# EUDET test beam infrastructure for TPC R&D studies

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# Introduction

EUDET: Detector R&D towards the International Linear Collider

provides a framework for ILC detector R&D with larger prototypes

Started from 1.1.2006 for a duration of 4 years

Budget: 21.5 million Euro total, 7.0 million Euro EU contribution

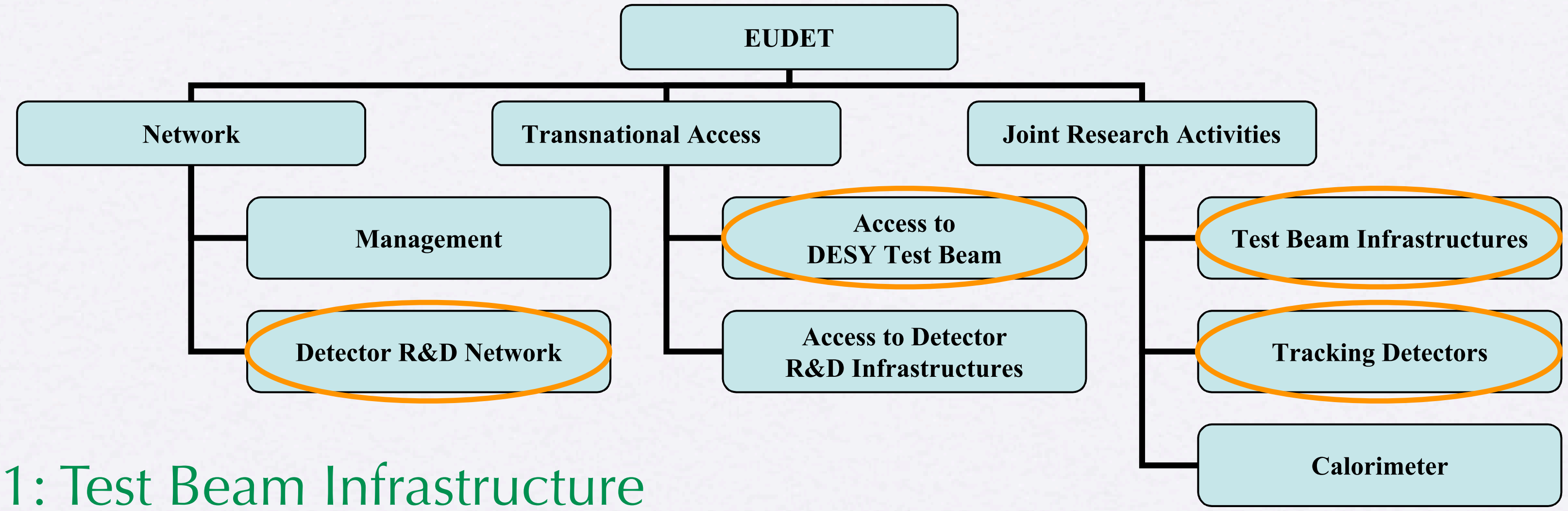
Manpower: ≈ 57 FTE total, ≈ 17 FTE funded by EU

- Other institutes (European & non-European) are invited to contribute to the development of the EUDET infrastructure and to exploit it (-> Transnational Access: see next slide)
  - link to developments in Asia and North america

# EUDET structure

## EUDET consists of 3 pillars:

Networking Activities (NA), Transnational Access (TA), Joint Research Activities (JRA)

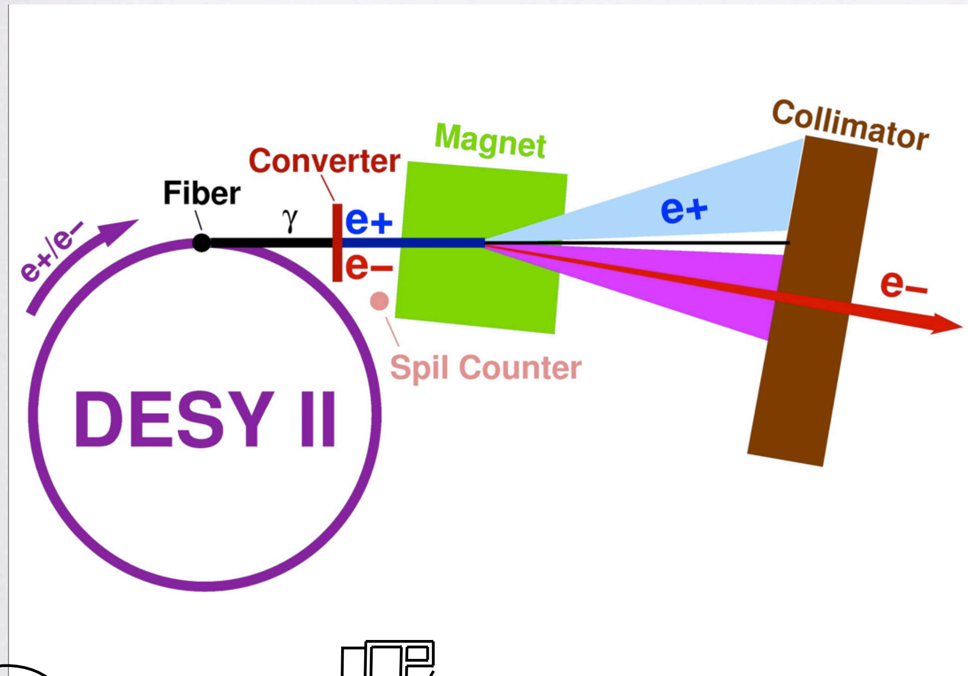



- JRA1: Test Beam Infrastructure
  - Large bore magnet (this talk in detail), Pixel beam telescope
- JRA2: Tracking Detectors
  - Large TPC prototype (this talk in detail), Silicon TPC readout, Silicon tracking
- JRA3: Calorimeter
  - ECAL, HCAL, Very forward calorimeter & FE electronics - DAQ system for the calorimeters
- NA2: (e.g.) Common software framework (testbeam analysis & ILC simulation), Small grid based computer cluster, Common DAQ, Deep-submicron rad-tolerant electronics (access through CERN contracts)
- TA1: using the DESY testbeam (as of 2006)
- TA2: using the EUDET infrastructures as soon as available (≥ 2008)
  - all EUDET infrastructure is movable (construction & initial tests at DESY)
  - later exploitation at CERN, FNAL etc. possible

