CERN/SPSC 2000-009
SPSC/M651
March 21, 2001

Memorandum

To: Members of the SPS Committee

From: CERES/NA45 Collaboration

Subject: Status of the CERES/NA45 experiment and plans for 2000

The CERES/NA45 experiment [1] is dedicated to the measurement of low-mass e^+e^- pairs in proton and ion-induced collisions at the SPS. The main result from this experiment was the observation of a significantly enhanced production of lepton pairs with respect to expectations based on hadron decays, in the mass range $250 < m_{ee} < 700$ MeV/c^2, in ion-induced collisions [2, 3, 4]. The experiment was upgraded [5] in 1998 by the addition of a radial TPC with an additional magnetic field in order to improve the mass resolution in the ρ/ω region to $\Delta m/m$ <2%.

The upgrade was commissioned during the 1998 heavy ion run and about 10 k complete events were collected in the so-called *slow readout* mode (1 event/burst). The data were used to map the electric field inside the TPC and to establish that the spatial resolution was in accordance with the design values ($\sigma_{r\phi} \sim 300\,\mu m$). The major results of the commissioning run have been reported at Quark Matter '99 [6].

In 1999 the upgrade was completed by the implementation of the electronics and data acquisition for the so-called *fast readout* (1000 events/burst) of the experiment. Although laboratory tests of individual components of the readout chain were successful at an early stage, the entire readout became operational only during the heavy ion run.The experiment was finally running under stable conditions about halfway into the run, at which point several days were lost due to 'critical days'. The performance of the individual detectors was good with only 2.5% missing channels in the silicon drift detectors, usual operation of the RICHes, and less than 1% dead channels in the TPC with an overall system noise of 1100 electrons. However, even under stable running conditions several errors in the readout chain (eight custom designed modules) could not be resolved, leading to part

of the recorded information being corrupted; this will partially be restored in the offline analysis (efficiencies of the various detectors are quoted below). Because of its large data volume the TPC was most severely affected by this deterioration. On average only about 65% of all channels could be successfully decoded. All data were taken using central data recording. The operation of central data recording with a total of seven receiving nodes was very stable, working at a sustained bandwidth of 30 MB/s.

About 15 million centrally triggered Pb+Au events were accumulated with a centrality of $\sigma_{top}/\sigma_{tot} \simeq 35\%$. Out of these, about 12 million events were taken under stable conditions. The trigger was derived from one of the silicon drift detectors of the experiment. Owing to the larger beamspot at 40 AGeV/c and pileup from delta electrons, it contained about 25% of non-target interactions. This results in about 9 million events for the e^+e^- pair analysis. In a first step of the analysis, the single track efficiencies of the various detectors have been determined in a preliminary fashion:

detector	96	99
SDD	0.94 * 0.88	0.97 * 0.97
RICH	0.81 * 0.86	0.95
PADC	0.96	-
TPC	-	0.6
total	0.55	0.54

As compared to 160 AGeV/c the overall number of charged particles is estimated to be about a factor of 1.6 smaller for the selected range of impact parameters. Under the assumption that the number of lepton pairs per charged particle stays constant with regard to the results at 160 AGeV/c [4], the expected number of e^+e^- pairs is estimated to be about 270 for electrons with $p_t > 200$ MeV/c. Since the rejection power for the main background (π° Dalitz decays) is expected to be much better in 1999 (no magnetic field between the RICH detectors), it is believed that the transverse momentum cut can be lowered to $p_t > 100$ MeV/c resulting in about 1070 e^+e^- pairs [1]. At the same time, the background is expected to significantly improve at 40 AGeV/c given the reduced multiplicity of charged particles. In addition, the electron analysis can now be based on the combined identification of electrons from both RICHes, resulting in increased efficiency, as well as better background rejection.

The expectations from these considerations can be compared to the results obtained in 1995 and 1996. Taking the statistical fluctuations of the background into account, the effective signal S_{eff} is defined as $S_{eff} = S/(1 + 2B/S)$, where B is the number of background pairs and S is the number of signal pairs, defined as $S = N_{e^+e^-} - 2\sqrt{N_{e^+e^+} \cdot N_{e^-e^-}}$. In summary:

[1] Previous results [4] imply that much of the enhancement in the di-electron yield is concentrated at low transverse momenta.

