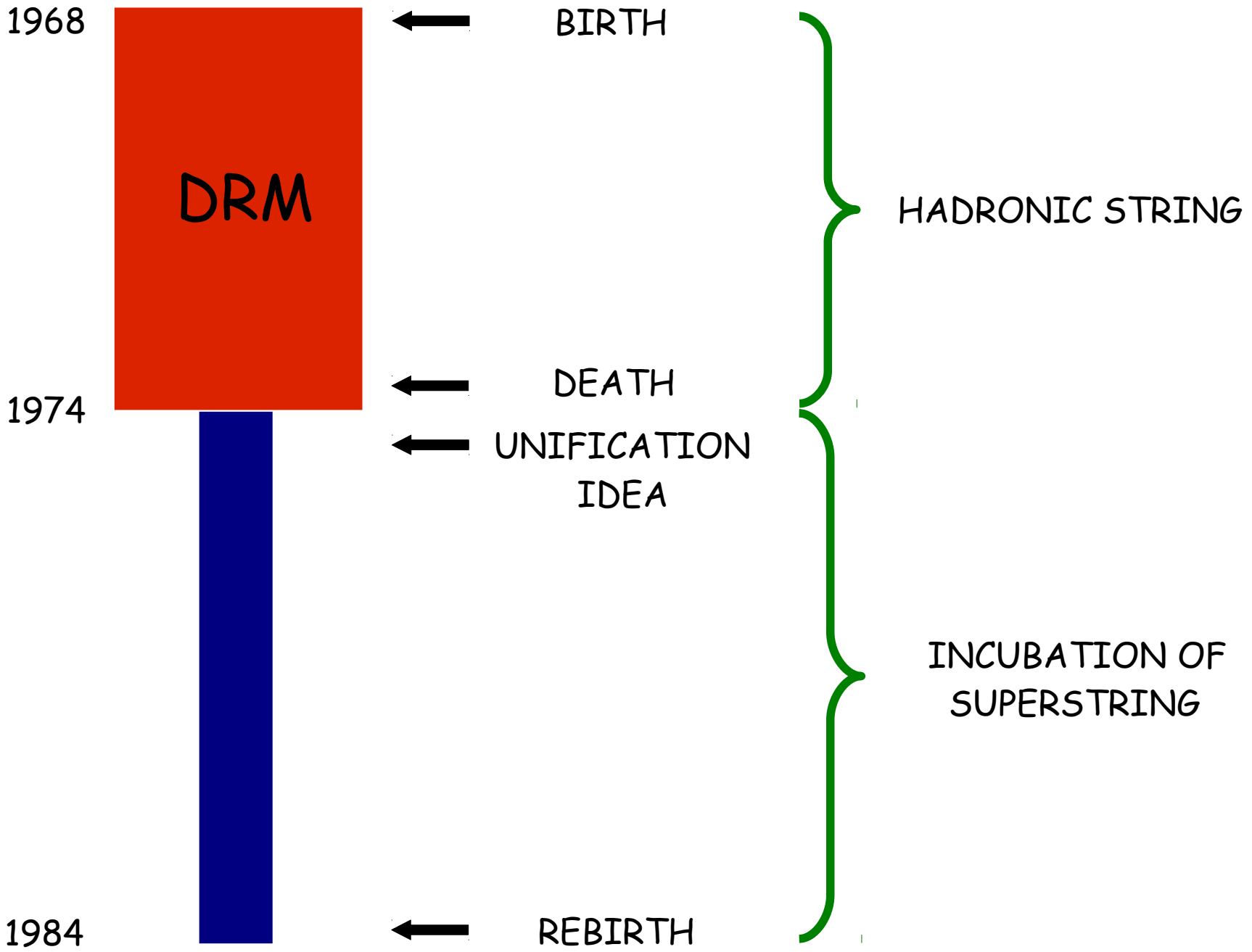
- seminar on history & philosophy of physics in Florence

