The Test Beam Facilities of CERN

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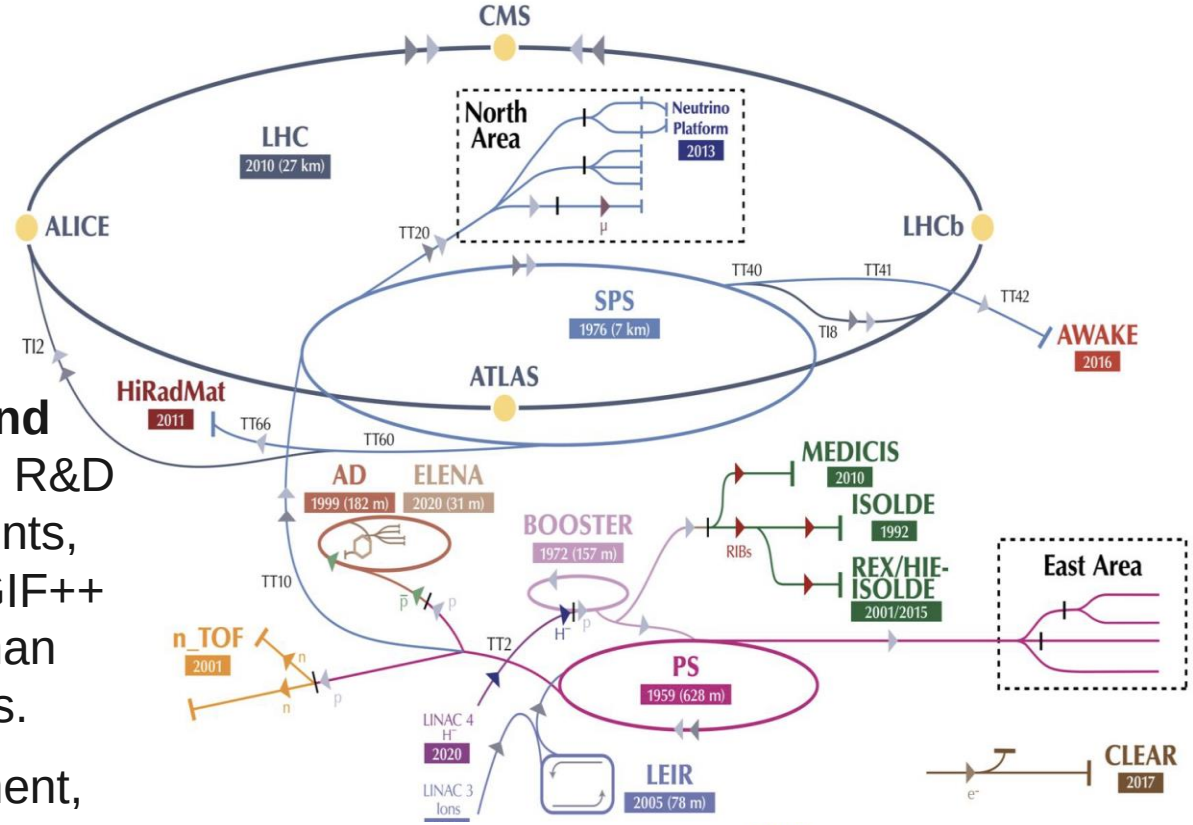
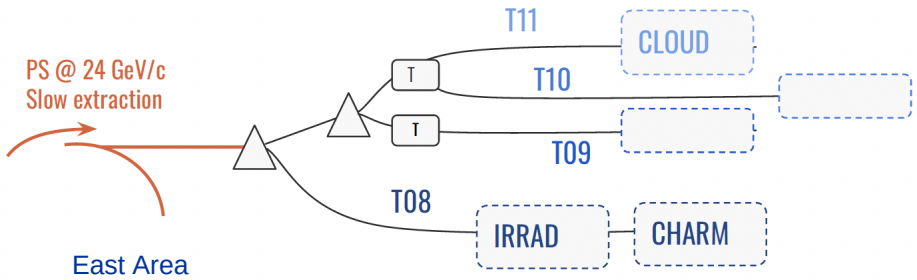
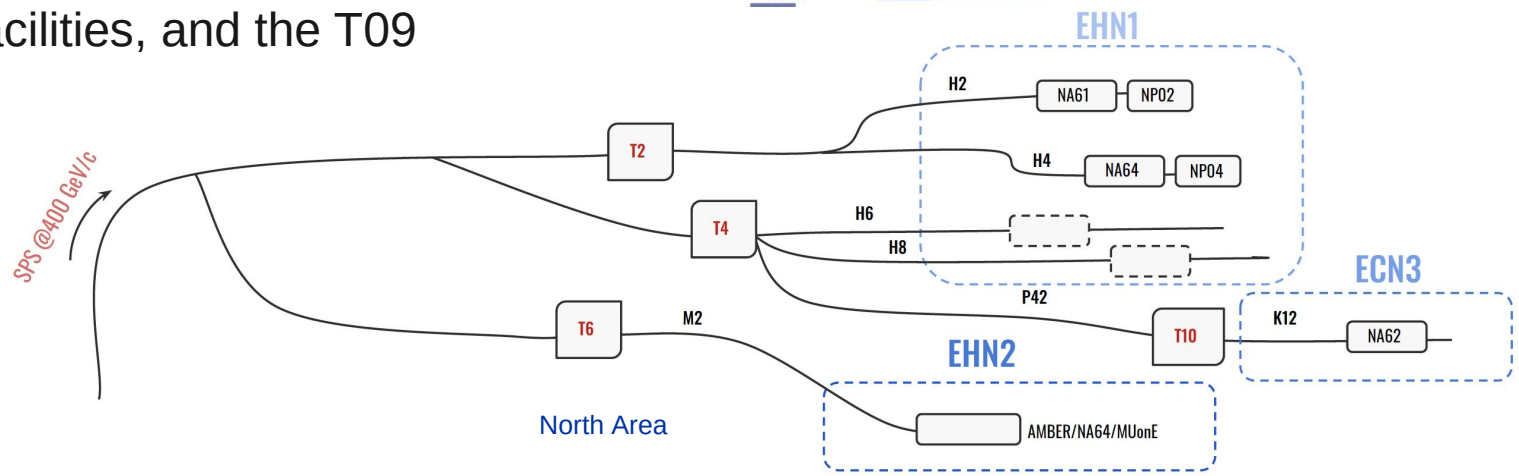
Secondary Beams at CERN

