Beam Test of a MPGD-Readout TPC in a B-Field

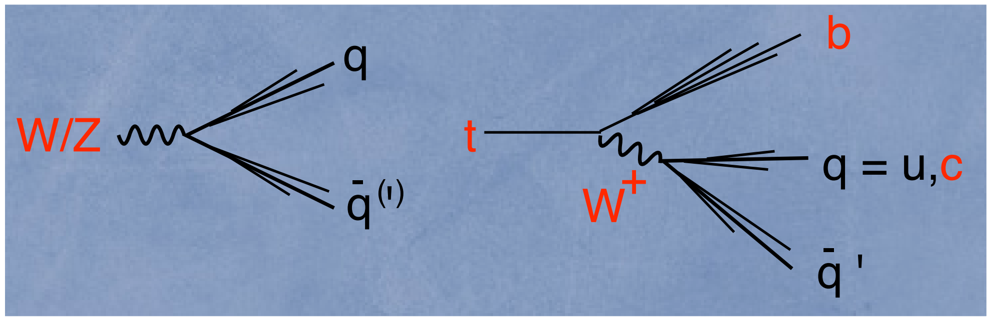
--- In the course of LC Detector R&D ---

Keisuke Fujii, in place of the spokesperson
Osamu Nitoh

Introduction

LC Detector Concept

- Reconstruct final states in terms of partons (q,l,gb)



2ndary & 3tiary vertex ID

Jet invariant mass --> W/Z/t ID --> p^μ
--> angular analysis --> s^μ

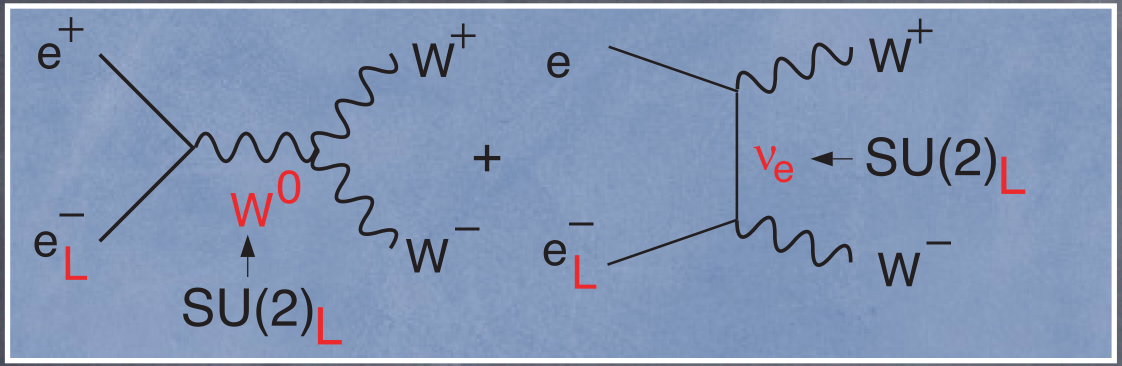
Energy Flow

Missing momentum --> neutrinos

Hermeticity

Visualize events as viewing Feynman diagrams!

- Select Feynman diagrams with beam polarization



In the symmetry limit

$$\sigma_{WW} \to 0$$

for R-handed e- beam

Study events as looking at S-matrix elements!

This requires a state-of-the-art detector!

2ndary & 3tiary vertex ID

Thin and high resolution vertexing

Energy Flow

High resolution tracking (--> next slide)

High granularity calorimetry

Hermeticity

down to O(10mrad) or better

Requirements for Central Tracker

- Momentum Resolution

$$\sigma_{p_T}/p_T \lesssim (1 \times 10^{-4}) \cdot p_T[\mathrm{GeV}]$$

- Two-Hit Separation

$$\Delta_{2\mathrm{hit}} \lesssim 2[\mathrm{mm}]$$

- Track-Cluster Matching (extrapolation error to CAL)

