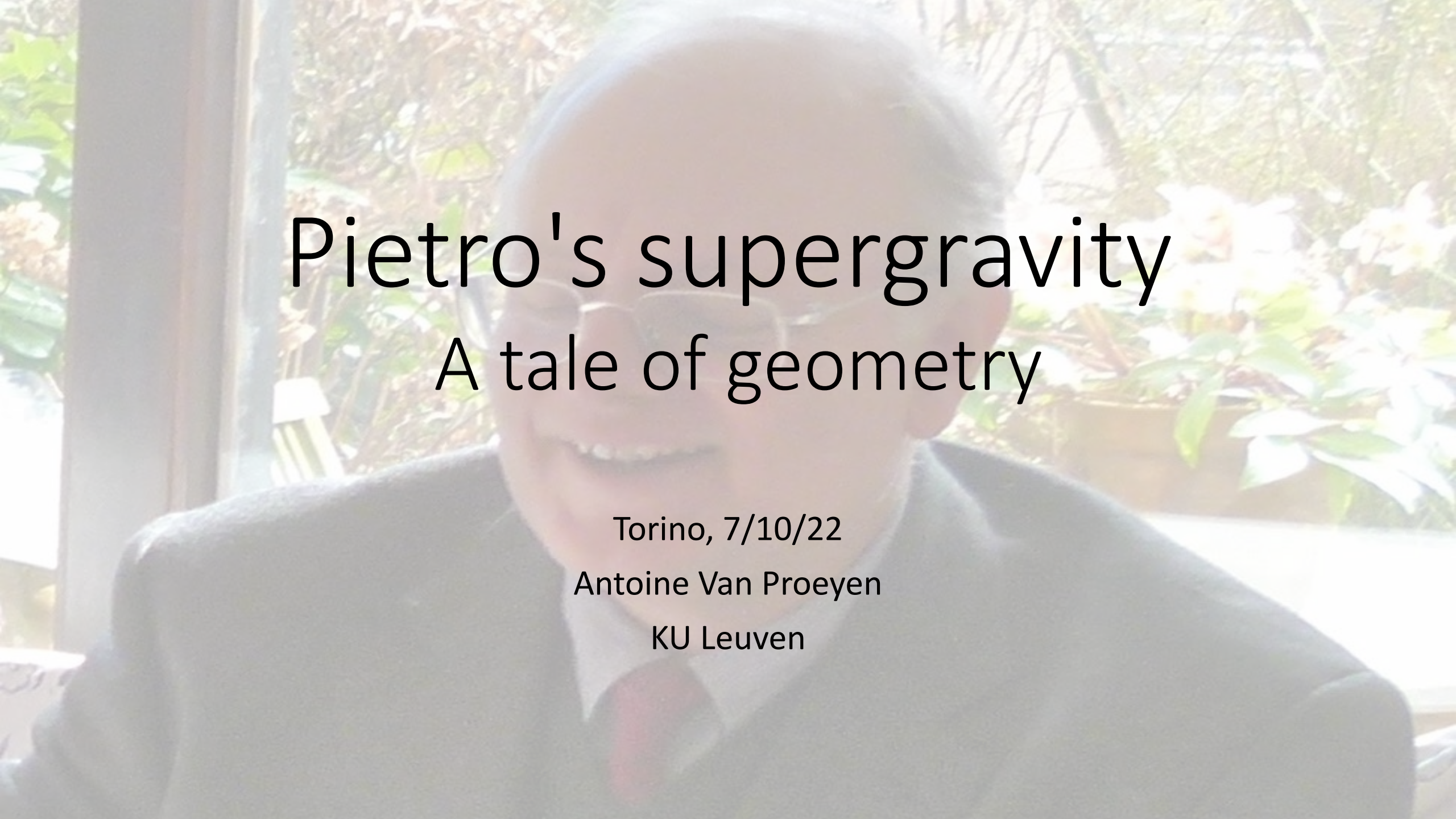


Pietro's supergravity

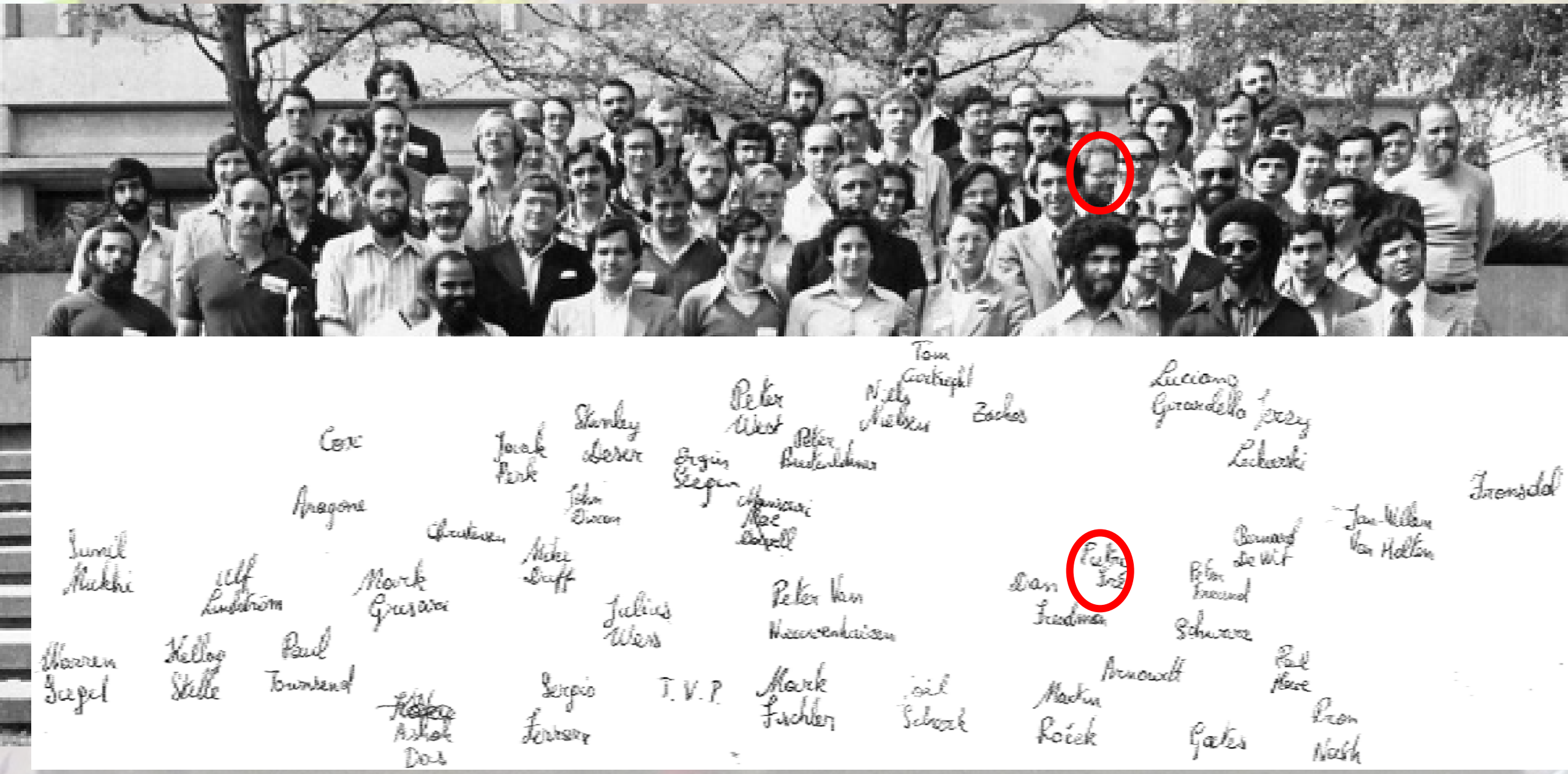
A tale of geometry

Torino, 7/10/22

Antoine Van Proeyen

KU Leuven

Stony Brook 1979



Stony Brook – Torino connection

Independently:
I stayed in Stony Brook for several months in 1979, and started to work on matter couplings in N=1 supergravity

