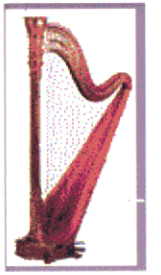

Harp

A hadron production experiment for the neutrino factory

NuFact'00 Workshop
May 22-26 2000
Monterey,California

M.G. Catanesi
INFN Bari-Italy

European R&D program towards the neutrino factory

- ✔ The *HARP* experiment at CERN PS (approved feb. 2000)
- ✔ Measurement of the large-angle scattering of low-momentum muon in liquid hydrogen
- ✔ Study of high-power (MW) targets
- ✔ Study of RF cavities in strong magnetic fields and under strong irradiation

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86 persons, 20 Institutions, 9 countries

Main deliverables of Harp will be:

- Input to Neutrino factory/muon colliders design
- Input to Atmospheric neutrino fluxes calculation
- Precise predictions of the neutrino fluxes for the k2k and MiniBooNE experiments
- Increase of reliability of hadron generetors in MonteCarlo simulation packages

Aim: hadronic $d\sigma/dP_t/dP_l$ - various beams and targets

- High statistics $O(10^6)$/"settings" & Low systematics errors

Goal: 2% accuracy over **all** phase space

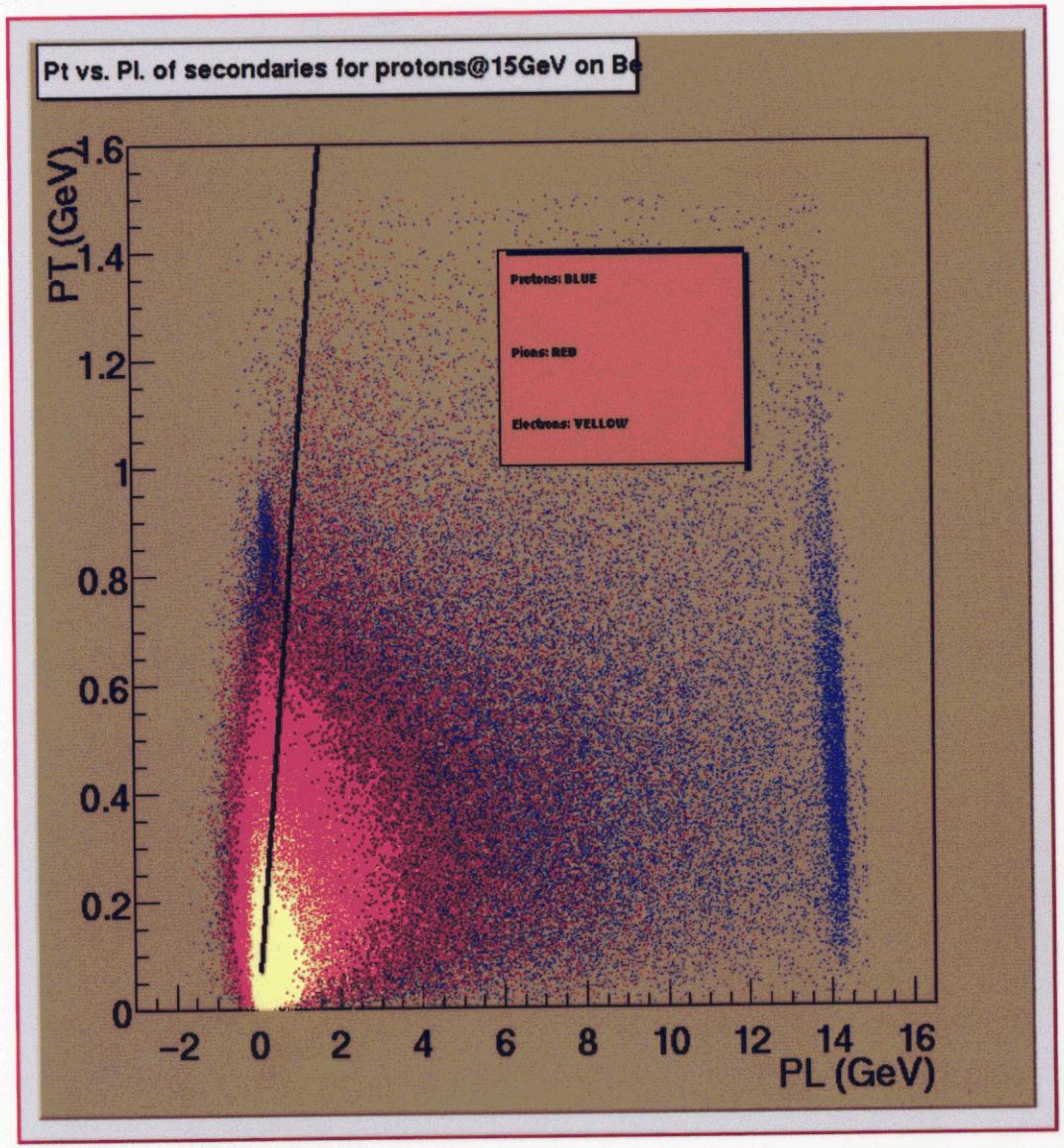
Stage I: proton/π beam in the range 2-15 GeV/c, multiple solid + cryo targets
Stage II: Additional (cryogenics) targets and additional Deuterium/Helium beam
Stage III: 15-100 GeV/c beams (SPS)

The experiment exploitation requires:

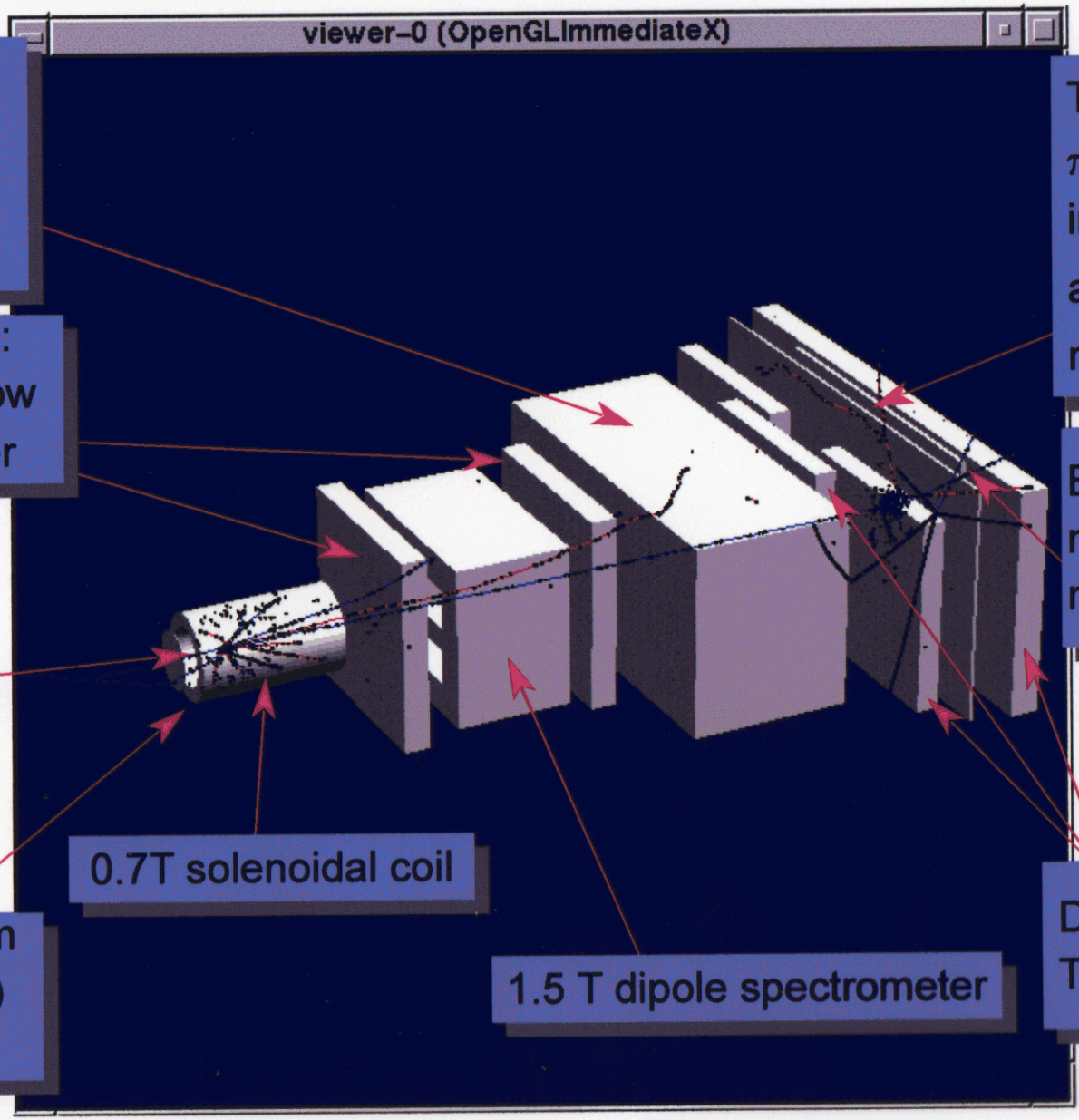
Momentum evaluation over 2 decades
(100 MeV-10 GeV)

Large acceptance
(even backward)

p/π separation
K/π separation
electron/π separation



The detector: *Acceptance, PID, Redundancy*



Threshold gas Cherenkov: π identification at large P_l

Drift Chambers: Tracking and low P_t spectrometer

Target-Trigger

TPC, momentum and PID (dE/dX) at large P_t

0.7T solenoidal coil

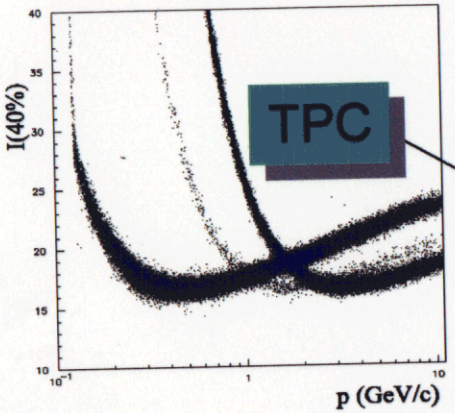
1.5 T dipole spectrometer

TOF: π identification in the low P_l and low P_t region

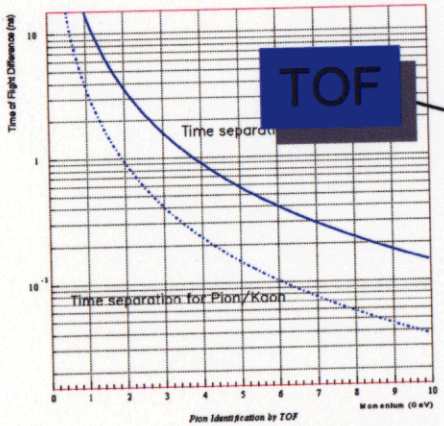
EM filter (beam muon ID and normalization)

Drift Chambers: Tracking

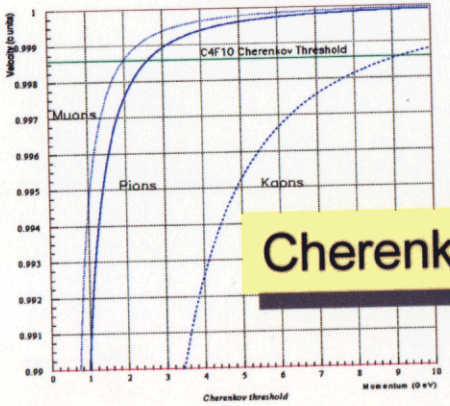
An example of PID redundancy in the Pt- Pl plane



