

# Coherent Bremsstrahlung

Ken Livingston  
GlueX Collaboration Meeting, Jlab May 2015



## Coherent Bremsstrahlung

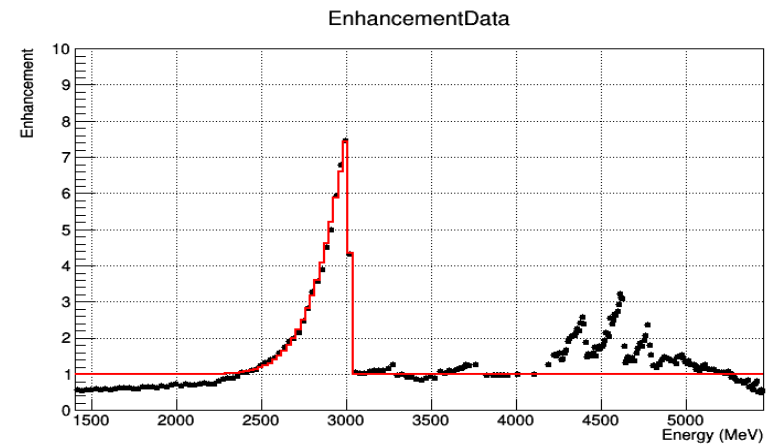
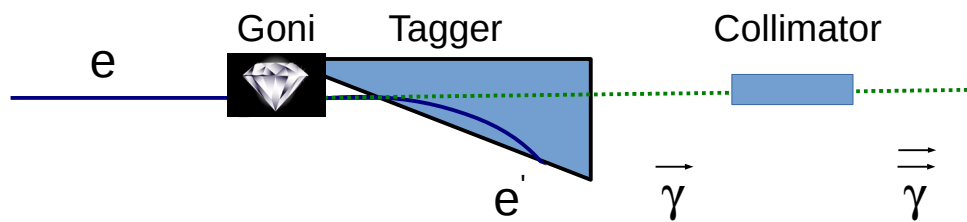
Hardware, Software

Alignment

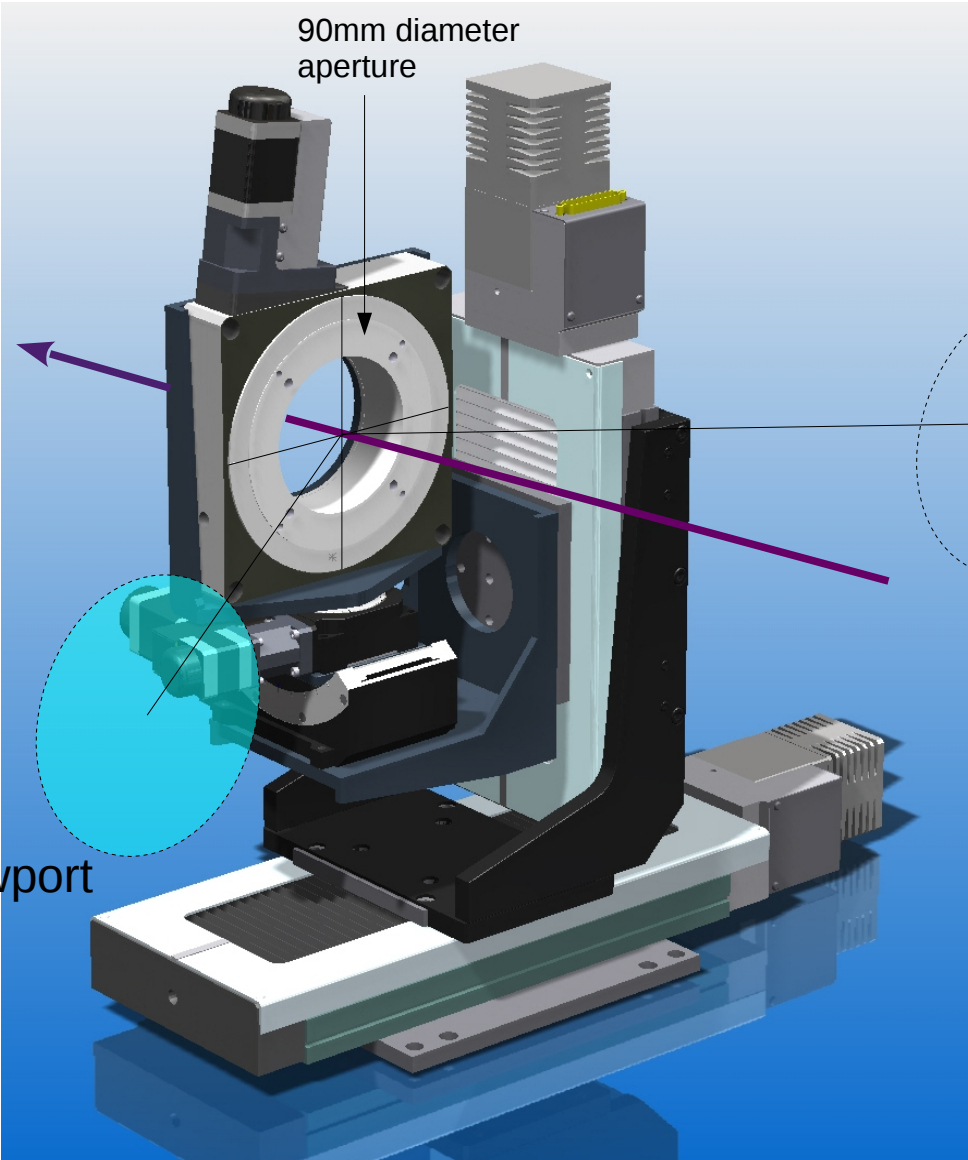
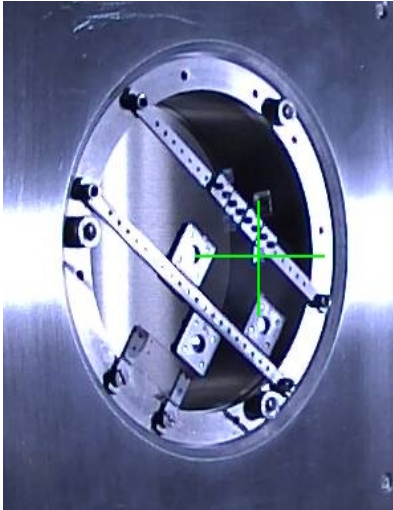
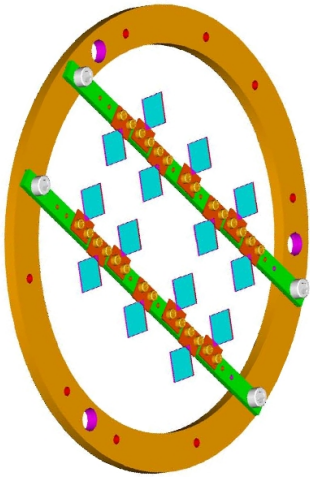
Coherent Peak

Reliability

Towards 12GeV



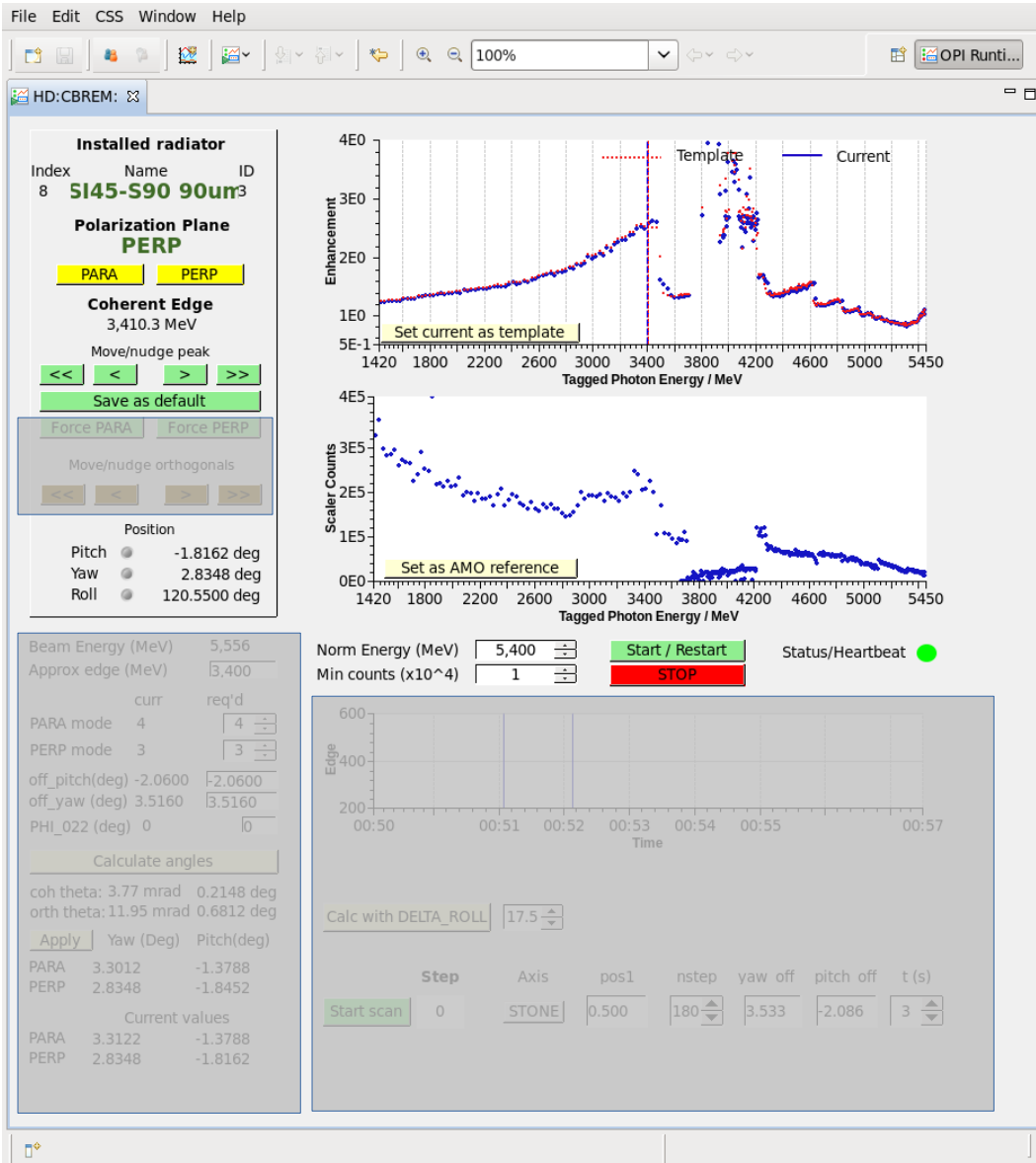
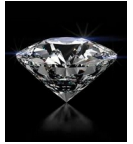
# Hardware



Viewport

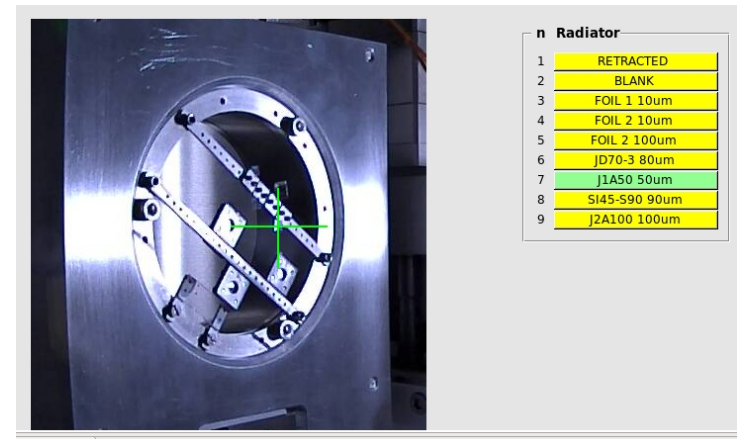
Viewport

# Software



EPICS  
Shell scripts  
ROOT macros

User GUIs

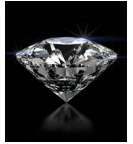


CSS GUI

Live goniometer camera image

Moveable cross to mark beam spot (with parallax)

# Software



File Edit CSS Window Help

HD:CBREM: 100%

**Installed radiator**

Index	Name	ID
8	SI45-S90 90um <sup>3</sup>	

**Polarization Plane**  
**PERP**

PARA PERP

**Coherent Edge**  
3,410.3 MeV

Move/nudge peak

<< < > >>

Save as default

Force PARA Force PERP

Move/nudge orthogonals

<< < > >>

Position

Pitch  -1.8162 deg  
Yaw  2.8348 deg  
Roll  120.5500 deg

Beam Energy (MeV) 5,556  
Approx edge (MeV) 3,400

curr req'd

PARA mode 4 4  
PERP mode 3 3

off\_pitch(deg) -2.0600 -2.0600  
off\_yaw (deg) 3.5160 3.5160  
PHI\_022 (deg) 0 0

Calculate angles

coh theta: 3.77 mrad 0.2148 deg  
orth theta: 11.95 mrad 0.6812 deg

Apply Yaw (Deg) Pitch(deg)

PARA	3.3012	-1.3788
PERP	2.8348	-1.8452

Current values

PARA	3.3122	-1.3788
PERP	2.8348	-1.8162

Enhancement

Tagged Photon Energy / MeV

Scaler Counts

Tagged Photon Energy / MeV

Norm Energy (MeV) 5,400 Start / Restart Status/Heartbeat ●  
Min counts (x10<sup>4</sup>) 1 STOP

Edge

Time

Calc with DELTA\_ROLL 17.5

Step	Axis	pos1	nstep	yaw off	pitch off	t (s)	
Start scan	0	STONE	0.500	180	3.533	-2.086	3

EPICS  
Shell scripts  
ROOT macros

Expert GUI

**n Radiator**

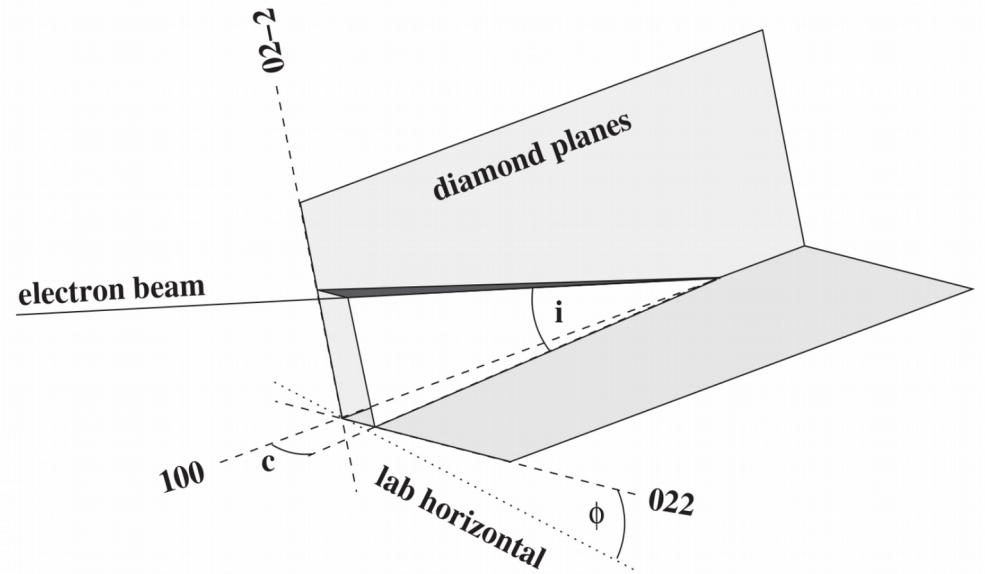
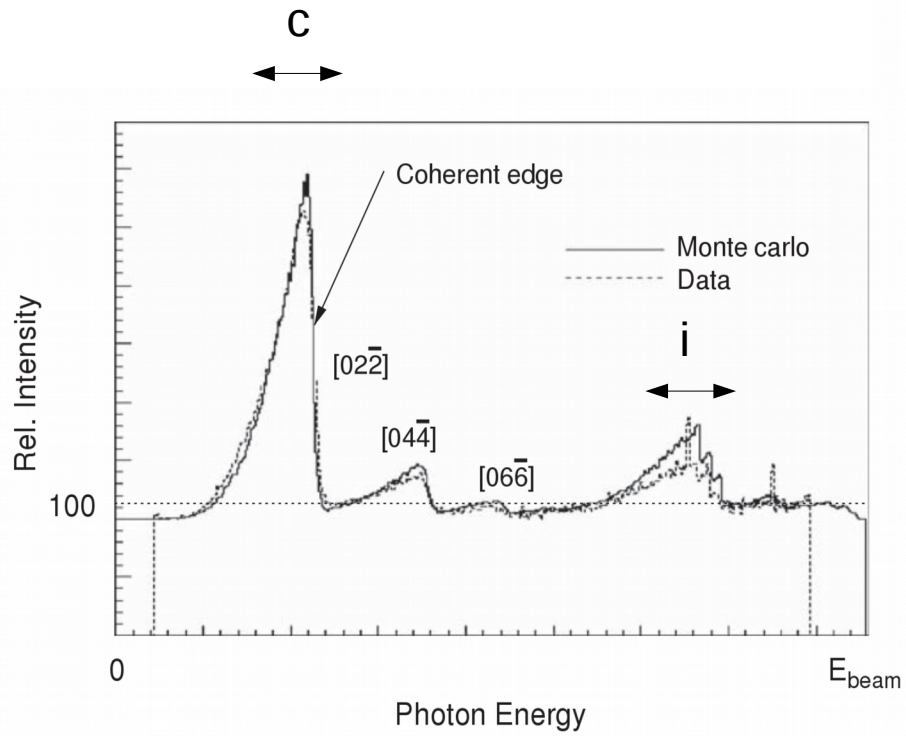
1	RETRACTED
2	BLANK
3	FOIL 1 10um
4	FOIL 2 10um
5	FOIL 2 100um
6	JD70-3 80um
7	J1A50 50um
8	SI45-S90 90um
9	J2A100 100um

