2011 WHCAL testbeams at SPS H8

Three testbeam periods

- 7 days in June: energies up to 50 GeV
- 7 days in July: energies up to 300 GeV
- 5 days end of this month: energies up to 300 GeV

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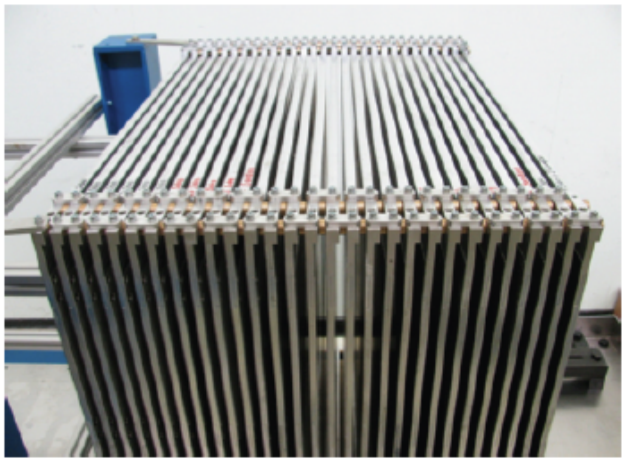
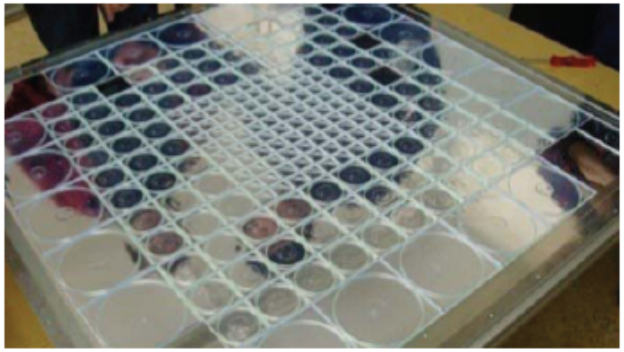
September 15th, 2011

Tungsten HCAL prototype

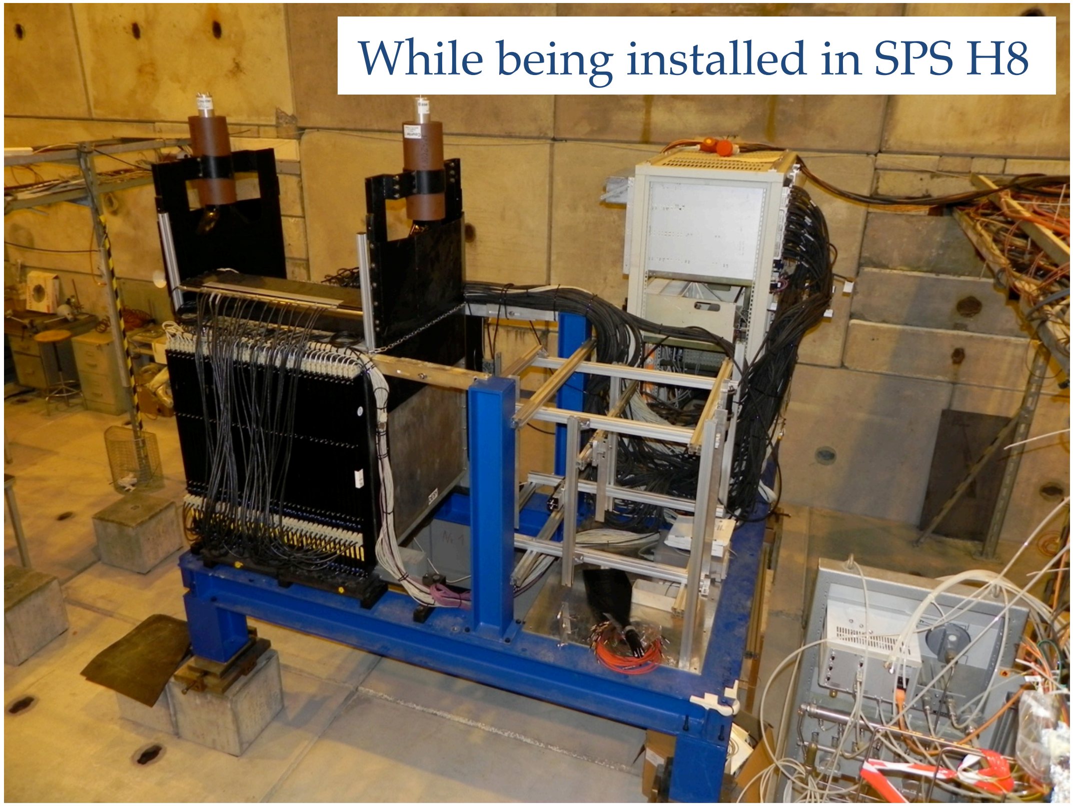
Main purpose: Validation of Geant4 simulation for hadronic showers in tungsten





Scintillator tiles 3x3 cm^2 (in centre)
Read out by SiPM

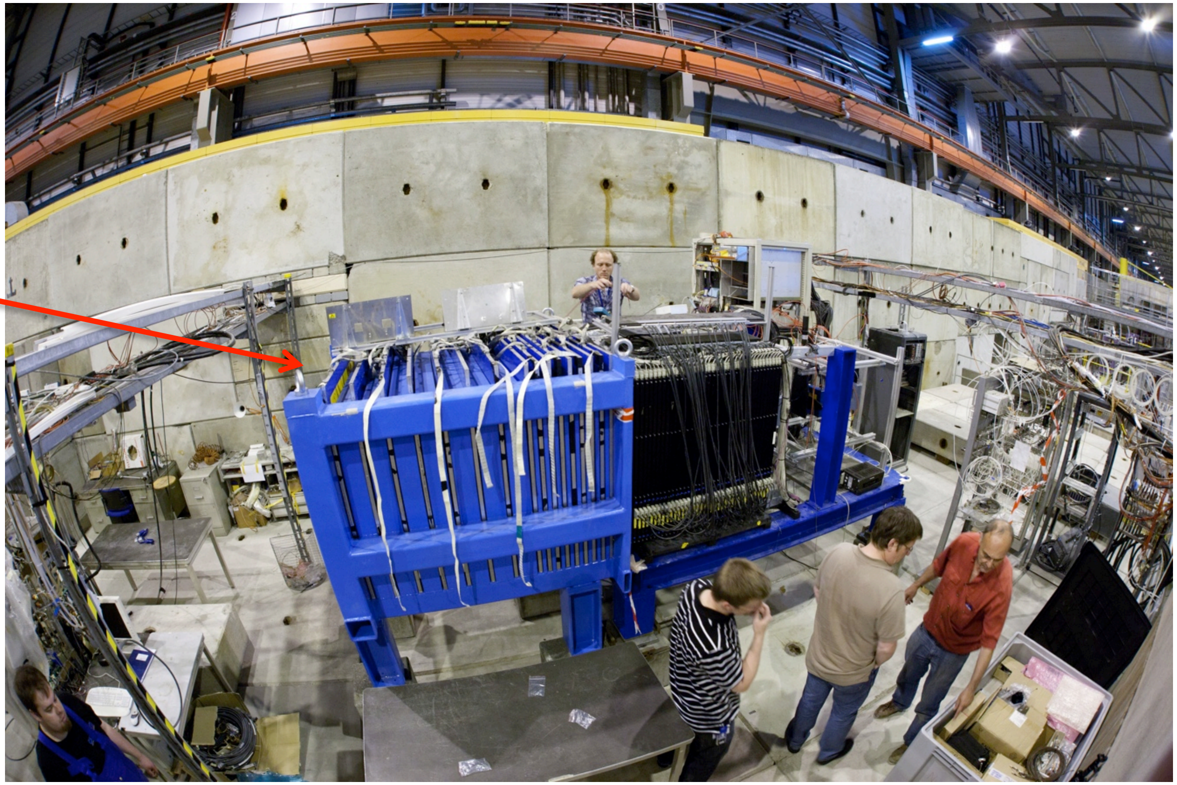
Current HCAL setup has 38 W layers.
Including active material this is ~4.8 λ



