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SMALL-ANGLE PHYSICS AT ISABELLE*

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INTRODUCTION

ISABELLE will be commissioned a few years after the $\bar{p}p$ colliders, whose plans and first results have been presented here. A look at the design goals for ISABELLE (Table I) reveals that the two salient features offered in compensation for the later turn-on are high luminosity and ($2 \times 10^5 - 10^6 \text{ mb}^{-1} \text{ sec}^{-1}$) and the number of intersections available for physics (6).

Table I. ISABELLE Design Parameters

Luminosity:	$2 \times 10^{32} - 1 \times 10^{33} \text{ cm}^{-2} \text{ sec}^{-1}$
Energy:	400 GeV per beam
Insertions:	Number: 6
	Length: $\pm 30 \text{ m}$

We have seen ample reconfirmation during this conference of the need for high luminosity. With expected Z^0 detection rates of in UA1,¹ it is clear that all but the most rudimentary features of the standard picture will remain obscure until ISABELLE-like luminosity is available. Some nonstandard models will be hard to distinguish from the standard one until high statistics can be accumulated above the masses of the standard vector bosons.

The availability of a relatively large number of intersections at ISABELLE means that there will be room for some highly specific setups which can capitalize on the high luminosity in high-precision or rare-process studies. This is the case in the forward direction, where ISABELLE can make room for two different approaches:

1. Completion of the forward direction of large solid-angle general purpose detectors.

2. Dedicated small-angle setups.

In this paper we discuss the present state of plans at ISABELLE to accommodate these two approaches. We touch on Experimental Area designs, conceptual designs for experiments, and a few topics in detector development. It should be kept in mind that as of this writing, there has not been a call for ISABELLE proposals; thus detailed plans have not yet been made.

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EXPERIMENTAL AREAS

Figure 1 shows the ISABELLE site plan with six experimental areas, numbered 2,4,6,8,10 and 12 for their clock-face positions. Table II lists the dimensions of the four halls (2,4,6,8) presently under construction. Areas 10 and 12 are to be designed and built after proposals are in hand.

Table II. Dimensions (In Meters And Tons)
Of The Four Experimental Areas So Far Designed

Area	Length	Width	Beam Height	Crane Hook Ht / Capacity
2. Small Angle				
Central Hall	28	12	1.7	6.1/20
Forward Experimental Building	68	7.9	1.7	5.3*
"Stub"	91	2.4	1.0	2.0*
4. Open Area	57 ⁺	37 ⁺	2.2	---*
6. Wide Angle	16	32	4.3	10/2x20
8. Major Facility				
Central Hall	19	15	5.2	11/40
Forward Exp. Bldgs. (2)	16	9	3.3	6.6*
Assembly Building	19	19	5.2	11/40+14/7.5

*No crane initially - ceiling height given

+Pad dimensions given

CONCEPTUAL DESIGN OF FORWARD ANGLE DETECTORS AT ISABELLE

With regard to forward angle physics two of the existing halls merit more detailed discussion. Major Facility Hall 8 (Figure 2) is equipped with extensions to the central research hall designed to house large forward-angle additions to the central detector. Figure 3 shows a possible detector arrangement for the Major Facility Hall. Compensation magnets serve as momentum analyzers for fast forward particles.

Small Angle Hall 2 was designed specifically to house small angle or low p_T experiments of modest transverse dimensions but possibly of great length (see Figure 4). The length scale is conservative, being set by the requirements of threshold Cerenkov counters for particle identification. Table III lists experiments for which area 2 is a natural location. These are divided into high cross-section processes, which can be done early in ISABELLE's operation when luminosities are below design, and lower cross-section studies. The former can be compared to the corresponding

$p\bar{p}$ experiments at the SPS and Tevatron colliders; the latter can only be studied in detail at ISABELLE. Figure 5 shows a conceptual sketch of a forward multiparticle spectrometer which could be used in Area 2 to study the rare processes suggested in Table III.

