Preparation of HCAL Beam Tests with Tungsten Absorber Plates

W. Klempt / CERN

Motivation

Goals and Objectives

Commercial available Tungsten Plates

Workshops in Annecy and DESY

Proposal for a W HCAL Prototype

Conclusion

CALICE Workshop at UT Arlington 12/03/10

Motivation

- Physics at CLIC with a center of mass energy of 3 TeV requires to build a calorimeter system with rel. small energy leakage.

  => Design value for $\lambda_{int} \geq 1$ (ECAL) + 7 (HCAL)

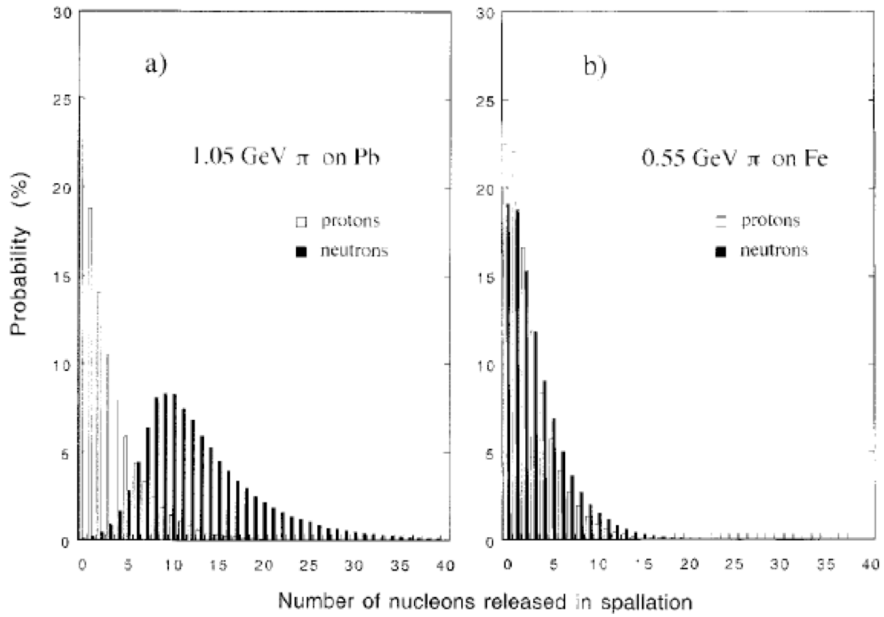
- Space available for barrel HCAL inside (reasonable sized) coil: $\Delta r \approx 1.40$ m

  => need to use a more dense material than Fe

- Why not use W as absorber material in HCAL??

Motivation

- No experience with W as absorber material in HCAL
- λ_{int} (W) = 10 cm , X_0(W) = 0.35 cm
- λ_{int} (Fe) / λ_{int} (W) = 1.7, X_0(Fe) / X_0(W) = 5
- For a W absorber:
  - less visible energy (ionization)
  - more neutrons (spallation)
- PFA analysis requires very fine granularity in both ECAL and HCAL
- For colorimeter design simulations need to be reliable and understood to a rather precise level.



Goals and Objectives for a W HCAL Prototype

- Validate and adjust simulations for HCAL performances
  - Linearity / energy
  - Resolution / energy
  - Shower structure in comparison to Fe
  - Time structure of signal (neutrons)
  - Compare scintillator with gaseous detectors
  - Experience with W plates

Later

- Other detector technologies
- Combine with ECAL proto
- …

Mechanical Properties of Tungsten

	Pure W	INERMET 176*	Steel
% Tungsten	100	92.5	-
Alloying materials	-	Cu, Ni	-
Elasticity (Young) [GPa]	400	350	200
Density [g/cm^3]	19.3	17.6	7.85
% Elongation at yield	< 5**	5	30-50

*Alloys used must be paramagnetic, **Tests required

Plate Size and Tolerances

- Currently available plate sizes

Pure Tungsten	INERMET
1200 mm x 1600 mm	400 mm x 600 mm

- Thickness of 10 mm is feasible for both
- Flatness tolerance ca. 1.5 mm
  - < 1 mm possible
- Thickness tolerance ± 0.5 mm
  - With machining ± 0.1 mm (cost ↑)

Workshop in Annecy on 24/9/09
Workshop in DESY on 2/3/10

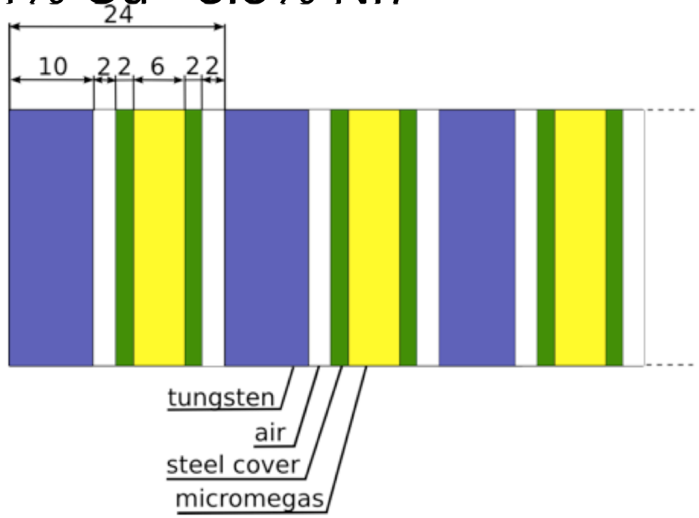
- The LCD-CERN, CALICE-DESY and LAPP groups agreed to work together and construct a W-HCAL prototype starting 2010.
- More collaborators should be found
- First test beam measurements scheduled for November 2010 at PS (π up to 12GeV/c)
- Test setup is starting to be prepared.

Prototype Simulations

Detectors:
- Scintillator
- Micromegas

Absorber:
- W with thickness between 10 to 12 mm
- Pure W vs W “alloy” (92.5% W + 4% Cu +3.5% NI)

Simulations:
- Shower size
- Containment
- Compare different absorber materials (i.e. W and Fe)
- Compare different physics lists in Geant 4

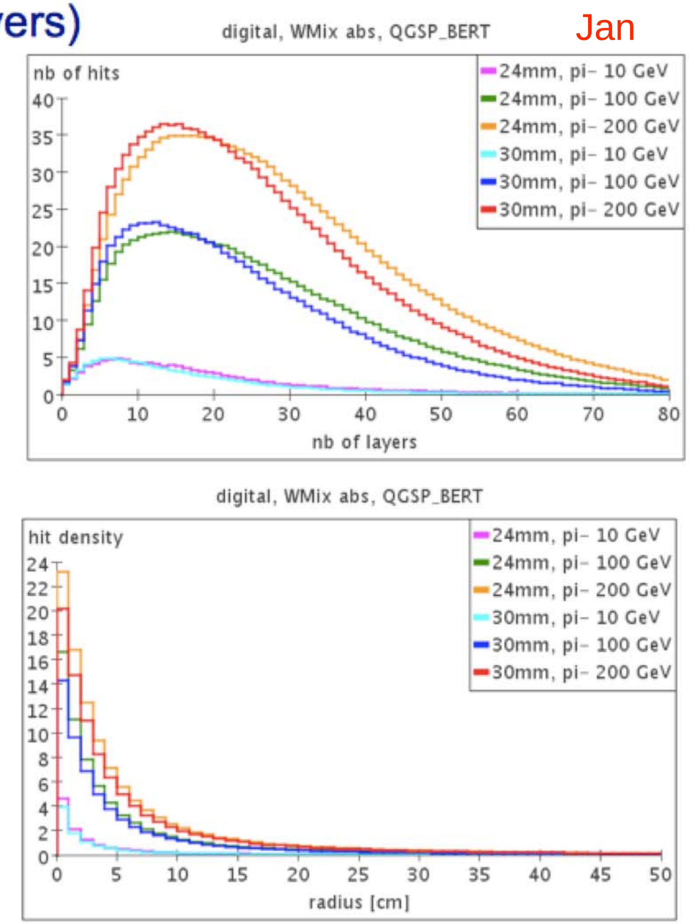


Simulations done by J. Blaha (LAPP), C. Grefe (CERN) and A. Lucaci-Timoce (DESY)

Shower Profiles

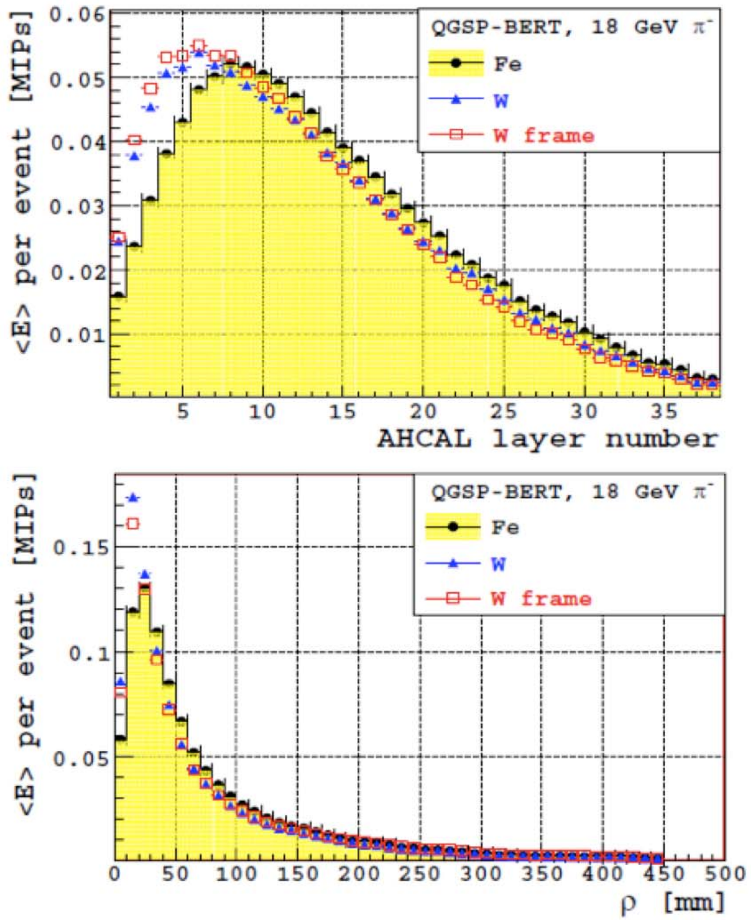
10 mm WMix + µMegas (two 2 mm Fe covers)

