Diagnostics at SARAF

L. Weissman on behalf SARAF

Beam Diagnostics in LEBT

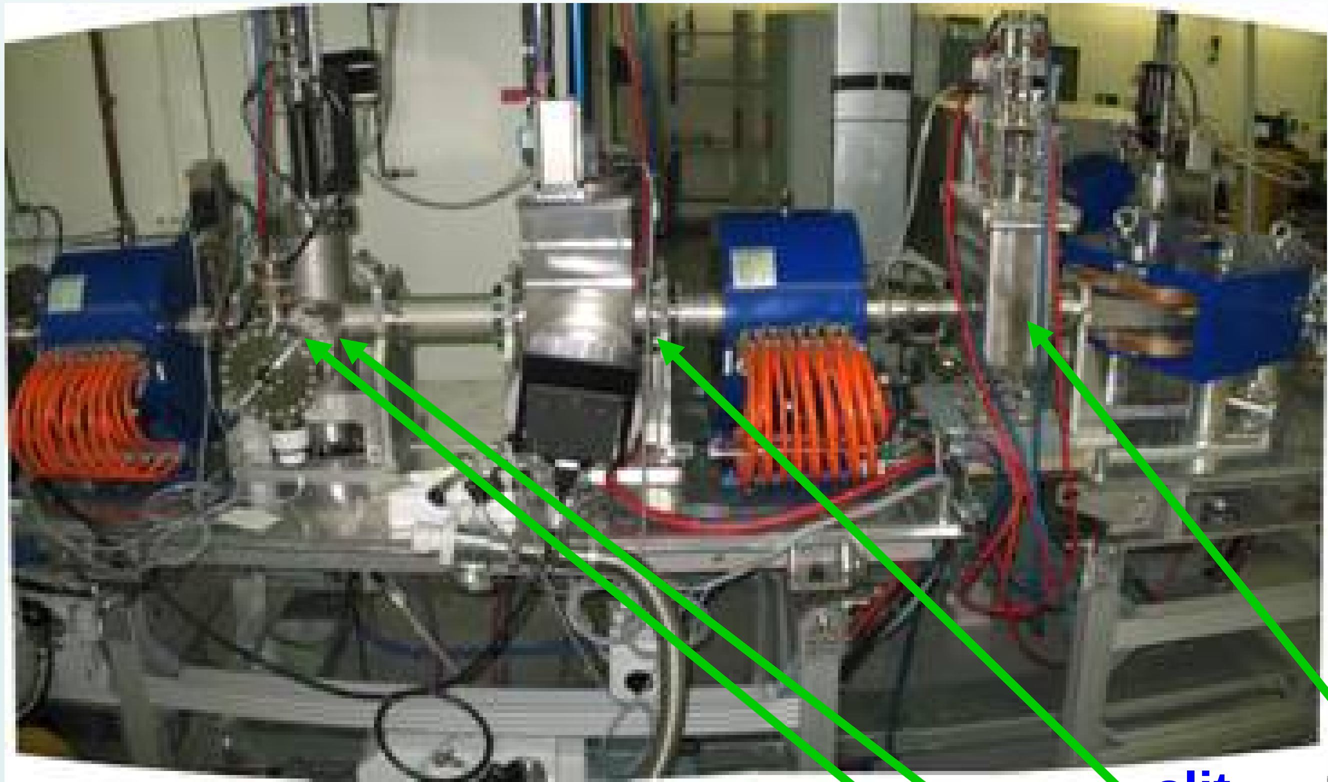
Beam Diagnostics in MEBT

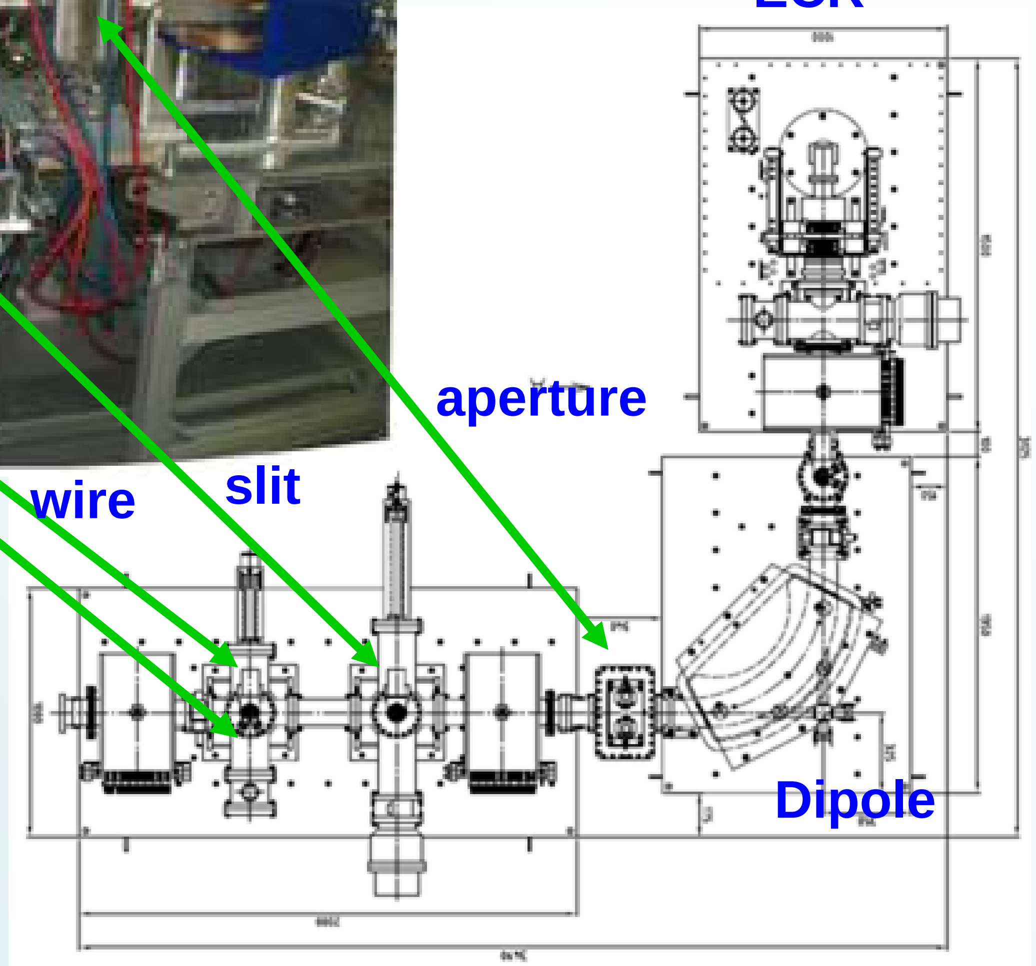
Beam Diagnostics in D-Plate
(including beam halo monitor)

Some ideas for diagnostics Phase II

Testing station, SARAF Phase I

LEBT – emittance measurement

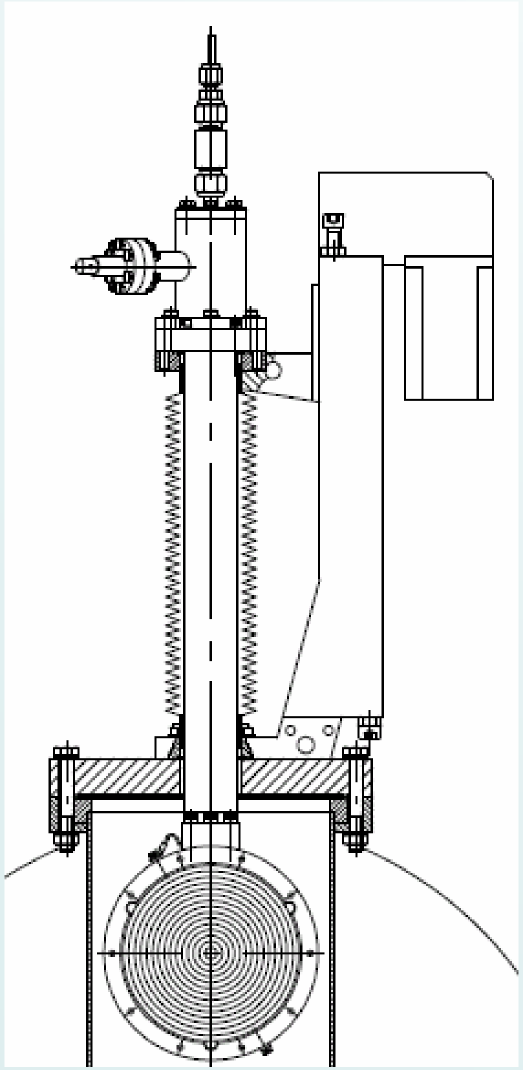


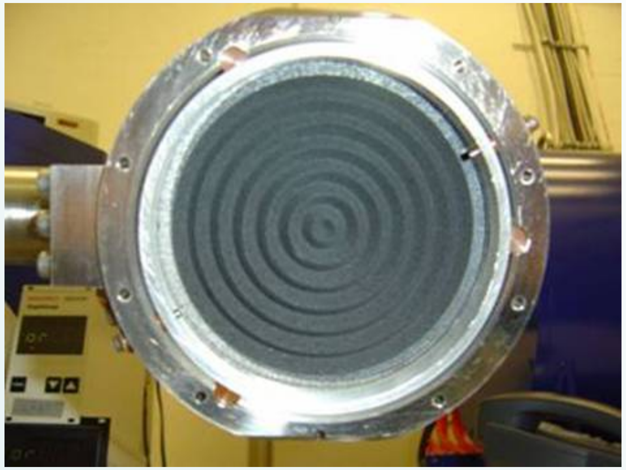


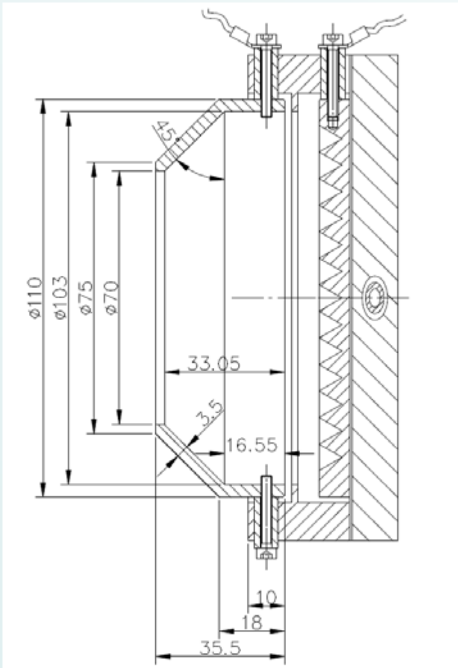
C. Piel EPAC 2006

F. Kremer ICIS 2007

Faraday Cup

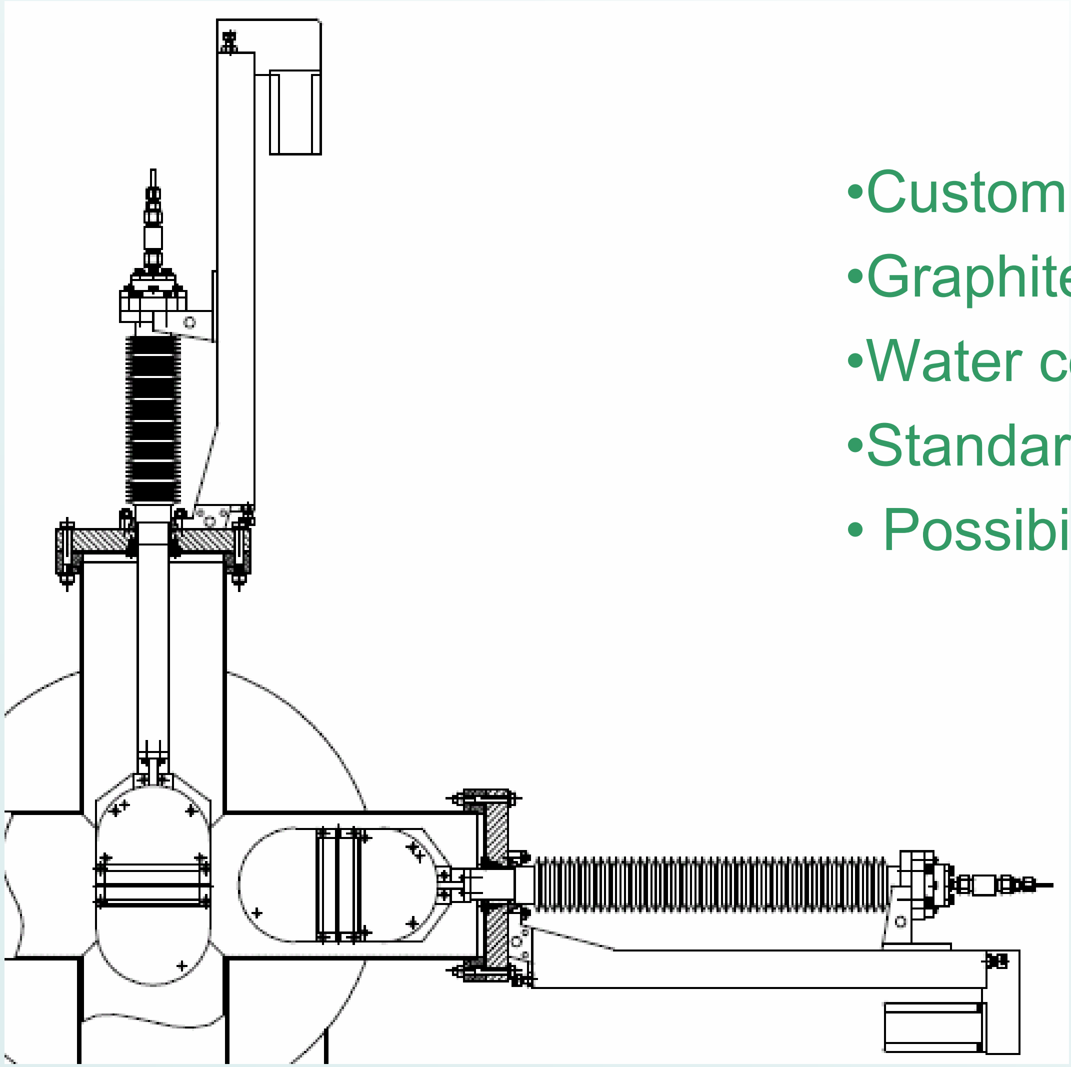






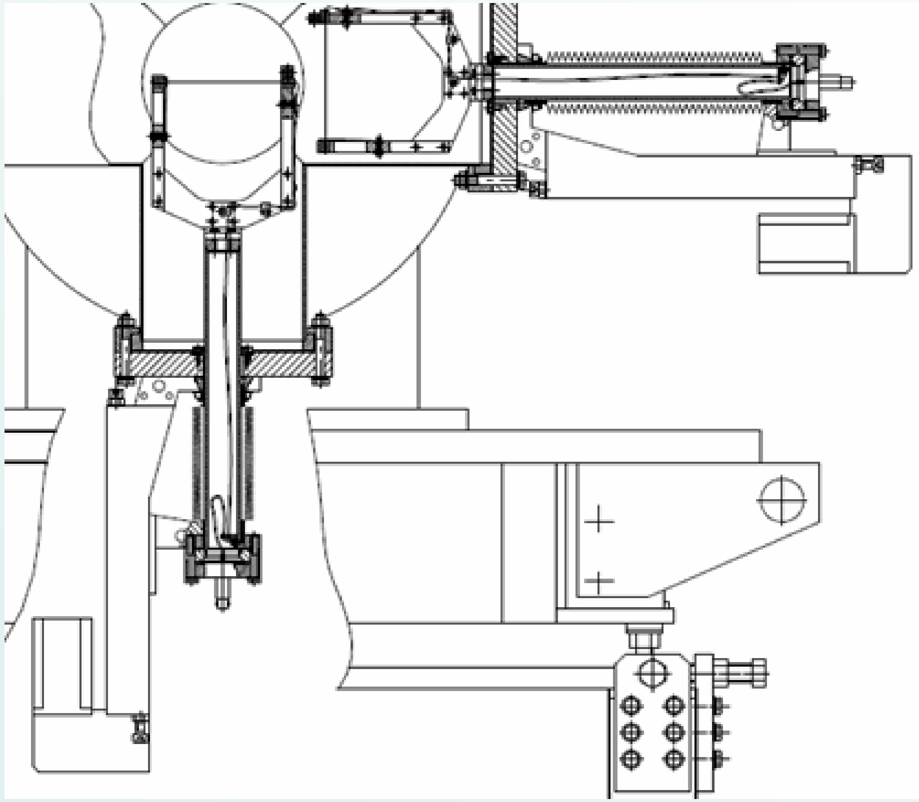
- Custom design
- Graphite collector for 200W
- Water cooled
- Current measured as voltage drop on resistor
- Read out via Field point modules from NI (cw)
- Read out with standard scope in pulsed operation
- Special cup design to overcome initial insufficient SEM suppression

