# FCC PED - Physics Program
# Plans & Inspirations

**Matthew McCullough, Frank Simon**

FUTURE CIRCULAR COLLIDER

*5th FCC Physics Workshop*
*February 2022*

MAX-PLANCK-INSTITUT FÜR PHYSIK

# The Mission: Defining the Science

*The overarching goal for Physics Program*

- Deliver on the scientific side of “Joachim’s Challenge” from Monday:

Why do we want the FCC and how we can justify the required resources?

- Particle physics is in competition with other fields (medicine, climate, energy, ...)
- They have also very appealing stories to tell, often much easier to understand than ours

I strongly believe that we have to strengthen and sharpen our physics arguments

- Just higher precision is not enough!
- What are the connections to the really big fundamental questions and miracles of the Universe?

We have to strengthen our efforts to convince public and politics provide very strong motivation: social, technological and scientific

Sharpen the physics case for FCC!

# A high-level View

*The overarching Goal*


- The FCC program combines the two key strategies of HEP:
  - precision measurements and testable predictions
  - open exploration of the energy frontier

# A high-level View

*The overarching Goal*


“precision” “exploration”

- The FCC program combines the two key strategies of HEP:
  - precision measurements and testable predictions
  - open exploration of the energy frontier

- “Sharpening” the physics case => A compelling narrative that shows that the questions FCC is addressing will be among the most fundamental scientific questions in **25** and in **50 years.**

An important element: **Discovery Stories**.

# Physics Program

*A High-Level Perspective*


*Physics Program*: Laying out the scientific program at FCC

- Contributing to the development of the “big picture”
- Identification of new measurement and discovery opportunities to further flesh out the potential of FCC - Connecting theory and experimental studies supported by *Physics Performance*