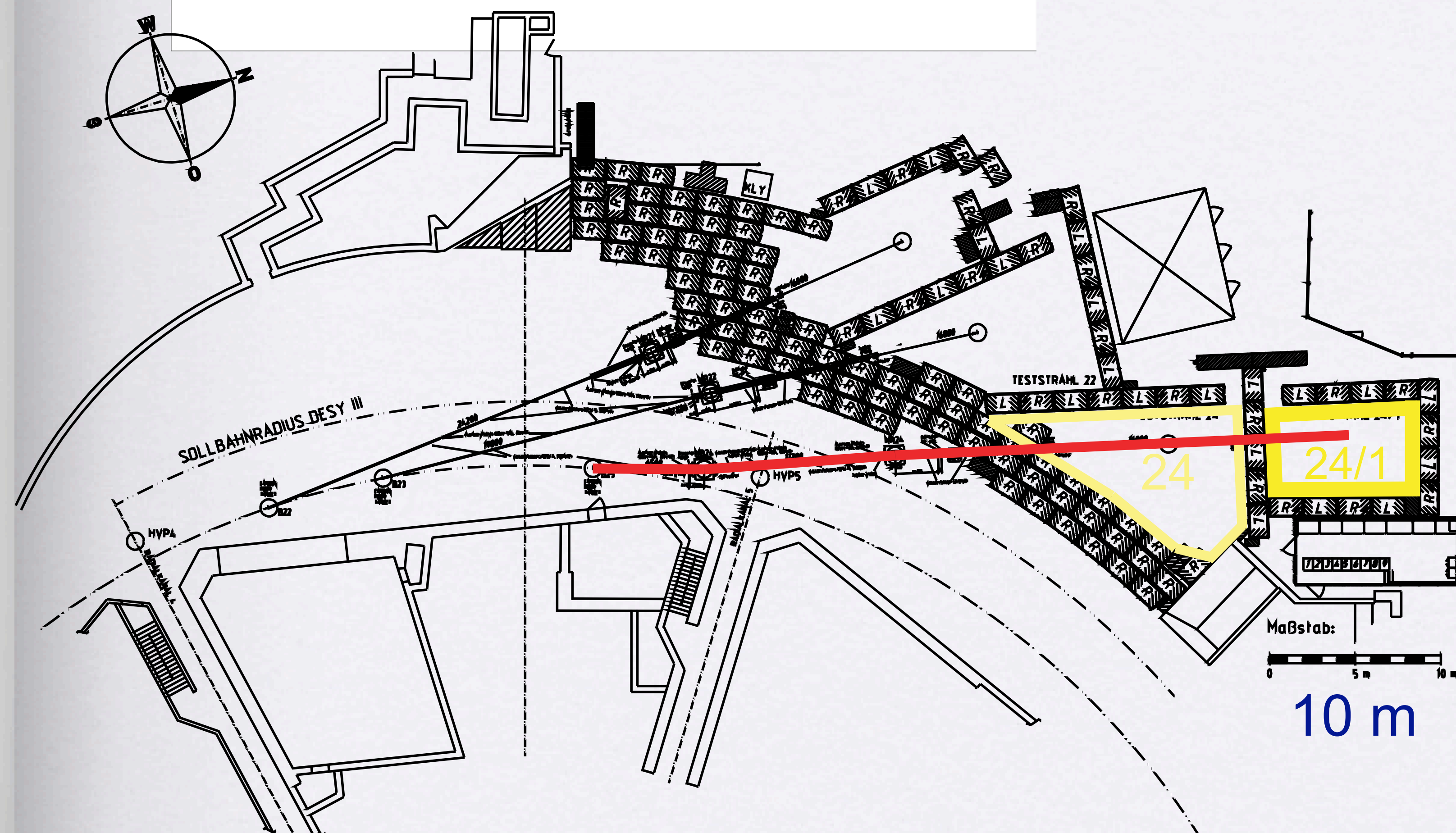
# LC-TPC & EUDET

- **Motivation & goal of LC-TPC R&D studies**
  - continuous 3D tracking, easy pattern recognition throughout large vol.
  - ~ 98-99% tracking efficiency in presence of backgrounds
  - minimum of $X_0$ inside Ecal (< 3% barrel, < 30% endcaps)
  - Spatial resolution ~ 150 μm (rφ) and ~ 500 μm (z) @ 3 or 4T
  - 2-track resolution < 2 mm (rφ) and < 5-10 mm (z)
  - dE/dx resolution < 5% -> e/pi separation, for example
  - time stamping capability together with inner silicon layer
  - design for full precision/efficiency at 50 x estimated backgrounds
- **Relation between LC-TPC & EUDET**
  - Build and operate the large prototype (Ø ~ 80 cm, drift ~ 60-70 cm) in conjunction with EUDET, which allows any MPGD technology, to test manufacturing techniques for MPGD endplates, field cage and electronics
  - Measurements in test beam & magnetic field to confirm small prototype results with larger scale device in particular: spatial resolution, dE/dx, homogeneity of large MPGD surfaces, long term stability

