The DA? NE Beam Test Facility

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Overview

- BTF Parameters
- BTF operation mode
- Commissioning results
- First users experience
- Future plans

Introduction

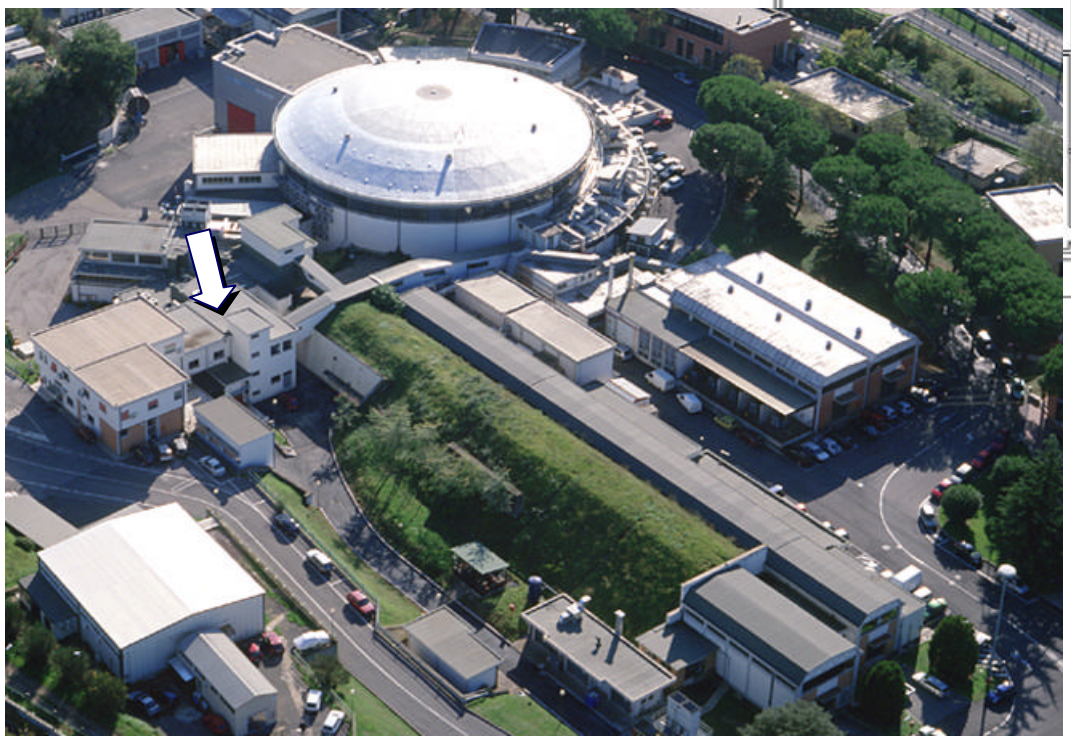
What is the BTF?

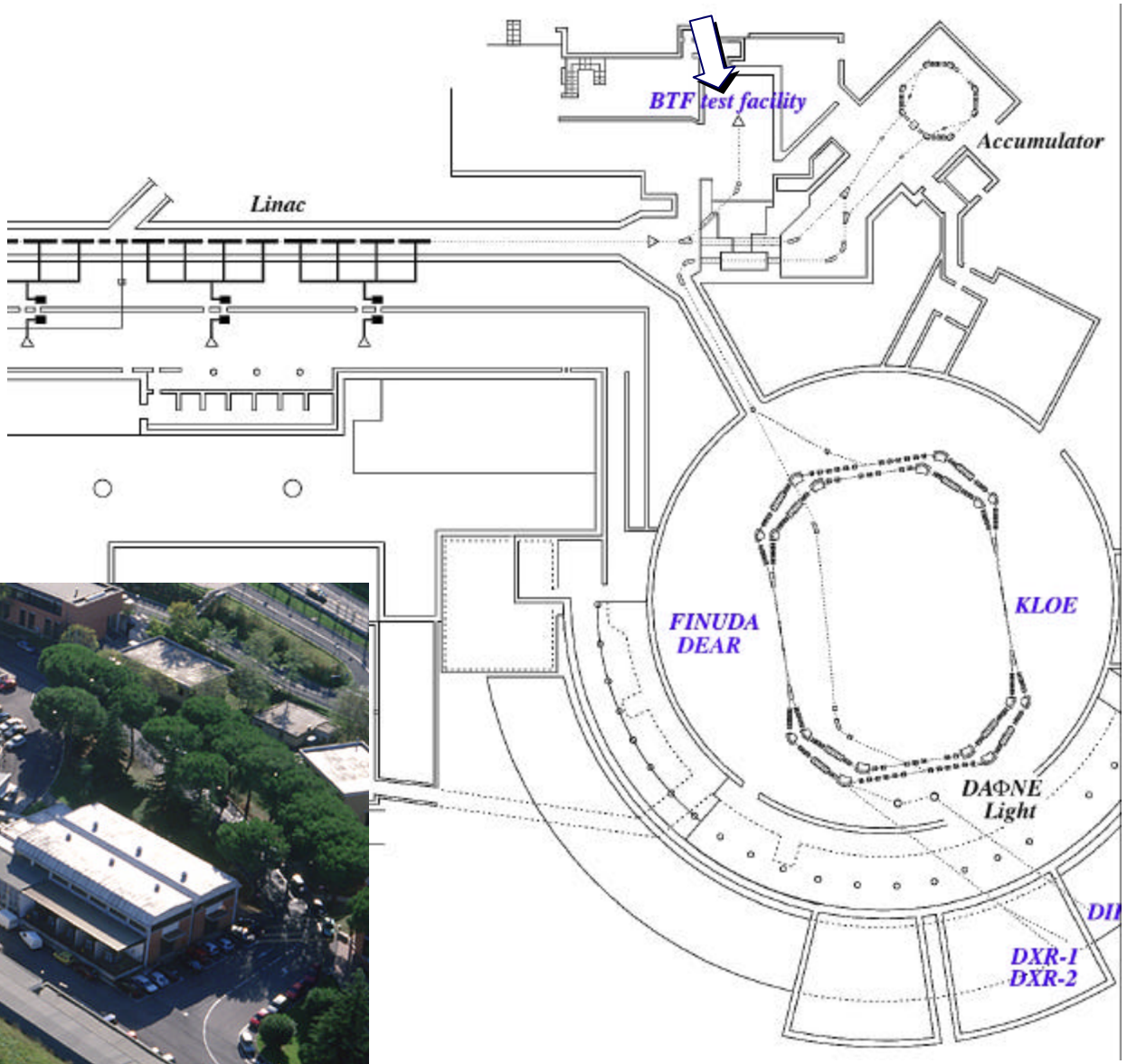
An electron test-beam facility already foreseen in the DA? NE project, profiting of the LINAC beam…

…but mainly intended for single electron operation

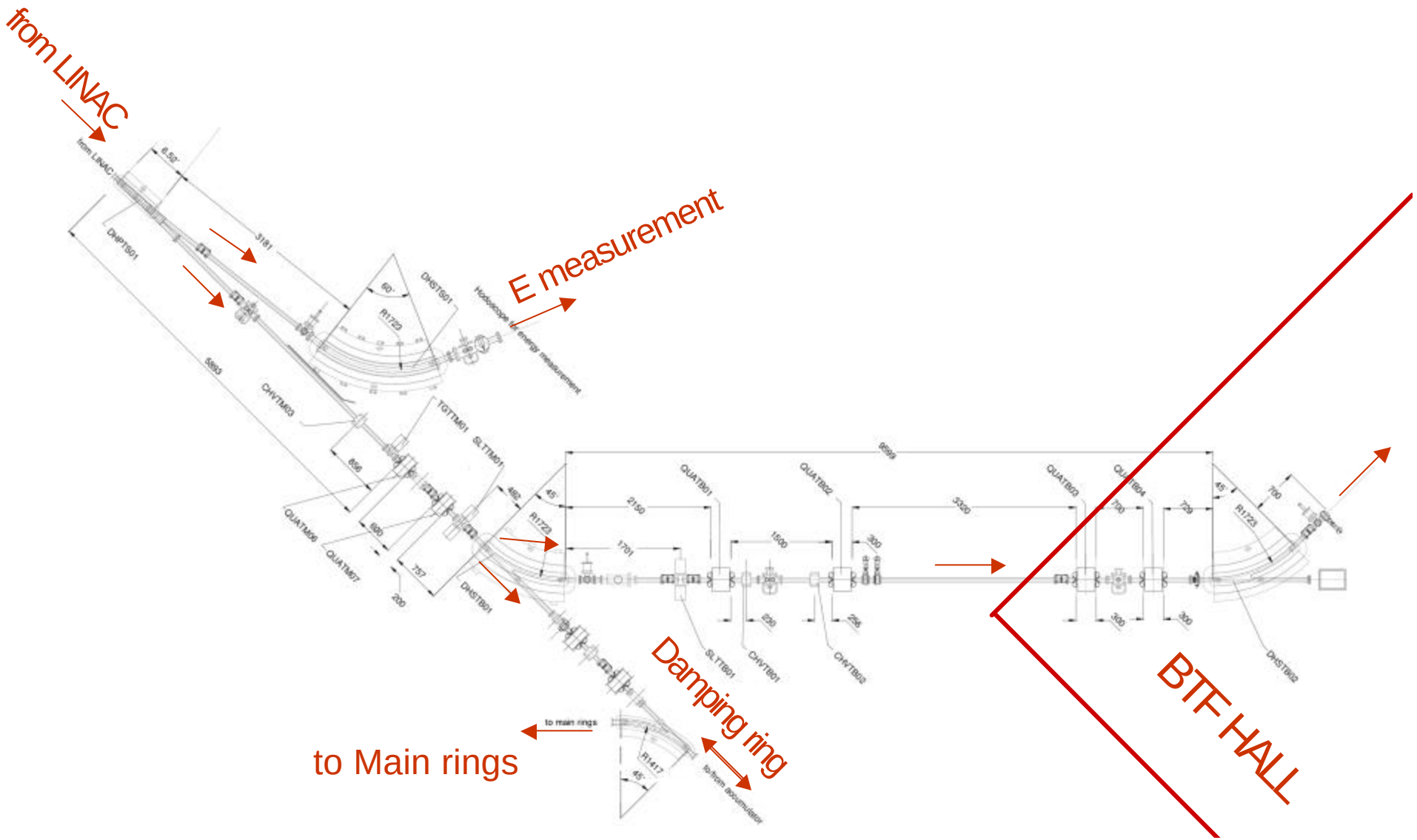
F. Sannibale, G. Vignola
'DA? NE-LINAC TEST BEAM'
DAFNE Technical Note **LC-2** (1991)

BTF layout

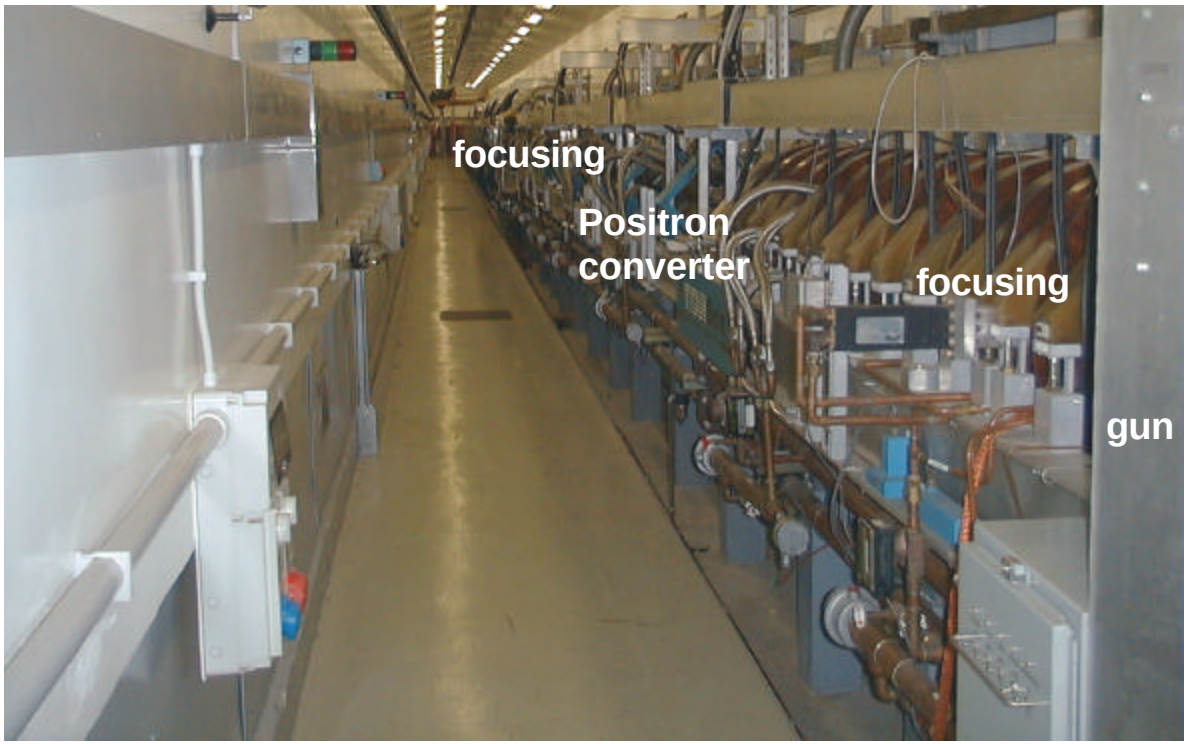



BTF test facility
Accumulator
Linac
FINUDA
DEAR
KLOE
DAΦNE
Light
DXR-1
DXR-2

BTF layout


from LINAC
E measurement
Damping ring
to Main rings
BTF HALL

DA? NE LINAC



Length:	50 m
Maximum energy:	850 (550) MeV e? (e?)
Transverse emittance:	< 1 (5) mm mrad e? (e?) mm mrad
Energy spread:	< 1% (2%) e? (e?)
Pulse duration:	10 ns
Max repetition rate:	50 Hz

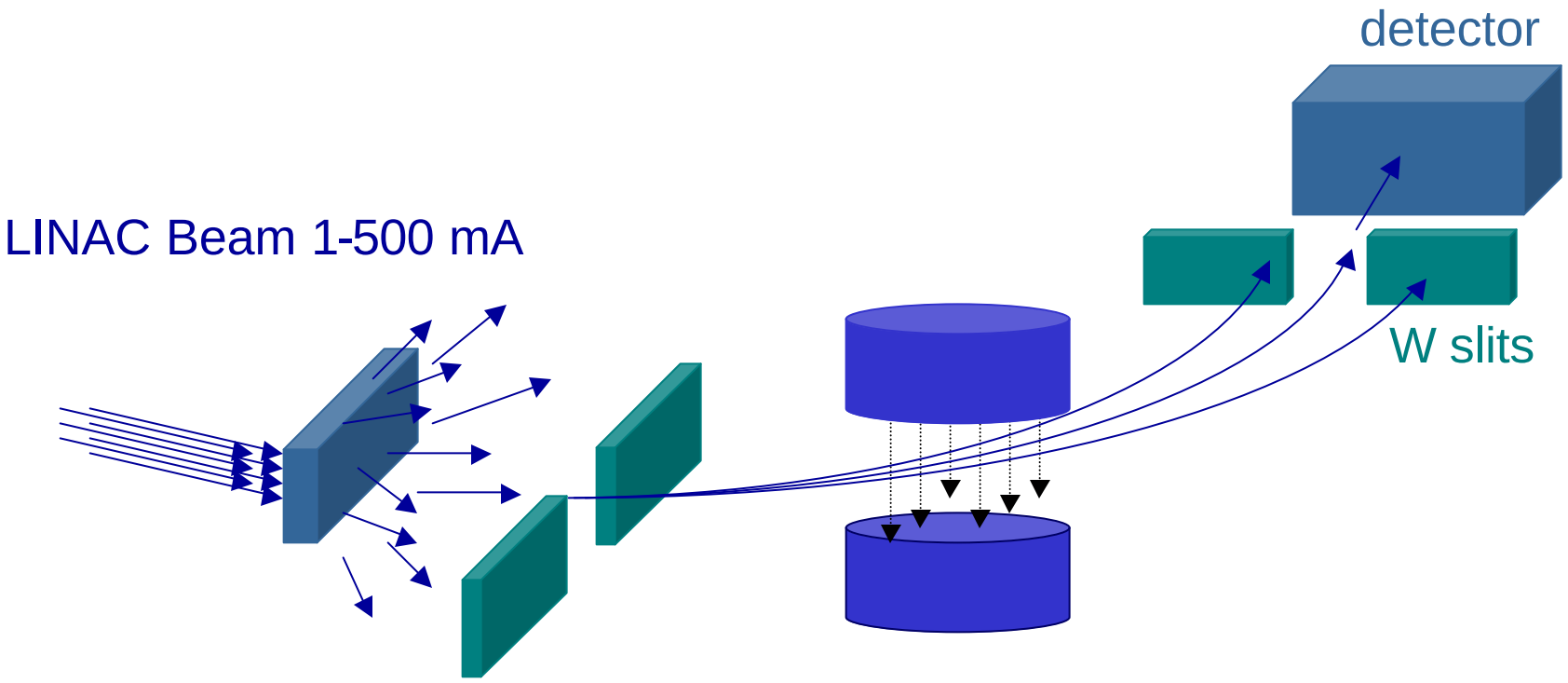
BTF parameters

- e? and e?
- Energy: 50 – 800 (500) MeV e? (e?)
- Repetition rate: 24 Hz (will be 49 Hz)
- Pulse Duration 10 ns (will be ?1.5 ns)
- Single particle production (1% energy selection)

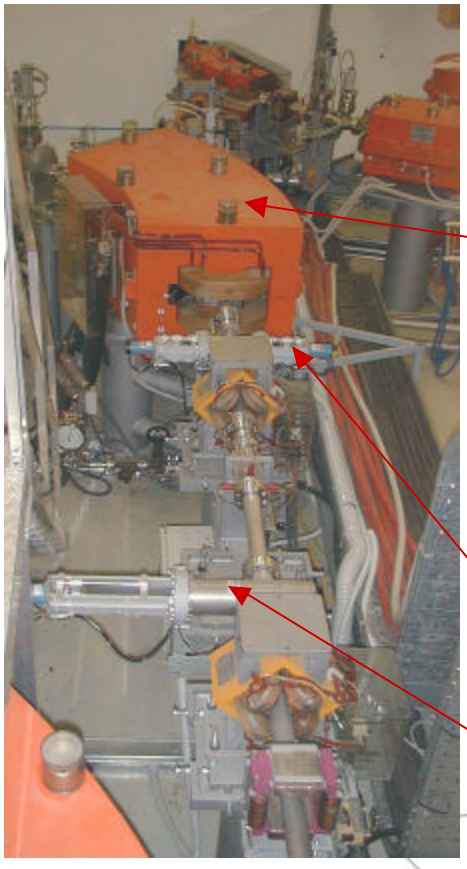
- Maximum current/pulse is 500 mA…
- … but up to 10^3 allowed electrons/sec
- Upgrade asked for 10^{10} allowed electrons/sec

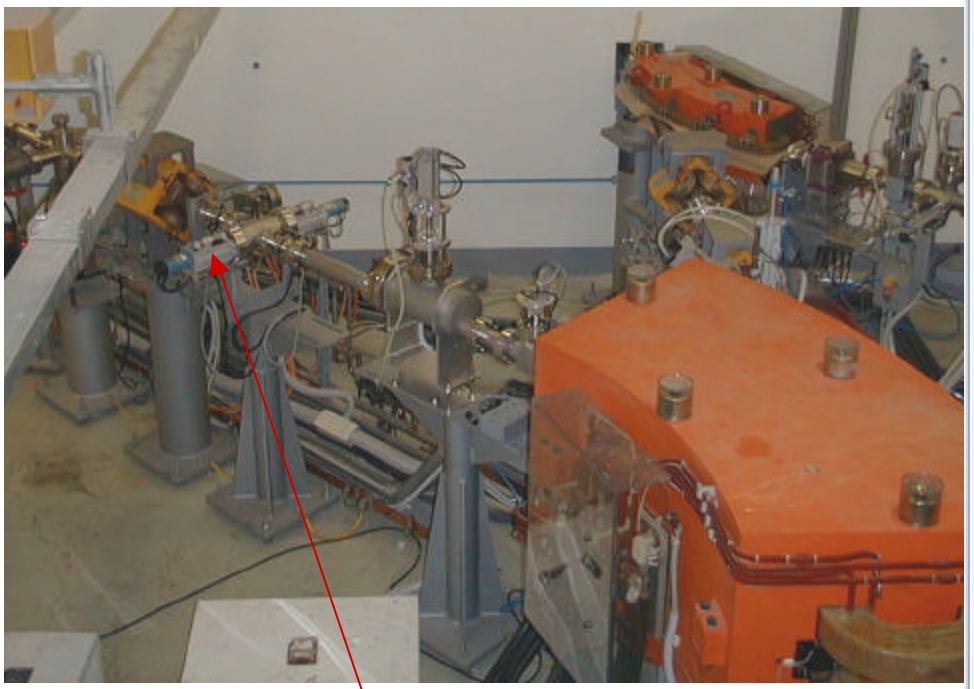
- 100 m^2 Experimental Hall

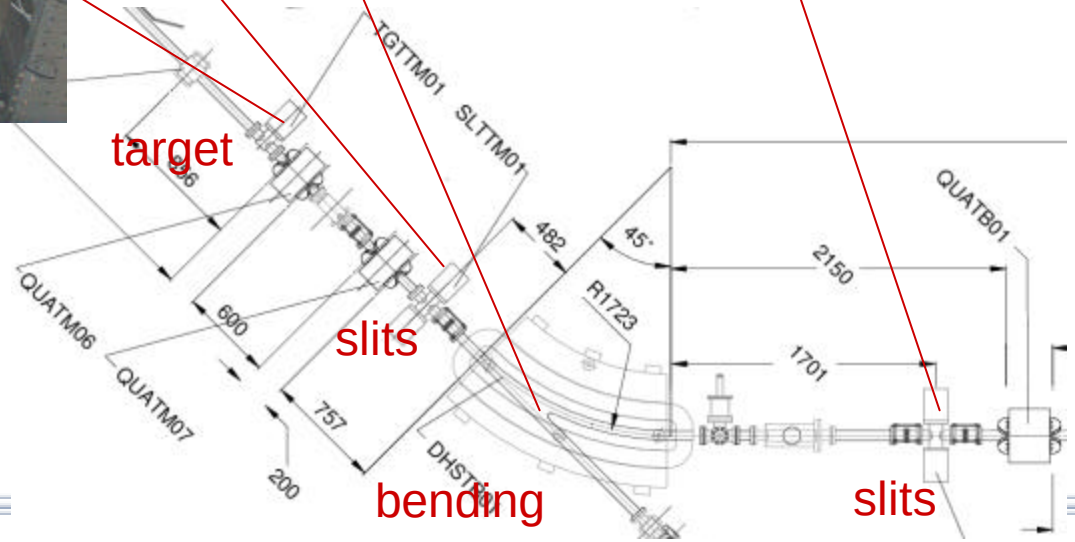
Single particle production



Single particle production



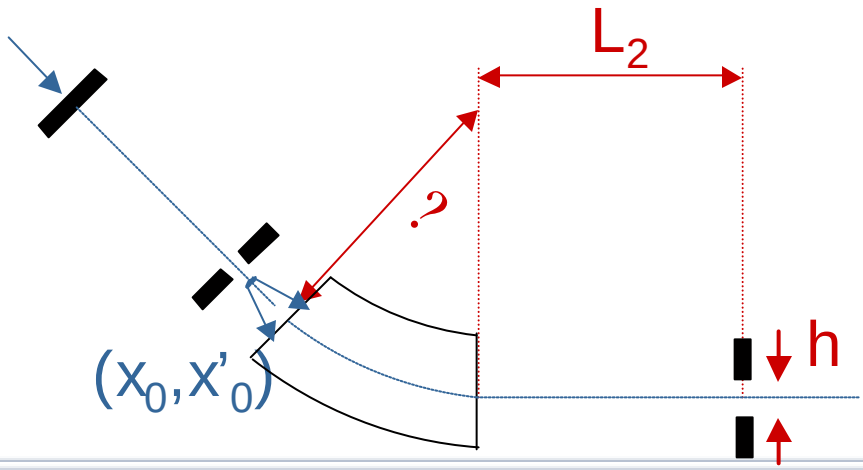




Energy selection resolution

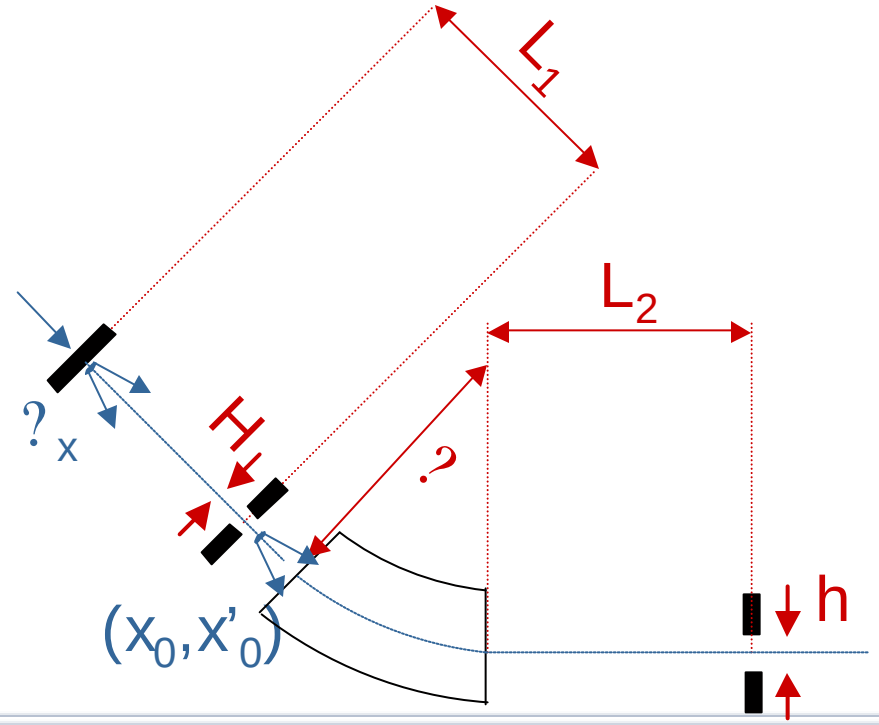
- L_2 ? ? = 1.72 m
- h = 5?10 mm

- (? E/E) ? $\frac{h/2}{L_2}$? ?? ? ?? $x'_{0\,max}$?



