

Pheno and GW group

Alberto Mariotti

IIHE meeting

28 November 2024



VRIJE
UNIVERSITEIT
BRUSSEL

BSM open questions

Many fundamental questions still open ...



Hierarchy problem ?

Force Unification ?

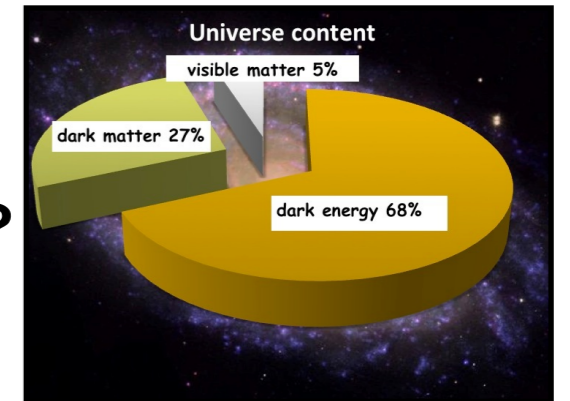
Inflation ?



Dark matter nature?

Flavour hierarchies ?

Baryogenesis ?

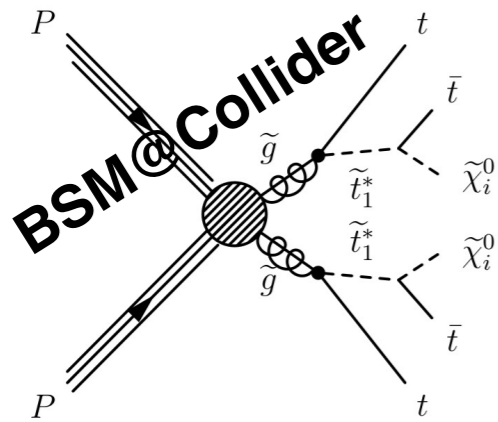


? What's next in Beyond Standard Model physics ?

? What's signal for Beyond Standard Model physics ?