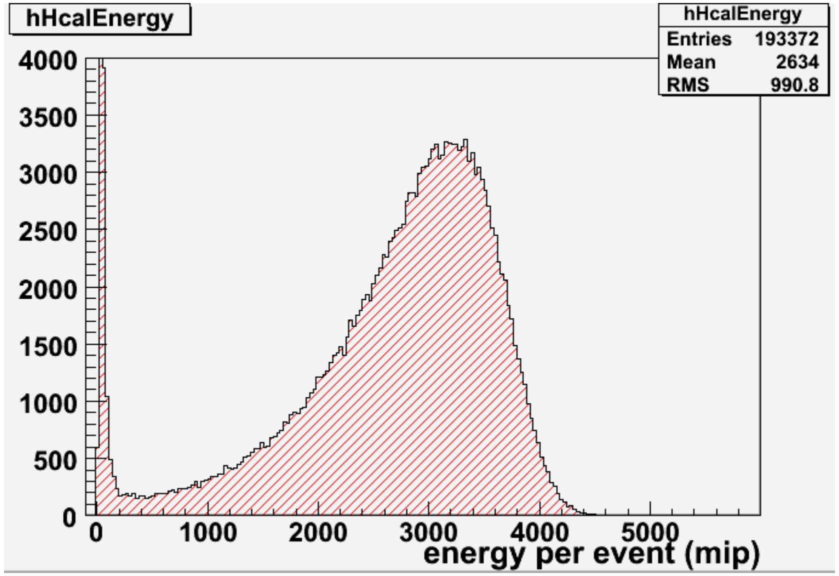
Tailcatcher for high energies

- Installation started immediately after the end of June run.
  - Installed and commissioned in 10 days available before July run.
  - Only the LED system for calibration does not function

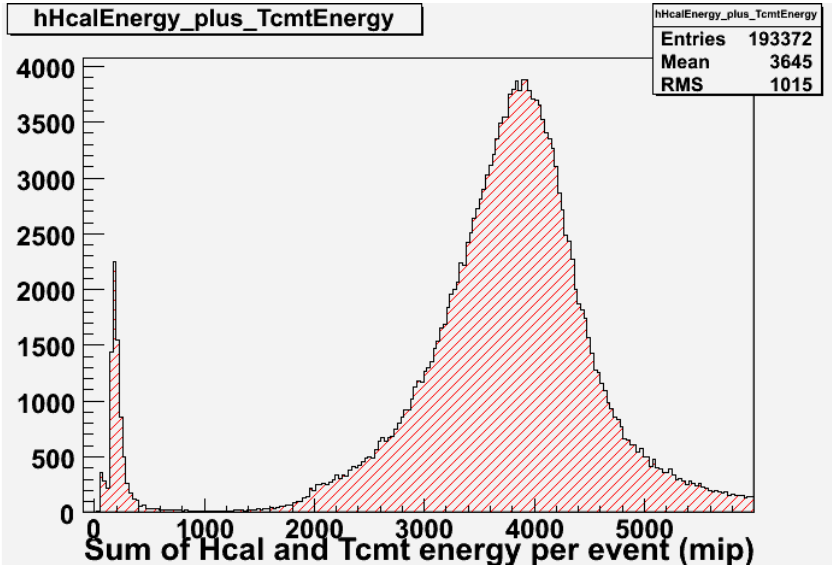
Steel / scintillator-strip sandwich calorimeter with 16 layers (~5.5 λ)



Energy sum only AHCAL



Energy sum AHCAL and TMCT

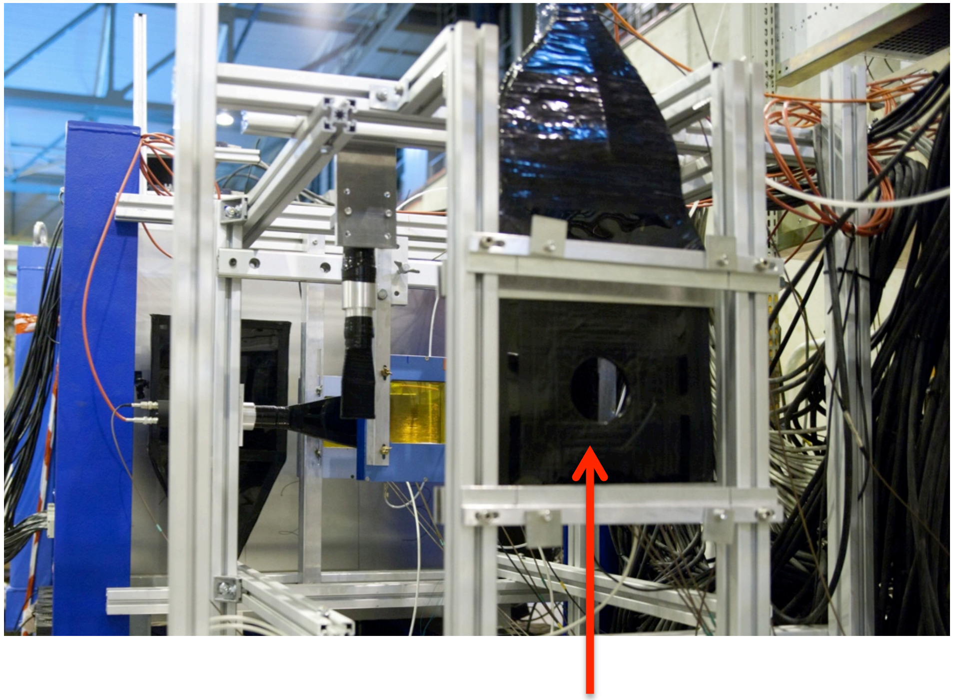


Here we see clearly that for high energies the tailcatcher is needed to contain the leakage beyond the HCAL.

Trigger setup

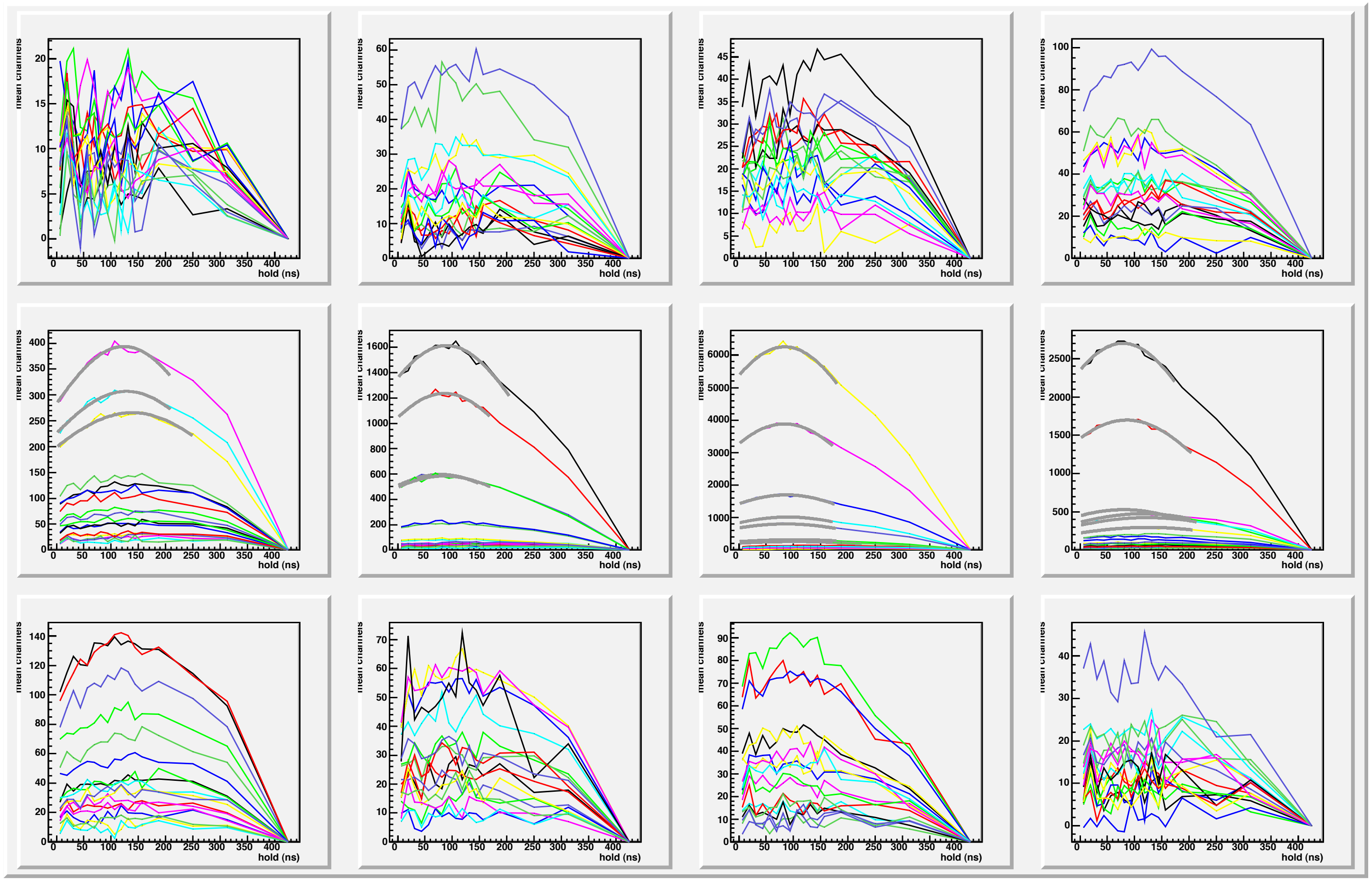
Two 80x80 cm^2 scintillators, one before and one after the calorimeter, are also mounted. Unfortunately not efficient at lower part of detector.