Table III. Small Angle Experiments Possible in Experimental Area 2

I. Large Cross-Section Processes

Low luminosity (i.e. early) experiments
Inclusive processes
Comparisons with $p\bar{p}$

- Total Cross-section and Small Angle Elastic Scattering

$$R_{\text{tot}} + L + \sigma_{\text{tot}}$$

$$\left. \frac{d\sigma}{dt} \right|_{t \rightarrow 0} (0.01 \lesssim |t| \lesssim 0.1 \text{ GeV}^2)$$

$$\text{C-N Interference } (0.001 \lesssim |t| \lesssim 0.01 \text{ GeV}^2)^{\rho_{\text{tot}}}$$

- Elastic Scattering

$|t| \lesssim 0.5 \text{ GeV}^2$: s-dependence of the slope of forward peak

$0.5 \lesssim |t| \lesssim 2 \text{ GeV}^2$: s-dependence of the dip-peak structure

- Diffractive and Charge Exchange Processes

- Particle Production

Single particle inclusive production
s-dependence of $\langle n \rangle$, $\langle p_T \rangle$, y-distributions
Correlations
Multiparticle production

II. Small Cross-section Processes

Close to ISABELLE design L required ($>10^{31}$)

Sophisticated (i.e. high-rate, selective, finely-segmented) detectors also required

- Moderate-to-Large t Scattering

At 400 GeV/c $|t|=10 \text{ GeV}^2 \leftrightarrow 7 \text{ mrad}$

$|t|=100 \text{ GeV}^2 \leftrightarrow 25 \text{ mrad}$

} t-dependence of $\frac{d\sigma}{dt}$

- Multiparticle Production

Jet cross-section vs x, p_T
Correlations within jets
Glueballs
Diffractive production of new flavors
(forward lepton trigger)
Centrauro events, etc.

DETECTOR DEVELOPMENT

High luminosity, ISABELLE's strong suit, makes severe demands on detectors. Tracking and calorimetry devices will have to be fine-grained and capable of high rates. Particle identification devices must be capable of working at high energies and high multiplicities. All this is especially true for the forward angle components of ISABELLE detectors. We list here a few of the detector development schemes currently being pursued with ISABELLE in mind.

1. Forward calorimetry: Studies are underway² on the properties of proportional wire gas sampling calorimeters of high density. Prototypes with effective density equal to 90% the density of iron have been tested (see Figure 6). Good energy resolution has been obtained for electrons over a wide range of angles of incidence (see Figure 7); such a device could be incorporated in the pole tip or yoke of a central detector magnet.

2. Particle identification by transition radiation. This technique is enhanced by eliminating the track-associated energy loss (dE/dx) in the detector. Studies³ with a longitudinal drift cell in which clusters above a threshold are counted, rather than total charge accumulated, appear to demonstrate the feasibility of π/K separation down to $\gamma \lesssim 10^3$ (see Figure 8).

3. Particle identification by dE/dx . This method is enhanced by eliminating delta-ray-associated energy deposits. In a technique⁴ complementary to B above, the signal from a longitudinal drift cell is digitized in time bins. In this way the highly localized delta-ray energy can be eliminated, improving the discrimination between particle types via the relativistic rise of dE/dx .

4. Semiconductor detector arrays. These devices offer the prospect of very small element size and spatial resolution as a way of coping with the high energies and track densities in the forward regions.⁵ At present, studies are being done with 1-dimensional "microstrip" detectors. Figure 9 envisions a very high resolution 2-dimensional detector array with onboard logic. When such devices become available some of our more ambitious plans for forward collider physics will begin to look more realistic. In addition, more compact central detectors could be designed, yielding possible cost savings by reducing field volume and calorimeter area.

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Fig. 1. ISABELLE general site plan.

PLAN VIEW
MAJOR FACILITY HALL

Fig. 2. Sketch of experimental area 8
(Major Facility Hall).

Fig. 3. Conceptual design of a general purpose ISABELLE detector.

A CONCEPTUAL SKETCH

Fig. 5. Conceptual design of a large acceptance, forward angle multi-particle spectrometer for ISABELLE.

RESOLUTION VS BEAM ENERGY AND ANGLE

x = DATA
o = MONTE CARLO
 $\sigma(\%) = \sigma_0 / \sqrt{E}$

Fig. 7. Electron energy resolution of the calorimeter for various energies and angles of incidence.

Fig. 8. Schematic view of the cluster counting longitudinal drift measurement of transition radiation.

Fig. 9. Sketch of a possible future two-dimensional high-resolution solid state detector prototype. The element size is $10\text{ }\mu\text{m}$.