CERN houses two main facilities for secondary beams and fixed-target experiments

- **North Area**, one of the most diverse experimental facilities, serving **proton, hadron, electron, muon, and ion beams** to yearly over 200 user teams for detector R&D and to the NA61, NA62, NA64, and AMBER experiments, the two large neutrino platform cryostats, and to the GIF++ and CERF irradiation facilities, with combined more than 2000 users. There are a total of 7 beam lines for users.
- The renovated **East Area** serves the CLOUD experiment, both IRRAD and CHARM irradiation facilities, and the T09 and T10 test beam lines.







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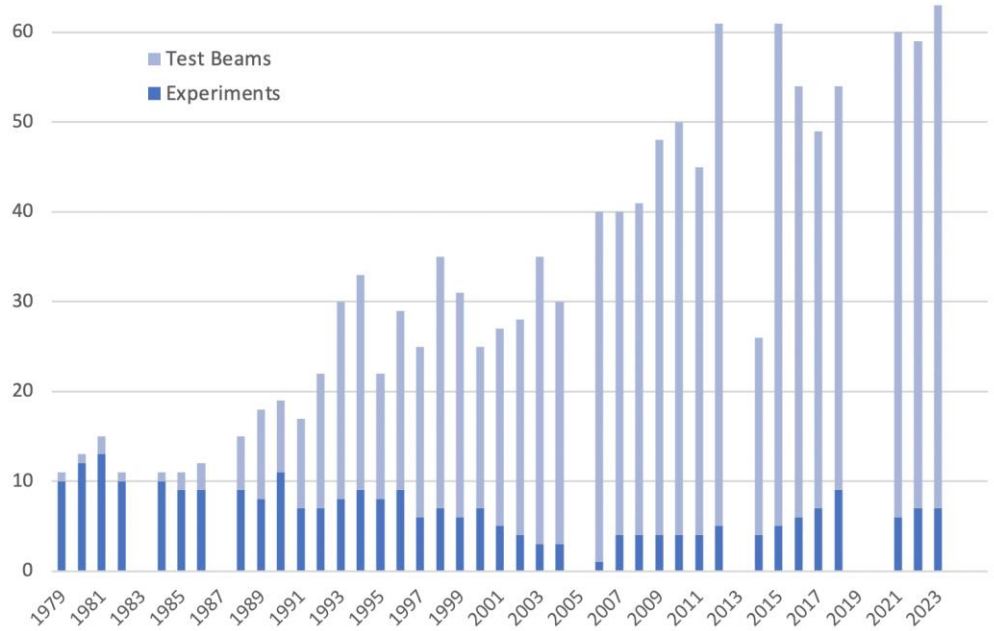
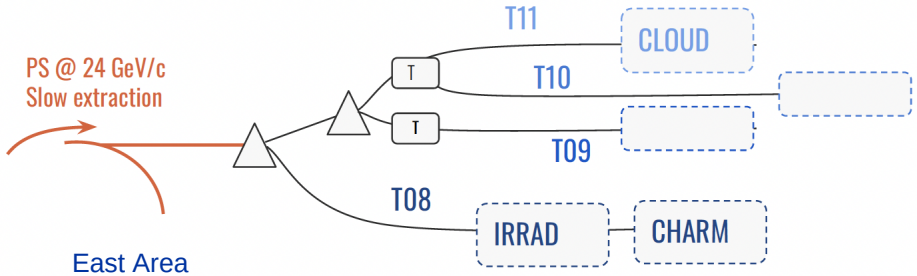
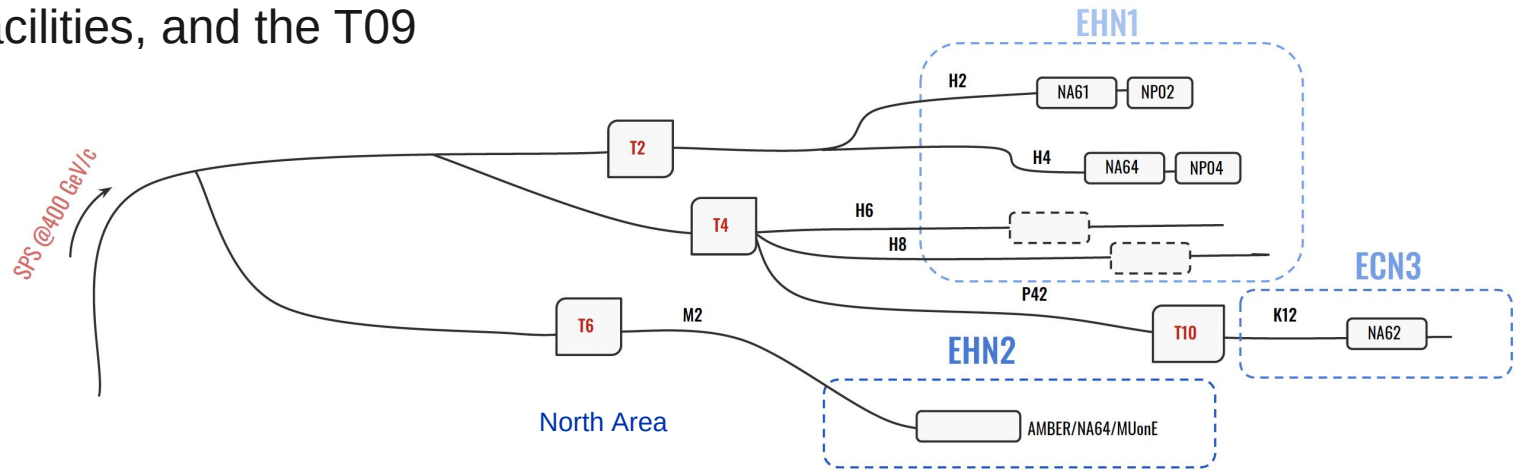




