# In memory of József Zimányi

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**(HUN-REN WIGNER RCP)**

**Zimányi Winter School, Budapest, 1 December 2025**

# ZIMÁNYI SCHOOL 2025

I. Csók: Lightning over Balaton

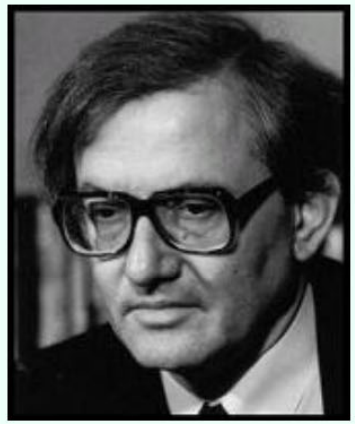
**25th ZIMÁNYI SCHOOL**

**WINTER WORKSHOP**

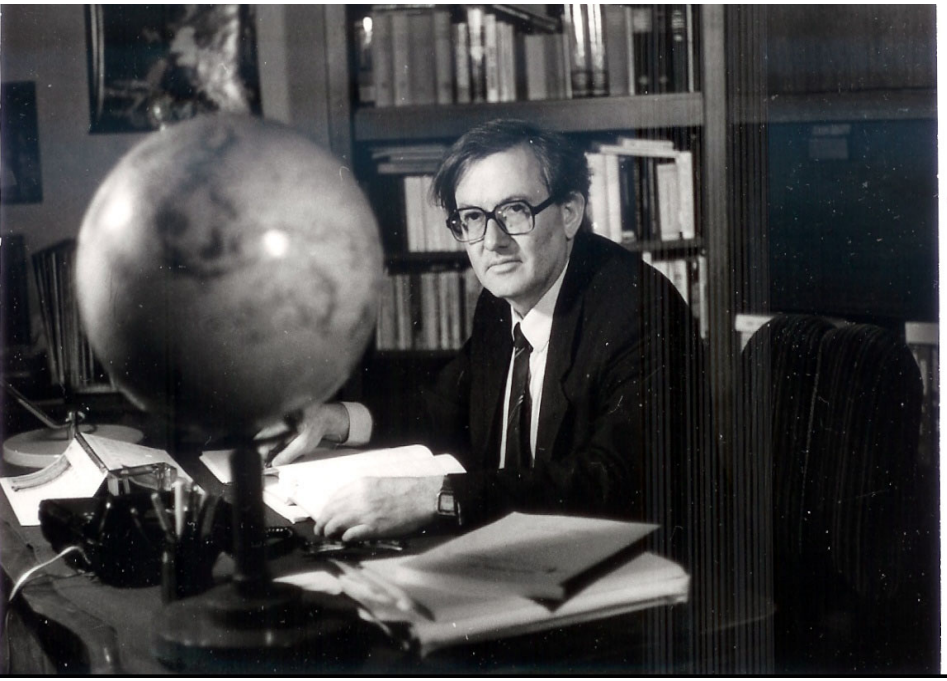
**ON HEAVY ION PHYSICS**

**December 1-5, 2025**

**Budapest, Hungary**



József Zimányi (1931 - 2006)



**Zimányi József (1931 - 2006) [‚Jozsó']**
**Member of the HAS (1990, 1995)**
**Széchenyi Prize (2000)**
**Officer's Cross of**
**the Hungarian Order of Merit (1992)**