# DESY test beam (Strahl 24)



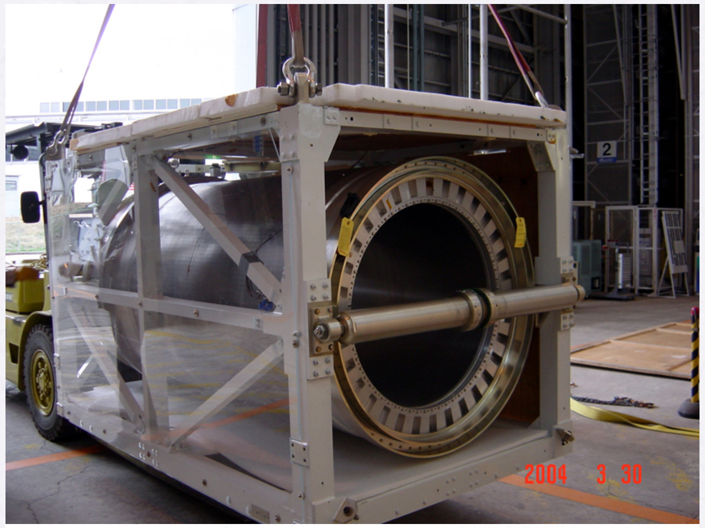

- EUDET team dominates test beam area 24 & 24/1
- Bremsstrahlungs/conversion beam with $E_e$ up to 6 GeV
- Beam momentum is chosen by magnet current
- Rates depending on energy, metal, collimator setting & operation

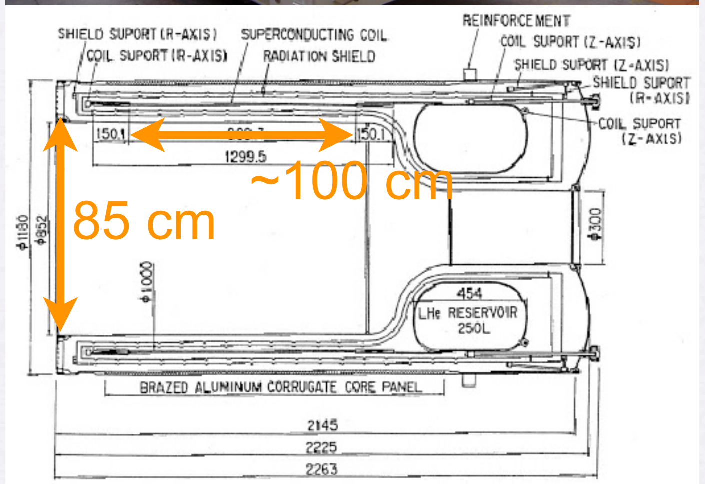


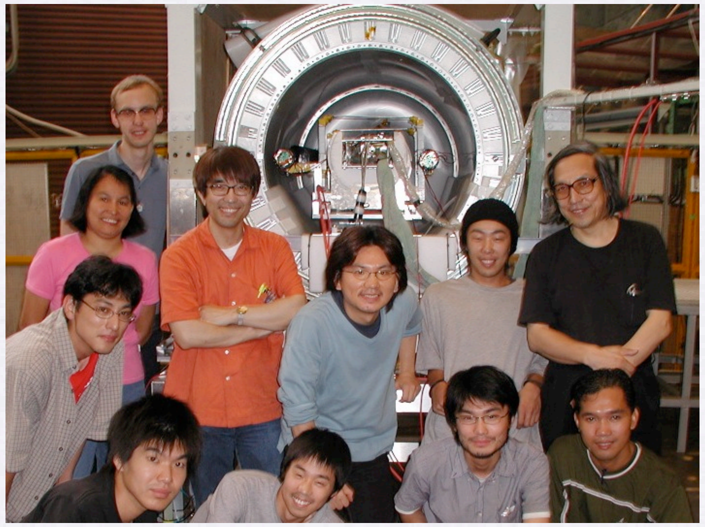

| Energy | Rates (w.r.t. target) | |
|---|---|---|
| | 3mm Cu | 1mm Cu |
| 1 GeV | ~330 Hz | ~220 Hz |
| 2 GeV | ~500 Hz | ~330 Hz |
| 3 GeV | ~1000 Hz | ~660 Hz |
| 5 GeV | ~500 Hz | ~330 Hz |
| 6 GeV | ~250 Hz | ~160 Hz |

# Superconducting magnet (PCMAG)

- $B_{max}$ = 1.2 T, Ø = 85 cm, $L_{eff}$ ~ 100 cm
- Provided from KEK for EUDET
- Originally developed for a balloon experiment in antarctica
  - Standalone operation (Persistent current mode, 250L LHe reservoir = refilling once a week)
  - Small material @half wall (0.13/0.19 $X_0$ for Coil/Coil+Cryostat) -> low multiple scattering
  - Light weight, No return yoke (~ 500 kg)
    - Movable -> Hadron beam @CERN or FNAL
    - Large stray field
- 2 year operation experience for small prototype TPC beam test @KEK 12GeV PS
  - Among Japan-Philippines-German-France-Canada TPC R&D groups
- Field homogeneity
  - Planning to 2D calculation & 3D field mapping