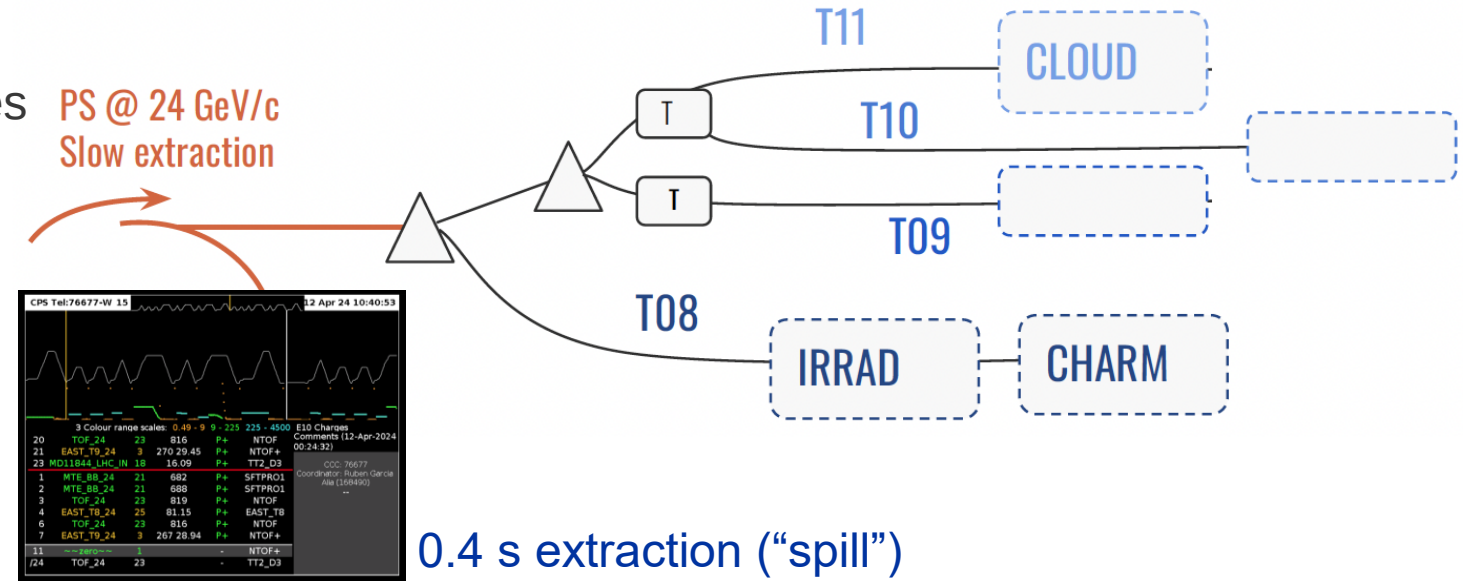


East Area

Test Beam Lines

Test Beams at the East Area – T09/T10

- Primary 24 GeV/c PS proton beam produces secondary beams on two targets – one for T09 and one shared for T10/T11.
- All important particle species for test beam available (pions, protons, kaons, electrons, muons) from 0.1 GeV/c to 16 GeV/c.
- Intensities of up to several 10^6 particles in spills of 0.4 s (= PS extractions).
- Very pure beams available
  - Electron and positron beams via $\pi^0 \rightarrow \gamma\gamma \rightarrow e^+e^-$ conversion (T09 only, upgrade for T10 being studied)
  - Lead absorbers to filter out electrons → pure hadron beams
  - Thick absorbers to filter all hadrons and electrons → pure muon beams



Parameter	T09	T10	T11
Secondary beam momentum (GeV/c)	0.1 - 16	0.1 – 11.5	3.5
$\Delta p/p$ in %	$\pm$0.7 to $\pm$15 (adjustable)		
Intensity/spill	Up to 10^6		
Available particle types	Pure electrons (T09 only), mixed/pure hadrons, pure muons		