TPC

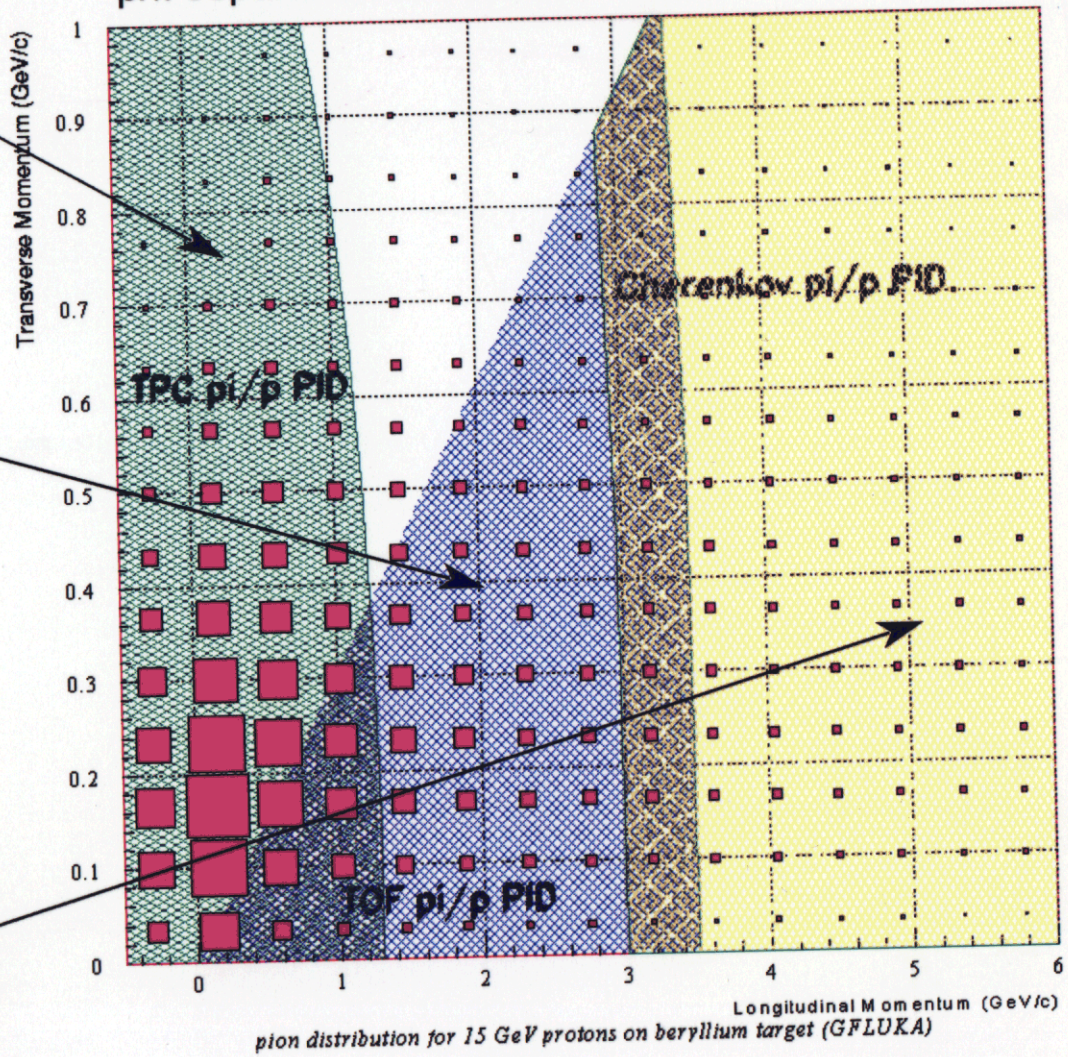


TOF



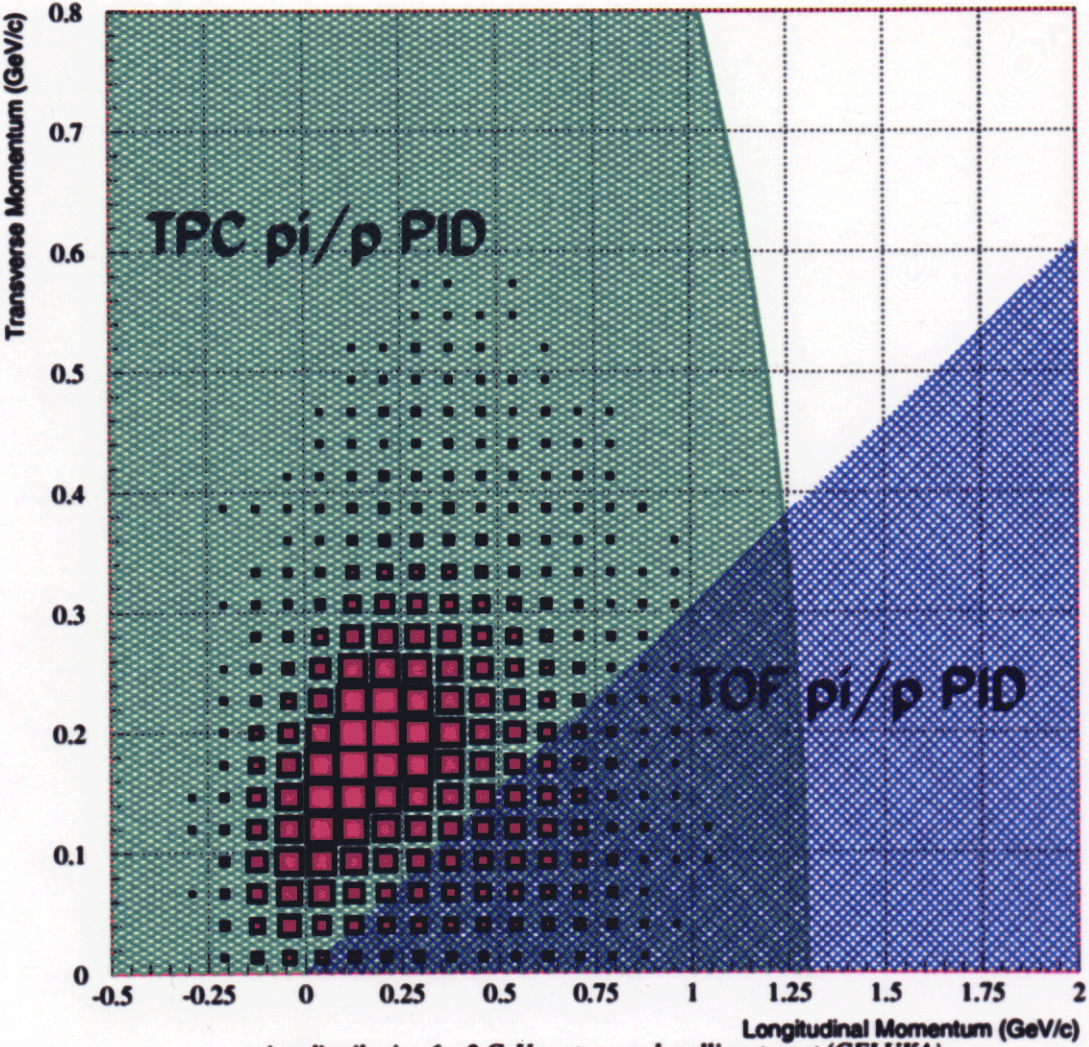
Cherenkov

p/π separation at 4σ level, "conservative" simplification

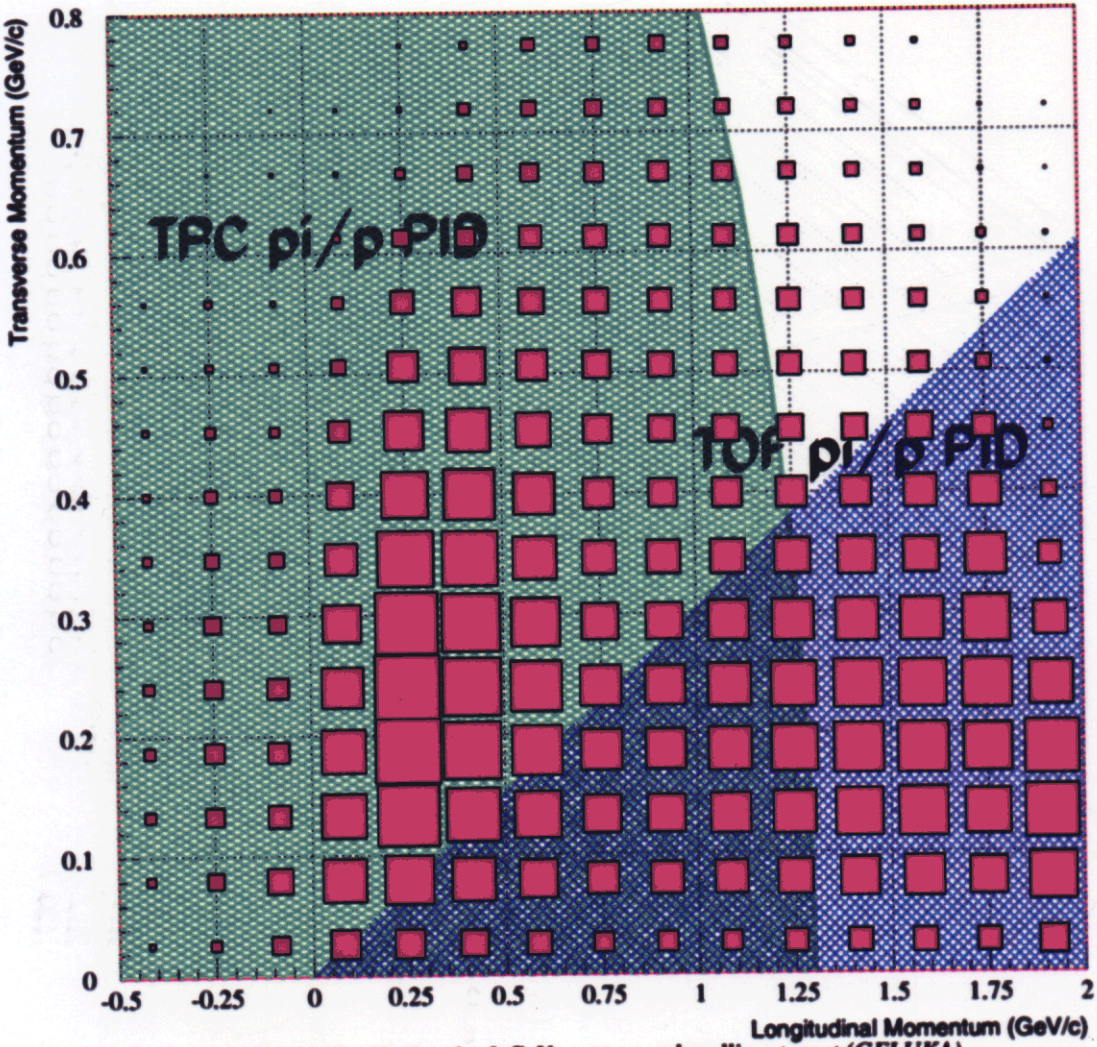


pion distribution for 15 GeV protons on beryllium target (GFLUKA)

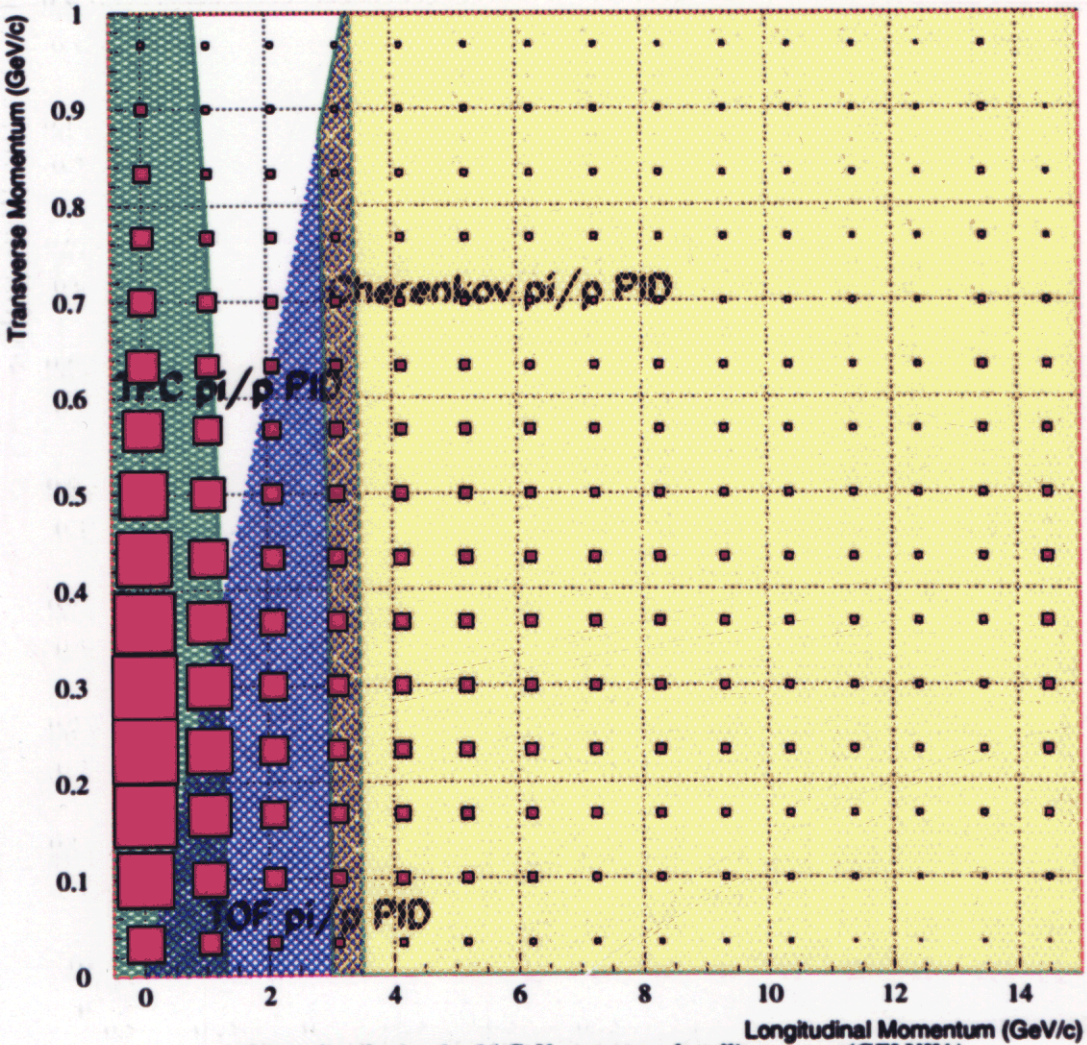
Pt-Pl box plot of π distribution from 15 GeV p on Be thin target



