COOLING WORKSHOP @ CERN 25-27.10.01

DESIGN of a 280-300 MeV μ BEAM at PSI for the μ-COOLING Experiment

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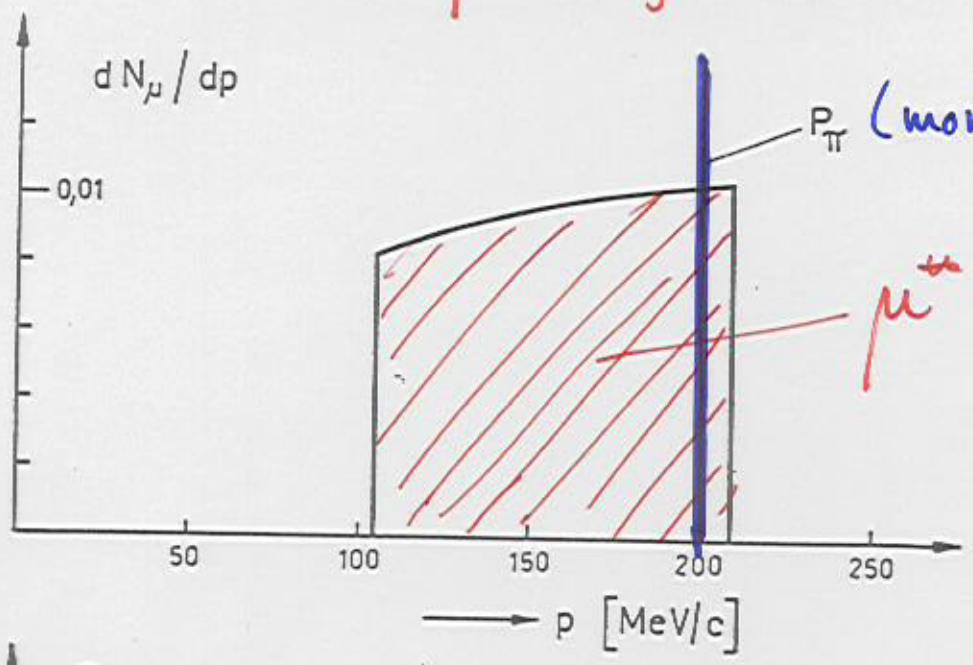
- Introduction:
  - μ beam requirements
  - $\pi \rightarrow \mu$ decay kinematics
- proposed layout at PSI
  - exp. hall
  - μE1 beam line ⊕
- Results of beam calculations
  - transport: envelopes
  - turtle: phase space distr.
  - properties, intensities
- Conclusions

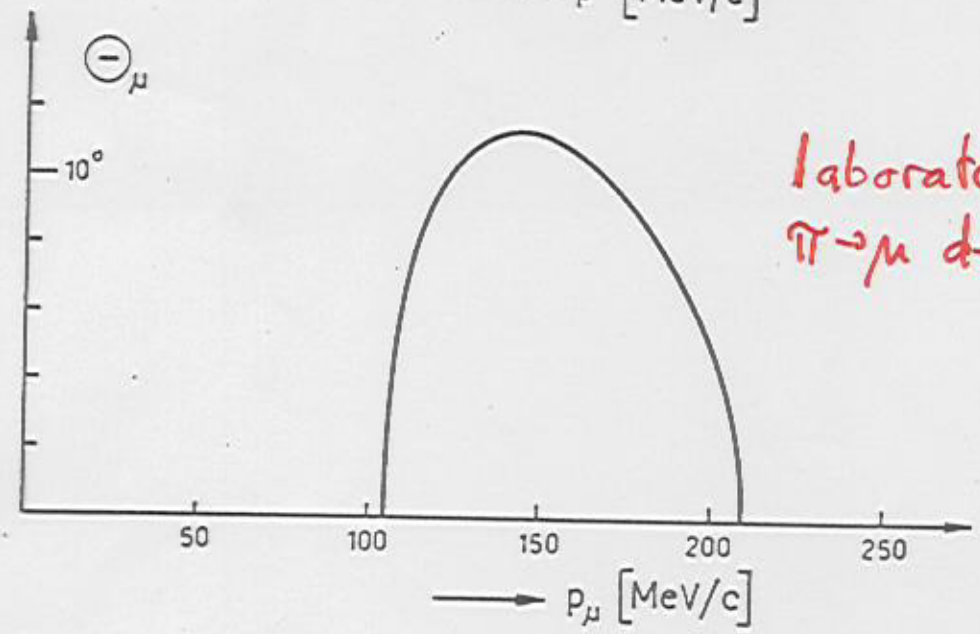
μ beam requirements for cooling exp.

