Perspectives for future CALET beam tests

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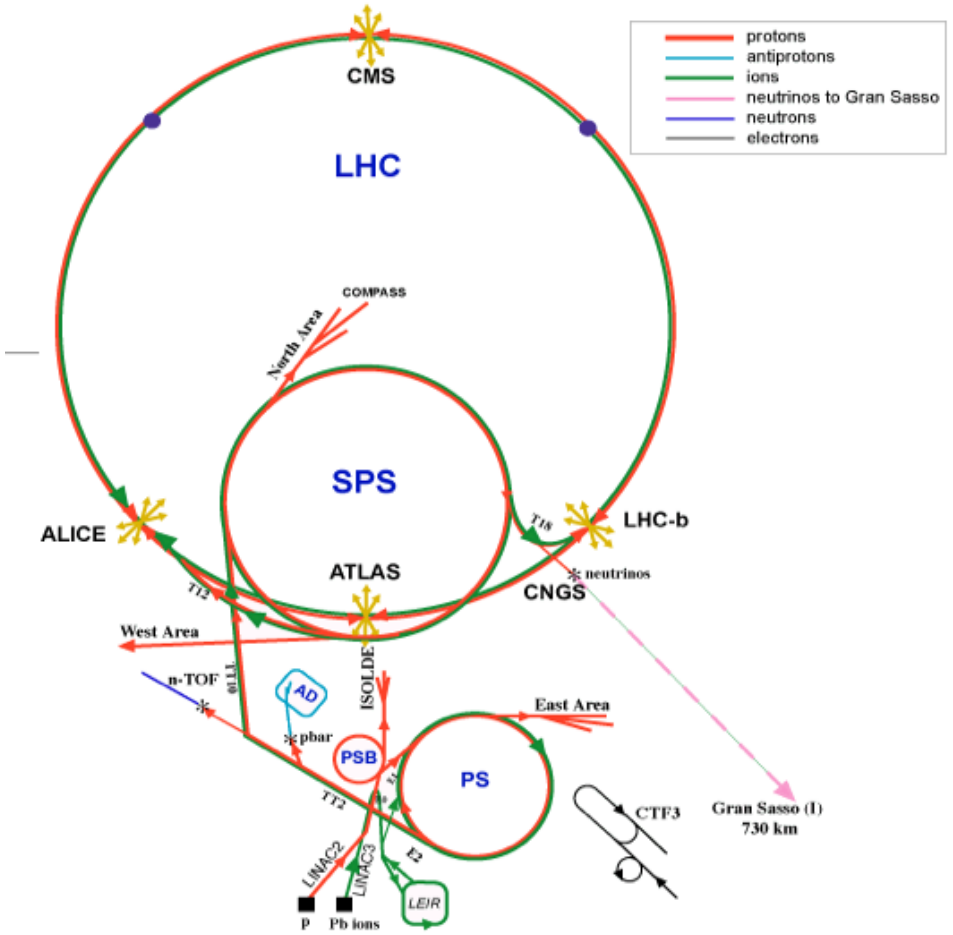
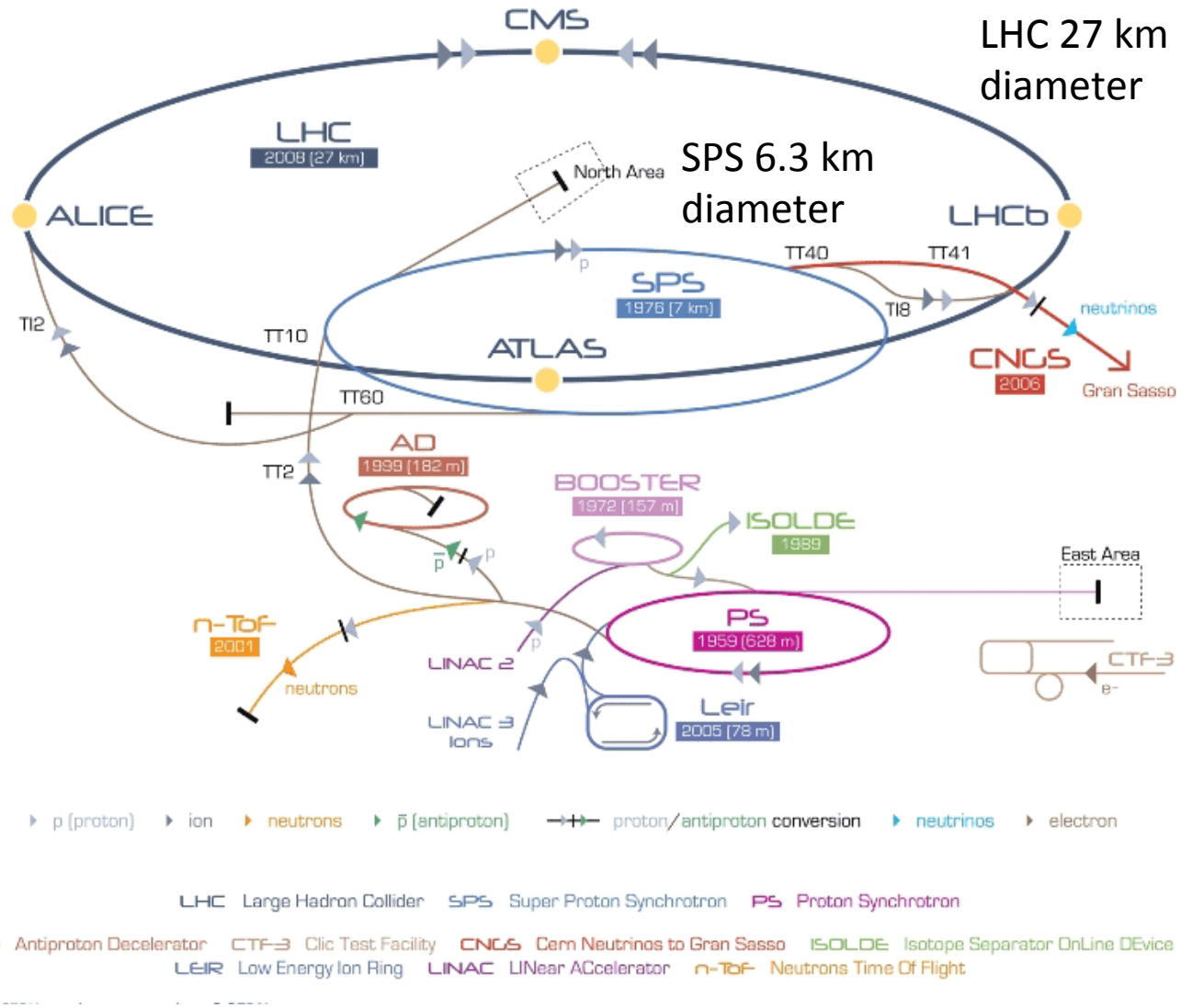
CERN Accelerator Complex