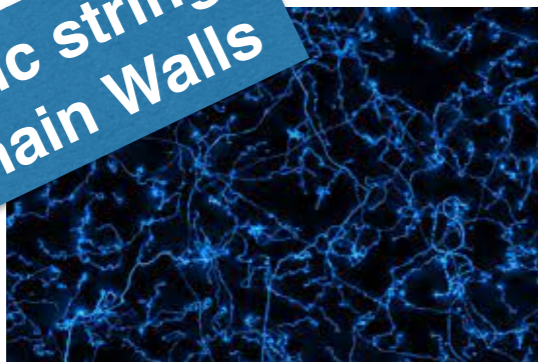
Our research Lines

★ BSM at collider



★ Topological defects

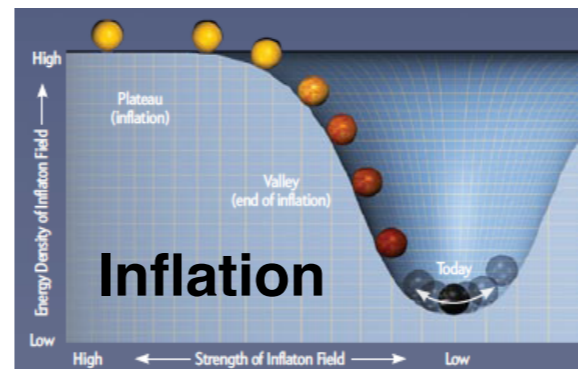
Cosmic strings
Domain Walls



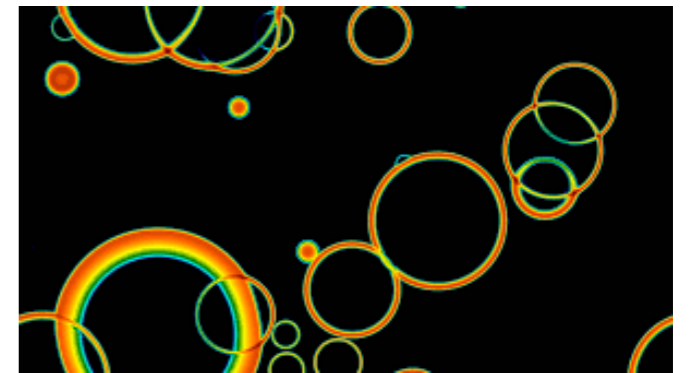
★ Dark Matter



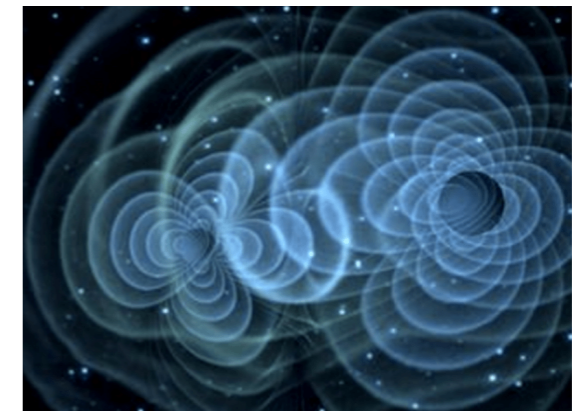
★ Inflation



★ Phase Transitions



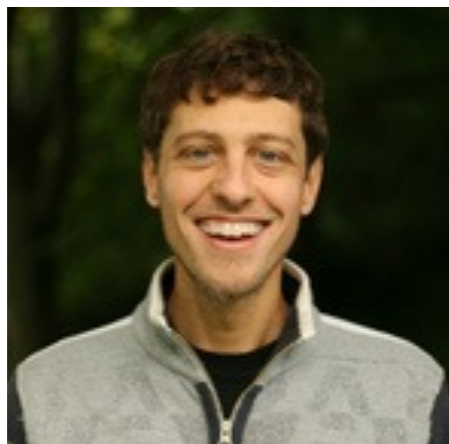
★ GWB and Data analysis for LVK



The group on BSM and GW physics

STAFF

Alberto Mariotti



Mairi Sakellariadou



Guest ZAP

Alex Sevrin



TENA

Miguel Vanvlasselaer



POSTDOC



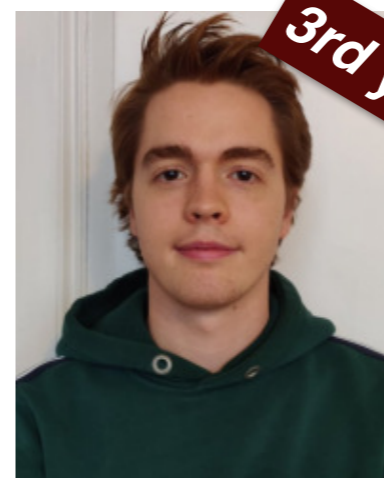
4th Year

Aaron Rase



3rd year

Hannah Duval



3rd year

Xander Nagels



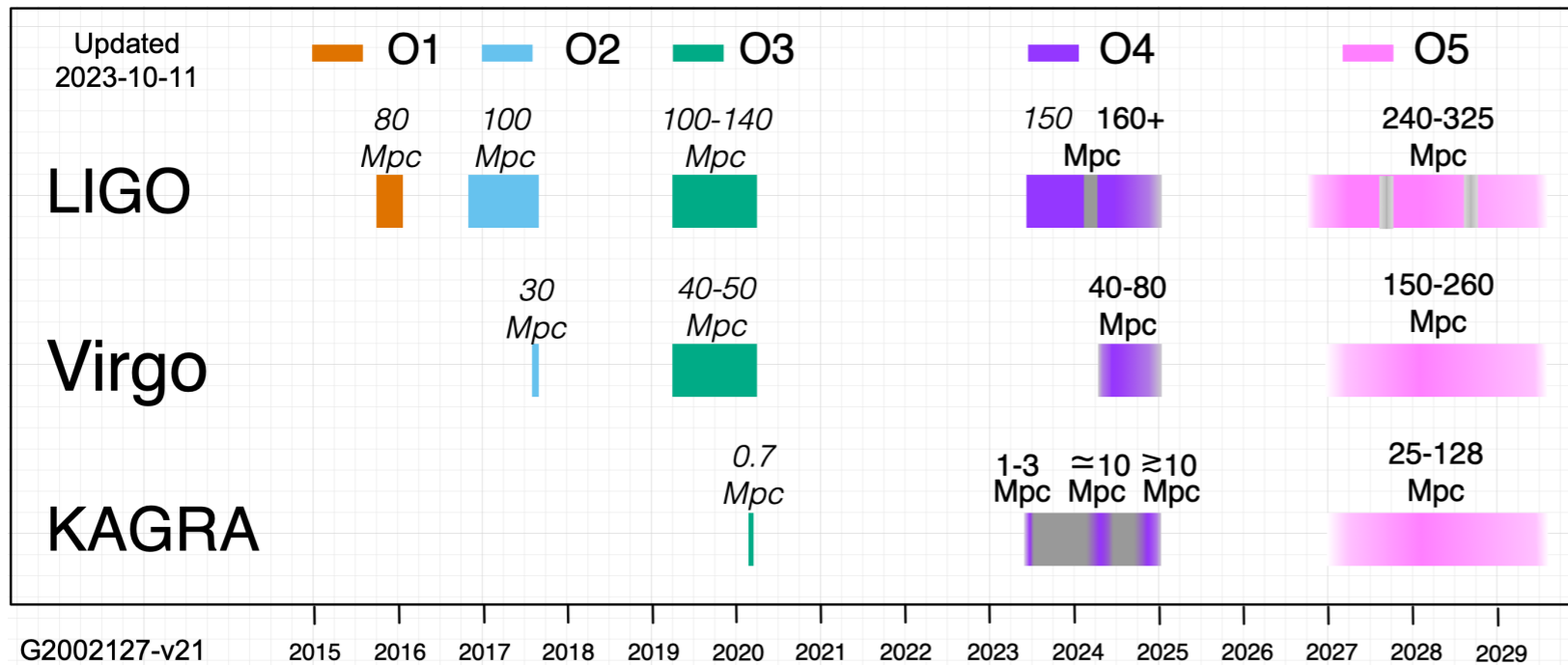
New PhD!