topic	values	PSI solution
• μ energy	100 – 300 MeV	✓
momentum	200 – 400 MeV/c	✓
• μ energy spread	±10% – ±20%	± 3.5% (Degr.!)
• beam size	10cm FWHM (x,y)	11 × 22 cm²
• divergencies	±100 mrad (x',y')	±60/±30 mrad (Degr.!)
• μ flux	10^6–10^7 s^{-1} instant. (pulsed or DC)	$5\cdot10^6$ – 10^8 (max.)
• time bunches	100μs at 10-50 Hz → η = 1–5 · 10^{-3}	DC (0.6ns every 20ns)
• purity	< 0.1 π/μ in beam	< 10^{-2}
	< 1% after electronics rejection	
• Pb degrader	~5X0 → ± 100 mrad → ΔE~36MeV (300 MeV)	

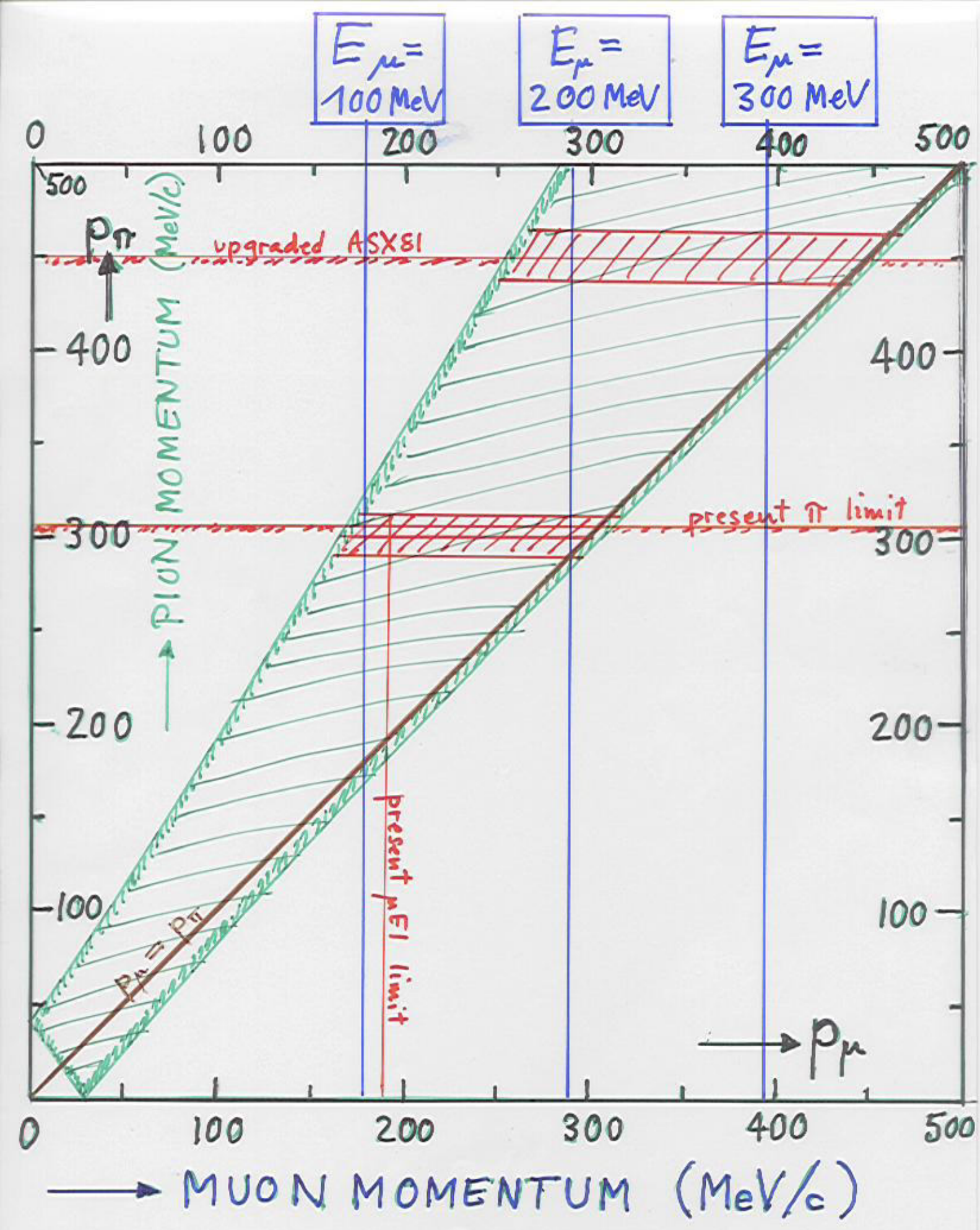
• area size	≳ 3m × 12m	4m × 14m
• el. power (cavities)	1.4 MW	✓
• cryo installations (+ cooling water)	needed	✓

