Report on Beam Instrumentation Workshop (BIW12): April 16-20, 2012 (continued)

Nathan Eddy, Vic Scarpine, and Alex H. Lumpkin

Presented at Department Seminar

May 24, 2012

Summary

I. BIW12: Hosted by JLAB. Last of the BIW series which started in 1989. (FNAL host 1990, 2006)

- 134 attendees from 22 countries
- 17 vendors
- 2 Tutorials, 10 invited, 19 contributed orals, 86 posters
- Preliminary proceedings are posted on BIW12 website

II. Series will transition to International Beam Instrumentation Conference (IBIC). Merge BIW, DIPAC, Asian workshops.

Preliminary Proceedings Online

BIW12

List of classifications

- Beam Charge and Current Monitors
- Beam Loss Detection
- Beam Position Monitoring
- Data Acquisition Technologies
- Feedbacks and Beam Stability
- Longitudinal Diagnostics and Synchronization
- Other
- Overview and Commissioning of Facilities
- Transverse Profiles, Screens, and Wires
- Transverse and Longitudinal Emittance Measurements
- Tune Monitors and Measurements

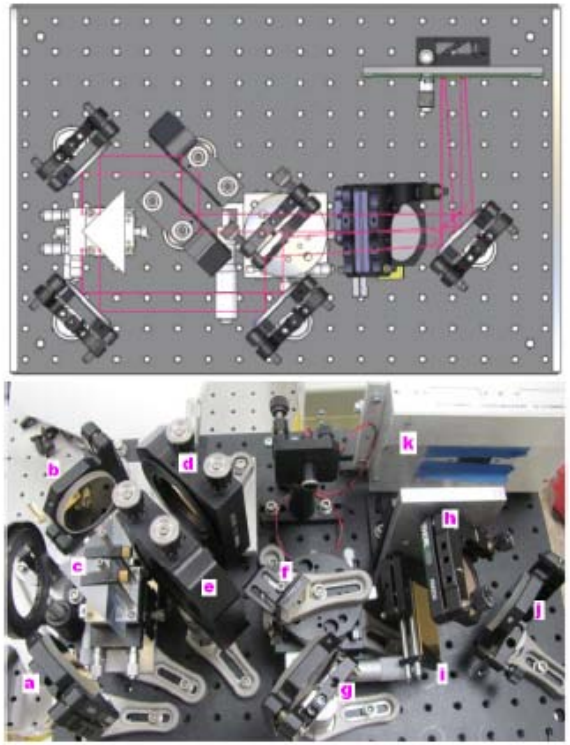
FNAL Input to BIW12

- Tutorial by Nathan on DSP and algorithms.
- Invited talk by Vic on proton H^- beam diagnostics
- Invited talk by Alex on Beam profiling techniques.
- Contributed talk by Charles Tobin on real time autocorrelation of coherent transition radiation at A0PI. Randy, Amber, Alex, co-authors
- Contributed talk by B. Walasek-Hohne on first OTR imaging of non-relativistic heavy ions. AHL proposed experiment realized.
- Manfred W. and Jim Z. on organizing program committee.

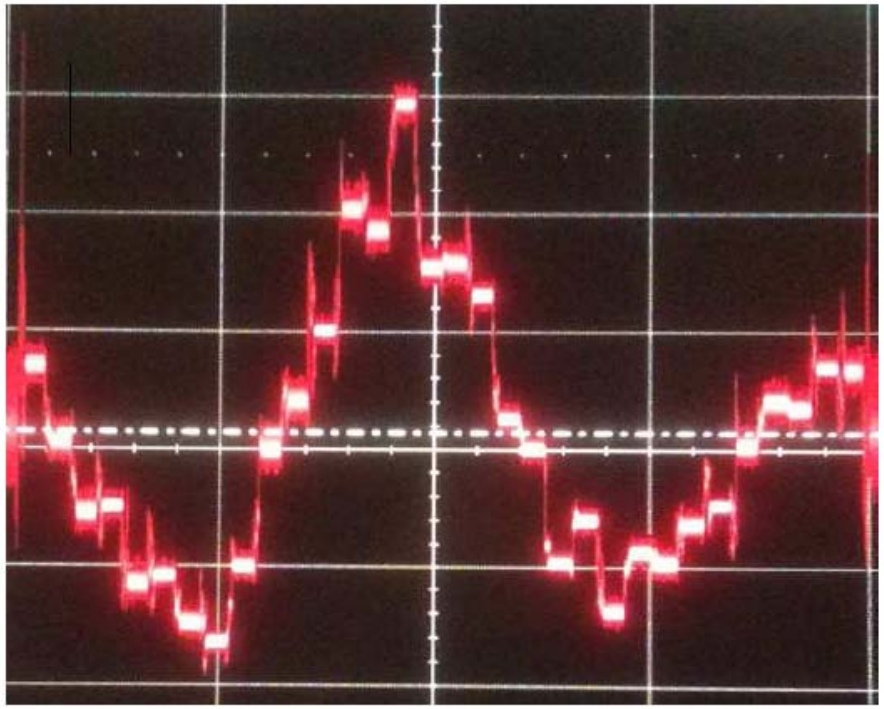
Real-time Interferometer (RTI)

- **RTI provides online spatial autocorrelation of coherent transition radiation with 32 element pyroelectric array.**

Diagnostic Layout



Raw autocorrelation



Outline-Trends

I. Introduction

II. Beam profiling with YAG:Ce scintillation

- Scintillator resolution
- Depth-of-focus issue
- Possible solution to coherent source interference