Elise Van den Bossche

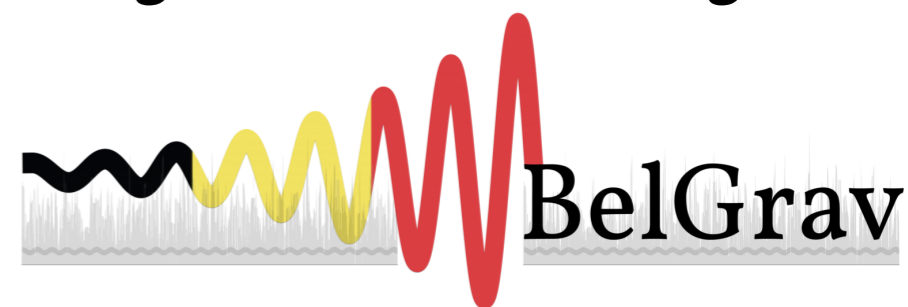
PHD

GW experiments

Members of LIGO-Virgo-Kagra collaboration



Virgo members in Belgium



We also work for future 3G detectors



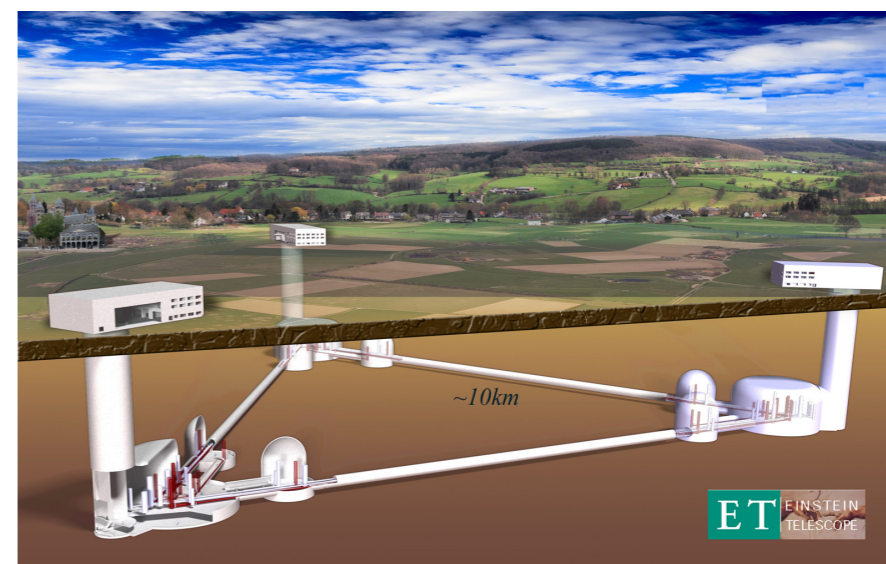
B-PHOT
BRUSSELS
PHOTONICS



Collaboration with B-Phot

<https://www.etpathfinder.eu>

Part of the ET collaboration



Our target: Background of GW

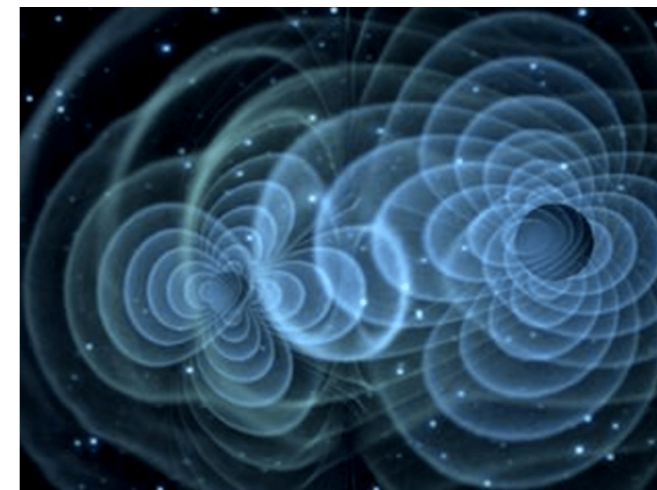
★AstroPhysical SGWB

- * Superposition of unresolvable sources

BBH

BNS

- * Predictable after LIGO/Virgo observations
LIGO/Virgo Phys.Rev.D 100 (2019)

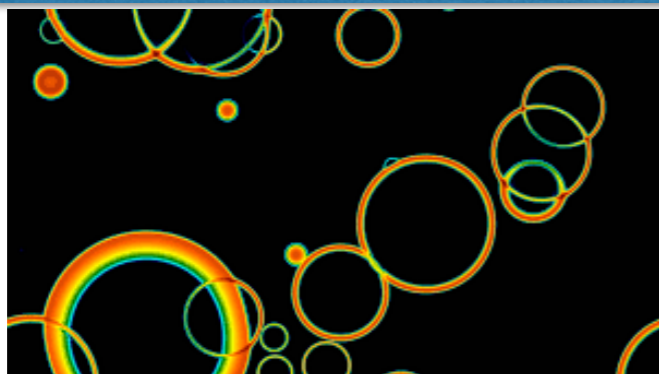


! Most likely measured in next few years in LVK!

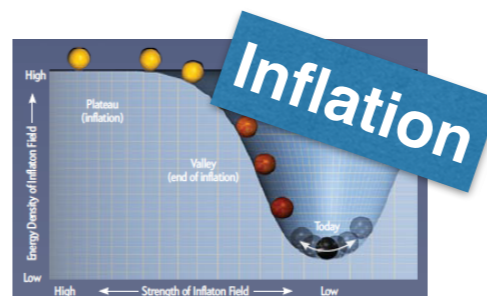
★Cosmological SGWB

- * Generated by energetic events during cosmological evolution

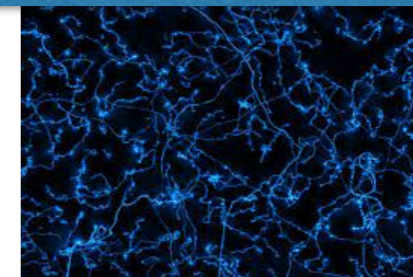
First Order Phase Transitions



arXiv: 1705.01783 D. Weir



Cosmic strings Domain Walls



Explore Universe earlier than CMB!

