Optical + mechanical characteristics and final requirements for the calorimeter crystals in view of disk assembly

Summary

- Status of production
- Latest issues/steps
  - Wrapping and frames
  - Outgassing level and pre-outgassing at SIDET
  - Optical Cross-talk => Need of TEDLAR ?
  - Dependence of LY vs Time
    - → LY vs hygroscopicity ? Need to flux Dry Air/N_2 inside calo
    - → Need of optical quartz (Caltech Proposal) ???
- Optical properties w.r.t. crystal position requirements
  - ✓ Total and instantaneous dose
- Mechanical properties
  - ✓ Organization in groups for crystal piling up

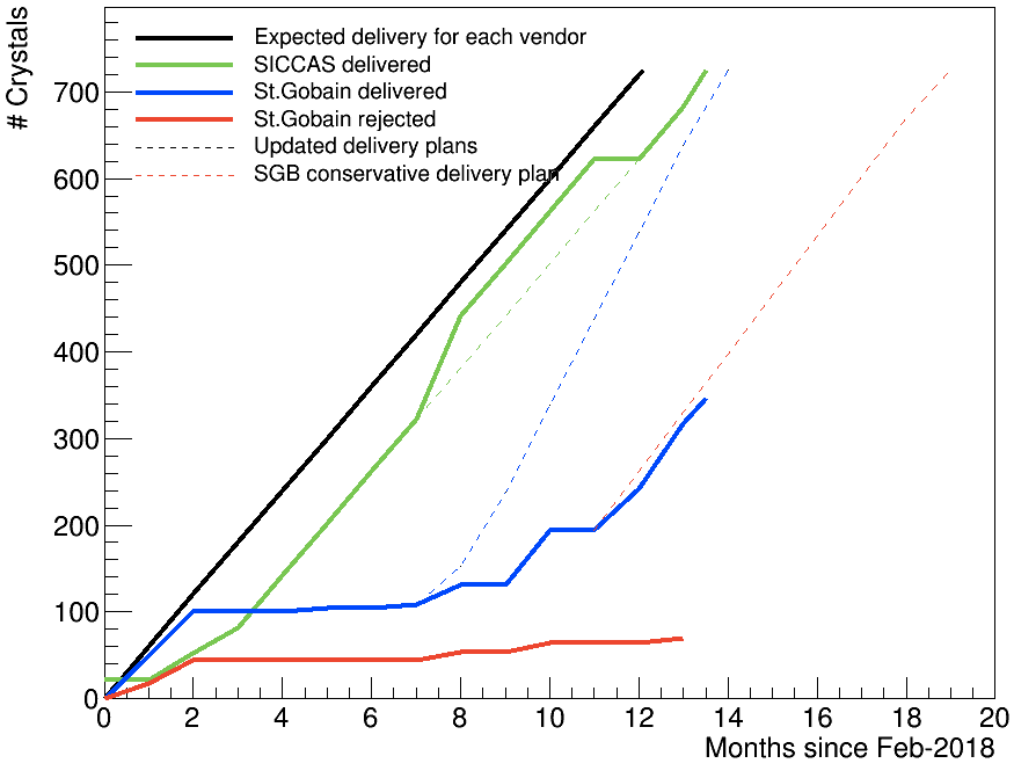
Status of CsI production status

SICCAS completed

- **725/725 crystals received = 100%**
- **Rejection factor: ~ 4%**
- Few units to be replaced next month

St.Gobain getting stabilized

- 347/725 received
- Keep following recovery plan
- **Current rejection fraction ~ 5-10%**
- Expected end of SGB production: **October 2019**