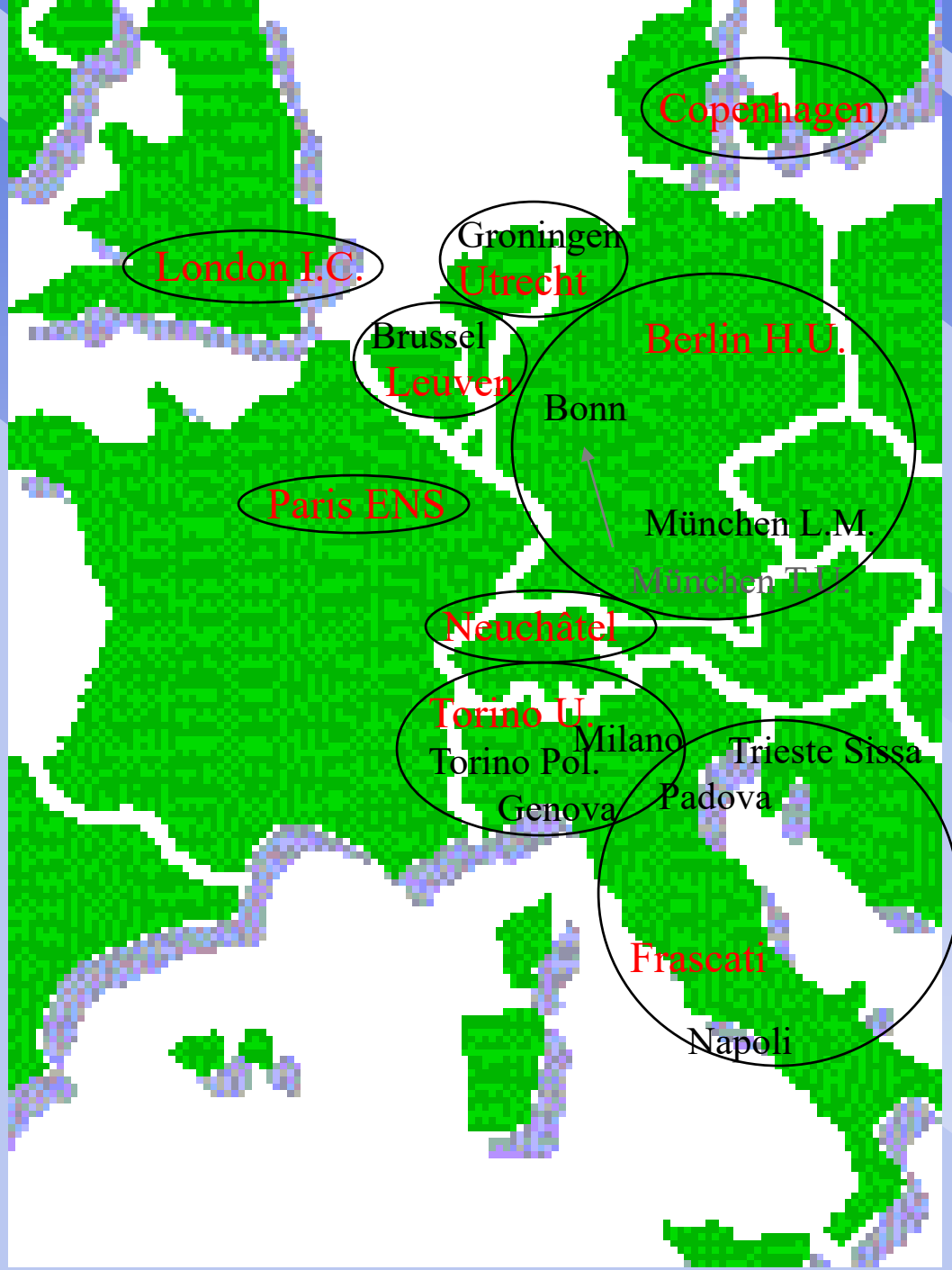
First encounters

- D=11 search for auxiliary fields;
  'the hidden supergroup' (Riccardo D'Auria and Pietro Frè)
- 5 sept. - 8 nov. 1985, Torino, conference in villa Gualino,
  Start of my stay for 2 months.
  Start of friendship with the whole group in Torino.
  I often came, and certainly with much pleasure
- Pietro often came to Leuven.
- EC collaborations

One of our contact persons in European networks

- Gauge theories, applied supersymmetry and quantum gravity, 1/9/1992- 31/8/1996
- Quantum aspects of Gauge Theories, Supersymmetry and Unification, 1/9/1996 - 31/8/2000
- The quantum structure of spacetime and the geometric nature of fundamental interactions, 1/10/2000 - 30/9/2004
- Constituents, Fundamental Forces and Symmetries of the Universe, MRTN-CT-2004-005104, EC Marie Curie, 1/11/2004 - 31/10/2008,

Structure of the network



9 main nodes

10 subcontractors

Slide mid-term meeting 1998, Corfu

Contact person meetings were occasions to meet

pictures , sept 2003, Kobenhavn: network contact person meeting

Contact person meetings

Barcelona, 2004

Present continuations of network activities

- networks were the start of European string workshops;
  2023: nr. 25: Oviedo – Gijon
  (there was already a SCIENCE contact meeting in Torino in 1994)
- Schools
  now yearly CERN winter school

1999	TMR School	Leuven 18-23 jan
2000	TMR School	Torino 2000 26 Jan-2 Feb
2001	RTN School	PARIS 2001 1-7 Feb
2002	RTN School	Utrecht 2002 17-22 Jan
2003	RTN School	Torino 2003 7-11 Jan
2004	RTN School	Barcelona 2004 12-16 Jan
2005	MRTN School	TRIESTE 2005 31 Jan-4 Feb
2006	MRTN School	CERN
...	"CERN winter school"	

- Common Postdoc applications.
  First time 1998-99. Still continuing.