Jan



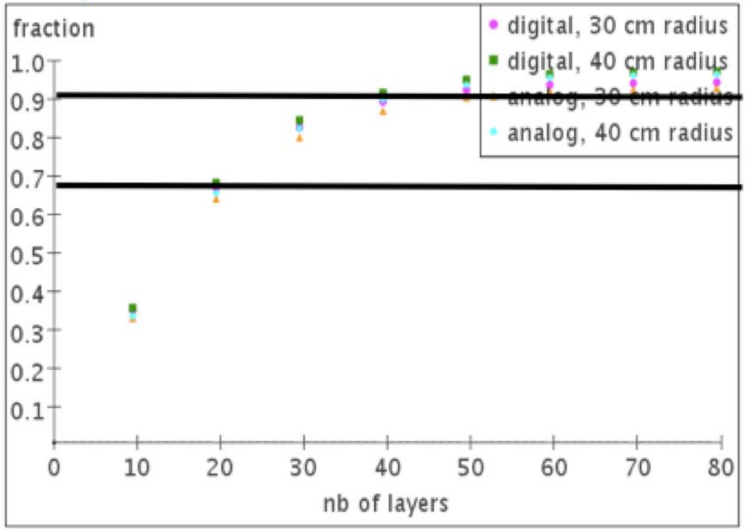
10 mm W + 2 mm air + 5 mm scint, 38 layers AHCAL

Angela

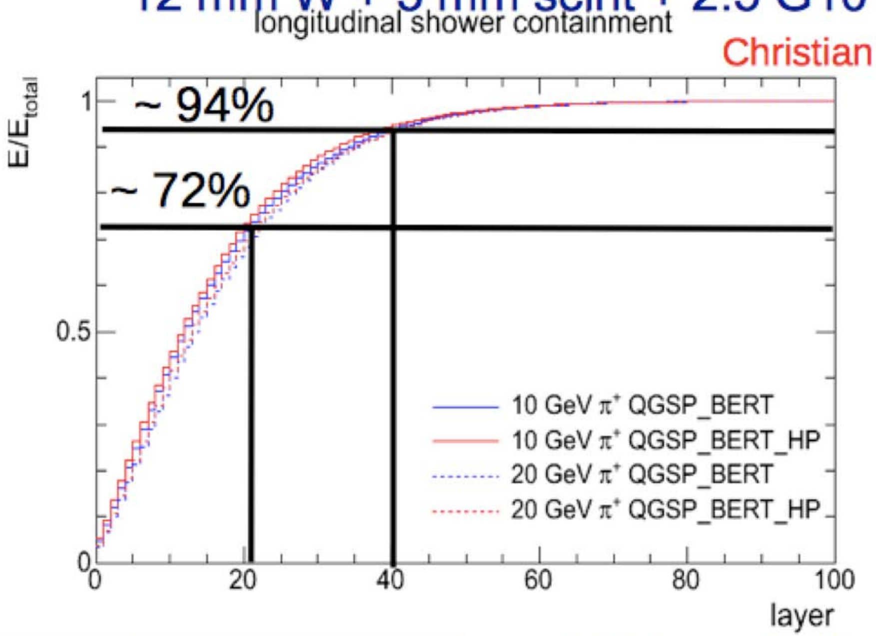


Longitudinal Containment

10 mm WMix + μMegas (two 2 mm Fe covers) — Jan



12 mm W + 5 mm scint + 2.5 G10 — Christian

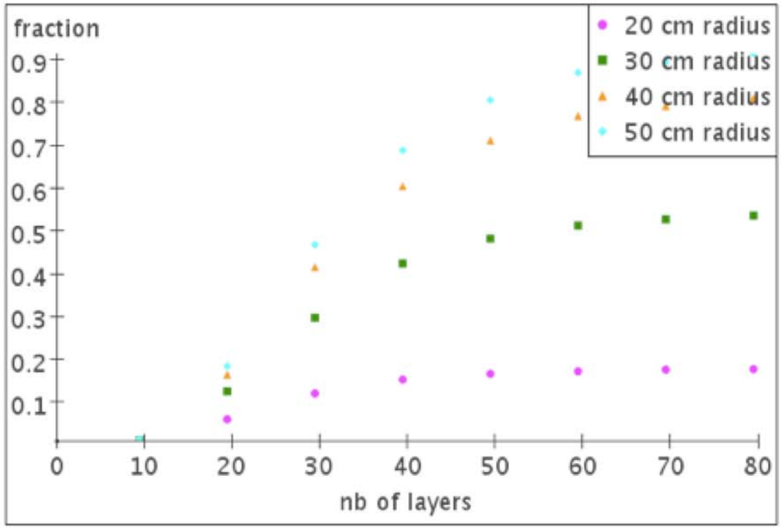


10 GeV pions	20 layers	40 layers
60 x 60 cm^2	68 %	89 %
80 x 80 cm^2	69 %	91 %

Infinite calorimeter

Fraction of 95 % Contained Events

10 mm WMix + μMegas (two 2 mm Fe covers)



Jan

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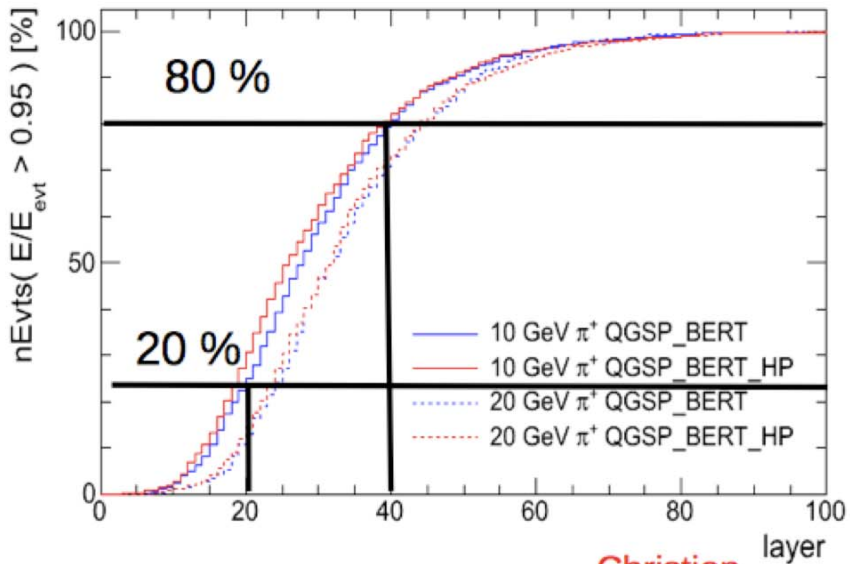
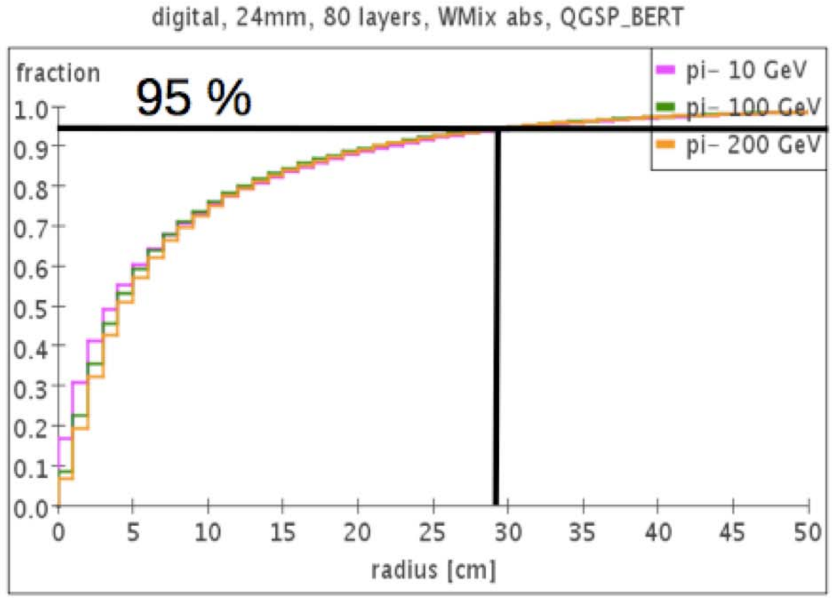