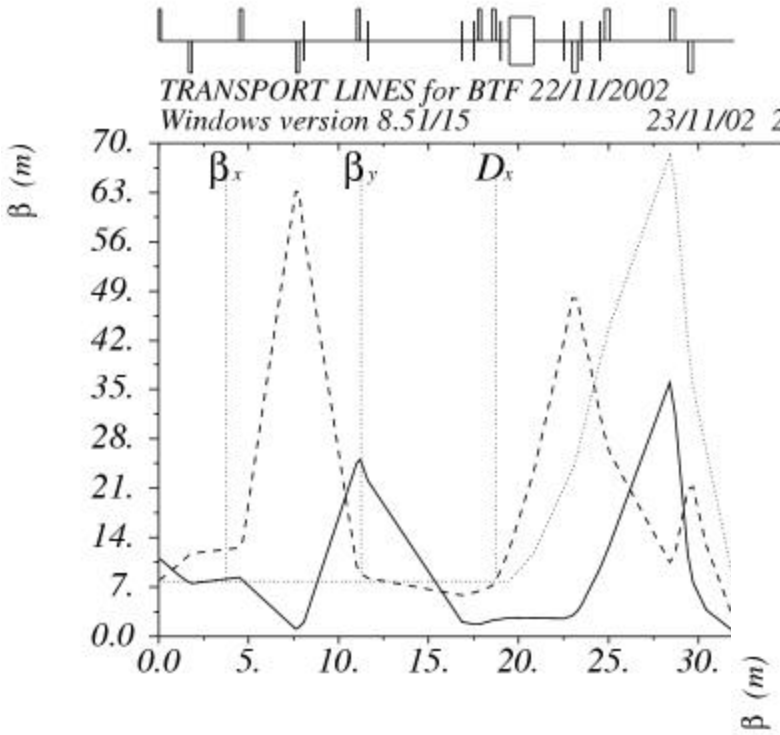
Energy selection resolution

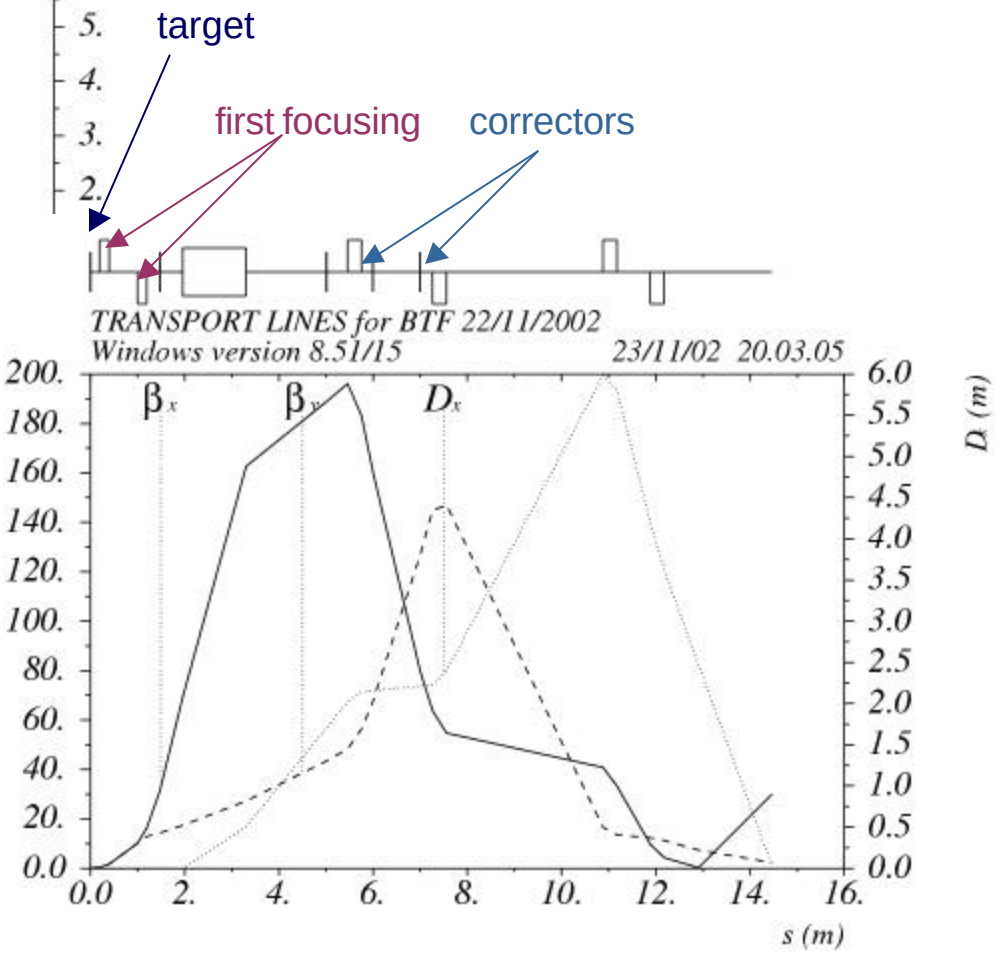
- L_1 = 1.48 m
- H = 2?5 mm
- ?x'$_{0\,max}$? $\frac{(?_x + H/2)}{L_1}$ $?_x$? ??mm
- (? E/E) ? $h/2L_2 + ?_x/L_1 + H/2L_1$? 0.3% + 0.4% + 0.1%



Optics

Without target…

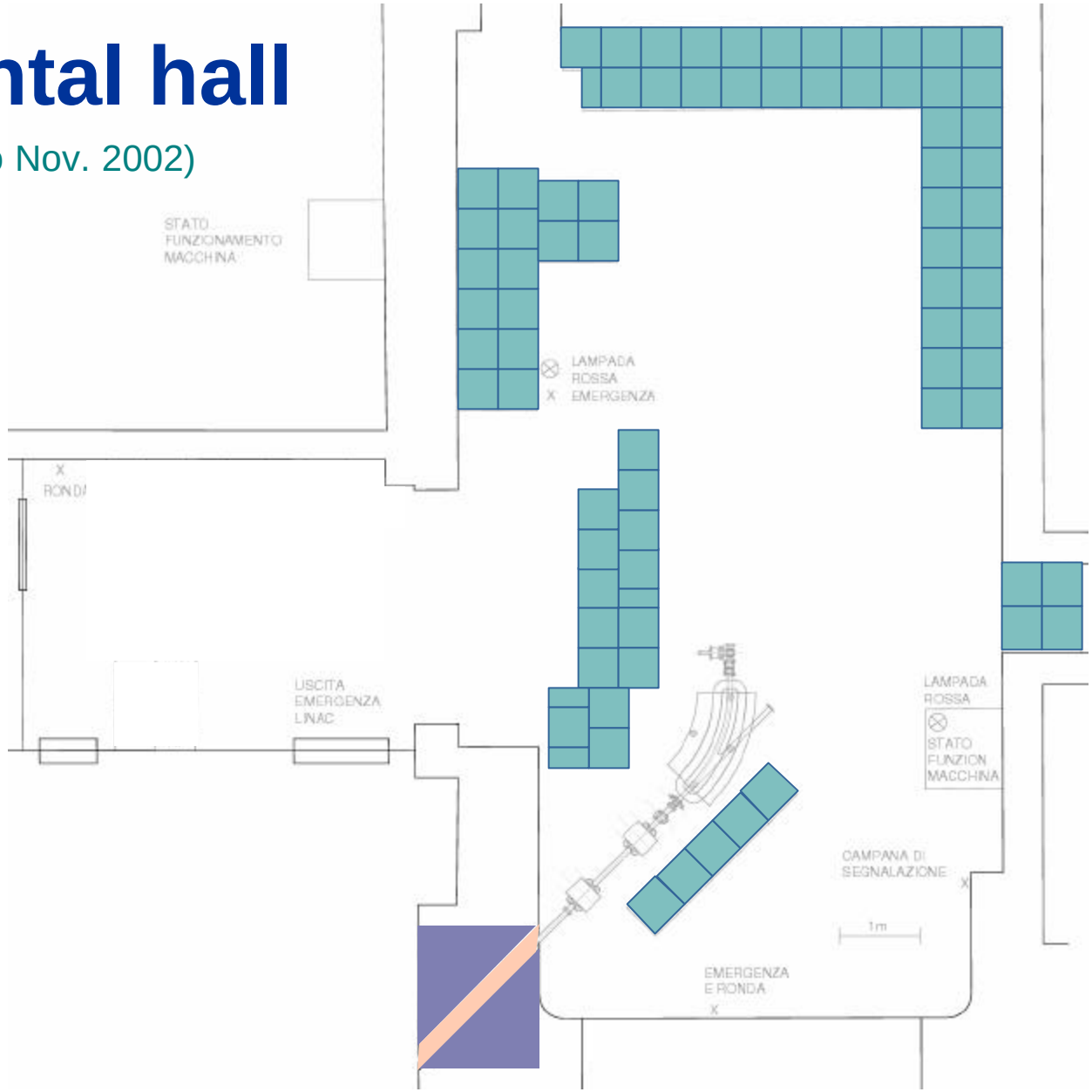




…with target: low ?, high divergence

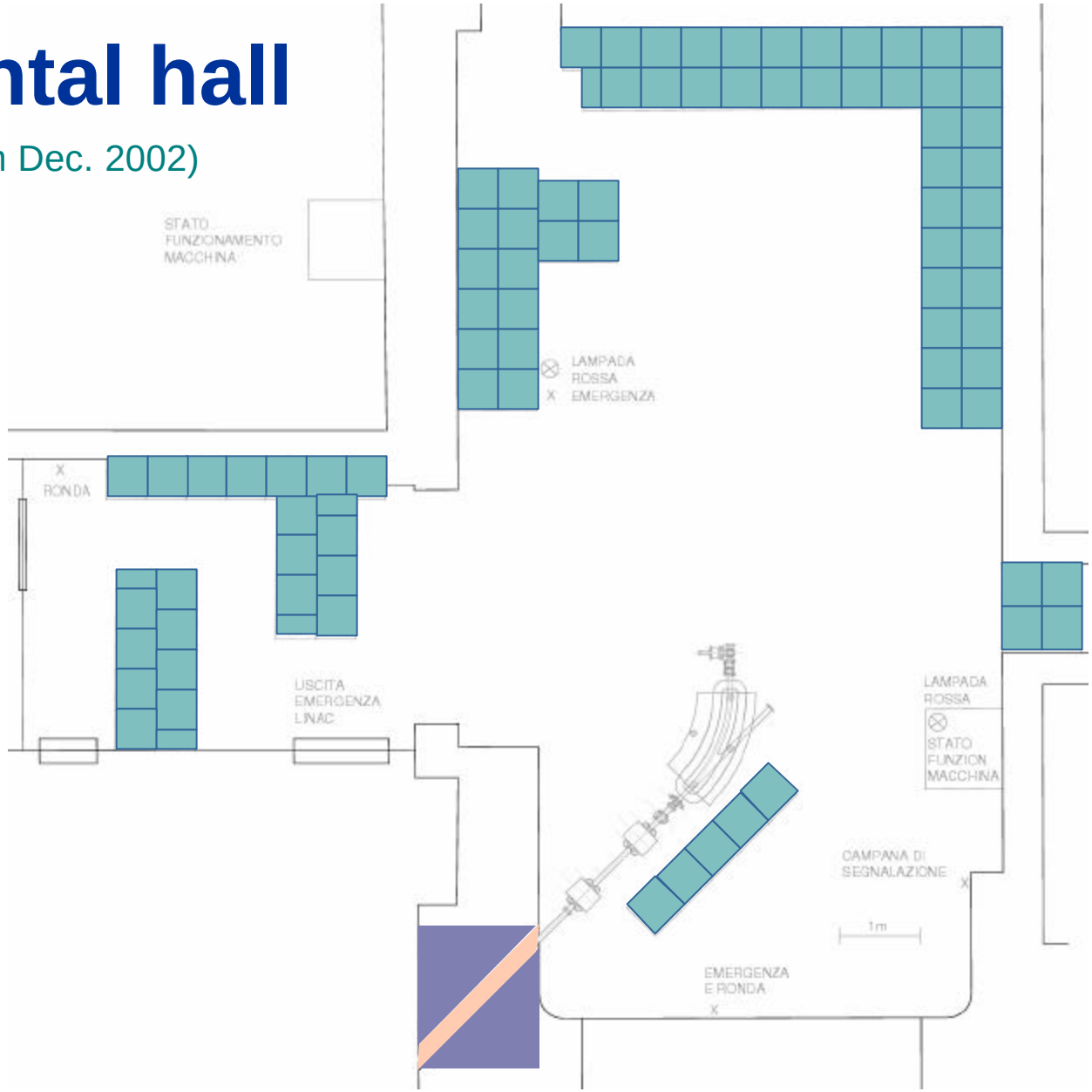
Experimental hall

(Old shielding, up to Nov. 2002)



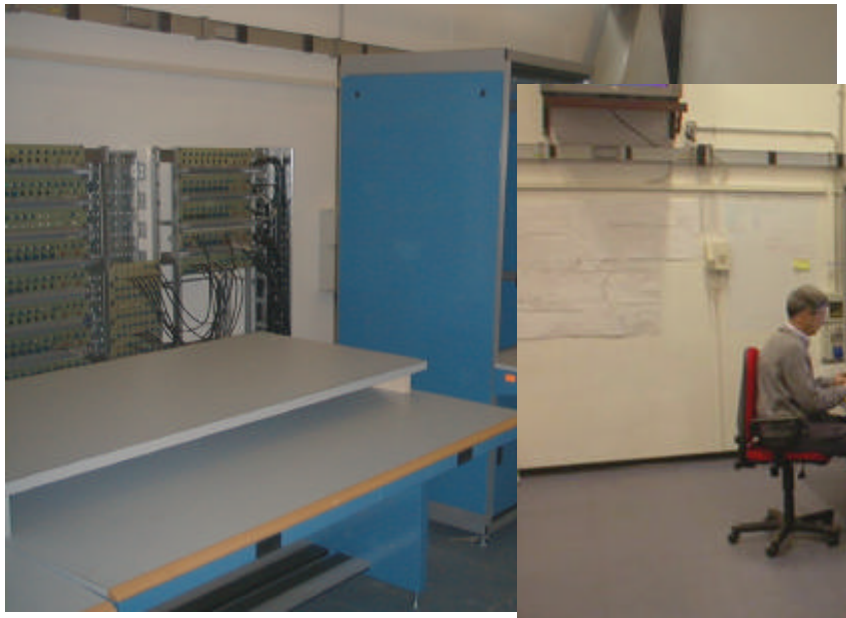
Experimental hall

(New shielding, from Dec. 2002)



Control Room

- 2 racks and PC dedicated to users
- Cables from/to experimental hall
- LNF-LAN



Cabling

16 coaxial cables “Andrew FSJ1-50A” N plug type

16 coaxial cables “Suhner RG223” BNC plug type

2 coaxial cables “Suhner RG 59” BNC plug type

2 coaxial cables “Suhner RG 59” SHV plug type

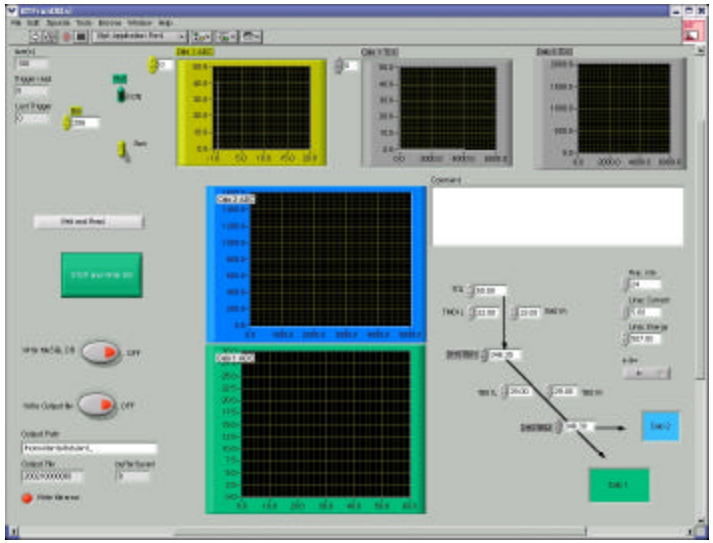
4 multi-polar cable twisted pair “Marlow Computer cable” sub D 9 pin plug type

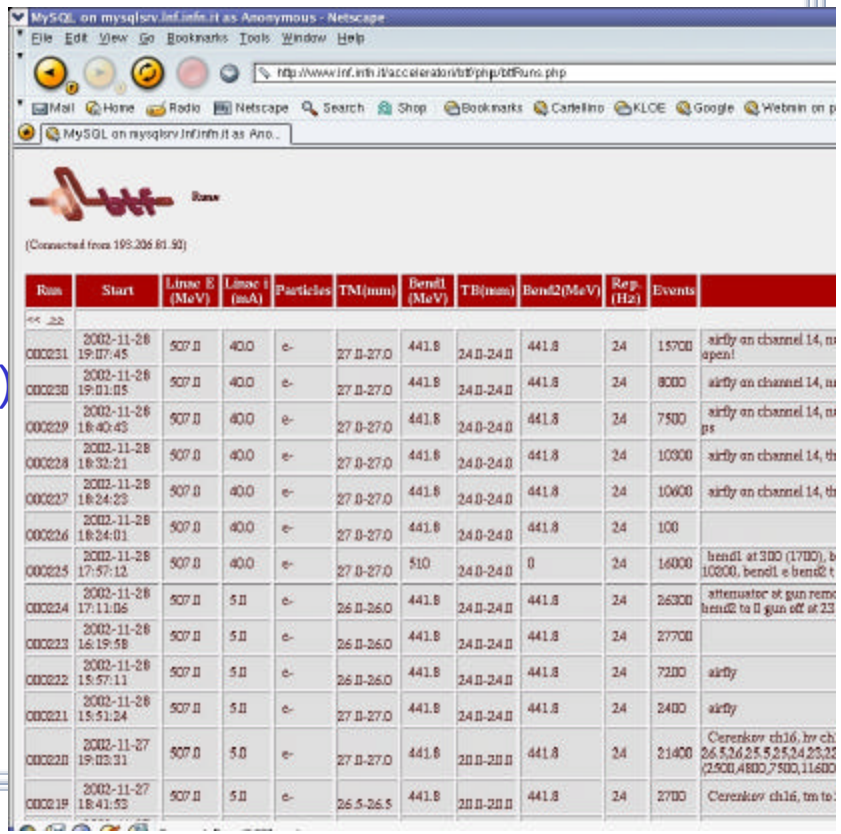
Network links

Cable ducts available for large experiments

Equipment

- 1 VME crate + CPU (VMIC Pentium)
  (dedicated to beam diagnostics)
- 1 NIM crate
- 1 CAMAC crate with branch to VME
- 1 VME crate + DAFNE VME CPU
- 1 DAFNE console, 1 PC
- LABView DAQ + MySQL database
- 1 rack (Exp. Hall) 2 rack (C.R.)
  (available to the users)
- High Voltage: CAEN SY127 + SY2527
- Motorized table (KLOE calorimeter prototypes)
- 1 Calorimeter, 1 AIR chamber, fingers, scintillator, etc.
- Gas system (coming soon…)





Run	Start	Linac E (MeV)	Linac I (mA)	Particles	TM(mm)	Bend1 (MeV)	TB(mm)	Bend2(MeV)	Rep. (Hz)	Events	
000231	2002-11-28 19:07:45	507.0	40.0	e-	27.0-27.0	441.8	24.0-24.0	441.8	24	15700	airfly on channel 14, n open!
000230	2002-11-28 19:01:05	507.0	40.0	e-	27.0-27.0	441.8	24.0-24.0	441.8	24	8000	airfly on channel 14, n
000229	2002-11-28 18:40:43	507.0	40.0	e-	27.0-27.0	441.8	24.0-24.0	441.8	24	7500	airfly on channel 14, n ps
000228	2002-11-28 18:32:21	507.0	40.0	e-	27.0-27.0	441.8	24.0-24.0	441.8	24	10300	airfly on channel 14, th
000227	2002-11-28 18:24:23	507.0	40.0	e-	27.0-27.0	441.8	24.0-24.0	441.8	24	10600	airfly on channel 14, th
000226	2002-11-28 18:24:01	507.0	40.0	e-	27.0-27.0	441.8	24.0-24.0	441.8	24	100	
000225	2002-11-28 17:57:12	507.0	40.0	e-	27.0-27.0	510	24.0-24.0	0	24	16000	bend1 at 300 (1700), b 10200, bend1 e bend2 t
000224	2002-11-28 17:11:06	507.0	5.0	e-	26.0-26.0	441.8	24.0-24.0	441.8	24	26300	attenuator at gun remo bend2 to 0 gun off at 23
000223	2002-11-28 16:19:58	507.0	5.0	e-	26.0-26.0	441.8	24.0-24.0	441.8	24	27700	
000222	2002-11-28 15:57:11	507.0	5.0	e-	26.0-26.0	441.8	24.0-24.0	441.8	24	7200	airfly
000221	2002-11-28 15:51:24	507.0	5.0	e-	27.0-27.0	441.8	24.0-24.0	441.8	24	2400	airfly
000220	2002-11-27 19:03:31	507.0	5.0	e-	27.0-27.0	441.8	20.0-20.0	441.8	24	21400	Cerenkov ch16, hv ch 26.5,26.25,5,25,24,23,22 (2500,4800,7500,11600
000219	2002-11-27 18:41:53	507.0	5.0	e-	26.5-26.5	441.8	20.0-20.0	441.8	24	2700	Cerenkov ch16, tm to:

Commissioning

- Feb. – Apr. ’02

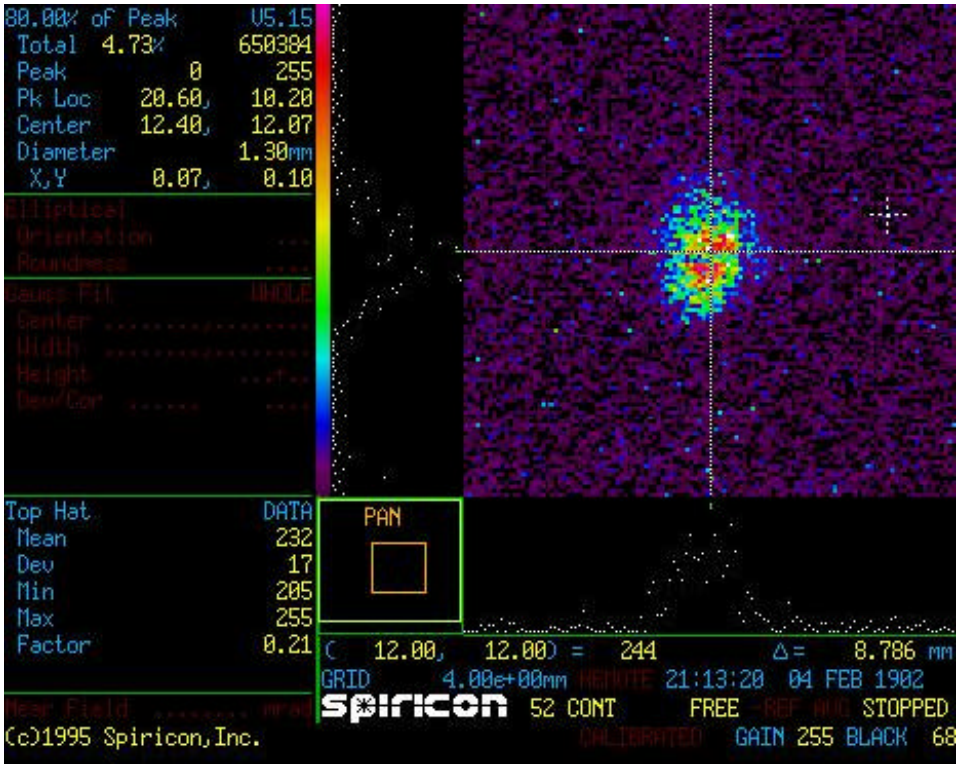
  Start of the commissioning of the line (single electron mode)

- Nov. – Dec. ’02

  Commissioning of the line (high multiplicity, energy range)

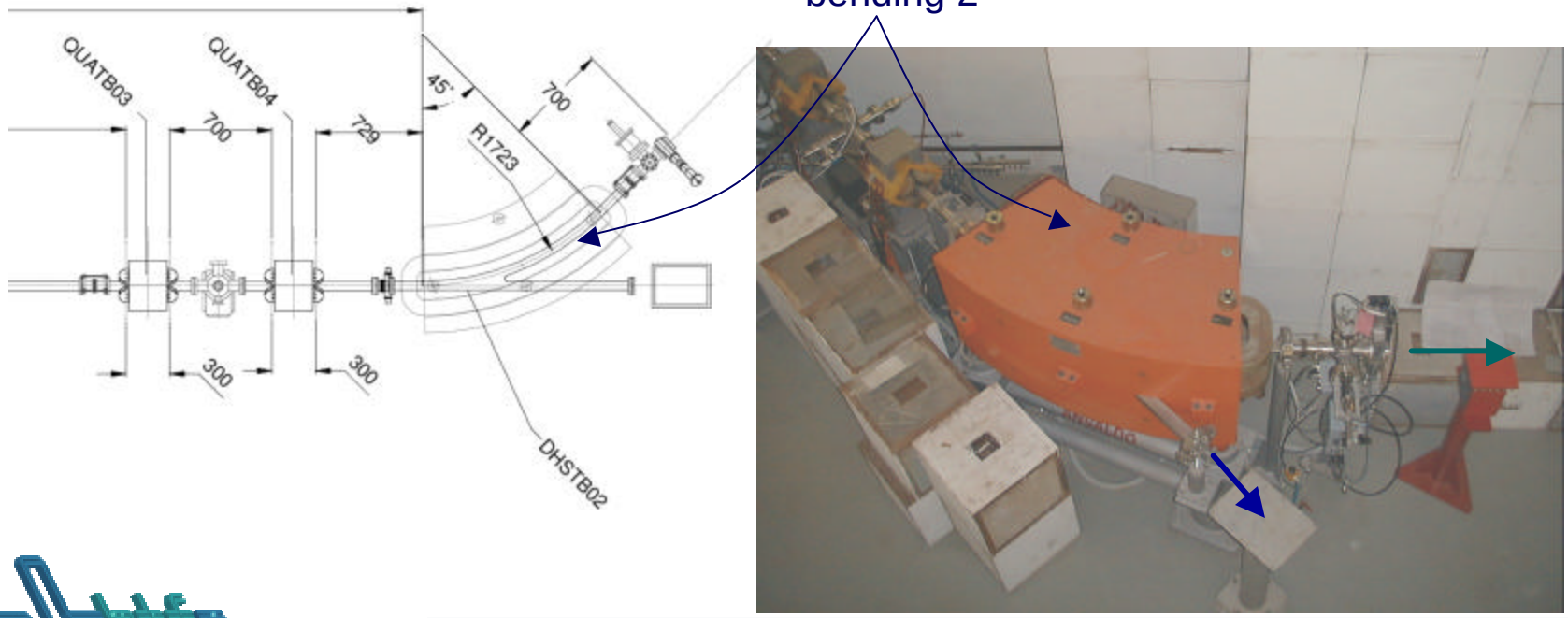
  First users access

Feb. 2002: first beam on fluorescent flag



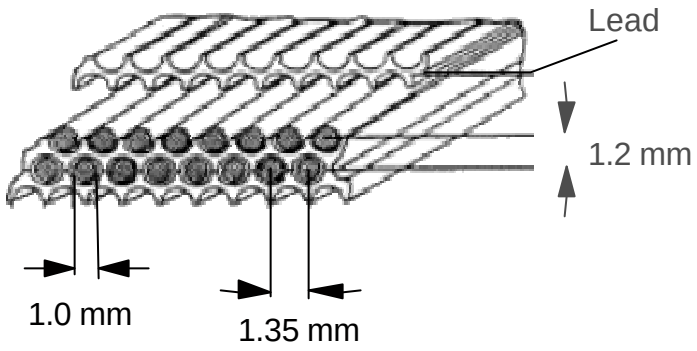
Detecting electrons…

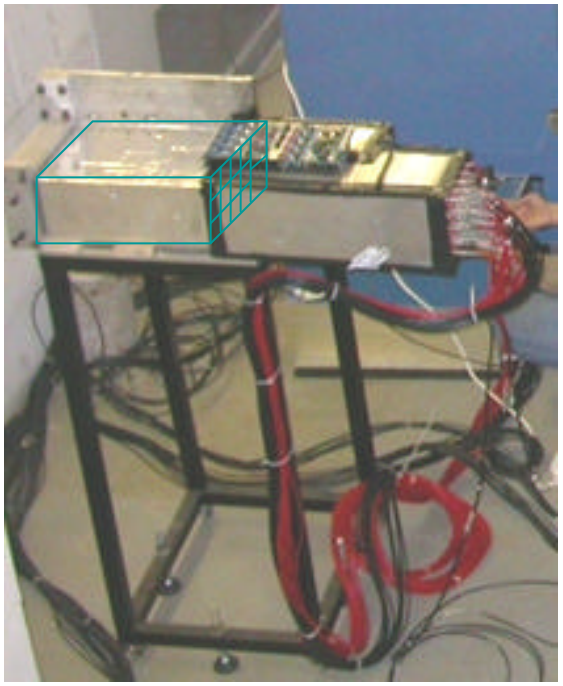
- Two calorimeters on moveable trolleys are used to detect electrons at the two possible line exits:
  - $I_2 = 0$ (straight line)
  - $I_2 = I_1$ (bending line)
- A Cerenkov counter has been also used at high multiplicity



Detecting electrons…

- Both calorimeters are of KLOE type, lead/scintillating fibers resolution: 4.7%/?E(GeV)

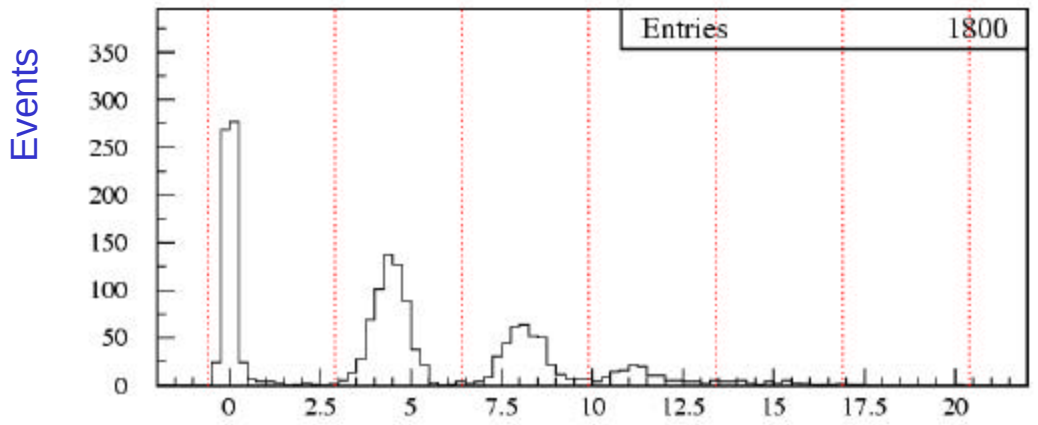




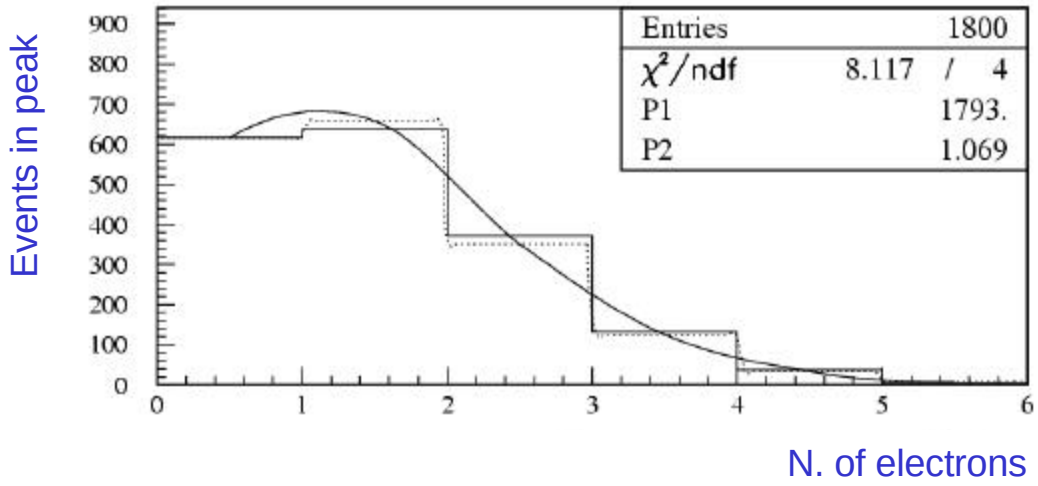
- 'Calorimeter 1' (KLOE prototype 0)
  - 15 X?
  - segmented (16 PMT)
- 'Calorimeter 2' (DEAR luminometer)
  - 11 X?
  - 1 PMT only, shorter fibers
  - useful at higher multiplicities (can be operated at lower gains)

Detecting electrons…

- Measured energy in the calorimeters reflects the Poisson distribution of the number of produced particles



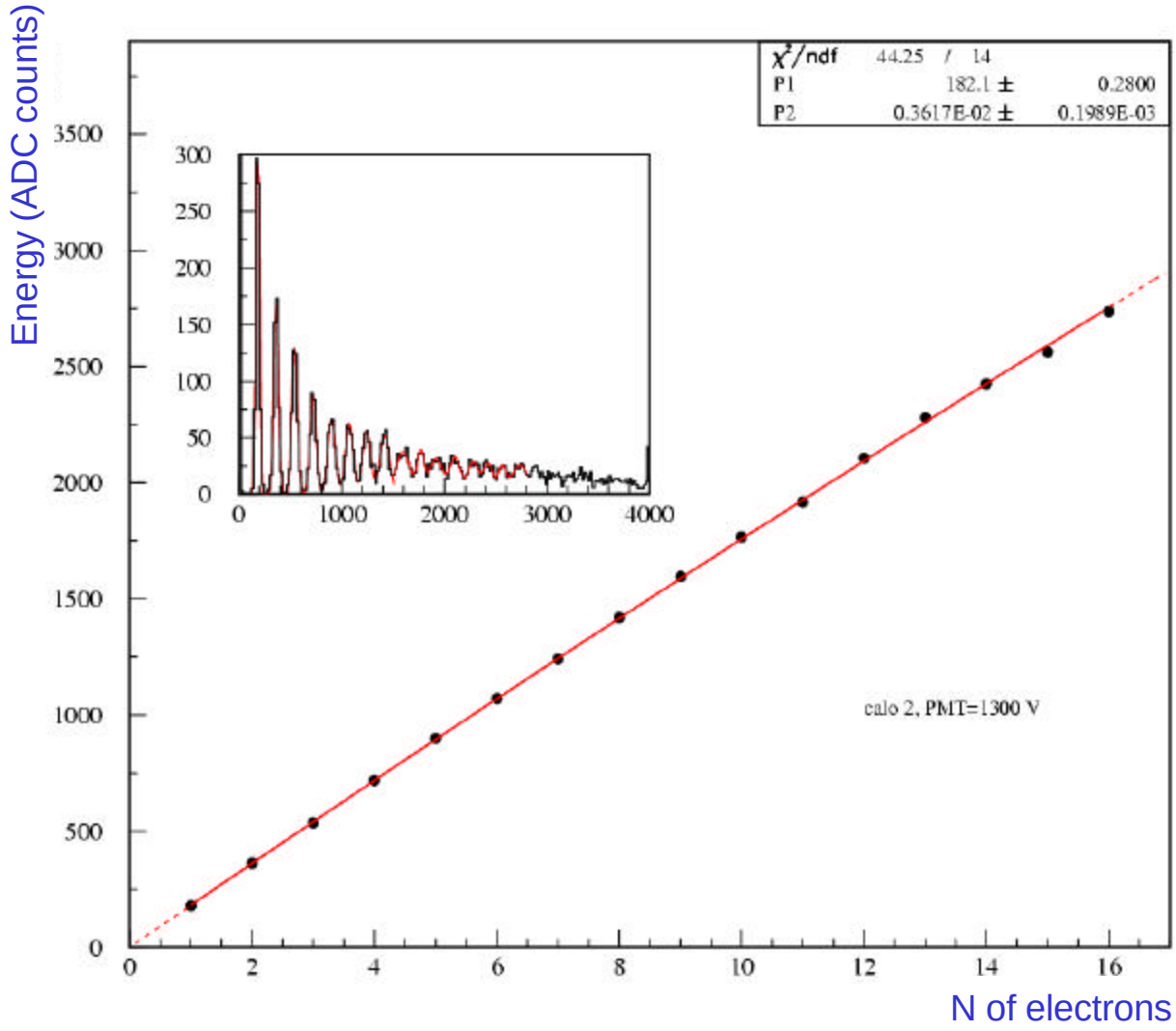
<N> ? 1
means P(0) ? P(1) ? 37%



Calorimeter performance

Calorimeter 2:

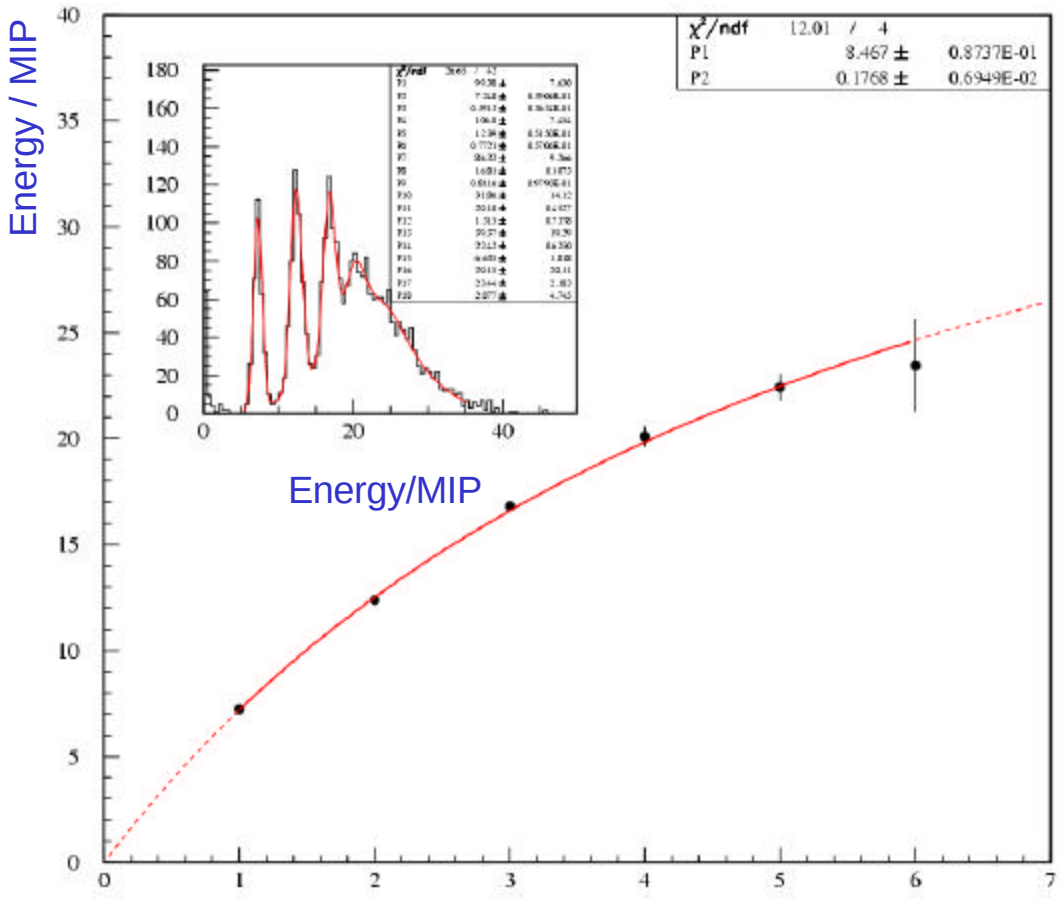
- Good linearity up to ?10 particles and more



Calorimeter performance

Calorimeter 1:

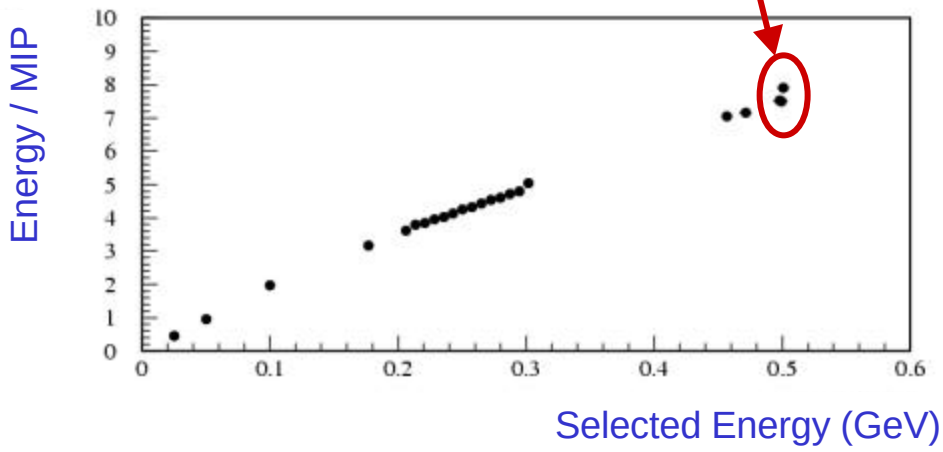
- Cells calibration with cosmic rays (MIPs)
- single electron resolution 8% @ 456 MeV after calibration
- Saturation for >1 e?



Again on energy selection…

Different deposited energy and multiplicity can be found at the same magnet setting if the hysteresis is not taken into account…

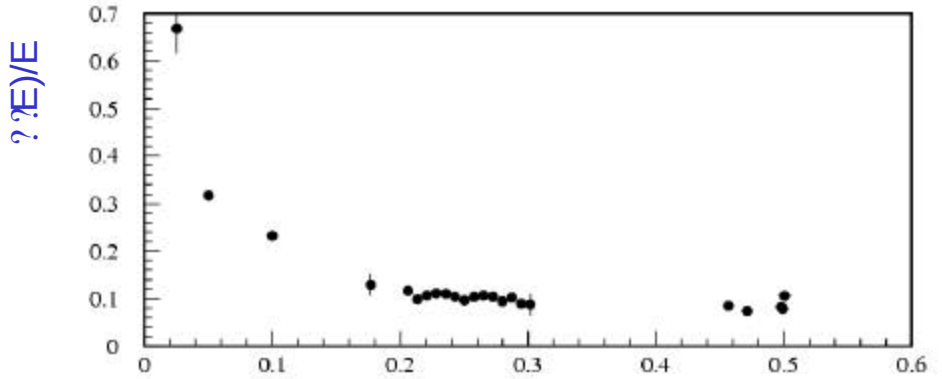
…the bending magnets should follow a ‘standard magnetization cycle’ (now automatic in the BTF control system)



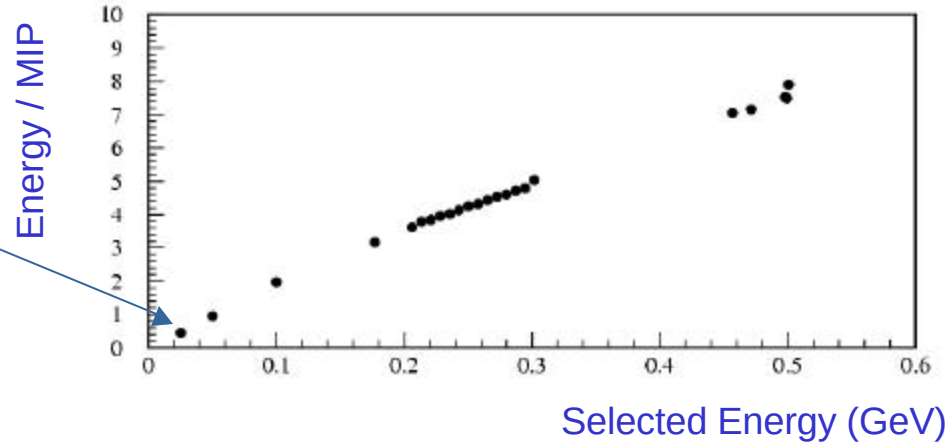
Energy range

Trying to explore all the available energy range, down to few tens of MeV…

- Good linearity changing e? selected energy
- Calorimeter resolution scales as ?E

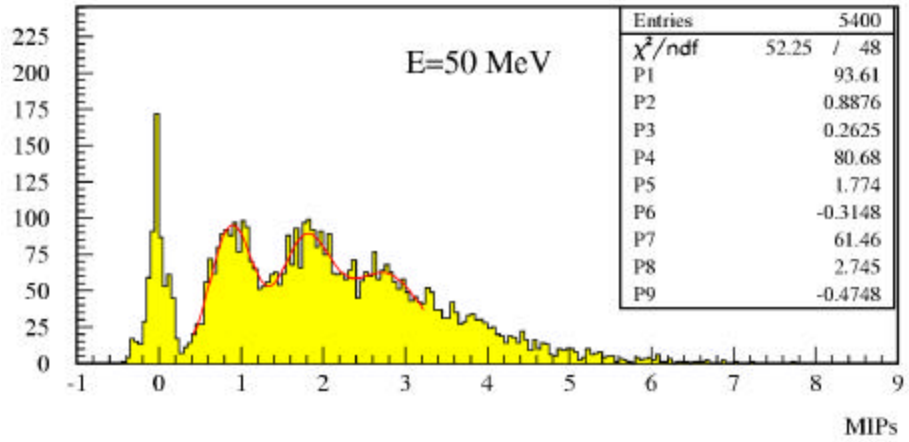


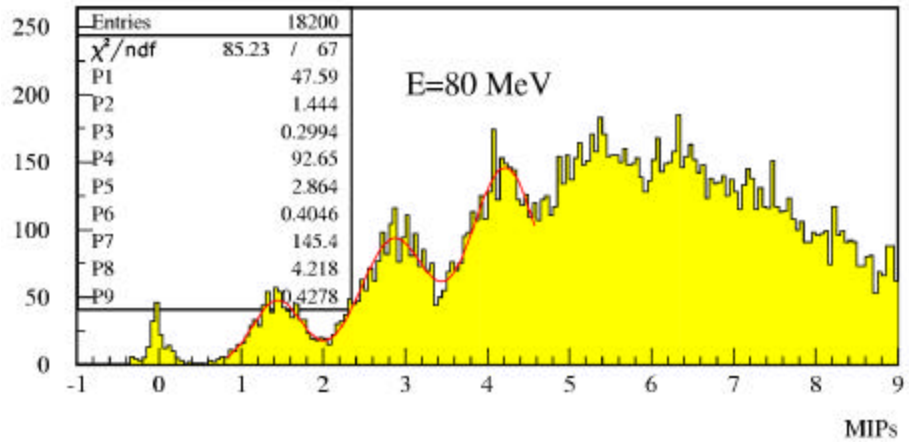
- We could each an energy as low as 25 MeV



Energy range

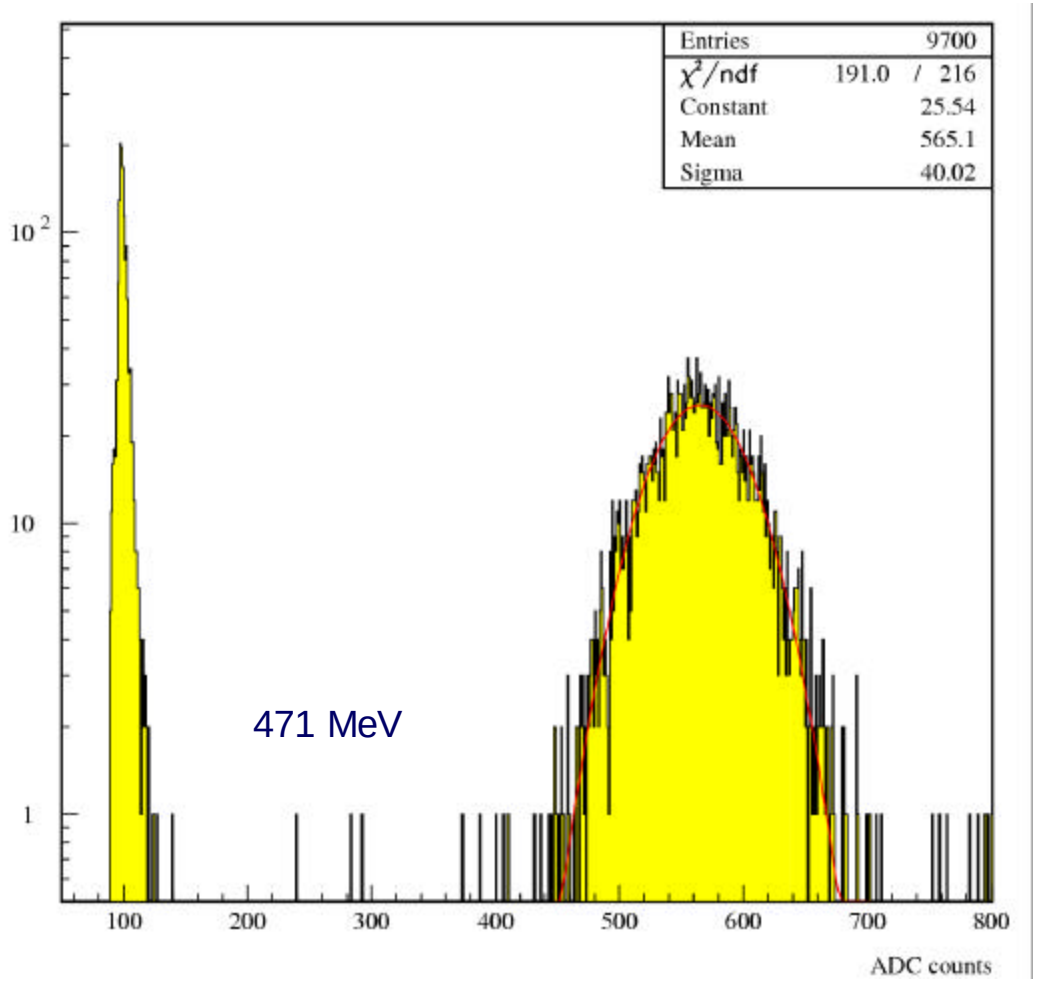
- Example: 50, 80 MeV starting from a LINAC energy of 320 MeV (not optimized!)