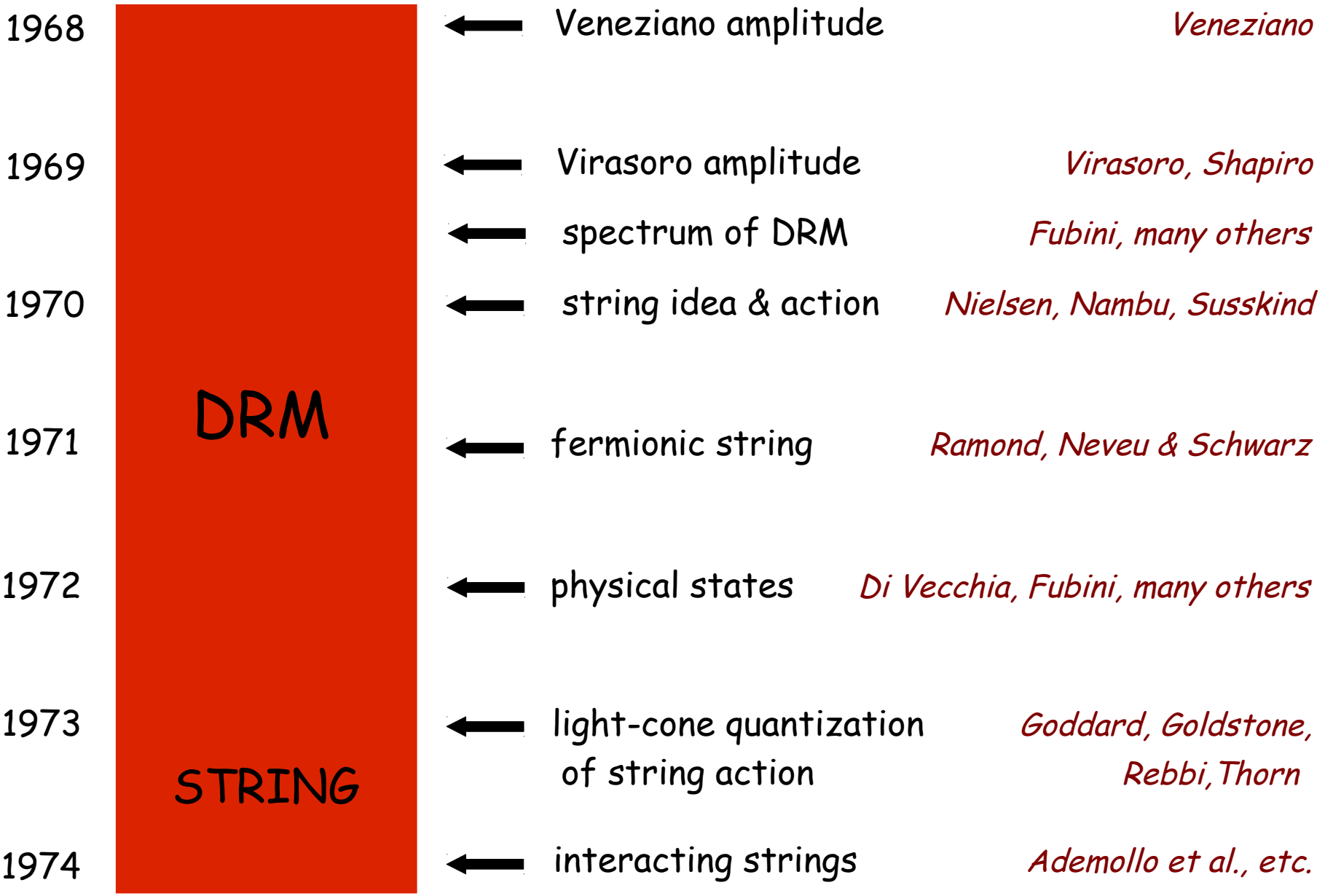
- workshop on string history at the Galileo Galilei Institute in May 2007

  within the first string program:

  enthusiasm → proceedings → book

- main points:
  - a "scientific saga", a choral work and a history with many twists
  - the right time to put it on record (2008-11)
  - for physicists: great ideas that were fully developed later and also found application in many other domains
  - for historians/philosophers: first-hand data for studying theory development and scientific method - `a case study'
  - introductory material for a wider readership


1968
DRM
BIRTH
HADRONIC STRING
DEATH
1974
UNIFICATION
IDEA
INCUBATION OF
SUPERSTRING
1984
REBIRTH


1968
1969
1970
1971
1972
1973
1974
DRM
STRING
Veneziano amplitude
Veneziano
Virasoro amplitude
Virasoro, Shapiro
spectrum of DRM
Fubini, many others
string idea & action
Nielsen, Nambu, Susskind
fermionic string
Ramond, Neveu & Schwarz
physical states
Di Vecchia, Fubini, many others
light-cone quantization
of string action
Goddard, Goldstone,
Rebbi, Thorn
interacting strings
Ademollo et al., etc.