CSS GUI

Live goniometer camera image

Moveable cross to mark beam spot (with parallax)

# Alignment



# Alignment



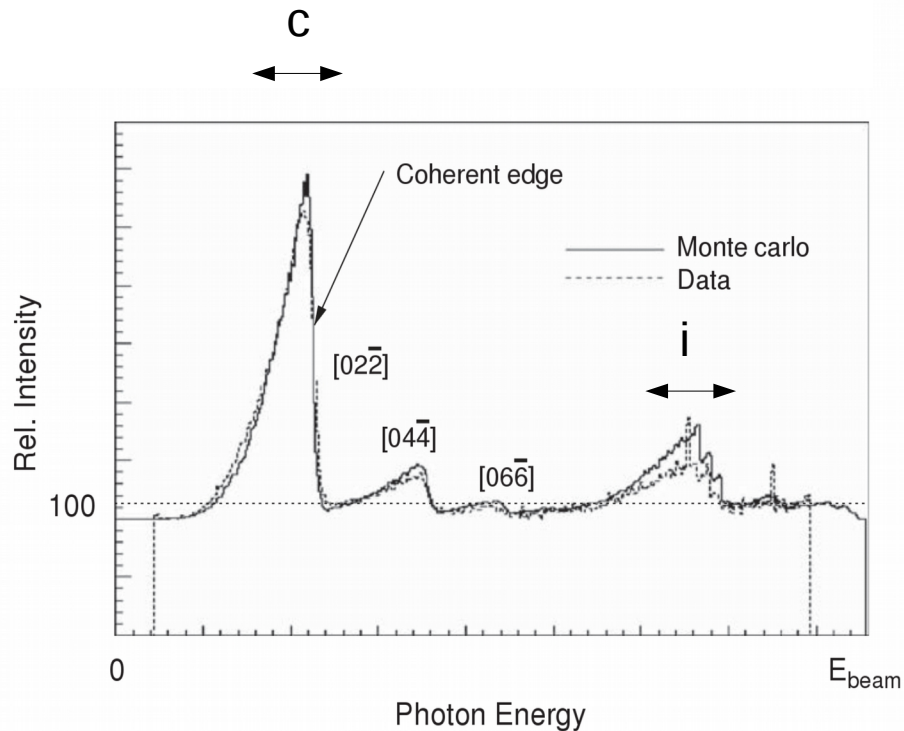
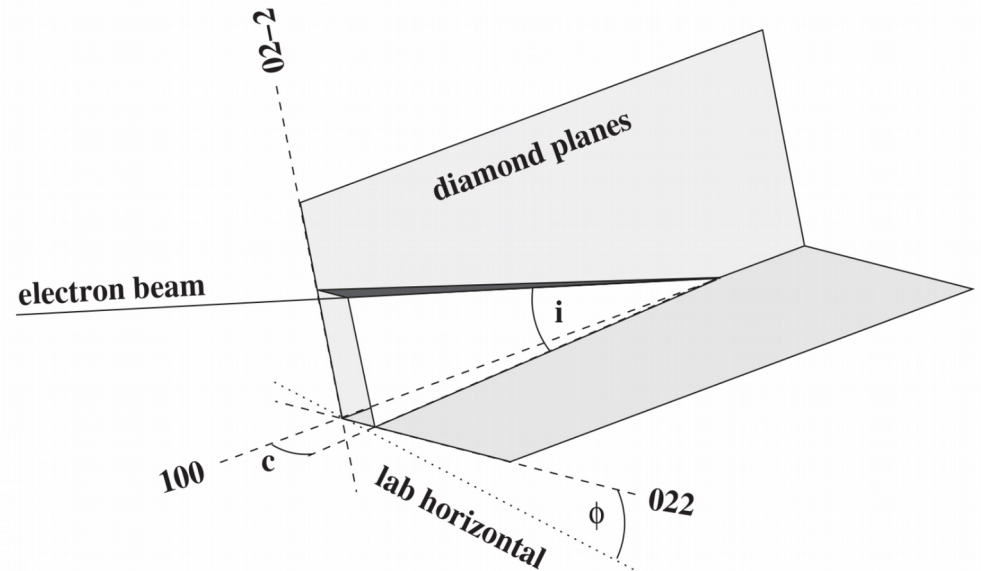
## Bookmakers Odds:

Phi: 1/45, I: 1/60 c: 1/60



Chance of good pos: 1/162000

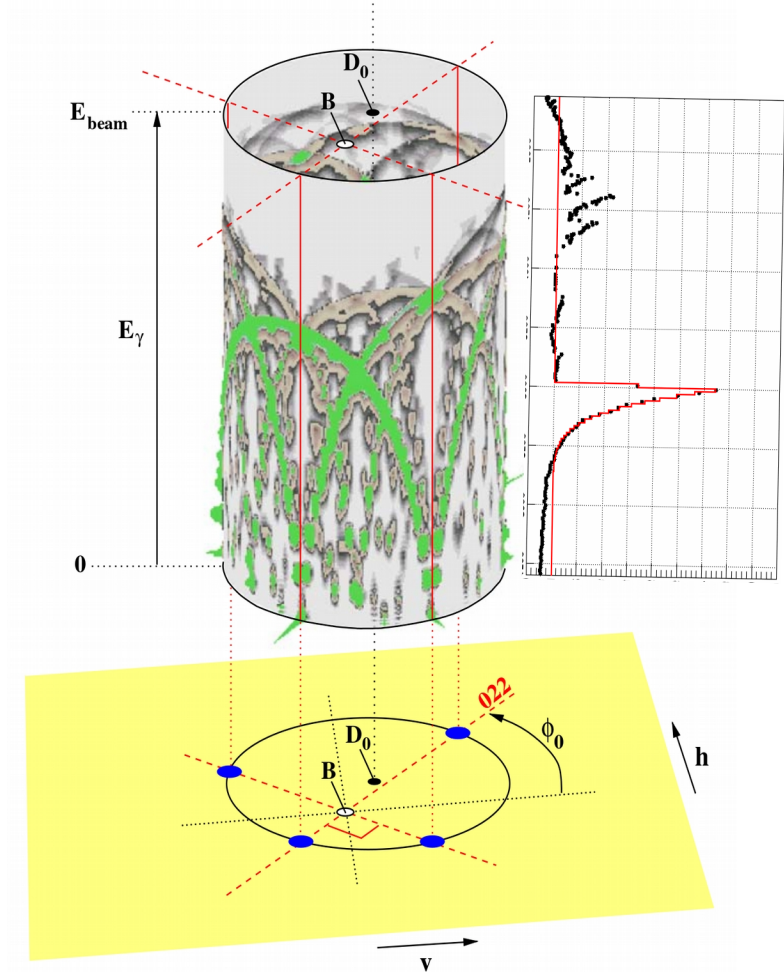
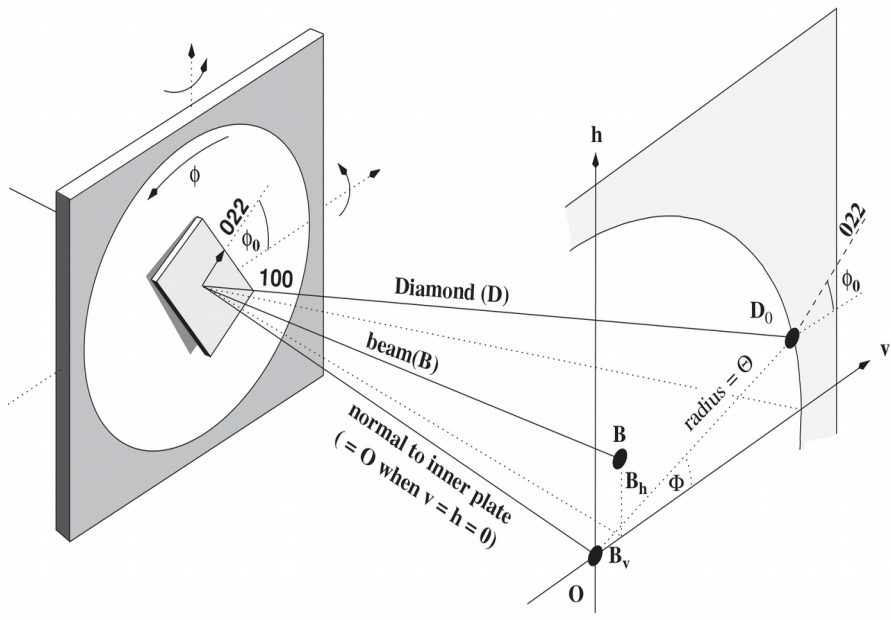
(Chance of knowing its good: 0)



Need a method of finding the orientation for the crystal relative to the beam.

An exercise in 3D trig and coherent beam.

# Alignment



## Stonehenge Technique

### Scan

Move diamond round in a cone:  $R \cos v$ ,  $R \sin h$   
 Hope the cone includes the beam.  
 For each step make an enhancement  
 Plot them all somehow.  
 Figure out phi 022, and offsets  $v\_off$ ,  $h\_off$

Set phi 022 as required – orientation of the pol plane  
 Repeat scan until  $v\_off$  and  $h\_off$  are precise enough

7 Now can put the coherent peak approximately where reqd.  
 Tweak until it's exact.

K. Livingston. The Stonehenge technique. A method for aligning coherent bremsstrahlung radiators. NIM A 603 (2009) 205–213

[Also see D. Luckey, R.F. Schwitters, NIM 81 (1970) 164]

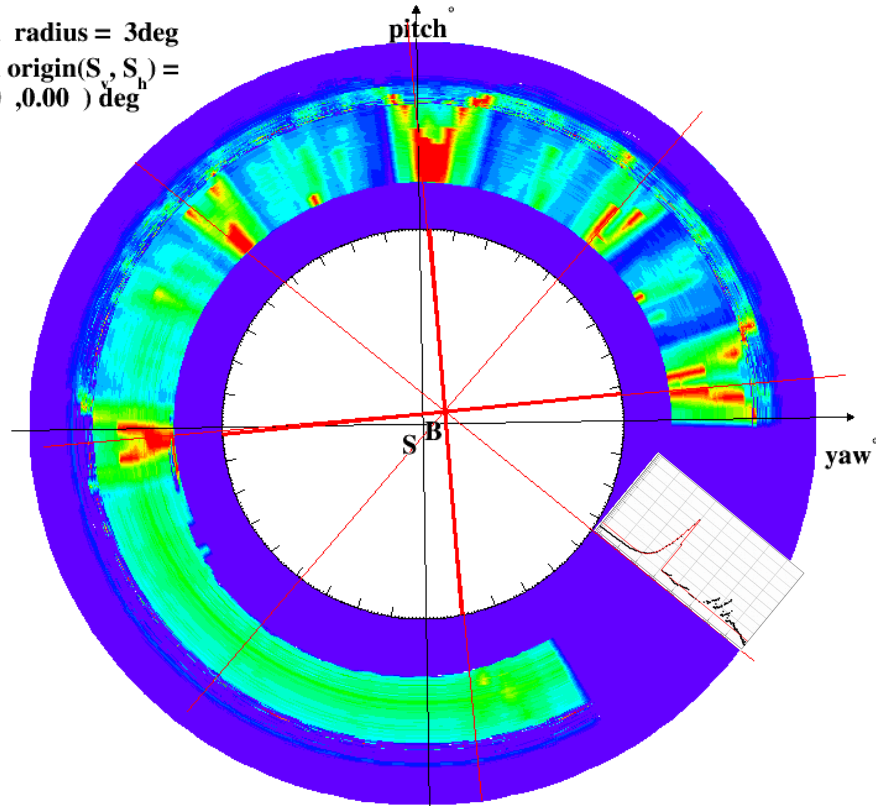
# Alignment



Try the best diamond: J1A 50um

../data/RadScanIndex0\_ID0\_STONE\_26\_04\_15:12\_51.txt

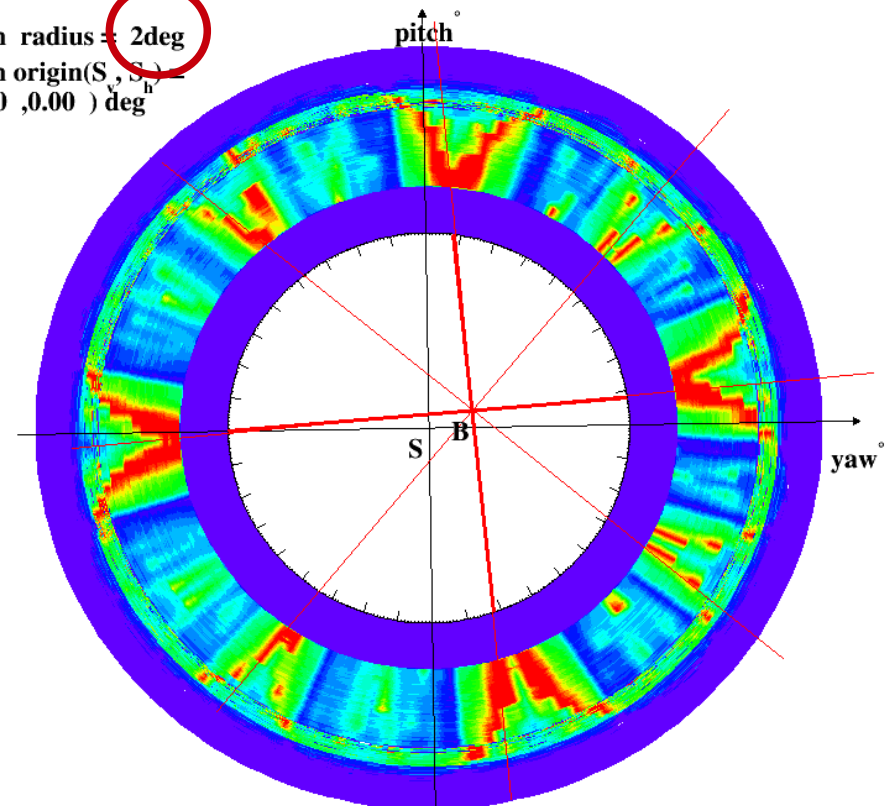
Scan radius = 3deg  
Scan origin( $S_v, S_h$ ) =  
(0.00 ,0.00 ) deg



Beam(SB)=( $SB_v, SB_h$ )=( 0.33, 0.19) deg,  $\phi_0 = -40.74$  deg  
Beam to Crystal vector BC = -(S+SB) = ( -0.33, -0.19) deg

../data/RadScanIndex2\_ID7\_STONE\_26\_04\_15:14\_51.txt

Scan radius = 2deg  
Scan origin( $S_v, S_h$ ) =  
(0.00 ,0.00 ) deg



Beam(SB)=( $SB_v, SB_h$ )=( 0.44, 0.17) deg,  $\phi_0 = 4.00$  deg  
Beam to Crystal vector BC = -(S+SB) = ( -0.44, -0.17) deg

Good enough to predict offsets, but beam moved off Diamond at -ve pitch. Find a better spot.

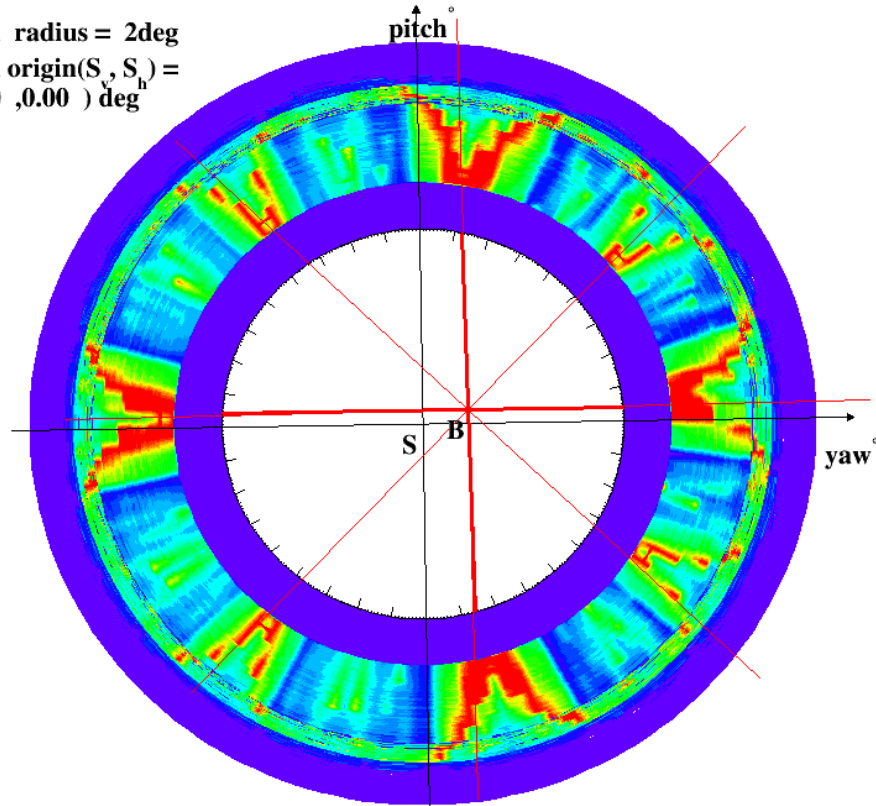


# Alignment



../data/RadScanIndex2\_ID7\_STONE\_26\_04\_15:15\_26.txt

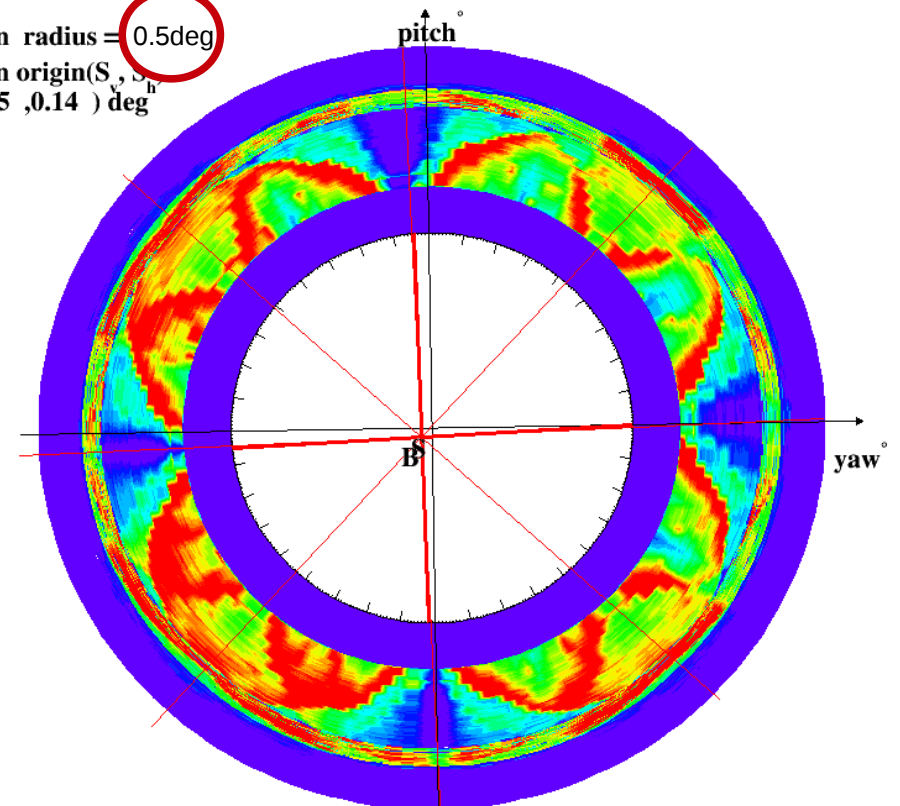
Scan radius = 2deg  
Scan origin( $S_v, S_h$ ) =  
(0.00 ,0.00 ) deg



