Precise Measurement of the $\pi^+ \longrightarrow e^+\nu$ Branching Ratio

Progress Report and 2008 Beam Request

Dinko Počanić (for the PEN Collaboration)

PSI BV39
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Outline

Experiment R-05-01 (PEN) collaboration members:

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[b] *Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland*
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PEN follows the PIBETA experiment

PIBETA program (precision checks of SM and QCD predictions):

- $\pi^+ \longrightarrow \pi^0 e^+ \nu_e$—main goal
  - SM checks related to CKM unitarity
- $\pi^+ \longrightarrow e^+ \nu_e \gamma$(or e^+e^-)
  - F_A/F_V, π polarizability (χPT prediction)
  - tensor coupling besides $V - A$ (?)
- $\mu^+ \longrightarrow e^+ \nu_e \bar{\nu}_\mu \gamma$(or e^+e^-)
  - departures from $V - A$ in $\mathcal{L}_{\mathrm{weak}}$

$\Rightarrow$ The **PEN** experiment:

- $\pi^+ \longrightarrow e^+ \nu_e$
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  - pseudoscalar coupling besides $V - A$
  - ν-sector anomalies, Majoron searches, m_{h^+}, PS l-q's, V l-q's, ...

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$\pi \longrightarrow e\nu$ decay: SM predictions; measurements

Modern theoretical calculations: $$B_{calc} = \frac{\Gamma(\pi \longrightarrow e\bar{\nu}(\gamma))}{\Gamma(\pi \longrightarrow \mu\bar{\nu}(\gamma))_{calc}} =$$

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Experiment, world average [current PDG]:

$$\frac{\Gamma(\pi \longrightarrow e\bar{\nu}(\gamma))}{\Gamma(\pi \longrightarrow \mu\bar{\nu}(\gamma))_{exp}} = (1.230 \pm 0.004) \times 10^{-4}$$

PEN goal: $$\frac{\delta B}{B} \simeq 5 \times 10^{-4}\,.$$

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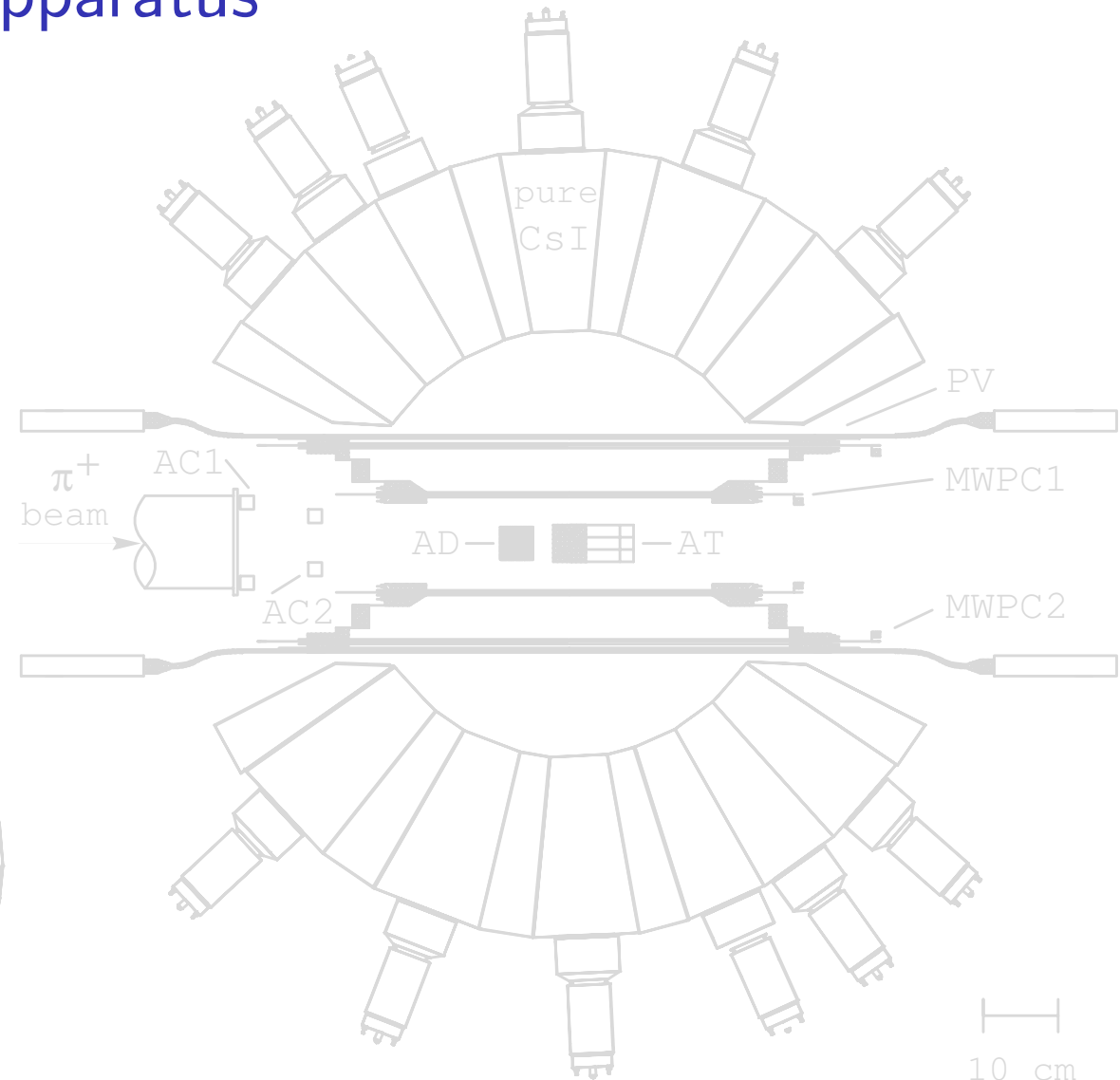
The PIBETA/PEN Apparatus

- stopped π^+ beam
- active target counter
- 240-det. CsI(p) calo.
- central tracking
- digitized PMT signals
- stable temp./humidity



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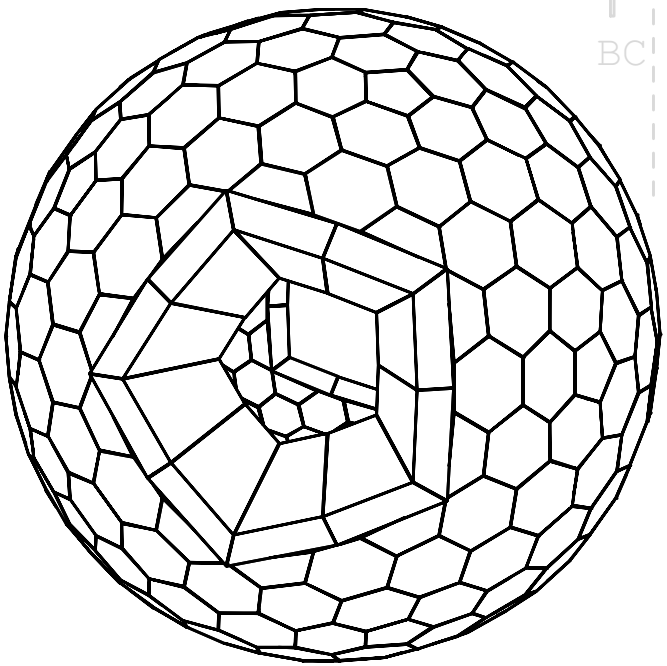