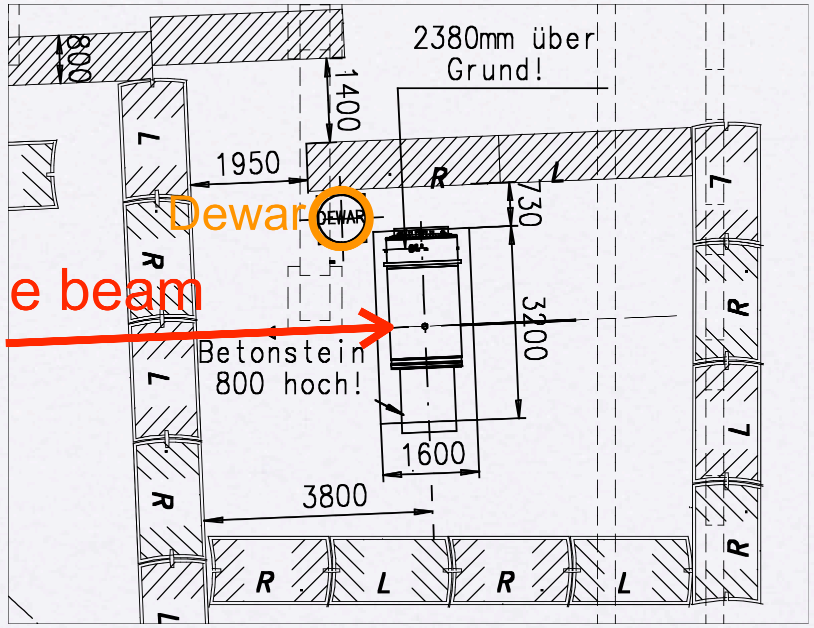


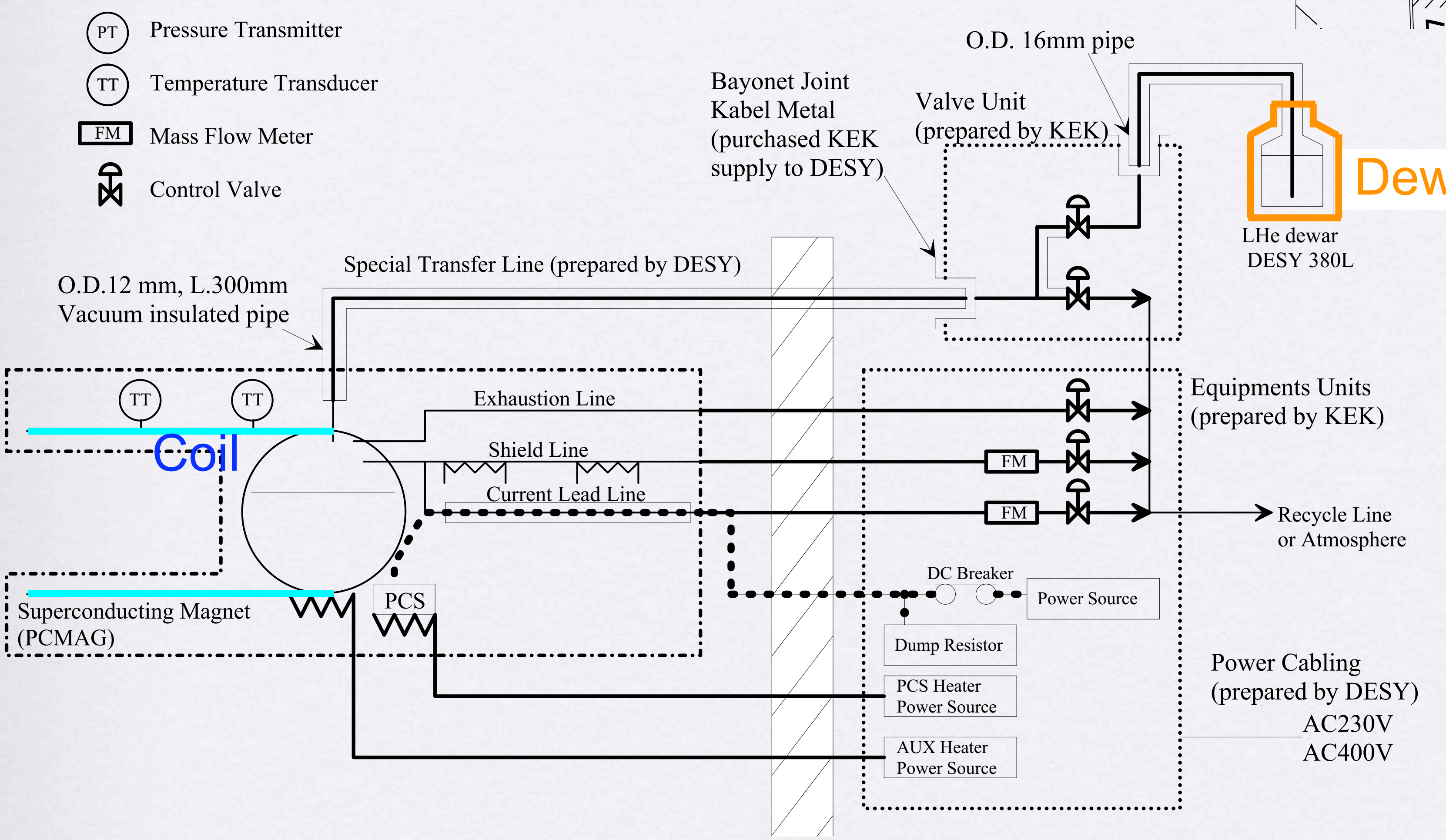


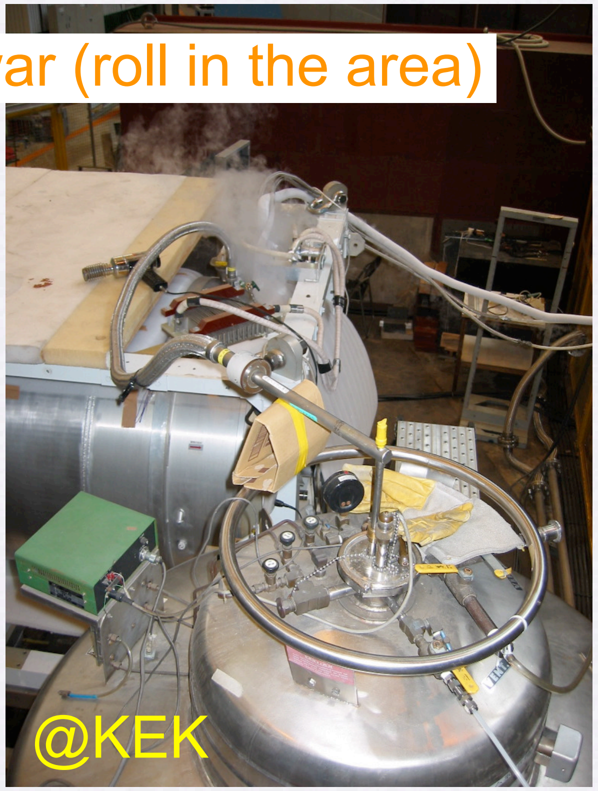



# PCMAG at DESY test beam area

- Place PCMAG at "Strahl 24/1"
- Automatic LHe refilling system proposed by KEK cryo. expert will be implemented & tested at KEK before shipping to DESY
- Allows LHe refilling during magnet excited



# EUDET activities for large prototype

- Development & building of a low mass field cage
  - should fit into the PCMAG
    - length: 60 - 70 cm, to be defined by field homogeneity of the magnet
    - diameter: ~ 80 cm (allow for silicon devices on both sides within 2 cm between field cage and magnet)