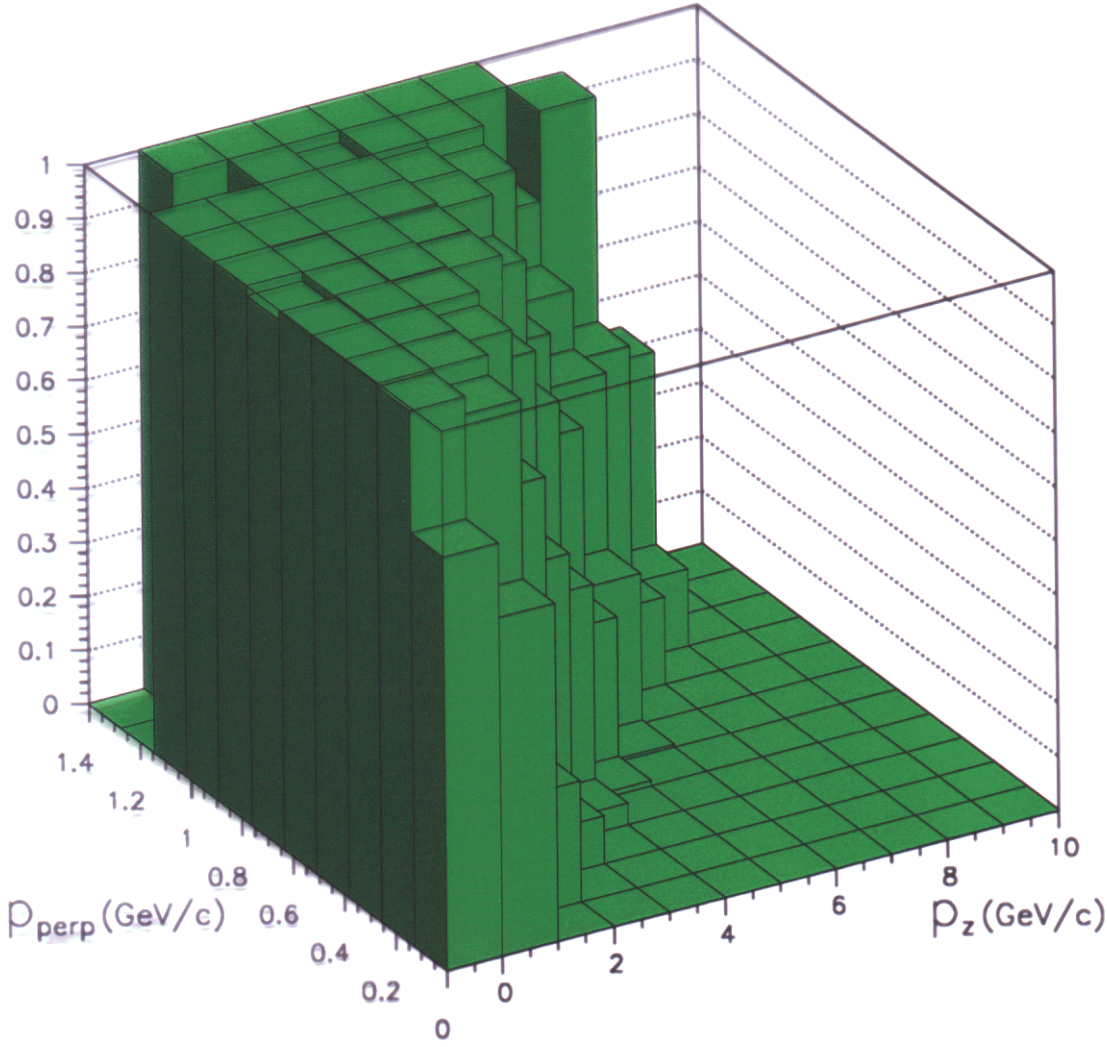
pion distribution for 2 GeV protons on beryllium target (GFLUKA)



proton distribution for 2 GeV protons on beryllium target (GFLUKA)



proton distribution for 13 GeV protons on beryllium target (GFLUKA)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0.6
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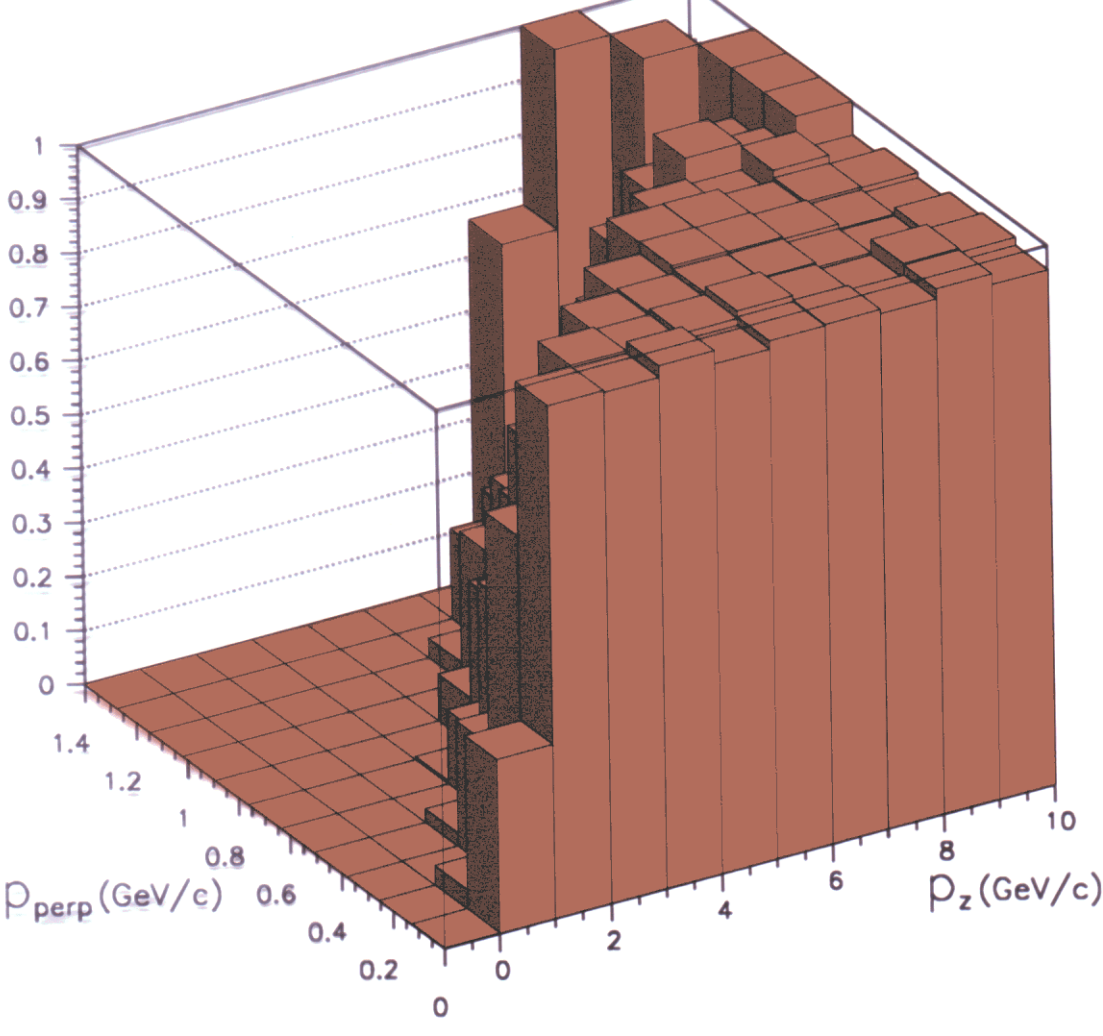
0.3
0.2
0.1
0
1.4
1.2
1
0.8
0.6
0.4
0.2
0
p_{perp} (GeV/c)
0
2
4
6
8
10
p_z (GeV/c)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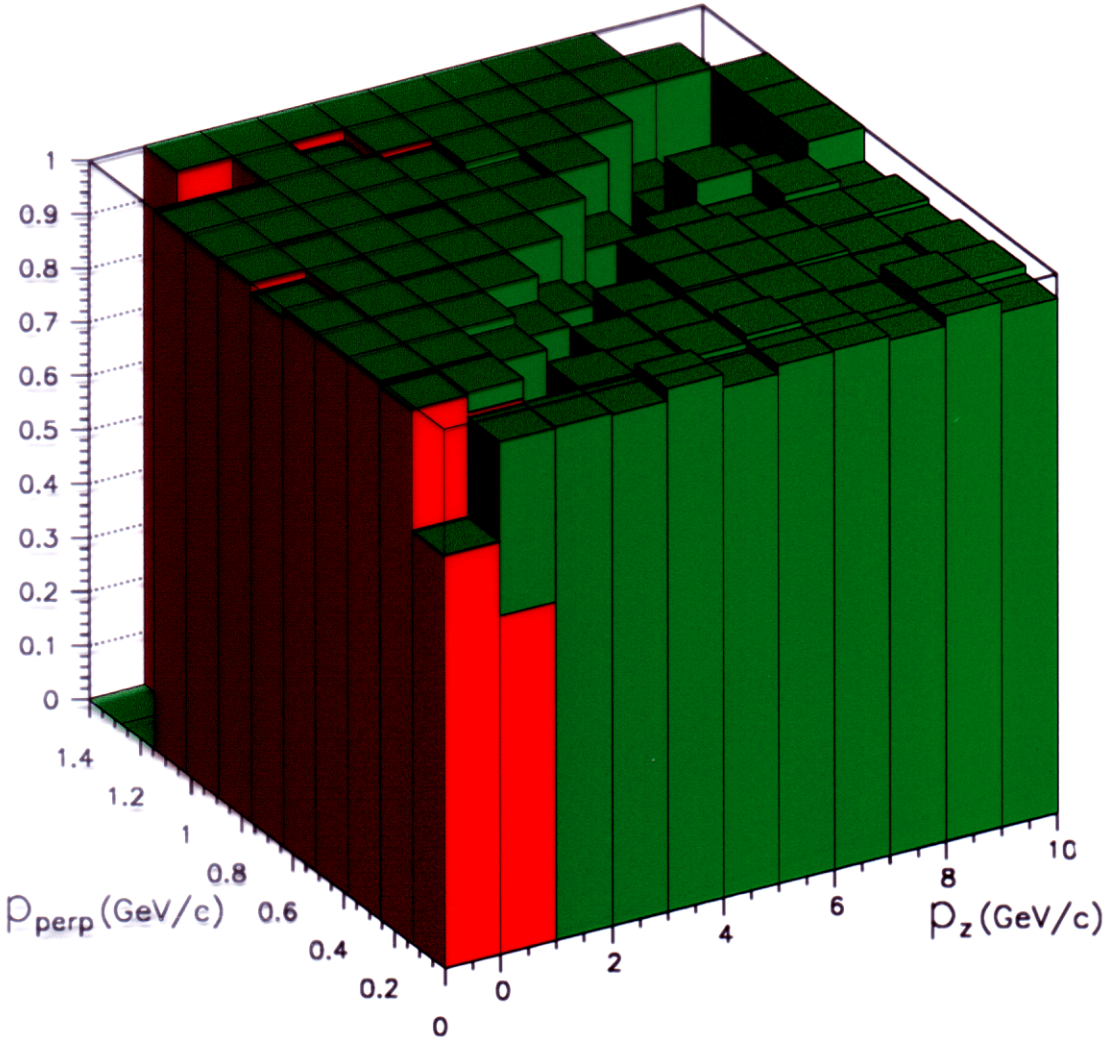
1
0.8
0.6
0.4
0.2
0
p_{perp} (GeV/c)
0
2
4
6
8
10
p_z (GeV/c)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p_{perp} (GeV/c)
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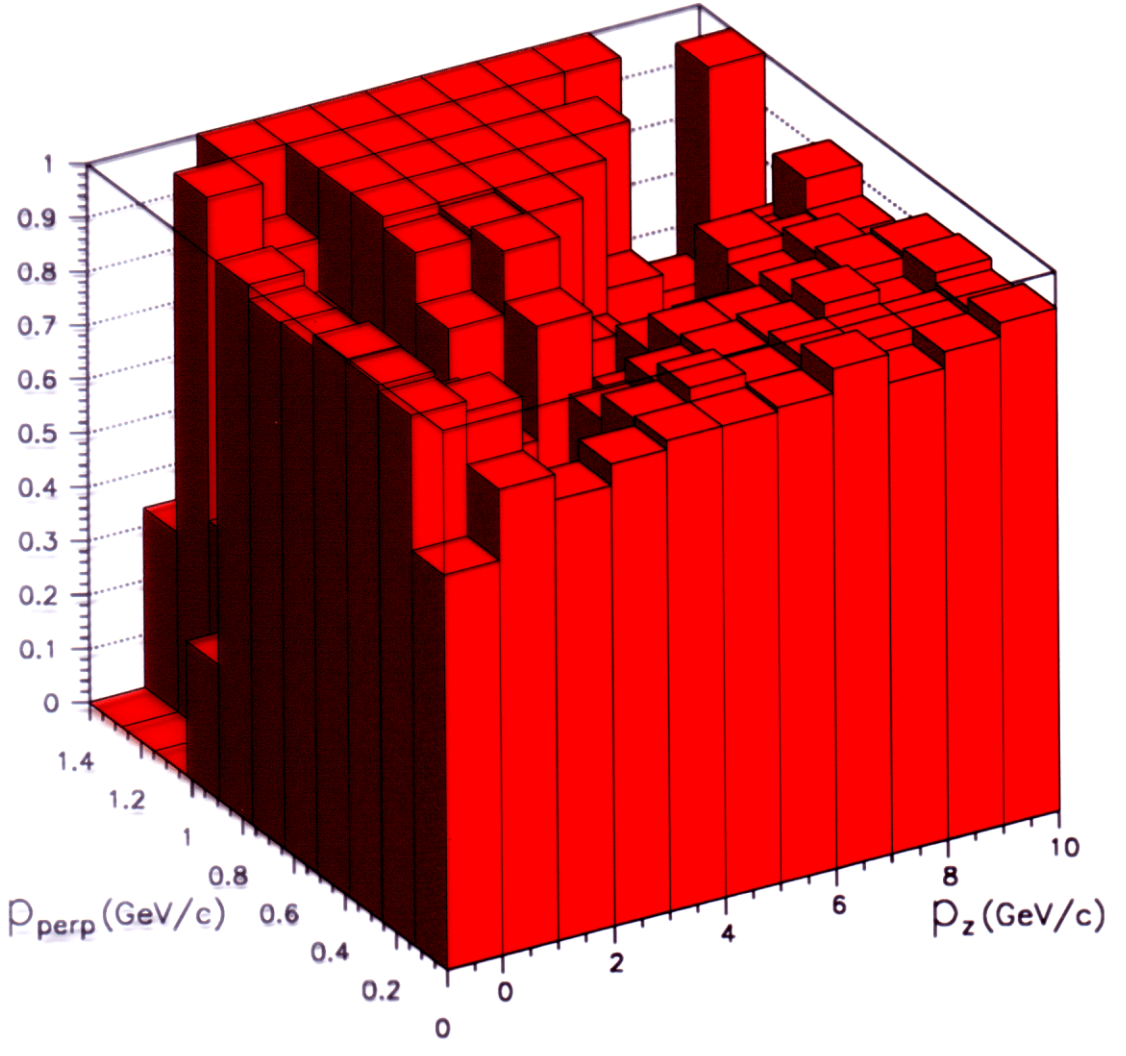
p_z (GeV/c)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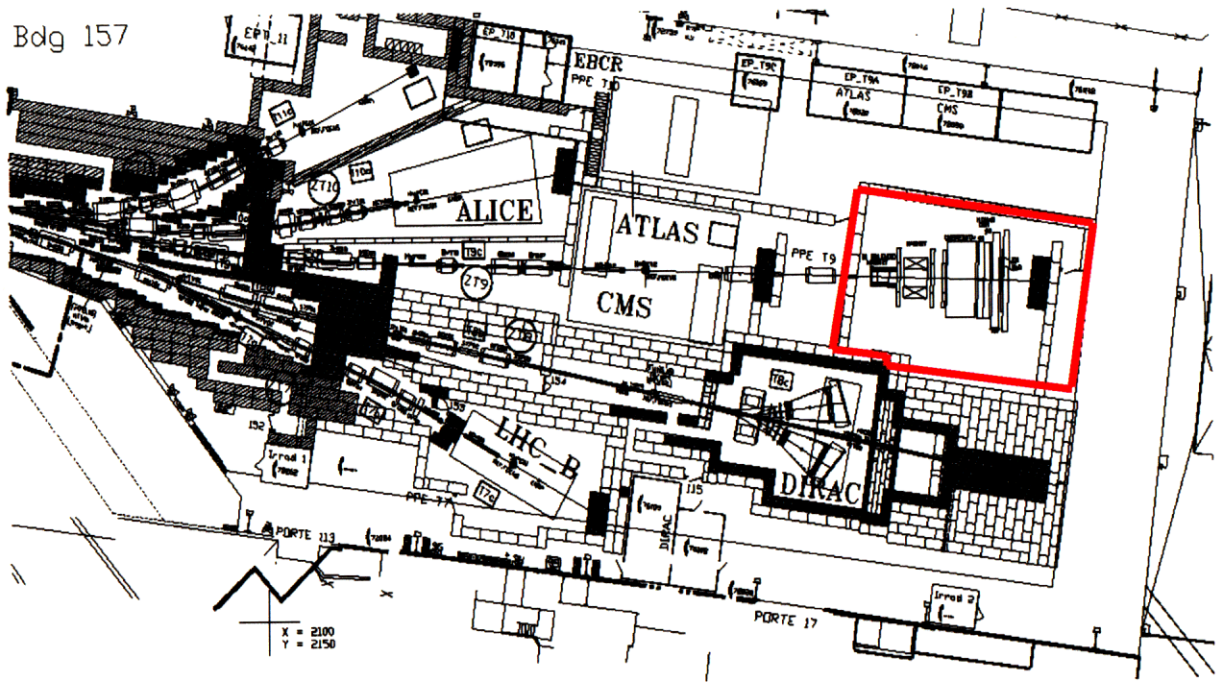
1.2
1
0.8
0.6
0.4
0.2
0
p_{perp} (GeV/c)
0
2
4
6
8
10
p_z (GeV/c)