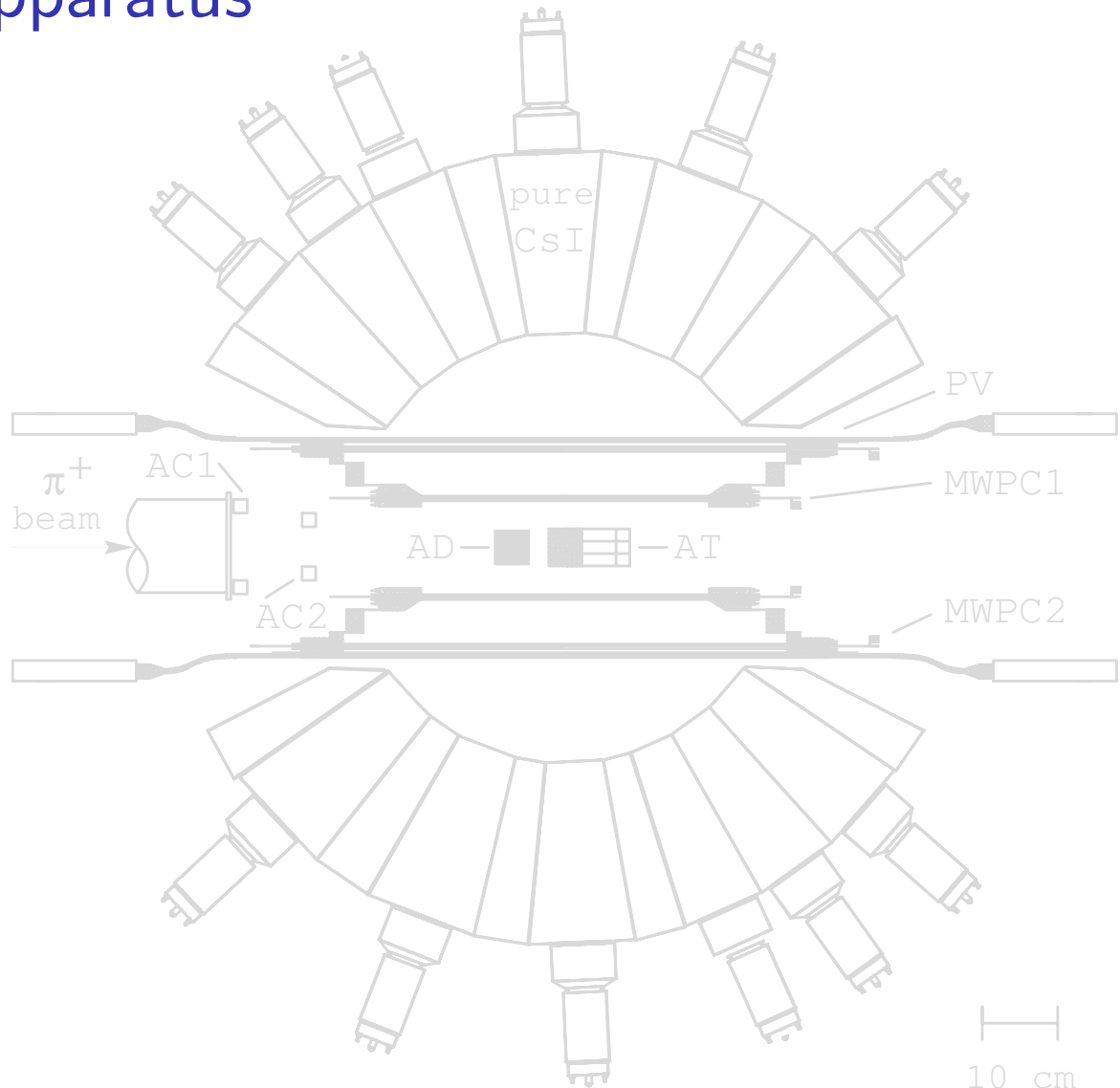

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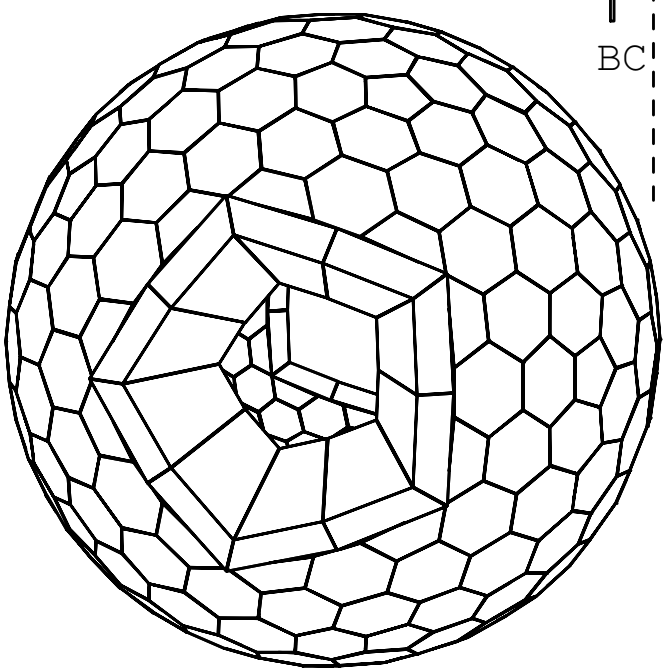
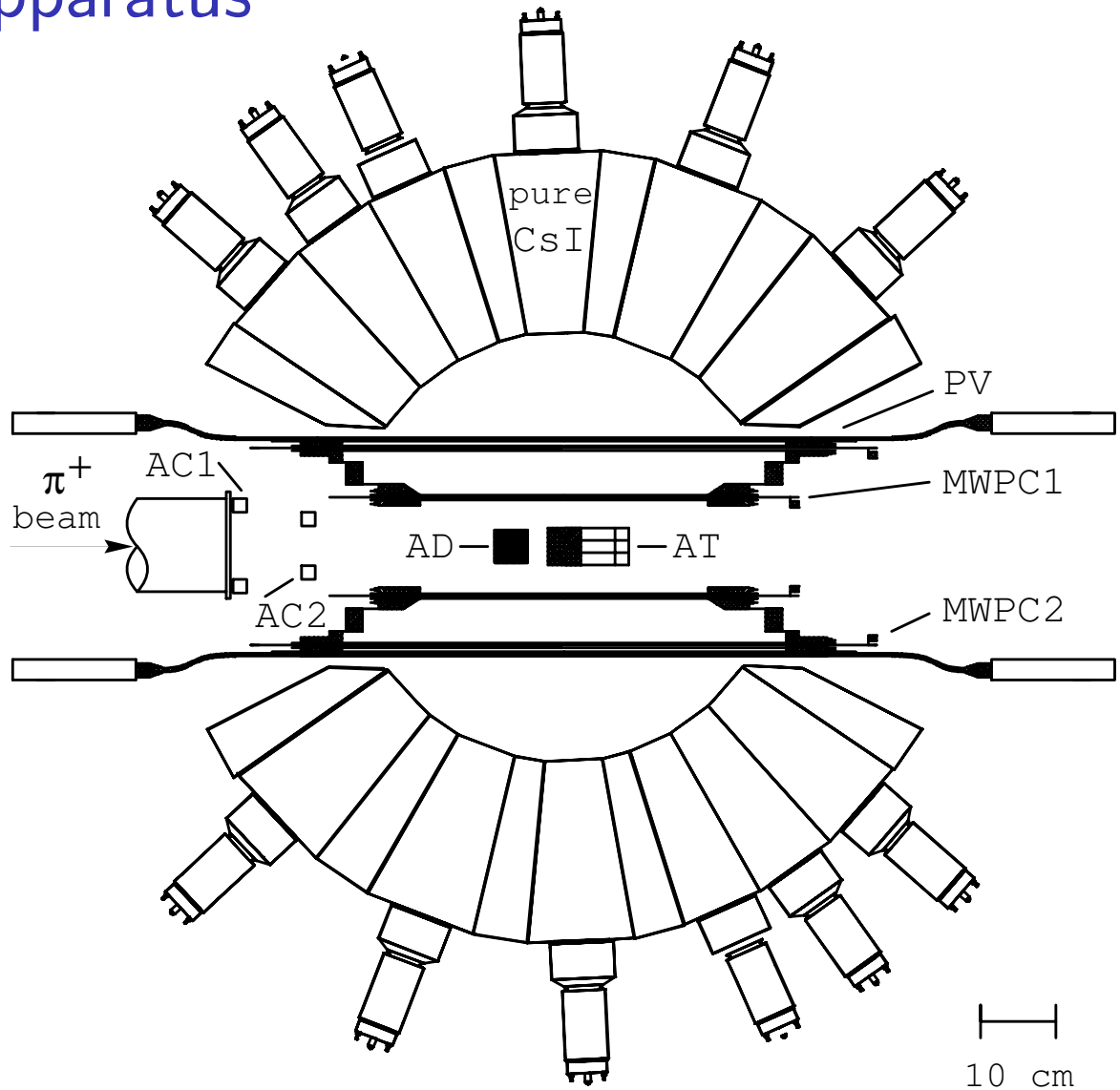
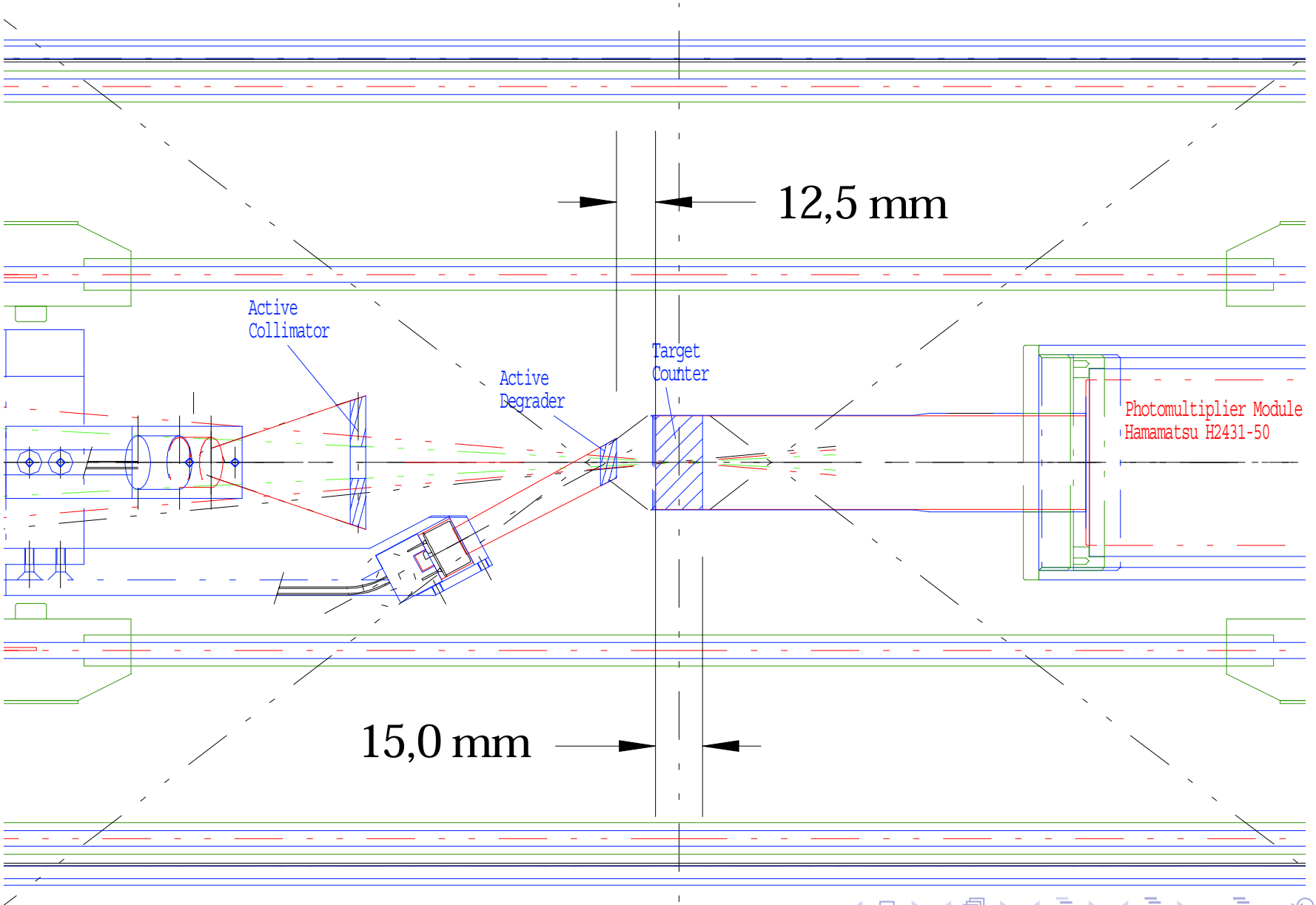




Changes and improvements for 2007

- New detectors: B0, Act. Coll., Act. Deg., TGT,
- Refurbished 20-bar Plastic Hodoscope (PV) det,
- Beamline shortened by $\sim$1 m (Q3, new compact B0 enclosure)
- Refurbished failed CsI PM's and dividers,
- Old LRS HV system replaced with new PSI-designed,
- New temperature sensors and controller,
- All-new Slow Control system and DAQ arm,
- New FE DAQ electronics based on GE Fanuc VMIVME-7807,
- Separate new FE DAQ computers for VME/FB and DSC/CAMAC,
- FB controller upgraded,
- ...

Central detector region for the 2007 run



Summary of 2007 run activities

- detector installed 24 Sept ($\sim$ 1 month later than planned),
- 22 days of setup and shakedown,
- 65 calendar days of running with $\mathbf{4.46 \times 10^6}$ sec of available beam (availability fraction 0.79),
- several detector system malfunctions (HV, DAQ-FB, etc.) resulted in 11 % downtime (availability fraction 0.89),
- we recorded $\sim$280,000 $\pi \longrightarrow e\nu$ decay events (prelim. analysis),
- ran with 68 MeV/c for most of the run; smaller data samples taken at 69 and 71 MeV/c
- all systems behaved as designed during "production" runs.