$$\Delta r\phi, Z \lesssim 1[\mathrm{mm}]$$

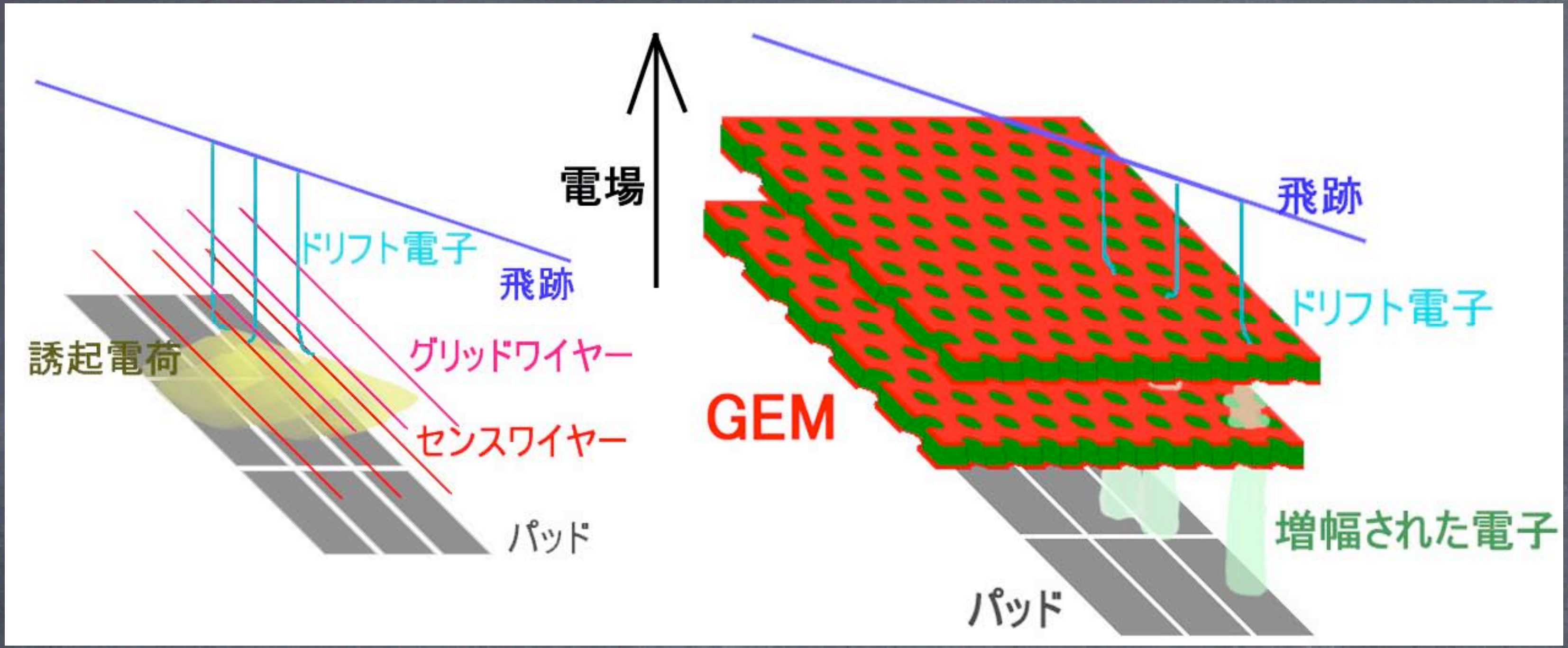
- Time Stamping Resolution

$$\sigma_{T_0} \lesssim 1.4[\mathrm{ns}]$$

Jet v.s. TPC

	CDC	TPC (MWPC)	TPC (MPGD)
Spatial Resolution	$\sigma_{xy} \lesssim 100\mu\mathrm{m}$ $\sigma_z \lesssim 1\mathrm{mm}(\mathrm{stereo})$	$\sigma_{xy} \lesssim 200\mu\mathrm{m}$ $\sigma_z \lesssim 0.5\mathrm{mm}$	$\sigma_{xy} \lesssim 100\mu\mathrm{m}?$ $\sigma_z \lesssim 0.5\mathrm{mm}$
Two-Hit Separation	$\Delta_{r\phi} \lesssim 2\mathrm{mm}$ $\Delta_z = N.A.$	$\Delta_{r\phi} \gtrsim 10\mathrm{mm}$ $\Delta_z \simeq 10\mathrm{mm}$	$\Delta_{r\phi} \lesssim 2\mathrm{mm}?$ $\Delta_z \simeq 10\mathrm{mm}$
Angular Coverage	limited by wire length	$<$ limited by diffusion/HV	$=$ limited by diffusion/HV
Sampling Points	$n < 100$	$n \gtrsim 100$	$n \gtrsim 200$
Sector Boundary	none	thick	thin?
Time Stamping	$\sigma_{T_0} \lesssim 2\mathrm{ns}$	N.A. if TPC alone	N.A. if TPC alone
Space Charge	warm only	cold OK	cold OK

GEM as the Readout MPGD



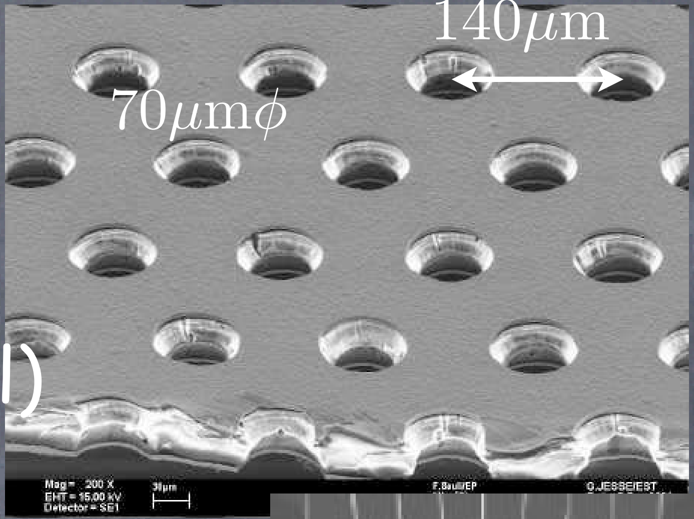
- Almost no ExB effects --> good spatial resolution
- Fast and spatially narrow induced signals
  --> good 2-track separation
- No wire --> thin sector boundaries
- Suppression of +ve ion feedback