**Zimanyi Medal awardees:**

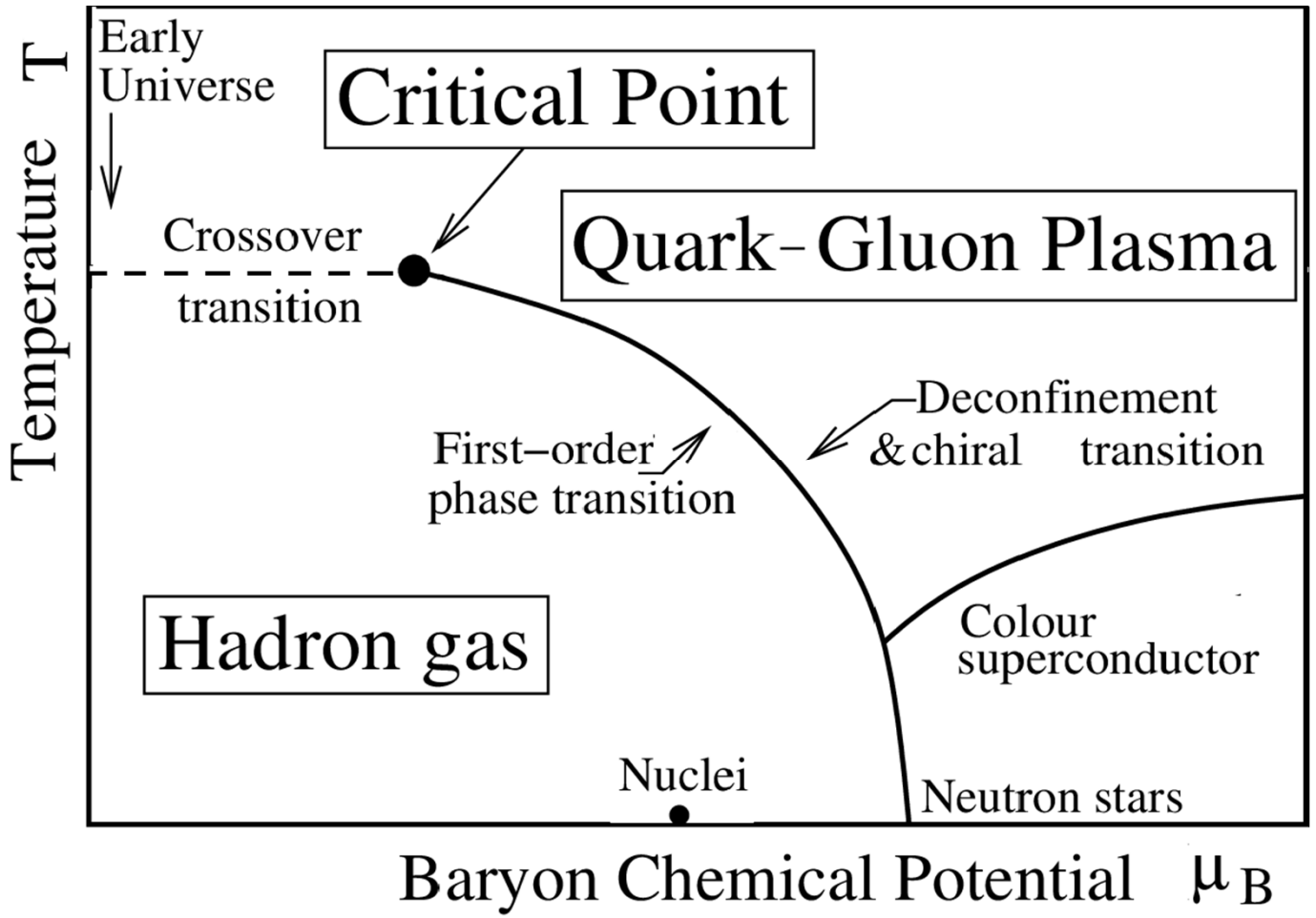
**2011 Tetsufumi Hirano§**
**2012 Péter Petreczky§**
**2014 Toumas Lappi**
**2015 Chihiro Sasaki***
**2017 Björn Schenke***
**2018 Hannah Elfner***
**2019 Aleksi Kurkela***
**2021 Sören Schlichting**
**2023 Gabriel Silveira Denicol***
**2025 Attila Pasztor§**
**2027 ???**

# The key periods in József Zimányi's scientific carrier:

1. 1954 – 74: ELTE → KFKI, Dept. of Atomic Physics, supervised by Károly Simonyi, …
   → → 1972: KFKI RMKI, Dept. Of Theoretical Physics
   Exp: Angular correlation in decays and parity of atomic nucleus
   The: Analytical treatment of DWBA, stripping matrix elements [PLB, 84 cit.]
   1973 – 84: Head of the KFKI RMKI Dept. of Theoretical Physics
2. 1969 – 78: Visiting Niels Bohr Institute, Prof. Jacob Bondorf
   → Neural networks [1978] (CsernaiL, BíróT)
   → Analytic hydrodynamic model for expanding fireballs [1978] (BondorfJ)
   → Hadrochemistry [1979] (Montvayl)
   → Bose-condensation [1979] (FaiG)
   → Thermodynamics/hydrodynamics in HIC [1980] (LukácsB, ……)
3. 1978 – 93: Heavy ion collisions at low and intermediate energies (theory+exp)
   → Quarkochemistry, QGP formation [1982] (BíróT)
   → Relativistic mean-field theory for hadronic matter [1984] (FRA, LévaiP, …)
   → Pion correlation [1990] (CsörgőT, …)
   → Quark coalescence for rehadronization [1993](BiróT, CsörgőT, LévaiP, …)
4. 1992 – 2006: CERN physics, NA49 member, scientific delegate to CERN Council, …
   → TH analysis of data from CERN NA49, RHIC PHENIX and STAR.