Dataset (pt cut)	Signal	B/S	S_{eff}
92 S (200MeV)	445	4.3	46
95 Pb (200MeV)	648	8	38
96 Pb (200MeV)	2018	13	75
99 Pb (200MeV)	270	3	36
99 Pb (100MeV)	1070	4.5	107

Given the above mentioned statistics for the 1999 run, it will probably not be possible to exploit the significantly improved mass resolution of the setup. However, based on the above table, it should be possible to derive a measurement of the enhancement of e^+e^- pair production above $p_t > 100$ MeV/c at the expected higher baryon density at 40 AGeV/c, comparable in quality to the 1996 data.

Planning for 2000

Analysis

A full Monte Carlo of the new setup is being developed in parallel to the data analysis of the 1999 run. Calibration of the individual detectors and geometric alignment of the spectrometer are well under way. Detailed calculations of the complex electric field in the TPC have been performed using MAFIA and are currently being refined with a different approach in Dubna. With the precise map of the magnetic field, the final momentum calibration of the spectrometer can be verified using decays of long-lived resonances (K°_s, Λ); this is expected to be accomplished within the next three months. The first production of a data sample containing electron pairs will take about six weeks and is planned to be finished by the middle of July. At that point, the e^+e^- pair analysis will proceed by optimizing background rejection and determination of all experimental efficiencies. This will be aggressively pursued in order to produce first results in time for Quark Matter in January 2001.

Further, analysis of the data on a reduced subset of the data concentrates on hadronic observables, i.e. particle spectra and flow, identification of resonances via hadronic decays, and identical particle correlations.

Run Preparation

The collaboration is currently faced with the departure of the two main designers of the front-end electronics. Given the prevailing problems of the *fast readout*, it was decided to adopt a modified readout scheme for the TPC in order not to endanger the successful running of the experiment in 2000. The readout chain for the silicon detectors and RICHes is currently being debugged and will be kept unchanged. The error-prone components in the readout chain of the TPC, i.e. the optical links from the motherboard to the receivers as well as the receivers themselves will be replaced. The modified TPC readout will use a VME-based system,

which was originally designed for ALICE [7] and is currently also being adapted for use in HARP. All modifications are prepared in close collaboration with the developers in EP.

In detail, a modification of the TPC FEE cards is necessary. A linear buffer will be implemented on each card. They will drive additional cables from the detector into dedicated VME crates in the experimental area, where the multiplexed signals from the frontend electronics are digitized. All detector mounted electronics has been dismantled and complete reassembly is expected to conclude before the beginning of SPS operations at the end of April.

On the side of the VME readout the electronics also needs to be modified to cope with the large data volume of the CERES TPC. All components have been ordered and the complete readout chain should be ready for beam tests by the end of June. Following the changes in the readout scheme the data acquisition system will be adapted accordingly.

In order to decrease deadtime a new, scintillator-based, trigger detector will be implemented in the target area.

All detectors as well as the electronics and data acquisition system should be fully operational for the proton run at the end of August. Estimates based on results of the 1998 160 AGeV/c run show that, with the highly parallel readout scheme CERES/NA45 should be able to record central collisions of Pb+Au at a rate of 200 Hz. This will ensure a successful completion of the experimental program as outlined in the proposal [5].

Beyond 2000

CERES/NA45 would like to keep the experimental setup in its location in H8 beyond the end of 2000. Depending on the outcome of the data analysis and possible new theoretical arguments, it is expected that a decision on any possible further operation of the experiment will be made in 2001.

References

[1] CERES Collaboration, Proposal to the SPSLC, CERN/SPSLC 94–1/P280,CERN/SPSLC 88-25/P237, CERN/SPSLC 88-25/P237, Add. 1.

[2] G. Agakichiev et al., CERES Collaboration, Phys. Rev. Lett. 75 (1995) 1272.

[3] G. Agakichiev et al., CERES Collaboration, Phys. Lett. B422 (1998) 405.

[4] G. Agakichiev et al., CERES Collaboration, Nucl. Phys. A654 (1999) 627c; Nucl. Phys. A661 (1999) 23c; detailed publication in preparation.

[5] CERES Collaboration, Addendum to the Proposal to the SPSLC, CERN/SPSLC 94–1/P280, CERN/SPSLC 96–35/P280 Add. 1.

[6] A. Marín et al., CERES Collaboration, Nucl. Phys. A661 (1999) 673c.

[7] L. Musa et al., Proc. of the 4th Workshop on Electronics for LHC Experiments, CERN-LHCC-97-60.