Short Introduction to the use of the H6 beam

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updated version for 2000:

In order to facilitate the search in the H6 zones, the upstream part of the old zone 146 has been separated and a <u>new zone 136</u> has been created. This is an EA zone only, note used for tests or experiments, but on occasions the users of H6 might have to press "end of access" on door PPE136.

<u>REVIEW of your past runs:</u>
In order to allow users to find their way back to what was done to their beamline in the past, the LOG files are now available on the web:
http://nicewww.cern.ch/ sl/eagroup/eaframe.html   -- choose Logfiles and choose H6. For the information from previous years, go to the end of the page ("Older Logfiles"), then make your choice.

The H6 beam is a secondary particle beam that provides hadrons, electrons or muons of energies between 10 (5?) and 205 GeV/c, depending on the conditions in H8. This beam is a part of the SPS North Area, located in EHN1 (bldg. 887). This note gives a short introduction to the basic elements of the H6 beam. For more detailed information the users are referred to the H6 handbook or to one of the SL-EA liaison physicists.

1. The Layout of the H6 beam
(see also the drawings in your H6 handbook)

A 450 GeV/c primary proton beam is extracted from the SPS and directed on the T4 primary target. Typical intensities of this primary beam are several 10^{12} protons per burst. *For proper operation of the beams the symmetry on the T4 target should be at least 80%.* These numbers can be read from the so-called 'PAGE-1' TV screens in the counting rooms of tests and experiments, as well as all over CERN. From the T4 target, three secondary beams are derived (see figure next page): the P0 beam to ECN3, the H8 and the H6 beams. The momenta and polarities of the three beams are strongly correlated. For example, if the P0 beam runs at 450 GeV/c, the H8 beam can run at any negative polarity (-10 to -400 GeV/c) or at positive polarities up to 180 GeV.

The H6 beam always runs at the polarity of the H8 beam and typically up to about 50% of the momentum chosen in H8. Any of these "front-end" changes of the beams imply a possible danger to damage equipment and should therefore be done by an SL-EA liaison physicist.

a) different modes of H6 operation

There are three distinct modes of operating the H6 beam:

1)   in the high resolution mode
2)   in the high transmission mode
3)   in the **"filter" mode** (test-beam mode, also used
                        to produce tertiary beams)

For a user asking for different particles/energies, the "filter" mode is the optics used to calculate the beam files - it provides a large range in energies from 5 to 205 GeV/c and several possibilities to create tertiary beams (see below).

b) beams available in H6

If the P0 beam is off, the H8 beam can run e.g. in the 450 GeV/c "micro-beam" mode. If this is the case, H6 runs at +205 GeV (secondary beam) and the correspondingly deduced tertiary beams.

If the H8 beam runs as a (positive or negative) secondary hadron or electron beam (i.e. most of the time as from 1994), the H6 momentum is coupled to the H8 as described above. Tertiary beams are only available in sufficient intensities, if the secondary H6 beam has at least an energy of 100 GeV. In both cases, H6 can run in the "filter" mode: a further "TARGET" can be introduced into the beam to produce **tertiary** beams of lower energy. Typically, this is done when H6 runs at +205 GeV/c or ±120 GeV, and tertiary beams then range from ±5 to ±80 (100) GeV/c. This "filter" mode of operation allows an easy change of beam momentum, which can be done by the H6 users from their beam control terminal - without interference to the H8 beam.

c) experimental areas in H6

NOTE: Like all other beams in EHN1, we distinguish experimental areas (at present none in H6) and test zones: for the moment zone H6A with tests of ALICE (barrack HNA451), H6B with ATLAS (EMEC) using the ex-NA31 cryostat (barracks HNA453 and HNA455), and H6C with ATLAS (HEC + FCAL) (barrack HNA457) (in geographical order). Some test activities of the TIS-RP and in collaboration with universities (a collaboration called CEC) take place in zone PPE126 (this is not an official experimental area).

2. The Control Tree

The user wants to select the energy and polarity of the particles in his beam, to steer the particles into a selected part of the detector and to adjust the spot size (focussing). He needs to choose the type of beam particles, control the beam intensity and eventually to stop the beam and get access to his experimental zone. He will use the beam instrumentation to check certain properties of the beam. Finally he needs to monitor that all the equipment in the beam is functioning correctly.

