Test beams @ CERN for ν-detector R&D Experiments

3rd Hyper-Kamikande - EU meeting, April 27, 2015

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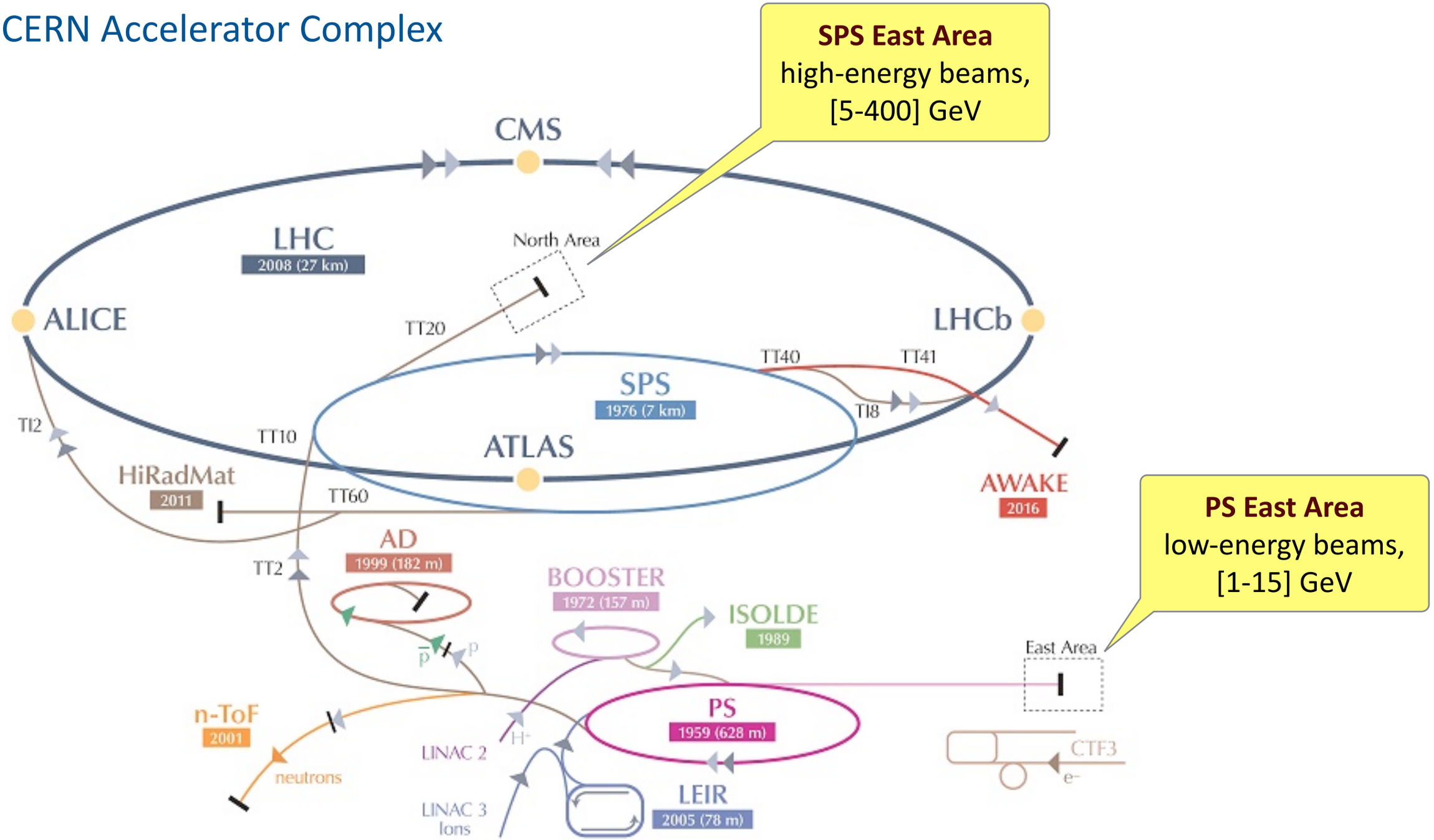
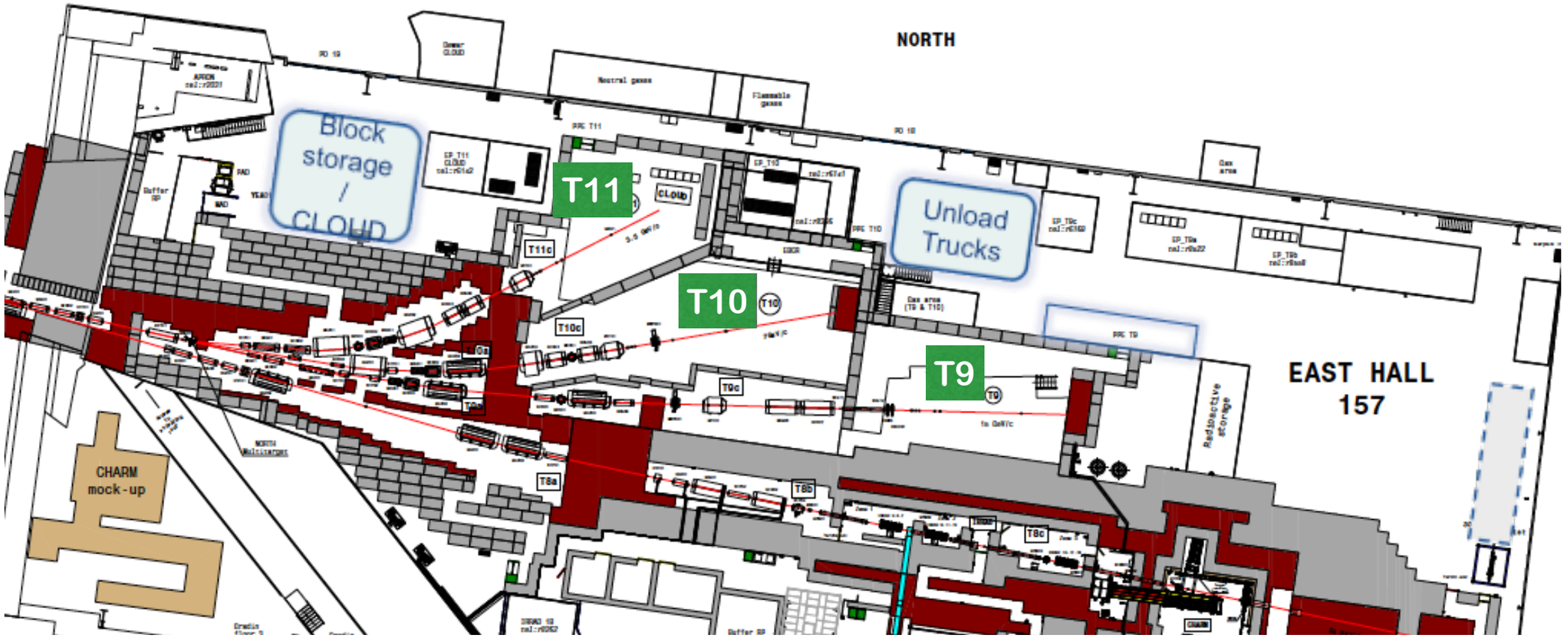
CERN | EN ENGINEERING DEPARTMENT