- Extended with two 30x30 cm^2 to scan over full surface for muons.



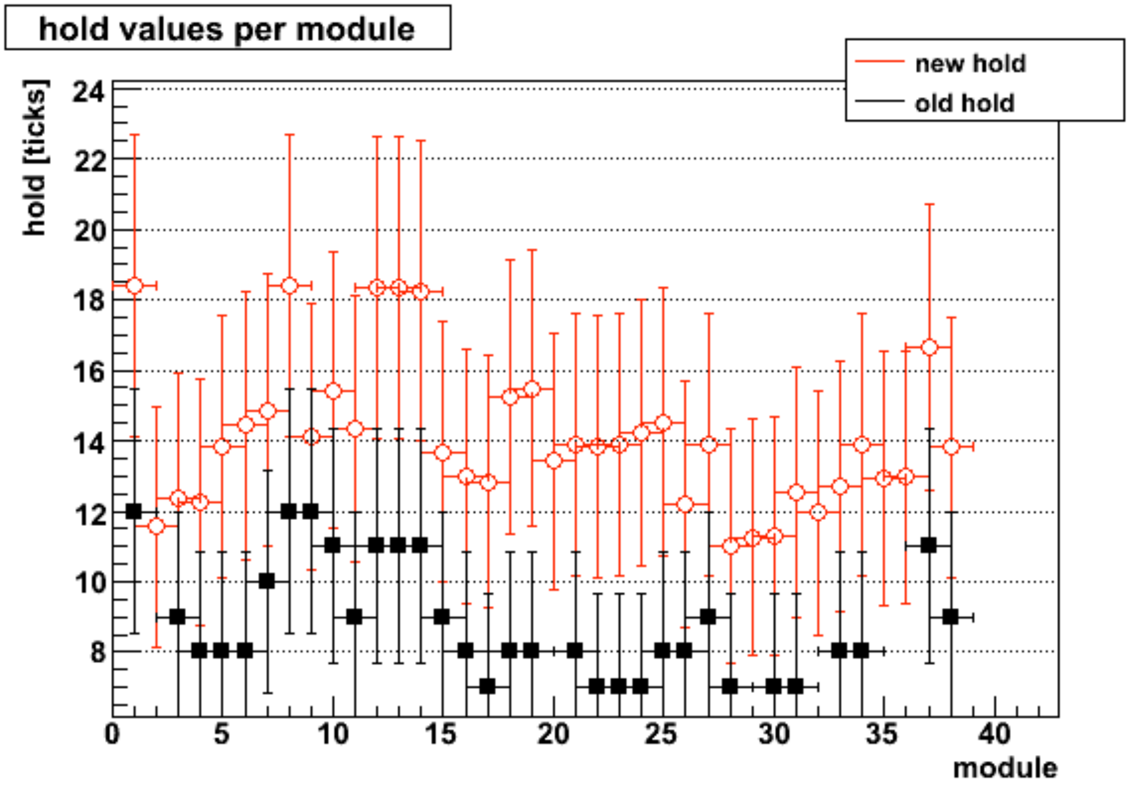
20x20 cm^2 with a hole of 8 cm for vetoing, to be used in the offline analysis.

Iterative procedure in which a useful range is found to be fitted:



Example: run361217 mod #9

- At the PS-T9, we shifted all holdvalues by -8 ticks (see 'old hold')
- With the new scan that shift seems to have been too much (see 'new hold').
- New fit results seem more stable, implemented 'new hold' values for each module.



Setting up a beam in SPS-H8

SPS aims 400 GeV primary beam at a target.

- Both H6 and H8 beam start after this target. These two secondary beams are linked in energy by the wobbling magnet settings.
- Most of the time we ran with wobbling of +180, -180 or -300 GeV.

In the beam line we can produce a tertiary beam at lower energy by inserting secondary target:

- 400 mm Cu target for hadron production
- 6 mm Pb target for e+- production.

The "hadron" beam is actually a mixed beam consisting of e+, mu+, pi+, p+

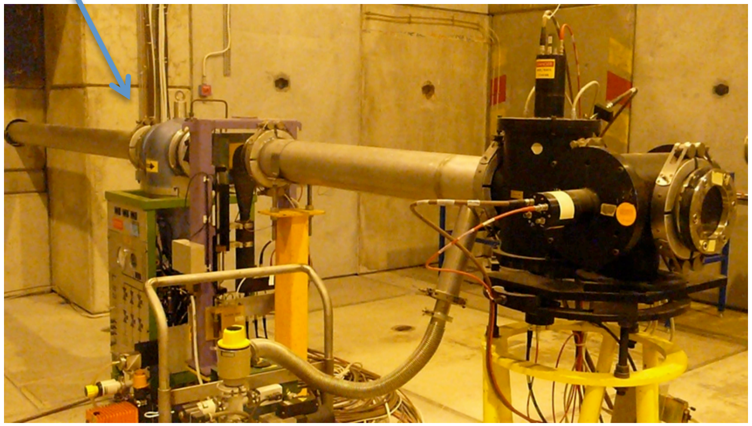
- Can be stripped of the e+ with an absorber of 4 mm, 8 mm or 18 mm thick Pb.

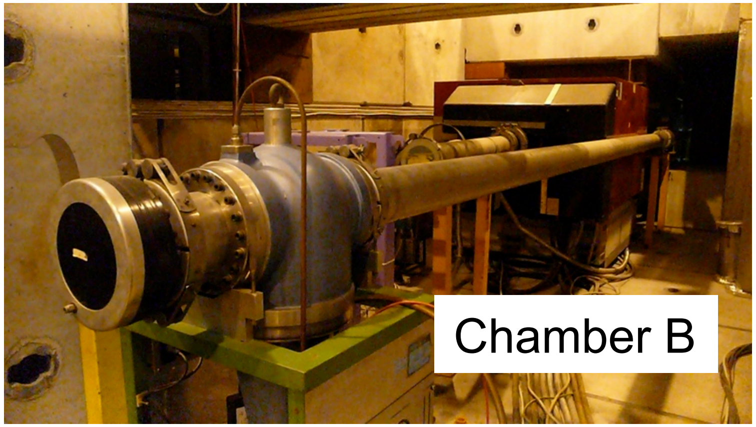
Particle identification

H8 beam line has two Cherenkov chambers for particle ID.

- The information was that they are 100% efficient from 30 mb onwards.
  - This unfortunately turned out to be wrong. We put the pressure slightly above the pion threshold, to be efficient for electrons (no electrons in the pi sample).
  - ➢ Some 10%-30% of pi in the e-+ sample.
  - ➢ We had dedicated electron runs in July period.