All these tasks can be performed from the X-terminal, connected to a cluster of HP UNIX computers running the NODAL system. From this terminal the user controls the beam and related equipment through the so-called TREE program, invoked by the command 'RUN TREE', or if necessary 'RUN <index> TREE' , where the 'index' is 203 for H6A, 213 for H6B and 241 for the test zone (index 219 is used for the TIS-RP tests). From then onward the user just follows the menus offered by the control tree.

Note that the NODAL system still mostly accepts only UPPER CASE! In case you get lost or stuck, you can leave the control tree by typing CTRL_C. You can then enter the tree again by typing 'RUN TREE' to re-start, or 'BACK' to go back to the branch were you got lost. In case of mis-typing, you should use '**backspace**'. In emergency cases only, switch terminal OFF/ON. In the new control system with X-terminals, you can use the **DICO option** for special displays, e.g. beam profiles, etc.. **Printing of a window** is done by clicking the left mouse button in the "dark" are of the screen and choosing "print window" for normal size print, "print logbook" for reduced size prints. "Print Inverted" should be used for the DICO windows. Default printer is one in CRN, but on request your liaison physicist can define any printer declared on CERN's "springer" as default printer, e.g. the laser printer in your barrack.

3. Beam Files

Normally each user has a number of different beam energies and corresponding beam intensities at which he wants to run his experiment. These sets of conditions are described by Beam Files. In each index (203, 213, 219 or 241) there are 10 read-only beam files for the EA group, and up to 50 beam files, for use by the experiments. The EA files are called H6.A to H6.J and the user files are numbered H6.1 to H6.50. These files contain all magnet and collimator settings. A list of available files is obtained by

FILES / LIST

The actual conditions in use at any given time are described by another beam file, called **BIM.0**.

The user can select new conditions by loading a file from the tree:

FILES / LOAD / H6.nn

and then answering the questions. In particular one has the option to change only magnets, only collimators or both. Magnet current changes are fast, collimator changes may be much slower. This command copies the values of file H6.nn into BIM.0 and sets the proper magnet currents and/or collimator positions. Usually beam files are prepared by or after discussion with the responsible EA liaison physicist, although experienced users will sometimes change files themselves.

It is wise to check that the equipment has responded correctly to the requested changes by typing

STATUS / MAGNETS or **STATUS / COLL**

and verifying that the currents (positions) read back correspond within tolerances to the currents (positions) in BIM.0. Tolerable deviations are 0.2-0.3 Amps for BENDS and QUADS, 0.5 Amps for TRIMS, max. 0.2 mm for collimators. In case of problems, try once more to load the file. If the problem still persists, call the CRN operator (over the intercom - CRN/PCR - or over 75566 and the NATEL 16-0137). The liaison physicist can do nothing for you in this case!

4. Fine Steering and Focussing of the Beam

BENDs   Steering of a beam is done by BENDing magnets (dipoles). Normally the currents in the dipole magnets are defined correctly in the beam files and the user should not modify them without discussing with the EA physicists - **you might change the momentum of your beam!** Only exception in H6 is the last magnet in the beam, BEND9, which is used to vertically displace the beam in the H6B and H6C areas.

QUADs   Quadrupoles are like lenses in conventional optics, they are used to (de-)focus the beam and thus change the spot size of the beam. The spot size of the beam is controlled by the last QUADs in front of each experiment. Which quad controls what projection depends on the beam file used. In the beam files these quads are originally defined to minimise the spot size at the main experiment locations, but may have been changed by users. Focus changes for H6 experiments are done with Q15 and Q16.

Examples for a +100 GeV beam (currents scale roughly with E):

focus at	MWPC7+8	MWPC9+10	in H6B	in H6C
Q15	-220.6 A	-130.6 A	-113.0 A	-103.0 A
Q16	-224.6 A	- 95.4 A	- 79.4 A	- 71.0 A

TRIMs   TRIM magnets are correction dipoles, used for fine steering of the beam. Normally the last TRIMs upstream of each experiment should only be used for steering. Fine steering to the H6 experiments is done with TRIM5 (vertical) and TRIM6 (horizontal).

Examples for a +100 GeV beam (currents scale roughly with E):

move by 10 mm	at MWPC9+10	in H6B	in H6C
TRIM5+6(V+H)	37 A	24.7 A	18.5 A

(find the sign by trial and error!)

The currents in these magnets can be set using, e.g.

<div align="center">

TUNE / SET/ QUAD / 16 / _current_
TUNE / SET/ TRIM / 5 / _current_

</div>

These changes are **not** saved in the files (except the BIM.0 file for the present status)!