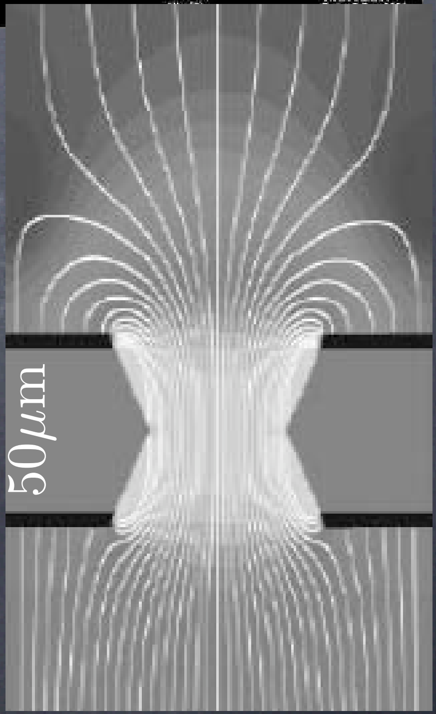
Major R&D Items

Proof of Principle

- GEM Itself
  - Operational stability
  - Scalability (large area GEM foil)
- Application to TPC
  - Spatial resolution
  - 2-track separation
  - Positive ion feedback

→ B-dependent





So far no beam test of a MPGD-readout TPC made with a magnetic field!

Purpose of This Experiment

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- Compare basic chamber performances such as
  - Spatial resolution
  - 2-track separation
  - Positive ion feedback
- for MWPC and MPGD (GEM in particular) readout planes of the same test TPC
- varying
  - Beam particle, energy, position & angle, intensity
  - B-field
- Compare these data with simulations and establish design procedure for the full scale MPGD-TPC

Collaboration

GLC CDC+X Group-MPI/DESY-IPN Orsay

- GLC CDC+X Group
  - Hiroshima: H.Kuroiwa, T.Takahashi
  - KEK: K.Fujii, K.Ikematsu, M.Kobayashi, T.Matsuda, et al
  - Kogakuin: T.Watanabe
  - Kinki: Y.Kato
  - MSU: A.Bacara, J.Gooc, R.Reserva
  - Saga: N.Sakamoto, A.Sugiyama, M.Yamaguchi
  - Tokyo: M.Inuzuka, S.Yamashita, et al
  - Tsukuba: A.Yamaguchi
  - TUAT: S.Arai, T.Kijima, A.Miyazaki, O.Nitoh, et al
- MPI/DESY Group
  - MPI: R.Settles, V.Eckerdt, et al
  - DESY: M. Hamman, T.Kuhl, P.Wienemann, et al
- IPN Orsay Group
  - J.Rothas, P.Rosier, V. Lepeltier, et al