Infrastructures

PS East Hall



- Experimental Hall available until end of 2001
- Subdetector assembling space defined

Beam Line

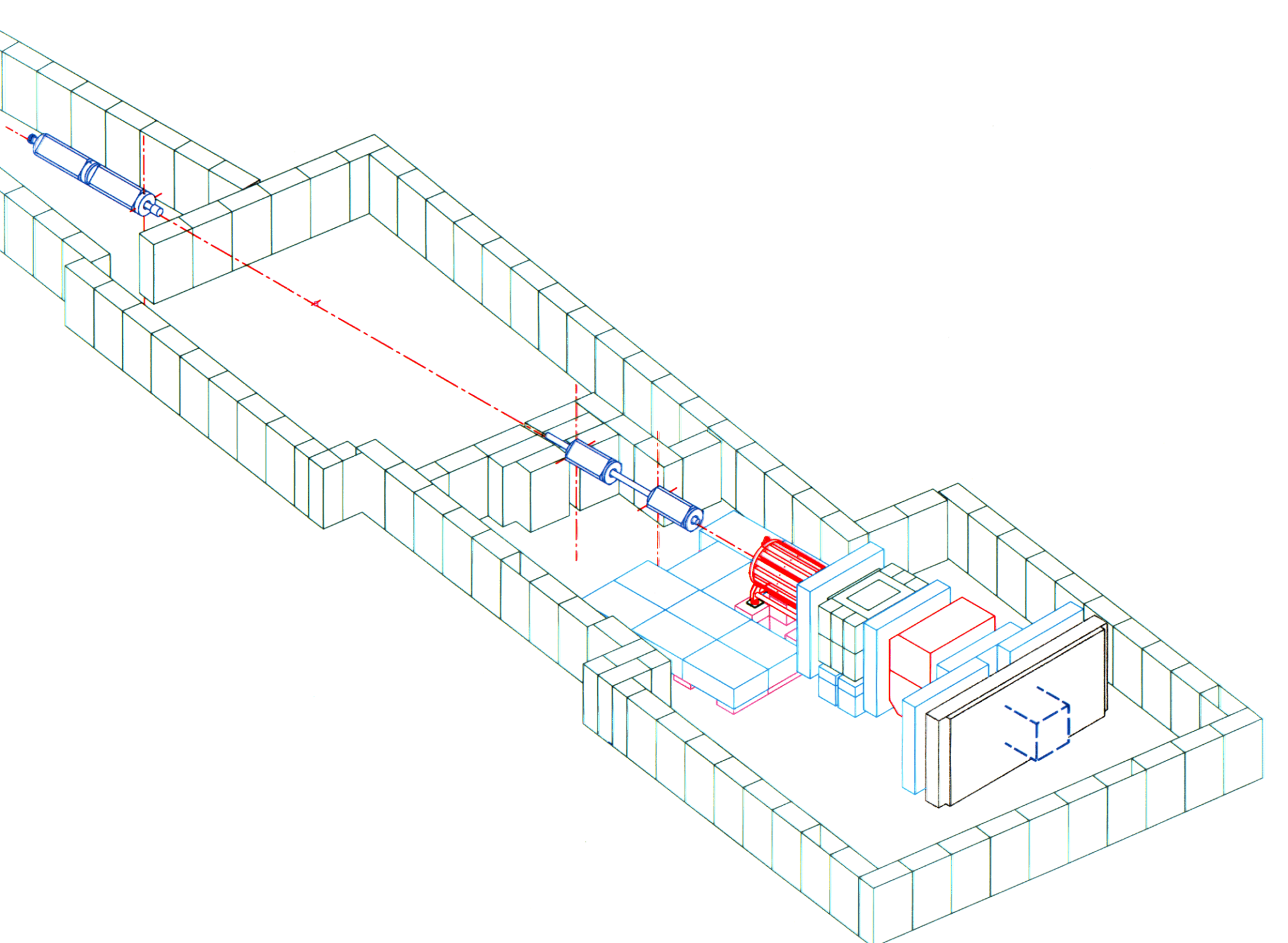
➔We will use the T9 beam line @ PS

➔ The energy range (1.0 \15.0 GeV) with a momentum resolution of 0.24 % is good

➔ the flux of protons and pions of ~10^5 per spill is adeguate

➔Beam optics design (PS/CA/99-027): ~5x5 mm2 beam

➔ Beam instrumentation checked and upgraded (XMWC+TOF+C for beam purity/normalization)



TARGETS

- **General**: covering a range of elements

Solid Material	Thin Target (cm)	Thick target (cm)
Be	0.81	40.70
C	0.76	38.00
Al	0.79	39.44
Ni	0.30	
Cu	0.30	15.00
Sn	0.45	
Ta	0.22	11.14
W	0.19	
Pb	0.34	17.05

Criogenic	(cm)
H_2	14.36
D_2	6.76
N_2	2.18
O_2	1.59

Specific Targets
(only for certain projects)

Neutrino Factory	Li,Ni,Ta,Hg
K2K	60cm Al rod
MiniBooNe	65cm Be rod
(Minos)	76cm C or Be rod