5. The type of particles in your beam

Overview of your present beam:

In order to get rapid information on the beam you are currently using, you may type

------------>>>> **STATUS / GENERAL**

You will get the status of TARGET, ABSORBER and relevant collimators, together with the beam intensity (optional) as measured in a coincidence of two TRIG counters. The beam profiles in MWPC5+6 are also shown in a DICO window.

Choose/change the beam mode (particle composition):

Type

→   **TUNE / SPECIAL / MODE / HELP**

and follow the instructions there.

'Pure' electrons   **(1) secondary beams:** These are obtained by loading the appropriate file and by assuring that the dangerous material (lead sheets and TRIG counters etc.) are removed from the beam. To this end, use

/ **TUNE / SPECIAL / MODE / TARGET / air**
/ **TUNE / SPECIAL / MODE / ABSORBER / air**
and   / **TUNE / MEAS / TRIG / out**

Separation of electrons from hadrons - at energies above 100 GeV - is achieved by the synchrotron radiation energy loss in the BENDs.

(2) tertiary beams: Are obtained by loading the appropriate file and choosing **Pb** as a TARGET (see below). Downstream of the TARGET, all other Pb sheets (in particular the ABSORBER) and TRIGs should be out of the beam. Momentum selection of the tertiary beam in the second main BEND, separation from hadrons due to production mechanism in the Pb foil TARGET (degrading electrons (by bremsstrahlung) much more than the hadrons).

'Pure' hadrons   **(1) secondary beams:** Choose the appropriate beam file and put in the **Pb** TARGET to remove electrons. In addition, further purification can be obtained by entering an ABSORBER into the beam.

'Pure' hadrons	**(2) tertiary beams:** Choose the appropriate file and use **Cu** or **POLY** as a TARGET. Momentum selection as above, **use ABSORBER** to "kill" the electrons in the tertiary beam.
Mixed beam	Do you really want it? You get it by <u>not</u> applying the prescriptions above, e.g. choose a tertiary hadron beam and do not remove electrons by lead sheets.
Muons	Choose a secondary hadron beam file and close collimator **C8 and C9** asymmetrically (i.e. setting the jaws to +45 and +46 mm respectively). The muon momentum is selected by BEND6. Note that the intensity is highest if collimators upstream of C8 are opened (use +205 GeV, if possible, or +/- 120 GeV, to produce high intensity muon beams).

The TARGET can be changed by

TUNE / SPECIAL / MODE / TARGET /

the ABSORBER is moved in and out by

TUNE / SPECIAL / MODE / ABSORBER /

and the situation of the TRIG counters can be observed or changed by

TUNE / MEAS / TRIG /

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6. Beam Intensity and Momentum Spread

The beam intensity is normally controlled by three collimators, namely:

C3   Momentum defining collimator (vertical),

C5 and C6   H and V acceptance collimators.

For secondary beams, the momentum defining collimator C3 defines the momentum byte of the particles transported to your detector. The momentum byte $\Delta p/p$ is proportional to the opening of the collimator. A gap of 10 mm gives a $\Delta p/p$ of approximately 0.5% in high-transmission and filter (i.e. test-beam) mode..

More accurately, the general expression to calculate the **full width** momentum spread is

$$\Delta p/p = (C3^2 + C8^2)^{1/2} \ / \ 19.4 \ [\%]$$

where C3 and C8 are the **full width** opening of these collimators **in mm**, 19.4 mm/% is the vertical momentum dispersion of the beam at C3 compared to C8. This expression holds for a tertiary beam in all cases, while for a secondary beam C8 is often more open than the beam image and should be replaced by 2 mm (the T4 target thickness, i.e. the "source size" of a high energy secondary beam), in which case C3 usually dominates the resulting $\Delta p/p$.

Decreasing the opening of C5 and C6 results in a (sometimes non-linear) reduction of rate. It is not related to the momentum band of the beam. The collimators are controlled by (e.g.)

TUNE / SET / COLL / 3 / JAWS/ -5 / 5

or

TUNE / SET / COLL / 6 / SLIT / 24

Note that depending on momentum byte requirements it may be more advantageous to close C3 rather than C5/6, or conversely, to open C5/6 rather than C3.

Sometimes it turns out not to be possible to reduce the rate sufficiently by closing C5 and C6. Other collimators can be closed in those cases, e.g. C1.