**Mission of József Zimányi in his last 30 years:**

**to describe the properties of the strongly interacting matter and to understand the phasetransition between the different regions.**

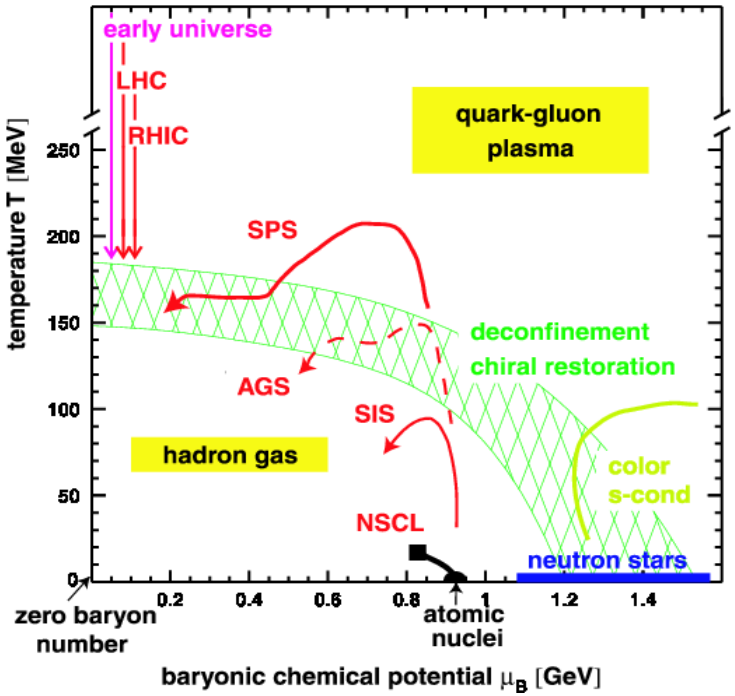


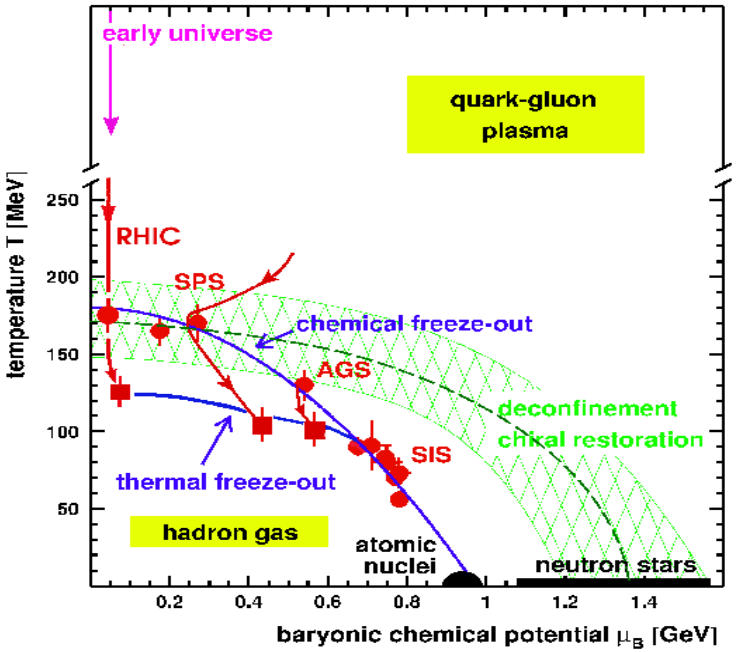
# What did I learn from Jozsó ?