Beam( $SB$ )=( $SB_v, SB_h$ )=( 0.45, 0.14) deg,  $\phi_0 = -0.00$  deg  
Beam to Crystal vector  $BC = -(S+SB) = ( -0.45, -0.14)$  deg

../data/RadScanIndex2\_ID7\_STONE\_26\_04\_15:15\_52.txt

Scan radius = 0.5deg  
Scan origin( $S_v, S_h$ ) =  
(0.45 ,0.14 ) deg



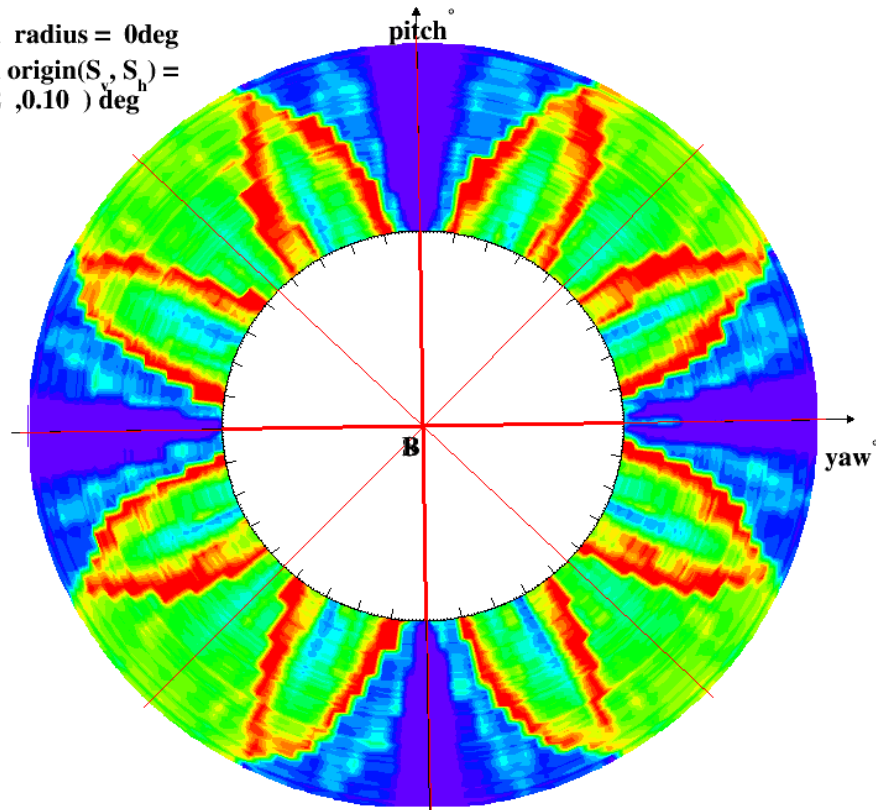
Beam( $SB$ )=( $SB_v, SB_h$ )=(-0.025,-0.023) deg,  $\phi_0 = 2.5$  deg  
Beam to Crystal vector  $BC = -(S+SB) = (-0.425,-0.117)$  deg

# Alignment



../data/RadScanIndex0\_ID7\_STONE\_26\_04\_15:16\_34.txt

Scan radius = 0deg  
Scan origin( $S_v, S_h$ ) =  
(0.42, 0.10) deg



Beam( $SB$ )=( $SB_v, SB_h$ )=( 0.000, 0.000) deg,  $\phi_0 = -0.0$  deg  
Beam to Crystal vector  $BC = -(S+SB) = (-0.417, -0.096)$  deg

Scan can be done with Hall-D setup.

Did not use prior info on Diamond.

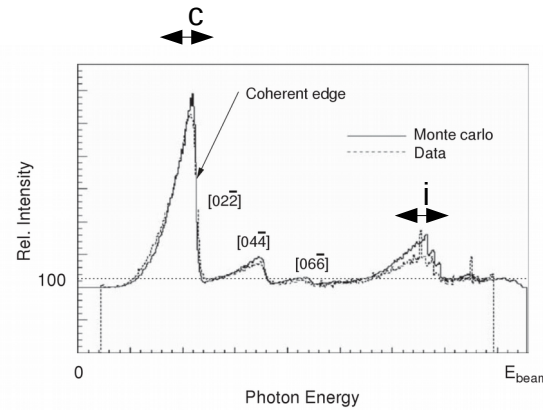
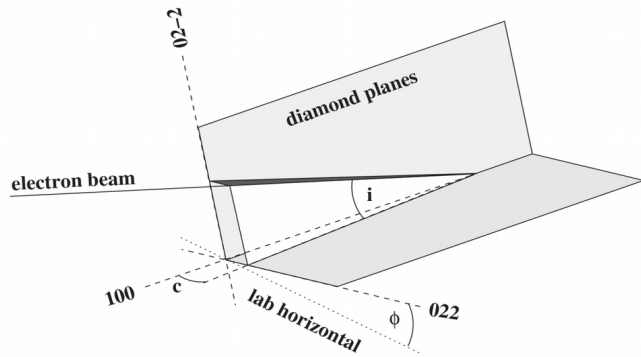
Easy to interpret because the crystal was mounted to within ~0.5 deg of beam.

Try so set up coherent peak in PARA and PERP with peak in reasonable position.

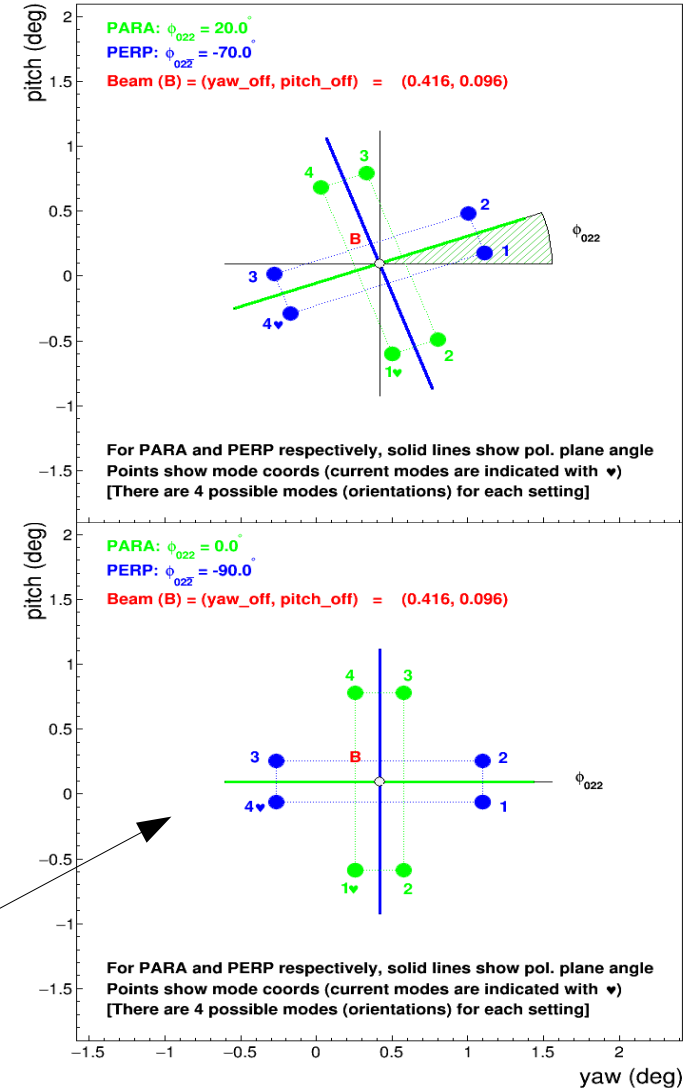
# Coherent Peak



## A reminder of the scattering angles



## Coherent bremsstrahlung modes



## 4 possible modes for PARA and PERP

Small angle (c) with one set of planes.  
Adjust this to change the position of the coherent peak.

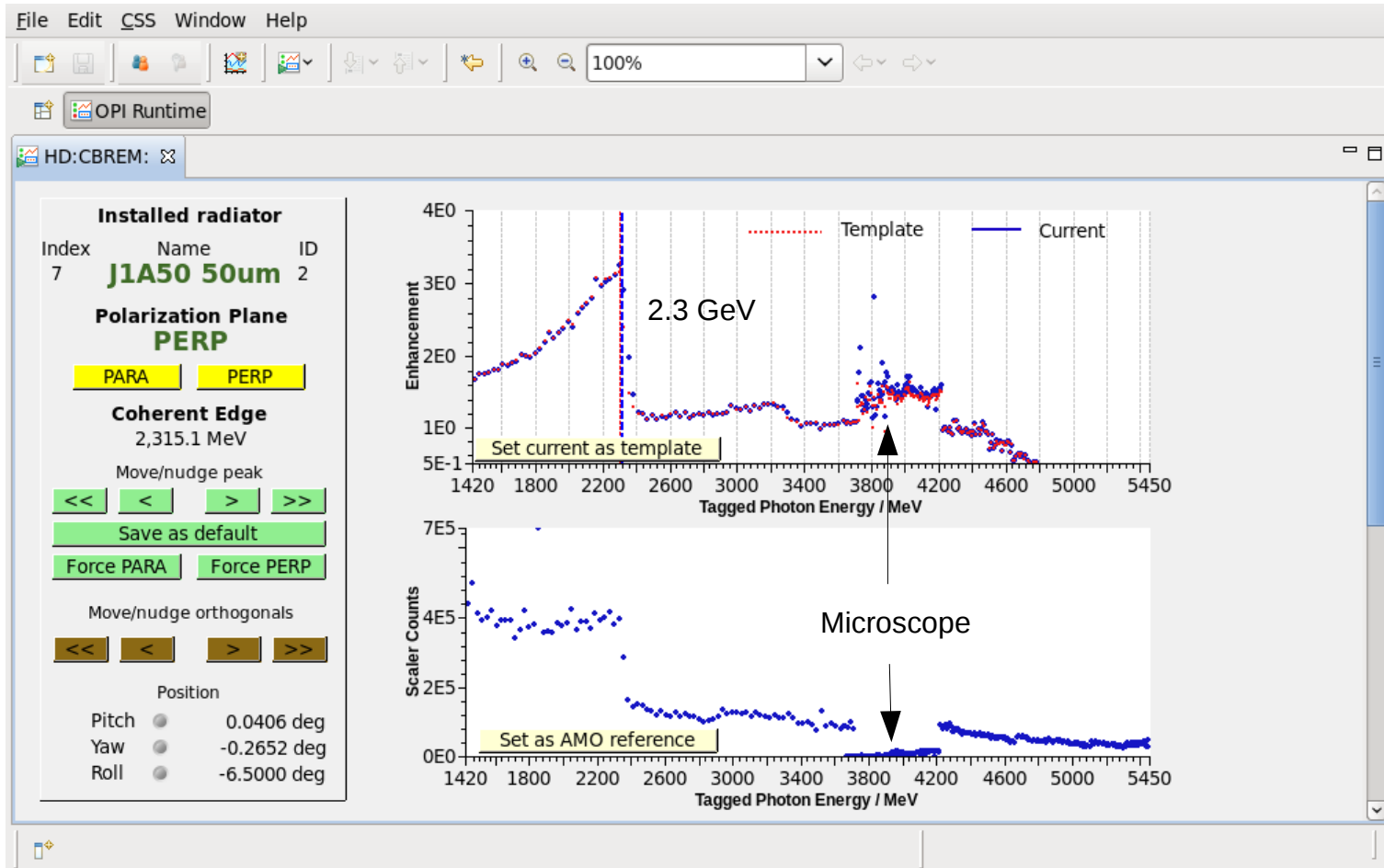
Larger angle (l) with orthogonal planes  
Adjust this to adjust to move the orthogonals away

For general phi022  
Need to move yaw and pitch to adjust l or c

For phi022 = 0 deg  
Yaw and pitch map directly to c and l for.

By adjusting phi022 to 0 deg, we've choose this setting:  
Select the modes that are closest to the goniometer origin. **PARA 1**, **PERP 4**.

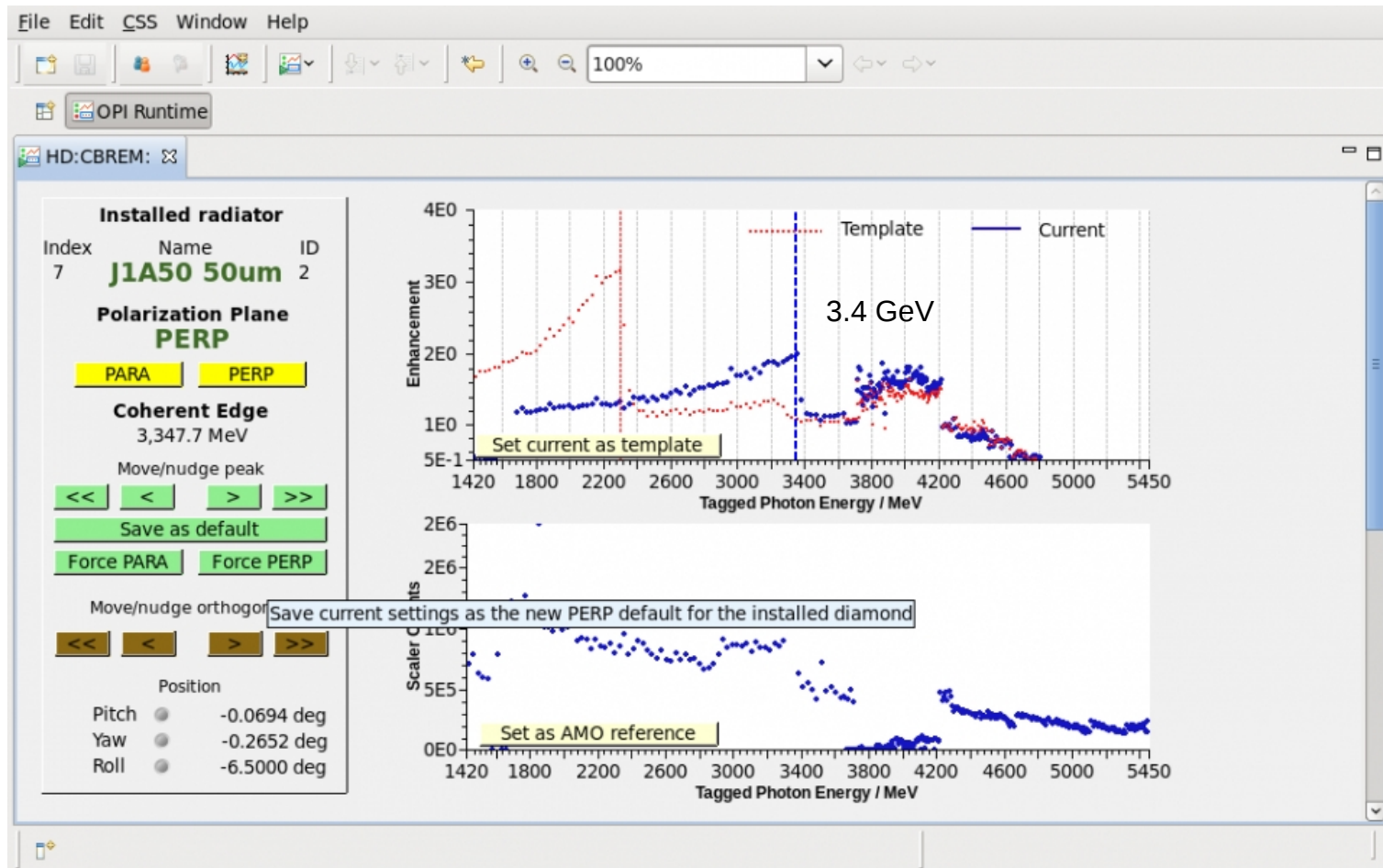
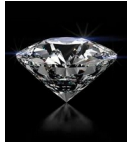
# Coherent Peak



## User interface for Coherent Bremsstrahlung.

- Calculate the approximate settings for PARA and PERP with the peak at the required energy.
- Fine tune using the adjustment buttons.
- Save as default settings.

# Coherent Peak



## Peak closer to microscope region

Results based on free running HODO/MICRO scalers. I.e. No timing coincidence.

Can be noisy, even as a ratio.

No effect of collimation. Look at events which make it through the collimator.

