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# Summary of Concepts and Scenarios

J. Barnard, R. Briggs, G. Caporaso, H. Takahashi,  
K. Takayama, R. Yamada

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## Summary of induction accelerator architectures

Architecture	Focusing	Advantages	Remarks
<b>Linacs:</b>			
Induction Linac (e <sup>-</sup> )	Solenoid	High peak power; High efficiency;	
Induction Linac (H <sup>+</sup> )	Quads	High peak power; Longit. compress.	
Dielectric Wall Accel.	Magnetic/ Electrostatic	Very high gradient	<~ few 100 ns early dev.
<b>Rings:</b>			
Induction Synchrotron	Quads	Current const. over super bunch; Higher luminosity	
Induction barrier bucket	Quads	Highly flexible waveform shape;	DARHT kicker POP for modul.
Induction buncher	Quads		
Induction FFAG	FFAG	Compact, low cost;	Larger phase sp.
Induction recirculator	Quads (static)	Low cost;	Vacuum; Dipole losses; Resonance trav.

## Summary of applications for induction accelerators

<b>Application/ Architecture</b>	<b>Voltage</b>	<b>Beam Current</b>	<b>Pulse length</b>	<b>Rep. rate</b>	<b>Issues/comments</b>
<b>Hadron collider/ p<sup>+</sup> ind. synchrotron</b>	<b>31 TeV; 3 MeV/turn</b>	<b>25 A</b>	<b>500 ns</b>	<b>100 kHz CW</b>	<b>feasibility study going on; require upgrade of most existing detector components for higher L. competitor: low harmonic rf</b>
<b>RK Two Beam Acc for Linear Colliders/e<sup>-</sup> ind. linac</b>	<b>10 MeV, 0.3 MeV/m</b>	<b>1 kA</b>	<b>50 - 200 ns</b>	<b>180 Hz</b>	<b>fundamental aspect has been demonstrated; no current funding</b>
<b>Neutrino factory;μ- collider / μ<sup>-</sup>ind. linac</b>	<b>200 MeV 2 MeV/m</b>		<b>100 ns</b>	<b>4 pulse @ 3 MHz; 15 Hz avg.</b>	<b>feasibility study going on; competition with low freq rf device; can survive rad. env.;</b>
<b>Heavy Ion Fusion/ HI<sup>+</sup> ind. linac</b>	<b>4 GeV 1.5 MeV/m</b>	<b>0.2 - 10 kA</b>	<b>20 μs - 10 ns</b>	<b>~6 Hz</b>	<b>Significant program ongoing</b>

## Summary of applications for induction accel's-cont'd

<b>Application/ Architecture</b>	<b>Voltage</b>	<b>Beam Current</b>	<b>Pulse length</b>	<b>Rep. rate</b>	<b>Issues/comments</b>
<b>Spallation n- source/ p<sup>+</sup> ind. linac</b>	<b>1 GeV</b>	<b>60 - 100 A</b>	<b>1600 - 160 ns</b>	<b>50 Hz</b>	<b>Will be easier to sell if induction technology more widespread</b>
<b>Radiography/ e<sup>-</sup> ind. linac</b>	<b>18.4 MeV</b>	<b>2-4 kA</b>	<b>~50 ns</b>	<b>~2 MHz bursts of 4 pulses</b>	<b>DARHT-II built and undergoing testing. Ion-hose, beam-target interactions AHF to use protons/synch.</b>
<b>Sub-critical reactor/ ind. FFAG; H- driver for spallation n- source; Accel. Trans. Waste (H- ind. FFAG)</b>	<b>~ 1 GeV 1-3 GeV</b>	<b>30 mA 10 mA (avg)</b>	<b>~few 100 ns</b>	<b>1 kHz CW</b>	<b>May combine rf + ind.(Ind barrier only); cost/MW beam power is low rel. to rf linac; early design, at idea stage</b>
<b>Driver for Microwave source FEL's, BWO</b>	<b>~few MeV</b>	<b>~kA</b>	<b>~few 100 ns</b>	<b>~kHz</b>	<b>Very attractive match</b>

By R.Yamada (G1 group convener)

- **Induction Acceleration Scheme** is shown now well established in many applications, as was reported in many reported talks and summarized in the Table.
- The **Induction Acceleration Devices** are now well advanced with recent technological achievement in magnetic core materials as well as high current and high frequency solid state devices.
- At the workshop the idea of **Super-bunch Induction Acceleration** is well explained, and well supported by many people as well as favorably by the LHC design group.
- Although the test result of Super-bunch at the KEK-PS is urgently waited, but it seems the **Induction Synchrotron with Super-bunch** should be strongly encouraged. The replacement of the RFs of the existing proton synchrotron and high intensity machines under design and construction should be considered for their upgrade with the future application of **Super-bunch**. In the **Future Hadron Collider** should be designed with the concept of **Super-bunch**.