III. Optical Transition Radiation (OTR)

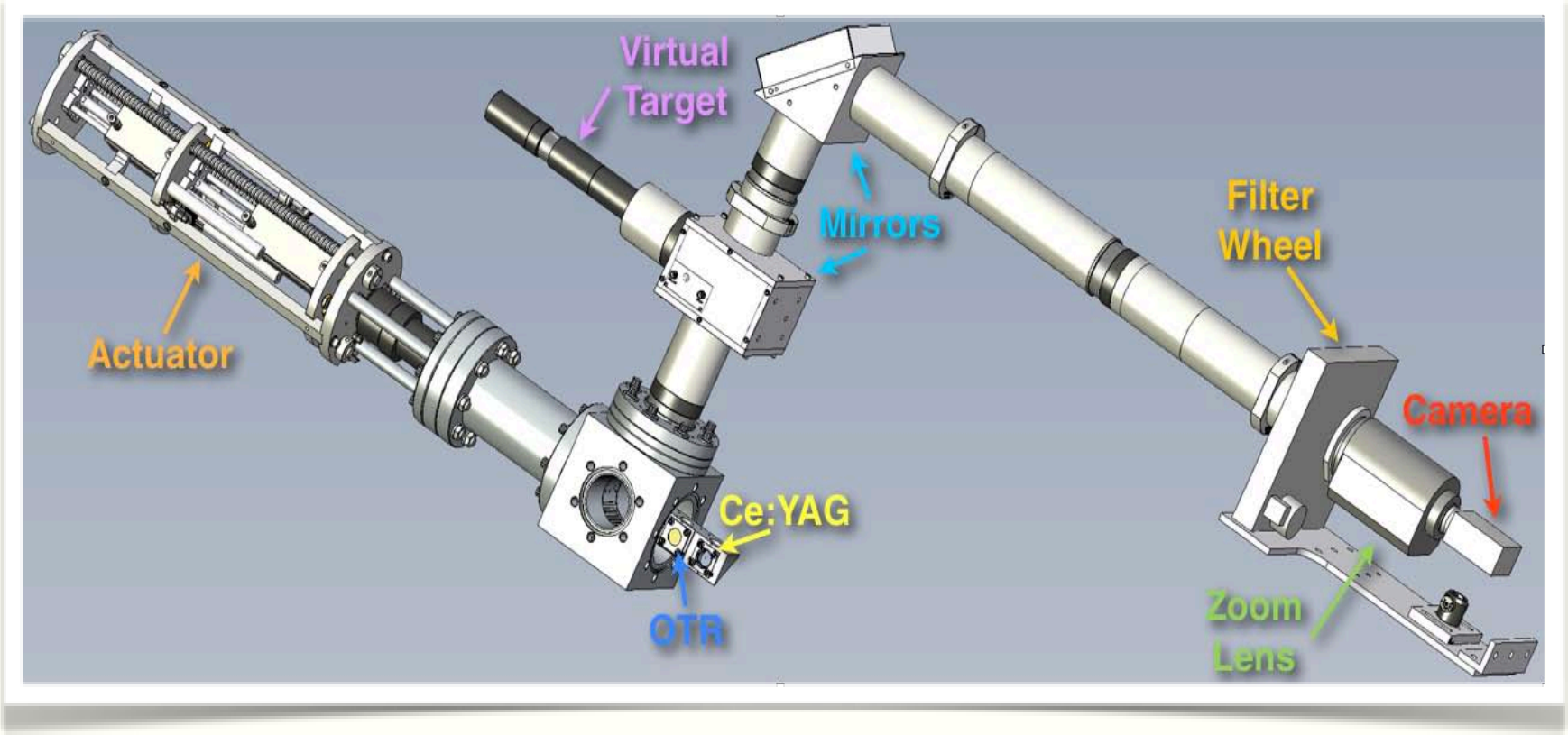
- OTR basics
- OTR point-spread-function (PSF) aspects
- Microbunching instability and coherent OTR (COTR)
- Non-intercepting aspect with optical diffraction rad. (ODR)
- Non-relativistic beams

IV. Future tests

V. Summary

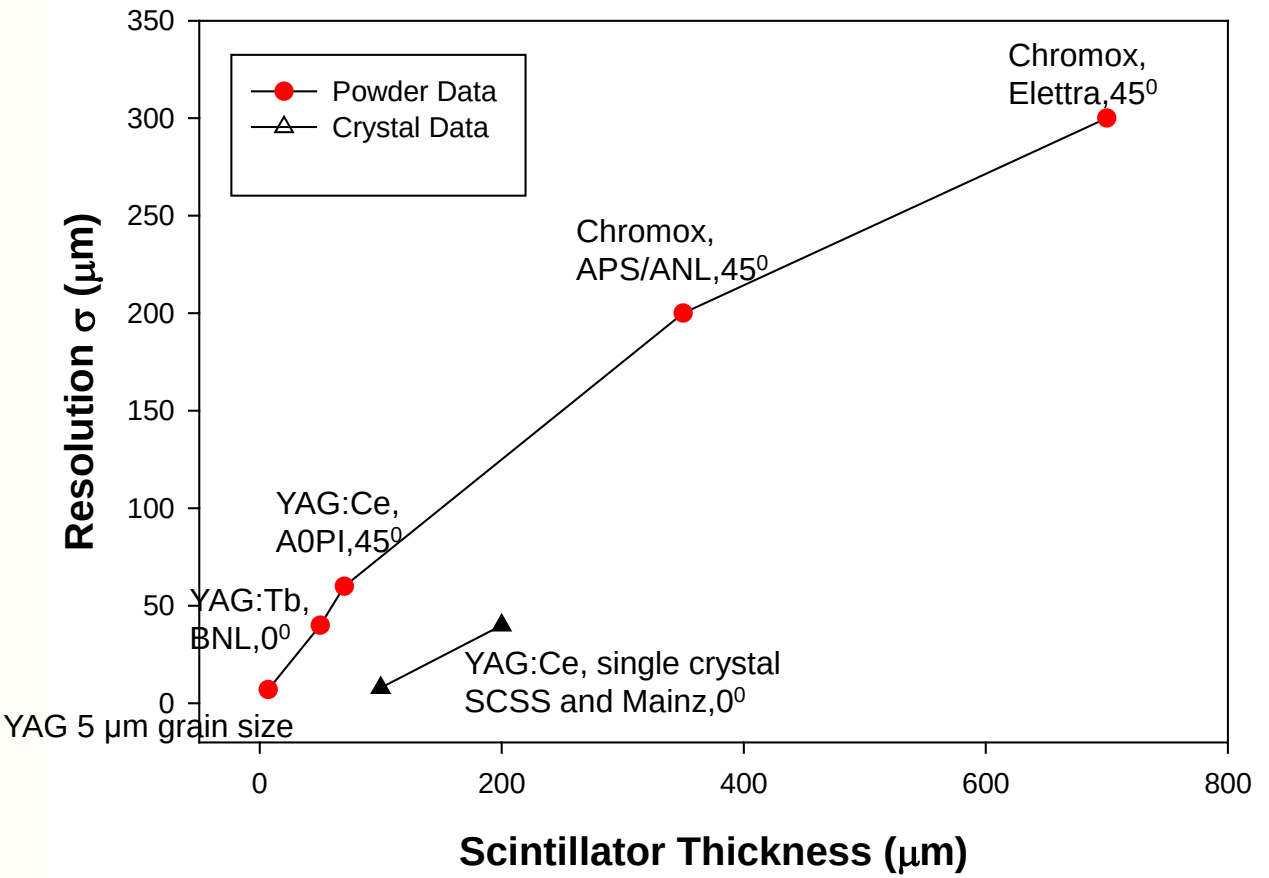
Prototype Imaging Station

- New developed imaging station in collaboration with RadiaBeam, Inc.