Energy resolution

- The resolution is very close to the intrinsic calorimeter resolution (? E/E ? 1%)

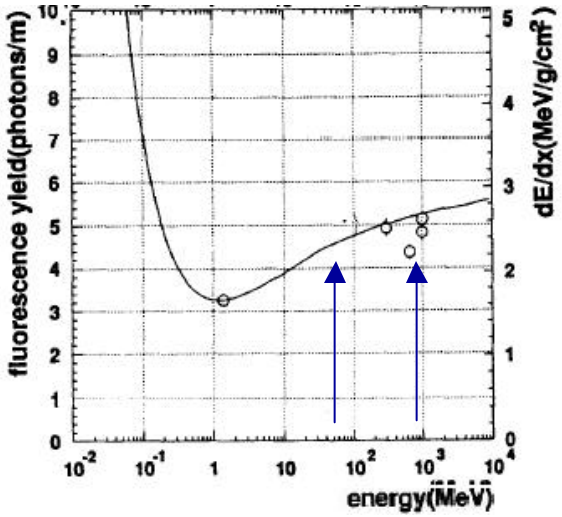


First users: AIRFLY

Aim:

- measure energy dependence of fluorescence in air/nitrogen in the energy range relevant for the core of an extensive air shower (the most probable energy of electrons in the EAS core is 80 MeV)

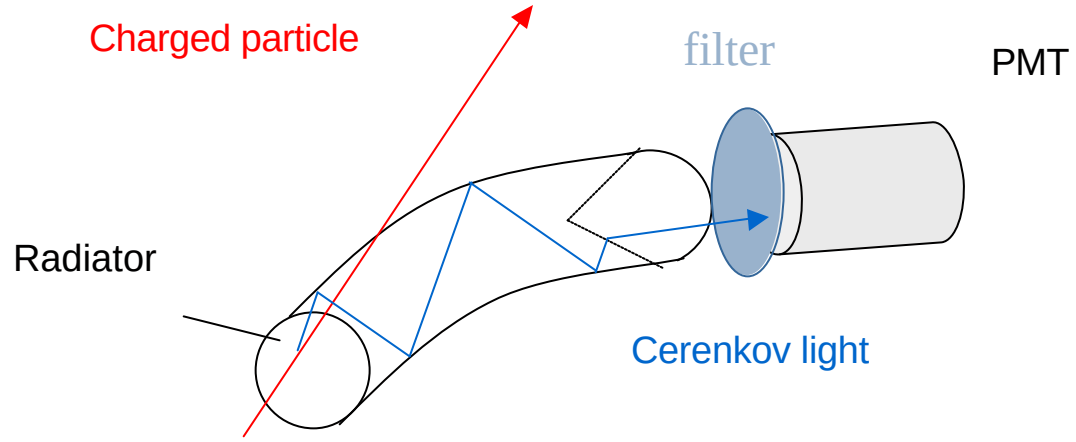
Nucl. Instrum. Meth. *A 372 (1996) 527-533*



Requests:

- Multiplicity between a few electrons and 10^4
- Energy in the range 50 – 800 MeV

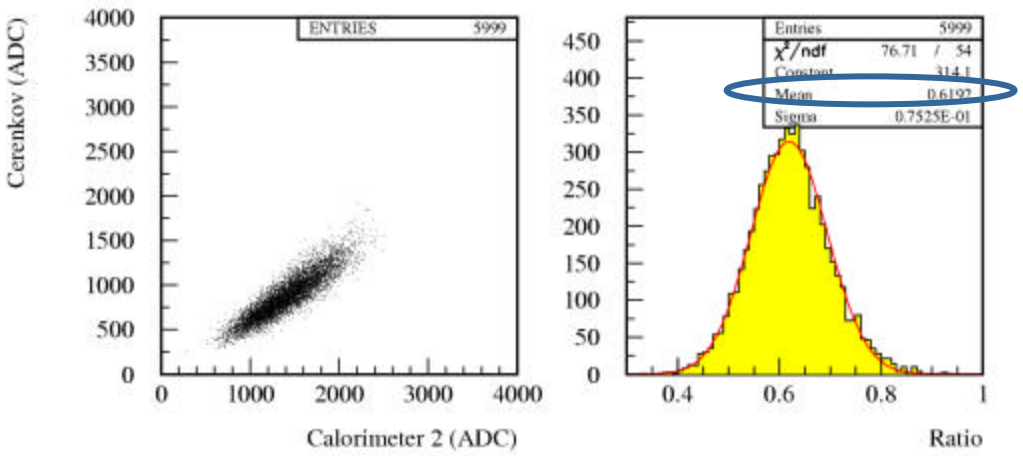
Cerenkov counter (AIRFLY)

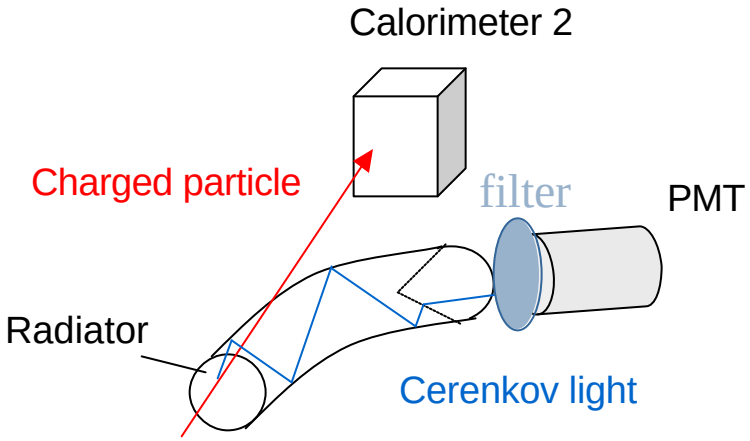


- Cerenkov light is produced in a plexiglass radiator
- Cerenkov light is extracted from the radiator by appropriate shaping of the end part, without optical connection to the PMT
- Calibrated attenuating filters allow the measurement of the beam intensity over several order of magnitudes.
- First test was successful. Improved version with optimal light extraction and collection foreseen

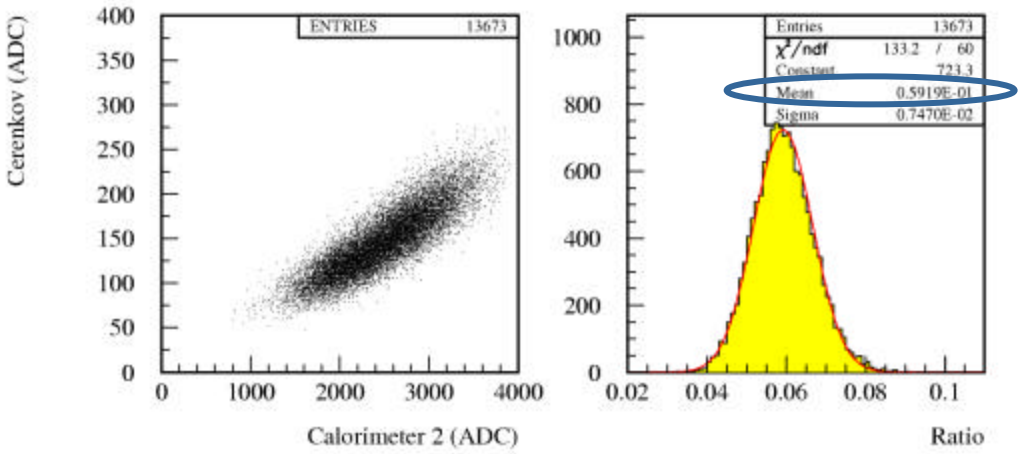
Cerenkov vs. calorimeter

No filter





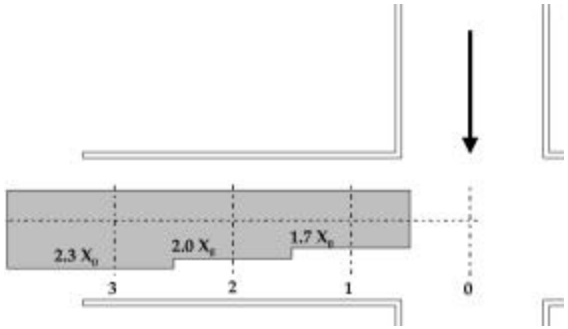
:10 filter

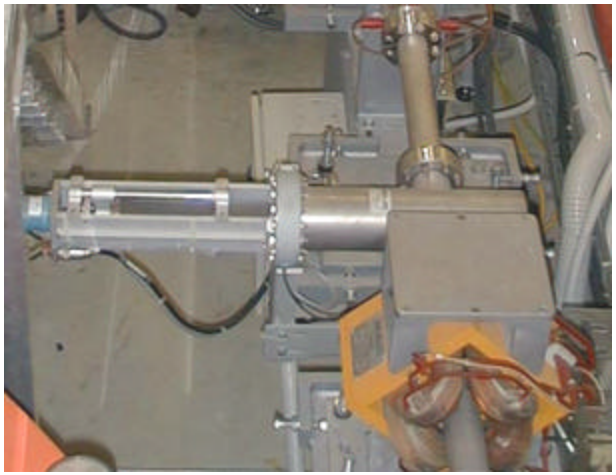


Signal is reduced by a factor 0.096

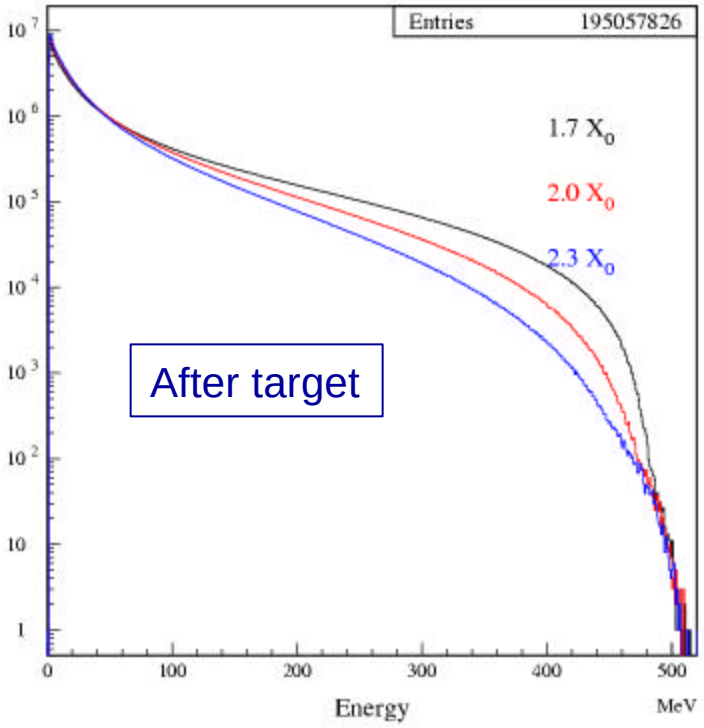
Multiplicity

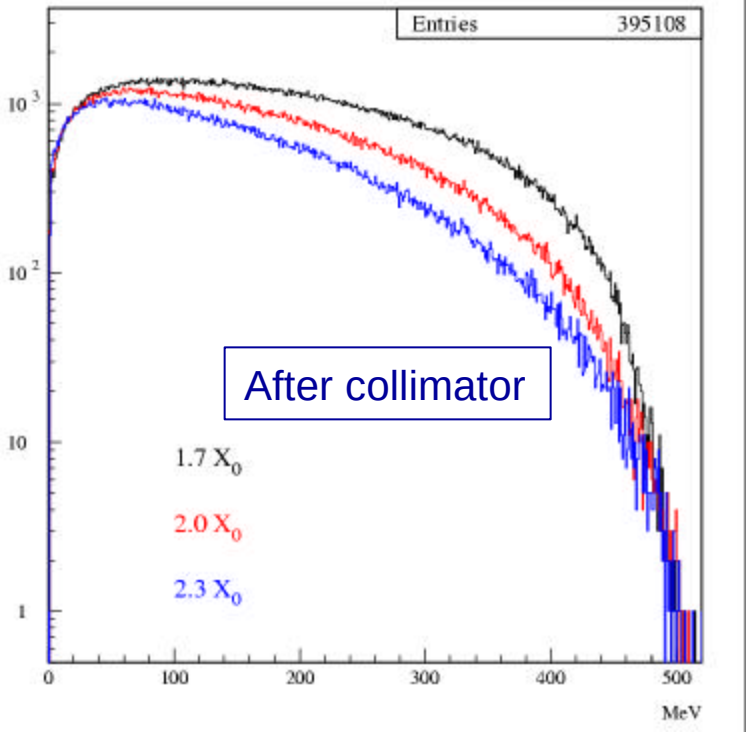
Tunable W target





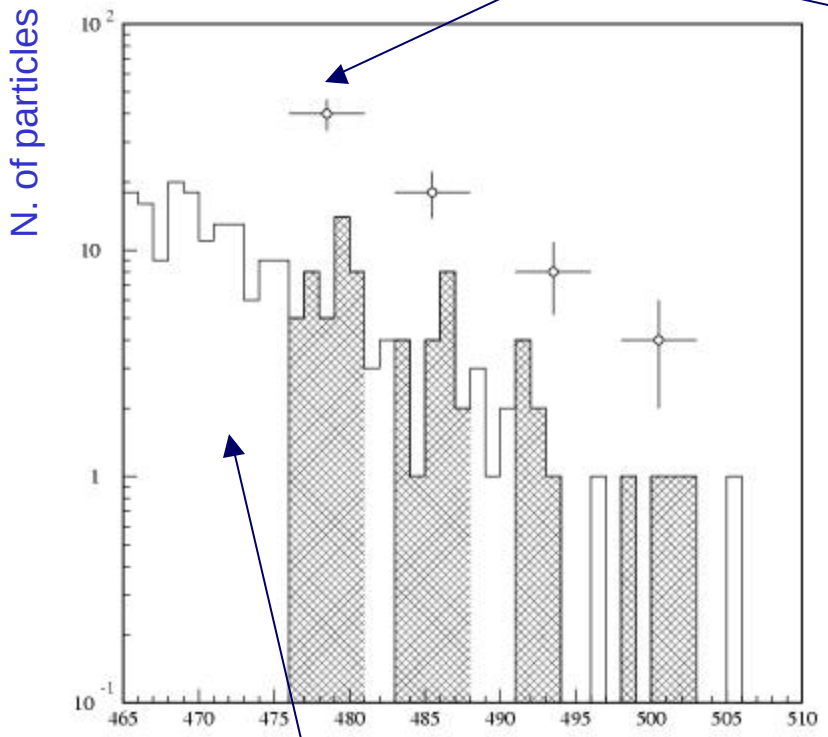
Monte Carlo: 1×10? e? from LINAC

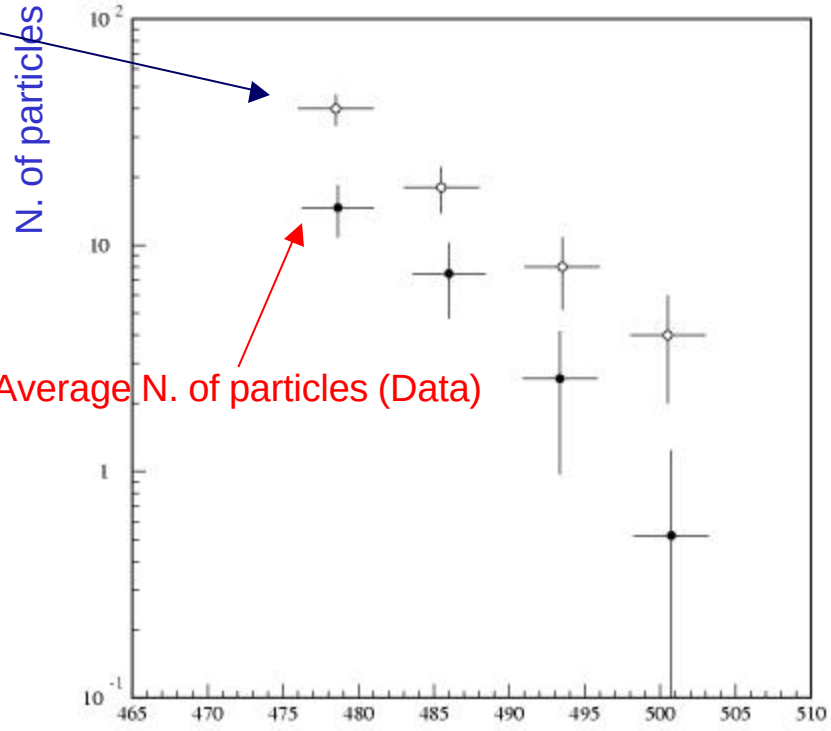




Multiplicity tuning

Empty dots: N. of particles in a 1% energy slice (Monte Carlo)





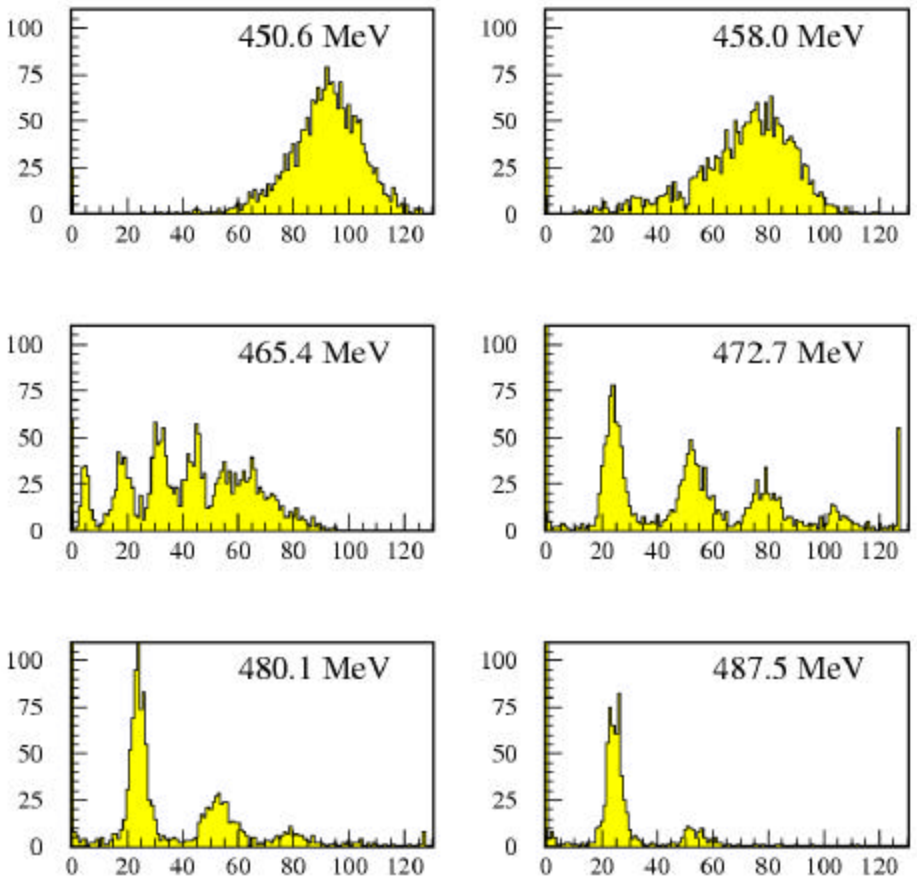
Average N. of particles (Data)

Histogram: energy distribution out of target (Monte Carlo)

Multiplicity tuning

Tuning the electron multiplicity:

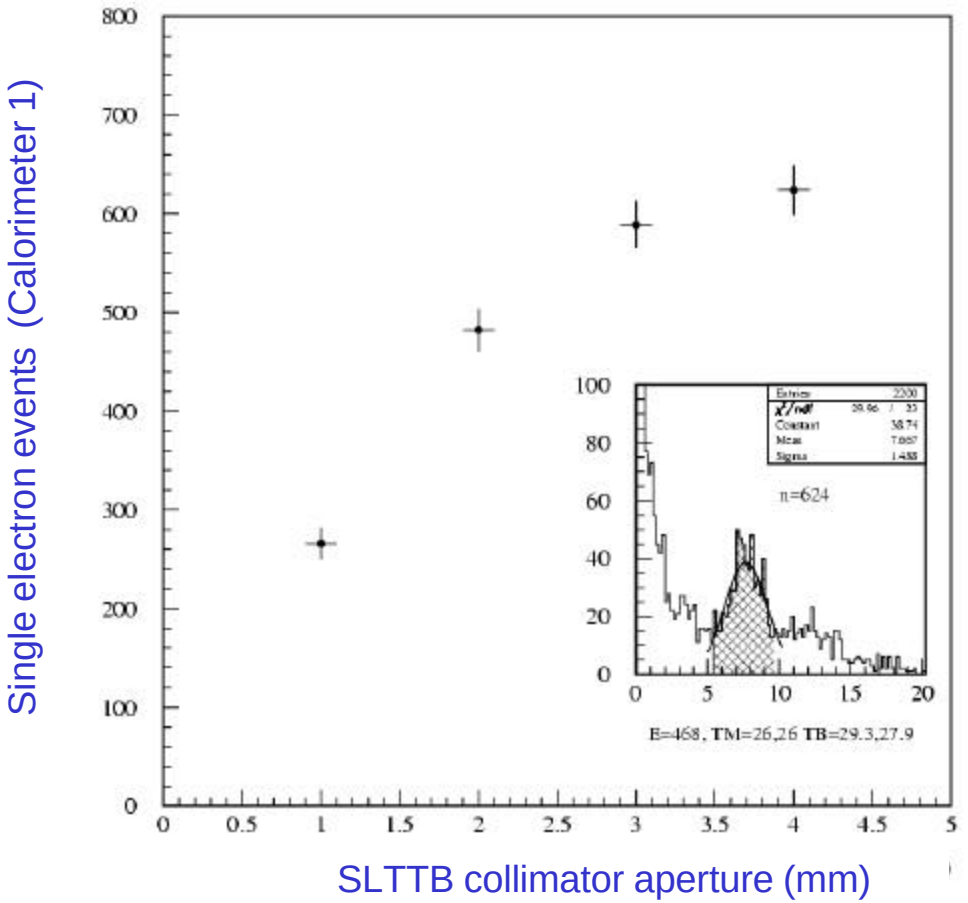
- Due to the energy distribution out of the attenuator target, N increases by lowering the selected energy



