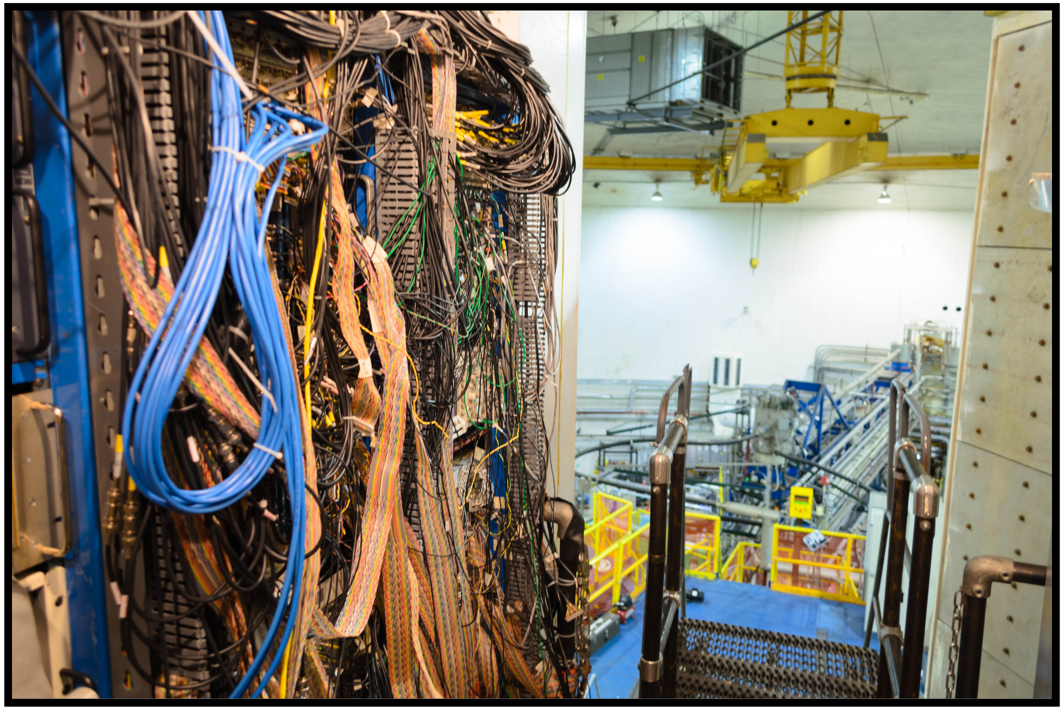
Instrumentation for the g2p experiment

- Target
- Beamline
- Detector
- DAQ



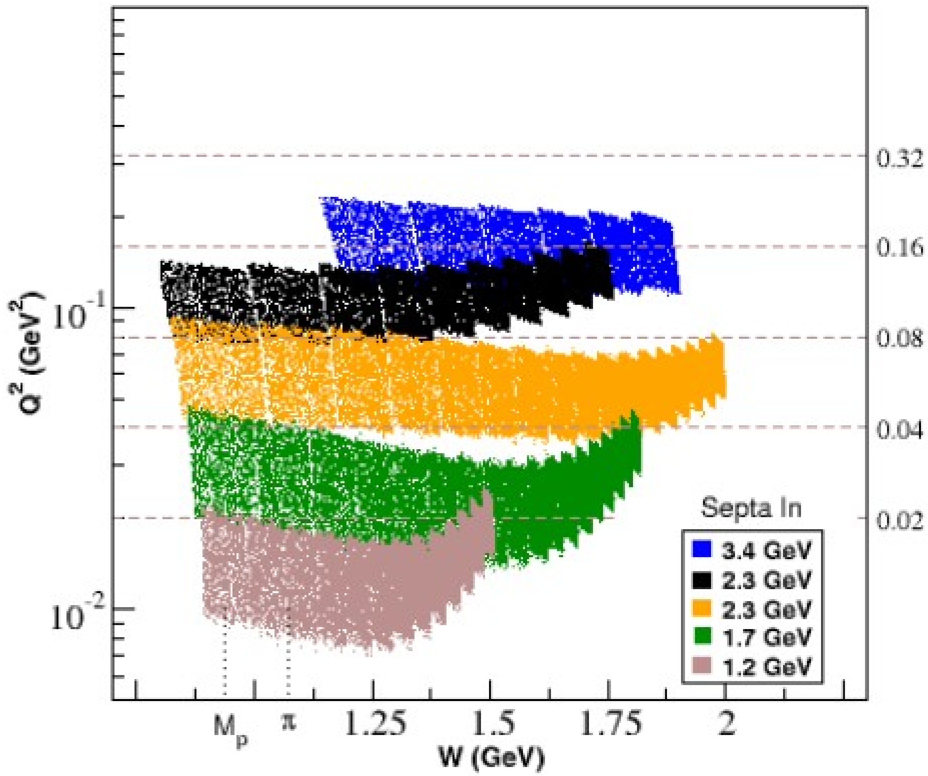
Pengjia Zhu

USTC, on behalf of the E08-027 collaboration

The 7th International Workshop on Chiral Dynamics

Review for g2p

Ran in Hall A from Feburary to May in 2012



Q^2 $0.02-0.20\ GeV^2$

6^o *forward angle detection*

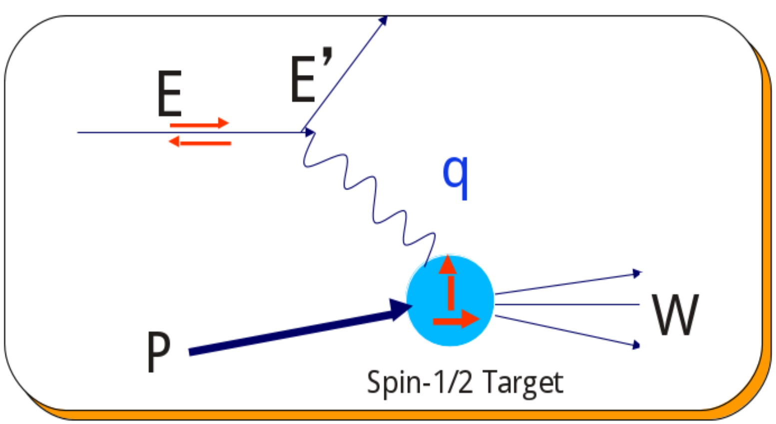
Luminorsity: $10^{34}-10^{35}\ cm^{-2}\ s^{-1}$

Energy: 1.1−3.3GeV

Expected Uncertainty ~ 5~7%

Inclusive Polarized Cross Section

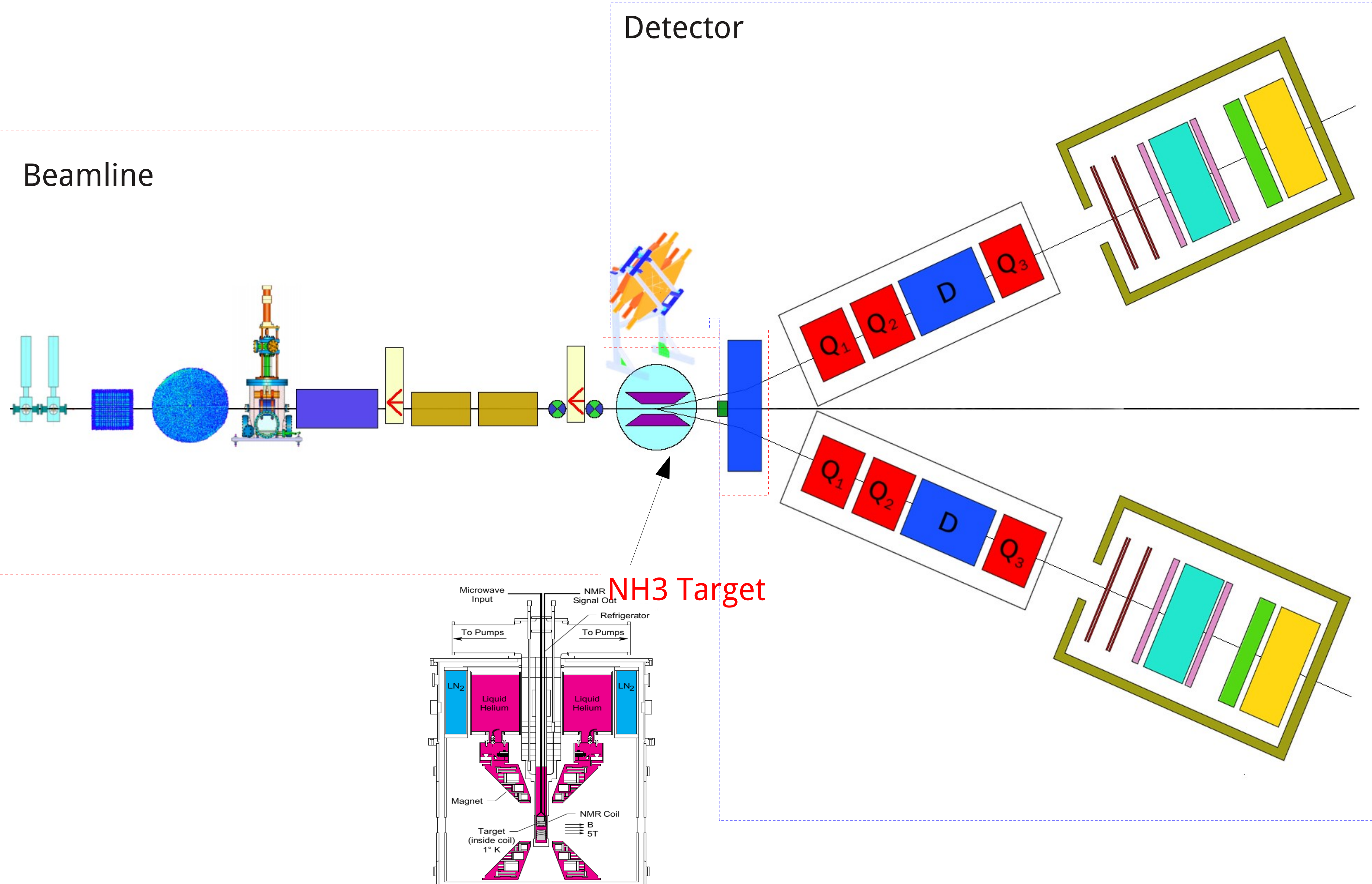
$$\frac{d^2\sigma}{d\Omega dE'} = \sigma_{Mott}\left[\alpha F_1(x,Q^2) + \beta F_2(x,Q^2) + \gamma g_1(x,Q^2) + \delta g_2(x,Q^2)\right]$$