Test Beam Facilities @ CERN

- The CERN Accelerator Complex

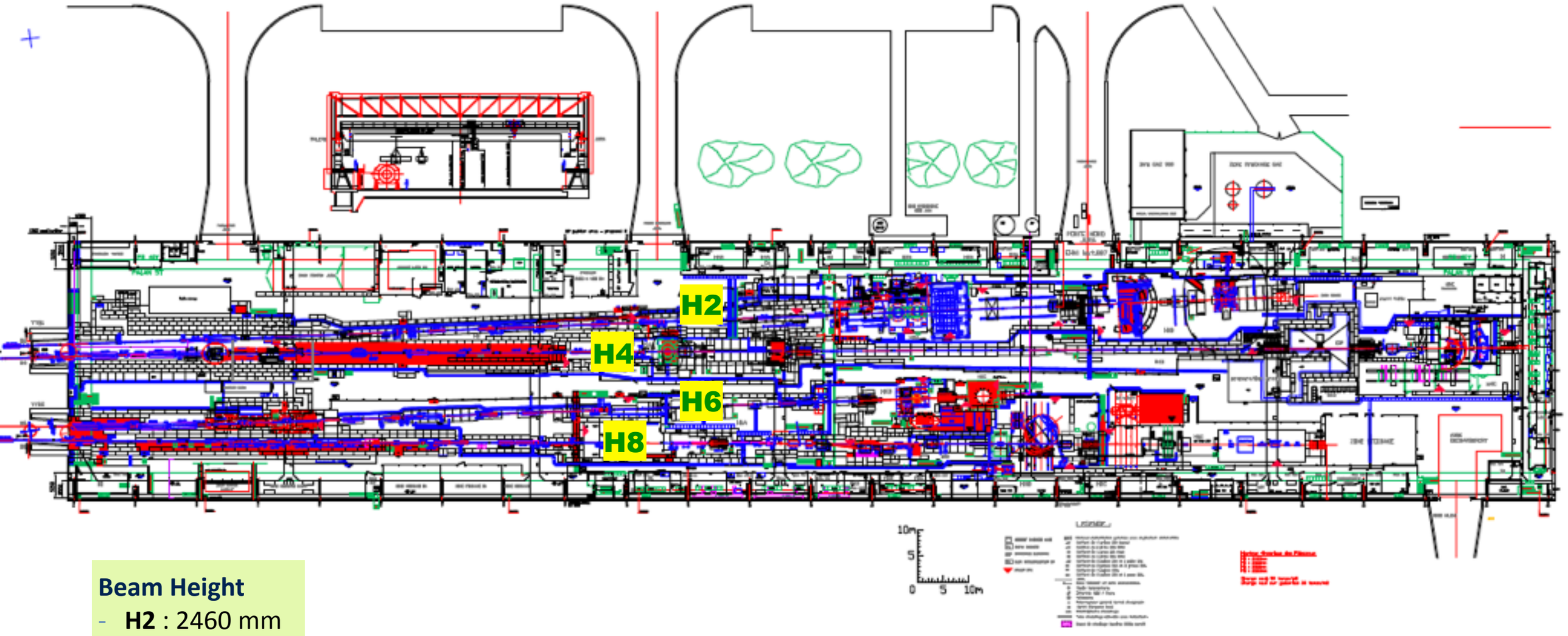


The PS East Area



- Two beam lines : **T9**: 1(0.5)-15 GeV beams, ~50m long, **T10** : 1-7 GeV beams, ~30m long
- Variable energy, particle type beams (e, π, p, μ) - beam instrumentation and PID available
- Issues to consider:
  - beam height from floor ~2.5m, available infrastructure for experiments, space in the areas for large detectors
- Presently the EA beams can reach ~0.5 GeV - going below is rather challenging
  - particle decays (π-beams), strength of magnets/power supplies, limited PID
  - if a strong request for very-low energy beams is made, we can study possibilities and possibly profit from the upcoming consolidation program to adapt to a new layout and specifications in the magnetic elements

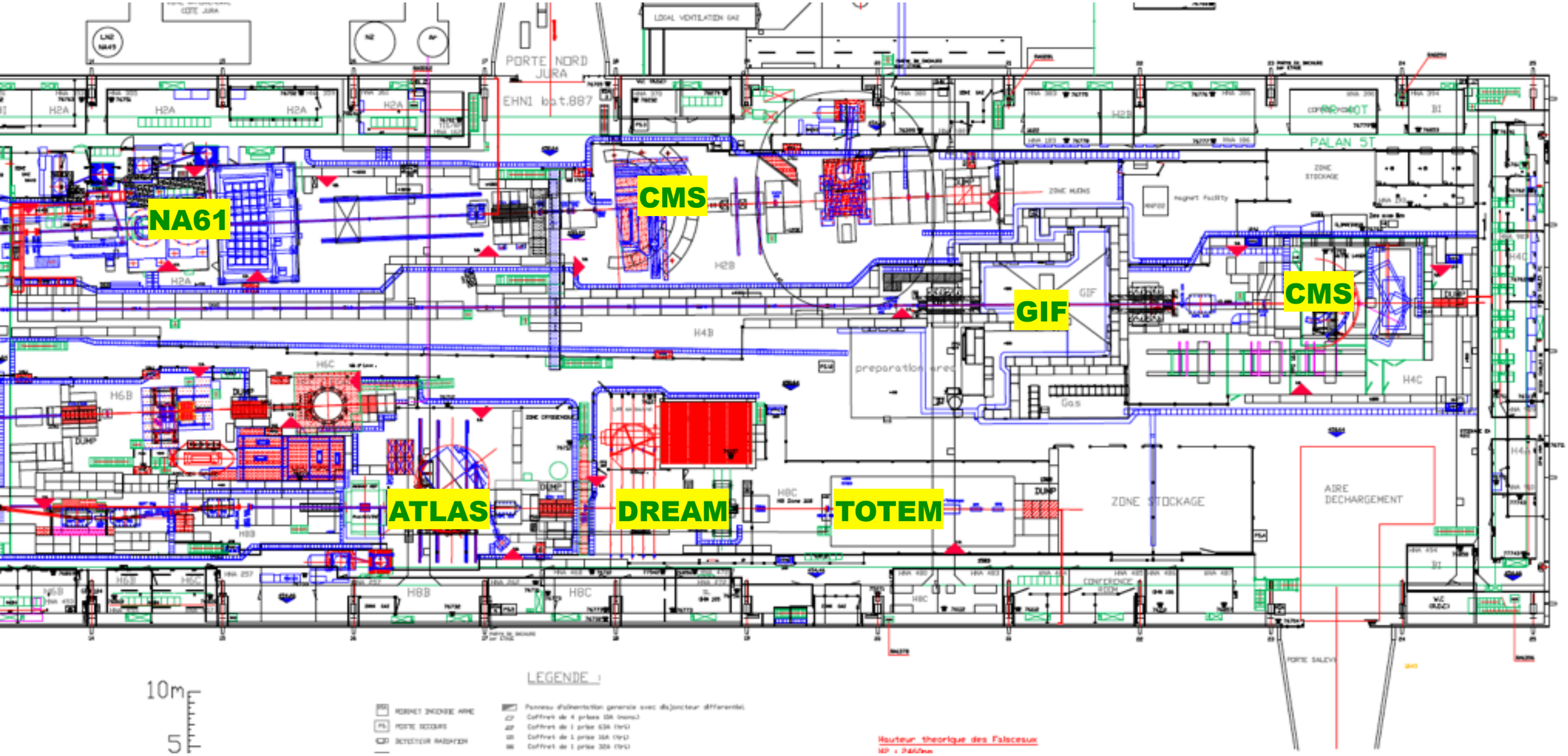
The SPS North Area - EHN1 Experimental Hall beams