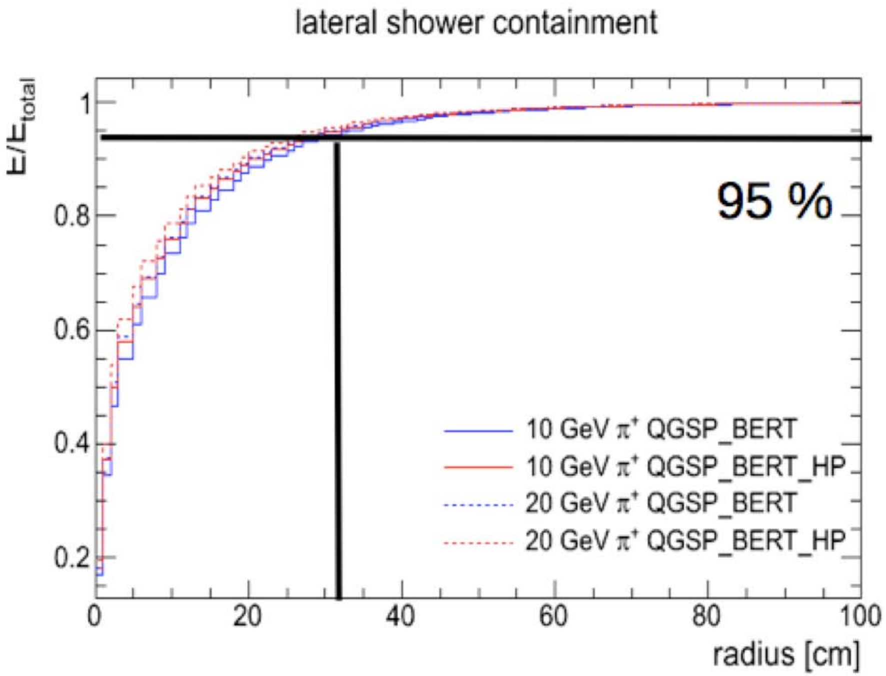
Christian

10 GeV pions	20 layers	40 layers
60 x 60 cm^2	12 %	41 %
80 x 80 cm^2	16 %	60 %

Lateral Containment



Jan

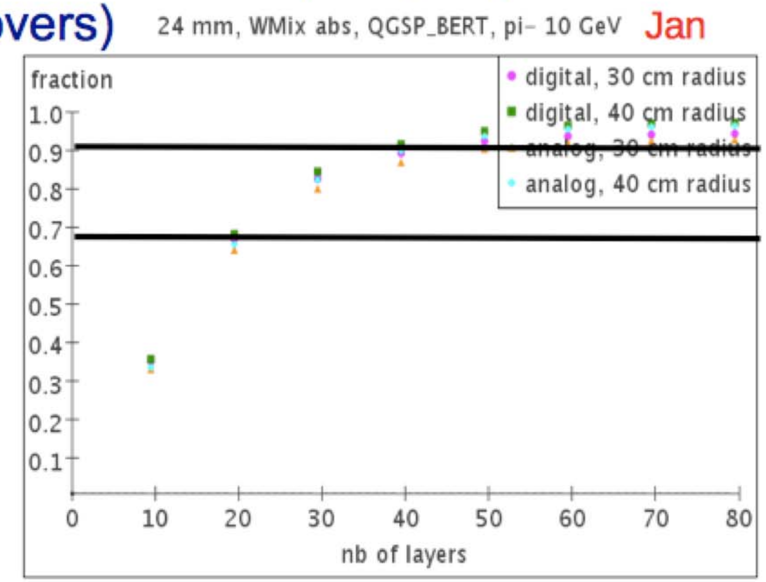


Christian

- In deep calorimeter (80 layers or “infinite”), 95 % of energy is contained in calorimeter with lateral size ~ 60 cm

Lateral Containment

10 mm WMix + µMegas (two 2 mm Fe covers)



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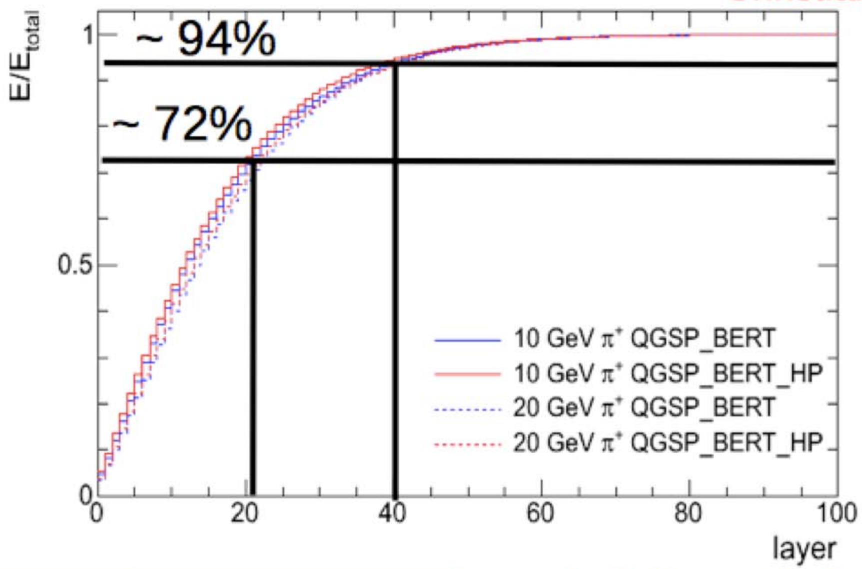

Infinite calorimeter

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60 x 60 cm^2	68 %	89 %
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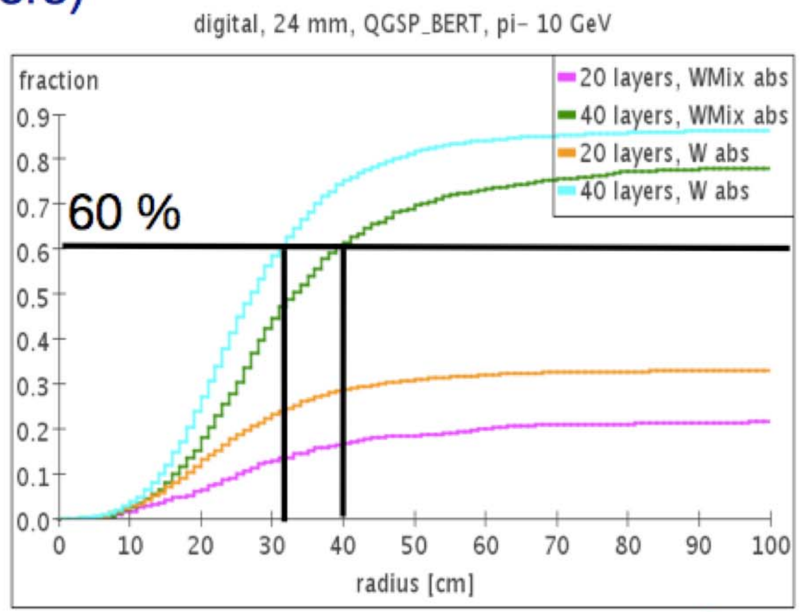
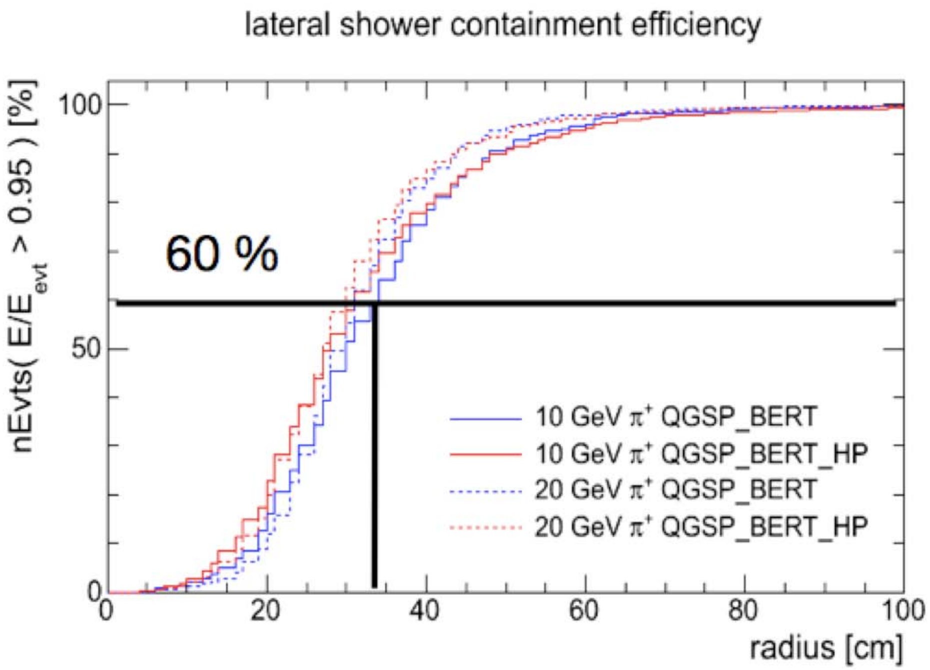
Fraction of 95% Contained Events

10 mm WMix + μMegas (two 2 mm Fe covers)



Jan

12 mm W + 5 mm scint + 2.5 G10



Christian

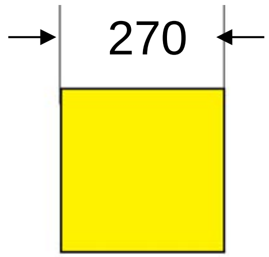
- Significant difference in number of fully contained events for W alloy and pure W → larger lateral size should be considered for WHCAL prototype with alloy absorber in comparison with pure W

W HCAL Prototype

- Start 2010 with a “small” prototype:
  - Start with ~20 W plates size ca 81x81 cm^2, 1 cm thick
  - Use as much as possible existing equipment from CALICE AHCAL (detector planes, readout electronics, DAQ, mechanical infrastructure…..)
  - First test beam at PS in autumn 2010
  - Later increase depth to 38 or more layers