Multiplicity tuning

Tuning the electron multiplicity:

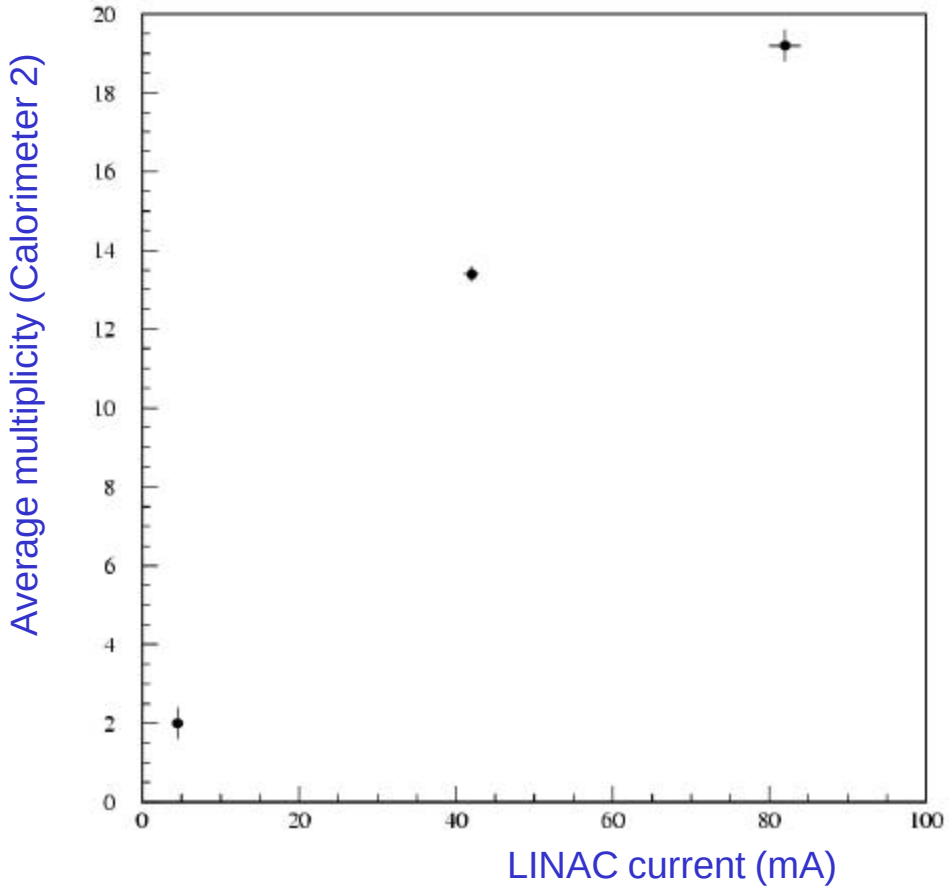
- N should increase by opening the collimators (up to the beam spot size)



Multiplicity tuning

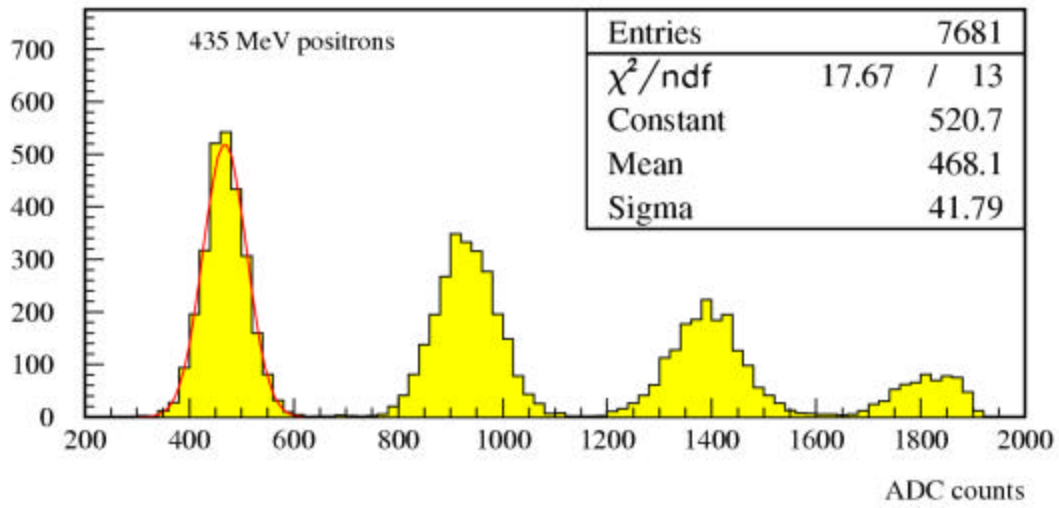
Tuning the electron multiplicity:

- N should be proportional to the LINAC current



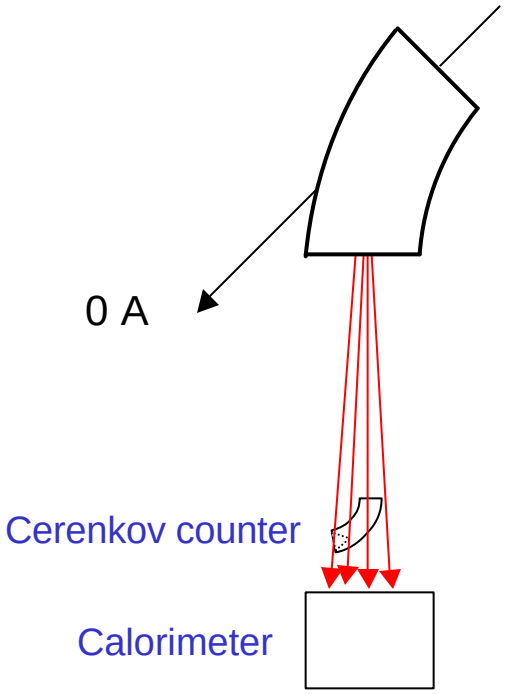
Positron production

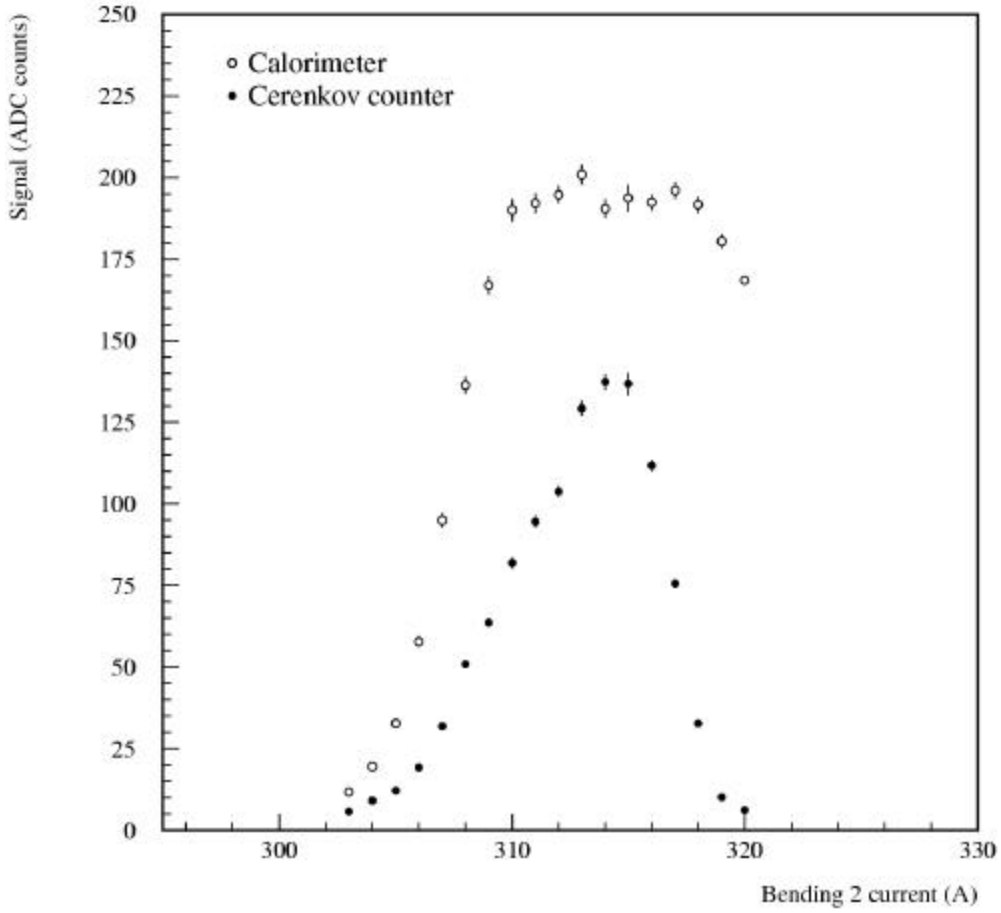
Just reversing the sign of all the magnets…



Beam line acceptance

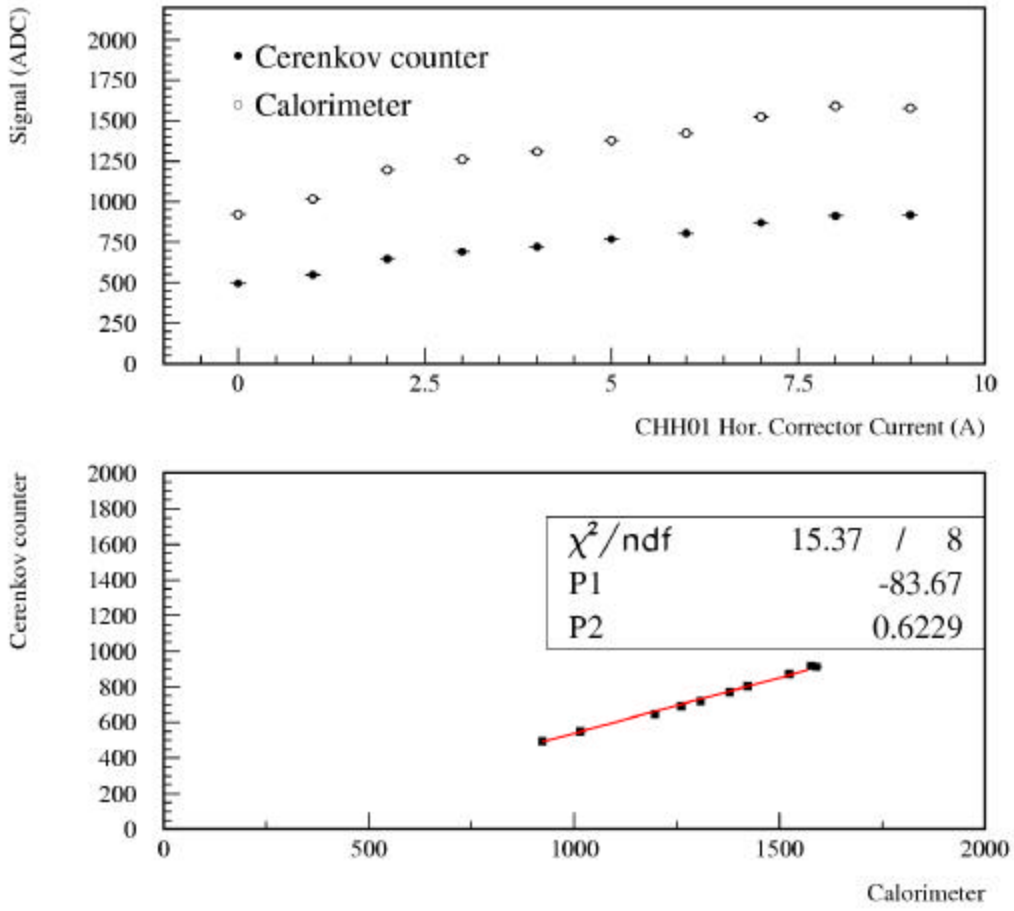
Beam pipe *horizontal* acceptance can be measured by moving the beam (changing the current of bending 2)





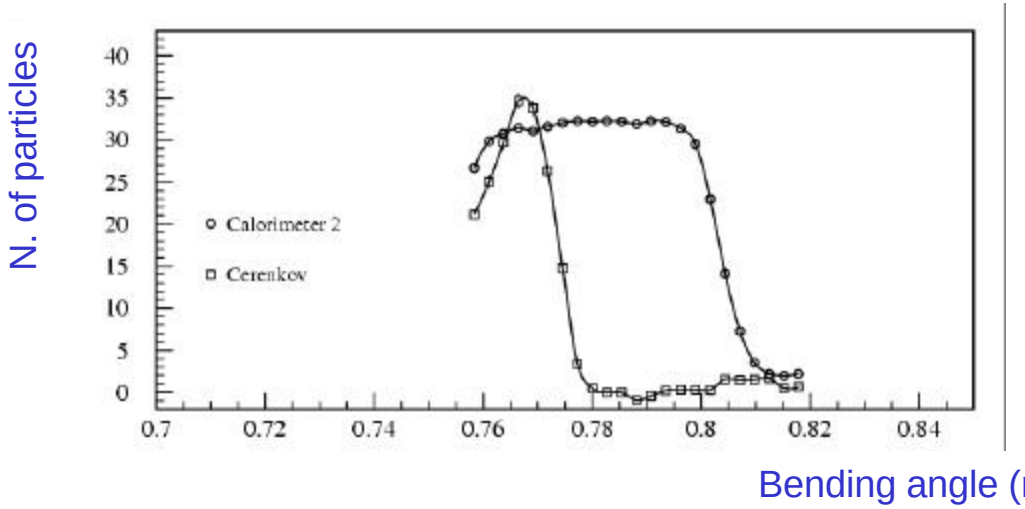
Beam line acceptance

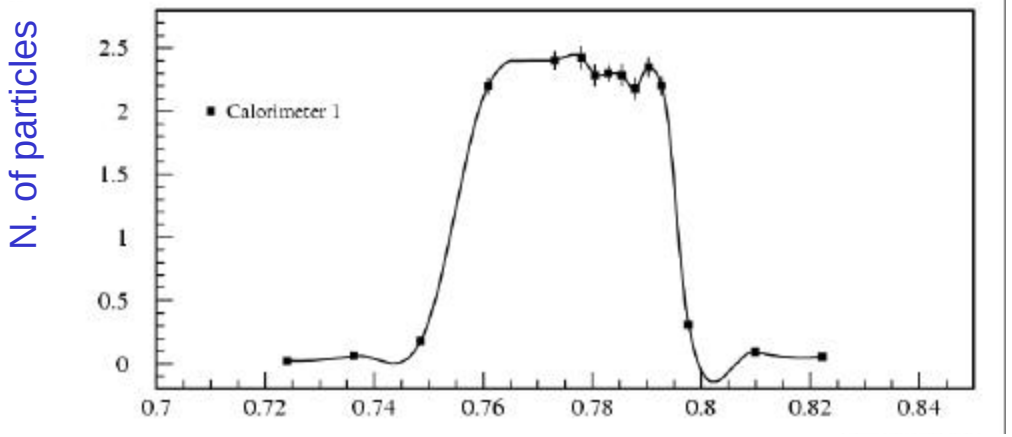
- The same scan can be performed *partially* using the horizontal correctors



Beam line acceptance

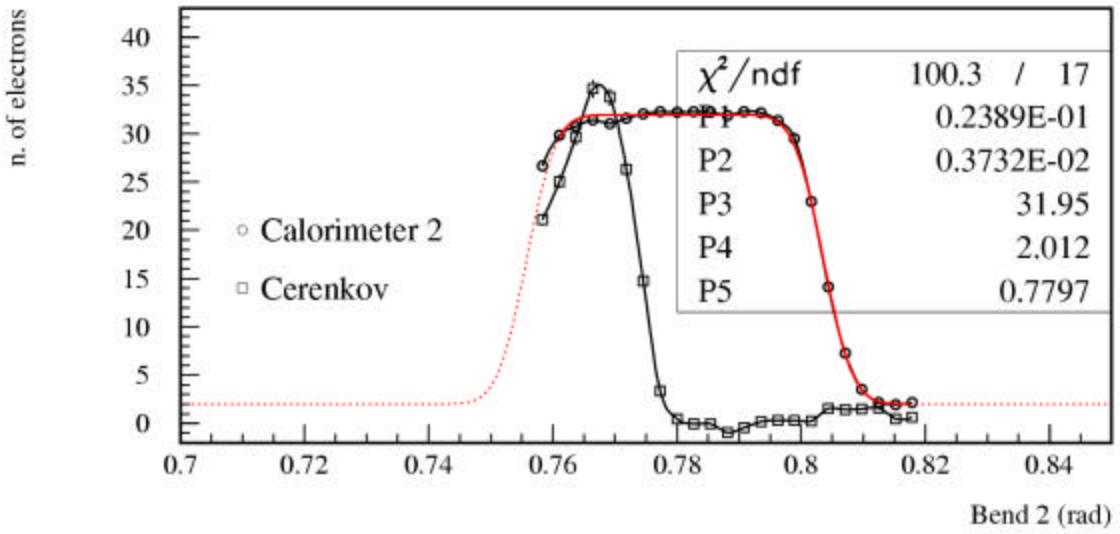
- Beam pipe *horizontal* acceptance was measured with both calorimeters…





Beam size

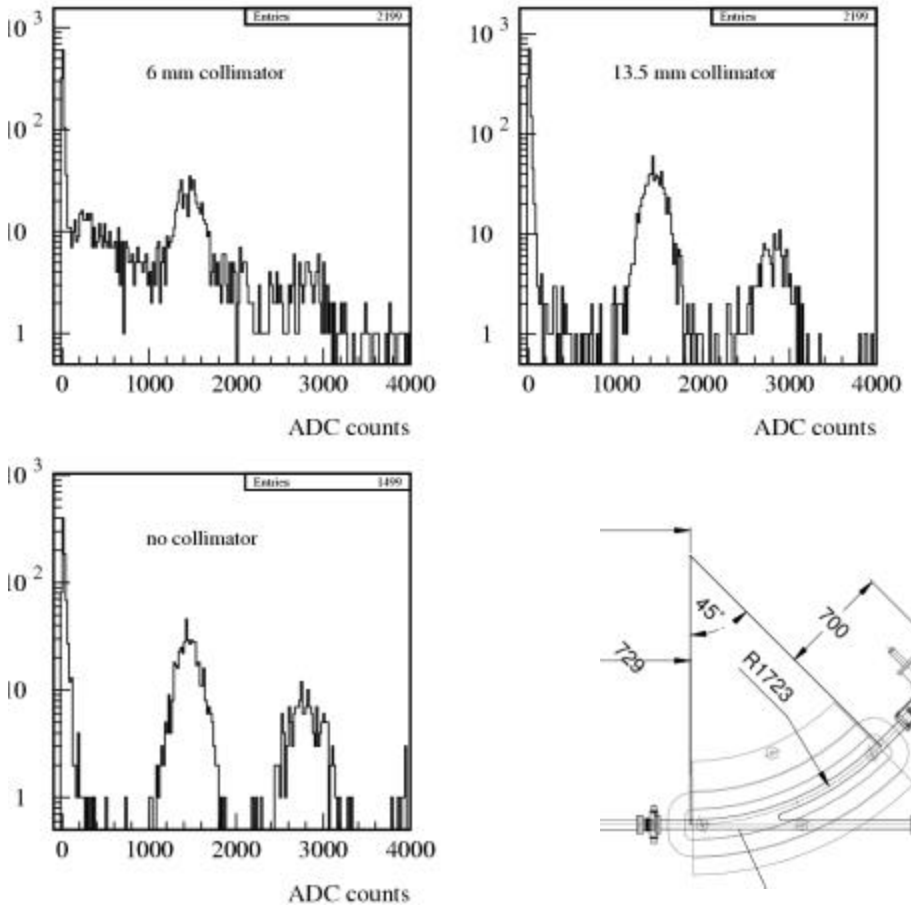
- Beam profile detector not yet ready, but…

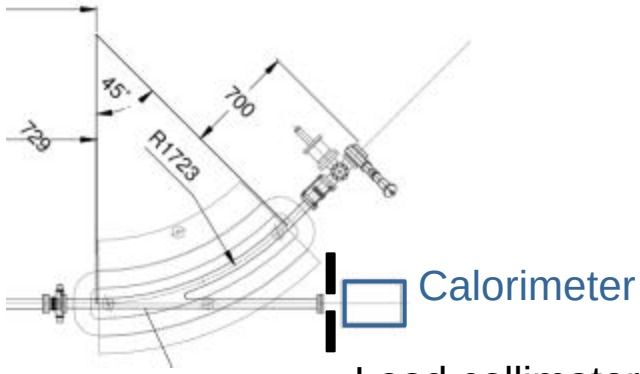


- … taking into account the beam pipe diameter, we can estimate:

  ? ? 0.0037/0.024 ? 30 mm = 4.7 mm

Beam size





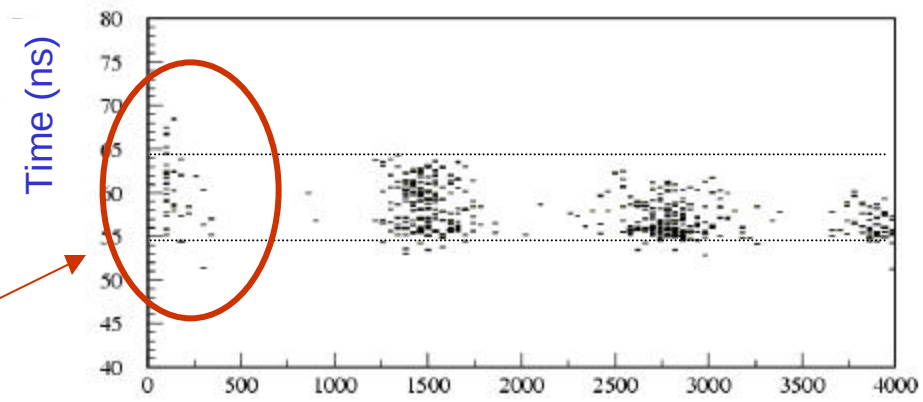
- Very rough estimate:
  3? ? 13 mm

Time distribution

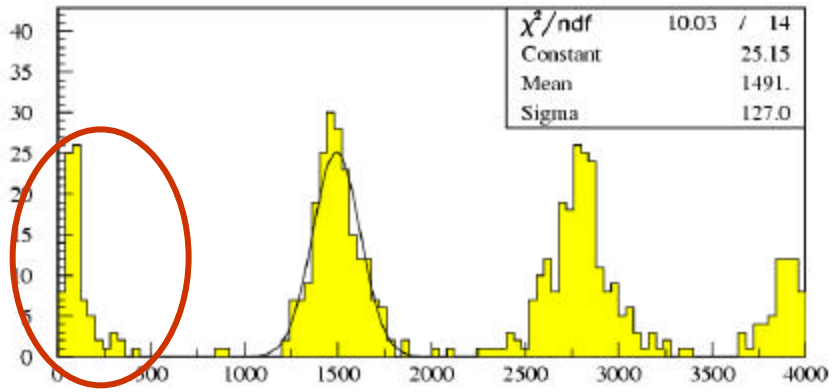
✍ Nominal pulse duration is ?10 ns (in 'parasitic' mode, i.e. in the standard LINAC configuration), the time distribution in the calorimeter should reflect this time structure…

The pedestal has a tail of on-time events…

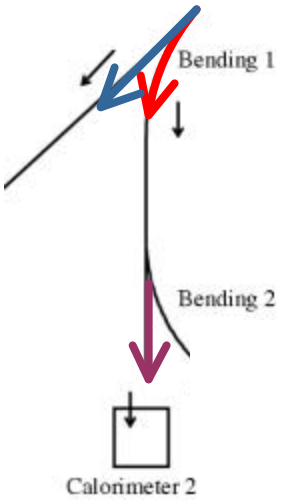
Low energy particles?