Beam Height

- **H2** : 2460 mm
- **H4** : 2060 mm
- **H6** : 2060 mm
- **H8** : 2860 mm

The Experimental Hall North 1 - EHN1



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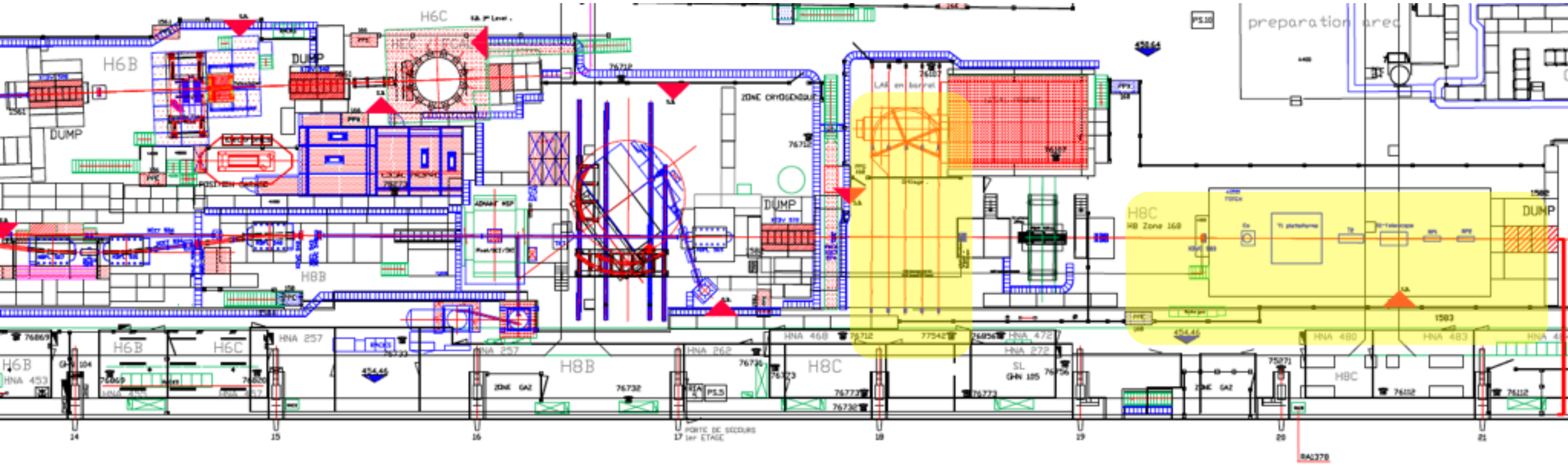
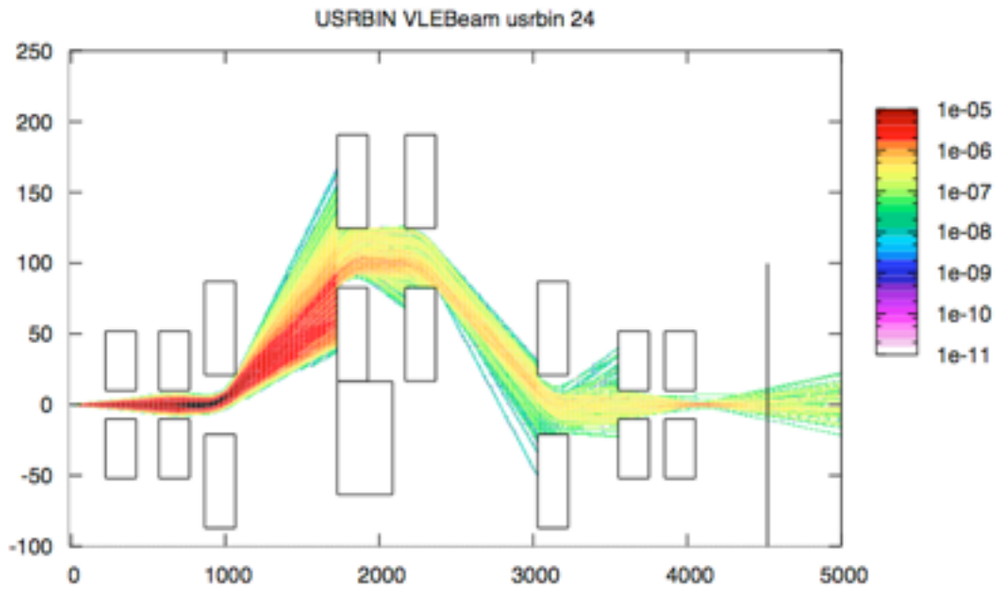
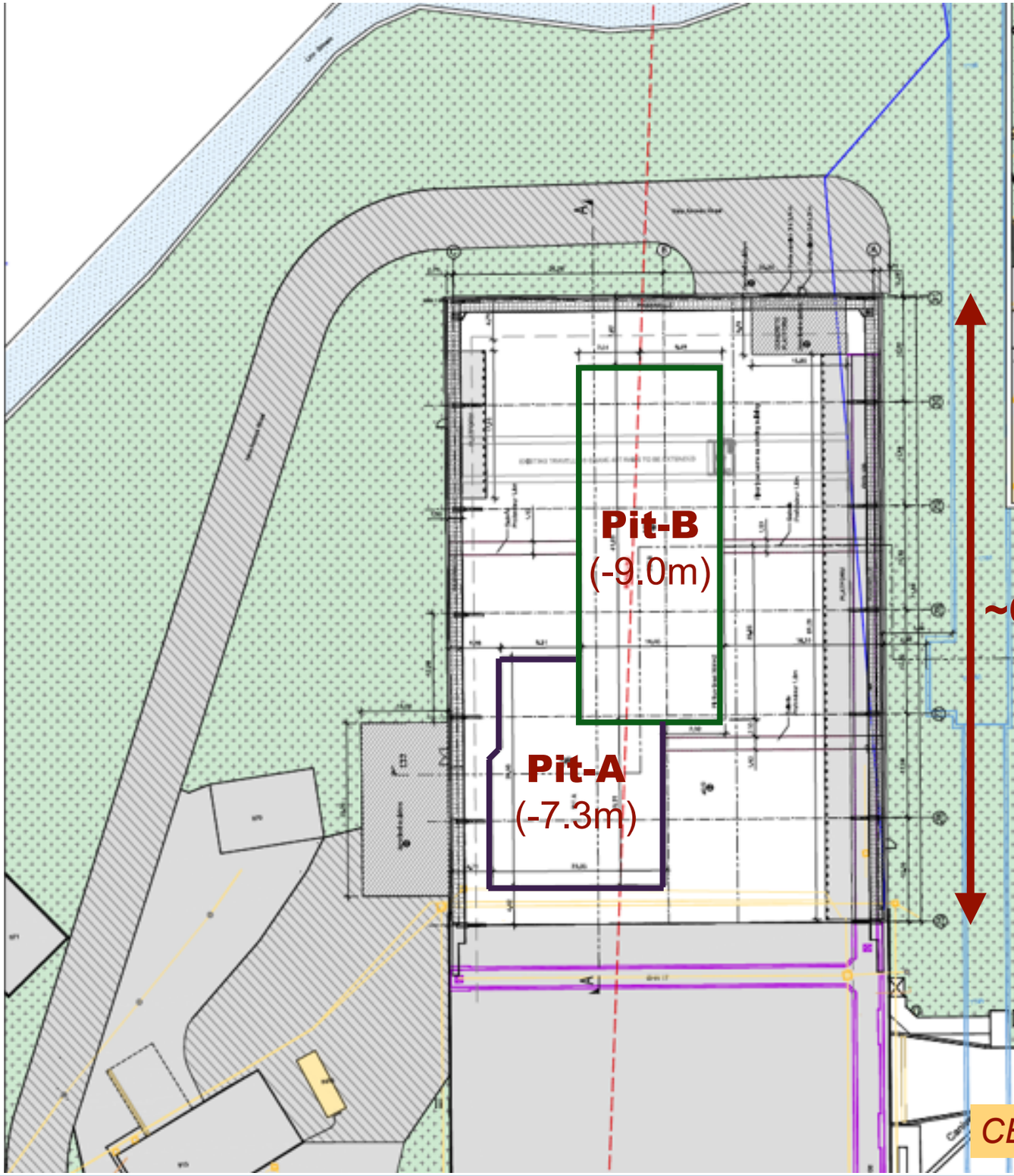
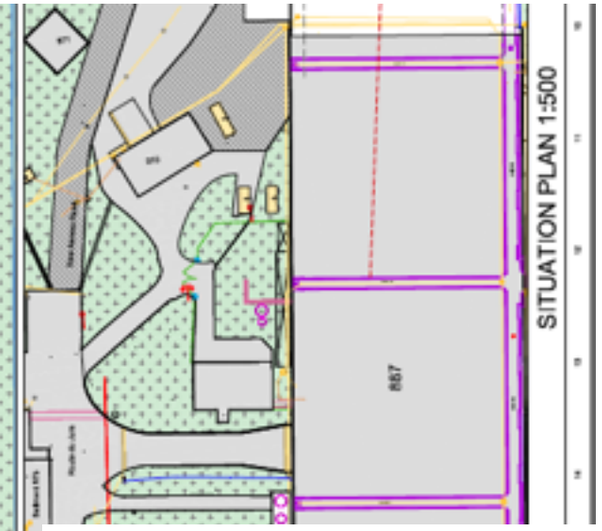


- Possibility to host new (**small size**) test setups in the existing beams (H8) and VLE tertiary branch studied within the AIDA EU/FP7 project
  - AIDA-D8.3 (http://cds.cern.ch/record/1637970?ln=en)
- Such a tertiary beam could offer adequate performance in the [1(0.5) - 9] GeV range
  - the limitation towards the low-energy again from the beam length and magnet/ps strength
  - important constraint : the tertiary beam layout should remain compatible with the high-energy beam layout for the other users of the line