Slits



- Custom design
- Graphite collector for 200W
- Water cooled
- Standard stepper motor driven actuator
- Possibility to read current

Wire scanner

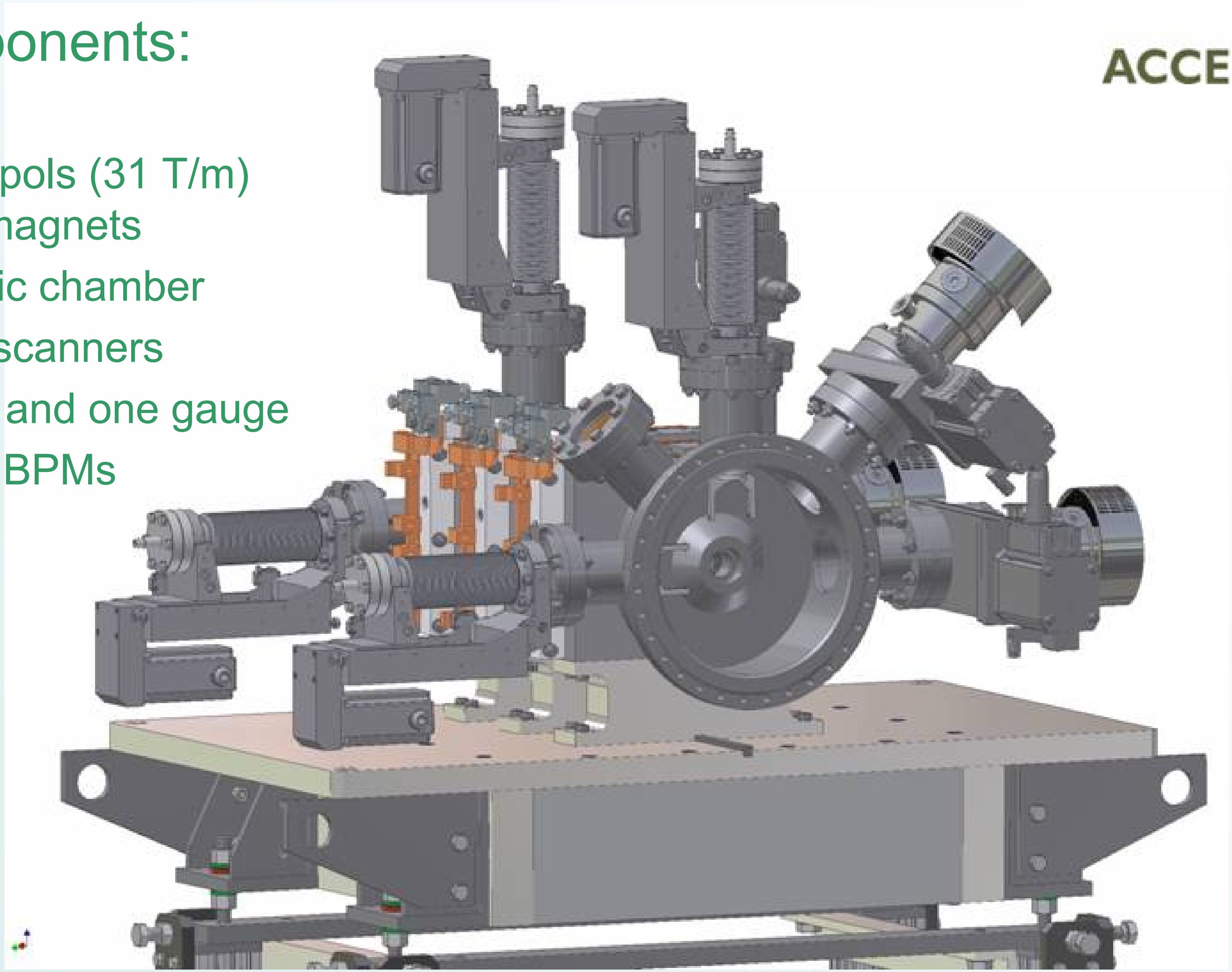


- Custom design
- Tungsten wire (0.1 mm diameter)
- Standard stepper motor driven actuator
- Planes separated for higher stability, further no interaction is guaranteed
- Current measured as voltage drop on resistor
- Read out via Field point modules from NI (cw)
- Read out with standard scope in pulsed operation

MEBT: Overview

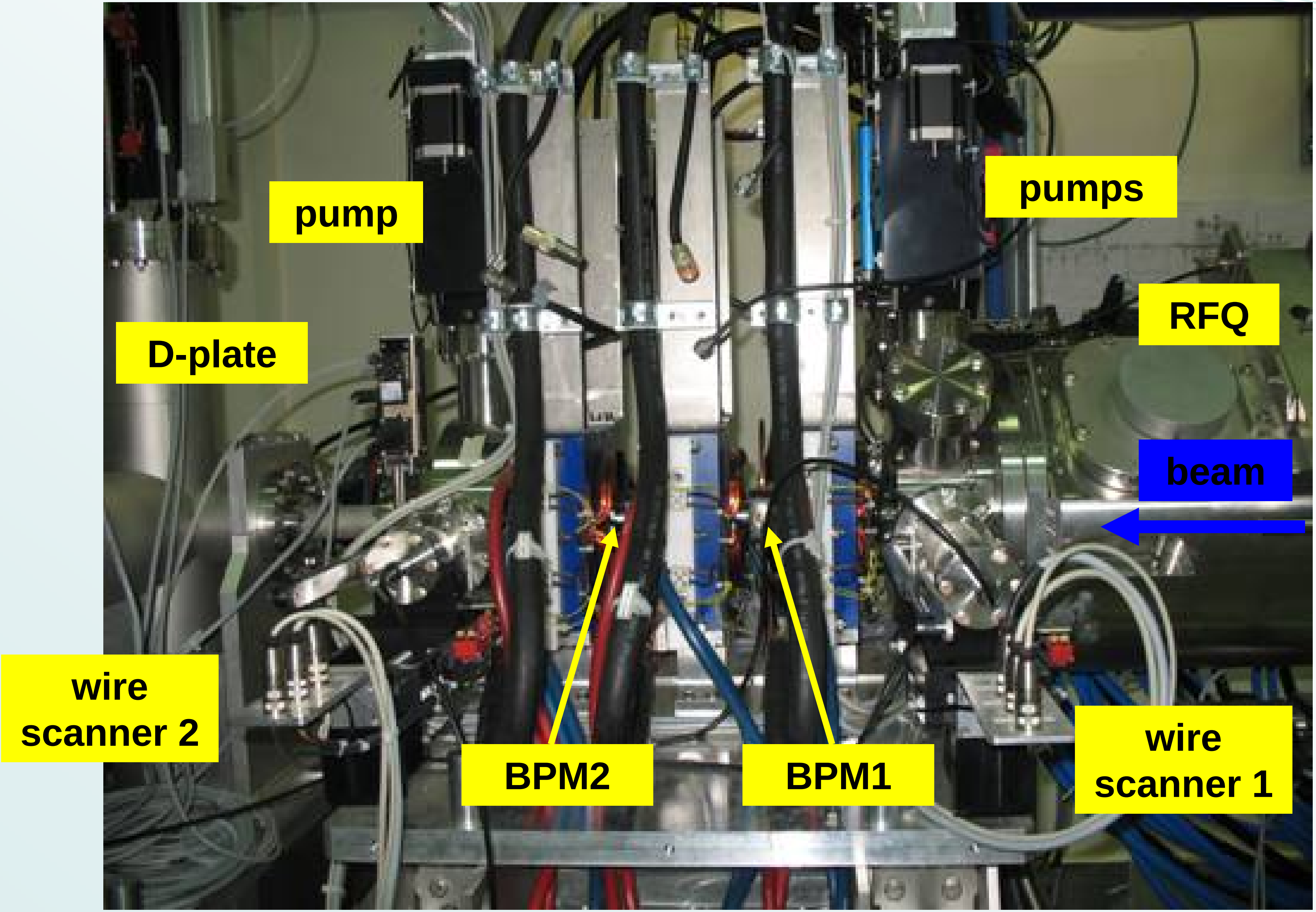
Main components:

- Three quadrupols (31 T/m) with steering magnets
- Two diagnostic chamber
- Two x/y wire scanners
- Three pumps and one gauge
- Two 4-button BPMs
  - Position
  - Phase
  - Current

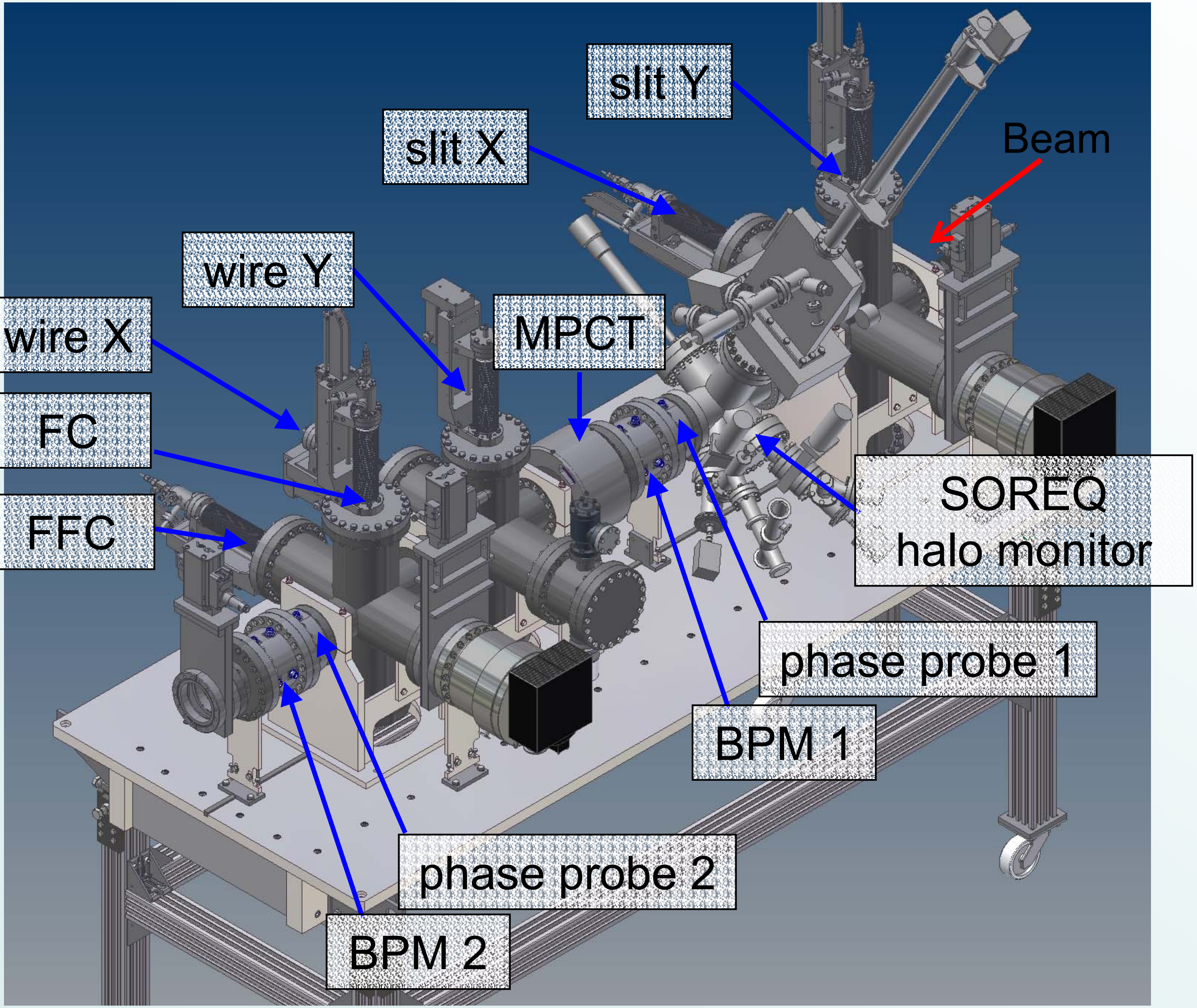


MEBT

650 mm


pump
pumps
RFQ
D-plate
beam
wire scanner 2
BPM2
BPM1
wire scanner 1

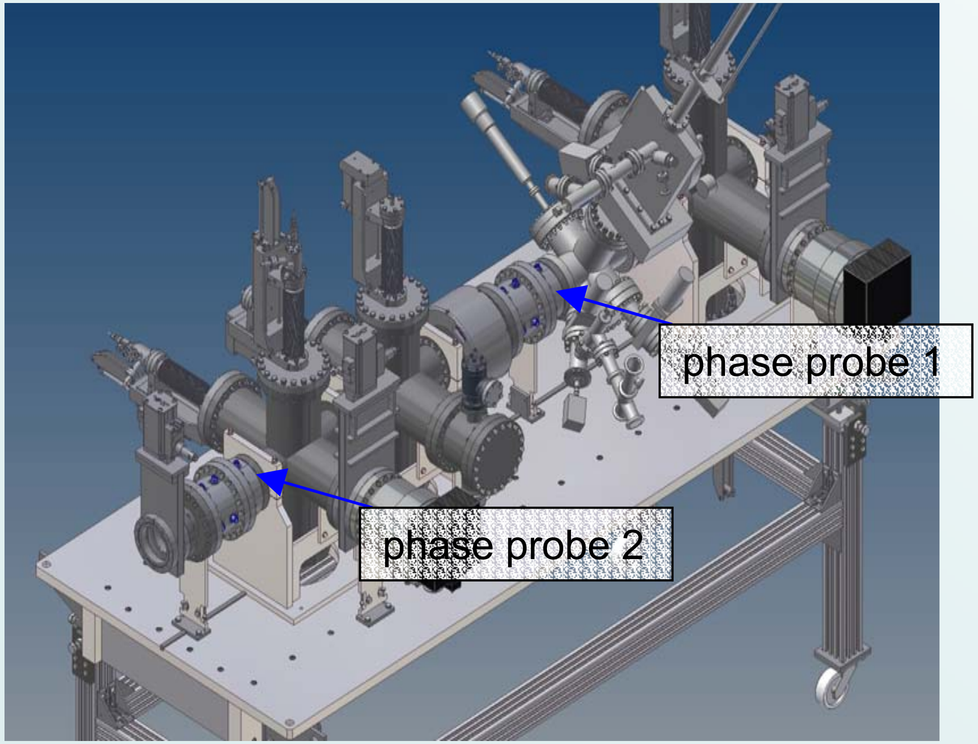
The Diagnostic Plate (D-Plate)