Two additional Structure Functions needed

Chao Gu talked about it in detail in previous talk

Instrumentation for g2p



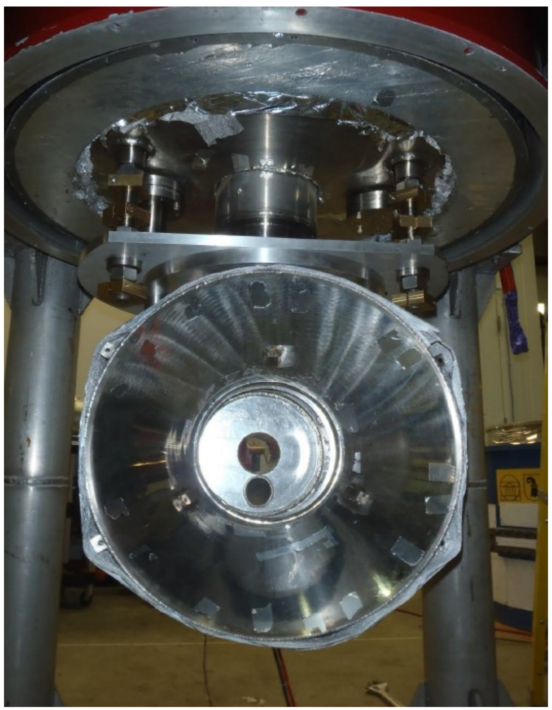
g2p polarized target

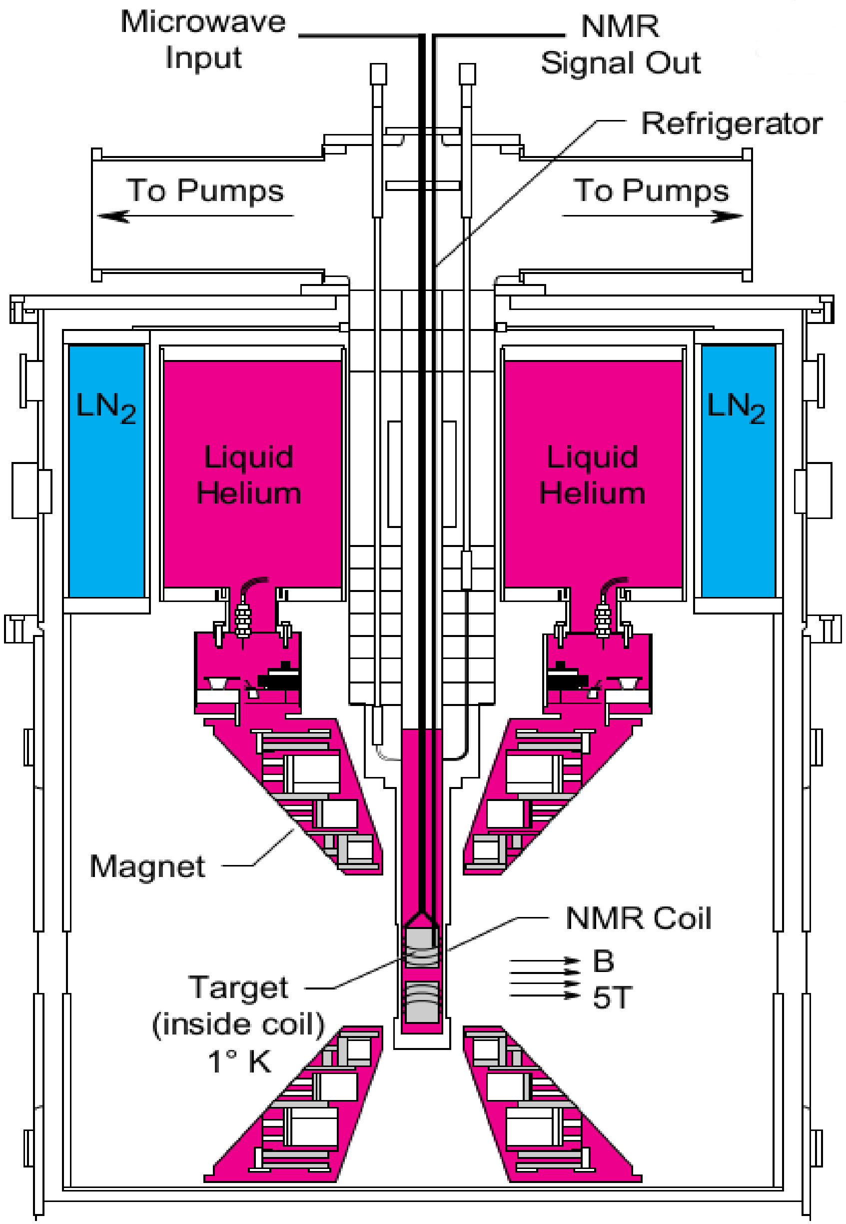
Used in SLAC,Hall C

First time to use in
Low energy and small forward angle

Polarized NH3 target

- 1K Refrigerator
- 2.5/5T Transverse target field
  (1.1GeV need to use lower field because of large bending casued by target field)
- 3W microwave,powered at 1k

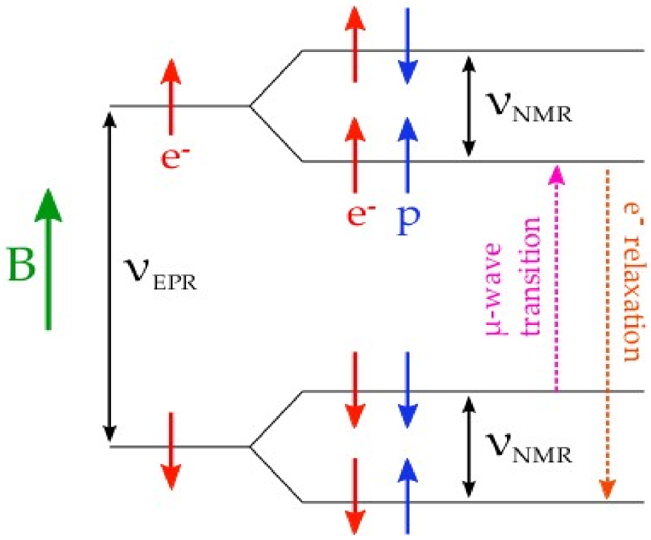


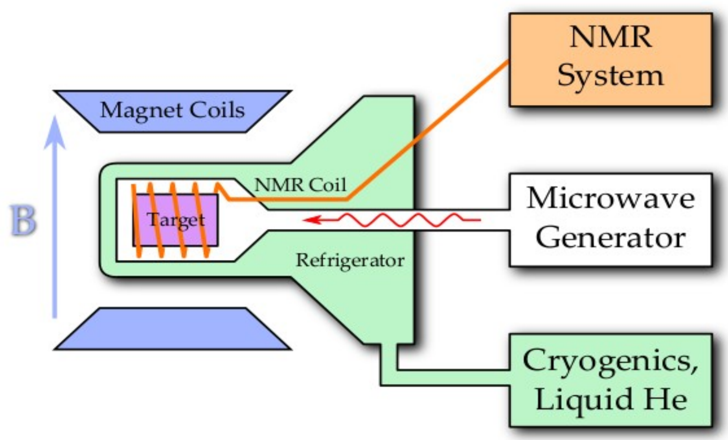


Target magnet coils were damaged in Nov, 2011, JLab target group replacing them with coils from the Hall B target magnet. The repair was successful but caused g2p a delay of about 3 months.

g2p polarized target

Dynamic Nuclear Polarization

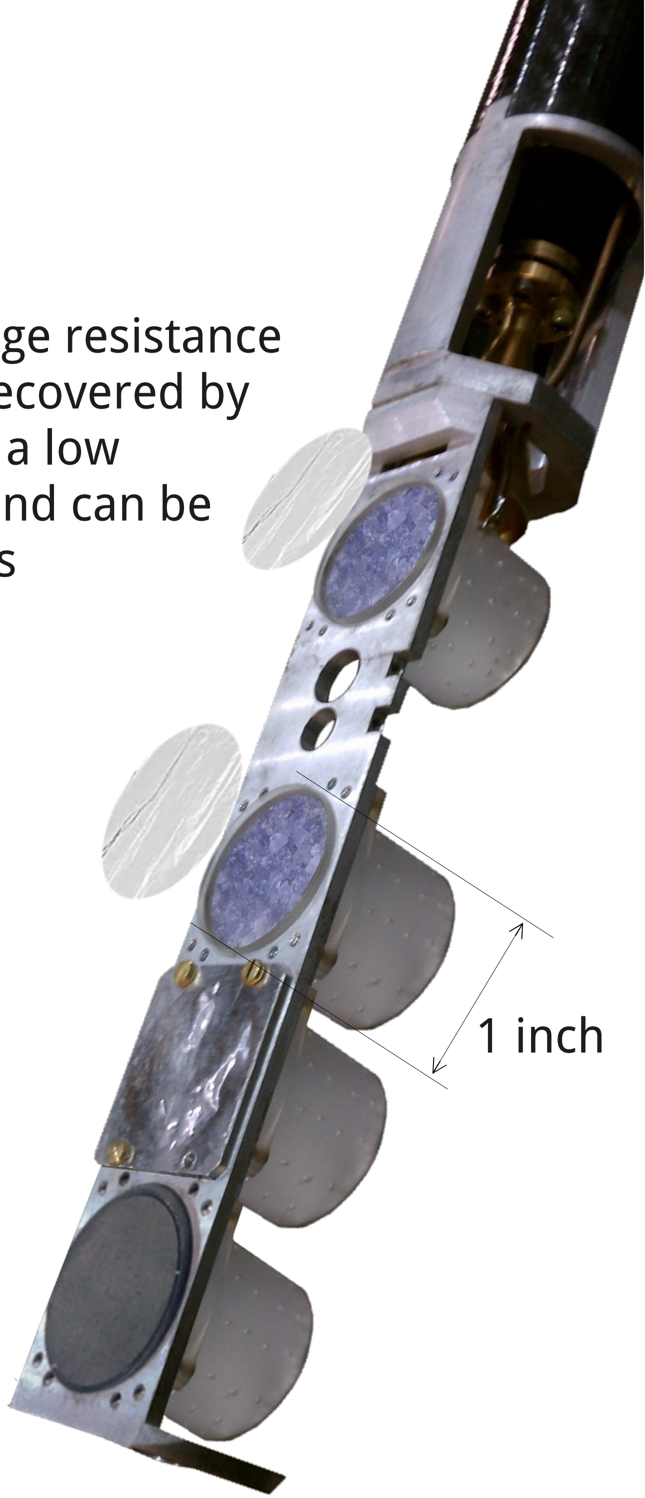




Why NH3?
High radiation damage resistance
Can be completely recovered by annealing sample at a low temperature(~77k) and can be repeated many times