Market Survey on Tungsten Supply

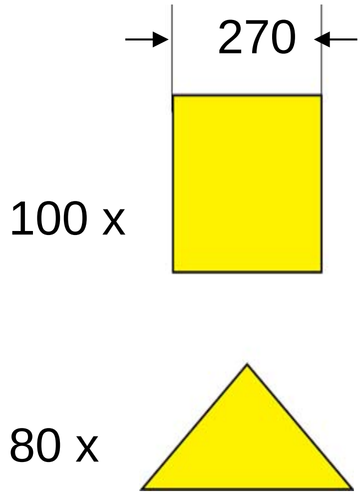
- MS presented to CERN Finance Committee in dec 2009
- Send out 20.1.2010 to 9 companies
- MS closed on the 19.2.2010
- Received 3 positive answers
  - PLANSEE Metall GmbH, Austria
    pure W ρ ≈ 19.3 g/cm3
  - PLANSEE Tungsten Alloys – CIME BOCUZE, France
    pure W ρ ≈ 17.5 g/cm3
  - Special Metals and Products, Spain
    pure W ρ ≈ 19.3 g/cm3



Tungsten plates

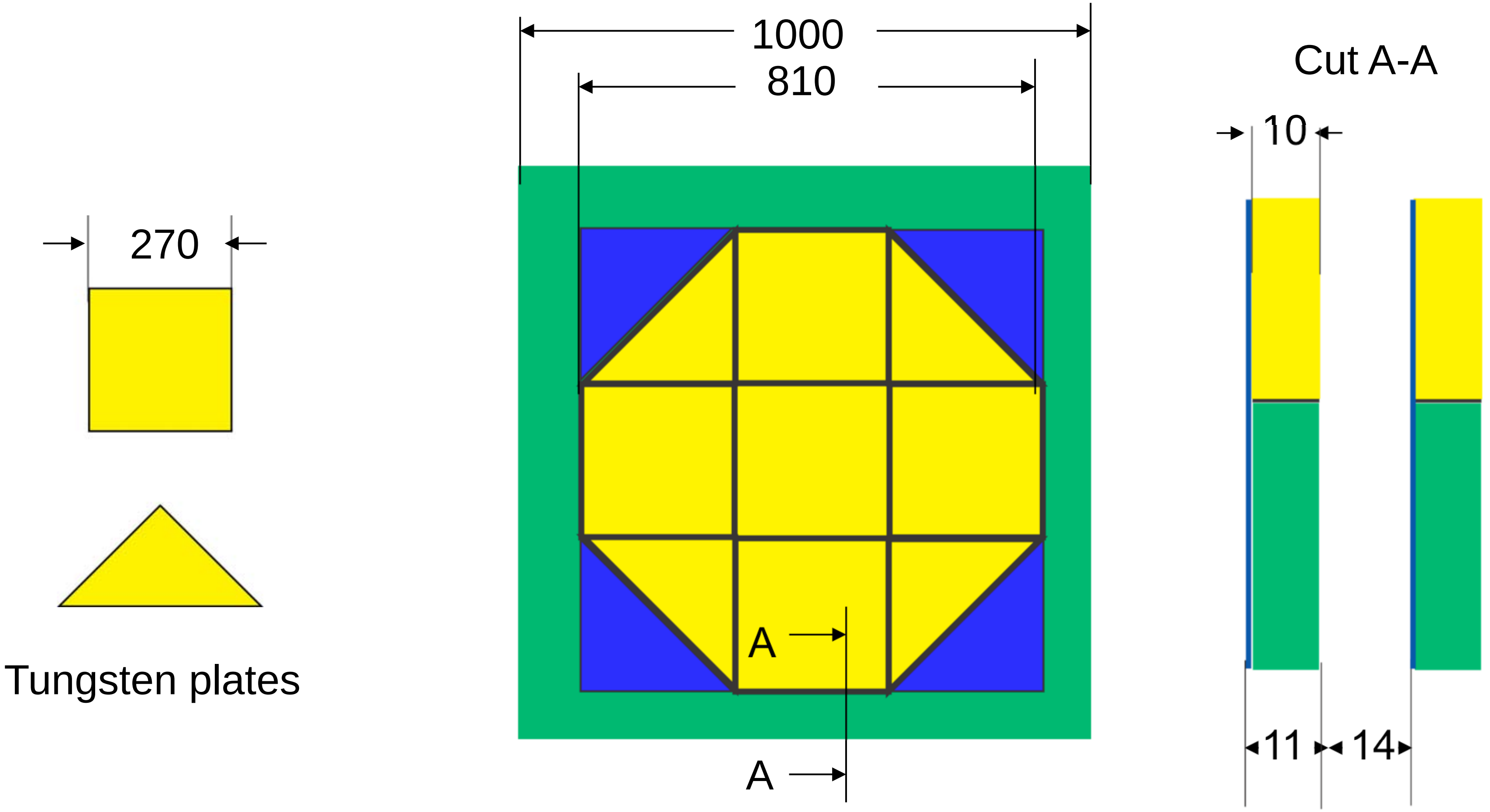
Invitation to Tender

- Invitation to tender is prepared now, will be send out this week
- Delay for answers is 4 weeks
  invitation for tender will be closed
  by ~ 15.3.2010
- Place order by 30.4.2010
- Receive 4 batches of 25 squares and 20 triangles on
  15 June, 30 June, 15 July and 31 July
- Start to equip absorber plates from 15 June onwards