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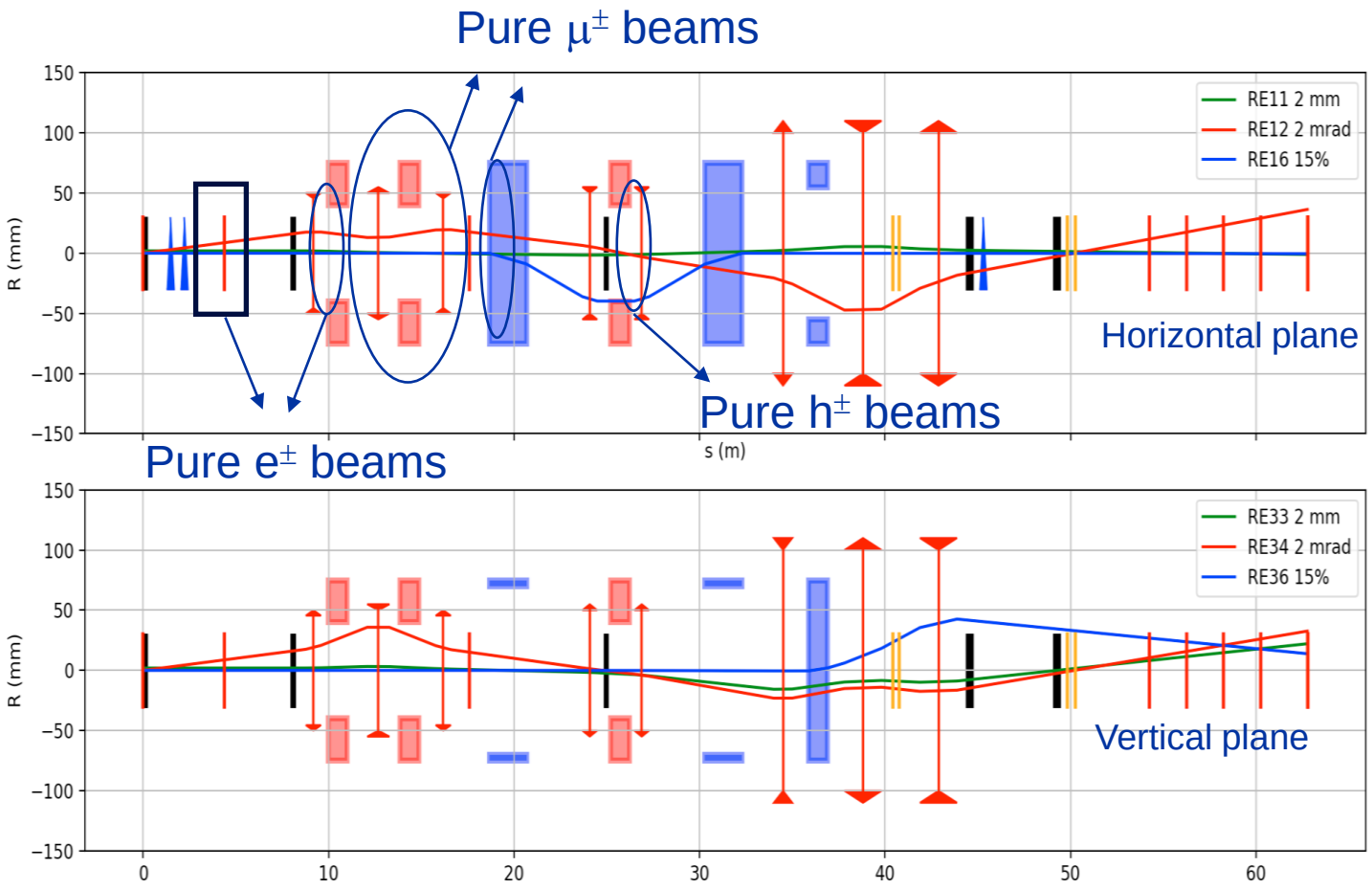

Test Beams at the East Area – T09/T10

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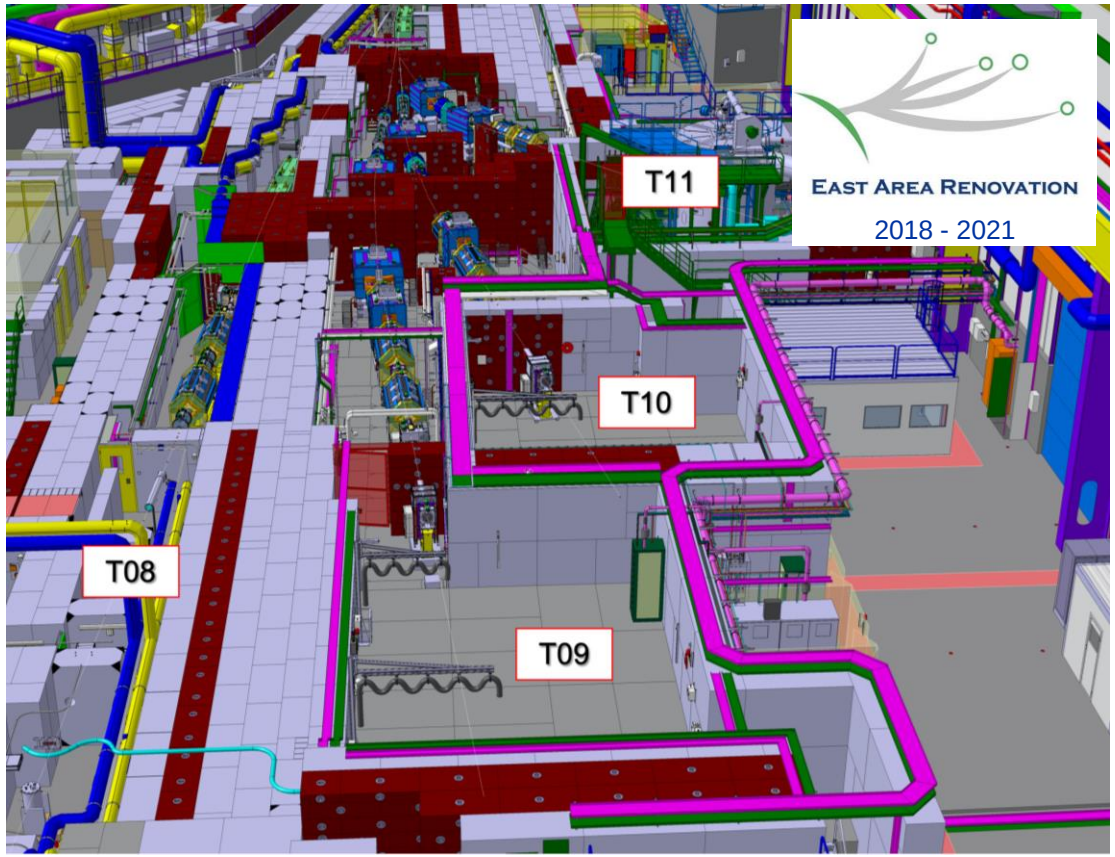