LHC: Large Hadron Collider
SPS: Super Proton Synchrotron
AD: Antiproton Decelerator
ISOLDE: Isotope Seperator OnLine DEvice
PSB: Proton Synchrotron Booster
PS: Proton Synchrotron
LINAC: LINear ACcelerator
LEIR: Low Energy Ion Ring
CNGS: Cern Neutrinos to Gran Sasso

CERN Accelerator Complex



LHC 27 km diameter

SPS 6.3 km diameter

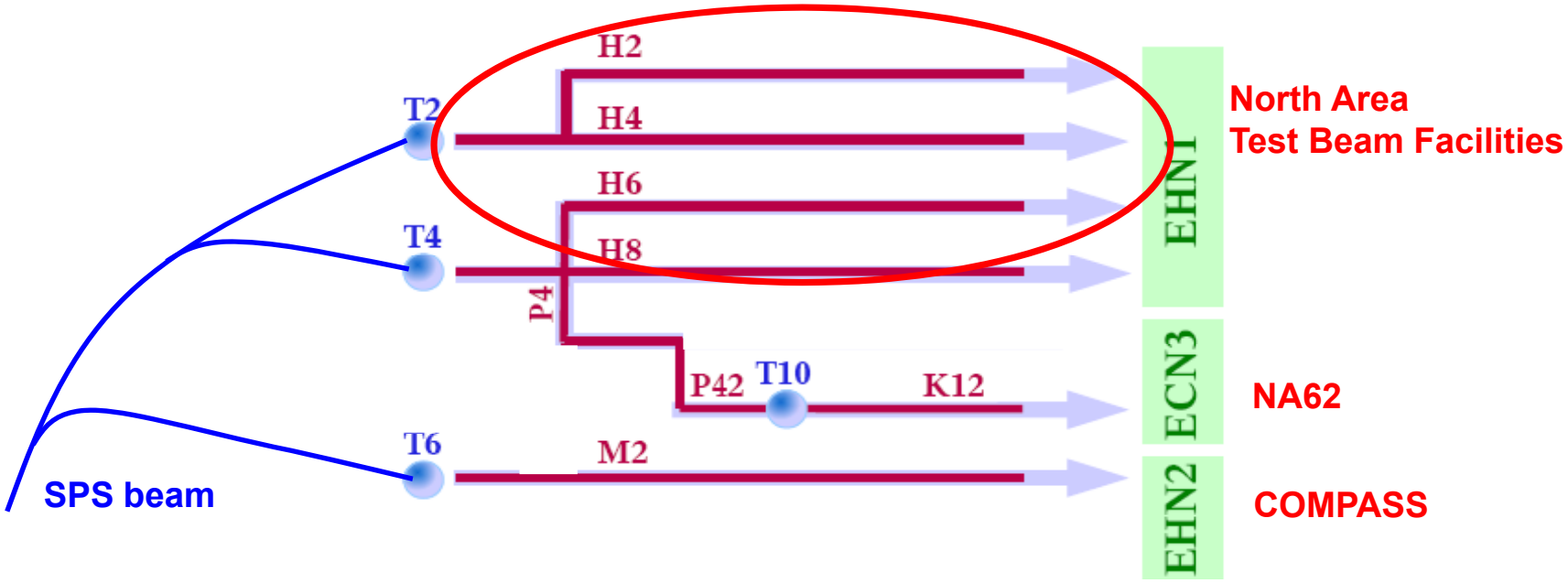
CERN SPS North Area - 1

- 7 beam lines – total length 5.8 km
- 3 experimental halls: ENH1, EHN2, ECN3
- CALET runs in ENH1