Conclusion: Main goals of the run have been realized.

Sample waveforms

$\pi \longrightarrow \mu \longrightarrow \mathbf{e}$
(in TGT)

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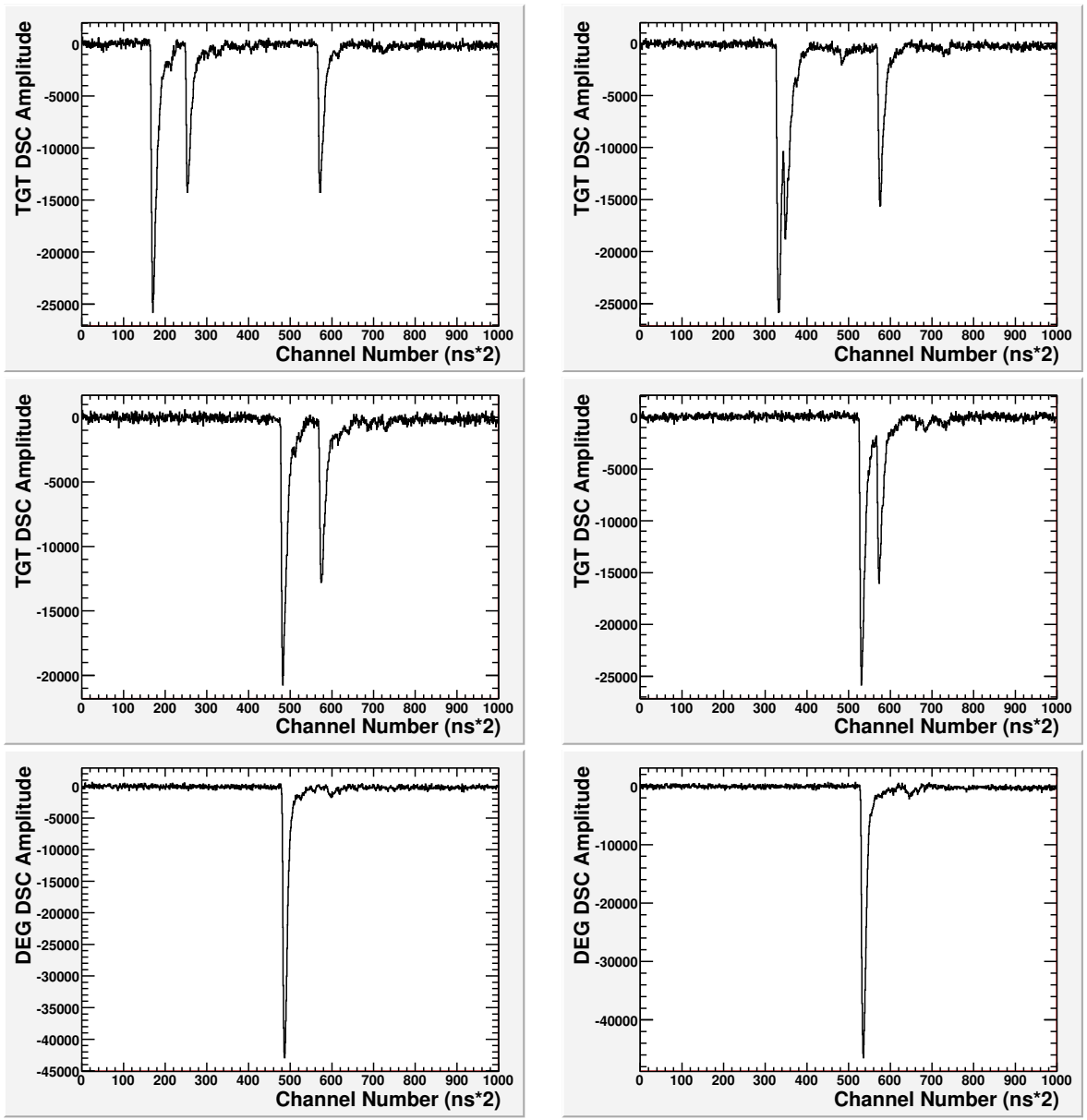
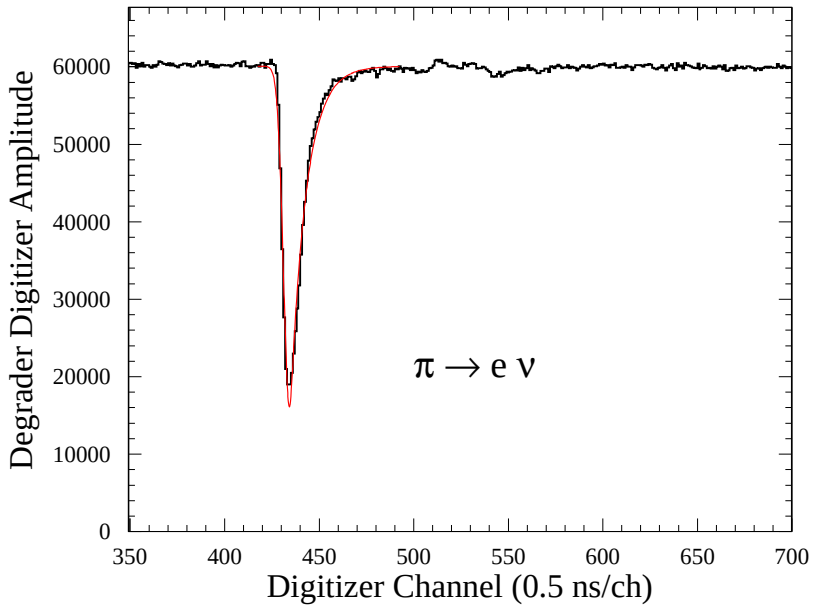
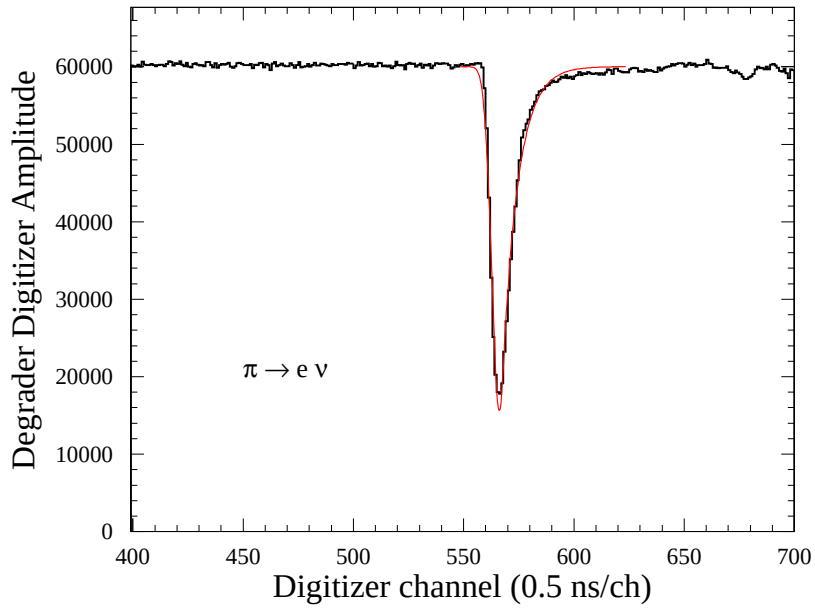
(in TGT)