PS, Tagger, or Detector

# Coherent Peak

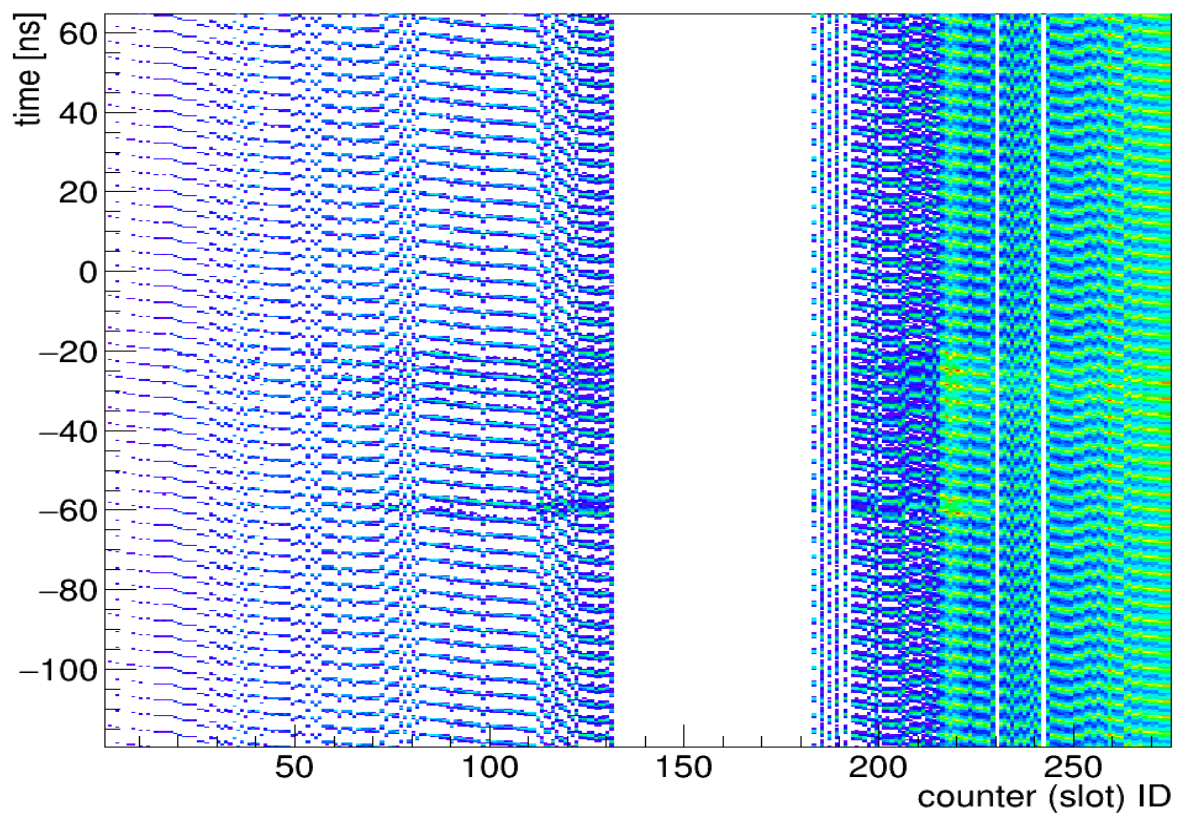


**Look for timed coincidences in the event by event data.**

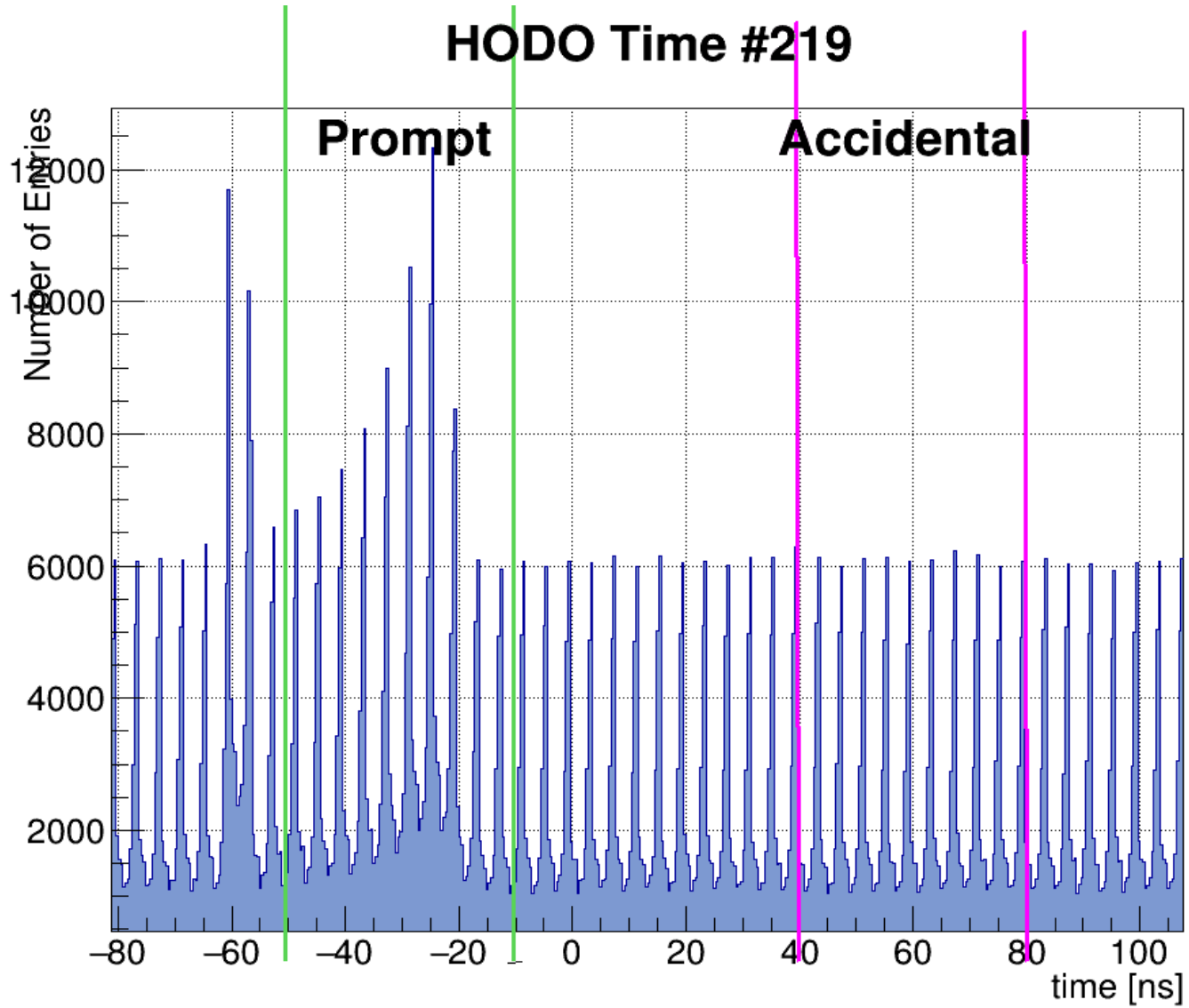
Nathan suggested slicing up TAGH fADC time vs counter ID

Try runs `hd_root_003185.root` (diamond) and `hd_root_003180.root` (amorphous)

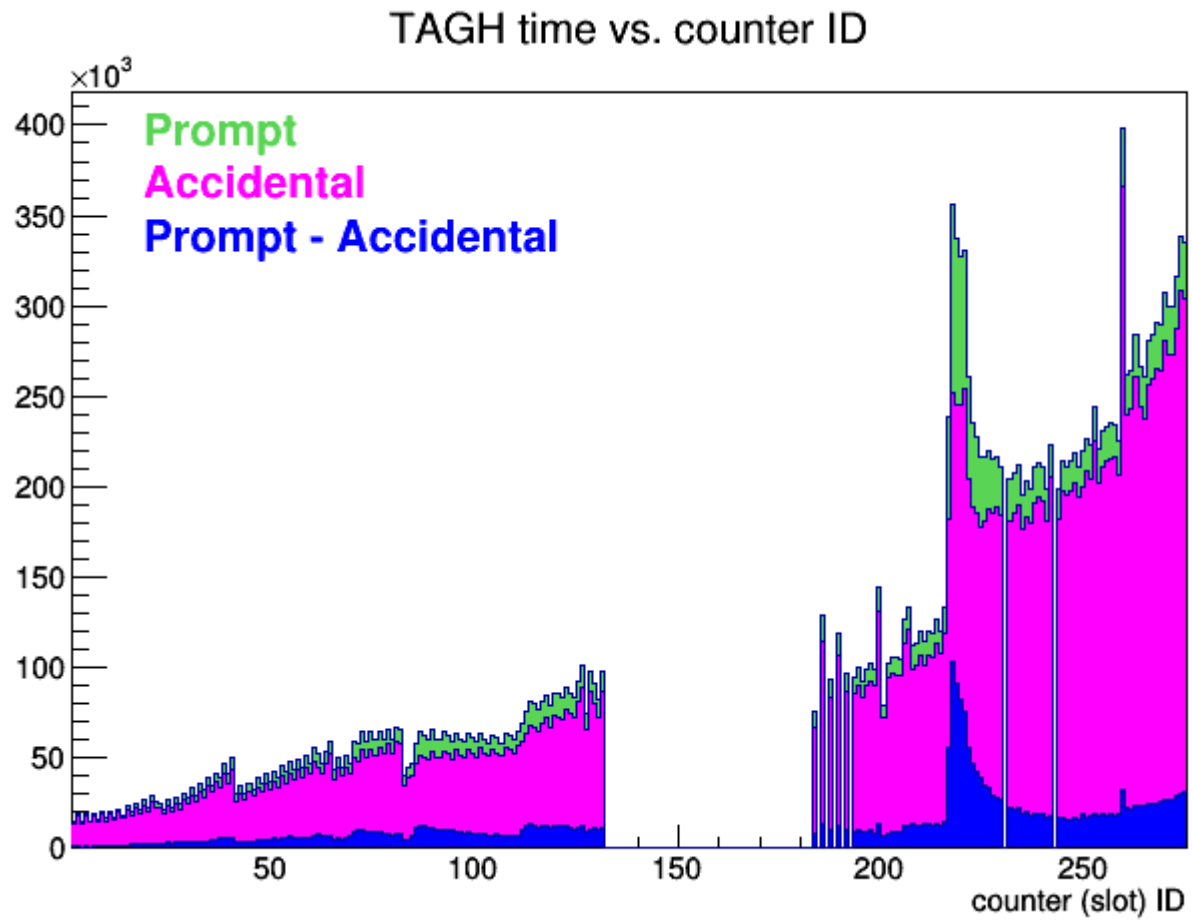
TAGH fADC time vs. counter ID



# Coherent Peak

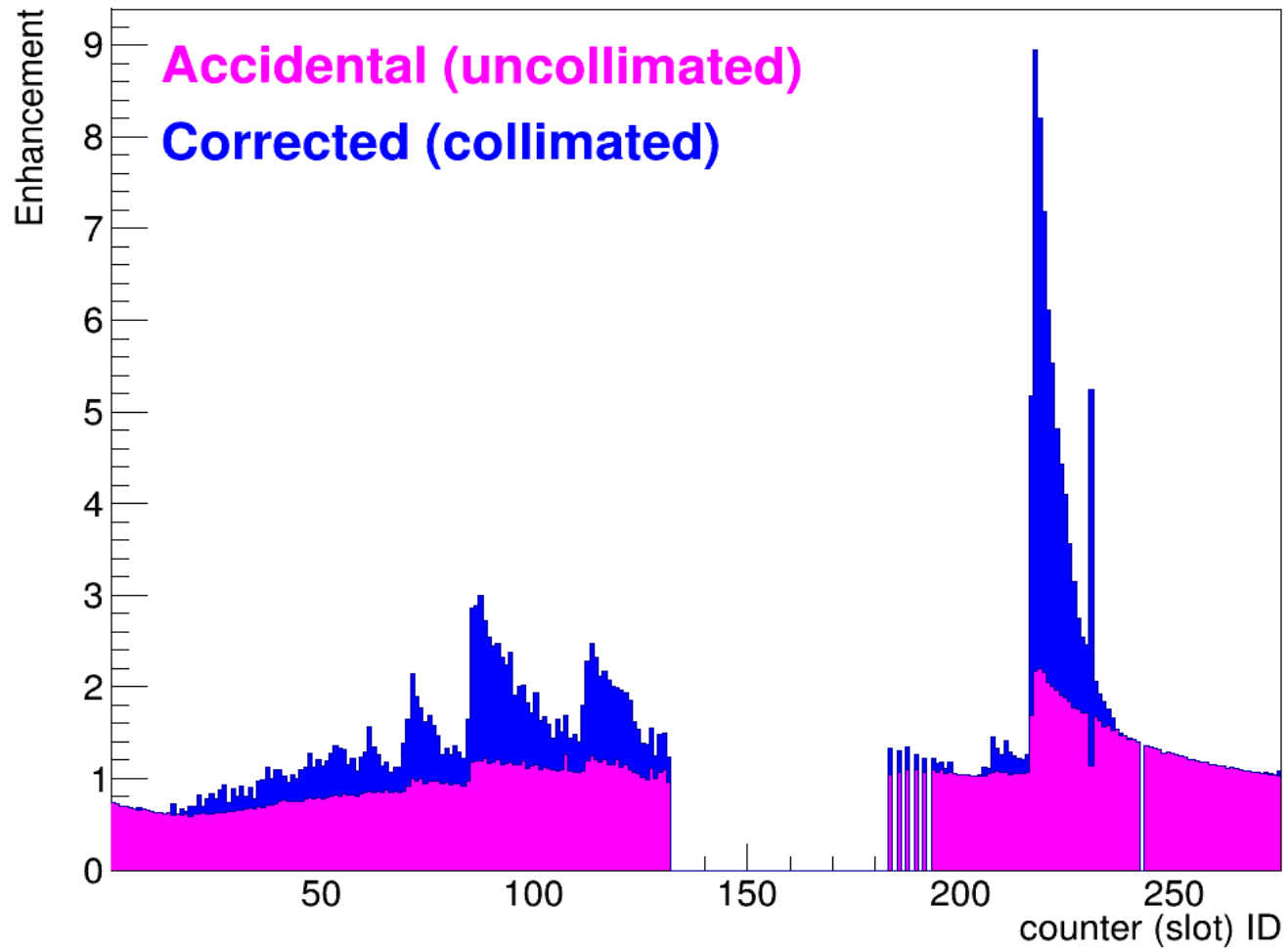


# Coherent Peak

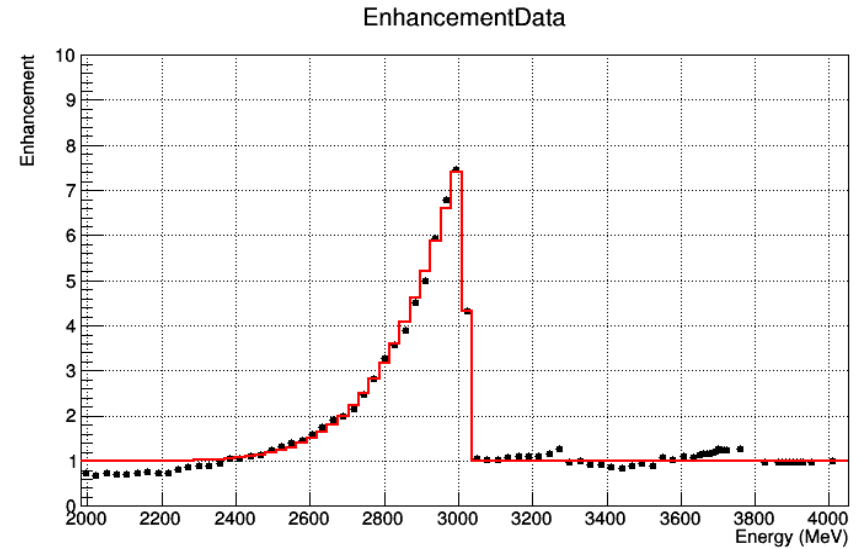
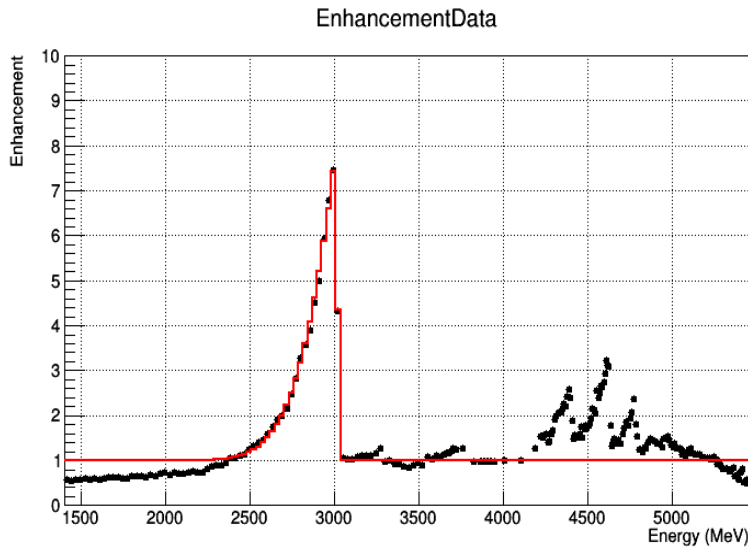