The North Experimental Areas at the SPS

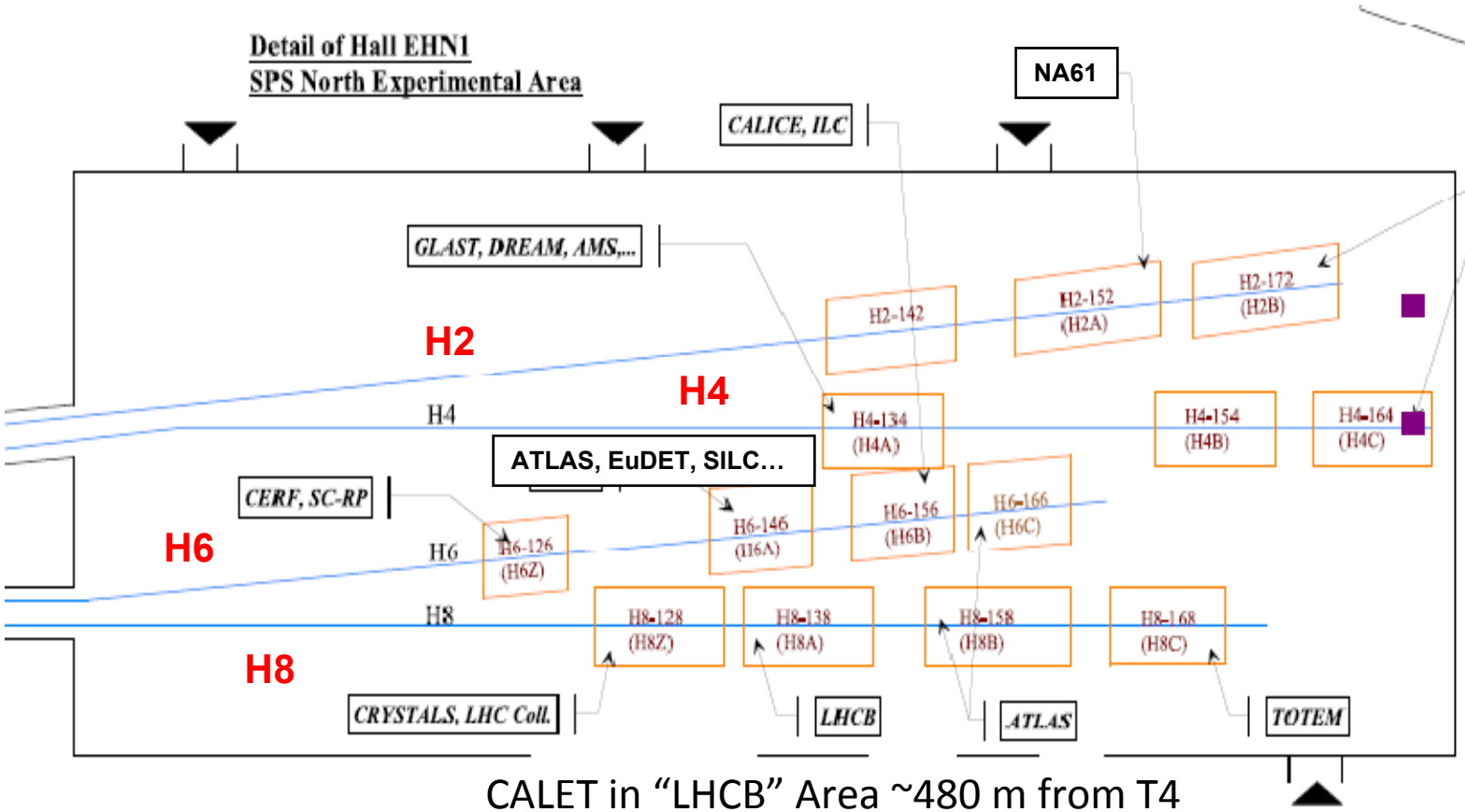
- The SPS proton beam (400/450 GeV/c) slowly extracted to North Area
- Directed towards the three North Area primary targets T2, T4 and T6
- From the primary targets:
  - T2 → H2 and H4 beam lines
  - T4 → H6 and H8 beam lines

    and P42/K12 beam line (NA62)
  - T6 → M2 beam line (NA58/COMPASS)