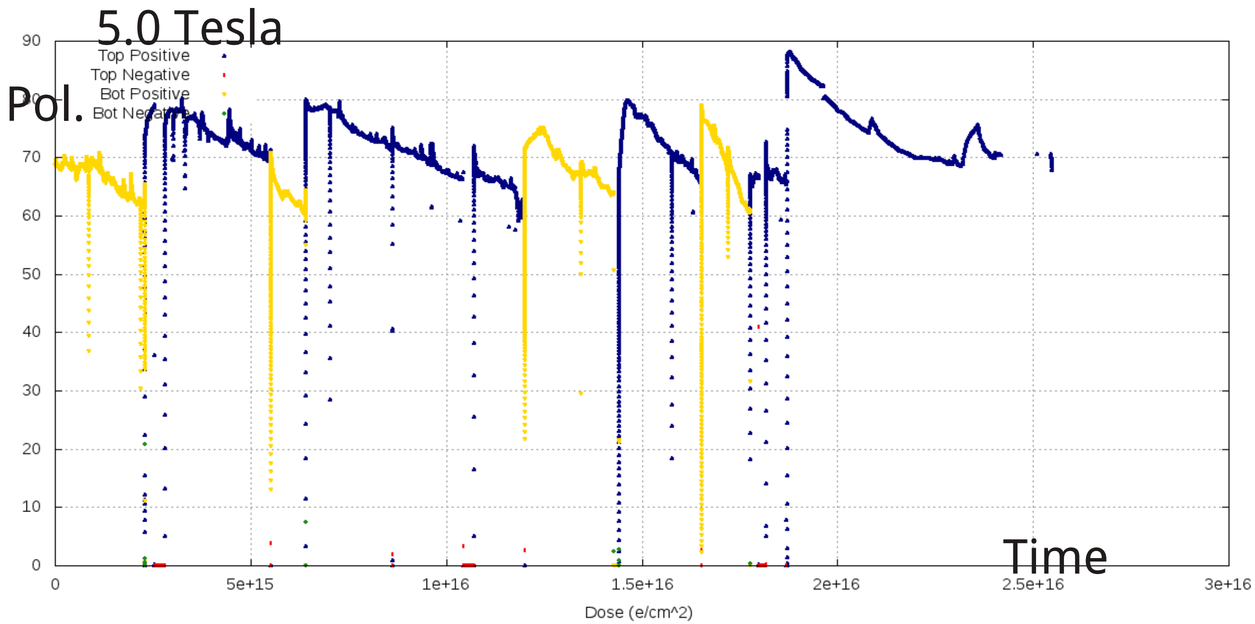
Calibrate NMR:
Thermal equilibrium

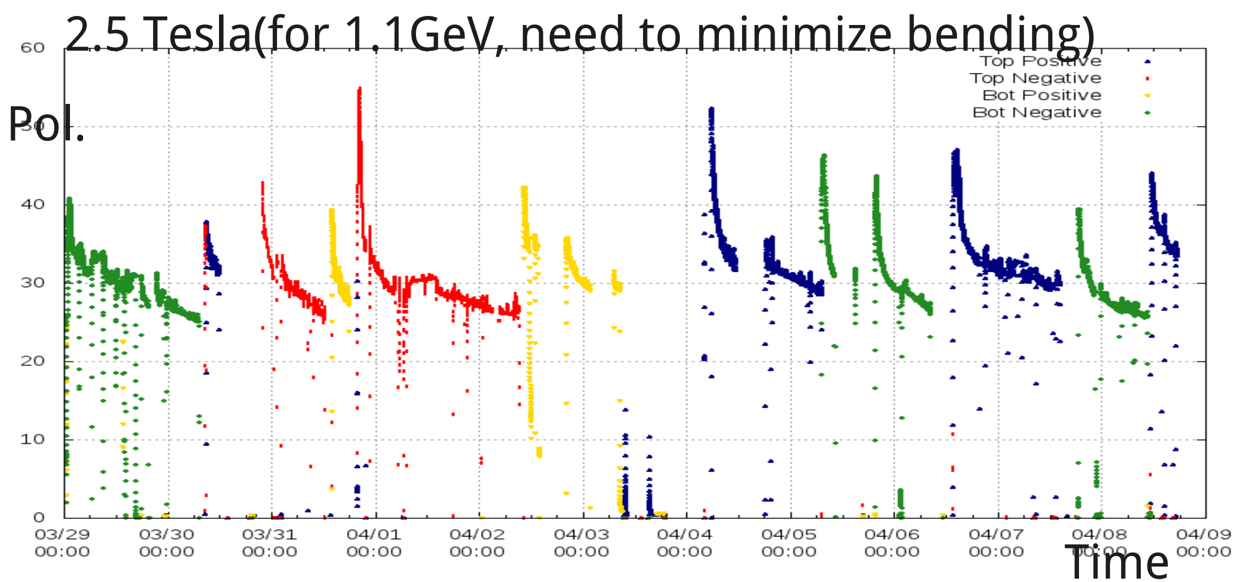
$$Polarization = \tanh\left[\frac{\mu_B H}{kt}\right]$$



g2p polarized target

Online Polarimetry





Maximum Polarization(without beam)

~55% at 2.5 Tesla/70 GHz
~92% at 5.0 Tesla/140 GHz

Average Polarization(with 50nA beam)

>30% at 2.5 Tesla/70 GHz
>75% at 5.0 Tesla/140 GHz

Polarization influencing factors:

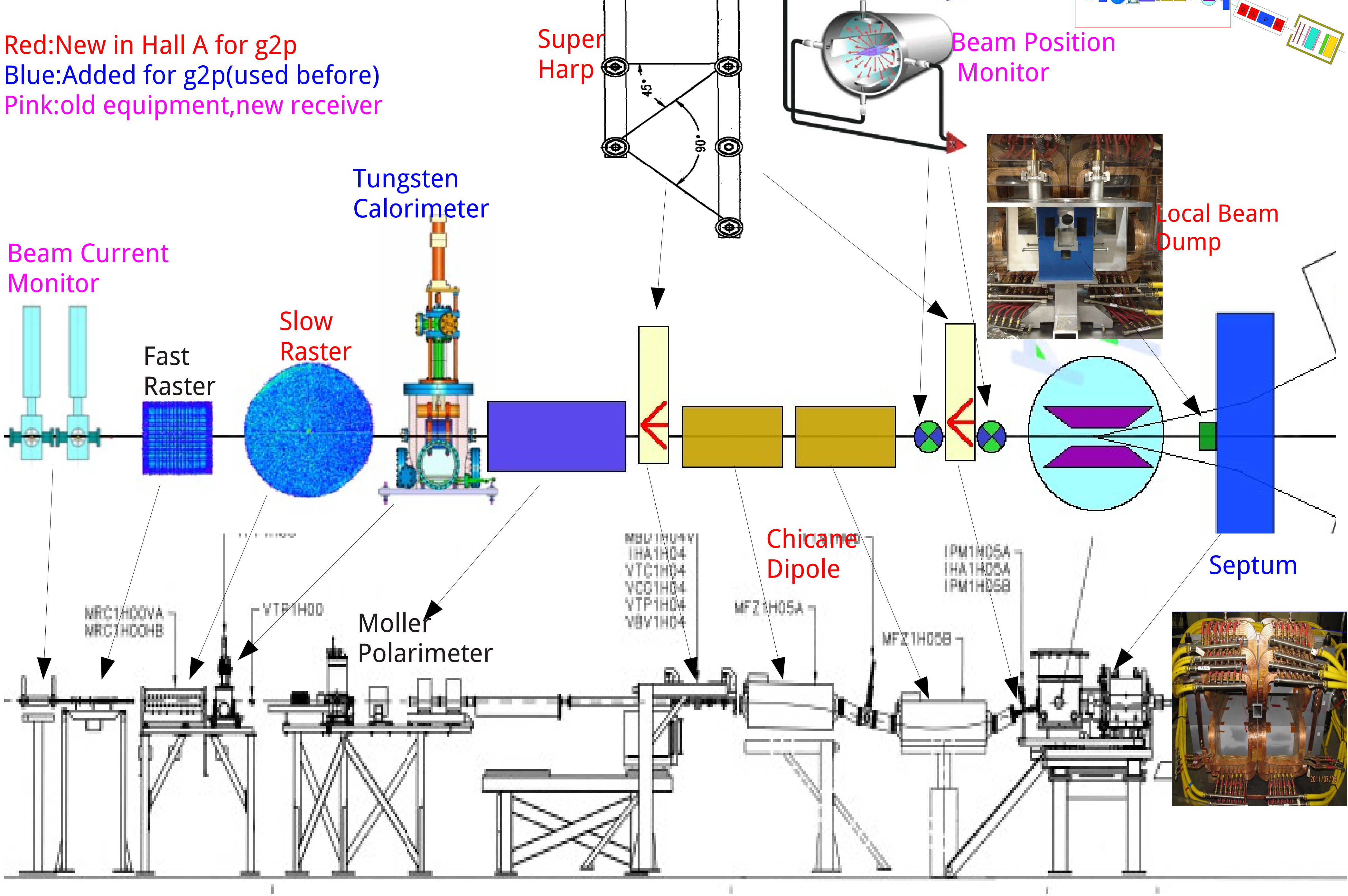
- Temperature
- Radiation damage
- …

Need to run in low current! ~50nA

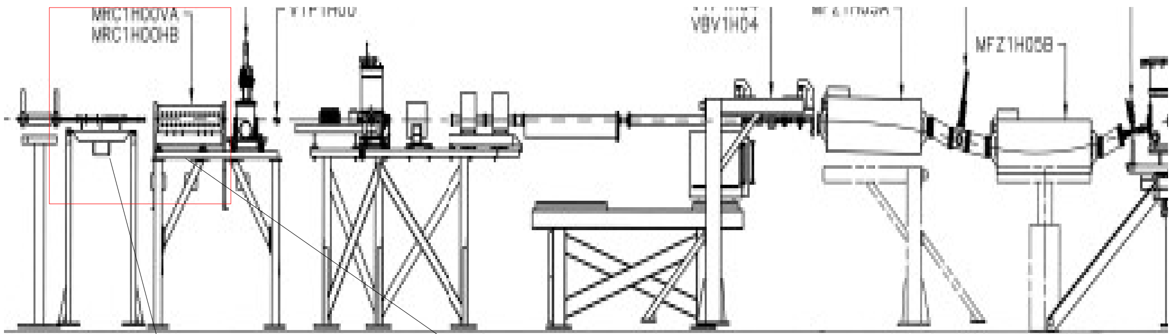
thanks to J. Maxwell

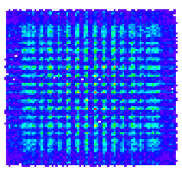
g2p beamline

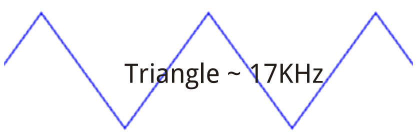
Red:New in Hall A for g2p
Blue:Added for g2p(used before)
Pink:old equipment,new receiver



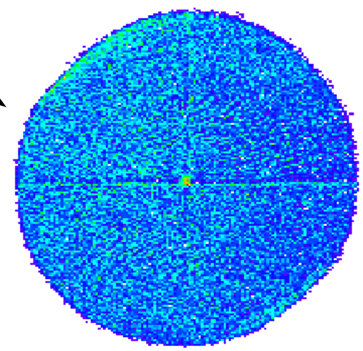
Raster System

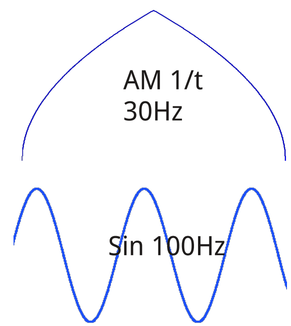




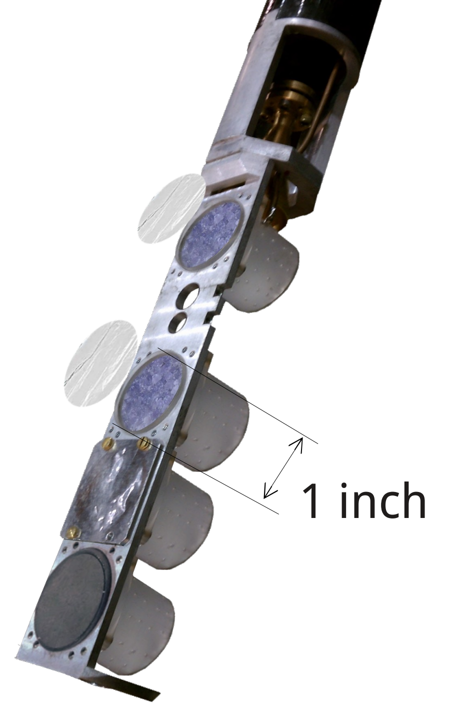


Fast Raster
~2mm

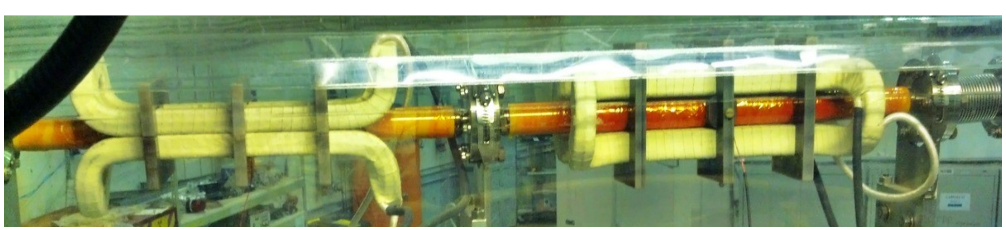


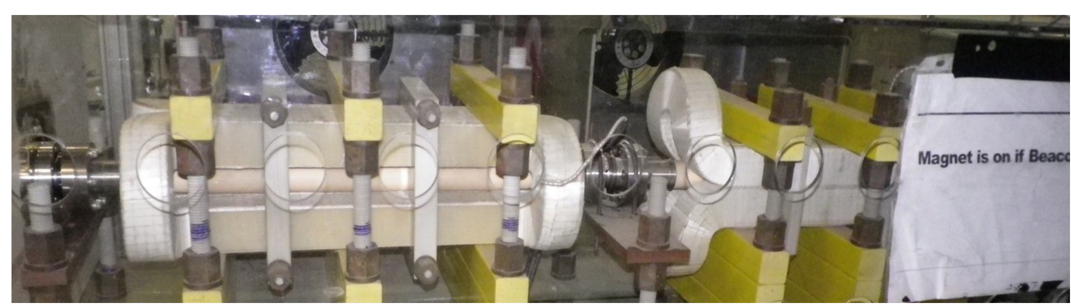


Slow Raster
~2cm

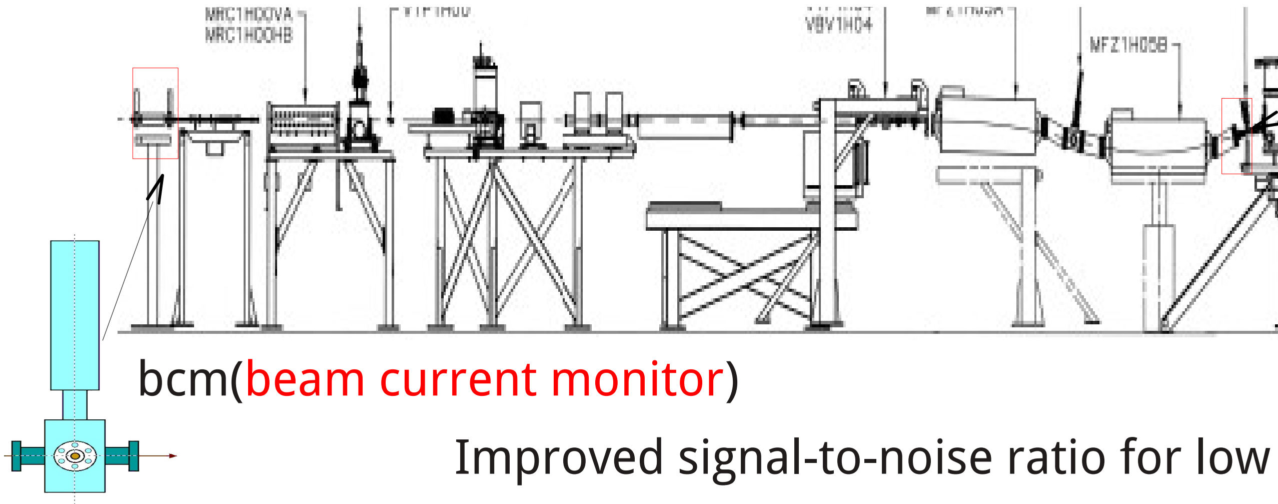


- minimize depolarization
- reduce radiation damage
- less systematic error for target polarization measurement

