INSTITUTE OF FLUID PHYSICS
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R&D STATUS OF HIGH CURRENT ACCELERATORS AT IFP

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Outline

- INTRODUCTION
- R&D OF KEY TECHNOLOGIES AND COMPONENTS FOR HIGH CURRENT ACCELERATORS
- DEVELOPMENTS OF LINEAR INDUCTION ACCELERATORS
- R&D OF HIGH CURRENT ACCELERATORS FOR Z-PINCHES
- R&D OF HIGH CURRENT ACCELERATOR FOR OTHER APPLICATIONS
- SUMMARY

INTRODUCTION

- High current accelerator is of great importance for many applications due to its unique characteristics of high power.

- Many important applications such as
  - Z-pinches
  - high power microwave
  - free electron laser
  - imploding liner
  - radiography
  - ….

INTRODUCTION

- **Research and development of high current accelerators started at Institute of Fluid Physics in the early of 1960's with development of pulsed accelerator (1.6MV, 5kA, 400ns) for flash X-ray radiography.**

INTRODUCTION

- **The researches and developments for high current accelerators at IFP include**

key technologies and components

high voltage switches with low jitter

multi-pulse technologies

high speed diagnostics

linear induction accelerators (LIA) with energies ranging from hundreds keV to 20 MeV

Mini-LIA LIAXFU ITS Dragon-I Dragon-II

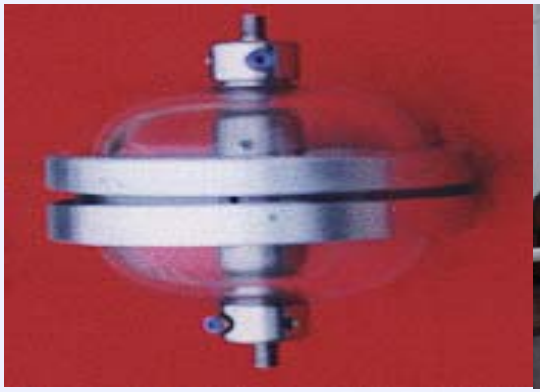
High current accelerators for Z-pinch and imploding liner