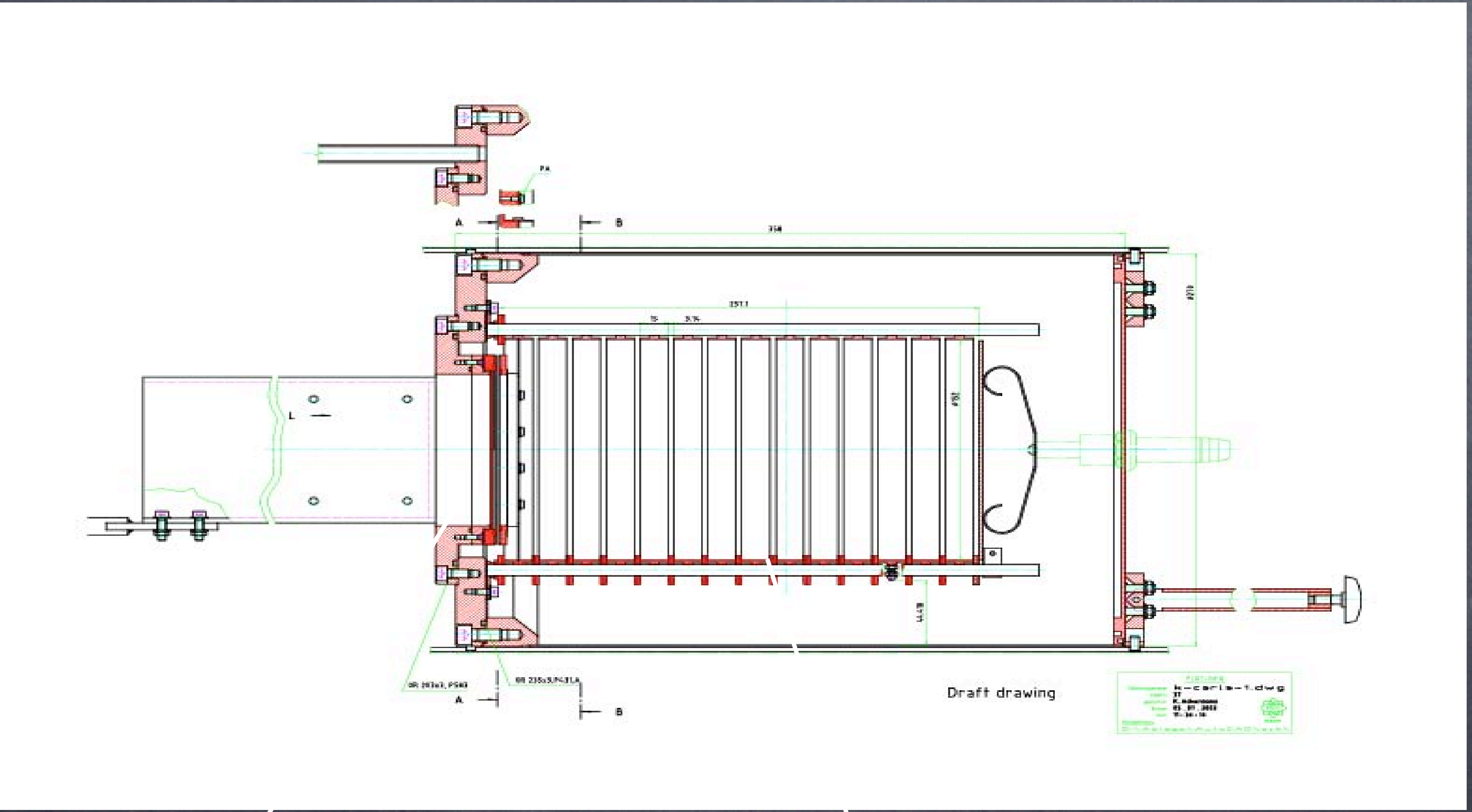
Job Sharing

GLC CDC+X Group-MPI/DESY-IPN Orsay

- GLC CDC+X Group (Hiroshima, KEK, Kogakuin, Kinki, Saga, Tokyo, Tsukuba, TUAT)
  - Beam, Magnet, Mechanical Support, Trigger, Setup, Data Taking, Analysis
- MPI/DESY Group
  - TPC itself, Readout Electronics, Setup, Data Taking, Analysis
- IPN Orsay
  - MPGD plane (GEM)