# Physics Program

*A High-Level Perspective*

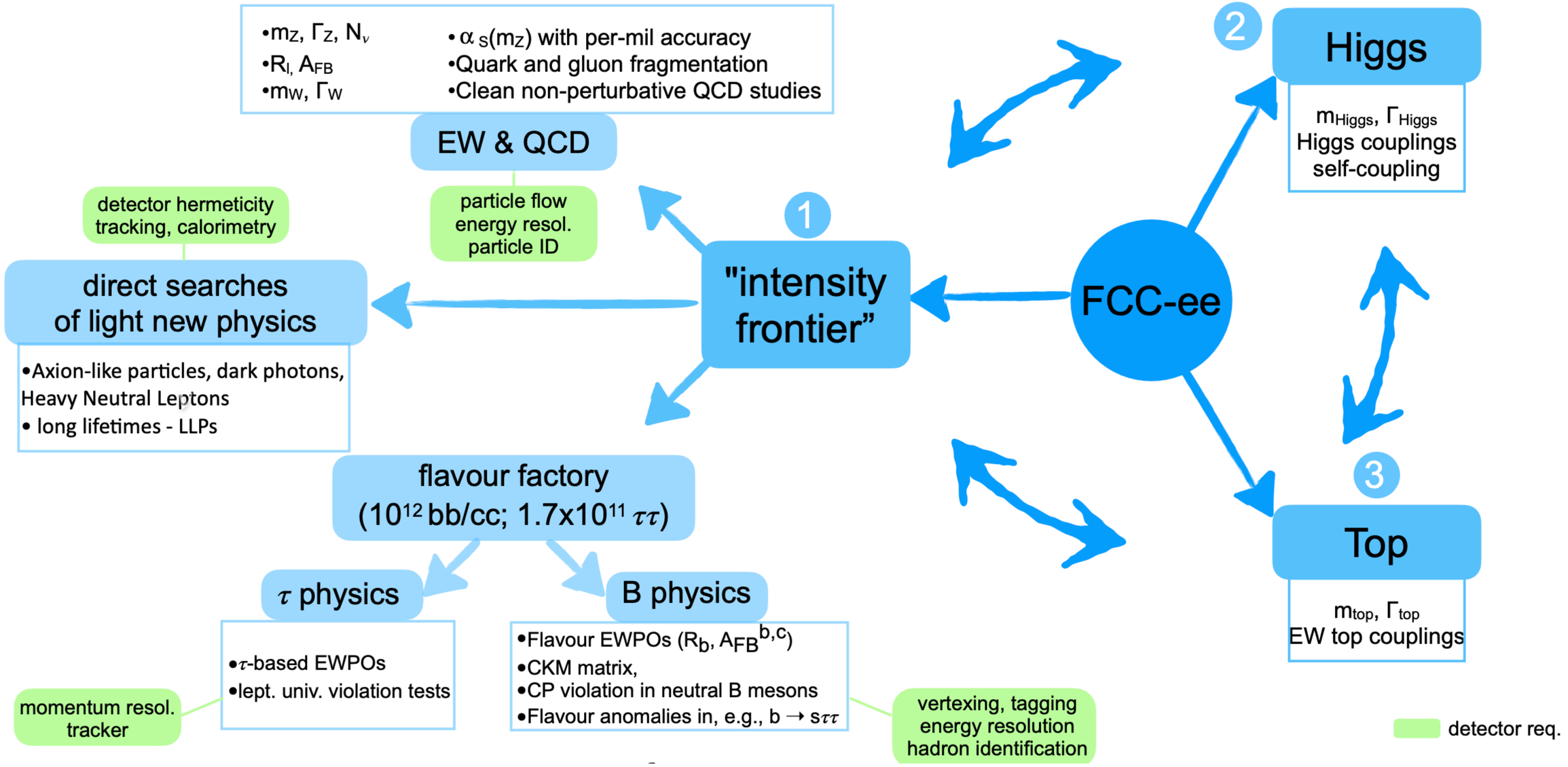

*Physics Program*: Laying out the scientific program at FCC

- Contributing to the development of the “big picture”
- Identification of new measurement and discovery opportunities to further flesh out the potential of FCC - Connecting theory and experimental studies supported by *Physics Performance*

- A natural focus on FCC-ee: The first stage, highest priority future project in the strategy, key for project approval
- But: also follow up the physics of FCC-hh / FCC-eh

# FCC-ee

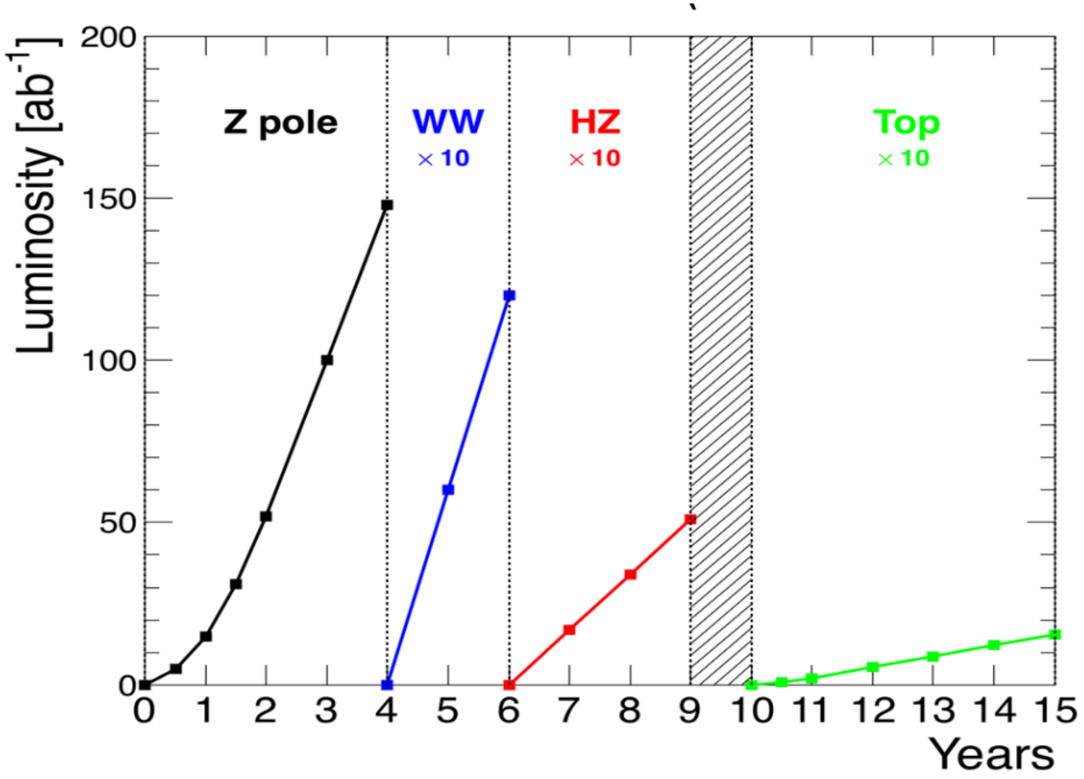
*Main physics thrusts - mapped onto energy stages*