Screen Resolution vs. Thickness

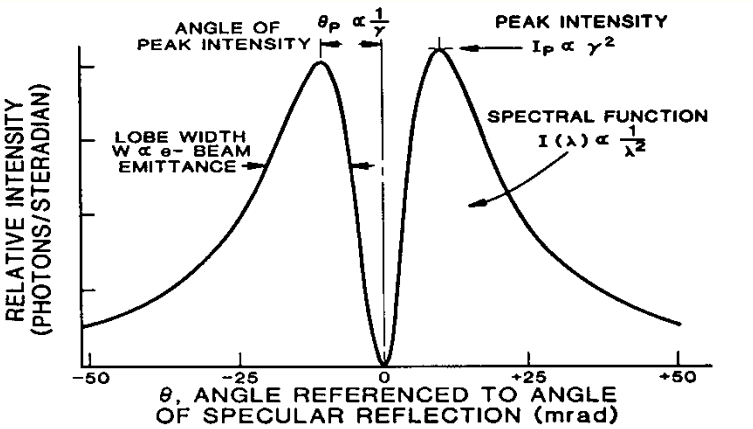
- **Scintillator screen resolution vs. thickness after applying corrections discussed on page 6.**

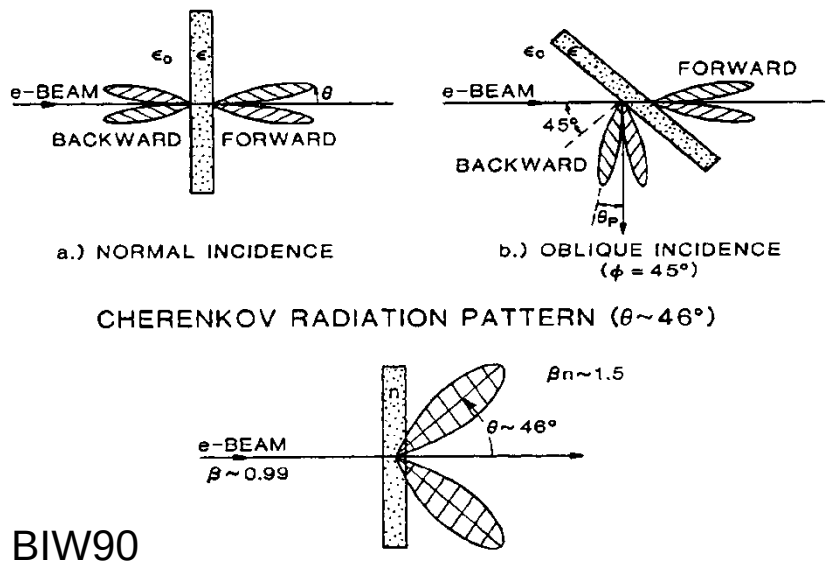


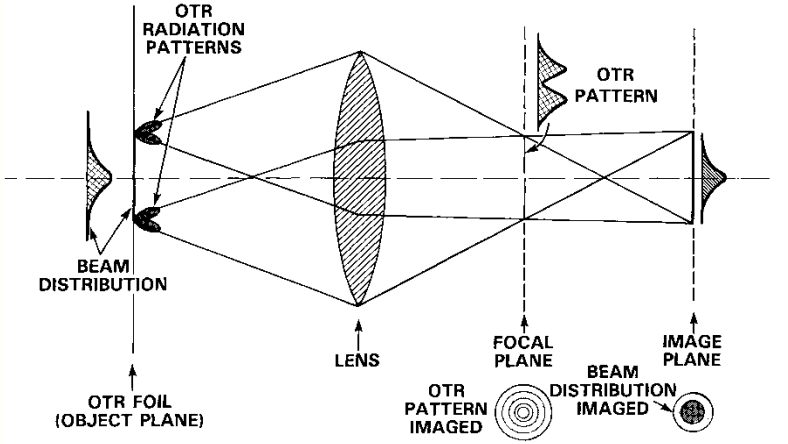
Optical Transition Radiation (OTR)

- **OTR can be used for beam**
  - **profile / size**
  - **position**
  - **divergence**
  - **energy,**
  - **relative intensity**
  - **bunch length**
- **Charged particle passing a media boundary (EM dipole).**