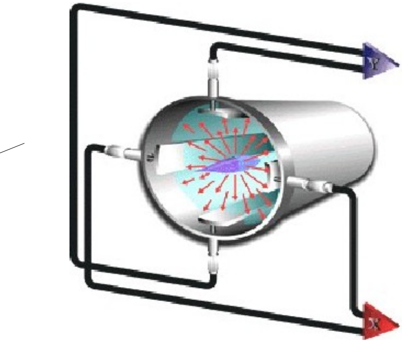




New BPM and BCM Receiver



bcm(beam current monitor)

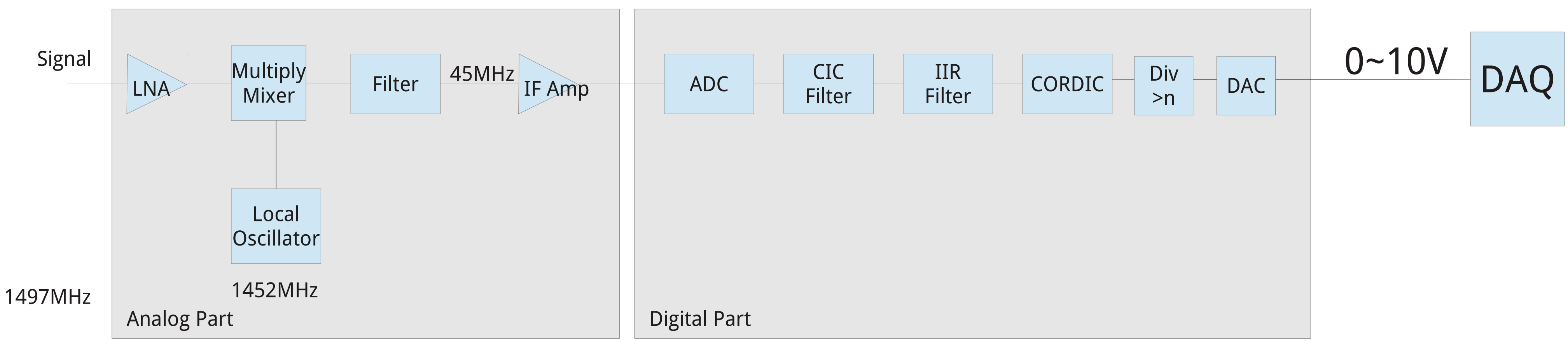


Antenna bpm
(beam position monitor)

Improved signal-to-noise ratio for low current

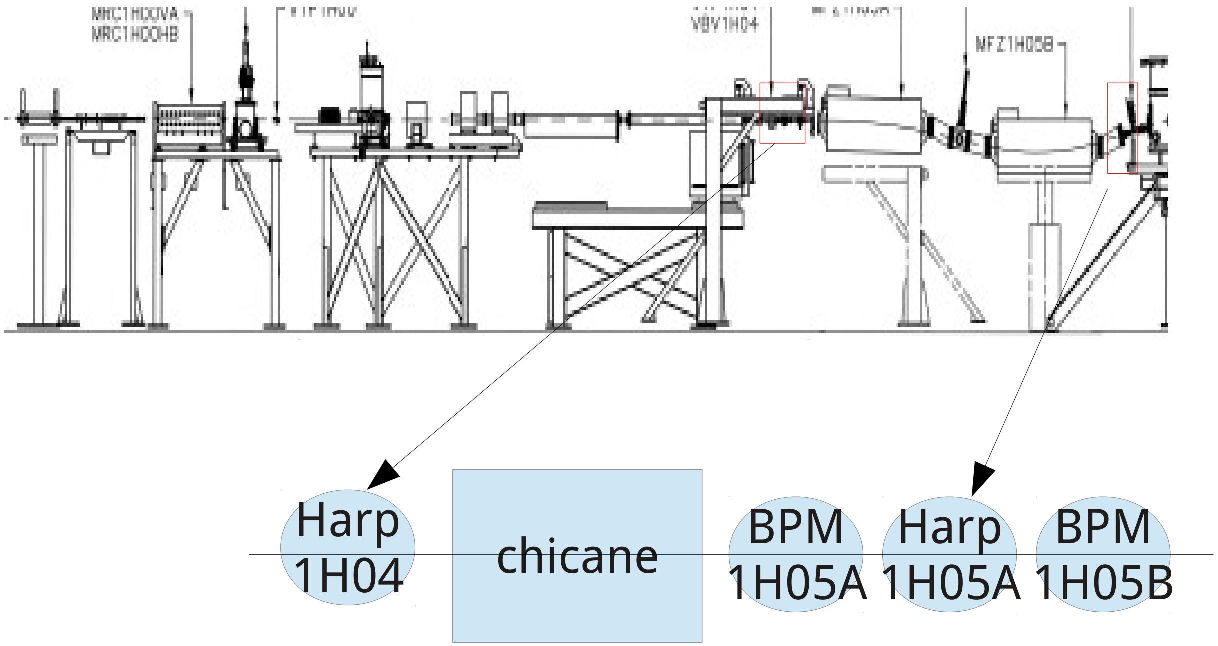
Resolution:
0.18mm with 50nA
0.12mm with 100nA

Works well with
50nA~100nA



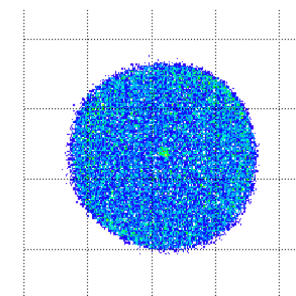
Thanks to John Musson,Trent Allison, Keith Cole

Super Harp ----------> Calibrate 2 BPMs

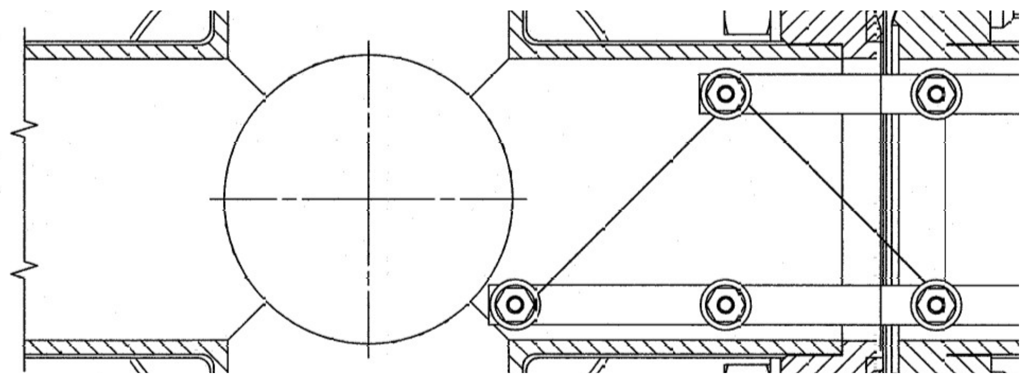


50um wires
Worked in pulsed beam mode

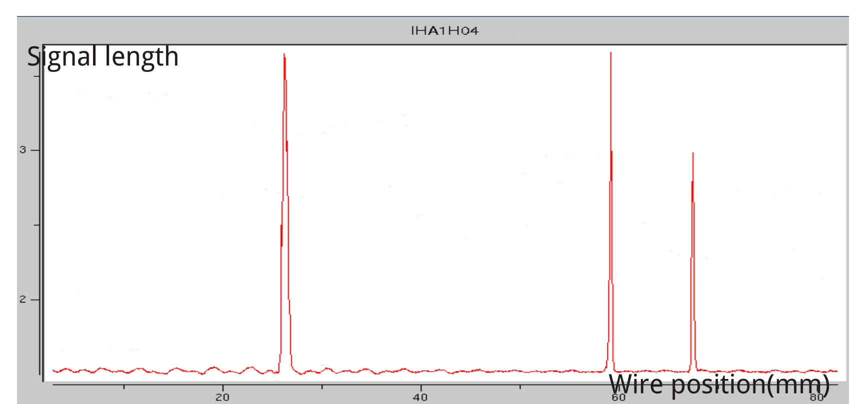
Slow raster shape in Calibrated BPM



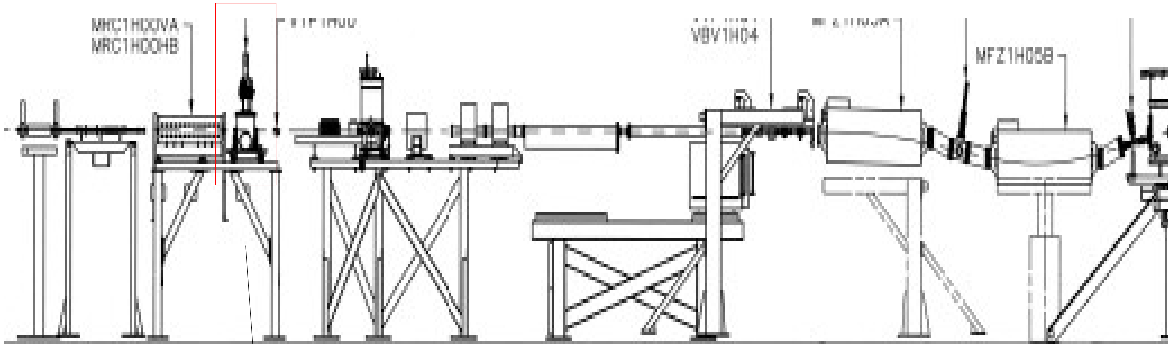
Calibrated in Straight Through Configuration