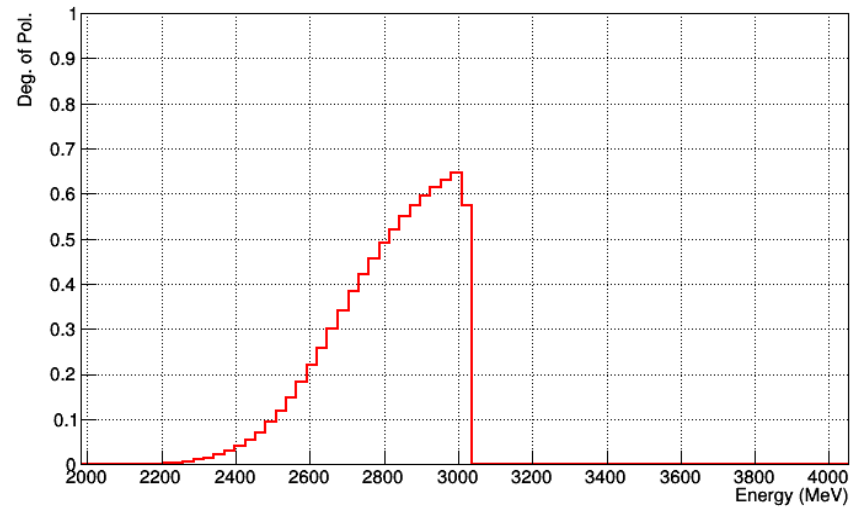
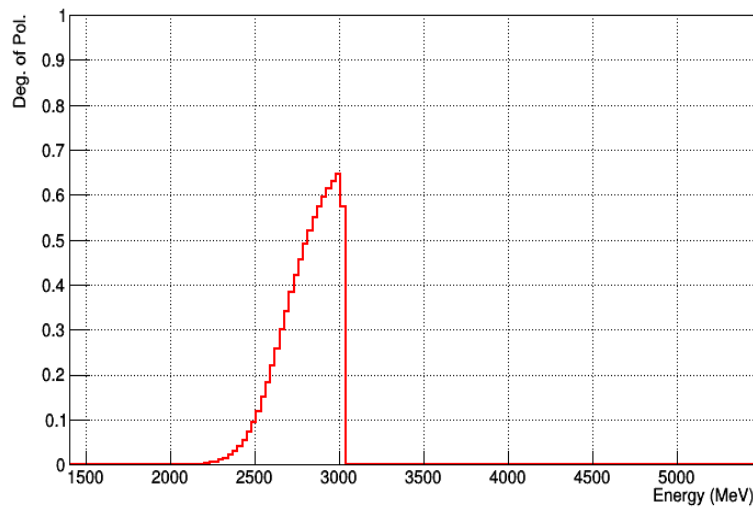
# Coherent Peak



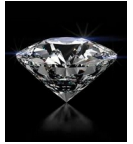
# Coherent Peak



Polarization **Prelim: Peak polarization ~ 65%** Polarization

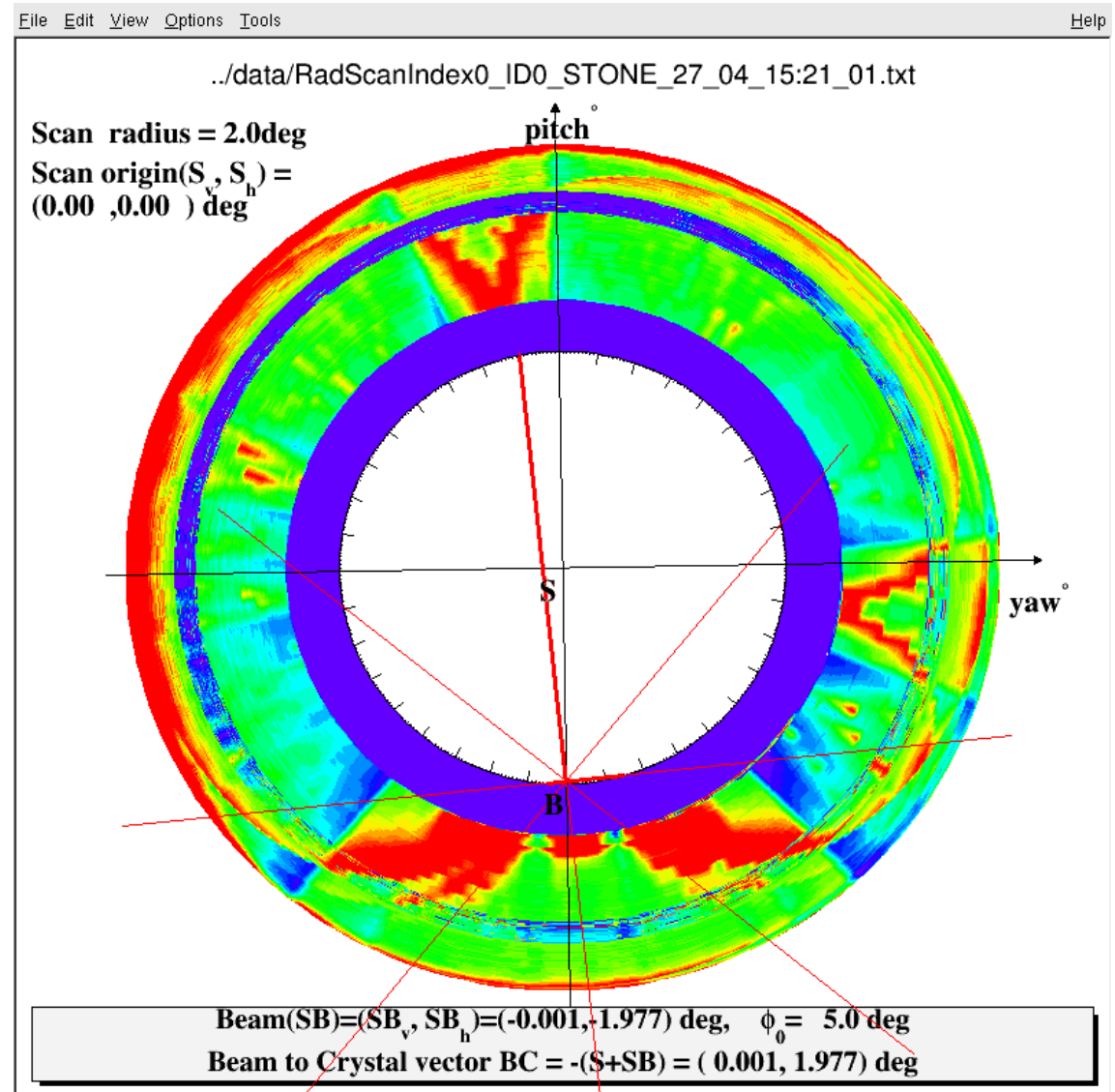


# Reliability

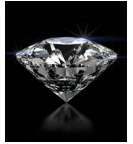


Try another diamond.  
[Hovanes and Paul M ]

Local understanding of the  
Slow Controls and method.

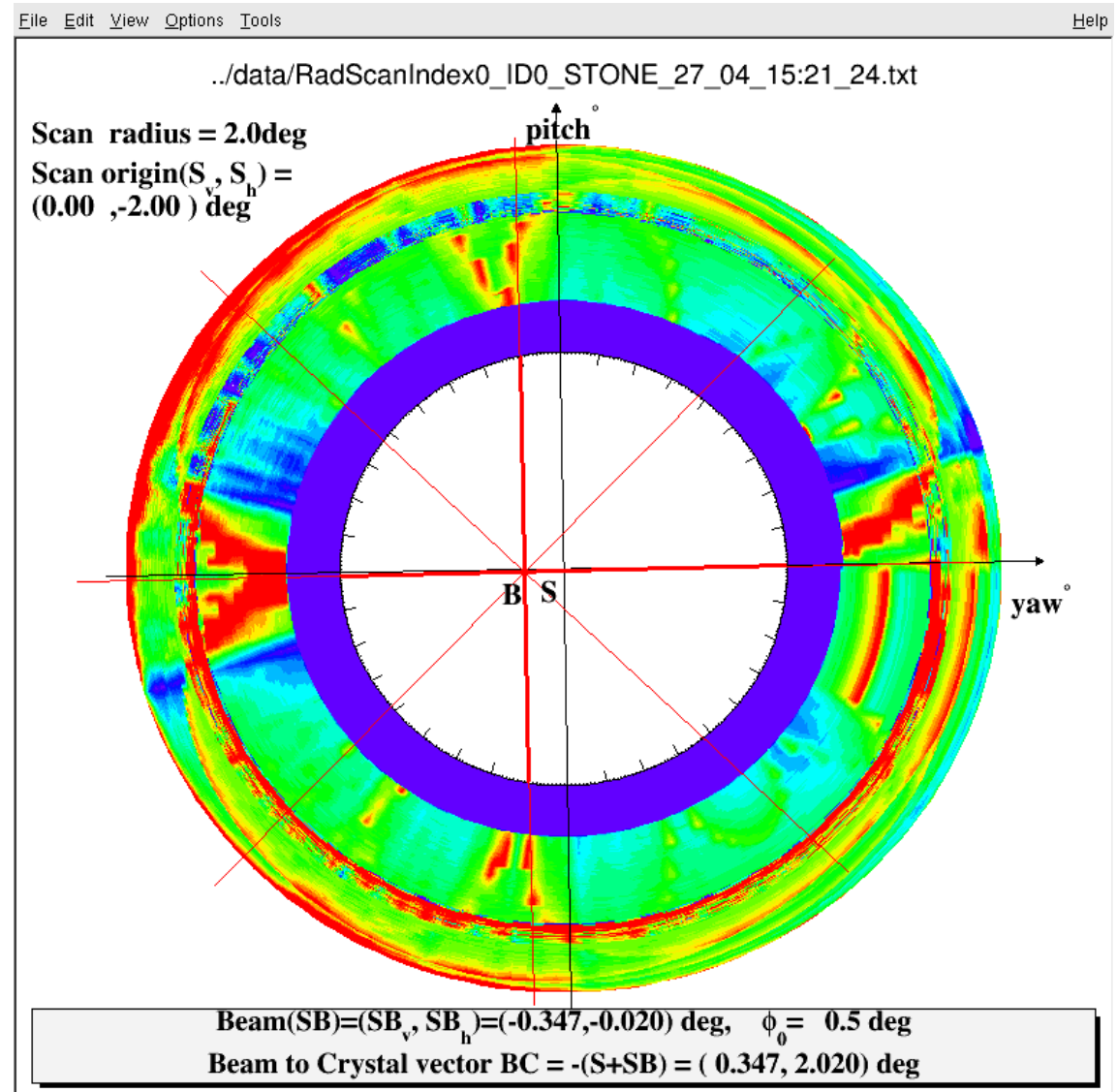


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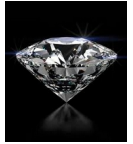


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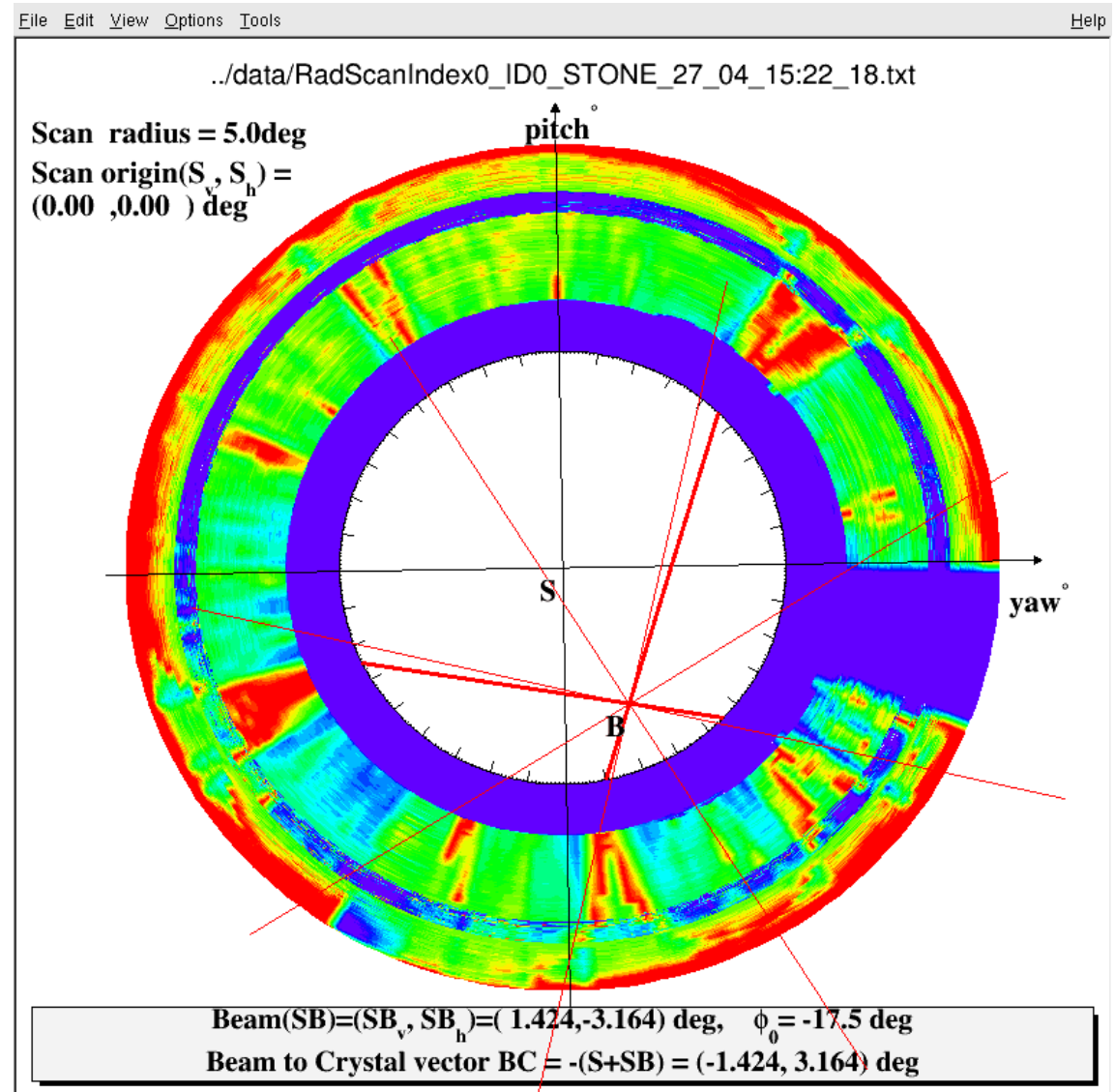


# Reliability

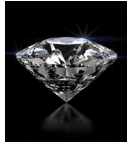


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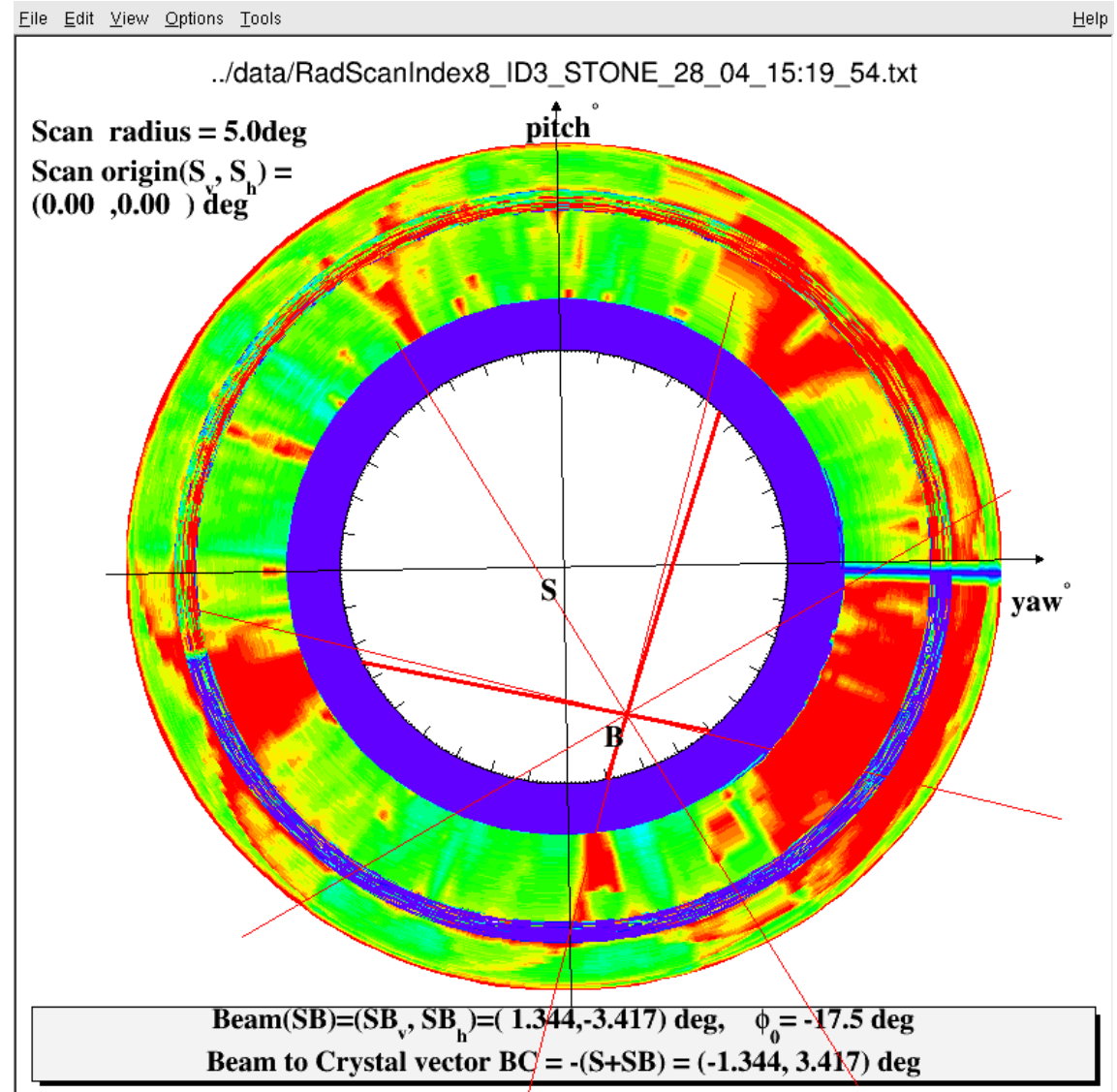