$\pi \to \mu$ decay kinematics

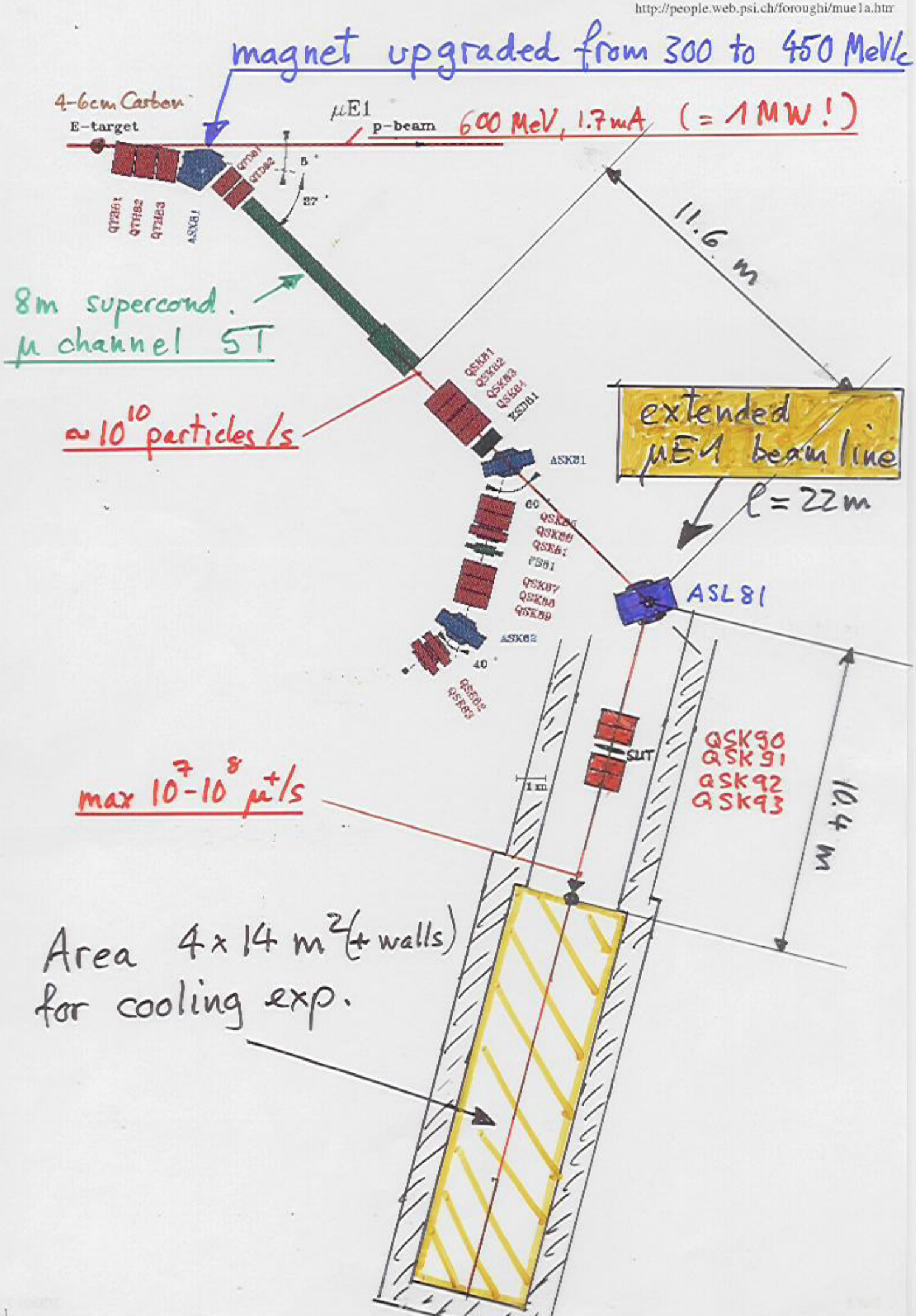


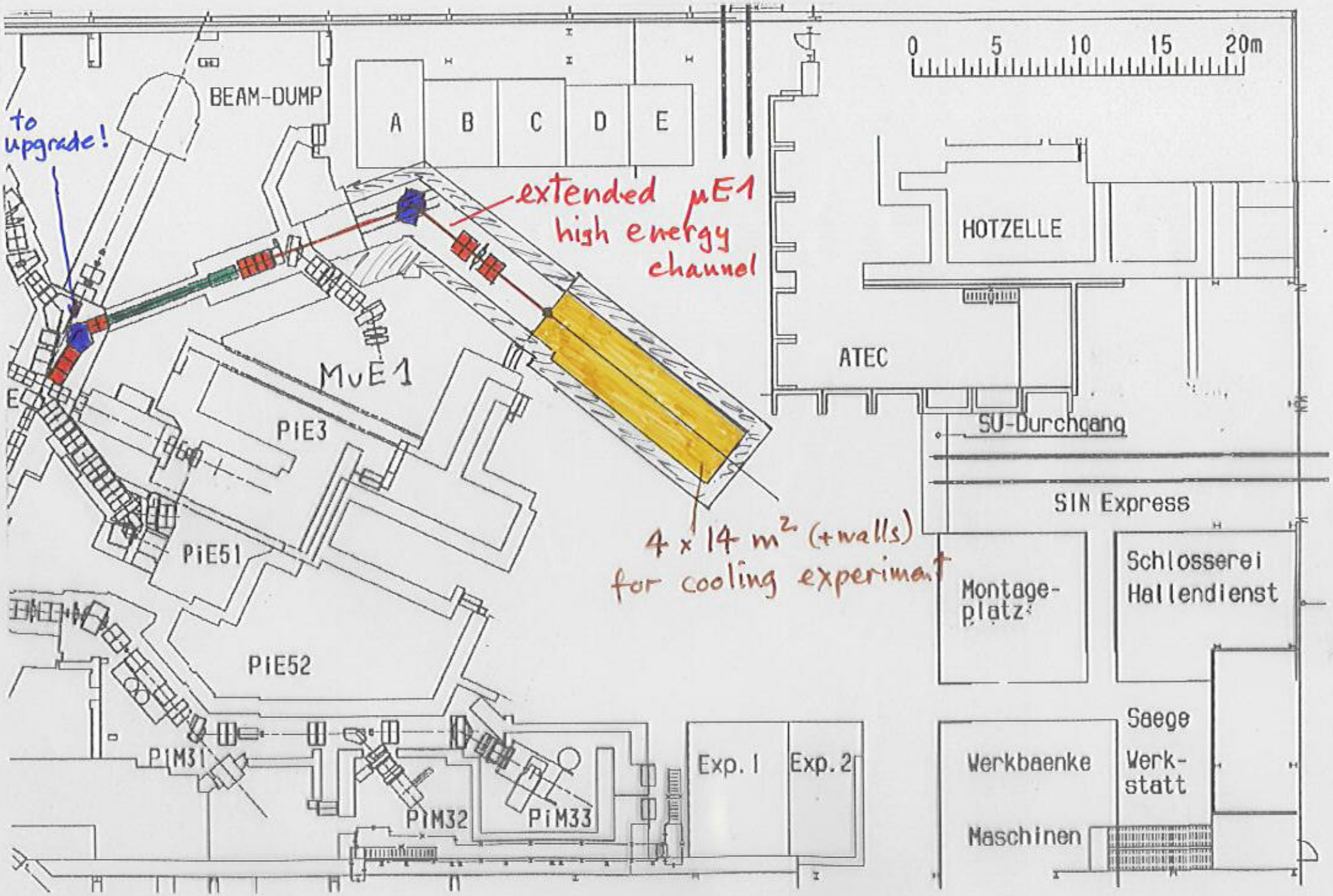


laboratory
$\pi \to \mu$ decay angle



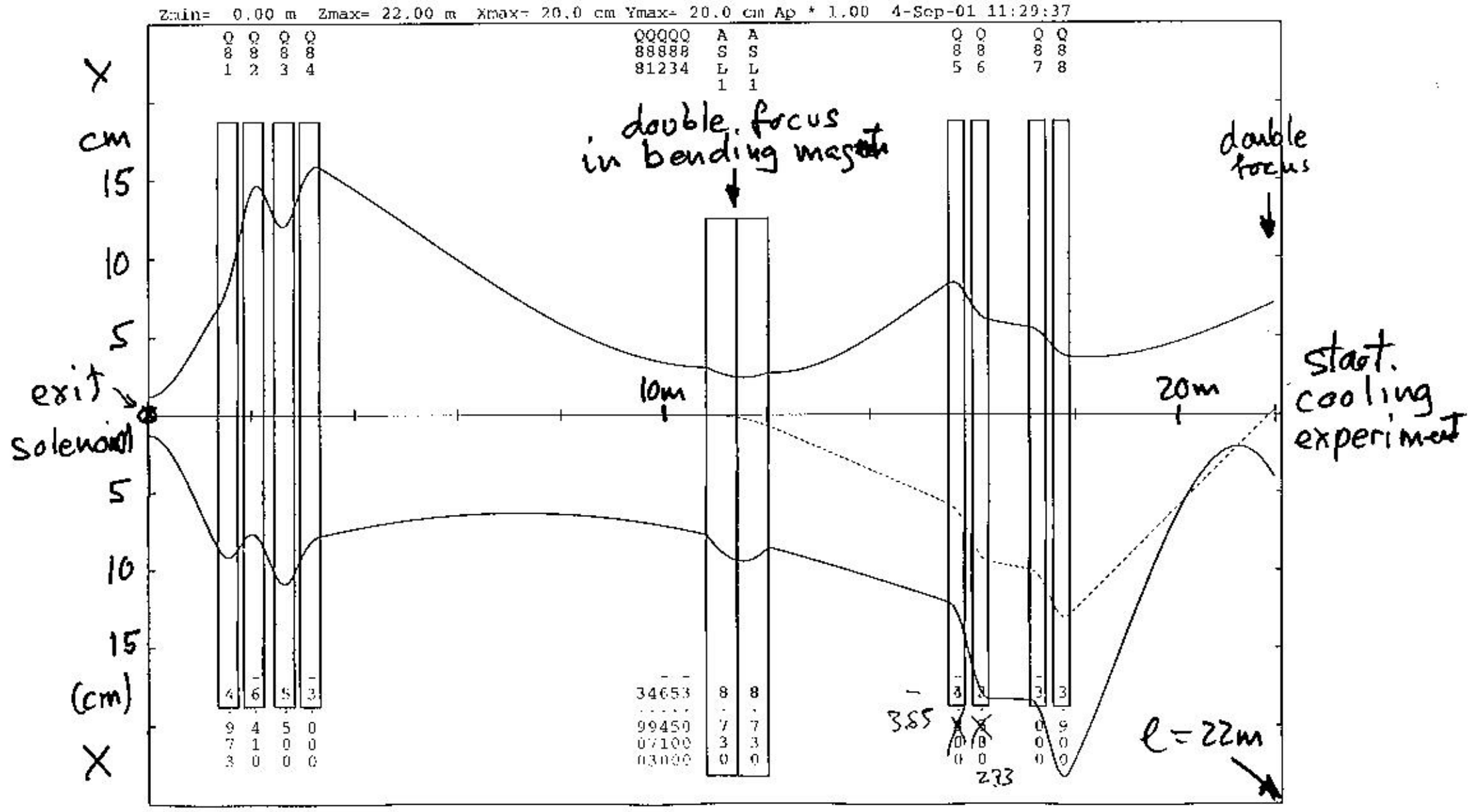
$\pi \rightarrow \mu$ DECAY KINEMATICS


magnet upgraded from 300 to 450 MeV/c
4-6cm Carbon
E-target
μE1
p-beam
600 MeV, 1.7mA (= 1 MW!)
11.6 m
8m supercond.
μ channel 5T
≈ 10^10 particles/s
extended
μE1 beam line
ℓ = 22m
ASL81
max 10^7-10^8 μ+/s
QSK90
QSK91
QSK92
QSK93
10.4 m
Area 4 x 14 m^2 (+ walls)
for cooling exp.


BEAM-DUMP
to upgrade!
A
B
C
D
E
extended μE1 high energy channel
MuE1
PiE3
PiE51
PiE52
PiM31
PiM32
PiM33
Exp. 1
Exp. 2
4 x 14 m² (+walls) for cooling experimat
0 5 10 15 20m
HOTZELLE
ATEC
SU-Durchgang
SIN Express
Montage-platz
Schlosserei Hallendienst
Saege
Werkbaenke
Werk-statt
Maschinen