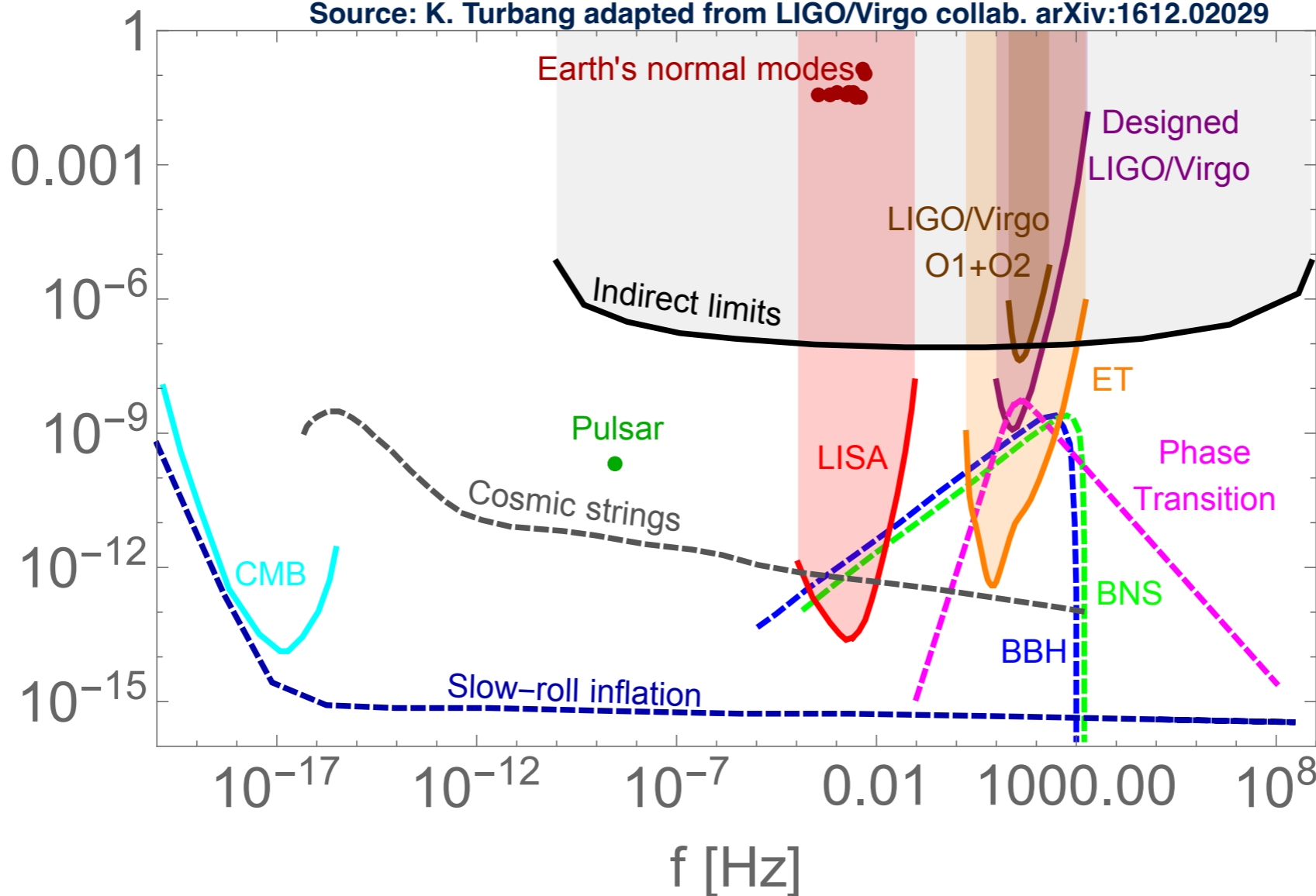
Stochastic Background of GW



WHAT IS IT? *Looks like noise, detected by cross-correlation*
 Allen Romano gr-qc/9710117