The EHN1 Extension - General layout

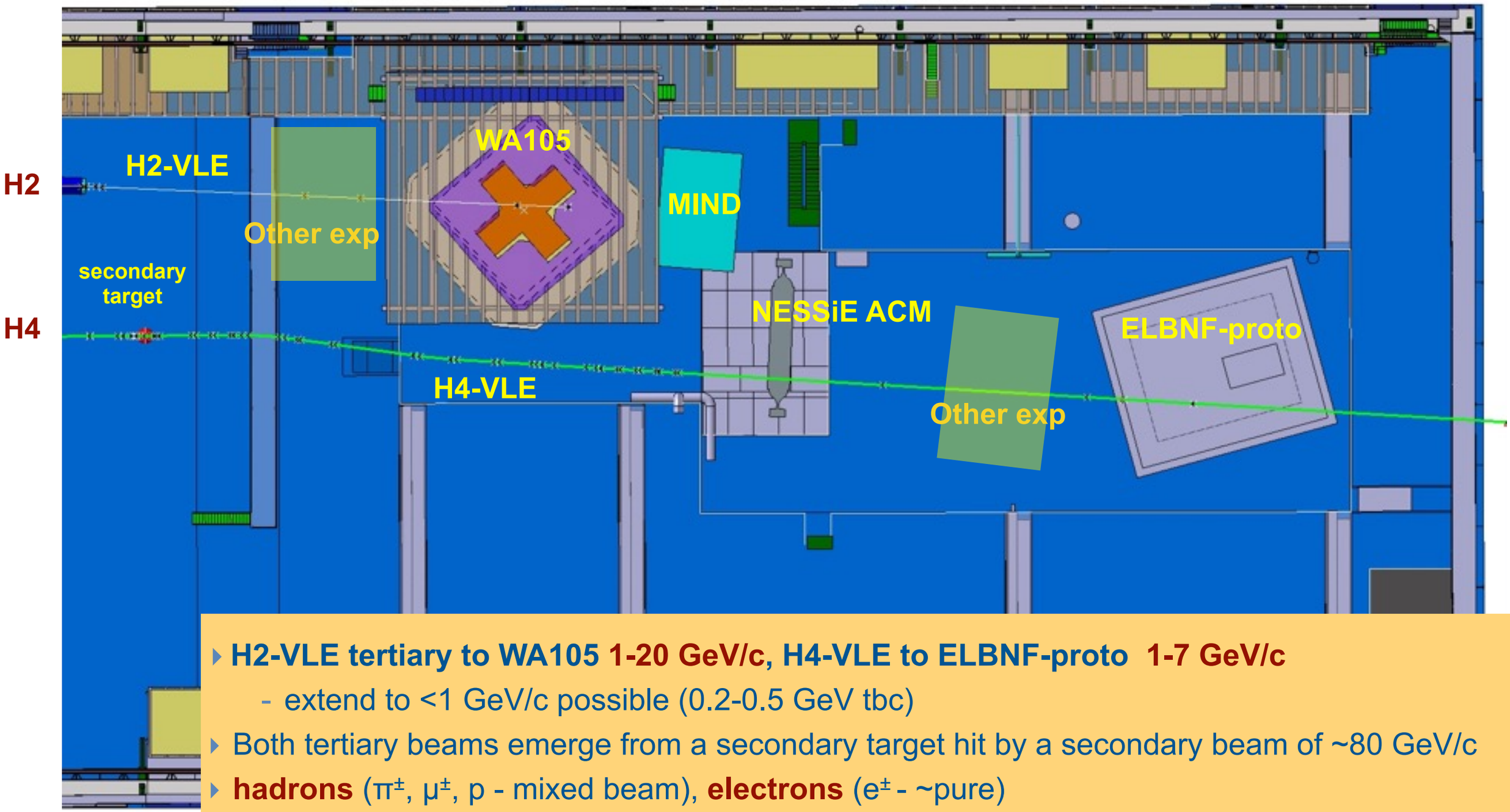




- EHN1 Experimental hall extension designed to accommodate large-volume prototypes for ν-detector experiments
  - remain compatible for a future possible ν-short baseline @ CERN
- Surface building structure compatible with the present EHN1 hall
  - allows easy extension of the beam lines, services (overhead cranes), and access
  - large underground pit for the experiments
    - resolves height, access and safety issues for the large LArgon detectors envisaged
    - offers nice background rejection from the beams for TPC-like detectors

The EHN1 Extension for ν-detector R&D prototypes

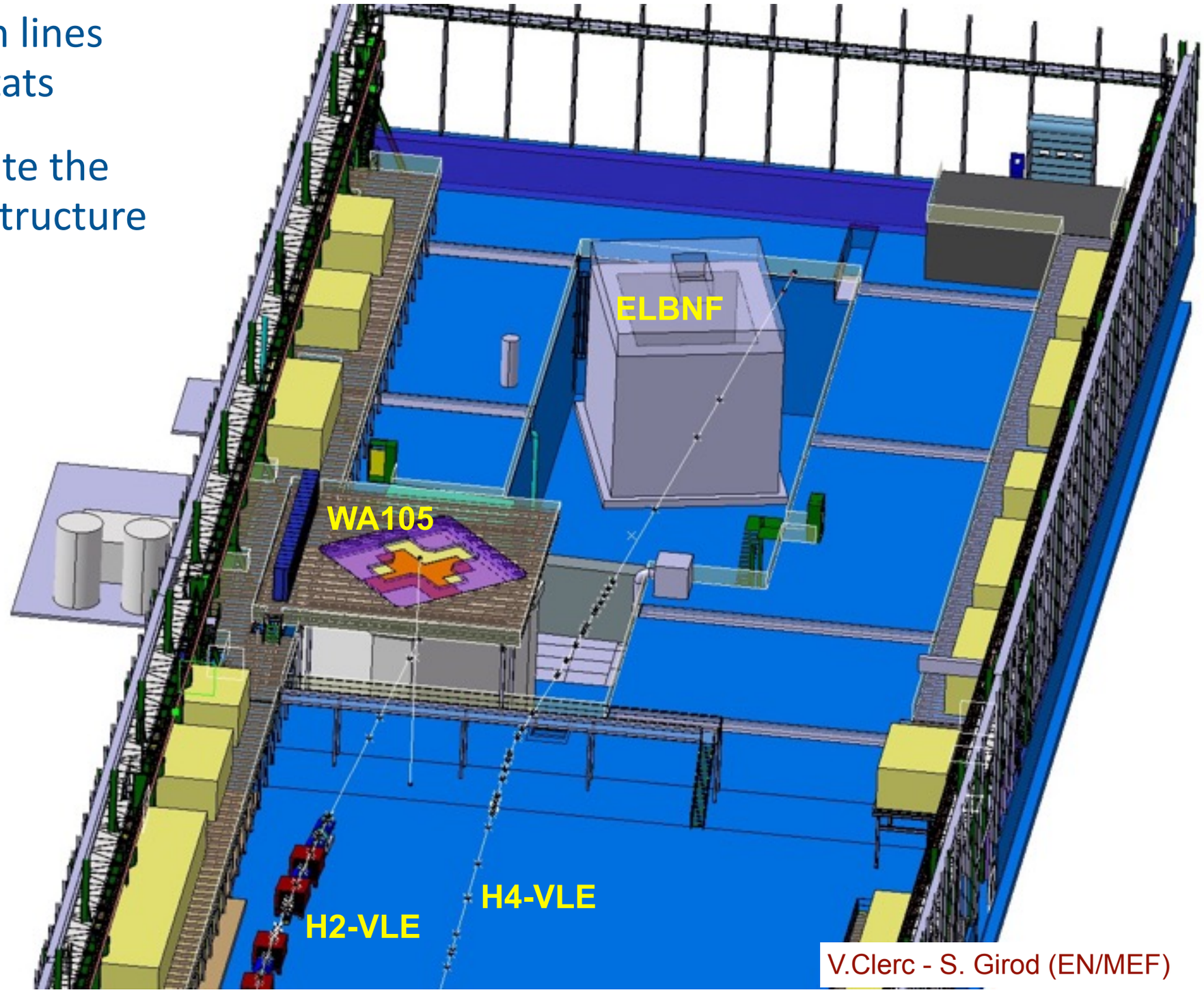
- Integration study (top view)



- **H2-VLE tertiary to WA105 1-20 GeV/c, H4-VLE to ELBNF-proto 1-7 GeV/c**
  - extend to <1 GeV/c possible (0.2-0.5 GeV tbc)
- Both tertiary beams emerge from a secondary target hit by a secondary beam of ~80 GeV/c
- **hadrons** ($\pi^{\pm}$, $\mu^{\pm}$, p - mixed beam), **electrons** ($e^{\pm}$ - ~pure)