1968	Veneziano amplitude	*Veneziano*
1969	Virasoro amplitude	*Virasoro, Shapiro*
	spectrum of DRM	*Fubini, many others*
1970	string idea & action	*Nielsen, Nambu, Susskind*
1971	fermionic string	*Ramond, Neveu & Schwarz*
	extra dimensions	*Lovelace*
	world-sheet supersymmetry	*Gervais & Sakita*
1972	physical states	*Di Vecchia, Fubini, many others*
	field-theory limit	*Scherk, Neveu, Yoneya*
1973	light-cone quantization of string action	*Goddard, Goldstone, Rebbi, Thorn*
1974	interacting strings	*Ademollo et al., etc.*

Hadronic string

- Reasons to be born (1968)

  - Veneziano amplitude: simple closed-form solution to S-matrix bootstrap

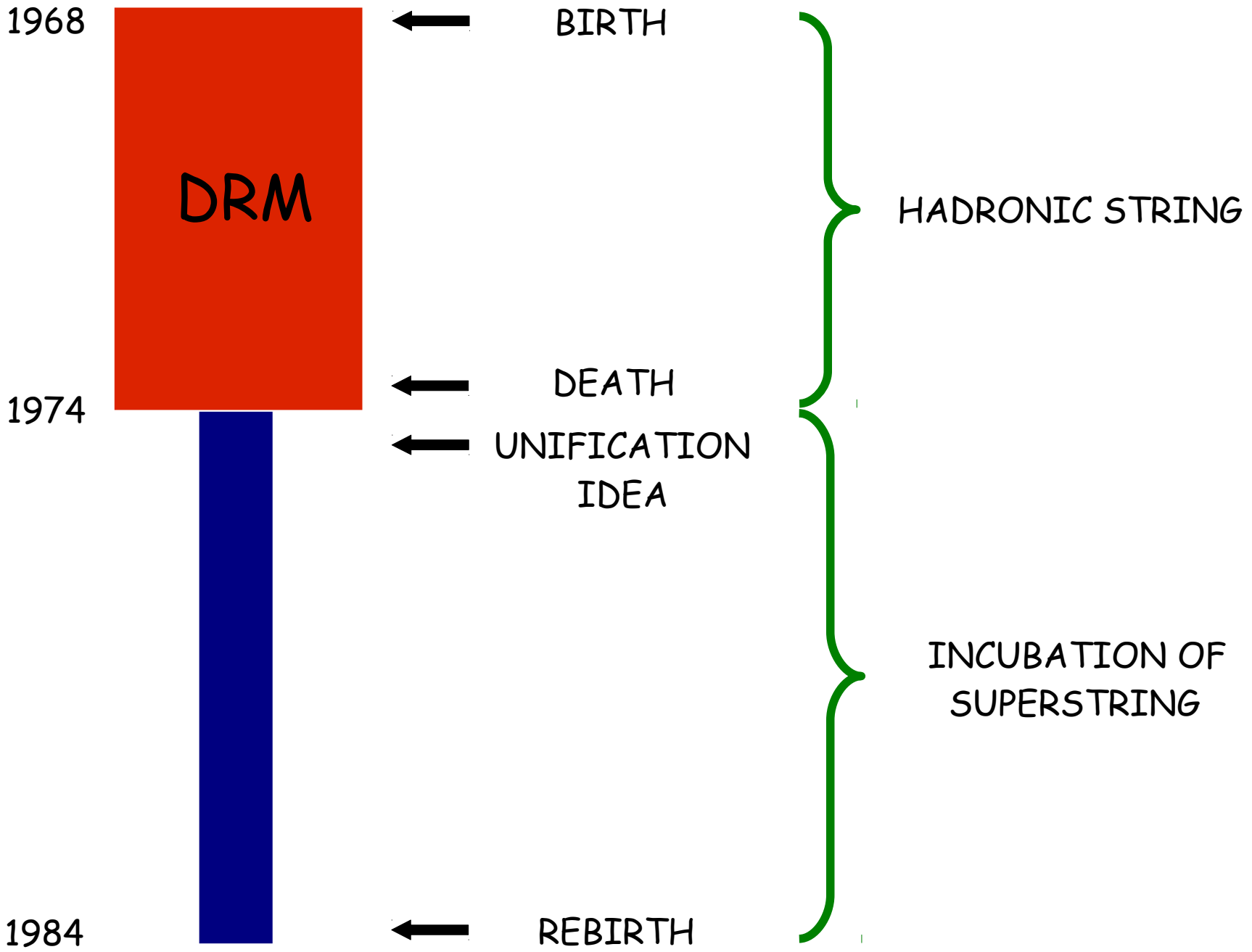
  - initial phenomenological appeal was replaced by fascination for the beautiful structure of the theory (stemming from two-dimensional conformal symmetry)

- Reasons to die (1974)

  - $D = 26$

  - $\alpha_0 = 1, 2$ i.e. massless particles with spin 1 and 2

  - soft scattering  Deep Inelastic Scattering & QCD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Superstring unification (1974)

- the $\alpha' \to 0$ limit shows that string theory is an extension of field theory rather then an alternative to it