  - "generic" field cage to be used for different end-det. technologies
  - realistic field cage to test mechanical structure and HV behavior
  - end-plate as realistic as possible to test MPGD behavior
    - not realistic due to easy exchange for different end-plates
  - cathode not realistic in first iteration (massive construction: G10 plate, Cu clad on the inside, ground plane on the outside), but possibility to make a realistic version should exist
  - connection between field cage and end cap designed for robustness
  - Based on the DESY small prototype TPC (Medi-TPC) field cage design

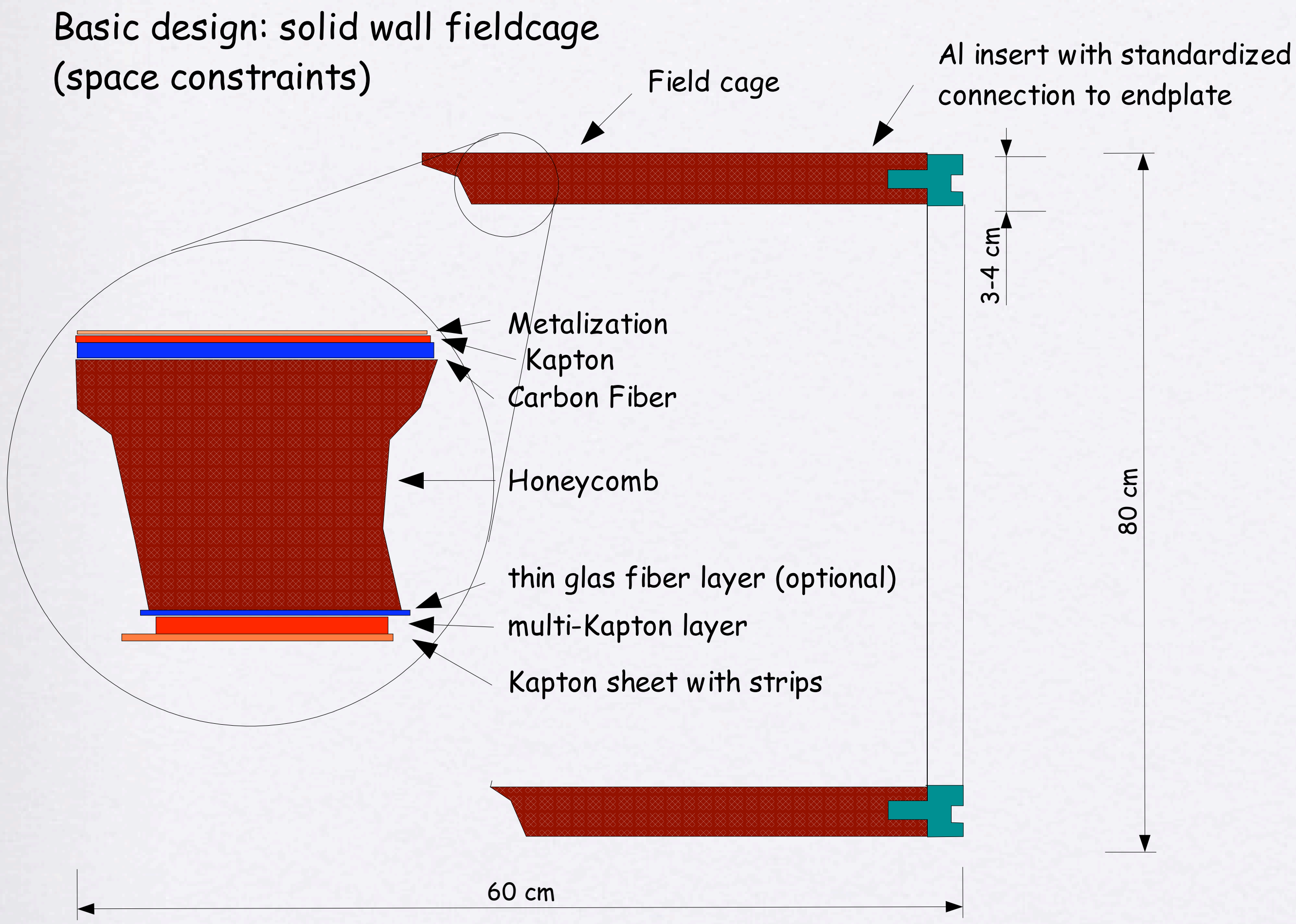
# EUDET activ. for large prototype (cont'd)