OTR angular intensity distribution of a single charged particle



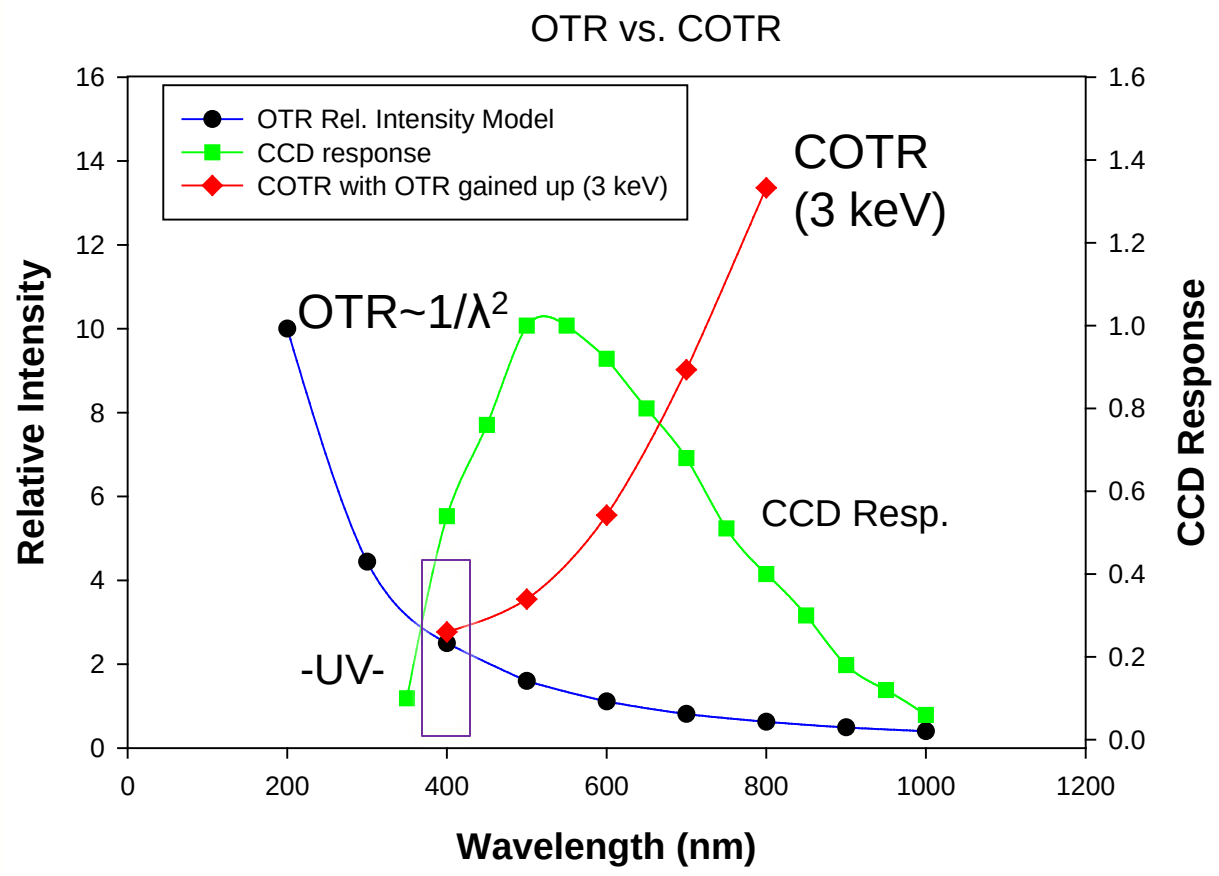




BIW90

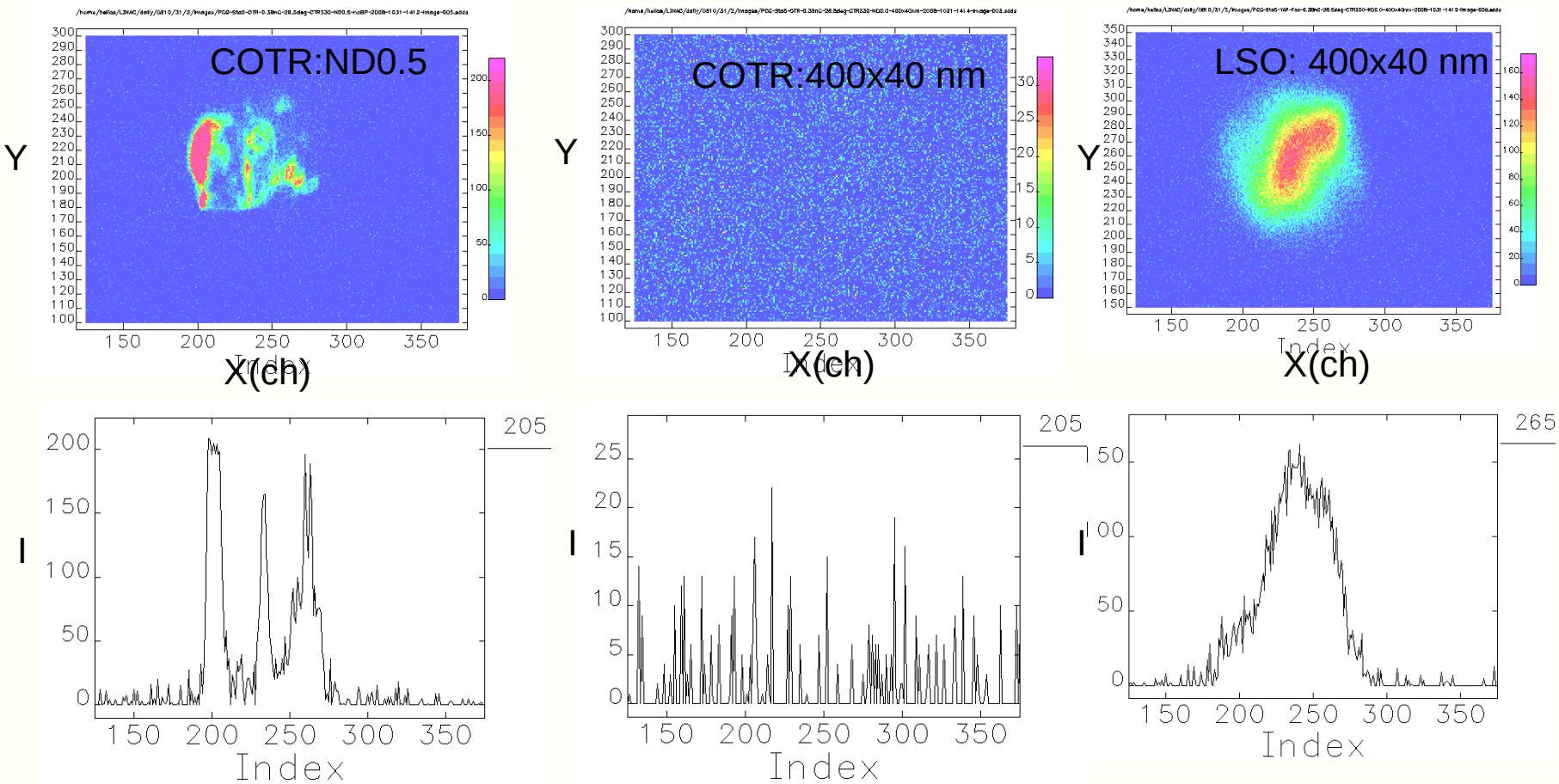
COTR Case at 250 MeV

- **Estimation of OTR/COTR spectral effect for LCLS case.**



COTR Mitigation Test at St-5/ANL

- **Reduction of COTR effects with 400x40 nm BPF, but need more sensitive camera than 40dB analog CCD to see remaining OTR.**

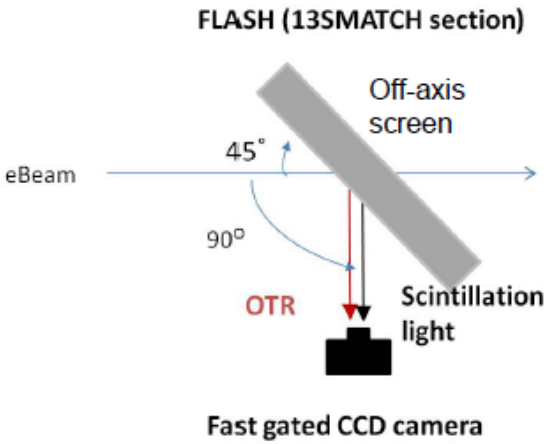


FLASH : Gated ICCD on COTR

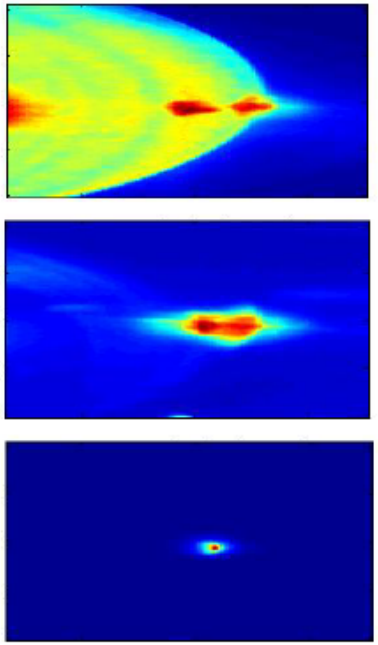
- **MCP gate used to reject prompt COTR emissions**