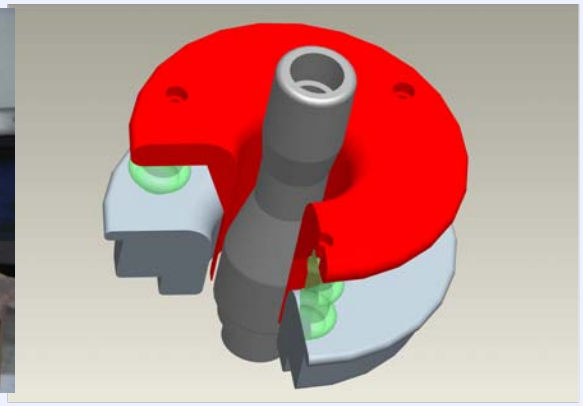
Yang Primary Test Stand (PTS) FP-1

X-ray machine and high power microwave

R&D of High Power Switches With Low Jitter

➢ Field-Distortion Spark Gap Switches





~200 kV

Jitter: ~1 ns

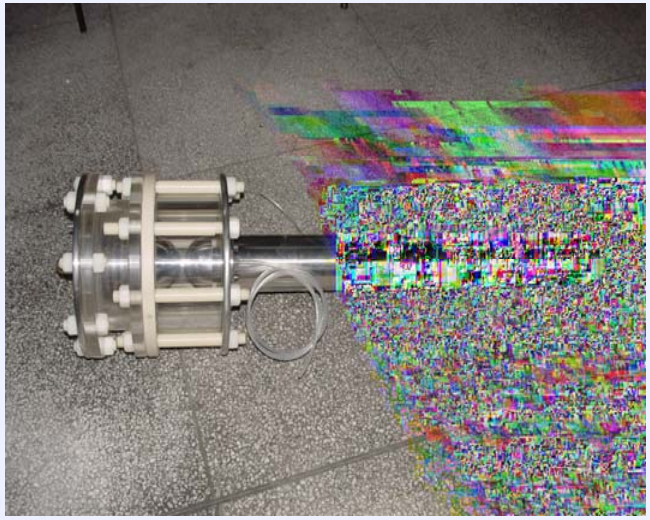
~300kV

Jitter: <1 ns

R&D of High Power Switches With Low Jitter

➢Laser-Triggered Spark Gap Switches

Working Voltage: 200 kV~5MV
Time Jitter: ~ 1 ns



200 kV

5MV switch

■ R&D of High Power Switches With Low Jitter

➢ **Solid State Switches**

MOSFET

Photo-conductive
GaAs SiC

MoA2-3 Dr. Yuan

MoA2-4 Dr. Liu

Novel method to generate multi-pulses

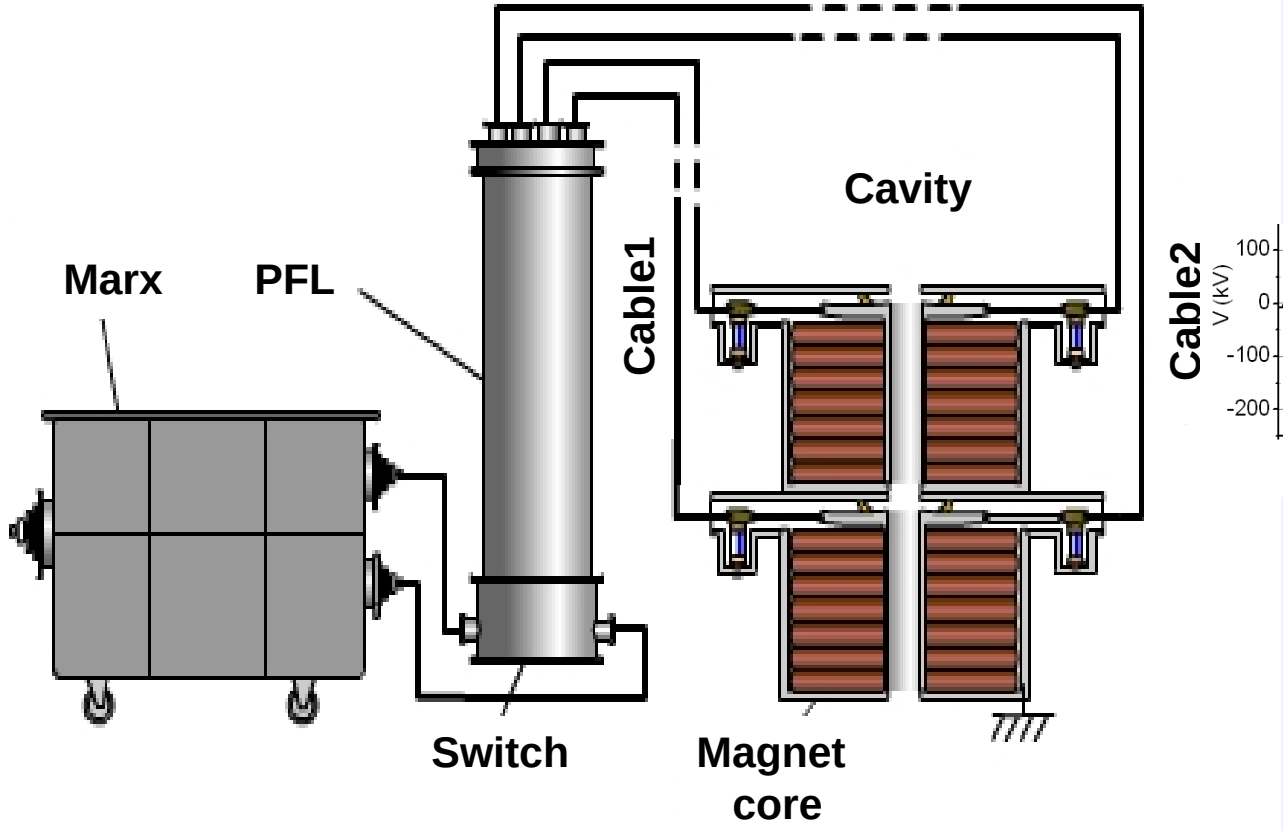
High current accelerator with high rep-rate is of great interest in some applications but is extremely difficult to realize due to high power, especially in MHz range.

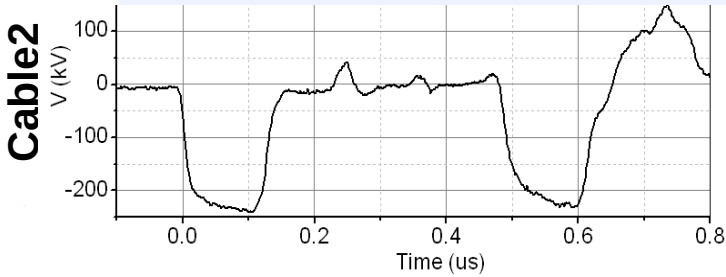
Several novel methods to generate multi-pulses are proposed and verified

- Double pulses based on Cable-Delay-Method
- Controlled-Pulse-Adder based on spark gap switch

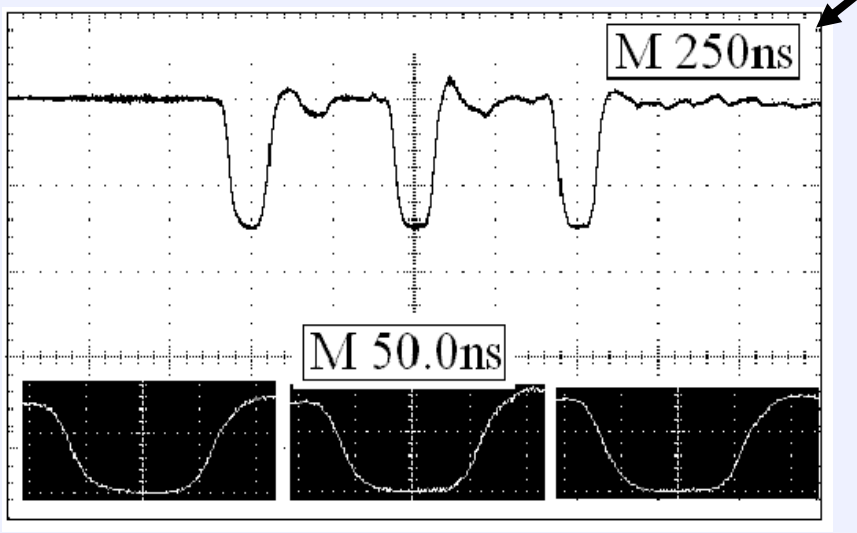
TuA1-4 Dr. Huang

- **Novel method to generate multi-pulses**
  - ➢ **Double pulses based on Cable-Delay-Method**