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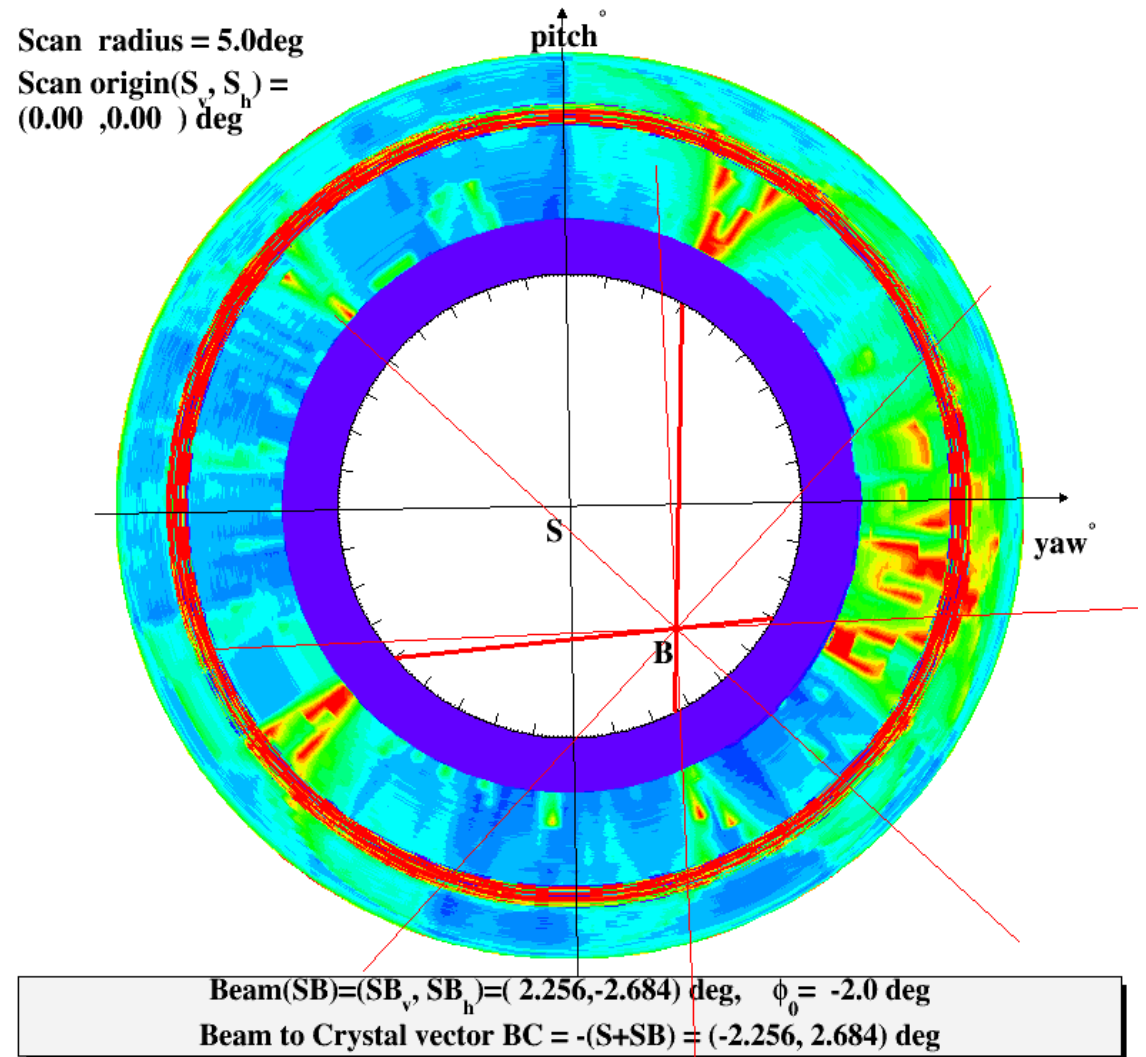
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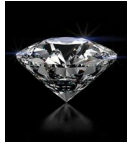
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../data/RadScanIndex0\_ID0\_STONE\_28\_04\_15:21\_18.txt

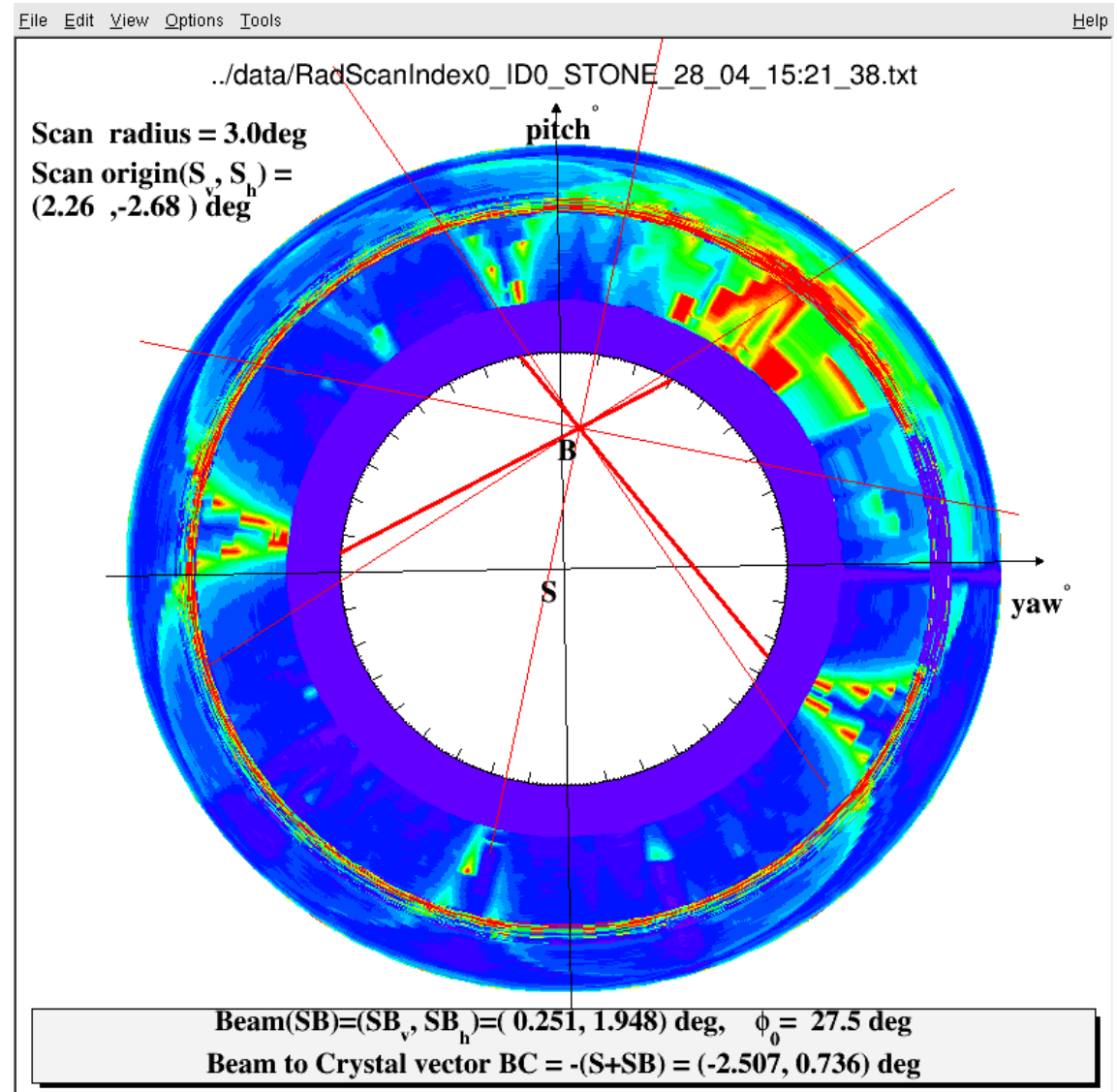


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# Reliability



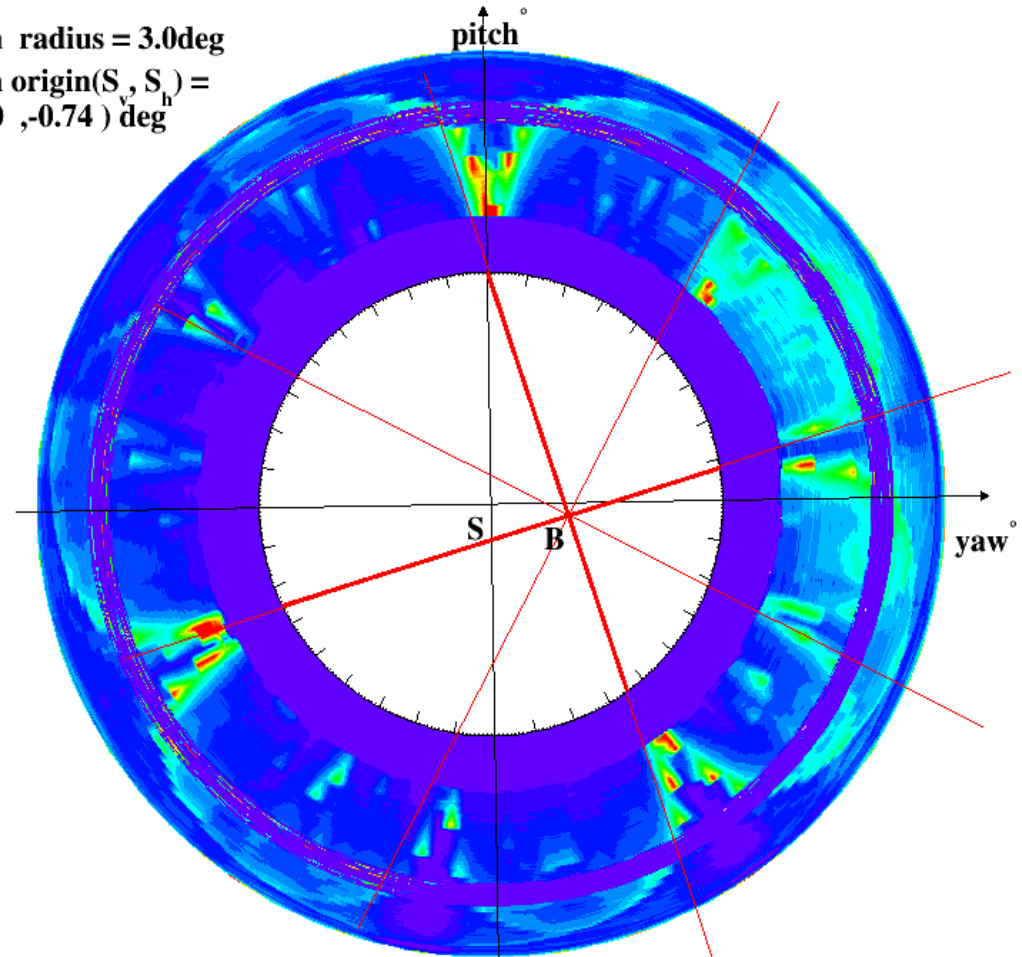
Try another diamond.  
[Hovanes and Paul M ]

Local understanding of the  
Slow Controls and method.

../data/RadScanIndex0\_ID0\_STONE\_28\_04\_15:21\_59.txt

Scan radius = 3.0deg

Scan origin( $S_v, S_h$ ) =  
(3.00 , -0.74 ) deg



Beam( $SB$ )=( $SB_v, SB_h$ )=( 0.999,-0.167 ) deg,  $\phi_0 = 16.5$  deg

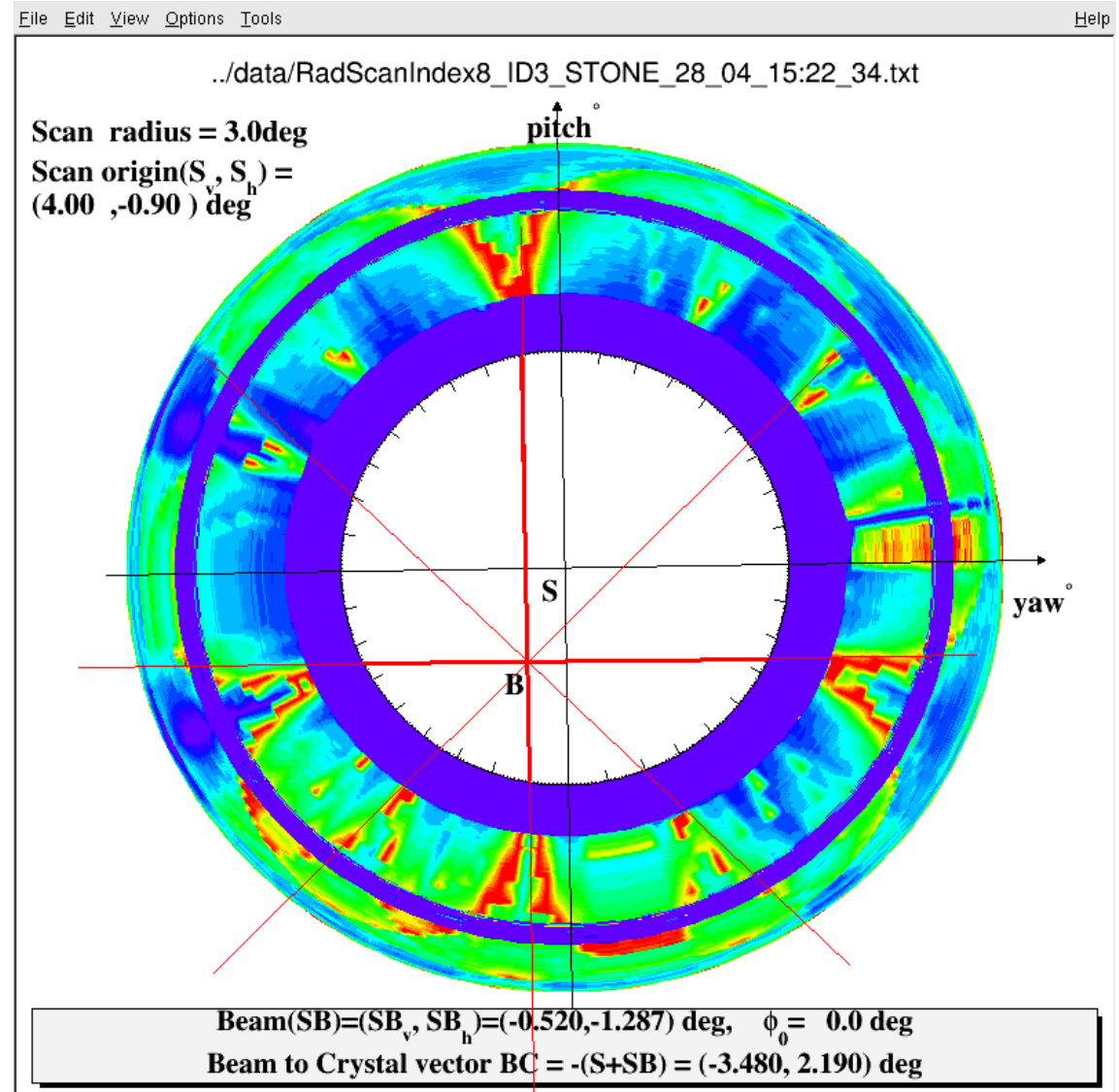
Beam to Crystal vector  $BC = -(S+SB) = (-3.999, 0.903)$  deg

# Reliability

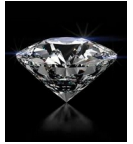


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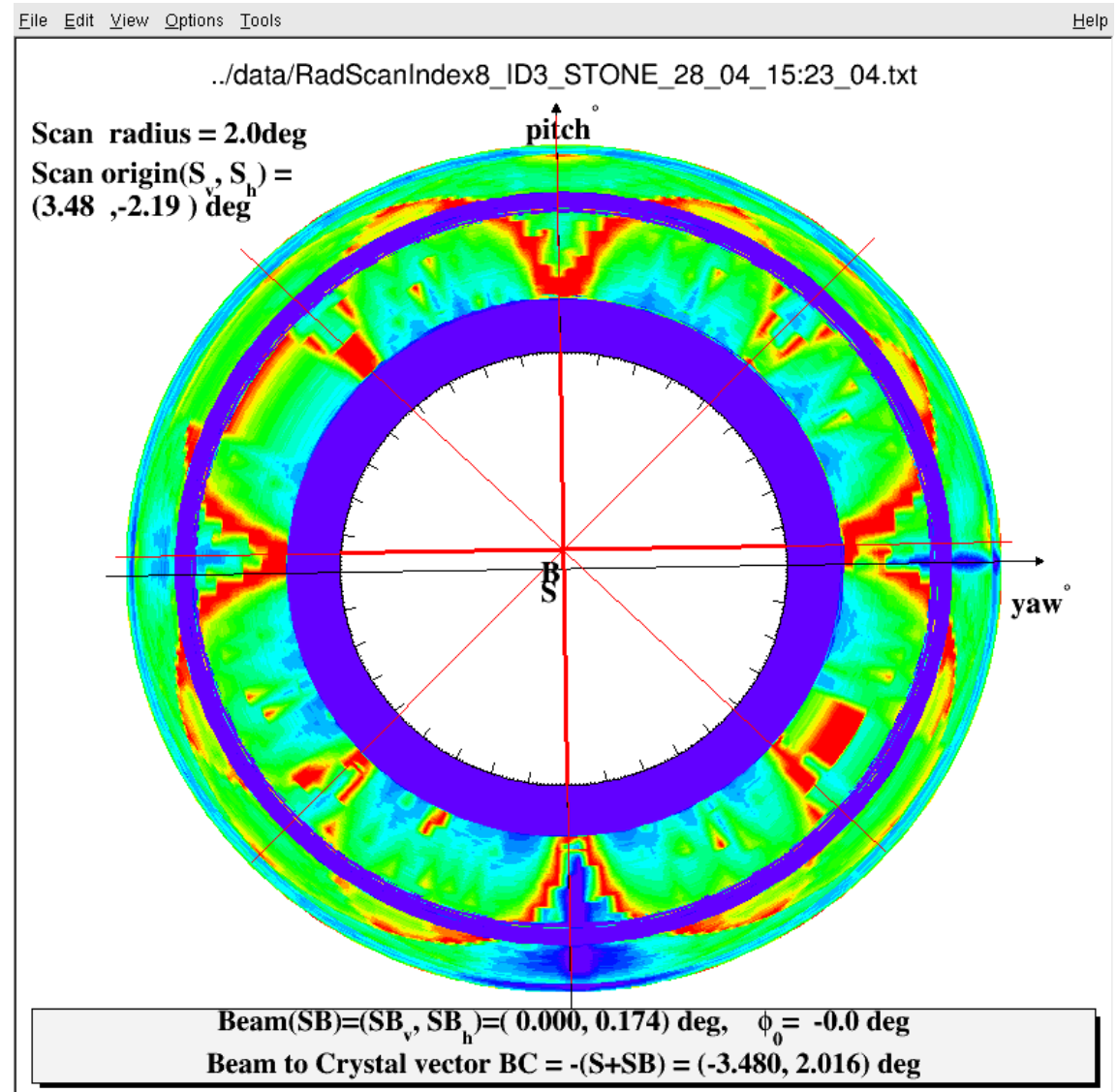