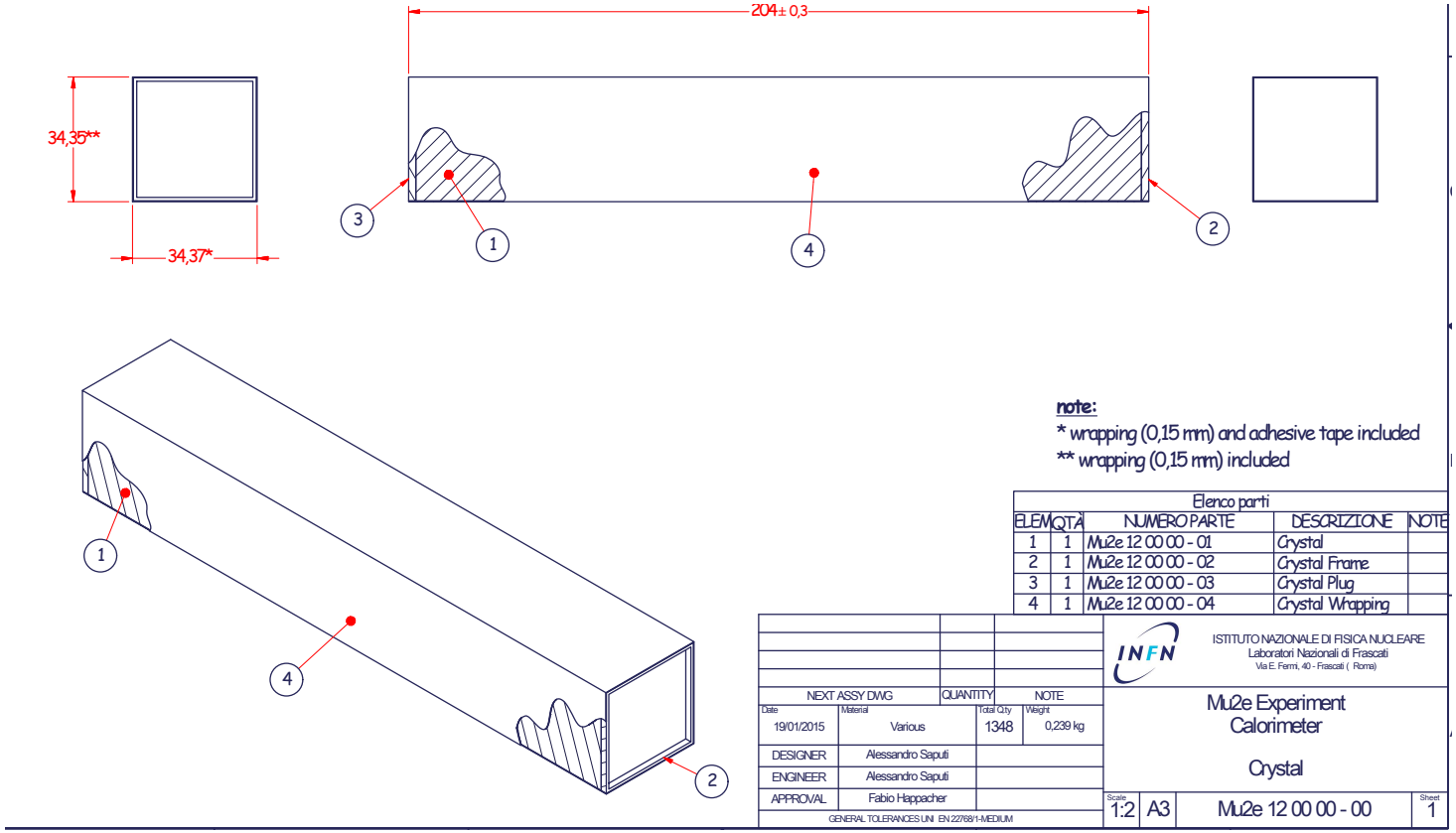


Ready for 1 calorimeter today, for two disks in October

w.o. considering final adjustments:
Tedlar + outgassing + Quartz window

	SICCAS	St.Gobain	Total
Arrived	725+13	347	1085
CMM + inspection	725+13	347	1085
Sent to Caltech	214	73	287
Back to Vendor	13	44	57
Irradiation at Caltech	10	2	12