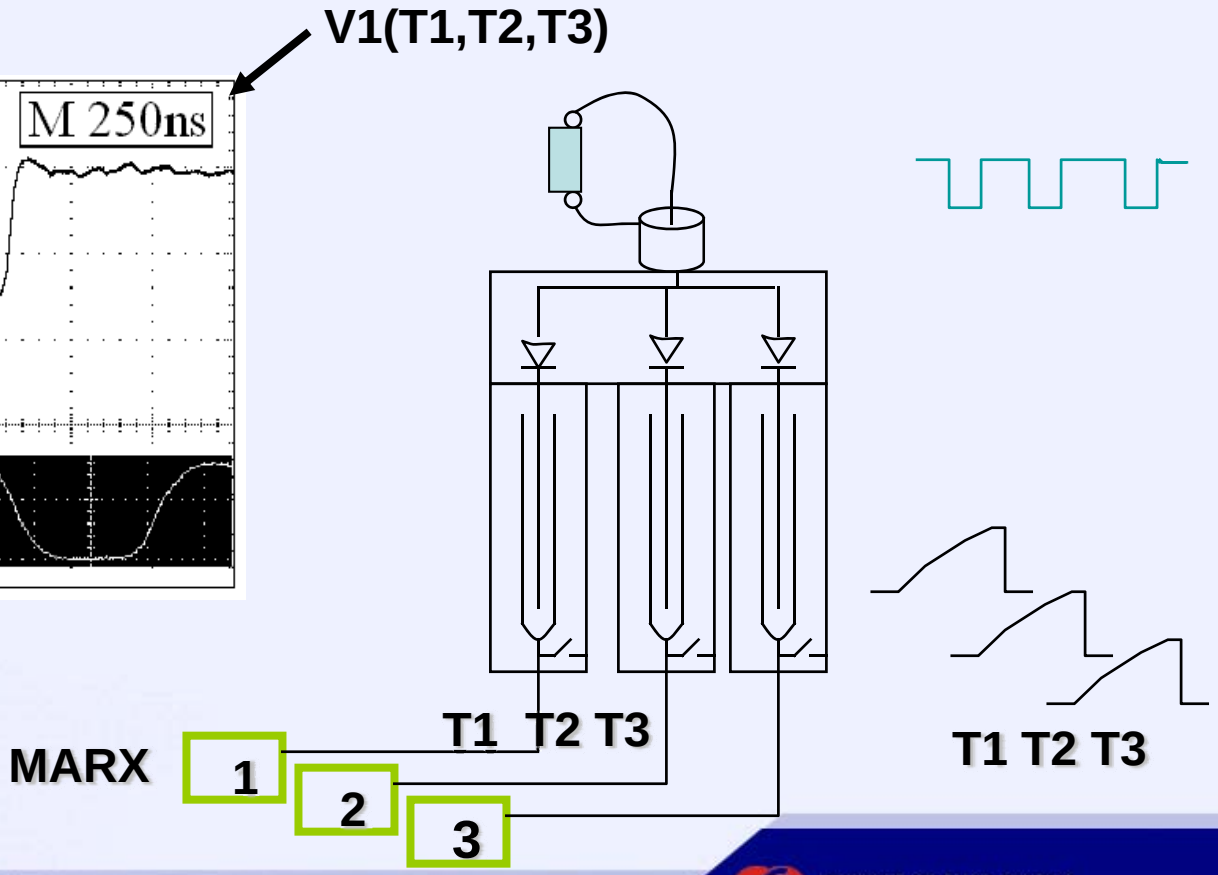




- **Novel method to generate multi-pulses**
  - ➢ **Controlled-Pulse-Adder based on spark gap switch**



300kV



DEVELOPMENTS OF LIA—LIAXFU

Linear Induction Accelerator X-ray Facility Upgraded (LIAXFU)

(12MeV,2.5kA,60ns,~4mm,1995)

Add 4 cavities
Other improvements

Linear Induction Accelerator X-ray Facility

(LIAXF, 10MeV,2.0kA,60ns,~6mm,1992)

DEVELOPMENTS OF LIA—LIAXFU

Linear Induction Accelerator X-ray Facility Upgraded (LIAXFU)

(12MeV,2.5kA,60ns,~4mm)

Injector: Inductive adder -1MV/4cell

1MeV,3kA,90ns

Accelerating section: 32 cells

350kV,90ns

Integrated Test Stand (ITS) for Intense Beam Physics Researches

ITS was built for induction linac technologies and intense beam physics researches in 2004

4MeV ,2.5kA, 90ns

DEVELOPMENTS OF LIA --ITS

Injector: Inductive adder -1.0MV/+1.0MV

2MeV,2.5kA,90ns

8 cells

Accelerating section: 8 cells

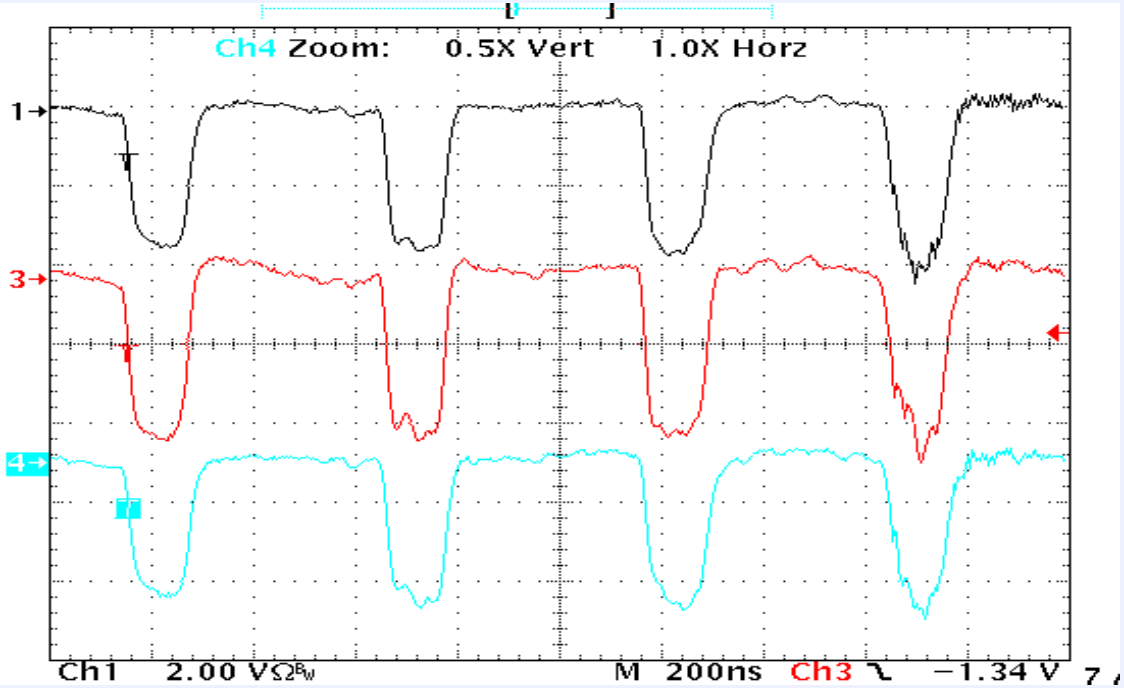
250kV,120ns, 70ns flattop with +/-1% variation

DEVELOPMENTS OF LIA --ITS

Studies on multi-pulse intense beam generation, acceleration and transportation have been conducted on ITS

Voltage pulses 500kV

Beam pulses 2kA



DEVELOPMENTS OF LIA—Dragon-I

Dragon-I Linear Induction Accelerator

(19.2MeV,2.54kA,70ns,~1mm, 2003)