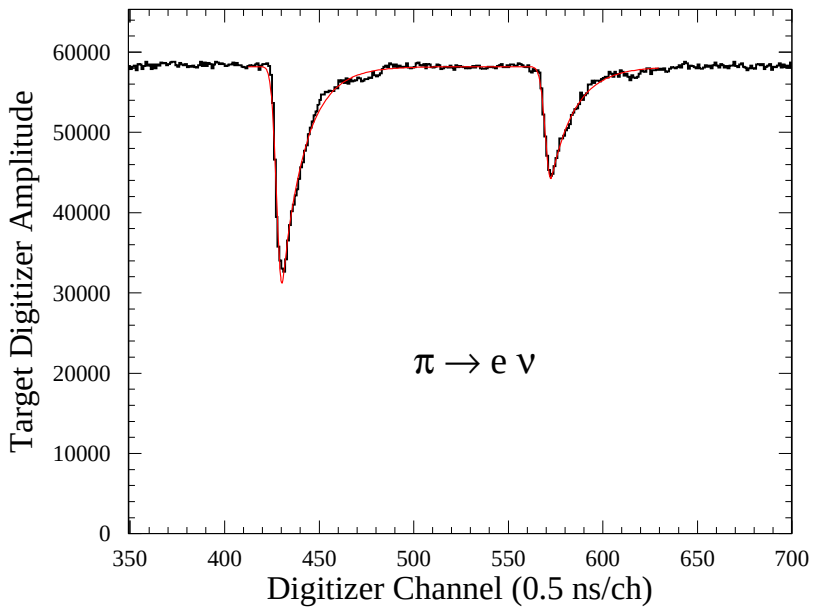
Beam π^+
(in DEG)