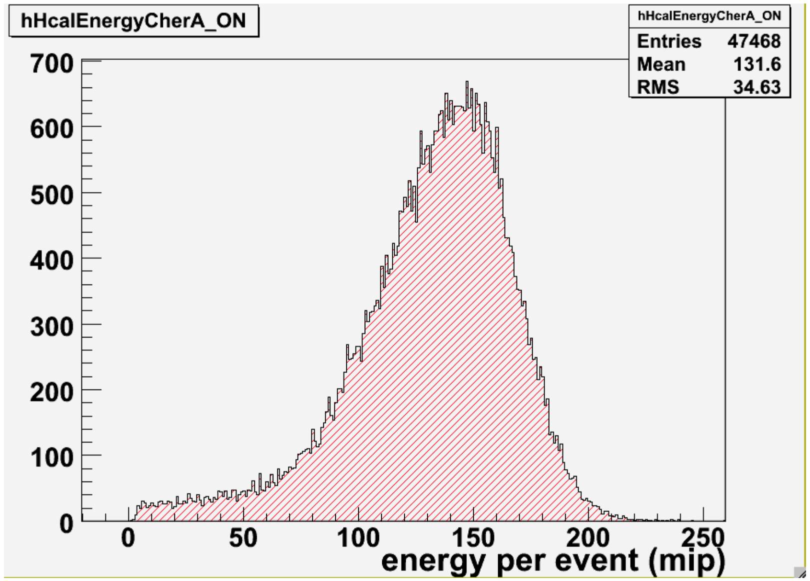
Chamber A

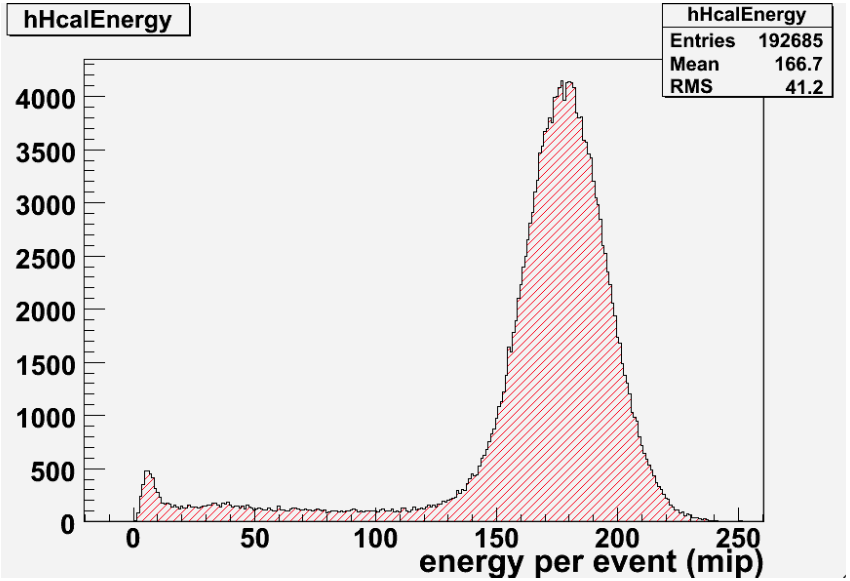




Material and air along the beam

Electrons are very sensitive to material in the beam





10 GeV e- signal from June run,
With 80m air and some material in beam

10 GeV e- signal from July run.
Material in the beam minimized
Vacuum beam pipe installed

Low energy scan – June run

- Unfortunately we could only get a very broad & low intensity beam in the first days of June run. Scanning the low energies with tertiary beam was extremely slow.
  - With H6 agreed that for the last day of June run we got control of the secondary beam.
- Set so-called wobbling of secondary beam to -20, -30, and -50 GeV
  - At such low energies, -10 or -25 GeV particles can also be found from the primary target.
- With no secondary target the intensity is much higher
  - Full scan with negative polarity was done in 30 hours!
- Total #events taken: ~ 5 Million.

High energy scan – July run

With the secondary beam at -180 GeV we set up tertiary beams at lower energies. Rates again too low:

- Beam rate @ -100 GeV: 300 counts/spill

Unlike first week, there was not the option of setting up wobblings of lower energies.
Tested selecting lower energy particles directly from the secondary beam

- Beam rate @ -100 GeV: 3200 counts/spill

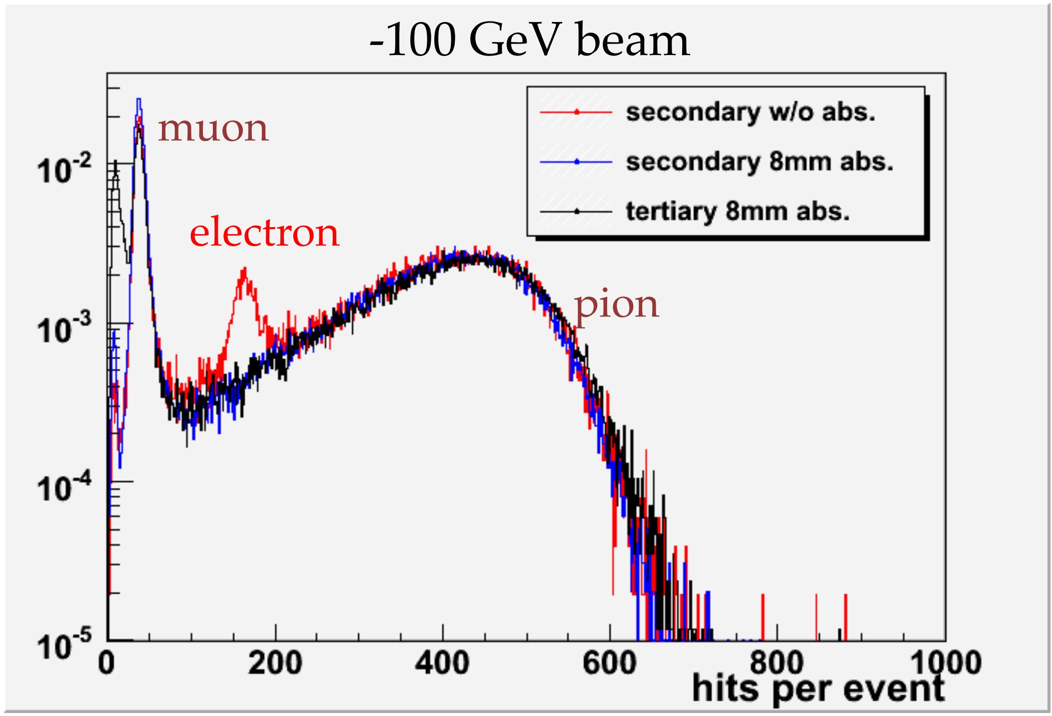
Yet this is not how it is supposed to be done at the H8 beamline

- Theoretically, for these high energies, the optics are not able to select particles with different energies immediately from the focal point on the primary target.

As we would never be able to go through our program with 300 counts/spill, we tried it out →

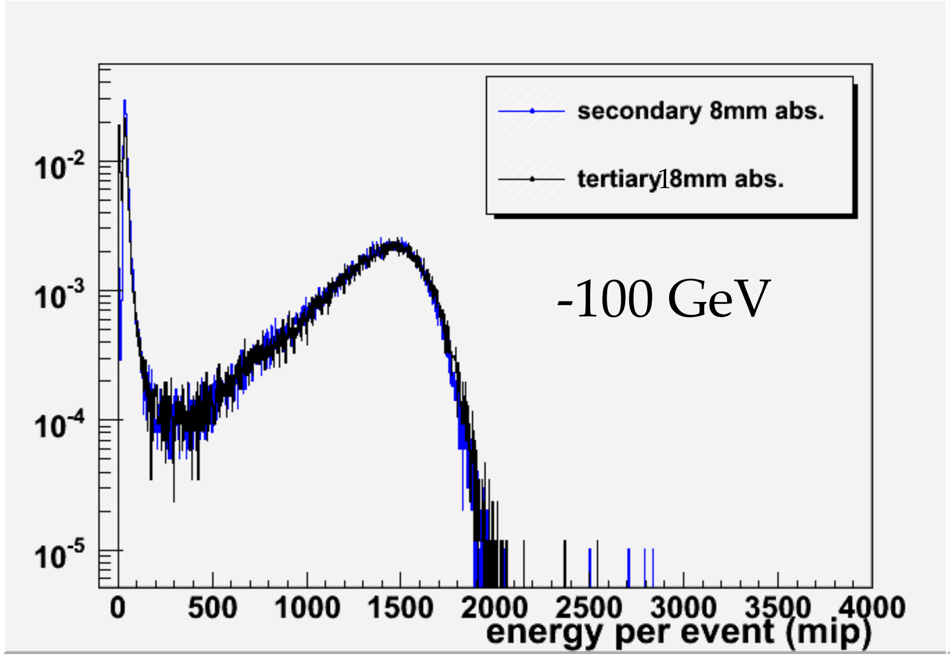
Check of secondary beam quality: contamination