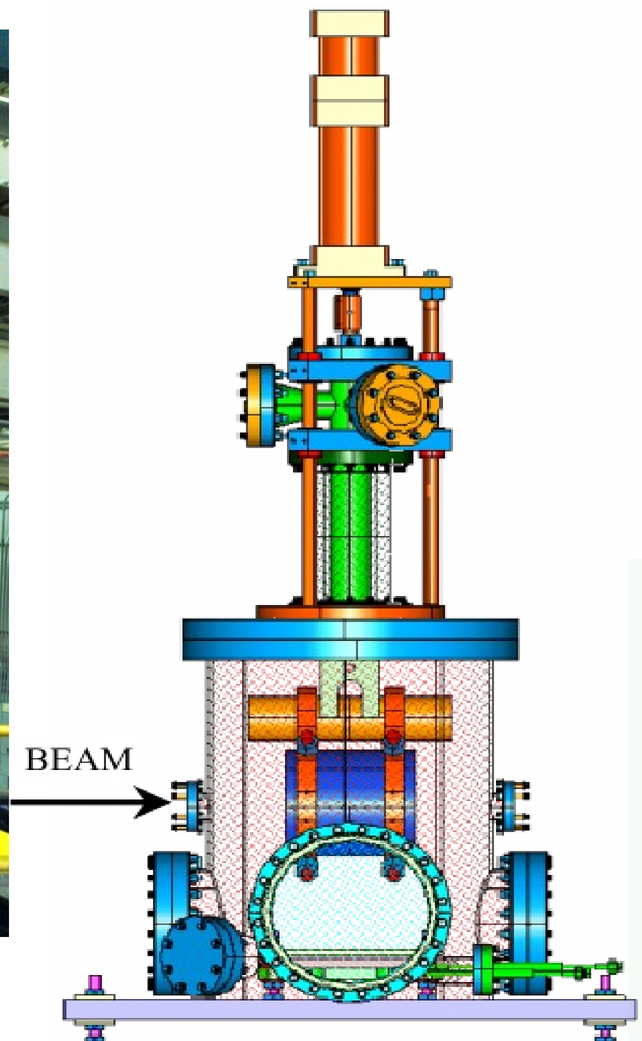
Did the harp scan in ~5uA pulsed beam
At the same position took run in 100~50nA CW beam

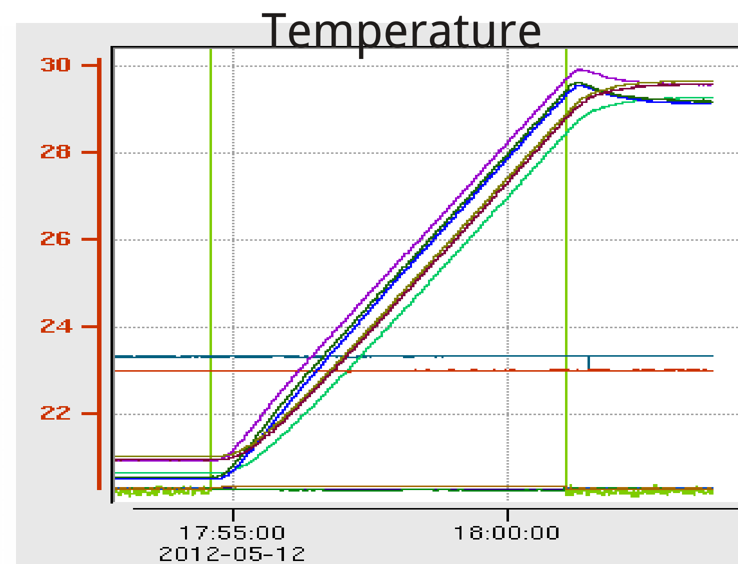


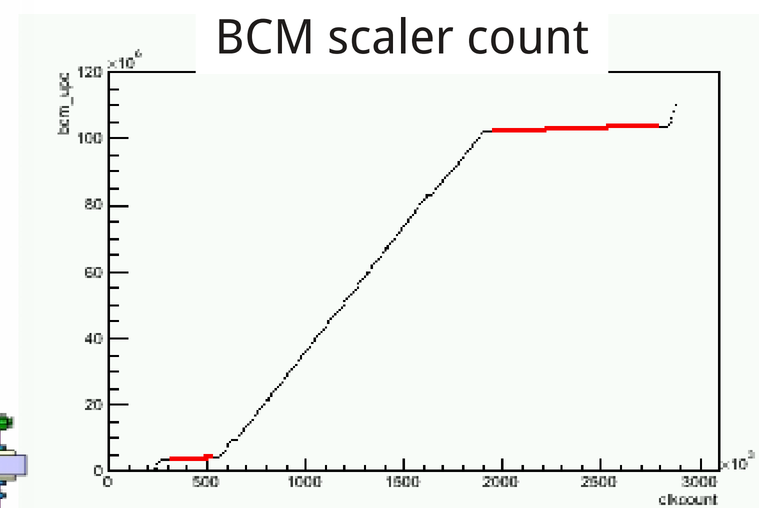
Tungsten Calorimeter -------> Calibrate Beam Current Monitor



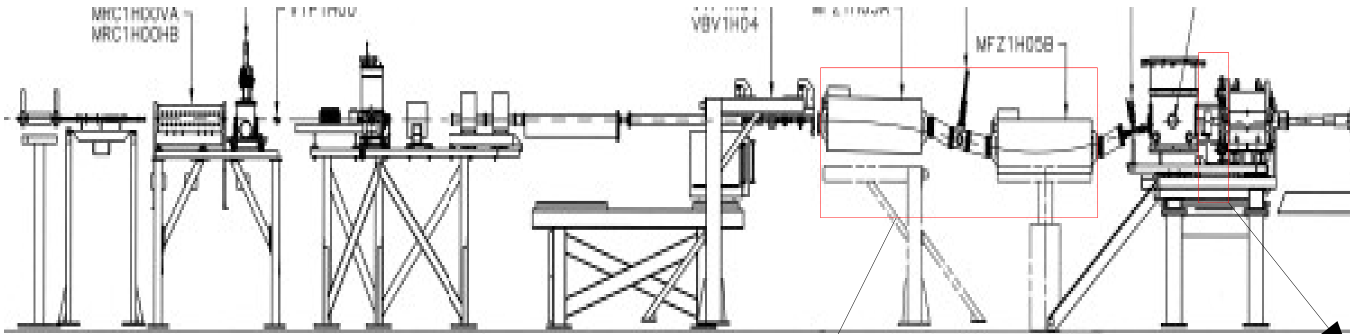
Get Total Charge from Temperature
Then Calibrate BCM count



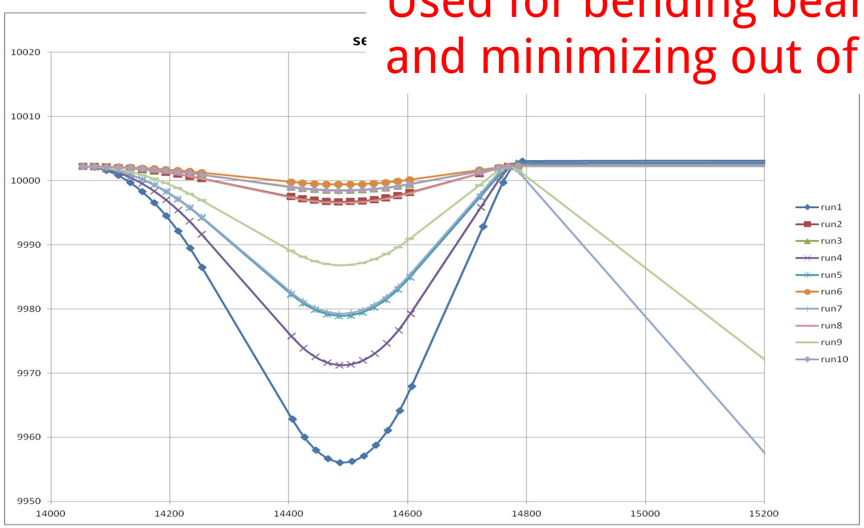


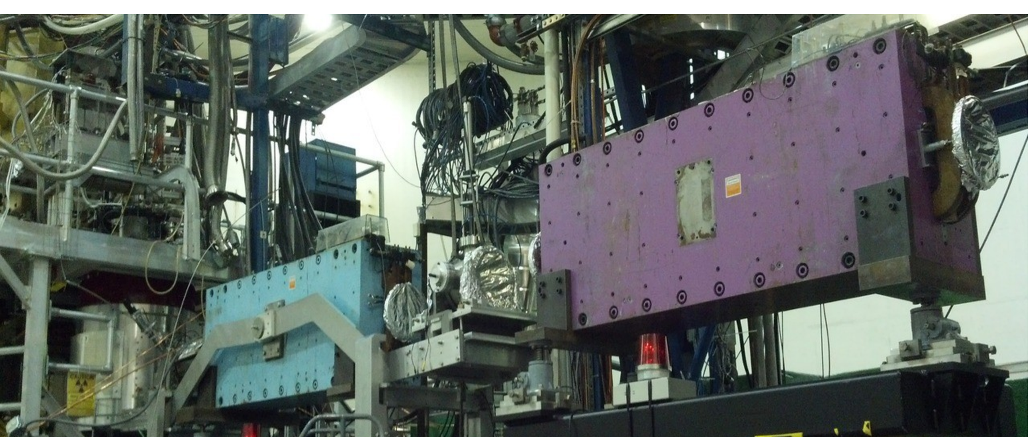


Chicane Magnet

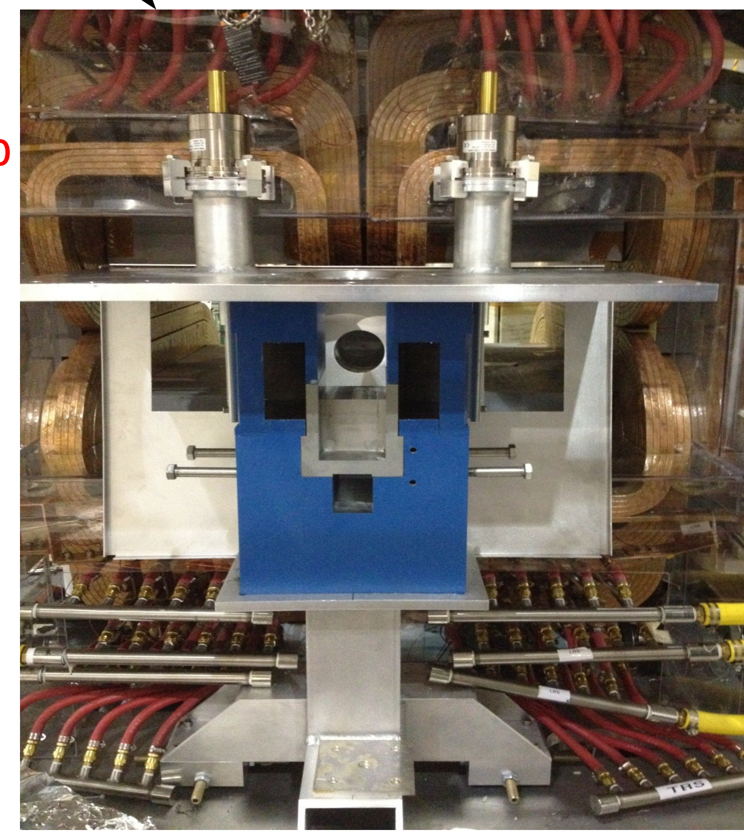


2.5/5T Transverse Target Magnet Field
Used for bending beam to hall A dump
and minimizing out of plane angle