CERN SPS North Area - 3

North Area Test Beams

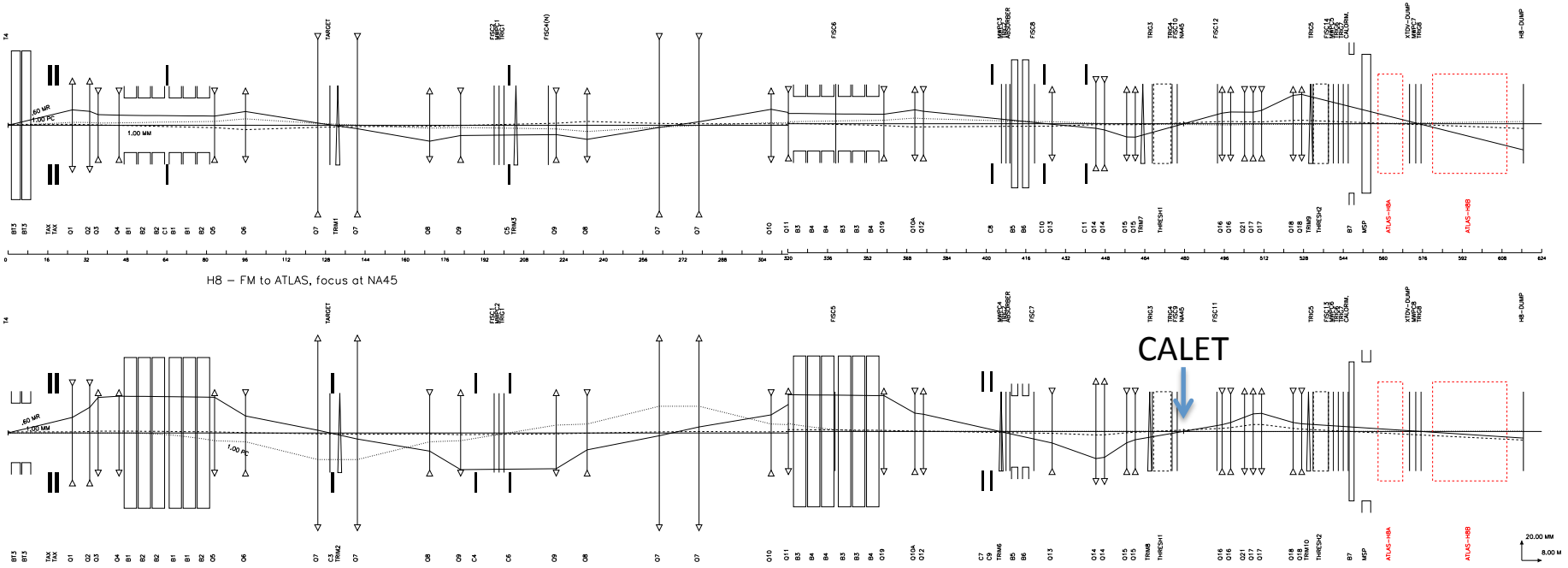


5.8 Km of beam lines

About **1000** beamline components

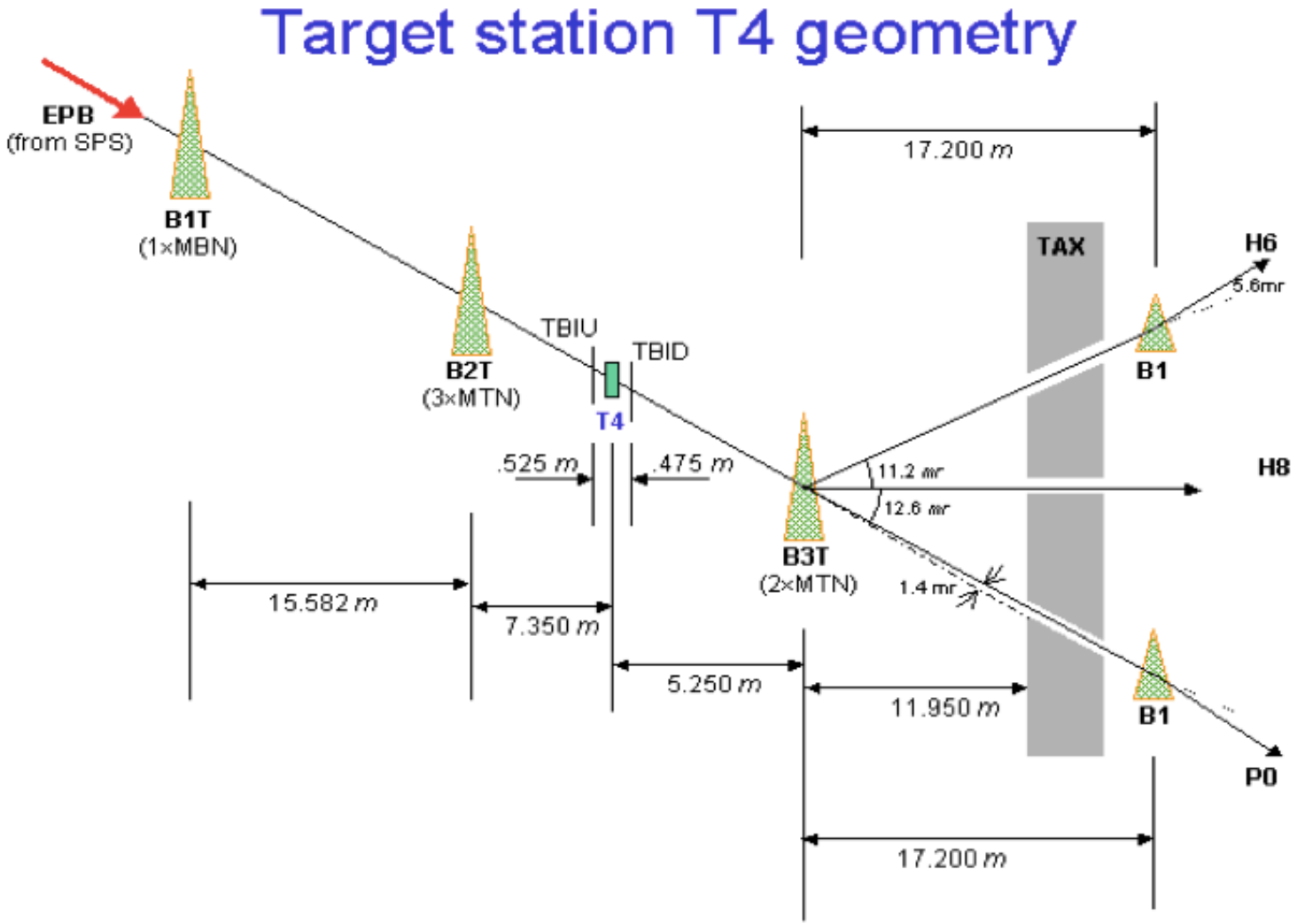
CALET in “LHCB” Area ~480 m from T4

H8 Beam Optics



- CALET test location is at at a focal point about 480 m from the T4 target.
  - ✧ Focus of Quad 14 and Quad 15
  - ✧ Beam location controlled by Trim 3 and Trim 4 dipole magnets

T4 Target Configuration



CERN Pb Run November/December 2015
Approved 23 June 2015

- Beam will be Pb at 30 A GeV/c (this cannot be changed).
- SuperTIGER/HNX/CALET was awarded 6 days (25 Nov – 1 Dec) in beamline H8.
- Will have access both to the primary Pb beam and to fragments.
- SuperTIGER and HNX need to test and calibrate charge resolution for "ultra-heavy" elements (Z≥30) – compatible with CALET CHD tests as beam is produced by fragmentation and all elements with selected A/Z will be present.
- A major goal of the SuperTIGER tests is to develop a better model of scintillator response to very high dE/dx. Intitial modeling shows that current parameterizations are not accurate enough for SuperTIGER. Model will be of benefit to CALET as well.