- **Relativistic hydrodynamics (in equilibrium and for stationer state)**
- **Relativistic thermodynamics, entropy, conserved quantities**
- **Field theory and phenomenology**
- **Equation of state**
- **Phase transitions in multicomponent systems**
- **The applicability of phenomenological models (and their limit)**
- **The nature of mesoscopic systems**
- **Boundary/overlap between micro and macro**

- **➔ ➔ Hadronmatter – QGP phase transition**
  **Cross-over phase transition?**
  **Confinement mechanism ? Description ?**

# The description of heavy ion collisions in a dinamical frame based on thermodynamics and hydrodynamics.




## Compression period

## Expansion period

**Large segment of information will be lost in the compression and the expansion time-period, if the final hadronic cocktail is really in thermal and chemical equilibrium.**

# ALCOR: Algebric Coalescence and Rehadronization model (1993-2006)

## J, Zimányi, T.S. Biró, P. Lévai, T. Csörgő

## MICOR: Microscopical Coalescence and Rehadronization model (1996-2008) [If charm is not in equilibrium !]

## P. Lévai, P. Csizmadia

literature | find au levai and au zimanyi and title coalescence

ALCOR: A Dynamic model for hadronization #1

T.S. Biro (Budapest, RMKI), P. Levai (Budapest, RMKI), J. Zimanyi (Budapest, RMKI) (Nov, 1994)

Published in: *Phys.Lett.B* 347 (1995) 6-12

DOI | cite | claim | reference search | 162 citations

Quark liberation and coalescence at CERN SPS #2

J. Zimanyi (Budapest, RMKI), T.S. Biro (Budapest, RMKI), T. Csorgo (Budapest, RMKI), P. Levai (Budapest, RMKI) (Apr, 1999)

Published in: *Phys.Lett.B* 472 (2000) 243-246 • e-Print: hep-ph/9904501 [hep-ph]

pdf | DOI | cite | claim | reference search | 88 citations

Quark coalescence in the mid-rapidity region at RHIC #3

T.S. Biro (Budapest, RMKI), P. Levai (Budapest, RMKI), J. Zimanyi (Budapest, RMKI) (Dec, 2001)

Published in: *J.Phys.G* 28 (2002) 1561-1566 • Contribution to: 6th International Conference on Strange Quarks in Matter: 2001: A Flavorspace Odyssey (SQM2001) • e-Print: hep-ph/0112137 [hep-ph]

pdf | DOI | cite | claim | reference search | 40 citations

Particle spectra from the ALCOR model #4

J. Zimanyi (Budapest, RMKI), T.S. Biro (Budapest, RMKI), T. Csorgo (Budapest, RMKI), P. Levai (Budapest, RMKI) (May, 1996)

Published in: *Acta Phys.Hung.A* 4 (1996) 15-32 • Contribution to: Workshop on Strangeness in Hadronic Matter (Strangeness 96) • e-Print: hep-ph/9609328 [hep-ph]

pdf | DOI | cite | claim | reference search | 17 citations

Simple predictions from ALCOR(c) for rehadronization of charmed quark matter #5

P. Levai (Budapest, RMKI), T.S. Biro (Budapest, RMKI), T. Csorgo (Budapest, RMKI), J. Zimanyi (Budapest, RMKI) (Jul, 2000)

Published in: *New J.Phys.* 2 (2000) 32 • e-Print: hep-ph/0007247 [hep-ph]

pdf | DOI | cite | claim | reference search | 6 citations

## CERN SPS NA49 : Pb+Pb at 200 GeV/nucl

## ALCOR prediction based on S+S results in 1996

## Strangeness'96 Conference, Budapest

**Table 1.** Particle numbers: prediction of ALCOR model for the Pb+Pb collision and the results of full equilibrium thermal models, 'Thermal I-II'.