Analogue of CMB
 but for GW

Source: K. Turbang adapted from LIGO/Virgo collab. arXiv:1612.02029



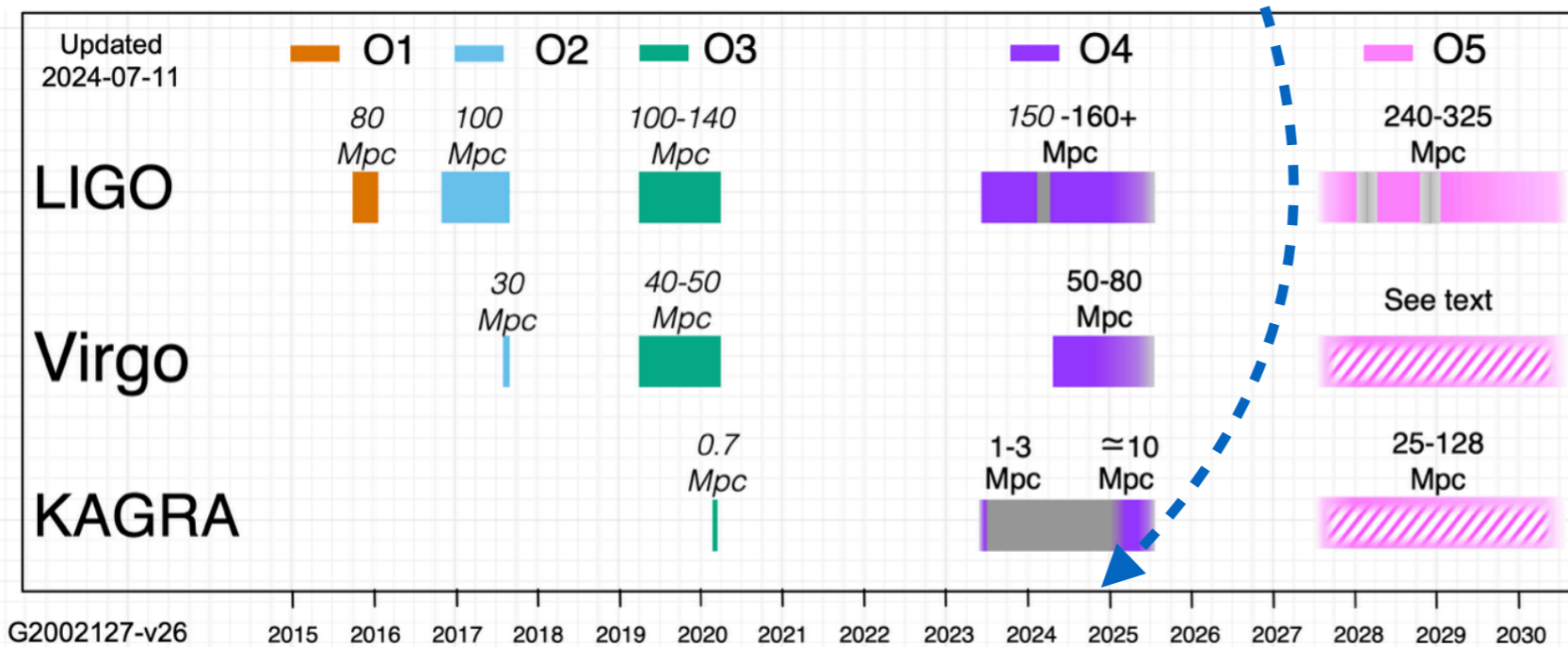
SGWB energy density over critical one



How to disentangle the two?

Flashes of contributions in GW exp.

O4 run is soon finishing



Stochastic LVK Group

★ **Cosmological Implications**

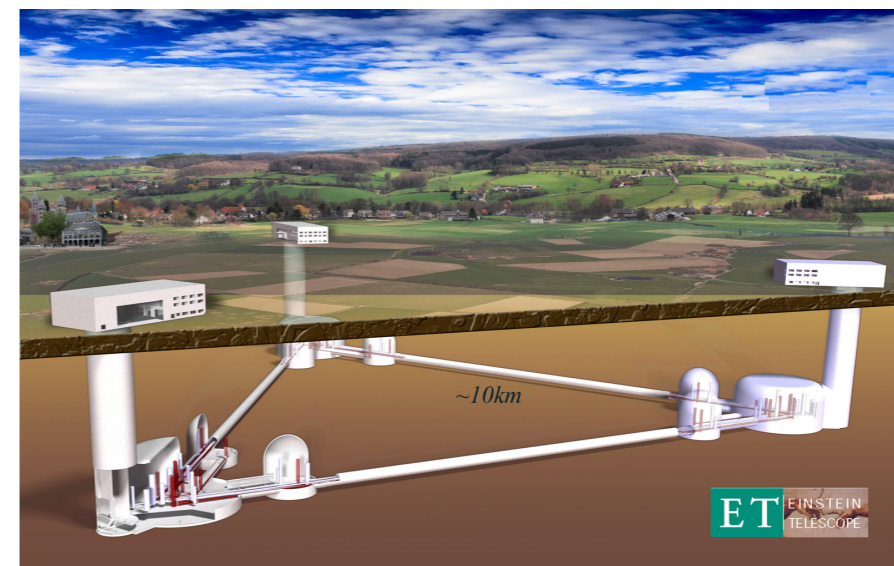
Stay Tuned!

For future 3G detectors



Ask Elise!