In 1996, for the NA56/SPY run, two new collimators were inserted between Q2 and Q3, very far upstream: C10 (H) and C11 (V) (see the layout drawing attached). Closing these collimators stops pions early and thus reduces the muon content of the beam.

Note that the value of **B5** should always be left untouched - it is the **reference value** for your beam energy. For example, for 120 GeV hadrons B5 should be at 566.4 A. For corrections in the vertical plane, B3 should be used.

7. Access to your zone

Frequently you will need access to your zone in order to modify, adjust, move or repair your apparatus. This is done through the command e.g.
ACCESS / DOOR / 146 / OPEN   (for H6A).

Type in your name when the program asks for it. Wait until you get the message which confirms that you have access! Then go to the door (e.g. marked PPE146), make sure the lights 'ACCESS WITH KEY' are flashing, push the button with a key on it, take the key for which the red diode lights up and use it to open the door and enter the zone (PRESS THE DOOR HANDLE SLOWLY!!!). **Every person entering the zone should take a key and keep it with him** - your safety depends on this action!!! When you come out of the zone you should put back the key and turn it into its normal position. When the last person has finished, check that nobody is left in the zone, put back the last key, push the red button marked 'END OF ACCESS' (do not forget - otherwise you will not get beam and have to walk back to the door later...!) and go back to your barrack. At your beam terminal, type e.g.
ACCESS / DOOR / 146 / BEAM ON
type in your name (you are responsible for persons left in the zone!) and wait until the beam comes back.
New since 1998:
>   (a) **When a door stays open longer than 1 minute, the area will go automatically on FREE access (exception H6C/166: 5 minutes)**
>   (b) **If you know that many people have to enter the zone and do bigger jobs, you can choose**
>   --->>>>>>>>>   ACCESS/ DOOR / 146 / **FREE**   <<<<<<<<---
>   **(after DOOR/146/OPEN) from your beam terminal.**

Both situations require that **after the access the zone is properly searched.** This can be done by the CRN operators. If authorised by the Radiation Safety Officer of EP or SL Division, the GLIMOS or other senior physicist can also take this "search and secure" responsibility.

In 2000, a **new zone 136** has been created upstream of zone 146 (H6A).

After an access, it is wise to check that all magnet currents are OK by typing
STATUS / MAGNETS
If the magnets do not switch on properly, then try "ACCESS / BEAM ON" again or try to set them to their BIM.0 value by TUNE / SET. If the problem persists, call the CRN operators.

> **Important :** In the door itself, next to the handle, there is a round 'pastille' with a dim red light in it, which should be pushed **in emergency cases only !** Whenever this button is pushed, it requires an operator to come over and reset the emergency stop manually. This may cause significant loss of beam time.

8. Using the detectors / beam-tuning

The H6 beam is equipped with various detectors:

CED CEDAR Cerenkov counter - see the special description, CERN yellow report 82-13.
Control via branch **DETECTORS / CEDAR/...** .
It has become "tradition" to leave this CEDAR in the H6 beam all year.

XWCA (MWPC) Wire chambers that allow to make beam profiles. They only perform reasonably for beam rates above 1000 particles per burst. These profiles are made by typing
TUNE/ MEAS / MWPC / PROFILE / ...
Often, the first profiles look strange - repeat profiles, because HV adjustment in the chambers is done automatically with every profile. MWPC7+8 give the profiles at the upstream, MWPC9+10 the ones at the downstream end of zone 146 (H6A).

FISC Scintillation counter filaments of e.g 0.2 mm widths, moving through the beam at 1 step per burst, which provide horizontal and vertical profiles. To use a FISC, type

TUNE / MEAS / FISC / PROFILE / fisc number /
/ 2 / start mm / end mm / step-size mm/

TRIG Scintillation counters. TRIG-1 counts the rate between the two main BENDs. TRIG-7 at the upstream end and TRIG-8 at the downstream end of zone 146 (H6A) are used to monitor the total intensity at the end of the H6 beam. TRIG-5 and TRIG-6 are used as trigger counters for the XCED CEDAR counter. Their rates can be measured by

TUNE/ MEAS/ TRIG/ 5/ USE/ 2/*nr bursts*

Note that the scintillator can be moved in to and out of the beam with TUNE*/* MEAS */* TRIG .