Wrapping and frames

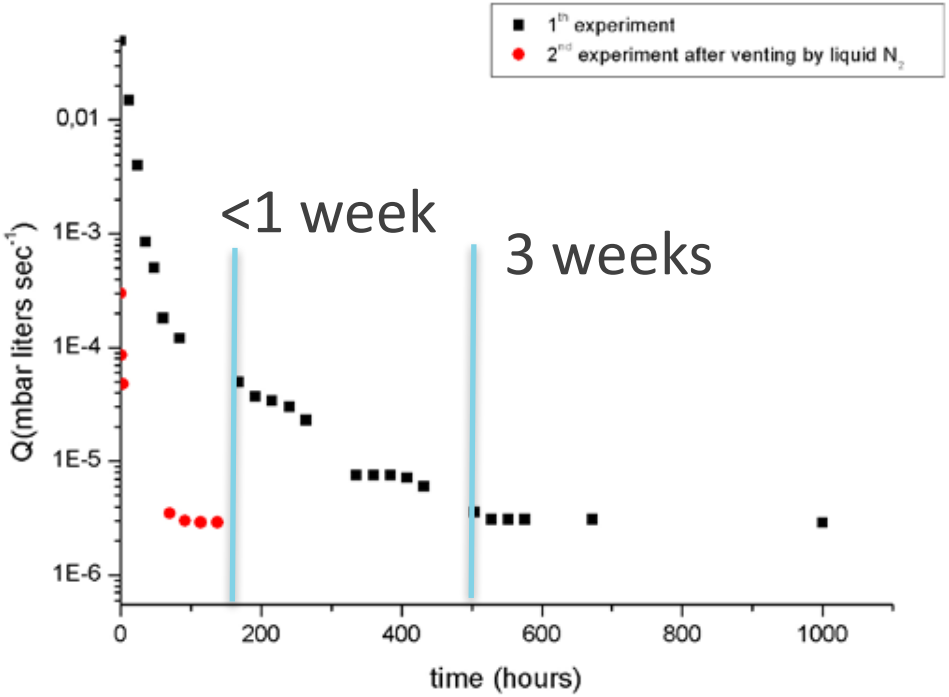


Wrapping is proceeding well with 150 um thick Tyvek, LASA frames of 2 mm (as in Drawings DOCDB # 22220) + 2 layers Tyvek in the back and LASA caps

See Daniele for survey of stacking and tolerances after wrapping

Outgassing measurement

- 4 crystals wrapped with 150 um Tyvek + scotch tape measured @ LNF w/o LASA frames
- LASA frames and caps outgassing contribution found to be very small w.r.t. CsI+Tyvek
- Comparing with Module-0 where LASA frame were introduced outgassing looked comparable



- Plateau reached in 3 weeks w/o venting and few days with N_2 venting
- Final level of 2.4E-3 Torr l/sec obtained out ot 8E-3 allowed for the total calorimeter contribution

Optical cross-talk w.r.t. Tedlar

- Optical cross talk of O(2%) between adjacent crystals found in Module-0 Test Beam data analysis and Laser Scan (May 2017, Feb 2019)
- Down-select between diffusion from "white" ZEDEX FEE plate and Tyvek done in test setup measurement at LNF Feb-2019
  Tyvek layer is responsible for transmittance
- Tyvek transmittance single layers is of O(5%). Tested with green LASER in SiDet transmittance for 1-2-3-4 layers … scaling law is not the product of transmittance
  Ex. Double layer is not 2.5 10^{-3} but confirms order of 2-2.5%

- Final test done at LNF adding 1 layer of 50 um Tedlar in between adjacent crystals
  Effect reduced to per mil level
- Proposal is to add 1 layer of Tedlar btw one side of crystal "only" between adjacent crystals in horizontal row (test done in SiDet)
  → 1 Additional layer of flat Tedlar has to be positioned in between Y-Layers

https://www.dupont.com/products-and-services/membranes-films/pvf-films/brands/tedlar-pvf-films/uses-and-applications/tedlar-composite-applications.html

Outgassing requirement in situ

- **We need to do measurement for Tedlar outgassing "now"**
- Add 1 Tedlar layer, one side (50 um if we do not find 25um)
- Repeat a final test of assembled unit in vacuum after review
- **Organizing an outgassing test at SIDET for the production to make N2 venting before assembly**