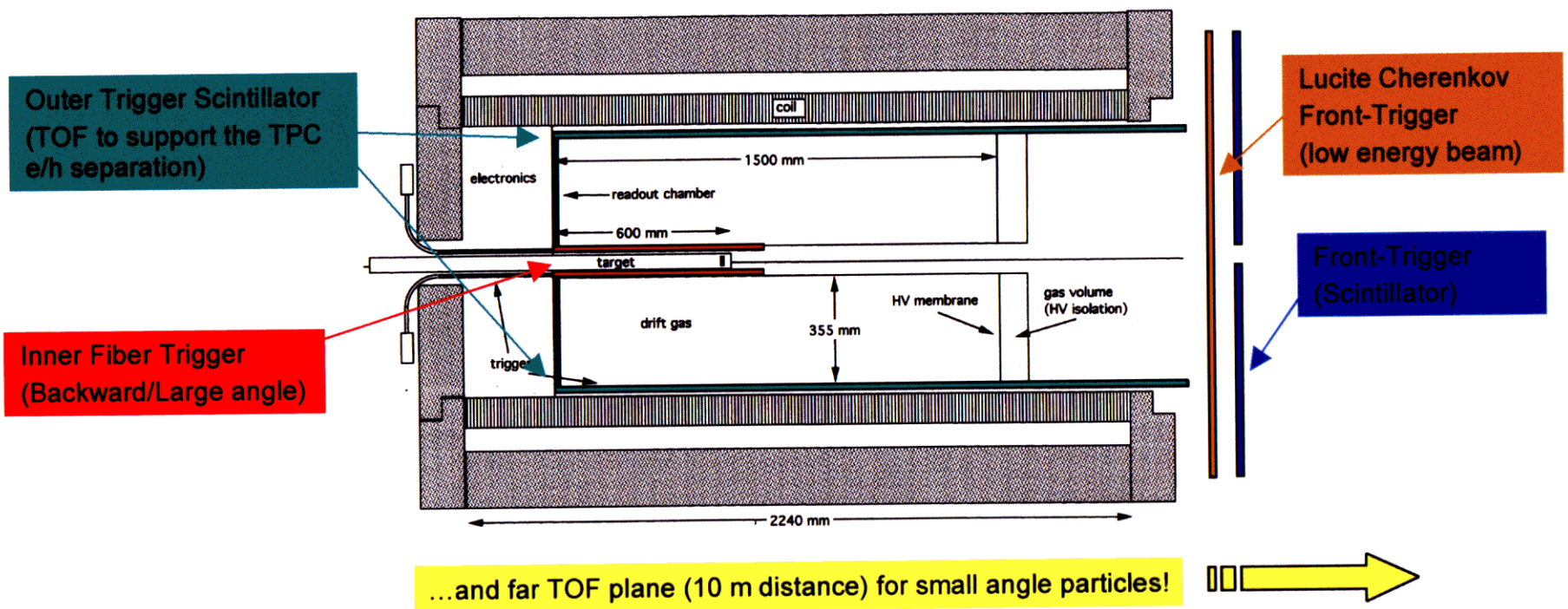
The design and prototyping for the support plate + internal support for trigger fibres was realised.

In particular two support plates are required:

- thin and thick targets
- K2K and MiniBooNe targets

Trigger

- Trigger: internal (sci-fibs) AND external. TOF AND Cherenkov.