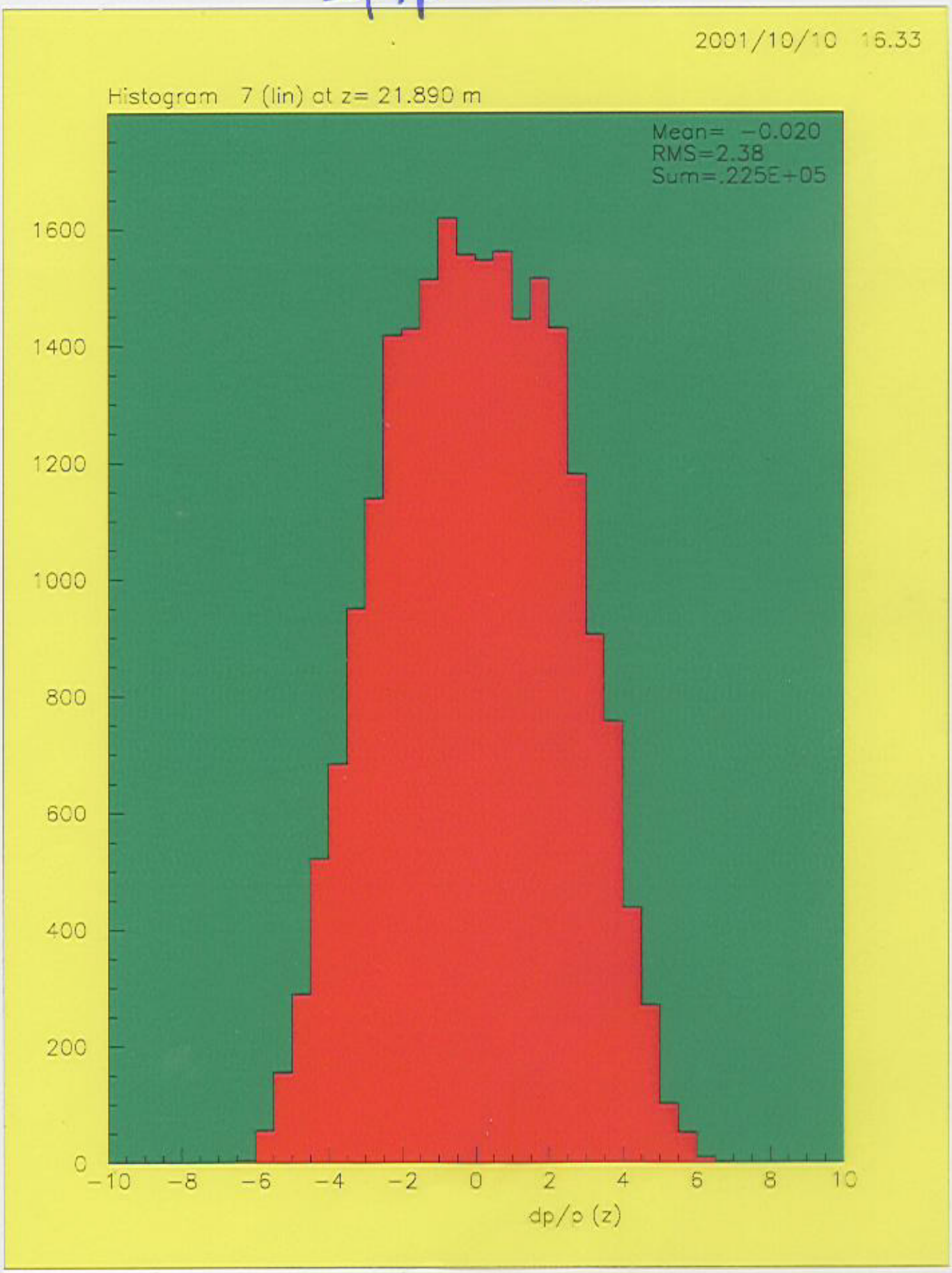
TRANSPORT result of beam envelopes

mucool_2.dat



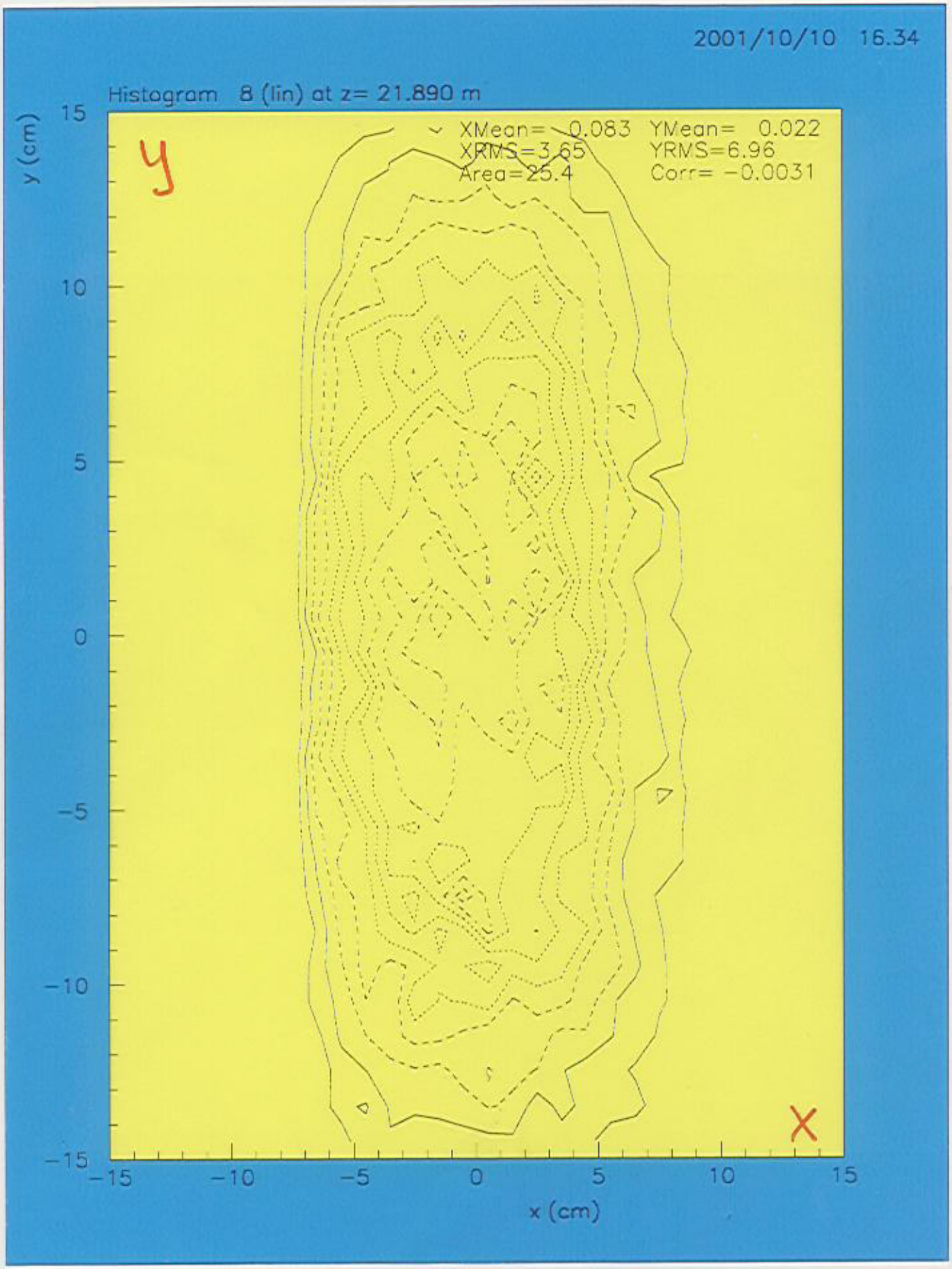
TURTLE (MC) Results

$\Delta p/p = 7\%$ FWHM



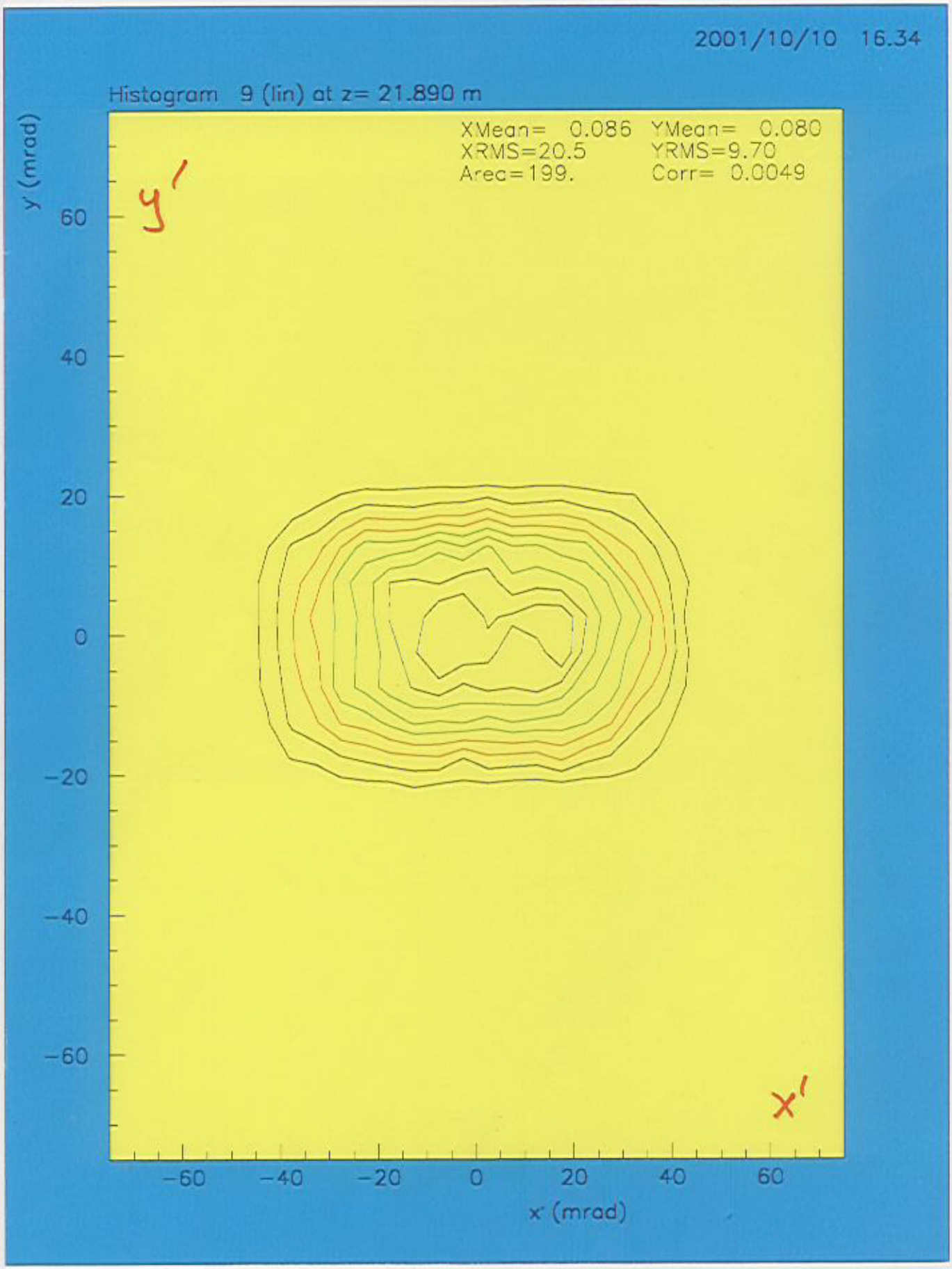
μ beam spot at cooling experiment

$\Delta x = 11\,cm$ FWHM $\Delta y = 22\,cm$ FWHM



μ divergencies at cooling experiment

$\Delta x' = \pm 60$ mr $\Delta y' = \pm 30$ mr



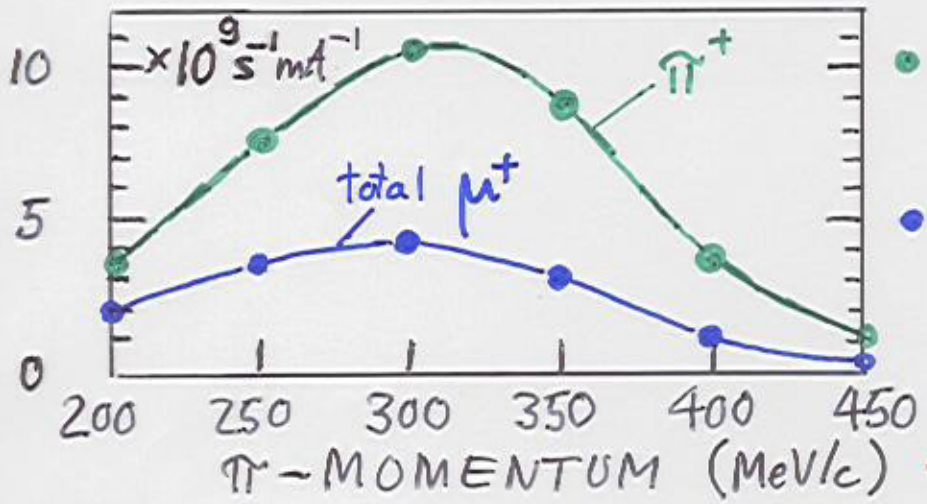
High energy muon beam at PSI

Table of properties

(a) π injection into μE1 solenoid

$\Delta\Omega$ p-target	~ 30 msr	
$\Delta p_\pi / p_\pi$	~ 8-10 %	FWHM