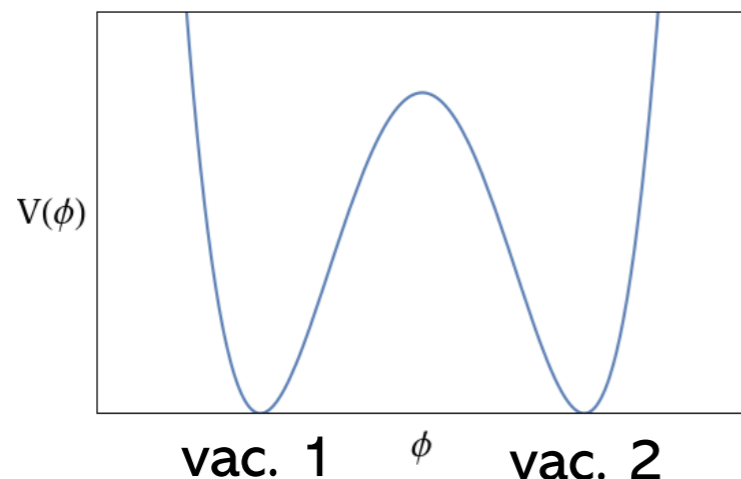
<https://www.etpathfinder.eu>



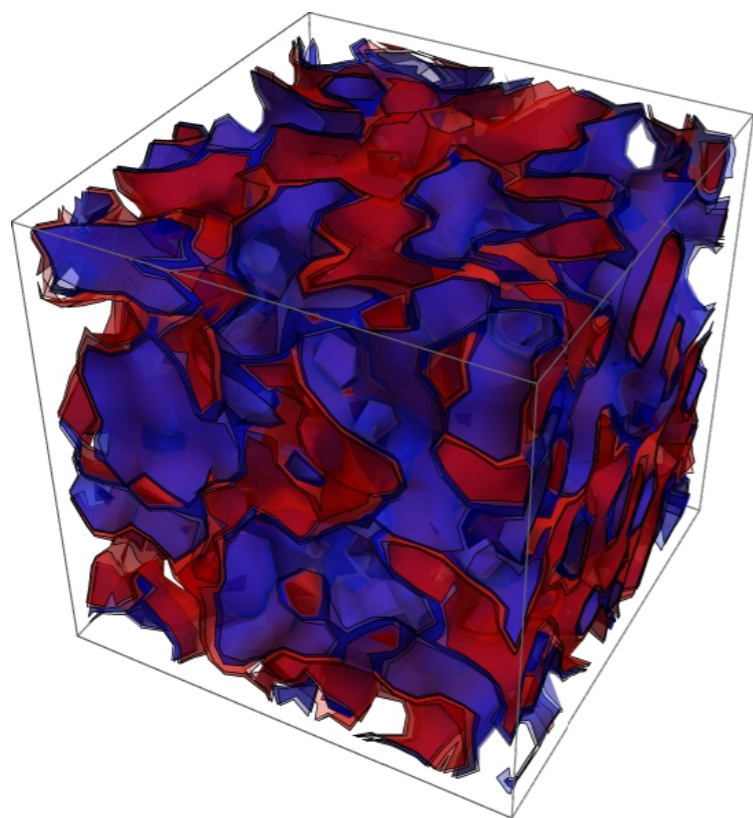
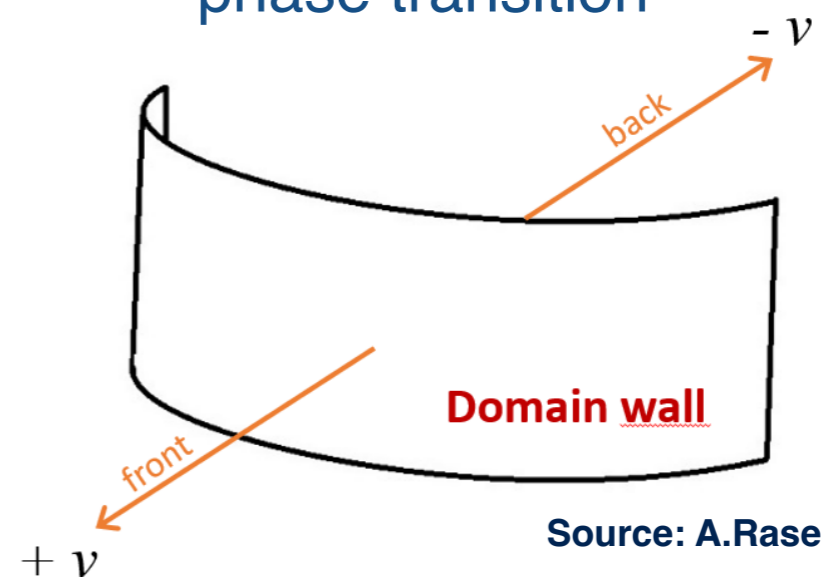
**Contribute to upcoming
ET Blue Book**

Domain Wall dynamics

Theory with discrete symmetry spontaneously broken



Domain Walls get formed at phase transition



- ★ Early Universe can be filled by DW network
- ★ Extended object with large energy density (tension)
- ★ Their dynamics/motion/collapse induce GW
- ★ Generate a background of GW detectable today
- ★ Collapse can also catalyze processes

Domain Wall Genesis

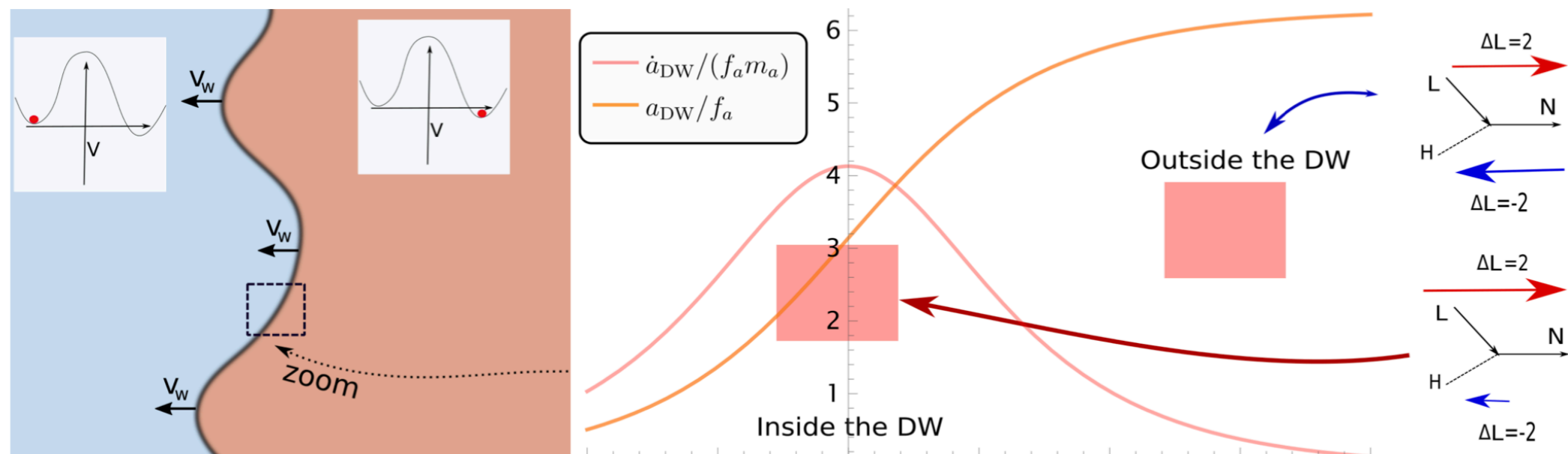
★ *Matter/anti-matter origin is still open question*