- Many scientific collaborations

Dubna

we all hope that these friendly encounters with the Russians will come back

Herwig Schopper,CERN Director-General from 1981 to 1988.

"*what I consider most important is to prepare for the situation after the war. Somehow and sometime there will be a solution to the Russian invasion. On that "day after", it will be necessary to talk to each other again and build a new world out of the ruins. This was facilitated after World War II because, despite the Nazi reign of terror, some far-sighted scientists maintained human relations as well as scientific ones….*

A vision for the day after requires courage and more Science for Peace than ever before. "

Different methods for supergravity

- Noether method (Stony Brook)
- Superspace
- Group manifold, R. D'Auria, **P. Frè**, T. Regge
  (or rheonomic approach)
- superconformal tensor calculus

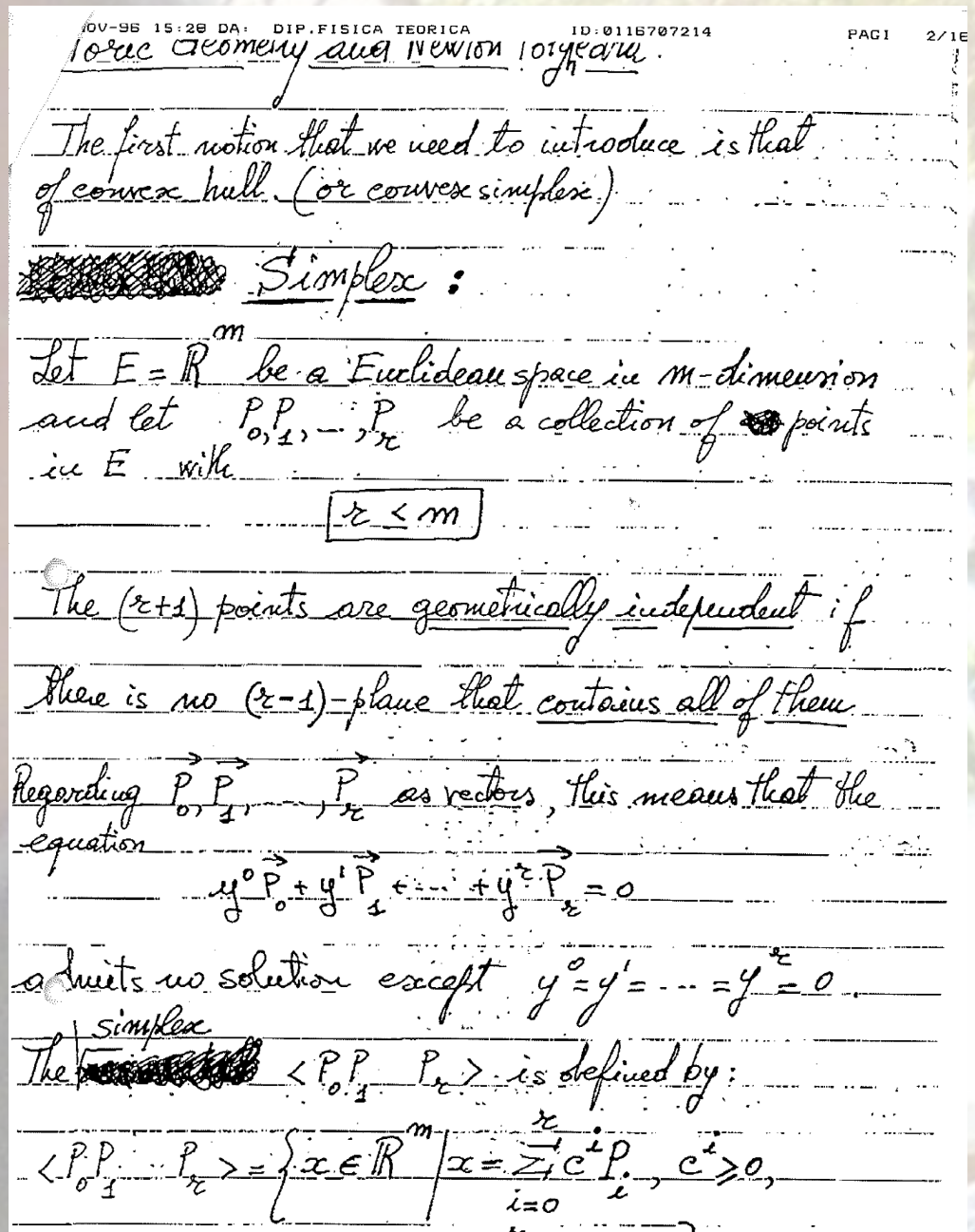
Structures are related and can easily be compared.
Collaborations were easy.