EXPT   Experimental scalers do not count any of **our** detectors but rather **yours**. In your barrack there is a panel with four (or more) plugs. In each of the four you can provide a standard NIM-signal that is counted over each burst and read into the SPS computer system. These counts are displayed by
TUNE/ MEAS/ EXPT/ *scaler* / 2 / *nr bursts*
where the scaler number depends on the barrack (see a new list appended).

The TRIG and EXPT counters are very useful in beam tuning. Steering can be somewhat more automatic by the SCAN procedure:

TUNE / SCAN / EXPT / 5 / 2 / TRIM / 5 / -50 / 50 / 20

will vary the Trim-5 current from -50 to +50 Amps in steps of 20 Amps (one step per burst), measure the count in EXPT-5 (**you** know what that count means!), normalise it to NORM-2 and display the ratio of EXPT-5 and NORM-2 versus the TRIM-5 current at the end. This technique of using a normalisation counter helps to be less sensitive to fluctuations in the SPS itself.

The SCAN procedure allows to choose the optimum current for e.g. TRIM-5. You can set this current by

TUNE / SET / TRIM / 5 / *current*

and eventually save it into the beam file by

FILES / WRITE / H6.nn / *comment* / TRIM / 5 / *current*

where the comment is a text of up to 30 characters ('return' leaves the old comment). Alternatively the whole BIM.0 (present setting) can be saved with the

FILES / SAVE / H6.nn

command.

Two normalisation counters are available:

        Norm-1 :   Interaction rate in primary target T4,
        Norm-2 :   Incident rate on primary target T4,

Normally it is recommended to use Norm-2. If none is available, use Norm-0, which is a clock. On request, your beam physicist can program other counter to become NORM counters, e.g. one of your EXPT counters.

9. Further problems

1.   The HELP command might give you a general list of questions and suggestions on what to do - even though it might not be specific to your beamline, it could still be of use... if it works.

2.   Under INFO / LOGBOOK you find the last changes to magnet currents and collimator settings, files loaded etc.. You may find hints to what went wrong. **NEW in 1999: this information is also available on the SL-EA www page.**

3.   Run the STATUS /CHECK program to assure that no magnet nor collimator has failed, and **STATUS / GENERAL** / to verify the precise status of the beam. In particular, this could help to see why you don't get electrons, etc... .

4.   Do NOT FORGET: in case you are stuck with the X-terminal of your beam, just switch it off and on again - after a few minutes, you will be back in your TREE. Use CAPs inside NODAL !

5.   Call the CRN operators if all this fails – 75566.

EXPT scalers in H6 counting rooms

	HNA447	sc.	1	EXPT.1
			2	2
			3	3
			4	4
			5	5
			6	6
			7	7
			8	8
	BX80	sc.	1	EXPT.9
			2	10
			3	11
			4	12
			5	13
			6	14
			7	15
			8	16
H6A	HNA451	sc.	1	EXPT17
			2	18
			3	19
			4	20
H6B	HNA455	sc.	1	EXPT21
			2	22
			3	23
			4	24
H6C	HNA457	sc.	1	EXPT25
			2	26
			3	27
			4	28
TIS_cage			1	EXPT29
			2	30
			3	31
			4	32
			5	33
			6	34
			7	35
			8	36

New names for H6 TRIG counters, **as of 1999**

BEATCH name	"old" name	new" name	comment
XTRS041225	TRIG1	TRIG1	with MWPC1,2
XTRI041244	---	TRIG2	removed
XTRI041268	---	TRIG3	removed
XTRS041368	TRIG2	TRIG4	with MWPC3,4
XTRI041438	TRIG3	TRIG5	with MWPC5,6
XTRI041450 (moved to 444)	TRIG4	TRIG6	after CEDAR
XTRI041475	---	TRIG7	**new position**, with MWPC7,8
XTRI041513	---	TRIG8	**new position**, with MWPC9,10

New names for H6 TRIM magnets, as of 1997

(see also the beam layout drawing attached!)

Due to the installation of an additional horizontal TRIM magnet, the TRIMs in H6 had to be re-numbered. Below are given the new names valid as of 1997, together with the "official" name and the function of the TRIMs.

official name function		**new name**
MDXV041130	vertical steering	TRIM1
MDXV041194	vertical steering	TRIM2
MDXH041195	horiz. steering	**TRIM3**
MDXV041385	vertical steering	**TRIM4**
MDXV041473	vertical steering	**TRIM5**
MDXH041474	horiz. steering	**TRIM6**