| Pb+Pb | ALCOR | Thermal I. | Thermal II. |
|---|---|---|---|
| $h^-$ | 730.41 | 798.72 | 839.44 |
| $\pi^+$ | 603.87 | 603.97 | 603.54 |
| $\pi^0$ | 618.95 | 620.70 | 619.16 |
| $\pi^-$ | 634.68 | 637.91 | 635.31 |
| $K^+$ | 84.15 | 174.57 | 205.68 |
| $K^0$ | 84.15 | 177.74 | 211.29 |
| $\overline{K}^0$ | 41.65 | 103.10 | 119.46 |
| $K^-$ | 41.65 | 104.86 | 122.69 |
| $K^0_S$ | 62.90 | 140.42 | 165.38 |
| $p^+$ | 170.90 | 141.58 | 129.97 |
| $n^0$ | 188.57 | 148.20 | 133.44 |
| $\Sigma^+$ | 12.86 | 24.21 | 41.27 |
| $\Sigma^0$ | 13.63 | 25.04 | 42.37 |
| $\Sigma^-$ | 14.43 | 25.89 | 43.51 |
| $\Lambda^0$ | 68.20 | 55.87 | 42.37 |
| $\Xi^0$ | 8.82 | 10.92 | 11.99 |
| $\Xi^-$ | 8.89 | 11.09 | 12.31 |
| $\Omega^-$ | 1.48 | 1.56 | 2.92 |
| $\overline{p}^-$ | 25.07 | 13.28 | 14.57 |
| $\overline{n}^0$ | 25.07 | 12.68 | 14.19 |

# Hadronmatter – QGP phase transition C.M. Ko &P. Lévai (1992; 2003)

## Mass of mesons (Rho and Phi) in dense nuclear matter

## Quark coalescence as mechanism to understand the anomalous Antiproton-Pion ratio at RHIC energies

Parton coalescence at RHIC #2

V. Greco (Texas A-M), C.M. Ko (Texas A-M), P. Levai (Budapest, RMKI) (May, 2003)

Published in: *Phys.Rev.C* 68 (2003) 034904 • e-Print: nucl-th/0305024 [nucl-th]

pdf DOI cite claim reference search 583 citations

Parton coalescence and anti-proton / pion anomaly at RHIC #3

V. Greco (Texas A-M), C.M. Ko (Texas A-M), P. Levai (Texas A-M and Budapest, RMKI) (Jan, 2003)

Published in: *Phys.Rev.Lett.* 90 (2003) 202302 • e-Print: nucl-th/0301093 [nucl-th]

pdf DOI cite claim reference search 785 citations

M(T) scaling in dilepton spectrum as a signature for quark - gluon plasma #4

M. Asakawa (Texas A-M and Budapest, RMKI), C.M. Ko (Texas A-M and Budapest, RMKI), P. Levai (Texas A-M and Budapest, RMKI) (1993)

Published in: *Phys.Rev.Lett.* 70 (1993) 398-401

DOI cite claim reference search 32 citations

Rho meson in dense hadronic matter #5

M. Asakawa (Texas A-M and Budapest, RMKI), C.M. Ko (Texas A-M and Budapest, RMKI), P. Levai (Texas A-M and Budapest, RMKI), X.J. Qiu (Texas A-M and Budapest, RMKI) (Oct 1, 1992)

Published in: *Phys.Rev.C* 46 (1992) 4, R1159

DOI cite claim reference search 153 citations

Phi meson in dense matter #6

C.M. Ko (Texas A-M and Budapest, RMKI), P. Levai (Texas A-M and Budapest, RMKI), X.J. Qiu (Texas A-M and Budapest, RMKI), C.T. Li (Taiwan, Natl. Normal U.) (1992)