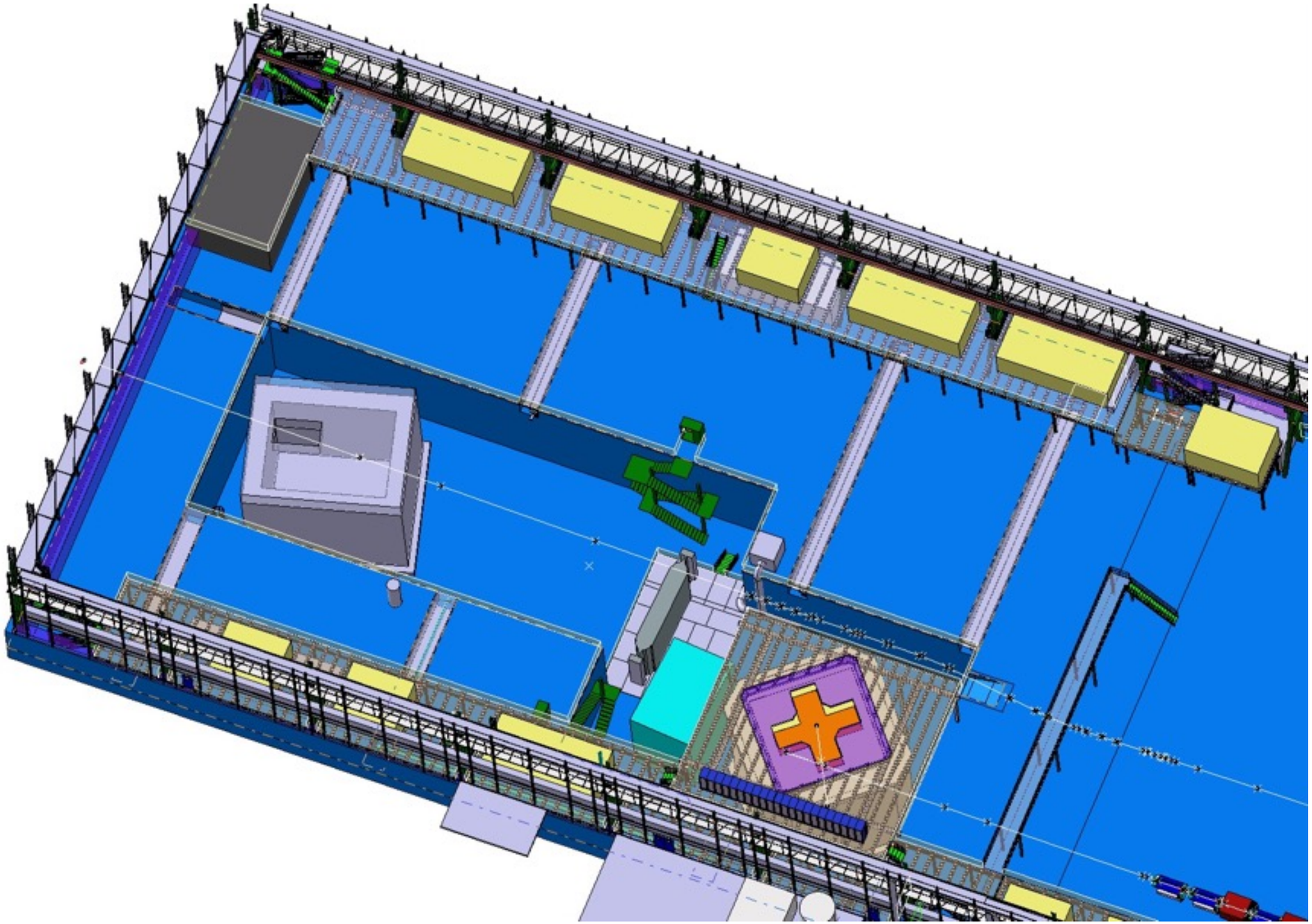
EHN1-Ext - Integration status

- Basic layout of the beam lines and experimental cryostats
- Work ongoing to integrate the services and basic infrastructure of the building

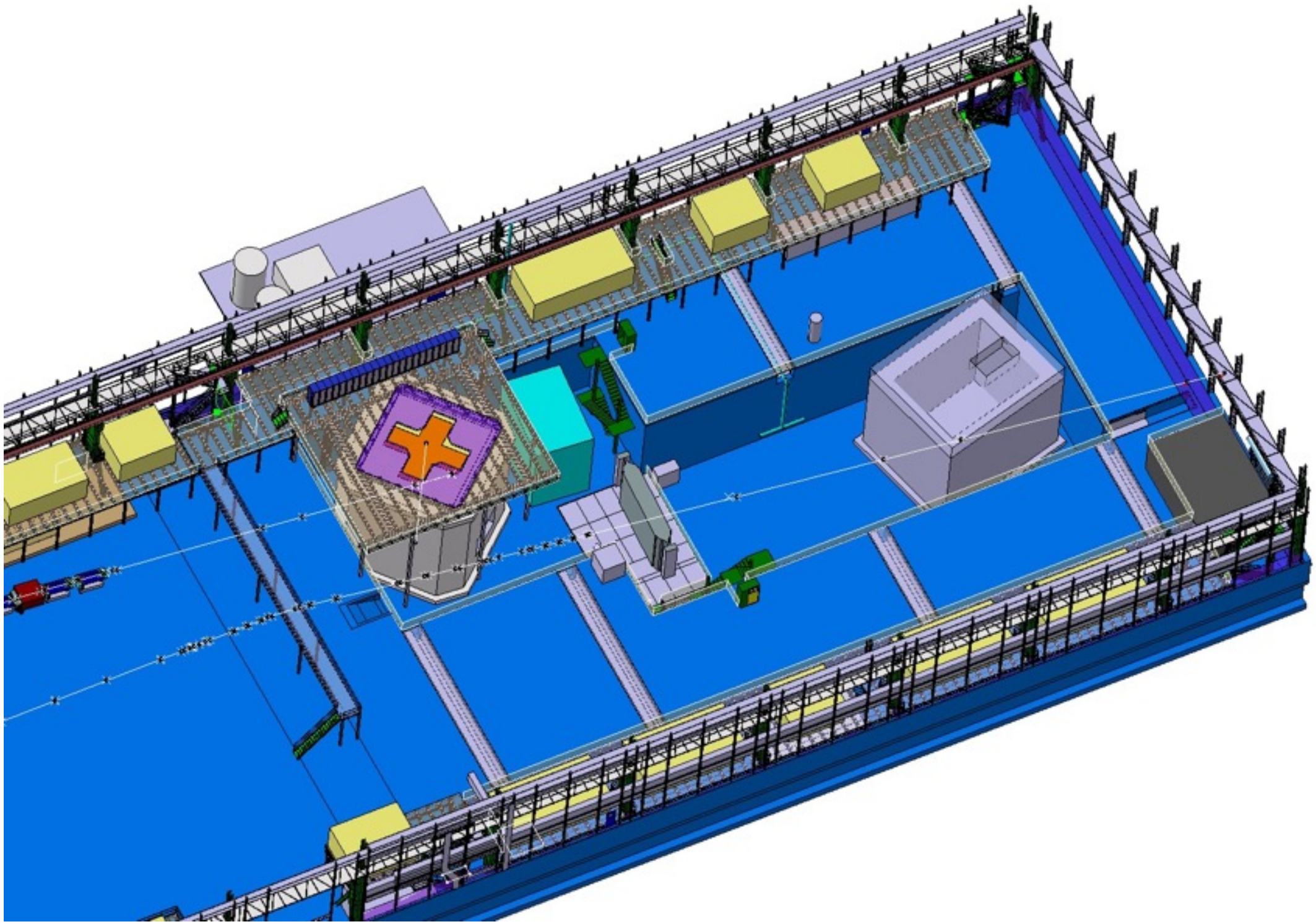


V.Clerc - S. Girod (EN/MEF)