SPS-Pb: November 2015

schedule issue date: 22-Jun-2015 Version: 2.4

		Mon 2 Nov	Tue 3 Nov	Wed 4 Nov	Thu 5 Nov	Fri 6 Nov	Sat 7 Nov	Sun 8 Nov	Mon 9 Nov	Tue 10 Nov	Wed 11 Nov	Thu 12 Nov	Fri 13 Nov	Sat 14 Nov	Sun 15 Nov	Mon 16 Nov	Tue 17 Nov	Wed 18 Nov	Thu 19 Nov	Fri 20 Nov	Sat 21 Nov	Sun 22 Nov	Mon 23 Nov	Tue 24 Nov	Wed 25 Nov	Thu 26 Nov	Fri 27 Nov	Sat 28 Nov	Sun 29 Nov	Mon 30 Nov	Tue 1 Dec	Wed 2 Dec	Thu 3 Dec	Fri 4 Dec	Sat 5 Dec	Sun 6 Dec
Week		45							46							47							48							49						
Machine					UA9 7h						7h	7h 17h							7h	17h														UA9 7h	7h		
North Area	T2 - H2	NA61 SHINE			D. Lazic PPE172							CMS ECAL				A. Aduszkiewicz PPE152												NA61 SHINE								
	T2 - H4	RD51 (+GIF)			NA58 ECAL G. Mallot PPE134							H. Dong PPE134	HERD							NUCLEON L. Tkachev PPE134							RE21 CBM D. Emschermann PPE134								
	T4 - H8	RD52 DREAM			H. Schindler PPE138							LHCb				UA9 W. Scandale PPE138				RE29 DAMPE X. Wu PPE138							RE25 CALET/SuperTIGER J. Mitchell PPE138								