Published in: *Phys.Rev.C* 45 (1992) 1400-1402

DOI cite claim reference search 51 citations

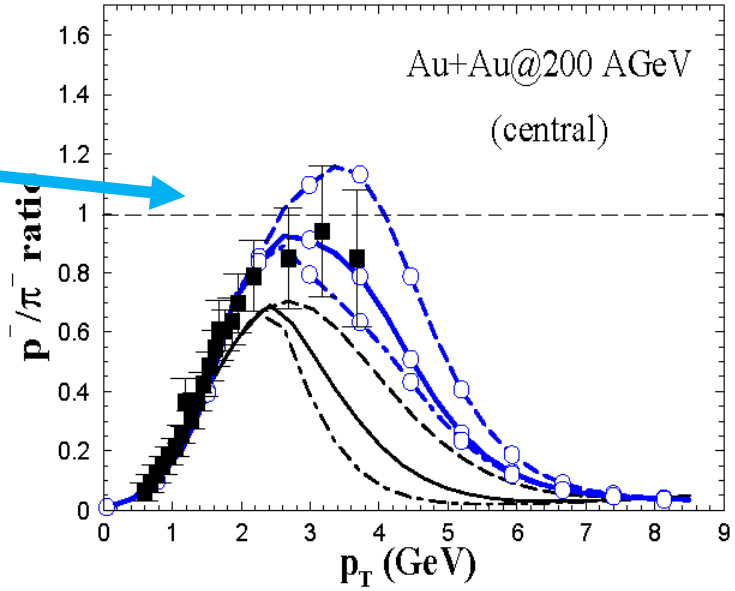


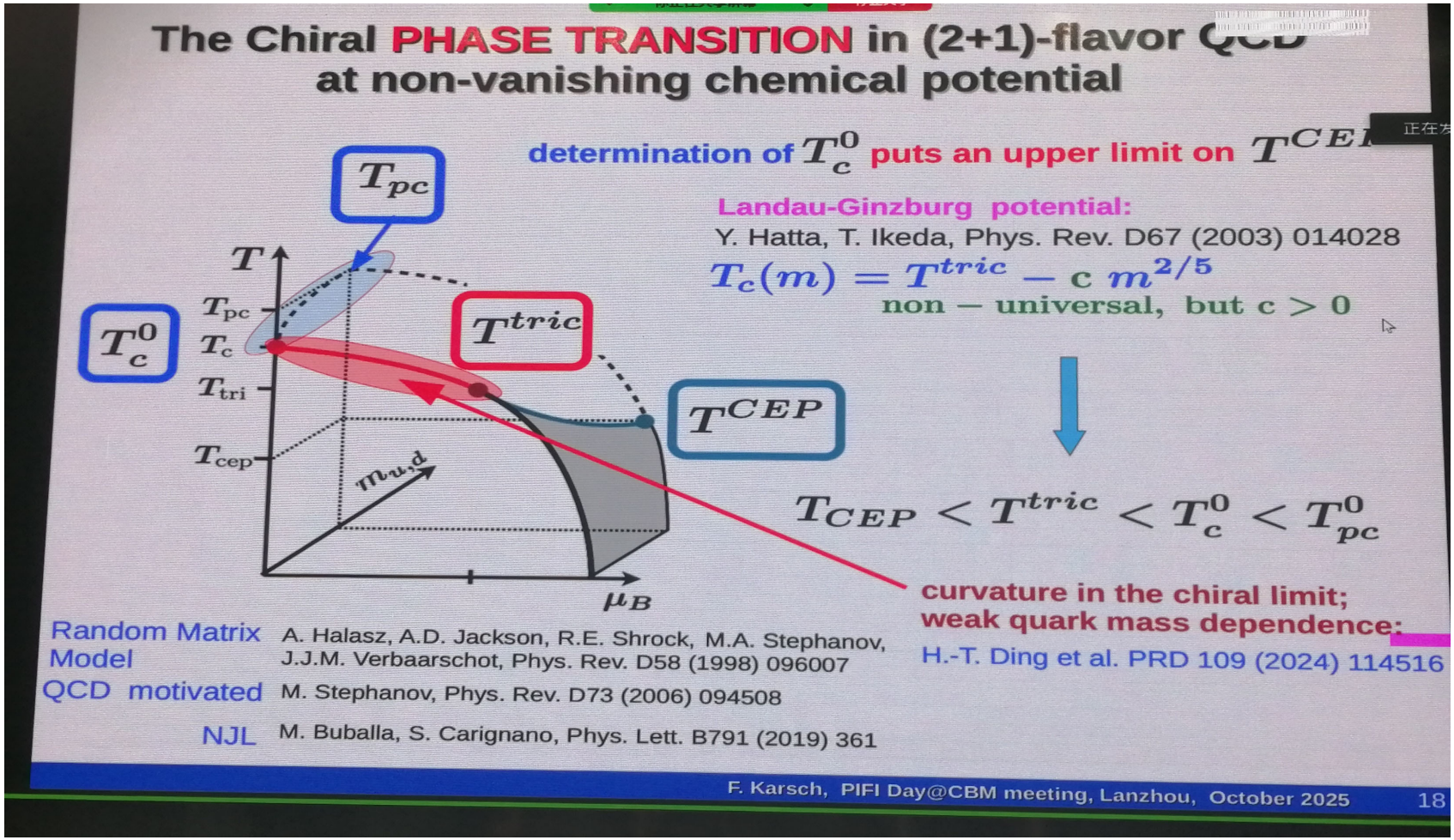

FIG. 3: Antiproton to pion ratios from Au+Au collisions at $\sqrt{s} = 200$ AGeV. Dash-dotted, solid, and dashed curves are results using, respectively, 240, 300, and 340 MeV for the inverse slope parameter of intermediate $p_T$ antiprotons. Corresponding results including also contributions from coalescence of minijet and QGP partons are shown with open circles. Filled squares are the experimental data [11].