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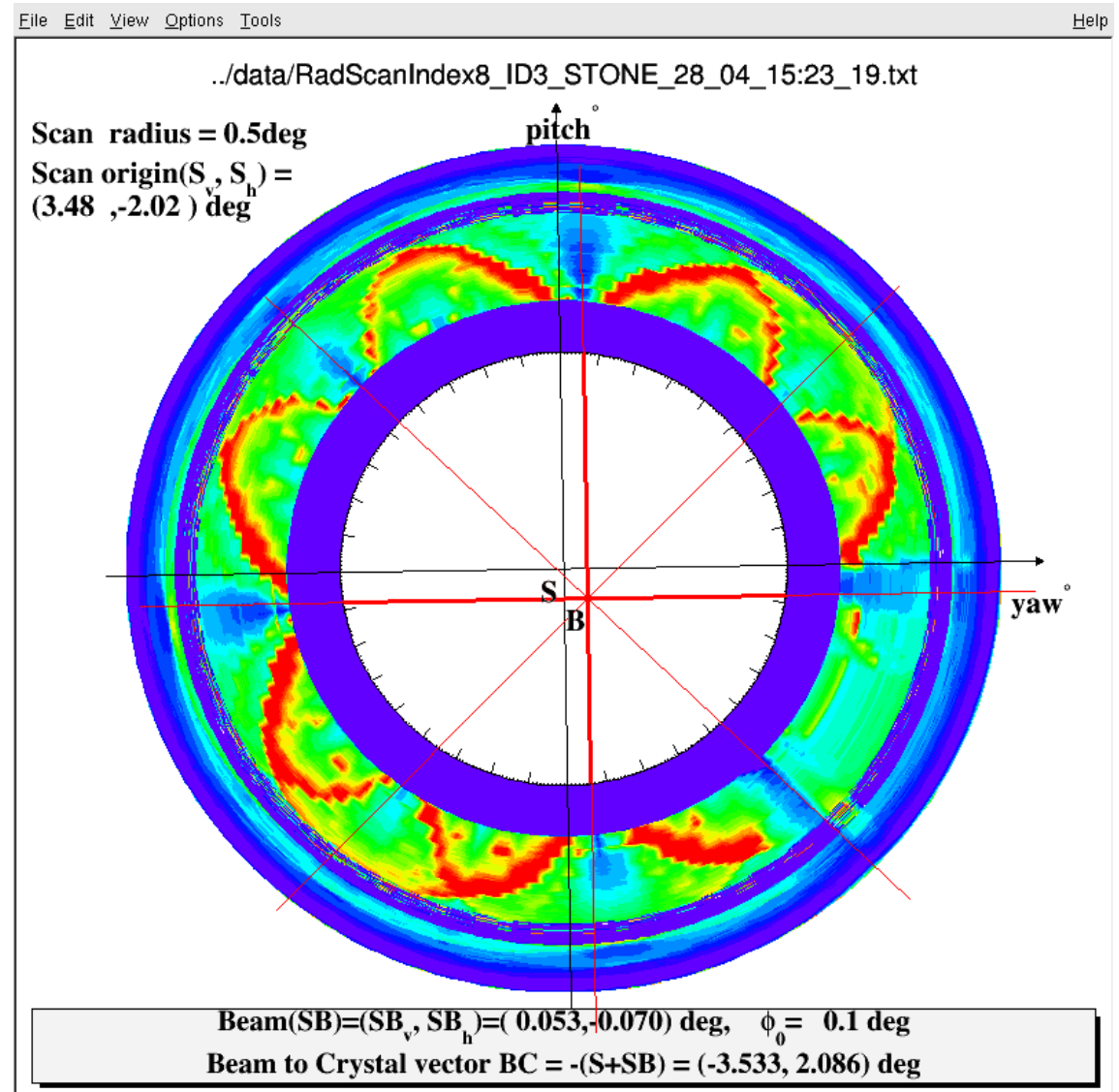


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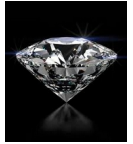


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# Reliability



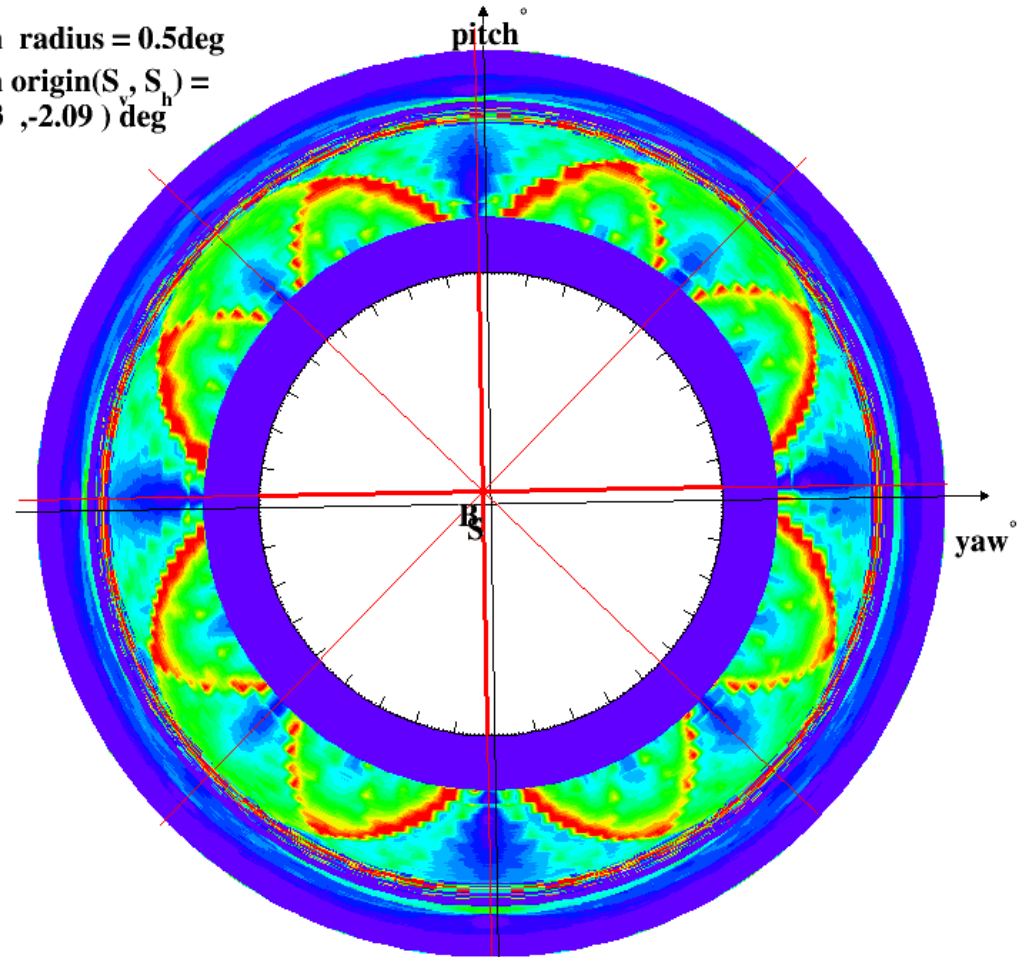
Try another diamond.  
[Hovanes and Paul M ]

Local understanding of the  
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../data/RadScanIndex8\_ID3\_STONE\_29\_04\_15:00\_17.txt

Scan radius = 0.5deg

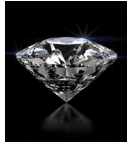
Scan origin( $S_v, S_h$ ) =  
(3.53 , -2.09 ) deg



Beam( $SB$ )=( $SB_v, SB_h$ )=(-0.017, 0.026) deg,  $\phi_0 = -0.0$  deg

Beam to Crystal vector  $BC = -(S+SB) = (-3.516, 2.060)$  deg

# Reliability

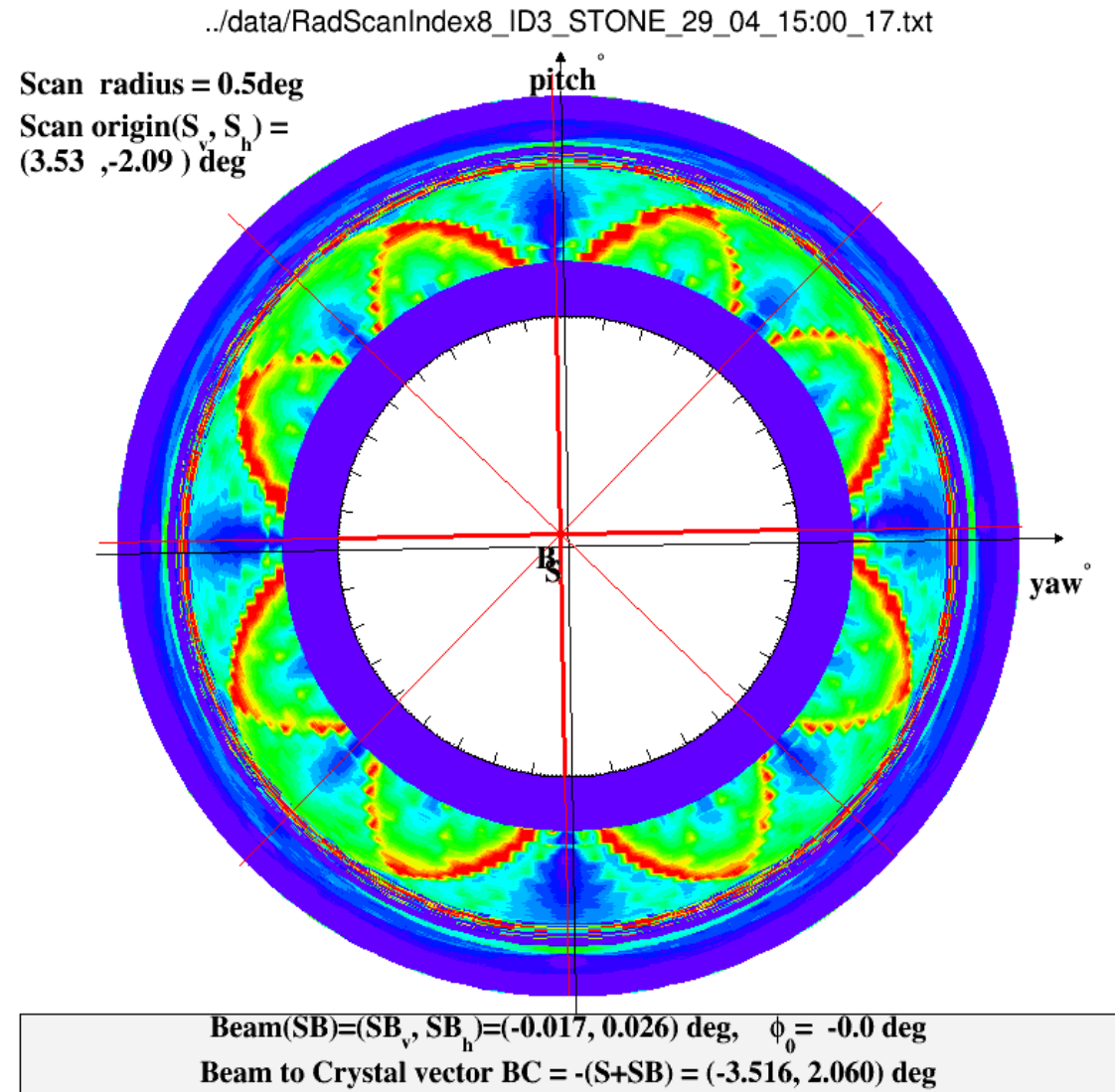


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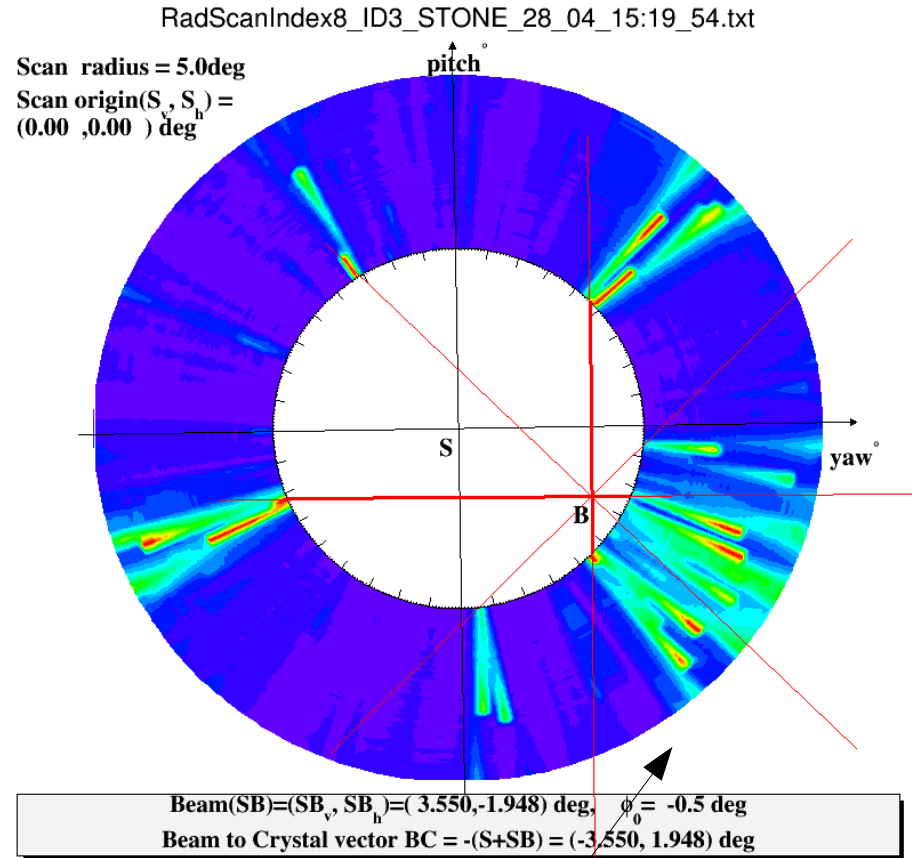
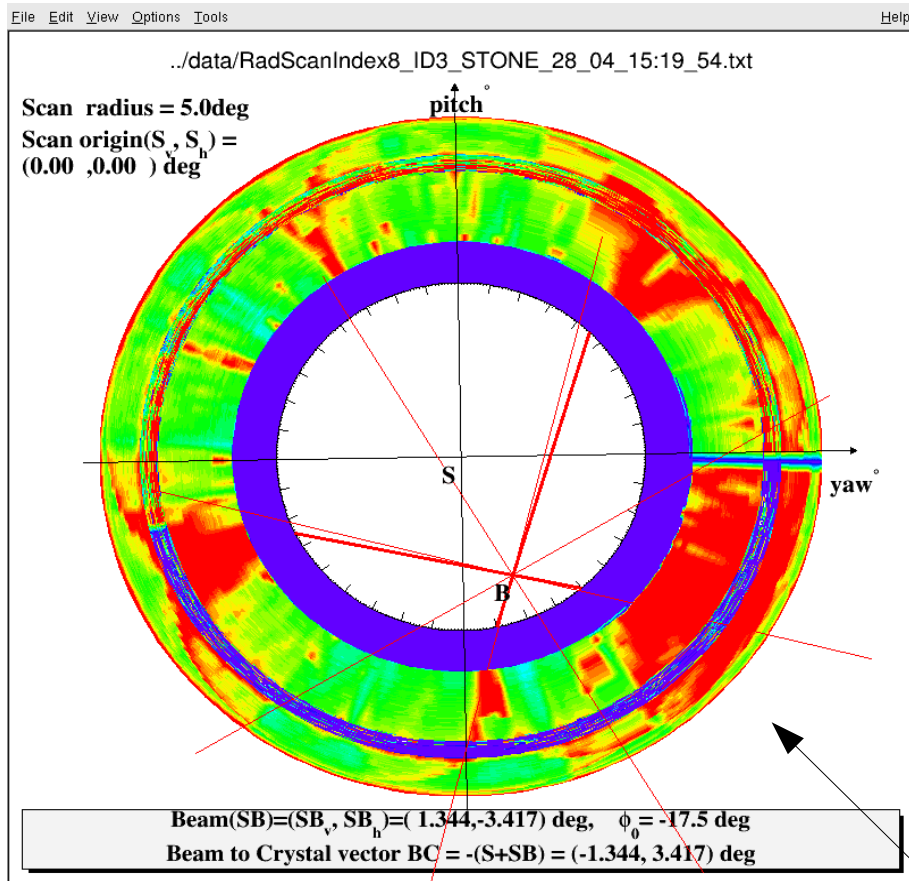
Local understanding of the  
Slow Controls and method.

**Congratulations!**  
**Got there in the end.**

Offsets: 3.5, 2.1 deg.  
Lattice > 4 deg from beam.



# Reliability



1<sup>st</sup> 5 deg scan was wrongly interpreted. This should have been this.  
Hindsight is a wonderful thing.

31 Lesson: Try to survey crystals as well as possible before scanning.

# Towards 12 GeV: Alignment and setup.



Try to know as much about the diamonds before scanning.