2015 Ion Beam for CALET - 1

- Beam energy is determined by NA61/SHINE.
  - Successor to NA49
  - Main goal is study of p-p and p-nucleus physics with focus on quark-gluon plasma and the phase boundary between hadron “gas” and QGP.
  - NA61 is the reason the SPS heavy-ion run is taking place. NA61 chooses beam species, energy and duration. All other users (e.g. CALET) are secondary.
- Maximum beam rigidity is limited by SPS magnets to 400 GV/c (really 450 GV/c but that is rarely used now) – for nuclear beams A/Z has to be considered.
- Beam planned for NA61 in 2015 is Pb 30 A GeV/c.
- CALET will run together with SuperTIGER and HNX – all three instruments have similar needs for the heavy-ion run.
- Run is scheduled in H8 beamline (used in 2012 proton run and 2013, 2015 heavy ion runs) from morning 25 November until morning 1 December.
- 1 December is scheduled for UA9 and I expect that we can continue to run behind UA9.
- Run will use primary Pb and beam resulting from fragmentation in a thin target installed in the T4 target station (nominally selected as A/Z=2).
- May also use local fragmentation target.

2015 Ion Beam for CALET - 2

- Peripheral fragmentation takes place when a beam particle (projectile) impacts a target nucleus (target).
- Fragmentation results from a combination of two processes:

1) Simple removal of nucleons by scattering interaction between projectile and target nucleons
2) Emission of nucleons or groups of nucleons (e.g. alpha particles) from the (possibly unstable) remnant projectile nucleus.

  - Most probable (highest cross-section) interaction is removal of a single nucleon.
  - Next most probable is emission of an alpha.