Collaborations

- Mostly in context of N=2 supergravity.
- Because there the geometry plays a big role.
- Pietro is expert in applications of geometry and Lie groups in physics

Papers with Pietro and me

- 1995: M. Billò, R. D'Auria, S. Ferrara, **P. Frè**, P. Soriani, AVP,
  R symmetry and the topological twist of N=2 effective supergravities of heterotic strings
- 1996: M. Billò, A. Ceresole, R. D'Auria, S. Ferrara, **P. Frè**, AVP,
  A Search for nonperturbative dualities of local N=2 Yang-Mills theories from Calabi-Yau threefolds
- 1998: M. Billò, F. Denef, **P. Frè**, I. Pesando, W. Troost, AVP, D. Zanon
  - A detailed case study of the rigid limit in Special Kähler geometry using K3
  - Special geometry of Calabi-Yau compactifications near a rigid limit
  - The rigid limit in Special Kähler geometry; From K3-fibrations to Special Riemann surfaces: a detailed case study



Papers with Pietro and me

- **1999:** M. Billò, S. Cacciatori, F. Denef, **P. Frè**, AVP, D. Zanon
  The 0-brane action in a general D = 4 supergravity background
- **2003: P. Frè**, M. Trigiante, AVP
  - Stable de Sitter vacua from N=2 supergravity
  - N=2 supergravity models with stable de Sitter vacua
- **2006: P. Frè**, F. Gargiulo, J. Rosseel, K. Rulik, M. Trigiante, AVP
  Tits-Satake projections of homogeneous special geometries

N=2 supergravity-matter

- supergravity multiplet: spin $(2, \frac{3}{2}, \frac{3}{2}, 1)$
- n gauge multiplets : $n * (1, \frac{1}{2}, \frac{1}{2}, 0, 0)$
- m hypermultiplets $m * \left(\frac{1}{2}, \frac{1}{2}, 0, 0, 0, 0\right)$

Important features:

- R-symmetry: $SU(2) \times U(1)$
- *(n+1)* vectors , which will imply duality transformations in *Sp(2(n+1))*
- *n* complex scalars, transforming under the *U(1):* Kähler manifold, but due to the symplectic symmetry: extra structure: Special Kähler manifold
- *m* quaternion scalars*:* transforming under the *SU(2):* Quaternionic-Kähler manifold

Geometry became clear after several steps:

Potentials and symmetries of general gauged N = 2 supergravity-Yang-Mills models,
B. de Wit, AVP, April 1984

Vector multiplets coupled to N = 2 supergravity :
super-Higgs effect, flat potentials and geometric structure
E. Cremmer, C. Kounnas, AVP, J.P. Derendinger, S. Ferrara, B. de Wit, L. Girardello, Sept 1984

Lagrangians of N = 2 supergravity-matter systems,
B. de Wit, P. Lauwers, AVP, Dec. 1984

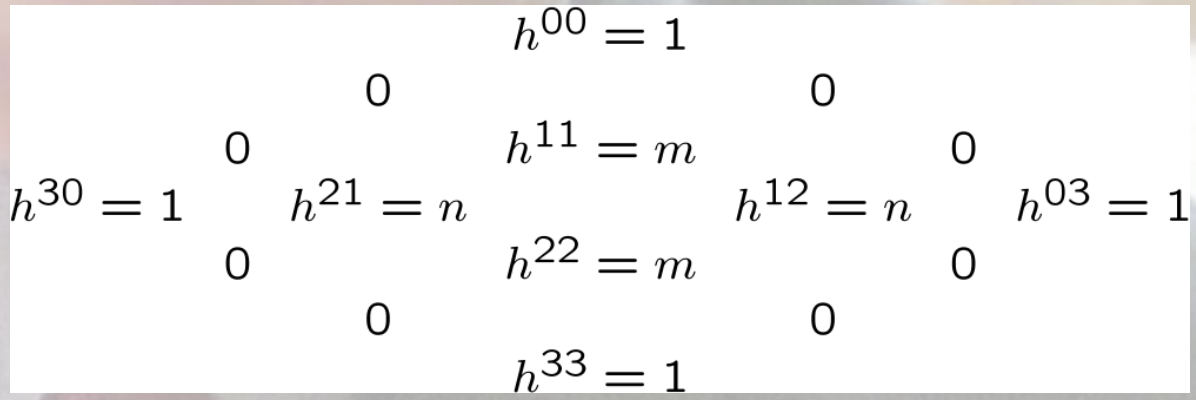
Special Kähler Geometry: An intrinsic formulation from N=2 Space-time Supersymmetry,
L.Castellani, R. D'Auria and S. Ferrara, Febr. 1990