- Energy
- Current
- Transversal emittance
- Longitudinal emittance

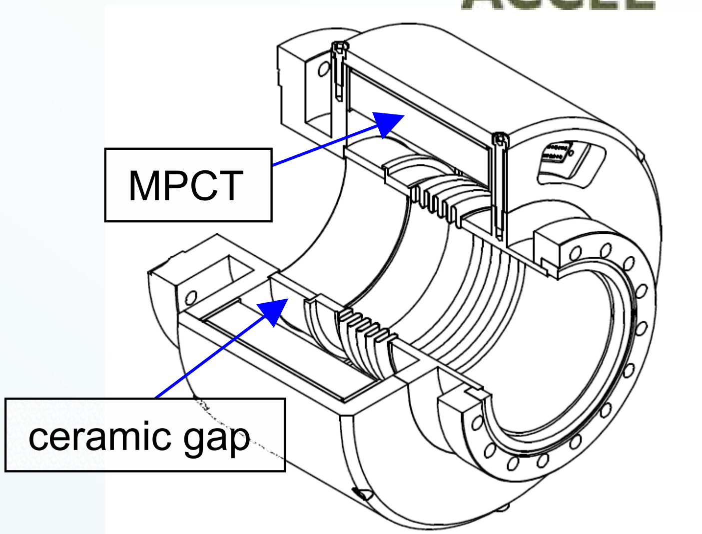
Measurement of Beam Energy

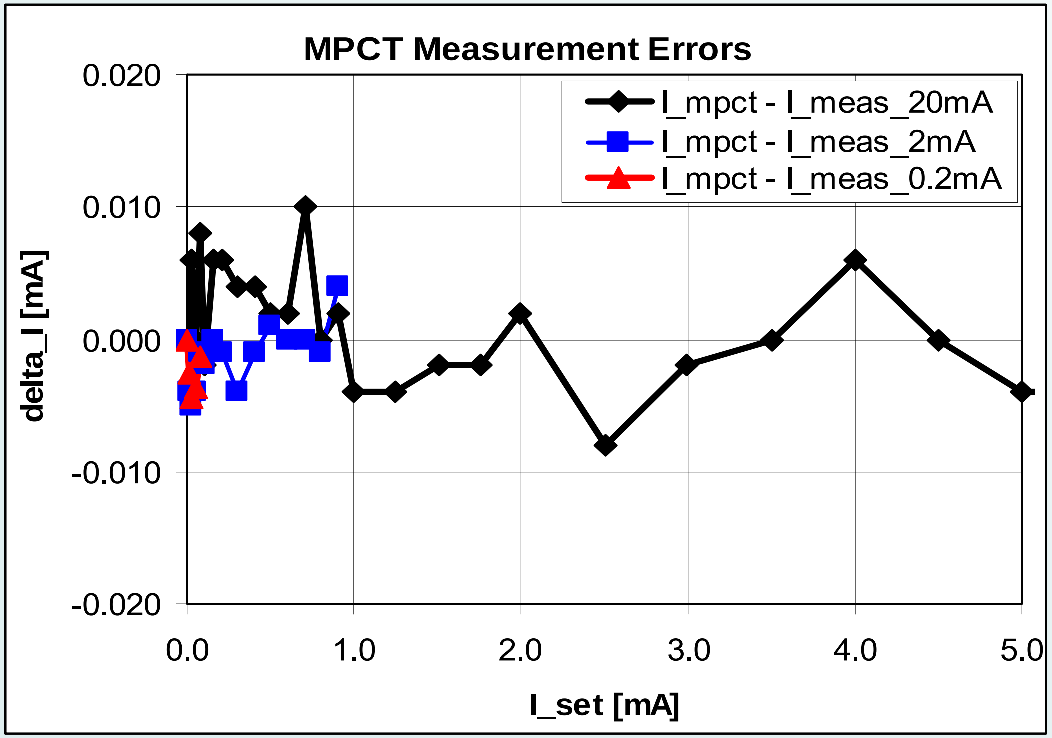
- energy will be measured by time-of-flight method
- signal delay of two phase probes installed in D-Plate will be analyzed with fast oscilloscope
- non destructive: full power cw and pulsed beam can be measured
- energy spread → longitudinal emittance measurement

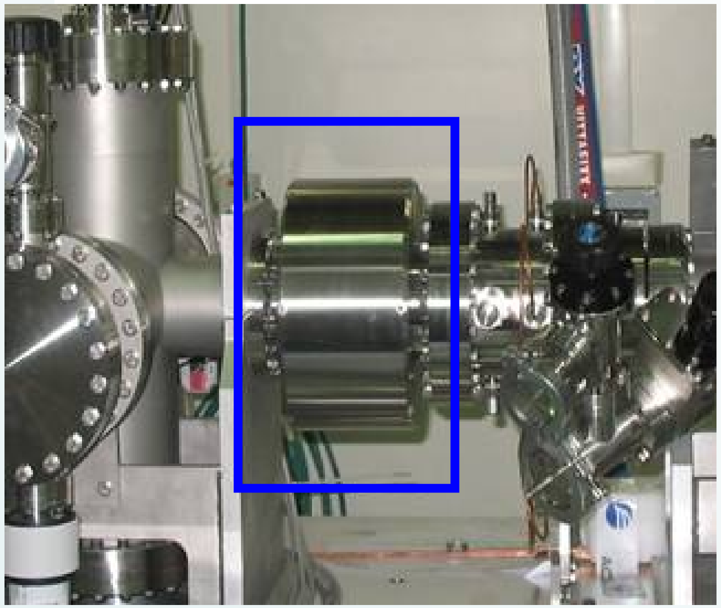


Measurement of Beam Current I

- MPCT modular parametric current transformer (BERGOZ)
- ceramic gap, vacuum chamber/housing
- non destructive, current range up to 10 mA
- resolution 10 µA, accuracy <100 µA
- bandwidth DC to 4.2 kHz

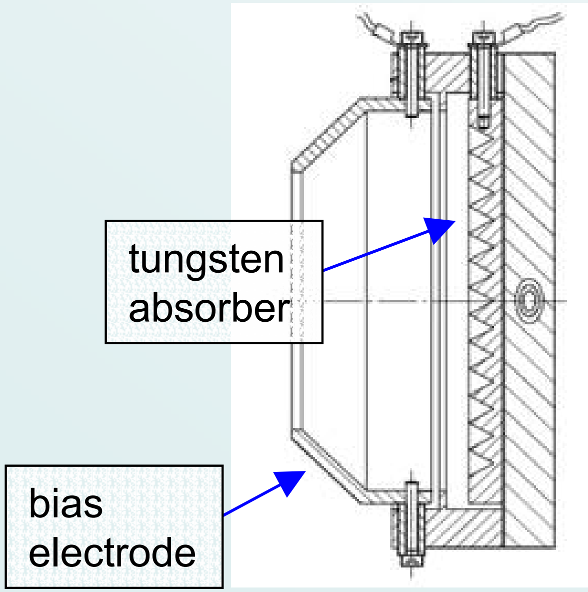


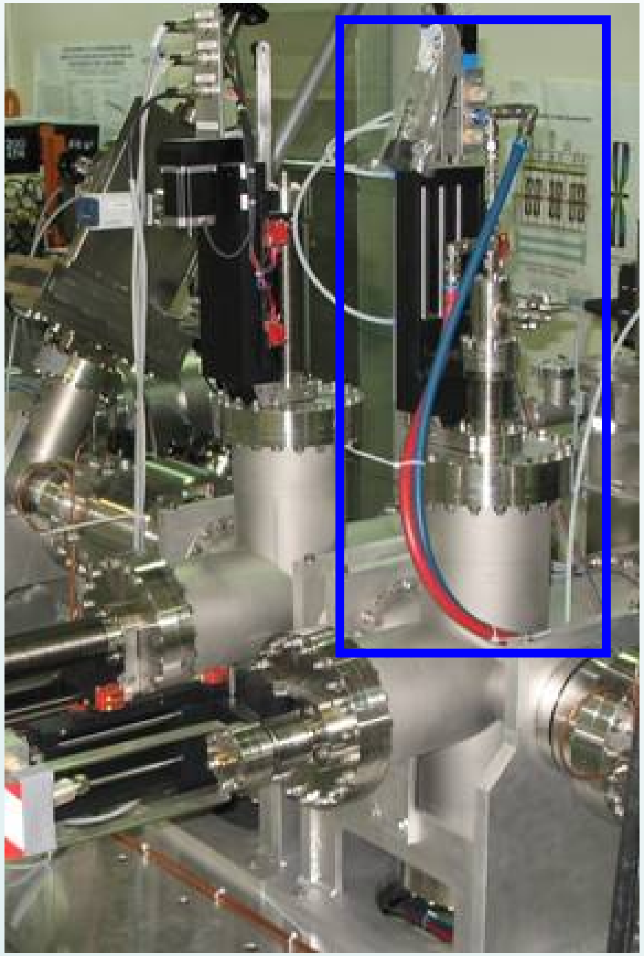


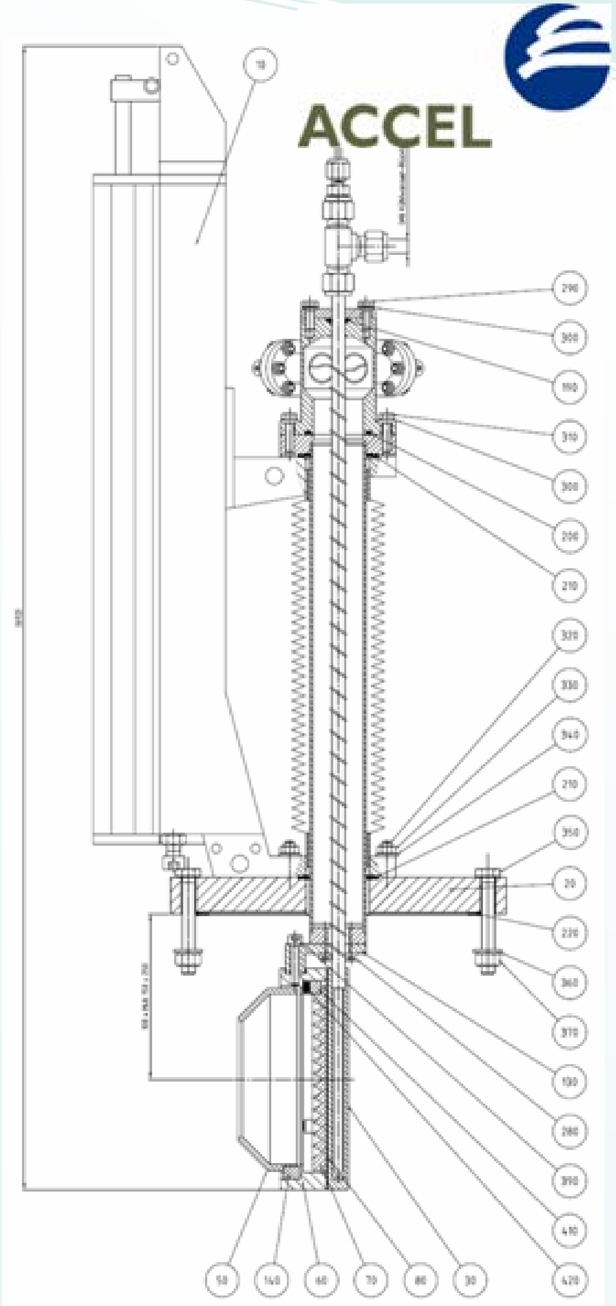


Measurement of Beam Current II

- “slow” Faraday-Cup
- destructive, maximum beam power 200 W
- resolution <5 μA
- bandwidth >50 kHz