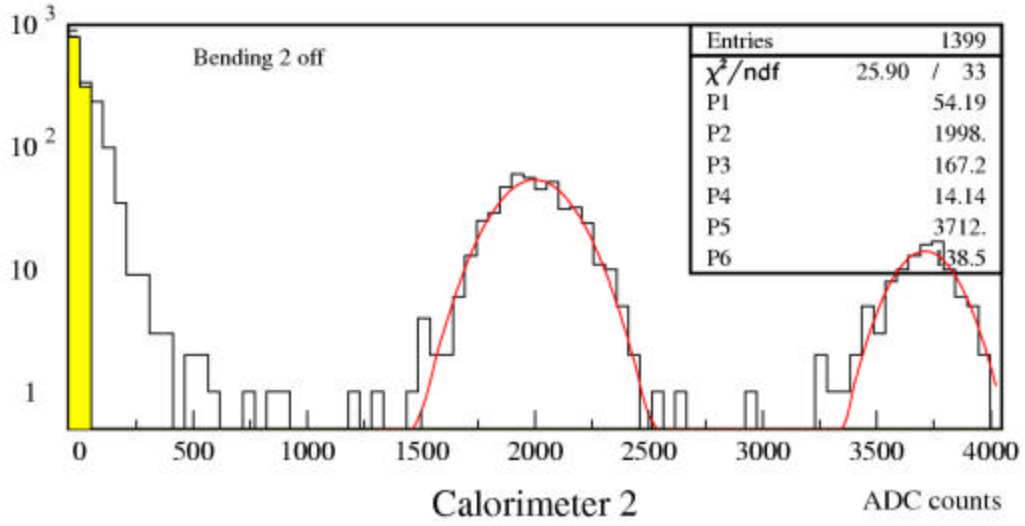


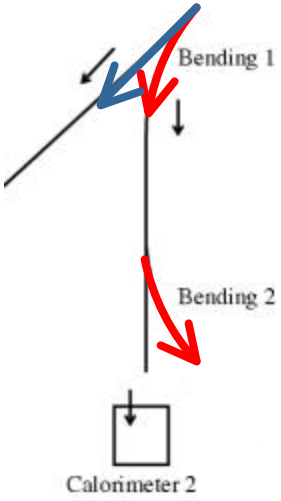
10 ns

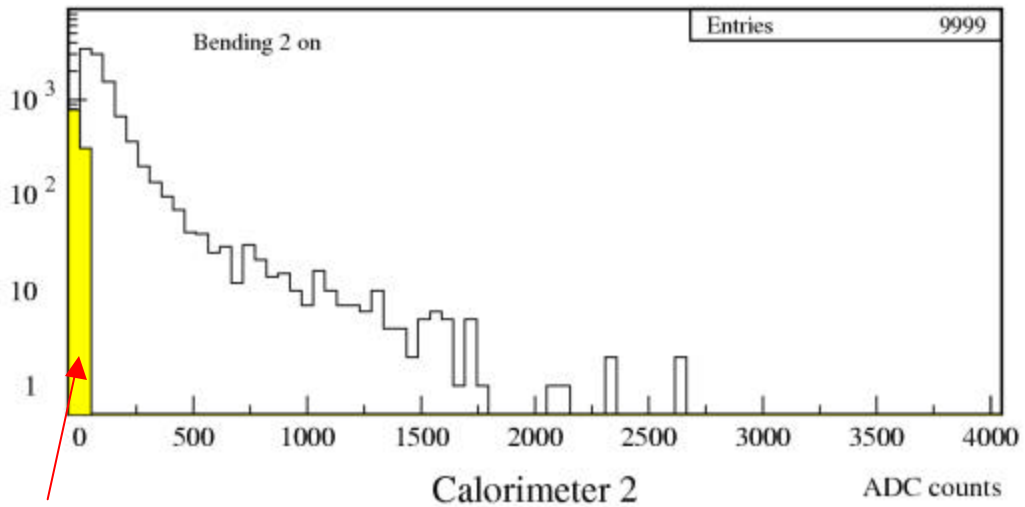


Background





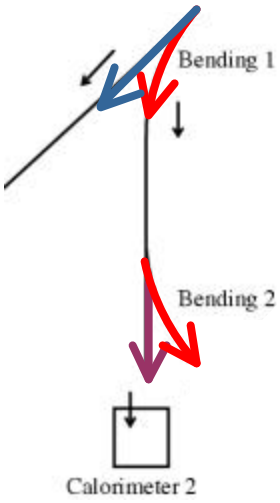


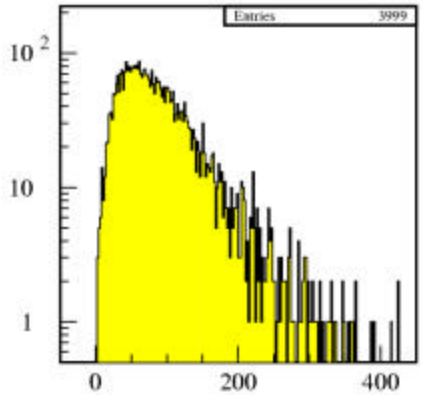


True pedestal (LINAC off)

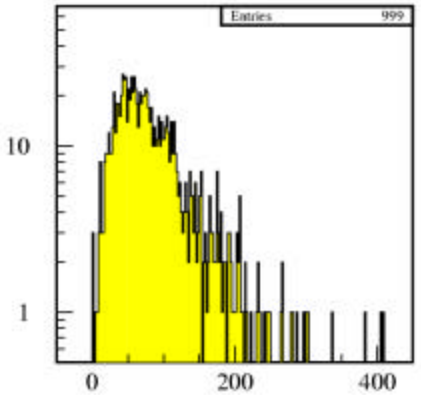
Background

✍The background is still present when switching off the first transport magnet (Bending 1)

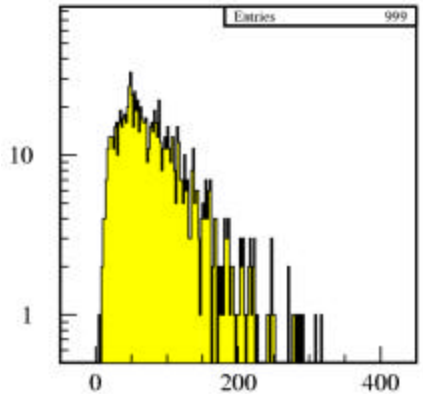




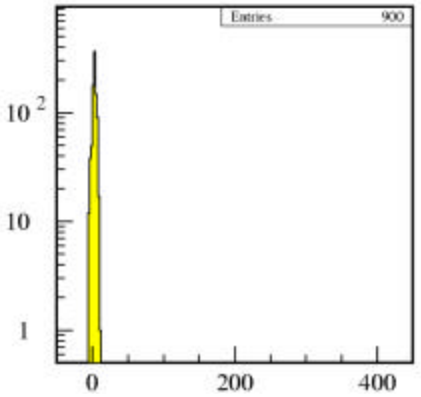
Bending 1 on, 2 on



Bending 1 off, 2 on



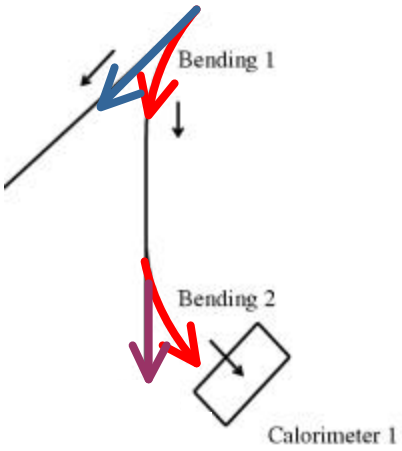
Bending 1 off, 2 off

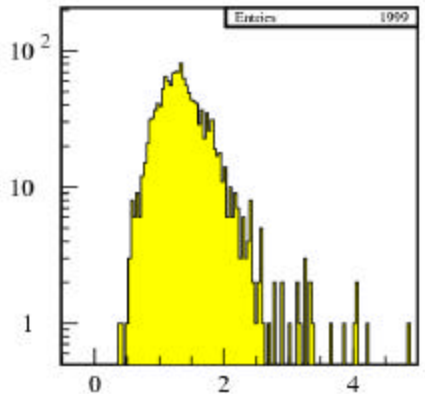


LINAC gun off

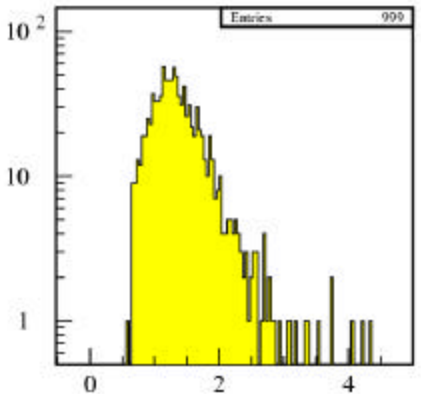
Background

✍The background is still present when switching off the first transport magnet (Bending 1)

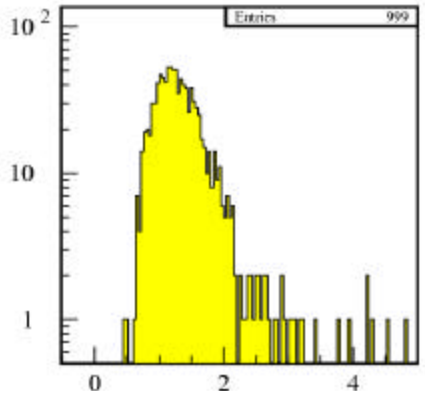




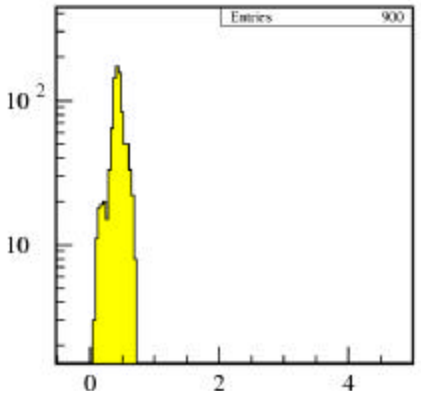
Bending 1 on, 2 on



Bending 1 off, 2 on

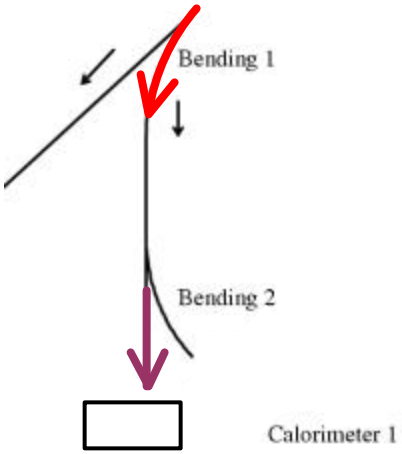


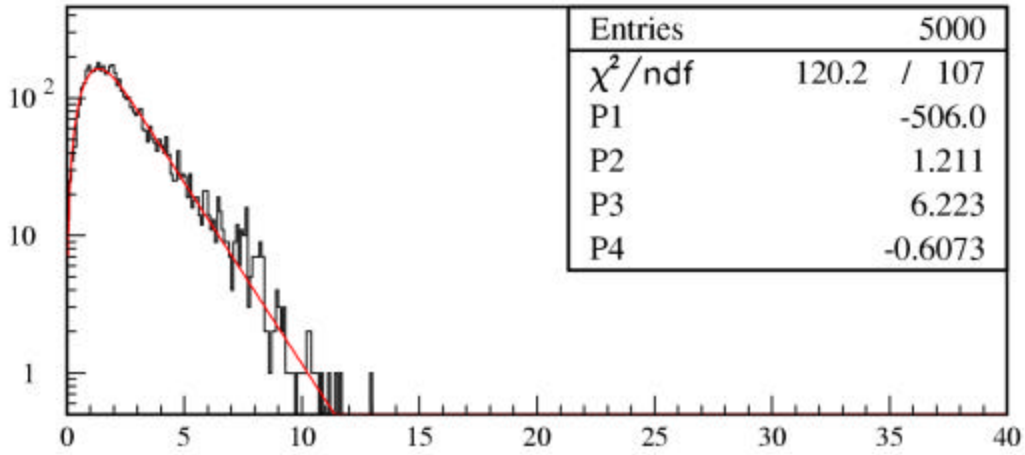
Bending 1 off, 2 off



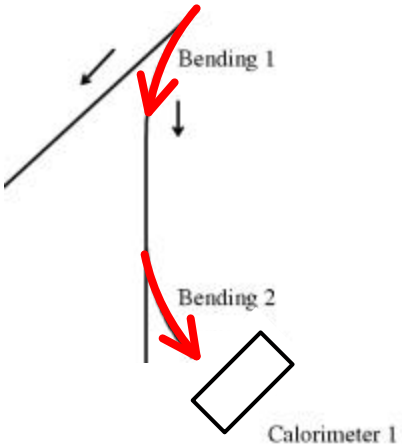
LINAC gun off

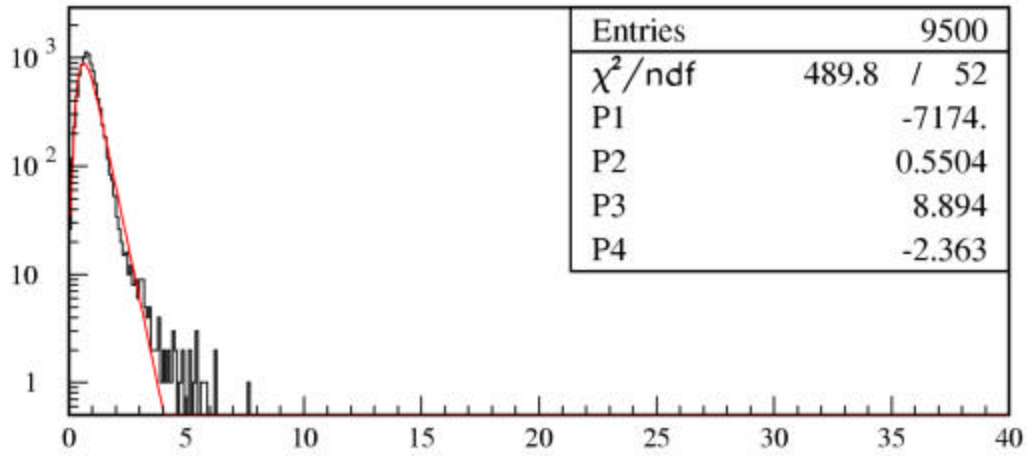
Background





Energy in calorimeter 1/MIP



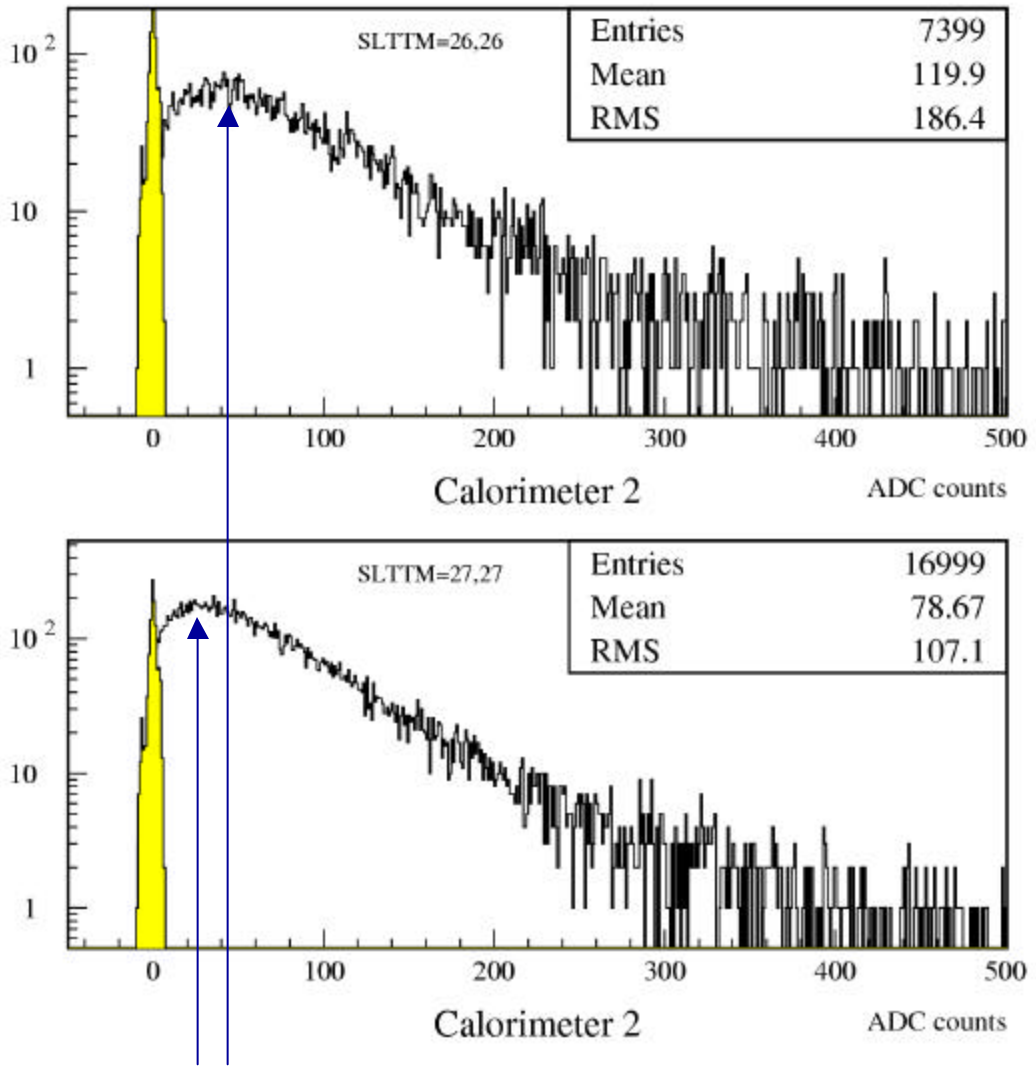


Energy in calorimeter 1/MIP

✍The background level is higher on the straight line

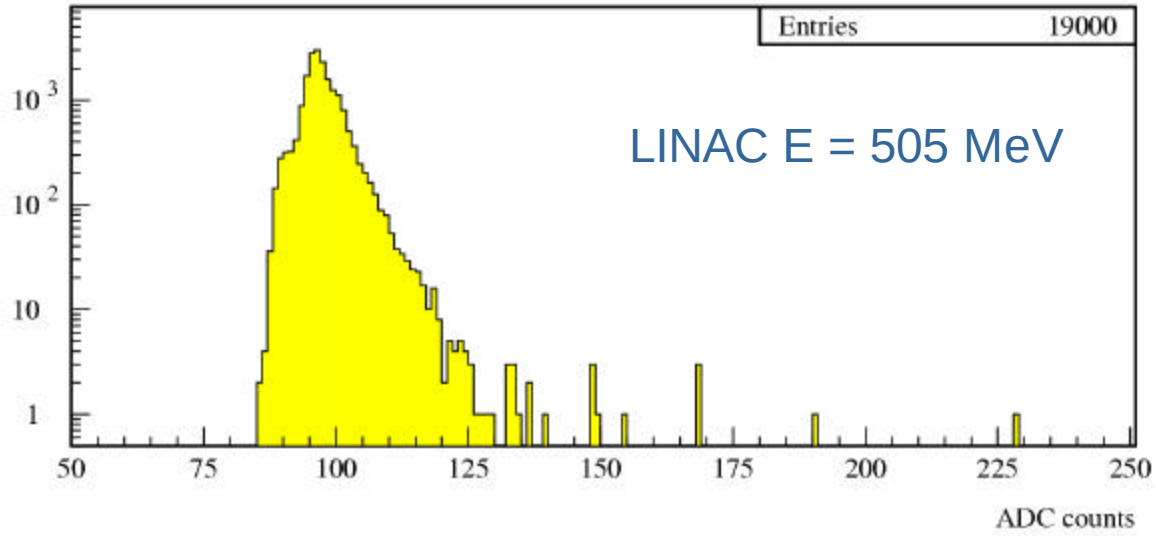
Background

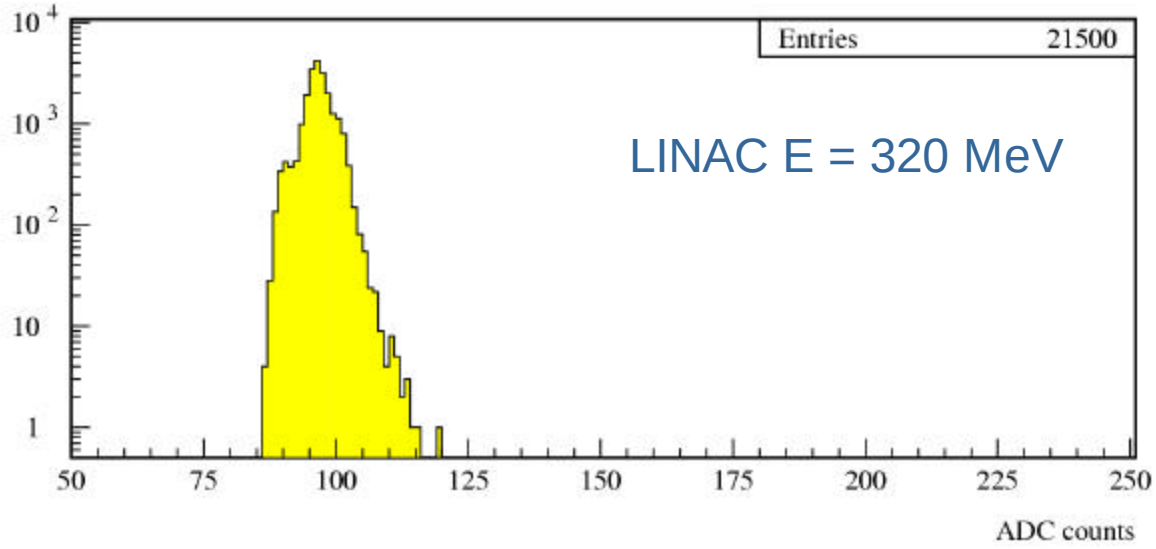
✍The background level decreases by closing the collimators



Background

✍The background level is lower at lower LINAC energies

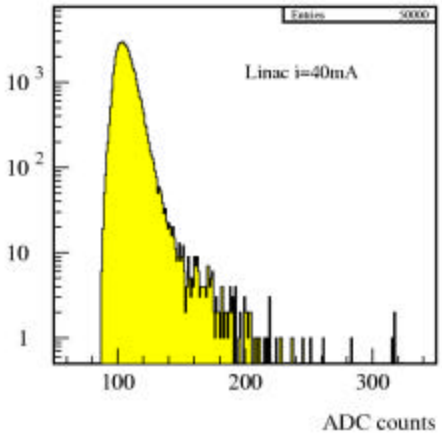


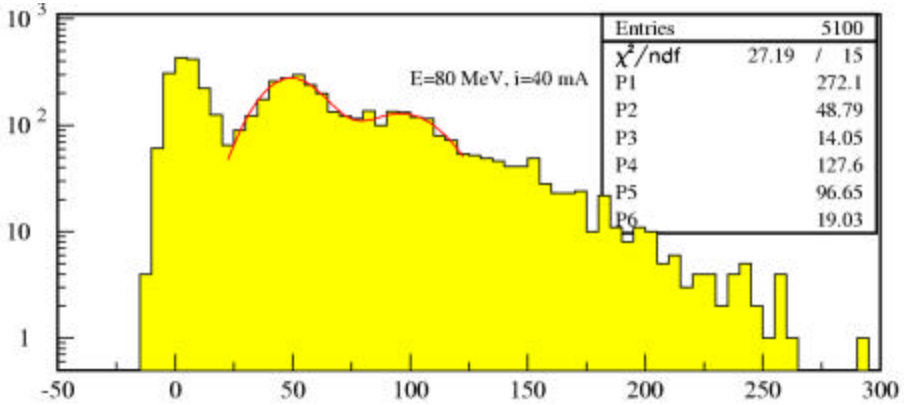


Background

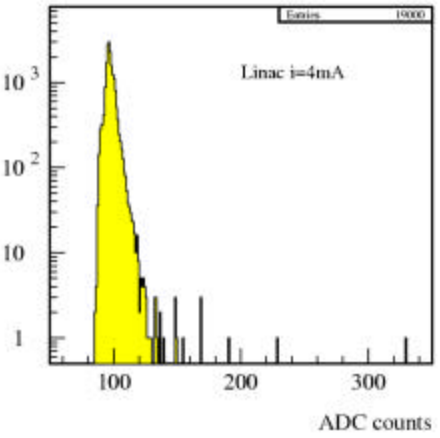
- The background level increases by increasing the LINAC current

