

# SECAR

## SEparator for CApture Reactions

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# Proposal submitted to DOE

## Principal investigators:

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- K.E. Rehm, Argonne National Laboratory
- M.S. Smith, Oak Ridge National Laboratory
- M. Wiescher, University of Notre Dame
- H. Schatz, Michigan State University

## Collaborators:

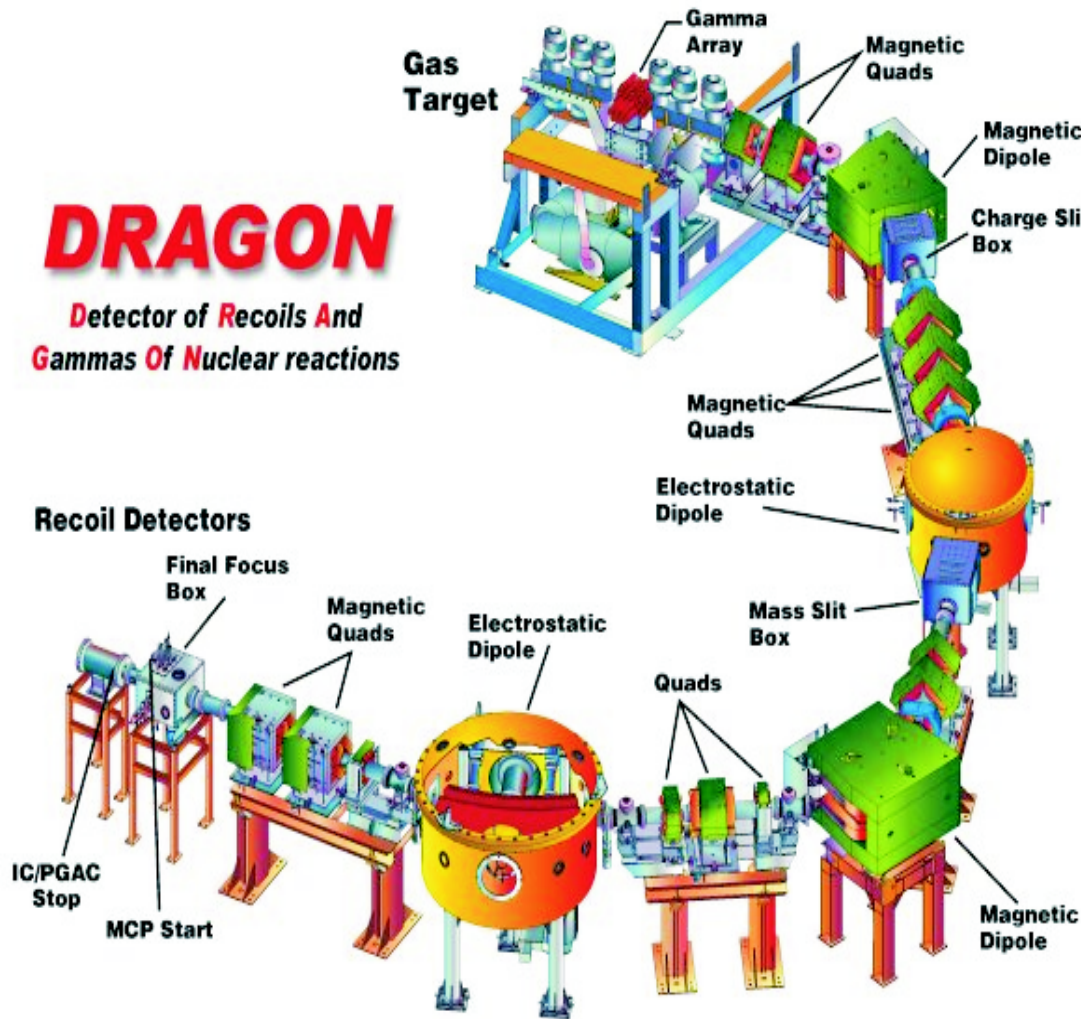
- G. Berg, University of Notre Dame
- M. Couder, University of Notre Dame
- M.S. Smith, Oak Ridge National Laboratory
- A. Zeller, National Superconducting Cyclotron Laboratory

We propose to design and build an advanced recoil separator SECAR for nuclear astrophysics experiments with rare isotope beams. This device will enable direct cross section measurements of astrophysical proton and alpha capture reactions at NSCL and later FRIB. Such reactions play a critical role in various explosive astrophysical scenarios including X-ray bursts, novae, supernovae and need to be understood to address fundamental questions related to the origin of elements and the nature of neutron stars.