Injector: Inductive adder -2.1MV/+1.5MV

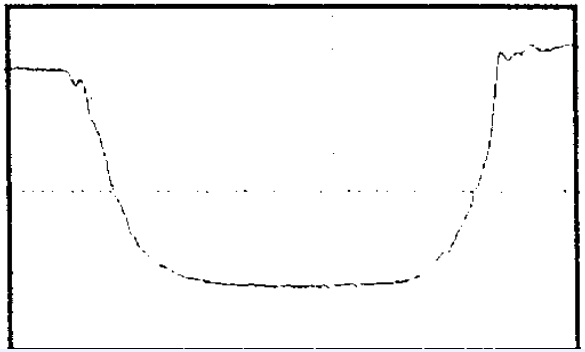
3.6MeV,2.7kA,90ns

12 cells

DEVELOPMENTS OF LIA—Dragon-I

Accelerating section: 72 cells

250kV,120ns,



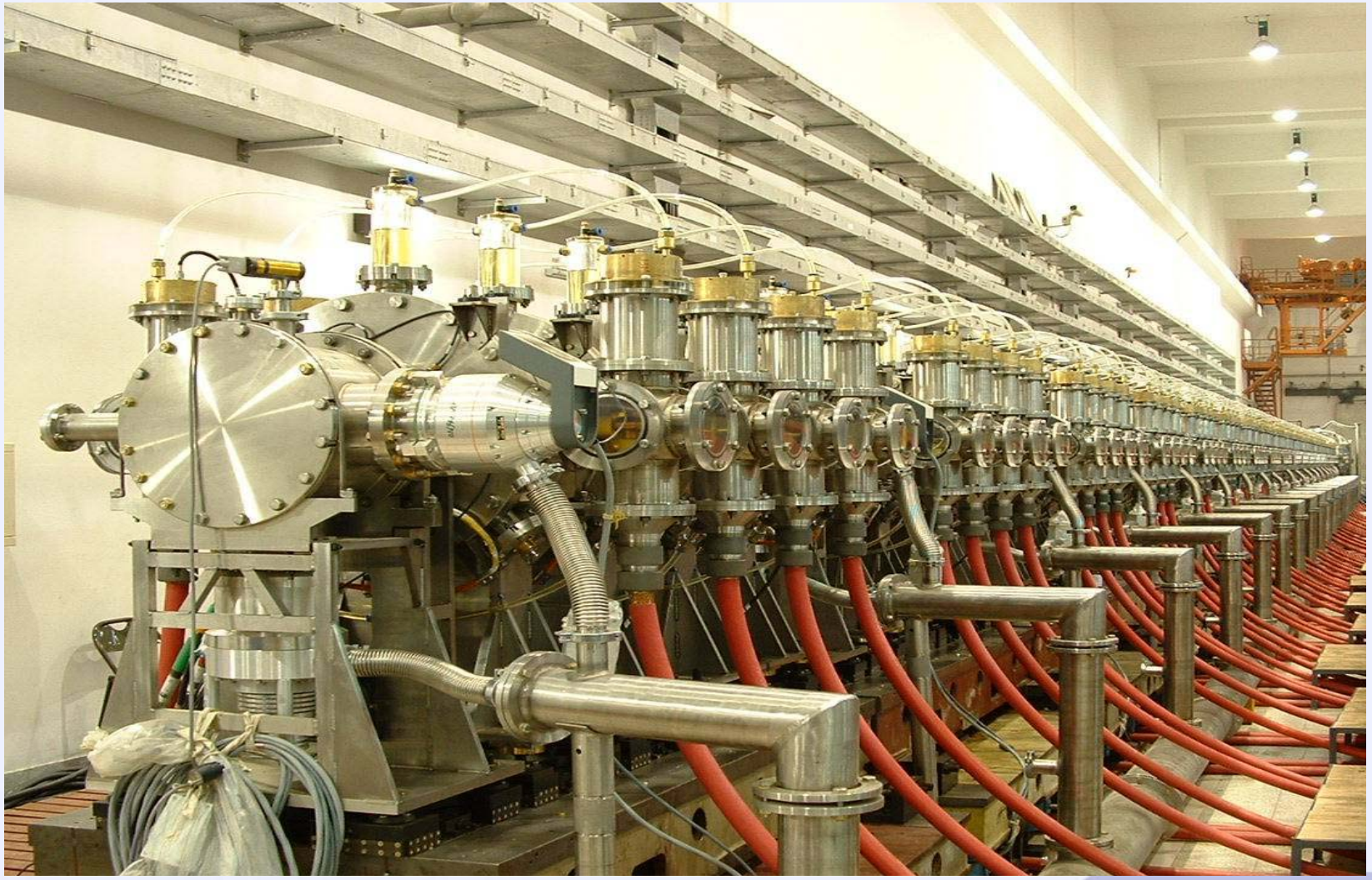
70ns flattop with +/-1% variation

WeB3-1 Dr. Liao

Beam centroid variation <0.5mm

Spot size: ~1mm

DEVELOPMENTS OF LIA—Dragon-I



- **Mini-LIA (Double-pulse electron beams)**

240keV ,1A , 2x80ns

The first LIA
based on the novel Cable-Delay-Method

The first designed double pulses LIA
working at MHz rep-rate in burst mode in the world

The smallest LIA in the world

DEVELOPMENTS OF LIA—Mini-LIA

- **Mini-LIA (Double-pulse electron beams)**

Designed for multi-pulse beam physics studies

Collaborate with Tsinghua Univ.(injector)

DEVELOPMENTS OF LIA—Mini-LIA

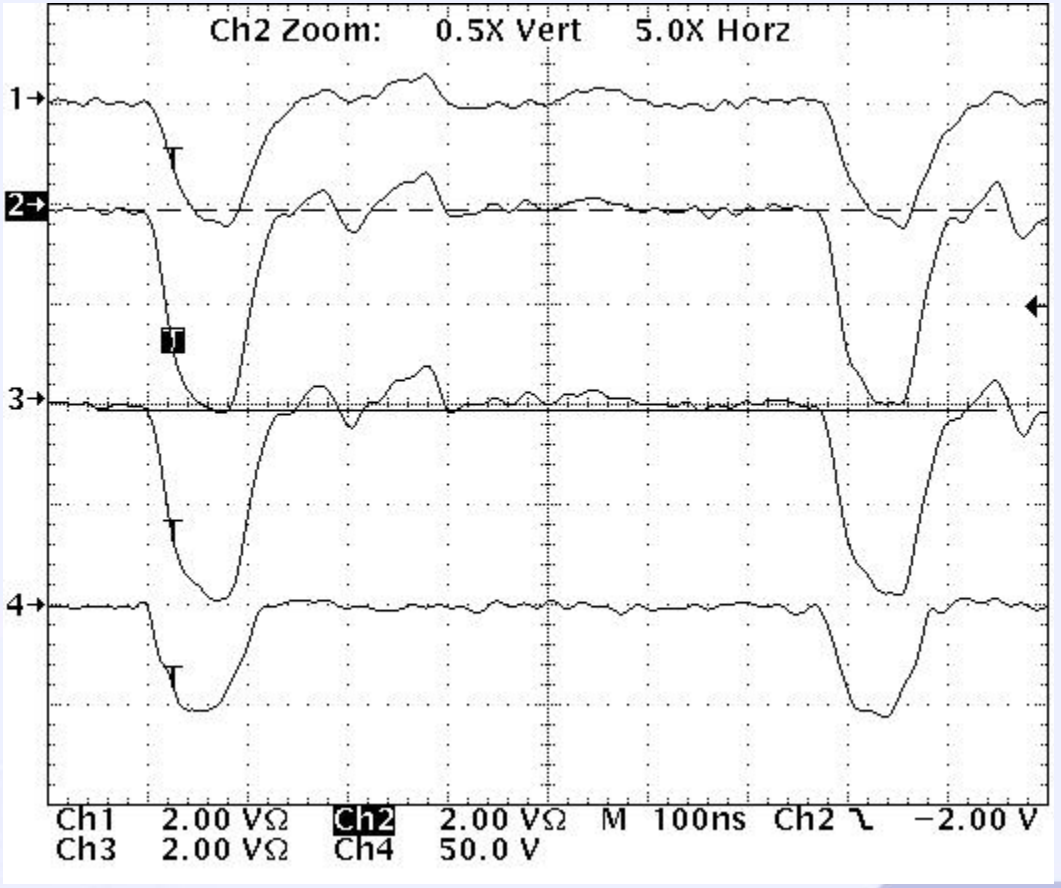
- Mini-LIA (Double-pulse electron beams)