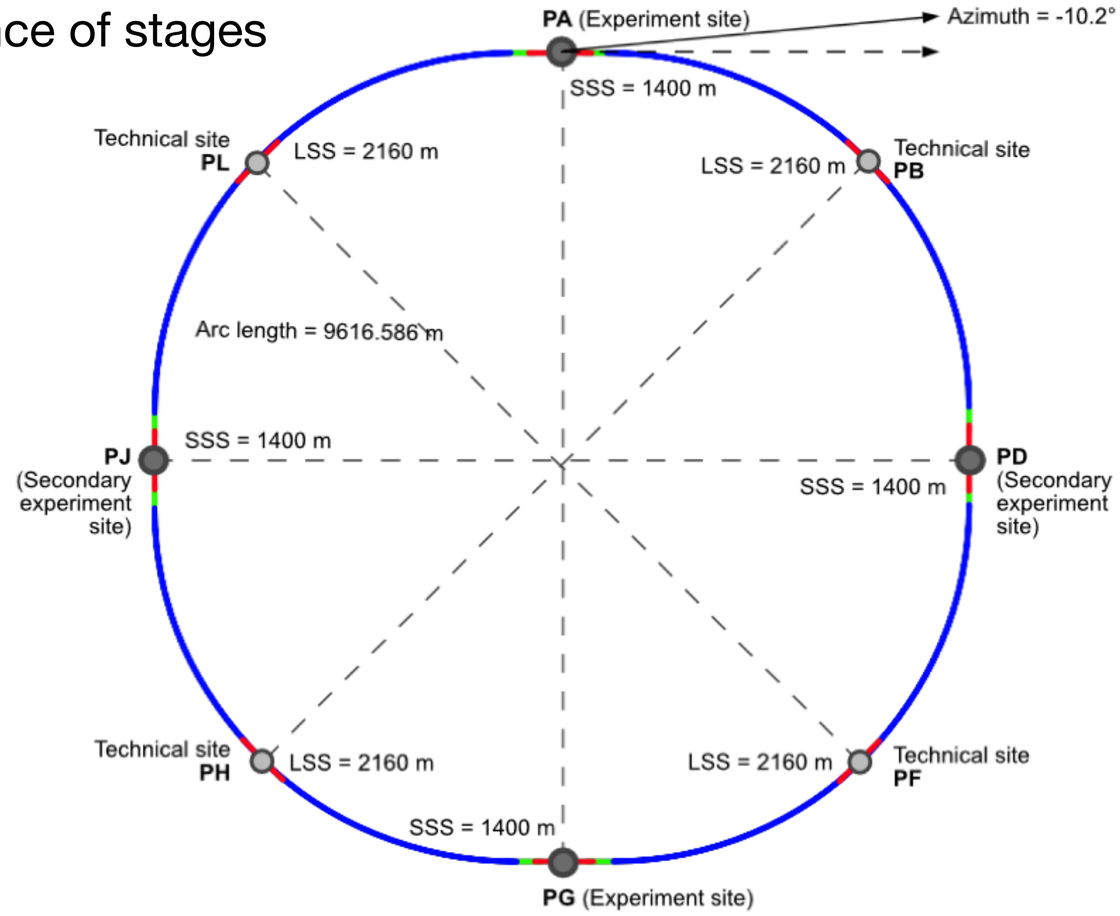

C. Grojean, Monday

# From Physics to a Run Plan

*Justifying (and re-thinking) choices*



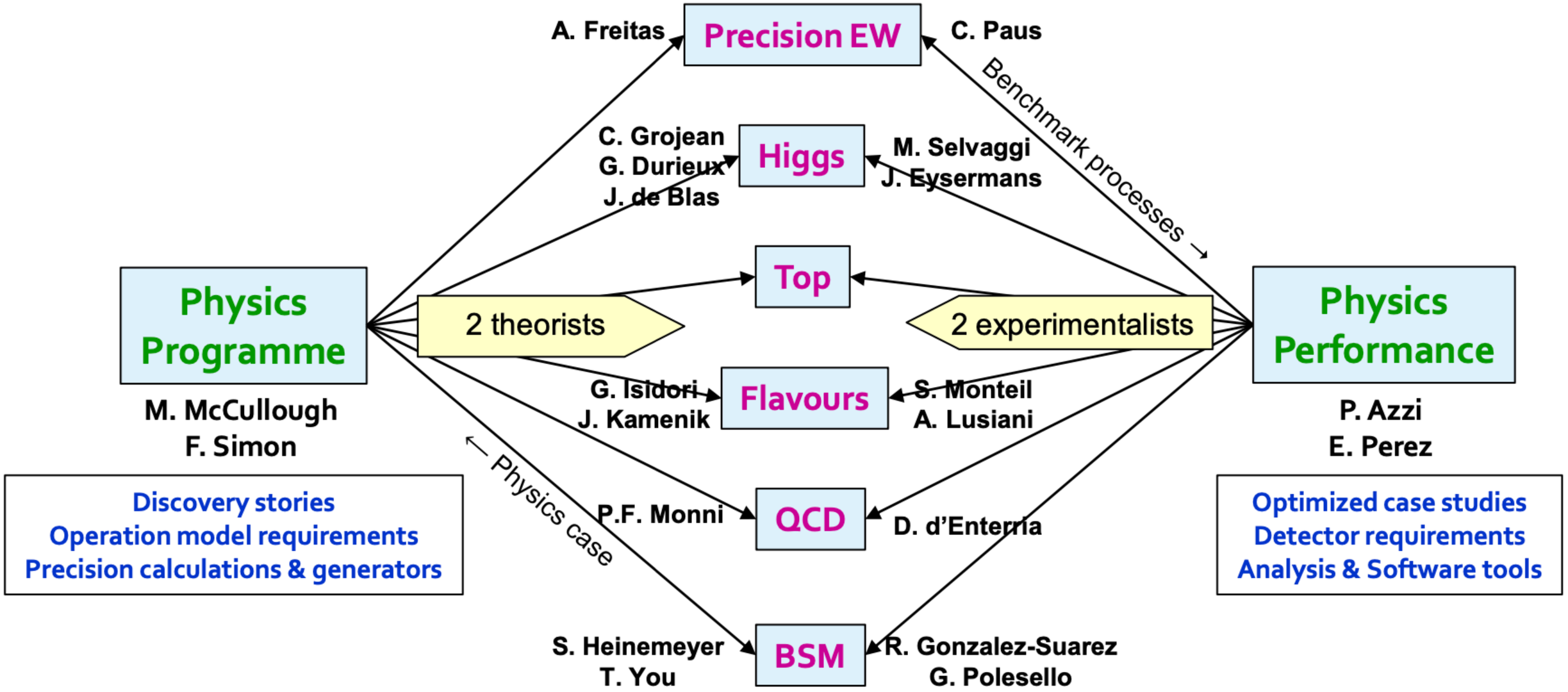

- Energy points, integrated luminosity, requirements on accelerator parameters
- Sequence of stages




- Number of experiments, complementarity requirements
- …

# The Organisation

*Many opportunities to contribute*



# Inspiration

*A few ideas discussed this week*

- Not a summary - rather a not quite random, personally biased selection, with my own views sprinkled in.