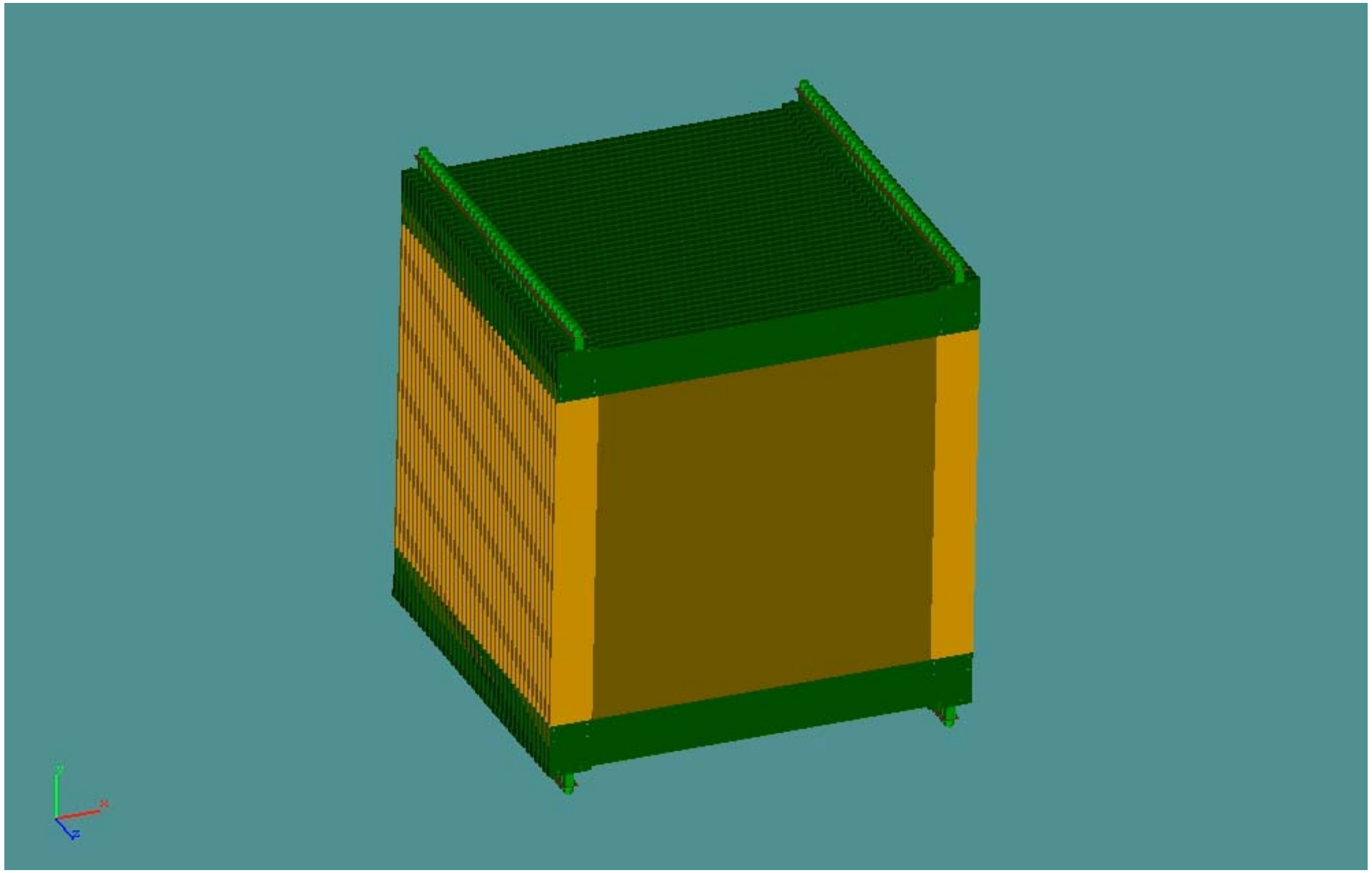


Tungsten plates
Thickness 10 mm

Design of Frames

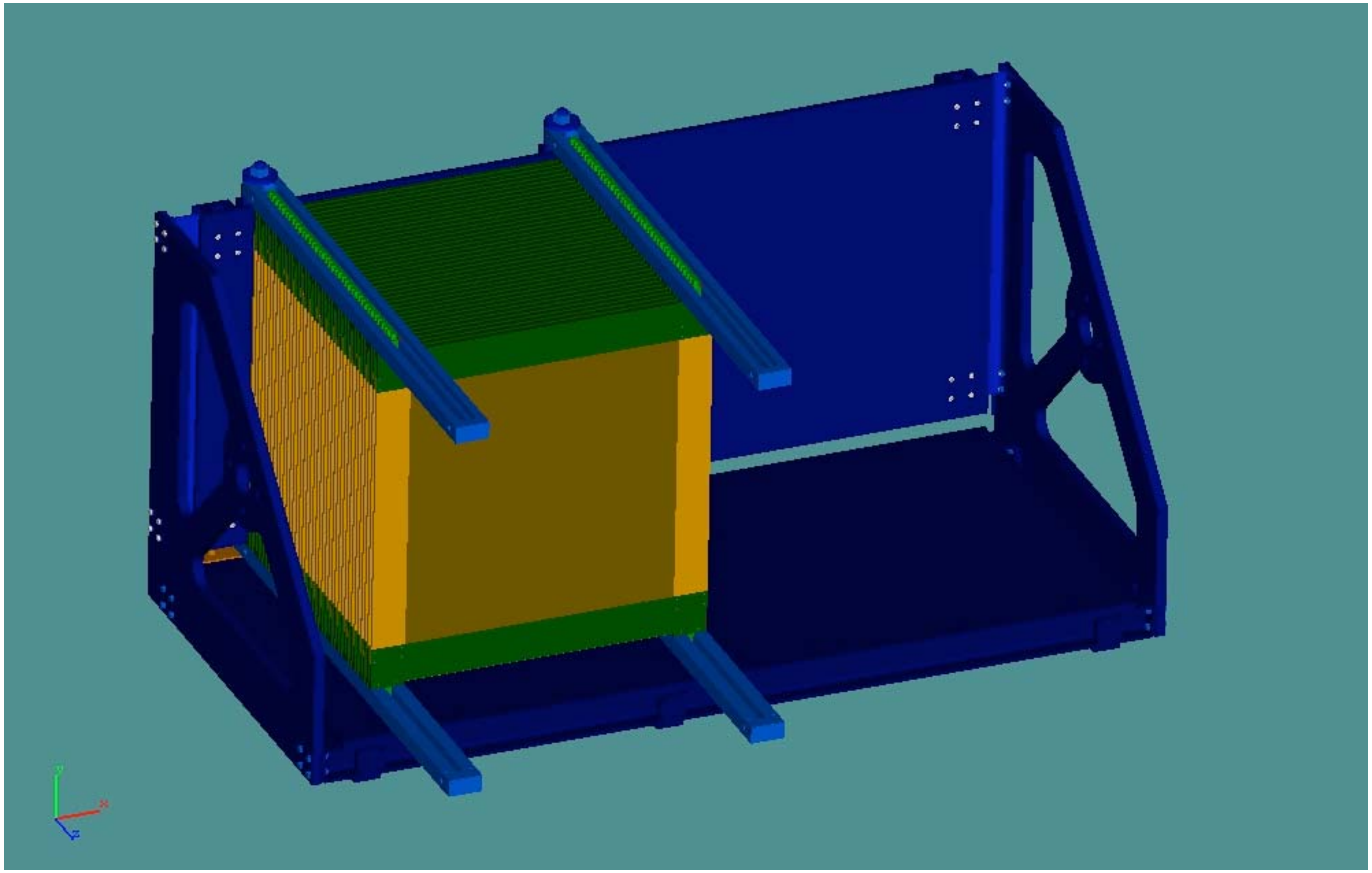


Tungsten Absorber Stack

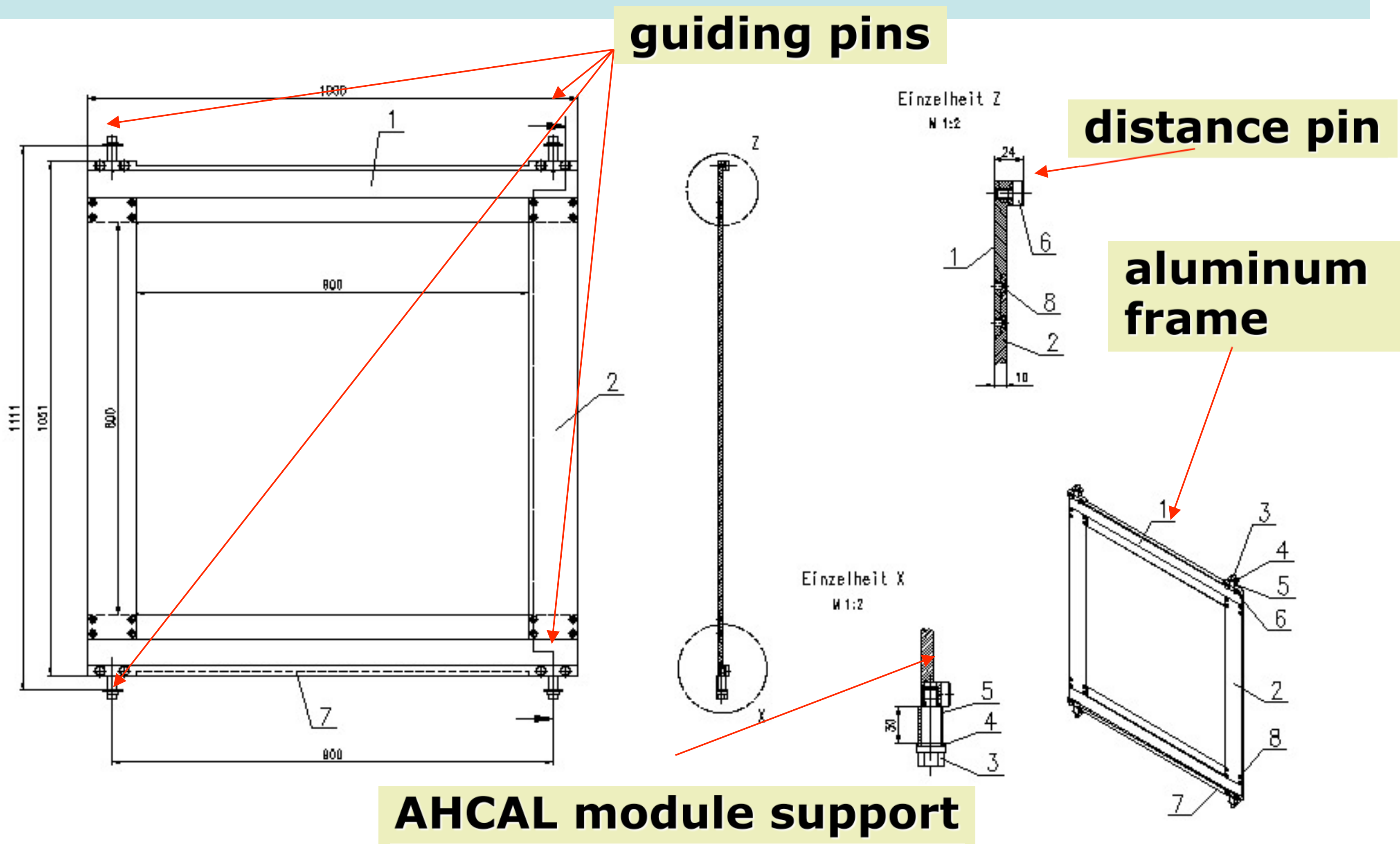


Compatible with movable table

Tungsten Absorber Stack with Stack Support for the Movable Table