MiniLIA(Double-pulse electron beams)

Injector current

Accel pulses

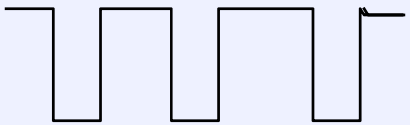
Beam pulses



Dragon-II Linear Induction Accelerator

New accelerator under construction with higher performance

Novel design to generate triple pulses based on Controlled-Pulse-Adder



Adjustable time interval from hundreds nanoseconds to microseconds

Dragon-II Linear Induction Accelerator

Injector: Inductive adder -1.75MV/+1.25MV

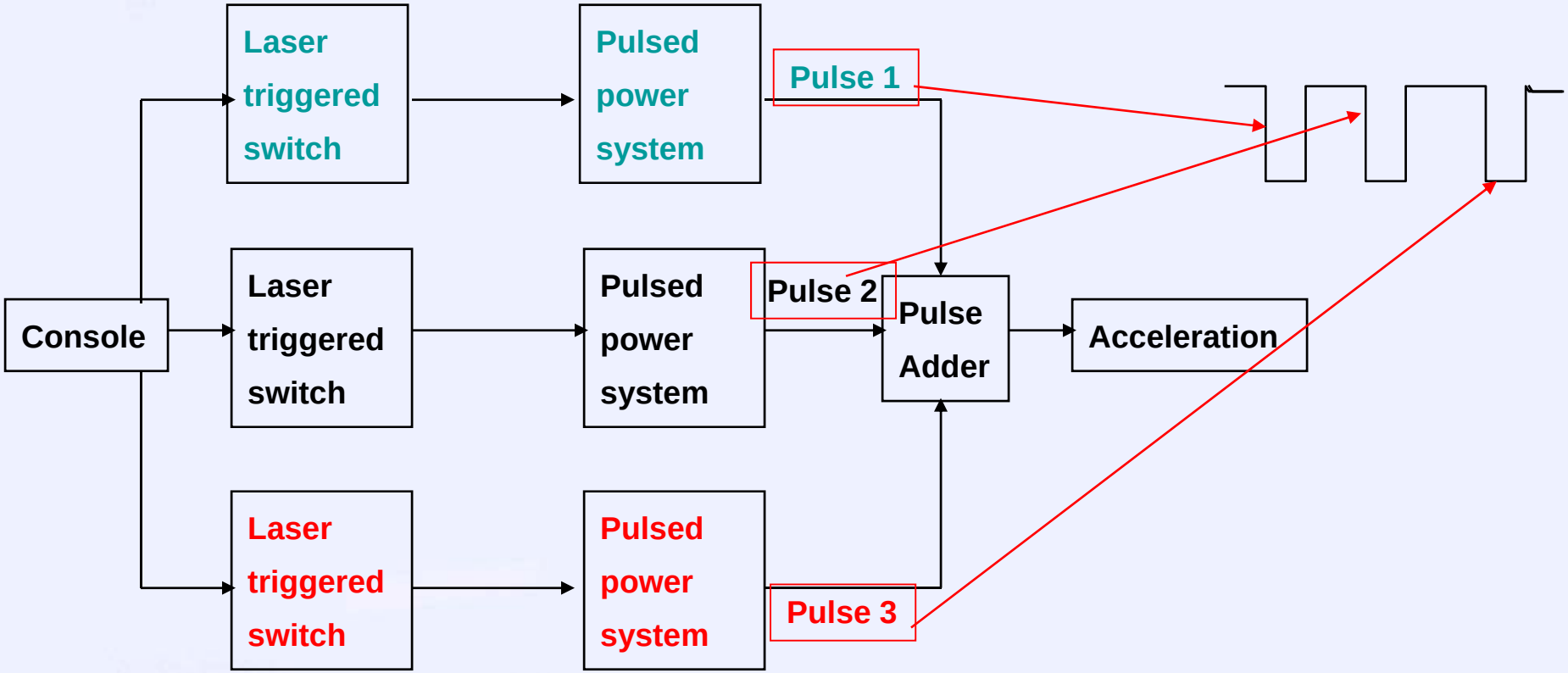
3.0MeV,2.5kA,3x90ns, 12 cells, 36 Blumlein PFLs

Accelerating section: 80 cells,120 Blumlein PFLs

~200kV,120ns, 3x60ns flattop with +/-1% variation

Each pulse is controlled by a laser triggered spark gap switch to meet the requirement of time interval between three pulses.