- ◆ Possible explanations necessitate BSM physics

New class: Domain Wall genesis of Matter/Anti-matter asymmetry

arXiv: 2411.13494: AM, X. Nagels, A. Rase, M. Vanvlasselaer

- ★ Collapse of domain wall coupled to baryonic current can induce baryon asymmetry and explain matter/anti-matter asymmetry



- ★ GW signal seems to be too faint to be detectable at ET, but ...

Exotic Cosmology imprint in GW

Cosmological history in between end of inflation and BBN is unknown

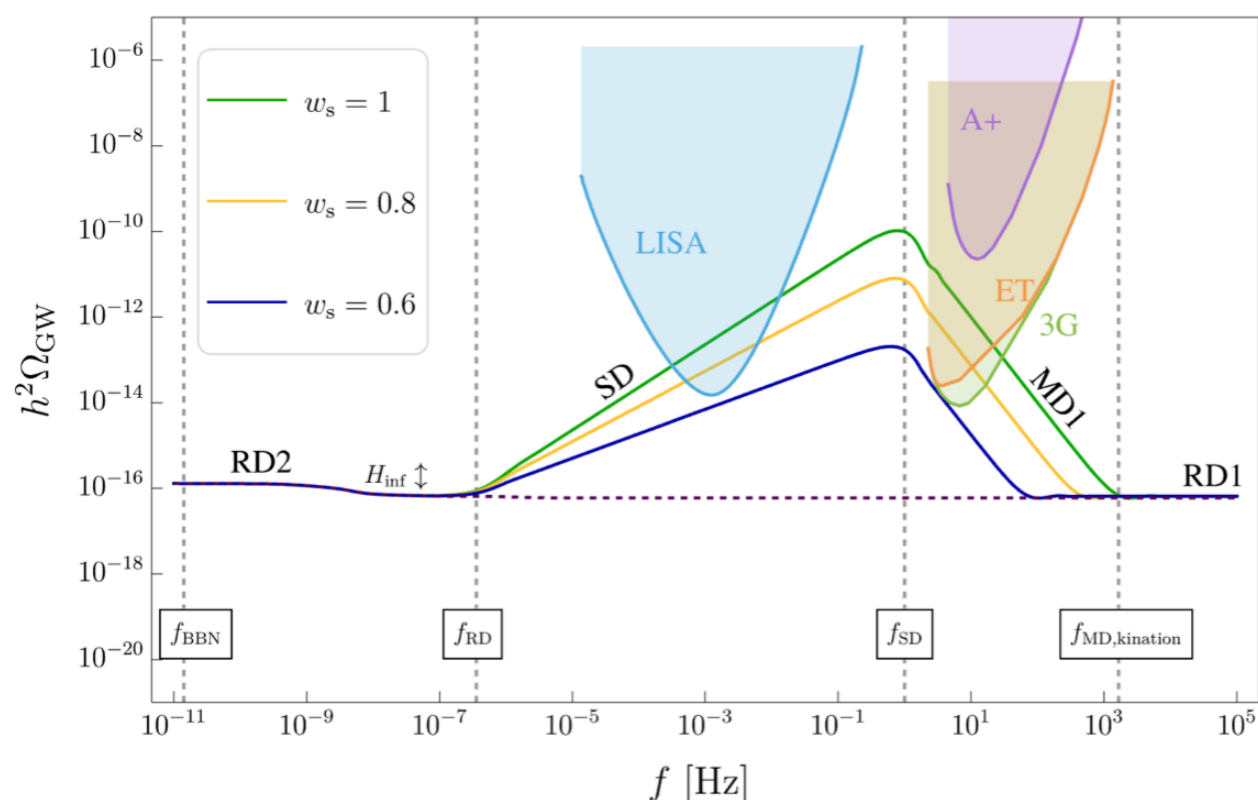
Equation of state of Early Universe
can depart from radiation