Magnetic/Electrostatic Field studies

Yoke opened on one side and longer

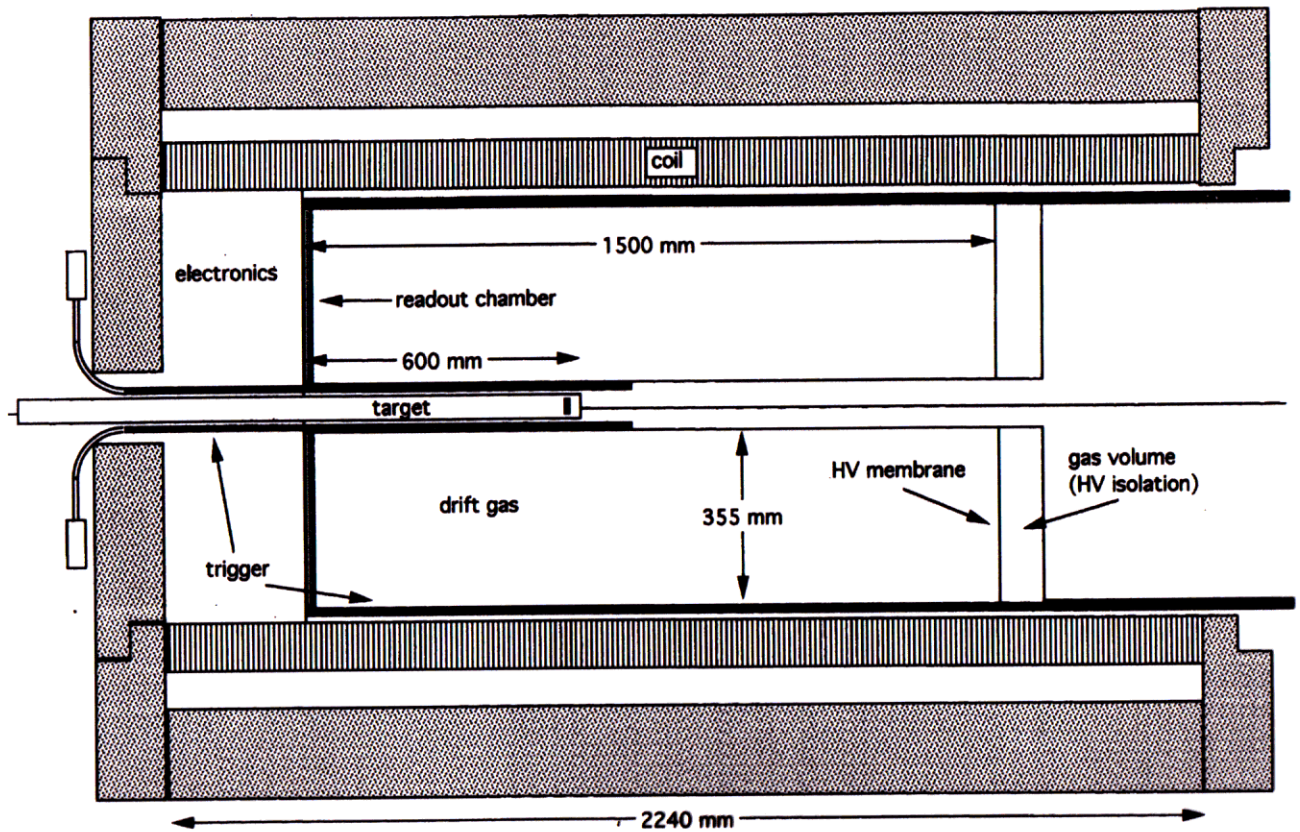
New Internal cage, all along the TPC

New pad plane/HV membrane

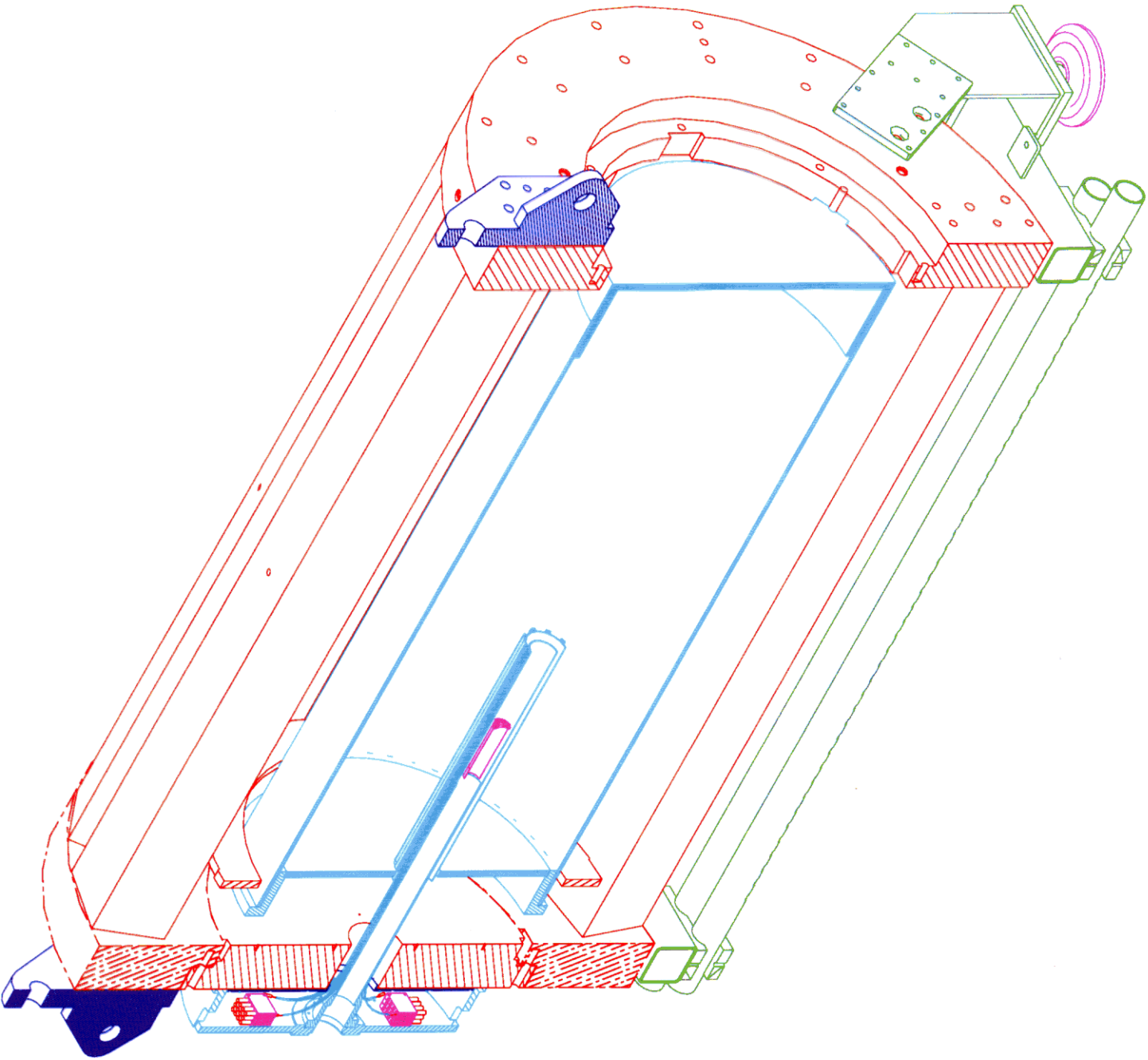
New pad geometry

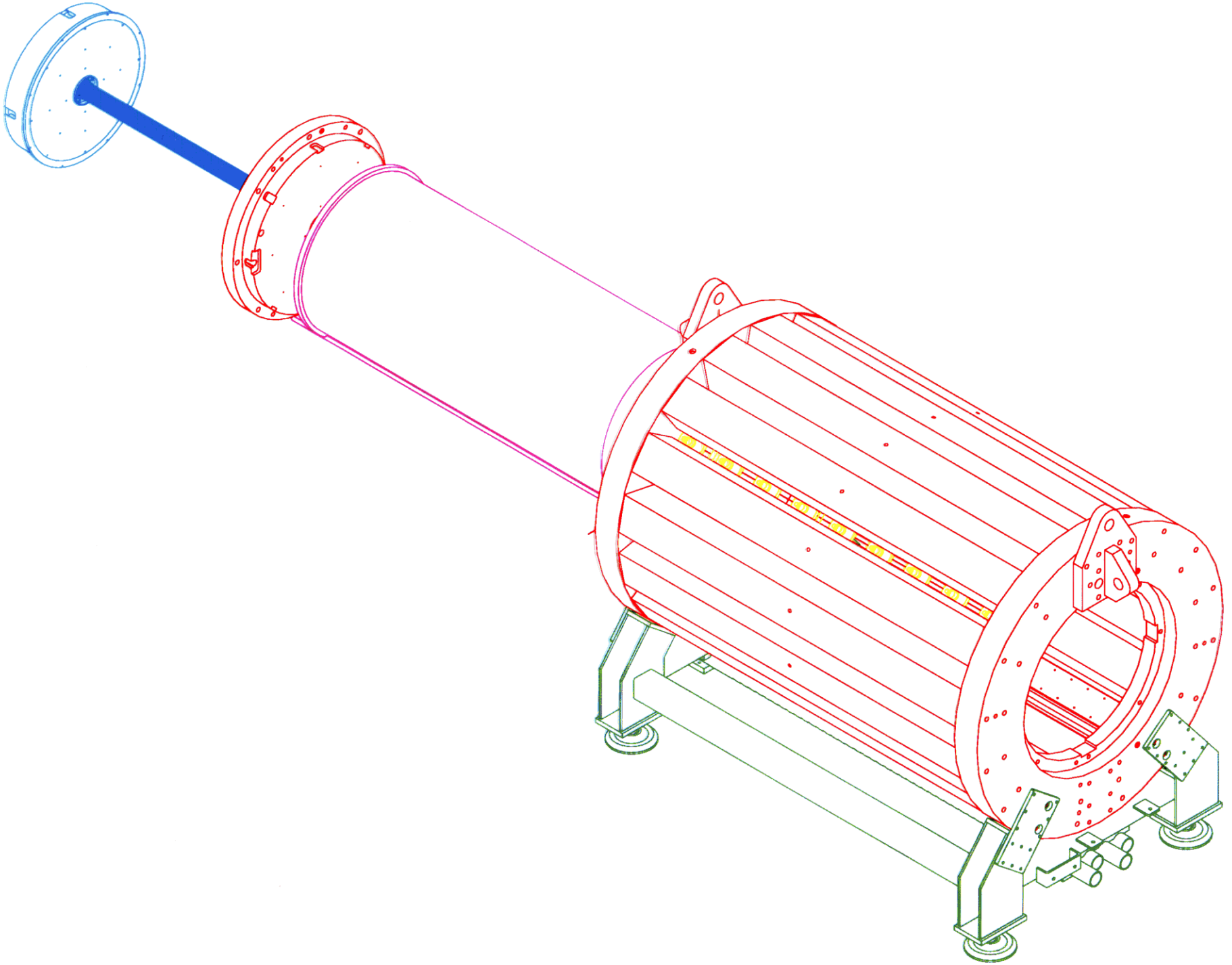
The TPC project status

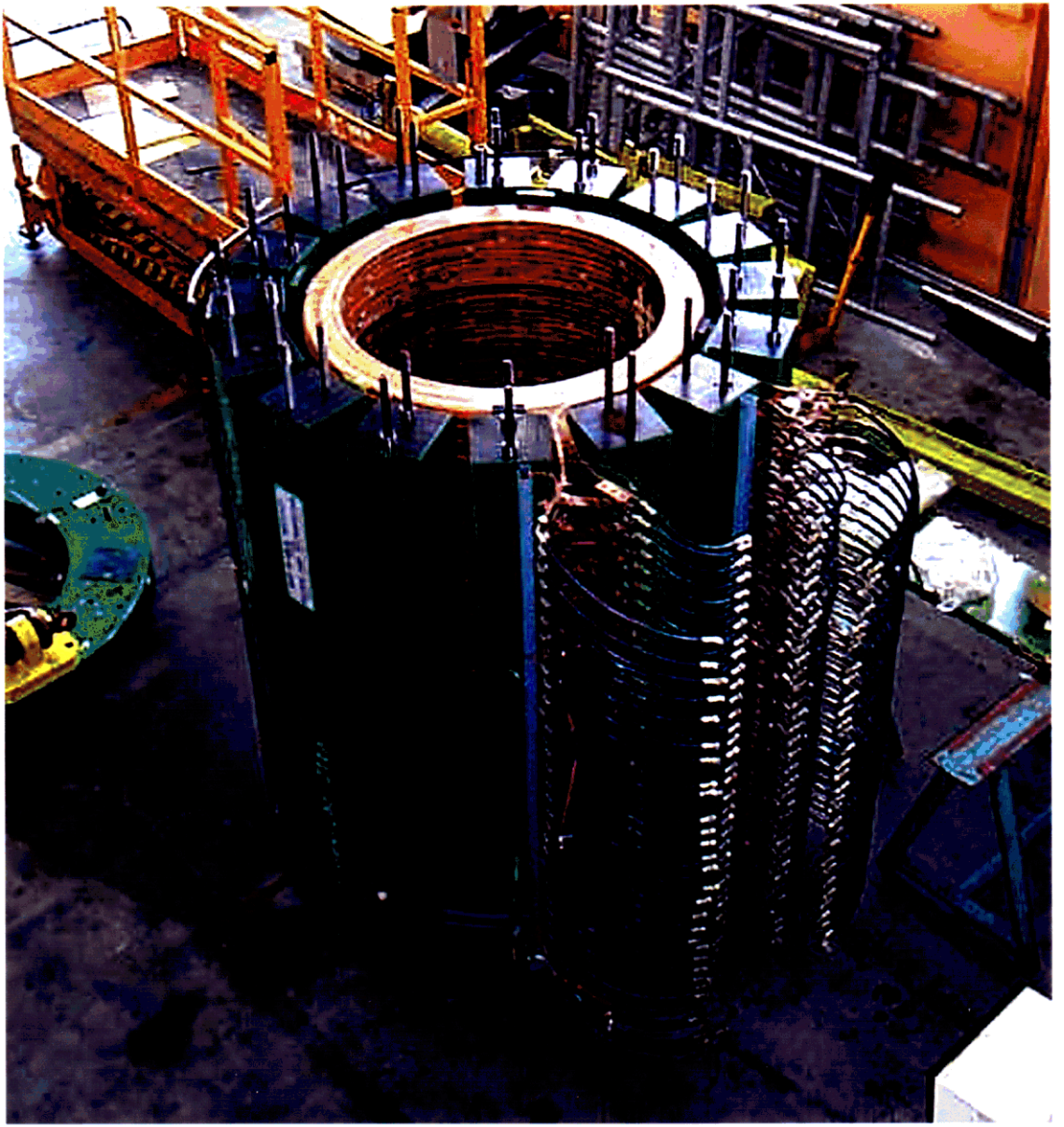
Upgrades of ALEPH TPC90 based on existing experience.



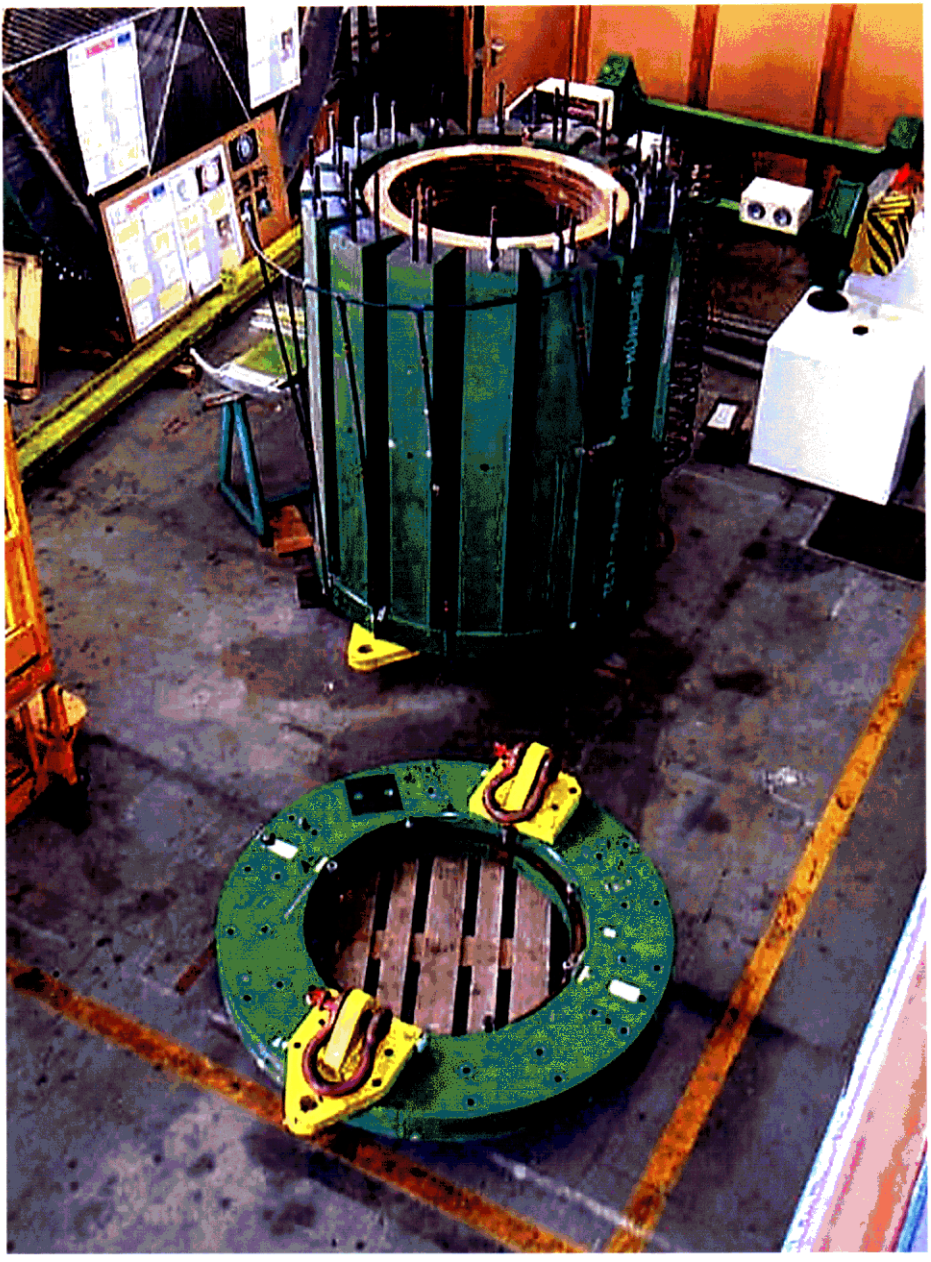
dE/dx Res~6%







HARP TPC magnet 5 May 2000



HARP TPC magnet 5 May 2000

R&D "The TPCino"

Our TPC should work in a high rate ~ 10^3 Hz
(ex Aleph few Hz)

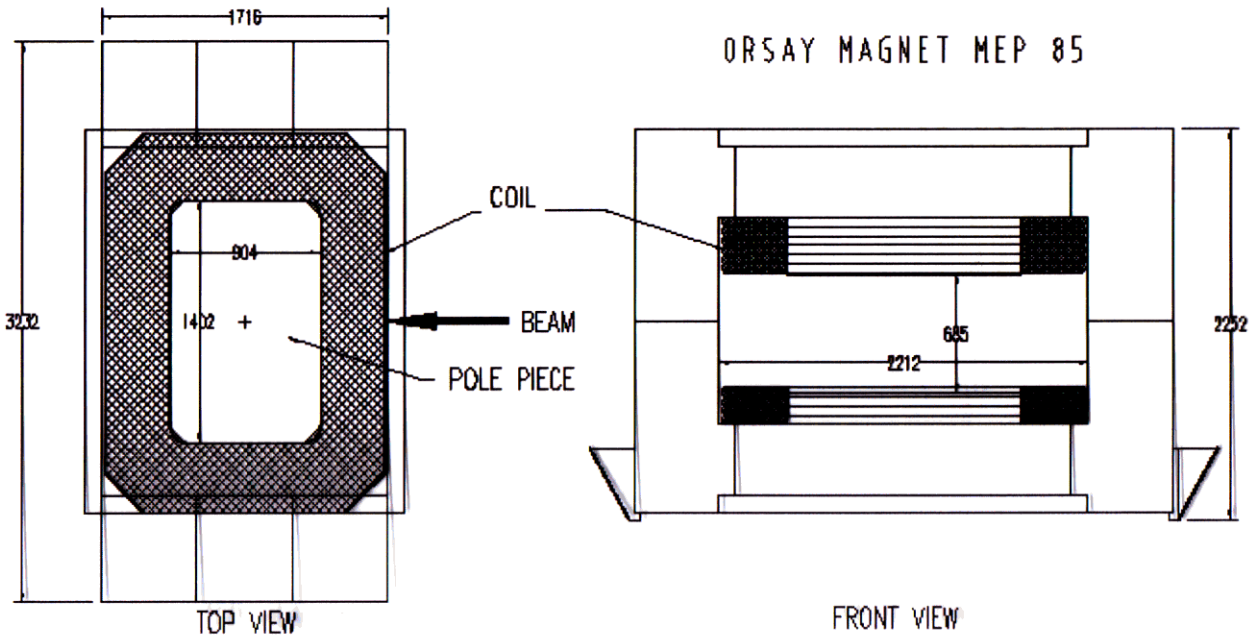
To test a full chain of the electronics: preamplifier + Front-End Digitizer Card (FEDC: 10MHz ADC + programmable 0-suppression + memory) developed for the ALICE TPC a small prototype (~5x10 cm) equipped with the a full electronic chain (24 channels) was made