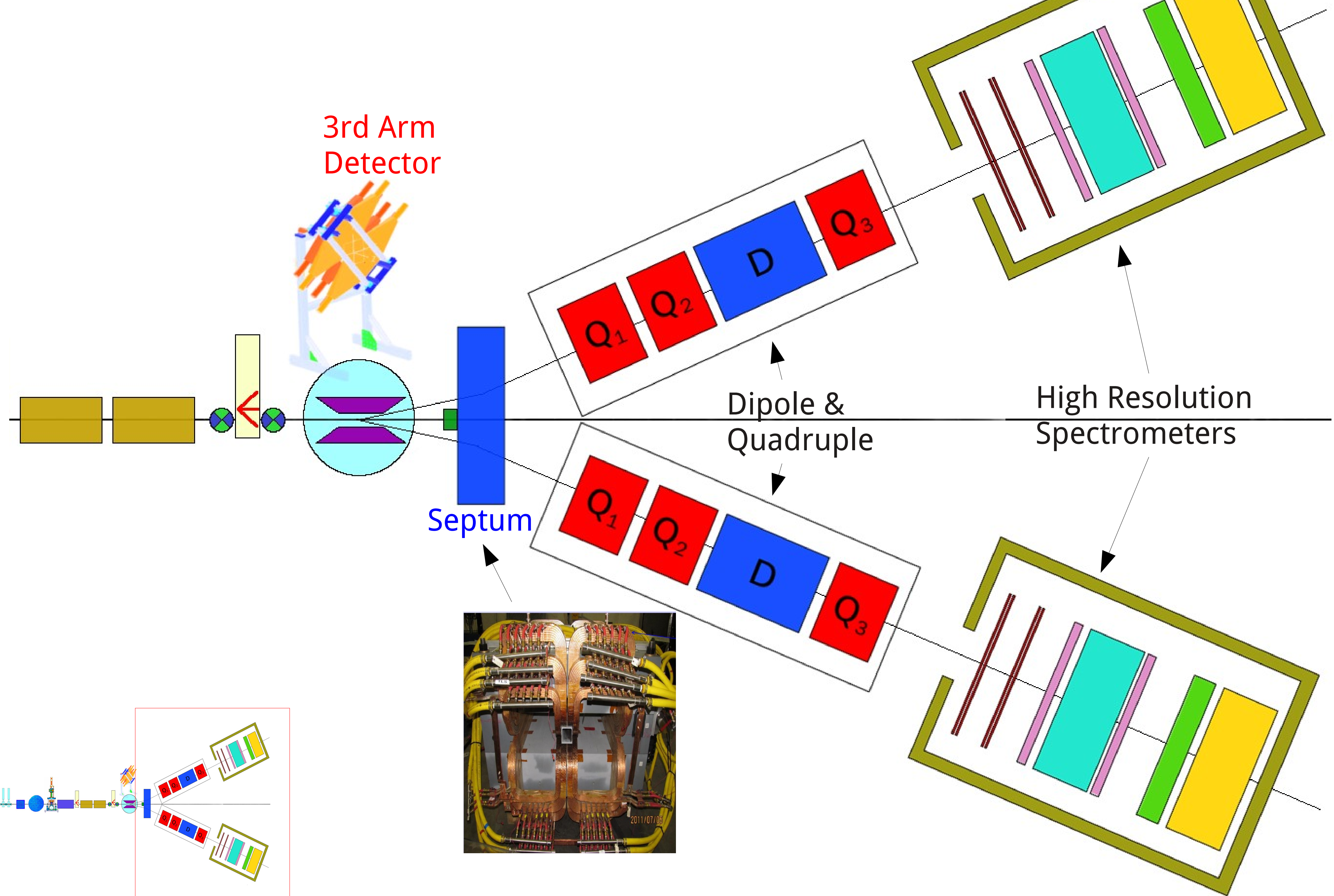


Local beam dump



Used for dumping the primary beam during 5T run.Radiation effects carefully studied before running.Worked well during experiment, radiation damage was not excessive.