# CORE - ISSUES

- COMMON  
• DESIGN INFORMATION / CHARACTERIZATION  
OF CORE MATERIAL (SURPRISES  
→ DATABASE (Proceedings) WHEN USED)
- CIRCULATION OF INFORMATION  
(COMMUNITY OUTREACH)
- HIGH REP. - HV - HIGH CURRENT
- CHOICE OF CORE MATERIAL  
(RUSSIA, ...)
- CORE
  - COST
  - INSULATION / QA
  - SINGLE PROVIDER
  - MATERIAL DEV.  
(LOW LOSS)
- EM - MODELLING
- COOLING → SYNCHROTRON  
CORE LOSS → HIF
- CONTROL OF BEAM INTERACTION

# CORE - HIGHLIGHTS

- FLEXIBILITY  $\begin{cases} \rightarrow \text{MODULATORS / WICKER} \\ \rightarrow \text{AGILE WAVEFORM CONTROL} \end{cases}$
- INSULATORS (HGI)
- FLATNESS OF PULSE (DARHT-II)  
(COMMUNITY OUTREACH)
- INDUCTIVE ADDER (HV, Low V)
- FINEMET NOT ONLY MAT. (RUSSIA)
- FEEDBACK / PRECISE WAVEFORM CONTROL  
(FNL,  $\phi$  vs. FOURIER SERIES)

# Modulators

## Issues

- device development
  - switch time ( $di/dt$ )
  - peak power ( $I_{pk}$ ,  $V_{pk}$ )
- radiation hardness (synchrotron application)
  - coupling energy to core (transmission lines)
- system cooling (high rep. rate)

## Highlights

- wide range of applications ... most require agile waveform control

## Future

demonstration of technology will help gain acceptance for other applications

↓  
when more people ask for cores (eg.) → ↓\$

# Summary by Group G4

## **Heavy ion fusion**

IBX experiment

Examines most of HIF driver issues, but not all

Issues:

- \* Interaction with module impedance
- \* Electron cloud effects
- \* Accurate cost
- \* Long pulse effects

## **Bunching & Halo formation**

Formalism exists to address this problem

Issues:

- \* Different distribution functions
- \* Module impedance
- \* Model IBX experiment
- \* More realistic core model
- \* PIC simulation – WARP possibly

## Radiography

Multiple pulses interaction with target  
biggest concern

### Issues:

- \* Exact details of ion emission
- \* No multiple pulse experiments at high energy  
(20MeV)
- \* Continuous two pulse experiments at 6MeV
- \* Multipulse experiments must await DARHT-II  
Commissioning

## Longitudinal beam chopper

Demonstration of Bunch Matching,  
Short bunch and Bucket waveform demonstration

### Issues:

- \* (High  $\mu$  at high freq.) Magnetic cores and compact FET SW
- \* Apply to Barrier Bucket RF
- \* Bunch compressor
- \* Bunch rotation

# Summary G5: beam dynamics in circular machines

*A) Superbunch colliders*

*B) High-intensity  $p$  synchrotrons*

**G5 members: W. Chou, J. Marriner, Y. Shimosaki,  
T. Toyama, F. Zimmermann**

## Rf scheme

Barrier bucket or sine wave?  
acceleration of superbunch

## Beam-beam

synchrobetatron resonances & end effects?  
strong-strong (simulation, analytical, can we learn  
from the ISR?)  
crossing scheme? (x-y vs inclined)  
(experiments at RHIC?)

## Collective effects

conventional instabilities of long bunches

(experiments in KEK PS?)

does coasting beam theory apply?

e- cloud (experiment at PSR, FNAL?)

momentum spread

slippage factor (B)

## Diagnostics & feedbacks

noise, sensitivity, ground motion etc.

*novel feature and main outcome of this workshop:*

***communication between  
induction linac & synchrotron  
communities!***