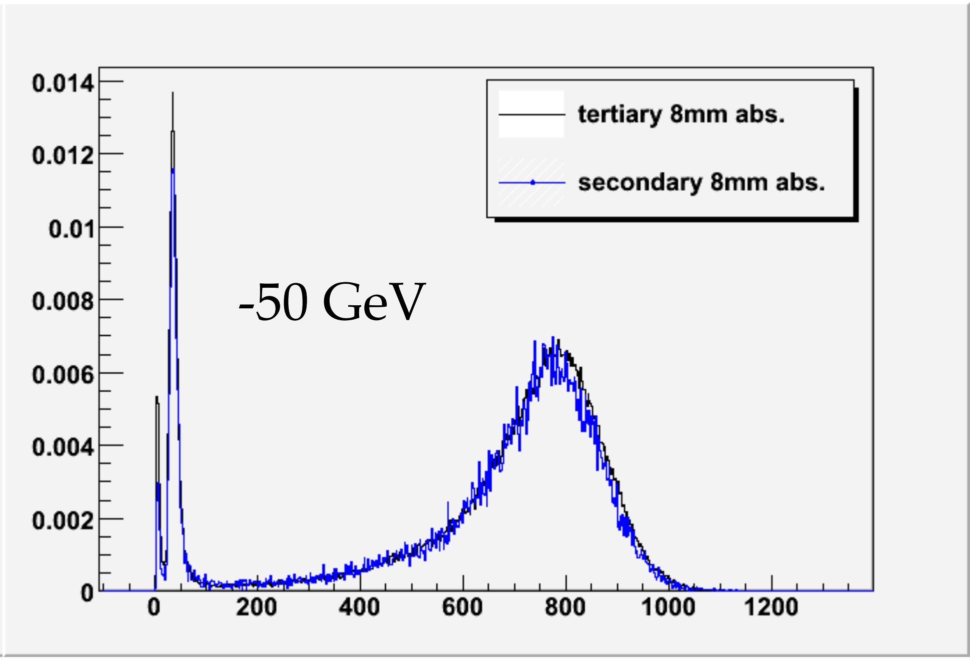
run #	fraction pedestal	fraction muons	fraction pions
tertiary	10%	25%	65%
secondary	0%	35%	65%



Tertiary vs secondary beam

Check of secondary beam quality: energy





Two energy points crosschecked between tertiary and secondary beam

- Same energy distribution
- ➢ Even though it is unclear where exactly the particles are created, the particles have the correct energy.

Data taken

AHCAL:

		# events
π^- :	16 energy points in range from 10 to 300 GeV	11.4 M
π^+ :	5 energy points in range from 10 to 50 GeV	2.7 M
e^- :	6 energy points in range from 10 to 40 GeV	1.2 M
μ :	large 80x80 triggers	2.1 M
	30x30 triggers, in lower 1/3 of detector area	0.3 M

(see backup slide for all energy points)

- Analysis is ongoing, got delayed because of CDR

T3B:
The same events in sync with AHCAL, plus ~4 M standalone events.

Program for September/October run

- From 27/9 to 12/10 we have a combined CALICE run in SPS-H8
  - 27/9 to 3/10: W-HCAL
  - 3/10 to 12/10: SDHCAL

- Program for W-HCAL:
  1) Positive charge at selected energies 50 GeV $\leq E \leq$ 300 GeV

  2) Muons with 30 x 30 cm^2 scintillator in 9 positions.

  3) Large samples of events (10^6) at 50GeV, 60GeV and/or 80GeV to get high statistic Kaon samples (N_K / N_π $\approx$ 2-5%)

Conclusion & outlook

- Detector performed well.
  - Tailcatcher commissioned and operational. Except for LEDs.
- Beam operation took some time to learn, but went very well once understood, even with unconventional settings for secondary beam.
- 2011 program with scintillator AHCAL almost finished and completed.

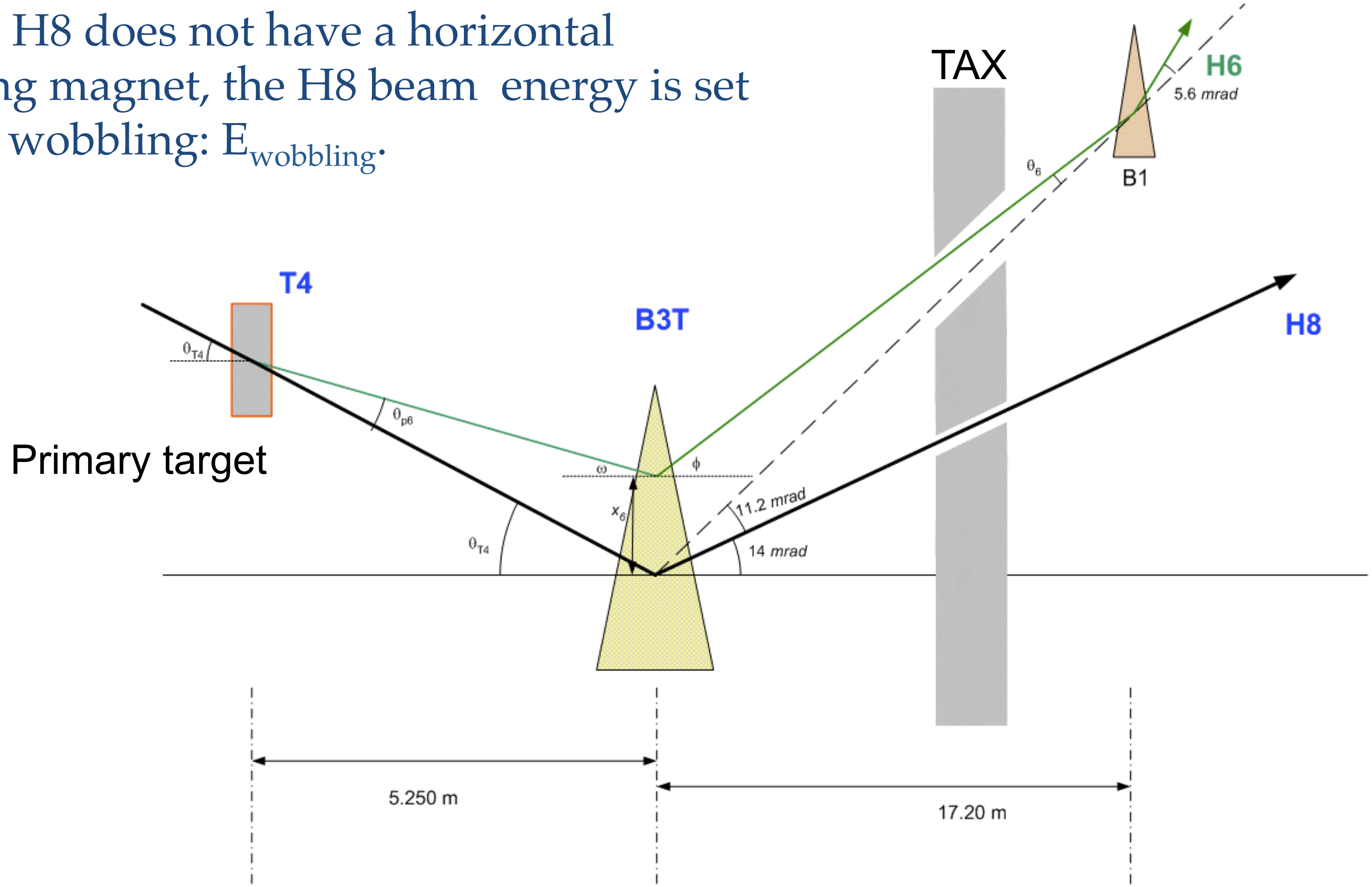
- Plan for next year is to test tungsten HCAL with gaseous readout.
  - Due to slow neutrons from W, energy resolution of a W-HCAL with gas readout might not be the same as with scintillators. This needs testing.