- Accessible beam instrumentation (beam PID via threshold Cherenkov counters in the full momentum range, scintillators, scintillating fibres for timing and ToF)
- Electrical distribution (standard 230V up to 400V/64A)
- Wide array of gases for detectors available directly in the experimental area
- Movable XY tables for experiment set-ups
- Direct network connection to CERN data center and general-purpose network (wired and fibre)
- Timing signals to trigger on extraction (now also including high-precision / white rabbit)
- Patch panel providing connection between experimental area and control room
- Full control of beam parameters from user control room with automatic setting management of all beam line equipment (magnets, collimators, absorbers, access etc)
- Soon: virtual tour and online technical visits possible to discuss ahead of scheduled beam time

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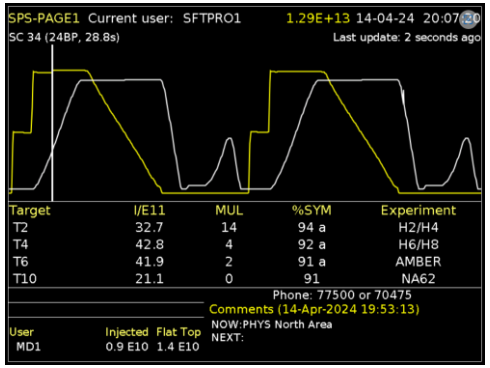
Virtual Tour Prototype

Meet the Team of the East Area

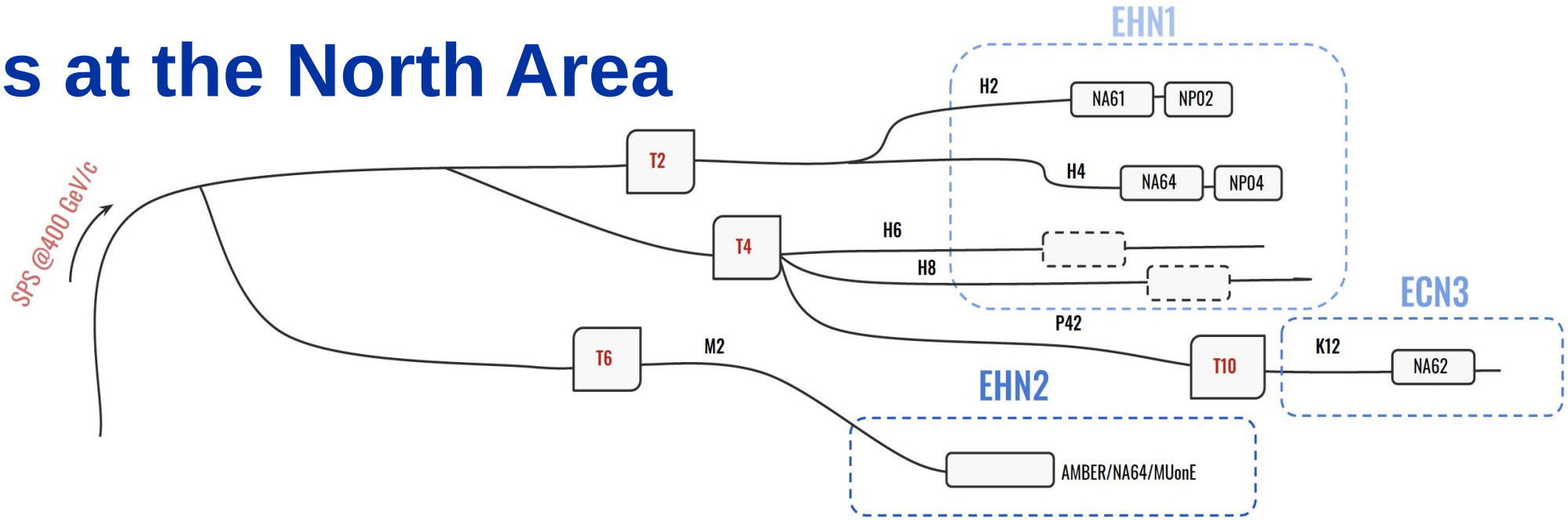
North Area

Test Beam Lines

Test Beams at the North Area



4.8 s extraction (“spill”)



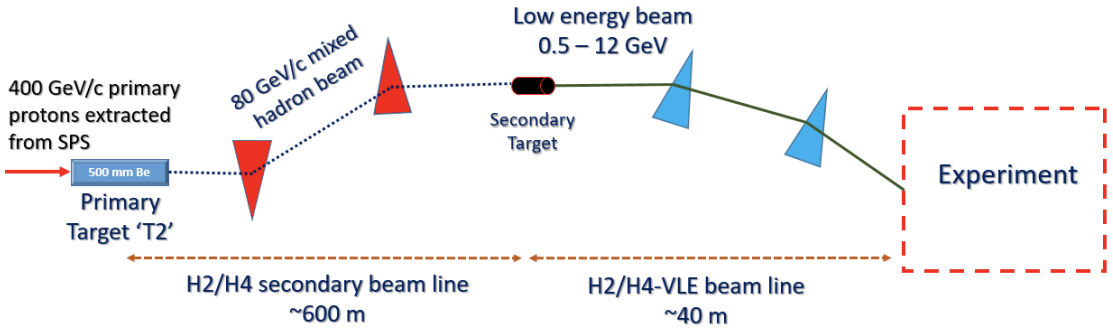
Parameter	T2 Target		T4 Target	
Beamline	H2	H4	H6	H8
p attenuated primary / secondary beam momentum in GeV/c	400 / 360	400 / 360	– / 205	400 / 360
Maximum $\Delta p/p$ in %	± 2	± 1.4	± 1.5	± 1.5
Maximum intensity/spill (hadrons/electrons)	10^7 / 10^6	10^7 / 10^7	10^7 / 10^5	10^7 / 10^5
Available particle types	Primary protons, pure electrons, pure/mixed hadrons, pure muons			
Ion beam availability	Yes	Yes	No	Yes