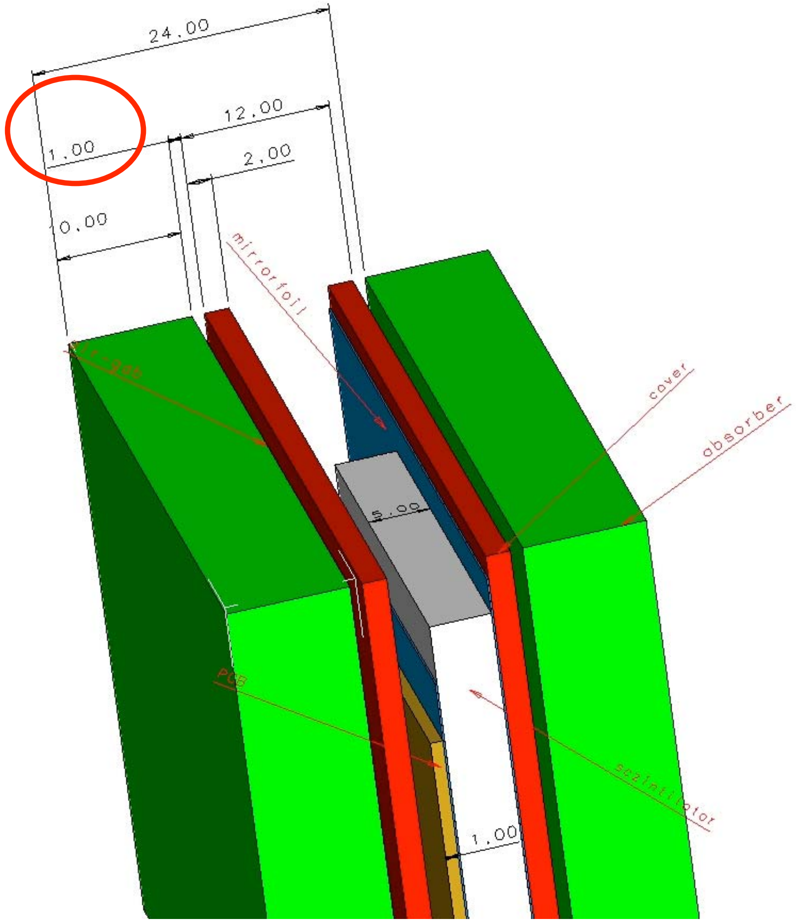


Tungsten Absorber Layer

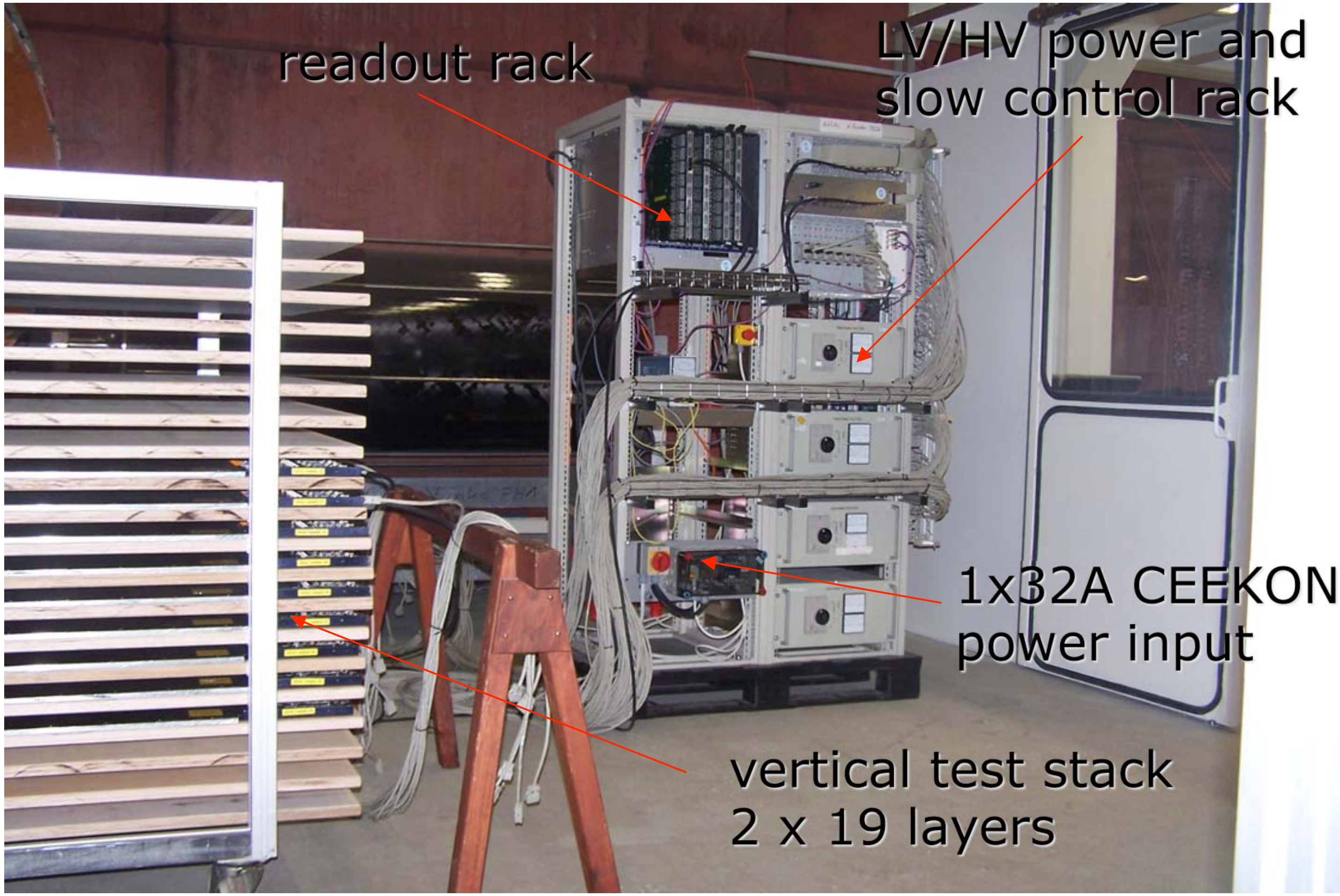


Layer structure with tungsten absorber plates

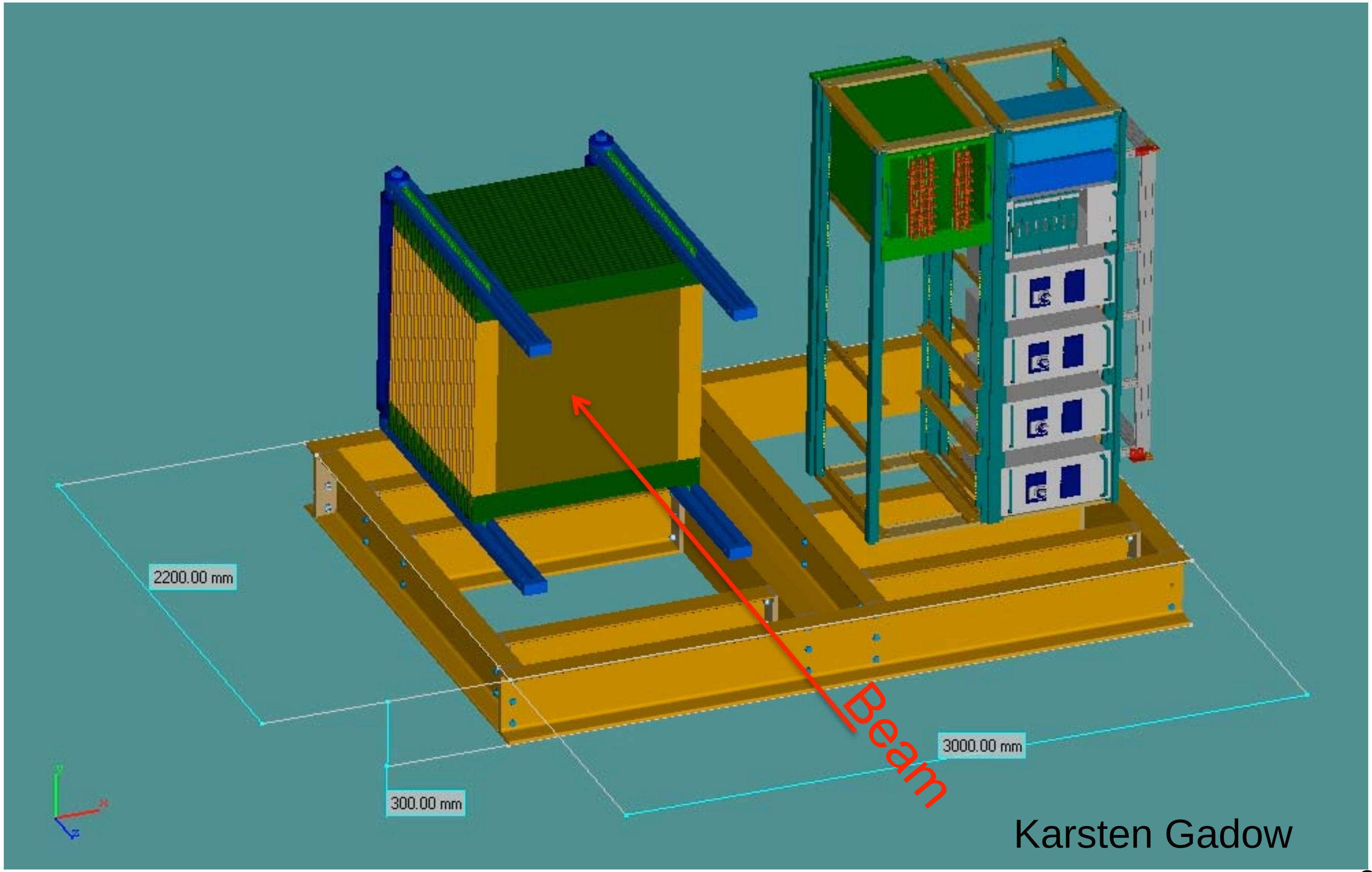
(with sensitive layer modification)