Motivation

> Scintillation screen + gated camera



Camera image: FLASH, 13SMATCH section, 9.Jan.2011



Al coated Si OTR screen,
COTR light,
Coherent SR

LuAG screen,
COTR & scintillation light

LuAG screen
+100ns delay
Only scintillation light

Minjie Yan | Influence of observation geometry on resolution| 15.2.2011 | Page 6

M.Yan,GSI WS 2011

Proposed OTR Application to Heavy Ions

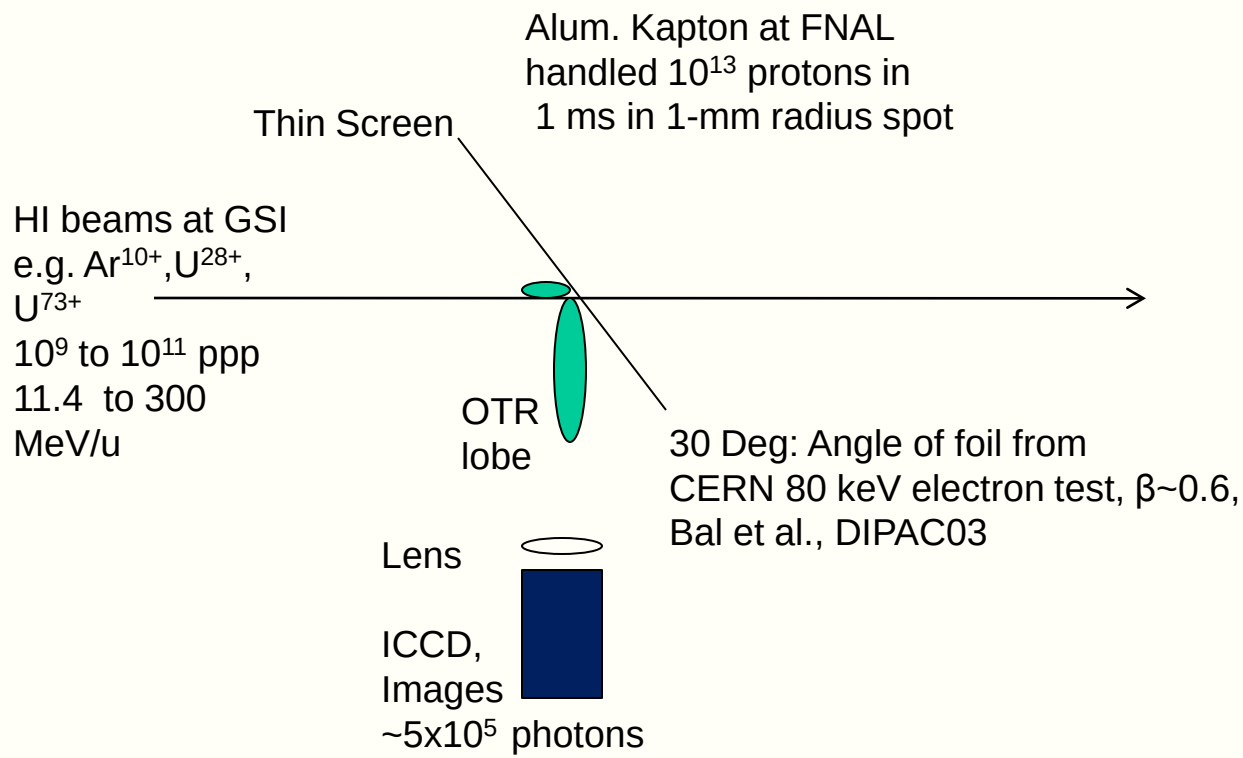
- **Consider applying technologies and concepts for ions.**
- **Take advantage of charge state for OTR generation.**

For a non-relativistic charge Q, traveling with velocity v, the spectral energy density of transition radiation is,

$W(\omega) = 4 Q^2 \beta^2/3\pi c$,

where $\beta = v/c$ and c is the speed of light.

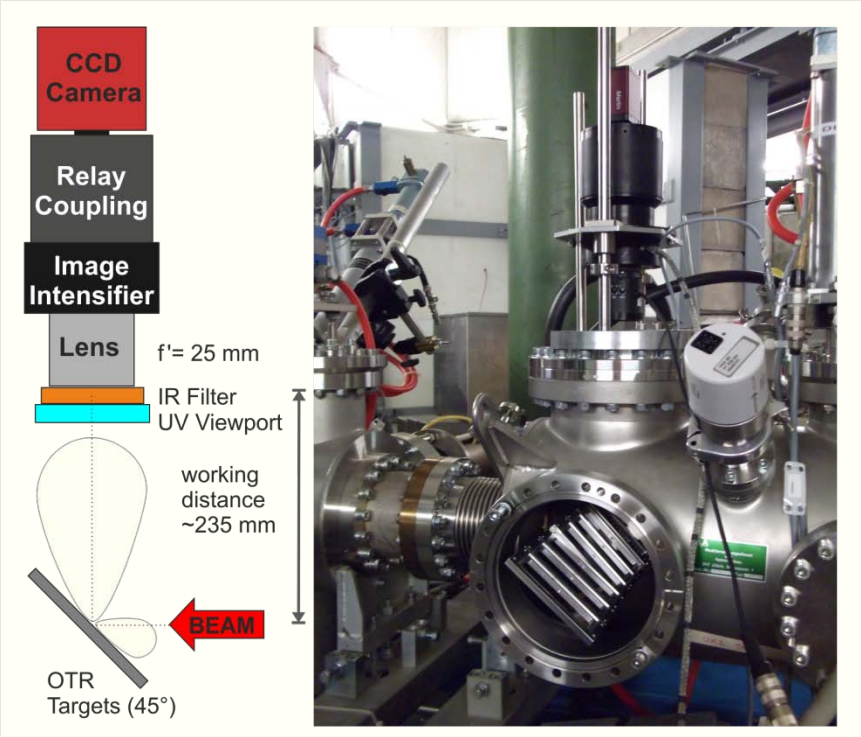
Ginzburg and Tsyovich,(1984)



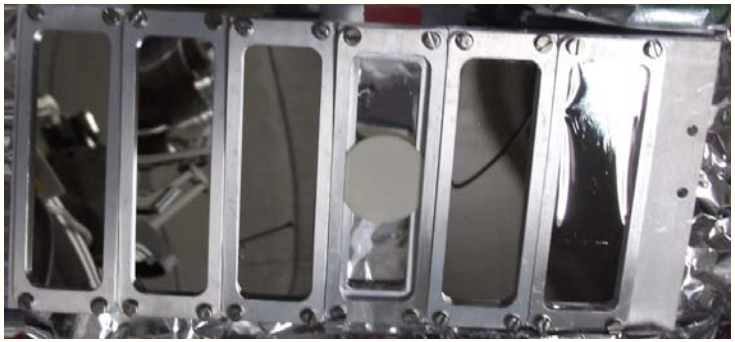
More than a "gedanken" experiment!

Experimental Setup at GSI

Experimental setup consists of an OTR target ladder (6 targets on one ladder) and image-intensified CCD camera system (ICCD) from PROXITRONIC.