✓ A FNAL facility (far from SIDET) exists, allowing to outgas crystals and make N2 venting. Cost of 40 k$! It looks like we can do it for free now

(thanks to a Lab agreement)

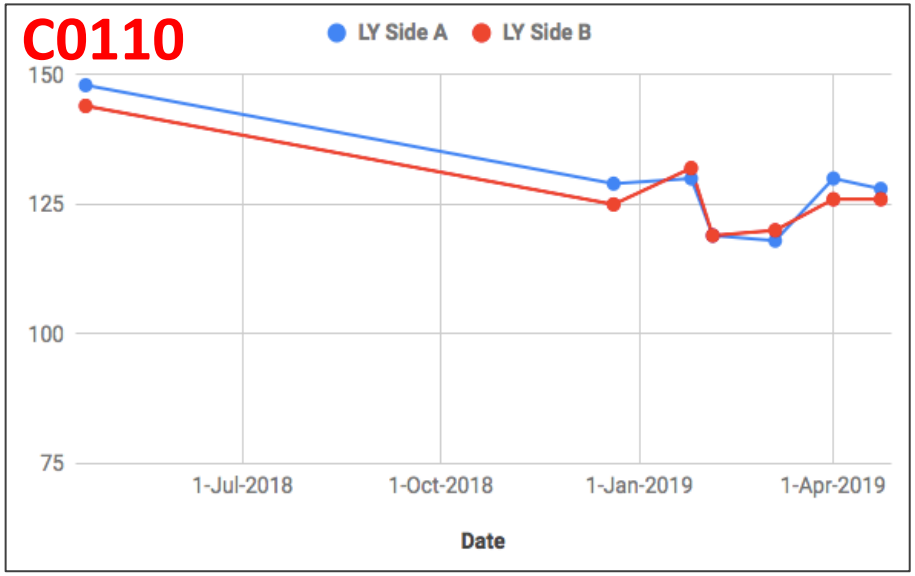
- **Still obnoxious since we should move crystals (in group of 100) out of SiDet**

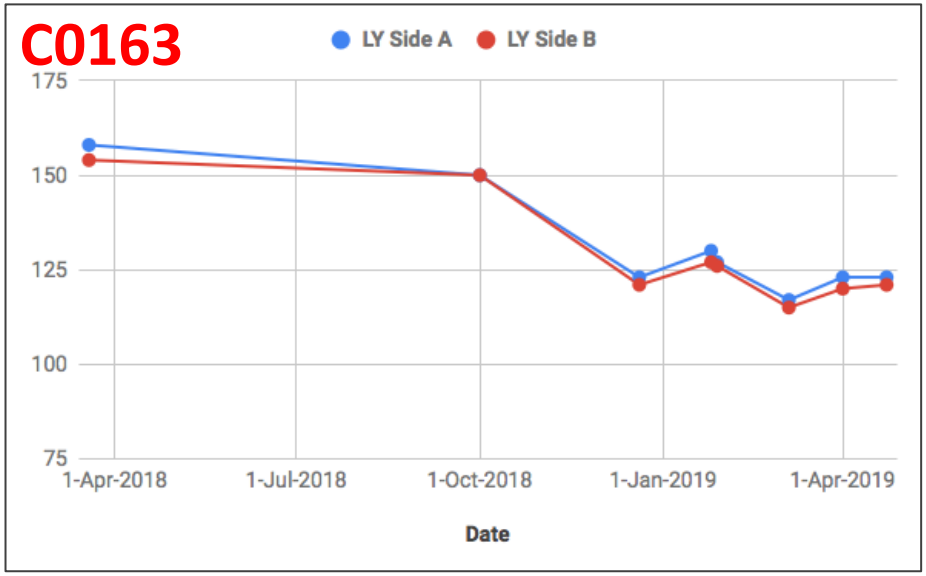
✓ Bringing Large LNF Vacuum Vessel ???