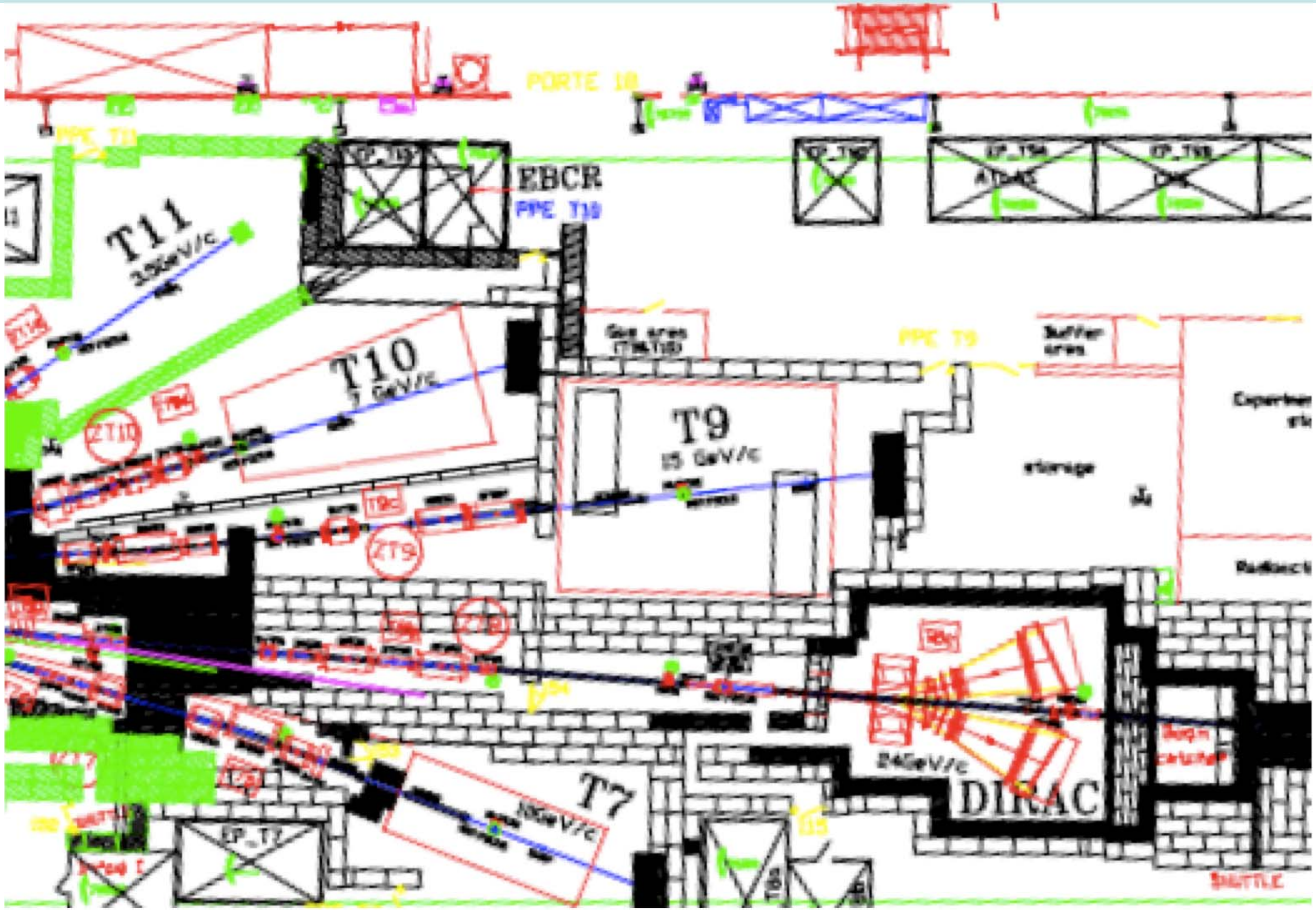
AHCAL vertical test setup



Test Module

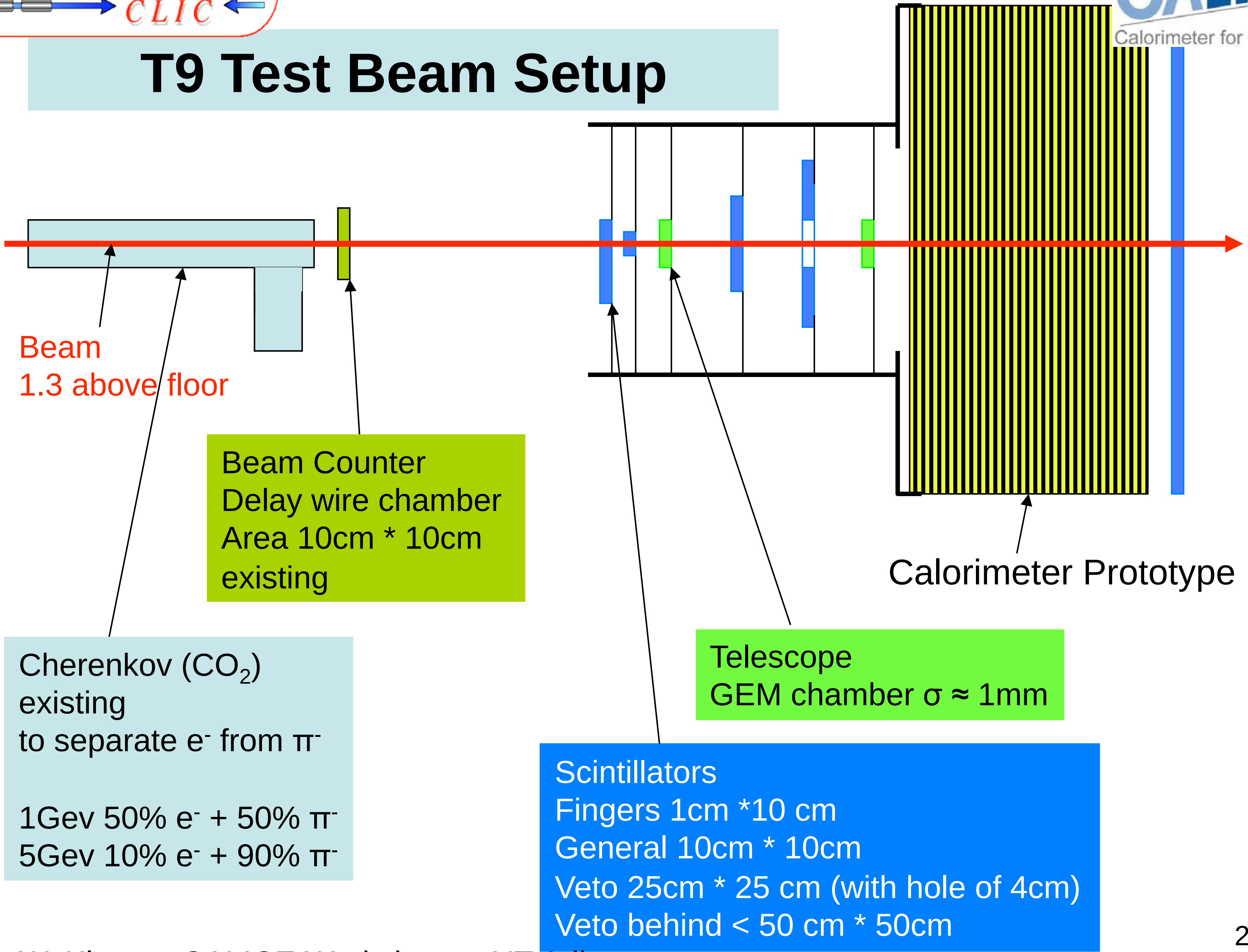


East-Hall/ T9 Layout

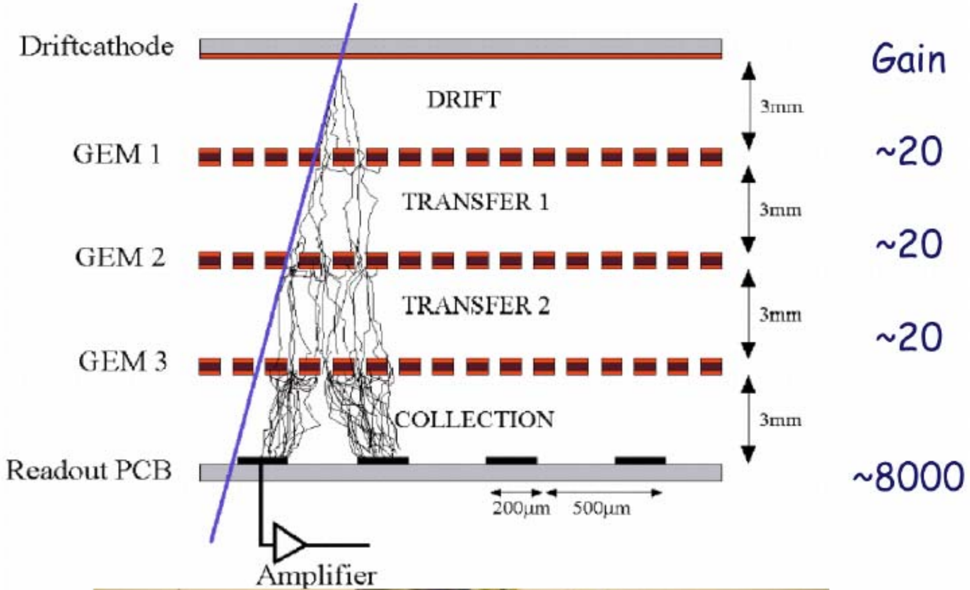


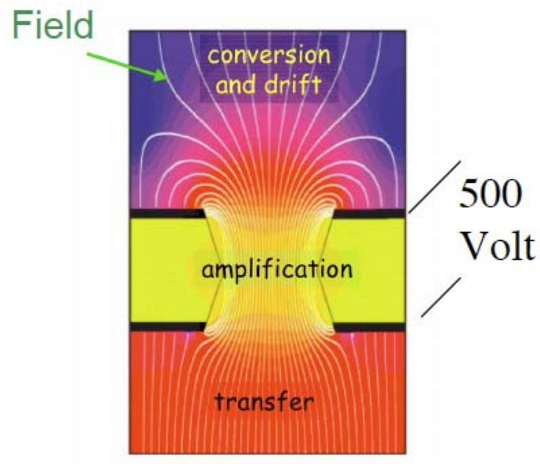
East-Hall/ T9 Layout

T9 Test Beam Setup



Triple-GEM Detector



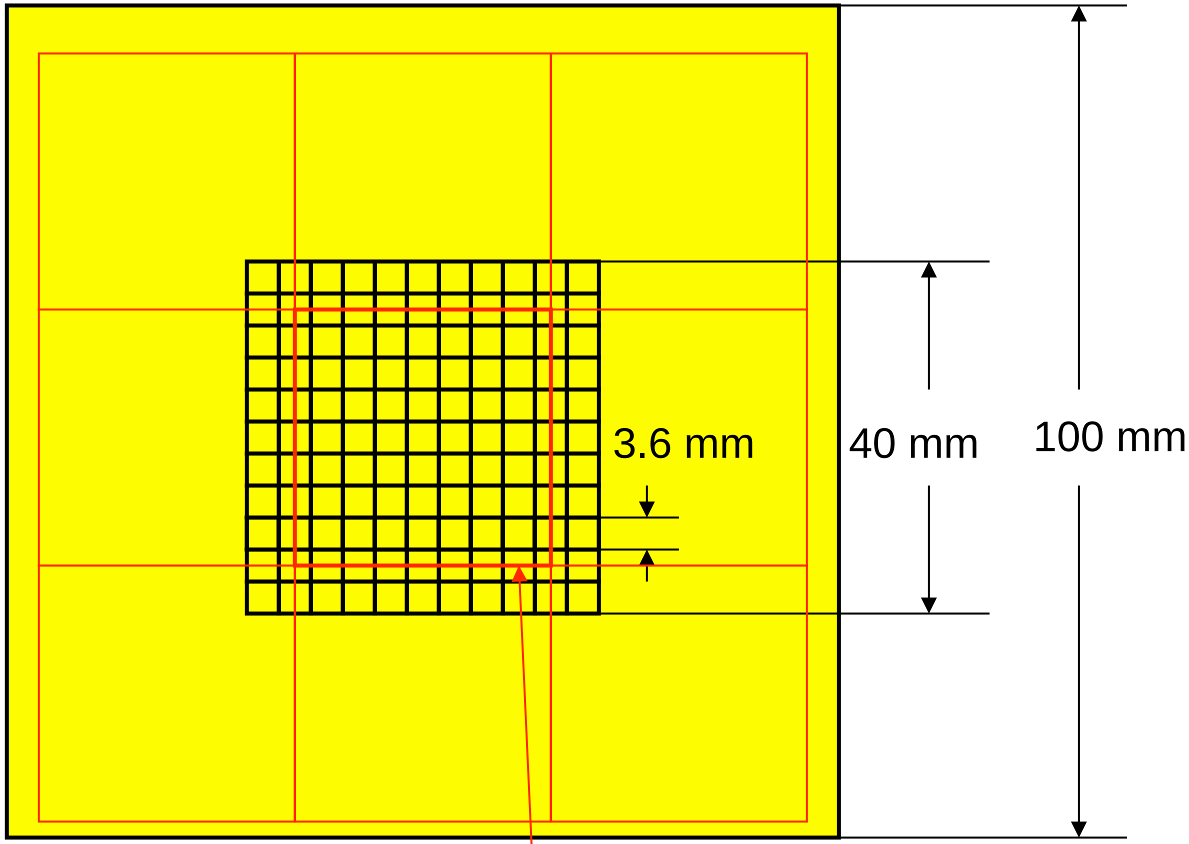


"Standard" size :
10cm * 10cm

Ar/C02 70:30 gas-mixture

One may choose pad plane geometry

Cathode Plane and Read Out



Central sintillator

Resolution:

$$\sigma = \frac{3.6\,mm}{\sqrt{12}} \cong 1\,mm$$

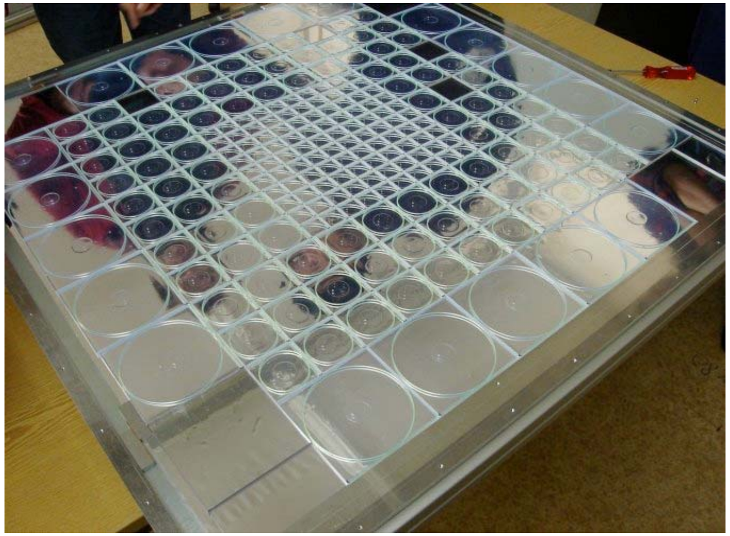
11*11 = 121 Channels

Digital read out
AVP-25 chip
128 channels per chip
Need 1 chip/ chamber

H. Mueller is producing read out chain

Detectors to be used

- In 2010 start with existing CALICE scintillator cassettes