Duality Transformations in Supersymmetric Yang-Mills Theories coupled to Supergravity,
A. Ceresole, R. D'Auria, S. Ferrara, AVP, 9502072

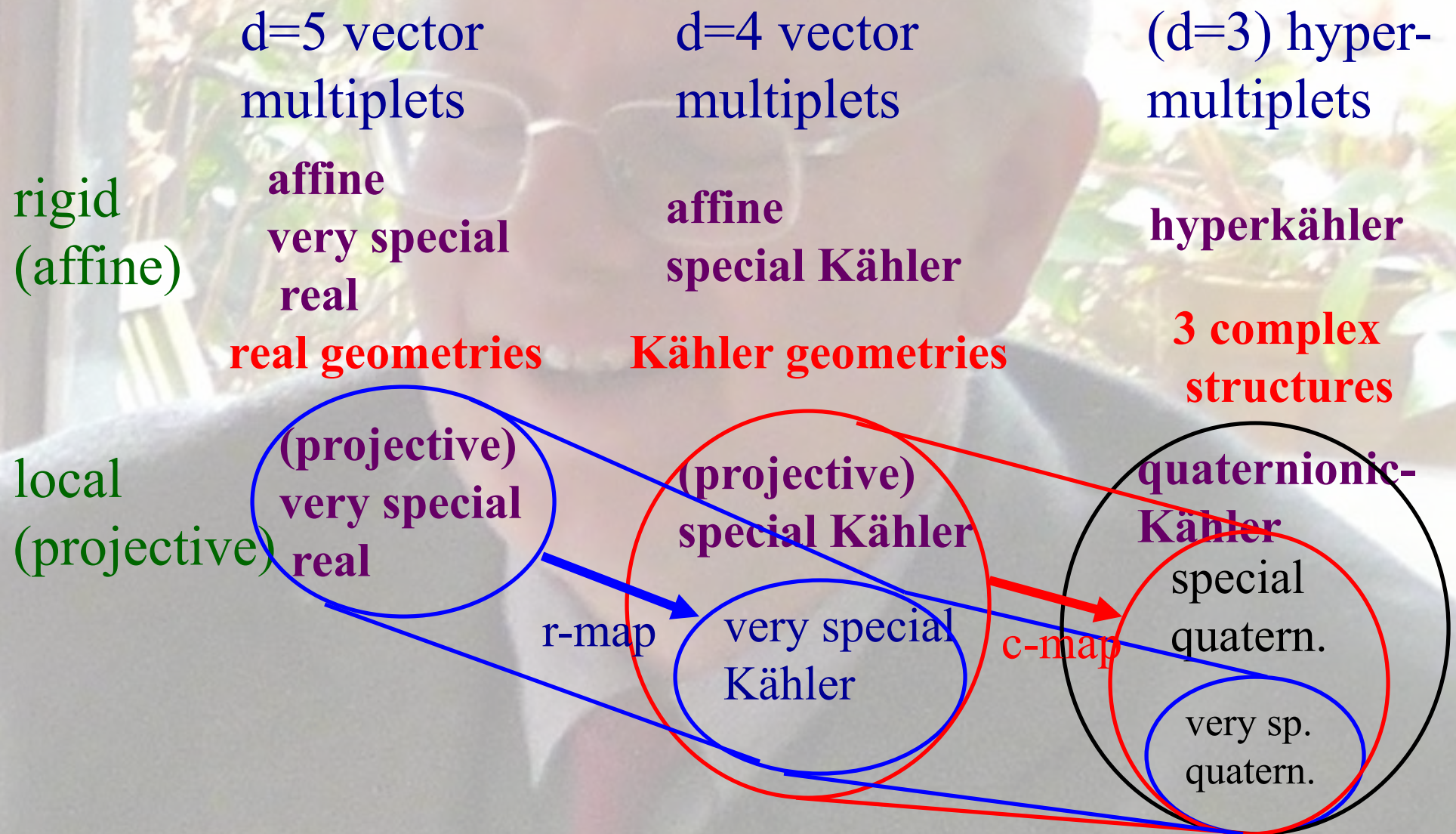
N=2 Supergravity and N=2 Super Yang-Mills Theory on General Scalar Manifolds: Symplectic Covariance, Gaugings and the Momentum Map
L.Andrianopoli, M.Bertolini, A. Ceresole,
R. D'Auria, S.Ferrara, **P.Frè**, T. Magri, 9605032

In string theory from moduli of Calabi-Yau manifolds

- Special Kähler scalars are the complex structure moduli of Calabi-Yau manifolds
- complex 3-dim manifolds with (p,q) forms with Hodge diamond



The family of special geometries from reductions of multiplets in d=5,4,3



Homogeneous, symmetric ?