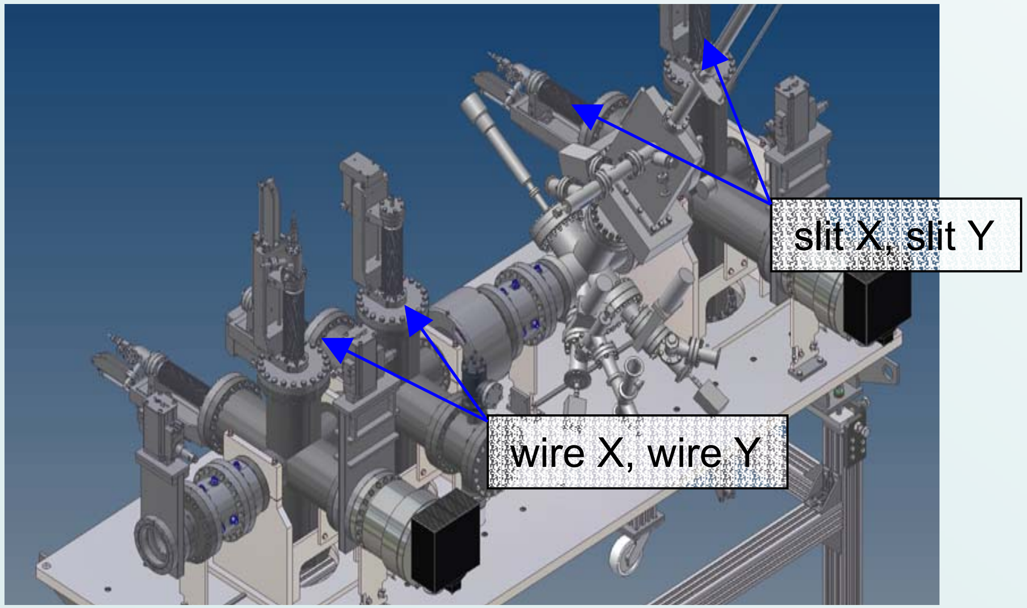


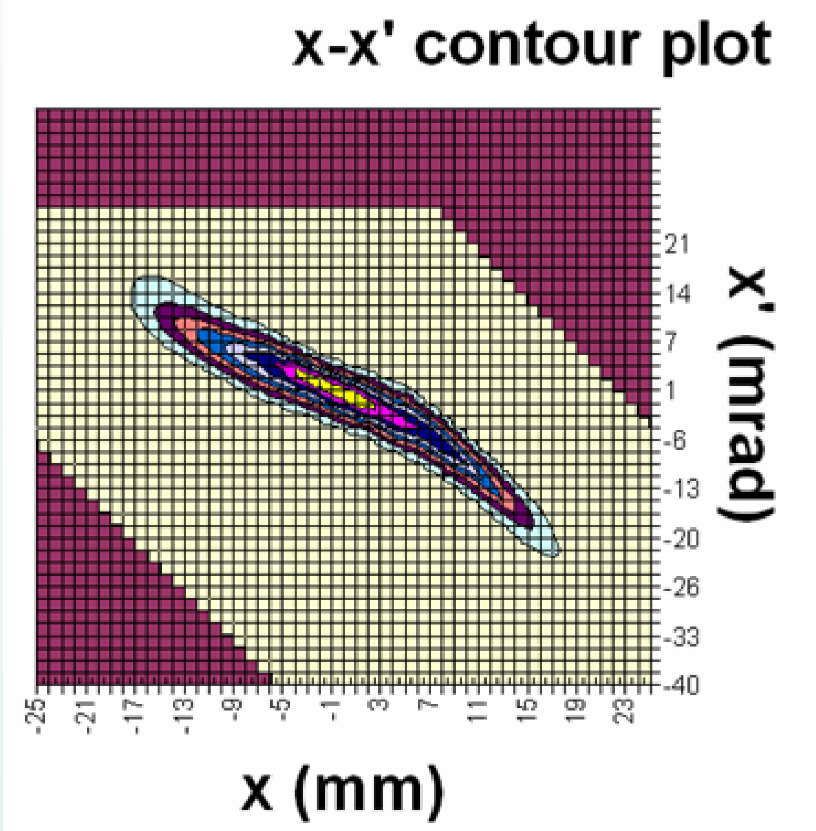




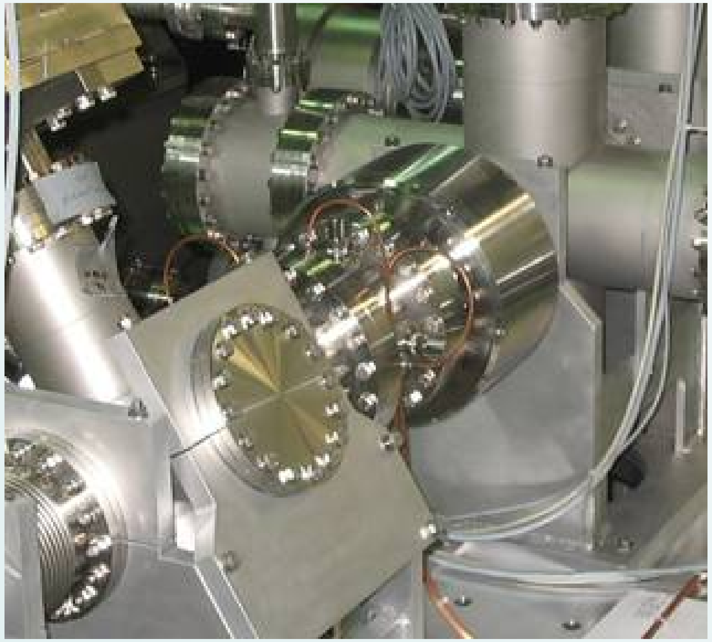
Measurement of Transversal Emittance

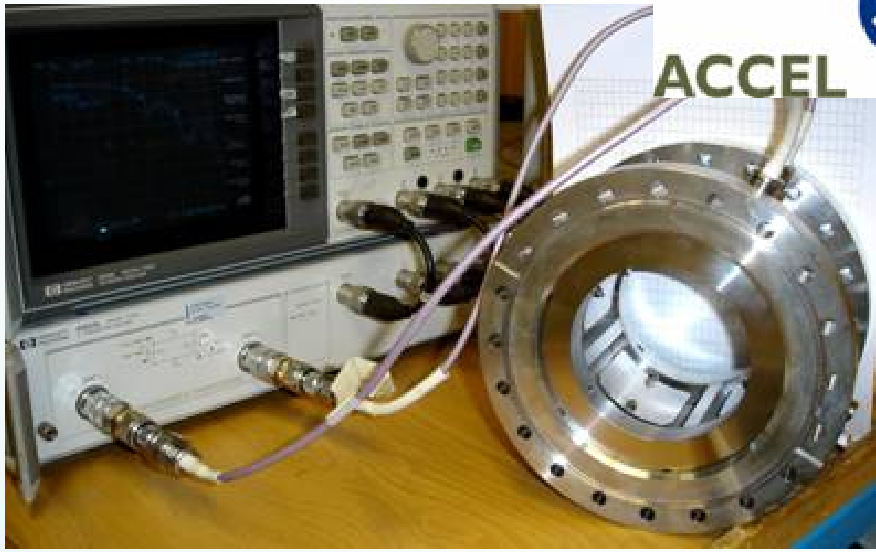
- slit and wire method
- same devices as used in LEBT, but
  - slit absorber is made tungsten instead of carbon
  - slit gap height 0.25 mm, wire diameter 0.1 mm
- destructive, maximum beam power 200 W
- resolution ~5 % for SARAF I

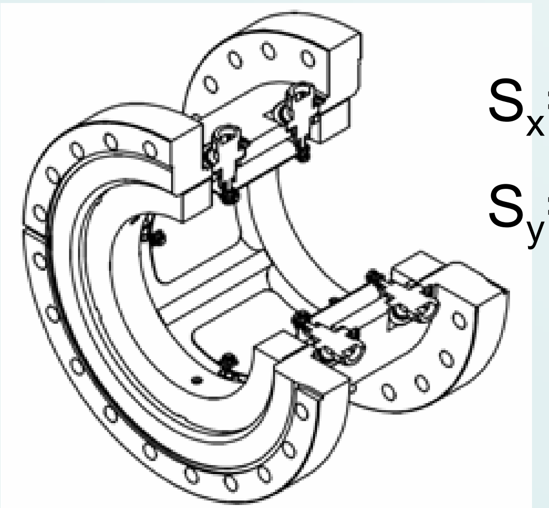




Measurement of Beam Position

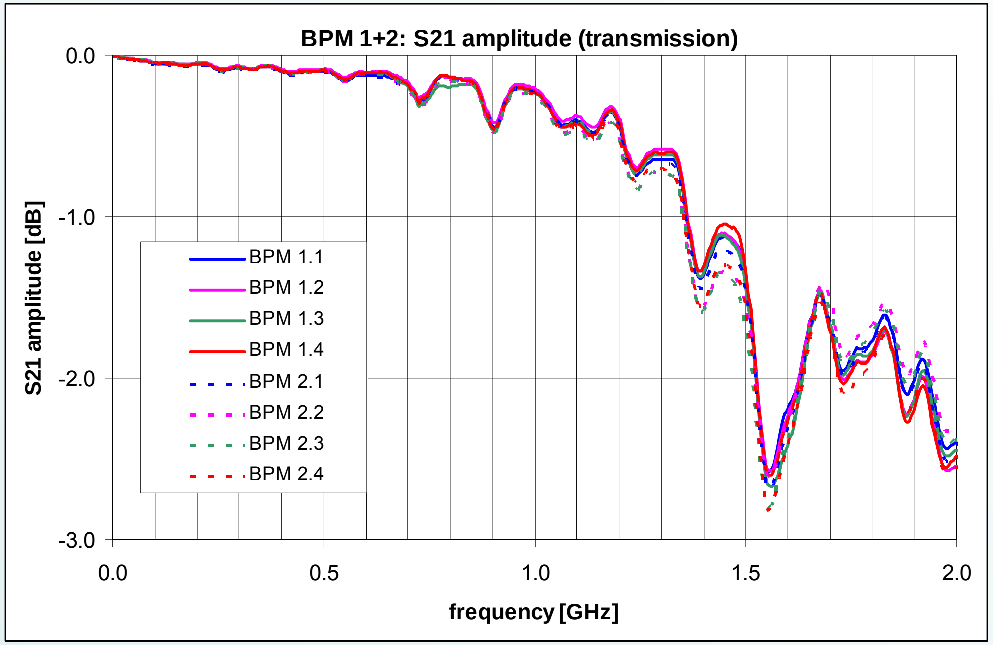






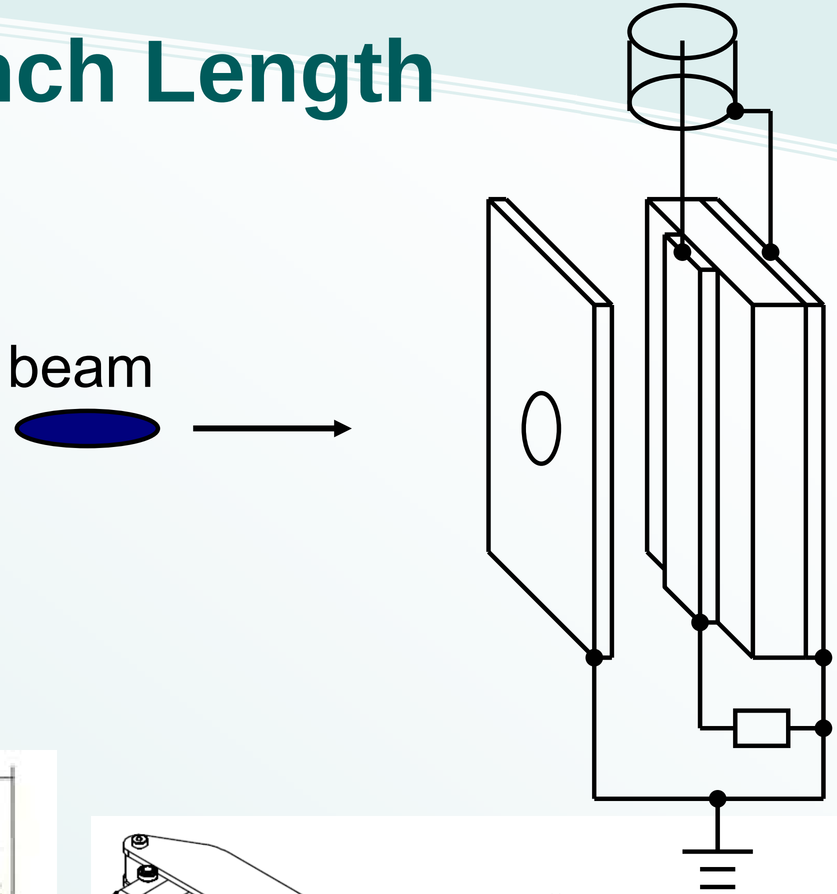
$S_x = S_{right} - S_{left}$

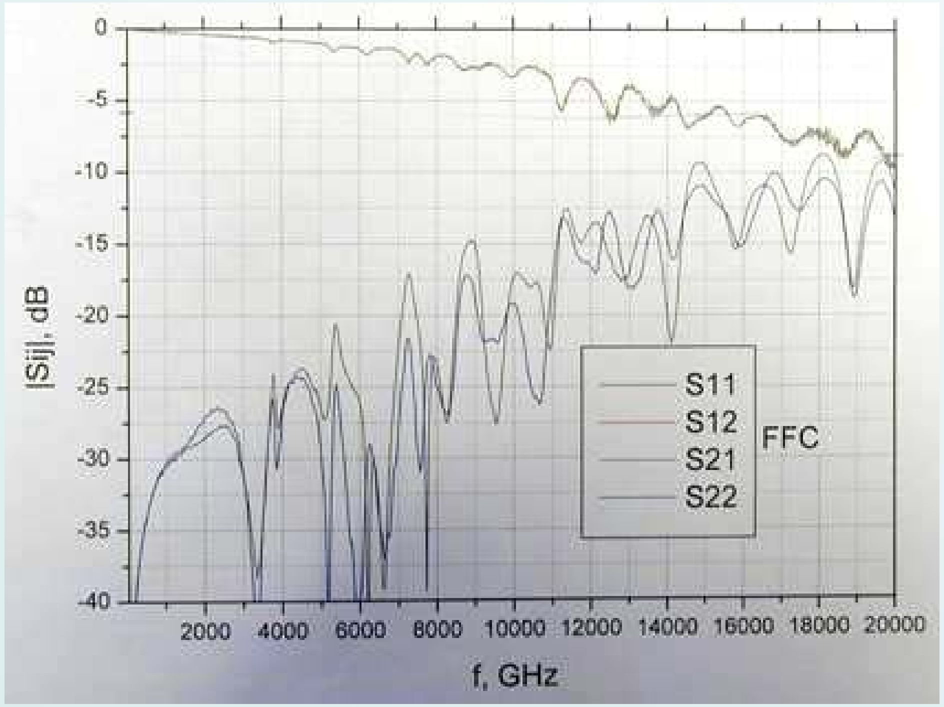
$S_y = S_{up} - S_{down}$

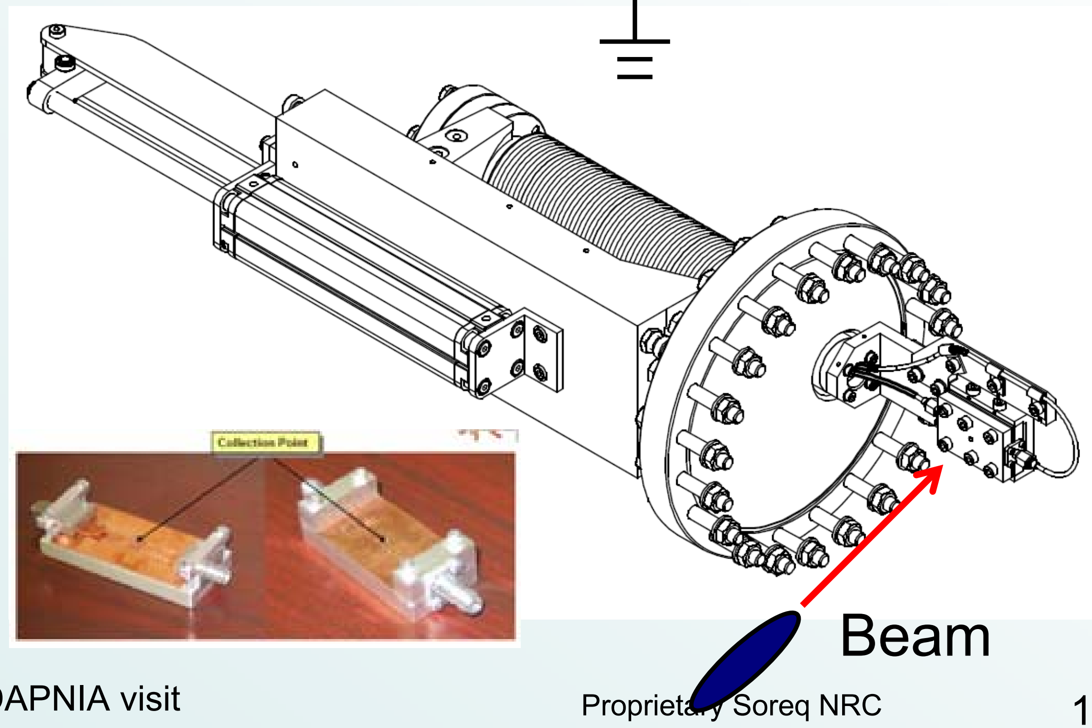


Measurement of Bunch Length

- fast Faraday-Cup (FFC)
- 50Ω-stripline-technique
- adapted SNS-design
- Overall bandwidth > 6 GHz
  - Allows measurement of bunch lengths σ > 26 ps