Current Status of Preparation

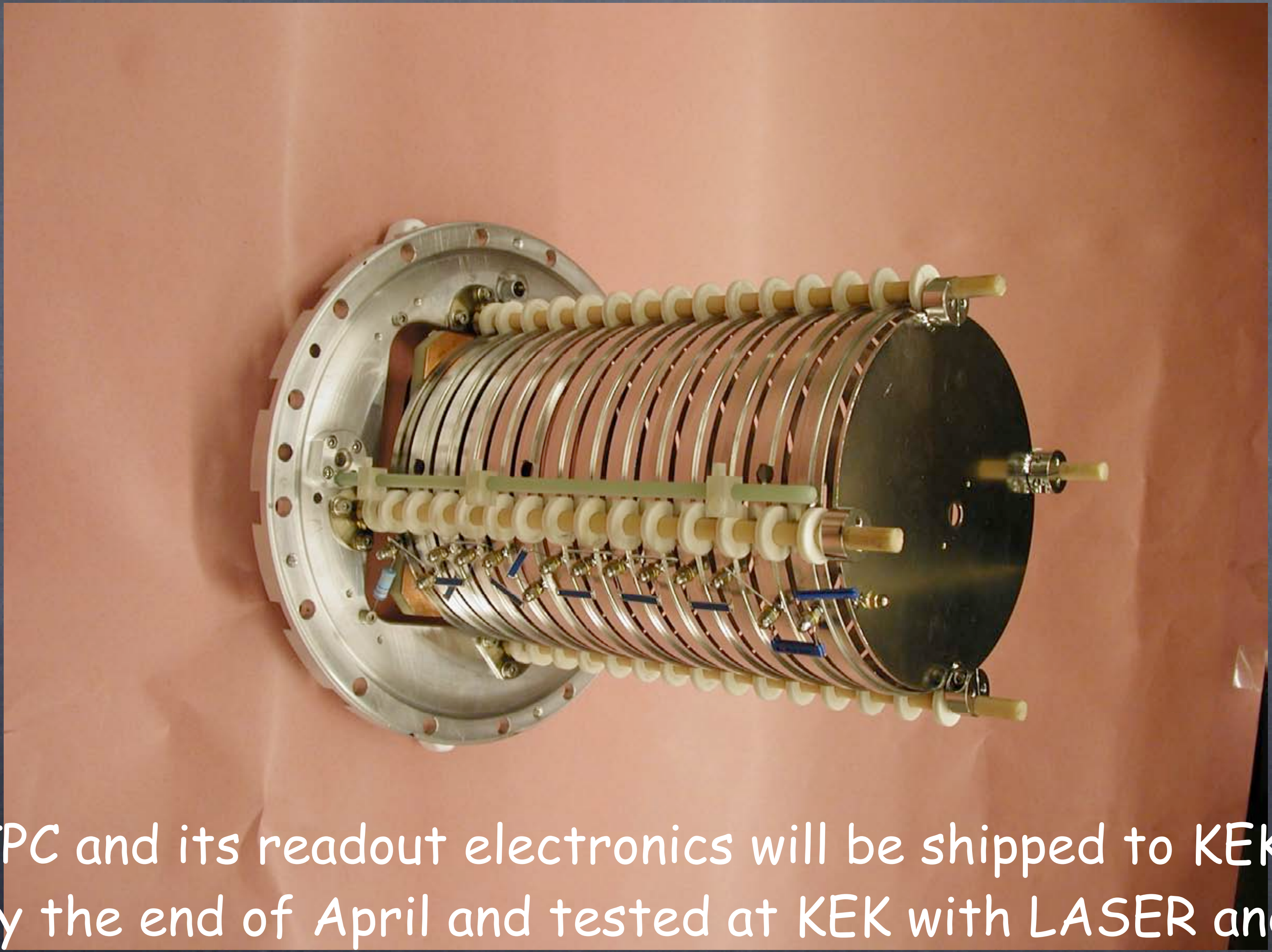
MPI TPC



Field cage: maximum drift distance = 27 cm

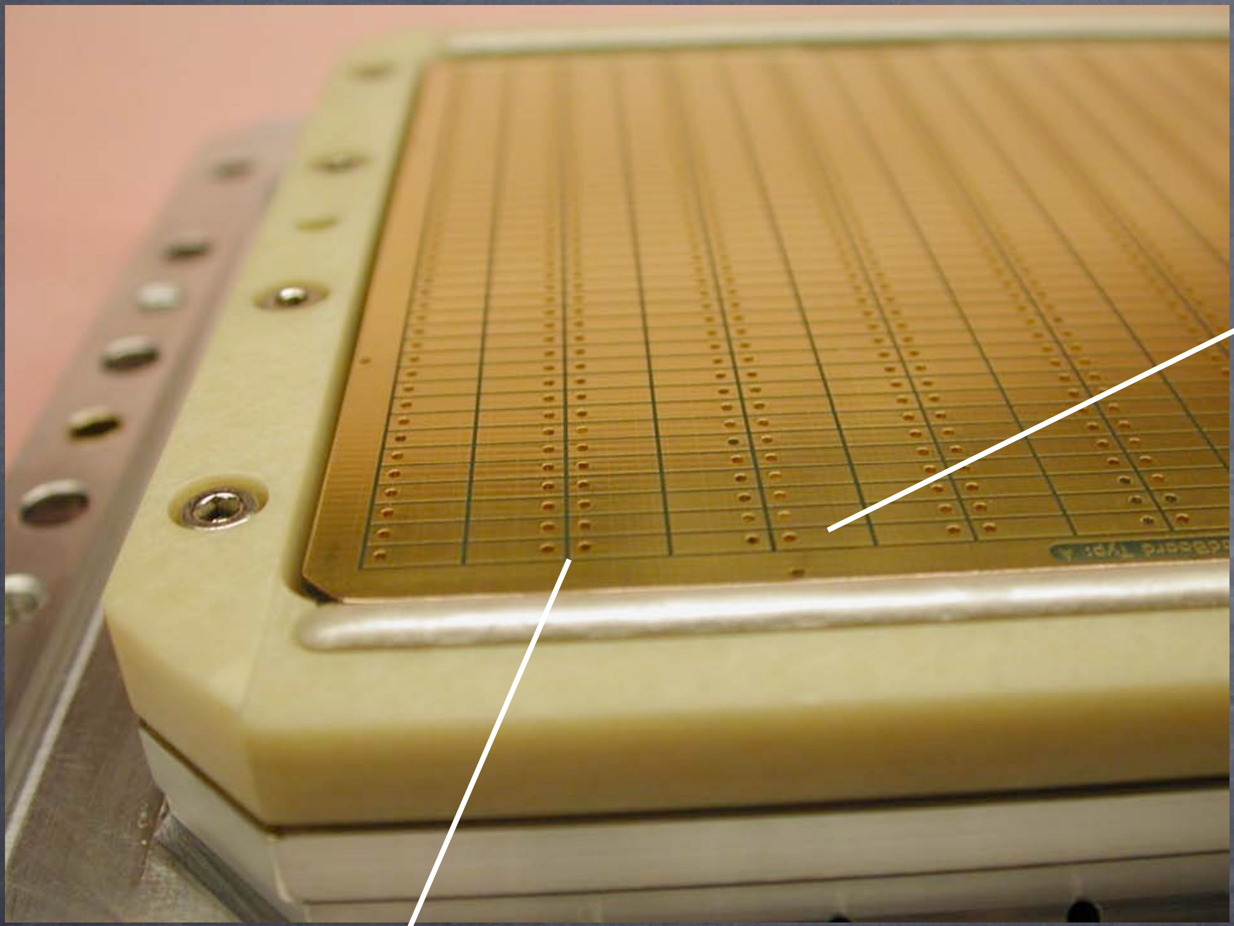
Pad plane : 10cmx10cm (12 rows of 64 2mmx6mm pads instrumented --> common for MWPC and MPGD)

MPI TPC Field Cage



TPC and its readout electronics will be shipped to KEK by the end of April and tested at KEK with LASER and cosmic rays!

Readout Plane (MWPC)