Dragon-II Linear Induction Accelerator



Primary Test Stand(PTS) for Z-Pinch

PTS is being under construction

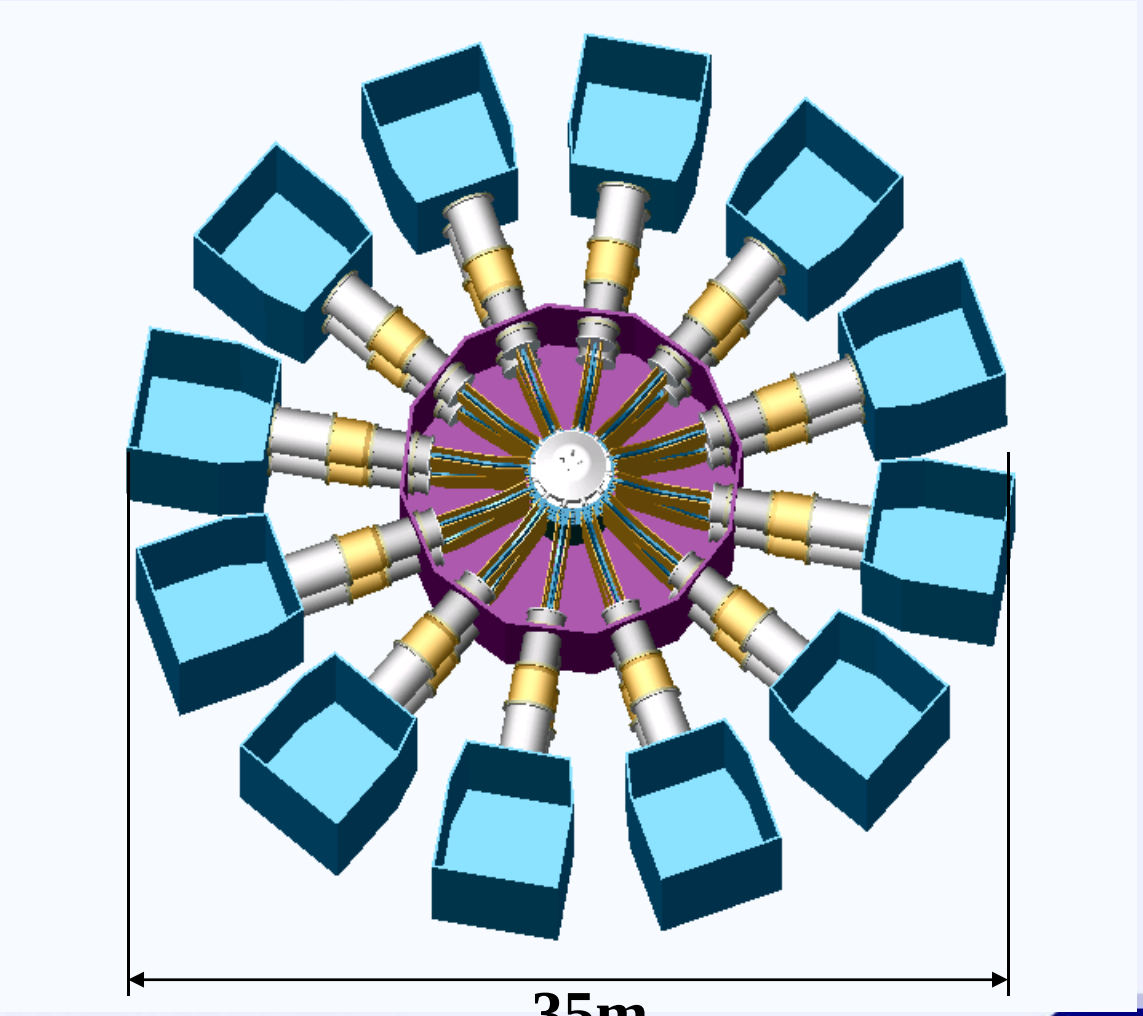
Stored energy: 7.2MJ

Current on load: 8~10 MA

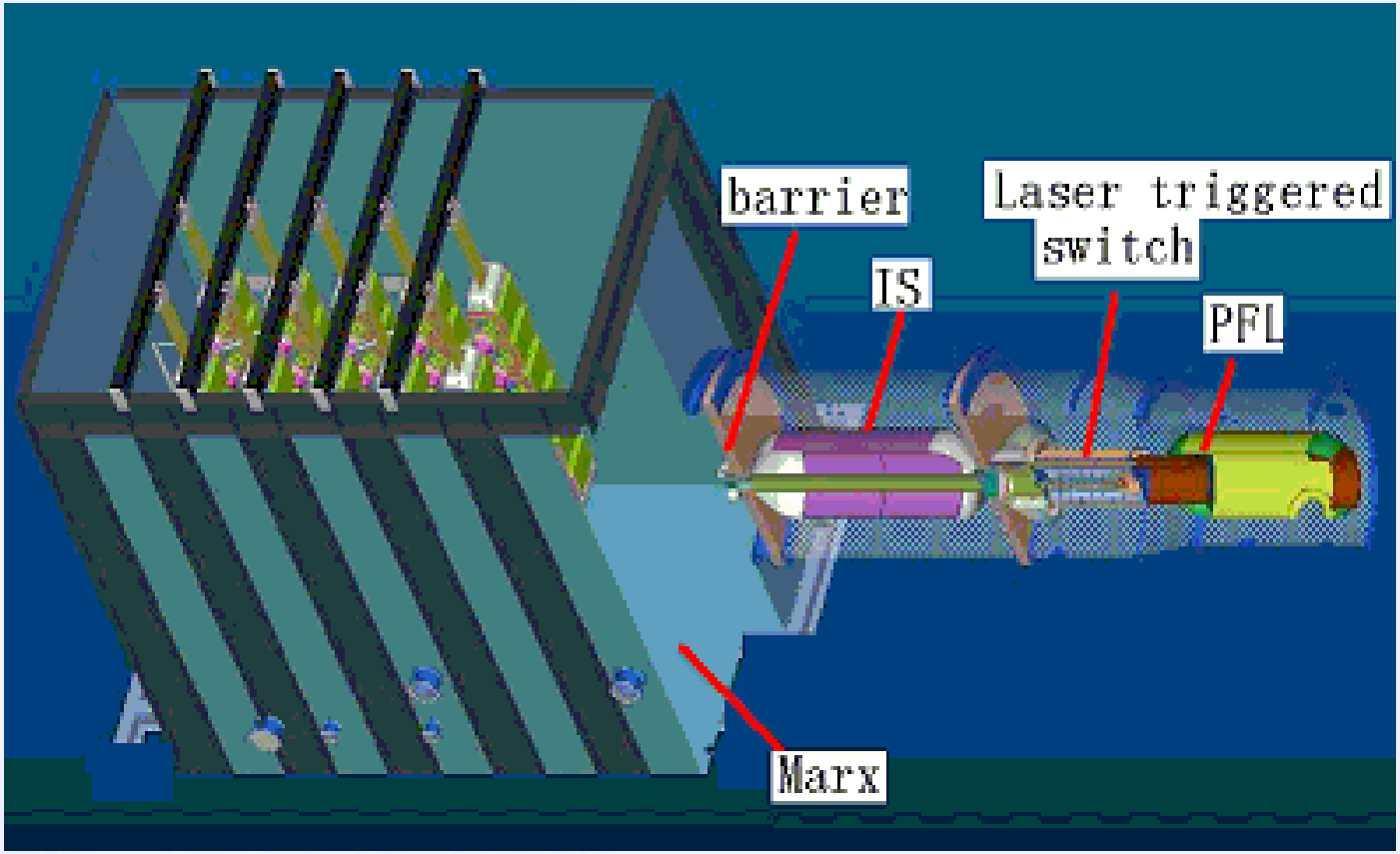
Pulse width:130ns

Rise time: 90ns

PTS **24 modules**



Single module for PTS



WeA3-3,Dr. Li

Primary Test Stand(PTS) for Z-Pinch

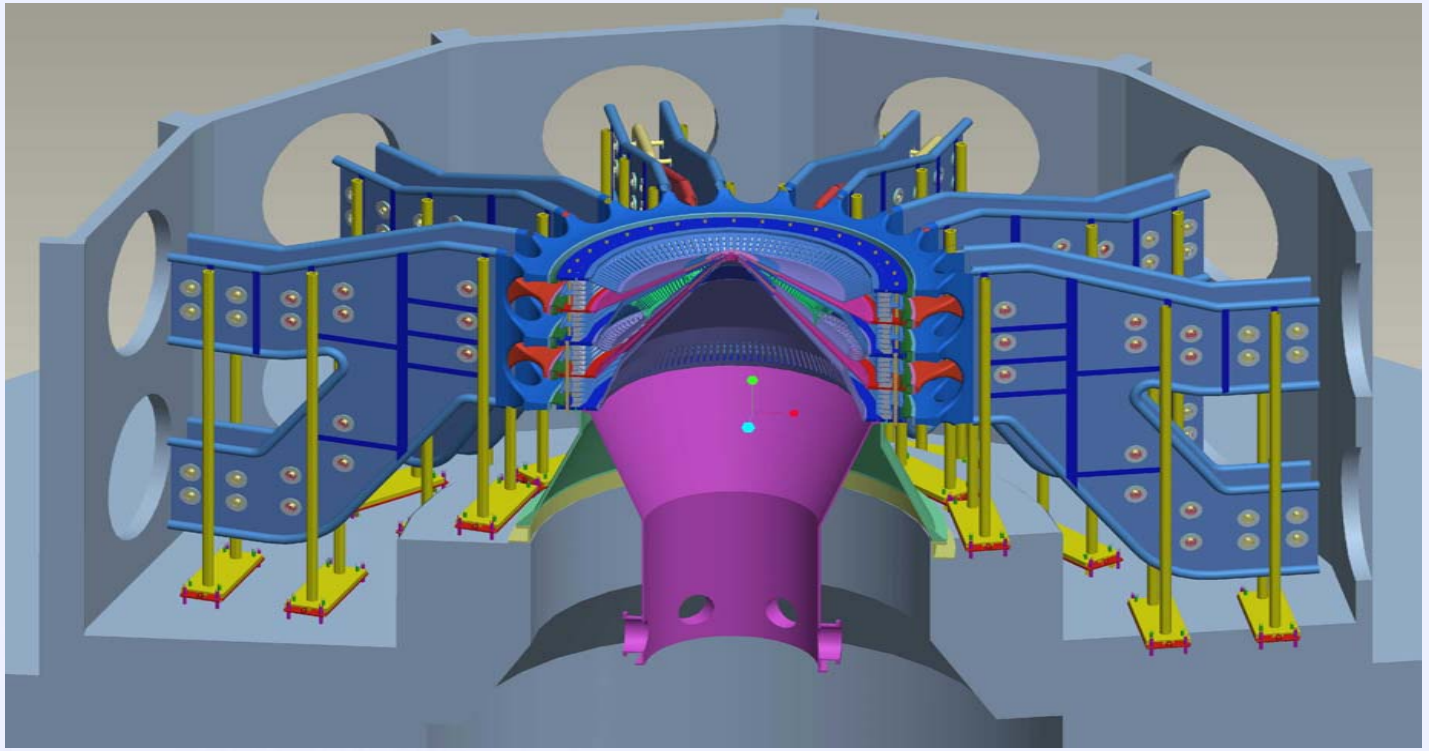
Most part of PTS has been fabricated

All the 24 Marx generators have been established and tested

Most of the laser triggered switches have been assembled and tested