Test Beams at the North Area

Similar infrastructure and services as in the East Area are also available in the North Area, adapted to the higher energies. In addition:

- Beam instrumentation: Differential Cherenkov detectors for tagging of a particle species in a wide momentum range (CEDARs), delay wire chambers and MWPCs for beam profiles
- Spectrometer magnets:
  - M1 / H2, 3 T, superconducting, 82 cm gap, 1.4 m diameter;
  - Goliath / H4, 1.5T, normal conducting,1.6 × 2.4 × 3.6 m^3 aperture;
  - Morpurgo / H8, 1.5T, superconducting, 1.6 m round aperture, 4 m long;
- Beam telescopes (externally provided, contact A. Rummler)
  - ACONITE in H6A
  - AIDA telescope in H6B
  - AZALEA, a mobile telescope, is also available

Test Beams for Neutrino Detector R&D – H2/H4

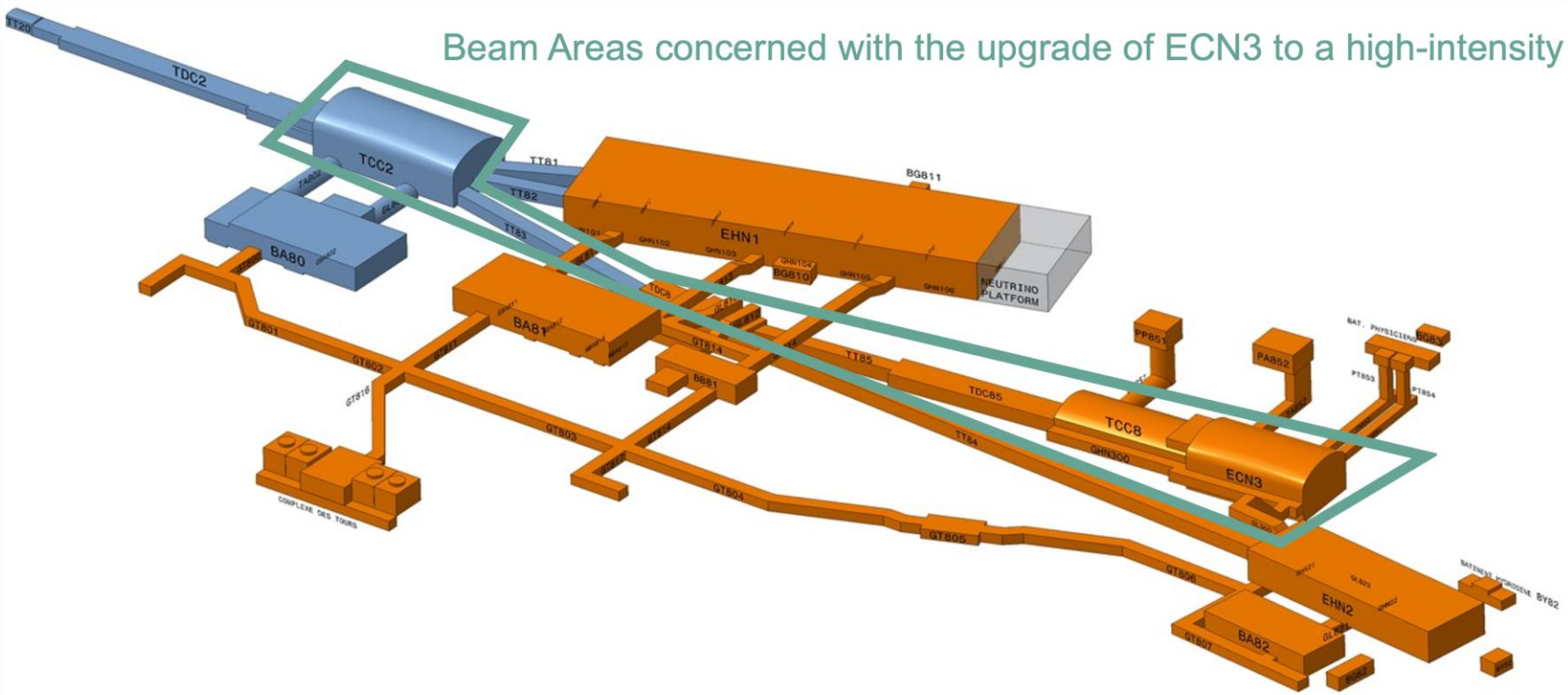


- Primary 400 GeV/c SPS proton beam produces a secondary hadron beam of 80 GeV/c.
- Secondary beam is used to produce a tertiary very low energy beam (VLE) beam in the range of about 0.3 to 7 respectively 12 GeV/c.
- Low intensity of about 100 particles per s in 4.8 s spills.
- Tertiary beams are composed of pions, protons, kaons, electrons, muons → ideal to check detector response for a wide range of particles.
- Different target materials to optimize total particle rate vs. pion-positron-ratio: copper for p > 3 GeV/c, tungsten for p ≤ 3 GeV/c, lead for pure electron beams.
- Main users at the moment are the two large-sized ProtoDUNE detectors (LArTPC) in the framework of the CERN Neutrino Platform.
- Beams with higher rates are also available in the East Area, e.g. next being used by WCTE (Water Cherenkov Test Experiment).