# Dragon @ Triumf

**DRAGON**

Detector of Recoils And  
Gammas Of Nuclear reactions



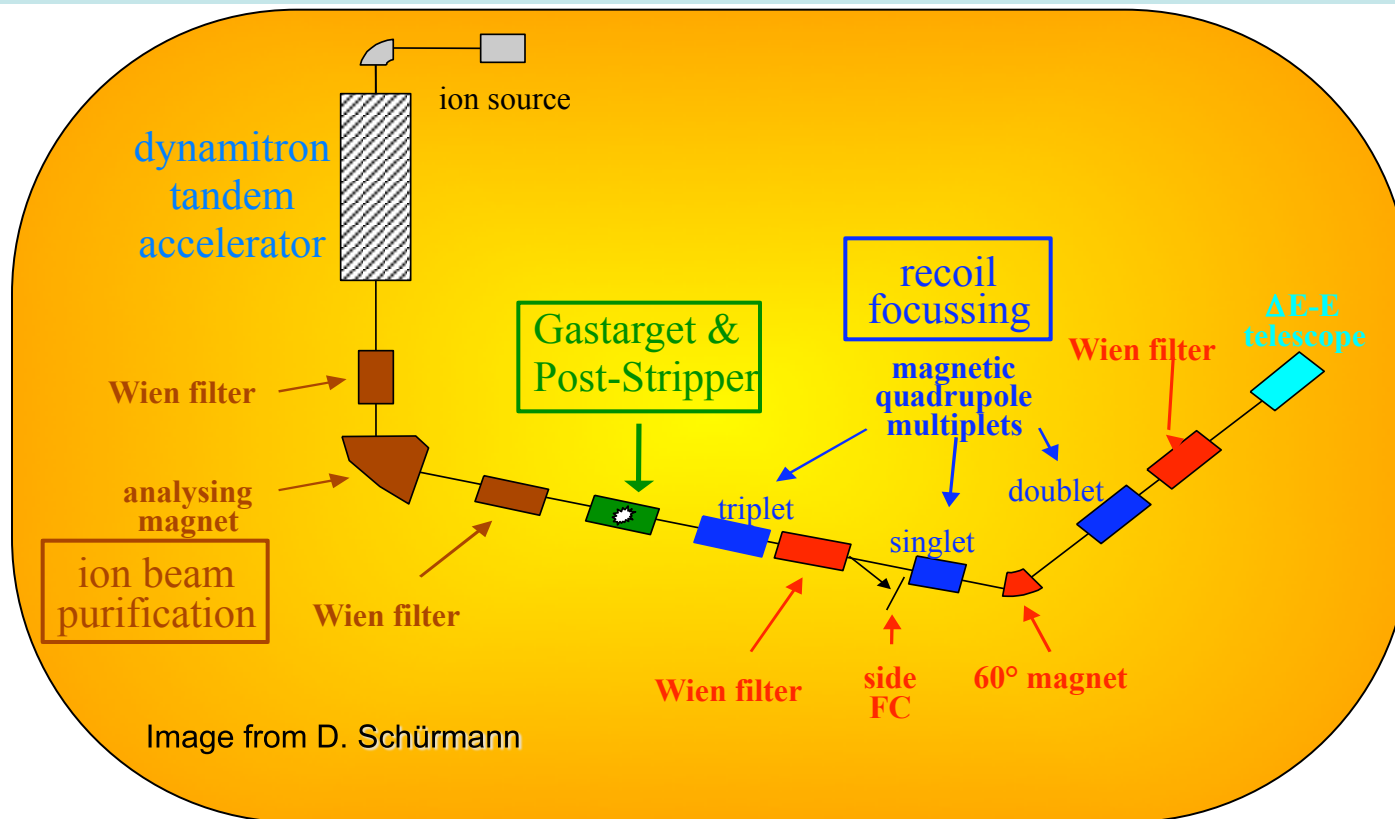
Designed for radiative capture  
 $e$ , installed and used at TRIUMF