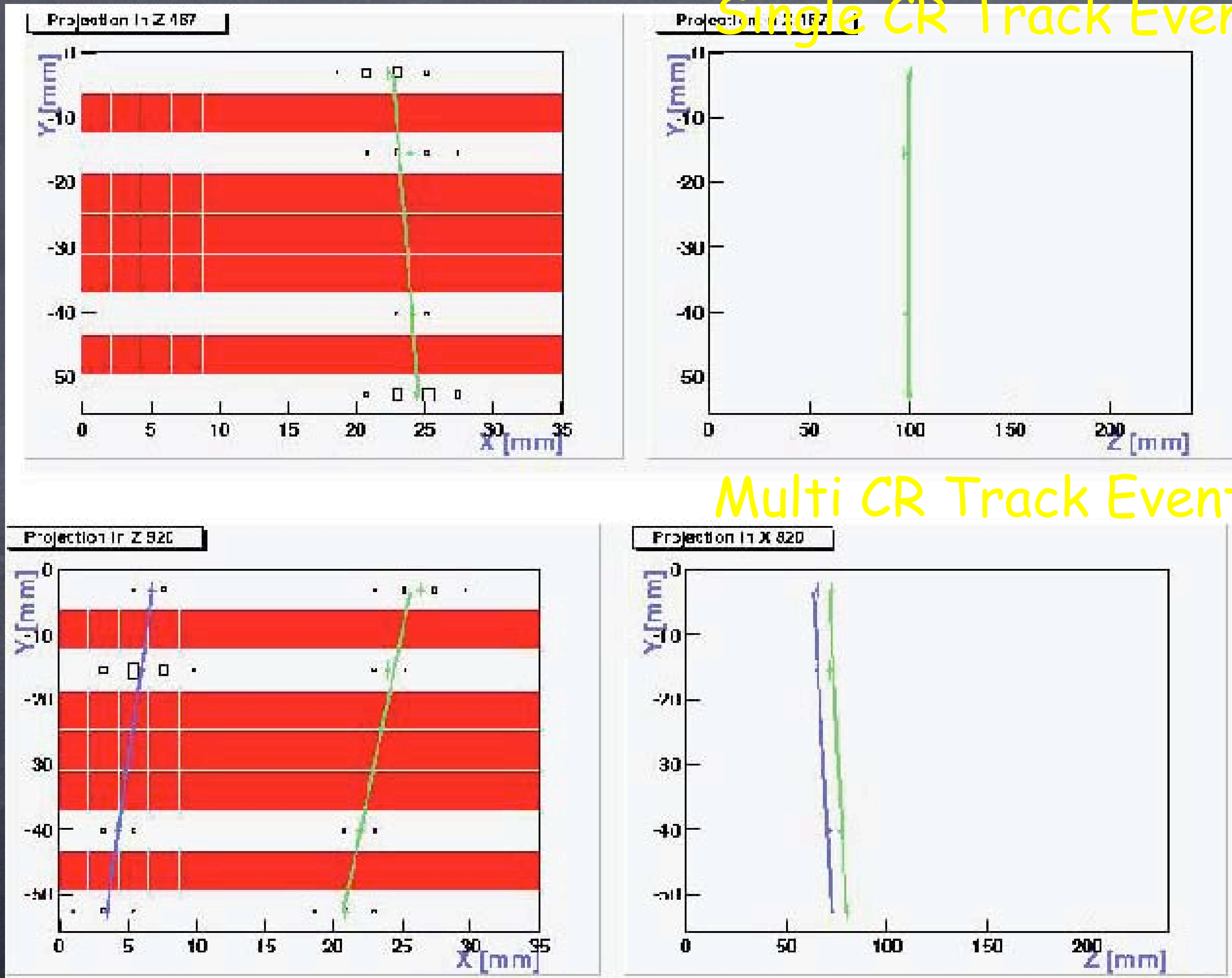
Wire spacing = 2mm

Wire-cathode gap = 1mm ---> sigma (PRF) = 1.4mm

The readout MWPC is ready!

Single CR Track Event

Multi CR Track Event



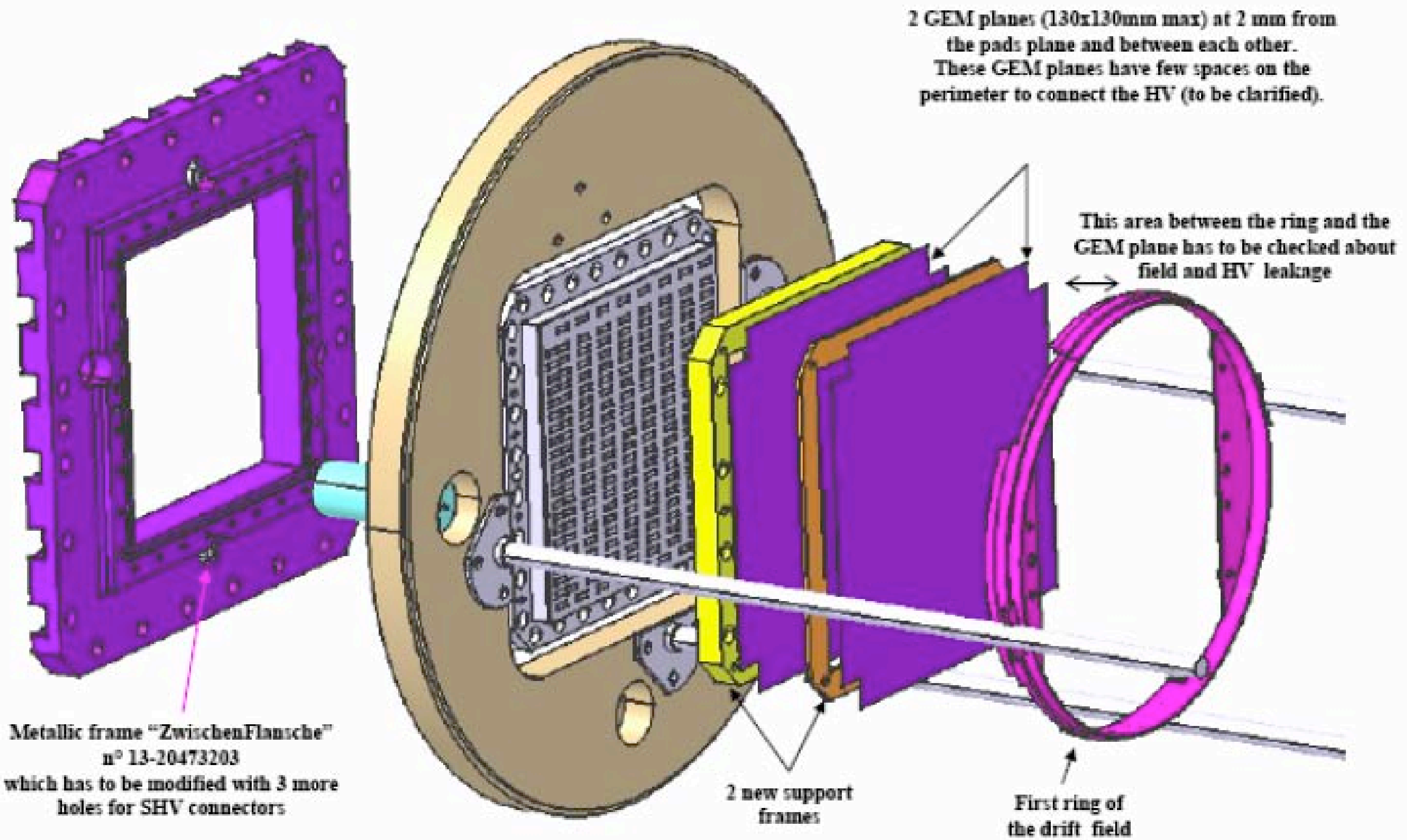
And operational!