- In general, these special manifolds are not homogeneous spaces.
- But there are homogeneous manifolds called $L(q,P)$ or $L(4n,P,\dot{P})$
  These are in 1-to-1 correspondence with representations of
  P irreps of Euclidean real Clifford algebras in dimension $q+1$.

Special geometry, cubic polynomials and homogeneous quaternionic spaces,
B. de Wit, AVP, 9112027

- For special values of q,P: symmetric

	real	Kähler	quaternionic
$L(-1,0)$	$SO(1,1)$	$\left[\frac{SU(1,1)}{U(1)}\right]^2$	$\frac{SO(3,4)}{(SU(2))^3}$
$L(0,P)$	$SO(1,1)\otimes\frac{SO(P+1,1)}{SO(P+1)}$	$\frac{SU(1,1)}{U(1)}\otimes\frac{SO(P+2,2)}{SO(P+2)\otimes SO(2)}$	$\frac{SO(P+4,4)}{SO(P+4)\otimes SO(4)}$
$L(1,1)$	$\frac{S\ell(3,R)}{SO(3)}$	$\frac{Sp(6)}{U(3)}$	$\frac{F_4}{USp(6)\otimes SU(2)}$
$L(2,1)$	$\frac{S\ell(3,C)}{SU(3)}$	$\frac{SU(3,3)}{SU(3)\otimes SU(3)\otimes U(1)}$	$\frac{E_6}{SU(6)\otimes SU(2)}$
$L(4,1)$	$\frac{SU^*(6)}{Sp(3)}$	$\frac{SO^*(12)}{SU(6)\otimes U(1)}$	$\frac{E_7}{SO(12)\otimes SU(2)}$
$L(8,1)$	$\frac{E_6}{F_4}$	$\frac{E_7}{E_6\otimes U(1)}$	$\frac{E_8}{E_7\otimes SU(2)}$

making contact with

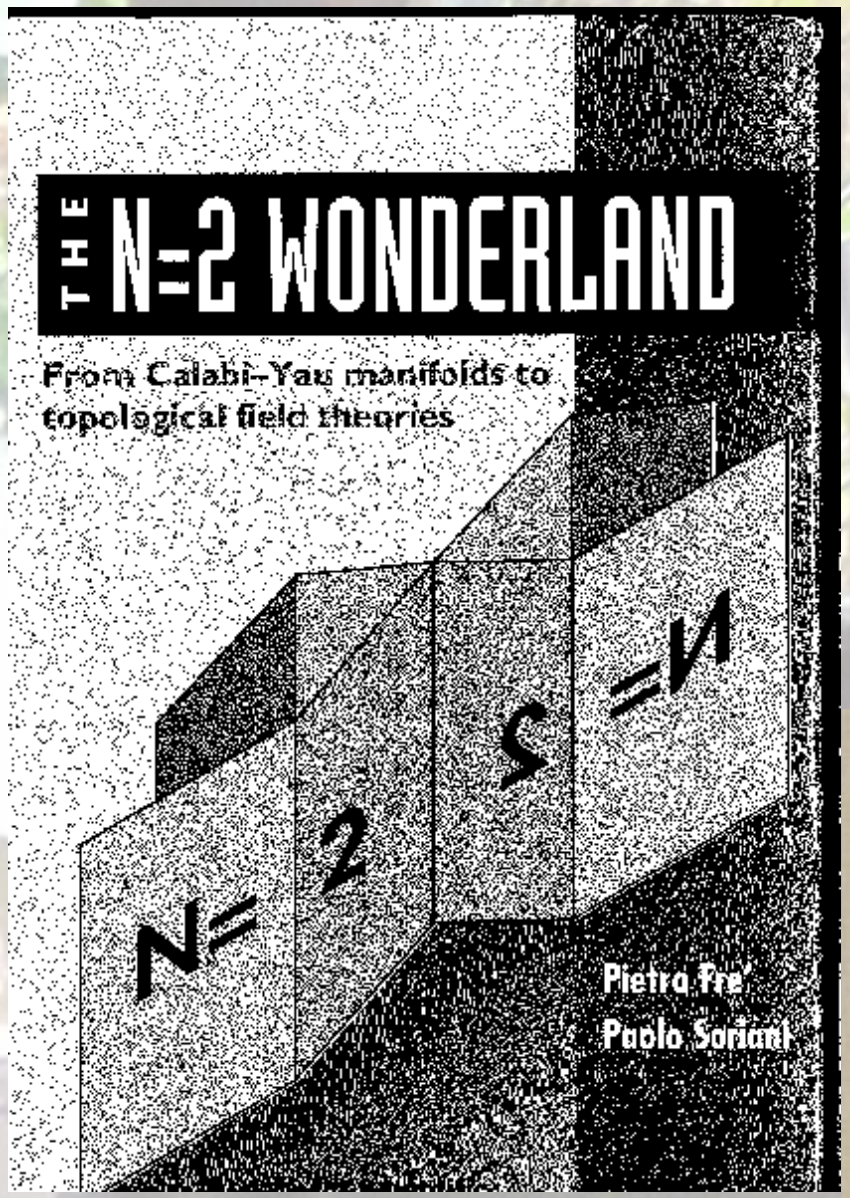
Exceptional supergravity theories and the magic square,
M. Günaydin, G. Sierra, P. Townsend, 1983