# Inspirations

*A biased selection*

- Evolution of the understanding of Naturalness
  - Explore new concepts in rare Z decays, H coupling deviations at (or below) the percent level
  - Complemented by high-scale observables at FCC-hh

Monday

# Inspirations

*A biased selection*

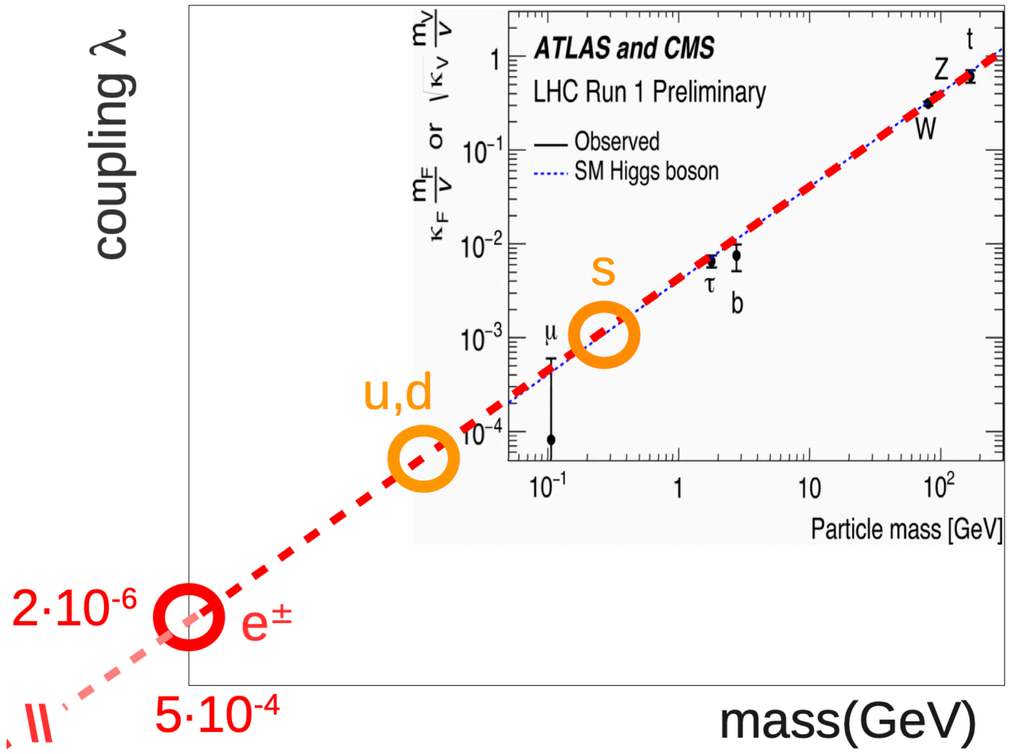
- Evolution of the understanding of Naturalness
  - Explore new concepts in rare Z decays, H coupling deviations at (or below) the percent level
  - Complemented by high-scale observables at FCC-hh

Monday

- S-channel Higgs production - the ultimate challenge?

  Interesting consequences for the overall program:
  Several years at 125 GeV, with 4 Detectors capable of excellent H detection / background rejection

Tuesday



# Inspirations

*A biased selection*

- Bringing the flavour program into focus
  - Enormous statistics at the Z pole - using 3rd generation observables to probe high scales: Taus, (rare) B decays, LFV / LFU
  - Looking beyond, at FCC-hh

Tuesday, Friday

Evaluation of potential in view of Belle II, LHCb HL-LHC capabilities, theory requirements

Specific detector capabilities needed to deliver key channels?

# Inspirations

*A biased selection*

- Bringing the flavour program into focus
  - Enormous statistics at the Z pole - using 3rd generation observables to probe high scales: Taus, (rare) B decays, LFV / LFU
  - Looking beyond, at FCC-hh

Tuesday, Friday

Evaluation of potential in view of Belle II, LHCb HL-LHC capabilities, theory requirements

Specific detector capabilities needed to deliver key channels?

- The precision challenge: Electroweak. Needs:
  - (Significantly) improved calculations
  - Advances in generators
  - Control (also theory) over luminosity uncertainty

Wednesday

- QCD - a central ingredient on the path to precision
  - strong coupling, hadronisation, parton structure

Wednesday

# Inspirations

*A biased selection*

- The search for beyond-the-Standard Model physics as an overarching theme
  - touches all aspects of the FCC program

  Near-limitless ideas - with a number of directions to be followed up to explore the potential more concretely.