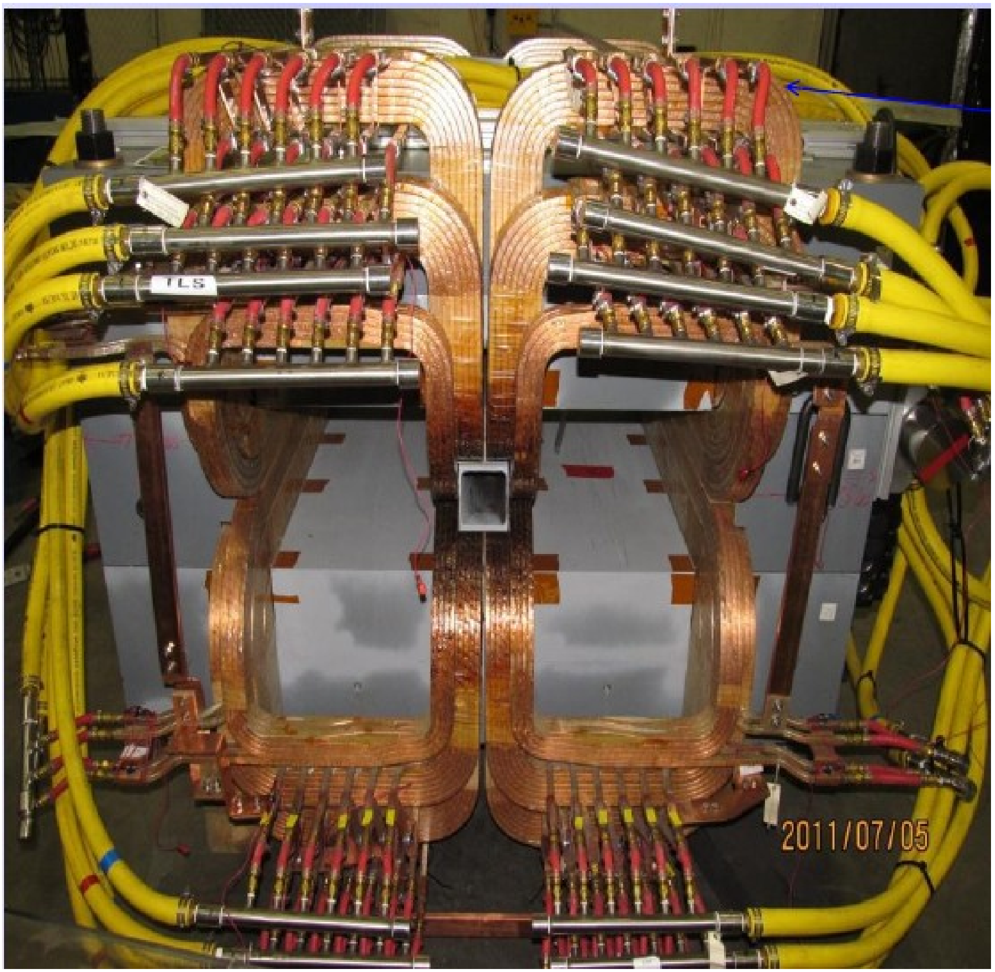
g2p Detectors

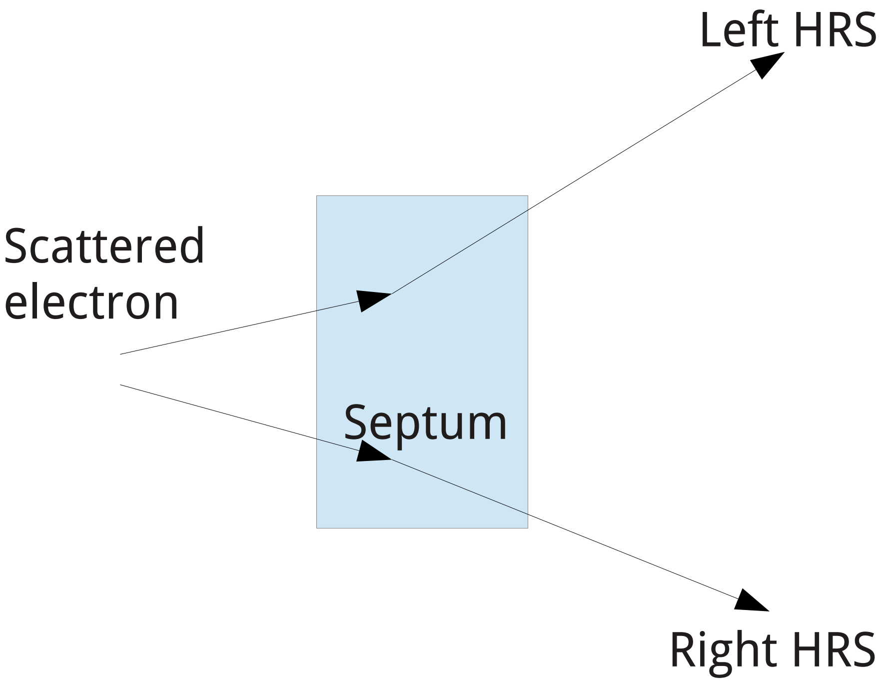


Septum

HRS Minimum Angle:12.5deg

Reduce to 6 deg

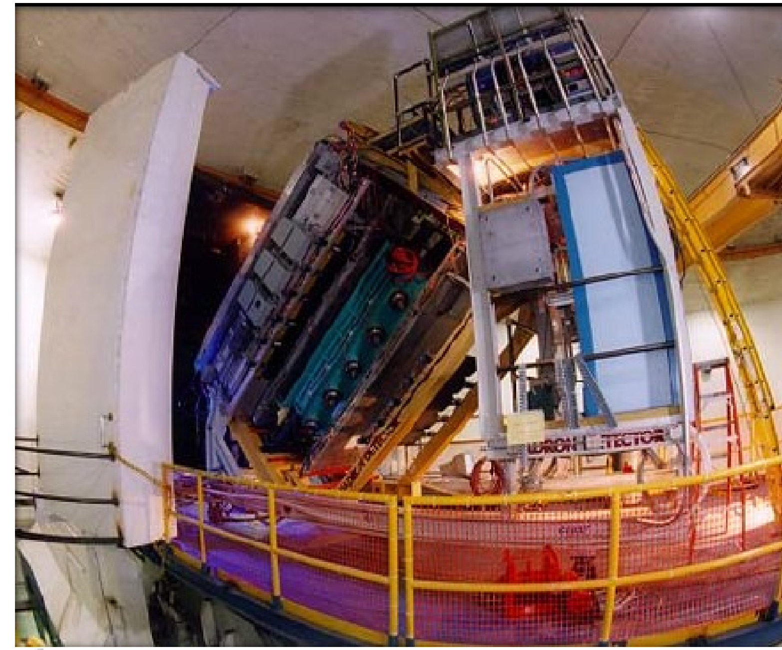


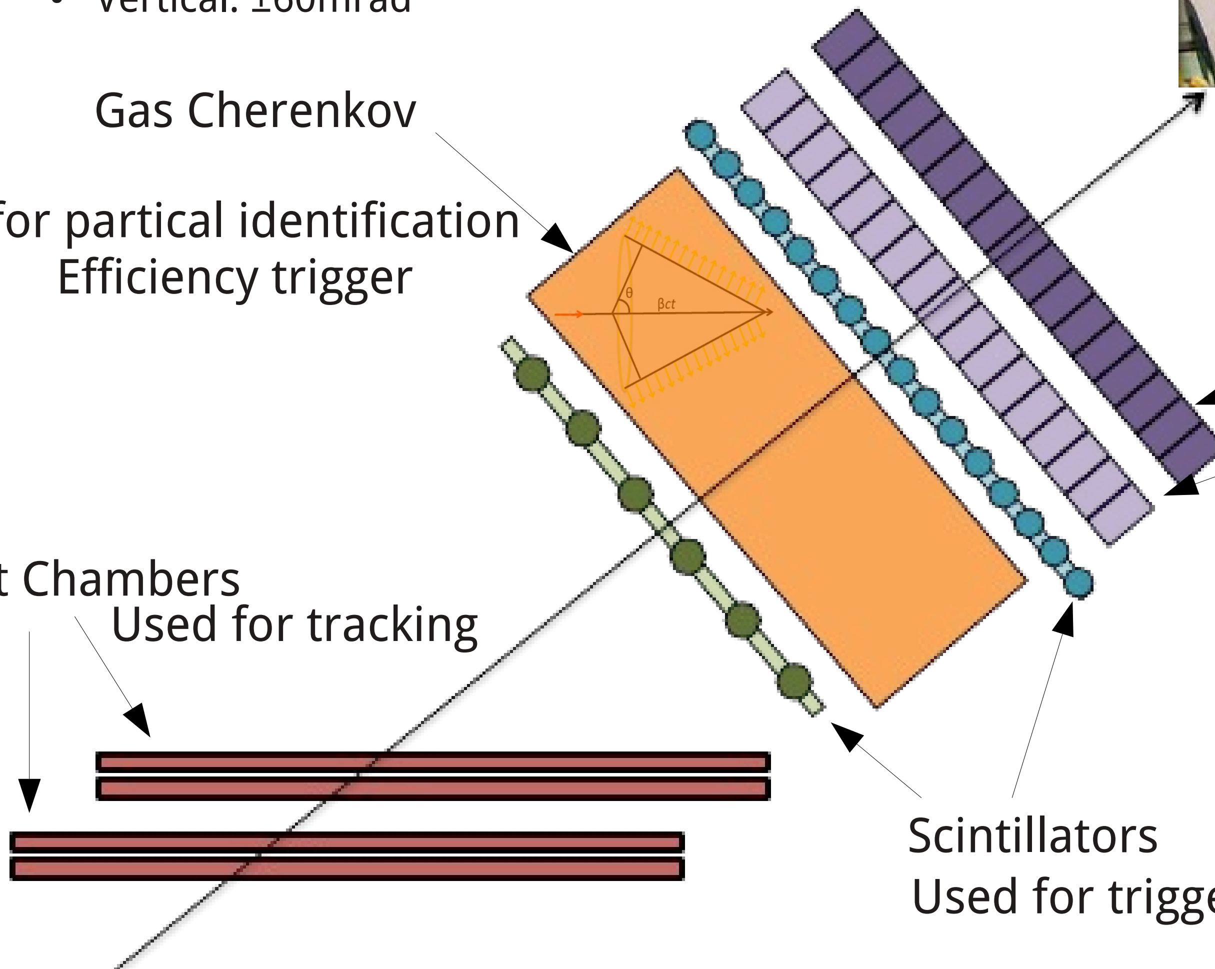


Coils were damaged two times during experiment but fixed quickly

Hall A High Resolution Spectrometers

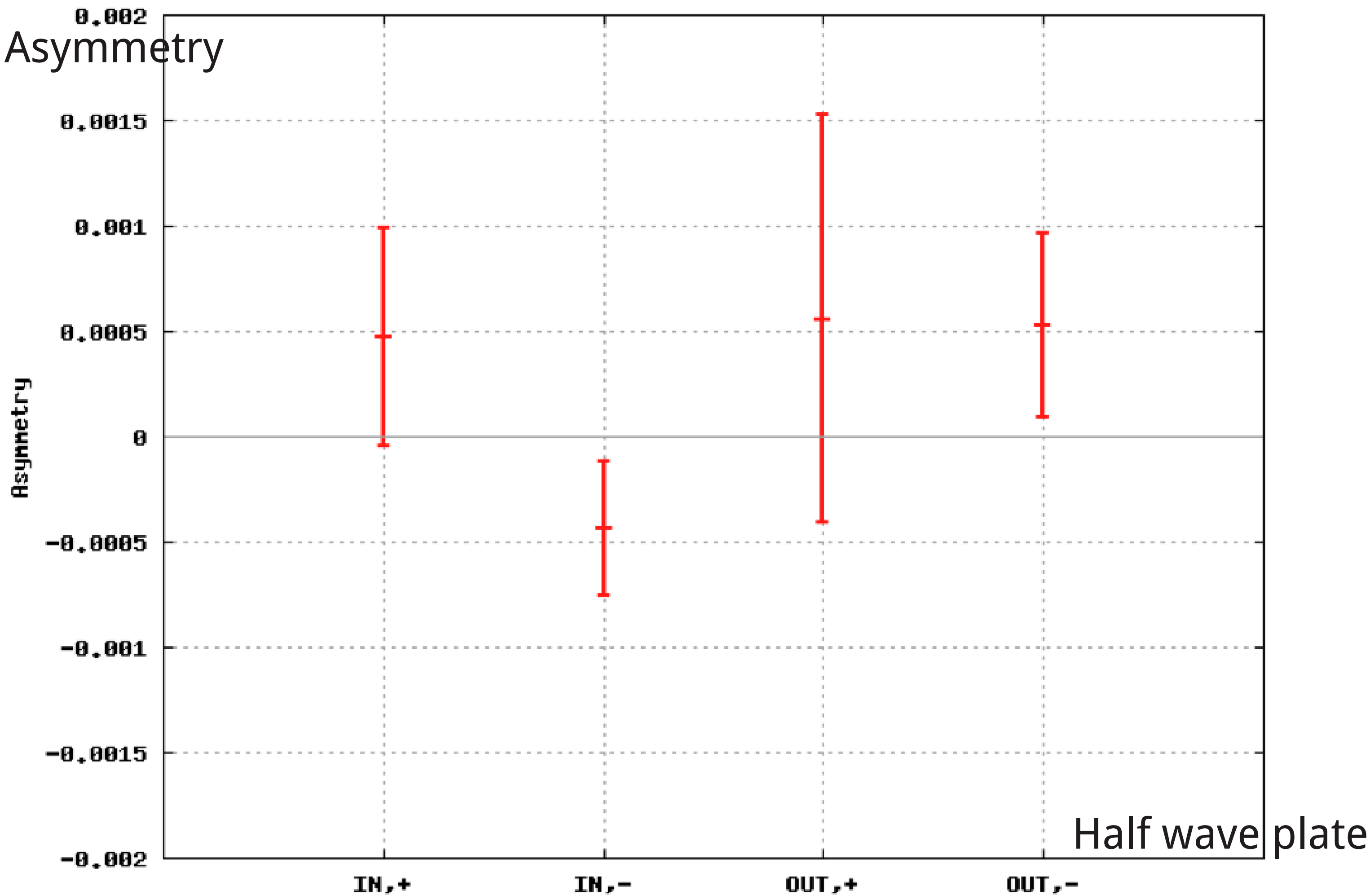
- High momentum resolution: 10e-4 level over a range of 0.8-4.0GeV/c
- High momentum acceptance: |δp/p|<4.5%
- Wide range of angular settings
  - 12.5 -150 deg (LHRS)
  - 12.5 -130 deg(RHRS)
- Solid angle at δp/p=0,y0=0: 6msr
- Angular acceptance:
  - Horizontal: ±30mrad
  - Vertical: ±60mrad

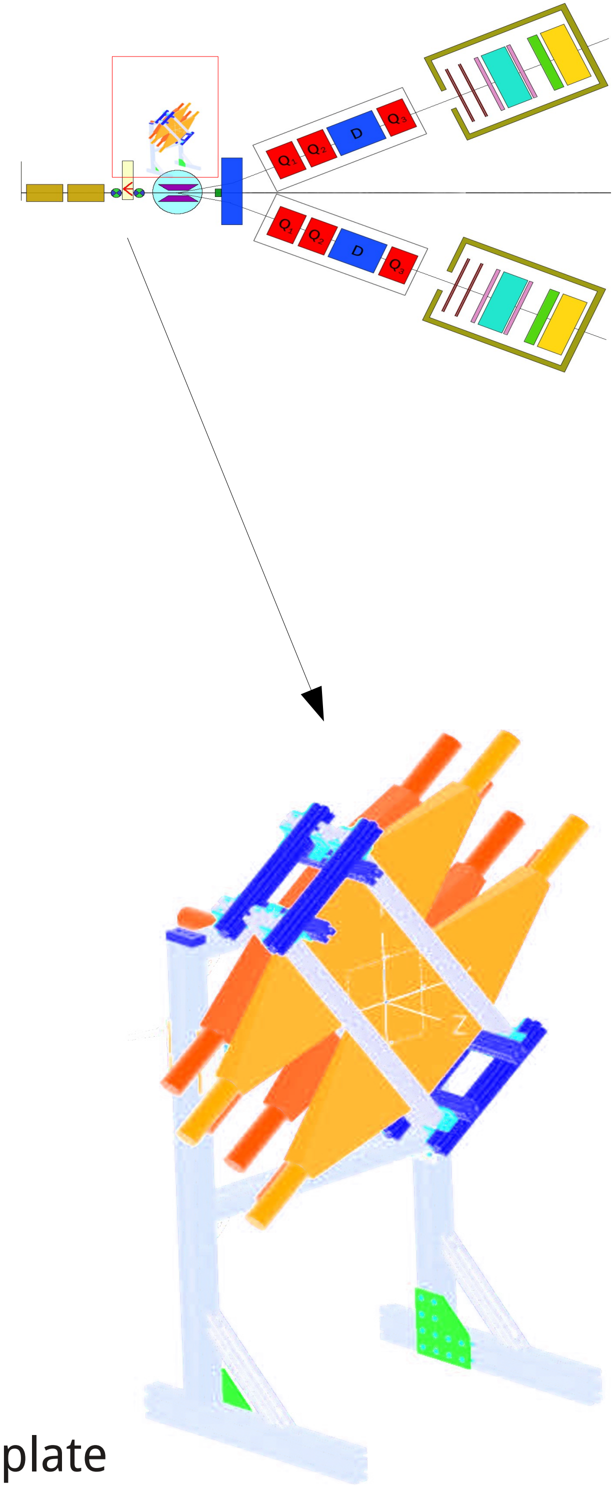




Third Arm

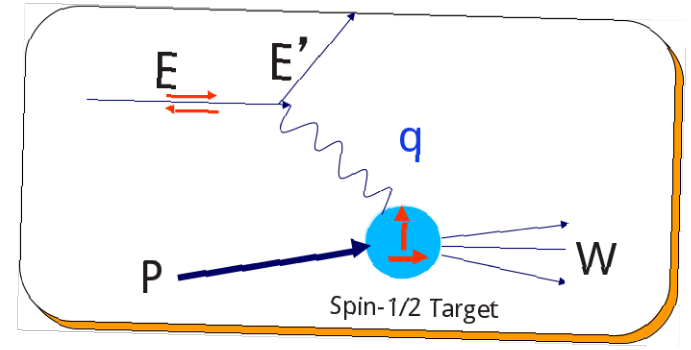
- Measure elastic asymmetry to monitor beam and target polarization(10% level)
  - A_raw = P_b * P_t * D * A_phy
- Cross-check for beam (Moller) and target (NMR) polarization measurement
- Used for tuning beam during experiment