- the remaining particles are massless with spin one and two

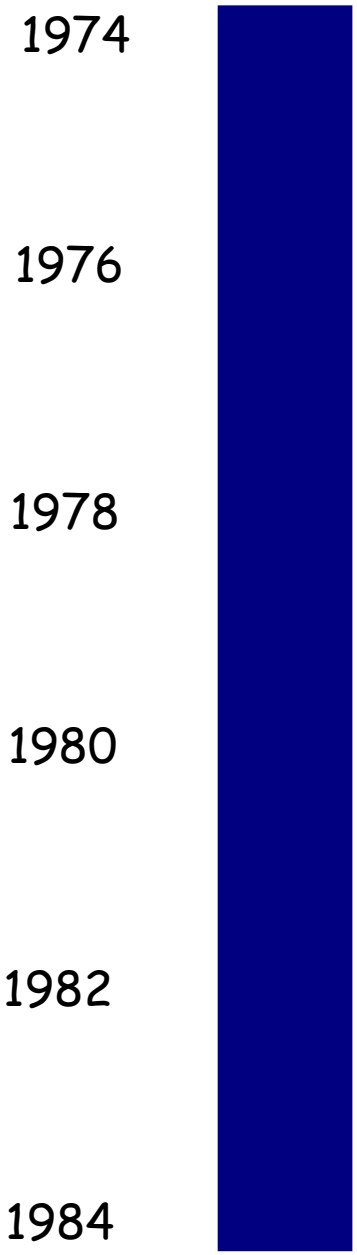
- the superstring is consistent quantum mechanically

- dynamics of massless particles is uniquely determined:

  - non-Abelian gauge theories for spin one

  - gravity for spin two

→ string theory unifies (predicts) gauge theories and gravity



gauge & gravity unification — *Scherk & Schwarz, Yoneya*

Kaluza-Klein compactification — *Cremmer, Scherk*

open superstring (type I) — *Gliozzi, Scherk, Olive*

RNS string action — *Brink, Di Vecchia, Howe; Deser, Zumino*


1974
1976
1978
1980
1982
1984
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space-time supersymmetry
Wess & Zumino
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supergravity
Freedman, Van Nieuwenhuizen, Ferrara
d=11 supergravity
Cremmer, Julia, Scherk

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supergravity — *Freedman, Van Nieuwenhuizen, Ferrara*

d=11 supergravity — *Cremmer, Julia, Scherk*

modern convariant quantization — *Polyakov*

IIA & IIB closed superstrings — *Green & Schwarz*

gravitational anomalies — *Alvarez-Gaumé & Witten*

anomaly cancellation in type I — *Green & Schwarz*

heterotic strings — *Gross, Harvey, Martinec, Rohm*

Calabi-Yau compactifications — *Candelas, Horowitz, Strominger, Witten*

Superstring

- Reasons to be reborn (1984)

  Unification of gauge theories and gravity beyond the Standard Model, with:

  - chiral fermions without chiral anomalies
  - supergravity without infinities
  - five (six) consistent theories

A source of many ideas

- supersymmetry and extra dimensions
- theoretical physics ⟷ many areas of mathematics
- conformal field theory
  gauge/gravity correspondence → statistical mechanics
  & condensed matter

→ NEW TOOLS in theoretical physics ←

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"~~Rock & Roll~~ String theory saved my physicist's life " (Wim Wenders)

A Case Study

- Historians and philosophers of science want to understand/categorize how research in (recent) theoretical physics is done:

  - characterize `models' vs `theories'

  - role of experiments

  - interplay with mathematics

  - generalizations, analogies, conjectures

  - research networks

  - interplay with society and the cultural and political period

Bibliography

- Book web page: http://theory.fi.infn.it/colomo/string-book/

- Three choral books on history of fundamental interactions:

  - The Rise of the Standard Model — *(1997) Hoddeson, L., Brown, L. M., Riordan, M., Dresden, M. eds.*

  - Pions to Quarks: Particle Physics in the 50s — *(2009) Brown, L. M., Dresden, M. , Hoddeson, L. eds.*

  - The Birth of Particle Physics — *(2009) Brown, L. M., Hoddeson., L. eds.*

- Other volumes on history & philosophy of string theory (no pop science):

  - Forty Years of String Theory: Reflecting on the Foundations — *(2013) De Haro, S., Dieks, D., 't Hooft, G., Verlinde, E. eds., Foundations of Physics 43*

  - A Brief History of String Theory: from Dual Models to M-Theory — *(2014) Rickles D., Springer*

About history

"The garbage of the past often becomes the treasure of the present (and *vice versa*)"

A. M. Polyakov

"When a good idea is around, many people have it at the same time: the credit goes to the one that explains it better"

S. Fubini

"...although to study the history of physics and to distribute credits is an interesting enterprise, I am not yet prepared for it"

A. M. Polyakov