Target ladder before high current irradiation



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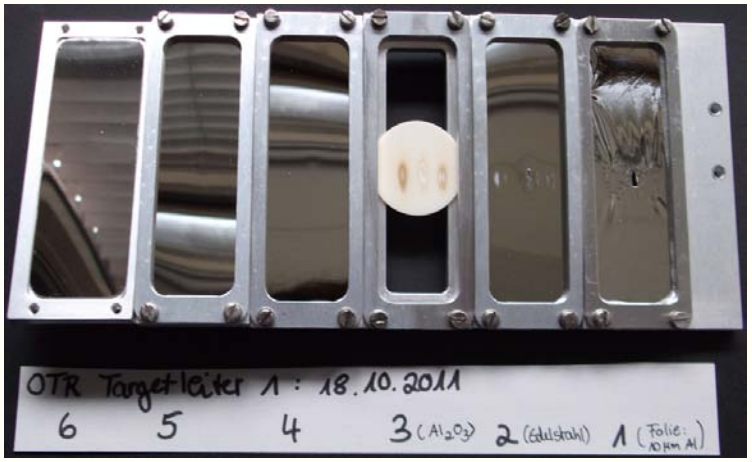
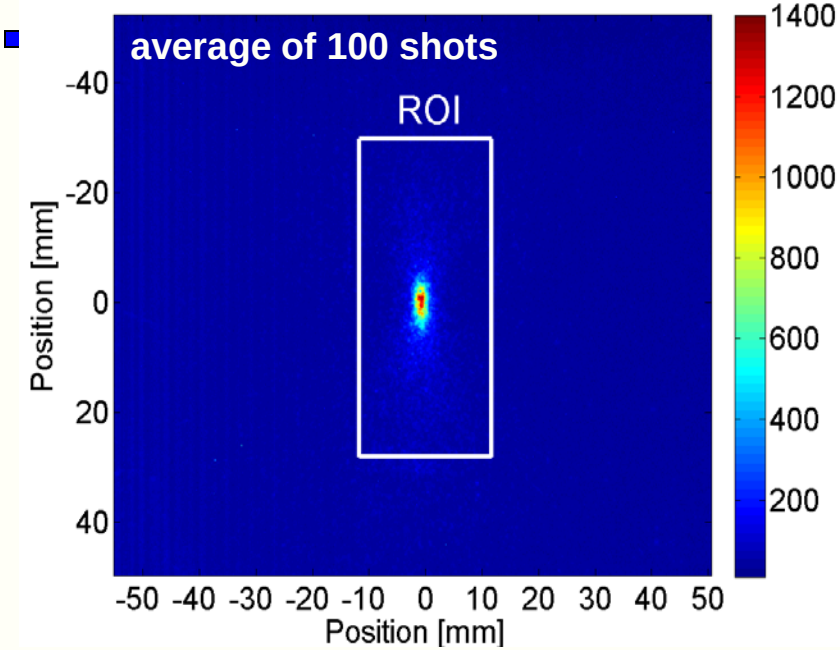


- the exact ICCD gating feature (down to 10 µs) was used to select preferentially the prompt OTR signal versus any background sources in the scene.

*GSI slides provided by B. Walasek-Hohne

For future investigations we reduced beam current!

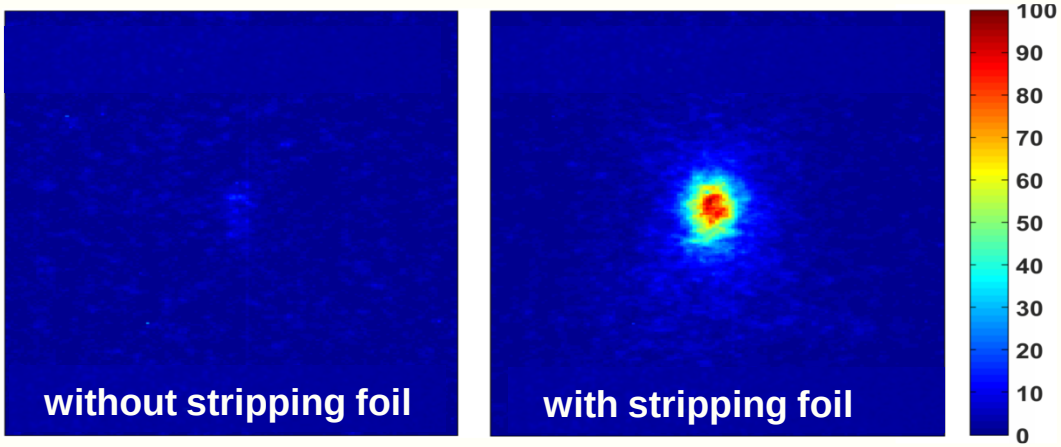
First results – first pictures

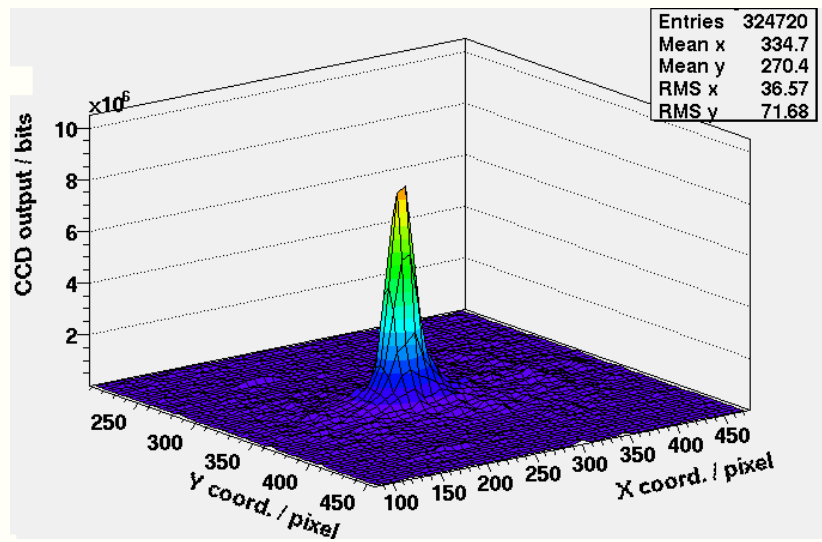


First, there is a signal!