EHN1-Ext - Integration

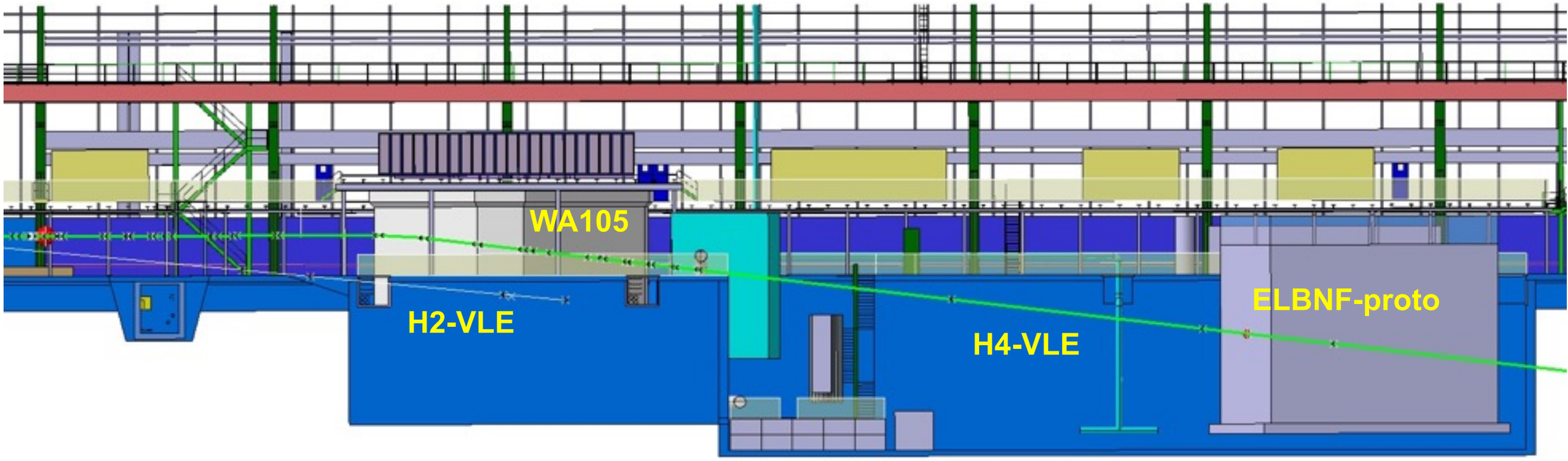


EHN1-Ext - Integration



H2/H4 - VLE Beam Design

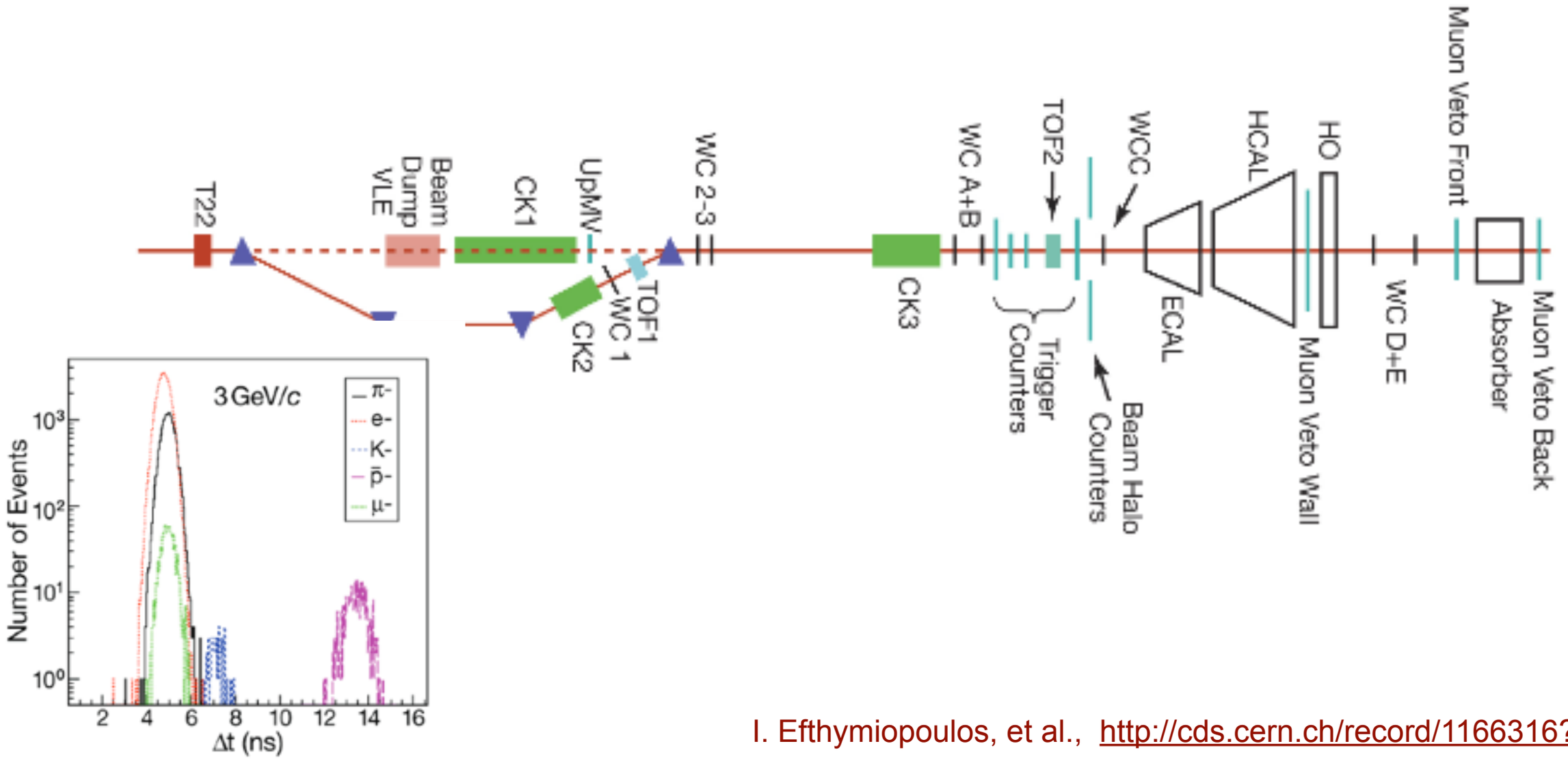
- Integration study (side view)



- Beam parameters:
  - down slope of ~5.3÷6 deg, enter cryostats at an angle angle, also in the h-plane (by rotation)
  - VLE beam length approx. 30-50m, mainly due to the angles required
    - low-energy reach determined by the angles and energy span: 0.1 - 10 GeV ==> ×100 in current!

VLE Beam Design

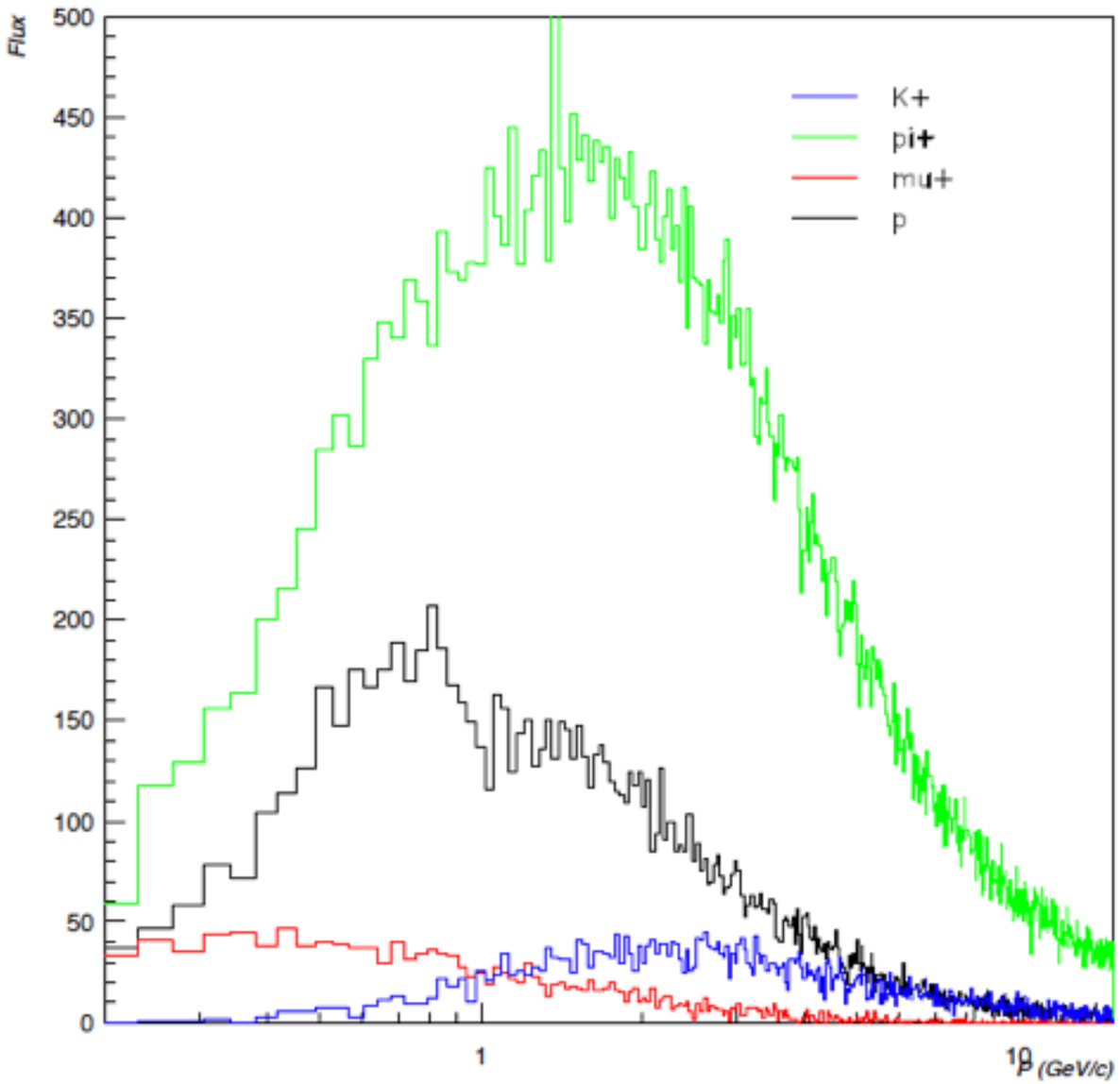
- Good example of past VLE implementation : H2 beam for CMS
  - CK1 filled with CO_2, CK2 filled with Freon134a
  - combined particle ID with TOF, CK1,CK2, and scintillators