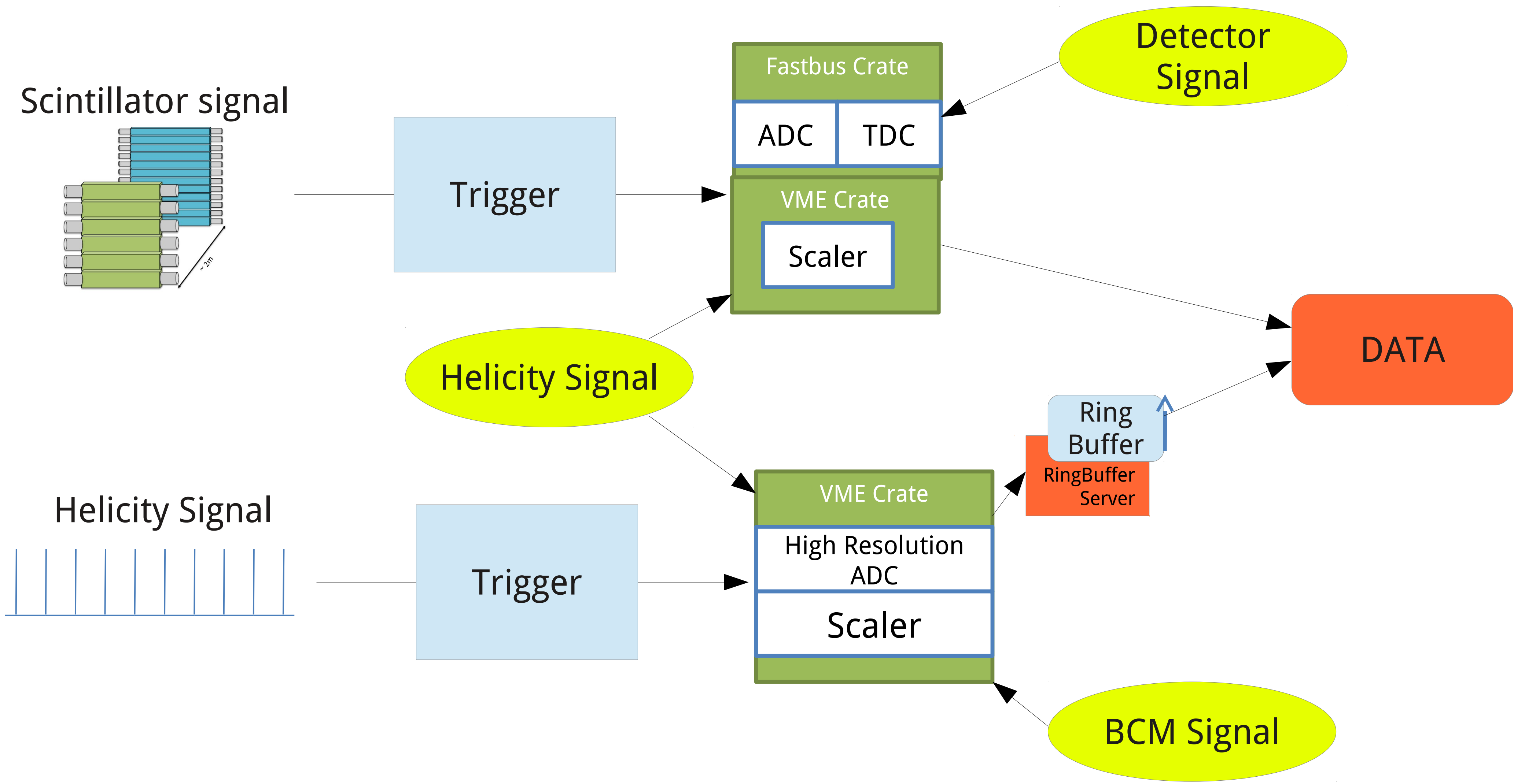


Thanks to Kalyan Allada and ChaoGu

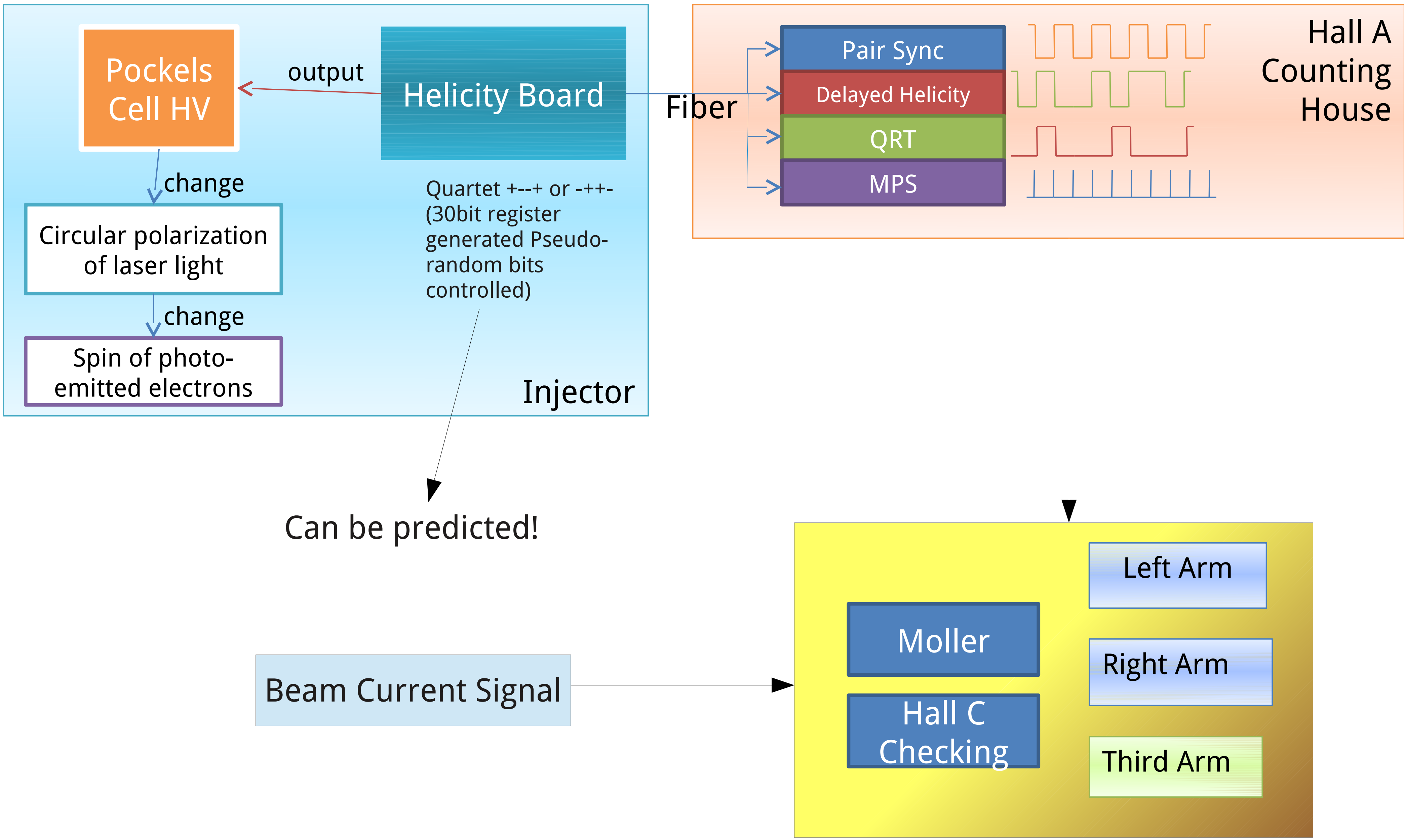
Data Acquisition System
--Single arm DAQ



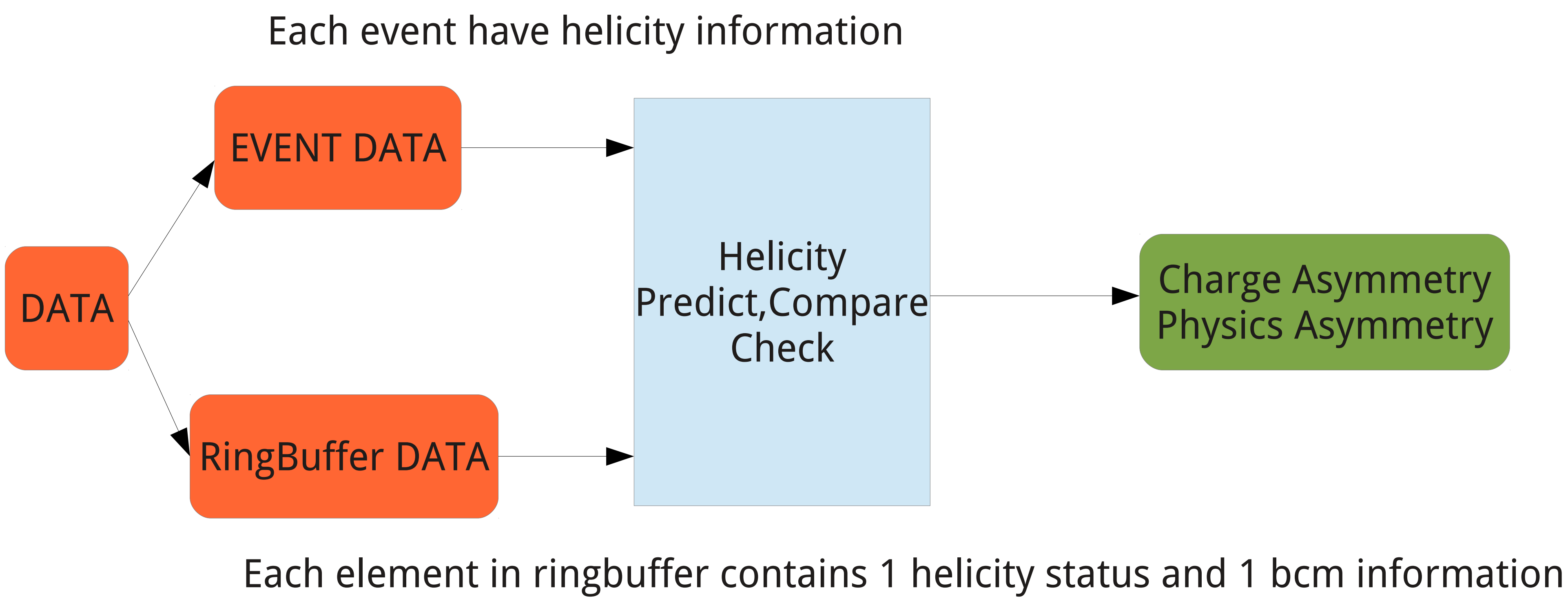
- LHRS and RHRS DAQ operate independently (singles)
- 3 fastbus crates, 2 VME crate on each arm



Helicity and BCM diagram



Get Asymmetry



DAQ Performance

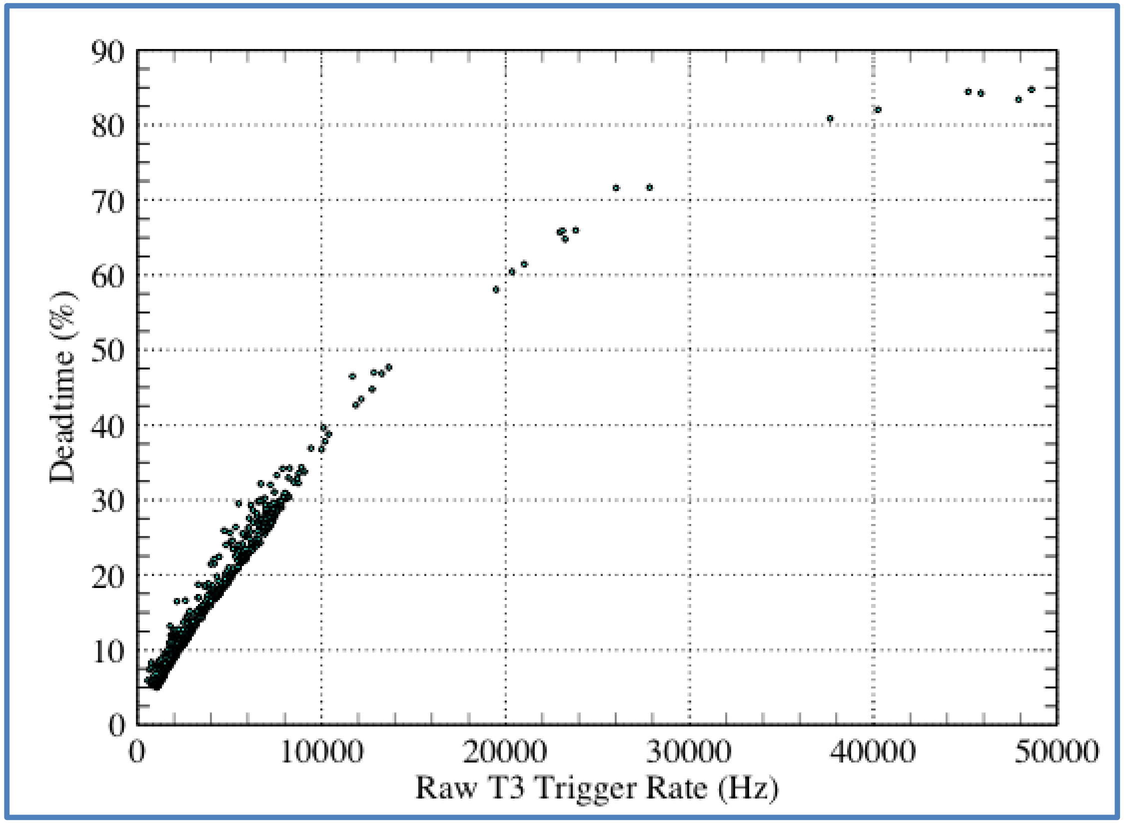
LHRS RESULTS

Production running **6.5 kHz** with ~**25% deadtime** at prescale=1**!**

Before in Hall A it is 4kHz(20% deadtime)

Hall A Record!

Production Running



trigger (kHz)	PS	DT (%)
6.5	1	25
15	2	20
22	3	20
30	4	20

Summary

The target magnet coil failed prior to start of the experiment. It was replaced by the target group causing a 3 month delay. The target then performed extremely well.

Upgraded beamline instrumentation worked well to accommodate
the low beam current and pre-bending required by the polarized target operation.

Septum magnets were used to reach forward angle of 6 degrees.

The third arm will provide an independent cross check of the product PbPt at the 10% level.

DAQ performance improved and stay on low deadtime(25%) in high rate(6kHz)
New Record in Hall A

E08-027 will provide the definitive measurement of g_2 at low Q2

Thanks!

Thanks for target group in Jlab and Uva's hard work for reliable target performance during experiment
Thanks for Alexandre's help for beamline study
Thanks for John Musson,Trent Allison, Keith Cole's help for BPM and BCM receiver's maintenance,optimize
Thanks for Tony,Chad's hard work for harp
Thanks for Arny, Ahamad's help for tungsten calorimeter
Thanks for Bob,David Abbott,Ed Jastrzembski's help for happex DAQ improvement
Thanks for Jack,Ed's help during experiment
Thanks for Toby,Chao,Min,Jie,Ryan,Mellisa's hard work for g2p preparation,running and data analyze.
Thanks for Karl,Jianping,Kalyan,Jixie,Vince,james
Thanks for everyone helped G2p experiment