Readout Plane (GEM)

Exploded view of the modified MPI TPC equipped with 2 GEM planes

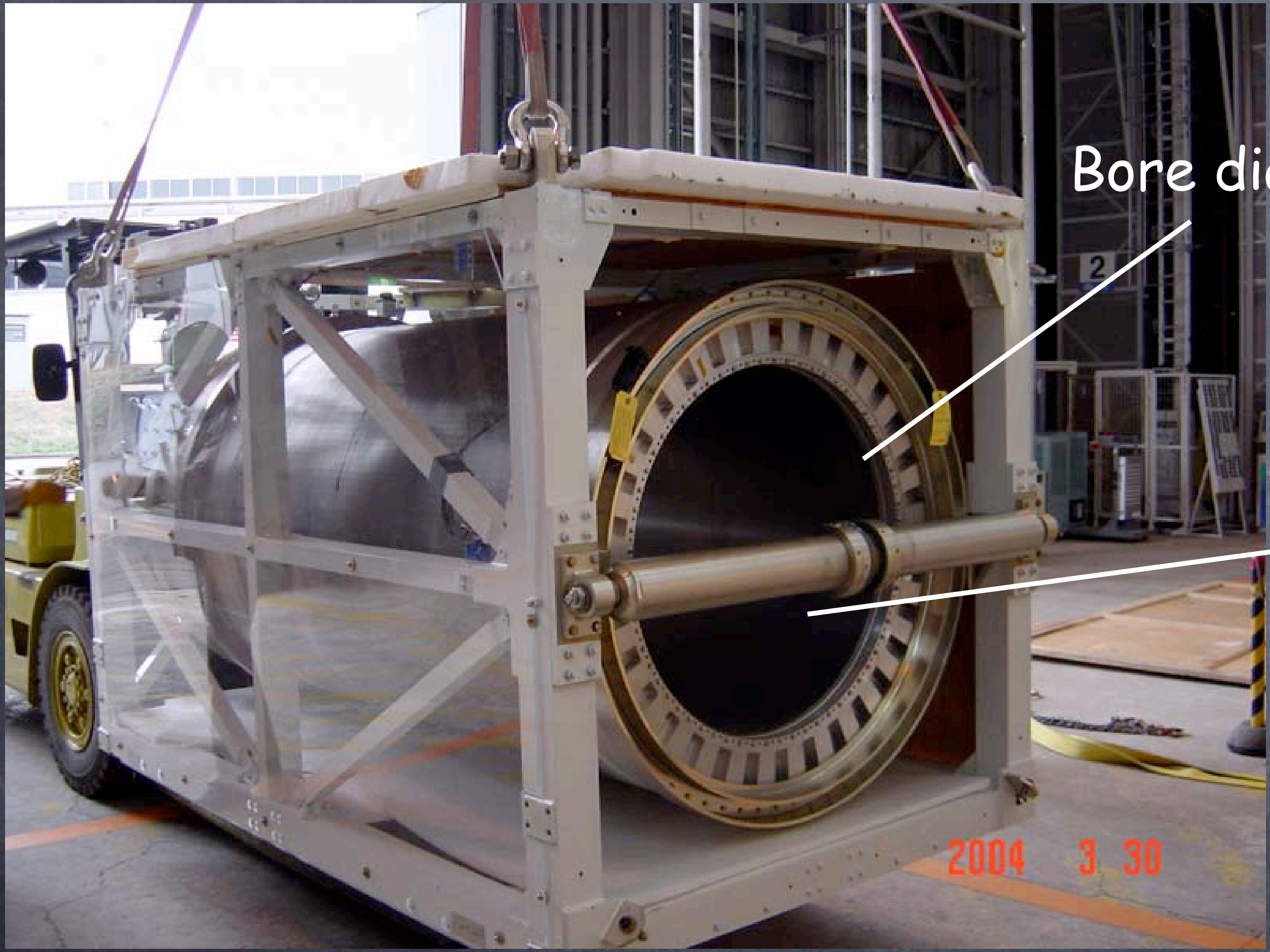
MPI TPC – GEM study
DRAFT

- Some minor modifications seems already necessary: More holes for the SHV connectors.
- 2 support frames for GEM can be built.