Meet the Team of the North Area

North Area Consolidation

Consolidation Phase 1 (2019 – 2028):
Primary areas incl. TT20, TDC2, TCC2, BA2, BA80 & beamlines leading to EHN1, EHN2 & TCC8

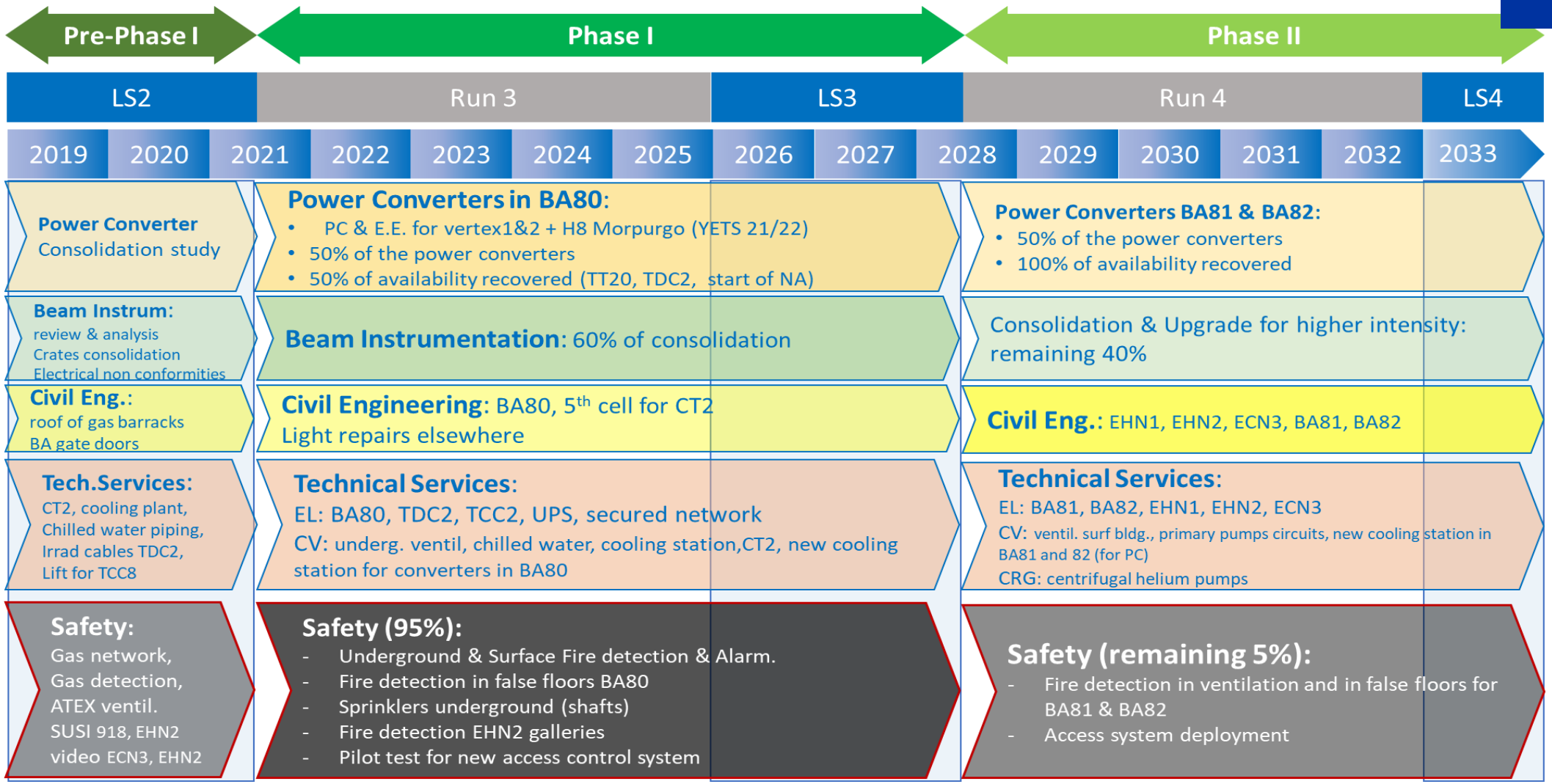


TCC2/P42:
- Magnets
- Beam instrumentation
- Beam intercepting devices
- Vacuum
- Shielding

TCC8/ECN3:
- Beam Dump Facility
- HI Target Complex
- Related Infrastructure and Services

Consolidation Phase 2 (2029 – 2034): BA81, BA82, EHN1, EHN2 & associated beamlines

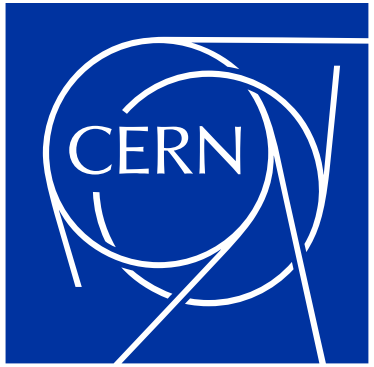
North Area Consolidation



Summary and Outlook

- CERN's test beam facilities provide a multitude of particle beams ($\pi^{\pm}, p, \bar{p}, K^{\pm}, \mu^{\pm}, e^{\pm}$, ions) in a wide momentum range from 0.1 GeV/c up to 400 GeV/c for the test beam and detector R&D community.
- Recent, significant investments in consolidation and renovation secure operation of the facilities in the coming decades and offer modern, safe, and accessible infrastructure for our users, fully in line with the recommendations of the ECFA Detector R&D Roadmap.
- The new TELMAX beam line has just been commissioned in the AD/ELENA complex, providing very low energy antiproton beams to test beam users. A first test run is currently on-going for CERN-internal projects, and we expect to have a call for beam time for next year.