Halo measurements

Electrical current measurement:

mini Faraday Cup scanning the beam periphery

Nuclear reactions with 2.5-4 MeV proton beam :

1. A thin gold foil (.3 mg/cm^2)

   Rutherford proton scattering

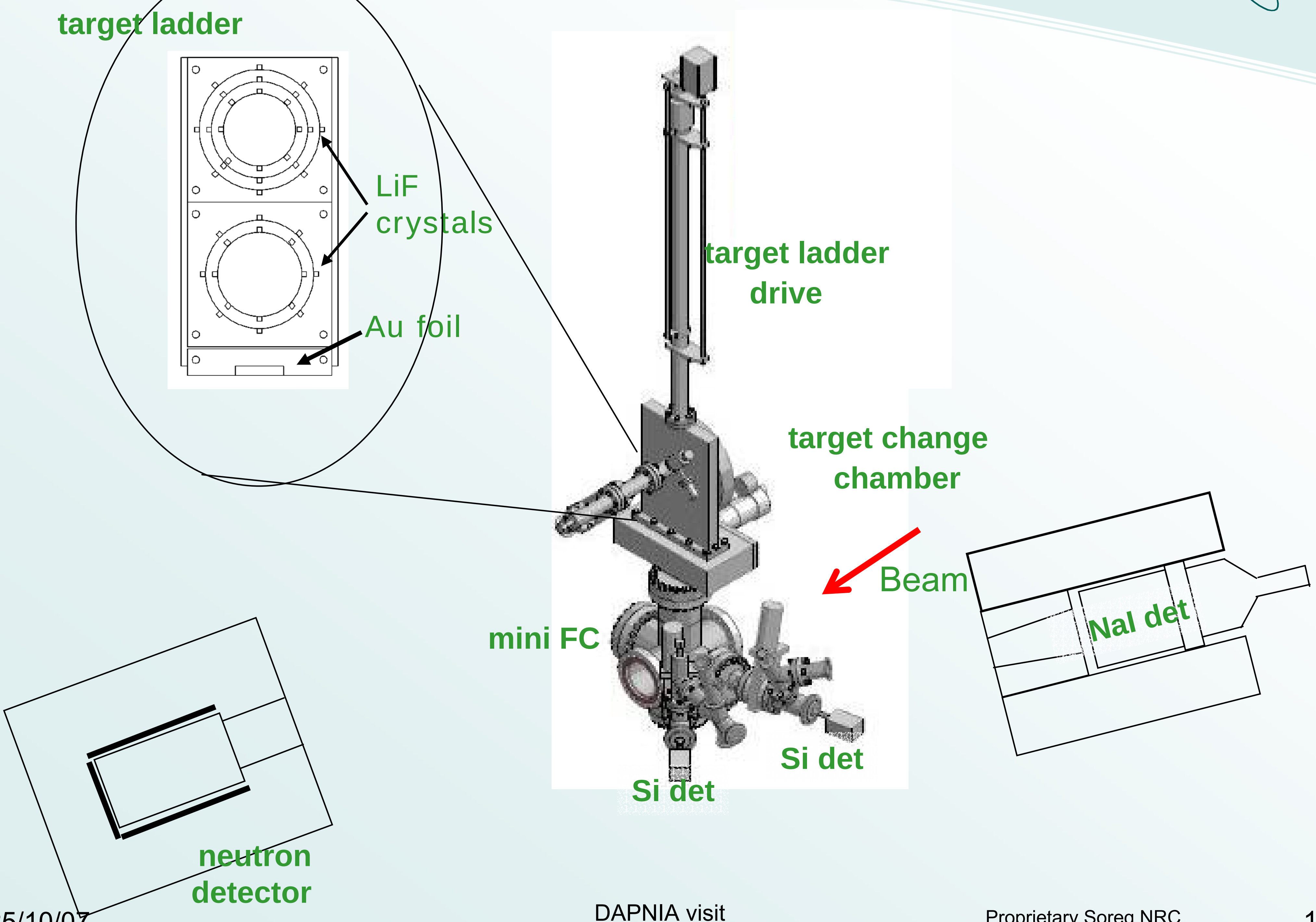
2. LiF targets

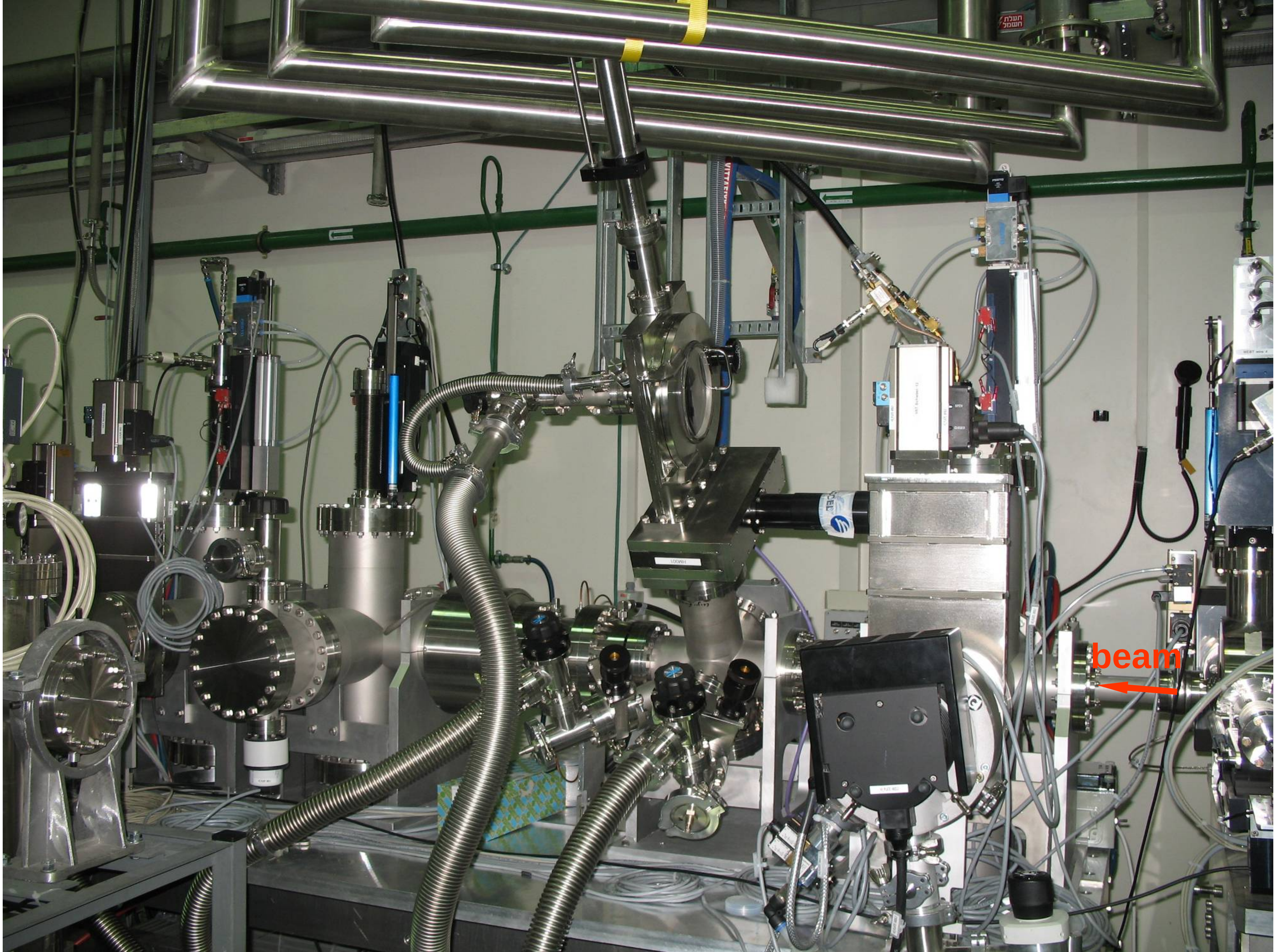
   High-energy **gammas** from ^{19}F(p,$\alpha\gamma$) reaction (on-line)
   Neutrons from ^{7}Li(p,n)^{7}Be reaction (on-line)
   Measuring ^{7}Be **activity** ^{7}Li(p,n)^{7}Be (off-line)

Well studied reactions
Cross-checks and consistency checks
Halo measurements to the level 100 pA
Measurement of beam energy with high resolution

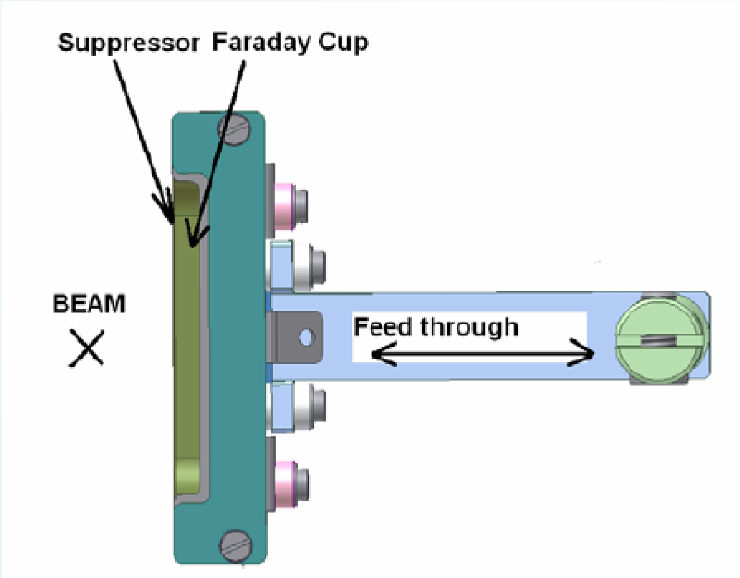
Feasibility study at Pelletron Accelerator (Weizmann Institute)
I. Mardor et al, LINAC 2006