✓ Recycle a new large cylindrical vessel found last week

- Phi = 65 cm, Height = 80 cm
- Test it in SiDet in the next weeks

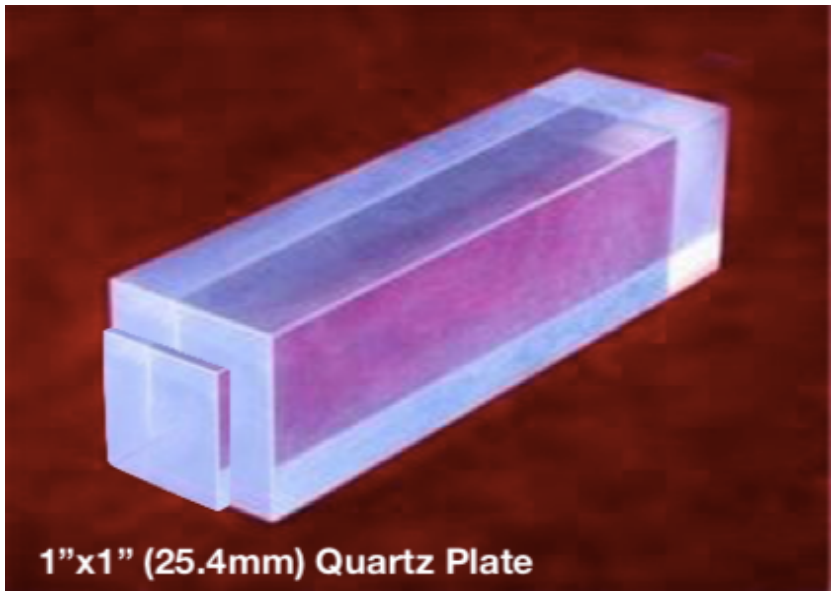
Dependence of LY w.r.t time and RH

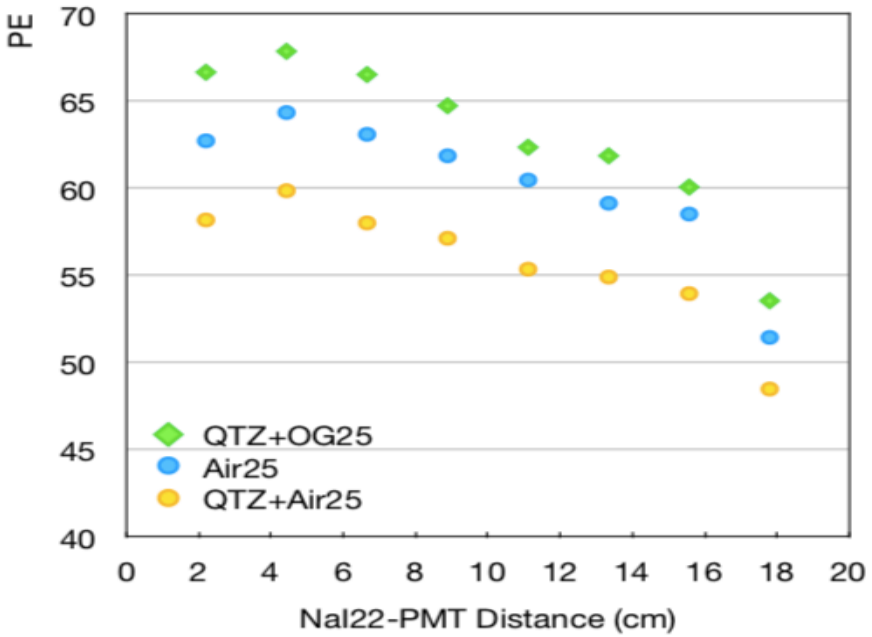




- It looks like that CsI crystals have a fast loss (up to 20%) and then stabilize to a plateau. This loss seems to be related to CsI hygroscopicity
- It was partially proven by recovering LY when polishing again 100 um of crystal small face at SICCAS
- After 1.5 years, Module-0 light yield seems to be stable
- **We need to work in DRY-AIR as much as possible when in the Mu2e hall**