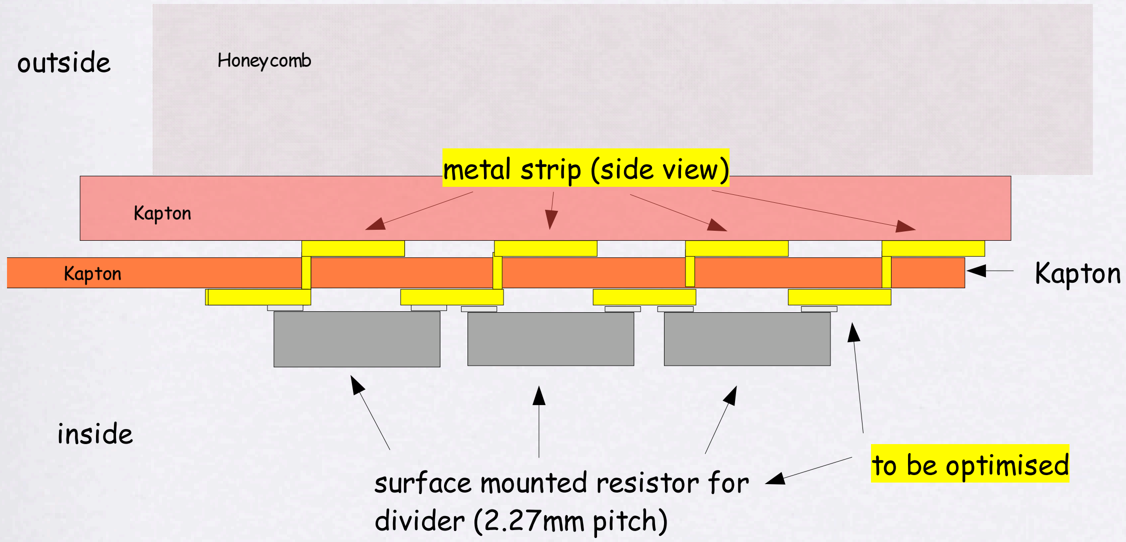
- Modular endplate system for large surface GEM & MicroMEGAS sys.
  - Field cage provides defined interface to end-plates
    - Groups can arrive with a ready-designed and built end-plate and operate it within the field cage
    - Also on the electronics side (standardized connectors)
  - Not included end-plate itself in the framework of EUDET
- Prototyping of a compact new readout electronics for GEM & MicroMEGAS
  - Traditional approach: FADC readout for timing and charge information
    - proposal for a system available as prototype by middle of 2007:

      pre-amp-shaper chips: programmable ASIC developed at CERN, peaking time of shaper >= 20 ns, i.e. about 1/2 of typical pulse length

      digitizer: modified version of the ALTRO chip (40 MHz sampling rate)
  - Alternative approach: TDC based system (measure charge through timing system)
    - The time of arrival is derived using the leading edge discriminator. The charge of the input signal is encoded into the width of output digital pulse.
- HV and slow controls facility

# Field cage design

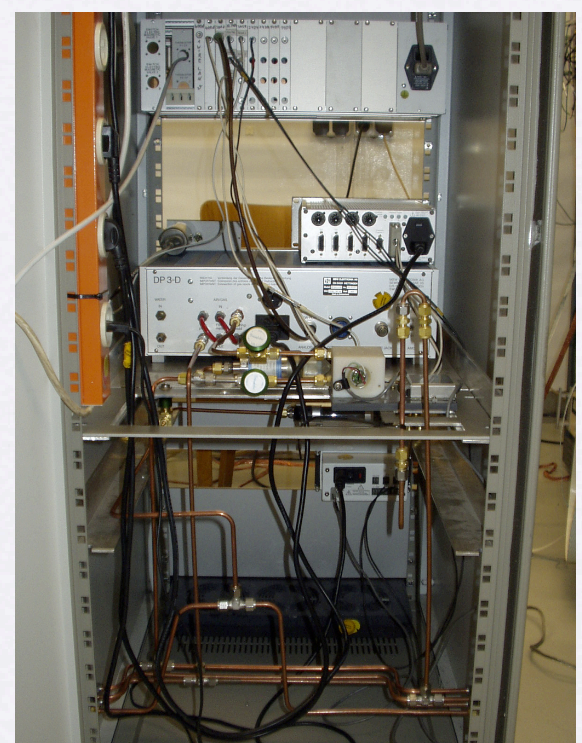



- layered construction, light weight, composite structure with honeycomb core, carbon fibre layer on the outside, possibly thin glas fibre on the inside
- Kapton foils for insulation on the inside
- field strips with pitch 2.7 mm (Cu strips)
- second row of field strips shifted by 1/2 period for shielding purposes
- resistive divider mounted on the inside of the field cage, inside the gas volume, from surface mount resistors
- 4 divider chains for redundancy and reduced heat load
- approx thickness of field cage wall: 3-4 cm
- thin Al layer on the outside as ground shield