$$a(t) \sim t^{\frac{2}{3(1+w)}}$$

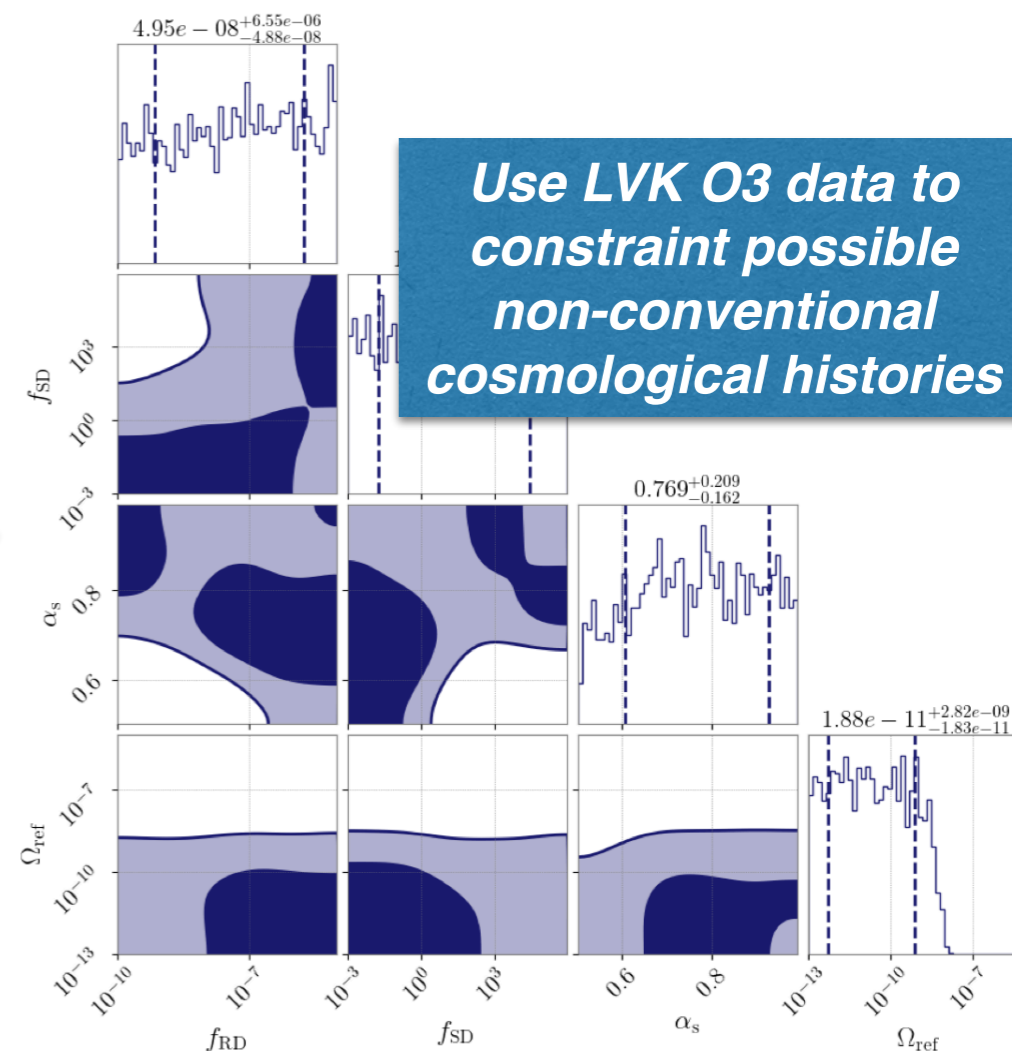
$$w = P/\rho \begin{cases} w = 0 & \text{Matter} \\ w = 1/3 & \text{Radiation} \\ w > 1/3 & \text{Stiff} \end{cases}$$

Exotic eqn of state arise
in axion models or in SUSY

◆ *Different Hubble evolution implies different propagation of primordial GW background*



*Example with a stiff equation period
enhancing the inflationary GW spectrum*



arXiv:2405.10201: H.Duval, S.Kuroyanagi, AM,A.Romero-Rodriguez, M. Sakellariadou

Pheno Life & Network

Common activities with neighbour groups

UCL

Université
catholique
de Louvain

*Large Group
working in LHC
and GW*



Universiteit
Antwerpen

*Group working in
GWB at LVK and ET*



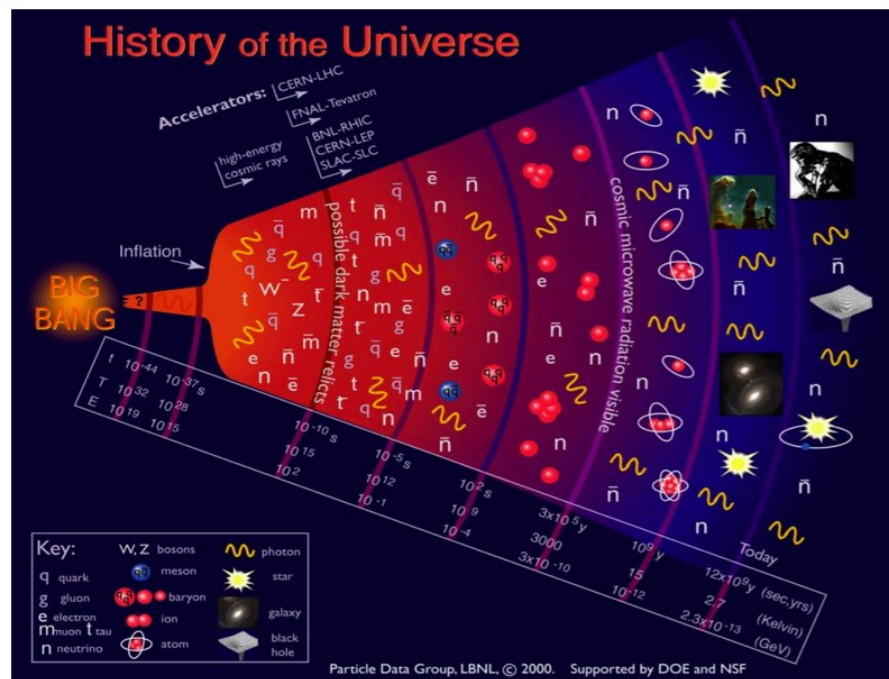
*Large Pheno Group,
expertise in Dark
Matter and GW*

Typical Week

- ★ **Friday morning: group meeting**
- ★ **Wednesday: BelGrav meeting**
- ★ **Thursday: HEP@VUB meeting**
- ★ **Friday: IIHE seminar and ULB-Pheno seminar**

Conclusions

Many years of interesting Physics are in front of us!



*Shedding light into
Early History
of our Universe*