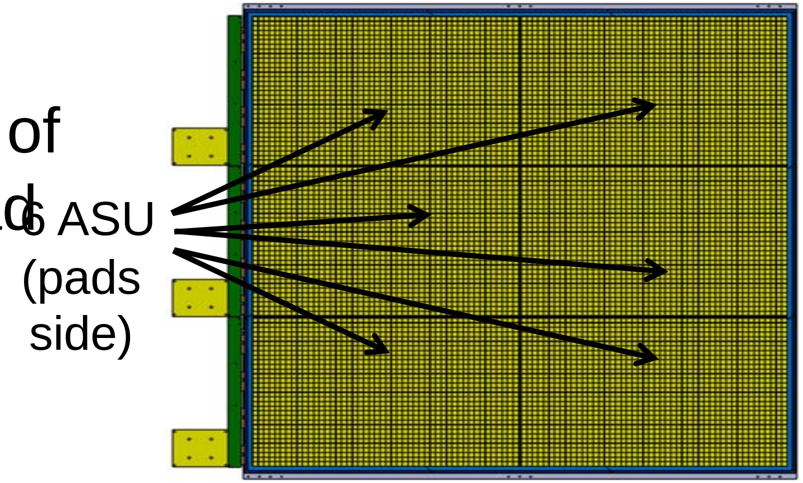


Overall size 90 x 90 cm^2
Central area equipped with small (3 x 3 cm^2) cells

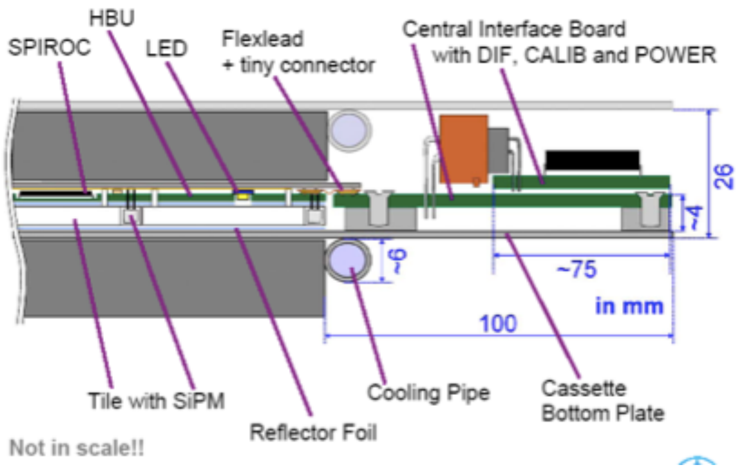
Equipped with readout and calibration

Future Detector Planes

- Micromegas detector planes with a cell size of 1x1cm^2 and digital read out

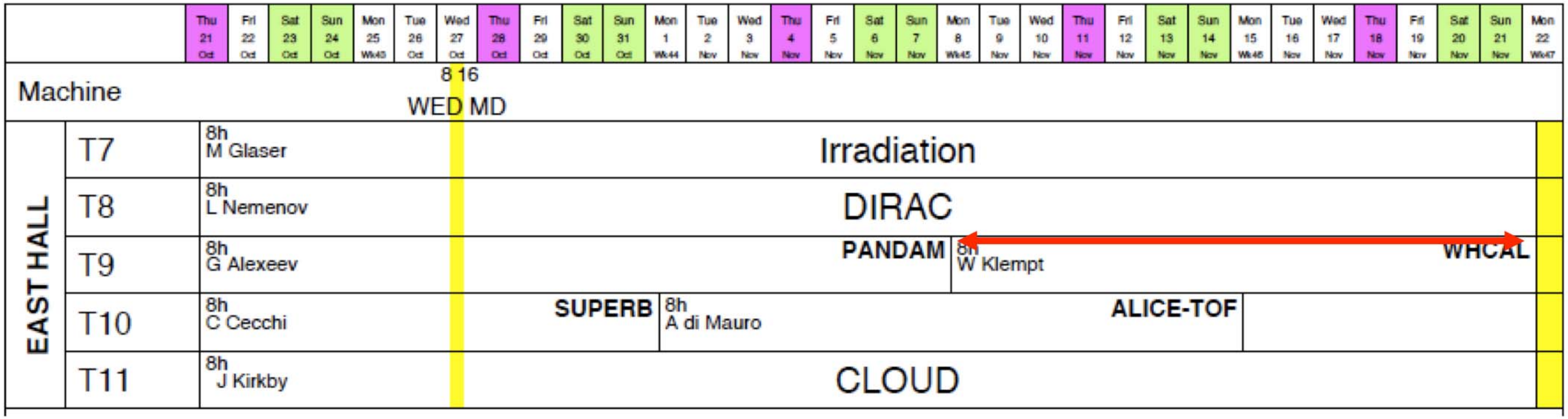


- Scintillator planes with a cell size of 3x3cm^2 over the whole surface and analog readout



Schedule

Preliminary PS/SPS Schedule: we run 8/11 to 22/11



Conclusion

- Tungsten offers maybe the possibility to build a compact HCAL with fine granularity readout at CLIC.
- No experience with W in an HCAL

  => need to validate W as absorber material in a prototype.
- Use of existing equipment enables us to get to first experimental result already end of this year