Asztal 6:42 2025. 12. 01.

**2025: What do we know about the HM-QGP phase-transition?**

**CHIRAL phase-transition is investigated in details (LQCD, RMM, …., NJL) [Karsch, ,2025]**

**But what about the confinement-deconfinement phase-transition and the hadronization ???**
**What did we learn during last 40 years ??? What Jozsó would think about our results ???**



# What did I learn from Jozsó and his contemporaries?

- Quantummechanics (non-rel. and relativistic)
- Quantum field theory
- Strong interaction
- Basis of QCD
- QCD equation of state
- Understanding lattice QCD results
- Interpretation of experimental data and theoretical predictions

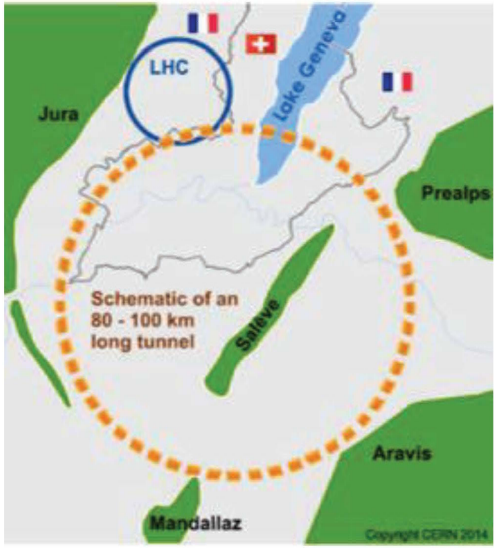
- To look for interesting effects and to realize surprising results
- To finish the comprehension process
- To see the future, well before it would arrive !