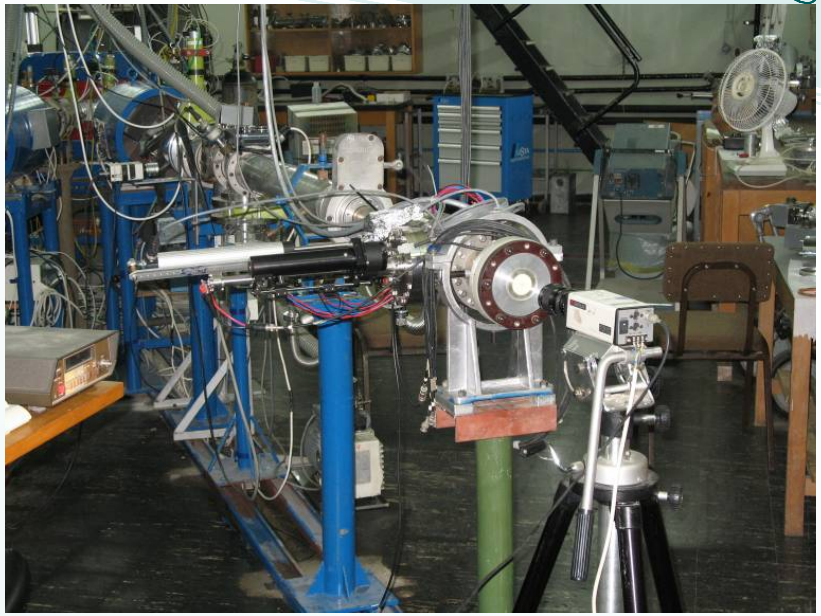
Beam Halo monitor



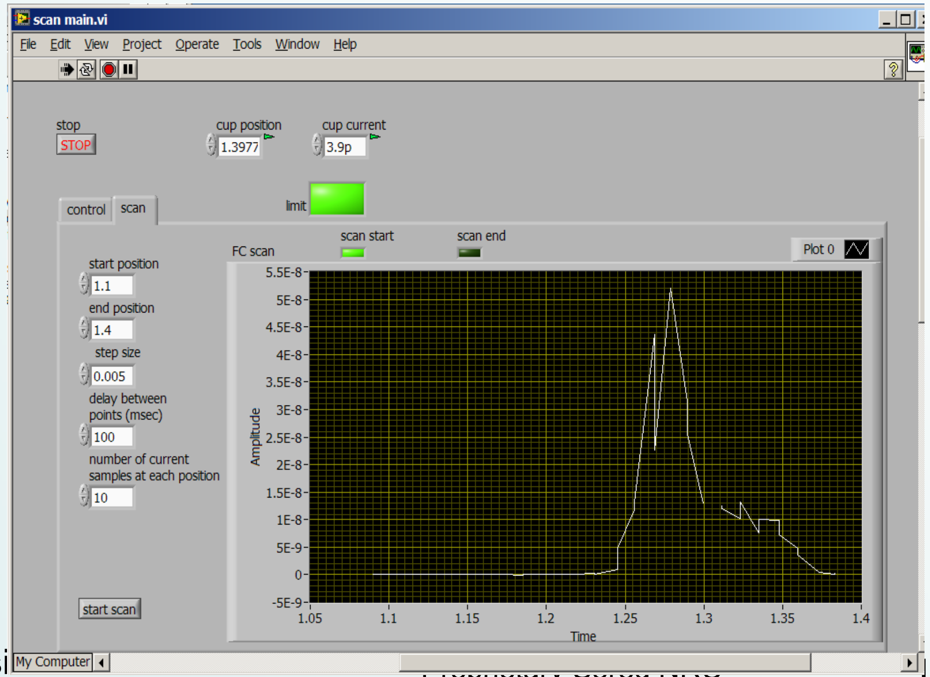

beam

Mini FC

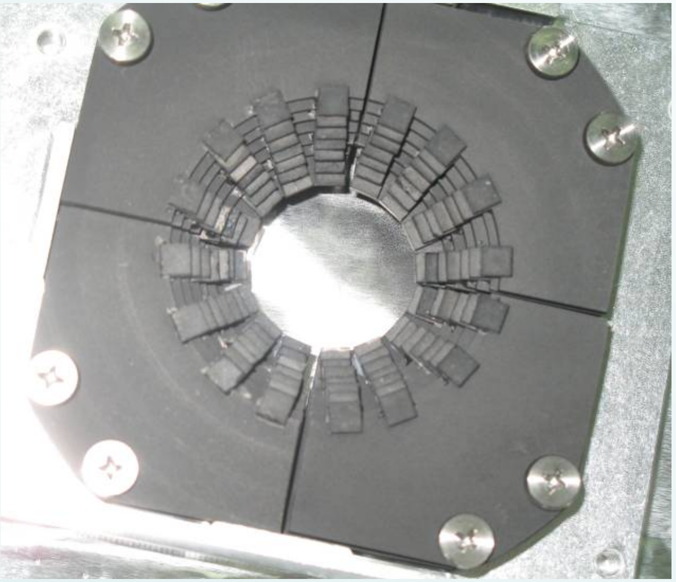


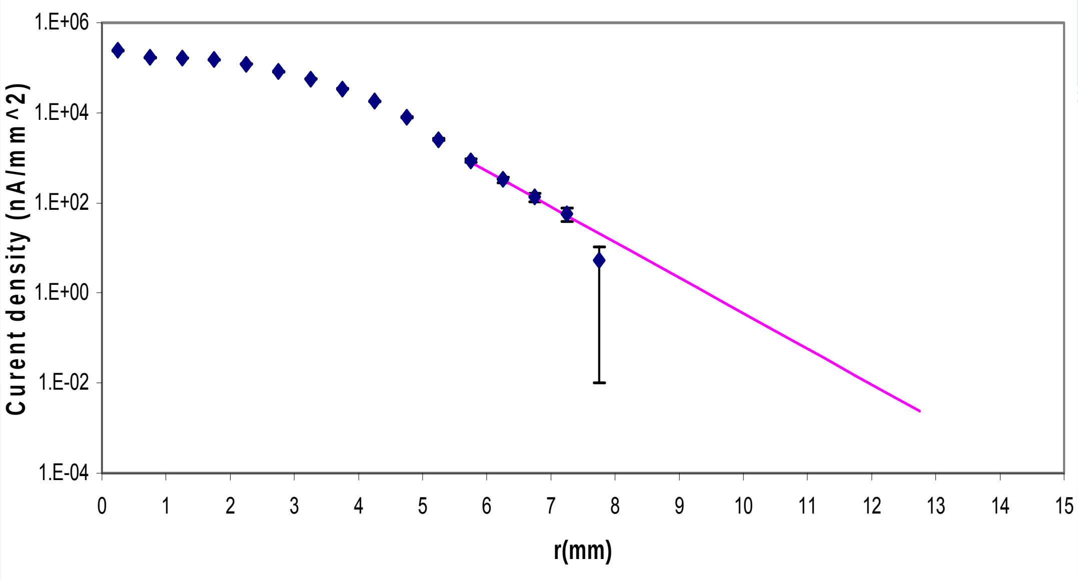


Test at VDG, Weizmann Institute



LiF Targets $^{7}Li(p,n)^{7}Be$ activation



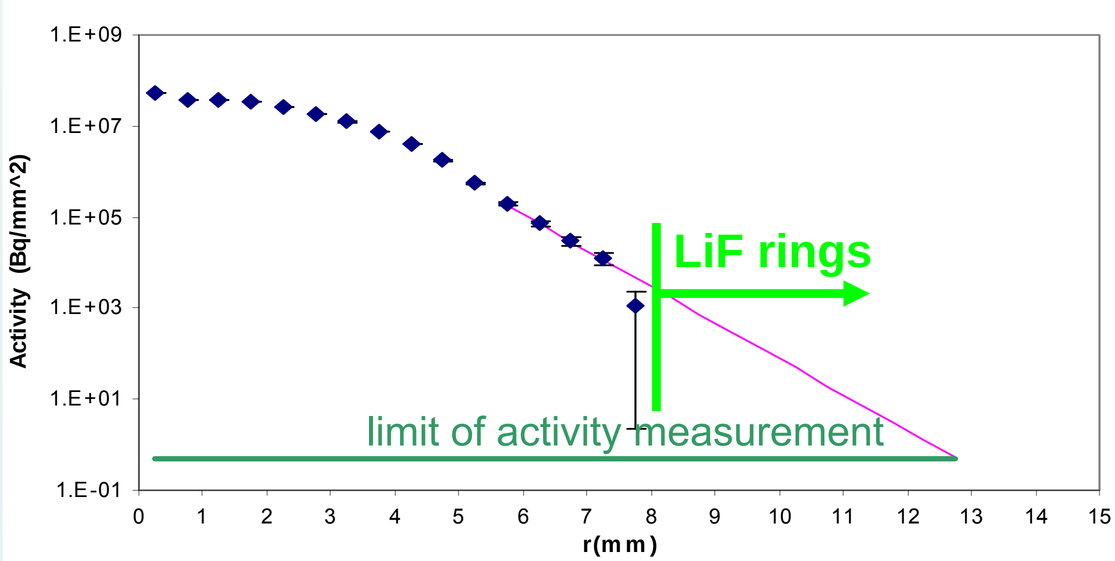


Offline activation measurements
Spatial resolution 1 mm
After activation there is sufficient time for detailed analysis ($T_{1/2}(^{7}Be)$=53 days)

Simulated current density distribution based on RFQ simulations 40000 particles

Expected activation of thick LiF target
5 mA protons at 4 MeV
half hour irradiation

Expected activity:
4 MeV and thick LiF target , 30 min irradiation is **250 Bq/nA**

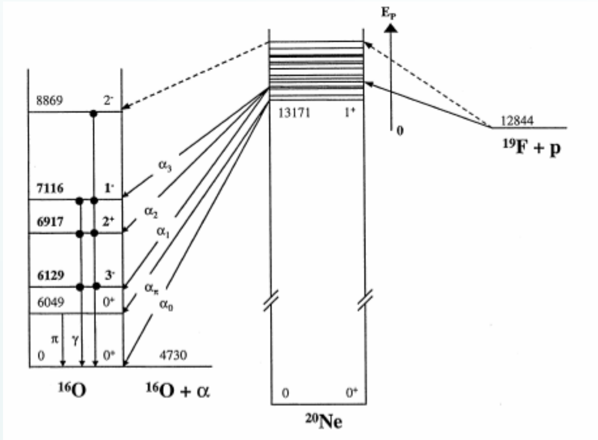


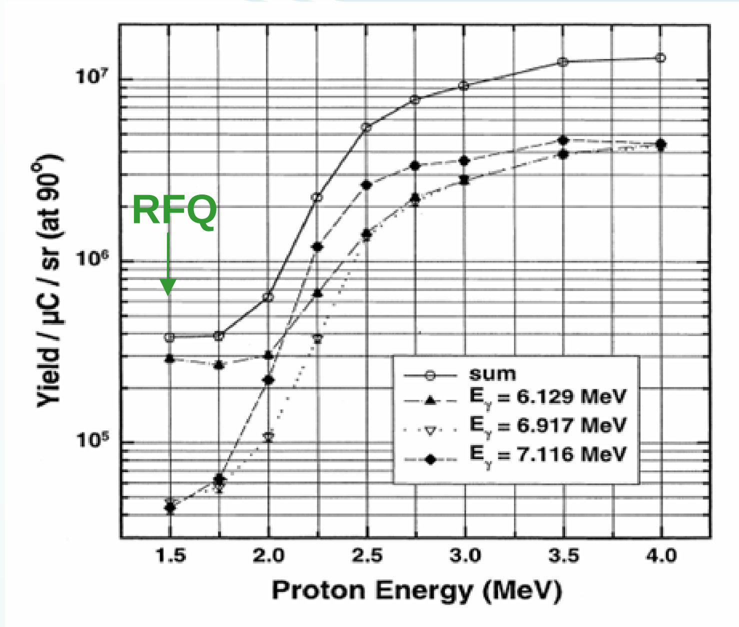
LiF Targets $^{18}F(p,\alpha\gamma)$ prompt γ detection

High-energy gamma-rays
Clean spectrum
Can use large volume NaI
Yield is known in literature

Measurement the total proton charge in beam periphery

Expected rate at 0.15 sr
2500 peakcounts/s/nA (including escape peaks)

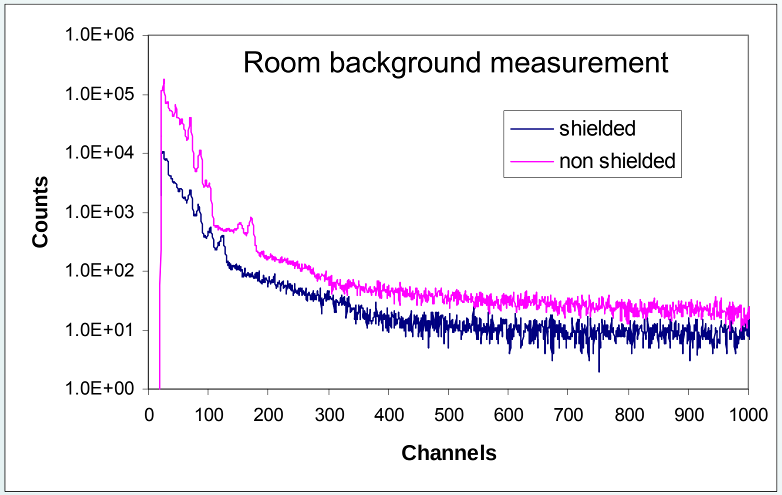




A. Fessler et al,
NIM A 450 (2000) 353

6" NaI detector

Movable lead shield



The main background during experiment will be (p,γ), $(p,\alpha\gamma)$ from RFQ and beam dump. Low energy gammas

LiF Targets $^{7}Li(p,n)$ prompt neutron detection

High-energy neutrons
Yield is known in literature
Thick target yield ~10^{-4} n/p for 4 MeV,

Measurement the total proton charge in the beam periphery
Expected rate at 70 cm is
3.1 mrem/hour/nA

Background (p,n) reactions from beam dump

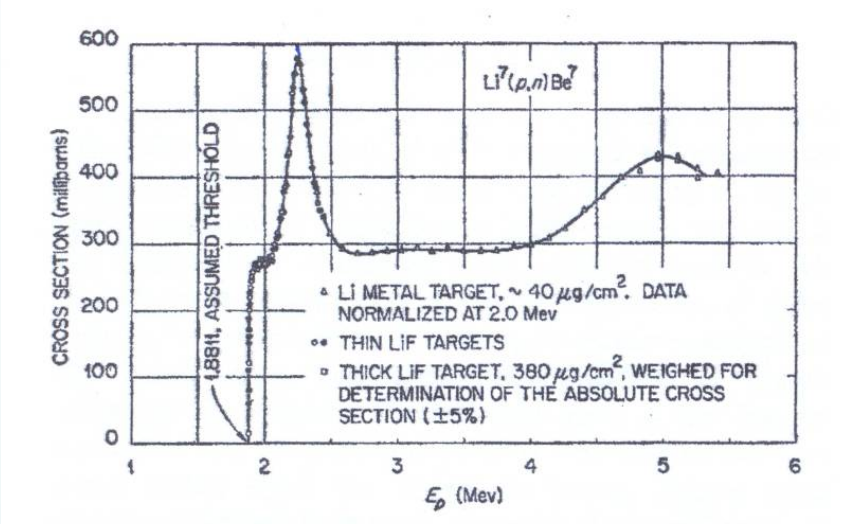


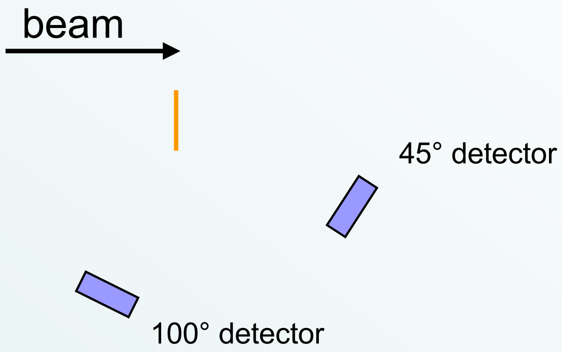
FIG. 4. $Li^7(p,n)Be^7,Be^{7*}$ cross section as a function of energy.