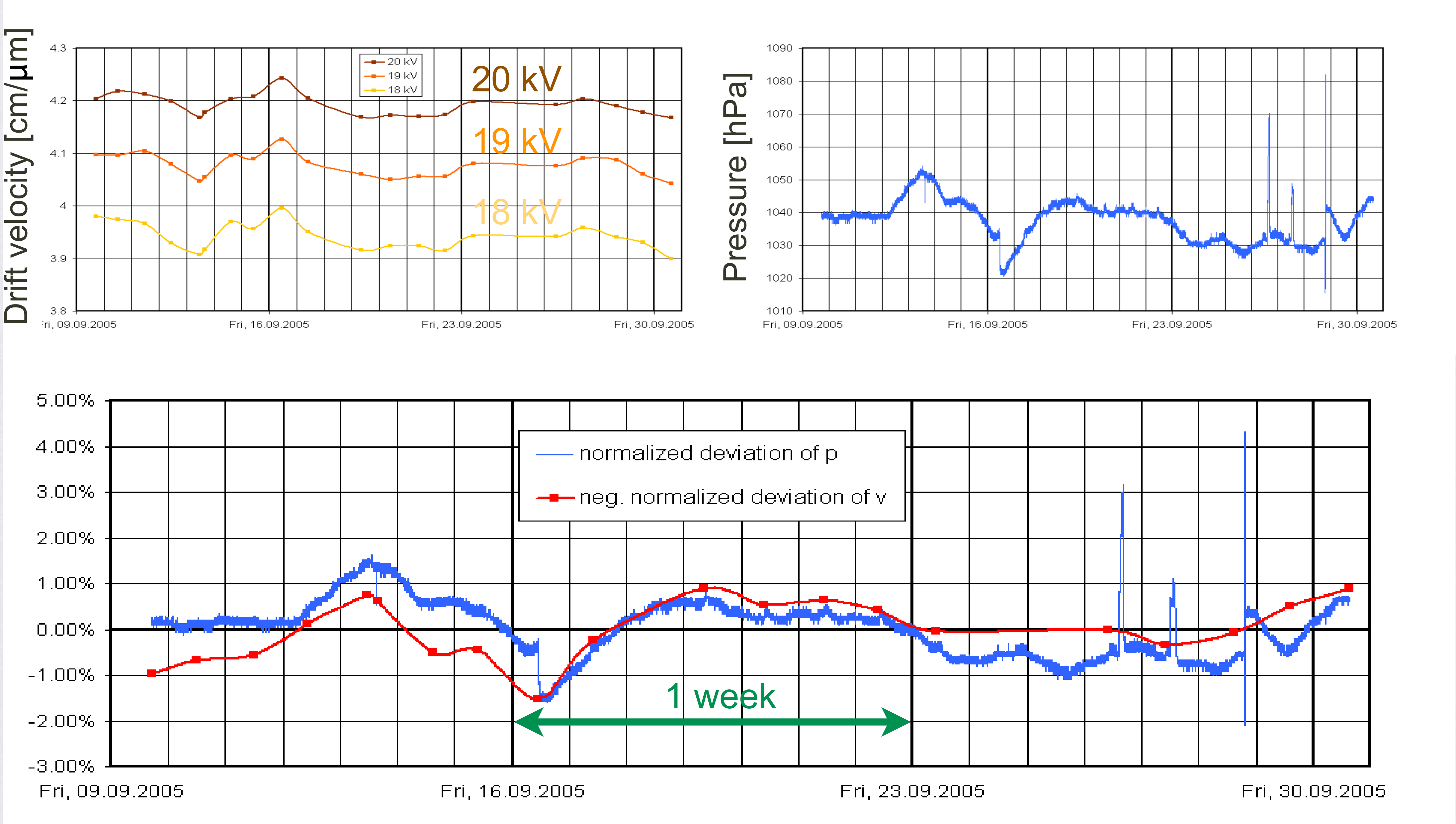
# Slow control system

- Slow control parameters for TPC
  1. Gas parameters (p, gas flow, $O_2$, $H_2O$)
  2. Environmental conditions (p, T, humidity etc.)
  3. Electrical conditions (HV for drift field & GEMs)
  4. (Magnetic field)
- 1. & 2. installed in a rack
  - Use industrial standard for read out
- 3. & 4. controlled separately (for the moment)

# Drift velocity vs gas pressure

- Correlation between drift velocity and gas pressure




- The result shows good agreement, but better to confirm w/ Magboltz

# Milestones

- First half 2006:
  - Field cage: iteration with EUDET & LC-TPC on the design & the parameters
    - calculation to estimate the mechanical strength
    - tests on the field cage structure (HV stability, mechanical stability)
  - Magnet: development, test & construction of a cryo. system at KEK, Ship to DESY
- Second half 2006:
  - Field cage: develop “production” facility at DESY to wind the field cage
  - Magnet: Commissioning at DESY test beam area
- First half 2007:
  - Field cage: build the field cage, Commissioning at lab.
  - Magnet: 3D field mapping
- Summer 2007:
  - Field cage, magnet & (part of) prototype elec.: ready to be used