→ **Results availables soon !!**

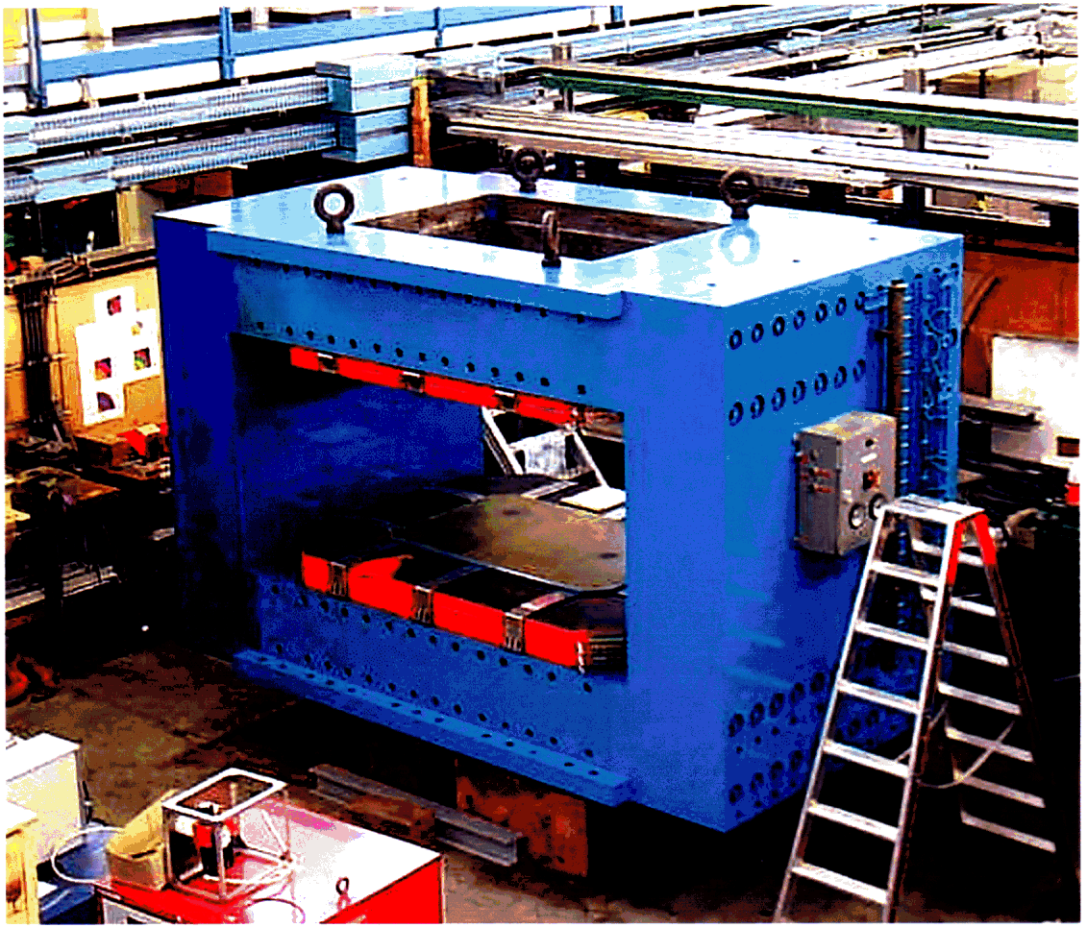
Forward Spectrometer

- ✔ "Orsay" magnet (change of orientation) ready for test
- ✔ Nomad Drift Chambers ready to be re-operated

Field =1.5 T



Spectrometer magnet HARP
5 May 2000

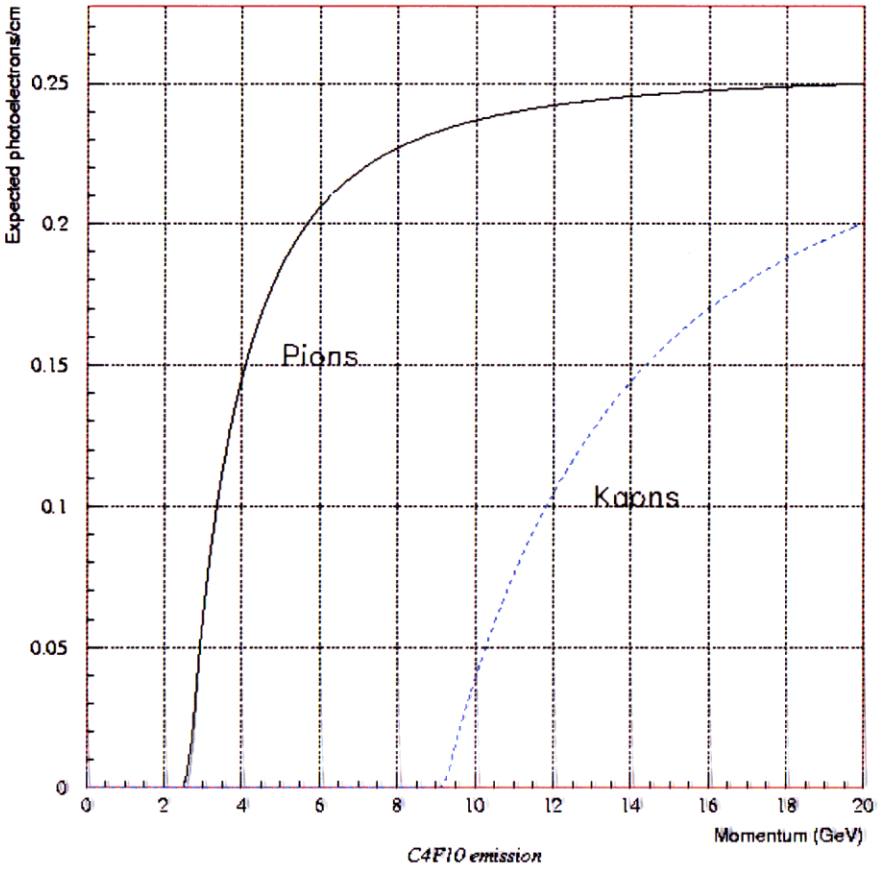


To be finished:
Coil fixation, connections, controls.

Will be mapped in the East Hall
during the summer

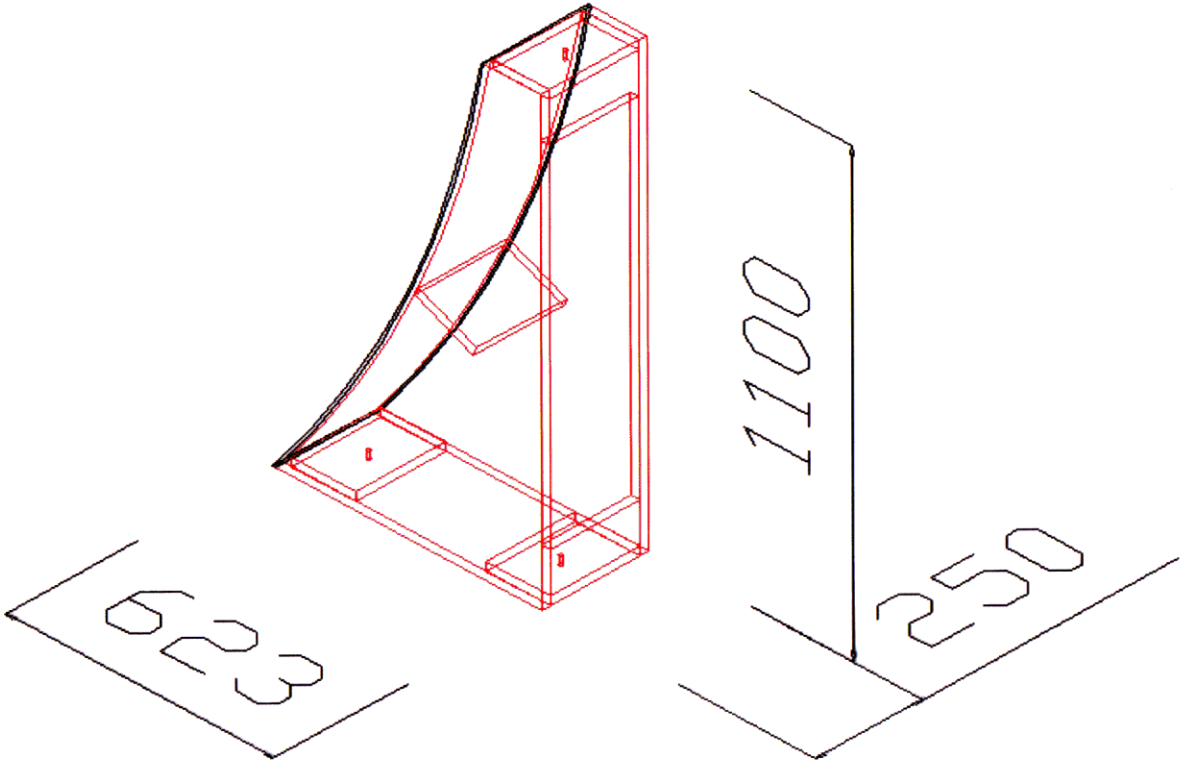
Cherenkov Design

- C_4F_{10} threshold mode
- 34 Chooz PMs EMI 9356KA
- Electron background occupancy simulation vs. granularity
- PM shielding requirements
- Mirrors/focussing design scheme (and technology)
- mechanical structure designs



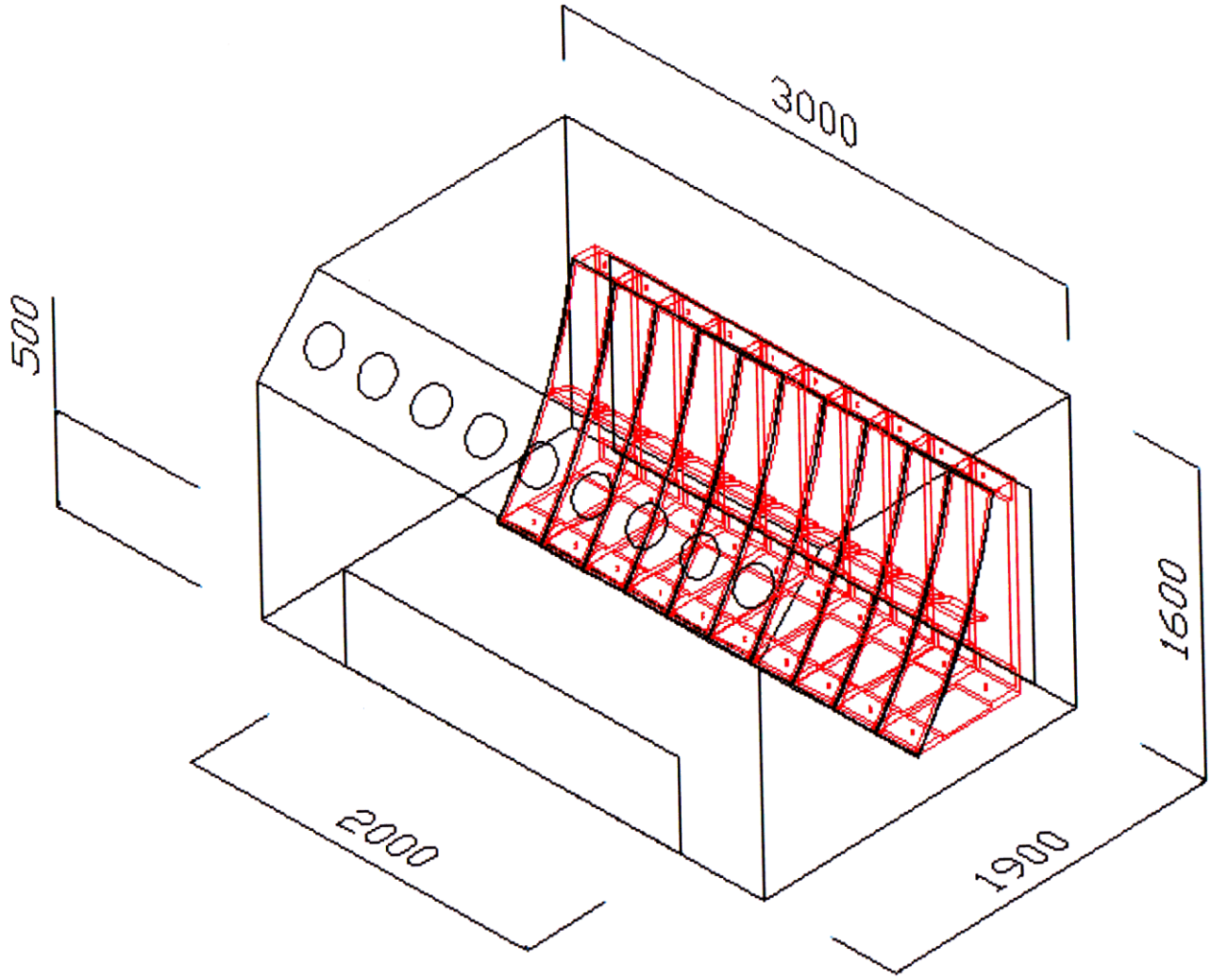
Cherenkov Design

Prototype mirror element



Cherenkov Design

Upper half



Volume=9 m^3

TOF - eId

The **TOF** wall will be made using the scintillators of a previous experiment (~ 300 ps)