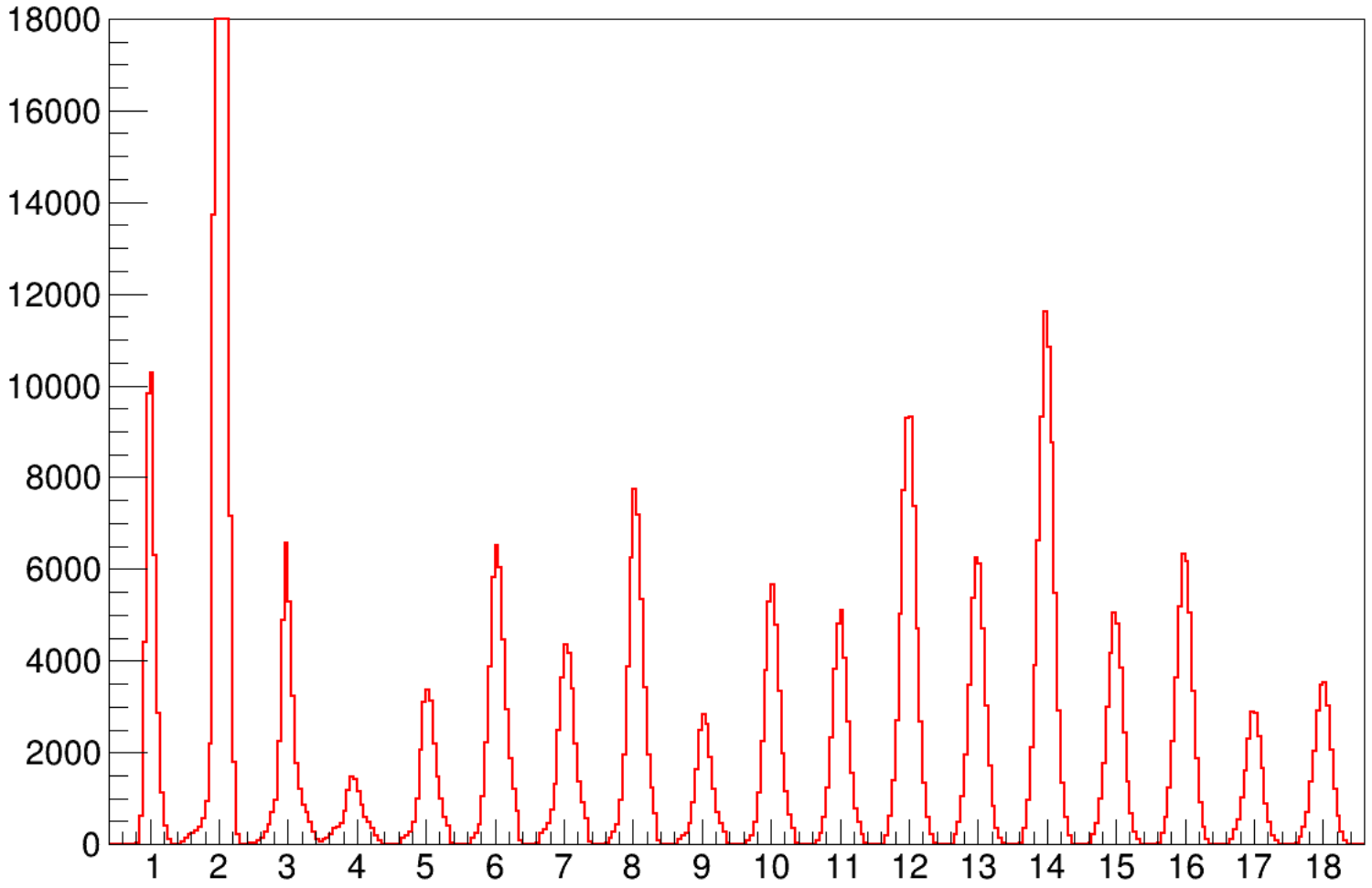
- Fragments are emitted approximately in the direction of the projectile and travel at approximately the velocity of the projectile.
  - The fragment is affected by the net vector Fermi momentum (momentum of the nucleons in the nucleus) of the removed nucleons (250 MeV/c per nucleon).
  - The direction is altered by the ratio of the transverse component of the Fermi momentum to the total momentum and by multiple scattering. Both effects are small at these energies.
  - The velocity is altered by the longitudinal component of the Fermi momentum.

2015 Ion Beam for CALET - 3

- Beamline is a highly selective (<1% momentum resolution) magnetic spectrometer. This is mainly driven by the "big bends" that bring the beam from the underground SPS tunnel and T4 target area to the surface.
- Beams are selected by magnetic rigidity (momentum/charge). Because the velocity is approximately the same for all particles, this effectively selects A/Z.
- Normally we run A/Z=2 to span full range of fragment Z from Z=1 (deuterons) to the primary beam (depending on the A/Z of primary).
- Relatively thick targets available previously in T4 made multiple interactions likely.
  - Final fragment momentum depends on the net effect of all Fermi momentum dispersion as well as differential energy loss in the target, depending on the interaction depth
- Momentum dispersion from multiple fragmentation and energy loss dispersion in the thick target makes selectivity less effective than might be expected.
- Experience has shown that we cannot get isotope resolution from beamline except for light elements.
- For February 2015 (Ar beam) thinner targets (e.g. 10 cm polyethylene) were installed at CALET request to reduce multiple interactions.

2015 Ion Beam for CALET - 4

- Ar beam fragments from10 cm polyethylene target.
- Note relatively high population of heavy fragments –> little multiple fragmentation.
- This target (or 5 cm polyethylene) will be used in Pb beam tests.



Future Beam Test Prospects

- CALET is a CERN Recognized Experiment (RE25), which gives it privilaged access to beams.
- SPS will continue with proton test-beam program for forseeable future.
- SPS will likely conduct one or two heavy-ion runs of 2 weeks to 1 month each year.
- CALET will determine utility of beam tests based on the performance of the instrument on orbit.
- Possibilities:
  - Studies of position dependence of PWO response.
  - PWO temperature dependence.
  - CHD saturation and response with flight FEE.
  - Check on observed on-orbit performance.
  - Etc.