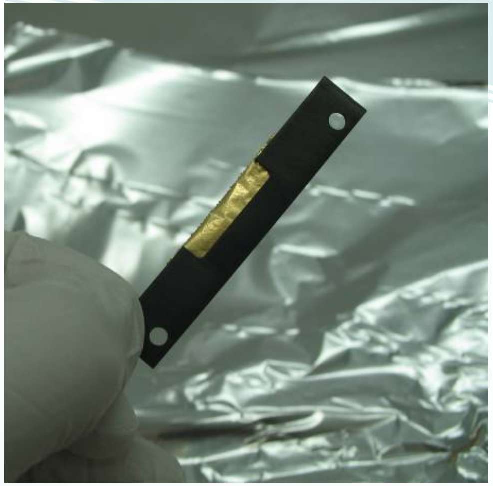
Gibbons&Malkin, Phys. Rev. 114 (1959) 571

"Snoopy" neutron monitor (30 % accuracy)

Seforad ^{3}He neutron counter spectroscopic information

Rutherford backscattering





300 μg/cm2 gold foil
glued on graphit frame

Introduction into the beam a thin 300 $\mu g/cm^2$ gold foil
Two 100 mm^2 500 μm thick ion-implanted Si detector at 100° and 45°
to measure the scattering protons

Well-known cross-sections (still purely Rutherford at 4 MeV).
Expected yields per 1 nA beam at 35 cm from the target :

48 cnts/s and **2.7 cnts/s** for 45° and 100° respectively

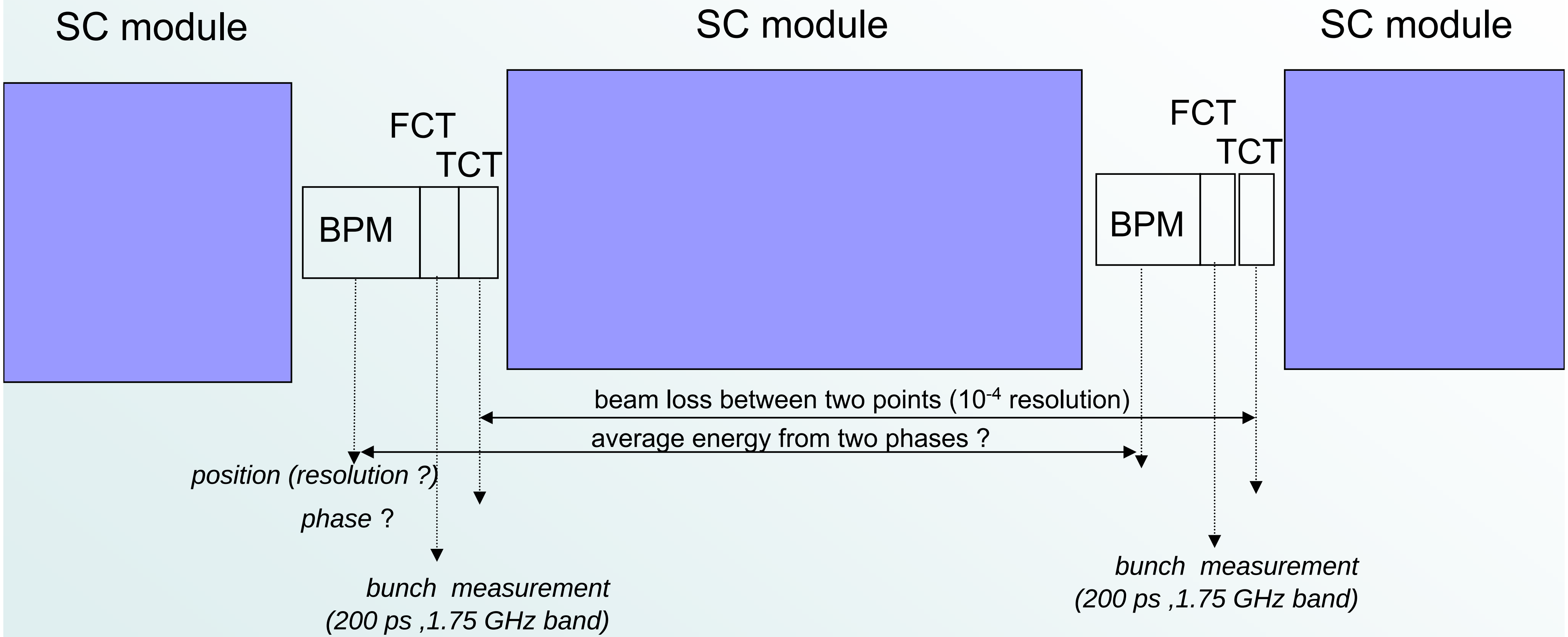
Energy resolution of detector 12 keV, using a thin foil will allow one to obtain information on energy distribution of the beam

It might be also interesting to see if energy in the halo different form the nominal value

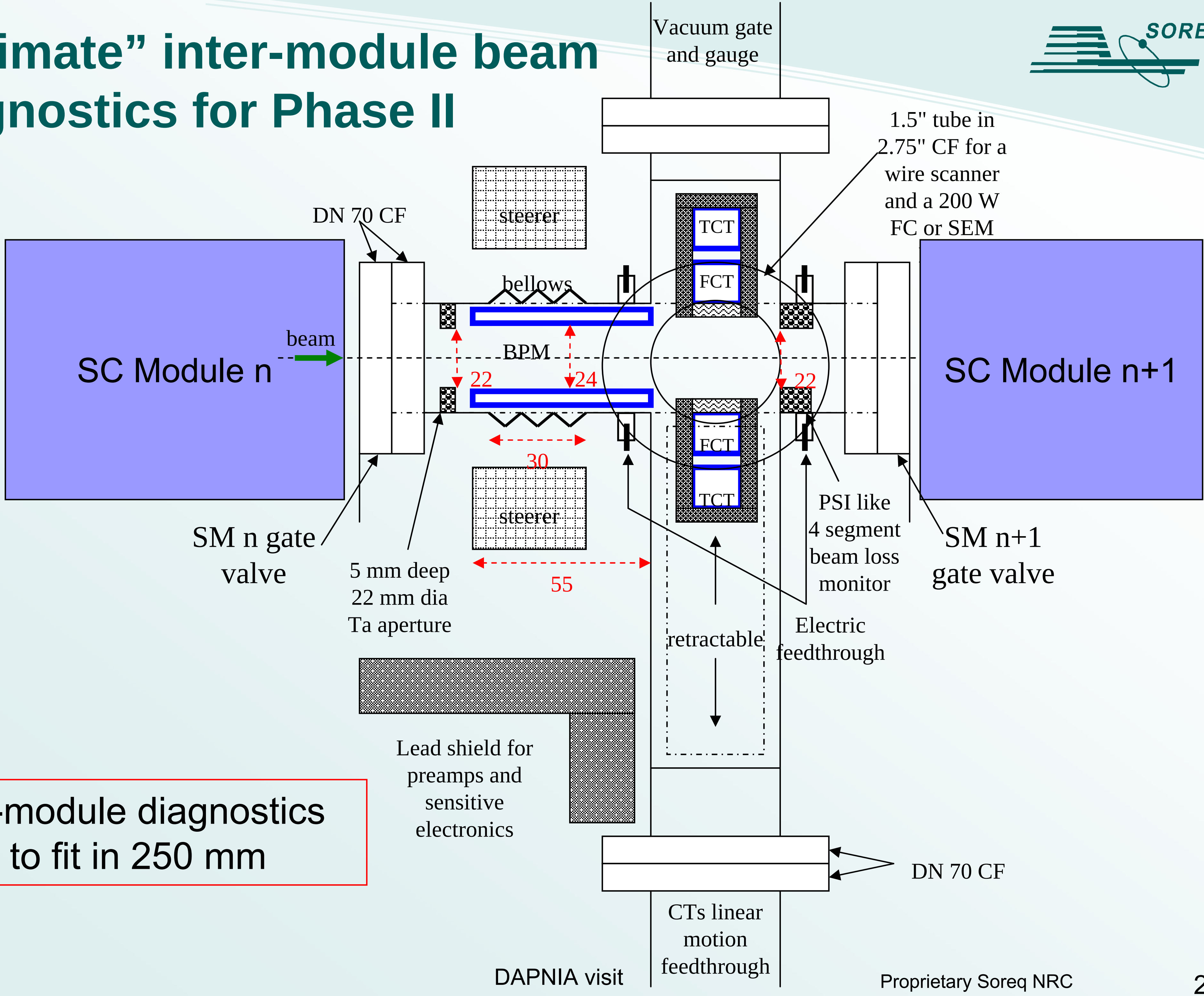
Expected problems:

- Stray scattered protons
- Stray electrons
- Electronic noise in linac environment

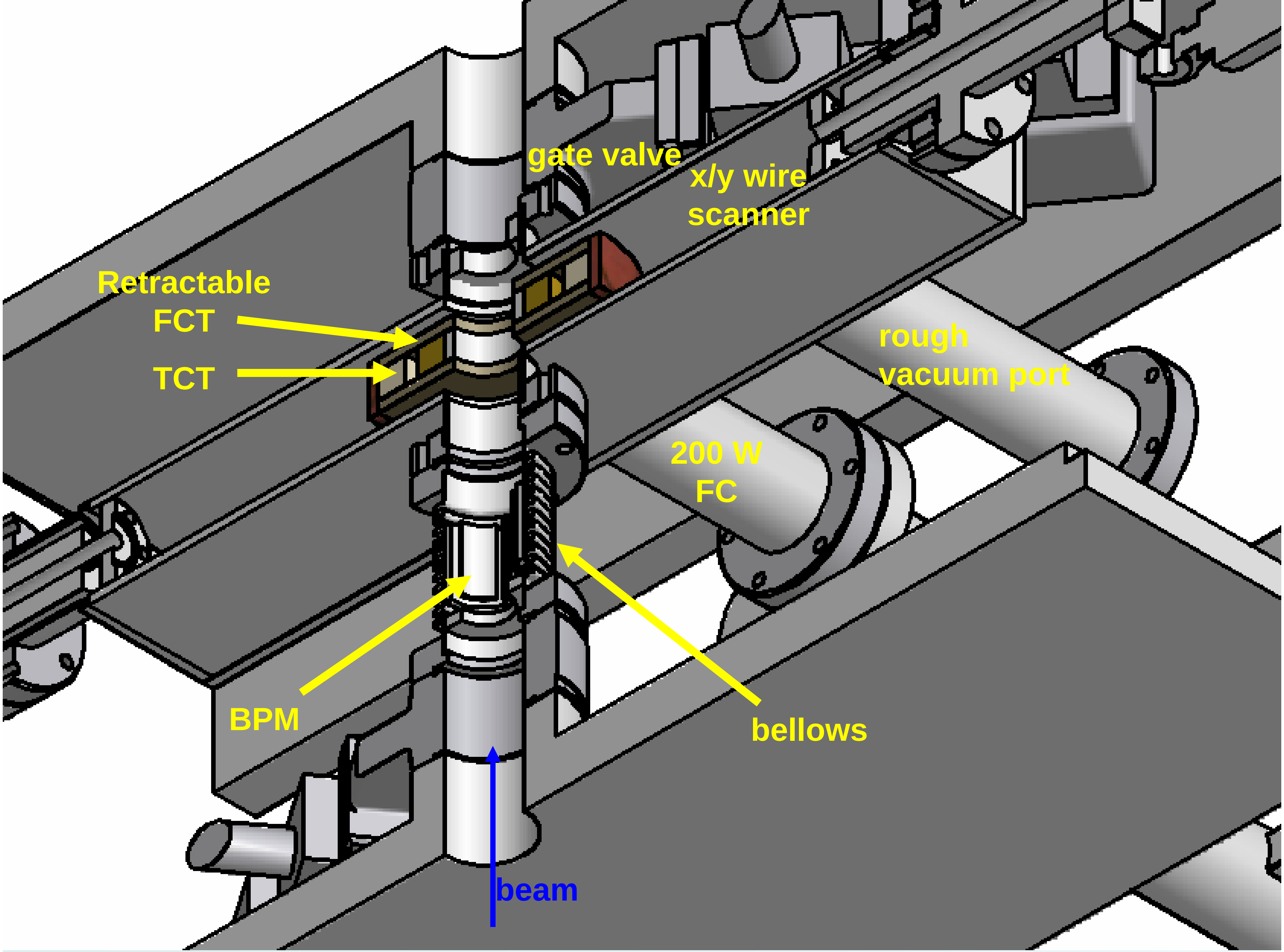
Concept for Phase II Diagnostics



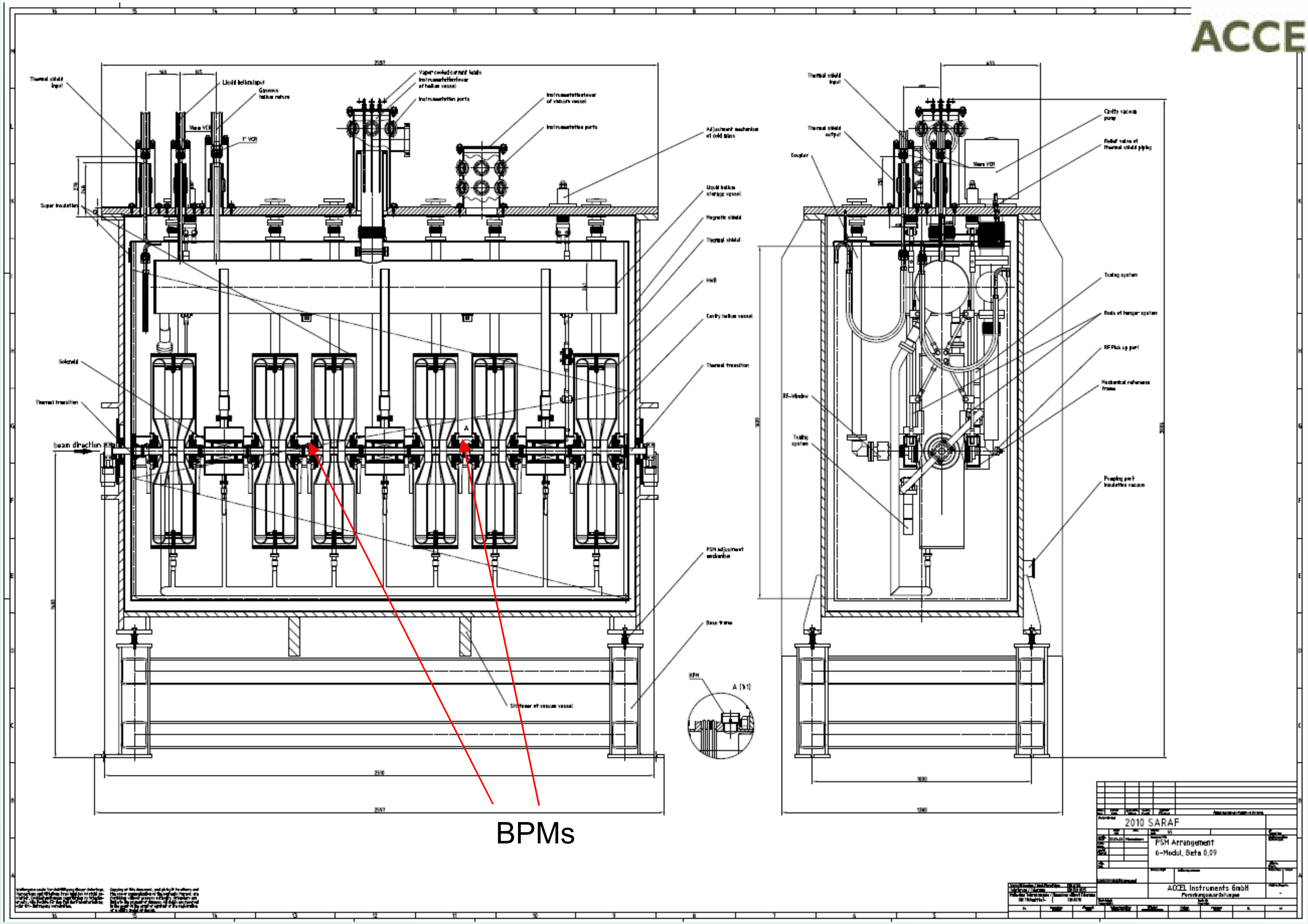
"Ultimate" inter-module beam diagnostics for Phase II



Inter-module diagnostics need to fit in 250 mm


gate valve
x/y wire scanner
Retractable FCT
TCT
rough vacuum port
200 W FC
BPM
bellows
beam

Intra-module diagnostics: Cold BPMs



SPIRAL 2 preparatory phase proposal

SOREQ

COMBINATION OF COLLABORATIVE PROJECT AND COORDINATION AND SUPPORT ACTION

Construction of new infrastructures - preparatory phase

FP7-INFRASTRUCTURES-2007-1

		new detectors for SPIRAL 2			
WP6	Technical Work 2: European activities linked to Linear Accelerator	To solve reminding technical challenges and enlarge possibilities for the SPIRAL 2 driver	IFIN-HH	1519675	550000
WP7	Technical Work 3:	To solve remaining	INFN	1851580	546125

temperatures and/or different power densities. At thebeginning of 2009, a decision will be made in order to choose the more promising approach for the Spiral2 project.