A new geometry was designed

A new Laser calibration system is under development

The **eID** will be made reusing some chorus pb/scintillating fiber modules

Software Design:

From the Software point of view, an experiment crossing the FORTRAN/OOP centuries is a DIFFICULT experiment!

but we decided to look at the future :

Single-Platform: **LINUX** (Online & Offline)

C++ for Online/Offline

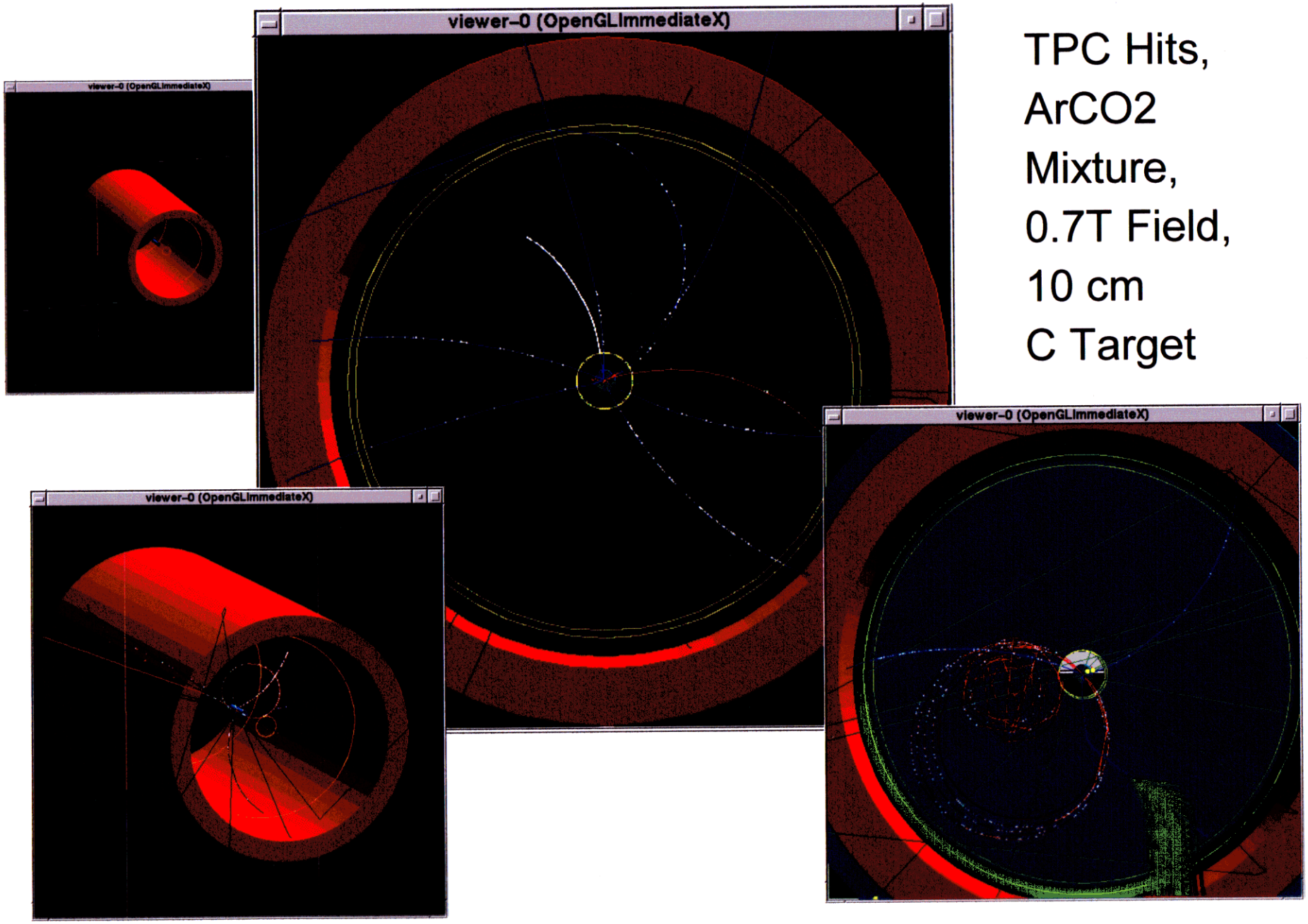
OBJECTIVITY as DB

GEANT4 as simulation tool

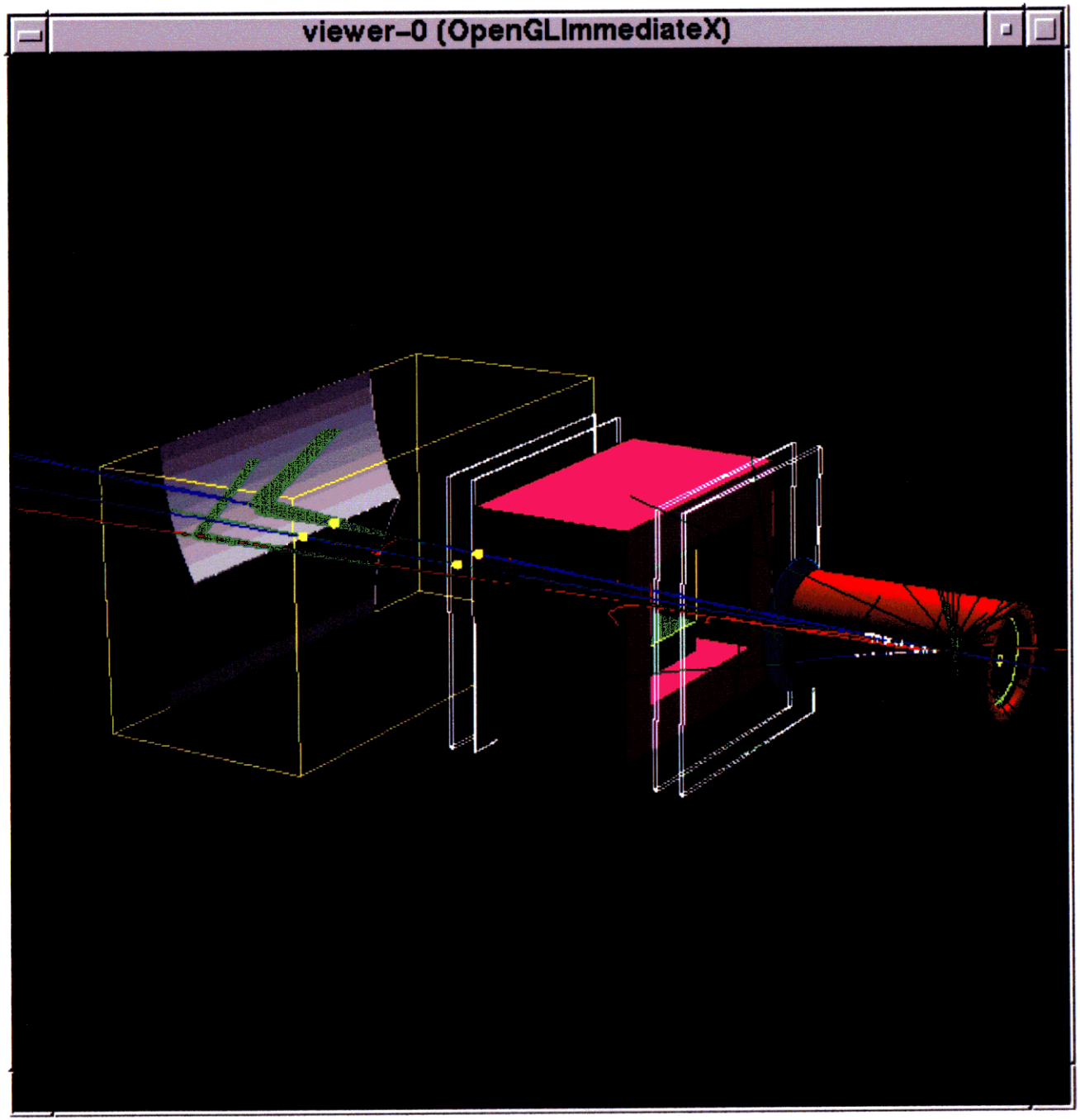
ROOT as analysis frame

Comment: non negligeable data rate!! ~ 30 Gb/Hour

Prototype of the TPC simulation in the GEANT4 framework



TPC Hits,
ArCO2
Mixture,
0.7T Field,
10 cm
C Target



Cherenkov Simulation

C4F10 Gas Volume

Polarized photon generation

Rayleigh Scattering

Optical Absorption Length

Aberrations (spectral n)

5mm Plastic Walls

Fresnel refraction
(polarization included)

Alu Mirrors spectral efficiency

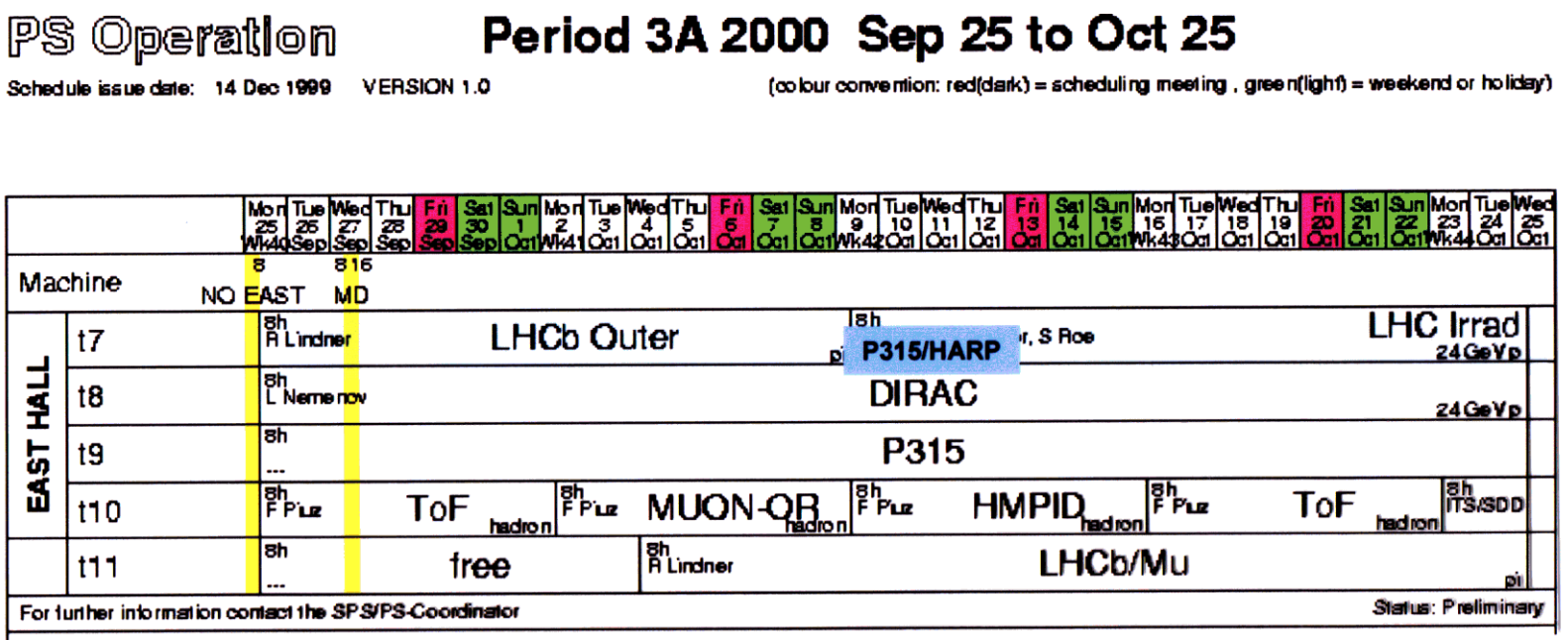
Multi-Hits:
- InGoing particles
- Mirror Hit
- Outgoing Optical Photon

Technical Run in Oct 2000:

- Hardware operational except TPC and Cherenkov;
- Beam operational;
- DAQ skeleton operational;

to achieve:

- commissioning of the beam over the full momentum range, with intensities and particle compositions understood;
- straight track data for alignment purposes and detector calibration;



Harp design and construction is advancing rapidly for all the subdetector and projects

Our schedule is very ambitius!

Technical run 25 september / 25 october 2000

Data taking 2001

Plans for a Phase II with D and He beams in the first half of 2002