p_π	~ 100 - 450 ⊛	MeV/c
E_π	~ 30 - 330 ⊛	MeV

⊛ needs upgraded ASX81 magnet !



- π^+ flux injected into μ channel
- total μ^+ flux at channel end from π^+ decay's

↓

~ 2% of μ^+ go into cooling area!

(b) μ extraction from solenoid to cooling area

FWHM acceptances:

$\Delta x \cdot \Delta x'$ ~	3.8 cm × 175 mr	(53%)
$\Delta y \cdot \Delta y'$ ~	4.8 cm × 92 mr	(36%)
$\Delta p_\mu / p_\mu$ ~	7 %	

→ 4-dim phase space transmission 19 %

(c) expected μ^+ fluxes at cooling experiment

			purity
p_π ~ 350 MeV/c	E_μ ~ 200 MeV	$7 \cdot 10^7 \mu^+ s^{-1}$	< 1%
p_π ~ 450 MeV/c	E_μ ~ 300 MeV	$5 \cdot 10^6 \mu^+ s^{-1}$	< 1%
today ...	... 100 MeV	$10^8 \mu^+ s^{-1}$	$\leq 10^{-3}$

CONCLUSIONS

- PSI can offer μE1 beam line as a perfect high energy μ channel
- coverage of the full range of desired energies requires redesign of π injection magnet (250 kFr.)
- all other requirements can be easily met
- 1.6 MW power will be installed for our medical project PROSCAN. Could be shared by limiting μ-cooling runs to weekends (200 kFr)
- our beam purity is outstanding! (principle of backward μ decay)

Finances for H.E. μ beam:	kFr
– upgrade ASX81	250
– 1.6 MVA power (trafo)	200
– " cooling (water)	50
Investment	500 kFr