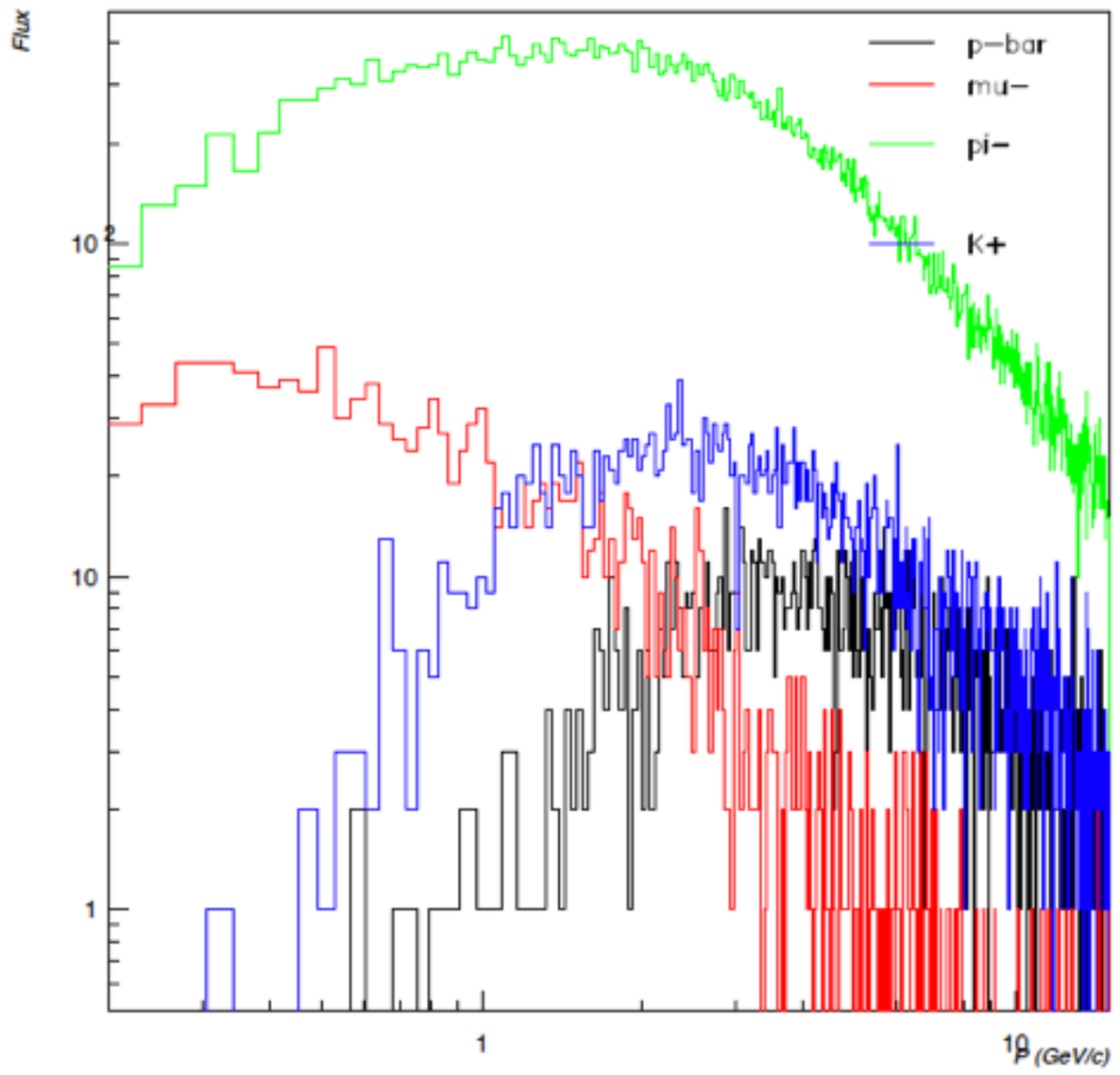


I. Efthymiopoulos, et al., http://cds.cern.ch/record/1166316?ln=en

H2/H4 - VLE Beam Design

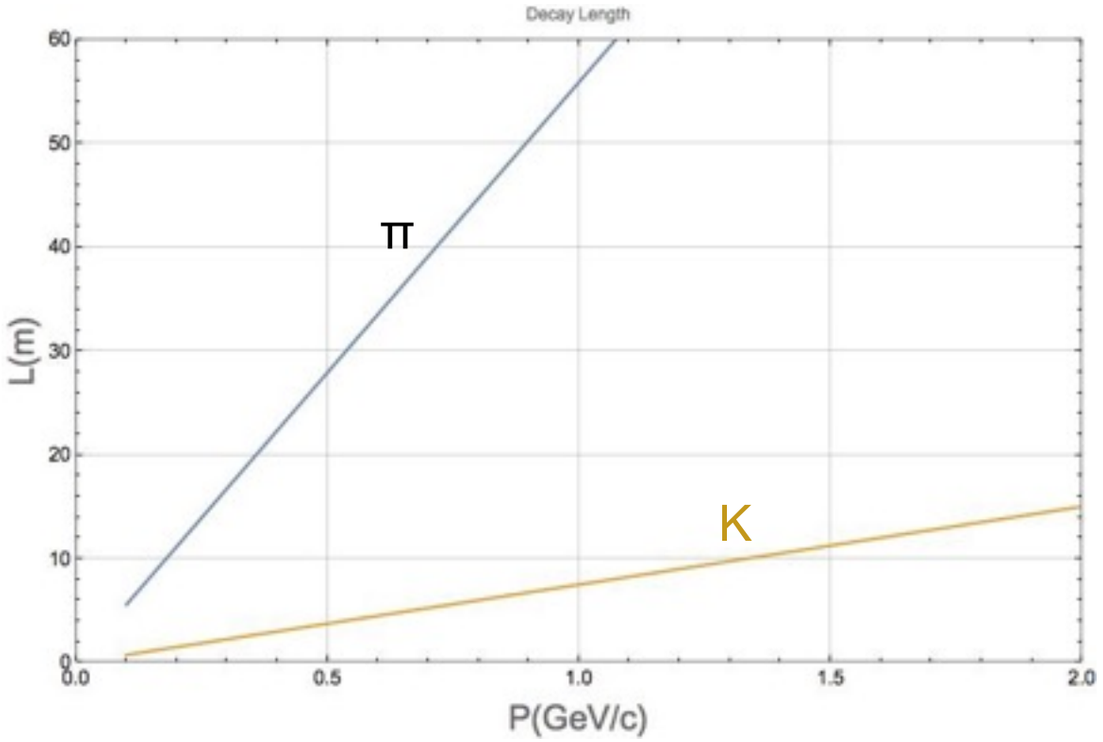
- Example: particle rates (full acceptance)
  - 80 GeV pi+ beam, 15cm Cu secondary target, 100k primaries (10% SPS spill)