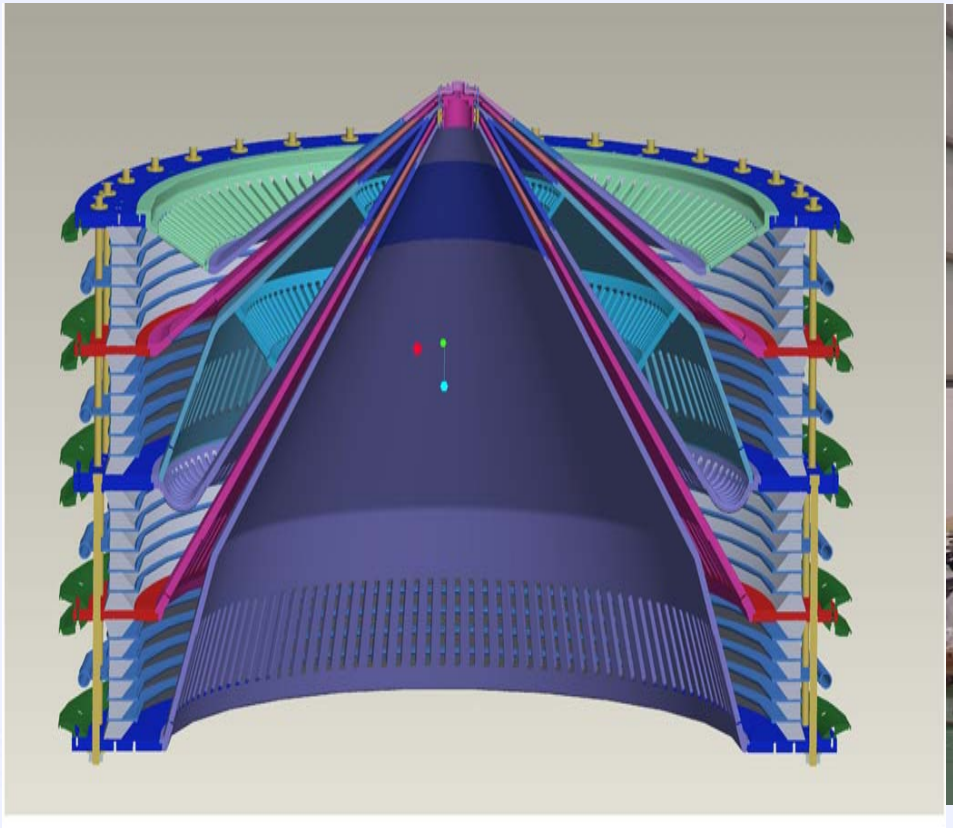
Primary Test Stand(PTS) for Z-Pinch

Water transmission line and vacuum chamber



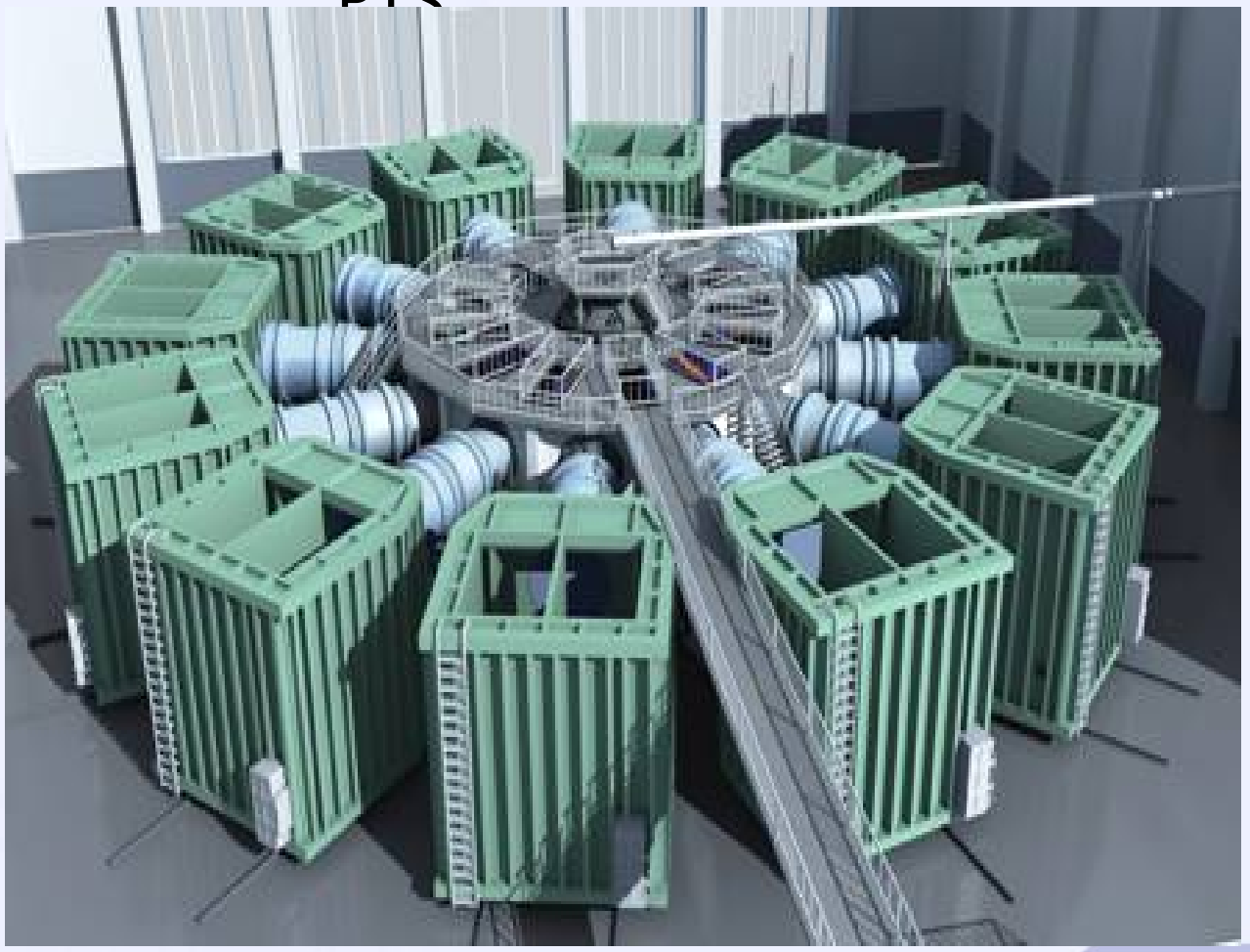
Primary Test Stand(PTS) for Z-Pinch

Vacuum chamber



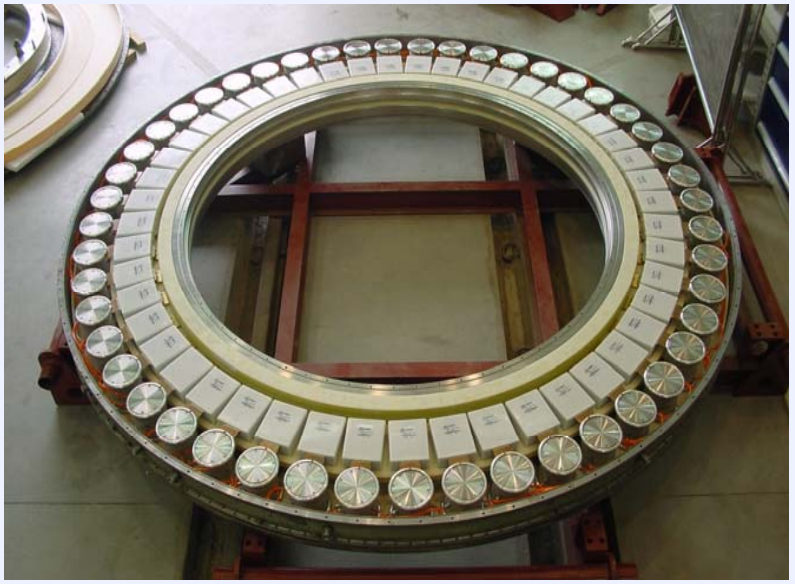
Insulator stack

Overview of the PTS



High current accelerator Based on LTD

1MV, 100kA LTD facility



1MA, 100kV LTD module

TuA3-4,Dr. Zhou

High current accelerator for X-ray machine

A series of pulsed X-ray machines have been developed with energies ranging from hundreds keV to several MeV

Marx-PFL-Diode

LTD-Diode

SUMMARY

The R&D status of high current accelerators at IFP are overviewed

Activities including R&D of key technologies and components, linear induction accelerators for intense beam physics research and flash X-ray radiography, Z-pinch, accelerators based on LTD technology

Two novel methods to generate multi-pulse have been introduced. New accelerators based on such methods are described briefly.

Two big high current accelerators(Dragon-II, PTS) are under construction at IFP

Thanks...