Caltech proposal …





- Caltech group proposes to “seal” the crystal edges by gluing a “0.5 mm” quartz cap in front of the readout face
- Test with neutrons in progress, outgassing and irr. dose planned
- It looks like it does fine for the LY ..
- Problems: do we really need it? It is going to be a new work-line.
  If we can avoid it we do not touch crystals again, apart Tedlar that is fast
  → We should prove we do not need it

Crystal organization inside disks: irr. dose

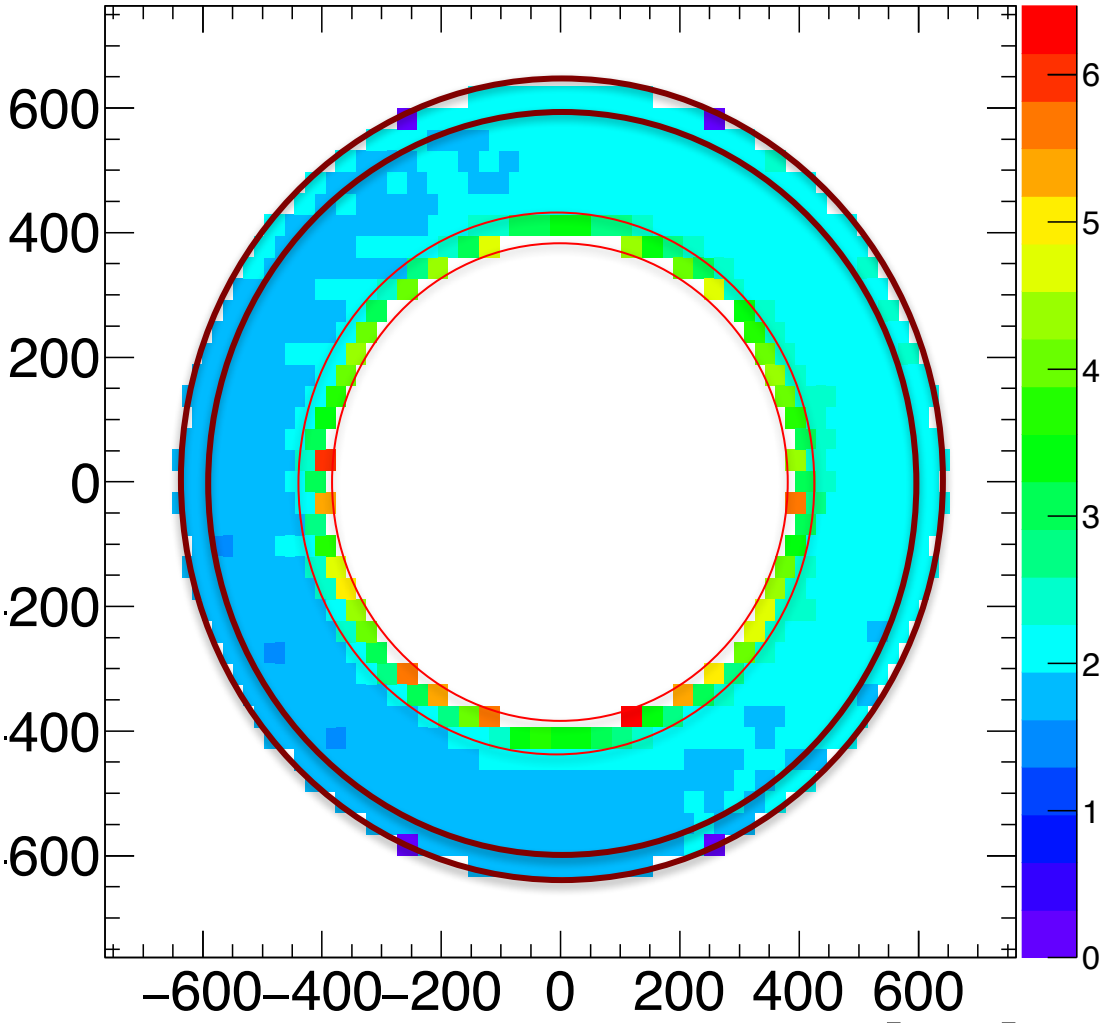
Crystals have a large difference on irradiation dose and occupancy