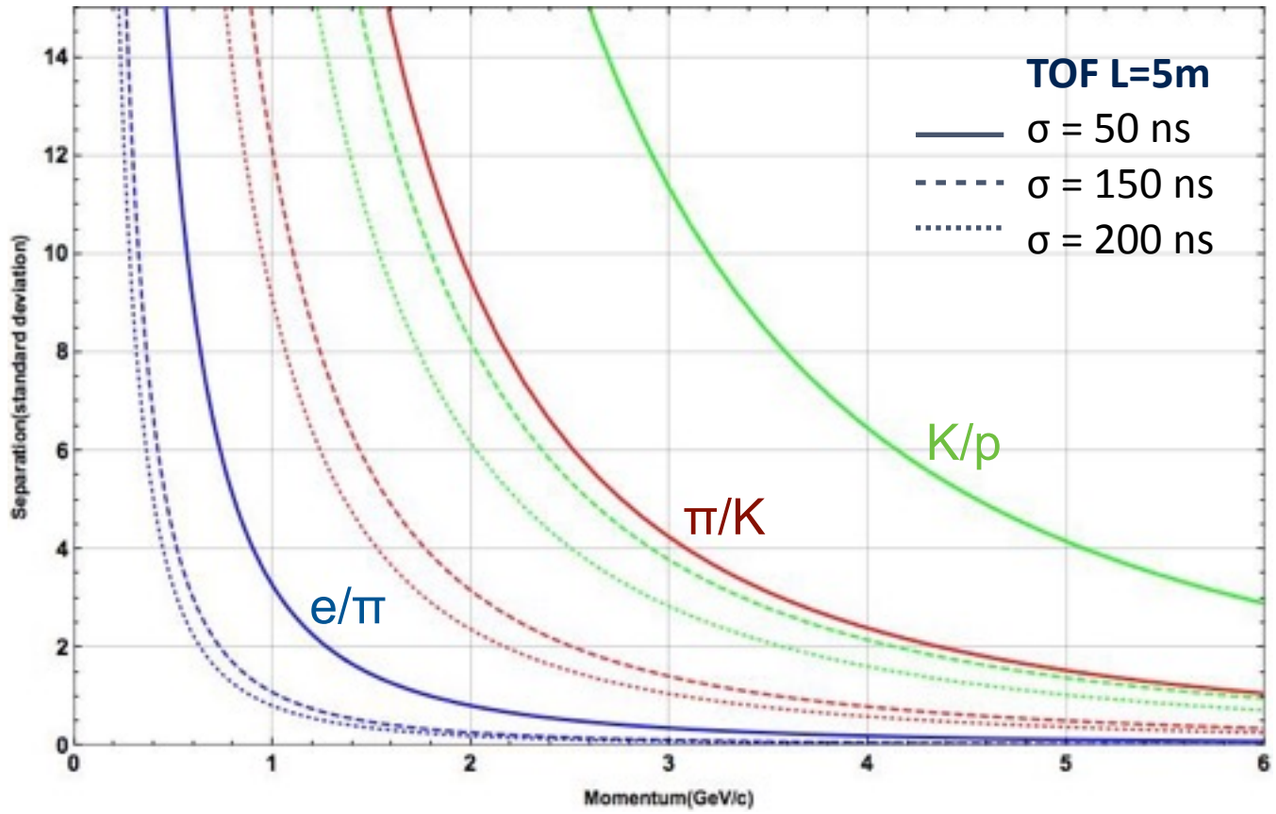


H2/H4 - VLE Beam Design Considerations

- decay length to consider for sub-GeV particles



- Particle ID with threshold Cherenkov counters or TOF measurement

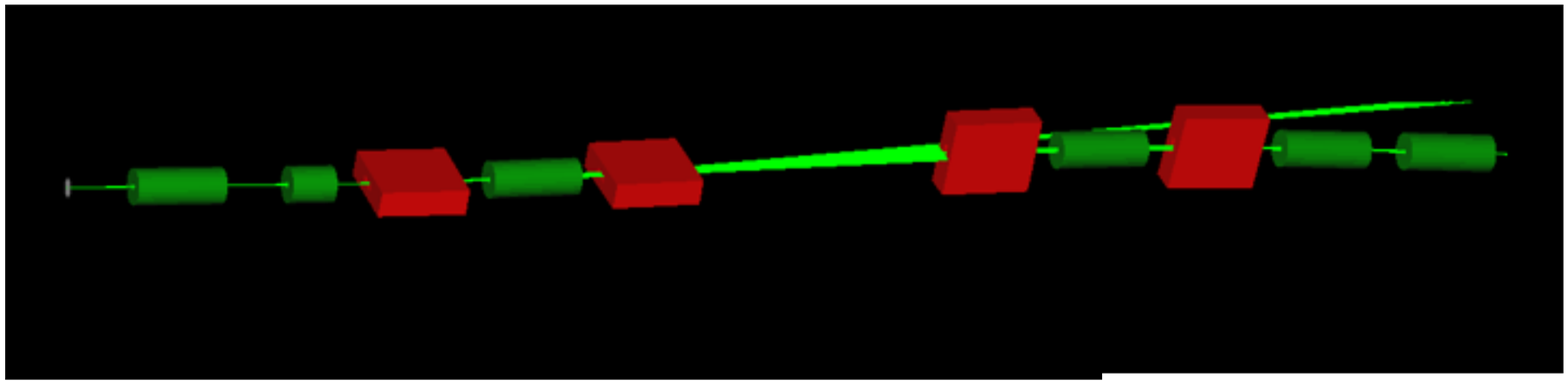


- study to move the H4 VLE target closer to the experiment, to have ~30m of beam length
  - leaving sufficient space for experiments upstream the ELBNF cryostat!

Also important to consider the amount of additional material in the beam from the instrumentation!

Status - next steps

- Basic design available
  - beam layout and entry point to cryostats to validate with the designs



H2/H4-VLE G4BL implementation
N. Charitonidis - EN/MEF

- Current work on beam optics
  - optimise use of quadrupoles (and type)
  - integrate the possible beam instrumentation
    - beam profile : development ongoing for a SciFi tracker embedded in the beam vacuum
      - 0.5mm square fibres, 0.5mm spacing, 10×10 cm coverage (today - but we would need 20×20 cm)
    - partice ID: ToF & threshold Cherenkov counters at higher energies
  - important: need to keep the material budget low to avoid loosing much of the low-energy beam

Summary

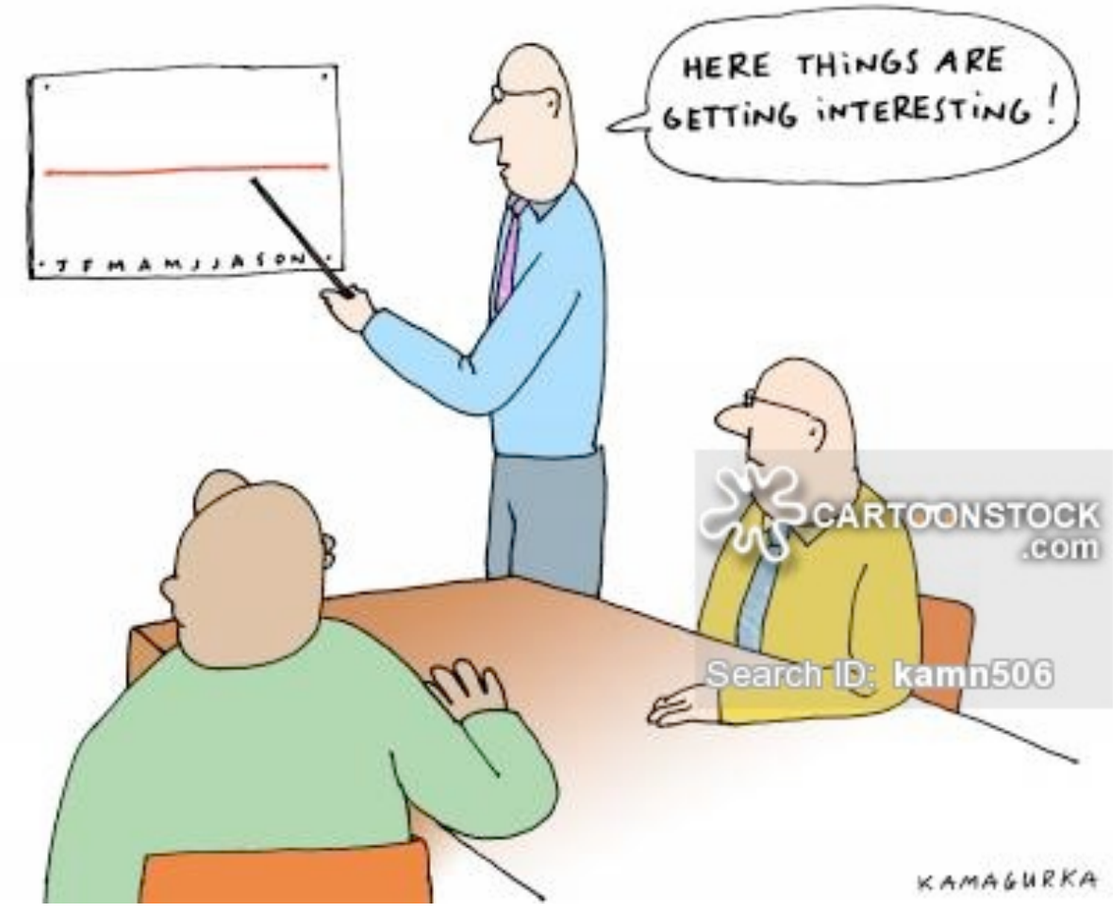
- CERN offers a variety of options in the PS East Area and the SPS North Area for test beam experiments for detector R&D
  - the present beam configurations offer secondary/tertiary particle beams in a wide spectrum of energies and particle types
  - very low-energy beam (VLE) extensions in the SPS North Area beams have been made operational for the LHC experiments (ATLAS/H8, CMS/H2), to provide beams in the range of 1(0.5) - 9 GeV
  - this VLE beam design was further studied and optimised for ν-detector small size prototypes within the AIDA DS

- The ongoing EHN1 extension for the **ν-platform** will open the possibility to test with particle beams LARGE detector prototypes for several future ν experiments
  - whilst maintaining the versatility to accommodate smaller detectors profiting from the foreseen beam lines

- The very-low-energy beam design to reach sub-GeV partible beams is challenging, highlights of the present layout of the beams in the EHN1 extension was shown
  - basic design based on the previous VLE design and outcome from the AIDA studies

Still lot of things to do

…but that's also the fun part!



Thank You!

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