Under preparation at IPN Orsay!

Magnet (JACEE)



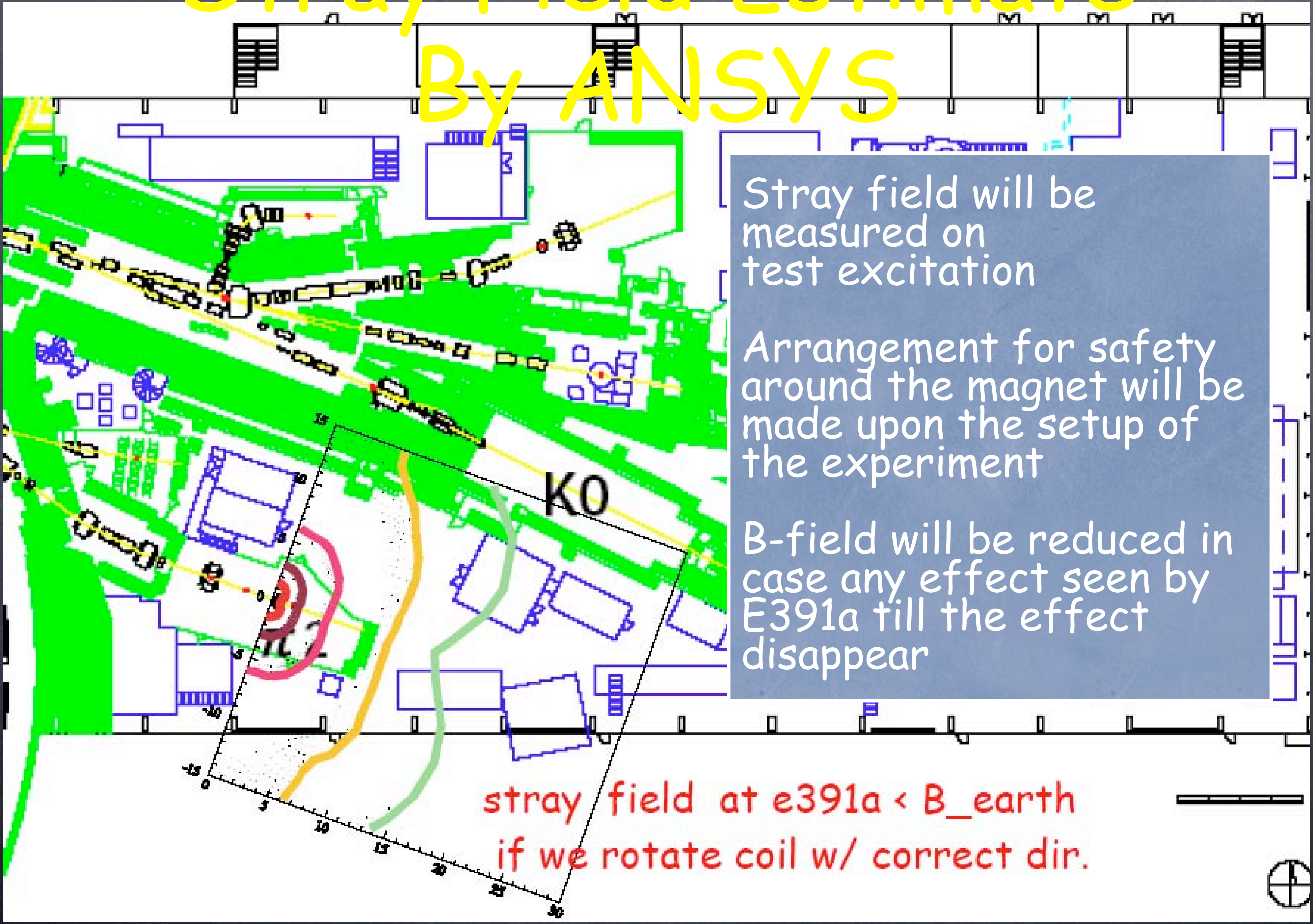
Bore diameter: about 80cm
Length: about 1m

B up to 1.2 T

Field Uniformity
< 1.3% in R
< 0.4% in Z
in the TPC region

Now being checked out for cooling and excitation with great helps from the KEK cryogenic group !

Stray Field Estimate By ANSYS



Stray field will be measured on test excitation

Arrangement for safety around the magnet will be made upon the setup of the experiment

B-field will be reduced in case any effect seen by E391a till the effect disappear

Running Plan for the Machine Time

Overview of Data Taking Procedure

- MWPC-TPC Run
  - Tuning of setup, electronics, daq at B=0T
  - Beam energy, angle, position, p, intensity dependence at B=0T
  - Same at B=0.5 and 1T
- Replace MWPC by MPGD and refill LHe
- MPGD-TPC Run
  - Repeat the same measurements with MPGD

Machine Time Request = 40 Shifts

- Setup and Tuning --> 6 shifts
  - Need to spend enough time at the beamline to make sure that the magnet and the new readout system are working properly.
- MWPC-TPC Run --> 720 pts x 10min --> 15 shifts
  - 6 positions x 5 phis x 4 thetas --> 120 pts
  - 2 different beam intensities --> x 2
  - B = 0, 0.5, and 1T --> x 3 --> 720 pts
- MPGD-TPC Run --> 720 pts x 10min --> 15 shifts
- The other type of MPGD/Contingency --> 4 shifts