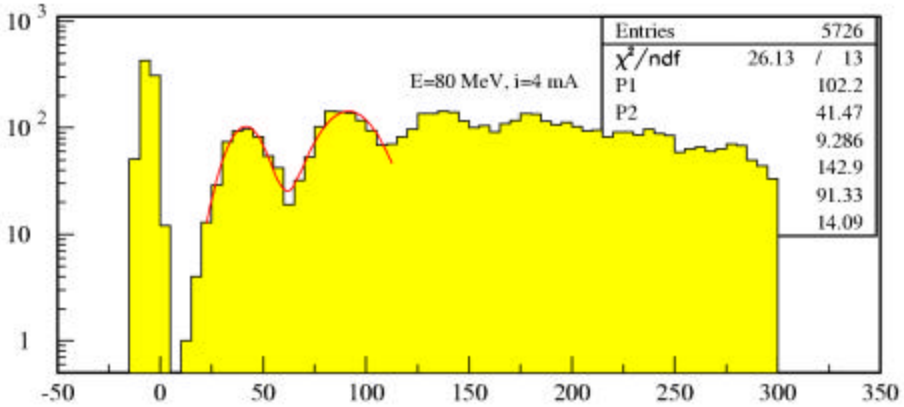
i=40 mA





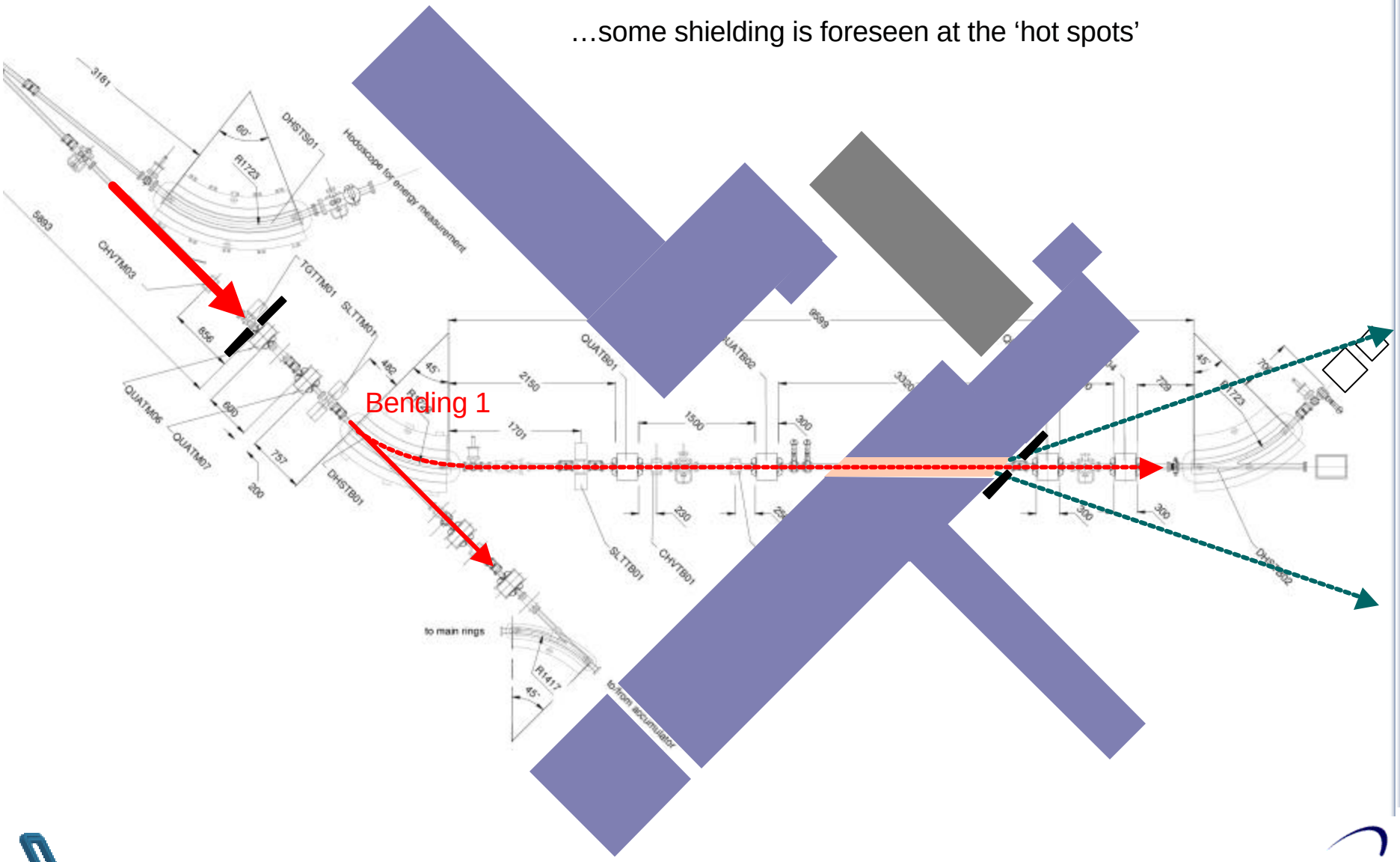
i=4 mA





Background

…some shielding is foreseen at the ‘hot spots’



First users: LCCAL

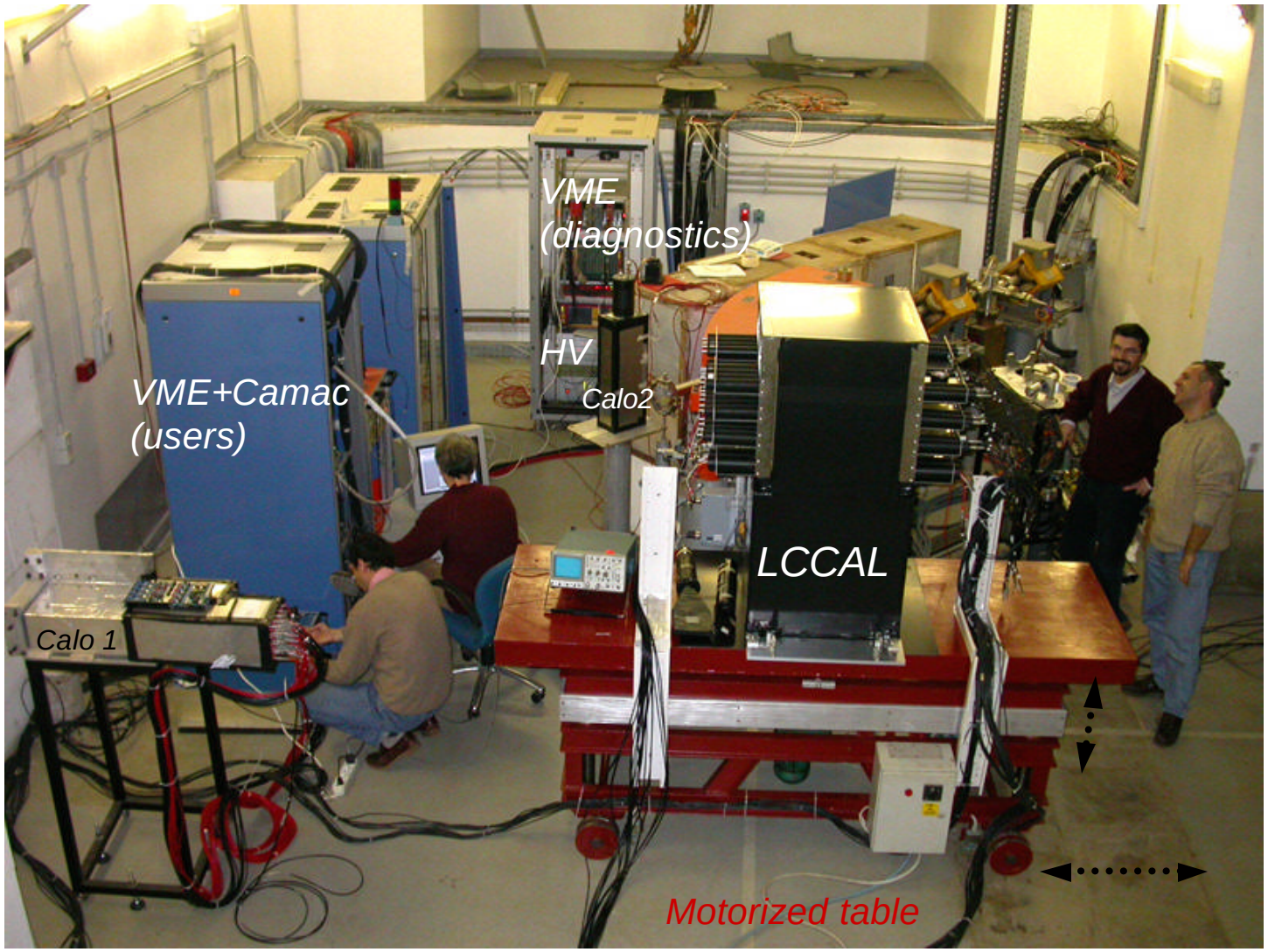
Aim:

- Electromagnetic calorimeter prototype efficiency tests
- Energy in the range 100 – 500 MeV
- Efficiency scans (in transverse plane)

Requests:

- Single electron distribution
- Energy in the range 100 – 500 MeV
- Efficiency scans (in transverse plane)

First users: LCCAL

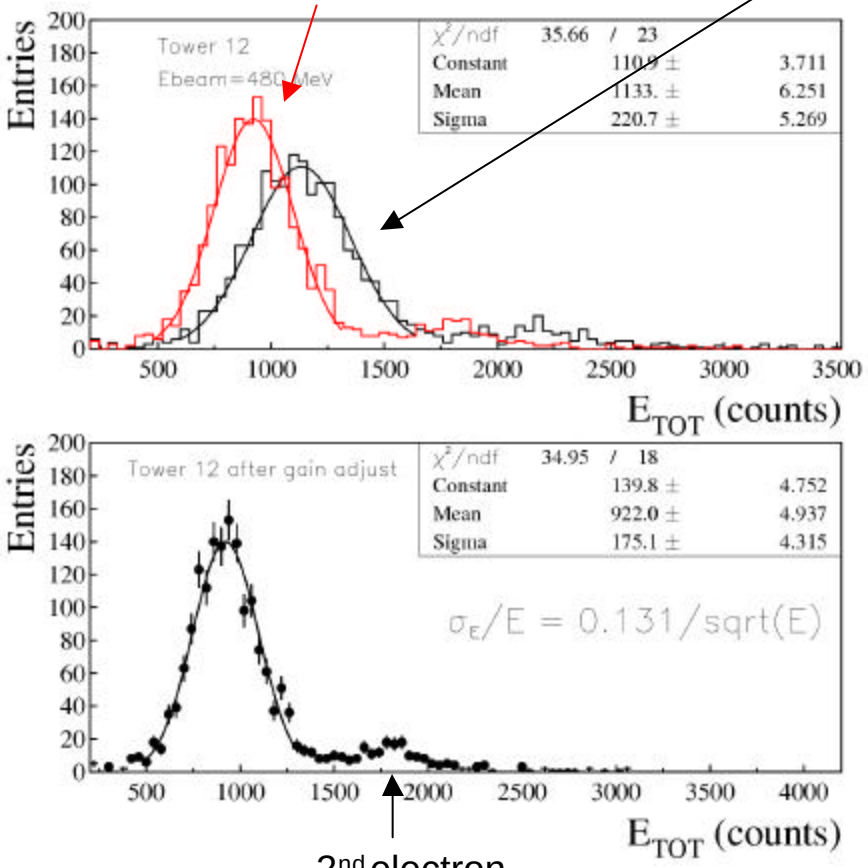


First users: LCCAL

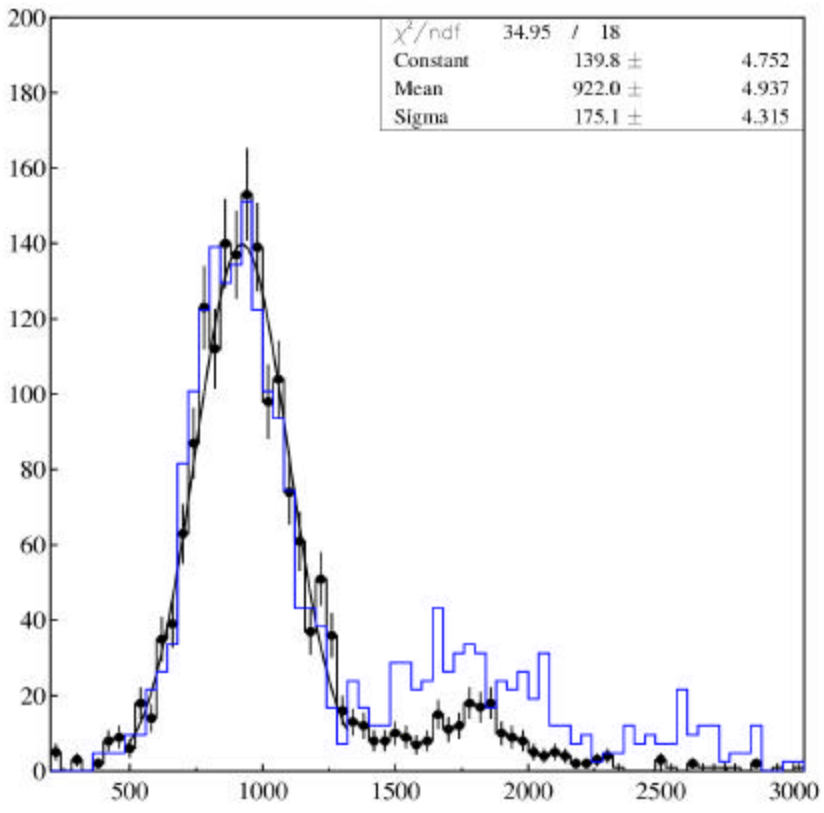
First users: LCCAL

Energy in tower **before** gain equalization

Energy in tower **after** gain equalization



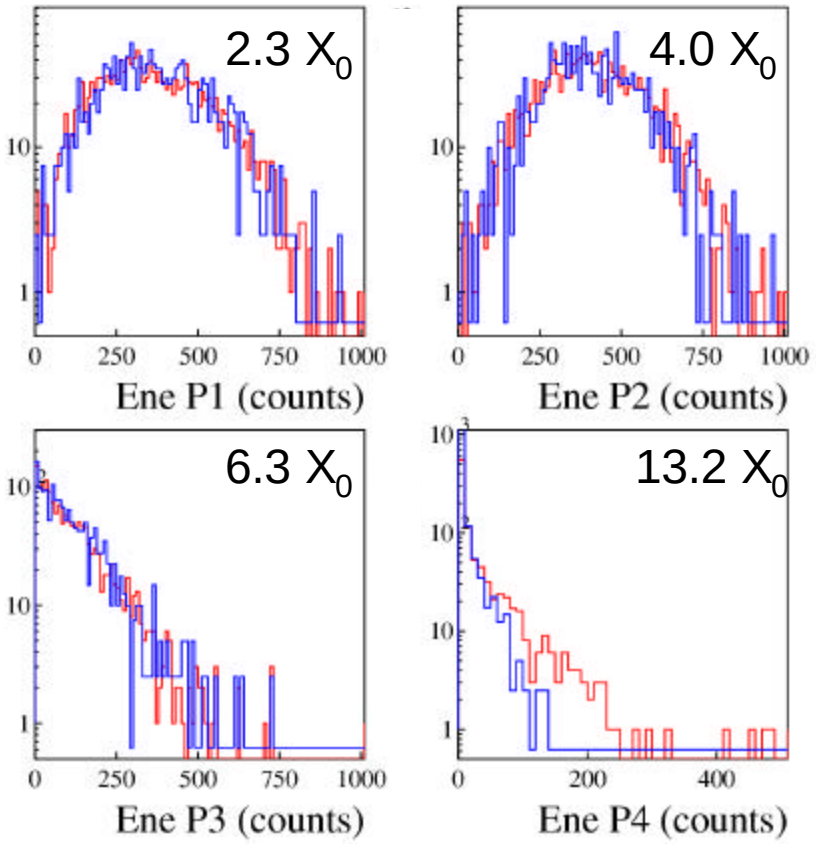
2nd electron



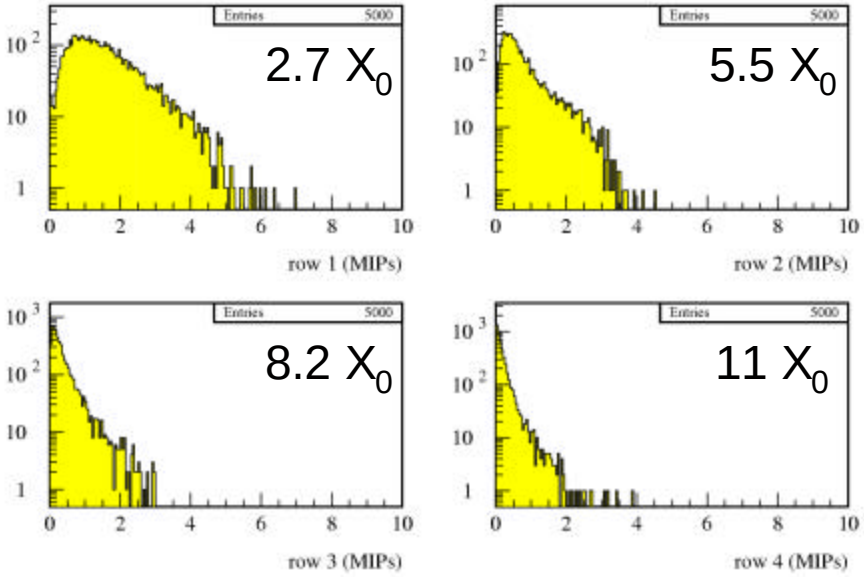
Tower comparison (ADC counts)

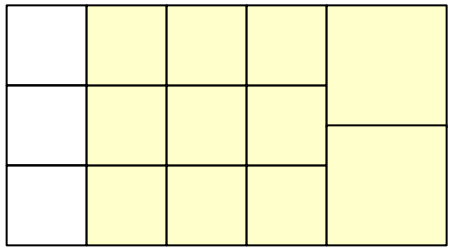
Shower longitudinal profile

Shower longitudinal profile (**LCCAL**)



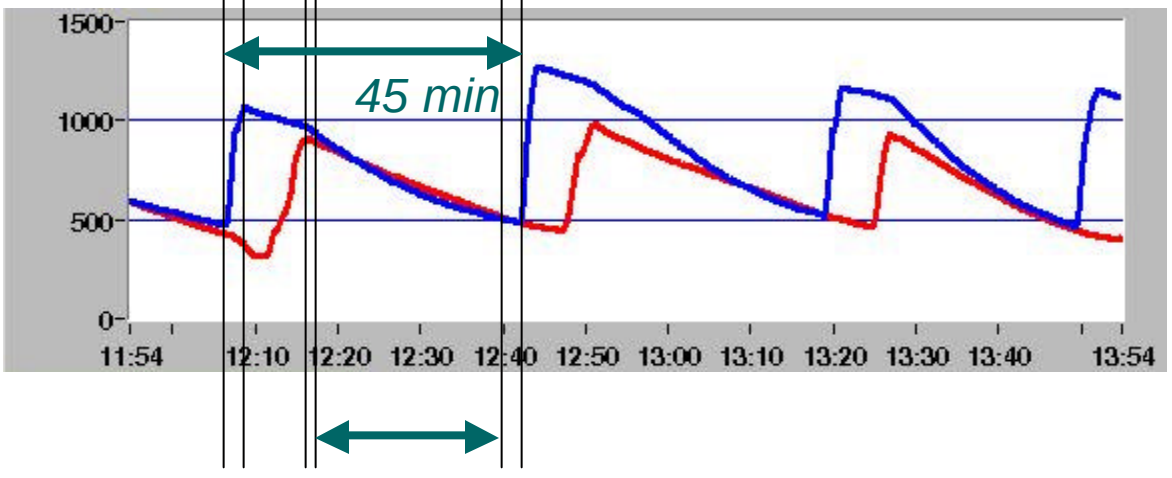
Shower longitudinal profile (**Calorimeter 1**)