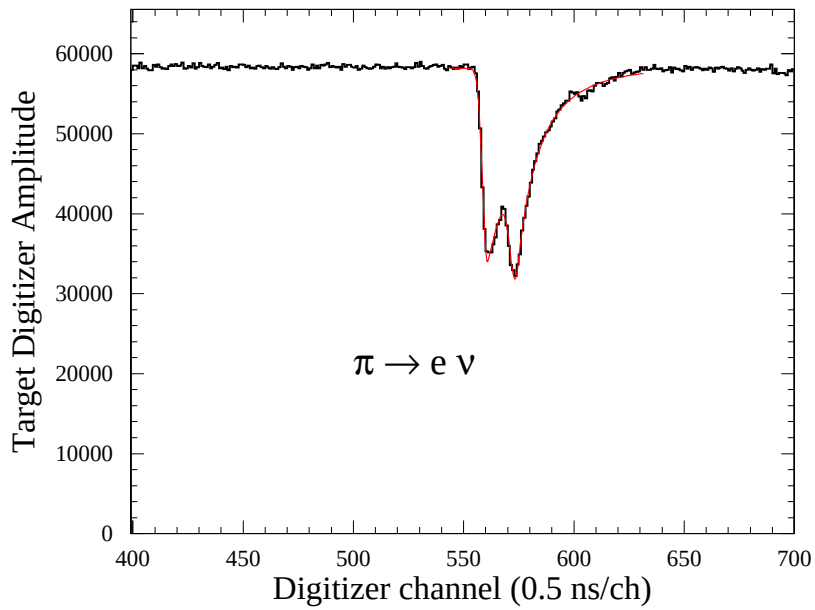


Waveforms: a closer look

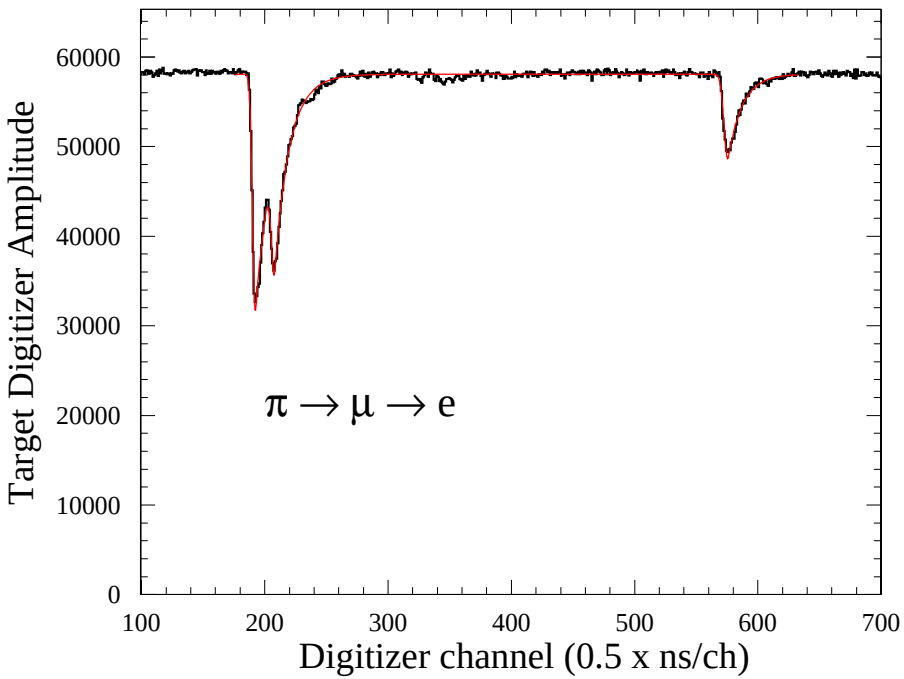


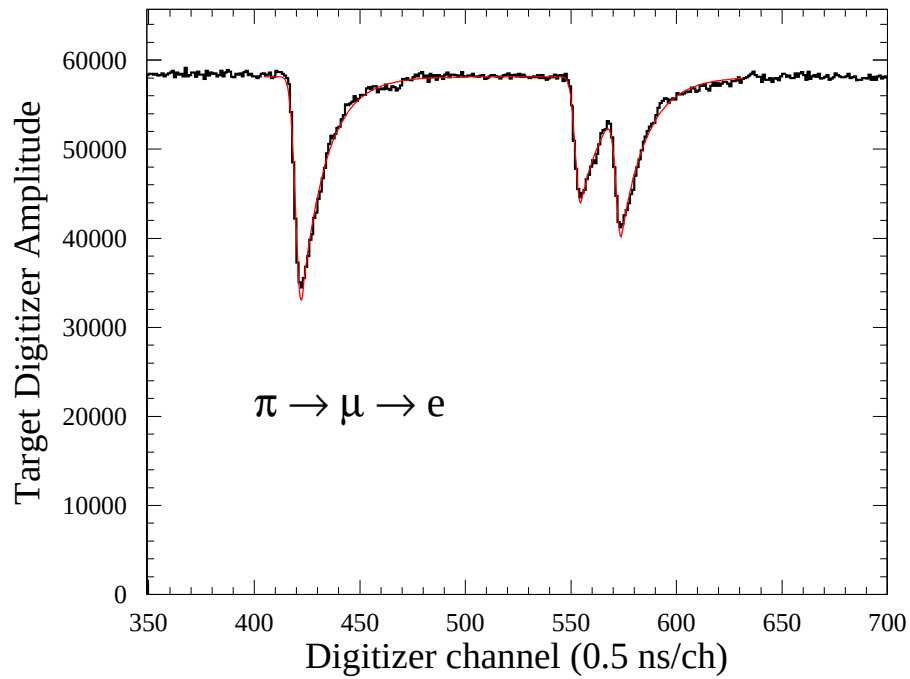




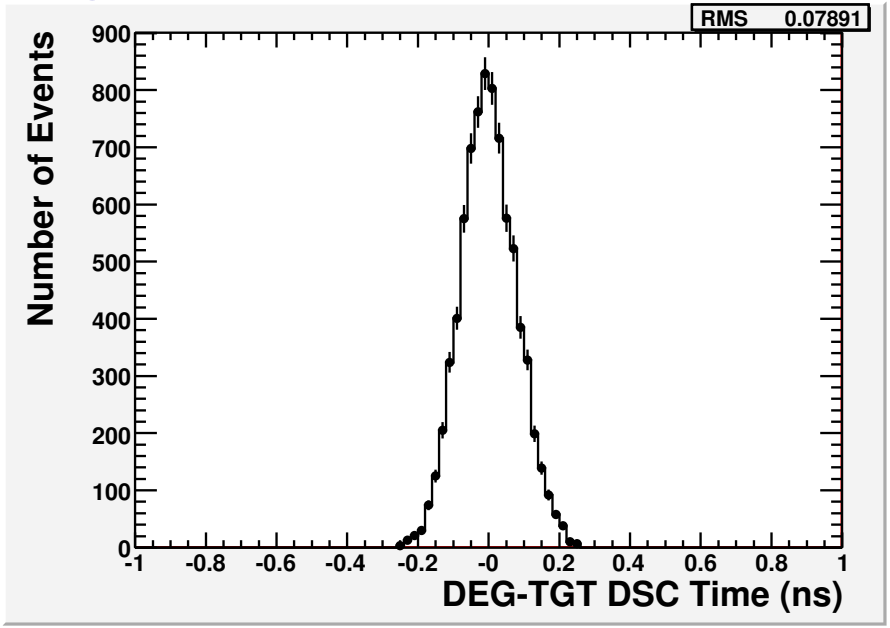


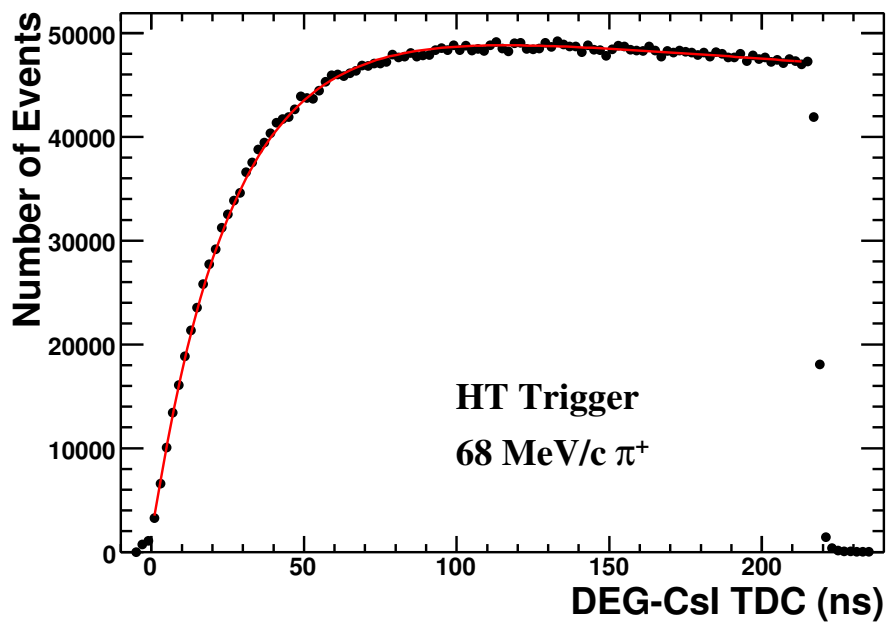
Waveforms: a closer look (II)