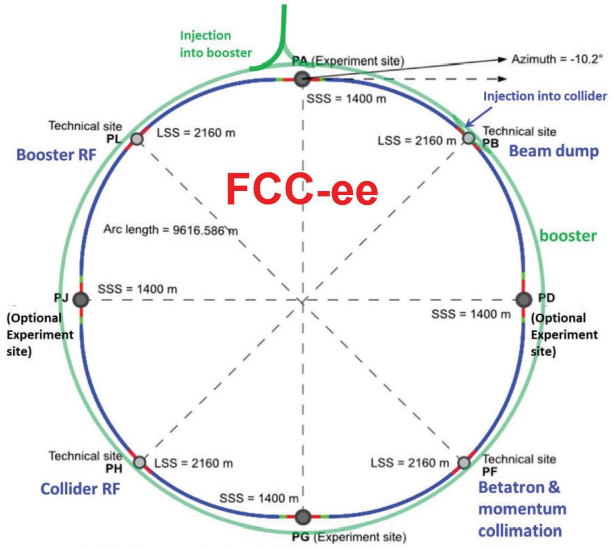
FUTURE CIRCULAR COLLIDER

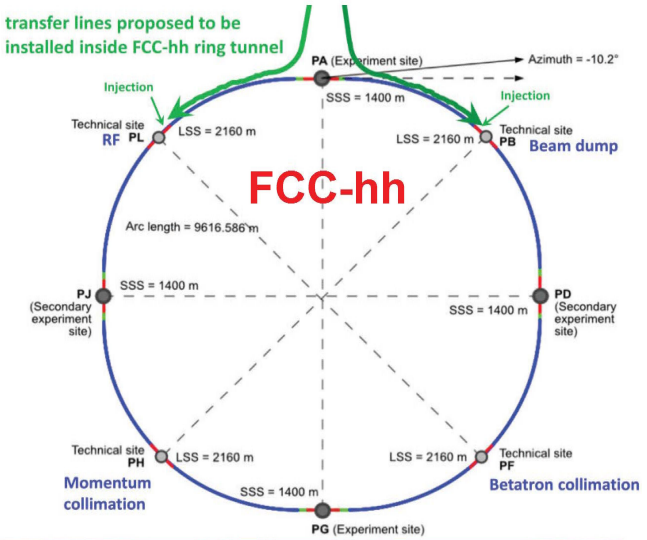
# FCC integrated program

**comprehensive long-term program maximizing physics opportunities**

- **stage 1: FCC-ee (Z, W, H, $t\bar{t}$) as Higgs factory, electroweak & top factory at highest luminosities**
- **stage 2: FCC-hh (~100 TeV) as natural continuation at energy frontier, pp & AA collisions; e-h option**
- highly synergetic and complementary programme boosting the physics reach of both colliders (e.g. model-independent measurements of the Higgs couplings at FCC-hh thanks to input from FCC-ee; and FCC-hh as "energy upgrade" of FCC-ee)
- common civil engineering and technical infrastructures, building on and reusing CERN's existing infrastructure
- FCC integrated project allows the start of a new, major facility at CERN within a few years of the end of HL-LHC



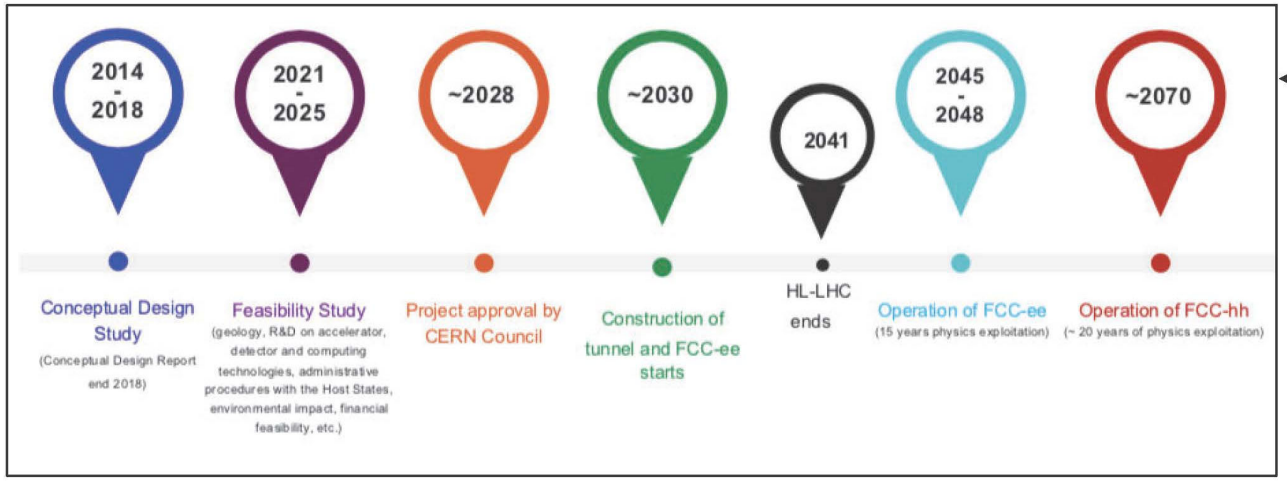




2020 - 2040 | 2045 - 2063 | 2070 - 2095



→ → The 120 year old man

# FCC estimated timeline




**"Realistic" schedule** taking into account:

- ❑ past experience in building colliders at CERN
- ❑ approval timeline: ESPP, Council decision
- ❑ that HL-LHC will run until 2041
- → **ANY future collider at CERN cannot start physics operation before ~ 2045**

**1st stage collider, FCC-ee**: electron-positron collisions 90-360 GeV
Construction: 2033-2045 → Physics operation: 2048-2063

**2nd stage collider, FCC-hh**: proton-proton collisions at ≥ 100 TeV
Construction: 2058-2070 → Physics operation: ~ 2070-2095

**Note:**
Care should be taken when comparing to other proposed facilities, for which in some cases only the (optimistic) technical schedule is shown

# Extraordinary CERN Council meeting: 29 May 2026
# Ratification of ESPP strategy: Gala Hall of MTA, Budapest

**One of**
**the heritage of**
**József Zimányi**

**The next 60 years**
**of HE Nucl. Phys.**