Summary of VPC Working Group Discussions

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4. Consider two beam-pipe options:

   a) Λ decay within beam pipe $\Rightarrow$ big pipe ($r \approx 10$ cm)
   b) Λ decay outside beam pipe $\Rightarrow$ narrow pipe ($r \approx 1$ cm)

5. Rates:

   $\mathcal{L}\sigma = 100$ MHz $\rightarrow$ 500 MHz $\pi^{\pm,0}$, 200 MHz $\pi^{\pm}$

   $\rightarrow$ MicroMegas ($\approx 10^8$ Hz/cm^2), SciFi, SiPix,...

   Question: can the physics be done if multiple interactions?

6. Trigger?

   Want to veto events with charged particles within ≈few mm of beam

   a) need *fast* veto: 1 ns $\rightarrow$ ~10% accidental veto loss
      $\Rightarrow$ Cherenkov plates? Maybe only 1 A

   b) need beam unbunched or bunched at f $\gtrsim$100 MHz

   Idea á là BTeV, LHC:

   Digitize *all* data into fast pipeline $\rightarrow$ online pattern recognition of signal characteristics

7. Compatible with ß-decay?

   $\rightarrow$ need redundant e ID $\Rightarrow$ shower counters + TOF? Cherenkov?

8. Don't forget other (bread-and-butter) physics

   e.g. $\sigma[\bar{p}p \rightarrow \bar{\Lambda}\Lambda(1405)] \rightarrow$ is $\Lambda(1405)$ uds or KN molecule?

Design of Hyperon CPV Experiment:

0. Need to start simulation studies!

1. Consider fixed-target experiment with internal target (gas jet) → boost (important)

2. Could study (Valencia)

	signal	process	p[GeV/c]	σ[μb]
a)	A_Λ ($\Lambda\to p\pi^-$)	$\bar{p}p\to\bar{\Lambda}\Lambda$	1.642	≈65
b)	B_Ξ ($\Xi^-\to\Lambda\pi^-,\Lambda\to p\pi^-$)	$\bar{p}p\to\bar{\Xi}\Xi$	≈3.5	≈2?
c)	Δ_Ω($\Omega\to\Xi^0\pi^-,\Xi^0\to\Lambda\pi^0,\Lambda\to p\pi$)	$\bar{p}p\to\bar{\Omega}\Omega$	>4.93	≈0.06?

No statistical advantage of b) over a),
b) harder systematically,
c) hard & very speculative

⇒ a)

3. Good idea(?):

Consider higher $p_{beam} \approx 1.7$ GeV/c

→ symmetrize $\Lambda,\bar{\Lambda}$ momenta, ∠s ⇒ reduce systematics.
increase σ ≈20%

But: contamination from $\bar{p}p\to\bar{\Lambda}\Sigma,\Sigma\to\Lambda\gamma$
→ would this dilute CP asymmetry?

Machine-experiment interface

- Beam size and divergence matter – want small beam pipe *and* small divergence

⇒ Cool before injection, decelerate in MI

  – ideal if inject on-energy

  → topping up beam to maintain $\mathcal{L} \approx$ constant

- $\mathcal{L} \approx 10^{33} \Rightarrow$ stack at 30 mA/hr

currently:	10 mA/hr
near-term goal:	20 mA/hr by March
Run IIB goal:	100 mA/hr using e^- cooling in recycler

(other improvements also possible, e.g. slip-stacking)

- What ring(s) to build when?

Best scenario:

  – dedicated ≈2 GeV/*c* ring for Hyp. CPV to run constantly with e^- cooling á là IUCF + LCHR

  – additional 1–10 GeV/*c* ring for other physics (10 GeV cooling more demanding, 15 GeV too costly)

→ Build 2-GeV ring first for NASA/PET? ≈$10M?

- We give up for now slow-extracted beam – needed only for expt's with polarized target (or stopping $\bar{p}$ for which already plenty of data)

Hyperon Beta Decay

1.) High Statistics sample for precision form factors, New Physics - Precision SM tests

2.) $\Lambda - \Sigma^0$ mixing with: $\Sigma^- \to \Lambda^0 e^- \bar{\nu}$ and $\Sigma^+ \to \Lambda^0 e^+ \nu$

3.) Form factors outside of Octet } broken V-A
i.e. $\Omega^- \to \Xi^0 e^- \bar{\nu}$
$\Lambda_c^+ \to \Lambda^0 e^+ \nu$

4.) CP tests by B.F. of Λ and $\bar{\Lambda}$ Beta decay
$\Lambda \to p e^- \bar{\nu}$ } backgrounds
$\bar{\Lambda} \to \bar{p} e^+ \nu$
other Hyperons may be better
Ξ^0, Ξ^-, Ω^-

5.) g_3 form factors with μ^- decay of Hyperon
$\Xi^0 \to \Sigma^+ \mu^- \bar{\nu}$
$\Omega^- \to \Xi^0 \mu^- \bar{\nu}$ has big B.R.

	V_{us}
• $\Lambda \to p e \nu$	$0.2130 \pm .002$
$\Sigma^- \to n e \nu$	0.2318 ± 0.004
$\Xi^- \to \Lambda e \nu$	0.243 ± 0.008

V_{us} in These decays should all be the same

And agree with V_{us} from $K_{\ell 3}$

$$V_{us} = 0.2188 \pm 0.0016$$

$|f_1 V_{us}|$ is what we experimentally measure

will free quarks to measure V_{us}

PDG Quote Hyperon measurements of V_{us} are unreliable

While setting a $g_2 \neq 0$
would be how errors would
the standard width.

Donoghue notes in his text-book
that a $\frac{g_2}{g_1} = 0.2 \pm 0.07$
makes all Hyperon
$V_{us} = 0.220 \pm 0.004$
in agreement with Kl3 V_{us}

He also comments that

$\Sigma^- \to \Lambda e^- \bar{\nu}$ } are the best
or } places to look
$\Sigma^+ \to \Lambda e^+ \nu$ } for SU(3) breaking

since in these decays V_{us} does
not enter since it is just an
Axial-current contribution.

Are there advantages of doing
beta decays in $p\bar{p}$ collisions.

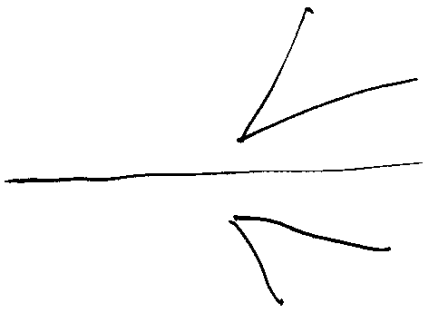
1.) $p\bar{p} \to H\bar{H}$ has
well determined energy

2.) has equal $\bar{H}$ to H
B.R. and F.F.
so can do them with equal
statistics. Is $\bar{H}$ antihyperon same as H?

3.) Use decay on one side
to tag what was decaying
on the other, as well
as know something about
its polarization.

Detector Requirements

1.) Two V on opposite sides



2.) Good background rejection, probably best done by
a.) particle I.D.
b.) momentum & energy resolution to know if reaction was which type of Hyperon.

3.) As I understand it the biggest problem is to live with the high rates of K reactions.

If a $p\bar{p}$ source exists for Hyperon production Then This Physics Program is Valuable

Can you justify this accelerator just on this? Human

Can you justify a special detector just for this? Maybe

My personal view is: Plan to do all the Physics we can, let our interest be the guide.