Backup

Wobbling

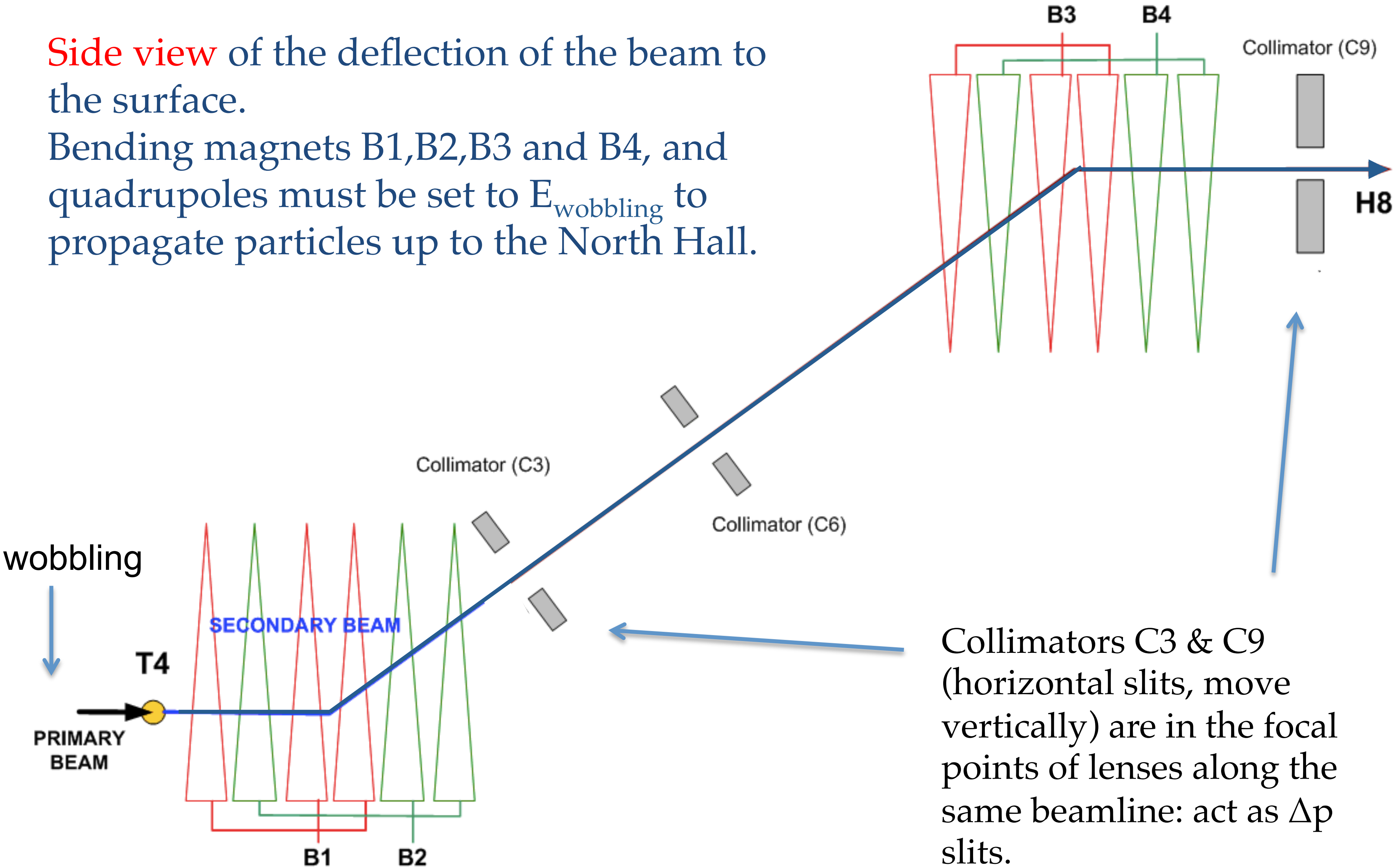
Top view of the end deflection of the beam in the wobbling

- As the H8 does not have a horizontal bending magnet, the H8 beam energy is set by the wobbling: $E_{wobbling}$.



H8 secondary beam

Side view of the deflection of the beam to the surface.
Bending magnets B1,B2,B3 and B4, and quadrupoles must be set to $E_{wobbling}$ to propagate particles up to the North Hall.

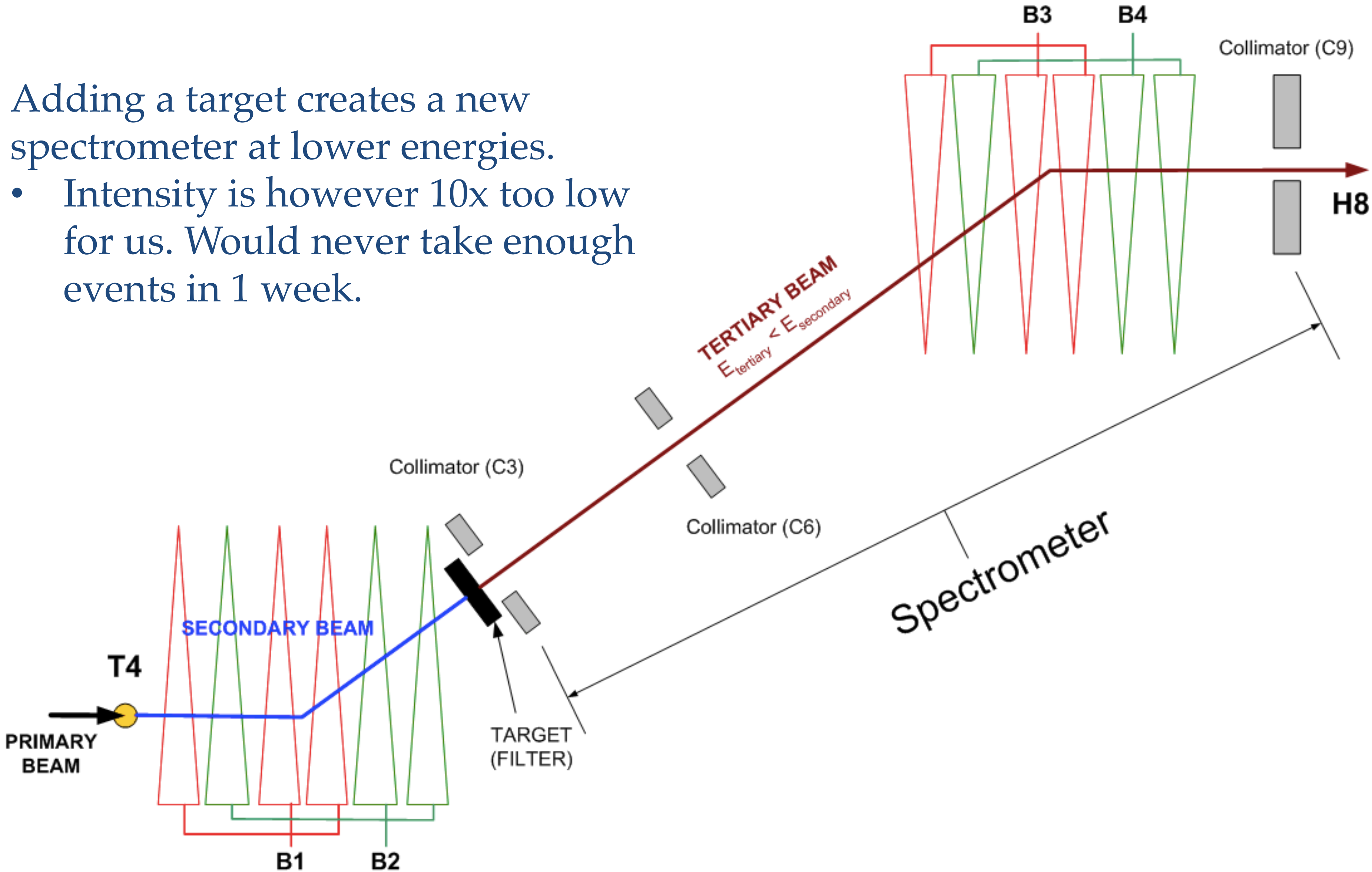


Collimators C3 & C9 (horizontal slits, move vertically) are in the focal points of lenses along the same beamline: act as Δp slits.