1. Preserve phi022 from CHESS measurements.
2. Survey in situ to get pitch and yaw offsets



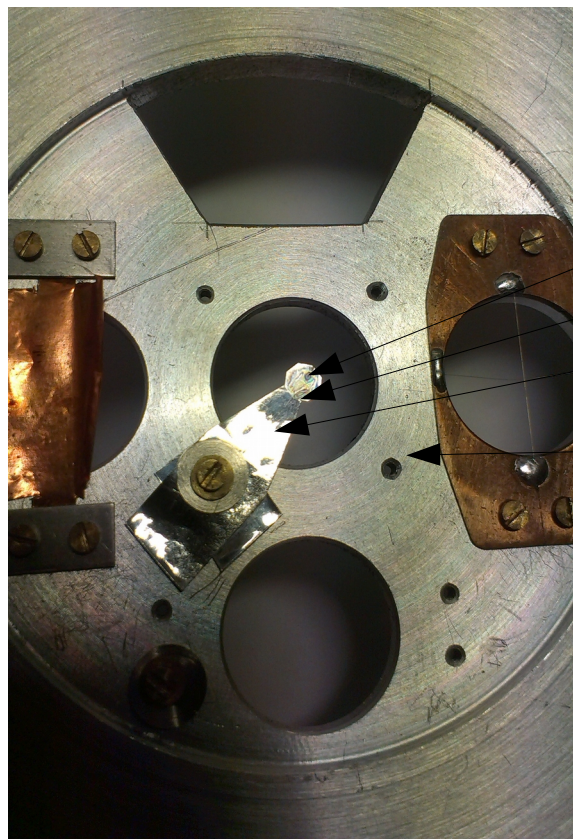
# Towards 12 GeV: Alignment and setup.



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1. Preserve phi022 from CHESS measurements.
2. Survey in situ to get pitch and yaw offsets

Here's an example of my own High Tech alignment method from Mainz



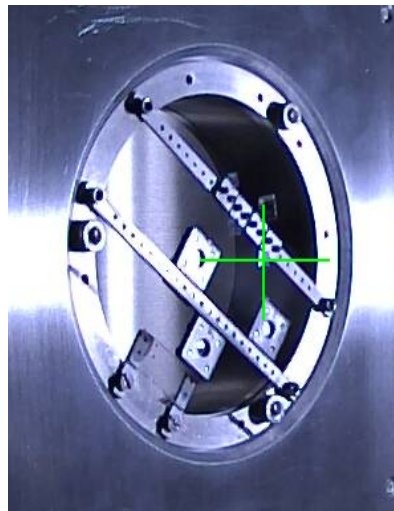
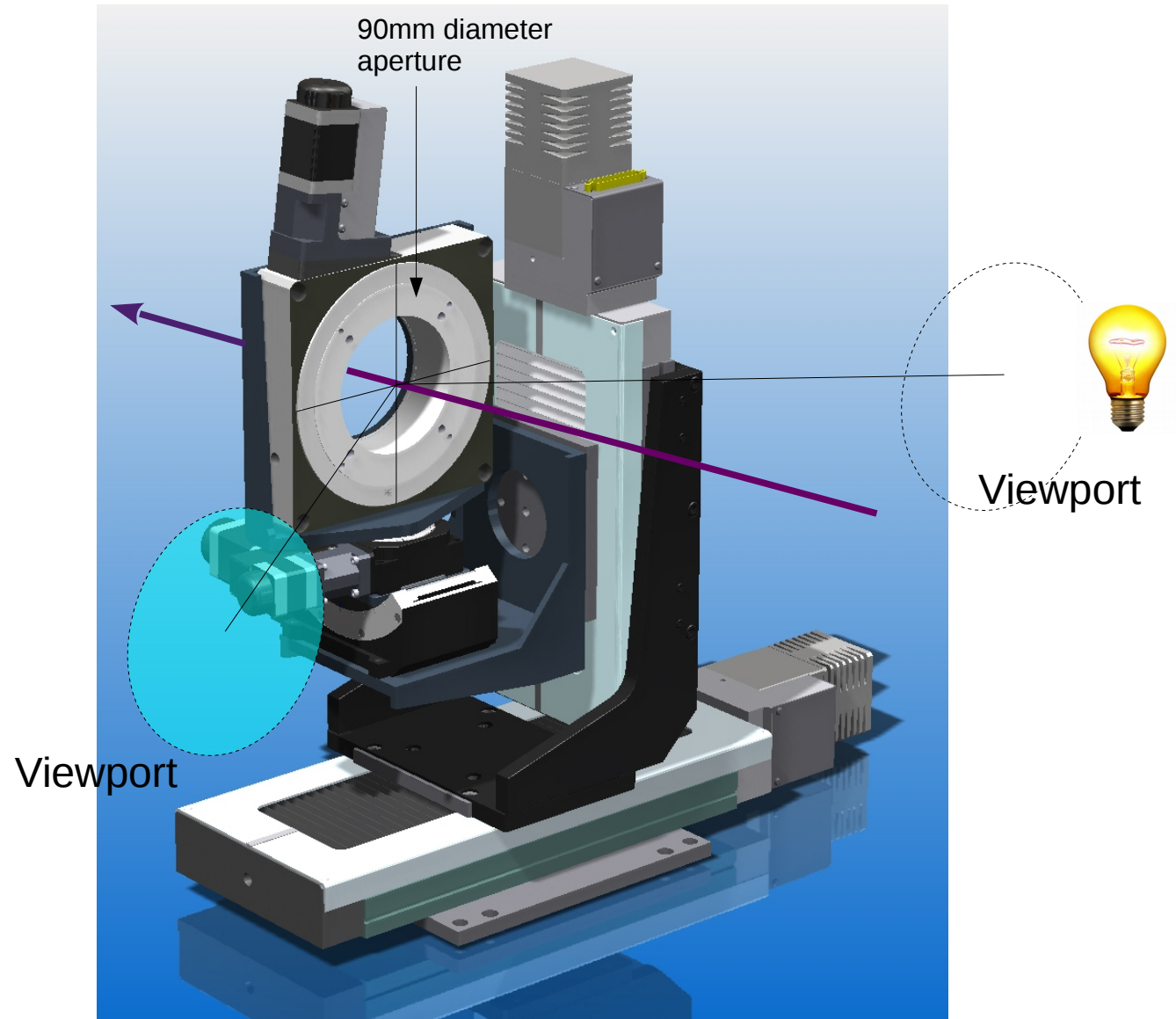
- Diamond
- Nail varnish
- Flexible Al foil
- Gonioneter wheel
- Vice
- Laser pointer
- Sticky tape
- Angle poise lamp



# Towards 12 GeV: Alignment and setup.



Try a similar alignment here through the chamber viewports.

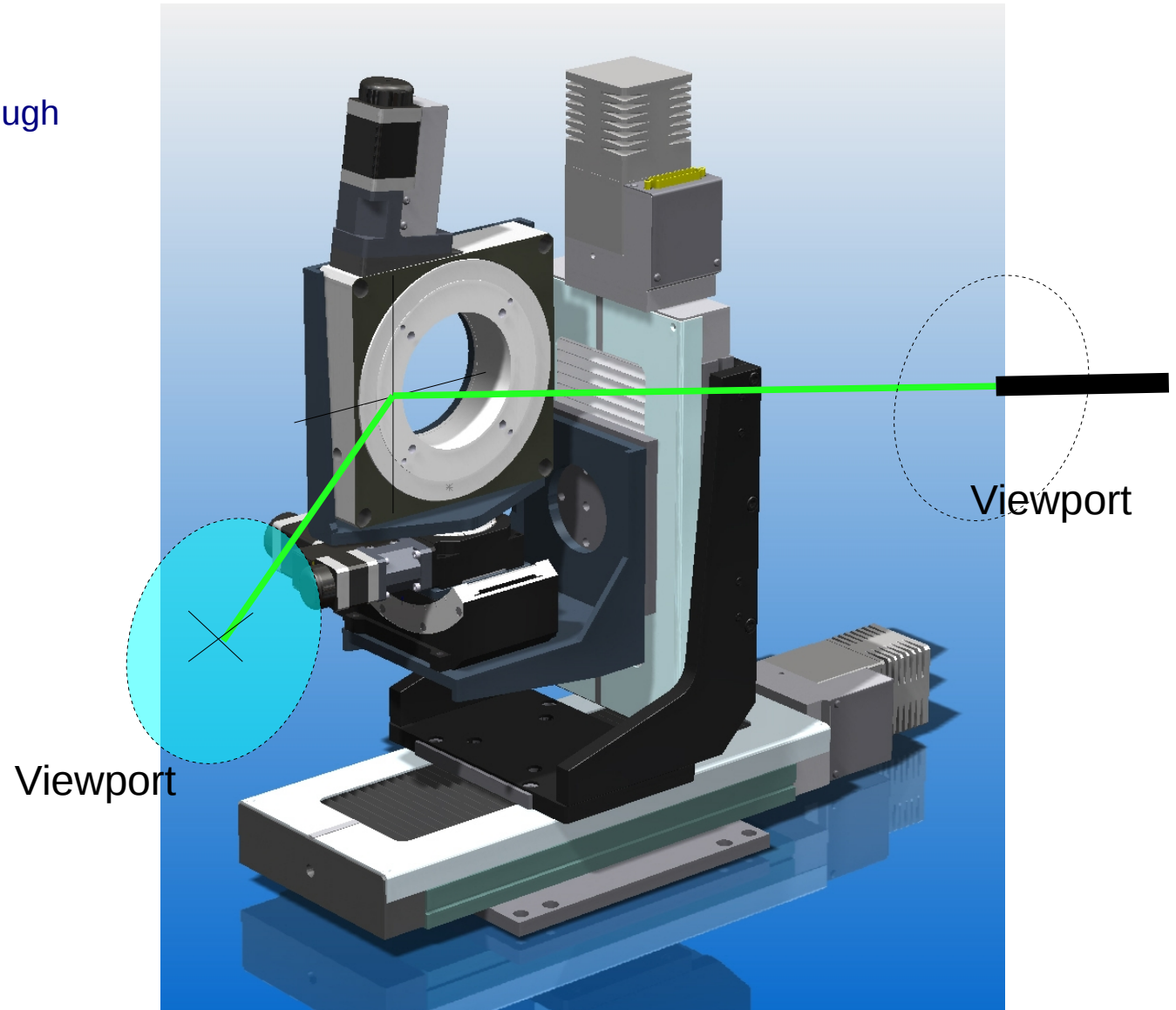
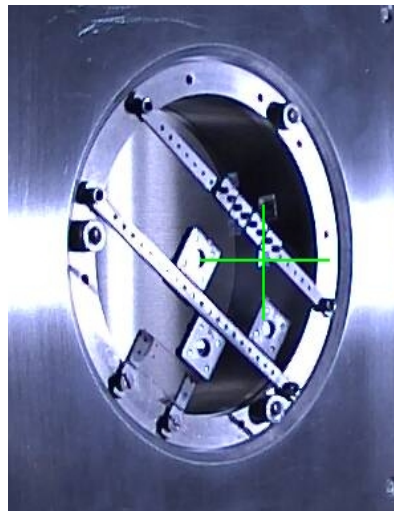


# Towards 12 GeV: Alignment and setup.



Try a similar alignment here through the chamber viewports.

We just want to know  
Pitch\_offset, Yaw\_offset  
< 1deg



# Towards 12 GeV: Coherent peak monitoring.

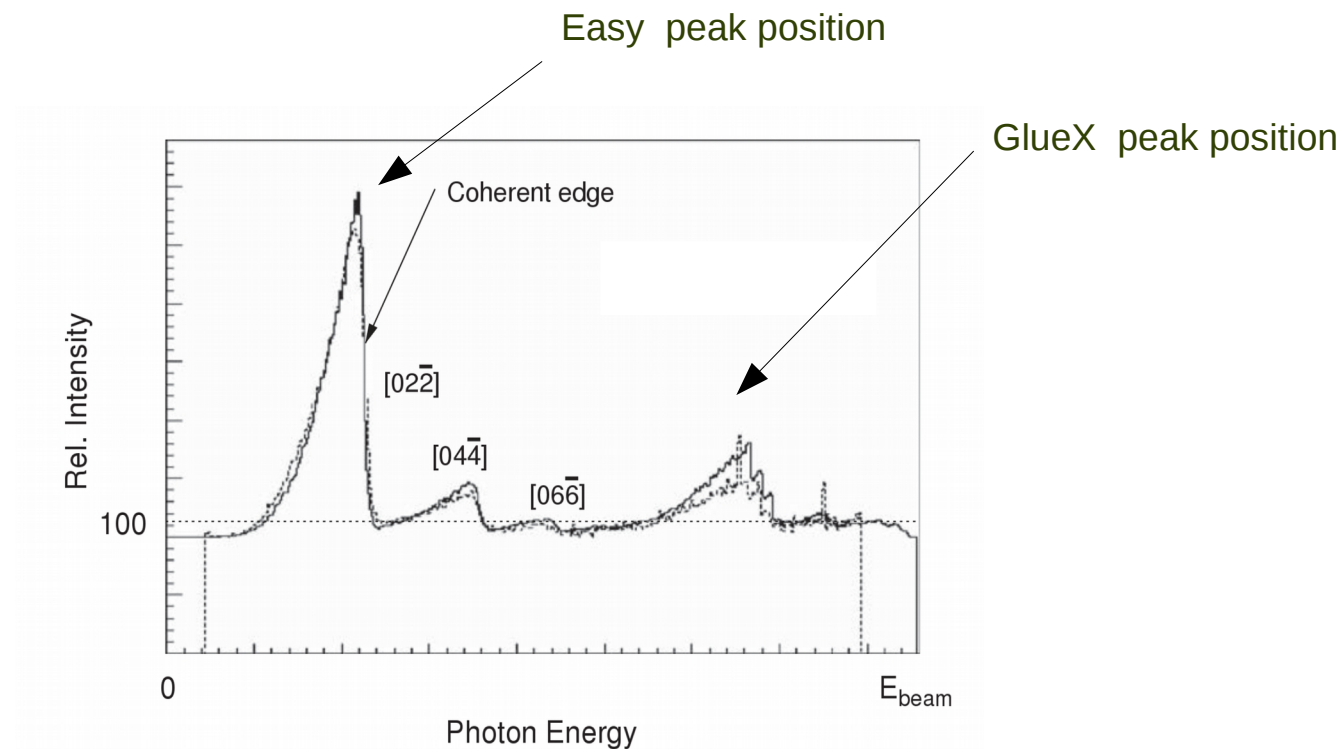


FP Scalers have high rate, but don't show effect of collimation

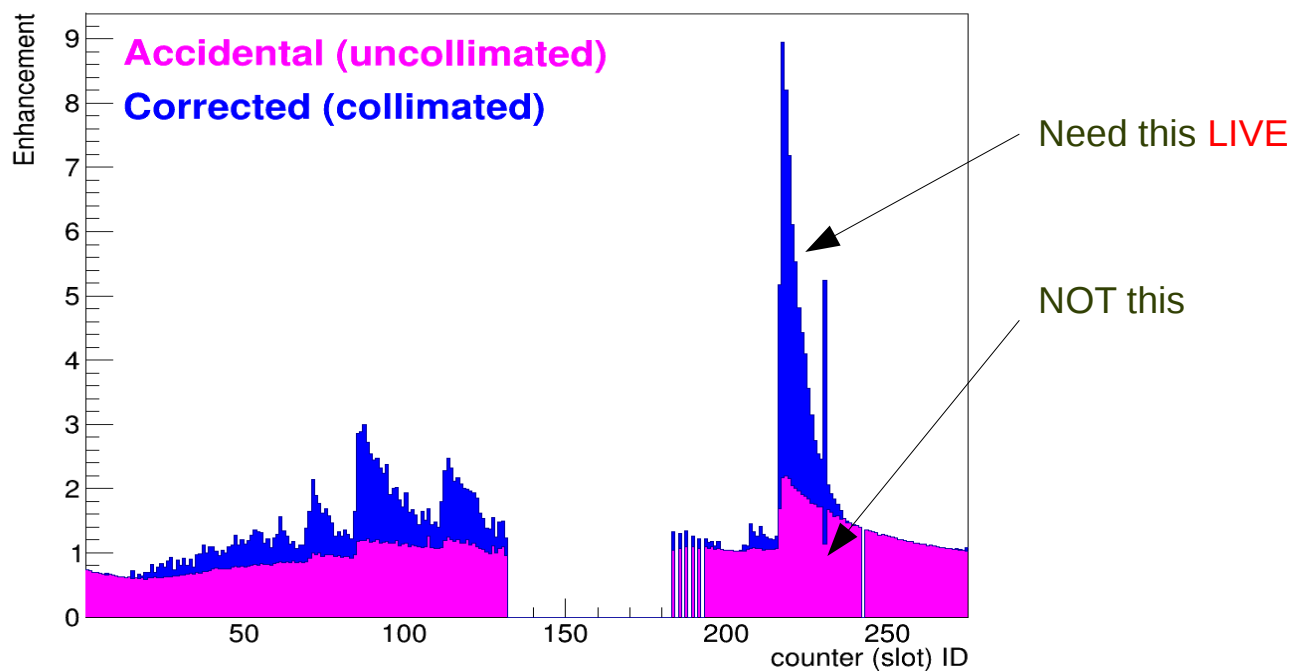
That's OK with peak at  $<0.5$  EP energy

At higher energies peaks all bunch up and tails run into each other

We need to see the collimated enhancement **live**.



# Towards 12 GeV: Coherent peak monitoring.



## How to achieve this.

1. Random subtracted HODO / MICRO hits from triggered events.
2. Pair Spectrometer Scalers

# Conclusion



Coherent Bremsstrahlung is up and running.

Some details to improve:

Initial alignment of diamonds

Feedback on coherent peak for 9/12 GeV.

User and Expert guides and documentation.

Many in GlueX contributed to this in some way

Hovanes, Paul, Ken: EPICS, goniometer and alignment

Tim and engineering: Goniometer, cameras, chamber

Franz, Nathan et al: Hodoscope

Richard, Alex, Brendan: Microscope, Diamonds

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