4.4 ? 4.4 cm^2

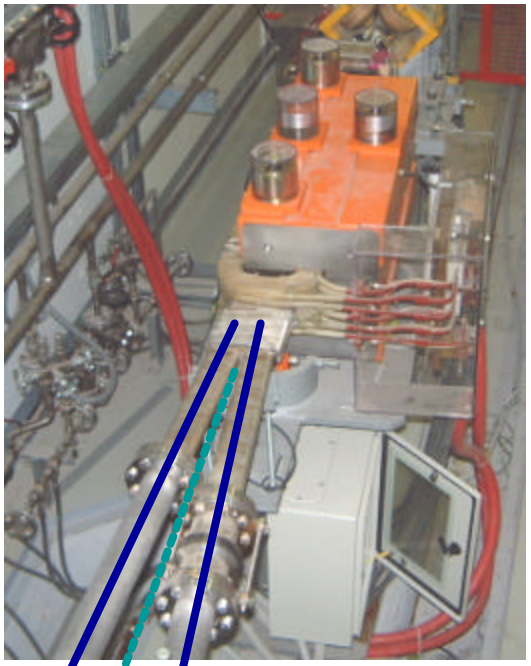
‘Parasitic’ operation



50% duty cycle

5?10^5 single e?/day

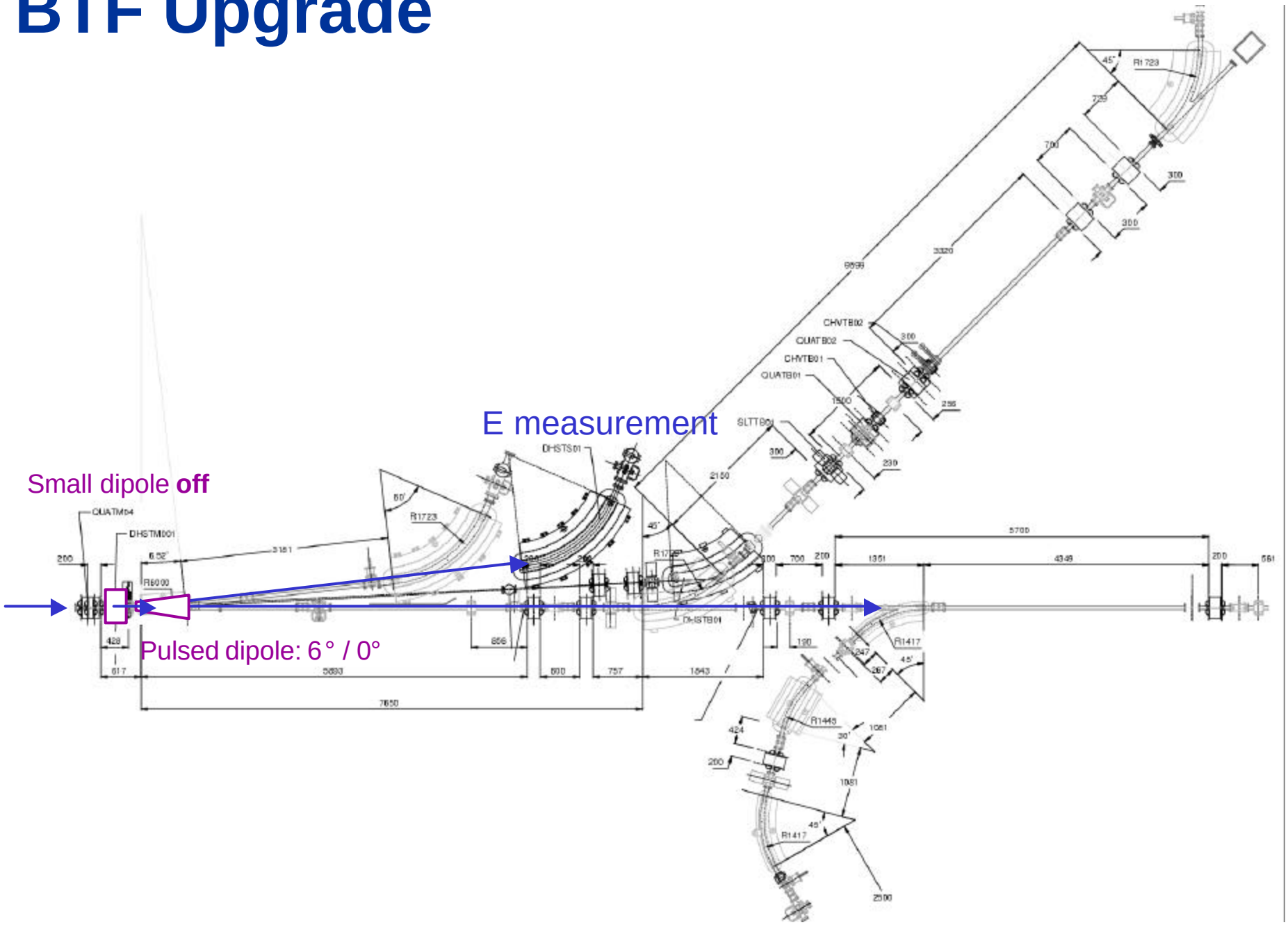
BTF Upgrade



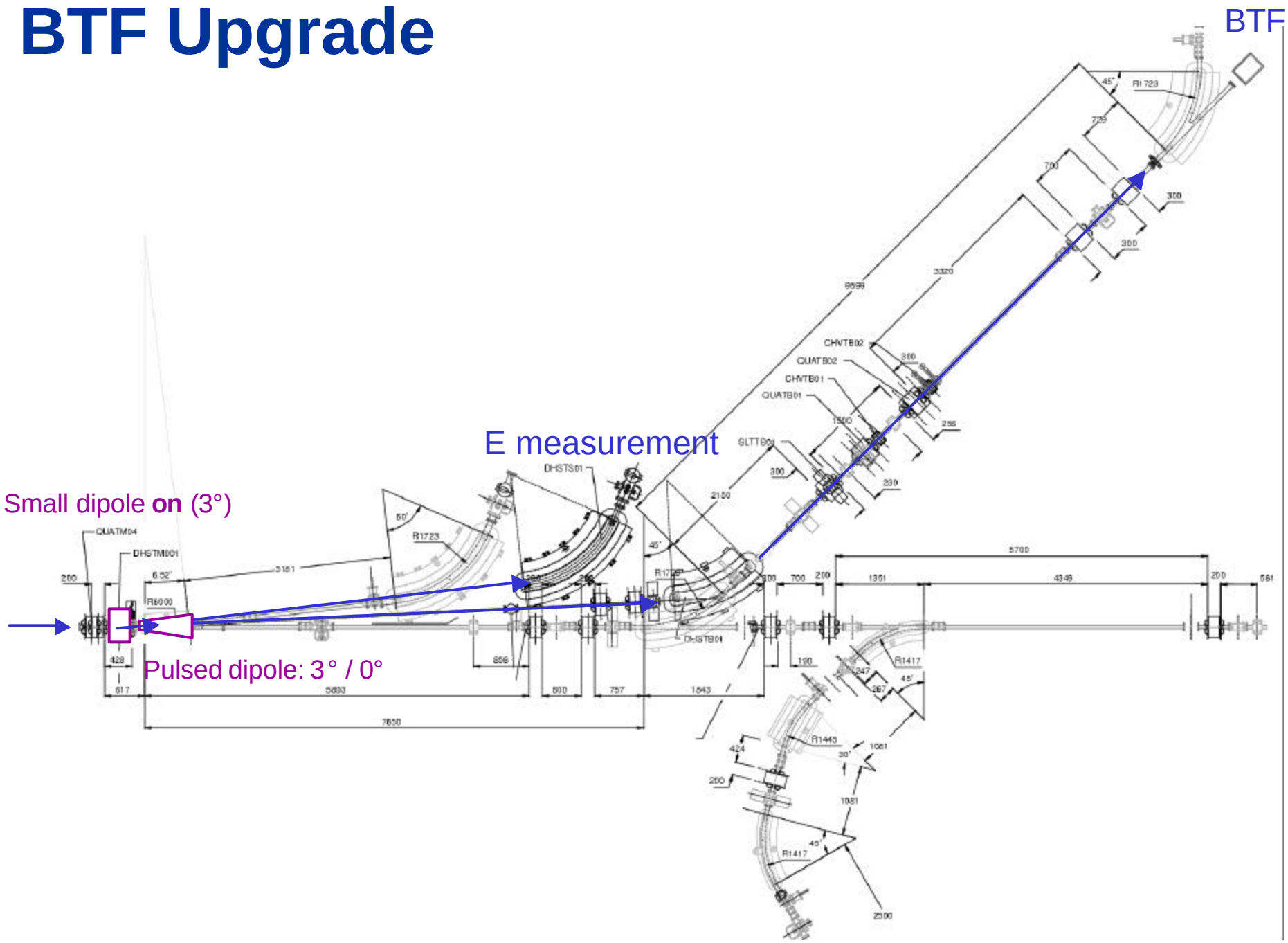
- An independent line is now being designed in order to operate the BTF in a true parasitic mode…

- The allowed dose (10^3 particle/sec) will be increased up to 10^{10} (for neutron, photon production, beam diagnostics device test, detector aging, etc.)

BTF Upgrade


E measurement
Small dipole **off**
Pulsed dipole: 6° / 0°
QUATM04
DHSTM001
DHSTS01
DHSTB01
CHVTB02
QUATB02
CHVTB01
QUATB01
SLTTB01
R1723
R1417
R1445
R6000
5700
7650

BTF Upgrade


BTF
E measurement
Small dipole **on** (3°)
Pulsed dipole: 3° / 0°
QUATM04
DHSTM001
R6000
R1723
DHSTS01
DHSTB01
CHVTB02
QUATB02
CHVTB01
QUATB01
SLTTB01
R1417
R1443
2500
7650

2003 program

17 March 2003 – 12 May 2003 **dedicated** operation (24h/day)
19 May 2003 – End Finuda run **parasitic** operation

- AGILE (Calorimeter and silicon tracker efficiency tests)
- AIRFLY (Air fluorescence yield)
- CAPIRE (RPC efficiency tests)
- LCCAL (Hadronic calorimeter efficiency test)
- LHCb (wire chambers and GEM efficiency tests)
- Nanotubes (positrons, TARI n. 23)
- RAP (acoustic detection of particles in a superconducting resonant detector)

2004

- BTF upgrade
- …

Access to the facility

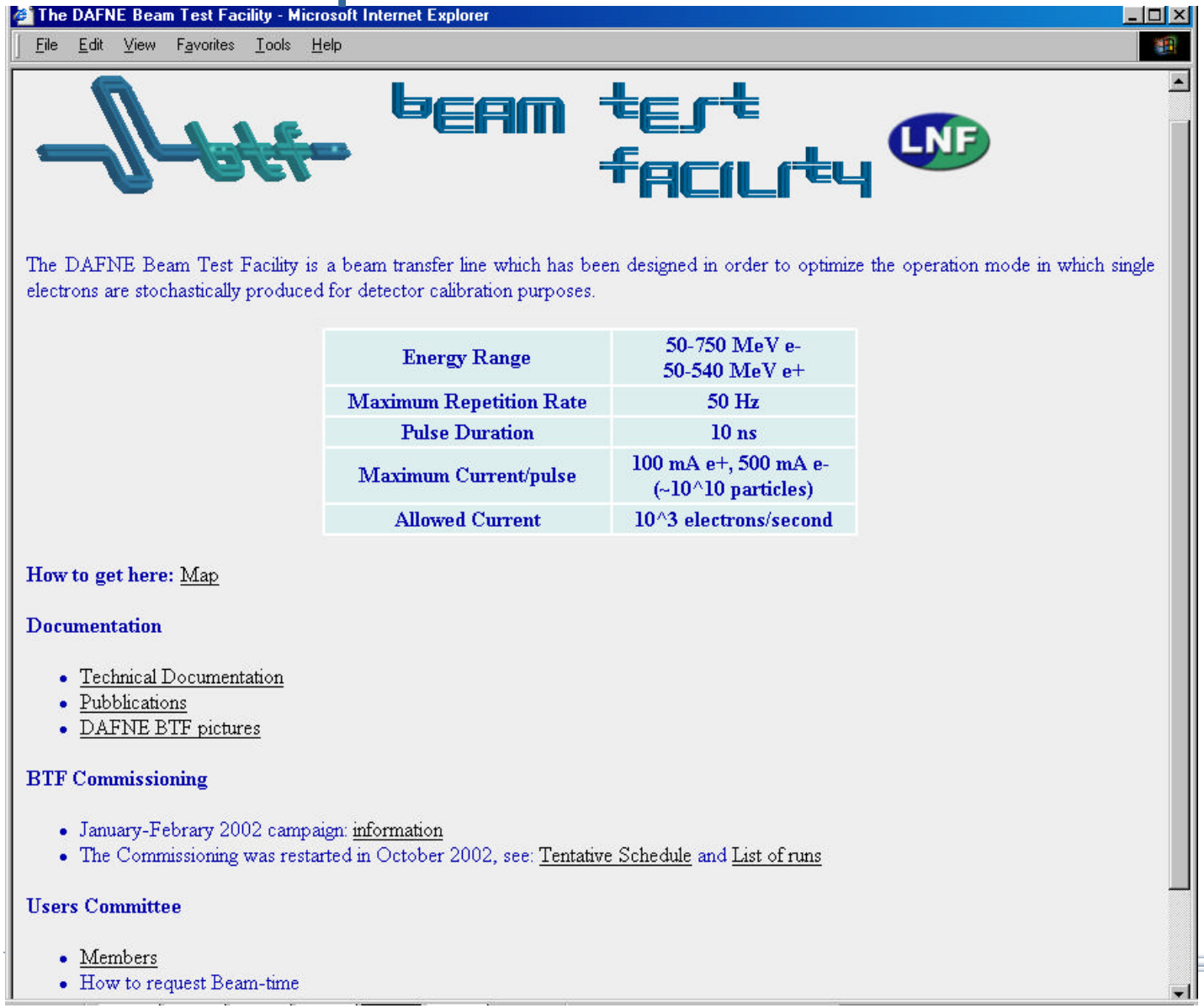
- The LNF Director formed a ‘Users Commission’:
  - P. Gianotti
  - G. Mazzitelli (responsible)
  - S. Miscetti
  - M. Preger (chairperson)
  - P. Valente

- All requests should be addressed to the commission and/or the facility responsible
- A Web form will be available soon

- The BTF is one of the LNF TARI facilities (European Union program)

More details…

http://www.lnf.infn.it/acceleratori/btf/



More work to do…

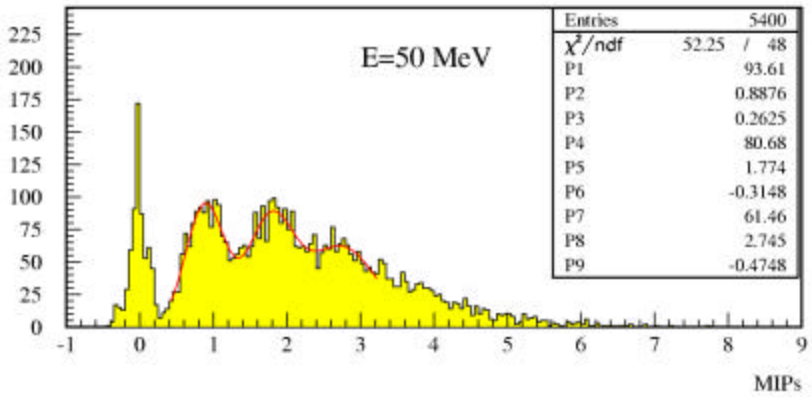
- Improve diagnostics at high multiplicity:
  - More detectors are needed in order to cover a wider range
  - cross-calibrations and absolute calibrations are needed
- Position sensitive detectors are needed for beam profiling:
  - now developing a scintillating fiber hodoscope
  - a MWPC system is coming (from the HARP experiment)
- Improve shielding (at the target and at the hall entrance)
- Alignment of the line and reference system (small laser)
- Simple user interface for energy and multiplicity selection

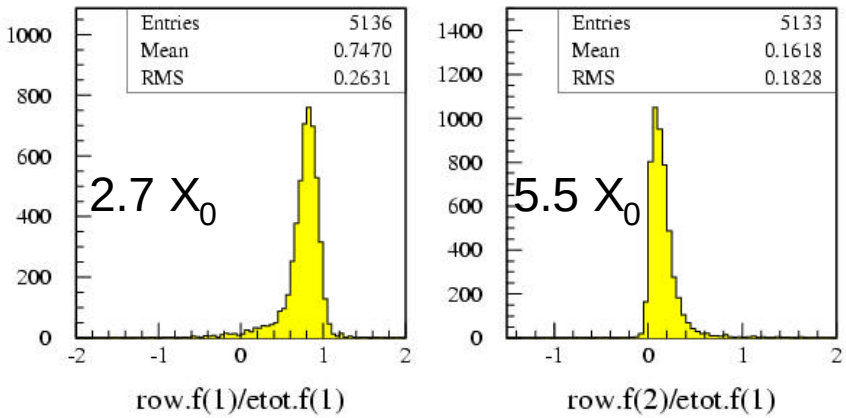
Summary

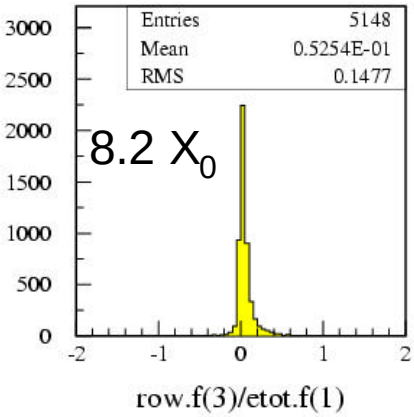
- The DA? NE Beam Test Facility has been successfully commissioned
- The operation in “parasitic mode” is possible and first users already started to use the facility
- The BTF can provide particles in a wide range of energy and multiplicity (with good repeatability)
- First users experience was very positive
- Many experiments are already scheduled until summer 2003
- With the future upgrade (planned Jan. 2004) the facility will be even more useful…
- …but more work is needed!

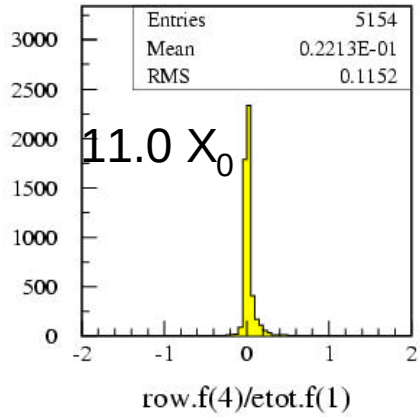
We would like to thank sincerely all the technicians of the* Divisione Acceleratori *for their fundamental work, the members of the BTF commission, and the collaboration of many LNF colleagues…

Energy range



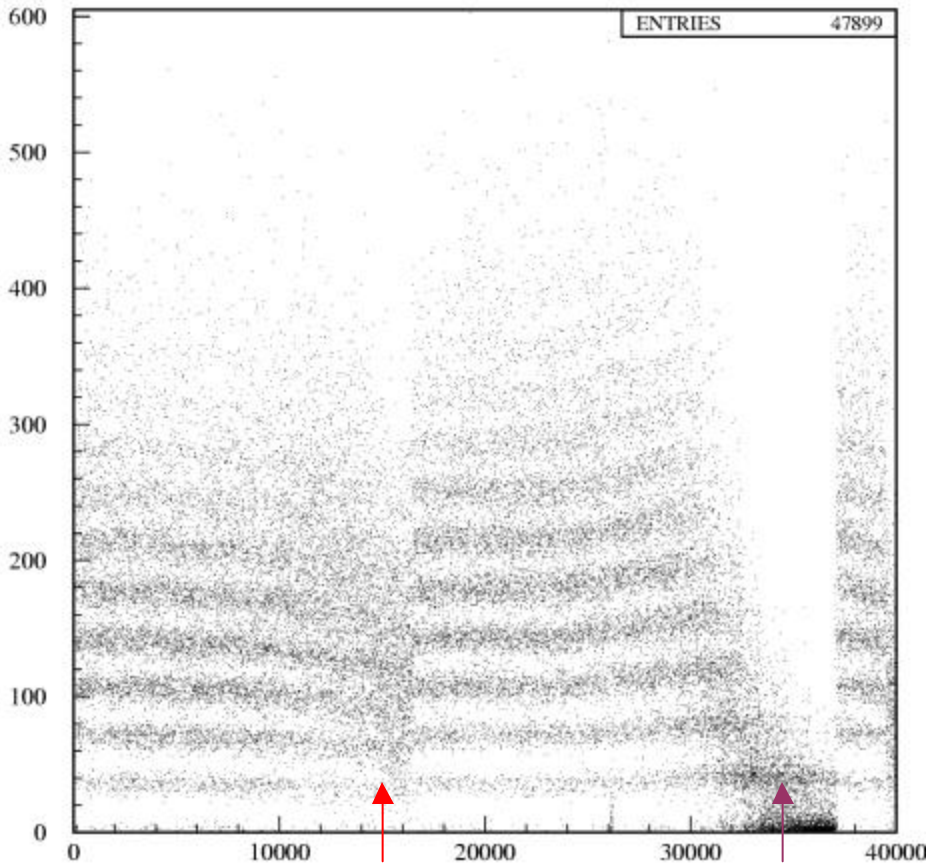


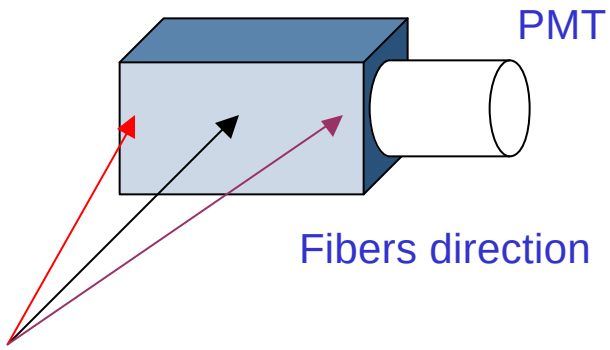




Beam line acceptance

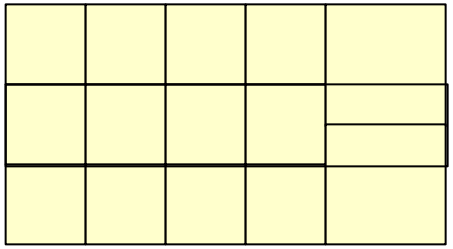
• Horizontal scan with the calorimeter turned side-on: the signal changes due to the different distance between the impact point on the fibers and the PMT

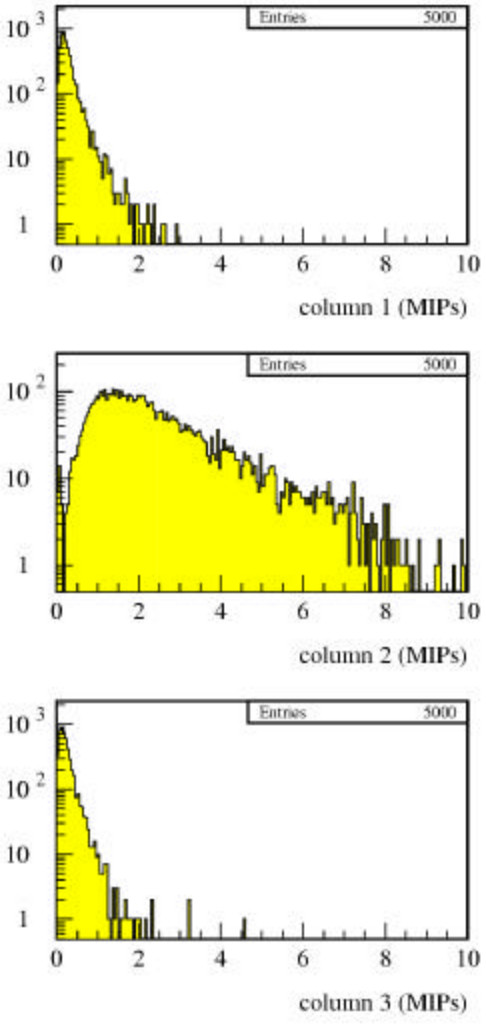


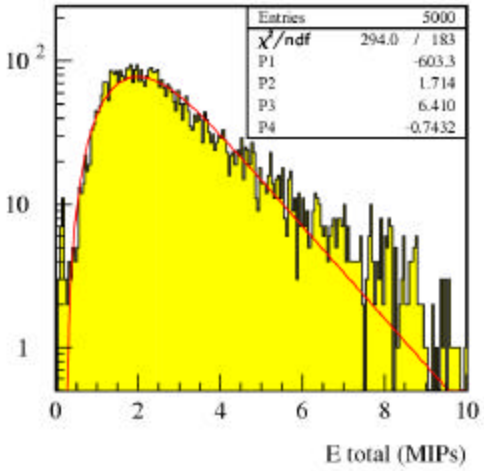


Shower transverse profile

4.4 ? 4.4 cm^2

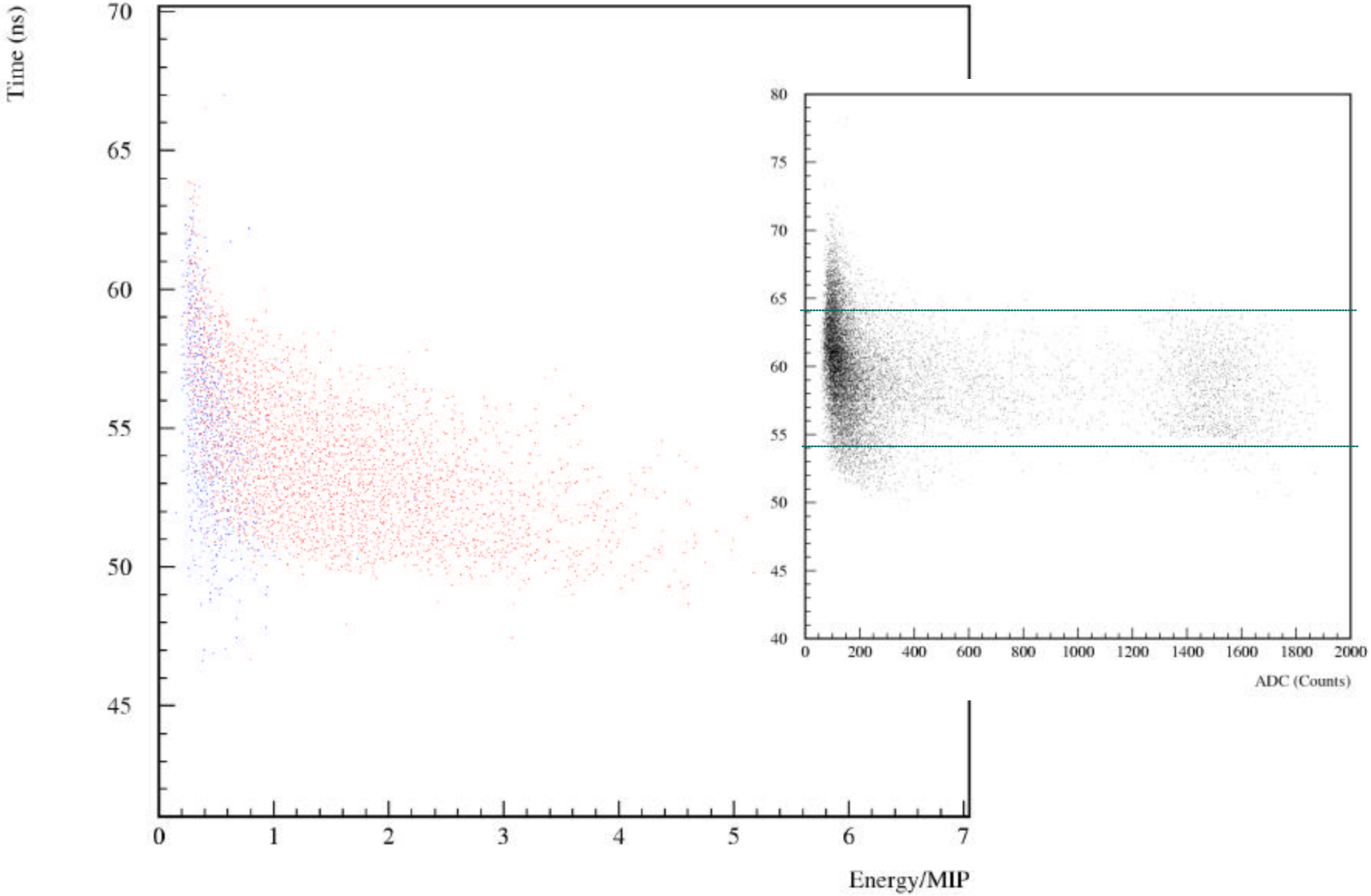






Background

Background time distribution



Background

Background time distribution