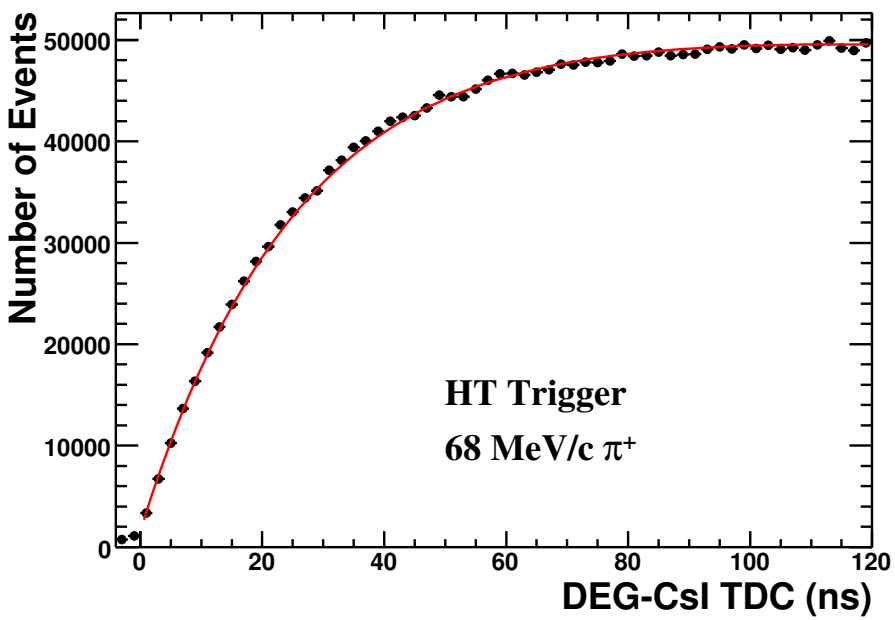


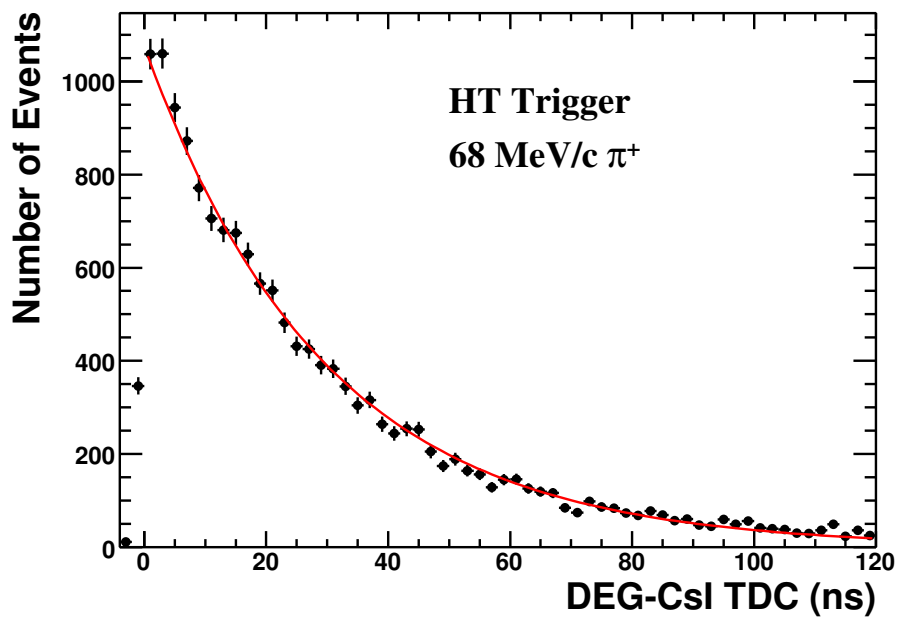


Timing in the central beam detectors

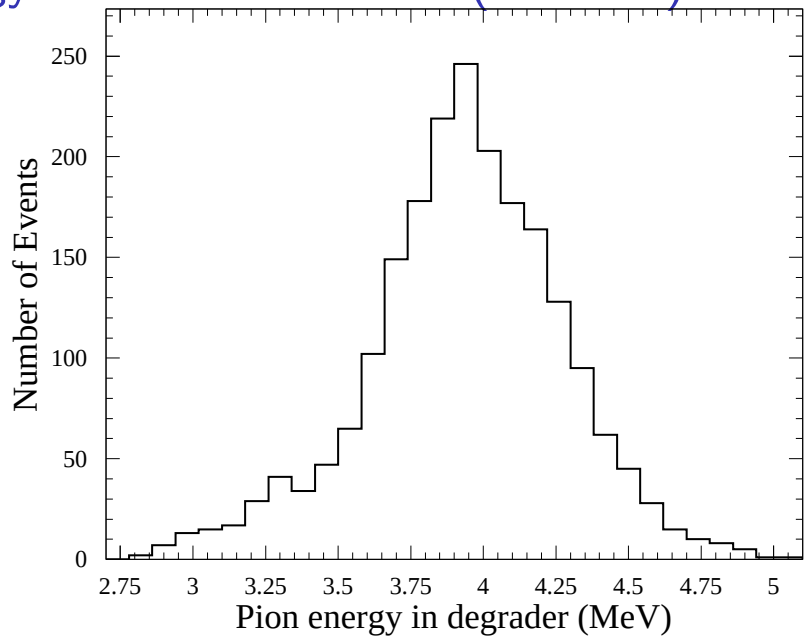


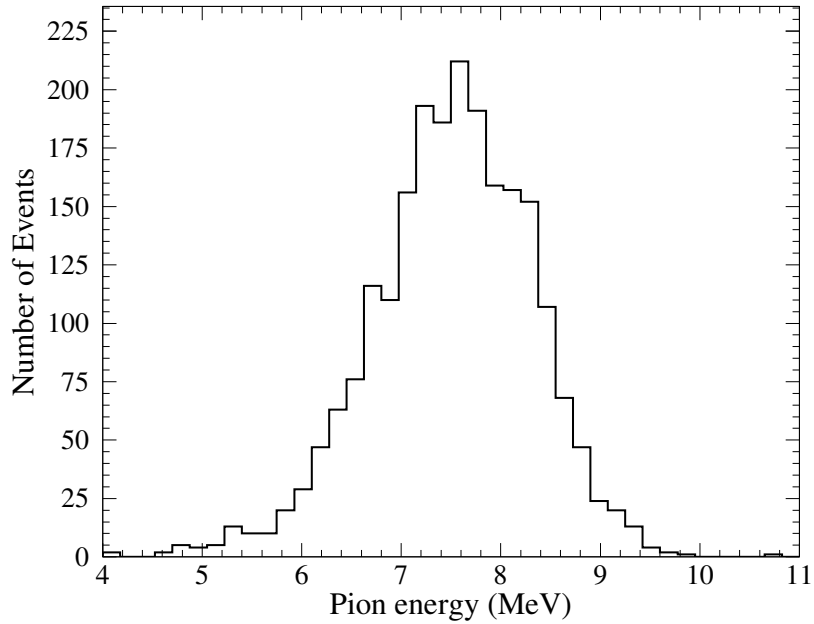


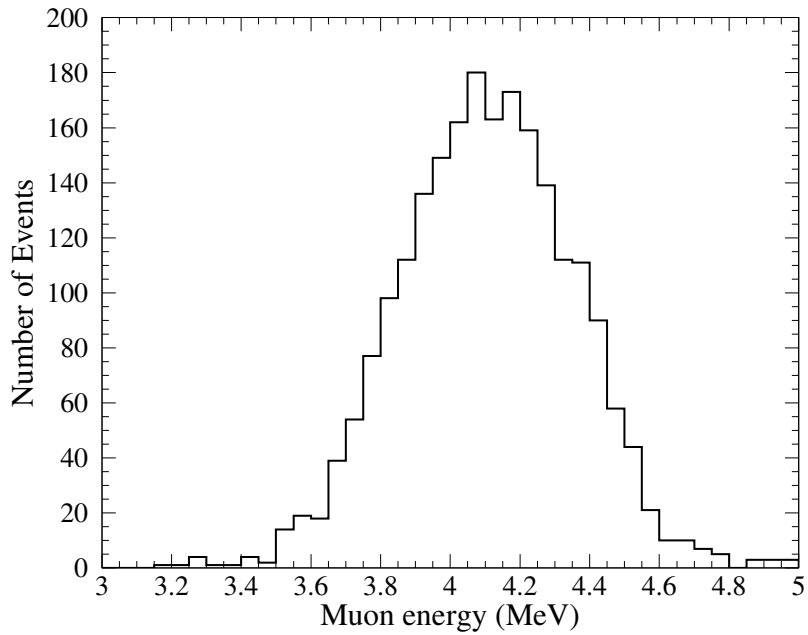


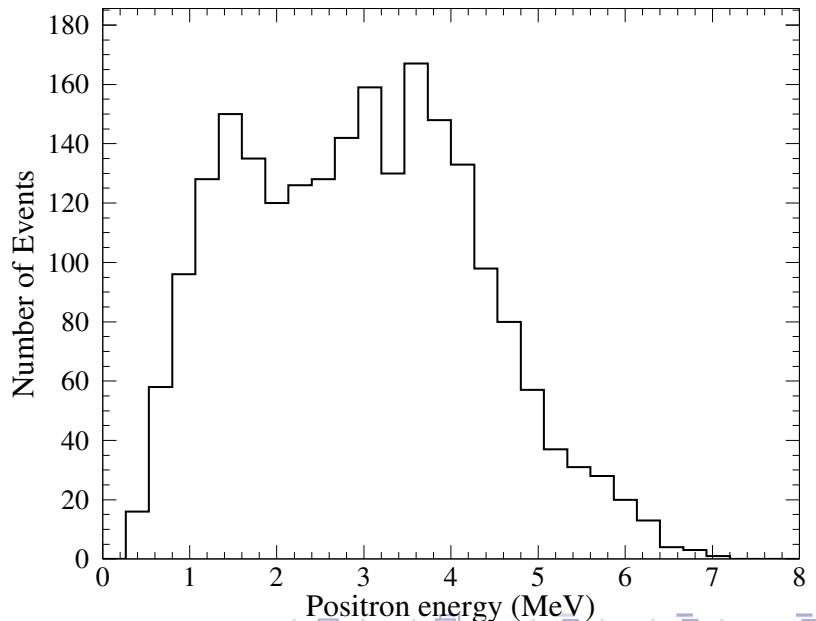


Energy in DEG and TGT (one run)