3 areas can be identified:

1. Innermost ring
   - high total dose
   - high instantaneous dose
   - large leakage

2. Outer ring
   - small occupancy
   - smaller dose

3. Central region
   - transition region



Crystal optical properties “groups”: first idea

674 crystals for each disk

Group 1: <u>Innermost ring</u>

- Low Radiation Induced Noise
- Large Fast/Total ratio
- High Light Yield
- Uniformity not very important: resolution is leakage dominated
- Response to irradiation dose:
  - Npe/MeV(SIC)>100 after 100 krad
  - Irradiation dose test still to be done for St.Gobain

- **Two innermost CsI rings correspond to ~ 120 crystals/disk**
- **For the second disk, we can do this for one CsI ring, if needed**

Group 2: <u>Outer ring</u>

- High Radiation Induced Noise
- Small Fast/Total ratio
- Low Light Yield
- Large Longitudinal Response Uniformity

~ 120 crystals/disk

Group 3: <u>Central region</u>

- All the rest

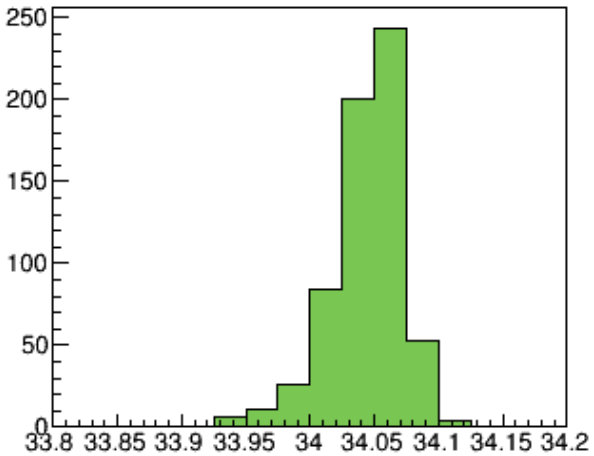
~ 430 crystals/disk

Proposal for crystal stacking

Since the mounting assumes the aluminium inner step having a smaller height than crystals + spacers to compensate the difference

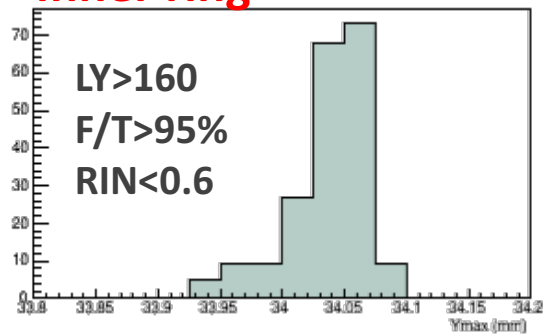
- Lower crystals to be stacked are the ones with larger thickness (Y CMM dimension if aluminium tape + Tedlar are positioned among crystals of the same row)