→ transversal light distribution is observed

→ better signal by using stripping foil





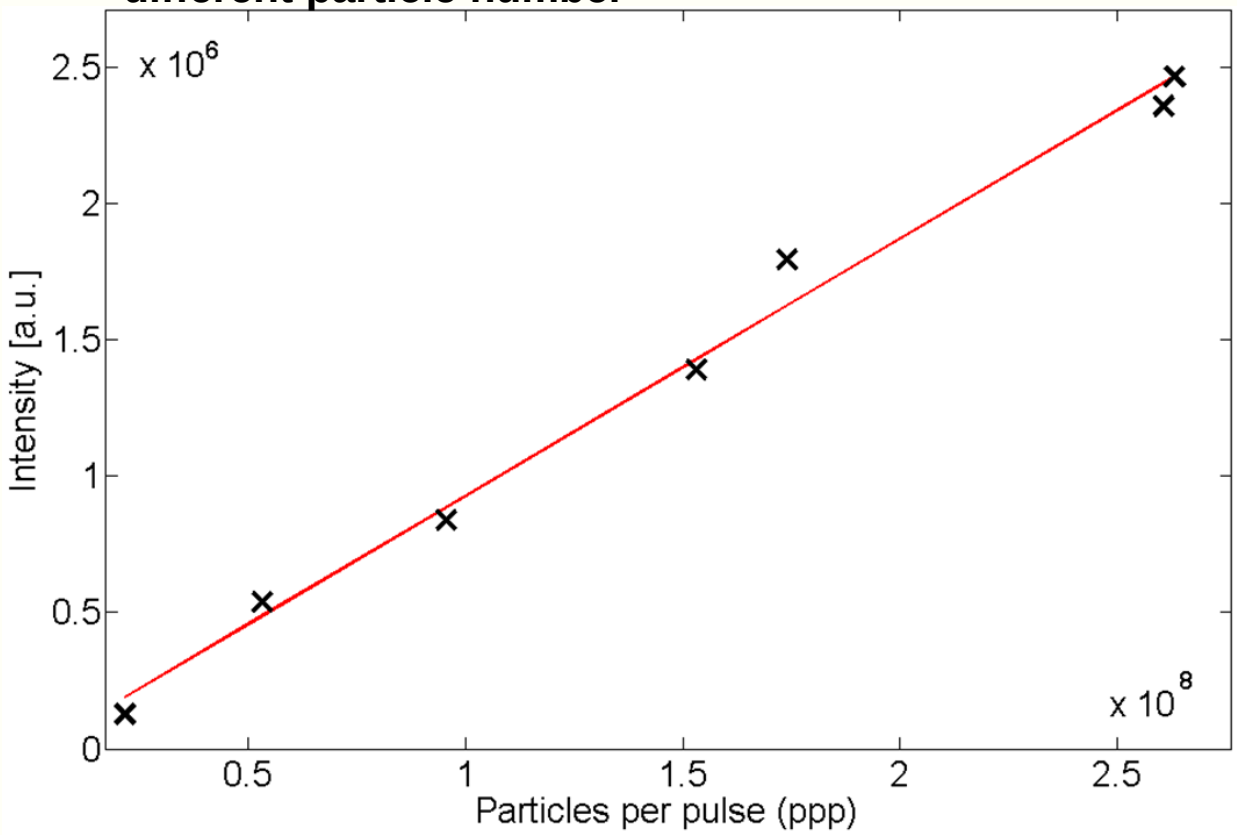
Beam parameters: Uranium, 11.4 MeV/u, **2.6 · 10^8 ppp** in 300 µs

From B. Walasek-Hohne

First results – signal strength

OTR is expected to show linearity to the number of charges crossing without risk of saturation.

OTR signal strength as relative total ICCD intensity for different particle number



OTR signal strength scales linearly with particle number

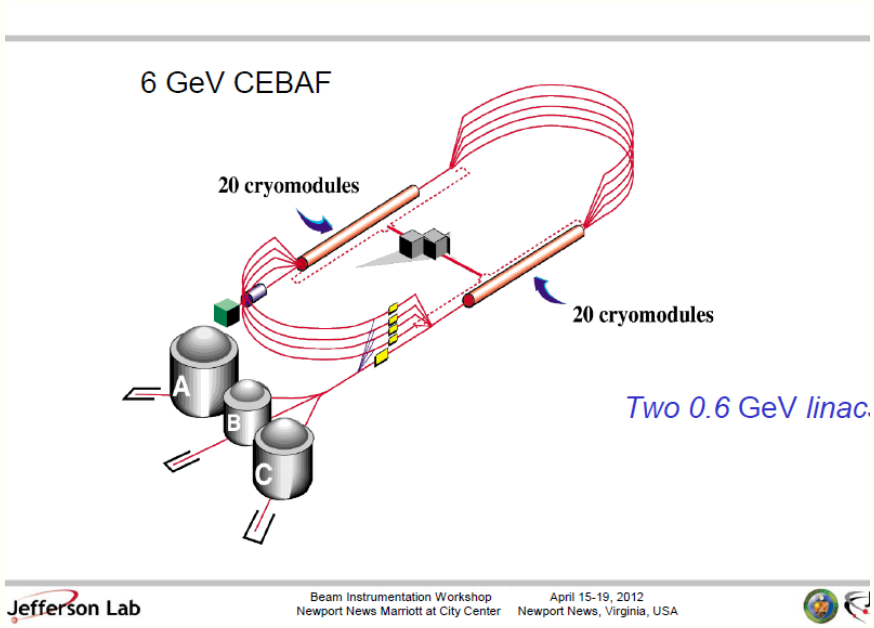
From B. Walasek-Hohne

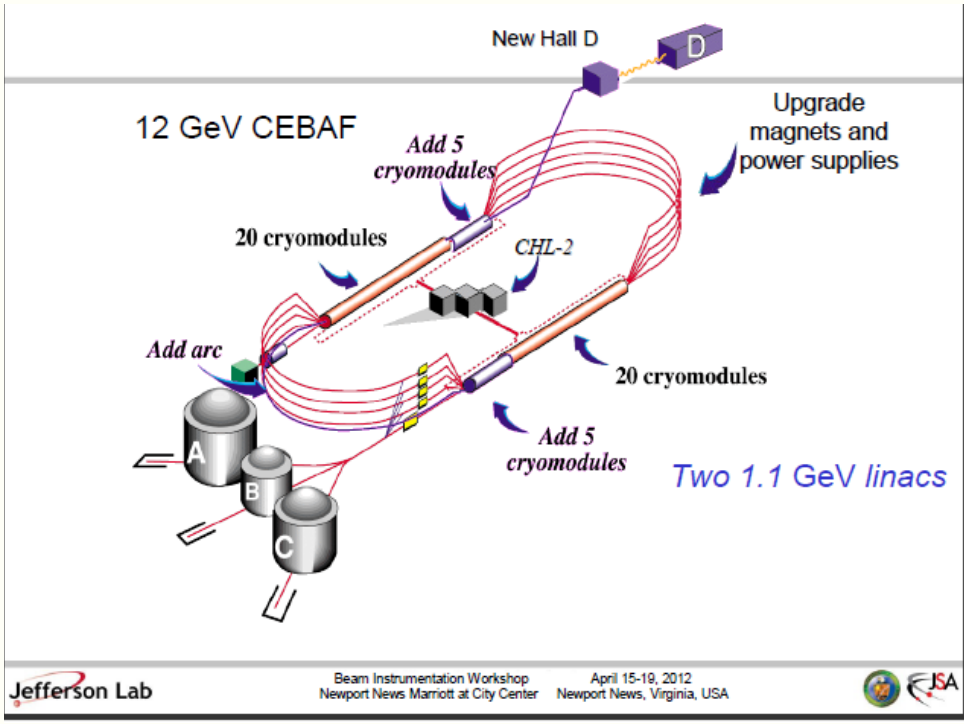
Beam parameters: $U^{\sim 73+}$, 11.4 MeV/u, **$1 \cdot 10^7$ - $3 \cdot 10^8$ ppp** in 300 µs

Summary

- Scintillator resolution terms should be characterized,
  - Use normal incidence of beam as preferred geometry to minimize depth-of-focus issues in beam images.
  - Scintillators may be used more for ultra-bright electron beams.
- OTR polarization effects need to be elucidated
  - Plan to use linear polarizers with OTR imaging for the perpendicular profile components at ASTA.
- Mitigate microbunching instability effects for profiling of bright beams.
  - Plan to use 400x40 nm band pass filters and LYSO:Ce crystals after bunch compression at ASTA to suppress expected diagnostics complications due to COTR.
- New paradigm for heavy-ion beam imaging with OTR.
- The future remains bright for imaging techniques.