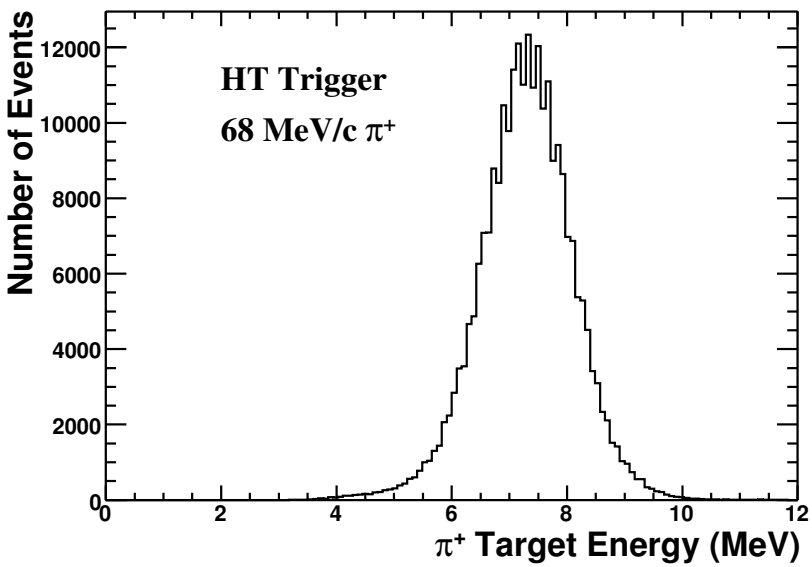


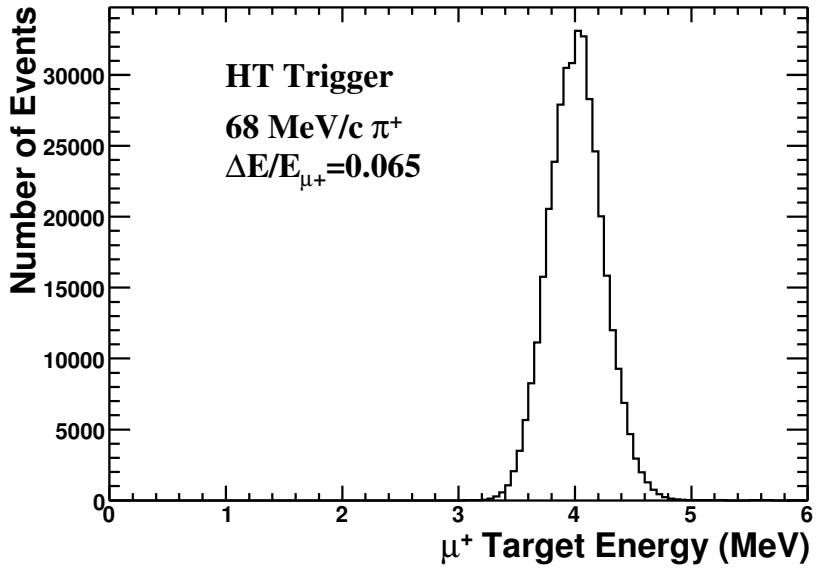


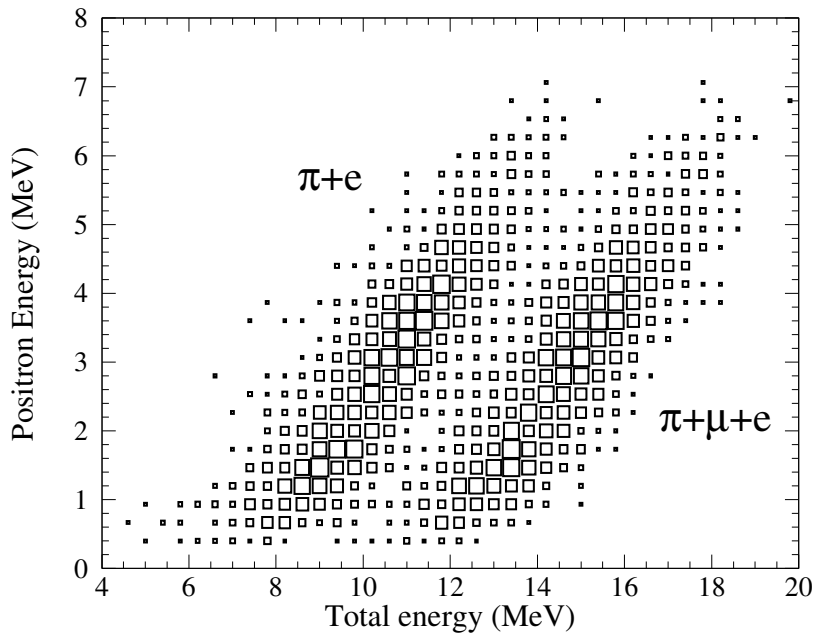


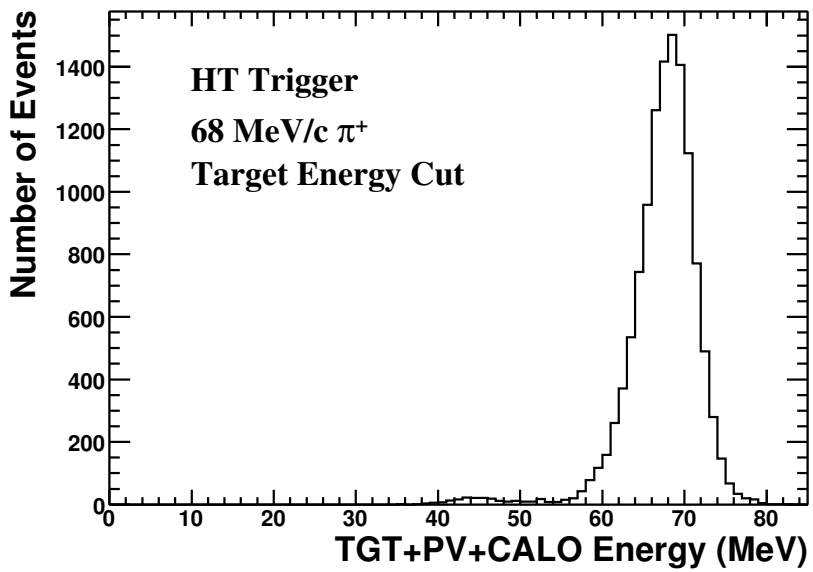


Energy in TGT (many runs)









2008 beam request

Plans for the 2008 run:

- Run with approx. 10k pion stops/sec (or more with DAQ upgrades currently under way).
- Run for 15 weeks (plus 2 weeks of set-up and calibration) starting in mid-April.
- Acquire $\sim \mathbf{4-5\times10^6}$ $\boldsymbol{\pi_{e2}}$ decay events, or $\mathbf{(\delta B/B)_{stat} \simeq 5\times10^{-4}}$

Resources requested are modest, similar to 2007 level:

- material costs of operating the detector (MWPC gas, other supplies and consumables),
- partial support for local expenses for collaborators from former socialist countries.