Beam up to 50 pA (for  $^{12}\text{C}$ )  
Two stages  
Electric Dipole

Mass resolution first stage: 200  
Mass resolution 2<sup>nd</sup> stage: 600

$\theta_{\text{max}} = 20 \text{ mrad}$

# ERNA @ Bochum



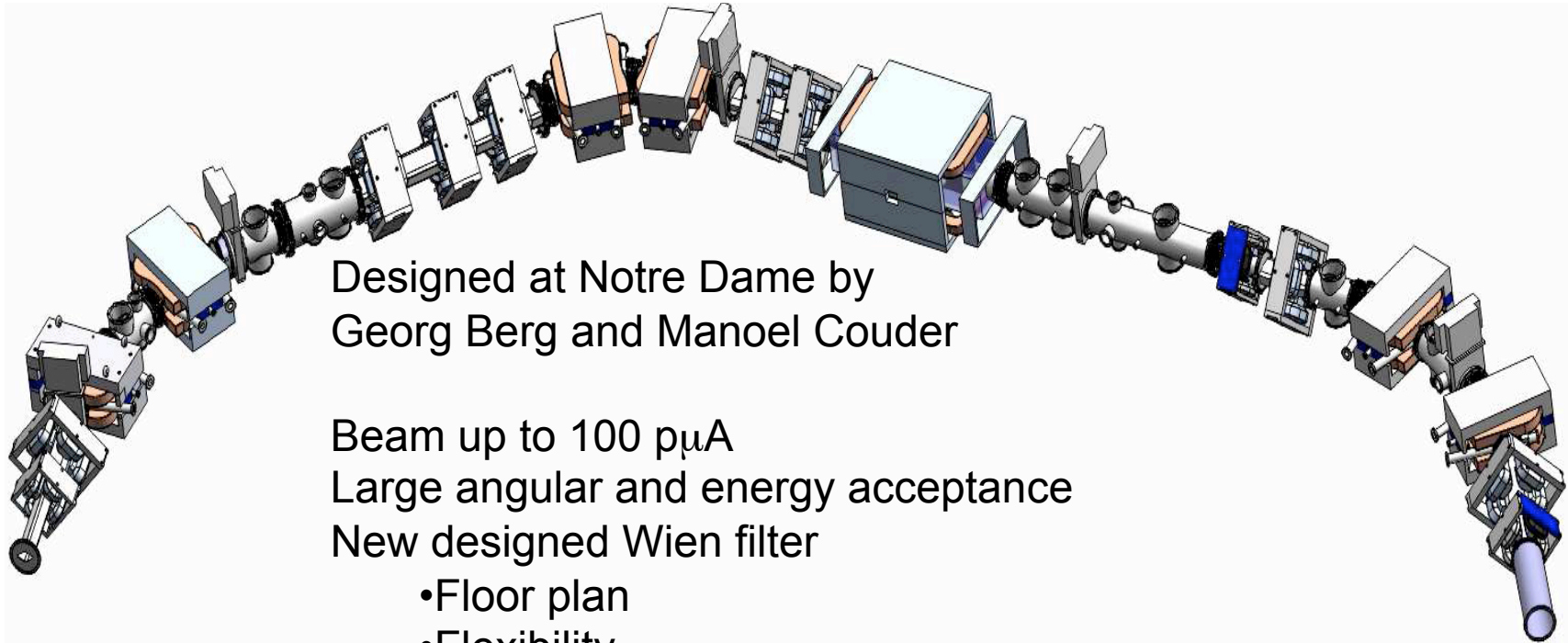
Designed for  $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$

Beam up to  $25 \mu\text{A}$

Two stages Wien filter - Mass resolution not provided

$\theta_{\text{max}} \approx 30 \text{ mrad}$

# St. George @ ND– First stage ( $\alpha, \gamma$ )



Designed at Notre Dame by  
Georg Berg and Manoel Couder

Beam up to  $100 \mu\text{A}$   
Large angular and energy acceptance  
New designed Wien filter

- Floor plan
- Flexibility

Mass resolution  $M/\Delta M=200$   
Ready by spring of 2009

# Challenges for SECAR

- Large mass  $\rightarrow \Delta m/m$  smaller
  - Larger mass resolution required
- Low beam energy
  - Large angular and energy acceptance
  - Particle ID more difficult
- Charge state efficiency measurement
- More than radiative capture
  - large angular and energy acceptance

# Critical elements

- Target
  - Gas target
    - DRAGON extended ~12 cm effective length
      - Reduced mass resolution
    - ERNA extended ~10cm + jet target underdevelopment
    - St. George Jet gas target ~3mm width (+post-stripper)
- Detectors at the target
  - $\gamma$  array and charged particle
- Focal plane detector
  - $\Delta E$ -E (ionization chamber)
  - Position sensitive Si detector
  - Time of flight (MCP)

# New design

- Take into account strong point and weakness of other RMS
  - Acceptance limitation
  - Charge state background
- Incoming beam quality (emittance, energy resolution...)
- Jet Gas target design (JINA proposal)
  - should be

# Very preliminary design parameters

- Angular acceptance  $\theta_{\max} = 30 \text{ mrad} = 1.7 \text{ degrees}$
- (p, $\gamma$ ) up to mass 65
- $\sim\pm 3.5\%$  energy acceptance
- Single charge state separation
- Wien filter  
with mass separation  $m/dm = 200$  ( $\sim$ St. George 1<sup>st</sup> phase)
- Additional Wien filter to increase  $m/dm$  to 600 – 800
- Detection system with a  $10^{-3}$  to  $10^{-4}$  rejection factor

Important remarks:

– Mass separation

is a design parameter for the first order ion optics

– It is not possible to simulate beam rejection

# Very, very, very, ... preliminary design