- For a beam time request and any questions, please contact in advance sps.coordinator@cern.ch and our team at sba-operation@cern.ch to optimally use your beam time and the facilities.
- Visit https://ps-sps-coordination.web.cern.ch/ps-sps-coordination/ for the schedule and other useful information.
- Subscribe to the ps-sps-users e-group at CERN for schedule updates.
- Visit https://cern.ch/experimental-areas for further information on the various beamlines.



Thank you very much for your attention!

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Test beams: ECFA Detector R&D Roadmap 2021

General Strategic Recommendations (GSRs)

GSR 1 - Supporting R&D facilities.

It is recommended that the structures to provide Europe-wide coordinated infrastructure in the areas of: **test beams**, large scale generic prototyping and irradiation be **consolidated and enhanced to meet the needs of next generation experiments** with adequate centralised investment to avoid less cost-effective, more widely distributed, solutions, and to maintain a network structure for existing distributed facilities, e.g. for irradiation.

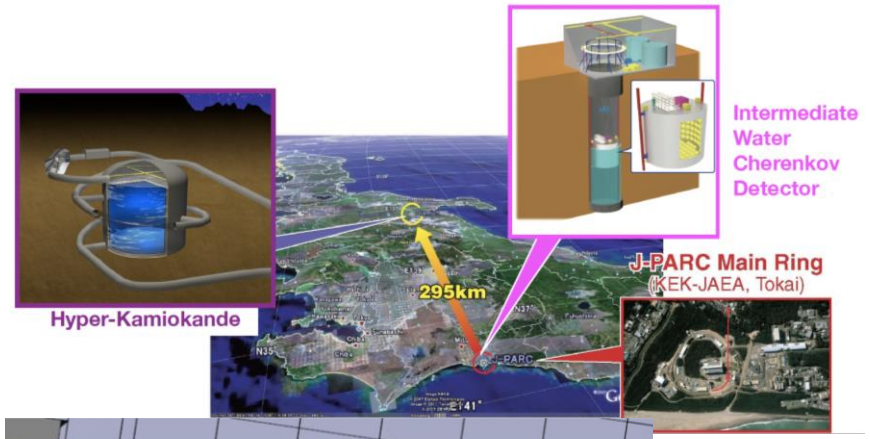
Strongly recommended also by the ESPP Update 2020:

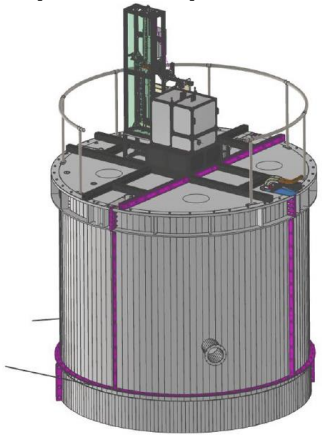
The CERN test-beam facilities, for example, are at present used at full capacity. It is expected that the development of instrumentation for approved and future projects will maintain, even possibly increase, **the need of the community to have access to these types of facilities**. https://cds.cern.ch/record/2691414

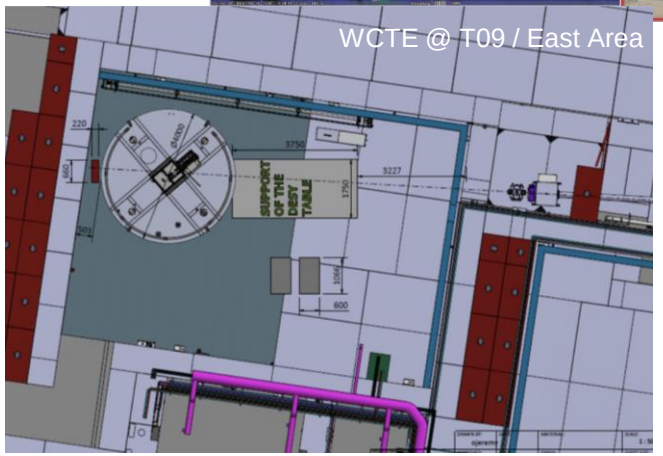
https://cds.cern.ch/record/2784893

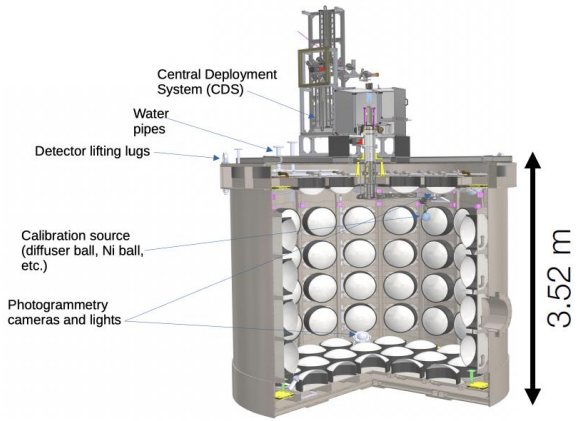
Example: Test Beams for Neutrino Detector R&D in the East Area

- Users included several TPCs (e.g. high pressure TPC with optical readout, ARIADNE, …)
- Next: Water Cherenkov Test Experiment (WCTE)









- A 40-ton water Cherenkov Detector
- Operate in the T9 beam line in East Hall
- Particle fluxes of $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$ and p in the 200 MeV/c to 1000 MeV/c range
- Operating phase with $Gd_2(SO_4)_3$ loading to allow for neutron detection
- Primary photon detection system is 100 multi-PMT photosensors mounted on inside of detector
- Proposal document: SPSC-P-365

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