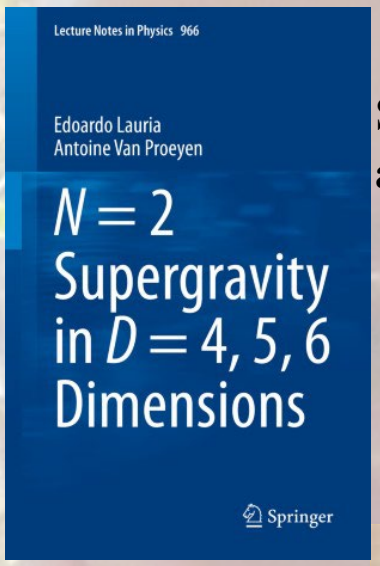
Further studied in our last paper with Pietro

Tits-Satake projections of homogeneous special geometries
P. Frè, F. Gargiulo, J. Rosseel, K. Rulik, M. Trigiante, AVP, 0606173

- Tits-Satake projection of simple algebras (defining the real forms). Extended to all solvable Lie algebras occurring in the homogeneous special geometries.
  These then act as isometries of these homogeneous spaces.
- makes use of Paint groups, first looked at in the context of *billiard cosmologies*
  (*Paint group = compact group, commuting with the generating solvable algebra*)
  in string theory interpretation : permutation of coloured branes

Structure of $N=2$ contains much more





Springer book, or
arxiv 2004.11433

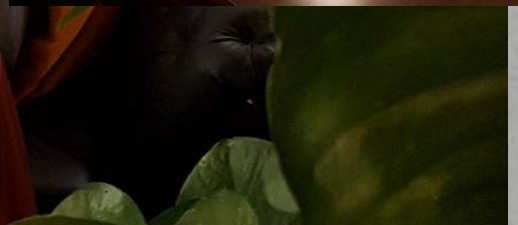
Recently

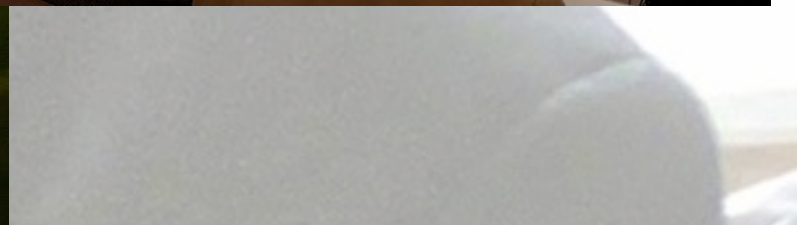
- new possibilities for supersymmetry breaking, using new types of Fayet-Iliopoulos terms.
- new conformal multiplets, allowing higher-derivative terms and off-shell formulations for supersymmetric localization.

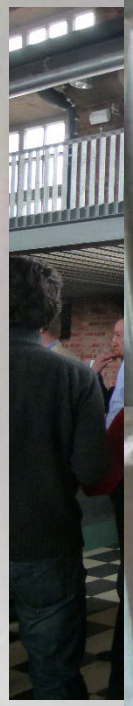
Many conferences

- 2005: The legacy of supergravity,
  in honour of Sergio Ferrara,
  Villa Mondragone

2016: GGI, workshop "Supergravity in Action"








BURGERHUIS
ORVAL
Duvel

And now …

- participate to what you like, and refrain from other obligations.

- Pietro, enjoy the memories and the future (your N=2 life) !