CEBAF/JLAB Upgrade Funded

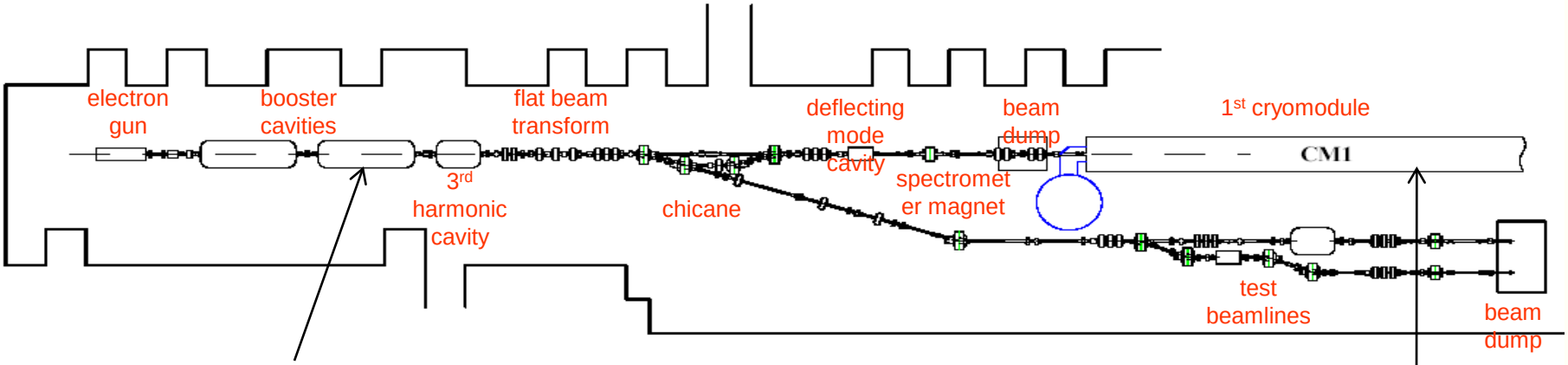




40-MeV Injector for ASTA/FNAL

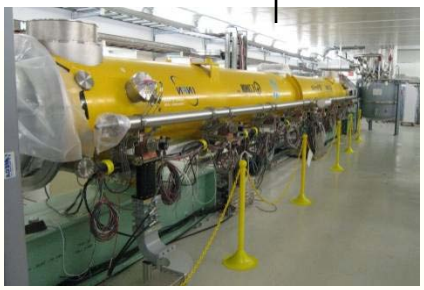
- **Injector being installed with First beam expected in 2012.**

40-MeV Injector



Booster cavity 2 (from DESY and Saclay) installed in NML

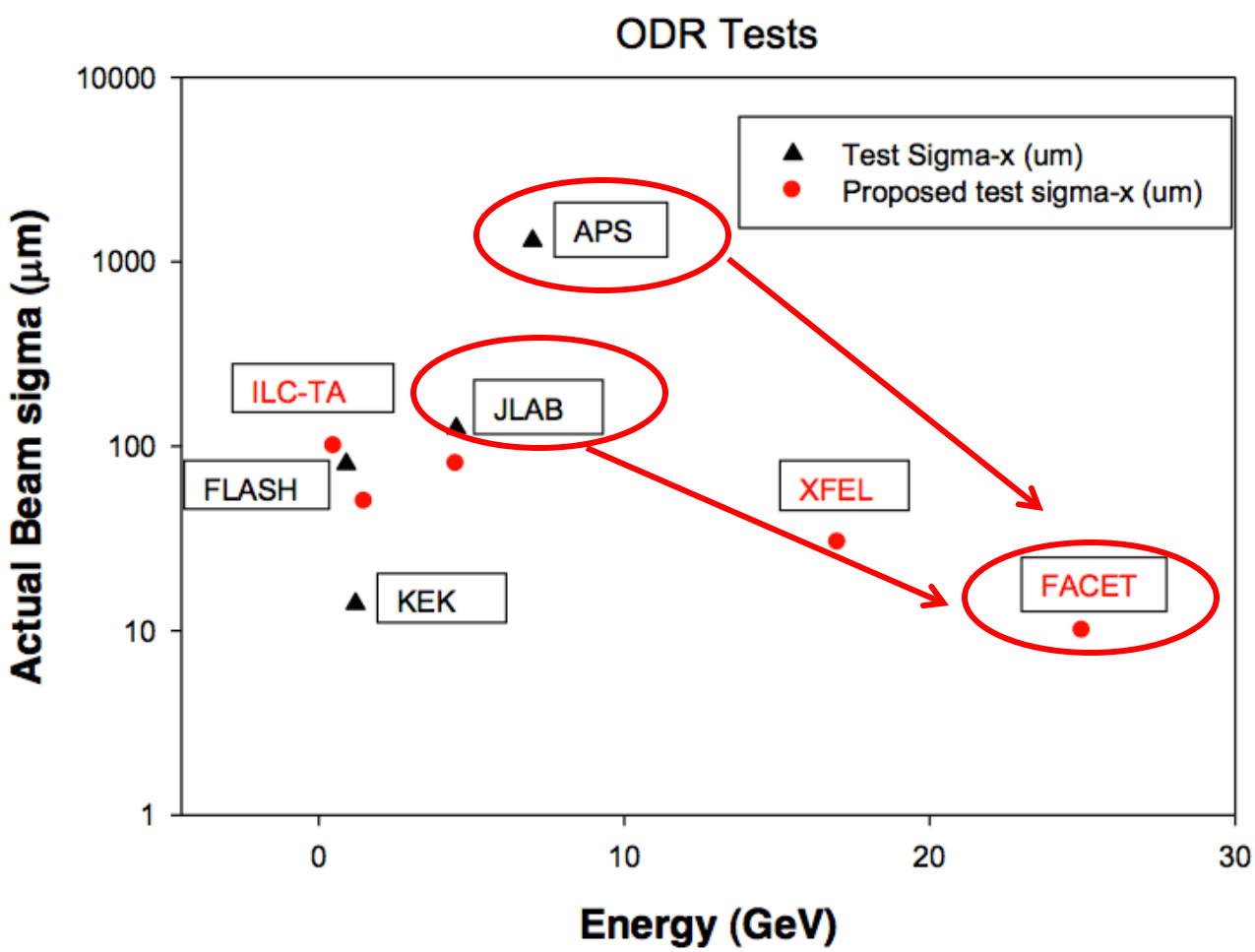
Courtesy of *M. Church*



First cryomodule (from DESY) installed at NML.

OTR/ODR Studies Proposed

- **Path to test near-field imaging on 10-µm size at 23 GeV.**



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- IBIC12 at Tsukuba, Japan: Oct. 1-4, 2012
- IBIC13 at Oxford, England: Sept. 16-19, 2013
- IBIC14 at San Francisco, CA: Sept. 2014?