H8 tertiary beam

Adding a target creates a new spectrometer at lower energies.

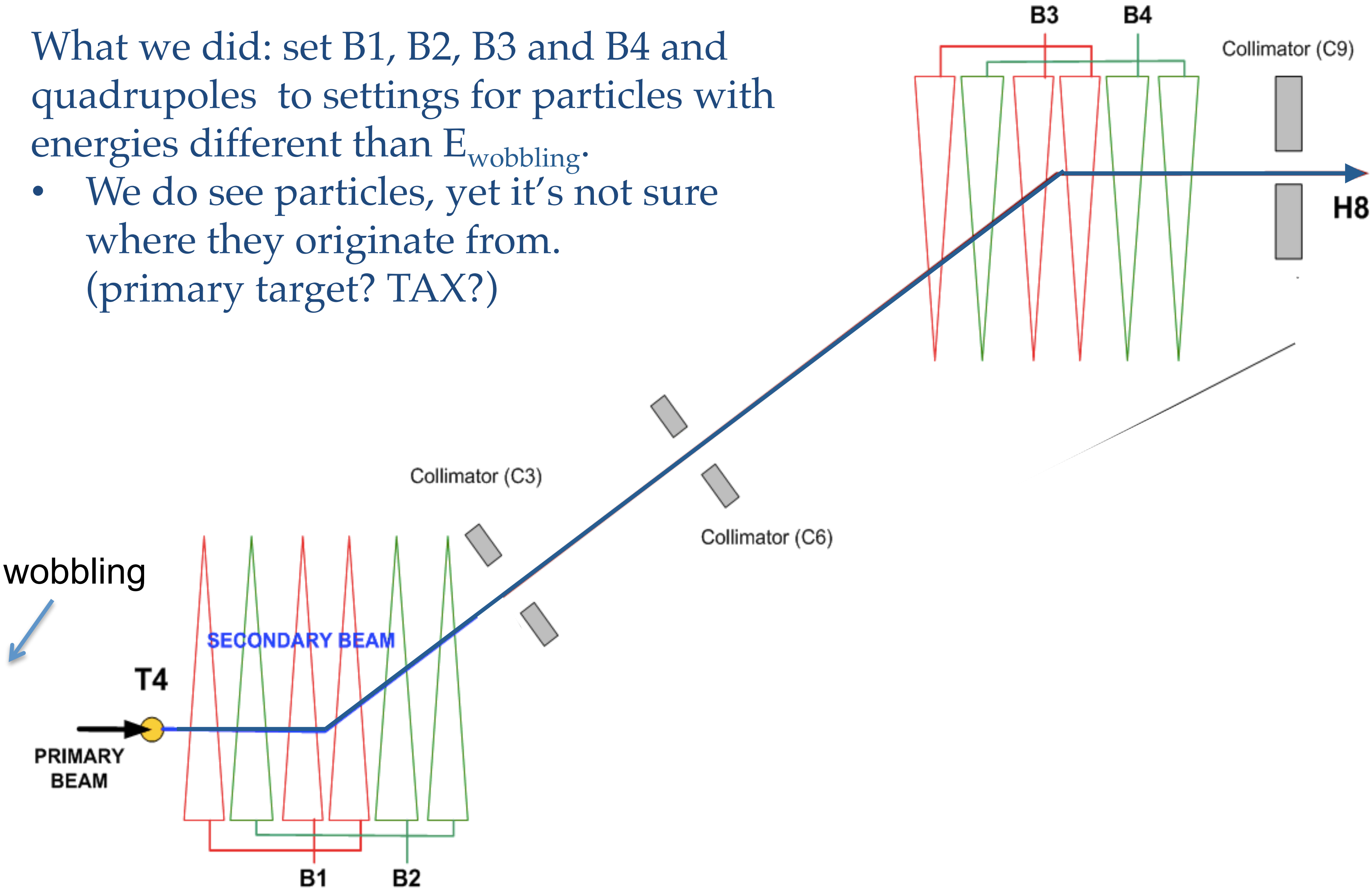
- Intensity is however 10x too low for us. Would never take enough events in 1 week.



H8 spectrometer

What we did: set B1, B2, B3 and B4 and quadrupoles to settings for particles with energies different than $E_{wobbling}$.

- We do see particles, yet it's not sure where they originate from. (primary target? TAX?)



Data taken

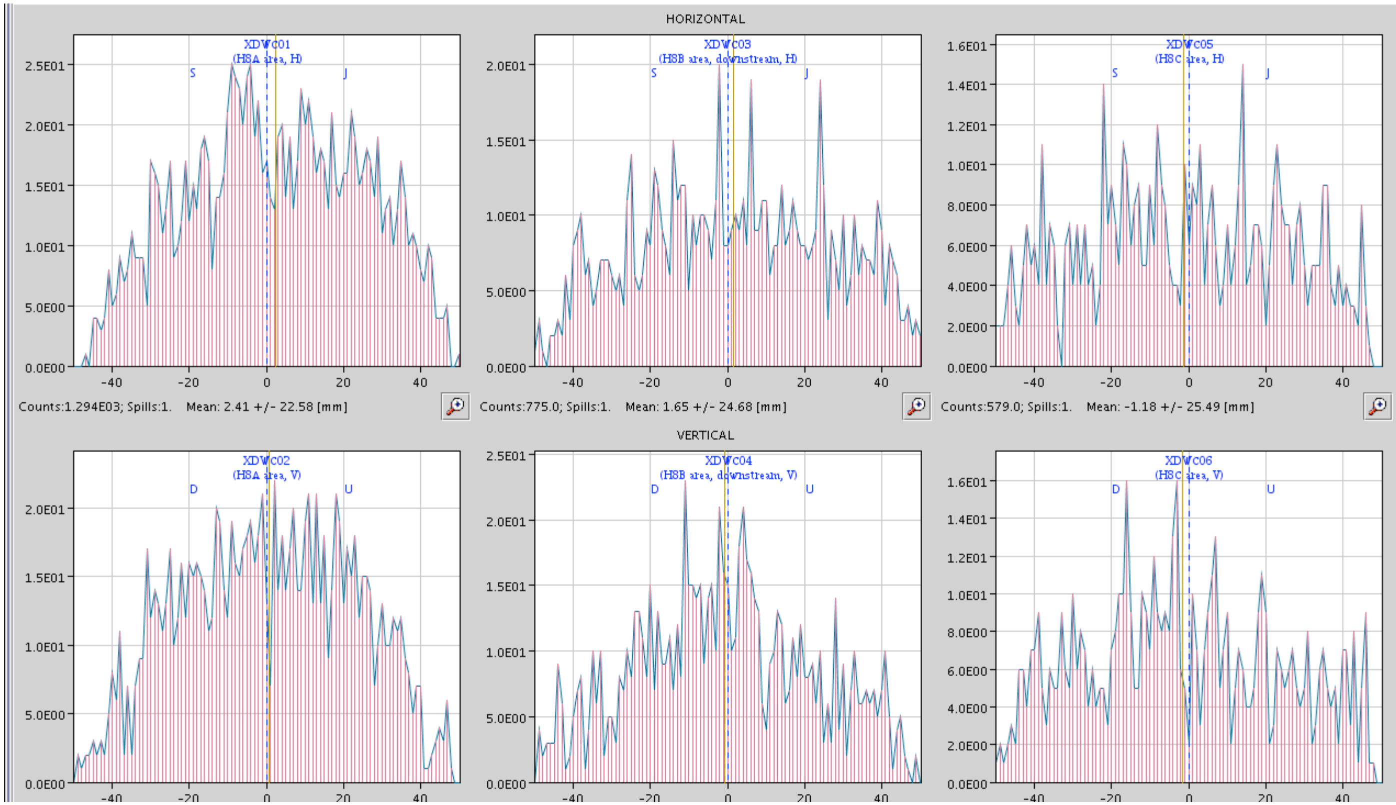
E[GeV]	# evts[k]	# evts[k]	# evts[k]
	June	July	total
π^-			
-10	212	100	312
-15			202
-20	517	243	760
-25	240		240
-30	630		630
-40	200		200
-50	490	1465	1955
-60		403	403
-80		804	804
-100		604	604
-120		604	604
-150		1476	1476
-180		602	602
-200		840	840
-250		892	892
-300		813	813
Total π^-			**11337**