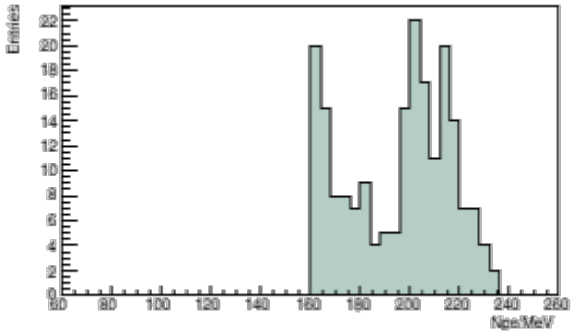
Ymax distribution,
25 um binning

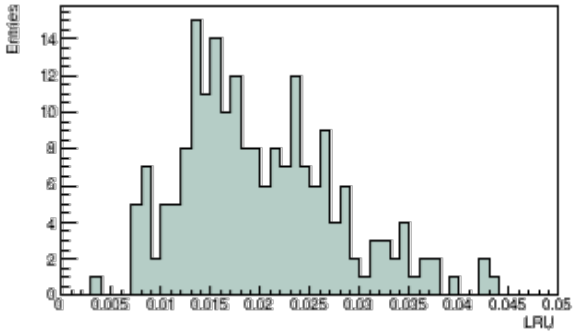


First test of crystal selection

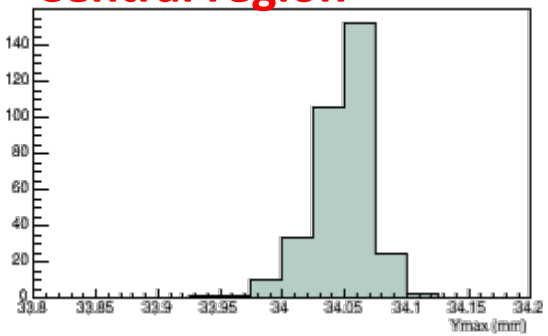
Inner ring

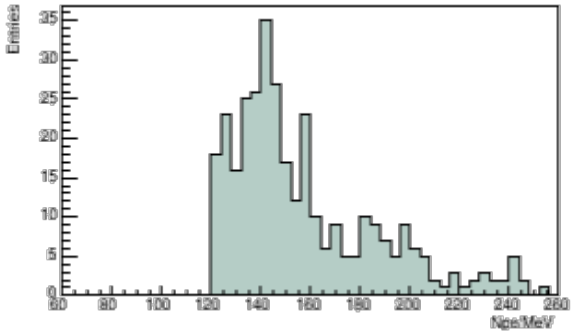


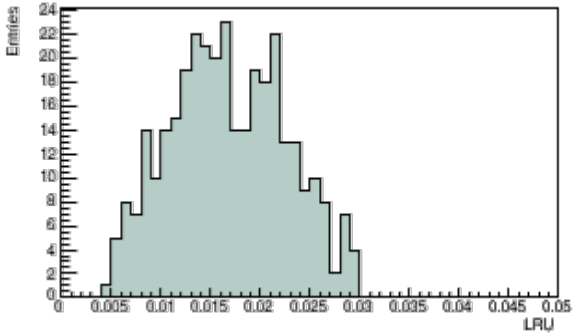




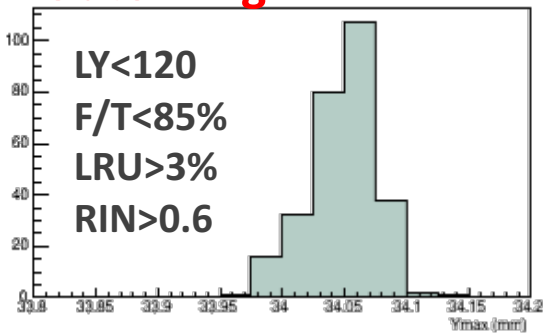
Central region

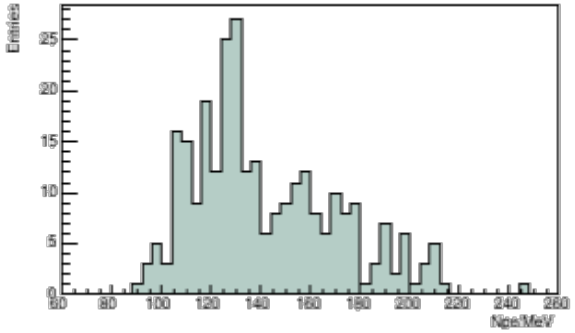


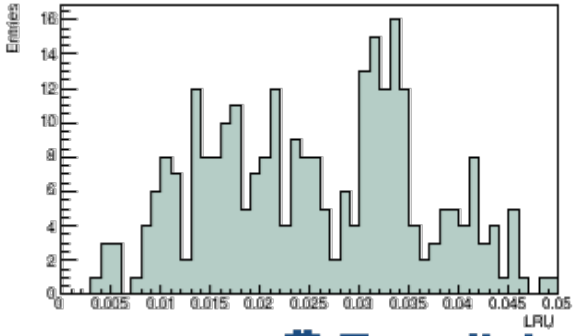




Outer ring







Fermilab