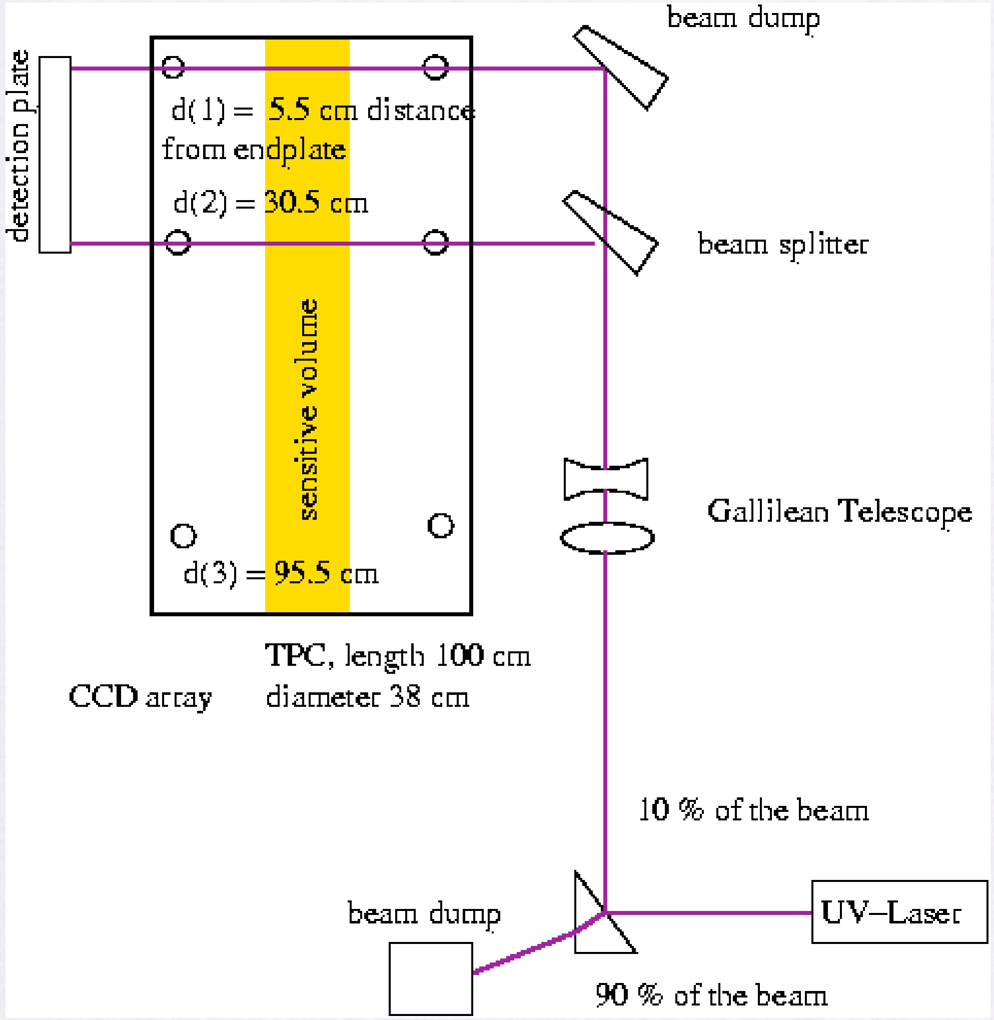
# Summary

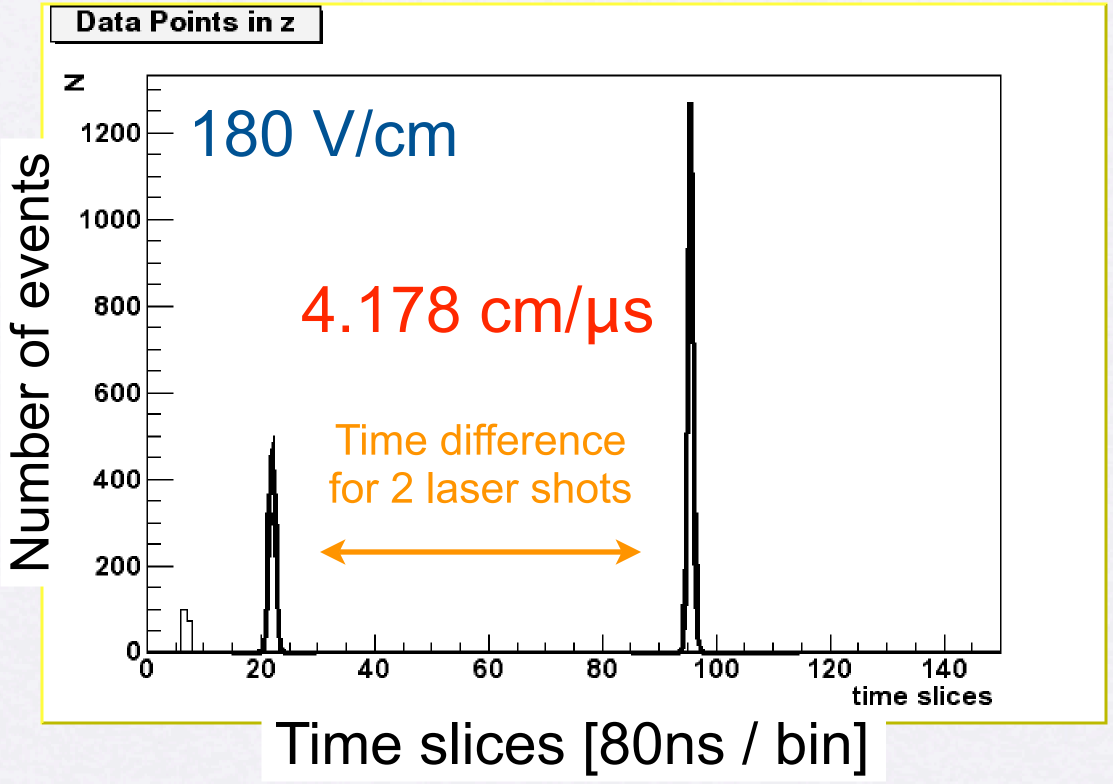
- The EUDET TPC facility aims to provide an infrastructure to proceed TPC R&D studies for the ILC
  - Non-associated institutes are invited to contribute to the development of the infrastructure and to exploit it
- EUDET dominates DESY test beam area 24 & 24/1: Place large bore magnet (PCMAG) as a test beam infrastructure
  - later exploitation at CERN, FNAL etc. possible
- EUDET activities for the large TPC prototype studies
  - Development & building of a low mass field cage
  - Modular endplate system for large surface GEM & MicroMEGAS system
  - Prototyping of a compact new readout electronics for GEM & MicroMEGAS
  - HV and slow controls facility

# Backup slides

# Measurement of drift velocity with Laser beams

- Setup for a drift velocity scan between 120 - 200 V/cm
  - 2 laser shots shoot directly through the TPC
  - Count track-cluster points per time-bin for 2 laser shots
  - Gaussian fit for the time distributions and calculate drift velocity



# LC-TPC milestones

- 2006-2009 Test Large Prototype, decide technology
- 2010 Final design of LC TPC
- 2014 Four years construction
- 2015 Commission/Install TPC in LC Detector