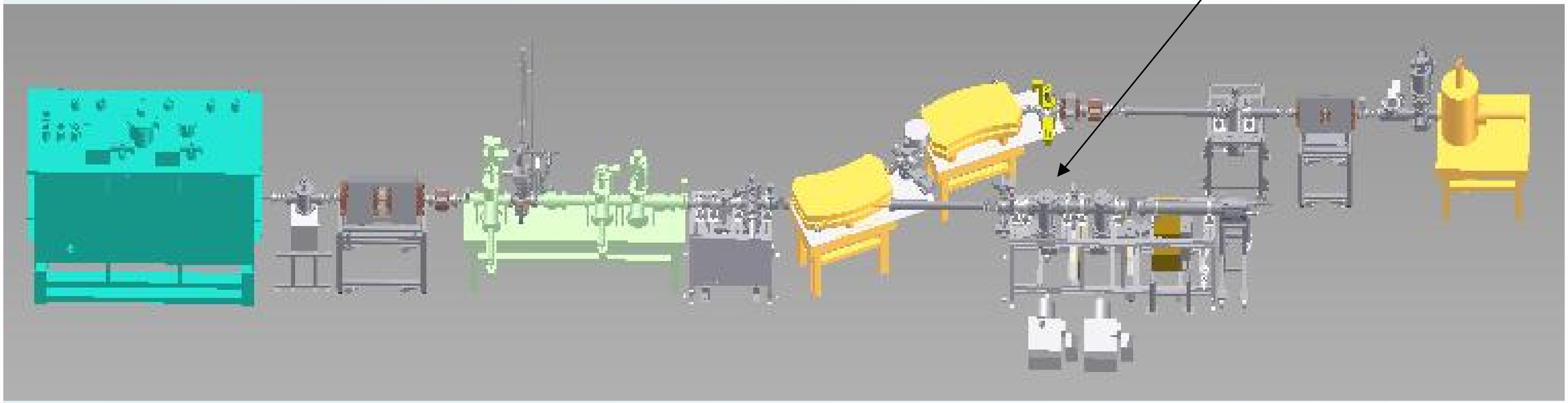
<u>Task 6.4 Tests of ion beam diagnostic systems for SPIRAL2 facility.</u> (L Weissman, SOREQ)

Different types of beam diagnostics will be used at the SPIRAL2 facility during the commissioning period and routine operation. The diagnostic instrumentation must provide sufficient information for the facility

Test station at Phase I SARAF

Phase I SARAF : Up to 2 mA proton beam at 4-5 MeV maximal energy
Temporary beam line for Phase I

suggested position
for the station



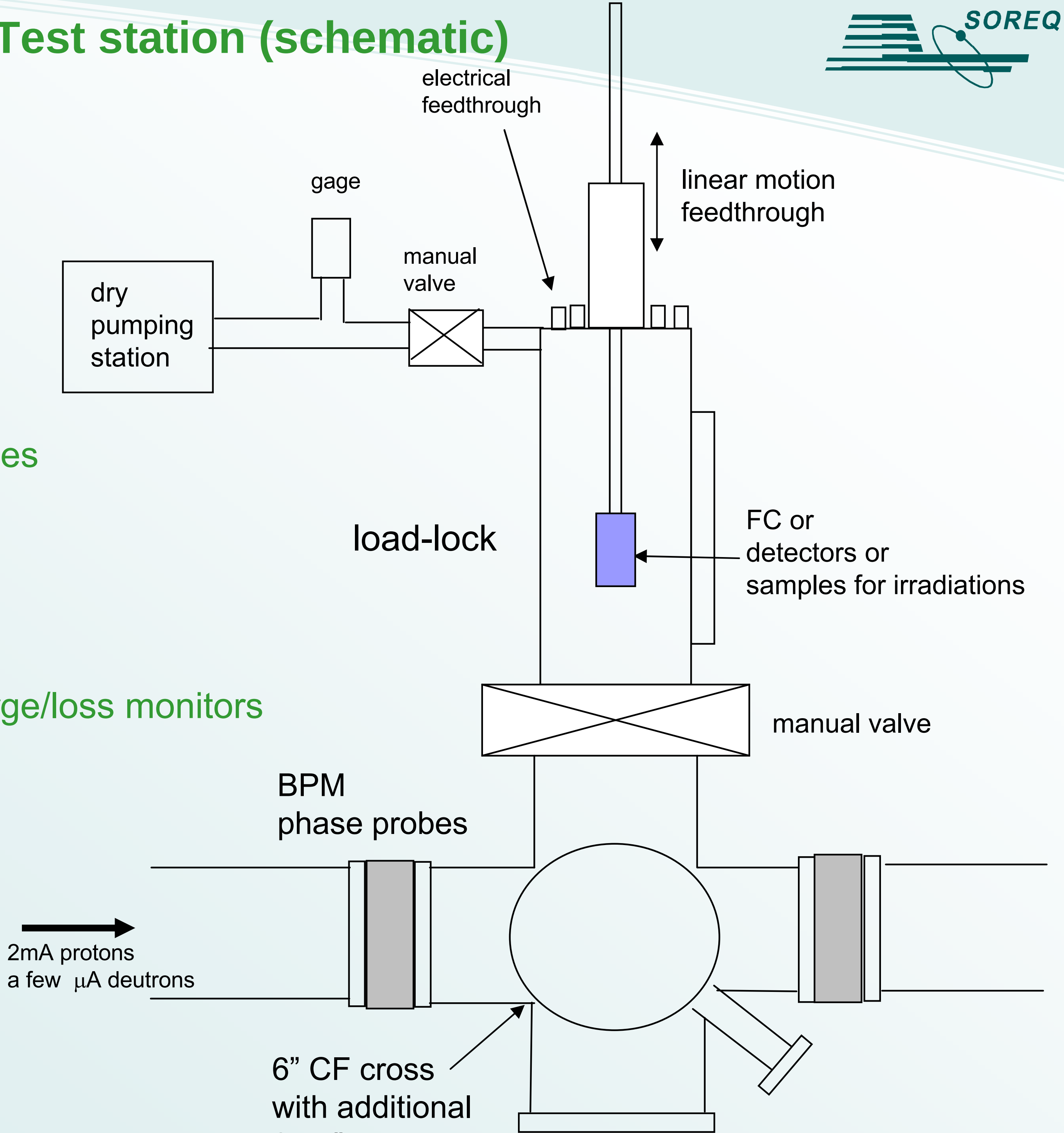
Idea is to build a flexible general use station for test of various equipment.
The major interest is testing diagnostic tools for linac and Phase II beam lines.
Building of the station and some of these tests will be done within SPIRAL II FP7 proposal.

Other propositions are welcome!

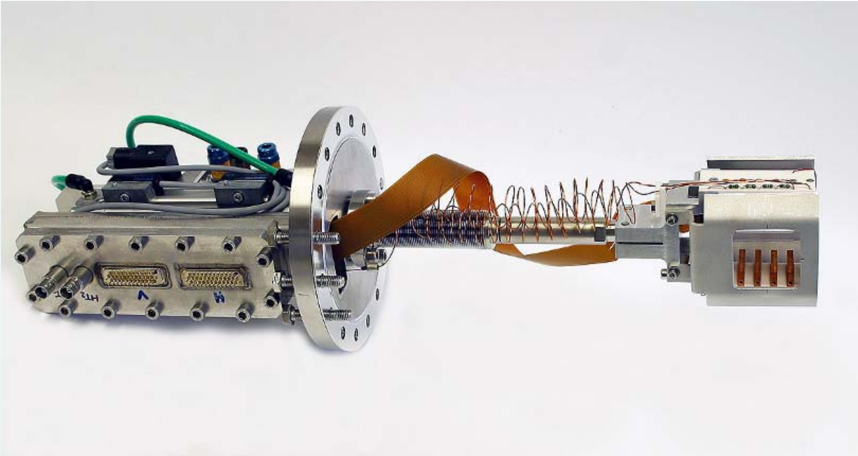
Test station (schematic)

Possible applications :

- Controlled irradiation of samples
  - test of materials
  - measurement of cross-sections
- Diamond detectors
- BPM made for SPIRAL
- Diamond foils
- Commercial BPM/current/charge/loss monitors
- Residual gas monitor
- Beam-loss monitor

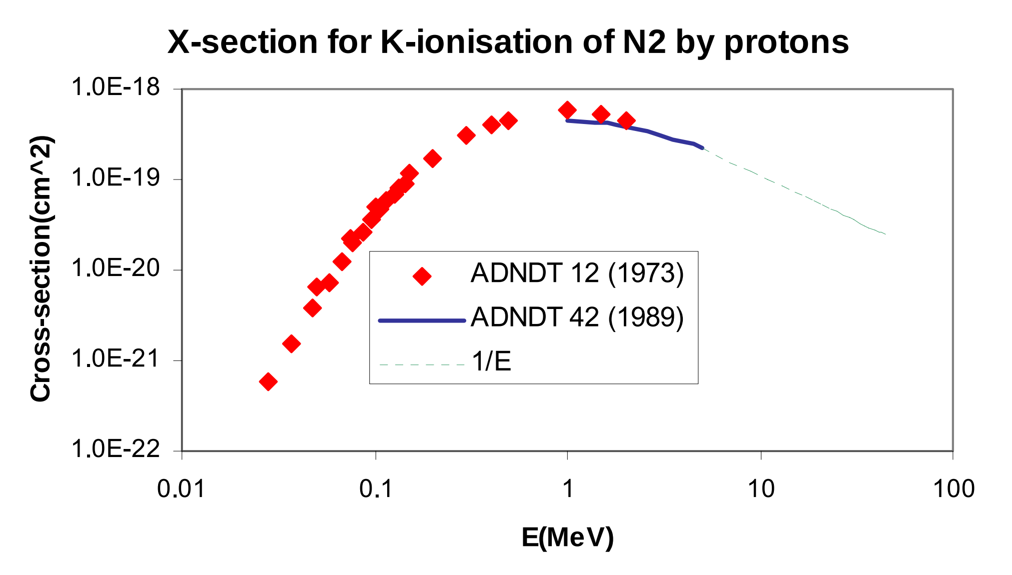


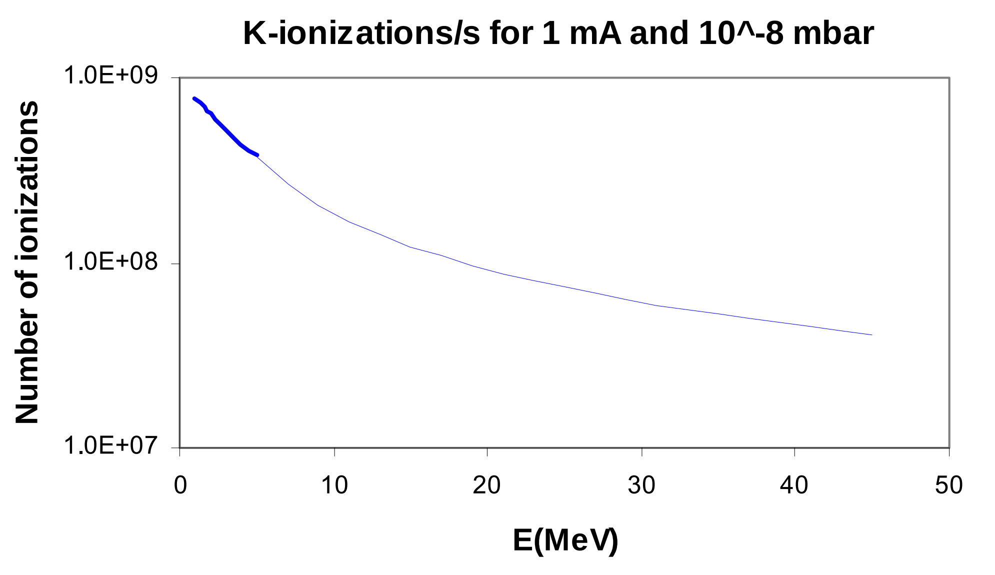
Residual gas monitors



device used at GANIL

Can one use residual gas ionization at 10^{-8} mbar ?





Thin diamond foil

CVD diamond foil is planned to use for stripping at SNS *(Shaw et al)*

10x20 mm^2, 1 micron thick

Tests at BNL:

H^-, 750 keV, 2 mA (**200 W** power)

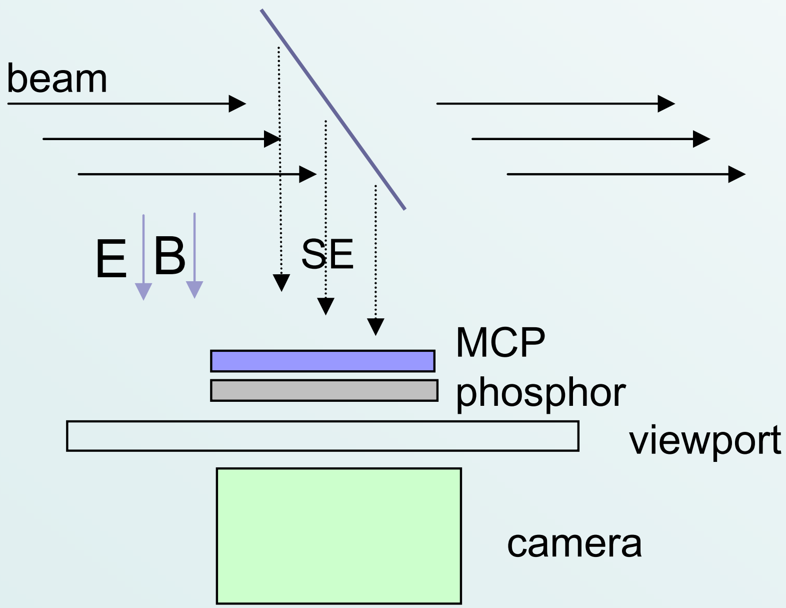
~ **100** hours of stable operation (in 100 h current is down by 10**%)**

For our 40 MeV beam power is **4 W/mA** only (Phase I, 4 MeV 30 W/mA)

Beam energy degraded by .01 %, RMS scattering angle ~0.4 mrad

One can assume that such a foil will operate for **1000** hours

Beam diagnostic based on a diamond foil



Allows for observation of the beam spot and x-y profiling

Good for high-energy

Could be used at several positions