  - Higgs, Flavour, Precision - of course
  - Open searches exploiting radiative return (and others) for anomaly detection
  - Long-lived particles - exploiting $e^+e^-$ environment, defining detector requirements
  - …

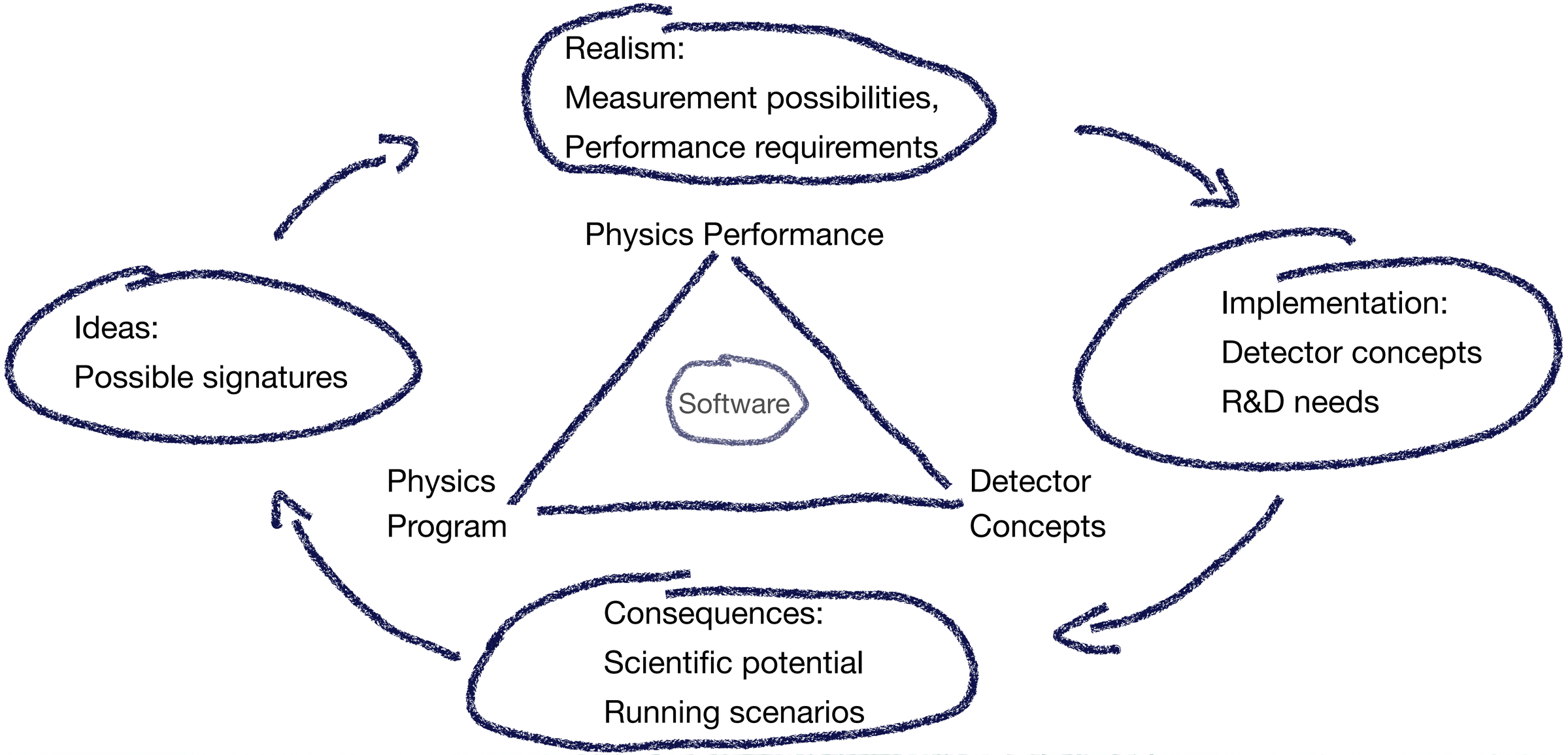
Thursday, Friday

# Next Steps

*Getting organized*

# Sharpening the Physics Case

*Ideas and Projections*



# Getting Things Done

*An evolving plan*

- Activities of Physics Program getting started - working out the next steps in close coordination with Physics Performance

    - First thoughts:
        - Monthly meetings which will focus on each subgroup in turn.
        - Topical workshops, again focussing mainly on activities of each subgroup.
        - The usual physics meetings, which will broaden in scope significantly.

- Contributions welcome!