E[GeV]	# evts[k]	# evts[k]	# evts[k]
	June	July	total
π^+			
20	237		232
25	221		221
30	305		305
40	1716		1716
50	261		261
Total π^+			**2735**
e^-			
-10			200
-15			220
-20			200
-25			200
-30			200
-40			201
Total e^-			**1221**
μ			
10x10			417
80x80			2110
lower 1/3			299
Total μ			**2826**

	Wire chamber #1	Wire chamber #2	Wire chamber #3

H

V

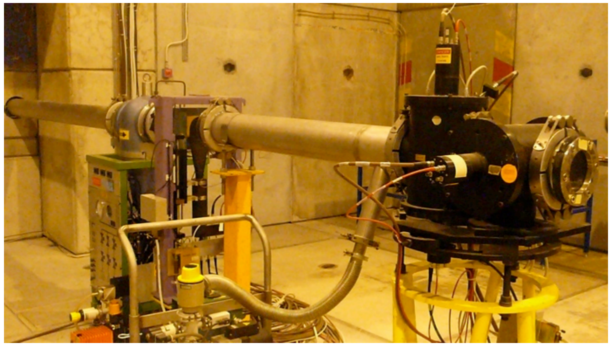


Very broad & low intensity beam, we could not get it more focused.

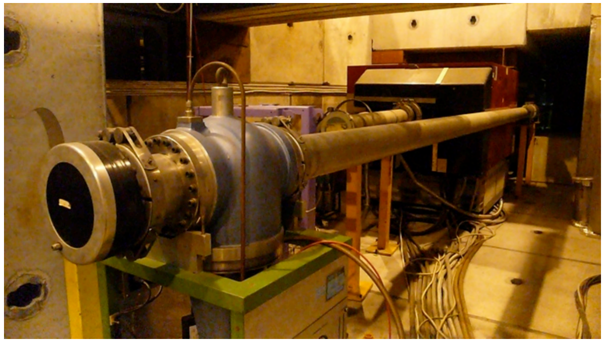
Particle identification

2 Cherenkov threshold counters

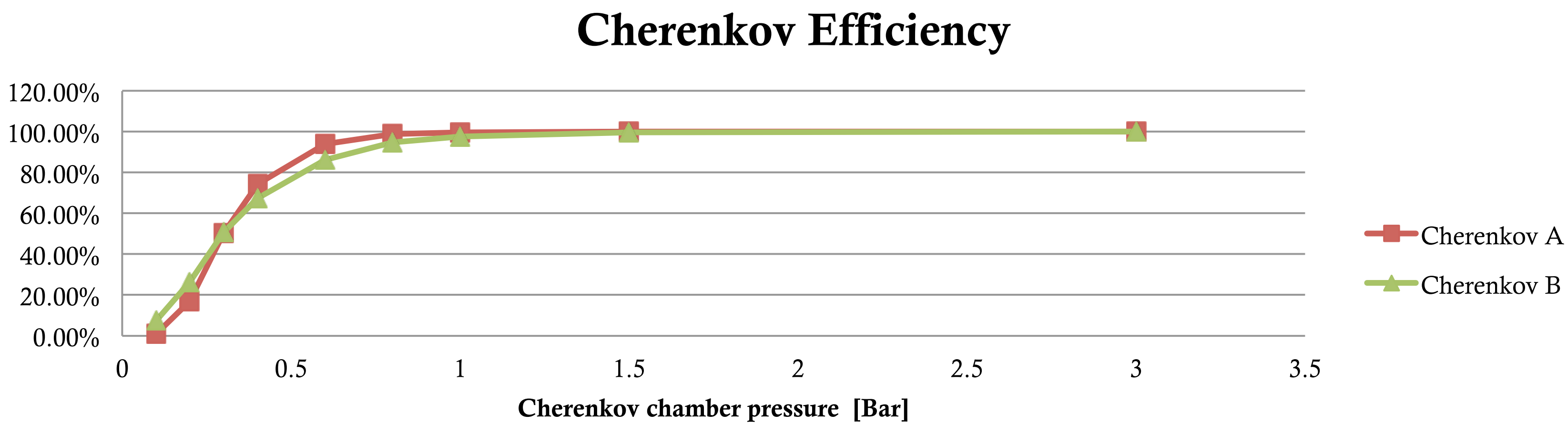
Absorber : 4mm, 8mm, and 18mm Pb (strip of electrons)



Cherenkov A 130m up



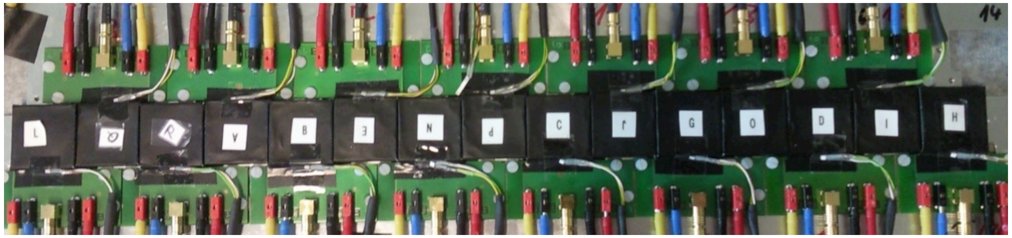
Cherenkov B 70m up



The T3B experiment

T3B is positioned behind the CALICE W-HCAL

- Measures time development in hadronic shower

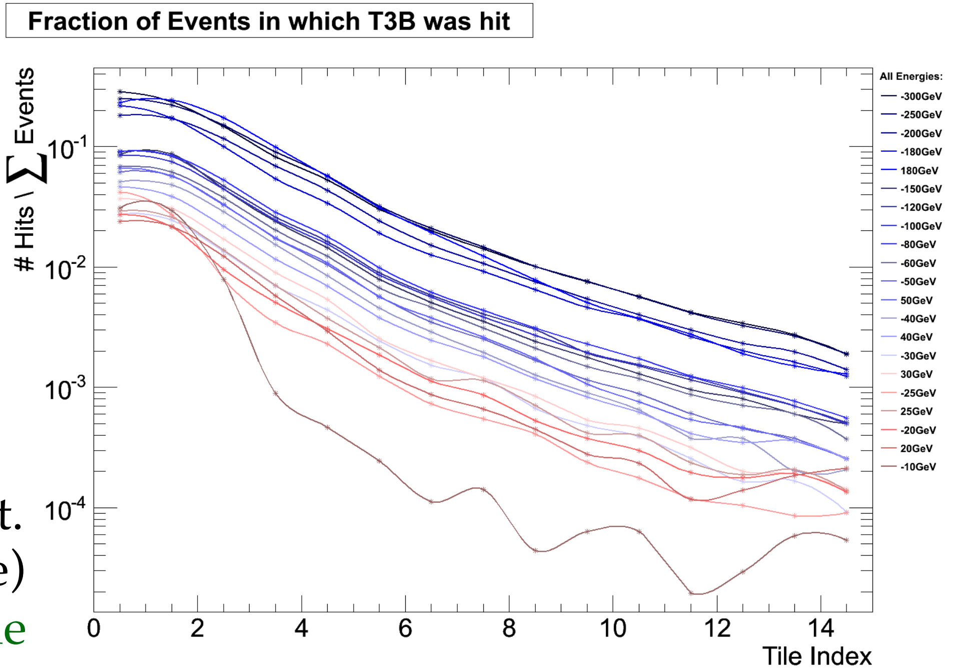


New trigger system enables

1. high rate standalone acquisition (10kEv/Spill)
2. stable oscilloscope synchronization

Quite some leakage for > 40GeV

→ nice for T3B



Fraction of Events in which T3B was Hit.
All Energies: 10(pink) to 300GeV(dark blue)
→T3B took a nice Data Sample